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# PHYSICS DIVISION ANNUAL REPORT 2004

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# FOREWORD

This report highlights the research performed in 2004 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, medium energy nuclear research and accelerator research and development. The intellectual challenges of this research represent some of the most fundamental challenges in modern science, shaping our understanding of both tiny objects at the center of the atom and some of the largest structures in the universe. A great strength of these efforts is the critical interplay of theory and experiment.

Notable results in research at ATLAS include a measurement of the charge radius of He-6 in an atom trap and its explanation in ab-initio calculations of nuclear structure. Precise mass measurements on critical waiting point nuclei in the rapid-proton-capture process set the time scale for this important path in nucleosynthesis. An abrupt fall-off was identified in the sub-barrier fusion of several heavy-ion systems. ATLAS operated for 5559 hours of research in FY2004 while achieving 96% efficiency of beam delivery for experiments.

In Medium Energy Physics, substantial progress was made on a long-term experiment to search for the violation of time-reversal invariance using trapped Ra atoms. New results from HERMES reveal the influence of quark angular momentum. Experiments at JLAB search for evidence of color transparency in rho-meson production and study the EMC effect in helium isotopes.

New theoretical results include a Poincare covariant description of baryons as composites of confined quarks and non-point-like diquarks. Green's function Monte Carlo techniques give accurate descriptions of the excited states of light nuclei and these techniques been extended to scattering states for astrophysics studies. A theoretical description of the phenomena of proton radioactivity has been extended to triaxial nuclei.

Argonne continues to lead in the development and exploitation of the new technical concepts that will truly make RIA, in the words of NSAC, "the world-leading facility for research in nuclear structure and nuclear astrophysics." The performance standards for new classes of superconducting cavities continue to increase. Driver linac transients and faults have been analyzed to understand reliability issues and failure modes. Liquid-lithium targets were shown to successfully survive the full-power deposition of a RIA beam. Our science and our technology continue to point the way to this major advance. It is a tremendously exciting time in science for RIA holds the keys to unlocking important secrets of nature. The work described here shows how far we have come and makes it clear we know the path to meet these intellectual challenges.

The great progress that has been made in meeting the exciting intellectual challenges of modern nuclear physics reflects the talents and dedication of the Physics Division staff and the visitors, guests and students who bring so much to the research.

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