DUNE ND Hall Update

Mike Wilking
Stony Brook University
DUNE-PRISM Engineering Meeting
July 30th, 2018
• Working conceptual layout for the hall over the past year was
55 ft “long” (beam-direction) \times 140/120 ft (= 42.7/36.6 m)
“wide” (off-axis direction)

• This is the +50% option that was agreed upon by the ND
  group in March, 2017 (although oriented at 90° relative to
  the initial proposal)

• Original DUNE-PRISM goal was to make measurements up to
  ~33 m off-axis

  • But this must include non-fiducial LAr & cryostat width, etc.
  
  • May also need additional width near on-axis position for
    magnet infrastructure

• Language in original ND Report Recommendation:

  R6) The experimental floor area must be at least 35 m \times 17 m
  and the hook height must be at least 13 m, measured from the floor.

  • Note: “experimental floor area of 35 m…”
    rather than “LAr FV reach of 35 m…”
How Far Off-Axis?

- Further off-axis = lower reach in neutrino energy

- 500 MeV flux peaks at 26 m off-axis

- To properly understand events at 500 MeV, we need access lower energies at further off-axis positions

- One method to determine the lowest needed energy is to construct a Gaussian energy spectrum at 500 MeV (10% width) using linear combinations of off-axis fluxes

- This is not the only method one could employ (see next slides)

- The 500 MeV Gaussian fit clearly begins to degrade when fluxes between 30 m & 33 m are excluded
Oscillated Flux Fits

- We can also use linear combinations of off-axis fluxes to construct an oscillated flux seen at the far detector for any currently allowed set of oscillation parameters.

- Again, this is not the definitive metric, but it does show how well such a fit can resolve the bump below the 2nd oscillation maximum (which peaks as low as ~500 MeV, depending on $\Delta m_{32}^2$).

- The following slides probe the 9 points in $\Delta m_{32}^2$, $\theta_{23}$ space shown in the top figure.

- Vary off-axis range used in fits.
Fluxes Up to 40 m Off-Axis

- Can even somewhat resolve the peak below the 3rd oscillation maximum for all values of $\Delta m_{32}^2$

\[ \sin^2 \theta_{23} = 0.4 \quad \sin^2 \theta_{23} = 0.5 \quad \sin^2 \theta_{23} = 0.6 \]

\[ \Delta m^2 = 3.0 \times 10^{-3} \quad \Delta m^2 = 2.6 \times 10^{-3} \quad \Delta m^2 = 2.2 \times 10^{-3} \]
Fluxes Up to 33 m Off-Axis

- Can still generally resolve bump below 2nd oscillation maximum for all values of $\Delta m_{32}^2$, although some fluctuations are seen in the ratio to the unoscillated flux

$\sin^2\theta_{23} = 0.4$

$\sin^2\theta_{23} = 0.5$

$\sin^2\theta_{23} = 0.6$

$\Delta m_{32}^2 = 3.0 \times 10^{-3}$

$\Delta m_{32}^2 = 2.6 \times 10^{-3}$

$\Delta m_{32}^2 = 2.2 \times 10^{-3}$
Fluxes Up to 30 m Off-Axis

- Poor fits around the 2nd oscillation maximum for low $\Delta m_{32}^2$ region; ability to constrain systematics in this region may be compromised

$\sin^2 \theta_{23} = 0.4$

$\sin^2 \theta_{23} = 0.5$

$\sin^2 \theta_{23} = 0.6$
Fluxes Up to 28 m Off-Axis

- Very poor fits around the 2nd oscillation maximum for low $\Delta m_{32}^2$; limiting to 28 m can cause harm to 2nd oscillation maximum physics

$\sin^2 \theta_{23} = 0.4$

$\sin^2 \theta_{23} = 0.5$

$\sin^2 \theta_{23} = 0.6$

$\Delta m^2 = 3.0 \times 10^{-3}$

$\Delta m^2 = 2.6 \times 10^{-3}$

$\Delta m^2 = 2.2 \times 10^{-3}$
In response to the original ND group proposal, the revised LBNF design provided exactly 17 m x 35 m of floor space.

- Note this is 1.6 m *less* in the off-axis direction than the conceptual design we have been working with.

This is problematic, since we need to make measurements of neutrino interactions up to 30-33 m off-axis.

- Recently, the ND group has reworked its hall length requirement.
LBNF Proposed Site Plan
Extra 50 cm volume required on either side of the active ArgonCube modules
LAr Size Assumptions

- The ND group is currently considering a somewhat longer (7-8m wide) LAr Fiducial volume, which is reflected on the next slide.

- Cryostat walls are assumed to be 0.7m thick.

- 50 cm of inactive LAr is required on either side of the ArgonCube modules (inside the cryostat) for cryo-coolers, pumps, and instrumentation (previous slide).

- The FV considered in this study has a 1.5 m of active area on either side of the detector in which event vertices are not allowed.
  - This is to make the efficiency due to hadronic shower containment uniform across the fiducial volume.
  - This value has not yet been optimized, but 1.5 m is likely to be sufficient (may be able to shrink this somewhat).

- Also included is a 2 x 6.4 m platform next to the LAr detector for cryogenics and electronics systems that can move with the detector.
Hall Layout

Final (?) ND Recommendations

https://indico.fnal.gov/event/17516/contribution/0/material/slides/0.pdf
Final(?)) ND Recommendations

• A revised ND recommendations document is now available on DUNE docdb 8184, and contains the following recommendations

  R5) The dimension of the hall in the beam direction that is usable for the experiment must be at least 17 m. A wider span should be considered, if the geo-technical conditions are favorable.

  R6) The experimental floor area must be at least 42.5 m × 17 m and the hook height must be at least 13 m, measured from the floor.

• The travel distance required is 28.3 m for an 8 m detector

  • (29.3 m for a 7 m detector, etc.)

• The full required width for a non-moving, “long” cryostat would be 38.6 m (from the outside edges of the cryostat walls)