BUSINESS CONFIDENTIAL

MINUTES OF THE MEETING OF THE INTERIM INTERNATIONAL EXECUTIVE BOARD (iiEB) FOR FERMI NATIONAL ACCELERATOR LABORATORY

October 1, 2014

The interim international Executive Board (iiEB) for Fermi National Accelerator Laboratory held a meeting by teleconference and in the One East Conference Room at Fermi National Accelerator Laboratory, Batavia, IL, on September 23 and 24, 2014 at 8:30 a.m.

The following Board members were in attendance for all or part of the meeting and a quorum was present at all times: Nigel Lockyer (FNAL - interim Chair), Dario Autiero (IPNL), Edward Blucher (Chicago), Brajesh Choudhary (Delhi), Milind Diwan (BNL), Antonio Ereditato (Bern), Carlos Escobar (UNICAMP), Bonnie Fleming (Yale), Takuya Hasegawa (KEK), Chang Kee Jung (Stony Brook), Ed Kearns (Boston), Yury Kudenko (INR), Thomas Patzak (Université Paris-Diderot), Andre Rubbia (ETH), Carlo Rubbia (GSSI-INFN), Federico Sanchez (Barcelona, IFAE), Kate Scholberg (Duke), Stefan Soldner-Rembold (Manchester), Hiro Tanaka (UBC), Mark Thomson (Cambridge), Bob Wilson (Colorado State), Agnieszka Zalewska (H. Niewodniczański Institute), Kate Scholberg (Duke), and Marco Zito (Saclay).

Present as Stakeholders were the following individuals: Sergio Bertolucci (CERN), Fleming Crim (NSF), Fernando Ferroni (INFN), Jim Siegrist (DOE), John Womersley (STFC).

Present in an Ex Officio capacity or as guests were the following: Kenneth Long (Imperial), Joseph Lykken (FNAL), Marzio Nessi (CERN), Robert Roser (FNAL), Jim Strait (FNAL), Elaine McCluskey (FNAL), Alberto Guglielmo (ICARUS), Delia Salmieri (ICARUS), Michael Weis (DOE Site Office), Paul Derwent (FNAL), Stephany Unruh (FNAL - Board Secretary).

September 23, 2014

1. Welcome and Logistics/Process for Decision Making by Nigel Lockyer

Nigel Lockyer called the meeting to order at 8:31 a.m., welcoming the Board members as well as guests from the various laboratories, organizations and agencies. Mr. Lockyer thanked all attendees and participants for their attendance as many traveled long distances to attend. Mr. Lockyer then discussed the basis for determining agreement throughout the meeting and it was determined that there would be no voting and a quasi-consensus would be required for a conclusion to be made. It was agreed upon that silence would be considered consent on all topics thereafter discussed and decided upon.

2. Background Context for this Meeting by Kenneth Long and Robert Roser

Mr. Lockyer welcomed Kenneth Long and Robert Roser to begin the first presentation/discussion. Mr. Long and Mr. Roser's presentation focused on the background and context for the meeting which included the P5 recommendation to form a new international collaboration to design and execute a highly capable long-baseline neutrino facility hosted by the United States. The recommendation identified that a project plan with identified resources must be developed to meet minimum requirements of the report. The long-baseline neutrino facility is the highest-priority large project in its timeframe.

Mr. Long and Mr. Roser also summarized the International Meeting for Large Neutrino Infrastructures held in Paris. The meeting gathered PI's and funding agency representatives to re-assess the physics case and also to create a

single “agency ear” to help support and align the global neutrino community. Next, a summary of the ICFA Neutrino Panel included excerpts from its initial report which recognized that to maximize discovery potential in the neutrino program the international community must have timely access to complementary and powerful facilities through the exploitation of the CERN, J-PAC and FNAL infrastructures and that each international region must make a unique and critically important contribution. This combination will make the long-baseline neutrino facility program an exciting, unique and critically important *cornerstone* to the international neutrino community.

Finally, Mr. Long and Mr. Roser discussed the outcomes of the Neutrino Summit held at Fermilab on July 21-22, 2014. The Summit concluded with two assumptions which included that Fermilab would provide the source of neutrinos for the facility and that the baseline would be such that the matter effect could be exploited. The Summit noted the convergence of the field on the development of two concepts: a longer baseline, wide-band approach hosted in the U.S. and the shorter baseline, narrow-band approach hosted in Japan. It was also acknowledged that there is an urgency to establish a path forward on the long-baseline neutrino facility as the window of opportunity could close. It was agreed to establish the interim international Executive Board (iiEB) to assist in delivering the LOI. Most importantly, the iiEB was designated to report to the emerging collaboration, be constituted and given its mandate by the ad-hoc funding agency/lab director group and be superseded by the collaboration governance as soon as it had been formed.

In conclusion, Mr. Marco Zito presented his concern for the procedure and communication of the Board due to the sense of urgency of the project. He indicated his need to come out of the iiEB meeting with a comprehensive idea of the entire process while having a timeline to prepare for future steps and communications. This sentiment was agreed upon by Mr. Thomas Patzak.

Action Items: Draft a terms of reference and timeline, Develop a communication plan with no short notice meetings.

3. Goals for this Meeting and Process for Moving Forward by Kenneth Long and Robert Roser

Kenneth Long and Robert Roser presented the agenda for the iiEB Meeting and the goals for the meeting as a whole. The goals included agreement upon the following:

- Terms of reference and a decision making process for the Board;
- An optimal approach to a world class neutrino long-baseline experiment including scientific strategy, phasing, sense of urgency, etc.;
- A 10 year timeline;
- On how to map near term efforts for SBN to facilitate the long-baseline neutrino facility;
- On a primary detector technology;
- On a process for selecting interim leaders and their length of term;
- On working groups needed and names of people to lead them;
- On the main points that will comprise the LOI to be submitted to the Fermilab PAC in January 2015;
- On how to handle the details of forming the CDR proposal;
- On the timeline to write the CDR by summer of 2015 and the milestones needed along the way to achieve the CDR;
- To work toward U.S. DOE CD-2 baseline approval by FY18.

Mr. Long and Mr. Roser also discussed a brief tentative timeline of milestones that included:

- **Current iiEB Meeting:** Agree on LOI bullet points, launch working groups, decide how to select interim leaders and start the process;

- **October/November 2014:** Start of working group meetings to agree on a charge, to assemble needed information and to perform studies, and draft an LOI;
- **December 2014**: Hold a second iiEB meeting, delivery of working group reports, finalize and approve the LOI, select spokespeople;
- **January 2015:** Hold a PI meeting called together by spokespeople, present the LOI to working groups and request signatures to form the collaboration, begin process of developing the collaboration governance;
- **January-March 2015:** Working groups continue accordingly;
- **March 2015:** Hold a third iiEB meeting, hear working group progress reports, iiEB begin to assemble CDR;
- **May 2015:** Hold iiEB/Collaboration meeting, finalize CDR with iiEB and collboaration and approve governance model/bylaws;
- **June/July 2015:** The iiEB will present LOI and CDR to PAC for approval, begin election process for non-interim leadership.

Discussion followed Mr. Long and Mr. Roser's points which included a dialogue on barriers to completion such as CD-2 funding and where the funding would be coming from? What are the current and future funding commitments? What are the challenges that need to be determined and met to create a baseline cost? Is the FY18 CD-2 goal definitive? During the following conversation it was determined that momentum has been established to meet the CD-2 FY18 "no later than" goal on the project.

Action Items: What is the formal process? And what is included in this process to be approved by the undersecretary? A long term outline must be established.

4. View from Department of Energy by Jim Siegrist

Mr. Lockyer next introduced Jim Siegrist from the Department of Energy to give an overview and historical perspective on the long-baseline neutrino facility project from the DOE perspective. Mr. Siegrist detailed that the DOE is confident in the P5 push for an international experiment and hopes that the report has created a sense of urgency from the science community and international governments involved. The DOE's position with Washington is one that the time is right to create this neutrino program with the international community. Mr. Siegrist continued to highlight the amount of interest on the results of this process and that these results could boost the neutrino program internationally while moving things much faster than otherwise previously thought. He emphasized that the P5 is not really a plan but a vision to be developed.

In response to the previous dialogue on barriers to completion and challenges, Mr. Siegrist indicated that there are many opportunities to develop new partnerships both within the DOE context and internationally throughout the community to overcome these barriers. He urged the Board to take a broad approach to help lay a good foundation for the collider community as well as the neutrino program community. Mr. Lockyer also indicated that the iiEB and Fermilab have much support from Jim Siegrist's office and the Office of Science, including Secretary Moniz. The coming challenge to the long-baseline neutrino facility will be the OMB and Congress putting together the future budgets for the program. This process is already a few years ahead based on the political processes in Washington and the FY16 budget proposed by President Obama to be discussed in Congress February 2015.

Hirohisa Tanaka presented a question about what the effect of the 2016 presidential election will have on the funding and approval processes for the facility? In response Mr. Lockyer indicated that the overall budget could change based on the results of the election but you have to work with the information that is available. Also in response to Mr. Tanaka's question, Mr. Siegrist indicated that there is a fair amount of remembrance within the DOE and OMB offices and that this high level of politics should not drive the decision making process. Finally,

Chang Kee Jung posed the issue of private funding and the view of the DOE on private funding. In response it was indicated that the DOE is positive on the private funding but OMB can often be suspicious on why private funding is needed. Since private funding is a good source of forward funding, if OMB is invested in P5 and the long-baseline project, then the reaction should be positive based on the internationalization of the neutrino program. The best source of private funding is University funding.

5. Status from the "International Governance" Stakeholders Committee by Joseph Lykken

Joseph Lykken presented the Board with an overview and status update on the International Governance Stakeholders Committee, formed as a working group for the long-baseline neutrino facility. As per Mr. Lykken, the group is an informal forum for discussions and coordination with the iiEB in regards to the international governance aspects of the long-baseline neutrino facility. The goal of the group is to develop a possible model for governance which includes a strong international footprint and answers the question of how the DOE project system will work with the host lab (Fermilab) to interface with this global project, the international funding agencies and the scientific community.

The current major observations of the Committee include that the international collaboration should develop the science strategy, design and "bottom-up" optimization process for the project. The collaboration should play a crucial role in the design of the experiment as it must have a well-defined global infrastructure with an approach that will allow funding agencies to coordinate the scope with the available resources. The Committee assumes that as the host laboratory, Fermilab will act as an agent for the DOE and have overall responsibility for the construction, maintenance and development of the beam line. In addition, domestic and international agreements will be needed to allow for the development of infrastructure and for Fermilab to become the single point of contact for all collaborators and stakeholders. As Mr. Lykken points out, this can be difficult as bilateral agreements in various countries are at different stages of participation and funding agencies will be looking for scope proposals from their own communities.

Discussion included questions on the timing of funding and if the agencies/sources will be able to keep up with the ambitious timeline of the project. In response to the question presented by Carlo Rubbia, Jim Siegrist indicated that some funding is currently available but that in many other countries the development of the program and funding has not yet caught up with the timeline. This is an important factor as the right frame of reference is needed to determine if the international community is on board with the baseline parameters that have been set. Mr. C. Rubbia indicated that many international funding agencies are not willing to give funding directly but they are willing to contribute to the program through the creation of product/jobs within their home country that they can export to support the program.

It is also indicated by Mark Thomson that it is important to not go too slowly based on funding because the collaboration and project cannot lose momentum. The loss of momentum spurred Chang Kee Jung to point out that it is important for the Board to have a sufficiently detailed LOI created early to give time for each country to go back and define the CDR enough for each country to determine what they are contributing both financially and scientifically. The more detail put into the LOI, the more people/countries it will attract which then will increase the involvement from the international community and funding sources. It will be important to define transparency to help involve the community in what is going on based on the "bottom up" approach.

-Action Item: Talk to the OPA within DOE to describe the contributions and explain who is bringing what to the table in regards to funding. We have to expect right away that there will be a delay in contributions with some starting initially and others coming later based on how quickly each country can proceed in the future.

6. What will be the Mechanisms by which CERN can help Europe Organize and Work with the Host Lab by Sergio Bertolucci

Invited by Mr. Lockyer, Sergio Bertolucci presented the Board with CERN's contributions to the future of neutrino physics programs. CERN and Europe have a long history of neutrino physics and an agreed upon strategy that is based on paving the way for future long-baseline experiments while exploring the possibility of major participation in neutrino projects in the U.S. and Japan. Based on this strategy, Mr. Bertolucci proceeded to explain the different experiments and technologies that are being used at CERN such as the proposed short-baseline CERN Neutrino Facility (CENF) designed to support ICARUS and NessiE, the LAGUNA-LBNO EU FP7 design study for a neutrino beam pointing to Finland, and the ESS long-baseline study group just forming for the development of a super beam at the new ESS facility in Lund. Given the still evolving road map on long-baseline neutrino activities in the U.S., Europe and Japan, CERN has adopted a short term position to support generic research and development on neutrino detectors and beams and to support physics related to a neutrino short-baseline.

In June 2014, the CERN council decided to implement the proposed Medium Term Plan which dedicates an important allocation of resources in the next 5 years to the Neutrino CERN Platform. The offering of this platform for Neutrino detectors research and development is an active way for CERN to support WA104, WA 105 and other proposals in their initial phases. As part of the Plan, CERN will construct a large neutrino test area with charged beam capabilities, collaborate with Fermilab on the design of the new long-baseline neutrino facility and assist the EU neutrino community in their long term common plans. CERN will not be funding experiments unless there is a CERN collaboration working on the project; they are solely acting as a laboratory and as an available infrastructure. Throughout discussions on CERN, Mr. C. Rubbia cautioned to be careful how the Board couples the new international collaboration with CERN because the 26 EU member states have already contributed funding to CERN. There must be a separation or clarification in the difference between the contribution to the long-baseline neutrino facility and the funding of experiments. Mr. Thomson supported this caution as there must be a distinction between the funding to the facility and the experiments.

7. Timeline for New Site Approval by Michael Weis

In regards to location for the new long-baseline neutrino facility, Michael Weis presented the Board with an overview and timeline for new site approval by the Department of Energy. He indicated that the DOE role as a program sponsor and owner/landlord requires involvement in providing approvals for a variety of activities. The first of these activities includes access to the site of the experiment including the options of land transfer if the land is currently federally owned, land purchase, land lease or other means such as eminent domain. Mr. Weis also discussed the assessment of proposed activities and alternatives driven by legal requirements of land acquisition. These included the necessary environmental analyses and National Historic Preservation Act reviews that would need to be conducted prior to the transfer of land for development.

Next, any development of land for use in the long-baseline neutrino experiment would require the survey of local communities, local governments, the public and any traditional Native American tribes for comments or concerns that could affect them. Any comments and/or concerns from these parties would have to be addressed prior to the project being able to move forward. And finally, the DOE as representative, must acquire the necessary permits required for operations at a federal facility. The typical site permits require surveys and permits on air, water and other forms of environmental effects. If the collaboration makes a decision to lease land from another entity, the lessor would be required to obtain these types of permits before development of the land can continue. On average this entire process can take 18-24 months if no other activities are currently taking place at the decided upon site.

Mr. Siegrist indicated that it should be taken into consideration that the South Dakota location at Sanford National Laboratory is already in the process of obtaining all required permissions for the LBNE experiment which will continue for a significant amount of time in the future. Finally, Bob Wilson questioned whether there were any benefits to separating the site from the FNAL agreement. Per Mr. Weis, if the money comes from the US government there is no benefit to separating the Fermilab contract from the project. The current model is that the land/facilities would be leased for this project.

8. Discussion 1a: Scientific Strategies, Co-Existing with HyperK by Joseph Lykken and Andre Rubbia

Presented by Joseph Lykken and Andre Rubbia, the Board discussed the scientific strategy for the long-baseline neutrino facility. Offered first was the scope of the project: To execute a world class, deep-underground liquid argon neutrino experiment for long-baseline neutrino oscillations, neutrino astrophysics and proton decay searches that are scheduled to start taking data with large initial mass around 2025 and will extend beyond 2035. Through initial debates a question was raised as to if the first outcome should be based on the underground facility or on the beam development for the facility. Lastly, the timeline was questioned to determine if the project will start with smaller mass data around 2025 and become more productive as it reaches the 2035 goal. This timeline was based on a time scale of 10 years with the goal being that based on the P5 report, a large detector has started to take place at this time. It is important that the timing is done right and on a tight time schedule as the project should not be delayed any further.

Secondly, the strategic science goals for the project were defined as compelling and competitive with physics aims for measurements with unprecedented precision. The long-baseline neutrino program has a high probability to discover new phenomena and to expand frontiers with various scientific capabilities. The emphasis of the physics goals should be on the discoveries through the use of CP Violation, Neutrino Mass Hierarchy, the Three-Flavor Paradigm, Neutrino Astrophysics, nucleon decay and high statistics neutrino interactions. While there were concerns that the program will not be broad enough for all individuals in all countries to take part, there are many levels of the program and multiple lower levels that will allow individuals in the community to be involved for many years to come.

Next, it was determined that the strategic science goals can be reached through various configurations of experimental setups. The long-baseline neutrino facility is based on liquid argon technology and adopts a set of configuration parameters to execute science in a complementary way to HyperK. These parameters include the nominal neutrino beam power, nominal detector mass, the baseline and the beam energy profile. These configuration parameters can affect the performance, costs and timescale of the project and should be used to emphasize the strengths of the program. Mr. Jung pointed to a critical issue with comparing HyperK to the long-baseline program as the funding in each could be critically different. This position was supported and Mr. Escobar and Mr. Thompson made a critical argument that the long-baseline neutrino program is a world class facility and must stand alone despite it being complementary in configuration to HyperK. The Board must demonstrate that the long-baseline facility is a standalone program that should not be dependent on any other program to attain its goals. The long-baseline program has larger parameter space reach than HyperK and should be represented as such. Mr. Ereditato concluded the configuration discussion by stating that the Board and new collaboration must make a positive statement as to why liquid argon was chosen over water to support the difference between the long-baseline neutrino facility with HyperK.

Another aspect of configuration to consider is the location for the far site baseline. A far site baseline at Sanford Underground Research Laboratory defines a baseline of 1300 km but other alternative sites should be considered at longer 2000-2300 km distances to give the several potential sites. Per Mr. C. Rubbia the overall timing must be

looked at along with the location versus how many people will be working at the location. Logistics on the location and access to the location are important if you plan on having people working there on a daily basis. Items to consider when selecting a location are the delays associated with the approval process associated with this "green field" venture, whether the estimation of operational costs for the facility should be a fixed or variable cost program and what type of liquid argon technology will be used in the highly capable detector.

Finally, prior to adjourning for afternoon break, the scientific priorities and strategies were presented to the Board. The configurations for the long-baseline project are defined according to priorities and an adopted strategy. The priorities are comprised of determining δCP via spectral shape behavior relative to measurement of ν/νbar asymmetry, of mass hierarchy measurement on a competitive timescale, and of priority of astrophysics (non-accelerator program). In addition, a strategy for phased/incremental approach to achieve physics goals given funding or technical limitations on the overall program schedule will be necessary.

Vital questions were raised while discussion commenced on near detector options such as how many are needed, is there space for it to be tested in the current NuMI beamline and what is the minimal near detector needed? Mr. Jung indicated that it could be possible that the near detector is being put forward too early without vital information that will be coming to the collaboration in the future. Mr. C. Rubbia pointed out that the Board cannot move from a small detector to a large detector with new technology quickly and that the process must be taken in baby steps with much background research. A large scientific community of people will be needed to learn a different way of putting together knowledge and technology to accomplish the goal. Mr. Tanaka also supported this with his opinion that it is important that the near detector hall has the options for many different experiments and will attract the experiments/community rather than just the creation of a detector. It should be a near detector facility.

9. Role of SBN Program in Preparation for the LBN Program by Bonnie Fleming and Carlo Rubbia

Offered by Bonnie Fleming and Carlo Rubbia to the Board is the role that the short-baseline program has in preparing for the long-baseline program. As discussed by Ms. Fleming, the short-baseline program is a stepping stone to the successful completion of the long-baseline program. The short-baseline technical neutrino oscillation and neutrino scattering measurements combined with the development program for LArTPC are vital tools to developing the beam line booster and detectors in the neutrino program. In addition, while the two programs have significantly different physics goals, they are related based on experimental goals and the precision of the LAr detectors. All three LArTPC detectors are conventional ICARUS style detectors that build on experience from ICARUS towards new developments for long-baseline programs. The goal of all three is to test new ideas and gain experience for building larger LArTPC's, develop/ refine reconstruction tools and produce timely physics results.

In summary, the short-baseline experiments bring early physics and development to the long-baseline programs. They are development test-beds for technology, physics measurements and reconstruction development, coordination of analysis efforts for both near and far comparisons and they foster collaboration on physics and technology. The program is a model for international collaborations working together to fund, build and analyze data. As stated by Mr. C. Rubbia the enlargement of the detector yields an interesting result, off access beam events coming from the high energy NUMI beamline neutrinos which could in the future be accessed for the long-baseline facility while waiting for the larger detector to be developed. As pointed out by Mr. Jung, a timeline must be determined from past experience in the short-baseline program for the detector in the new program. Mr. C. Rubbia estimated that the first 10kton detector could be built in less than a 5 yeartime span.

Concern was raised within the Board that a long timeline could allow for the scientific justification of the program to disappear and that the timeline should be strictly followed. Since the short-baseline program is so attractive currently, the Board cannot allow for the loss of this community in the transition to long-baseline and the best way to attract the scientific community is to allow the community to possibly have contributions in both worlds. A question to Bonnie Fleming was asked as to the number of individuals who are interested in joining the long-baseline project? Ms. Fleming stated that currently the majority, if not more, are interested in joining this program.

10. Discussion 1b: Scientific Strategies – Continue Discussion by Joseph Lykken and Andre Rubbia

In continuance of the previous 1a discussion on scientific strategies, Mr. Lykken and Mr. A. Rubbia presented the Board with preliminary considerations on mass hierarchy and CPV. The sensitivity of the LBN program scales roughly as exposure, defined in kt*MW*years, where a nominal year of running is assumed for the accelerator. MH sensitivity depends strongly on the baseline. It is likely that reactor experiments and atmospheric measurements will have difficulties in reaching this sensitivity. In the end, only the long-baseline experiment can give such a measurement. Hence, the competitiveness to determine MH, compared to other reactors and atmospheric experiments, is defined by the ability to reach delta chi^2 = 9 first. The ability to discover CPV depends mildly on the distance compared to MH. In the initial phases, it is dominated by statistics.

As discussed with the Board, Mr. A. Rubbia indicated that the sensitivities that are reached should be significantly less than what you are aiming at. There must be a clear understanding of what the goals are for MH and CPV while it is most important to get sufficient statistics in neutrino and anti-neutrino mode to get enough spectral information. The collaboration must go for the best statistics; one could tune this data to find the ultimate sensitivity that will be dominated by systematics. Per Mr. Thomson, the difference between the shorter and longer baselines is also important in the determination of the detector size while depth also needs to be addressed.

Action Items: More work is needed to assess the validity of the assumptions on systematic errors and the initial fiducial mass to address CPV should be at least 25kton, regardless of the baseline.

In discussions on the start-up process with a pilot detector it was proposed that the full science would require an initial mass of 25kton to be commissioned around 2025. The execution of a “pilot” detector of the size of 5kton on a timescale of 2020 could establish the long-baseline facility as a key player in the deep underground non-accelerator physics field. In response to this proposal Mr. A. Rubbia indicated that if the program is to be competitive there is a need for a detector with a larger mass than 5kton. A “pilot” detector would test many aspects of the underground location, and provide an early physics program but it would still require the same amount of development as an initial modular detector. The goal must be to build something quickly that can be modular in nature and be built upon to create a larger mass that is calculated in detail.

During examination of the start-up process, Mr. Jung expressed concern that the bureaucratic process will be a long one and that this must be kept in mind when considering the timeline and size of the initial modular detector. The initial detector is a goal to keep the community focused and to keep the project moving forward. Mr. A. Rubbia believed that this process can be done in a timely manner but that the costs of the phasing process must be kept in mind. The timeline has to be planned as a full scale project from the beginning with the goal of the international collaboration developing the detector phasing process through the fostering of certain criteria and community input.

The science strategy and a project plan, as presented by Mr. Lykken and Mr. A. Rubbia, will be developed in two steps: a LOI and a proposal. Working towards a plan, matching scientific ambition and realism, is a process that involves two main actors liaising with their respective funding agencies: the hosting laboratory and the international collaboration. Together they will develop the final scientific configuration parameters. The host laboratory will provide a high power neutrino beam, a near infrastructure for detectors and beam monitors and a far infrastructure for large deep underground detectors. In support of the "top-down" approach the far site process is selected and managed by the host lab. And to encourage the "bottom-up" approach, the international collaboration will be responsible for the near and far detectors. Signatories of the LOI must express a commitment to define and decide upon scientific priorities and strategies and the configuration parameters.

A global combination of neutrino oscillation results can help determine MH and CPV, and exclude regions of the parameter space. Future external goals should include the updating of the long-baseline "wish-list" for the SBN program, the development of a "wish-list" for CERN WA's and neutrino platform program, CERN NA61 as a potential location to perform dedicated hadron-production measurements, and NUSTORM as a potential experiment to execute dedicated measurements of the neutrino cross-section.

In conclusion, the scientific impact of the long-baseline neutrino facility will be strongly dependent on the possibility to timely install and commission a very massive far detector. An attractive science program likely requires an initial mass of 25kton around 2025. A well-developed and prioritized plan to achieve this target is needed. A Pilot project with a timescale <10 years could test many aspects and retire several risks providing an early physics program. The long- baseline neutrino project should become the world class experiment that "everybody wants to do."

11. LBNE Project Status – The Budget, What has been Spent/Accomplished. What do we Wish to Accomplish in FY15? By Elaine McCluskey

Invited by the Board to give an update on the LBNE project status, Elaine McCluskey presented the current status of LBNE. Starting with an overview of the history of the project, she walked the Board through the CD-0 stage at DOE in January 2010 through the reconfiguration and difficult CD-1 approval process in 2012. Ms. McCluskey presented the post-approval funding strategy for LBNE which included sufficiently securing additional domestic and/or international funding commitments prior to CD-2 which would allow the project scope to be refined to include other opportunities.

Ms. McCluskey also informed the Board of what has been done on the project since CD-1 including establishment of a reference scope which might become international in nature, the associated cost/schedule/risk, an internal change control process and a strong technical and management team. In addition, she also reiterated the projects progress on the Far Detector, CF Far Site, Beamline, Near Detector Systems, and CF Near Site. Next, in reference to selecting a site for the long-baseline neutrino facility, the status of the Sanford Underground Research Facility (SURF) was discussed. Currently, SURF has an underground science program with more than $130M invested from the state of South Dakota with upgrades scheduled to be completed in early 2017. Ms. McCluskey also reviewed the necessary National Environmental Policy Act, a U.S. government policy/process to assess impacts to environmental, cultural and historic resources during federal project activities such as the long-baseline neutrino facility project.

Finally, Ms. McCluskey gave the Board a summary of the current LBNE budget for reference. Total since 2010 about $80M has been spent on the project calculated based on U.S. accounting standards. This budget includes escalation, overheads, contingency and all but the scientific labor but does not include the near detector that may

be partially funded by India, nor the funding profile from DOE or any other countries. Main goals for the upcoming FY15 included submittal of the LOI through the iiEB, completion of the full proposal to move the experiment and project forward and continuing the research and development to keep moving on other aspects of the project. In summary, the LBNE project CD-1 provides a basis upon which a long-baseline neutrino experiment and facility can be developed.

In discussion Mr. Choudhary mentioned that India has offered to build a Fine Grained Tracking Near Detector for the program. Discussions are still on-going between India (DAE) and USA (DOE) and are at quite at an advanced stage, although, no formal signing of agreement has been completed. Mr. Choudhary also mentioned a LBNE-ND workshop was held at the end of July which was in some sense the first international discussion on the subject where colleagues from LBNE, LBNO, ICARUS, T2K, HK and other experiments were invited. The meeting lasted for two days and it was broadly agreed (or seem to be a consensus) that a LAr detector by itself will not be sufficient to fulfill the role of a ND for LBN* project. It was also broadly agreed (or seem to have the consensus) that the LBN* experiment will need a Fine Grained Tracker supplemented by a small LAr detector.

12. LBNO – What has been Learned for a Fermilab Hosted Experiment? By Dario Autiero*

Mr. Dario Autiero gave the iiEB an overview on what has been learned for a Fermilab hosted experiment. The long-baseline neutrino program plan has undergone multiple significant transformations since the 2008 P5 report was formulated. Originally formulated as a domestic experiment with a small limited detector, the plan has morphed into a more ambitious project that has been urged by the Snowmass community study and interest from physicists around the world. Based on this data, a change in the project approach is required where the activity should be reformulated under a new international collaboration that is internationally funded, with Fermilab as host. The goal should be to exceed the physics demands through the expertise and resources of the international neutrino community.

This transition to a larger international long-baseline project raises a variety of questions which will need to be addressed by the iiEB. These questions include: the DOE funding commitment of the neutrino project and what the breakdown of the actual cost estimates are; the optimization of the performance/funding ratio based on the experience of LBNO; the amount of the LBNO design/costing that is exportable to an experiment hosted in the US and the best way to jointly design the best possible experiment with ambitious physics goals as recommended by P5. From the beginning the goal was to build an affordable underground detector. During discussion, Ms. Fleming raised concern on this topic in regards to the size of 5kton for the proposed detector referenced in the pilot program as a recommendation from P5. She indicated there is no justification for the 5kton size decision and that the size should be considered carefully. Mr. C. Rubbia supported her comments and also requested as to where the funding for the ultimate detector will be coming from. It was recorded that the ultimate funding would be coming from the EU regional funds as well as DOE funding.

13. Timeline of Accelerator Complex for Neutrinos – PIP/PIPII by Paul Derwent

Next, Mr. Lockyer invited Paul Derwent to give the Board an overview of Fermilab's accelerator complex for neutrinos. Mr. Derwent proceeded to define Fermilab's goal as one to construct and operate the foremost facility in the world for particle physics research utilizing intense beams. Based on the P5 report, accomplishment of this goal will require an upgrade to the Fermilab Proton Accelerator Complex (PIP-II) to produce higher proton intensity beams to support the NoVA, Mu2e, short-baseline, g-2 and long-baseline programs. The PIP-I Plan addresses this issue in a near-term goal of doubling the Booster beam repetition rate to 15 Hz while addressing the Booster's reliability concerns by 2018. The Plan's longer-term goal is to increase the beam power delivered from the Main Injector by an additional 50% and to provide increased beam power to the 8 GeV program by 2023 while providing a platform for the future long-baseline project.

This plan builds on the significant infrastructure while capitalizing on investments in superconducting technologies and eliminates operational risks in the existing linac. Currently the PIP-II Plan is in the development phase and is not yet recognized as a formal DOE project despite strong support in the P5 report, from DOE/OHEP and the Fermilab Director. In summary, PIP and PIP-II have been developed as steps in establishing a world-leading facility for particle physics research based on intense beams at Fermilab. PIP-II retains flexibility to eventually realize the full potential of the Fermilab complex. During the Board meeting, concerns were raised by Mr. C. Rubbia in regards to the relative small energy provided from the Booster. His concerns centered around what the current emittance of the Booster is at injection. In response, it was indicated that the Booster is currently at 22 GeV/second. In addition, Mr. A. Rubbia requested to be advised on the current beam losses as it puts additional constraints on the current beam and will need improvements to the Booster and Recycler prior to the start of the long-baseline project.

14. Discussion 2: Optimal Beam Characteristics by Marzio Nessi and Yury Kundenko*

Optimal beam characteristics for the long-baseline neutrino facility project were discussed and presented by Marzio Nessi and Yury Kundenko. At the moment there are several proposals for beams on long-baseline experiments but the final decision should be carefully considered. It is important that the option of the beam to cover 1st and 2nd oscillation maxima be carefully studied. The importance of the power of the 2nd oscillation maximum and its importance at a 1300 km baseline should also be considered. As observed by Mr. Tanaka, the impact of the 2nd oscillation maximum depends on how much information you are getting from the 1st maximum. If you do not reach the first, it is hard to reach the second and therefore obtain useful data at this level. It will also be important to look into beam options that have been abandoned in the past for cost reasons to provide potential options for the new beam line. In addition, new ideas are now emerging and will be seriously analyzed in the next few months for other beam line options.

15. Discussion 3: Formation of Working Groups by Kate Scholberg and Mark Thomson

As the last presentation of the day, Kate Scholberg and Mark Thomson laid out the primary discussion issues regarding the initial formation of the long-baseline working groups. In their presentation they defined the aims of the working groups as to provide input to the iiEB, defining the main scientific and technical issues for implementation as well as to prepare the scientific and technical arguments for the LOI. As a result of the July 2014 Neutrino Summit, there was consensus that there should be three main working groups formed. These groups will cover the presentation of arguments for the physics program, present the site-specific project implementation issues and consider the impact of potential uncertainties while evaluating the required measurements to overcome these uncertainties and meet the systematic goals of the long-baseline program.

Two types of organizational formats were considered for the working groups, including one having two co-chairs that represent the interests of the collaboration and the international community and another with an independent chair and two additional deputies that represent both entities as a whole. Leadership of these groups would be determined at a later date once additional decisions had been made. The working groups would operate on one of two possible models, a closed selected group or an open group with free membership. Finally, it was proposed that each working group be charged to produce a short briefing document for the iiEB that would define key scientific and technical arguments that could be used to develop the LOI.

Upon further discussion of the working group potential models, Mr. Rubbia presented to the Board that it is important to select individuals who will not require a learning curve and that can complete the work that is asked of them in a timely manner in order to keep up with the LOI time schedule. The implementation of the project is the foremost and ultimate goal of the working groups. In response, Mr. Jung also voiced his concern that without

the identification for a potential site, it will be difficult to give the working groups a strong indication on what the project goals will be. Mr. Lockyer also reiterated that with a goal of a bottom-up approach for the development of the collaboration it will be vital to have open working groups that promote transparency.

16. Adjourn for the day

With no further discussion, the Board adjourned for the day at 5:34 p.m. by Nigel Lockyer.

September 24, 2014

1. Thoughts/Questions/Comments/Review from Day 1 by Nigel Lockyer, Robert Roser and Kenneth Long

Nigel Lockyer called the meeting to order at 8:31 a.m. and reviewed the presentations and discussions from the previous day. In his discussion he identified the following action and decision items which will be circulated to Board members for discussion.

- Decision Items:
    1) This is a world class discovery experiment that stands on its own… (three pillars are: neutrinos, particle astrophysics, and proton decay).
        a) Spectral information is critical for CP violation.
        b) Information about 1st and 2nd oscillations maxima important.
        c) Other experiments may be complementary to parts of the science program
    2) Two Flagship measurements…CP and Mass Hierarchy (in that order 5 sigma for both) but also a broad program of supporting important science e.g. mixing from atmospheric neutrinos, proton decay, SN neutrinos, cross sections.
    3) Date fixed…..we are aiming for 2025 to begin…no renouncing of date.
    4) Agreement that far detector must be large, > 25kTons and modular with > 3000 m water equivalent overburden.
        a) Modular design and build. Can get initial ~10kton in < ~5 years.
        b) Technology is liquid argon.
        c) No decision on big versus modular caverns.
        d) Initial science ASAP.
    5) Near detector “facility” must ultimately be: flexible high precision tracker & argon capable of dealing with systematics.
    6) Continue structure of existing collaborations until PIs meet and form a new collaboration.
    7) Keep working group activities within collaboration until new collaboration formed leaders.
    8) The LOI is being drafted and “Shepherded” by Ken Long and Rob Roser.
    9) Wait until workshop/visit (October 8-10) to Sanford to inform the Board on site.
    10) After visit of “international expert team” we anticipate a discussion on issues that we will have to work through and/or also begin process to pursue a new site.
        a) Site is Sanford unless there is a flaw that causes the Board to reconsider.
    11) Phone meeting of iiEB October 20th, 2014 at 10:00 am CDT.
        a) To get update on visit to Sanford;
        b) Attempt to converge on LOI and decide who will sign LOI (all, PIs only,…);
        c) Begin discussion on next steps and meeting….ideally PI meeting (where and when).
    12) Once PI’s sign the LOI, the new collaboration can begin to form…this is the clear transition point and iiEB is dissolved in favor of IEB.

13) No Spokespeople will be appointed by the iiEB, but two contact persons will act as shepherds, and Spokespeople will be then be chosen/elected by the new collaboration.

- Action Items:
    1) Provide more transparency for community.
        a) Minutes will be public (after being sent around)…set up on web page (Stephany);
        b) WG will be open (collaboration will choose leaders).
    2) Write Terms of Reference for iiEB (start with Rob/Ken slides)
    3) Determine a communication plan of iiEB…..email updates, dates of next face-to-face meeting…phone meetings.
    4) Discuss with OPA (office of project assessment DOE) whether FY18 is reasonable, given international issues.
        a) Do we need a (Sergio style) money matrix (already being asked for)?
        b) Can any other funding agencies meet aggressive DOE funding schedule?
        c) Will be important for some countries to work through CERN (save VAT)?
        d) Timeline set by US-CERN "LHC annex" and "neutrino annex" FY17 they must be done (Implementing Agreement is at CERN now and Annexes starting).
    5) Ask PAC Chair what they would like to see in "CDR"…includes cost, schedule+++
        a) Expect reviews by DOE to be done by collider community and they will set the bar very high;
        b) Bottoms up approach…collaboration must own CDR;
        c) Top down resources meets bottoms up;
        d) SBN program allows people to get involved now and build momentum…important to keep moving forward and growing funding adiabatically with non-DOE funding agencies including NSF (some think this is a diversion and defocuses so we need to be careful and look at governance of SBN experiments);
        e) Should we explore study electrons from off axis K decay from Numi beam line?
    6) Can the LOI be earlier than Rob and Ken proposed in timeline (they suggested early December for next iiEB)?
        a) More configuration details in LOI the better.
        b) Begin to define contents of CDR ASAP.
    7) When does the collaboration form?
    8) How will access to tenders work for the project?
    9) We need to optimize not only how Fermilab acts as a host but also how CERN works to support a host…new role for each lab.
        a) A visible presence at CERN will be critical…WA105 involvement for example;
        b) Countries work through CERN for in-kind contributions;
        c) Cannot ask funding agencies to pay twice…CERN can contribute to infrastructure …countries primarily contribute to the detectors.
    10) Mike Weis…Sanford… DOE "paper work" in good shape…new site a couple of years.
        a) Siegrist DOE already at Sanford…two experiments there Lux/LZ and Majorana demonstrator.
        b) Determine cost of operations at Sanford site…needed for PAC.
    11) Should we consider a near detector in NUMI for reducing systematic type effects in final measurements and this should be informed by T2K and Nova?
    12) We need to make a thorough comparison of costs between LBNO and LBNE….there may be significant savings…..form a cost committee….iJOG could review?

13) Consider inviting funding agencies to Sanford.
14) Place relevant documents on web page for funding agencies…
15) Transition phase plan (a team?) needs to be developed for forming the new collaboration. Important to keep momentum going.
16) What is payment model…to both infrastructure and detector…should we adopt an approach similar to CERN's LHC model?

2. Discussion 4: Transition Plans/New Collaboration by Milind Diwan

Mr. Milind Diwan offered discussion points for a transition plan to the new collaboration for the long-baseline neutrino project. To begin, Mr. Diwan recognized the current status which includes the new iiEB, two current organized science collaborations with by-laws and working groups with knowledgeable scientific and technical members. Next, Mr. Diwan presented to the Board the ending point goal of the transition to the new collaboration. This end point includes a single collaboration with a set of scientific goals that has a recognized, unified leadership team committed to the goals and how to achieve them. The collaboration will also have a decision making process that includes all stakeholders, funding agencies and scientists to allow for a funding plan to be created which is feasible and accepted by the appropriate international funding agencies. Scientific and technical working groups must have international leadership and membership that is highly capable with a deep level of trust.

Mr. Diwan also presented discussion items to consider for the roles and responsibilities of the institutional board, executive board, spokespeople, management council, project directors and resource coordinator. He pointed out that these bodies must be thought about and there should be understanding and agreement during the transition on these between the iiEB and the newly formed collaboration. Communication during the transition between all parties will be vital and there should be a coordinated plan or strategy for communication between the collaboration and the iiEB during important events such as scientific reviews, technical design reviews, cost and schedule reviews, funding reviews of the collaboration and oversight of DOE/NSF supported groups and public/political interactions including outreach. Finally, a strong team dedicated to safety and quality control with access to the FNAL Director and the DOE should be in place throughout the process in case of a safety or quality emergency/situation.

In regards to the long-baseline transition, there are a few items that require guidance from the iiEB. These include the timeline regarding the process of arriving at the new collaboration and structure and the maintenance of the interim structure until a definite transition point can be defined. Decisions must be made by the new collaboration on how to transition the already existing detailed organizational structures for LBNE and LBNO. As pointed out by Mr. Ereditato, these groups cannot be overlooked as the current capital/individuals in LBNE are a resource for the new project. The collaboration should try to bring everyone interested into the new program through a transparent process and open communication with understanding between the individual and the Lab. Structure with people they know will give individuals direction in the interim.

3. Discussion 5: Selecting (Co)-Spokespeople by Chang Kee Jung and Stefan Soldner-Rembold

Chang Kee Jung and Stefan Soldner-Rembold presented the Board with a list of several possible options for selecting collaboration spokespeople. To prepare for the discussion, Mr. Jung and Mr. Soldner-Rembold surveyed relatively large (~500 members or larger) modern international collaborations for their history and practice of selecting spokespersons, especially in the beginning and early stages of the experiments. In their survey they asked for feedback on structure of the top management of the collaboration and the process of selecting spokespeople. In summary, the survey resulted in top management having an equal number of collaborations with one or two

spokespeople where the typical European model had one spokesperson and the US model had two individuals. The process of selecting spokespersons in the early stage of an experiment had an equal number of collaborations with self-appointed, committee or lab director appointed and elected spokespeople. Most of the collaborations eventually transitioned to an "election" model.

Mr. Jung and Mr. Soldner-Rembold then proposed to the Board a potential to outline of a procedure for appointing the leadership of the future collaboration in the interim phase before a fully functional international new collaboration can be formed. This new collaboration will then write its own by-laws which are expected to address questions such as the nomination procedure, the length of terms and their possible staggering, the election procedure, and possible rules about how the new collaboration may ensure that there are both a U.S. and a non-U.S. spokespeople. Generally, it was proposed to have a total of two spokespeople which will be filled from a U.S. and non-U.S. institution equally. The nominal terms for these individuals will be two years with a term limit. The initial spokesperson will either be appointed by the chair of the iiEB, elected by the non-stakeholder iiEB members, appointed by the iiEB representatives or elected by the new collaboration once it has been formed.

As stated by Mr. Lockyer, the current situation is different than other models as the surveyed collaborations were aware of the coming changes. Currently, the iiEB is in a position where a decision has to be made to define when and how the collaboration will form once the LOI is written. At this point, a meeting of the PI's will be called to form the collaboration from the "bottom up" and to minimize the involvement of the iiEB. Mr. Jung and Ms. Fleming pointed out that it is the job of the iiEB to "shepherd" this process through a contact person but to not be directly involved. It is the job of the spokespeople and PI's to make the decisions on the election process based on the formed by-laws. Because of the scope and size of this international collaboration, there may be a need to have more than one contact person at any given time. Finally, Mr. Lykken presented the question on how the LOI will be signed. Will the PI's sign by going to a website or will the Board have individual conversations with each PI prior to signing? Mr. Lockyer responded by saying he hopes we are heading towards a PI meeting for signing where the scientific community is invited to give their opinions.

4. Discussion 6: Drafting Bullets to Form the Basis for LOI by Kenneth Long and Robert Roser

To conclude the meeting, Kenneth Long and Robert Roser presented their LOI bullet points for discussion to the Board. These bullet points assumed that the October 8-10, 2014 visit to Sanford Underground Research Facility will be a successful one. As presented by Mr. Roser, the overall scope of the LOI should include that the long-baseline neutrino facility is a deep-underground neutrino observatory for long baseline neutrino oscillations, neutrino astrophysics and proton decay searches which utilizes liquid argon as its primary technology. The facility will utilize Sanford Lab and have a 1300 km baseline and a fine grained highly capable far detector that is located underground. The detector will be a unique, exciting and challenging program which adopts a modular approach to get construction and first science early. The long-baseline facility will start its full data-taking period as soon as 2025 and extend until approximately 2035.

The scientific goals of the LOI should present a long-baseline physics case that is compelling and competitive. The LOI must put emphasis on the discovery opportunities of the program as well as the unprecedented precise performance measurements of the facility that will expand frontiers with outstanding capabilities in long-baseline, supernova, proton decay, and near detector technology. To achieve these goals the collaboration must rapidly establish itself as a main player in the deep underground physics field (accelerator and non-accelerator) while beginning the construction of a facility which includes an initial 10kton modular detector at Sanford Lab by early 2021. While the first modular detector is operating, a second modular detector would immediately follow and this process would continue until the desired 35kton detector goal is reached. The installation of a preliminary module will engage the collaboration early, test all the aspects of the underground installation and operation, provide an

early underground physics program that can be ready for beam physics as soon as PIPII is commissioned and provide a competitive advantage to create and train the data analyzers that will be needed for the full scale 35kton detector.

Discussion on Mr. Roser's LOI bullet points was limited to a few main points such as one supplied by Mr. Siegrist and Mr. Ereditato which stated that the current points do not mention the international component of the project. The LOI must emphasize that this is an international project with the need for an international collaboration. Secondly, Mr. Soldner-Rembold also indicated that there seems to be some misunderstanding logistically that the program will have multiple collaborations; the LOI should define that the program will house a single international collaboration that is named separately from the actual facility. At the conclusion of discussions, it was decided that Mr. Long and Mr. Roser would be the best candidates to write the LOI to allow for a quick completion of the process and allow for a PI meeting to happen earlier than originally proposed. The message in the LOI is the most important and it should be completed in the most concise and complete way as possible. The Board must keep in mind the timeline and also present the best case possible. The quick creation of a short and precise LOI caused Ms. Scholberg to pose the question of the necessity of working groups prior to the collaboration forming? In response, Ms. Fleming believed that the transition could be achieved without the formation of working groups and that the status quo could continue until the LOI is written and a PI meeting is called.

Action Item: What do we call it now if we are not planning on calling it LBNF at the final product?
Action Item: We must engage the countries that are not represented at the iiEB. How do we engage those individuals?

5. Date of Next Meeting by Robert Roser

Based on the discussion led by Robert Roser, it was decided to hold a one hour teleconference on October 20th at a time to be announced. During this teleconference there will be discussion of the LOI, the visit to Sanford and perception of the potential site and how to have the PI's declare their intent to attend the PI meeting. During this meeting there will also be a decision made on a December date for the PI meeting as well as the next iiEB meeting. It was expressed to schedule this meeting in the evening in accordance with the time change with CERN as many Board members will be at CERN this day.

6. Adjourn:

With no further discussion, the Board adjourned at 12:11 p.m. by Nigel Lockyer.

Respectfully submitted by:

_____ Date:_____

Stephany Unruh
Board Secretary

_____ Date:_____

Nigel Lockyer

Interim Chair