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Director

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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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Donald F. Geesaman, Director, Physics Division



# TABLE OF CONTENTS

Page

|           |  |    |
|-----------|--|----|
| <b>I.</b> | <b>HEAVY-ION NUCLEAR PHYSICS RESEARCH</b> .....  | 1  |
| <b>A.</b> | <b>REACTIONS OF ASTROPHYSICAL IMPORTANCE</b> .....   | 3  |
| a.1.      | Measurement of the E1 Component of the Low-Energy $^{12}\text{C}(\alpha,\gamma)^{16}\text{O}$<br>Cross Section .....                     | 3  |
| a.2.      | Results from the First $^{16}\text{N}$ Decay Experiment .....  | 4  |
| a.3.      | $^{18}\text{Ne}(\alpha,p)^{21}\text{Na}$ , a Possible Breakout Reaction from the Hot CNO Cycle<br>to the rp Process .....                | 6  |
| a.4.      | Level Structure and Mass of $^{22}\text{Mg}$ .....   | 8  |
| a.5.      | In-Beam Spectroscopy Above the Proton Threshold in $^{27}\text{Si}$ and the<br>Production of $^{26}\text{Al}$ in Novae .....             | 8  |
| a.6.      | Re-Evaluation of the $^{30}\text{P}(p,\gamma)^{31}\text{S}$ Astrophysical Reaction Rate in Novae .....                                   | 9  |
| a.7.      | Measurement of $^{44}\text{Ti}$ Half-Life .....  | 10 |
| a.8.      | The $^{40}\text{Ca}(\alpha,\gamma)^{44}\text{Ti}$ Reaction at Astrophysical Energies .....   | 10 |
| a.9.      | New Half-life Measurement of $^{182}\text{Hf}$ : An Improved Chronometer for the<br>Early Solar System .....                             | 11 |
| <b>B.</b> | <b>PHYSICS OF TRAPPED IONS</b> .....   | 13 |
| b.1.      | Ordering and Temperature in Ions Trapped in Radiofrequency Fields .....  | 13 |
| b.2.      | Q Value of the Superaligned $\beta$ -Decay of $^{22}\text{Mg}$ and the Calibration of the<br>$^{21}\text{Na}(p,\gamma)$ Reaction .....   | 14 |
| b.3.      | Q Value of the Superaligned Decay of $^{46}\text{V}$ and the Unitarity of the<br>CKM Matrix .....  | 18 |
| b.4.      | Precise Mass Measurement of Light Fission Fragments from $^{252}\text{Cf}$ Source .....  | 22 |
| b.5.      | The RFQ Decay Trap Component of the Advanced Penning Trap System .....   | 23 |
| <b>C.</b> | <b>SPECTROSCOPY OF VERY HEAVY ELEMENTS</b> .....   | 27 |
| c.1.      | Strength of Octupole Correlations in the Actinides: Contrasting Behavior<br>in the Isotones $^{239}\text{Pu}$ and $^{237}\text{U}$ ..... | 27 |
| c.2.      | Behavior of $^{240}\text{Pu}$ at the Highest Spins .....   | 29 |
| c.3.      | Proton Single-Particle States in $^{249}\text{Bk}$ ( $Z = 97$ ) .....  | 30 |
| c.4.      | Properties of the Lightest Nobelium Isotopes .....   | 31 |
| c.5.      | Structure of $^{253}\text{No}$ .....   | 31 |
| c.6.      | Electrons from a 0.3s Isomer in $^{254}\text{No}^*$ .....  | 33 |
| c.7.      | Gamma Decay from a 0.3s Isomer in $^{254}\text{No}$ .....  | 34 |
| c.8.      | Limiting Angular Momentum in $^{254}\text{No}$ .....   | 35 |

|           |   |    |
|-----------|---|----|
| <b>D.</b> | <b>STRUCTURE OF NUCLEI FAR FROM STABILITY</b> .....   | 37 |
| d.1.      | Neutron-Rich Nuclei .....   | 37 |
| d.1.1.    | High Spin Structure in Neutron-Rich Ti and Cr Isotopes: Possible<br>N = 32 and 34 Shell Gaps and the Onset of Deformation .....   | 37 |
| d.1.2.    | Search for $^{82}\text{Ge}_{50}$ Using Deep Inelastic Reactions.....  | 41 |
| d.1.3.    | The $\nu 9/2[404]$ Orbital and the Deformation in the A ~ 100 Region .....  | 42 |
| d.2.      | Proton-Rich Nuclei .....  | 43 |
| d.2.1.    | The A = 31 Mirror Nuclei $^{31}\text{P}$ and $^{31}\text{S}$ Used to Investigate the Charge-<br>Symmetry-Breaking “Electromagnetic Spin Orbit” Interaction $V_{\text{eso}}$ ..... | 43 |
| d.2.2.    | High Spin States of T = 3/2 $^{37}\text{Ca}$ and $^{37}\text{Cl}$ .....   | 43 |
| d.2.3.    | High Spin States in the N = Z - 3 Nucleus $^{49}\text{Fe}$ : Coulomb Effects at<br>Large Proton Excess .....  | 44 |
| d.2.4.    | Shape Co-Existence in $^{71}\text{Br}$ and the Question of the Groundstate Spin<br>of $^{71}\text{Kr}$ .....  | 48 |
| d.2.5.    | Fast Alpha Decays Above $^{100}\text{Sn}$ .....   | 49 |
| d.2.6.    | Discovery of the Deformed Proton Emitter $^{121}\text{Pr}$ .....  | 50 |
| d.2.7.    | Recoil-Decay Tagging Study of $^{146}\text{Tm}$ .....   | 51 |
| d.2.8.    | Multi-Particle Configurations in N = 84 Isotones Located at the Proton<br>Drip-Line.....  | 52 |
| d.2.9.    | Alpha Decay of $^{181}\text{Pb}$ .....  | 53 |
| d.2.10.   | Level Structure of $^{181}\text{Tl}$ .....  | 53 |
| <b>E.</b> | <b>OTHER NUCLEAR STRUCTURE RESEARCH</b> .....   | 55 |
| e.1.      | Investigation of $^{12}\text{C}(^{12}\text{C},\gamma)^{24}\text{Mg}$ Radiative Capture .....  | 55 |
| e.2.      | Variation with Mass of B(E3; $0^+ \rightarrow 3^-$ ) Transition Rates in A = 124-134<br>Even-Mass Xenon Nuclei .....  | 56 |
| e.3.      | Rotational Damping, Ridges and the Quasicontinuum of $\gamma$ Rays in $^{152}\text{Dy}$ .....   | 57 |
| e.4.      | Study of Multi-Quasiparticle Isomers in the A ~ 180 Region Using Deep-<br>Inelastic and Multi-Nucleon Transfer Reactions .....  | 60 |
| e.5.      | Pair Gaps in the Normal- and Super-Deformed Wells of $^{191}\text{Hg}$ .....  | 62 |
| e.6.      | Temperature and Spin Dependence of the Giant Dipole Resonance Width<br>in $^{117,118}\text{Sn}$ .....   | 62 |
| e.7.      | Observation of the Hot GDR in Neutron-Deficient Thorium Evaporation<br>Residues .....   | 63 |
| <b>F.</b> | <b>THE PHOBOS EXPERIMENT AT RHIC</b> .....  | 65 |
| f.1.      | The Phobos Experiment at RHIC .....   | 65 |
| <b>G.</b> | <b>REACTION MECHANISM STUDIES</b> .....   | 73 |
| g.1.      | Study of $^7\text{He}$ Using the $d(^6\text{He},p)^7\text{He}$ Reaction.....  | 73 |
| g.2.      | Neutron Spectroscopic Factors in $^9\text{Li}$ from the $d(^8\text{Li},p)^9\text{Li}$ Reaction.....   | 74 |
| g.3.      | Is the Nuclear Spin-Orbit Interaction Changing with Neutron Excess?.....  | 76 |

|  |   |            |
|--|---|------------|
| g.4.   | Hindrance of Heavy-Ion Fusion at Extreme Sub-Barrier Energies in<br>Open-Shell Colliding Systems.....                                 | 76         |
| g.5.   | $^{58}\text{Ni} + ^{89}\text{Y}$ Fusion Hindrance at Extreme Sub-Barrier Energies.....  | 81         |
| g.6.   | Hindrance of Heavy-Ion Fusion at Extreme Sub-Barrier Energies for a<br>Small Q-Value System $^{28}\text{Si} + ^{64}\text{Ni}$ .....   | 88         |
| <b>H. DEVELOPMENT OF NEW EXPERIMENTAL<br/>EQUIPMENT.....</b>       |   | <b>91</b>  |
| h.1.   | Target Laboratory Developments.....   | 91         |
| h.2.   | New Control System Hardware and Software for the FMA.....   | 92         |
| h.3.   | The Isobar Separator Ion Trap for the APT and CPT Trapping Systems.....   | 92         |
| h.4.   | A Solenoid Spectrometer for Reactions in Inverse Kinematics.....  | 93         |
| h.5.   | A New Focal-Plane Detector System at the Argonne Fragment Mass<br>Analyzer for Low Fusion-Evaporation Cross Section Measurements..... | 94         |
| h.6.   | Performance of a Compton Camera Using Digital Pulse Processing.....   | 104        |
| h.7.   | Ambiguity in Gamma Ray Tracking of “Two Interaction” Events.....  | 105        |
| h.8.   | A Bragg Scattering Method to Search for the Neutron Electric Dipole<br>Moment.....  | 105        |
| h.9.   | Heavy Element Scattering Chamber Upgrade.....   | 106        |
| h.10.  | The MUSIC Detector.....   | 107        |
| h.11.  | Digital Bragg Curve Spectroscopy.....   | 108        |
| h.12.  | The New Focal Plane Detector for the Notre Dame Spectrometer.....   | 108        |
| h.13.  | Deployment of a Centrally Managed Windows Cluster.....  | 110        |
| h.14.  | Status of the SCARLET Data Acquisition System.....  | 111        |
| h.15.  | Progress on the New Gammasphere Data Acquisition.....   | 112        |
| h.16.  | Gammasphere Operations.....   | 112        |
| h.17.  | Gammasphere Move.....   | 113        |
| h.18.  | X-Array Developments.....   | 113        |
| h.19.  | Degradation of the $^{16}\text{N}$ Beam to Very Low Energy.....   | 115        |
| h.20.  | Improvement of the Experimental Setup for the Study of the $^{16}\text{N}$ $\beta$ Delayed<br>$\alpha$ Decay.....                     | 117        |
| h.21.  | The Twin Ionization Chambers.....   | 118        |
| h.22.  | Backgrounds and Sensitivity to Beta Particles.....  | 120        |
| h.23.  | Simulation of the Detector Response in the $^{16}\text{N}$ $\beta$ -Delayed $\alpha$ Decay<br>Experiment.....                         | 122        |
| <b>I. HIGH-PRECISION AND HIGH-SENSITIVITY<br/>EXPERIMENTS.....</b> |   | <b>123</b> |
| i.1.   | Search for X-Ray Induced Decay of the 31-y Isomer of $^{178}\text{Hf}$ .....  | 123        |
| <b>J. ATLAS USER PROGRAM.....</b>                                  |   | <b>125</b> |
| a.   | Experiments Involving Outside Users.....  | 126        |
| b.   | Outside Users of ATLAS During the Period<br>October 1, 2003 - September 30, 2004.....   | 130        |

|             |   |     |
|-------------|---|-----|
| <b>II.</b>  | <b>OPERATION AND DEVELOPMENT OF ATLAS</b>   | 133 |
| <b>A.</b>   | <b>OPERATION OF THE ACCELERATOR</b>   | 135 |
| a.1.        | Operations Summary  | 135 |
| <b>B.</b>   | <b>DEVELOPMENTS RELATED TO ATLAS</b>  | 139 |
| b.1.        | Status of the ECR Ion Sources   | 139 |
| b.1.1.      | Hexapole and Plasma Chamber Re-Design   | 139 |
| b.1.2.      | Special Helium Source for AMS   | 139 |
| b.1.3.      | Plasma Potential Measurements and Ion Lifetime  | 139 |
| b.1.4.      | Other ECR Source Improvements   | 140 |
| b.2.        | ECR Source High-Voltage Monitoring and Control  | 141 |
| b.3.        | An Improved Pneumatic Frequency Control for Superconducting Cavities                          | 141 |
| b.4.        | New Harmonic Buncher RF Control System  | 142 |
| b.4.1.      | RF Power Amplifier  | 143 |
| b.4.2.      | Harmonic Buncher RF Control Chassis   | 144 |
| b.5.        | ATLAS Control System  | 148 |
| b.6.        | ATLAS Cryogenic System  | 149 |
| b.6.1.      | Valve Automation Project  | 149 |
| <b>III.</b> | <b>R&amp;D RELATED TO A FUTURE RARE ISOTOPE ACCELERATOR FACILITY</b>                          | 151 |
| <b>A.</b>   | <b>SUPERCONDUCTING RF</b>   | 153 |
| a.1.        | Spoke Cavity Development for RIA  | 153 |
| a.2.        | Superconducting Cavity Surface Processing Facilities  | 154 |
| a.3.        | Tuners and Couplers for the RIA Cavities  | 154 |
| a.4.        | Cavities and Prototype Cryomodule for RIA and the ATLAS Upgrade                               | 155 |
| <b>B.</b>   | <b>BEAM DYNAMICS AND INJECTORS</b>  | 157 |
| b.1.        | Design and Construction of a One-Segment Prototype of the RIA Driver RFQ                      | 157 |
| b.2.        | Alternating-Phase Focusing in Low-Velocity Heavy-Ion Superconducting Linac                    | 158 |
| b.3.        | Design Update of the Injector Section of the RIA Post-Accelerator                             | 160 |
| b.4.        | Progress with the 2Q-LEBT Prototype   | 162 |
| b.5.        | Modifications and rf Tests of the 12 MHz RFQ for Acceleration of a $^{240}\text{U}^{1+}$ Beam | 163 |
| b.6.        | Error Simulations and Beam Loss Studies in the RIA Driver Linac                               | 164 |
| b.7.        | Longitudinal Fine-Tuning of a Multiple-Charge-State Heavy-Ion Beam                            | 166 |
| b.8.        | Front End Design of a Multi-GeV H-Minus Linac   | 167 |



|            |  |            |
|------------|--|------------|
| b.9.       | Reliability and Availability Studies in the RIA Driver Linac.....  | 169        |
| b.10.      | Optimization of Steering Elements in the RIA Driver Linac .....  | 170        |
| <b>C.</b>  | <b>RARE ISOTOPE PRODUCTION AND SEPARATION .....</b>  | <b>173</b> |
| c.1.       | Characterization Studies of Prototype ISOL Target Material for RIA.....  | 173        |
| c.2.       | Development of a Windowless Liquid Lithium Stripper for RIA .....  | 174        |
| <b>IV.</b> | <b>MEDIUM-ENERGY NUCLEAR PHYSICS</b>   |            |
|            | <b>RESEARCH.....</b>   | <b>191</b> |
| <b>A.</b>  | <b>HADRON PROPERTIES.....</b>  | <b>195</b> |
| a.1.       | New Measurement of $(G_E/G_M)$ for the Proton .....  | 195        |
| a.2.       | High-Resolution Search for the $\Theta^+$ Pentaquark at JLab .....   | 196        |
| a.3.       | Search for Additional Pentaquark States at JLab.....   | 197        |
| a.4.       | $N \rightarrow \Delta$ Transition Form Factors .....   | 197        |
| a.5.       | The Charged Pion Form Factor.....  | 198        |
| a.6.       | Separated and Unseparated Structure Functions in the Nucleon Resonance<br>Region.....                                      | 198        |
| <b>B.</b>  | <b>HADRONS IN THE NUCLEAR MEDIUM.....</b>  | <b>201</b> |
| b.1.       | Search for the Onset of Color Transparency: JLab E02-110 Experiment .....  | 201        |
| b.2.       | Measurement of High Momentum Nucleons in Nuclei and Short Range<br>Correlations.....                                       | 203        |
| b.3.       | Measurement of the EMC Effect in Very Light Nuclei.....  | 205        |
| b.4.       | Proton Polarization Angular Distribution in Deuteron Photo Disintegration.....   | 205        |
| b.5.       | Measurement of the Nuclear Dependence of $R = \sigma_L/\sigma_T$ at Low $Q^2$ .....  | 206        |
| b.6.       | Electroproduction of Kaons and Light Hypernuclei.....  | 206        |
| <b>C.</b>  | <b>QUARK STRUCTURE OF MATTER.....</b>  | <b>209</b> |
| c.1.       | The Structure of the Pion .....  | 209        |
| c.2.       | Studies of Nucleon Spin Structure and Related Measurements of Deep-<br>Inelastic Scattering at HERA .....                  | 209        |
| c.2.1.     | Polarization of the Strange Quark Sea in the Proton from Semi-Inclusive<br>Deep-Inelastic Scattering on the Deuteron ..... | 210        |
| c.2.2.     | Azimuthal Asymmetries and Transversity.....  | 211        |
| c.2.3.     | New Results for Collins and Sivers Asymmetries with a Transversely<br>Polarized Target.....                                | 212        |
| c.2.4.     | The Deuteron Tensor Polarized Structure Function $b_1$ .....   | 214        |
| c.2.5.     | Measurements of Deeply-Virtual Compton Scattering at HERMES .....  | 215        |
| c.2.6.     | Quark Fragmentation to Pions, Kaons, and Nucleons in the Nuclear<br>Environment.....                                       | 216        |

|           |   |            |
|-----------|---|------------|
| c.2.7.    | Extraction of Hadron Multiplicities from Deep-Inelastic Scattering Data .....   | 217        |
| c.2.8.    | Search for an Exotic $S = -2$ , $Q = -2$ Baryon Resonance with Mass Near<br>1862 MeV .....  | 218        |
| c.2.9.    | Study of Factorization and Flavor Content of the Nucleon in Unpolarized<br>Semi Inclusive Deep Inelastic Scattering at HERMES ..... | 219        |
| c.3.      | Measurement of the Absolute Drell-Yan Cross Section on Hydrogen and<br>Deuterium .....  | 220        |
| c.4.      | Drell-Yan Measurements with 120 GeV Protons, FNAL E906 .....  | 221        |
| <b>D.</b> | <b>ATOMIC TRAP TRACE ANALYSIS</b> .....   | <b>223</b> |
| d.1.      | Laser Spectroscopic Determination of the Nuclear Charge Radius of ${}^6\text{He}$ .....   | 223        |
| d.2.      | Fine Structure of the $1s3p\ {}^3P_J$ Level in Atomic ${}^4\text{He}$ : Theory and Experiment .....                                 | 225        |
| d.3.      | Atmospheric ${}^{81}\text{Kr}$ as an Integrator of Cosmic Ray Flux Over the Past<br>$\sim 3 \times 10^5$ Years .....                | 225        |
| <b>E.</b> | <b>FUNDAMENTAL SYMMETRIES IN NUCLEI</b> .....   | <b>227</b> |
| e.1.      | Probing the Intercombination Transition $7s^2\ {}^1S_0 - 7p\ {}^3P_1$ in ${}^{225}\text{Ra}$ Atoms<br>for an EDM Measurement .....  | 227        |
| e.2.      | Measurement of $\sin^2\theta_w$ Through Parity Violation in Deep Inelastic<br>Scattering (PV DIS) on Deuterium .....                | 228        |
| e.3.      | Feasibility Study for a Charge Symmetry Violating Quark Distribution<br>Measurement .....   | 230        |
| <b>V.</b> | <b>THEORETICAL PHYSICS</b> .....  | <b>233</b> |
| <b>A.</b> | <b>NUCLEAR DYNAMICS WITH SUBNUCLEONIC<br/>DEGREES OF FREEDOM</b> .....  | <b>235</b> |
| a.1.      | Aspects and Consequences of a Dressed-Quark-Gluon Vertex .....  | 236        |
| a.2.      | Pseudoscalar Meson Radial Excitations .....   | 236        |
| a.3.      | Nucleon Electromagnetic Form Factors .....  | 237        |
| a.4.      | Electromagnetic Properties of Ground and Excited State Pseudoscalar<br>Mesons .....   | 239        |
| a.5.      | Charge Form Factors of Quark-Model Pions .....  | 241        |
| a.6.      | Axial Transition Form Factors and Pion Decay of Baryon Resonances .....   | 242        |
| a.7.      | Quark-Hadron Duality and Parity Violating Asymmetry of Electroweak<br>Reactions in the $\Delta$ Region .....                        | 242        |
| a.8.      | Dynamical Coupled-Channel Model of Electromagnetic Meson Production<br>Reactions .....  | 245        |
| a.9.      | Study of N Resonances with Kaon Photoproduction Reactions .....   | 246        |
| a.10.     | Medium Effects on the Electromagnetic $\rho$ Meson Production on Nuclei .....   | 247        |
| a.11.     | Pentaquark $\theta^+(1540)$ Production in $\gamma N \rightarrow K \bar{K} N$ Reactions .....  | 247        |

|           |   |     |
|-----------|---|-----|
| <b>B.</b> | <b>NUCLEAR FORCES AND NUCLEAR SYSTEMS</b> .....   | 249 |
| b.1.      | Quantum Monte Carlo Calculations of Light Nuclei Energies.....                                    | 250 |
| b.2.      | Scattering Methods for Quantum Monte Carlo Calculations .....                                     | 251 |
| b.3.      | Spectroscopic Factors and Cluster Form Factors of Light Nuclei.....                               | 252 |
| <b>C.</b> | <b>NUCLEAR ASTROPHYSICS</b> .....   | 255 |
| c.1.      | Moments Methods for Response Functions with Momentum Transfer<br>Dependence.....                  | 256 |
| c.2.      | Short-Lived Nuclei in the Early Solar System and AGB Stars .....                                  | 258 |
| <b>D.</b> | <b>NUCLEAR STRUCTURE AND HEAVY-ION<br/>REACTIONS</b> .....  | 259 |
| d.1.      | Coupled-Channels Calculations of Heavy-Ion Fusion Reactions.....                                  | 260 |
| d.2.      | Modeling the Quadrupole Mode in $^{100}\text{Mo}$ .....   | 262 |
| d.3.      | Constraints on the $^7\text{Be}(p,\gamma)^8\text{Be}$ Reaction from Charge Symmetry .....         | 264 |
| d.4.      | Model Dependence of the $^7\text{Be}(p,\gamma)^8\text{Be}$ Reaction Rate.....                     | 265 |
| d.5.      | Reconciling Coulomb Dissociation and Radiative Capture Measurements .....                         | 266 |
| d.6.      | Mean Field and Many Body Wave Functions .....   | 268 |
| d.7.      | Neutron-Proton Pairing.....   | 269 |
| d.8.      | Energy Levels of the Heavy Elements.....  | 271 |
| d.9.      | Self-Consistent Beyond-Mean-Field Calculations in Exotic Heavy Nuclei.....                        | 272 |
| d.10.     | A New Microscopic Pairing Force for Self-Consistent Mean-Field<br>Calculations.....               | 273 |
| d.11.     | Configuration Mixing of Particle-Number and Angular-Momentum<br>Projected Cranked HFB States..... | 273 |
| d.12.     | Collective States in the $20 < Z < 28$ and $28 < N < 40$ Region.....                              | 273 |
| d.13.     | Systematics of Ground-State Correlations in Even-Even Nuclei .....                                | 274 |
| d.14.     | QRPA of Spherical Nuclei with Skyrme Interactions .....   | 274 |
| <b>E.</b> | <b>ATOMIC THEORY AND FUNDAMENTAL QUANTUM<br/>MECHANICS</b> .....                                  | 275 |
| e.1.      | Interactions of Photons with Matter.....  | 275 |
| e.2.      | Interactions of Charged Particles with Matter .....   | 276 |
| e.3.      | Photon Beam Polarization and Non-Dipolar Angular Distributions .....                              | 276 |
| e.4.      | The Theory Experiment Connection: $R_n$ Space and Inflationary<br>Cosmology .....                 | 276 |
| <b>F.</b> | <b>OTHER ACTIVITIES</b> .....   | 279 |
| f.1.      | Hadron Physics: Modern Methods for Modern Challenges .....  | 279 |
| f.2.      | 17 <sup>th</sup> Annual Midwest Nuclear Theory Get-Together .....                                 | 279 |

|   |     |
|---|-----|
| <b>VI. OTHER EDUCATIONAL AND COMMUNITY<br/>OUTREACH ACTIVITIES</b> .....                            | 281 |
| a. Minority Program.....  | 281 |
| b. Third RIA Summer School.....   | 282 |
| c. Homeland Security Activities - Scientific Support of the Radiological<br>Assistance Program..... | 283 |
| d. Repair and Refurbishment of Germanium Detectors.....   | 284 |
| Staff List.....   | 285 |
| Publications.....   | 297 |