

Introduction

April 1, 2013 – March 31, 2014

Progress in research and operations at the Texas A&M Cyclotron Institute is summarized in this report for the period April, 1, 2013 through March 31, 2014. 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.*

This year we have seen important changes in our faculty. Dr. Grigory Rogachev has joined us as a Professor of Physics. Dr. Robert Tribble has begun an 80% appointment as the Assistant Scientific Director at BNL. Dr. Tribble remains in charge of the Upgrade Project and supervising his research program. Dr. Joseph Natowitz, a long time member of the Institute faculty, retired from the chemistry department, but retains a 25% appointment and a very active research program at the Cyclotron Institute. Additionally, this year Dr. Dan Melconian was tenured and promoted to Associate Professor of Physics. On March 1st I was appointed Director of the Cyclotron Institute.

We were pleased that the construction on the new floor of offices was successfully completed this year and all Institute personnel have moved back in to the building.

We have now completed 9 ½ years of the Upgrade Project, which when finished will give us accelerated radioactive beams at intermediate energies. During this reporting period the K150 cyclotron provided 2,038 hours of beams including strip extracted protons, ¹²C, ¹⁶O beams for the development of the light-ion guide system, and high intensity ⁴⁰Ar beams at various energies to work towards reaching the final milestone of the project. Over 1,500 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 commissioning work on the light-ion guide via ^{nat}Zn(p,n)⁶⁴Ga at 15 MeV showed very high production efficiency from the gas cell. The final step of transporting the radioactive ions from the gas cell to charge breeding ECR ion source using the helium-jet method is in progress. The LN₂ cryopanel was installed and tested with ⁴⁰Ar beams and yielded an intensity improvement of ~25%. An even larger gain is expected when the cryopanel is cooled by LHe or cold He gas. Improvements to ECR2 including plasma chamber water chilling, increasing the output power of the 14.4 GHz transmitter and a better biased plate design yielded a record production of 46 μA of ⁴⁰Ar¹³⁺. Despite all the improvements made, about a factor of 2 in either ECR output or throughput efficiency is still needed to reach the project milestone of 0.9 pμA of ⁴⁰Ar¹³⁺ at 13.7 MeV/u. Also the heavy-ion guide system and its many components are now being installed in the ion-guide cave.

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

- The energies of the giant monopole resonance in mass 92 nuclei and in some Ca isotopes are not reproduced in mean field calculations, suggesting nuclear structure is significantly affecting the position of the GMR in these nuclei.
- A nucleation-time moderated chemical equilibrium model has been developed and used to probe the clusterization in the low-density neck region of a ternary fissioning nuclei.
- Measurements of transverse single-spin asymmetries, A_N , for forward multi-photon, jet-like events in $\sqrt{s} = 500$ GeV pp collisions indicate the large A_N that has been observed for forward inclusive hadron production at RHIC does not arise from conventional parton fragmentation to jets.
- The measured cross sections of ^{45}Sc and ^{50}Ti projectiles reacting with lanthanide targets are substantially smaller than those for ^{48}Ca -induced reactions, suggesting that discovering new elements using ^{45}Sc or ^{50}Ti projectiles could be very difficult.
- Analysis of the first-ever measurement of the beta asymmetry parameter, A_β , using laser-cooled atoms at TRIUMF is nearing completion, with an expected total uncertainty of 2%. We have upgraded our system and taken data with much higher statistics and expect to reach 0.3% sensitivity.
- We have measured the lifetime and are analyzing the data from a branching ratio measurement of the beta decay of ^{37}K . Once completed, the ft value of this isobaric analogue decay will be the best known among the T=1/2 mirror transitions.
- A pair of mirror superallowed transitions – $^{38}\text{Ca} \rightarrow ^{38}\text{K}^m$ and $^{38}\text{K}^m \rightarrow ^{38}\text{Ar}$ – has been fully characterized for the first time. The ratio of their ft values has been measured with 0.2% precision and the result provides a first step in constraining the isospin-symmetry-breaking corrections used to extract the value of V_{ud} from superallowed nuclear decays.
- Work aimed at understanding stellar reaction rates for proton capture around $A \sim 28$ has continued with the neutron transfer experiment $^{13}\text{C}(^{27}\text{Al}, ^{28}\text{Al})^{12}\text{C}$. Using charge symmetry, this provides information for the $^{27}\text{Si}(p, \gamma)^{28}\text{P}$ reaction.
- A method for determining the mean-field directly from data on single particle matter density has been developed and applied to the case of the charge density difference between the isotones $^{206}\text{Pb} - ^{205}\text{Tl}$, associated with the proton $3S_{1/2}$ single particle orbit.
- Calculations of isoscalar dipole (ISD) strength distributions in nuclei, within the Hartree-Fock based random phase approximation, demonstrate that the ISD in neutron-rich nuclei provides substantial contribution to the nuclear Schiff moment which is central to the measurement of time reversal violation in an atom.
- Including both partonic and hadronic mean fields in a multiphase transport model, we have found that the relative elliptic flow differences between protons and antiprotons as well as between positively and negatively charged kaons in the STAR data at RHIC can be reproduced if the ratio of the partonic vector to scalar coupling is appreciable, which is expected to have significant implications in understanding the QCD phase structure at finite baryon chemical potential.
- A theory of the deuteron stripping populating bound states and resonances based on the surface-integral formalism using ADWA (adiabatic distorted wave approach) and CDCC (continuum

discretized coupled channels) has been developed. To test the theory first experiments $^{14}\text{C}(d,p)^{15}\text{C}$ were performed at 23.4 and 60 MeV.

- A link between dilepton data and chiral symmetry restoration in high-energy heavy-ion collisions has been established by evaluating QCD and Weinberg sum rules. Based on the in-medium ρ spectral function that describes dilepton spectra, and in-medium condensates from lattice QCD, an in-medium a_1 spectral function has been found that gradually degenerates with the ρ channel.
- The calculation of the $\omega(782)$ width in nuclear matter using existing in-medium ρ and π propagators yields results consistent with what is observed in ω photoproduction off nuclei. This corroborates the hadronic many-body approach as a suitable framework to study hadron properties in matter.
- In preparation for accelerated radioactive beams, significant upgrades are being made to improve the isotopic resolution of the MDM focal-plane detector.
- Construction of a prototype of a general purpose active target detector (Texas Active Target Prototype, TexAT-P) for wide variety of experiments with rare isotope beams at the Cyclotron Institute has been initiated.
- The Quadrupole Triplet Spectrometer beam line to focus heavy residues for time of flight measurements has been commissioned. The QTS is designed to be run in conjunction with the FAUST array.
- The FAUST detector array has been upgraded with position sensitive detectors (the Dual-Axis Dual-Lateral "DADL" detectors).
- A gas stopper for a future online chemistry program has been commissioned. The data shows that the device can be operated in either a fast extraction or a maximum efficiency mode.
- Received the first irradiated sample for a new nuclear forensics program. The first destructive analyses were conducted shortly after the cutoff date of this publication.

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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