

DUNE ND Hall Update

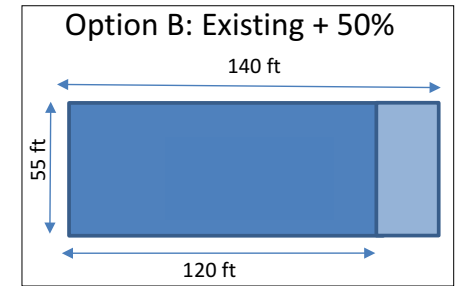
Mike Wilking
Stony Brook University
DUNE-PRISM Engineering Meeting
July 30th, 2018

ND Hall Size Requirements

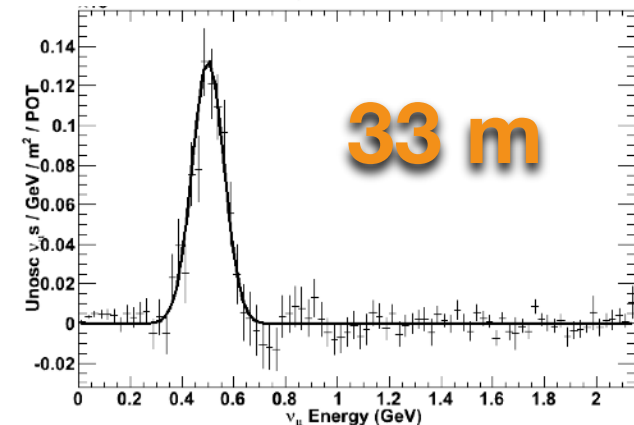
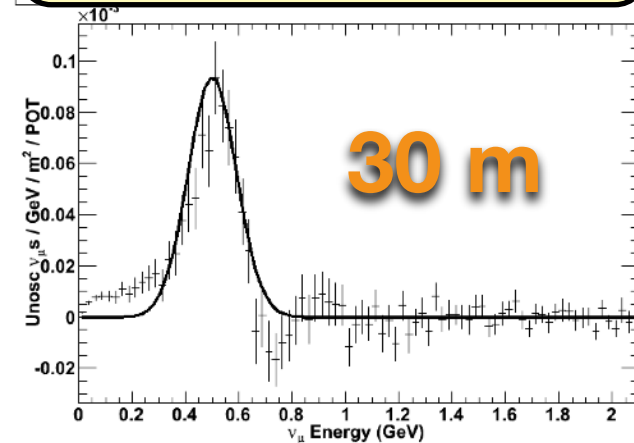
- Working conceptual layout for the hall over the past year was 55 ft “long” (beam-direction) x 140/120 ft (= 42.7/36.6 m) “wide” (off-axis direction)
 - This is the +50% option that was agreed upon by the ND group in March, 2017 (although oriented at 90° relative to the initial proposal)
- Original 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 × 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...”

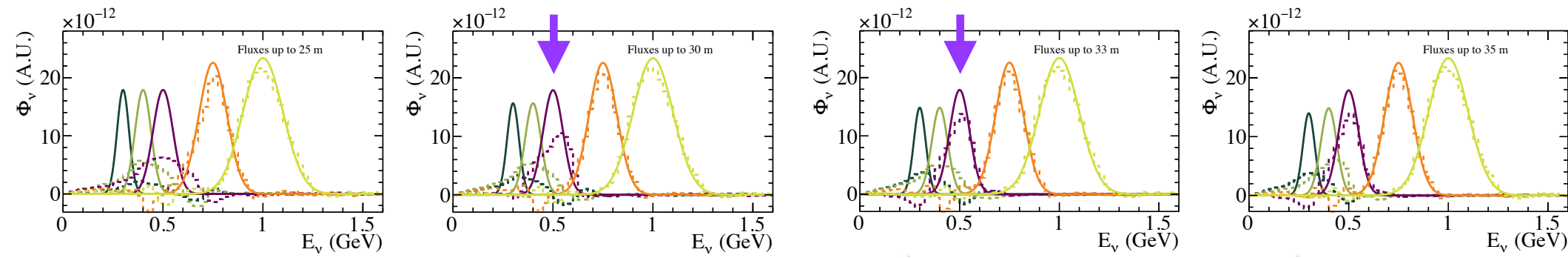
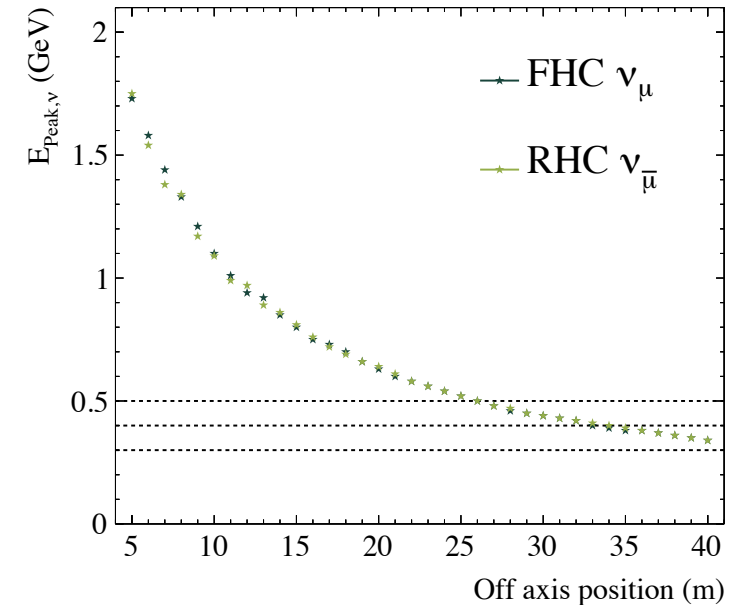


DUNE-PRISM 0.5 GeV



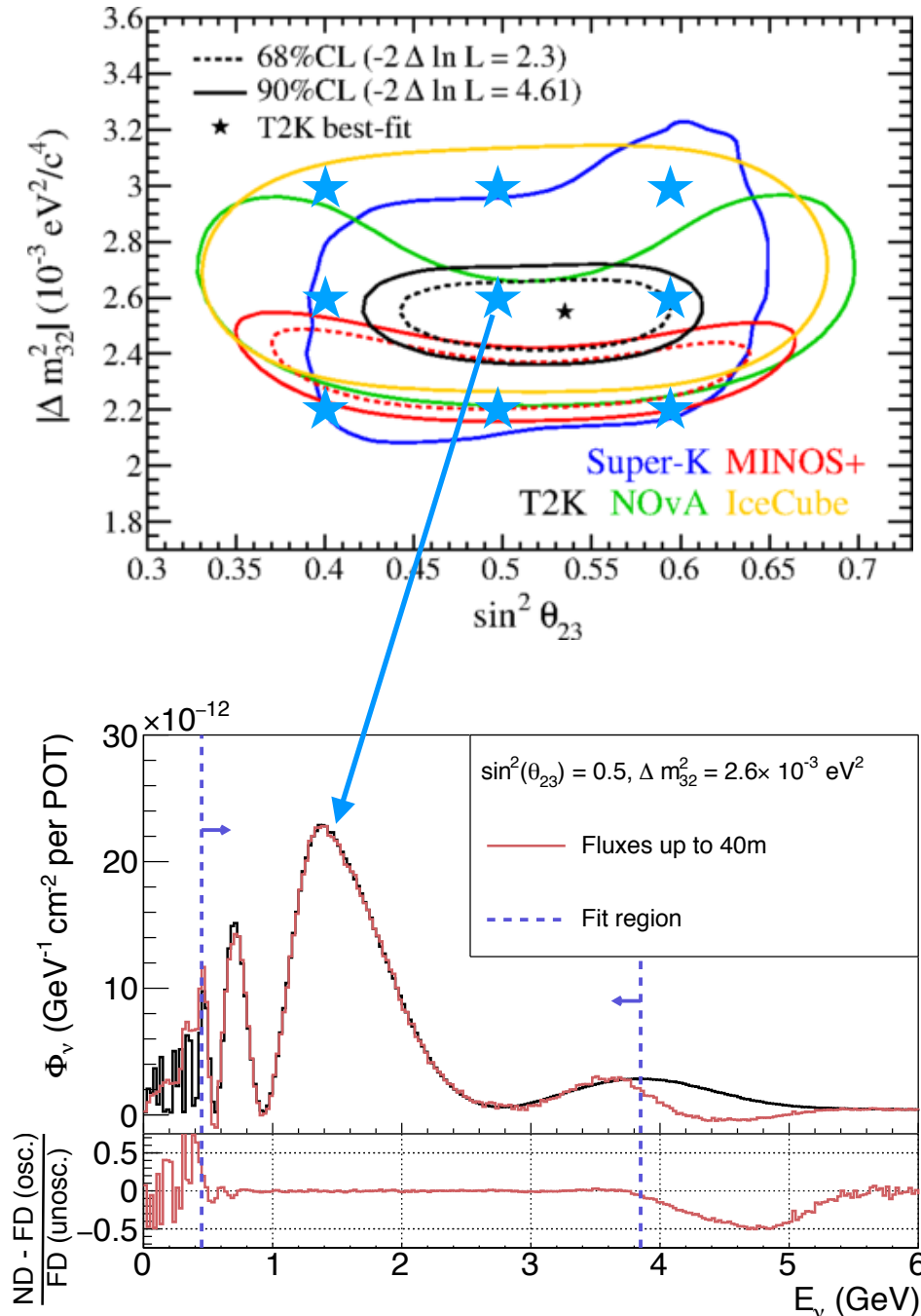
How Far Off-Axis?

- 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

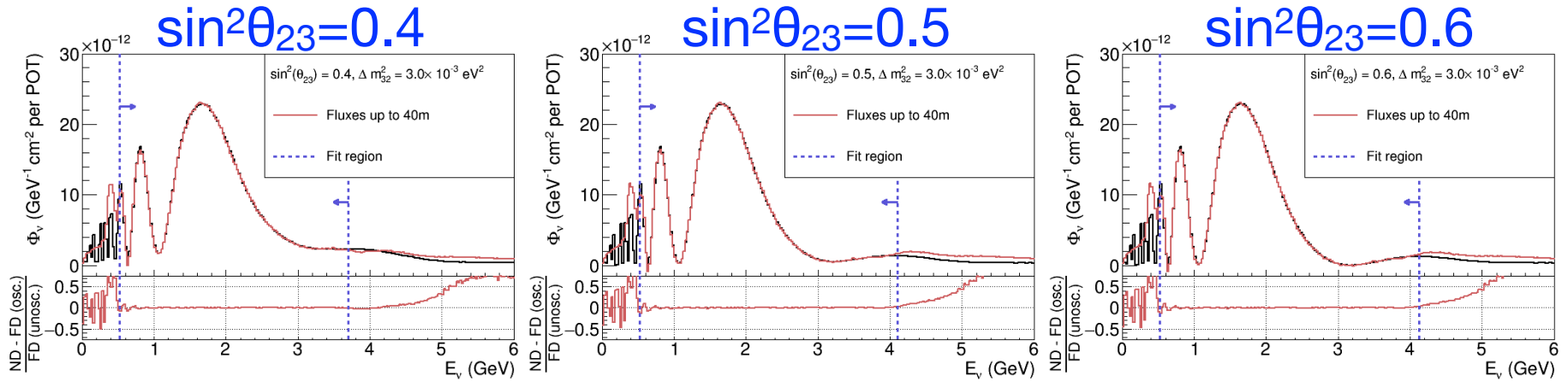
- We can also use linear combinations of off-axis fluxes to construct an oscillated flux seen at the far detector for any currently allowed set of oscillation parameters
 - Again, this is not the definitive metric, but it does show how well such a fit can resolve the bump below the 2nd oscillation maximum (which peaks as low as ~ 500 MeV, depending on Δm_{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



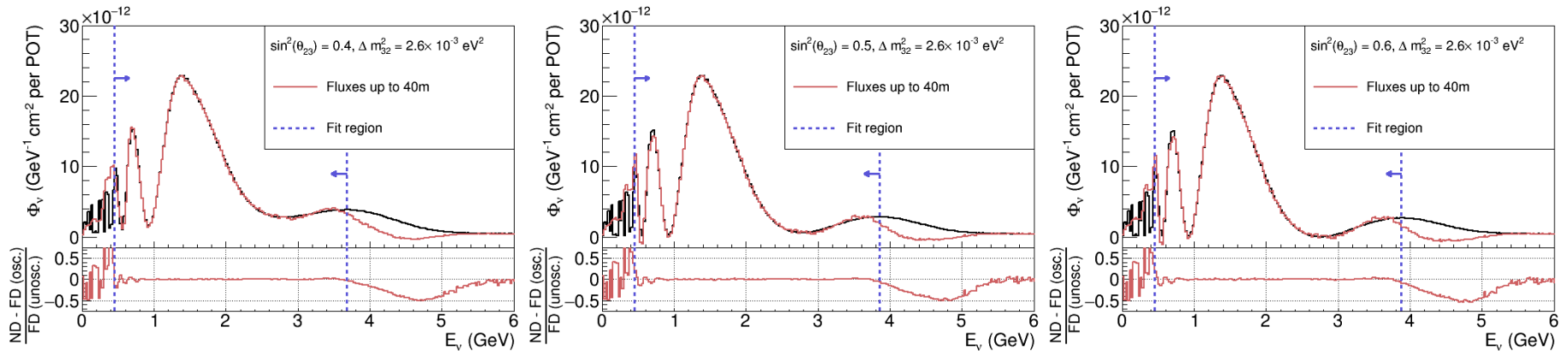
Fluxes Up to 40 m Off-Axis

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

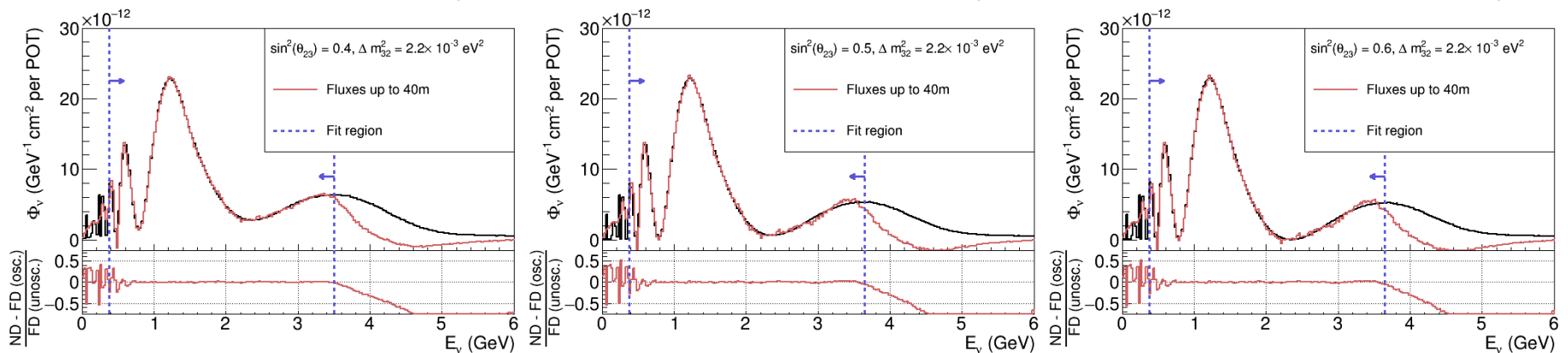
$\Delta m^2 = 3.0 \times 10^{-3}$



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



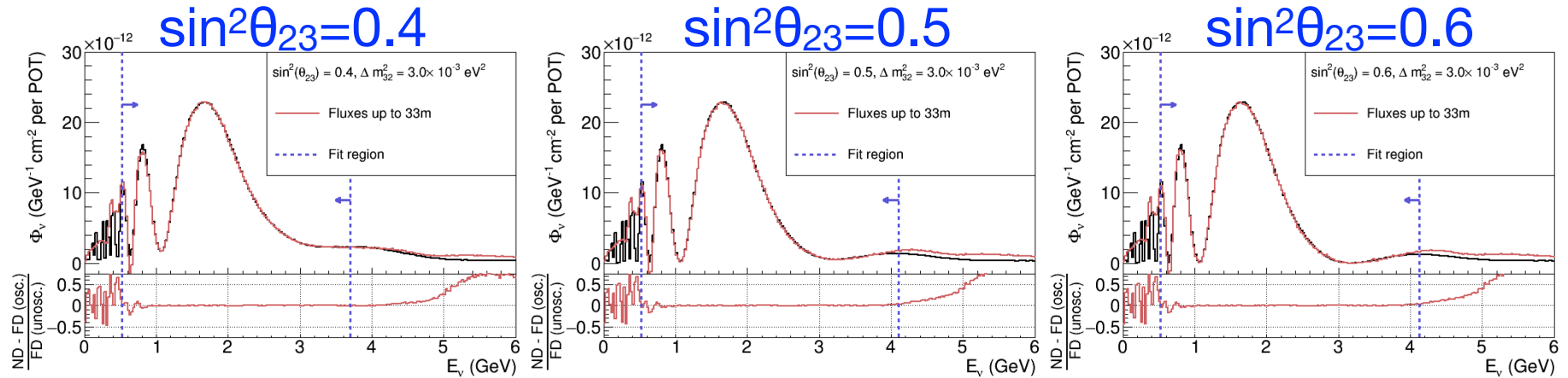
$\Delta m^2 = 2.2 \times 10^{-3}$



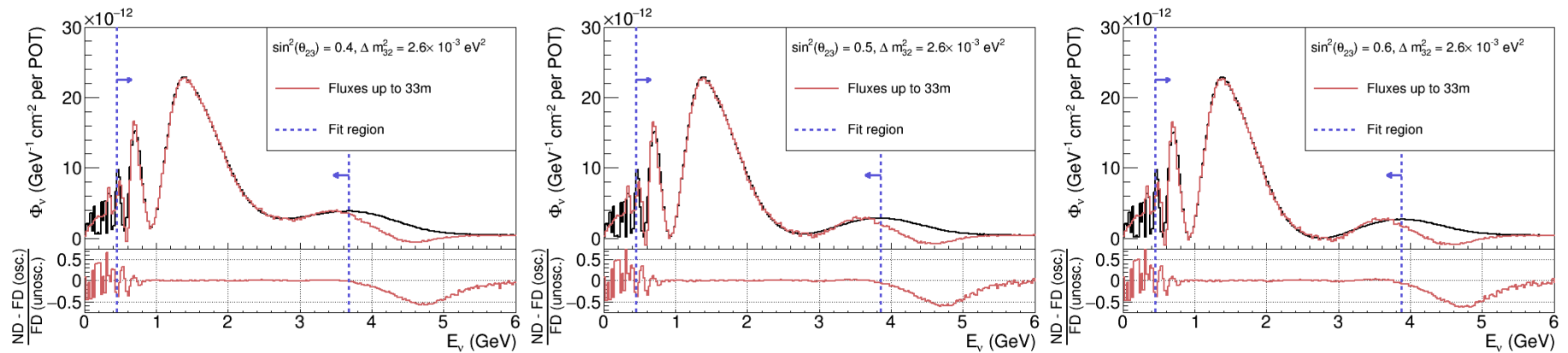
Fluxes Up to 33 m Off-Axis

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

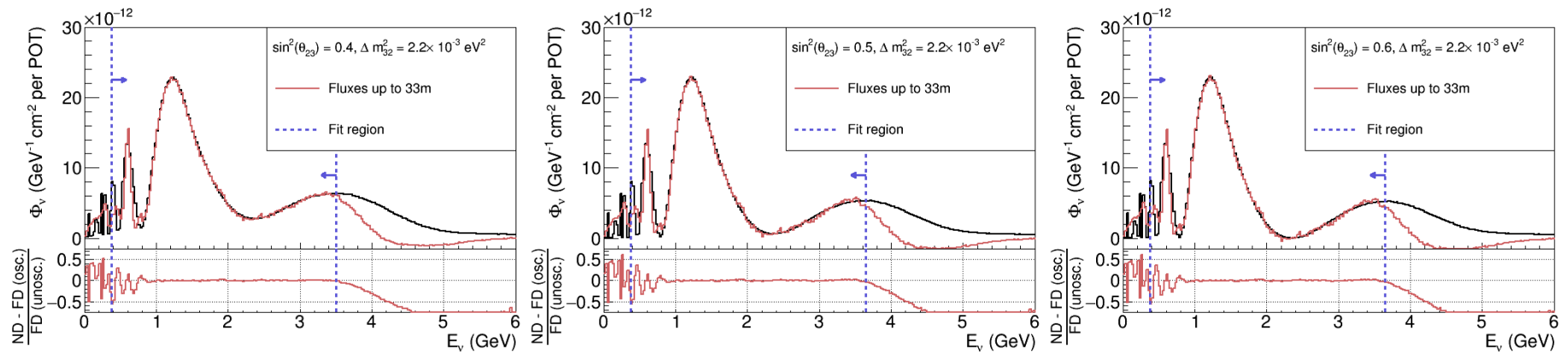
$\Delta m^2 = 3.0 \times 10^{-3}$



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



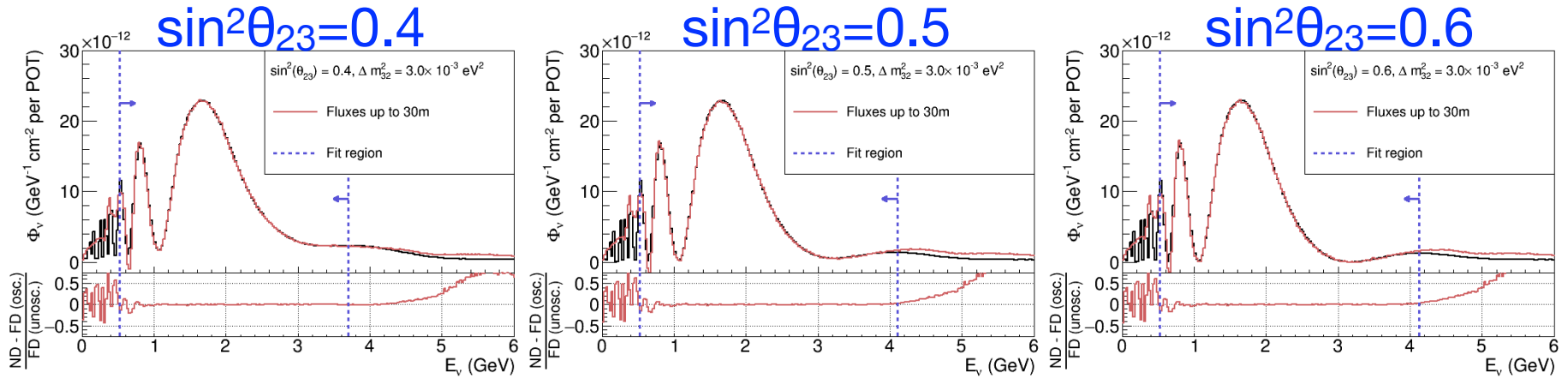
$\Delta m^2 = 2.2 \times 10^{-3}$



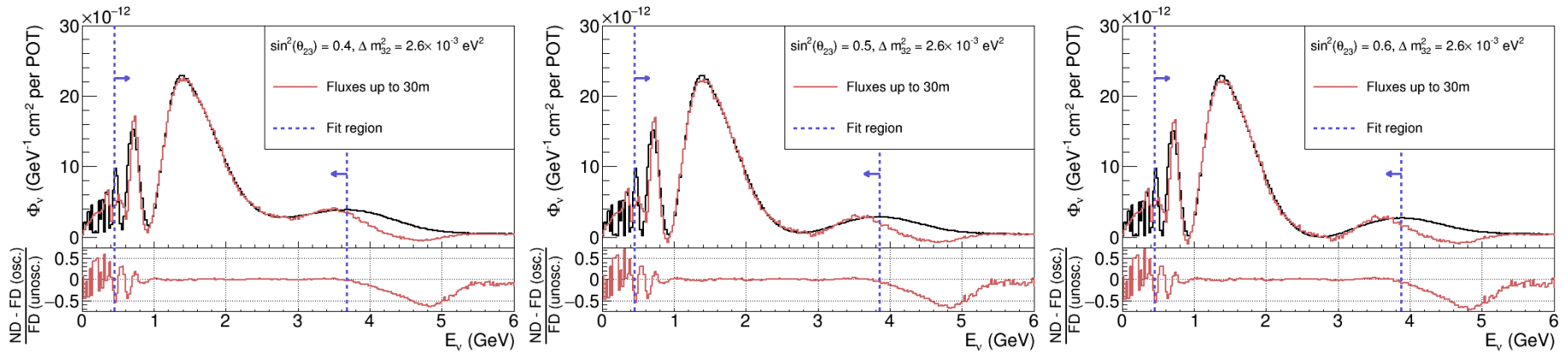
Fluxes Up to 30 m Off-Axis

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

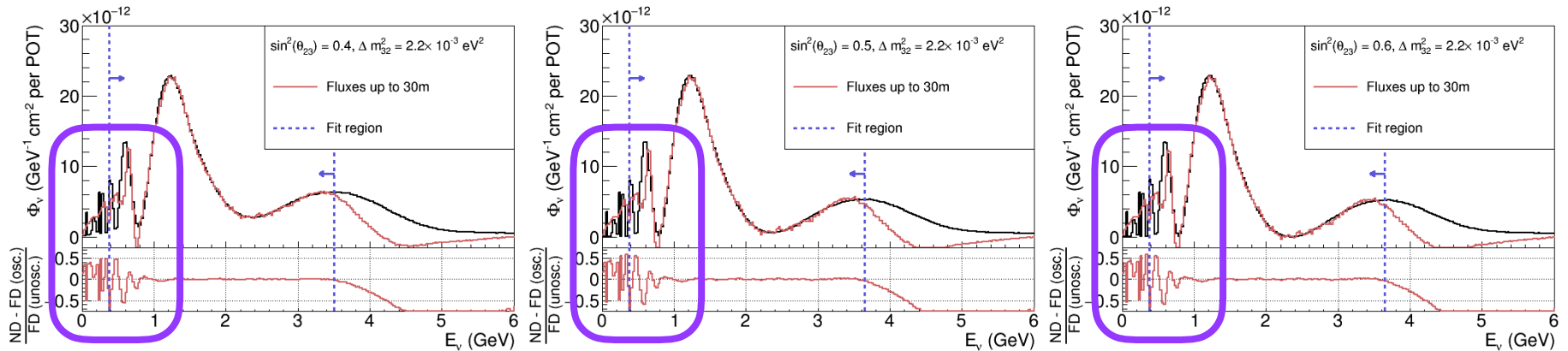
$\Delta m^2 = 3.0 \times 10^{-3}$



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



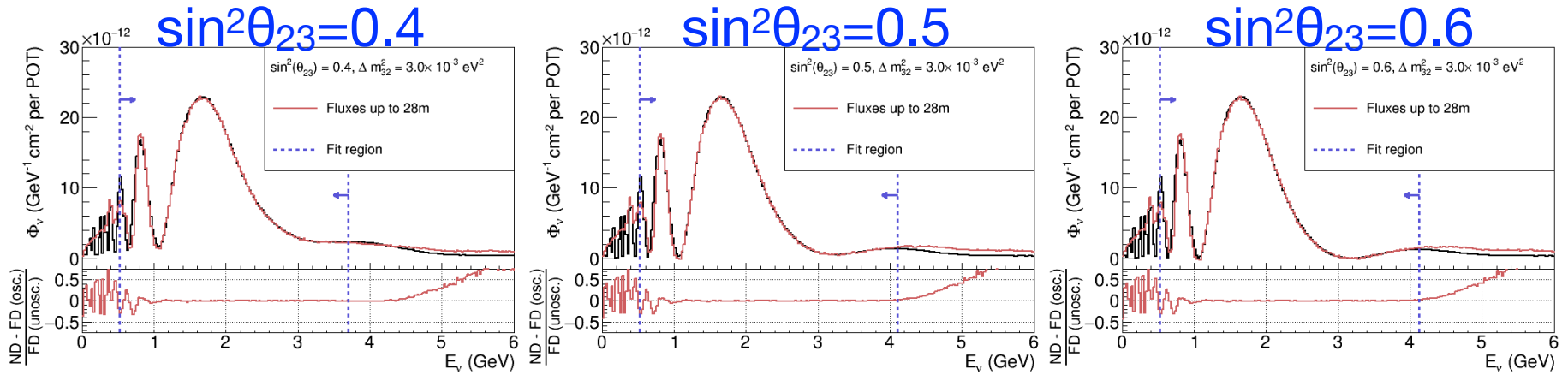
$\Delta m^2 = 2.2 \times 10^{-3}$



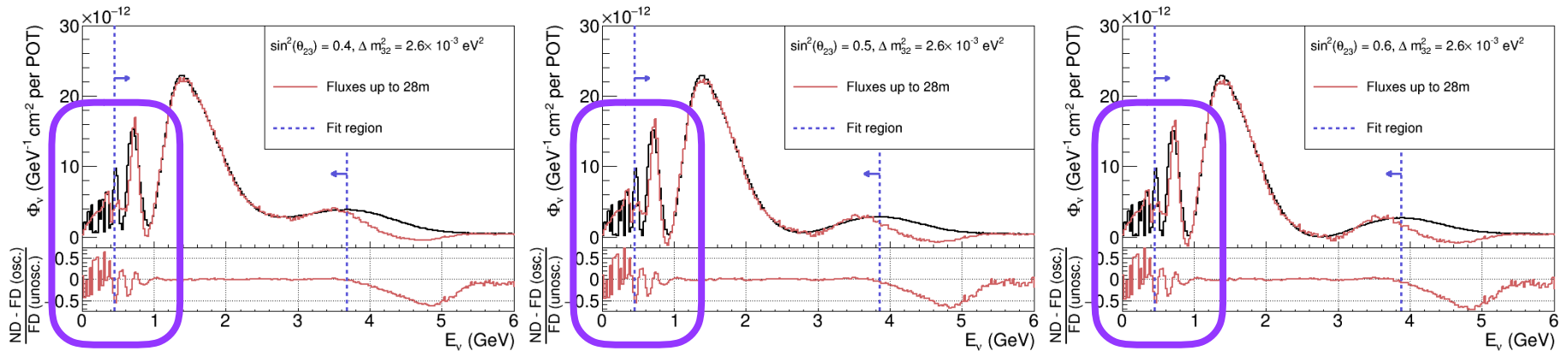
Fluxes Up to 28 m Off-Axis

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

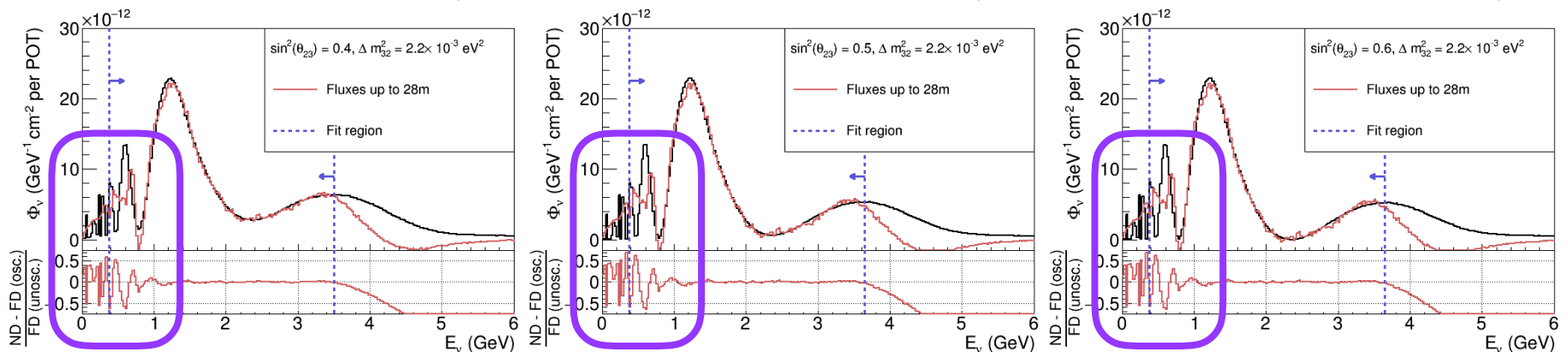
$\Delta m^2 = 3.0 \times 10^{-3}$



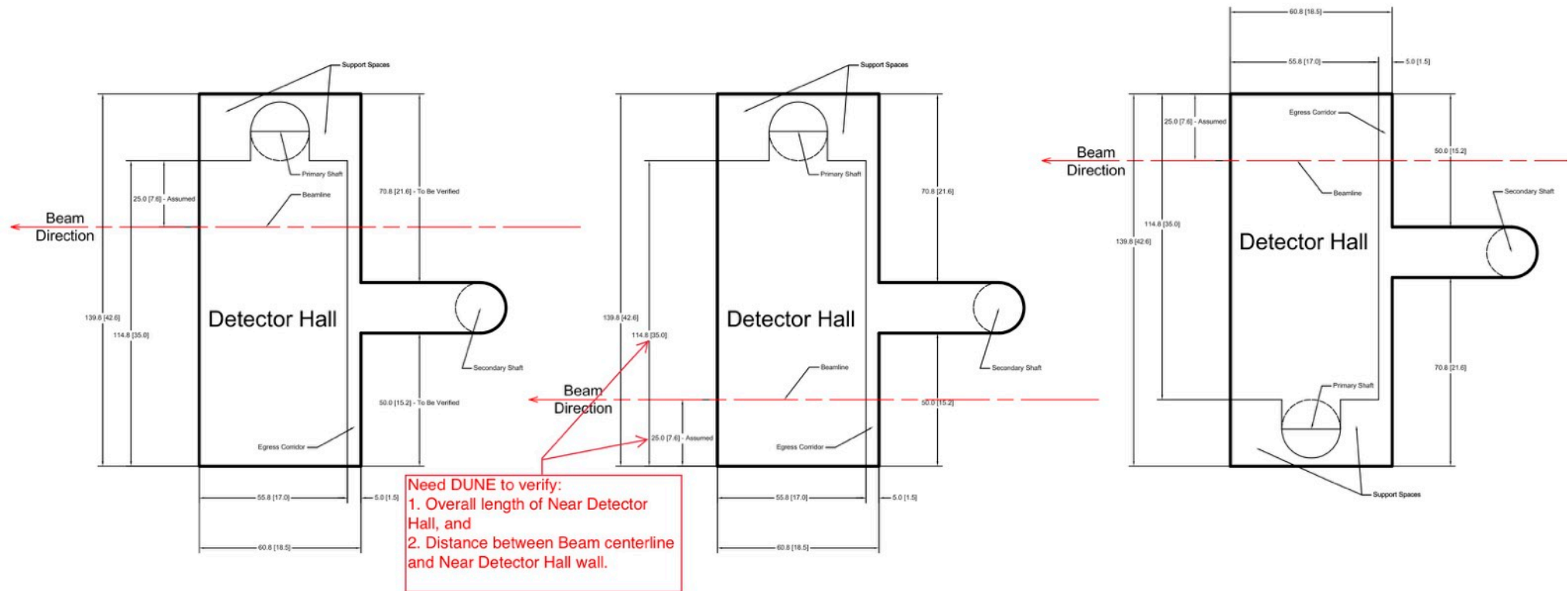
$\Delta m^2 = 2.6 \times 10^{-3}$



$\Delta m^2 = 2.2 \times 10^{-3}$

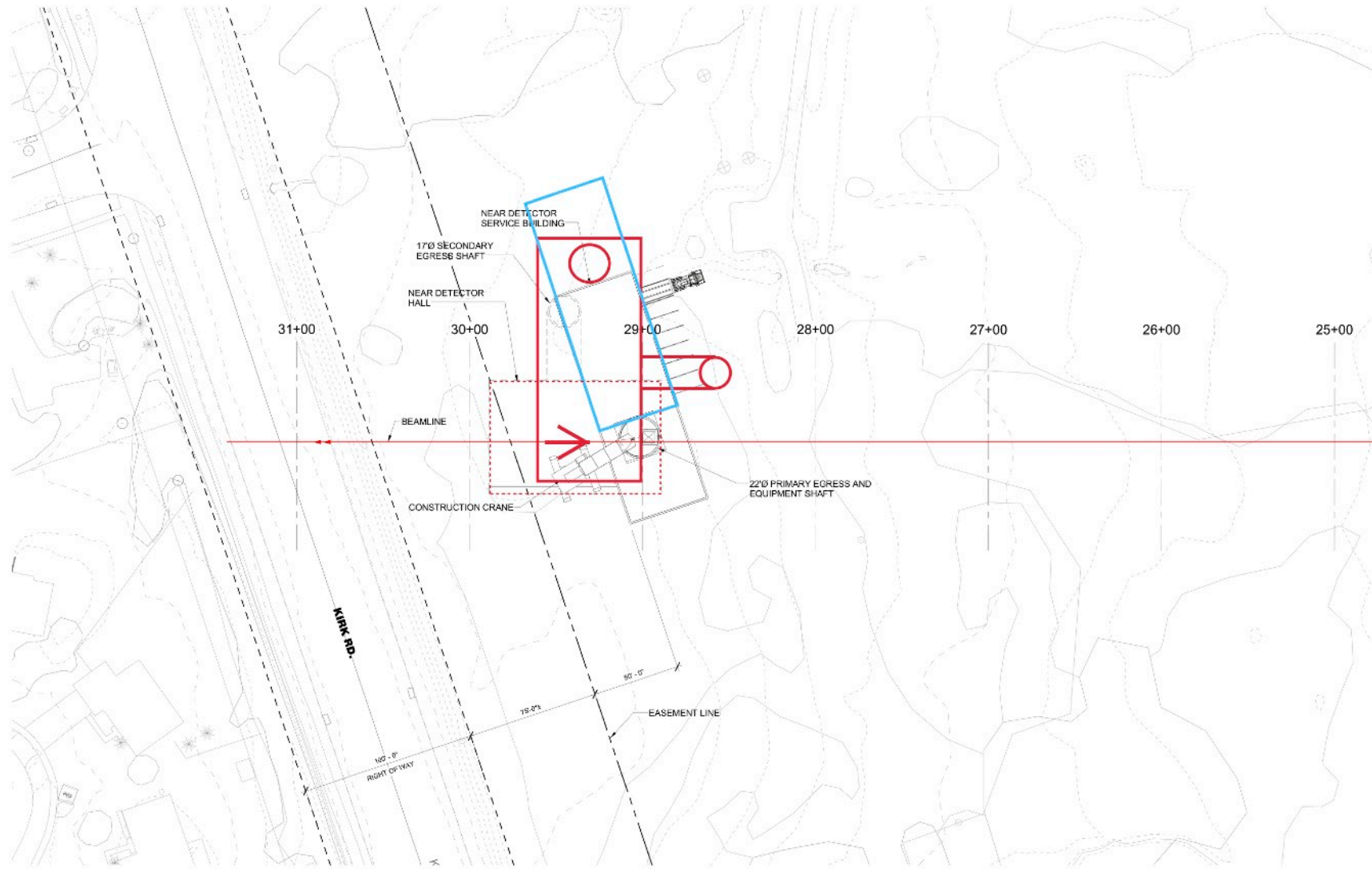


First LBNF Proposal



- 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

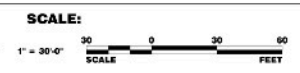
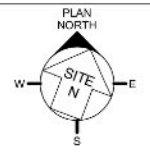


SITE PLAN

SCALE: 1" = 30'-0"

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REV.	DATE	DESCRIPTION
0	06/15/15	CD-1 REFRESH - WORK IN PROGRESS
REVISIONS		

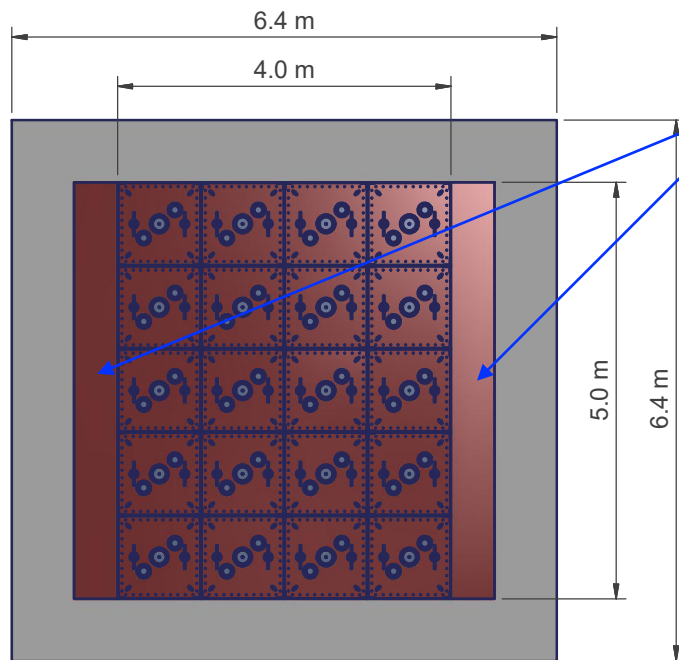
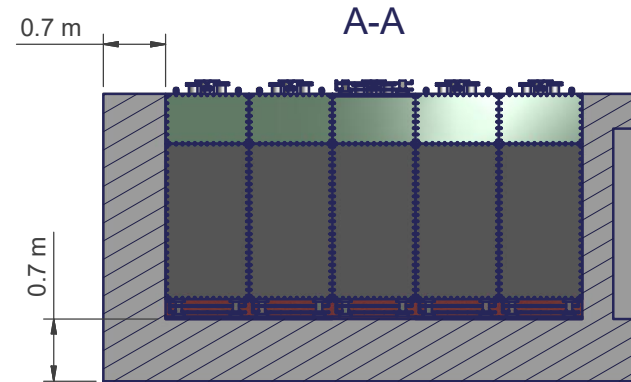
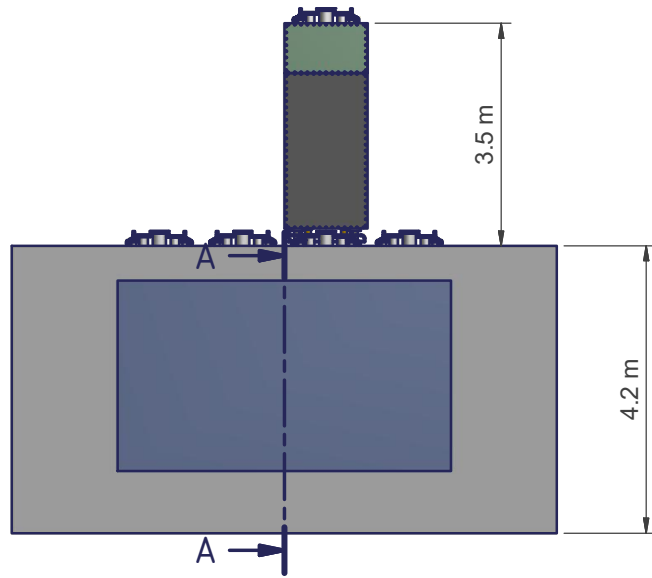


Fermilab Facilities Engineering Services Section <small>Managed by Fermi Research Alliance for the U.S. Department of Energy Office of Science</small>	
DESIGNED:	K. HARTSFIELD
DRAWN:	A. CANCIO
CHECKED:	T. HAMERNIK

LBNF CONVENTIONAL FACILITIES		
NEAR DETECTOR		
SITE PLAN		
DRAWING NO.	6-14-1	REV. 0
	CDR-108	

26 MAR 2015

Previous Cryostat Design

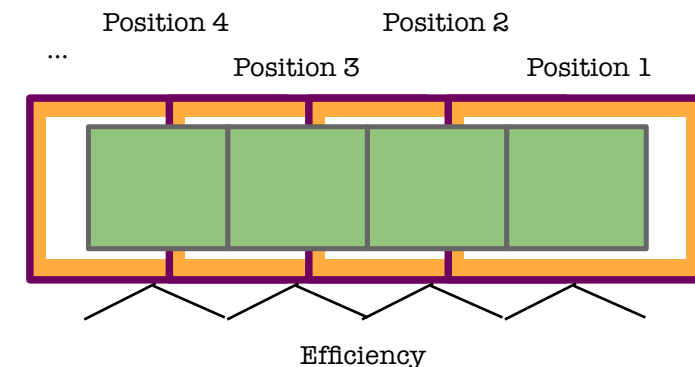
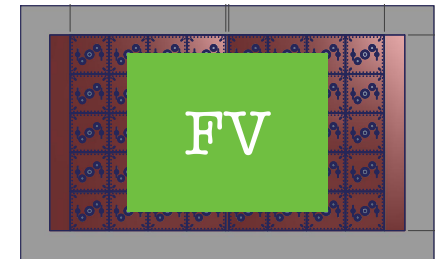
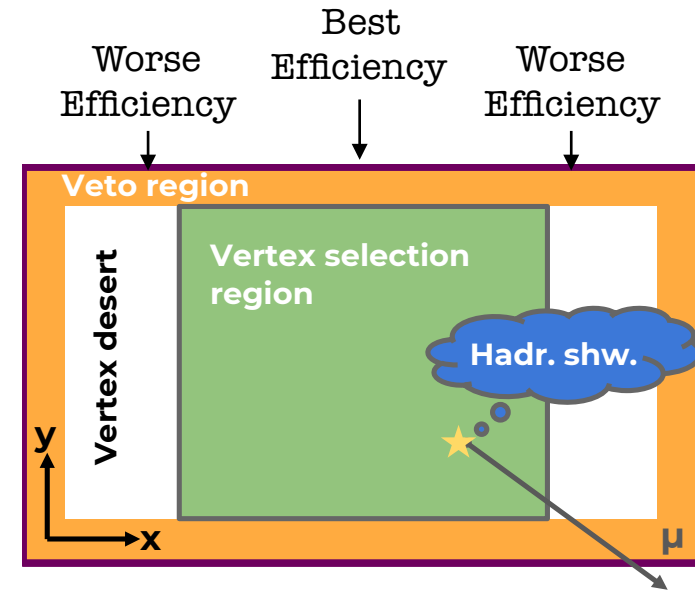


Extra 50 cm volume required on either side of the active ArgonCube modules

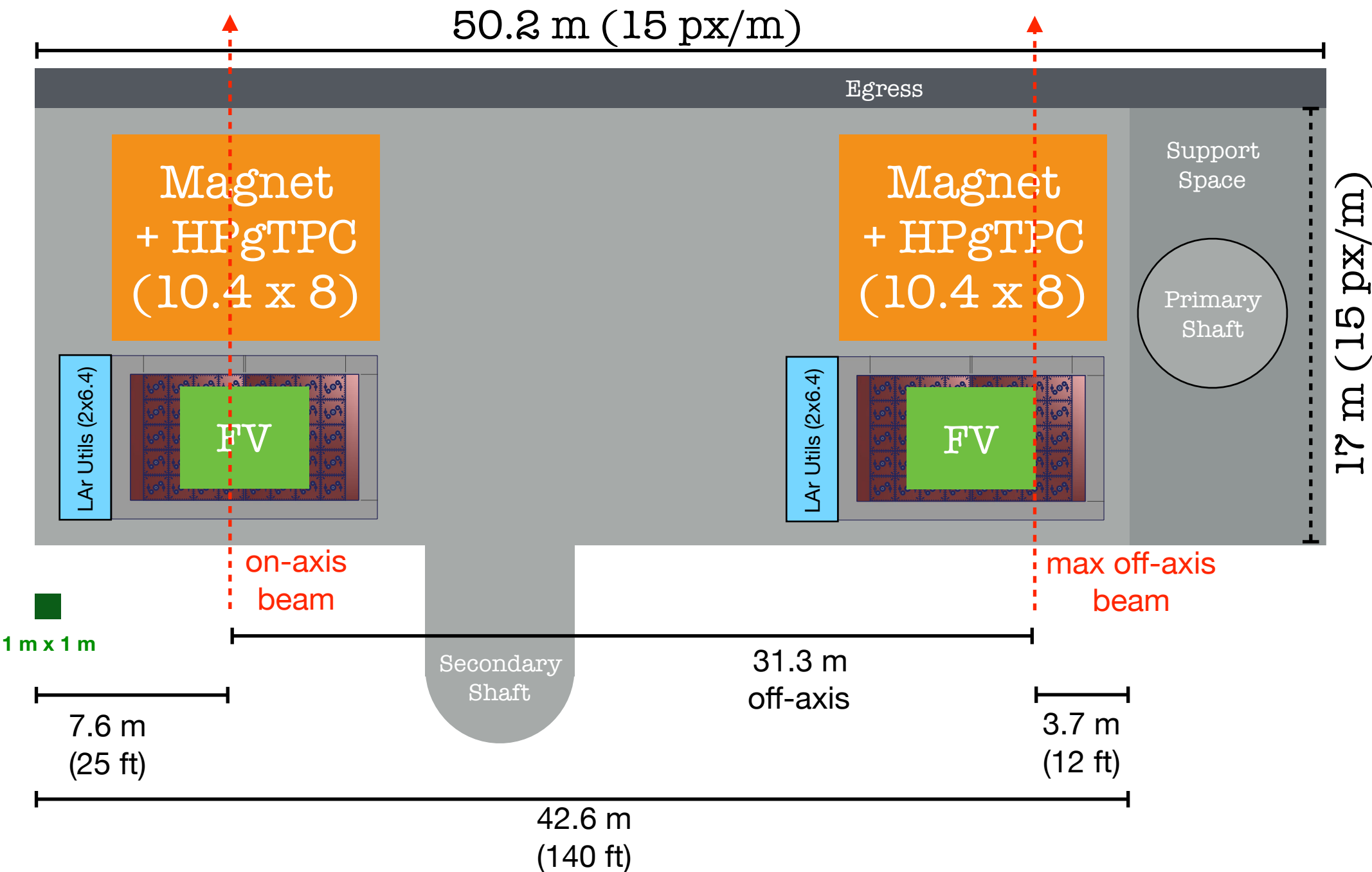
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					Assembly_ND	Ausgabe	Blatt Nr.	Massstab
							1 von 1	
Ausgabe	Änderung	Datum	Name	Zusammenst. Nr.:	Ersatz für:	Ersetzt durch:		

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

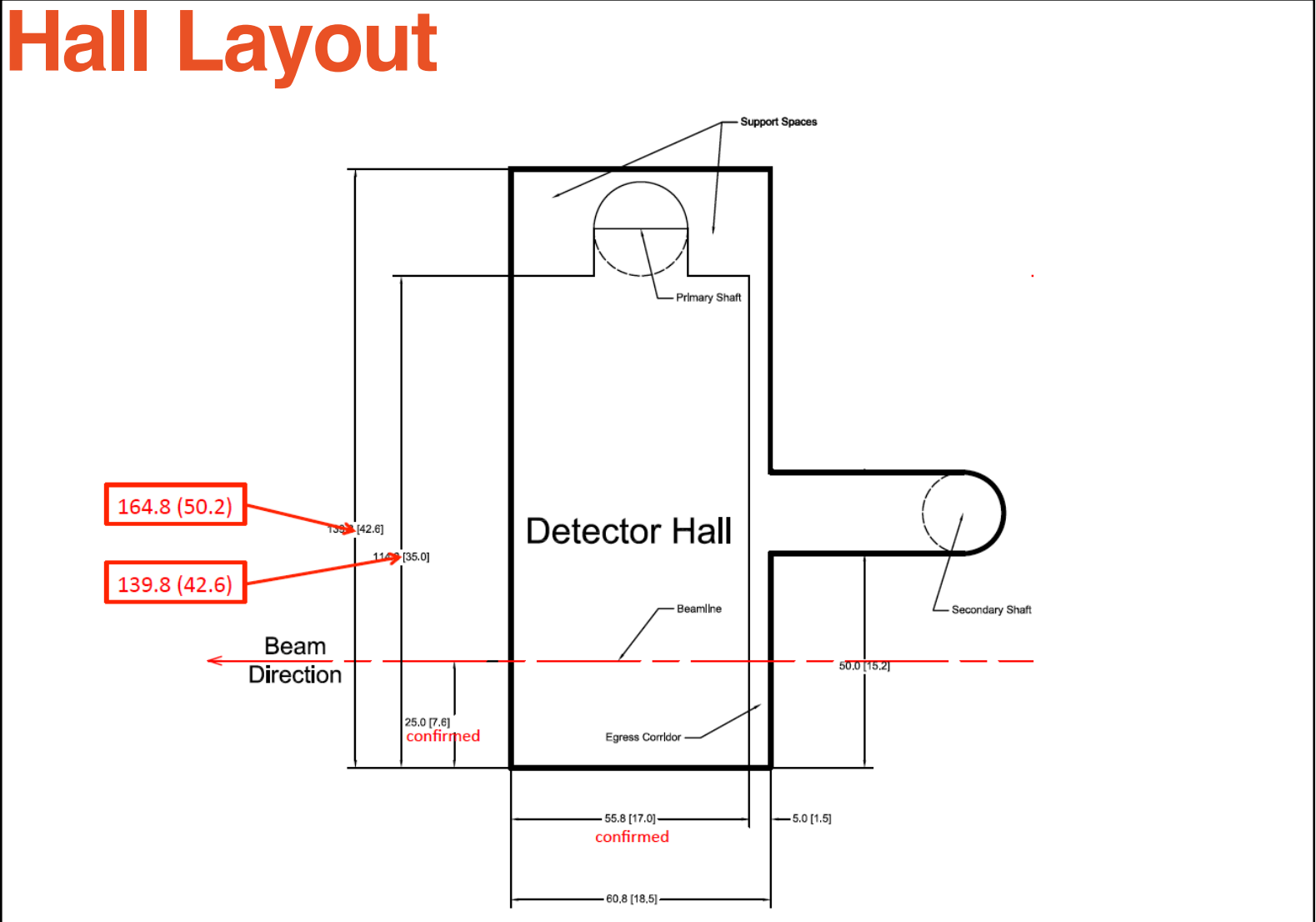


ND Hall Layout



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)