In addition, recent studies have shown very long relaxation times in polarized solid xenon.[2] If xenon is shown to exhibit large parity violating effects, then a polarized xenon target could be an attractive target in which to search for time reversal violating effects.

The Indiana group is responsible for constructing the xenon target. The target will consist of 1 kg of liquid xenon of natural isotopic abundance immersed in a 120 g holding field for maintaining the neutron polarization. Target design is nearing completion, and tests of the target will begin in the summer of 1994. The experiment is projected to run at LANCSE in 1995.

1. C. M. Frankle, *et al.*, Phys. Rev. Lett. **67**, 564 (1991).
2. M. Gatzke, *et al.*, Phys. Rev. Lett. **70**, 690 (1993).

MEGA: A SEARCH FOR THE DECAY $\mu \rightarrow e\gamma$

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We continue to play a major role in the MEGA rare muon-decay experiment at LAMPF. The experiment is now in production, with runs having taken place or scheduled during the summers of 1992-1994. We now have sufficient data that, after a complete analysis, the sensitivity of the MEGA experiment to the decay mode $\mu \rightarrow e\gamma$ is a factor of 12-15 better than the existing best measurement. We have also taken data to improve the measurement of the muon decay parameter ρ by a factor of three or better. The new world-best measurement of $\mu \rightarrow e\gamma$ is the thesis project of IU student Keith Stantz.

In previous years, the IUCF group has built substantial portions of the hardware for the first- and second-level trigger systems. The hardware was installed in spring, 1992 and has run for the last two years with few problems. Our group has the responsibility to install, debug and maintain the entire hardware trigger system. One of us (KMS) has also had a leadership role in the installation and commissioning of the electron spectrometer multiwire proportional chambers (MWPCs). These chambers, as discussed below, are truly state-of-the-art in terms of their rate capability and their low mass (3×10^{-4} radiation lengths). (Note that in this report we use the word electron to represent e^+ or e^-). Our final hardware responsibility was to diagnose problems in the (more than 130) FASTBUS modules, and to calibrate the FASTBUS TDC modules.

During 1993, we received funding from The Foundation to upgrade the computing power of the MEGA workstation farm. The workstation farm provides the third-level (software) trigger for the experiment. We purchased upgrades to six existing DECstation 5000-200 workstations, as well as purchasing one new DECstation 5000-240 and memory upgrades to the DECstations and the VAX-station used for data logging. The workstation farm worked well during the 1993 data-taking run and provided sufficient computing power for the third-level trigger algorithms.

Because the MEGA experiment is now concentrating on production data-taking, and not hardware development, the Indiana Group has moved strongly into data analysis tasks. Our analysis responsibilities include: precision location of the target with respect to the electron chambers, analysis of the electron arm chambers and scintillators for the high-rate $\mu \rightarrow e\gamma$ production data, analysis of the muon inner-bremstrahlung decay mode $\mu \rightarrow e\gamma\nu\bar{\nu}$, and extraction of the final $\mu \rightarrow e\gamma$ branching ratio (or limit).

The summer, 1992 and 1993 data-taking runs were quite successful, and proved that the MEGA detector works. All of the positron detectors were in place and, during the 1993 run, operated at high rates. The stop rate used for production data-taking was 250 MHz, which is a rate on the chamber of $10^4/\mathrm{mm}^2/\mathrm{s}$ (or, in excess of 3 MHz per wire!). The chambers performed well in these high-rate conditions and it appears that only 10% of the events have contamination of the tracks by rate-induced bursting effects. In addition, all three of the photon, pair spectrometers were in place in 1993 and performed well. Production data were taken for 4 weeks during 1993.

A portion of each summer's run was used to measure the Michel ρ parameter, which describes the energy spectrum of positrons emitted in muon decay. Our present data set should improve the measurement precision of this parameter by a factor of 3. The ρ parameter is sensitive to non-V-A terms in the weak interaction; for the left-right symmetric model, the ρ parameter sets a limit on the mixing angle between left- and right-handed W bosons.

The ρ-parameter measurement is done by precisely measuring the shape of the positron energy spectrum from muon decay. Analysis of the ρ-parameter data set is proceeding. Of particular concern are the effects of scintillator and chamber efficiencies on the shape of the energy spectrum. Monte Carlo studies of these effects are an important component of the analysis.

The decay $\mu \rightarrow e\gamma$ is separated from backgrounds by determing that the e and γ are produced at the same time, at the same point, are produced back-to-back, and each have an energy equal to half the muon rest mass, or 52.8 MeV. Thus, the parameters that the data analysis must determine are the energy, direction and decay time for each electron and photon considered in the analysis. In addition, the resolution functions in electron and photon energy, direction and decay time need to be determined (actually, it is the time difference between the electron and photon decay times that is relevant).

The analysis of the $\mu \rightarrow e\gamma$ data set is divided into the photon spectrometer analysis and electron spectrometer analysis. The two analyses have the goals of measuring the energy, direction and decay time of the photon and electron. Figs. 1 and 2 show magnified views of the photon and electron spectrometers, respectively, for the same $\mu \rightarrow e\gamma$ production data event. The photon spectrometer works by converting a photon into an e^+ e^- pair. The e^+ and e^- are then tracked in chambers and scintillators. The event in Fig. 1 shows a fit to the chambers hits for the first loop of the trajectory of the e^+ and the e^-. Subsequent loops are smaller, and give the chamber hits shown within the first loop. The event in Fig. 2 shows the electron spectrometer hits. The track superimposed on the hits is the trajectory the electron must follow, according to the information measured in

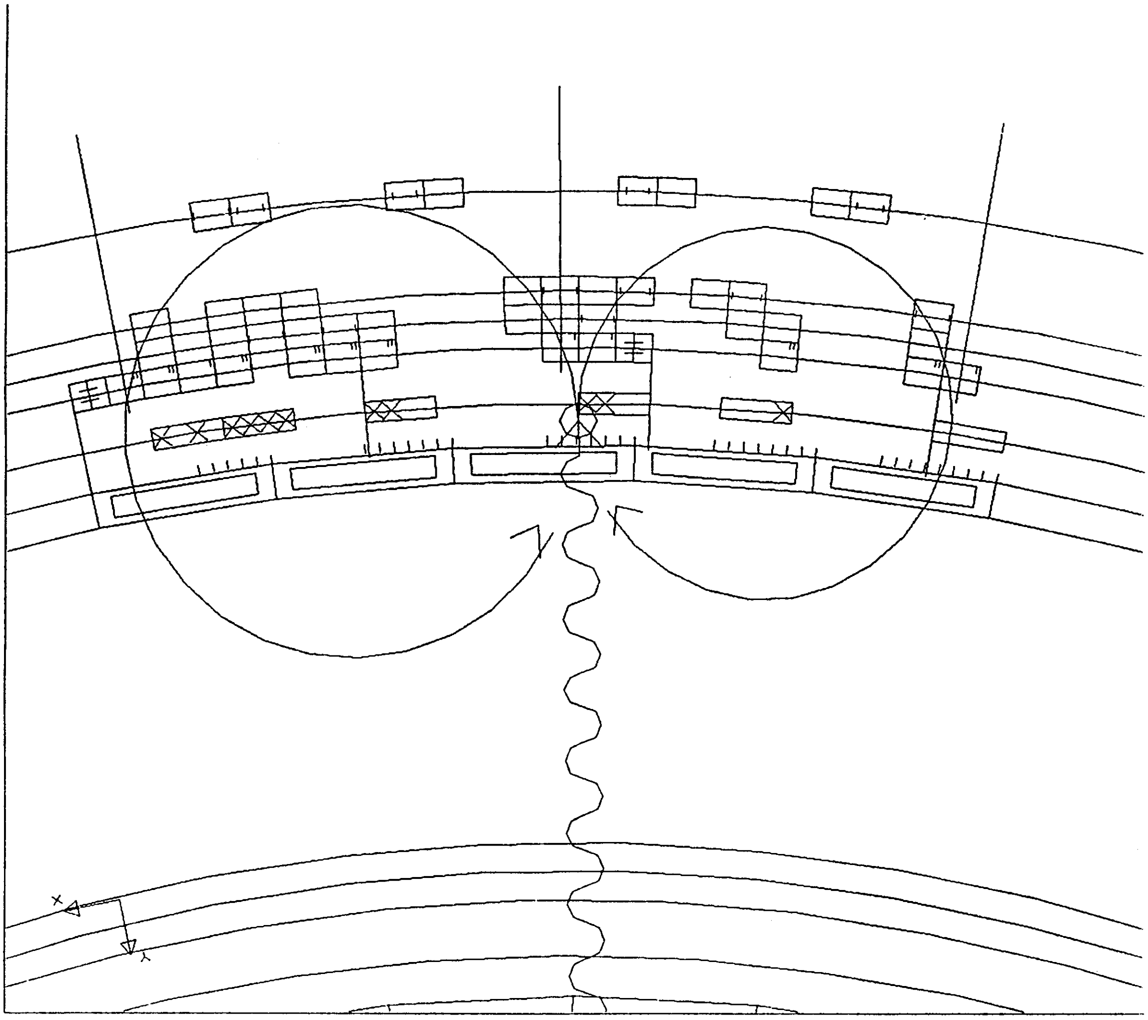

Figure 1. An end view of a $\mu \rightarrow e\gamma$ production data event as seen in the photon spectrometer. Hits in drift chambers (small square boxes), MWPCs (rectangles with crosses inside) and scintillators (rectangles within rectangles) are shown. The two tracks are fits to a subset of the drift chamber hits, as discussed in the text.

the photon spectrometer and if the event is a $\mu \rightarrow e\gamma$ decay. These two figures show the typical environment within which the tracking algorithms need to work.

Because we are doing a substantial portion of the electron spectrometer analysis at Indiana, we are interested in good graphics tools to display event information. The electron trajectories are helices, and we decided that three-dimensional display of the helices would be helpful in understanding the reconstruction algorithms and the general quality of the data. To this end, we have developed software that uses the Advanced Visualization System (AVS) from the company of the same name. AVS allows the user to define objects, which AVS then manipulates in an extremely flexible way (e.g., rotation, translation, coloring, and the transparency of objects is done by AVS). At this point, we have displays of the electron spectrometer and associated detector hits in 3-D form. Devlopment is continuing on this system, to make it a complete single-event display for the electron spectrometer.

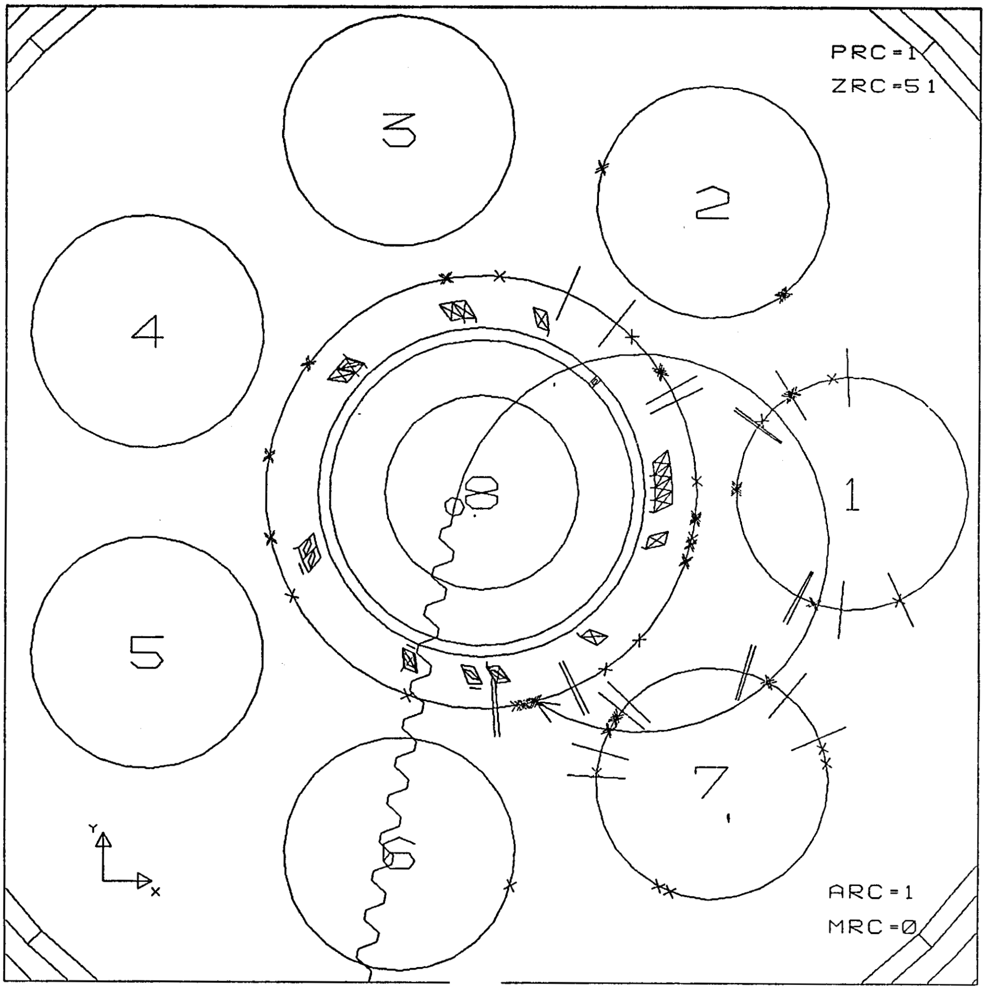

Figure 2. An end view of a $\mu \rightarrow e\gamma$ production data event as seen in the electron spectrometer. Hits in MWPCs (crosses on the circular chamber outlines) and scintillators (small parallelograms) are shown. The track is the trajectory the electron must follow, according to the information measured in the photon spectrometer, if the event is a $\mu \rightarrow e\gamma$ decay.

Reconstruction algorithms are undergoing development. Very preliminary results are shown in Figs. 3 and 4 for the photon and electron energy spectra. The photon energy spectrum is characteristic of inner bremsstrahlung decay of the muon, and drops at high energy. The recontruction algorithms are improving steadily. The electron energy spectrum is characteristic of the normal Michel decay of the muon, $\mu \rightarrow e\nu\bar{\nu}$, and would have a peak at 52.8 MeV, the fall-off point. Efficiency considerations reduce the spectrum near the fall-off. The fall-off rate at 52.8 MeV is intrinsically sharp, and is used to measure the electron energy resolution. This resolution is improving steadily as the recontruction algorithms are improved and magnetic-field non-uniformities are taken into account.

The timing resolution function of the MEGA detector is measured using the decay $\mu \rightarrow e\gamma\nu\bar{\nu}$ (muon inner-bremsstrahlung decay). Figure 5 shows a spectrum of the time-

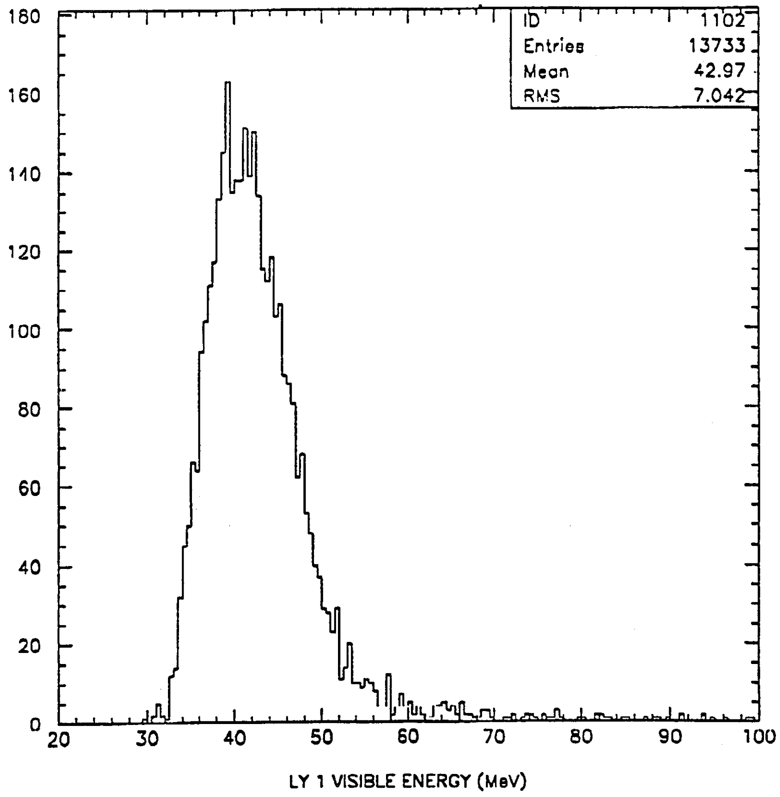

Figure 3. Photon energy spectrum taken with $\mu \to e\gamma$ production data. The photons in this spectrum are produced in the decay $\mu \to e\gamma\nu\bar{\nu}$.

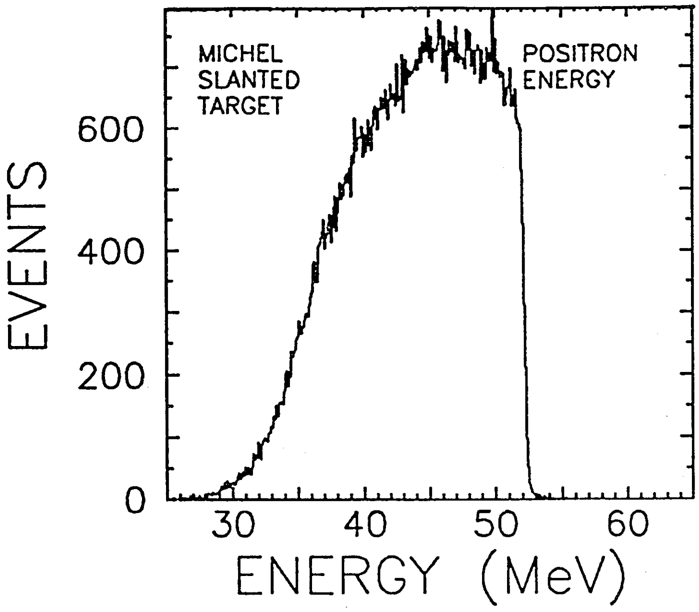

Figure 4. Electron energy spectrum taken at low rates. The electrons are produced in the decay $\mu \to e\nu\bar{\nu}$ and have a peak at high energy, which is characteristic of the Michel spectrum.

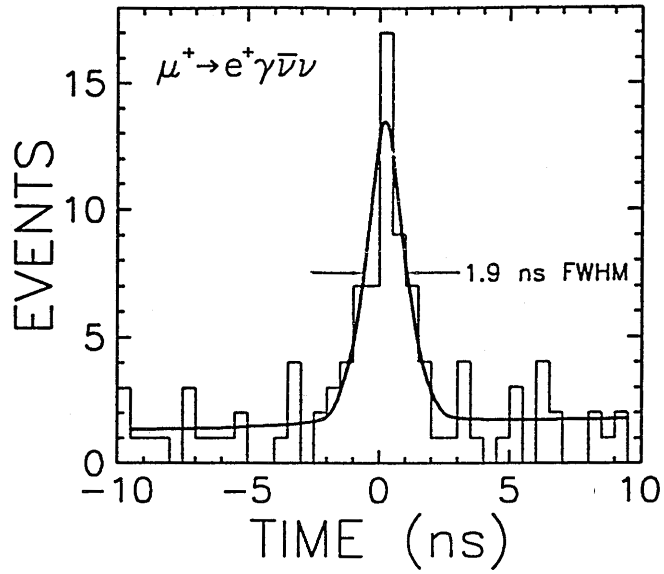

Figure 5. Time difference spectrum taken between the photon and positron spectrometers.

difference taken between the positron and photon spectrometers for inner-bremsstrahlung decay. The peak at zero time difference clearly shows the presence of the muon inner-bremsstrahlung decay in the data set. The observation of this decay mode proves that the detector is capable of measuring a process that has a single muon decaying into a positron and a gamma, as for $\mu \to e\gamma$. The resolution is expected to improve to 1 ns or better after walk corrections in the positron scintillators are made and the optimal use of all scintillator times is included.

The experiment will continue to take data in 1994. The only major hardware change is to the electron spectrometer MWPCs, where the readout electronics has been changed according to the specifications of Indiana Group member Keith Stantz. The modifications were made to improve the rate capability of the electron spectrometer. By running for a longer time, running more efficiently and at higher rates, and with a higher proportion of good events, we expect to acquire twice as much data in 1994 as we have from 1993. This will lead to a sensitivity, after analysis, 40-50 times better than the existing world-best measurement.

The MEGA Collaboration consists of the following member institutions: UCLA, Univ. of Chicago, Fermilab, Hampton Univ., Univ. of Houston, Indiana Univ., Los Alamos National Laboratory, Queens Univ., Stanford Univ., Texas A&M Univ., Univ. of Virginia, Virginia Polytechnical Inst. and State Univ., Univ. of Wyoming, and Yale Univ.