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INDIANA UNIVERSITY HIGH ENERGY PHYSICS GROUP*

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The Indiana University High Energy Physics Group has been actively involved in a variety of research programs during the current contract year. These programs are associated with major experiments conducted by our group at SLAC, Fermilab and CERN. The physics areas under study include an exploration of polarization phenomena in hadron processes (FNAL E522), a study of low- p_t and high p_t collisions utilizing the Multiparticle Spectrometer at Fermilab (E110/260/523/557), studies of psi meson production in hadron interactions (CERN WA-11), and a high resolution study of e^+e^- interactions at high energy at SLAC (PEP HRS experiment). The status of the various efforts will be discussed within this report.

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FNAL E522

During the past year E522, the inclusive polarization experiment, was completed. The data taking for this experiment finished in 1978. The last of the analysis was finished up by a graduate student as part of his thesis for a Ph.D., which he received in the summer of 1979. The initial results were published in a Physical Review Letter.¹

During the last several months the final documentation of this experiment and the elastic scattering experiment which preceded it (E313) has been completed. A Physical Review article² covering both these experiments has been submitted for publication.

E522 was conducted in the internal target area of Fermi National Accelerator Laboratory. The polarization in the process $p + p \rightarrow p + X$ was measured by rescattering the slow recoil proton in a carbon block of known analyzing power. Using the circulating beam at Fermilab and a warm hydrogen gas jet target, we could measure this process over the beam momentum range of 100 to 400 GeV/c. This was an order of magnitude gain in beam momentum from earlier measurements.

Although it is a general feeling among physicists that spin dependent terms should be less important at higher energies, there are several experiments that have indicated the exact opposite. At 12 GeV an Argonne experiment has shown that cross sections for 90 degree scattering depend strongly on the relative spin orientation of the two protons, and a measurement at CERN and Fermilab of $p + p \rightarrow \Lambda + X$ found a large Λ polarization that grows with transverse momentum. Thus the simpler process $p + p \rightarrow p + X$ appeared to be an important one to measure in order to understand this spin dependence.

Our measurement showed a small polarization at a transverse momentum of 0.5 GeV/c; however this went to zero at higher transverse momenta, unlike the Λ case. Although ours was a null result it is important because it constrains

any models of LAMBDA polarization based on quark spin effects.

In addition we found that the small polarization at a transverse momentum of 0.5 GeV/c mentioned above was not consistent with the energy dependence of a triple Regge model of inclusive proton polarization. On the other hand a very straightforward analysis of these data indicates that the spin flip amplitude at 400 GeV must be sizable in order to explain the 0.5 GeV/c data.

One additional effect was also noticed in this experiment. In the process $p + C \rightarrow p + X$ the polarization of the outgoing proton was found to be -7% at a transverse momentum of 1.0 GeV/c. We believe that this is due to rescattering of the proton in the carbon nucleus. This is a surprising result at 400 GeV.

FNAL E110/260/557 and P523

This experimental program involves the study of high- p_t (E260 and E557) and low- p_t (E110 and P523) hadron-hadron collisions. All of these experiments use the Fermilab Multiparticle Spectrometer (MPS). The Indiana Group was part of the collaboration which designed and built the MPS, which has now become a facility at Fermilab. The MPS has been described in a report prepared by A. Dzierba, E. Malamud and D. McLeod for the MPS Workshop, Fermilab, 1977.³

E260

This was the first experiment carried out using the MPS. The main feature of this experiment was the use of a large calorimeter to trigger the MPS on events producing particles at large transverse momentum. Data-taking was completed in 1976. The analysis of the data from this experiment has been completed. The results have been presented in five publications.⁴⁻⁸

The following Ph.D. theses, based on the analysis of E260, have also been written:

1. "Study of Hadronic Jets Produced by Charged Pion and Proton Beams Incident on Hydrogen and Aluminum Targets" (by K. Yung, Caltech Ph.D. Thesis, 1979).

2. "Jet Production in High Energy Hadron-Proton Collisions"
(by J. Rohlf, Caltech Ph.D. Thesis, 1980).
3. "Correlations between High- p_t Hadrons in $\pi^{\pm}p$, K^-p and pp
Collisions at 200 GeV/c". (by R. Stanek, UICC Ph.D. Thesis,
1980).

In addition, two articles recently have been submitted for publication.^{9,10}

A. Dzierba presented an invited talk at the 1979 Washington meeting of the American Physical Society summarizing the results of E260 and other jet experiments at Fermilab.

Early E260 results established the usefulness of the calorimeter trigger. This experiment was the first to publish data on the large ratio (~ 500) of jet to single particle production at a given p_t . Subsequent analysis showed that the jet cross section measured in this experiment is in good qualitative agreement with predictions of a model based on quantum chromodynamics (QCD). The beam ratio of p/π^- for jet production is ~ 1.5 at the lowest p_t and falls to ~ 0.5 at $p_t = 6.5$ GeV/c, indicating that at the higher p_t 's π^- mesons are more efficient at producing jets than are protons. This result is consistent with high p_t π^0 production and is consistent with the quark model since in a π^- the available momentum per quark is larger than in a proton at a given beam energy. E260 also compared the jet cross section of Al and H targets and found that both the cross sections and jet structure are found to depend strongly on the beam and target types. Results have also been presented on the production of single charged particles with transverse momentum in the range of 0.8 - 4.5 GeV/c in $\pi^{\pm}p$, K^-p and pp collisions. The 22-cell Cerenkov counter in the MPS (see reference 3) was used to identify secondary particles. Results are in good agreement with QCD.

A. Dzierba and W. Kropac were involved in this experiment, which included

physicists from Cal Tech, Fermilab, UCLA, and the University of Illinois at Chicago Circle.

E557

This is an approved experiment to continue the jet studies begun in E260. The goals of the experiment are to extend the jet studies to a higher momentum, from 200 GeV/c (E260) to 400 GeV/c (E557), to a higher p_t range, and to study jets in greater detail.

The physics goals of E557 are summarized in the table below, which includes the quantities we will measure along with the possible physics interpretation. In order to accomplish these goals the MPS has been modified from its E260 configuration. The modifications include:

- a. addition of a superconducting bend string in the M6 beam line to upgrade the beam momentum to 400 GeV/c;
- b. - addition of a transition radiation detector to aid in incident K identification;
- c. removal of the spectrometer magnet pole tips to increase the magnet aperture;
- d. repositioning the spark chambers to enhance track-finding and pattern recognition;
- e. replacement of Čerenkov counters $\check{C}_1$ and $\check{C}_2$ with $\check{C}_A$ and $\check{C}_B$. $\check{C}_A$ will be placed inside the magnet;
- f. adding cathode strip chambers and lead sheets for π^0 and η^0 identification; and
- g. replacing the E260 calorimeter. Whereas the E260 calorimeter consisted of two separate sections, each of which subtended 1 steradian in the c.m., the new calorimeter subtends about 8 steradians. The E260 calorimeter had a total of 8 electron units and 8 hadron units while the E557 calorimeter consists of 126 front electron modules, 126 front hadron

modules and 28 back hadron modules. Each module consists of lead scintillator or steel scintillator sheets with the scintillator light collected by wavelength shifter bar (plastic doped with BBQ), light guide and phototube. The new calorimeter has finer granularity, which allows for better neutral particle identification (than in E260), and also for better energy resolution.

Summary of E557 Physics Goals

<u>Data (What we will measure)</u>	<u>Possible Interpretation</u>
Di-Jet cross sections as a function of $\sqrt{s}$, beam type, jet p_t . Jet charge composition and $\langle z \rangle$ will also be measured.	Quasi 2-body process: Parton + Parton $\rightarrow$ Parton + Parton Separation of QCD subprocesses: $q\bar{q} \rightarrow q\bar{q}$, $g\bar{g} \rightarrow q\bar{q}$, etc.
Single jet studies: jet composition, particle rank in z according to species, comparison with e^+e^- , np and $p\bar{p}$ jets.	Universality of jet fragmentation
Cross sections for K^+p and $p\bar{p} \rightarrow$ Jet + Anything	Effect of s quarks and antiquarks in initial state.
Anomalous nuclear enhancement: $h + A \rightarrow$ Jet + Anything where h = incident hadron and A = target with atomic number A .	Time evolution of parton fragmentation
Forward jet studies	Diquark fragmentation
Search for 3 high p_t jets	Hard gluon bremsstrahlung

A test run of the modified MPS was performed during November, 1979 through January, 1980. Data taking will begin in Nov., 1980. Most of the modifications described above were completed in time for the test run. About 1/5 of the calorimeter and a portion of the strip chambers were in place. The test run was very successful in that no flaws were found with the fundamental layout of the MPS or with the design of the calorimeter. The beam line worked well at 400 GeV/c.

The Indiana group responsibilities for E557 include:

- a. online software;
- b. offline software;
- c. calorimeter positioning;
- d. calorimeter trigger electronics;
- e. calorimeter calibration and monitoring system.

Except for item (b), the above are the sole responsibility of the I.U. group.

Online Software

E260 used a version of MULTI adapted for the PDP11/45 under the DOS operating system by A. Dzierba and W. Kropac. E557 uses a version of MULTI running under the RT11 operating system. The new online software package also includes routines which allow MULTI to pass data to and receive data from an LSI-11 microprocessor. The LSI-11 is part of the calorimeter calibration system. Part of the online software development project involved incorporating software to read data from the new LeCroy high-density ADC system and the computer-controlled high voltage system. Much of the new system was exercised in the test run.

Offline Software

The offline software package, TEARS, used for E260 and E110 has been undergoing modifications to handle data from new hardware. Also, changes in track finding algorithms were made necessary by going to higher energies. Tracks have been successfully reconstructed from chamber data taken during the test run. H.J. Martin has recently found well defined peaks in the vertex distribution corresponding to cells in a segmented target used in the test run.

Calorimeter Positioning

The I.U. group worked on the design of a table to support the E557 calorimeter. The table moves under either manual or computer control so that each of the 126 front modules and each of the 28 back modules can separately be moved into the beam. Part of the machining for the table was done in the I.U. Physics Department

machine shop. The position readout system as well as a position controller (made to fit in a CAMAC crate) have been designed, built and tested.

Calorimeter Trigger Electronics

As a result of Monte Carlo simulation of jets based on variations of the Field and Feynman model for parton-parton scattering and parton fragmentation, we have designed a triggering scheme which meets two basic goals. One of these goals is to collect data on single-jet and double-jet production with as little bias as possible on the jet size. Another goal is to get a sample of events in which the leading particles in a jet have sufficient momentum to allow particle identification. To meet the latter goal we plan to trigger the MPS on large energy deposited in a restricted region of the calorimeter. For this we divide the calorimeter surface into 16 regions or 16 groups. To meet the former goal we require large energy in either both left and right portions of the calorimeter or top and bottom portions. Thus we have 16 group triggers and either a LEFT/RIGHT or TOP/BOTTOM trigger. Another trigger involves triggering on energy in the entire calorimeter and this is called the GLOBAL trigger.

The triggers above involve forming the analog sums. At the first level signals from the 280 individual tubes are grouped and summed to yield 16 electron group sums, 16 front hadron group sums and 6 back hadron group sums. At subsequent levels, these group sums are used to form LEFT, RIGHT, TOP, BOTTOM and GLOBAL sums. Before these analog sums are used in discriminators to form trigger logic signals they are input into integrate-and-hold circuits to remove "jittering" due to differences in module sizes and hence differences in time of arrival of the complete signal.

We decided to build our own summing units rather than use commercial units such as the LeCroy 428 Linear Fan In/Fan Out. The reasons for this decision were:

- a. commercial units have insufficient fan-in and fan-out capability (the 428's have 4 fan-ins and 4 fan-outs). We need to sum up to 10 module signals in forming some of the group sums. The large fan-out capability is needed to feed later levels of summation. We also use one of the outputs at each level to read into an ADC so that the computer can monitor sums.
- b. commercial units have too high of a temperature coefficient (the 428's temperature coefficient is $60 \mu\text{V}/^{\circ}\text{C}$) which becomes a problem after several levels of summation, especially since we are triggering on a steeply falling (with p_t) cross section.

Thus we are building 40 first-level-summers to form the group sums. These come 4 per rack drawer with BNC inputs on the back and Lemo outputs on the front. We are also building 15 second-level-summers to form sums at the second and (if needed) subsequent stages. These units use the same board as the first-level-summers and are packaged as single-width NIM modules. The second-level-summers also have 10 inputs and 6 outputs. Prototypes have been assembled and tested and found to have excellent linearity and low temperature coefficients ($\sim 10 \mu\text{V}/^{\circ}\text{C}$).

Integrate-and-hold circuits have been built and were tested in the test run. Based on these tests minor modifications have been made.

Any other drifts will be monitored by reading the output of the integrate-and-hold units using a computer generated gate during interspill time. The computer will then use this measurement to generate an output signal via a D/A to be subtracted from the event signal input into the integrate-and-hold. The D/A units are single-width CAMAC modules (with 8 outputs) also being built by the I.U. group. In addition the temperature at various points in the calorimeter and trigger electronics will be monitored by an I.U.-built CAMAC temperature monitor.

The entire trigger electronics for the calorimeter will be placed in an enclosed, temperature-controlled house.

Calorimeter Calibration and Monitoring System

The heart of this system is a UV laser designed, built and tested by the I.U. group. The box housing the laser has a fiber bundle fanned out to an array of 300 bulkhead connectors on the back of the box. The laser is viewed by the fiber bundle and 3 reference photodiodes. At the calorimeter end each light guide-wave bar assembly has a short fiber directing the light into the wavebar where it is reflected back at the far end of the wavebar and then into the phototube. These short fibers at the wavebar end are connected to the laser box with long fiber cables. Neutral density filters with different transmission coefficients can be moved in place by a stepping motor under computer control. The filters come between the laser and the fiber bundle and photodiodes. A double-width CAMAC laser controller has been built and tested. This controller triggers the laser and moves the filters.

The laser will be fired in interspill time and pulse-heights, relative to the reference photodiodes, will be monitored by the LSI-11. The LSI-11 communicates with CAMAC via a Branch Driver also built and designed by the I.U. group. This Branch Driver was used in the test run. The LSI-11 will pass monitoring data to the PDP11 via a CAMAC memory module. The LSI-11 system includes a Tektronix terminal and a color graphics unit.

The laser system will be used with the computer-controlled high voltage system to check out the trigger system. Under computer control all calorimeter phototube high voltages will be lowered except for the module under test. The laser will be fired and the ADC monitoring at various levels of summation will verify that the signal appropriately feeds down through the trigger.

A special version of MULTI has been written to use the computer-controlled high voltage system and calorimeter positioning system to position each module in the beam and vary the high voltage so that the pulse height from the module is in the beam registers on a predetermined ADC channel.

The I.U. physicists involved in this project are R. Crittenden, A. Dzierba, J. Florian, R. Heinz, J. Krider, H.J. Martin, D. Petersen and P. Smith. The collaboration also includes physicists from Fermilab, University of Illinois at Chicago Circle, University of Maryland and Rutgers.

E110

This experiment studies low- p_t , low multiplicity reactions resulting from hadron-proton collisions over a rather large momentum range (20-175 GeV/c). The purpose of this experiment is to study the production dynamics of known resonances as well as to search for new resonances. A multiplicity-trigger system, built by the Indiana group, allowed us to trigger the MPS on the following kinds of reactions:

- a. 2 charged particles forward
- b. 3 charged particles forward
- c. 1 or 2 charged particles plus a neutral strange Vee decay
(e.g., $K^0 \rightarrow \pi^+ \pi^-$)
- d. 2 strange Vces.

The input to the multiplicity trigger was derived from PWC hit data stored in a shift register. We ran the MPS in a multiple-trigger mode to collect data on the reactions shown in the table below. Many of the higher-rate reactions were rationed so as not to saturate the trigger. The bulk of the data were taken with negative beam. Incident π^- dominate although we do have beam $\checkmark$ Cerenkov counters to distinguish incident K^- and $\bar{p}$. We list the final state (based on multiplicity requirements) assuming that the incident beam particle is a π^- .

<u>Final State</u>	<u>Approximate Fraction of Triggers</u>
$\pi^- p$	5%
$\pi^+ \pi^- \pi^- p$	5%
$\pi^+ \pi^- n$	40%
$\pi^+ \pi^- X$	15%
$K^0 K^- p$	15%
$K^0 \pi^+ \pi^- X$	15%
$K^0 K^- X$	5%

In the above, "X" refers to slow (non-forward) particles produced in the laboratory. A summary of the numbers of triggers collected in two data-taking runs in 1977 and 1978 is given below.

<u>Negative Beam: Momentum (GeV/c)</u>	<u>Number of Triggers (Thousands)</u>
20	130
50	295
100	1500
175	1800

Total: 3.7 Million Triggers

We are currently analyzing data from this experiment. The physics goals of this experiment are:

- a study of ρ^0 production (s and t dependence) in the reaction

$$\pi^- p \rightarrow \pi^- \pi^+ n$$
- a general study of $\pi\pi$ scattering in the above reaction, and
- a study of meson spectroscopy in $K\pi$, $K\pi\pi$, $KK\pi$, KKK and KK channels.

Acceptance correction studies for the $\pi\pi n$ final state have been carried out at IU and Caltech. A publication on the 100 GeV/c data is in preparation and will be completed in September, 1980. The analysis of the 175 GeV/c $\pi\pi n$ data has begun and will be completed by December, 1980. This

will form the basis for a thesis by IU graduate student Frank Fredricksen.

A paper has been written summarizing the results of the 50 and 100 GeV/c data from the neutral V plus 2 charged particle trigger. The title of this paper is "Observations of the D and E Mesons and Three Possible Kaon Enhancements in $\pi^- p \rightarrow K^0 K^+ \pi^- X$, $K^0 K^+ K^- X$ at 50 and 100 GeV/c", and has been accepted for publication in the Physical Review.¹¹ Results of this study were also presented at the Brookhaven Meson Spectroscopy Conference in May, 1980. The D meson is seen in the $\delta\pi$ mode, while the E meson is observed in both the $\delta\pi$ and the $K^* K$ modes. In addition, there are two possible enhancements in the three kaon final state. The first ($M=1840$ MeV) is associated with the $K^0 \phi$ mode and is consistent with being the charmed D^0 . The second, a K state ($M = 2003 \pm 14$ MeV, $\Gamma = 87 \pm 43$ MeV), decays into KA_2 .

Work has also begun at IU analyzing data from the neutral V^0 and single charged particle trigger. This trigger provides data on the reactions $\pi^- p \rightarrow K^0 K^- p$ and $K^- p \rightarrow K^0 \pi^- p$. The Indiana participants in this experiment include A. Dzierba, F. Fredricksen, J. Krider, R. Heinz, H.J. Martin, and D. Petersen. The E110 collaboration includes physicists from Caltech, Fermilab, University of Illinois at Chicago Circle and Indiana. A. Dzierba is scientific spokesman.

P523

P523 is a proposal which would extend the studies of E110 to include a π^0 or η^0 in the forward meson system. For example, the knowledge of the π^0 momentum in the reaction:

$$\pi^- p \rightarrow \pi^- \pi^+ \pi^0 n$$

allows us to study resonances which decay into three pions in a reaction free from large diffractive backgrounds. (Note: $\pi^- p \rightarrow \pi^- \pi^- \pi^+$ is dominated by diffraction whereas $\pi^- p \rightarrow \pi^- \pi^+ \pi^0$ cannot be easily triggered on.) This

reaction enables us to study $\pi^- p \rightarrow \omega^0 n$, which is dominated by ρ exchange at high energy. However, current ω^0 production data show no sign of the dip at $t = -0.6$ $(\text{GeV}/c)^2$ seen in the ρ -exchange reaction $\pi^- p \rightarrow \pi^0 n$. This $\pi^- p$ charge exchange reaction is dominated by a spin-flip amplitude while the ω^0 spin makes $\pi^- p \rightarrow \omega^0 n$ dominated by non-flip and double-flip amplitudes. Current phenomenology attributes the failure of Regge theory to this difference in spin structure. By studying the similarities and differences between $\pi^- p \rightarrow \pi^0 n$ and $\pi^- p \rightarrow \omega^0 n$, one hopes to gain new insight into the validity of Regge theory.

Motivated by this, we added to the MPS the photon-detector built by the Caltech group and used to measure $\pi^- p$ charge exchange at high energies. This detector was added prior to the 1978 E110 data run to parasitically study the reaction $\pi^- p \rightarrow \omega^0 n$. In fact, this reaction provides some part of the background to the E110 reaction $\pi^- p \rightarrow \pi^- \pi^+ n$. The Indiana group designed and built a system for reading in data from the detector and monitoring gains of the detector phototubes based on a microcomputer (LSI-11). The LSI-11 was purchased with University funds. The software and hardware necessary to interface the photon detector to the MPS were completed in time for the 1978 E110 run. A "clean" π^0 was observed and we also have a clean η^0 and ω^0 signal in the $\pi^+ \pi^- \pi^0$ channel. Analysis of the $\omega^0 n$ final state is continuing.

Currently the Proposal P523 is in "deferred" status at Fermilab. We have asked the Fermilab PAC to postpone further action on P523 until we have completed preliminary analysis of E110 data. A. Dzierba is scientific spokesman.

CERN WA-11

This experiment is a collaboration of physicists from Indiana University, Saclay and Imperial College. The experiment used a π^- beam of 150-200 GeV/c

incident on a Be target to study interactions which contain a high-mass dimuon final state. The trigger produced an enriched sample of interactions involving a Ψ meson. Unlike beam dump experiments this experiment makes momentum measurements and particle identification on those particles produced in association with the dimuon. This enables, for instance, the study of states produced in association with the Ψ meson. The original purpose of the experiment was to search for charmed mesons.

To date there have been two journal articles published on data from this experiment. The first of these¹² reported on various observations concerning the production and decay of Ψ and Ψ' mesons produced on beryllium by 150 GeV/c π^- mesons. A second article¹³ was concerned with high-mass (>3.8 GeV) $\mu^+\mu^-$ pairs and reported evidence for QCD corrections to the Drell-Yan production mechanism.

One of the most interesting results of this experiment has been the appearance of a beauty signal in the $\Psi K\pi$ decay channel. This was first reported at the 1979 International Conference on High Energy Physics in Geneva, Switzerland. As a result of this the experiment was extended for an additional year from July, 1979 to June 1980. The data taking phase of the experiment ended on June 16, 1980. During this period the data sample was increased from 10,000 Ψ 's to 40,000 Ψ 's. At the completion of the analysis of these data we will be able to make a conclusive statement about beauty.

Three papers¹⁴⁻¹⁶ have been written on the equipment designed and built by the Indiana group for this experiment. These concern multiwire proportional chambers, scintillator hodoscopes and a fast pileup gate. They will be submitted for publication in August, 1980.

PEP

The High Resolution Spectrometer, HRS, is being built by Indiana University, University of Michigan, Purdue University and Argonne National Laboratory. It is scheduled for completion this year.

This experimental facility will be located in intersection #6 of the 30 GeV e^+e^- storage ring, PEP, at the Stanford Linear Accelerator Center. The hall at the intersection region is complete, the counting house is finished, and the VAX computer has been installed. We are beginning to assemble all the electronics to run the experiment. In June, 1980 the final iron assembly for the magnet was completed. The cryostat for the superconducting magnet should be ready for cool down in October, 1980. We expect to be ready for installation in the beam by December, 1980.

PEP has begun initial operation at 11 GeV per beam and by August should be at full design energy. We have already begun luminosity monitoring and chamber testing in the beam.

This has been a very busy and productive year for the PEP experiment and for Indiana University. A contingent of about 30 physicists and graduate students are now at SLAC working on the experiment. The Indiana University contribution to a potential December turn on time is crucial.

Indiana University is involved in numerous HRS projects, including the following.

Outer Drift Chambers

The measurement of the particle trajectory at the largest radial point inside the magnet is made by the outer drift chambers. These chambers allow us to measure momenta with a resolution that is at least six times better than any other detector at PEP or PETRA.

The design, construction and testing of these chambers was completed at Bloomington. The chambers were finished in December, 1979 and shipped to SLAC.

At SLAC they were again tested, and the signal and HV electronics were attached and debugged. They are now awaiting installation.

The design for these chambers was tested a year earlier at Argonne National Laboratory using a short prototype cluster of eight chambers. The results of these tests in a high magnetic field were recently published in Nuclear Instruments and Methods.¹⁷

Preliminary installation of both outer and inner chambers will begin in July at SLAC. The configuration will be tested in the light assembly building at SLAC to understand alignment, chamber electronics and cosmic ray reconstruction before insertion into the magnet.

End Cap Shower Counters

Indiana University and Argonne National Laboratory have teamed up to produce the shower counters for both end caps of the HRS. Indiana has been responsible for construction and purchase of the read out and pulse height electronics, construction of the light guides, and the machining of much of the mechanical assembly.

These counters will be ready this Fall for installation. We expect them to be part of our first running configuration. They will give shower coverage over 97% of the solid angle. The energy resolution for photons or electrons should be better than $17\%/\sqrt{E}$. They also will allow us to tag electrons (with a very small pion contamination) using a hardware trigger processor.

The operation of the HRS at PEP will be very similar to that of a bubble chamber; at each crossing the drift chambers will be interrogated to find out if an event has been recorded. The drift chambers themselves will function as the trigger. The hardware processor makes the quick decisions necessary for selecting the wire multiplicity and track curvature. This processor was constructed at Indiana University and Purdue University. It is now complete and functioning.

The first tests will be possible when the chambers are set up in the light assembly building recording cosmic rays. This fall we will also add the capability to select the source point along the beam line.

Laser Light Test Facility

Indiana and Argonne National Laboratory are designing and building a laser light scintillator test facility for the shower counters in HRS. The system uses a triggerable nitrogen laser designed by the Indiana group to feed fast rise time light pulses to a bundle of optical fibers that feed light into each light guide. These will be used for testing the timing and calibrating the pulse height measurement of the shower counters.

The first facility built at Indiana Univeristy is now in operation at Fermilab. The second system will be completed and shipped to SLAC in September or October of 1980.

Gas Monitor System

We have also designed and built a gas monitor system to measure and record drift times for various gases. This will be used to sample the gas purity of all drift chambers in the HRS system. This monitor uses two alpha sources and has a two inch drift space. It has been calibrated and tested at SLAC. The completed system will also measure gas flow into each of the subsystems, gas pressure, and time averaged properties, using a microprocessor linked to our main VAX computer.

Software

Indiana has also been working on several software projects for the HRS. The VAX computer now installed at Bloomington is beginning to play a major part in the 'VEE' finding and tracking programs. These are being developed in

conjunction with Argonne National Lab. The HRS detector will be able to profit from high resolution in this area of neutral decays.

The alignment and calibration programs are now virtually complete and running. Work on these programs has been proceeding for the past half year. They are especially important to us since the high resolution capability of the HRS is obtained only with a knowledge of all chamber positions to better than 100 microns. When the chambers are set up in the light assembly building these programs will be tested.

Muon Chambers

In addition to all of the above we have also been working with Purdue University on the final design and prototype testing of the muon blanket drift chambers. Two of the spare outer drift chamber octants will be used initially with the large Purdue muon chambers to measure muon pairs outside the HRS iron. We are also testing the muon chamber prototypes in the interaction region of IR6 to understand potential background problems.

The principal investigators covered by this contract are R. Heinz and H. Neal. R. Heinz has devoted 100% of his time for 11 summer weeks and approximately 40% of his time during the academic year to this research project. H. Neal has devoted approximately 30% of his time for the calendar year to this research project. It is anticipated that these percentages will apply for the remainder of the contract year. To the best of our knowledge, compliance with the contract requirements has been complete.

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