The NuMI Off-axis ν_e Appearance Experiment (NOνA)

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Outline

NOνA Experiment
- NuMI Beam
- The NOνA Detectors
- Current Status

NOνA Physics Reach

Summary

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NOνA Physics Reach

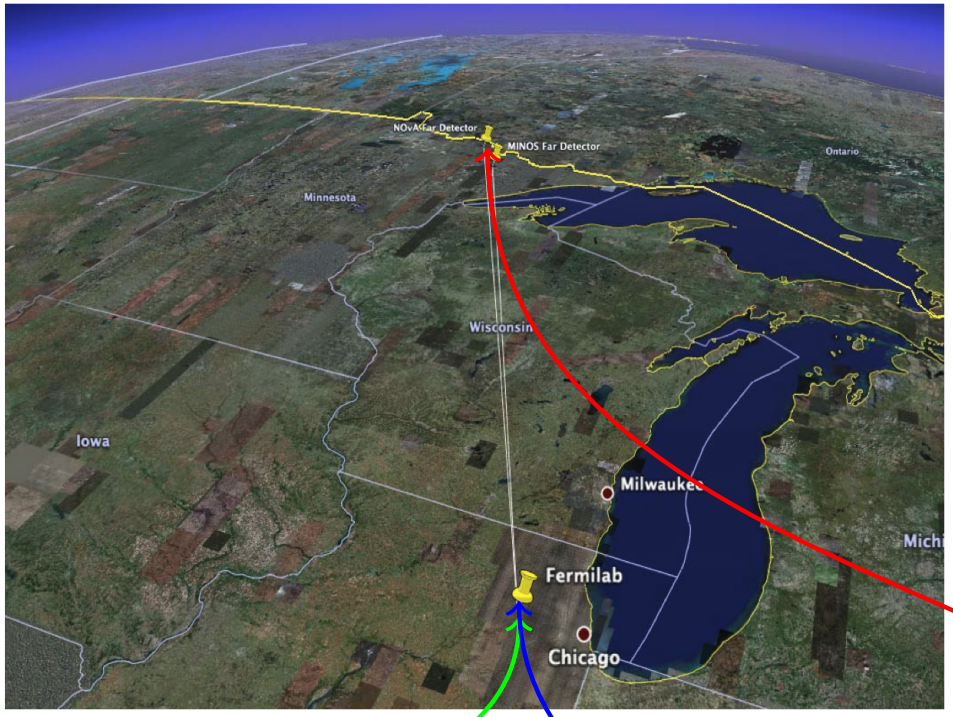
Summary

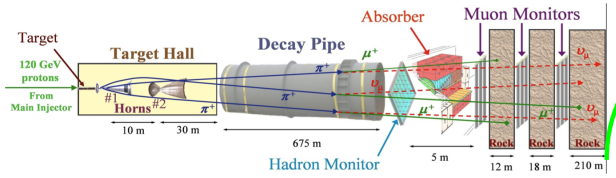
The NOνA Experiment

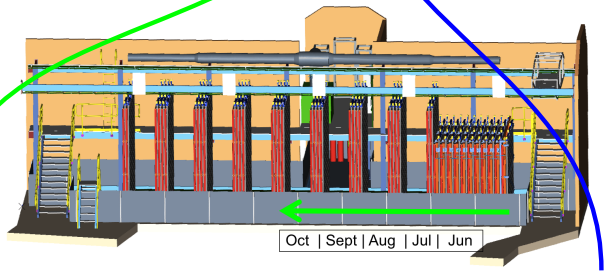
- Intense medium energy ν beam - 700 kW
- Off-axis narrow band beam peaks at $\sim$2 GeV (suppress backgrounds)
- Long baseline 810 km (more matter effect)
- 73% active near and far detectors
- 14 kt total far detector mass

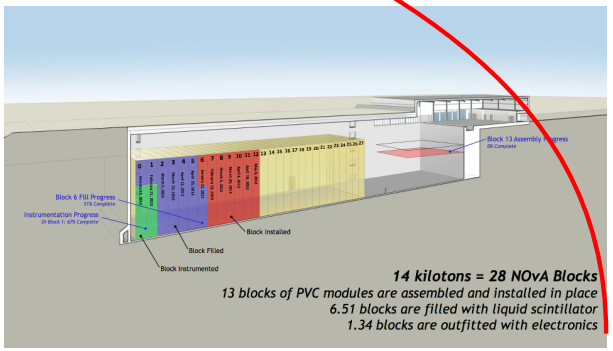
- Precision measurements of θ_{13}, θ_{23}, and Δm^2_{32}
- Determine the θ_{23} octant
- Determine the mass hierarchy
- Search for δ_{CP}
- Exotic physics, *etc.*

The NOνA Experiment

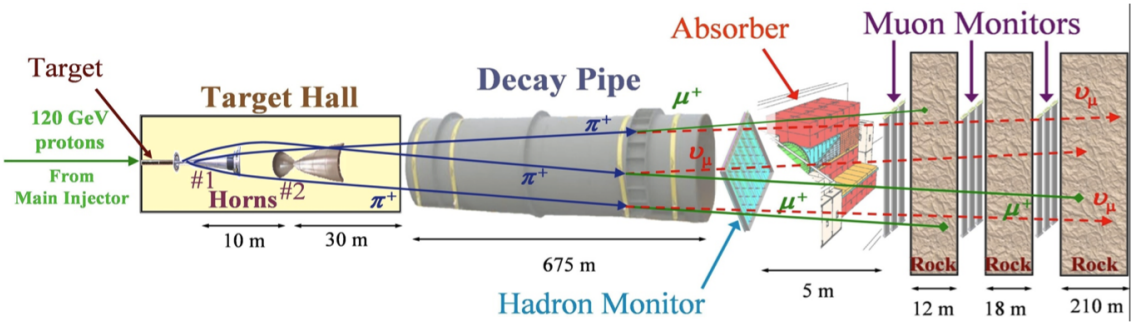


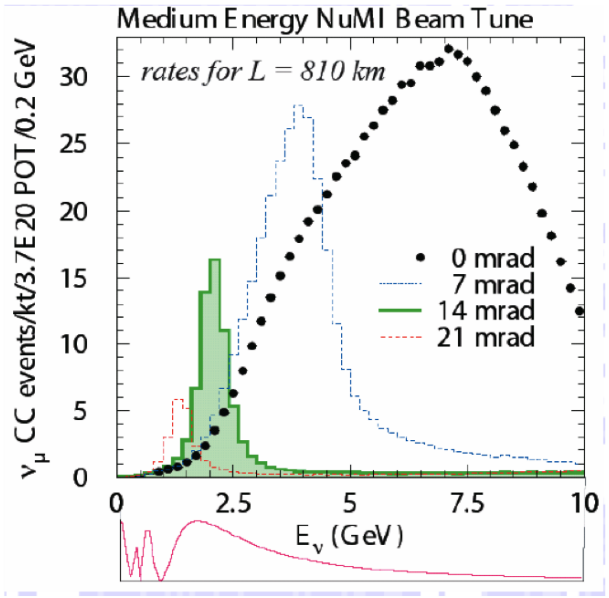






NuMI (Neutrinos at the Main Injector) Beam

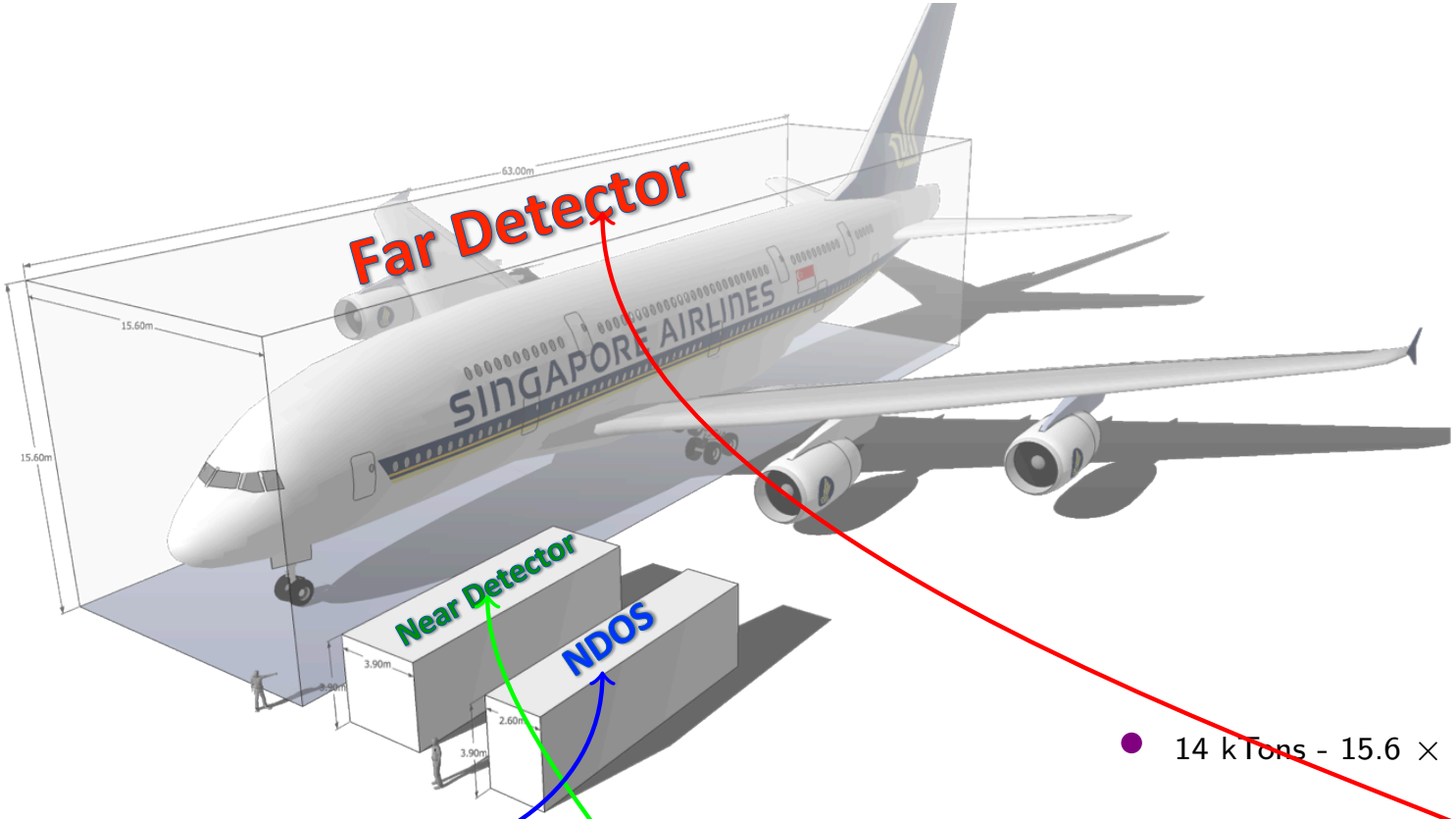




- Beam Spectrum tunable by horn currents, relative placement of target horns
  - ν or $\bar{\nu}$ predominant beam depending on horn current polarity
- 10 μs beam spill every 1.33 sec
- Operating since 2005
  - MINOS, MINERνA, ArgoNEUT
- Turn on in June with low power, ~500 kW in 5 months, expect 5e20 POTs in July 2014, 1e21 POTs in July 2015

- 14 mrad off-axis medium energy peaks at ~2 GeV, the 1st oscillation maximum
- Low contamination
  - 1% $\bar{\nu}_\mu$ of ν_μ-enhanced beam
  - 5% ν_μ of $\bar{\nu}_\mu$-enhanced beam
- Narrow Band Beam suppresses backgrounds (NC, τ)

The NOνA Detectors



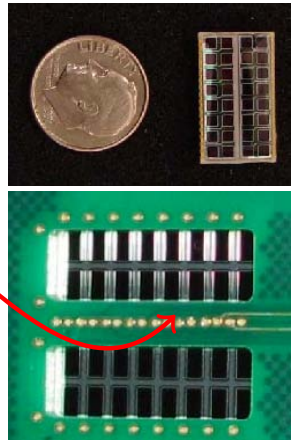
- 225 Tons - 4.1 $\times$ 2.9 $\times$ 14.3 m
- Each plane just 0.15 X_0 ($X_0 = 38$ cm), great for electrons

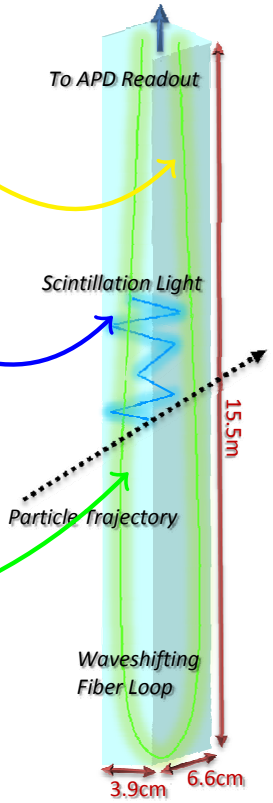
- 300 Tons - 4.1 $\times$ 4.1 $\times$ 14.8 m
- Includes muon catcher for ranging out μ's

- 14 kTons - 15.6 $\times$ 15.6 $\times$ 60 m
- Alternating X/Y measuring planes for 3D reconstruction
- Over 344,000 independent measurement cells
- $>$ 70% of total mass is active

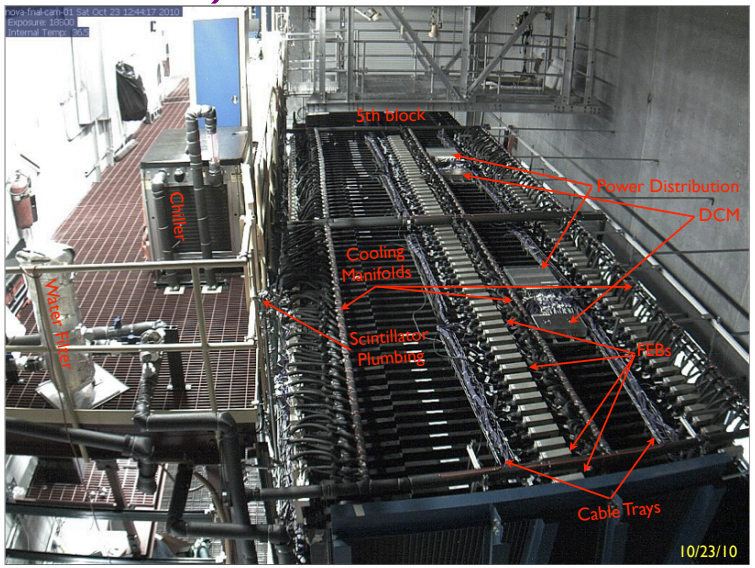
Detector Components

- Avalanche photodiode (APD) converts light to electrical signal (11,160 devices, each 32 pixels)
  - 85% quantum efficiency
- Liquid Scintillator (3 million gallons)
  - Contained in 3.9 cm$\times$6.6 cm$\times$15.6 m cells
  - 3.9 cm as seen by the beam
- Cell walls are rigid PVC (5 kilotons)
  - Loaded with 15% anatase form of titanium dioxide
  - Diffuse reflection at walls keeps light near (within $\sim$1 m) particle path
- Looped wavelength-shifting fiber collects light (11,160 km)
  - Fiber diameter 0.7 mm
  - Fiber shifts wavelength to $\sim$ 520-550 nm along the fiber



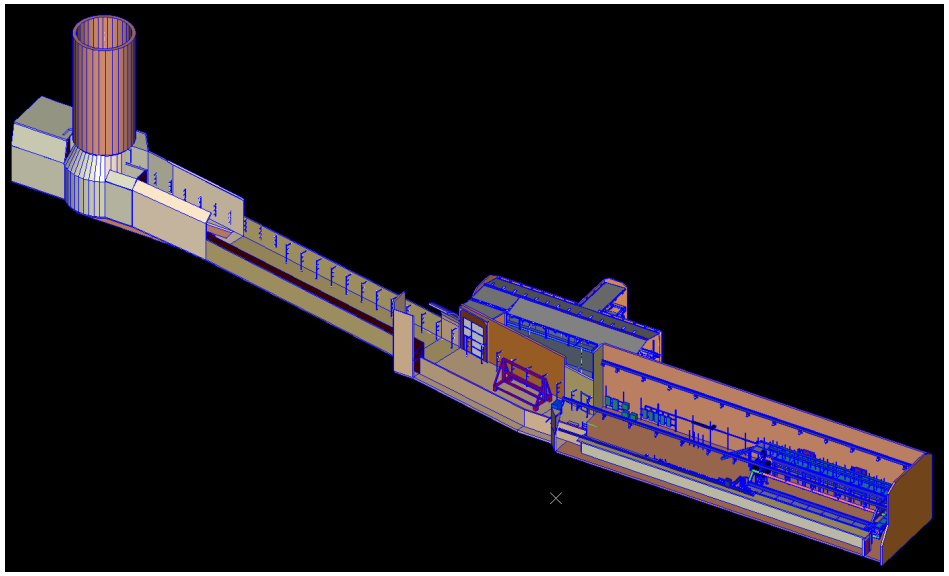


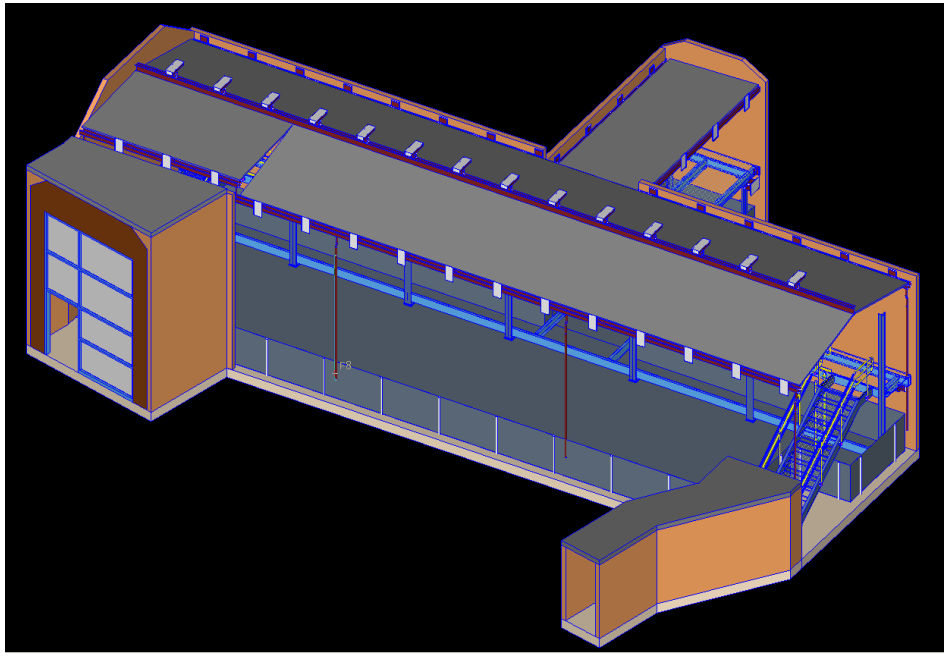
Near Detector on the Surface (NDOS)



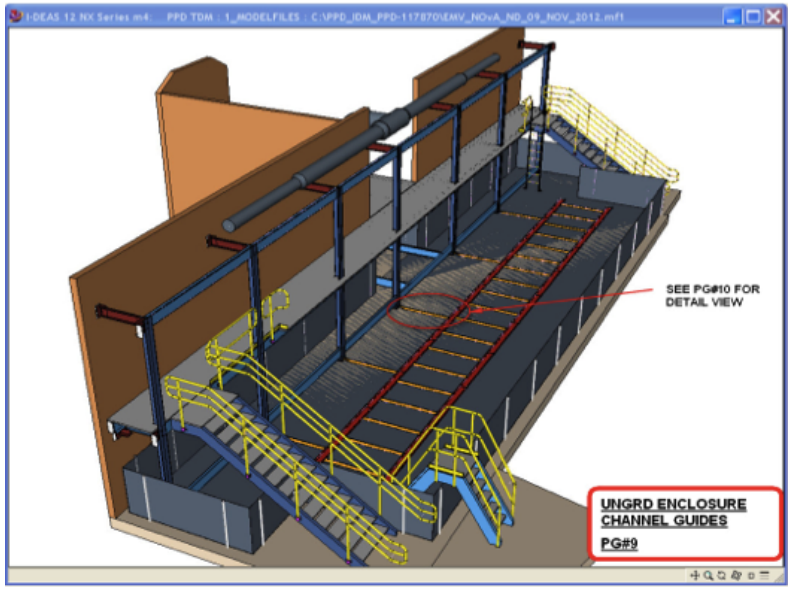
- 225 tons, 199 plastic planes + 10 steel planes, ~1/3 instrumented
- Serves as a test stand for DAQ HW and SW, installation procedures
- Real data ($\sim 10^{20}$ POTs) for calibration, reconstruction and data analysis
  - Expected neutrino candidates - $\sim$ 500
  - Measure ν_μ QE cross section
  - Measure the inclusive cross section of charged current ν_μ for energies ~2 GeV
- The Muon Catcher will be decommissioned and recycled for Near Detector

Near Detector Tunnel and Hall

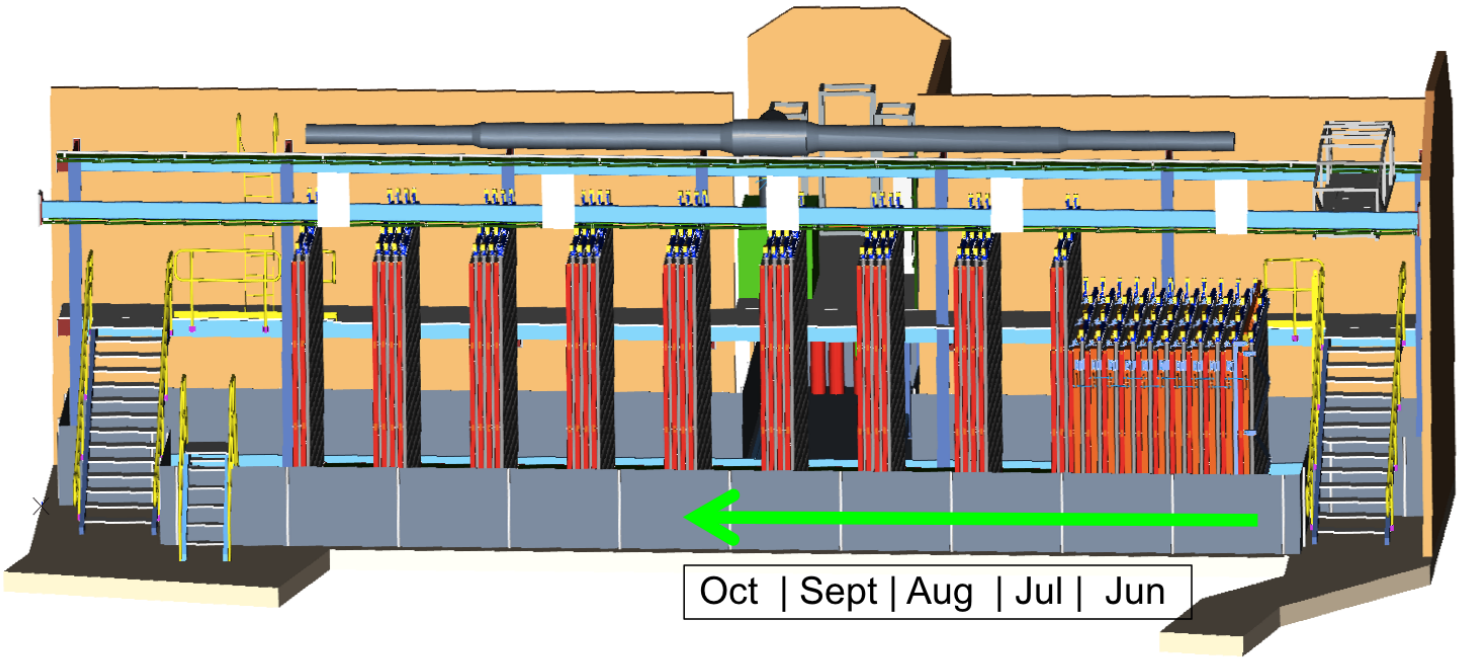




Near Detector Hall - Beneficial Occupancy on May 10th



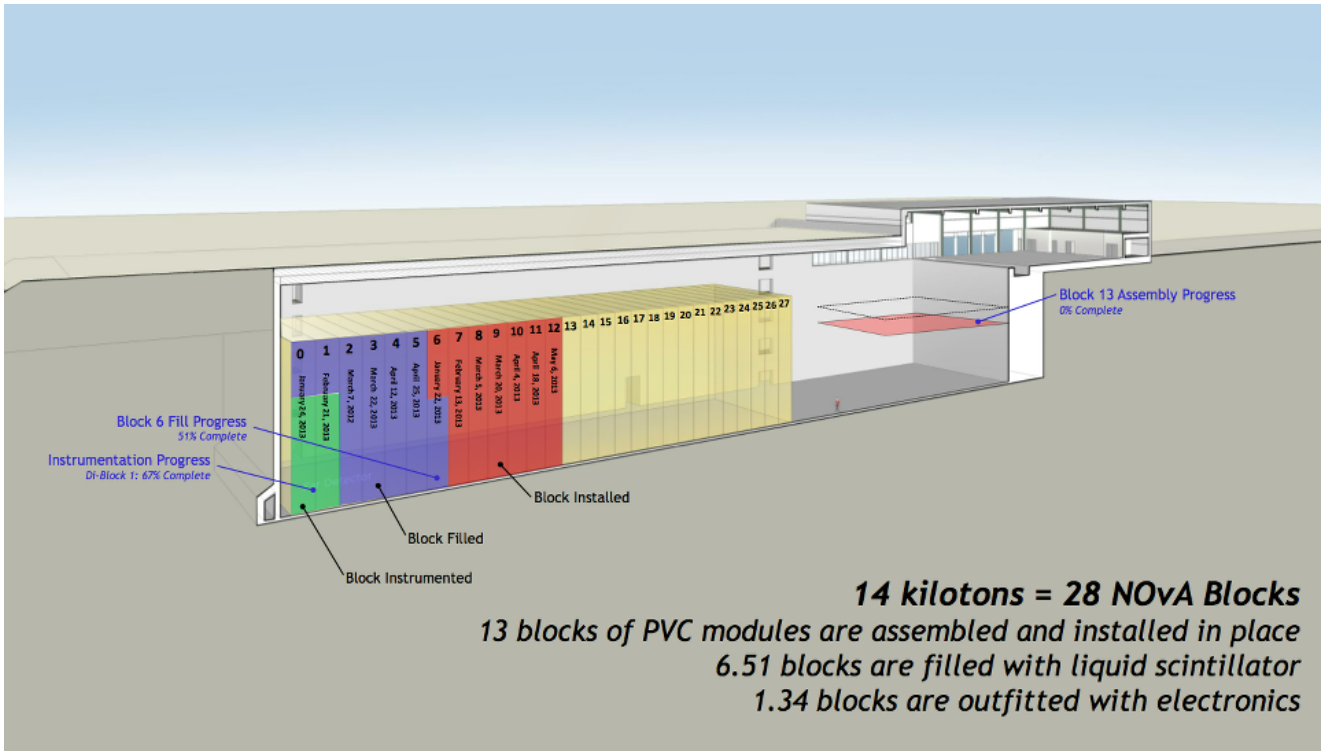
Near Detector Schedule



- Blocks 5-8 [1], and Muon Catcher installation: July - December 2013
  - Steel plates in Muon Catcher are refurbished from NDOS.
- Blocks 1-4: Jan/Feb - May/June 2014

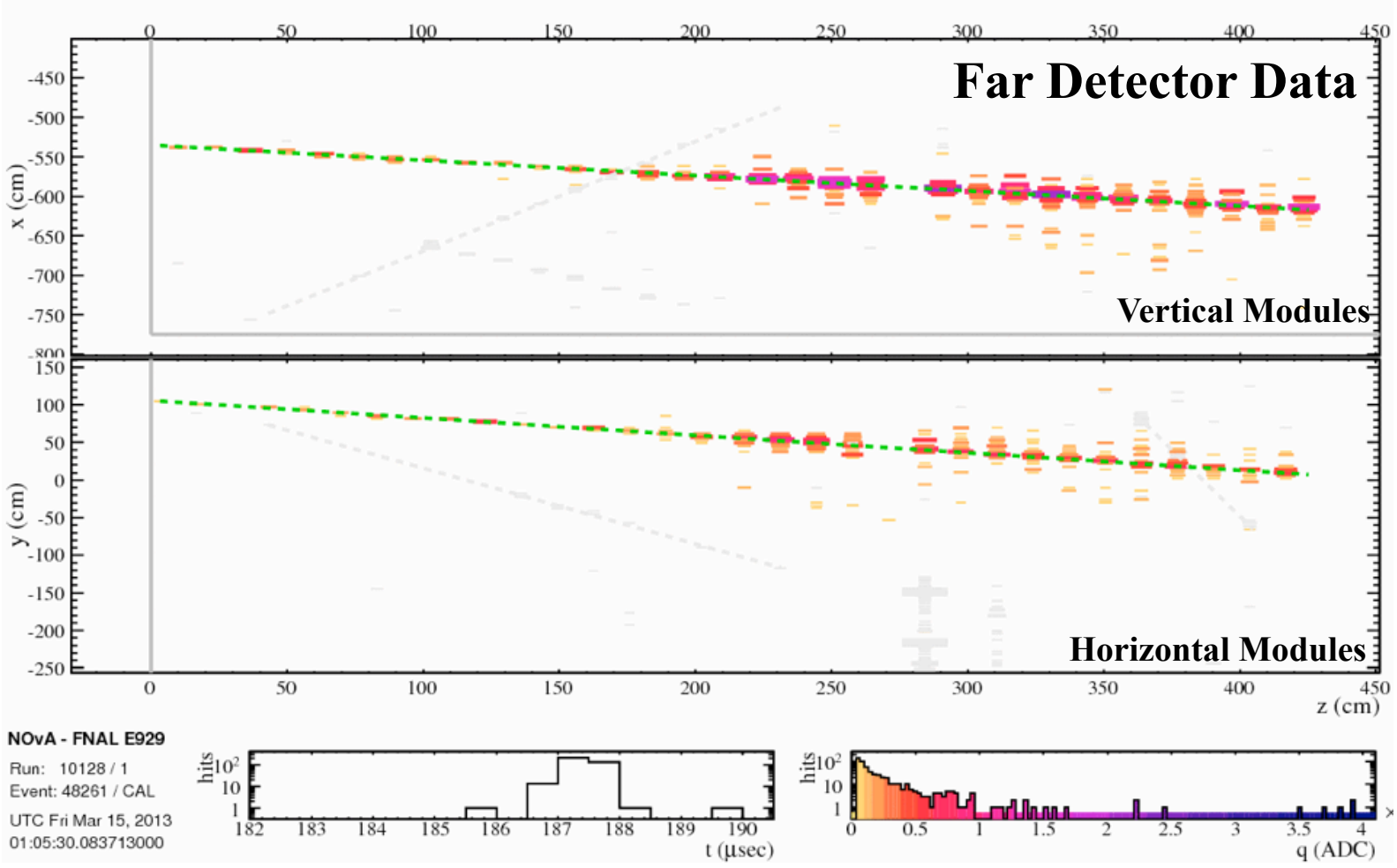
[1] Real detector has no gaps.

Far Detector - May 7, 2013

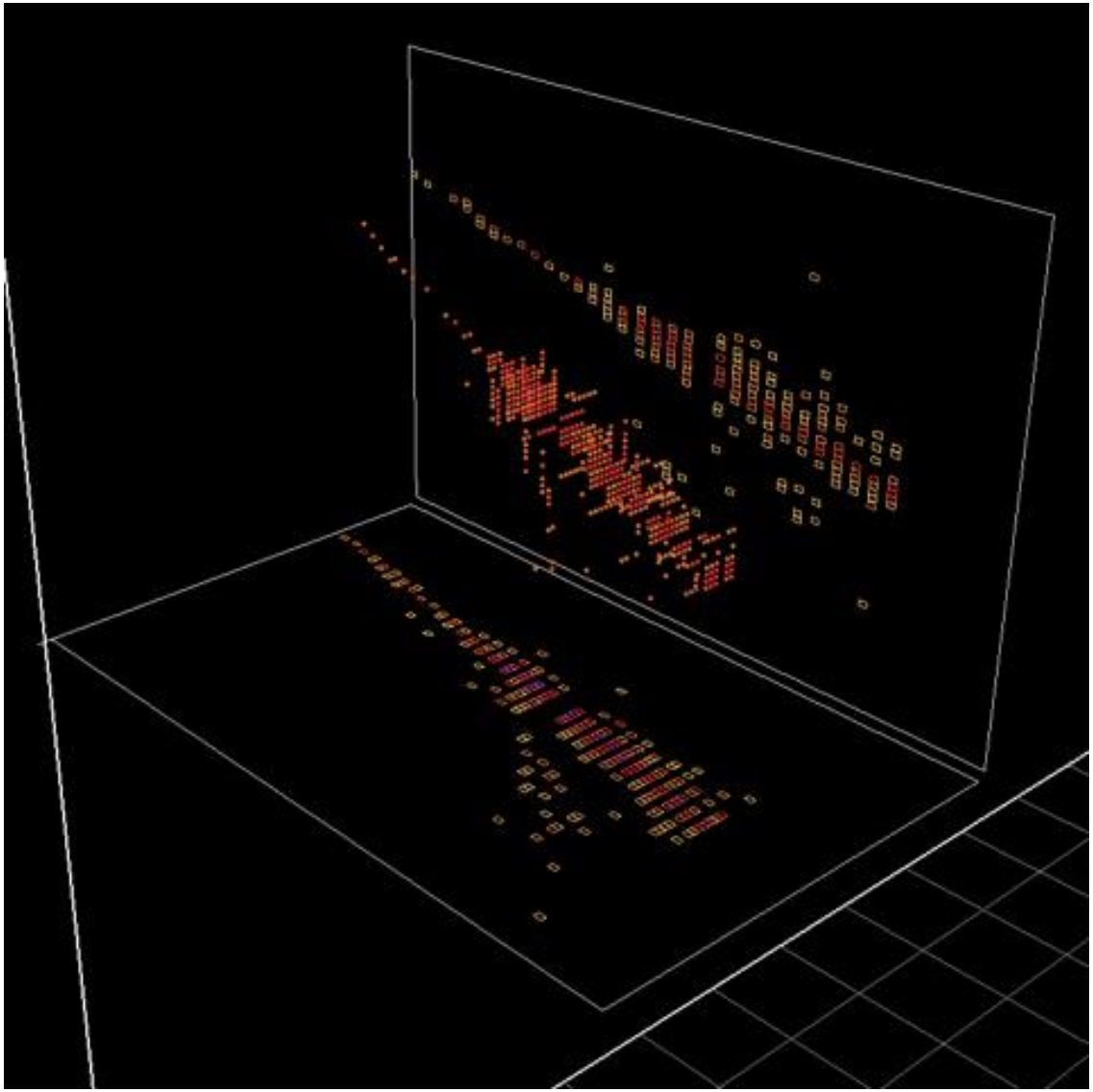


- First block installed on Sept. 10, 2012
- 2.5 kt far detector mass fully instrumented when beam returns in June
- 14 kt in Aug. 2014

Cosmic Event Pictures - 2D



Cosmic Event Pictures - 3D



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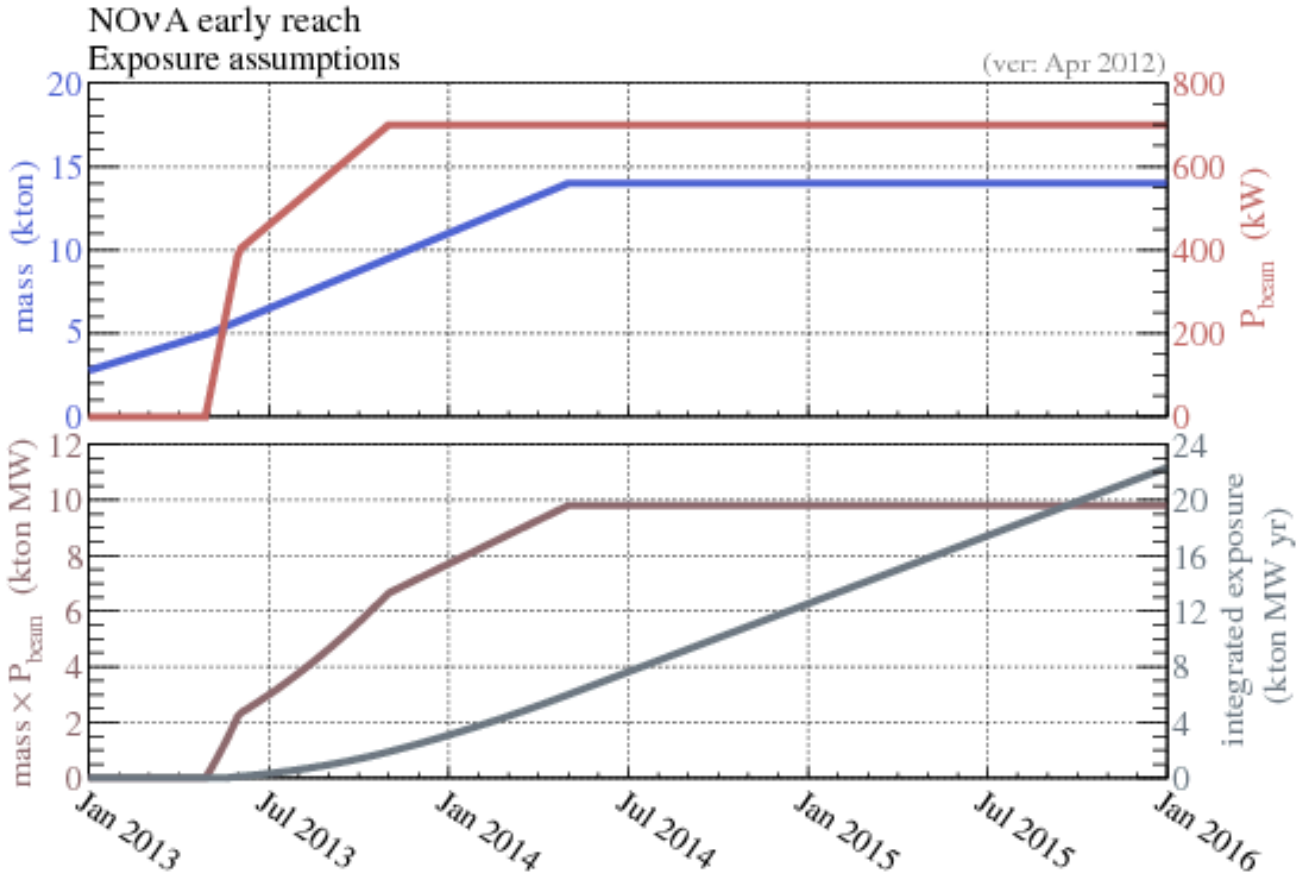
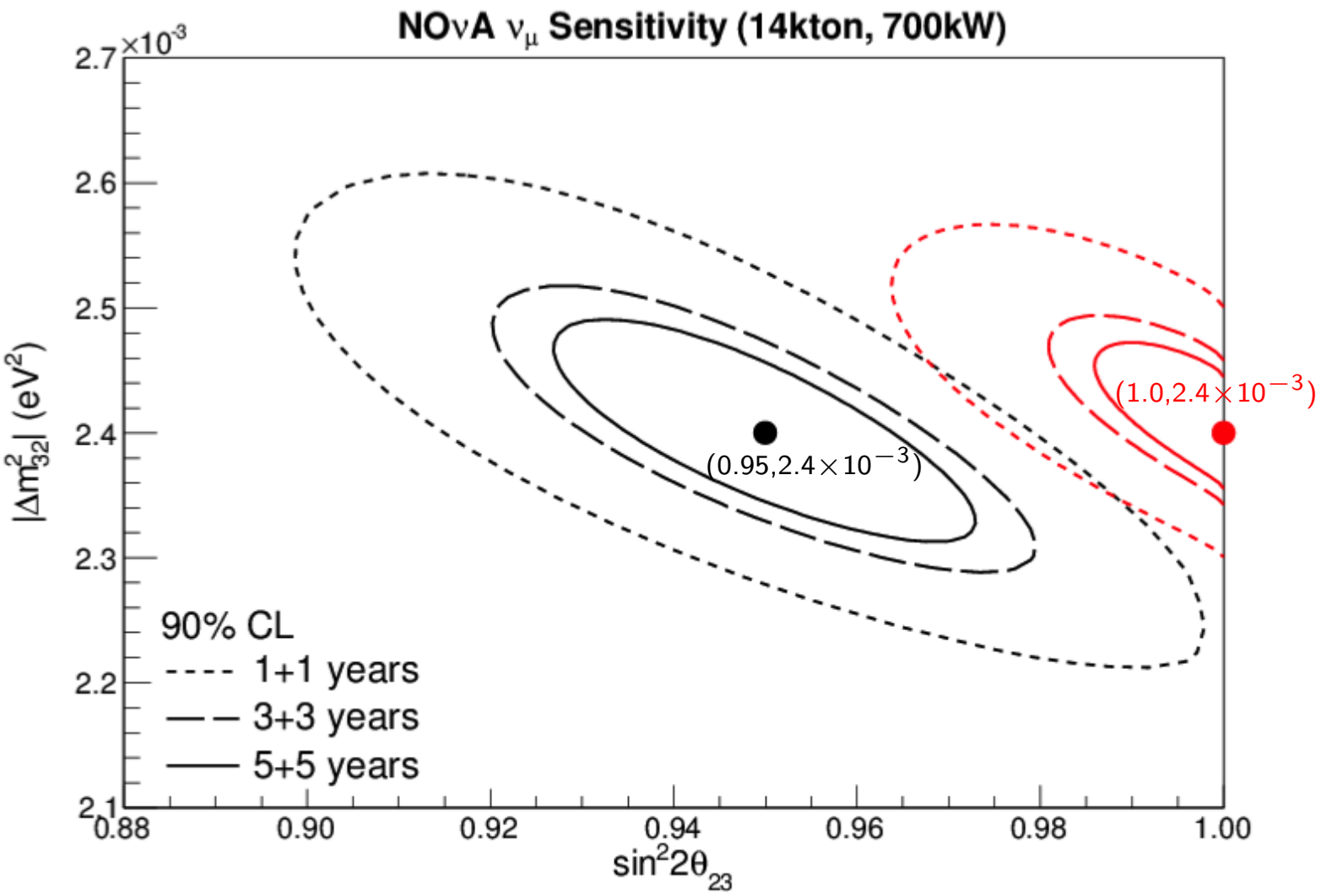
Beam, Mass and Beam $\times$ Mass

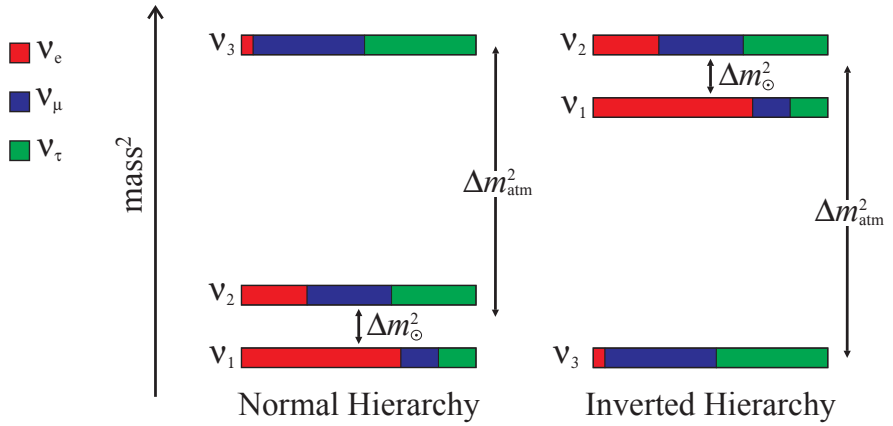


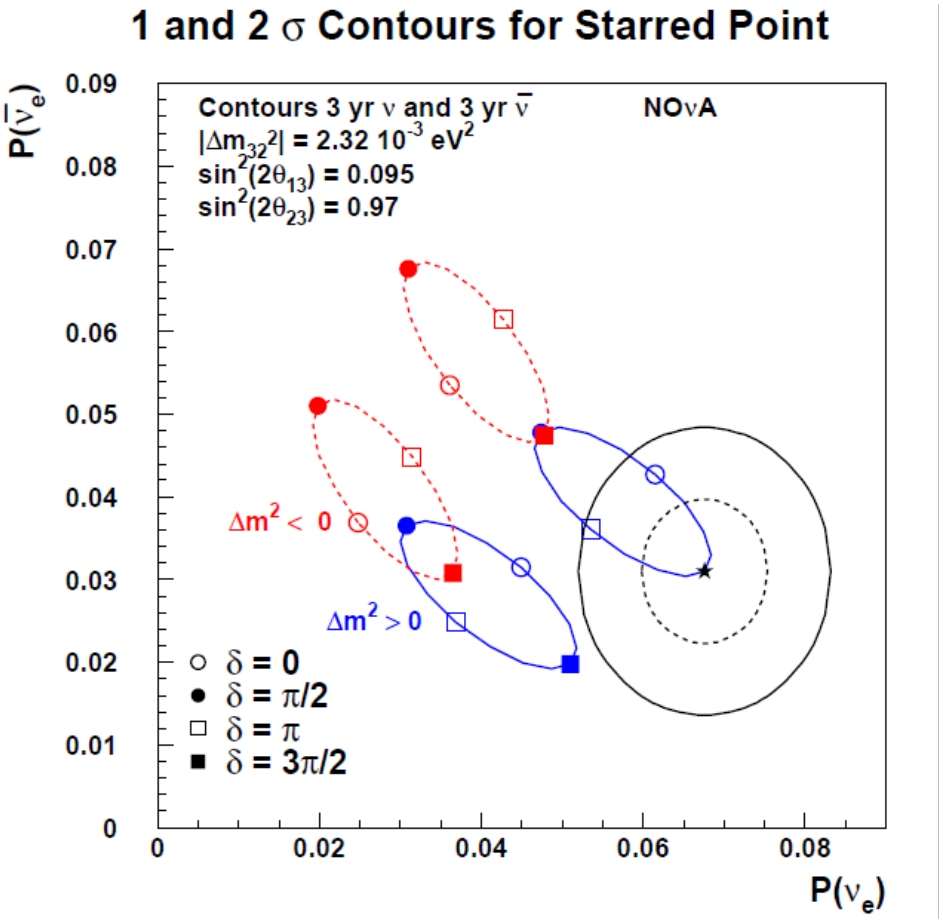
- 2.5 kt far detector mass when beam returns in June with low power
- 1 year neutrino running and then antineutrino running

NOνA Physics Reach - θ_{23}

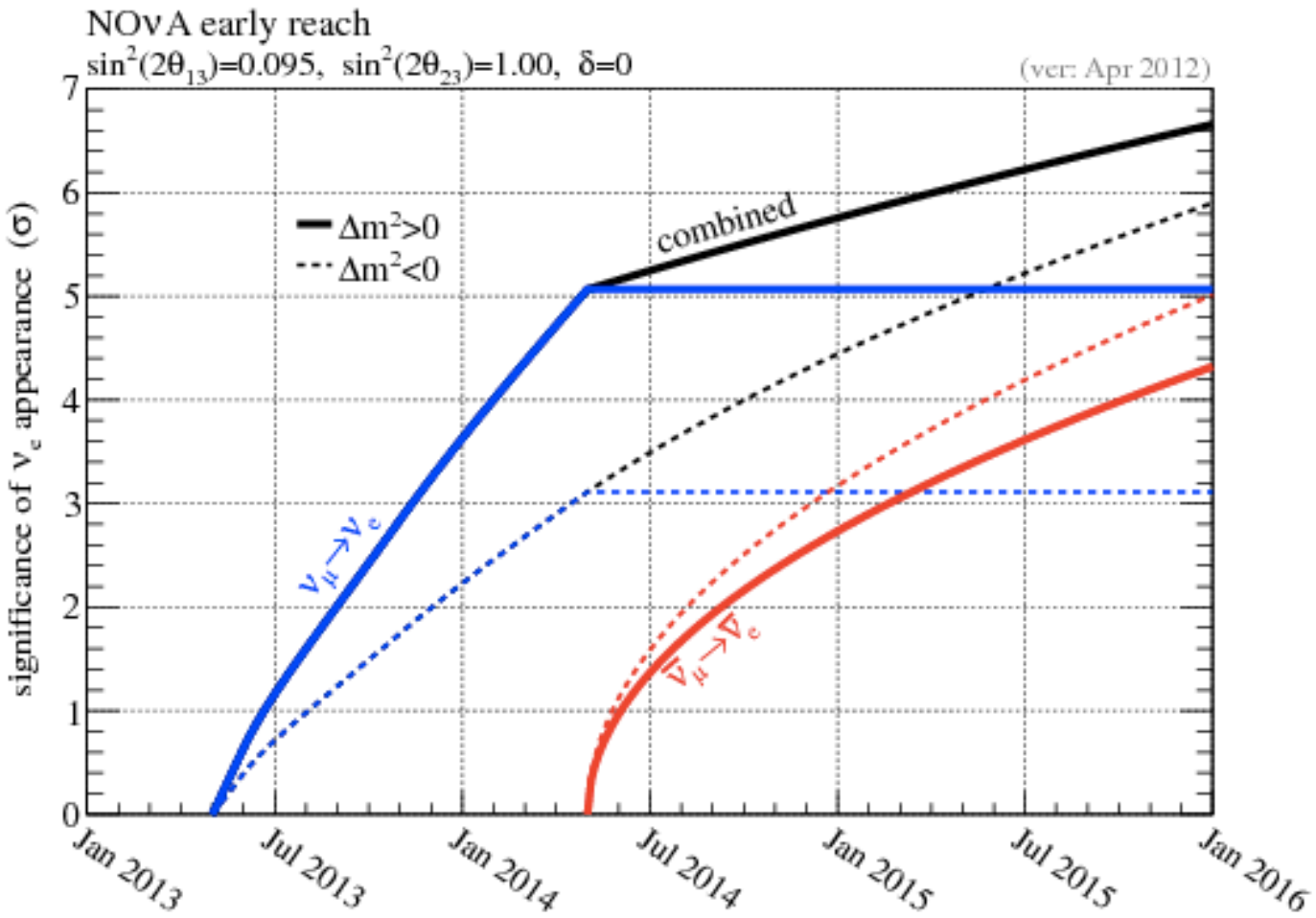


NOνA Physics Reach



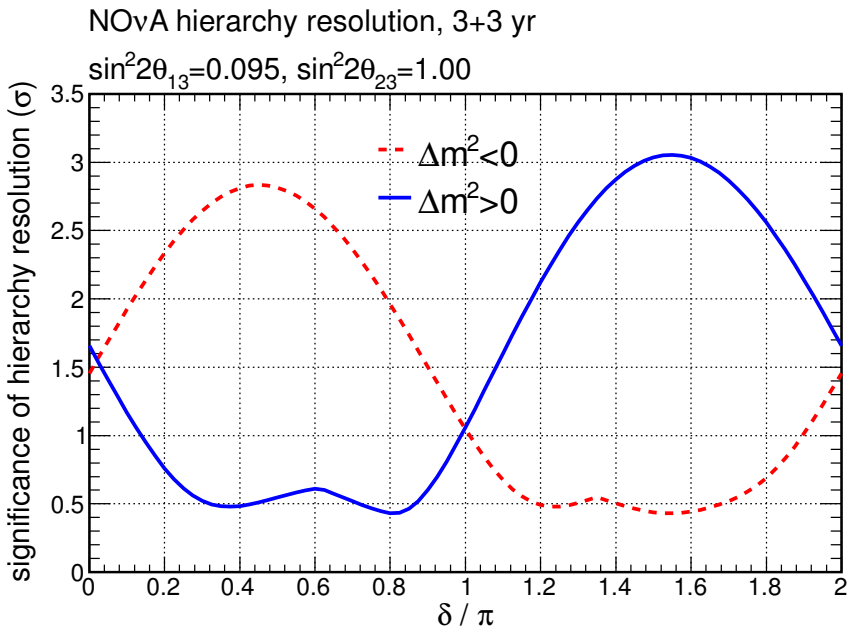


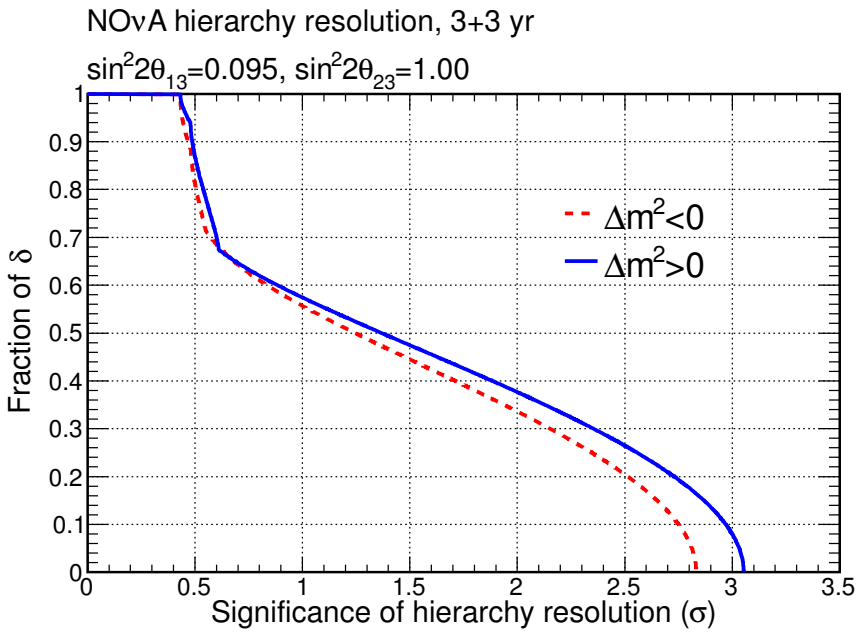
NOνA Physics Reach - θ_{13}



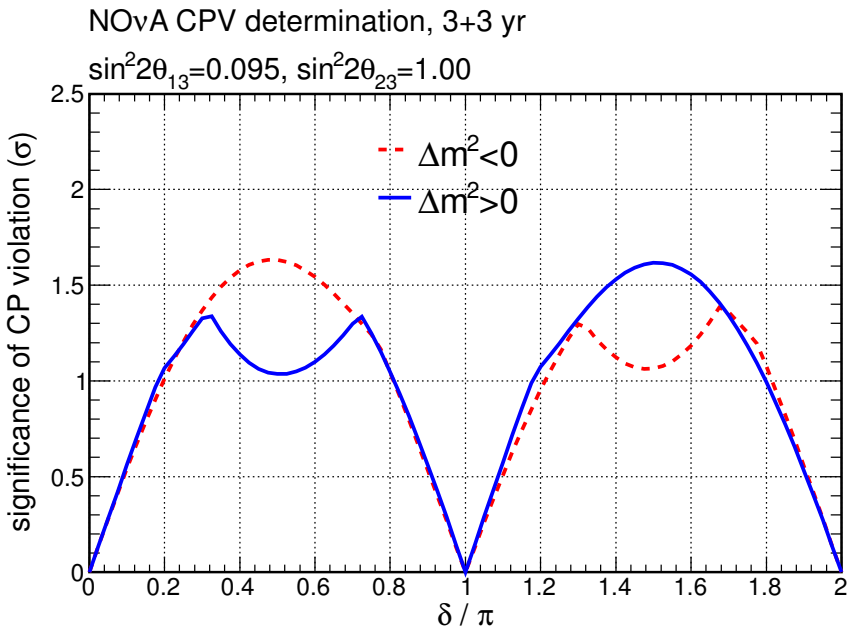
- 5σ (3σ) of ν_e appearance within first year for NH + $\delta_{CP} = 0$ (IH + $\delta_{CP} = 0$).

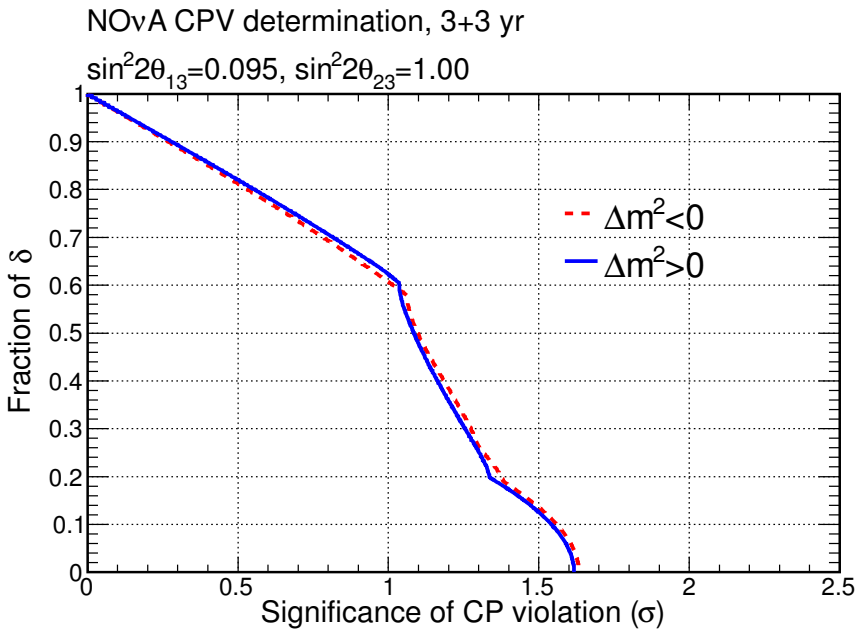
NOνA Physics Reach - Mass Hierarchy



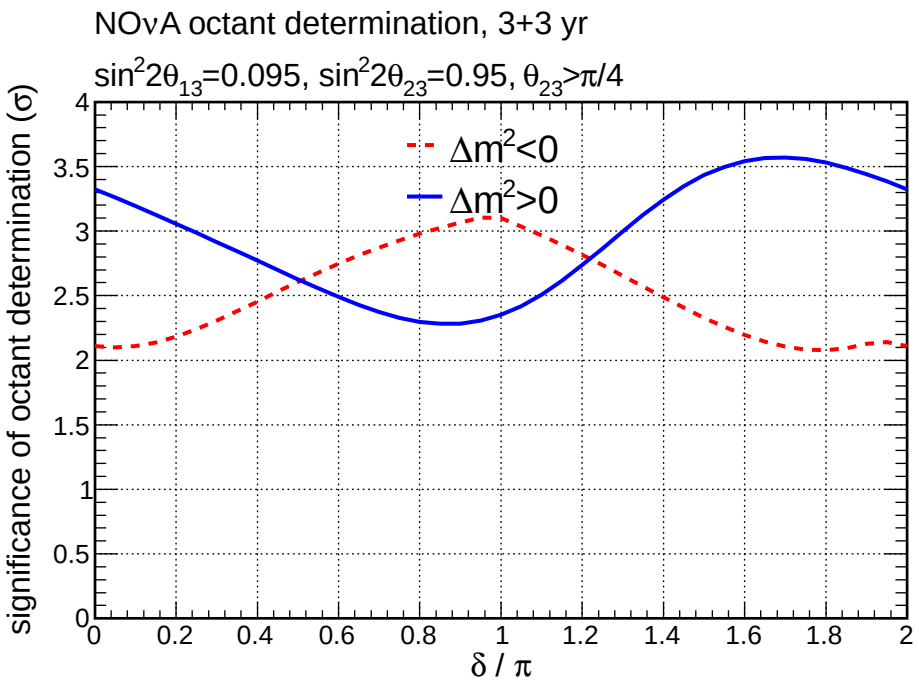


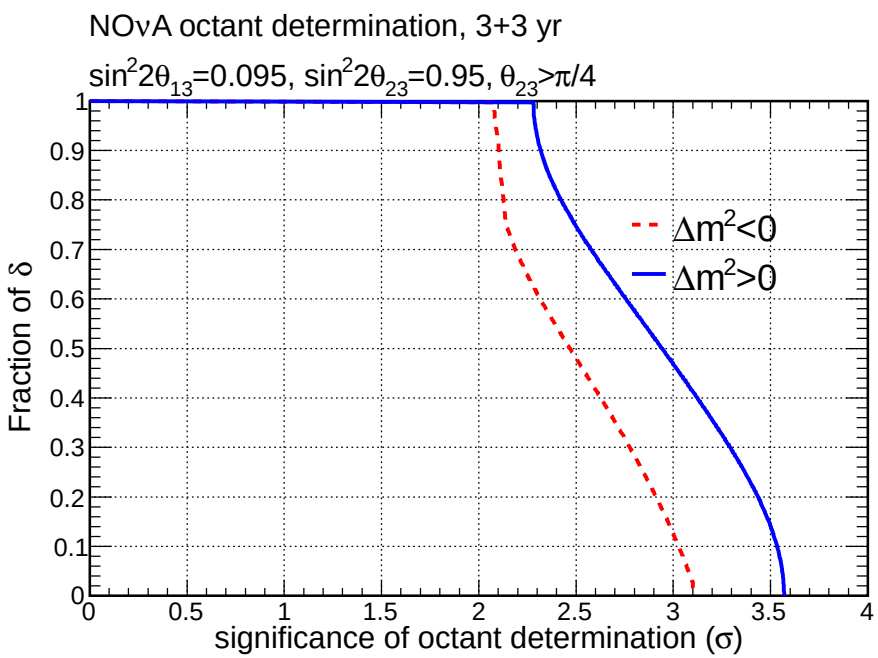
NOνA Physics Reach - CP





NOνA Physics Reach - θ_{23} Octant





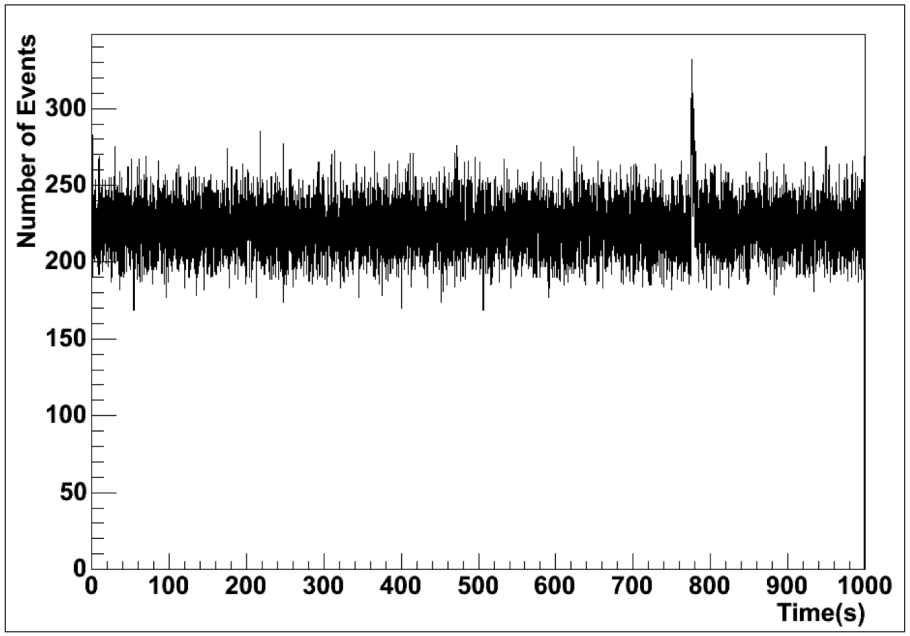
Summary

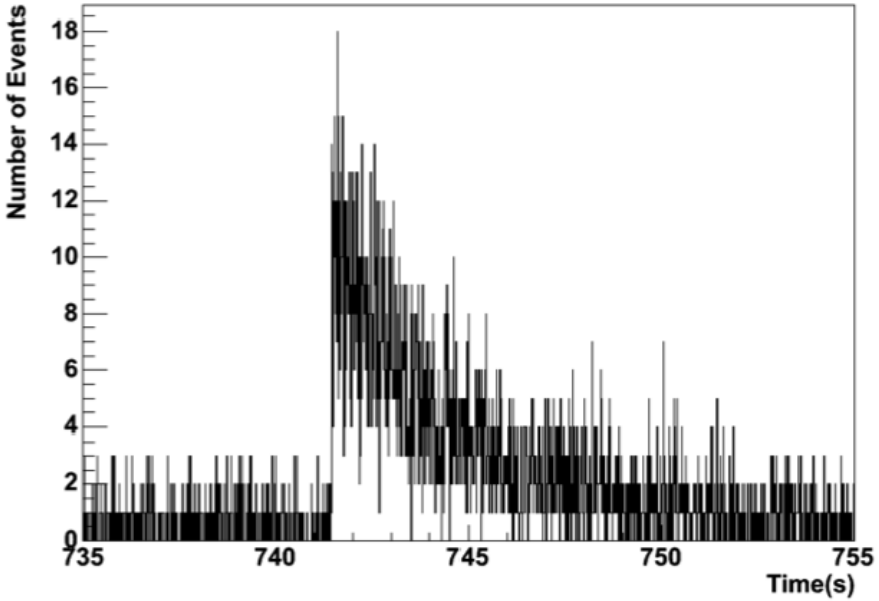
- Near Detector will have 4 blocks of PVC modules and muon catcher up and running by the end of 2013
- 50% of the Far Detector modules are assembled and installed in place
- Far detector has been recording and analyzing cosmic data
- First beam data in June with 2.5 kt detector mass

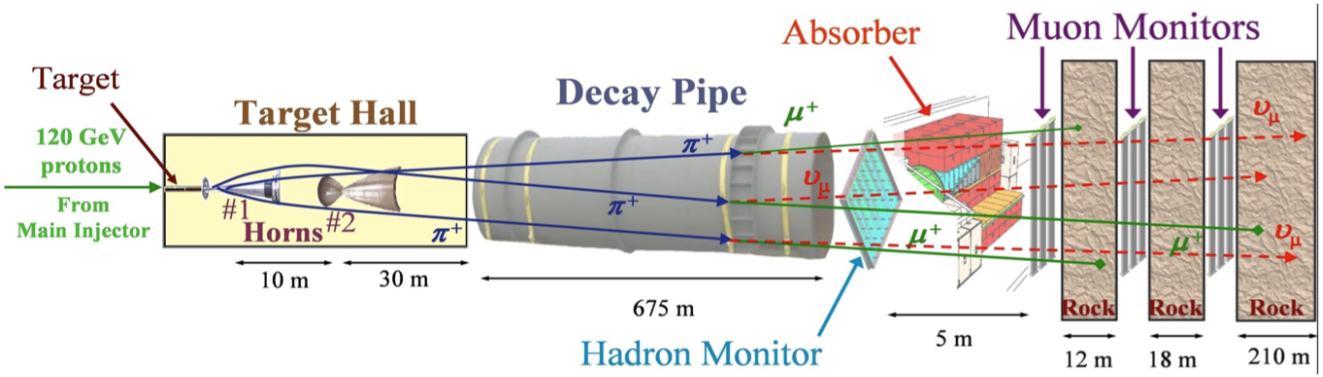
Backup Slides

NOνA Physics Potential - Supernova

- 10 second 5000event burst for a supernova near the center of galaxy





Accelerator & NuMI Upgrades

- Beam in neutrino mode will be turn on June 1st with low power, ramp up to 150 kW in 2 weeks, and 300 kW by July 1st
- Beam will be running at 500 kW from December until summer, then switch to ant-neutrino mode after two months shutdown