

UIUC ICAR 2004

D. ERREDE

OCT. 12, 2004

THE UNIVERSITY OF ILLINOIS IS A MEMBER OF THE ILLINOIS CONSORTIUM FOR ACCELERATOR RESEARCH. WE HAVE SEVERAL PROGRAMS WHICH WE ARE PUSHING FORWARD. THE EMPLOYEES WHO PARTICIPATE IN OUR WORK ARE THE FOLLOWING:

ZACHARY CONWAY - GRADUATE STUDENT, THESIS PROGRAM IN ACCELERATOR PHYSICS
DEBORAH ERREDE - PI, ACCELERATOR PHYSICS, BEAM DYNAMICS, ADVISER
DAVID LESNY - SYSTEM MANAGER FOR MUCOOL CLUSTER
MICHAEL HANEY - ELECTRICAL ENGINEER, ACCELERATOR PHYSICS
KYOKO MAKINO - VISITING ASSOCIATE PROFESSOR OF PHYSICS, BEAM DYNAMICS (ENDED@UIUC FEBRUARY 2004)
LARRY NELSON - ASSISTANT SYSTEM MANAGER FOR MUCOOL CLUSTER
KEVIN PAUL - POSTDOCTORATE, BEAM PHYSICS
GEFEI QIAN - GRADUATE STUDENT, CONDENSED MATTER THEORY
IGOR RAKHNO - VISITING ASSISTANT PROFESSOR, NUCLEAR THEORIST
ED BLACK - ENGINEERING CONSULTANT (SUMMER 2004 ONLY)

MOST OF THE WORK DONE BY THE UIUC GROUP WAS DIRECTED AT THE DEVELOPMENT OF LARGE EMITTANCE MUON ACCELERATORS AND THE MEANS TO REDUCE THE 6 DIMENSIONAL PHASE SPACE. WORK CONTRIBUTED BY OUR PH.D. GRADUATE STUDENT, ZACHARY CONWAY, WILL NOT ONLY BE EMPLOYED AT THE ATLAS ACCELERATOR AT ARGONNE, BUT WILL PROVE USEFUL FOR A PROTON DRIVER UPGRADE (SUPERCONDUCTING LINAC) AT FERMILAB AND SOLVING SOME OF THE DE-TUNING ISSUES ASSOCIATED WITH A FUTURE SUPERCONDUCTING LINEAR ACCELERATOR FOR TEV ENERGY COLLIDING ELECTRONS. A NEW HIGH INTENSITY TEST BEAM AREA (400 MEV PROTONS) AT FERMILAB HAS BEEN BUILT WITH LIQUID HYDROGEN AND HELIUM CAPABILITY AS A RESULT OF THE EFFORTS OF OUR AND THE REST OF THE MUCOOL SECTION OF THE ICAR CONSORTIUM.

SUPERCONDUCTING RF CAVITY R&D (CONWAY)

THIS RESEARCH IS SUPERVISED BY KEN SHEPARD AT ARGONNE NATIONAL LABORATORY. I AM HIS UIUC ADVISER. ZACK IS A UIUC STUDENT, PART OF OUR GROUP, THAT IS WORKING AT ARGONNE TO OBTAIN A THESIS IN SCRF RESEARCH.

ZACK HAS CHOSEN A THESIS TOPIC, THE DEVELOPMENT OF TEM RESONATORS IN PULSED MODE OPERATION, AND HIS PRELIMINARY EXAM IS BEING SCHEDULED LATER THIS FALL.

AT ARGONNE, THE PROJECTS THAT ZACK HAS WORKED ON ARE AS FOLLOWS:
DESIGNED AND CONSTRUCTED A MANOSTAT FOR HIGH FLOW PRESSURE REGULATION.
PERFORMED NIOBIUM RESIDUAL RESISTANCE RATIO MEASUREMENTS, IMPORTANT FOR DETERMINING THE PURITY OF NIOBIUM, LINKED TO THE THERMAL CONDUCTIVITY AND HENCE QUENCH PROPERTIES OF THE MATERIAL.

SLOW AND FAST TUNERS FOR SUPERCONDUCTING QUARTER-WAVE AND HALF-WAVE RF CAVITIES (WHICH HAVE A NARROW Q, HENCE TIGHT RESONANCE REQUIREMENTS) ARE UNDER DEVELOPMENT FOR RIA AND AN UPGRADE TO ATLAS (ARGONNE ACCELERATOR). THE SLOW TUNER IS A SET OF WIRE ROPES AND GUIDES TENSIONED BY WELDED METAL BELLOWS THAT SQUEEZE ALONG THE BEAM AXIS. TWO TYPES OF FAST TUNERS, A CERAMIC PIEZO ACTUATOR AND A MAGNETOSTRICTIVE ACTUATOR, ARE BEING TESTED FOR USE ON A DOUBLE SPOKE CAVITY. THE LATER WAS DESIGNED AND BUILT BY ENERGEN INCORPORATED.

EPOXY BONDING OF NIOBIUM TO THE EXTERIOR OF A NIOBIUM RESONATOR WAS INVESTIGATED AS AN ALTERNATIVE TO WELDING WHICH CAN CAUSE DEFORMATION OF THE STRUCTURE HENCE MOVE THE CAVITY OFF RESONANCE.

MUON COOLING ABSORBER R&D (ERREDE, HANEY, QIAN, CONWAY, BLACK)

UIUC IS A COLLABORATOR ON THE MUON IONIZATION-COOLING PROJECT, MUCOOL. THE PURPOSE OF MUCOOL IS TO DEMONSTRATE THE OPERATION OF THE THREE MAJOR COMPONENTS OF A SOLENOID-FOCUSED COOLING CHANNEL: HIGH-FIELD

SOLENOID MAGNETS, 200 MHZ RF CAVITIES, AND ENERGY ABSORBERS. THE UIUC GROUP PARTICIPATES PREDOMINANTLY IN THE ABSORBER PROJECT. INCLUDED IN THE MU-COOL EXPERIMENT IS THE CONSTRUCTION OF A HALL IN WHICH TO PERFORM THE NECESSARY TESTS FOR ALL OF THESE COMPONENTS. UIUC PROVIDED A MAJOR PORTION OF THE ENGINEERING EXPERTISE TO BRING THE ABSORBER WINDOW PRESSURE TESTS. THIS INCLUDED DESIGNING AND COMMISSIONING THE DATA ACQUISITION SYSTEM.

WE HAVE SINCE FOCUSED OUR EFFORTS MORE HEAVILY TOWARDS THE MU-COOL TEST AREA, A BEAM TEST FACILITY USING THE REDIRECTED PROTON LINAC 400 MEV BEAM. HERE OUR RESPONSIBILITIES INCLUDE INSTRUMENTATION OF THE ABSORBER ITSELF BUT ALSO COORDINATING ALL SIGNALS FROM THE MU-COOL TEST AREA AND IMPLEMENTING PROPER ENVIRONMENTAL CONDITIONS TO MEET THE STRINGENT SAFETY REQUIREMENTS MANDATED BY THE FERMILAB SAFETY GROUP. FERMILAB HAS FULL RESPONSIBILITY FOR SAFETY IN THIS TEST FACILITY. CURRENTLY WE (QIAN, ERREDE, HANEY) ARE TESTING A DATA ACQUISITION SYSTEM FOR READOUT OF SLOW TEMPERATURE AND PRESSURE MONITORS. THE SYSTEM INCLUDES GATEWAY E-4000 PC (1.8 GHZ, 1 GBYTE RAM, 0.5 GBYTE CACHE, 120 GBYTE DISK), LAKESHORE 218S MONITORS (8-CHANNEL READOUT), CX-1030-SD AND 1050-SD RTD SENSORS AND A LABVIEW SOFTWARE INTERFACE WRITTEN BY CONWAY FOR THE COLLECTION OF DATA. THE SYSTEM ALSO HAS THE FAST RATE CAPACITY (PCI-MIO-16E-1 16 CHANNEL ADC AT 1.25 MSAMPLES/SEC, 12 BITS). WE ARE ALSO RESPONSIBLE FOR THE CONNECTION OF OUR SIGNALS TO THE REST OF THE LABORATORY THROUGH THEIR STANDARD SYSTEM, ACNET, USING AN IRM (INTERNET RACK MONITOR). THE IRM INCLUDES A 64 CHANNEL MULTIPLEXED ADC (16 BIT, 100 KSAMPLES/SEC). INTRINSICALLY SAFE MTL7055AC AND MTL7060AC BARRIERS ARE INSERTED BETWEEN THE ELECTRONICS AND HAZARDOUS REGION IN THE MU-COOL TEST AREA. TESTING OF THE SYSTEM IS DELAYED ACCORDING TO THE MU-COOL TEST AREA SCHEDULE.

IN URBANA, THE UIUC GROUP IS PERFORMING FRONTIER R&D ON RELATIVELY NEW FIBER OPTIC TEMPERATURE AND STRAIN GAUGES USING THE WHITE LIGHT SPECTRUM (FISO FOS-N STRAIN SENSORS AND FOT-L TEMPERATURE SENSORS). THESE HAVE BEEN SHOWN TO

WORK IN HIGH RADIATION ENVIRONMENTS (AS NECESSARY FOR A MUON BEAM OF 10^{13} PARTICLES PER PULSE) BY H. KIRK ET AL. OF THE BROOKHAVEN CONTINGENT OF OUR MUON COLLABORATION. OPERATION AT CRYOGENIC TEMPERATURES (10K TO 20K) HAS NOT YET BEEN DEMONSTRATED; WE ARE UNDERTAKING EXACTLY THAT TASK. THIS EFFORT HAS BEEN DELAYED IN ORDER TO GET THE STANDARD RESISTIVE THERMAL DEVICES OPERATIONAL. WE ACHIEVED BENEFICIAL OCCUPANCY OF THE MTA IN THE FALL OF 2003.

SUMMER 2004 ED BLACK AND MYSELF HAD THE FORCED FLOW TYPE ABSORBER CONSTRUCTED WITH A 1/16" THICK ALUMINUM WINDOW ON ONE SIDE AND A 1/4" PLEXIGLASS WINDOW ON THE OTHER. THE INSIDE CURVATURE OF THE WINDOW WAS DESIGNED IN ACCORDANCE WITH THE ACTUAL WINDOW DESIGN TO BE IMPLEMENTED. A PLUMBING SYST WAS CONSTRUCTED TO DELIVER HOT THEN COLD WATER TO THE ABSORBER. THE INTENTION IS TO STUDY THE HEAT FLOW OF THE WATER WITH AN INFRARED CAMERA. DUE TO DELAYS IN THE DELIVERY OF THE CORRECT COMBINATION OF WORKING CAMERA AND LENS FROM OUR SOURCE THE ACTUAL EXPERIMENT IS RESCHEDULED FOR LATER IN THE FALL OF 2004.

ACCELERATOR BEAM DYNAMICS (ERREDE, MAKINO, PAUL)

A MAJOR EMPHASIS OF THE UIUC GROUP IS WORK ON BEAM DYNAMICS BY MAKINO, ERREDE, AND PAUL, IN COLLABORATION WITH MARTIN BERZ AT MICHIGAN STATE UNIVERSITY AND CAROL JOHNSTONE AT FERMILAB. SIGNIFICANT WORK HAS BEEN DONE ON SIMULATIONS AND IMPROVEMENTS IN DESIGN OF MUON STORAGE RINGS, MUON COOLING RINGS, AND NOTABLY THE PRESENT EFFORT TOWARDS PROVIDING A WORKING OPTION TO THE EXISTING SOLENOID LINEAR COOLING CHANNEL DESIGN, THE LINEAR QUADRUPOLE COOLING CHANNEL. THE STUDY 2 SOLENOID FOCUSING COOLING CHANNEL HAS BEEN SIMULATED AND COMPARED WITH THE ALTERNATIVE QUADRUPOLE COOLER. THIS QUADRUPOLE CHANNEL HAS A 4M CELL CONSISTING OF THREE 205 MHZ RF CAVITIES, AND TWO PAIRS OF ALTERNATING FOCUSING AND DEFOCUSING QUADRUPOLE MAGNETS WITH A POLE TIP FIELD OF 1 TESLA AND A 35 CM LENGTH LIQUID HYDROGEN ABSORBER. THE CHANNEL HAS A MOMENTUM ACCEPTANCE OF 155-400 MEV/C AND INITIAL TESTS SHOW 65% TRANSMISSION.

MAKINO HAS ALSO CONTRIBUTED HER SIMULATION WORK TOWARD THE TETRA MUON RING COOLER DESIGNED BY VALERI BALBEKOV. THE RING INCLUDES EMITTANCE EXCHANGE CAPABILITY THROUGH THE USE OF WEDGE ABSORBERS, SOLENOID AND BENDING MAGNETS AND 205 MHZ RF CAVITIES. LIQUID HYDROGEN ABSORBERS PROVIDE TRANSVERSE EMITTANCE COOLING CAPABILITY

PAUL HAS DESIGNED A DECAY CHANNEL FOR THE UPSTREAM END OF A COOLING CHANNEL WITH 50% IMPROVEMENT IN TRANSMISSION. THE CHANNEL INCLUDES A 20T SOLENOID AND A MATCHING SECTION THAT ADIABATICALLY INCREASES THE RADIUS AND DECREASES THE FIELD KEEPING BR^2 CONSTANT TRANSFERRING THE CHARGED PIONS INTO A 1.5T SOLENOID DECAY CHANNEL. PAUL, WHEN HE STARTED WORKING FOR UIUC, DID A MULTIPLE SCATTERING CALCULATION FOR THE PROTON BEAM TRANSFERS BETWEEN THE MAIN INJECTOR AND THE RECYCLER. HIS CALCULATION HAS SHOWN THAT THE TITANIUM WINDOWS INCREASED THE EMITTANCE OF THE PROTON BEAM BY A FACTOR OF TWO, WHICH HAS SINCE BEEN OBSERVED IN THE TRANSFER LINES. HE ALSO CONTRIBUTED TO THE COSY INFINITY CODE DEVELOPMENT BY PRODUCING AN EFFICIENT RANDOM NUMBER GENERATOR FOR A GAUSSIAN PROBABILITY DISTRIBUTION. PAUL ALSO CONTRIBUTED TO AN AMERICAN PHYSICAL SOCIETY'S NEUTRINO STUDY FOR THE FUTURE OF NEUTRINO PHYSICS. INCLUDED ARE CALCULATIONS OF NEUTRINO FLUXES FROM A PARTICULAR U.S. NEUTRINO FACTORY DESIGN, (E.G. 2 MW PROTON DRIVER AND A CARBON TARGET), AND THE EVENT RATES IN A DETECTOR FROM THE STUDY. THE GROUP ALSO STUDIED FLUXES FROM A NEUTRON SPALLATION-LIKE TARGET. PAUL INTENDS TO DEVELOP A QUADRUPOLE PHASE ROTATION SCHEME TO BE IMPLEMENTED UPSTREAM OF A QUADRUPOLE COOLING CHANNEL, DESCRIBED PREVIOUSLY.

THE BEAM DYNAMICS GROUP HAS PRODUCED MANY PAPERS IN THE LAST TWO YEARS, BUT MOST RECENTLY HAS PRESENTED EIGHT TALKS AT THE ICAPO2 AND THE CPO-6 CONFERENCES. PAPERS ON THESE TALKS ARE PENDING, SOON TO BE MERGED INTO THE FULL PAPER DESCRIBING THE DESIGN AND VIABILITY OF THIS QUADRUPOLE CHANNEL. MAKINO AND BERZ ALSO ARE ENGAGED IN DEVELOPMENT OF BASIC BEAM DYNAMICS THEORY APPLICATIONS AND HAVE PRESENTED TALKS AND WRITTEN PAPERS ON THESE TOPICS, INCLUDING THE RELATIVE PERFORMANCE OF

THEIR OWN AND OTHER DYNAMIC INTEGRATOR SCHEMES.

MUCOOL COMPUTING FARM (LESNY, NELSON)

OUR GROUP (D. LESNY, L. NELSON) HAS ALSO DESIGNED, COMMISSIONED AND IMPLEMENTED A MUON COOLING CLUSTER CONSISTING OF 15 – 20 DUAL PENTIUM 3- AND 4-PROCESSOR MACHINES TO PROVIDE THE NECESSARY MUSCLE FOR LONG RANGE COMPUTING EFFORTS FOR NOT ONLY OUR GROUP BUT ALSO THE GREATER MUON COLLABORATION. FOR EXAMPLE, PRESENTLY FIELD DESIGN CALCULATIONS BY UNIVERSITY OF MISSISSIPPI, LHC MAGNET SIMULATIONS BY MICHIGAN STATE UNIVERSITY, AND UIUC DECAY CHANNEL SIMULATIONS ARE BEING DONE ON OUR CLUSTER. THE CLUSTER HAS 99.5% SYSTEM AVAILABILITY.

MUCOOL TEST AREA SHIELDING AND THE MICE EXPERIMENT (RAKHNO)

IGOR RAKHNO HAS CALCULATED RADIATION LEVELS AND SHIELDING REQUIREMENTS FOR THE MUCOOL TEST AREA. THIS IS DONE WITH 3D MONTE CARLO MODELING OF HIGH-ENERGY RADIATION TRANSPORT IN MATTER WITH MARS CODE.

THESE CALCULATIONS ARE NECESSARY FOR THE SHIELDING TO BE PROPERLY CONFIGURED BEFORE THE AREA IS SAFETY-CERTIFIED TO RECEIVE BEAM FROM THE LINAC. HE INVESTIGATED THE FOLLOWING PROBLEMS: A) PROPER CLASSIFICATION OF ALL THE AREAS AROUND THE MUCOOL TEST AREA AT NORMAL OPERATION ACCORDING TO RADIATION SAFETY REGULATIONS; B) AN ALTERNATIVE SHIELDING OPTION IN THE TARGET HALL TO AVOID EXTRA SHIELDING IN THE SERVICE BUILDING; C) THE HYPOTHETICAL WORST CASE EXPERIMENTAL SETUP IN THE TEST AREA (ACCORDING TO RADIATION SAFETY REGULATIONS, IT IS A MANDATORY STUDY).

ENHANCEMENTS TO THE MARS CODE WERE ADDED, INCLUDING THE CAPABILITY TO MODEL HEAVY ION STOPPING POWER. IT WAS SHOWN THAT THE BETHE-BLOCHE FORMULA WITH CORRECTIONS BY BARKAS AND LINDHARD-SORENSEN PROVIDES THE BEST AGREEMENT BETWEEN THEORY AND EXPERIMENT IN THE ENERGY RANGE 1 MEV/NUCLEON UP TO 1 TEV/NUCLEON FOR PROJECTILES RANGING FROM HELIUM UP TO THE URANIUM NUCLEI.

HE HAS ALSO SIMULATED HOW SENSITIVE THE MICE EMITTANCE MEASUREMENT IS TO CHANGES IN LIQUID HYDROGEN DENSITY TO GUIDE THE MICE DESIGN. THESE STUDIES ARE REQUIRED TO ASCERTAIN WHETHER MICE CAN MEET ITS PROPOSED PERFORMANCE OF

A 1-PER-MIL EMITTANCE MEASUREMENT, AND WHAT CONSTRAINTS ARE NECESSARY TO ASSURE THIS PERFORMANCE. HE HAS THE FOLLOWING PAPER IN PROGRESS:

RADIATION SHIELDING ISSUES FOR MUCOOL TEST AREA AT FERMILAB. RAKHNO,

C. JOHNSTONE. A SENSITIVITY STUDY FOR A MUCOOL LIQUID HYDROGEN ABSORBER.

D. ERREDE, I. RAKHNO. PHYSICS MODELS IN THE MARS15 CODE FOR ACCELERATOR AND

SPACE APPLICATIONS. N.V. MOKHOV, K.K. GUDIMA, S.G. MASHNIK, I.L. RAKHNO, A.J. SIERK, S.I. STRIGANOV.

MODELING OF HEAVY ION IONIZATION LOSS IN THE MARS15 CODE. I.L. RAKHNO, N.V. MOKHOV S.I. STRIGANOV.

BEAMLINE AND MAGNET DESIGN (BLACK)

BLACK HELPED DESIGN TWO BEAM PULSE MAGNETS TO BE INSTALLED IN THE MUCOOL TEST AREA AND INCURRED CHANGE IN EXISTING BEAM TRANSPORT EQUIPMENT. (BLACK WAS EMPLOYED SUMMER 2004 ONLY.)

UNDERGRADUATE PARTICIPATION (CRNKOVIC)

THE UIUC GROUP HAS TAKEN ON SEVERAL SUMMER STUDENTS. MOST RECENTLY (SUMMER 2003), JASON CRNKOVIC, THROUGH THE REU PROGRAM, PRODUCED RESULTS FROM THE TEMPERATURE DEVICE EXPERIMENT, FINDING THE SOURCE OF SEVERAL SYSTEMATIC ERRORS. STEPHANIE MAJEWSKI WORKED DURING SUMMER 2001 ANALYZING ABSORBER-WINDOW PRESSURE TESTS. LAUREN DUCAS MEASURED FIELD EMISSION FROM AN ACCELERATING CAVITY IN FERMILAB'S LAB G. MAJEWSKI WENT ON TO STANFORD UNIVERSITY FOR GRADUATE STUDY IN PHYSICS. DUCAS CONTINUES IN HER STUDY OF PHYSICS AS AN UNDERGRADUATE AT THE UNIVERSITY OF ILLINOIS.

A LIST OF UIUC PUBLICATIONS FOLLOWS:

RADIATION SHIELDING CALCULATIONS FOR MUCOOL TEST AREA AT FERMILAB.

RAKHNO, C. JOHNSTONE. FERMILAB-TM-2248 (2004).

TOWARDS A HEAVY-ION TRANSPORT CAPABILITY IN THE MARS15 CODE^{*)}. N.V.

MOKHOV, K.K. GUDIMA, S.G. MASHNIK, I.L. RAKHNO, S.I. STRIGANOV.
FERMILAB-CONF-04/052-AD.

RECENT ENHANCEMENTS TO THE MARSIS CODE^{*)}. N.V. MOKHOV, K.K. GUDIMA,
C.C. JAMES, M.A. KOSTIN, S.G. MASHNIK, E. NG, J.-F. OSTIGUY, I.L. RAKHNO,
A.J. SIERK, S.I. STRIGANOV. FERMILAB-CONF-04/053-AD.

MODELING RADIATION LOADS TO DETECTORS IN A SNAP MISSION^{*)}. N.V. MOKHOV,
I.L. RAKHNO, S.I. STRIGANOV, T.J. PETERSON.

^{*)}PRESENTED PAPERS AT THE 10TH INTERNATIONAL CONFERENCE ON RADIATION
SHIELDING, FUNCHAL (MADEIRA), PORTUGAL, MAY 9-14, 2004. THE PAPERS ARE ACCEPTED
FOR PUBLICATION IN THE JOURNAL RADIATION PROTECTION DOSIMETRY (UK) IN 2005.

K. MAKINO, M. BERZ, D. ERREDE, AND C. J. JOHNSTONE.
HIGH ORDER MAP TREATMENT OF SUPERIMPOSED CAVITIES, ABSORBERS, AND
MAGNETIC MULTIPOLE AND SOLENOID FIELDS.
NUCLEAR INSTRUMENTS AND METHODS, SUBMITTED.

D. ERREDE, M BERZ, C. J. JOHNSTONE, K. MAKINO, AND A. VAN GINNEKEN.
STOCHASTIC PROCESSES IN MUON IONIZATION COOLING.
NUCLEAR INSTRUMENTS AND METHODS, SUBMITTED.

C. J. JOHNSTONE, M. BERZ, D. ERREDE, AND K. MAKINO.
MUON BEAM IONIZATION COOLING IN A LINEAR QUADRUPOLE CHANNEL.
NUCLEAR INSTRUMENTS AND METHODS, SUBMITTED.

M. BERZ AND K. MAKINO.
NEW APPROACHES FOR THE VALIDATION OF TRANSFER MAPS USING
REMAINDER-ENHANCED DIFFERENTIAL ALGEBRA.
NUCLEAR INSTRUMENTS AND METHODS, SUBMITTED.

K. MAKINO AND M. BERZ.
SOLENOID ELEMENTS IN COSY INFINITY.
IN 7TH INTERNATIONAL COMPUTATIONAL ACCELERATOR PHYSICS CONFERENCE,
SUBMITTED.

C. O. MAIDANA, M. BERZ, AND K. MAKINO.
MUON BEAM RING COOLER SIMULATIONS USING COSY INFINITY.
IN 7TH INTERNATIONAL COMPUTATIONAL ACCELERATOR PHYSICS CONFERENCE,
SUBMITTED.

N. REVOL, K. MAKINO, AND M. BERZ.

TAYLOR MODELS AND FLOATING-POINT ARITHMETIC: PROOF THAT ARITHMETIC OPERATIONS ARE VALIDATED IN COSY. SUBMITTED.

M. M. ALSHARO'A ET AL.

RECENT PROGRESS IN NEUTRINO FACTORY AND MUON COLLIDER RESEARCH WITHIN THE MUON COLLABORATION.

PHYSICAL REVIEW ST-AB, IN PRINT, 2003.

K. MAKINO AND M. BERZ.

VERIFIED GLOBAL OPTIMIZATION WITH TAYLOR MODEL METHODS.

INTERNATIONAL JOURNAL OF COMPUTER RESEARCH,
IN PRINT, 2003, SUBMITTED, 2000.

M. BERZ AND K. MAKINO.

CONSTRUCTIVE GENERATION AND VERIFICATION OF LYAPUNOV FUNCTIONS AROUND FIXED POINTS OF NONLINEAR DYNAMICAL SYSTEMS.

INTERNATIONAL JOURNAL OF COMPUTER RESEARCH,
IN PRINT, 2003, SUBMITTED, 2000.

K. MAKINO AND M. BERZ.

TAYLOR MODELS AND OTHER VALIDATED FUNCTIONAL INCLUSION METHODS.

INTERNATIONAL JOURNAL OF PURE AND APPLIED MATHEMATICS,
4,4:379--456, 2003.

K. MAKINO.

THE COSY 8TH ORDER RUNGE KUTTA INTEGRATOR.

NEUTRINO FACTORY MUON COLLIDER NOTE 238, 2002.

K. MAKINO, D. ERREDE AND M. BERZ.

COOLING CHANNEL SIMULATIONS BASED ON MAP METHODS.

IN PROCEEDINGS OF
THE FUTURE OF PARTICLE PHYSICS, SNOWMASS 2001. 2002.

K. MAKINO AND M. BERZ.

RECENT APPLICATIONS OF COSY TO NONLINEAR BEAM DYNAMICS PROBLEMS.

IN PROCEEDINGS OF
THE FUTURE OF PARTICLE PHYSICS, SNOWMASS 2001. 2002.

M. BERZ AND K. MAKINO.

NORMAL FORM METHODS AND OPTIMIZATION FOR NONLINEAR PROPERTIES OF COOLING CHANNELS - PART I.

IN PROCEEDINGS OF
THE FUTURE OF PARTICLE PHYSICS, SNOWMASS 2001. 2002.

M. BERZ AND K. MAKINO.

NORMAL FORM METHODS AND OPTIMIZATION FOR NONLINEAR PROPERTIES
OF COOLING CHANNELS - PART II.
IN PROCEEDINGS OF
THE FUTURE OF PARTICLE PHYSICS, SNOWMASS 2001. 2002.

M. BERZ AND K. MAKINO.
RECENT ADVANCES IN DIFFERENTIAL ALGEBRAIC METHODS.
IN PROCEEDINGS OF
THE FUTURE OF PARTICLE PHYSICS, SNOWMASS 2001. 2002.

K. MAKINO AND M. BERZ.
HIGH-ORDER FLOWS AROUND FIXED POINTS AND VERIFICATION OF
STABILITY OF LOCAL DYNAMICS WITH APPLICATIONS TO PARTICLE ACCELERATORS.
COMPLEXITY. ACCEPTED, 2002.

K. MAKINO, B. ERDELYI AND M. BERZ.
MAGNET FRINGE FIELDS, NONLINEAR EFFECTS,
AND COMPENSATION IN LARGE ACCEPTANCE RINGS.
IN PROCEEDINGS OF
2001 PARTICLE ACCELERATOR CONFERENCE. 2001.

K. MAKINO, C.J. JOHNSTONE, M. BERZ, B. ERDELYI, D. ERREDE.
CONTRIBUTION TO THE CHAPTER ON THE STORAGE RING, IN
FEASIBILITY STUDY-II OF A MUON-BASED NEUTRINO SOURCE,
ED., S. OZAKI, R. PALMER, M. ZISMAN, AND J. GALLARDO, BNL-52623. 2001.

K. MAKINO AND M. BERZ.
MAP-BASED MUON COOLING CHANNEL SIMULATIONS WITH COSY INFINITY.
IN PROCEEDINGS OF
6-MONTH FEASIBILITY STUDY ON HIGH ENERGY MUON COLLIDERS (ED. B. KING),
[HTTP://PUBWEB.BNL.GOV/PEOPLE/BKING/MUCOLL/INDEX.HTML](http://pubweb.bnl.gov/people/bking/mucoll/index.html) , 2001.

TALKS (MAKINO ONLY)

OCTOBER 23, 2002.
``COSY INFINITY'',
CPO-6, 2002 INTERNATIONAL CHARGED PARTICLE OPTICS CONFERENCE,
%UNIVERSITY OF MARYLAND,
GREENBELT, MARYLAND, OCTOBER 22 - 25, 2002. CODE DEMONSTRATION PRESENTED.

OCTOBER 23, 2002.

``HIGH ORDER MAP TREATMENT OF CAVITIES AND ABSORBERS WITH SUPERIMPOSED SOLENOIDAL FIELDS'',
CPO-6, 2002 INTERNATIONAL CHARGED PARTICLE OPTICS CONFERENCE,
%UNIVERSITY OF MARYLAND,
GREENBELT, MARYLAND, OCTOBER 22 - 25, 2002.

OCTOBER 17, 2002.

``NEW SOLENOID ELEMENTS IN COSY INFINITY'',
7TH INTERNATIONAL COMPUTATIONAL ACCELERATOR PHYSICS CONFERENCE,
MICHIGAN STATE UNIVERSITY, EAST LANSING, MICHIGAN, OCTOBER 15 - 18, 2002.

MAY 31, 2002.

``TAYLOR MODELS - HAND CALCULATION FOR A LINEAR ODE SYSTEM'',
FIELDS INSTITUTE, THEMATIC PROGRAMS,
NUMERICAL AND COMPUTATIONAL CHALLENGES IN SCIENCE AND ENGINEERING,
VALIDATED METHODS FOR OPTIMIZATION,
TORONTO, CANADA, MAY 27 - JUNE 1, 2002.

MAY 29, 2002.

``TAYLOR MODELS - ORDER OF CONVERGENCE, THE LINEAR DOMINATED BOUNDER'',
FIELDS INSTITUTE, THEMATIC PROGRAMS,
NUMERICAL AND COMPUTATIONAL CHALLENGES IN SCIENCE AND ENGINEERING,
VALIDATED METHODS FOR OPTIMIZATION,
TORONTO, CANADA, MAY 27 - JUNE 1, 2002.

MAY 28, 2002.

``TAYLOR MODELS - ROUND OFF'',
FIELDS INSTITUTE, THEMATIC PROGRAMS,
NUMERICAL AND COMPUTATIONAL CHALLENGES IN SCIENCE AND ENGINEERING,
VALIDATED METHODS FOR OPTIMIZATION,
TORONTO, CANADA, MAY 27 - JUNE 1, 2002.

MAY 23, 2002.

``TAYLOR MODEL BASED VERIFIED INTEGRATION FOR THE VOLTERRA EQUATIONS AND THE LORENZ SYSTEM'',
SIAM WORKSHOP ON VALIDATED COMPUTING,
TORONTO, CANADA, MAY 23-25, 2002. HIGHLIGHTED TALK.
(PRESENTED BY M. BERZ.)

MAY 21, 2002.

``TIGHT RANGE ENCLOSURES WITH TAYLOR MODEL METHODS'',
SIAM CONFERENCE ON OPTIMIZATION,
TORONTO, CANADA, MAY 20-22, 2002.
(PRESENTED BY M. BERZ.)

MAY 13, 2002.

``NONLINEAR EFFECTS IN QUADRUPOLE COOLING CHANNELS'',
NEUTRINO FACTORY AND MUON COLLIDER COLLABORATION MEETING,
SHELTER ISLAND, NEW YORK, MAY 9-15, 2002.

MARCH 8, 2002.
``COSY SIMULATION CODE'',
RING COOLER WORKSHOP,
UCLA, LOS ANGELES, CALIFORNIA, MARCH 7-8, 2002.

MARCH 7, 2002.
``LINEAR/NONLINEAR COOLING THEORY'',
(PRESENTED FOR M. BERZ),
RING COOLER WORKSHOP,
UCLA, LOS ANGELES, CALIFORNIA, MARCH 7-8, 2002.

OCTOBER 10, 2001.
``COOLING CHANNEL SIMULATION BY COSY INFINITY'',
EMITTANCE EXCHNAGE WORKSHOP,
LAWRENCE BERKELEY NATIONAL LABORATORY, BERKELEY, CALIFORNIA, OCTOBER 3-16, 2001.

OCTOBER 9, 2001.
``QUAD COOLING CHANNEL SIMULATION'',
EMITTANCE EXCHNAGE WORKSHOP,
LAWRENCE BERKELEY NATIONAL LABORATORY, BERKELEY, CALIFORNIA, OCTOBER 3-16, 2001.

SEPTEMBER 14, 2001.
``DEPENDENCY FREE RANGE BOUNDING'',
FIELDS INSTITUTE, THEMATIC PROGRAMS,
NUMERICAL AND COMPUTATIONAL CHALLENGES IN SCIENCE AND ENGINEERING,
VALIDATED METHODS FOR ODES AND DAES,
TORONTO, CANADA, SEPTEMBER 10-14, 2001.

SEPTEMBER 13, 2001.
``VERIFIED INTEGRATION WITH TAYLOR MODELS - NONLINEAR EXAMPLES'',
FIELDS INSTITUTE, THEMATIC PROGRAMS,
NUMERICAL AND COMPUTATIONAL CHALLENGES IN SCIENCE AND ENGINEERING,
VALIDATED METHODS FOR ODES AND DAES,
TORONTO, CANADA, SEPTEMBER 10-14, 2001.

SEPTEMBER 11, 2001.
``VALIDATED ODE INTEGRATION OF TAYLOR MODELS AND EXAMPLES'',
FIELDS INSTITUTE, THEMATIC PROGRAMS,
NUMERICAL AND COMPUTATIONAL CHALLENGES IN SCIENCE AND ENGINEERING,
VALIDATED METHODS FOR ODES AND DAES,
TORONTO, CANADA, SEPTEMBER 10-14, 2001.

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