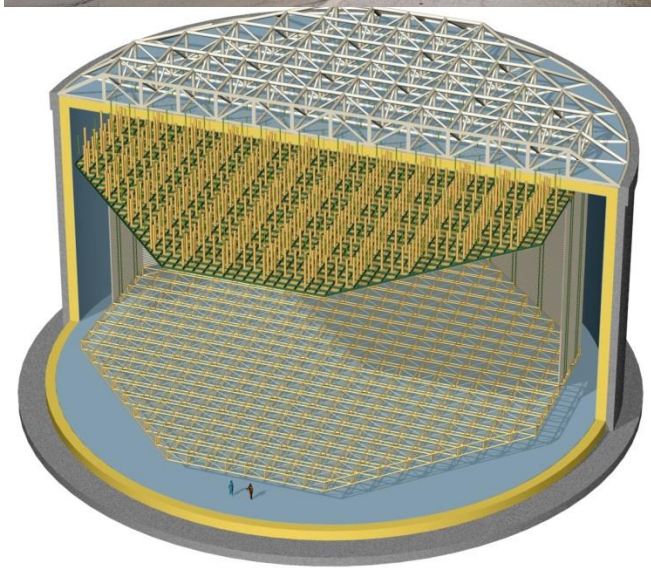
The last months path to (E)LBNF

GDR Neutrino Marseille, 26 November 2014

D. Autiero (IPNL Lyon)



Chronology:

1) The P5 report (May 2014)

2) The APPEC Neutrino Strategy Meeting Paris 23-24 June 2014

2) The Neutrino Summit (Fermilab 21-22 July 2014)
→ *Constitution of the Interim International Executive Board (IIEB)*

3) First IIEB meeting (23-24 September 2014)
→ *Writing of the LOI*

4) Geotechnical meeting at Homestake (Sanford Underground Lab.)
8-10 October 2014, some outcomes presented at NNN14

5) Meetings for the presentation of the LOI CERN 5 December, FNAL 12 December

6) Next …

Neutrino Oscillation Experiments (Long Baseline)

- For a long-baseline oscillation experiment, based on the science Drivers and what is practically achievable in a major step forward, we set as the goal a mean sensitivity to CP violation of better than 3σ (corresponding to 99.8% confidence level for a detected signal) over more than 75% of the range of possible values of the unknown CP-violating phase δ_{CP}.
  - By current estimates, this corresponds to an exposure of 600 kt*MW*y assuming systematic uncertainties of 1% and 5% for the signal and background, respectively. With a wideband neutrino beam produced by a proton beam with power of 1.2 MW, this implies a far detector with fiducal mass of more than 40 kilotons (kt) of liquid argon (LAr) and a suitable near detector.
- **The minimum requirements to proceed are the identified capability to reach an exposure of at least 120 kt*MW*yr by the 2035 timeframe, the far detector situated underground with cavern space for expansion to at least 40 kt LAr fiducial volume, and 1.2 MW beam power upgradable to multi-megawatt power. The experiment should have the demonstrated capability to search for supernova (SN) bursts and for proton decay, providing a significant improvement in discovery sensitivity over current searches for the proton lifetime.**

These minimum requirements are not met by the current LBNE project's CD-1 minimum scope.

Neutrino Oscillation Experiments (LBNF)

- The long-baseline neutrino program plan has undergone multiple significant transformations since the 2008 P5 report. Formulated as a primarily domestic experiment, the minimal CD-1 configuration with a small, far detector on the surface has very limited capabilities.
- A more ambitious long-baseline neutrino facility has also been urged by the Snowmass community study and in expressions of interest from physicists in other regions.
- To address even the minimum requirements specified above, **the expertise and resources of the international neutrino community are needed.**

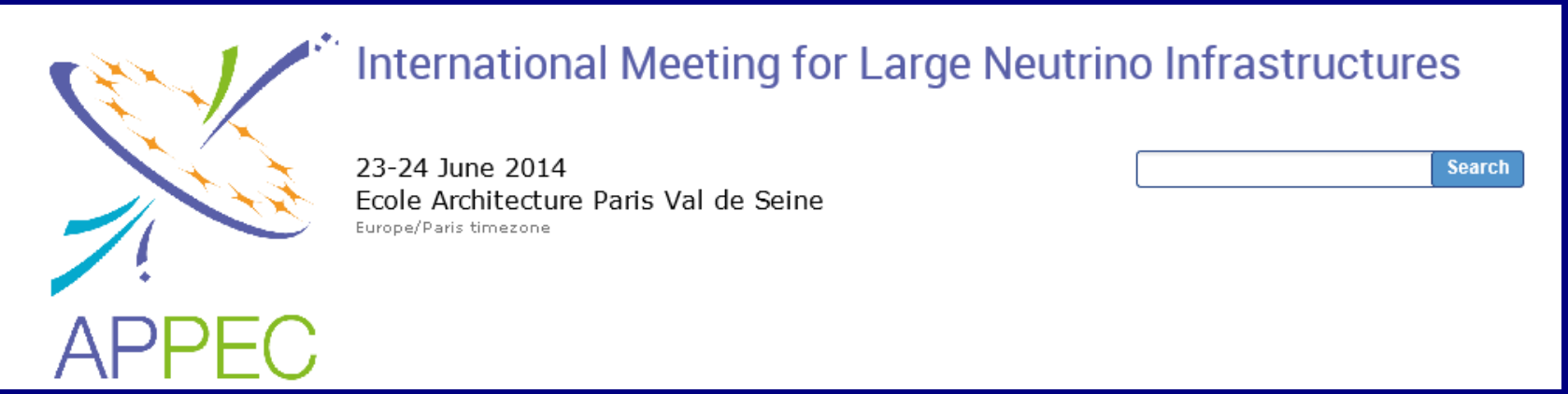
- **A change in approach is therefore required**: The activity should be reformulated under the auspices of a new international collaboration, as an internationally coordinated and internationally funded program, with Fermilab as host. There should be international participation in defining the program's scope and capabilities. The experiment should be designed, constructed, and operated by the international collaboration. The goal should be to achieve, and even exceed if physics eventually demands, the target requirements through the broadest possible international participation.

Form a new international collaboration to meet the P5 requirements, LBNF is the highest priority project

Neutrino Oscillation Experiments (LBNF)

- Key preparatory activities will converge over the next few years: in addition to the international reformulation described above, PIP-II design and project definition will be nearing completion, as will the necessary refurbishments to the Sanford Underground Research Facility. Together, these will set the stage for the facility to move from the preparatory to the construction phase around 2018. The peak in LBNF construction will occur after HL-LHC peak construction.

- **Recommendation 13: Form a new international collaboration to design and execute a highly capable Long-Baseline Neutrino Facility (LBNF) hosted by the U.S. To proceed, a project plan and identified resources must exist to meet the minimum requirements in the text. LBNF is the highest-priority large project in its timeframe.**



https://indico.cern.ch/event/303475/ **→Press release:**
http://www.appec.org/9-features/82-neutrino-physics-enters-the-global-era.html

The agencies[1] and laboratory directors[2] gathered at the International Meeting on Large Neutrino Infrastructures hosted by APPEC[3] in Paris on 23 and 24 June 2014, agreed that the understanding of the neutrino sector is a worldwide priority promising physics beyond the Standard Model, ….

They support the vision of the HEPAP/P5 report to host an international facility for short and long-baseline neutrino oscillations at Fermilab, where internationally driven collaborations are encouraged to propose a program optimised in baseline and detector technology. This approach, in parallel with the decision of Fermilab to upgrade its beam infrastructure (PIP-II) gives the opportunity for a rich international neutrino program at Fermilab.
The agencies and laboratory directors invite the neutrino scientific community to develop urgently a coherent international program which exploits the above opportunities. They will meet again in early 2015 in the U.S.A, to evaluate the progress made with respect to this goal.

P5 recommendation:

Form a new international collaboration to design and execute a highly capable Long-Baseline Neutrino Facility (LBNF) hosted by the U.S. To proceed, a project plan and identified resources must exist to meet the minimum requirements in the text [of the report]. LBNF is the highest-priority large project in its timeframe.

P5's Minimum Requirements for LBNF:

- Exposure > 120 kt·MW·yr by 2035 timeframe
- Underground far detector,
  expandable to 40 kt LAr fiducial volume
- 1.2 MW beam power, upgradable
- Capability to search for SNe bursts, proton decay

N. Lockyer established the summit as a means to initiate the process of establishing the necessary international collaboration.

Neutrino summit meeting chaired by K.Long and R.Roser 21-22 July 2014
Slide on the Summit presented by K.Long to the Fermilab PAC on 23/7/2014

Mandate and invitation:

June 12, 2014

Dear Neutrino Invitee,

I am writing to invite you to a meeting at Fermilab July 21-22, 2014. This meeting is an outcome of the recent May 2014 US P5 report, "Building for Discovery." The 12th recommendations states: "In collaboration with international partners, develop a coherent short-and long-baseline neutrino program hosted at Fermilab." The 13th recommendation states: "Form a new international collaboration to design and execute a highly capable Long-Baseline Facility (LBNF) hosted by the US. To proceed, a project plan and identified resources must exist to meet the minimum requirements stated in the report. LBNF is the highest-priority large project in its timeframe."

The ICFA Neutrino Panel has issued its first report (May 27, 2014—see attached) and has identified the beginnings of what might constitute an exciting international accelerator-based neutrino program.

The US Department of Energy has indicated the time critical nature for determining whether the international community is prepared to embrace the offer that Fermilab and the US host an international long-baseline neutrino program. We are therefore calling a meeting to determine whether the world accelerator-based neutrino community can come together and form a new collaboration to design and propose together a program that meets the P5 requirements.

We propose to have an open discussion that entertains all views as to how best to design an international facility so that we optimize the physics outcome within agreed upon constraints. We think it important for the initial discussion that everything should be on the table. The planned growth in short-baseline program and its coherence with the long baseline program may be of interest as well. Practical constraints will be presented by DOE and will need to be factored into the discussions. Ken Long, Chair of the ICFA Neutrino Panel, and Rob Roser, a Fermilab scientist, have agreed to co-chair the meeting.

I invite you to attend this "by invitation only" meeting on July 21-22, 2014 at Fermilab. We are aiming a working meeting and a limited participation of 20-30 people. This will be the first of several workshops to reach our goal. The agenda and format of the meeting will be prepared by the co-chairs once we know who can attend. Please respond to Hema Ramamoorthi (hema@fnal.gov) with your intention to attend by Monday, June 16, 2014. We hope you recognize this is an excellent opportunity for the world accelerator-based neutrino community to realize its ambitious physics goals.

- Invitation sent to key leaders in the field across the world.

Slide on the Summit presented by K.Long to the Fermilab PAC on 23/7/2014

Summit attendees:

Summit#1 Attendees					
Last name	*First name*	*Affiliation*	*Last name*	*First name*	*Affiliation*
KATSENEVAS	Stavros	APC, Paris (France)	NAKAYA	Tsuyoshi	Kyoto (Japan)
KRUECKEN	Reiner	Vancouver (Canada)	KIM	Soo Bong	
STONE	Alan	DOE	ZELLER	Sam	
SIEGRIST	Jim	DOE	BRICE	Steve	Fermilab
ESCOBAR	Carlos	Latin America	DIWAN	Milind	BNL (USA)
TANAKA	Hirohisa		FLEMING	Bonnie	Yale (USA)
OSER	Scott	UBC (Canada)	JUNG	Chang Kee	SUNY Stony Brook (USA)
WANG	Yifang	IHEP (China)	Klein	Joshua	University of Pennsylvania
BLONDEL	Alain	Geneva (Switzerland)	LANG	Karol	U Texas, Texas (USA)
DRACOS	Maros	IN2P3, Strasbourg (Frande)	MESSIER	Mark	Indiana (USA)
LODOVICO (de)	Francesca	QMUL (UK)	RAMIEKA	Gina	FNAL (USA)
SANCHEZ	Federico	IFAE/Barcelona (Spain)	SVOBODA	Bob	UC Davis (USA)
STANCO	Luca	Padova (Italy)	WALTER	Chris	Duke (USA)
THOMSON	Mark	Cambridge (UK)	WATER (van de)	Richard	LANL (USA)
TOURAMANIS	Christos	Liverpool (UK)	WILSON	Bob	Colorado State (USA)
WARK	Dave	STFC/RAL (UK)	Wilson	Peter	Fermilab
ZITO	Marco	CEA Saclay (France)	LIN	Cheng-Ju Steve	
WASCKO	Morgan		GEER	Steve	Fermilab
DUCHENEAU	Dominiques		SCHOLBERG	Kate	Duke (USA)
AUITERO	Dario	IPNL -CNRS/IN2P3 in France	KEARNS	Ed	Boston (USA)
RUBBIA	Carlo		Strait	Jim	Fermilab
NESSI	Marzio	CERN (Switzerland)	GANDHI	Raj	HRI/Fermilab
KOBAYASHI	Takashi	KEK, Tskuba (Japan)	HUBER	Patrick	VT, Blacksberg, VA (USA)
NAKAHATA	Masayuki	IPMU (Japan)	PASCOLI	Silvia	IPPP (UK)
NAKAYA	Tsuyoshi	Kyoto (Japan)	PARKE	Stephen	FNAL, Chicago (USA)

48 participants spanning the three regions, experiment, theory and phenomenology

Slide on the Summit presented by K.Long to the Fermilab PAC on 23/7/2014

Neutrino Summit Meeting

from Monday, July 21, 2014 at **09:00** to Tuesday, July 22, 2014 at **14:45** (US/Central)
at **Fermilab (1 West)**

Monday, July 21, 2014

09:00 - 09:15 Welcome and Logistics *15'*
Speakers: Dr. Robert Roser (Fermilab), Prof. Kenneth Long (Imperial College London)
Material: **Slides**

09:15 - 09:35 View from DOE *20'*
Speaker: Jim Siegrist (DOE)
Material: **Slides**

09:35 - 09:45 Questions + Answers *10'*

09:45 - 10:10 View from Fermilab *25'*
Speaker: Dr. Nigel Lockyer
Material: **Slides**

10:10 - 10:20 Questions + Answers *10'*

10:20 - 10:50 Coffee Break *30'*

10:50 - 11:20 PIP -II Status, Plans and Characteristics *30'*
Speaker: Stephen Holmes (Fermilab)
Material: **Slides**

11:20 - 11:30 Questions + Answers *10'*

11:30 - 11:45 Summary of International Meeting for Large Neutrino Infrastructures *15'*
Material: **Slides**

11:45 - 12:00 **What are the overall goals/plans for this workshop** *15'*

Topics for 2 Discussion Groups

1. *What are the Physics Priorities and how to attack them*
- *baseline and energy*
- *broad beam vs narrow*
- *advantages of liquid Argon, liquid scintillator, water for neutrino's, proton decay, supernova*
- *appropriate size of cavern*
- *hybrid solutions (two different technologies in a single cavern) -- what is gained, what is lost...*

2. *Near Detector Optimization*
- *What is the right technology/size*
- *Does it make sense to build it early and install it in our NUMI beam line*
- *Systematics – how does near detector choice impact them*
- *characterizing beam -- is it a different set of priorities if 1st/2nd maximum?*
- *Other physics one can do in near detector program*

- *This can also be part of a larger discussion on short baseline physics, what do we need to do and how does the SBN community fit into the LBN community*

3. *Beam Characteristics*

- *How do we set up the beam to optimize science*
- *Would a slightly steerable beam help?*
- *Is it realistic to change beam energy to SURF and do 2nd maximum physics?*

Speakers: Dr. Robert Roser (Fermilab), Prof. Kenneth Long (Imperial College London)

Material: **Slides**

12:00 - 13:00 **Working Lunch** *1h0'*

13:00 - 16:00 **2 Discussion Groups** *3h0'* (1 East and Comitium)

- *Half of the attendee's in each group to discuss all of the above points – and other topics if appropriate*

16:00 - 17:00 **Short report back from each group -- no slides, just main themes, hot spots, where people are tripping** *1h0'*

17:00 - 19:00 **Reception - Dinner** *2h0'* (Chez Leon)

Tuesday, July 22, 2014

09:00 - 10:30	Continue Discussions in the two groups *1h30'* *Identify next steps....* Material: **Slides**
10:30 - 11:00	Coffee Break
11:00 - 12:00	Continue Discussion Groups
12:00 - 13:00	Working Lunch *1h0'*
13:00 - 14:30	Formal Closeout with slides *1h30'*
14:30 - 14:45	Wrap-up *15'* Speakers: Dr. Robert Roser (Fermilab), Prof. Kenneth Long (Imperial College London) Material: **Slides**

Agenda full material available at:

https://indico.fnal.gov/conferenceDisplay.py?confId=8689

Working groups:

- Facility configuration:
  - Benefit to physics programme by:
    - Energy/baseline
    - Beamline optimisation
    - Detector optimisation:
      - Including:
        - » LAr, H_2O, Scintillator-doped H_2O, hybrid options, staging
- Facility implementation:
  - Far site:
    - Conventional facilities impact:
      - Cost & schedule;
      - Depth of near detector;
      - Site survey and available infrastructure
  - Near site
    - Size, depth, services
  - Beam and laboratory infrastructure
- Supporting programme:
  - Systematics
  - Use of test beams (CERN platform, FNAL, …)
  - Ancillary measurement programme required to reach precision:
    - Hadro-production, hadron-nucleus scattering, neutrino-nucleus scattering

Exploiting studies, information and resources of the work that has been done in US and Europe

Slide on the Summit presented by K.Long to the Fermilab PAC on 23/7/2014

Background and assumptions:

- Summit follows two other meetings of FA/Lab representatives (Paris and FNAL) who were:
  - Supportive of developing urgently a coherent international program (of which LBNF is part) that exploits current opportunities being offered in the US
- Successful execution of a long-baseline program at the necessary level of requires:
  - Worldwide efforts of experimenters, theorists & phenomenologists to:
    - Control systematics; and
    - Perform the necessary detector R&D
- Only two assumptions were made:
  - Fermilab would provide the source of neutrinos;
  - The baseline would be such that the matter effect could be exploited

  i.e. baseline, beam energy and detector optimisation were all open for discussion.

Slide on the Summit presented by K.Long to the Fermilab PAC on 23/7/2014

Convergence and urgency:

- The community has converged on the develoment of two concepts:
  - Longer baseline, wide-band approach hosted in the US:
    - Matched to LAr, possibly enhanced through H_2O/H_2O-scint
  - Shorter baseline, narrow-band approach hosted in Japan:
    - Matched to H_20-Cherenkov

- Community acknowledges:
  - Urgency to establish a coherent and unified path forward or the window of opportunity could close

  and has agreed:
  - A timetable for the preparation of the LOI and the full proposal (CDR)

Slide on the Summit presented by K.Long to the Fermilab PAC on 23/7/2014

Building the collaboration:

- It was agreed to establish an
  - *Interim International Executive Board (IIEB)*

  to help form the collaboration and to:
  - Deliver (through the w/gs) the LOI; and to
  - Guide the development of the CDR
- The IIEB will:
  - Report to the emerging collaboration;
  - Be constituted and given its mandate by the ad-hoc funding-agency/lab-director group referred to above;

  and *importantly* will …
  - Be superseded by the collaboration governance as soon as the collaboration has been formed;

Slide on the Summit presented by K.Long to the Fermilab PAC on 23/7/2014

Tuesday, Aug. 19, 2014

Search GO

Director's Corner

Doing our part to make the P5 vision a reality

Fermilab Director Nigel Lockyer

Three months ago the Particle Physics Project Prioritization Panel (P5) released its recommendations for the future of particle physics in the United States. Many lab employees, users and members of the broader scientific community have worked hard this summer to kick-start the effort to achieve the P5 vision. Today's column provides an update of where we stand in our effort to align the lab's priorities and activities to match those recommended by P5.

Building a world-leading neutrino physics program

The biggest challenge P5 delivered to our laboratory is to host a world-leading short- and long-baseline neutrino physics program. Since May, Fermilab's neutrino team has worked intensely with national and international partners to lay

Interim International Advisory Board (IIEB)

Chaired by N. Lockyer ~30 members
Composition: representatives from LBNE,LBNO, « others », F.A. ex-officio

First meeting 23/9/2014 at Fermilab
→ Define the format and content of the LOI

Full material available at:
https://indico.fnal.gov/conferenceDisplay.py?confId=8937

+ a few additional phone meetings to refine the LOI

IIEB web page:
https://web.fnal.gov/project/iiEB/Pages/iiEB-home.aspx

Agendas, minutes, LOI draft, LOI signature page, LOI Pis meeting invitation

Parallel activity:
International Governance Stakeholder Committee, chaired by J.Lykken

iiEB Board Meeting Agenda

from Tuesday, September 23, 2014 at **08:00** to Wednesday, September 24, 2014 at **12:10** (US/Central)
at **Fermilab (1 East)**

Go to day

Tuesday, September 23, 2014

08:00 - 08:30 Continental Breakfast *30'*

08:30 - 08:40 Welcome & logistics/process for decision making *10'*
Speaker: Dr. Nigel Lockyer

08:40 - 09:00 Background Context for this meeting *20'*
Speakers: Prof. Kenneth Long (Imperial College London), Dr. Robert Roser (Fermilab)
Material: Slides

09:00 - 09:30 Goals for this meeting and process for moving forward *30'*
Speakers: Prof. Kenneth Long (Imperial College London), Dr. Robert Roser (Fermilab)
Material: Slides

09:30 - 09:45 View from DOE *15'*
Presentation for 5 mins + Discussion
Speaker: Jim Siegrist (DOE)

09:45 - 10:00 Status from the "international governance" stakeholders committee *15'*
How does the DOE project system work and how will the host lab (Fermilab) interface with this global project, the international funding agencies and community
Speaker: Dr. Joseph Lykken (Fermilab)
Material: Slides

10:00 - 10:30 COFFEE BREAK *30'* (Atrium - West side)

10:30 - 11:00 What will be the mechanisms by which CERN can help Europe organize and work with the host lab *30'*
Speaker: Sergio Bertolucci (CERN)
Material: Slides

11:00 - 11:15 Timeline for new site approval *15'*
Speaker: Michael Weis
Material: Slides

11:15 - 12:30 Discussion 1a: Scientific strategies, co-existing with HyperK *1h15'*
Speakers: Dr. Joseph Lykken (Fermilab), Andre Rubbia
Material: Slides

First IIEB Meeting FNAL 23/9:2014

12:30 - 13:30 LUNCH *1h0'* (2nd Crossover)

13:30 - 13:45 Role of SB program in preparation for the LB program *15'*
Speakers: Prof. Bonnie Fleming (Yale University), Carlo Rubbia
Material: Slides

13:45 - 15:00 Discussion 1b -- Scientific Strategies –Continue discussion– *1h15'*
Speakers: Andre Rubbia, Dr. Joseph Lykken (Fermilab)

15:00 - 15:30 Coffee Break *30'* (Atrium - West side)

15:30 - 15:50 LBNE Project Status-- The budget, what has been spent/accomplished. What do we wish to accomplish in FY15 *20'*
Speaker: Elaine McCluskey (Fermilab)
Material: Slides

15:50 - 16:10 LBNO--What has been learned for a Fermilab hosted experiment? *20'*
Speaker: Dario Autiero
Material: Slides

16:10 - 16:25 Timeline of Accelerator Complex for Neutrinos – PIP/PIPII *15'*
Speaker: Paul Derwent (Fermilab)
Material: Slides

16:25 - 16:40 Discussion 2-- Optimal Beam Characteristics *15'*
Speakers: Prof. Marzio Nessi (CERN), Prof. Yury Kudenko (Institute for Nuclear Research, Moscow)
Material: Slides

16:40 - 17:30 Discussion 3 -- Formation of Working Groups *50'*
Speakers: Kate Scholberg (Duke University), Mark Thomson
Material: Slides Working-Groups

17:30 - 17:31 Adjourn for the day *1'*

Wednesday, September 24, 2014

08:00 - 08:30	Continental Breakfast *30'*
08:30 - 09:00	Thoughts/questions/comments from Day 1 *30'* Speakers: Dr. Robert Roser (Fermilab), Prof. Kenneth Long (Imperial College London)
09:00 - 10:00	Discussion 4: Transition plans/new collaboration *1h0'* Speaker: Dr. Milind Diwan (BNL) Material: Slides
10:00 - 10:30	Coffee Break *30'* (Atrium - West side)
10:30 - 11:00	Discussion 5: Selecting (co)-spokespeople *30'* Speakers: Chang Kee Jung, Prof. Stefan Soldner-Rembold (University of Manchester) Material: Slides
11:00 - 12:00	Discussion 6 Drafting Bullets to form the basis for LOI *1h0'* Speakers: Prof. Kenneth Long (Imperial College London), Dr. Robert Roser (Fermilab) Material: Slides
12:00 - 12:05	Date of next meeting *5'* Speaker: Dr. Robert Roser (Fermilab)
12:05 - 12:06	Adjourn *1'*

Main discussion on day 2: IIEB decisions based on Day1 discussion + LOI format

CERN Neutrino Platform

Summary:

- ✓ CERN offers a platform for Neutrino detectors R&D. This platform is now part of the CERN MTP. We will support this platform in an active way and will help WA104, WA105 and others proposals in this initial phase
- ✓ CERN will construct a large neutrino test area (EHN1 extension) with charged beams capabilities, available in 2016
- ✓ CERN will collaborate with FERMILAB on the design of the LBNF infrastructure
- ✓ CERN will assist the EU neutrino community in their long term common plans. For the moment CERN is not committing to any neutrino beam at CERN, in view of an agreed road map between all partners

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S. Bertolucci IIEB talk: « CERN Contribution to the Future ν Programs"

D.Autiero IIEB talk on « LBNO vision »

Outline:

1) The P5 report
(the origin of LBNF)

2) The LBNO world
(the general interest of its outcome/achievements for LBNF)

- *The LAGUNA-LBNO design study:*
  technological developments/costs optimizations for large underground detectors, staging/costing
- *The LBNO-DEMO/WA105 experiment at CERN:*
  a clear path for the detector technology demonstration
- *A PILOT experiment*
- *Physics strategy:*
  Mass Hierarchy
  Use of second maximum and spectral information for CP complementarity, systematics

3) LBNF as seen/being learnt from the LBNO community
(the LBNF opportunity and the IIEB process)

- LBNO design phase concluded

→ Outcome: optimized configuration for a LBL experiment studied in Europe (as recommended by CERN, APPEC) with associated technological developments, innovative solutions and full costing

- Deliverables to the EC, outcome of the design study, documented in
  >4000 pages (0.5 GB)

- Final design study meeting in Helsinki (24-28 August 2014)

- Conclusions of that meeting are represented in this presentation

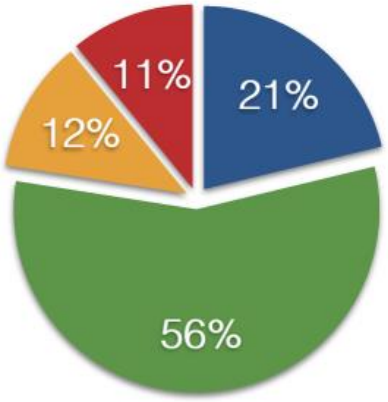
→ Explore the application of all these developments for a US hosted experiment

- First step: assessment meeting at Homestake (8-10 October) in collaboration with the industrial partners in order to understand the feasibility of LBNO-like detector

LBNO costs from design study deliverables

Element	20 kton (Meur)	20+50 kton (Meur)
Excavation Work (Tunnels and Caverns)	38,7	57,8
Civil Works & Underground infrastructure	9,4	12,3
Membrane Tank	45,4	117,4
Detector	41,5	111,8
Liquid Infrastructure Equipment	40,4	52,6
Liquid Argon	26,3	86,0
Contingency (Risks)	24,7	45,5
Total	226,4	483,4

~126 Meur



Costs are evaluated with the industrial partners "key in hands" including manpower

How much are they dependent from the optimization provided by the Pyhasalmi site and by the careful technological choices ?

For which aspects are they exportable/implementable in the US ?

Staged physics/construction approach 20/50 kton
→ limited resources for the first phase

Detailed evaluation of contingency by risk analysis

→ 9 years and 226Meur needed for the construction of the 20 kton detector

LBNF as seen from LBNO:

❖ It represents an strong opportunity:

- P5 and US HEP community support to the fundamental physics case related to MH and CP violation and underground physics
- Future availability of 1.2 MW proton beam at Fermilab (PIP II)
- DOE funding commitment for LBNF “highest priority experiment” (past evaluations based on 34kton at Homestake)

❖ It implies a series of open questions we are trying to understand:

(being addressed by the ongoing work of the IIEB, to which we are very glad to contribute)

1) The DOE funding commitment on LBNF is a large amount of money, comparable to the cost of a LHC detector:

- Which is the breakdown of the actual cost estimates ?
- Can the « performance/funding » ratio be optimized on the basis of the experience of LBNO ?
- How much of the LBNO design/costing is exportable to an experiment hosted in the US or site specific ?

2) Can we jointly design the best possible experiment, Fermilab hosted, with ambitious physics goals, as recommended by P5 ?

« the experiment that everybody would like to do, the experiment which will not risk to arrive second »

→ This possibility is deeply related to the scientific strategy discussion, the baseline/site optimization, the technological strategy

- LAGUNA-LBNO was a purely science driven effort. Under the mandate of CERN and APPEC, LAGUNA-LBNO has been intensively working on an optimized experiment in Europe in order to address these physics questions and it has successfully completed the Design Study phase commitment to the EC.

- Following the global strategy, the LAGUNA-LBNO community is now committed to explore, on the basis of the outcome of the DS, the possibility of building a Fermilab hosted experiment of comparable performance and with comparable costs to LBNO. (Physics is fortunately translations invariant, technical issues have to be assessed)

- It is important to understand the feasibility of a LBNO-like detector at Homestake and/or in alternative sites with horizontal access. A first practical step in this direction will be the visit/meeting at Homestake (8-10 October 2014) checking/discussing several technical aspects.

- The WA105 experiment at CERN (LBNO-DEMO) is starting and it will verify on a full scale test the innovative technologies developed in the LAGUNA-LBNO DS. There is clear path for the detector technology assessment for LBNF.

- A pilot detector installation would represent an important milestone/early startup of the LBNF program, training the community and satisfying the P5 requirements on astroparticle physics performance assessment

- The ongoing process promoted by Fermilab and DOE is moving in the direction of assessing the conditions for the best implementation of LBNF.

- It is a big challenge for the IIEB to find a working scheme to solve all the open questions and determine the best scientific and technological/site strategy for a Fermilab hosted experiment
  → IIEB discussions and work and WGs operation in the following months

- The LBNF program is a huge investment/responsibility
  → This investment will have to result in an aggressive scientific strategy and an efficient use of resources

LBNE-LBNO Geotechnical meeting at Homestake 8-10 October 2014

Technical and industrial teams of LBNE and LBNO

Overview of Homestake resulting from the discussions at this meeting presented at the NNN14 conference by G. Nuijten.

→ Side-by-side technical comparison of the Pyhasalmi and Homestake sites:

https://indico.in2p3.fr/event/10162/contribution/53/material/slides/0.pdf

Understanding (and possible technical optimization) of US costs is ongoing

ROCKPLAN

PYHÄSALMI + HOMESTAKE
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PYHÄSALMI + HOMESTAKE
INFRASTRUCTURE COSTS (SITE PREPARATION)

ROCKPLAN

LAGUNA

Excavation underground infrastructure	**38.7 M€**
Project Management costs, Legal Fees etc.	5.2 M€
Overall general design + Final Layout	2.5 M€
Executive rock engineering design	1.7 M€
Additional site investigations (mainly for shaft)	0.9 M€
MDC Cavern and U/G infra Excavation costs	11.7 M€
MDC Cavern and U/G infra Reinforcement costs	9.0 M€
Shaft infrastructure realization costs (raise bore)	7.7 M€
Civil Works construction U/G infra.	**9.4 M€**
Project Management costs, Legal Fees etc.	1.2 M€
Executive civil works design	0.5 M€
Enabling Works (HVAC etc.)	3.3 M€
Auxiliary Room Constructions	4.1 M€
Tank deck accesses	0.3 M€
Contingency *(15.3% of total)*	**8.7 M€**
Contingency costs for a 20kT excavation works	5.2 M€
Contingency costs for shaft infrastructure	1.2 M€
Contingency costs for civil works	2.3 M€
TOTAL EXCAVATION + CIVIL WORKS	**57 M€**

For hoisting a 20kT LAr detector + possible MIND
or hoisting a 50kT LAr detector

Excavation underground infrastructure	**248 M$**
Project Management and concept through CD1	4 M$
Conceptual design beyond CD-1	5 M$
Preliminary design	9 M$
Final Design	19 M$
Construction Management	30 M$
MDC Cavern and U/G infra Reinforcement costs	230 M$
Site infra, buildings, U/G infrastructure	**42 M$**
Contingency *(10.5% of total)*	**34 M$**
TOTAL CONVENTIONAL FACILITIES	**324 M$**

For hoisting a 10+24kT LAr detector

1 US$ = 0.789 € (25.10.2014)

TOTAL CONVENTIONAL FACILITIES **256 M€**

For hoisting a 10+24kT LAr detector

Guido Nuijten

PYHÄSALMI + HOMESTAKE OPERATIONAL COSTS

Operation subject	4) Operational of science
Decline operation and maintenance	100 000,00 €
Main hoist (operational costs) incl. crusher	400 000,00 €
Water pumping and operational costs	200 000,00 €
Ventilation arrangements and operational costs	100 000,00 €
Main service level (-1400m) maintenance and operation	70 000,00 €
Other operational costs (social spaces, ITC, electricity, rail yard)	320 000,00 €
Rock mechanical monitoring and analyzing costs	55 000,00 €
TOTAL OPERATIONAL COSTS	**1 245 000,00 €**

TOTAL OPERATIONAL COSTS (estimate) 1.25M€

Excavation underground infrastructure	**3.4 M$**
Lab. Management	659 k$
Business services	105 k$
EHS	1,360 k$
Engineering	815 k$
Science support	473 k$
Infrastructure preservation	**3.5 M$**
Dewatering activities	**3.7 M$**
Early Science	**2.8 M$**
TOTAL CONVENTIONAL FACILITIES	**13.4 M$**

1 US$ = 0.789 € (25.10.2014)

TOTAL OPERATIONAL COSTS (FY2014) 10.6M€

PYHÄSALMI CONCLUSIONS

GOOD, NEUTRAL, CHALLENGING or PROBLEMATIC

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31. Bill of Quantities
32. Liquid spill / risk assessment
33. Dynamic analysis / risk assessment
34. Experiment (not addressed)
35. Status of design
36. Preparation works and costs
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38. Cost references
39. Infrastructure costs (site preparation)
40. Mine transfer issues
41. Operational costs

Guido Nuijten

Guido's personal conclusions at NNN14

ROCKPLAN

HOMESTAKE CONCLUSIONS

GOOD, NEUTRAL, CHALLENGING or PROBLEMATIC

1. Global deep science lab caverns and facilities
2. Site Location
3. Mine introductions
4. On-surface access
5. Existing infrastructure at experiment level
6. Horizontal drifts / accesses
7. Decline (not present)
8. Ventilation
9. Dewatering / drainage
10. Hoist, when refurbished
11. Shaft reinforcement / lining
12. (Hoist) Control room
13. Rock hoisting capacity
14. Rock waste handling on surface
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36. Preparation works and costs
37. Infrastructure construction programme (??)
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Guido Nuijten

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Guido's personal conclusions at NNN14

November 5, 2014

Experimental program at the Long-Baseline Neutrino Facility (ELBNF)

Letter of Intent to Form an International Collaboration

Executive Summary

This Letter of Intent (LOI) brings together a global neutrino community to pursue an accelerator-based long-baseline neutrino experiment, as well as neutrino astrophysics and nucleon decay, with an approximately 40-kton (active mass) modular liquid argon TPC (LAr-TPC) detector located deep underground. Several independent worldwide efforts, developed through many years of detailed studies, have now converged around the opportunity provided by the megawatt neutrino beam facility planned at Fermilab and by the new significant expansion with improved access foreseen at the Sanford Underground Research Facility in South Dakota. The new international team has the necessary expertise, technical knowledge, and critical mass to design and implement this exciting discovery experiment in a relatively short timeframe. The goal is the deployment of the first 10-kton detector on the timescale of 2021. The PIP-II accelerator upgrade at Fermilab will provide 1.2 MW of power by 2024 to drive a new neutrino beam line at Fermilab. With the availability of space for expansion and improved access at the Sanford laboratory, this international collaboration will develop the necessary framework to design, build and operate a world-class deep-underground neutrino observatory. Fermilab will act as the host laboratory. This plan is aligned with the European Strategy Report and the US HEPAP P5 report.

Science Case

The study of the properties of the neutrino has already provided many surprises, representing the first evidence of physics beyond the Standard Model of particles

ELBNF

LOI DRAFT

Mail sent to GDR neutrino on 6/11/2014

Latest version available on the IIEB web site

Will be presented at the PIs meetings for the signature organized by December 5th at CERN and December 12th at FNAL

(open meetings to present the LOI at the scientific community)

Access to this potentially groundbreaking science is now possible because of the important opportunity provided by the expected availability of a new intense neutrino beam at Fermilab and of underground infrastructures at the Sanford Underground Research Facility, which is at a distance of 1300 km from Fermilab. These facilities will make viable the experimental physics program needed for the elucidation of the fundamental questions described above.

Fermilab is prepared to host the Long-Baseline Neutrino Facility (LBNF), strongly recommended by the P5. As host, Fermilab will provide the infrastructure required to carry out a long-baseline neutrino oscillation experiment with the combination of the required accelerators, beamline, target and horn. The LBNF will include:

- The LBNF accelerator complex: a pulsed high-energy proton source capable of delivering a peak beam power of 1.2 MW sourced by the PIP-II improvement program, a proton transfer line to a conventional neutrino beam infrastructure (target, horns, decaypipe). The beam power can be upgraded, with the goal of 2.4 MW before 2030.

- The LBNF far site infrastructure with newly expanded underground space at the SURF, which is foreseen to be created after the complete refurbishing of the Ross shaft in 2017 and other site improvements necessary to house the massive LAr-TPC experimental apparatus.

- The LBNE near site infrastructure required to house the near detector complex.

- The conventional infrastructure, including the primary technical infrastructure such as the cryostat and associated cryogenics for the liquid argon detector.

Opportunity provided by the LBNF facility

(Beam + far and near sites infrastructure including cryogenics)

To address the groundbreaking physics program made possible by the LBNF, the large international collaboration (referred to here as ELBNF), identified in the author list presented in Appendix A, proposes to construct a deep-underground neutrino observatory based on a 40 kton liquid-argon (LAr) time-projection chamber (TPC) at the Sanford Underground Research Facility. Potential designs for the ELBNF far detector have been developed by a number of groups, who now have come together within ELBNF, including both single-phase and dual-phase readout technology. The far detector may employ just one of these technologies, or possibly different technologies in a phased implementation, depending on the performance and developing maturity of the candidate designs. These options are being explored by several groups at the CERN Neutrino Platform (e.g. WA105) as well as Fermilab's short-baseline neutrino program. The collaboration also proposes to build a fine-grained highly-capable

Facility in South Dakota. The new international team has the necessary expertise, technical knowledge, and critical mass to design and implement this exciting discovery experiment in a relatively short timeframe. The goal is the deployment of the first 10-kton detector on the timescale of 2021. The PIP-II accelerator upgrade at Fermilab will provide 1.2 MW of power by 2024 to drive a new neutrino beam line at Fermilab. With the availability of space for expansion and improved access at the Sanford laboratory, this international collaboration will develop the necessary framework to design, build and operate a world-class deep-underground neutrino observatory. Fermilab will act as the host laboratory. This plan is aligned with the European Strategy Report and the US HEPAP P5 report.

Collaboration for the detector 40 kton LAr underground (ELBNF)

First 10 kton pilot installation by 2021

The LBNO Collaboration is developing a dual-phase readout LAr-TPC, whose anode is assembled from modules that can be combined to produce a detector of any size. A test of a TPC with the scale of 1 m x 3 m anode plane and a 1-meter drift is currently under construction at CERN. It is planned to build a 6 m x 6 m x 6 m TPC demonstrator (WA105) inside a 8 m x 8 m x 8 m cryostat, illuminated by a charged particle test beam, in the CERN Neutrino Platform. Construction has started for an extension of the EHN1 building in the North Area at CERN to house this and potentially the LBNE test., with the goal of executing initial beam tests before the start of the next long shutdown for LHC upgrades.

A complete conceptual design for a fine-grained near detector with argon and other nuclear targets has been developed by the LBNE collaboration. A design for a near detector based on a high-pressure gas Ar TPC is under development by LBNO.

Acknowledgement of LBNO expertise and technical achievements on LAr far detector (including WA105 effort), near detector and beam design.

complex are accomplished. The LBNO team has developed designs for beamlines that would utilize the CERN SPS or a proposed 50 or 75 GeV high power PS (HPPS) that are optimized for a 2300 km baseline. Preliminary studies suggest that the horn focusing system developed for the HPPS beam, if applied to the 1300 km baseline from Fermilab to Sanford Lab, would improve the reach for both CP violation and mass hierarchy determination relative to the LBNE-designed beam.

November 22, 2014

Letter from Nigel Lockyer

Dear Colleagues,

This message is to remind you that there are two identical open meetings (everyone welcome) to communicate the Letter of Intent to the scientific community. They will take place as follows:

December 5, 2014 CERN (Council Chambers) 1 pm-6 pm local time
December 12, 2014 Fermilab (1 West) 10 am- 3 pm local time

The call in information is as follows -- +1 866 740 1260 access code 4010695#
For international members, use this link to get the toll free number --
http://www.readytalk.com/account-administration/international-numbers

The agenda for the open meetings is as follows

- Welcome and Background Introduction (Nigel Lockyer) 15+15 min
- The Fermilab Facility -- what it entails (Jim Strait) 30+15 min
- Summary of the Letter of Intent (LOI) for LBNF (Rob Roser and Ken Long) 30+15 min
- International Governance Working Group Report (Joe Lykken)-- 15 +15 min
- Coffee Break 30 minutes
- Panel Discussion with seeded questions as well as extended Q&A with audience (2 hours)

PLEASE register for the meetings at:
https://indico.fnal.gov/conferenceDisplay.py?confId=9127

To support the LOI: https://indico.fnal.gov/conferenceDisplay.py?confId=9090

Finally -- please reserve January 22-24 2015 for the first proto-collaboration meeting of the entire community: at location still to be determined.

We encourage you to share this message with any of your colleagues that may be interested.

Nigel

IIEB Letter of Intent Support

from November 11, 2014 to January 11, 2015 (US/Central)
US/Central timezone

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Letter of Intent

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To support the iiEB Letter of Intent, select the "Support the LOI" link on the left and enter your information.

Supporting the LOI indicates that the signer agrees with the referred to "Letter of Intent to Form an International Collaboration for the Experimental program at the Long-Baseline Neutrino Facility (ELBNF)"

Signing does not imply a commitment to participate in the experiment or a commitment of resources, but rather an indication that you wish to participate in the formation of the new collaboration.

The Letter of Intent (LOI) brings together a global neutrino community to pursue an accelerator-based long-baseline neutrino experiment, as well as neutrino astrophysics and nucleon decay, with an approximately 40-kton (active mass) modular liquid argon TPC (LAr-TPC) detector located deep underground.

Conclusions:

- The direction of Fermilab, following the P5 recommendations, has set up a process to propose a Fermilab based long-baseline experiment joining the international efforts (LBNE+LBNO+ …)

- The LBNO people have spent a large effort in these discussions and in evaluating the transfer all the technologies (detector and underground implementation) developed in the LAGUNA-LBNO design study to LBNF. CERN will support the finalization of this effort and detector R&D with WA105

- The IIEB has drafted a LOI (an expression of interest) to gather the neutrino community around the opportunity provided by the envisaged LBNF facility (beam+far site infrastructure) in order to form a collaboration for the ELBNF experiment

- The LOI draft will be presented at CERN and FNAL at the open meetings on Dec. 5th and 12th in order to collect the signatures

- Then a proto-collaboration should start forming and meet in January 2015 in view of producing during 2015 a CDR