Fermilab update

Joe Lykken

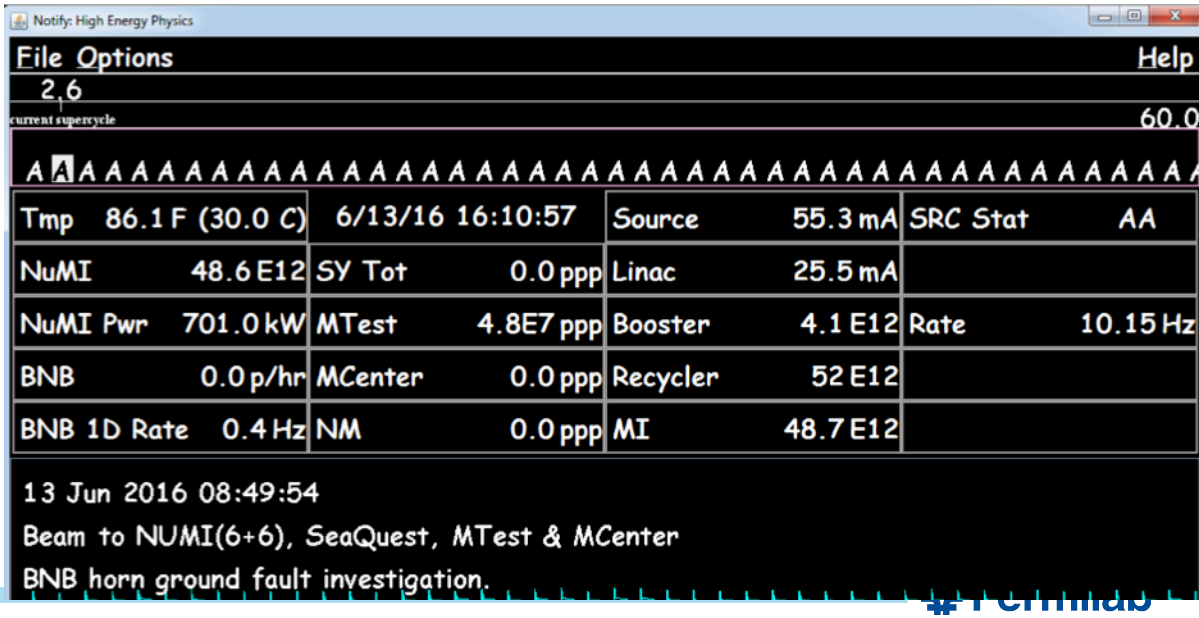
12 August 2016

State of Fermilab

- Lab science program producing world-leading results: neutrinos, CMS, cosmic
- Lab is on track to host the world for neutrino science
- Lab projects are on budget and on schedule
- Lab operations were reviewed as lean, effective, and efficient (Facilities Operations Review, May 16-18, 2016)

Fermilab accelerator operations

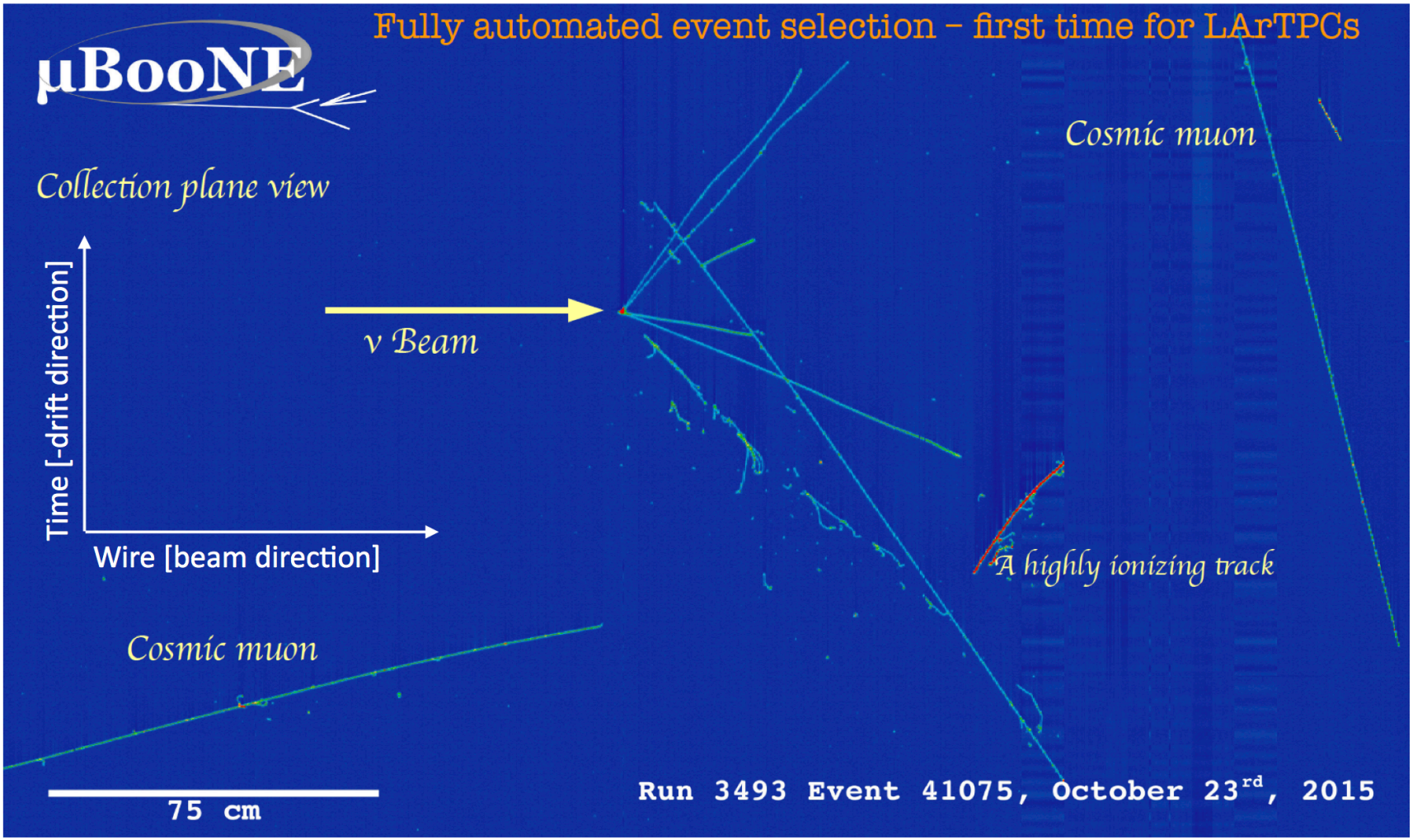
- In summer shutdown now
- FY16 running very successful, ~85% up time
- 700 kilowatts to NuMI achieved!
- 700 kW will become standard after the shutdown (need to install new collimators to reduce losses in the Main Injector)
- PIP improvements continue
- Muon campus construction on track to deliver muons to g-2 next year



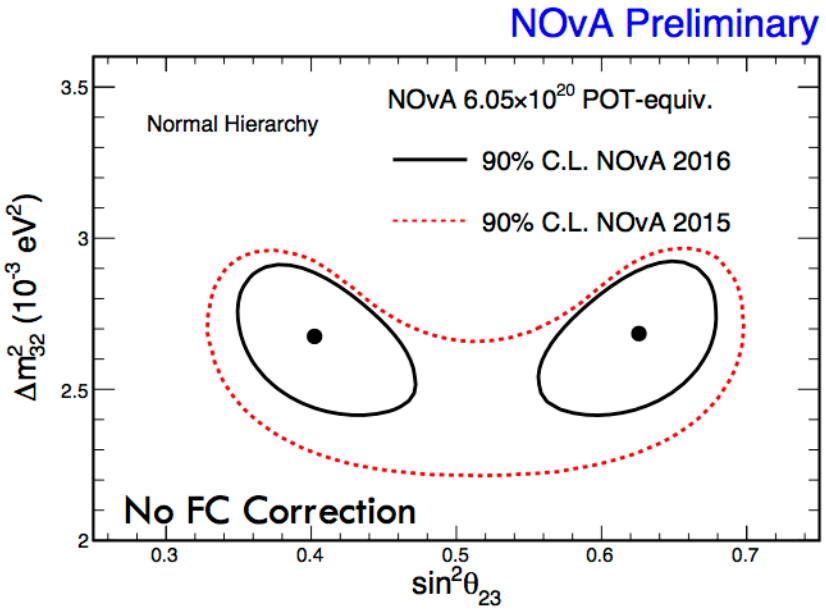
Fermilab current neutrino program

- Successful completion of the MINOS and MINOS+ programs; decommissioning at Soudan has begun
- Lots of neutrino cross section results from MINERvA:
  - 7 Wine&Cheese seminars in past year
  - 9 papers
  - 6 PhDs

Fermilab current neutrino program



Fermilab current neutrino program



- Fit for Δm^2 and $\sin^2\theta_{23}$
- Dominant systematic effects included in fit:
  - Normalization
  - NC background
  - Flux
  - Muon and hadronic energy scales
  - Cross section
  - Detector response and noise

Best Fit (in NH):

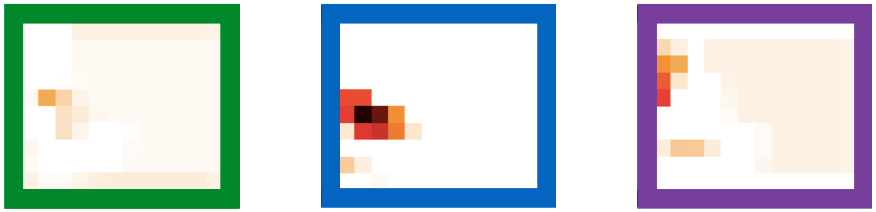
$$|\Delta m^2_{32}| = 2.67 \pm 0.12 \times 10^{-3}\text{eV}^2$$
$$\sin^2\theta_{23} = 0.40^{+0.03}_{-0.02}(0.63^{+0.02}_{-0.03})$$

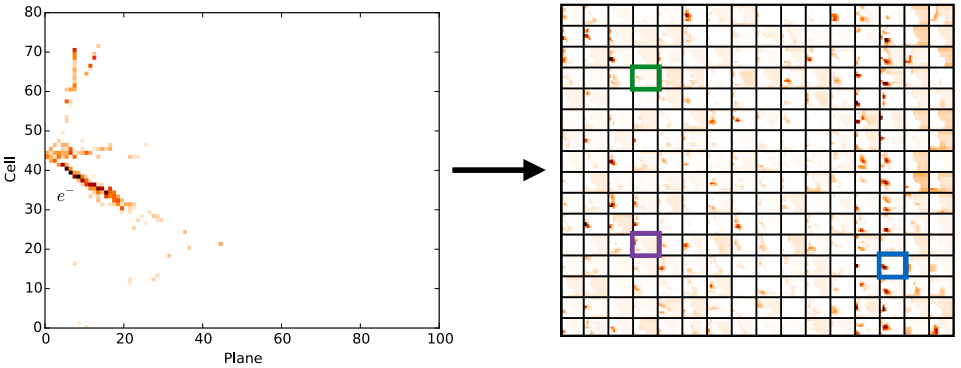
Maximal mixing excluded at 2.5σ

Improved Event Selection

- This analysis features a new event selection technique based on ideas from computer vision and deep learning

- Calibrated hit maps are inputs to Convolutional Visual Network (CVN)
- Series of image processing transformations applied to extract abstract features
- Extracted features used as inputs to a conventional neural network to classify the event

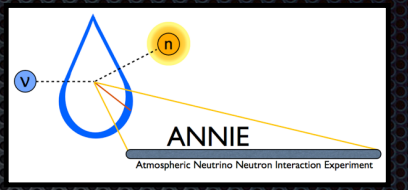




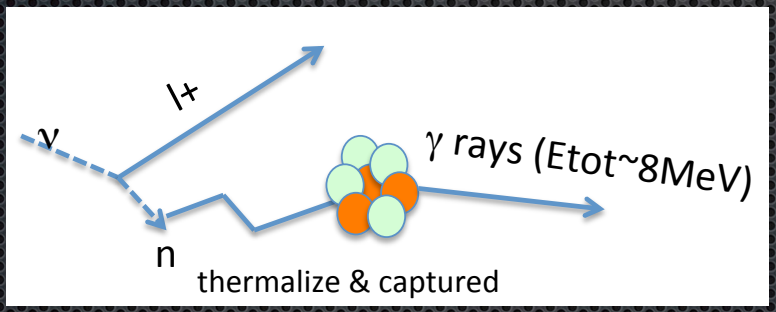
Improvement in sensitivity from CVN equivalent to 30% more exposure

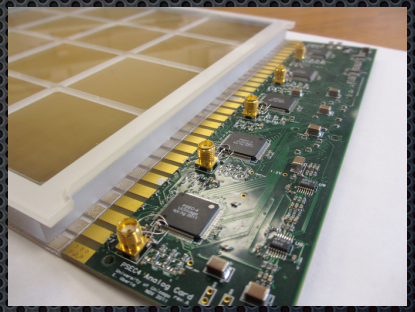
Fermilab

The ANNIE experiment



- Seeks to measure the abundance of final state neutrons from neutrino interactions in water, as a function of energy (arXiv:1409.5864, arXiv:1504.01480).
- Tests LAPPDs in a neutrino experiment for the first time!





- ✦ The ANNIE collaboration is about 30 collaborators (11 institutions).
- ✦ Installation of phase I has been completed, currently under commissioning. Next phase will demonstrated LAPPD readiness.

Phase I and Ib - neutron background measurement - in progress
Phase II - physics measurement - proposed

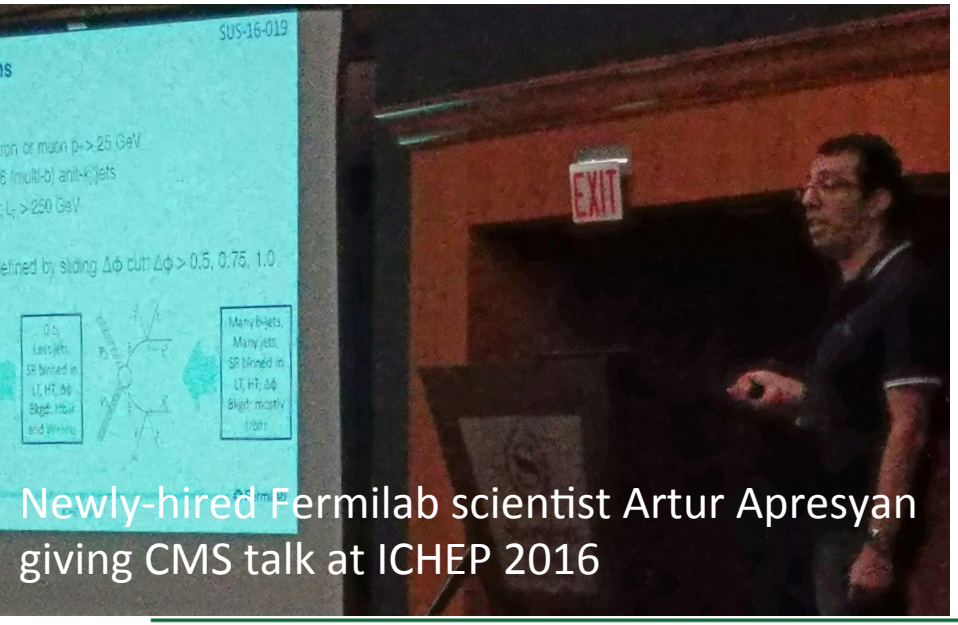
Mayly S

Fermilab PAC report from their June 20-22 meeting:

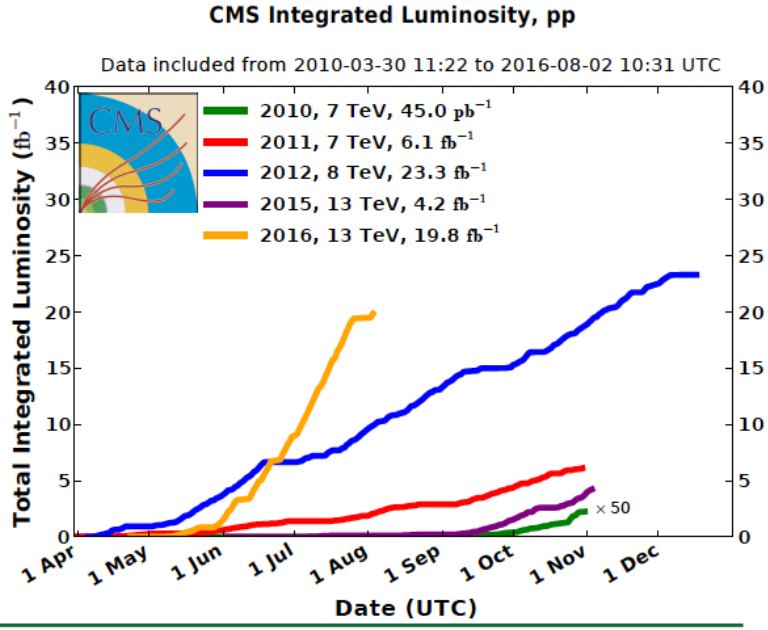
"The PAC commends the ANNIE Collaboration's success in commissioning its detector and with their first detection of events. The plans for Phase Ib, which is an opportunity afforded by the success of their proposal to the Intermediate Neutrino Research Program, is compelling and cost effective. The Committee believes this should proceed. To move beyond Phase Ib to Phase II, the Committee expects that a formal proposal will be submitted at an appropriate time determined by Fermilab."

LHC is Performing Excellently!

- LHC continues to set new performance records:
  - Unprecedented peak instantaneous luminosity of ~1.25 x 10^{34} $cm^{-1}s^{-1}$ exceeds design luminosity by 25%!
  - Number of proton bunches
- Data accumulation on track for over 40 fb^{-1} by end of 2016
- **Congratulations to the CERN accelerator team for the hard work in operating the LHC, and to the experiments for the high performance efficiency in acquiring data!**



Newly-hired Fermilab scientist Artur Apresyan giving CMS talk at ICHEP 2016



Overview of the Fermilab CMS Group

- **Fermilab is the largest US group in CMS and 2nd largest group overall**
  - Approximately 60 scientists (~50 FTEs), including 15 postdocs
  - Total effort on CMS (incl. professionals) is >100 FTE
  - Concentrated mostly in PPD and SCD
  - Collaboration across divisions in physics analysis

Joel Butler

- **Main activities of Fermilab scientists:**
  - Analysis of CMS data from Run 2
  - Construction of Phase 1 Upgrades and R&D for HL-LHC:
    - Hadron Calorimeter, Forward Pixels, Outer Tracker, Trigger
  - Computing - Host of US Tier-1 and studying computing model for HL-LHC
  - Core, reconstruction, and simulation software

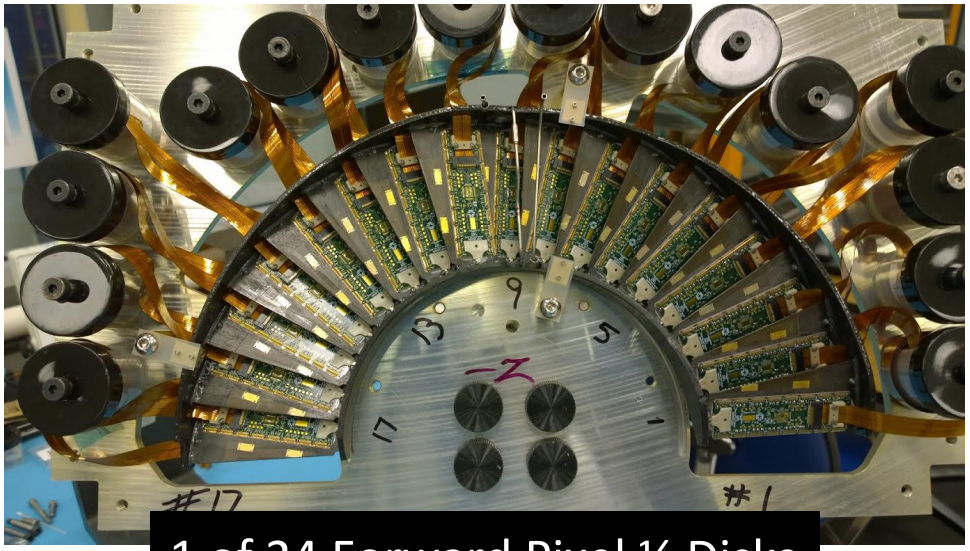
- **Fermilab is the host lab for CMS in the US**
  - Manage the USCMS Operations Program and Upgrade Projects, and host the LHC Physics Center (LPC) and Remote Operations Center (ROC)

LHC CMS Detector Upgrade

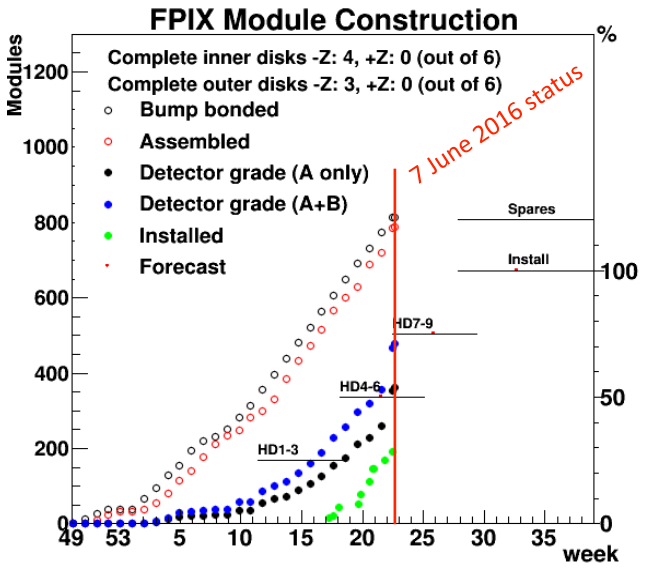
LHC Science

Milestones:

- Level 1 Trigger – installed and operational
- Hadron Calorimeter
  - Backend electronics installed and operating with legacy frontends
  - Frontend electronics (forward & endcap) will be installed early in 2017
  - Frontend electronics (barrel) will be installed 2019
- Forward pixel detector (below) - on target for installation early in 2017



1 of 24 Forward Pixel ½ Disks

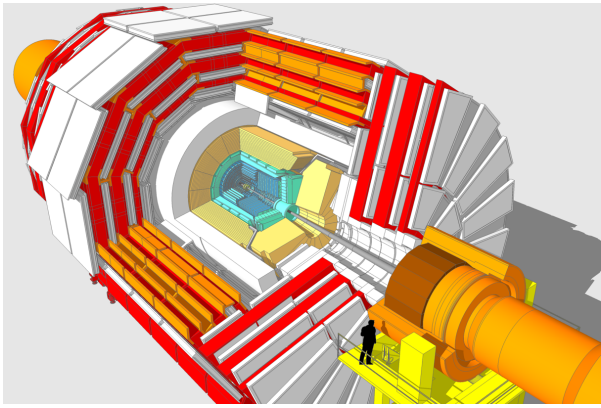


- Project 70% complete with 45% contingency on work remaining

Fermilab

HL-LHC CMS Detector Upgrade

LHC Science



Recent achievements:

- Received CD-0 (April 13, 2016)
- Successful NSF CDR (April 17, 2016)

Upcoming Milestones:

- CMS Technical Design Reports to be completed 2017
- CD-1: July 2017
- CD-2/3: 2019
- NSF PDR (2017), NSF FDR (2019)

– **Detector Upgrades:** ***Additional $1.25M in FY17 for each of ATLAS/CMS R&D***

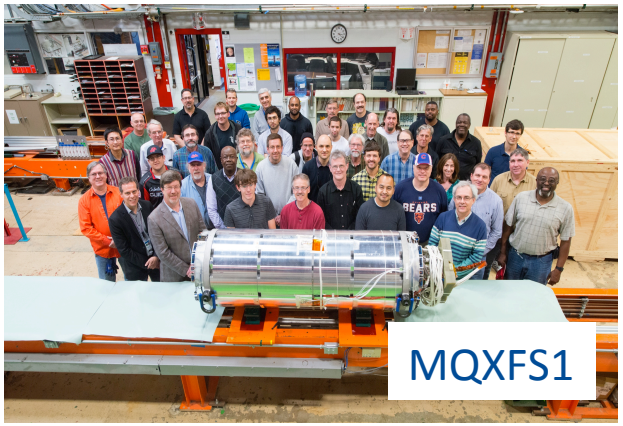
- **HEP identified this additional $2.5M total that can be redirected to HL-LHC ATLAS and CMS R&D from lower-priority tasks**
- **These funds are in addition to the CD-0 profile shown earlier**

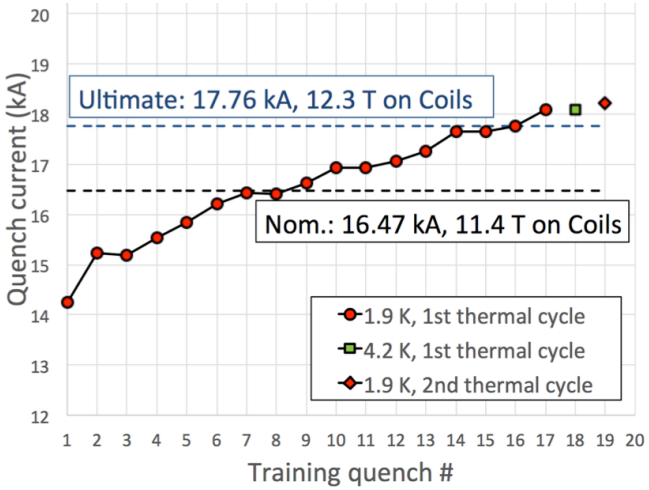
In the longer term, we plan to continue working with U.S. HL-LHC projects to optimize HL-LHC project profiles, including increasing TPC, as we move toward CD-1 (planned for FY17)

High-Field Magnets: Production for CERN HL-LHC Upgrades

Lab objectives (FY16, FY17):

- Continue progress on Nb_3Sn models and prototypes to advance HL-LHC
- Plan (and execute) construction of pre-series crab cavities at FNAL





Recent achievements:

- 1st short Nb_3Sn magnet (MQXFS1) successfully tested at FNAL in February 2016.
- U.S. High Luminosity Upgrade Project (HL-LHC AUP) received CD-0 in April 2016.
- LARP uses final production specifications to place orders for prototype components such as Nb_3Sn strand, magnet parts, and magnet mechanical structures.

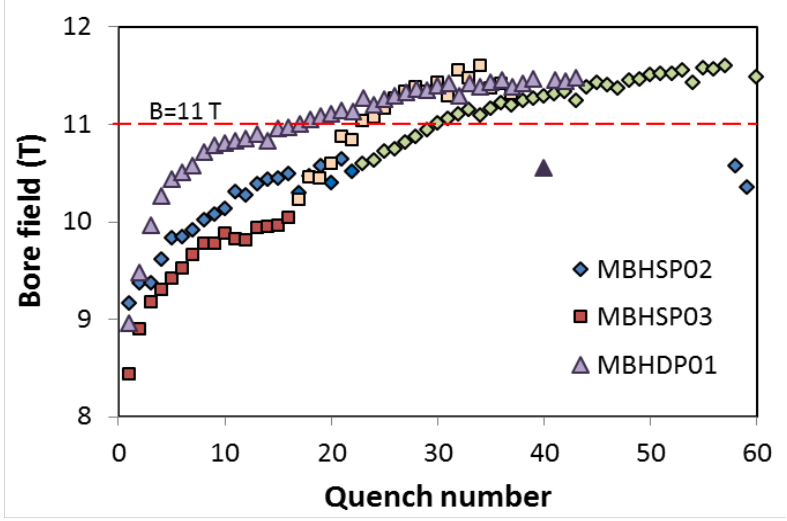
– **Accelerator Upgrades:** ***Additional $2M in FY17***

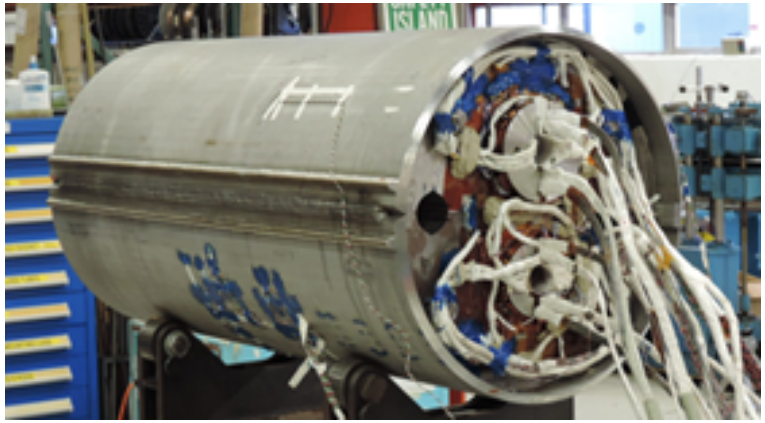
- **This is a first step, with funding redirected from lower-priority directed accelerator R&D to LARP for HL-LHC**
- **LARP and HL-LHC completely coordinated for U.S. to deliver Nb_3Sn magnets**

High-Field Magnets: R&D for Next Generation

Breakthroughs in materials, systems, engineering are needed for higher fields

- HE-LHC is increasingly popular path for upgrades and future of CERN's LHC





1 meter long 2-in-1 Nb_3Sn magnet successfully tested at Fermilab to 11.6T

Lab objectives (FY17 to FY20):

- Fermilab will focus intellectual effort on Nb_3Sn (conductor and magnet engineering)
  - Just as in SRF, basic understanding of materials physics can create breakthroughs
  - Coordinated with other labs
- Milestones will support U.S. and CERN discussion of participation in HE-LHC

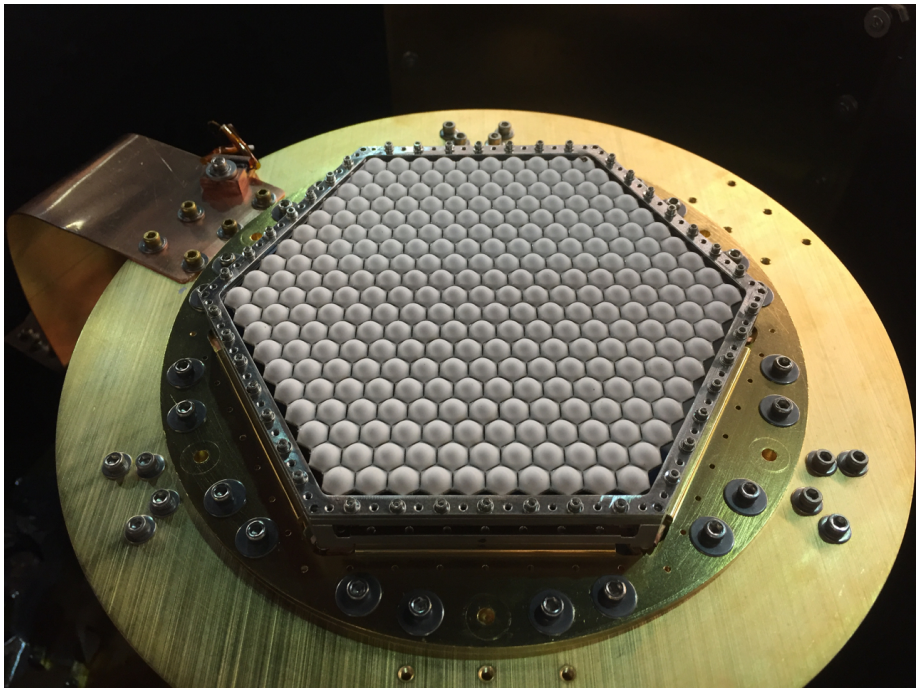
Dark Energy and CMB

Cosmic Science

Science goal:
Use large optical sky surveys and cosmic microwave background to study our universe

Lab objectives:

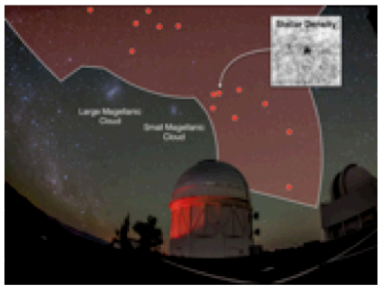
- Complete SPT-3G camera with 16,400 detectors (2017)
- Complete operations of DES (2018) and extract dark energy science
- Deliver barrel, plate maker, online database, CCD testing for DESI (2019)
- Advance computing and software to enable LSST science at first light
- Continue leadership in Cosmic Visions group to define CMB-S4 (~ 500,000 detectors)

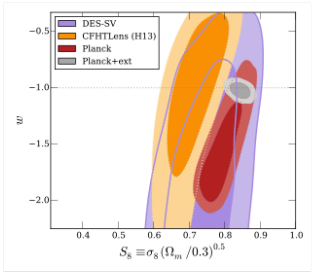


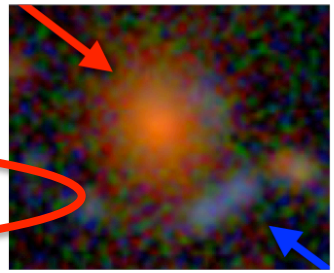
A full, prototype SPT-3G detector array packaged at Fermilab

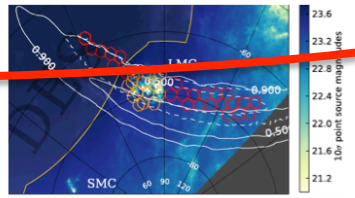
Recent Accomplishments by Fermilab Scientists

- Dark Energy Survey
  - Year 3 observing successfully completed. Earthquakes and El Nino survived!
  - 77+ papers submitted to refereed journals, 58+ published or accepted
  - 29 major presentations by Fermilab scientists and postdocs, plus 53 colloquia, seminars, summer school lectures and public/outreach talks
  - Fermilab Science leadership in many papers.
  - First cosmology results: arxiv:1507.05552
  - Highlights (Fermilab first authors)
    - Discovery of new Milky Way dwarf satellites:
      - ApJ 813 109, 2015 ***Drlica-Wagner*** et al
      - ApJ 809 L4 (2015) ***Drlica-Wagner*** et al
    - Observation of 6 new Strong Lenses
      - arXiv:1512.03062 ***Nord*** et al
    - Search for optical counterparts to LIGO gravitational wave events:
      - ApJ 823, L33 (2016) **Soares-Santos** et al
      - ApJ 823, L34 (2016) **Annis** et al
    - DECam Instrument paper
      - ApJ 150 150 (2015) **Flaugher, Diehl** et al









- CMB: SPT
  - Constraints on dark energy and neutrino mass from the SPT survey: de Haan, **Benson**, et al. (2016), arXiv:1603.06522

Scientists
Postdocs

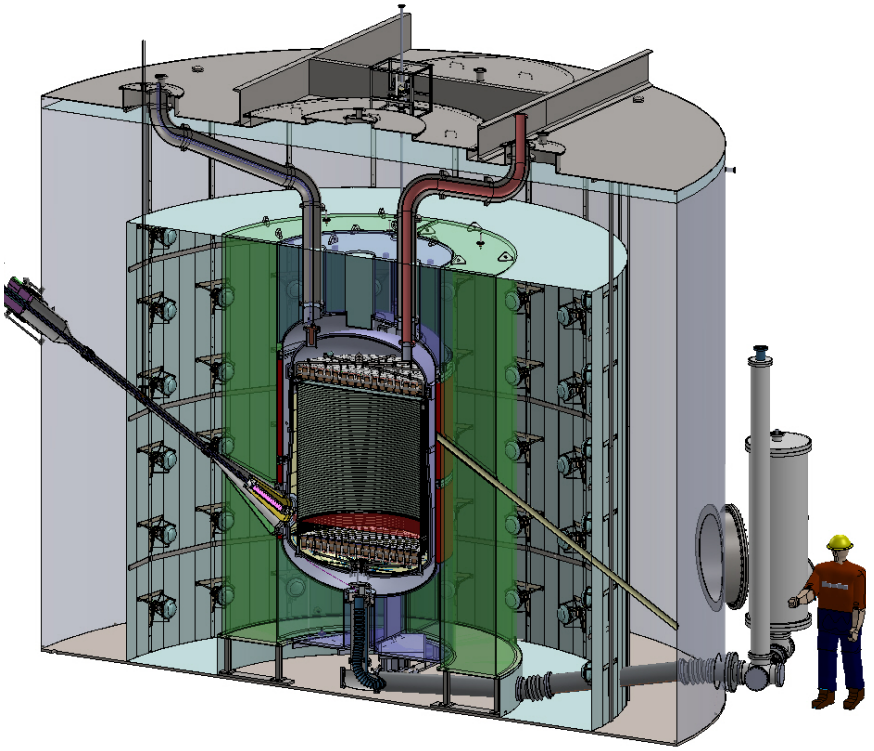
Dark Matter

Cosmic Science

Science goal:
Identify and study the new physics of dark matter

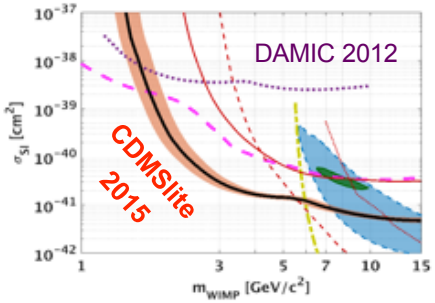
Lab objectives:

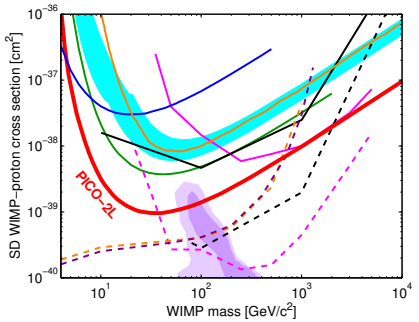
- Extract final results from Generation 1 (G1) dark matter experiments to achieve world-leading results
- Build & commission SuperCDMS
- Provide process control, cryogenic, and scientific expertise for LZ
- Develop tunable high-Q RF cavities for ADMX G2 high-frequency axion search
- Strategic engagement with Italy on DarkSide

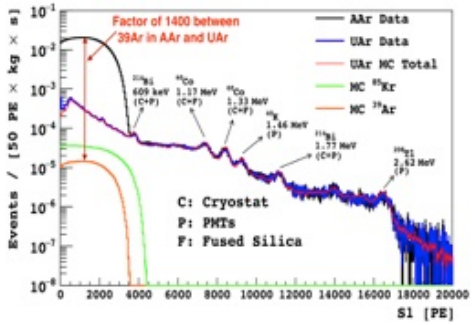


Recent Accomplishments by Fermilab Scientists

- Dark Matter:
  - SuperCDMS Soudan
    - CDMSlite world best low-mass WIMP limits: Phys. Rev. Lett. 116, 071301 (2016)
    - Basu-Thakur (UIUC student based and Fermilab) primary author
    - **Hsu** analysis coordinator
  - PICO 2L
    - World Best Spin-dependent proton WIMP limits: Phys. Rev. Lett. 114, 231302 (2015)
    - **Crisler** led detector design and fabrication
  - DAMIC – 10
    - reached 0 bkg running (1DRU): new results at UCLA Feb.'16: Limit and 1st low energy nuclear recoil calibration
    - ***Tiffenberg*** leading analysis and paper writing
  - Darkside 50
    - First results with low radioactivity Argon: Phys. Rev. D 93, 081101 (2016)
    - **Pordes** led purification system effort, ***Guardincerri*** leads DAQ

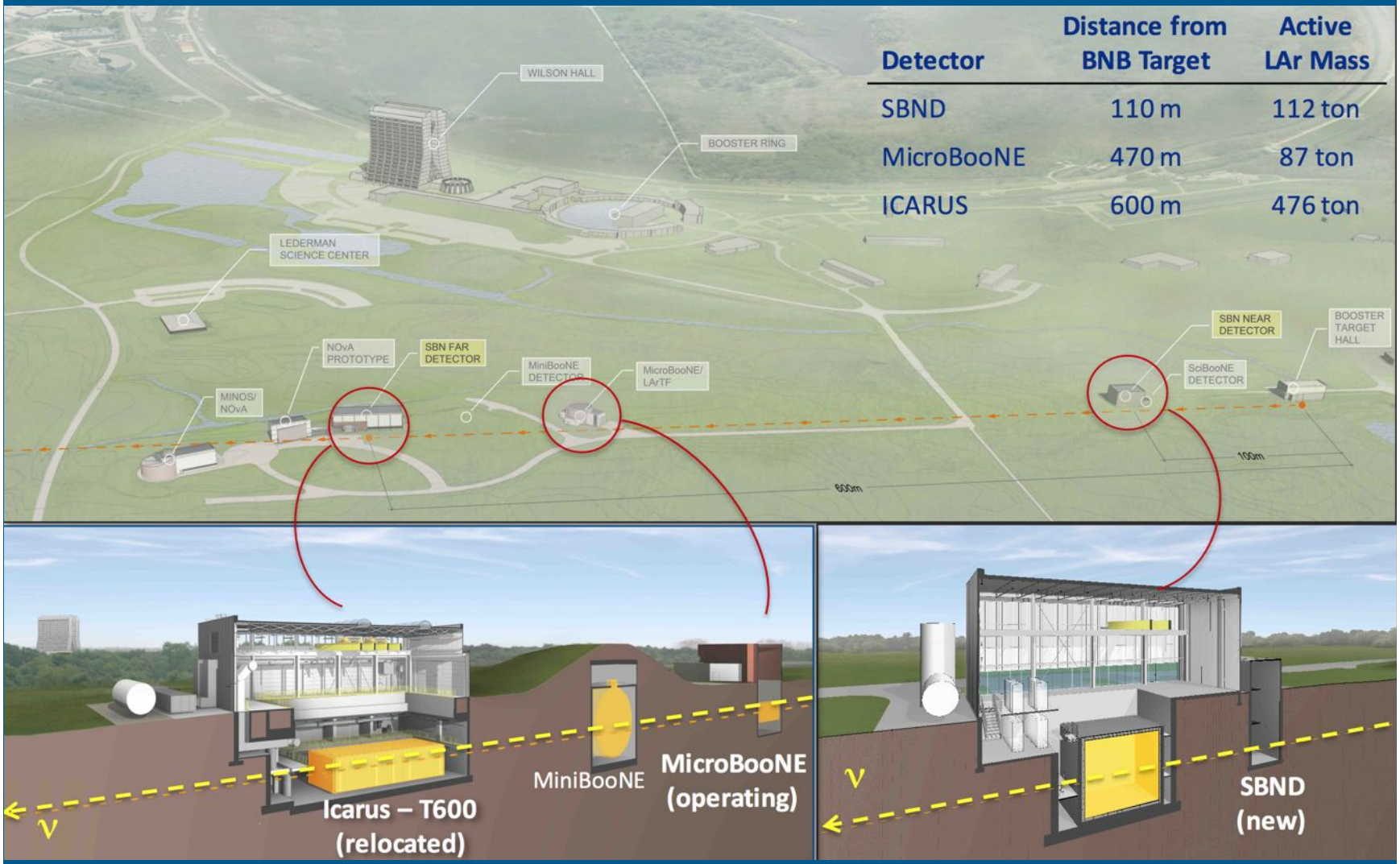






Fermilab PAC report from their June 20-22 meeting:

"The PAC congratulates the leadership of the Particle Astrophysics effort at Fermilab in presenting a coherent and compelling program, which is both diverse and balanced. The Fermilab Particle Astrophysics group provides key contributions to a large number of high-profile experiments in the national and international portfolio, which are expected to facilitate fundamental measurements and, possibly, new discoveries. These contributions exploit Fermilab's infrastructure and know-how, and provide elements central to the success of these experiments. The PAC also noted that the planned transition from G1 to G2 dark matter searches is now under way. The future transition between DES/DESI and LSST is under planning and was clearly articulated."



Detector	Distance from BNB Target	Active LAr Mass
SBND	110 m	112 ton
MicroBooNE	470 m	87 ton
ICARUS	600 m	476 ton

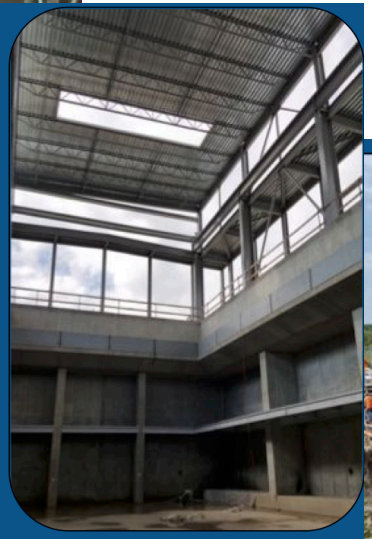
SBN Program Detectors – LAr TPCs

Summary from SBN Briefing for DOE/NSF, August 1-2

- Significant progress toward realization of both the near and far detectors
  - More details in the talks to follow
- Director's review recommendations have all been closed in iTrack as action plan is in place for all recommendations
- Plan for ICARUS CRT is now solidifying
- Plan for online systems progressing with appointment of new coordinators
- Installation of ICARUS will start in January 2017
  - During first stages (cryostats and cryogenics) will primarily involve technical staff of INFN, Fermilab and CERN
  - Will need scientists (eg postdocs and students) at Fermilab starting next summer to complete installation and for commissioning. Opportunity for US groups to learn about the detector.
- Installation of SBND will follow several months later with a similar set of needs

https://indico.fnal.gov/conferenceDisplay.py?confId=12624

ICARUS cold vessel and new PMTs at CERN



Far Detector Building Civil Construction Underway (left) 9 June 2016, (right) 20 July 2016

Near Detector Civil Construction Underway - 1 July 2016

GPP projects for SBN at FNAL

Fermilab

ICARUS

Argonne National Lab, USA
Brookhaven National Lab, USA
CERN, Switzerland
Colorado State University, USA
Fermi National Lab, USA
INFN Sez. di Catania and University, Catania, Italy
INFN GSSI, L'Aquila, Italy
INFN LNGS, Assergi (AQ), Italy
INFN Sez. di Milano Bicocca, Milano, Italy
INFN Sez. di Napoli, Napoli, Italy
INFN Sez. di Padova and University, Padova, Italy
INFN Sez. di Pavia and University, Pavia, Italy
H. Niewodniczanski Inst. of Nucl. Phys., Polish Academy of Science, Krakow, Poland
Institute for Nuclear Research (INR),
Institute of Physics, University of Silesia, Katowice, Poland
Inst. for Radio-Electronics, Warsaw University of Technology, Warsaw, Poland
Los Alamos National Lab, USA
National Centre for Nuclear Research, Warsaw, Poland
University of Pittsburgh, USA
Russian Academy of Science, Moscow, Russia
SLAC, USA
Texas University at Arlington, USA

MicroBooNE

University of Bern, Switzerland
Brookhaven National Lab, USA
University of Cambridge, UK
University of Chicago, USA
University of Cincinnati, USA
Columbia University, USA
Fermi National Lab, USA
Illinois Institute of Technology, USA
Kansas State University, USA
Lancaster University, UK
Los Alamos National Lab, USA
University of Manchester, UK
MIT, USA
University of Michigan, USA
New Mexico State University, USA
Oregon State University, USA
Otterbein University, USA
University of Oxford, UK
University of Pittsburgh, USA
Pacific Northwest National Laboratory, USA
Princeton University, USA
Saint Mary's University of Minnesota, USA
SLAC, USA
Syracuse University, USA
University of Texas at Arlington, USA
Tubitak Space Tech. Research Inst., Turkey
Virginia Tech, USA
Yale University, USA

SBND

Argonne National Lab, USA
University of Bern, Switzerland
Brookhaven National Lab, USA
University of Cambridge, UK
University of Campinas – UNICAMP, Brazil
CERN, Switzerland
University of Chicago, USA
Columbia University, USA
Federal University of ABC – UFABC, Brazil
Federal University of Alfenas – UFAL, Brazil
Fermi National Laboratory, USA
Illinois Institute of Technology, USA
Indiana University, USA
Kansas State University, USA
Lancaster University, UK
University of Liverpool, UK
Los Alamos National Lab, USA
University of Manchester, UK
University of Michigan, USA
MIT, USA
University of Oxford, UK
Pacific Northwest National Lab, USA
University of Pennsylvania, USA
University of Puerto Rico
University of Sheffield, UK
Syracuse University, USA
University of Texas, Arlington, USA
University College London, UK
Virginia Tech, USA
Yale University, USA

SBN Program Collaborations – Institutions (July 2016)

International Contributions

Convener: Peter Wilson (Fermilab)

10:35 **ICARUS Plan and Italian Contributions** *40'*

Speaker: Prof. Antonio Masiero (INFN and Univ. of Padua)

Material: **Slides**

11:15 **CERN Contributions** *25'*

Speaker: Prof. Marzio Nessi (CERN)

Material: **Slides**

11:40 **UK Contributions** *20'*

Speaker: Prof. Stefan Soldner-Rembold (University of Manchester)

Material: **Slides**

12:00 **Swiss Contributions** *15'*

Speaker: Prof. Antonio Ereditato (University of Bern)

Material: **Slides**

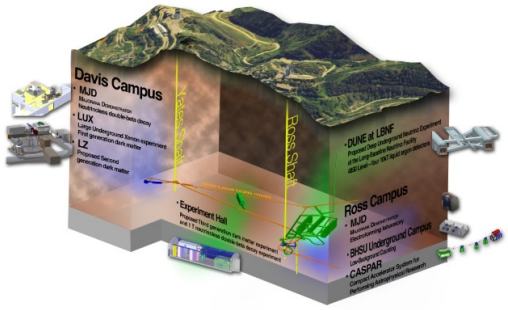
12:15 **Brazilian Contributions** *15'*

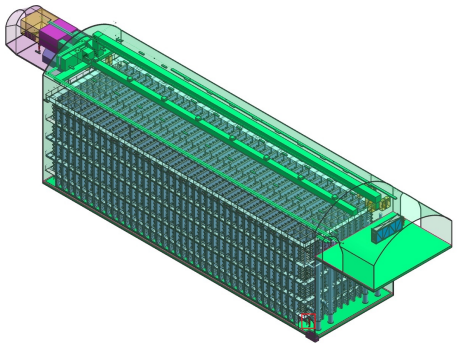
Speaker: Prof. Ernesto Kemp (University of Campinas - UNICAMP)

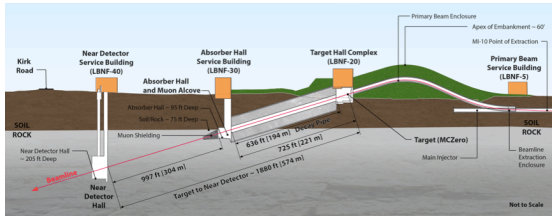
Material: **Slides**

DUNE Timeline

DEEP UNDERGROUND NEUTRINO EXPERIMENT

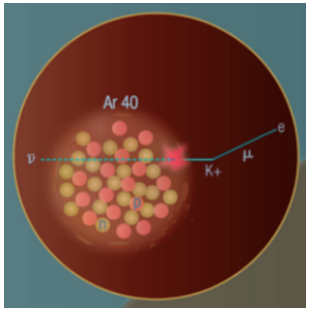






- 2017: Far Site Construction Begins
- 2018: protoDUNEs at CERN
- 2021: Far Detector Installation Begins
- 2024: Physics Data Begins (20 kt)
- 2026: Neutrino Beam Available

The CERN Neutrino Platform



LBNF/DUNE Progress

- P5 regards LBNF/DUNE as the highest priority large project in its time frame
- Progress has been extremely rapid since the P5 report was released:
  - ✓ Framework for internationalization of LBNF/DUNE established
  - ✓ DUNE Spokespersons and Technical & Resources Coordinators appointed
  - ✓ DUNE Executive Committee in-place
  - ✓ DUNE Institutional Board Chair elected
  - ✓ Experiment-Facility Interface Group (EFIG) established
  - ✓ U.S.-CERN bilateral International Cooperation Agreement signed
  - ✓ Fermilab Deputy Director for LBNF appointed
  - ✓ CD-1 Refresh Review held
  - ✓ CD-1 Refresh DOE-agency Approval
  - ✓ Approval of Protocols to the U.S.-CERN International Cooperation Agreement
  - ✓ CD-3A (Early Far-Site Construction) Review held
  - ✓ Supported in FY 2017 U.S. President's Budget Request & U.S. Congressional Budget Marks
- Next steps:
  - ❑ CD-3A DOE-agency Approval
  - ❑ Solidify international partnerships via investments in site preparation & cavern excavation
  - ❑ CD-2 [baseline] Review & DOE-agency Approval
  - ❑ Establish Common Projects and Common Funds for international DUNE
  - ❑ Develop operations program structure for DUNE operations

Tentative ESAAB date scheduled for Sept 1

LBNF Far Site Conventional Facilities Scope *by Approval Phase*

- **CD-3a Scope Justification**:
  - the initial construction work required, prior to baselining the LBNF/DUNE Project, to support installation of cryostats and cryogenic systems **to support installation** of two DUNE **detectors** starting in **2021/22**.
  - Includes half of gas piping (in addition to all conventional utilities) in the shaft in order to provide **flexibility** in schedule planning as the project progresses

CD-3a Cost: **$225M** base + **$77M** contingency = **$302M**

Approval Phase	Scope	
Site Preparation (FY16-18)	**SURF reliability projects**	**$14M**
	Ross Shaft rehab	
	Oro Hondo Fan replacement	
	4850L and adit ground support	
	Ross skip and cage, bearings,/bushings, switches & brakes replm't	
	Ross skip and cage motor rehabilitation	
	Refuge chamber upgrade	
CD-3a Scope (FY17-20) **$225M** Click here for detailed CD-3a scope summary	**FSCF Construction Management (CM)**	**$27M**
	SDSTA staff construction support	
	A/E construction phase services	
	CM construction phase services	
	Pre-Excavation Work (Pre-EXC)	**$44M**
	Pre-EXC General Conditions	
	Pre-EXC work: Ventilation/blast containment, util. relocation, Surface and U/G rock disposal sys, Ross shaft elect/data sys, concrete batch plant, slick line, Ross headframe reinforcement	
	Cavern & Drift Excavation (EXC)	**$106M**
	EXC General Conditions	
	Phase 1: drifts, chamber 1, and central utility cavern	
	Phase 2: chamber 2	
	Building & Site Infrastructure (BSI)	**$48M**
	BSI General Conditions	
	Phase 1: chamber 1 and central utility cavern utilities & infrastructure; surface building and utilities	
	Phase 2: chamber 2 utilities & infrastructure	
	Shaft gas piping - 50% of scope	
CD-3c Scope (FY20-22) **$58M**	**FSCF Construction Management (CM)**	**$10M**
	Cavern & Drift Excavation (EXC)	**$39M**
	Phase 3: chamber 3 and 4	
	Building & Site Infrastructure (BSI)	**$9M**
	Shaft gas piping - 50% of scope	

CHARGE QUESTION 1, 3

LBNF Status: What's happened since December IPR – 1 of 3

Item	Status Update	Details
SURF reliability projects, including Ross Shaft renovation	• Ross renovation contract transitioned from SDSTA to DOE funded in Jan-15; transition to FNAL contract in Jan-16. • Ross shaft reno. now at 74% complete • Reliability projects refined and planned	• Headley P03 • Willhite P10
CM/GC contract for CD-3a work	• Acquisition plan and RFP approved by DOE HCA Jun-16. • Advertised June-16. • Pre-proposal meeting held Jul-16.	• Lark P09
Excavated rock disposal site selected	• Open cut site selected • City easement obtained by SDSTA May-16	• Headley P03 • Willhite P06
Blast vibration study	• Study completed Mar-16 • Informing planning and design	• Headley P03 • Willhite P06
Staffing	• Hired far site project engineer • Hired LBNF QA coordinator • Offer in progress for sr procurement administrator • Final interviews for ESH coordinator	• Various presentations

Status of the International Partners

- LBNF will be the first international "mega-science" project hosted by the U.S.
  - As the host, DOE will provide the bulk of the facility
    - Conventional facilities, needed technical infrastructure, etc.
    - Similar to CERN's role in the LHC accelerator
  - Active negotiations with potential international partners are underway…
- The excavation of the caverns is a DOE responsibility as the host nation and it is the first activity to start
  - CD-3A (Early Far-Site Construction) scope is driven by excavation work (70% of base costs) and does not include any international contributions
- International partners are considering their roles in cooperation
  - CERN already has one LBNF cryostat (of four total in LBNF) and the infrastructure for protoDUNE in their medium term (5-year) budget plan
  - Other countries are considering major roles in LBNF, DUNE, and the FNAL accelerator upgrade necessary to provide a >1 MW neutrino beam (PIP-II)
  - Potential partners are also planning towards 2021 DUNE detector installation with first data in 2024

International Partnerships

- CERN is a **major partner** in facility infrastructure at Sanford Lab and is also key to facilitate European engagement.
- Brazil, India, Italy, Switzerland, and the UK are showing **early leadership and strong interest**
- DOE developed new “International CRADA” template to facilitate and expedite agreements between Fermilab and international partners
- First wave of iCRADAs moving through the system now

CD-3a approval sends strong message to international community

DUNE Collaboration

DEEP UNDERGROUND NEUTRINO EXPERIMENT

890 collaborators from 154 institutions in 28 nations

1. DUNE Timeline

- **Met many milestones in the last 16 months**
  - **March** Co-spokespersons elected and TC/RC appointed ✔
  - April First DUNE Collaboration Meeting ✔
  - **May** First DUNE Executive Committee meeting ✔
  - **July** DOE CD-1-R Review ✔
  - **July** Scientific/Detector Coordinators appointed ✔
  - Sept 2nd Collaboration Meeting and move to regular WG schedule ✔
  - **Dec** DOE CD-3a Review ✔
  - **Dec** Full integration of dual-phase (WA105) into DUNE ✔
  - **Dec** ProtoDUNE-SP approved at CERN ✔

2015

2016

  - **Jan** ProtoDUNE-SP leadership team in place ✔
  - Jan 3rd Collaboration Meeting & ProtoDUNE "Expressions of Interest" ✔
  - **Apr** European and Latin Americas DUNE meetings ✔
  - **May** ProtoDUNE organization defined ✔
  - May 4th Collaboration Meeting (South Dakota) ✔
  - **Jun** Collaboration strategy for 2016-2019 approved ✔
  - **July** Institutional responsibilities for ProtoDUNE defined ✔

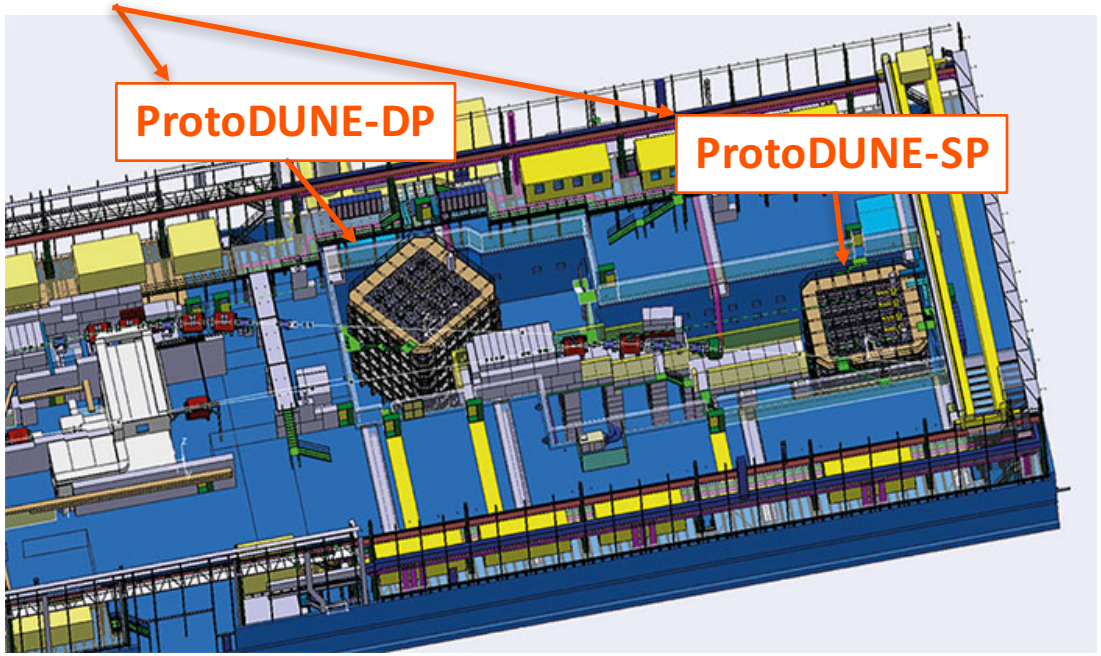
5. ProtoDUNEs

CERN North Area: 27/4/2016

CERN Neutrino Platform

CERN support of international neutrino program

- **Major** CERN infrastructure investment for DUNE:
  - New building: EHN1 extension in the North area
  - Two tertiary charged-particle beam lines
  - Two large (8x8x8 m^3) cryostats & cryogenic systems

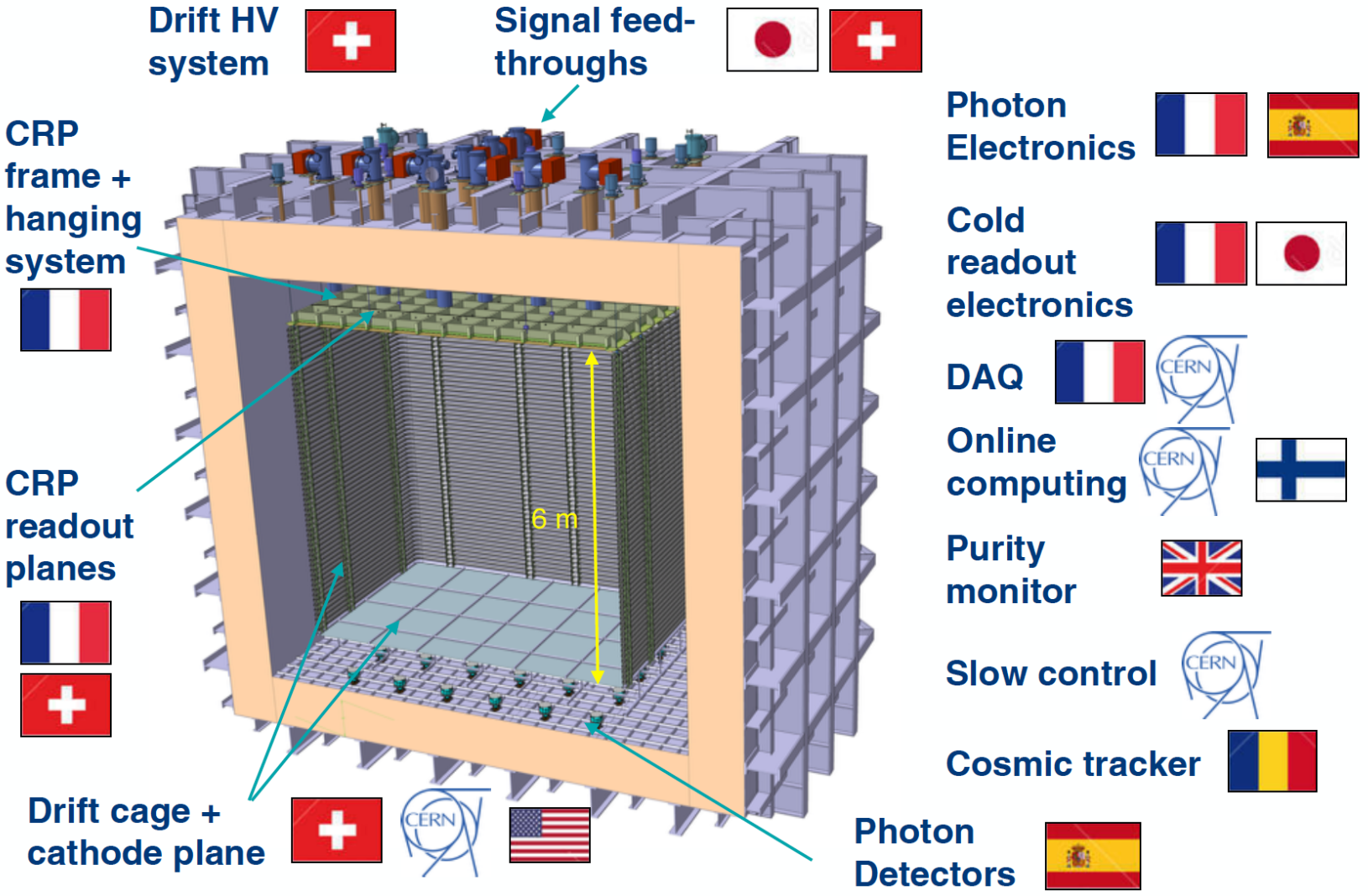


Beneficial occupancy later this year

ProtoDUNE EoIs

- **January 2016 "ProtoDUNE":**
  - Call for "Expressions of interest" in PD-SP & PD-DP
    - Covered detector construction & scientific activities
  - Provided opportunity for all collaborating institutes to participate
- **Generally very successful process**
  - 59 institutes submitted EoIs
  - All areas covered!
  - WG convenors, coordinating assembly of final teams
- **Tasks/Resource Matrix**
  - Responsibilities (mostly ~90 %) finalized at the end of **July 2016**
- **Recent news**
  - Significant UK (STFC) investment in ProtoDUNE-SP:
    - Three of the six PD-SP APAs and contribution to DAQ system

ProtoDUNE-DP Responsibilities



ProtoDUNE-SP Responsibilities

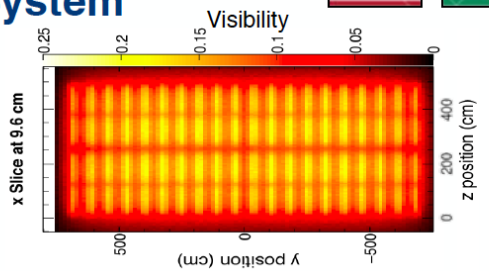
Drift HV system

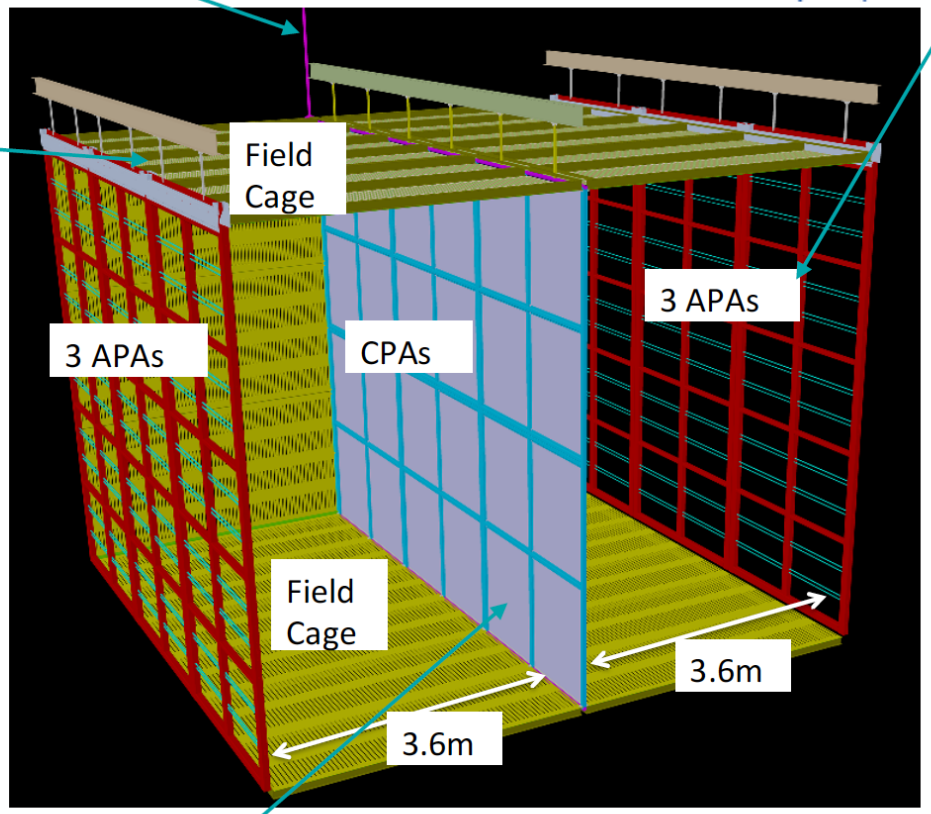
Signal feed-throughs

Anode Plane Assemblies (APA)

Field cage

Photon Detector System





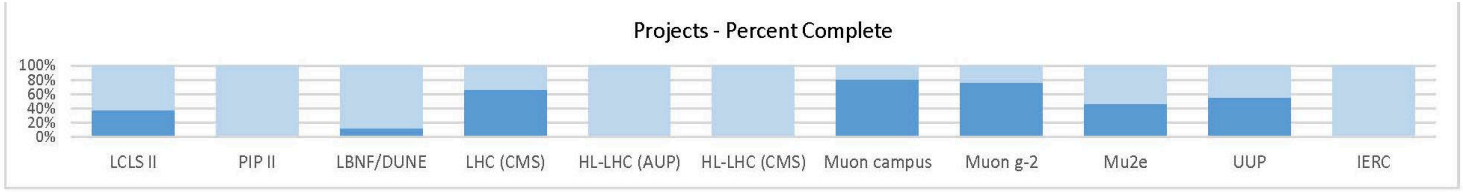
Cold readout electronics

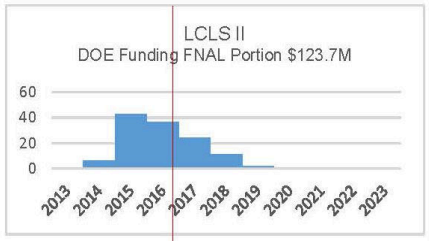
DAQ

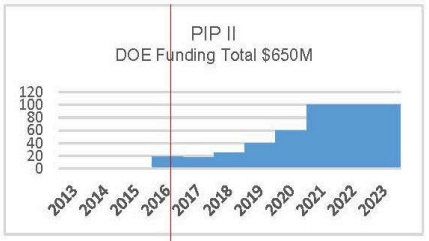
Slow control

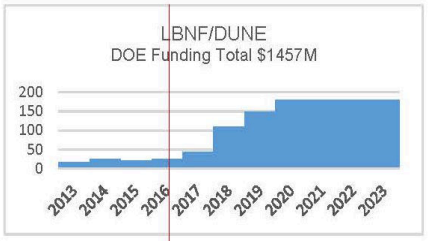
Cathode Plane Assemblies (CPA)

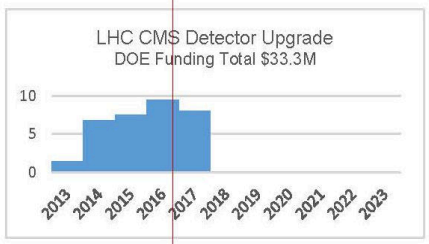
Project Dashboard: all FNAL projects doing well

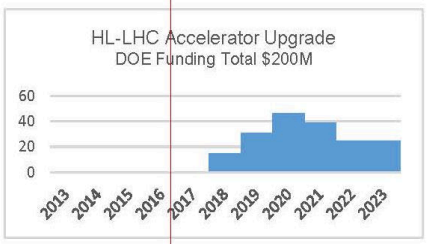


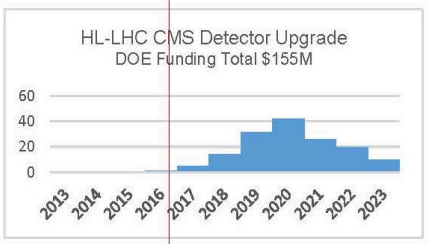


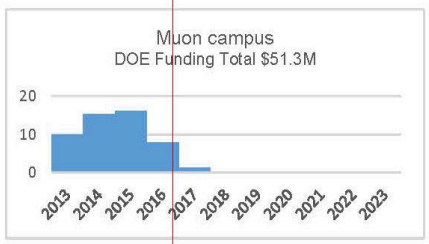


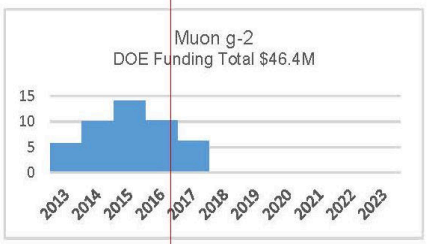


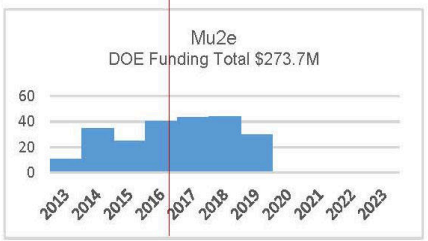


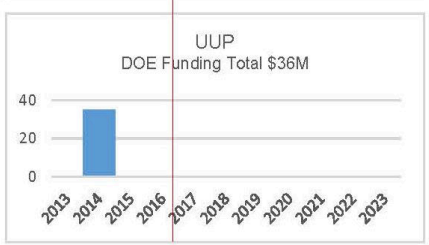


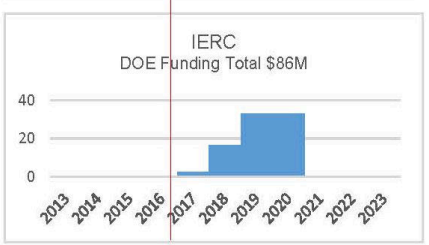












All DOE O413.3B projects and the Muon Campus are included in the dashboard.

PIP-II

CD-0 approved:

>1 MW of beam power at LBNF startup; platform for rejuvenation of the Fermilab accelerator complex.

Front end development:

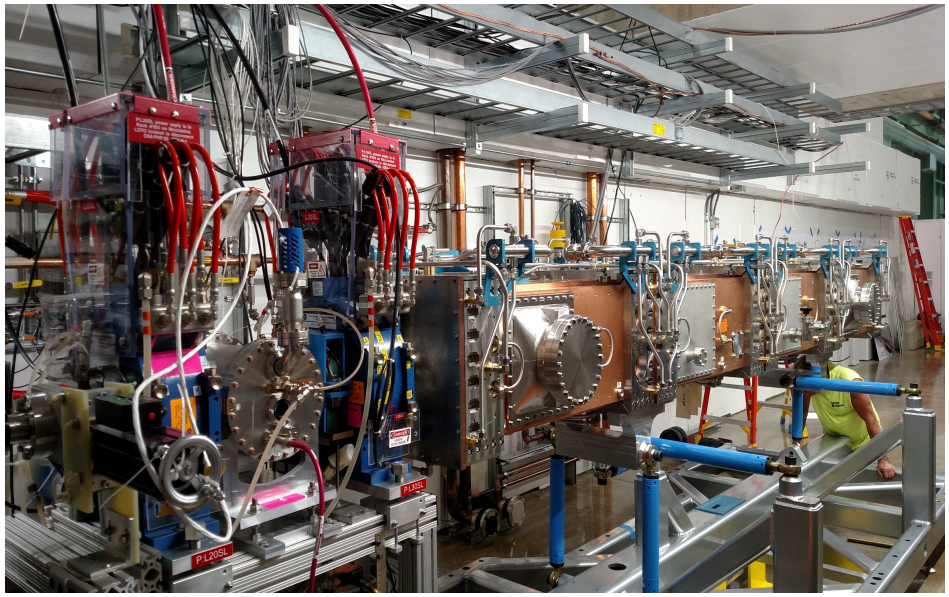
- RFQ delivered from LBNL and commissioned with beam

SRF development:

- Prototype cryomodules (HWR & SSR1) in fabrication at ANL and Fermilab
- Capitalizing on advances made in the Fermilab cavity development program

India Collaboration:

- Indian magnets incorporated as part of the medium energy beam transport (MEBT) downstream of the RFQ
- Two Indian cavities successfully tested. These will be incorporated into the SSR1 cryomodule



RFQ installed in the front-end test facility at Fermilab

Status: CD-0 (targeting CD-1 in FY17)

Operations start: ~FY2025

Partnerships:

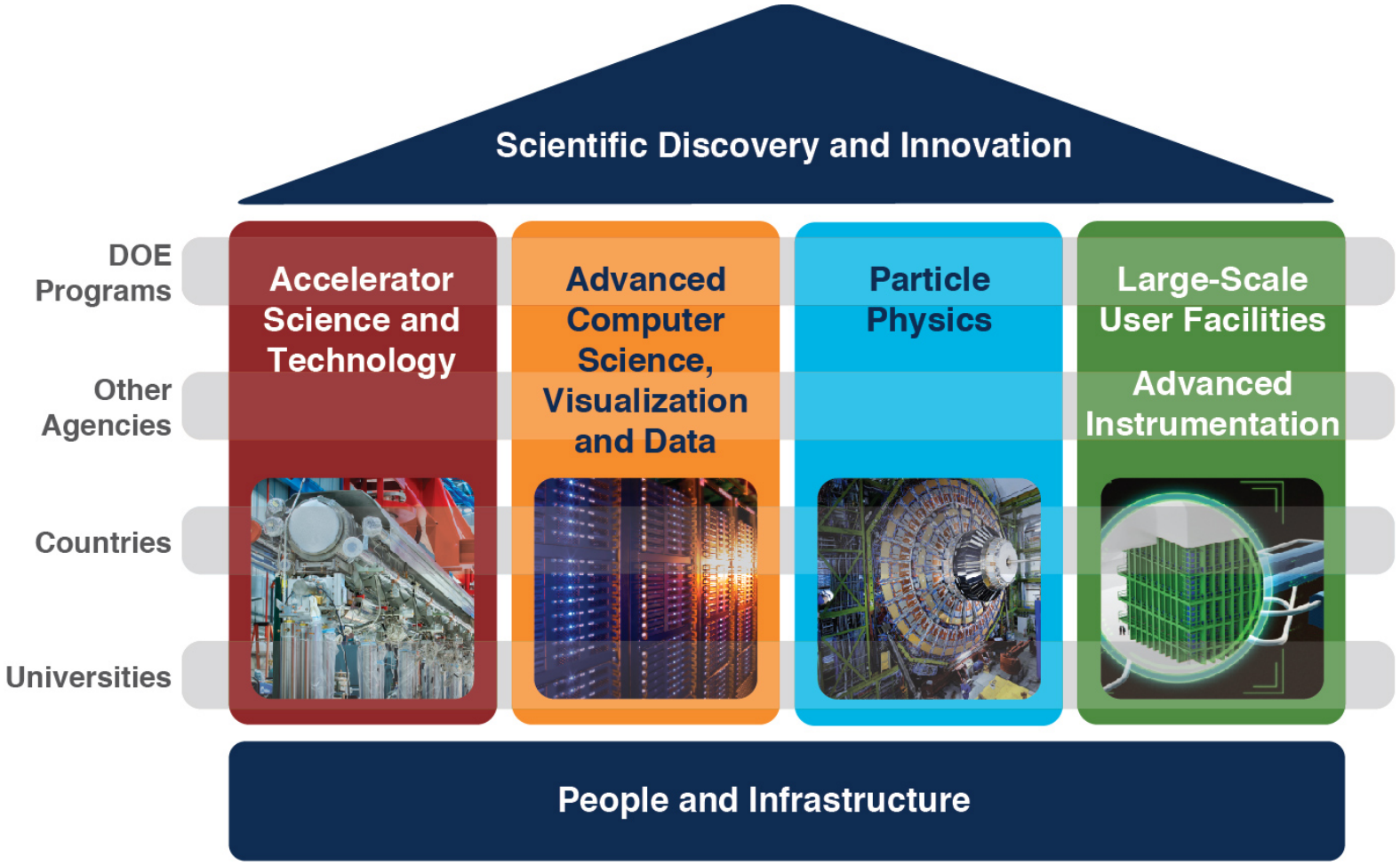
DOE labs: ANL, LBNL, ORNL

International:

IIFC = BARC, IUAC, RRCAT, VECC

Talking to Italy, UK, …

Our strategy depends on partnerships



The Fermilab “priorities slide”… has been retired

- A slide developed for our internal All Hands meetings
- Original purpose was to answer questions like “Mu2e and SuperCDMS both want the same engineer at the same time; who gets her?”
- Also used to make the point that projects, as per P5, have (in some general sense) priority over operations and research; note this was a big cultural change for Fermilab, where operations had reigned supreme during the Tevatron era
- It also introduced Lockyer’s Theorem:

  Priority = Importance * Criticality

- Unfortunately all of this requires nuanced explanation

Fermilab partnerships

- Another way to think about priorities is in terms of Fermilab's partnerships. Thus:
- FNAL has a critical partnership with CERN on LHC and neutrinos.
  - Thus Fermilab must deliver on LHC ops and LHC upgrades including magnets
  - This partnership includes universities in CMS and other labs in LARP, but FNAL must backstop the entire effort
  - And Fermilab must deliver on our end of neutrinos
- FNAL has a partnership with SLAC and BES on LCLS-II
- FNAL has a partnership with LBNL (and SLAC and universities) for LZ
- FNAL has a partnership with INFN for liquid argon based experiments
- FNAL has a partnership with India for PIP-II and neutrinos

etc.

Partnering with ASCR

Science Goal: Achieve the best possible physics results by using all available DOE computing resources (leveraging HEP and ASCR investments)

- The future depends on effective use of Exascale computing
- HEP is fully engaged in ASCR requirements, architecture, and design activities

Photo credit: http://www.alcf.anl.gov/mira

Technical Challenge: New architectures

- **Software must be rewritten** for Exascale ecosystem
- **Algorithms must be modernized** for new computing chips
- **Data must be served to many CPU cores** through ultra-high-speed networking

Recent achievements: Starting the evolution

- **Port common software framework** (*art*) to HPC (LDRD)
- **I/O and data modeling** (SciDAC-DATA) on Mira
- **Next generation simulation** (GeantV) on new architectures

HEPCloud

Science Goal: Satisfy the computing resource needs for the HEP community

- Hide the complexity of computing from the scientist so they can focus on the science

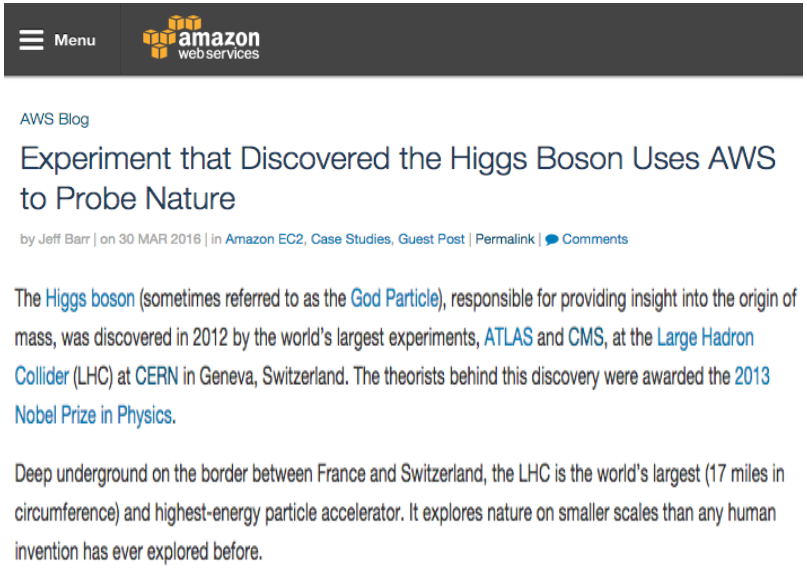
Technical Challenge: A **single portal** to access a wide range of computing resources (University Grids, Commercial Clouds, ASCR Supercomputers, etc.)

- Expert knowledge not required
- Computing resources can expand and shrink on short notice to meet demands (elastic expansion for example to meet conference deadlines)

Recent achievements: CMS and NOvA first in using HEPCloud

- CMS: Simulation for Moriond 2016 conference
- NOvA: Analysis for Neutrino 2016 conference

Amazon Press Release


Menu amazon web services

AWS Blog

Experiment that Discovered the Higgs Boson Uses AWS to Probe Nature

by Jeff Barr | on 30 MAR 2016 | in Amazon EC2, Case Studies, Guest Post | Permalink | Comments

The Higgs boson (sometimes referred to as the God Particle), responsible for providing insight into the origin of mass, was discovered in 2012 by the world's largest experiments, ATLAS and CMS, at the Large Hadron Collider (LHC) at CERN in Geneva, Switzerland. The theorists behind this discovery were awarded the 2013 Nobel Prize in Physics.

Deep underground on the border between France and Switzerland, the LHC is the world's largest (17 miles in circumference) and highest-energy particle accelerator. It explores nature on smaller scales than any human invention has ever explored before.

Partnerships

DOE labs: BNL

U.S. universities: Univ. of Wisconsin Madison, Univ. of Nebraska, UCSD

International: In discussion with CERN

Challenges and concerns

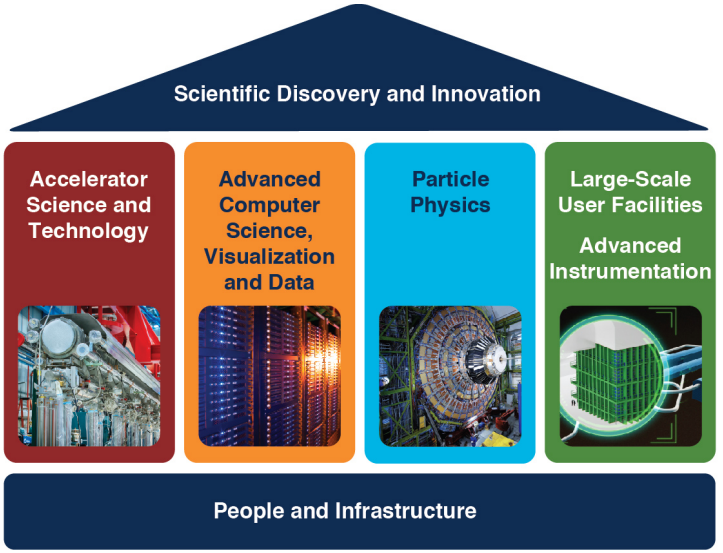
Budget-related issues:

- Fermilab operations review said that we are too lean in several areas
- There is almost no free energy in the HEP system to solve problems, but problems will arise
- Maintaining Fermilab's core capabilities requires investment
- Making new partnerships requires bringing something to the table
- Once you fall behind, e.g. on computing or theory, may never catch up again

Communications:

- Messaging with our stakeholders in Washington and internationally is a continuing challenge
- Fermilab, DOE HEP, and the whole U.S. community need to coordinate better to be more effective

Conclusion



- Fermilab's core capabilities are enabling the U.S. plan for particle physics.
- The plan includes major initiatives that depend on partnerships with DOE, national labs, universities, and the international HEP community.
- Fermilab is on track to host the world for neutrino science.
- Lab projects are on budget and on schedule.
- Lab operations were reviewed as lean, effective, and efficient (Facilities Operations Review, May 16-18, 2016).
- We understand our greatest challenges, and we are working on them.