



U.S. DEPARTMENT OF
ENERGY

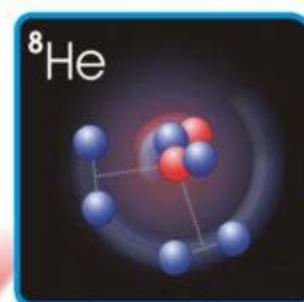
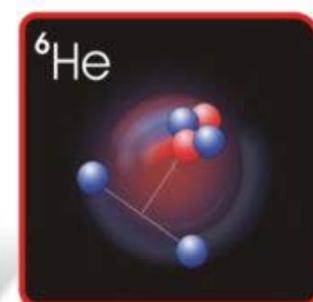
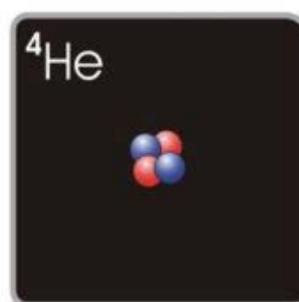
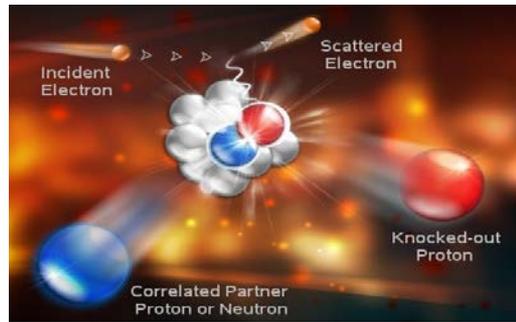
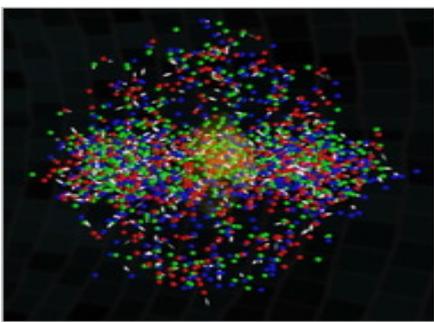
Office of
Science

Perspectives and News from Nuclear Physics

RHIC & AGS Annual User Meeting
Brookhaven National Laboratory
June 23, 2011

Timothy J. Hallman
Associate Director for Nuclear Physics
Office of Science, U.S. Department of Energy

- To enable U.S. world leadership in discovery science illuminating the properties of nuclear matter in all of its manifestations
- To provide the tools necessary for scientific and technical advances which will lead to new knowledge, new competencies, and groundbreaking innovation and applications
- To make strategic investments in facilities and research to provide the U.S. with the premier facilities in the world by the end of the decade for research on:
 - New states of matter 100 times more dense than “normal” nuclear matter at the Relativistic Heavy Ion Collider
 - The force which binds quarks and gluons in protons and neutrons at the 12 GeV Continuous Electron Beam Accelerator Facility
 - The limits of nuclear existence for neutron and proton rich nuclei at the Facility for Rare Isotope Beams and the Argonne Tandem Linac Accelerator System
 - Innovative, effective and reliable isotope production with a new dedicated isotope facility



Discovering, exploring, and understanding all forms of nuclear matter

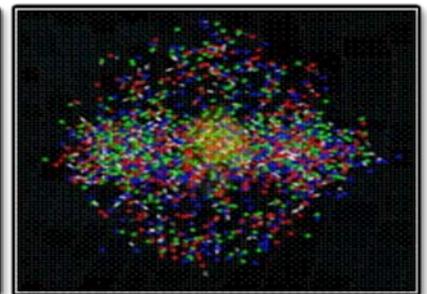
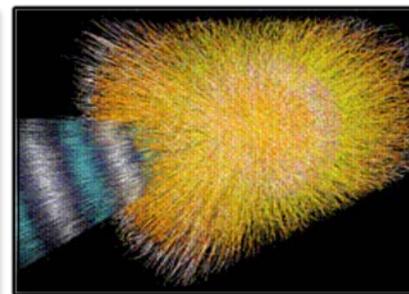
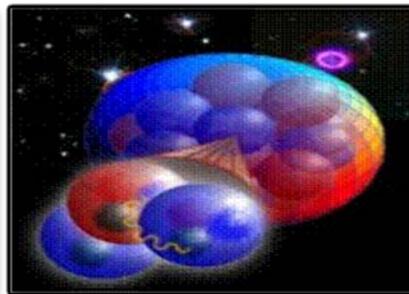
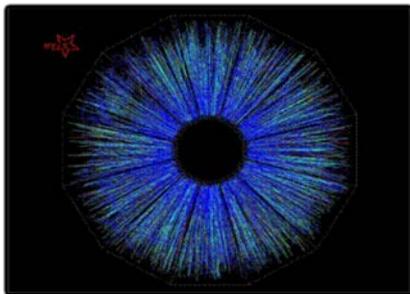
The Scientific Challenges:

Understand:

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

FY 2012 Highlights:

- 12 GeV CEBAF Upgrade to study exotic and excited bound systems of quarks and gluons and for illuminating the force that binds them into protons and neutrons.
- Design of the Facility for Rare Isotope Beams to study the limits of nuclear existence.
- Operation of three nuclear science user facilities (RHIC, CEBAF, ATLAS); closure of the Holifield Radioactive Ion Beam Facility at ORNL.
- Research, development, and production of stable and radioactive isotopes for science, medicine, industry, and national security.



Nuclear Physics FY 2012 Congressional Request

	FY 2010 Approp.	FY 2010 Approp. with SBIR / STTR	FY 2011 Approp . with SBIR / STTR	FY 2012 Request	FY 2010 to FY2012 Change		FY 2010 with SBIR/STTR to FY2012 Change	
					\$k	%	\$k	%
Medium Energy	122,113	127,481	127,730	130,380	+8,267	+6.8%	+2,899	+2.3%
Heavy Ion	205,063	210,725	208,619	219,984	+14,921	+7.3%	+9,259	+4.4%
Low Energy	116,216	117,642	105,153	126,536	+10,320	+8.9%	+8,894	+7.6%
Theory	39,952	39,952	42,924	42,166	+2,214	+5.5%	+2,214	+5.5%
Isotope Program	19,116	19,200	19,760	20,234	+1,118	+5.8%	+1,034	+5.4%
Construction	20,000	20,000	35,928	66,000	+46,000	+230.0%	+46,000	+230.0%
Total	522,460	535,000	540,114	605,300	+82,840	+15.9%	+70,300	+13.1%

FRIB
+\$18M

12 GeV
Upgrade
+\$46M

- The FY 2012 budget request is dominated by continued support, as planned, for the two highest priorities in the Nuclear Science Community. **Of the \$70.3M increase requested in FY 2012, \$64M is for these two projects.**
 - The **12 GeV Continuous Electron Beam Accelerator Facility (CEBAF) Upgrade** which is being constructed at the Thomas Jefferson National Laboratory **(+\$46M)**.
 - The **Facility for Rare Isotope Beams (FRIB)**, within the Low Energy subprogram, which is being constructed at Michigan State University **(+\$18M)**.
- These investments in forefront facilities for new research capability, the first in the NP program in over ten years, will secure global U.S. leadership in research on the quark structure of nucleons, nuclear structure, and nuclear astrophysics.

FY 2012 Congressional Request (\$k)

Nuclear Physics – Highlights

PLANNED PROFILE INCREASES FOR HIGH PRIORITY CONSTRUCTION PROJECTS	+\$64,000
<ul style="list-style-type: none"> ▪ 12 GeV Continuous Electron Beam Accelerator Facility Upgrade – per baselined construction funding profile + 46,000 ▪ Facility for Rare Isotope Beams (FRIB) – per Cooperative Agreement with Michigan State University + 18,000 	
FUNDING CHANGES IN THE REST OF THE NP PROGRAM	+ 6,300
<ul style="list-style-type: none"> ▪ DUSEL – to support minimal, sustaining operations at the Homestake mine in South Dakota + 5,000 ▪ Facility Operations + 8,675 <ul style="list-style-type: none"> ▪ RHIC – 24 weeks of operations at increased luminosity (+\$7.4M) ▪ CEBAF – 27 weeks of operations, maximum possible with 12 GeV installation schedule (+\$0.6M) ▪ ATLAS – 39 weeks, including commissioning of new accelerator components (+\$0.6M) ▪ Other Facilities (Isotope Facilities, 88-Inch, ORELA) and BNL GPE (+\$0.1M) ▪ HRIBF – closure as a national user facility in FY 2012 to support higher priority activities within the NP program - 10,259 ▪ Research – core research is held flat with FY 2010 at universities and national laboratories except for targeted increases for build-up of Hall D experimental groups; R&D and operations associated with recently completed and new MIEs to optimize investments (RHIC experiments, FNPB, HI LHC, GRETINA, KATRIN, CUORE, Majorana); development of the experimental program at the recently completed FNPB; and isotope production research (a redistribution of efforts previously categorized as operations. Increases are partially offset by decreases for SciDAC, shutdown of the Yale accelerator, and termination of RIB Science Initiatives. + 10,196 ▪ Majorana Demonstrator R&D ramps-up according to planned profile – effort to demonstrate proof-of-principle for neutrino-less double beta decay; initiated in FY 2010 + 2,500 ▪ Major Items of Equipment - 9,812 <ul style="list-style-type: none"> ▪ STAR HFT – ramps up per planned profile for RHIC high luminosity run in FY 2013 (+\$1.9M) ▪ nEDM – slowed relative to project plans approved at CD-1 (-\$3.4M) ▪ Funding completion for ALICE EMCal, CUORE and GRETINA per planned profiles (-\$8.3M) 	
TOTAL NUCLEAR PHYSICS	+\$70,300

SCIENCE

Appropriation, 2011	\$4,842,665,000
Budget estimate, 2012	5,416,114,000
Recommended, 2012	4,800,000,000
Comparison:	
Appropriation, 2011	– 42,665,000
Budget estimate, 2012	– 616,114,000

The Office of Science funds basic science research in support of the Department of Energy's core energy-focused missions. Through science research in physics, biology, chemistry, and other fundamental science and technology disciplines, the Department pushes the limits of scientific understanding and helps to maintain the nation's leadership in energy innovation. Through national laboratories, universities, and other partnerships, the Office of Science funds a significant portion of science research nationwide.

NUCLEAR PHYSICS

The Committee recommends \$552,000,000 for Nuclear Physics, \$11,886,000 above fiscal year 2011 and \$53,300,000 below the request. The recommendation includes \$24,000,000 for the Facility for Rare Isotope Beams, \$6,000,000 below the budget request.

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2011
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2012
(Amounts in thousands)

	FY 2011 Enacted	FY 2012 Request	Bill	Bill vs. Enacted	Bill vs. Request
Accelerator facility (was project 07-SC-001), Newport News, VA.....	35,928	66,000	40,000	+4,072	-26,000
Subtotal, Nuclear physics.....	540,114	605,300	552,000	+11,886	-53,300

The bill recommends the following changes in program budgets from this year:

- Fusion Energy Sciences: Up 8.1 percent
- Nuclear Physics: Up 2.2 percent
- Advanced Scientific Computing: Up 1.2 percent
- Basic Energy Sciences: Up 0.6 percent
- High Energy Physics: Up 0.2 percent
- Biological and Environmental Research: Down 10.6 percent

Office of Science
FY 2012 Funding Status
(budget authority in thousands of dollars)

	FY 2011	FY 2012					
	Approp. ^{a/}	Request	House Committee	House vs. FY 2011		House vs. Request	
Advanced Scientific Computing	421,997	465,600	427,093	+5,096	+1.2%	-38,507	-8.3%
Basic Energy Sciences	1,678,195	1,985,000	1,688,145	+9,950	+0.6%	-296,855	-15.0%
Biological and Environmental Research	611,823	717,900	547,075	-64,748	-10.6%	-170,825	-23.8%
Fusion Energy Sciences	375,462	399,700	406,000	+30,538	+8.1%	+6,300	+0
High Energy Physics	795,420	797,200	797,200	+1,780	+0.2%	—	—
Nuclear Physics	540,114	605,300	552,000	+11,886	+2.2%	-53,300	-8.8%
Workforce Development	22,600	35,600	17,849	-4,751	-21.0%	-17,751	-49.9%
Science Lab Infrastructure	125,748	111,800	103,487	-22,261	-17.7%	-8,313	-7.4%
Safeguards and Security	83,786	83,900	83,900	+114	+0.1%	—	—
Science Program Direction	202,520	216,863	180,000	-22,520	-11.1%	-36,863	-17.0%
Subtotal, Science	4,857,665	5,418,863	4,802,749	-54,916	-1.1%	-616,114	-11.4%
Use of prior year balances	-15,000	-2,749	-2,749	+12,251	+81.7%	—	—
Total, Science	4,842,665	5,416,114	4,800,000	-42,665	-0.9%	-616,114	-11.4%

^{a/} FY 2011 Enacted Appropriation is prior to the Small Business Innovation Research/Technology Transfer reprogramming and appropriations transfer.

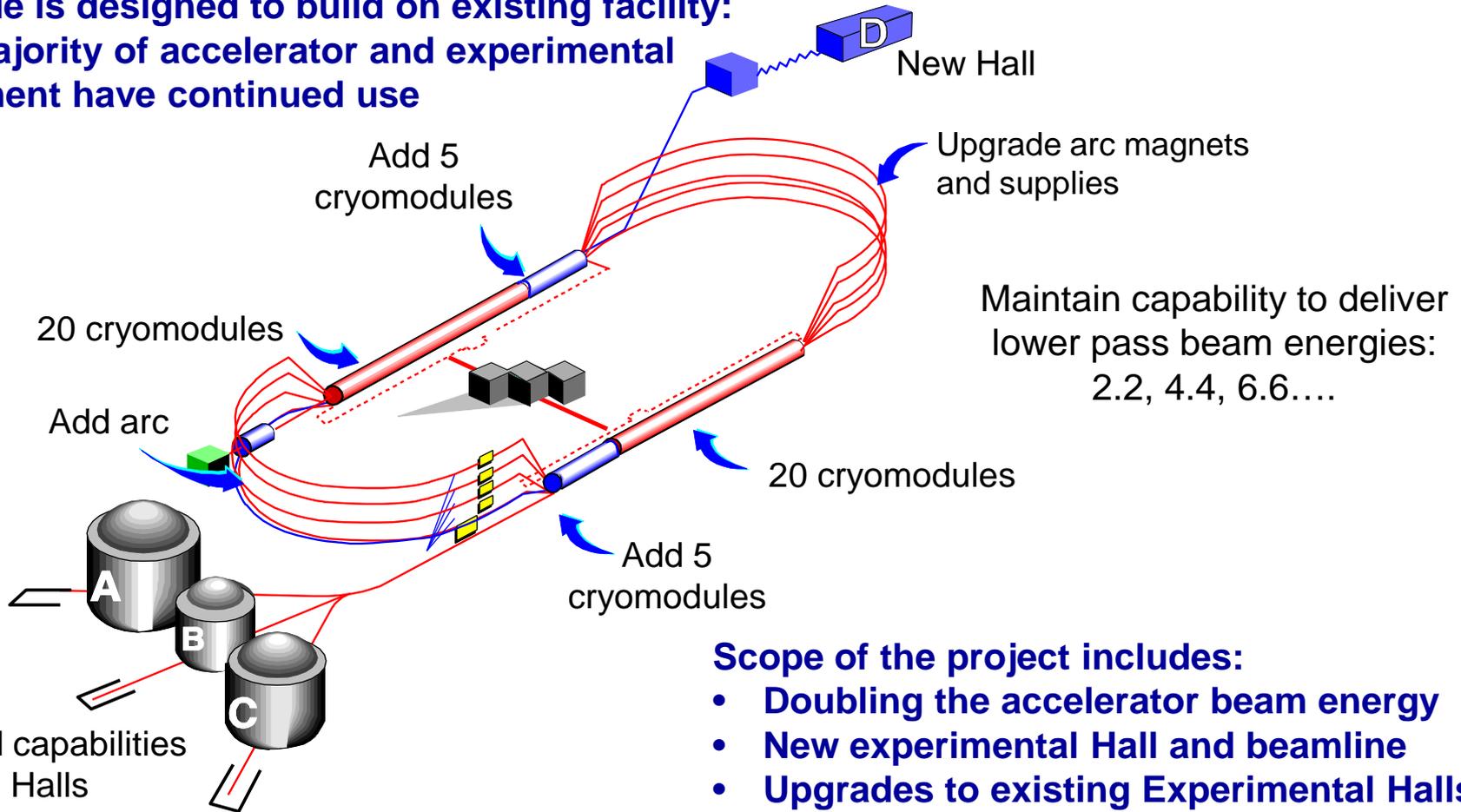


The Committee notes that the Nuclear Physics program has unique experimental capabilities for testing materials under irradiative environments. Materials stressed by intense radiation are important to many technologies, including nuclear fission and nuclear fusion. After the completion of the fusion energy experiment ITER, for example, the most significant technical obstacle to construction of a fully-operational demonstration fusion reactor is the development of containment materials that can withstand a sustained high flux of neutrons without significant degradation. The Committee encourages the Department to consider ways to strengthen productive cooperation between Nuclear Physics and other programs at the Department of Energy to better understand and develop materials that can withstand high levels of radiation.

12 GeV CEBAF Upgrade Project

The energy of CEBAF is being upgraded to 12 GeV
and a new experimental hall is being built

**Upgrade is designed to build on existing facility:
vast majority of accelerator and experimental
equipment have continued use**



Baselined	PYs	FY09 ARRA	FY10	FY11	FY12	FY13	FY14	FY15	Total
TPC \$M	60	65	20	36	66	43	18	2	310

12 GeV CEBAF Upgrade Project: On Schedule, On Budget

With the planned completion of the 12 GeV CEBAF Upgrade in FY 2015, researchers will address

- The search for exotic mesons—a quark and an anti-quark held together by gluons, but unlike conventional mesons, the gluons are excited.
- Physics beyond the Standard Model via high precision studies of parity violation.
- The spin and flavor dependence of valence parton distributions—the heart of the proton, where its quantum numbers are determined.
- The structure of atomic nuclei, exploring how the valence quark structure is modified in a dense nuclear medium.
- Nuclear tomography to discover and explore the three-dimensional structure of the nucleon.

FY 2012 Activities

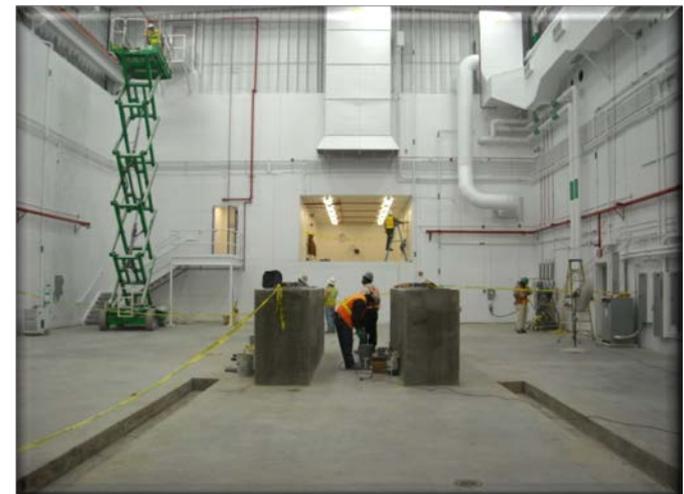
- Start installation for existing Halls
- Accelerator installation shutdown for 6 months from May-November 2011, and for 12 months from May 2012-May 2013
- Complete accelerator tunnel extension

First completed
12 GeV cavity
string being
moved into the
cryomodule
assembly area



Winter 2010

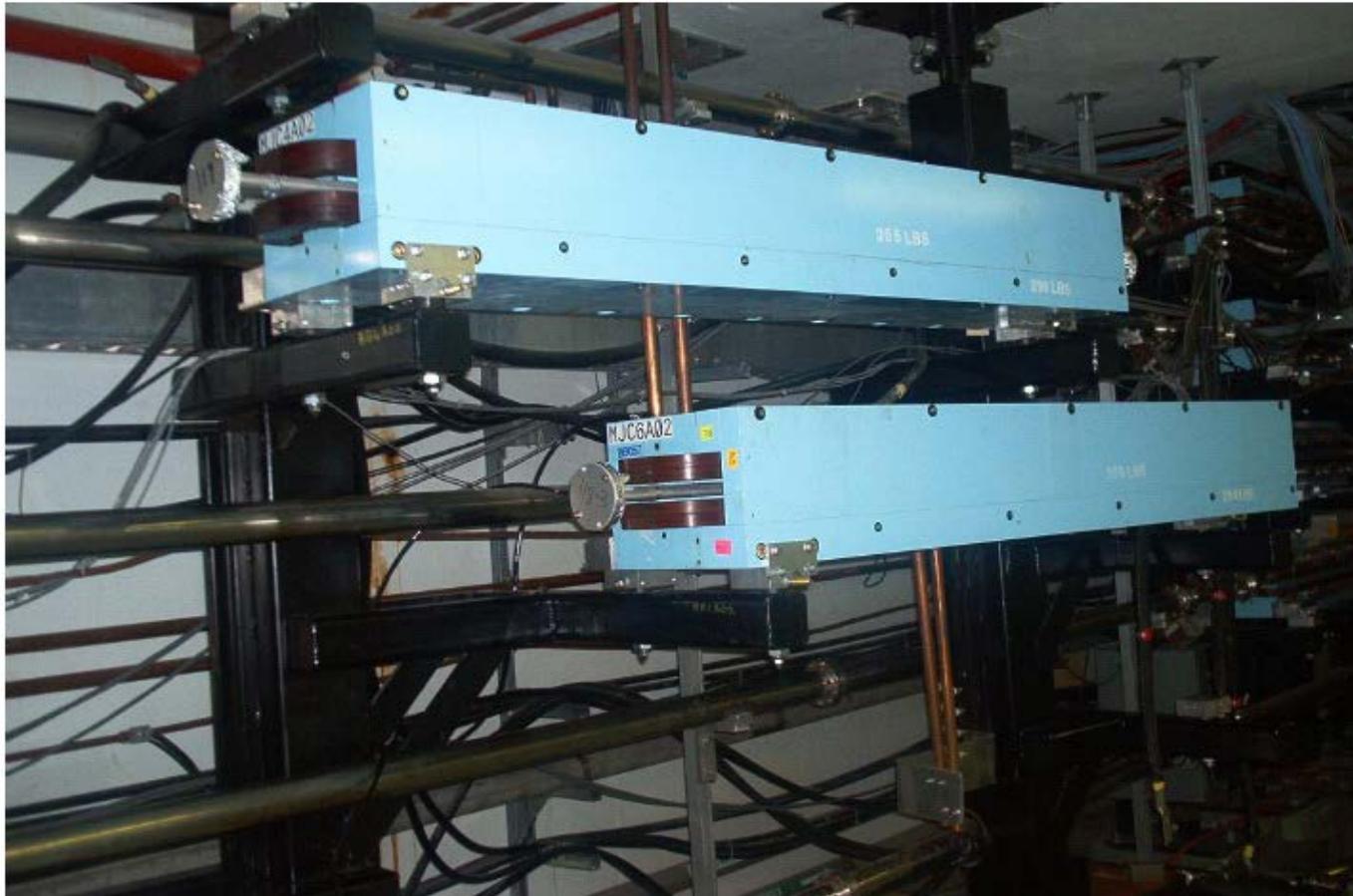
Pouring the foundation for the Hall D complex.



New Experimental Hall D - December 2010



First Two Installed 12 GeV Magnets



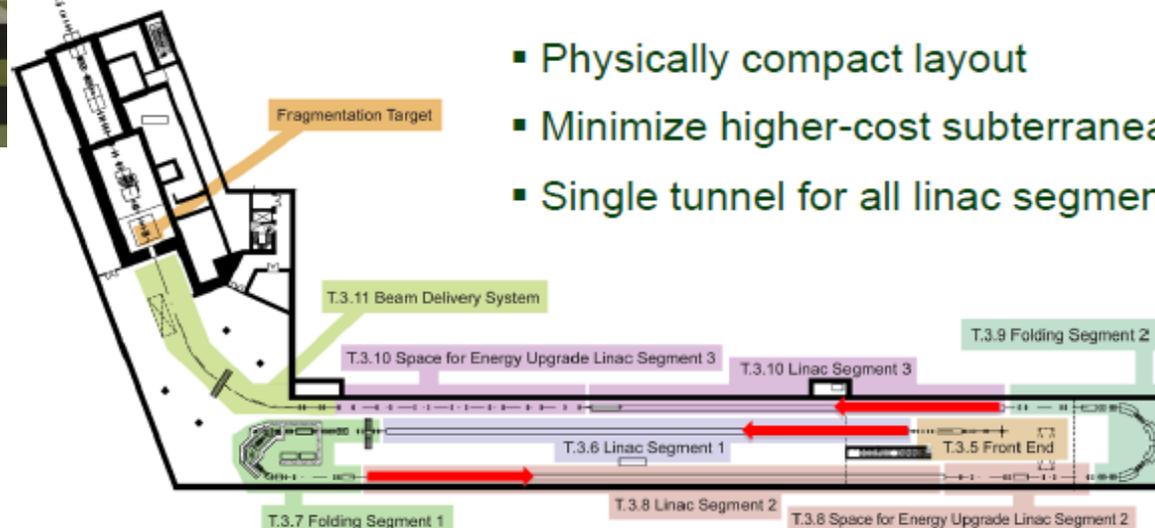
Facility for Rare Isotope Beams at MSU

A New “Microscope” to Study the Structure of Nuclei



Existing NSCL Laboratory

- Critical Decision-1, September 2010
- Steady progress towards Critical Decision-2 (performance baseline)
- DOE Total Project Cost range is \$500M-\$550M (not including \$94.5M from MSU)
- Executed under a Cooperative Agreement with Michigan State University



- Physically compact layout
- Minimize higher-cost subterranean structures
- Single tunnel for all linac segments

DOE TPC	\$M
FY09	7
FY10	12
FY11	10
FY12	30
Outyears	441-491
Total Range	500-550

Science Drivers for FRIB

▪ Nuclear Structure

- Explore the limits of existence and study new phenomena
- Possibility of a broadly applicable model of nuclei and how they interact
- Probing neutron skins
- Synthesis of superheavy elements

▪ Nuclear Astrophysics

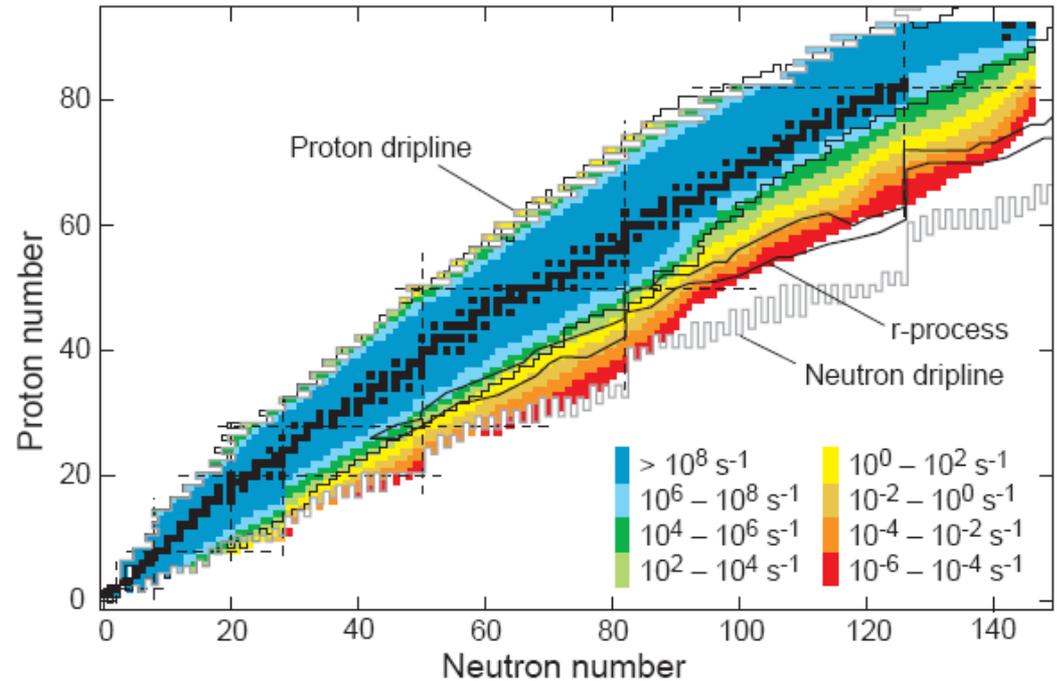
- The origin of the heavy elements
- Explosive nucleosynthesis
- Composition of neutron star crusts

▪ Fundamental Symmetries

- Tests of fundamental symmetries, Atomic EDMs, Weak Charge

▪ Other Scientific Applications

- Stockpile stewardship, materials, medical, reactors



FY 2012 Activities

- Continue engineering and design efforts
- Initiate long-lead procurements
- Possibly pursue a phased-construction start to reduce project risks

First Beam Accelerated to Full Energy Through the Beta=0.041 ReA Cryomodules at MSU

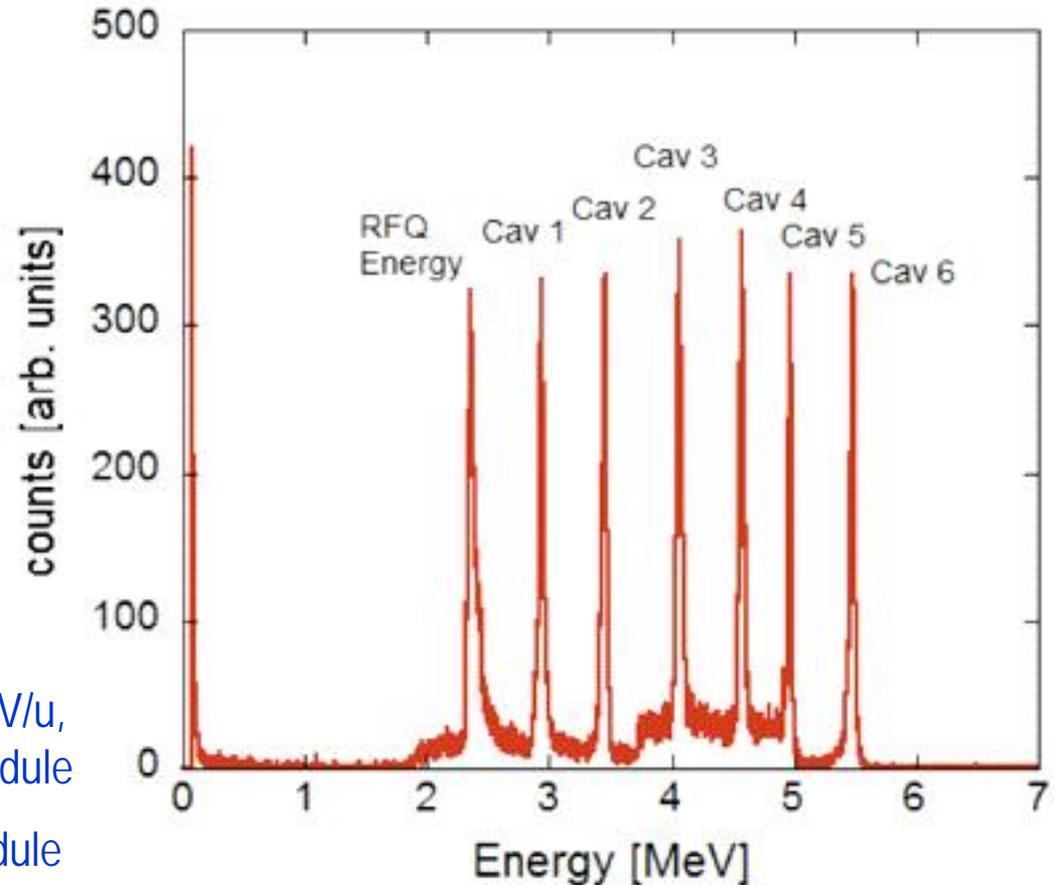
ReA

- A superconducting linac designed to accelerate rare isotope beams from [NSCL's Coupled Cyclotron Facility](#).
- Will provide a wide variety of exotic isotopes at variable energies.
- When [FRIB](#) is completed, ReA will be part of the new facility and serve as its post accelerator.

A He⁺ beam accelerated by RFQ to 0.6 MeV/u, then rebunched using the first SRF cryomodule

Further accelerated by the second cryomodule to just above the design energy of 1.38 MeV/u.

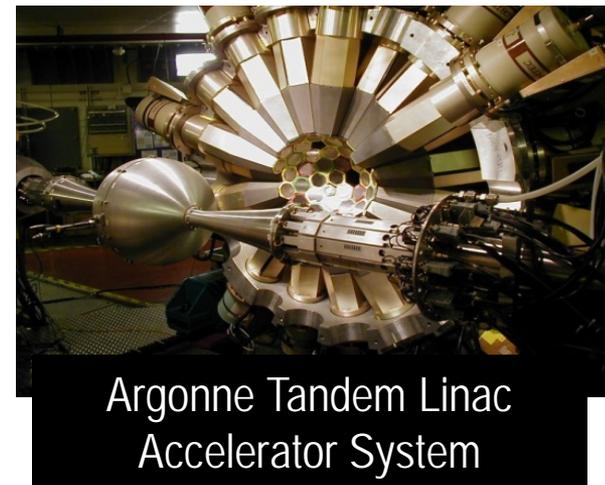
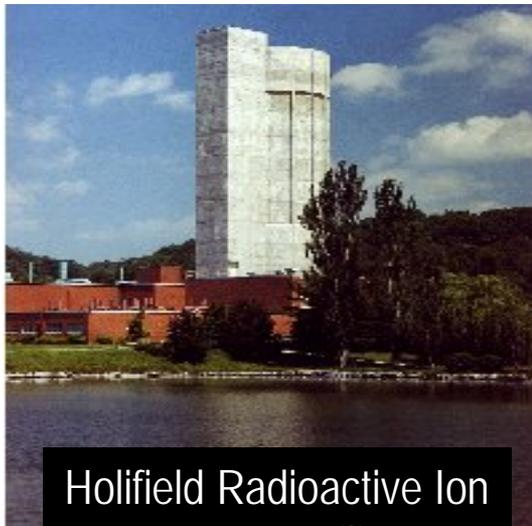
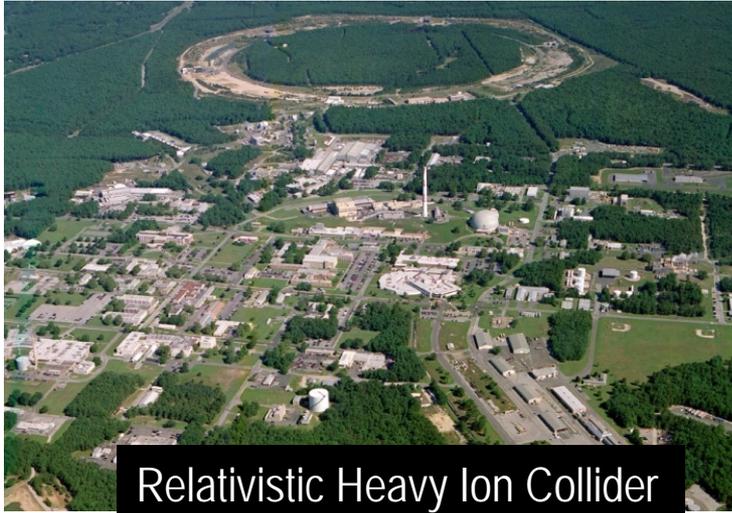
All six cavities operated continuously for 2 weeks with phase and amplitude locked.



Energy spectrum of the accelerated beam using only the RFQ together with the spectrum obtained when one cavity after the other in a 6 cavity cryomodule was turned on and phased for acceleration.

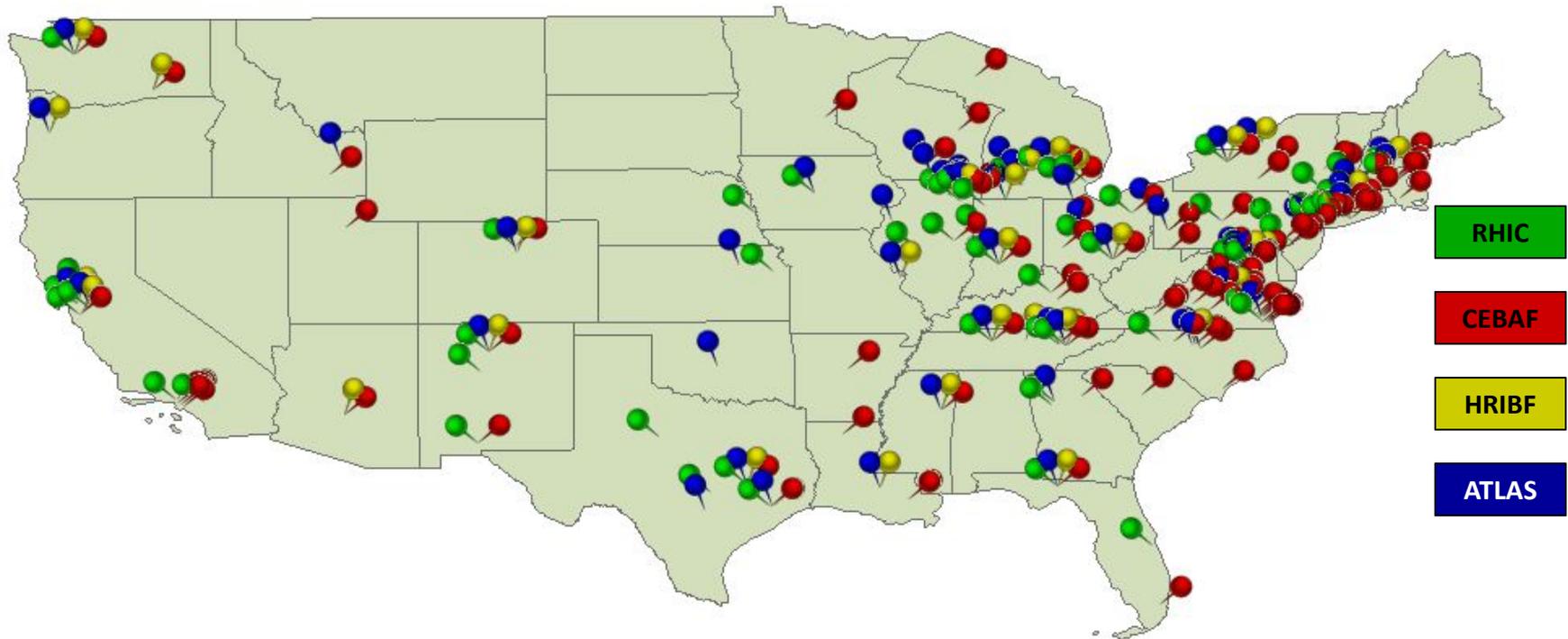
At Present NP Operates Four National User Facilities

“Microscopes” capable of groundbreaking research



U.S. Institutions Conducting Research at Nuclear Physics National User Facilities

Approximately 1,900 U.S. users from 32 states and the District of Columbia



NP supports a scientific workforce of approximately 2,900 FTE's to carry out operations and research at the National User Facilities and related programs

HRIBF is closed as a national user facility in FY 2012, and users will be transitioned to other parts of the program where possible. When FRIB comes on line, the Nuclear Physics program will gain the current NCSL/FRIB user community.

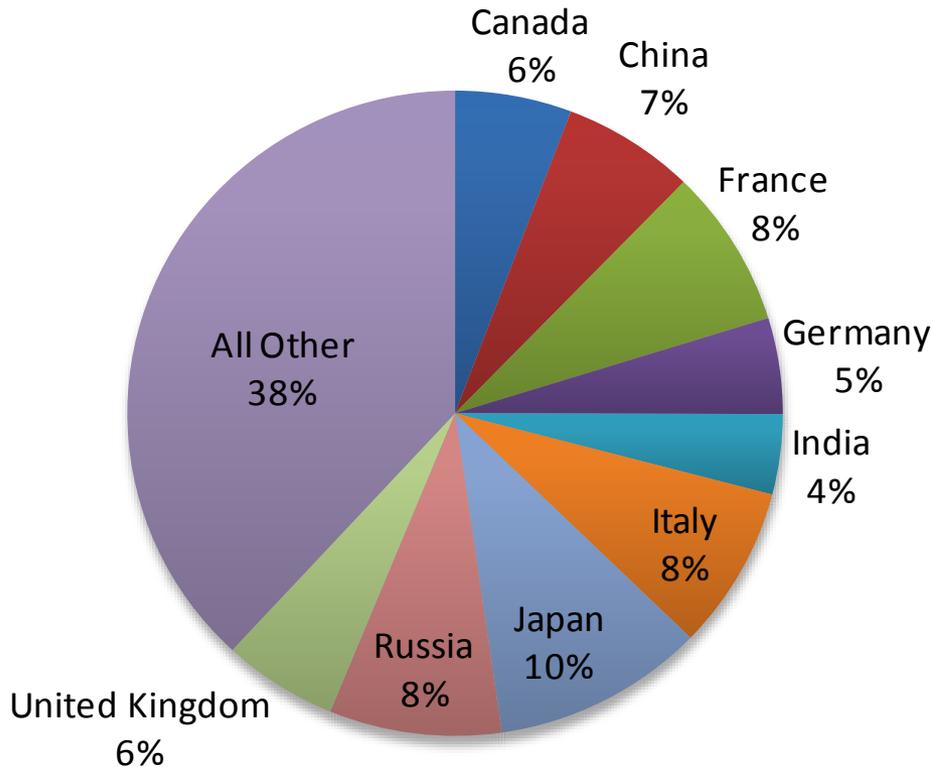
The Closure of HRIBF

- The decision to close HRIBF in the FY 2012 Request was necessary to maintain planned progress towards the construction of the Facility for Rare Isotope Beams to provide the premier facility in the world for nuclear structure and nuclear astrophysics by the end of the decade.
- According to present planning, the range of possible dates for the start of FRIB operation is from 2018 to 2020.
- Some isotope species will not be available prior to the start of FRIB operation. HRIBF is also the only facility in the United States with Isotope Separator On-Line (ISOL) capability, which enhances the intensity that can be achieved for some rare isotope beams.
- These sacrifices are necessary to achieve planned progress towards the goal of providing the national nuclear structure and nuclear astrophysics communities with the most advanced isotope research capability in the world by the end of this decade. ISOL capability will be an upgrade option for the FRIB facility in the future.
- This decision underscores that FRIB is of sufficient priority that it must be constructed, even if some existing capability must be phased out. It is supported by the conclusions of the 2007 Long Range Plan.
- The closure of HRIBF impacts approximately 250 U.S. scientists. Many have already become involved in the User Groups at the Argonne Tandem Linac Accelerator System (ATLAS) at Argonne National Laboratory and the National Superconducting Cyclotron Laboratory (NSCL) at Michigan State University.
- The Nuclear Physics program office will work to mitigate impacts on the HRIBF community.

Foreign Participation at Nuclear Physics User Facilities

Approximately 1,300 foreign users from 50 countries conduct research at NP User Facilities

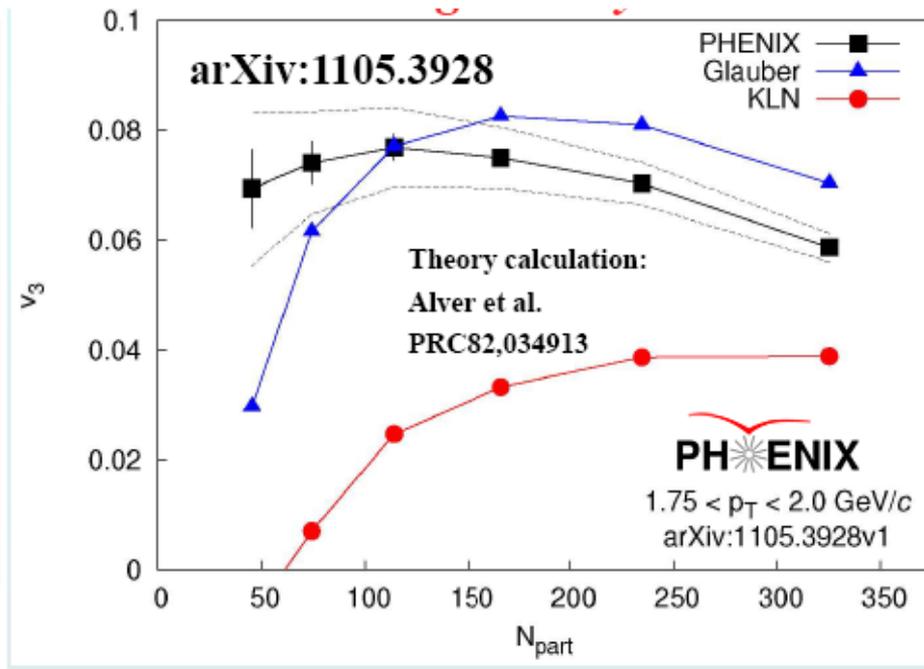
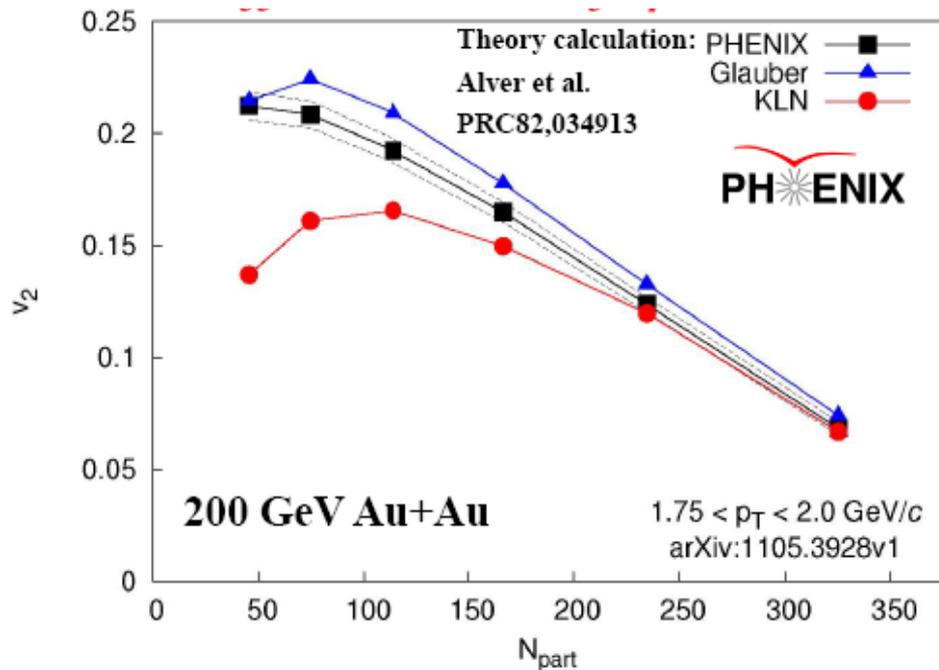
Percentage of Users by Country



Foreign Participation at U.S. NP National User Facilities provides excellent value:

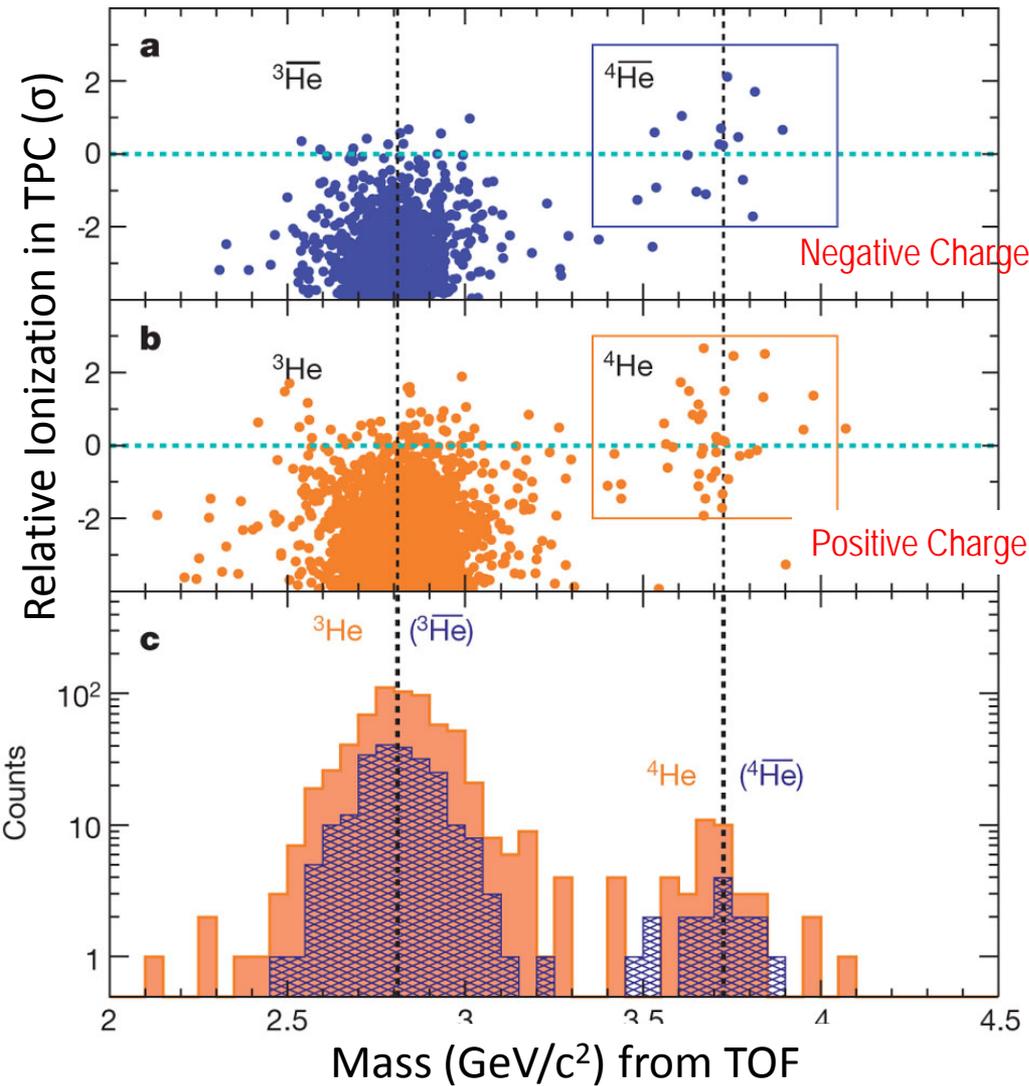
- U.S. investment at Foreign facilities (e.g. the LHC) is very modest but provides full access to scientific data.
- Foreign participation at U.S. facilities provides very significant capital contributions
- It provides a continuous flow of new ideas and technology.
- It provides very significant contributed effort.

Measurement of Higher Harmonics of Collective Flow \Rightarrow Path to Quantify How Perfect is the 'Perfect Fluid'



- Elliptic flow v_2 is sensitive to centrality (impact parameter), shear viscosity/entropy density (η/s), initial-state geometry + fluctuations
- Red and blue theory curves use different models of initial-state matter densities and fluctuations, can ~fit v_2 with η/s values differing by factor ~2
- Odd flow harmonics would vanish if nuclear overlap were perfectly left-right symmetric, but v_3 arises (primarily) from geometry fluctuations
- For given η/s , different models yield quite different v_3 vs. $v_2 \Rightarrow$ new data will better constrain η/s vis-à-vis String Theory quantum limit $\eta/s \geq \frac{1}{4}\pi$
- Still higher v_n should be more sensitive to viscosity damping \Rightarrow constrain η/s even further by measuring v_n for various colliding species and energies

US – CAS Collaboration on the Discovery at RHIC of the Heaviest Antimatter Nucleus



This discovery results directly from US – China collaboration (NNSFC, CAS, MOST) on construction of MRPC Time of Flight detector for RHIC/STAR with major contributions from CAS Institutes:

SINAP, USTC, IMP/Lanzhou

LETTER

doi:10.1038/nature10079

Observation of the antimatter helium-4 nucleus

The STAR Collaboration*

Nature Letters:

Received 14 March;

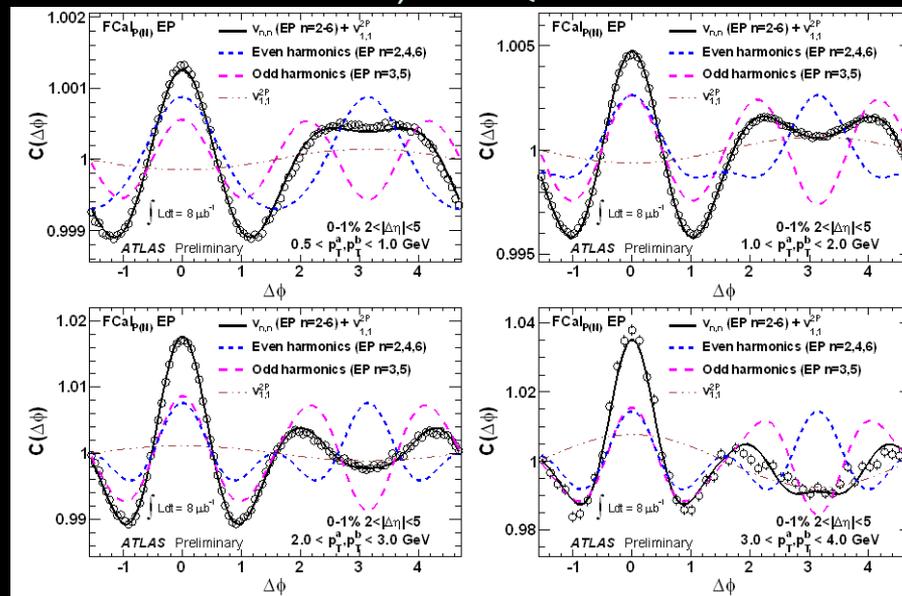
Accepted 4 April 2011.

Published online 24 April 2011.

Two-particle Correlations, Fluctuations – Away with the Mach Cone???

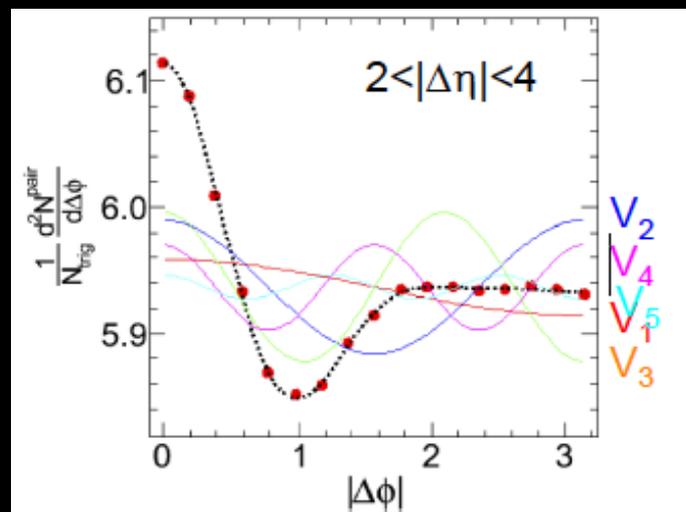
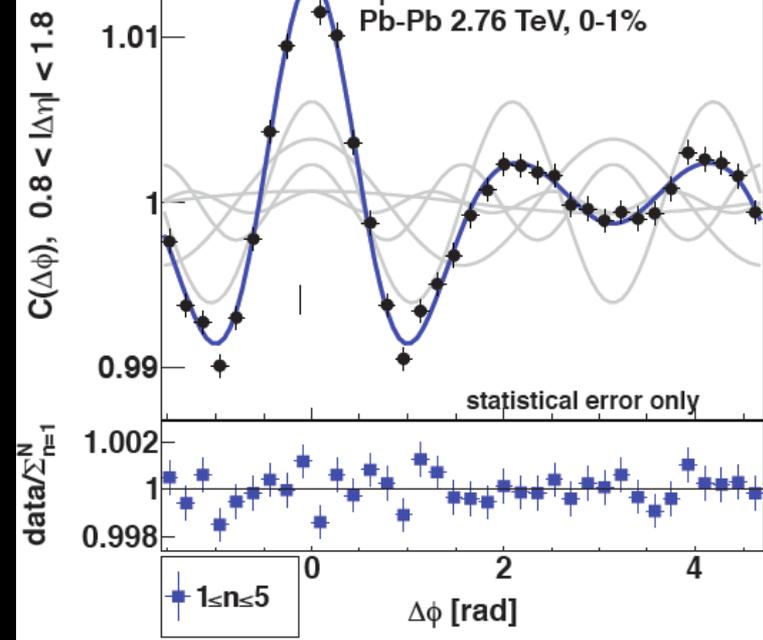
ATLAS, J. Jia QM 2011

ALICE, A. Adare QM 2011



blue curve: sum (not a fit!)

$p_T^{\text{trig}} 2-2.5 \text{ GeV}/c$
 $p_T^{\text{assoc}} 1.5-2 \text{ GeV}/c$
 Pb-Pb 2.76 TeV, 0-1%



CMS, B. Wyslouch QM 2011

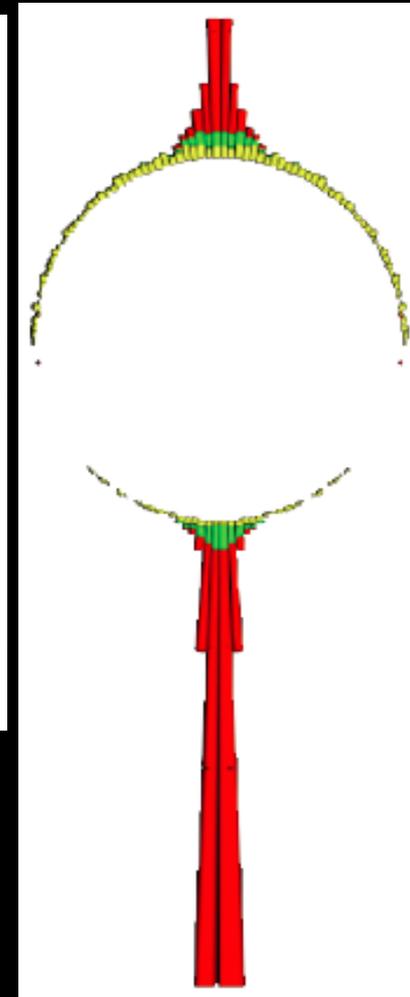
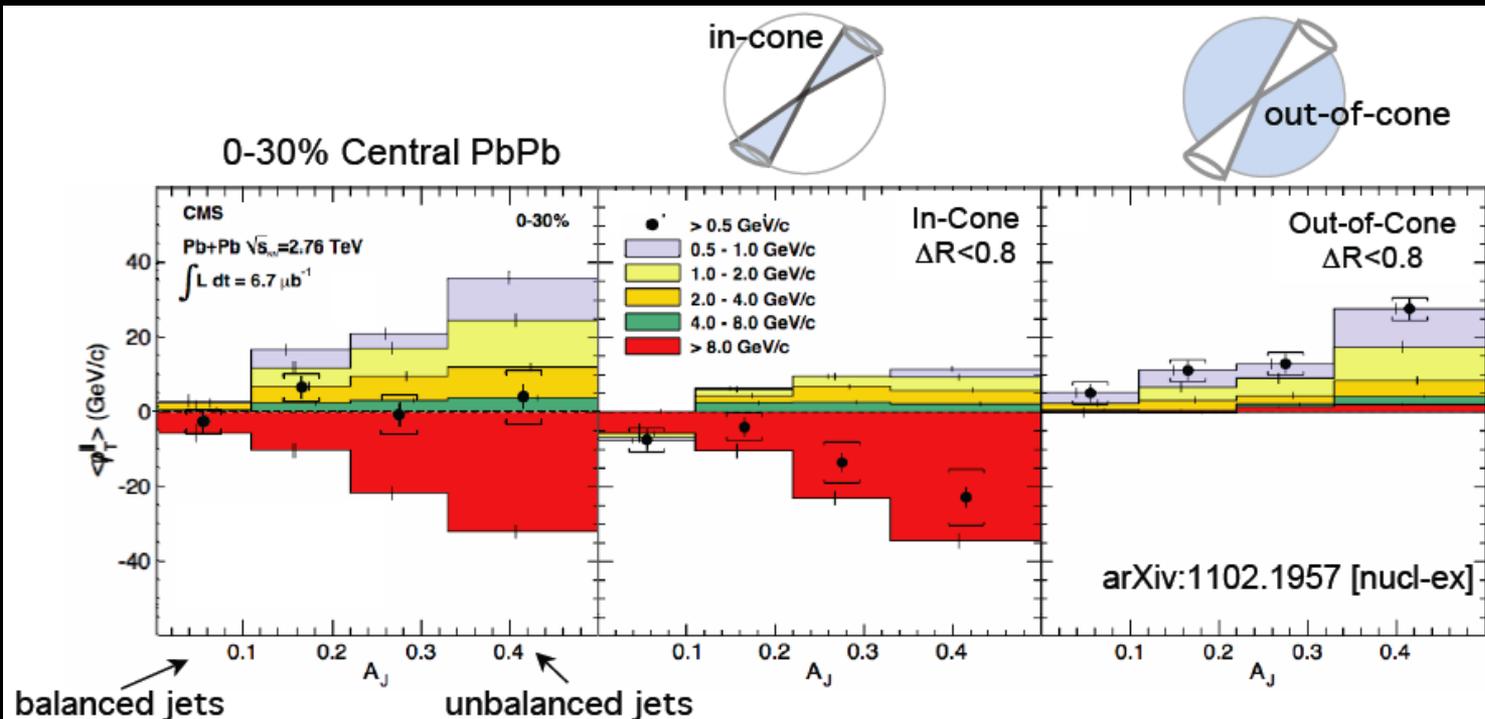
Workshop on Future Strategy for RHIC, BNL, June 21 - 24, 2011

John Harris (Yale)

Di-Jets at the LHC – CMS

CMS: arXiv:1102.1957

CMS, C. Roland QM 2011

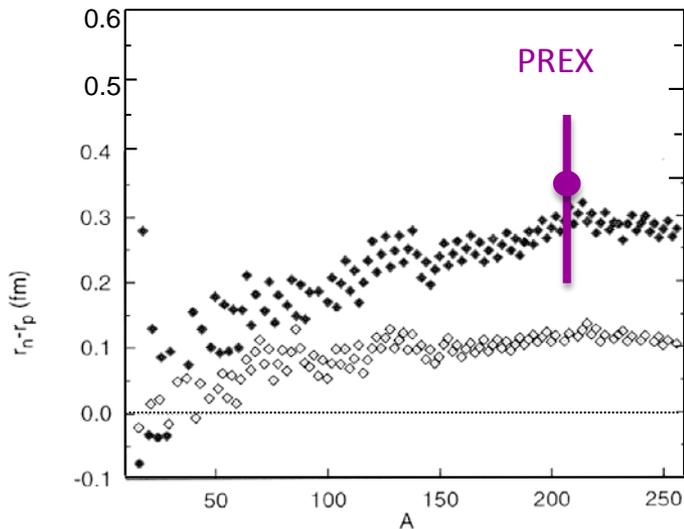


Di-jet energy imbalance offset by lower momentum particles opposite leading jet and outside away-side jet.

Elastic Scattering Parity-Violating Asymmetry

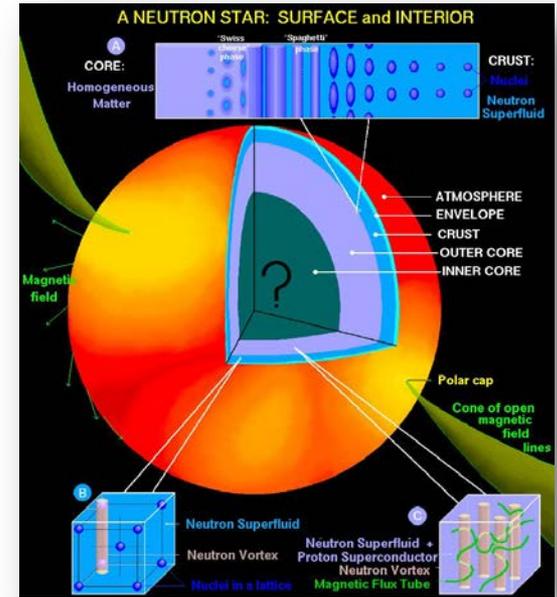
Z^0 : Clean Probe Couples Mainly to Neutrons

Applications: Nuclear Physics, Neutron Stars,
Atomic Parity, Heavy Ion Collisions



Relativistic mean field

Nonrelativistic skyrme

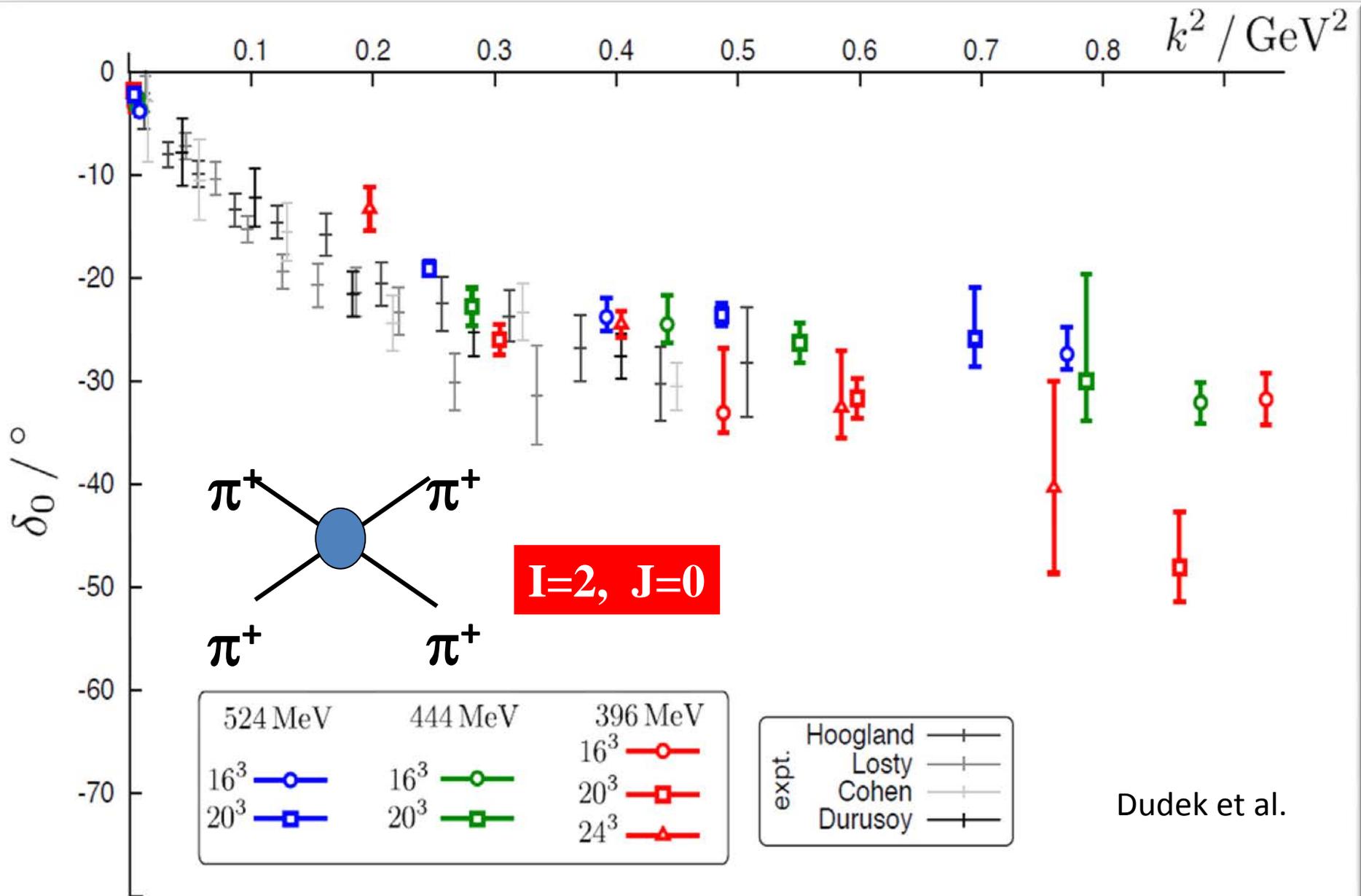


A neutron skin of 0.2 fm or more has implications for our understanding of neutron stars and their ultimate fate

- The Lead (^{208}Pb) Radius Experiment (PREX) finds neutron radius larger than proton radius by +0.35 fm (+0.15, -0.17).
- Result provides model-independent confirmation of the **existence of a neutron skin** relevant for neutron star calculations.
- Follow-up experiment planned to reduce uncertainty by factor of 3 and pin down symmetry energy in EOS



Phase Shifts Calculated on the Lattice



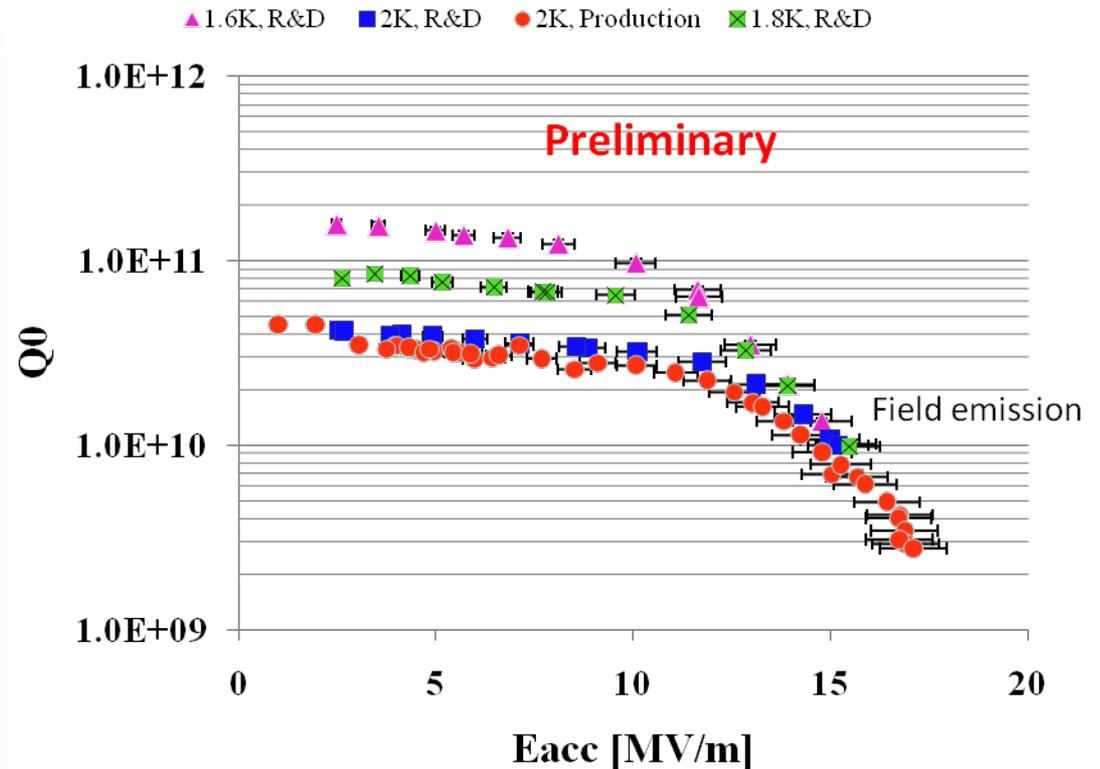


650 MHz Cavity for Project X

- 650 MHz $\beta=0.61$ single cell, designed and fabricated at JLab
- First baseline process cycle using Buffered Chemical Polish
- Field emission limited at higher gradient
- Nice low-field Q_0



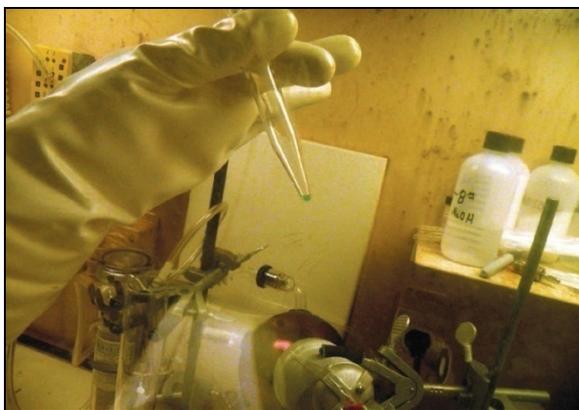
650 MHz Cavity #1, Test #2



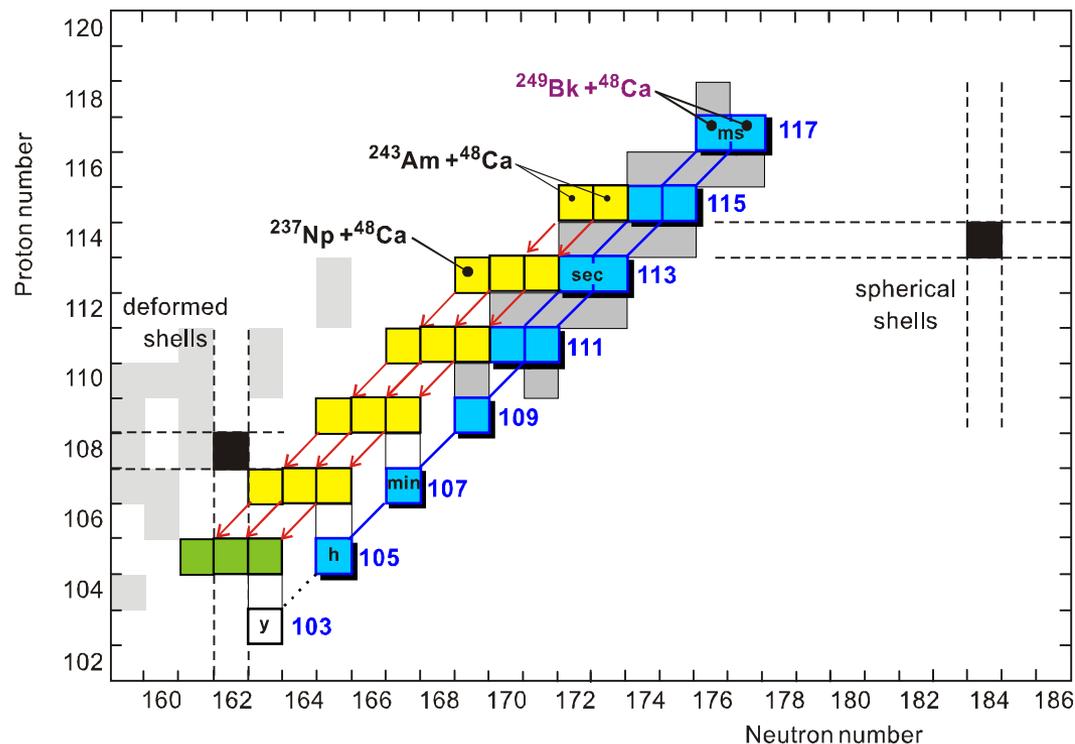
Discovery of Element 117

A new super heavy element (SHE) with atomic number 117 was discovered by a Russian-U.S. team with the bombardment of a Berkelium target by 48-Ca. The existence and properties of SHEs address fundamental questions in physics and chemistry:

- How big can a nucleus be?
- Is there a “island of stability” of yet undiscovered long-lived heavy nuclei?
- Does relativity cause the periodic table to break down for the heaviest elements?



Rare short-lived ^{248}Bk was produced at HFIR and processed in Isotope Program hot cell facilities at ORNL to purify the 22 mg of target material used for the discovery of element 117.



- Experiment conducted at the Dubna Cyclotron (Russia) with an intense 48-Ca beam
- Berkelium target material produced and processed by the Isotopes Program at ORNL
- Detector and electronics provided by U.S. collaborators were used with the Dubna Gas-Filled Recoil Separator

Isobar
Separator

Gas Catcher

Source
Transport
Cask

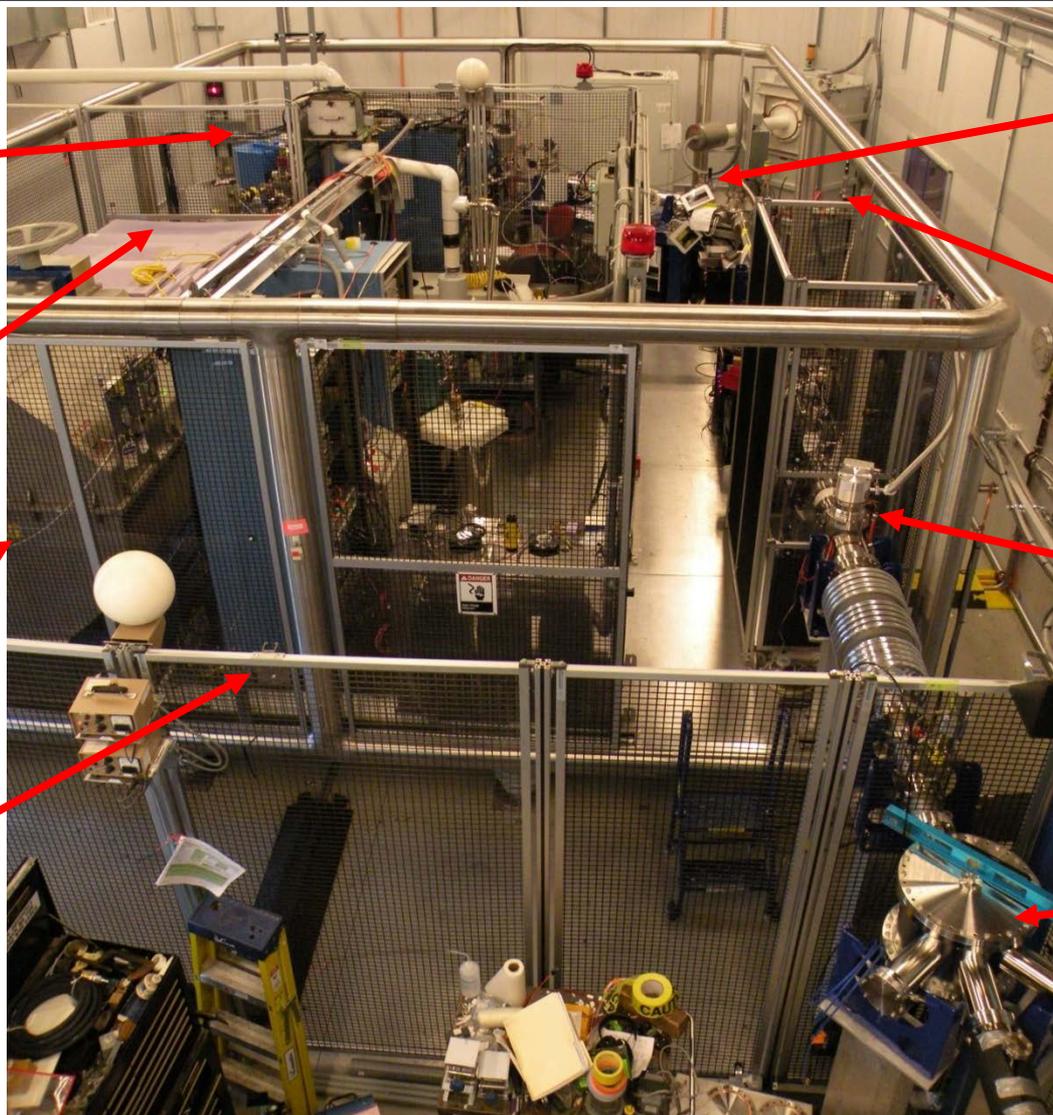
HV Platform

Switchyard

Beam line to
ECR Breeder

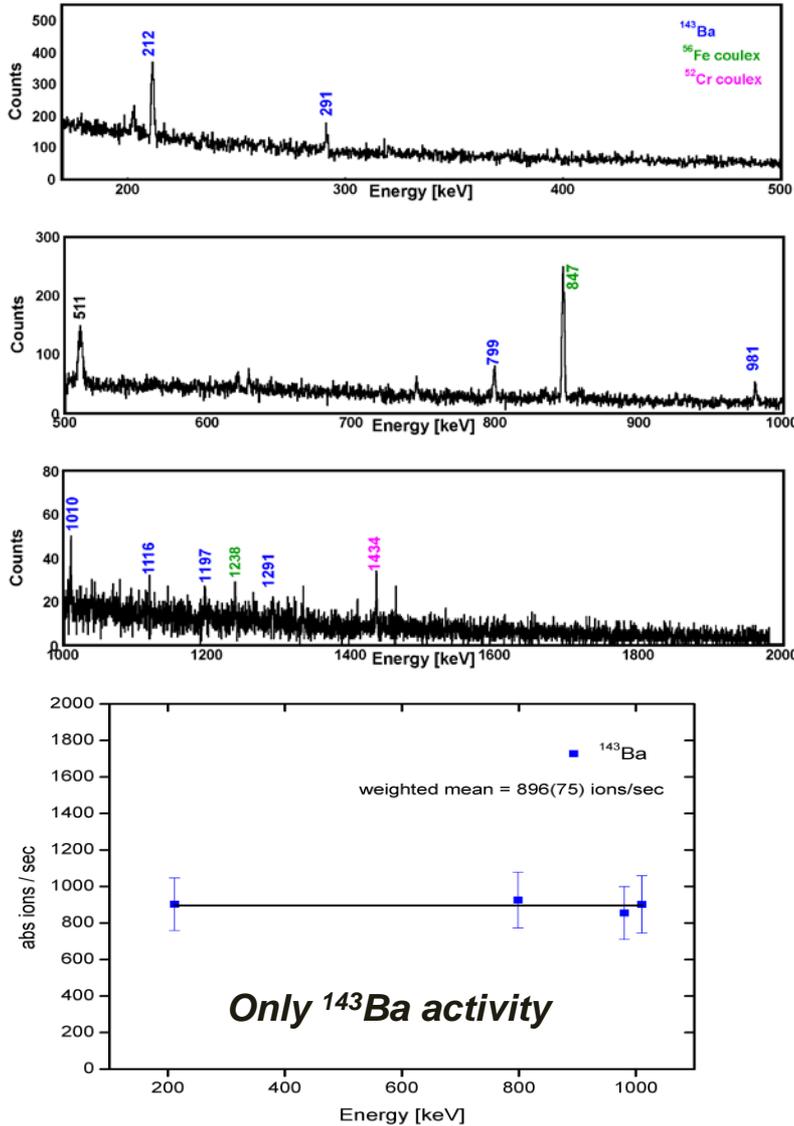
RFQ Buncher

Low-Energy
Beam line



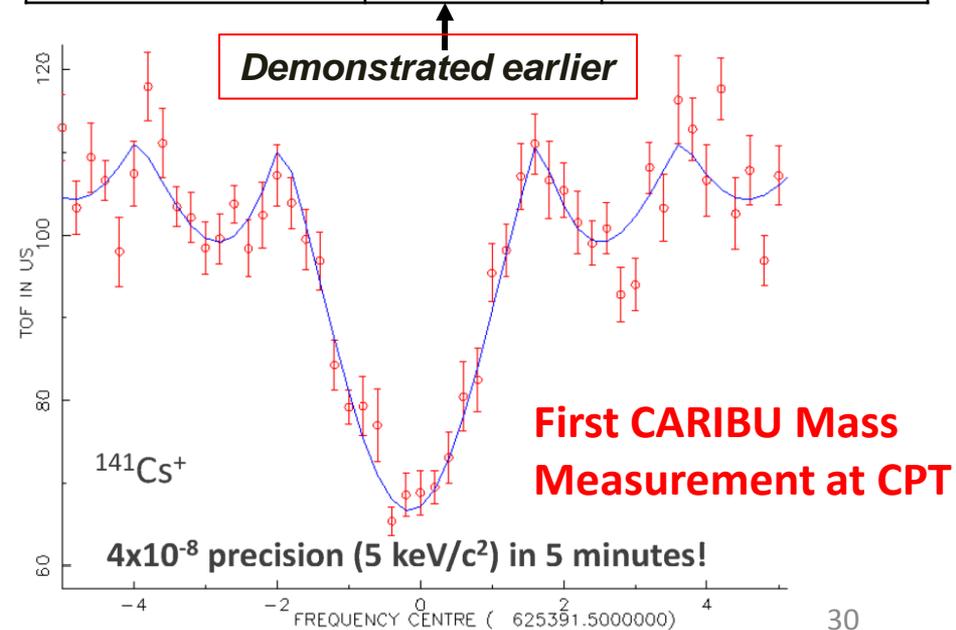
Installation complete, commissioning complete, development on-going

Spectrum measured after acceleration



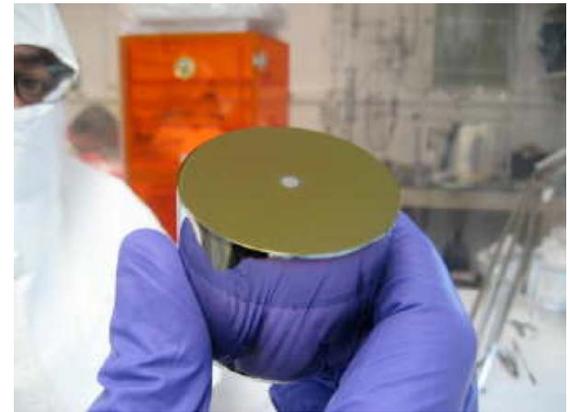
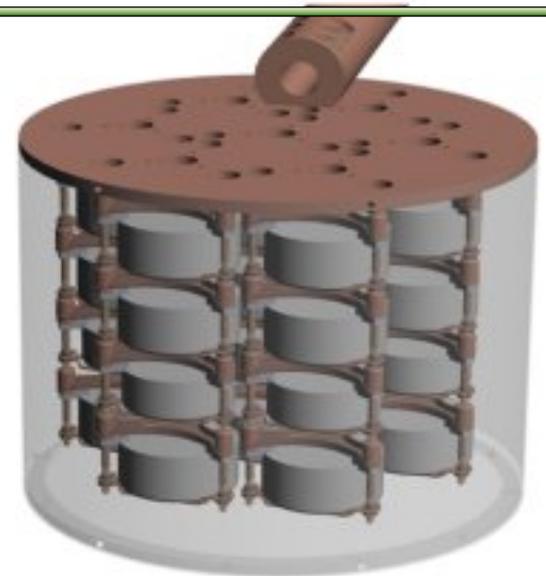
All requirements met or exceeded

Parameter	Required Value	Achieved on May 2&3, 2011
Beam from Gas Catcher	¹⁴³ Ba ²⁺	¹⁴³ Ba ²⁺
Intensity at Isobar Separator Exit	≥1.2x10 ⁴ ions/s	>6.0x10 ⁴ ions/s
Intensity at ATLAS Diagnostics	≥430 ions/s	896±75 ions/s
Charge from Charge Breeder	≥18+	27+
Accelerated Beam Energy	6 MeV/u	6.1 MeV/u
HV Platform Voltage	175 kV	136 kV



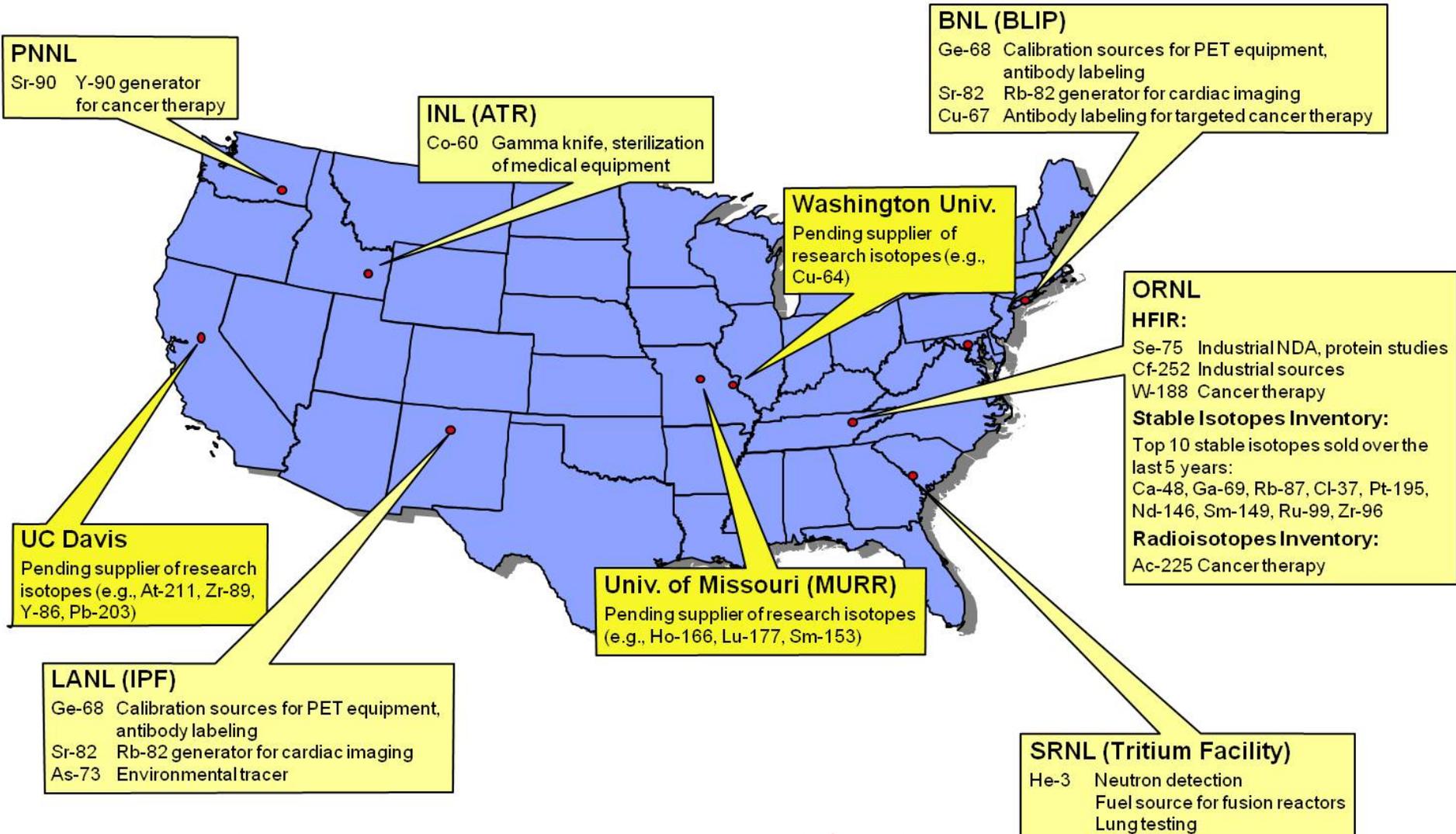
Present Status of DOE Plans for Underground Science

- DOE remains committed to the science it has planned within its mission:
 - CP violation in the neutrino sector
 - The nature of Dark Matter
 - Search for $0\nu\beta\beta$ decay.
- It is assessing the impacts and viability of underground science using only DOE resources.
- DOE has asked an independent panel to help identify cost-effective options. Final Report, June 15th, 2011.
- NSF will provide \$4M to bridge the funding gap between June and September 2011.
- The Office of Science is requesting \$15M in FY 2012 to maintain the viability of the Homestake Mine while assessing its options (\$5M of the \$15M is requested by Nuclear Physics).



Silicon detector and the cryostat for Majorana Demonstrator, an experiment to determine if the neutrino is its own anti-particle

Other Operations: Production Sites Presently Integrated into the Isotope Program



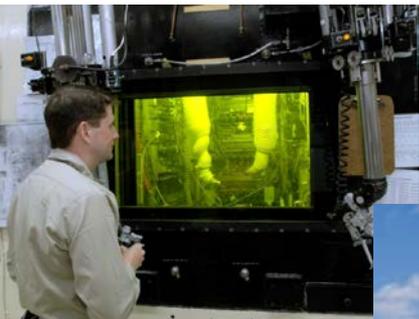
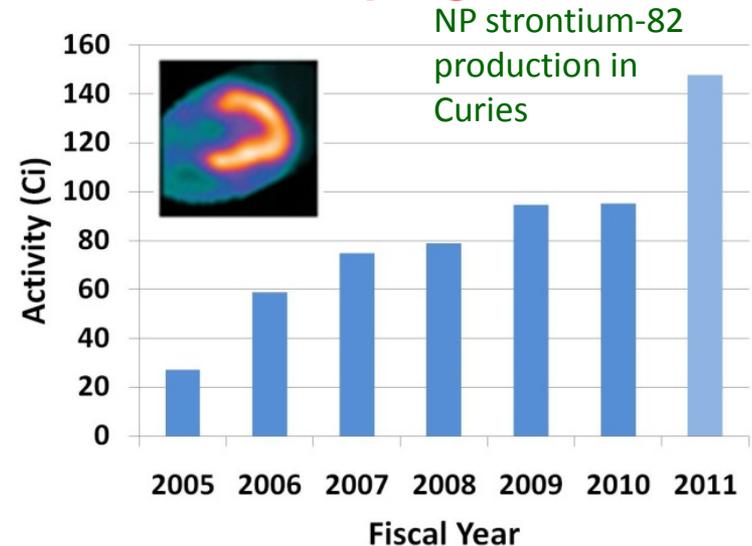
New Production Solicitation expected in March/April 2011

Impacts of NP Facility Operations: Radioisotope Production for Research and Commercial Applications

The result of “know-how” from the basic research program

NP is Increasing strontium-82 (Sr^{82}) production for cardiac imaging in response to molybdenum-99 supply challenges

- 200,000 patients per year in U.S.
- ~ \$300,000,000 in reimbursable procedures
- DOE supplies ~ 75% of domestic Sr^{82} market



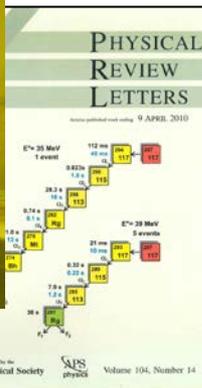
Californium-252 production for oil and gas exploration, nuclear fuels, homeland security, and nuclear science research experiments

- DOE supplies 97% of domestic market; **californium supply is critical** to oil and gas exploration and nuclear reactor industries
- Domestic oil and gas production **employs 210,000 Americans** and 920,000 jobs. **Contributes ~\$100 billion to the U.S. economy**
- 104 domestic nuclear reactors produced ~ 20% of total electricity in U.S. **Contributes ~\$240 billion to the U.S. economy**

The result of “know-how” from the basic research program

Basic Research Supported

- NP is providing rare isotopes for research not previously available
- NP is the sole provider of research isotopes for super heavy element discovery research
- 22 mg of berkelium-249 produced as by-product of californium production for collaborative experiment between U.S. and Russia leading to the discovery of element 117
- NP is supporting production of 20 mg of Bk-249 for a follow-up search to discover element 119 and 120

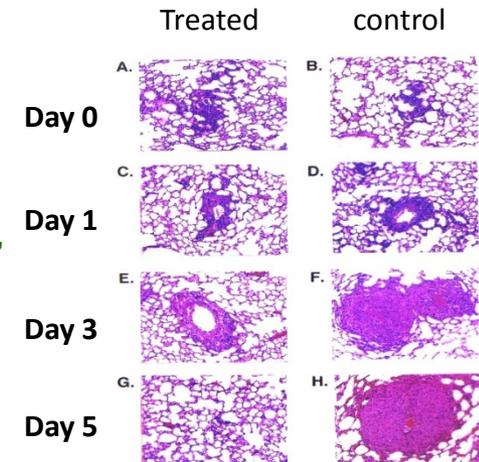


Bk-249, contained in the greenish fluid in the tip of the vial, was used to discover element 117.

Applied Research Supported

- ~\$6 M invested in development of production technologies for alpha-emitting medical radio-nuclides
- Promising R&D for treating cancers affecting hundreds of thousands of lymphoma, leukemia, breast, and prostate cancer patients
- NP developing cost-effective production strategy to support clinical trials

Cancer-cell culture experiment: Tumor cells treated with Ac-225 radiopharmaceutical were “cured” while untreated control cells proliferated



A budding Industry Catalyzed by Technology Development at SC Labs for Basic Science

New Jobs, Increasing Revenues, International U.S. Leadership

Advanced Energy Systems (founded 1998)

Medford, New York

- SRF revenues **doubled** from 2009-2010
- **Close to 20 new hires** in 2010

Meyer Tool and Manufacturing (SRF work started 1995)

Oak Lawn, Illinois

- Anticipate **25% of sales from SRF in 2012**
- SRF sales are presently 25% of the backlog
- Expected growth in sales is 3-5%
- Anticipate hiring **42 new employees** including 5 engineers and 32 manufacturing staff
- **Present staff is 38 employees**

NIOWAVE (founded 2005)

Lansing, Michigan

- Revenues of ~\$10M in 2010
- **Workforce expected to triple from 50 – 150**
- Second manufacturing facility planned



Highly optimized particle
acceleration cavity

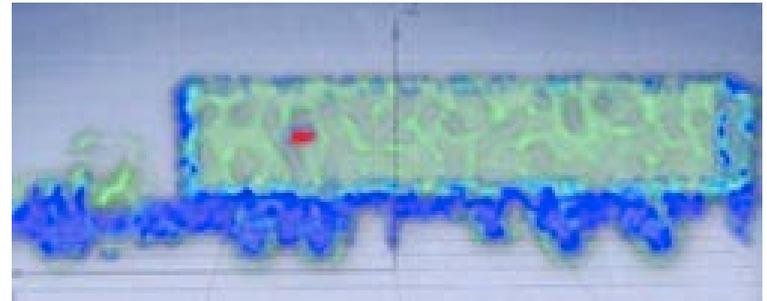
Current market is modest. Potential market is very large.

The result of “know-how” from the basic research program

Muon Tomography:

A cosmic-ray induced tracking technology that produces 3-D tomographic images of vehicles and their contents. Suitable for screening for hidden nuclear weapons components at ports of entry.

- Technology transferred to Decision Sciences Corp.
- Large units under construction for installation.
- Potentially a very large market.
- Non-NP program support, but **capability created as a result of NP research.**



A tomographic analysis of a truck showing a "hotspot" of radioactivity. (courtesy Decision Sciences International Corp.)

Proton Radiography:

NNSA funded study of dynamic phenomena of importance to nuclear weapons, including high explosives performance, material damage, and the performance of materials under extreme pressures.

- This **capability was invented by scientists trained in the NP program.**
- Scientists partially funded by NP participate in this program today.

NP National Nuclear Data Center:

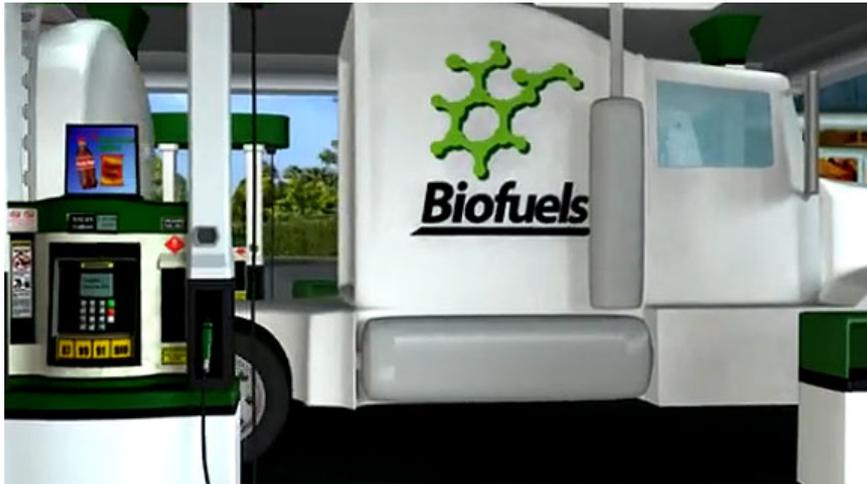
Compiles and verifies data important for well logging, neutron therapy, and development of fast reactors.

- **2.6 million data retrievals by business, government, and research in 2010.**

Identification of Options for Medium/Long-Term Mitigation Efforts at Fukushima

Technical staff at LANL continue to identify potential technical options for addressing challenges at the site. One example

Collaborating with the High Energy Accelerator Research Organization (KEK) to develop and approach for using cosmic ray muons to measure the internal position of fuel in the Daiichi reactors. If there is extensive damage to the fuel, the muon technique will identify voids in the fuel structure, or abnormal presence of fuel in lower regions of the reactor pressure vessel. Results will include images of the internal structure of the reactor cores with position resolution in the range 20-30 cm, and should be sufficient to distinguish between volumes of uranium, steel, water, and concrete. These measurements will provide crucial data to decision-makers, to help plan remediation and recovery of the reactor cores. This will be the first time information like has been available for unopened reactors.



<http://science.energy.gov/>

[Explaining Energy Genomics
by DOE Joint Genome Institute](#)

[Argonne: Discovery on a Mission](#)



[Firm Uses DOE's Fastest
Supercomputer to Streamline
Long-Haul Trucks](#)



Working to get the word out more effectively about the value and importance of SC supported research and technical developments

Dudek, Jozef, Old Dominion University, Norfolk, VA, "Meson Spectroscopy from Quantum Chromodynamics"

Ferracin, Paolo, Lawrence Berkeley National Laboratory, Berkeley, CA, "Development of Nb₃Sn Superconducting Magnets for Fourth Generation ECR Ion Sources"

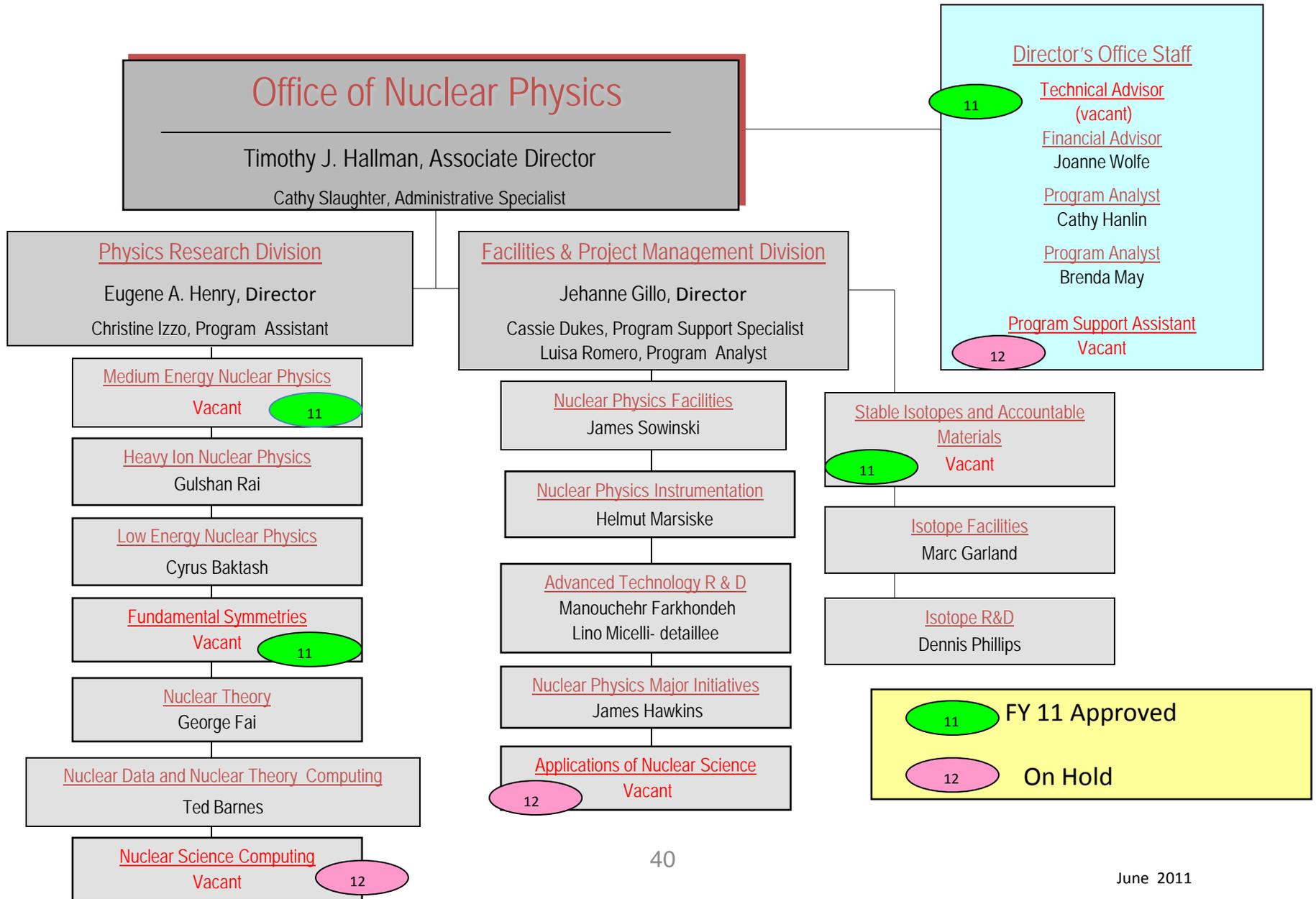
Kneller, James P., North Carolina State University, Raleigh, NC, "The Neutrino: A Better Understanding Through Astrophysics"

Lapi, Suzanne E., Washington University, Saint Louis, MO, "Direct Production of ^{99m}Tc Using a Small Medical Cyclotron"

Melconian, Daniel, Texas A&M University, College Station, TX, "Fundamental Electroweak Interaction Studies Using Trapped Atoms and Ions"

Mueller, Peter, Argonne National Laboratory, Argonne, IL, "Weak Interaction Study Using Laser Trapped ⁶He Atoms"

Quaglioni, Sofia, Lawrence Livermore National Laboratory, Livermore, CA, "Solving the Long-Standing Problem of Low-Energy Nuclear Reactions at the Highest Microscopic Level"





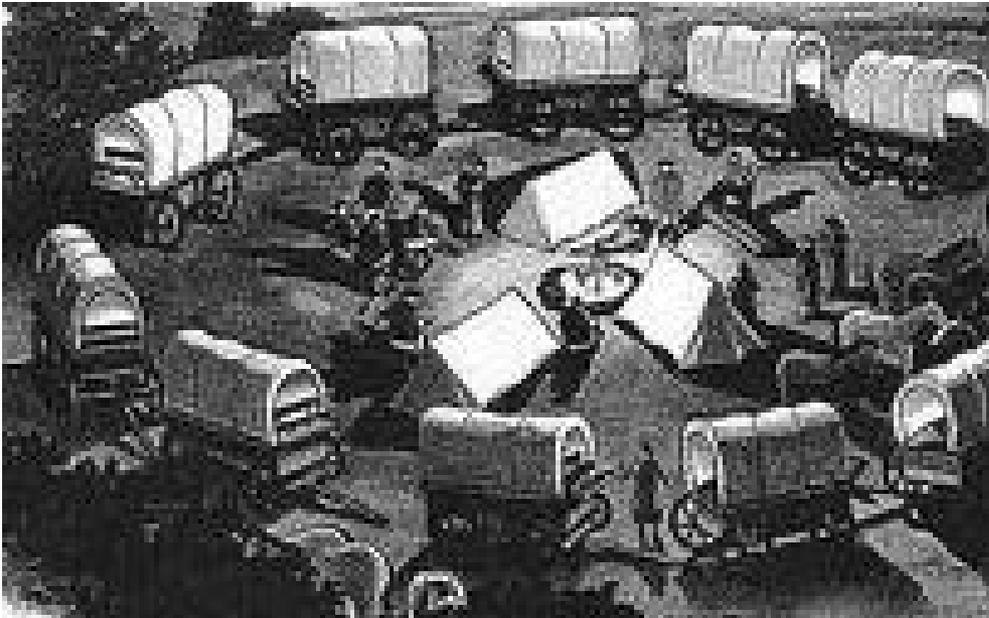
The FY 2012 President's request for Nuclear Physics provides the resources needed:

- To enable U.S. world leadership in discovery science illuminating the properties of nuclear matter in all of its manifestations.
- To provide the tools necessary for scientific and technical advances which will lead to new knowledge, new competencies, and groundbreaking innovation and applications.
- To make strategic investments in facilities and research to provide the U.S. with the premier facilities and tools in the world by the end of the decade for research on:
 - New states of matter 100-1000 times more dense than “normal” nuclear matter at the Relativistic Heavy Ion Collider.
 - The force which binds quarks and gluons in protons and neutrons at the 12 GeV Continuous Electron Beam Accelerator Facility.
 - The limits of nuclear existence for neutron and proton rich nuclei at the Facility for Rare Isotope Beams and the Argonne Tandem Linac Accelerator System.
 - The nature and fundamental properties of neutrinos and neutrons and their role in the matter-antimatter asymmetry of the universe.
 - The development, and production of stable and radioactive isotopes for science, medicine, industry, and national security.

If we want his budget, we are all going to have to work for it

Translation:

- Keep doing the compelling science that got us here
- Keep demonstrating excellence in every thing we do (science, construction projects, R&D, outreach)
- Keep spreading the word (importance, relevance, value)

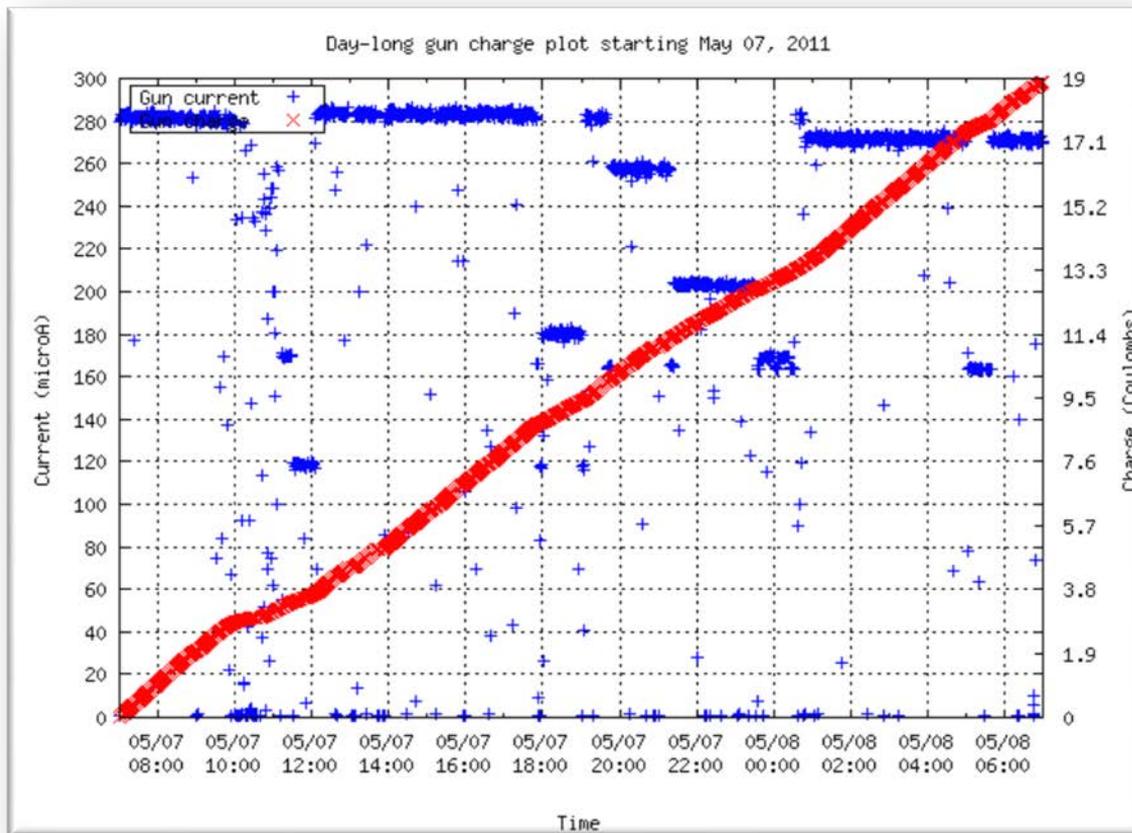


Also: previous experience shows
in challenging times it is very
Important to point the guns
In the right way direction
when the wagons are circled

As the Chinese proverb says:
A great tide floats all boats

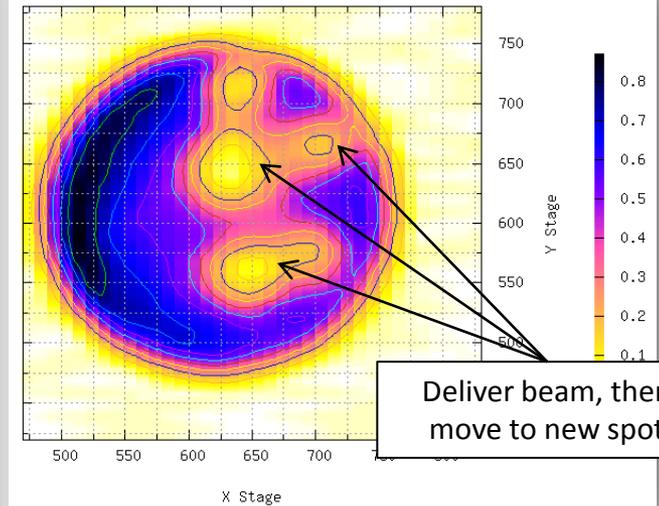


Additional Information

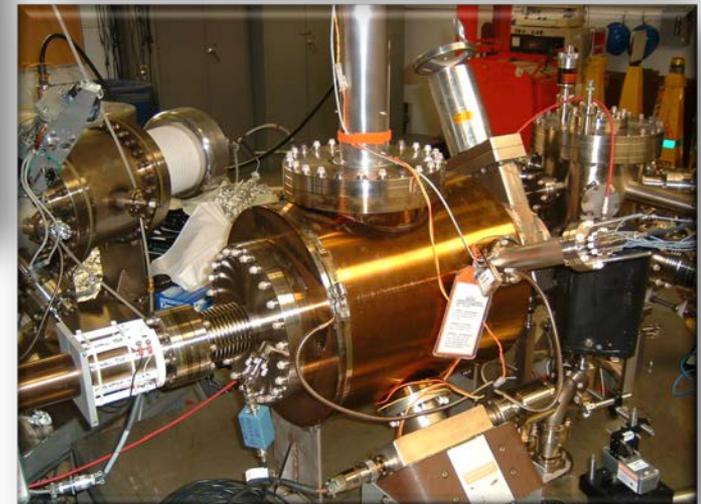


Photocathode QE scan

QE (%) MAX:0.870 MIN:0.003



Deliver beam, then
move to new spot



- Polarized electron source: successful operation at high current and **polarization > 85%**
- New record: **280uA and 19C per day**
- Excellent beam quality for parity violation exp.

ANL Crab Cavity Development

Joint ANL/Jlab Collaboration in development of a deflecting cavity for the Short Pulse X-Ray program

Two Cavities developed for project (Mark I and Mark II)

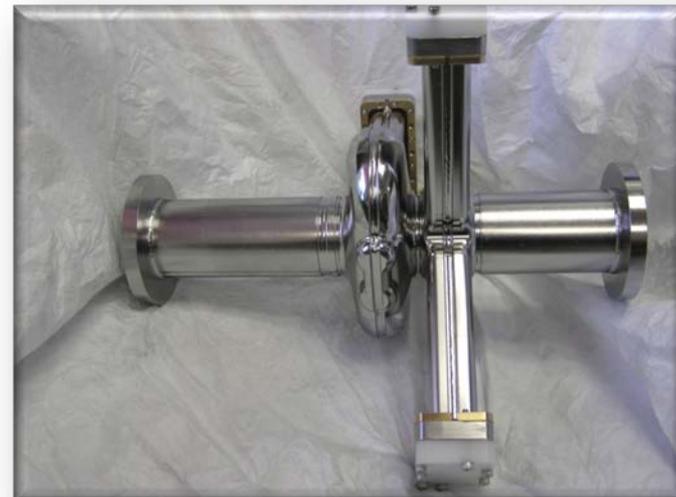
Freq- 2.815 GHz

Bp- 100mT

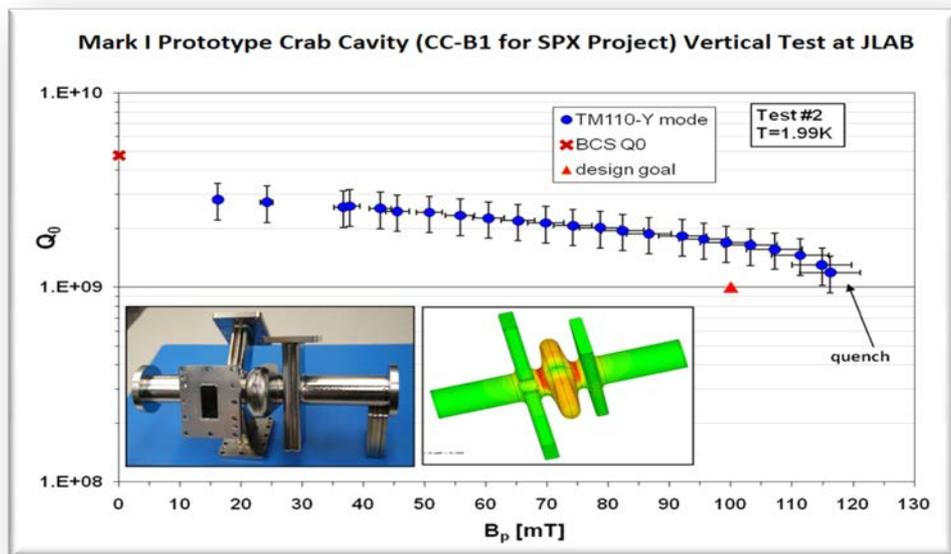
Crabbing voltage - 2MV

Cavities Per Cryomodule (4)

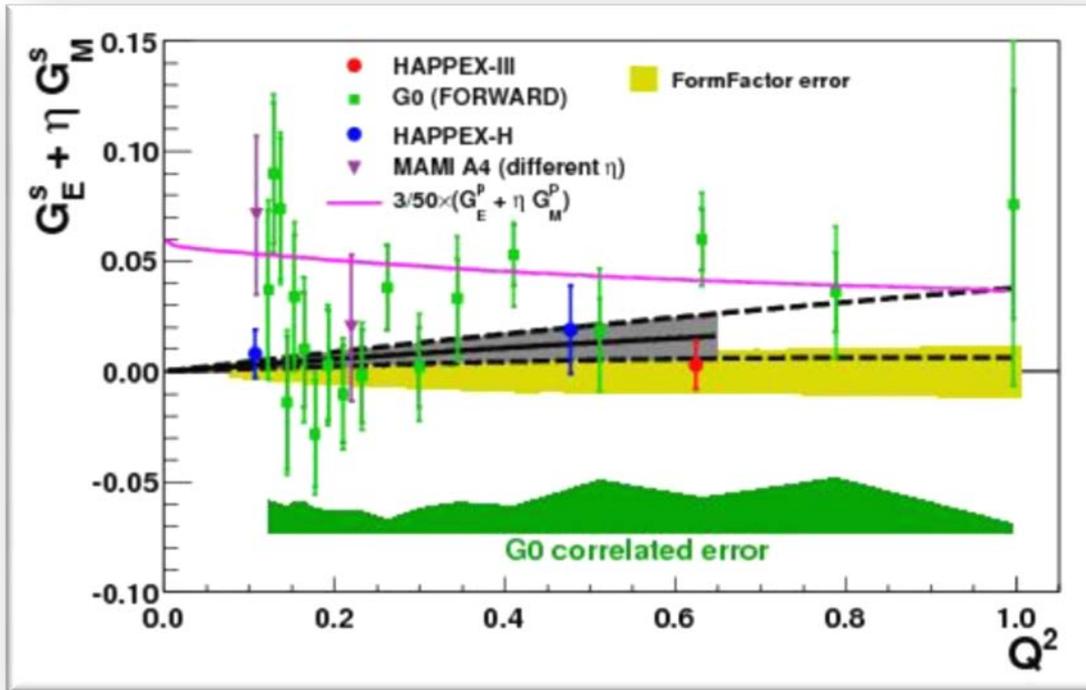
Mark II cavity fabrication complete!



Mark I Cavity qualification complete!



Strangeness Contribution to Nucleon Form Factors



Pink line represents 2% of the proton form factors (in the same combination of electric and magnetic as the strange form factors) \rightarrow strange quarks represent less than 2% of the proton form factors.

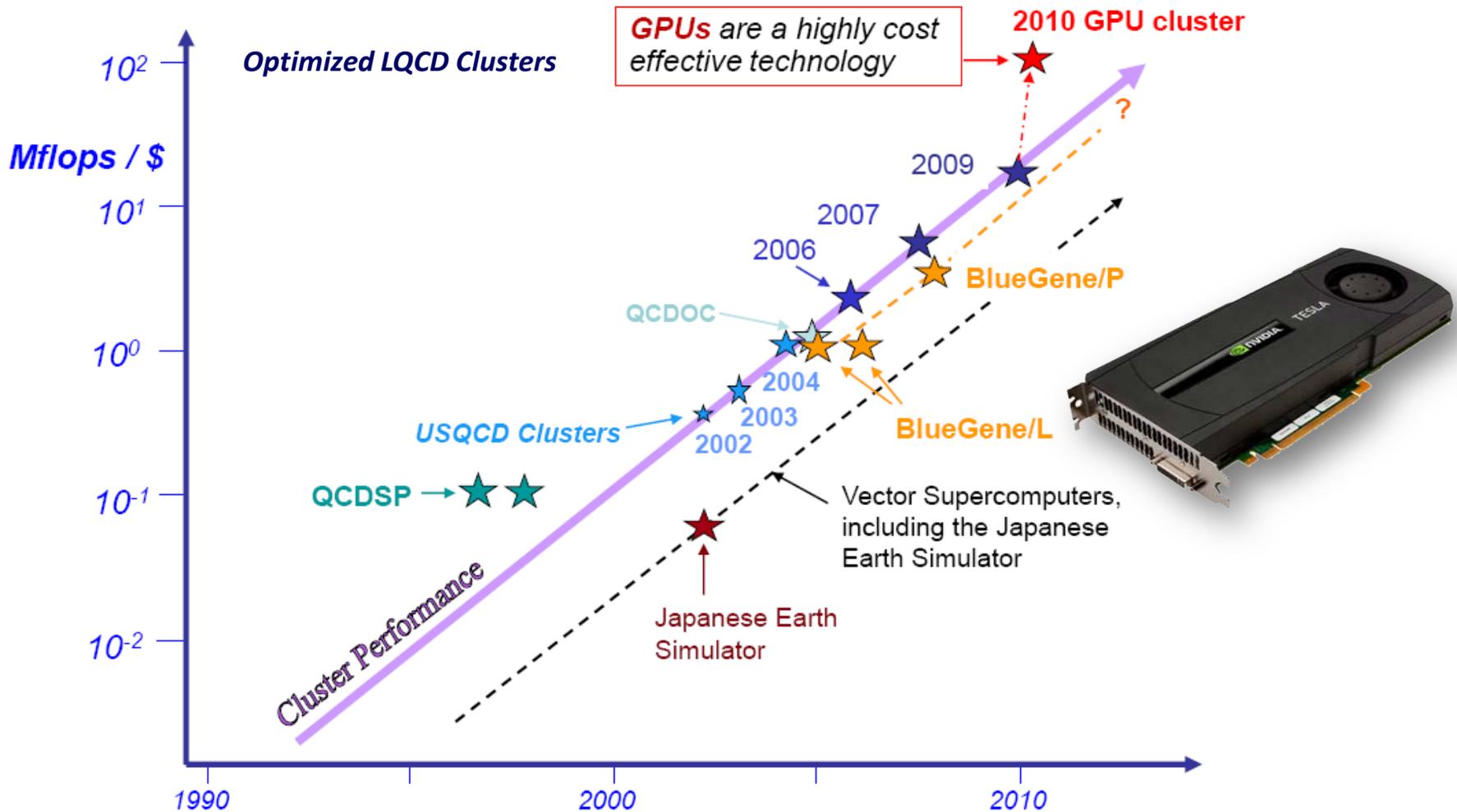
HAPPEX-III results final, publication in preparation

- accurate measurement at $Q^2 = 0.6 \text{ GeV}^2$, completing the parity-violating program constraining the contributions of strange quarks to the proton's charge & magnetization.
- contributions to these distributions are found to be minimal.
- **strange quarks do not play a substantial role in the long-range electromagnetic structure of nucleons**

Completes Performance Measure HP4

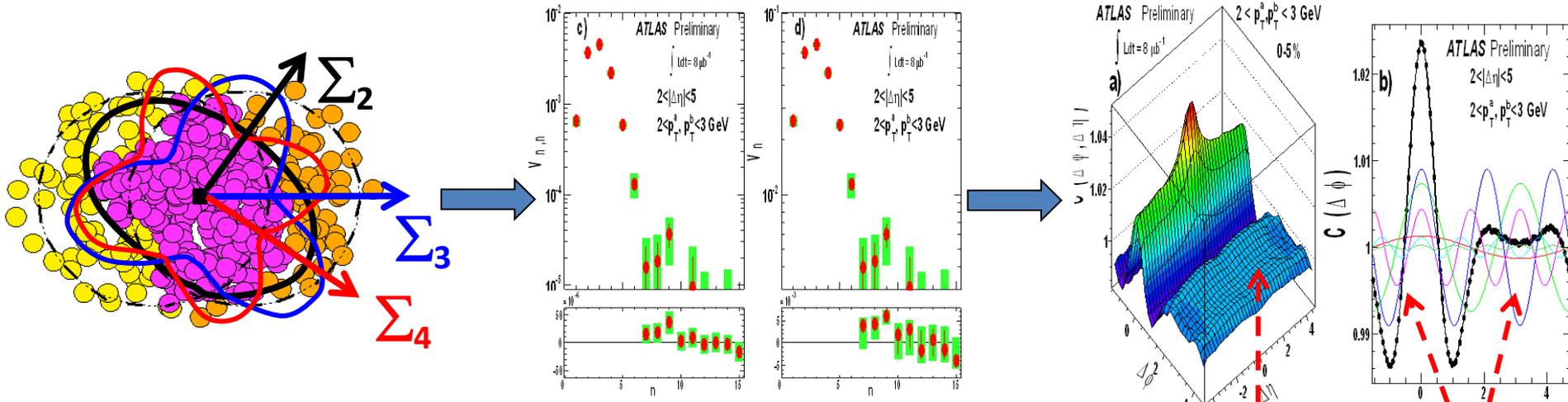
Advancement of Compute Engines

- Crays/BlueGene for Gauge Generation - **capability**
- Graphical Processing Units (GPUs) for physics measurements - **capacity**



Competition Constraints: Impressions and Lessons Learned from Quark Matter 2011

1) Field is maturing – e.g., initial characterization of collective flow of matter via elliptic multipole only now replaced by full Fourier decomposition, providing natural account for two previously puzzling phenomena:



Similar results shown by all collaborations, should \Rightarrow characterization of initial-state geometry quantification of fluid's "perfection."

question: does the medium respond collectively to the energy lost by quarks & gluons passing through it?

better
Near-side
ridge
fluctuations, hence

But they reopen another

Away-side
'Mach cone'

2) No fundamental new discoveries, but interesting, unanticipated results on \sqrt{s} -dependence of behavior from RHIC and on medium effect on jets from LHC

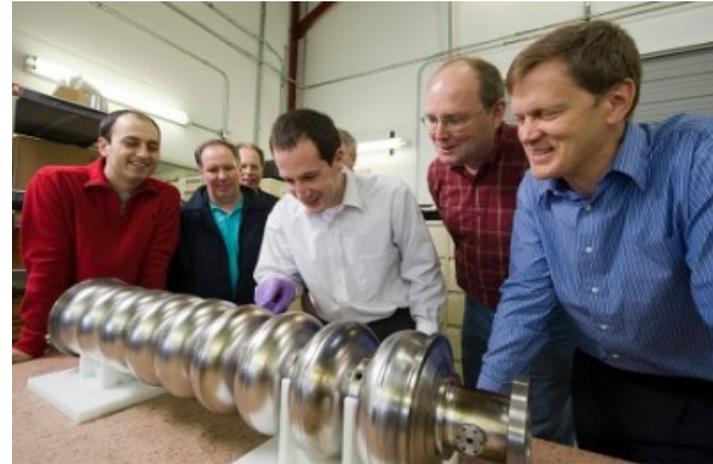
Washington, D.C. – The U.S. Department of Energy, the largest civilian contracting agency within the Federal government, is holding its 12th Annual Small Business Conference & Expo at the Kansas City Convention Center in Kansas City, Missouri from May 10-12, 2011. ...

"Small businesses are the building blocks of the clean energy economy, helping to create jobs and drive the innovation that will help the U.S. to win the future," said Energy Secretary Steven Chu.

SBIR/STTR Small Business of the Year: Niowave, Inc. (Lansing, MI)

[CBS Detroit.com](http://CBSDetroit.com)

In 2010, Niowave became the only company in the world to successfully design, build, commission and test a superconducting electron accelerator [...] under a federal Small Business Innovation Research grant [...] totaling just over \$1 million...



The project has already directly led to more than \$4 million in contracts... Before the SBIR project was even completed, the SBIR investment of \$1 million has realized a 400 percent return [...]. This return will continue to grow, and Niowave expects the commercialized returns to be in the tens of millions within the next 5 years.