LBNE Collaboration Perspective

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BROOKHAVEN NATIONAL LABORATORY

Outline

- Comments on the scientific opportunity
- Collaboration and project organization
- Milestones in the last two years
- Current schedule for LBNE
- Plans for expansion and full scope

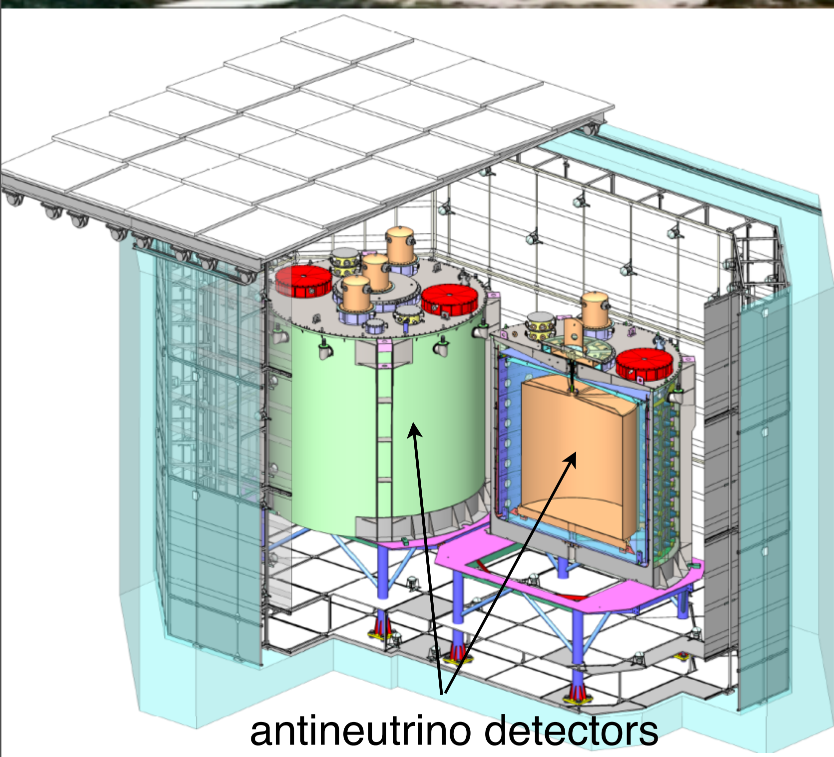
Vision

- The LBNE collaboration is planning for an experiment with these elements:
  - ✦A long-baseline to allow full exploration of neutrino oscillations: mass hierarchy, CP violation, and precision measurements with sensitivity to new physics and non-standard interactions.
  - ✦A capable large detector located deep to obtain statistics and explore rare physics of proton decay and supernova.
  - ✦An advanced near detector for precision measurements of oscillations and other precision measurements.

Implementation

- The collaboration recognizes that all of the above are not currently planned in phase 1 due to the cost constraint, but the reconfiguration choice allows us the best path to achieve it over time.
- The LBNE design, organization are ready, and most importantly the science is timely.
- The collaboration and the project are well organized and want to get construction started rapidly to maintain leadership in this science.

Daya Bay θ_{13} Results



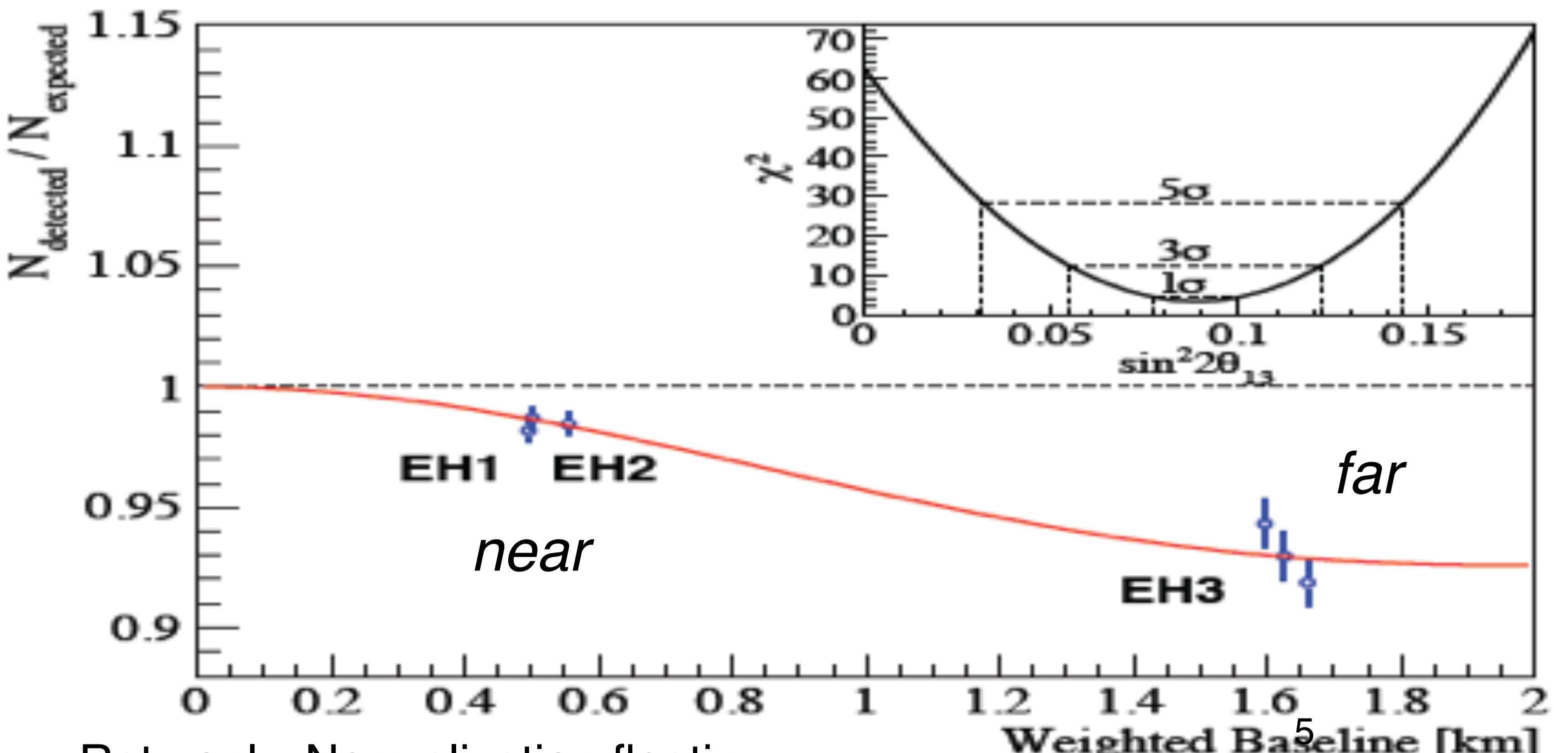
Observe electron-antineutrino disappearance

six 2.9 GWth reactors

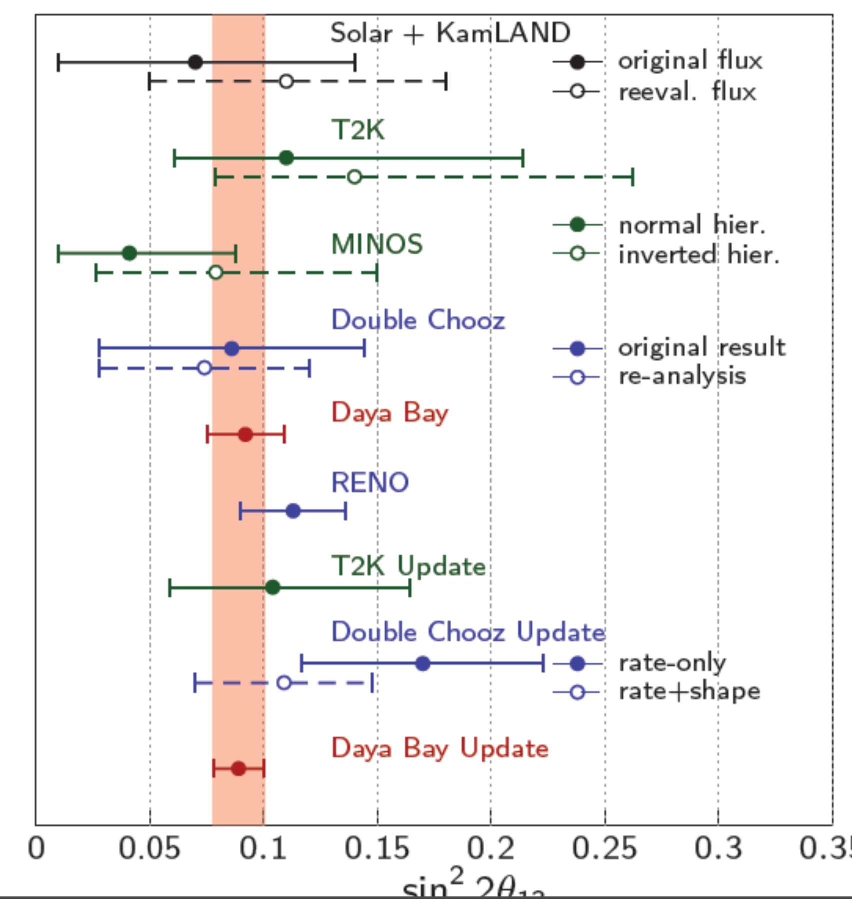
six 20-ton detectors: 3 near (~500m), 3 far (~1650m)

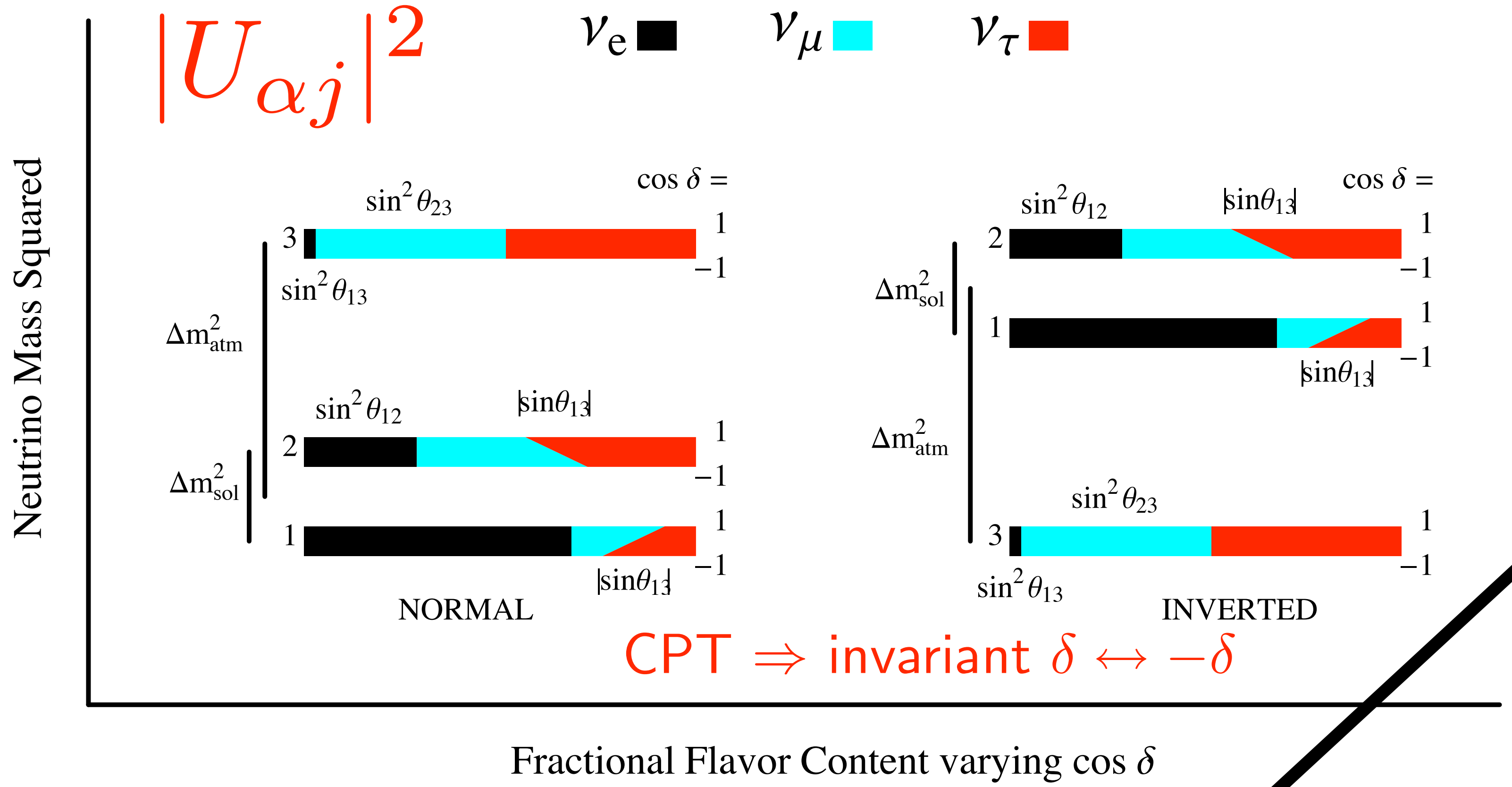
139 days of running

$\sin^2 2\theta_{13}$=0.089+-0.010(stat)+-0.005(syst)



Rate only. Normalization floating





Both quantities are fortunately just right for a practical laboratory experiment.

$$\delta m^2_{sol} = +7.6 \times 10^{-5}\ eV^2 \qquad \sin^2\theta_{12} \sim 1/3$$

$$|\delta m^2_{atm}| = 2.4 \times 10^{-3}\ eV^2 \qquad \sin^2\theta_{23} \sim 1/2$$

$$|\delta m^2_{sol}|/|\delta m^2_{atm}| \approx 0.03 \qquad \sin^2\theta_{13} = 0.023$$

$$\sqrt{\delta m^2_{atm}} = 0.05\ eV < \sum m_{\nu_i} < 0.5\ eV = 10^{-6} * m_e \qquad 0 \leq \delta < 2\pi$$

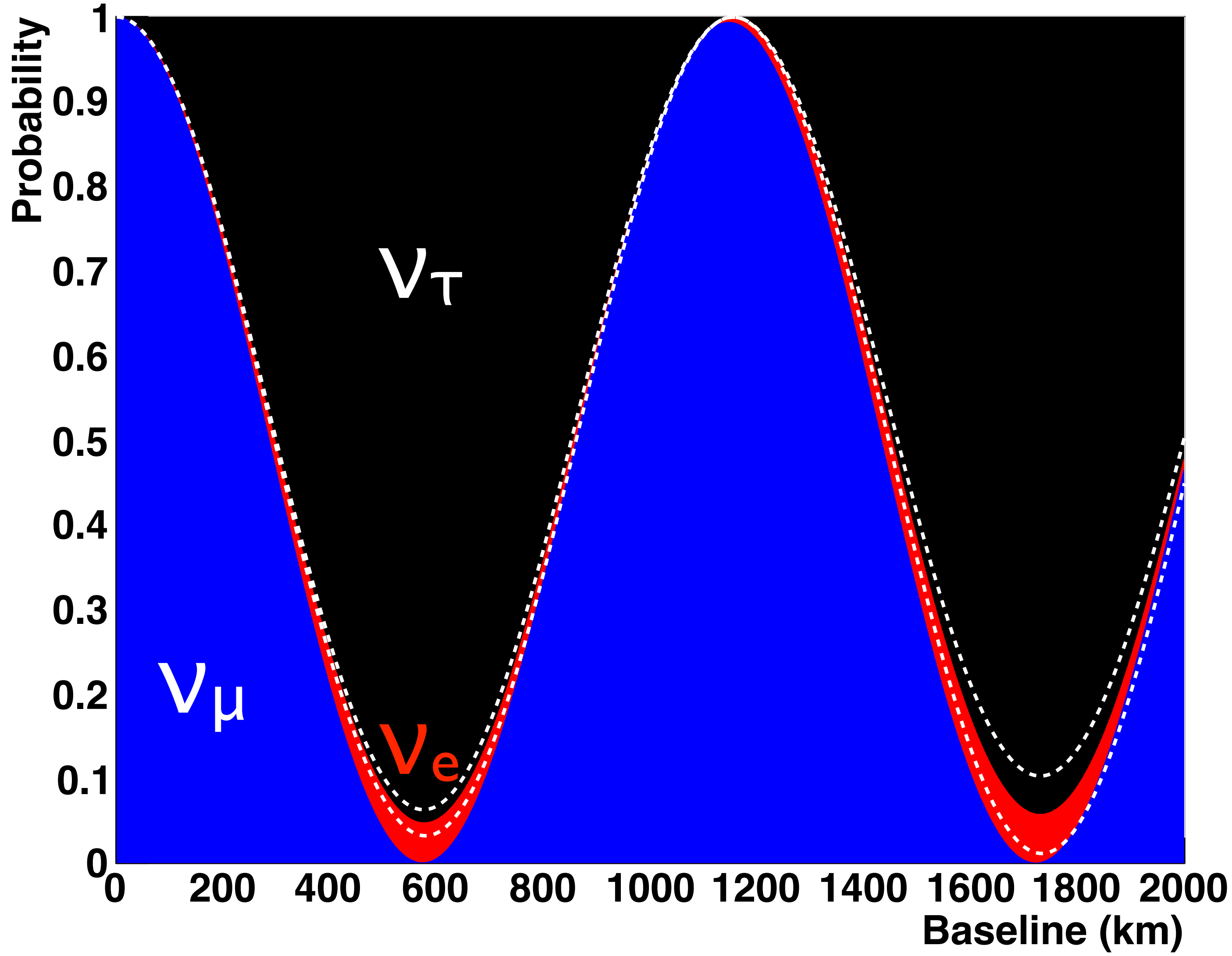
$\theta_{12} \approx \theta_{sol} \approx 34°$, $\theta_{23} \approx \theta_{atm} \approx 37\text{-}53°$, $\theta_{13} = 9°$

δ would lead to $P(\bar{\nu}_\alpha \rightarrow \bar{\nu}_\beta) \neq P(\nu_\alpha \rightarrow \nu_\beta)$. ~~CP~~

Since there are 3 neutrinos, there must be a 3x3 matrix with 3 angles and 1 phase (observable) and 2 Δm^2. LBNE will determine if this holds true.

The full picture of the oscillation effect

Probability for ν_μ oscillation at 1 GeV

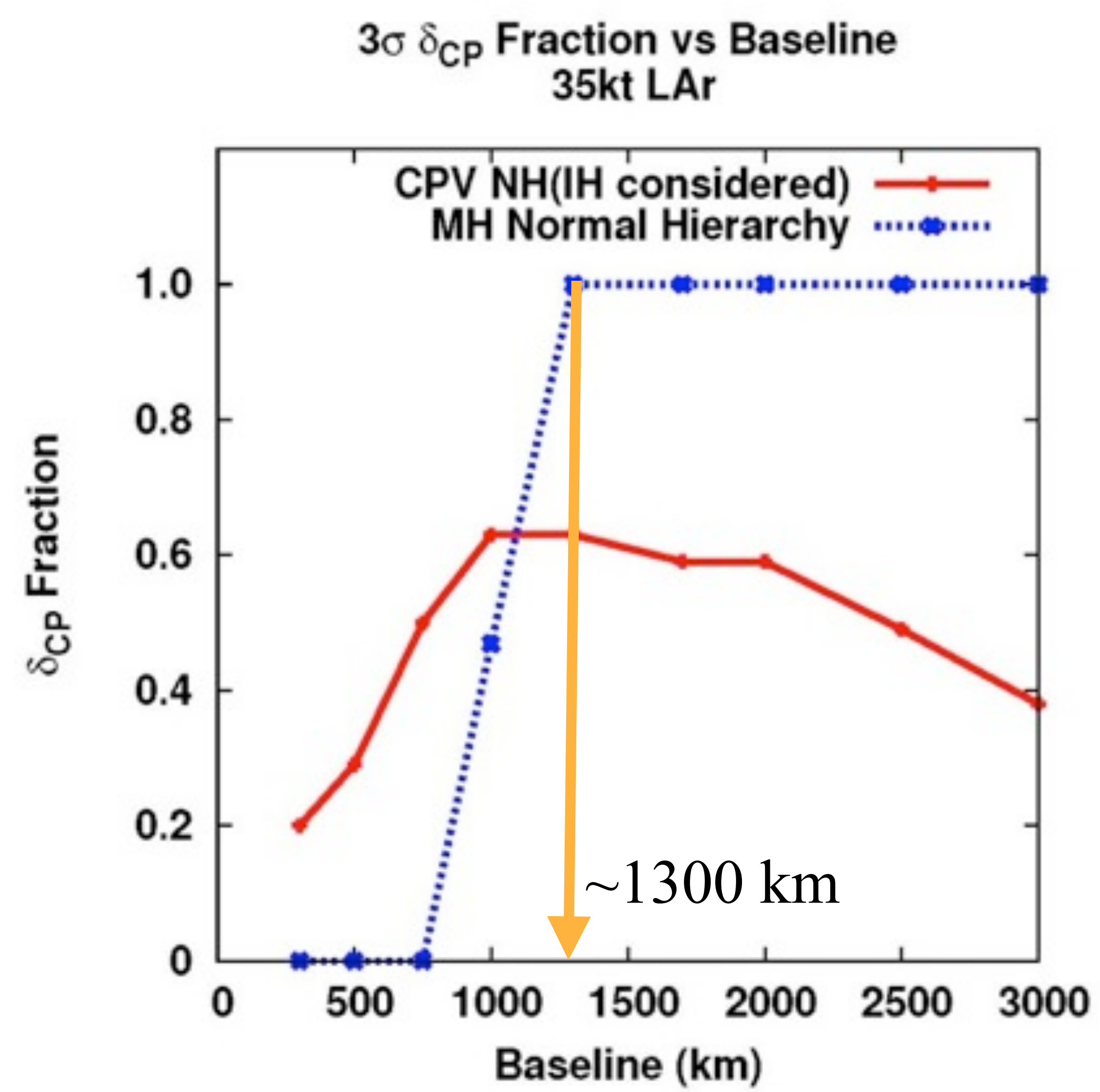


Dashed white lines correspond to CP violation

- The neutrino oscillation model is based on limited dataset
- With very precise predictions:
  - Large Matter Effects
  - Potentially large CP violation
  - LBNE will test this picture with a detailed spectrum

The scientific opportunity

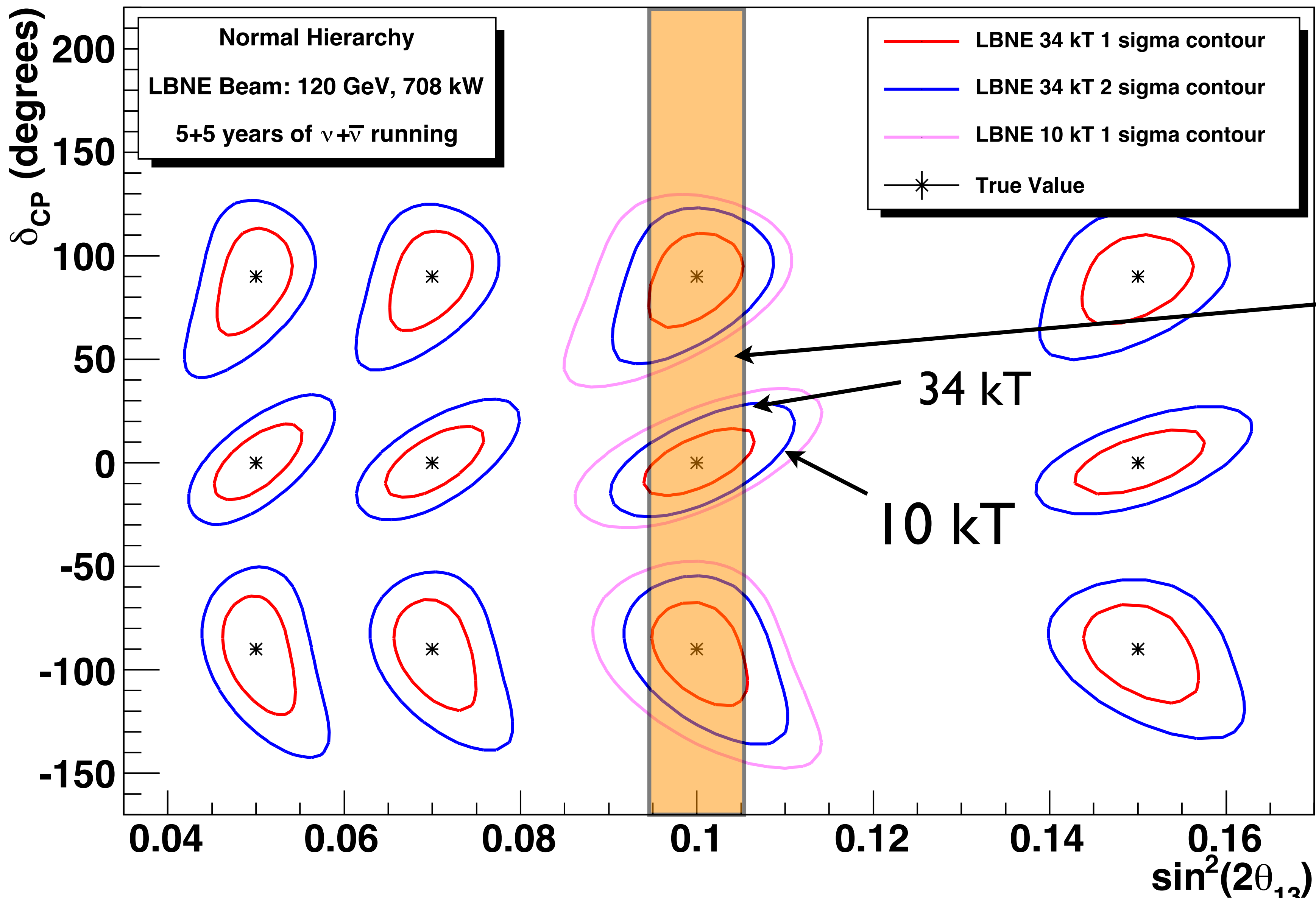
- The design for a US based CP violation program started ten years ago before we knew the solar LMA solution and θ_{13}
- The scale of the program needed is only weakly dependent on θ_{13} because the CP asymmetry is smaller for larger θ_{13}
- Our scientific choices and the design could not be any better.
- The investment requested by P5 and carried out by the DOE/NSF was timely and has paid off.
- The US program is best positioned right now to explore CP violation in neutrinos.



This calculation optimizes the beam from the Fermilab Main injector for each distance and calculates the full sensitivity for θ_{13}= 9 deg.

LBNE Parameter measurement

Phase I ν_e(anti-ν_e) ~50 (~20) events per year with >50% modulation



Expected final 1 sigma error from reactors (centered on 0.1)

- LBNE will have a definitive determination of the mass hierarchy.
- LBNE will have a measurement of the phase and θ_{13} with no ambiguities.
- The phase measurement will range from ±20 to ±30 deg for Phase I when combined with reactor data.
- Parameter measurement will continue to improve with statistics.

Long-Baseline Neutrino Experiment Collaboration

Alabama: S.Habib, I.Stancu
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Indiana: W.Fox, C.Johnson, M.Messier, S.Mufson, J.Musser, R.Tayloe, J.Urheim
Iowa State: I.Anghel, G.S.Davies, M.Sanchez, T.Xin
IPMU/Tokyo: M.Vagins
Irvine: G.Carminati, W.Kropp, M.Smy, H.Sobel
Kansas State: T.Bolton, G.Horton-Smith
LBL: B.Fujikawa, V.M.Gehman, R.Kadel, D.Taylor
Livermore: A.Bernstein, R.Bionta, S.Dazeley, S.Ouedraogo
London: A.Holin, J.Thomas
Los Alamos: M.Akashi-Ronquest, S.Elliott, A.Friedland, G.Garvey, E.Guardincerri, T.Haines, D.Lee, W.Louis, C.Mauger, G.Mills, Z.Pavlovic, J.Ramsey, G.Sinnis, W.Sondheim, R.Van de Water, H.White, K.Yarritu
Louisiana: J.Insler, T.Kutter, W.Metcalf, M.Tzanov
Maryland: E.Blaufuss, S.Eno, R.Hellauer, T.Straszheim, G.Sullivan
Michigan State: E.Arrieta-Diaz, C.Bromberg, D.Edmunds, J.Huston, B.Page
Minnesota: M.Marshak, W.Miller
MIT: W.Barletta, J.Conrad, B.Jones, T.Katori, R.Lanza, A.Prakash, L.Winslow
NGA: S.Malys, S.Usman
New Mexico: J.Mathews
Notre Dame: J.Losecco
Oxford: G.Barr, J.de Jong, A.Weber
Pennsylvania: S.Grullon, J.Klein, K.Lande, T.Latorre, A.Mann, M.Newcomer, S.Seibert, R.vanBerg
Pittsburgh: D.Naples, V.Paolone
Princeton: Q.He, K.McDonald
Rensselaer: D.Kaminski, J.Napolitano, S.Salon, P.Stoler
Rochester: L.Loiacono, K.McFarland, G.Perdue
Sheffield: V.Kudryavtsev, M.Richardson, M.Robinson, N.Spooner, L.Thompson
SDMST: X.Bai, C.Christofferson, R.Corey, D.Tiedt
SMU.: T.Coan, T.Liu, J.Ye
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South Dakota State: B.Bleakley, K.McTaggert
Syracuse: M.Artuso, S.Blusk, T.Skwarnicki, M.Soderberg, S.Stone
Tennessee: W.Bugg, T.Handler, A.Hatzikoutelis, Y.Kamyshkov
Texas: S.Kopp, K.Lang, R.Mehdiyev
Tufts: H.Gallagher, T.Kafka, W.Mann, J.Schnepps
UCLA: K.Arisaka, D.Cline, K.Lee, Y.Meng, A.Teymourian, H.Wang
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Washington: H.Berns, S.Enomoto, J.Kaspar, N.Tolich, H.K.Tseung
Wisconsin: B.Balantekin, F.Feyzi, K.Heeger, A.Karle, R.Maruyama, B.Paulos, D.Webber, C.Wendt
Yale: E.Church, B.Fleming, R.Guenette, K.Partyka, A.Szelc

347 Members
59 Institutions
25 US States
5 Countries

19 July 2012 (347)

Institutions in LBNE (59)

Argonne
Alabama
Boston University
Brookhaven
Caltech
Cambridge
Catania
Columbia
Chicago
Colorado
Colorado State
Columbia
Crookston
UC/Davis
Drexel
Duke
Duluth
Fermilab
Hawaii
Houston
Indian Universities[BHU, Delhi U., IIT(G), Panjab U.]
Indiana
Iowa State
IPMU-Tokyo
UC/Irvine
Kansas State
Lawrence Berkeley National Lab
Livermore
London UCL
Los Alamos
Louisiana State
Maryland
Michigan State
Minnesota
MIT
NGA
New Mexico
Notre Dame
Oxford
Pennsylvania
Pittsburgh
Princeton
Rensselaer
Rochester
Sheffield
South Carolina
South Dakota
South Dakota State
SDSMT
Southern Methodist
Syracuse
Tennessee
Texas
Tufts
UCLA
Virginia Tech
Washington
Wisconsin
Yale

59 institutions, ~350 collaborators

University: ~220
Laboratory: 115

Tenure Track or recently tenured: ~23

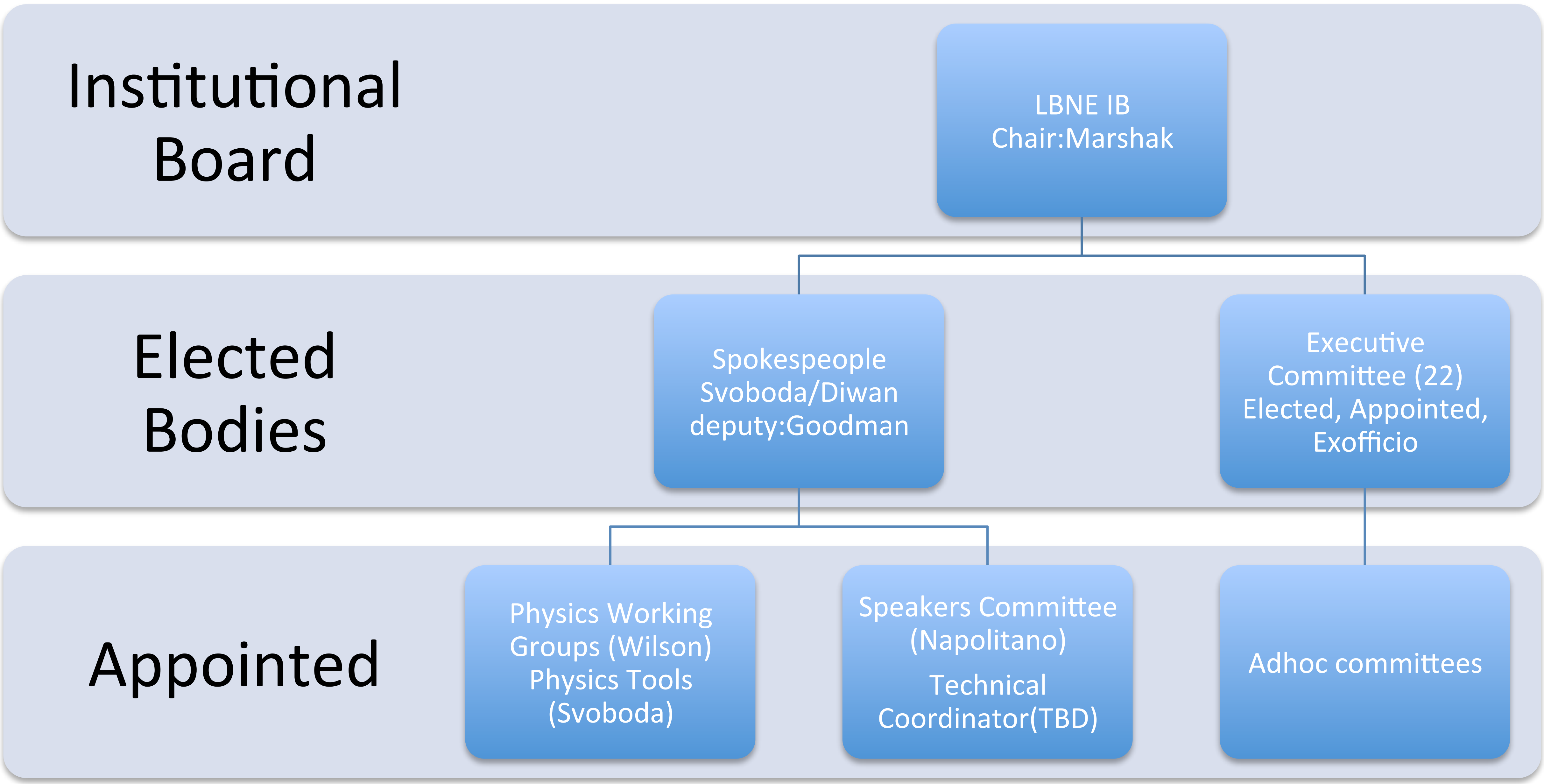
Postdocs + students: ~20
Postdocs and students supported part time during design and construction.

There are ~15 working groups.

Project costed personnel ~30-50 FTE.

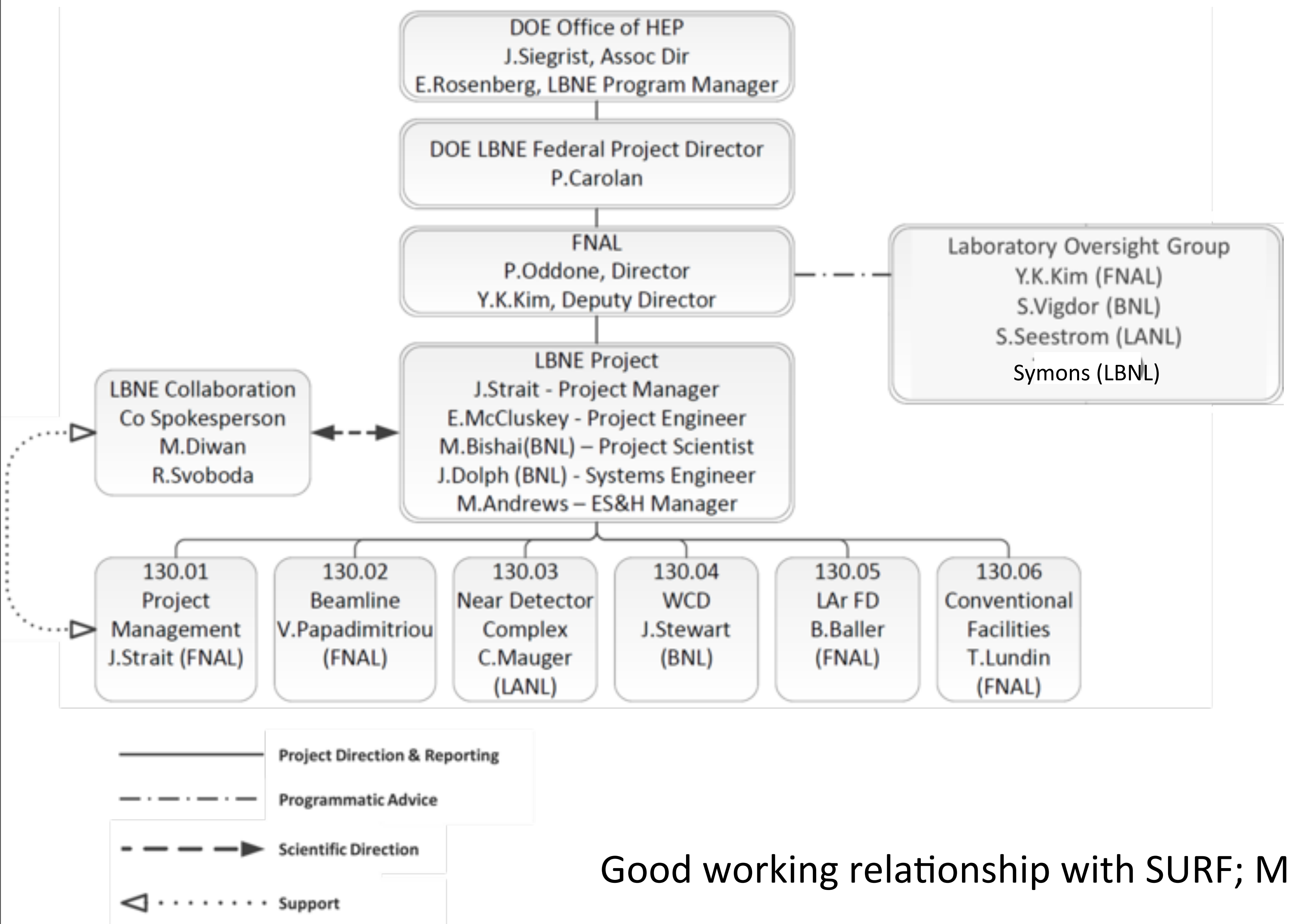
Projections indicate need of about ~500 members. Future growth planned to be international.

Collaboration structures



Large efforts with large and diverse funding need a corporate structure. IB is ruled by a governance document that sets the charge for each office and terms of appointment or election. There have been 3 elections so far.

Project Organization



- Fermilab is the Lead Lab
- The BNL/FNAL/LANL project leadership are well integrated.
- Substantial University participation to be strengthened further.
- Exploring further strengthening of the Project Office.
- The Project and Collaboration are well integrated.

Good working relationship with SURF; MOU expected soon

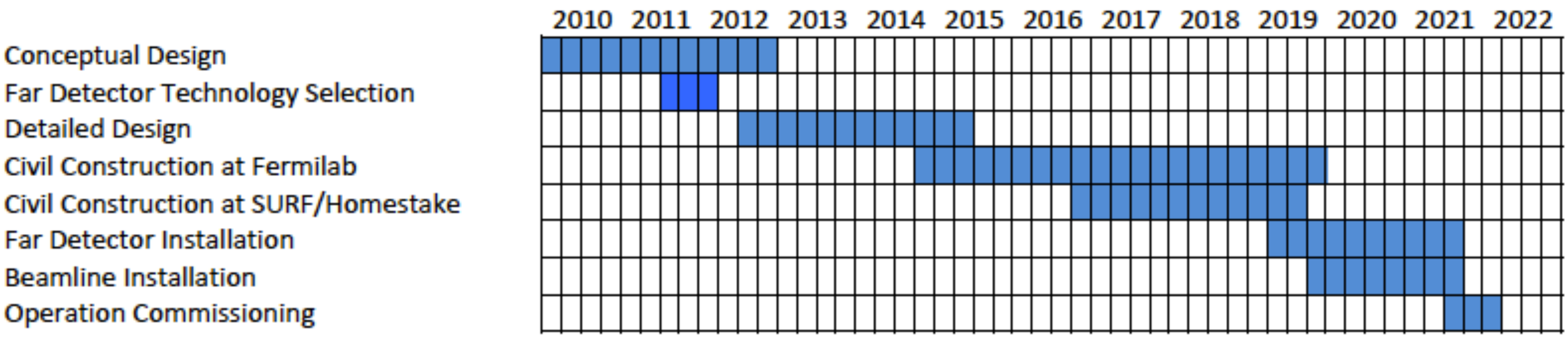
Important Events

- December 2010, NSB turned off NSF consideration for DUSEL.
- 2011 Review from the NRC/BPA committee reaffirmed the science for LBNE and DUSEL.
- July 2011 Marx/Reichanadter committee reviewed the costs and technologies. Costs for LBNE roughly known since summer of 2011. Clear that could not afford both a water and LAr detectors (the collaboration preference).
- Fall of 2011, extensive internal reviews for detector technology choice.
- In December 2011, the LBNE Exec Board/Fermilab/DOE had extensive negotiations over the far detector technology. The collaboration board preferred the water detector because of the cost/schedule certainties.
- Final decision was for a 34 kTon LAr detector based on the better performance for higher energies (due to L/E and 1300 km) and uniqueness of the technology: complementarity for proton decay and supernova physics to existing water detectors.
- Deemed ready for CD1 review in March when the Daya Bay result was announced.
- DOE asked that LBNE be structured in phases leading to the reconfiguration panel.

Collaboration Effort

- Level and quality of effort has been very high for LBNE. The physics working group has produced numerous reports. The reconfiguration panel relied on the collaboration for physics input.
- Active collaboration with > 6000 documents in the document database so far.
- The collaboration has grown since Dec. 2010 by about 5 institutions.
- The collaboration remains committed and strong and will seek expansion of the science program.

LBNE Phase 1 Schedule



- This is the technically driven schedule. Current funding profile is expected to cause 11 month delay.
- The period up to far detector construction start offers good opportunity to seek major non-DOE and international partners.
- Deep placement of far detector as well as a near detector expansion can be accommodated in the current plan by CD2.

Costs after Reconfiguration

Scope	Cost (TPC)
LBNE 34 kTon@4850L and near detector	$1.440B
LBNE Phase I, 10 kTon surface	$0.789B
+Place Underground	$0.924B
+ Near Detector	$1.054B

Our plans for expansion of science program

- Locating the detector underground will cost $135M or 15% of the LBNE Phase I total and enable the physics of proton decay and supernova neutrinos.
- Similarly, a full capability near detector needs about $130M including civil construction.
- Collaboration is considering various non-DOE proposals/ avenues to enable underground placement of the detector for substantial broadening of the program.
- There will be conversations with European physicists at the ESPG on Sep. 10-12, 2012. There are technical collaborations with UK/RAL already.
- High level agreements with India are proceeding regarding a substantial contribution for the near detector.

Conclusion

- The goal of finding the phenomena of CP violation in the neutrino sector is extraordinary and has been strongly endorsed.
- Our accelerator/detector technological capability and the geographical situation could not be better matched to the science of neutrino oscillations.
- The LBNE collaboration and project are well organized and ready to construct and operate LBNE.
- The steering panel report is a culmination of a very long process of design/costing/planning by a broad section of the community. It puts us on a track to a massive detector for CP violation and proton decay.
- The collaboration (with FNAL and DOE) will work towards strong international investment and expansion of the science program.

Backup Slides

LBNE Executive Committee

- The Executive Committee (EC) is responsible for making major scientific and technical decisions. These decisions include the total scientific scope of the experimental project, and the technical choices for the experiment.
- 6 appointed by spokespeople, 6 elected by IB, Ex-officio from collab. and project.
- EC meets on a regular basis on the phone and has in person meetings with formal agenda.
- EC is the main body where Collaboration/Project interactions takes place.

Ref: LBNE governance document

European Strategy Group Submission

Abstract The Long-Baseline Neutrino Experiment (LBNE) collaboration plans a comprehensive experiment that will fully characterize neutrino oscillation phenomenology using a high intensity 1300 km baseline accelerator neutrino beam and an advanced liquid argon TPC as the far detector. The goals for this program are well recognized to be the determination of leptonic CP violation, the neutrino mass hierarchy, and underground physics, including the exploration of proton decay and supernova neutrinos. The collaboration and the project are well organized and the U.S. Department of Energy has stated their intention to carry out this program in a phased manner. The scope of the initial phase focuses on accelerator neutrino physics and does not include deep underground placement of the far detector or the full near detector. The incremental cost of moving the phase 1 detector underground or of building a full-capability near detector complex are relatively modest: the cost of each of these is only about 15% of the LBNE phase 1 cost of ~US$800M. LBNE represents a substantial investment from the US in a frontier facility for high energy physics. Thus, there is significant opportunity for new collaborators to leverage this major investment and add substantial scientific scope. Collaboration on the design and construction of the far detector, near detector, or neutrino beam could provide sufficient additional resources to allow us, together, to place the far detector underground in the first phase, and include a sophisticated near detector which would not only improve the accuracy of the long-baseline oscillation measurements, but have rich physics program in its own right. In the following we describe the complete project as well as the phasing strategy.

ESPG document
https://indico.cern.ch/abstractDisplay.py/getAttachedFile?abstractId=150&resId=0&confId=175067

ESPG submission from Pier Oddone.
https://indico.cern.ch/abstractDisplay.py/getAttachedFile?abstractId=84&resId=0&confId=175067

Authors: Strait, Svoboda, Diwan, August 15, 2012