Conference Experience for Undergraduates
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6P - Poster Session
Wednesday evening, 8:00pm

Contributions

The Strong Interaction Energy Shifts and
Widths of Antiprotonic $^3$He and $^4$He
T. ASAI, University of Washington, M. ALBERG, University of Washington and
Seattle University – An antiprotonic atom is formed when one of
the electrons in an atomic orbit is replaced by an antiproton. The strong interaction between the antiproton and the
nucleus causes shifts and broadening (widths) of energy levels
from the pure electromagnetic case. We calculate these shifts and
widths using an optical potential which depends on both the
nucleon density distribution and the elementary phasor in-
teraction. Perturbation theory is inadequate for the calcula-
tion, so we use more accurate numerical methods. Among the
many antiprotonic atom measurements that have been made,
there is a large discrepancy between theoretical and experi-
mental values for the 2p widths of $^7p$ and $^9pHe$. The focus of
our study is to determine the nucleon density distributions in the
He isotopes which best fit the experimental data.

Use and Testing of Grating Stabilized Laser for Atom
Trapping
R. BANERJI, University of Illinois, Urbana-
Champaign, Z.-T. LU, Y. LEE, T. O’CONNOR, Argonne Na-
tional Laboratory – Now that magneto optical traps have be-
come more efficient, the issues of reproducibility and cost are
being more closely scrutinized. Currently, the trapping system
we have set up uses an argon ion laser to pump a Ti:sapphire
ring laser, often with unstable results. The object of my re-
search this summer was to finish construction and tune two
diode lasers using a technique of optical feedback known as
grating stabilization. Diode lasers using this feedback tech-
nique exhibit better spectral properties than free running diode
lasers. Also the physical setup allows for scanning over a large
range of frequencies with the aid of piezo electric devices. To
aid in testing of these lasers a photo detector was built, in ad-
dition to setup of a Fabry-Perot interferometer. These devices
were used to test the sensitivity of the laser, while a cesium
gas cell was used to fine tune the lasers to the D2 line. This
design compensates for many of the normal variables of laser
design, such as temperature, drive current and proper electri-
cal grounding. One excellent feature of this laser design is the
ability to “swap” laser diodes in and out to move from one
wavelength range to another. This gives this design an un-
precedented range and stability for a fraction of the price of an
argon/sapphire setup.

High $j$ = 1 + 1/2 States in $^{173,175,177}$Yb
T. BRINK, J. CIZEWSKI, Rutgers University, K. SWARTZ, D. VISSER,
Yale University – The $^{172,174,176}$Yb($^{16}$O,$^{18}$O) neutron transfer reactions at 120 MeV were performed at the Wright Nuclear
Structure Laboratory (WNSL) at Yale University. It had been
previously shown that these reactions preferentially populate $j$
= 1 + 1/2 single-particle states with high angular momentum.
The Yale ESTU accelerator and Enge split-pole spectrometer were
utilized in conjunction with a focal plane gas proportional
counter with a position sensitive wire. The $^{18}$O groups were
easily identified and separated from the $^{16}$O groups and the in-
elastically scattered $^{16}$O particles. By setting gates on the sig-
nals from the focal plane detector, good position information
has been obtained and neutron f/2 and i13/2 excitations in
$^{173,175,177}$Yb have been been identified. These measurements
were performed to study neutron i13/2 and possibly j15/2 ex-
citations in rare-earth nuclei. In the future we plan to study
prompt gamma rays in coincidence with the reaction products
to aid in the assignment of levels.

Very Low Energy Measurements of
Pion-Nucleon Charge Exchange Scattering
A.W. BROWN, L.D. ISENHOWER, M.E. SADLER, B.M BROOKS, T. BLACK,
K. GRAESSLE, J.A. REDMON, Abilene Christian University,
J.D. BOWMAN, D.H. FITZGERALD, J.N. KNUDSON, H.W.
BAER [DECEASED], A.A. BROWMAN, P. HUESI, F. IROM,
E. PIASETZKY, Los Alamos National Laboratory, W.J.
BRISCOE, A. BERGMAN, The George Washington Univer-
sity – LAMPF E882 measured the differential cross sections for
$\pi^+ p \rightarrow \pi^0 n$. These data include the lowest energies ever
measured for this interaction and are the only low-energy
data to cover the entire angular region from 0 to 180 degrees.
Kinetic energies of the incoming negative pions at the center
of each target are 10.6, 20.6, and 39.4 MeV. The differential
cross sections have been determined to approximately 10%.
This experiment was done at the Clinton F. Anderson Meson
Physics Facility at Los Alamos (LAMPF) using the $\pi_0$ spec-
trometer in the Low Energy Pion (LEP) beam line to detect
the two gamma rays from the decay of the $\pi_0$ particles. The
$\pi_0$ spectrometer detects photons with two detection arms loca-
ted symmetrically about the beam line. The main strength
of this detection technique is that it measures the opening an-
gle between the two photons, reducing the need for precise
measurement of the gamma energies.

Non-Linear Expansion: A Possible Improvement for
Radiation Effects and Proton Therapy
C. BURG, New York University; G. BERG, C. FOSTER, Indiana University
Cyclotron Facility – An experiment was performed to demon-
strate the concept of Non-Linear Expansion using an octupole
magnet and an existing proton beam line. The octupole was
placed in the beam line and beam profile measurements were
observed. No effect from the octupole was seen, due to weak-
ness in its field. This lack of effect was interpreted by means
of TRANSPORT and TURTLE calculations. The preliminar-
ies to the experiment, the experiment itself, and the result
interpretation will be emphasized. Finally, predictions for a
possible effective octupole will be discussed.

Development of Simulation Software for Acceptance
Studies at PHENIX
J.A. CONLEY, J. NAGLE, Columbia University – The PHENIX experiment at the Relativistic Heavy
Ion Collider at Brookhaven National Laboratory will study
the possible phase transition of matter to the Quark-Gluon
Plasma. Of the possible signatures for this transition, some of
the more promising are the potentially suppressed yields of
heavy vector mesons (e.g., \( J/\psi \)). For detecting these and other particles, PHENIX in its final configuration will consist of four spectrometer arms—two muon arms and two central arms—and three large magnets—two muon magnets and one central magnet. In order to study the acceptance and trigger efficiencies of various particles, especially the heavy vector mesons, via their di-leptonic decays, a fast simulation utility program was written. The particular usefulness of the program is in the fast analysis of the acceptance variation during the changing configuration of spectrometer arms and magnetic field during the initial stages of completion of the full apparatus. The program has been used for high statistics studies of the F, J/\( \psi \), and \( U \) and as an input filler for the full GEANT-based simulation. The development of this software and the analysis and interpretation of its results have been the focus of the research.

Francium Alpha Decay and Beam Transport

M. DENTON, University of Central Arkansas, G. SPROUSE, State University of New York at Stony Brook – At the Nuclear Structure Laboratory (NSL) in the State University of New York at Stony Brook Francium (Fr) atoms are created through a nuclear reaction using the superconducting LINAC. Current plans are to study the energy levels and eventually parity non-conservation in the 87th element. Using lasers, these newly created Fr atoms are then cooled and confined so they may be studied more carefully. These atoms are made in the NSL because there are no stable isotopes with a half-life greater than 20 minutes. Since these particles are so short lived, we can tell which isotopes we have by looking at the alpha particles that they emit. I have been analyzing data to determine whether the \( ^{210}\text{Fr} \) atoms emit alpha particles or undergo electron capture. This ratio, known as the branching ratio, is currently known to within only 30%. I have also been working with the beam transport of the Fr ions to the laser trap. Once the projectile (\( ^{180}\text{O} \)) fuses with the target (\( ^{197}\text{Au} \)), Fr is made and accelerated from the target, which is kept at a high voltage. Then the particles liberated from the gold target are steered using electrostatics. Electrostatics however is not mass sensitive, and allow much more than the Francium atoms be steered down the beam line. These other elements are from impurities in Au that are alkali metals like Fr that easily give up one electron. These particles have the same charge as the Fr ions but could be removed with a mass sensitive steering system. In order to remove these impurities, I have placed a magnet in the beam line and have tested it to see if particles of different masses can be bent with deflection differences large enough to steer the particles into the beam line.

**Tests of the Independent Particle Nuclear Shell Model**

S. DONELLY, University of Maryland, G. RAWITSCHER, University of Connecticut – A modification to the conventional Woods-Saxon potential for the independent particle nuclear shell model is proposed and tested. In order to achieve better agreement with experimental measurements of nuclear energy levels, a Gaussian-type bump is introduced into the bound state potential energy function. The effects of this bump are then examined for the \( ^{16}\text{O} \) nucleus.

**Evolution of the Giant Dipole Resonance Width With Nuclear Temperature in \( ^{152}\text{Sn} \)**

K. EISENMAN, Kalamazoo Area Math and Science Center, M. THOENENESSEN, Michigan State University, National Superconducting Cyclotron Laboratory, N.D. DANG, Institute of Physical and Chemical Research, Japan – The temperature dependence of the giant dipole resonance width (GDR) in hot nuclei is still an unresolved question. This property connects the internal excitations with the collective motion of the nuclei. Previous theoretical calculations have compared only the width of the resonance at an average temperature. We recently developed tools to include theoretical strength functions into full statistical model calculations accounting for the multi-step decay of hot nuclei and the detailed shape of the GDR. In the present work we applied the microscopic phonon damping model (PDM) to recent experiments with \( ^{120}\text{Sn} \). The analysis shows that the entire experimental shape of the hot GDR can be reproduced reasonably well with the strength functions from the PDM.

**Effects of Controlled and Uncontrolled Torques on Pure Electron Plasmas**

J. ELLSWORTH, Wells College, R. POLLOCK, Indiana University Cyclotron Facility – The IUCF plasma group investigates the fundamental properties of non-neutral plasmas. Electron plasma is contained in a modified Penning-Malmberg trap at the IUCF. Uncontrolled torques on the system are the result of asymmetries in the trap and imperfect vacuum. The lifetime of an unheated plasma and the radius of the plasma as it decays were investigated. Controlled torques are applied to a heated plasma with a high frequency rotating dipole electric ‘motor’. The effects of the motor to compress the plasma and to excite a dipole Gould-Trivelpiece resonance were studied.

**Compressibility of Nuclear Matter from Isoscalar Giant Monopole Resonance Energies**

T. FACKLER, H.L. CLARK, Y.-W. LUI, D.H. YOUNGBLOOD, Texas A&M University – An accurate determination of the compressibility of nuclear matter (\( K_{\text{sym}} \)) is important for the study of supernova, neutron stars, heavy-ion collisions, and properties of nuclei (radii, masses, giant resonances, etc.). The isoscalar giant monopole resonance (GMR) is of particular interest because its energy is directly related to \( K_{\text{sym}} \). In order to account for contributions from finite nuclei and extract \( K_{\text{sym}} \), the energy of the GMR must be accurately known in nuclei over a wide range of A. At the Cyclotron Institute at Texas A&M University, we excite the GMR in nuclei with 240 MeV alpha particle scattering. We have developed a detection system that is highly sensitive to the GMR by measuring the inelastically scattered alpha particles at forward angles, including 0 degrees. We report here our most recent results on the GMR and will discuss the impact of the measured GMR energies on the value of \( K_{\text{sym}} \).

**Tests of the Independent Particle Nuclear Shell Model**

M. DENY, Indiana University Cyclotron Facility – The IUCF plasma group investigates the fundamental properties of non-neutral plasmas. Electron plasma is contained in a modified Penning-Malmberg trap at the IUCF. Uncontrolled torques on the system are the result of asymmetries in the trap and imperfect vacuum. The lifetime of an unheated plasma and the radius of the plasma as it decays were investigated. Controlled torques are applied to a heated plasma with a high frequency rotating dipole electric ‘motor’. The effects of the motor to compress the plasma and to excite a dipole Gould-Trivelpiece resonance were studied.
that experiment. The baseline system currently monitors approximately 10,000 parameters. At completion the system will monitor over 25,000 parameters. The software toolkits being used are EPICS (Experimental Physics and Industrial Control System) and CDEV (Control DEVice). Undergraduate contribution to this project has been, and continues to be, significant in both the development and implementation of the system. The architecture of STAR hardware controls will be presented, as well as a summary of the results of operation of the integrated baseline system.

Event Reconstruction Efficiencies from Various Trigger Configurations in the PHENIX Muon Arms

J. FREEMAN, J. NAGLE, Columbia University – There are two primary goals of the PHENIX experiment, held at the RHIC at BNL. The first is to discover and analyze the Quark Gluon Plasma, which QCD theory predicts should be created when gold nuclei are collided at ultrarelativistic speeds. The second is to find undiscovered contributors to the total spin of the proton (possibly sea quarks or gluons) through polarized proton-proton collisions. In each case, it is critical for the PHENIX detector to be able to trace muons released from dimuon decays. These decays, which result from Drell-Yan processes, Gauge Boson decays, J/Ψ and U decays need to be identified and these events saved. For this purpose, at the north and south ends of the detector, two muon arms are under construction. Since the front end electronics can transmit events at a maximum rate of 10 kHz, and we can record data at a level of 20 MB/s, only a limited number of the total events can be analyzed by software. Therefore, we present computer simulations being developed to examine the effects of different hardware trigger configurations and of different algorithms run in the event builder trigger processors. A particular focus will be placed on an investigation of J/Ψ efficiency given these simulated conditions.

Inclusive Nucleon Resonance Electroproduction Database

C.R. FURMAN, C. KEPPEL, Hampton University / Thomas Jefferson National Accelerator Facility – I have compiled a global database of inclusive nucleon resonance electroproduction data. Previously, inclusive resonance electroproduction data has been used in studying the deep inelastic region of electron-nucleon scattering. This database, which spans decades of experiments and is to my knowledge the first of its kind, compiles experiments from SLAC and TJNAF. Available on the web, it includes measured differential cross sections and has other available kinematics. A first use of this new database was to find data from the various experiments suitable for extracting the longitudinal and transverse components of the cross section separately, a comparison not possible with any one of the existing data sets alone. Suitable data was determined by data with similar Q^2 and W^2 values. A C++ program, which I wrote, was used to make matched data sets with a Q^2 range of +/- 0.1 (GeV/c)^2 and a W^2 range of +/- 0.05 GeV^2. Results from these efforts will be presented along with general database information.

Simulations for an η Meson Photoproduction Experiment at Jefferson Lab

J. GARDNER, T.J. CARROLL, M.F. VINEYARD, Department of Physics, University of Richmond – Jefferson Lab Experiment 93-008 will use the CEBAF Large Acceptance Spectrometer (CLAS) and the photon tagging system in Hall B to measure inclusive η(547) meson photoproduction in nuclei. The primary motivation of this experiment is to investigate nuclear medium modifications of nucleon resonances and the η-nucleon interaction. Simulations for the experiment are being performed with the CLAS GEANT simulation code GSIM to determine the acceptance of the CLAS so that quantitative results can be extracted from the experiment and to develop the data analysis software. The simulations will be described and preliminary results will be discussed.

Cooling System for the PHENIX Drift Chamber Detector at RHIC

Y. GLANVILLE, J.L. THOMAS, B. JACAK, SUNY Stony Brook – The Relativistic Heavy Ion Collider (RHIC) is now starting operation to collide Au ions. The PHENIX experiment uses a drift chamber to measure the momentum of particles created in the collisions. The anode signal wires of the drift chamber are read by the ASD/TMC board with six ASD8 chips to amplify, shape and discriminate the signals. Hits above threshold move on to the Time Memory Cell (TMC) chips. These components generate approximately 10W of power on each board, and are directly coupled to heat pipe assemblies to remove the heat. Four ASD/TMC boards feed each front end module (FEM) which contains a G-Link receiver and two transmitter daughter boards, an Arcnet communications board as well as the front end circuitry. Providing power to all components associated with one FEM board generates approximately 71W. The power converter is cooled by direct contact to a copper plate. My focus will be on the components, testing, and performance of the cooling system.

η and η' Photoproduction at CEBAF

A. GODBER, M. DUGGER, J. BALL, B.G. RITCHIE, R. JACOB, W. KAUFMANN, Arizona State University, HALL B COLLABORATION, Thomas Jefferson National Accelerator Laboratory – Investigations of η(549) and η'(958) meson photoproduction on the proton provide great insight into the structure of these mesons and their interactions with the nucleon and its excited states. At CEBAF, these cross sections have been measured using the CEBAF Large Acceptance Spectrometer (CLAS) and the Hall B Photon Tagger. The η cross sections were measured with greater precision than previous experiments, while at the same time, the measurements were extended to much higher energies. Extensive precision measurements of η' photoproduction cross sections were made for the first time. The preliminary results are compared to predictions using an updated Hicks Model based on the data obtained.

Quantum Behavior of Particles on One- and Two-Dimensional Waveguides

D.S. GOLDBAUM, Ohio Wesleyan University, J.T. LONDERGAN, Indiana University, Nuclear Theory Center, D. MURDOCK, Tennessee Technological University – The bound state energy and transmission probabilities of a one dimensional waveguide of L-shaped geometry were calculated. The transmission properties of straight one dimensional waveguides with geometrical stub scattering were also calculated using transform matrices. The transform matrix formalism allowed the study of arrays of scatterers, which in some cases precipitated bound states amongst a continuum of energies. The bound states displayed properties that may be fundamental consequences of quantum interference in the array.

Trigger Energy and Invariant Mass Calibrations of Crystal Ball Simulator

S.T. HAYDEN, M. SADLER, Abilene Christian University, CRYSTAL BALL COLLABORATION, ACU, ANL, ASU, BNL, GWU, KSU, PNPI, RBI, UCLA, UCol, UKa, UReg, VaU – A new program in baryon spectroscopy is underway using the Crystal Ball Spectrometer (E913/914) at the Brookhaven AGS facility. The Crystal Ball, which consists of 672 NaI(Tl) crystals covers 96% of 4π steradians, was originally built for studies of the excited charmonium spectrum at SLAC. Differential cross sections for pion-nucleon
charge exchange scattering, $\pi^- + p \rightarrow \pi^0 n$, have been obtained from measurements at fifteen momenta from 153 MeV/c to 660 MeV/c. Trigger energy and invariant mass calibrations of the Crystal Ball Monte Carlo simulation package are necessary to evaluate the acceptance of the Crystal Ball for the charge exchange reaction. Also, due to the vast amount of CPU time needed for the GEANT simulation, one 486 and three 386 computers were upgraded to 450 MHz AMD processors with accessories. The upgrade was the most effective plan available: 1) the expense of the upgrade was less than that of one new system, 2) the time to make one complete pass through all fifteen momenta in the Crystal Ball simulator was reduced from two weeks to a few days, facilitating the analysis of the Crystal Ball data.

Simulation for Radioactivity Analysis of KamLAND Detector Components L.K. HOFFMAN, A. PIEPKE, R. MCKEOWN, J. BEACOM, P. VOGEL, F. BOEHM, K.B. LEE, California Institute of Technology – The solar neutrino deficit and the results obtained by SuperKamiokande have prompted the construction of the Kamioka Liquid scintillator Anti-Neutrino Detector. The largest liquid scintillation detector built to date, KamLAND will search for neutrino oscillations in disappearance mode using antineutrinos from nuclear power reactors $\nu_e + p \rightarrow e^- + n$. Since the predicted neutrino flux is based on a reactor rather than a solar emission model, reproduction of the solar deficit at KamLAND will be truly model independent. Low antineutrino energies of 0-8 MeV will allow for the detection of neutrino oscillations at low $\Delta m^2$. KamLAND will be sensitive to the large-mixing-angle solution of the solar neutrino problem. Our Caltech group is involved in selecting construction materials which minimize the effects of background. This study developed a low energy Monte Carlo simulation to quantify the influence of each construction material being tested. The Monte Carlo software GEANT was used to simulate the proposed KamLAND geometry. Appropriate subroutines generate radiation randomly distributed throughout each component of the detector, e.g. the ropes which support the balloon or the glass of the phototubes. The user chooses to generate monoenergetic gammas or the gamma, alpha, and beta spectrum emitted by isotopes such as $^{232}$Th. The data acquired with this simulation will be presented.

Simulation Evaluation for STAR A. HUMMEL, T. SAKREJDA, J. SEGER, M. LEE, Creighton University, STAR COLLABORATION – The Solenoidal Tracker at RHIC (STAR) is a detector at Brookhaven National Laboratory that will search for quark-gluon plasma signatures in heavy ion collisions. A quark-gluon plasma is a phase of matter where quarks and gluons, which are normally confined to individual protons and neutrons, mix with quarks and gluons of neighboring protons and neutrons. The main detector of the STAR experiment, the Time Projection Chamber (TPC), has already taken test data from cosmic ray events and will take data from gold on gold collisions in December 1999. Once collision data is available, it will be important to examine the ability of the TPC software to accurately reconstruct events. To do this, simulated data is combined with real data. After the TPC software reconstructs the combined data, the reconstruction efficiency is evaluated by examining the fraction of recovered simulated data. This evaluation of reconstruction efficiency can begin once the simulators are tested and tuned to accurately reproduce the characteristics of the TPC. An analysis of simulator capacity for reproducing the resolution of the TPC based on the cosmic ray data will be presented.

Detectors for Nuclear Astrophysics Experiments Using Radioactive Ion Beams B.A. JOHNSON, R. KOZUB, J.M. COX, Tennessee Technological University, J.C. BLACKMON, M.S. SMITH, T.A. LEWIS, D.E. PIERCE, Oak Ridge National Laboratory, D.W. BARDAYAN, University of North Carolina/Oak Ridge National Laboratory – Our research involves the study of the nuclear reactions that take place in stellar explosions such as novae, supernovae, and X-ray bursts. In these reactions, the capture of protons and alpha particles by light radioactive nuclei is important; therefore, the use of radioactive ion beams (RIBs) in reverse kinematics reactions is necessary. Given the typically low beam currents of RIBs and the wide angular dispersion of the ejectiles, detector arrays which cover a large solid angle are required. A detector array subtending up to 5 sr has been designed and is being constructed for use at the HRIBF at ORNL. It consists of a layered E-\Delta E array of Si detector wedges having 16 strips per wedge in a hexagonal "lamp shade" arrangement. Due to the low energy ejectiles in some reactions, normal E\Delta E telescopes cannot always be used for particle identification. Thus, large solid angle, hexagonal array using microsphere plate detectors is being developed for use with the Si array to facilitate time-offlight mass identification of low energy particles. The status of the project will be presented.

Production of Neutron-Transmutation-Doped Germanium Thermistors for CUORICINO J.S. JUR, University of South Carolina, R.J. MCDONALD, E.B. NORMAN, A.R. SMITH, E.E. HALLER, J.W. BEE-MAN, Lawrence Berkeley National Laboratory – CUORICINO will be a new cryogenic bolometer experiment to search for the Coulombless double beta decay of $^{128}$Te. The experimental apparatus will consist of fifty-six 750-g TeO$_2$ crystals cooled to $\leq 20$ mK. Neutron transmutation doped thermistors will be
attached to the crystals to detect the small temperature rises produced by double beta decay. We have begun the production of the thermistors by irradiating ultra-pure germanium wafers at the University of Missouri Research Reactor. Monitor foils were placed in the reactor to determine both the thermal and fast neutron fluxes seen by the germanium. Results of these measurements and their implications for CUORICINO will be presented.

**Optimization of the $^3\text{He}$ Target Polarization**

E.K. LAKURIQI, Z.-E. MEZIANI, Temple University, S. INCERTI, Bordeaux I University, F. XIONG, Massachusetts Institute of Technology – The optimization of the pick-up coils guarantees a better NMR signal. The $^3\text{He}$ polarization is determined by laser pumping and we only use the signal to deduce the polarization. Given a certain $^3\text{He}$ polarization, we shall try to optimize the signal by changing the pick-up coil geometry. Careful modeling of the pick-up coils is necessary to take into the account the differences in the dimensions, positions and relative densities between the $^3\text{He}$ cells and the water cell. In addition, coil modeling allows one to calculate from first principles the expected size of the water signal.

**Detector Studies for the TRINAT Experiment**

B.L. LEE, University of Victoria, J. BEHR, TRIUMF – The TRI-NAT (TRIUMF Neutral Atom Trap) experiment’s current setup is designed to measure the b-n correlation in the b decays of $^{38}\text{K}$ isomer and of $^{37}\text{K}$ ($K\rightarrow\text{Ar}+e^++\nu$). The detectors used to observe the Ar and positron decay products are a microchannel plate, and, mounted opposite to it, a "b telescope" consisting of a position sensitive silicon strip detector backed by a plastic scintillator. The potassium atoms are trapped in a Zeeman Optical Trap (ZOT) between the two detectors and allowed to decay. This research concentrated on the behaviour of the plastic scintillator. The plastic scintillator’s linearity of response and energy resolution were studied for event energies near 5 MeV by analysing the Compton edges and double escape peaks of the 4.44 MeV and 6.13 MeV gamma rays emitted by a $^{241}\text{Am}/^{244}\text{Be}$ calibration source and a $^{244}\text{Cm}/^{13}\text{C}$ calibration source. The pair production events which caused the double escape peaks were tagged by detecting the pair production annihilation radiation in two NaI detectors flanking the plastic scintillator.

**SAMPLE Experiment - Software Analysis Project**

T.P. LEE, R. MCKEENOW, California Institute of Technology, THE SAMPLE COLLABORATION – The neutral weak magnetic form factor of the proton ($g_1^p$) can be extracted from the parity-violating asymmetry in elastic electron scattering from the proton. It also contains new information on the contribution of strange quark-antiquark pairs to the magnetic moment of the proton. The SAMPLE experiment, conducted at MIT-Bates Linear Accelerator Center, used a 200 MeV longitudinally polarized electron beam incident on a 40 cm long liquid hydrogen target. The scattered electrons were detected in a large solid angle air Cerenkov detector. Data from over 100 Coulombs of charge was collected in 1998, in addition to the 35 Coulombs collected in 1995 and 1996. The results from our model with a hydrogen target include an uncertainty in the axial radiative correction term ($R_{1}^{A}$). To improve our determination of the neutral weak magnetic form factor, the experiment was performed using a liquid deuterium target in 1999. The deuteron asymmetry is sensitive to the axial radiative correction but is almost completely insensitive to the strange magnetic moment. The uncertainty can thus be reduced by taking the ratio of the deuteron asymmetry to the proton asymmetry to remove sensitivity to $R_{1}^{A}$.

**The Uniformity of Cesium Iodide Crystals**

M. LENNEK, University of Alabama, W. LYNCH, Michigan State University – THE LASSA detector array has very high energy resolution requirements. These requirements necessitated the application of several different correction methods. These correction methods were all somewhat thwarted by the discovery of relatively large local variations of light output from the crystals. These local variations could not be globally corrected, and therefore the general correction methods used were not as effective as they could have been. These local variations will have to be mastered and understood before the optimum energy resolution can be achieved.

**Station One Cathode Strip Chambers for Muon Tracking at PHENIX (RHIC)**

E. LOCKNER, McGill University, D.E. FIELDS, University of New Mexico, THE PHENIX MUON COLLABORATION AT RHIC/BNL – The PHENIX experiment is one of four experiments at Brookhaven National Laboratory designed to study collisions from protons to Gold ions at relativistic speeds. One focus of the PHENIX experiment is to study muons produced in this collision. These muons provide insight into the creation of the Quark-Gluon Plasma (QGP), and into the spin content of the proton. Three detection stations are required to track the muons through the magnetic field of the PHENIX muon arms with sufficient resolution. Each station covers 360° azimuthal and 12° to 35° in $\theta$, and must provide 60 μ absolute position resolution for each track. The University of New Mexico team is responsible for the design, assembly and testing of the detection chamber closest to the collision point, Station One. The assembly of the detector panels has involved the development of automated wiring techniques, innovative vacuum bagging apparatus, and the construction of a clean tent. Assembly and testing of the panels is scheduled to finish in December of 1999.

**Proposal for Drell-Yan Measurements of Nucleon and Nuclear Structure with the FNAL Main Injector**

N. LONGBOTHAM, L.D. ISENHOWER, Abilene Christian University, P906 COLLABORATION – The Fermilab Proposal 906 is a follow-up experiment that would complement the findings of Fermilab Experiment 866 (E866/NuSea), measuring cross sections for Drell-Yan processes. Cross sections for the Drell-Yan process in proton-deuteron and proton-proton collisions allow one to calculate the ratio of anti-down quarks to anti-up quarks in the nucleon sea. The results of E866 were surprising and showed the ratio increasing with Bjorken-$x$ of the target ($x_2$) and then decreasing at larger $x_2$. There has been significant interest in extending these measurements to $x_2$ values above 0.3. Using the new Fermilab Main Injector at 120 GeV, P906 will do exactly that. The experiment will be able to use proton induced Drell-Yan reactions to precisely measure the fractional momentum dependence of the ratio of anti-down to anti-up quarks. High intensity proton beams from this accelerator make it possible to make precise measurements of this ratio at large $x$ ranges.

**Effects of Isospin Mixing on the Distribution of Shell-Model Transition Probabilities**

K. MAHAR, J.B. SHRINGER, Tennessee Technological University, G.E. MITCHEL, North Carolina State University and TUNL, B.A. BROWN, Michigan State University – Study of the statistical properties of nuclear levels and transitions has provided a wealth of information over the years. Realization of a connection between statistical distributions and chaotic or regular behavior of systems has provided new impetus for such studies. Of special interest in recent studies has been the effect
of broken symmetries on statistical properties. Recent works have shown how symmetry-breaking affects several statistical nuclear properties such as spacing distributions, but the effect of broken symmetries upon transition strength distributions is relatively unstudied. The only studies available for transition distributions thus far examine theoretical systems with good symmetries; these studies suggest that transition distributions follow a $\chi^2$ distribution with $n = 1$ degree of freedom in chaotic systems and a $\chi^2$ distribution with $n > 1$ in regular systems. However, experimental data from $^{26}$Al did not follow a $\chi^2$ distribution; it was suggested that this disagreement might reflect the fact that isospin is not a conserved quantity. To test this hypothesis, we analyzed two sets of $^{26}$Al shell model calculations, one with conserved isospin and one with non-conserved isospin.

Quantum Scattering of Composite Particles
M. MATTHEWS, Linfield College, V. ZELEVINSKY, A. SAKHARUK, Michigan State University, National Superconducting Cyclotron Laboratory – A simple model for the scattering of compound particles against an infinitely high potential wall is studied. The interplay between the internal structure of the particle and the center of mass motion is examined. Also investigated is the dependence of the reflection on mass of the component particles. It is found that the mass of the particles with respect to each other in particular greatly affects the scattering behavior.

Population and Fission Cross-section of the 26 Minute Isomer of $^{235}$U
E. MELO, United States Naval Academy, A. HAYES, M. CHADWICK, Los Alamos National Laboratory – We summarize our calculations of the population of the 26 minute isomer of $^{235}$U as a function of neutron energy. Also included is a summary of our calculations of the fission cross section of the isomer with respect to the ground state as a function of neutron energy. These calculations can have an important effect on nucleocosmochronometers that use $^{235}$U.

Laser Calibration System for the FTPC and for the STAR Collaboration
K. NEFF, D. CEBRA, University of California, Davis, STAR COLLABORATION – The Forward Time Projection Chamber (FTPC) will be sensitive to charged particles in the $2.5 < |\eta| < 4.0$ region allowing better overall coverage of the STAR detector. This coverage will resolve the distortions which are present in the electric or magnetic fields. The design of the FTPC laser calibration system will be presented along with reasons why the calibration is necessary. In addition, an overall description of the FTPC used in the STAR experiment at RHIC will be presented.

Distinguishing Nonphysical Events in the Sudbury Neutrino Observatory
N. OBLATH, Cornell University, K.T. LESKO, Lawrence Berkeley National Laboratory, Y. OPACHICH, Contra Costa College – The Sudbury Neutrino Observatory (SNO) is a new $^{24}$Mg Cherenkov solar neutrino detector. Although the purpose of SNO is to detect solar neutrinos, various other events are detected as well, including two types of non-physics events called "shark fins" and "flashes." This poster investigates the time variation of these events, and the relation between the rates of shark fins, flashes and the type of run (calibration or neutrino) that is taking place. Because shark fins and flashes are non-physics events, it is important to determine ways in which they can be filtered from the data. This poster also shows possibilities for filtering out these events, based on various parameters. Results from SNO’s recent run history will be presented.

Carbon Activation Using High Energy Neutrons
H. OLLIVER, S.J. PADALINO, S. THOMPSON, SUNY Geneseo, C. SANGSTEER, Lawrence Livermore National Lab, V. GLEBOV, University of Rochester Laboratory for Laser Energetics, E. MORRSE, A. BELLIAN, Lawrence Berkeley National Lab – The Laboratory for Laser Energetics at the University of Rochester has been conducting experiments using laser induced nuclear fusion as a possible alternative energy source. The Ariel density of an inertial confinement fusion (ICF) reaction can be determined by calculating the ratio of the tertiary neutron yield to the primary neutron yield. During an ICF reaction, 14.1 MeV neutrons emitted from the T(d,n) fusion reaction strike fuel deuterons causing them to accelerate. These deuterons then collide with tritium fuel to produce tertiary T(d,n) reactions that produce high energy neutrons in the range of 18 to 32 MeV. A pure carbon sample is placed near the reaction where it becomes activated through the $^{12}$C(n,2n)$^{12}$C reaction. This reaction has a high neutron threshold near 17 MeV and the primary 14.1 MeV neutrons cannot activate the carbon. Once activated, the sample is removed from the reaction area. The $^{12}$C consequently beta decays by emitting positrons. NaI detectors can then count, in coincidence, the back to back 511 keV gamma rays emitted from the positron annihilation. The number of gamma rays counted is directly related to the tertiary neutron yield of the fusion reaction. The chief concern of using this method is that back to back 511 keV gamma rays may be produced from reactions other than the $^{12}$C(n,2n)$^{12}$C reaction. These reactions include $^{14}$N(n,2n)$^{14}$N and $^{12}$C(p,$\gamma$)$^{13}$C, among others. This recently was investigated at the University of California at Berkley using the Rotating Target Neutron Source (RTNS) which produces copious amounts of mono energetic 14 MeV neutrons. Further studies will be conducted using the accelerator at the Triangle University Nuclear Lab, which is capable of producing large amounts of high-energy gamma rays. Those gamma rays can be used to study the $^{12}$C($\gamma$,n)$^{12}$C reaction which also produces unwanted back to back 511 keV gamma rays. Eventually the carbon activation diagnostic will be used at the National Ignition Facility in Livermore, California.

Plasma Calorimeter Calibration
M. OLSEN, SUNY Geneseo – The Laboratory for Laser Energetics (LLE) at the University of Rochester is using a set of plasma calorimeters to study the energy produced in laser-driven inertial confinement fusion reactions. Seventeen of these plasma calorimeters are mounted around the implosion site. Each calorimeter consists of two 25 mm thick tantalum foils and a copper reference plate of equivalent thermal mass. A set of type-E thermocouples is used to make three differential temperature measurements (foil 1-reference, foil 2-reference, and foil 1-foil 2). We are developing a technique to calibrate the plasma calorimeters using proton beams of several hundred keV from the 2 MV Van de Graaf accelerator located at the Geneseo Nuclear Structure Laboratory (GNSL). Using a pair of electrostatic plates, the proton beam is directed toward each of the calorimeter foils in turn. The protons deposit their energy in the foils and foils. The calorimeter signals are directed to electrometers that convert the signals to a voltage output, which is recorded and
analyzed using the LabVIEW interface program. Before striking the calorimeter, the beam passes through 0.086 mm gold foil, and a 100 mm silicon detector is used to count the protons that scatter at a 45 angle. Rutherford scattering is used to measure the current of the beam, which is needed to determine the power of the incident protons. The power and voltage are compared for the calorimeter calibration.

**Destinguishing Nonphysical Events in the Sudbury Neutrino Observatory**

Y. OPACHICH, Contra Costa College, K.T. LESKO, Lawrence Berkeley National Laboratory, N. OBLATH, Cornell University – This summer my research involved analyzing data from the Sudbury Neutrino Observatory for nonphysical events called flashers and shark fins. I investigated the trends in the rates of shark fins and flashers over time, and researched the performance of a filtering program, the First Pass Filter (FFF) that was developed to remove nonphysical events such as flashers, and shark fins. Shark fins and flashers are a common occurrence in SNO, and could be an indicator of how well the detector’s photon multiplier tubes and electronics are performing. The exact cause of these events is unknown, however they do have a specific signature and could be removed from the main data, and then monitored. Monitoring such events is important, because a change in their behaviour could be an indicator of problems within the detector. During my stay with the SNO group at LBNL, I found that the first pass filter, a program that removes obvious nonphysical events from the raw data set, is performing its job. That the rates of shark fins and flashers are relatively constant, and that for laser ball runs and when there is work being done on the detector, the rate of flasher events increases.

**Production of a Low Current, Monoenergetic Beam of Electrons to Study Detector Response**

R. PATTERSON, B. FILIPPONE, California Institute of Technology, An experiment at Los Alamos National Laboratory will study the beta decay of spin-polarized, ultra-cold neutrons. The electrons resulting from these decays can have energies ranging from zero to 748 keV. A detector is being developed at Caltech to measure these energies with the desired resolution. The work discussed here is the design and construction of an accelerator that will produce a narrow, low current, monoenergetic beam of electrons to be used to study the detector’s response in the 0 - 120 keV range. A tungsten filament produces the electrons which must be extracted, focused, and accelerated. An einzel lens provides the primary focusing. Also, since the desired beam current (picocamps) is not readily measurable, the detection of the beam current on filament bias, extraction voltage, and beamline geometry must be well understood.

**Detector Testing for Jefferson Lab G0 Experiment**

S.K. PHILLIPS, Mississippi State University, B. HUTCHINSON, Louisiana Tech, D. LARSON, University of Maryland, G0 COLLABORATION – The goal of the G0 experiment (E91-017) is to measure parity-violating asymmetries over the range of Q squared from 0.1 to 1.0 GeV² at both forward and backward angles. These measurements will be used to separate the GE and GM form factors (the neutral weak current analogs of the electric form factor GE and the magnetic form factor GM). Using these form factors, the u, d, and s quark contributions to the charge and current of the nucleon can be determined. The G0 detector will be able to measure asymmetries at both forward and backward angles. It is comprised of a toroidal array of eight super-conducting coils, designed to focus particles of the same momentum and scattering angle from the target to a single point. The detector will have sixteen scintillator pairs for each of eight octants which surround the beamline to cover \( \phi = 360^\circ \) for maximum solid angle.

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**Testing Lead Glass Photon Detectors for the Charge-Symmetry-Violating Reaction d+d→π⁰+π³**

R. POOSER, New York University, A. BACHER, Indiana State University, M. PICKAR, Minnesota State University, Mankato – A study was made of the efficiency of available lead glass detectors for the detection of photons from decayed neutral pions produced in the charge symmetry violating (CSV) reaction d+d→π⁺+π⁻. Light collection was measured using a muon tagging apparatus consisting of 1.2 meter long scintillators above and below the lead glass detectors. The lead glass detectors were found to be very efficient for trajectories perpendicular to the long, tapered sides of the wedge-shaped modules that the gammas will enter in the CSV reaction. Light collection was found to be slightly larger (15%) at the smaller tapered ends then right next to the phototube. The time resolution of the lead glass varies with incident angle, but maintains an average of about 1.5ns for all event positions. The results indicate that the lead glass detectors are excellent candidates for a gamma detection apparatus for use in the search for the d+d→π⁺+π⁻ reaction.

**Performance Testing of Trigger Systems**

W. RAY, P. YEPEZ, M. DEMELLO, Rio University – The new generation of Particle Physics Experiments (STAR, PHENIX, ATLAS, CMS) will generate several PetaBytes of data every year. The extraction of the interesting physics from these data will require sophisticated analysis and efficient triggers. The last trigger level, which can be considered as the first stage in the analysis chain, is usually implemented as a farm of fast processors. Such a farm decides which events should be kept for further analysis. A prototype of such a farm, consisting of 10 Dual Pentium computers connected through fast ethernet, was built and tested. The system consists of a master node and nine analyzing nodes. The master node generates data and sends it for analysis to the other processors. The data consists of space points in a tracking chamber generated by collision in a generic collider detector. The analysis processors reconstruct tracks and send the results back to the master nodes. Results on the performance of the system will be presented.

**X-ray Fluorescing the Elements**

G. RECH, University of California, Berkeley, E.B. NORMAN, Lawrence Berkeley National Laboratory, L. GUTHRIE, Acalanes High School, J. LEE, University of California, Irvine – This project is designed to be an aid to high school science and students alike to further their understanding on atomic processes. What we’re doing is to be fluoresced, get back the “unknown” spectra, compare it to the standards on the web and determine which elements are in there “unknown”. We hope that this will provide a good visual aid to go along with the abstract concepts found in atomic science.

**Level and Width Statistics from Neutron Spectroscopy**

of \(^{166}\)Ho W. REISNER, Reed College, C. GOULD, North Carolina State University, E. SHARAPOV, JINR-Dubna and TUNL – Symmetry violating effects can be significantly enhanced in the neighborhood of interfering neutron resonances with suitable quantum numbers, thus making it possible to study the properties of the weak (or other small) interactions through nuclear physics transmission experiments. In order to investigate these effects, suitable resonance pairs must be identified and their resonance parameters must be known as accurately as possible. As part of a study of the fea-
sibility of a resonance test of $P$-even time reversal violation, a high resolution neutron spectroscopy study was undertaken of $^{160}$Ho. The Oak Ridge Electron Linear Accelerator (ORELA) was used to produce a pulsed epithermal neutron beam. Both transmission and capture data were obtained. The transmission was fitted up to 500 eV using the R-matrix code SAMMY; nine new resonances were identified. Typical analysis was performed on the parameters: the histograms nearest-neighbor spacings were shown to fit a Wigner distribution and the reduced widths agree satisfactorily with a Porter-Thomas. In order to obtain a further check on the quality of the parameters, work is underway to analyze the capture data. Sample fits of transmission and capture data will be presented together with analysis of the width and spacing distributions.

**Monte Carlo Design Studies of a Photon Compton Scattering Experiment Utilizing the New FEL at Duke University**

A. SANDIFER K. KEETER, Idaho State University; H. WELLER, J. KELLEY, E. WULF, S. CANON, B. CROWLEY, S. NELSON, K. SABOUROV, E. SCHREIBER, C. HOWELL, W. TURNOW, R. TILLEY, Duke University, R. PRIOR, M. SPRAKER, North Georgia College and State University – An experimental program is planned at the new Duke Free-Electron Laser Laboratory (DFELL) for measuring Compton scattering off the proton and the neutron. The first experiment will be utilizing a hydrogen target and a linearly polarized gamma beam of 60 MeV. Design studies have been performed for the experimental setup with the Monte Carlo simulation package GEANT. Results of these simulations will also be used to determine background rates and precise detector solid angles. The goal of this experiment is to determine the electric and magnetic polarizabilities of the proton. The use of polarized gamma rays will permit determination of these quantities without invoking the so-called Dispersion Sum Rule for the first time. The polarizabilities are fundamental quantities which provide information on the internal structure of the proton. Recently an effective field theory based on QCD has been used to calculate these polarizabilities as well as the analyzing powers which will be measured in this experiment [Bernard et al., Int. J. Mod. Phys. E4 (1995)]. The results of this experiment will be compared to these theoretical predictions.

**Solar Neutrinos Unsolved**

A. HAYES, Y. QIAN, Los Alamos National Laboratory – One possible solution to the solar neutrino problem could be the production of enough neutrinos in the sun for the $p-p$ reaction to compete with the $p-p$ reaction. This is because the $p-p$ reaction produces deuterons without producing neutrinos. In order for this to be the case, the relative neutron-to-proton ratio in the sun must be $2 \times 10^{-25}$. The most common source of neutrons in the sun is photo induced nuclear disintegration. The most significant sources of photons for the photo induced nuclear disintegrations are the $p$-d, the $p$-$^3$He, and the $^3$He-$^4$He reactions plus a few other reactions in the CNO cycle. The neutron-to-proton ratio in the sun is found to be $7 \times 10^{-34}$, which doesn’t solve the solar neutrino problem.

**SAMPLE Experiment - Target Density Studies**

V. SAVU, E. BEISE, R. MCKEOWN, California Institute of Technology – The SAMPLE Experiment, located in the North Experimental Hall at Bates Linear Accelerator Center in Middleton, MA, is designed to measure the strange quark contribution to the proton magnetic form factor. The experiment probes the structure of the proton using the weakly interacting Z boson exchanged between a polarized electron and an unpolarized proton at a momentum transfer of $Q^2 = 0.1$ (GeV/c)$^2$. A 200 MeV electron beam polarized to 95% or higher is incident on a 40 cm long liquid deuterium target. A system of 10 Cerenkov counters covering a solid angle of 1.5 sr is used to detect the electrons scattered at backward angles from the liquid deuterium target. The asymmetry in the elastic cross section for positive and negative helicity electrons scattered from protons is used to investigate the contribution of strange quarks to the neutron. A major concern regarding target performance is the possibility of boiling effects. The investigated data concerning target density fluctuations are crucial input to the design of a new liquid hydrogen target for a future measurement of the parity violating asymmetry in Møller scattering at SLAC.
CR-39 Track Diameter Distributions for 13.8-MeV Protons Through Aluminum Degradation Foils B. SCHWARTZ, K. FLETCHER, SUNY Geneseo – The purpose of the Laboratory for Laser Energetics at the University of Rochester is to study Laser driven inertial confinement fusion reactions. One of the many nuclear diagnostics used to examine these reactions is the charged particle spectrometer. The magnetic spectrometer is designed to detect the mass and energy of charged particles produced by either d-d or d-t reactions. As the charged reaction products enter the spectrometer they are bent by its magnetic field through various paths and thus directed toward and detected by an array of CR-39 track emulsions. Upon impact with the emulsion, the particles produce tracks in the CR-39 whose diameter and depth are directly related to the particle’s mass and energy. Aluminum degrading foils are used to range high-energy charged particles to lower energies where CR-39 detection is most sensitive. In addition to lowering the average energy of the initially monoenergetic protons, energy straggling through the aluminum results in a broadening of the energy distribution. This, in turn, contributes to a broadening of the distribution of the track diameters in the CR-39. We investigated this experimentally using the 2-MeV Van de Graaff accelerator at the SUNY Geneseo Nuclear Structure Laboratory. High-energy protons were produced via the $^3\text{He}(d,p)^4\text{He}$ reaction, initiated with 450-kV deuteron on a $^3\text{He}$ target. These protons were ranged down by aluminum absorbers of differing thickness and directed toward CR-39. The distributions of the track diameter were then compared to predicted results.

Neutron Enrichment in Heavy Ion Collision S.M. SEUN, M. PFABE, Smith College, B. TSANG, P. DANIELEWICZ, NSCL/Michigan State University – In this project we examined the neutron enrichment between the proton-rich $^{124}\text{Sn} + ^{112}\text{Sn}$ and the neutron rich $^{124}\text{Sn} + ^{124}\text{Sn}$ systems. The production of t and $^3\text{He}$ was measured for $^{124}\text{Sn} + ^{112}\text{Sn}$ and $^{124}\text{Sn} + ^{124}\text{Sn}$ reactions at incident beam energy E/A = 50 MeV using the LASSA (Large Area Silicon Strip Array) at the National Superconducting Cyclotron Laboratory at Michigan State University. A comparative study of the experimental observations with predictions from microscopic Boltzmann-Uehling-Uhlenbeck (BUU) transport calculations has been performed. Simulations were performed for the two systems with impact parameters ranging from 0 fm to 9 fm. The model was investigated to check whether it would reproduce the large magnitude of the t/$^3\text{He}$ ratio observed experimentally, the dependence on the isospin of the incident systems, and the sensitivity of the dynamics of intermediate-energy heavy-ion collisions to the equation of state of nuclear matter. The BUU model suggests strong correlation between t/$^3\text{He}$ and n/p ratios. However, it significantly under predicts the experimental t/$^3\text{He}$ yield ratio and the isospin dependence of the t/$^3\text{He}$ ratio.

The Search for the Quark Gluon Plasma A. SICKLES, Gonzaga University, G. WESTFALL, Michigan State University/NSCL – The STAR collaboration at the Relativistic Heavy Ion Collider at Brookhaven will be able to detect photons in its Electromagnetic Calorimeter. This research focused on the ability to see the photons originating from the Quark Gluon Plasma (QGP) above the background of photons from decayed neutral pions. Using a computer model of the detector and the Heavy Ion Jet Interaction Generator (HIJING) simulated events were run and analyzed leading to the creation of a signal with the QGP. An approximate background of photons was then created using only what would be known in a real event. The background was subtracted and what remained was identified as the Quark Gluon Plasma.

Development of Thin Foil Faraday Collectors for Low Energy, High Flux Charged Particle Spectrometers C.J. SUTTON, N. WASINGER, F.E. CECIL, Colorado School of Mines – We have completed a feasibility study to determine the use of thin-foil Faraday collectors to measure the energy and flux of low energy ion beams. One application of such a detector would be to measure lost ions from high yield Tokamak d-t fusion plasmas (e.g. JET, ITER). We have built a prototype detector and tested it with a 180keV General Ionex (Model 1545) accelerator. These tests demonstrated the viability of this detector concept. The present detector consists of five foils of 0.1 micron gold leaf and utilizes a modular design. It is capable of resolving ion energies from about 50 to 170 keV. Future designs will incorporate a metal deposition chamber and a plasma enhanced chemical vapor deposition system to deposit conducting and insulating layers.

Development of an Asymmetric Full Data Cube for DCO Ratio Analysis J. TERRY, W. MA, P. VARMETTE, Mississippi State University, M. BERGSTROM, Universität zu Köln, B. HERSKIND, Niels Bohr Institute – DCO (Directional Correlation of Oriented nuclei) ratio analysis is a very common and important approach to find the multipolarity of gamma transitions in order to determine the spin and parity of excited nuclear states. Traditionally DCO analysis has been accomplished through the analysis of double coincidence data using an asymmetric 2-D matrix. However, this method often failed for weak transitions in a complex level scheme or at high spins. The high-fold, high-statistics data from large detector arrays such as “Gammasphere” and “Euroball”, together with the high speed and large disk space of modern workstations have made it possible to perform triple coincidence analysis using a 3-D asymmetric cube. The aim of this project is to develop procedures and complete computer code to analyze a data set for the 168Hf nucleus obtained recently from a Gammasphere experiment at ANL using the reaction of $^{76}\text{Ge} + ^{96}\text{Zr}$. Since an asymmetric cube cannot be folded, compress ion techniques were implemented for the generation of an angle-sorted 1024x1024x800 channel cube, reducing the size by approximately a factor of three (0.5 GB). By gating on gamma rays of interests along the Z-axis, a series of slices of XY planes can be obtained which are equivalent to many traditional asymmetric matrices, but much cleaner. A graphical interface was developed to make the analysis easier. The principle and technique will be demonstrated.

Gain Matching the Medusa Array S. THOMPSON, H. OLLIVER, S.J. PADALINO, SUNY Geneseo, V. GLEBOV, University of Rochester Laboratory for Laser Energetics, C. SANGSTER, Lawrence Livermore National Lab – The Laboratory for Laser Energetics at the University of Rochester is currently investigating laser driven inertial confinement fusion with hopes of producing, capturing, and eventually utilizing the copious amounts of energy released in nuclear fusion reactions. Medusa, an array of over 800 proton recoil detectors, is one constituent of the melange of diagnostics used to collect information about each fusion experiment. In particular, Medusa is utilized to detect neutrons that are produced in the T(d,n) and D(d,n) reactions. Recently, while conducting investigations at LLNL regarding the efficiency of the Medusa array, it was discovered that the detectors were not satisfactorily gain matched. This issue was examined in more detail using neutrons from an 80 gram PuBe source at the State University of New York at Geneseo. Using a representative set of detectors from the Medusa array and the PuBe source that emits a range of neutrons with energies up to 11 MeV, it was
observed that the net difference in the endpoints of the detectors' energy spectra was 3.2 MeV. To determine the manner in which the array should be re-gain matched, the set of detectors was gain matched using both a 1274 keV gamma ray source and the large PuBe source. It was concluded that it is most accurate and efficient to gain match the detectors using neutrons from the PuBe source. The Medusa array is scheduled to be gain matched in January 2000.

**Neutron Simulations in GEANT for the Crystal Ball Experiment J. THOMS, S. STANISLAUS, B. MANWEILER, D. KOETKE, Valparaiso University, CRYSTAL BALL COLLABORATION** – This experiment, known as the Crystal Ball experiment, is designed to study all neutral particle final states resulting from (π-p) and (K-p) interactions in a liquid hydrogen target. The Crystal Ball has been positioned in line C of the Alternating Gradient Synchrotron (AGS) at Brookhaven National Laboratory. The significant feature of the detector is its ability to detect neutral particles from the decay of short-lived neutral Baryon excited states. A cylindrical barrel scintillator surrounding the target rejects charged events. It is in this physics regime that the Crystal Ball affords a unique contribution to hadron spectroscopy.

**Gamma Irradiation Facility**

L. TYNES JR., Hampton University, D. MECHAM, INEEL, A. STONE, Utah State University, N. BROWN, Southern Louisiana University – The new gamma facility will be the location of a new gamma project. This project is a spin off of a previous gamma project. The present project is meant to be better and more adequate for scientific use. A cylindrical tube will be placed in a gamma field, where an object of choice will be inside the capsule. Once in the gamma field the object (toys, food, medical equipment) will be irradiated and examined for any changes that may have occurred within the structure or without. The world's fastest golf ball is a product of a similar experiment.

**Nuclear Thermometers**

P. UNDERHILL, Washington University, S. PRATT, Michigan State University/NSCL – In intermediate-energy nuclear collisions (E/A 50MeV), nuclei collide and compress, forming a compound nucleus. As the compound nucleus cools and expands, it undergoes multi-fragmentation. These fragments then begin to cool by emitting small nuclei. By observing the populations of nuclei in their ground and first few excited states, effective temperatures are calculated. This study addresses the question of whether these nuclei can be used as nuclear thermometers to find out about the temperature of the initial compound nucleus. A computer simulation was performed by statistically generating the nuclear energy levels, populating the levels to approximate experimental findings, and sequentially decaying the nuclei. It was found that the heavier nuclei near 14N do not make good nuclear thermometers.

**Studying Collective Flow of Pions in La + La Collisions** D. VALENTE, C. MADER, Hope College – The behavior of particles created in a nuclear collision can provide much information about the workings of a nuclear system. Using the Boltzmann-Uehling-Uhlenbeck (BUU) transport model for nuclear collisions, the 139La + 139La system was studied at both 400 MeV/A and 1200 MeV/A. The flow of pions created in the collision was analyzed to gain insight on pion production and behavior in energetic nuclear collisions. Presentation of this systematic study will focus on pion flow as a function of impact parameter, beam energy, and nuclear equation of state. Significant changes in flow due to variations of these parameters lead to an understanding of the source and behavior of pion flow. Comparison of these predictions with experiment may lead to better determination for the parameterization of the equation of state.

**Comparison of Software in the SRIM-2000 Package** T. WAKEMAN, S.J. PADALINO, K. FLETCHER, B. SCHWARTZ, M. OLSEN, SUNY Geneseo, R. PETRASSO, Massachusetts Institute of Technology – Versions .09 and .10 of the SRIM range tables for protons on Aluminum were compared to Monte Carlo calculations. The program TRIM (Transport and Range of Ions In Matter) written by J.P. Biersack was used extensively. The SRIM program (Stopping and Range of Ions In Matter) is used widely in modeling charged particle transport through matter. SRIM produces evaluated stopping range tables from experimental data. The TRIM program is a Monte-carlo simulation of charged particle trajectories and energy loss which traces the complete history of the particle as it passes through matter. Trim calculations of protons passing through Aluminum at initial energies from 8 MeV to 16 MeV were run and compared to SRIM. The two versions of SRIM, both in wide use today, were found to be inconsistent with each other and with TRIM. Surprisingly, the earlier version, v.09, was found to be more consistent with TRIM, which compared well with measured data taken at S.U.N.Y. Geneseo's accelerator lab.

Fundied in part by the United States Department of Energy.

**Development of Thin Foil Faraday Collectors as Low Energy, High Flux Charged Particle Spectrometers** N. WASINGER, C.J. SUTTON, F.E. CECIL, Colorado School of Mines – We have completed a feasibility study to determine the use of thin-foil Faraday collectors to measure the energy and flux of low energy ion beams. One application of such a detector would be to measure lost ions from high yield Tokamak d-t fusion plasmas (e.g. JET, ITER). We have built a prototype detector and tested it with a 180keV General Ionex (Model 1545) accelerator. These tests demonstrated the viability of this detector concept. The present detector consists of five foils of 0.1 micron gold leaf and utilizes a modular design. It is capable of resolving ion energies from about 50 to 170 keV. Future designs will incorporate a metal deposition chamber and a plasma enhanced chemical vapor deposition system to deposit conducting and insulating layers.