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Director

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FOREWORD

This report summarizes the research performed in the past year in the Argonne Physics Division. The Division's programs include operation of ATLAS as a national heavy-ion user facility, nuclear structure and reaction research with beams of heavy ions, accelerator research and development especially in superconducting radio frequency technology, nuclear theory and medium energy nuclear physics. The Division took significant strides forward in its science and its initiatives for the future in the past year. Major progress was made in developing the concept and the technology for the future advanced facility of beams of short-lived nuclei, the Rare Isotope Accelerator. The scientific program capitalized on important instrumentation initiatives with key advances in nuclear science.

In 1999, the nuclear science community adopted the Argonne concept for a multi-beam superconducting linear accelerator driver as the design of choice for the next major facility in the field, a Rare Isotope Accelerator (RIA) as recommended by the Nuclear Science Advisory Committee's 1996 Long Range Plan. Argonne has made significant R&D progress on almost all aspects of the design concept including the fast gas catcher (to allow fast fragmentation beams to be stopped and reaccelerated) that, in large part, defined the RIA concept, the superconducting rf technology for the driver accelerator, the multiple-charge-state concept (to permit the facility to meet the design intensity goals with existing ion-source technology), and designs and tests of high-power target concepts to effectively deal with the full beam power of the driver linac. An NSAC subcommittee recommended the Argonne concept, and set as the design goal Uranium beams of 100-kwatt power at 400 MeV/u. Argonne demonstrated that this goal can be met with an innovative, but technically in-hand, design.

The heavy-ion research program focused on Gammasphere, the premier facility for nuclear structure gamma-ray studies. One example of the ground-breaking research with Gammasphere was the first study of the limits of stability with angular momentum in the shell stabilized nobelium isotopes. It was found that these heaviest nuclei could be formed at surprisingly high angular momentum, providing important new insight into the production mechanisms for super-heavy elements. Another focus continues to be experiments with short-lived beams for critical nuclear astrophysics applications. Measurements revealed that ^{44}Ti is more readily destroyed in supernovae than was expected. Major progress was made in collecting and storing unstable ions in the Canadian Penning Trap. The technique of stopping and rapidly extracting ions from a helium gas cell led directly to the new paradigm in the production of rare isotope beams that became RIA.

ATLAS provided a record 6046 hours of beam use for experiments in FY99. The facility pressed hard to support the heavy demands of the Gammasphere research program but maintained an operational reliability of 93%. Of the 29 different isotopes provided as beams in FY99, radioactive beams of ^{44}Ti and ^{17}F comprised 6% of the beam time.

The theoretical efforts in the Division made dramatic new strides in such topics as quantum Monte Carlo calculations of light nuclei to understand microscopic many-body forces in nuclei; QCD calculations based on the Dyson-Schwinger approach which were extended to baryon systems and finite temperatures and densities; the structure of heavy nuclei; and proton decay modes of nuclei far from stability.

The medium-energy program continues to focus on new techniques to understand how the quark-gluon structure of matter impacts the structure of nuclei. The HERMES experiment began making measurements of the fraction of the spin of the nucleon carried by the glue. Drell-Yan experiments study the flavor composition of the sea of the proton. Experiments at Jefferson lab search for clues of QCD dynamics at the hadronic level. A major advance in trace isotope analysis was realized with pioneering work on Atom Trap Trace Analysis, exploiting the exquisitely sensitive nature of laseratom traps to detect, background free, ^{81}Kr at the 10^{-13} level. This technique provides a valuable new approach to such diverse problems as dating old ground water, the solar neutrino problem, measuring charge radii of exotic nuclei and medical applications.

The performance of the Division in 1999 is, in large part, a result of the seven years of leadership of Walter Henning. Walter left the Division in the fall of 1999 to become the Director of GSI. His mark on the Division was unmistakable. I will endeavor to ensure that Walter's spirit of creative, world-class research and gracious behavior remains the hallmark of the Division in the next millennium.

Donald Geesaman, Director, Physics Division

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