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SEMI-ANNUAL PROGRESS REPORT
NASA GRANT NAG5-720

A SUMMARY OF MAJOR ACTIVITIES OF THE UNH AND NRL GROUPS FOR THE PERIOD 1987 NOVEMBER 15 - 1988 MAY 14

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Prepared by:

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Prepared for:

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NASA Grant NAG5-720
SMM GRS - Semi-Annual Status Report
Period 1987 November 15 - 1988 May 14

SUMMARY

In this report we summarize the major activities of the *SMM GRS* team members at UNH and NRL since the last *Semi-Annual Report* through 1988 May 14. In the yearly report we will provide an updated list of published papers and invited papers or contributed papers presented at scientific meetings.

The material for this report was provided by:

Dr. D.J. Forrest – UNH
Dr. W.T. Vestrand – UNH
Dr. G.H. Share — NRL
Mr. K. Levenson – UNH
Dr. E.L. Chupp – UNH

SEMI-ANNUAL PROGRESS REPORT

University of New Hampshire Activities

Period 1987 November 15 – 1988 May 14

1. Scientific Activities

a. Solar Flare Studies

Continued work, with Cliver *et al.*, on a paper titled "Solar Flare Nuclear Gamma Rays and Interplanetary Proton Events." This effort studies the correlation of >100 solar flare events observed in either or both impulsive phase γ rays and/or interplanetary energetic protons (or SEP). The objective is to determine if these two particle populations originate from one acceleration process. This paper will be submitted to the *Astrophysical Journal* within the next 6 months by D.J. Forrest *et al.*.

Work has continued on the preparation of a joint paper titled "Gamma-Ray Emission Outside of the Impulsive Phase of flares Associated with Escaping SEPs." The objective of this effort is to search for, and set limits on, particle acceleration/trapping well before and well after the impulsive phase of the solar flare where most γ-ray observations are made. We hope to submit this paper to *Astrophysical Journal* within the next 6 months by D. J. Forrest *et al.*.

A series of calculations on the 2.22 MeV neutron capture line and its Compton tail in solar flare spectra were performed. The results show that the relative strength of the Compton tail can be used as an independent measure of both the angular distribution and the energy spectrum of flare accelerated ions. A paper describing this study will be published in the proceedings of the *Workshop on Nuclear Spectroscopy of Astrophysical Sources* by W.T. Vestrand *et al.*

Continued to develop procedures for spectral analysis of observed flare energy-loss spectra. A paper titled "The De-Convolution of Gamma-Ray Energy Loss Spectra" was presented at the Kansas City AAS Meeting in June 1988 by D.J. Forrest. The objective of this effort is to develop a model-independent procedure to extract the maximum amount of information from the GRS *SMM* flare observations. A paper describing this procedure will be submitted to the *Astrophysical Journal* in the near future along with a paper using this procedure on GRS flare observations.

b. Special Issue of the Journal Solar Physics

A special issue of Solar Physics, emphasizing high-energy solar observations, is in preparation and several papers are authored and coauthored by UNH GRS *SMM* group members using *SMM* data.

i. Lead Author Papers

"High-Energy Continuum Emission from Solar Flares," W.T. Vestrand.
This paper reviews the properties of solar flare continuum emission at energies >300 keV. Emphasis is placed on observations made during the *21st solar maximum* by γ-ray detectors aboard the *SMM* and *Hinotori* satellites. The statistical properties of high-energy flares are presented, including their size-frequency distribution, spectral-index distribution, position distribution, and associated soft X-ray size. The temporal structure of the high-energy continuum is reviewed as well as attempts to model the structure by two-step acceleration and particle trapping. Evidence for the directivity of flare radiation is presented and statistical and stereoscopic analysis techniques are compared and contrasted. The first obsevations of flare γ rays at energies >10 MeV are examined. The results show that the very high-energy emmision must be a mixture of pion decay radiation and primary electron bremsstrahlung. Also, the extended phase of the giant 1982 June 3 flare seems to require a new acceleration component.

"Nuclear Line Spectroscopy of Solar Flares," D.J. Forrest and R.J. Murphy.
This paper is a review of the nuclear line properties of one large flare observed by GRS *SMM*. It covers the spectroscopy of individual lines including line positions and widths which set limits on energetic particle anisotropy. This paper also covers solar abundances which are dependent on the relative line intensities from several elements.

"Solar Neutron Observations and their relation to Solar Flare Acceleration Problems," E.L. Chupp.
This paper reviews all observations bearing on the solar flare neutron flux. These include the neutron-proton capture line at 2.223 meV, the observation of neutron decay protons in space, the direct observation of neutrons by the *SMM* GRS and by ground level neutron monitors. The current knowledge on the flare produced neutron spectrum and the acceleration time of primary protons which produce the highest energy neutrons is also discussed.

ii. Co-Authored Papers

"Hard X-Ray and Low-Energy Gamma Ray Spectrometers," D.J. Forrest with N. Gehrels *et al.*

"Gamma-Ray Spectrometers (>10 MeV)," P.P. Dunphy with A. Owens.
"Neutron Techniques," E.L. Chupp with G. Frye *et al.*

c. Second Impulsive Solar Flare Workshop

The *SMM* Gamma-Ray Astronomy Group is sponsoring an international workshop on solar flares under the support of this grant NAG5-720. The second circular for the workshop was sent out in this grant period and the agenda and list of poster papers is included herewithin as a part of this report.

Second Workshop on Impulsive Solar Flares
at the University of New Hampshire
26-27-28 September 1988

A G E N D A

A Schedule of Overview Talks
and Topics for the Various Sessions

Sunday, 1988 September 25

1st Morning Session

1830–2200	Registration followed by a Reception Sponsor: Institute of Earth, Oceans and Space

Monday, 1988 September 26

0900–0915	Review of Workshop Purpose
0915–0935	Overview Talk - H. Zirin Optical Observations of Impulsive Solar Flares
0935–0955	Overview Talk - G. A. Doschek Ultra Violet and Soft X-ray Observations of Impulsive Solar Flares
1000–1200	Contributed Papers D. Batchelor - Models for Time Behavior of Impulsive Bursts E. Antonucci - Explosive Evaporation during the Impulsive Phase of the 1984 April 24 Flare J. Wang - Major Flares on 1986 February 4, 1986 February 6 and 1980 June 21. M. Hagyard - Non-Potential Magnetic Fields at the Site of the 1984 April 24 Flare Onset R. Moore - Observed Form and Action of the Magnetic Field in the Great Flare of 24/25 April 1984

1st Afternoon Session

1200–1400	Lunch and Study of Poster Papers
1400–1420	Overview Talk - M. Pick Meterwave and Microwave Observations of Impulsive Solar Flares
1420–1440	Overview Talk - V. Petrosian Hard X-ray and γ-ray Observations of Solar Flares
1440–1640	Contributed Papers S. White - Multi Frequency VLA Observations of Impulsive Solar Flares H. Nakajima - Meterwave and Microwave Observations of the Impulsive Phase of the 1984 April 24 Flare M. R. Kundu - Millimeter Observations through the Next Solar Maximum with the BMA Array H. S. Sawant - High Sensitivity High Frequency (24-18) GHz Solar Observations K. Kai - Energy Spectra of Non-Thermal Electrons Generated in Solar Flares L. Orwig - Hard X-Ray Signatures of the 1982 June 3, 1980 June 21, and 1984 April 24 Flares
1640–1645	Announcements Regarding Social Function and Transportation
1645–1745	Study of Poster Papers and Refreshments**

Tuesday, 1988 September 27

2nd Morning Session

0815–0840	Assessment of Workshop to date
0840–0900	Overview Talk - R. Ramaty Nuclear Reactions in Solar Flares (γ-ray and Neutron Production)
0920–0940	Special Topic - G. E. Kocharov (Solar Neutrons - Current and Future Perspectives)
0940–1000	Overview Talk - E. L. Chupp Emission Characteristics of (3) Intense High-Energy Flares Observed in Cycle 21.
1000–1200	Mainly Contributed Papers on Specific Large *SMM* GRS Flares, for example 1984 April 24, 1982 June 3, 1980 June 21. M. Yoshimori - Solar γ-ray and Neutron Observations in Japan D.J. Forrest - Emissions from Relativistic Particles P.P. Dunphy - Solar Flare Neutron Spectral Shapes W.T. Vestrand - The Neutron Capture Line from Solar Flares S. Kane - Energetic Electrons in Solar Flares R. Lingenfelter - Depth Distribution of Neutron Production in Solar Flares

2nd Afternoon Session

1200–1400	Lunch and Study of Poster Papers
1400–1500	Overview Talk – D.V. Reames Solar Energetic Particle (SEP) Events Associated with Impulsive Flares
	Overview Talk - H. Debrunner Signature of Solar CR Ground Level Events Produced by Impulsive Flares
	Overview Talk - P. Evenson Solar Neutron Decay Proton Observations in Cycle 21
1500–1630	Contributed Papers
	H. Cane (Reames) - The Relationship Between Interplanetary Particle Fluxes and Flare Characteristics in Impulsive Flares
	G. Mason - Impulsive Injection of Ions ^{3}He-rich Flares
	F. MacDonald - Helios I/II Observations of Energetic Particles Associated with Impulsive Solar Flares
	G. Guzik (J. Cooper) - ONR – 602 Results for 1982 Flares
	K. Kudela - Search for Possible Signals from Solar Neutrons in Lomnicky Stit Data

Wednesday, 1988 September 28

3rd Morning Session

0830–0900	Assessment of Workshop To Date
0900–0920	Overview Talk - G. Haerendel Particle Acceleration Theories
0920–0940	Special Topic - J. Sakai Particle Acceleration in Loop Coalescence Models
0940–1200	Contributed Papers J. Henoux - Impact Linear Line Polarization as a Diagnostic of Deka-keV protons X. Hua - Nuclear Line and Neutron Production in Solar Flare Magnetic Loops N.Z. Mandzhavidze - Generation of Neutron and γ-ray Emissions in Solar Flare Loops Y. Ohsawa - Prompt Ion Acceleration to Relativistic Energies by Large Amplitude Magnetosonic Waves D. Smith - Combined GRS - HXRBS Multiple Power - Law Fits to Flares and their Interpretations N. Vilmer (Trottet) - A Trap and Precipation Model for Ions Producing Prompt γ-ray Lines During Solar Flares
1200–1400	Lunch and Study of Poster Papers

3rd Afternoon Session

1400–1420	Theory of Solar Flares - P. Sturrock
1420–1600	Contributed Papers John X. Brown - Are Proton Beams Relevant to Hard X-Ray Emission or to Flare Heating? Yu E. Charikov - Solar Flare Precursors and the Problem of Energy Build Up M. Karlicky - Dissipation Spreading Process in Flare Current Systems - Numerical Results R. Murphy - Solar Abundances Using Gamma Ray Spectroscopy of Solar Flares K. Ohki - Characteristics of Impulsive γ-ray Flares as Observed with Hinotori Hard X-Ray Imager A. Stepanov - Consequences of Strong Pitch Angle Diffusion of Particles in Solar Flares
1600–1700	Assessment of Workshop and Future Directions
1700	Workshop Ends

Note: The conference room arrangement is such that refreshments will be available throughout the workshop.

** All contributed papers will be (15 minutes + 5 minutes for questions).

Second Workshop on Impulsive Solar Flares
at the University of New Hampshire
26-27-28 September 1988

NAME	TENATIVE POSTER PRESENTATIONS
(P) Dr. P. Bornmann	Are the Discrete Wavelength Shifted CA XIX Features Observed During the Impulsive Phase the Onset of Turbulence or Statistical Fluctuations
(P) Edward Cliver	Coronal Type II Shocks and γ-ray Line Emission
(P) Dr. Emilia Correia	Rise Times in CM-Bursts
(P) Dr. Joaquim Costa	Problems with Removing the Gradual Component in Analysis of Solar Impulsive Bursts
(P) Dr. E. Flückiger	Yield Function of Neutron Monitors for Solar Neutrons
(P) Dr. Terry G. Forbes	Shocks Produced by Impulsively Driven Reconnection
(P) Dr. G. Frye, Jr.	Solar Neutron Detection
(P) Dr. S. Kahler	CMES from Inpulsive Flares
(P) Dr. G. Kanbach	Ion Beams in Solar Flares
(P) Dr. P. Kaufmann	(1) MM -Wave and IR Spectral Component of Solar Flares (2) Problems with Removing the Gradual Component in Analysis of Solar Impulsive Bursts
(P) B. V. Koshevenko	(1) Ionic Composition Anomalies in the Post-Flare Solar Plasma as Observed on Prognos-10 Spacecraft (2) Perspective of Solar Atmosphere Active Processes Investigations
(P) Dr. T. Kosugi	X-ray and γ-ray Emission from Behind-the-Limb Solar Flares
(P) Renato Martin	Velocity - Temperature Distribution in the Evaporating Plasma During the Impulsive Phase of Flares
(P) Prof. P. Meyer	1. Electron Spectra from Solar Flares; 2. Solar Neutron Emission
(P) Dr. J. Miller	Bremsstrahlung Productin in Solar Flare Magnetic Loop
(P) Dr. J. Ryan	Stochastic Acceleration and Particle Propagation in a Coronal Loop
(P) Dr. G. Share	2.223 MeV Neutron Capture Line Observations
(P) Dr. P. Stoker	Spectra of Relativistic Solar Proton GLEs Recorded at Sanae, Antartica, During the 21st Solar Cycle
(P) Dr. B. Tsurutani	Interplanetary and Geomagnetic Activity Associated with Intense Impulsive Solar Flares Seen by the SMM/GRS
(P) Dr. H. Zhang	Study on Solar Limb Event of 4-27-81
(P) Dr. A. Zodi Vas	Electron High Energy Cutoff
(P) Dr. J. Cooper	ONR-602 Results for 1982 Flares

d. Supernova 1987A

Work continued on attempts to place interesting limits on the > 10 MeV photon flux from Supernova 1987A. At present the study is focusing on attempts to establish the aspect and rigidity dependence of the background counting rate to compare with the supernova observations.

UNH continues to support the operations aspects of SN1987A monitoring and provides monitoring of quick look data.

A paper has been prepared on the search for γ rays during the time of the neutrino burst on 23 February 1987. These results were presented at the Austin AAS Meeting on January 13, 1988. A copy of the press release prepared for this meeting follows:

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FOR RELEASE: January 13, 1988

SOLAR MAXIMUM MISSION SATELLITE DETECTS GAMMA-RAY LINE EMISSION FROM SUPERNOVA IN THE LMC AND ALSO PROVIDES DIRECT CONSTRAINTS ON NEUTRINO LIFETIMES

Today, work has been reported to the 171st American Astronomical Society meeting at Austin, Texas by a team of US and German scientists, who have detected gamma-ray emission from the bright, nearby supernova SN1987A, which occurred on February 23 of 1987 in the Large Magellanic Cloud. The team also presented significant constraints on supernova neutrino lifetimes.

One report described the detection of gamma rays from radioactive cobalt in the debris of the supernova and was presented by Drs. Gerald Share, Steven Matz, and Mark Leising of the Naval Research Laboratory in Washington D.C., Professor Edward Chupp and Dr. Thomas Vestrand of the University of New Hampshire, Durham, New Hampshire, and Dr. Claus Reppin of the Max Planck Institute for Extraterrestrial Physics in the Federal Republic of Germany. A paper detailing these measurements was submitted for publication in the British journal *Nature*, earlier this month.

The measurement was made with the gamma-ray spectrometer (GRS) on NASA's Solar Maximum Mission *SMM* satellite, which was launched in 1980. The spectrometer was designed and built by the University of New Hampshire and West German scientists, under the direction of Professor Chupp, the Principal Investigator. The analysis which revealed the radioactive cobalt was performed at the Naval Research Laboratory in collaboration with the scientists at the University of New Hampshire.

It is now well established that in SN1987A the core of a star, ten to twenty times more massive than the Sun, collapsed to form a neutron star or a black hole. The high temperatures and pressures produced in the explosion cause nuclei to fuse, making heavier elements from lighter ones. Some of the nuclei created by this process are unstable, or radioactive, and they decay into other elements, giving off energy in the process, some of which is in the form of gamma rays.

The detection of gamma rays from radioactive cobalt confirms that supernovae are the principal birthplaces of elements found in the universe, such as iron. These elements are created from the fusion of lighter elements during the explosion of the star. The force of the explosion expels these heavy elements along with the lighter elements, such as carbon, which were synthesized in the star at earlier times. The elements are dispersed in space and ultimately are recycled to form new stars and planetary systems, such as our own.

'These cataclysmic deaths of stars have planted the seeds for the birth of life on Earth,' says Dr. Share of the Naval Research Laboratory (NRL).

The detection of gamma rays from the supernova was complicated by the fact that the direction to the Large Magellanic Cloud is at right angles to the viewing direction of the gamma-ray spectrometer. Only about a third of the gamma rays from the supernova are able to make their way through the spacecraft and reach the detector. The design of the satellite prevents the detector from being pointed directly at the supernova. However, it can be pointed to within about 50 degrees of the supernova, for short periods of time, as shown in Figure 1., to enable more of the gamma rays to reach the detector.

The scientists also devised a way to use the disk of the Earth to prove that the gamma rays came from the direction of the supernova. They did this by separately accumulating data when the supernova was visible and when it was blocked by the Earth. The gamma rays only appeared when the supernova was visible.

The gamma-ray lines, emitted during the decay of radioactive cobalt to stable iron, first appeared in August of 1987, about the same time as energetic X-rays were observed by the Japanese Ginga satellite and Soviet and West German experiments on the Soviet MIR space station.

The most intense gamma-ray line at 847 keV expected from the decay of cobalt was detected. This is revealed in the top portion of Figure 2. which shows the measured intensities of this radiation from the direction of the supernova since 1981. The last two points covering the period from August to October of 1987 are significantly higher than the rest. The second most intense line at 1238 keV exhibited a marginal increase at the same time. (See lower portion of Figure 2.)

The detection of the lines is illustrated in the spectrum accumulated over the same time period and plotted in the top of Figure 3. The lines are not apparent in a spectrum

accumulated over a similar period two years earlier which is shown at the bottom of the figure.

The early appearance of the gamma radiation and the ratio of the intensities of these two lines suggest that the cobalt may have been directly exposed to us, in contrast to what is expected if the cobalt were embedded in a massive cloud. Figure 4. is an artist's conception of three different scenarios for the distribution of the radioactive cobalt in the supernova. From left to right: the cobalt is concentrated at the center of the expanding envelope, the cobalt is symmetrically mixed into the envelope, and the cobalt is distributed in blobs and jets expelled during the explosion. The *SMM* observations suggest that a small fraction (one to two percent) of the radioactive cobalt may have been able to move toward the outer edge of the envelope, directly exposing the radioactivity to us.

Preliminary measurements from *SMM* which cover the period from the middle of November to the middle of December, suggest that the massive envelope covering the remaining radioactive cobalt may be clearing. If so, this will allow detailed studies of the radioactivity by the SMM gamma-ray spectrometer and by balloon-borne instruments to be launched by NASA in the coming months.

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The *SMM* team also made a significant discovery pertaining to our understanding of elementary particles, using the fact that no gamma-ray burst was observed coincident with the supernova neutrino flash. Professor Chupp and Dr. Vestrand of the University of New Hampshire reported, on behalf of their colleagues, that this result allows a strong constraint to be placed on the lifetime of massive neutrinos, if they are produced in the stellar collapse. This additional *SMM* observation improves upon earlier indirect estimates

of massive neutrino lifetimes by more than a factor of 100, as has recently been pointed out by Drs. Kolb and Turner of the Fermi National Accelerator Laboratory.

Some astronomers and physicists also believe that supernova events could give rise to a burst of gamma rays from the interaction of particles that are accelerated by the shock wave which is believed to initiate the optical outburst. Also, some astronomers believe that a rotating neutron star may have been formed in the collapse of the original star. If so, the rapidly spinning star, with a strong magnetic field, could generate high-energy particles called cosmic rays. These in turn may produce gamma rays with energies above 10 million electron volts in the outer part of the supernova remnant.

Professor Chupp also reported that continuing efforts are in progress to study these other sources of supernova gamma rays.

For More Information Contact:
At the University of New Hampshire:
Professor E.L. Chupp (603-862-2750)
At the Naval Research Laboratory:
Dr. Gerald H. Share (202-767-3027)

e. Workshop on Nuclear Spectroscopy of Astrophysical Sources (December 14-16, 1987.)

The following papers were presented by the *SMM* GRS group at UNH:

"Observations of Nuclear Emissions in Solar Flares," D.J. Forrest.

This paper reviewed the observations, interpretations and limitations of *SMM* GRS nuclear observations in two energy bands 0.3-9 MeV and 10-100 MeV. Nuclear emissions in these two bands include nuclear line spectra and energetic pion decay γ-rays. This paper will be published in the *AIP Proceedings of the Workshop.*

"The Neutron Capture Line and its Associated Compton Continuum in Flare Spectra," W.T. Vestrand *et al.*

Compton scattering of line photons produces a low-enegy "tail" on γ-ray lines. We show how the strength of this Compton continuum can place limits on the depth of neutron capture in the solar atmosphere. These limits can, in turn, be used to constrain both the angular distribution of the energetic parent ions. We derive these constraints for the intense flare of 1982 June 3.

"Gamma-Ray Astronomy in the Nuclear Transition Region (The Promise The Problems)," E.L. Chupp.

The search for primary gamma rays extends back to the ealiest studies of cosmic rays from balloons. The well known, inspiring predictions by Morrison (1958) stimulated enthusiastic groups of fledgling experimentalists, who with their younger colleagues, to this day are seeking the fruits of nature. The unique information carried by γ-ray lines and continuous γ rays enables us to study the acceleration of particles in solar flares, the evidence for galactic nucleosynthesis, the dynamics of an evolving supernova, the enigmatic γ-ray bursts, and other yet unkown phenomena. The current list of accomplishments is meager for a field with so much promise, but that promise is even greater today. There are, nevertheless, serious questions about the interpretation of the exciting observations of the cosmic ^{26}Al and the positron-electron annihilation γ-ray lines and as well the γ-ray lines from solar flares. We will review briefly some of the conflicts in the observational scene and suggest approaches for future development of the field."

f. Conference on High-Energy Radiation Background in Space

November 3-5,1987

The following papers were presented by members of the UNH *SMM* GRS Group.

"Background Observations on the SMM High-Energy Monitor at Energies >10 MeV," D.J.

Forrest, W.T. Vestrand, P.P. Dunphy, E.L. Chupp and G.H. Share

"Comparison of Background in Gamma-Ray Spectrometers on OSO-7 and SMM Spacecrafts," P.P. Dunphy, D.J. Forrest, E.L. Chupp, and G.H. Share

h. Miscellaneous

Work is in progress to search for periodicity from the Geminga source region using the *SMM* GRS data.

The UNH group has provided support to the *SMM/Phobos* collaboration by attending a coordination meeting in April 1988 and submitting a plan for use of *SMM* GRS data.

The UNH group also reviewed a group of 1988 Guest Investigator proposals and made recommendations to the IWG meeting in May 1988.

UNH has provided support to Guest Investigators J. Higdon and J. Ling by providing data and through extensive consultations.

A major effort by the UNH *SMM* team in January 1988 has been the preparation of a report for the *SMM* operations review.

2. Summary of Computer Operations and Production Processing

During the period from November 1987 through May 1988 the UNH *SMM* GRS computer facility underwent very significant changes. These changes were highlighted by the groups acquisition of two VAXStation 2000's and our move to a new location during April 1988. The two new VAXStations were acquired during December 1987 and immediately added a significant enhancement to our graphics capability as well as our overall computing power. These two systems were incorporated into our Local Area VAX Cluster system very nicely and became additional CPU resources to all users on the network. The

long awaited move of our group took place during April. It took several weeks to coordinate and organize the move of the computer equipment and the more than five thousand tapes. The new location was prewired for RS232 and *Thick wire Ethernet* which made the new computer facility setup much quicker as well as making the entire configuration more reliable and updated. The new area was also wired with *Thin wire Ethernet*, prior to our move which made our Local Area VAX Cluster very easy to reinstall. With each new office having access to the *Thin wire Ethernet* it was also possible to network many of our PCs to our Vax Cluster using Ethernet cards and Digital's DECnet DOS software. PCs that were not connected via Ethernet were connected via the RS232 ports that are available in each office. Since our relocation our Computer System has become a highly integrated, networked and modern system. The Honeywell minicomputer system which was the workhorse computer for many years was finally retired, prior to the move.

Work during this period concentrated on continuing the monitoring of SN1987A. As well as the daily analysis using the "quick look" tapes sent by IPD, a significant effort was being made to look through the entire SN1987A data-base at different energy bands searching for long-range variances. It has been during this period of time that we have truely shifted our analysis technique to incorporate long periods of data. Work continues on developing tools and techniques for working with the long term data bases in an attempt to understand the data itself as well as an effective method in manipulating large quantities of data using the finite resources that limit our facility. Other work done on our system during this time included pulsar period searches for various sources, solar atmospheric modeling, and the on going study of solar flares.

SEMI-ANNUAL PROGRESS REPORT

Naval Research Laboratory Activities

Period 1987 November 15 - 1988 May 14

1. Scientific Activities

a. Papers Published

"SMM Detection of Diffuse Galactic 0.511 MeV Positron Annihilation Radiation," G.H. Share, R.L. Kinzer, D.C. Messina, W.R. Purcell, E.L. Chupp, D.J. Forrest, and C. Reppin, Proc. 20th International Cosmic Ray Conf. **OG-1**, 156 (1987).

"Search for Gamma-Ray Lines from Recent Supernovae," S.M. Matz, G.H. Share, R.L. Kinzer, E.L. Chupp, D.J. Forrest, and C. Reppin, Proc. 20th International Cosmic Ray Conf. **OG-1**, 168 (1987).

"Gamma-Ray Line Emission from SN1987A," S.M. Matz, G.H. Share, M.D. Leising, E.L. Chupp, W.T. Vestrand, W.R. Purcell, M.S. Strickman, and C. Reppin, Nature **331**, 416 (1988).

"SMM Detection of Diffuse Galactic 511 keV Annihilation Radiation," G.H. Share, R.L. Kinzer, J.D. Kurfess, D.C. Messina, W.R. Purcell, E.L. Chupp, D.J. Forrest, and C. Reppin, Ap. J. **326**, 717 (1988).

"Gamma-Ray Limits on ^{22}Na Production in Novae," M.D. Leising, G.H. Share, E.L. Chupp, and G. Kanbach, Ap. J. **328**, 755 (1988).

b. Papers Accepted for Publication in Conference Proceedings

"Long-Term Variations in the Gamma-Ray Background on SMM," J.D. Kurfess, G.H. Share, R.L. Kinzer, E.L. Chupp, D.J. Forrest, and C. Reppin, to be published in AIP Proceedings of the Conference on the High Energy Radiation Background in Space (Fall 1988).

"Instrumental and Atmospheric Background Lines Observed by the SMM Gamma-Ray Spectrometer," G.H. Share, R.L. Kinzer, M.S. Strickman, J.R. Letaw, E.L. Chupp, D.J. Forrest, and E. Rieger, to be published in AIP Proceedings of the Conference on the High Energy Radiation Background in Space (Fall 1988).

"SMM Gamma-Ray Observations of SN 1987A," S.M. Matz, G.H. Share, and E.L. Chupp, to be published in AIP Proceedings of the Workshop on Nuclear Spectroscopy of Astrophysical Sources (Sept. 1988).

"Observations of Diffuse Galactic Gamma Radiation," G.H. Share, to be published in AIP Proceedings of the Workshop on Nuclear Spectroscopy of Astrophysical Sources (Sept. 1988).

"Spatial Distribution of Interstellar ^{26}Al *Gamma-Rays: Preliminary Results Using SMM,"* W.R. Purcell, M.P. Ulmer, G.H. Share, R.L. Kinzer, E.L. Chupp, to be published in AIP Proceedings of the Workshop on Nuclear Spectroscopy of Astrophysical Sources (Sept. 1988).

c. Papers Accepted for Publication in Refereed Journals

"Satellite Observation of Atmospheric Nuclear Gamma Radiation," J.R. Letaw, G.H. Share, R.L. Kinzer, R. Silberberg, E.L. Chupp, D.J. Forrest, and E. Rieger, Journal of Geophys. Res.

"Search for Doppler Shifted Gamma Ray Emission from SS433 using the SMM Spectrometer," B.J. Geldzahler, G.H. Share, R.L. Kinzer, J. Magura, E.L. Chupp, and E. Rieger, Ap. J.

d. Research in Progress

Cen A Supernova: – Improved limits on the mass of ^{56}Ni have been obtained; draft of paper to be submitted to the *Astrophysical Journal* in preparation.

Diffuse Galactic Lines: – Significant limits have been set on the intensity of deexcitation lines of C and O due to cosmic-ray interactions with interstellar medium. Poster paper presented at June AAS meeting. Draft of paper for *Astrophysical Journal* in preparation.

Solar Gamma-Ray Lines: – An empirical fitting technique has been developed for studying nuclear gamma-ray lines in flares. Technique has been applied to 1981 April 27 flare. Draft of paper to be submitted to the *Astrophysical Journal*, in preparation.

Provided list of transient events detected by *SMM* GRS in July 1980 to R. Wilson of MSFC as part of Guest Investigator Program.

Began development of a method for obtaining γ-ray spectra from discrete celestial sources.

Completed a study of the measured Totals/Singles efficiencies of the GRS using the atmospheric line radiation using the processing producing of the compressed data base. Results are consistent with ground based calibrations.

Steve Matz modified the UCSD Monte Carlo program to approximate the geometry of the *SMM* experiment. This routine was utilized in order to obtain its angular response. A response matrix (Energy vs. Angle) has been provided to UNH.

2. Production Processing

(a) NASA data processed through 1988 May 1.

(b) Data screened for bursts and flares through 1988 May 1. Long-term data-base processed through 1988 May 1.

(c) Compressed 1-minute data base for ultimate submission to NSSDC developed. Copy of data base covering period from February 1980 to beginning of 1987 submitted to UNH for review. Data-base has been corrected for errors in ephemeris.

(d) Microfilm through August 1987 sent to UNH, MPE, and NASA/GSFC.

3. Transients Detected

Two solar flares and five γ-ray bursts were detected in a search of data from our last report through 1988 May 1.

Day of Year	Time (UT)	Type
1987		
222	07:55	Burst
252	08:40	Burst
284	16:00	Burst
294	19:07	Burst
1988		
070	03:41	Burst
075	19:32	Burst
105	19:38	Flare
115	01:10	Flare