000-3244-29

ABSTRACT

The Carnegie-Mellon University Users Group has concentrated on LAMPF projects and Σ^- atomic x-ray studies this year. The highlight of the latter effort has been a new and more precise measurement of the magnetic moment of the Σ^- hyperon. Our result (-1.48 ± 0.37 nm) is in agreement with the sign given by simple SU(3) theory but differs from the predicted value of -0.9 nm. The group's activities at LAMPF have been concentrated in three areas: (a) Prototype intrinsic Ge particle spectrometer development and tests at the LEP and P^3 channels; (b) Set up and execution of experiments #153/#159 on the External Proton Beam line; and (c) Continued development and testing of the data acquisition system for EPICS. Extensive measurements with the intrinsic Ge charged particle spectrometer on the LEP, P^3 and External Proton Beams have both demonstrated its great promise and indicated some development work that needs to be done. An experiment to study multiple alpha particle emissions in high energy proton induced reactions has been set up and is now producing data on the EPB line. The EPICS data acquisition system is now largely operational in terms of data flow and control. We have tested it extensively under actual experimental conditions. Computer programs have been written and tested for theoretical analysis of the elastic and inelastic pion scattering data we are planning to collect at EPICS and the LEP channel.

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Experimental Nuclear Physics

AEC Contract AT ~~(30-1)~~^{//} - 3244
formerly AT (30-1) - 4040

Carnegie-Mellon University

Pittsburgh, Pennsylvania 15213

Annual Progress Report

June, 1973-June, 1974

I. Introduction

This twelve-month period coincided with a major shift in emphasis in the activities of the CMU Users Group. A major part of the group's resources in hardware and personnel were brought to LAMPF in early July, 1973 for the purpose of helping in the final tuning of the LRP and P^3 pion channels and setting up the EPB line. After a variety of measurements in these three beam lines we are now set up and taking data in the External Proton Beam. This represents the end product of extensive effort in developing a new type intrinsic germanium spectrometer for baryons and mesons, checking out our PDP11/45-electronics data collection system and development of an extensive software capability. Our K mesonic x-ray program (ZGS/ACS) continued with extensive running at BNL last fall. It has been highlighted by a significant improvement in our earlier measurement of the Σ^- magnetic moment. We now have made a $\pm 25\%$ measurement in slight disagreement with the SU3 prediction. Details of this work are provided in Section III.B; the LAMPF program in Section III.A; and some terminated projects in Section III.C. Published papers, internal reports and talks delivered during the year are listed in Section IV. The personnel in the group are listed in Section II.

II. Personnel

During the past year the group consisted of

- (a) Peter D. Barnes, Principal Investigator
Associate Professor of Physics
- (b) Robert A. Eisenstein
Assistant Professor of Physics
- (c) James Amann, Research Physicist
Appointment started August 15, 1972
- (d) Albert Thompson, Research Physicist
Appointment started October 1, 1972
- (e) Frances E. Megahan, Laboratory Assistant
Full time
- (f) James Miller, Graduate Student
- (g) Jack Penkrot, Graduate Student
- (h) Steve Dytman, Graduate Student
- (i) Mohan Doss, Graduate Student

III. Research Program

A. LAMPF Program.

The main thrust of our efforts has been the development and testing of a new intrinsic germanium-charged particle spectrometer and its utilization as a high-energy resolution device for the final tuning of the P^3 and LEP pion channels. The experience obtained and the techniques developed have serious implications for the future of these devices at LAMPF and we are preparing this material for publication. Now, at the year end, we are set up in the EPB line taking data (experiment #1153/1158) on proton-induced reactions. (The C-MU instrumental trailer is now fully operational at LAMPF.)

1. Ge Detector Development and Tests at LEP and P^3

During this year we obtained from the LBL germanium detector group a 2 crystal detector system which was built to our specifications. This

system consists of two large high purity germanium detectors (33 mm diam by 15 mm thick) mounted in the same cryostat (1 mil Havar entrance and exit windows) in a transmission geometry on a common cold finger. Each detector is connected to a separate preamp, amplifier and ADC. The data is controlled, monitored and recorded by a PDP 11/45 computer system.

This system was tested at the LEP and P^3 beam lines at LAMPF. At the LEP channel we placed our detector in a beam of 41 MeV protons and measured an energy resolution of 210 keV (limited by the capability of the channel). We also studied the response of our detector to 50 MeV positive pions. These pions stop in our detector and after using a large veto scintillator and a pileup gate we were able to obtain a very clean pion spectrum. The promising use of these detectors for pions has led us to submit a proposal (#180) for a π^+ scattering experiment using this equipment.

At the P^3 channel we have measured the energy resolution for 100 MeV protons to be 520 keV (again the resolution is limited by the channel). Using 200 MeV pions from this channel, we measured the timing resolution between the germanium detectors and a scintillator to be about 600 psec for both detectors.

Neutron radiation damage is a major question in the applicability of high purity germanium detectors to intermediate energy physics. During our testing our detectors were exposed to a neutron flux of about 10^9 n/cm² which degraded the ^{60}C resolution from 2.2 keV to 16 keV. By warming the cryostat cold finger to 91°C (boiling water at Los Alamos) for 200 h, we were able to restore the resolution to 4 keV. After this procedure, however, we found the Li contact layer on the detectors had increased from $\approx 20\mu$ to $> 250\mu$. Energy straggling in this window could seriously degrade our particle energy resolution so the Li contact was lapped off and a new thin window applied. We are

presently investigating whether other materials than Li could be used for this contact.

During this year we have developed a powerful and reliable data acquisition system and have gained valuable experience in using these detectors in experimental conditions.

2. Data Acquisition System.

During the past year the CMU data acquisition system has developed into a flexible working unit capable of being used in the varied experimental situations encountered at LAMPF with only minor specific additions being required to a basic package. Data may be taken and recorded on an event by event basis on 7 track magtape to be analyzed later while critical spectra are being accumulated and displayed on the 4010 scope. These spectra may then be separately saved on DECTape. Full use of the software priority interrupt structure of the PDP-11/45 allows such lower priority items as displays to be operated at a true background level. An event itself may be analyzed at as many as three separate priority levels depending on available time or the results of various tests. This use of software interrupts along with buffering of the data input from CAMAC allows the highest possible data rates, being always ready to accept and store data during the beam pulse and analyzing between pulses.

A flexible command structure has been developed allowing the user control of data collection, display, and analysis functions from the 4010 keyboard. Additional routines such as peak fitting, background subtraction, etc. may be added to the system and executed at keyboard command by someone with no knowledge of assembly language programming. Similarly the user need only know FORTRAN for the analysis of each event since the data read from CAMAC is put into an array and the user supplied routines are triggered via the software interrupts.

The ability to select and display any of several stored spectra has been added as well as the ability to select and plot on the 4010, in real time, any two data parameters against one another in the form of a dot plot.

For the past six months the system has been used in actual data taking in a variety of situations. Particle spectra have been taken and recorded on the P^3 and LEP channels using the CMU intrinsic Ge detector. The system has served as a dual 8192 channel ADC for taking γ -ray spectra on line EPB for experiment 153. It has also been used to test helical proportional chambers on line P^3 and the playback portion of the system has been used to re-analyze data taken on the Rice computer using the CMU Ge detector and Rice wire chambers.

Currently in progress are the incorporation into this system of a histogramming package written by M. Kellogg of IAMPF which allows the real time recording of large core parameter spectra on disk. We are also testing, in conjunction with the EPICS data acquisition system, the use of memory segmentation and an additional 16k of memory to provide additional high speed histogramming capability beyond the 28k core limitations imposed by DOS.

3. Experiment #153.

In a recent CMU study¹ of nuclear gamma-ray emission following stopped K^- absorption on nuclei near $A \sim 60$, strong lines were observed in the spectra corresponding to transitions in nuclei where one or more α -particles (or corresponding nucleons, $2n2p$) had been removed from the target nucleus. The existence of such transitions might suggest that kaon absorption on correlated four nucleon structures may be important. Since such absorption is likely to be strongly surface peaked, the observation of such transitions may indicate the presence of four-nucleon clusters at the nuclear surface.

Similar studies²⁻⁵ have been performed with stopped π^- 's on several light

nuclei ($A \lesssim 40$). In those cases, in addition to the expected gamma-rays from nuclei corresponding to np and pp emission, unusually high yields were observed for transitions from states in nuclei corresponding to 2n2p emission in qualitative agreement with the stopped kaon results. These results again may suggest the presence of four nucleon clusters near the surface. Recent experiments⁴ have been performed with in flight pions with results qualitatively similar to the stopped pion data. Taken at face value these results seem to be teaching us about important new features of the nuclear surface and as a result have generated a great deal of interest among nuclear physicists. On the other hand the data taken at existing pion and kaon facilities often suffer from poor statistics and high background, while the use of thick natural targets has (a) made multiple interactions in the target possible, and (b) led to confusion as to which isotope was the target nucleus. Often the sensitivity to odd A nuclear products is quite low, with a resulting bias in the analysis of the data. It is important therefore to generate high quality data, free of the above ambiguities, to see if the interpretation suggested above remains valid.

In order to study, in a systematic way, the effects of binding energy, nuclear structure, and as well the absorption mechanism on the products of pion interactions, we propose a two-phase experimental program. In the first phase we are studying three target nuclei adjacent in mass in the External Proton Beam to see if similar results can be obtained with a completely different projectile and interaction mechanism. We will use in the second phase the π^- and π^+ beams from the P^3 Channel on three neighboring nuclei at energies below, above, and near the (3,3) resonance.

We are now set up at the EPB beam area at LAMPF. We have completed a study of the background radiation and have set up and tested a 3 scintillator

telescope to monitor the beam intensity. All of the target materials have been purchased and a scattering chamber has been built which will hold four targets and can be remotely positioned.

To detect the gamma rays we have available two germanium detectors. One detector is a 7% efficiency Ge(Li) coaxial detector. The other detector is our 2 crystal intrinsic germanium spectrometer which has a resolution of 2.2 keV at 1.17 MeV for both detectors. This spectrometer will also be used to study α particle emission.

All of the hardware and software necessary to perform the experiment has been extensively tested. With this system we have the capability of taking data from up to 3 detectors concurrently and the ability to monitor, display and tape the data with a PDP 11/45 computer.

In May and June we are scheduled to have prime beam time during which we will study the gamma ray and alpha particle emission resulting from incident 800 MeV protons on a variety of targets. Also see Experiment #158 below.

During July and August we hope to complete the proton beam part of this experiment and to move to the P^3 area to begin a study of (π, γ) reactions.

4. Experiment #158.

There are many interesting reactions of intermediate energy protons on light nuclei which are difficult to study at present because existing detectors have limited energy resolution and low efficiency. The recent development of techniques for the production of large intrinsic germanium detectors has raised the possibility for using them for particle detection in the intermediate energy range of LAMPF. These detectors should have excellent resolution, good particle identification and reasonable efficiency for intermediate energy particles. On the other hand, they are very sensitive to the high neutron and gamma ray fluxes expected in the primary proton beam areas.

As the first stage in an investigation of baryon and meson production cross sections at LAMPF energies, we will use these detectors to study the production cross sections of $^{27}\text{Al} + p \rightarrow X + \text{anything}$ where X is either a deuteron, triton, ^3He , ^4He , pion, or kaon. We will measure these cross sections at back angles and at the operating LAMPF energy. The anticipated problems of background neutron and gamma ray fluxes will be studied.

These measurements will be made with the apparatus now set up in the External Proton Beam in conjunction with Experiment #153.

5. Large Scale Germanium Spectrometer.

The extensive measurements we have conducted with our prototype detectors have demonstrated its great promise for LAMPF and made apparent a variety of shortcomings that make it inflexible and/or impractical in specific cases for use as a charged particle spectrometer. We have proposed acceptable solutions for essentially all these problems and now are collaborating with Fred Goulding and Richard Pehl at Berkeley to develop a total system that will be generally useful for a large variety of physics experiments at LAMPF. A paper describing the properties of and our experience with the prototype detector has been prepared for publication.

6. Tuning of the LAMPF Accelerator.

One side benefit of our detector development program has been the realization that this device would be extremely useful in the tuning of the low energy end of the accelerator. Apparently most of the problems in accelerator start up and reproducibility are related to the tune of the first 100 MeV beam. A careful measurement at this point, of beam energy (centered and spaced) may solve many tuning problems. We are starting to investigate this possibility with Don Hagerman (MP-DO) and Robert Jameson (MP-9).

7. Energetic Pion Channel and Spectrometer (EPICS)

The C-MU group has several approved experiments for this facility when it comes into operation. During the past year we have assumed general responsibility for the supervision of maintenance and operation of the EPICS computer, done a small amount of programming for the EPICS magnet mapping program and participated in the mapping program itself. James Amann (C-MU) has given two series of lectures to LAMPF personnel and Users on the general operation of DOS-8 (Disc Operating System) for the PDP-11's and published a LAMS report on that same subject. The main effort has been in the further development of the data-acquisition system for EPICS. Because of the highly modular character of the system, almost all routines such as display, keyboard command structure, tape logging, software priority interrupts, etc., are identical in both the C-MU and EPICS data acquisition systems. The only fundamental differences arise in the communication with the CAMAC system since EPICS uses a LAMPF developed processor/interface called the MBD while C-MU uses a Kinetic Systems crate controller interface. Basically, however, almost all work on the C-MU system in the past year is directly applicable in the EPICS system.

The data acquisition program is currently being used on EPICS for a cosmic-ray test of helical proportional chambers and will shortly be used in conjunction with one of those chambers in an α -particle resolution test of the first channel-bending magnet. The current efforts in this direction are the incorporation of M. Kellog's histogramming package into the system and the development of programming to utilize the recently installed 16k of memory (for a total of 40k) as additional 12k of histogramming space beyond the 28k allowed by DOS.

The general progress on EPICS looks reasonably good with magnet mapping becoming a relatively routine procedure and the current hope is

to have all four channel magnets measured and installed by the end of the Fall shutdown.

8. Theoretical Analysis.

During the past year two computer codes have been developed to enable us to calculate differential cross sections for elastic and inelastic pion scattering. In this work we have had as collaborator Dr. G. A. Miller of Carnegie-Mellon.

Program PIRK calculates, as a potential scattering problem in coordinate space, the elastic differential cross section for pions scattering from nuclei. Various optical model representations of the strong interaction potential are available: The Kisslinger (non-local) form, the (local) Laplacian form, and some improved versions of the Kisslinger form. The problem is solved by partial wave decomposition of the scattering amplitude; the cross section is expressed in terms of the phase shifts for each partial wave.

Program DWPI calculates, using the distorted wave Born Approximation, the inelastic scattering differential cross section for pions on nuclei. The change in angular momentum in going from ground to excited state may be as large as 5. The ground state spin may be non-zero. Since PIRK is used to generate the distorted waves, there is a wide range of possible distorting potentials. At present, the nuclear form factor used is phenomenological, the excitation strength being expressed in terms of a deformation parameter β_L .

III.B. Mesonic and Sigma Atom Program.

9. Σ^- Hyperon Magnetic Moment.

The past year has seen a continuation of our experiments to measure the magnetic moment of the Σ^- hyperon. In an earlier publication

we reported the first measurement of the magnetic dipole moment of the Σ^- hyperon. Our earlier determination placed limits on the magnitude of the Σ^- moment but was insensitive to its sign. A three week run in October at the AGS at BNL has provided considerably more data and we have made a more comprehensive analysis of all of our data. We now have the first indication of the sign of the Σ^- magnetic moment as well as a much more precise value than that previously reported.

As in our earlier experiment, K^- mesons produced by the slow extracted proton beam of the Brookhaven National Laboratory alternating gradient synchrotron were brought to rest in targets of Pb, separated ^{208}Pb , and Pt. The Σ^- hyperons were produced in those targets by nuclear K^- capture. The resulting K^- , Σ^- and π^- x rays were observed using two 50 cm³ true coaxial Ge(Li) detectors which exhibited instrumental resolutions of 1.10 keV and 0.98 keV full width at half maximum at 292 keV, the energy of the K ($n = 9 \rightarrow n = 8$) atomic transition in Pb. Careful analysis of $n = 12 \rightarrow n = 11$ Σ^- x ray line has resulted in a value for $\mu(\Sigma^-)$ of:

$$\mu(\Sigma^-) = (-1.89 \pm 0.47) \mu_N$$

or, equivalently,

$$\mu(\Sigma^-) = (-1.48 \pm 0.37) \mu_N$$

Our value for $\mu(\Sigma^-)$ differs by 1.6 standard deviations from the SU(3) value:

$$\begin{aligned} \mu(\Sigma^-) &= \mu(\Sigma^-) = -(\mu(p) + \mu(n)) \\ &\approx -0.9 \mu_N. \end{aligned}$$

We note, however, that our result is in agreement with the recent measurement of $\mu(E^-)$ by Cool, et al., who obtained

$$\mu(E^-) = (-2.2 \pm 0.8) \mu_N.$$

Since the mass of the Σ^- is 27% greater than that of the proton, the presence of an appreciable mass correction term in the magnetic moment would not be surprising. However, as mentioned by Cool, et al., there is at present no fully acceptable method for calculating such a correction. Certainly at the present level of experimental precision no definitive disagreement with the value predicted by SU(3) is implied by our result. Another 300 hour run is scheduled. A paper describing these results has been submitted to Physical Review Letters.

10. Strong Interaction Effects in Exotic Atoms.

The effort to generate optical potentials to describe the nuclear field has continued. All our data is now analyzed and we have found that a local potential with the shape of the mass density can describe the data over the field mass range up to Pb and U. This result appears to contradict the results of calculations.

At the Chicago APS meeting, P. Barnes presented an invited 30 minute talk on "Nuclear Physics with Stopping Kaon Beams" and J. Miller gave a contributed talk on the "Measurement of Kaonic X rays from Al, Si, Ni and Cu." A paper of the same title has been submitted to Nuclear Physics. A paper entitled "Observation of Antiprotonic X rays ${}^6\text{Li}$ and ${}^4\text{He}$ " has been submitted to Physics Letters.

11. $\bar{p}p$ and K^-p Atomic Systems.

We have been approved for 700 hours of beam time at BNL for study of the $\bar{p}p$ and K^-p atomic systems. The observation of a width and shift in the terminating line of the x-ray series would provide very useful information on these fundamental elementary particle systems.

III.C. Terminated Projects

12. Pion Absorption Experiment.

The data analysis and interpretation of these Berkeley measurements is now complete. A paper on the (π, p) reaction has now appeared in the Physical Review and a paper on the $(\pi, 2p)$ reaction is ready to be submitted for publication.

13. Level Structure of ^{211}Pb and ^{209}Tl .

Analysis of the low energy study of the $^{210}\text{Pb}(t, d)^{211}\text{Pb}$ and $^{210}\text{Pb}(t, \alpha)^{209}\text{Tl}$ reactions is now complete. A paper has been written and submitted to Nuclear Physics.

14. D + P Backward Elastic Scattering - Albert Thompson.

Results from these measurements have now appeared in the Proceedings of the Uppsala Conference (1973), described in an invited paper delivered at the Berkeley APS meeting by Albert Thompson (C-MU), and reported in the Physical Review.

IV. Publications, Reports, Proposals and Talks

A.I. Papers Published or Submitted for Publication During the Past Year.

1. Canada, T. R., R. A. Eisenstein, C. Ellegaard, P. D. Barnes, J. Miller, "The Gamma Decay of Two-Particle States in ^{210}Bi ," Nucl. Phys. A 205 (1973), 145.

2. Fox, J. D., W. C. Lam, P. D. Barnes, R. A. Eisenstein, J. Miller, R. B. Sutton, D. A. Jenkins, M. Eckhause, J. R. Kane, B. L. Roberts, R. E. Welsh and A. R. Kunselman, "A Measurement of the Σ^- Magnetic Moment," Physical Review Letters, 31 (1973), 1084.

3. Amato, J., R. L. Burman, R. Macek, J. Oostens, W. Shlaer, E. Arthur, S. Sobottka, W. C. Lam, "Cross Sections for (π^+, p) Reactions on ^6Li , ^9Be , ^{12}C and ^{16}O ," Physical Review C, 9 (1974), 501.

4. Roberts, L., C. R. Cox, M. Eckhause, J. R. Kane, R. E. Welsh, W. C. Lam, D. A. Jenkins, P. D. Barnes, R. A. Eisenstein, J. Miller, R. B. Sutton, A. R. Kunselman, R. J. Powers, "A New Measurement of the Σ^- Magnetic Moment," Submitted to Physical Review Letters.

5. Barnes, P. D., R. A. Eisenstein, W. C. Lam, J. Miller, R. B. Sutton, M. Eckhause, J. R. Kane, R. E. Welsh, D. A. Jenkins, R. J. Powers, A. R. Kunselman, R. P. Redwine, R. E. Segel, "Measurement of Kaonic X rays From Al, Si, Ni and Cu", Submitted to Nuclear Physics.

6. Ellegaard, C., P. D. Barnes, E. R. Flynn, "Levels of ^{209}Tl and ^{211}Pb Populated in the $^{210}\text{Pb}(t, \alpha)$ ^{209}Tl and $^{210}\text{Pb}(t, d)$ ^{211}Pb Reaction," submitted to Nuclear Physics, April, 1974.

7. Eckhause, M., J. R. Kane, B. L. Roberts, R. E. Welsh, R. P. Redwine, P. D. Barnes, R. A. Eisenstein, W. C. Lam, J. Miller, R. B. Sutton, D. A. Jenkins, R. J. Powers, and A. R. Kunselman, "Observation of Antiprotonic X-rays in ^6Li and ^4He ," submitted to Physics Letters, March, 1974.

8. Arthur, E. D., W. C. Lam, J. Amato, D. Axen, R. L. Burman, P. Fessenden, R. Macek, J. Oostens, W. Shlaer, S. Sobottka, M. Solomon, W. Swenson, "The (π^+, pp) Reaction on Several Light Nuclei," will be submitted to Physical Review.

9. Eisenstein, R. A., G. Miller, "PIRK - A Distorted Wave and Pion-Nucleus Elastic Scattering Program," submitted to Computer Physics Communications, May, 1974.

A.II. Internal Reports

1. Eisenstein, R. A., G. Miller, "PIRK - A Distorted Wave and Pion-Nucleus Elastic Scattering Program," CMU Report COO-3244-24, January, 1974.

2. Amann, J., P. D. Barnes, S. Dytman, J. Penkrot and A. C. Thompson, "Resolution Tests of the LEP Channel with the CMU Germanium Spectrometer," LAMPF Report #MP-DOC-1.

3. Amann, J., "Introduction to PDP-11 DOS-8," LASL Report LA-5343-MS September, 1973.

4. Amann, J., P. D. Barnes, S. Dytman, J. Penkrot, A. C. Thompson, "Resolution Tests of the P^3 Channel with the CMU Charged Particle Germanium Spectrometer," LAMPF Report #MP-DOC-1.

B. Contributions to International Conferences and American Physical Society Meetings.

1. Fox, J. D., W. C. Lam, P. D. Barnes, R. A. Eisenstein, J. Miller, R. B. Sutton, D. A. Jenkins, M. Eckhause, Jr. R. Kane, B. L. Roberts, R. E. Welsh, A. R. Kunselman, "A Measurement of the Σ^- Magnetic Moment," Fifth International Conference on High-Energy Physics and Nuclear Structure, Uppsala, Sweden, June 1973.

2. Barnes, P. D., "Nuclear Physics with Stopping Kaon Beams," Brookhaven National Laboratory Conference on Nuclear and Hypernuclear Physics with Kaon Beams, July 1973, BNL 18335.

3. Fox, J. D., W. C. Lam, P. D. Barnes, R. A. Eisenstein, J. Miller, R. Sutton, M. Eckhause, J. Kane, B. L. Roberts, R. E. Welsh, R. P. Redwine, R. E. Segel, D. A. Jenkins, R. J. Powers, A. Kunselman, "Experimental Studies of Medium and Heavy K^- Atoms," International Conference on Nuclear Physics, Munich, Germany, August 1973.

4. Thompson, A. C., "Measurement of dp Backward Elastic Scattering at Deuteron Beam Momenta of 3.43, 4.50, 5.75 and 6.60 GeV/c," Bull. Am. Phys. Soc.

5. Barnes, P. D., R. A. Eisenstein, W. C. Lam, J. Miller, R. B. Sutton, D. A. Jenkins, R. J. Powers, M. Eckhause, J. R. Kane, B. L. Roberts, R. E. Welsh, R. P. Redwine, R. E. Segel, and A. R. Kunselman, "Strong Interactions in K^- Atoms," Bull. Am. Phys. Soc. 19 (1974) 83.

6. Roberts, C. R., C. R. Cox, M. Eckhause, J. R. Kane, R. E. Welsh, D. A. Jenkins, W. C. Lam, R. A. Eisenstein, J. Miller, R. B. Sutton, A. R. Kunselman, R. J. Powers, "Measurement of the Σ^- Magnetic Moment", Bull. Am. Phys. Soc. 19 (1974) 19.

7. Roberts, B. L., M. Eckhause, J. R. Kane, R. E. Welsh, D. A. Jenkins, W. C. Lam, P. D. Barnes, R. A. Eisenstein, J. Miller, R. B. Sutton, A. R. Kunselman, R. J. Powers and J. D. Fox, "Measurement of the Magnetic Moment of the Antiproton," Bull. Am. Phys. Soc. 19 (1974) 562.

8. Thompson, A. C., J. F. Amann, P. D. Barnes, S. A. Dytman, J. A. Penkrot, R. H. Pehl and F. S. Goulding, "Use of an Intrinsic Ge Charged Particle Spectrometer at LAMPF," Bull. Am. Phys. Soc. 19 (1974) 551.

C. Proposals Submitted

Los Alamos Meson Physics Facility

- X 1. Study of the $(\pi^\pm, d)$ Reaction With an Intrinsic Ge Detector, #140.

P. D. Barnes, Spokesman

P. D. Barnes, R. A. Eisenstein, A. C. Thompson, J. Amann,

2 Graduate Students, Carnegie-Mellon University

Action deferred until 50 MA proton beam available.

2. Investigation of Nuclear Gamma-Rays Resulting from In-Flight Pion and Proton Reactions, #153.

R. A. Eisenstein, Spokesman

P. D. Barnes, R. A. Eisenstein, J. F. Amann, A. C. Thompson,
S. Dytman and J. Penkrot, Carnegie-Mellon University.

Approved and in progress.

3. Charged Particle Emission in Proton Induced Reactions as a Feasibility Study in the Use of Intrinsic Ge Detectors with the Primary LAMPF Beam, #158.

R. A. Eisenstein, Spokesman

~~P. D. Barnes~~, R. A. Eisenstein, A. C. Thompson, J. F. Amann,
S. Dytman, J. Penkrot, Carnegie-Mellon University.

Action: Approved for parasite on #2 above, and now in progress.

4. Elastic and Inelastic π^+ -Nucleus Scattering at 25, 50 and 75 MeV, #180.

R. A. Eisenstein, Spokesman

~~P. D. Barnes~~, J. F. Amann, A. C. Thompson, S. Dytman, J.
Penkrot, Carnegie-Mellon University.

Action: Submitted to P.A.C.

Brookhaven National Laboratory - A.G.S.

5. Measurements of X-Rays Transitions for Stopped $\bar{p}$ and K^- in Gaseous Hydrogen and Helium, $\bar{p}$ Mass Measurement and Strong Interaction Shifts in Complex Atoms, #643.

J. R. Kane, Spokesman

C. R. Cox, M. Eckhause, J. R. Kane, R. E. Welsh, D. A.
Jenkins, W. C. Lam, R. A. Eisenstein, R. B. Sutton, A. R.
Kunselman, R. J. Powers.

Action: Approved for 700 hours.

D. Invited Talks, Colloquia and Seminars

1. Invited Talk: "Measurement of dp Backward Elastic Scattering at Deuteron Beam Momenta of 3.43, 4.50, 5.75 and 6.60 GeV/c", at the Conference of the Division of Particles and Fields of the American Physical Society, Berkeley, - A. C. Thompson.

2. Invited Talk: "Nuclear Physics with Stopped Kaon Beams", International Conference on Nuclear and Hypernuclear Physics with Kaon Beams, July 1973, Brookhaven National Laboratory, BNL #18335, - Peter D. Barnes.

3. Seminar: "Recent Experiments in Exotic Atoms", Bartol Institute, Philadelphia. Nov., 1973, - R. A. Eisenstein.

4. Seminar: "Recent Experiments in Exotic Atoms", Weizmann Institute, Israel. Aug., 1973, - R. A. Eisenstein.

5. Seminar: "Recent Experiments in Exotic Atoms", Technical H.S., Darmstadt, Germany. Sept., 1973, - R. A. Eisenstein.

6. Colloquium: Penn-State University, "The Physics of Exotic Atoms", January, 1974, - Peter D. Barnes.

7. Invited Talk: "Kaonic Atoms", American Physical Society Meeting, Chicago, Illinois, January, 1974, - Peter D. Barnes.

8. Seminar: "LAMPF Data Handling Workshop - Introduction to PDP-11, DOS-8", LAMPF, - J. Amann.

9. Seminar: "Recent Measurements at LAMPF and the BNL-AGS", Physics Dept., University of Maryland, March, 1974, - P. D. Barnes.

10. Seminar: "Nuclear Physics with Stopped Kaon Beams", Physics Dept., Yale University, P. D. Barnes.

11. Colloquium: U.C.L.A., "The Physics of Exotic Atoms", May 1974, - Peter D. Barnes.

12. Seminar: "Recent Results from Studies of Kaonic, Anti-protonic and Sigma Atoms", LAMPF, Aug. 1973, - Peter D. Barnes.

E. Conferences Attended

1. Fifth International Conference on High-Energy Physics and Nuclear Structure, Uppsala, Sweden, 18-22 June, 1973 - P.D. Barnes.
2. Brookhaven National Laboratory Conference on Nuclear and Hypernuclear Physics with Kaon Beams, July 1973 - P. D. Barnes.
3. LAMPF Conference on Pion-Nucleus Scattering - L.A.S.L., 23-26 July, 1973 - R. Eisenstein, P. D. Barnes, J. Amann, A. C. Thompson.
4. LAMPF Study Group on Two Arm Spectrometers Systems, 30-31 July, 1973 - P. D. Barnes.
5. International Conference on Nuclear Physics, Munich, Germany August 1973 - R. A. Eisenstein.
6. Topical Conference on Gamma Ray Emissions from Highly Excited Nuclei, April, 1974 - Physics Dept., University of Maryland - R. A. Eisenstein, A. C. Thompson.