U.S. DEPARTMENT OF ENERGY | Office of Science

DOE Office of Science

LHC Users Meeting

October 29, 2010

Dr. W. F. Brinkman
Director, Office of Science
U.S. Department of Energy
www.science.doe.gov

The Administration's S&T Priorities for the FY 2011 Budget

"We double the budget of key agencies, including the National Science Foundation, a primary source of funding for academic research, and the National Institute of Standards and Technology, which supports a wide range of pursuits – from improving health information technology to measuring carbon pollution, from testing "smart grid" designs to developing advanced manufacturing processes. And my budget doubles funding for the Department of Energy's Office of Science which builds and operates accelerators, colliders, supercomputers, high-energy light sources, and facilities for making nano-materials. Because we know that a nation's potential for scientific discovery is defined by the tools it makes available to its researchers."

President Barack Obama
April 27, 2009

U.S. DEPARTMENT OF ENERGY

Energy R&D Organizations

- **Secretary** Steven Chu
  Deputy Secretary Daniel B. Poneman
  - **Under Secretary for Energy** Cathy Zoi(A)
    - **Energy Efficiency & Renewable Energy** Cathy Zoi
    - **Fossil Energy** James Markowski
    - **Nuclear Energy** Pete Miller
    - **Electricity Delivery and Energy Reliability** Pat Hoffman
  - **Under Secretary for Science** Steven E. Koonin
    - **Office of Science** William Brinkman, Patricia Dehmer
      - **Basic Energy Sciences** Harriet Kung
      - **High Energy Physics** Dennis Kovar
      - **Advanced Scientific Computing Research** Dan Hitchcock(A)
      - **Nuclear Physics** Tim Hallman
      - **Biological & Environmental Research** Anna Palmisano
      - **Fusion Energy Sciences** Ed Synakowski
      - **Workforce Development for Teachers & Scientists** Bill Valdez
  - **Advanced Research Projects Agency – Energy** Arun Majumdar

Office of Science (SC) FY 2011 Budget Request to Congress

(B/A in thousands)

	FY 2009		FY 2010	FY 2011		
	Current Base Approp.	Current Recovery Act	Current Approp.	Request to Congress	Request to Congress vs. FY 2010 Approp.	
Advanced Scientific Computing Research	358,772	161,795	394,000	426,000	+32,000	+8.1%
Basic Energy Sciences	1,535,765	555,406	1,636,500	1,835,000	+198,500	+12.1%
Biological & Environmental Research	585,176	165,653	604,182	626,900	+22,718	+3.8%
Fusion Energy Sciences	394,518	91,023	426,000	380,000	-46,000	-10.8%
High Energy Physics	775,868	232,390	810,483	829,000	+18,517	+2.3%
Nuclear Physics	500,307	154,800	535,000	562,000	+27,000	+5.0%
Workforce Development for Teachers & Scientists	13,583	12,500	20,678	35,600	+14,922	+72.2%
Science Laboratories Infrastructure	145,380	198,114	127,600	126,000	-1,600	-1.3%
Safeguards & Security	80,603	——	83,000	86,500	+3,500	+4.2%
Science Program Direction	186,695	5,600	189,377	214,437	+25,060	+13.2%
Small Business Innovation Research/Technology Transfer (SC)	104,905	18,719	——	——	——	——
Subtotal, Science	**4,681,572**	**1,596,000**	**4,826,820**	**5,121,437**	**+294,617**	**+6.1%**
Congressionally-directed projects	91,064	——	76,890	——	-76,890	-100.0%
Small Business Innovation Research/ Technology Transfer (DOE)	49,534	36,918	——	——	——	——
Use of prior year balances	-15,000	——	——	——	——	——
Total, Office of Science	**4,807,170**	**1,632,918**	**4,903,710**	**5,121,437**	**+217,727**	**+4.4%**

ROLES AND RESPONSIBILITIES

Office of Science

- Understand interactions of energy and matter spanning wide range of space, time and energy scales
- Develop new theoretical, experimental and computational tools to probe and study Nature
- Understand structure, function, dynamics, and transitions of atoms and molecules in inorganic and organic materials as well as biological systems
- Understand and develop predictive tools for complex systems such as climate
- Create human capital in science and engineering

ARPA-E

Combine science and engineering to create new technologies, devices and prototype systems that:

- address agency mission;
- do not exist in today's energy market;
- are too risky for private sector investment;
- if successful:
  - could make today's technologies obsolete;
  - could have large commercial impact;
  - could produce new learning curves and new markets

INDUSTRY

Applied Energy Offices

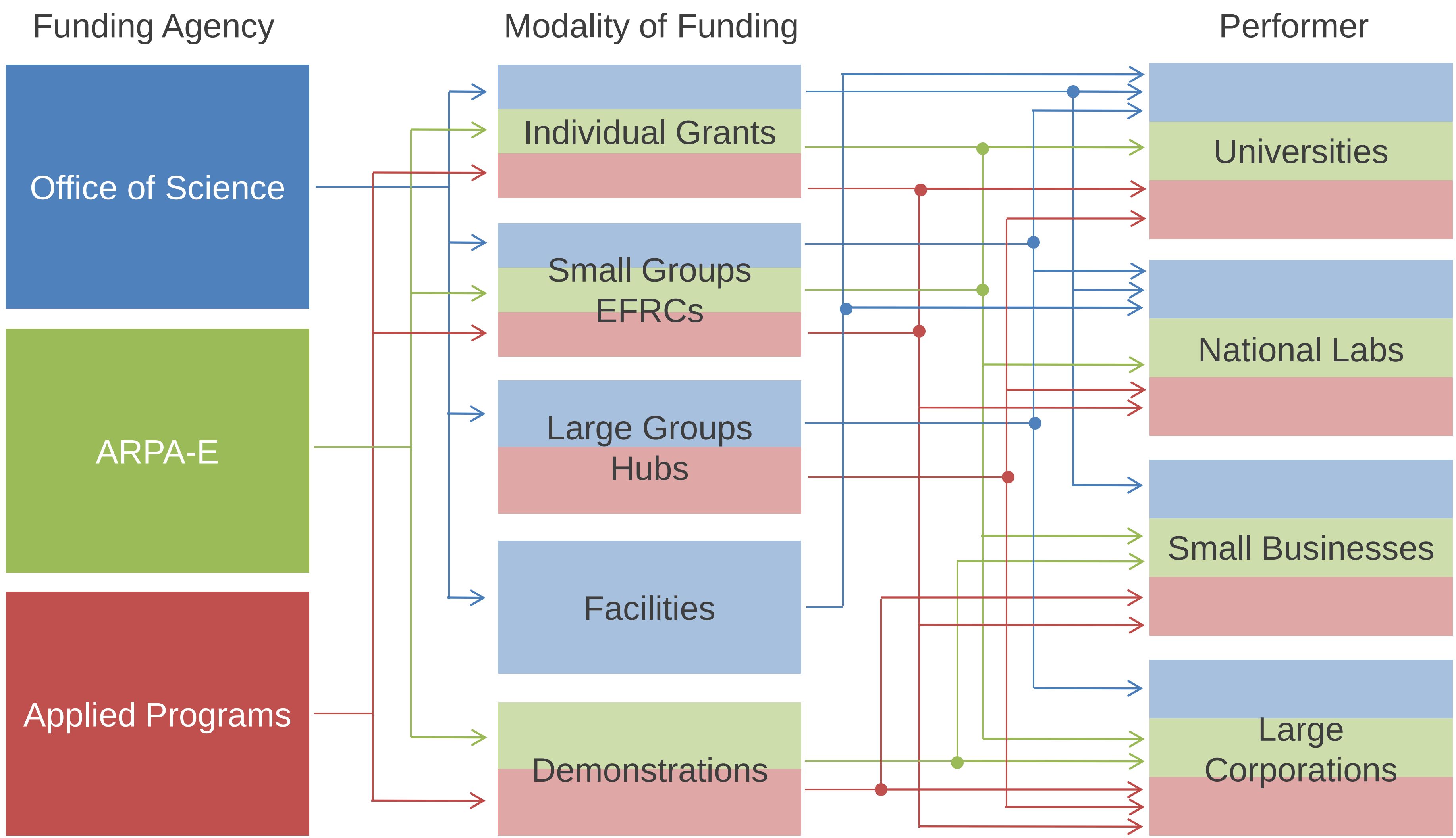
Combine science and engineering to improve technologies, devices and integrated systems that:

- have presence and learning curves in today's energy markets;
- need further R&D to improve performance and reduce cost to enable large market adoption;
- need technology demonstrations to reduce technology & market risks
- need small-scale deployment for market adoption

Basic Science Research | **Feasibility Research** | **Technology Development** | **Technology Demonstration** | **Small Scale Deployment** | **Large Scale Deployment**

Technology Readiness Level

Funding Process



Prospects for Solar Fuels Production

What We Can Do Today

Two Limits

$12/kg H_2 @ $3/pW PV
(BRN on SEU 2005)

PV cell

balance of system

current

electrolyzer

gas

fuel storage

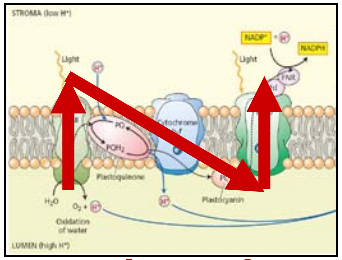
H_2 compression

High capital costs

We do not know how to produce solar fuels in a cost effective manner.

Ultimate Goal

solar microcatalytic energy conversion



liquid

fuel storage

gas

fuel storage

compression

Low capital costs

Chemists do not yet know how to photoproduce O_2, H_2, reduce CO_2, or oxidize H_2O on the scale we need.

Award of the "Fuel From Sunlight" Hub

- Winning team led by Cal Tech and LBNL
- Other institutions involved:
  - SLAC National Accelerator Laboratory
  - Stanford University
  - UC Berkeley
  - UC Santa Barbara
  - UC Irvine
  - UC San Diego
- Professor Nate Lewis leader
- Looking for a factor of 10 over nature
- Strong push to integrate processes to form a complete system

FY 2011 Energy Innovation Hub for Batteries and Energy Storage

Addressing science gaps for both grid and mobile energy storage applications

The Administration's Energy Plan has two goals that require improvements in the science and technology of energy storage:

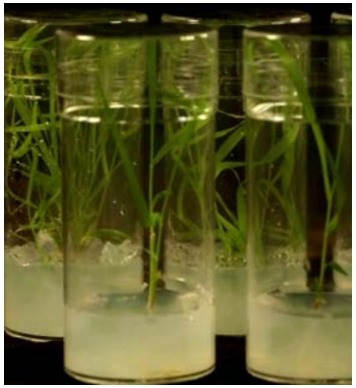
- ➢ Solar and wind providing over 25% of electricity consumed in the U.S. by 2025
- ➢ 1 million all-electric/plug-in hybrid vehicles on the road by 2015

- **Grid stability and distributed power require innovative energy storage devices**
  - Grid integration of intermittent energy sources such as wind and solar
  - Storage of large amounts of power
  - Delivery of significant power rapidly
- **Enabling widespread utilization of hybrid vehicles requires:**
  - Substantially higher energy and power densities
  - Lower costs
  - Faster recharge times

Bioenergy Research Centers: Recent Highlights

BESC
BioEnergy Science Center

- Identification of key lignin biosynthesis genes in switchgrass, providing potential targets for improving switchgrass as a bioenergy crop.



jbei
Joint BioEnergy Institute

- Used synthetic biology toolkit to construct the first microbes to produce an advanced biofuel directly from biomass.

GREAT LAKES BIOENERGY RESEARCH CENTER

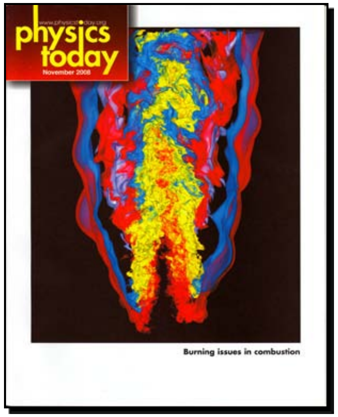
- Characterized soil microbial community structure to understand impacts of biomass crop growth on marginal lands

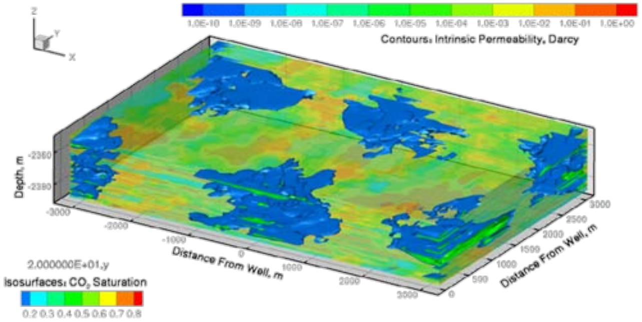
Exascale Initiative

The Goal: *"Provide the United States with the next generation of extreme scale computing capability to solve problems of National importance in Energy, the Environment, National Security, and Science"*

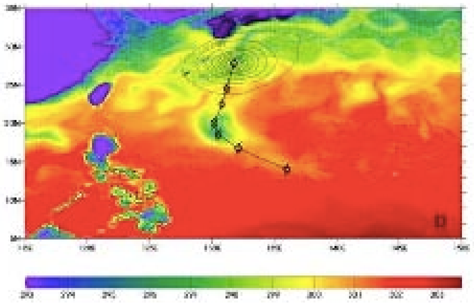
Why do Exascale?

- Environment
- Energy
- National Security
- Science and Innovation
- American Competitiveness



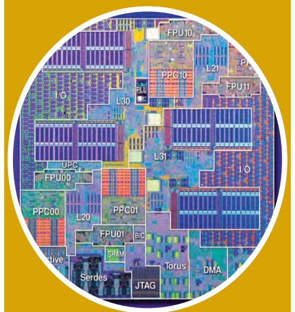


Geologic sequestration



Massive Earth System Model ensembles
(e.g. decadal forecasts, extreme weather)

Exascale Initiative Major Components



Platform R&D

2 Vendor Tracks

- Power
- Integration
- Risk Mitigation

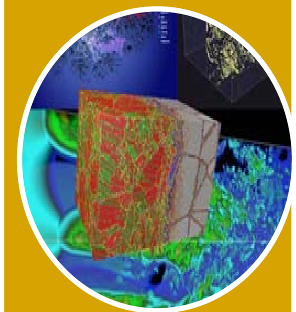
Critical Technologies

(everyone benefits)

- Memory
- Nonvolatile storage
- Optics

Software and Environments

- Operating environment
- Systems Software
- System reliability
- Programming model



Co-design

- Physics Models
- Applied Math
- Performance models
- Simulators
- Applications integration with vendors

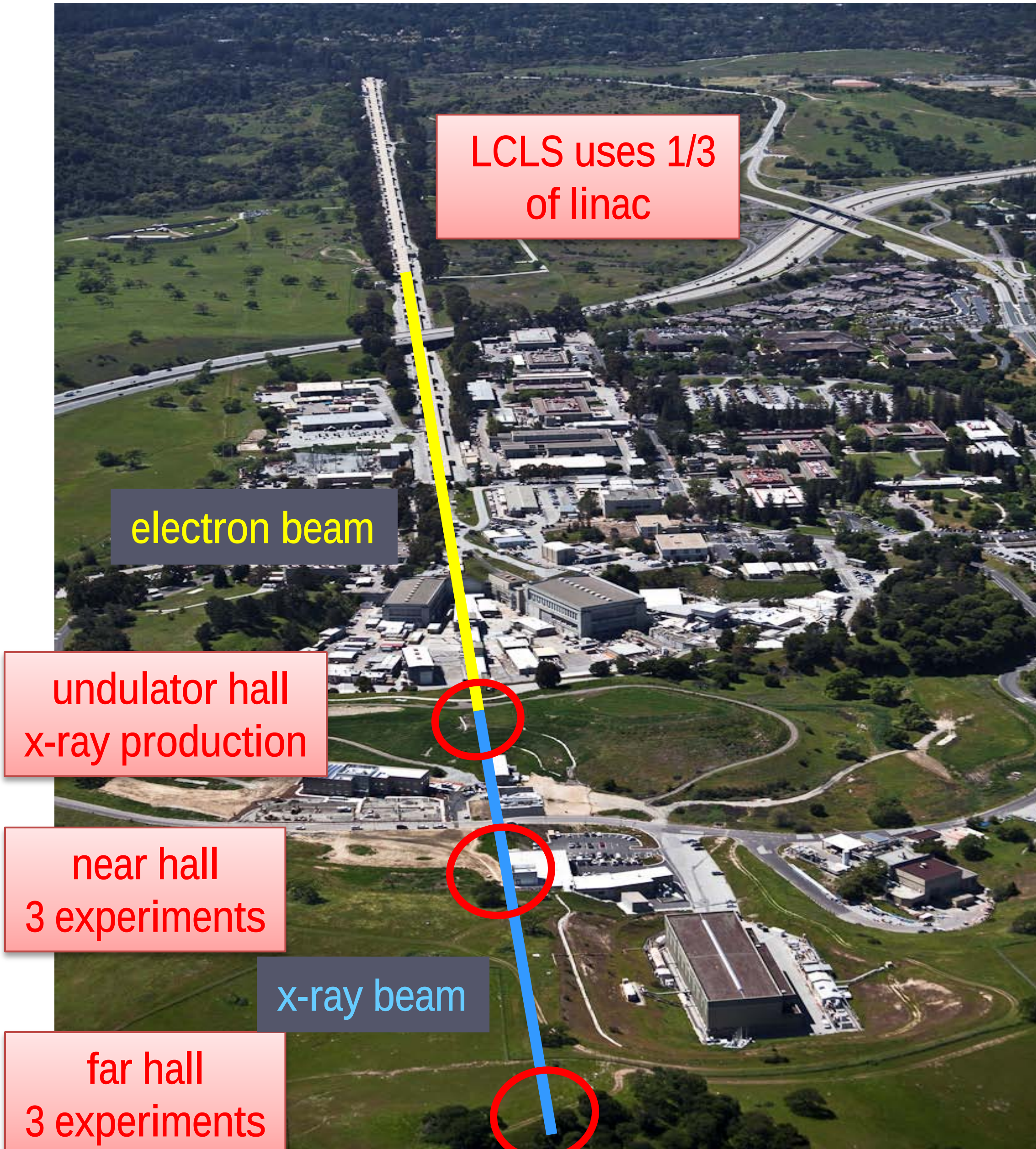
Platforms

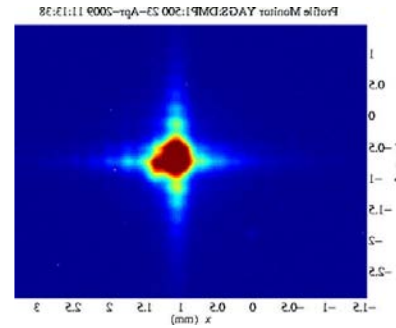
- Early prototypes to ensure component integration and usefulness
- Risk mitigation for vendors – Non recoverable engineering cost

Exascale Initiative

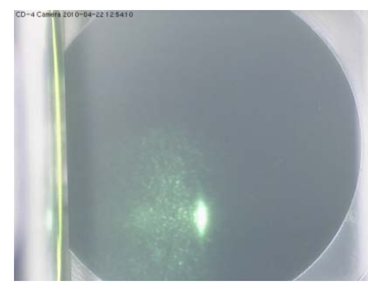
Linac Coherent Light Source or “LCLS” at SLAC

The World’s First X-ray Laser





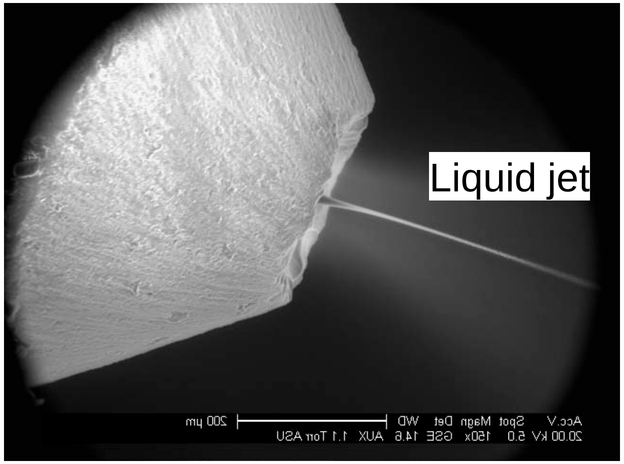
First X-rays: ~ 1 PM PDT 4/15/2009



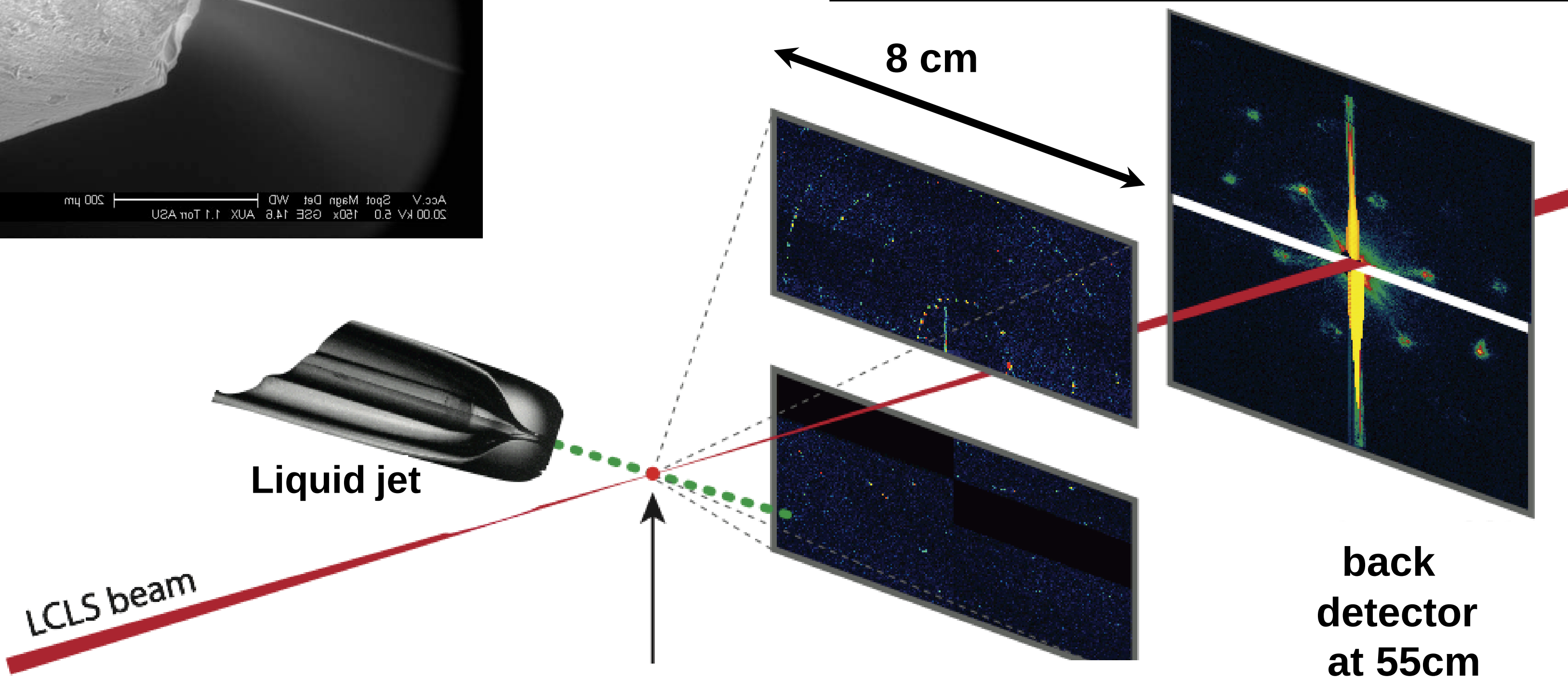
Detection of X-ray at Far Hall ~ 1 PM PDT 4/22/2010

Early Studies at LCLS: Nanocrystals in Water Microjet

John Spence et al. ASU



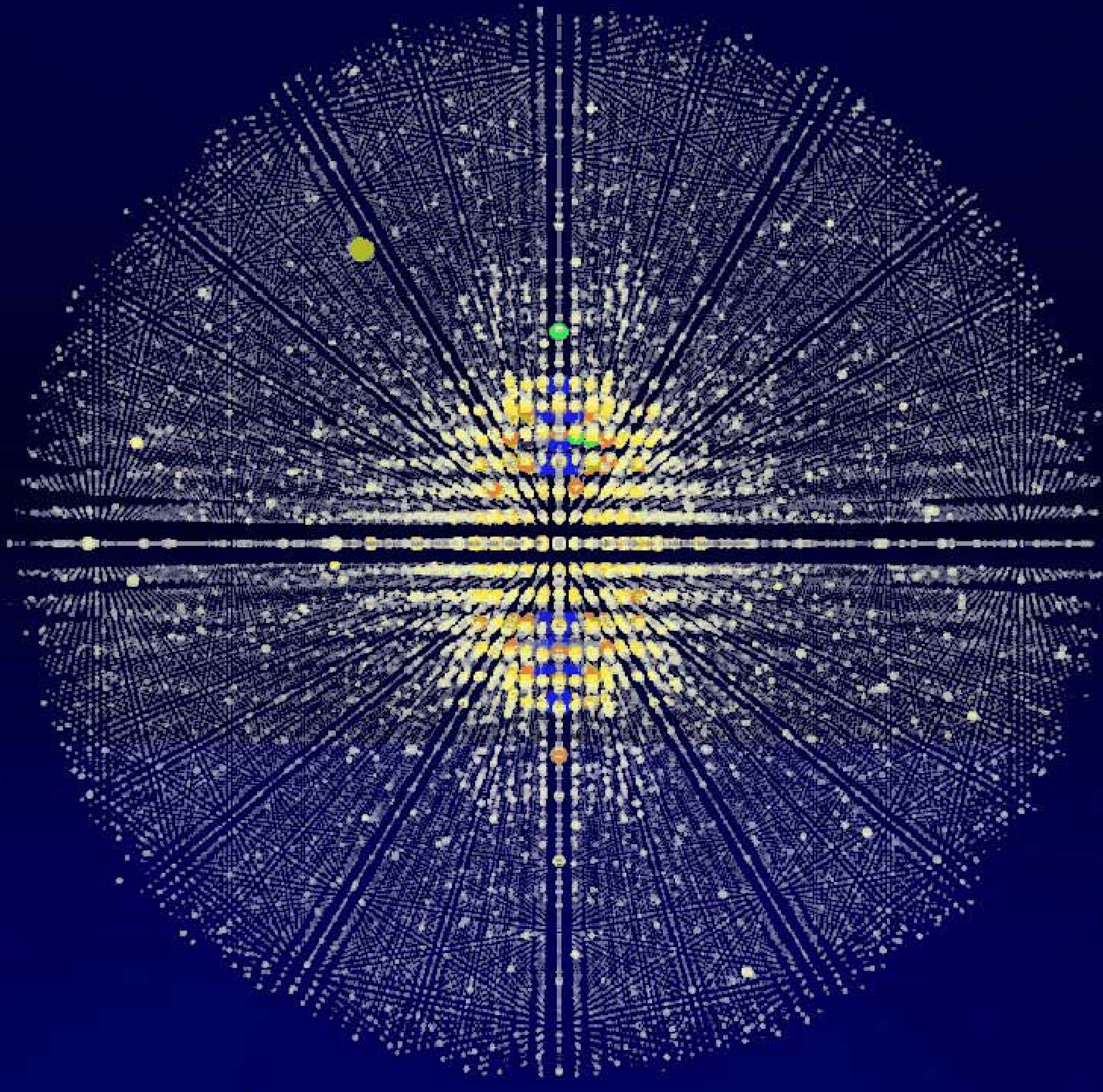
Spokesperson: **Henry Chapman** et al.
collaboration of
Center for Free Electron Laser Science DESY
Arizona State University, Max Planck CFEL
ASG, SLAC, LLNL, CBST, Uppsala University



1.8 keV
60 - 300 fs pulses
10^{13} photons / pulse

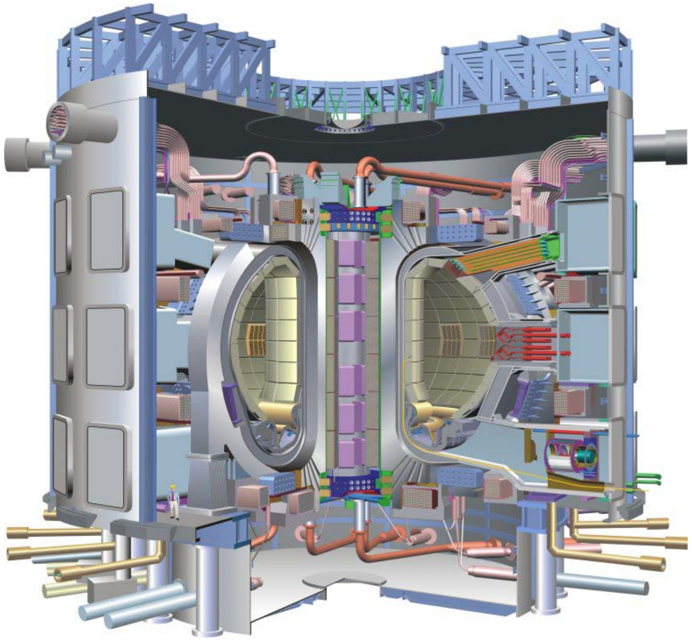
x-rays: 7 μm
liquid jet: 4 μm

front detector at 7cm



ITER

- ITER (Latin for "the way") is a first of a kind major international research collaboration on fusion energy.
- U.S. is a 9.09% partner.
- ITER Goals
  - Designed to produce 500 MW of fusion power (Q $\geq$ 10) for at least 300-500 seconds
  - *Burning plasma* dynamics and control
    - U.S. emphasizes the value of ITER, its flexibility, and its diagnostics as a scientific instrument: develop a predictive capability of the burning plasma state
  - Will optimize physics and integrate many of key technologies needed for future fusion power plants
- The *Agreement on the Establishment of the ITER International Fusion Energy Organization for the Joint Implementation of the ITER Project*, entered into force in October 2007 for a period of 35 years.



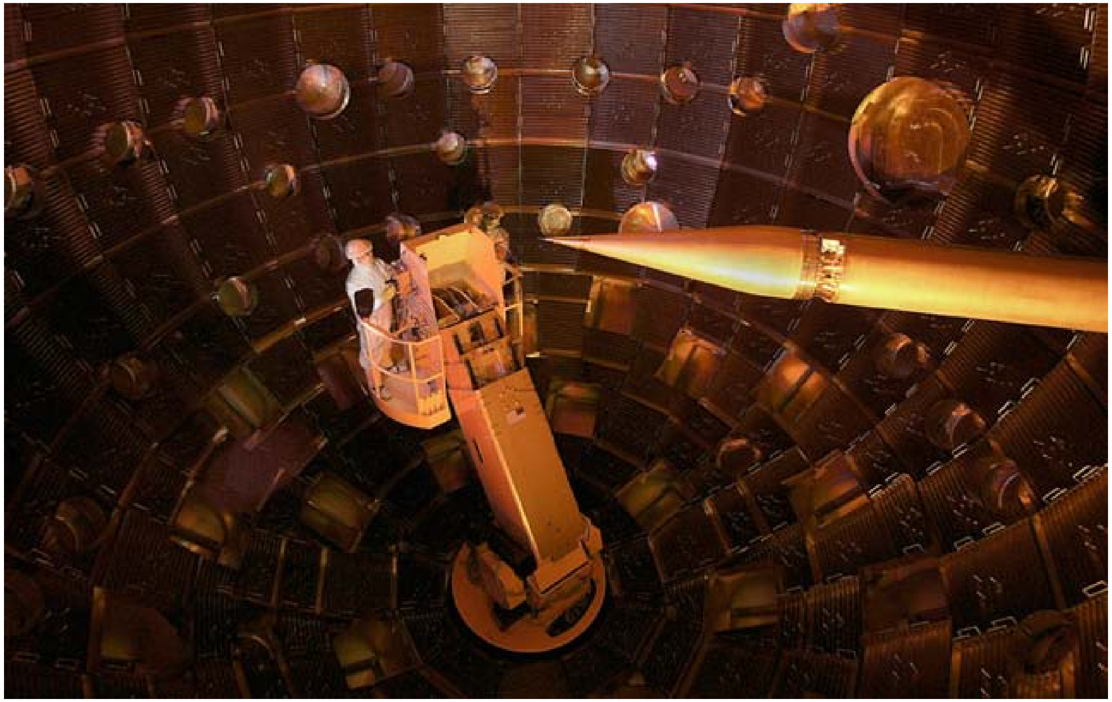
ITER Tokamak – Cross Sectional View

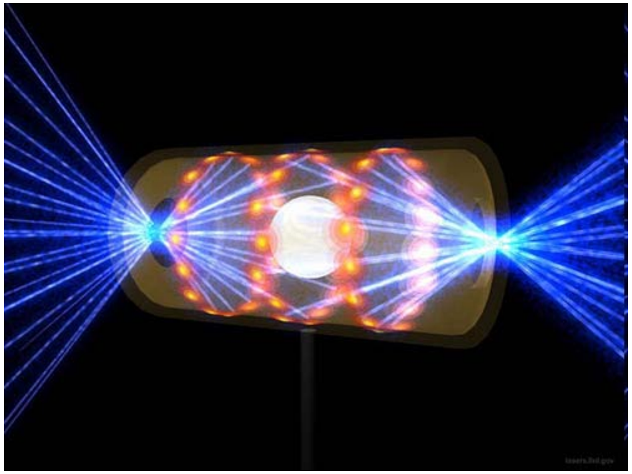
ITER Background

- The ITER Organization (IO), located at Cadarache, France, has been established as an independent international legal entity comprised of personnel (~400) from all of the Members.
- Like all non-host Members, the U.S. share for ITER's construction is $1/11^{th}$ (9.09%) of the total value estimate.
  - roughly 80% will be in-kind components manufactured largely by U.S. industry and beyond that, the United States has agreed to fund 13% of the cost for operation, deactivation, and decommissioning.
  - At Critical Decision 1 (January 2008), the Total Project Cost (TPC) range for the U.S. share of the Construction Phase was estimated to be $1.45-2.2 B

Inertial Fusion Energy: Nearing Ignition

- The newly completed National Ignition Facility – the world's most powerful laser system – recently began full operations
- NIF is on track to achieve the first laboratory demonstration of "ignition" or net energy gain





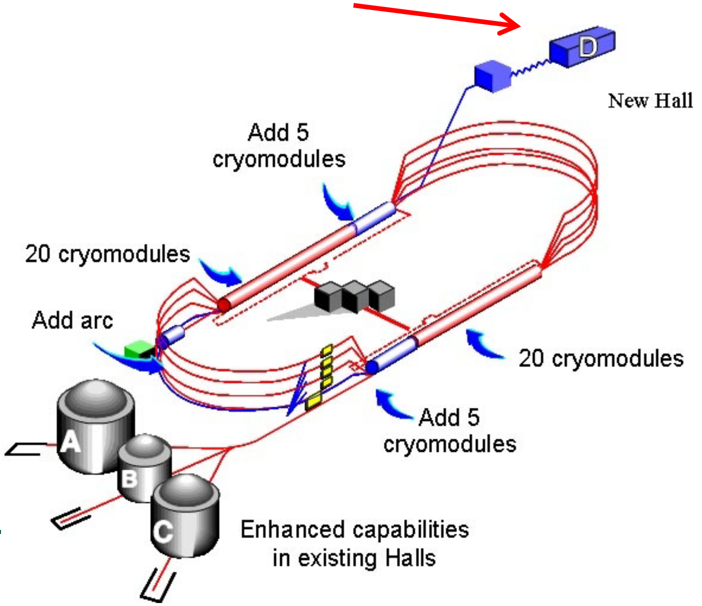
Construction of the 12 GeV CEBAF Upgrade

New physics reach provided by the 12-GeV CEBAF Upgrade:

- Nuclear tomography to discover and explore the three-dimensional structure of the nucleon
- The search for exotic mesons—a quark and an anti-quark held together by gluons
- Physics beyond the Standard Model via precision studies of parity violation
- Spin and flavor dependence of valance parton distributions
- Exploring how valence quark structure is modified in the nuclear medium

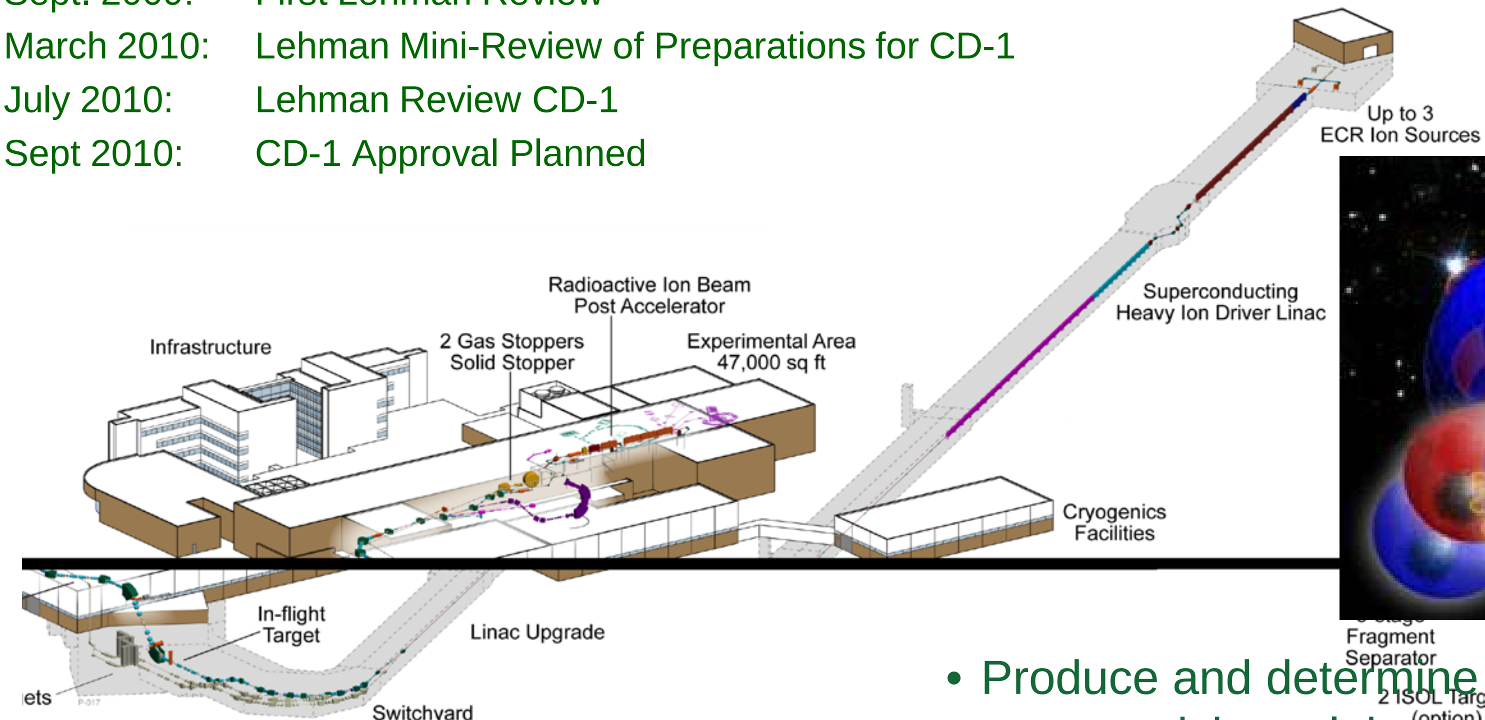
Project Status:

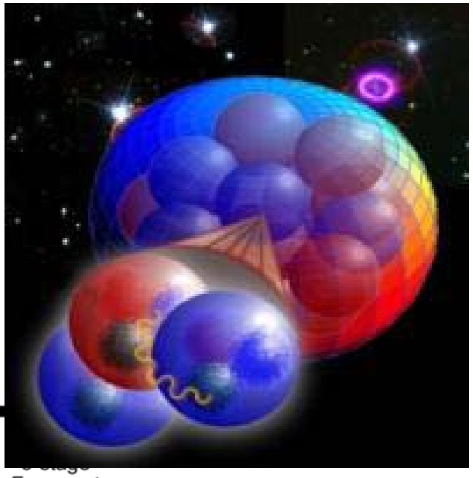
- Construction activities underway.
- Project on cost and schedule.



Status of the Facility for Rare Isotope Beams

Dec. 2008: DOE selects MSU to establish FRIB
June 2009: Cooperative Agreement between DOE and MSU
Sept. 2009: First Lehman Review
March 2010: Lehman Mini-Review of Preparations for CD-1
July 2010: Lehman Review CD-1
Sept 2010: CD-1 Approval Planned



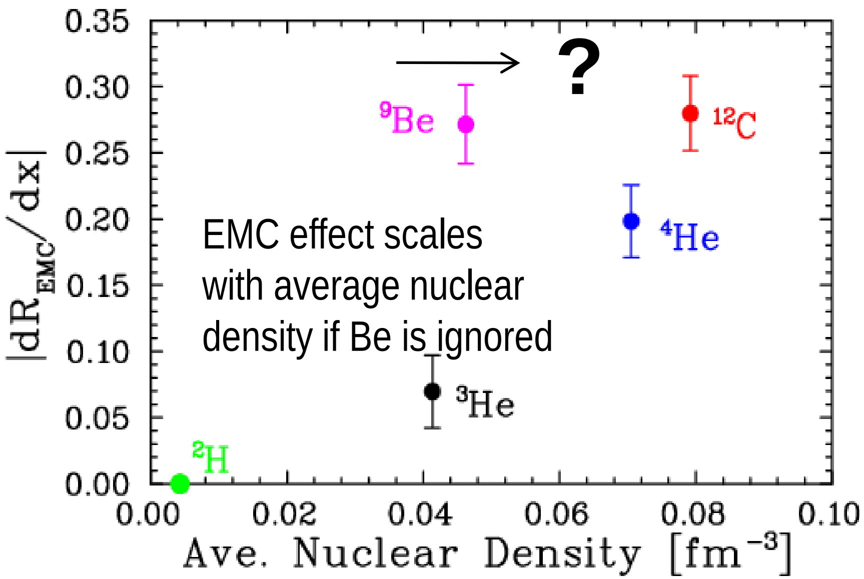


- Produce and determine properties of neutron rich nuclei
- Astrophysics of heavy element production

Engineering design scheduled to start in FY 2011

Recent Advances in Understanding the Quark-Gluon Structure of Nuclei

The Quark-Gluon Structure of Nuclei - EMC Effect in Very Light Nuclei at TJNAF

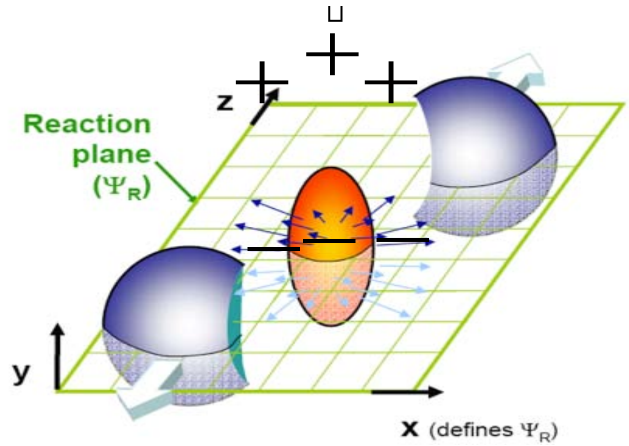


Be = 2 α clusters
(^{4}He nuclei) + "extra" neutron.

Suggests EMC effect depends on local nuclear environment.

Fundamental Properties of a Quark-Gluon Liquid – Suggestion of an event-by-event EDM at RHIC

Magnetic field generated by motion of ions



Event-by-event preference for like-sign (opposite-sign) charges to emerge in same (opposite) direction with respect to magnetic field produced by colliding nuclei observed.

DOE Office of Science Graduate Fellowships

The FY 2011 request doubles the number of graduate fellowships in basic science

$10 million will be available in FY 2011 to fund about 170 additional fellowships

Purpose: To educate and train a skilled scientific and technical workforce in order to stay at the forefront of science and innovation and to meet our energy and environmental challenges

Eligibility:

- Candidates must be U.S. citizens and a senior undergraduate or first or second year graduate student to apply
- Candidates must be pursuing advanced degrees in areas of physics, chemistry, mathematics, biology, computational sciences, areas of climate and environmental sciences important to the Office of Science and DOE mission

Award Size:

- The three-year fellowship award, totaling $50,500 annually, provides support towards tuition, a stipend for living expenses, and support for expenses such as travel to conferences and to DOE user facilities.

FY 2010 Results:

- 160 awards will be made this Spring with FY 2010 and American Recovery and Reinvestment Act funds.

FY 2011 Application Process:

- Funding Opportunity Announcement issued in Fall 2010
- Awards made in March 2011

Office of Science Early Career Research Program

Investment in FY 2011 will bring 60 new scientists into the program

$16 million will be available in FY 2011 to fund about 60 additional Early Career Research Program awards at universities and DOE national laboratories.

Purpose: To support individual research programs of outstanding scientists early in their careers and to stimulate research careers in the disciplines supported by the Office of Science

Eligibility: Within 10 years of receiving a Ph.D., either untenured academic assistant professors on the tenure track or full-time DOE national lab employees

Award Size:

- University grants $150,000 per year for 5 years to cover summer salary and expenses
- National lab awards $500,000 per year for five years to cover full salary and expenses

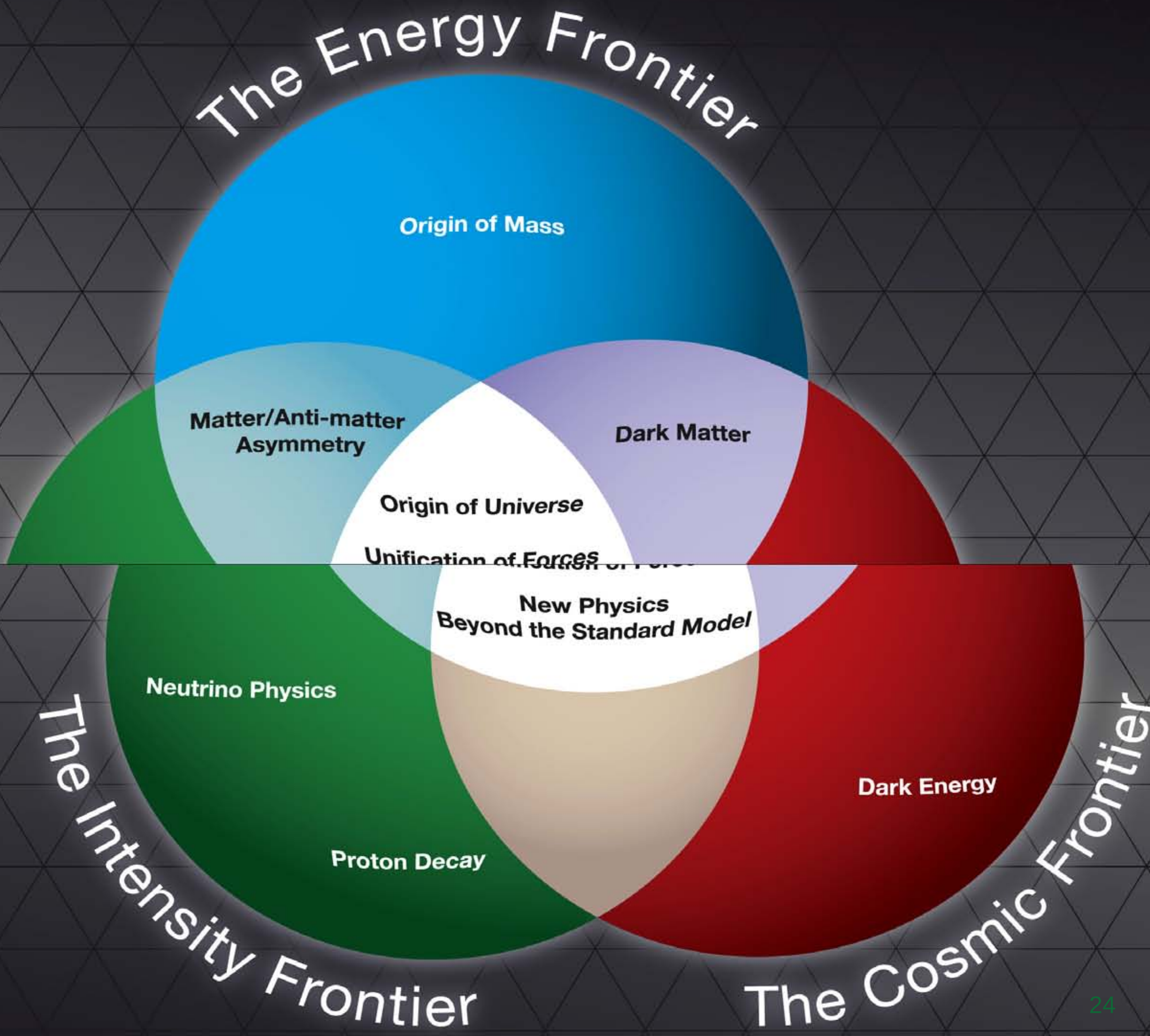
FY 2010 Results:

- 69 awards funded via the American Recovery and Reinvestment Act
- 1,750 proposals peer reviewed to select the awardees
- 47 university grants and 22 DOE national laboratory awards
- Awardees are from 44 separate institutions in 20 states

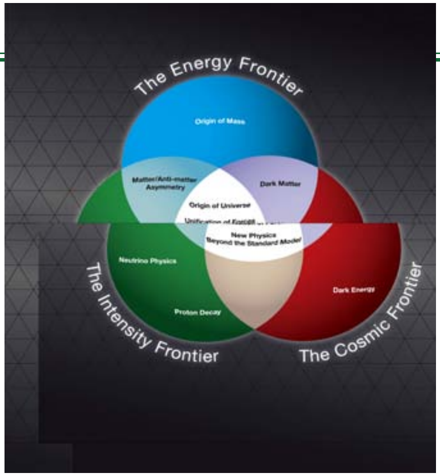
FY 2011 Application Process:

- Funding Opportunity Announcement issued in Spring 2010
- Awards made in the Second Quarter of 2011

http://www.science.doe.gov/SC-2/early_career.htm


The Energy Frontier
Origin of Mass
Matter/Anti-matter Asymmetry
Dark Matter
Origin of Universe
Unification of Forces
New Physics Beyond the Standard Model
Neutrino Physics
Proton Decay
Dark Energy
The Intensity Frontier
The Cosmic Frontier

The P5 Roadmap

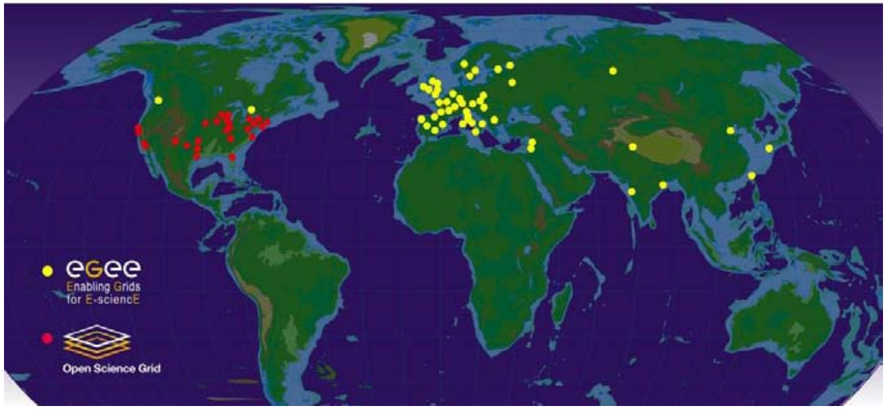


- The ENERGY FRONTIER
  - The Tevatron
  - The LHC
  - ILC and Accelerator R&D
- The INTENSITY FRONTIER
  - MINOS, MiniBOONE -> NOvA, MicroBOONE ->LBNE,DUSEL
  - Reactor neutrino expts DoubleCHOOZ, DayaBay
  - Precision Meas: Mu-to-e conversion
  - Proton Decay Searches
- The COSMIC FRONTIER
  - Direct Dark Matter Searches
  - Dark Energy from Ground and Space

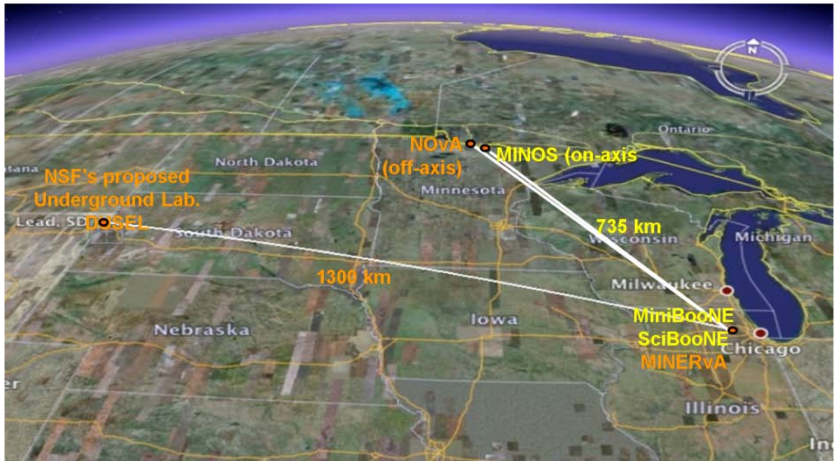
The U.S. High Energy Physics Program

The U.S. is uniquely positioned for a world-leading program in neutrino physics

The U.S. is a critical and strategic partner in global scientific collaborations that push the boundaries of High Energy Physics. The U.S. has developed components for the Large Hadron Collider at CERN and hosts centers for data analysis.



Network sites of the Open Science Grid and Enabling Grids for E-sciencE used for transmitting experimental data from the LHC to scientists worldwide.

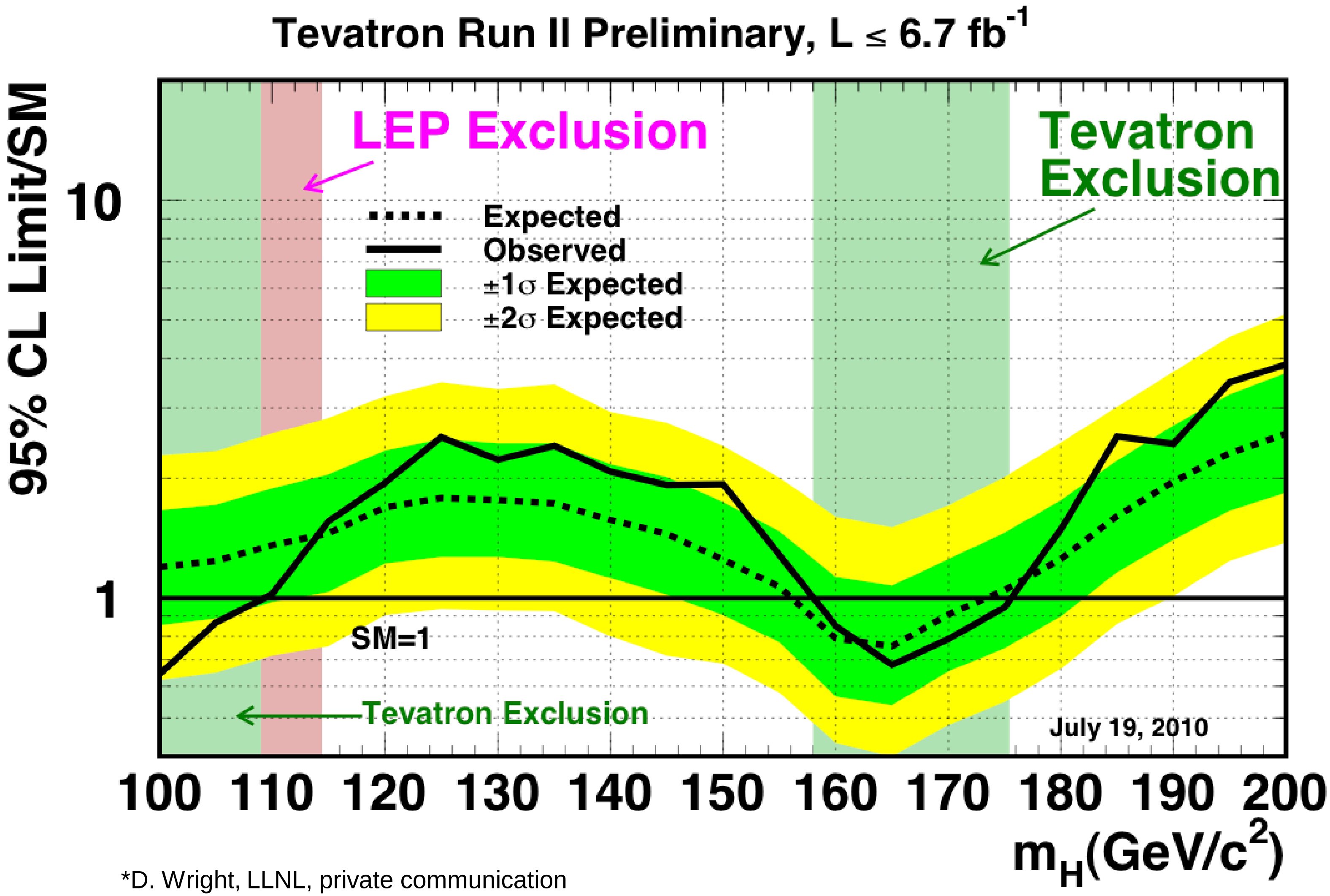


The NuMI beamline provides the world's most intense neutrino beam for the MINOS experiment and proposed NOvA and LBNE experiments

At home, HEP builds on its investments in tools and facilities to capture the unique opportunities of neutrino science. These opportunities are fundamental to the science of particle physics.

At the heart of the DOE HEP program is the *NuMI beamline* at Fermilab, the world's most intense neutrino source, which serves MINERvA and MINOS and will support NOvA and the proposed LBNE (+$12,000K, HEP, initiated in FY 2011).

Progress Toward the Higgs Particle*



*D. Wright, LLNL, private communication