Introduction
April 1, 2014 – March 31, 2015

Progress in research and operations at the Texas A&M Cyclotron Institute is summarized in this report for the period April, 1, 2014 through March 31, 2015. The format follows that of previous years. Sections I through III contain reports from individual research projects. Operation and technical developments are given in Section IV. Section V lists the publications with Cyclotron Institute authors and outside users and the Appendix gives additional information including talks presented by members of the Institute during the past year. Once again, the full volume of this year's Progress in Research is available only on our web site (http://cyclotron.tamu.edu). *Since most of the contributions presented here are truly reports on progress in research, results and conclusions should not be quoted from the report without the consent of the authors.*

We are pleased to announce that we have successfully completed a search for a new tenure track faculty position. We had a number of outstanding candidates and were fortunate to convince the University to allow us to hire two of them. We will be joined by Dr. Gregory Christian and Dr. Ania Kwiatkowski in the fall. Both are outstanding young experimentalists that will be relocating from TRIUMF. We also have been given permission to search for a theorist to complement our local experimental efforts, and that search is underway.

The K150 cyclotron provided 2,917 hours of beams including strip extracted protons, alpha particles, ^{12}C, ^{13}C, ^{16}O, ^{20}Ne, ^{28}Si beams for science experiments and for the development of the light-ion guide system, despite 8 weeks of downtime for the repairs on the cooling-water heat exchanger and the deflector spark shields. Over 2,300 hours of beams from the K150 cyclotron were provided during simultaneous operation with the K500 cyclotron. This demonstrates that once the ion guides are fully functional, the laboratory is operationally ready for radioactive beam production. The light-ion guide project continued to advance with a campaign of experiments designed to improve the transport efficiency of radioactive ions from the gas cell to the charge-breeding ECR (CB-ECR) ion source. The single sextupole transport device was replaced with two shorter sections that offered finer control but also improved the pumping speed in the region of poor vacuum. In the experiments, 15 MeV proton beams on natural Zinc targets were used to produce ^{64}Ga and ^{66}Ga radioactive ions as test ions and were successfully transported through the CB-ECR ion source. Diagnostic detectors are now being added to the system in order to tune the beam line sections before and after the CB-ECR ion source. Also the main components of the heavy-ion guide gas cell have been assembled and testing with a Cf source will begin in the fall

As in previous reports, I include here some highlights of work carried out over the past year.

- An in-depth analysis of the applicability of popular astrophysical equations of state for describing the neutrino sphere region in a supernova, using heavy ion collision data from the NIMROD detector, clearly indicates that a description of nuclear matter at the densities and temperatures of interest

requires: (i) consideration of *all* relevant particle degrees of freedom, (ii) mean-field effects of the unbound nucleons, and (iii) a suppression mechanism for bound clusters at high densities.

- We have published a new critical survey of world data for superallowed $0^+ \rightarrow 0^+$ β decays, the seventh in a series that began in 1973 and the first in six years. The value obtained for V_{ud}, the up-down quark-mixing element of the Cabibbo-Kobayashi-Maskawa matrix, is consistent with, but more precise than, values we have obtained previously. A new limit was also set on the possible existence of scalar interactions.
- Strong evidence that the super-heavy helium isotope, ^{9}He, is unbound by about 3 MeV instead of ~0.2 MeV, as suggested previously, has been found through the measurement of the T=5/2 isobaric analog states in ^{9}Li.
- The first unambiguous high statistics observation of ^{10}N ground states were observed in ^{9}C+p elastic scattering, resulting in a definitive spin-parity assignment.
- Efficient separation of the group 13 elements In and Tl was achieved using a cation exchange column indicating a possible means of investigating the liquid-phase chemistry of element 113.
- The upgraded RFQ cooler and buncher for the TAMUTRAP facility has been commissioned with a demonstrated 60% efficiency in continuous mode.
- Analysis of the polarimetry results from the June 2014 TRINAT data is complete, with an average nuclear polarization of ⟨P⟩=99.1(2)%. We expect in our next experiment to reduce the uncertainty to below the 0.1% threshold needed for the angular distribution measurement.
- The FAUSTUPS-QTS experimental line has been fully comissioned.
- Measured *xn* cross sections of ^{45}Sc and ^{44}Ca with various lanthanides, and demonstrated that the survivability of the compound nucleus is strongly affected by small changes in its fission barrier and neutron binding energy.
- HF-RPA calculations with the KDE0v1 interaction (the overall best in an independent test of 240 Skyrme interactions) gave energies of the GMR in ^{96,98,100}Mo and ISGDR in ^{92,96,98,100}Mo in agreement with experiment, but for each of the isotopes the measured GQR energies were somewhat lower than predicted and the measured HEOR energies were substantially lower(~ 1.5MeV) than predicted.
- Stringent constraints on the values of nuclear matter properties, needed for determining the next generation energy density functional, were obtained by carrying out extensive calculations of isoscalar and isovector giant resonances of multipolarities L=0 to 3 for a wide range of nuclei using over 30 commonly employed Skyrme type interactions.
- The energy-averaged double transition densities for giant resonances were determined, for the first time, within the particle-hole optical model and compared with the quasi-classical collective model forms commonly used in experimental analysis of excitation of giant resonances.
- Made the first-ever observations of the Collins effect, which convolutes quark transversity with the spin-dependent Collins fragmentation function, in p+p collisions.
- Performed the first measurements of the longitudinal double-spin asymmetry for inclusive jet production in p+p collisions at 510 GeV, thereby obtaining sensitivity to gluon polarization down to $x > 0.02$.

- The theory of the deuteron stripping to resonance states based on the surface-integral formalism and CDCC was developed.
- Review of indirect methods in nuclear astrophysics was published.
- The dependence of the ratio of positively to negatively charged pions produced in heavy ion collisions on the stiffness of nuclear symmetry energy at high densities has been better understood after including in a relativistic transport model the effect due to medium modification of the pion production threshold in these collisions.
- The implementation of ρ and a_1 mesons into the chiral pion lagrangian using the local Massive-Yang Mills gauging procedure has been achieved with a fully resummed ρ propagator in the a_1 selfenergy, which enables a simultaneous description of the vacuum vector and axialvector spectral functions (as measured in hadronic τ decays) within a local-gauge approach.
- The nonperturbative framework for heavy-flavor diffusion and hadronization in QCD matter, implemented into a hydrodynamic modeling for Pb-Pb collisions at the LHC, has resulted in fair agreement with ALICE and CMS data for charm and bottom observables at low and intermediate transverse momenta implying a diffusion coefficient of $D_s \cong 4/(2\pi T)$.
- A novel idea to measure high energy photons from jets, using jets at opposite azimuthal angle (around the beam axis) from the photon as triggers, has been proposed to allow direct access to the interaction mechanism of jets with quark gluon plasma.

Institute scientists remain active in a number of collaborative research efforts around the world. Major programs include: mass measurements using the Penning Trap at the University of Jyväskylä; continued work with the STAR collaboration at RHIC; measurements of beta decays with the TRINAT collaboration at TRIUMF; ANASEN at MSU; and participation in the SAMURAI collaboration at RIBF in Tokyo, Japan.

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