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9700 S. Cass Avenue
Argonne, Illinois 60439-4801

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Donald F. Geesaman
Director

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Edited by Karen J. Thayer

FOREWORD

This report summarizes the research performed in 2001 in the Physics Division of Argonne National Laboratory. The Division's programs include operation of ATLAS as a national user facility, nuclear structure and reaction research, nuclear theory and medium energy physics research and accelerator research and development. The results reflect the talents and dedication of the Physics Division staff and the visitors, guests and students who bring so much to the research.

In 2001, the U.S. nuclear physics community continued its exemplary tradition of thoroughly examining the progress of our science and developing a long-term plan for the future. Several hundred scientists directly participated in the process to create the Nuclear Science Advisory Committee's Long Range Plan. I am very proud of the leadership provided by Argonne scientists in identifying and taking the pioneering steps in the science and in playing leading roles in the discussions and the formation of the NSAC plan. The final report, published in April 2002, names the Rare Isotope Accelerator as the highest priority of our field for major new construction. The essential concepts for RIA: a superconducting heavy-ion linac capable of accelerating all ions from H to U, the acceleration of multiple charge states to greatly enhance the available beam powers for the heaviest ions, the fast-gas-catcher to stop fast ions from fragmentation beams and rapidly extract them for reacceleration and trapping, and viable, innovative designs for high power targets were all developed and proven in the Physics Division. In the words of the Long Range Plan, "RIA will be the world leading facility for research in nuclear structure and nuclear astrophysics".

Research at ATLAS continues to define the frontiers of nuclear physics. New precision results on the beta decay spectrum of ^{8}B promise to have an impact on the understanding of neutrino oscillation results from solar neutrino detectors. Precise mass measurements with the Canadian Penning trap are helping to elucidate the rapid-neutron capture process while other direct and indirect measurements are playing a similar role in the rapid-proton capture process of nucleosynthesis. Nuclear structure measurements are defining the essential interplay of collective and single particle degrees of freedom in neutron-rich nuclei, proton rich nuclei and at high and low spin.

Unfortunately, budgetary constraints forced us to scale back ATLAS operations to ~5 days per week in mid 2001. In spite of this reduction, ATLAS provided over 5700 hours of beam for research with the remarkable operating reliability of 96%. Significant improvements were made to the accelerator. Most notably, a number of the original superconducting cavities were reconditioned with a high-pressure water rinse technique that resulted in operation at accelerating gradients that exceeded their original new-construction values. Accelerator Mass Spectroscopy was brought to a new level of sensitivity with the detection of Ar-39 at the 10^{-16} level, which permits investigation of the circulation of deep ocean currents for global climate studies.

In medium energy research, a remarkable, unexpected angular dependence was observed in the induced polarization in pion photoproduction from the proton. The HERMES collaboration is making the first flavor decomposition of the polarized structure functions in deep inelastic positron scattering from the nucleon. Both HERMES and FNAL Drell-Yan results are constraining the poorly understood energy loss of fast quarks in nuclear material. Several new research proposals were approved at JLab and FNAL, promising exciting future courses of research.

The Division's role in theory ranges from the quark substructure of mesons to heavy nuclei and beyond to the fundamentals of quantum mechanics and quantum computing. Notable results were the application of Dyson-Schwinger equations to the structure of baryons. Comprehensive studies of meson photoproduction have guided much of the understanding obtained from recent Jefferson Lab data. With accurate ab-initio calculations of the spectra of all nuclei up to mass 10, there is a deeper understanding of which features of the nucleon-nucleon interaction are important for nuclear level structure: what makes it just so. Predictions of new regions of very extended shapes in nuclei are inspiring a new cycle of experiments.

While hiking in Chaco Canyon, New Mexico this summer, I came upon the Supernova Pictograph, an Anasazi eyewitness's rendering in stone of the 1054 supernova in the Crab nebula. Separated by almost a millennium in time, I could not help but feel a close kinship to this remarkable artist. We must share the passion for understanding why the world is just so. I see this passion in my colleagues in the Division daily and it shines through in the work reported here.

Donald F. Geesaman, Director, Physics Division

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