LBNE Accelerator Activities

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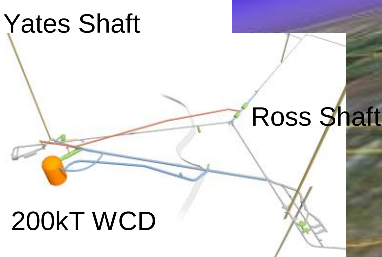
Planning and Strategy Workshop
of the Fermilab Accelerator Sector

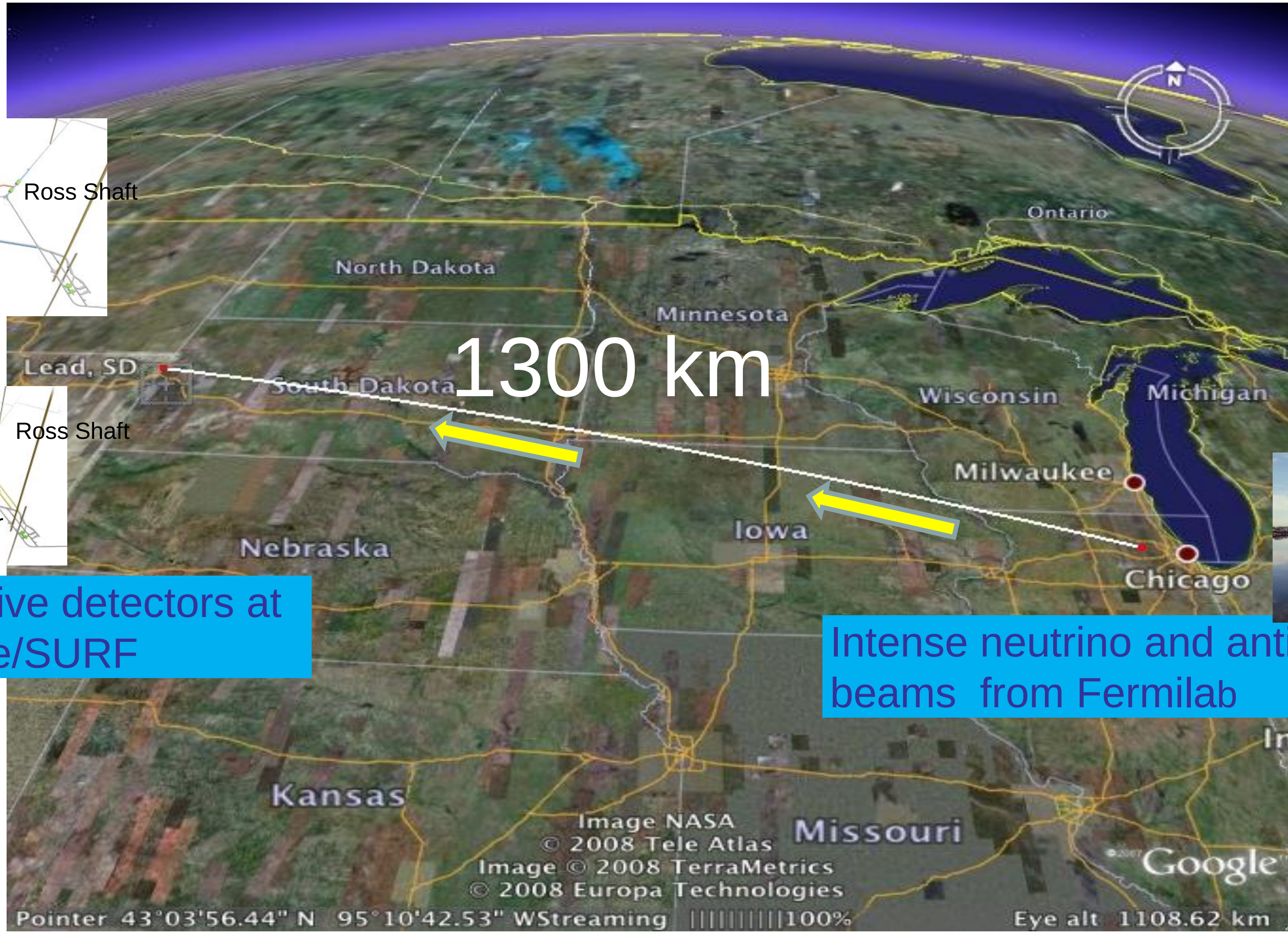
October 27-28, 2011

Outline

- Introduction (Background information, history, recent accomplishments)
- Short term and long term goals
- Resources
- Risks

Long Baseline Neutrino Experiment



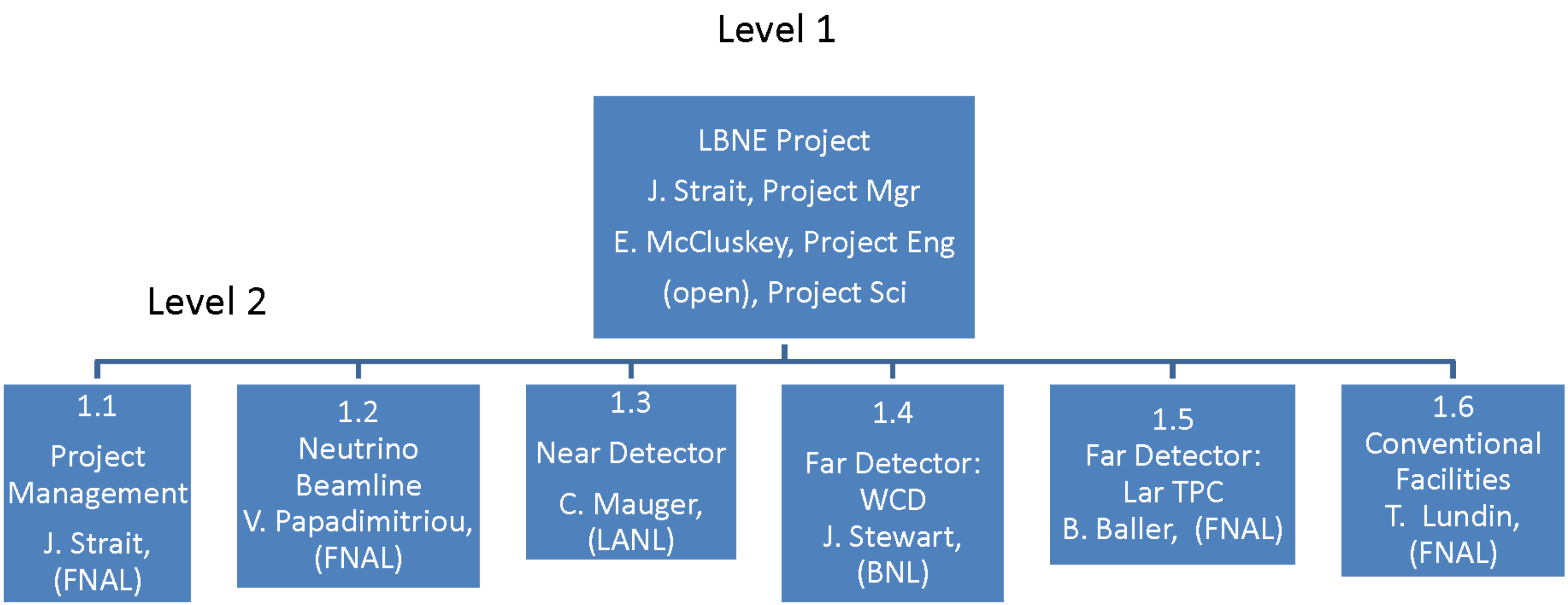


Very massive detectors at Homestake/SURF

Intense neutrino and anti-neutrino beams from Fermilab

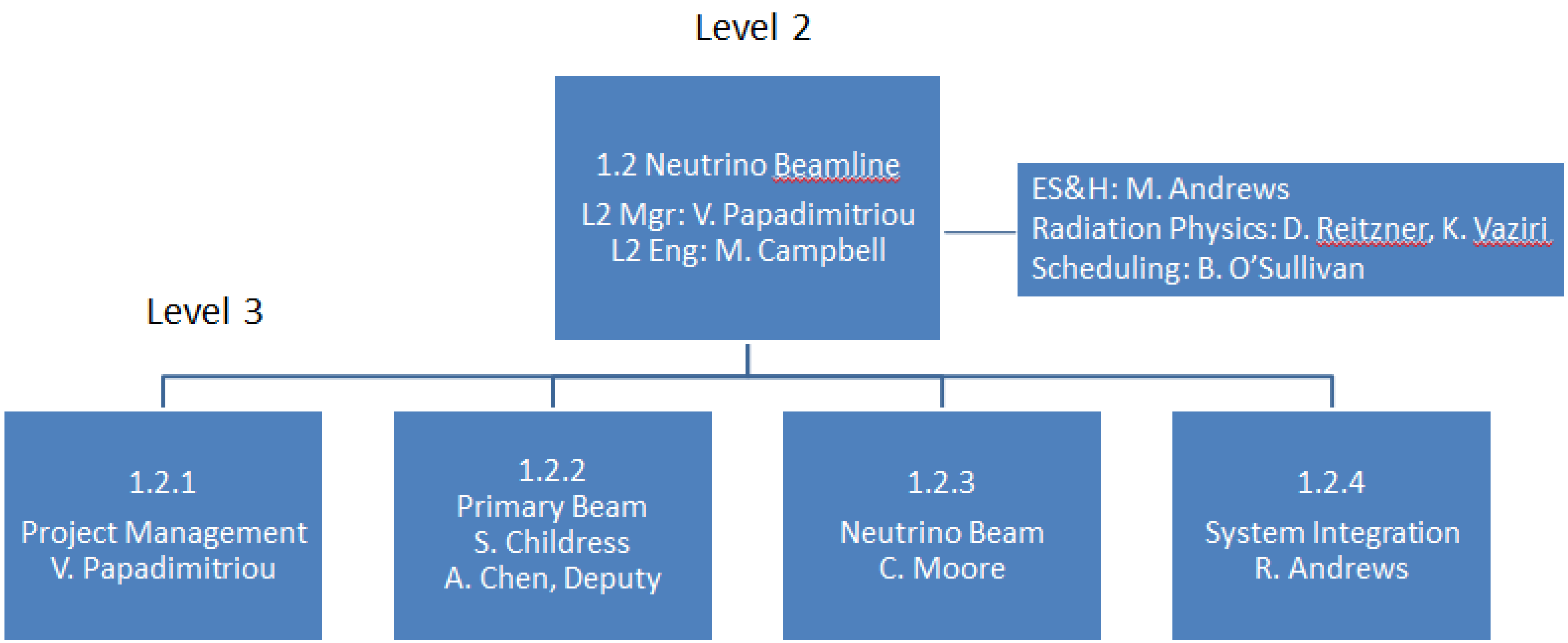
Critical Decision 0 (CD-0) approved on January 8, 2010
Aiming for CD-1 (conceptual design) review in Spring of 2012

LBNE Project Organization



A lot of interaction between Neutrino Beamline and the Near Site Conventional Facilities (we provide the specifications for the Beamline Conventional Facilities). Close communication as well as with the Near Detector.

Organization WBS 1.2



22 L4 Systems

The Neutrino Beamline Team

- From Fermilab's Accelerator, Particle Physics and Technical Divisions, FESS, ES&H and Accelerator Physics Center.
- 18 L4 Leaders: 10 from AD, 4 from APC, 3 from PPD,1 from TD
- Also Collaborators/Contractors from ANL, BNL, IHEP (Protvino), RAL (UK), ORNL, Bartoszek Eng., Design Inovations

High Level Beam Design Considerations

- The driving physics considerations for the LBNE Neutrino Beamline are the long baseline neutrino oscillation analyses.
- Optimizing for Eν below 10 GeV (focusing in the area 0.5-5.0 GeV).
- Flexibility to operate in the proton beam energy range of 60-120 GeV.
- Start with a 700 kW beam, and then be prepared to take profit of the significantly increased beam power (~2.3 MW) available with Project X.

Key Assumptions for the LBNE Neutrino Beamline

- The lifetime of the LBNE Beamline facility is expected to be about 30 years. Some components are expected to last significantly longer so that they can meet radiological requirements until the decommissioning of the facility.
- The beam is aimed to DUSEL in South Dakota (a 48/7 degree horizontal bend).
- The Neutrino Beamline Facility will be contained within Fermilab property.
- The ANU/NOvA program is expected to deliver 708 kW at proton energy of 120 GeV.
- There may be concurrent running of NOvA and LBNE (MI-60 extraction). Several vertical bends (up to 150 mrad) to preserve this capability and to get past existing beamlines.
- Maximize the distance between the target and the Near Detector in addition to allowing for muon range-out.
- Implement in the design the “lessons learned from NuMI”

Key Assumptions for the LBNE Neutrino Beamline

- There are a few systems in the Neutrino Beamline that are conceptually designed for 2.3 MW in order to enable the facility to run with an upgraded accelerator complex that will provide higher beam power. These systems include the shielding of the primary beam extraction enclosure, the target shield pile, the decay pipe shielding and the absorber. Upgrading these systems after beam exposure is inconsistent with ALARA considerations, technically impractical and cost inefficient. The underground space requirements for the Neutrino Beam Facility are sized for 2.3 MW as the overheads for initiating the underground construction are large. Remote handling is conceptually designed for 2.3 MW as well since most of the remote handling infrastructure cannot be upgraded or replaced after commissioning with beam.

Milestones

- NSF/DUSEL decoupling – February 2011
- LBNE presentations at the DOE Office of Science Review, April 2011.
- "DOE Office of Science Review of Options for Underground Science" report available – June 2011
- National Research Council assessment of DUSEL available – July 2011
- DUSEL changes scope – SURF (Sanford Underground Research Facility)
- Waiting for DOE/Office of Science Decision
- In the mean time LBNE is trying to reduce the overall cost – significant value engineering effort.

positive

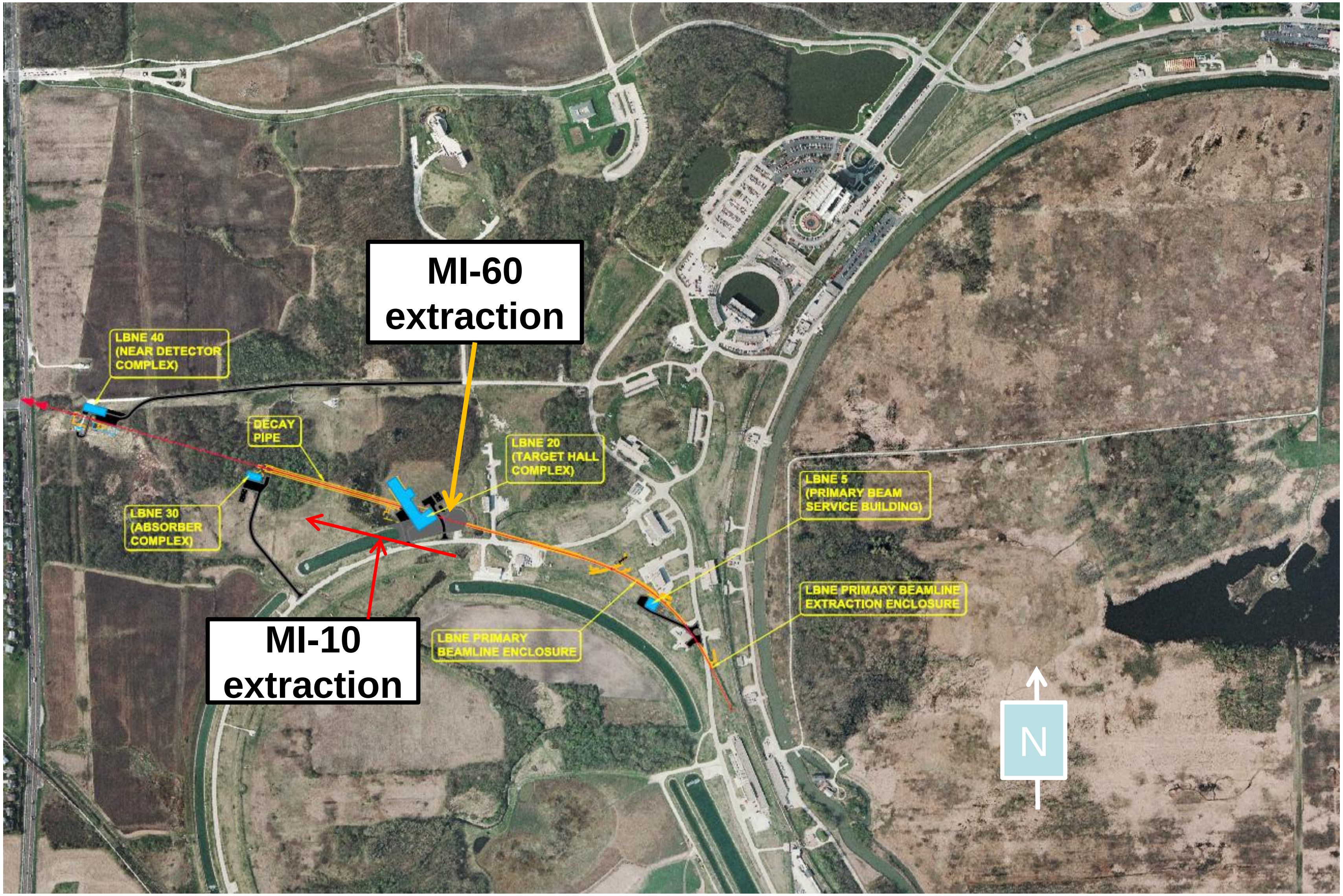
Recent Beamline Accomplishments

- For the Beamline (NuMI style conceptual design) we had 7 internal design and cost/ schedule reviews between April 2010 and September, 2010. CDR completed, September 2010.
- External Beamline design and cost/schedule review, September 20-22, 2010. Conclusion: **Technical status of the Neutrino Beamline already at a level suitable for CD-1**
- From October 2010 and on we entered in the 2nd/3rd phase of value engineering with the goal to reduce the cost significantly. We have evaluated ~15 Value Engineering proposals so far. A Beamline Technical Board was established in March 2011 to help review the proposals as well as provide recommendations and advice on important technical decisions.
- Four beamline facility concepts and a cost range were developed for the DOE Office of Science review in April 2011.

The Four Configurations Considered

- Four separate beamline / facility configurations have been defined with accompanying conceptual level cost estimates. These are:
  - MI-60 beam extraction, Deep (similar to NuMI design) and MI-60 beam extraction, Shallow
  - MI-10 beam extraction, Deep and MI-10 beam extraction, Shallow
- Deep options feature excavations in soil and in rock.
- Shallow options feature a large berm into which facilities would be constructed. This is to minimize excavations in rock.
- Decay tunnel length varies between 200m and 250m (about 10% effect in neutrino flux). Diameter is 4m.
- The options MI-10, Shallow and MI-60, Deep define the cost range.

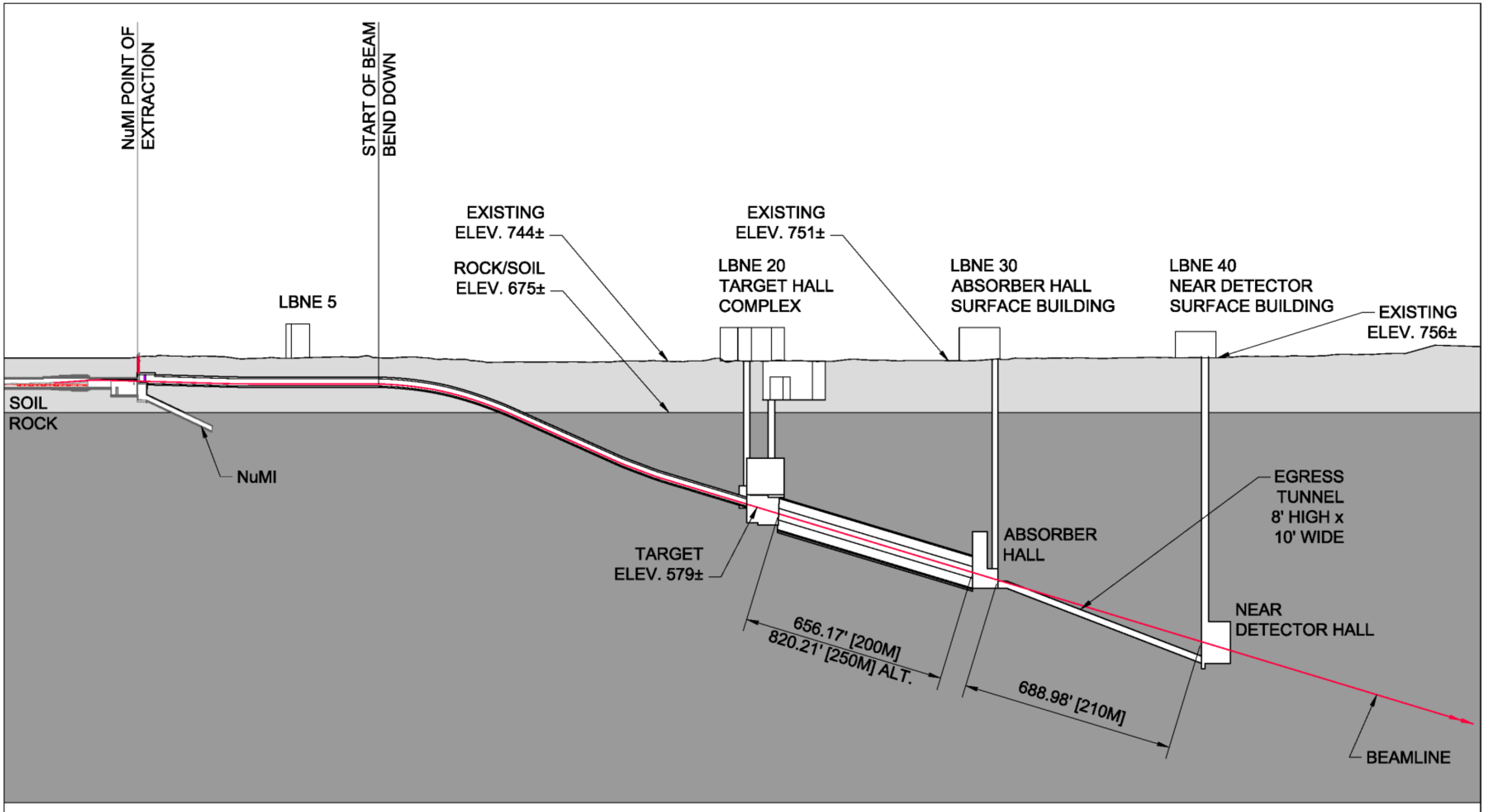
The LBNE Neutrino Beamline Facility at Fermilab



Recent Beamline Accomplishments

- In the end of June 2011 we selected two of the four concepts to pursue aggressively towards CD-1. Two Reference Designs: MI-60, Deep and MI-10, Shallow. We tried to apply in both designs as many VE proposals as possible and compare them for the same decay pipe length and muon range-out distance.
- We have developed two CDR volumes (~200 pages each) for the Beamline; one for each design. We have updated L2/L3/L4 requirement documents and have developed a set of risks covering both designs (43 risks and 2 opportunities so far).
- In the process of updating BOEs and cost estimates in preparation for a Director's review in February 2012.
- Aiming for a technical review of the LBNE Near Site on November 1-3, 2011 and CD-1 Review in the Spring of 2012.

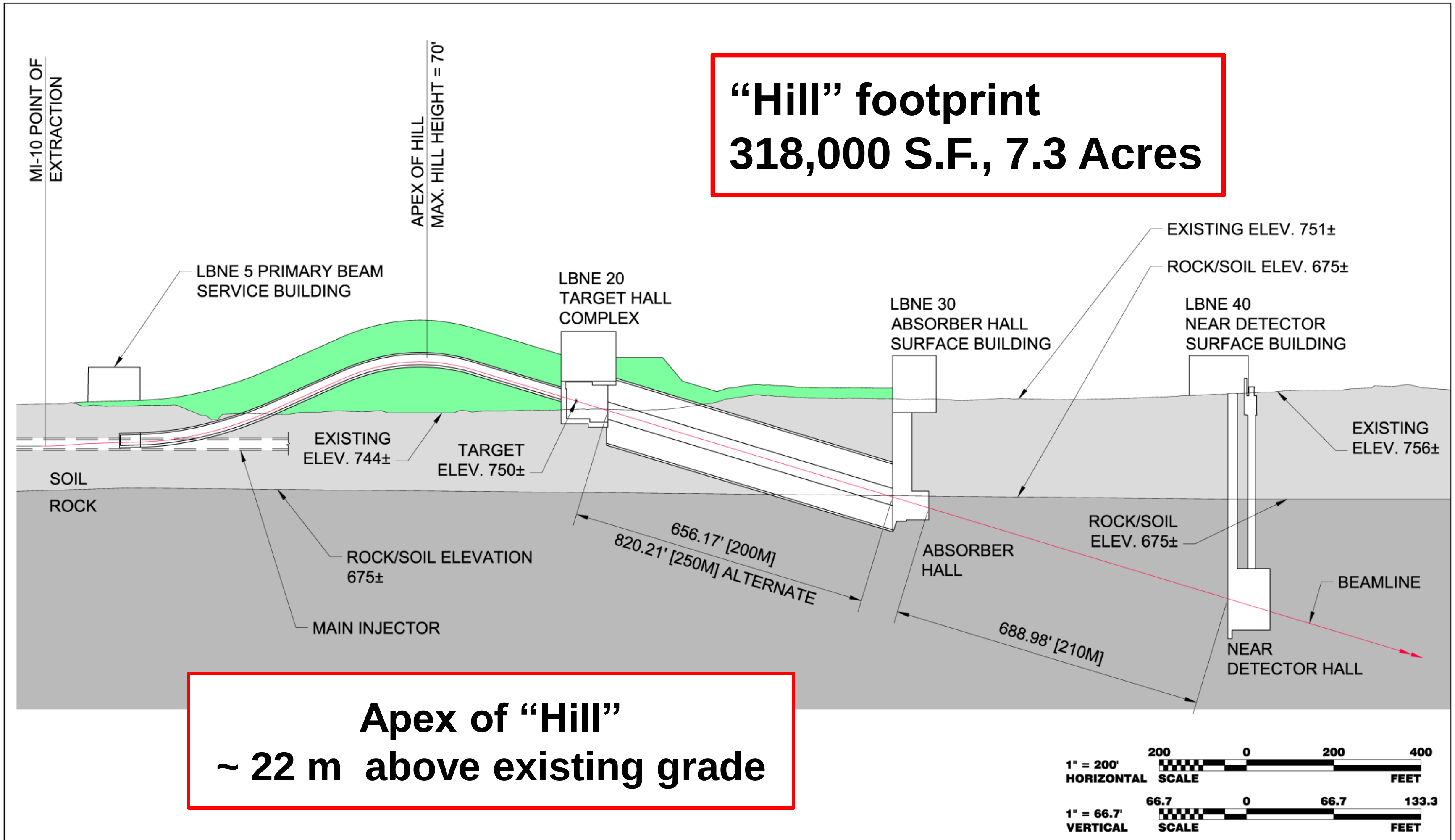
MI-60 Extraction, deep



Existing extraction point for NuMI

Sufficient space available to increase significantly decay pipe/muon range out distances

MI-10 Extraction, shallow



Introduce a drift tube to minimize the impact on MI and therefore cost and downtime.

New issues: stability (deep foundations), impact on MI, muon-shine, position of decay pipe/absorber (geomembranes)

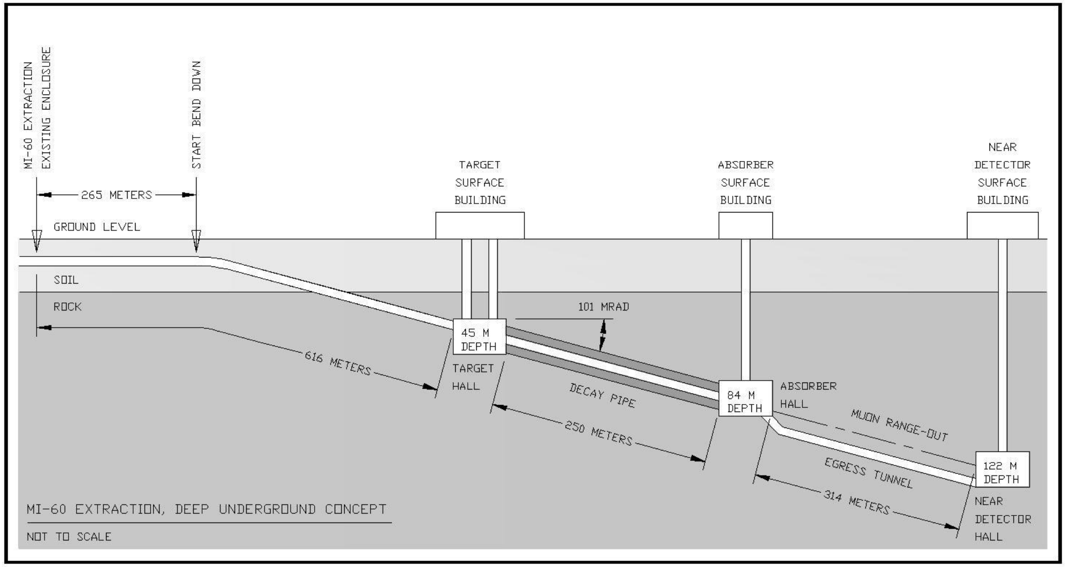
The Neutrino Beamline Scope/Activities

Primary Beam (magnets, magnet power supplies, LCW, vacuum, beam instrumentation, beam optics and beam loss calculations)

Neutrino Beam (primary beam window, baffle, target, 2 focusing horns, horn power supplies, decay pipe, absorber, RAW, tritium mitigation, target pile, remote handling, modeling, storage of radioactive components)

System Integration (controls, interlocks, alignment, installation infrastructure)

Conventional facilities in separate WBS, 1.6.2



Accords, MOUs, SOWs, Contracts

- We established collaborations with ANL, BNL, IHEP (Russia), ORNL, RAL(UK), Bartoszek Eng., Design Inovations and made sure we have sufficient supervision and integration effort at Fermilab.

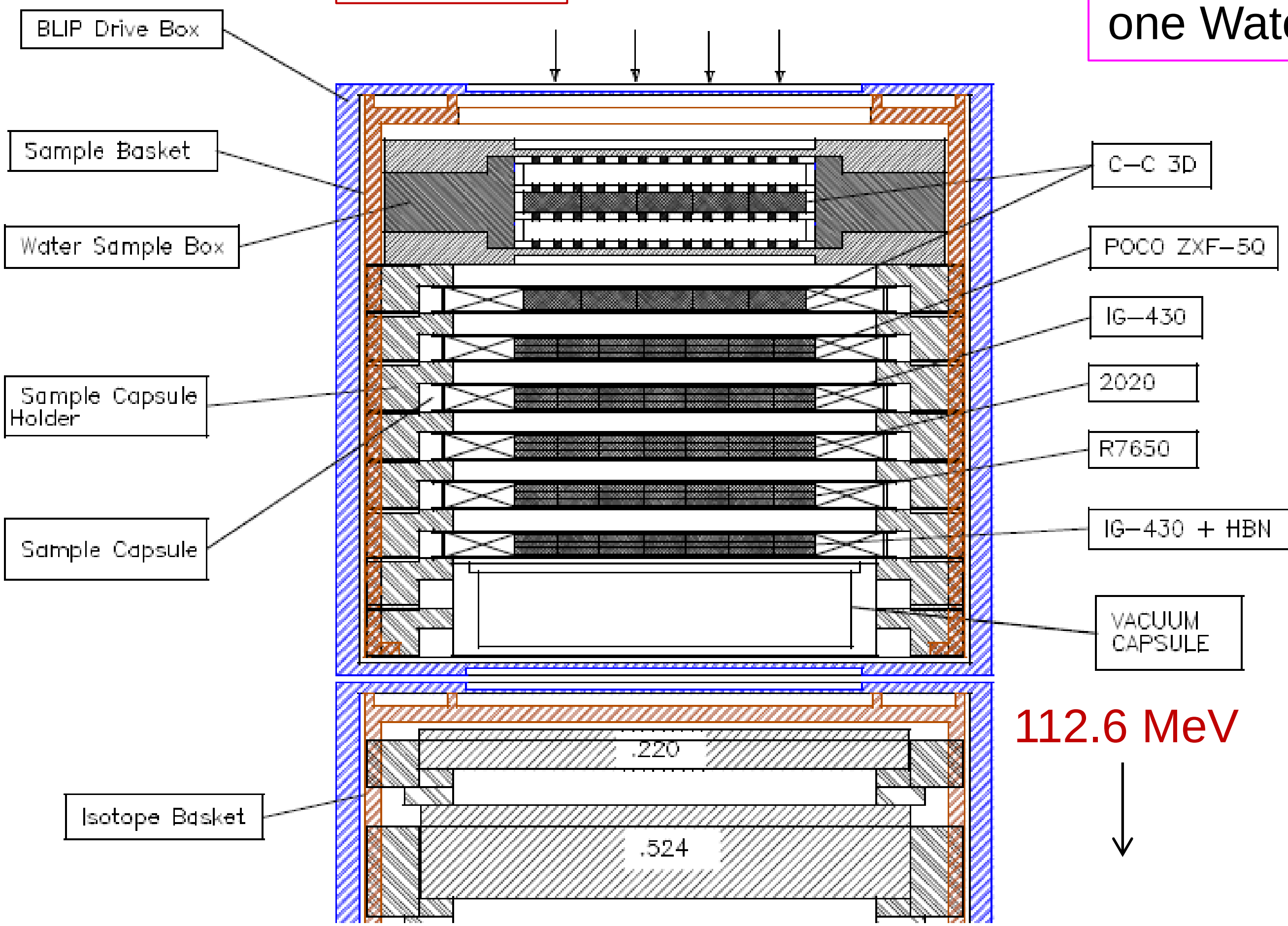
  - ✓ Accord with IHEP for the conceptual design of a 700 kW graphite target.
    - Complete
  - ✓ MOU with ANL (2 MW target R&D) to investigate hydraulic shock in the cooling water (water hammer effect).
    - Complete
  - ✓ MOU with BNL for a 9-week irradiation study at BLIP to investigate candidate target materials (started in March 2010).
    - Run complete. Analysis in progress.

BNL/BLIP irradiation study March-June, 2010
~ 9 weeks of beam

Beam in at 181 MeV, must reach isotope box at 112.65 MeV (changed from proposal)

Top View BEAM 178 MeV

Six Argon capsules and one Water capsule



Carbon-carbon composite

NuMI target graphite

Japanese graphite

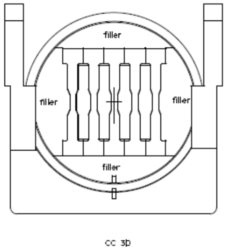
Another graphite, higher thermal shock metric

NuMI baffle graphite

Highest therm. shock metric

112.6 MeV

Beam View of Samples and Holder



Accords, MOUs, SOWs, Contracts

- ✓Accord with RAL (700 kW/2 MW R&D) to: investigate Be as possible target material; cooling concepts; conceptual design for a beam window.
  - Complete
- ✓ SOW with ORNL on remote handling issues.
  - Complete
- ✓ SOW with Bartoszek Eng. on Baffle and Horn support structures.
  - Complete
- ✓ Contract with Design Inovations on magnet installation equipment.
  - Complete
- ✓ Expect to have MOU with University group(s) on target hall instrumentation after CD-1.

Plan to reactivate after CD-1some of the currently complete MOUs towards detailed design

LBNE milestones

- LBNE Beamline depth/extraction decision - November 2011
- LBNE Far Detector technology decision - January 2012
- CD-1Review complete - April 2012
- CD-2 (baseline) Review complete - June 2013
- CD-3A Review complete - August 2013
- CD-3B Review complete - September 2014
- Installation of Beamline components to start in the Fall of 2018 (start having beneficial occupancy).
- Far detectors ready for Beam Summer 2021/Spring 2022 (depending on technology)

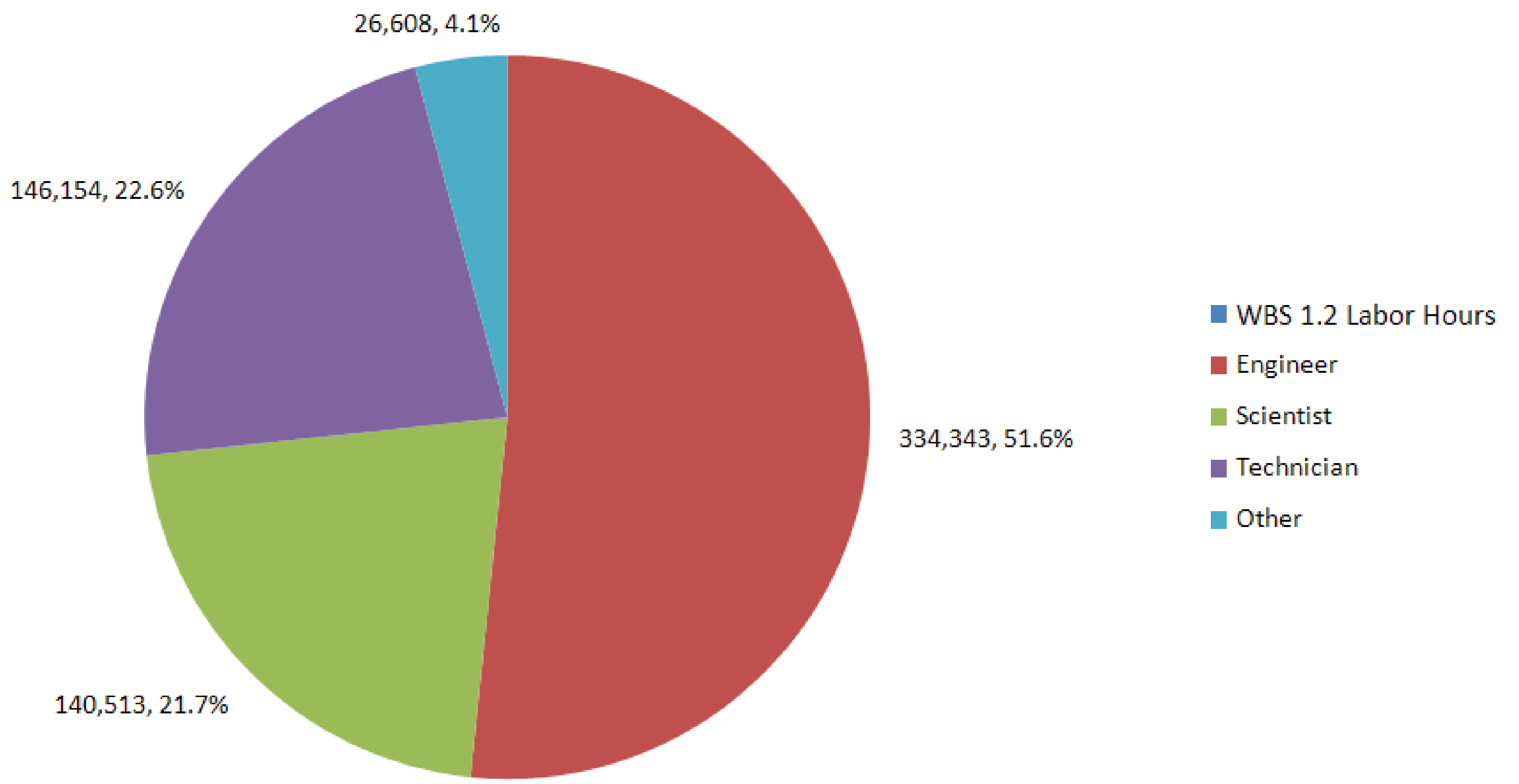
Short term and long term goals

- In 10 years from now we should be delivering beam to the FAR Detectors
- By the end of FY2012 we should have received CD-1 (summer 2012?) and started the detailed design for all beamline subsystems

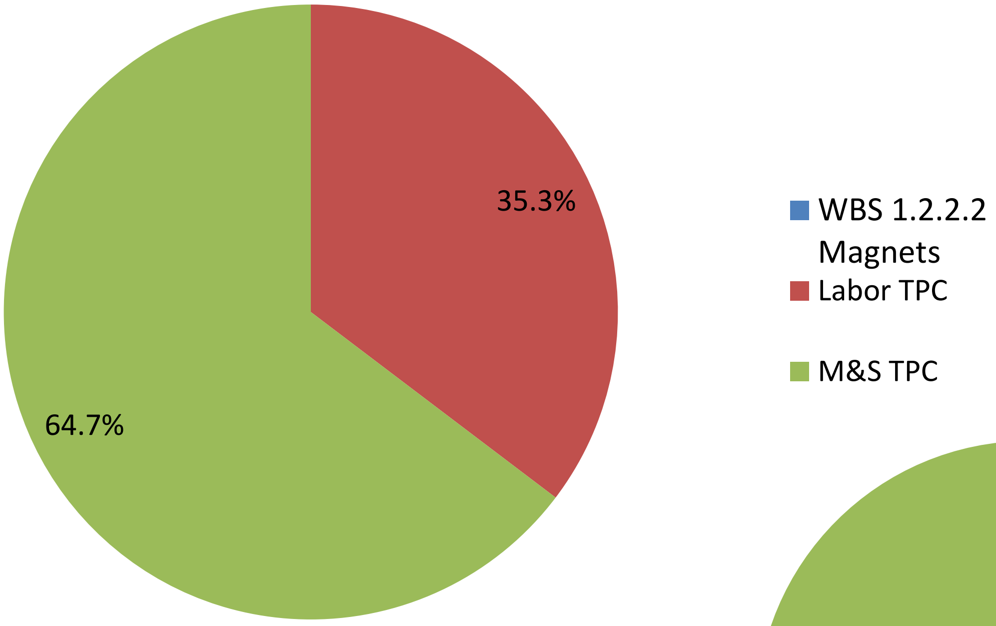
Resources

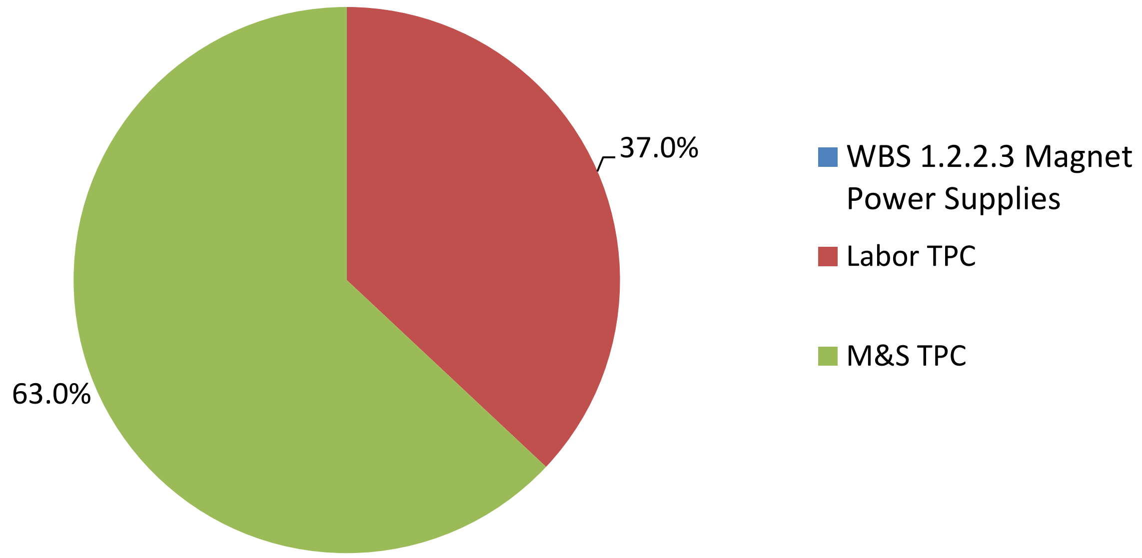
- Resources needed to meet the FY2012 goals.
  - Budget request (costed) for Beamline ~13 FTE. DSC allocation ~ 13 FT but some mis-matches in type of labor allocated
  - Eg. Asked for 3.53 FTE MEs from AD and was allocated 3.03 FTEs and recently about 0.5 FTE had to be redirected to other urgent project needs. Similarly, smaller allocations for MEs from TD and PPD. Contractors under consideration cannot be of help till after CD-1.
  - Delays in re-evaluating costs, etc.
- Resources needed to meet the 10 year goals:

Neutrino Beamline Effort



M&S vs Labor for magnets and magnet power supplies (MI-10, shallow)





Risks

- What are the risks to the FY2012 plan?
  - Funding, FNAL resources availability (both costed and uncosted), inefficiency due to discontinuity and effort in rebuilding team.
- What are the risks for achieving the10 year plan goals?
  - Funding, FNAL resources availability (costed/uncosted), contractor delays or low quality product (IHEP), off-project deliverables do not materialize (storage space for radiocative spent components, TeV power supplies, upgrade to master substation,…), Quality Assurance issues (eg. Geomembrane installation), ES&H issues (tritium mitigation for Project X beam power), technical issues (targets and horns at Project X beam power),…

Conclusions

- The LBNE Beamline Team has made very good progress towards the conceptual design and evaluated several alternatives. (There was one year delay for the entire project due to external factors (DUSEL) and in the effort to reduce the overall project cost).
- Achieving CD-1 within the 3rd quarter of 2012 is critical for the project and its scientific goals. This implies that effort needs to ramp up quickly and be front-loaded. We need specific expertise but there is room for consolidation if we are allocated bigger fractions of engineers/scientists.
- Lots of vigilance needed to keep on track towards the 10 year goals.

Backup

Cost range – L2

- Lowest cost scenario for MI-10 extraction, shallow:

Total cost in unescalated $FY2010:

$149,664,334 (Beam) + $180,799,304 (CF) =

$ 330,463,638

- Highest cost scenario MI-60 extraction, deep (NuMI like):

Total cost in unescalated $FY2010:

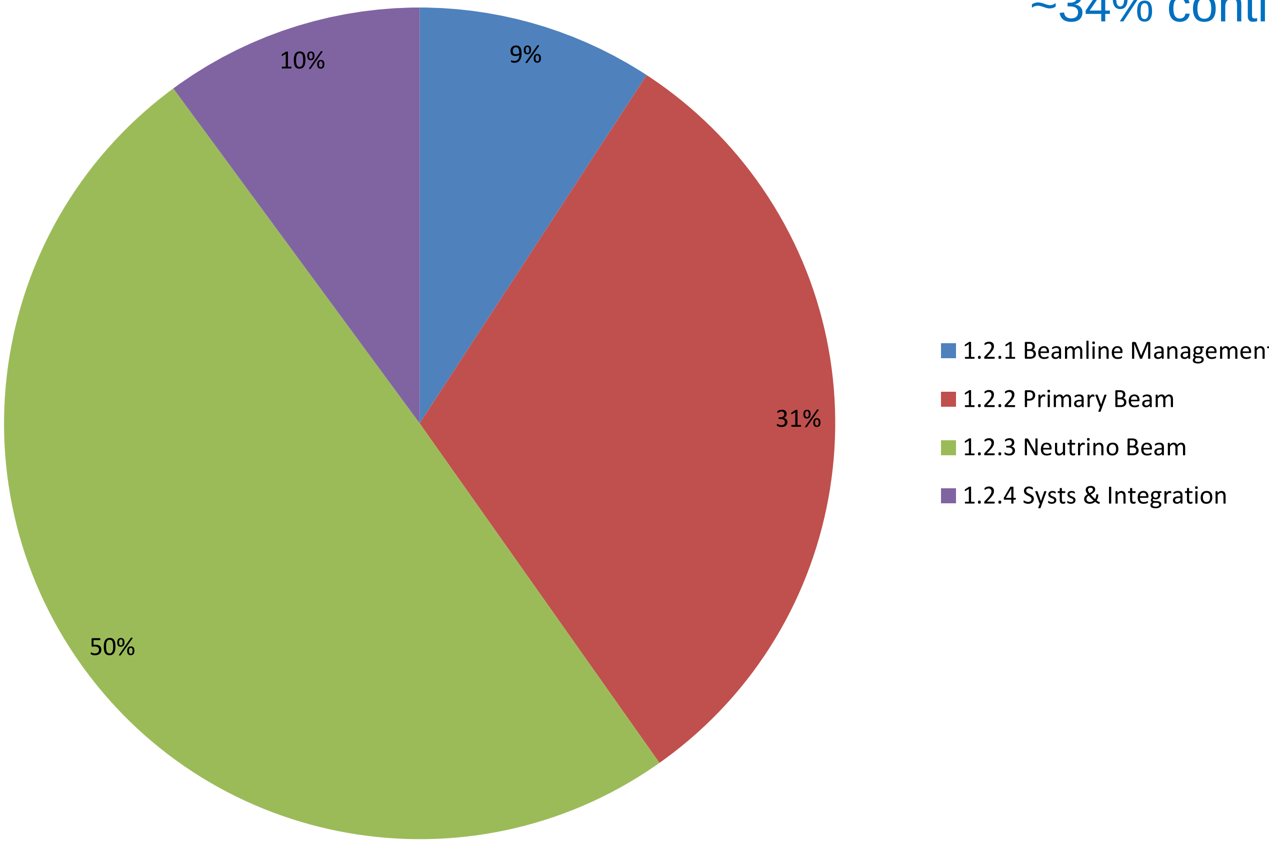
$163,371,740 (Beam) + $281,279,304 (CF) =

$ 444,651,044

Neutrino Beamline (MI-60, deep) TPC (no escalation)

$163.4 M

~34% contingency included



~$50 M
~$80 M

LBNE Magnets (Main Injector style magnets (built new, on the basis of existing design)

- The current cost estimate is based on most of the work being done on contract in industry.(Magnet fabrication requires large, specialized equipment under the supervision of experienced engineers. The job is suited for a company or laboratory that is already equipped for the work).
- The dipoles dominate the cost. Fermilab buys the steel and directly contracts for the lamination stamping. The vast majority of the labor is in the fabrication of the cores from those laminations and the fabrication of the magnet coils (industry).
- Assembly in-house, as done for the Main Injector, in order to allow close QC on the cores and components. Applying FNAL QA procedures gives confidence that the magnets will perform as needed. Requiring the vendor to meet our performance specification for a complete magnet would add significantly to the total cost.

LBNE Magnets

- For the quadrupole magnets we assume construction at Fermilab since the technique used (vacuum impregnating the whole magnet instead of the 4 coils separately) is not common in industry. The work though would involve contract technicians.
- The fabrication of the trim dipoles is also to be contracted out.