

Report of the Workshop “Step Forward to FRIB”
Argonne National Laboratory
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for

The FRIB Users Community

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Executive Summary

The workshop “Step Forward to FRIB” was held at Argonne National Laboratory on May 30-31, 2009. It had a goal of engaging the potential user community of the Facility for Rare Isotope Beams (FRIB) and involving them in the processes that will lead to the actual facility that will be built. This workshop required some education of the community about the facility proposed by MSU, required the reaffirmation of the key physics goals, started the process of more clearly defining the facility requirements, equipment and workforce, and developing a framework for user involvement. The users chose this forum to officially modify their charter and evolve from the broad advocacy group, the RIA Users Organization, to the more specific FRIB Users Organization.

The workshop was organized on short notice, but was well attended with more than 210 people participating, from more than 47 institutions, and we had contributions from about 50 other people who could not attend. The work was intense, with breakout groups strenuously attempting the difficult task of setting priorities. In most areas, this workshop was seen as a beginning. The need for a series of smaller, focused workshops was clear, especially focused on development of specific pieces of equipment.

In a final plenary session a series of key findings were developed. Most importantly, the community remains excited by the prospects for science at FRIB and having a world-leading Low Energy nuclear research facility in the USA. After many delays, the entire community wants to move forward as quickly as possible. The need for early development of higher energy reaccelerated beams to >10 MeV/u for all beam species, through the ReA12 project, was seen as critical. The need to retain the option for ISOL capability, and for energy upgrading of the driver linac to 400 MeV/u were also seen as very important for the base design. Finally, the critical need to start growing the research community at all levels including students, technical experts, and research scientists, is seen as a central component for achieving the science goals when FRIB comes online.

Motivation for the Workshop

The construction of the Facility for Rare Isotope Beams (FRIB) will start a new era for nuclear physics research in the United States. The Rare Isotope Accelerator (RIA) Users Executive Committee and Michigan State University (MSU) staff worked together to organize a workshop to help chart the new path towards FRIB operation expected in ~2017. Several immediate goals were apparent: to educate the prospective user community about the proposed facility, to begin to integrate the community into the facility planning process, to identify how the community could interact with new management structures most effectively, and to hear users concerns about the path forward. The workshop could serve as a forum to amend the charter of the RIA Users Organization and become the FRIB Users Organization. Choosing Argonne National Laboratory as the host laboratory appeared to be a good opportunity for restoring harmony after the difficult FOA site selection process. Choosing a date at the end of May, immediately following the international RNB8 conference, and before the COMEX conference appeared to be least disruptive for users and offered travel advantages for many potential participants. Thus, many of the parameters were established for the workshop and the organization of the meeting could begin.

The workshop was organized by the RIA Users Executive Committee in a series of telephone conference calls. The goal was to have a no-registration-fee workshop in order to maximize participation. To facilitate this aim, Argonne National Laboratory and the National Superconducting Cyclotron Laboratory (NSCL) at MSU provided equal funding. Oak Ridge Associated Universities were very helpful in establishing and amending the workshop web-site.

Workshop Goals

<http://www.orau.org/ria/frib-workshop09/goals.htm>

There was considerable discussion about the scope and objectives for the workshop. The following issues were selected and posted on the conference website. There was emphasis that the issues need community involvement, as there were no “right” answers and the time for setting priorities was approaching. The key issues were:

- Present the user community with details of the current FRIB design as proposed by MSU to DOE during the FOA process.
- Discuss the immediate scientific goals and how we can achieve them as rapidly as possible. This involves prioritization of resources and effort. Some projects may be achieved before FRIB is running, given suitable equipment development.
- Discuss the proposed capabilities and design of FRIB and evaluate if it matches the scientific needs. This also involves prioritization of resources and effort.
- Discuss and prioritize additional capabilities that are not in the current design.
- Discuss the development of the FRIB Users group and how they can most efficiently be involved in the path forward. A new charter will be needed, and a formal structure for interacting with FRIB management.

Organization

To facilitate transportation from the RNB8 conference in Grand Rapids and to the subsequent conferences in Mackinac Island (COMEX) and Ann Arbor (Weak Interactions), the workshop was held from Saturday afternoon May 30 until the end of Sunday May 31. Transportation was arranged between these meetings to facilitate user participation. The limited timeframe demanded an efficient schedule, with all catering arranged near the conference center. The conference was held in the Advanced Photon Source (Building 401 at ANL) as this could accommodate a significant number of people in parallel breakout sessions.

The Saturday evening session had two components. Firstly, there was a review the science opportunities presented by FRIB (Gelbke), followed by a technical presentation of the proposed facility (Glasmacher). Secondly, there was a RIA business meeting to propose changes to the RIA Users Group charter.

The Sunday sessions were organized as parallel breakout groups. In the morning, science opportunities were discussed. In the afternoon, facility capabilities and equipment were discussed. There were plenary sessions to combine ideas, have open discussion, and arrive at final conclusions. Appendix A has the full schedule of events.

RIA Users Organization Charter

On May 30, 2009 the charter was altered from being the RIA Users Organization to being the FRIB Users Organization. The amended charter is given in Appendix B. Beyond directly supporting FRIB at MSU, a broader mandate was adopted, especially for the pre-FRIB era, in which advocacy for rare-isotope science in general is part of the mission.

Attendance Analysis

The workshop had 210 registered participant scientists. They came from 11 countries and represented 47 different institutions. From the USA, 28 universities were represented and 6 national laboratories. 53% of the participants were from USA universities, 36% from USA national laboratories and 11% from overseas institutions. The full list of registrants is in Appendix C.

It is clear that we will have to be energetic in actively developing our community as the FRIB project evolves. This process takes time and needs to start now. Age, gender and diversity are all causes for concern for the time when FRIB is fully operational. There will be a generation turnover in the scientists leading the project forward between now and 2020. Compared to society as a whole, and even compared to other areas of physics, our nuclear field has fewer women scientists and minorities than in similar disciplines.

Budget

The approximate budget for the workshop was about \$20,000 which was split equally between Argonne National Laboratory and Michigan State University. There was no conference fee. The dominant cost for the workshop was for catering: in order to keep participants together and working, all meals, including dinner on the first day, breakfast and lunch on the second day, and coffee breaks were all provided. Smaller items included funding transportation to and from other meetings (including vans from RNB8) and for technical support for the audio-visual equipment used at the APS.

Acknowledgements

The workshop involved close collaboration between Argonne National Laboratory and Michigan State University. Robert Janssens and Brad Sherrill played decisive roles in the funding arrangements. The FRIB Users Executive Committee had many meetings to refine the workshop plan and program. However, the workshop secretaries, Barbara Weller and Jeannie Glover, carried the brunt of detailed organizational work, especially in the travel, gate-pass, meals and accommodation areas, and deserve very high praise for their commitment to make this workshop both successful and happy.

The Sunday Breakout Sessions

Brad Sherrill opened the breakout sessions with a brief introduction. He offered a charge to participants from the FRIB User Executive Committee:

“Identify the most compelling science that should be pursued prior to FRIB and in the earliest phases of operation.”

- Clear priorities from the user community will guide FRIB planning and development.
- Common science goals will guide the formation of equipment collaborations.

Morning Breakout Sessions (Physics Drivers)

A) Nuclear Astrophysics (Convenors: Blackmon/Nollett/Schatz) [30 Participants]

The working group identified five goals:

- To reaffirm the science case for nuclear astrophysics at FRIB.
- Create awareness in the community of ongoing equipment development projects and existing ideas for FRIB equipment to create opportunities to broaden existing collaborations and trigger the formation of new ones.
- Discuss and prioritize equipment needs for a FRIB nuclear astrophysics program.
- Discuss facility requirements for FRIB nuclear astrophysics program.
- Discuss the organization of a nuclear astrophysics users group.

The program consisted of a set of short oral presentations (10 min) with interspersed discussion, and a discussion period at the end. Ten presentations encapsulated the key thrusts of the proposed research programs.

The main findings were:

- The science case for a nuclear astrophysics program with radioactive beams was reaffirmed, noting that rapid progress in astronomy and astrophysics often drives the need for new nuclear physics input for our astrophysics simulations. Close interaction between nuclear physics and astrophysics during development and execution of the science program is therefore required.
- The highest equipment priority for the FRIB nuclear astrophysics program is a dedicated nuclear astrophysics recoil separator optimized for the direct measurement of charged particle capture reactions at astrophysical energies.
- A critical facility requirement for the nuclear astrophysics program is the delivery of high intensity ($>10^8$ pps), low energy (<3 MeV/u), high quality reaccelerated beams of rare isotopes often near stability. This capability is essential for a program of direct cross section measurements with a recoil separator.
- In addition, the nuclear astrophysics program will take advantage of the fast, stopped, and reaccelerated beams provided at FRIB using a wide range of dedicated equipment, as well as equipment that is shared with the nuclear structure and reaction programs. While some of this equipment was presented at the workshop, this is clearly not an exhaustive list. Some equipment is already funded, but other important pieces are still in the conceptual or proposal stage. While there is some overlap of requirements for nuclear astrophysics experiments and nuclear physics experiments, in many cases there are significant differences. It will be important for nuclear astrophysicists to be engaged in these other equipment projects. In that respect a concern was raised about running the astrophysics working group in parallel to other equipment relevant working groups. This should be addressed in future workshops.
- The group agreed to form a nuclear astrophysics user group at FRIB that includes a broad range of experimentalists interested in various FRIB experiments, as well as theorists working at the interface of nuclear physics and astrophysics.

B) Fundamental Interactions (Convenors: Chupp/Lu) [30 participants]

The group directly addressed the most compelling science issues that should be pursued prior to FRIB and in the earliest phases of operation:

- Electric Dipole Moment measurements, parity violation
- Beta decay angular correlations for physics beyond the Standard Model
- Isospin symmetry breaking (to investigate V_{ud} and structure)

The group identified the key facility requirements of FRIB needed to reach these scientific goals:

- The need for ISOL beams (Intense Fr, Rn, Ra) AND gas-stopped beams (Na, Ne, K...), and at least ~8-9 experimental end stations
- Space, need 4500 ft² > expected low energy area (3100 ft²), with long-term access for calibration and equipment development
- A stable beam source for equipment development
- Laser laboratories and other “off-line” space for equipment development
- A well controlled laboratory environment for precision measurements (including temperature, vibration, mechanical cleanliness, low magnetic fields, very clean power)

The group tried to identify the equipment and workforce resources needed to achieve FRIB goals:

- Lasers
- Beta spectrometers (high field, high resolution, beta and particle)
- Atom and Ion traps
- Tape station and detector array
- Beta NMR
- Collinear laser spectrometry

Above all, there is a pressing need for more resources to attract young scientists into the field and develop the skills of strong technical support personnel.

C) Applications/Surrogates (Convenors: Beausang/Cizewski) [15 Participants]

This session was charged to examine the broad range of applications of nuclear science that could be realized at FRIB, and in particular the development of surrogates for neutron-induced reactions. Most of the participants had primary research interests in basic nuclear science. Therefore, input for this session was also solicited from individuals outside of the nuclear science community.

Dennis McNabb (LLNL) set the context for this session with a broad overview of the applications important for nuclear energy, counter proliferation, stockpile stewardship and health and medicine, and the nuclear science research and technology needed to address these national needs.

A consensus recommendation was the need to harvest rare isotopes for both basic and applied research. Brad Sherrill (MSU) presented an overview of where isotope harvesting could occur at FRIB. The breakout group recommended writing a white paper to develop the case for harvesting isotopes, which is key to many applications as well as basic research. This white paper would outline the science case (what to do with isotopes), the facility requirements (including hot cells and stopped beams), and the need to energize the radiochemistry workforce. Mark Stoyer (LLNL) and Brad Sherrill (MSU) agreed to play a leadership role in developing this white paper, which would also require active participation from all stakeholders, including those in the medical isotope R&D community.

The breakout group also recognized that heavy actinide beams, such as Cf, could be important for both basic and applied nuclear sciences. Again, the group recommended that a white paper be developed that would outline the science case (fission reactions, harvested isotopes, heavy element structure, applications) and the facility requirements and challenges. Dennis McNabb (LLNL) agreed to be the applications co-convenor for this white paper; another co-convenor should come from the basic nuclear science community.

Neutron-induced reactions, in particular neutron capture (n,γ), are important for nuclear astrophysics (s and r process nucleosynthesis), nuclear energy, and stockpile stewardship. Dennis McNabb (LLNL) and David Vieira (LANL) were willing to lead the efforts from the nuclear security community to examine the prospects for a neutron generator on site at FRIB which could capitalize on the availability of harvested isotopes. Since such a facility could also provide data needed for nuclear astrophysics and other applications, additional participants from these communities would be needed to develop the case for such a facility.

However, direct measurements of neutron-induced reactions are only possible on relatively long-lived rare isotopes; currently limits are $t_{1/2} > 100$ days. Given the importance of neutron-induced reactions on short-lived isotopes, such as (n,γ) for r -process nucleosynthesis or (n,f) for nuclear forensics, there has been considerable effort in recent years to develop and validate effective surrogates for neutron-induced reactions. Darren Bleuel (LLNL) summarized the status of these efforts with light-ion beams on heavy stable targets. William Peters (Rutgers) outlined the current and near term efforts to develop the techniques for surrogate reactions in inverse kinematics, needed for such studies with very short-lived isotopes. Equipment needed include particle-gamma-recoil coincidences (with high energy and angular resolution particle and gamma detector arrays), hydrogenic or helium targets (that are thin, robust, compact, and possibly active), and possibly the capability to measure total spectrum of particles and gammas. Beam requirements include ≈ 10 MeV/u beams (consistent with the recommendation of an early implementation of ReA12) and possibly actinide beams, as well as lighter species.

Nuclear energy is another area important for national needs where FRIB could provide needed data. The case was presented by Chris Chiara and Filip Kondev (ANL) for a Total Absorption Gamma Spectrometer (TAGS) that would be coupled to a moving tape collector for nuclear decay heat measurements.

FRIB can also contribute to basic physics outside of nuclear science. Although Rob Kiefl (TRIUMF) was unable to attend the meeting, he shared with Jolie Cizewski (Rutgers) how beta-NMR with rare isotopes can be used to probe interfaces in materials at a well-resolved depth. The goal would be to reproduce the facility currently at ISAC, including a team of at least 3 scientists with expertise in materials science, UHV cryogenics, beam transport, lasers, and NMR/NQR spectrometers. With an investment of about \$5M and a commitment for about 20 weeks of beam time per year, parasitic with basic nuclear science experiments, such a facility would have a very high potential for discovery in materials science.

In summary, the participants in the applications session shared a broad range of applied and basic research interests and a commitment to develop the case for new tools, techniques, and areas of study. Central was the need to harvest isotopes at FRIB. Equipment priorities emphasized

ReA12 as soon as possible, as well as high efficiency, highly segmented arrays of gamma and charged particle detectors; target development (cryo/gas/active); TAGS; and possibly a neutron generator. To realize this research will require a diverse workforce excited about the challenges and opportunities and committed to making the case, developing new tools, and realizing the science.

D) Nuclear Structure (Convenors: Gade/Galindo-Uribarri/Lee) [70 participants]

In the Nuclear Structure Session, 15 speakers summarized about 40 contributions. A mini-talk format allowed participation from a broad spectrum of members of the nuclear physics community and reflected a high degree of cooperation among them. The session concluded with an open discussion. A wide variety of nuclear structure topics was covered, broadly summarized by the following list:

- Evolution of nuclear shell structure
- Moments, radii, lifetimes and shapes
- Driplines, weakly-bound nuclei, halos and skins
- New collective modes
- Properties of heavy elements
- Connection to astrophysics and nuclear reactions

Reoccurring approaches to tackle the physics questions were, in general, the study of key nuclei in the proximity of magic or not-so-magic numbers and systematic measurements along chains of isotopes and isotones. Fast, stopped and reaccelerated beams emerged as absolutely necessary to address the wealth of nuclear structure topics with different experimental approaches.

The whole spectrum of experimental techniques proposed to extract the observables of interest included interaction cross section measurements, measurements of charge radii (laser spectroscopy), measurements of electromagnetic moments and transition strength, excited-state g-factor measurements, decay studies and determination of weak interaction strength, in-beam spectroscopy with gamma and/or light-particle detection, conversion electron spectroscopy, particle-gamma coincidence spectroscopy, implantation-decay correlation measurements, mass measurements of bound and unbound systems, and the characterization of single-particle properties as well as collective observables.

These techniques employ the whole spectrum of nuclear reactions, including fragmentation, elastic and inelastic scattering, nucleon knockout reactions, charge-exchange reactions, one and two nucleon transfer, deep-inelastic reactions with multi-nucleon transfer, fusion evaporation, incomplete fusion, and sub-barrier, intermediate-energy and unsafe Coulomb excitation.

These measurements often require gamma-ray spectroscopy and existing and future devices mentioned were GRETINA/GRETA and digital Gammasphere gamma arrays for high-resolution studies, and scintillator arrays like CsI(Na) arrays and the BaF₂ array for high efficiency studies and for high energy gamma rays. For decay spectroscopy a high efficiency α - β - γ -e decay station was highlighted as very important, and also the need for several arrays for the detection of fast and slow neutrons. The importance of the recoil detection, identification and tracking of

products in reactions was pointed out for all energy regimes, requiring mass separators for experiments with reaccelerated beams and spectrographs like the S800 and the Sweeper Magnet at high energies. “Non-magnetic” recoil detectors, which also have an important role in stand-alone mode, were pointed out, e.g. Si detectors, PPACs, phoswich detectors and diamond detectors. Charge-particle detection is mandatory for many proposed measurements, employing detection systems like Microball, HyBall, Bambino, Chico and their successors. Advanced target systems, like active targets and time projection chambers, polarized targets, gas, liquid and cryogenic targets and plunger devices were stated as a need. Especially for low-energy transfer reactions, HELIOS was mentioned as an advanced detection system. For fast-beam experiment, the need for high-rate tracking detectors was voiced.

Participants particularly highlighted the need for GRETA and CERDA for future gamma-ray and decay spectroscopy, stressed the importance of mass separators, spectrographs and recoil detectors optimized for reaccelerated-beam and fast-beam experiments as well as an early implementation of ReA12 at NSCL.

Points for thoughts were brought up in the end, including the possibility of multi-user capability and ISOL, prioritization and formation of collaborations and the particular need of some experimental programs for very long beam times, e.g. the study of giant resonances might require measurements with >60 shifts, the spectroscopy of heavy elements might need >30 shifts.

Clearly, nuclear structure with radioactive beams is one of the keystones of the FRIB research program. There is ample motivation on the enhanced physics opportunities that FRIB will provide and there is a need to continue future discussions of these topics keeping the "momentum" shown in this meeting and moving forward with new initiatives.

E) Nuclear Reactions (Convenors: Jones/Thompson/Wuosmaa) [35 Participants]

Nuclear reaction studies span a vast range of topics and have strong overlap with most other research areas. Reactions are a tool to probe the quantum structure of nuclei and to investigate the bulk properties of nuclear matter. They are the core of understanding energy production in nuclear astrophysics. However, the field can be subdivided into four broad themes:

- Transfer reactions
 - Probing changes in shell structure via single-particle information
 - Going to unbound (open) systems
 - Astrophysics

- Fusion/fission
 - Spectroscopy of heavy nuclei
 - Chemistry
 - Understanding the production and survival of Super Heavy Elements

- Equation of state
 - Isospin dependence of the Equation of State (EOS)
 - Probing neutron/proton effective masses
 - New probes (pion production)

- Reaction theory
 - Improved reaction theory for heavier ion reactions including continuum
 - Connecting reaction and structure theory

 - Joining many-body interior to periphery
 - Scattering experiments required for improved optical potentials

Each of these topics currently has a good basis of understanding developed from research with reactions on stable nuclei. FRIB opens the possibility of extending these powerful techniques to exotic nuclei. However, the experiments have to be performed on the beam particles, i.e., in “inverse kinematics”, so new experimental tools need to be developed. Additionally, as many of the most interesting beams have low intensity, much more efficient experiments have to be developed. Thus, although the working group was focused on physics goals, the issues of experimental technology were identified as critically important. For reaction studies the quality of the accelerator beam is of paramount importance.

Some key experimental issues were:

- Magnetic spectrometers (ISLA {Time of Flight}, Recoil Tagging, HELIOS {solenoidal}, Gas Filled Separator/Solenoid for Heavy Elements)
- Silicon detector arrays, backward (SIDAR), forward (MUST, HiRA), close to 90 (ORRUBA)
- Gammas in coincidence with transfer reactions
- Focal Plane systems for spectrometers (Channel Plates, Ion Chambers, Silicon, Hybrids)
- Active targets/Time Projection Chambers
- Neutron detectors: both discrete for low energy neutrons and Neutron TOF walls for breakup research
- Radiochemical Techniques (for long lifetimes)
- Charged particle arrays for “hot nuclear” investigations
- Multiplicity counters
- Windowless gas targets

And some other key issues were discussed:

- ReA12 upgrade is of crucial importance to allow direct reactions on exotic nuclei.
- Pure beams are crucial for many experiments, especially in fusion/fission studies.
- ISOL beams are probably better than reaccelerated fragmentation beams for many fusion and heavy element studies (an intensity issue).

- Development of a well trained community (both in reaction theory groups and in experimental teams)
- Resources for theorists

Some open issues which need further study were:

- Defining the needed beam intensities for various projects: what can really be achieved with (10^3 , 10^6 , 10^9).
- Good emittance is crucial for most experiments and needs quantifying.
- Trojan horse methods are very important but need understanding better.
- Higher beam energies for reaccelerated beams (~ 20 MeV/u) are desirable to allow the possibility of Equation Of State (EOS) measurements at 2 times normal nuclear densities.

F) Nuclear Theory (Convenors: Ormand/Volya) [13 participants]

The key compelling issues for the low energy theory community are focused on a comprehensive and unified microscopic description of the structure of all nuclei and their low-energy reactions from the basic interactions between the constituent protons and neutrons. The unified approach is centered on building bridges to allow the development of a consistent understanding that spans from quarks to neutron stars.

The roadmap to achieve this goal is well documented, for example in the RIA Theory Group Blue Book, the 2007 NSAC Long Range Plan for Nuclear Physics, and the National Academy RISAC report.

Some specific nuclear structure questions that were discussed include:

- How does the NN and NNN interaction emerge from QCD? How do NNN correlations affect the structure of heavy nuclei?
- What are the limits of stability? (including angular momentum, isospin, mass and charge)
- How does shell structure evolve with neutron number?
- How do simple symmetries arise in complex systems?
- Can we describe large-amplitude collective motion? (And can we have a predictive theory for fission for understanding the r -process and Advanced Fuel Cycles?)
- What is the microscopic underpinning of emergent phenomena?
- How do nuclei react with each other? (Can we describe some reactions from first principles)? Can we develop a comprehensive theory of direct reactions? What is the impact of the continuum on nuclear properties?
- What is the EOS of neutron matter?
- What can nuclei tell us about other small systems (cold trapped atoms, pairing, quantum dots, phase transitions)?

Afternoon Breakout Sessions (Facility, Workforce and Equipment)

The charge for the afternoon sessions was based on more practical issues identifying what is needed to achieve the science goals of FRIB. This encompassed both the actual accelerator facility (energy, intensity, emittance, purity) and other issues which are essential for success (equipment, floor space, computing, workforce, etc).

A) Stopped Beam Requirements (Mantica/Savard) [26 participants]

The stop beam area will be used for a wide variety of physics. The working group identified the most promising anticipated areas of research:

- Nuclear Structure
 - Beta decay studies
 - Nuclear moments and charge radii
 - Masses for mass surface analysis
- Astrophysics
 - Masses and decay properties
- Fundamental Interactions and Precision Measurements
 - EDM, parity violation
 - Beta decay angular correlations
 - Isospin symmetry breaking (V_{ud} and structure)
- Applications
 - Beta-NMR for materials studies

To achieve this science program there are a significant number of accelerator and equipment issues which need to be addressed:

- ISOL implementation should feed to low energy area.
- Multi-user capability would enhance science program. Parasitic operation would be a major advantage.
- There is a need for expansion into laboratory space appropriate for experiment development with crane and ceiling clearance.
- An isobar separation stage is needed immediately after the gas cell that is critical for wide range of experiments at low energy (it may be desired by reaccelerated beam users as well).
- Work areas are needed separate from experimental area.

The group identified an equipment list which needs effort:

- 3 Atom traps
 - Ion traps
- collinear laser spectroscopy
- high resolution time of flight

- Specify filtering & optics modes.
- The beam angle on target should be variable (polarization).
- Specify the details of the envisioned momentum compression.
- Establish possible schemes for slowing down radioactive beams.
- How does the concept of the separator fit with requirements for TOF-mass measurements?
- Proton-rich RIB purification (provide details of the envisioned RFFS).

D) ISOL Needs (Nolen) [17 participants]

The ISOL group discussed the important physics issues that can be uniquely addressed by ISOL capabilities, and the possible integration of ISOL capability into the FRIB design. The key point was that very intense radioactive beams, up to 10^{12} particles in some cases can probably be prepared, which would offer unique opportunities in fundamental interactions and heavy element studies.

Georg Bollen discussed the MSU vision for integrating ISOL into FRIB. This is not in the current base program, but there was universal support for a facility design with plenty of space being left for two ISOL target stations. The proposal has a beam line to transport ISOL products to the “Stopped” beam area for research, or prepare it for reacceleration. A design for remote target handling, based on the SNS facility has been considered. A variety of possible ion-source configurations have been thought about.

The issue of multi-user capability was discussed and was seen as important for leveraging more physics from the facility.

ISOL is a world-wide approach, and it was considered vital to compare and contrast the various ISOL facilities worldwide, as this could be a driver in setting priorities: a new facility would offer the same suite of beams, so would become a world-leader only if it can produce more activity, or cleaner beams. This can only be achieved by either higher production, or by more efficient extraction. A presentation from GANIL made interesting comparisons for Krypton nuclei, including the expectations for HI-ISOLDE and ISAC2.

Emphasis was put on the isotopic quality of beams, especially in separating isobaric contamination. As the most interesting nuclei are frequently very low in intensity, suppressing the contaminants is frequently the driving issue in spectroscopy.

In fundamental interactions, precision measurements of nuclear Electric Dipole Moments depend on source strength. Existing radioactive thorium sources produce 4×10^7 ^{225}Ra ions/second and FRIB is predicted to offer 1×10^{12} allowing an improvement in EDM sensitivity of more than 100. In studies of ^{223}Rn , FRIB should offer an enhancement over ISAC of >1000.

E) Theory Requirements (Nazarewicz) [14 participants]

The theory working group was enthusiastic about FRIB prospects. It will provide crucial data on exotic nuclei which will help “calibrate” nuclear theories, it will encourage closer collaborations

between theorists and experimentalists, and the new data will rejuvenate the Low Energy theory community. The guiding principles for the theory community remain those outlined in a recent NSAC report “A Vision for Nuclear Theory”. The key issue is re-growing the theory community in order to be well positioned to take advantage of the new data when it comes from FRIB. This involves:

- Attracting, educating and retaining the most talented young scientists
- Re-establishing LE theory in top-ranked universities. Grow the LE theory community
- Developing “New Initiatives” to generate new funding

Practically, it was suggested that:

- An Undergraduate and Graduate FRIB fellowships program be set up
- Postdoctoral FRIB Prizes be awarded
- FRIB-related theory positions in Universities and National Laboratories created
- Topical theory centers established
- Leveraged support of FRIB sabbaticals

And when FRIB is established:

- Have topical workshops
- A visitor program
- A local theory liaison office
- Visitor-friendly computing environment
- Theory webinars

Summary

The final session of the meeting was aimed at finding general consensus issues which were supported by the entire community. Thomas Glasmacher suggested some topics. After lengthy discussion, the following findings were unanimously agreed on:

- The community is excited about the prospects for FRIB. It will enable breakthrough discoveries in understanding the atomic nucleus, in quantitatively describing how nuclei interact, in quantitative modeling of astrophysical environments, in improving precision tests of nature’s fundamental symmetries, and for applications of isotopes for society.
- We urge the implementation of ReA12 as soon as possible with appropriate experimental space and instrumentation.
- We support including space to implement an ISOL option.
- We support integrating the capability to upgrade the 200 MeV/u 400 kW driver to 400 MeV/u.
- We support the FRIB theory initiative and efforts to grow the FRIB experimental community.

Appendix A

Program

<http://www.orau.org/ria/frib-workshop09/program.htm>

Saturday, May 30, 2009 (in APS Auditorium, Bldg. 401)

4:15 pm-6:00 pm Reception and Buffet Dinner
6:00 pm-6:10 pm Welcome (Janssens)
6:10 pm-6:50 pm FRIB: The Big Picture (Gelbke)
7:00 pm-7:40 pm The Proposed FRIB Facility as MSU (Glasmacher)

7:40 pm-8:00 pm *Break*

8:00 pm-8:45 pm From the RIA Users Group Charter to a FRIB Users Group:
Engagement in FRIB and the Challenges for the Community
(Casten/Lister)

Sunday, May 31, 2009 (in APS Building 401, many venues)

8:30 am-8:45 am Homework Assignments
8:45 am-10:45 am **Physics Discussion Sessions**
Astrophysics Working Group (Blackmon/Nollett/Schatz)
Fundamental Interactions Group (Chupp/Lu)
Applications/Surrogates (Beausang/Cizewski)
Structure Working Group (Gade/Galindo-Urbarri/Lee)
Reactions Working Group (Jones/Thompson/Wuosmaa)
Theory Working Group (Ormand/Volya)

10:45 am-11:15 am *Coffee Break*

11:15 am-12:00 pm Physics Findings (Casten, Chair)

12:00 pm-1:00 pm *Lunch*

1:00 pm-3:00 pm **Facility Discussion Sessions**
Stopped Beam Requirements (Mantica/Savard)
Reaccelerated Beam Requirements (Back)
Fast Beam Requirements (Bazin/Wiedenhöver)
ISOL Needs (Nolen)
Theory Requirements (Nazarewicz)

3:00 pm-3:45 pm *Afternoon Tea Break*

3:45 pm -4:30 pm Facility Findings (Sherrill, Chair)
4:30 pm-5:30 pm Plenary Discussions and Closeout (Glasmacher, Chair)

Appendix B

Charter

Facility for Rare Isotope Beams (FRIB) Users Organization Charter

1. Definition and Purpose:

The FRIB Users' Organization is a group whose members are interested in the Facility for Rare Isotope Beams (FRIB) for the purpose of conducting scientific research and developing new technology. The purposes of this association are:

- (a) To work towards the realization and timely construction of FRIB and the development of its instrumentation and physics program;
- (b) To act as an advocate for the needs of the FRIB user community during project construction;
- (c) To articulate and promote the scientific case for rare-isotope science and its significance to society;
- (d) To act as an advocate for the field of rare-isotope science in the USA in order to maximize its scientific potential.

2. Membership:

The membership of the FRIB Users' Organization is open to all practicing scientists, engineers, and students interested in the research and/or technical programs associated with FRIB. New members will be added upon receipt of requests submitted on the FRIB User's web site. The membership list is held by the Secretary of the Executive Committee of the FRIB Users' Organization.

3. Executive Committee:

An Executive Committee will conduct most of the day-to-day business of the FRIB Users' Organization. This committee consists of nine voting members selected from the FRIB Users' Organization membership. The members of this committee are expected to articulate the needs and priorities of the users group to the funding agencies and, in the future, to the FRIB management. The Executive Committee also provides a direct interface between the funding agencies, the future FRIB management and the user community. No two members of the Executive Committee can be from the same institution.

The first election for the Executive Committee will be conducted as follows. The current FRIB Steering Committee will appoint a five member nominating committee who are charged with selecting a slate of fifteen candidates for the nine open positions. It is anticipated that nine of the candidates will come from the present FRIB Steering Committee, for the purposes of continuity

of the present FRIB effort, and that the remaining six nominations, subject to the criteria of section 3, will be filled via the procedures outlined in Section 3.

The subsequent election will be held by electronic ballot with the three nominees having the largest number of votes serving for three years, the next three for two years and the next three for one year.

All subsequent elections will follow the procedures established in the following paragraphs. The term of office is three years. Three members of the Executive Committee will be elected annually by an electronic election to be conducted no later than October 15 of that year. The electronic ballot for the election will be distributed prior to October 1 of that year to the membership as of September 1 of that year. The newly elected members of the Executive Committee shall take office on January 1 of the following year. The first election will be held in 2004.

The nominating committee, whose charge will be to propose a slate of at least five candidates for the three elected positions on the Executive Committee will be composed of three Executive Committee members selected by the Executive Committee Chair and approved by the whole Executive Committee. Nominations signed by at least fifteen members of the Users' Organization from a minimum of three different institutions shall also be accepted. Current members of the Executive Committee may be nominated for re-election and can serve for a maximum of two terms.

The Executive Committee will select one of its members to serve as Chair and another to serve as Secretary. Neither the Chair nor the Secretary of the Committee will be from the laboratory where FRIB is built. The terms of the Chair and Secretary are for one year and are renewable.

If a vacancy arises on the Executive Committee, the remaining Committee members will select a member of the FRIB Users' Organization to serve out the unexpired term. In the event that the Chair's or the Secretary's position becomes vacant, the members of the Committee shall first select a new member as described above, and then proceed with an election to the vacated position. The newly selected Committee member is not a candidate to the Chair's or Secretary's position.

4. Procedures:

- (a) The Executive Committee will meet in person or by video or phone conference at least once each quarter of any given year. The minimal quorum for all meetings of the Executive Committee is seven members.
- (b) The Executive Committee may, on its own initiative, and shall, upon request of a minimum of 30 members of the FRIB Users' Organization from a minimum of five different institutions, submit questions for consideration to the full membership. Issues raised by a majority of those present at an official meeting of the FRIB Users' Group must also be presented for consideration to the full membership.

- (c) The Users' Organization shall meet at least once a year at a time and place designated by the FRIB Executive Committee. This meeting will usually be held in conjunction with a meeting of the Division of Nuclear Physics of the American Physical Society. In addition, the Executive Committee shall organize, and/or assist the FRIB project management in organizing FRIB-related workshops.
- (d) The Executive Committee will have regular meetings with the FRIB project management in an effort to provide input into matters related to the facility. Such meetings are also necessary to organize timely distribution of information concerning FRIB to the Users' community.
- (e) The elections to the Executive Committee will be organized by the Secretary of the Executive Committee.
- (f) The Executive Committee of the Users Organization will establish and maintain close collaboration with all other groups interested in activities related to FRIB such as, for example, the RIA Theory Group or groups assembling to design and construct specific instruments for the facility. Such contacts will occur on a quarterly basis at the minimum through exchanges between the representatives of these other groups and the Chair of the FRIB Users Organization. It is the expectation that the members of all other groups concerned with aspects of FRIB will also be members of the FRIB Users Organization so that all individuals involved with all aspects of the FRIB program will remain at all times fully informed of all issues that affect them.

5. Amendments:

Amendments to this Charter require a two-thirds majority vote of ballots cast by the membership at large. Proposed changes may be submitted by majority vote at a meeting or workshop, or by petition to the Executive Committee from a minimum of 30 members of the FRIB Users' Organization from a minimum of five different institutions.

Appendix A - Acceptance of the Charter of the RIA Users Organization

The final draft of the proposed Charter of the RIA Users Organization will be sent electronically to all those registered on the RIA Users web site. Members will be asked to register a yes or no vote for it by September 8, 2004. The ballots will be collected and tabulated by a person designated by the current RIA Users Group Chair. A simple majority of those voting will be taken as acceptance or rejection of this proposed charter by the community.

Amendment 1. May 2009

The name of the RIA Users' Organization shall be changed to the FRIB Users' Organization and the references to the name of the Organization in the Users' Organization Charter shall be updated to reflect this change.

Amendment 2. May 2009

The purpose of this association shall be updated in the Charter and changed from:

- (a) To work towards the realization and timely construction of RIA
- (b) To articulate and promote the scientific case for RIA and its significance to society
- (c) To promote and enhance the RIA research and development effort and other FRIB related activities to maximize its scientific potential
- (d) To act as an advocate for the needs of the RIA users

to:

- (a) To work towards the realization and timely construction of FRIB and the development of its instrumentation and physics program;
- (b) To act as an advocate for the needs of the FRIB user community during project construction;
- (c) To articulate and promote the scientific case for rare-isotope science and its significance to society;
- (d) To act as an advocate for the field of rare-isotope science in the USA in order to maximize its scientific potential.

Amendment 3. May 2009

Amendments to this Charter may be proposed to the full Organization by the Executive Committee upon approval of the amendment by a three-fourths vote of the full Executive Committee.

Appendix C

Participants

NAME	FIRST	INSTITUTION
Ahmad	Irshad	Argonne National Laboratory
Ahn	Tan	Yale University
Ahsan	Naureen	Florida State University
Alcorta	Martin	IEM-CSIC
Allmond	Mitch	University of Richmond
Almaraz-Calderon	Sergio	University of Notre Dame
Anantaraman	Raman	Michigan State University
Arrington	John	Argonne National Laboratory
Ashenfelter	Jeff	Yale University
Back	Birger	Argonne National Laboratory
Bandura	Laura	Argonne National Laboratory
Bardayan	Dan	Oak Ridge National Laboratory
Batchelder	Jon	Oak Ridge Associated Universities
Bauer	Wolfgang	Michigan State University
Baumann	Thomas	Michigan State University
Bazin	Daniel	Michigan State University
Beausang	Cornelius	University of Richmond
Behr	John	TRIUMF
Berryman	Jill	Michigan State University
Bickley	Abigail	Michigan State University
Bingham	Carrol	University of Tennessee
Blackmon	Jeff	Louisiana State University
Bleuel	Daniel	Lawrence Livermore National Laboratory
Blumenfeld	Yorick	CERN
Bollen	Georg	Michigan State University
Brida	Ivan	Argonne National Laboratory
Brown	Alex	Michigan State University
Caldwell	Shane	Argonne National Laboratory
Campbell	Bryan	Oak Ridge Associated Universities
Campbell	Chris	Michigan State University
Carpenter	Mike	Argonne National Laboratory
Casperson	Robert	Yale University
Casten	Rick	Yale University
Charity	Bob	Washington University
Chasman	Bob	Argonne National Laboratory
Chaudhuri	Ankur	Argonne National Laboratory
Chiara	Chris	University of Maryland
Chipps	Kelly	Rutgers University
Chowdhury	Partha	University of Massachusetts-Lowell
Chupp	Tim	University of Michigan
Cizewski	Jolie	Rutgers University

Clark	Roderick	Lawrence Berkeley National Laboratory
Clark	Jason	Argonne National Laboratory
Collon	Phillippe	University of Notre Dame
Couder	Manoel	University of Notre Dame
Crawford	Heather	Michigan State University
Davids	Cary	Argonne National Laboratory
Deibel	Catherine	Argonne National Laboratory/JINA
deSouza	Romualdo	Indiana University/IUCF
Devlin	Matt	Los Alamos National Laboratory
DiGiovine	Brad	Argonne National Laboratory
Erdelyi	Bela	Northern Illinois University
Esbensen	Henning	Argonne National Laboratory
Estrade	Alfredo	Michigan State University
Faestermann	Thomas	TU Munich
Famiano	Michael	Western Michigan University
Fischer	Susan	DePaul University
Fukuda	Naoki	RIKEN
Gade	Alexandra	Michigan State University
Galindo-Uribarri	Alfredo	Oak Ridge National Laboratory
Garcia	Alejandro	University of Washington
Garcia Borge	Maria Jose	IEM/CSIC
Garg	Umesh	University of Notre Dame
Geissel	Hans	GSI
Gelbke	Konrad	Michigan State University
Geppert	Christopher	University of Mainz
Gillaspy	John	NIST
Ginter	Tom	Michigan State University
Glasmacher	Thomas	Michigan State University
Goldberg	Vladilen	Texas A&M University
Greife	Uwe	Colorado School of Mines
Grinyer	Geoff	Michigan State University
Gurdal	Gulhan	Rutgers University
Gwinner	Gerald	University of Manitoba
Hagel	Kris	Texas A&M University
Hausmann	Marc	Michigan State University
Henderson	Dale	Argonne National Laboratory
Henning	Walter	Argonne National Laboratory
Henry	Gene	DOE
Henzl	Vladimir	Michigan State University
Henzlova	Daniela	Michigan State University
Hipple	Robert	Michigan State University
Hoffman	Calem	Argonne National Laboratory
Horoi	Mihai	Central Michigan University
Hudan	Sylvie	Indiana University
Janssens	Robert	Argonne National Laboratory
Jiang	Cheng-lie	Argonne National Laboratory

Jing	Hao	University of Michigan
Johnson	Ron	University of Surrey (UK)
Johnstad	Harald	Argonne National Laboratory
Jones	Kate	University of Tennessee
Jost	Cara	Oak Ridge National Laboratory
Kashiv	Yoav	University of Notre Dame
Kay	Ben	Argonne National Laboratory
Khoo	Teng Lek	Argonne National Laboratory
Knoebel	Ronja	GSI
Koerner	Gabriele-Elisabeth	NuPECC
Kondev	Filip	Argonne National Laboratory
Kondrashev	Sergey	Argonne National Laboratory
Kubo	Toshiyuki	RIKEN
Kulp	David	Georgia Institute of Technology
Lamm	Larry	University of Notre Dame
Lauritsen	Torben	Argonne National Laboratory
Lee	Hyeyoung	Argonne National Laboratory
Lee	I-Yang	Lawrence Berkeley National Laboratory
Lee	Hiu Ching (Jenny)	Michigan State University
Lewitowicz	Marek	GANIL
Li	Gang	Argonne National Laboratory
Liang	Felix	Oak Ridge National Laboratory
Liddick	Sean	Lawrence Livermore National Laboratory
Lisa	Mike	Ohio State University
Lister	C. J. (Kim)	Argonne National Laboratory
Loveland	Walter	Oregon State University
Lu	Fei	Michigan State University
Lu	Zheng-Tian	Argonne National Laboratory
Lynch	Bill	Michigan State University
Ma	Chi	University of Notre Dame
Ma	Wenchao	Mississippi State University
Madurga-Flores	Miguel	University of Tennessee
Manikonda	Shashikant	Argonne National Laboratory
Mantica	Paul	Michigan State University
Marley	Scott	University of Western Michigan
McCutchan	Libby	Argonne National Laboratory
McIntosh	Alan	Indiana State University
McNabb	Dennis	Lawrence Livermore National Laboratory
Melconian	Dan	Texas A&M University
Mercier	Damien	Indiana University
Meyer	Deseree	Rhodes College
Minamisono	Kei	Michigan State University
Mitchell	Joe	Florida State University
Mittig	Wolfgang	Michigan State University
Moore	Frank	Argonne National Laboratory
Mueller	Paul	Oak Ridge National Laboratory

Mueller	Peter	Argonne National Laboratory
Mustapha	Brahim	Argonne National Laboratory
Nazarewicz	Witek	University of Tennessee/ORNL
Nolen	Jerry	Argonne National Laboratory
Nörtershäuser	Wilfred	University of Mainz
Notani	Masahiro	University of Notre Dame
Ohnishi	Tetsuya	RIKEN
Ormand	Erich	Lawrence Livermore National Laboratory
Ostroumov	Peter	Argonne National Laboratory
Padgett	Stephen	University of Tennessee
Padilla-Rodal	Elizabeth	Instituto de Ciencias Nucleares
Pain	Steve	Oak Ridge National Laboratory
Parker	Peter	Yale University
Paul	Michael	Hebrew University
Paul	Nancy	University of Notre Dame
Paulauskas	Stanley	University of Tennessee
Perdikakis	Georgios	Michigan State University
Pereira	Jorge	Michigan State University
Peters	William	Rutgers University
Piechaczek	Andreas	Oak Ridge National Laboratory
Pieper	Steve	Argonne National Laboratory
Potterveld	David	Argonne National Laboratory
Pritychenko	Boris	Brookhaven National Laboratory
Rajabali	Mustafa	University of Tennessee
Rehm	Ernst	Argonne National Laboratory
Reviol	Walter	Washington University
Riley	Mark	Florida State University
Robertson	Daniel	University of Notre Dame
Rogachev	Grigory	Florida State University
Rogers	Andrew	Michigan State University
Rykaczewski	Kristof	Oak Ridge National Laboratory
Saladin	Jurg	University of Pittsburgh
Sanetullaev	Alisher	Michigan State University
Sarantites	Demitrios	Washington University
Sarazin	Fred	Colorado School of Mines
Savard	Guy	Argonne National Laboratory
Schatz	Hendrik	Michigan State University
Schiffer	John	Argonne National Laboratory
Schmitt	Kyle	University of Tennessee
Schröder	Udo	University of Rochester
Seweryniak	Darek	Argonne National Laboratory
Sherrill	Bradley	Michigan State University
Shetty	Dinesh	Western Michigan University
Signorini	Cosimo	University of Padova
Smith	Michael	Oak Ridge National Laboratory
Solvignon	Patricia	Argonne National Laboratory

Sternberg	Matt	University of Chicago
Stolz	Andreas	Michigan State University
Stoyer	Mark	Lawrence Livermore National Laboratory
Sun	Tao	Argonne National Laboratory
Symons	James	Lawrence Berkeley National Laboratory
Tabor	Sam	Florida State University
Tan	Wanpeng	University of Notre Dame
Tang	Xiaodong	University of Notre Dame
Tarasov	Oleg	Michigan State University
Teh	Ken	Argonne National Laboratory
Terry	Russell	Yale University
Thoennessen	Michael	Michigan State University
Thompson	Ian	Lawrence Livermore National Laboratory
Toh	Yosuke	JAEA, Japan
Torres-Isea	Ramon	University of Michigan
Tripathi	Ram	NASA/LaRC
Truran	James	University of Chicago
Tsang	Betty	Michigan State University
Varner	Robert	Oak Ridge National Laboratory
Volya	Alexander	Florida State University
Walters	Bill	University of Maryland
Wiedenhöver	Ingo	Florida State University
Winger	Jeff	Mississippi State University
Winkelbauer	Jack	Michigan State University
Wiringa	Bob	Argonne National Laboratory
Wood	John	Georgia Institute of Technology
Wu	Ching-Yen	Lawrence Livermore National Laboratory
Wuosmaa	Alan	Western Michigan University
Young	Ross	Argonne National Laboratory
Zganjar	Edward	Louisiana State University
Zhu	Shaofei	Argonne National Laboratory

RIA Users Executive Committee 2009

The current elected RIA Users Executive Committee (now FRIB Users Executive) is:

Jeff Blackmon

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Term ends 12-31-11

Rick Casten

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Term ends 12-31-11

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Term ends 12-31-10

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Term ends 12-31-10

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Term ends 12-31-11

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Term ends 12-31-10

Erich Ormand, Secretary

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Term ends 12-31-09

Michael Smith

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Term ends 12-31-09

Michael Wiescher

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Term ends 12-31-09