Findings
Indiana University Cyclotron Facility

Fiscal Year 2004

This is the third year of the nuclear physics program under the current grant. This grant has been extended by half a year for administrative reasons so that our next grant can begin on April 1, 2005. This report covers FY2004 activities between October 1, 2003, and September 30, 2004. As this fiscal year came to a close, we submitted the proposal "Studies in Experimental Nuclear Physics at Indiana University" for a three-year grant to cover from the middle of FY2005 to the middle of FY2008. A site visit from the NSF was conducted this past November. Much of the material presented in this Annual Report is obtained from this proposal.

This year has seen the continuation of our outside user efforts at a number of laboratories. The summer was spent on the completion of the electronics readout for the STAR detector at RHIC. We now have all channels instrumented, including the extra readouts at the front and back to give information on the difference between electromagnetic and hadronic showers. Work has moved ahead with the radiative capture parity violation experiment at Los Alamos. The liquid hydrogen target was shipped to LANL and made operational there. Work is now starting at IUCF to produce a low-field enclosure for the neutron spin rotation experiment that is planned for NIST. Running continues with the MiniBooNE detector at Fermilab. Toward the end of 2005, the collaboration expects to make the pass through the data to produce events to compare with the LSND results from Los Alamos.

This past year has seen a very successful effort in getting new faculty positions for nuclear physics (as well as accelerator physics and materials science with LENS) in the Department of Physics. Manuel Calderón de la Barca Sánchez started with the Department this fall. Manuel's specialty is the study of relativistic heavy ion collisions at RHIC and he will be involved in the extraction of yields for J/Ψ particles from the RHIC data. The Department's offer to Chen-Yu Liu was also accepted. Chen-Yu plans to come in the summer of 2005 and start work on two projects: the development of an ultra-cold neutron source based on solid oxygen as the moderator and the development of a search for an electric dipole moment using garnet crystals to generate a bulk magnetization when placed in a strong electric field.

While the complete endcap calorimeter detector has been in place at STAR since 2003, the electronics necessary for the readout of most of the channels was installed only this year. New PMT boxes were built and mounted on the back of the STAR poletip, constituting 2/3 of the readout for the shower maximum detector. Good progress was made on the software necessary to control and monitor the detector, and the shakedown of the detector readout is well underway as the 2005 RHIC run starts. The calibration of the tower readout is complete using minimum ionizing particles (MIPs) as the standard. This will shortly be checked by using the detector to reconstruct the π^0 mass.

On the analysis side, the observation of π^0's with just the towers has been augmented by the information from the shower maximum detector. Neutral pions have been seen with both proton and heavy ion beams. The proton data has yielded information on jet finding, one of the ingredients that will be essential to the observation of quark-gluon scattering for the measurement of the polarized gluon structure function.

The polarized proton running time in FY2004 was shortened to five weeks and organized to support the efforts of the jet target group to obtain a calibration of the proton polarization. This effort was very successful. The jet target was installed and had a large and stable polarization. Using just the

asymmetries associated with the jet, it was possible to obtain an excellent measurement of the analyzing power for proton-proton scattering in the CNI region. From a comparison of the jet asymmetries to the asymmetries associated with the circulating "blue" beam, it was possible to deduce that the polarization was about 0.4 during the latter part of the proton run. Some data was also taken at 24 GeV as well as the larger set at 100 GeV.

The equipment needed for the parity-violating $np \rightarrow d\gamma$ radiative capture experiment is essentially complete at the neutron line in Los Alamos. The main contributions from IUCF have been the CsI array for the detection of the photon and the liquid hydrogen target. The neutron flux at Los Alamos remains limited, and security concerns also meant that a significant fraction of the year was not available for work on the experiment. Nevertheless, there were data taken on the parity violating signal from a number of the materials that are present in the construction of the apparatus. Non-vanishing signals were seen on ^{35}Cl and ^{129}La, and upper limits were set on ^{26}Al, ^{6}Li, and ^{10}B. The future of this experiment was reviewed, with the recommendation that it be moved to the SNS in about two years when that neutron source becomes operational.

A subset of the neutron group at IUCF is now engaged with the development of a low field container for the neutron spin rotation experiment. A mockup has been constructed and tests are underway. The hope is to have this ready for installation at NIST in the fall of 2005 and to collect data for about half a year.

MiniBooNE is still taking data aimed at the determination of a rate for the conversion of muon into electron neutrinos. If the result from LSND at Los Alamos stands, then there will be enough distinct mass differences measured at various experiments to require a fourth neutrino flavor. The collaboration is keeping the data on the conversion sealed until they are confident of the operation of their detector and feel that the analysis can proceed without prejudice. In the meantime, analysis is proceeding on the extraction of events pertinent to other physics goals, including the muon-neutrino, charged-current inelastic scattering, neutral-current pion production, and neutral-current elastic scattering.

The detector for the FINeSSE experiment is being developed. This experiment intends to use neutrino-nucleon neutral-current elastic scattering to measure the axial formfactor of the nucleon. The large volume detector needs position readout within the volume. So the plan is to use a liquid scintillator with a three-dimensional array of wavelength-shifting fibers running through it. From the signals on the fibers, it is possible to reconstruct the distribution of light output in the event. A prototype was built and tested using the RERP facility to demonstrate that it was possible to obtain information with such a device. The proposal for this experiment was not supported by the Program Committee at Fermilab. Subsequently, a letter of intent was submitted to the Program Committee at Brookhaven and received an encouraging review.

At the beginning of 2004, the Brookhaven management asked the deuteron EDM collaboration to prepare a proposal for consideration by the Program Committee in the fall. The next half year was devoted mainly to the preparation of that proposal, particularly the consideration of systematic errors in the storage ring design. The Program Committee responded that the physics motivation and the technical aspects of the ring design were both good. But they were concerned that the proposal was not competitive against other experiments on atomic systems (for example) that could be carried forward with a much smaller financial investment. So they did not approve the experiment. The collaboration intents to reconsider the ring design as well as another alternative based on the observation of a resonance between the anomalous precession of the deuteron and synchrotron oscillations that can be used to pump the EDM signal. In the meantime, preparations were made to measure various reaction channels for deuteron-induced reactions on carbon. This was planned for the KVI in Groningen in October.

The two main construction activities carried out at IUCF during FY2004 were the completion of the electronics for the STAR endcap calorimeter and the development of a low-field container for the neutron spin rotation experiment. This represented a reduction in the effort required of the IUCF staff compared to previous years. Some help continues to be needed for debugging the STAR electronics at Brookhaven.

Nuclear physics activities at the cyclotron continue to support a number of post-docs and students as they work on their projects. Undergraduates were involved with research at IUCF through various part-time jobs as well as the Research Experience for Undergraduates program. That program now spans both IUCF and the Department of Physics with students involved in activities both at the cyclotron as well as on campus. In all of these activities, diversity in the workforce is considered. IUCF faculty continue to be involved with the development of undergraduate courses and labs within the Department of Physics.

The amount of time and energy going into outreach activities is increasing. Both of the historical spin-offs from IUCF, the Moment of Science program on public radio and the Wonderlab interactive science museum in downtown Bloomington, are doing well. There is now faculty participation in activities designed to interest pre-college students in the scientific potential of Indiana University, including IUCF. A new effort is underway to make visits to local schools for special science presentations. It is also planned to improve our communication of the science of IUCF to the general public through tours, public lectures, Web pages, etc.