Near Detector Options: Current Status

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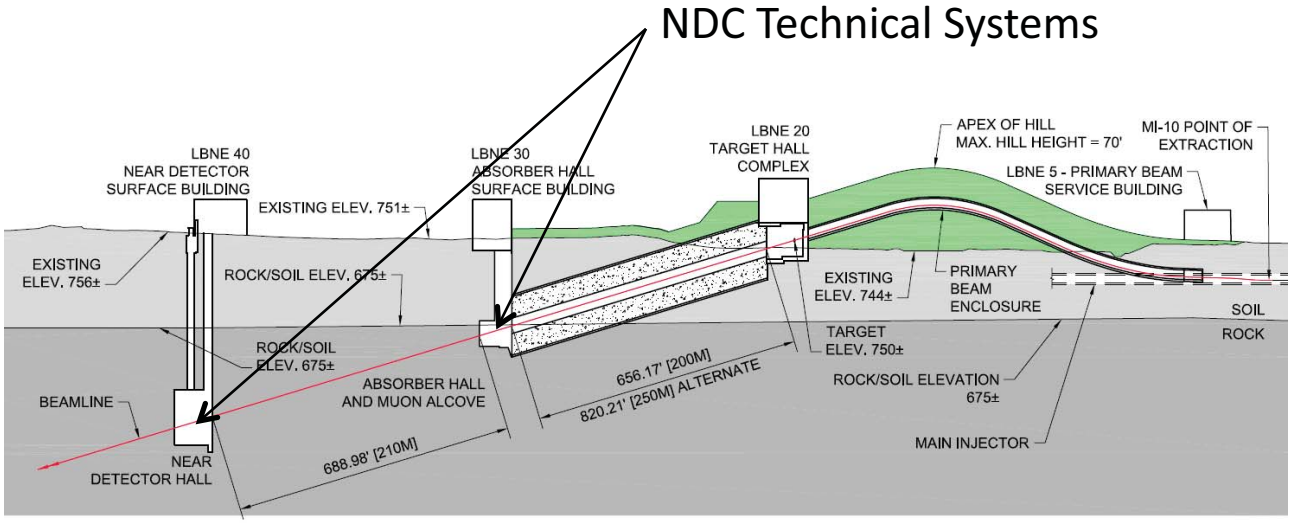
Outline

- Current LBNE design of the Near Detector Complex (NDC)
- LBNE Staging Options
- LBNE Alternatives

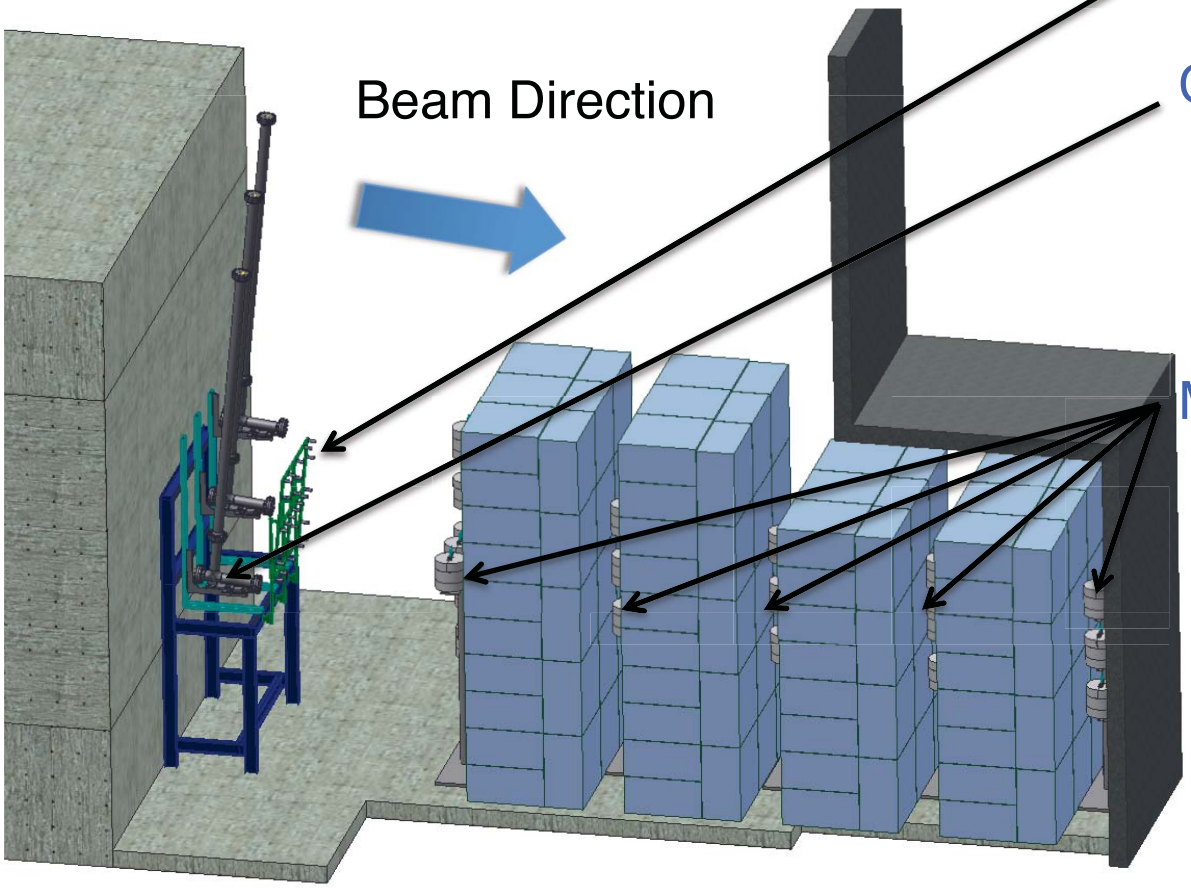
Content of this talk is a collective effort of the LBNE Near Detector Working Group and the LBNE NDC Subproject. Drawings are by Jan Boissevain and Larry Bartoszek.

LBNE Near Detector Complex

- Two sets of detector systems
  - detectors to measure the muons that pass through the absorber
  - detectors to measure the neutrinos at the near site
- Data acquisition system tying the detector systems to the rest of the experiment and determining the absolute timing of events



Three Beamline Measurement Systems



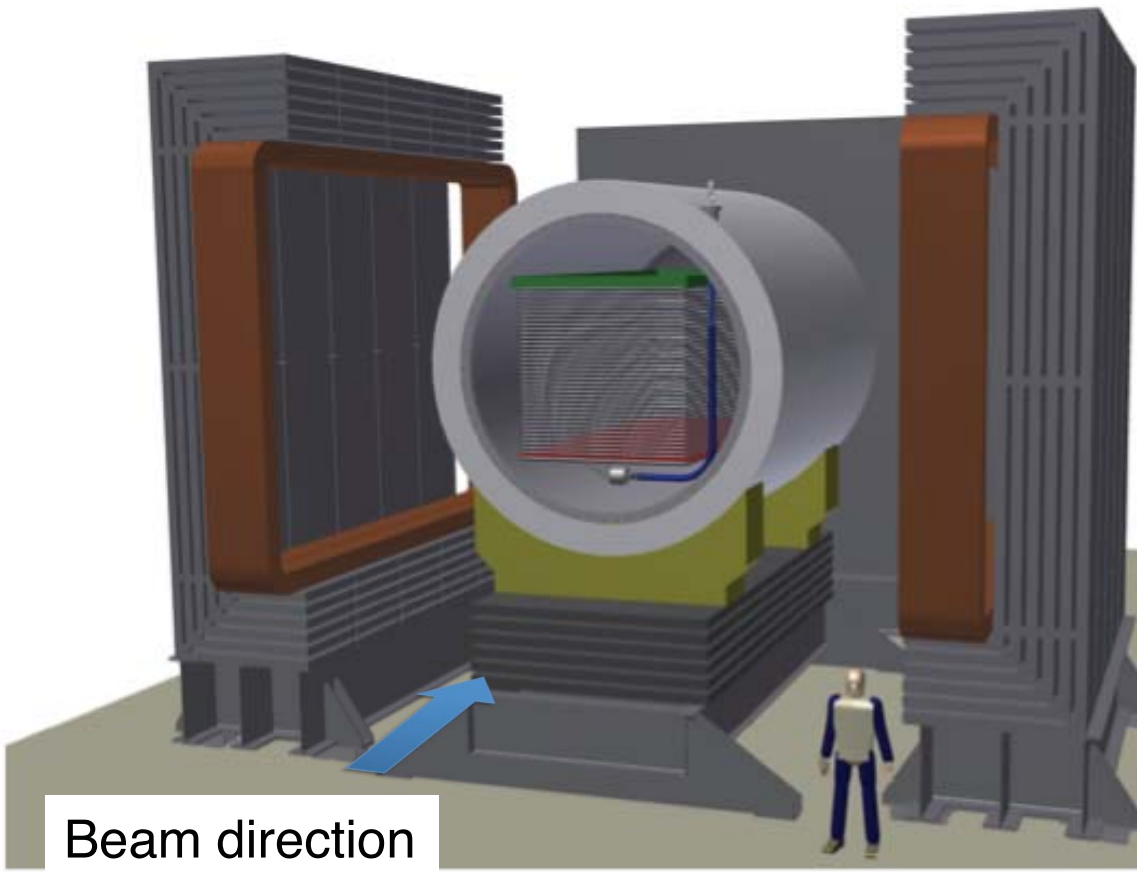
Ionization Chambers:
- spill-by-spill beam profile

Cherenkov Detectors:
- measure all muons above a variable threshold
- constrains muon spectrum (correlated with E_ν)

Michel Decay Detectors:
- measure muons that stop at a given depth in material
- constrains muon spectrum
- may give absolute flux constraint

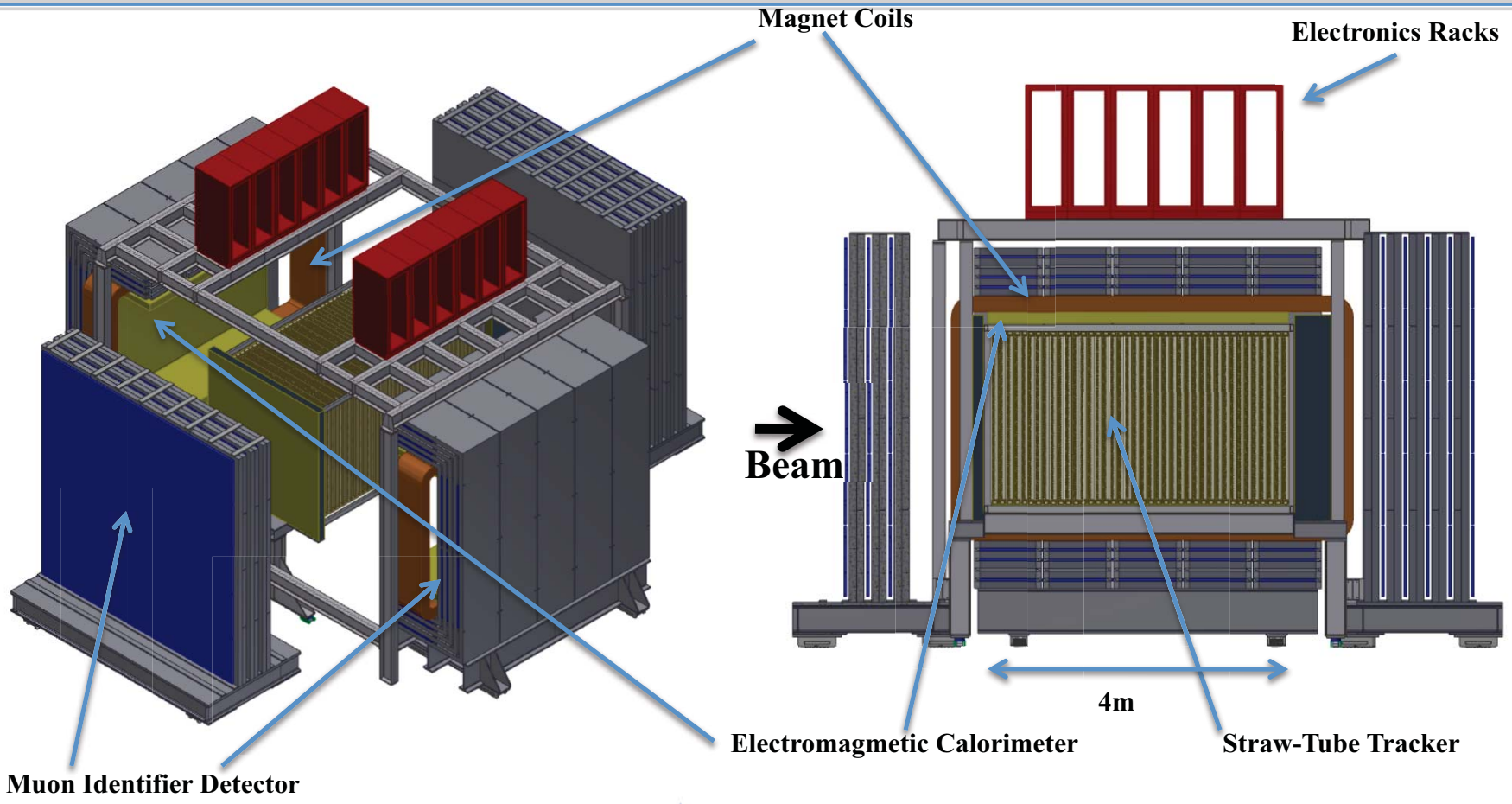
Includes planning measurements of hadron production on materials from which the target and horns are composed in external beamlines

Magnetized Liquid Argon TPC



- Based on MicroBooNE design
- 4.0m x 1.8m x 1.8m active volume – 18 tons of liquid argon
- Tracks charged particles
- Electromagnetic calorimetry
- 0.4 Tesla field
- Sign of muons, momentum for long tracks
- Downstream/side detectors in steel layers for muon/pion separation

Drawings of the Fine Grained Tracker (FGT)

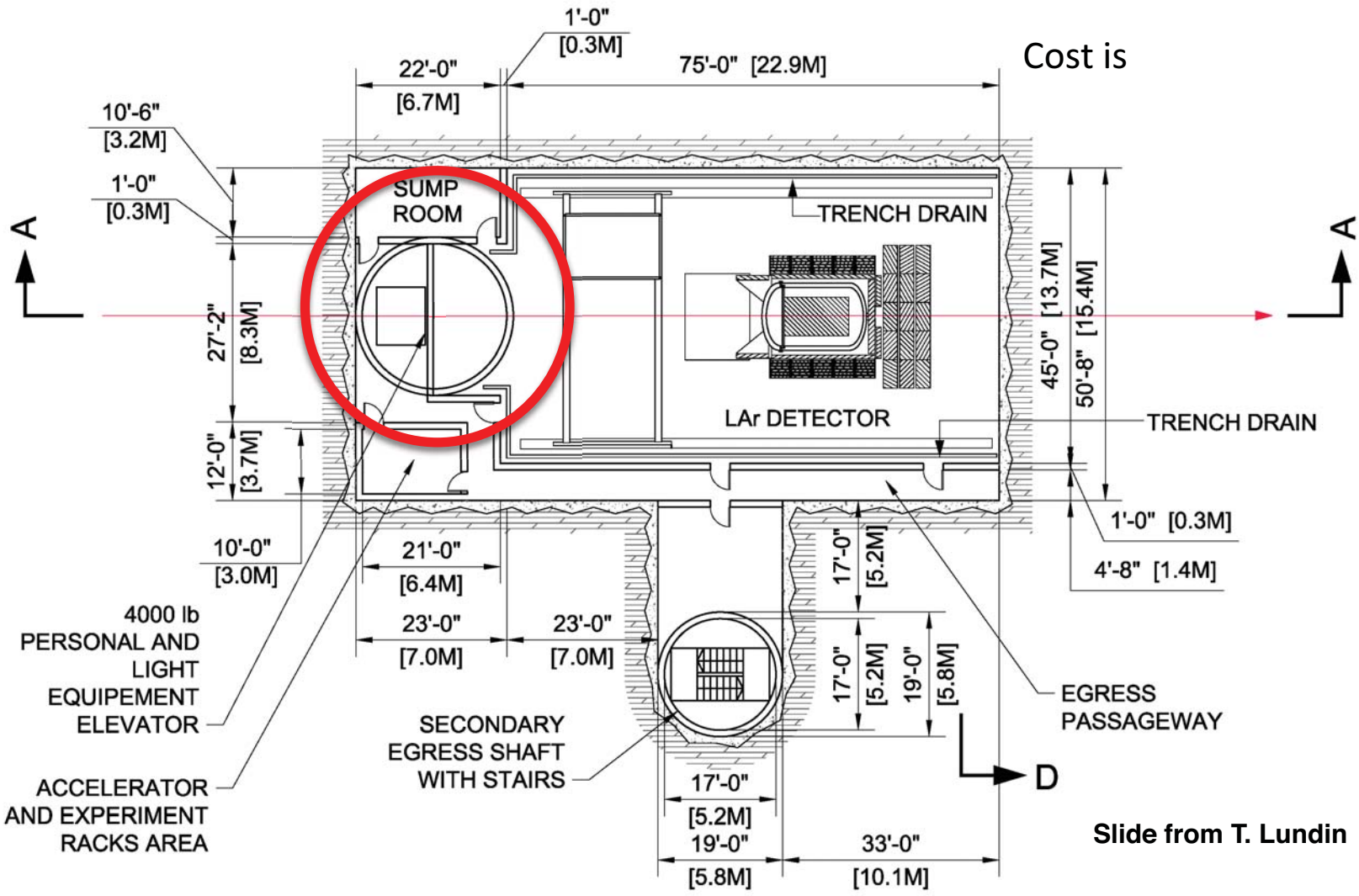


The FGT consists of a 40 module straw-tube tracker (2.5m x 2.5m x 4m) and an electromagnetic calorimeter inside of a 0.4T dipole magnet. Muon identifier detectors are embedded in the steel of the magnet and upstream and downstream of the magnet. Water targets are attached to the first 20 straw-tube modules, giving a total water target mass of ~1.2 tons.

Staging Options

- Full NDC - $42M (liquid argon TPC), $51M (straw-tube tracker)
  - Build either the full reference design or the alternate design in a single phase
  - Potentially important to do this early
    - Better characterization of the beam
    - International context – strong interest in a highly capable near neutrino detector from India
- Mini-NDC
  - Build the detectors in the absorber region – possibly an enhanced version
  - Neutrino detector
    - Build one of the two shafts required for the full near neutrino hall
    - Commission a scaled-down detector on the surface
    - Deploy it in the shaft
    - Operate it remotely

Near Detector Hall – Mini-NDC Option (red)



Slide from T. Lundin

Mini-LBNE – Near hall shaft

- The primary 22-ft diameter shaft
- Minimal service building – 25% of the size of the reference design
- No permanent crane, stairs or elevator
- Cost $16M + $4M contingency = $20M

Mini-NDC Option – Neutrino Detectors I

- What are the requirements on neutrino measurements for mini-LBNE options?
- Very basic: Measure the intrinsic aggregate of electron neutrino and anti-neutrino event rates in the beam as a function of (far) reconstructed neutrino energy?
- Basic: Above, plus
  - measure muon neutrinos and anti-neutrinos separately (magnetic field)
  - make measurements on the far detector target nucleus
  - detailed background subtraction from neutrons
- Enhanced:
  - NC backgrounds (containment)
  - 4π coverage for all above event classes
- Exploring this further during the NDWG parallel session at the LBNE collaboration meeting

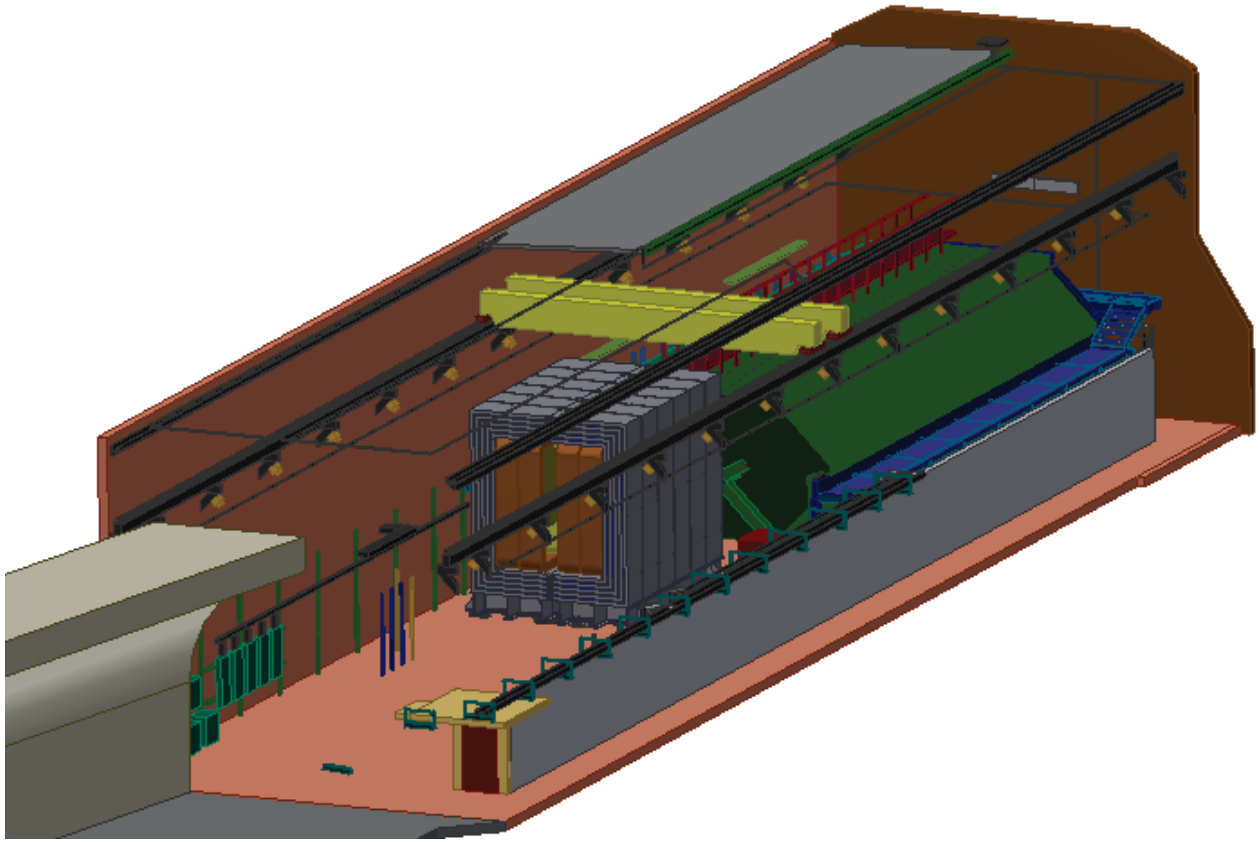
Mini-NDC Option – Neutrino Detectors II

- All options use detectors for the tertiary muon flux - $4M
- Very basic: scintillator planes with radiator material
  - Costs for detector material and fabrication $2.5M (could be lower with reuse)
  - Commissioning and installation $1.5M
- Basic and enhanced: argon targets, magnet with toroidal field (MINOS-style)
  - liquid argon would be advantageous – safety issues
  - gas targets more plausible from safety standpoint – difficult to get appropriate relative masses (subtraction analysis)
  - thought and work ongoing
- Total cost for mini-NDC subproject (including management) is $11M + $2M (contingency) = $13M

Alternatives to LBNE

- Considering Soudan and Ash River (no progress on Ash River)
- Soudan options starting point
  - Put current LBNE near neutrino detector designs into the NUMI hall
  - Make adjustments to maintain the same fiducial mass
    - haven't demonstrated required fiducial mass
    - haven't analyzed the containment issues associated with the squeezing in the transverse dimensions
- Liquid Argon Detector Cost Differential - $1M more expensive
  - more magnet C's but smaller, more channels, more rigging
- Straw-tube Tracker Cost Differential - $100k more
  - more rigging

Straw-tube tracker in the NUMI hall



Summary

- Described the standard LBNE Near Detector Complex
  - measurements of the tertiary muon fluxes
  - neutrino measurements – both magnetized
    - Reference design – liquid argon TPC (MicroBooNE-based design)
    - Alternate design – straw-tube tracker
- Described the approach to mini-LBNE
  - cost will depend on the true requirements
    - what are the physics goals?
  - very basic approach is far less expensive than the shaft
  - more enhanced approaches also likely to be lower cost than the shaft
- Described the approach to NUMI alternatives
  - additional costs, but not large
  - potential savings with using MINOS as a downstream tracker