Introduction
April 1, 2008 – March 31, 2009

Progress in research and operations at the Texas A&M Cyclotron Institute is summarized in this report for the period April, 1, 2008 through March 31, 2009. The format follows that of previous years. Sections I through IV contain reports from individual research projects. Operation and technical developments are given in Section V. Section VI lists the publications with Cyclotron Institute authors 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 have now completed 4 1/2 years of the Upgrade Project which ultimately will give us accelerated radioactive beams at intermediate energies. The progress on the project continues to be good—we remain reasonably close to schedule. The K150 cyclotron is operational but routine operation awaits the full radiation monitoring system, which is being installed now. Beam line magnets and vacuum systems for the refurbished machine are in place and operational. A change in scope for the project was approved at the last Technical review. We now plan to run H^- and D^- beams with a foil stripper rather than H^+ and D^+ through the deflector. This should substantially reduce the buildup of radioactivity at the exit of the machine.

Institute programs continue to thrive. Dr. Cody Folden joined the Institute us as a new Assistant Professor of Nuclear Chemistry. He is developing a program in heavy-element research. During the past year, Dr. Saskia Mioduszewski won the APS Goeppert-Mayer Award and Dr. Rainer Fries received an NSF Career Award.

Some highlights of work over the past year are given below.

Research highlights:

(1) Prompted by a flood of new measurements on superallowed beta decay since the 2005 survey, a new critical survey of world data has been published, which also includes improved isospin symmetry-breaking corrections, an updated analysis of the possible contribution of systematic uncertainties to these corrections, and the inclusion of atomic effects in the calculated statistical rate functions *f*. The resultant corrected $\mathcal{Ft}$ values are self consistent and yield a more precise value of the CKM matrix element V_{ud} than has been obtained before. When this result is combined with the best current value for V_{us}, the CKM unitarity sum becomes 0.99995(61), a stunning confirmation of the standard model expectation.

(2) A new technique has been developed to determine spectroscopic factors for neutron transfer reactions. The new technique uses the asymptotic normalization coefficient to fix the geometry of the neutron bound in the residual nucleus and the peripheral contribution to the cross section.

(3) Experimental evidence for a quantum phase transition in nuclei, driven by the neutron/proton asymmetry has been found. Free energies derived using the Landau approach are consistent with a line of first-order phase transitions terminating at a point where the system undergoes a second-order transition.

(4) Work at TAMU previously demonstrated that the beta-minus decay of ^{198}Au in gold was in fact independent of temperature (<0.04% difference between 19K and room temperature) and we have now obtained a similar result for the electron-capture decay of ^{97}Ru.

(5) As part of the UCNA collaboration, the β asymmetry parameter in neutron decay has been measured for the first time using ultra-cold neutrons. Improvements to the system and the greater statistics accumulated this year are expected to result in a 0.3% measurement, which would be competitive with existing cold neutron beam experiments.

(6) The heavy element group has begun preparations for their initial experiments, including target preparation, constructing a data acquisition system, and simulations of MARS for the transmission of complete-fusion evaporation products. In summer 2009, alpha particles slowed by degraders will be used to calibrate the MARS velocity filter for slow ions (~0.02c).

(7) We have observed isoscaling for elements with Z=1-17 over a broad range of isotopes from the reactions of ^{86}Kr and ^{78}Kr projectiles with ^{64}Ni and ^{58}Ni targets. The N/Z of the source was calculated from the isotopically identified fragments and experimentally measured neutrons emitted from reconstructed quasi-projectiles. The isoscaling parameter alpha is seen to increase with increasing difference in the neutron composition of the sources and decrease with increasing excitation energy.

(8) The in-medium ρ-meson spectral function developed at TAMU, which has been widely used to interpret dilepton spectra in heavy-ion collisions, has been applied to dilepton photo-production off nuclear targets. Without tunable parameters, a good description of the dilepton invariant-mass spectra, as measured by CLAS at JLAB, emerges, providing a link between heavy-ion and JLAB physics.

(9) The spectral functions of pions in asymmetric nuclear matter become dependent on their charges. Using those determined from the couplings of pions to the delta-resonance--nucleon-hole excitations in nuclear matter, we have studied in a thermal model their effects on the ratio of negatively charged to positively charged pions. In the neutron-rich matter formed in heavy ion collisions, this ratio is enhanced by the isospin-dependent pion in-medium effect, and the effect is comparable to that due to

the uncertainties in the theoretically predicted stiffness of the nuclear symmetry energy at high densities.

(10) A new surface-integral based scattering and reaction theory for charged particles has been developed which bypasses existing difficulties focusing on integrated properties.

(11) Our resonance recombination model, which improves quark coalescence models for hadronization at RHIC, has been implemented into relativistic Langevin simulations for strange and charm quarks in an expanding fireball for semi-central 200 AGeV Au-Au collisions. The elliptic flow of the resulting meson spectra can reproduce the empirically observed constituent quark-number scaling in kinetic energy from 0 to 3 GeV.

(12) The relaxation time and thereby the shear viscosity of nuclear matter were determined within a semi-classical kinetic approach, using the experimental data on the centroid energies and widths of the isoscalar giant monopole and dipole resonances.

As in the past, Institute scientists remain active in a number of collaborative research efforts around the world. Major programs include: a measurement of Michel parameters in normal μ^+ decay at TRIUMF in Vancouver, B.C.; mass measurements using the Penning Traps at Argonne National Laboratory and the University of Jyvaskyla; continued work with STAR collaboration at RHIC; and the measurement of neutron beta decay with the UCNA collaboration.

Once again, I am indebted to Dr. Y.-W. Lui for assembling this report.

R.E. Tribble
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