Fermilab Vision

Joe Lykken
DPF meeting
8 August 2015
14 months ago: the P5 plan

- A strategic plan for U.S. particle physics maximizing opportunities for breakthrough science
- Guided by the community APS/DPF Snowmass study
- Explicit prioritization, hard choices made within realistic budget scenarios
- Particle physics community unified behind the plan
P5 plan in a nutshell

- Continue U.S. commitment and leading roles in the LHC
- Build a neutrino program at Fermilab that will attract the world community
- Continue U.S. leading efforts in dark matter, dark energy, and cosmic microwave background
- Pursue the Fermilab-based muon experiments
- Invest in the accelerator and detector technologies that we will need in the future

It is a feature of this plan that the major components reinforce each other
P5 hard choices and redirection

- Muon experiments
- Project X
- LBNE -> recast as LBNF with new international collaboration DUNE
- PIP-II
- LHC and LHC upgrades
- ORKA
- Generation 2 & 3 dark matter experiments
- LSST
- DESI
- Muon collider
- MAP and MICE
- ILC (US contribution) (waiting for decision in Japan)
- NuSTORM
- Detector R&D redirected
- Accelerator R&D redirected
Recommendation 1: Fund generic high-power component R&D at a level necessary to carry out needed thermal shock studies and ionizing radiation damage studies on candidate materials that are not covered by project-directed research.

Recommendation 2: Construct the IOTA ring, and conduct experimental studies of high-current beam dynamics in integrable non-linear focusing systems.

Recommendation 3: Support a collaborative framework among labs and universities that assures sufficient support in beam simulations and in beam instrumentation to address beam and particle stability including strong space charge forces.

Recommendation 4: Direct appropriate investment in superconducting RF R&D in order to inform the selection of the acceleration technology for the multi-MW proton beam at Fermilab.

Fermilab is fully aligned to these recommendations; looking forward to continuing dialog and optimization of the national GARD effort.
Fermilab is “Building for Discovery”

- NOvA CD-4 Sept 2014 ✔
- CMS phase 1 upgrades CD-2/3 Nov 2014 ✔
- MicroBooNE CD-4 received Dec 2014 ✔
- Utility SLI baselined Dec 2014 ✔
- Mu2e CD-2/3b received March 2015 ✔
- Successful PIP-II CD-0 review June 2015
- Successful Muon g-2 CD-2/3 review June 2015
- Successful DUNE/LBNF CD-1 refresh review July 2015
- Successful DESI CD-2 review July 2015
- IER building SLI CD-0 approval July 2015 ✔
- US CMS HL-LHC upgrades Directors Review Sept 2015
- LBNF CD-3a review Dec 2015
- US HL-LHC accelerator is pre-CD-0 but moving ahead
Muon Campus construction

- New beamline enclosure for connection from Delivery Ring (former antiproton rings) to g-2 and Mu2e experiments nearing completion
Short Baseline Neutrino Program…roaring ahead

Far Detector Building
*Construction Start – Summer 2015*

Near Detector Building
*Construction Start – Fall 2015*
Fermilab is responsible for corrector barrel, the new cage and rings, as well as the CCD packaging and testing (similar to DECam).
P5 Headline: Particle Physics is Global

• US HEP plan needs to make sense in the context of global HEP
• US involvement in LHC at CERN seen as a successful example of international collaboration
• International partnerships of growing importance in US science, particle physics seen as a leader of this trend
U.S. – CERN partnership
Upgrades: Phase 1 and HL-LHC (Phase 2)

Fermilab supports the U.S. CMS community in the construction and management of the CMS upgrades. These projects take advantage of the unique Fermilab detector test facilities:

- ASIC engineering
- SiDet
- Scintillator extrusion
- and test beams
**Example: CMS Phase II Upgrade**

**New Tracker**
- Radiation tolerant - high granularity - less material
- Tracks in hardware trigger (L1)
- Coverage up to $\eta \sim 4$

**Muons**
- Replace DT FE electronics
- Complete RPC coverage in forward region (new GEM/RPC technology)
- Investigate Muon-tagging up to $\eta \sim 3$

**Barrel ECAL**
- Replace FE electronics
- Cool detector/APDs

**Trigger/DAQ**
- L1 (hardware) with tracks and rate up $\sim 750$ kHz
- L1 Latency 12.5 $\mu$s
- HLT output rate 7.5 kHz

**New Endcap Calorimeters**
- Radiation tolerant
- High granularity

**Other R&D**
- Fast-timing for in-time pileup suppression
- Pixel trigger
In-kind contributions and collaborations for design, prototypes and production

Discussions ongoing with other countries, e.g. Canada...

Q1-Q3: R&D, Design, Prototypes and in-kind USA
D1: R&D, Design, Prototypes and in-kind JP
MCBX: Design and Prototype ES
HO Correctors: Design and Prototypes IT
Q4: Design and Prototype FR

CC: R&D, Design and in-kind USA
CC: R&D and Design UK

August 8th 2015

The Vision of CERN, P. Collier
Successful test of first HL-LHC coil

• First model coil for HL-LHC magnets assembled and tested in mirror configuration at Fermilab. The Mirror Magnet was tested in the IB1 Vertical Magnet Test Facility using for the first time an upgraded 30kA setup.
  • Higher current needed for higher-performing Nb$_3$Sn magnets
• Coil achieved HL-LHC “operating current” (16.5kA) in 3 quenches during the first day of testing.
• Next goal: Test of first 4-coil complete quadrupole later in CY15.
LBNF Cryostat Extrapolation

Inner dimension (liquid+gas):
- L = 62.00 m
- W = 15.10 m
- H = 14.00 m

SS skin
Top cap & Detector supports
possible supports to the cavern wall
LAr = 17'432 tons (95% liquid)

outer warm structure

August 8th 2015
The Vision of CERN, P. Collier
P5 neutrino mandate for Fermilab

• Encourage formation of a new international collaboration to build large liquid argon detectors deep underground
• Provide a > 1megawatt neutrino beam for LBNF (PIP-II)
• Develop a short baseline neutrino program that advances liquid argon R&D
DUNE/LBNF will be the first truly international “mega science” project hosted by DOE on US soil, expected to eventually serve more than 2,000 scientists from around the world.
The DUNE Collaboration

As of today:

776 Collaborators

from

26 Nations

Armenia, Belgium, Brazil, Bulgaria, Canada, Colombia, Czech Republic, France, Germany, India, Iran, Italy, Japan, Madagascar, Mexico, Netherlands, Peru, Poland, Romania, Russia, Spain, Switzerland, Turkey, UK, USA, Ukraine

DUNE already has broad international support
Spokesperson: André Rubbia  
ETH

Spokesperson: Mark Thomson  
Cambridge

Technical Coordinator: Eric James  
FNAL

Resource Coordinator: Chang Kee Jung  
Stony Brook

International Project Manager: Steve Kettell  
Brookhaven

Institutional Board Chair: Maury Goodman  
Argonne

8 August 2015
LBNF/DUNE Overview

International from the start

Nigel S. Lockyer
LBNF/DUNE DOE
CD-1 Refresh Review
July 14-16, 2015
Conclusion

• LBNF and DUNE provide unprecedented international and game-changing opportunities for neutrino physics.

• DUNE is a highly-motivated, experienced, and well-organized international team that has assembled quickly and is anxious to begin.

• LBNF is a natural progression from NUMI/MINOS and NOvA, and the expertise exists at Fermilab to host this facility.

• The accelerator complex is being upgraded to continue to provide the most powerful neutrino beam in the world.

• U.S. has a unique opportunity to host a global program that leads to the discovery of CP violation in the leptonic sector.
Closeout Report on the
DOE/SC CD-1 Review of the

Long Baseline Neutrino Facility/Deep Underground Neutrino Experiment (LBNF/DUNE) Project

Fermi National Accelerator Laboratory
July 14-16, 2015

Stephen W. Meador
Committee Chair
Office of Science, U.S. Department of Energy

http://www.science.doe.gov/opa/
Comments

- LBNF/DUNE embodies a high level of management challenge
  - Transition from LBNE
  - First International megaproject hosted by US
- Fermilab management, including the Lab Director, is fully engaged in LBNF/DUNE in a positive way.
- Very (very) strong management team members in place on both projects; also good news that full-time LBNF Project Director about to start
- It is impressive that the DUNE collaboration has already made significant progress given that it met for the first time at Fermilab in April. It is important to maintain that momentum.
- There is a strong commitment to regular and substantive communication both within, and between, LBNF and DUNE.
- For example, EFIG has already proved productive.
- Strong link demonstrated between science objectives & detector specifications
Welcome to Chris Mossey, who started July 20 as FNAL Deputy Director for LBNF and LBNF Project Director

Rear Admiral Christopher J. Mossey, CEC, USN (retired), P.E.

Rear Admiral Chris Mossey is a private consultant with over three decades of experience leading design, construction, environmental, and facility programs for the Department of the Navy.

His last active duty assignment was as the Commander of the Naval Facilities Engineering Command, a 19,000 person global organization that provides over $12 billion in annual planning, engineering, and public works support to the Navy, Marine Corps, and other defense organizations. While serving in this position, Mossey helped to develop the Navy’s sustainability and installation climate change strategies as the shore engineering expert on the Navy’s Energy and Climate Change Task Forces. Working with a diverse array of stakeholders, he also oversaw the ongoing build-out of the Navy’s “smart grid” utility network at 78 bases around the world.
A very (very) strong project team

Elaine McCluskey
LBNF Project Manager

Marzio Nessi
CERN LBNF Project Manager

Mike Headley
LBNF Far Site Project Manager
Opening of Sanford Lab Homestake Visitor Center 6/30/15

Governor Dennis Daugaard talking about neutrinos
Modified text: 

**LBNC**

- Recommended by the Fermilab PAC as a new committee focused on DUNE/LBNF and the new short baseline program
- Modeled after the LHCC at CERN
- To review the scientific, technical and managerial decisions/preparations of the experiment

o Chair: David MacFarlane (SLAC)  
o Ursula Bassler (IN2P3)  
o Francesca Di Lodovico (Queen Mary)  
o Patrick Huber (Virginia Tech)  
o Mike Lindgren (FNAL)  
o Naba Mondal (TIFR)  
o Tsuyoshi Nakaya (Kyoto)

o Dave Nygren (UT Arlington)  
o Stephen Pordes (FNAL)  
o Kem Robinson (LBNL)  
o Nigel Smith (SNOLAB)  
o Dave Wark (Oxford)
Science is happening

- LHC Run 2 analysis @ Fermilab
- NOvA, MINERvA, MINOS+ all producing results
- Discoveries already from the Dark Energy Survey
- Muon g-2 powers up soon
- Holometer results
- SeaQuest results
- Lots of Tevatron analyses wrapping up
- Great theory papers (not by me)
CMS results from Run 2

Plot from Fermilab postdoc Zhen Hu
- **13 TeV**: 37 pb⁻¹, \( M_{jj} = 5 \) TeV, **8 TeV**: 19.7 fb⁻¹, \( M_{jj} = 5.15 \) TeV

- **Close to Run 1 limit** ➔ **interesting times ahead of us 😊**
DES Summary

- Setting up observing schedule for Year 3 (starts early August)
- Engineering run scheduled to maintain cooling system

Completion after Y2

Projected completion after Y3

- 11 papers submitted for 16 talks at April APS meeting
- ~10 more planned for this month
## Cosmic Frontier Experiment Status

**July 6, 2015**

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Location</th>
<th>Status</th>
<th>Start of operations</th>
<th>Nominal end of operations</th>
<th>Physics</th>
</tr>
</thead>
<tbody>
<tr>
<td>SuperCDMS</td>
<td>Soudan</td>
<td>Operating</td>
<td>Mar 2012</td>
<td>Sep 2015</td>
<td>Dark Matter</td>
</tr>
<tr>
<td>COUPP/PICO 2L</td>
<td>SNOLAB</td>
<td>Operating</td>
<td>Dec 2013</td>
<td>Sep 2017</td>
<td>Dark Matter</td>
</tr>
<tr>
<td>COUPP/PICO 60</td>
<td>SNOLAB</td>
<td>Refurbishing</td>
<td>June 2013</td>
<td>Sep 2017</td>
<td>Dark Matter</td>
</tr>
<tr>
<td>Darkside 50</td>
<td>LNGS (Gran Sasso)</td>
<td>Operating</td>
<td>Jan 2014</td>
<td>Sep 2017</td>
<td>Dark Matter</td>
</tr>
<tr>
<td>DAMIC</td>
<td>SNOLAB</td>
<td>Operating</td>
<td>Dec 2012</td>
<td>Sep 2016</td>
<td>Dark Matter</td>
</tr>
<tr>
<td>Dark Energy Survey</td>
<td>CTIO, Chile</td>
<td>Operating</td>
<td>Sep 2013</td>
<td>Feb 2018</td>
<td>Dark Energy</td>
</tr>
<tr>
<td>Holometer</td>
<td>Meson Lab</td>
<td>Operating</td>
<td>Sep 2014</td>
<td>Sep 2016</td>
<td>Spacetime</td>
</tr>
</tbody>
</table>
First NOvA results!

NOvA Electron Neutrino Appearance

- If we take the reactor measurement of $\theta_{13}$ as an input we can ask how well the NOvA event counts fit to particular choices of the mass ordering and $\delta_{\text{CP}}$
- Both LID and LEM prefer normal mass ordering with $\delta_{\text{CP}}$ between $\pi$ and $2\pi$
- For LID ($n=6$, top plot) there is some tension with the inverted hierarchy especially for $\delta_{\text{CP}}$ near $\pi/2$
- For LEM ($n=11$, bottom plot) the inverted hierarchy is everywhere disfavored at $2\sigma$
  
  **Beware of trials factor of choosing to only look at LEM results** - true answer is most likely somewhere in between top and bottom results. We will have roughly $x2$ more data to report at Neutrino in July, 2016
- A further note: The jagged contours are a result of small-number statistics

This is just the beginning:

We expect to be giving NOvA a 700 kW beam next year
News Flash: first events from MicroBooNE!

Run 1148 Event 778. A

Run 1153 Event 40. August 6th 2015 21:07
In 10 years, Fermilab will have a modern, centralized campus catering to a large international user community doing neutrinos, LHC, muons, and cosmic

CD-0 approval granted July 17 from DOE SLI program for new Integrated Engineering Research building at Fermilab
Thank you!

(don’t look down)