"Building Blocks" for Phased LBNE Options and for Aternatives to LBNE

J. Strait

10 April 2012

Summary List

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 at surface at Homestake

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.

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

II. Beamline to Homestake

A. Conventional Facilities

B. Beamline technical components

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

Summary List

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 (15~30 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 (15~30 kt fiducial mass) LAr detector at 2340 foot depth
3. Small or full-size LAr detector at surface

V. Far Detector at Ash River

A. Conventional Facilities

1. CF infrastructure required for any installation at Ash River
2. CF infrastructure for a full-size LAr detector at Ash River

B. LAr Far Detector

1. Full-size (1 or 2 x 17 kt fiducial mass) LAr detector Ash River

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

"Building Blocks" for Phased LBNE Options and for Aternatives to LBNE

J. Strait

10 April 2012

List With Commentary

Phased LBNE Options

I. Far Detector at Sanford

A. Conventional Facilities

1. CF infrastructure required for any installation at 4850

- Assume cryo utilities down Yates shaft per "omnibus VE"
- Latest guidance from OHEP is that is of common use for any experiment at 4850 will not be part of the LBNE budget, but we need to understand the scope and cost of this infrastructures since a) it may come back onto our plate at any time – we have the only CD-0 to support it; b) the cost of it will come from the same OHEP budget as does the LBNE budget; c) we need this work to be done if we want to build anything at 4850, therefore we cannot let it out of our sight, irrespective of whose budget it gets charged to.

2. CF infrastructure for a small (~5 kt fiducial mass) LAr detector at 4850

- Need "bare bones" design, costed according to a model that favors low cost over fast schedule (e.g. self-managed by Sanford Lab, if this is within their capabilities)
- Imagined to be inside the triangle, using the east drift for ventilation and not for personnel access to LBNE or anything else. This is a guess as to the most cost-effective location. If another, more cost-effective location is identified, we should take it. If another location is equally cost-effective and yields more excavation and infrastructure that can be used in subsequent phases, we should take it.

3. CF infrastructure for a small (~5 kt fiducial mass) LAr detector at surface at Homestake

- Assume that this is in a pit excavated at the surface, with overburden similar to NOvA's
- Need to identify a "flat" location large enough to host this device. Ideally this would be close enough to existing buildings, e.g. the Yates Crusher building, that could be used for cryogenic equipment, etc.

4. CF infrastructure for a full-size (1 or 2 x 17 kt fiducial mass) LAr detector at 4850

- Assume location and cryo utilities based on "omnibus VE"

a. Cavern and other underground and surface spaces and infrastructure required for a single 17 kt fiducial mass detector.

b. Cavern and other underground and surface spaces and infrastructure required for a second 17 kt detector if CF construction is done at the same time as for the first detector.

c. Cavern and other underground and surface spaces and infrastructure required for a second 17 kt detector if CF construction is done at a later time than for the first detector.

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

a. All equipment and systems required for a single 17 kt fiducial mass detector: designed, validated, and installed.
b. All equipment and systems required for a second 17 kt fiducial mass detector: designed, validated, and installed, if constructed at the same time as the first detector.
c. All equipment and systems required for a second 17 kt fiducial mass detector: designed, validated, and installed, if constructed at the a later time than the first detector.

II. Beamline to Homestake

A. Conventional Facilities

- I know of no way to stage this – either we build it or we don't
- Need to consider if there is *any* way to lower the cost.
  - Are we willing to shrink the decay pipe further?
  - Reduced shielding? Can it be done in a way so that more can be added later if there ever is a beam power upgrade to 2 MW?

B. Beamline technical components

- I know of no way to stage the beam in an overall way – either we build it or we don't. However, there may be ways to save nickels and dimes here and there that could add up to enough to be worth considering for a first phase, if the alternative is not to build a beam at all.
- Use old main ring magnets after all? Are there any other beamline magnets in the world that we could scrounge?
- Install only a fraction of the planned magnets and limit the beam energy to <120 GeV until we can afford more?
- Use existing NuMI horn designs and either NuMI or NOvA targets – to save on design and development costs – and recycle existing horns (and targets?) to save construction costs. Accept that this would give us, in the first phase, a less-than-ideal spectrum and beam power, and might mean, if we take their horns, that NOvA could not run once we are ready to install horns.
- Plan for initial operation at < 700 kW?
  - Compromises on absorber or other cooling systems?
  - Not install shielding that could be put in later?
  - Build remote handling systems later?
  - Other scrimping and scraping?

III. Near Detector Complex for Beam to Homestake

A. Conventional Facilities

1. Main shaft alone, outfitted and otherwise provided with utilities and infrastructure to support placement and operation of a mini-detector at the bottom
2. Full ND hall
   a. Done later, after the shaft has been built as a separate, phase 1 project.
   b. As a full construction project done together with the main shaft in one go

B. Near Detector

1. More extensive muon detectors if we only have a mini-ND?
2. Sketch and order of magnitude cost estimate for mini-ND
   - Need to know bare minimum requirements to match mini-FD
   - Cheapest possible design that meets bare minimum requirements
3. Full-scale ND
   - Any difference in plan or cost (other than escalation) if implemented in phase 2 vs. phase 1?

List With Commentary

Alternatives to LBNE

IV. Far Detector at Soudan

A. Conventional Facilities

1. CF infrastructure required for any installation at 2340 foot depth

- Guess that at least the following would be required to allow safe access and operation with a large LAr detector:
  - Second (new) personnel/equipment access shaft
  - New ventilation shaft
  - Bulkheads or other mechanisms to control the air flow and positively ensure airflow down both personnel access shafts at all times.

2. CF infrastructure required for a small (~5 kt fiducial mass) LAr detector at 2340 foot depth

- This could likely be fit in the existing MINOS cavern
- Cryo equipment could go, perhaps, in the Soudan 2 cavern
- Need to understand what additional CF infrastructure – excavation, UGI, surface – would be needed to support this detector.
- Where to put cryo plant
- Power needed and available?
- Access for delivery of cryogens

3. CF infrastructure for a full-size (15~30 kt fiducial mass) LAr detector at 2340 foot depth

- Number and dimensions of modules TBD (17 kt each as at Sanford Lab or some other unit? Same detector width as at Sanford Lab or some other aspect ratio? …) How does the local structure and quality of rock affect this?
- How much of existing underground structure and spaces can be used?
- Need to understand what additional CF infrastructure – excavation, UGI, surface – would be needed to support this detector.
- Where to put cryo plant
- Power needed and available?
- Access for delivery of cryogens
- If built in modules in (quasi-)independent caverns:

a. Cavern and other underground and surface spaces and infrastructure required for first detector.

b. Cavern and other underground and surface spaces and infrastructure required for second and subsequent detectors if CF construction is done at the same time as for the first detector.

c. Cavern and other underground and surface spaces and infrastructure required for second and subsequent detectors if CF construction is done at a later time than for the first detector.

4. CF infrastructure for a small or full-size LAr detector at surface
- Is there any point to doing this???
- Is there a site where this could be built?
- Power, road access for heavy trucks, etc.?

B. LAr Far Detector

1. Small (~5 kt fiducial mass) LAr detector at 2340 foot depth
- How is detector different from same one at Homestake?
- Design, layout, installation of cryo system is surely different from Homestake
- Installation?

2. Full-size (15~30 kt fiducial mass) LAr detector at 2340 foot depth
- Assume this is built in 2 or more modules:

a. All equipment and systems required for first detector: designed, validated, and installed.
b. All equipment and systems required for a second and subsequent detectors: designed, validated, and installed, if constructed at the same time as the first detector.
c. All equipment and systems required for a second and subsequent detectors: designed, validated, and installed, if constructed at the a later time than the first detector.

V. Far Detector at Ash River

A. Conventional Facilities

1. CF infrastructure required for any installation at Ash River
- Power, additional access roads?

2. CF infrastructure for a full-size (1 or 2 x 17 kt fiducial mass) LAr detector at Ash River
- Imagine that one could roughly duplicate the NOvA building, which might hold ~18 kt x 1.4 = 25 kt total ≈ 17 kt fiducial mass detector
- Additional building for cryo plant + LN and LAr storage/buffer tanks, etc.
- Adequate space at existing site for 1 or more 17 kt fiducial mass detectors?
- Power needed and available?
- Access for delivery of cryogens
- How much overburden is required?

a. Buildings and infrastructure required for first detector.
b. Buildings and infrastructure required for second detector if CF construction is done at the same time as for the first detector.
c. Buildings and infrastructure required for second detector if CF construction is done at a later time than for the first detector.

B. LAr Far Detector

1. Full-size (1 or 2 x 17 kt fiducial mass) LAr detector Ash River
- Modifications to detector design for operation on the surface:
  - Shorter Drift
  - Eliminate photon detectors?
  - Other thing?
- How much overburden?

a. All equipment and systems required for a single 17 kt fiducial mass detector: designed, validated, and installed.
b. All equipment and systems required for a second 17 kt fiducial mass detector: designed, validated, and installed, if constructed at the same time as the first detector.
c. All equipment and systems required for a second 17 kt fiducial mass detector: designed, validated, and installed, if constructed at the a later time than the first detector.

VI. NuMI Beam for LBNE

Questions – applicable to both CF and technical systems
- What is limit on beam power that can be tolerated?
- Are there feasible upgrades or modifications that could raise the beam power limit?
- Are there "non-replaceable" or "non-maintainable" items that are at risk of reaching their integrated radiation or operating time limit before LBNE could reach its scientific goals?

A. Conventional Facilities
- No known work required for the beam, unless the answer to question 2nd or 3rd above is "yes" that would require CF work to deal with.

B. Beamline technical systems
- No work *required* unless answer to 3rd question above is "yes."
- If modifications that could raise the limit on accepted beam power are possible *and* a phased Project X can be considered as part of the LBNE phasing plan, then these could be part of the second phase of LBNE.
- Are there modifications of the target-horn system that could lower the nu beam energy? Would lowering the proton beam energy help? Can the NuMI primary beamline transport 60 GeV beam?

VII. Near Detector Complex for NuMI Beam for LBNE

A. Conventional Facilities

1. On-axis (Soudan) far detector
- Is existing ND hall large enough to accommodate one of the LBNE ND designs?
- If we implement the LAr Tracker design, are there ventilation or other modifications that must be made to allow implementation at ODH Class 0 (or 1)? Are they feasible?

2. Off-axis (Ash River) far detector
- Is existing NOvA ND hall large enough for us to put an LBNE ND into it? If not, can it be enlarged, or do we need to make a new off-axis hall? Will the rock at that point support a larger off-axis hall?
- Same ODH question as above.

B. Near Neutrino Detector

1. On-axis (Soudan) far detector
- What is the minimal modification/addition to the existing detectors (MINOS + MINERvA) in the MINOS Near Hall that would allow us to get going and make a respectable measurement?
- Can we modify one or both of our existing ND designs to fit into the existing ND hall?

2. Off-axis (Ash River) far detector
- Can we use the NOvA ND for initially? After how much exposure must we have something better?
- Can we modify one or both of our existing ND designs to fit into the existing NOvA ND hall?