# Cost and Engineering Working Group Introduction

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Deputy Chair, Cost and Engineering Working Group

# Cost and Engineering Working Group

- Cost and Steering Working Group members
  - Mark Reichanadter (SLAC COO), Chair
  - Jim Strait (FNAL, LBNE Project Manager), Deputy Chair
  - Bruce Baller (FNAL, LAr Far Detector Project Manager)
  - Mike Headley (SURF Director)
  - Marvin Marshak (U of MN, Director of Soudan and Ash River Labs)
  - Christopher Mauger (LANL, LBNE Near Detector Project Manager)
  - Elaine McCluskey (FNAL, LBNE Project Engineer)
  - Bob O'Sullivan (FNAL, LBNE Project Controls Lead)
  - Vaia Papadimitriou (FNAL, LBNE Beamline Project Manager)
  - Jeff Sims (ANL, APS Upgrade Project Managment)
  - Jeffrey Appel (FNAL Directorate), Scientific Secretary
- Invited to work with the Working Group
  - Tracy Lundin (FNAL, LBNE Conventional Facilities Project Manager)
  - Jeff Dolph (BNL, LBNE Project Systems Engineer)
  - Jim Stewart (BNL, LBNE Water Detector Project Manager)
  - Joel Sefcovic (FNAL, LBNE Project Controls for Conventional Facilities)

# LBNE Project Cost Estimates

- LBNE has developed a complete Conceptual Design and cost estimate, which has been reviewed many times and found to be sound. Recent Director's Review stated:

The committee finds that the Conceptual Design for the LBNE project is sound, and should achieve the Project's scientific goals. Our determination is that the level of technical detail across the entire breadth of the LBNE project is sufficient to address the question of overall capability to achieve the scientific goals, as appropriate for this stage of the project. There are a number of components of the project that have advanced well beyond the conceptual stage.

The committee is confident that the LBNE project can be ready for a CD-1 review on the time scale given to the committee, the summer of 2012, if issues related to the funding profile and the resulting schedule are resolved. The management systems and documentation for the project are appropriate for a CD-1 review.

Given the breadth of the LBNE project, and the wealth of documentation associated with the project, the committee examined selective portions of the documents to evaluate the quality of the information. Our finding is that the technical information, costing information, task level duration estimates, Value Engineering information, etc. is of high quality.

*Full LBNE Cost Estimate as presented to the Director's Review , 26-30 March 2012*

# Cost at WBS L2
# Fixed (FY2010) dollars

| FY2010 M$ | Base | Est Uncert | | | Risk Cont. | | | PM / Top-Down | | Total | % | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WBS L5 | Budget | Cont. | % | TPC1 | | % | TPC2 | Cont. | % | Cont. | Cont. | TPC3 |
| **130 LBNE Project** | **1,094** | **272** | **25%** | **1,366** | **50** | **5%** | **1,416** | **126** | **12%** | **448** | **41%** | **1,542** |
| *Unclassifiable Top-Down Contingency* | | | | | | | | *50* | | | | |
| 130.01 LBNE Project Office | 56 | 9 | 16% | 65 | 6 | 10% | 71 | 5 | 9% | 20 | 36% | 76 |
| 130.02 LBNE Beamline | 133 | 38 | 29% | 171 | 4 | 3% | 175 | 6 | 5% | 48 | 36% | 181 |
| 130.03 Near Detector Complex (NDC) | 34 | 8 | 23% | 42 | | 1% | 42 | 9 | 25% | 17 | 50% | 51 |
| 130.04 Water Cherenkov Detector | 11 | | - | 11 | | - | 11 | | - | | - | 11 |
| 130.05 Liquid Argon Far Detector | 291 | 50 | 17% | 341 | 32 | 11% | 373 | 27 | 9% | 109 | 37% | 399 |
| 130.06 LBNE Conventional Facilities | 570 | 166 | 29% | 736 | 8 | 1% | 745 | 30 | 5% | 205 | 36% | 775 |

| | |
|---|---|
| Project Office | $76M (5%) |
| Near Site* | $542M (35%) |
| Far Site* | $924M (60%) |
| TPC | $1,542M (100%) |

| | |
|---|---|
| Project Office | $76M (5%) |
| Technical Systems* | $665M (43%) |
| Conventional Facilities* | $802M (52%) |
| TPC | $1,542M (100%) |

* "Unclassifiable Top-Down Contingency" assigned proportionately to these groupings

# Contingency Development *for Full LBNE Cost Estimate*

Our contingency analysis has three components:

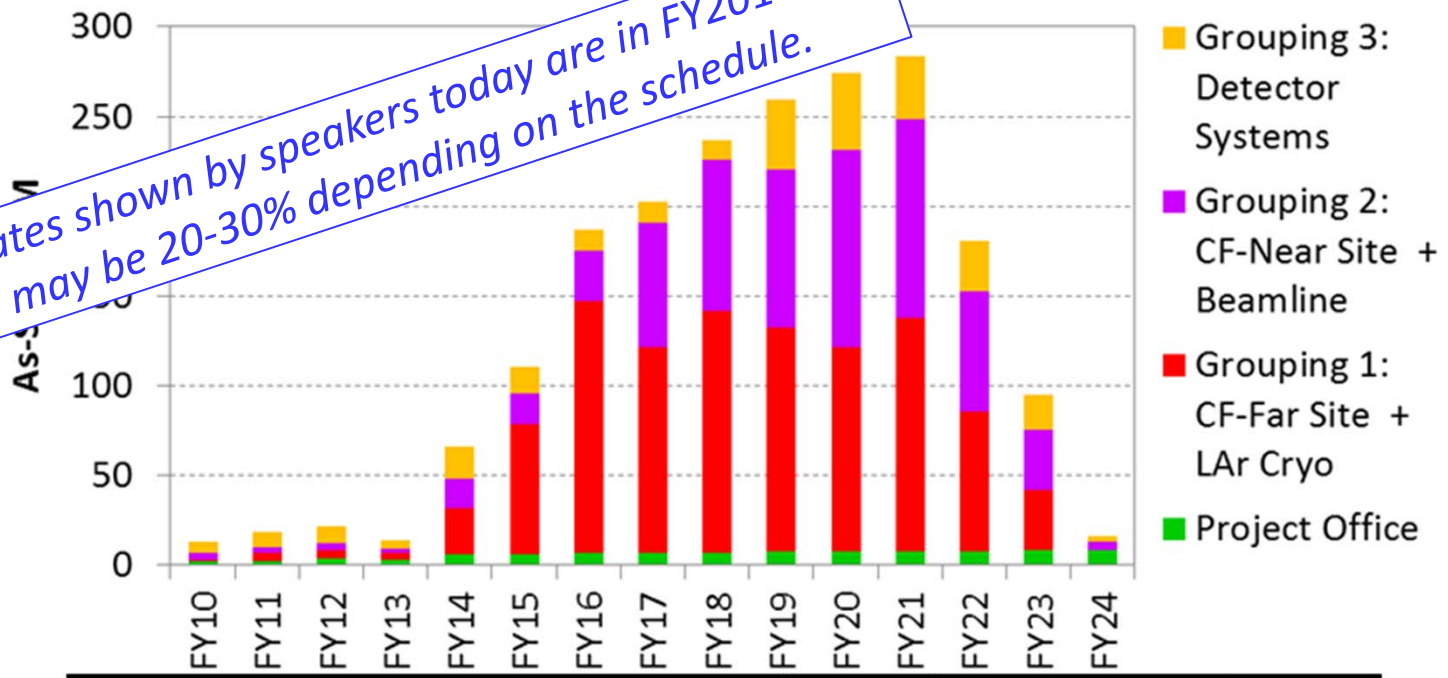
- Estimate uncertainty (How well do we understand the costs, assuming that things go according to plan?)
  This is done "from the bottom up" as part of the cost estimating and is documented on the BOE's as a percentage of labor or M&S cost.
- Risk analysis (What things could go wrong and what would the cost be to recover?)
  We have done a formal risk analysis and documented the results for the most important risks.
- "Top-down" contingency (How much additional contingency do we need to set aside, based on project management judgment, beyond that required by estimate uncertainty and risk?)

*Cost estimates shown by other speakers include estimate uncertainty contingency and some include risk contingency.*

*Full LBNE Cost Estimate as presented to the Director's Review , 26-30 March 2012*

# Obligation Profile by Sub-project Groupings

*Cost estimates shown by speakers today are in FY2010 $; escalation may be 20-30% depending on the schedule.*




| As-Spent $M | Base Budget | Contingency | | TPC |
|---|---|---|---|---|
| Project Management | 67 | 36% | 24 | 91 |
| Grouping 1: CF-Far Site + LAr Cryo | 704 | 40% | 282 | 985 |
| Grouping 2: CF-Near Site + Beamline | 454 | 41% | 185 | 640 |
| Grouping 3: Detector Systems | 163 | 61% | 99 | 262 |
| TPC | 1,388 | 43% | 590 | 1,978 |

# Building Blocks – Phased LBNE Options

## I. Far Detector at Sanford

### *A. Conventional Facilities*

1. CF infrastructure required for any installation at 4850
2. CF infrastructure for a small (5 kt fiducial mass) LAr detector at 4850
3. CF infrastructure for a small (5 kt fiducial mass) LAr detector on surface
4. CF infrastructure for a full-size (1 or 2 x 17 kt fiducial mass) LAr detector at 4850
   a. Cavern, etc. for one detector.
   b. Cavern, etc. for second detector built at the same time as the first.
   c. Cavern, etc. for second detector built later.
5. CF infrastructure for a full-size (1 or 2 x 17 kt fiducial mass) LAr on surface

### *B. LAr Far Detector*

1. Small (5 kt fiducial mass) LAr detector at 4850
2. Small (5 kt fiducial mass) LAr detector at surface
3. Full-size (1 or 2 x 17 kt fiducial mass) LAr detector at 4850
4. Full-size (1 or 2 x 17 kt fiducial mass) LAr detector at surface

# Building Blocks – Phased LBNE Options

## II. Beamline to Homestake

***A. Conventional Facilities***

***B. Beamline technical components***

- *Seeking opportunities for further cost reductions or phasing of construction*

## III. Near Detector Complex for Beam to Homestake

***A. Conventional Facilities***

1. Main shaft only
2. Full ND hall
   a. Done later.
   b. Done together with the main shaft

***B. Near Detector***

1. More extensive muon detectors if we only have a mini-ND?
2. Mini-ND
3. Full-scale ND

# Building Blocks – Alternatives to LBNE

## IV. Far Detector at Soudan

### *A. Conventional Facilities*

1. CF infrastructure for any installation at 2340 foot depth
2. CF infrastructure for a small (5 kt fiducial mass) LAr detector at 2340 foot depth
3. CF infrastructure for a large (1 or 2 x 17 kt fiducial mass) LAr detector at 2340 foot depth
4. CF infrastructure for a small or full-size LAr detector at surface

### *B. LAr Far Detector*

1. Small (5 kt fiducial mass) LAr detector at 2340 foot depth
2. Full-size (1 or 2 x 17 kt fiducial mass) LAr detector at 2340 foot depth
3. Small or full-size LAr detector at surface

# Building Blocks – Alternatives to LBNE

## V. Far Detector at Ash River

### *A. Conventional Facilities*

1. CF infrastructure required for any installation at Ash River
2. CF infrastructure for a small (5 kt fiducial mass) LAr detector at Ash River
3. CF infrastructure for a large (1 or 2 x 17 kt fiducial mass) LAr detector at Ash River

### *B. LAr Far Detector*

1. Small (5 kt fiducial mass) LAr detector Ash River
2. Large (1 or 2 x 17 kt fiducial mass) LAr detector Ash River

# Building Blocks – Alternatives to LBNE

## VI. NuMI Beam for LBNE

- Are any modifications required?
- Are any feasible modifications beneficial?

## VII. Near Detector Complex for NuMI Beam for LBNE

***A. Conventional Facilities***

1. On-axis (Soudan) far detector
2. Off-axis (Ash River) far detector

***B. Near Neutrino Detector***

1. On-axis (Soudan) far detector
2. Off-axis (Ash River) far detector

# Cost Estimate Approach – Phased LBNE Options

- Phased LBNE option costs are based on cost estimates developed for the full LBNE Project
  - applied directly where applicable (e.g. CF infrastructure that doesn't scale with detector or beam design).
  - Scaled where not (e.g. 5 kt detector implementation).
  - Cost estimates for conventional facilities for surface detectors at Homestake are based on actual costs for NOvA construction.
- Opportunities for phasing the LBNE beam construction are being explored, for which crude first estimates of cost savings are being developed.

# Cost Estimate Approach – Alternatives to LBNE

- For LBNE alternatives using the Soudan Lab, conventional facilities cost estimates are a combination of
  - Estimates scaled from the LBNE/Homestake cost estimates
  - Independent information and estimates provided by the U of MN.
- Some of the scaled Homestake costs appear to be higher than what is expected based on information/experience from past construction at Soudan; we are working to understand these differences.
- For surface far-detector options (Soudan, Ash River), conventional facilities estimates are based on actual NOvA construction costs.
- For LBNE alternatives using the NuMI beamline
  - The estimated cost of the LBNE near detector is included, assuming that no significant modifications must be made to the existing MINOS near detector cavern.
  - An allowance is included for beam modifications/upgrades, but no actual estimate has been made yet.

*This is still a work in progress!*

# Representative Cost Estimates
## Including escalation and full contingency

Options for LBNE *Phase 1*

- Option 0 – Far Detector at Homestake 4850L only:
  - 33 kt $1.0~1.2B
  - 17 kt $0.7~0.9B
- Option 0' – Beam and Near Detector only: $0.6~0.7B
- Option 1 – LBNE on surface (beam+ 17 kt detector): $0.9~1.1B
- Option 2 – LBNE at 4850L (beam + 5 kt detector): $1.0~1.2B

Alternatives to LBNE

- Option 3 – Soudan @ 2340 feet (17 kt detector) $0.9~1.1B
- Option 4 – Soudan @ surface (17 kt detector) $0.5~0.6B
- Option 5 – Ash River @ surface (17 kt detector) $0.5~0.6B
- Option 6 – Soudan @ 2340 feet
  plus Ash River at Surface Not available yet

# Work Yet to Do

- Complete filling out the “building blocks” cost estimates.
- Reconcile Homestake- and Soudan-based cost estimates for conventional facilities.
- Assemble cost estimates for full phased LBNE program (beyond phase 1, which has been the focus up to now).
- Understand near detector options and costs for NuMI-based alternatives.
- Understand and estimate work that must be done on NuMI beam to support alternatives that use it.
- Subtract costs incurred through FY2012, which are not included in the budget guidance from DOE.
- Proof-read and scrub the cost estimates to ensure accuracy and completeness.
- Other stuff we haven’t thought of yet….