



U.S. DEPARTMENT OF  
**ENERGY**

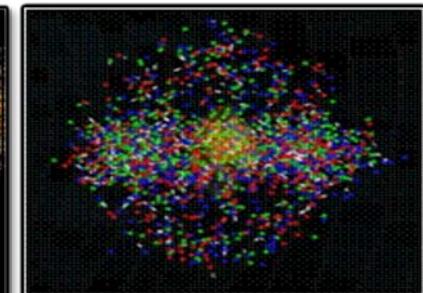
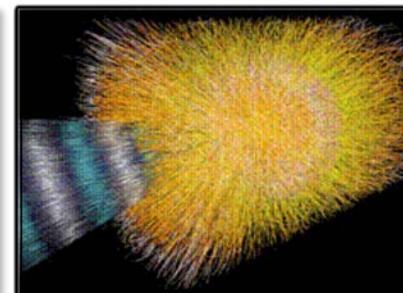
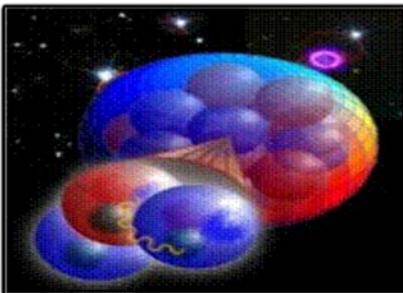
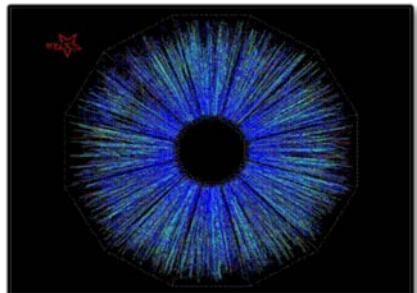
Office of  
Science

# Overview of the DOE Office of Science Nuclear Physics Program

Nuclear Science Advisory Committee Meeting

December 19, 2013

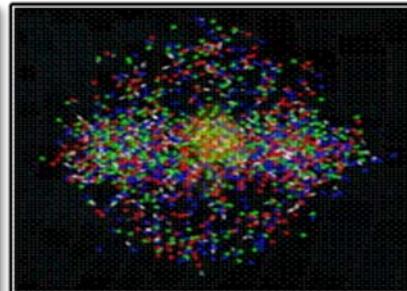
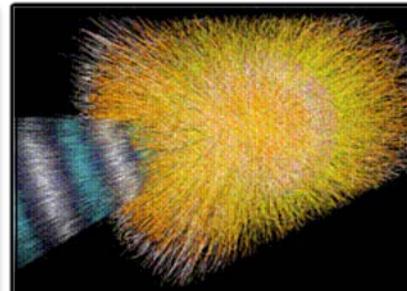
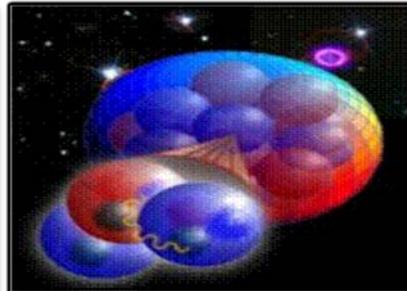
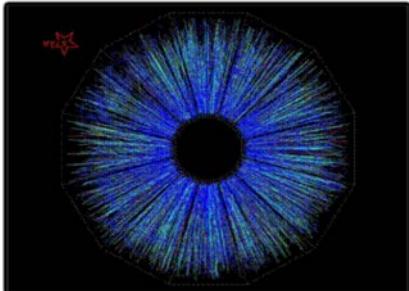
Dr. Timothy J. Hallman  
Associate Director for Nuclear Physics  
DOE Office of Science



**Discovering, exploring, and understanding all forms of nuclear matter**

## The Scientific Challenges

- 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



# SC NP is a Primary Federal Steward of U.S. Nuclear Science

DOE/SC is the largest supporter of nuclear physics in the U.S. and operates large National User Facilities

## Responsible for Strategic Planning and Funding

- Identify the scientific opportunities for discoveries and advancements
- Build and operate forefront facilities to address these opportunities
- Develop and support a research community that delivers significant outcomes
- Work with other agencies/countries to optimize use of U.S. resources

## Goals

- **World-class facility research capabilities**
  - to make significant discoveries/advancements
- **A strong, sustainable research community**
  - to deliver significant outcomes
- **Forefront advanced technologies, capabilities**
  - for next-generation capabilities
- **A well-managed and staffed, strategic sustainable program**
  - that ensures leadership/optimizes resources

## Deliverables

- New insights and advancements in the fundamental nature of matter and energy
- New and accumulated knowledge, developed and cutting-edge technologies, and a highly-trained next-generation workforce that will underpin the Department's missions and the Nation's nuclear-related endeavors
- Isotopes for basic and applied sciences

PHYSICS 2010

**Nuclear Physics**  
Exploring the Heart of Matter



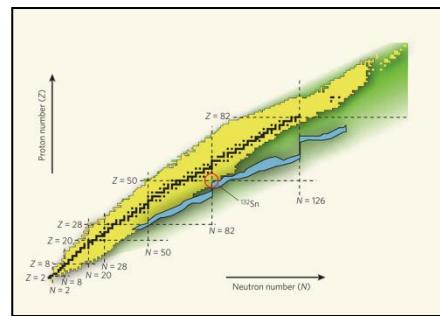
NATIONAL RESEARCH COUNCIL  
OF THE NATIONAL ACADEMIES

# The FY 2014 Presidential Request and House and Senate Marks

	FY 2013 Approp	FY 2014 President's Request	FY 2014 House Mark	Change from Request	FY 2014 Senate Mark	Change from Request
<b>Operations and Maintenance</b>	<b>479,287</b>	<b>544,438</b>	<b>526,413</b>	<b>-18,025</b>	<b>544,438</b>	<b>0</b>
<i>Marks within Operations and Maintenance</i>						
<i>Facility for Rare Isotope Beams</i>	22,000	55,000	55,000	0	55,000	0
<i>RHIC Operations</i>	155,021	165,224	165,224	0	165,200	-24
<i>ATLAS Operations</i>	16,429	17,255	—	—	17,255	0
<b>Construction</b>						
12 GeV CEBAF Upgrade (TEC)	40,572	25,500	25,500	0	25,500	0
<b>TOTAL NP</b>	<b>519,859</b>	<b>569,938</b>	<b>551,913</b>	<b>-18,025</b>	<b>569,938</b>	<b>0</b>

- The **House Mark** provides **\$18M less than the FY 2014 Request** and direction on funding for FRIB and RHIC operations. With research essentially flat in the FY 2014 Request, the cut needs comes from the remainder of the program.
- The **Senate Mark** provides **the FY 2014 Request** with a minor change to the amount earmarked for RHIC Operations.

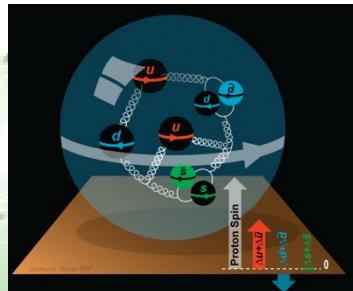
# JLab: Medium Energy Nuclear Science and Some Broader Impacts



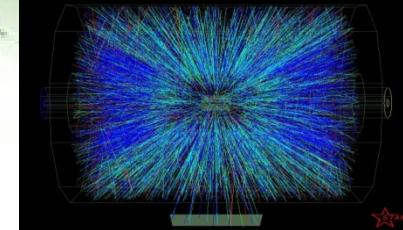
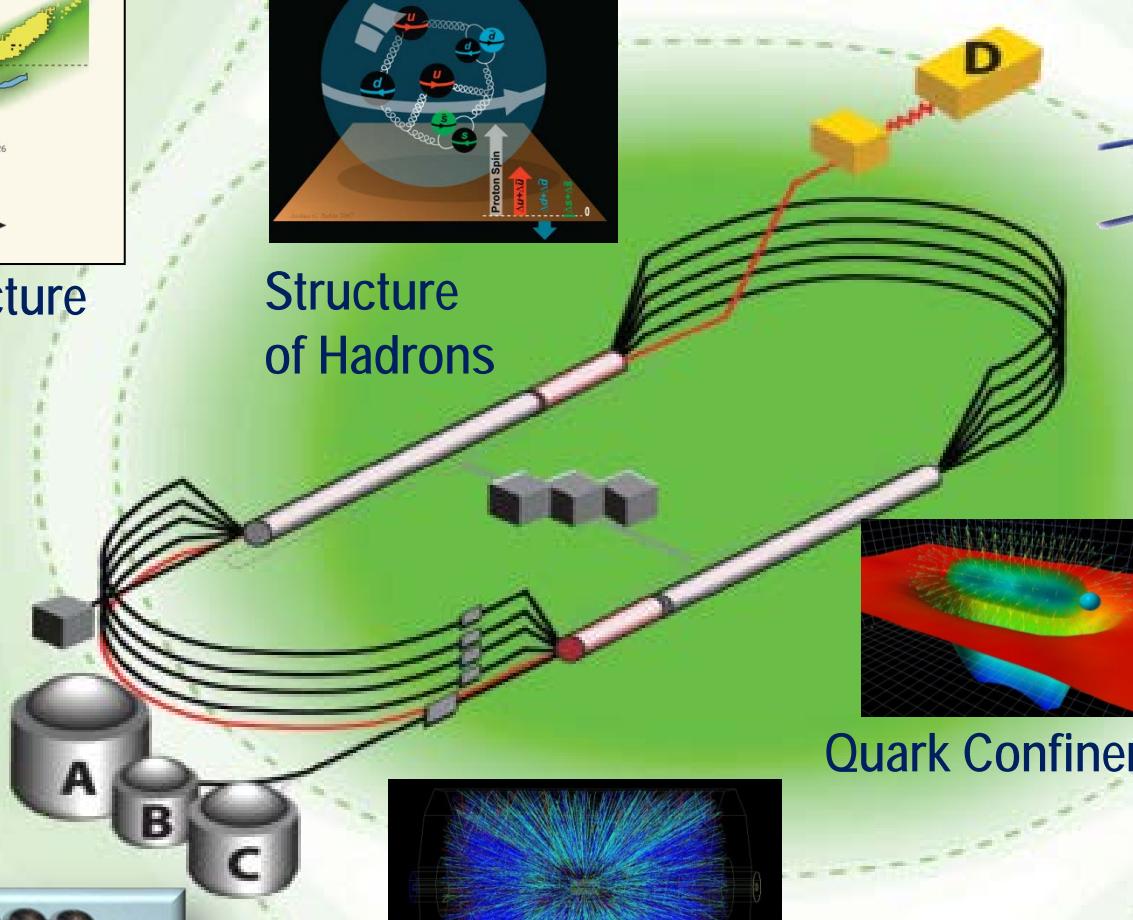
Nuclear Structure



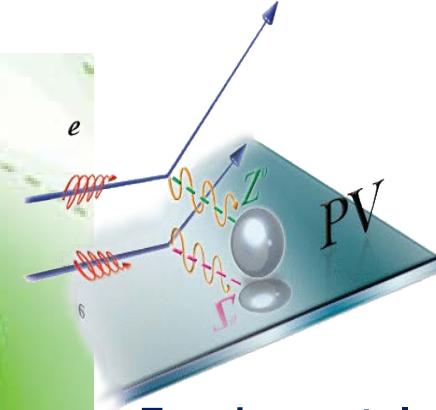
Medical Imaging



Structure of Hadrons



Hadrons from QGP



Fundamental Forces & Symmetries



Accelerator S&T

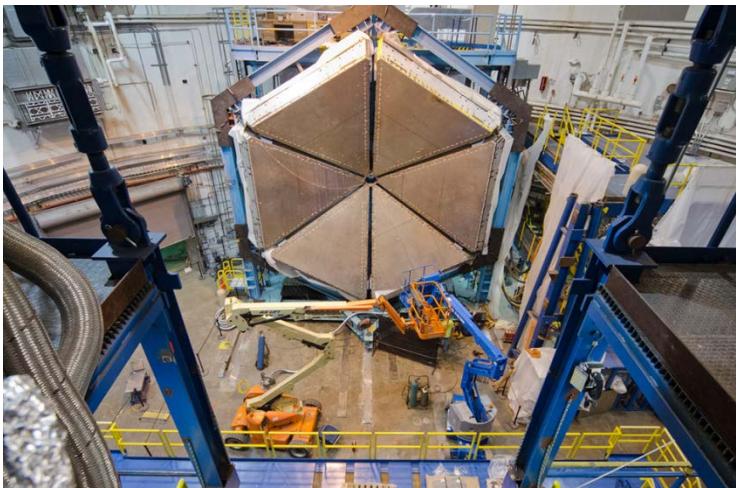


Theory and Computation

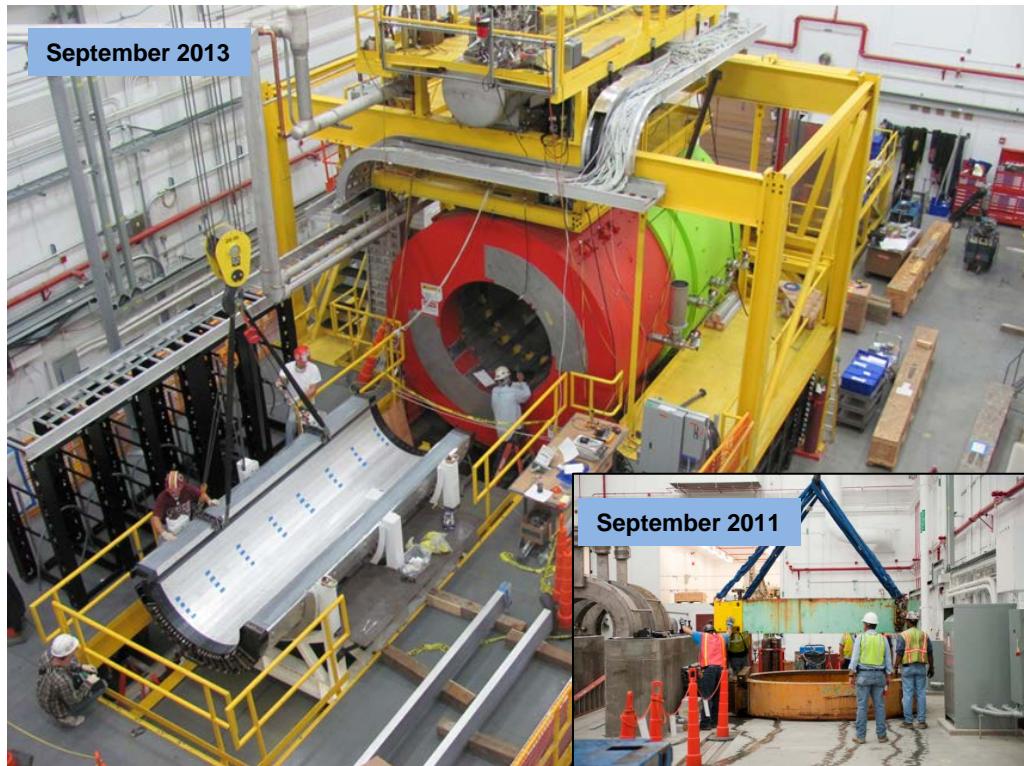
# The 12 GeV CEBAF Upgrade at TJNAF is ~ 83% Complete

**With the completion of the 12 GeV CEBAF Upgrade, researchers will address:**

- The search for exotic new quark anti-quark particles to advance our understanding of the strong force
- Evidence of new physics from sensitive searches for violations of nature's fundamental symmetries
- A detailed microscopic understanding of the internal structure of the proton, including the origin of its spin, and how this structure is modified when the proton is inside a nucleus



Experimental Hall B  
Steelwork nearing  
completion



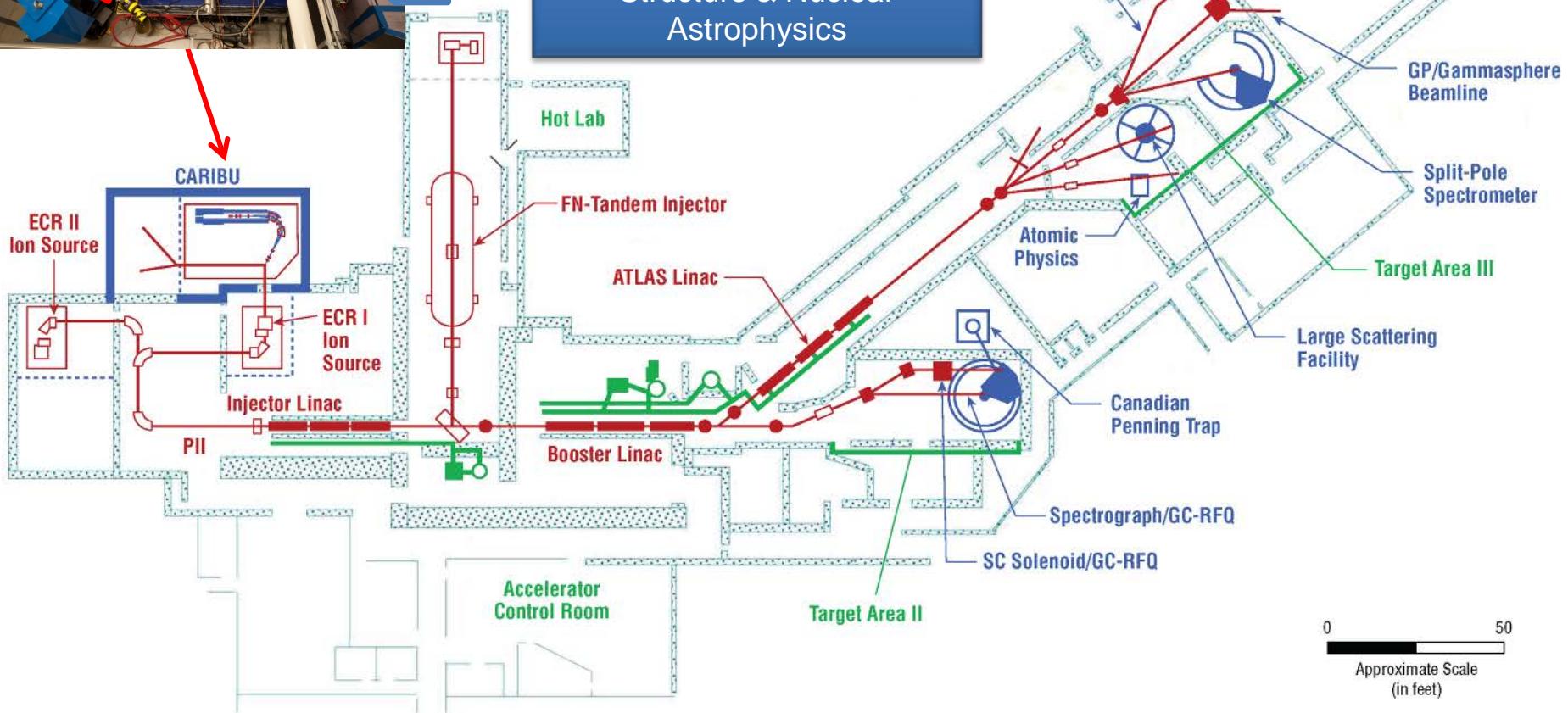
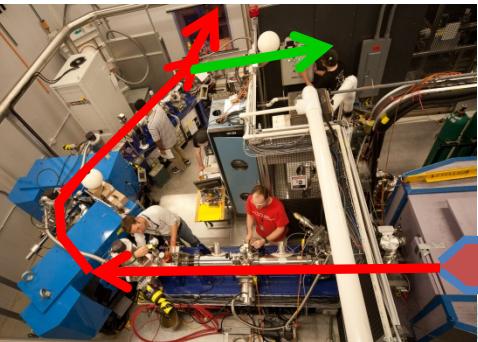
Accelerator installation nearing  
end of 16-month shutdown

**Project was re-baselined  
in September 2013 with  
a Total Project Cost of  
\$338M and completion  
in September 2017**

# ATLAS at ANL Uniquely Provides Low Energy SC Research Opportunities Through Most of the Coming Decade

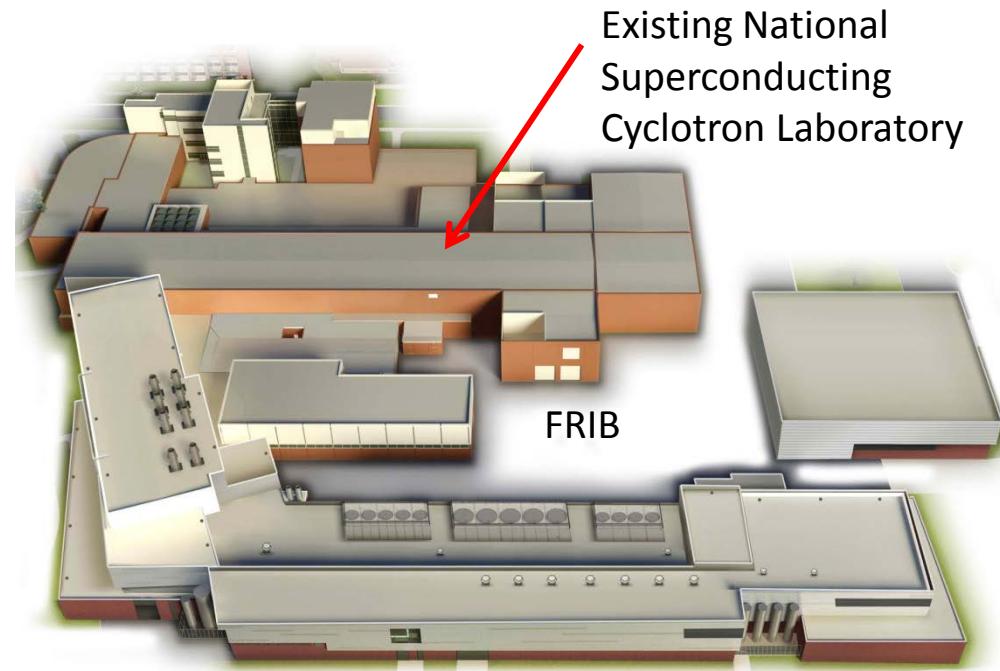
## ATLAS

ATLAS is a unique premier Stable Beam Facility for research on Nuclear Structure & Nuclear Astrophysics



# Facility for Rare Isotope Beams

"On August 1, 2013, the Department of Energy's Office of Science approved Critical Decision-2 (CD-2), Approve Performance Baseline, and Critical Decision-3a (CD-3a), Approve Start of Civil Construction and Long Lead Procurements, for the Facility for Rare Isotope Beams (FRIB) construction project, which will be located at Michigan State University.



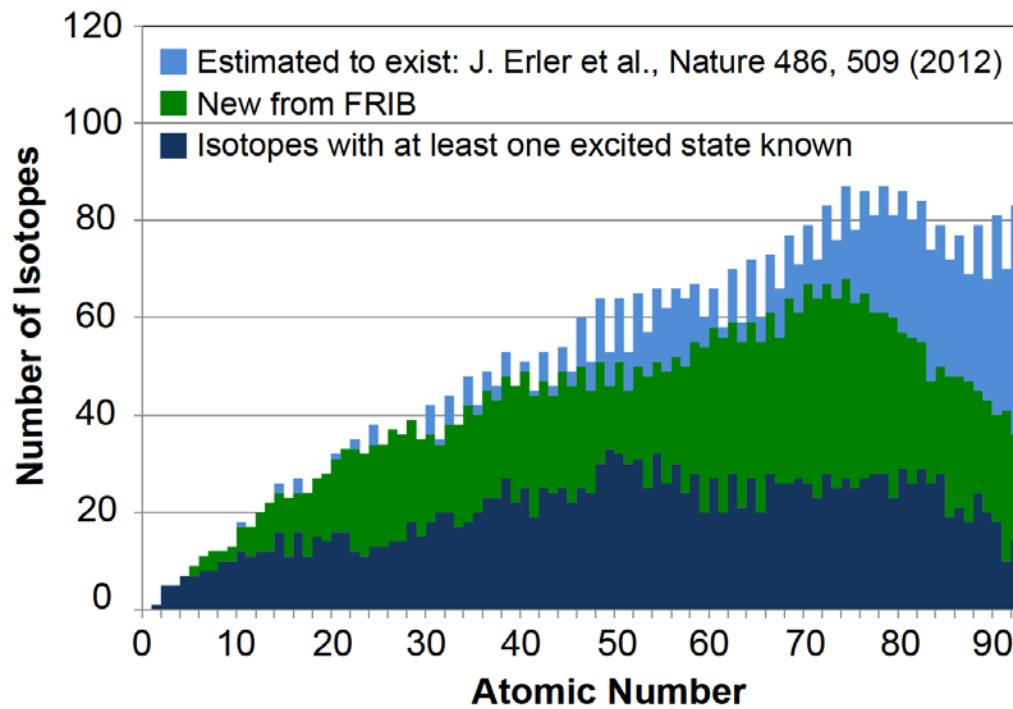
As with other DOE Office of Science construction projects, CD-2 formally establishes the cost and schedule for the FRIB project. The Total Project Cost for FRIB is \$730M, of which \$635.5M will be provided by DOE and \$94.5M will be provided by Michigan State University. The project will be completed by 2022.

The CD-3a decision allows the project to proceed with long lead procurements. Commencement of the start of civil construction is subject to a Fiscal Year 2014 appropriation.

FRIB will be constructed under a Cooperative Agreement between MSU and DOE

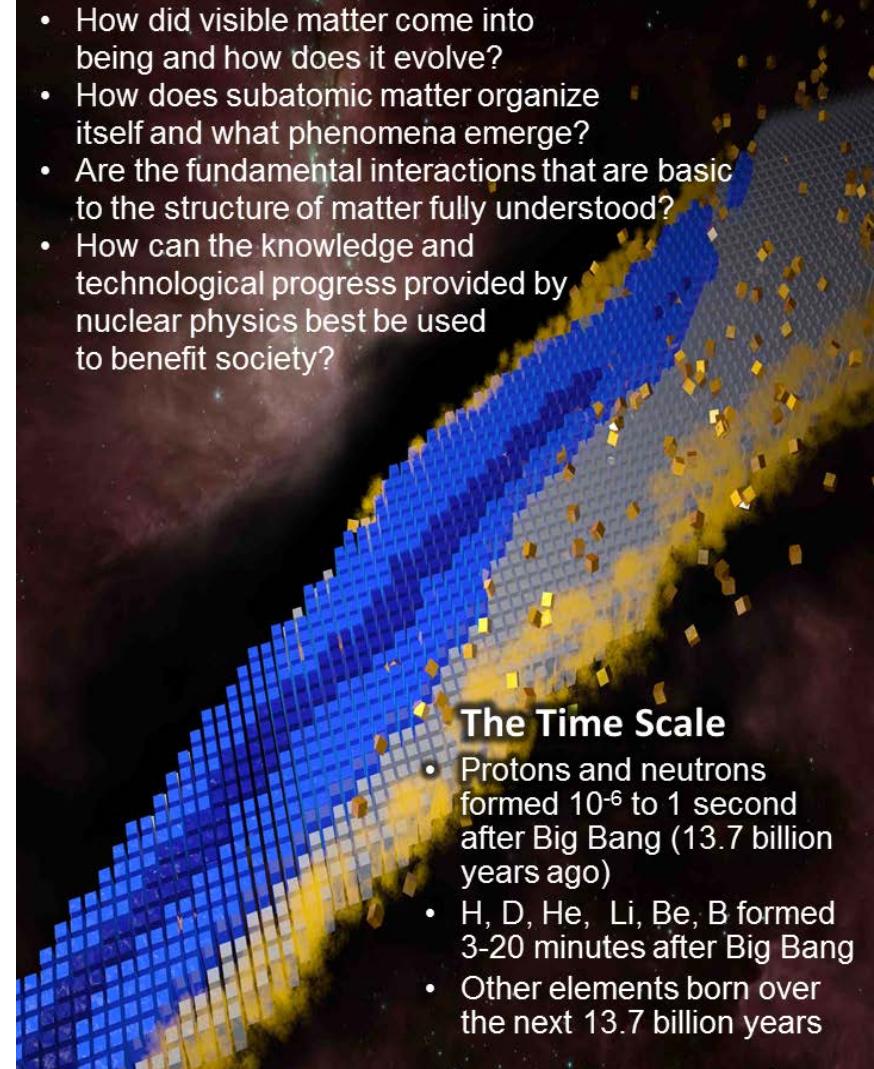
# FRIB: 21st Century Science Questions

- 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



## NRC Decadal Study Overarching Questions

- How did visible matter come into being and how does it evolve?
- How does subatomic matter organize itself and what phenomena emerge?
- Are the fundamental interactions that are basic to the structure of matter fully understood?
- How can the knowledge and technological progress provided by nuclear physics best be used to benefit society?

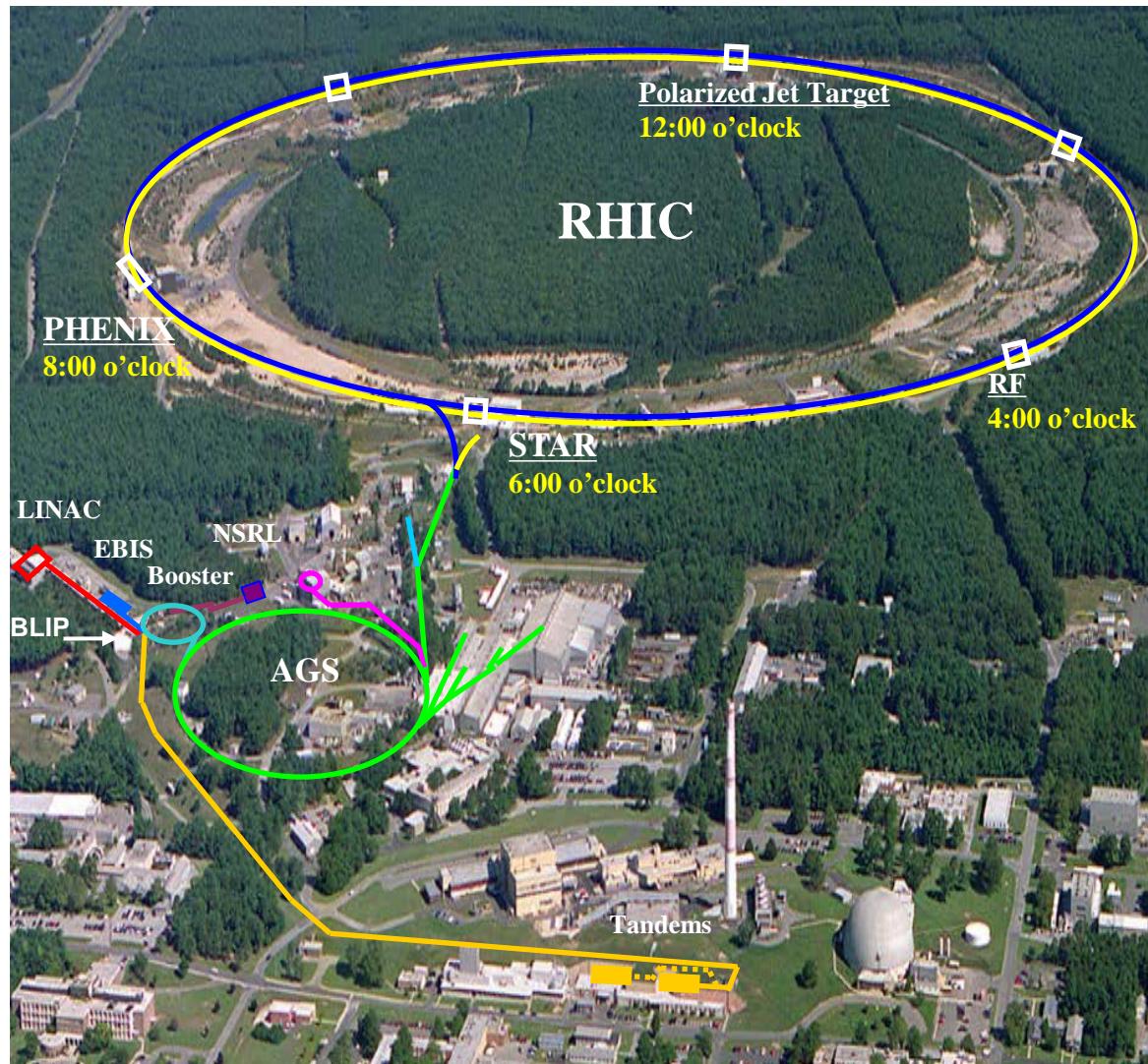


# Research at the Relativistic Heavy Ion Collider

**RHIC, the most capable and successful collider operation in the world, discovered a completely new state of matter—a perfect quark-gluon liquid.**

Over 1200 scientists from 134 institutions in 17 countries continue to urgently research the properties (e.g., transport properties, equation of state, degrees of freedom) of this new state of matter by actively taking data and participating in the RHIC experimental program. Collaborating countries include: the United States, Brazil, China, Croatia, Czech Republic, Finland, France, Germany, Hungary, India, Israel, Japan, Pakistan, Poland, Russia, South Korea, Sweden.

Researchers from institutions outside of the U.S. provide very significant benefits to leverage the U.S. program through contributed capital, human capital, experimental equipment, and intellectual contributions.



# RHIC Science is at a “Watershed” Moment

**RHIC has discovered a completely new state of matter  
(a perfect quark-gluon liquid)**

There is a rich program of science ongoing and planned in the next 3 -5 years 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 and knowledge gained
- search for new discoveries such as the postulated Critical Point in the phase diagram of QCD
- explore the gluon and sea quark contributions to the spin of the proton using the only collider with polarized beams

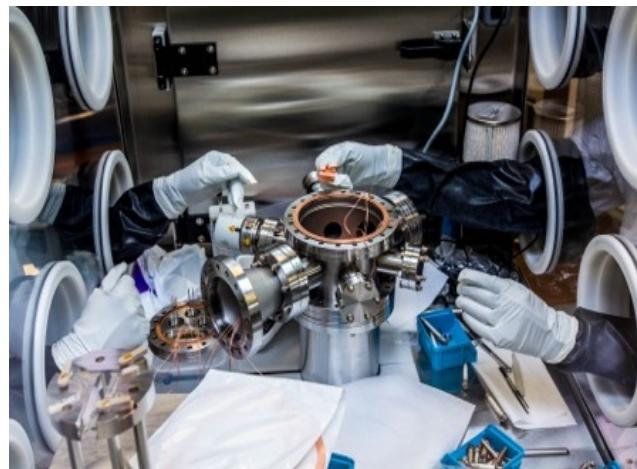
# Preparations for NP Stewardship Neutrino-less Double Beta Decay Experiments

R&D on one of several approaches by U.S. scientists is ongoing at Lead, South Dakota



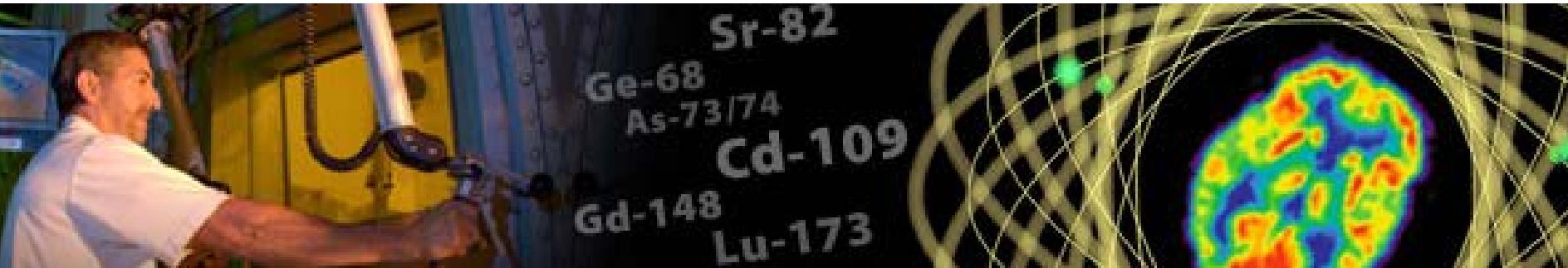
4800 feet below ground, the copper needed for a cryostat to cool sensitive Germanium detectors is being electroformed to avoid induced backgrounds caused by cosmic rays

With techniques that use nuclear isotopes inside cryostats, often made of ultra-clean materials, scientists are “tooling up” to study whether neutrinos are their own anti-particle. The answer could help determine why the matter/anti-matter ratio today is far different than in the early cosmos.



The cyrostat, made from some of the purest copper in the world, is also prepared 4800 ft underground

# Isotope Program Mission



## The mission of the DOE Isotope Program is threefold

- Produce and/or distribute radioactive and stable isotopes that are in short supply, associated byproducts, surplus materials and related isotope services.
- Maintain the infrastructure required to produce and supply isotope products and related services.
- Conduct R&D on new and improved isotope production and processing techniques which can make available new isotopes for research and applications.

Produce isotopes that are in short supply only – The Isotope Program does not compete with industry

**More than 225 customer orders in FY2013**

**More than 470 shipments in FY2013**

# From Discovery to Deployment

## R&D Creates New Production Method for Actinium-225



- A new isotope project at LANL shows promise for rapidly producing major quantities of a new cancer-treatment agent, actinium 225.
- Using proton beams, LANL and BNL could match current annual worldwide production of the isotope in just a few days.
- A collaboration among LANL, BNL, and ORNL is developing a plan for full-scale production and stable supply of Ac-225.
- Ac-225 emits alpha radiation. Alpha particles are energetic enough to destroy cancer cells but are unlikely to move beyond a tightly controlled target region and destroy healthy cells. Alpha particles are stopped in their tracks by a layer of skin—or even an inch or two of air.

# NP News and Events

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- Pass back delayed until January 2014
- Successful RHIC Operations Review carried out by the Office of Project Assessment on August 6-8, 2013. "RHIC Operations efficient, cost effective, and appropriately scoped"
- 12 GeV Upgrade rebaselined in September 2013. New TPC is \$338M.
- FRIB baselined (CD2/3a) August 1<sup>st</sup>, after Lehman review June 4-6. Baseline assumes a construction start April 1, 2014
- SC Facilities Charge exercise nearing completion
- NP 2013 Comparative Research Review Completed
- DBD charge given to NSAC
- Mo-99 charge given to NSAC
- The Isotope Program held a second Federal Isotope Workshop, September 19, 2013
- Plans are beginning to be discussed related to possible FY2014 NSAC Charges
- Dan Lehman is retiring January, 2014
- nEDM had successful review December 2013 retiring a number of concerns from the NSAC review
- DOE implementation strategy related to open access proposed to OSTP

## What's New

### **2014 DOE NP Competitive Review of New Proposals**

As part of its ongoing effort to steward a research program of the highest quality and impact, the DOE Office of Nuclear Physics (NP) is planning to hold a competitive review of all new University and National Laboratory research proposals received from October 1, 2013 until May 1, 2014. The review will take place in the summer 2014 timeframe in order to inform FY 2015 NP Research Division awards, subject to the availability of funds. Applications received during the period May 2 – September 30, 2014 may not receive consideration for funding until FY 2016. The planned competitive review will address topics and proposed activities within the portfolio of the NP Physics Research Division. Research efforts that are not included in this review are the Accelerator R&D Program, the Isotope Program, the Nuclear Data Program, the NP SciDAC Program, Topical Collaborations in Nuclear Theory, and international collaboration awards.

This guidance is specific to the Office of Nuclear Physics and supplements the Office of Science (SC) annual [Funding Opportunity Announcement \(FOA\) DE-FOA-0000995](#) (306KB). Further information on the competitive research review process will be posted.

# Update on COV Recommendations

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The COV recommended in 2007 and stressed again in 2010 that it was imperative to develop and implement a database to track relevant proposal and grant information. We reiterate the critical need for the rapid implementation of such a database.

We recommend that NP track the participation of underrepresented groups and make the information available. The COV urges that the necessary authorization be obtained, consistent with Federal requirements, to track diversity and demographic information.

We recommend that, after the PAMS system is in operation, its effectiveness to address the relevant issues raised in this report (such as tracking demographics of the workforce, proposal and grant applications, workload of Project Managers, and impact on NP operations) be evaluated. We request that NP report to NSAC yearly on this evaluation.

**While the full functionality of PAMS has yet to be realized, partial functionality has been rolled out and is in use. As the above recommendations become possible in the foreseeable future, they will be addressed using PAMS**

# Update on COV Recommendations

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The COV recommends an increased focus on timely delivery of reports, and development of a set of written guidelines for Laboratory Review Reports to streamline the process.

Work in progress; reviews since COV have been reported out within the timeframe set by NP policy including the CRR which was a major undertaking

The COV recommends the development of a set of guidelines defining roles, responsibilities, authorities and accountability for both the research and facilities Program Managers. Such guidelines across the NP portfolio would help to consolidate best practices throughout.

Written document not yet accomplished

The NP should work with the community to enhance the peer review process for university grants such that, while continuing to be fair, it is even more discriminating in the evaluation process. The NP could consider the implementation of a quantitative component into the grant evaluation process.

Work in progress; successful experience with the Comparative Research Review; some lessons can be generalized to the standard grant peer review processes

# Update on COV Recommendations

It is essential that the NP complete the filling of the Research Division Director and Medium Energy Program Manager positions. **Work in progress**

The COV recommends that NP define the process and timeframes for the major reviews including the 2013 Comparative Review and communicate this to the field as soon as possible. It is important to provide the guidance to the PIs of the groups and to the panel as soon as possible.

**Goal accomplished**

The NP should perform further analysis of the workforce data and develop plans as needed to mitigate the impact of potentially constrained budgets on the workforce.

**Recommendation continually being addressed**

We recommend continued engagement with the User Facilities to establish facility performance metrics that more directly measure the scientific productivity of those facilities.

**Further engagement has taken place.**

The COV recommends that the coordination and the information exchange of accelerator R&D activities between SC offices be strengthened.

**NP has initiated an SC information exchange forum on accelerator R&D with HEP and BES**

# Update on COV Recommendations

We recommend a systematic assessment of computational needs across all theoretical and experimental subfields, especially for the smaller-scale projects in the Medium and Low Energy programs to see if further coordinated efforts within NP are needed.

**Survey planned starting with Fundamental Symmetries; will be released to the community shortly**

The COV endorses the creation of a distinct neutrino, neutron, and fundamental symmetries portfolio within the office.

**First step planned, Kyungseon Joo will work with Cyrus Bakdash**

We recommend that NP advocate for a change in the administration of the ECA program to give greater control to the individual programs over the size and number of ECA awards. The NP should provide direct feedback to the Early Career Award applicants regarding the relative competitiveness of their proposals, relevance to the priorities of the NP program, and potential alternative routes for funding for the declined proposals.

**Recommendation being addressed in the FY2014 process**

# Conclusion Talking Points

- **The future of nuclear science in the United States may not be exactly as envisioned in the last NP Long Range Plan, but it remains rich with science opportunities.**
- **Long term, QCD research may become consolidated around a single facility but both RHIC and TJNAF continue to have independent, distinct, vital science missions at present.**
- **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

# 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: Prioritization of scientific facilities to ensure optimal benefit from Federal investments. 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.*

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

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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

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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

The ability of the facility to contribute to world-leading science in the next decade (2014 – 2024). 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.

The readiness of the facility for construction. 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](mailto:patricia.dehmer@science.doe.gov)). Thank you for your help with this important task.

# 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.

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.

Report at:

[http://science.energy.gov/~/media/np/nsac/pdf/20130201/2013\\_NSAC\\_Implementing\\_the\\_2007\\_Long\\_Range\\_Plan.pdf](http://science.energy.gov/~/media/np/nsac/pdf/20130201/2013_NSAC_Implementing_the_2007_Long_Range_Plan.pdf)

# The NP Isotope Program Continues 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 manufacturing controls
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

