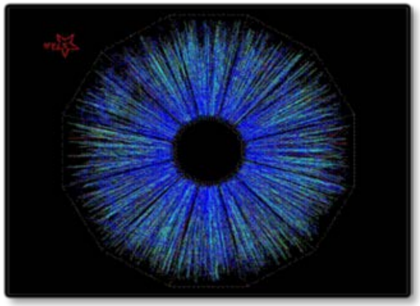
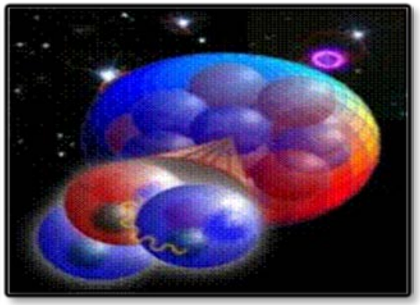
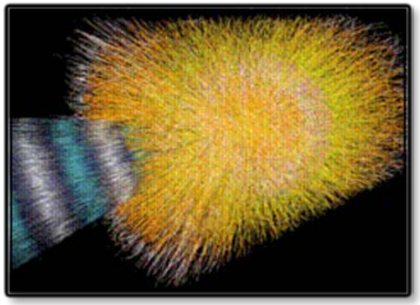
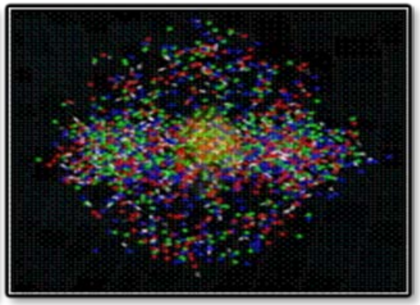
Perspectives from DOE Nuclear Physics

NSAC Meeting
November 17, 2014

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

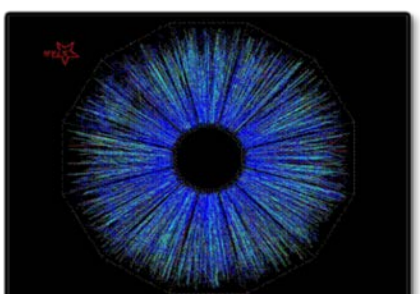
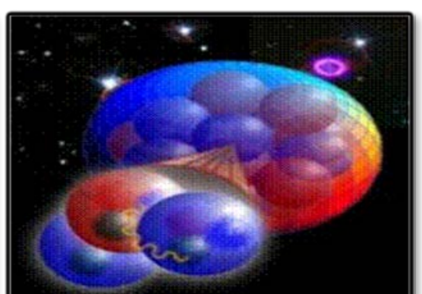
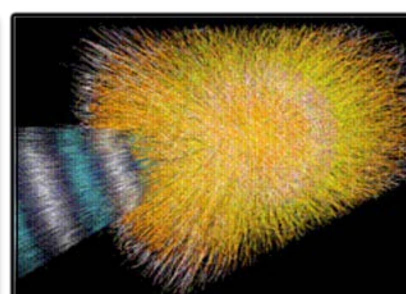
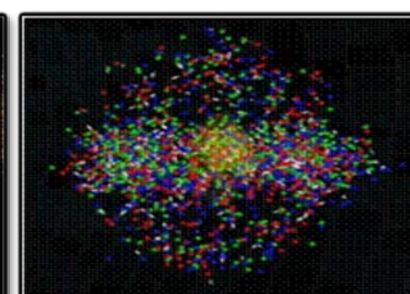





Nuclear Physics’ Mission

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 neutrons and the neutrino and their role in the evolution of the early universe

The 2016 Long Range Plan: A Tool for Evidence-Based Planning

NSAC partnership with the Division of Nuclear Physics of the APS to tap the full intellectual capital of the US nuclear science community in identifying exciting, compelling science opportunities and a strategic plan for the next 5-10 years:

Nuclear Structure & Nuclear Astrophysics meeting *Nuclear Structure Conveners:* Mark Riley (Florida State University) and Charlotte Elster (Ohio University); *Nuclear Astrophysics Conveners:* Hendrik Schatz (Michigan State University) and Michael Wiescher (University of Notre Dame), *Venue:* Mitchell Institute, Texas A&M University, Aug. 21-23, 2014
Meeting website: http://www.lecmeeting.org/

Hadron and Heavy Ion QCD meeting, *QCD Heavy Ion Conveners:* Paul Sorensen (Brookhaven National Laboratory) and Ulrich Heinz (Ohio State University), *QCD Hadron Conveners:* Haiyan Gao (Duke University) and Craig Roberts (Argonne National Laboratory), *Venue:* Temple University, Howard Gittis Student Center, 1743 N 13th St., Philadelphia, PA 19122, Sept. 13-15, 2014
Website: https://phys.cst.temple.edu/qcd

Fundamental symmetries, Neutrinos, Neutrons, and the relevant Nuclear Astrophysics, *Conveners:* Hamish Robertson (University of Washington), Michael Ramsey-Musolf (University of Massachusetts), *Dates:* Sept. 28-29, 2014
Venue: Crowne Plaza hotel near Chicago's O'Hare airport on 5440 North River Road, Rosemont, IL 60018
Website: http://fsnutown.phy.ornl.gov/fsnuweb/index.html

Nuclear Theory Computing:
High performance computing (Computation in nuclear physics), Washington DC, July 14-15, 2014

Education [NSF scope - Workforce Training in DOE] **and Innovation... across all areas of nuclear physics** *Conveners:* Michael Thoennessen (Michigan State University), Graham Peaslee (Hope College) *Venue:* NSCL, Michigan State University, Aug. 6-8, 2014; *Website:* http://meetings.nscl.msu.edu/Education-Innovation-2014

Resolution Meeting: spring of 2015 **Long Range Plan: October 2015**

Nuclear Science Advisory Committee

- Current NSAC Activity
  - Subpanel to conduct a new study of the opportunities and priorities for isotope research and production resulting in a long range strategic plan for the Department of Energy (DOE) Isotope Program
  - A new Long Range Plan exercise to study the opportunities and priorities for United States nuclear physics research and recommend a long range plan that will provide a framework for coordinated advancement of the Nation's nuclear science research programs over the next decade.
- Recent NSAC Reports
  - To provide guidance on an effective strategy for implementing a possible second generation U.S. experiment on neutrinoless double beta decay (NLDBD) capable of reaching the sensitivity necessary to determine whether the nature of the neutrino is Majorana or Dirac. Report issued in April 2014.
  - To form a Subcommittee to assess the effectiveness of the National Nuclear Security Administration-Global Threat Reduction Initiative's Domestic Molybdenum-99 (Mo99) Program, in accordance with direction given to the DOE in the National Defense Authorization Act for FY 2013. Report issued in May 2014.
  - To form a subpanel to examine potential gaps in training and workforce critical to the NP/SC. Report issued in July 2014.

Evidence Based Planning and Quality Assurance

Competitive Research Review 2014

Total number of proposals: 80
Total number of proposals from CRR 2013: 39
Total number of new proposals: 41
Total amount requested: $60 M

Program Name	CRR 2014	CRR 2013	New Proposals	Amount Requested ($M)
Fundamental Symmetries	10	4	6	6.7
Medium Energy	16	8	8	16.4
Heavy Ions	14	7	7	12.8
Nucl. Str and Nucl. Astro	13	9	4	10.3
Nuclear Theory	27	11	16	13.7
Total	**80**	**39**	**41**	**59.9**

CRR2014 will be complete in the first quarter of FY2015

Nuclear Physics
FY 2015 Budget Status

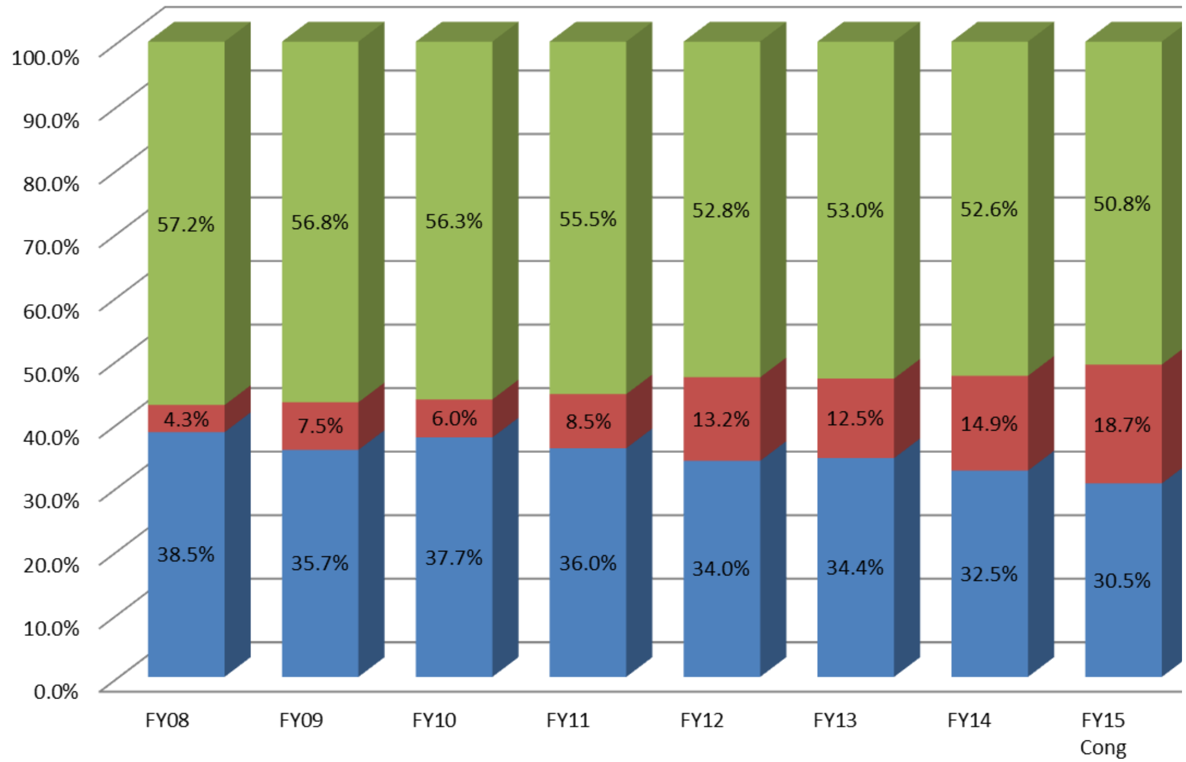
Nuclear Physics	FY 2013 Approp. with SBIR/ STTR	FY 2014 Enacted Approp.	FY 2015 President's Request	FY 2015 Request vs. FY 2014	FY 2015 House Mark	FY 2015 House vs. Request	FY 2015 Senate Mark	FY 2015 Senate vs. Request	FY 2015 Senate vs. House
Operation and maintenance									
Medium Energy	128,328	148,695	149,892	+1,197	153,842	+3,950	157,942	+8,050	+4,100
TJNAF Operations	*78,123*	*94,493*	*96,050*	*+1,557*	*100,000*	*+3,950*	*104,100*	*+8,050*	*+4,100*
Heavy Ions	193,229	199,693	198,966	-727	201,466	+2,500	198,966	-	-2,500
RHIC Operations	*157,021*	*165,072*	*165,072*	*-*	*167,572*	*+2,500*	*165,072*	*-*	*-2,500*
Low Energy *	78,190	75,704	75,269	-435	75,269	-	75,269	-	-
ATLAS Operations	*16,429*	*17,026*	*17,541*	*+515*	*17,541*	*-*	*17,541*	*-*	*-*
Nuclear Theory	39,057	45,142	43,096	-2,046	43,096	-	43,096	-	-
Isotope Program	18,483	19,404	19,850	+446	19,850	-	19,850	-	-
Undistributed	-	-	-	-	-23	-23	-50	-50	-27
Total, Operation and maintenance	**457,287**	**488,638**	**487,073**	**-1,565**	**493,500**	**+6,427**	**495,073**	**+8,000**	**+1,573**
Construction									
14-SC-50 Facility for Rare Isotope Beams	22,000	55,000	90,000	+35,000	90,000	-	90,000	-	
06-SC-01 12 GeV CEBAF Upgrade	40,572	25,500	16,500	-9,000	16,500	-	16,500	-	
Total, Construction	**62,572**	**80,500**	**106,500**	**+26,000**	**106,500**	**-**	**106,500**	**-**	**-**
Total, Nuclear Physics	**519,859**	**569,138**	**593,573**	**+24,435**	**600,000**	**+6,427**	**601,573**	**+8,000**	**+1,573**

* Funds for FRIB in FY13 were provided under Low Energy but are moved to the FRIB Construction line in this table.

NP bottom line increase in FY15 is dominated by the construction profile of FRIB

Research as a percentage of the NP Budget
FY 2008-FY2015

Construction has stressed all aspects of the NP program – not just Research

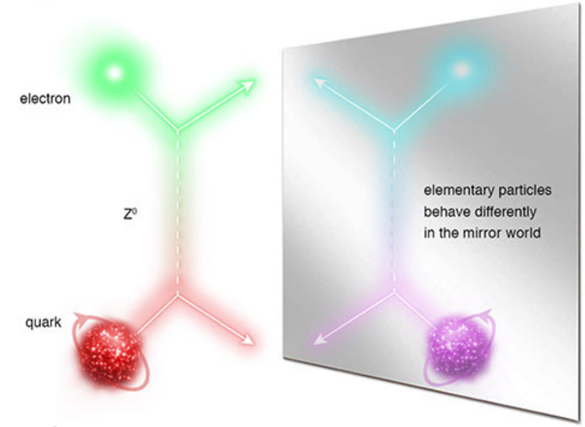


Measurement of the Parity-Violating Asymmetry in eD Deep Inelastic Scattering

Nature 506, 67–70 (06 February 2014)

The Jefferson Lab PVDIS Collaboration

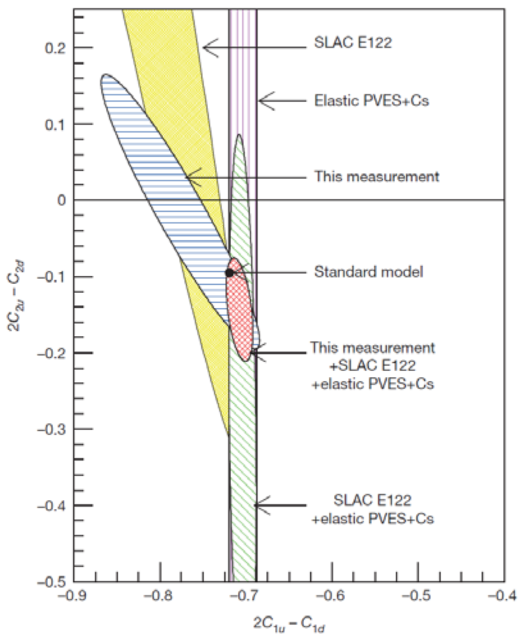
See also News & Views, *Nature* 506, 43–44 (06 February 2014)



Longitudinally Polarized Electron Scattering from Unpolarized Deuterium

$$A_{LR} = A_{PV} = \frac{\sigma_\uparrow - \sigma_\downarrow}{\sigma_\uparrow + \sigma_\downarrow} \sim \frac{A_{weak}}{A_\gamma} \sim \frac{G_F Q^2}{4\pi\alpha}(\alpha\,[2C_{1u} - C_{1d}] + \beta\,[2C_{2u} - C_{2d}])$$

- The present result leads to a determination of the effective electron-quark weak coupling combination $2C_{2u} - C_{2d}$ that is five times more precise than previously determined.
- It is the first experiment to isolate, when combined with previous experiments like Qweak, a non-zero C_{2q} (at 95% confidence level).
- This coupling describes how much of the mirror-symmetry breaking in the electron-quark interaction originates from the quarks' spin preference in the weak interaction. The result provides a mass exclusion limit on the electron and quark compositeness and contact interactions of ~5 TeV.



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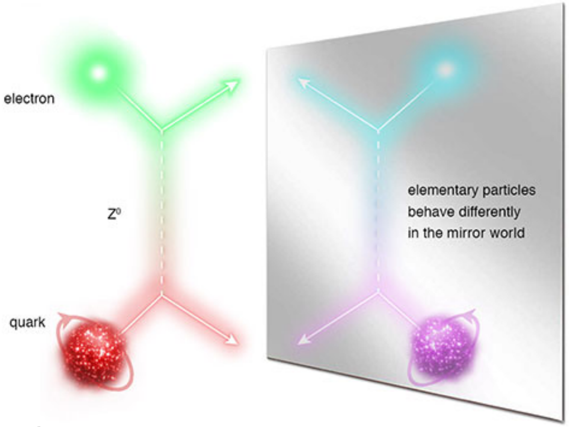

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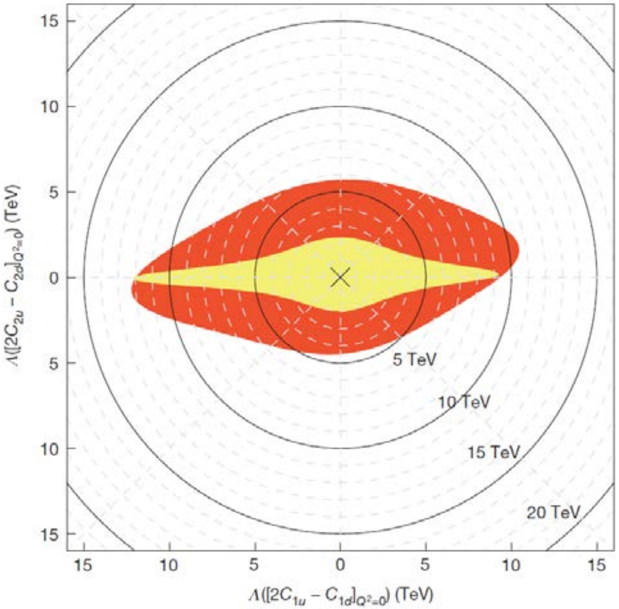
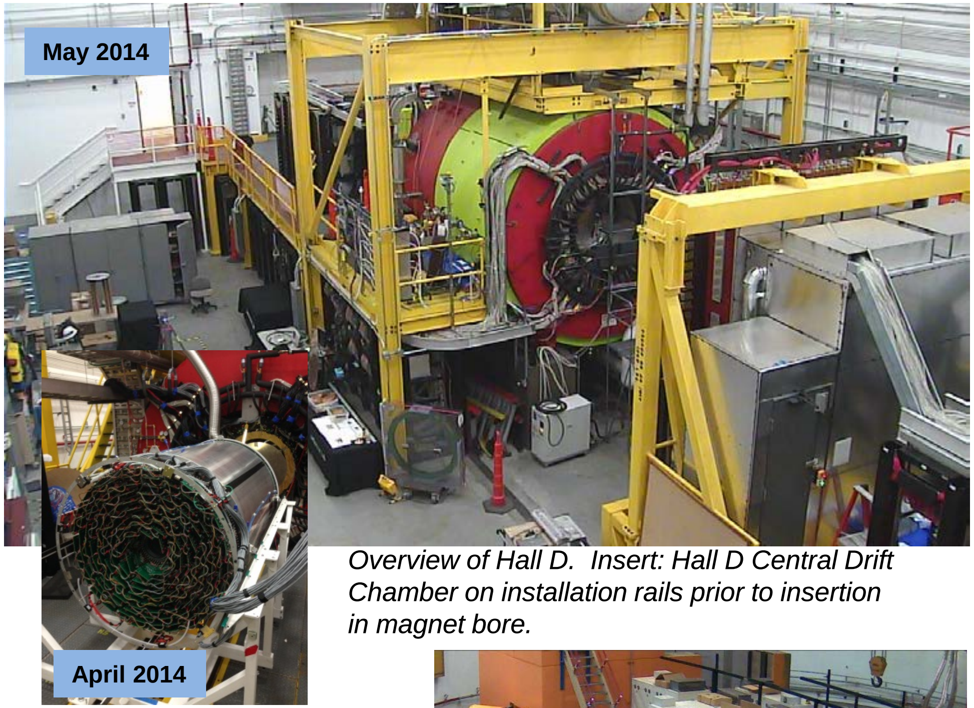


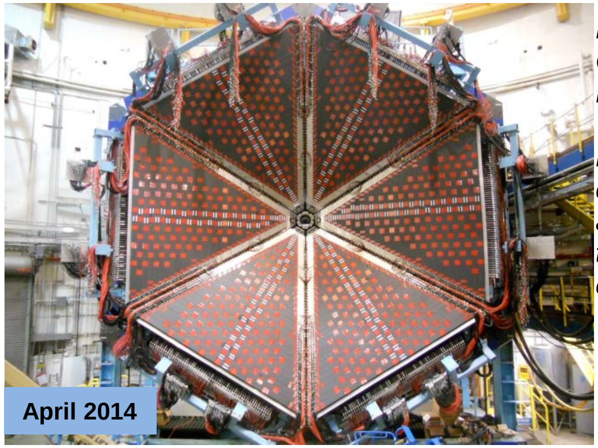
The 12 GeV CEBAF Upgrade at TJNAF is 90% Complete

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



Overview of Hall D. Insert: Hall D Central Drift Chamber on installation rails prior to insertion in magnet bore.

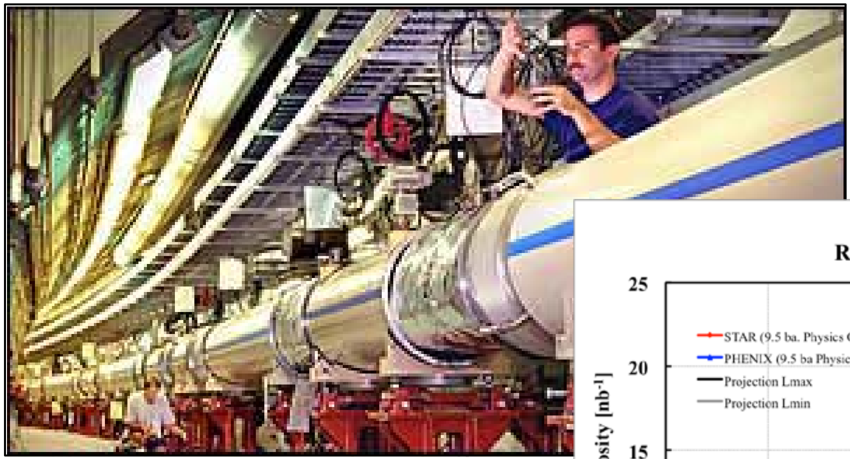


Hall B: Completed Forward Time-of-Flight detector arrays on the forward carriage

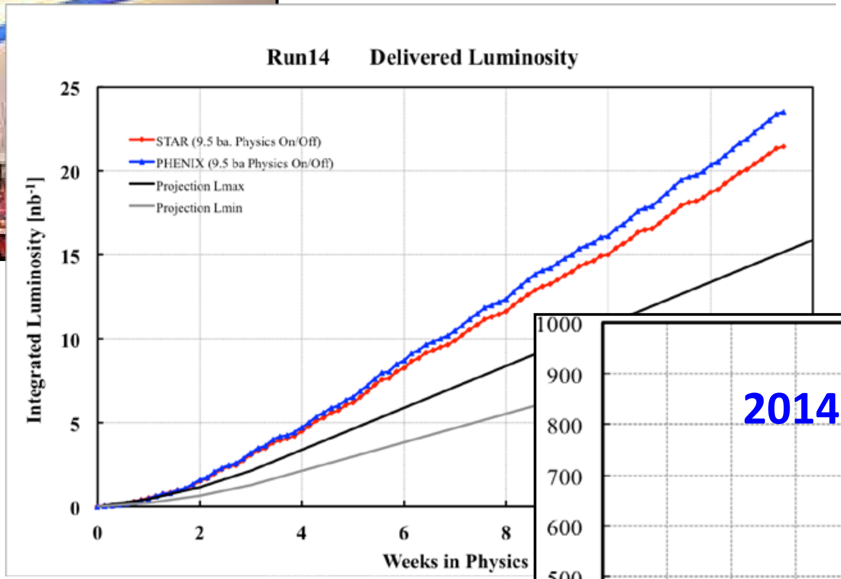
Project received CD-4A, *Approve Accelerator Project Completion*, on July 30, 2014.

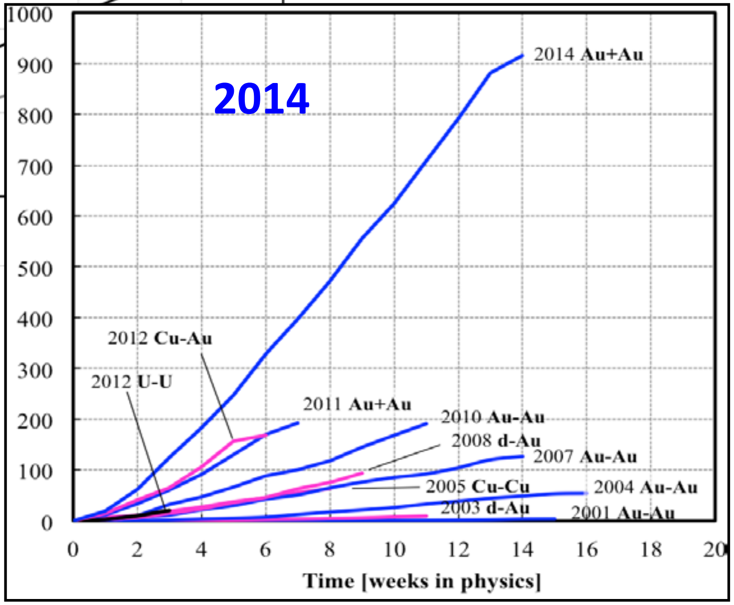
Hall C–Shield House & Power supplies on Super-High Momentum Spectrometer carriage

RHIC Machine Performance Sets New Records in FY 2014



Heavy ion runs



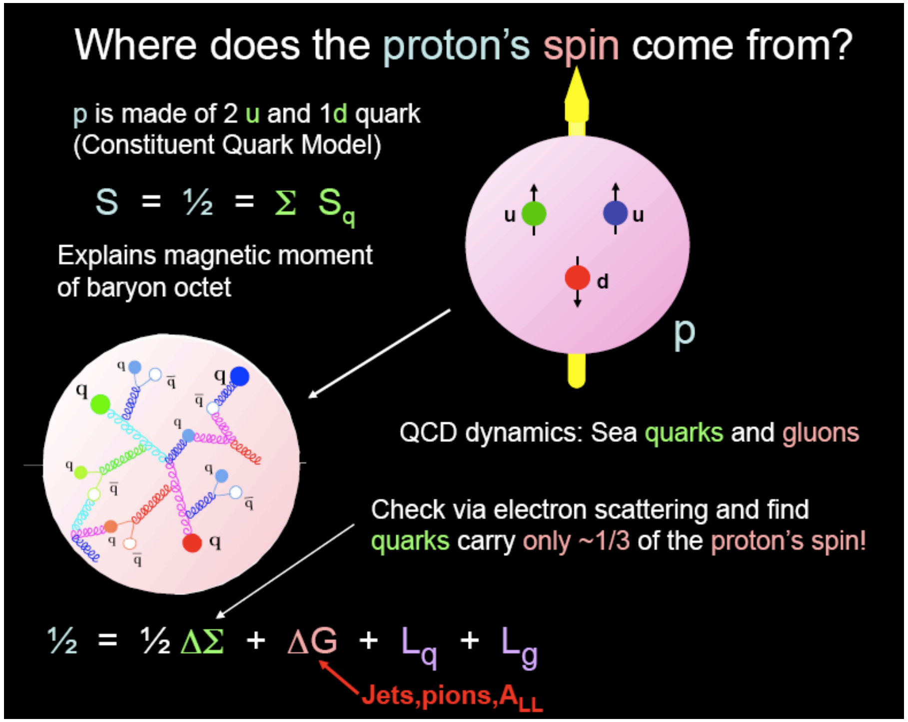


Au + Au integrated luminosity from Run 14 exceeded all previous Au+ Au runs combined

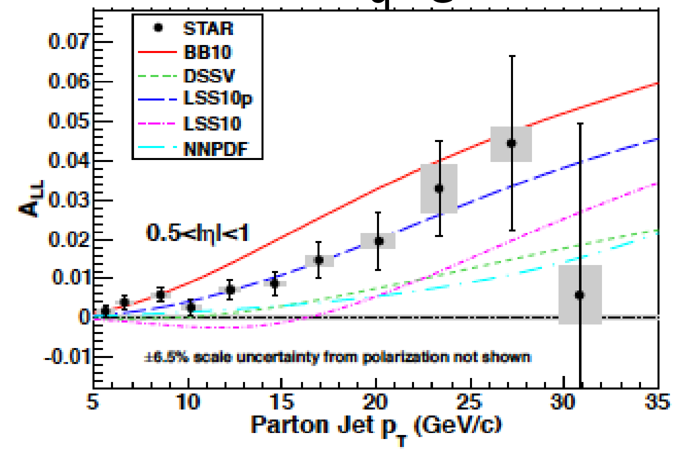
No other facility worldwide, existing or planned, can rival RHIC in range and versatility as a heavy ion collider. It is the only polarized proton collider in the world.

RHIC Science Remains World Leading

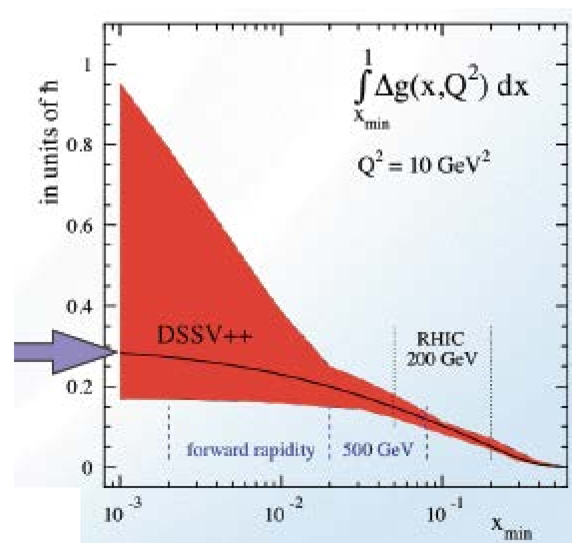
A worldwide scientific quest:



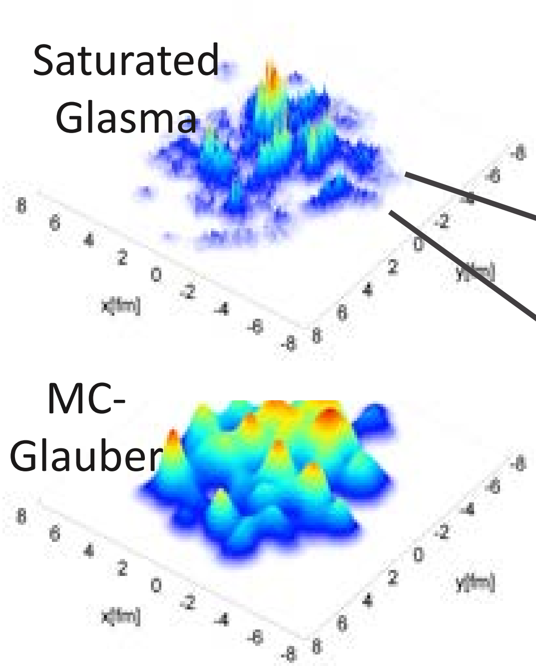
$$A_{LL} \sim \frac{\Delta q}{q}\,\frac{\Delta G}{G}$$



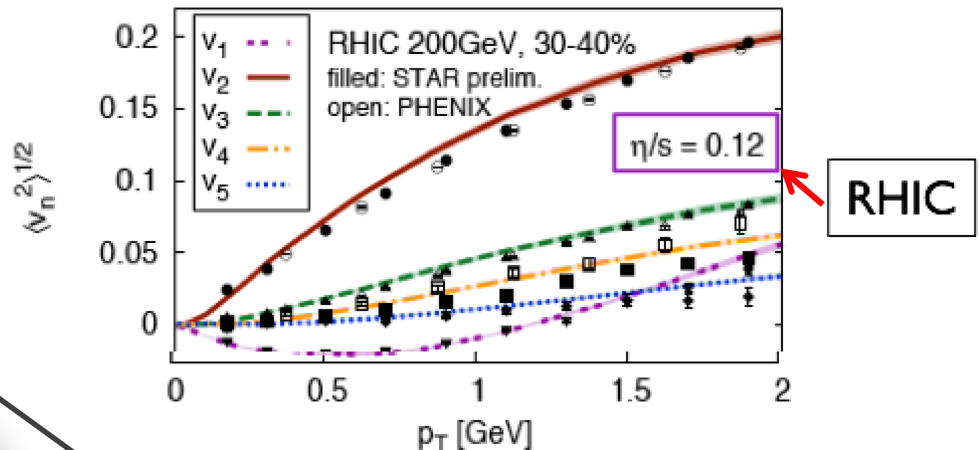
After almost two decades of focused study, RHIC results indicate the contribution to the proton spin is significant and within uncertainties, accounts for ~ 60% of the proton spin.

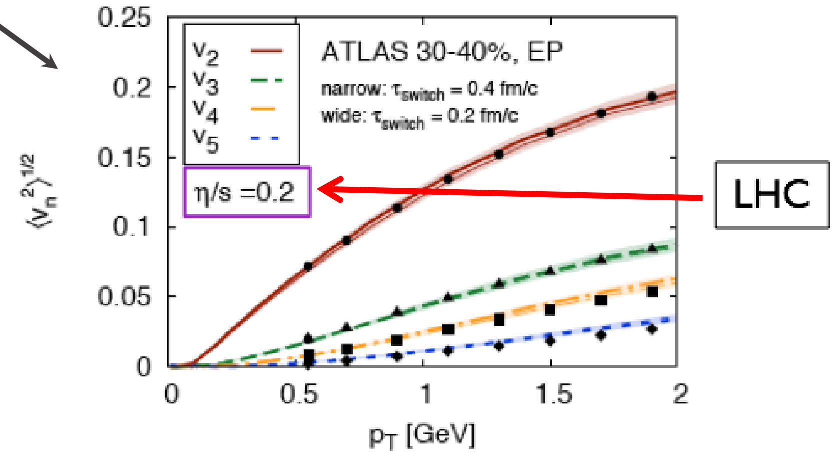


RHIC Results Providing Deeper Insight on the Origin of the Perfect QGP Liquid



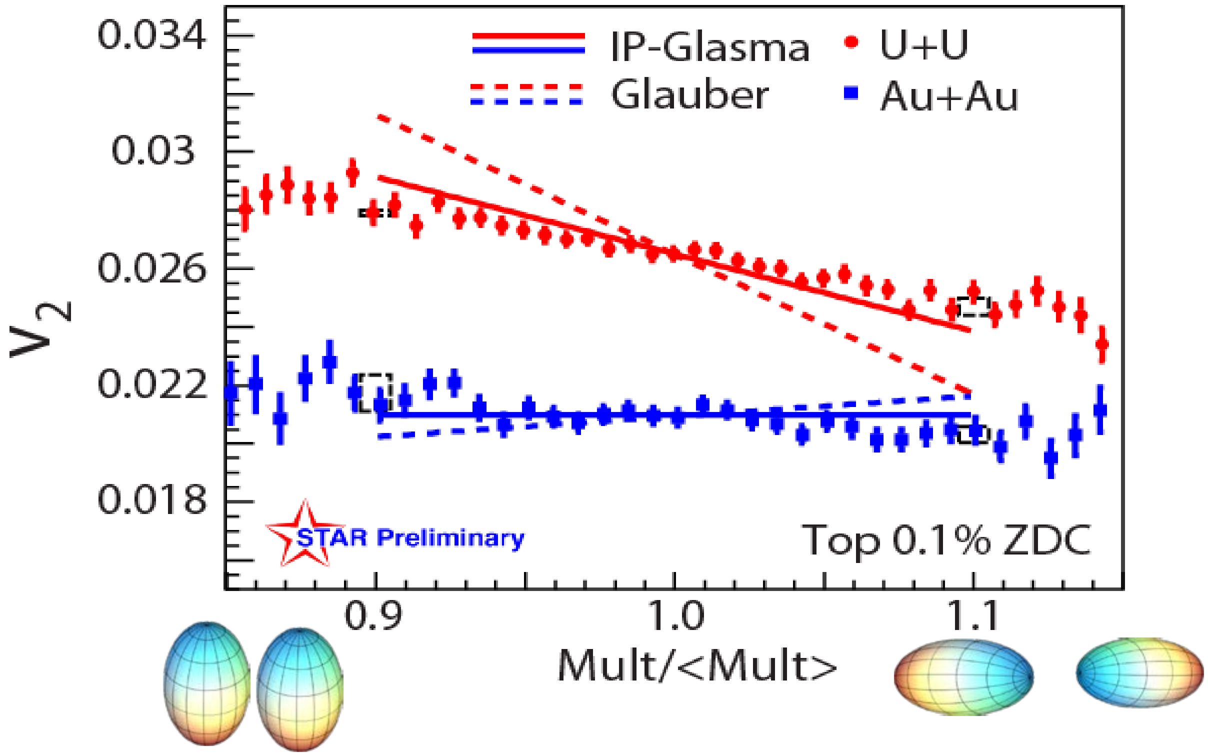
RHIC's "perfect" liquid is closer to perfection than LHC's: The hot soup of early-universe matter created in RHIC's heavy ion collisions found to have a lower specific shear viscosity (η/s).





Björn Schenke, winner of the 2013 IUPAP Young Scientist Prize, 2014 DOE Early Career Award, and world leader in modeling the early stage evolution of the dense fireball created in heavy ion collisions at RHIC

Confirmation from World-Leading New Capability

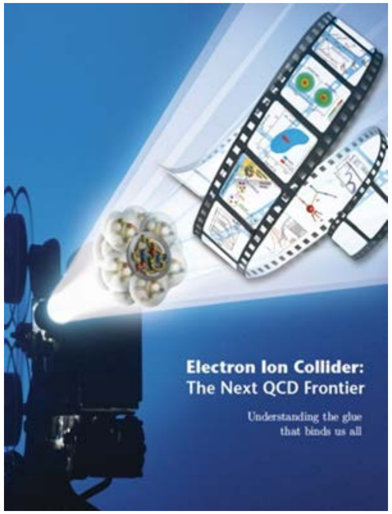


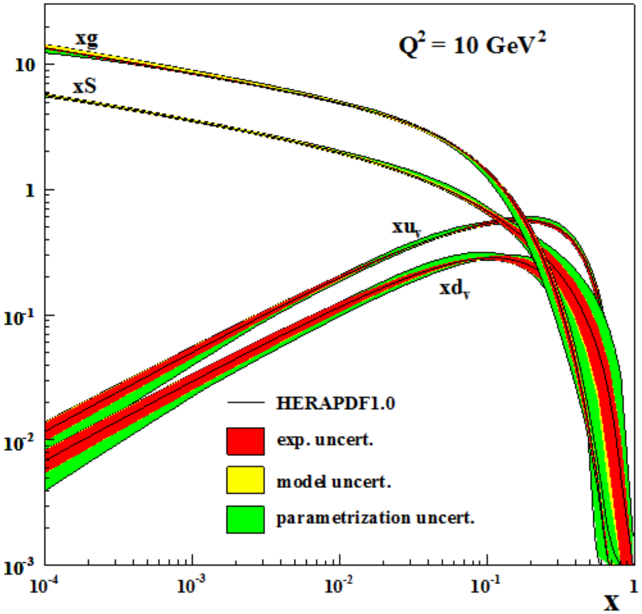
Deformed geometry of U+U allows discrimination between models of initial state fluctuations.

New capability afforded by completion of Joint NASA-DOE Construction Project to construct an Electron Beam Ion Source

EIC science: Understanding the glue that binds us all

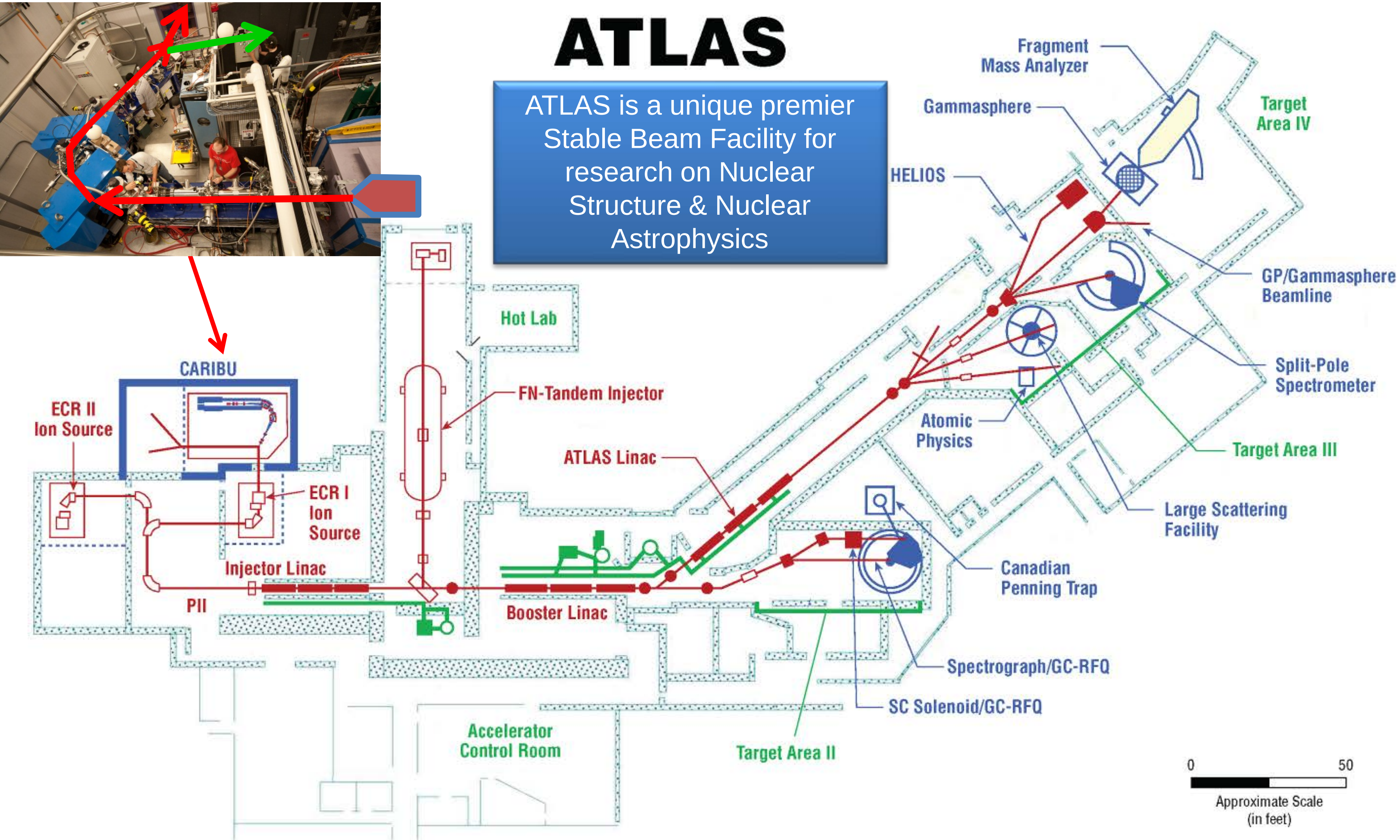
- Proton (and nuclei) and black holes are the only fully relativistic (high enough energy density to excite the vacuum) stable bound systems in the universe. Protons can be studied in the laboratory.
- Protons are fundamental to the visible universe (including us) and their properties are dominated by emergent phenomena of the self-coupling strong force that generates high density gluon fields:
  - o The mass of the proton (and the visible universe)
  - o The spin of the proton
  - o The dynamics of quarks and gluons in nucleons and nuclei
  - o The formation of hadrons from quarks and gluons
- The study of the high density gluon field that is at the center of it all requires a high energy, high luminosity, polarized Electron Ion Collider





The 2013 NSAC *Subcommittee on Future Facilities* identified the physics program for an Electron-Ion Collider as ***absolutely central*** to the nuclear science program of the next decade.

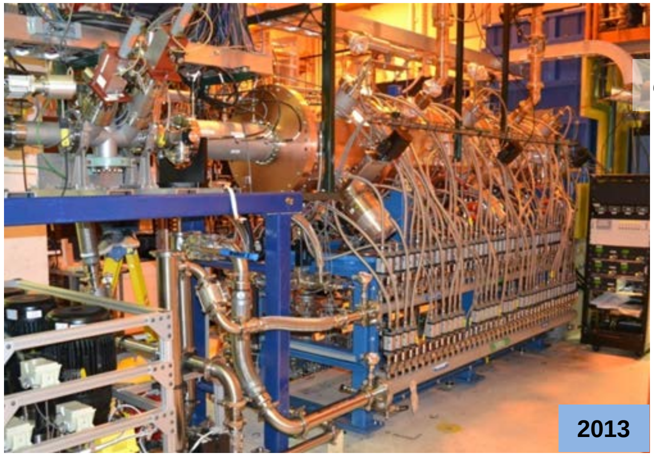
ATLAS at ANL Uniquely Provides Low Energy SC Research Opportunities



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

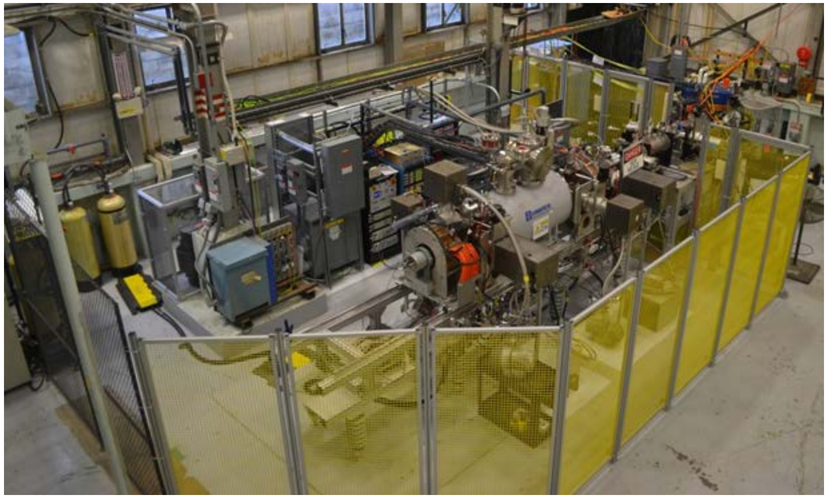
Recent ATLAS Upgrade Projects

New RFQ Accelerator Section for PII Linac (ARRA-funded), Replacement of First Booster Cryostat Module & Liquid Helium Upgrade (ARRA-funded), and Electron Beam Ion Source (EBIS)



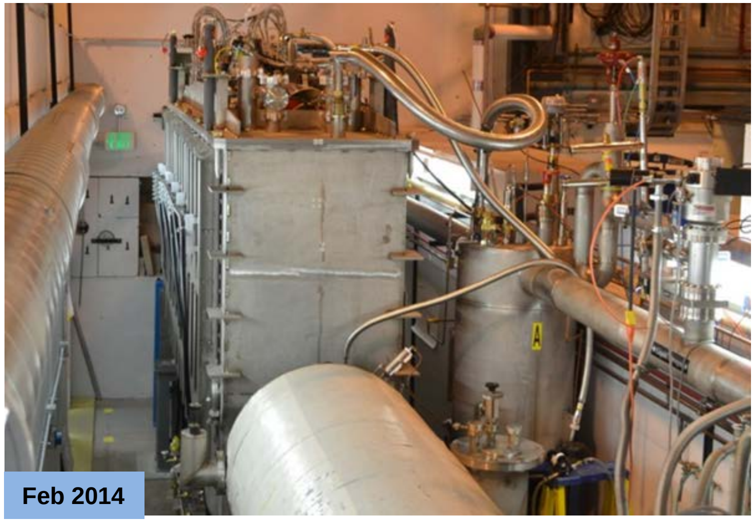
60 MHz RFQ

EBIS: will be installed on-line in 2015



Assembly stand for the 72 MHz Cryomodule

First Beam delivered with the 72 MHz Intensity Upgrade Cryomodule (enclosed in the tunnel)



Facility for Rare Isotope Beams

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.

Project received CD-3B, *Approval to Start Technical Construction*, on August 26, 2014.

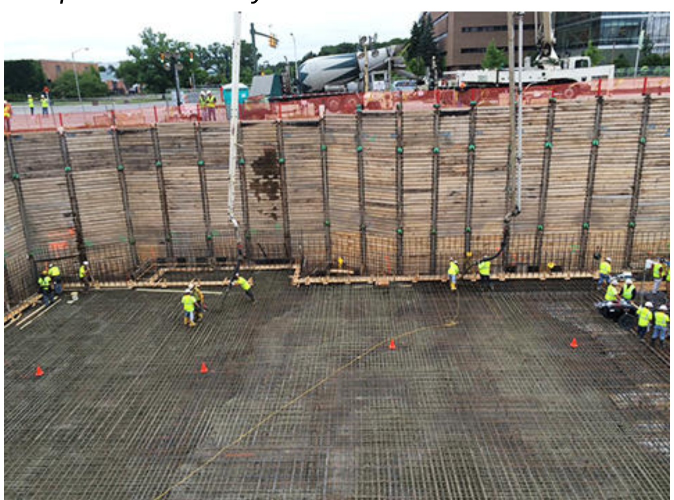
Five of fifteen nonconventional utility process tanks to be installed during conventional construction.

Progress of the Facility for Rare Isotope Beams at MSU

Ground breaking ceremony on March 17, 2014.

In July 2014, 140 truckloads of concrete arrived at MSU.

Workers placing 1,400 cubic yards of concrete in the first structural concrete placement in July for the linear accelerator tunnel.



Preparations for NP Stewarded Neutrino-less Double Beta Decay Experiments

R&D on one of several approaches by U.S. scientists is ongoing 4800 feet below ground at the Sanford Underground Research Facility (SURF)

MJD requires precision machining. These tiny parts are made in Majorana's machine shop. These small pins will hold the conductive wire in the copper clip at right.

Copper cryostat, as seen from above, will hold the extremely sensitive detector strings. This is a prototype of the ultra-pure copper that will be used in the actual module of the Majorana Demonstrator.

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 was charged to identify the criteria for a next generation double beta decay experiment.

Engineering Majorana's shield: The lead brick "castle" contains 3400 bricks

Nuclear Theory

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

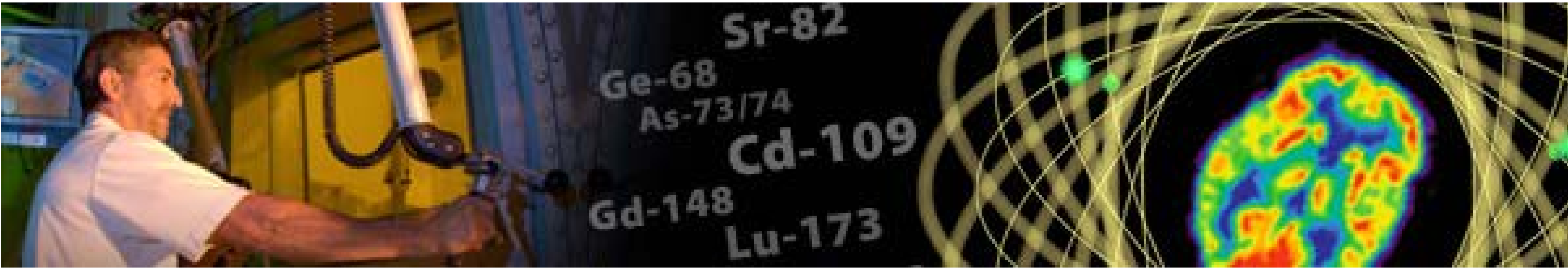
A strong Nuclear Theory effort:

- 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 successful new approach for NP—Theory Topical Collaborations are fixed-term, multi-institution collaborations established to investigate a specific topic

- "A new direction to enhance the research effort by bundling scientific strength and expertise located at different institutions to reach a broader scientific goal for the benefit of the entire nuclear science community… an extremely promising approach for funding programmatic and specific science goal oriented research efforts."

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 FY 2013

More than 470 shipments in FY 2013

Increased Availability of Isotopes

Bk-249	Produced 22 mg target that led to the discovery of element 117; produced 26 mg for further super-heavy element research
Cf-249	Provided for actinide borate research
Cf-252	Re-established production in FY 2009, new six-year contract for FY 2013-2018; industrial applications
Cu-67	Production campaigns available starting Feb 13; cancer therapy
Li-6	Production of metal form for neutron detector isotope sales
Np-237	Established inventory for dispensing bulk quantities and capability to fabricate reactor dosimeters
Se-72/As-72	Developed production capability for Se-72 for use in a generator to provide the positron emitter As-72; medical diagnostic
Si-32	Produced in the 1990s for oceanographic and climate modeling research, inventory depleted, new production campaign has made the isotope available again
Th-227/Ra-223	Established Ac-227 cows for the provision of Th-227 and Ra-223 (alpha emitters for medical applications)
Y-86	Established production capability of the positron emitter Y-86; medical diagnostic
Cm-243	Acquired curium with a high Cm-243 content for research applications

Isotopes under Development

Ac-225:	Developing accelerator production capability
At-211:	Funding production development at four institutions to establish nationwide availability
Am-241:	Initiated project to produce Am-241 in association with an industrial consortium
C-14:	Investigating economic feasibility of reactor production
Cd-109:	Working with industry to assess product specific activity
Co-57:	Evaluating production of Co-57 for commercial source fabricators
Cs-137 HSA:	Pursuing reactor production feasibility for research applications
Cu-64:	Funding production development at multiple institutions
Gd-153:	Pursuing feasibility of reactor production
Ho-166:	Establishing reactor production capability
I-124:	Funding production development at one institution
K-40:	Evaluating possibility of reactor production by irradiating K rather than electromagnetically enriching K-40
Li-7:	Working to establish reserve for nuclear power industry to mitigate potential shortage
Np-236:	Pursuing feasibility of accelerator-based production for security reference materials
Pa-231:	Purifying 100 mg for applications such as fuel cycle research
Sr-89:	Investigating economic feasibility of reactor production
U-233:	Acquisition of mass separated U-233 for research applications
U-234:	Investigating alternatives for provision of U-234 for neutron flux monitors
Zn-62/Cu-62:	Funding production development for Zn-62 for use in a generator to provide the positron emitter Cu-62
Zr-89:	Funding production development at multiple institutions

Alpha-Emitter Production for Targeted Radiotherapy
NSAC High Priority

Actinium-225
- Continue to process Th-229 for Ac-225; up to about 360 mCi per year.
- R&D has been supported to demonstrate the viability of production of Ac-225 via high energy proton-induced spallation of Th-232 targets.
- Developing production scale targets and processing techniques in order to implement **regular, full-scale production of Ac-225.**

Actinium-227
- Separated and purified Ac-227 from surplus actinium-beryllium neutron sources at ORNL and from legacy Ac-227 at PNNL.
- Ac-227 used as a source (cow) for the decay production of **Th-227 and Ra-223**, important alpha-emitting isotopes for medicine.
- **Developing reactor-based production of Ac-227.**

Astatine-211
- Developing **nationwide production network** at four institutions.

Lead-212/Bismuth-212
- Separated Th-228 from U-233 at ORNL
- Th-228 used as a cow for the decay production of Ra-224, the parent of Pb-212 and Bi-212, important alpha-emitting isotopes for medicine.

New SC Requirement

Department of Energy
Office of Science
Washington, DC 20585

JUL 28 2014

Dear Colleagues:

The U.S. Department of Energy's Office of Science today issued new requirements for the management of digital research data. All proposals for research funding submitted to the Office of Science will be required to include a Data Management Plan that describes whether and how the digital research data generated in the course of the proposed research will be shared and preserved.

The new requirements were formulated in response to a February 2013 Office of Science and Technology Policy directive requiring that all Federal agencies with over $100 million in annual R&D expenditures ensure that recipients of research grants and contracts develop Data Management Plans as part of their research proposals.

New SC requirements on proposals

The new requirements will appear in funding solicitations and invitations issued by the Office of Science beginning October 1, 2014. A statement of the new requirements, including guidance on the development of a Data Management Plan, can be found on the Office of Science web site at http://science.energy.gov/funding-opportunities/digital-data-management/.

Thank you for your attention to these new requirements.

Sincerely,

Patricia Dehmer
Acting Director, Office of Science
U.S. Department of Energy

Other news

Additional Requirements regarding open access the results of Federally Funded Research will be published soon

Role and Management of DOE labs being examined by two panels

DOE NP positions posted in the near future:

- Division Director for the Physics Research Division
- Program Manager for Heavy Ion Physics
- Program Manager for Fundamental Symmetries

No news on Office of Science Director Nomination

High Level concerns: % of Research Funding; articulating interface with HEP on FS to OMB, OSTP and Congressional Stakeholders

Outlook

- **The future of nuclear science in the United States continues to be rich with science opportunities.**
- **Long term, an electron-ion collider may be the optimum path towards new opportunities in QCD research.**
- **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