

ANNUAL REPORT  
OF THE  
MICHIGAN STATE UNIVERSITY  
NATIONAL SUPERCONDUCTING CYCLOTRON LABORATORY  
FOR THE PERIOD  
JANUARY 1, 1986 TO DECEMBER 31, 1986

ACKNOWLEDGEMENTS

COORDINATOR, THEORY GROUP:  
SHARI CONROY

COORDINATOR, EXPERIMENTAL GROUP:  
JACKIE BARTLETT

PRODUCTION COORDINATOR:  
JACKIE BARTLETT

GRAPHICS:  
ORILLA MCHARRIS

MAY 1987  
EAST LANSING, MICHIGAN

This Annual Report describes the activities of the National Superconducting Cyclotron Laboratory (NSCL) from January 1, 1986 to December 31, 1986. During this period the efforts of the laboratory were concentrated on two principal activities: operation of the K500 superconducting cyclotron and its associated experimental apparatus as a national users facility and continuing construction of the K800 cyclotron and other Phase II facilities. Considerable effort was also devoted to construction and development of the Electron Cyclotron Resonance (ECR) ion sources which have become centrally important to the overall program of the laboratory.

The K500 Cyclotron was shut down from January through March 1986 for installation of the Room Temperature ECR source. First ECR beam was extracted from the K500 cyclotron on March 26 and ECR beams have been routinely used in experiments since then, entirely displacing the previous PIG source beams. Later in 1986, a compact and inexpensive one stage ECR source was constructed, designed especially for production of metallic ions; employing the compact source for the heavily used Li beams and for other relatively easy beams will reduce turnaround time in changing accelerated ions and free up the Room Temperature source for further ECR development. The compact source will also provide beams for initial startup and testing of the K800 cyclotron. Funding has been requested (and approved in 1987) for an ECR source using superconducting coils which will permit operation at high frequencies (expected to greatly improve the intensity of high charge state ions) and detailed study of the sensitivity of source performance to a broader regime of magnetic field shapes. Further significant improvements in ECR performance are expected from this source to the point where the goals of the K800 program can be achieved with the cyclotron operating in a stand-alone mode rather than in the originally planned mode with the K500 functioning as an injector for the K800.

A number of K500 improvements in addition to the ECR were put in place during the year including: 1) additional water cooling circuits on the radio-frequency resonator structures to permit operation at higher voltages and hence higher energies, 2) phase slits to better define the beam acceptance of the K500 and permit operation at burst widths of 1 nsec or less, and 3) operation on the second harmonic to permit operation below 10 MeV/nucleon when needed for special experiments and to provide higher quality beams at intermediate energies. As a result of these improvements, the K500 is now operating at its design specifications, routinely producing beams up to mass 16 at 50 MeV/nucleon, with weaker beams available at energies up to 55 MeV/nucleon, Ar beams to 35 MeV/nucleon and Kr beams to 20 MeV/nucleon.

In spite of the three month shutdown for ECR installation and a shorter shutdown for installation of the water cooled resonators, the K500 operated for 4146 hours in 1986, supplying beams to experiments in all experimental areas. Overall reliability was significantly better than last year. As in the past, experiments were split roughly evenly between those aimed at understanding the mechanisms of heavy ion collisions and those aimed at a better understanding of nuclear structure. Meetings of PAC-5 (April 6-7) and PAC-6 (October 26-27) were held during 1986; the Committees considered requests for 4823 hours of beam time and recommended allocation of a total of 2400 hours. Presently, all PAC 5 experiments have been run or scheduled, as well as about three quarters of those recommended by PACs 6 and 7. PAC 8 will meet May 3-4 1987 and PAC 9 after beam is available from the K800.

Phase II construction efforts in 1986 centered on the K800 cyclotron; significant progress was also achieved in the development of prototype magnets for the Phase II beam transport system and on construction of the  $4\pi$  array for detection of charged particles from high-energy heavy-ion collisions.

Early in the year, the magnet for the K800 was reassembled with trim coils in place and the incremental effect of each trim coil was determined in an extensive set of magnet mapping runs which will provide the primary data base for computing operating points for the cyclotron throughout its life. The field maps included penetrations in the magnet yoke, fabricated in a rapid turn around process just before the mapping and just after a long awaited decision to freeze the design of the extraction system based on extensive favorable numerical analysis of the "Mark V" extraction geometry. After the mapping runs, the magnet was once more disassembled to begin the intricate process of installing median plane penetrations through the cryostat for the external beam, a possible future injected beam and other related elements. In parallel with the magnet work, fabrication of the many subsystems which go to make up the resonator structure for the rf system was in process and by years end, the most complicated of these sub-assemblies, the copper liners which overlay the hills and valleys of the magnet poles with 0.5 mm clearance were nearly complete. The three power amplifiers for the rf system were also completed and extensively tested. Overall, the expectation of tests with beam in mid 1987 seems an achievable goal for the K800 program.

Beams from the K800 will first be available in an interim experimental area located near the cyclotron and containing a 92" diameter by 120" long scattering chamber and the MSU  $4\pi$  detector. Limited space for other setups will also be available. To the extent it is consistent with lab resources, K500 operation will continue in the S320 spectrograph and RPMS areas, while the remaining part of the experimental area is being reconfigured with Phase II cryogenic beam lines and experimental apparatus. This phased approach will permit earliest possible use of K800 beams in the energy range above 100 MeV/nucleon and incur only small shutdown times for installation of new experimental apparatus. A workshop is planned for August 1987 to discuss these plans with the user community and to obtain input to guide the details of the development.

The NSCL will be sponsoring three conferences during the next years. The Fourth Gull Lake Nuclear Physics Conference on "Energetic Products of Heavy Ion Collisions" organized by Walter Benenson, George Bertsch and Alex Brown will be held May 17-20, 1987--about 100 participants are expected. From November 16-18, 1987, an International Conference on ECR Ion Sources and their Applications, organized by Tim Antaya, Henry Blosser and Jerry Nolen, will be held at East Lansing. This meeting will bring together those involved in the design construction and operation of ECR sources. From May 23-27, 1988 a conference on Phase Transitions in Nuclear Collisions organized by Laszlo Csernai and Gary Westfall will be held at Gull Lake. For each of these conferences, the organizers can be contacted for further information.

A further important development of the year is the new additions and changes in the laboratory faculty. Alex Brown and Gary Westfall have moved from appointments in the Laboratory to appointments in the Department of Physics as Associate Professors. Mitsuru Tohyama from Tokyo University and Giessen has joined the Department of Physics as Assistant Professor working in nuclear theory. During 1986 Konrad Gelbke and Jerry Nolen were awarded Fellowship in the APS, Bill Lynch held a Presidential Young Investigator award and Brad Sherrill shared the APS Division of Nuclear Physics Dissertation Award.

Closing, we solicit advice and suggestions from all readers as to any ways in which the contents of this Annual Report could be made more useful, and things we could do to make the NSCL a more supportive and convenient place for you to conduct research.

Sam Austin

Henry Blosser

Members of the Users' Executive Committee serve three-year terms, beginning November 1 (formerly two-year terms beginning October 1). Members are elected each year from the general membership of the Users' Group, and a non-voting liaison representative from MSU is appointed by the Director of the NSCL. Committees to date are:

A. Galonsky	MSU, Liaison
D. Kovar	Argonne Nat'l Laboratory Chair
K. Kwiatkowski	IUCF
L. Lee	SUNY, Stony Brook
J.X. Saladin	University of Pittsburgh

## NSCL Program Advisory Committee

October 1, 1982 - September 30, 1983

F. Becchetti	University of Michigan, Chair
A. Galonsky	MSU, Liaison
J. Kolata	Notre Dame University
V. Viola	Indiana University
D. Youngblood	Texas A&M University

October 1, 1983 - September 30, 1984

A. Galonsky	MSU, Liaison
J. Kolata	Notre Dame University, Chair
F. Prosser	University of Kansas
R. Tickle	University of Michigan
D. Youngblood	Texas A&M University

October 1, 1984 - October 31, 1985

A. Galonsky	MSU, Liaison
J. Kolata	Notre Dame University
L. Lee	SUNY, Stony Brook
F. Prosser	University of Kansas
R. Tickle	University of Michigan Chair

November 1, 1985 - October 31, 1986

A. Galonsky	MSU, Liaison
D. Kovar	Argonne National Laboratory
L. Lee	SUNY, Stony Brook
F. Prosser	University of Kansas Chair
R. Tickle	University of Michigan

At present the Program Advisory Committee of the NSCL meets about every six months to review proposals for beam time; the possibility of more frequent meetings is under consideration. There are no oral presentations.

Meetings to date:

PAC-1	February 1982
PAC-2	September 30, 1983
PAC-3	July 2, 1984
PAC-4	January 13-14, 1985
PAC-5	July 28-29, 1985
PAC-6	April 6-7, 1986
PAC-7	October 26-27, 1986
PAC-8	May 3-4, 1987

PAC Members:

H.C. Britt (LANL)	1,2
D. Cline (Rochester)	1,2,3,4,5
S.E. Koonin (CalTech)	1,2,3,4,5,6
P. Paul (Stony Brook)	1,2
D.K. Scott (MSU)	1,2,3
J. Cramer (Washington)	3,4,5,6,7
V. Viola (Indiana)	3,4,5,6,7,8
W. Benenson (MSU)	4,5,6,7,8
Non-voting Chair	1,2,3
P. Siemens (Texas A&M)	5,6,7,8
F. Stephens (LBL)	6,7,8
J. Vary (Iowa State)	7,8
G. Young (ORNL)	8

## SECTION I.

Page

Page

1. NUCLEAR REACTIONS--EXPERIMENTAL

High Energy Gamma Ray-Proton Correlations, A.R. Lampis, J. Stevenson, W. Benenson, C. Bloch, D. Cebra, J. Clayton, D. Fox, E. Kashy, D. Morrissey, M. Samuel, R. Smith, A. Tam, G. Westfall, K. Wilson, J. Winfield . . . . .	1	Subthreshold Pion Production with La Beams and a Multiplicity Filter, J. Miller, W. Benenson, J. Bercovitz, G. Claesso, J.-F. Gilot, G. Krebs, G. Landaud, G. Roche, L. Schroeder, J. van der Plicht and J. Winfield . . . . .	21
Neutron Emission From Heavy-Ion Collisions, F. Deak, A. Galonsky, C.K. Gelbke, L. Heilbronn, J. Kasagi, A. Kiss, S. Langer, W. Lynch, T. Murakami, B. Remington, H. R. Schelin, Z. Seres and M.B. Tsang . . . . .	4	Streamer Chamber Study of Near-Central Collisions with CCD Cameras, S.P. Angius, G.M. Crawley, C. Djalali, D. Fox, M. Maier, R.S. Tickle, and G. Westfall . . . . .	23
Unstable Resonances From 500 MeV p + Ag, D.A. Cebra, W. Benenson, Y. Chen, R. Helmer, E. Kashy, R. Korterling, D.J. Morrissey, A. Pradhan, R.S. Tickle, G.D. Westfall, W.K. Wilson and A. VanderMolen . . . . .	6	Neutron Decay of Excited Nuclear States in Heavy Ion Collisions, C. Bloch, W. Benenson, A.I. Galonsky, E. Kashy, J. Heltsley, L. Heilbronn, M. Lowe, B. Remington, D.J. Morrissey, and J. Kasagi . . . . .	25
Transition From Bound to Unbound Systems, D.A. Cebra, D. Fox, J. Karn, C. Parks, E. Norbeck, G.D. Westfall, W.K. Wilson, J. van der Plicht . . . . .	9	Spallation and Fragmentation of Medium-A Targets by Heavy Ions, N.T. Porile, S.Y. Cho, Y.H. Chung and D.J. Morrissey . . . . .	30
Production of Unstable Resonances in 35 MeV/Nucleon $^{14}\text{N}+\text{Ag}$ , D. Fox, D.A. Cebra, C. Parks, R.S. Tickle, A. VanderMolen, J. van der Plicht, G.D. Westfall and W.K. Wilson . . . . .	11	Nuclear Fragmentation and Sequential Decay, D.J. Fields, C.K. Gelbke, W.G. Lynch, and J. Pochodzalla . . . . .	31
Large Angle Correlations in $^{12}\text{C}$ -Induced Reactions at 40 and 50 MeV/Nucleon, D. Fox, D.A. Cebra, J. Karn, C. Parks, G.D. Westfall and W.K. Wilson . . . . .	13	Fragmentation Studies of $^{18}\text{O}$ on $^{58}\text{Ni}$ at Forward Angles, M.M. Torres, S.P. Angius, D. Cebra, G.M. Crawley, D. Fox, A. Machiavelli, Menchaca-Rocha, A. Pradhan, A. Toledo, G.D. Westfall and K. Wilson . . . . .	35
Spin Alignment in the Reaction $^{22}\text{Ne} + ^{170}\text{Er}$ at 10 MeV/A, R. Aryaeinejad, D.J. Morrissey, R. Blue, R. Ronningen, M. Kaplan, C. Knott, H. Takai, J.X. Saladin, D. Winchell, and I.Y. Lee . . . . .	16	Dependence of Two-Particle Correlation Functions on Linear Momentum Transfer to Composite System, Z. Chen, C.K. Gelbke, J. Pochodzalla, C.B. Chitwood, D.J. Fields, W.G. Lynch, and M.B. Tsang . . . . .	36
Very-High Energy ( $E \rightarrow E_{\text{Beam}}$ ) Light Particle Production Near $0^\circ$ in Heavy-Ion Collisions, $E/A < 40$ MeV/U, F.D. Becchetti, J. Jänecke, S. Shaheen, R. Stern, A. Nadasen, and D. Kovar . . . . .	18	External Coulomb Distortion of Proton-Deuteron Final-State Interactions for $^{14}\text{N}$ Induced Reactions on $^{197}\text{Au}$ at $E/A=35$ MeV, J. Pochodzalla, C.K. Gelbke, C.B. Chitwood, D.J. Fields, W.G. Lynch, M.B. Tsang, and W.A. Friedman . . . . .	40

Multiplicity Dependent Light Particle Correlations, J. Pochodzalla, C.K. Gelbke, W.Lynch, M. Maier, A. Kyanowski, F. Saint-Laurent, D. Ardouin, H. Delagrangé, H. Doubre, C. Gregoire, W. Mittig, A. Peghaire, J. Peter, Y.P. Viyogi, B. Zwieglinski, J. Quebert, G. Bizard, F. Lefebvres and B. Tamain . . . . 42

Source Properties of Intermediate Mass Fragments Emitted in the  $E/A = 35$  MeV  $^{14}\text{N} + ^{232}\text{Th}$  Reaction, M. Fatyga, K. Kwiatkowski, V.E. Viola, W.G. Wilson, M.B. Tsang, J. Pochodzalla, W.G. Lynch, C.K. Gelbke, D.J. Fields and C.B. Chitwood . . . . . 44

Nuclear Temperature Measurements and Feeding from Particle Unbound States, H.M. Xu, D.J. Fields, W.G. Lynch, M.B. Tsang, C.K. Gelbke, M.R. Maier, D.J. Morrissey, J. Pochodzalla, D.G. Sarantites, L.G. Sobotka, M.L. Halbert, D.C. Hensley, D. Hahn, and, H. Stöcker . . . 46

## 2. NUCLEAR REACTIONS--THEORY

Transverse Momentum Distributions in Intermediate Energy Heavy-Ion Collisions, G.F. Bertsch, W.G. Lynch and M.B. Tsang . . . . . 50

Tensor Alignment of  $^7\text{Li}$  and Astrophysical S-Factor for  $^4\text{He}(t,\gamma)^7\text{Li}$ , T. Kajino, G.F. Bertsch, and K.-I. Kubo . . . 52

Application of Time Dependent Density Matrix Method to  $^{16}\text{O} + ^{16}\text{O}$  Reactions, M. Tohyama . . . . . 54

Quantum Effects on High Energy  $\gamma$  Production in heavy Ion Collisions, M. Tohyama . . . . . 56

Light Particle Correlations in Heavy Ion Collisions, W. Bauer . . . . . 58

## 3. NUCLEAR STRUCTURE--EXPERIMENT

Beta Decay Halflife Measurements for  $^{17}\text{B}$  and  $^{19}\text{N}$ , M. Samuel, B.A. Brown, D. Mikolas, J. Nolen, B. Sherrill, J. Stevenson, J. Winfield and Z. Q. Xie . . . . 60

Search for the Neutron Rich Nucleus  $^{10}\text{He}$ , J. Stevenson, Y. Chen, J. Nolen, J. Winfield, E. Kashy, W. Benenson, D. Mikolas, M. Samuel, A.R. Lampis . . . . . 62

Energy Dependence of  $^{12}\text{C} + ^{12}\text{C}$  Single Particle Transfer Cross Sections, J.S. Winfield, S.M. Austin, Z. Chen, G.M. Crawley, C. Djalali, K. Dutch, R.J. Smith and M. Torres . . . . . 64

Isovector and Isoscalar Spin-Flip Excitations, G.M. Crawley, C. Djalali, A. Galonsky, A. Brown, N. Marty, M. Morlet, A. Willis . . . . . 67

High-Resolution  $^{12}\text{C}(^7\text{Li},t)$  Data,  $E = 70$  MeV, F.D. Becchetti, J. Jänecke, P. Lister, M. Dowell, A. Nadasen and J.S. Winfield . . . . . 72

Splitting of the Dipole and Spin-Dipole Resonances, S.M. Austin and E.C. Adamides . . . . . 73

Measurement of the Recoil Polarization of  $^6\text{Li}^*$  (2.186 MeV, 3+) Using a Multi-PSD Array, R. Aryaeinejad, W.R. Falk, D. Steski, O. Abou-Zeid, A. Mirzai, and J.R. Campbell . . . . . 76

Gamow-Teller Strength in the  $^{26}\text{Mg}(p,n)^{26}\text{Al}$  Reaction at 136 MeV and its Fractionation into  $T = 0, 1$  and 2 Isospin Channels, R. Madey, B.S. Flanders, B.D. Anderson, A.R. Baldwin, C. Lebo, J.W. Watson, S.M. Austin, A. Galonsky, B.H. Wildenthal and C.C. Foster . . . . . 78

<u>Page</u>	<u>Page</u>
Particle Response Functions in the Samarium and Europium Isotopes, J. Duffy, G.M. Crawley, J. van der Plicht, O. Scholten, J. Finck, R.S. Tickle, S. Gales and C.P. Massolo . . . . .	Effective Interactions for the SD and FP Shells, B.A. Brown and W.A. Richter . . . . .
81	107
<u>5. PHASE I OPERATIONS</u>	
States in <sup>107</sup> Ag From the Decay of <sup>107</sup> Cd, J. Batchelder and Wm.C. McHarris . . . . .	K500 Cyclotron Operating Experience, P. Miller, D. Poe, H. Thulin . . . . .
85	109
Rotational Bands in Odd-Odd Re Nuclei, W.A. Olivier, W.-T. Chou, R. Aryaeinejad, and Wm.C. McHarris . . . . .	K500 Vacuum Studies, M.L. Mallory . . . . .
87	111
Search for <sup>12</sup> C Clusters in <sup>28</sup> Si, A. Nadasen, F.D. Becchetti, J.W. Janecke, G. Gunderson, M. McMaster, A. Judd, S. Villanneva, K.T. Hecht, J. Winfield, A. Galonsky and R.E. Warner . . . . .	ECR Injection Line Vacuum Requirements, M.L. Mallory . . . . .
89	112
A Search for High-Excitation-Energy Structures in <sup>208</sup> Pb and <sup>90</sup> Zr, Using 25 and 30 MeV/A Neon beams, S. Fortier, S. Gales, S.M. Austin, W. Benenson, G.M. Crawley, C. Djalali, J. Winfield . . . . .	Operation of Liquid Helium Level Sensors at Elevated Pressures, A.F. Zeller, H. Laumer and J.A. Nolen . . . . .
90	113
<u>4. NUCLEAR STRUCTURE--THEORY</u>	Extraction of <sup>6</sup> He Beam from the K500 Cyclotron, M.L. Mallory, R. Blue, D. Mikolas, F. Marti, W. McHarris, P. Miller, J. Nolen, R. Ronningen, W.T. Chou, and W. Olivier . . . . .
Quasiparticle Relativistic G-Matrix Interaction, K. Nakayama, S. Drozd, S. Krewald, and J. Speth . . . . .	115
92	Water Cooling of the K500 RF Corona Rings, M.L. Mallory, J. Kuchar, P. Miller, D. Poe, and J. Ottarson . . . . .
Comment on "Can an Isovector Dipole Mode of Nuclear collective Motion give a Signature Duplicating That of an Isoscalar Monopole Mode?", K. Nakayama and G.F. Bertsch . . . . .	117
95	Magnet Supply Installation and Control For the ECR Ion source Complex, W. Nurnberger, T. Antaya, L. Foth, and J. Vincent . . . . .
On the Description of the Giant Resonances Within an RPA Formalism with Good isospin, E. Bauer, F. Krmpotic, and K. Nakayama . . . . .	120
97	Low Energy Buncher for the K500 Cyclotron, F. Marti, J. Moskalik and J. Vincent . . . . .
IBFFA Caclulations - Interacting Boson Calculations Extended to Odd-Odd Nuclei, W.T. Chou, W.A. Olivier, Wm.C. McHarris, O. Scholten . . . . .	125
99	Experimental Facilities Operation, R. Blue, N. Anantaraman, R. Ronningen, and J. Winfield . . . . .
Prediction of a New High-Spin Mode of Transverse Excitation in Electron Scattering from Nuclei, B.A. Brown and B.H. Wildenthal . . . . .	129
103	Nuclear Electronics Development, M.R. Maier, M. Robertson, James Vincent . . . . .
	131
	Nuclear Physics Preprints, N. Anantaraman and E. Kales . . . . .
	132

6. ACCELERATOR AND INSTRUMENTATION  
R & D AND CONSTRUCTION

Status of K800 Cyclotron, T. Antaya, R. Au, S.M. Austin, H. Blosser, R. Blue, S. Bricker, D. Cole, M. Fowler, M. Gordon, L. Harwood, H. Hilbert, D. Johnson, E. Kashy, H. Laumer, D. Lawton, M. Mallory, F. Marti, P. Miller, B. Milton, R. Morin, J. Nolen, J. Ottarson, B. Sherrill, G. Stork, J. Vincent, X. Wu, and A. Zeller . . . . .	133	Effects on a Beam of Prolonged Weaving Around the $\nu_r = 2\nu_z$ Coupling Resonance, M.M. Gordon, F. Marti, and X.Y. Wu . . . . .	164
K800 RF Status, T.R. Jones, J. Brandon, J. Ottarson, D. Scott and J. Vincent . . . . .	139	Analytical Permanent Magnet Design Code Permag, Z.Q. Xie and T. Antaya . . . . .	166
General RF Design and Analysis Techniques for Two-Conductor, Non-Symmetric, and Non-Uniform Resonators, John Vincent . . . . .	141	Present Operation of the RT-ECR Ion Source, T.A. Antaya, D.P. Sanderson, W.D. Nurnberger and Z.Q. Xie . . . . .	171
Current Regulation for the K800 Cyclotron Superconducting Magnet, A. McGilvra, J. Priller, J. Vincent . . . . .	145	The Compact ECR Ion Source CP-ECR for Light Ions and Lithium, T.A. Antaya, Z.Q. Xie and D.P. Sanderson . . . . .	174
Status of Integrated Software Project for Cyclotron Design, L.H. Harwood . . . . .	147	The High Frequency Superconducting ECR Ion Source Project, T.A. Antaya, H.G. Blosser, J.A. Nolen and A.F. Zeller . . . . .	176
Improvements in the Numerical Model of the NSCL K800 Superconducting Cyclotron Magnet, L.H. Harwood . . . . .	149	Metal Ion Production in the ECR Ion Sources at NSCL, D.P. Sanderson, T.A. Antaya, and Z.Q. Xie . . . . .	179
Magnetic Field Measurements of the NSCL K800 Cyclotron Magnet, L.H. Harwood, B. Sherrill, J.A. Nolen Jr., and A.F. Zeller . . . . .	153	Beamline Quadrupole Progress Report, J.C. DeKamp, C.T. Magsig, J.A. Nolen, A.F. Zeller . . . . .	184
Design of Harmonic Compensation Holes in the Median Plane Section of the K800 Magnet Yoke, L.H. Harwood . . . . .	156	16 Degree Dipole Construction and Testing, J.C. DeKamp, C.T. Magsig, J.A. Nolen, A.F. Zeller . . . . .	186
The K800 Exit Beamline Design, A.F. Zeller, J.A. Nolen, R.T. Swanson, and R.D. Hay . . . . .	157	Beam Optics of Adjustable Permanent-Magnet Quadrupole and Dipole Magnets, S. Tanaka, J.A. Nolen, and A.F. Zeller . . . . .	188
Phase Probe Tests, R.M. Ronningen, B.F. Milton, J. Yurkon, M. Maier, and F. Marti . . . . .	159	Improved ECR Beamline X-Y Steering Magnets, M.F. Williams, A.F. Zeller and J.A. Nolen . . . . .	191
Radiation Effects on Permanent Magnet Materials, A.F. Zeller and J.A. Nolen . . . . .	161	Beam Current Meter: Everything up Front, A. McGilvra . . . . .	192
		Medical Cyclotron Studies, E. Blosser, G. Blosser, H. Blosser, J. DeKamp, J. Griffin, D. Johnson, F. Marti, R. Maughan, B. Milton, W. Powers, J. Purcell, J. Vincent and W. Young . . . . .	194
		Beam Extraction Studies for a 250 MeV Superconducting Synchrocyclotron, M.M. Gordon and X.Y. Wu . . . . .	198



	<u>Page</u>
A Method for the Uniform Charged Particle Irradiation of Large Targets, E. Kashy and B. Sherrill . . . . .	201
Trial of Beam Reconstruction Using a Filtered Back Projection, Y.D. Ahn, S.M. Austin . . . . .	204
Status of the MSU 4 $\pi$ Array, G.D. Westfall, M. Maier, L. Morris, D. Swan, S. Tanaka, A. Vander Molen, J. van der Plicht, J. Winfield, M. Williams and J. Yurkon . . . . .	206
High Resolution Heavy Fragment Hodoscope, T.K. Nayak, T. Murakami, W.G. Lynch, K. Swartz, D.J. Fields, C.K. Gelbke, Y. Kim, K. Kwiatkowski, J. Pochodzalla, M.B. Tsang, F. Zhu . . . . .	208
Particle Identification by Pulse Shape Discrimination with Inorganic Scintillators, D.A. Cebra, D. Fox, M.R. Maier, D. Swan, P.B. Ugorowski, G.D. Westfall, D.K. Wilson and J.E. Yurkon . . . . .	210
Gas Chromatography as a Technique For Detecting Traces of H <sub>2</sub> in Cryogenic He, J.C. Batchelder and Wm.C. McHarris . . . . .	212
Activation of <sup>Nat</sup> Cu by 480 MeV <sup>12</sup> C, R.M. Ronningen . . . . .	214

	<u>Page</u>
SECTION II.	
Publications List . . . . .	215
Conference Proceedings . . . . .	218
Invited Talks . . . . .	221
Thesis Titles . . . . .	224
SECTION III.	
Experiments Approved at Program Advisory Committee Meetings . . . . .	225