NAG-8-276

U·A·L·R

Department of Physics and Astronomy

NASA/CR-97-   205886

TO: Mr. Maury Estes, JOVE Program Manager

FROM: Don Wold

DATE: April 25, 1996

RE: JOVE Final Report

Here is my JOVE Final Report including separate lists for Publications, Extramural Funding, and Awards. Also, I have enclosed an abstract of work which I am doing with two students who are funded by the Arkansas Space Grant Consortium. Would you please note that my JOVE funding began in 1992 and ended in 1995.

Thank you for the opportunity to share in the JOVE program and I wish you continued success with it.

Donald C. Wold

PC: Dr. S. A. Covington, Director, Office of Research and Sponsored Programs

UNIVERSITY OF ARKANSAS at LITTLE ROCK ♦ 2801 S. University Avenue ♦ Little Rock, AR 72204
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UNIVERSITIES SPACE RESEARCH ASSOCIATION

Atmospheric Sciences · Microgravity Sciences · Astronomy · JOVE

4950 Corporate Drive · Suite 100 · Huntsville, Alabama 35806 · 205-895-0582 · FAX 205-895-9222

MEMORANDUM

TO: JOVE Faculty Research Associates

FROM: JOVE Program Office

SUBJECT: 1996 JOVE Abstract Book

DATE: March 18, 1996

The JOVE Program Office will be putting together an Abstract book for the *1996 Retreat in Hampton, Virginia*, and we want to include an Abstract for each JOVE Faculty Research Associate. Please send an Abstract even if you aren't planning to have a poster presentation at the Retreat.

Listed below are guidelines for your Abstract:

• Title of the Abstract should be in capital letters.
• Provide first name, middle initial, and last name of the author and co-authors.
• Underline your name and provide your institutional affiliation
• List your mentor and NASA facility location at the bottom of your Abstract
• Type abstract in 10 font and fit within a space 6.5" x 4.0" and sent to us by May 1, 1996.

You may FTP your Abstract to jove@space.hsv.usra.edu using the password frank or send on a diskette to:

USRA / JOVE
4950 Corporate Drive, Suite 100
Huntsville, AL 35806

We look forward to hearing from you.

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Memorandum

DATE: March 18, 1996

TO: JOVE Program Coordinator and PI's

FROM: Maury Estes, JOVE Program Manager

RE: JOVE Final Report

CC: Frank Six, JOVE Program
Director/NASA

Enclosed is the report form for your use in submitting your JOVE final report. This report should include a summary of your JOVE research including, accomplishments in your third year of participation, data on the program's overall impact on your campus, and information on the future direction of your JOVE research. Also, we have enclosed a synopsis of your JOVE accomplishments to date which we ask that you check to make sure that our records accurately reflect your institution's JOVE achievements.

On behalf of the JOVE program office, your participation and accomplishments are very much appreciated. We look forward to staying in touch with you as a JOVE alumnus. If you have any questions regarding this report or other matters, please contact me or Cheryl Hewett at 205-895-0582.

Astrophysics Experiments with the Compton GRO and MILAGRO

Wold, Donald C. (University of Arkansas at Little Rock)

MILAGRO is a water-Cherenkov detector for observing cosmic gamma rays over a broad energy range of 100 GeV to 100 TeV. MILAGRO will be the first detector that has sensitivity overlapping both air-Cherenkov and air-shower detectors. With this detector scientists in the collaboration will study previously observed celestial sources at their known emission energies, extend these observations into a new energy regime, and search for new sources at unexplored energies. The diffuse gamma-radiation component in our galaxy, which originates from interactions of cosmic rays with interstellar gas and photons, provides important information about the density, distribution, and spectrum of the cosmic rays that pervade the interstellar medium. Events in the Compton Gamma Ray Observatory (GRO) are being observed up to about 30 GeV, differing by slightly more than order of magnitude from the low energy threshold of MILAGRO. By looking in coincidence at sources, correlated observations will greatly extend the astrophysics potential of MILAGRO and NASA's GRO. A survey of cosmic-ray observatories is being prepared for scientists and others to provide a resource and reference which describes high energy cosmic-ray research activities around the world. This summary presents information about each research group, such as names of principal investigators, number of persons in the collaboration, energy range, sensitivity, angular resolution, and surface area of detector. Similarly, a survey of gamma-ray telescopes is being prepared to provide a resource and reference which describes gamma-ray telescopes for investigating galactic diffuse gamma-ray flux currently observed in the GeV energy range, but is expected to extend into the TeV range. Two undergraduate students are compiling information about gamma-ray telescopes and high energy cosmic-ray observatories for these surveys.

JOVE PUBLICATIONS

UNIVERSITY	NAME	TITLE OF PUBLICATION	JOURNAL
University of Arkansas at Little Rock	Donald C. Wold	Yang, Zibin, Russell Gillum, Donald C. Wold. (1994). Monte Carlo simulation of the scintillating optical fiber calorimeter (SOFCAL).	*Proceedings of the Arkansas Academy of Science*, 48: 223-229.
University of Arkansas at Little Rock	Donald C. Wold	Wold, D.C., Evans, C.R., Dancer, J.E., & Montague, J.C., (1994). SPINE test scores and measures of tongue deviancy in speakers with severe-to-profound hearing loss.	*American Annals of the Deaf, 139, 352-357.*
University of Arkansas at Little Rock	Donald C. Wold	Harris, J.W. and STAR Collaboration (1994). The STAR experiment at the Relativistic Heavy Ion Collider.	*Nuclear Physics*, A566, 277c-286c.
University of Arkansas at Little Rock	Donald C. Wold	Wold, Donald C., Yang, Zibin B., & Gillum, Russell (1994). Monte Carlo simulation of a scintillating optical fiber calorimeter.	*Proceedings of the First International Symposium on Cosmic Ray Physics in Tibet (ISCRP-I)*, pp. 320-323. Tibet University, August 12-17, 1994, Lhasa, China.
University of Arkansas at Little Rock	Donald C. Wold	Murai, Kazuhiko, Carlos A. Sánchez, and Donald C. Wold. (1995). Using GEANT to model calorimeter response for electromagnetic cascades from nucleus-nucleus interactions in a cosmic ray detector.	*Proceedings of the Arkansas Academy of Science*, 49: 121-126.
University of Arkansas at Little Rock	Donald C. Wold	Sánchez, Carlos A., Kazuhiko Murai, & Donald C. Wold. (1995). Using FRITIOF to model nucleus-nucleus interactions in a cosmic ray detector.	*Proceedings of the Arkansas Academy of Science*, 49, 160-165.
University of Arkansas at Little Rock	Donald C. Wold	Wold, Donald C. (1995). High energy physics and environmental health: a note by a metropolitan university physicist.	*Metropolitan Universities: An International Forum:* Fall 1995, 6: 75-78.

EXTRAMURAL FUNDING

UNIVERSITY	NAME	GRANTING AGENCY	PROPOSAL TITLE
University of Arkansas at Little Rock	Donald C. Wold	Arkansas Space Grant Consortium	"Cosmic Ray Studies at NASA Marshall Space Flight Center" Outreach Grant from February 1, 1993 to June 30, 1993 for students to visit Gamma and Cosmic Ray Branch at MSFC.
University of Arkansas at Little Rock	Donald C. Wold	Arkansas Department of Pollution Control and Ecology	Monitoring stage at Chamberlain Creek barite pit and measuring precipitation at Magnet Cove High School, 1993-94: $1,500.
University of Arkansas at Little Rock	Donald C. Wold	United States Geological Survey	Monitoring stage at Chamberlain Creek barite pit and measuring precipitation at Magnet Cove High School, 1993-94: $1,200.
University of Arkansas at Little Rock	Donald C. Wold	Arkansas Department of Pollution Control and Ecology	Monitoring stage at Chamberlain Creek barite pit and measuring precipitation at Magnet Cove High School, 1994-95: $1,560
University of Arkansas at Little Rock	Donald C. Wold	United States Geological Survey	Monitoring stage at Chamberlain Creek barite pit and measuring precipitation at Magnet Cove High School, 1994-95: $1,260.
University of Arkansas at Little Rock	Donald C. Wold	Arkansas Space Grant Consortium	Lectures on Results from BATSE in the Gamma Ray Observatory, Dr. Geoffrey N. Pendleton, University of Alabama, Huntsville and NASA Marshall Space Flight Center, Feb. 8 and 9, 1994.
University of Arkansas at Little Rock	Donald C. Wold	Arkansas Space Grant Consortium	Lectures on Results from EGRET in the Gamma Ray Observatory, Dr. Robert C. Hartman, astrophysicist, NASA Goddard Space Flight Center, March 29 and 30, 1994.
University of Arkansas at Little Rock	Donald C. Wold	Arkansas Space Grant Consortium	Lectures on Extending Gamma Ray Observations Beyond the GRO, Professor Jordan Goodman, University of Maryland - College Park, March 8 and 9, 1994.
University of Arkansas at Little Rock	Donald C. Wold	Arkansas Space Grant Consortium	Lectures on Cosmic Ray Physics and Particle Astrophysics, Professor R. Jeffrey Wilkes, University of Washington - Seattle, March 16 and 17, 1994.
University of Arkansas at Little Rock	Donald C. Wold	Arkansas Space Grant Consortium	Lectures on Composition of High Energy Cosmic Rays: , Professor Michael L. Cherry, Louisiana State University - Baton Rouge, April 14 and 15, 1994.
University of Arkansas at Little Rock	Donald C. Wold	Arkansas Space Grant Consortium	Lectures on astrophysics with high energy neutrinos: the AMANDA detector. Francis Halzen, Hilldale Professor of Physics, University of Wisconsin - Madison, March 7 and 8, 1995.

EXTRAMURAL FUNDING

UNIVERSITY	NAME	GRANTING AGENCY	PROPOSAL TITLE
University of Arkansas at Little Rock	Donald C. Wold	Arkansas Space Grant Consortium	"Survey of Cosmic-Ray Observatories" Scholarship for Undergraduate Student: Trevis A. Crane. Grant period: from September 1995 to September 1996.
University of Arkansas at Little Rock	Donald C. Wold	Arkansas Space Grant Consortium	"Survey of Gamma-Ray Observatories and Telescopes" Scholarship for Undergraduate Student: Michael G. LaCour. Grant period: from September 1995 to September 1996.
University of Arkansas at Little Rock	Donald C. Wold	Arkansas Space Grant Consortium	"Astrophysics Experiments with the Compton Gamma-Ray Observatory and MILAGRO" Research Infrastructure Grant from September 1995 to September 1996.
University of Arkansas at Little Rock	Donald C. Wold	Arkansas Space Grant Consortium	"Searching for the Origin of Extremely High Energy Cosmic Rays" and "The Fly's Eye Experiment". Professor David B. Kieda, University of Utah - Salt Lake City, January 22 and 23, 1996.
University of Arkansas at Little Rock	Donald C. Wold	Arkansas Space Grant Consortium	"Cosmic Rays and their Origin", "MILAGRO - A New Gamma-Ray Telescope", and "Working with Fermi as a Graduate Student at the University of Chicago", Professor Gaurang B. Yodh, University of California - Irvine, February 18, 19 and 20, 1996.
University of Arkansas at Little Rock	Donald C. Wold	Arkansas Space Grant Consortium	"Prospects for Long-Baseline Neutrino Oscillation Experiments" Dr. Maury Goodman, Argonne National Laboratory, March 4 and 5, 1996.

AWARDS

UNIVERSITY	NAME	AGENCY	TITLE
University of Arkansas at Little Rock	Donald C. Wold	University of Arkansas at Little Rock College of Science and Engineering Technology	Faculty Excellence Award in Public Service 5 May 1995 in Little Rock

University of Arkansas at Little Rock

College of Science and Engineering Technology

Faculty Excellence Award

The University Faculty Excellence Award in **Public Service** is hereby conferred on

Donald C. Wold

this fifth day of May 1995 in Little Rock

J.W. Wiggins, Interim Dean

Faculty Excellence Awards Dinner

May 5, 1995
7:00 p.m.

Presiding
Joel E. Anderson
Vice Chancellor and Provost

Presentation of
College and School Faculty Excellence Awards
Charles E. Hathaway
Chancellor

Announcement and Presentation of
University Faculty Excellence Awards

Teaching
Dr. and Mrs. H. A. Ted Bailey Jr.
David Henry
Chief Financial Officer of Bailey Corporation

Research
The Society of Philanthropy for UALR
Frank L. Whitbeck
Foundation Fund Board

Public Service
Arkansas Power and Light Company

College of Professional Studies

TEACHING: Dr. Linda Pledger, associate professor of speech communication, understands the unique needs of the metropolitan university student because she was one. She returned to school in her early 30s after raising children and managing her husband's medical practice. That first-hand knowledge has prompted her to use innovative teaching methods including helping to develop an interactive video/computer lab and teaching courses through newspaper and television. Students say her teaching, both in the classroom and out, has had a positive impact on their careers and lives. RESEARCH: Dr. Susan Mercer, professor of social work, has concentrated her research efforts in the area of social work and aging. Her research on dressing behavior in the elderly has given hope to victims of Alzheimer's and other elderly persons who are institutionalized. Mercer recently lived on a Navajo reservation for more than six weeks while conducting research on aging in the Navajo Nation. Her work has been used to request funding for special aging projects on the reservation. PUBLIC SERVICE: Dr. Patricia G. Conway, associate professor of social work, has a strong commitment to improving services for persons with HIV/AIDS. Conway serves as president of AIDS Outreach of Arkansas, an organization that provides rental assistance to people with HIV/AIDS who are low income or homeless. She helped establish Unity Coalition, a consortium of service providers in Arkansas, and volunteers with the Regional AIDS Interfaith Network, providing counseling for persons with HIV/AIDS and their support network.

College of Science and Engineering Technology

TEACHING: Dr. Thomas J. Lynch, professor of biology, is a productive research scholar who shares his knowledge of cell and molecular biology and microbiology as a first-rate classroom teacher. He also team-teaches a course he developed on AIDS, which students consistently rate as excellent and important. His students have four times won the Arkansas Academy of Science award for outstanding undergraduate research. He brings to the classroom 16 years of teaching and research experience at UALR, plus experience as a research associate at St. Jude's Children's Research Hospital in Memphis.
RESEARCH: Dr. Jerome "Jerry" Darsey, associate professor of chemistry, is described by his department chair as "the premier scientific scholar at this University." He has obtained more than $1.2 million in external funding for research since joining UALR less than five years ago. His publication record includes 40 articles published in or submitted for refereed journals and three chapters in scientific books. He has done more than 60 research presentations at scientific meetings and seminars.
PUBLIC SERVICE: Dr. Donald C. Wold, professor of physics, has worked diligently in an effort to convince the U.S. Department of Energy to fund a resource recovery project in Hot Spring County. He has involved community leaders from Magnet Cove and Malvern, a congressman, several state officials and students from three local high schools in the effort. The original interest in the site was for development of an international scientific consortium's proposal to develop a gamma ray and neutrino detector in the huge pit. As Wold became more involved with the site, he developed the separate proposal for resource recovery.

PUBLIC SERVICE

Dr. John C. Pickett

Professor
Economics
College of Business Administration

Dr. Pickett has focused his public service efforts on shaping Arkansas law and public policy. His work is published in many outlets ranging from newspaper columns to prestigious journals and monographs.

Dr. Robert K. Rittenhouse

Professor
Teacher Education
College of Education

Dr. Rittenhouse helped make the Arkansas School for the Deaf an "electronic" school by helping the school acquire classroom computers and training. He has worked with deaf educators and parents of deaf children in Santa Cruz, Bolivia.

Dr. Don C. Wold

Professor
Physics and Astronomy
College of Science and Engineering Sciences

Dr. Wold has worked diligently in an effort to convince the U.S. Department of Energy to fund a resource recovery project in Hot Spring County. The project would be a test site for developing technology to clean-up many other contaminated water sources.

JOVE Final Report
1995-6

Donald C. Wold
University of Arkansas at Little Rock

JOVE Final Report: Academic Year 1995-96

Dr. Donald C. Wold   University of Arkansas at Little Rock   April 30, 1996
Name   Institution   Date

I. Research

Brief description of research results to date on your project:

This research report covers the same period of time as my JOVE funding which began in 1992 and ended in 1995. The research project proposed in 1992 for the JOVE program was described in the report entitled: "Final Report for Summer 1992." A copy of this document may be found in Appendix A.

A scintillating optical fiber calorimeter (SOFCAL) was developed by NASA/Marshall Space Flight Center for use in balloon-borne experiments to study the spectrum of high-energy cosmic rays and gamma rays. SOFCAL will not saturate for long exposures like nuclear emulsions do when exposed to charged particles. Consequently, this section of the calorimeter can remain aloft for long periods of time. SOFCAL will be useful in emulsion chambers to study primary cosmic-ray nuclei with energies from 100 GeV to 1,000 TeV. We used the event generator FRITIOF to model the collision of a cosmic-ray projectile with a target nucleus in an emulsion chamber. The measurements of charged particles from the interaction in the emulsions are related to the energy of the primary cosmic ray nucleus and those particles produced in the collision. For gamma-rays from the nucleus-nucleus interaction, computer simulations of electromagnetic cascades allow computation of the energy ΣE_y deposited in different regions of the calorimeter. We used the Monte Carlo program GEANT to model SOFCAL response to incident gamma rays and to compute the measure of energy deposition ΣE_y in different layers of the calorimeter within the emulsion chamber. The partial coefficient of inelasticity k_y, defined by $\Sigma E_y = k_y E_0$, was computed for different energies E_0 of primary cosmic rays. The $f(k_y)$-distributions were computed and compared with existing calorimeter data.

For primary nuclei with energies much greater than 10^{14} eV, nucleus-nucleus interactions are likely to exhibit characteristics of a quark-gluon plasma (QGP). We used particle event generators to model the collision of a cosmic-ray nucleus with a target nucleus in an emulsion chamber. We chose FRITIOF with the enhancement of LUCIAE II to simulate the effects of a QGP and to model collisions of primary cosmic rays in an emulsion chamber with SOFCAL. Also, pseudo-rapidity distributions were computed for protons on lead at 200 GeV/c and compared with experimental data. Pseudo-rapidity distributions were computed for protons or iron incident on a carbon or silver nucleus. For gamma-rays from nucleus-nucleus interactions, the total energy of the electromagnetic component ΣE_y was computed. The accumulative $f(k_y)$-distributions were computed and compared with existing data.

The Monte Carlo simulations described here were meant to complement and confirm those done at NASA using different computer programs. Our results agreed nicely with those which had been done by the Gamma Ray and Cosmic Ray Branch at Marshall Space Flight Center.

JOVE Final Report: Academic Year 1995-96

<u>Dr. Donald C. Wold</u>   <u>University of Arkansas at Little Rock</u>   <u>April 30, 1996</u>
Name   Institution   Date

Where do you see your JOVE research going after the initial JOVE funding expires?

Even though my JOVE funding expired a year ago in 1995, I have two undergraduate students who will be going to Fermi National Laboratory this summer. They will work under Dr. Paul Mantsch, group leader for the proposed Pierre Auger Cosmic Ray Observatory. The construction of two large detectors in the northern and southern hemisphere will be required for this international project. Consequently, scientists in many countries are collaborating on this project. The Fly's Eye Experiment in Utah has detected a cosmic ray with an energy greater that 10^{20} eV. The origin of such high energy particles is still a mystery and Auger will detect the highest energy cosmic rays.

I am compiling information about gamma-ray telescopes and cosmic-ray observatories all over the world. It will be useful to have a central source which provides information about the status of each experiment, characteristics of the detectors, data obtained, the degree to which they overlap, and names of principal investigators or contact persons. Two undergraduate students have been funded through the Arkansas Space Grant Consortium to work on this project with me.

Communication with NASA Colleague

My NASA mentor was Dr. Tom Parnell, Marshall Space Flight Center (MSFC). MSFC is an active participant in the JACEE experiments. If the University of Arkansas at Little Rock (UALR) were to join the Japanese American Co-operative Emulsion Experiment (JACEE), then our students could conduct simulations and data analysis for JACEE. Dr. Geoffrey Pendleton visited UALR as part of our lecture series, which included presentations on the BATSE and EGRET experiments. I hope other researchers from MSFC will have an opportunity to present updates at UALR on the JACEE experiments and the BATSE experiments. We would be happy to have Dr. Parnell share his experience with NASA cosmic-ray detectors and the spectacular results from the BATSE collaboration.

My current interests are in gamma-ray astronomy at higher energies than those measured by the Compton Gamma-Ray Observatory. It is likely that we could collaborate with the MILAGRO group which is constructing a ground-based gamma-ray observatory in the mountains near Los Alamos National Laboratory. Two advanced undergraduate students from UALR have been invited to work at Fermi National Laboratory this summer. They are capable of conducting simulations for the Pierre Auger Cosmic Ray Observatory, which is being designed at Fermilab. I hope that UALR will become a member of the Auger collaboration to participate in the proposed experiment.

JOVE Final Report: Academic Year 1995-96

Dr. Donald C. Wold	University of Arkansas at Little Rock	April 30, 1996
Name	Institution	Date

Refereed Journal Articles Published:

Yang, Zibin, Russell Gillum, Donald C. Wold. (1994). Monte Carlo simulation of the scintillating optical fiber calorimeter (SOFCAL). *Proceedings of the Arkansas Academy of Science*, 48: 223-229.

Wold, D.C., C.R. Evans, J.E. Dancer, J.C. Montague. (1994). SPINE test scores and measures of tongue deviancy in speakers with severe-to-profound hearing loss. *American Annals of the Deaf*, 139, 352-357.

Harris, J.W. and STAR Collaboration (1994). The STAR experiment at the Relativistic Heavy Ion Collider, *Nuclear Physics*, A566, 277c-286c.

Wold, Donald C., Yang, Zibin B., & Gillum, Russell (1994). Monte Carlo simulation of a scintillating optical fiber calorimeter. *Proceedings of the First International Symposium on Cosmic Ray Physics in Tibet (ISCRP-I)*, pp. 320-323. Tibet University, August 12-17, 1994, Lhasa, China.

Murai, Kazuhiko, Carlos A. Sánchez, and Donald C. Wold. (1995). Using GEANT to model calorimeter response for electromagnetic cascades from nucleus-nucleus interactions in a cosmic ray detector, *Proceedings of the Arkansas Academy of Science*, 49: 121-126.

Sánchez, Carlos A., Kazuhiko Murai, & Donald C. Wold. (1995). Using FRITIOF to model nucleus-nucleus interactions in a cosmic ray detector, *Proceedings of the Arkansas Academy of Science*, 49, 160-165.

Wold, Donald C. (1995). High energy physics and environmental health: a note by a metropolitan university physicist. *Metropolitan Universities: An International Forum:* Fall 1995, 6: 75-78.

Refereed Journal Articles Submitted:

Oral and Poster Papers Presented:

Wold, Donald C., Russell B. Gillum, and Zibin B. Yang, Monte Carlo simulations of cosmic rays for the detector SOFCAL. Poster presentation by Donald C. Wold at the JOVE Retreat, Galveston, Texas, July 10, 1993.

Gillum, R., Z. Yang, and D. Wold. Monte Carlo Simulations of a NASA Scintillating Optical Fiber Calorimeter for 10- to 1,000-MeV Gamma Rays. Oral presentation by Russell Gillum at the 1994 Spring Meeting of the Texas Section of the American Physical Society, Richardson, TX, on March 11-12, 1994.

Yang, Z., R. Gillum, and D. Wold. Monte Carlo Simulations of a NASA Scintillating Optical Fiber Calorimeter for 0.5- to 1.5-TeV Gamma Rays. Oral presentation by Zibin Yang at the 1994 Spring Meeting of the Texas Section of the American Physical Society, Richardson, TX, on March 11-12, 1994.

Dr. Donald C. Wold   University of Arkansas at Little Rock   April 30, 1996
Name   Institution   Date

Gillum, R., Z. Yang, and D. Wold. Monte Carlo Simulations of a NASA Scintillating Optical Fiber Calorimeter for 10- to 1,000-MeV Gamma Rays. Oral presentation by Russell Gillum at the Spring Meeting of the Arkansas Academy of Science, Jonesboro, Arkansas, April 8-9, 1994.

Yang, Z., R. Gillum, and D. Wold. Monte Carlo Simulations of a NASA Scintillating Optical Fiber Calorimeter for 0.5- to 1.5-TeV Gamma Rays. Oral presentation by Zibin Yang at the 1994 Spring Meeting of the Arkansas Academy of Science, Jonesboro, Arkansas, April 8-9, 1994.

Wold, Donald C., Zibin B. Yang, and Russell B. Gillum. Monte Carlo simulation of a scintillating optical fiber calorimeter. Poster presentation by Donald C. Wold at the JOVE Retreat, July 6-9, 1994, Cocoa Beach, Florida.

Wold, Donald C., Zibin B. Yang, and Russell B. Gillum. Monte Carlo simulation of a scintillating optical fiber calorimeter. Oral presentation by Donald C. Wold at the first International Symposium on Cosmic Ray Physics in Tibet, August 12-17, 1994, Lhasa, Tibet, China.

Murai, Kazuhiko, Carlos A. Sánchez, and Donald C. Wold. Using GEANT to model calorimeter response for electromagnetic cascades from nucleus-nucleus interactions in a cosmic ray detector. Oral presentation by Kazuhiko Murai at the Arkansas Academy of Science, Pine Bluff, Arkansas, April 7-8, 1995.

Sánchez, Carlos A., Kazuhiko Murai, and Donald C. Wold. Using FRITIOF to model nucleus-nucleus interactions in a cosmic ray detector. Oral paper presented by Carlos A. Sánchez at the Arkansas Academy of Science, Pine Bluff, Arkansas, April 7-8, 1995.

Sánchez, Carlos A., Kazuhiko Murai, and Donald C. Wold. Using FRITIOF to model nucleus-nucleus interactions in a cosmic ray detector. Oral paper presented by Carlos A. Sánchez at the 1995 National Conference on Undergraduate Research, Union College, Schenectady, NY, April 20-22, 1995.

Crane, Trevis A., and Donald C. Wold, Survey of high energy cosmic-ray observatories. Oral presentation by Trevis A. Crane at the Arkansas Academy of Science, 80th Annual Meeting, April 12-13, 1996. Westark Community College, Fort Smith, Arkansas.

LaCour, Michael G., Trevis A. Crane, and Donald C. Wold. Survey of gamma-ray astronomy telescopes. Oral presentation by Donald C. Wold at the Arkansas Academy of Science, 80th Annual Meeting, April 12-13, 1996. Westark Community College, Fort Smith, Arkansas.

Dr. Donald C. Wold   University of Arkansas at Little Rock   April 30, 1996
Name   Institution   Date

Crane, Trevis A., for Trevis A. Crane and Donald C. Wold, Survey of high energy cosmic-ray observatories. Oral presentation by Trevis A. Crane at the Fourth Annual Arkansas Space Grant Symposium, April 26, 1996. University of Central Arkansas, Conway, Arkansas.

Wold, Donald C., Astrophysics experiments with the Compton GRO and MILAGRO, Fourth Annual Arkansas Space Grant Symposium, April 26, 1996. University of Central Arkansas, Conway, Arkansas.

Proposals Awarded:

[The Arkansas Space Grant Consortium (ASGC) provided funds for many of the following projects.]

- Cosmic Ray Studies at NASA Marshall Space Flight Center. Outreach Grant from February 1, 1993 to June 30, 1993 for physics students to visit Gamma and Cosmic Ray Branch at MSFC. ASGC: $950.

- Arkansas Department of Pollution Control and Ecology, December 1993. $1,500 plus matching funds from the U.S. Geological Survey. Monitoring stage at Chamberlain Creek barite pit and measuring precipitation at Magnet Cove High School.

- Geological Survey. $1,200. Monitoring stage at Chamberlain Creek barite pit and measuring precipitation at Magnet Cove High School. 1993-94.

- Arkansas Department of Pollution Control and Ecology, December 1994. $1,560 plus matching funds from the U.S. Geological Survey. Monitoring stage at Chamberlain Creek barite pit and measuring precipitation at Magnet Cove High School.

- Geological Survey. $1,260. Monitoring stage at Chamberlain Creek barite pit and measuring precipitation at Magnet Cove High School. 1994-95.

- *Lectures on Results from BATSE in the Gamma Ray Observatory.*
  Dr. Geoffrey N. Pendleton from the University of Alabama - Huntsville and NASA Marshall Space Flight Center. Feb. 8 and 9, 1994. Discussions and presentations were held with students, faculty, and guest lecturer at the University of Arkansas at Little Rock and Arkansas State University. ASGC: $765.

- *Lectures on Results from EGRET in the Gamma Ray Observatory.*
  Dr. Robert C. Hartman, astrophysicist from NASA/Goddard Space Flight Center March 29 and 30, 1994. Discussions and presentations were held with students, faculty, and guest lecturer at the University of Arkansas at Little Rock and with State Senator George Hopkins in Malvern. ASGC: $600.

JOVE Final Report: Academic Year 1995-96

Dr. Donald C. Wold   University of Arkansas at Little Rock   April 30, 1996
Name   Institution   Date

- *Lectures on Extending Gamma Ray Observations Beyond the GRO.*
  Professor Jordan Goodman from the University of Maryland - College Park. March 8 and 9, 1994. Discussions and presentations were held with students, faculty, and guest lecturer at the University of Arkansas at Little Rock and at University of Central Arkansas. ASGC: $1,325.

- *Lectures on Cosmic Ray Physics and Particle Astrophysics.*
  Professor R. Jeffrey Wilkes from University of Washington - Seattle. Mar. 16 and 17, 1994. Discussions and presentations were held with students, faculty, and guest lecturer at the University of Arkansas at Little Rock and at Henderson State University. ASGC: $1,275.

- *Lectures on Composition of High Energy Cosmic Rays.*
  Professor Michael L. Cherry from Louisiana State University - Baton Rouge. April 14 and 15, 1994. Discussions and presentations were held with students, faculty, and guest lecturer at the University of Arkansas at Little Rock and at Harding University. ASGC: $680.

- *Lectures on astrophysics with high energy neutrinos: the AMANDA detector.*
  Francis Halzen, Hilldale Professor of Physics, University of Wisconsin - Madison. ASGC Guest Lecturer Grant: $1,200. Presentations were held at the University of Arkansas at Little Rock and the University of Arkansas at Pine Bluff on March 7 and 8, 1995, respectively.

- *Survey of Cosmic-Ray Observatories*
  Faculty mentor for Trevis A. Crane
  ASGC Undergraduate Student Scholarship $3,060.
  Grant period: from September 1995 to September 1996.

- *Survey of Gamma-Ray Observatories*
  Faculty mentor for Michael G. LaCour.
  ASGC Undergraduate Student Scholarship $3,350.
  Grant period: from September 1995 to September 1996.

- *Astrophysics Experiments with the Compton Gamma-Ray Observatory and MILAGRO.* ASGC Research Infrastructure Grant: $2,800.
  Grant period: from September 1995 to September 1996.
  Undergraduate students involved: Michael G. LaCour and Trevis A. Crane.

- *Searching for the Origin of Extremely High Energy Cosmic Rays* Arkansas State University. *The Fly's Eye Experiment* University of Arkansas at Little Rock.
  Professor David B. Kieda, University of Utah - Salt Lake City. Presentations were held at Arkansas State University and at the University of Arkansas at Little Rock on January 22 and 23, 1996, respectively. ASGC Guest Lecturer Grant: $850.

JOVE Final Report: Academic Year 1995-96

Dr. Donald C. Wold   University of Arkansas at Little Rock   April 30, 1996
Name   Institution   Date

- *Cosmic Rays and their Origin* University of Central Arkansas.
  MILAGRO - A New Gamma-Ray Telescope University of Arkansas at Little Rock
  Working with Fermi as a Graduate Student at the University of Chicago University of Arkansas at Little Rock. Professor Gaurang B. Yodh, University of California - Irvine. Presentations were held at the University of Central Arkansas and at University of Arkansas at Little Rock on February 19 and 20, 1996, respectively. ASGC Guest Lecturer Grant: $1,200.

- *Prospects for Long-Baseline Neutrino Oscillation Experiments*
  Dr. Maury Goodman, Argonne National Laboratory. Presentations were held at Harding University and at the University of Arkansas at Little Rock on March 4 and 5, 1996, respectively. ASGC Guest Lecturer Grant: $700.

Are you utilizing the Internet or other network? If other, which?

Yes. Internet is an important part of the computer services offered at UALR. Internet is used daily in the Department of Physics and Astronomy.

Please identify the data sets, if any, used in your research.

We find it necessary to use sophisticated programs designed for high energy particle physics. Many were developed at CERN, the European Organization for Nuclear Research. They have a computing staff which maintains GEANT and PAW (Physics Analysis Workstation). The data files containing the programs are very large and are usually in compact form. Internet is necessary to obtain the software. Physicists at high energy physics laboratories, the world over, use these programs. They have become standard in the high energy physics community and are readily accepted in publications.

II. Education

Assessment of Student Impact: Indicate the impact over your institution's three years in JOVE, that the program has had on student enrollment and/or recruitment? Please provide before and after numbers for science majors by discipline, course enrollments, etc. Attach additional sheets as required.

The JOVE program has given undergraduate students and graduate students the opportunity to work directly with the same data and computer programs which are used at NASA research centers and research universities. With our series of outside speakers funded through the Arkansas Space Grant Consortium, our undergraduate students have been able to hear and to talk with prominent scientists from all over the United States, who are collaborating with astrophysicists from around the world.

The student research assistants have presented papers at regional meetings of the American Physical Society and state meetings of the Arkansas Academy of Science. One student presented a paper at the National Conference on Undergraduate Research. These enrichment experiences give them an edge over other students.

JOVE Final Report: Academic Year 1995-96

Dr. Donald C. Wold   University of Arkansas at Little Rock   April 30, 1996
Name   Institution   Date

Many of our physics majors come from the University's Scholars Program. The presence of the JOVE program has helped to show potential majors that there are exciting things going on in the UALR Department of Physics and Astronomy. One of our faculty members has been collaborating with the Solenoidal Tracker at RHIC (STAR) group, which is designing a major detector for the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory. The interactions between undergraduate and graduate students working on JOVE projects and STAR projects is very healthy and illustrates the way scientific research should function.

We teach an introductory course in astronomy and an intermediate level course in astronomy. For these courses, the instructor downloads Hubble Space Telescope pictures. In addition, the UALR planetarium downloads NASA photographs for public use. For upper level physics courses, I talk about gamma-ray astronomy as it relates to the Compton Gamma-Ray Observatory and the balloon-borne cosmic ray experiments which NASA has supported for many years.

JOVE Final Report: Academic Year 1995-96

Dr. Donald C. Wold   University of Arkansas at Little Rock   April 30, 1996
Name   Institution   Date

Student Research Assistants

Undergraduate Assistants:	Research Area	Major	Source of Funding
Michael G. LaCour	Gamma-ray astronomy with the Compton GRO	Biology	ASGC
Trevis A. Crane	High energy cosmic-ray particle astrophysics	Physics and Astronomy	ASGC
Carlos A. Sánchez	Cosmic ray physics: Monte Carlo modeling of nucleus-nucleus interactions using FRITIOF and LUCIAE.	Physics	JOVE

Graduate Assistants:	Research Area	Major	Source of Funding
Russell Gillum	Design of a calorimeter for balloon-borne cosmic ray detectors.	Physics	JOVE
Kazuhiko Murai	Monte Carlo modeling in cosmic ray and high energy physics	Applied mathematics and computer science	JOVE
Zibin Yang	Design of a calorimeter for balloon-borne cosmic ray detectors and an all-sky gamma ray detector	Applied mathematics and computer science	JOVE

III. Curriculum Development

The trend in universities is to reduce the number of courses offered, unless that course belongs to the core group. UALR has an introductory course and an intermediate course in astronomy. It would be hard to justify a separate course in space science. Certainly one can make an effort to include examples in advanced courses, such as mechanics.

New Curricula:
New Courses:
Amended Courses or Augmented Courses:
Reading or independent study courses:
Do you anticipate additional curricula changes as a result of the JOVE program?

Dr. Donald C. Wold   University of Arkansas at Little Rock   April 30, 1996
Name   Institution   Date

IV. Outreach

Students:

Outreach Effort	Location	Attendees
1. Presentation on cosmic ray physics and the video tape: "The Infinite Voyage." Many questions and discussions of space science. December 1, 1993.	Magnet Cove High School, Magnet Cove, Arkansas. Contacts: Jerry Whatley, teacher, and Basil Miller, principal.	About 12 students in the physics class.
2. Presentation on cosmic ray physics and the video tape: "The Infinite Voyage." Many questions and discussions of space science. December 6, 1993.	Malvern High School, Malvern, Arkansas. Contact: Mr. Bob Cowling, instructor, and Mr. Steve Williams, principal.	About 15 students in the physics class.
3. Presentation on cosmic ray physics and the video tape: "The Infinite Voyage." Many questions and discussions of space science. December 8, 1993.	Glen Rose High School, Glen Rose, Arkansas. Contact: John Lancaster, teacher, Bob Morrison, teacher, and Craig Fraiser, principal.	About 28 students in combined chemistry & physics classes.
4. Presentation, discussions and questions concerning segments of the video tapes entitled: "Living in Space" and "HST Incredible Time Machine." Many questions about the solar system, living in space, astronauts, the Hubble space telescope, and black holes, etc. February 25, 1994.	Glen Rose Elementary School, Glen Rose, Arkansas. Contact: Karen Clements, teacher. Talked to two second grade classes and one third grade class.	About 80 second graders and 50 third graders.
5. Presentation on cosmic ray physics and the video tape: "The Infinite Voyage." Many questions and discussions of space science. July 20, 1994.	Talk and presentation to high school students in UALR Summer Chemistry Institute for gifted and talented students.	About 30 students in the group.
6. Presentation on cosmic ray physics with demonstrations on electrostatics using an electrostatic generator and electroscope at mathematics/science primary school. Many questions and discussion. February 23, 1995.	Booker T. Washington Magnet School, Little Rock. Contact: Ms. Nava Gazitt, Young. Astronaut Program Specialist, for the primary school.	About 30 students in the science class.

JOVE Final Report: Academic Year 1995-96

Dr. Donald C. Wold   University of Arkansas at Little Rock   April 30, 1996
Name   Institution   Date

7. Member of panel discussion with speakers on Young Astronauts' Day in auditorium at magnet school for mathematics and science. Many questions and discussions about space science. April 27, 1995.	Booker T. Washington Magnet School, Little Rock. Contact: Ms. Nava Gazitt, Young Astronaut Program Specialist, for the primary school.	About 120 students in combined classes.
8. Participated in the Arkansas School for Mathematics and Sciences (ASMS "Careers: Onward and Upward" shadowing project on March 5, 1996.	Department of Physics and Astronomy, University of Arkansas at Little Rock.	Two high school students from ASMS.

Teachers:

Public:

V. Summer Programs

VI. "Roadblocks" to Progress

NASA makes it very difficult for their own people to travel. The only NASA employee who visited was Bob Hartman from Goddard. He came when he was officially on vacation from NASA because the red tape is so complicated.

VII. How could the program be changed to make it more effective?

I suggest that NASA make it easier for their own employees to visit colleges and universities. Undergraduate students are not full-time researchers and they usually have a full course load or commensurate responsibilities outside the university. If NASA researchers had the time and resources to visit colleges and universities, they would have a better grasp of the strengths and limitations of undergraduate students.

VIII. Overall, what has been your institution's greatest benefit from participating in JOVE.

The interactions of undergraduate and graduate students with researchers at NASA sites, government laboratories, and academic research centers may be the greatest benefit. It is important to be on the forefront of research and meet scientists in the mainstream. Attending conferences such as the International Cosmic Ray Conference, or ICRC as it is called, is important to provide visibility to the international community. The First International Conference on Cosmic Ray Physics in Tibet is another example. Both NASA's JOVE Program and that of the University of Arkansas at Little Rock were mentioned in the abstract to the paper which was presented at the conference in Lhasa, Tibet or China.

Dr. Donald C. Wold   University of Arkansas at Little Rock   April 30, 1996
Name   Institution   Date

IX. Please list all subject inventions as a result of this award or provide a statement that there were none.

I do not believe that there were any inventions which resulted from this award.

1996 NASA UNIVERSITY JOINT VENTURE

STUDENT INFORMATION

Donald C. Wold   4/22/96

1993 NASA / UNIVERSITY JOINT VENTURE -- STUDENT INFORMATION

General

Name: _Russell Gillum_   Social Security Number: ████████

Permanent Mailing Address: _9211 Daybright Circle_

School Mailing Address: _Department of Physics and Astronomy_
University of Arkansas at Little Rock
2801 S. University Avenue, Little Rock, AR 72204

Phone (permanent): _501 888-6647_ Phone (school / work): _501 569-3275_

Undergraduate Career

Undergraduate Institution: _University of Arkansas at Little Rock_

Graduation Date / Degree / Department: _Dec 92/ January 1993 /B.S. Physics_

Major Declared as a Freshman: _____

Post-Graduate Career

Graduate Institution: _Will enroll at UALR in August 1993._

Graduation Date / Degree / Department: _____

Thesis / Dissertation: _____

Employer / Position: _____

JOVE Participation

Begin Date: _Nov. 1, 1992_   End Date: _____

JOVE Faculty Advisor / Department: _Donald C. Wold / Physics and Astronomy_

JOVE Scholarship—Assistantship / Amount: _$2,069 (May 25, 1993)_

Scholarship—Assistantship Requirements: _____

JOVE Presentations / Publications / Proposals: _____

How did you learn about the JOVE program? _From Dr. Wold who was teaching Physics 4321 Electromagnetism._

Has the JOVE program affected your future plans? If so, how? _Influenced my decision to pursue graduate degree._

In order to determine the degree to which members of the diverse segments of the population are involved in this program, we request that you fill in the appropriate blocks. Completion of this part is voluntary.

_✓_ Male   _____ Female   _U.S.A._ Citizenship

Racial Minority: _____ No   _____ Yes (If yes, please check below.)

_____ Black   _____ Hispanic   _____ American Indian

_____ Oriental (Chinese, Japanese, Korean, Vietnamese)   _____ Other (Please specify)

1993 NASA / UNIVERSITY JOINT VENTURE –– STUDENT INFORMATION

General

Name: _Zibin Yang_ Social Security Number: ███████

Permanent Mailing Address: _220 N. Filmore, Apt 9, Little Rock, AR 72205_

School Mailing Address: _Physics dept., 2801 South University, UALR, Little Rock, AR 7220_

Phone (permanent): _661 9003_   Phone (school / work): _569 8123_

Undergraduate Career

Undergraduate Institution: _Beijing Institute of Technology_

Graduation Date / Degree / Department: _July. 1984 / BSE / Computer Science_

Major Declared as a Freshman: _Computer Application_

Post–Graduate Career

Graduate Institution: _University of Arkansas at Little Rock_

Graduation Date / Degree / Department: _Aug. 1994 / M.S. / Mathematics, Computer Science_

Thesis / Dissertation: _____

Employer / Position: _____

JOVE Participation

Begin Date: _Dec. 16, 1992_   End Date: _____

JOVE Faculty Advisor / Department: _Donald C. Wold / Physics & Astronomy_

JOVE Scholarship–Assistantship / Amount: _$3,800 (May 25, 1993)_

Scholarship–Assistantship Requirements: _____

JOVE Presentations / Publications / Proposals: _NASA Marshall Space Flight Center January 29, 1993_

How did you learn about the JOVE program? _From Dr. Wold, who was teaching Physics 4321 Electromagnetism._

Has the JOVE program affected your future plans? If so, how? _Considering a career in High Energy Physics Computing_

_X_ Male   ___ Female   _P. R. China_ Citizenship

Racial Minority: ___ No   _X_ Yes (If yes, please check below.)

___ Black   ___ Hispanic   ___ American Indian

Chinese Oriental (Chinese, Japanese, Korean, Vietnamese)   ___ Other (Please specify)

1994 NASA / UNIVERSITY JOINT VENTURE -- STUDENT INFORMATION

General

Name: _Russell E. Gillum_ Social Security Number: ████████

Permanent Mailing Address: _9211 DAYBRIGHT CIRCLE, MABELVALE AR 72103_

School Mailing Address: _Department of Physics, UALR, 2801 S. Univ., Little Rock, AR 72204_

Phone (permanent): _501-888-6647_ Phone (school / work): _501-758-1707_

Undergraduate Career

Undergraduate Institution: _UNIVERSITY OF ARKANSAS AT LITTLE ROCK (UALR)_

Graduation Date / Degree / Department: _DEC 92 / BS / PHYSICS_

Major Declared as a Freshman: _PHYSICS_

Post—Graduate Career

Graduate Institution: _UALR_

Graduation Date / Degree / Department: _ADDITIONAL UNDERGRADUTE COURSEWORK IN CHEMISTRY_

Thesis / Dissertation: _____

Employer / Position: _US POSTAL SERVICE / TIMEKEEPER_

JOVE Participation

Begin Date: _NOV 1992_ End Date: _____

JOVE Faculty Advisor / Department: _DR DC. WOLD / PHYSICS_

JOVE Scholarship—Assistantship / Amount: _$2316 in 92-93 / $3086 in 93-94_

Scholarship—Assistantship Requirements: _2/1/0_

JOVE Presentations / Publications / Proposals: _SOFCAL LOW ENERGY SIMULATIONS USING GEANT_

How did you learn about the JOVE program? _UALR PHYSICS DEPT_

Has the JOVE program affected your future plans? If so, how? _NO_

____✓____ Male _____ Female ___US___ Citizenship

Racial Minority: ___✓___ No _____ Yes (If yes, please check below.)

_____ Black _____ Hispanic _____ American Indian

_____ Oriental (Chinese, Japanese, Korean, Vietnamese) _____ Other (Please specify)

1994 NASA / UNIVERSITY JOINT VENTURE -- STUDENT INFORMATION

General

Name: ZIBIN Yang   Social Security Number: ▓▓▓▓▓▓▓▓▓▓

Permanent Mailing Address: 220 N. Filmore, Apt 9, Little Rock, AR 72205

School Mailing Address: 220 N. Filmore, Apt 9, Little Rock, AR 72205

Phone (permanent): (501) 6619003   Phone (school / work): (501) 569.8973

Undergraduate Career

Undergraduate Institution: Beijing Inc. of Tech.

Graduation Date / Degree / Department: July.84 / B.S. / Computer Science

Major Declared as a Freshman: Computer science

Post-Graduate Career

Graduate Institution: University of Arkansas at Little Rock

Graduation Date / Degree / Department: May, 94 / M.S. / Applied Math.

Thesis / Dissertation: Numerical Study of Hyperthermia

Employer / Position: Arkansas Systems / programmer

JOVE Participation

Begin Date: Dec, 1992   End Date: _____

JOVE Faculty Advisor / Department: Dr. Donal Wold / Physics & Astronomy

JOVE Scholarship—Assistantship / Amount: $5293 in '92-'93 /$5521 in '93-'94

Scholarship—Assistantship Requirements: _____

JOVE Presentations / Publications / Proposals: 2 / 1 / 0

How did you learn about the JOVE program? Electromaganetics Class.

Has the JOVE program affected your future plans? If so, how? Yes, considering career in ~~high energy~~ Nuclear Physics

In order to determine the degree to which members of the diverse segments of the population are involved in this program, we request that you fill in the appropriate blocks. Completion of this part is voluntary.

_____ Male   _____ Female   P.R.China Citizenship

Racial Minority: _____ No   X Yes (If yes, please check below.)

_____ Black   _____ Hispanic   _____ American Indian

X Oriental (Chinese, Japanese, Korean, Vietnamese)   _____ Other (Please specify)

1995 NASA / UNIVERSITY JOINT VENTURE -- STUDENT INFORMATION

General

Name: Russell E. Gillum   Social Security Number: ██████████

Permanent Mailing Address: 9211 Daybright Circle, Mabelvale, AR 72103

School Mailing Address: 2801 S. University Avenue, Little Rock, AR 72204

Phone (permanent): 501/888-6647   Phone (school / work): 501/569-3275

Undergraduate Career

Undergraduate Institution: University of Arkansas @ Little Rock (UALR)

Graduation Date / Degree / Department: 12/92   BS   Physics & Astronomy

Major Declared as a Freshman: Physics   --

Post-Graduate Career

Graduate Institution: _____

Graduation Date / Degree / Department: _____

Thesis / Dissertation: _____

Employer / Position: _____

JOVE Participation

Begin Date: November 1992   End Date: April 30, 1994

JOVE Faculty Advisor / Department: Dr. Donald C. Wold/Physics

JOVE Scholarship—Assistantship / Amount: $839.46 (1994/95)

Scholarship—Assistantship Requirements:

JOVE Presentations / Publications / Proposals: 1) Annual Regional APS 1993, 2) Arkansas Academy of Science 1993/SOFCAL Research in Annual Proceedings of Arkansas Academy of Science 1994

How did you learn about the JOVE program?   Faculty Advisor

Has the JOVE program affected your future plans? If so, how?   Increased interest in graduate work

In order to determine the degree to which members of the diverse segments of the population are involved in this program, we request that you fill in the appropriate blocks. Completion of this part is voluntary.

___x___ Male   _____ Female   US   Citizenship

Racial Minority: _____ No   _____ Yes (If yes, please check below.)

_____ Black   _____ Hispanic   _____ American Indian

_____ Oriental (Chinese, Japanese, Korean, Vietnamese)   _____ Other (Please specify)

1995 NASA / UNIVERSITY JOINT VENTURE -- STUDENT INFORMATION

General

Name: Kazuhiko Murai   Social Security Number: ███████

Permanent Mailing Address: 6200 Asher Avenue, Apt. 225, Little Rock, AR 72204

School Mailing Address: 2801 S. University Avenue, Little Rock, AR 72204

Phone (permanent):   501/568-3034   Phone (school / work): 501/569-8971

Undergraduate Career

Undergraduate Institution: University of Arkansas at Little Rock

Graduation Date / Degree / Department: January 1992, BS/Mathematics

Major Declared as a Freshman:

Post-Graduate Career

Graduate Institution: University of Arkansas at Little Rock

Graduation Date / Degree / Department: August 11, 1995/MS/Mathematics

Thesis / Dissertation:

Employer / Position: UALR Department of Mathematics & Statistics
UALR Department of Physics & Astronomy/Dr. D. C. Wold/Jove Grant

JOVE Participation

Begin Date: 1/16/95   End Date: 6/30/95

JOVE Faculty Advisor / Department: Dr. Donald C. Wold, Department of Physics & Astronomy

JOVE Scholarship—Assistantship / Amount: $4720.00

Scholarship—Assistantship Requirements: $357.00

JOVE Presentations / Publications / Proposals: Arkansas Academy of Science

How did you learn about the JOVE program?   advisor - Dr. Donald C. Wold

Has the JOVE program affected your future plans? If so, how?   Increased interest in
study of Physics, computer experience will increase opportunities.

In order to determine the degree to which members of the diverse segments of the population are involved in this program, we request that you fill in the appropriate blocks. Completion of this part is voluntary.

| x   Male | _____ Female | _____ Japan   Citizenship |

Racial Minority: _____ No   x   Yes (If yes, please check below.)

| _____ Black | _____ Hispanic | _____ American Indian |

| x   Oriental (Chinese, Japanese, Korean, Vietnamese) | _____ Other (Please specify) |

1995 NASA / UNIVERSITY JOINT VENTURE -- STUDENT INFORMATION

General

Name: Carlos A. Sanchez   Social Security Number: ████████

Permanent Mailing Address: Arkansas address: 3101 S. Taylor, #659, Little Rock, AR 72204
Sapin: Avenida De La Estacion SA 2nd D. Alicante 03003, SPAIN

School Mailing Address: 2801 S. University Avenue, Little Rock, AR 72204

Phone (permanent): _____   Phone (school / work): 501/569-3275

Undergraduate Career

Undergraduate Institution: University of Arkansas at Little Rock

Graduation Date / Degree / Department: BS-Physics, Physics & Astronomy

Major Declared as a Freshman: _____

Post-Graduate Career

Graduate Institution: _____

Graduation Date / Degree / Department: _____

Thesis / Dissertation: _____

Employer / Position: _____

JOVE Participation

Begin Date: September 1994   End Date: May 31, 1995

JOVE Faculty Advisor / Department: Dr. Donald C. Wold

JOVE Scholarship—Assistantship / Amount: $2172.86

Scholarship—Assistantship Requirements: $2172.86

JOVE Presentations / Publications / Proposals: Presented paper @ Arkansas Acad. of Science 7th Mtg.
" " " 9th Nat'l Conf. on Undergraduate
Research entitled "Using Gritiof to Model Nucleus-Nucleus Interactions in Cosmic Ray Detector'

How did you learn about the JOVE program? Dr. Donald C. Wold

Has the JOVE program affected your future plans? If so, how? _____

| x Male | _____ Female | Spain _____ Citizenship |

Racial Minority: _____ No   X Yes (If yes, please check below.)

_____ Black   _____ Hispanic   _____ American Indian

_____ Oriental (Chinese, Japanese, Korean, Vietnamese)   Spanish Other (Please specify)

1995 NASA / UNIVERSITY JOINT VENTURE -- STUDENT INFORMATION

General

Name: CARLOS ANDRES SANCHEZ   Social Security Number: ▮▮▮▮▮▮▮

Permanent Mailing Address: AVDA DE LA ESTACION 5A 2°D ALICANTE 03003 SPAIN

School Mailing Address: UNIVERSITY OF ARKANSAS AT LITTLE ROCK PHYSICS 103
2801 S. UNIVERSITY AVENUE L.R, AR 72204

Phone (permanent): 011-34-65-9224-35   Phone (school / work): _____

Undergraduate Career

Undergraduate Institution: UNIVERSITY OF ARKANSAS AT LITTLE ROCK

Graduation Date / Degree / Department: BS PHYSICS FALL 96

Major Declared as a Freshman: NONE

Post–Graduate Career

Graduate Institution: UNDECIDED

Graduation Date / Degree / Department: ~~PHYSICS~~

Thesis / Dissertation: _____

Employer / Position: _____

JOVE Participation

Begin Date: SEPTEMBER 94   End Date: _____

JOVE Faculty Advisor / Department: Dr DONALD WOLD

JOVE Scholarship–Assistantship / Amount: _____

Scholarship–Assistantship Requirements: _____

JOVE Presentations / Publications / Proposals: ARKANSAS ACADEMY OF SCIENCE NCVR 95

How did you learn about the JOVE program? FROM PROFESSOR

Has the JOVE program affected your future plans? If so, how? YES. IT ALLOWED ME TO START DOING RESEARCH RIGHT AWAY.

___✓___ Male   _____ Female   _____ Citizenship

Racial Minority: _____ No   ___✓___ Yes (If yes, please check below.)

_____ Black   ___✓___ Hispanic   _____ American Indian

_____ Oriental (Chinese, Japanese, Korean, Vietnamese)   _____ Other (Please specify)

Appendix A
JOVE Final Report
1995-6

Final Report for Summer 1992

Donald C. Wold

NASA MSFC

Final Report for Summer 1992
Donald C. Wold, JOVE Faculty Research Associate
NASA Marshall Space Flight Center, Astrophysics Division

Student involvement is an important component of the JOVE (JOint VEnture) Program. Thus research activities in the Gamma and Cosmic Ray Branch were examined to determine their suitability for undergraduate participation, based on existing resources at the University of Arkansas at Little Rock (UALR).

As the scale of cosmic ray, gamma ray, and high energy physics experiments increase, simulation studies require more care and become essential to: design and optimize the detectors, develop and test the reconstruction and analysis programs, and interpret the experimental data. Many people were contacted regarding the suitability and availability of simulation programs for gamma ray astronomy, cosmic ray research, and space radiation environments research. The list of persons is given in the Appendix.

As a result of these discussions, several persons provided sufficient information about their organization's file directories to allow all the programs to be copied. Most of the people contacted were more familiar with GEANT3 and the European Organization for Nuclear Research (CERN) Program Library. Other simulation programs, such as CALOR89 (along with HETC, MORSE, and EGS4) are used also. CALOR89 has been ported to DEC 5000 (Ultrix) workstations.

GEANT3 is a three-dimensional Monte Carlo simulation program, which is used to track particles through an experimental setup for acceptance studies or simulation of detector response. The graphical representation of the setup and the particle trajectories can be displayed or printed.

One advantage of using GEANT3 for simulations is that the program is used by many research groups. Furthermore, it is being modified, updated, and supported by computer personnel at CERN. Documentation is available for programs in the CERN Program Library. As a subscriber to the GEANT file list server at CERN, information about changes or problems is frequently received via email. Several students at the University of Arkansas at Little Rock are using GEANT3 to carry out simulations for the Relativistic Heavy Ion Collider experiment. The programs are running on DEC 5000 (Ultrix) workstations.

For the JOVE program, UALR can build on student and faculty experience with programs in the CERN Program Library to conduct simulations of existing cosmic ray detectors and those proposed for NASA experiments. If a program is not appropriate for the particles or energies involved in a simulation, then it may be

necessary to run other programs such as CALOR89. Thus research studies related to work in the Gamma & Cosmic Ray Branch of the Astrophysics Division at NASA Marshall Space Flight Center would be appropriate for faculty and students at UALR.

A long term goal is to study the spectrum of high-energy cosmic rays. Ballon-borne emulsion chambers are used to detect these particles in high energy nucleus-nucleus interactions. The detectors have "target sections" and calorimeter sections for measurements of produced charged particles and gamma-rays, respectively. The target section includes many layers of nuclear emulsion plates to measure the charge of the incident particle and the emission angles of the produces charged particles. The calorimeter includes layers of nuclear emulsion and x-ray film to measure the electron distributions from the electromagnetic cascades initiated by gamma-rays from pi-zero decay.

The electromagnetic cascade is one key to estimating the energy of the original cosmic ray. The maximum electron number in an electromagnetic cascade can be related to the total energy of the electromagnetic component. A high-powered microscope may be used to count individual electron tracks in the shower for each of several layers of emulsion, but this procedure is time consuming. Consequently, indirect counting techniques, which rely on optical density measurements of the x-ray film, are used to study the development of cascades.

A scintillating optical fiber calorimeter (SOFCAL) is being developed for use in emulsion chambers. With this technique, the time required to measure the energy in an electromagnetic cascade would be reduced. Furthermore, the device would not saturate for long exposures at very high energies where the flux is extremely low and long exposures over years in space are required. The calorimeter (SOFCAL) would record positions, angles, and temporal information of cosmic ray nuclei and gamma-rays. It may be possible to extend the measurements of cosmic rays to event energies around 1000 TeV, where a drastic change of elemental composition is indicated.

At the beginning of the JOVE program, it is proposed to use GEANT3 for simulation of electromagnetic cascades and compute the energy deposited in different regions of the detector (SOFCAL). GEANT3 may be used to develop and test reconstruction and analysis programs and to interpret the experimental data. For example, the output data from GEANT3 will be compared with simulations of electromagnetic cascades being carrying out by NASA researchers with another program called EGS3. Simulations done with GEANT3 will provide an important validation of those done using EGS3.

During the summer, the initial data required to initialize the simulation programs were collected. This information includes detailed dimensions of the

detector (SOFCAL) and typical energies of gamma rays which strike the detector. In order to implement the simulation and graphics programs in the CERN Program Library, disk space for a project directory on a Space Science Laboratory (SSL) VAX was requested. After this directory has been set up, the basic libraries will be copied from the CERN VAX to the SSL VAX.

An extension of this work would be to study simulations of nuclei-nuclei collisions at energies which are comparable to those of cosmic rays. Identification of the primary particles striking the "target sections" of the balloon-borne emulsion chambers is very important. Simulation of events enables the measurements of charged particles in the emulsions to be related to the primary energy and particles involved in the collision. The computer program, FRITIOF, in the CERN Program Library, is suitable for some beam and target particles. For other nuclei-nuclei collisions encountered in the emulsion cosmic ray detectors, the program would have to be modified. The output data from these simulations would be useful for optimization of existing detectors and design of future cosmic ray detectors.

Appendix to Final Report

Summer 1992

The following people were contacted regarding the suitability and availability of simulation programs for gamma ray astronomy, cosmic ray research, and space radiation environments research:

Tony W. Armstrong, Science Applications International Corp.

Charles Byrd, University of Arkansas at Little Rock (UALR)

Federico Carminati, CERN and Princeton University

Martyn J. Corden, Supercomputer Computations Research Institute,
        Florida State University

Soren Frederiksen, Superconducting Super Collider (SSC) Laboratory

Tony Gabriel, Oak Ridge National Laboratory

Clark McGrew, University of California, Irvine

Miguel Marquina, CERN and Princeton University

Brent Moore, University of Mississippi, Oxford

Thomas A. Parnell, NASA Marshall Space Flight Center

Ellen Roberts, NASA Marshall Space Flight Center

David Roetzel, University of Arkansas at Little Rock

John Watts, NASA Marshall Space Flight Center

Gaurang Yodh, University of California, Irvine

Saul Youssef, Supercomputer Computations Research Institute,
        Florida State University

Appendix B
JOVE Final Report
1995-6

Refereed Journal Articles
Published:

Monte Carlo Simulation of The Scintillating Optical Fiber Calorimeter (SOFCAL)

Zibin Yang, Russell Gillum and Donald C. Wold
Department of Physics and Astronomy
University of Arkansas at Little Rock
Little Rock, AR 72204

Abstract

A scintillating optical fiber calorimeter (SOFCAL) is being developed by NASA/Marshall Space Flight Center for use in balloon-borne emulsion chambers to study the spectrum of high-energy cosmic rays and gamma rays. SOFCAL will not saturate for long exposures, and the detector will be helpful for the study of primary cosmic-ray nuclei energies from 100 GeV to 1,000 TeV. For a given incident particle and energy, computer simulations of electromagnetic cascades allow computation of energy deposited in different regions of the calorimeter. For these initial simulations, a 5-cm x 5-cm x 7-cm calorimeter was used. Each subsection contained a 0.4-cm thick lead plate or two 0.2-cm lead plates and two layers of optical fibers, 90° to each other. There were 100 square fibers in a layer, and the length of an edge was 0.5 mm. For incident gamma ray energies of 0.5 to 1.5 TeV, the energy deposited in each layer of fibers was computed. Due to the limited dynamic range of the imaging electronics, a window for the energy deposition (ΣE_γ) in the fibers was explored to determine the best measure of energy deposition in the calorimeter.

Introduction

The Monte Carlo method in GEANT (CERN, 1992a) was used to simulate the photon and electron events in the Scintillating Optical Fiber Calorimeter (SOFCAL), which is under development at NASA/Marshall Space Flight Center for future applications in cosmic ray and gamma ray measurements.

Emulsion chambers employing calorimeters have been used for direct measurements of cosmic-ray composition (protons through Fe) between 10^{12} and 10^{15} eV using balloon-borne emulsion chambers (Kaplon et al., 1952; Minakawa et al., 1958; Niu et al., 1971; Burnett et al., 1986; Burnett et al., 1987; Parnell et al., 1989; Burnett et al., 1990; Asakamori et al., 1991). The emulsion chamber shown in Fig. 1 is composed of four parts: (1) a charge-determination module, (2) a target module with ~0.2 vertical interaction mean free paths for protons, (3) a spacer module, and (4) an emulsion calorimeter module with about fourteen vertical radiation lengths. In one emulsion chamber (Burnett, et al., 1986), the thickness of each part was as follows: primary charge detector, 1.78 cm; target module, 15.92 cm; drift space, 12.08 cm; and calorimeter section, 6.30 cm. The thickness was measured along an axis perpendicular to the plates. The simulations described here are for a scintillation optical fiber counterpart to the calorimeter section in the emulsion chamber.

The part of the primary energy going into gamma-rays, ΣE_γ, is the parameter most easily related to the primary cosmic ray spectrum in emulsion chamber experiments. The ability to measure energies of electron-photon cascades is one of the most important functions of the calorimeter. Following an interaction above or in the top of the calorimeter, a fraction of the total primary energy (5 - 25% of the energy released depending on impact parameters and atomic mass numbers of the colliding nuclei), will be deposited in the calorimeter in the form of photon energy, ΣE_γ. The photons originating from an interaction will develop individual electromagnetic cascades in the calorimeter. For these simulations, a calorimeter module with ten vertical radiation length of Pb was used. In the geometrical configuration shown in Fig. 2, each subsection of the calorimeter consisted of a 4-mm lead block, 100 square fibers (each 0.5-mm thick) in the x-direction and 100 square fibers (each 0.5-mm thick) in the y-direction. In these initial simulations, this lead and optical fiber combination was repeated fourteen times.

Materials and Methods

The Monte Carlo Method in GEANT.--GEANT and PAW (CERN, 1992b) are a system of detector description and simulation tools developed by CERN. The Monte Carlo simulations, which used GEANT Version 3.21, were done on DEC 5000 workstations. The principal application of GEANT in High Energy Physics are (1) the track-

Charge Detector: Measure Z by δ ray counting in emulsions and etch pit size in CR39.
Target: Interaction probability $\sim$ 0.2 for protons and $\sim$ 0.9 for iron nuclei.
Spacer: Primary fragments
- Produce $\pi^{\pm}$, and
- Gamma rays from π^0 decay spread out so they may be measured individually.
- θ (typical) = 2×10^{-3} radians at 10^{12} eV/amu.

Calorimeter: Gamma rays produce
- Copious $e^{\pm}$, γ's in lead.
- Number of $e^{\pm}$ counted in emulsions or X ray film.
- Optical density measured = ΣE_γ.
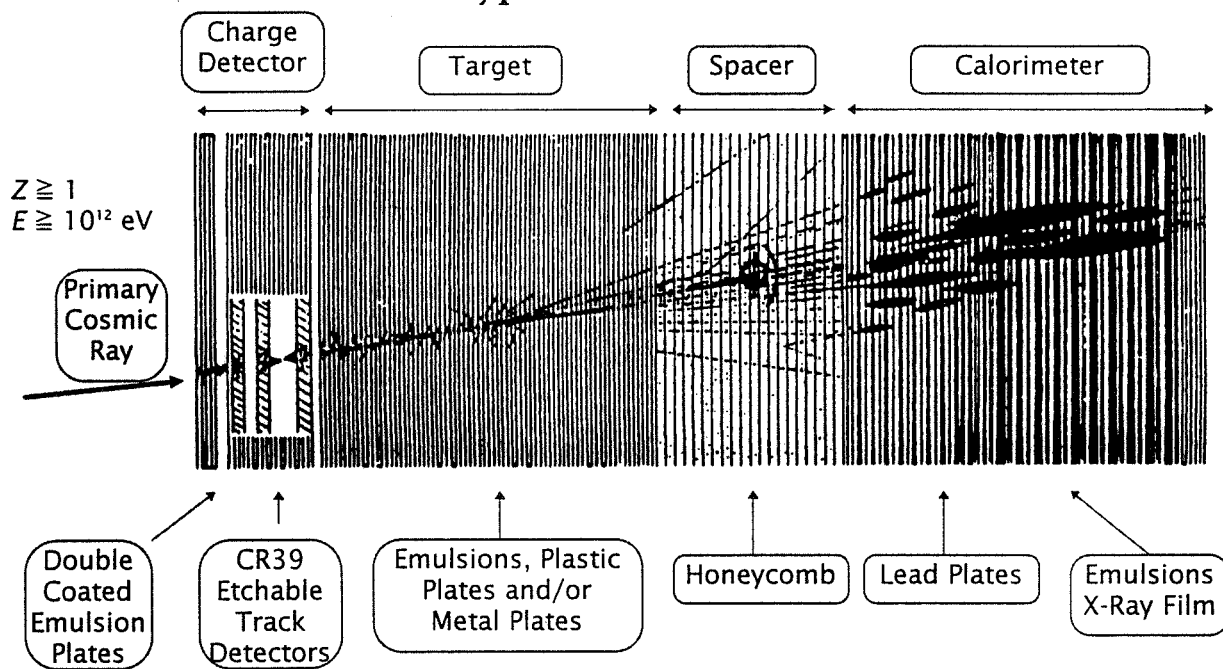
Typical Emulsion Chamber

Fig. 1. Schematic diagram of an emulsion chamber.

ing of particles through an experimental setup for simulation of detector response, and (2) the graphical representation of the setup and of the particle trajectories. These two are often combined interactively in simulations.

The methods in these simulations include the following steps:

(1) *Describe an experimental setup using geometry setup routines.* The setup is represented by a structure of geometrical volumes. Each volume is given a medium number by the user. Different volumes may have the same medium number. A medium is defined by the so-called tracking medium parameters, which include reference to the material filling the volume.

(2) *Accept events simulated by standard Monte Carlo generators.* The Monte Carlo method is based on a statistical theorem which says that the distribution of a Cumulative Distribution Function is uniform. So random seeds generated by a random number generator (uniform) can be used to calculate events in a certain distribution. GEANT is interfaced with the event generator, FRITIOF. This Monte Carol program (Lönnblad, 1992) simulates events of hadron-hadron, hadron-nucleus, or nucleus-nucleus collisions at high energies.

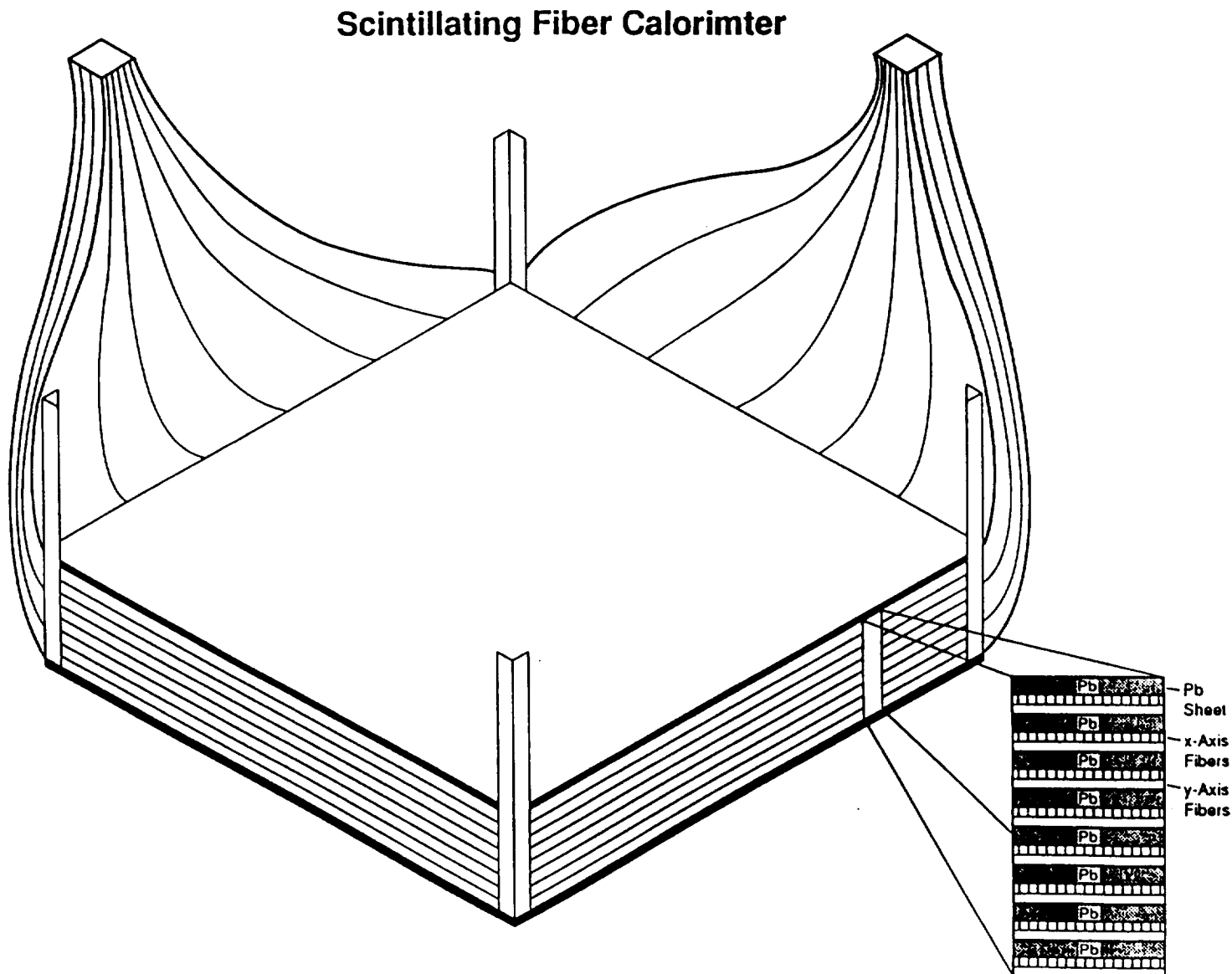(3) *Simulate the transport of particles through the various*

Scintillating Fiber Calorimter

Fig. 2. Geometry of Scintillating Fiber Calorimeter (SOFCAL).

regions of the setup. GEANT can take into account the interactions of these particles with the matter and the boundary of the setup. GEANT is able to simulate the dominant processes which can occur in the energy range from 10 kV up to 10 TeV.

(4) *Record elements of the particle trajectories and the response from the sensitive detectors.*

(5) *Visualize the detectors and the particle trajectories.*

The Monte Carlo Program for SOFCAL Simulations (SOFCALS).--The process of optimization requires frequent design changes, so users should be able to change the geometry easily. The time required to modify GEANT

programs containing geometry information about the detector can be enormous. Therefore a subroutine was developed to read in the geometrical configuration from a separate file in an ASCII format. This subroutine reads not only detector setup, but also other parameters needed for the simulation such as tracking medium parameters. The data are stored and later used for computing energy deposited by each particle in the cascade (Fig. 3) which was initially produced by a gamma ray.

Energy deposition is calculated from the lowest level geometry. Total energy deposition is integrated using step functions. When a threshold is imposed due to limi-
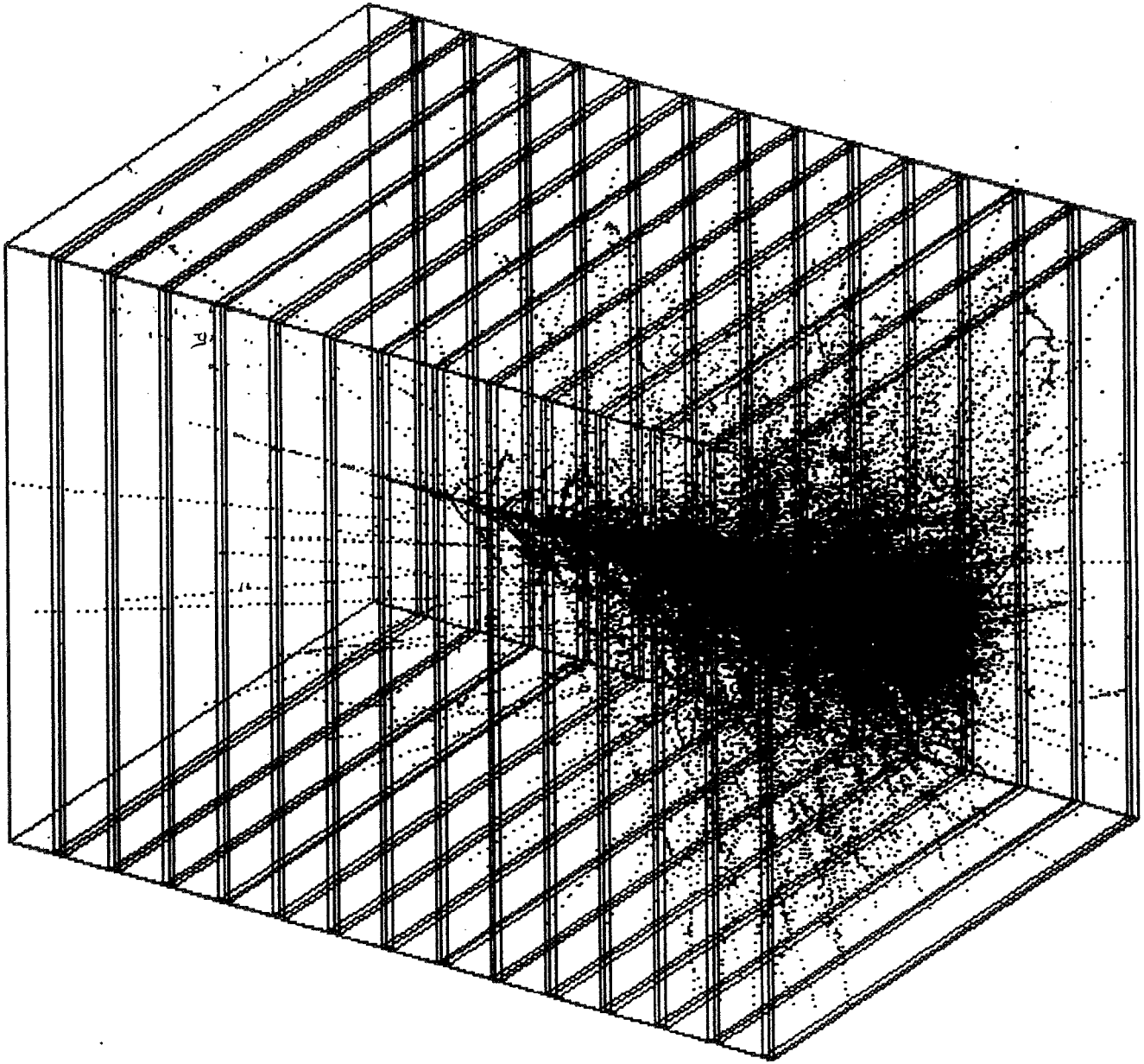
The Shower Caused by a Photon with E=100 GeV

Fig. 3. The trajectories of a photon event with energy of 0.1 TeV.

tations in the electronic read out devices, then the measured energy is less than the energy actually deposited in each fiber. The program SOFCALS has interactive routines which are called to draw the trajectories of an individual gamma ray event.

Results

Energy Deposition Transition Curve and the Shower Event.—The typical detector (emulsion chamber) shown in Fig. 1 has a "target section" and "calorimeter section" designed for measuring produced charged particles and gamma rays, respectively. The target section includes many layers of nuclear emulsion plates to measure the charge of the incident particle and the emission angles of

the produced charged particles with high accuracy (0.01 mrad). The spacer section is a drift space that permits closely collimated gamma rays from an upstream vertex to diverge from each other before cascade development in the downstream calorimeter. The calorimeter includes layers of nuclear emulsion and X-ray film among lead plates to measure the electron distributions from the electromagnetic cascades initiated by gamma rays from π^0 decay. The calorimeter is used to measure the spectrum of energy deposition $\sum E_\gamma$ from which the primary energy spectrum is derived.

It is difficult to measure the momenta of produced charged particles in emulsion chambers. However gamma rays from the π^0 decay are observed in the calorimeter and the emitted angles and energies can be measured individually if they are well separated. For high multiplicity events, they overlap in the forward region.

The incident energy of the cosmic ray projectile is not measured directly, but it can be estimated from the total gamma ray energy. The angular distribution and energy distribution of gamma rays from each π^0 decay are needed. Isospin symmetry is assumed so the number of π^0s which decay into pairs of gamma rays is about half that of the charged π mesons.

Figure 3 illustrates the cascade of electrons and photons produced by an incoming gamma ray with incident energy of 0.1 TeV. Figure 4 shows the energy deposited in each x-layer of fibers as a function of distance through the calorimeter. The incident particle is a gamma-ray with energies of 0.5, 1.0, and 1.5 TeV. The three curves are based on ten events each.
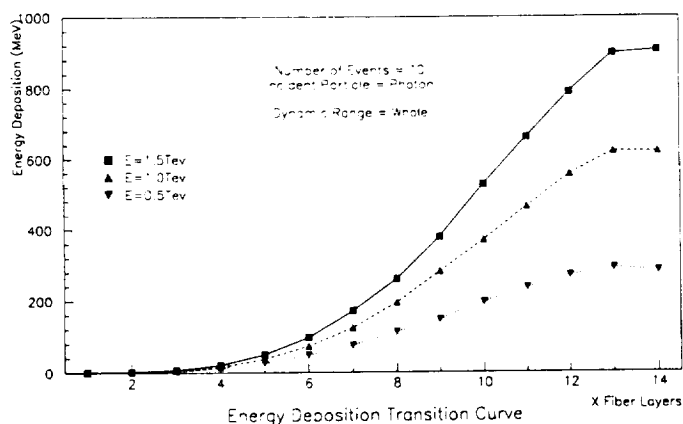
Discussion

In these simulations of gamma rays incident on the SOFCAL detector, the direction of the incoming photon lies along the z-axis which is normal to the plane of each lead plate and layer of fibers. The energy transition curves show the energy deposited in each layer of optical fibers. They are used to determine parameter settings of the data acquisition devices.

The dynamic range is one limitation of the output image intensifier CCD electronics. Typical devices are limited to a dynamic range of approximately 256. For example, if the threshold energy is set to 1 MeV, then the highest energy which can be measured is only 256 MeV. Due to this limitation, a specific threshold and window may be needed to optimize the measurements. For these initial simulations of SOFCAL, a dynamic range of 100 was used. In Fig. 5, a threshold of 2 MeV appears to be optimal. Figures 5 to 8 show that the 2-MeV to 200-MeV range differentiates between gamma ray energies from 0.5 to 1.5 TeV better than other ranges. These figures should be compared with the energy deposition curve in Fig. 4, for which no threshold or range limitation has been imposed. For simulations of the primary cosmic rays, calculations must be performed with event generators, such as FRITIOF, to predict the distributions in $\sum E_\gamma$ and then use GEANT for associated optimum "window" settings.
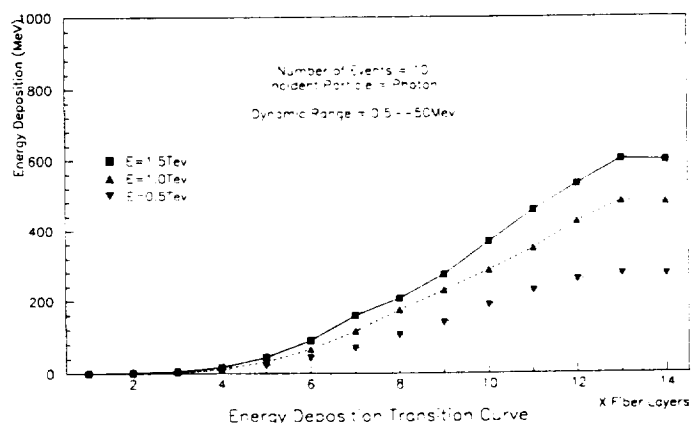

Fig. 5. The energy transition curves of photons with different energies. The dynamic range is 0.5 MeV to 50 MeV.

Fig. 4. The energy transition curve of a photon with energies of 0.5 TeV, 1 TeV, and 1.5 TeV.

Fig. 6. The energy transition curves of photons with different energies. The dynamic range is 1 MeV to 100 MeV.
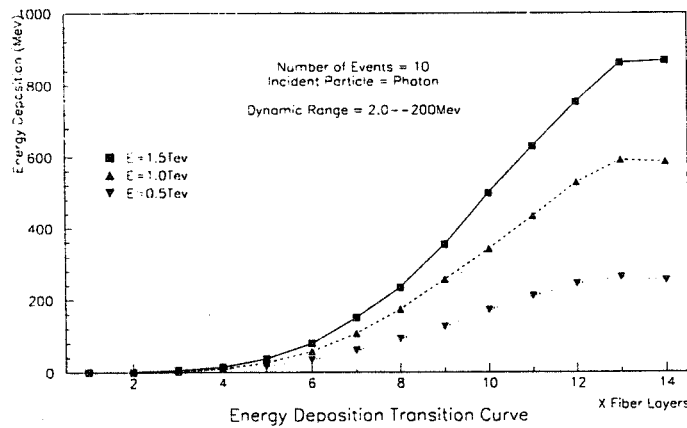
Fig. 7. The energy transition curves of photons with different energies. The dynamic range is 2 MeV to 200 MeV.
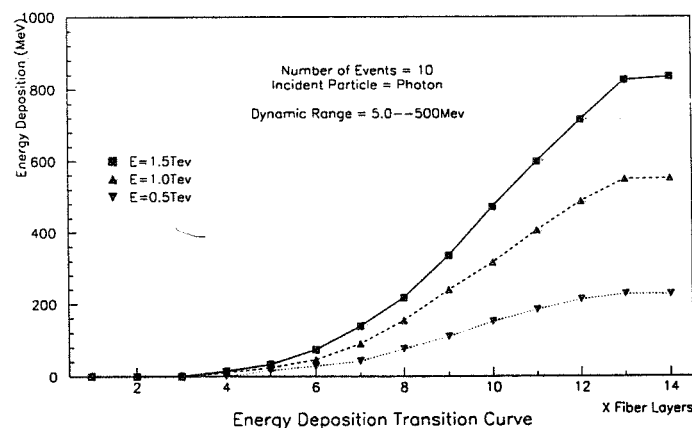
Fig. 8. The energy transition curves of photons with different energies. The dynamic range is 5 MeV to 500 MeV.

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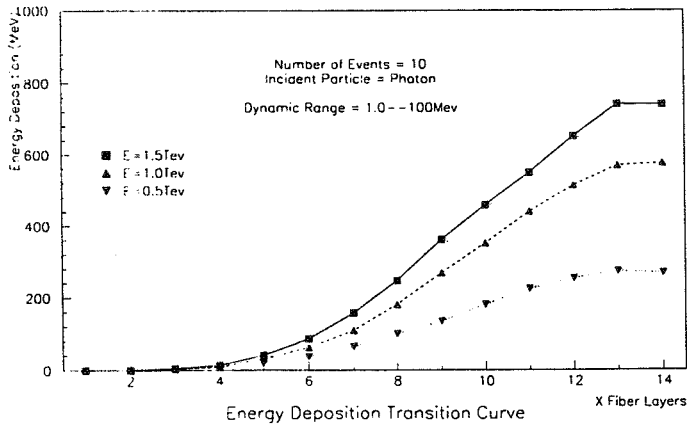
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A Pilot Study of SPINE Test Scores and Measures of Tongue Deviancy in Speakers with Severe-to-Profound Hearing Loss

Two developments show promise in the assessment and remediation of defective speech production in persons with hearing loss. A perceptual speech-intelligibility test, the SPINE (for Speech Intelligibility Evaluation), is a simple, clinician-administered instrument which is valid, reliable, and clinically efficient. In addition, the development of acoustic measures of tongue deviancy, computed from formant frequencies, makes possible a direct lateral visualization of tongue placement in relation to standard vowel placement. In this study, SPINE test scores of 28 persons with severe-to-profound hearing loss were correlated with two measures of tongue deviancy during production of the vowels \i\, \a\, and \u\. For both measures of tongue deviancy, correlations with the SPINE were significant for the three vowels combined and for the isolated vowel \i\. These findings suggest that clinicians may ultimately have two different but complementary means of assessing speech production in persons with hearing loss.

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The verbal speech of persons with severe-to-profound hearing loss is often difficult to understand. Poor speech intelligibility may result in part from inappropriate tongue placement (tongue deviancy) during vowel production, which in turn may distort coarticulated sounds. Although improvement in speech intelligibility through remedial training is desirable, the effectiveness of training is seldom assessed (Monsen, 1981) and continues to be debated (Dagenais, 1992). Part of the problem is that traditional perceptual scales are considered too cumbersome for routine clinical use (Monsen, 1978).

Perceptual measures used to assess speech intelligibility in persons with hearing loss have traditionally included listeners' ratings of conversational speech on an anchored equal-distance scale and listeners' transcriptions of what they hear from a speech sample. With such ratings, clinicians are more inclined

to transcribe and record deviant consonants, although deviant vowels may relate as much or more to intelligibility. Perceptual approaches to speech assessment present problems in that they are subjective and lack quantitative standards. Factors that have been found to affect ratings include listeners' hearing acuity and experience and the stimulus materials used in the intelligibility task (Geffner, Levitt, Freeman, & Gaffney, 1978; Hudgins, 1949; Hudgins, Finch, Lamb, New, & Numbers, 1943; Hudgins & Numbers, 1942; E. Johnson, 1939; D. Johnson, 1976; Levitt, 1980; Markides, 1970; McDermott & Jones, 1984; McGarr, 1980, 1983; Silverman, 1943; Smith, 1975, 1982; Subtelny, 1977). Valid and reliable perceptual assessment of intelligibility is essential to the planning and measurement of feedback strategies for communication rehabilitation with persons who are hearing impaired.

Another assessment-related problem

is posed by the invasive procedures for investigating speech production, such as radiography, palato-graphy, and electromyography. These procedures can be uncomfortable, can distort the speech signal, and generally are unavailable on a real-time basis to the practicing clinician assisting people with severe-to-profound hearing loss. Thus, a lack of objective and noninvasive physiological measures of tongue deviancy hampers the clinician's efforts to offer necessary and timely feedback as training progresses.

Reliable means of obtaining perceptual and physiological measurements that correlate with each other need to be developed to assist the person with a hearing loss in efforts to monitor and modify his or her vocal tract. These instruments should be easy to administer and relatively inexpensive, and should provide data that are valid with respect to speech intelligibility. The information such instruments would provide would make possible an initial assessment baseline and an objective approach to assessing the efficacy of treatment.

Two developments show promise in the assessment and remediation of defective speech production. First, a perceptual speech intelligibility test for persons with hearing loss called SPINE (for Speech Intelligibility Evaluation; Monsen, 1981) provides a simple, clinician-administered instrument that is valid, reliable, and clinically efficient (Kelly, Dancer, & Bradley, 1986). Second, acoustic measures of tongue deviancy computed from format frequencies (Wold, 1985) offer the clinician and the client a direct visualization of tongue placement in relation to a standard or norm. Such feedback, based on a noninvasive objective technique, can provide the client a visual target (tongue placement for normal vowel production) for training and practice.

The purpose of this preliminary

study was to determine whether clinician-generated SPINE test scores are correlated with objective computer-generated measures of tongue deviancy during vowel production in persons with severe-to-profound hearing loss between the ages of 14 and 20. The three vowels of the Ling Five Sound Test (Ling, 1976)—\i\, \a\, and \u\—were chosen for initial analysis because they represent articulatory extremes and correspondingly different regions of acoustic energy relating to high-front, low-back, and high-back tongue placement. The front vowel \i\ shows maximum oral constriction, while the back vowels \a\ and \u\ show maximum pharyngeal constriction and lip protrusion, respectively (Borden, Harris, & Raphael, 1994).

Method

Subjects

In this study, there were 28 subjects with hearing loss, 15 females and 13 males, ranging in age from 14 to 20 years. All attended a state-supported day and residential school for the Deaf in a metropolitan area. Subject selection was based on pure-tone audiometric averages for 500, 1000, and 2000 Hz in the better ear, which ranged from 63 dB HL to 120 dB HL. All subjects were of normal intelligence as determined by their performance on the IQ section of the Weschler Intelligence Scale. They were also enrolled in speech therapy and used both speech and manual signs to communicate. For the 28 subjects, the mean and standard deviation of the better-ear hearing losses were 91.3 dB HL and 14.4 dB HL, respectively. To ensure that subjects could read the simple words from the SPINE, only individuals who read at the elementary level or higher were included. In addition, subjects were free of other handicapping conditions and had no apparent concomitant visual impairments.

Administration of the SPINE Test

The SPINE test for words (Monson, 1981) contains 10 decks of cards. Each card in a deck has one of four words printed on one side, such as *feel, fail, fill,* and *feil.* Thus each deck has monosyllables that are acoustically similar except for the embedded vowel. Other card decks consist of groupings such as *net, Nat, nut, not* and *pull, pole, pool, Paul.* Within each deck, the four similar words are repeated on four cards; consequently there are 16 cards per deck. The examiner shuffles the 16 cards in each deck and uses only the first 10 for testing purposes; thus, the number of responses totals 100 per test (10 decks with 10 presented words per deck). The clinician does not know which of the four words in a deck is actually presented visually for the subject to speak at any given time. Thus the clinician records that word he or she perceives on the basis of the subject's production of the embedded vowel.

The SPINE test was administered in a routine clinical fashion to each subject individually in a quiet, well-lit room with the subject seated at a table facing two examiners with normal hearing. Both examiners were familiar with the speech of persons with severe-to-profound hearing loss. Test instructions were given by the primary examiner through a combination of oral speech, manual signs, and fingerspelling.

After a familiarization task, the primary examiner shuffled all the decks so that she would not know the order of the words. She then held the cards up one at a time as the subject verbally produced oral responses to each word printed on the card. While the word printed on the card was read by the subject, the primary examiner and a second examiner immediately wrote on separate answer sheets the word they believed the subject had uttered. Rather than determine qualitatively

how well the words were spoken, the judges had to make a forced choice of one word from among the four words with similar but different vowels.

The cumulative score for the SPINE test was equal to the number of correct word choices made by the judges, with 100 being the highest possible score and 25 (or one out of four) being the baseline score expected to result from guessing. The scores computed by the judges were compared, averaged, and evaluated for interjudge reliability. Because the mean SPINE test scores were obtained from the scores of the two examiners, the results could be construed as being more reliable than what would be obtained in actual clinical practice with a single clinician doing the scoring. However, the average score differed very little from either of the individual scores and the result was reflected in a high interjudge reliability correlation of +.96.

Speech Acoustic-Sampling Procedure

The vowels selected for analysis were the imbedded, coarticulated vowels from three of the test words in the SPINE itself: the high-front \i\ from *feel*, the high-back \u\ from *pool*, and the low-back \a\ from *not*. The vowels provided three distinctly different points of articulation and acoustic resonance targets. To obtain better control of ambient noise and thereby gain a highly favorable signal-to-noise ratio for the acoustic recording and later analysis of the vowels, voice recordings of all subjects producing the three words with the embedded vowels were made in a session separate from the more clinical administration of the SPINE.

For recording, high-quality instrumentation was used, consisting of a dynamic microphone (Electro-Voice model RE55) with a preamplifier (Tandberg model 11) and a tape recorder (TEAC model A-3440). Recordings of the test words were made in a sound-treated double-walled audio-

metric suite. The subject and the primary examiner sat in the testing booth facing each other. An assistant situated outside the booth operated the recording equipment. To coordinate recording, the examiner and assistant communicated manually through the window. The subjects were required to repeat each of the stimulus words three times at a mouth-to-microphone distance of 15 cm. The master tapes were duplicated on open-reel recording tape (Ampex Grand Master +56) at a speed of 38.1 cm/sec with a half-track two-channel tape recorder (Tandberg model 10XD). The speech samples totaled 252 single-word productions (nine for each of the 28 subjects).

For each subject, the examiner listened to the recordings with earphones and selected the best of three productions for each vowel based on a minimum of perceived ambient noise. The selected vowel samples were digitized with a computing spectrum analyzer (Rockland FFT 512'S). Only an 80-msec central window in the middle of the selected vowel in each word was digitized in order to reduce the possible effects of initiation and termination on the formant frequencies. Obtained from a linear prediction analysis (Viswanathan & Makhoul, 1979), the formant frequencies were visually checked for accuracy by comparison with prominent harmonics in the power spectrum and maxima in the envelope of the modal spectrum. All formant frequencies were independently verified with broadband spectrograms from a Kay Elemetrics Digital Sona-Graph model 7800.

Vocal tract shapes for each subject were generated from the formant frequencies (Wold, 1985), and then compared with vocal tract shapes determined from the average formant frequencies for men and women (Peterson & Barney, 1952). This method (Ladefoged, Harshman, Goldstein, & Rice, 1978) has shown that tongue shapes of vowels can be

adequately described by certain proportions of a front-raising and a back-raising component of the tongue. Two methods were used to assess the similarity or dissimilarity of each subject's vocal tract shape and the corresponding reference vocal tract shape. First, the root-mean-square (RMS) deviation between the two shapes was computed from the first three formant frequencies. Second, the sum of the absolute deviations in the front- and back-raising components (FBC) of the tongue shape, which is easier to calculate, was computed from the same formant frequencies. Given the vocal tract shape of the subject and the reference vocal tract shape, it can be shown that the RMS deviation is always less than or equal to the sum of the absolute deviations in the components of tongue shape. Pearson product-moment correlation coefficients and multiple-correlation coefficients were then computed between the SPINE-test scores in rationalized arcsine units (Studebaker, 1985) and the reciprocals of both acoustic measures of tongue deviancy.

Results

Individual SPINE test scores ranged from 34% to 96% with a group mean of 61% and a standard deviation of 17%. According to Monsen's (1981) interpretation of scores, a mean score of 61% indicates that, in general, "people listening to these subjects would experience difficulty in understanding simple material, and that the communication process would be labored and difficult" (p. 850).

Table 1 shows the deviations in tongue shape as determined by the means, standard deviations, and ranges of the root-mean-square measure and the sum of the absolute deviations in the front and back components. Note that \i\, the highest front vowel, shows the most deviation from the normative tongue position in centimeters, while \u\, the highest back vowel, shows the least. The low-back vowel \a\ shows intermediate tongue-deviancy values.

Table 1

Comparative Statistical Attributes of Two Measures of Tongue Deviancy

	Measures of tongue deviancy					
Vowel segment	RMS M (cm.)	FBC M (cm.)	RMS SD (cm.)	FBC SD (cm.)	RMS Range (cm.)	FBC Range (cm.)
\i\	.74	.88	.34	.34	1.47	1.41
\a\	.62	.72	.40	.39	1.70	1.77
\u\	.36	.59	.17	.23	.73	.92

RMS. root-mean-square deviations in tongue space

FBC. sum of the absolute deviations of the front- and back-raising components
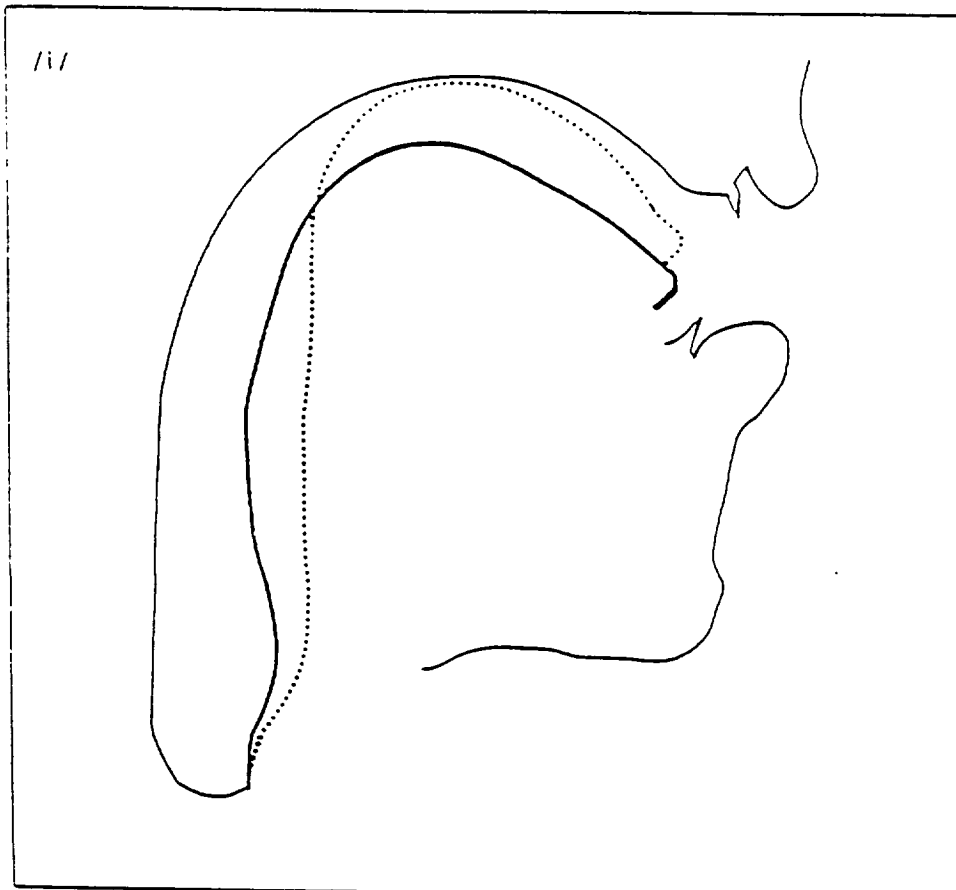

Figure 1

Vocal Tract Shape (Solid Line) Computed from the Formant Frequencies of a Woman with Impaired Hearing Compared to the Vocal Tract Shape (Dotted Line) Computed from the Average Formant Frequencies of Men (Peterson & Barney, 1952). The Subject Has Uttered a Vowel Sound Corresponding to \i\.

Table 2

Correlation Coefficients between SPINE Test Scores and Two Measures of Tongue Deviancy

Measures of tongue deviancy (Pearson product-moment correlation coefficients)		
Vowel segments	RMS	FBC
\i\	52*	58*
\a\	20	19
\u\	01	18
Multiple correlation coefficient		
	59ª	.62*

RMS. root-mean-square deviations in tongue space

FBC. sum of the absolute deviations of the front- and back-raising components

* Significant at the .01 level of confidence

ª Significant at the .02 level of confidence

Table 2 shows Pearson product-moment correlation coefficients and the multiple-correlation coefficient between SPINE test scores and two measures of tongue deviancy: (a) the reciprocals of the root-mean-square values and (b) the reciprocals of the sum of the absolute deviations of the front and back components. Note that both measures of tongue deviancy yielded a statistically significant moderate correlation with the vowel \i\ in isolation and with the vowels \i\, \a\, and \u\ combined into a multiple-correlation coefficient. Neither tongue-deviancy measure was significantly correlated with the vowels \a\ and \u\ in isolation.

In Figure 1, a hearing-impaired subject's utterance of \i\ (solid line) is compared with a normative production (dotted line). Note that the subject's tongue was placed in a more neutral articulatory position.

Discussion

The data from this study suggest that speakers with severe-to-profound hearing loss are more deviant in their production of front vowels, such as \i\, than they are in their production of back vowels, such as \u\. This inference supports previous findings (Mangan, 1961; Boone, 1966; Nober, 1967; Smith, 1975; Geffner, 1980) and may relate primarily to the high-frequency, low-intensity F2 formants of front vowels. Persons with hearing loss are less likely to perceive and use such higher-frequency formants in speech production, even with amplification. A back vowel such as \u\, with more intense lower-frequency F2 energy, is more likely to be perceived and produced correctly with proper amplification. In addition, quantal theory predicts that front vowels allow for less variability in their formants, and thereby require more precise tongue placements for correct production than do the back vowels (Stevens, 1972). Although \a\ is a back vowel, with lower-frequency energy in both F1 and F2, quantal theory predicts that the close proximity in F1-F2 restricts this vowel's variability and increases the precision of tongue placement necessary for correct production and perception. In this sense, \a\ is a special-case back vowel, since it tends to require the more precise vocal tract configuration required of front vowels.

The statistically significant correlation between the vowel \i\ and overall SPINE scores suggests that front vowels, with relatively high F2 formant energy and less formant variability, may be more related to overall speech intelligibility than are back vowels, whose low, more variable F2 formants may be perceived by persons with severe-to-profound hearing loss when appropriate amplification is provided. A limitation of this study is that correlation data on only three, widely separated vowels are included. As previously indicated, these vowels were selected for this pilot study because they represent contrasting regions of acous-

tic energy and physiological place and movement characteristics. Future research should involve correlation of all the vowels with their respective SPINE embedded counterparts. This would determine which vowel or combination of vowels relates most strongly to speech intelligibility.

The sound quality of a vowel is primarily dependent upon the vocal tract configuration. The primary vowel articulator of this resonator is the tongue. Providing visual cues for vowels is especially frustrating because they are all produced in the mouth with minimal external visual lip rounding and tensing cues. Persons with severe-to-profound hearing loss may develop vowel systems based on an inappropriate model because they have a reduced number of distinct auditory targets (Rubin, 1985). Thus, it becomes crucial to introduce real-time visual physiological feedback to clients during clinical therapy for verbal speech production. Incorporating computer-generated analysis of the deviant speech signal will not only provide quantitative measures of acoustic and physiological properties but will provide the visual feedback necessary for learning correct vowel production. Future advances in microcomputer design may reduce the cost of equipment capable of such tasks and increase the speed of analysis to the point where persons with severe-to-profound hearing loss can receive virtually instantaneous feedback on tongue placement during speech production.

The need for real-time analysis brings up another limitation of this study, since the vowel productions used in measuring tongue deviancy were recorded separately from the SPINE test administration. Although the laboratory environment provides better control over vowel recording than does the clinical setting, it does produce a situation in which the speaker's words judged for their SPINE scores differ from those used for vowel acoustic measures. Whether

the vowels produced by the subjects in the laboratory are acoustically different from those produced during the SPINE administration and whether such differences might affect overall vowel-SPINE test relationships are important questions, especially because such questions relate to the efficacy of the laboratory versus real-time, clinical uses of computer measures of tongue deviancy. Also, variances in tongue deviancy during repeated productions of the same vowel need to be explored, within both the laboratory and the clinic.

Visual cues such as those obtained from the generation of vocal tract shapes can be used as indicators of progress in learning correct vowel articulation. Visual cues can also provide a means of evaluating and comparing different methods of teaching speech production. This could be done by generating vocal tract shapes at the onset of therapy and then overlaying vocal tract shapes obtained at a later time. By doing this, one could see the degree of raising and lowering or forward and backward placement of the tongue. Comparisons could also be made between clinician and client productions.

Previous studies by Monsen (1981) and Kelly, Dancer, and Bradley (1986), along with the findings of this study, suggest that the SPINE test has validity and reliability as a means of judging overall speech intelligibility of persons with severe-to-profound hearing loss. In addition, the SPINE test can be administered quickly and easily. Although perceptual methods of assessing speech intelligibility are the most widely used, computer analysis of the speech acoustic signal constitutes a relatively objective yet noninvasive means of quantifying hypothesized physiological properties of speech. Thus, computing vocal tract shapes from formant frequencies appears feasible and may be a faster alternative to the more traditional approaches to assessing speech intelligibility of persons with hearing loss. In addition, this

procedure may provide more clinically relevant information for individual habilitation and educational planning. The correlation of SPINE test scores to computer measures of tongue deviancy in the production of high-front vowels such as \i\ suggests that the clinician may use the SPINE test as a means of rapid clinical verification of improvement in tongue positioning.

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The STAR Experiment at the Relativistic Heavy Ion Collider

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1. INTRODUCTION

The primary motivation for studying nucleus-nucleus collisions at relativistic energies is to investigate partonic, hadronic and nuclear matter at high energy densities ($\varepsilon > 1$-2 GeV/fm^3). Early speculations of possible exotic states of matter focused on the *astrophysical implications* of abnormal states of dense nuclear matter.[1] Subsequent field theoretical calculations, assuming chiral symmetry in the σ model, resulted in predictions of abnormal nuclear states and excitation of the vacuum.[2] This generated an interest in *particle and nuclear physics* to transform the state of the vacuum by using relativistic nucleus-nucleus collisions.[3] Shortly thereafter, a phase transition to a system of deconfined quarks and gluons, the Quark-Gluon Plasma (QGP),[4] was predicted. This had implications for both *early cosmology and stellar evolution*. Many theoretical developments have since brought us to the present, still infant state of understanding[5] of the behavior of highly excited partonic, hadronic and nuclear matter in relativistic nucleus-nucleus collisions.

The early dynamics of these collisions involving hard parton-parton interactions can be calculated using perturbative QCD.[6] Various theoretical approaches result in predictions that highly excited ($T_{effective} \sim 500$ MeV), predominantly gluonic matter will be formed within the first 0.3 fm/c of the collision process.[7] QCD lattice calculations[8] exhibit a phase transition between a QGP at a temperature near 250 MeV and hadronic matter. Such phases of matter may have existed shortly after the Big Bang and may exist in the cores of dense stars. An important question is whether such states of matter can be created and studied in the laboratory. The Relativistic Heavy Ion Collider (RHIC) is

being constructed at Brookhaven National Laboratory to investigate these new and fundamental properties of matter.

2. THE STAR EXPERIMENT

The STAR experiment[9] will concentrate on measurements of hadron production over a large solid angle to be able to study observables on an event-by-event basis. STAR will search for signatures of QGP formation and investigate the behavior of strongly interacting matter at high energy density. Since there is no single definitive signature for the QGP, it is essential to use a flexible detection system at RHIC. STAR will simultaneously measure many experimental observables to study signatures of the phase transition and the space-time evolution of the collision process. This requires an understanding of the microscopic structure of hadronic interactions, at the level of quarks and gluons, at high energy densities. The experiment will utilize two aspects of hadron production that are fundamentally new at RHIC: correlations between *global observables on an event-by-event basis* and the use of *hard scattering of partons* as a probe of the properties of high density nuclear matter.

The event-by-event measurement of global observables - such as temperature, flavor composition, collision geometry, reaction dynamics, and energy or entropy density fluctuations - is possible because of the very high charged particle densities, $dn_{ch}/d\eta =$ 1000 expected in nucleus-nucleus collisions at RHIC. This will allow novel determination of the thermodynamic properties of single events. Correlations between observables made on an event-by-event basis may isolate potentially interesting events.

Measurable jet yields at RHIC will allow investigations of hard QCD processes via both highly segmented calorimetry and high p_t single particle measurements in a tracking system. A systematic study of particle and jet production will be carried out over a range of colliding nuclei from pp through p-nucleus up to Au-Au, over a range of impact parameters from peripheral to central, and over the range of energies available at RHIC. The pp interactions will help establish the gluon structure functions, the p-nucleus interactions will be used to study the nuclear gluon distributions and thus the extent of shadowing of gluons in the nucleus, while the nucleus-nucleus interactions are essential to determine the degree of quenching of hard scattered partons in the surrounding nuclear, hadronic, and partonic matter. Measurements of the remnants of hard-scattered partons will be used as a penetrating probe of the QGP, and will provide new information on the nucleon structure function and parton shadowing in nuclei.

Measurements will be made at midrapidity over a large pseudo-rapidity range ($|\eta|$ < 1) with full azimuthal coverage ($\Delta\phi = 2\pi$) and azimuthal symmetry. The detection system is shown in Fig. 1. It will consist of a silicon vertex tracker (SVT) and time projection chamber (TPC) inside a solenoidal magnet with 0.5 T uniform field for tracking and momentum analysis over $|\eta| < 2$, and particle identification via dE/dx at low p_t; a time-of-flight system surrounding the TPC for particle identification at high momenta; electromagnetic calorimetry just inside the solenoid to trigger on and measure jets and the transverse energy of events; and external time projection chambers (not shown in Fig. 1) located downstream outside the solenoid to extend the tracking coverage to $|\eta| = 4.5$. Additional fast trigger detectors will be installed to trigger on collision geometry and the position of the primary interaction vertex.
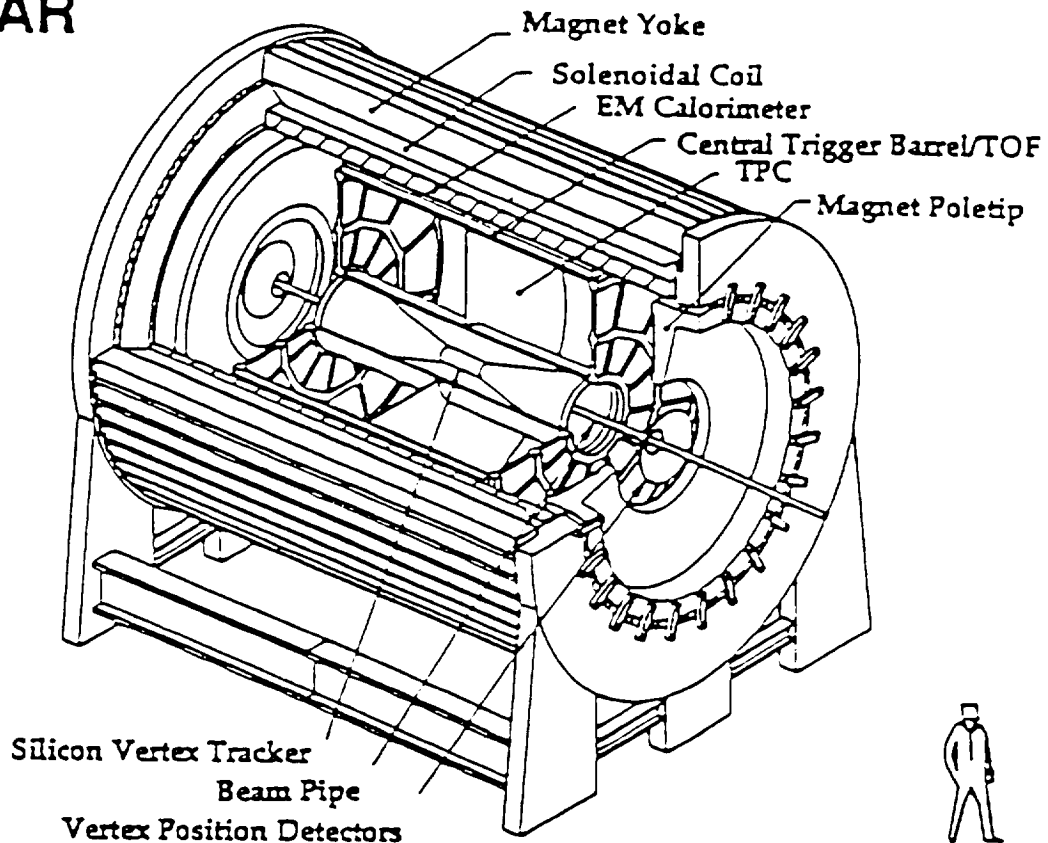
Figure 1. Schematic layout of the Solenoidal Tracker At RHIC.

3. PHYSICS OF STAR

3.1 Parton Physics from Jets, Mini-Jets and High p_t Particles

The early stages of the collision process can be studied by measuring the products of QCD hard scattering processes. The partons in a single hard scattering, whose products are observed near midrapidity, must traverse distances of several fermi through highly excited matter in a nucleus-nucleus collision. The energy loss of these propagating quarks and gluons is predicted[10] to be sensitive to the medium and may be a direct method of observing the excitation of the medium. Passage through hadronic or nuclear matter is predicted to result in an attenuation of the jet energy and broadening of jets. Relative to this damped case, a QGP is predicted to be transparent and an enhanced yield at a given transverse energy is expected. The yield of jets will be measured as a function of the transverse energy of the jet.

Mini-jets are expected to be produced copiously in collisions at RHIC.[11,12] Similar to the case for high p_t jets, the observed yield of mini-jets is expected to be influenced strongly by the state of the high density medium through which they propagate. It is important to study the degree of fluctuation of the transverse energy and multiplicity as a function of rapidity and azimuthal angle ($d^2E_t/dyd\phi$ and $d^2n/dyd\phi$) *event-by-event*, which should be strongly affected by the presence of mini-jets.[13].
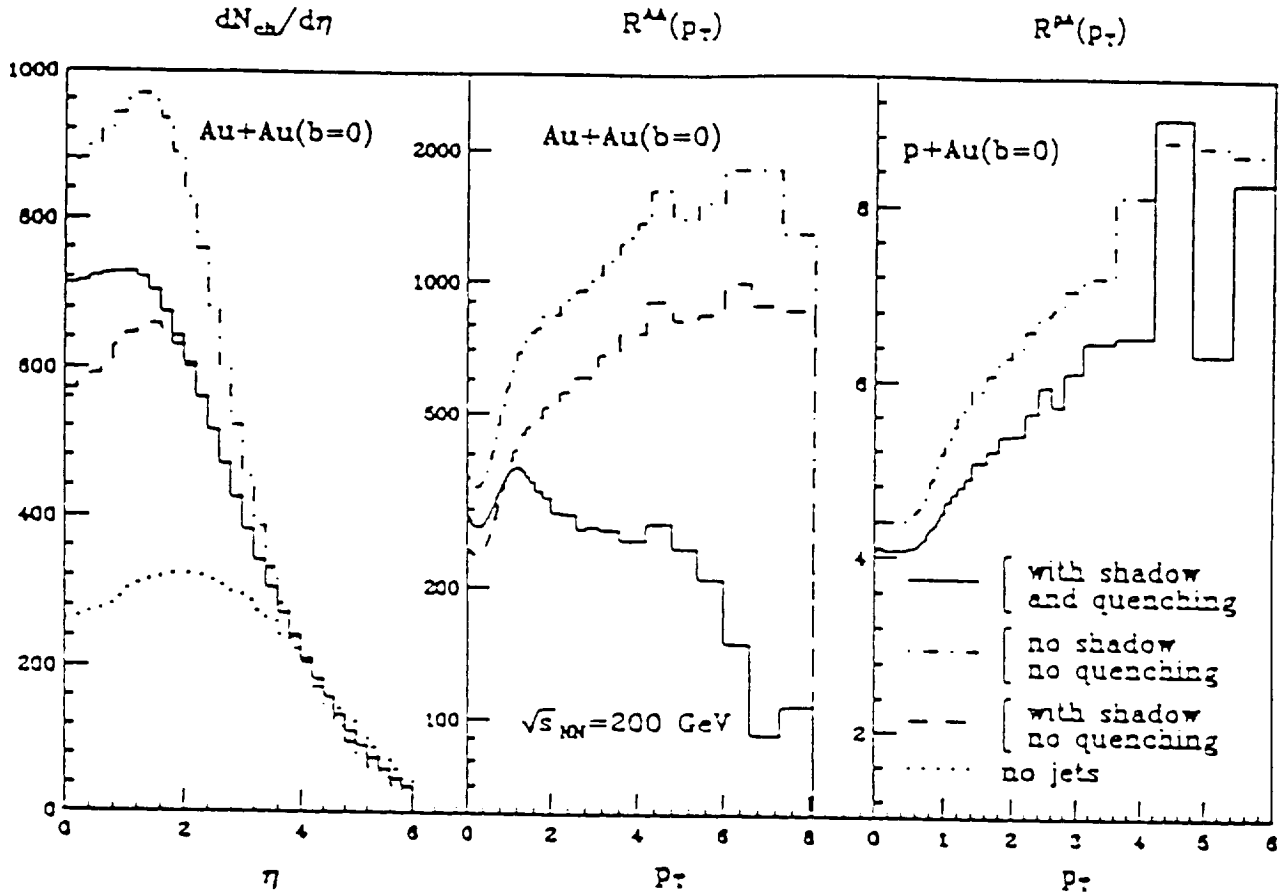
Figure 2. Results from HIJING calculations for central Au+Au and p+Au interactions at RHIC. The dependence of the inclusive charged hadron spectra on mini-jet production (dash-dotted), gluon shadowing (dashed) and jet quenching (solid) assuming that the gluon shadowing is identical to that of quarks. $R^{AB}(p_t)$ is the ratio of the inclusive p_t distribution of charged hadrons in A+B nuclear interactions to that of p+p (see Ref. 14).

The *inclusive* p_t distributions and rapidity distributions of hadrons will also be influenced by jets, mini-jets, gluon shadowing and quenching[14] as can be seen in Fig. 2. A systematic study of pp, p-nucleus and nucleus-nucleus collisions will be necessary to unravel the degree to which shadowing and quenching contribute to the spectra of particles in nucleus-nucleus collisions. The expected rates for measuring various hard-scattering processes in STAR are given in Table 1.

3.2 Particle Spectra

As a consequence of the high multiplicities in central nucleus-nucleus events, the slope of the transverse momentum (p_t) distribution for pions and the $<p_t>$ for pions and kaons can be determined *event-by-event*. Thus, individual events can be characterized by a pion slope parameter T_0 (effective "temperature") or $<p_t>$, and a kaon $<p_t>$ in order to search for events with extremely high temperature, predicted[15] to result from deflagration of a QGP. The accuracy of measuring $<p_t>$ per event as a function of the

Table 1
Rates for hard QCD processes expected in STAR.

Observable	$\sqrt{s}_{nn}$ (GeV)	Colliding System	Luminosity $\mathcal{L}$ (cm^{-2}s^{-1})	p_t Range (GeV/c)	STAR Rate (#/10^{7}s)
jets, (inclusive) $|\eta|<0.5$	200	pp	5×10^{30}	> 20	2.3×10^6
				> 40	4.2×10^3
		p Au (min. bias)	3.2×10^{28}	> 20	2.8×10^6
				> 40	5.0×10^3
		Au Au (central)	2×10^{26}	> 20	5.5×10^5
				> 40	1.0×10^3
	500	pp	1.4×10^{31}	> 20	1.1×10^8
				> 40	2.5×10^6
				> 60	1.3×10^5
π^0, π^+, or π^- (inclusive) $|\eta|<1$	200	pp	5×10^{30}	$10 \pm .5$	4.8×10^4
				$15 \pm .5$	1.5×10^3
		p Au (min. bias)	3.2×10^{28}	$10 \pm .5$	5.8×10^4
				$15 \pm .5$	1.8×10^3
		Au Au (central)	2×10^{26}	$10 \pm .5$	1.2×10^4
				$15 \pm .5$	~350
	500	pp	1.4×10^{31}	$10 \pm .5$	4×10^6
				$20 \pm .5$	3×10^4
				$35 \pm .5$	$\sim 1.2 \times 10^3$

charged particles measured per event is displayed in Fig. 3a. The determination of $<p_t>$ for pions can be made very accurately on the single event basis in this experiment, over the expected range of multiplicities in central collisions from Ca + Ca to Au + Au. For kaons, with ~ 200 charged kaons per event in the acceptance for central Au + Au events, $<p_t>$ can be determined accurately for single events.

Inclusive p_t distributions of charged particles will be measured with high statistics to investigate effects such as collective radial flow and critical temperature at low p_t, and mini-jet attenuation[16] at high p_t. The p_t spectra of baryons and anti-baryons at midrapidity are particularly interesting for determining the stopping power of quarks. Measurements of the net baryon number and net charge are important for establishing the baryo-chemical potential $\mu_B(y)$ at midrapidity.

3.3 Strangeness Production

One of the first predictions of a signature for the formation of a QGP was the enhancement in the production of strange particles resulting from chemical equilibrium of a system of quarks and gluons[17]. A measurement of the K/π ratio provides information on the relative concentration of strange and nonstrange quarks, i.e. $<(s + \bar{s})/(u + \bar{u} + d + \bar{d})>$. This has been suggested[18] as a diagnostic tool to differentiate between a hadronic gas and a QGP, and to study the role of the expansion velocity. The K/π ratio will be measured in STAR *event-by-event* with sufficient accuracy (see Fig. 3b) to classify the events for correlations with other event observables.
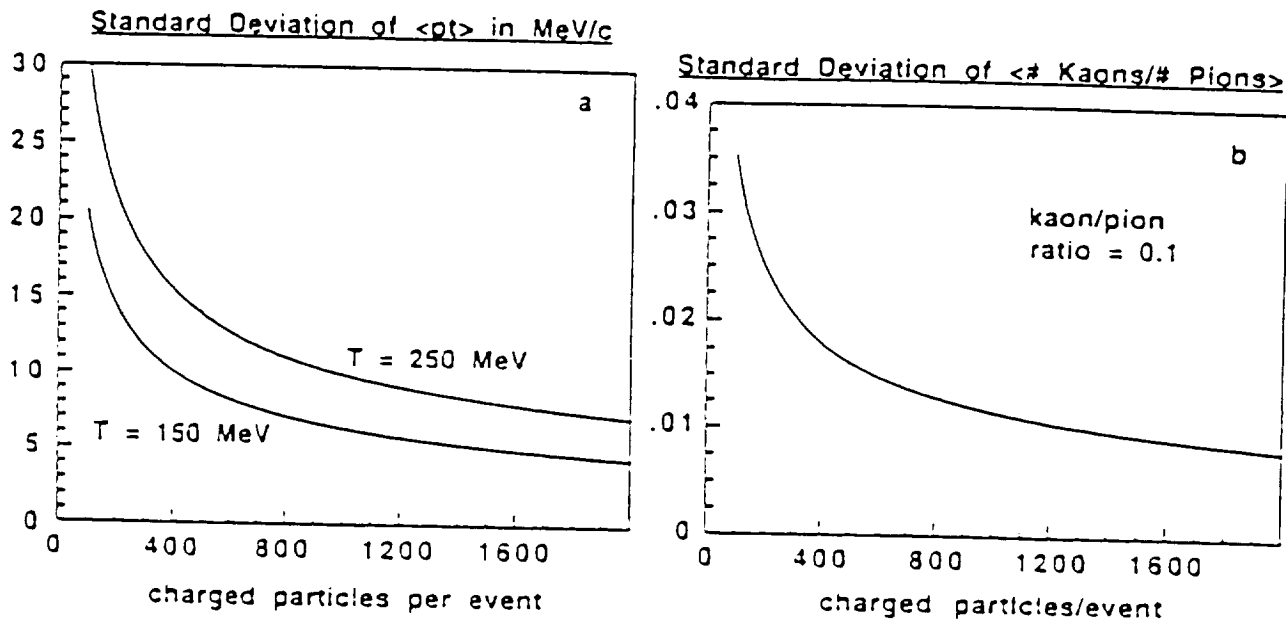
Figure 3. Plotted as a function of the charged-particle multiplicity measured in an event are the standard deviations of a) the measured $<p_t>$ for single events generated with a Boltzmann distribution with temperatures of 150 MeV and 250 MeV (corresponding to $<p_t>$ = 375 and 610, respectively) and b) the ratio K/π assuming that $<K/\pi>$ = 0.1.

Another unique feature of STAR is its ability to measure strange and anti-strange baryons (e.g. K^0_s, $\bar{\Lambda}$, Λ, Ξ^-, $\bar{\Xi}^-$, Ω^-) over a wide rapidity interval about midrapidity. Enhancements to the strange antibaryon content due to QGP formation have been predicted.[19] Furthermore, the multiply-strange baryons (Ξ^-, $\bar{\Xi}^-$, Ω^-) may be more sensitive to the existence of the QGP.[20]

The production cross section of φ-mesons can be measured *inclusively* in STAR via the decay φ ⟹ K^+ + K^-. Measurement of the yield of the φ. which is an $\bar{s}s$ pair, places a more stringent constraint on the origin of the observed flavor composition[21] than the K/π ratio and is expected to be more sensitive to the presence of a QGP. The φ production rate is also expected to be extremely sensitive to changes in the quark masses[22,23] due to a possible chiral phase transition at high energy densities.

3.4 Hanbury-Brown and Twiss (HBT) Interferometry

Correlations between identical bosons provide information on the freezeout geometry, the expansion dynamics and possibly the existence of a QGP.[24] It will be unprecedented to measure the pion source parameters via pion correlation analysis on an *event-by-event* basis and to correlate them with other event observables. In an individual event with 1000 negative pions within $|\eta|$ < 1, the number of $\pi^-\pi^-$ pairs will be $n_{\pi^-}(n_{\pi^-}-1)/2$ = 500,000. This is similar to the accumulated statistics published in most papers on the subject.

The correlations of like-sign charged kaons or pions will be measured on an *inclusive* basis to high accuracy. The dependence of the source parameters on the transverse momentum components of the particle pairs will be measured with high statistics.

Measurement of correlations between unlike-sign pairs will yield information on the Coulomb corrections and effects of final state interactions. The KK correlation is less affected by resonance decays after hadronic freeze-out than the $\pi\pi$ correlations. The K's are expected to freeze out earlier[25] than π's in the expansion. Depending upon the baryo-chemical potential and the existence of a QGP, the K^+ and K^- are also expected to freeze out at different times.

By reconstructing the decay topologies of $K^0_s \rightarrow \pi^+\pi^-$, STAR will be able to measure $K^0_s K^0_s$ correlations.[9] In this case the absence of Coulomb repulsion, as compared to like-sign charged particle correlations, will enable a more precise measurement of the large source dimensions expected at RHIC. Since the K^0_s is not a strangeness eigenstate, the $K^0_s K^0_s$ correlations will contain an interference term which should provide additional space-time information and exhibit strangeness distillation effects in regions where the baryochemical potential is significant.[26]

3.5 Electromagnetic/Charged Particle Energy Ratio

The measurement of EM energy vs. charged-particle energy is an important correlation to measure in the search for the QGP and other new physics. The unexplained imbalance between charged particle and neutral energy observed in Centauro and other cosmic ray events emphasizes the need for EM/charged particle measurements.[27]

3.6 Fluctuations in Energy, Entropy, Multiplicity and Transverse Momentum

It has long been known that a prime, general indicator of a phase transition is the appearance of critical dynamical fluctuations in a narrow range of conditions. Such critical fluctuations can only be seen in individual events where the statistics are large enough to overcome uncertainties ($\sqrt{N}$) due to finite particle number fluctuations. The large transverse energy and multiplicity densities at midrapidity in central collisions allow *event-by-event* measurement of fluctuations in particle ratios, energy density, entropy density and flow of different types of particles as a function of p_t, rapidity, and azimuthal angle. Fluctuations have been predicted to arise from the process of hadronization of a QGP.[28]

4. SUMMARY

It should be emphasized that the capability of measuring several different observables event-by-event is unique to STAR. Events can be characterized event-by-event by their temperature, flavor content, transverse energy density, multiplicity density, entropy density, degree of fluctuations, occurrence of jets and source size. The presence of a QGP is not likely to be observed in an average event, nor is it expected to be observed in a large fraction of events. Since there is no single clearly established signature of the QGP, access to many observables simultaneously will be critical for identifying the rare events in which a QGP is formed.

ACKNOWLEDGMENTS

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PROCEEDINGS OF THE FIRST INTERNATIONAL SYMPOSIUM ON COSMIC RAY PHYSICS IN TIBET

(ISCRP—I)

TIBET UNIVERSITY

AUGUST 12—17,1994

LHASA, CHINA

MONTE CARLO SIMULATION OF A SCINTILLATING OPTICAL FIBER CALORIMETER

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Abstract

A scintillating optical fiber calorimeter (SOFCAL) is being developed by
NASA/Marshall Space Flight Center for use in balloon-borne experiments to study
the spectrum of high-energy cosmic rays and gamma rays. SOFCAL will not
saturate for long exposures and the calorimeter will be helpful for the study of
primary cosmic-ray nuclei energies from 100 GeV to 1,000 TeV. For a given incident
particle and energy, computer simulations of electromagnetic cascades allow
computation of energy deposited in different regions of the calorimeter. For these
initial simulations, a 5-cm x 5-cm x 7-cm calorimeter was used. Each subsection
contained a 0.4-cm thick lead plate or two 0.2-cm lead plates and two layers of
optical fibers, 90° to each other. The 100 fibers in a layer were 0.5-mm thick with a
square cross-section. For incident gamma ray energies of 0.5 to 1.5 TeV, the energy
deposited in each layer of fibers was computed. Due to the limited dynamic range
of the imaging electronics, a window for the energy deposition in the fibers is
explored to determine the best measure of energy deposition (ΣE_γ) in the
calorimeter. Funding was provided by the NASA/University Joint Venture (JOVE)
Program.

1 Introduction

The Monte Carlo method in GEANT was used to simulate the photon and electron
events in the Scintillating Optical Fiber Calorimeter (SOFCAL), which is under
development at NASA/Marshall Space Flight Center for future applications in cosmic
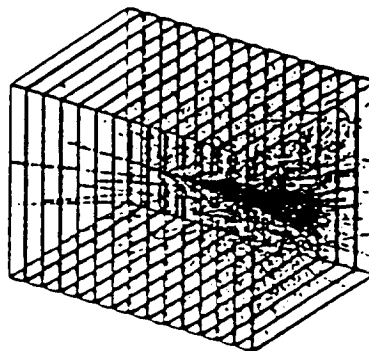ray and gamma ray measurements.

Emulsion chambers employing calorimeters have been used for direct
measurements of cosmic-ray composition (protons through Fe) between 10^{12} and 10^{15}
eV using balloon-borne emulsion chambers [1], [2], [3], [4], [5], [6], [7]. The typical
emulsion chamber [4] is composed of four parts: (1) a charge-determination module,
(2) a target module with ~0.2 vertical interaction mean free paths for protons, (3) a
spacer module, and (4) an emulsion calorimeter module with about fourteen vertical
radiation lengths. The simulations described here are for a scintillation optical fiber
counterpart to the calorimeter section in the emulsion chamber.

The part of the primary energy going into gamma-rays, ΣE_γ, is the parameter most easily related to the primary cosmic ray spectrum in emulsion chamber experiments. The ability to measure energies of electron-photon cascades is one of the most important functions of the calorimeter. The photons originating from an interaction will develop individual electromagnetic cascades in the calorimeter. For these simulations, a calorimeter module with ten vertical radiation lengths of Pb was used. In one geometrical configuration, each subsection of the calorimeter consisted of a 4-mm lead block, 100 fibers (0.5-mm thick) in the x-direction and 100 fibers (0.5-mm thick) in the y-direction. In these initial simulations, this lead and optical fiber combination was repeated fourteen times.

2   The Monte Carlo Program for SOFCAL Simulations (SOFCALS)

The Monte Carlo simulations which used GEANT3 were done on DEC 5000 workstations. The process of optimization requires frequent design changes, so users should be able to change the geometry easily. The time required to modify GEANT programs containing geometry information about the detector can be enormous. Therefore a subroutine was developed to read in the geometrical configuration from a separate file in an ASCII format. This subroutine reads not only detector setup, but also other parameters needed for the simulation, such as tracking medium parameters.

Energy deposition is calculated from the lowest level geometry. Total energy deposition is integrated using step functions. When a threshold is imposed due to limitations in the electronic read out devices, then the measured energy is less than the energy actually deposited in each fiber. The program SOFCALS has interactive routines which are called to draw the trajectories of an individual gamma ray event.

Fig. 1. Trajectories of a 0.1 TeV event.

3   Results

Fig. 1 illustrates the shower of electrons and photons produced by an incoming gamma ray with incident energy of 0.1 TeV in the SOFCAL detector. In these simulations, the incident gamma ray lies along the z-axis which is normal to the plane of each lead plate and layer of fibers. The typical detector (emulsion chamber [4]) has a "target section" and "calorimeter section" designed for measuring produced charged

particles and gamma rays, respectively. The target section includes many layers of nuclear emulsion plates to measure the charge of the incident particle and the emission angles of the produced charged particles with high accuracy (0.01 mrad). The calorimeter includes layers of nuclear emulsion and X-ray film among lead plates to measure the electron distributions from the electromagnetic cascades initiated by gamma rays from π^0 decay. The calorimeter is used to measure the spectrum of energy deposition ΣE_γ from which the primary energy spectrum is derived [4].

For the simulations, the angular distribution and energy distribution of gamma rays from each π^0 decay is needed. Isospin symmetry is assumed so the number of π^0 s which decay into pairs of gamma rays is about half that of the charged π mesons.

For 1 TeV gamma rays and 100 events, Fig. 2 shows the energy deposited within each adjacent layer (#12) of x- and y-fibers. The energy transition curve in

Fig. 2. Energy deposition in layer #12.

Fig. 3 shows the total energy deposited within each x-layer of fibers as a function of distance through the detector SOFCAL. The incident particle is a gamma-ray with energies of 0.5, 1.0, and 1.5 TeV. The three curves are based on ten events each.
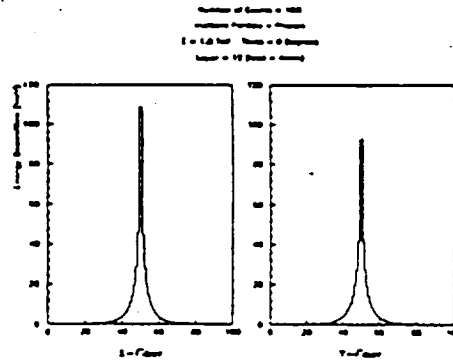
4 Discussion

In these simulations of gamma rays incident on the SOFCAL detector, the energy transition curves show the energy deposited in each layer of optical fibers. These curves have been determined for gamma rays from 10 MeV to 1.5 TeV. Within single layers of fibers, the energy deposited in each fiber has been computed and plotted. GEANT has the advantage that it is relatively easy to modify the geometry of the detector. Simulations were done for a second geometrical configuration with 2-mm lead sheet, x-layer of fibers, 2-mm lead sheet, and y-layer of fibers in each subsection.

The dynamic range is one limitation of the output image intensifier CCD electronics. Typical devices are limited to a dynamic range of approximately 256. For example, if the threshold energy is set to 1 MeV, then the highest energy which can be measured is only 256 MeV. Due to this limitation, a specific threshold and window may be needed to optimize the measurements. For these initial simulations of SOFCAL, a dynamic range of 100 was used. In Fig. 4, a threshold of 2 MeV appears to be optimal. Fig. 5 and Fig. 6 show the energy transition curve for a 0.5- to 50-MeV

window and 5- to 500-MeV window, respectively. When compared with the energy transition curve in Fig. 3, for which no threshold has been imposed, these figures show that a 2- to 200-MeV window differentiates between gamma ray energies from 0.5 to 1.5 TeV better than other windows. For simulations of the primary cosmic rays, calculations must be performed with event generators, such as FRITIOF, to predict the distributions in ΣE_γ, and then use GEANT for associated optimum "window" settings.
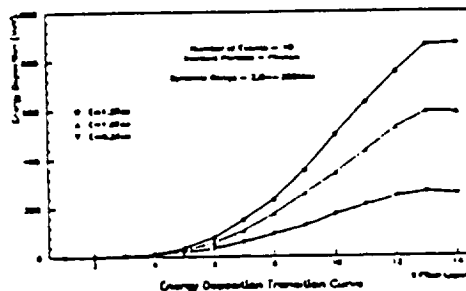

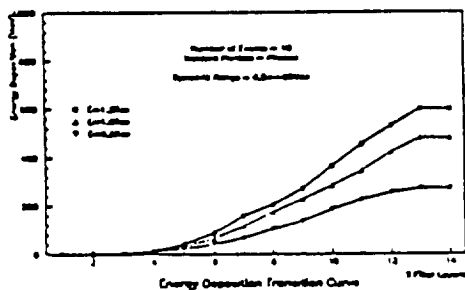Fig. 3. The energy transition curve.

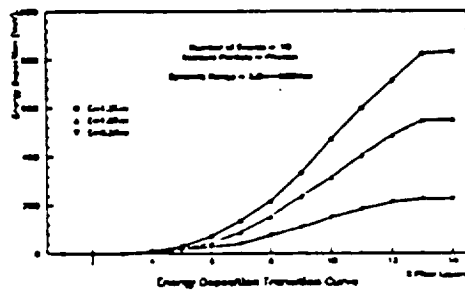Fig. 4. The threshold is 2 MeV.

Fig. 5. The threshold is 0.5 MeV.

Fig. 6. The threshold is 5 MeV.

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Using Geant to Model Calorimeter Response for Electromagnetic Cascades from Nucleus-Nucleus Interactions in a Cosmic Ray Detector

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Abstract

A scintillating optical fiber calorimeter (SOFCAL) is being developed by NASA/Marshall Space Flight Center for use in balloon-borne experiments to study the spectrum of high-energy cosmic rays and gamma rays. SOFCAL will not saturate for long exposures and the calorimeter will be useful in emulsion chambers to study primary cosmic-ray nuclei with energies from 100 GeV to 1,000 TeV. The event generator FRITIOF was used to model the collision of a cosmic-ray projectile with a target nucleus in an emulsion chamber. The measurements of charged particles from the interaction in the emulsions are related to the energy of the primary cosmic ray nucleus-nucleus interaction, computer simulations of electromagnetic cascades allow computation of the energy ΣE_γ deposited in different regions of the calorimeter. The Monte Carlo program GEANT was used to model SOFCAL response to incident gamma rays and to compute the measure of energy deposition ΣE_γ in different layers of the calorimeter within the emulsion chamber. The partial coefficient of inelasticity k_γ defined by $\Sigma E_\gamma = k_\gamma E_0$, was computed for different energies E_0 of primary cosmic rays. The k_γ distributions were computed and compared with existing calorimeter data. Funding was provided by the NASA/University Joint Venture (JOVE) Program.

Introduction

Cosmic rays are now known to span the energy range from 10^9 to beyond 10^{20} eV (Asakimori et al., 1993a; Asakimori et al., 1993b; Swordy, 1994; Teshima, 1994). They are, predominantly, the nuclei of atoms from hydrogen to iron. Above 10^{14} eV the particles are so rare that their detection relies mainly on observations of the giant cascades or extensive air showers created in the atmosphere which may be observed with arrays of particle and optical detectors at ground level. The flux of particles decreases inversely as the square of the energy rises, up to 10^{19} eV, and continues to decrease above 10^{19} eV as only about one particle per km$_2$ per year is collected (Watson, 1994). The origin of these particles is unknown and how they are accelerated to such high energies is a major astrophysical puzzle (Bird et al., 1993).

Even though the flux of the primary cosmic rays is so low that small detectors in spacecraft or balloons can intercept only a small number for study, emulsion chambers are an important tool for the direct measurement of the composition and spectra of primary cosmic rays above 10^{12} eV/nucleus (Parnell et al., 1989). The emulsion chamber method (Burnett et al., 1986) is especially useful for ultrahigh energy cosmic ray observations because (1) the efficiency for detecting interactions

approaches 100% above about 10 TeV and (2) the energy resolution is approximately constant with energy for a given incident species. Most other energy measuring techniques are impractical for balloon observations of primary cosmic rays at such high energies.

Balloon-borne emulsion chambers employing calorimeters (Fig. 1) have been used for direct measurements of cosmic-ray composition (protons through Fe) between 10^{12} and 10^{15} eV (Kaplon et al., 1952; Minakawa et al., 1958; Niu et al., 1971; Burnett et al., 1986; Takahashi et al., 1986; Burnett et al., 1987; Parnell et al., 1989; Burnett et al., 1990; Asakimori et al., 1933a; Asakimori et al., 1993b). The typical emulsion chamber (Burnett et al., 1986) is composed of four parts: (1) a charge-determination module, (2) a target module with ≈0.2 vertical interaction mean free paths for protons, (3) a spacer module, and (4) an emulsion calorimeter module with about fourteen vertical radiation lengths.

The "target section" includes many layers of nuclear emulsion plates to measure the charge of the incident particle and the emission angles of the produced charged particles with high accuracy (0.01 mrad). The "calorimeter section" includes layers of nuclear emulsion and X-ray film among lead plates to measure the electron distributions from the electromagnetic cascades initiated by gamma rays from π^0 decay. The calorimeter is used to

measure the spectrum of energy deposition ΣE_γ from which the primary energy E_0 spectrum is derived (Burnett el al., 1986). The SOFCAL simulations (Yang et l., 1994) described here are for a scintillation optical iber counterpart to the calorimeter section in the emulsion chamber.
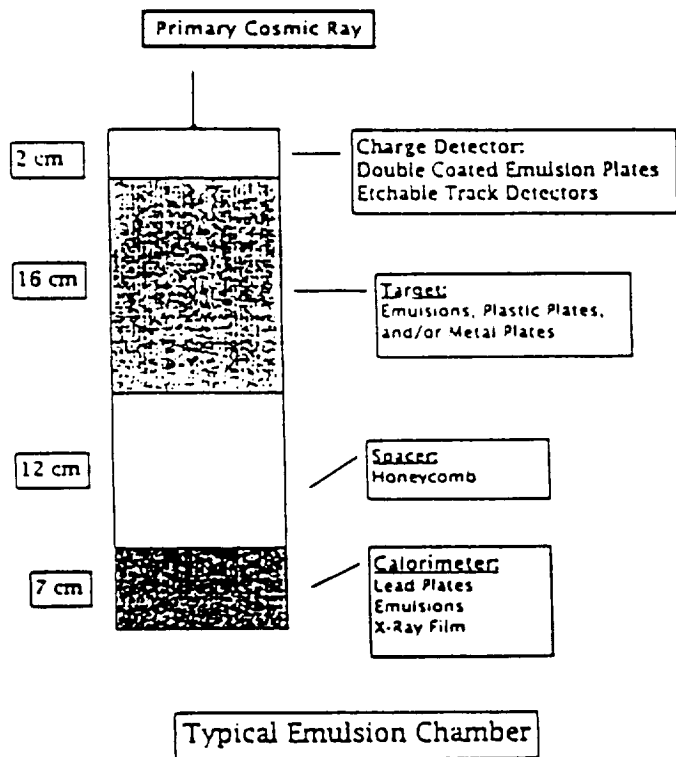

Primary Cosmic Ray

2 cm		Charge Detector: Double Coated Emulsion Plates Etchable Track Detectors
16 cm		Target: Emulsions, Plastic Plates, and/or Metal Plates
12 cm		Spacer: Honeycomb
7 cm		Calorimeter: Lead Plates Emulsions X-Ray Film

Typical Emulsion Chamber

Fig. 1. Block diagram of an emulsion chamber (Parnell et al., 1989).

Methods

That part of the primary energy going into gamm-rays ΣE_γ is the parameter most easily related to the primary cosmic ray spectrum in emulsion chamber experiments. The photons originating from a primary interaction will develop individual electromagnetic cascades in the calorimeter. The ability to measure the energies of these electron-photon cascades is one of the most important functions of the calorimeter. In the initial simulations, a calorimeter module with ten vertical radiation lengths of Pb was used. In one geometrical configuration each subsection of the calorimeter consisted of a 4-mm lead block, 100 fibers (0.5-mm thick) in the x-direction and 100 fibers (0.5-mm thick) in the y-direction. This lead

and optical fiber combination was repeated fourteen times.
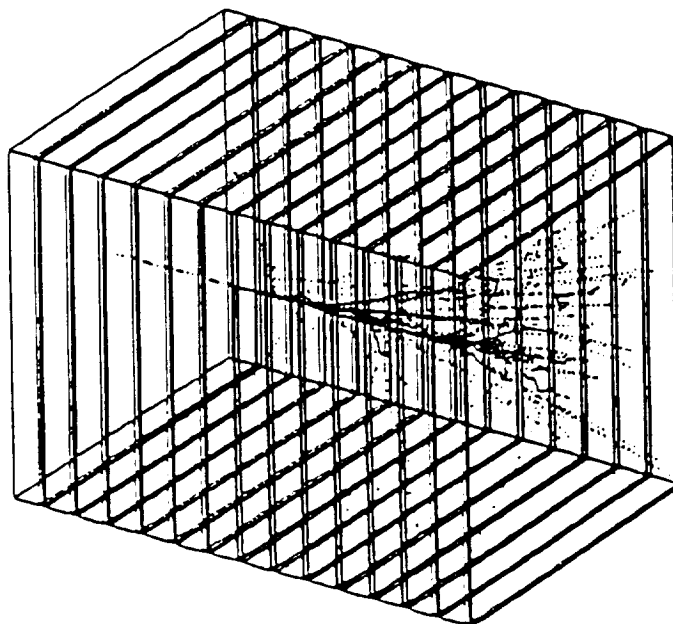
The Shower Caused by a Photon with E=1 GeV

Fig. 2. The trajectories of a photon event with 1 GeV energy in the calorimeter SOFCAL. The cascade was modeled with GEANT and PAW for the graphic simulation.
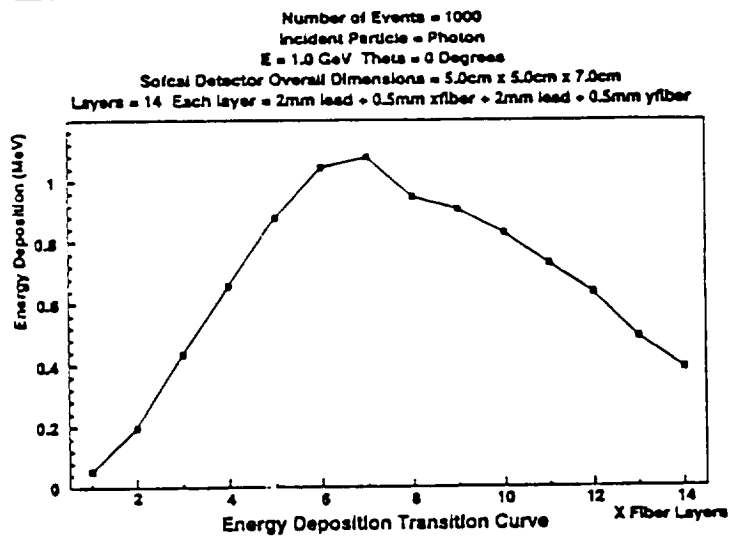

Fig. 3. The corresponding energy deposition and transition curve for 1 GeV photons incident on the calorimeter SOFCAL.

The trajectories or cascade of electrons and photons produced by a gamma ray with an incident energy of 1 GeV is illustrated in Fig. 2. For these simulations with

GEANT, the incident gamma ray lies along the z-axis which is normal to the plane of each lead plate and layer of fibers. The corresponding energy deposited in each x-layer of fibers, as a function of distance through the calorimeter, is shown in Fig. 3. GEANT has the advantage that it is relatively easy to modify the geometry of the SOFCAL detector and to observe changes in the location and size of the electromagnetic cascade within the calorimeter.

For modeling primary cosmic ray interactions, calculations must be performed with particle event generators to predict distributions in the electromagnetic component ΣE_γ. The event generator FRITIOF and LUCIAE (Sjöstrand and Begtsson, 1987; Pi, 1992; Sa and Tai, 1994) were used to model nucleus-nucleus interactions in an emulsion chamber and the subsequent emission of particles. The Monte Carlo program GEANT (CERN 1992a) and PAW (CERN 1992b) are used to determine the associated optimum "window" settings for the calorimeter. GEANT computes the energy deposited in each layer of the calorimeter by those gamma rays which enter the calorimeter (Yang et al., 1994). The primary cosmic ray interactions were modeled with FRITIOF and LUCIAE on a DEC 3000 AXP processor. The photon and electron events in the Scintillating Optical Fiber Calorimeter (SOFCAL) were modeled with GEANT version 3.21 on DEC 5000 workstations.

The event generator program included LUCIAE 2.0 for simulating gluon emission in the FIRECRACKER model and the rescattering of produced particles in the nuclear environment. The program, written in FORTRAN 77, was used with FRITIOF7.02R, JETSET7.3, PYTHIA5.5, and ARIADNE4.02R. The task of PYTHIA is to describe the partonic processes taking place in hadronic collisions. How these partrons are transformed into the experimentally measurable particles, i.e., the process of fragmentation, is handled by JETSET. PYTHIA can be combined with any well-defined fragmentation scheme. Although independent fragmentation is included as an option, the fragmentation scheme of JETSET is the Lund string model. ARIADNE is a Monte Carlo program for QCD cascades in the color dipole formulation. Gluon splitting into quark-antiquark paris and photon emission in the dipole cascade are allowed.

The measured spectrum of ΣE_γ is a convolution of the primary cosmic ray spectrum with energy response function of the detector. The latter depends on the distribution of partial inelasticity k_γ. There is a unique relation or simple scale shift between the ΣE_γ spectrum and the corresponding primary spectrum (Parnell et al., 1989), as long as the spectral index and the characteristics of the interactions do not change substantially over the observed energy range. When the differential primary (E_0) spectrum of a cosmic ray species is given by the simple power law relation

$$g(E_0)dE_0 = I_0 E_0\text{-}\beta\text{-}1 \, dE_0,$$

the differential spectrum (E_m) measured by an emulsion chamber is given by

$$G(E_m)dE_m = F(\beta) \, I_0 E_m\text{-}\beta\text{-}1 \, dE_m.$$

Therefore, the measured spectrum has the same slope as the primary spectrum but the normalization has changed by the factor (Burnett et al., 1986)

$$F(\beta) = \int_0^1 k^\beta \, f(k) dk$$

This result holds for any $f(k)$ as long as that distribution is independent of energy. Furthermore, it can be shown that the conversion factor

$$Ck_\gamma = [F(\beta)]^{1/\beta}$$

represents the energy scale shift required to go from the E_0 spectrum to the $E_m = \Sigma E_\gamma$ spectrum. Therefore, the primary E_0 spectrum can be found by shifting the E_m spectrum up in energy by the factor, $[Ck_\gamma]^{-1}$, the reciprocal of Ck_γ

Results

Typical emulsion chambers contain plastic (CHO) and emulsion targets (Burnett et al., 1987; Parnell et al., 1989). The composition of CHO was 33% C, 53% H, 14% O. The composition of emulsion was 17.5% C, 40.7% H, 4.0% N, 12.0% O, 0.17% S, 12.7% Br, 12.8% Ag, and 0.07% I. The main absorber material in a typical calorimeter is lead, which is used to improve energy resolution. Therefore, a light target nucleus (C) and a heavier target nucleus (Ag) were used in modeling the interaction of cosmic ray particles within the emulsion chamber. For a proton, nitrogen, and iron nucleus incident on a fixed target carbon nucleus, the distribution of gamma rays produced by an incoming projectile with an incident energy of 1000 GeV/nucleon is shown in Fig. 4. For these primary cosmic rays incident on a fixed target silver nucleus, the distribution of gamma rays produced by an incoming projectile with an incident energy of 1000 GeV/nucleon is shown in Fig. 5. Each distribution was based on 2000 events.

In a calorimeter the maximum electron number in an electromagnetic cascade can be related to the total energy of the electromagnetic component ΣE_γ. This quantity is directly proportional to the energy E_0 of the original cosmic ray: $\Sigma E_\gamma = k_\gamma E_0$. The factor k_γ is the partial coefficient

of inelasticity, which represents that fraction of the energy of the primary cosmic ray used to create the γ-rays. It is a function of the mass number of both the primary nucleus and the target nucleus (Burnett et al., 1986). Once the target nucleus and the primary cosmic ray have been identified in an emulsion layer of the apparatus, the distribution of k_γ becomes a known quantity. This distribution and the energy of the electromagnetic cascade are used to estimate the energy of the primary cosmic ray (Parnell et al., 1989).

target lead nucleus. These Ck_γ should be compared with those calculated with the Multi-Chain Model (Asakimori et al., 1993b), where all successive collisions are included. For events that interact within the calorimeter section of the chamber, they found that the energy conversion factors Ck_γ are typically 0.273 and 0.108 for proton and iron, respectively, (Parnell et al., 1989).
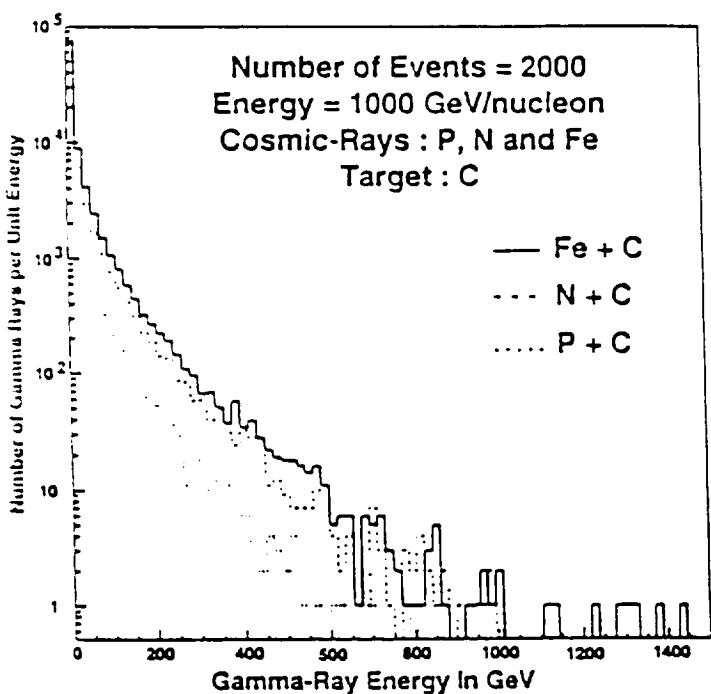

Fig. 4. The energy distribution of gamma rays due to a proton, nitrogen or iron nucleus incident on a fixed target carbon nucleus. Only gamma rays within a polar angle of 30° from the axis of the incident projectile were counted.
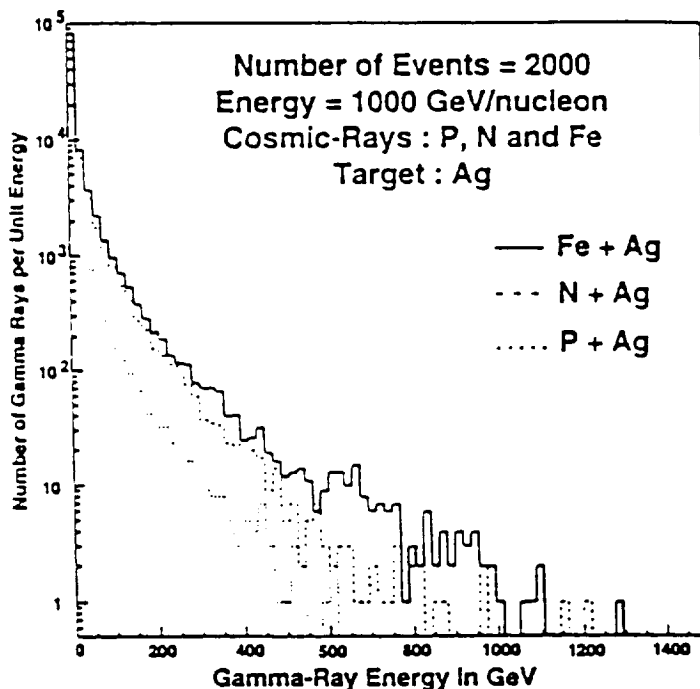

Fig. 5. The energy distribution of gamma rays due to a proton, nitrogen or iron nucleus incident on a fixed target silver nucleus. Only gamma rays within a polar angle of 30° from the axis of the incident projectile were counted.

Using 2000 events, representative distributions for $f(k_\gamma)$ are shown in Fig. 6 for a cosmic ray proton, nitrogen, or an iron nucleus colliding with a fixed target lead nucleus (A = 207) in an emulsion chamber. Each projectile has an energy of 200 GeV/nucleon. By using FRITIOF and LUCIAE to generate gamma rays from the primary interaction, partial inelasticity distributions were calculated from those gamma rays within a polar angle of 30° from the z-axis. The energy conversion factors Ck_γ for obtaining the primary E_0 spectrum energy from ΣE_γ were 0.256 and 0.108 for proton and iron, respectively, where β = 1.7 is the assumed primary particle spectral index. An energy of 200 GeV/nucleon was used for the primary energy of the proton and iron nucleus that interacts with a fixed

Discussion

Cosmic rays span a very large energy range from 10^9 to beyond 10^{20} eV. A realistic modeling of particle detectors should include those energies which are likely to be encountered and measured by the cosmic ray or gamma ray detector. The primary cosmic rays were modeled for nucleus-nucleus interactions in an emulsion chamber. These simulations were done with FRITIOF and LUCIAE up to 1000 GeV/nucleon and appear to agree well with existing data. For detailed modeling of electron-photon cascades in the calorimeter, GEANT and PAW were used to determine energy deposition and transition curves for the electromagnetic energy incident on the calorimeter. By using the actual dimensions of the SOFCAL detector, which will be tested in a balloon flight this year, the modeling of SOFCAL will be useful for analyzing cosmic ray

events. At the same time, modeling the primary cosmic ray interaction in the emulsion chamber should be done at energies higher than 1000 GeV/nucleon with FRITIOF and LUCIAE to determine primary energy and composition of the incident cosmic rays.
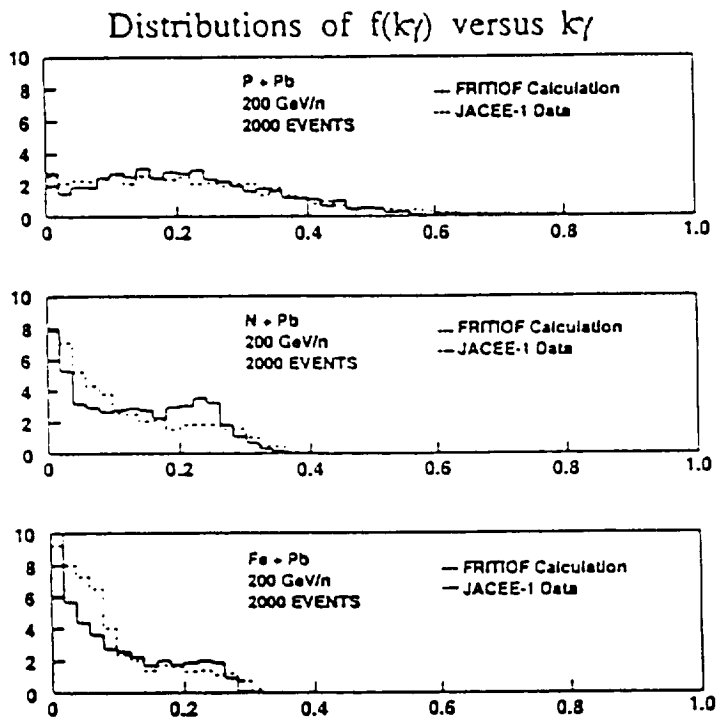
Distributions of $f(k_\gamma)$ versus k_γ

Fig. 6. Some distributions of k_γ for the partial inelasticity into gamma rays $f(k_\gamma)$. These are for a primary proton, nitrogen, and iron nucleus which interact with a fixed target nucleus of lead. The assumed primary particle spectral index was $\beta = 1.7$. The electromagnetic component was calculated with FRITIOF and LUCIAE.

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Using FRITIOF to Model Nucleus-Nucleus Interactions in a Cosmic Ray Detector

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Abstract

A scintillating optical fiber calorimeter (SOFCAL) is being developed by NASA/Marshall Space Flight Center for use in experiments to study the spectrum of high-energy cosmic rays and gamma rays from 100 GeV to 1,000 TeV. SOFCAL will not saturate for long exposures and this calorimeter in these balloon-borne emulsion chambers will be helpful for the study of the composition of primary cosmic-ray nuclei. For primary nuclei with energies much greater than 10^{14} eV, nucleus-nucleus interactions are likely to exhibit characteristics of a quark-gluon plasma (QGP). A particle event generator was used to model the collision of a cosmic-ray nucleus with a target nucleus in an emulsion chamber. FRITIOF with LUCIAE was chosen to model collisions of primary cosmic rays in an emulsion chamber with SOFCAL. Pseudo-rapidity distributions were computed for protons on lead at 200 GeV/c and compared with experimental data. Pseudo-rapidity distributions were computed for protons or iron incident on a carbon or silver nucleus. For gamma-rays from nucleus-nucleus interactions, the total energy of the electromagnetic component ΣE_γ was computed. The partial coefficient of inelasticity k_γ, defined by $\Sigma E_\gamma = k_\gamma E_0$, was computed from the primary energy E_0 of the cosmic rays. The $f(k_\gamma)$-distributions were computed and compared with existing calorimeter data. Funding was provided by the NASA/University Joint Venture (JOVE) Program.

Introduction

Cosmic rays are now known to span the energy range from 10^9 to beyond 10^{20} eV (Asakimori et al., 1993a; Asakimori et al., 1993b; Swordy, 1994; Teshima, 1994). They are predominantly the nuclei of atoms from hydrogen to iron. Above 10^{14} eV the particles are so rare that their detection relies mainly on observations of the giant cascades or extensive air showers created in the atmosphere which may be observed with arrays of particle and optical detectors at ground level. The flux of particles decreases inversely as the square of the energy rises (Fig. 1), up to 10^{19} eV, and continues to decrease above 10^{19} eV as only about one particle per km^2 per year is collected (Watson, 1994). The origin of these particles is unknown and how they are accelerated to such high energies is a major astrophysical puzzle (Bird et al., 1993).

Even though the flux of the primary cosmic rays is so low at these energies that small detectors in spacecraft or balloons can intercept only a small number for study, emulsion chambers are an important tool for the direct measurement of the composition and spectra of cosmic rays above 10^{12} eV/nucleon. The emulsion chamber method (Burnett et al., 1986) is especially useful for ultra-high energy cosmic ray observations because (1) the efficiency for detection interactions approaches 100% above about 10 TeV and (2) the energy resolution is approximately constant with energy for a given incident species. Most other energy measuring techniques are impractical for balloon observations of primary cosmic rays at such high energies.

Balloon-borne emulsion chambers, employing calorimeters, have been used for direct measurements of cosmic-ray composition (protons through Fe) between 10^{12} and 10^{15} eV (Kaplon et al., 1952; Minakawa et al., 1958; Niu et al., 1971; Burnett et al., 1986; Takahashi et al., 1986; Burnett et al., 1987; Parnell et al., 1989; Burnett el al., 1990; Asakimori et al., 1993a; Asakimori et al., 1993b). The typical emulsion chamber (Burnett et al., 1986) is composed of four parts: (1) a charge-determination module, (2) a target module with -0.2 vertical interaction mean free paths for protons, (3) a spacer module, and (4) an emulsion calorimeter module with about fourteen vertical radiation lengths.

The "target section" includes many layers of nuclear emulsion plates to measure the charge of the incident particle and the emission angles of the produced charged particles with high accuracy (0.01 mrad). The "calorimeter section" includes layers of nuclear emulsion and X-ray film among lead plates to measure the electron distributions from the electromagnetic cascades initiated by gamma rays from π^0 decay. The calorimeter is used to measure the spectrum of energy deposition ΣE_γ from which the primary energy spectrum is derived (Burnett et

Differential Cosmic-Ray Spectrum:
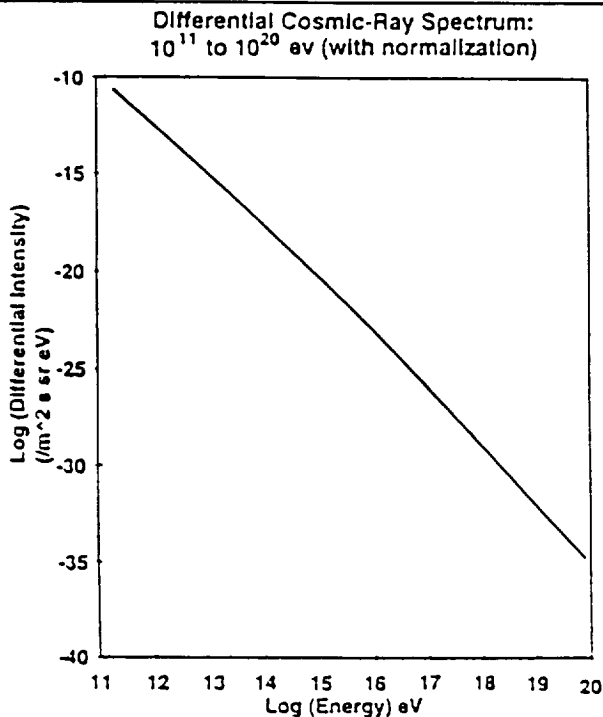10^{11} to 10^{20} ev (with normalization)

Fig. 1. The shape of the all-particle spectrum of the cosmic rays for the energy range from 10^{11} to 10^{20} eV per particle or nucleus.

al., 1986). The scintillationing optical fiber calorimeter (SOFCAL) is a scintillation optical fiber counterpart to the calorimeter section in the emulsion chamber. SOFCAL is under development at NASA/Marshall Space Flight Center for future applications in cosmic ray and gamma ray measurements.

Materials and Methods

For modeling the primary cosmic ray interactions, calculations must be performed with event generators, such as FRITIOF, to predict distributions of the electromagnetic component ΣE_γ in the calorimeter. FRITIOF (Bengtsson and Sjöstrand, 1987; Nilsson-Almqvist and Stenlund, 1987; Sjöstrand and Bengtsson, 1987; Pi, 1992; Sa and Tai, 1994) was used to model nucleus-nucleus interactions in an emulsion chamber and the subsequent emission of particles. GEANT (CERN, 1992a) and PAW (CERN, 1992b) are used for associated optimum "window" settings of the calorimeter.

For the initial modeling of SOFCAL (Yang et al., 1994), a calorimeter module with ten vertical radiation lengths of Pb was used. In one geometrical configuration, each subsection of the calorimeter consisted of a 4-mm lead block, 100 fibers (0.5-mm thick) in the x-direc-tion and 100 fibers (0.5-mm thick) in the y-direction. This lead and optical fiber combination was repeated fourteen times. Photon and electron events in SOFCAL were modeled with GEANT on DEC 5000 workstations.

Event Generator for Modeling Nucleus-Nucleus Collisions.--FRITIOF is a Monte Carlo program that implements the Lund string dynamics for hadron-hadron, hadron-nucleus, and nucleus-nucleus collisions (Bengtsson and Sjöstrand, 1987). At high energies, a collision between nuclei can be regarded as incoherent collisions between their nucleons. Thus, a nucleon from the projectile interacts independently with the encountered target nucleon as it passes through the nucleus. Each of these sub-collisions can be treated the same way as the usual hadron-hadron collision.

In FRITIOF an interacting hadron behaves like a relativistic string with a confined color field. Two hadrons interact with each other as their fields overlap, and momentum transfer takes place. It is assumed that no net color is exchanged between the hadrons despite the momentum transfer. The possibility of one of the momentum transfers corresponding to large transverse momentum scattering is properly treated according to QCD. After the exchange of momenta, the hadrons are assumed to become two excited string states, which further emit gluconic radiation in a color dipole approach to the QCD parton branching. The final hadronization is performed by using the Lund string fragmentation model.

When both baryon density and energy density are high enough in heavy ion collisions, new features appear compared with hadron-hadron collisions, e.g., high P_T enhancement, strangeness enhancement, anti-baryon production, etc. They reveal that heavy-ion collisions may possess unknown characteristics or collectivity which are not able to be described by superposition of independent hadron-hadron collisions. The formation of a new state of matter (Harris et al., 1994), Quark-Gluon Plasma (QGP), has been suggested to explain those new features.

Usually, there are many "strings" formed through relativistic heavy-ion collisions. Those strings can thus overlap with each other and produce a heavily interacting system in which the behavior of an individual "string" is affected by the presence of other "strings", which can not be treated independently any longer. In the version of FRITIOF used for the nucleus-nucleus interactions, the Fire Cracker Model (FCM) was used to model the emission of gluons from a system containing several strings formed during collision. In the model, gluons can be emitted collectively from the color field of the multi-string system. Because many particles are produced in high energy nucleus-nucleus collisions, they will scatter with each other and spectator nucleons when going through the interaction region. This rescattering effect

(RESCATTERING) has been considered important in heavy-ion collisions. FCM and RESCATTERING, implemented in the Monte Carlo program LUCIAE 2.0, are able to describe high P_T enhancements and increase of strangeness.

The event generator program included LUCIAE 2.0 for simulating gluon emission in the FIRECRACKER model and the rescattering of produced particles in the nuclear environment. The program is written in FORTRAN 77 and was used together with FRITIOF7.02R, JETSET7.3, PYTHIA5.5, and ARIADNE4.02R. The task of PYTHIA is to describe the partonic processes taking place in hadronic collisions. How these partons are transformed into the experimentally measurable particles, i.e., the process of fragmentation, is handled by JETSET. PYTHIA can be combined with any well-defined fragmentation scheme. Although independent fragmentation is included as an option, the fragmentation scheme of JETSET is the Lund string model. ARIADNE is a Monte Carlo program for QCD cascades in the color dipole formulation. Gluon splitting into quark-antiquark pairs and photon emission in the dipole cascade are allowed. The primary cosmic ray interactions were modeled with FRITIOF and LUCIAE on a DEC 3000 AXP processor.

Primary Energy Spectrum Analysis.—In emulsion chamber experiments, that part of the primary cosmic-ray energy E_0 going into gamma-ray energy $E_m = \Sigma E_\gamma$ is the parameter most easily related to the primary cosmic ray spectrum. The photons originating from an interaction will develop individual electromagnetic cascades in the calorimeter. The ability to measure energies of electron-photon cascades is one of the most important functions of the calorimeter because the primary energy E_0 spectrum can be found from the E_m spectrum.

In a calorimeter the maximum electron number in an electromagnetic cascade can be related to the total energy of the electromagnetic component ΣE_γ. The measured spectrum of Em is a convolution of the primary cosmic ray spectrum with the energy response function of the detector (Burnett et al., 1986). The quantity E_m is directly proportional to the primary energy E_0 of the original cosmic ray: $\Sigma E_\gamma = k_\gamma E_0$. The response function depends on the distribution of partial inelasticity k_γ. There is a unique relation (Parnell et al., 1989) or simple scale shift between the ΣE_γ spectrum and the corresponding primary spectrum, as long as the spectral index and the characteristics of the interactions do not change substantially the observed energy range. It can be shown (Burnett et al., 1986) that the energy conversion factor

$$C = \{ \int_0^1 k^\beta \, f(k) dk \, F(\beta) \}^{1/\beta}$$

represents the energy scale shift required to go from the

E_0 spectrum to the $E_m = \Sigma E_\gamma$ spectrum. Therefore, the primary E_0 spectrum can be found by shifting the E_m spectrum up in energy by the factor, C^{-1}, the reciprocal of C (Parnell et al., 1989; Asakimori et al., 1993b).

Results

For these initial calculations of nucleus-nucleus interactions, the event generator program modeled the emission of gluons from a system containing several strings formed during collision and the rescattering effect. As an illustration of the event generator program results, Fig. 2 shows the distribution of all charged particles as a function of pseudo-rapidity distribution for 200 GeV/c protons incident on fixed target lead nucleus. The predicted values are compared with experimental data (Elias et al., 1980). In Fig. 3 the rapidity distributions for production of all π^- and K^- are shown for 1000 GeV/nucleon iron nuclei incident on a fixed target silver nucleus. In Fig. 4 the rapidity distributions for production of all protons and antiprotons are shown for 1000 GeV/nucleon ion nuclei incident on a fixed target silver nucleus. The event generator program included FRITIOF and LUCIAE.
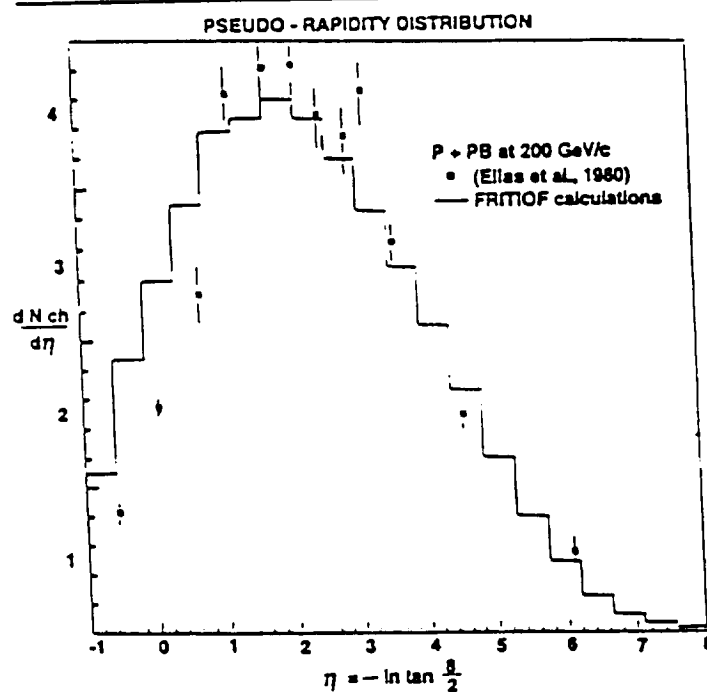

Fig. 2. The distribution of all charged particles as a function of pseudo-rapidity for a proton incident on fixed target lead nucleus (Elias et al., 1980). The proton energy was 200 GeV and 2000 events were used in the simulation FRITIOF and LUCIAE were used to model the interaction.
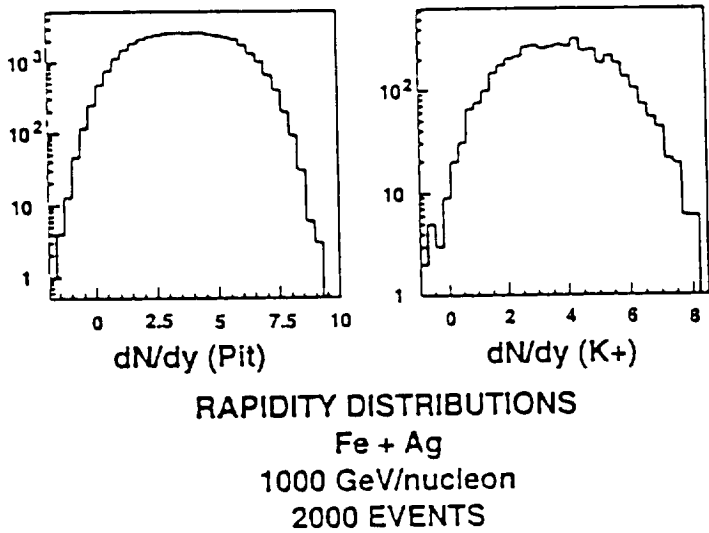
RAPIDITY DISTRIBUTIONS
Fe + Ag
1000 GeV/nucleon
2000 EVENTS

Fig. 3. Rapidity distributions of K^+ and π^- mesons produced by an iron nucleus primary (Fe), with an energy of 1000 GeV/nucleon, incident on a silver target nucleus (Ag). FRITIOF and LUCIAE were used to model the interaction.

Kγ Distribution
(Integral)

Number of
Events
$(> K\gamma)$

Number of Events = 2000
Energy = 400 GeV/Nucleon
Cosmic-Ray : P
Target : Pb

↑   Dake et al. (1980)
—   Simulation

Fig. 5. Integral k_γ-distributions for a proton with an energy of 400 GeV incident on a fixed target lead nucleus (Dake et al., 1980). FRITIOF and LUCIAE were used to model the interaction.

RAPIDITY DISTRIBUTION
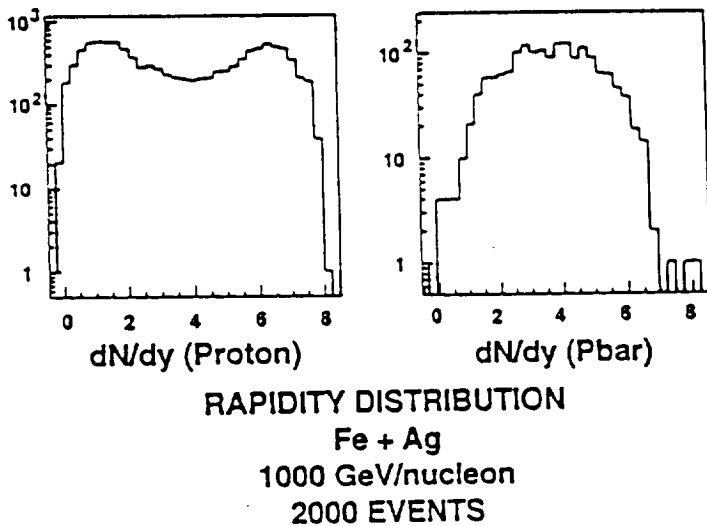Fe + Ag
1000 GeV/nucleon
2000 EVENTS

Fig. 4. Rapidity distributions of protons and anti-protons mesons produced by an iron nucleus primary (Fe), with an energy of 1000 GeV/nucleon, incident on a silver target nucleus (Ag). FRITIOF and LUCIAE were used to model the interaction.
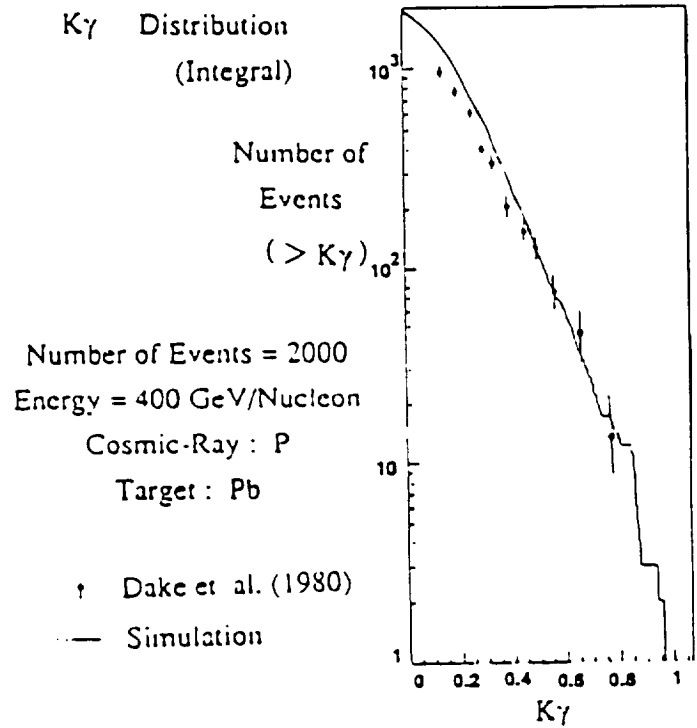
Typical emulsion chambers contain plastic (CHO) and emulsion targets (Burnett et al., 1987; Parnell et al., 1989). The composition of CHO was 33% C, 53% H, 14% O. The composition of emulsion was 17.5% C, 40.7% H, 4.0% N, 12.0% O, 0.17% S, 12.7% Br, 12.8% Ag, and 0.07% I. Therefore, a light target nucleus (C) and a heavier target nucleus (Ag) were used in modeling the interaction of cosmic ray particles with the target section of the emulsion chamber.

The factor k_γ is the partial coefficient of inelasticity, representing that fraction of the energy of the primary nucleus used to create γ-rays. It is a function of the mass number of both the primary nucleus and the target nucleus (Burnett et al., 1986). Once the target nucleus and the primary cosmic ray have been identified in an emulsion layer of the apparatus, the distribution of k_γ becomes a known quantity. This distribution and the energy of the electromagnetic cascade are used to estimate the energy of the primary cosmic ray. Integral or cumulative distributions of k_γ for a proton incident on a fixed target lead nucleus (Drake et al., 1980) are shown in Fig. 5. The proton energy was 400 GeV and 2000 events were used in the simulation.

Discussion

Cosmic rays span a very large energy range from 10^9 to beyond 10^{20} eV. A realistic modeling of particle detectors should include those energies which are likely to be encountered and measured by cosmic ray and gamma ray detectors. The primary cosmic rays were modeled for nucleus-nucleus interactions in an emulsion chamber. These simulations were done with FRITIOF and LUCIAE up to 1000 GeV/nucleon and appear to agree well with existing data, but modeling primary cosmic-ray interactions in the emulsion chamber will be more useful at higher energies where we hope to find evidence for the formation of a quark-gluon plasma. The next step is to show that the primary cosmic ray interaction can be modeled at such energies with FRITIOF and LUCIAE to determine primary energy and composition of the incident cosmic rays. The modeling of SOFCAL can be done with GEANT.

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Metropolitan Universities ⵣ ■

An International Forum

Public Health

Also in this Issue:

Donald C. Wold

Effective communication with community leaders and public officials at local, state, and federal levels is essential if faculty and administrators of metropolitan universities are to be successful in accomplishing their unique mission. However, examples of involvement by physical scientists are rare. This brief report describes multidirectional communication and linkages established by a physicist at the University of Arkansas at Little Rock in connection with plans for a high energy astrophysics experiment that led instead to a proposal for a Resource Recovery Project.

High Energy Physics and Environmental Health:

A Note by a Metropolitan University Physicist

In a recent issue of *Metropolitan Universities* (Winter 1994) Daniel Johnson describes multidirectional communication in the metropolitan university as "linking the university with public officials and agencies...in a network that fosters the flow of information and encourages interaction and partnership in addressing important community issues." Linkages between metropolitan university social and behavioral science faculty, community leaders, and public officials are increasingly common in response to the need to address local and regional social problems. However, there are far fewer examples of relationships and communication between metropolitan university physical scientists, the business community, and public policy makers focused on addressing environmental health. This report illustrates one example of such multidirectional communication by describing linkages established by a physicist at the University of Arkansas at Little Rock (UALR) in connection with a high energy astrophysics experiment proposed for an abandoned barite mine site. The proposal raised numerous public policy issues, including environmental health concerns affecting both the project scientists as well as those people

who live along the creeks and river into which the contaminated water from the mine pit area flows. Acid drainage from this site has existed for over 50 years. As an example of a metropolitan university physicist's role in public policy issues, this personal chronicle also indicates the complexity of the interactions when questions of environmental health and public policy are raised. In the end, these interactions resulted in a proposal for a resource recovery project to demonstrate viable technologies for recovering clean water from an abandoned heavy metal mine.

GRANDE Project

In 1987, an international group of physicists was formed to investigate the important new fields of neutrino and gamma-ray astrophysics. The group included over 30 scientists from universities and research institutes in the United States, Poland, and the then Soviet Union. The goal of the collaboration was to construct the world's largest, most advanced Gamma-Ray And Neutrino DEtector (GRANDE), a unique detection facility that would make important contributions to these exciting new fields of science. After an extensive nation-wide search, an abandoned barite mine about 45 miles from Little Rock was selected as the most suitable site for the proposed facility.

Environmental Health

From the inception of UALR's involvement in the GRANDE project, attention was given to the environmental issues raised by discharging contaminated water from an abandoned mine. Work done over a five year period in preparing the various GRANDE proposals resulted in much useful environmental data. The open-pit mine and underground barite mine are located in the upper drainage basin of Chamberlain Creek near Magnet Cove, Arkansas. The water in the pit (almost 4 billion gallons in 1995) and the abandoned mine spoils around it form the headwaters region of Chamberlain Creek. For a typical rainfall of 55 inches per year, about 0.5 million gallons per day are added to this volume by the surface and groundwater systems that drain into the pit. Consequently, acid mine drainage has been a problem for people who live along Chamberlain Creek.

When the initial hydrologic studies were done in 1988, the stage or elevation of the surface of the water in the pit was about 77 feet below the lowest known point along the shore, where an unregulated discharge of water would overflow into Chamberlain Creek. Now, seven years later, the stage is only 15 feet below that point. As the stage continues to rise, the water in the pit itself becomes a more obvious point source for acidic water containing heavy metals sulfates in the Chamberlain Creek basin and downstream reaches, in-

cluding the Ouachita River from which the city of Malvern draws its drinking water.

Preliminary sampling in 1988 of water in the Chamberlain Creek barite pit indicated that water quality does not meet national secondary drinking standards for chloride, iron, manganese, pH, sulfate, sodium, and total dissolved solids. If water overflows from the pit, these discharges will cause concentrations of chlorides, sulfates, and total dissolved solids in Chamberlain Creek to exceed the guidelines for regulatory compliance to discharge water, and cause concentrations to exceed the applicable criteria in the tributary streams.

The contamination of water filling abandoned mines with barite and other heavy metal ores is a nationwide problem. Heavy metals pose a significant threat both to human health and safety and to aquatic environments. Some metals are neurotoxicants (lead, mercury, cadmium), while others form potentially carcinogenic organometallics.

There are currently more than 300,000 abandoned hard rock mine sites in the United States that pose a threat to health and the environment due to acid mine drainage. Runoff containing acids, metals, and chemicals from abandoned mine sites has contaminated more than 12,000 miles of rivers and streams and more than 180,000 lakes and reservoirs. Surface and groundwater contamination by heavy metals is a problem at numerous sites within the United States. Thus substantial exists interest in so-called resource recovery: finding ways of purifying the water and, at the same time, capturing the valuable heavy metals in the liquid.

Resource Recovery Project

In 1993, the district chief of the U.S. Geological Survey drew the attention of UALR physicists to a pilot Resource Recovery Project at Butte, Montana, using water from an abandoned copper mine. The project was being conducted by the Office of Technology Development in the Office of Environmental Management in the U.S. Department of Energy (DOE). This information led the UALR scientists to engage in discussions with Arkansas Congressman, Jay Dickey, and with representatives of DOE to explore the possibility of a project similar to the one in Montana. In April 1994, a proposal for a resource recovery project in Arkansas was completed and split into two parts, one requesting federal funds from DOE and the other requesting state funds through the Arkansas Energy Office. These pending proposals have been endorsed by the Board of Directors of the Industrial Development Corporation of Hot Spring County. The Industrial Development Corporation would be involved in the execution of right-of-access agreements for collecting water samples and monitoring water level. Further-

more, right-of-way agreements and leases would be required for demonstrating technologies at pilot-scale. The agreements and leases would be between the landowners and the Industrial Development Corporation of Hot Spring County, not the University of Arkansas at Little Rock.

The proposed Resource Recovery Project will evaluate, test, and demonstrate technologies for reclaiming clean useable water and marketable mineral resources from water in the Chamberlain Creek barite pit. The project will focus on resource conservation; end-use of the recovered water and mineral resources, including industrial, commercial, and agricultural uses; and nonuseable by-product minimization. Resource recovery/remediation costs for the water will be determined using economic analyses of each technology and the costs offset by recovered resources.

The goals and technical objectives will be carried out by the Office of Technology Development in the U.S. Department of Energy, and MSE, Inc., the DOE contractor at Butte, Montana. As an outgrowth of its experience with the Montana Resource Recovery Project, the latter is qualified to assist with the technology screening, selection, and implementation for the water in the barite pit.

Information transfer resulting from the technology demonstrations at the barite pit and its associated groundwater system will provide the following benefits:

First, the data gathered will assist in selecting the most appropriate and cost-effective technologies for recovering the water for beneficial uses. Second, the project will demonstrate which mineral resources are recoverable in marketable quantities, if any, and qualities from the water in the pit. Finally, the data gathered will provide the direct benefit of developing and assessing technologies that may be used to recover similar water resources found on DOE lands and those near abandoned mine sites.

This demonstration project will be watched closely by other communities with similar problems. Although the immediate beneficiaries will be the local residents, the state and nation as a whole will benefit from the project. The project itself would not be possible without the active participation of numerous individuals at the University of Arkansas and the community.

Appendix C
JOVE Final Report
1995-6

Oral and Poster Papers Presented:

JOVE FACULTY RESEARCH ASSOCIATES

Poster Presentation Abstracts

JOVE Retreat

July 10, 1993

Galveston, Texas

The Variation of Spectral Line Strength Across Close Binary Star Surfaces

Van Hamme, W. (Florida International University) and R. E. Wilson (University of Florida)

We examine the effects of the variation of the strength of a spectral line across the surface of a tidally distorted binary star component. In particular, we are interested in the influence line strength variations have on radial velocity calculations. Using the latest ATLAS stellar atmosphere models, and the ATLAS program itself, we determine how the strength of a stellar absorption line, as measured by its equivalent width, varies as a function of effective temperature, surface gravity, chemical composition, and the angle between the local normal to the surface of the star and the line of sight. These equivalent widths are used to compute a flux-weighted and equivalent width-weighted mean radial velocity of the visible disk of the star relative to its center of mass. We then compare radial velocity proximity effects based on this method with those based solely on flux-weighted averages.

Understanding Blazars: Interpretation of the Multifrequency Spectrum of 3C 279 from Radio through Gamma-Rays

Webb, James R. (Florida International University)

We have complied observations of 3C 279 covering 15 decades in frequency in order to understand the physics associated with the non-thermal emission of Blazars. We present two multifrequency particles in a strong magnetic field. We find the differences in the spectra from one observation to the next is adequately explained in terms of variations in the maximum electron energies injected into the magnetic field.

Monte Carlo Simulations of Cosmic Rays for the Detector SFOCAL

Wold, Don (University of Arkansas, Little Rock)

A long term goal is to study the spectrum of high-energy cosmic rays. Balloon-borne emulsion chambers are used to detect these particles in high energy nucleus-nucleus interactions. The detectors have "target sections" and calorimeter sections for measurements of produced charged particles and gamma-rays, respectively. A scintillating fiber optical calorimeter (SFOCAL) is being developed for use in emulsion chambers. With this technique, the data are available for immediate use, and the time required to measure the energy in an electromagnetic cascade is significantly reduced. There is no need to wait processing X-ray films or emulsions. The data are stored in digital form which reduces the labor-intensive process of tracing events.

GEANT is being used for computer simulation of electromagnetic cascades to compute the energy deposited in different regions of the detector (SFOCAL). The energy deposition does not include any energy produced as secondary particles in the nucleus-nucleus interaction. The results agreed nicely with a different approach to detector geometry used by the Gamma Ray and Cosmic Ray Branch at NASA Marshall Space Flight Center. The next step is to model the nuclear cascades using FRITIOF, VENUS, or HIJING. The detector response for electromagnetic cascades, resulting from nucleus-nucleus interactions (i.e., carbon on lead) will then be modeled using GEANT.

Suggested title of session
in which paper should be placed
Cosmic Ray Physics

Monte Carlo Simulations of a NASA Scintillating Optical Fiber Calorimeter for 10- to 1,000-MeV Gamma Rays. R. GILLUM, Z. YANG, D. WOLD, University of Arkansas at Little Rock, - A scintillating optical fiber calorimeter (SOFCAL) is being developed by NASA/Marshall Space Flight Center for use in balloon-borne emulsion chambers. SOFCAL will not saturate for long exposures and will record positions, angles and temporal information about cosmic-ray nuclei and gamma rays. For a given incident particle and energy, computer simulations of electromagnetic cascades allow computation of energy deposited in different regions of the calorimeter. For the simulations, a 5-cm x 5-cm x 7-cm calorimeter was used. Each subsection contained a 0.4-cm thick lead plate or two 0.2-cm lead plates and two layers of optical fibers, 90° to each other. The square cross-section of each fiber was 0.5-mm thick. For incident gamma ray energies of 10, 20, 50, 100, 200, and 1,000 MeV, curves were plotted to ascertain the energy deposition in the x-layer and y-layer fibers. The same simulations were repeated with electrons as the incident particles. The simulations and detector response were compared with those obtained using gamma rays. Funding for this project was provided by the NASA/University Joint Venture (JOVE) Program.

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Suggested title of session
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Cosmic Ray Physics

Monte Carlo Simulations of a NASA Scintillating Optical Fiber Calorimeter for 0.5- to 1.5-TeV Gamma Rays. Z. YANG, R. GILLUM, D. WOLD, University of Arkansas at Little Rock, - A scintillating optical fiber calorimeter (SOFCAL) is being developed by NASA/Marshall Space Flight Center for use in balloon-borne emulsion chambers to study the spectrum of high-energy cosmic rays. SOFCAL will not saturate for long exposures and the detector will be a valuable tool for the study of primary cosmic-ray nuclei from 10 GeV to 1,000 GeV. For a given incident particle and energy, computer simulations of electromagnetic cascades allow computation of energy deposited in different regions of the calorimeter. For the simulations, a 5-cm x 5-cm x 7-cm calorimeter was used. Each subsection contained a 0.4-cm thick lead plate or two 0.2-cm lead plates and two layers of optical fibers, 90° to each other. The square cross-section of each fiber was 0.5-mm thick. For incident gamma ray energies of 0.5 to 1.5 TeV, the energy deposition in each x-layer and y-layer fibers was computed. For a limited dynamic range of the electronics, a window with a threshold of 2 MeV and upper limit of 200 MeV deposited energy was found to be optimal for incident gamma rays in the 0.5 to 1.5 TeV range. Funding for this project was provided by the NASA/University Joint Venture (JOVE) Program.

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78th Annual Meeting
April 8-9, 1994
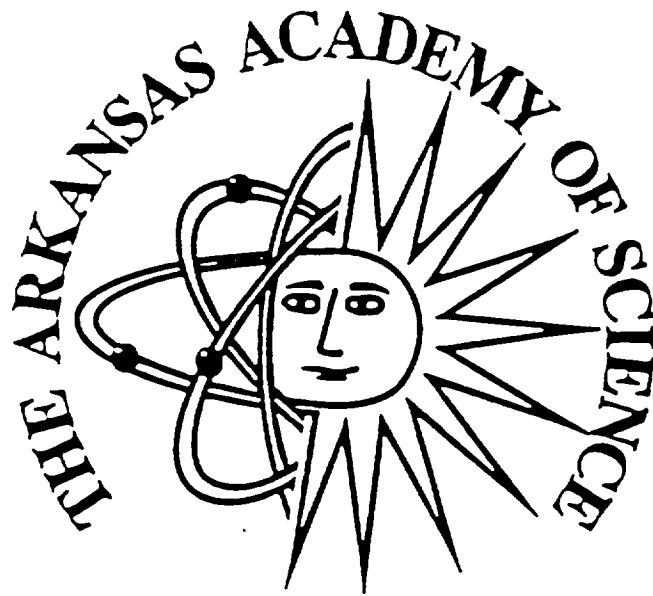
Abstracts
(in alphabetical order by author)

Arkansas State University

MONTE CARLO SIMULATIONS OF A NASA SCINTILLATING OPTICAL FIBER CALORIMETER FOR 10- TO 1,000-MEV GAMMA RAYS.

R. GILLUM, Z. YANG, D. WOLD, Department of Physics and Astronomy, University of Arkansas at Little Rock,2801 S. University Avenue, Little Rock, AR 72204

A scintillating optical fiber calorimeter (SOFCAL) is being developed by NASA/Marshall Space Flight Center for use in balloon-borne emulsion chambers. SOFCAL will not saturate for long exposures and will record positions, angles and temporal information about cosmic-ray nuclei and gamma rays. For a given incident particle and energy, computer simulations of electromagnetic cascades allow computation of energy deposited in different regions of the calorimeter. For the simulations, a 5-cm x 5-cm x 7-cm calorimeter was used. Each subsection contained a 0.4-cm thick lead plate or two 0.2-cm lead plates and two layers of optical fibers, 90° to each other. The square cross-section of each fiber was 0.5-mm thick. For incident gamma ray energies of 10, 20, 50, 100, 200, and 1,000 MeV, curves were plotted to ascertain the energy deposition in the x-layer and y-layer fibers. The same simulations were repeated with electrons as the incident particles. The simulations and detector response were compared with those obtained using gamma rays. Funding for this project was provided by the NASA/University Joint Venture (JOVE) Program.

ENZYMATIC DEGRADATION OF BIODEGRADABLE PLASTIC BY MYXOBACTERIA

David F. Gilmore, Dept. of Biological Sciences, Arkansas State Univ., State University, Arkansas 72467, and R. Clinton Fuller, Dept. of Biochemistry and Molecular Biology, Univ. of Massachusetts, Amherst, Massachusetts 01003

Several strains of myxobacteria, a common soil bacterium, appear to be capable of degrading PHB and PHO, two examples of biodegradable polyesters that are found as inclusion bodies in various species of bacteria. To show that the disappearance of the polyesters was the result of enzymatic activity, we have carried out experiments using a novel method for evaluating enzymatic degradation of the polyester PHBV. Agar which contained thin strips of PHBV film and PHB-containing bacteria as a nutrient source was inoculated with myxobacteria. After several days, the myxobacteria had lysed the food bacteria and caused the disappearance of their PHB inclusions. The films became turbid indicating that enzymatic degradation had occurred. When the films were then washed and incubated in a buffered solution, they became more turbid, demonstrating the presence of bound enzyme.

REGULATION OF THE EXTRACELLULAR SIGNAL REGULATED KINASE 2 (ERK2) BY PHORBOL ESTERS AND FETAL CALF SERUM IN HUMAN MELANOMA CELLS.

Miriam Glass[1], Fan Yang[1] and Estela E. Medrano[1]. University of Arkansas at Pine Bluff[1], Pine Bluff, AR 71601. University of Cincinnati, Cincinnati, OH[2].

The Extracellular-Signal Regulated Kinases (ERKs) are a family of enzymes considered to be a major signal transducer pathway since they are rapidly activated in response to ligand binding to receptors with tyrosine kinase activity, or after activation of protein kinase C (PKC). We wished to determine the mechanisms involved in ERK2 phosphorylation by phorbol esters which are negative growth stimulators, and FCS, a positive growth stimulator, in the human melanoma cell line UCD-Mel-N,. For that, cells were stimulated for 15 minutes with 100 nM PMA in the presence or absence of the PKC inhibitor H-7, or with 10% FCS. Cell extracts were run in a 7.5% acrylamide gel. Proteins were blotted to a nitrocellulose membrane and treated with the antibody 691, which recognizes both, ERK1 (44KD) and ERK2 (42 KD) proteins. Antigen-antibody binding was visualized using the ECL chemiluminescence method. The pattern obtained in untreated cells differed from the one obtained in cells treated with either H-7, PMA or FCS, suggesting possible modifications of ERK2 by phosphorylation. To confirm these results, membranes were stripped and probed with specific ERK2 and ERK1 antibodies. The results show a clear shift in ERK2 protein while ERK1 remains unchanged. We conclude that ERK2 is possibly phosphorylated by PKC-dependent and independent pathways. (Supported by NIH MARC Grant #GM08025-09)

ABSTRACT

MONTE CARLO SIMULATIONS OF A NASA SCINTILLATING OPTICAL FIBER CALORIMETER FOR 10- TO 1,000-MEV GAMMA RAYS.

R. GILLUM, Z. YANG, D. WOLD, Department of Physics and Astronomy, University of Arkansas at Little Rock,2801 S. University Avenue, Little Rock, AR 72204

A scintillating optical fiber calorimeter (SOFCAL) is being developed by NASA/Marshall Space Flight Center for use in balloon-borne emulsion chambers. SOFCAL will not saturate for long exposures and will record positions, angles and temporal information about cosmic-ray nuclei and gamma rays. For a given incident particle and energy, computer simulations of electromagnetic cascades allow computation of energy deposited in different regions of the calorimeter. For the simulations, a 5-cm x 5-cm x 7-cm calorimeter was used. Each subsection contained a 0.4-cm thick lead plate or two 0.2-cm lead plates and two layers of optical fibers, 90° to each other. The square cross-section of each fiber was 0.5-mm thick. For incident gamma ray energies of 10, 20, 50, 100, 200, and 1,000 MeV, curves were plotted to ascertain the energy deposition in the x-layer and y-layer fibers. The same simulations were repeated with electrons as the incident particles. The simulations and detector response were compared with those obtained using gamma rays. Funding for this project was provided by the NASA/University Joint Venture (JOVE) Program.

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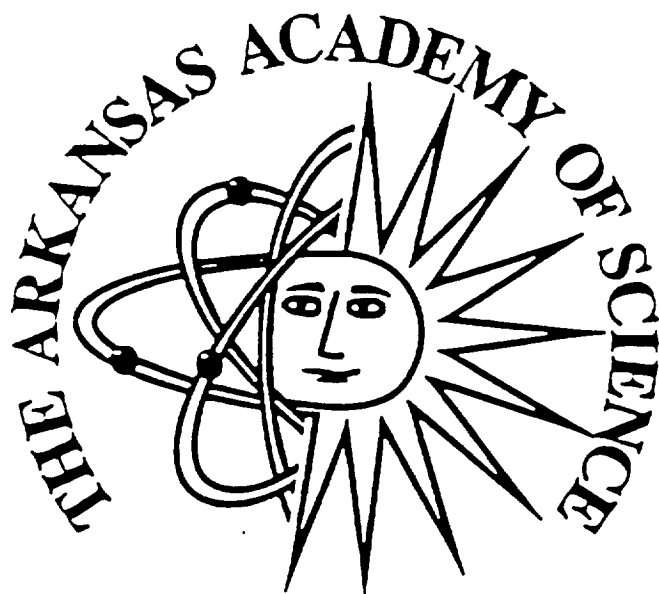
Preferred Section: Cosmic ray physics or high energy physics

Projection Equipment: Overhead projector

Paper is to be considered for a graduate student award:

_____Graduate Student - Physical Science

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The Arkansas Academy of Science
78th Annual Meeting
April 8-9, 1994

Abstracts
(in alphabetical order by author)

Arkansas State University

SEX RATIO AND SUCCESS, AN ASSESSMENT OF <u>LINDERA MELISSIFOLIA</u> IN ARKANSAS

Robert D. Wright, 68 Crestview Road, Conway, AR 72032

<u>Lindera melissifolia</u>, pondberry, is a federally endangered dioecious shrub found in Arkansas and four other southeastern states. Although by far the greatest area exists in Arkansas, it is broken into numerous small single-sex clones concentrated in two locations. Several stands have been lost during the 1980's according to records of the Arkansas Natural Heritage Commission. Even casual observation reveals that there are more males than females. This suggests dependence on vegetative reproduction, with possible bias against females. This paper reports on work investigating this suggestion. It was found that a 7:1 bias in sex ratio favors males. Poor survival of seedlings and transplants indicates that only apomictic reproduction is successful. Females allocate 45 times more resources to reproduction than males. Stem dieback occurs in both sexes but regrowth is vigorous. Shoot moisture stress, and response of net photosynthesis and conductance, favor growth of males.

MONTE CARLO SIMULATIONS OF A NASA SCINTILLATING OPTICAL FIBER CALORIMETER FOR 0.5- TO 1.5-TEV GAMMA RAYS.

Z. YANG, R. GILLUM, D. WOLD, Department of Physics and Astronomy, University of Arkansas at Little Rock, 2801 S. University Avenue, Little Rock, AR 72204

A scintillating optical fiber calorimeter (SOFCAL) is being developed by NASA/Marshall Space Flight Center for use in balloon-borne emulsion chambers to study the spectrum of high-energy cosmic rays. SOFCAL will not saturate for long exposures and the detector will be a valuable tool for the study of primary cosmic-ray nuclei from 10 GeV to 1,000 GeV. For a given incident particle and energy, computer simulations of electromagnetic cascades allow computation of energy deposited in different regions of the calorimeter. For the simulations, a 5-cm x 5-cm x 7-cm calorimeter was used. Each subsection contained a 0.4-cm thick lead plate or two 0.2-cm lead plates and two layers of optical fibers, 90° to each other. The square cross-section of each fiber was 0.5-mm thick. For incident gamma ray energies of 0.5 to 1.5 TeV, the energy deposition in each x-layer and y-layer fibers was computed. For a limited dynamic range of the electronics, a window with a threshold of 2 MeV and upper limit of 200 MeV deposited energy was found to be optimal for incident gamma rays in the 0.5 to 1.5 TeV range. Funding for this project was provided by the NASA/University Joint Venture (JOVE) Program.

UV-INDUCED CHROMOSOMAL BREAKS AND THE DNA REPLICATION FORK

<u>Daniel M. Yoder</u>, Jason M. Hiles, and Gaston Griggs

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Our most recent experimentation was initiated to investigate UV-induced chromosomal aberration production in eukaryotic cells. Specifically, appropriate Bromodeoxyuridine labelling techniques were developed and applied, in conjunction with conventional techniques, for exploring correlations between the DNA replication fork progression and radiation-induced chromosomal aberrations in S phase eukaryotic cells. Direct evidence for the role of the DNA replication fork in converting some UV-induced pre-aberrational DNA damage to chromosomal deletions was observed.

ABSTRACT

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Preferred Section: Cosmic ray physics or high energy physics

Projection Equipment: Overhead projector

Paper is to be considered for a graduate student award:

_____Graduate Student - Physical Science

JOVE FACULTY RESEARCH ASSOCIATES

Poster Presentation Abstracts

JOVE Retreat

July 6–9, 1994

Cocoa Beach, Florida
and
Kennedy Space Center

Gamma Ray Emissions from Binary Pulsar Systems

Hall, Tony A.* and Andrew T. Sustich (Arkansas State University)

A method is developed for estimating the gamma ray flux impinging upon the Earth from production in binary pulsar systems. We calculate production of the 6.13 MeV gamma ray line characteristic of ^{16}O. These are produced by protons emitted by the pulsar interacting with ^{16}O atoms at the surface of the companion. We examine different types of companion stars and estimate the gamma ray flux at the Earth as a function of proton emission from the pulsar and distance from the Earth. Prospects for detection from Earth are discussed.

* student

(Dr. Sustich is working with Dr. Carol Crannell of the Goddard Space Flight Center.)

Line Strength-Weighted Binary Star Radial Velocities

Van Hamme, Walter (Florida International Univesity) and R. E. Wilson (University of Florida)

We present further results on our new method of computing binary star radial velocities. A key element of the method is the inclusion of proximity effects based on flux and line strength-weighted averages over the visible stellar disks. Earlier results indicated that effects due to line strength-weighting amount to a few percent in terms of the radial velocity semi-amplitudes. Further experimentation has revealed these effects to be more important for extreme mass ratio contact binaries (type AW UMa), and early spectral type (hot) near-contact systems (type TU Mon, V701 Sco). Results for both types are shown.

(Dr. Van Hamme is working with Dr. Robert Wilson of the University of Florida.)

Monte Carlo Simulation of a Scintillating Optical Fiber Calorimeter

Wold, Donald C., Zibin Yang* and Russell Gillum* (University of Arkansas at Little Rock)

A scintillating optical fiber calorimeter (SOFCAL) is being developed by NASA/Marshall Space Flight Center for use in balloon-borne experiments to study the spectrum of high-energy cosmic rays and gamma rays. SOFCAL will not saturate for long exposures and the calorimeter will be helpful for the study of primary cosmic-ray nuclei energies from 100 GeV to 1,000 TeV. For a given incident particle and energy, computer simulations of electromagnetic cascades allow computation of energy deposited in different regions of the calorimeter. For these initial simulations, a 5-cm x 5-cm x 7-cm calorimeter was used. Each subsection contained a 0.4-cm thick lead plate or two 0.2-cm lead plates and two layers of optical fibers, 90° to each other. The 100 fibers in a layer were 0.5-mm thick with a square cross-section. For incident gamma ray energies of 0.5 to 1.5 TeV, the energy deposited in each layer of fibers was computed. Due to the limited dynamic range of the imaging electronics, a window for the energy deposition in the fibers is explored to determine the best measure of energy deposition (ΣE_γ) in the calorimeter.

* student

(Dr. Wold is working with Dr. Thomas Parnell of the Marshall Space Flight Center.)

PROCEEDINGS OF THE FIRST INTERNATIONAL SYMPOSIUM ON COSMIC RAY PHYSICS IN TIBET

(ISCRP—I)

TIBET UNIVERSITY

AUGUST 12—17, 1994

LHASA, CHINA

MONTE CARLO SIMULATION OF A SCINTILLATING OPTICAL FIBER CALORIMETER

Donald C. Wold, Zibin Yang, and Russell Gillum

Department of Physics and Astronomy, University of Arkansas at Little Rock,
2801 S. University Avenue, Little Rock, AR 72204, USA

Abstract

A scintillating optical fiber calorimeter (SOFCAL) is being developed by
NASA/Marshall Space Flight Center for use in balloon-borne experiments to study
the spectrum of high-energy cosmic rays and gamma rays. SOFCAL will not
saturate for long exposures and the calorimeter will be helpful for the study of
primary cosmic-ray nuclei energies from 100 GeV to 1,000 TeV. For a given incident
particle and energy, computer simulations of electromagnetic cascades allow
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optical fibers, 90° to each other. The 100 fibers in a layer were 0.5-mm thick with a
square cross-section. For incident gamma ray energies of 0.5 to 1.5 TeV, the energy
deposited in each layer of fibers was computed. Due to the limited dynamic range
of the imaging electronics, a window for the energy deposition in the fibers is
explored to determine the best measure of energy deposition (ΣE_y) in the
calorimeter. Funding was provided by the NASA/University Joint Venture (JOVE)
Program.

1 Introduction

The Monte Carlo method in GEANT was used to simulate the photon and electron
events in the Scintillating Optical Fiber Calorimeter (SOFCAL), which is under
development at NASA/Marshall Space Flight Center for future applications in cosmic
ray and gamma ray measurements.

Emulsion chambers employing calorimeters have been used for direct
measurements of cosmic-ray composition (protons through Fe) between 10^{12} and 10^{15}
eV using balloon-borne emulsion chambers [1], [2], [3], [4], [5], [6], [7]. The typical
emulsion chamber [4] is composed of four parts: (1) a charge-determination module,
(2) a target module with ~0.2 vertical interaction mean free paths for protons, (3) a
spacer module, and (4) an emulsion calorimeter module with about fourteen vertical
radiation lengths. The simulations described here are for a scintillation optical fiber
counterpart to the calorimeter section in the emulsion chamber.

The part of the primary energy going into gamma-rays, ΣE_γ, is the parameter most easily related to the primary cosmic ray spectrum in emulsion chamber experiments. The ability to measure energies of electron-photon cascades is one of the most important functions of the calorimeter. The photons originating from an interaction will develop individual electromagnetic cascades in the calorimeter. For these simulations, a calorimeter module with ten vertical radiation lengths of Pb was used. In one geometrical configuration, each subsection of the calorimeter consisted of a 4-mm lead block, 100 fibers (0.5-mm thick) in the x-direction and 100 fibers (0.5-mm thick) in the y-direction. In these initial simulations, this lead and optical fiber combination was repeated fourteen times.

2 The Monte Carlo Program for SOFCAL Simulations (SOFCALS)

The Monte Carlo simulations which used GEANT3 were done on DEC 5000 workstations. The process of optimization requires frequent design changes, so users should be able to change the geometry easily. The time required to modify GEANT programs containing geometry information about the detector can be enormous. Therefore a subroutine was developed to read in the geometrical configuration from a separate file in an ASCII format. This subroutine reads not only detector setup, but also other parameters needed for the simulation, such as tracking medium parameters.

Energy deposition is calculated from the lowest level geometry. Total energy deposition is integrated using step functions. When a threshold is imposed due to limitations in the electronic read out devices, then the measured energy is less than the energy actually deposited in each fiber. The program SOFCALS has interactive routines which are called to draw the trajectories of an individual gamma ray event.

The Shower Caused by an Electron with E=100 GeV

Fig. 1. Trajectories of a 0.1 TeV event.

3 Results

Fig. 1 illustrates the shower of electrons and photons produced by an incoming gamma ray with incident energy of 0.1 TeV in the SOFCAL detector. In these simulations, the incident gamma ray lies along the z-axis which is normal to the plane of each lead plate and layer of fibers. The typical detector (emulsion chamber [4]) has a "target section" and "calorimeter section" designed for measuring produced charged

particles and gamma rays, respectively. The target section includes many layers of nuclear emulsion plates to measure the charge of the incident particle and the emission angles of the produced charged particles with high accuracy (0.01 mrad). The calorimeter includes layers of nuclear emulsion and X-ray film among lead plates to measure the electron distributions from the electromagnetic cascades initiated by gamma rays from π^0 decay. The calorimeter is used to measure the spectrum of energy deposition ΣE_γ from which the primary energy spectrum is derived [4].

For the simulations, the angular distribution and energy distribution of gamma rays from each π^0 decay is needed. Isospin symmetry is assumed so the number of π^0 s which decay into pairs of gamma rays is about half that of the charged π mesons.

For 1 TeV gamma rays and 100 events, Fig. 2 shows the energy deposited within each adjacent layer (#12) of x- and y-fibers. The energy transition curve in

Fig. 2. Energy deposition in layer #12.

Fig. 3 shows the total energy deposited within each x-layer of fibers as a function of distance through the detector SOFCAL. The incident particle is a gamma-ray with energies of 0.5, 1.0, and 1.5 TeV. The three curves are based on ten events each.

4 Discussion

In these simulations of gamma rays incident on the SOFCAL detector, the energy transition curves show the energy deposited in each layer of optical fibers. These curves have been determined for gamma rays from 10 MeV to 1.5 TeV. Within single layers of fibers, the energy deposited in each fiber has been computed and plotted. GEANT has the advantage that it is relatively easy to modify the geometry of the detector. Simulations were done for a second geometrical configuration with 2-mm lead sheet, x-layer of fibers, 2-mm lead sheet, and y-layer of fibers in each subsection.

The dynamic range is one limitation of the output image intensifier CCD electronics. Typical devices are limited to a dynamic range of approximately 256. For example, if the threshold energy is set to 1 MeV, then the highest energy which can be measured is only 256 MeV. Due to this limitation, a specific threshold and window may be needed to optimize the measurements. For these initial simulations of SOFCAL, a dynamic range of 100 was used. In Fig. 4, a threshold of 2 MeV appears to be optimal. Fig. 5 and Fig. 6 show the energy transition curve for a 0.5- to 50-MeV

window and 5- to 500-MeV window, respectively. When compared with the energy transition curve in Fig. 3, for which no threshold has been imposed, these figures show that a 2- to 200-MeV window differentiates between gamma ray energies from 0.5 to 1.5 TeV better than other windows. For simulations of the primary cosmic rays, calculations must be performed with event generators, such as FRITIOF, to predict the distributions in ΣE_γ and then use GEANT for associated optimum "window" settings.

Fig. 3. The energy transition curve.

Fig. 4. The threshold is 2 MeV.

Fig. 5. The threshold is 0.5 MeV.

Fig. 6. The threshold is 5 MeV.

References

[1] M. F. Kaplon et al., Phys. Rev., 85, 295 (1952).
[2] O. Minakawa et al., Suppl. Nuovo Cimento, 8, 761 (1958).
[3] K. Niu et al., Prog. Theor. Phys., 46, 1644 (1971).
[4] T. H. Burnett et al., Nucl. Instr. Meth., A251, 583 (1986).
[5] T. H. Burnett et al., Ap.J., 349, L25 (1990).
[6] T. A. Parnell et al., in Proc. COSPAR 1988, Adv. Space Res., 9, 45 (1989).
[7] K. Asakimori et al., Proc. 23rd Int. Cosmic Ray Conf. (Calgary), 2, 21 (1993).

USING GEANT TO MODEL CALORIMETER RESPONSE FOR ELECTROMAGNETIC CASCADES FROM NUCLEUS-NUCLEUS INTERACTIONS IN A COSMIC RAY DETECTOR

KAZUHIKO MURAI, CARLOS A. SÁNCHEZ, JASON E. ELMORE, DONALD C. WOLD, Department of Physics and Astronomy, University of Arkansas at Little Rock, 2801 S. University Avenue, Little Rock, AR 72204

A scintillating optical fiber calorimeter (SOFCAL) is being developed by NASA/Marshall Space Flight Center for use in balloon-borne experiments to study the spectrum of high-energy cosmic rays and gamma rays. SOFCAL will not saturate for long exposures and the calorimeter will be helpful for the study of primary cosmic-ray nuclei energies from 100 GeV to 1,000 TeV. For a given incident particle and energy, computer simulations of electromagnetic cascades allow computation of energy deposited in different regions of the calorimeter. The event generator FRITIOF was used to model nucleus-nucleus collisions encountered in the cosmic ray detector. The measurements of charged particles in the emulsions are related to the primary energy and particles produced in the collision. For incident gamma-ray energies determined by different nucleus-nucleus interactions, the energy deposited in each layer of fibers was computed. The Monte Carlo program GEANT was used to model SOFCAL response to gamma rays and compute the measure of energy deposition (ΣE_γ) corresponding to different nucleus-nucleus interactions in the calorimeter. Funding was provided by the NASA/University Joint Venture (JOVE) Program.

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USING FRITIOF TO MODEL NUCLEUS-NUCLEUS INTERACTIONS IN A COSMIC RAY DETECTOR

CARLOS A. SÁNCHEZ, KAZUHIKO MURAI, JASON E. ELMORE, DONALD C. WOLD, Department of Physics and Astronomy, University of Arkansas at Little Rock, 2801 S. University Avenue, Little Rock, AR 72204

A long term goal is to study the spectrum of high-energy cosmic rays. Balloon-borne emulsion chambers are used to detect these particles in high energy nucleus-nucleus interactions. The detectors have "target sections" and "calorimeter sections" for measurements of produced charged particles and gamma-rays, respectively. Identification of the primary particles striking the target section of the emulsion chamber is very important. The target section includes many layers of nuclear emulsion plates to measure the charge of the incident particle and the emission angles of the produced charged particles. The calorimeter includes layers of nuclear emulsion and x-ray film to measure the electron distributions from the electro-magnetic cascades initiated by gamma-rays from pi-zero decay. The event generator FRITIOF was used to model nucleus-nucleus collisions encountered in the cosmic ray detector. The measurements of charged particles in the emulsions are related to the primary energy and particles produced in the collision. The Monte Carlo program GEANT was used to model calorimeter response for electromagnetic cascades, resulting from the nucleus-nucleus interactions. Representative primary heavy ion and energy spectra will be presented up to 10^5 GeV/nucleon. Funding for this project was provided by the NASA/University Joint Venture (JOVE) Program.

Abstract Submitted
for the 1995 Spring Meeting of the
Arkansas Academy of Science
79th Annual Meeting, April 7-8, 1995
University of Arkansas at Pine Bluff, Pine Bluff, AR 71601

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April 20-22, 1995

NCUR95

NATIONAL
CONFERENCE ON
UNDERGRADUATE
RESEARCH

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COLLEGE
SCHENECTADY, NY

CONFERENCE PROGRAM
& ABSTRACT BOOK

DETECTION OF MAGNETIC MONOPOLES USING SQUID-BASED MAGNETOMETERS
José Miguel Hurtado, Jr., Sponsored by Dr. Joseph L. Kirschvink, Department of Geological and
Planetary Sciences, California Institute of Technology, Pasadena, California 91125

2291
3:20 pm
SE 210

A useful property of magnetic monopoles is their quantized magnetic flux which can take on integer multiples of twice the flux quantum of superconductivity, $2\Phi_0$ ($\Phi_0 = 2.02 \times 10^{-7}$ G cm^2). This coincidence, along with the phenomenon of flux exclusion from a superconducting loop, make superconductors ideal for use in monopole detectors. Using the superconducting magnetometers in the Caltech Paleomagnetics and Biomagnetics Laboratory and their ultra-sensitive SQuID electronics as detectors, a magnetic monopole search was conducted. The computer-controlled search was done nightly for one month using both magnetometers in the laboratory. The computer program looked for the unique step function signal expected from a monopole passing through the magnetometers' Helmholtz-geometry pickup loops. The expected magnitude of the step relative to the background magnetic "noise" ranged between 1.057×10^{-10} A m^2 and 2.178×10^{-7} Am^2, depending on which magnetometer and axis, x or z, the monopole passed through. While numerous candidate monopole events were detected, all of them appear to have been triggered by noise and imperfect electronics. No magnetic monopoles were detected to date.

USING FRITIOF TO MODEL NUCLEUS-NUCLEUS INTERACTIONS IN A COSMIC RAY DETECTOR
Carlos A. Sánchez, Jason E. Elmore (Donald C. Wold), Department of Physics and Astronomy, University of Arkansas at Little Rock, Little Rock, AR 72204

2292
3:40 pm
SE 210

A long term goal is to study the spectrum of high-energy cosmic rays. Balloon-borne emulsion chambers are used to detect these particles in high energy nucleus-nucleus interactions. The detectors have "target sections" and "calorimeter sections" for measurements of produced charged particles and gamma-rays, respectively. Identification of the primary particles striking the target section of the emulsion chamber is very important. The target section includes many layers of nuclear emulsion plates to measure the charge of the incident particle and the emission angles of the produced charged particles. The calorimeter includes layers of nuclear emulsion and x-ray film to measure the electron distributions from the electromagnetic cascades initiated by gamma-rays from pi-zero decay. The event generator FRITIOF was used to model nucleus-nucleus collisions encountered in the cosmic ray detector. The measurements of charged particles in the emulsions are related to the primary energy and particles produced in the collision. A scintillating optical fiber calorimeter (SOFCAL) is being developed for use in emulsion chambers. The Monte Carlo program GEANT was used to model SOFCAL response for electromagnetic cascades, resulting from the nucleus-nucleus interactions. Representative primary heavy ion and energy spectra will be presented up to 10^6 GeV/nucleon. Funding for this project was provided by the NASA/University Joint Venture (JOVE) Program.

THE INFLUENCE OF A NEAR-SOLAR CORONAL DUST-FREE ZONE
Van M. Savage and (R. M. MacQueen) Department of Physics,
Rhodes College, Memphis, TN, 38112

2293
4:00 pm
SE 210

Interplanetary dust is believed to spiral slowly toward the sun under the influence of Poynting-Robertson drag, and ultimately to vaporize under intense insolation, creating a "dust-free" zone near the sun. The observational signature of such a zone is subtle, particularly in the visible wavelength region of the spectrum, where light scattered by the near-solar dust dominates any thermal emission signature. We have calculated the effects such a dust-free zone would have on the solar F-coronal brightness, under conditions of various materials comprising the interplanetary dust population, differing sizes of zones, and differing wavelengths. These calculations will be compared to current models of the solar F-corona, and the observational implications explored.

LASER ENHANCEMENT OF DIFFUSION PROCESSES IN ION-IMPLANTED SILICON Bryan M. Barnes, Royal G. Albridge, Alan V. Barnes, Mark T. Graham, James T. McKinley, Qun Yan, (Norman H. Tolk), Center for Molecular and Atomic Studies at Surfaces, Department of Physics and Astronomy, Vanderbilt University, Nashville, TN 37235

2294
4:20 pm
SE 210

High power peak lasers offer unique opportunities for wavelength-selective materials alteration. Ion-implanted silicon samples were prepared with several ion species to study impurity-specific laser-enhanced diffusion. A free-electron laser tunable in the 1 to 10 μm range was used to irradiate the samples. To verify diffusion, atomic force microscopy, raman, and SIMS measurements were taken.

Arkansas Academy of Science

80th Annual Meeting
Fort Smith, Arkansas
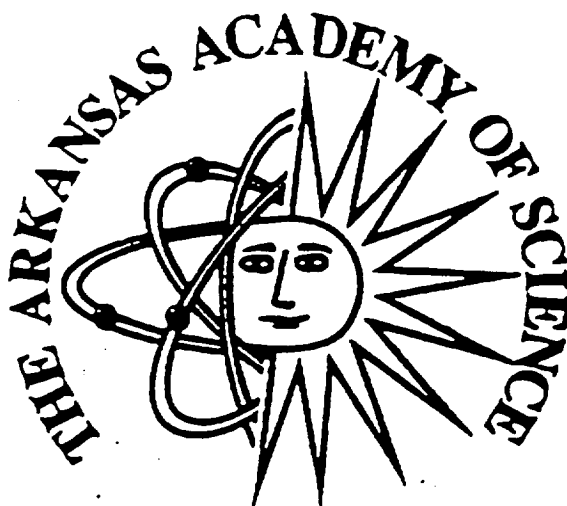
PROGRAM

Westark Community College
April 12 - 13, 1996

Arkansas Academy of Science

80th Annual Meeting
Fort Smith, Arkansas

Abstracts are arranged alphabetically
by the last name of the first author. Underlined names indicate presenters.

*	Contestant for undergraduate paper award
**	Contestant for graduate paper award
☞	Arkansas River Symposium
🗐	Poster session

Westark Community College
April 12 - 13, 1996

Physics, Mathematics and Geology Paper Session Continued

<u>Location: Math/Science Building Room 204</u>   * Undergraduate ** Graduate

Chairperson: Dr. Edwin S. Braithwaite, Cedarville College, Cedarville, Ohio

<u>Time</u>   <u>Topic</u>

10:00   * <u>Danny R. Crawford</u>, G. Douglas Mauldin, Charles W. Ford, Jr. and W. J.
                Braithwaite, University of Arkansas at Little Rock, 2801 S. University Ave., Little
                Rock, AR 72204. INSTALLATION & ADMINISTRATION OF A LINUX
                NETWORK FOR SCIENTIFIC COMPUTING NEEDS AT THE UNIVERSITY OF
                ARKANSAS AT LITTLE ROCK

10:15   * <u>A. Kevin Nance</u>, Dept. of Earth Sciences, Univ. of Arkansas at Little Rock,
                Little Rock, AR; Ian Richards, Dept. of Geological Sciences, Southern Methodist
                Univ., Dallas, TX; Jeffrey B. Connelly, Dept. of Earth Sciences, Univ. of
                Arkansas at Little Rock, Little Rock, AR. OXYGEN ISOTOPIC COMPOSITION
                OF UNUSUAL QUARTZ VEINS: IMPLICATIONS FOR ORIGIN OF THE
                MINERALIZING FLUIDS

10:30   * <u>Trevis A. Crane</u> and Donald C. Wold, Department of Physics and Astronomy,
                University of Arkansas at Little Rock, 2801 S. University Ave, Little Rock, AR
                72204. SURVEY OF HIGH ENERGY COSMIC-RAY OBSERVATORIES

10:45   * <u>Amber D. Climer</u>, Univ. of Arkansas at Little Rock and Lawrence Berkeley
                National Laboratory, Iwona M. Sakrejda, Lawrence Berkeley National
                Laboratory, MATH/SCIENCE BUILDING ROOM 70A-3307, Berkeley, CA 94720
                and W.J. Braithwaite, Univ. of Arkansas, Little Rock, AR 72204. AN
                ACCEPTANCE AND EFFICIENCY STUDY FOR DETECTION OF K$^+$ AND K$^-$
                WITHIN THE TIME PROJECTION CHAMBER OF THE SOLENOIDAL
                TRACKING INSTRUMENT, FOR USE AT THE RELATIVISTIC HEAVY ION
                COLLIDER

11:00   * <u>Christine A. Byrd</u> and W.J. Braithwaite, Department of Physics and Astronomy,
                University of Arkansas at Little Rock, 2801 S. University Ave., Little Rock, AR
                72204. MEASURING STRANGENESS PRODUCTION FROM RELATIVISTIC
                COLLISIONS BETWEEN PAIRS OF NUCLEI USING A VERTEX TIME
                PROJECTION CHAMBER

Arkansas Academy Of Science
Saturday, April 13, 1996

Paper Sessions

Physics, Mathematics and Geology

Location: Math/Science Building Room 204

* Undergraduate ** Graduate

Chairperson: Dr. W. J. Braithwaite, University of Arkansas at Little Rock, Little Rock, Arkansas

Time	Topic
8:30	Mostafa Hemmati and Steven Young, Physical Science Department, Arkansas Tech University, Russellville, Arkansas 72801. **WAVE PROFILE FOR PROFORCE CURRENT BEARING WAVES**
8:45	* Christopher P. Sheesley, and Rahul Mehta, Department of Physics and Astronomy, University of Central Arkansas, Conway, AR 72035. **THE STUDY OF METEORITES USING X-RAY FLUORESCENCE**
9:00	Edwin S. Braithwaite, Science and Mathematics, Cedarville College, Cedarville, OH 45314, and Wilfred J. Braithwaite, Department of Physics and Astronomy, University of Arkansas at Little Rock, 2801 South University Avenue, Little Rock, AR 72204. **ELIMINATION OF SYSTEMATIC SUMMING ERRORS FOUND IN LINEAR AND NON-LINEAR OPTIMIZATION OF BINOMIAL & POISSON DISTRIBUTED DATA**
9:15	* Sue Ellen McCloskey, Jeffery E. Clayton and W. J. Braithwaite, Department of Physics and Astronomy, University of Arkansas, 2801 So. Univ. Ave., Little Rock, AR 72204. **ESTIMATING MILKY-WAY DARK MATTER: ITS AMOUNT AND DISTRIBUTION**
9:30	* Michael LaCour, Trevis A. Crane, and Donald C. Wold, Department of Physics and Astronomy, University of Arkansas at Little Rock, Little Rock, AR 72204. **SURVEY OF GAMMA-RAY ASTRONOMY TELESCOPES**
9:45	Break

SURVEY OF HIGH ENERGY COSMIC-RAY OBSERVATORIES

Trevis A. Crane and Donald C. Wold, Department of Physics and Astronomy,
University of Arkansas at Little Rock, 2801 S. University Ave, Little Rock, AR 72204

Efforts to advance our understanding of the origin of cosmic rays and the
astrophysical processes that create and accelerate them involve many scientists and
observatories world wide. One goal is to extend present measurements to lower
energy and to greater levels of sensitivity in order to study the variety of galactic and
extragalactic sources that are being discovered at lower energies with detectors on
the NASA Compton Gamma-Ray Observatory. A survey of cosmic-ray
observatories was prepared for scientists and others to provide a resource and
reference which describes high energy cosmic-ray research activities around the
world. This summary presents information about each research group, such as
names of principal investigators, number of persons in the collaboration, energy
range, sensitivity, angular resolution, and surface area of detector. Similar
information for those observatories soon to be operational will be presented. The
cosmic-ray observatories included in the summary are Arobic, AMANDA, CASA-
MIA, Celeste, Fly's Eye, MILAGRO, HEGRA, KASCADE, LVD, Whipple
Observatory, MACRO,. EAS-TOP, Tibetan Air Shower Array, AGASA, Solar-II,
SPASE2 and VULCAN. Funding for this project was provided by the Arkansas
Space Grant Consortium.

Name and Address for Correspondence:
Professor Donald C. Wold
Department of Physics and Astronomy
University of Arkansas at Little Rock
2801 S. University Avenue
Little Rock, Arkansas 72204

Phone: (501) 569-8962   **Fax:**   (501) 569-3314

Preferred Section: Cosmic ray physics or high energy physics

Projection Equipment: Overhead projector

Paper is to be considered for an undergraduate student award:

_____Undergraduate Student - Physical Science

THE POTENTIAL USE OF SMALL PROTEINASE INHIBITORS IN THE REGULATION OF BLOOD PRESSURE.

* Sidney Wayne Collins and Rose McConnell. Division of Mathematics & Sciences, University of Arkansas at Monticello, Monticello, Arkansas 71656.

The proteolytic enzymes renin and kallikrein play important roles in the regulation of blood pressure. Renin is involved in the production of angiotensin II, a vasoconstricting peptide. And kallikrein catalyzes the formation of vasodilating peptides called kinins. The relative amounts of angiotensin II and the kinins found in the blood determine the overall blood pressure. Therefore, the development of small inhibitors of both renin and kallikrein, as a means of regulating blood pressure, is warranted. This approach will be discussed and compared to current blood pressure regulating agents.

SURVEY OF HIGH ENERGY COSMIC-RAY OBSERVATORIES

* Trevis A. Crane and Donald C. Wold, Department of Physics and Astronomy, University of Arkansas at Little Rock, 2801 S. University Ave, Little Rock, AR 72204

Efforts to advance our understanding of the origin of cosmic rays and the astrophysical processes that create and accelerate them involve many scientists and observatories world wide. One goal is to extend present measurements to lower energy and to greater levels of sensitivity in order to study the variety of galactic and extragalactic sources that are being discovered at lower energies with detectors on the NASA Compton Gamma-Ray Observatory. A survey of cosmic-ray observatories was prepared for scientists and others to provide a resource and reference which describes high energy cosmic-ray research activities around the world. This summary presents information about each research group, such as names of principal investigators, number of persons in the collaboration, energy range, sensitivity, angular resolution, and surface area of detector. Similar information for those observatories soon to be operational will be presented. The cosmic-ray observatories included in the summary are Arobic, AMANDA, CASAMIA, Celeste, Fly's Eye, MILAGRO, HEGRA, KASCADE, LVD, Whipple Observatory, MACRO,. EAS-TOP, Tibetan Air Shower Array, AGASA, Solar-II, SPASE2 and WLCAN.

SURVEY OF GAMMA-RAY ASTRONOMY TELESCOPES

Michael LaCour, Trevis A. Crane, and Donald C. Wold, Department of Physics and Astronomy, University of Arkansas at Little Rock, Little Rock, AR 72204

The diffuse gamma-radiation component in our galaxy, which originates from interactions of cosmic rays with interstellar gas and photons, provides important information about the density, distribution, and spectrum of the cosmic rays that pervade the interstellar medium. This survey of gamma-ray telescopes was prepared for scientists and others to provide a resource and reference which describes gamma-ray telescopes for investigating galactic diffuse gamma-ray flux currently observed at energies up to around 20 GeV, but is expected to extend into the TeV range. The study includes a summary of the characteristics of detectors for low energy gamma rays as observed in the NASA Compton Gamma Ray Observatory to detectors for higher energy gamma rays. Information about each research group, such as names of principal investigators, number of persons in the collaboration, and characteristics of the experiments, is presented. These features include energy range, sensitivity, angular resolution, and surface area of detector. Similar information for proposed telescopes will be presented. The gamma-ray telescopes included in this survey are BATSE, COMPTEL, EGRET, OSSE, MILAGRO, Arecibo, GLAST, and AGATE. Funding for this project was provided by the Arkansas Space Grant Consortium.

Name and Address for Correspondence:
Professor Donald C. Wold
Department of Physics and Astronomy
University of Arkansas at Little Rock
2801 S. University Avenue
Little Rock, Arkansas 72204

Phone: (501) 569-8962   **Fax:**   (501) 569-3314

Preferred Section: Cosmic-ray physics and astrophysics or high-energy physics

Projection Equipment: Overhead projector

Paper is to be considered for an undergraduate student award:

_____Undergraduate Student - Physical Science

INTESTINAL HELMINTHS OF BEAVERS FROM SOUTHWEST ARKANSAS

🌑 Micheal Knox,[1] Herbert M. Matthews, and Mark Clark,[2] Biology Department, Henderson State University,[1] and Ross Foundation,[2] Arkadelphia, AR.

Few studies of the gastrointestinal fauna of beavers, *Castor canadensis*, have been reported from their southern range. Beavers trapped in Clark and Ouachita counties in southwest Arkansas were necropsied by first separating the stomach, cecum, small intestine, and large intestine; then opening each with a longitudinal incision. Lumen contents were washed with saline and examined with a 3x magnifying lens. Helminths were fixed in alcohol-formalin-acetic acid (AFA) solution, and stored in 70% ethanol. No worms were found in the stomach. *Stichorchis subtriquetrus*, a trematode, was found in the other regions of all animals (prevalence = 100%) and was the only worm detected. The intensity, or range, of infection was 25 to 342 worms per beaver. Worms were found in both the cecum and large intestines of 67% of the animals, but not in the small intestine. Only 20% of the animals had significant numbers of worms in the small intestine and these were much smaller than worms elsewhere. The abundance, mean number of worms per animal, was 136+/-113 (SD). Arkansas beavers have parasitic worm infestations more similar to animals from southern Texas and Louisiana than from animals examined from their northern range.

SURVEY OF GAMMA-RAY ASTRONOMY TELESCOPES

* Michael LaCour, Trevis A. Crane, and Donald C. Wold, Department of Physics and Astronomy, University of Arkansas at Little Rock, Little Rock, AR 72204

The diffuse gamma-radiation component in our galaxy, which originates from interactions of cosmic rays with interstellar gas and photons, provides important information about the density, distribution, and spectrum of the cosmic rays that pervade the interstellar medium. This survey of gamma-ray telescopes was prepared for scientists and others to provide a resource and reference which describes gamma-ray telescopes for investigating galactic diffuse gamma-ray flux currently observed at energies up to around 20 GeV, but is expected to extend into the TeV range. The study includes a summary of the characteristics of detectors for low energy gamma rays as observed in the NASA Compton Gamma Ray Observatory to detectors for higher energy gamma rays. Information about each research group, such as names of principal investigators, number of persons in the collaboration, and characteristics of the experiments, is presented. These features include energy range, sensitivity, angular resolution, and surface area of detector. Similar information for proposed telescopes will be presented. The gamma-ray telescopes included in this survey are BATSE, COMPTEL, EGRET, OSSE, MILAGRO, Arecibo, GLAST, and AGATE.

Mailing Address of Principal Author:

Name: _____

Phone: _____ FAX: _____

University Grant No: _____

Address: _____

Email: _____

Type Abstract Here - Stay Within Border

Survey of High Energy Cosmic-Ray Observatories
T. A. Crane and D. C. Wold

Department of Physics and Astronomy, University of Arkansas at Little Rock, 2801 S. University Avenue, Little Rock, AR 72204

Efforts to advance our understanding of the origin of cosmic rays and the astrophysical processes that create and accelerate them involve many scientists and observatories world wide. One goal is to extend present measurements to lower energy and to greater levels of sensitivity in order to study the variety of galactic and extragalactic sources that are being discovered at lower energies with detectors on the NASA Compton Gamma-Ray Observatory. A survey of cosmic-ray observatories was prepared for scientists and others to provide a resource and reference which describes high energy cosmic-ray research activities around the world. This summary presents information about each research group, such as names of principal investigators, number of persons in the collaboration, energy range, sensitivity, angular resolution, and surface area of detector. Similar information for those observatories soon to be operational will be presented. The cosmic-ray observatories included in the summary are Arobic, AMANDA, CASA-MIA, Celeste, Fly's Eye, MILAGRO, HEGRA, KASCADE, LVD, Whipple Observatory, MACRO, EAS-TOP, Tibetan Air Shower Array, AGASA, Solar-II, SPASE2 and VULCAN. Funding for this project was provided by the Arkansas Space Grant Consortium.

Abstracts Due Wednesday, March 27, 1996

Presentation Preference:
    Oral Presentation: ☐
    Exhibit: ☐
    Poster Presentation: ☐

Category: (Check one only)
    Faculty: ☐
    Graduate Student: ☐
    Undergraduate: ☐

_____
Student Signature

_____
Faculty or Mentor Signature

PLEASE DO NOT FOLD THIS FORM

Return To: ATTN: Dr. James Pasley, UAMS, Mail Slot 505
Little Rock, AR 72205

Fourth Annual
Arkansas Space Grant Symposium
University of Central Arkansas
Friday, April 26, 1996

Abstract Form

Mailing Address of Principal Author:

University Grant No: UALR0061

Name: Donald C. Wold

Address: University of Arkansas at Little Rock

Phone: 501 569-8962   Fax: 501 569-3314

Email: dcwold@ualr.edu

Astrophysics Experiments with the Compton GRO and MILAGRO
Donald C. Wold

Department of Physics and Astronomy, University of Arkansas at Little Rock,
2801 S. University Avenue, AR 72204

The diffuse gamma-radiation component in our galaxy, which originates from interactions of cosmic rays with interstellar gas and photons, provides important information about the density, distribution, and spectrum of the cosmic rays that pervade the interstellar medium. This survey of gamma-ray telescopes was prepared to provide a resource and reference which describes gamma-ray telescopes for investigating galactic diffuse gamma-ray flux currently observed at energies up to around 20 GeV, but is expected to extend into the TeV range. The study includes a summary of the characteristics of detectors for low energy gamma rays as observed in the NASA Compton Gamma Ray Observatory to detectors for higher energy gamma rays. MILAGRO is a water-Cherenkov detector for observing gamma rays over a broad energy range from about 1 to 1,000 TeV. With this cosmic-ray observatory, previously observed celestial sources will be observed at their known emission energies and these observations will be extended into a new energy regime and search for new sources at unexplored energies. Two undergraduate students are compiling information about gamma-ray telescopes and high energy cosmic-ray observatories. Funding for this project was provided by the Arkansas Space Grant Consortium.

Presentation Preference:
    Oral Presentation: Yes.
    Exhibit
    Poster Presentation:

Category: (Check only one)
    Faculty: Yes
    Graduate Student
    Undergraduate Student

Student Signature

Faculty or Mentor Signature

PLEASE DO NOT FOLD THIS FORM

Return to: ATTN: Dr. James Pasley, UAMS, Mail Slot 505, Little Rock, AR 72205

Appendix D
JOVE Final Report
1995-6

Proposals Awarded:

onald C. Wold   4/22/96

1 February 1993
NL-3011G

Dr. Don Wold
Department of Physics & Astronomy
University of Arkansas at Little Rock
Little Rock, Arkansas 72204

Dear Dr. Wold:

On behalf of the Planning Committee of the Arkansas Space
Grant Consortium, it is my pleasure to inform you of the
approval of your ASGC Outreach Program application:

   Cosmic Ray Studies at NASA Marshall Space Flight Center.

The amount of the grant is $ 950, as you requested. That
amount reflects the Planning Committee's approval of your
additional request of $ 200. These funds are to be expended
under UALR Account No. 43-60-50 in accordance with the budget
in your proposal. Should you have reason to wish to spend
funds in some other manner, please contact me (569-8212)
before doing so.

Purchase orders should be approved by me. Your expenditure of
these funds should follow the enclosed Guidelines. Should
you have questions concerning the billing process, please
discuss them with me.

This grant is valid through 30 June 1993.

Again, congratulations on your award. NASA and the Arkansas
Space Grant Consortium look forward to your ASGC Outreach
accomplishments.

Sincerely yours,

Gaylord M. Northrop, Dr. Engr.
Director, Arkansas Space Grant Consortium

Copies:

Ms. Linda Burnett, Grants Accounting/UALR

h; in. Newney 1-7-93 @
11.20
@l4

Application for an ASGC Outreach Grant
Year One
Arkansas Space Grant Consortium
(Please Type)

Outreach Project Title:	Date: 1 / 7 / 93
Cosmic Ray Studies at NASA Marshall Space Flight Center	

Institution:	Street/Box No.	City		Zip
University of Arkansas at Little Rock	Physics & Astronomy 2801 S. University Avenue	Little Rock	,AR	72204

Names of Faculty Involved:	Title:	Department:	SSN
1. Dr. Donald C. Wold	Professor	Physics & Astronomy	████████
2.			
3.			
4.			

Principal Investigator's Telephone No.: (501) - 569 - 8962

Names of Students Involved:	Standing	Major:	CGP	SSN
1. Mr. Edward D. Bearden	Senior	Physics	2.49	████████
2. Mr. Russell Gillum	BS 1/93	Physics	3.41	████████
3. Mr. Zibin Yang	GA	Math	4.0	████████
4. Mr. Morgan Burks	Senior	Physics	3.40	████████

Abstract of Project:

During Fall 1992, four students at UALR began studying cosmic rays. They have been using a Monte Carlo program to simulate the interaction of these particles in a new NASA detector. Therefore, it is proposed to visit the Gamma and Cosmic Ray Branch at NASA Marshall Space Flight Center. Dr. Tom Parnell, Branch Chief, will be our host. On the second day we will visit the Huntsville Space and Rocket Center.

The students will spend one day at the Space Sciences Laboratory and see cosmic ray detectors. MSFC has an excellent nuclear emulsion processing laboratory. They will have the opportunity to visit with some NASA staff scientists and see data being acquired from a detector on the orbiting NASA Compton Gamma Ray Observatory.

Travel will be Thursday, January 28 through Saturday, January 30, 1993.

Summary of Funds Requested for This Outreach Grant:

1. Travel (mileage, etc.) .... $ 750.00	5. _____ $ _____
2. Equipment (State Funds).... $ _____	6. _____ $ _____
3. Materials .... $ _____	7. _____ $ _____
4. _____ $ _____	Total .... $ 750.00

10-12-92

Outrech1.pub

Arkansas Space Grant Consortium

ASU · Harding U. · UAF · UALR · UAMS · UAPB · UCA

NASA

Dr. Don Wold
Department of Physics & Astronomy
University of Arkansas at Little Rock
Little Rock, Arkansas 72204

Dear Dr. Wold:

On behalf of the Planning Committee of the Arkansas Space
Grant Consortium, it is my pleasure to inform you of the
approval of your ASGC Guest Lecturer Program application:

  Lectures on Results from BATSE in the Gamma Ray Observatory.
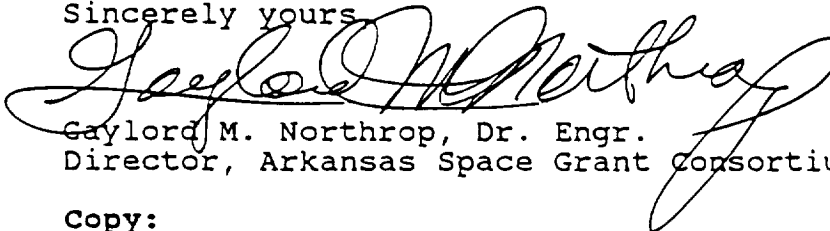
The amount of the grant is $ 765, as you requested. These
funds are to be expended under UALR Account No. 43-60-40 in
accordance with the budget in your proposal. Should you have
reason to wish to spend funds in some other manner, please
contact me (569-8212) before doing so.

Purchase orders should be approved by me. Your expenditure
of these funds should follow the enclosed Guidelines. Should
you have questions concerning the billing process, please
discuss them with me first.

This grant is valid through 28 February 1995.

Again, congratulations on your award. NASA and the Arkansas
Space Grant Consortium look forward to the success of your
ASGC Guest Lecturer Grant.

Sincerely yours,

Gaylord M. Northrop, Dr. Engr.
Director, Arkansas Space Grant Consortium

Copy:

Ms. Linda Burnett .... Grants Accounting/UALR

Application for an ASGC Guest Lecturer Grant
Year Three
Arkansas Space Grant Consortium

Outreach Project Title:			Date: 05/02/94

Lectures on Results from BATSE in the Gamma Ray Observatory

Institution:	Street/Box No.	City	Zip
UALR	2801 S. University Avenue	Little Rock, AR	7220 4

Names of Faculty Involved:	Title:	Department:	SSN
1. Donald C. Wold.	Professor	Physics and Astronomy	██████████
2. See below.			
3.			

Principal Investigator's Telephone No.: (501) 569-8962

Abstract of Project:

    The funding of a seminar speaker is proposed. The speaker is Dr. Geoffrey N. Pendleton, Research Associate in the Department of Physics at the University of Alabama at Huntsville, Huntsville, Alabama. Dr. Pendleton was awarded NASA contract NAS8-38609 in 1992. He is a member of the Burst and Transient Source Experiment (BATSE) group at NASA/George C. Marshall Space Flight Center. The BATSE gamma ray detector is part of NASA's Compton Gamma Ray Observatory. He will speak on "The Gamma Ray Sky Observed by the Burst and Transient Source Experiment (BATSE)". For the less technical audiences, the title of his talk is: "The Mystery of Gamma-Ray Bursts". Presentations are planned at the University of Arkansas at Little Rock and Arkansas State University on February 8 and 9, 1994, respectively. Hosts will be Professor Donald C. Wold of the Department of Physics and Astronomy, UALR, Professor Andrew Sustich, Department of Physics, ASU. Support is requested for travel by car, local transportation, hotel costs, meals, and honorarium.

    Dr. Pendleton will speak on current observations of NASA's Compton Gamma Ray Observatory. Dr. Pendleton has agreed to arrive on Tuesday, February 8, 1994, to present a public seminar in the afternoon at 4:15 p.m., to leave Little Rock on Wednesday morning, February 9, to go to Arkansas State University, and to present a public seminar at 3:00 p.m. He will depart back to Huntsville late in the afternoon or evening, but may prefer to stay overnight in Memphis. The lecture at UALR will be more specialized, but both presentations are open to the general public. Faculty and students of all institutions making up the Arkansas Space Grant Consortium are invited to participate. Drs. Sustich and Wold will schedule individual conference with those consortium members who wish private interviews with Dr. Pendleton. The support of the Arkansas Space Grant Consortium will be acknowledged in the public announcements.

Summary of Funds Requested for This Outreach Grant:

1. Travel (mileage, etc.)	$190		5. Meals	$100
2. Equipment (State Funds)	$0		6. Honorarium	$250
3. Materials	$0		7.	$0
4. Hotels	$225		Total	$765

    Schedules are not firmly set at the present time, so hotel and meal costs are estimated for the longest possible period.

Gamma Ray Sky Observed

by the

Burst & Transient Source

Experiment

(BATSE)

by

Dr. Geoffrey N. Pendleton

Research Associate, Department of Physics
University of Alabama at Hunstville

February 8, 1994   NS101

Refreshments @ 4:00 p.m.
Seminar @ 4:15 p.m.

PHYSICS SEMINAR

MYSTERY .

of

GAMMA RAY BURSTERS

Dr. Geoffrey N. Pendleton

Research Associate

Department of Physics

University of Alabama at Hunstville

LSE 205

4:00 P.M.

Wednesday February 9

Refreshments Immediately following

Arkansas Space Grant Consortium

ASU · Harding U. · UAF · UALR · UAMS · UAPB · UCA

NASA

7 February 1994
NL-4010c

Dr. Don Wold
Department of Physics & Astronomy
University of Arkansas at Little Rock
Little Rock, Arkansas 72204

Dear Dr. Wold:

On behalf of the Planning Committee of the Arkansas Space Grant Consortium, it is my pleasure to inform you of the approval of your **ASGC Guest Lecturer Program** application:

Lectures on Results from EGRET in the Gamma Ray Observatory.
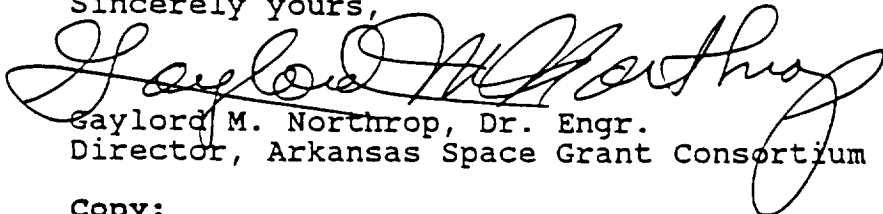
The amount of the grant is **$ 1,160**, as you requested. These funds are to be expended under **UALR Account No. 43-60-40** in accordance with the budget in your proposal. Should you have reason to wish to spend funds in some other manner, please contact me (569-8212) before doing so.

Purchase orders should be approved by me. Your expenditure of these funds should follow the enclosed Guidelines. Should you have questions concerning the billing process, please discuss them with me first.

This grant is valid through **28 February 1995**.

Again, congratulations on your award. NASA and the Arkansas Space Grant Consortium look forward to the success of your ASGC Guest Lecturer Grant.

Sincerely yours,

Gaylord M. Northrop, Dr. Engr.
Director, Arkansas Space Grant Consortium

Copy:

Ms. Linda Burnett .... Grants Accounting/UALR

Application for an ASGC Guest Lecturer Grant
Year Three
Arkansas Space Grant Consortium

Outreach Project Title:			Date: 05/02/94

Lectures on Results from EGRET in the Gamma Ray Observatory

Institution:	Street/Box No.	City	Zip
UALR	2801 S. University Avenue	Little Rock, AR	72204

Names of Faculty Involved:	Title:	Department:	SSN
1. Donald C. Wold.	Professor	Physics and Astronomy	
2. See below.			
3.			

Principal Investigator's Telephone No.: (501) 569-8962

Abstract of Project:

    The funding of a seminar speaker is proposed. The ASGC guest lecturer is Dr. Robert C. Hartman, Astrophysicist, Laboratory for High Energy Astrophysics, NASA/Goddard Space Flight Center. He is Co-Investigator of the GRO/EGRET High-Energy Gamma Ray Telescope. The EGRET gamma ray detector is part of NASA's Compton Gamma Ray Observatory. He will speak on "Results from the EGRET Instrument in the Compton Gamma-Ray Observatory" Presentations are planned at the University of Arkansas at Little Rock and the University of Arkansas at Pine Bluff on March 29 and 30, 1994, respectively. His hosts will be Professor Donald C. Wold of the Department of Physics and Astronomy, UALR, and Professor Ebo Tei, Professor of Psychology, Department of Social and Behavioral Science, UAPB. Support is requested for airplane fares, local transportation, hotel costs, and meals.

    Dr. Hartman will speak on current observations of gamma rays with the EGRET instrument on NASA's Compton Gamma Ray Observatory. Dr. Hartman has agreed to arrive on Tuesday, March 29, 1994, to present a public seminar in the afternoon at 4:15 p.m., to leave Little Rock on Wednesday morning, March 30, to go to the University of Arkansas at Pine Bluff, and to present a public seminar at 10:00 a.m. He will depart back to the NASA/Goddard Space Flight Center, Greenbelt, Maryland, in the afternoon or evening. The lecture at UALR will be more specialized, but both presentations are open to the general public. Faculty and students of all institutions making up the Arkansas Space Grant Consortium are invited to participate. Drs. Tei and Wold will schedule individual conference with those consortium members who wish private interviews with astrophysicist Dr. Robert C. Hartman. The support of the Arkansas Space Grant Consortium will be acknowledged in the public announcements.

Summary of Funds Requested for This Outreach Grant			
1. Travel (mileage, etc.)	$475	5. Meals	$50
2. Equipment (State Funds)	$0	6. Honorarium	$0
3. Materials	$0	7.	$0
4. Hotels	$75	Total	$600

    Current air fares were obtained on the day this proposal was submitted. They do require an advance purchase of tickets to obtain these coach prices. Schedules are not firmly set at the present time, so hotel and meal costs are estimated for the longest possible period.

Application for an ASGC Guest Lecturer Grant
Year Three
Arkansas Space Grant Consortium

Outreach Project Title:			Date: 02/02/94

Lectures on Results from EGRET in the Gamma Ray Observatory

Institution:	Street/Box No.	City	Zip
UALR	2801 S. University Avenue	Little Rock, AR	7220 4

Names of Faculty Involved:	Title:	Department:		SSN
1. Donald C. Wold.	Professor	Physics and Astronomy		███████
2. See below.				
3.				

Principal Investigator's Telephone No.: (501) 569-8962

Abstract of Project

The funding of a seminar speaker is proposed. The ASGC guest lecturer is Dr. Robert C. Hartman, Astrophysicist, Laboratory for High Energy Astrophysics, NASA/Goddard Space Flight Center. He is Co-Investigator of the GRO/EGRET High-Energy Gamma Ray Telescope. The EGRET gamma ray detector is part of NASA's Compton Gamma Ray Observatory. He will speak on "Results from the EGRET Instrument in the Compton Gamma-Ray Observatory" Presentations are planned at the University of Arkansas at Little Rock and the University of Arkansas at Pine Bluff on March 29 and 30, 1994, respectively. His hosts will be Professor Donald C. Wold of the Department of Physics and Astronomy, UALR, and Professor Ebo Tei, Professor of Psychology, Department of Social and Behavorial Science, UAPB. Support is requested for airplane fares, local transportation, hotel costs, and meals.

Dr. Hartman will speak on current observations of gamma rays with the EGRET instrument on NASA's Compton Gamma Ray Observatory. Dr. Hartman has agreed to arrive on Tuesday, March 29, 1994, to present a public seminar in the afternoon at 4:15 p.m., to leave Little Rock on Wednesday morning, March 30, to go to the University of Arkansas at Pine Bluff, and to present a public seminar at 1:00 p.m. He will depart back to the NASA/Goddard Space Flight Center, Greenbelt, Maryland, in the afternoon or evening. The lecture at UALR will be more specialized, but both presentations are open to the general public. Faculty and students of all institutions making up the Arkansas Space Grant Consortium are invited to participate. Drs. Tei and Wold will schedule individual conference with those consortium members who wish private interviews with astrophysicist Dr. Robert C. Hartman. The support of the Arkansas Space Grant Consortium will be acknowledged in the public announcements.

Summary of Funds Requested for This Outreach Grant:				
1. Travel (mileage, etc.)	$935		5. Meals	$75
2. Equipment (State Funds)	$0		6. Honorarium	$0
3. Materials	$0		7.	$0
4. Hotels	$150		Total	$1,160

Current air fares were obtained on the day this proposal was submitted. They do require an advance purchase of tickets to obtain these coach prices. Schedules are not firmly set at the present time, so hotel and meal costs are estimated for the longest possible period.

UALR

"Results from EGRET in the Gamma Ray Observatory"

by

Dr. Robert C. Hartman

Laboratory for High Energy Astrophysics
NASA/Goddard Space Flight Center
Greenbelt, MD

Tuesday, March 29, 1994

Natural Science 101

Refreshments @ 4:00 p.m.
Seminar @ 4:15 p.m.

Arkansas Space Grant Consortium

ASU · Harding U. · UAF · UALR · UAMS · UAPB · UCA

NASA

7 February 1994
NL-4010d

Dr. Don Wold
Department of Physics & Astronomy
University of Arkansas at Little Rock
Little Rock, Arkansas 72204

Dear Dr. Wold:

On behalf of the Planning Committee of the Arkansas Space
Grant Consortium, it is my pleasure to inform you of the
approval of your ASGC Guest Lecturer Program application:

**Lectures on Extending Gamma Ray
Observations Beyond the GRO.**
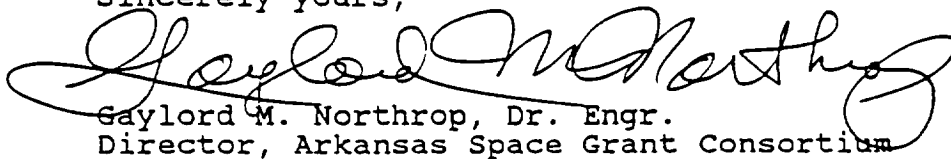
The amount of the grant is $ 1,325, as you requested. These
funds are to be expended under **UALR Account No. 43-60-40** in
accordance with the budget in your proposal. Should you have
reason to wish to spend funds in some other manner, please
contact me (569-8212) before doing so.

Purchase orders should be approved by me. Your expenditure
of these funds should follow the enclosed Guidelines. Should
you have questions concerning the billing process, please
discuss them with me first.

This grant is valid through **28 February 1995.**

Again, congratulations on your award. NASA and the Arkansas
Space Grant Consortium look forward to the success of your
ASGC Guest Lecturer Grant.

Sincerely yours,

Gaylord M. Northrop, Dr. Engr.
Director, Arkansas Space Grant Consortium

Copy:

Ms. Linda Burnett .... Grants Accounting/UALR

Application for an ASGC Guest Lecturer Grant
Year Three
Arkansas Space Grant Consortium

Outreach Project Title:		Date: 05/02/94

Lectures on Extending Gamma Ray Observations Beyond the GRO

Institution:	Street/Box No.	City	Zip
UALR	2801 S. University Avenue	Little Rock, AR	72204

Names of Faculty Involved:	Title:	Department:	SSN
1. Donald C. Wold.	Professor	Physics and Astronomy	██████
2. See below.			
3.			

Principal Investigator's Telephone No.: (501) 569-8962

Abstract of Project

   The funding of a seminar speaker is proposed. The speaker is Professor Jordan Goodman, Department of Physics, University of Maryland, College Park, Maryland. Professor Goodman is a member of the CYGNUS collaboration and the MILAGRO collaboration. These gamma ray detectors will provide coverage from low energy gamma rays currently detected with NASA's Compton Gamma Ray Observatory to much higher energies. He will speak on "Particle Astrophysics - AGN's, GRB's, PBH's, etc.". Presentations are planned at the University of Arkansas at Little Rock and University of Central Arkansas on March 8 and 9, 1994, respectively. Hosts will be Professor Donald C. Wold of the Department of Physics and Astronomy, UALR, and Professor Stephen R. Addison, Chair of Physics, UCA. Support is requested for airplane fares, local transportation, hotel costs, meals, and honorarium.

   Professor Goodman will speak on active galactic nuclei, gamma ray bursters, and primordial black holes as possible sources of gamma rays observed by NASA's Compton Gamma Ray Observatory. Professor Goodman has agreed to arrive on Tuesday, March 8, 1994, to present a public seminar in the afternoon at 4:15 p.m., to leave Little Rock on Wednesday morning, March 9, to go to University of Central Arkansas, and to present a public seminar at 1:00 p.m. He will depart back to the University of Maryland, College Park, in the afternoon or evening. The lecture at UALR will be more specialized, but both presentations are open to the general public. Faculty and students of all institutions making up the Arkansas Space Grant Consortium are invited to participate. Drs. Addison and Wold will schedule individual conference with those consortium members who wish private interviews with Professor Goodman. The support of the Arkansas Space Grant Consortium will be acknowledged in the public announcements.

Summary of Funds Requested for This Outreach Grant			
1. Travel (mileage, etc.)	$850	5. Meals	$75
2. Equipment (State Funds).	$0	6. Honorarium	$250
3. Materials	$0	7.	$0
4. Hotels	$150	Total	$1,325

   Current air fares were obtained on the day this proposal was submitted. They do require an advance purchase of tickets to obtain these coach prices. Schedules are not firmly set at the present time, so hotel and meal costs are estimated for the longest possible period.

UALR

"Particle Astrophysics -

AGN's, GRB's, PBH's, etc."

by

Professor Jordan Goodman

Department of Physics
University of Maryland
College Park, Maryland

Tuesday, March 8, 1994   NS101

Refreshments @ 4:00 p.m.
Seminar @ 4:15 p.m.

Arkansas Space Grant Consortium

ASU · Harding U. · UAF · UALR · UAMS · UAPB · UCA

NASA

18 March 1994
NL-4010g

Dr. Don Wold
Department of Physics & Astronomy
University of Arkansas at Little Rock
Little Rock, Arkansas 72204

Dear Dr. Wold:

On behalf of the Planning Committee of the Arkansas Space
Grant Consortium, it is my pleasure to inform you of the
approval of your ASGC Guest Lecturer Program application:

   Lectures on Cosmic Ray Physics and Particle Astrophysics.

The amount of the grant is $1,275, as you requested. These
funds are to be expended under UALR Account No. 43-60-40 in
accordance with the budget in your proposal. Should you have
reason to wish to spend funds in some other manner, please
contact me (569-8212) before doing so.

Purchase orders should be approved by me. Your expenditure
of these funds should follow the enclosed Guidelines. Should
you have questions concerning the billing process, please
discuss them with me first.

This grant is valid through 31 March 1995.

Again, congratulations on your award. NASA and the Arkansas
Space Grant Consortium look forward to the success of your
ASGC Guest Lecturer Grant.

Sincerely yours,

Gaylord M. Northrop, Dr. Engr.
Director, Arkansas Space Grant Consortium

Copy:

Ms. Linda Burnett .... Grants Accounting/UALR

Application for an ASGC Guest Lecturer Grant
Year Three
Arkansas Space Grant Consortium

Outreach Project Title:			Date: 05/03/94

Lectures on cosmic ray physics and particle astrophysics

Institution:	Street/Box No.	City	Zip
UALR	2801 S. University Avenue	Little Rock, AR	7220 4

Names of Faculty Involved:	Title:	Department:		SSN
1. Donald C. Wold.	Professor	Physics and Astronomy		
2. See below.				
3.				

Principal Investigator's Telephone No.: (501) 569-8962

Abstract of Project:

    The funding of a seminar speaker is proposed. The speaker is Research Professor R. Jeffrey Wilkes, Department of Physics, University of Washington, Seattle, Washington. Professor Wilkes is spokesman for the Japanese-American Cooperative Emulsion Experiment (JACEE). The detectors for these cosmic ray experiments are launched in balloons. JACEE experiments receive support from NASA. He will speak on "The JACEE Experiments in Cosmic Ray Physics". Presentations are planned at Henderson State University at Arkadelphia and the University of Arkansas at Little Rock on March 15, 1994. The topic of his lecture at UALR on March 16 will be "Particle Astrophysics with DUMAND." Hosts will be Professor Donald C. Wold of the Department of Physics and Astronomy, UALR, and Professor Charles Leming, Department of Physics, Henderson State University. Support is requested for airplane fares, local transportation, hotel costs, meals, and honorarium.

    Professor Wilkes will speak on cosmic ray experiments which have been performed by the JACEE collaboration at NASA/Marshall Space Flight Center and other places. Professor Wilkes has agreed to arrive on Monday evening, Monday, March 14, 1994, to present a public seminar Tuesday morning at 11:00 a.m. in Arkadelphia, to present a public lecture on Tuesday afternoon at 4:15 pm at UALR, and to present a public lecture Wednesday morning at UALR at 11:00 am.. He will depart back to the University of Washington, Seattle, in the afternoon.

    Both presentations are open to the general public. Faculty and students of all institutions making up the Arkansas Space Grant Consortium are invited to participate. Drs. Leming and Wold will schedule individual conference with those consortium members who wish private interviews with Professor Wilkes. The support of the Arkansas Space Grant Consortium will be acknowledged in the public announcements

Summary of Funds Requested for This Outreach Grant:				
1. Travel (mileage, etc.)	$800		5. Meals	$ 75
2. Equipment (State Funds)	$0		6. Honorarium	$250
3. Materials	$0		7.	$0
4. Hotels	$150		Total	$1,275

    Current air fares were obtained on the day this proposal was submitted. They do require an advance purchase of tickets to obtain these coach prices. Schedules are not firmly set at the present time, so hotel and meal costs are estimated for the longest possible period.

UALR

DEPARTMENT OF PHYSICS & ASTRONOMY SEMINAR
Co-sponsored by the Arkansas Space Grant Consortium

"Particle Astrophysics with DUMAND"

by

Dr. Jeffrey Wilkes

Department of Physics
University of Washington
Seattle, Washington

Wenesday, March 16, 1994

Physics 201

11:00 a.m.

UALR

DEPARTMENT OF PHYSICS & ASTRONOMY SEMINAR
Co-sponsored by the Arkansas Space Grant Consortium

"The JACEE

Experiments in Cosmic

Ray Physics"

by

Dr. Jeffrey Wilkes

Department of Physics
University of Washington
Seattle, Washington

Tuesday, March 15, 1994

NS101

Refreshments @ 4:00 p.m.
Seminar @ 4:15 p.m.

Arkansas Space Grant Consortium

ASU · Harding U. · UAF · UALR · UAMS · UAPB · UCA

NASA

18 March 1994
NL-4010f

Dr. Don Wold
Department of Physics & Astronomy
University of Arkansas at Little Rock
Little Rock, Arkansas 72204

Dear Dr. Wold:

On behalf of the Planning Committee of the Arkansas Space
Grant Consortium, it is my pleasure to inform you of the
approval of your **ASGC Guest Lecturer Program** application:

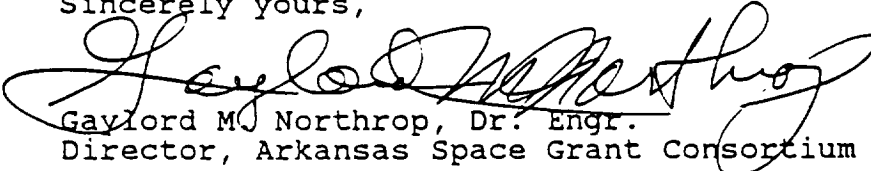   **Lectures on the Elemental Composition of Cosmic Rays.**

The amount of the grant is **$ 680**, as you requested. These
funds are to be expended under **UALR Account No. 43-60-40** in
accordance with the budget in your proposal. Should you have
reason to wish to spend funds in some other manner, please
contact me (569-8212) before doing so.

Purchase orders should be approved by me. Your expenditure
of these funds should follow the enclosed Guidelines. Should
you have questions concerning the billing process, please
discuss them with me first.

This grant is valid through **31 March 1995.**

Again, congratulations on your award. NASA and the Arkansas
Space Grant Consortium look forward to the success of your
ASGC Guest Lecturer Grant.

Sincerely yours,

Gaylord M. Northrop, Dr. Engr.
Director, Arkansas Space Grant Consortium

Copy:

Ms. Linda Burnett .... Grants Accounting/UALR

Application for an ASGC Guest Lecturer Grant
Year Three
Arkansas Space Grant Consortium

Outreach Project Title:		Date: 05/02/94

Lectures on Elemental Composition of Cosmic Rays

Institution:	Street/Box No.	City	Zip
UALR	2801 S. University Avenue	Little Rock, AR	7220 4

Names of Faculty Involved:	Title:	Department:	SSN
1. Donald C. Wold.	Professor	Physics and Astronomy	████████
2. See below.			
3.			

Principal Investigator's Telephone No.: (501) 569-8962

Abstract of Project:

　　　The funding of a seminar speaker is proposed. The speaker is Associate Professor Michael L. Cherry, Department of Physics and Astronomy, Louisiana State University, Baton Rouge, Louisiana. Professor Cherry is a member of the Japanese-American Cooperative Emulsion Experiment (JACEE). The detectors for these cosmic ray experiments are launched in balloons. JACEE experiments receive support from NASA. He will speak on "Composition of Cosmic Rays". Presentations are planned at the University of Arkansas at Little Rock and Harding University on April 14 and 15, 1994, respectively. Hosts will be Professor Donald C. Wold of the Department of Physics and Astronomy, UALR, and Professor Edmond W. Wilson, Jr., Professor of Chemistry, Harding University. Support is requested for airplane fares, local transportation, hotel costs, meals, and honorarium.

　　　Professor Cherry will speak on new results from the JACEE experiments concerning elemental compostion of cosmic rays. Professor Cherry has agreed to arrive on Thursday, April 14, 1994, to present a public seminar in the afternoon at 4:15 p.m., to leave Little Rock on Friday morning, April 14, to go to Harding University, and to present a public seminar at 1:00 p.m. He will return to the Louisiana State University, Baton Rouge, in the afternoon or evening. The lecture at UALR will be more specialized, but both presentations are open to the general public. Faculty and students of all institutions making up the Arkansas Space Grant Consortium are invited to participate. Drs. Wilson and Wold will schedule individual conferences with those consortium members who wish private interviews with Professor Cherry. The support of the Arkansas Space Grant Consortium will be acknowledged in the public announcements.

Summary of Funds Requested for This Outreach Grant:			
1. Travel (mileage, etc.)	$205	5. Meals	$75
2. Equipment (State Funds)	$0	6. Honorarium	$250
3. Materials	$0	7.	$0
4. Hotels	$150	Total	$680

　　　Current air fares were obtained on the day this proposal was submitted. They do require an advance purchase of tickets to obtain these coach prices. Schedules are not firmly set at the present time, so hotel and meal costs are estimated for the longest possible period.

UALR

"Composition of High Energy Cosmic Rays"

by

Dr. Michael Cherry

Department of Physics & Astronomy
Louisiana State University
Baton Rouge, LA

Thursday, April 14, 1994

Natural Science 101

Refreshments @ 4:00 p.m.
Seminar @ 4:15 p.m.

Arkansas Space Grant Consortium Speaker

Title of Presentation

Composition of High Energy Cosmic Rays

Speaker

Professor Michael Cherry, PhD

Time & Place

1:00 PM
Friday
April 15, 1994

Pryor Science Center Room 30

Professor Cherry is a member of the Department of Physics and Astronomy
at the Louisiana State University, Baton Rouge, Louisiana. Dr. Cherry
also is active in the Japanese-American Cooperative Emulsion Experiment,
JACEE. The Detectors for these cosmic ray experiments are launched in
balloons. JACEE experiments receive support from NASA.

All interested parties are invited and encouraged to attend. If you wish to
eat lunch with Dr. Cherry (Dutch Treat). We will probable eat at the
Cookie Basket about 11:30 on Friday. See Ed Wilson for details.

17 January 1995
NL-5010f
UALR0049

Dr. Donald Wold
Department of Physics and Astronomy
University of Arkansas at Little Rock
2801 S. University Ave.
Little Rock, Arkansas 72204

Dear Dr. Wold:

On behalf of the Planning Committee of the Arkansas Space
Grant Consortium, it is my pleasure to inform you of the
approval of your **ASGC Guest Lecturer Program** application:

**Astrophysics with High Energy Neutrinos:
the AMANDA Detector.**

The amount of the grant is **$1,200**, as you requested. These
funds are to be expended under **UALR Account No. 43-60-40** in
accordance with the budget in your proposal. Should you have
reason to wish to spend funds in some other manner, please
contact me (569-8212) before doing so.

Purchase orders should be approved by me. Your expenditure
of these funds should follow the enclosed Guidelines. Should
you have questions concerning the billing process, please
discuss them with me first.

This grant is valid through **31 January 1996.**

Again, congratulations on your award. NASA and the Arkansas
Space Grant Consortium look forward to the success of your
ASGC Guest Lecturer Grant.

Sincerely yours,

Gaylord M. Northrop, Dr. Engr.
Director, Arkansas Space Grant Consortium

Copy:

Mr. Jerry Crittenden .... Grants Accounting/UALR

Application for an ASGC Guest Lecturer Grant
Year Three
Arkansas Space Grant Consortium

Outreach Project Title:		Date: 02/07/95

Lectures on astrophysics with high energy neutrinos: the AMANDA detector

Institution:	Street/Box No.	City	Zip
UALR	2801 S. University Avenue	Little Rock, AR	72204

Names of Faculty Involved:	Title:	Department:	SSN
1. Donald C. Wold.	Professor	Physics and Astronomy	
2. See below.			
3.			

Principal Investigator's Telephone No.: (501) 569-8962

Abstract of Project:

　　The funding of a seminar speaker is proposed. The speaker is Hilldale Professor Francis Halzen, Phenomenology Institute, Department of Physics, University of Wisconsin - Madison, 1150 University Avenue, Madison, WI 53706. Professor Halzen is spokesman for the AMANDA collaboration. The detectors for these neutrino experiments are located in the Antarctica. The Cherenkov tubes are immersed in the polar ice cap. He will speak on "The Antarctic Muon and Neutrino Detector Array (AMANDA)". Presentations are planned at the University of Arkansas at Little Rock and the University of Arkansas at Pine Bluff on March 7 and 8, 1995, respectively. Hosts will be Professor Donald C. Wold of the Department of Physics and Astronomy, UALR, and Professor Ebo Tei, Professor of Psychology, Department of Social and Behavioral Science, University of Arkansas at Pine Bluff. Support is requested for airplane fares, local transportation, hotel costs, meals, and honorarium.

　　Professor Halzen will speak on particle physics and astrophysics with high energy neutrinos. Professor Halzen has agreed to arrive on Monday evening or Tuesday morning to present a seminar on Tuesday afternoon at 4:00 p.m. in Little Rock. He will present a public lecture from 11:30 a.m. to 12:30 p.m. on Wednesday at UAPB. Dr. Halzen will be available for informal discussions with students and faculty at 10:00 am or earlier if desired. He will depart back to the University of Wisconsin, Madison, in the afternoon or evening.

　　Both presentations are open to the general public. Faculty and students of all institutions making up the Arkansas Space Grant Consortium are invited to participate. Drs. Tei and Wold will schedule individual conference with those consortium members who wish private interviews with Professor Halzen. The support of the Arkansas Space Grant Consortium will be acknowledged in the public announcements.

Summary of Funds Requested for This Outreach Grant:				
1. Travel (mileage, etc.)	$725		5. Meals	$75
2. Equipment (State Funds)	$0		6. Honorarium	$250
3. Materials	$0		7.	$0
4. Hotels	$150		Total	$1,200

　　Current air fares were obtained on the day this proposal was submitted. They do require an advance purchase of tickets to obtain these coach prices. Schedules are not firmly set at the present time, so hotel and meal costs are estimated for the longest possible period.

PHYSICS AND ASTRONOMY SEMINAR

COSPONSORED BY

ARKANSAS SPACE GRANT CONSORTIUM

"*The Antarctic Muon and Neutrino Detector Array (AMANDA)*"

by

Hilldale Professor Francis Halzen

Phenomenology Institute
Department of Physics
University of Wisconsin - Madison

March 7, 1995

Fribourgh Hall 101

refreshments @ 3:45 p.m.
seminar @ 4:00 p.m.

Everyone is invited

7 September 1995
NL-6014M
UALR0062

Mr. Trevis A. Crane, Undergraduate Student
University of Arkansas at Little Rock
Dept. of Physics & Astronomy
2801 S. University
Little Rock, AR 72801

Dear Mr. Crane:

On behalf of the Planning Committee of the Arkansas Space Grant Consortium, it is my pleasure to inform you of the approval of your Student Scholarship application:

Survey of Cosmic Ray Observatories.

The amount of the grant is $3,060, as you requested. These funds are to be expended under UALR Account No. 43-60-60 in accordance with the budget in your proposal. Should you have reason to wish to spend funds in some other manner, please contact your mentor, Dr. Donald Wold (569-8962), and me (569-8212) before doing so.

Your ASGC Grant Identification No. is UALR0062. This Identification Number should be clearly indicated on all purchase orders, invoices and correspondence. Your expenditure of these funds should follow the enclosed Guidelines. The enclosed Payments Summary Sheets are to be manually updated and a copy sent to the ASGC Program Office with each request for repayment (invoice) of expended funds. Purchase orders are to be approved initally by Dr. Wold. Should you have questions concerning the billing process, please discuss them first with Dr. Wold and then me, if necessary.

This grant is valid through 30 September 1996.

Again, congratulations on your award. NASA and the Arkansas Space Grant Consortium look forward to your accomplishments.

Sincerely yours,

Gaylord M. Northrop, Dr. Engr.
Director, Arkansas Space Grant Consortium

Copies:
Dr. Donald Wold .... Dept. of Physics & Astronomy/UALR
Mr. Bob Highfill .... Grants Accounting/UALR

Undergraduate Student Scholarship Application Form
Year Five
Arkansas Space Grant Consortium

Project Title:	Date: 09/06/95

Survey of Cosmic Ray Observatories

Institution:	Street/Box No.	City	Zip
UALR	2801 S. University Avenue	Little Rock, AR	72204

Name of Student:	Standing:	Program Major:	GPA	SSN
Trevis A. Crane	Sophomore	B. S. Physics	4.0	██████

Address:	Street:	2106 S. Gaines Street			
	City:	Little Rock	State:	AR	Zip	72206
	Telephone:	(501) 374 - 8493			

Names of Faculty Mentor(s):	Title:	Department:	Telephone
1. Donald C. Wold.	Professor	Physics and Astronomy	501 569 8962
2.			

Summary of Project: (Please follow the eight parts of the proposal. [See Guidelines])

1. **Enhancement of the Applicant's Capabilities:** The applicant will learn about gamma ray detectors in the NASA/GRO and higher energy gamma ray detectors. The applicant will communicate directly with spokespersons of the experiments being conducted with the cosmic ray observatories about the characteristics of the detectors.

2. **NASA Research or Space Centers to be Visited:** The applicant will visit Los Alamos National Laboratory and MILAGRO, a detector for 1 - 1,000 TeV cosmic gamma rays. The applicant will attend a collaboration meeting of the MILAGRO research group.

3. **Written Output Products of This Project:** The applicant will prepare a research paper summarizing the results of his survey of cosmic ray detectors, experiments, and observatories. The applicant will work with Mr. LaCour to produce a final report entitled: "Survey of Gamma Ray and Cosmic Ray Observatories."

4. **NASA Graduate Student Research Program:** Not applicable.

5. **Research Project Description:** The applicant's investigation will include a survey of the characteristics of detectors for low energy gamma rays detectors for higher energy gamma rays as measured at cosmic ray observatories. This applicant will concentrate on cosmic ray observatories, whereas Mr. LaCour will concentrate on gamma ray observatories.

6. **Use of Project Results:** This research project will be used as the basis for a professional paper to be submitted to the Arkansas Academy of Science, and for other presentations.

7. **Outreach Activity Plan:** The information about gamma ray detectors and cosmic ray observatories will be shared with astrophysicists, faculty and K-16 students.

8. **Quarterly and Final Reports:** The applicant will report as required on the progress of the grant activities.

Summary of Funds Requested for This Student Scholarship:			
1. Travel (airfare, motel, car)	$560	5. Materials	$400
2. Tuition	$0	6.	
3. Stipend	$2,000	7.	
4. Outreach Activities	$100	Total	$3,060

Current air fares were obtained on the day this proposal was submitted. They do require an advance purchase of tickets to obtain these coach prices. Schedules are not firmly set at the present time, so hotel and meal costs are estimated for the longest possible period.

7 September 1995
NL-6014L
UALR0060

Mr. Michael LaCour, Undergraduate Student
University of Arkansas at Little Rock
Dept. of Physics & Astronomy
2801 S. University
Little Rock, AR 72801

Dear Mr. LaCour:

On behalf of the Planning Committee of the Arkansas Space Grant
Consortium, it is my pleasure to inform you of the approval of your
Student Scholarship application:

> Detectors for Particle Astrophysics from the
> Compton GRO to the Giant Air Shower Array.

The amount of the grant is $3,300, as you requested. These funds
are to be expended under UALR Account No. 43-60-60 in accordance
with the budget in your proposal. Should you have reason to wish to
spend funds in some other manner, please contact your mentor,
Dr. Donald Wold (569-8962), and me (569-8212) before doing so.

Your ASGC Grant Identification No. is UALR0060. This Identification
Number should be clearly indicated on all purchase orders, invoices
and correspondence. Your expenditure of these funds should follow
the enclosed Guidelines. The enclosed Payments Summary Sheets are
to be manually updated and a copy sent to the ASGC Program Office
with each request for repayment (invoice) of expended funds.
Purchase orders are to be approved by Dr. Wold. Should you have
questions concerning the billing process, please discuss them first
with Dr. Wold and then me, if necessary.

This grant is valid through 30 September 1996.

Again, congratulations on your award. NASA and the Arkansas Space
Grant Consortium look forward to your accomplishments.

Sincerely yours,

Gaylord M. Northrop, Dr. Engr.
Director, Arkansas Space Grant Consortium

Copies:
Dr. Donald Wold .... Dept. of Physics & Astronomy/UALR
Mr. Bob Highfill .... Grants Accounting/UALR

Undergraduate Student Scholarship Application Form
Year Five
Arkansas Space Grant Consortium

Project Title:	Date: 09/05/95

Survey of Gamma Ray Observatories

Institution:	Street/Box No.	City	Zip
UALR	2801 S. University Avenue	Little Rock, AR	72204

Name of Student:	Standing:	Program Major:	GPA	SSN
Michael LaCour	Junior	Physics/Biology	3.4	████

Address:	Street:	1705 N. Pierce			
	City:	Little Rock	State:	AR	Zip 72207
	Telephone:	(501) 666 - 0276			

Names of Faculty Mentor(s):	Title:	Department:	Telephone
1. Donald C. Wold.	Professor	Physics and Astronomy	501 569 8962
2.			

Summary of Project: (Please follow the eight parts of the proposal. [See Guidelines])

1. **Enhancement of the Applicant's Capabilities:** The applicant will learn about gamma ray detectors in the NASA/GRO and higher energy gamma ray detectors. The applicant will communicate directly with spokespersons of the experiments being conducted with the gamma ray observatories about the characteristics of the detectors.

2. **NASA Research or Space Centers to be Visited:** The applicant will visit NASA\Goddard Space Flight Center, the U.S. Naval Research Laboratory, and the University of Maryland.

3. **Written Output Products of This Project:** The applicant will prepare a research paper summarizing the results of his survey of gamma ray detectors, experiments, and observatories. The applicant will work with Mr. Crane to produce a final report of the study entitled: "Survey of Gamma Ray and Cosmic Ray Observatories."

4. **NASA Graduate Student Research Program:** Not applicable.

5. **Research Project Description:** The applicant's investigation will include a survey of the characteristics of detectors for low energy gamma rays as observed in the Compton GRO to detectors for higher energy gamma rays. This applicant will concentrate on gamma ray observatories, whereas Mr. Crane will concentrate on cosmic ray observatories.

6. **Use of Project Results:** This research project will be used as the basis for a professional paper to be submitted to the Arkansas Academy of Science, and for other presentations.

7. **Outreach Activity Plan:** The information about gamma ray detectors and gamma ray observatories will be shared with astrophysicists, faculty and K-16 students.

8. **Quarterly and Final Reports:** The applicant will report as required on the progress of the grant activities.

Summary of Funds Requested for This Student Scholarship:

1. Travel (airfare, motel, etc)	$850	5. Materials	$400
2. Tuition	$0	6.	
3. Stipend	$2,000	7.	
4. Outreach Activities	$100	Total	$3,350

Current air fares were obtained on the day this proposal was submitted. They do require an advance purchase of tickets to obtain these coach prices. Schedules are not firmly set at the present time, so hotel and meal costs are estimated for the longest possible period.

7 September 1995
NL-6012B
UALR0061

Dr. Donald Wold
Department of Physics & Astronomy
University of Arkansas at Little Rock
2801 S. University
Little Rock, AR 72204-1099

Dear Dr. Wold:

On behalf of the Planning Committee of the Arkansas Space Grant
Consortium, it is my pleasure to inform you of the approval of
your Research Infrastructure Grant application:

Astrophysics Experiments with NASA's GRO and MILAGRO.

The amount of the grant is $ 2,550, which is less than you
requested. A 1:1 equipment match of $250 by UALR is
required. This proposal was approved with the condition that
the details of your budget be worked out between you and me.
These funds are to be expended under UALR Account No. 43-60-30
in accordance with the amended budget in your proposal. Should
you have reason to wish to spend funds in some other manner,
please contact me (569-8212) before doing so.

Your ASGC Grant Identification No. is UALR0061. This
Identification Number should be clearly indicated on all
purchase orders, invoices and correspondence. Your expenditure
of these funds should follow the enclosed Guidelines. The
enclosed Payments Summary Sheets are to be manually updated and
a copy sent to the ASGC Program Office with each request for
repayment (invoice) of expended funds. Purchase orders are to
be approved by me. Should you have questions concerning the
billing process, please discuss them with me.

This grant is valid through 30 September 1996.

Again, congratulations on your award. NASA and the Arkansas
Space Grant Consortium look forward to your accomplishments.

Sincerely yours,

Gaylord M. Northrop, Dr. Engr.
Director, Arkansas Space Grant Consortium

Copy:
Mr. Bob Highfill .... Grants Accounting/UALR

Application for a Research Infrastructure Grant
Year Five
Arkansas Space Grant Consortium

Project Title:				Date: 09/06/95

Astrophysics Experiments with the Compton GRO and MILAGRO

Institution:	Street/Box No.	City		Zip
UALR	2801 S. University Avenue	Little Rock, AR		72204

Names of Faculty Involved:	Title:	Department:		Telephone
1. Donald C. Wold.	Professor	Physics and Astronomy		501 569 8962
2.				

Principal Investigator's Telephone Number: (501) 569-8962

Name of Student Involved:	Standing:	Program Major:	GPA	SSN
Trevis A. Crane	Sophomore	B. S. Physics	4.0	■■■■■■
Michael LaCour	Junior	Physics/Biology	3.4	■■■■■■

Summary of Project: (Please follow the eight parts of the proposal. [See Guidelines])

1. Enhancement of the Applicant's Capabilities: The applicant will develop an understanding of NASA's Compton GRO for conducting coincidence experiments with MILAGRO, a new gamma ray telescope. Correlated observations will greatly extend the particle astrophysics potential of MILAGRO and the Compton Observatory.

2. NASA Research or Space Centers to be Visited: The applicant will visit NASA\Goddard Space Flight Center, the U.S. Naval Research Laboratory, the University of Maryland, and the Los Alamos National Laboratory.

3. Written Output Products of This Project: The applicant will prepare a research report summarizing the results of his visits and a proposal to the National Science Foundation for a Research Opportunity Award.

4. Student Mentoring: Several students will be involved in high energy gamma ray and cosmic ray physics research projects. Their activities will be funded by separate Arkansas Space Grant Consortium proposals and DOE funds at Los Alamos National Laboratory.

5. NASA Summer Faculty Fellowship Program: The applicant will apply for summer research support through the NSF Research Opportunity Award program.

6. Course Content Enhancement: This research experience will be integrated into Modern Physics and Mechanics as well as introductory physics courses.

7. Outreach Activity Plan: Information which has been gathered about gamma ray observatories will be shared with astrophysicists, faculty and K-16 students.

8. Quarterly and Final Reports: The applicant will report as required on the progress of the grant activities.

Summary of Funds Requested for This Faculty Enhancement Grant:

1. Travel (airfare, motel, etc)	$1,740	5.	
2. Equipment	$500	6.	
3. Materials	$500	7.	
4. Outreach Activities	$60	**Total**	$2,800

Current air fares were obtained on the day this proposal was submitted. They do require an advance purchase of tickets to obtain these coach prices. Schedules are not firmly set at the present time, so hotel and meal costs are estimated for the longest possible period.

16 November 1995
NL-6011E
UALR0065

Dr. Donald C. Wold
Department of Physics and Astronomy
University of Arkansas at Little Rock
2801 South University Avenue
Little Rock, AR 72204-1099

Dear Dr. Wold:

On behalf of the Planning Committee of the Arkansas Space Grant
Consortium, it is my pleasure to inform you of the approval of
your General Public (Guest Lecturer) Grant application:

> "Lectures on Cosmic Ray Physics: Extremely High Energy
> Cosmic Rays, by Dr. David B. Kieda."

The amount of the grant is $ 850, as you requested. These funds
are to be expended under UALR Account No. 43-60-40 in accordance
with the budget in your proposal. Should you have reason to wish
to spend funds in some other manner, please contact me (569-8212)
before doing so.

Your ASGC Grant Identification No. is UALR0065. This number
should be clearly indicated on all purchase orders, invoices and
correspondence. Your expenditure of these funds should follow the
enclosed Guidelines. The enclosed Payments Summary Sheet is to be
manually updated and a copy sent to the ASGC Program Office with
each request for repayment (invoice) of expended funds. Should
you have questions concerning the billing process, please discuss
them with me.

This grant is valid through 30 November 1996.

Again, congratulations on your award. NASA and the Arkansas Space
Grant Consortium look forward to your accomplishments.

Sincerely yours,

Gaylord M. Northrop, Dr. Engr.
Director, Arkansas Space Grant Consortium

Copy:
Mr. Bob Highfill .... Grants Accounting/UALR

Application for an ASGC Guest Lecturer Grant
Year Five
Arkansas Space Grant Consortium

Guest Lecturer Project Title:			Date: 11/06/95
Lectures on Cosmic Ray Physics: Extremely High Energy Cosmic Rays			

Institution:	Street/Box No.	City	Zip
UALR	2801 S. University Avenue	Little Rock, AR	72204

Names of Faculty Involved:	Title:	Department:	SSN
1. Donald C. Wold.	Professor	Physics and Astronomy	
2. See below.			
3.			

Principal Investigator's Telephone No.: (501) 569-8962

Summary of Project:

   The funding of a seminar speaker is proposed. The speaker is Professor David B. Kieda, Department of Physics, University of Utah, Salt Lake City, Utah 84112. Professor Kieda is a member of the Air Cherenkov Design Group at Fermi National Accelerator Laboratory (Fermilab) for the proposed giant air shower array or Pierre Auger cosmic Ray observatory. Professor Kieda is a member of the Organizing Committee for the 26th International Cosmic Ray Conference (1999).

   Professor Kieda will speak on the cosmic ray energy spectrum observed by the Fly's Eye detector and the proposed Pierre Auger cosmic ray observatory. Probable dates for his presentations are January 22 and 23, 1996, at the Arkansas State University and the University of Arkansas at Little Rock. The topic of his lecture will be "Searching for the Origin of Extremely High Energy Cosmic Rays." Hosts will be Professor Donald C. Wold of the Department of Physics and Astronomy, UALR, and Professor Andrew Sustich, Department of Physics, Arkansas State University. Professor Kieda will probably arrive on Sunday, January 21, and depart on Wednesday, January 24, 1996. Support is requested for airplane fares, local transportation from Little Rock to Jonesboro, hotel costs, meals, and honorarium.

   Professor Kieda's presentations will be open to the general public. Faculty and students of all institutions making up the Arkansas Space Grant Consortium will be invited to participate. Drs. Sustich and Wold will schedule individual conference with those consortium members who wish private interviews with Professor Kieda. The support of the Arkansas Space Grant Consortium will be acknowledged in the public announcements

Summary of Funds Requested for This Outreach Grant			
1. Travel (mileage, etc.)	$375	5.	$0
2. Honorarium	$250	6.	$0
3. Hotels	$150	7.	$0
4. Meals	$75	Total	$850

   Current air fares were obtained on the day this proposal was submitted. They do require an advance purchase of tickets to obtain these coach prices. Schedules are not firmly set at the present time, so hotel and meal costs are estimated for the longest possible period.

PHYSICS & ASTRONOMY

SEMINAR

(Open to the Public)

SPONSORED BY

ARKANSAS SPACE GRANT CONSORTIUM

"Searching for the Origin of Extremely High Energy Cosmic Rays"

by

Prof. David B. Kieda

Department of Physics
University of Utah

Tuesday, Jan. 23, 1996

FH 102

Refreshments @ 4:00 p.m.
Presentation @ 4:15 p.m.

7 September 1995
NL-6011A
UALR0059

Dr. Donald Wold
Department of Physics and Astronomy
University of Arkansas at Little Rock
2801 S. University Ave.
Little Rock, Arkansas 72204

Dear Dr. Wold:

On behalf of the Planning Committee of the Arkansas Space
Grant Consortium, it is my pleasure to inform you of the
approval of your **ASGC Public Service (Guest Lecturer) Program**
application:

> **Lectures on High Energy Gamma Ray Physics**
> **and Cosmic Ray Physics.**

The amount of the grant is $1,200, as you requested. These
funds are to be expended under **UALR Account No. 43-60-40** in
accordance with the budget in your proposal. Should you have
reason to wish to spend funds in some other manner, please
contact me (569-8212) before doing so.

Your ASGC **Grant Identification No.** is **UALR0059**. This
Identification Number should be clearly indicated on all
purchase orders, invoices and correspondence. Your
expenditure of these funds should follow the enclosed
Guidelines. The enclosed **Payments Summary Sheets** are to be
manually updated and a copy sent to the ASGC Program Office
with **each** request for repayment (invoice) of expended funds.
Purchase orders should be approved by me. Your expenditure
of these funds should follow the enclosed Guidelines. Should
you have questions concerning the billing process, please
discuss them with me.

This grant is valid through **30 September 1996.**

Again, congratulations on your award. NASA and the Arkansas
Space Grant Consortium look forward to the success of your
ASGC Guest Lecturer Grant.

Sincerely yours,

Gaylord M. Northrop, Dr. Engr.
Director, Arkansas Space Grant Consortium

Copy:
Mr. Bob Highfill .... Grants Accounting/UALR

Application for an ASGC Guest Lecturer Grant
Year Five
Arkansas Space Grant Consortium

Guest Lecturer Project Title:			Date: 09/06/95	

Lectures on High Energy Gamma Ray and Cosmic Ray Physics

Institution:	Street/Box No.	City		Zip
UALR	2801 S. University Avenue	Little Rock, AR		72204

Names of Faculty Involved:	Title:	Department:		SSN
1. Donald C. Wold.	Professor	Physics and Astronomy		
2. See below.				
3.				

Principal Investigator's Telephone No.: (501) 569-8962

Summary of Project:

The funding of a seminar speaker is proposed. The speaker is Professor Gaurang B. Yodh, Department of Physics, University of California, Irvine, California. Professor Yodh is a spokesperson for the MILAGRO collaboration. MILAGRO is a water-Cherenkov detector for observing cosmic gamma rays over a broad energy range of 1-1,000 TeV. They plan to look in coincidence with BATSE and EGRET if the Compton GRO is still working when MILAGRO is ready. These correlated observations will greatly extend the physics potential of both MILAGRO and NASA's GRO.

Professor Yodh will speak on "Cosmic Rays and their Origin". Probable dates for his presentations are October 8 and 9 at the University of Central Arkansas and the University of Arkansas at Little Rock. The topic of his lecture will be "MILAGRO - a New Gamma Ray Telescope." Hosts will be Professor Donald C. Wold of the Department of Physics and Astronomy, UALR, and Professor Stephen R. Addison, Department of Physics, University of Central Arkansas. Support is requested for airplane fares, local transportation, hotel costs, meals, and honorarium.

Both presentations are open to the general public. Faculty and students of all institutions making up the Arkansas Space Grant Consortium are invited to participate. Drs. Addison and Wold will schedule individual conference with those consortium members who wish private interviews with Professor Yodh. The support of the Arkansas Space Grant Consortium will be acknowledged in the public announcements

Summary of Funds Requested for This Outreach Grant:

1. Travel (mileage, etc.)	$725		5.	$0
2. Honorarium	$250		6.	$0
3. Hotels	$150		7.	$0
4. Meals	$75		Total	$1,200

Current air fares were obtained on the day this proposal was submitted. They do require an advance purchase of tickets to obtain these coach prices. Schedules are not firmly set at the present time, so hotel and meal costs are estimated for the longest possible period.

PHYSICS & ASTRONOMY SEMINAR

Open to the Public

SPONSORED BY

ARKANSAS SPACE GRANT CONSORTIUM

"Milagro: A New Gamma Ray Telescope"

by

Prof. Gaurang B. Yodh

University of California, Irvine

Tuesday, Feb. 20, 1996

PHYS 107

### Refreshments @ 4:00 p.m.
Presentation @ 4:15 p.m.

Abstract

A five million gallon water tank is being instrumented to become an all sky, continuously observing high energy gamma ray telescope. It is located in the Jemez mountains, near Los Alamos, New Mexico, at an altitude of 8,700 feet. It will be sensitive to gamma rays of energies between 100 GeV and 10,000 GeV coming from interesting celestial objects like Active Galactic Nuclei and Gamma Ray Bursters. The novel telescope and its capabilities will be outlined.

OPEN HOUSE

TO MEET DR. GAURANG B. YODH

Professor of Physics
University of California Irvine

Sunday, February 18, 7 to 9 p.m.

at the Wolds'
38 Pine Manor Drive
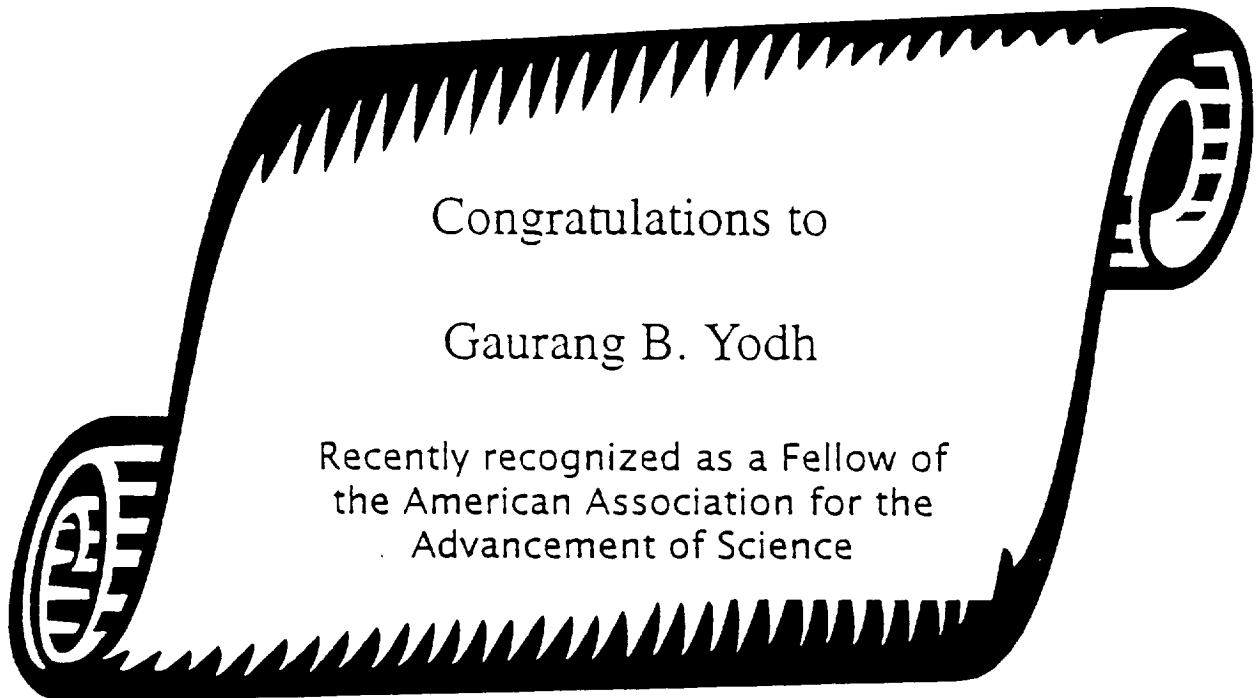
Congratulations to

Gaurang B. Yodh

Recently recognized as a Fellow of
the American Association for the
Advancement of Science

NASA

6 December 1995
NL-6011F
UALR0067

Dr. Donald C. Wold
Department of Physics and Astronomy
University of Arkansas at Little Rock
2801 South University Avenue
Little Rock, AR 72204-1099

Dear Dr. Wold:

On behalf of the Planning Committee of the Arkansas Space Grant
Consortium, it is my pleasure to inform you of the approval of
your **General Public** (Guest Lecturer) Grant application:

> "Lectures on Cosmic Ray Physics: Neutrino
> Oscillation Experiments, by Dr. Maury Goodman."

The amount of the grant is $ 700, as you requested. This grant
was approved with the condition that you try to include a
presentation at the University of Central Arkansas in Dr. Maury
Goodman's schedule. These funds are to be expended under **UALR
Account No. 43-60-40** in accordance with the budget in your
proposal. Should you have reason to wish to spend funds in some
other manner, please contact **me** (569-8212) before doing so.

Your ASGC Grant Identification **No.** is **UALR0067**. This number
should be clearly indicated on all purchase orders, invoices and
correspondence. Your expenditure of these funds should follow the
enclosed **Guidelines**. The enclosed **Payments Summary Sheet** is to be
manually updated and a copy sent to the ASGC Program Office with
each request for repayment (invoice) of expended funds. Should
you have questions concerning the billing process, please discuss
them with me.

This grant is valid through **31 December 1996.**

Again, congratulations on your award. NASA and the Arkansas Space
Grant Consortium look forward to your accomplishments.

Sincerely yours,

Gaylord M. Northrop, Dr. Engr.
Director, Arkansas Space Grant Consortium

Copy:
Mr. Bob Highfill .... Grants Accounting/UALR

Application for an ASGC Guest Lecturer Grant
Year Five
Arkansas Space Grant Consortium

Guest Lecturer Project Title:				Date: 12.05.95

Lectures on Cosmic Ray Physics: Neutrino Oscillation Experiments

Institution:	Street/Box No.	City		Zip
UALR	2801 S. University Avenue	Little Rock, AR		72204

Names of Faculty Involved:	Title:	Department:	SSN
1. Donald C. Wold.	Professor	Physics and Astronomy	
2. See below.			
3.			

Principal Investigator's Telephone No.: (501) 569-8962

Summary of Project:

The funding of a seminar speaker is proposed. The speaker is Dr. Maury Goodman, High Energy Physics Division, Argonne National Laboratory, Argonne, Illinois 60439. Dr. Goodman is Assistant Physicist and Physicist at Fermi National Accelerator Laboratory (Fermilab). Dr. Goodman is spokesman for Fermilab Proposal P-822, A Long-Baseline Neutrino Oscillation Experiment Using the Soudan 2 Neutrino Detector.

Dr. Goodman will speak on the use of the Fermilab neutrino detector for studies of cosmic rays. Probable dates for his presentations are March 4 and 5, 1996, at Harding University and the University of Arkansas at Little Rock. The topic of his lecture will be "Prospects for Long-Baseline Neutrino Oscillation Experiments." Hosts will be Professor Donald C. Wold of the Department of Physics and Astronomy, UALR, and Professor Edmond W. Wilson, Jr., Department of Physical Sciences, Harding University. Professor Goodman will probably arrive on Sunday, March 3, and depart on Tuesday, March 5, 1996. Dr. Goodman's presentation will be at 5:00 p.m. on Monday, March 4, at Harding University, and 4:00 p.m. on Tuesday, March 5, at the University of Arkansas at Little Rock. Support is requested for airplane fares, local transportation from Little Rock to Searcy, hotel costs, meals, and honorarium.

Professor Goodman's presentations will be open to the general public. Faculty and students of all institutions making up the Arkansas Space Grant Consortium will be invited to participate. Drs. Wilson and Wold will schedule individual conference with those consortium members who wish private interviews with Dr. Goodman. The support of the Arkansas Space Grant Consortium will be acknowledged in the public announcements

Summary of Funds Requested for This Outreach Grant:			
1. Travel (mileage, etc.)	$225	5.	$0
2. Honorarium	$250	6.	$0
3. Hotels	$150	7.	$0
4. Meals	$75	**Total**	$700

Current air fares were obtained on the day this proposal was submitted. They do require an advance purchase of tickets to obtain these coach prices. Schedules are not firmly set at the present time, so hotel and meal costs are estimated for the longest possible period.

PHYSICS & ASTRONOMY SEMINAR

Open to the Public

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ARKANSAS SPACE GRANT CONSORTIUM

"Prospects for Long-Baseline Neutrino Oscillation Experiments"
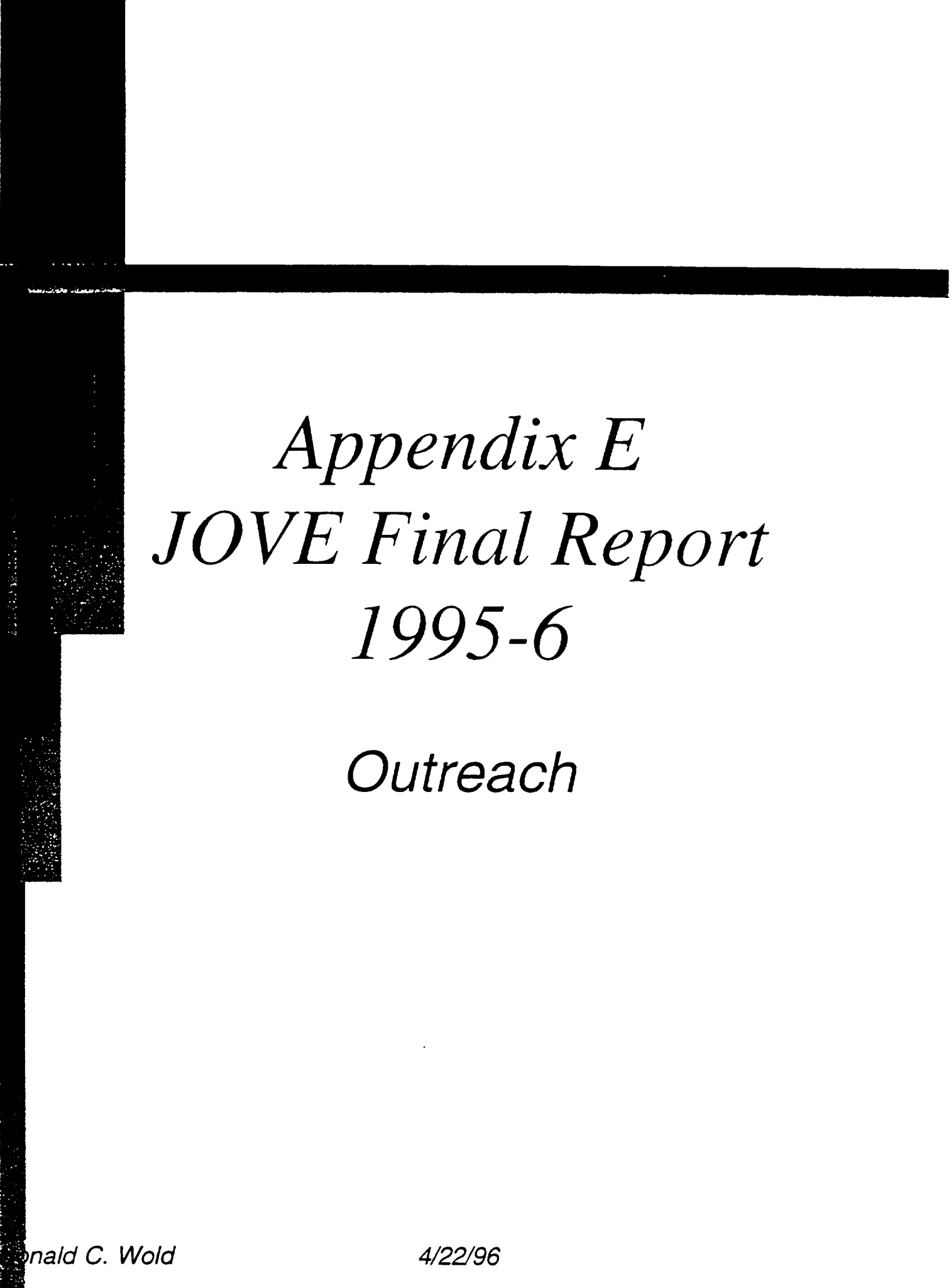
by

Dr. Maury Goodman
Argonne National Lab

Tuesday, March 5, 1996

PHYS 107

Refreshments @ 4:00 p.m.
Presentation @ 4:15 p.m.

Appendix E
JOVE Final Report
1995-6

Outreach

nald C. Wold   4/22/96

U·A·L·R
DEPARTMENT OF CHEMISTRY

July 20, 1994

Dr. Don Wold
Department of Physics
University of Arkansas at Little Rock
2301 South University
Little Rock, AR 72204

Dear Dr. Wold:

We thank you very much for sharing your knowledge of and interest in NASA with the participants of the 1994 UALR Summer Chemistry Institute. Many times high school students dream of being astronauts and traveling in space but they do not believe that they could really ever succeed in realizing that dream. Your presentation allowed them to see what opportunities a space science career would offer and what educational requirements are needed to achieve that goal. We hope that you will continue to address the students in all future SCI programs and well as the JR-TEAMS program. Thank you again for your interest and time.

Sincerely,

Marian Douglas
SCI Co-Director

ARKANSAS SCHOOL FOR MATHEMATICS & SCIENCES

200 WHITTINGTON AVENUE • HOT SPRINGS, ARKANSAS 71901

January 12, 1996

Dear A. Wald ,

Thank you for agreeing to participate in the Arkansas
School for Mathematics and Sciences "Careers: Onward
and Upward" shadowing project. One or more students
listed below have chosen your career field and are
assigned to you on the date(s) indicated. They will
arrive between 8:30 and 9:00 a.m. and will be picked
up for the return trip to ASMS between 4:00 and 4:30
p.m.

Jeffrey Terry _____ Wed, Mar 13

Snehal Patel _____ Wed, Mar 13

_____ _____

_____ _____

_____ _____

_____ _____

If the above date(s) is inconvenient, please let me
know as soon as possible. Students will be
instructed to bring money for their lunch. Thank you
again for your cooperation and support in our
shadowing project. We hope this will be a rewarding
experience for both you and our students.

Sincerely,

Melanie Nichols

Melanie Nichols
ASMS Shadowing Project Director
ASMS Director of Mathematics

"Nichols"

Email "melanien@ asms1.k12.ar.us"

"EXCELLENCE IN EDUCATION"

ARKANSAS SCHOOL FOR MATHEMATICS & SCIENCES

200 WHITTINGTON AVENUE • HOT SPRINGS, ARKANSAS 71901

April 5, 1996

Dear Professional,

The staff, faculty, parents and students of Arkansas School for Mathematics and Sciences wish to take this opportunity to thank you for your support and participation in our recent third annual "Careers: Onward and Upward" shadowing project.

As a part of this school-wide interdisciplinary project sponsored by the ASMS mathematics and humanities departments, all junior and many senior ASMS students were given the rich opportunity of shadowing a professional in the profession of their choice. You and other professionals offered their time and expertise to our students in a most positive way. Students shadowed at Lake Hamilton Animal Hospital, St. Joseph Regional Health Center, National Park Medical Center, law firms: Crawford, Hurst, Williams, and Vaccaro, Sentinel Record Newspaper, Team Rehabilitation Center, Taylor/Kempkes Architects, Walgreen Drug, Weyerhaeuser, Nichols Family Dentistry, Garland County Industrial Development, Hot Springs Rehabilitation Center, First Step School, Hot Springs Radiology Service, Second Baptist Church, Westshores Medical Clinic, Hot Springs Aquarium, Hi-Tech Engineering, AR Game and Fish Commission, Physical Therapy Services, Lake Ouachita Field Office, and U.S. Vanadium. Also participating were professionals from Maybelline, UAMS, AR Children's Hospital, AR Livestock and Poultry Commission, SWAB, National Center for Toxicological Research, AR State Crime Lab, AR Archeological Survey, KATV Channel 7, CH2M Hill, Orbit Valve, US Dept. of the Air Force, BCBS, Veteran's Hospital, KATV TV 4, AR Repertory Theater, UALR, LR Zoo, Central Flying Service, Falcon Jet, Zenecca, University Medical Center, Charter Hospital, US Cooperative Extension Service, Blass Architects, HFT-110, Entergy Corporation, Cromwell Architects/Engineering, FTN Associates, Excel School of Modeling, ALCOA, Acxiom, US Department of Justice, AR State University and AR Department of Education. In addition to the shadowing, many professionals sat on panels to discuss their profession in student-question directed sessions.

With sincere thanks the ASMS shadowing committee salute you for your dedication to education in Arkansas and support of Arkansas School for Mathematics and Sciences. This project would not be a success without your giving of your time and self. You have touched the lives of our students and have given direction to their futures. Thank you again.

Sincerely,

Melanie Nichols

Melanie Nichols
ASMS Director of Mathematics and Shadowing Project Committee Chair

"EXCELLENCE IN EDUCATION"