DOE Office of Science Planning Meeting for Fermilab

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June 10, 2013

U.S. DEPARTMENT OF ENERGY

Fermilab

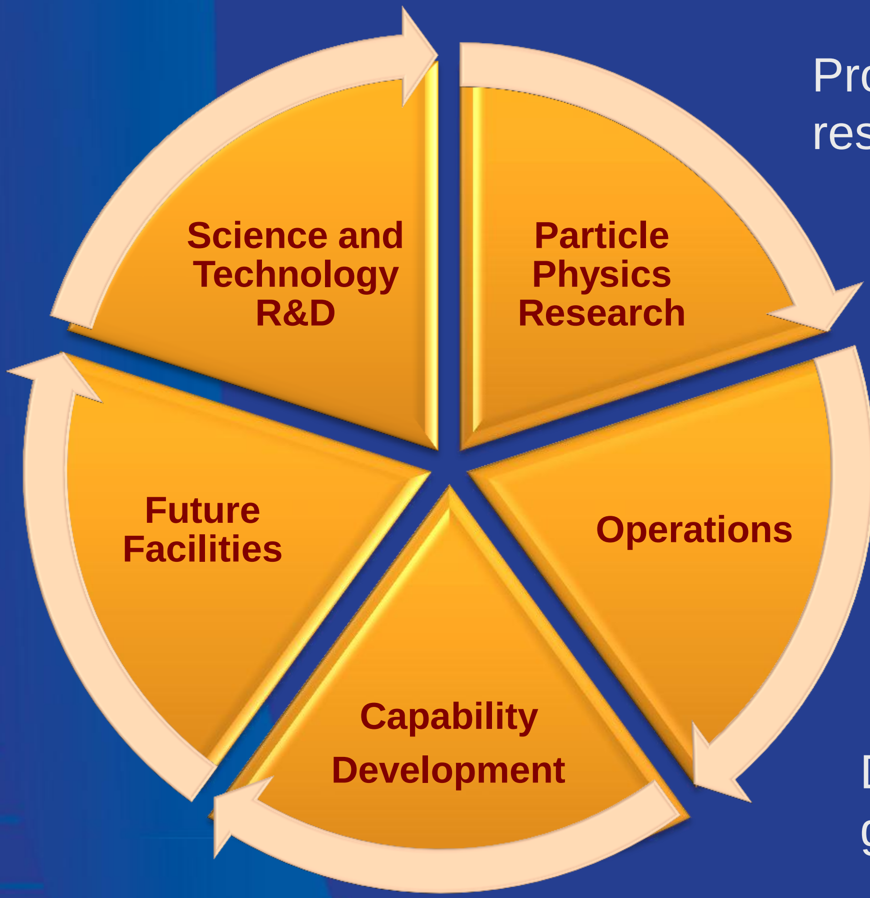
Outline

Topic	Slide #s	Speakers
• Mission • Overview • Lab-at-a-Glance	3 – 17	Pier Oddone
• Science Strategy for the Future • Major Initiatives	18 – 36	Young-Kee Kim
• Mission Readiness • Human Resources • Work for Others • Cost of Doing Business	36 - 50	Jack Anderson

Fermilab's Vision and Mission

- Fermilab: America's particle physics laboratory
- Vision: inspire the world and enable its scientists to solve the mysteries of matter, energy, space and time for the benefit of all.
- Mission: drive discovery in particle physics by:
  - building and operating world-leading accelerator and detector facilities
  - performing pioneering research with global partners
  - transforming technologies for science and industry.

Achieving our mission



Produce world-class particle physics results

Operate accelerators, detectors, and computing facilities at the highest levels of performance, efficiency and safety

Maximize capabilities through human resources development, system improvements and upgrades

Design and build the next generation of facilities

Develop, nurture and advance basic understanding of the technologies that will drive future facilities support 4,300 users

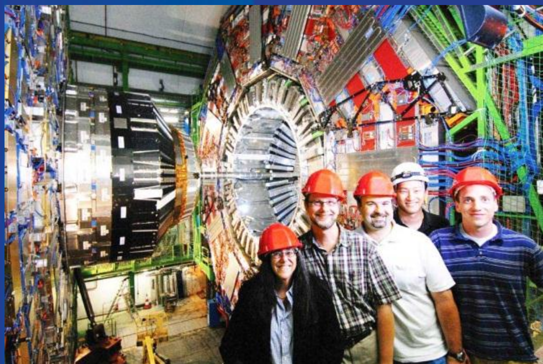
(2012 statistics: 2,200 onsite users + 2,100 offsite users)

27 countries

17 countries

24 countries

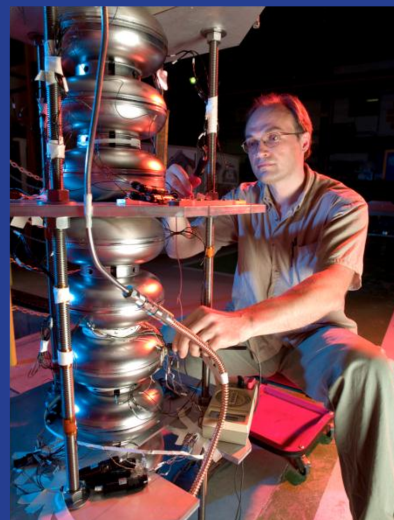
A simplified picture of global particle physics



- Europe has the LHC. It will dominate the energy frontier for the next two decades and keep Europe occupied. Very large US participation in the detectors and contributions to the accelerator.

Japan likely to propose hosting International Linear Collider. Culturally important for Japan. Japan will have a SuperB factory and proposes a megaton neutrino detector. All three vastly exceed capacity of Japanese HEP community

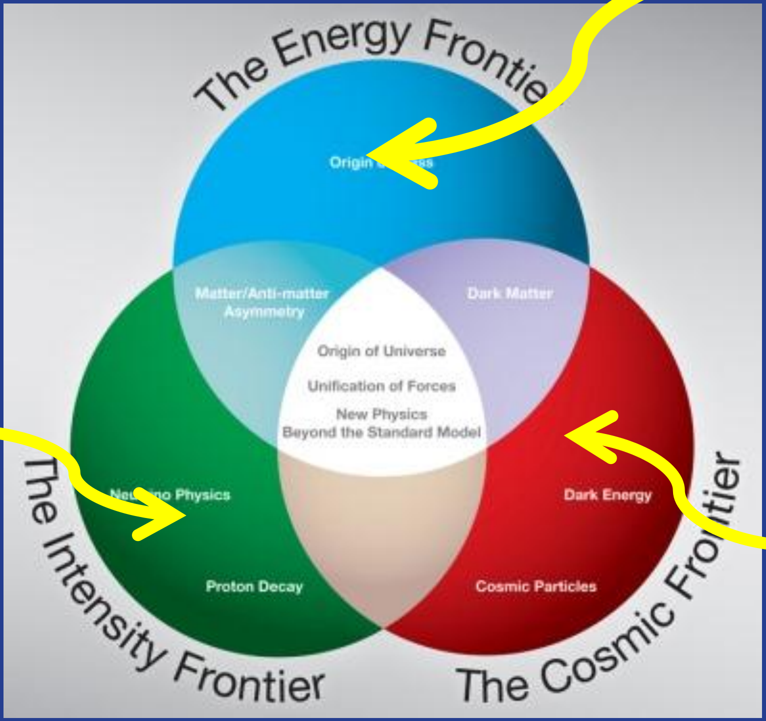
A simplified picture of particle physics



- U.S. is positioned to be the leader at the intensity frontier with world-class experiments in rare processes and neutrinos – both dependent on having the greatest flux of particles. A coherent plan for the next two decades that will bring international partners to a very strong and exciting program in the US. Big anchors of this program are LBNE (phased) and Project X (phased).

US at the three frontiers

- Participation in facilities hosted abroad (LHC, ILC?)
- R&D on future machines



DOE Leadership at the Intensity Frontier both in neutrinos and rare processes

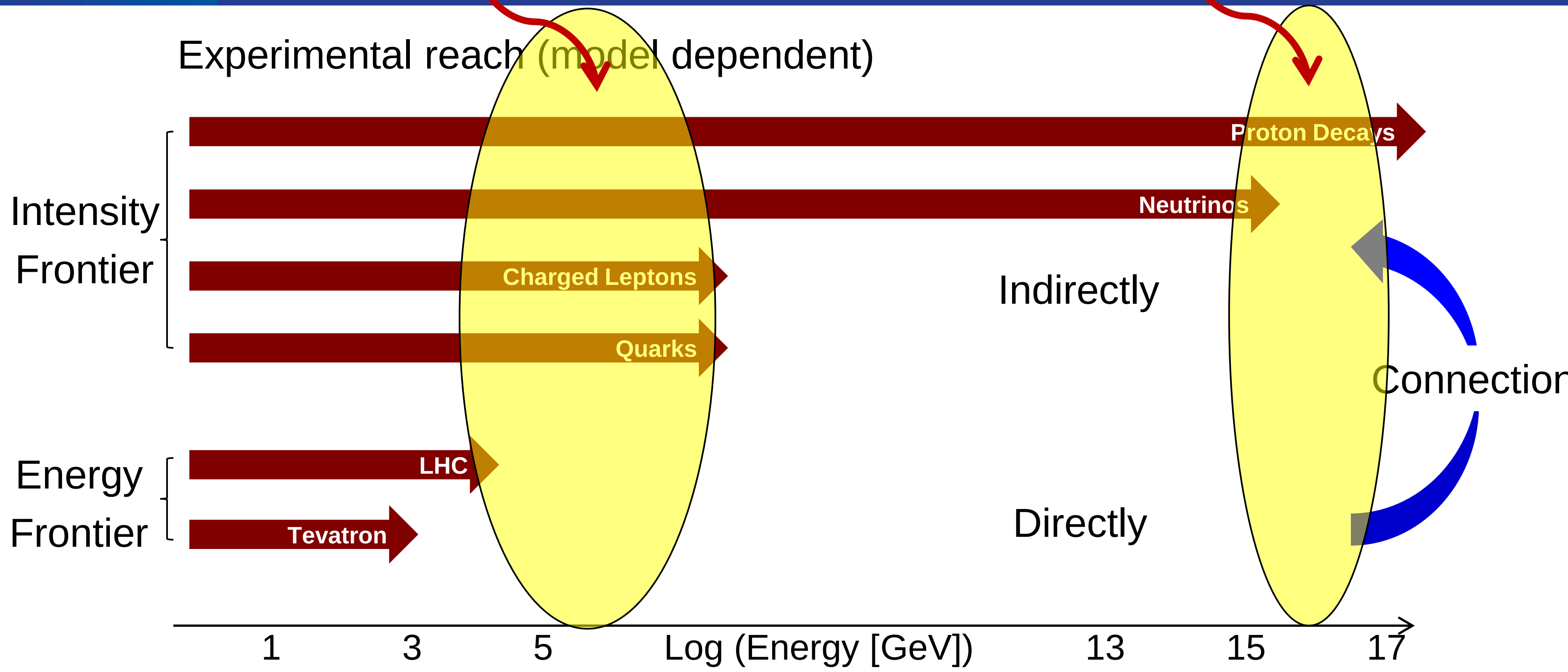
Dark matter and dark energy experiments, shared leadership with other agencies (NASA and NSF)

ALL THREE FRONTIERS ARE ESSENTIAL, THEY ARE INTERCONNECTED AND WORK IN HARMONY

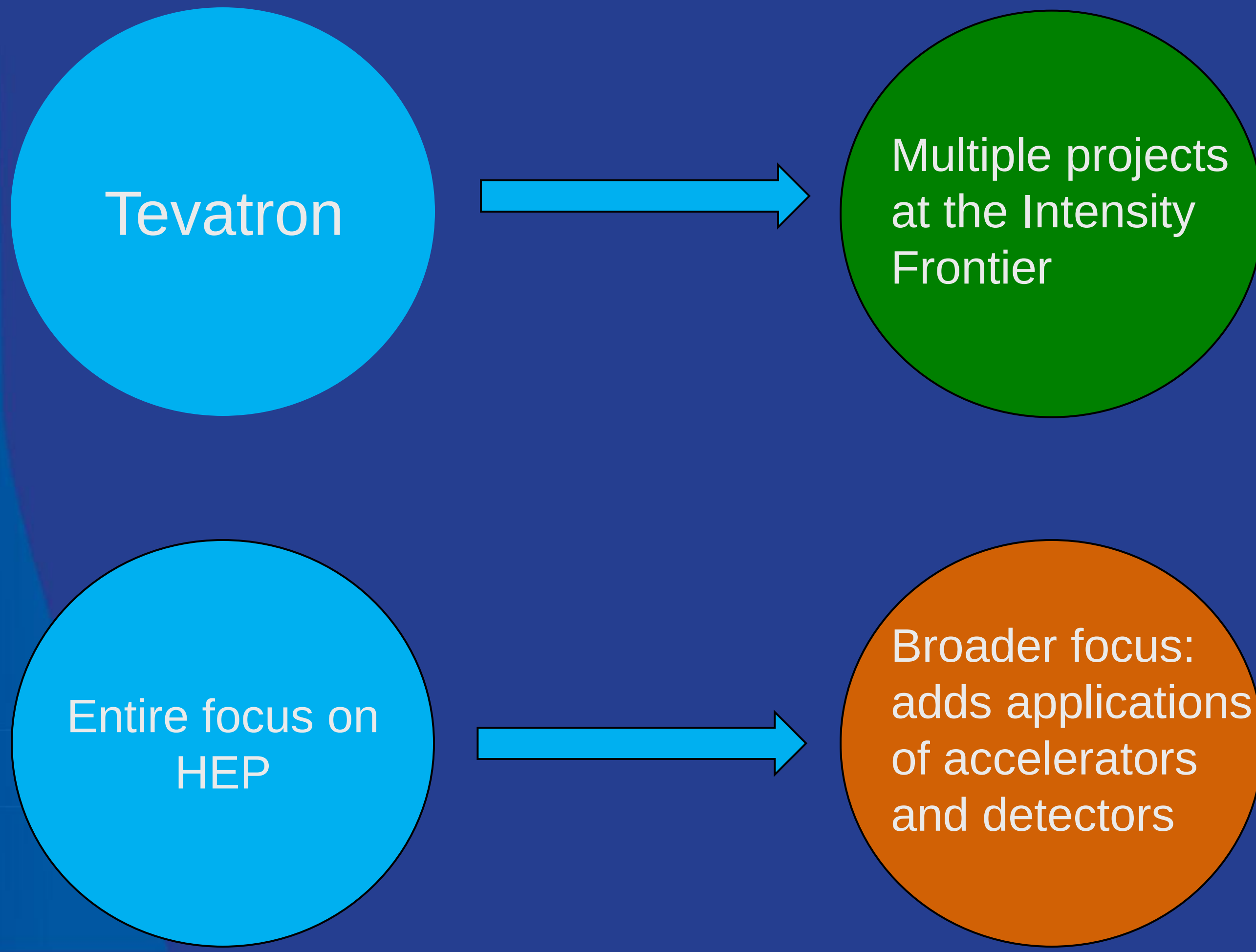
Why the intensity frontier?

Is there anything within two to three orders of magnitude of the mass of the Higgs ?

GUTs scale imprints patters we can read in neutrinos and proton decay



Two important "pivots" for Fermilab



Challenges in the first pivot

- Bringing the community along to a national program at the Intensity Frontier
- Convincing sponsors of the need for multiple projects: follows from the nature of the Intensity Frontier
- Unique opportunity to bring the world to invest in a major global facility hosted in the US: LBNE followed later by Project X
- Managing multiple projects while we are operating the largest accelerator complex in the country (even after the Tevatron shutdown), and while budgets are shrinking

Improving our game on project management

- Extremely good progress on NOvA and MicroBooNE: NOvA and MicroBooNE should finish on budget and on schedule. This would be 3rd and 4th projects after MINERvA and DES to finish on budget and on schedule
- Thorough review by the best managers in the system: we are implementing recommendations to improve our systems, training, qualification of managers
- Organizational changes to highlight integrated planning and performance management.
- An opportunity to develop a cadre of project managers both for DOE needs and positioning of our young people in a difficult job market

Challenges in the second pivot

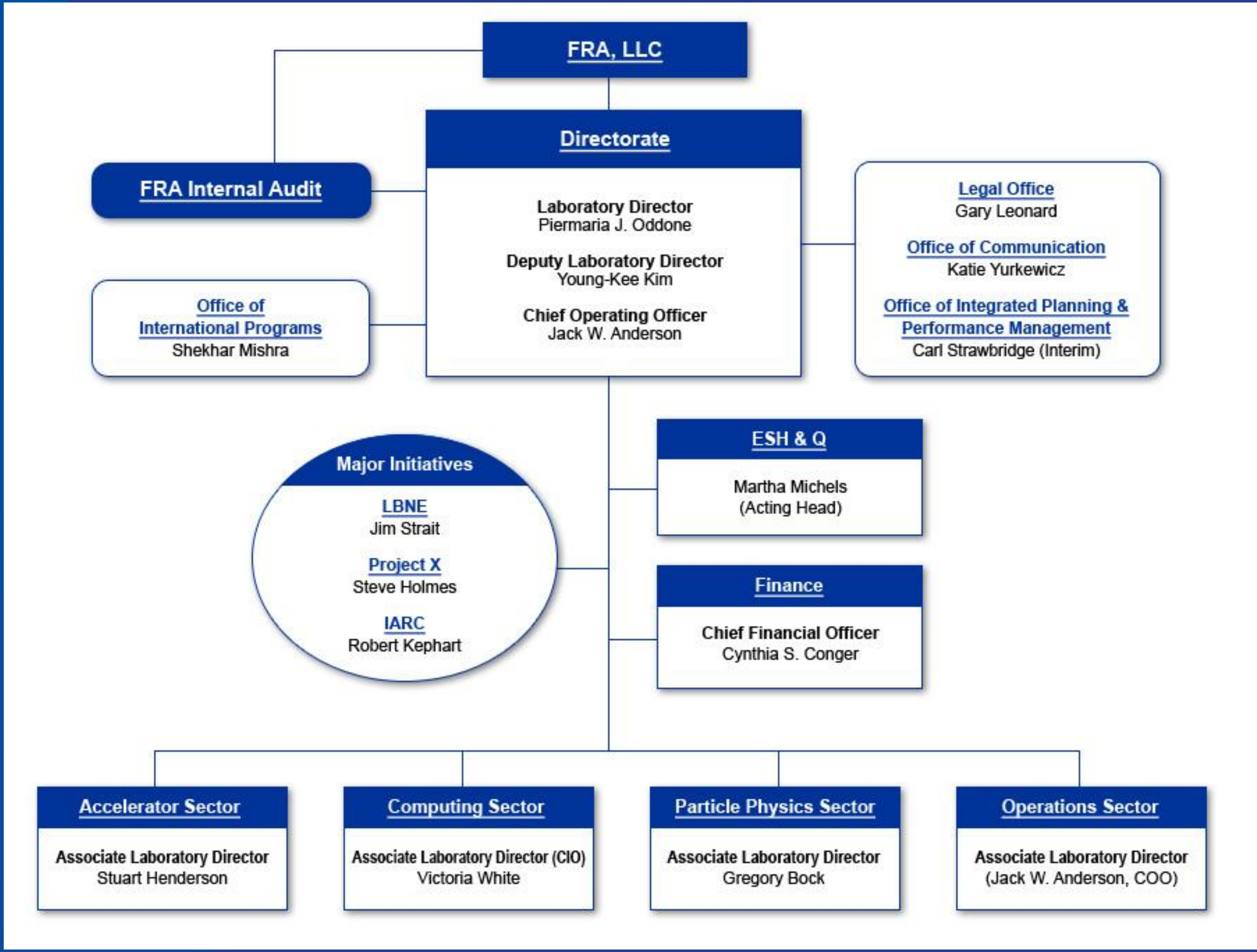
- Make Fermilab capabilities applicable to all Office of Science projects that would profit from our specialized expertise and test facilities (SC magnets and RF)

- Develop the capability of working effectively with industry as part of the accelerator stewardship mission of HEP

- To accomplish this, it is very important to finish the infrastructure that allows us to do this effectively:

  - The Illinois Accelerator Research Center (IARC)
  - Advanced Accelerator Test Facility (ASTA)

Fermilab organization to achieve the mission of the lab



Fermilab

The *“Fermilab Agenda”*

<u>A planning & communications framework that:</u>

- aligns Lab strategic objectives, critical outcomes and major initiatives in major mission areas of science & operations;
- provides top-level focus for Program Execution Plans that flesh out annual actions and performance plans to make progress toward the strategic vision; and
- stimulates improvement (sustain good ideas, end those not working out, innovate new ideas).

The ‘Agenda’ provides insight into key initiatives at Fermilab, but it does not encompass everything we do

Strategic Fermilab Agenda FY 2013 – FY 2018

Mission	*Fermilab's mission is to drive discovery in particle physics by building and operating world-leading accelerator and detector facilities, performing pioneering research with global partners, and transforming technologies for science and industry.*				
Strategic Objectives	**Excellence in Particle Physics, Accelerator Science and Technology, and Large-Scale User Facilities**				**Excellence in Laboratory Operations**
	Science			Facilities	
	Intensity Frontier	Energy Frontier	Cosmic Frontier		
Critical Outcomes	Intense particle beams reveal new physics through neutrino, muon and rare-decay experiments.	High-energy particle colliders discover new particles and probe the architecture of nature's fundamental forces.	Underground experiments and ground-based telescopes uncover the nature of dark matter and dark energy.	The Fermilab complex efficiently and safely delivers the highest levels of performance to worldwide users. Theoretical insights and new technologies support a future particle physics program.	World-class scientific, engineering, computing and support staff use well-integrated, efficient business and management systems to operate a safe, modern suite of facilities and infrastructure.
Strategies	Establish a world-leading program by leveraging international partnerships. Fully exploit the scientific potential of Fermilab's accelerator complex.	Exploit the full scientific potential of LHC, and support CMS and LHC upgrades. Prepare the scientific case for future Energy Frontier exploration.	Exploit the full scientific potential of dark energy and dark matter experiments. Compete for next-generation dark matter experiments. Prepare to play a key role in next-generation dark energy experiments.	Modernize the Fermilab accelerator complex to support future world-leading physics research. Strengthen US and international partnerships in advanced accelerator and detector technology development and construction. Compete for funds and establish CRADAs and WFO agreements to strengthen core competencies.	Become universally recognized as a successful manager of large science construction projects. Invest in infrastructure, and streamline and modernize business processes to support the laboratory mission and strategic goals. Optimize the cost of doing business. Provide an outstanding environment for staff, users and collaborators
Major Initiatives and Deliverables	1. Deliver NOvA project within baselines. 2. Plan and execute LBNE, Muon g-2, Mu2e and MicroBooNE projects within baselines. 3. Exploit neutrino physics programs: NOvA, MicroBooNE, MINOS+ and MINERvA. 4. Develop Project X physics program. 5. Develop concepts for future experiments: ORKA, nuSTORM and pEDM.	1. Plan and execute LHC upgrades including CMS and LARP. 2. Exploit physics from CMS. 3. Complete the Tevatron physics program, deliver results, and preserve knowledge and data.	1. Initiate physics program from DES. 2. Develop strategy for next generation of dark matter experiments. 3. Establish major roles in future dark energy experiments LSST and MS DESI.	1. Build the Muon Campus. 2. Deliver the Proton Improvement Plan. 3. Develop Project X pre-conceptual design and demonstrate PXIE. 4. Grow world-class accelerator science and technology programs including ASTA. 5. Complete IARC construction and establish an applied technology program. 6. Plan, authorize and execute the (IUUP) SLI project. 7. Produce MAP feasibility studies.	1. Enhance performance through broad implementation of HPI principles. 2. Initiate and deploy enhanced support for Fermilab projects. 3. Fully implement CAS. 4. Develop process and organizational framework for integrated planning and budgeting. 5. Establish strategic and critical hires list from OHAP. 6. Develop Site Master Plan. 7. Develop roadmap and execute projects to transform and modernize business processes and information systems. 8. Initiate an optimization study to reveal streamlining, cost-reduction and business system innovation opportunities. 9. Unify core IT services and maintain ISO20000 certification.
Enabling Capabilities	• A premier detector R&D program and expanded test beam capabilities. • Computing facilities, technologies and architectures that enable scientific output. • A world-class theory program.			• Construction projects that are planned and executed within baselines. • Partner laboratory relationships that support work for others.	

April 24, 2013

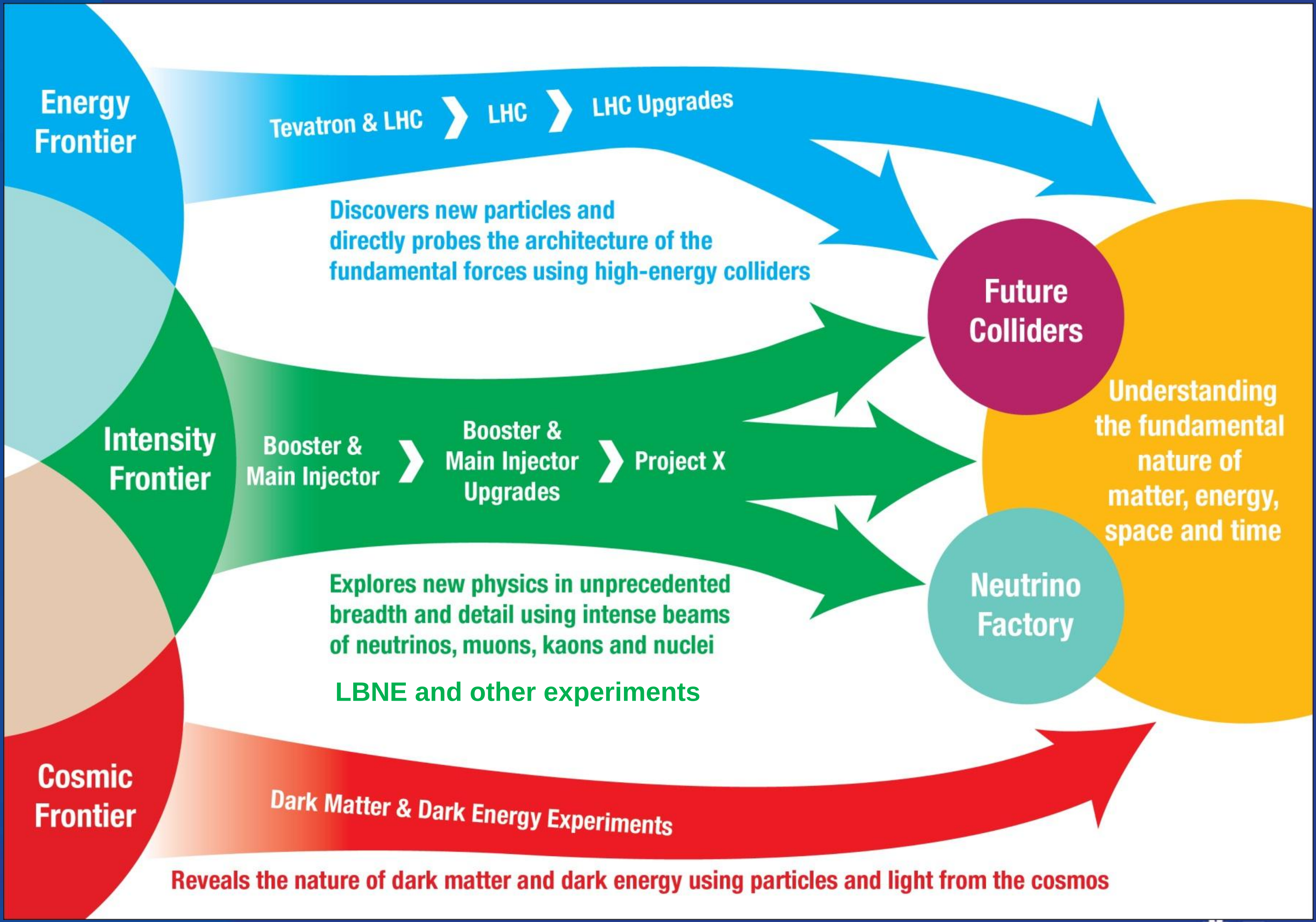
Strategy for the Future

Meets the following criteria:

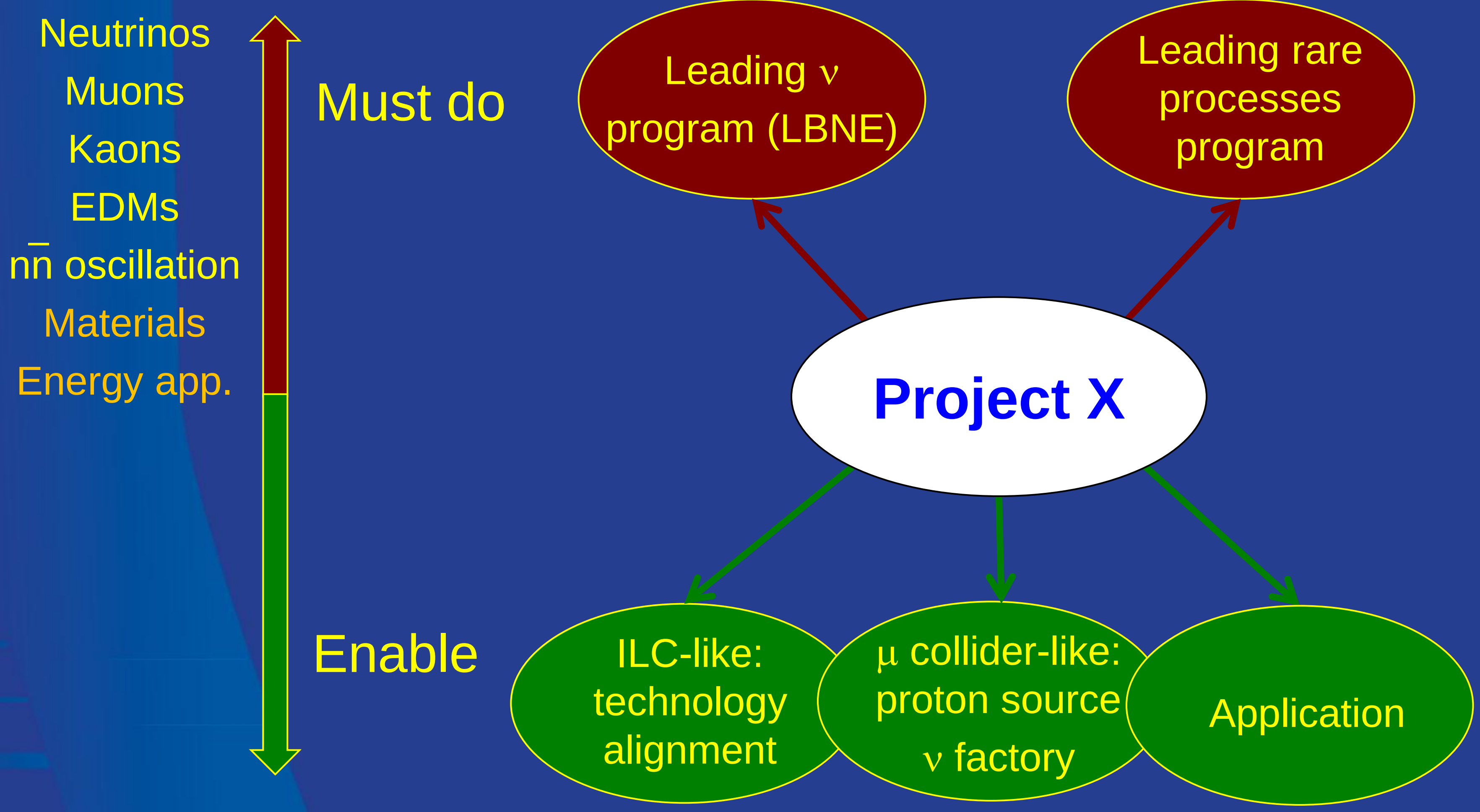
- Address critical and exciting scientific questions
- Is bold and establishes world leadership
- Leverages the laboratory's expertise and existing facilities
- Attracts international partners
- Fits within a global strategy for the field and within reasonable U.S. funding
- Is focused, yet broad enough to be resilient in the face of unexpected physics discoveries and funding fluctuations

Science and Facility Roadmap

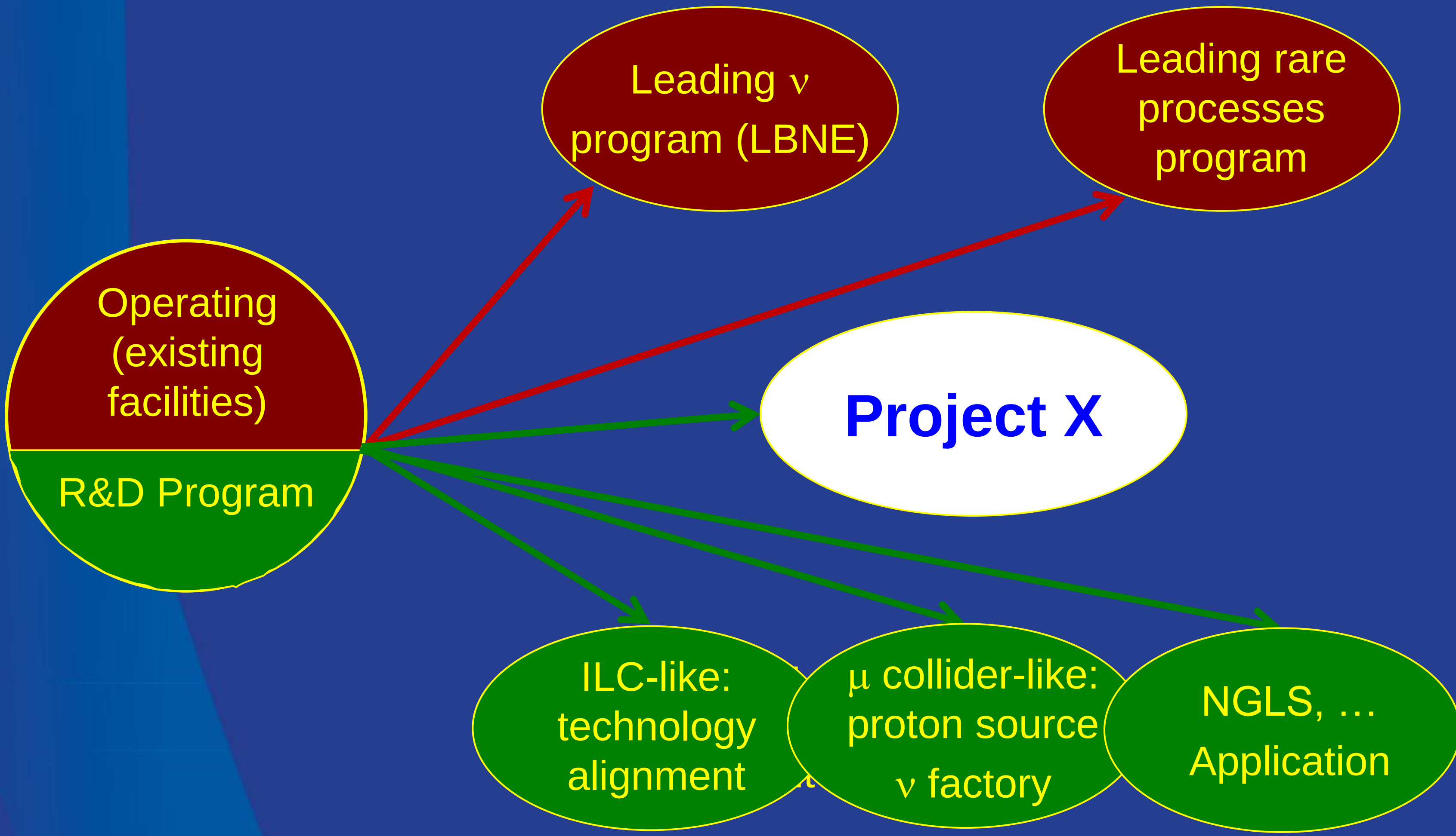
Short- and medium-term efforts at the three frontiers fit together to support long-term strategy for science and facilities.



Twenty-year term vision



Getting there: program this decade



Fermilab’s ten-year goals in executing its strategy

1. Lead the world at the Intensity Frontier

2. Be a world leader at the Energy Frontier, at the Cosmic Frontier, and in theoretical particle physics

3. Play a leadership role in developing the technology for next generation accelerator facilities and in advancing basic understanding

4. Play a leadership role in developing the technology for next generation detectors and computing facilities

5. Play a leading role in applying technologies to society’s problems by leveraging state and national investment in the IARC

Major Initiatives

1. Accelerator Improvement Plan; Second-generation neutrino experiments; the Muon Program → 2020s and beyond: LBNE and Project X

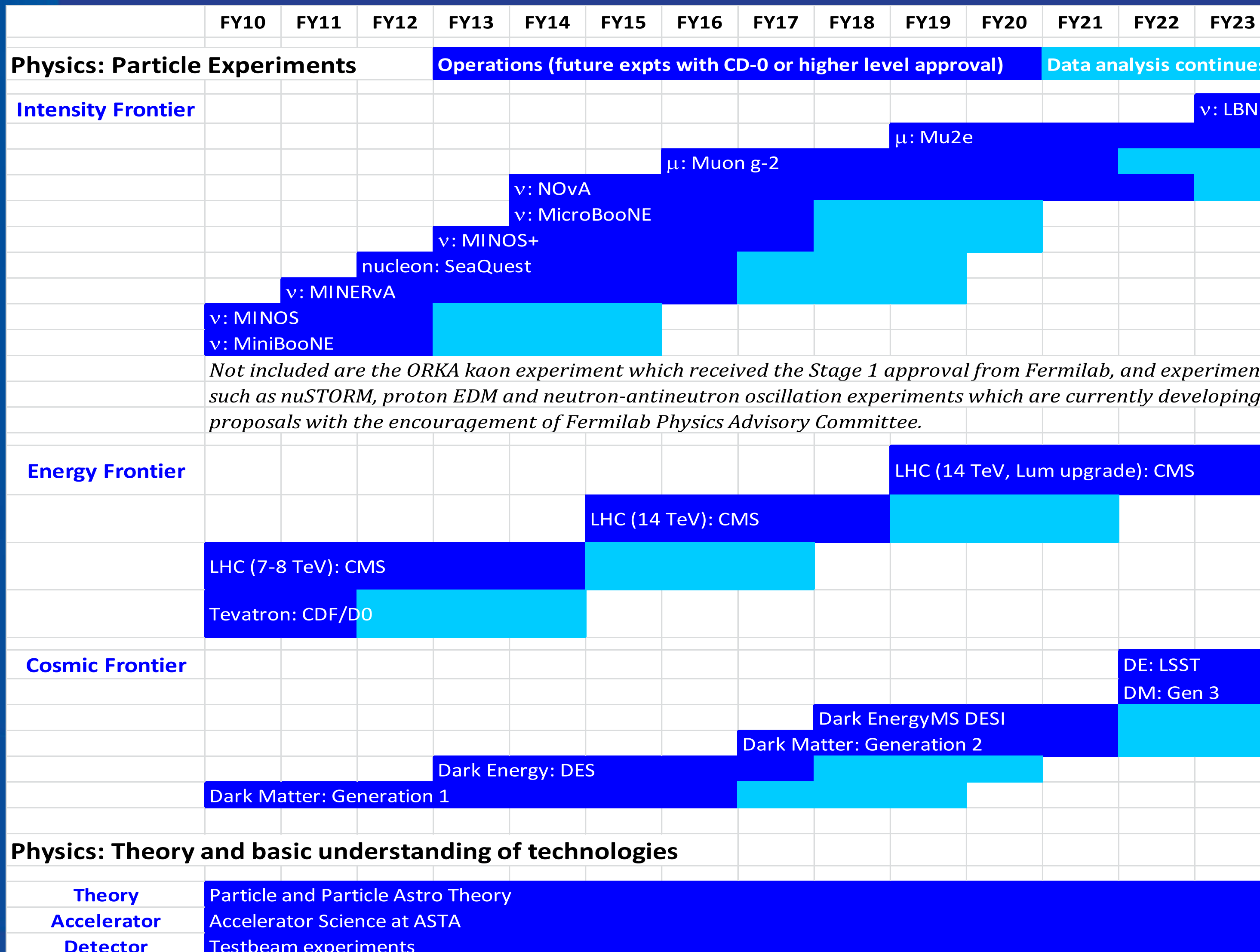
2. Large Hadron Collider Physics and Upgrade; Searching for Dark Matter and the Origin of Dark Energy

3. Accelerator R&D User Facility at the Advanced Superconducting Test Accelerator (ASTA)

4. Play a leadership role in developing the technology for next generation detectors and computing facilities

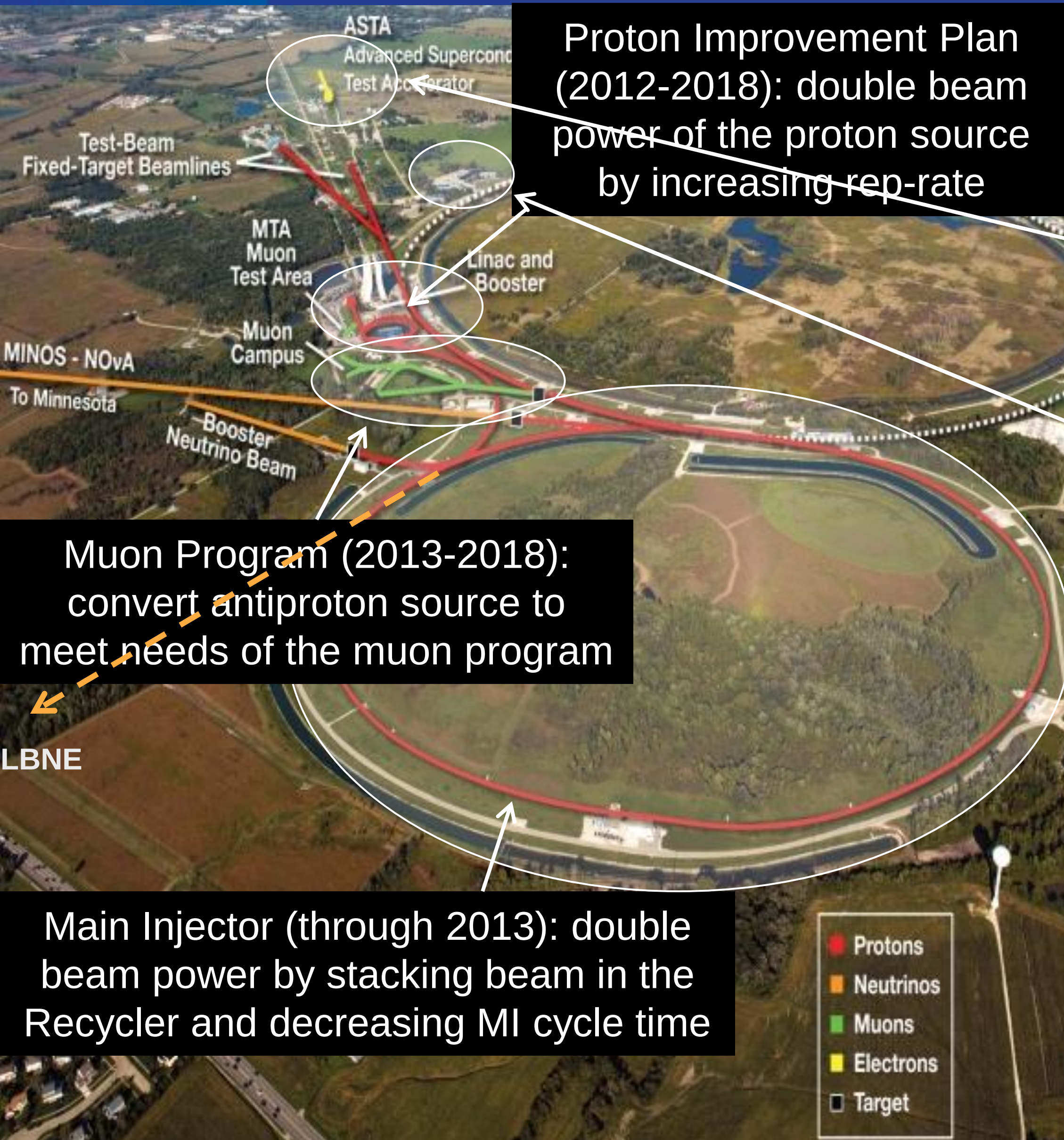
5. Play a leading role in applying technologies to society's problems by leveraging state and national investment in the IARC

Continuously produce physics results (next 10 years)



Fermilab

Accelerator Improvement Plan



Proton Improvement Plan (2012-2018): double beam power of the proton source by increasing rep-rate

Muon Program (2013-2018): convert antiproton source to meet needs of the muon program

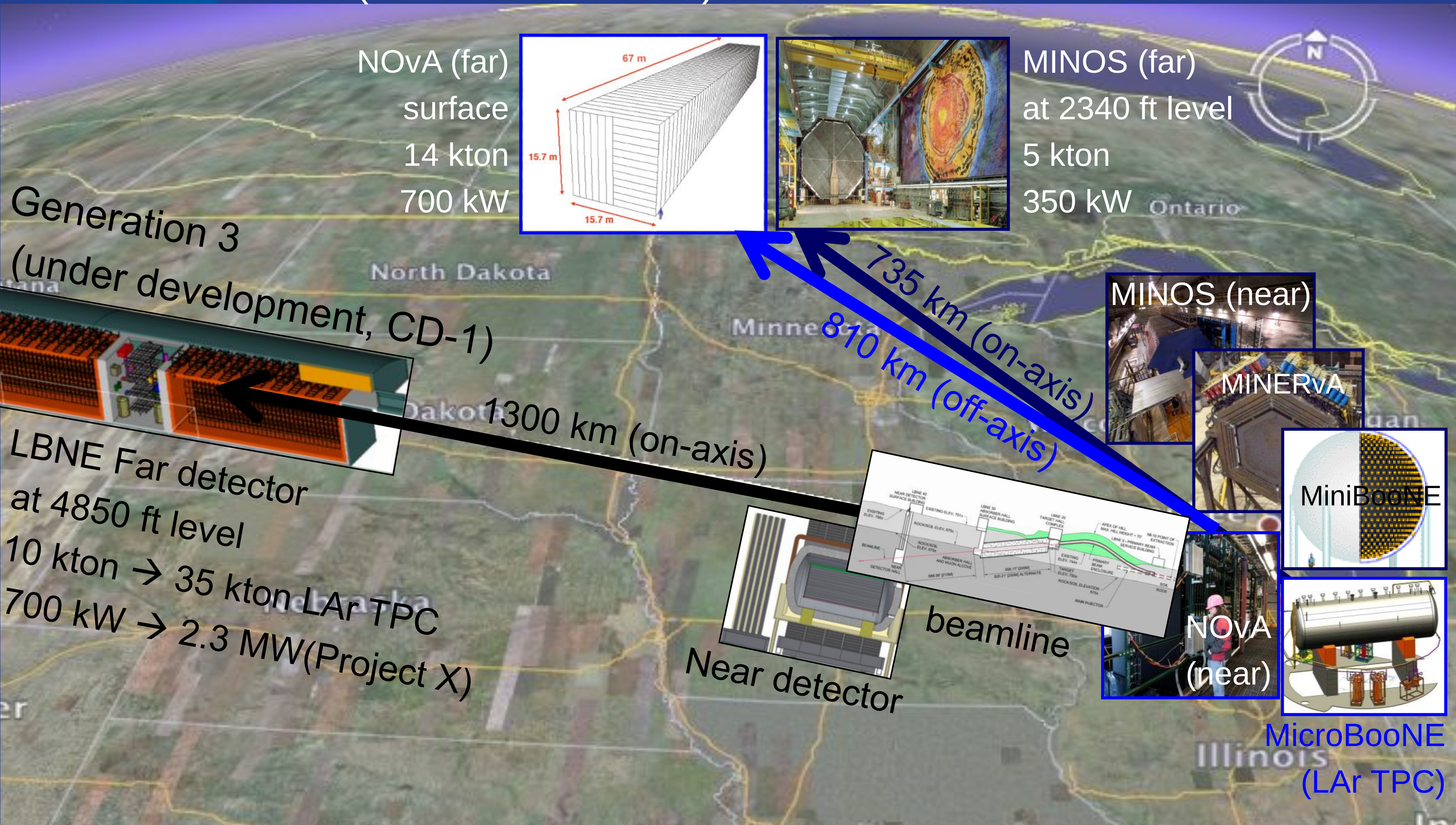
Main Injector (through 2013): double beam power by stacking beam in the Recycler and decreasing MI cycle time

Accelerator Science with ASTA (Advanced Superconducting Test Accelerator)

Illinois Accelerator Research Center (IARC)

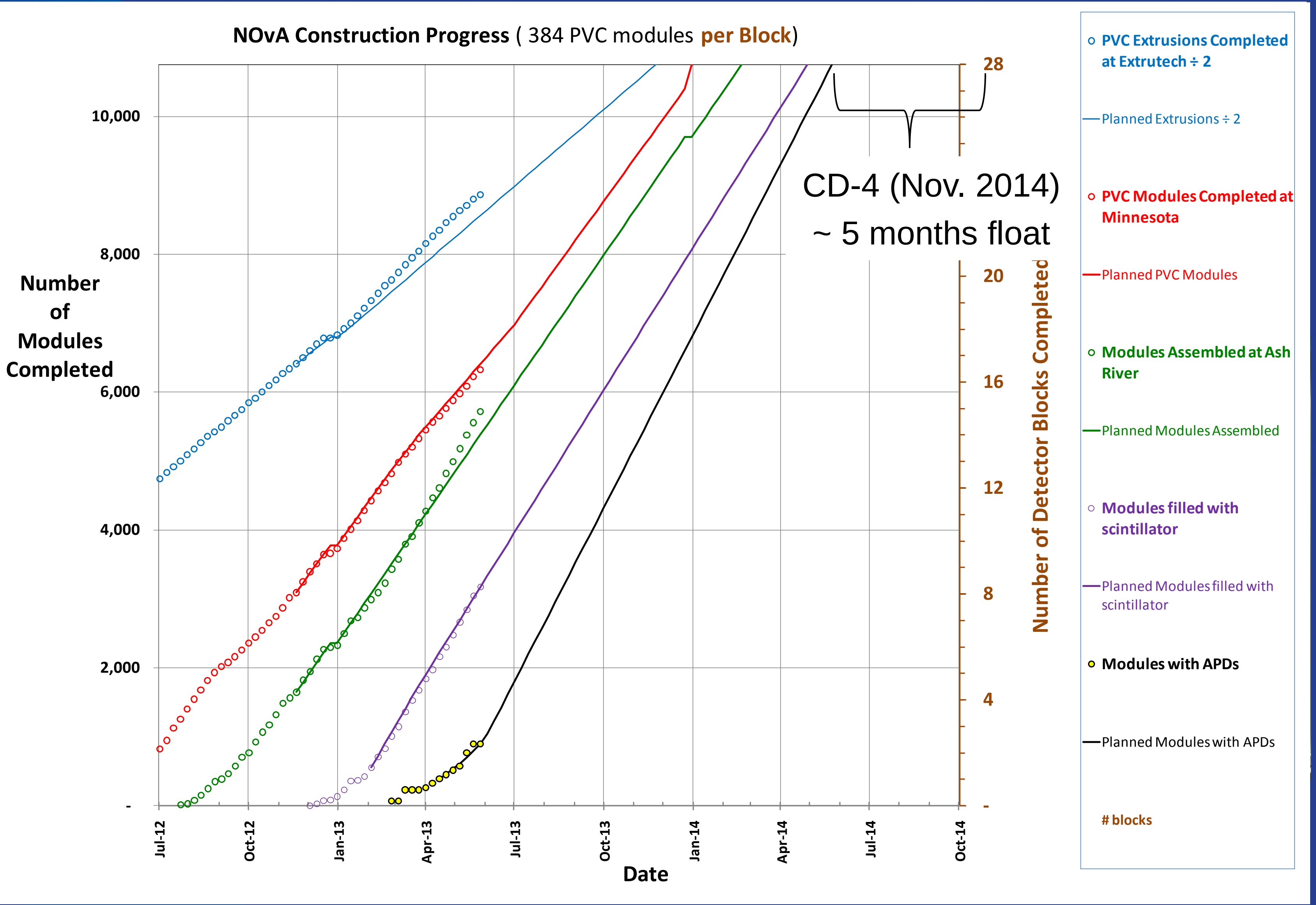
Evolution of U.S. Accelerator-based Neutrino Experiments

Generation 2 (under construction) — Generation 1



2nd generation long-baseline neutrino experiment: NOvA

will start taking data late spring 2013 with a partial detector

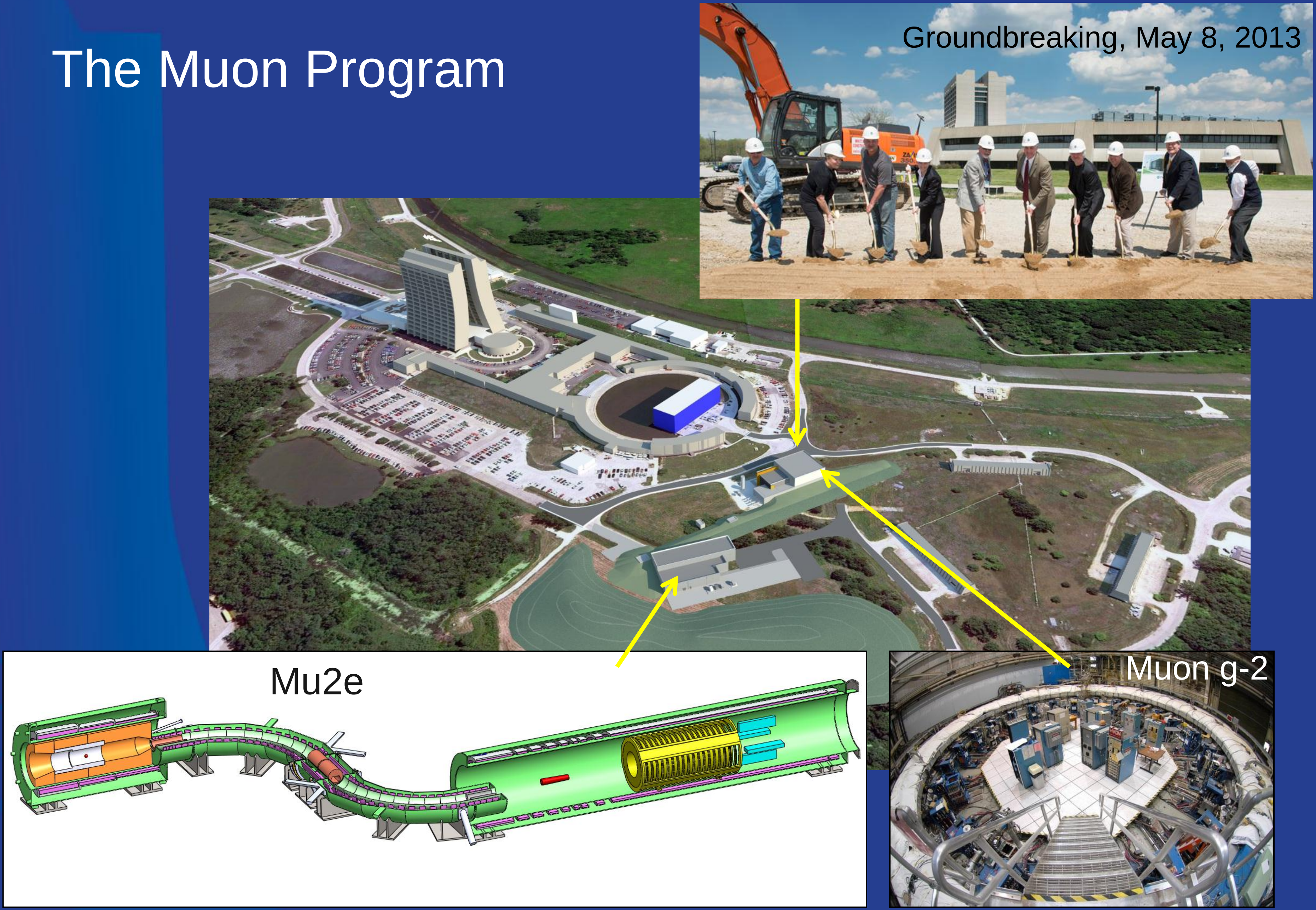


Fermilab

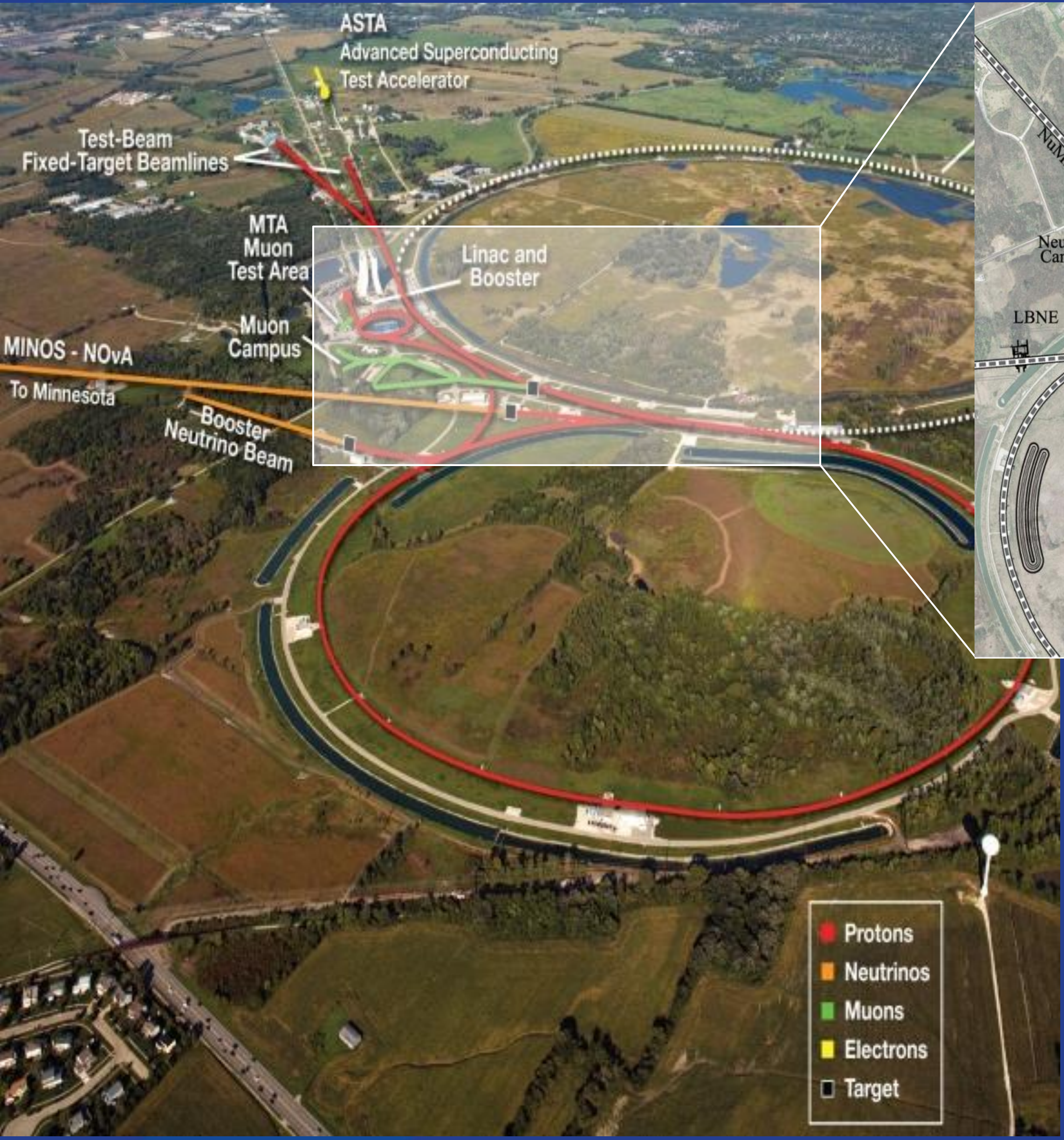
LBNE: Physics and Collaboration

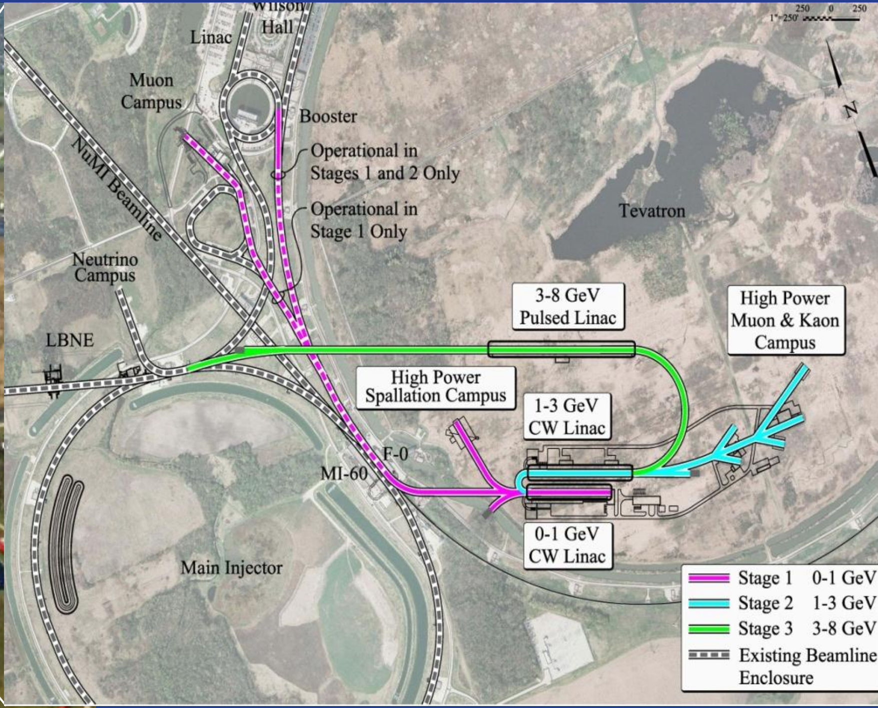
- Neutrino oscillation, proton decay, supernova neutrinos
- Collaboration (keep growing): 384 members from 67 institutions, 5 countries
- News: This week, LBNO (European “LBNE”) leadership proposed to merge LBNO and LBNE. This is consistent with the 2013 European strategy.
- This opens the door for CERN and European institutions to partner with U.S. on this project.
- Between CD-1 (Dec. 2012) and CD-2, with European participation in the far detector and Indian participation in the near detector, we hope to extend the physics scope, attracting a strong community support

The Muon Program



Accelerators in 2020s – Project X





Superconducting RF technology

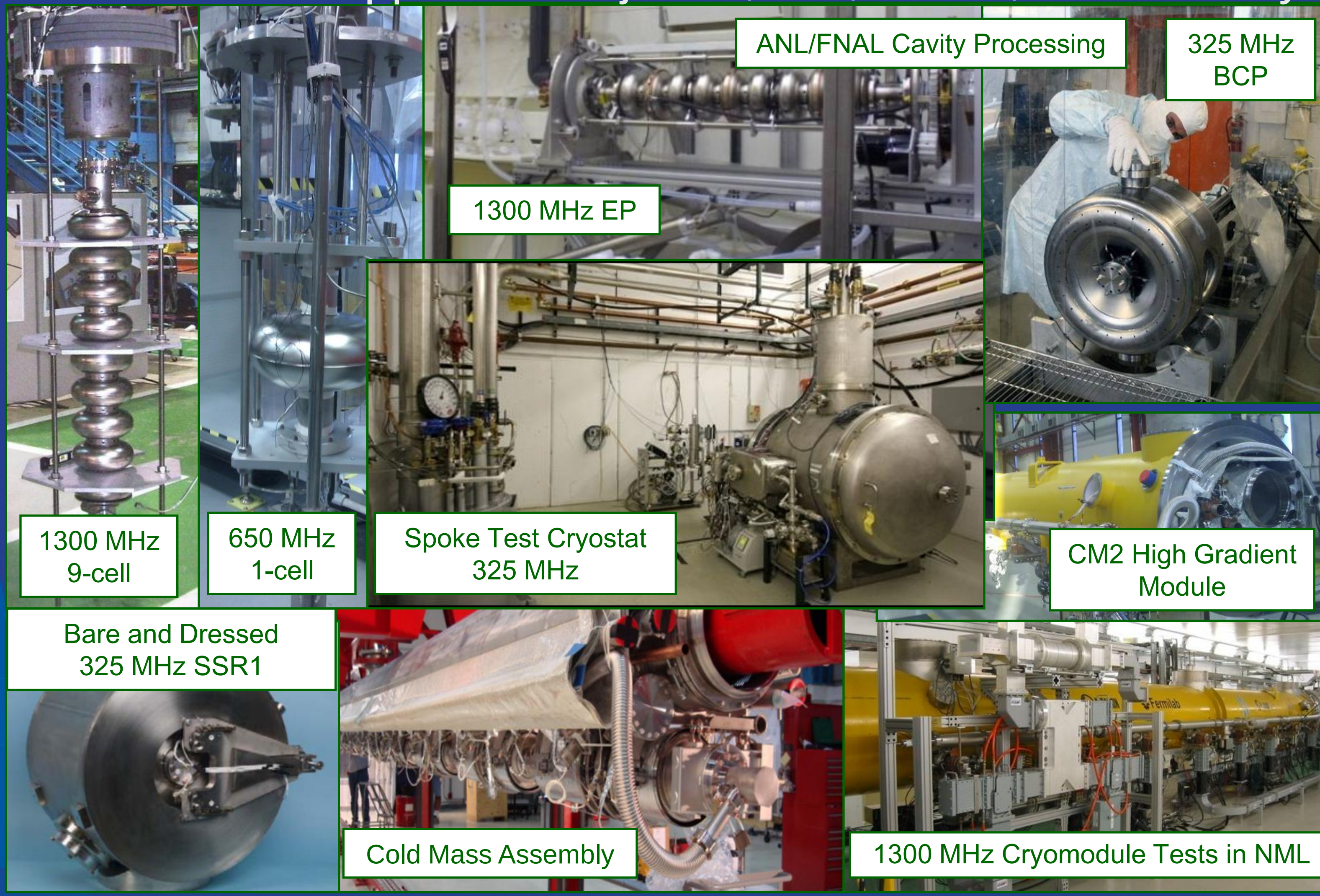
- > 6 MW total
- 1, 3, 8, 60-120 GeV beams
- Exquisite beam structures

MOUs:

- 12 US labs + universities
- 4 Indian institutions (DAE, …)

SCRF Technology Development

in support of Project X, ILC, NGLS, and industry



Advanced Accelerator R&D / Science

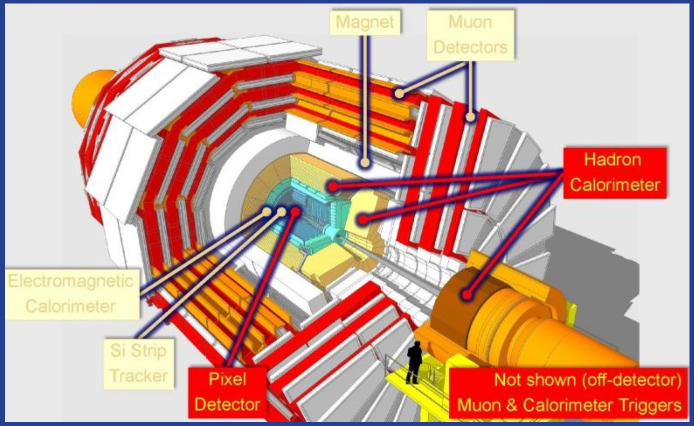
- Build on the existing program and the substantial investments in the SRF infrastructure

- A user facility with unique capabilities for advanced accelerator R&D based on SC linac technology at ASTA

- This will enhance accelerator technologies and facility developments across DOE Office of Science

LHC: U.S. CMS Detector Upgrades

- Fermilab is the lead lab and intellectual home of the U.S. CMS collaboration.
- LHC Physics Center serves as a resource and physics analysis hub for U.S. inst.s
  - > 350 users
  - > 100 residents
  - ~ 700 computing users
- Remote Operations Center
- Computing support
- Manage the CMS detector upgrade project



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LHC: Machine Upgrades

Developing and then building, in partnership with U.S. labs, Nb_3Sn magnets, crab cavity cryomodules and associated technology for LHC Upgrade as part of LHC Accelerator Research Program and Accelerator R&D Program


CERN Courier January/February 2013

LHC upgrade

Superconductivity leads the way to high luminosity

Recent progress and meetings highlight the work that is under way to upgrade the LHC in 10 years' time.

The LHC, the largest scientific instrument ever built, will extend its discovery potential at the beginning of the next decade through a fivefold increase in luminosity beyond the design value, in a new configuration called the High Luminosity LHC (HL-LHC). This extraordinary technical enterprise will rely on a combination of cutting-edge 11–13 T superconducting magnets, compact and ultraprecise superconducting radio-frequency cavities for beam rotation, as well as 300-m-long, high-power superconducting links with zero energy dissipation. In addition, the higher luminosities will make new demands on vacuum, cryogenics and machine protection, and will require new concepts for collimation and diagnostics, as well as advanced modelling for the intense beams.

Now, as the LHC nears the end of its first long run – from March 2010 to March 2013 – preparation work for this major upgrade is gathering speed. The past year has seen major developments in some of the key superconducting technologies, in particular for the new high-field magnets and the high-power links. Meanwhile, important decisions have been taken within the HiLumi LHC Design Study, which was launched just over a year ago. Supported in part by funding from the Seventh Framework Programme (FP7) of the European Commission (EC), this is the first phase of the larger HL-LHC project (*CERN Courier* March 2012 p19).

Work Packages of the HiLumi LHC FP7 Design Study (WP1 to WP6) within the High Luminosity LHC (HL-LHC) project.

Above: Cross-section for the 150 mm Nb_3Sn baseline option for the inner triplet quadrupole. Right: An 11 T magnet ready for cryogenic testing at Fermilab. (Image credit: Fermilab.)

ject management (WP1), which has CERN's Hermann Schmickler as its new technical co-ordinator. Various committees and bodies, in particular the newly formed HL-LHC Co-ordination Group, ensure the necessary link between the machine-upgrade and the detector-upgrade projects, under the supervision of CERN management. The recent Joint HiLumi LHC–LARP Annual Meeting reviewed their progress as well as the headway that has been made towards a final layout for the accelerator upgrade.

Good progress

The main target for the HL-LHC is to achieve an integrated luminosity of 250 fb^{-1} a year and a total of 3000 fb^{-1} over 12 years. A key step in reaching this target lies in reducing the β^* function (related to the focal length) at collision. With this in view, the team working on accelerator physics and performance (WP2) has collaborated closely with members of the LHC injector upgrade project as well as the current LHC operation group. As a result, they have defined possible sets of machine optics (in relation to β^* and the crossing angle) and beam parameters (emittance, bunch spacing, bunch charge) that can achieve their goal. A further important development in WP2 is the recent, successful test in the LHC of luminosity-levelling by varying β^*.

A reduced β^* in turn requires a redesign of the magnets in the insertion regions (IRs) where the collisions occur, which is the task of WP3. One important decision, taken in July in collaboration with WP2 and WP10 of HL-LHC (energy deposition and absorbers), was to opt for the maximum possible aperture for the quadrupoles of the inner triplets: 150 mm of coil-free bore. This choice was based on successful tests within US-LARP of a 4-m-long, 90 mm aperture quadrupole and a more recent 1-m-long structure with a

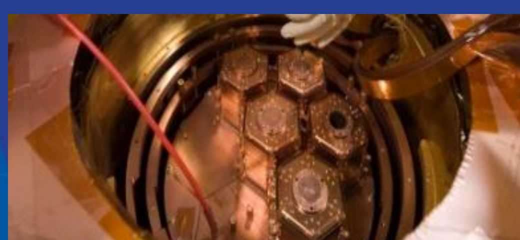
Dark Energy and Dark Matter

- Dark Energy: Progression SDSS → DES → DESI → LSST

Camera assembled / tested at SiDet, Fermilab (2011)

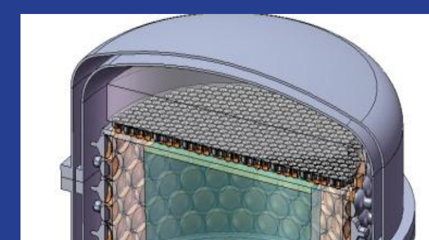
Chile

- Dark Matter: CDMS, COUPP, DarkSide → Generation 2 expt.



Soudan lab, U.S.

SNOLab, Canada



Gran Sasso Lab, Italy

Fermilab infrastructure summary

- $1.8 billion Replacement Plant Value
- 6800 acres; 36 miles of roads, 122 acres of parking lots
- 2.4 million gross square feet
- 2 primary electrical substations, 241 secondary substations, 115 miles of underground electrical cable, 3 miles of overhead transmission lines
- 27 miles of underground industrial cooling water piping
- 19 miles of underground domestic water piping
- 14 miles of underground sanitary piping
- 18 miles of underground natural gas piping

Core Capability	Current	5-year	10-year
Particle Physics	C	C	P
Accelerator Science	C	C	P
Large Scale User Facilities/Advanced Instrumentation	C	C	P
Utilities	M	N	N

C = Capable, P = Partially Capable, M = Marginally Capable, N = Not Capable

Science Laboratories Infrastructure (SLI)

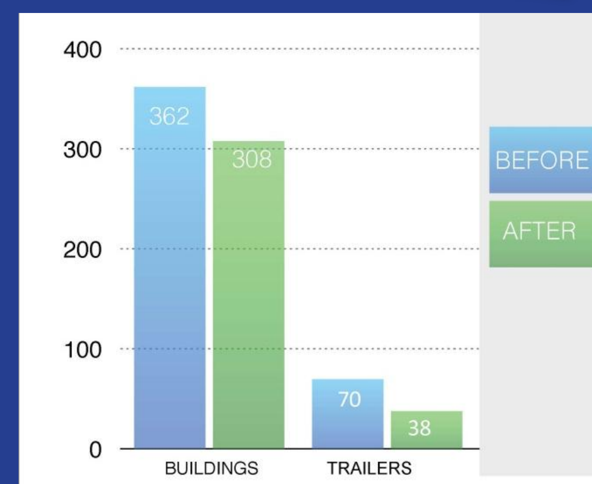
Priority investment -- Utilities Upgrade Project

- Scope ($35M)
  - High Voltage Electrical includes replacing one of two electrical substations (42 years old)
  - Industrial Cooling Water piping replacement
- Schedule
  - CD-1 achieved in November 2010
  - PED in FY13 PBR at $2.5M - CR delayed receipt
  - FY14 PBR supports project at $35M
  - Master Substation Bypass GPP at $2.7M underway in interim
- Urgency
  - FY14 funding is critically important in order to meet the electrical requirements of the Mu2e project to be served from the Master Substation in FY17

This utility project helps to improve performance by mitigating the Lab's highest infrastructure vulnerabilities.

Fermilab Campus Master Plan

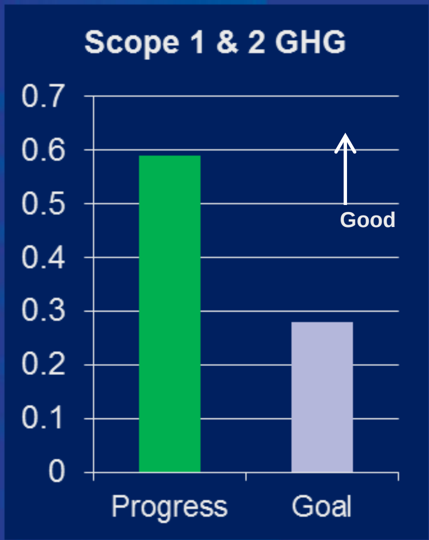
- Twenty-year time horizon
- Focus on intensity frontier initiatives, facility/staff consolidation & centralization
- Eliminates dispersed & inefficient support facilities
- Improves mission readiness for core capabilities
- SLI Project Proposals
  - Industrial Facilities Consolidation (existing project in SLI queue)
  - Integrated Engineering Research Building
  - Wilson Hall Modernization

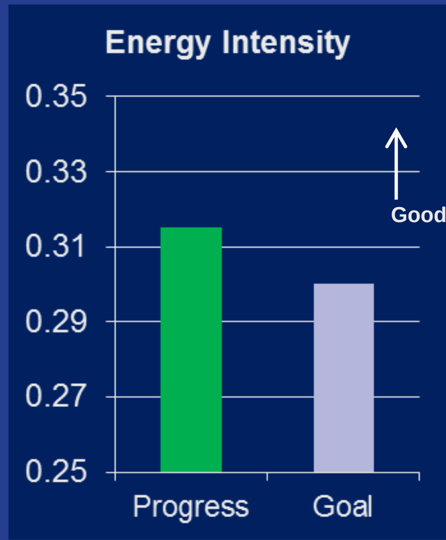


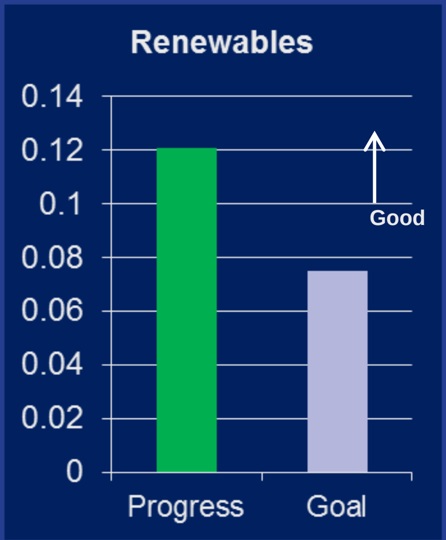
Campus Master Plan: Future SLI proposals

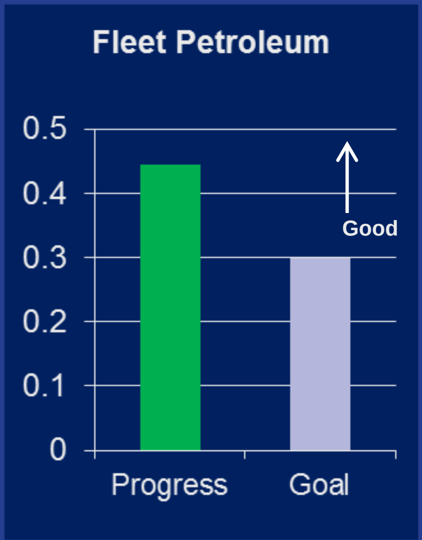
- *Industrial Facilities Consolidation*
  Modernization and relocation of accelerator and detector technology development functions
- *Integrated Engineering Research Building*
  Consolidate outdated and geographically-dispersed technical, assembly, machining, lab and office space into a new multi-disciplinary building close to Wilson Hall. Demolish vacated space, including flood-prone buildings in the village
- *Wilson Hall Modernization*
  Transform Fermilab's largest building into flexible and adaptable workspaces; improve occupancy, functionality and efficiency; promote collaboration; accommodate new technologies

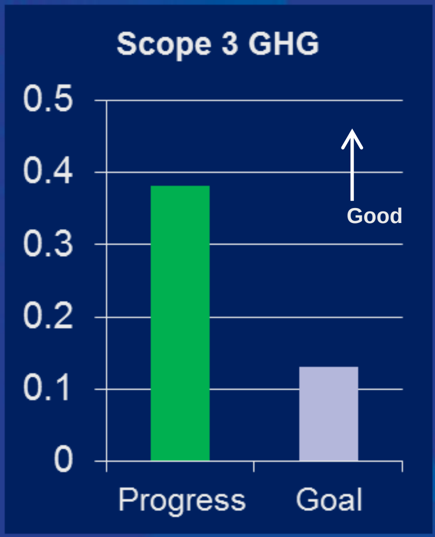
Sustainability (SSP Dec 2012)

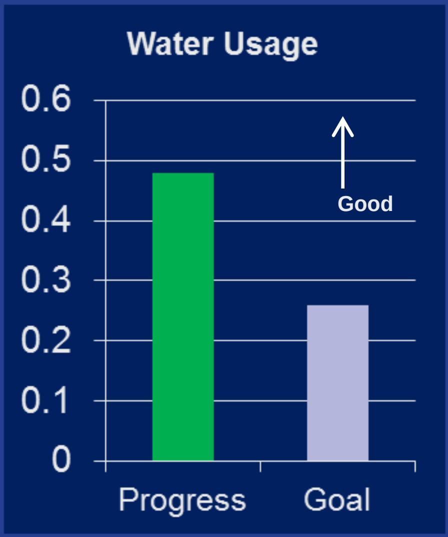


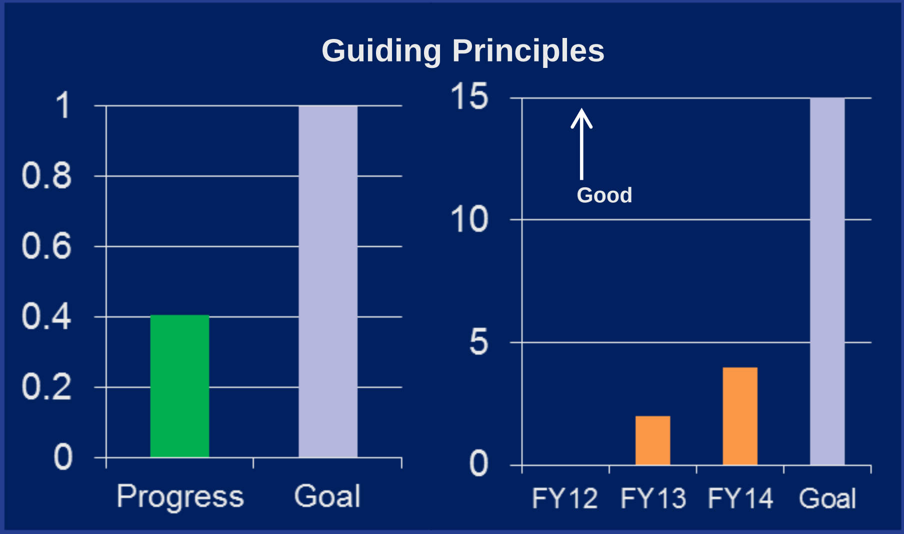




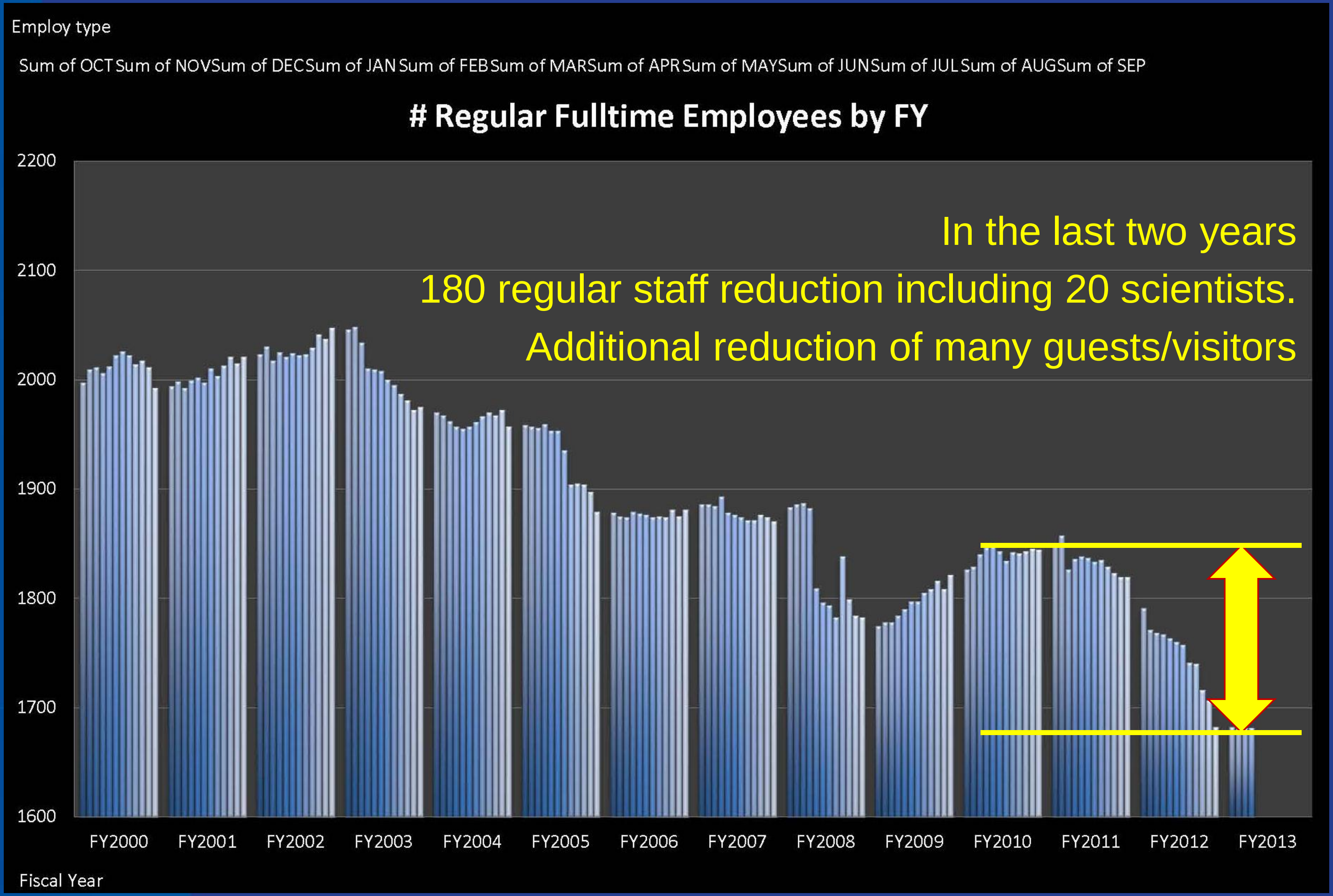








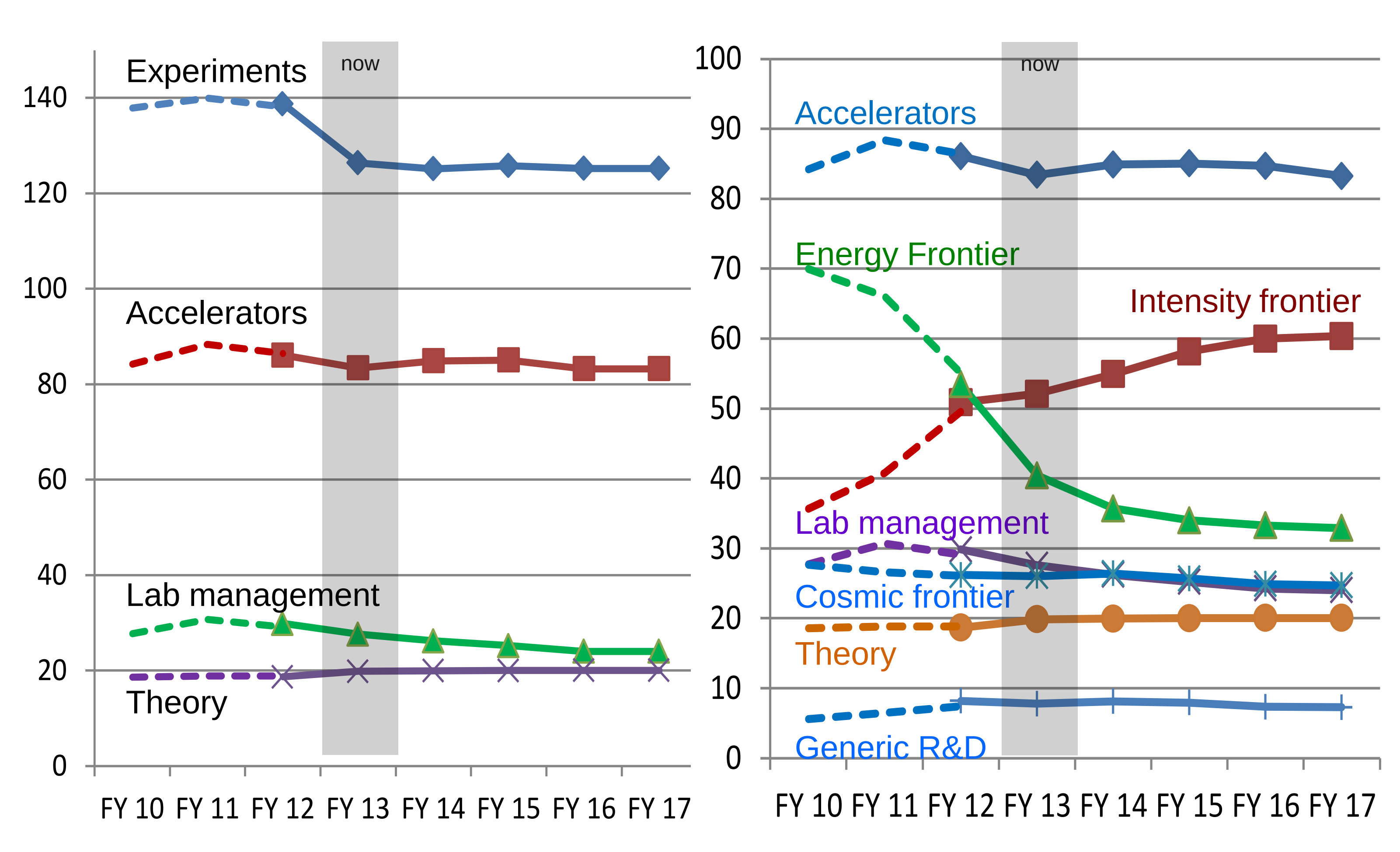
Human resources: Fermilab staff



Human resources: Fermilab scientists

Transition: Energy Frontier dominant → Intensity Frontier dominant

Actual (dotted) and anticipated activities (solid) Data: Nov. 2012



Human resources - Challenges and actions

Challenges

- Morale issues (staff reductions and budget austerity).
- Hiring and retaining employees with key skills (impact of salary freeze).
- Matrixed staff within a portfolio of new projects (with dynamic funding profiles).

Actions

- Invest in training and development opportunities for key staff.
- Increase workforce planning capabilities with a new *Human Capital Management* system.
- Perform job family reviews/equity studies for critical skill positions.
- Attract early career staff through fellowships, internships and co-op programs.
- Increase employee skills through the development and deployment of new tools (e.g.,Teamcenter).
- Succession planning for senior positions.

Project management initiative:

Enabling people and systems for successful project delivery

Revitalize
People & Performance

- **People:** developing leaders & teams with appropriate experience, training and certification. Establishment of Project Management Planning Board to set standards/ reconcile enterprise issues.
- **Performance:** emphasis on risk management, metrics and productive inquiry

Re-tool
Systems, Services & Information

- **Systems:** modernize and standardize systems & tools
- **Services:** refocused Integrated Planning and Project Support Services offices, resourcing (e.g., project controls, procurement staffing)
- **Information**: standardized, trendable information for accountable staff

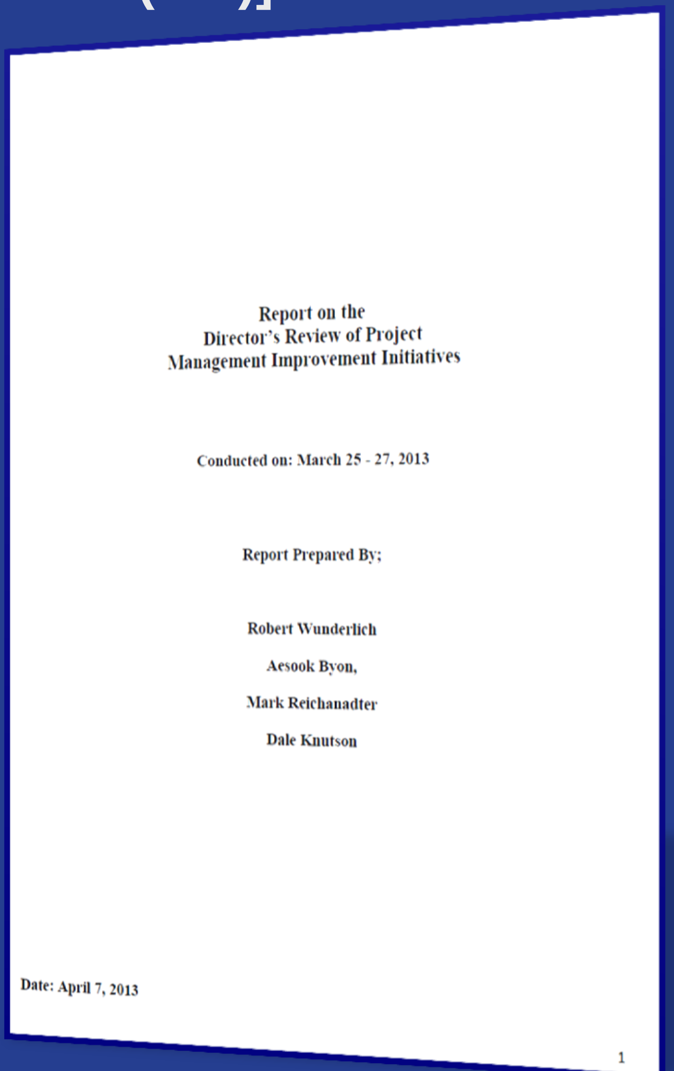
Review
Accountability & Oversight with Transparency

- **Accountability:** expectations expressed at all levels
- **Oversight**: engage at multiple levels (PMG's, POG) including monthly reviews w/direct interaction between project and Lab leadership
- **Transparency**: inclusive of DOE and open to independent review

Director’s review of project management

External team of experts [BNL, PNNL, SLAC, DOE (ret.)]

- **Assessed:**
  - Project managers & deputies
  - Line managers
  - Project Support Services
  - Systems
- **Six overarching recommendations**
  - 30 specific actions
- **General observations**
  - *“Fermilab has made progress…improvements made over the last six months were both needed and valuable.”*
  - *“Project Managers are competent and have the appropriate leadership attributes.”*
  - *“The Fermilab matrix management system has an inordinate number of requirements and constraints.”*



Report on the
Director’s Review of Project
Management Improvement Initiatives

Conducted on: March 25 - 27, 2013

Report Prepared By;

Robert Wunderlich

Aesook Byon,

Mark Reichanadter

Dale Knutson

Date: April 7, 2013

1

Work For Others

- Fermilab has a modest, but important, WFO program that is aligned with the Lab's core capabilities
  - Beam instrumentation and diagnostics
  - Accelerator design and technology
  - Superconducting technology

Hyper Tech Research, Inc.

NIU Institute for Neutron Therapy at Fermilab
Blending physics and medicine for accelerated cancer treatment

DCEO ILLINOIS DEPARTMENT OF COMMERCE & ECONOMIC OPPORTUNITY

MICHIGAN STATE UNIVERSITY Founded 1855

UNIVERSITY OF SOUTHERN CALIFORNIA 1880

PAVAC INDUSTRIES INC.

Illinois Accelerator Research Center Building

(State funded)

- New Building -> 48,000 gross square footage (145 offices); 3,700 SF Light Tech Space.
- Repurposed CDF -> 42,000 sq. ft.: 50 T crane; deep pit for radiation shielding of accelerators; cryogenic, electrical and cooling water infrastructure.
- Construction in Progress, estimated beneficial occupancy for outfitting Mar 2014.
- Business Plan and operating model under development; informed by collaboration with industry and University of Chicago; coordinating details with OHEP and FSO. Business Plan delivery scheduled for July 2013.

Cost of doing business

Cost driver	Actions to manage/mitigate effects
Electric power	• Energy Saving Performance Contract (in progress) • Competitive procurements through DoD Defense Energy Support Center • Participation in utility power curtailment programs
IT services	• Improved management system performance (ISO2000 certification) • SC Operations Improvement Council bulk pricing initiatives • Strategic roadmap for investment in critical technologies and systems
Infrastructure modernization	• SLI Utilities Upgrade Project • Risk mitigation via judicious General Plant Project planning and investment
Campus Development	• Essential investments to provide common infrastructure supporting muon program and repurposing science facilities • Aggressive materials recycling program (savings: $1M)
Employee benefits	• Transitioned medical/dental insurance funding arrangement to self-insurance model (est. saving: $1.3M) • Increased employee and retiree cost sharing (cost reduction: $2.8M) • Competing PPO/POS medical plans for cost and service improvements • Negotiated reduced 401(a) and 403(b) retirement plan administrative expenses (cost saving: $150K)

Cost of doing business

Strategic focus on managing costs and managing risks

- Increasing rigor around integration of risk assessment with annual budget planning

Trade-offs

- Senior management team highly engaged in assessment of issues, risks and investments
- During FY13 process, ~30% of incremental requests approved for allocation. Priority assigned to:
  - Health and safety
  - Reducing risk to experimental project cost and schedule targets
  - Advancing applied technology initiatives
  - Scientific staff talent development
- Unfunded requests, ~70% predominantly in areas of:
  - Deferred maintenance (re-evaluated in real-time during year)
  - Equipment upgrades, spare parts
  - Support staffing

Lab Agenda initiative (FY13/14) focusing on Cost Optimization study

Committed to management and operational excellence

- Continuing high level of attention to workplace safety and environmental protection

- *Fermilab Agenda* provides a central framework for focus and alignment of strategic initiatives in Science and Operations

- Leveraging ISM, contractor assurance and quality programs to improve operational performance