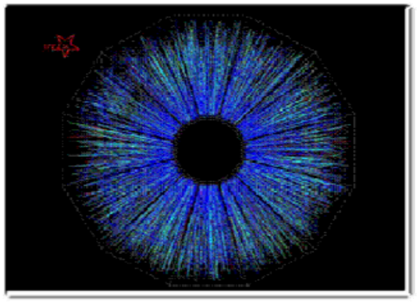
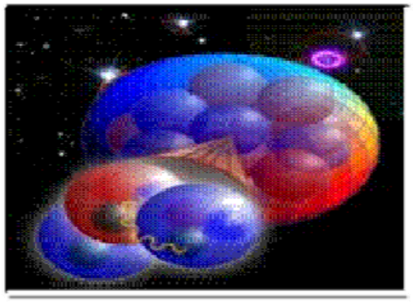
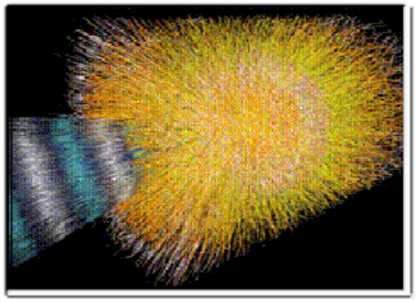
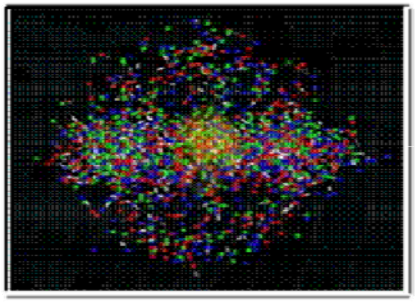
Perspectives from the DOE Office of Nuclear Physics

Nuclear Science Advisory Committee Meeting
March 8-9, 2013

Dr. T. J. Hallman
Associate Director for Nuclear Physics
DOE Office of Science

Office of Science FY 2013 Budget in the House Bill

Office of Science	FY 2012 Enacted	FY 2013 Pre-Sequester Annualized CR	FY 2013 Sequester	FY 2013 CR w/ Sequester
Advanced scientific computing research	440,868	443,566	-22,178	421,388
Basic energy sciences	1,688,093	1,698,424	-84,921	1,613,503
Biological and environmental research	609,557	613,287	-30,664	582,623
Fusion energy sciences program	400,996	403,450	-20,173	383,278
High energy physics	790,860	795,700	-39,785	755,915
Nuclear physics	547,387	550,737	-27,537	523,200
Workforce development for teachers and scientists	18,500	18,613	-931	17,683
Science laboratories infrastructure	111,800	112,484	-5,624	106,860
Safeguards and security	80,573	81,066	-4,053	77,013
Science program direction	185,000	186,132	-9,307	176,826
Total	4,873,634	4,903,459	-245,173	4,658,289

Office of Science FY 2013 Congressional Request

(Dollars in Thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request	$	%
Advanced Scientific Computing Research	410,317	440,868	455,593	+14,725	+3.3%
Basic Energy Sciences	1,638,511	1,688,093	1,799,592	+111,499	+6.6%
Biological and Environmental Research	595,246	609,557	625,347	+15,790	+2.6%
Fusion Energy Sciences	367,257	400,996	398,324	-2,672	-0.7%
High Energy Physics	775,578	790,860	776,521	-14,339	-1.8%
Nuclear Physics	527,684	547,387	526,938	-20,449	-3.7%
Workforce Development for Teachers and Scientists	22,600	18,500	14,500	-4,000	-21.6%
Science Laboratories Infrastructure	125,748	111,800	117,790	+5,990	+5.4%
Safeguards and Security	83,786	80,573	84,000	+3,427	+4.3%
Science Program Direction	202,520	185,000	202,551	+17,551	+9.5%
SBIR/STTR (SC funding)	108,418	—	—		
Subtotal, Office of Science	4,857,665	4,873,634	5,001,156		
SBIR/STTR (Other DOE funding)	54,618	—	—		
Use of prior year balances	-15,000	—	-9,104		
Total, Science Appropriation	4,897,283	4,873,634	4,992,052	+118,418	+2.4%

NP News and Events: Committee of Visitors (J. Harris, Chair) January 7-9, 2013

Charge:

For both DOE laboratory and university programs and projects

- Provide an assessment of the processes used to solicit, review, recommend, and document proposal actions and monitor active projects and programs

Within the boundaries defined by DOE missions and available funding

- Consider and provide an evaluation of the following major elements:
  a) The efficacy and quality of the processes used to solicit review, recommend, monitor, and document applications, proposals, and award actions; and
  b) The quality of the resulting portfolio, including its breadth and depth, and its national and international standing.

Comment on:

- observed strengths or deficiencies in any component or sub-component of the Office's portfolio and opportunities for improvements
- progress made towards addressing action items from the previous COV Review.

Report from the Chair at this meeting

Additional NP News and Events

- Process for making a permanent appointment for Medium Energy Program Manager was unsuccessful. The office will post another vacancy after March 15^{th} and try again.
- Process for making an appointment for Director of the Physics Research Division is ongoing.
- Kyungseon Joo (U Conn) has joined NP as an IPA; Kawtar Hafidi (ANL) has joined NP as a detailee
- Planning is in progress for comparative review of research efforts at Laboratories and Universities

  Target timeframe: (All dates are tentative until confirmed)

  Nuclear Structure/Nuclear Astro (May 20-24);

  Heavy Ions (May 28-31)

  Medium Energy (June 10-14)

  Nuclear Theory (June 17- 24)

  Fundamental Symmetries (June 25-28)

  Prescribed information submitted in advance

  Panel comparisons made within existing subfields
- The Isotope Program envisions a second All-Federal Isotope Workshop next spring
- Exploring some restructing within the Physics Research Division to enhance efficiency and impact:

  Will create a separate portfolio for Neutrons/Neutrinos and Fundamental Symmetries

Additional NP News and Events

- Passback received Monday January 28th, 2013. FY 2014 budget narrative in final preparation.
- The NP Office retreat is scheduled for March 13-14.
- A RHIC Operations Review by the Office of Project Assessment is presently scheduled for June 4-6, 2013.
- A review of the 12 GeV Upgrade to address primarily the impacts of the directed funding change in FY 2012 ($50M vs $66M in the project baseline) is presently scheduled for May 7-9, 2013.
- One-day site visit for TJNAF and S&T review for ATLAS planned in FY2013.
- NP, in discussion with the FRIB project team, is examining options to continue progress under the constraint of no new construction starts under a Continuing Resolution. The Project is ready for a CD2/3a review once a funding profile has been provided by NP.
- ECA process in progress
- NP candidate to attend the 63rd Meeting of the Nobel Laureates in Lindau, Germany June 30 to July 5th, 2013 has been accepted by Lindau Committee. DOE Conference approval is pending. The meeting topic is chemistry.

Additional NP News and Events

Within NP, and in preliminary discussion with HEP, there has begun to be some rumination about how to carry out a possible down-select process if the science "demands" that a ton-scale $0\nu\beta\beta$ experiment be carried out, and resources are available: Discussion with HEP on March 20, 2013

One concept is to reinstate a Neutrino Scientific Assessment Group (NuSAG) with members from NP and HEP to consider DBD R&D and downselect criteria. NuSAG could consider U.S. (pre-conceptual) R&D proposals for next generation experiments, in the context of related international planning efforts and report on:

- Merit of U.S. pursuing a next generation double beta decay experiment in current international landscape
- Identify potential candidates of next generation experiments – description, Status of R&D, remaining risks, priorities for future R&D
- Down select criteria for an internationally competitive experiment, including a sensitivity goal

These thoughts are formative for strategic planning purposes only at this point. As always, input from the community is welcome

New Charge Given to NSAC on Future Facilities Needed for SC's Mission

From: W. F. Brinkman
Director, Office of Science

I am writing to present a new charge to each of the Office of Science Federal Advisory Committees. I would like each Advisory Committee to help us with an important task—the prioritization of proposed scientific user facilities for the Office of Science. To meet a very compressed timetable, **we will need your final report by March 22, 2013**.

This charge derives from Administration efforts to improve the efficiency, effectiveness, and accountability of government programs and requirements of the Government Performance and Results Modernization Act of 2010. In order to improve the agency's performance, and in compliance with this Act, DOE has established several Priority Goals, including the following goal for the Office of Science:

Goal Statement: <u>Prioritization of scientific facilities to ensure optimal benefit from Federal investments.</u> By September 30, 2013, formulate a 10-year prioritization of scientific facilities across the Office of Science based on (1) the ability of the facility to contribute to world-leading science, (2) the readiness of the facility for construction, and (3) an estimated construction and operations cost of the facility.

Other News: The National Defense Authorization Act for FY2013 and NSAC

- SEC. 3173. IMPROVING THE RELIABILITY OF DOMESTIC MEDICAL ISOTOPE SUPPLY.
- (a) MEDICAL ISOTOPE DEVELOPMENT PROJECTS.—
- (1) IN GENERAL.—The Secretary shall carry out a technology-neutral program—
  - (A) to evaluate and support projects for the production in the United States, without the use of highly enriched uranium, of significant quantities of molybdenum-99 for medical uses;
  - (B) to be carried out in cooperation with non-Federal entities; and
  - (C) the costs of which shall be shared in accordance with section 988 of the Energy Policy Act of 2005 (42U.S.C. 16352).
- (2) CRITERIA.—Projects shall be evaluated against the following primary criteria:
  - (A) The length of time necessary for the proposed project to begin production of molybdenum-99 for medical uses within the United States.
  - (B) The capability of the proposed project to produce a significant percentage of United States demand for molybdenum-99 for medical uses.
  - (C) The capability of the proposed project to produce molybdenum-99 in a cost-effective manner.
  - (D) The cost of the proposed project.
- (3) EXEMPTION.—An existing reactor in the United States fueled with highly enriched uranium shall not be disqualified from the program if the Secretary determines that—
  - (A) there is no alternative nuclear reactor fuel, enriched in the isotope U–235 to less than 20 percent, that can be used in that reactor;
  - (B) the reactor operator has provided assurances that, whenever an alternative nuclear reactor fuel, enriched in the isotope U–235 to less than 20 percent, can be used in that reactor, it will use that alternative in lieu of highly enriched uranium; and
  - (C) the reactor operator has provided a current report on the status of its efforts to convert the reactor to an alternative nuclear reactor fuel enriched in the isotope U–235 to less than 20 percent, and an anticipated schedule for completion of conversion.

Other News: The National Defense Authorization Act for FY2013 and NSAC

(H. R. 4310— 581)

(4) PUBLIC PARTICIPATION AND REVIEW.—The Secretary shall—

(A) develop a program plan and annually update the program plan through public workshops; and

(B) use the Nuclear Science Advisory Committee to conduct annual reviews of the progress made in achieving the program goals and make recommendations to improve program effectiveness.

NP/ IDPRA (the Isotope Program) is considering the most effective means to propose for addressing this Congressional direction.

A concept being considered is to empanel a new NSACI subpanel to carry out the directed assessment as well as an assessment of the status and progress in addressing isotope needs broadly. As always, feedback from the community is welcome.

Management Priorities Going Forward

- Establishing short-term and long-term programmatic priorities in the face of significant fiscal uncertainty
- Maintaining scientific productivity with reduced facility operations
- Managing construction funding profiles and adressing the impacts of the directed change in the 12 GeV CEBAF funding profile in FY2012
- Optimizing core national laboratory and university research within constrained budgets
- D&D of HRIBF and transition of essential staff
- Nurturing the nuclear structure and astrophysics community prior to FRIB
- Meeting the stable and radioisotope needs of the Nation, and mitigating impacts, to the extent possible, of possible reduced production capability

Conclusion

The future of nuclear science in the United States may not be exactly as envisioned in the 2007 Long Range Plan, but it remains rich with science opportunities.

The United States continues to provide resources for and to expect:

- U.S. world leadership in discovery science illuminating the properties of nuclear matter in all of its manifestations.
- Tools necessary for scientific and technical advances which will lead to new knowledge, new competencies, and groundbreaking innovation and applications.
- Strategic investments in tools and research to provide the U.S. with premier research capabilities in the world.

Nuclear Science will continue to be an important part of the U.S. science investment strategy to create new knowledge and technology innovation supporting U.S. security and competitiveness

Additional Information

A new charge to NSAC on Future Facilities needed to achieve SC's Mission

To accomplish this goal, DOE will undertake the following steps. We will need your help with step #2, as described below.

The DOE/SC Associate Directors will create a list of proposed new scientific user facilities or major upgrades to existing scientific user facilities that could contribute to world leading science in their respective programs from 2014 to 2024 (the timeframe covered by this goal).

This step is complete. The Associate Directors have developed material describing the nature of a number of proposed new or upgraded facilities, the scientific justification for the facility or upgrade, and the various inputs from the scientific community that provided motivation for the proposal. Additionally, the Associate Directors have provided assessments of their existing scientific user facilities to contribute to world-leading science through 2024. The Associate Directors will be in touch with their respective FACA chairs shortly to submit this material directly to you.

The information developed by the DOE/SC Associate Directors will be used by the DOE/SC as the basis for engagement with the DOE/SC Federal Advisory Committees and others to seek advice and input on new or upgraded scientific user facilities necessary to position the DOE/SC at the forefront of scientific discovery. The Federal Advisory Committees will seek additional outside input as necessary. In particular, for programs that have a significant existing or potential user base outside of the DOE/SC, the Federal Advisory Committees will be encouraged to seek input from the broader scientific community and existing facility user committees.

A new charge to NSAC on Future Facilities needed to achieve SC's Mission

In order for your Advisory Committee to execute step #2, I suggest that you empanel a subcommittee to review the list of existing and proposed facilities provided to you by the program Associate Director, subtracting from or adding to the list as you feel appropriate. To address the concerns of the broad facilities user community, the subcommittees should include representatives of the broad, multi-disciplinary community that stands to benefit from these facilities, including representatives whose research is supported by other Federal agencies. In its deliberations, the subcommittees should reference relevant planning documents and decadal studies. If you wish to add facilities or upgrades, please consider only those that require a minimum investment of $100 million. More detailed instructions for the report are given below.

Finally, with input from the DOE/SC Federal Advisory Committees and other stakeholders, the DOE/SC Director will prioritize the proposed new scientific user facilities and major upgrades across scientific disciplines according to his/her assessment of the scientific promise, the readiness of the facility to proceed to construction, and the cost of construction and operation. In making this prioritization, the DOE/SC Director will consider the resource needs for research support and for robust operation of existing facilities and will engage leaders of other relevant agencies and the Administration to ensure priorities are coordinated with related investments by other agencies and reflect cross-agency needs where appropriate.

Please provide me with a short letter report that assigns each of the facilities to a category and provides a short justification for that categorization in the following two areas, but do not rank order the facilities:

A new charge to NSAC on Future Facilities needed to achieve SC's Mission

<u>The ability of the facility to contribute to world-leading science in the next decade (2014 – 2024)</u>. Please include both existing and proposed facilities/upgrades and consider, for example, the extent to which the proposed or existing facility or upgrade would answer the most important scientific questions; whether there are other ways or other facilities that would be able to answer these questions; whether the facility would contribute to many or few areas of research and especially whether the facility will address needs of the broad community of users including those supported by other Federal agencies; whether construction of the facility will create new synergies within a field or among fields of research; and what level of demand exists within the (sometimes many) scientific communities that use the facility. **Please place each facility or upgrade in one of four categories: (a) absolutely central; (b) important; (c) lower priority; and (d) don't know enough yet.**

<u>The readiness of the facility for construction</u>. For proposed facilities and major upgrades, please consider, for example, whether the concept of the facility has been formally studied; the level of confidence that the technical challenges involved in building the facility can be met; the sufficiency of R&D performed to-date to assure technical feasibility of the facility; and the extent to which the cost to build and operate the facility is understood. **Please place each facility in one of three categories: (a) ready to initiate construction; (b) significant scientific/engineering challenges to resolve before initiating construction; and (c) mission and technical requirements not yet fully defined.**

Each SC program Associate Director will contact the Chair of his or her Federal Advisory Committee to discuss and coordinate the logistics of executing this charge. We realize that the six SC programs will require somewhat different approaches, in part based on recent and future community planning activities. In addition, if you would like to discuss the charge further, please feel free to contact Pat Dehmer (patricia.dehmer@science.doe.gov). Thank you for your help with this important task.

This Exercise has Similarities to One Performed in 2003 and Updated in 2007

... if we are to continue that kind of success we need to look to the future. So I am here today to release a 20-year roadmap for future scientific facilities. These facilities and upgrades to our current inventory will revolutionize science and society. They are needed to extend the frontiers of science, to purse opportunities of enormous importance, and to maintain U.S. science primacy in the world.

We are the single largest supporter of basic research in the physical sciences, accounting for approximately 40 percent of all federal funds in this area over the past decade.

If we want to remain the focal point of scientific discovery, we must look to the future. And that is why I am here today. *Spencer Abraham, November 14, 2003*

Four Years Later: An Interim Report on *Facilities for the Future of Science: A Twenty-Year Outlook* August 2007

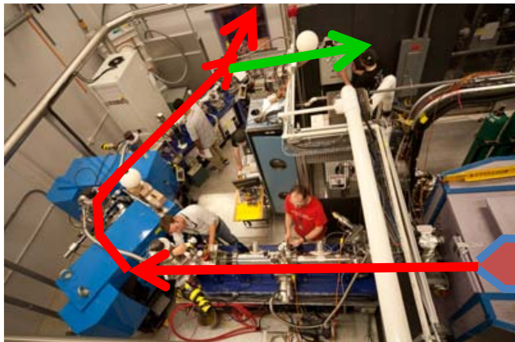
Review of NP Facilities in the FY 2013 House and Senate Marks

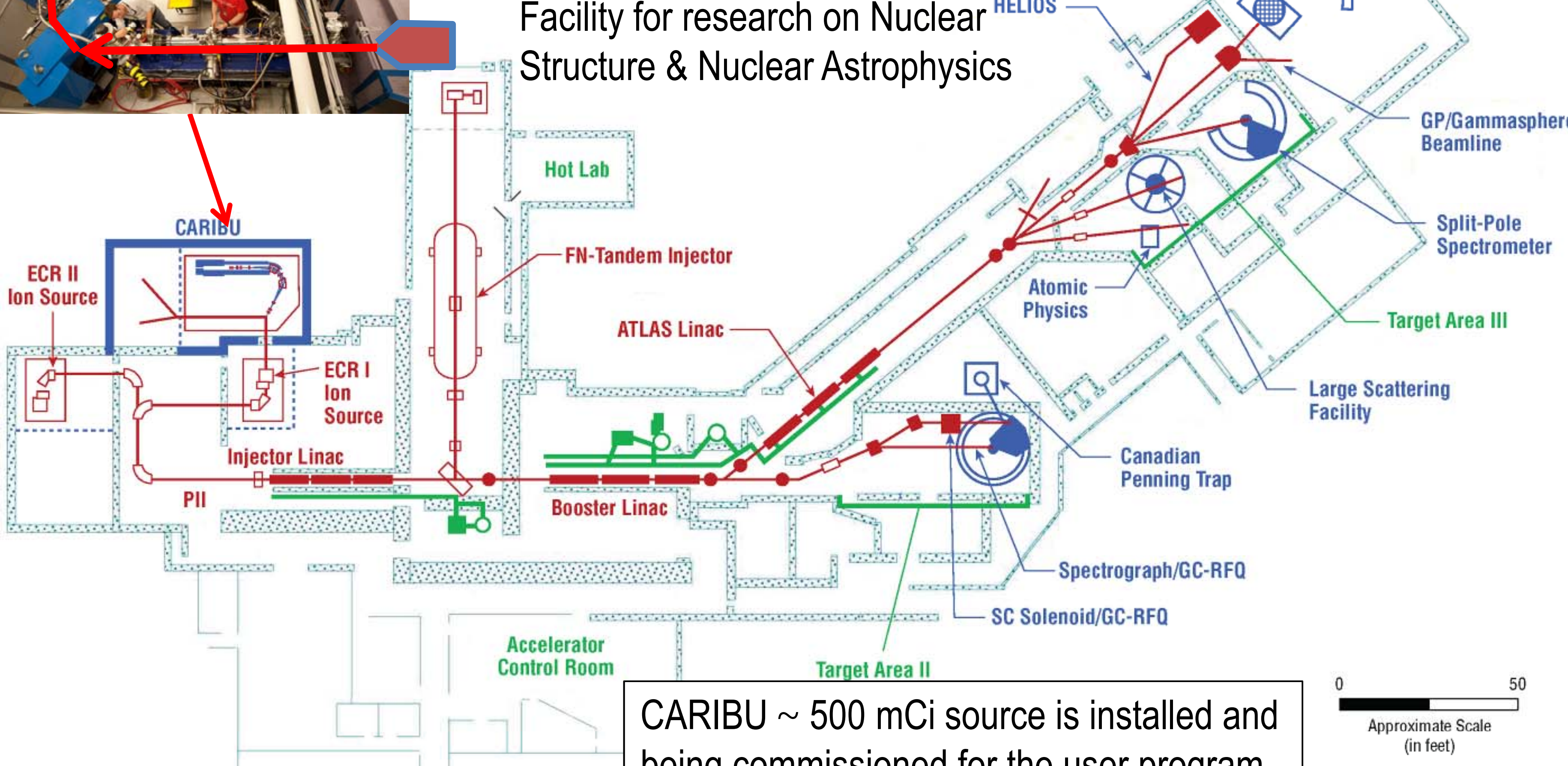
	FY 2012 Approp	FY 2013 Request	FY 2013 House Mark	+/- Request	FY 2013 Senate Mark	+/- Request
12 GeV CEBAF Upgrade (TEC)	50,000	40,572	40,572		40,572	
Facility for Rare Isotope Beams	22,000	22,000	40,000	+18,000	30,000	+8,000
Heavy Ion Operations						
RHIC Operations	157,617	156,571	159,571	+3,000	161,600	+5,029
Other Operations (BNL GPE)	3,000	2,000	2,000		2,000	
Total Heavy Ion Operations	160,617	158,571	161,571	+3,000	163,600	+5,029
All Other NP	314,770	305,795	305,795		305,766	-29
TOTAL NP *	**547,387**	**526,938**	**547,938**	**+21,000**	**539,938**	**+13,000**

* Includes SBIR/STTR in all years for comparability

- The **House Mark** provides an increase of **$21M above the FY 2013 Request** : $18M for FRIB to "continue activities leading towards the approval of construction;" and, $3M for RHIC to "support a standalone run of approximately 15 weeks in FY 2013."
- The **Senate Mark** provides an increase of **$13M above the FY 2013 Request** : $8M for FRIB to "complete design and engineering work and, if the Office of Science approves a performance baseline, site preparation activities;" and, an increase of $5M for RHIC to "maintain 20 weeks of operations."
- Both reports included language supporting NSAC's charge to review the scientific priorities of the Nuclear Physics program within constrained budgets.

ATLAS Uniquely Provides Low Energy Research Opportunities Within SC Until FRIB



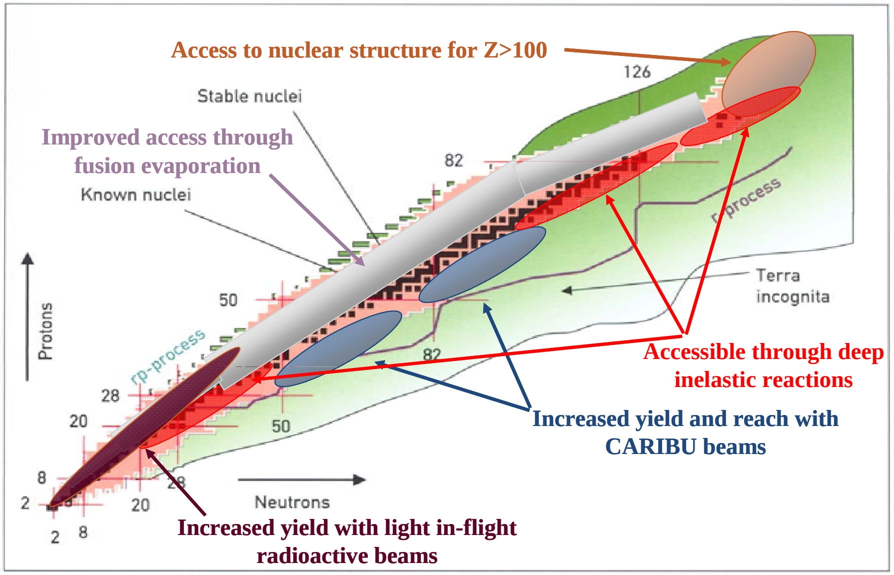


In the out years, ATLAS continues as a unique premier Stable Beam Facility for research on Nuclear Structure & Nuclear Astrophysics

CARIBU ~ 500 mCi source is installed and being commissioned for the user program

ATLAS Role and Goals

- It provide beams and facilities enabling world leading research at around Coulomb barrier energy, answering key questions in the fields of:
  - nuclear structure
  - low-energy tests of the Standard Model
  - nuclear astrophysics
  - applications of low-energy nuclear phy
- This is done through:
  - providing beamtime for research programs
    - Any stable beam from proton to uranium
    - some in-flight radioactive beams
    - Low-energy and reaccelerated CARIBU beams
  - developing new capabilities to address evolving needs of the field
    - new experimental equipment
    - new accelerator capabilities (accelerator R&D group)



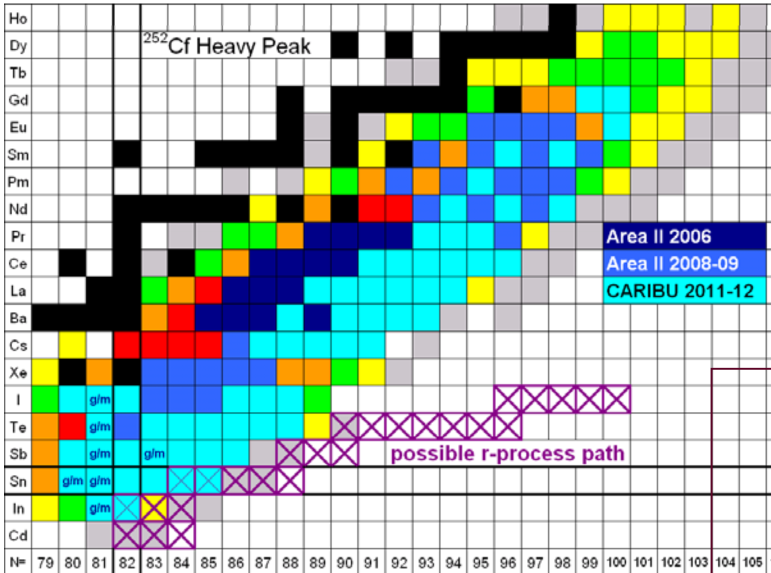
- ATLAS is developing capabilities and expertise that will be important for the physics program (focused mainly on reaccelerated beams) at FRIB and positioning ATLAS for its expected role as the high-intensity stable beam facility in the FRIB era.

Main ATLAS Research Thrusts

Nuclear astrophysics

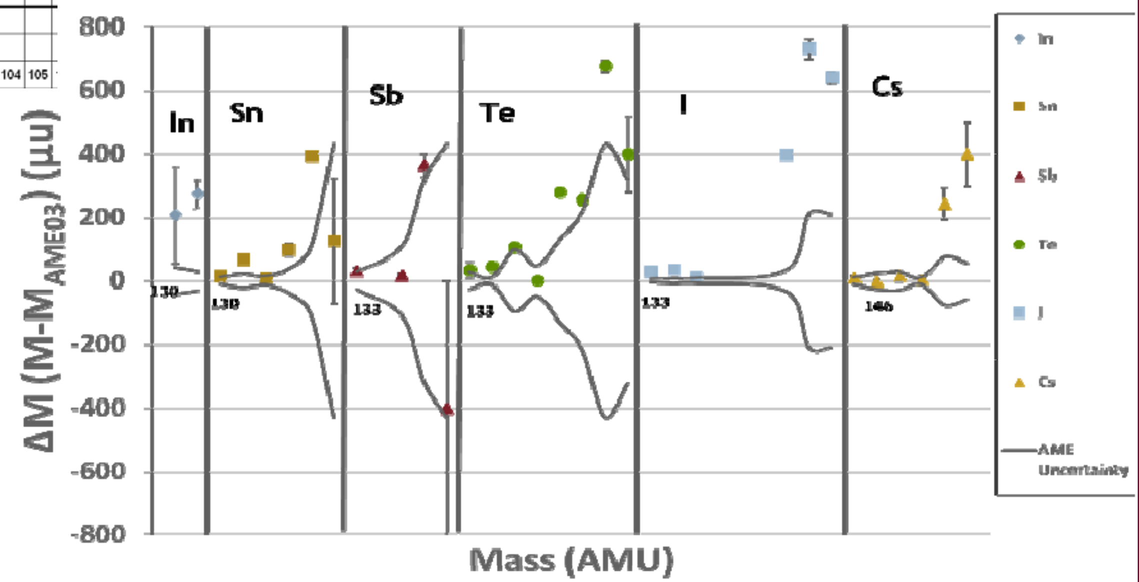
- High level goal is the understanding of the production of the elements in the cosmos through studies of the nuclear physics input to
  - rp-, αp- and np- process nucleosynthesis (reaction rates, masses, important spectroscopic information)
  - r-process path (masses, lifetimes, beta-delayed neutrons, surrogate reactions)
  - sub-barrier fusion hindrance
  - Break out from CNO cycle
  - Important quiescent reactions
- Main tools used
  - in-flight radioactive ion beam (RIB) separator, Enge, HELIOS, CPT Penning trap mass spectrometer
- Program pushes forward in new regions and with new capabilities offered by
  - New beams: CARIBU, deep-inelastic reactions, new in-flight RIB separator (AIRIS)
  - Higher efficiency: HELIOS with full detector array and gas target, bubble chamber detector

First Physics With CARIBU

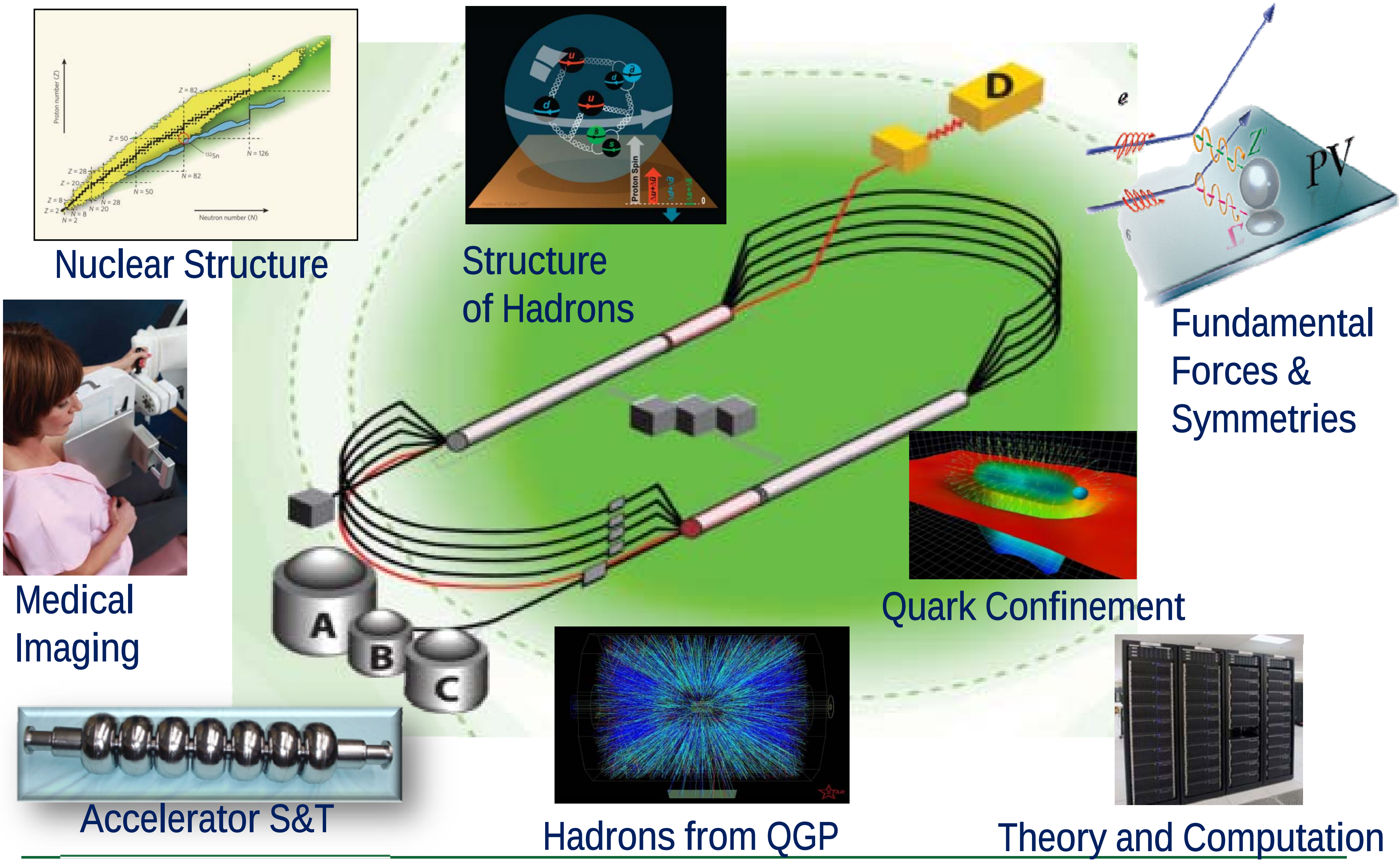


Neutron-rich isotopes are found to be systematically less bound than predicted

Mass measurements with the CPT at CARIBU

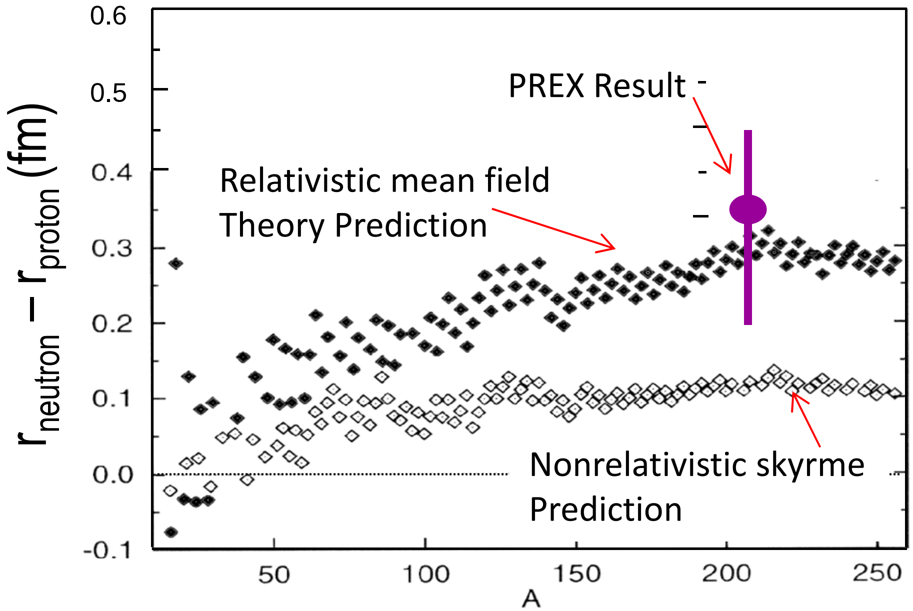


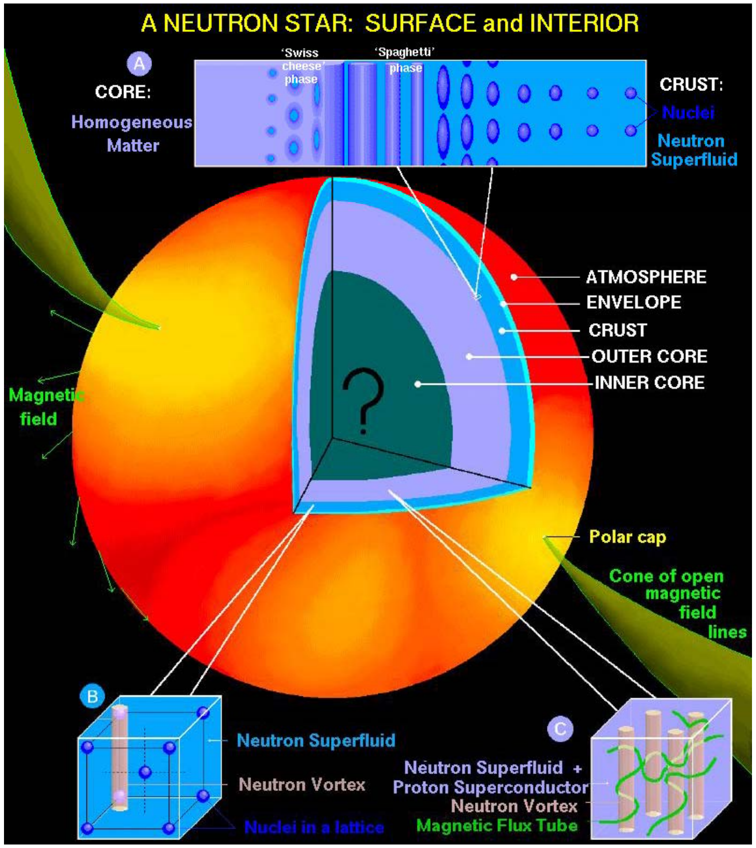
JLAB: A Multi-Thrust Laboratory for Nuclear Science



The PREX Experiment at TJNAF: "Skin-Deep Matters"

By studying a parity-violating asymmetry in elastic scattering of electrons off Lead (^{208}Pb) nuclei, the PREX experiment found that the neutron radius of the nucleus is larger than proton radius by +0.35 fm (+0.15, -0.17).

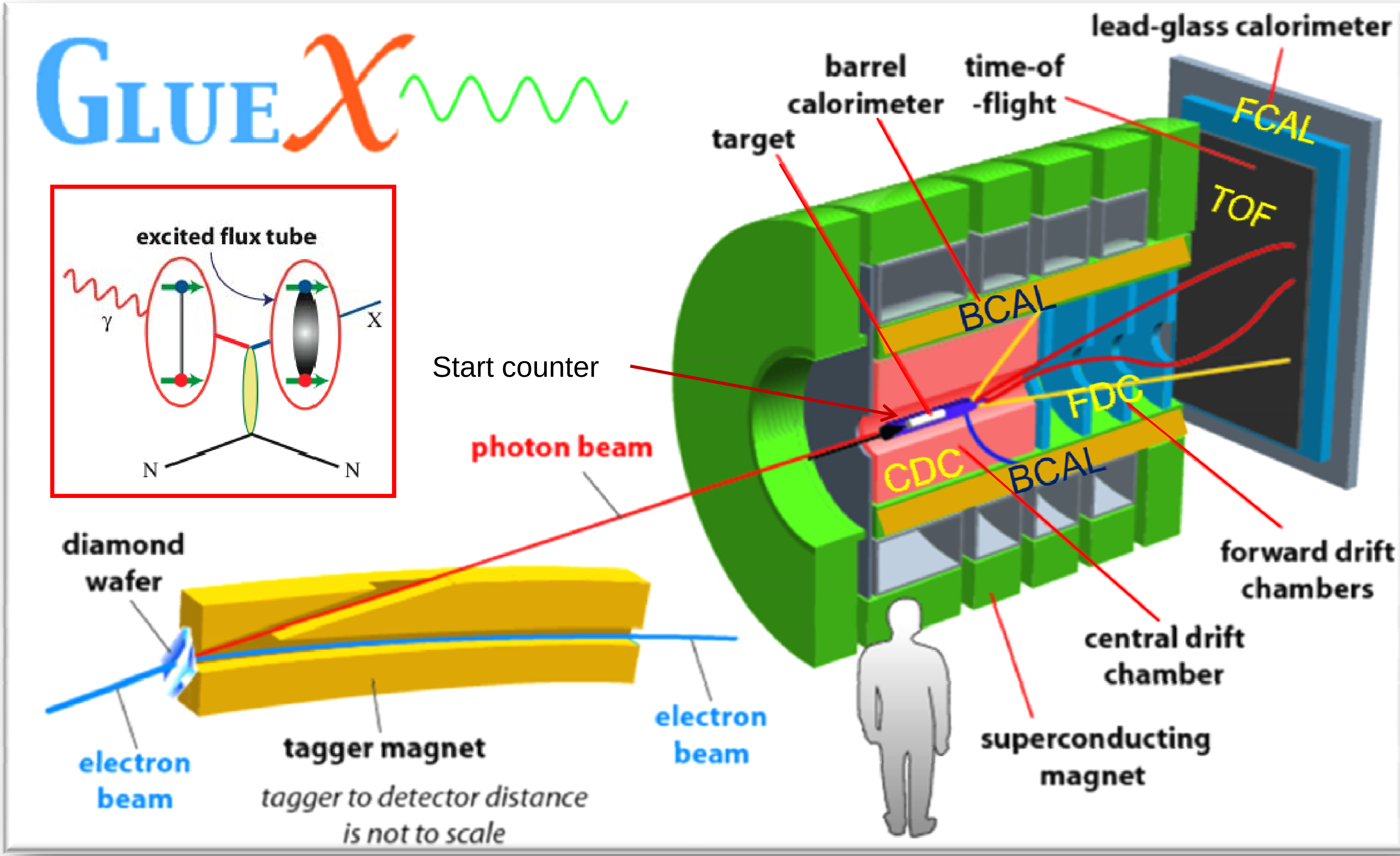




This result provides model-independent confirmation of the **existence of a neutron skin** relevant for neutron star calculations. Follow-up planned to reduce uncertainty by factor of 3 and pin down symmetry energy in EOS

A neutron skin of 0.2 fm or more has implications for our understanding of neutron stars and their ultimate fate

The Newly Constructed Hall D Promises a New NP Science Watershed



JLab: 21st Century Science Questions

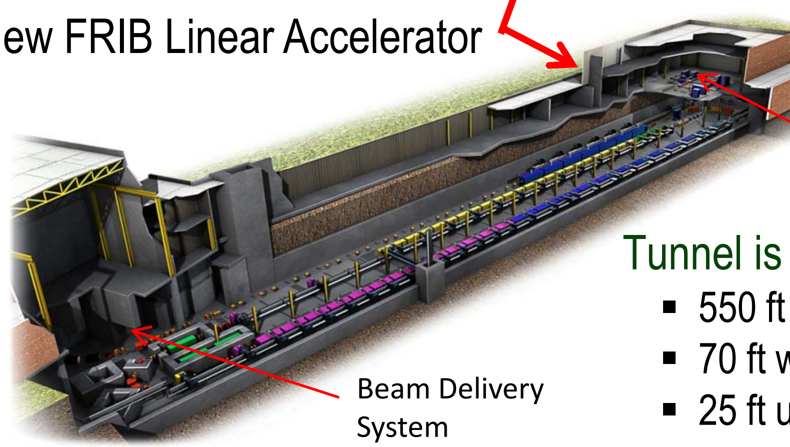
- What is the role of gluonic excitations in the spectroscopy of light mesons? Can these excitations elucidate the origin of quark confinement?
- Where is the missing spin in the nucleon? Is there a significant contribution from valence quark orbital angular momentum?
- Can we reveal a novel landscape of nucleon substructure through measurements of new multidimensional distribution functions?
- What is the relation between short-range N-N correlations and the partonic structure of nuclei?
- Can we discover evidence for physics beyond the standard model of particle physics?

The Office of Science is in the final phase of a major upgrade of the CEBAF Accelerator at TJNAF to provide forefront capability to address this science.

The Future of the Low Energy Subfield in the U.S. Depends on Construction of the Facility for Rare Isotope Beams

Existing National Superconducting Cyclotron Laboratory

New FRIB Linear Accelerator



Tunnel is
- 550 ft long
- 70 ft wide
- 25 ft underground

FRIB will increase the number of isotopes with known properties from ~2,000 observed over the last century to ~5,000 and will provide world-leading capabilities for research on:

Nuclear Structure

- The ultimate limits of existence for nuclei
- Nuclei which have neutron skins
- The synthesis of super heavy elements

Nuclear Astrophysics

- The origin of the heavy elements and explosive nucleo-synthesis
- Composition of neutron star crusts

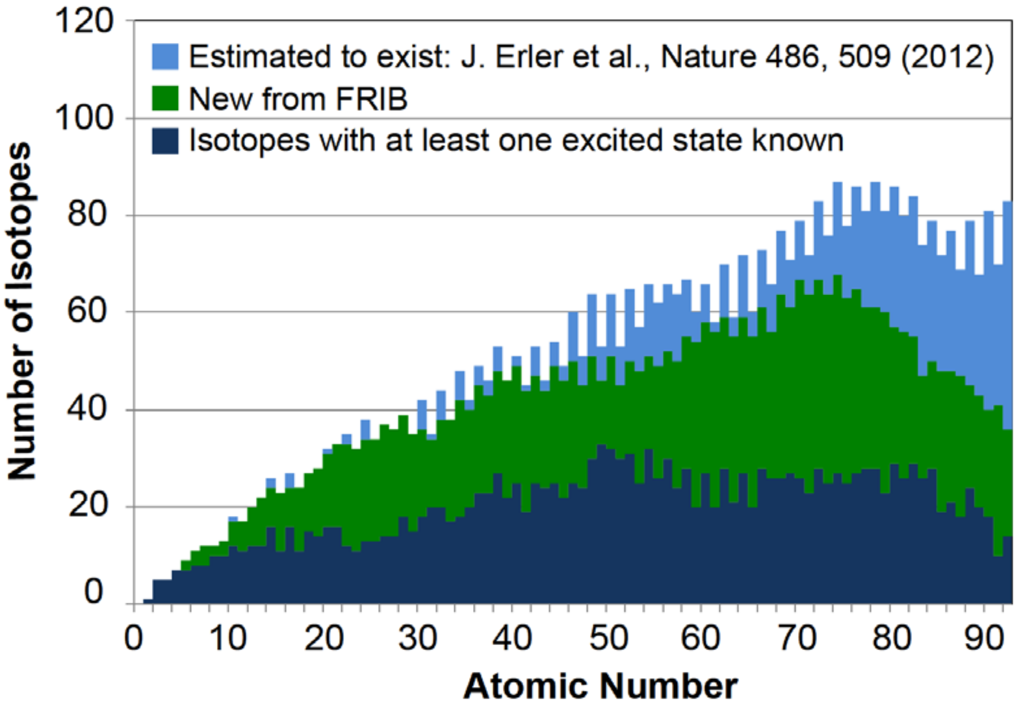
Fundamental Symmetries

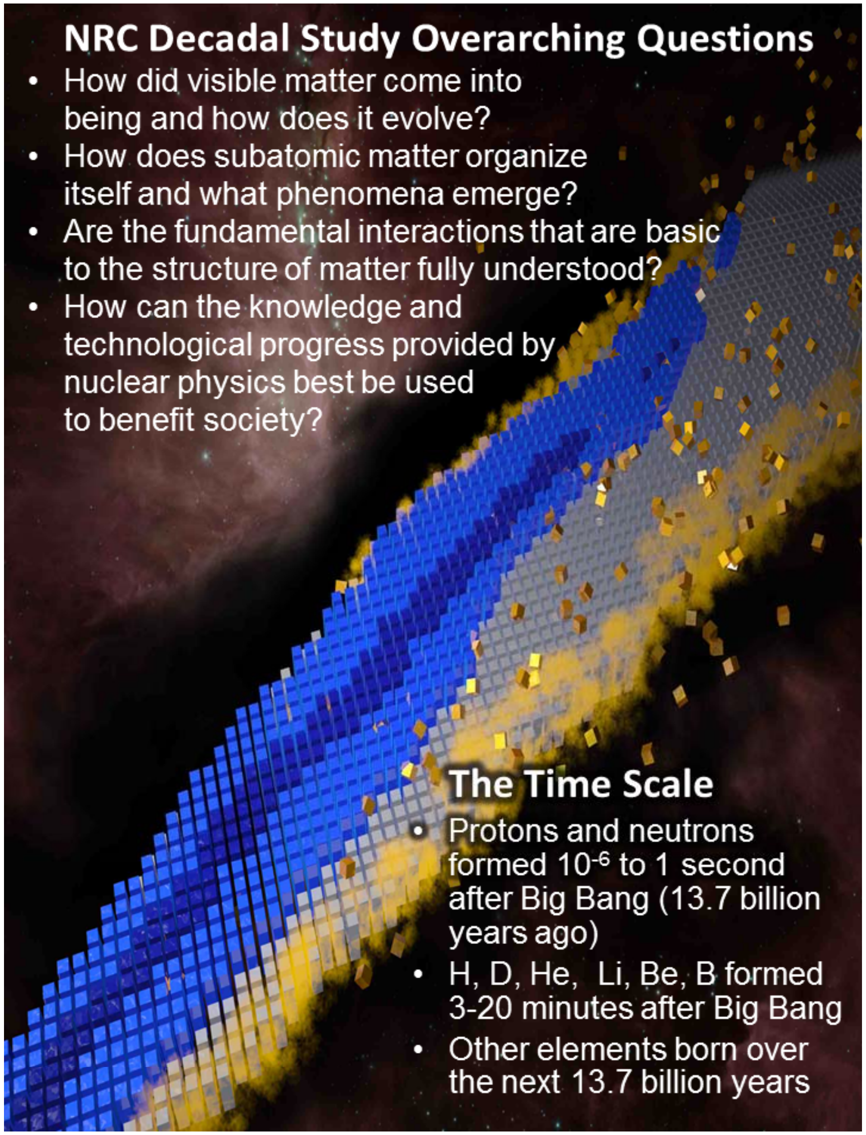
- Tests of fundamental symmetries, Atomic EDMs, Weak Charge

This research will provide the basis for a model of nuclei and how they interact.

FRIB: 21st Century Science Questions

- FRIB physics is at the core of nuclear science: “To understand, predict, and use”
- FRIB provides access to a vast unexplored terrain in the chart of nuclides

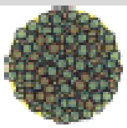




FRIB Science Will be Transformational

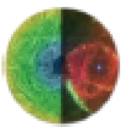
FRIB Science Is Important for the Nation

Articulated by National Research Council RISAC Report (2006), NSAC LRP (2007), NRC Decadal Survey of Nuclear Physics (2012)



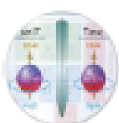
Properties of nuclei

- Develop a predictive model of nuclei and their interactions
- Many-body quantum problem: intellectual overlap to mesoscopic science, quantum dots, atomic clusters, etc.



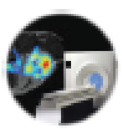
Astrophysical processes

- Origin of the elements in the cosmos
- Explosive environments: novae, supernovae, X-ray bursts …
- Properties of neutron stars



Tests of fundamental symmetries

- Effects of symmetry violations are amplified in certain nuclei



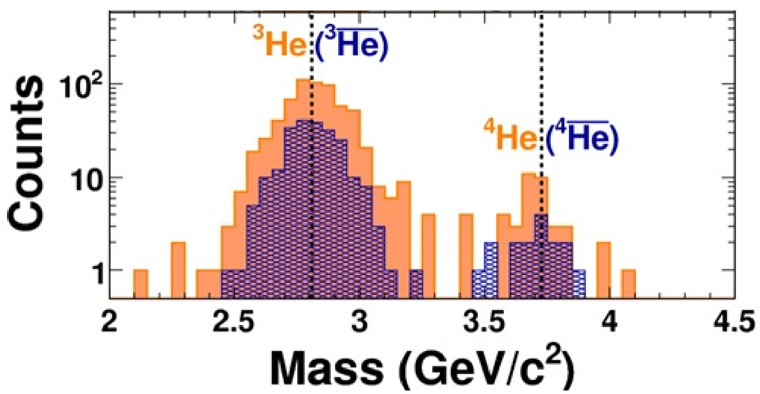
Societal applications and benefits

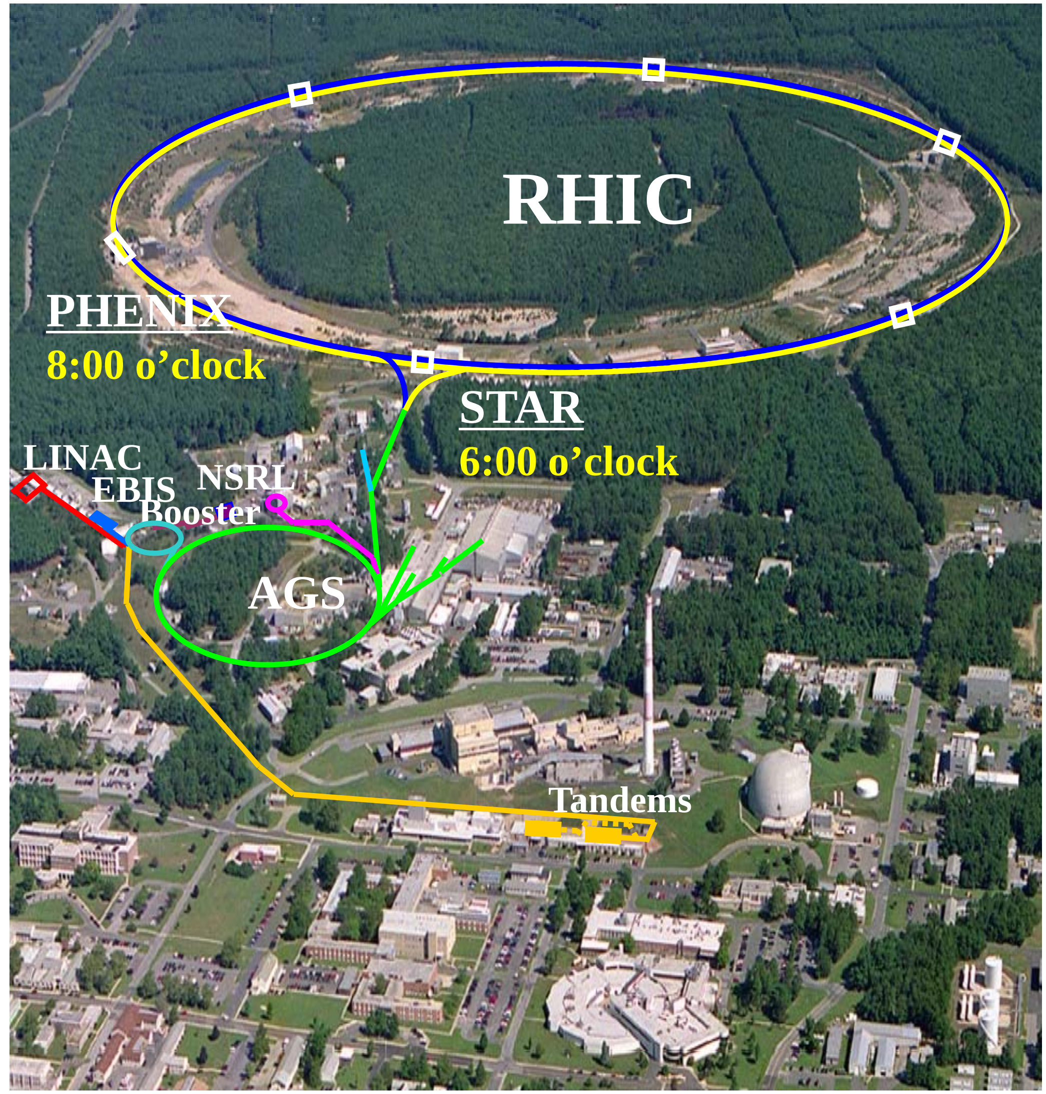
- Bio-medicine, energy, material sciences
- National security

> *"Data to date on exotic nuclei are already beginning to revolutionize our understanding of the structure of atomic nuclei. FRIB will enable experiments in uncharted territory at the limits of nuclear stability. FRIB will provide new isotopes for research related to societal applications, address long-standing questions about the astrophysical origin of the elements and the fundamental symmetries of nature."*
>
> 2012 NRC Decadal Study

Research Focus of the Relativistic Heavy Ion Collider

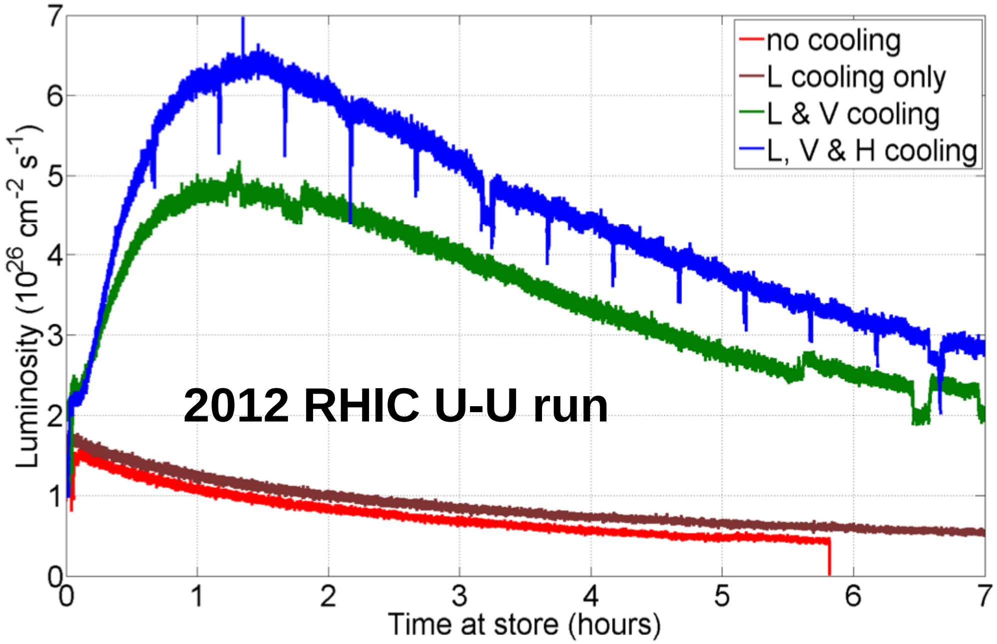
- To elucidate the fundamenal properties of the Perfect Liquid discovered in Au+Au collisions
- To determine the contribution to the proton spin from gluons, sea quarks/anti-quarks; to study transversity and advance understanding of contributions from orbital motion within the proton
- To address other scientific "targets of discovery opportunity" afforded by RHIC's capabilities





RHIC also stewards strong core competencies in accelerator physics

The Advantage of Keeping Cool



- A technical tour de force for the 2012 RHIC run saw completion of a stochastic cooling upgrade and 1st use of an electron beam ion source (EBIS)
- EBIS provided new capability for U+U collisions, while stochastic cooling resulted in the dramatic luminosity increase shown above from no cooling (red curve) to longitudinal, horizontal, and vertical cooling

New insight from this new capability:

Ultra-central U+U collisions made possible by this advance suggest there is little flow-related background to the chiral magnetic event EDM (charge separation) signal observed in high energy Au+Au collisions.

This lends further support for an interpretation of the event EDM effect in terms of hot matter manifestations of excited QCD vacuum fluctuations ("sphalerons"), analogous to electroweak sphalerons speculated as the site of baryon asymmetry in the infant universe.

Summary Outlook Going Forward:

RHIC has discovered a completely new state of matter (a perfect quark-gluon liquid) which is just as momentous and exciting as the discovery of high temperature superconductivity in condensed matter physics.

There is a rich program of science ongoing and goingn forward to:

- determine, with precision, the detailed properties of this new matter
- further explore and develop intellectual connections and broader impacts in other subfields of new insights &knowledge gained
- search for new discoveries such as the postulated Critical Point in the phase diagram of QCD
- further unfold the spin structure of the nucleon

RHIC: 21st Century Science Questions Yet to be Answered

Are there new states of matter at extremely high temperature and density?

Can the phase structure of a fundamental gauge theory be explored via nuclear collisions?

Can the study of strongly-coupled QCD matter inform the understanding of other gauge theories (including gravity)?

Is there a critical point in the QCD phase diagram?

Are exotic (locally CP-violating) states of matter formed in nuclear collisions?

At what (energy, mass, length) scale does the perfect liquid become resolvable into the underlying quarks and gluons?

What is the value of η/s and does it respect the conjectured quantum bound?

What is the numerical value (and energy dependence) of the coupling constant in the quark-gluon plasma at RHIC and LHC energies?

What is the value of the jet energy loss parameter, and is it consistent with purely perturbative calculations?

What are the magnitudes of cold nuclear matter (CNM) effects as a function of probe, root-s, and momentum, and how do these impact precision measurements in hot nuclear matter?

Vision for Fundamental Symmetries, Neutrons, and Neutrinos

Based on Science:

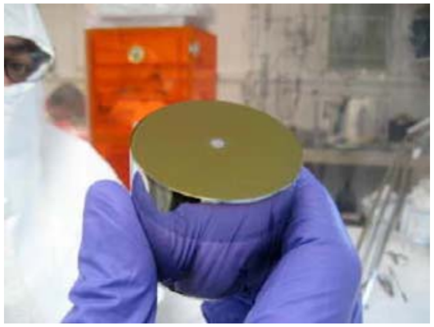
- There are selected NP science targets of opportunity with the potential for high-impact in fundamental symmetries, neutrons, and neutrinos.
- These experiments may take on even greater significance depending on the results of accelerator research in the next few years
- To the extent there are resources to pursue them and they are complementary to HEP research, such opportunities may be pursued.
- For nEDM the science goal continues to be stronly motivated and R&D continues; a decision point is expected within ~ 2 years whether to proceed with the full experiment
- $0\nu\beta\beta$ experiments are sufficiently costly, a down-select to the best technology across HEP and NP makes sense and is planned.

Neutrino-less Double Beta Decay

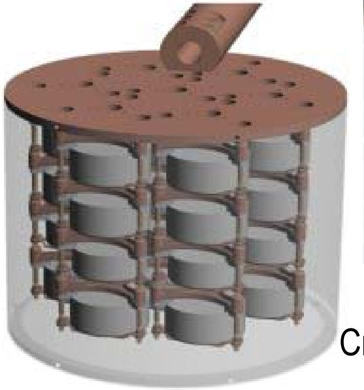
Grand challenge question: Is the neutrino its own anti-particle?

- An R&D effort on the Majorana Demonstrator (MJD) will help establish the feasibility of a tonne-scale ^{76}Ge neutrino-less double beta-decay experiment.
- The MJD technology demonstration is planned prior to a down-select between competing technologies
- MJD is on track with electroforming and with procurement and processing of enriched Ge.
- MJD went underground at the Sanford Laboratory (South Dakota) in summer 2012.
- The technology and the location of a future, international tonne-scale experiment is TBD based on the best value and the best science capability.

Germanium detector and the cryostat for the Majorana Demonstrator (MJD 40-kg ultra-clean Ge detector).



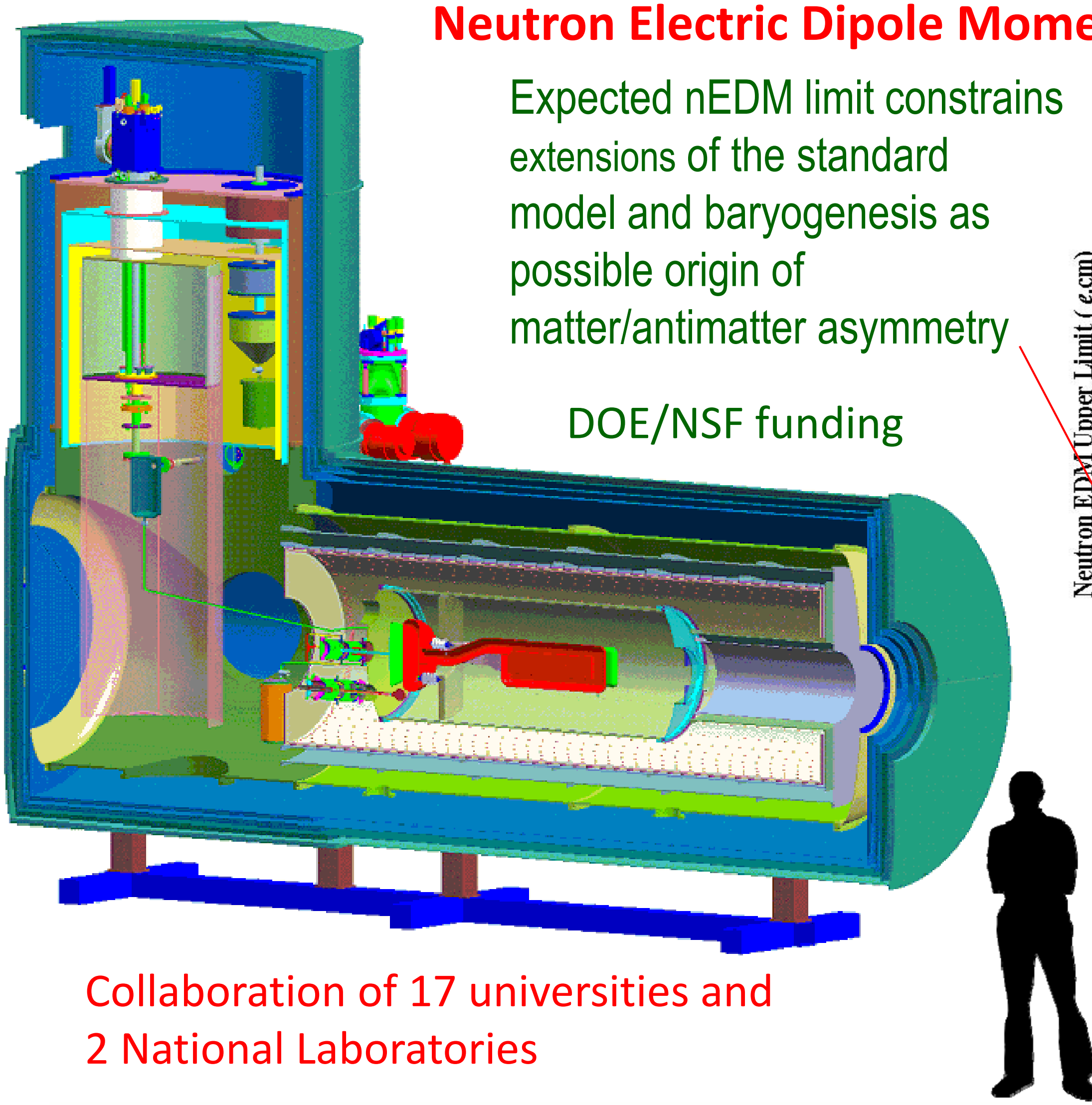
Cryostat for MJD



MJD Underground Electroforming lab at Sanford

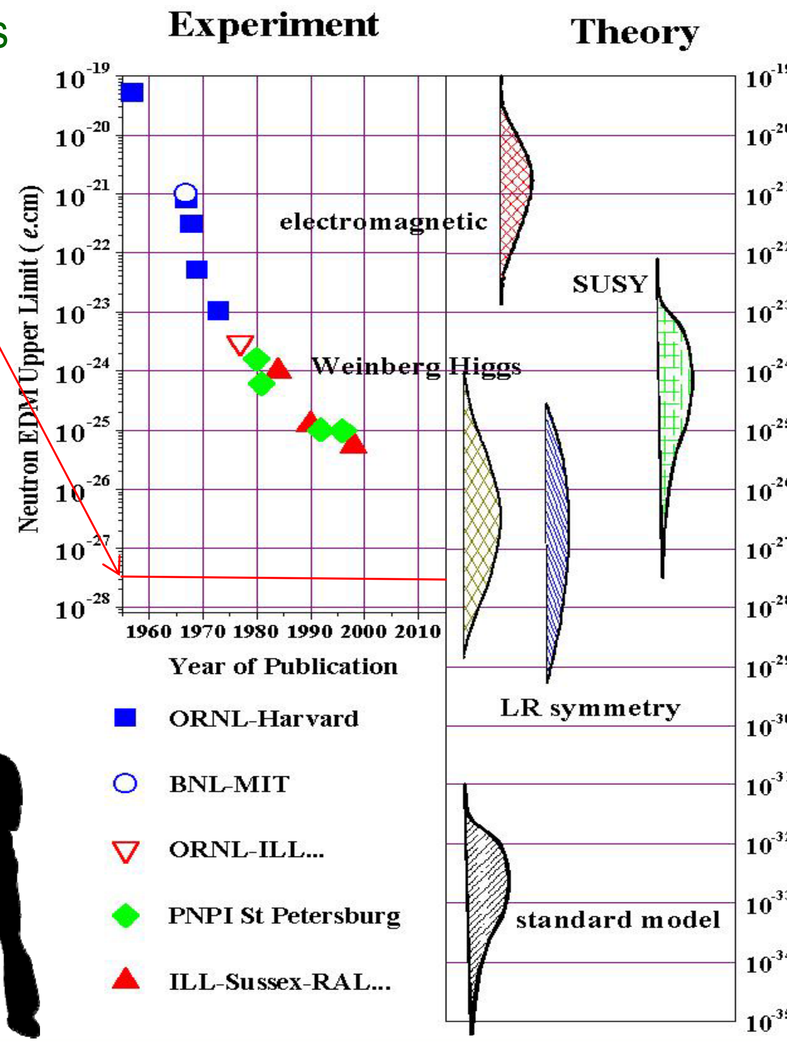
Fundamental Symmetries Using Neutrons

Neutron Electric Dipole Moment (nEDM)



Expected nEDM limit constrains extensions of the standard model and baryogenesis as possible origin of matter/antimatter asymmetry

DOE/NSF funding



Collaboration of 17 universities and 2 National Laboratories

Nuclear Theory

Research in nuclear theory spans the entire NP program

The essential role of a strong nulcear theory effort goes without saying:

- Poses scientific questions that lead to the construction of facilities
- Helps make the case for, and guide the design of new facilities, their research programs and their strategic operations plan
- Provides a framework for understanding measurements made at facilities
- Topical Collaborations (fixed-term, multi-institution collaborations established to investigate a specific topic) appear to have been very successful and, resources permitting, the model will likely be continued

Maintaining adequate support for a robust nuclear theory effort is essential to the productivity and vitality of nuclear science

NP will continue to provide Isotopes and Radioisotopes in Short Supply

Some key isotopes and radioisotopes and the companies that use them

Strontium-82, Rubidium-82	Imaging / Diagnostic cardiology
Germanium-68, Gallium-68	Calibration / PET scan imaging
Californium-252	Oil and gas exploration and manufacturingcontrols
Selenium-75	Radiography / Quality control
Actinium-225, Yttrium-90, Rhenium 188	Cancer / Infectious disease treatment
Nickel-63	Explosives detection at airports
Gadolinium-160, Neodymium-160	Tracers and contrast agents for biological agents
Iron-57, Barium-135	Standard sources for mass spectroscopy
Sulfur-34	Environmental monitoring
Rubidium-87	Atomic frequency / GPS applications
Lithium-6, Helium-3	Detection of Special Nuclear Materials
Samarium-154	Solar energy /transportation applications

NRD
ISOFLEX
GE Healthcare
Bracco Diagnostics Inc.
QSA GLOBAL
GE Energy
Schlumberger
Westinghouse
Inorganic Ventures
Isotope Products Laboratories
General Atomics and Affiliated Companies
Frontier Technology Corporation
Memorial Sloan-Kettering Cancer Center
Actinium Pharmaceuticals
PerkinElmer
NEC Corporation of America
Pain Therapeutics, Inc.
Spectrum Techniques
Boston Medical Center
The Linde Group
Alpha V
ICON
CIL
Excelitas Technologies
Thermo Fisher Scientific
Sanders Medical
Medical Isotopes, Inc.
Aldrich Chemistry

ATTA-3 at ANL to be Used to Map Major Aquifers around the World

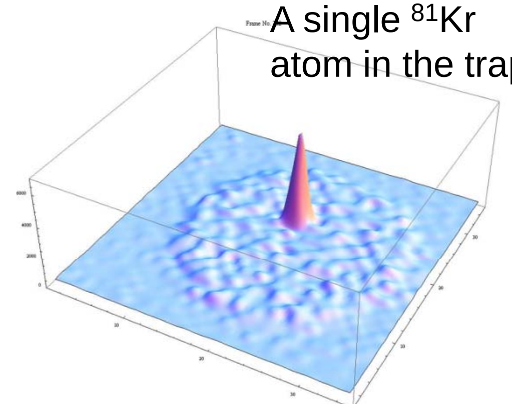
Developed ATTA-3 instrument with greatly improved sensitivity and selectivity

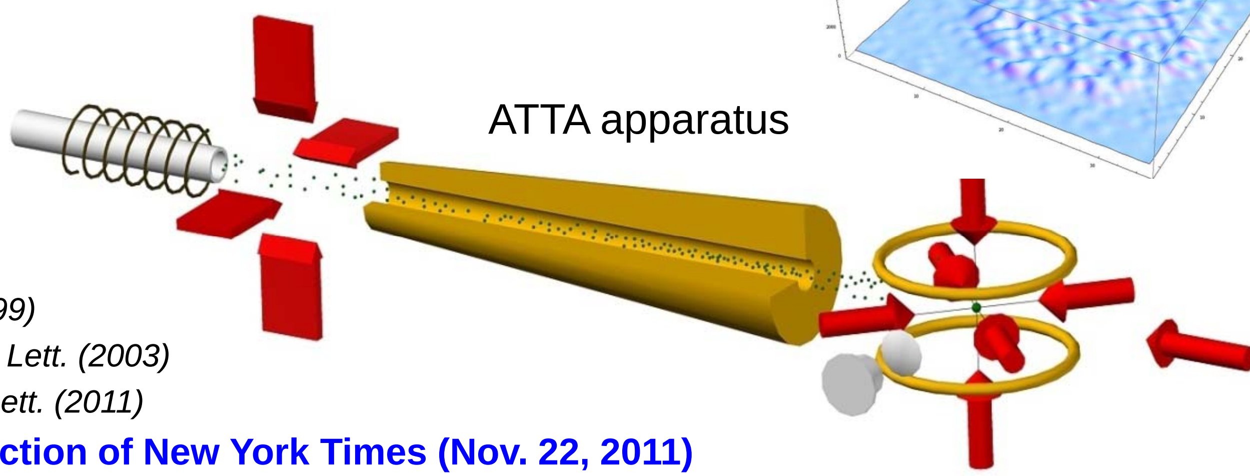
- Sensitivity: Capable of ^{81}Kr-dating with a sample of 10 micro-liter (STP) of krypton gas;
- Selectivity: Analyzed ^{39}Ar in environmental samples at the isotopic abundance level of 8×10^{-16}.

^{81}Kr-dating realized with a range of applications in earth & environmental sciences

Samples to be analyzed in 2011-2012

- Done: Yellowstone National Park, WIPP sites (with Sandia);
- In progress: Great Artesian Basin, Australia;
- In plan: Participate in a comprehensive study of world-wide aquifers (with IAEA).


A single ^{81}Kr atom in the trap


ATTA apparatus

References

- ATTA-1: *Chen et al., Science (1999)*
- ATTA-2: *Du et al., Geophys. Res. Lett. (2003)*
- ATTA-3: *Jiang et al., Phys. Rev. Lett. (2011)*
- **Featured in the Science Section of New York Times (Nov. 22, 2011)**

Nuclear Physics

Discovering, exploring, and understanding all forms of nuclear matter

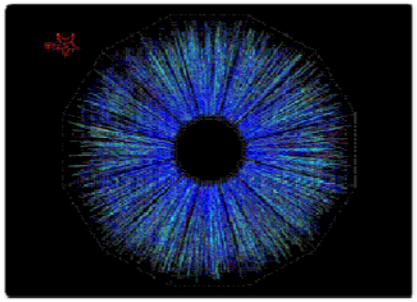
The Scientific Challenges:

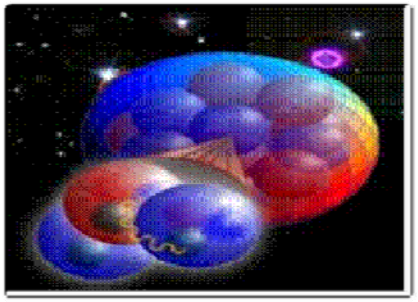
Understand:

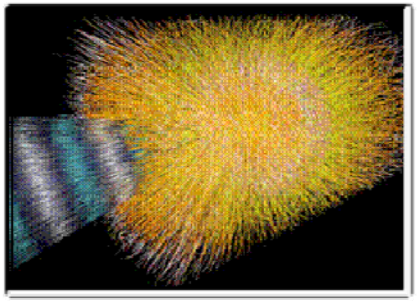
- The existence and properties of nuclear matter under extreme conditions, including that which existed at the beginning of the universe
- The exotic and excited bound states of quarks and gluons, including new tests of the Standard Model
- The ultimate limits of existence of bound systems of protons and neutrons
- Nuclear processes that power stars and supernovae, and synthesize the elements
- The nature and fundamental properties of neutrinos and neutrons and their role in the matter-antimatter asymmetry of the universe

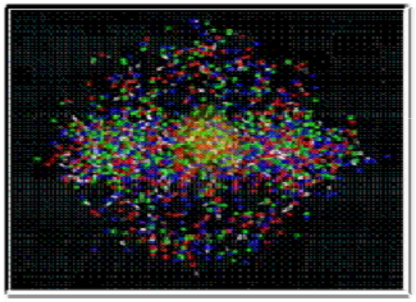
FY 2013 Highlights:

- Operations and research at three national nuclear science user facilities (RHIC, CEBAF, ATLAS).
- 12 GeV CEBAF Upgrade to study systems of quarks and gluons and the force that creates protons and neutrons.
- Continued preparation for construction of the Facility for Rare Isotope Beams to study the limits of nuclear existence.
- Research, development, and production of stable and radioactive isotopes for science, medicine, industry, and national security.
- Planning for comparative review of university and laboratory research in FY 2013.

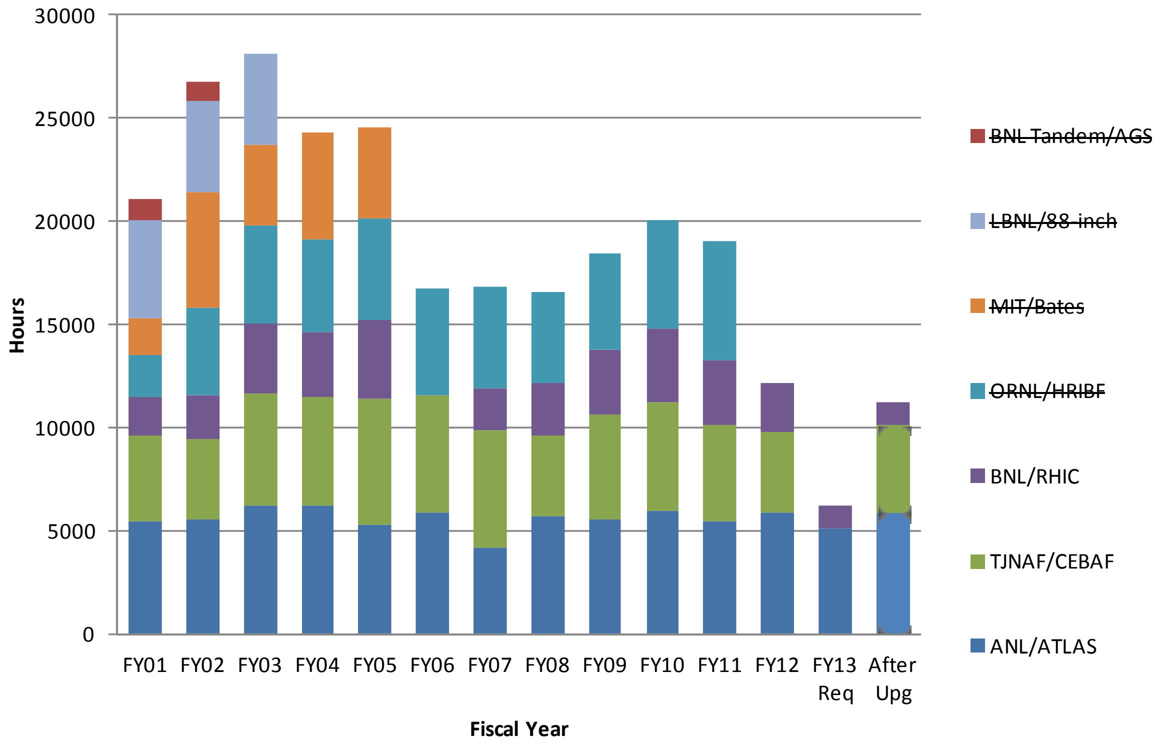








Status of Running Hours at NP User Facilities



	FY2012	FY 2013 PB	Optimum	FY13 %
RHIC	2,390	1,360	4,100	33%
CEBAF	3,940	0	0	0%
ATLAS	5,900	4,000	5,000	80%
Total	12,230	5,360	9,100	38%

NP Facilities operate at well below optimum utilization in FY2013

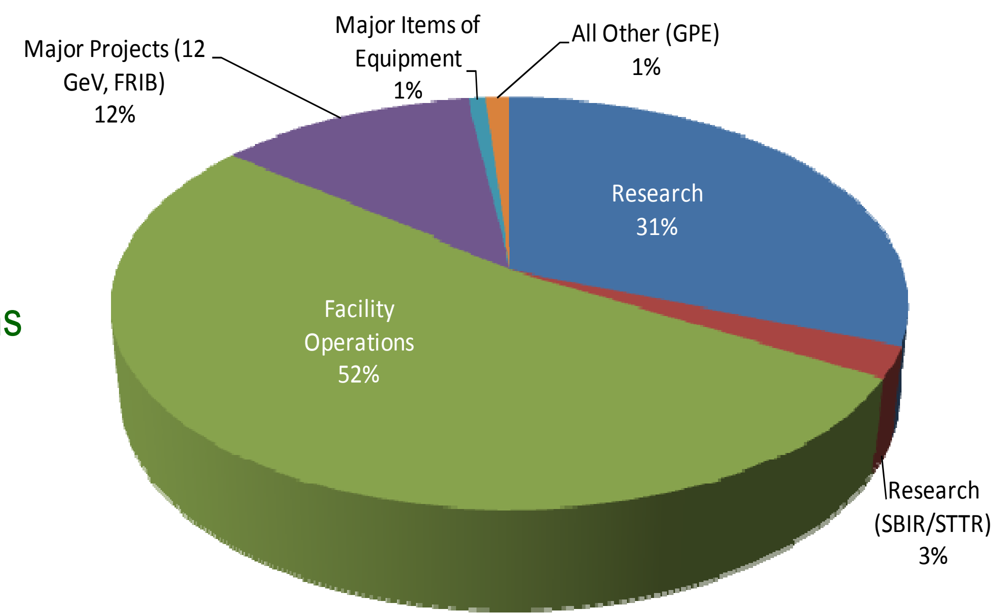
- RHIC Operations – In FY2013 request RHIC is supported for 1,360 hours (9-11 weeks)
- CEBAF Operations – Planned shutdown during FY 2013 for installation of 12 GeV Upgrade (lengthened)
- ATLAS Operations – Maximum number of hours ATLAS can operate in FY 2013 is 5,000 due to intensity upgrade
- HRIBF Operations – Operations as a national user facility ceased April 15, 2012

FY 2013 Congressional Request
Nuclear Physics by Major Category

66% of the FY 2013 NP budget supports operations or construction of facilities & instrumentation

The percentage devoted to major projects is 12% in FY 2013

Facillity operations are significantly constrained



Two consecutive cuts of ~5% (FY 12) and ~8% (FY 13) in research grant funding have increased the management challenge for research

ECA Program is also within this portfolio

FY 2013 Congressional Request
Total = $526.9M

* Within this portfolio, NP is managing 2 MIE projects in 2012

DOE—NSF Charge to NSAC

Seeking guidance in light of constrained funding

DOE and NSF are making significant progress toward achieving the vision of the 2007 Long Range Plan for Nuclear Science. However, DOE and NSF now seek your advice to continue the vision in the Plan so that the recommendations can move forward in light of projected constrained budgets.

We seek advice from NSAC on implementing the priorities and recommendations of the 2007 Long Range Plan in light of projected budgetary constraints and for guidance on developing a plan to implement the highest priority science in the context of likely available funding and world-wide capabilities. We request that NSAC examine the existing research capabilities and scientific efforts, assess their role and potential for scientific advancements, and advise the two agencies regarding the time and resources needed to achieve the planned programs. Your report should describe how to optimize …

Based on the priorities and opportunities identified and recommended in the 2007 Long Range Plan, the report should discuss what scientific opportunities will be addressed, and what existing and future facilities and instrumentation capabilities would be needed by the Federal nuclear science program to mount a productive, forefront program for each of the funding scenarios.

Nuclear Physics – FY 2013 Congressional Request

Budget Structure/Subprogram	FY 2011 Approp	FY 2012 Approp	FY 2013 Request	FY 2013 to FY2012 Change $k	%
Medium Energy Nuclear Physics	134,563	132,577	135,260	+2,683	+2.0%
Heavy Ion Nuclear Physics	201,594	200,594	197,201	-3,393	-1.7%
Low Energy Nuclear Physics	105,424	105,727	98,018	-7,709	-7.3%
Nuclear Theory	42,935	39,407	37,179	-2,228	-5.7%
Isotope Program	19,670	19,082	18,708	-374	-2.0%
Construction	35,928	50,000	40,572	-9,428	-18.9%
Total *	**540,114**	**547,387**	**526,938**	**-20,449**	**-3.7%**

- FY 2011 includes SBIR/STTR for comparability