Liquid Argon and the Long Baseline Neutrino Experiment (LBNE)

Gina Rameika
LBNE Acting Project Manager
November 23, 2009

Outline

- Origin of LBNE (Long Baseline Neutrino Experiment)
- Stakeholders
- The LBNE Project
  - DOE CD (Critical Decision) Process
  - CD Status
  - Project Scope
  - Alternatives Analysis
    - Why LAr20?
- Project Schedule

Fermilab-0801-AD-E
BNL-77973-2007-IR

Report of the US long baseline neutrino experiment study

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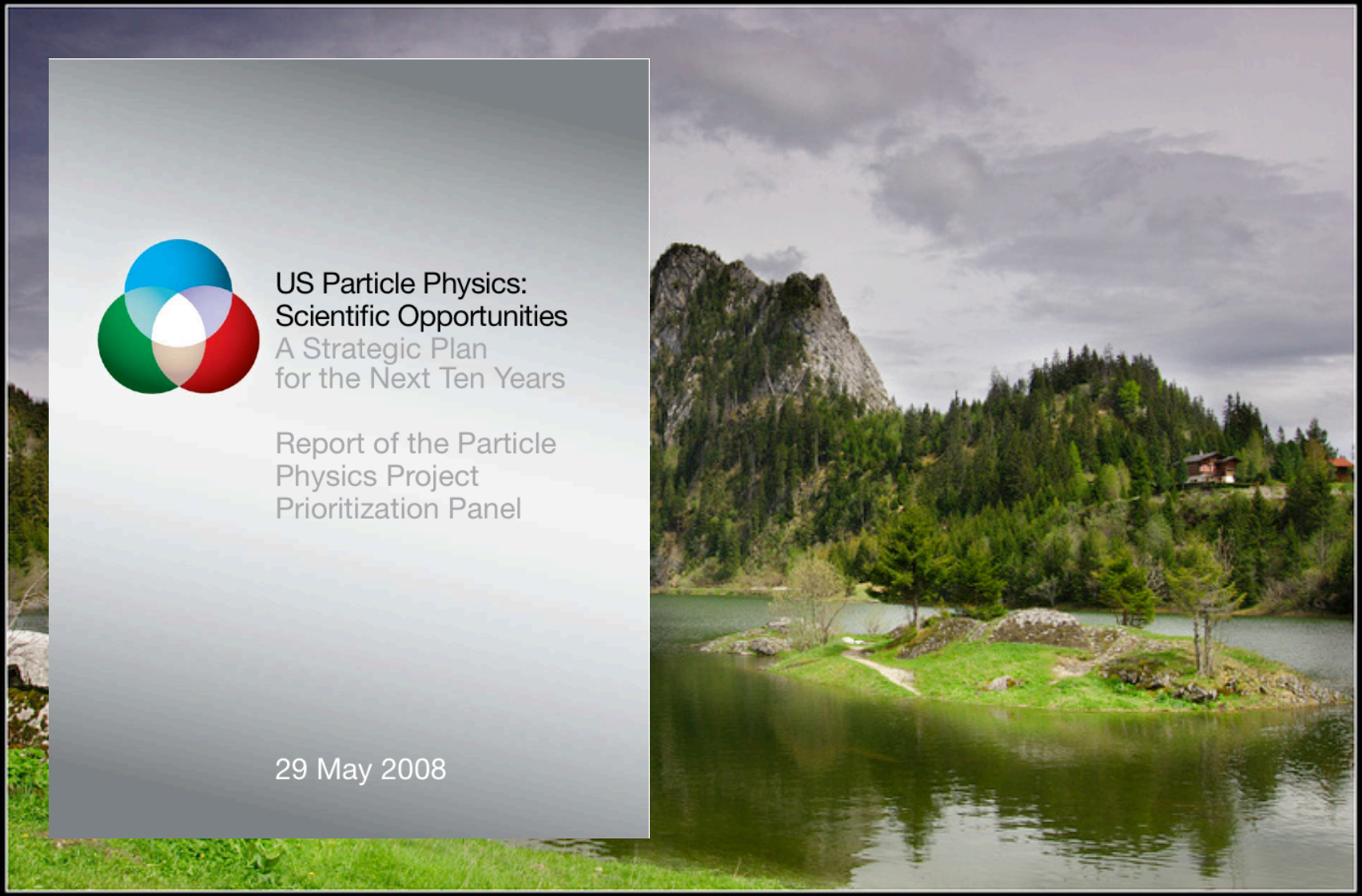
June 2007


US Particle Physics:
Scientific Opportunities
A Strategic Plan
for the Next Ten Years
Report of the Particle
Physics Project
Prioritization Panel
29 May 2008

From P5 report, May 2008

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

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

Construction of these facilities could start within the 10-year period considered by this report.

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

From P5 report, May 2008

Recommendations

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

The panel further recommends that in any funding scenario considered by the panel Fermilab proceed with the upgrade of the present proton source by about a factor of two, to 700 kilowatts to allow for an extended physics reach using the current beamline and a timely start for the neutrino program in the Homestake mine.

The panel recommends support for a vigorous R&D program on liquid argon detectors and water Cerenkov detectors in any funding scenario considered by the panel. The panel recommends designing the detector in a fashion that allows an evolving capability to measure neutrino oscillations and to search for proton decays and supernovae neutrinos.

Stakeholders

- Science Collaboration
- NSF DUSEL at Homestake
  - UC Berkley, LBNL
  - SDSTA, Sanford Laboratory
- DOE Long Baseline Neutrino Experiment (LBNE) Project

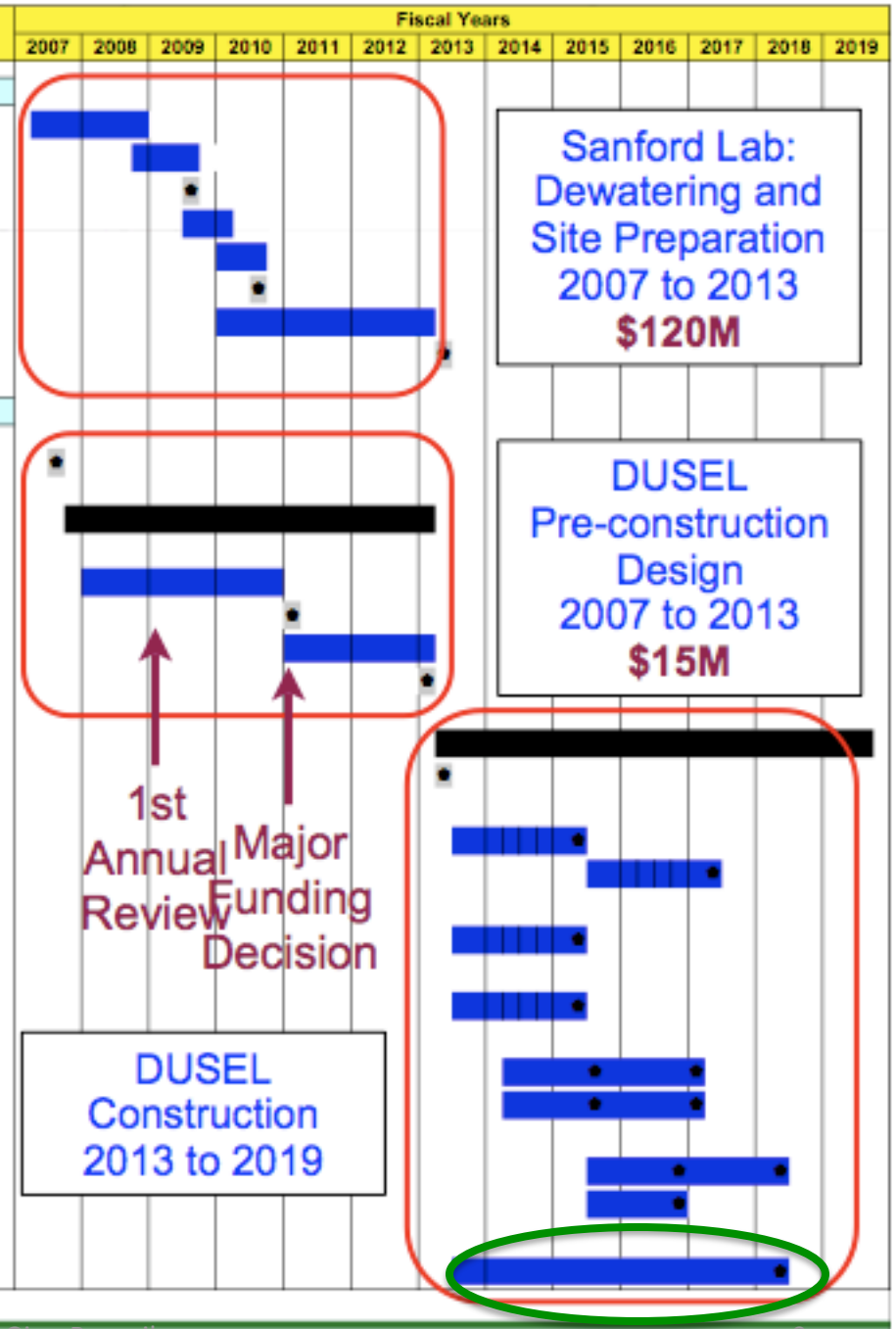
Collaboration Vision Statement

The primary goal of this collaboration is to perform a world-leading long-baseline neutrino oscillation experiment that will reach unprecedented sensitivity and precision for addressing the neutrino mass hierarchy, CP violation in neutrino mixing, and the value of the mixing parameter θ_{13}. This experiment will require the development and construction of new facilities that will also provide new capabilities to search for nucleon decay, observe neutrinos emitted by supernovae in our galaxy and beyond, and other important topics in physics and astrophysics.

The concept for this experiment includes a high-intensity neutrino beam generated at Fermilab and a large underground detector facility at the DUSEL site in Lead, South Dakota. The neutrino beam will be generated by a high-power proton beam that exceeds present capabilities, and the neutrino beam configuration must be optimized for the baseline and neutrino oscillation parameters. We have identified two detector technologies with the potential to achieve our science goals: water Cerenkov (WC) and liquid Argon (LA) Time Projection Chamber. Recent studies have indicated that total detector masses of >300kTon (fiducial) for WC or >50kTon (fiducial) for LA are suitable. We envision that the detector facility would consist of several detector modules, and an ideal experiment might be a mixture of WC and LA detector modules due to their complementary capabilities.

Achieving these goals will require an extension of present-day technologies on a challenging time-scale to insure that the US program maintains a competitive advantage. Our current anticipated schedule is to be ready to begin beamline and detector construction as early as FY13. This schedule will require immediate establishment of vigorous R&D and engineering efforts towards development of the beamline and both WC and LA detector technologies.

Proposed Timeline for Sanford Laboratory and DUSEL Facility Development	Start	Finish
Sanford Laboratory at Homestake		
Ross Shaft Rehab and Pumping Column Commissioning	Jan-07	Sep-08
Yates Shaft Rehab.	Aug-08	Aug-09
Gain safe access to 4850L for EIP construction start, and hold water level at 5000L		Jun-10
Install facility infrastructure for Davis Lab early experiments	Jun-10	Dec-10
Install and commission research instrumentation in Davis Lab	Sep-09	Jun-10
Early experiments in Davis Lab ready for operation		Jun-10
Continued rehabilitation and infrastructure upgrades for Sanford Lab		Dec-12
Transition from Sanford Lab to DUSEL Operations		Jan-13
NSF Deep Underground Science and Engineering Laboratory at Homestake		
Homestake site selection announcement		Jul-07
DUSEL Preconstruction Planning and Development (R&RA)	**Oct-07**	**Dec-12**
Preliminary Design Phase to develop Baseline Cost and Schedule	Oct-08	Dec-10
Preliminary Baseline Design Review and National Science Board Recommendation		Mar-11
Final Design Phase	Jan-11	Dec-12
Final Design Review and Authorization for Construction Start		Dec-12
DUSEL Facility - Construction and Commissioning (MREFC)	**Jan-13**	**Sep-19**
Proposed Construction Start		Jan-13
Surface Campus Construction		
Phase 1 Offices and Laboratories, Education and Outreach	Apr-13	Mar-15
Phase 2 Offices and Laboratories	Apr-15	Mar-17
Near-Surface Campus Construction at 300L		
300L Labs and Education and Outreach Facilities	Apr-13	Mar-15
Infrastructure Development to support underground construction		
Mid-Level and Deep-Level Campuses	Apr-13	Mar-15
Mid-Level Campus Construction at 4850 Level		
4850L Common Facilities and Lab Module #1 (Excavation & Lab Build-out)	Jan-14	Dec-17
4850L Davis lab Alterations and Lab Module #2 (Excavation & Lab Build-out)	Jan-14	Dec-17
Deep-Level Campus Construction at 7400 Level		
7400L Common Facilities and Lab Module #1 (Excavation & Lab Build-out)	Apr-15	Mar-18
7400L Lab Module #2 (Excavation Only)	Apr-15	Sep-16
Large Cavitly Excavation and Facility Infrastructure		
Infrastructure Development and Excavation	Apr-13	Mar-18



4850 Level Developmental Baseline for PDR:
Three Lab Modules & First Large Cavity, Plan View

NSF decided that the first detector module would be 100 kT Water Cerenkov

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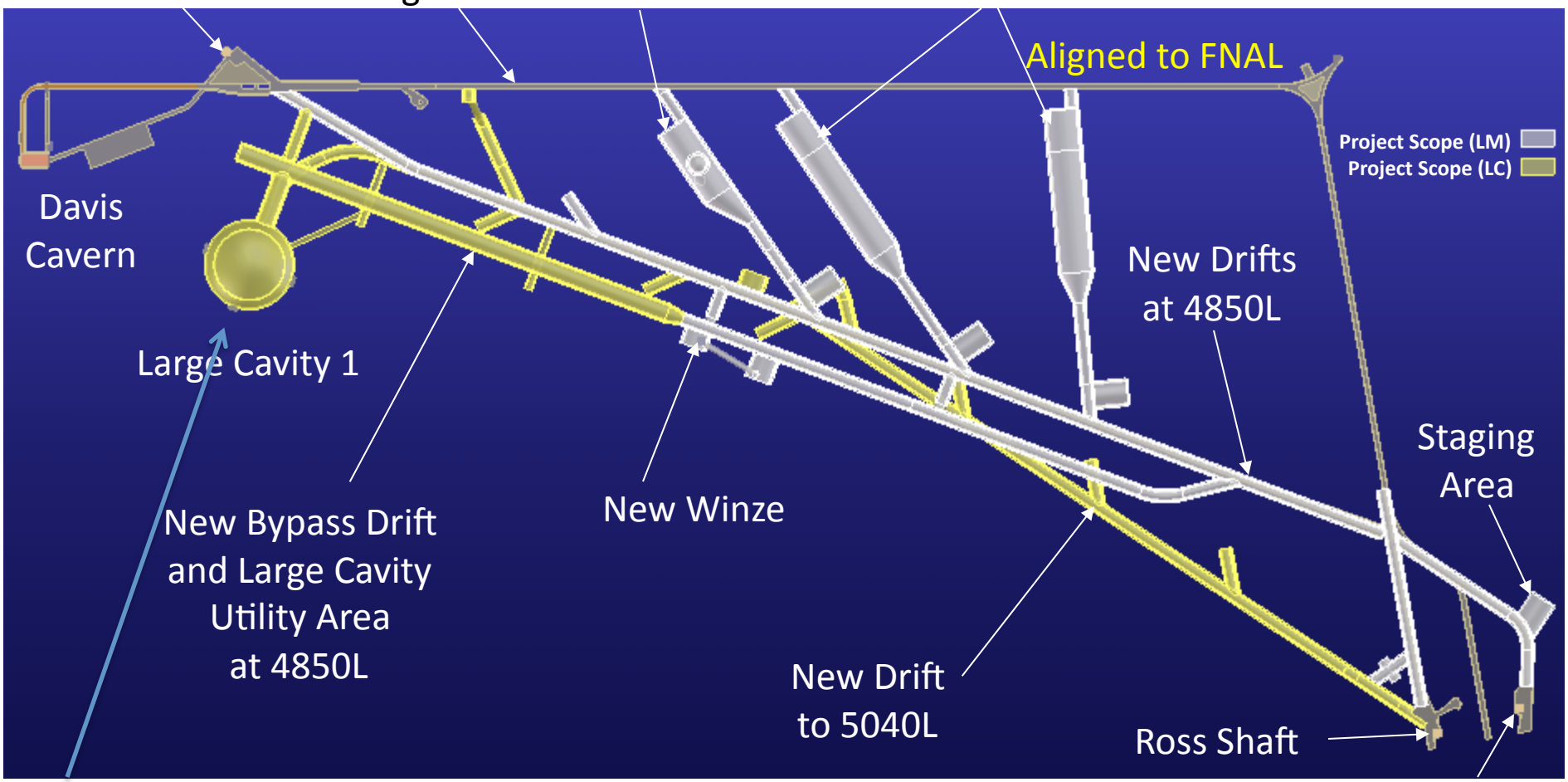

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Department of Energy projects get approval through a Critical Decision Process (DOE Order 413.3)

- CD-0 : Mission Need
- CD-1 : Evaluation/Selection of Alternatives and Development of the Cost Range
- CD-2 : Project Cost, Schedule and Technical Baseline approved
- CD-3 Start of Construction
- CD-4 Start of Operations

Department of Energy projects get approval through a Critical Decision Process (DOE Order 413.3)

- CD-0 : Mission Need (funding from base program)
- CD-1 : Evaluation/Selection of Alternatives and Development of the Cost Range (PED* funds)
- CD-2 : Project Cost, Schedule and Technical Baseline approved (PED funds)
- CD-3 Start of Construction (Line Item Construction and MIE funds)
- CD-4 Start of Operations

* Project Engineering and Design

U.S. DEPARTMENT OF ENERGY
Office of Science

Intensity Frontier
Accelerator Based Neutrino Program

Dennis Kovar
Nov. 2008
HEPAP

- DOE OHEP proceeding to develop a conceptual design for an accelerator long-baseline neutrino experiment
- Planning to get CD-0 approval by the end of CY 2008
  - Fermilab will have overall project management
  - Brookhaven will have responsibility for detector
- Expectation is that detector will be located at DUSEL and the beam line at Fermilab.
- Complete CD-1 by late 2009/early 2010.
  - Explore alternatives for detector (technology, size, location)
  - Explore alternatives for beamline (power, location)
  - Cost/benefit analysis - scientific reaches, cost ranges, etc.
- DOE OHEP & ONP collaborating with NSF
  - On Detector R&D
  - On development of a MOU for collaboration on nuclear and particle physics experiments.
  - First Joint Oversight Group (JOG) meeting scheduled for Dec 10th

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LBNE Project Status

- DOE has generated CD-0 (Mission Need) documentation
  - We have not been allowed to see it
  - Defines ***scope***, a ***cost range***, and a ***funding profile*** for the upper limit of the range
    - We believe the cost range in the document is $600M - $ 900 M
    - We have been told that the scope includes a beam, a near detector, a far detector (equivalent to the capability of a 100kT WC detector), the detector cavity and the laboratory infrastructure required to build that cavity and the detector
      - This protects the project in case the DUSEL were not approved
- The magnitude of the TPC requires the approval of the Deputy Undersecretary of Energy
  - After much review and discussion within the Office of Science it is awaiting approval by Dr. Binkman
  - Needs to be presented to an ESAB
  - End of year ? ?

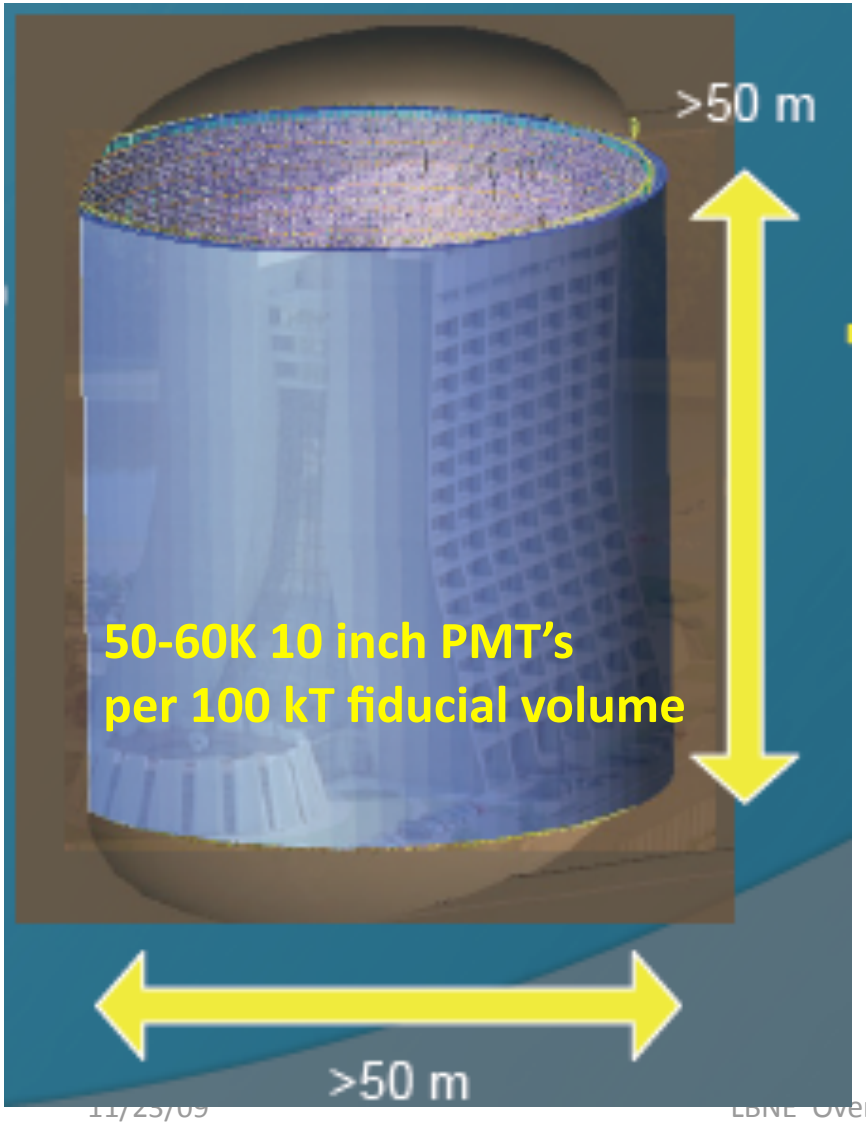
LBNE Project Status

- February 2009 : DOE requested a plan for getting to CD-1
  - Goal : Q1FY11 (~12 months from now)
  - Allows for project being funded by PED funds
    - ~$100M of the TPC is "allocated" for PED in FY11-13
  - CD-1 Plan presented to DOE on August 4
    - LAr Detector as an alternative – fully supported
    - $25 M plan, including $15 M RA funds, for conceptual design
      - $9 M ARRA at FNAL
      - $6 M ARRA at BNL ($1M for LAr)
    - LAr budget ~$5.4M
      - Supports design work at BNL, MSU, UCLA, IU
      - Consulting for cryogenics, cryostat and cavity construction
      - Consulting for risks
  - CD-11 in early FY11 is helpful to the DUSEL case before the National Science Board, expected for Spring 2011

Some ballpark cost "analysis"

- TPC < $900M
  - Beam requires ~ $300M - $350M
  - Near detector - ~$30M - 50M ???
  - TPC needs to cover the *scope* of one 100 kT module of water, including cavity + infrastructure to construct the cavity
    - Minimal infrastructure costs ~$100 - $200 M
    - $300M - $500 M for the detector plus cavity
- If NSF provides the infrastructure, the DOE TPC is likely to be reduced
- If NSF provides the cavity and or significant funding for the detector, the DOE detector scope can be increased, i.e. an additional detector module, liquid argon, …

Why LAr20?
100 kT WC module used to "develop" the TPC

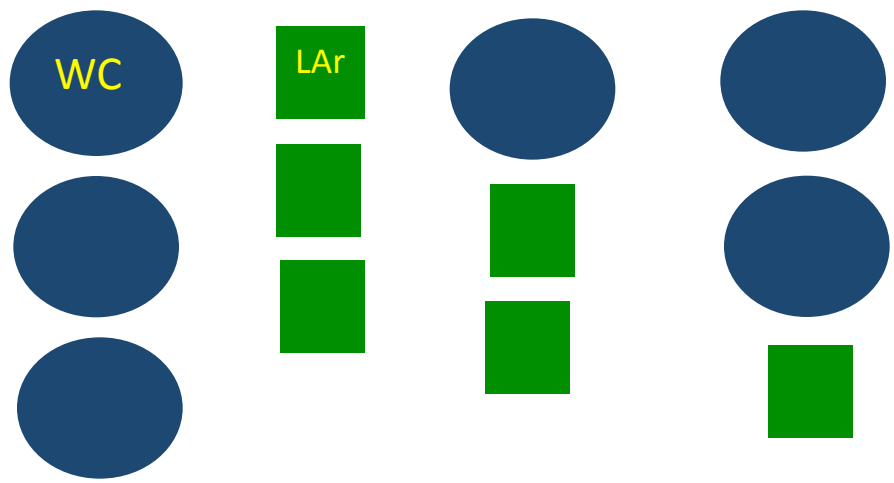


- Simple concept
  - Hole in the ground
  - Mount PMTs
  - Fill
- Some major issues
  - Containment vessel design
  - Cables (50K x 50m)
  - Water purity, temperature control
  - PMT implosion protection
  - NC background rejection

Technology Alternative compare "apples to apples"

	kilotons	
	WC	LAr
Physics Equality	300	50
Physics Module	100	17
Total Module	120	20
Dimensions	~55m diameter, ~60m height	16x16x60 m3 module;20x20x 80cavern

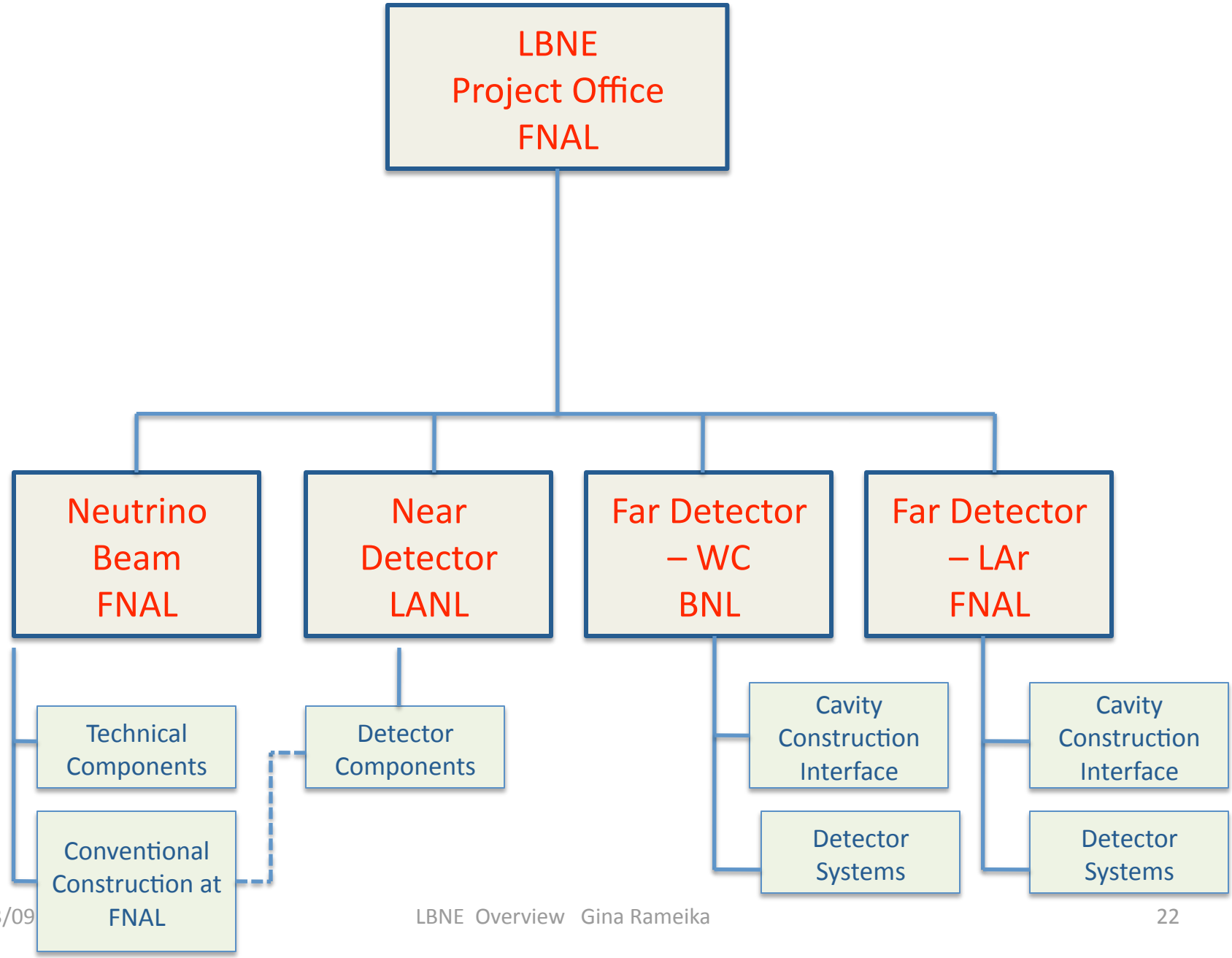
One can imagine 4 potential configurations

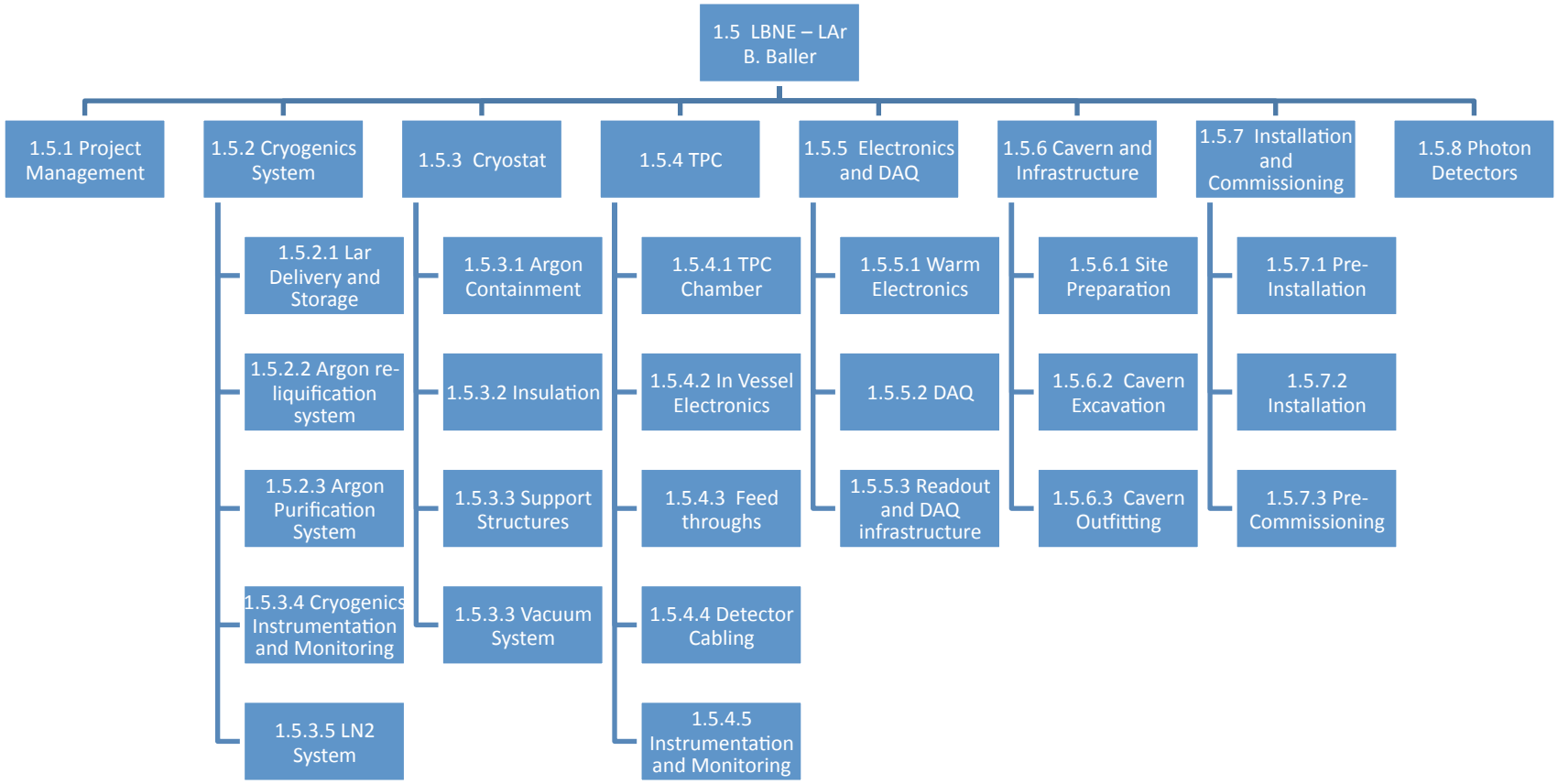


How can we optimize?

Depends on cost, schedule, technical performance…

LBNE : Project Definition Phase



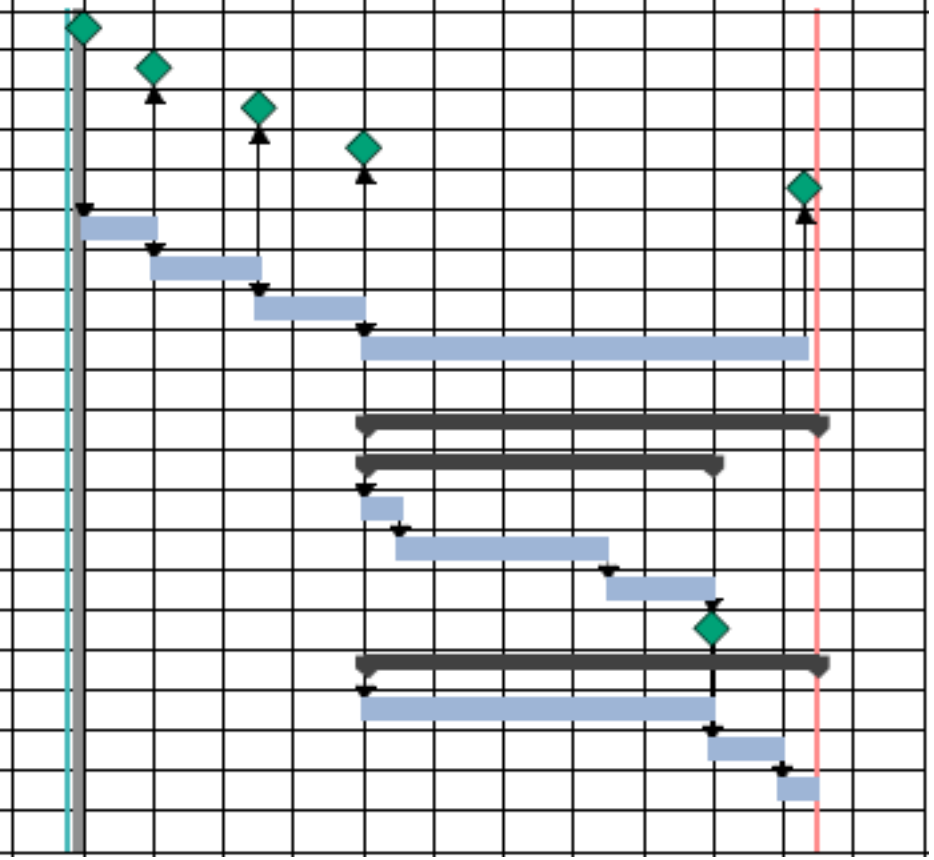

1.5 LBNE – LAr
B. Baller
1.5.1 Project Management
1.5.2 Cryogenics System
1.5.3 Cryostat
1.5.4 TPC
1.5.5 Electronics and DAQ
1.5.6 Cavern and Infrastructure
1.5.7 Installation and Commissioning
1.5.8 Photon Detectors
1.5.2.1 Lar Delivery and Storage
1.5.2.2 Argon re-liquification system
1.5.2.3 Argon Purification System
1.5.3.4 Cryogenics Instrumentation and Monitoring
1.5.3.5 LN2 System
1.5.3.1 Argon Containment
1.5.3.2 Insulation
1.5.3.3 Support Structures
1.5.3.3 Vacuum System
1.5.4.1 TPC Chamber
1.5.4.2 In Vessel Electronics
1.5.4.3 Feed throughs
1.5.4.4 Detector Cabling
1.5.4.5 Instrumentation and Monitoring
1.5.5.1 Warm Electronics
1.5.5.2 DAQ
1.5.5.3 Readout and DAQ infrastructure
1.5.6.1 Site Preparation
1.5.6.2 Cavern Excavation
1.5.6.3 Cavern Outfitting
1.5.7.1 Pre-Installation
1.5.7.2 Installation
1.5.7.3 Pre-Commissioning

CD-1 Deliverables : Documentation

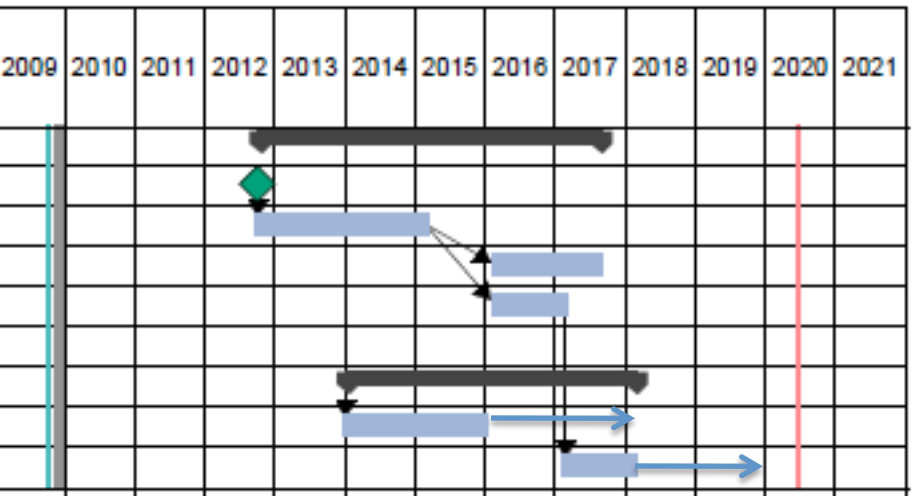
1. Prepare a Conceptual Design Report (~~proposed outline is below~~) - Project Team
2. Prepare an Acquisition Strategy - Project Team in consultation with DOE
3. Comply with the One-for-One Replacement legislation - Project Team in consultation with DOE
4. Prepare a Preliminary Project Execution Plan - Project Team in consultation with DOE
5. Approve appointment of the Federal Project Director -DOE
6. Establish and charter an Integrated Project Team -DOE
7. Conduct a design review of the conceptual design - Project Team , DOE
8. Prepare a Project Data Sheet - DOE
9. Approve long lead procurements (if necessary) - DOE
10. Implement Integrated Safety Management into management and work process planning - Project Team
11. Prepare environmental documents - Project Team
12. Prepare a Preliminary Security Vulnerability Assessment Report - Project Team
13. Determine that the Quality Assurance Program (institutional) is acceptable and continues to apply - Project Team and FNAL staff

Long Range Schedule

	Activity Name	Duration (Work Years)	Start Date	Finish Date	Predecessors
19	CD-0	0.00	12/31/09	12/31/09	
20	CD-1	0.00	12/31/10	12/31/10	24
21	CD-2	0.00	7/2/12	7/2/12	25
22	CD-3	0.00	12/27/13	12/27/13	26
23	CD-4	0.00	4/8/20	4/8/20	27
24	Conceptual Design	1.00	12/31/09	12/29/10	19
25	Technical Design	1.50	1/3/11	6/29/12	20
26	Final Design	1.50	7/2/12	12/27/13	21
27	Construction	6.30	12/30/13	4/8/20	22
28					
29	Neutrino Beam	**6.50**	**12/30/13**	**6/19/20**	
30	Civil Construction	**5.00**	**12/30/13**	**12/21/18**	
31	*Site preparation*	0.50	12/30/13	6/27/14	22
32	*Excavation*	3.00	6/30/14	6/23/17	31
33	*SB&O*	1.50	6/26/17	12/21/18	32
34	*Beneficial Occupancy*	0.00	12/21/18	12/21/18	33
35	Technical Components	**6.50**	**12/30/13**	**6/19/20**	
36	*Procurement and fabrication*	5.00	12/30/13	12/21/18	22
37	*Installation*	1.00	12/24/18	12/20/19	34
38	*Pre-commissioning*	0.50	12/23/19	6/19/20	37
39					

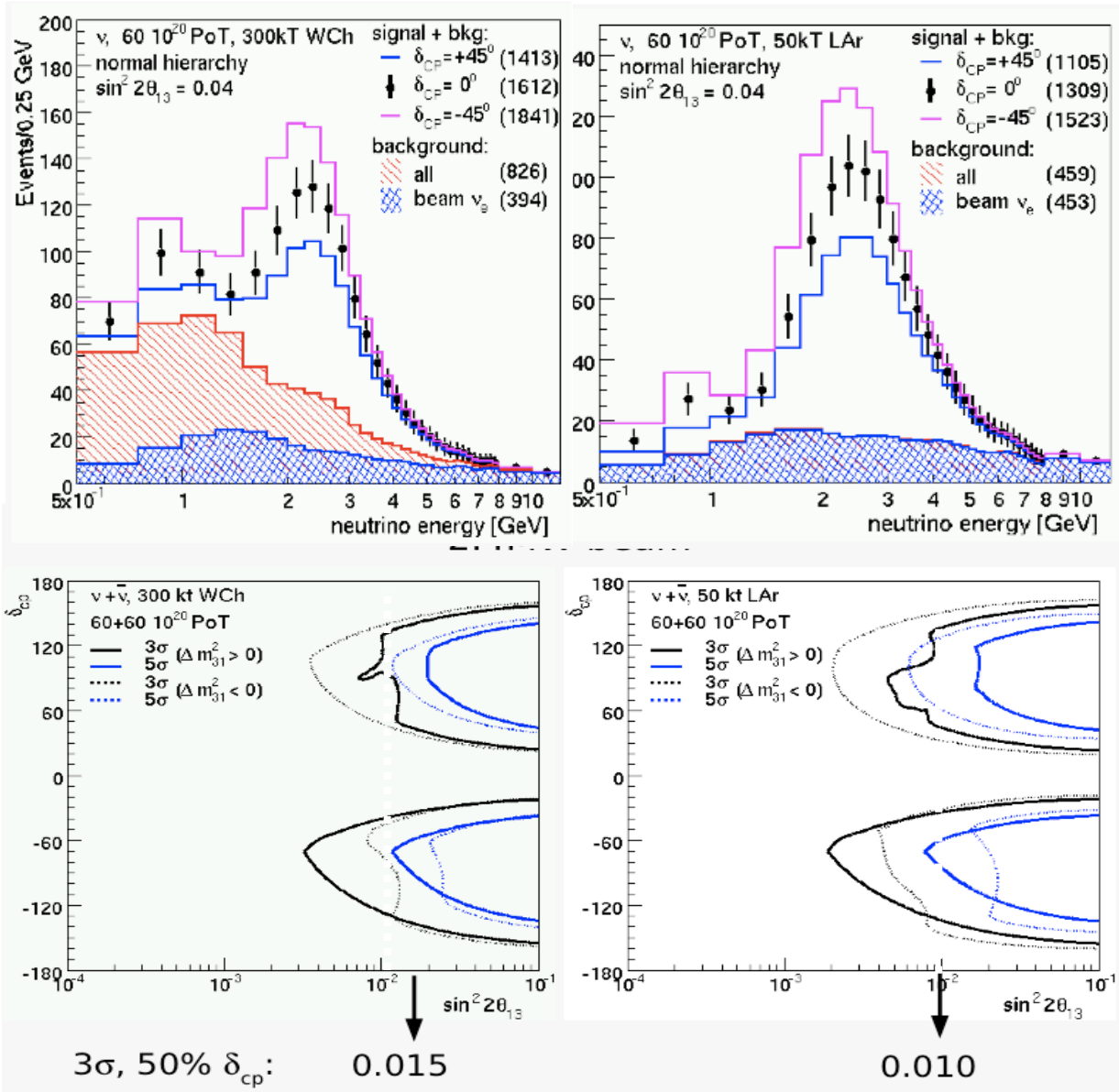


	Activity Name	Duration (Work Years)	Start Date	Finish Date	Predecessors
40	DUSEL	**4.90**	**10/1/12**	**8/17/17**	
41	Earliest construction funding	0.00	10/1/12	10/1/12	
42	Ross Shaft Rehabilitation	2.40	10/1/12	2/19/15	41
43	Large Cavity Excavation	1.50	2/19/16	8/17/17	42FS
44	Lab Module 3	1.00	2/19/16	2/16/17	42FS
45					
46	Detectors	**4.15**	**12/30/13**	**2/15/18**	
47	Earliest Construction Start	2.00	12/30/13	12/25/15	22
48	Installation	1.00	2/17/17	2/15/18	44



From K. Lesko, DUSEL Wksp, Sept. 30, 2009

300 kT WC 50 kT LAr



Mark Dierkxsen, 2008