Review of the DOE Office of Science Facilities Planning Exercise

Meeting of the Proton Beam Working Group (WG3)
of the
CSS-2013 Capabilities Frontier

April 17th 2013, BNL

R. Tschirhart
Fermilab

Resources & Executive Summary

- Material in this presentation was cribbed at nearly the 100% level from the presentations of Andy Lankford (UCI, HEPAP chair, Facilities sub-panel chair), and Mark Wise (Caltech, Facilities sub-panel member) at the March 11th HEPAP meeting.

- The Facilities sub-panel report has been ratified by HEPAP and accepted by the Office of Science as valid input for further deliberation.

- This discussion will focus on Intensity Frontier facilities.

- The HEPAP report is posted at:

http://science.energy.gov/hep/hepap/reports/

Context of Subpanel

- **The DOE Office of Science has charged all of its Federal Advisory Committees to help with "an important task" – prioritization of facilities.**

> *Goal Statement: Prioritization of scientific facilities to ensure optimal benefit from Federal investments.*
>
> *By September 30, 2013, formulate a 10-year prioritization of scientific facilities across the Office of Science based on (1) the ability of the facility to contribute to world-leading science, (2) the readiness of the facility for construction, and (3) an estimated construction and operations cost of the facility.*

- **3-step process:**
  1. *The DOE/SC Associate Directors (Siegrist) create a list of facilities or upgrades.*
     complete
  2. *DOE/SC Federal Advisory Committees (HEPAP) provide advice and input.*
     this exercise
  3. *DOE/SC Director (Brinkman) prioritizes proposed facilities and upgrades across scientific disciplines according to his/her assessment.*
     comes next

Lankford, HEPAP Subpanel Report, March 11, 2013 2

Role of Subpanel

- The DOE Office of Science has charged all of its Federal Advisory Committees to help with "an important task" – prioritization of facilities.

- At SC's suggestion, empanelled a subcommittee.
- The specific advice sought is an assessment of:
  - ability of facility to contribute to "world-leading science" in next decade
  - readiness of the facility for construction
- The assessment is to be summarized in broad categories:
  - Science
    a) absolutely central
    b) important
    c) lower priority
    d) don't know enough yet
  - Construction readiness
    a) ready to initiate construction
    b) significant scientific/engineering challenges to resolve before initiating construction
    c) mission and technical requirements not yet fully defined
- SC: "do not rank order the facilities"

- In the preceding presentation, Jim Siegrist has covered the relationship of this subpanel to the Community Planning & P5 process.

Lankford, HEPAP Subpanel Report, March 11, 2013 3

Science Classification

- **ability of facility to contribute to "world-leading science" in next decade**

- **Classes:**
  - a) **absolutely central**
  - b) **important**
  - c) **lower priority**
  - d) **don't know enough yet**

- **consider, for example:**
  - **Scientific impact:** extent to which the proposed or existing facility or upgrade would answer the most important scientific questions;
  - **Uniqueness:** whether there are other ways or other facilities that would be able to answer these questions;
  - **Breadth:** whether facility would contribute to many or few areas of research
  - **Breadth of users:** especially whether facility will address needs of the broad community of users including those supported by other Federal agencies;
  - **User demand:** what level of demand exists within the (sometimes many) scientific communities that use the facility.
  - **Synergies:** whether construction of the facility will create new synergies within a field or among fields of research;

Subpanel Timeline

12/20/2012	Brinkman letter w/charge
	Constitute committee
1/31/2013	1st subpanel telecon
2/ 7 /2013	2nd subpanel telecon
2/13/2013	Open Meeting
2/14/2013	Subpanel face-to-face meeting
	5 subpanel telecons
3/11/2013	Preliminary conclusions presented at HEPAP meeting discussion and feedback from HEPAP
	subpanel and drafting meetings
3/22/2013	Final (HEPAP approved) report due to SC

Lankford, HEPAP Subpanel Report, March 11, 2013 6

Subpanel Members

Andy Lankford,	*UC Irvine (chair)*
Sally Dawson,	*BNL*
Peter Fisher,	*MIT*
Joshua Frieman,	*Chicago/Fermilab*
Stuart Henderson,	*Fermilab*
Norbert Holtkamp,	*SLAC*
Mark Messier,	*Indiana U.*
Ritchie Patterson,	*Cornell*
Regina Rameika,	*Fermilab*
Marjorie Shapiro,	*UC Berkeley/LBNL*
Robert Tschirhart,	*Fermilab*
Andrew White,	*U. Texas, Arlington*
Mark Wise,	*Caltech*

- **Initial list provided by OHEP.**

Energy Frontier
- Hi Lum LHC Accelerator
- Hi Lum LHC detectors - ATLAS
- Hi Lum LHC detectors - CMS
- ILC (hosted in Japan) Accelerator
- ILC (hosted in Japan) ILC Detectors
- Higgs Factory

Intensity Frontier
- Mu2e
- LBNE
- Project X Accelerator
- Project X Detectors
- nuSTORM

Cosmic Frontier
- LSST
- G3 Dark Matter
- Next Generation Dark Energy

- **Subpanel may add or subtract from list.**
  - **additions must: US cost > 100M$ + be ready for CD-1 by 2024**

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Facilities List - final version

Energy Frontier

- Hi Lum LHC Accelerator
- Hi Lum LHC detectors - ATLAS
- Hi Lum LHC detectors - CMS
- ILC (hosted in Japan) Accelerator
- ILC (hosted in Japan) ILC Detectors
- ~~Higgs Factory~~

facility plan not sufficiently well defined to assess at this time
→ expect discussion at Snowmass

Intensity Frontier

- Mu2e
- LBNE
- Project X Accelerator
- Project X Detectors
- nuSTORM

Cosmic Frontier

- LSST
- G3 Dark Matter
- Next Generation Dark Energy

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- **Scope**
  - **(US) cost > 100M$**
  - **Timescale – 2024**
    - **Taken to mean ready for DOE CD-1 by 2024**

- **Next generation neutrino-less double beta decay experiment**
  - **On NSAC facilities list**
    - **Office of Nuclear Physics is currently steward.**
    - **Subpanel will monitor, to ensure our community's interests represented**

- **Other projects called to Subpanel's attention:**
  - Cherenkov Telescope Array (CTA)
  - e-NuMI
  - Dedaelus
  - Next generation axion searches (DM on list is G3 WIMP searches)
  - Next generation cosmic microwave background program
  - 80-100 km tunnel capable of pp and/or e+e- collider
  - **Much input material is posted on subpanel Open Meeting agenda page.**
- **These projects were estimated to be below or approx at the facility cost threshold and/or DOE/SC is not lead agency.**

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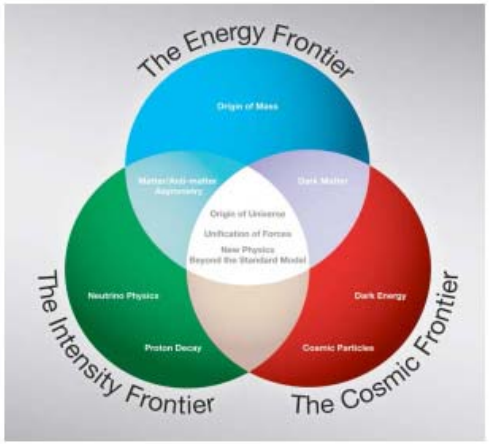
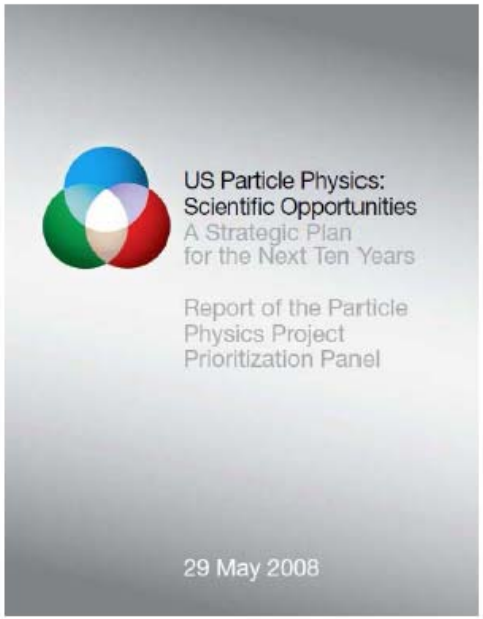
Reference frame



- **The subpanel is not without guidance.**
- **From charge letter:**

  "In its deliberations, the subcommittees should reference relevant planning documents and decadal studies."
- **HEP has a roadmap: 2008 P5 report**
  - **A balanced program on 3 frontiers**
  - **Nearly all facilities on the initial list are on P5 roadmap.**

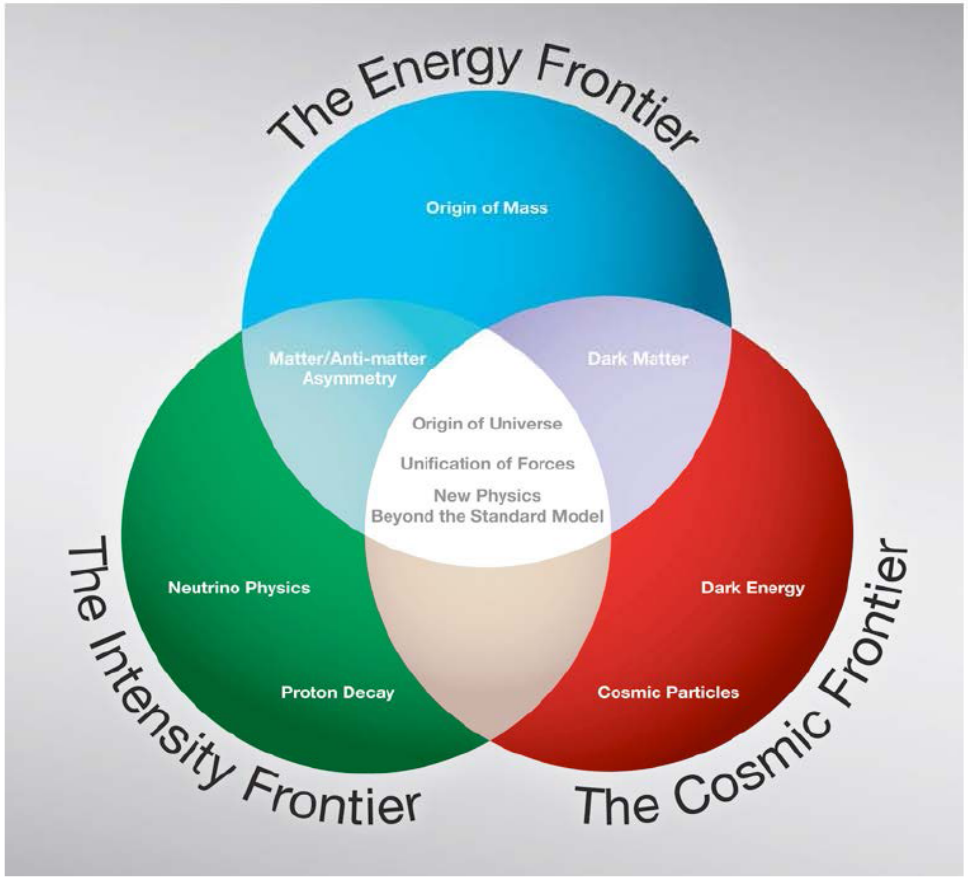


- **Other reports and studies, including:**
  - **2003 HEP facilities report**
  - **PASAG**
  - **NRC DUSEL report**
  - **NRC decadal survey for astronomy & astrophysics**
  - **LBNE reconfiguration report**
  - **Proposed Update of the European Strategy**

The facilities on list have generally been in planning, discussion, and on HEP roadmap for considerable time.
They are the facilities needed to address the most important science questions, on the 3 frontiers, in the near or longer term.

P5 Vision: A balanced program on 3 frontiers

to address the most important science questions.



The panel recommends that the US maintain a leadership role in world-wide particle physics.

The panel recommends a strong, integrated research program at the three frontiers of the field: the Energy Frontier, the Intensity Frontier and the Cosmic Frontier.

A program that:

- **continuously produces important results on each frontier**
- **harmonizes with the worldwide program**

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P5 – Intensity Frontier - 1

Neutrino program w/ Project X

The panel recommends a world-class neutrino program as a core component of the US program, with the long-term vision of a large detector in the proposed DUSEL and a high-intensity neutrino source at Fermilab.

The panel recommends an R&D program in the immediate future to design a multi-megawatt proton source at Fermilab and a neutrino beamline to DUSEL and recommends carrying out R&D on the technologies for a large multi-purpose neutrino and proton decay detector.

DUSEL

The panel endorses the importance of a deep underground laboratory to particle physics and urges NSF to make this facility a reality as rapidly as possible. Furthermore the panel recommends that DOE and NSF work together to realize the experimental particle physics program at DUSEL.

Other neutrino recommendations:

- **700 kW proton beam**
- **NOvA in all but bad budget scenario**
- **Daya Bay & DoubleCHOOZ**
- **Neutrinoless double beta decay**

Note:
Possible LBNE + Project X start within 10 yrs

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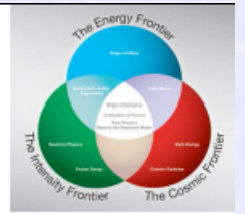
P5 – Intensity Frontier - 2



Precision measurements

The panel recommends funding for measurements of rare processes to an extent depending on the funding levels available, …

The panel recommends pursuing the muon-to-electron conversion experiment, subject to approval by the Fermilab PAC, under all budget scenarios considered by the panel.

The intermediate budget scenario, scenario B, would allow pursuing significant participation in one overseas next-generation *B factory*.

***The more favorable* funding scenario, scenario C, would allow for pursuing a program in rare *K decay* *experiments*.**

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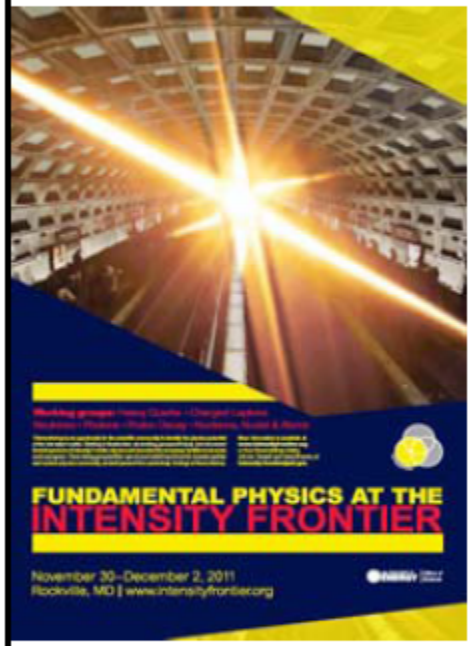
Intensity Frontier Workshop

SLAC



Fundamental Physics at the Intensity Frontier **: Rockville, MD Nov 30-Dec 2, 2011**

Jointly Sponsored by DOE office of HEP and Nuclear Physics

~500 participants

3 days of vibrant talks and discussion

Charge:

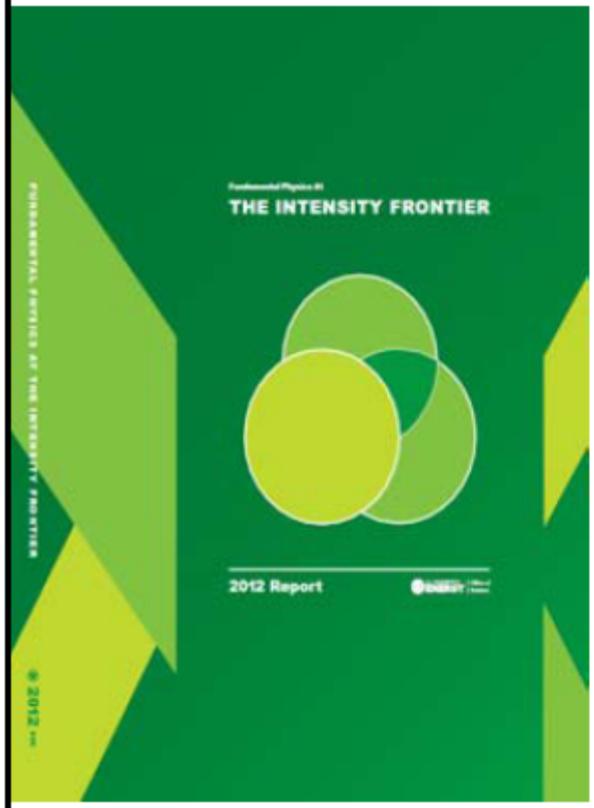
Document the science opportunities at the Intensity Frontier

Identify experiments and facilities needed for components of program

JoAnne Hewett, March 2013

Workshop Report

SLAC



arXiv:1205.2671

Everyone who contributed is an author

~ 440 authors

~ 220 pages

Contents:

Exec Summary

Chapter for each working group

Technical Summary

JoAnne Hewett, March 2013

Intensity Frontier – Vision, Status, Strategy

Vision: Implement comprehensive program to understand **neutrino mixing.**

Deliver much improved limits (measurements?) of **charged lepton mixing** and **hidden sector phenomena**

Explore **neutrino properties**: mass and nature

Status:

- **Diverse program** of existing experiments **beyond Fermilab**
  Daya Bay, Double-Chooz, K2K/SuperK, EXO-200, MJD, K0TO, Belle/Belle-II, BES III
- **Ongoing world-class neutrino program** at Fermilab
  Sterile neutrino sector: MicroBooNE (appearance), MINOS+ (disappearance)
  Establishing framework: MINERvA (neutrino cross-sections),
  NOvA (confirm θ_{13} thru appearance; determine mass hierarchy)
  Includes accelerator upgrade for NOvA & Proton Improvement Plan
- **Emerging program –** g-2, Mu2e, LBNE entering construction

Strategy:

- **Devote FNAL accelerator complex to IF to advantage of worldwide community**
- **Develop LBNE to its full potential**
- **Construct Project X to feed rich, world-leading IF program** w/ ν's, μ's, K's

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Relationship to Community Planning & P5 Process

- See recent letter from Fleming Crim (NSF) & Jim Siegrist (DOE).

- A multistep process
  - Each step will inform and prepare for the next.

- Facilities subpanel is 1st step.
  - Note well-defined scope: >100M$ & 10 years
  - No rank ordering by HEP
  - NOT intended to preclude add'l. ideas that emerge in subsequent steps

- DPF-led community planning ("*Snowmass*") process is 2nd step.
  - Capable of more detailed studies
  - Culminates in July 20 – August 10 workshop
  - Wider portfolio of activities
  - ~20 year time horizon

- Project prioritization subpanel is 3rd step.
  - Expected after Snowmass process complete
  - Work with input from Snowmass + budgetary input from DOE/NSF
  - Form strategic plan in various scenarios
  - HEPAP/P5 is one of few official paths for agencies to gather community input.

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Intensity Frontier - Facilities

Neutrino physics:

- Long baseline:
  - NOvA – coming on line this year; MINOS+ this year
  - LBNE – CD-1 approval for Stage 1, with possible further enhancements from international collaboration; further stage(s) in future
- Short baseline:
  - MINERvA, MicroBooNE
  - nuSTORM – conceptual stage

Flavor physics in the quark sector:

- PEP-II/BABAR & CESR/CLEO - closed 2008
- LHCb – small but important US participation
- Super-KEKB/BELLE-II

Muon physics:

- g-2 – in preparation
- Mu2e – CD-1 approved;

Project X:

- Project X accelerator: technically ready for construction
- Project X experimental program:
  - Significantly enhances LBNE & Mu2e (the CD-1 approved experiments)
  - Rich scientific program – in conceptual development

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Facility Characterization

- LBNE: Stage 1 begins a world leading program in neutrino physics +… . Science reach of Stage 1 is *important* and it lays the groundwork for an *absolutely central* facility. *Ready for construction,* planned start in 2016 and completed in 2023.
- MU2E: Will search for muon to electron conversion in the field of a nucleus with unparalleled sensitivity. It is *absolutely central. Ready for construction* starting in 2014, completed in 2018.
- PROJECT X: Unique world leading facility at Fermilab for intensity frontier physics. It is *absolutely central* and although it is pre CD0 it is *ready for construction*.
- nuSTORM: Muon storage ring that would provide neutrino beams with well defined flavor composition and spectrum. While the committee is not aware of major technical challenges in realizing nuSTORM, its performance *requirements are not yet fully defined*. While nuSTORM has great potential we *don't know enough* yet to assess nuSTORM's role in US world-leading science.

Mark Wise, HEPAP March 11th 2013

Conclusions

- Exciting times for particle physics, and new facilities are key to driving the field forward.
- Both the Facilities sub-committee and HEPAP are impressed by science opportunities enabled with next-generation particle sources produced with proton beams.
- The principal challenge is budgetary…and not by a lot. Technologies exist within our grasp and within imaginable resources to make major steps forward.
- Our challenge here is to explore and develop beam & facility concepts and strategies to meet this challenge.