U.S. DEPARTMENT OF ENERGY | Office of Science

DOE Nuclear Physics Outlook

US-China RIB Meeting
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Peking University, Beijing China

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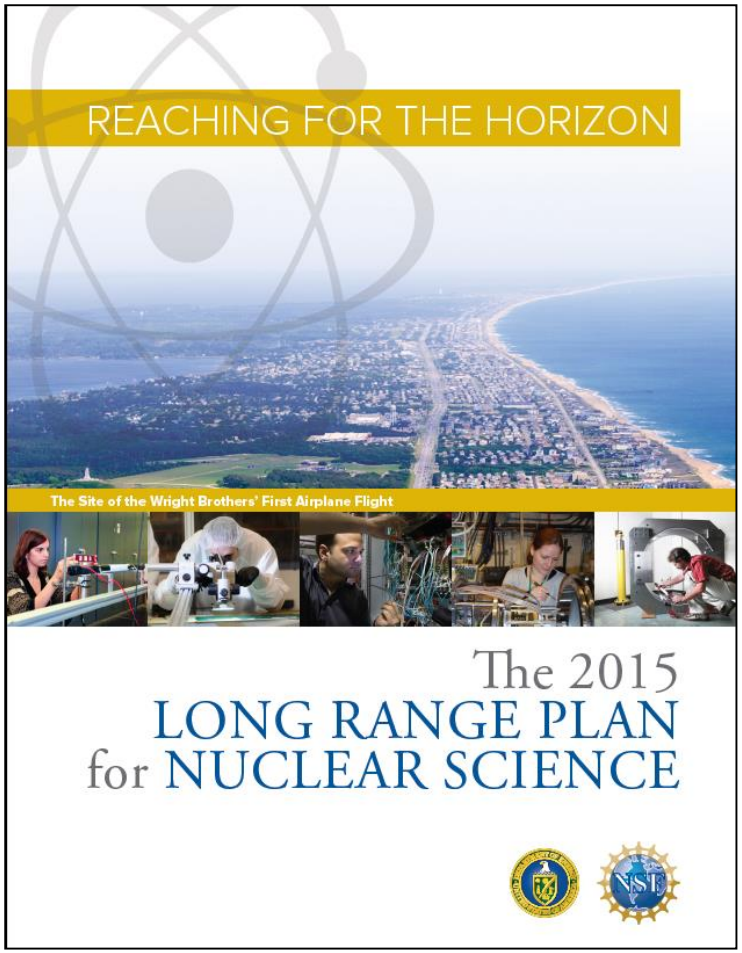
The 2015 Long Range Plan for Nuclear Science

Recommendations:

1. Capitalize on investments made to maintain U.S. leadership in nuclear science (CEBAF, FRIB, RHIC).
2. Develop and deploy a U.S.-led ton-scale neutrino-less double beta decay experiment.
3. Construct a high-energy high-luminosity polarized electron-ion collider (EIC) as the highest priority for new construction following the completion of FRIB.
4. Increase investment in small-scale and mid-scale projects and initiatives that enable forefront research at universities and laboratories.



For the moment, NP is continuing to pursue the 2015 LRP Vision

Facility for Rare Isotope Beams is > 80% Complete

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 limits of existence for nuclei
- Nuclei that have neutron skins
- 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 predictive model of nuclei and how they interact.

The FY 2018 Request supports:

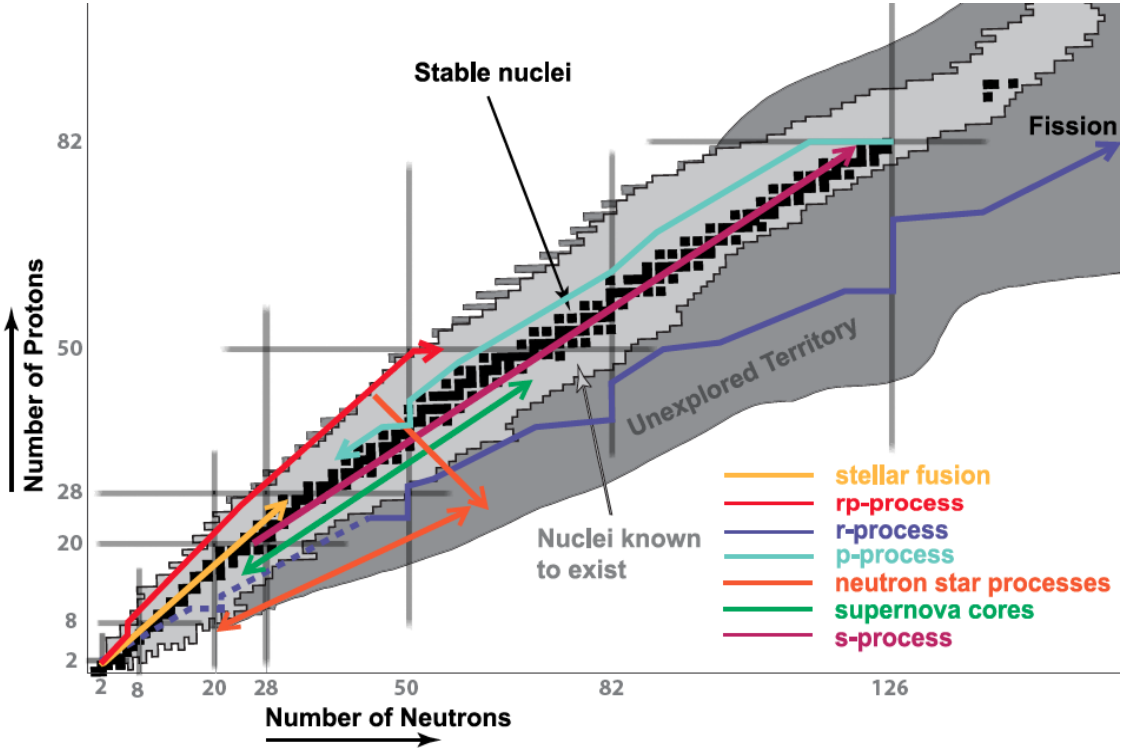
- Completing work on the fabrication and assembly of the cryogenics plant and distribution system.
- Remaining major procurements; fabrication, assembly and installation of technical systems including cryo-modules and experimental systems.
- Completing the commissioning of the FRIB ion source, and beginning the commissioning of the linear accelerator (linac) system.

FRIB Promises a Watershed in Understanding Astrophysical Scenarios

Possible New Paradigm for Production of Heavier Elements: Neutron STAR Mergers

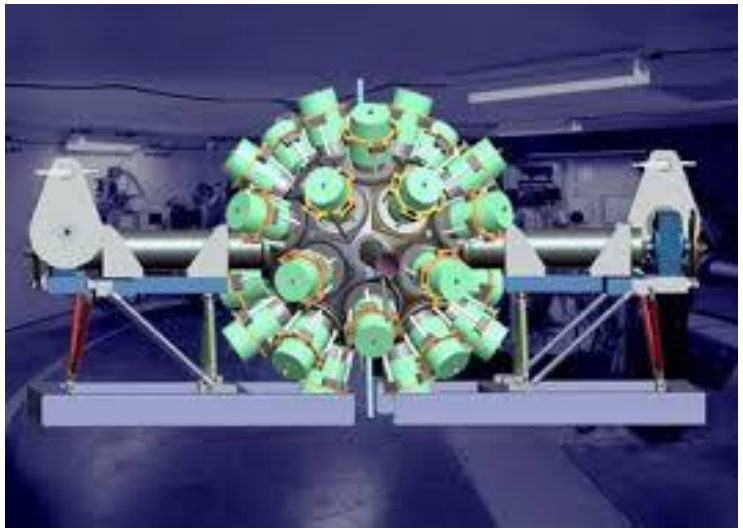
LIGO can illuminate the frequency of such events

FRIB can illuminate the r process rates for many nuclear reactions currently inaccessible, particularly for nuclei with an excess of neutrons

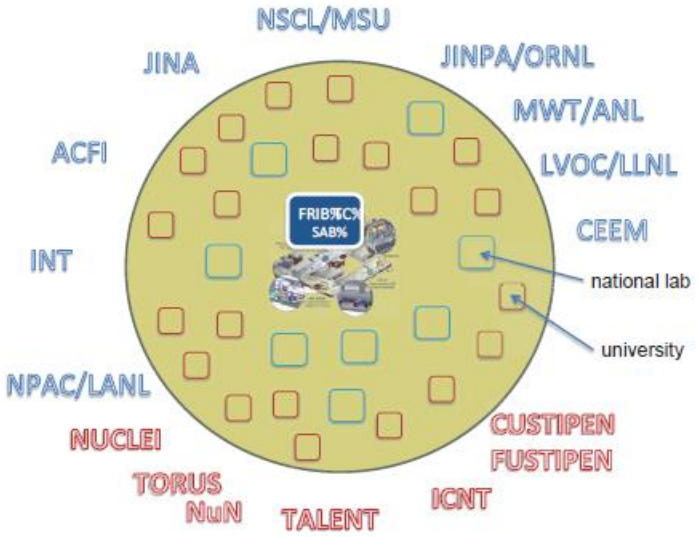


Together, LIGO and FRIB can finally "nail down" the cosmic nucleo-synthesis of heavy nuclei

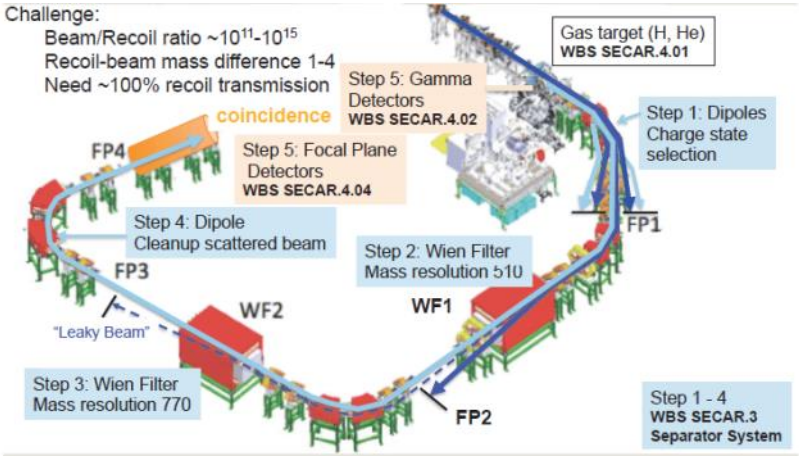
FRIB Instrumentation/Theory Effort Are Getting Underway



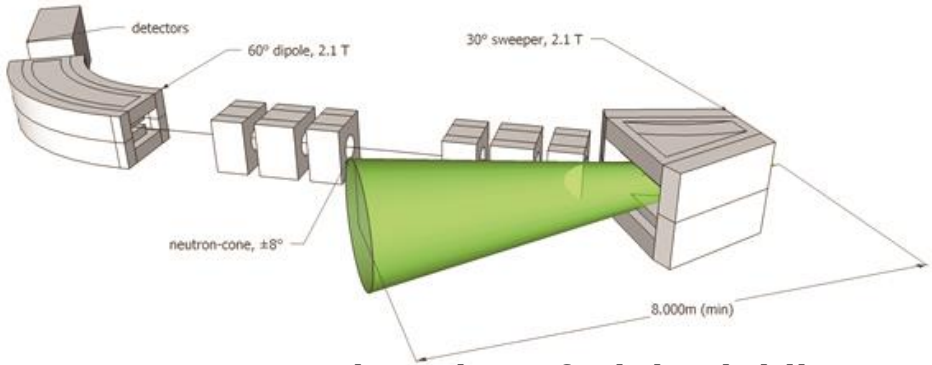
GRETA at CD1



FRIB Theory Alliance

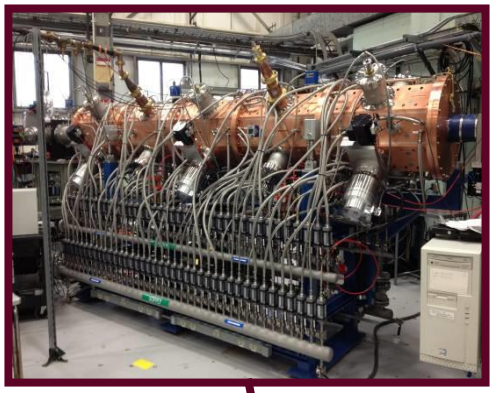


SECAR Under Construction



Pre-Conceptual Design of High Rigidity Spectrometer (HRS)

ATLAS Continues as DOE's Premier Stable Beam Facility



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

Improved instrumentation

New low-energy experimental hall

cryomodule and rebuncher rearranged

EBIS

CARIBU

Future in-flight separator (AIRIS)

MHB RFQ

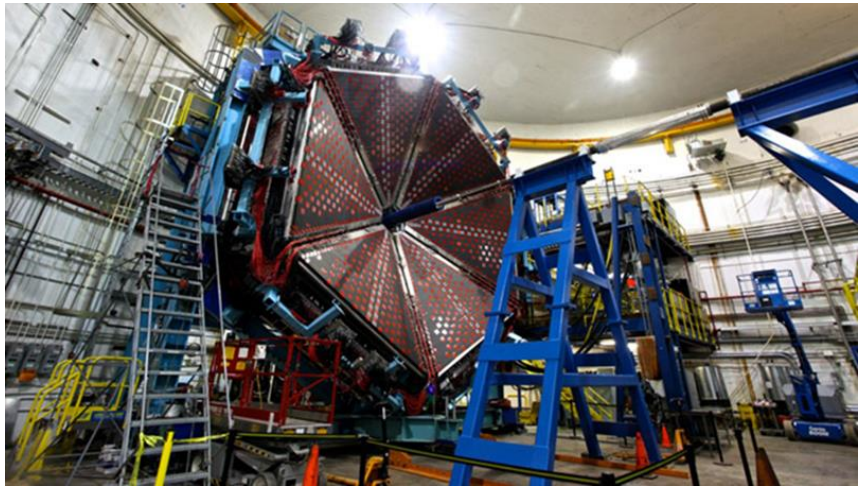
new cryomodule

The Continuous Electron Beam Accelerator Upgrade is Successfully Completed

12 GeV CEBAF Upgrade Science Program being initiated:

- The CEBAF science program restarts its first science data taking operations following the completion of the 12 GeV Upgrade.
- While concurrent operation of the 4 experimental halls is constrained by resources, sequential data taking in the four experimental halls, including the recently constructed Hall D, gets underway.

Hall D Solenoidal Spectrometer



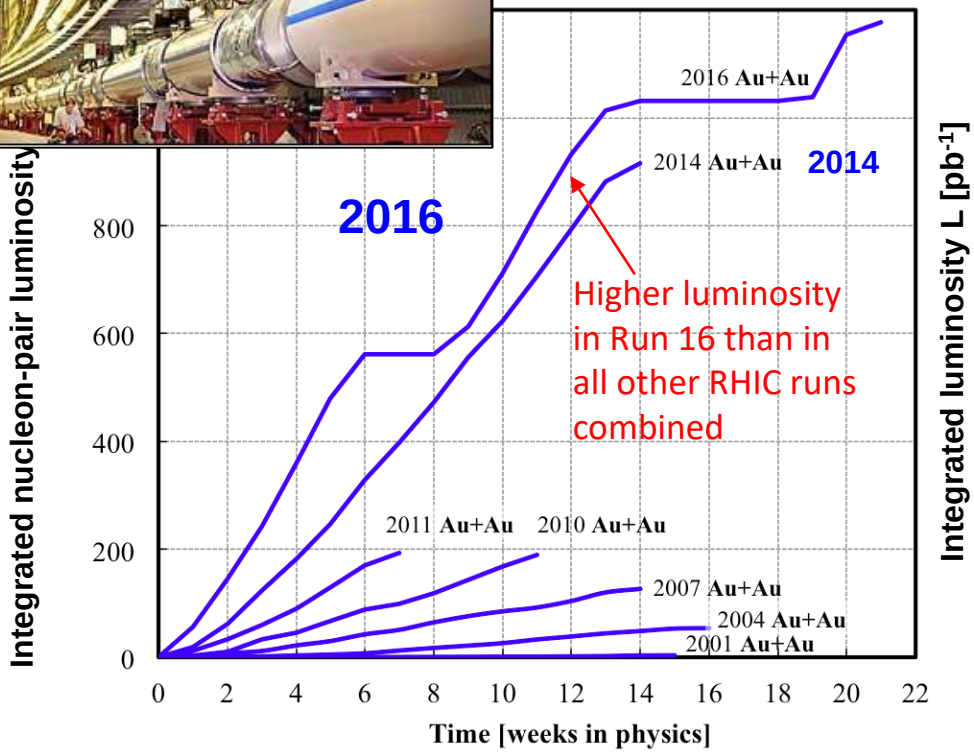
Hall B Time of Flight Detector

With the completed 12 GeV CEBAF Upgrade, researchers begin experiments to:

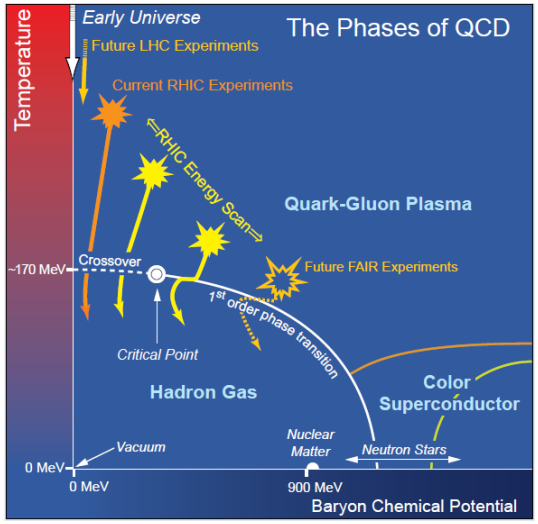
- Search for exotic new quark-anti-quark particles to advance our understanding of the strong force.
- Find evidence of new physics from sensitive searches for violations of nature's fundamental symmetries.
- Gain a microscopic understanding of the internal structure of the proton, including the origin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

Lattice QCD is essential to 12 GeV Research

RHIC Machine Performance Continues to Set New Records



- The FY 2018 request supports data taking to confirm the explanation of never-before-seen phenomena (chiral magnetic effect) in quark gluon plasma formation and preparations to search for a critical point between the phases of nuclear matter. A Critical Point search is the focus of FY19-20.
- The RHIC Spin Program is continuing with a strong focus on transverse spin asymmetries



- Consistently high facility availability (~ 85%)
- No other facility worldwide, existing or planned, rivals RHIC in science reach and versatility as a heavy ion collider. It is the only polarized proton collider in the world.

Preparations Continue for an NP Stewarded Neutrino-less Double Beta Decay Experiment

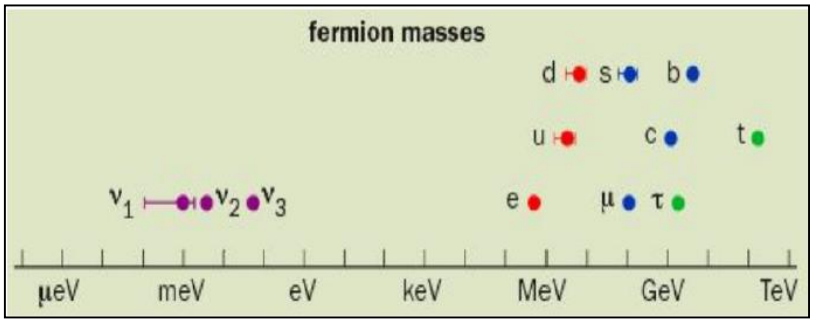
With techniques that use nuclear isotopes inside cryostats, often made of ultra-clean materials, scientists are "tooling up" to study whether neutrinos are their own anti-particle.

NSAC charged to provide additional guidance on effective strategy for implementing a possible 2nd generation U.S. experiment

Mandrel insertion in MJD electroforming lab

"Grand Challenge" science questions that will be addressed:

- Is the neutrino its own anti-particle?
- Why is there more matter than anti-matter in the present universe?
- Why are neutrino masses so much smaller than other elementary fermions?



Outlook on the Budget

U.S. budget formulation is a process informed by information gathering.

The challenge for U.S. program for the moment is to remain flexible and patient.

For the moment, The 2015 Long Range Plan for Nuclear Science continues to be pursued with vigor within available resources

The Outlook Today

- There is a wealth of science opportunity near term at ATLAS, and longer term at FRIB which will be world leading. NP is beginning to position the low energy experimental community to take full advantage of FRIB. The Theory Alliance (and support for theory in general) is also crucial.

- The U.S. has leadership roles in experimental QCD research. CEBAF and RHIC are both unique and at the “top of their game” with compelling “must-do” science in progress or about to start. Long term, the future of QCD science is pointing to the need for an electron-ion collider.

- A very high priority for the NP community is a U.S. leadership role in the science of neutrino-less double beta decay.

  - A specific challenge will be ensuring essential R&D for candidate technologies is completed in the next 2-3 years prior to a down-select for a ton-scale experiment.

- Research and production efforts to meet the United States’s need for isotopes in short supply are being strengthened; re-establishing U.S. capability for stable isotopes will be a major advance and will help address community concerns in this area documented in the 2009 and 2015 NSACI Strategic Plans.