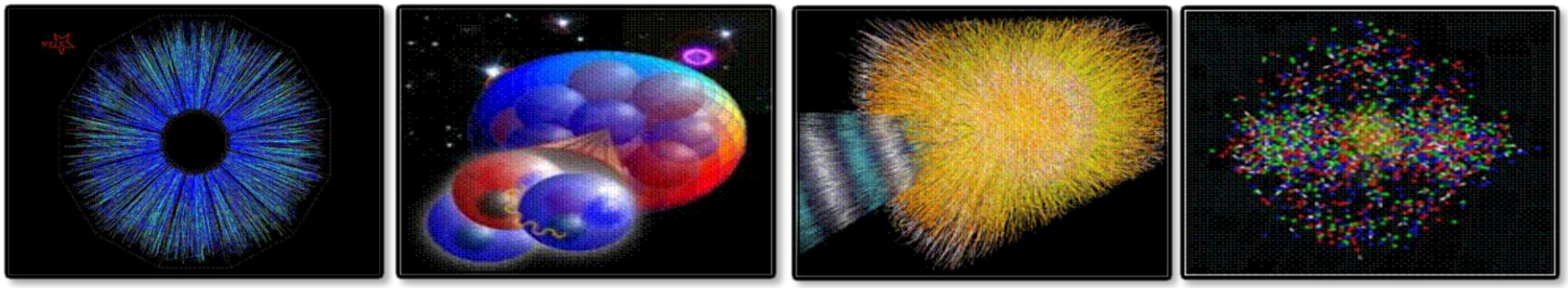
U.S. DEPARTMENT OF ENERGY | Office of Science

Perspectives from DOE NP

NSAC Meeting

October 28, 2016

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



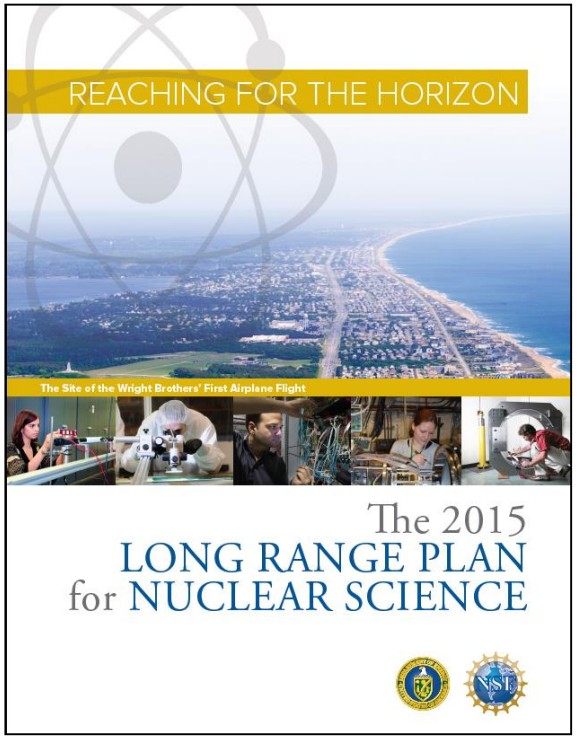
Two pieces of community guidance which DOE NP continues to pursue with vigor:

The 2015 Long Range Plan for Nuclear Science

NSAC and APS DNP partnered to tap the full intellectual capital of the U.S. nuclear science community in identifying exciting, compelling, science opportunities

Recommendations:

- The progress achieved under the guidance of the 2007 Long Range Plan has reinforced U.S. world leadership in nuclear science. ***The highest priority in this 2015 Plan is to capitalize on the investments made.***
- The observation of neutrinoless double beta decay in nuclei would…have profound implications.. ***We recommend the timely development and deployment of a U.S.-led ton-scale neutrinoless double beta decay experiment.***
- Gluons…generate nearly all of the visible mass in the universe. Despite their importance, fundamental questions remain…. These can only be answered with a powerful new electron ion collider (EIC). ***We recommend a high-energy high-luminosity polarized EIC as the highest priority for new facility construction following the completion of FRIB.***
- ***We recommend increasing investment in small-scale and mid-scale projects and initiatives that enable forefront research at universities and laboratories.***



NP is implementing these recommendations which are supported in the President's FY 2017 request

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.

DOE NP News Items

- COV recommendations and NP responses posted at:
http://science.energy.gov/~/media/sc-2/pdf/cov-np/2016/NP_COV_2016_Response.pdf
  - Seeking approval to re-open slot for Research Division Director
  - Gail Dodge has agreed to head a committee to identify candidates for NP DD search
  - FS and LE PM positions will be re-advertised November 14, 2016
  - IPA identified to manage HI program beginning in spring of 2017
  - Planning underway to enhance competitive peer review of renewal proposals
  - NP is proactively attempting to increase diversity on committees and panels
- Planned revision of the peer review process for renewals: up to two awards handled within the current approach via mail reviews; third proposed award included in competitive peer review with all new proposals from the annual "campaign" for that year.
- Paul Sorensen has joined NP as an IPA to manage the Fundamental Symmetries Portfolio
- Chris Gould has joined NP as an IPA to manage the Low Energy Portfolio
- $0\nu\beta\beta$ R&D FOA released August 29,2016; close date October 28, 2016 (http://science.energy.gov/np/funding-opportunities/)
- Joint DOE-AF-NASA NAS study on infrastructure needed for space radiation effects testing is getting underway: "*Space Radiation Effects Testing Infrastructure for the U.S. Space Program".* Committee constituted in 4-6 weeks, first meeting planned for February, 2016.

DOE NP News Items

- Subject to the usual caveats about funding etc. a new FOA for SciDAQ4 is anticipated; 1.5 Exascale awards made to NP PIs
- Pat Dehmer's last day at DOE is November 11, 2016
- Cherry Murray's last day at DOE will be on or before January 17, 2017
- Steve Binkley appointed SC Deputy for Science Programs on November 14, 2016
- NSAC subpanel on Mo99 has met and is preparing its annual assessment
- Effects of short term CR have been mitigated for now.
- Working together with NNSA (NA22), a fourth Topical Theory Collaboration award has been made.
- Interagency Working Group established on Nuclear Data; the possibility of some additional investment in targeted experiments with great leverage for enhancing nuclear data are under discussion with NNSA, NE, and potentially other Federal Offices.
- FRIB Theory alliance continues to progress
- Quadrennial review of Nuclear Theory was carried out; the report is in preparation

DOE NP News Items

- 12 GeV upgrade and FRIB construction continue to be on track
- Statement of Mission established for the MIT Research and Engineering center which will be reviewed November 7-9, 2016
- S&T review for RHIC (8/23-35)carried out as well as reverse site visits for JLAB (9/28) and ATLAS (10/20); Operations review of the 88 inch cyclotron is in the planning stages.
- Ops for Texas A&M to be reviewed November 14-15/2016
- A number of SC WDTS opportunities for faculty & students now open but will close in Nov
- Annual Fed Isotope Program Stakeholder meeting will be held 11/9-10
- Annual SBIR/STTR Stakeholder meeting was held 8/9-10; 2017 selection underway
- November workshop on a next generation laser-Compton gamma-ray source, Bethesda MD, November 17-19, 2016
- Jehanne Gillo orchestrated a major advance on documents underlying international collaboration
- 2016 SCGSR fellowships announced; 2017 ECA process is underway.
- Jehnane Gillo recognized with Meritorious Presidential Rank Award

Next Formal Step on the EIC Science Case

THE NATIONAL ACADEMIES OF SCIENCES, ENGINEERING, AND MEDICINE
Division on Engineering and Physical Science
Board on Physics and Astronomy
U.S.-Based Electron Ion Collider Science Assessment

Summary

The National Academies of Sciences, Engineering, and Medicine ("National Academies") will form a committee to carry out a thorough, independent assessment of the scientific justification for a U.S. domestic electron ion collider facility. In preparing its report, the committee will address the role that such a facility would play in the future of nuclear science, considering the field broadly, but placing emphasis on its potential scientific impact on quantum chromodynamics. The need for such an accelerator will be addressed in the context of international efforts in this area. Support for the 18-month project in the amount of $540,000 is requested from the Department of Energy.

"U.S.-Based Electron Ion Collider Science Assessment" is now getting underway. The Chair will be Gordon Baym. The rest of the committee, including a co-chair, will be appointed in the next couple of weeks. The first meeting is being planned for January, 2017

Community Review of EIC R&D Status and Needs, Kevin Jones, Chair

Kevin Jones, Chair (ORNL), Oliver Bruning (CERN), John Corlett (LBNL), George W. Dodson (ORNL), Oliver Kester (TRIUMF), John Lewellen (LANL), Daniela Leitner (MSU), Sergei Nagaitsev (FNAL), Alexander Romanenko (FNAL), John Seeman (SLAC), John P. Tapia (LANL), Jie Wei (MSU), Ying Wu (Duke), Frank Zimmermann (CERN)

The Review is scheduled for Nov 29-Dec 2 at the Hilton Washington DC/Rockville, Rockville, MD.

It will center around EIC design concepts: JLEIC Concept, Linac-Ring eRHIC Concept, Ring-Ring eRHIC Concept

As appropriate, Laboratories and Universities have been asked by the Chair to submit documents describing:

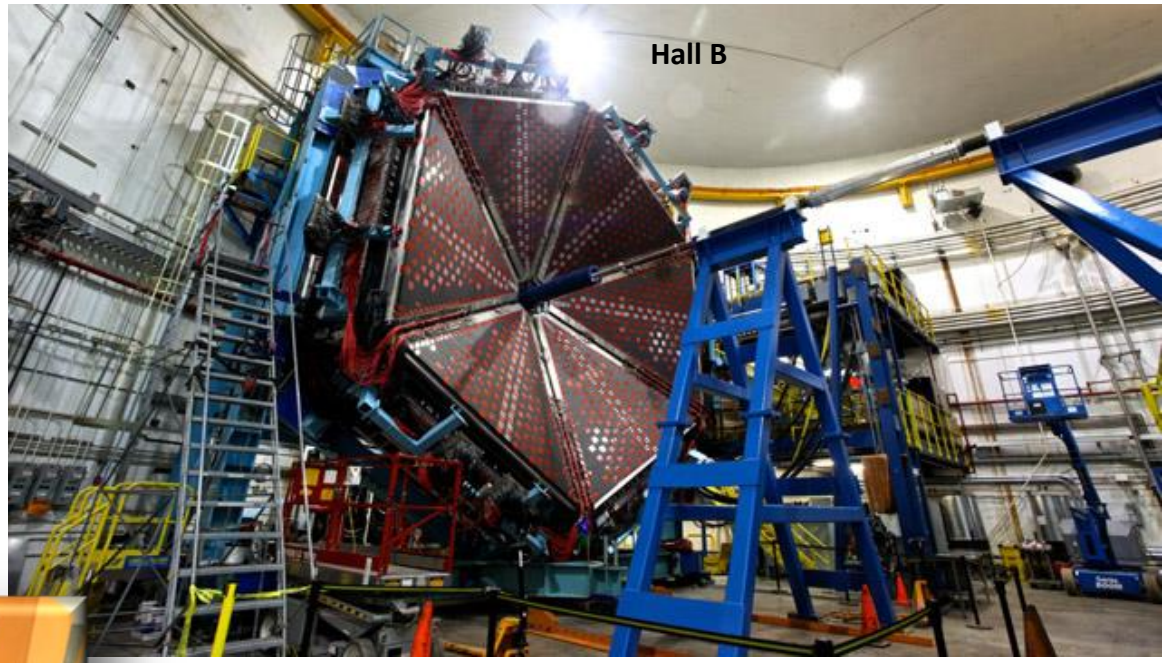
- their concept(s)
- a prioritized R&D list for the proposed concept
- related technical and planning documents.

Charge Elements

Status of EIC R&D to date:	Evaluate current state of EIC-related accelerator R&D supported to date.
EIC design concepts:	Examine the current EIC design concepts under consideration and identify a risk level (High, Medium or Low) for each.
Technical feasibility:	Identify key areas of accelerator technologies that must be demonstrated or advanced significantly in order to realize the technical feasibility of each concept;
Priority list of R&D:	Generate a list of R&D areas for each EIC design concept, prioritized (High, Medium, Low) in the context of associated risk and impact of activity to value engineering and technical feasibility. Identify R&D items that have relevance to multiple EIC design concepts; and
Cost and schedule range:	To the extent possible and within the time constraints of the meeting, provide an estimate of cost and schedule range for each item on the R&D list above.

The 12 GeV CEBAF Upgrade at TJNAF is ~ 98.4 % Complete

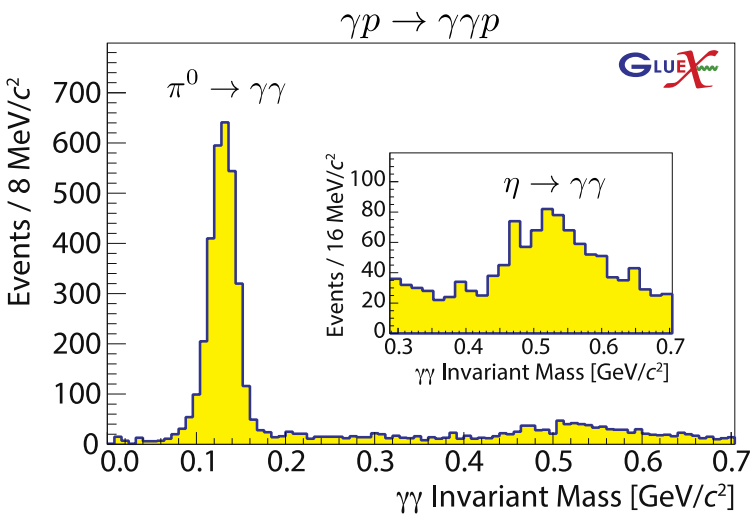
Project completion (CD-4B) is planned by the end of FY 2017

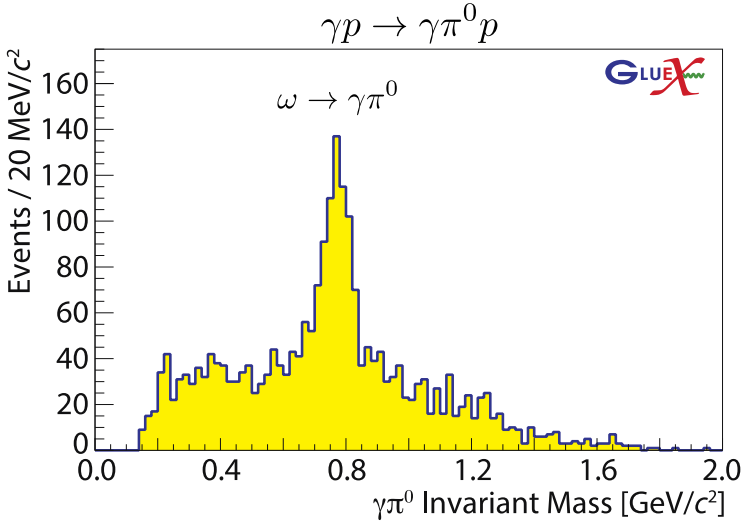


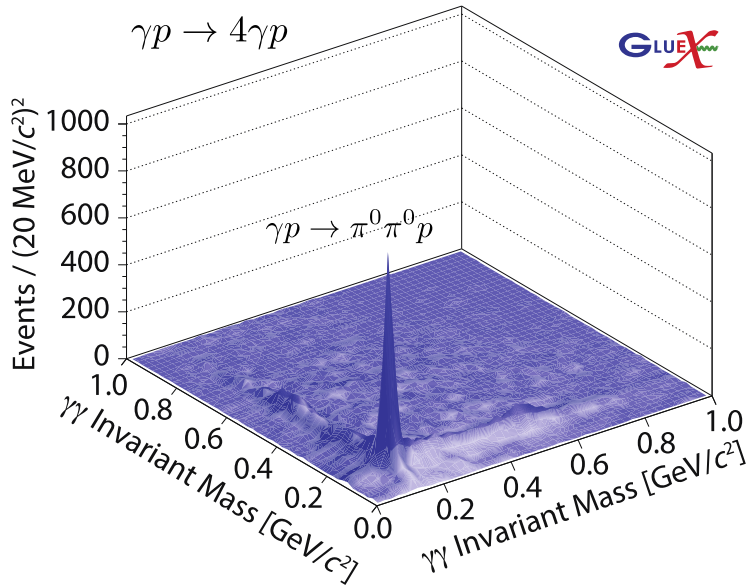
With the completion of the 12 GeV CEBAF Upgrade, researchers will address:

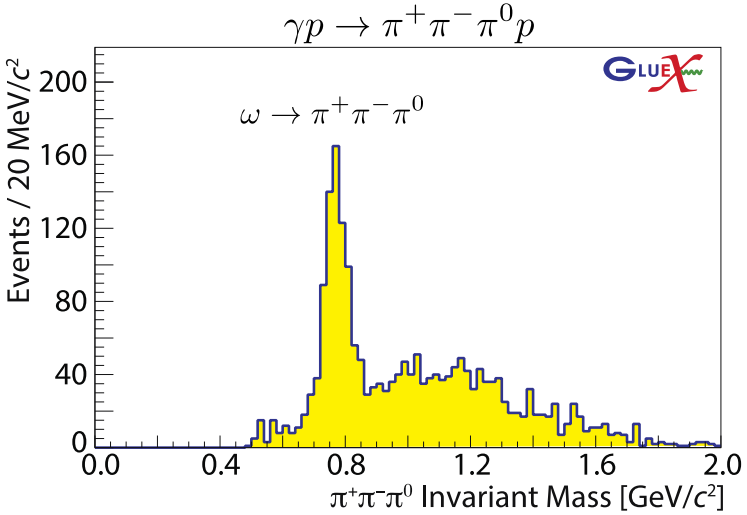
- The search for exotic new quark–anti-quark particles to advance our understanding of the strong force.
- Evidence of new physics from sensitive searches for violations of nature's fundamental symmetries.
- A detailed microscopic understanding of the internal structure of the proton, including the origin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

Some First Results Demonstrating the Promise of GLUEX

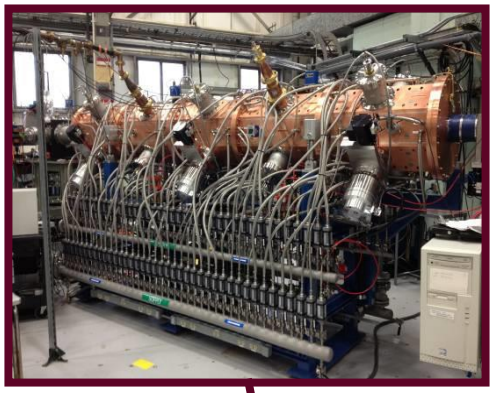








ATLAS After Recent Upgrades. Multi-User Upgrade Planned.



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

Facility for Rare Isotope Beams is Approaching 70% 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 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.

	PYs	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	DOE Total	MSU	TOTAL
FUNDING PROFILE	318,000	100,000	97,200	75,000	40,000	5,300	635,500	94,500	730,000

FRIB Construction Continuing to Advance Quickly

On Friday, October 14, 2016, the first FRIB ion beam was produced from the Artemis electron-cyclotron-resonance (ECR) ion source. About 300 euA of oxygen 3+ beam was extracted from the ion source and struck the Faraday Cup downstream (Figure 1).

The ECR ion source is installed on the newly constructed high voltage platform in the FRIB building. Supporting utilities in the FRIB building were made available before the Beneficial Occupancy Date of March 2017.

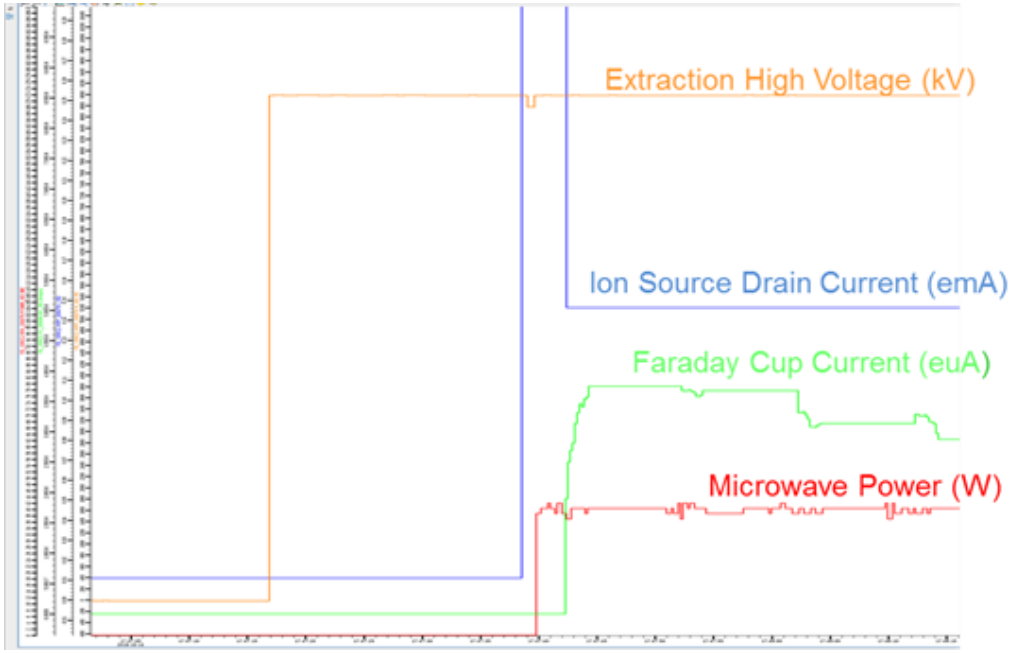
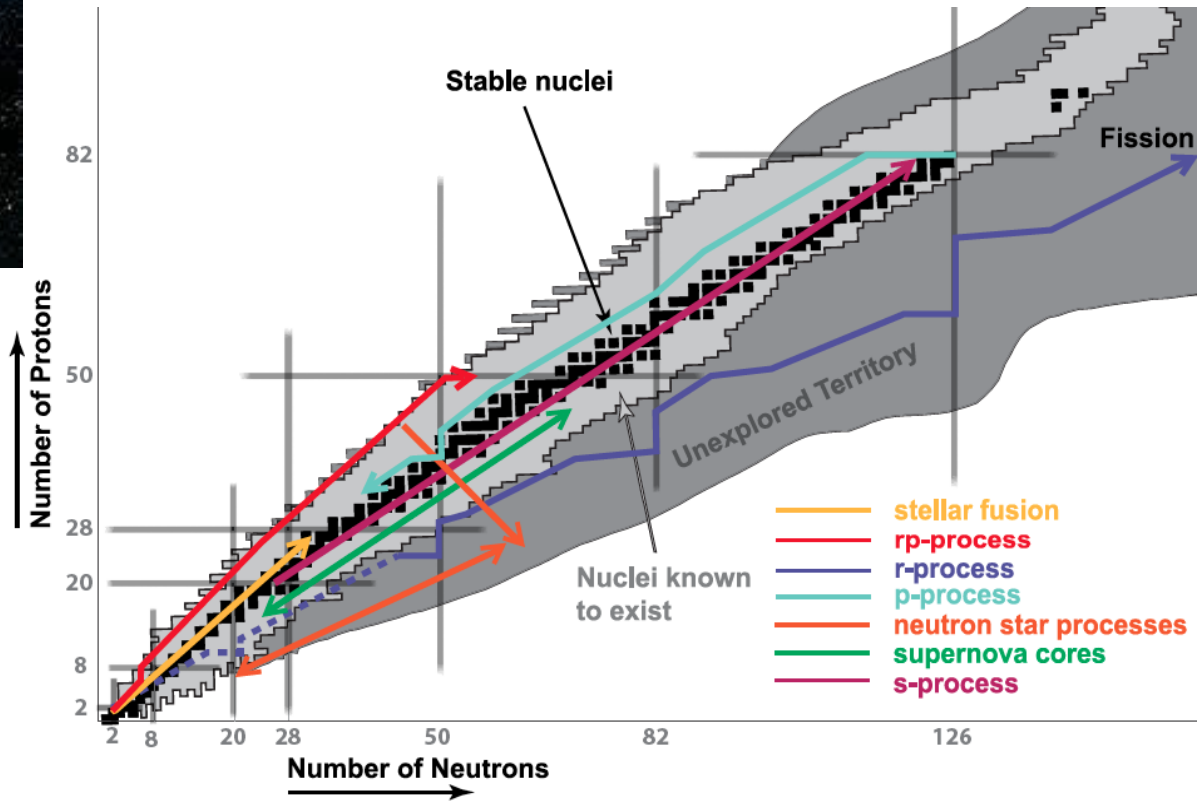


Figure 1: ion source drain current and current on the Faraday Cup downstream of the ARTEMIS ion source when the microwave power is turned on to triggered the ECR plasma and when the extraction voltage is applied. Congratulations to the ion source team members, who made the beam, and to the whole FRIB team, which advanced the baseline schedule through close collaboration between technical and civil construction divisions.

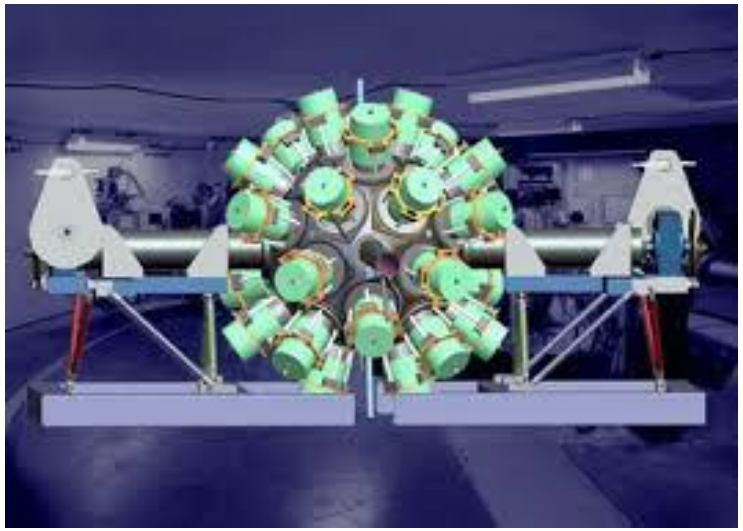
FRIB Promises a Watershed in Understanding Astrophysical Scenarios

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

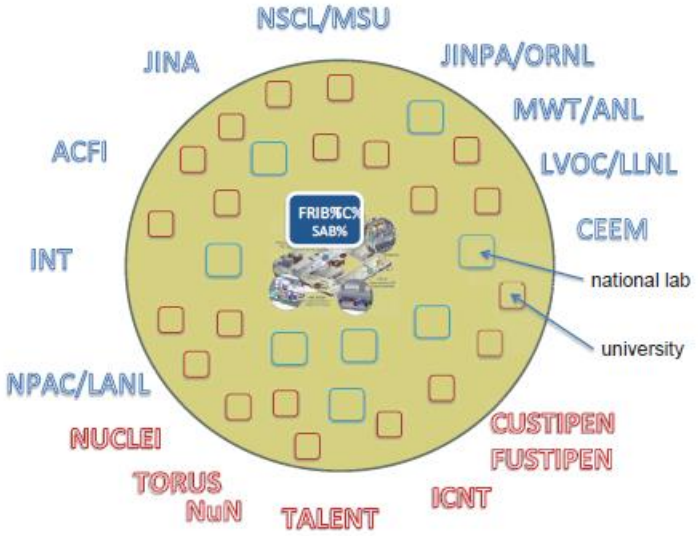
FRIB capabilities will illuminate the rates for many nuclear reactions currently inaccessible, particularly for nuclei with an excess of neutrons



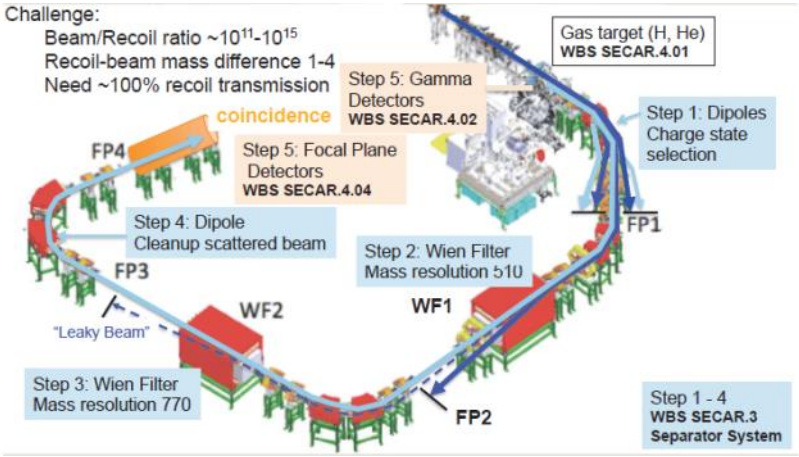
FRIB Instrumentation/Theory Effort is Underway



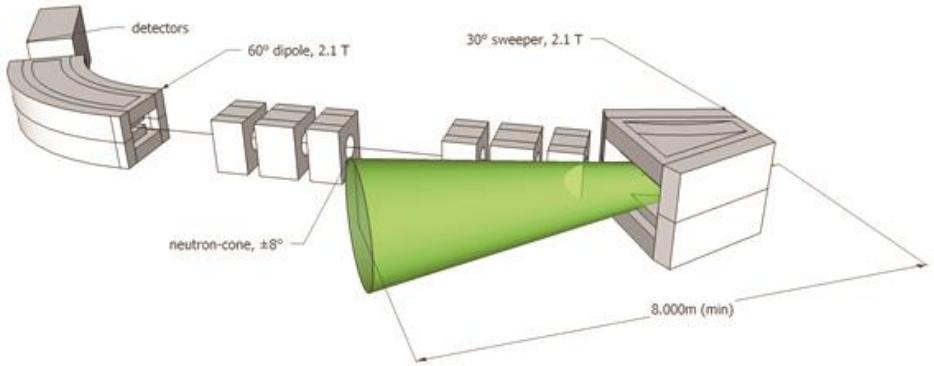
GRETA



FRIB Theory Alliance

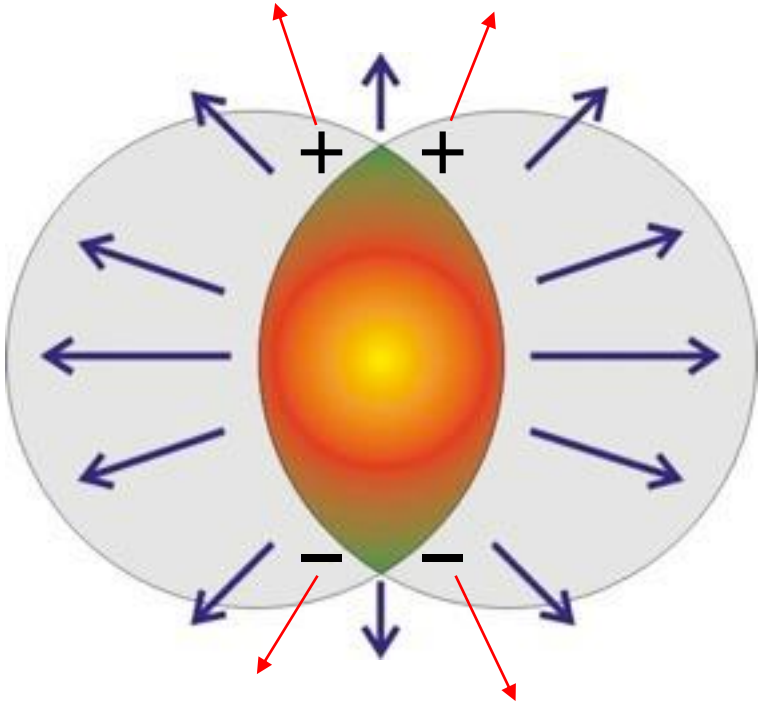


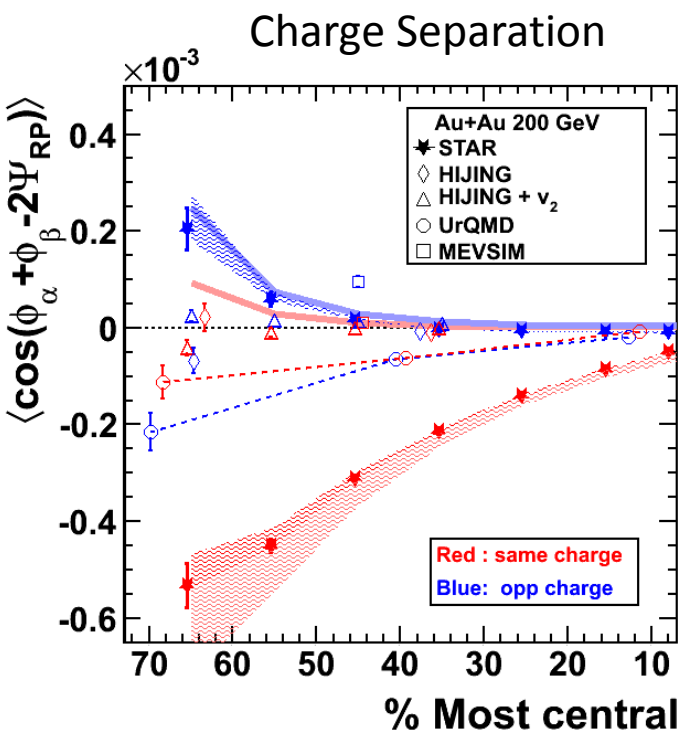
SECAR



Pre-Conceptual High Rigidity Spectrometer (HRS)

RHIC Poised for a Breakthrough in Understanding a Very Striking Phenomena





Other experimental observables studied,

- Beam energy dependence
- System size dependence

All observables studied to date are consistent with the interpretation the effect provides a direct window into the nature of the QCD vacuum

Final test: vary the magnetic field using isobars ^{96}Ru and ^{96} Zr

A 20% effect expected if the “Chiral Magnetic Effect” Interpretation is confirmed

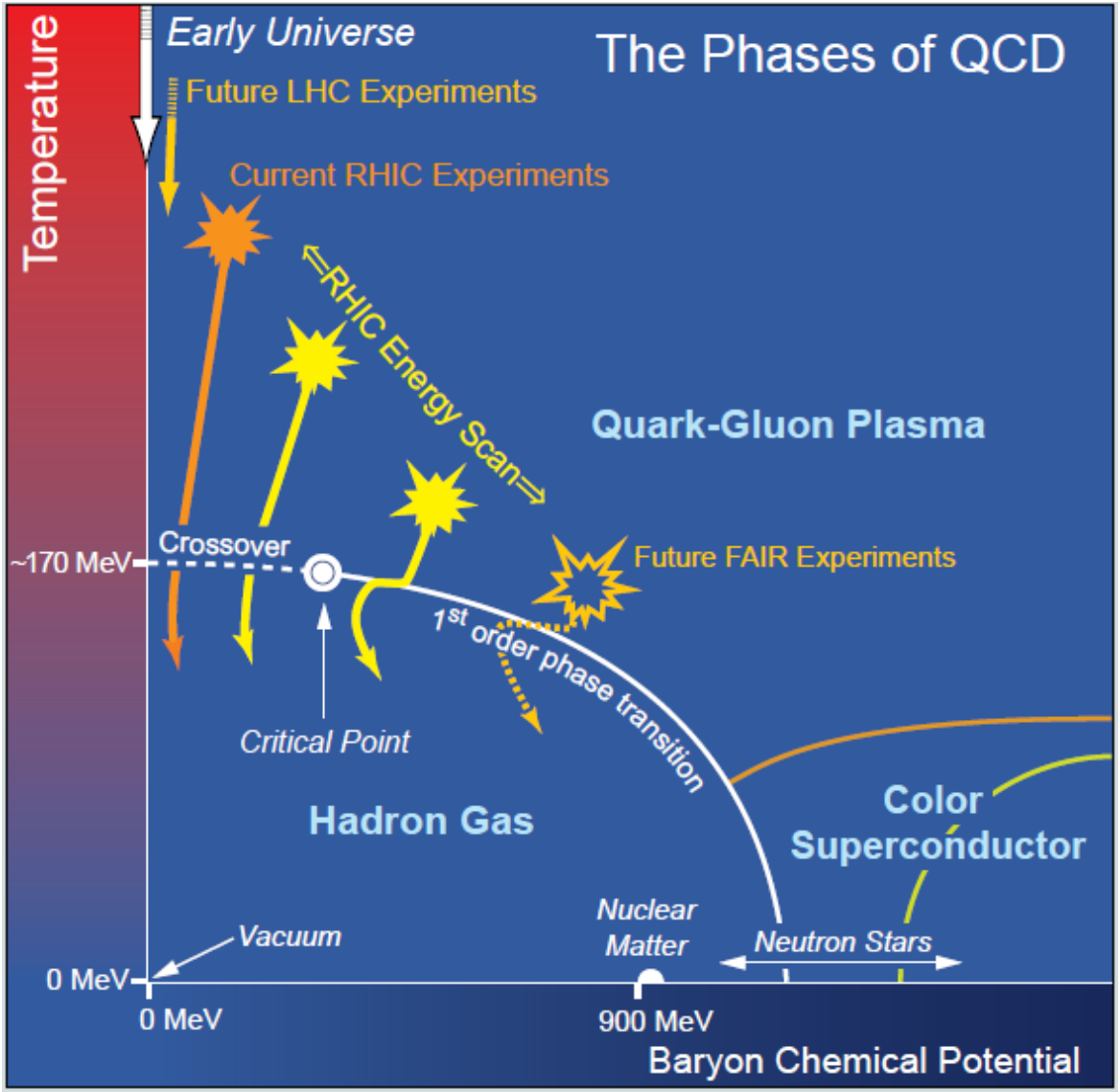
The QCD Critical Point Search: A Main Focus of RHIC Running in FY19-20

One striking fact is that the liquid-vapor curve can end. Beyond this "Critical Point" the sharp distinction between liquid and vapor is lost. The location of the Critical Point and of the phase boundaries represent two of the most fundamental characteristics for any substance.

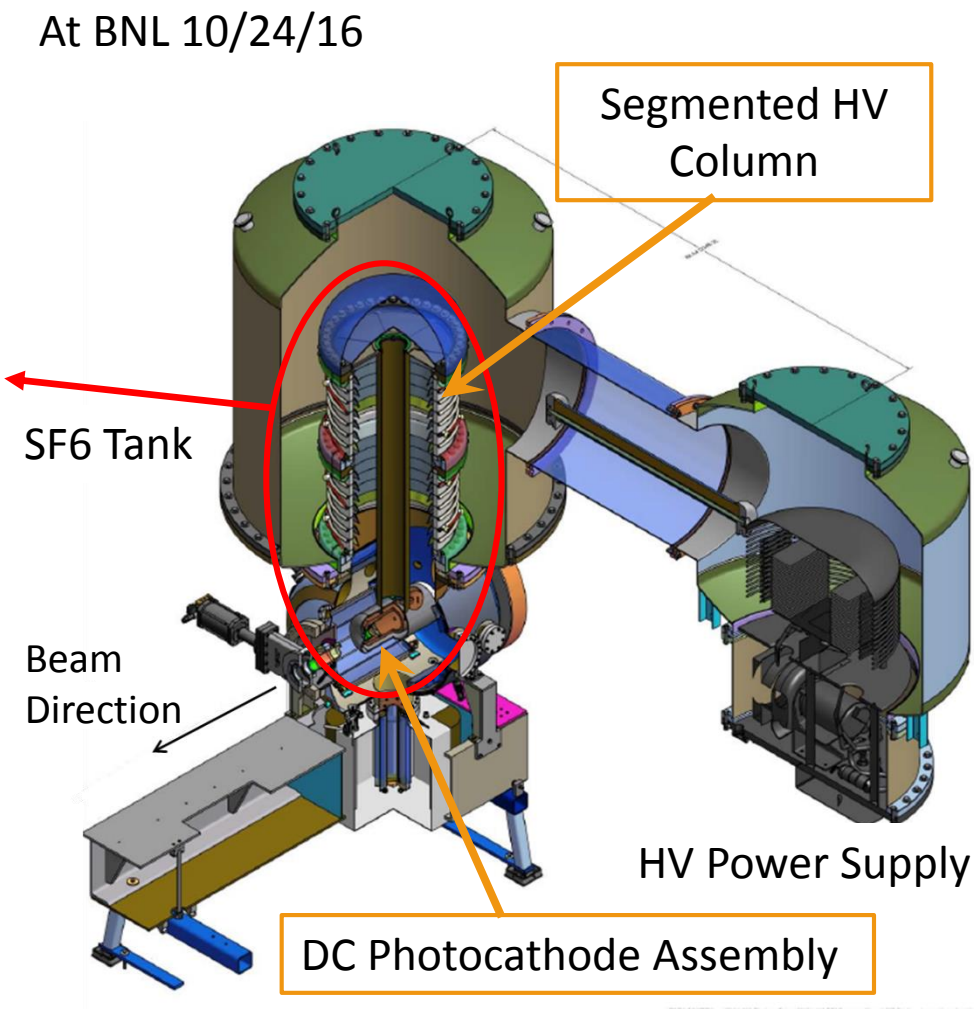
Experimentally verifying the location of fundamental QCD "landmarks" is central to a quantitative understanding of the nuclear matter phase diagram. Lattice QCD indicates that the Critical Point is in the range of temperatures and chemical potentials accessible with RHIC. The approach to the Critical Point will be signaled by large-scale fluctuations in key observables.

Status:

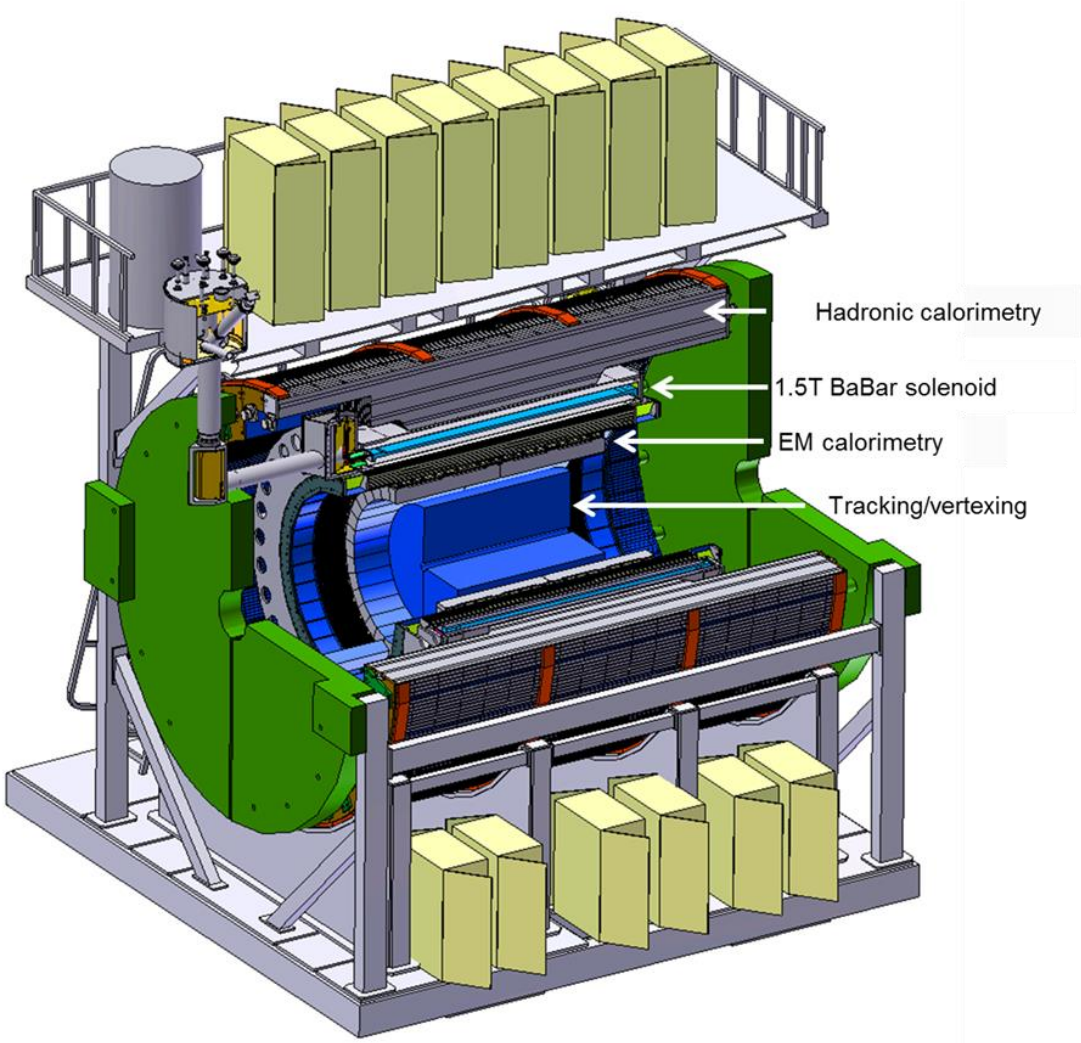
- BES I data are very intriguing
- Further high statistics data require e-cooling (LEReC) implemented in FY18
- BES II planned for FY19-20



LEReC DC PhotoEmission Gun



The Physics Thrusts of sPHENIX



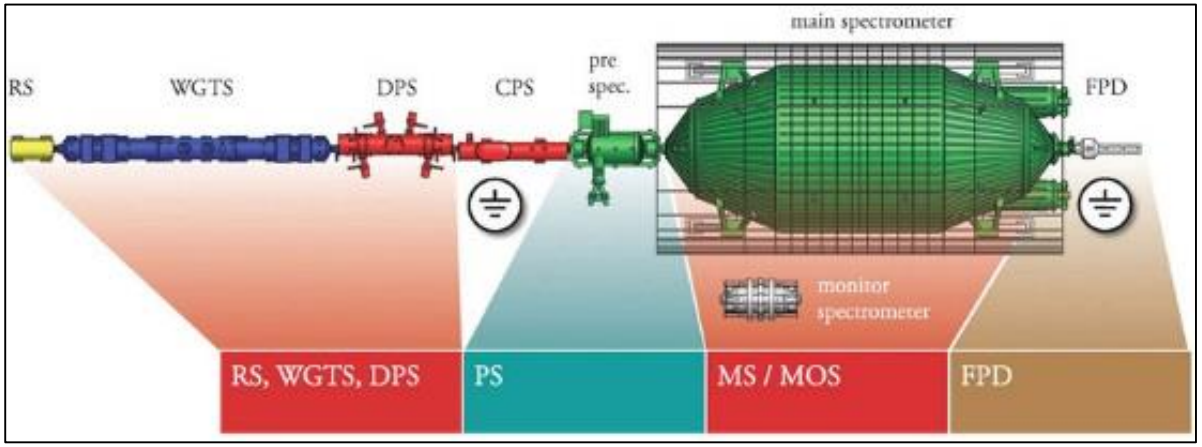
CD-0 approved for sPHENIX on September 27, 2016

The main scientific thrusts are:

- mapping the character of the hadronic matter under conditions of extreme temperature or net baryon density by varying the temperature of the medium, the virtuality of the probe, and the length scale within the medium
- understanding the parton–medium interactions by studying heavy-flavor jets
- probing the effect of the quark–gluon plasma on the Upsilon states by comparing the p-p (proton-proton), p-A (proton-nucleus), and A-A (nucleus-nucleus) collisions.

Fundamental Symmetries

First Light at KATRIN

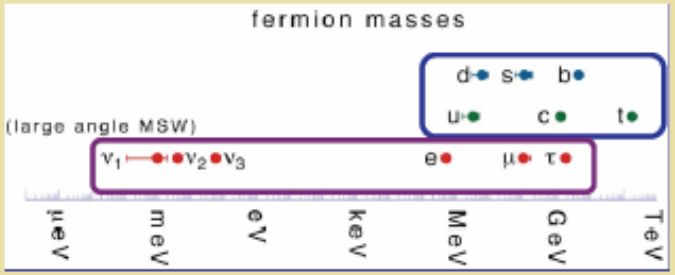


Overview of the 70 m long KATRIN experiment.

$0\nu\beta\beta$ a Science "Must Do" Experiment

What Questions Does It Address ?

- *Is the neutrino its own antiparticle ?*
- *Why is there more matter than antimatter in the present universe?*
- *Why are neutrino masses so much smaller than those of other elementary fermions ?*



MAJORANA DEMONSTRATOR

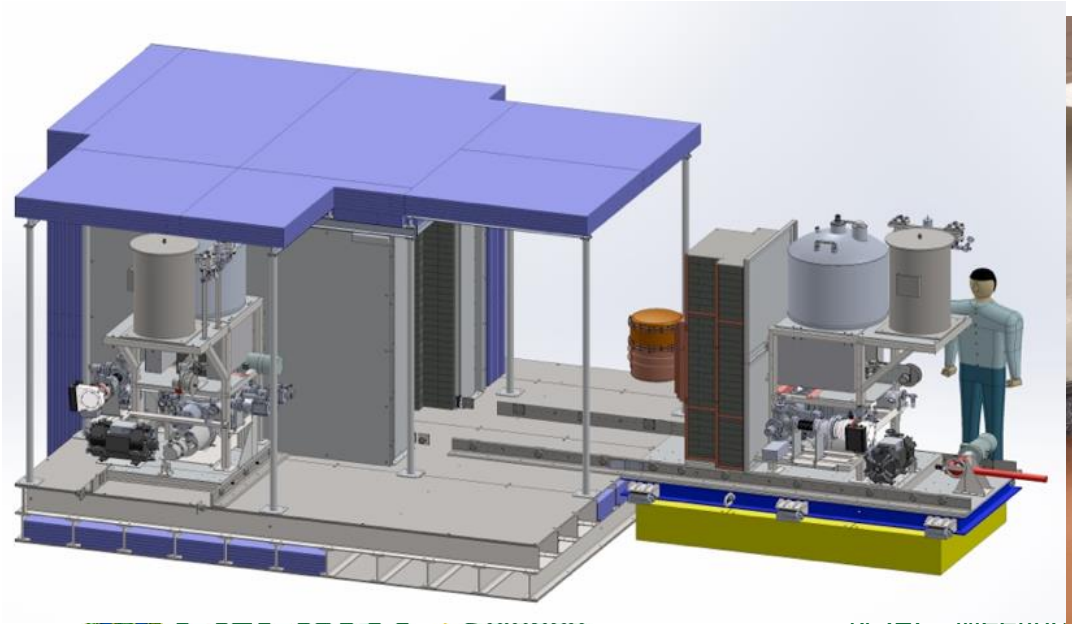
Goal: Demonstrate backgrounds needed for a tonne scale 0νββ experiment.

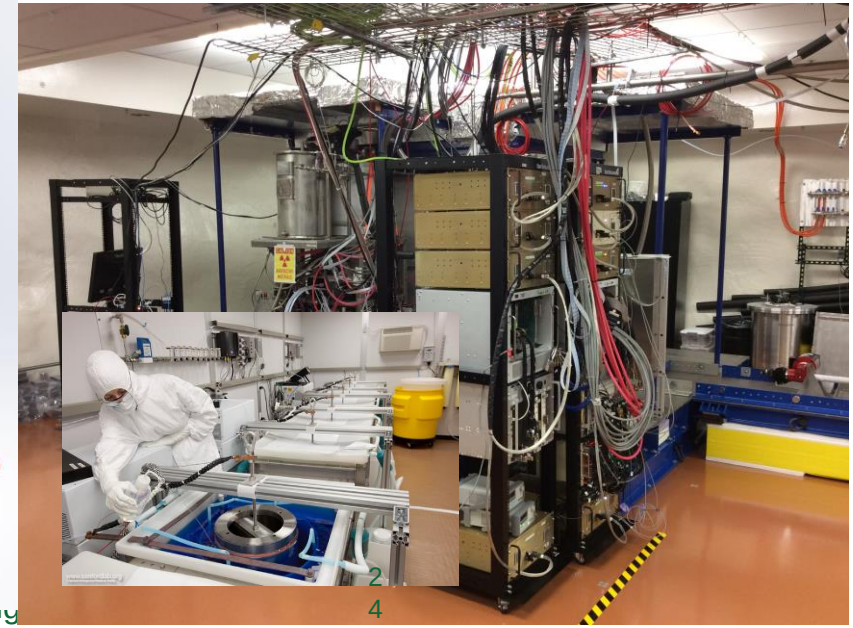
Configuration: 44-kg of Ge detectors, in two independent cryostats

29 kg of 87% enriched ^{76}Ge crystals; 15 kg of ^{nat}Ge, P-type point-contact detectors

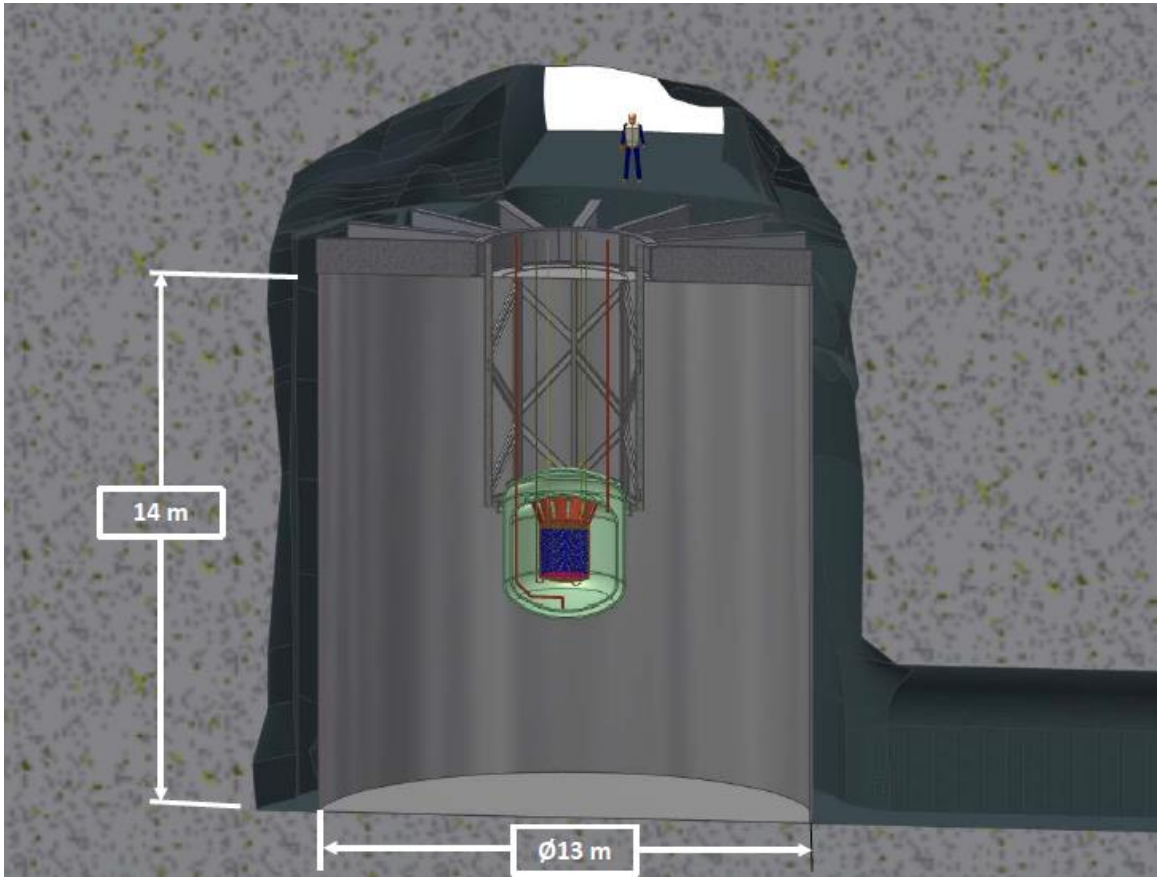
Module One: Installed in-shield and taking low background data since January 2016.
End-to-end analysis underway from to shake down data cleaning and analysis tools (relatively insensitive because of partial shielding) .
Expect to have first background information from 2016 run in the spring.

Module Two: construction and assembly proceeded on schedule, in-shield commissioning





nEXO Stewardship Transferred to NP in FY2017



In this concept the nEXO TPC is housed in a large graphite composite cryostat which in turn is submerged in a water shield equipped with photomultiplier tubes to double as a cosmic ray veto
detector.

General R&D Issues

- Charge collection
- SiPM and light collection testing
- Simulation of light and charge collection in LXe
- Effective Vetoing
- Material qualification

Nuclear Theory

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

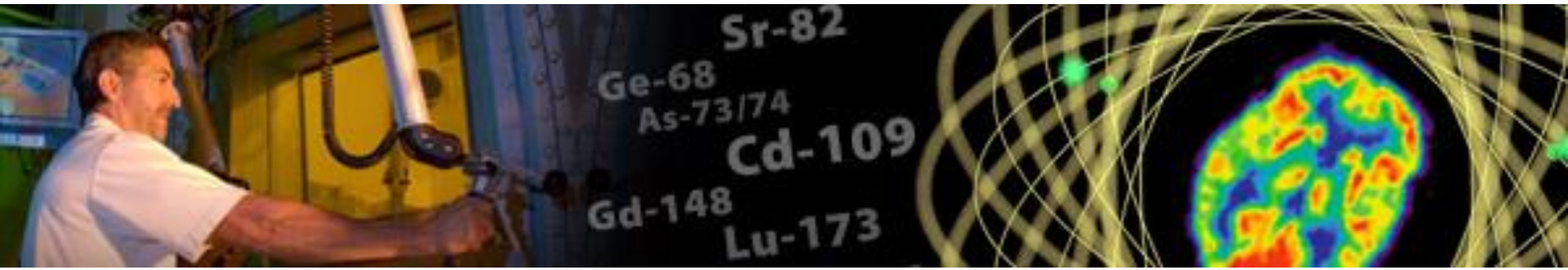
A strong Nuclear Theory effort:

- Poses scientific questions and presents new ideas that potentially lead to discoveries and 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 and interprets the results.

A highly successful new vehicle for Nuclear Theory was introduced in FY 2012—Theory Topical Collaborations: fixed-term, multi-institution collaborations established to investigate a specific topic:

- A review of the first group of collaborations found that the collaborations presented "… a new direction to enhance the research effort by bundling scientific strength and expertise located at different institutions to reach a broader scientific goal… an extremely promising approach…"
- The first cohort of Topical Theory Collaborations has completed its work. A new cohort will be announced in October 2015.

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

Stable Isotope Production Facility (SIPF) is Part of the FY2017 Request

- Project scope includes procuring and installing additional Electromagnetic Isotope Separator (EMIS) and Gas Centrifuge Isotope Separator (GCIS) machines in an existing building.
- No green site; building modifications may be needed; fabricated as an MIE.
- Hardware designs are known and proven in an existing well proven prototype pilot capability.
- Project received CD0, *Mission Need* on September 4, 2015.

Proposed for Full Funding in FY 2017
Estimated Total Project Cost: $9.5M-$10.5M
Estimated time frame for completion: FY 2020

The SIPF directly supports the DOE Isotope Program mission, restoring domestic capability that has been lacking since 1998. Renewed enrichment capability will benefit nuclear and physical sciences, industrial manufacturing, homeland security, and medicine.

Nuclear Physics
FY 2017 House and Senate Marks

Nuclear Physics	FY 2016 Enacted	FY 2017 President's Request	FY 2017 Request vs. FY 2016	FY 2017 House Mark	FY 2017 House vs. Request	FY 2017 Senate Mark	FY 2017 Senate vs. Request	FY 2017 Senate vs. House
Operation and maintenance								
Medium Energy	155,793	163,799	+8,006					
TJNAF Operations	*98,670*	*104,139*	*+5,469*	*104,139*	-			
Heavy Ions	207,910	216,131	+8,221					
RHIC Operations	*172,088*	*179,700*	*+7,612*	*179,700*	-	***179,700***	-	-
Low Energy	78,785	79,893	+1,108					
ATLAS Operations	*18,199*	*19,199*	*+1,000*					
Nuclear Theory	45,775	46,465	+690					
Isotope Program	21,337	29,370	+8,033					
Undistributed	-	-	-	*236,161*		*355,958*		
Total, Operation and maintenance	**509,600**	**535,658**	**+26,058**	**520,000**	**-15,658**	**535,658**	**-**	**+15,658**
Construction								
14-SC-50 Facility for Rare Isotope Beams	100,000	100,000	-	**100,000**	-	**100,000**	-	-
06-SC-01 12 GeV CEBAF Upgrade	7,500	-	-7,500	-	-	-	-	-
Total, Construction	**107,500**	**100,000**	**-7,500**	**100,000**	**-**	**100,000**	**-**	**-**
Total, Nuclear Physics	**617,100**	**635,658**	**+18,558**	**620,000**	**-15,658**	**635,658**	**-**	**+15,658**

Nuclear Physics
FY 2017 President's Request – Summary

($ in 000s)	FY 2015 Actual	FY 2016 Enacted	FY 2017 Request	FY 2017 vs. FY 2016
Research	167,195	176,815	187,151	+10,366
User Facility Operations	280,873	288,957	303,038	+14,081
Other Operations	24,313	24,507	22,826	-1,681
Projects	106,500	107,500	103,000	-4,500
Other	16,619	19,321	19,643	+322
TOTAL NP	**595,500**	**617,100**	**635,658**	**+18,558**

- **Research** – Support university and laboratory research across the program to address important opportunities identified by the research community, and to enhance high priority research that will foster significant advances in nuclear structure, nuclear astrophysics, the study of matter at extreme conditions, hadronic physics, fundamental properties of the neutron, neutrinoless double beta decay, and isotope production and processing techniques.
- **User Facility Operations** – Operate the three Nuclear Physics user facilities by supporting staff, equipment, and materials required for reliable operations for research focused on: advancing the understanding of strongly interacting matter and its description in QCD, and to search for evidence of new physics beyond the Standard Model at CEBAF; characterizing the perfect quark-gluon liquid discovered in collisions of relativistic heavy nuclei at RHIC; and advancing the areas of nuclear structure and reactions, low-energy tests of the standard model, and nuclear astrophysics at ATLAS.
- **Other Operations** – Maintain mission readiness of the Isotope Program facilities for the production of radioisotopes; continue operations of the 88-Inch Cyclotron at LBNL, and complete disposition activities for HRIBF at ORNL.
- **Projects** – Continue FRIB construction according to its baselined profile, and initiate two MIEs – GRETA and SIPF.
- **Other** – Provide required funding for the SBIR/STTR programs consistent with the legislative mandate (offset partially by transfer of WCF to SCPD).

Additional Comments on Budget

- **House Mark provides $620M, $15.7M below the request. Total reduction of $17M**
- **$100M is specified for construction of FRIB, as requested.**
- **Planned RHIC operation for 24 weeks, JLAB: operation for 26 weeks**

- **Senate Mark provides $635.7M, the same as the President's Request.**
- **Senate Mark supports implementation of the world-leading program of nuclear science envisioned in NSAC's 2015 Long Range Plan for Nuclear Science**

Outlook

- The CEBAF and RHIC programs 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.
- There is a wealth of science opportunity near term at ATLAS, and longer term at FRIB which will be world leading. It is not too soon to begin to position the low energy community to take full advantage of FRIB as soon as it becomes operational.
- A very high priority for the NP community is U.S. leadership 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
- An equally high priority for the NP community is increasing investment in research and projects as a percentage of the total NP budget. This will have to be accomplished while still respecting the unitarily limit.
- Research and production efforts to meet the Nation’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