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NOvA Test Beam Detector Calibration

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NOvA experiment

NOvA performs precision measurements of energy dependent ν_μ->ν_μ/ν_e and $\bar{\nu}_\mu$->$\bar{\nu}_\mu/\bar{\nu}_e$ oscillation effects between the near and the far detectors.

Energy (except for muons) is measured through the detectors' calorimetry.

Precision of the detectors' energy calibration is critical for NOvA's efforts!

Energy Calibration

1. Get equal response to energy deposited throughout each detector

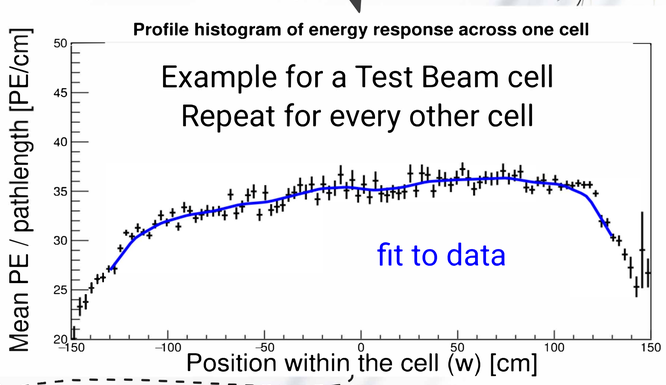
COSMIC MUON SAMPLE

Photo electrons (PE)
cell ID, plane ID
position in cell from ⊥ planes (w)
pathlength through cell [cm]

READOUT

THE TRI-CELL CONDITION

Apply correction for bias from cosmics (from simulation)



PE Corrected = PE (w, cell) * $\frac{\text{constant PE/cm}}{\text{fit result (w,cell)}}$

Save scale to database for future use

2. Get physical response equal among the detectors

Only select muons decaying into a Michel electron

Select cell hits 100-200 cm from end of track

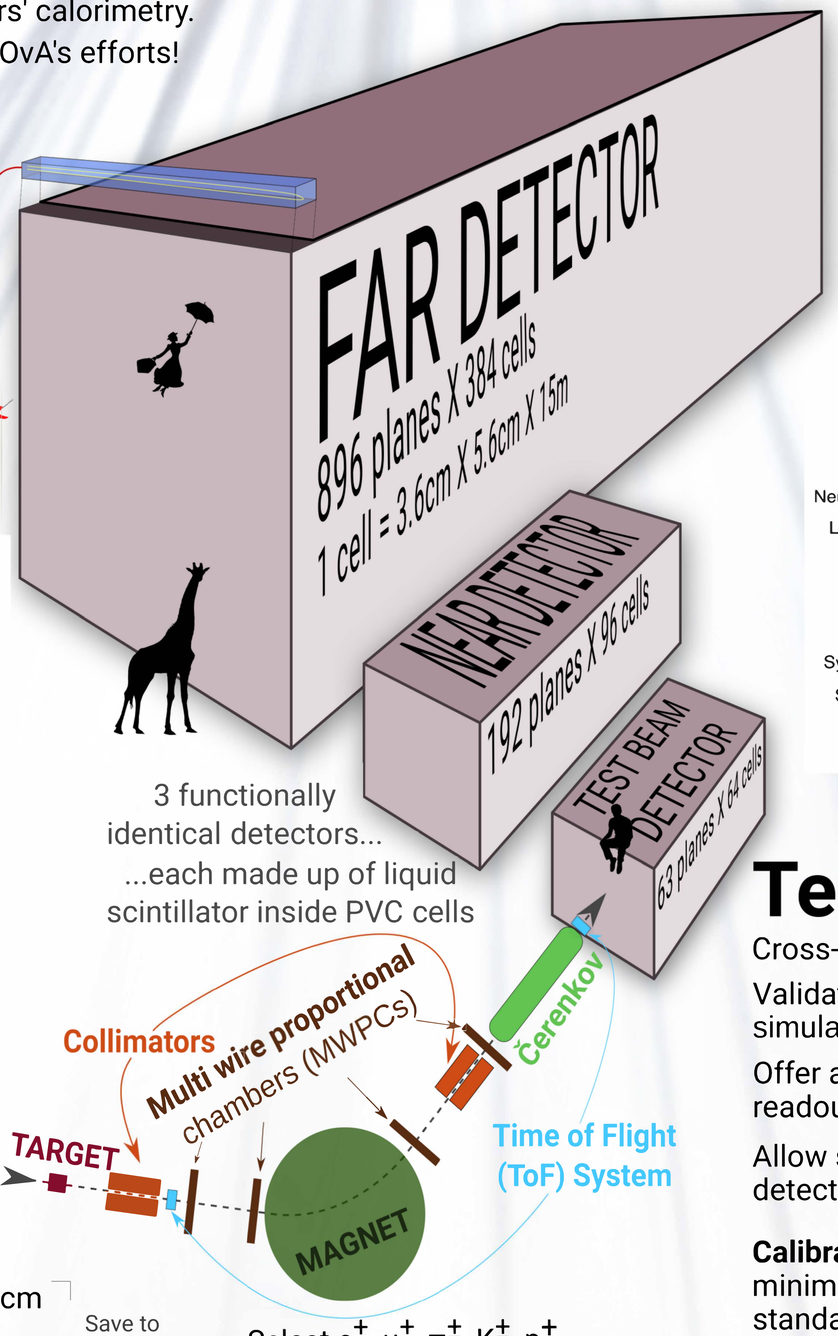
STOPING MUON SAMPLE

Well known energy deposition from Bethe-Bloch!

Detector response in physical units (MeV) = PE Corrected * $\frac{\text{Mean true response MeV/cm (from simulation)}}{\text{Mean response PECorrected/cm}}$

Save to database

*cosmics, not rain...
That umbrella won't help you



3 functionally identical detectors...
...each made up of liquid scintillator inside PVC cells

Select $e^\pm$, $\mu^\pm$, $\pi^\pm$, $K^\pm$, p^+
Measure their tracks and momenta

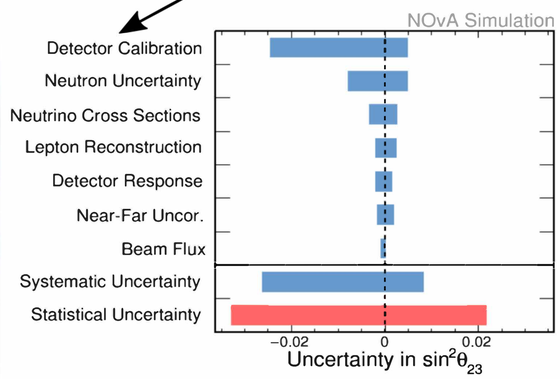
Uncertainties from calibration

Compare energy deposition between
Calibrated data VS Calibrated simulation

...in time
Detector ageing

...in shape
Energy deposition at cell edges (large |w|) isn't very well covered by our calibration

...in normalization
Compare dE/dx of beam (non-cosmic) muons and protons; Michel e^- spectrum; π^0 mass peak. Shift in both same and opposit direction between near and far detectors.



More detail in:
"An Improved Measurement of Neutrino Oscillation Parameters by the NOvA Experiment"; arXiv:2108.08219

LARGEST systematic uncertainty for oscillation analyses!

Test Beam detector will:

Cross-check absolute energy scale data/simulation comparisons;

Validate improvements to light level tune and Čerenkov tune in simulation;

Offer alternative method, independent of simulation, to translate readout (PE) to physical units (MeV);

Allow studies of temperature and seasonal effects of the detector's energy response.

Calibration of the NOvA Test Beam detector is essential to minimise any possible differences between the Test Beam and the standard detectors and to allow for direct comparisons!

Poster #455

Learn more about NOvA Test Beam and calibration on posters #272, #525, #532

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