Pions in the NOvA Test Beam

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The NOvA Experiment

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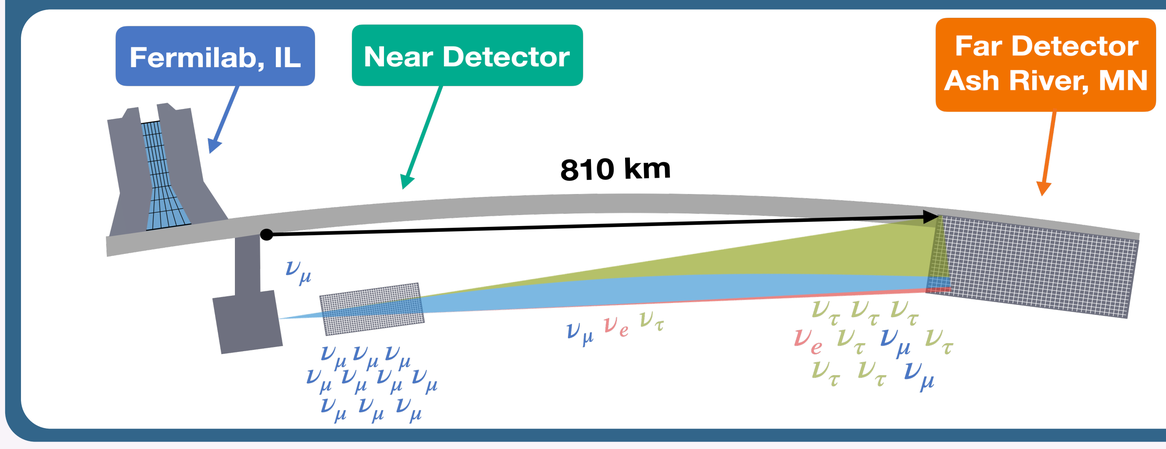
- NOvA (NuMI Off-Axis ν_e Appearance)
- Long-baseline neutrino oscillation experiment
- Neutrinos detected after 1 km by the Near Detector (290 ton)
- And 810 km away at the Far Detector (14 kt)



NOvA Test Beam Experiment

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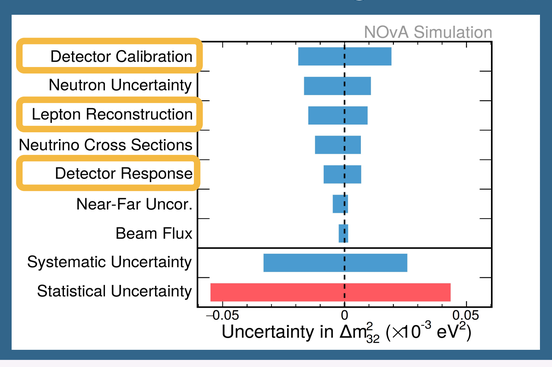
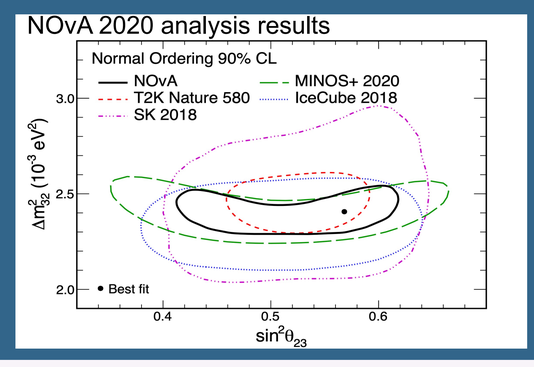
- It aims to understand some of the largest systematic uncertainties, such as detector response, detector calibration, and lepton reconstruction
- It uses a scaled-down NOvA detector (30 ton)
- Detector exposed to a beam of charged particles
- Beam composed of e, μ, π, K, p (0.4 to 1.8 GeV/c)
- Four momentum settings: 0.5, 0.75, 1 and 1.25 GeV/c





NOvA Test Beam Components

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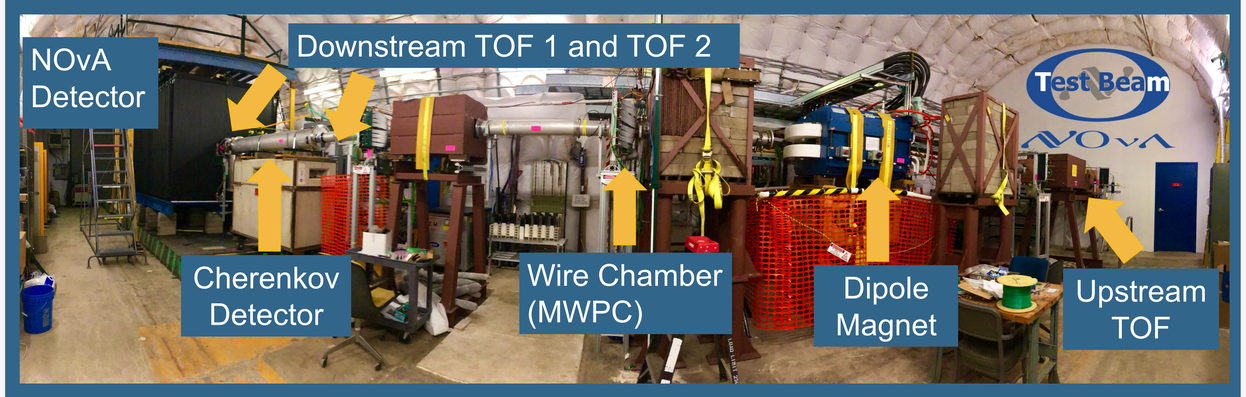
- **Time Of Flight (TOF) system**: Measures the time of flight of the beam particles
- **Dipole Magnet**: Selects momentum and charge of the particles through their deflections in the field
- **Wire Chambers (MWPCs):** Track particles through the beamline
- **Cherenkov Detector**: Tags electrons in the beam using Cherenkov light. The detector contains CO2 at 1 atm pressure
- **NOvA Detector**: Tracking calorimeter filled with liquid scintillator



Test Beam Experiment Panoramic picture

Run from 2019 to 2022

Pion Selection

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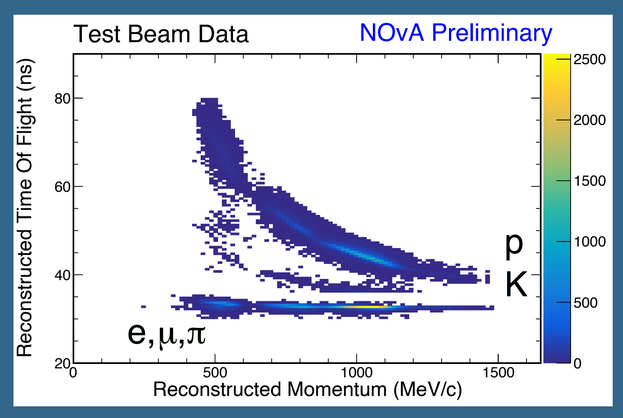
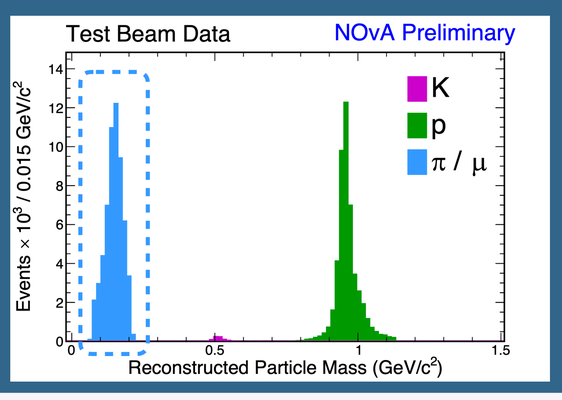
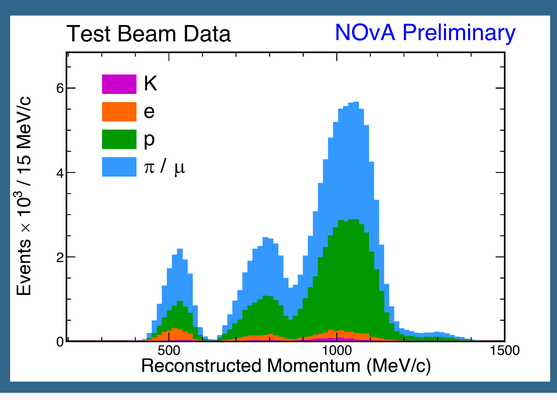
- Beamline instrumentation effectively separates slow from fast particles
- Cherenkov Detector tagging assists in filtering electrons
- Pions/muons selected from the sample (~4% total μ contamination)
- Pions/muons passed beamline and detector Data Quality selection criteria







Pions in the NOvA Detector

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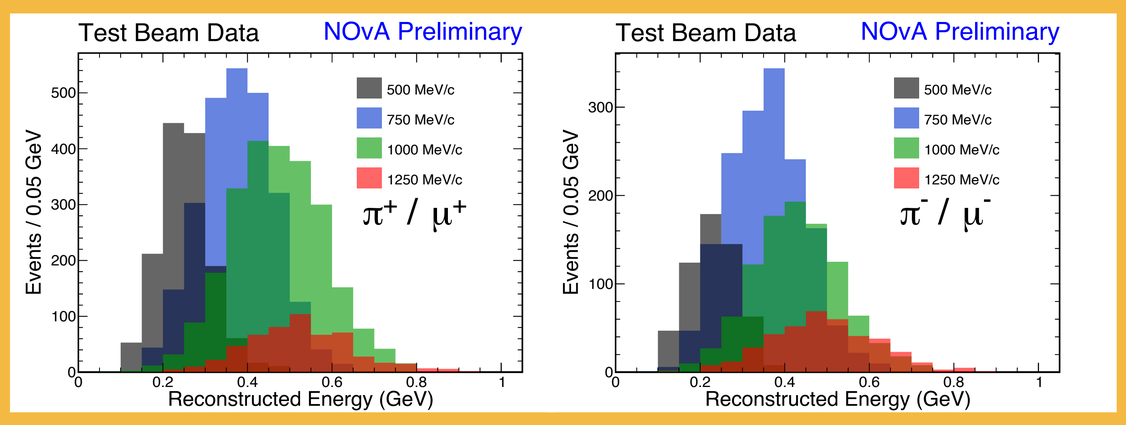
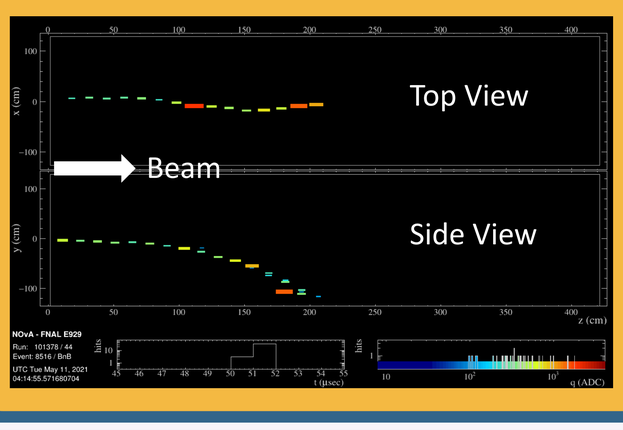
- Reconstructed Calorimetric Energy for selected pions/muons
- Samples separated by particle charge
- Reconstructed energy in the NOvA detector crucial for ongoing energy response studies





Pion Candidate

- **Event display showing a selected pion candidate with reconstructed momentum of 0.8 GeV/c**

Beamline Momentum Correction

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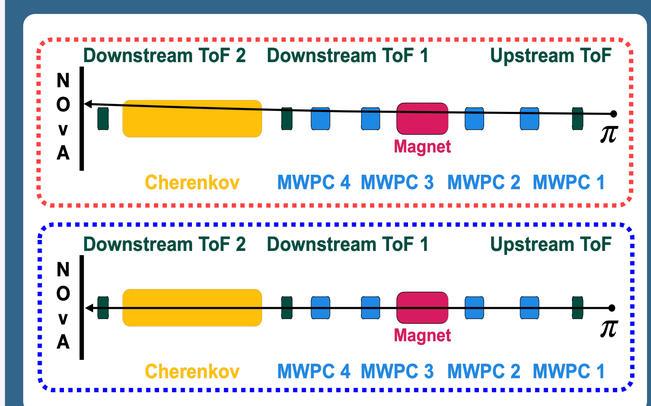
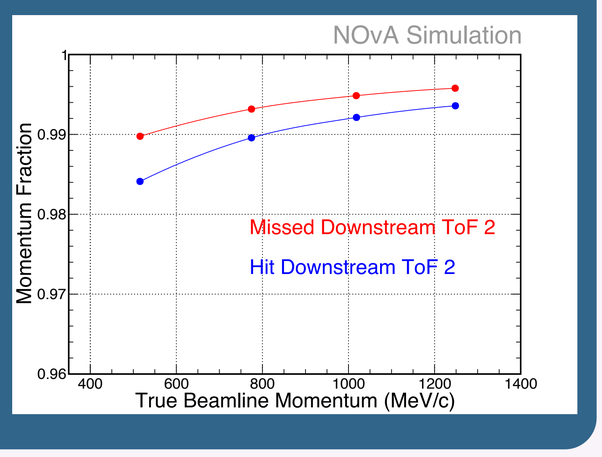
- Vital for energy response studies
- Missed and Hit Downstream TOF 2 samples
- Maximum energy loss in the beamline material ~ 10 MeV/c
- Momentum fraction aims to correct the beamline reconstructed momentum





Future Goals

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- Study data and simulation comparisons for positive and negative charge pions
- Assess the impact of beamline and detector systematics on the detector response
- Improve our understanding of some of the largest systematic uncertainties in NOvA analyses

Fermilab

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