LBNE/DUSEL Status

Gina Rameika
LBNE Project Scientist

Fermilab PAC
November 5, 2010

The Long-Baseline Neutrino Experiment

Outline

- Introduction
- Progress and status
- Schedule overview
- Summary

DOE Mission Need for LBNE

(January 2010)

- The Office of High Energy Physics proposes construction of an experiment comprised of a large detector illuminated by a distant, intense neutrino source and a much smaller detector located close to the source.

- The increased research capabilities afforded by a long baseline (distance between the detector and the neutrino source) neutrino experiment will enable a world-class program in neutrino physics that can measure fundamental physical parameters, explore physics beyond the Standard Model, and better elucidate the nature of matter and antimatter.

- The large detector, if located underground, and thus shielded from cosmic backgrounds, could also be sensitive to proton decay, predicted by grand unified theories which are natural extensions of the Standard Model. … Furthermore, an underground detector could serve as an observatory for neutrinos generated by supernovae since the beginning of time and for neutrinos generated more recently by supernovae in our galactic neighborhood, yielding new information on the collapse mechanisms of stars. (*emphasis added)

Long-Baseline Neutrino Experiment Collaboration

Alabama: J. Goon, I Stancu

Argonne: M. D'Agostino, G. Drake, Z. Djurcic, M. Goodman, X. Huang, V. Guarino, J. Paley, R. Talaga, M. Wetstein

Boston: E. Hazen, E. Kearns, J. Raaf, J. Stone

Brookhaven: M. Bishai, R. Brown, H. Chen, M. Diwan, J. Dolph, G. Geronimo, R. Gill, R. Hackenberg, R. Hahn, S. Hans, D. Jaffe, S. Junnarkar, S. Kettell, F. Lanni, L. Littenberg, J. Ling, D. Makowiecki, W. Marciano, W. Morse, Z. Parsa, C. Pearson, V. Radeka, S. Rescia, T. Russo, N. Samios,R. Sharma, N. Simos, J. Sondericker, J. Stewart, H. Tanaka, C. Thorn, B. Viren, Z. Wang, S. White, L. Whitehead, M. Yeh, B. Yu

Caltech: R. McKeown, X. Qian, C. Zhang

Cambridge: A. Blake, M. Thomson

Catania/INFN: V. Bellini, G. Garilli, R. Potenza, M. Trovato

Chicago: E. Blucher

Colorado: R. Johnson, A. Marino, M. Tzanov, E. Zimmerman

Colorado State: M. Bass, B. Berger, J. Brack, N. Buchanon, J. Harton, V. Kravtsov, W. Toki, D. Warner, R. Wilson

Columbia: R. Carr, L. Camilleri, C.Y. Chi, G. Karagiorgi, C. Mariani, M. Shaevitz, W. Sippach, W. Willis

Crookston: D. Demuth

Dakota State: B. Szczerbinska

Davis: R. Breedon, T. Classen, J. Felde, P. Gupta, M. Tripanthi, R. Svoboda

Drexel: C. Lane, J. Maricic, R. Milincic, K. Zbiri

Duke: J. Fowler, J. Prendki, K. Scholberg, C. Walter, R. Wendell

Duluth: R. Gran, A. Habig

Fermilab: D. Allspach, B. Baller, D. Boehnlein, S. Childress, T. Dykhuis, A. Hahn, P. Huhr, J. Hylen, M. Johnson, T. Junk, B. Kayser, G. Koizumi, T. Lackowski, C. Laughton, P. Lucas, B. Lundberg, P. Mantsch, J. Morfin, V. Papadimitriou, R. Plunkett, C. Polly, S. Pordes, G. Rameika, B. Rebel, D. Reitzner, K. Riesselmann, R. Schmidt, D. Schmitz, P. Shanahan, J. Strait, K. Vaziri, G. Velev, G. Zeller, R. Zwaska

Hawaii: S. Dye, J. Kumar, J. Learned, S. Matsuno, S. Pakvasa, M. Rosen, G. Varner

Indian Universities: V. Singh (Varanasi); B. Choudhary, S. Mandal (Delhi); B. Bhuyan (IIT); V. Bhatnagar, A. Kumar, S. Sahijpal(Panjab)

Indiana: W. Fox, C. Johnson, M. Messier, J. Musser, R. Tayloe, J. Urheim

Iowa State: M. Sanchez

IPMU/Tokyo: M. Vagins

Irvine: G. Carminati, W. Kropp, M. Smy, H. Sobel

Kansas State: T. Bolton, G. Horton-Smith

LBL: R. Kadel, B. Fujikawa, D. Taylor

Livermore: A. Bernstein, R. Bionta, S. Dazeley, S. Ouedraogo

London-UCL: J. Thomas

Los Alamos: S. Elliot, V. Gehman, G. Garvey, T. Haines, D. Lee, W. Louis, C. Mauger, G. Mills, A. Norrick, Z. Pavlovic, G. Sinnis, R. Van de Water, H. White

Louisiana State: W. Coleman, T. Kutter, W. Metcalf, M. Tzanov

Maryland: E. Blaufuss, 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, R. Lanza, P. Fisher

NGA: S. Malys, S. Usman

New Mexico: B. Becker, J. Mathews

Notre Dame: J. Losecco

Oxford: G. Barr, J. DeJong, A. Weber

Pennsylvania: J. Klein, K. Lande, A. Mann, M. Newcomer, R. vanBerg

Pittsburgh: D. Naples, V. Paolone

Princeton: Q. He, K. McDonald

Rensselaer: D. Kaminski, J. Napolitano, S. Salon, P. Stoler

Rochester: R. Bradford, K. McFarland

SDMST: X. Bai, R. Corey

SMU: T. Liu, J. Ye

South Carolina: H. Duyang, S. Mishra, R. Petti, C. Rosenfeld

South Dakota State: B. Bleakley, K. McTaggert

Texas: S. Kopp, K. Lang, R. Mehdiyev

Tufts: H. Gallagher, T. Kafka, W. Mann, J. Schneps

UCLA: K. Arisaka, D. Cline, K. Lee, Y. Meng, F. Sergiampietri, H. Wang

Virginia Tech: E. Guarnaccia, J. Link, D. Mohapatra, R. Raghavan

Washington: S. Enomoto, J. Kaspar, N. Tolich, H.K. Tseung

Wisconsin: B. Balantekin, F. Feyzi, K. Heeger, A. Karle, R. Maruyama, D. Webber, C. Wendt

Yale: E. Church, B. Fleming, R. Guenette, M. Soderberg, J. Spitz

280 collaborators, 54 institutions.

Stewardship, Scope

- By agency agreement:
  - NSF will steward DUSEL facility
  - DOE OHEP will steward LBNE
    - Includes beam line, near and far detectors
- LBNE CD0 approved Jan 8, 2010.
- Scope agencies are targeting is two 100-kton Water-Cherenkov-Equivalent (WCE) cavern/detector ensembles, near detector, & 700 kW beamline.
  - NSF will contribute to LBNE detector (& cavity).
  - Third detector will require an additional partner.
  - Overall scope will be responsive to cost.

Science Collaboration Physics Topical Groups

- Accelerator neutrino oscillations
- Proton decay
- Supernova bursts
- Relic supernovas
- Atmospheric neutrinos
- Solar neutrinos
- Geo and reactor neutrinos
- Ultra-high energy neutrinos
- Short-baseline/Near detector physics

Fall 2010 Report from the LBNE Physics Working Group

A. Beck, O. Benhar, F. Beroz, M. Bishai†, E. Blaufuss†, R. Carr, A. Dighe, M. Diwan, H. Duan, B. Fleming, A. Friedland, H. Gallagher†, G.T. Garvey, D. Gorbunov, R. Guenette, P. Huber, D. Jaffe, W. Johnson, E. Kearns†, S. Kettell, J. Kneller, J. Kopp, J.M. Link, W. Louis, C. Lunardini, W. Melnitchouk, S.R. Mishra, D. Mohapatra, A. Moss, V. Paolone, R. Petti†, J. Raaf, G. Rameika, D. Reitzner, K. Scholberg†, M. Shaevitz, M. Shaposhnikov, M. Smy†, R. Svoboda, R. Tayloe, N. Tolich†, M. Vagins†, B. Viren, D. Webber, L. Whitehead, R.J. Wilson*, G. Zeller†, R. Zwaska

† *Topical Group Convener* * *Physics Working Group Coordinator/Editor*

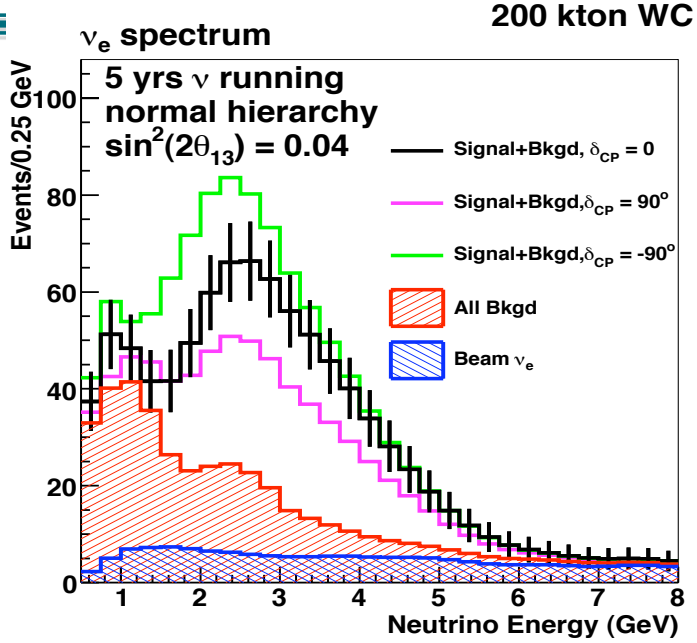
(Dated: September 30, 2010)

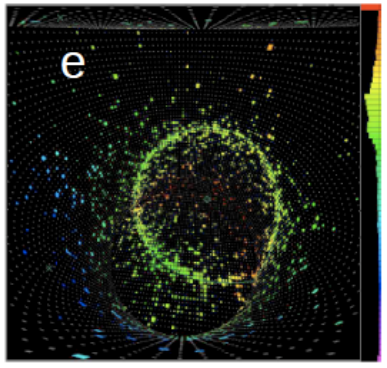
This report has been prepared by the LBNE Science Collaboration Physics Working Group at the request of the collaboration co-spokesmen and the Executive Committee. It is the first of an anticipated series of internal documents intended to assist the collaboration and the LBNE Project with establishing the best possible science case.

The primary purpose of this "Fall 2010" document is to assist in discussions of a collaboration statement on the Far Detector configuration. Nine initial topics were identified as scientific areas that motivate construction of a long-baseline neutrino experiment with a very large far detector. We summarize the scientific justification for each topic and the estimated performance for each of a set of Far Detector reference configurations. We report also on a study of optimized beam parameters and the physics capability of proposed Near Detector configurations.

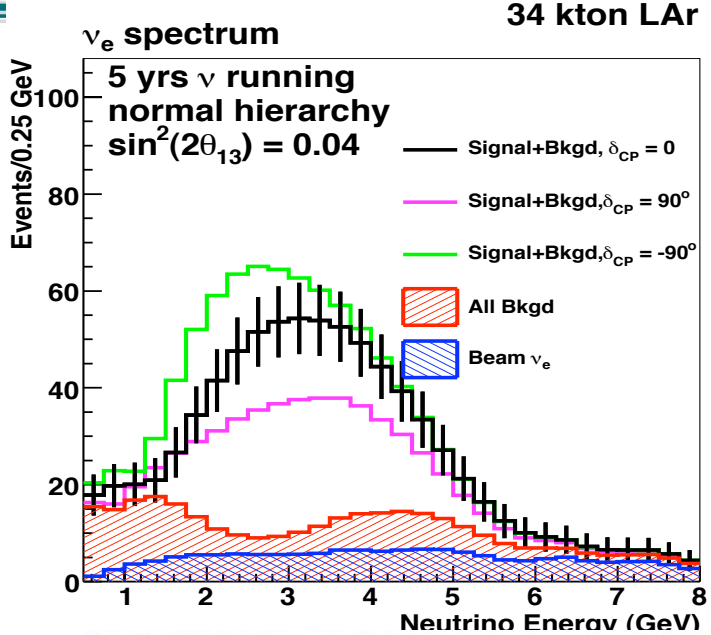
Two Detector Technologies

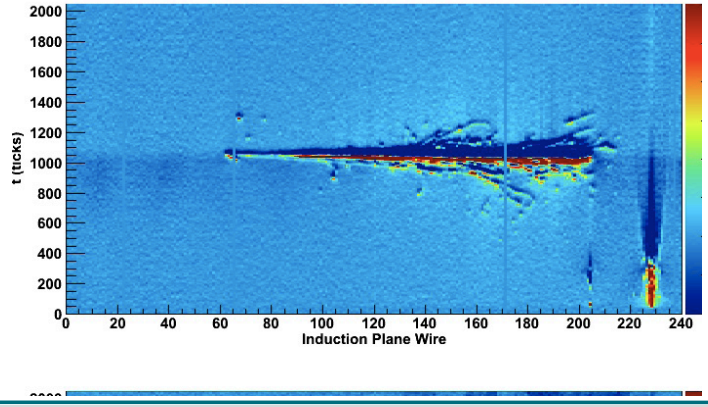
200 kton WC



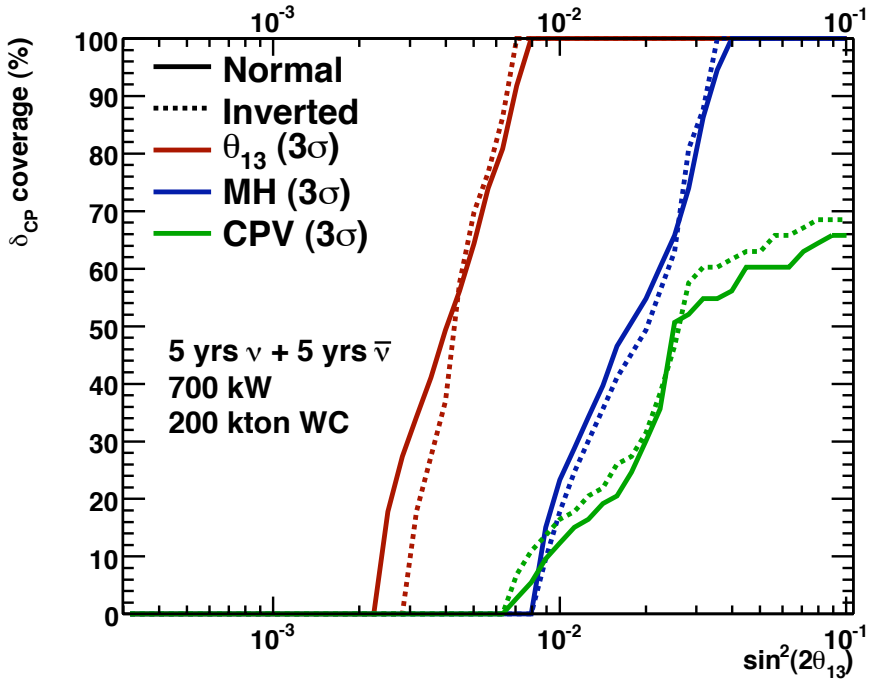


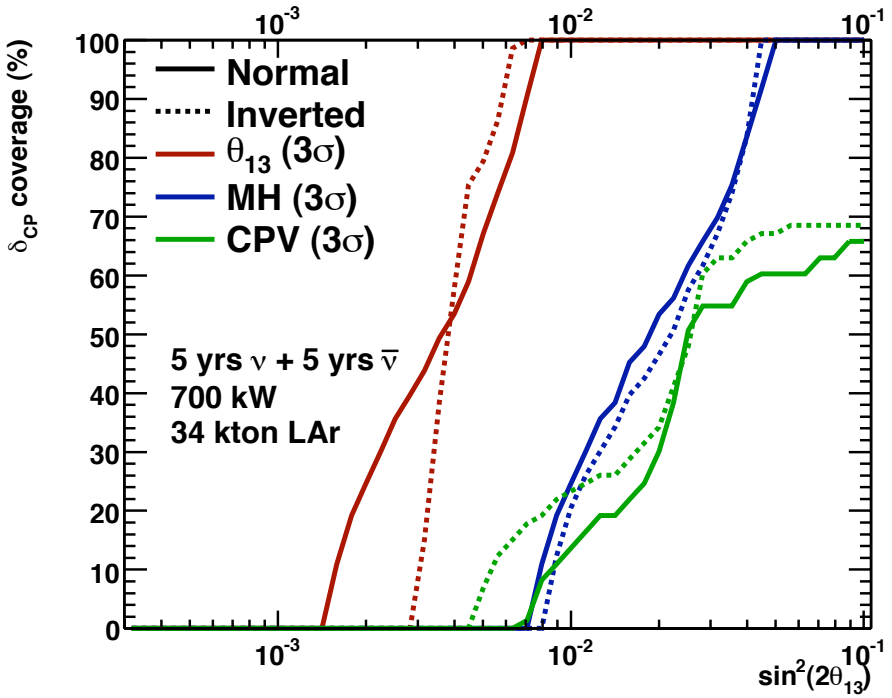
34 kton LAr





Oscillation Sensitivity Calculations

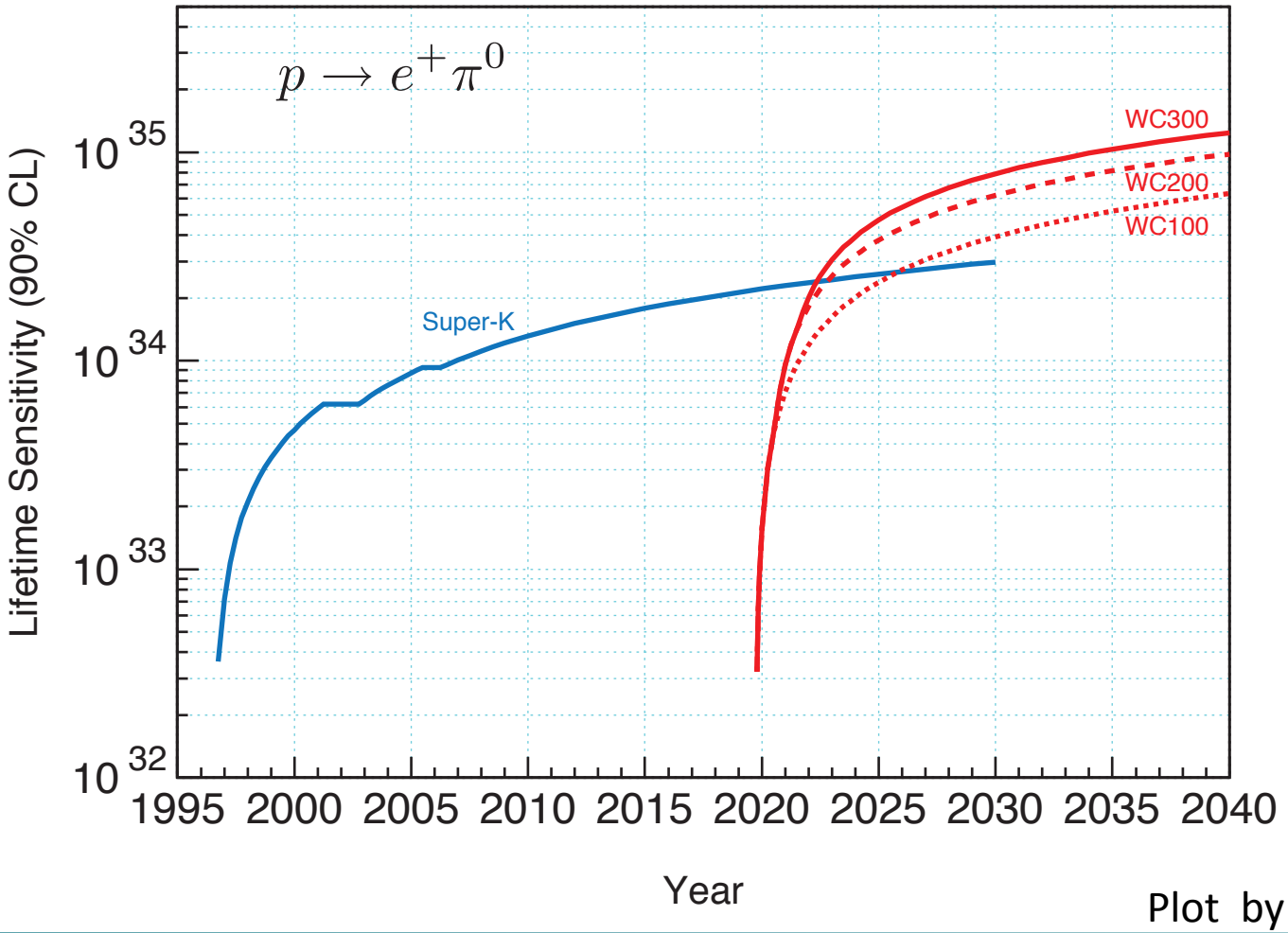




Right of line -> measurements

Plots by L. Whitehead, BNL

How to be significant for PDK



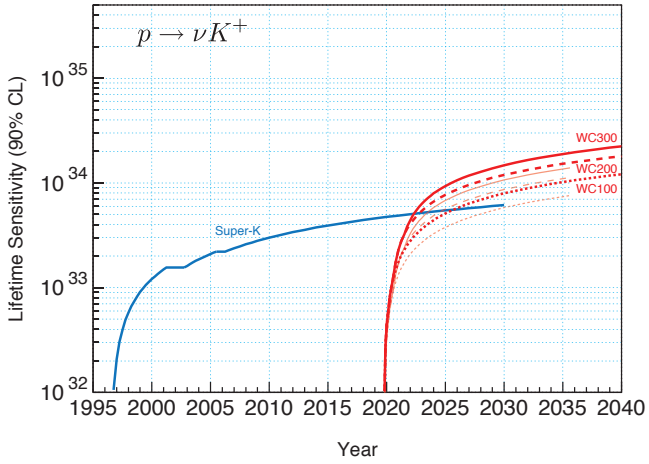
Plot by Ed Kerns, BU

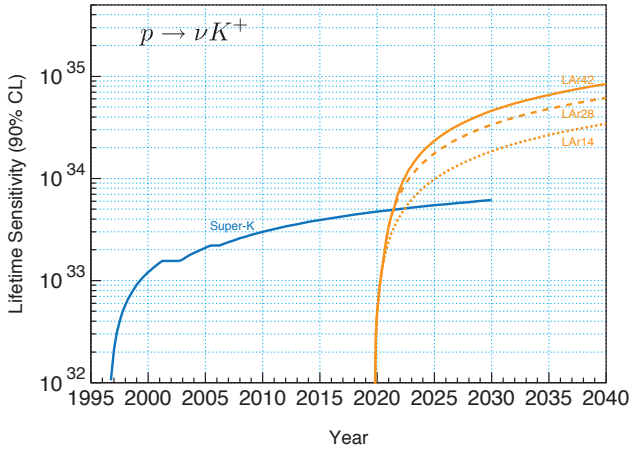
Proton Decay to $K^+\nu$

From Physics Working Group Report

Mode	Water Cherenkov		Liquid Argon	
	Efficiency	Background Rate (evts/100 kt-y)	Efficiency	Background Rate (evts/100 kt-y)
$p \to e^+\pi^0$	45% ± 19%	0.2(±40%)	45%	0.1
$p \to \nu K^+$	13.4% ± 22%	0.67(±30%) (SK1)	97%	0.1
$p \to \nu K^+$	10.6% ± 22%	0.83(±30%) (SK2)		

TABLE XIII. Efficiency and background numbers used for sensitivity calculations. The water Cherenkov numbers are based on published or preliminary Super-Kamiokande studies. The systematic uncertainties are included for reference but play no role in the sensitivity calculation. The liquid argon numbers come from the paper by Bueno *et al.* [37].





Plots by E. Kerns, Boston U.

Long Baseline Neutrino Experiment Project	Controlled Document	LBNE-doc-3056 Version 0.4 Date: 28 Oct 2010 Page 1 of 6

Key Assumptions:
Physics Research Goals of the LBNE Project

Prepared by: Date: 23 Sep 2010 James Strait LBNE Project Manager	Organization: LBNE Project Office	Telephone, e-mail 630-840-2826 strait@fnal.gov
Reviewed by: Date: Regina Rameika LBNE Project Scientist	Organization: LBNE Project Office	Telephone, e-mail 630-840-2262 rameika@fnal.gov
Reviewed by: Date: Elaine McCluskey LBNE Project Engineer	Organization: LBNE Project Office	Telephone, e-mail 630-840-2193 mccluskey@fnal.gov
Approved by: Date: James Strait LBNE Project Manager	Organization: LBNE Project Office	Telephone, e-mail 630-840-2826 strait@fnal.gov
Approved by: Date: Robert Svoboda LBNE Science Collaboration Co-Spokesperson	Organization: University of California, Davis	Telephone, e-mail 530-754-9610 svoboda@physics.ucdavis.edu
Approved by: Date: Milind Diwan LBNE Science Collaboration Co-Spokesperson	Organization: BNL	Telephone, e-mail 631-344-3327 diwan@bnl.gov
Approved by: Date: Pier Oddone Director, Fermi National Accelerator Laboratory	Organization: Fermilab	Telephone, e-mail 630-840-3211 pjoddone@fnal.gov
Approved by: Date: Pepin Carolan LBNE Federal Project Director	Organization: DOE Fermi Site Office	Telephone, e-mail 630-840-2227 pepin.carolan@ch.doe.gov
Approved by: Date: Eli Rosenberg LBNE DOE Program Manager	Organization: DOE Office of High Energy Physics	Telephone, e-mail 301-903-3711 eli.rosenberg@science.doe.gov
Approved by: *Date:* *DUSEL???*	*Organization:* *DUSEL Project Office*	*Telephone, e-mail*
Approved by: *Date:* *NSF???*	*Organization:* *NSF Physics Division*	*Telephone, e-mail*

Primary Objectives of LBNE

- Search for, and precision measurements of, the parameters that govern $\nu_\mu \rightarrow \nu_e$ oscillations. This includes measurement of the third mixing angle θ_{13} , for whose value only an upper bound is currently known, and if is large enough, measurement of the CP violating phase δ and determination of the mass ordering

Primary Objectives con't

- Precision measurements of θ_{23} and $|\Delta m^2_{32}|$ in the disappearance channel
- Search for proton decay, yielding a significant improvement in current limits on the partial lifetime of the proton in one or more important candidate modes, e.g. $p \to e^+\pi^0$ *or* $p \to K^+\nu$
- Detection and measurement of the neutrino flux from a core collapse supernova within our galaxy, should one occur during the lifetime of LBNE

Secondary Objectives*

- Other accelerator-based neutrino oscillation measurements
- Measurement of neutrino oscillation phenomena using atmospheric neutrinos
- Measurement of other astrophysical phenomena using medium energy neutrinos

*May be enabled by the facility that is designed to achieve the primary objectives

Additional Secondary Objectives*

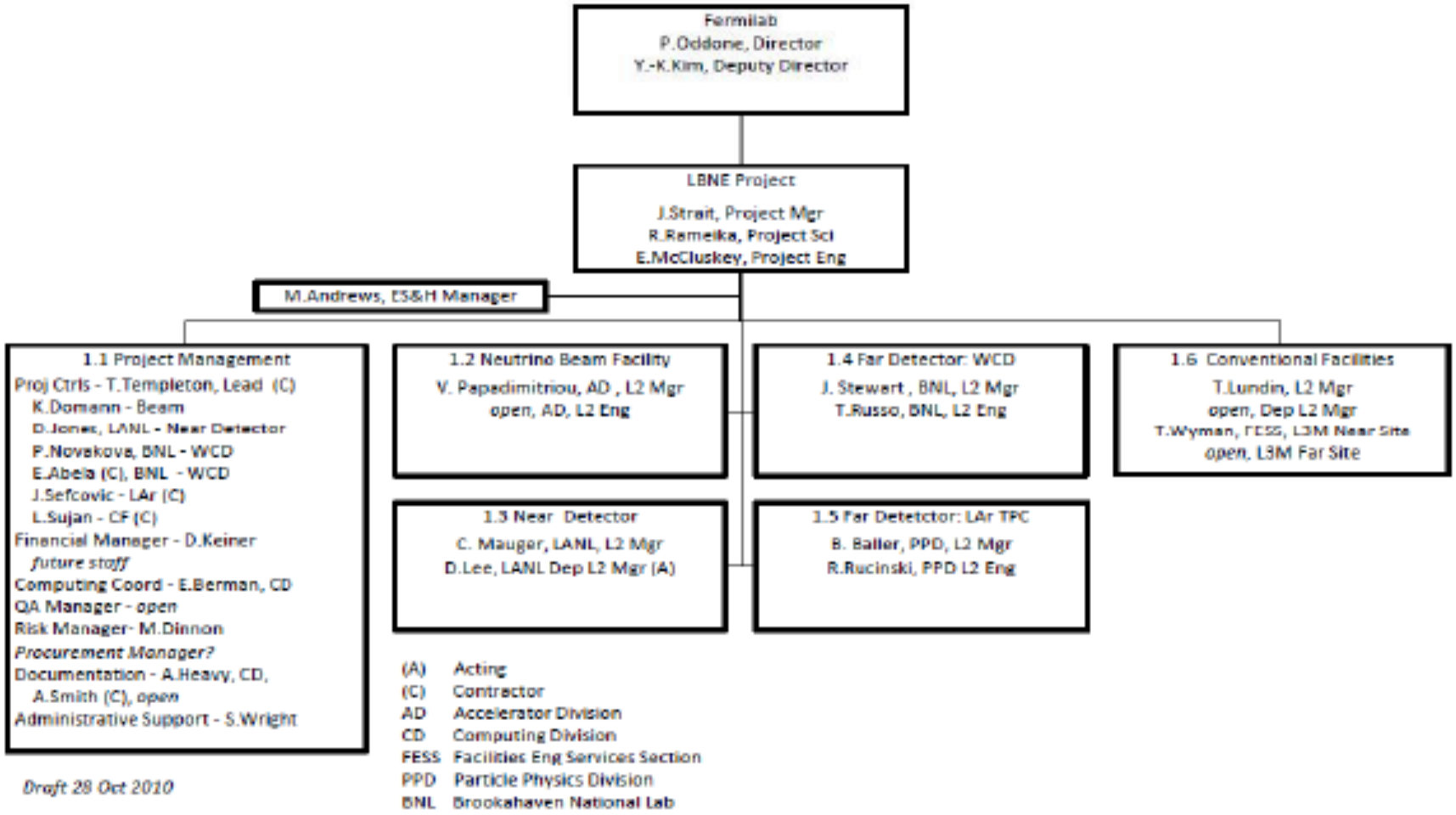
- Detection and measurement of the diffuse supernova neutrino flux
- Measurements of neutrino oscillation phenomena and of solar physics using solar neutrinos
- Measurements of astrophysical and geophysical neutrinos of low energy

*Achievement of these most likely require future upgrades to the facility and/or detectors that are designed to meet the primary objectives

The LBNE Project Organization

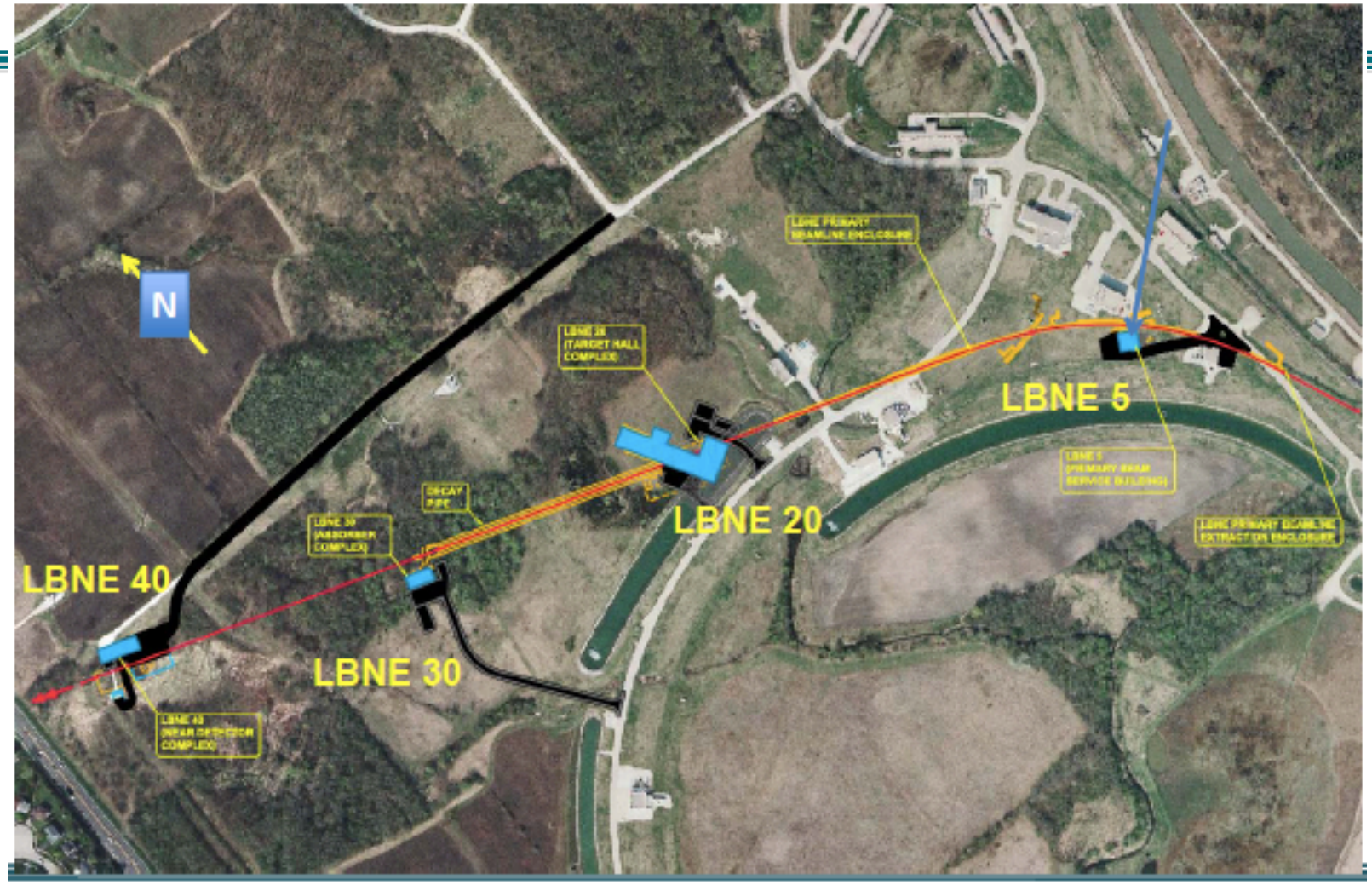
- 1.1 Project Management
- 1.2 Neutrino Beam
- 1.3 Near Detector
- 1.4 Water Cherenkov Detector
- 1.5 Liquid Argon Detector
- 1.6 Conventional Facilities
  - 1.6.2 at Fermilab (for 1.2 and 1.3)
  - 1.6.3 at DUSEL
    - Water Cherenkov at 4850' (1.4)
    - Liquid Argon at 800' ; including access from surface (1.5)

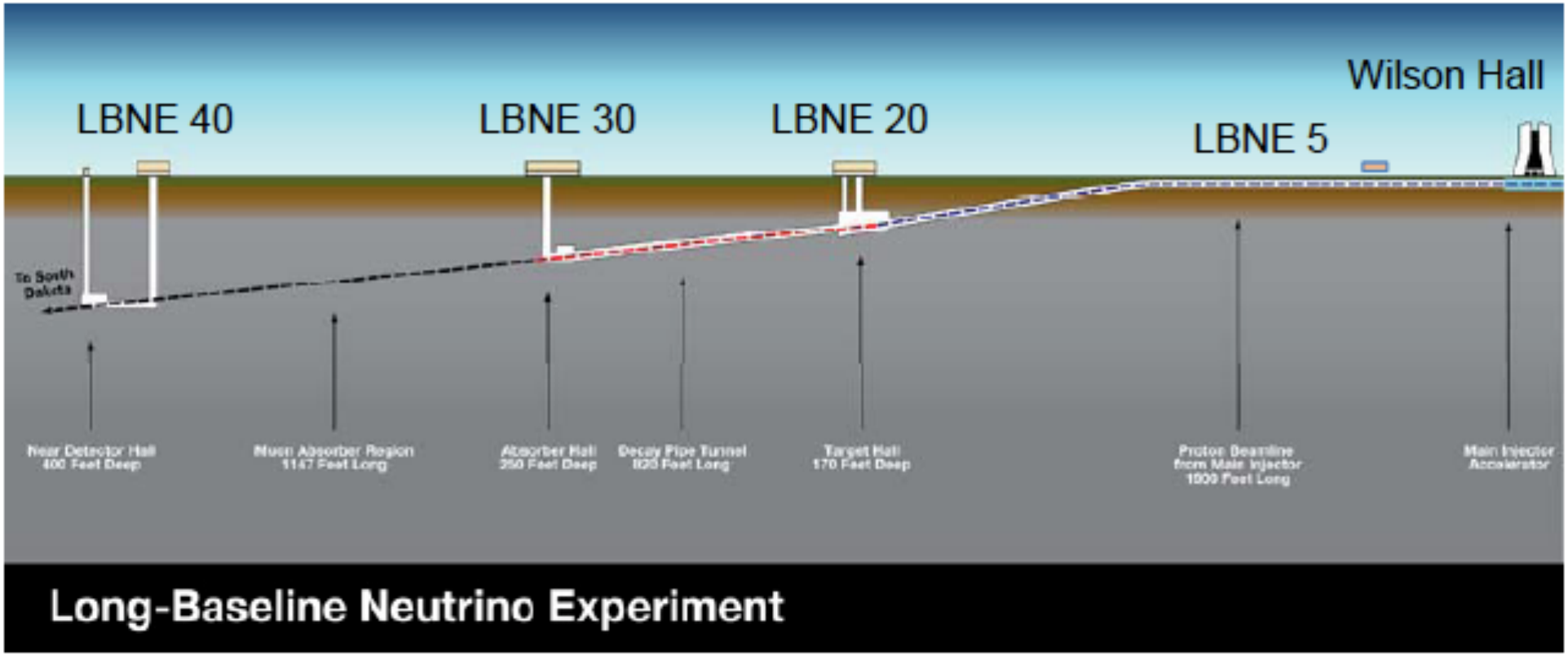
Project Organization



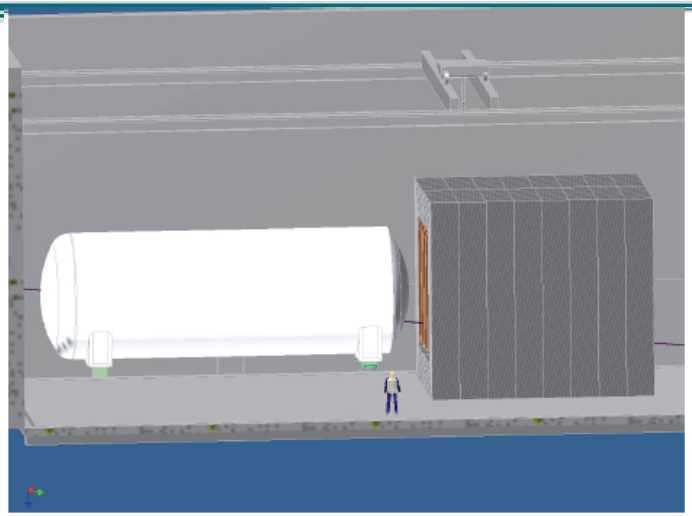

Tevatron
Project X
(proposed)
MINOS - NOvA
BooNE
LBNE
(proposed)
Main Injector

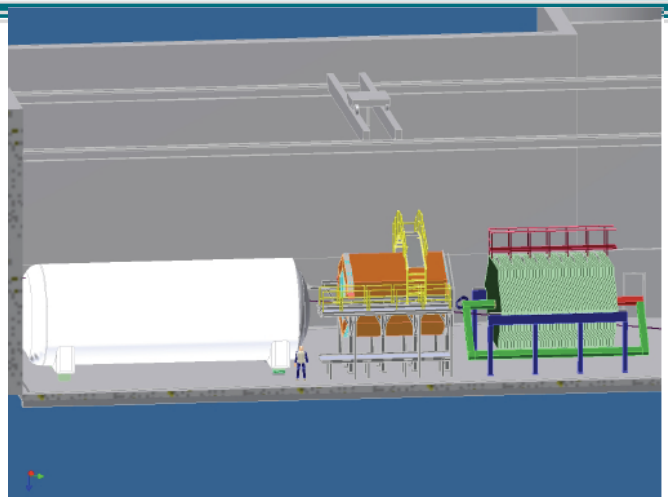
Neutrino Beam Facility

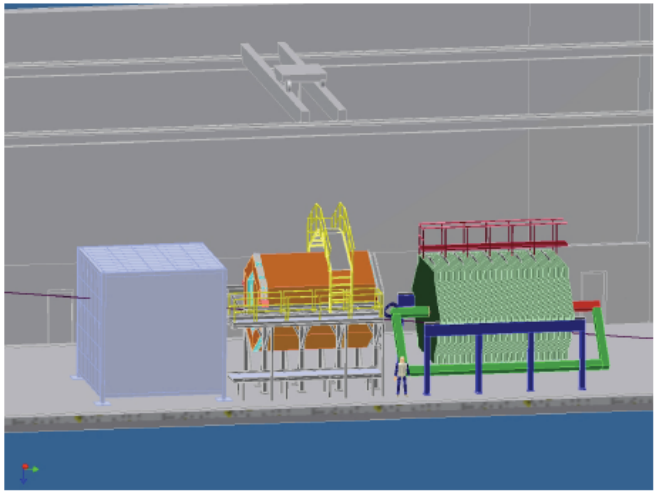


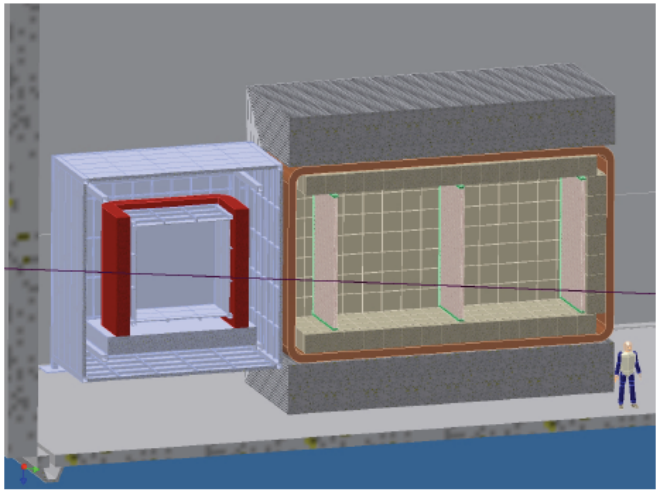

LBNE 40
LBNE 30
LBNE 20
LBNE 5
Wilson Hall
To South Dakota
Near Detector Hall
400 Feet Deep
Muon Absorber Region
1147 Feet Long
Absorber Hall
250 Feet Deep
Decay Pipe Tunnel
Target Hall
170 Feet Deep
Proton Beamline
from Main Injector
1000 Feet Long
Main Injector
Accelerator
Long-Baseline Neutrino Experiment

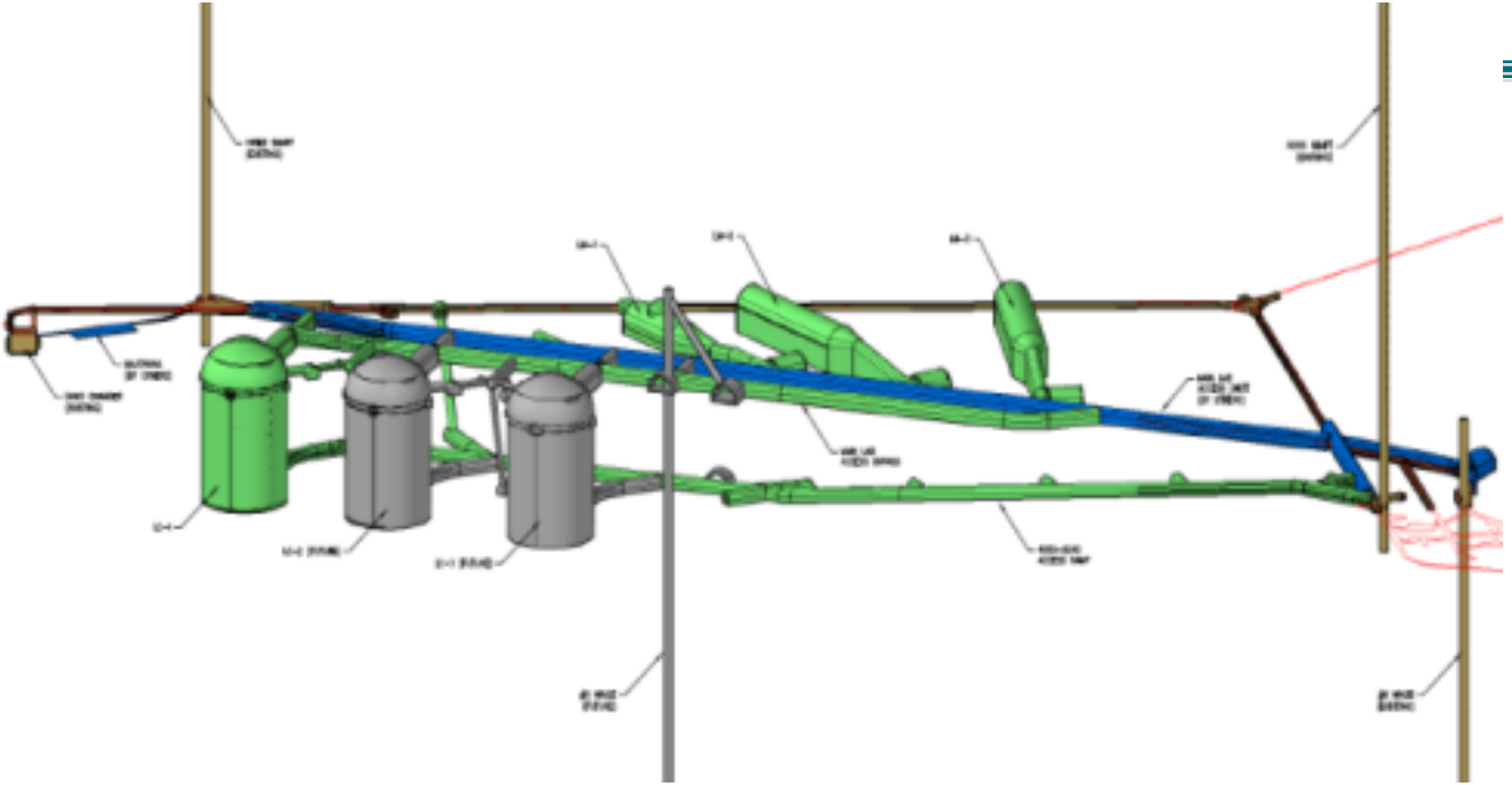
Options for the Near Detector



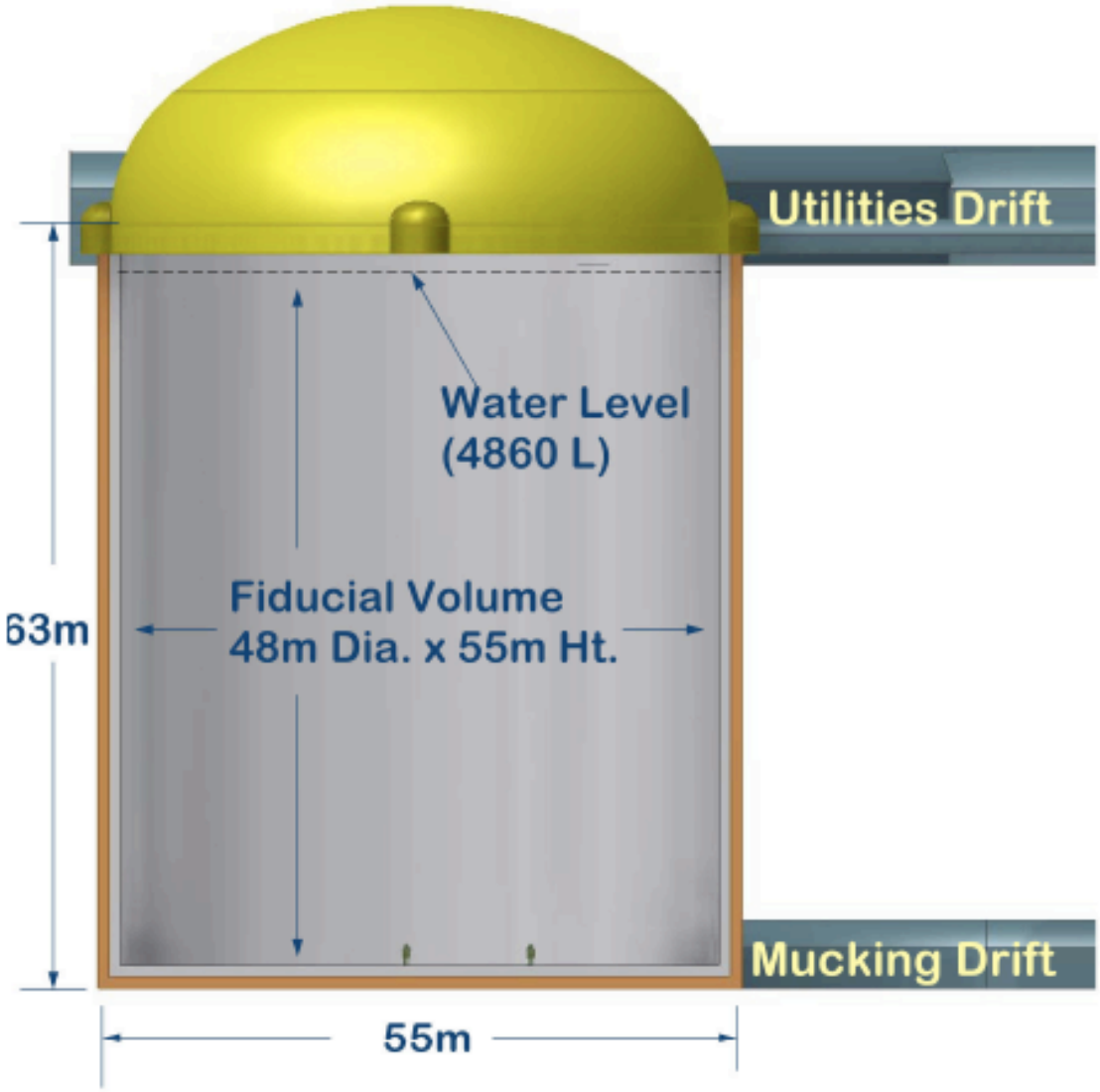








LBNE Water Cherenkov Design



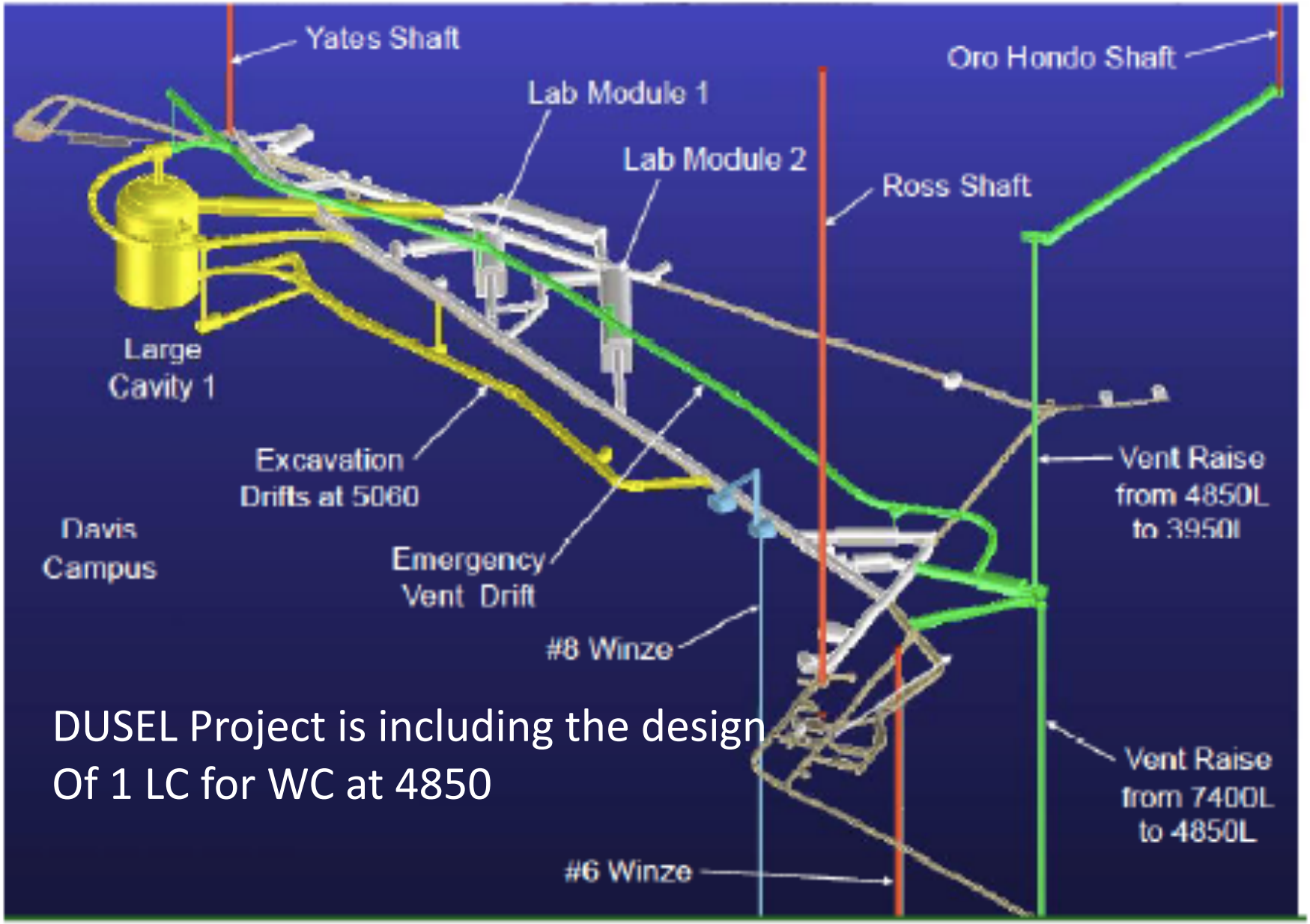
2 x 100 kton modules

Each module:

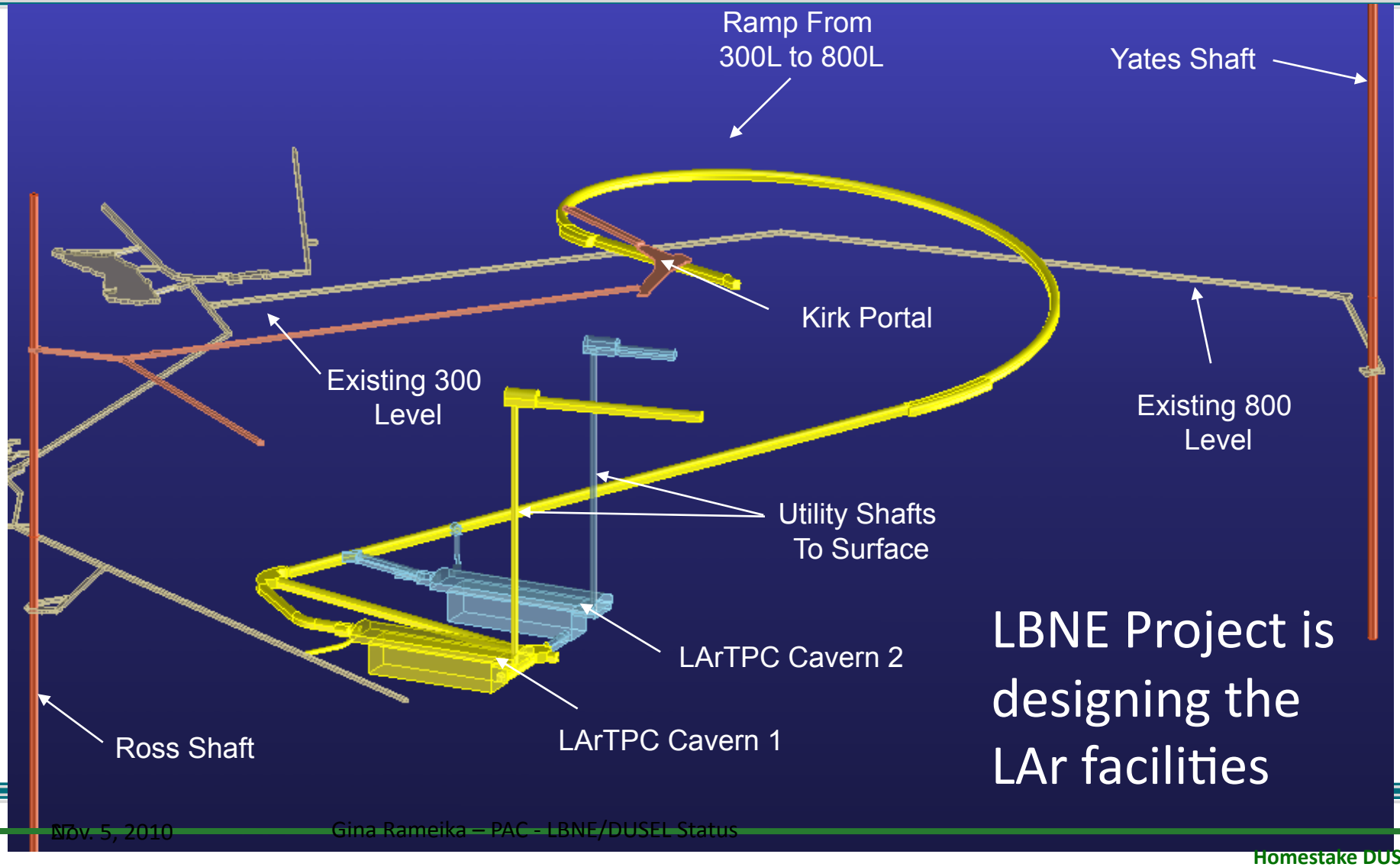
- Total water mass of 138 ktons
- Fiducial mass of 100 ktons
- ~50,000 10” PMTs (~20% coverage)

Far Detector Configuration Conceptual Design

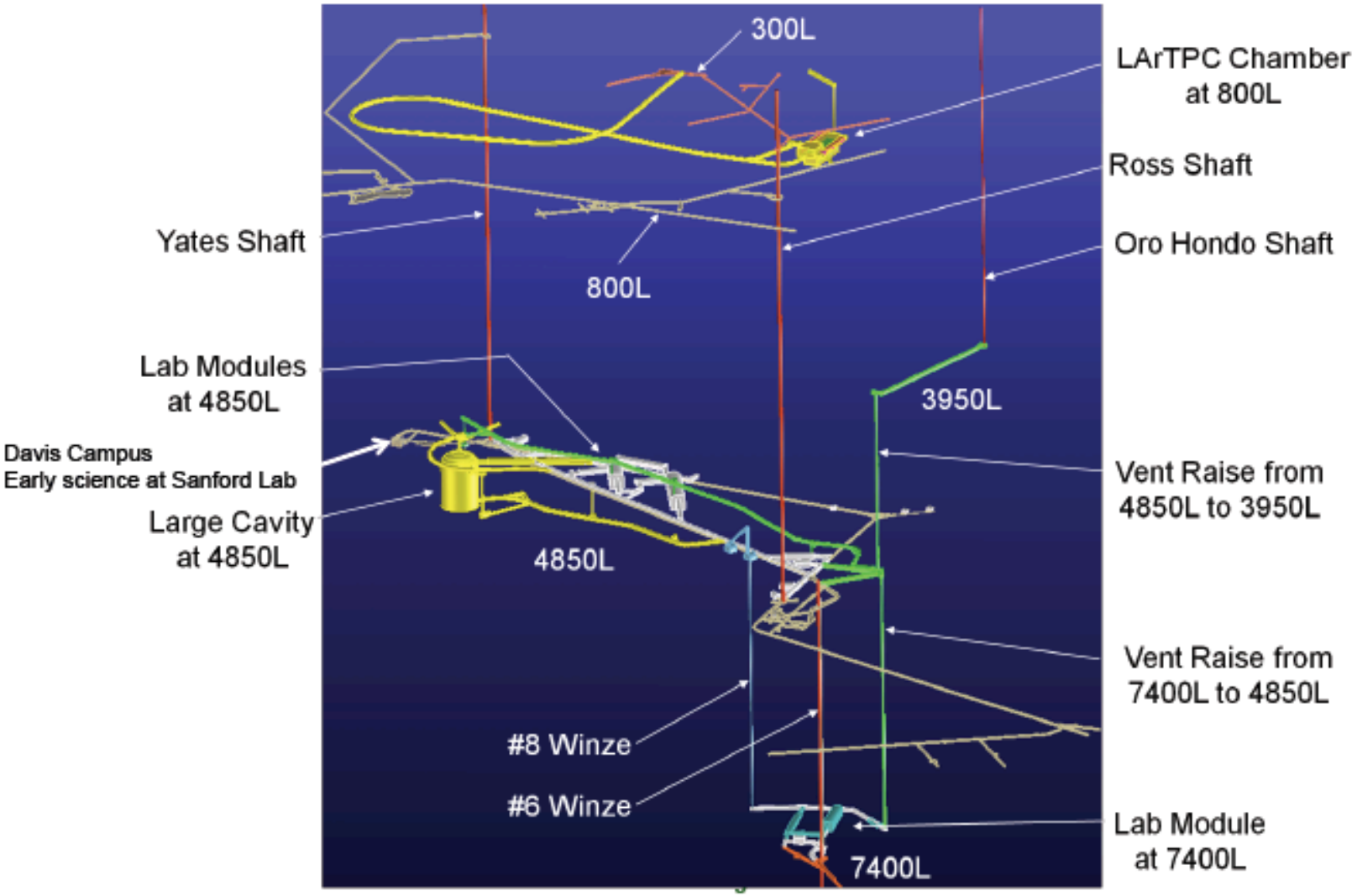
- 1 or 2 Water Cherenkov @ 4850
- 1 or 2 LAr @ 800'
- 1 WC @4850 + 1 LAr @ 800'


Yates Shaft
Oro Hondo Shaft
Lab Module 1
Lab Module 2
Ross Shaft
Large
Cavity 1
Excavation
Drifts at 5060
Davis
Campus
Emergency
Vent Drift
Vent Raise
from 4850L
to 3950l
#8 Winze
DUSEL Project is including the design
Of 1 LC for WC at 4850
Vent Raise
from 7400L
to 4850L
#6 Winze

LBNE, LArTPC, 300L – 800L Plan

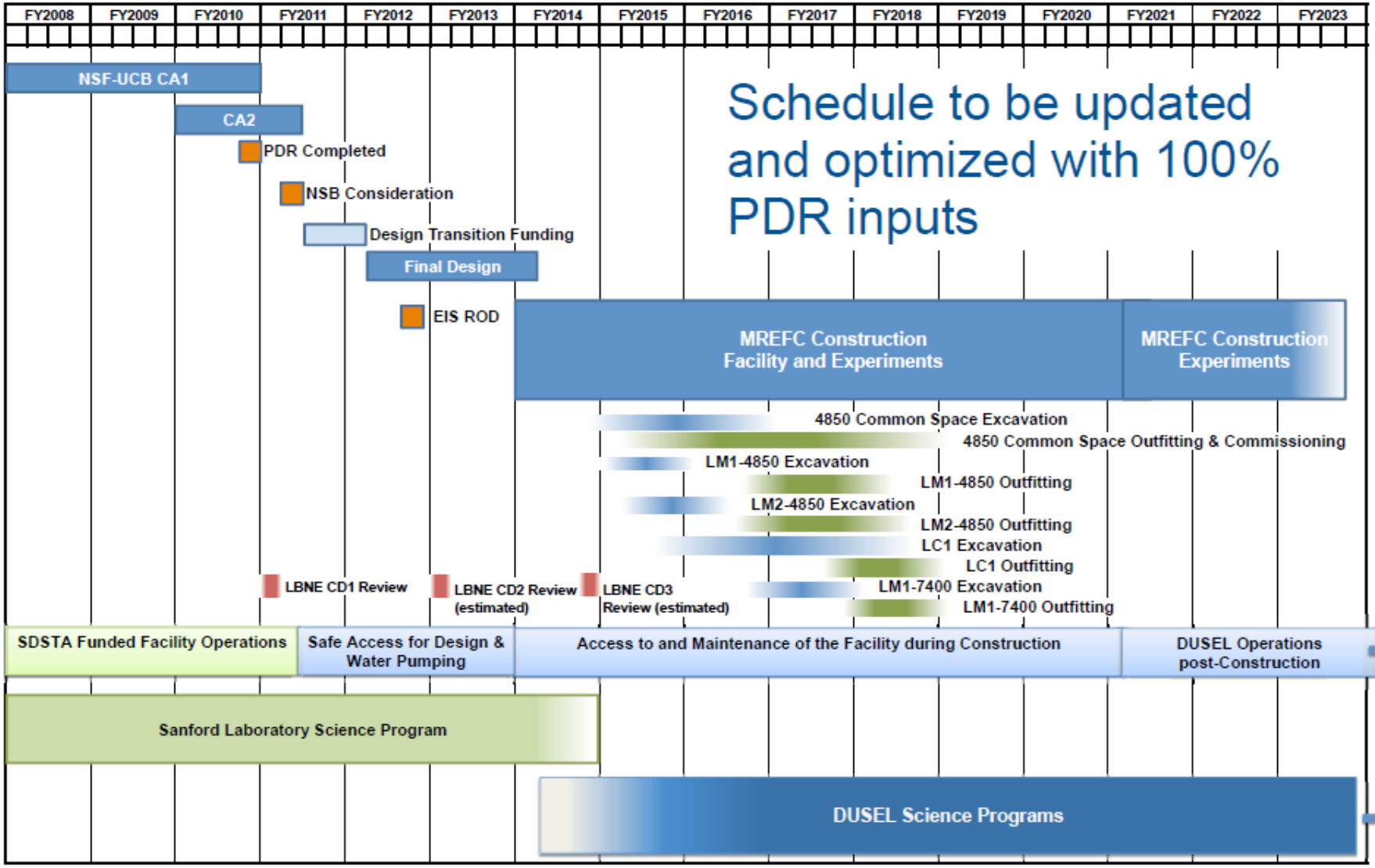


Underground Physics Lab Layout



Project Milestone Schedule through Construction

DUSEL Schedule
as of 2 weeks ago.



Relationship between DUSEL and LBNE

- NSF is developing a new national laboratory in Lead, South Dakota: Deep Underground Science & Engineering Lab (DUSEL)
  - NSF construction project (MREFC) is funding facility construction and a suite of science experiments - *NSF is the steward of the facility*
- LBNE will build, as part of its project, far detectors for neutrinos, and the preferred site is at DUSEL.
  - LBNE is funded by DOE, with NSF contributing $125M (FY09$) from its MREFC to LBNE for a (TBD) combination of facility and detector construction
  - *DOE is the steward for the LBNE experiment*, and LBNE is financially responsible for all work associated with its entire project: beamline, near detector, far detectors, and conventional faciliites.
- LBNE project team already actively participating in design and planning LBNE at DUSEL

LBNE Project Time Line

- DOE CD-0 (Approve Mission Need) January 2010
- CD-1 Review (Conceptual design, preliminary cost and schedule range) ~Apr 2011
- CD-1 (assuming successful CD-1 review) June 2011
- CD-2 (Project baseline)
  depending on funding . . . mid/late FY2013
- CD-3 (start construction)
  depending on funding . . . 2014 ~ 2015
- Schedule for construction under development
  => estimate that project will be complete $\gtrsim$2020

Long-Baseline Neutrino Experiment
Subproject Conceptual Design, Cost and Schedule Reviews
Charge

The LBNE Project Manager has called a series of reviews, one for each of the Level 2 subprojects (neutrino beam, near detector, water Cherenkov far detector, liquid Argon far detector, conventional facilities). The purpose of these reviews is to examine the status of the Conceptual Design and the corresponding cost and schedule estimates for each of the subprojects of the Long-Baseline Neutrino Experiment (LBNE), to identify areas of weakness, and to recommend actions necessary to bring these elements to the level required for a successful DOE CD-1 review. It is expected that none of the subprojects will be at a CD-1 ready level as of the time of these reviews; however, we would like to evaluate them against CD-1 standards, in order to assess the progress towards that goal. Specifically, the reviewers should address the following:

- Is the scope of the subproject well defined?
- Are the requirements (scientific, technical, etc.) appropriately defined and documented, with appropriate flow-down from the most basic high-level requirements to more detailed requirements?
- Are the assumptions for this subproject documented?
- Are interfaces to and dependencies on other LBNE subprojects and the DUSEL facility defined and documented?
- Is there a complete conceptual design for all elements of the subproject, that
  - achieves the system requirements?
  - is backed up by sufficient engineering analysis to ensure that it meets the requirements?
  - is well documented?

LBNE Calendar of Events Towards CD-1

	Event	Date
☑	Detailed outline of CDR	10 May 2010
☑	Detailed outline of Preliminary Project Management Plan (PPMP) and DUSEL-LBNE MOU; draft organization and definition of roles and responsibilities	19 May 2010
☑	LBNE Collaboration Meeting (Deadwood, SD)	25-28 May 2010
☑	Initial draft sub-project Resource Loaded Schedules	25 June 2010
☑	Intermediate draft CDR	25 June 2010
☑	Intermediate draft of PPMP and DUSEL-LBNE MOU	9 July 2010
☑	Readiness check for CD-1 (internal review)	15-16 July 2010
☑	LBNE Collaboration Meeting (Fermilab)	12-15 Sept. 2010
☑	Neutrino Beamline RLS and CDR final draft to PMO	13 Sept. 2010
☑	Neutrino Beamline Internal CDR, Cost and Schedule Review	20-22 Sept. 2010
☑	Water Cherenkov RLS and CDR final draft to PMO	20 Sept. 2010
☑	Water Cherenkov CDR, Cost and Schedule Review	27-29 Sept. 2010
☑	Near Detectors RLS and CDR final draft to PMO	27 Sept. 2010
☑	Near Detectors Internal CDR, Cost and Schedule Review	4-6 Oct. 2010
☑	**DUSEL Internal Review*	**18-20 Oct. 2010*
☑	Liquid Argon RLS and CDR final draft to PMO	25 Oct. 2010
☑	Conventional Facilities RLS and CDR final draft to PMO	27 Oct. 2010
☑	Liquid Argon Internal CDR, Cost and Schedule Review	1-3 Nov. 2010
☐	Conventional Facilities Internal CDR, Cost and Schedule Review	3-5 Nov. 2010
☐	Project Management Retreat	15-17 Nov. 2010
☐	Advanced draft of PMP and DUSEL-LBNE MOU	Dec. 2010
☐	LBNE Collaboration Meeting (UCLA)	26-29 Jan. 2011
☐	Director's CD-1 Design Review	Early Feb. 2011
☐	Director's CD-1 Cost, Schedule and Management Review	Early Feb. 2011
☐	**DUSEL PDR Review 1*	**22-24 Feb. 2011*
☐	DOE CD-1 Review	14-18 March 2011 (tentative)
☐	**DUSEL PDR Review 2*	**22-24 March 2011*

* Indicates a Deep Underground Science and Engineering Laboratory (DUSEL) milestone

Plans for Configuration Decisions

- Conceptual Design, cost and schedule development for each major configuration option:
  - 2 Water Cherenkov Detectors at 4850 foot depth.
  - 2 Liquid Argon Detectors at 800 foot depth.
  - 1 of each.
- "Value engineering" to bring the cost of each configuration into a common range, including adjustment of detector mass or of other parameters affecting the physics capabilities.
- Physics studies of the capabilities of each configuration for long-baseline neutrino oscillations, proton decay, neutrino astrophysics.
- Choose configuration with best physics reach.
- Project Office and LBNE Collaboration are working closely together on this process.
- Expect the major decisions to be made on the time scale of CD-1.

Summary

- The LBNE Project and Science Collaboration and DUSEL are working closely together to design the facilities and detectors for the LBNE
- Teams are preparing for a CD-1 review in the spring
- This is a long term project with an aggressive near term schedule to progress through the approval process to insure a timely construction start