The NOvA Test Beam Program

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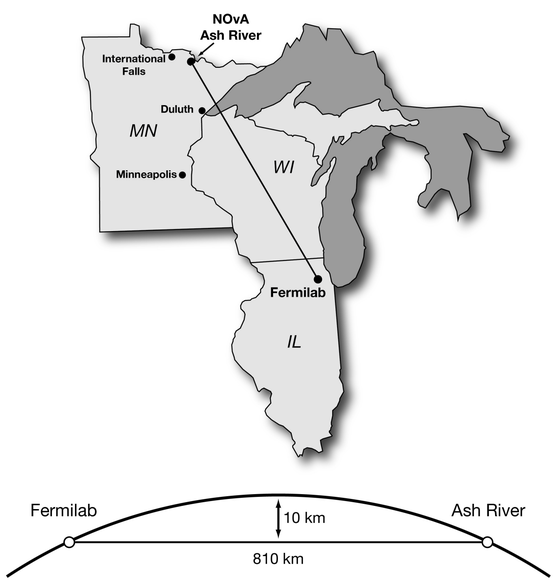
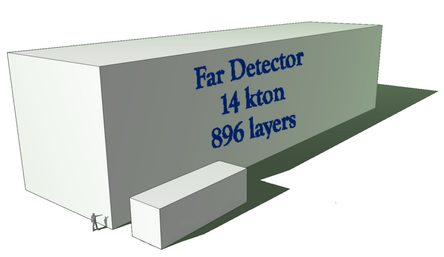
On behalf of the NOvA Collaboration

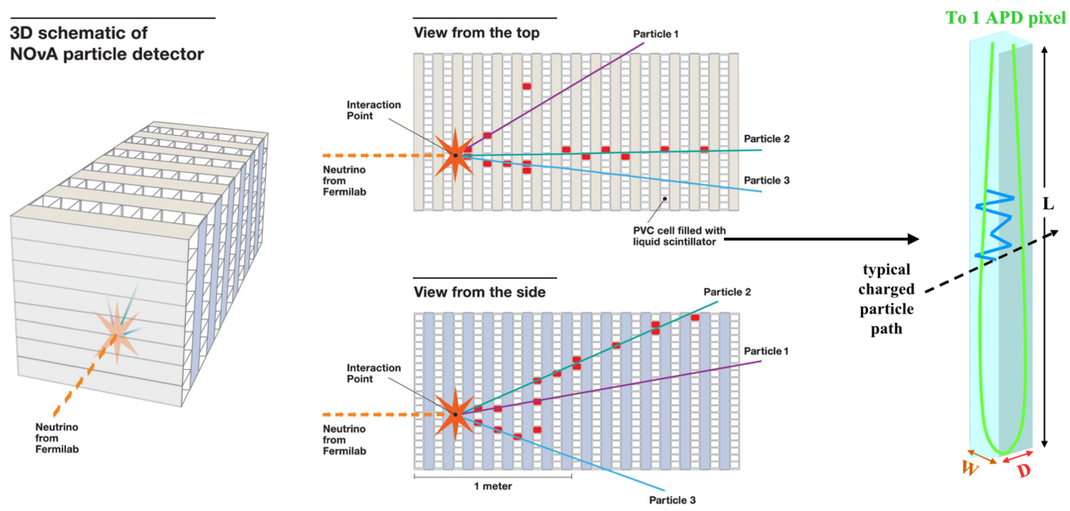
NOvA Experiment



- NuMI Off-axis ν_e Appearance Experiment
- measure both ν_μ disappearance and ν_e appearance
  - 810 km baseline
  - 14 kton far detector
  - 14.6 mrad off-axis beam
  - energy peaks at 2 GeV
- physics goals
  - neutrino mass ordering
  - leptonic CP violation
  - precision oscillation measurements e.g. θ_{23}



Detector Technology



- liquid scintillator filled in PVC cell of dimension 3.9 cm × 6.6 cm
- 0.7 mm wavelength shifting fiber coupled to avalanche photodiode
- cell planes are glued together to form a tracking sampling calorimeter

Standard Oscillation Systematics

- ν_μ **disappearance systematics:** muon energy scale, hadron energy scale, and scintillation model uncertainties combine to contribute 90% of the total systematic error for $\sin^2\theta_{23}$.

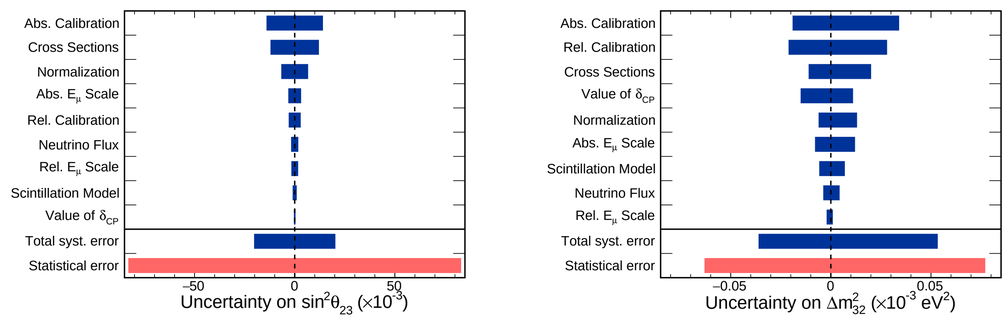


Figure 1: The uncertainty on the measured $\sin^2\theta_{23}$ (left) and Δm^2_{32} (right) due to each systematic.

- ν_e **appearance systematics:** energy calibration and detector response contribute 50% of the total systematic error.

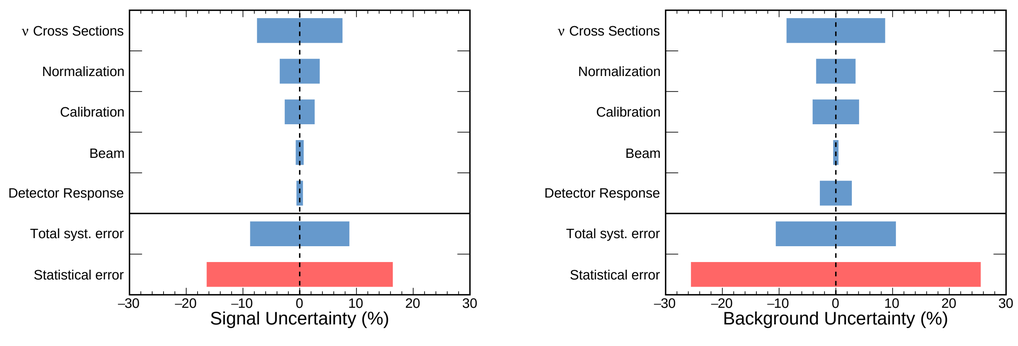
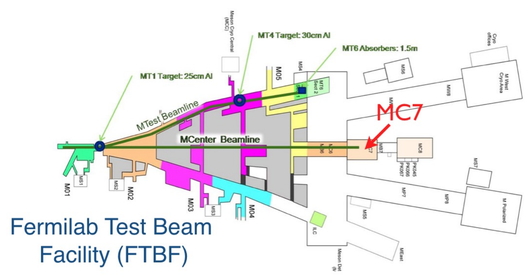


Figure 2: The uncertainty in the ν_e signal (left) and background (right) due to each systematic.

- these uncertainties will be addressed by the test beam program

Test Beam Program Overview

- under development at the MC7 area of Fermilab Test Beam Facility
- direct 0.3 to 2 GeV/c tagged electrons, muons, pions, kaons, and protons onto a downsized NOvA detector, in order to
  - study hadronic, muonic, and electromagnetic responses
  - build libraries for particle identification, among others
- data taking is scheduled to start in early 2019



Tertiary Beamline

- secondary hadronic beam (8 to 64GeV/c) directed onto a Cu target
- particle identification: time of flight (< 200 ps), Cherenkov counter
- momentum reconstruction (< 2%): dipole magnet, wire chambers

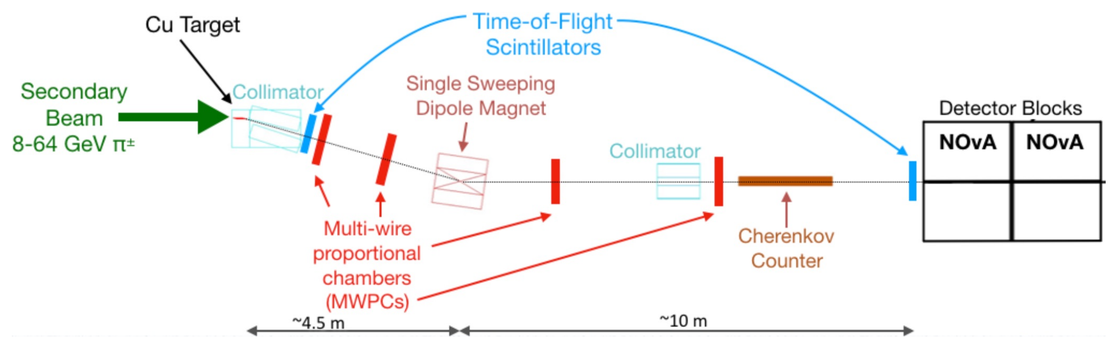


Figure 3: Tertiary beamline schematic (top) and its picture (bottom).

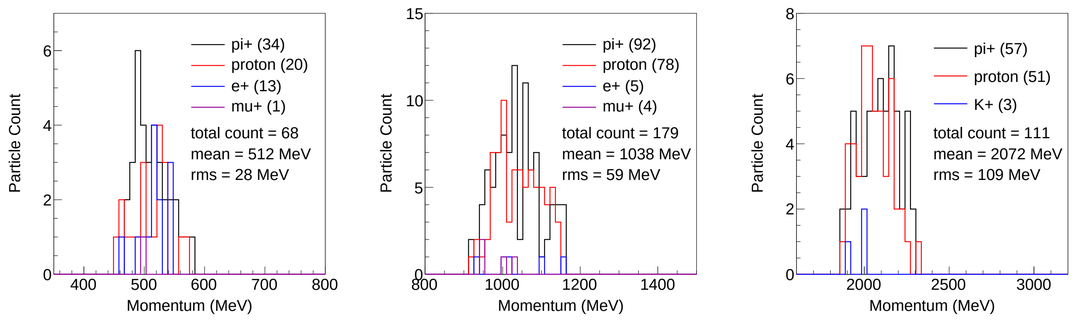


Figure 4: Simulated particle momenta for $B = 0.45$ T (left), 0.9 T (middle), and 1.8 T (right) using 9 million 64 GeV beam particles.

Test Beam Detector

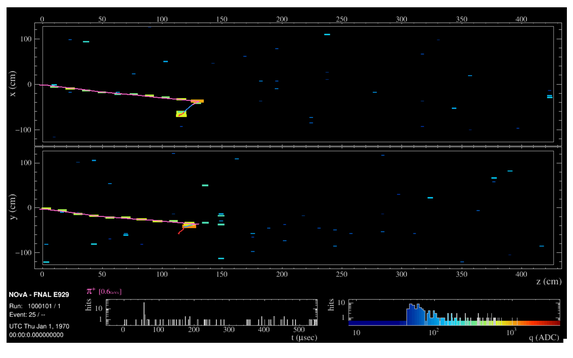


Figure 5: Left: 64 cells by 63 planes test beam detector (2.6 m × 2.6 m × 3.9 m). Right: a simulated 0.6 GeV π^+ in test beam detector.

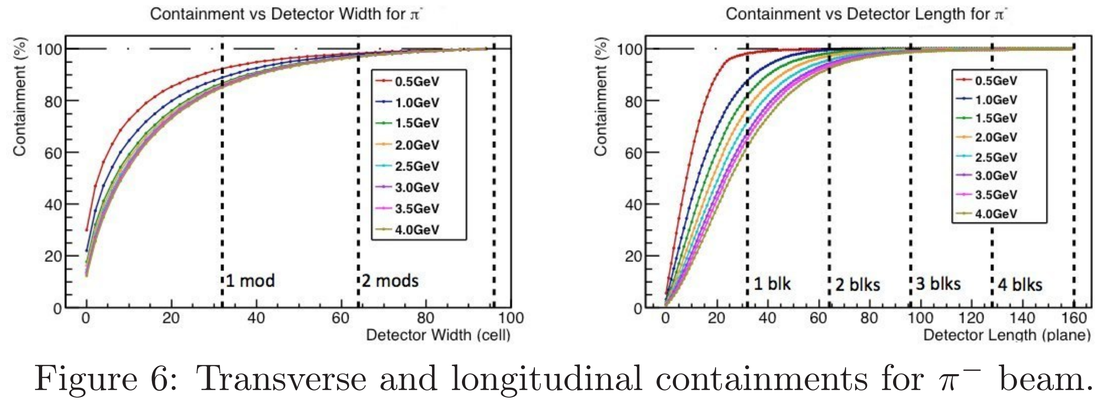


Figure 6: Transverse and longitudinal containments for π^- beam.