Electron Detection in the Reference Near Detector for DUNE and Constraints on the Anti-Electron-Neutrino Normalization

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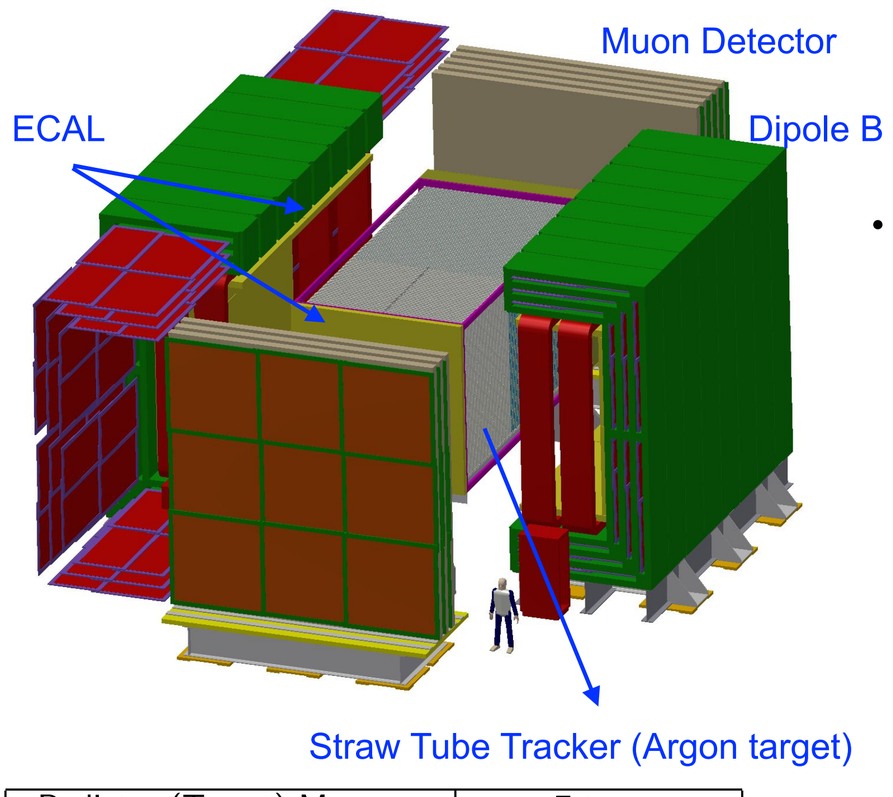
On behalf of the DUNE Collaboration

Overview

DUNE is a long-baseline neutrino experiment aiming to solve remaining questions in neutrino physics by measuring ν_μ to ν_e/$\bar{\nu}_\mu$ to $\bar{\nu}_e$ oscillation in one single experiment. It is therefore critical for DUNE to identify and measure the electrons and positrons precisely. The fine-grained tracker (FGT), the reference near detector for DUNE, is designed to provide a precise determination of the electron/positron identification, momentum, and energy.

A Fine-Grained Tracker (FGT) As the DUNE ND

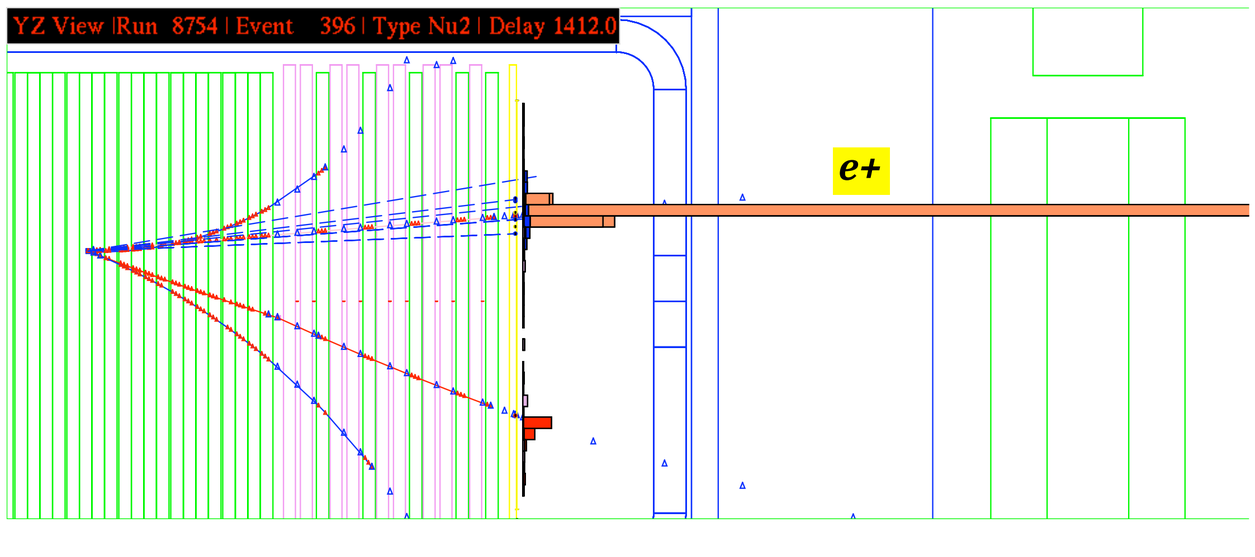
- ~3.5m×3.5m×6.5mSTT ($\rho \simeq 0.1$ g/cm^3).
- 4π ECAL in a dipole magnetic field (B = 0.4 T).
- 4π MuID (RPC) in dipole and up/downstream.
- Pressurized ^{40}Ar target ≃ ×10 FD statistics and ^{40}Ca target.



Radiator (Target) Mass	7 tons
Other Nuclear Target Mass	1–2 tons
Vertex Resolution	0.1 mm
Angular Resolution	2 mrad
E_e Resolution	$6\%/\sqrt{E}$ (4% at 3 GeV)
E_μ Resolution	3.5%
$\nu_\mu/\bar{\nu}_\mu$ ID	Yes
$\nu_e/\bar{\nu}_e$ ID	Yes
π^- .vs. π^+ ID	Yes
π^+ .vs. *proton* .vs. K^+	Yes
NCπ^0/CCe Rejection	0.1%
NCγ/CCe Rejection	0.2%
CCμ/CCe Rejection	0.01%

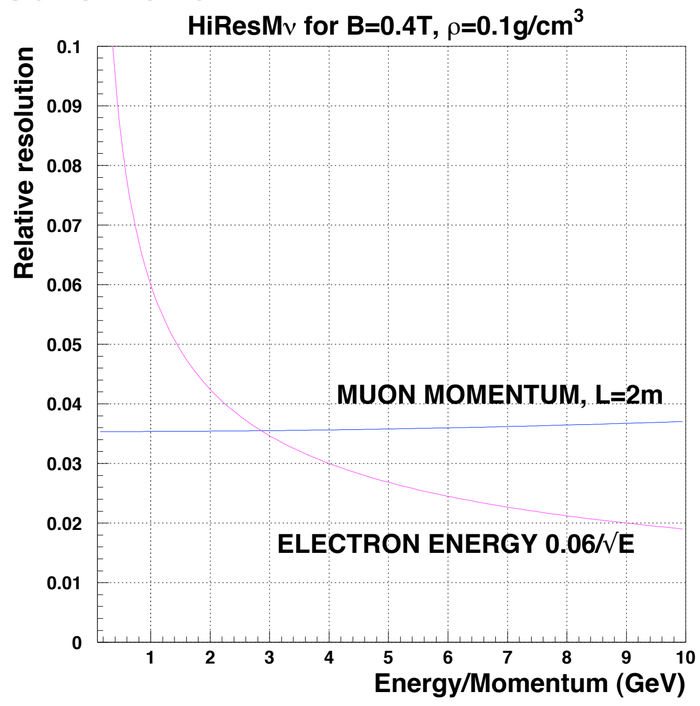
Anti-Electron Neutrino Event in FGT

- Electrons and anti-electrons make tracks in the FGT.
- Hadrons are also tracks.
- Able to measure lepton and hadron momentum vectors with high precision



Electron Momentum Measurement

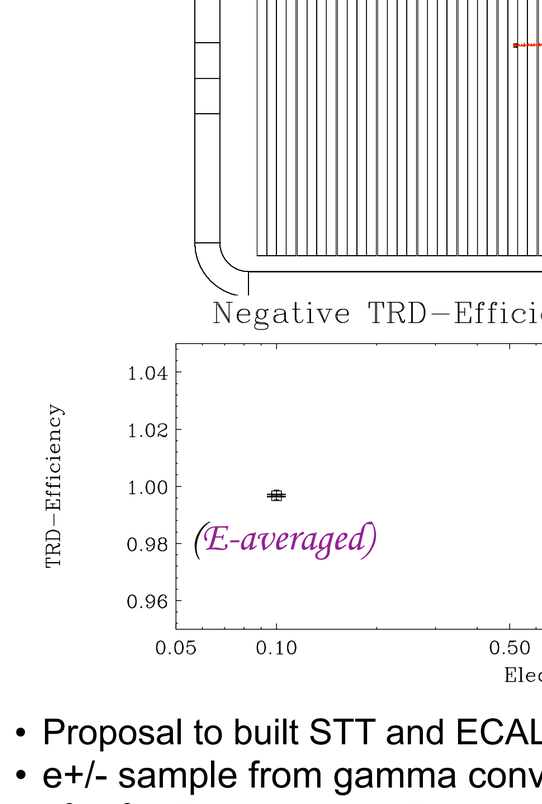
- Use the track curvature in the dipole magnetic field for the momentum measurement.
- Use ECAL for more precise energy measurement
- e+/e- momentum resolution: ~ 3.5% (at ~3 Gev).
- Dipole magnetic field allows distinguish e+ for e-, and therefore a measurement of anti-electron neutrino content in the beam.

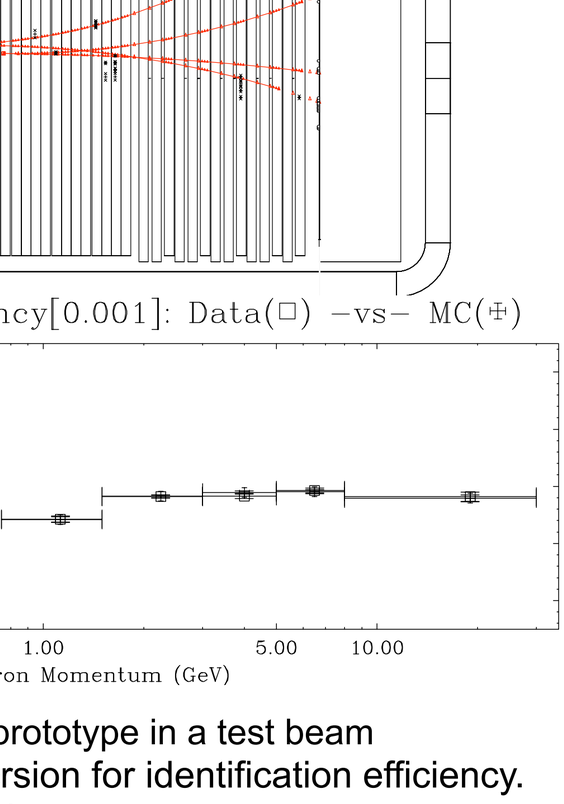


Electron Identification

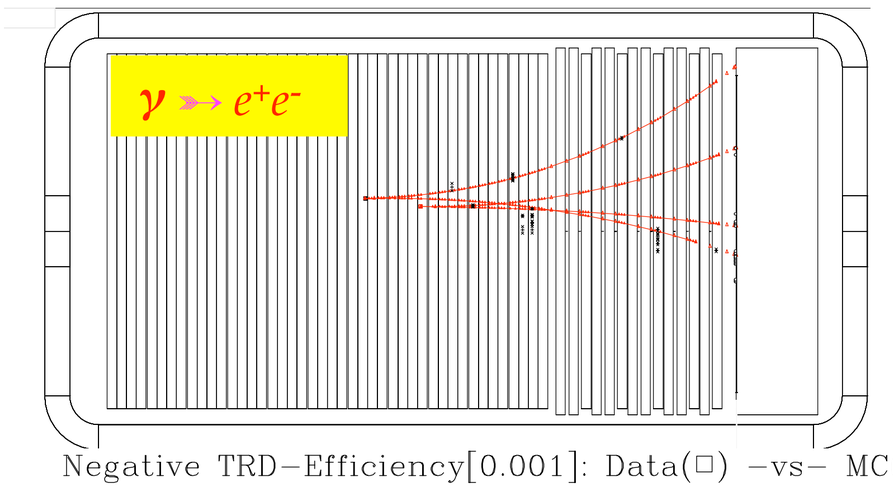
Informations that can be used for identification of electron:

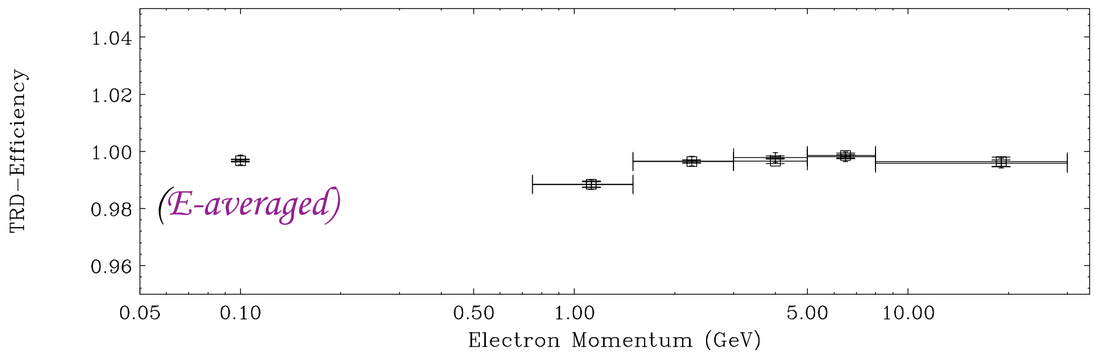
- Transition radiation (TR) measurement in the Staw Tube Tracker (STT).
- Longitudinal and transverse energy deposition pattern in the ECAL.
- Pattern of energy loss (helical track-fit) in STT.
- Efficiency ~58%, Purity > 90%. (p>0.5GeV, from fast MC)





Electron Measurement Validation





- Proposal to built STT and ECAL prototype in a test beam
- e+/- sample from gamma conversion for identification efficiency.
- π^0 /K^0/η for energy scale constraint.
- Experience from other experiments: NOMAD (STT), NOvA (ECAL).

Summary

A Fine-Grained Tracker ND for DUNE is able to precisely identify and measure electrons and positions. The particle identification involves measurements of the transition-radiation in the high-resolution straw tube tracker (STT) and the profile of the energy deposition in the ECAL; the momentum is determined from the track reconstruction in the STT within a dipole B-field. The ability to reconstruct the electron/positrons and the hadrons from the anti-electron neutrino interactions permits an accurate determination of the anti-electron neutrino content of the beam.