The Low-Energy Neutrino Factory

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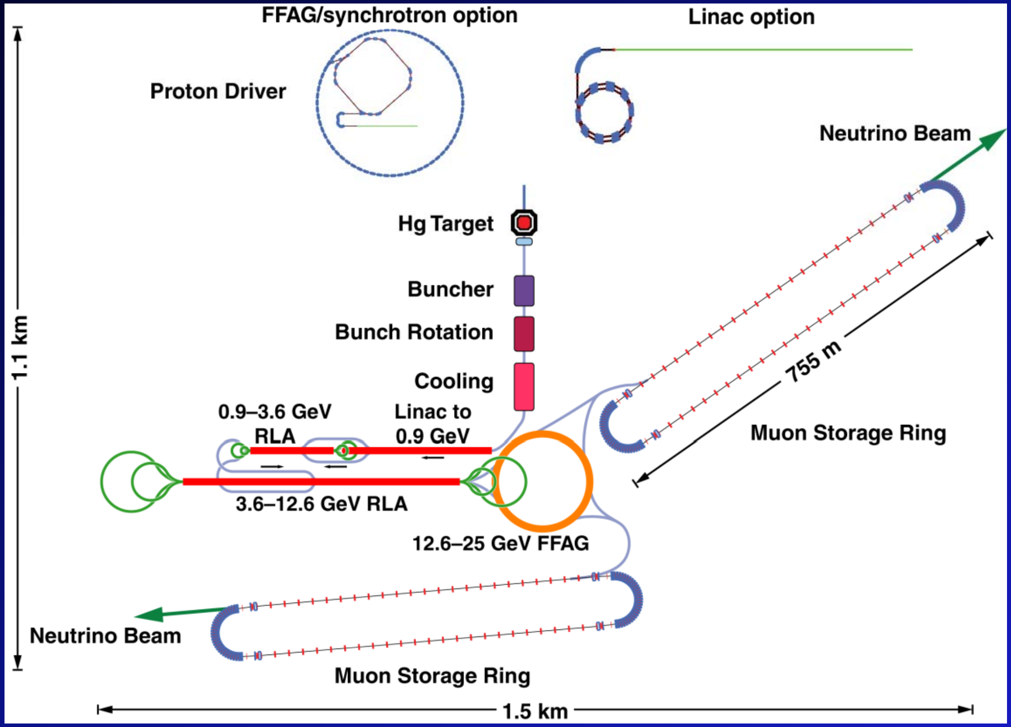
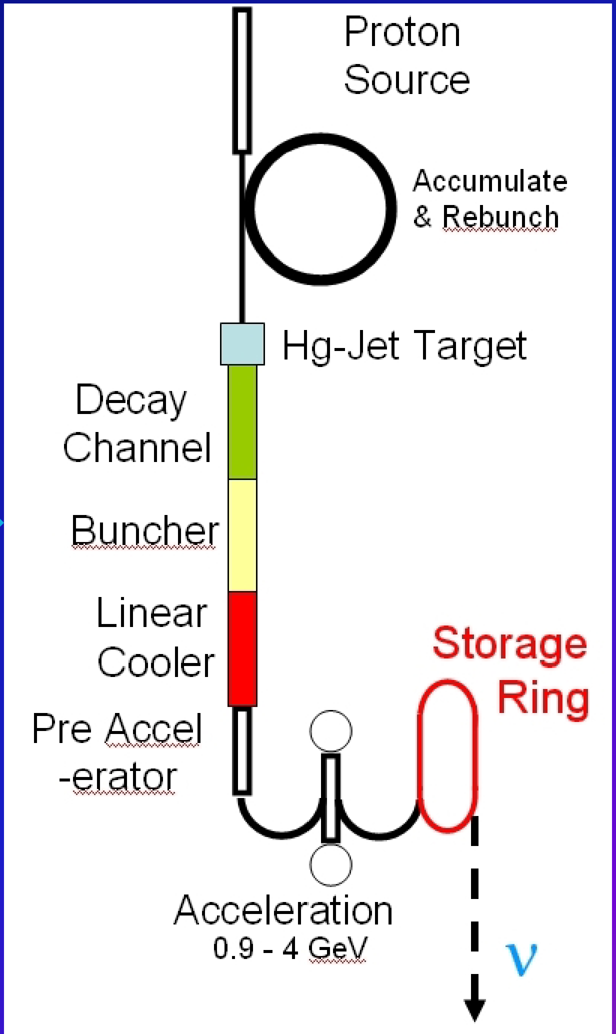
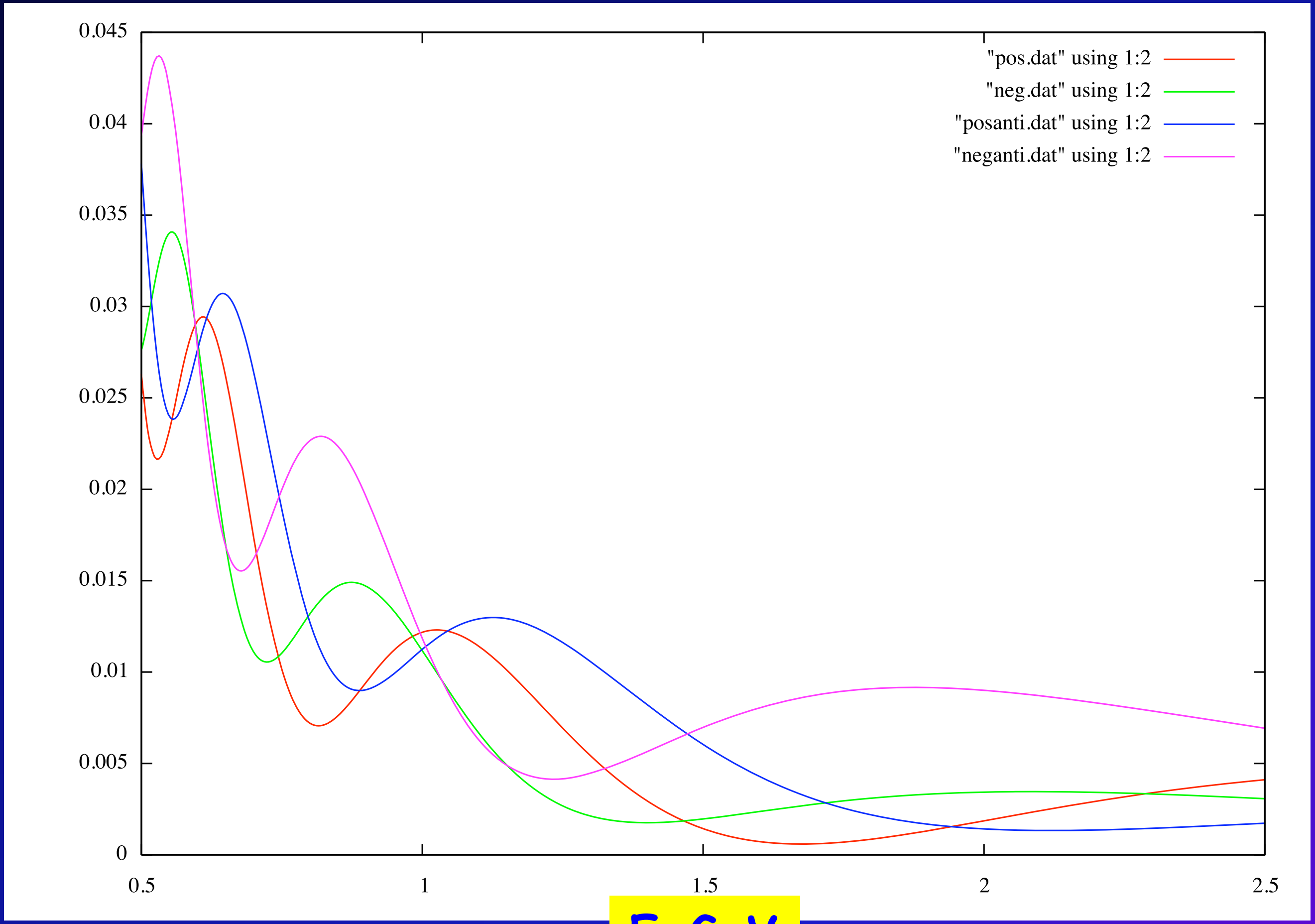
Low Energy Neutrino Factory Concept





Cost Savings of up to $500M

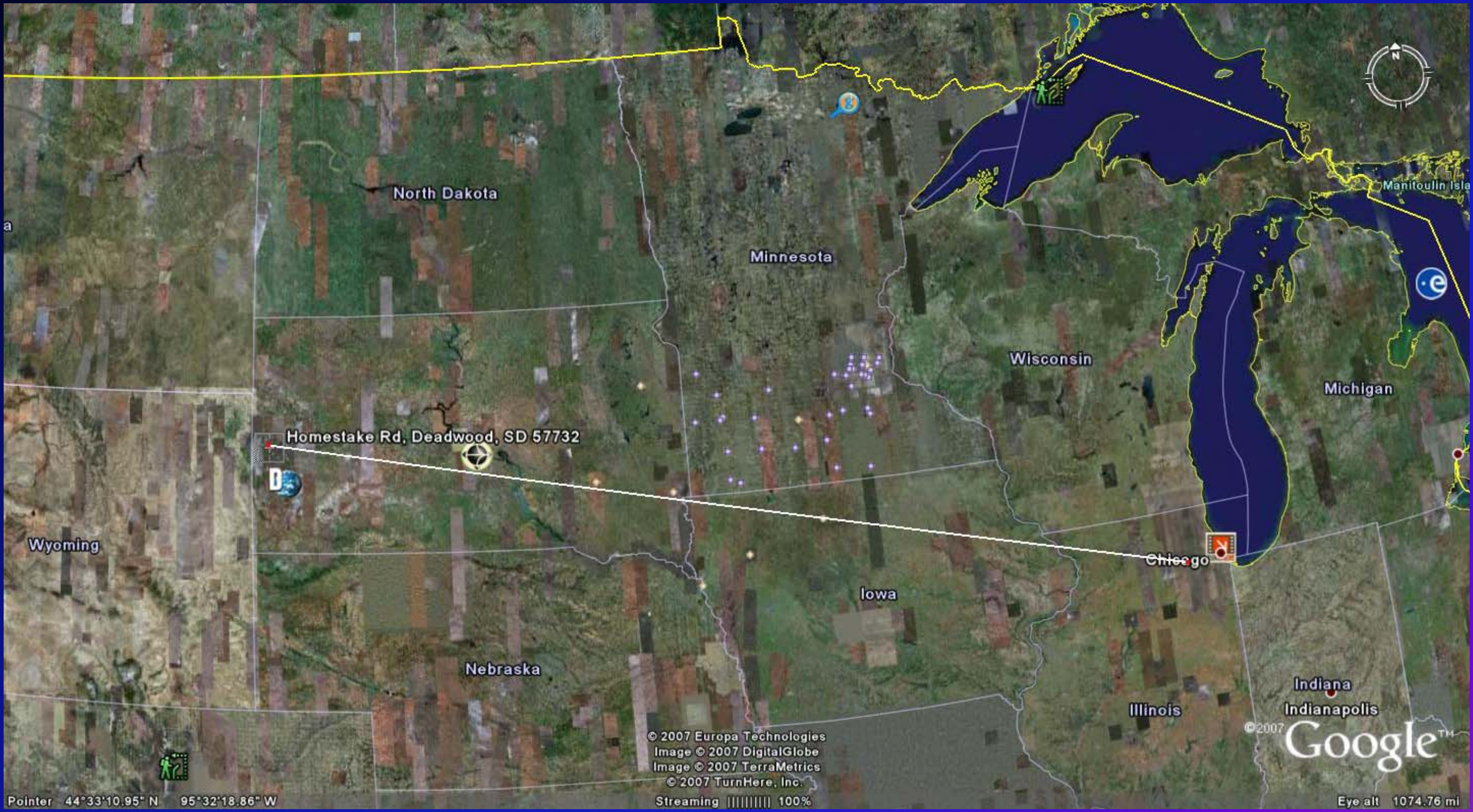
At Baseline of approximately 1300 km



E_ν GeV

- Very rich oscillation pattern at low energy → 0.5 to 1.5 GeV

Which is Quite Convenient
Fermilab ⇒ DUSEL

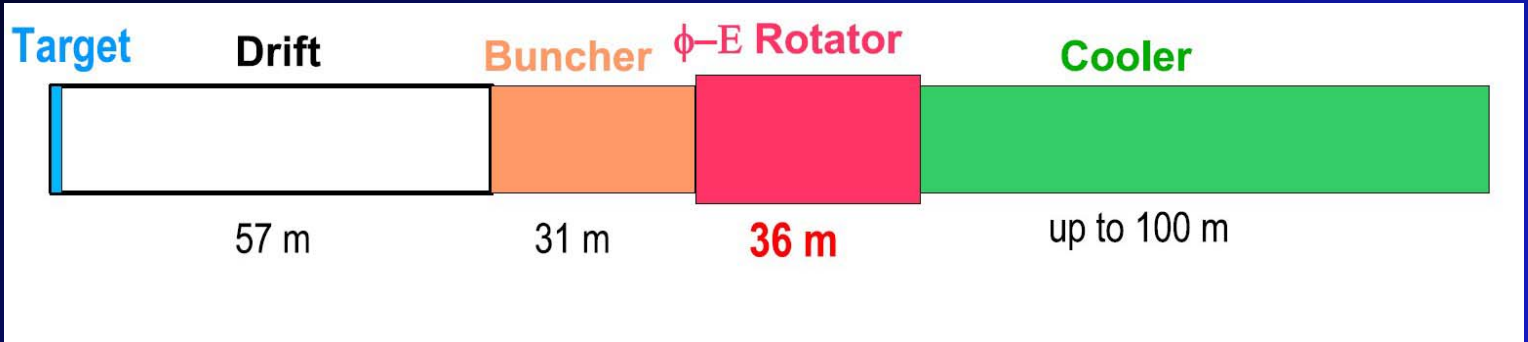


Low Energy Neutrino Factory Design Update

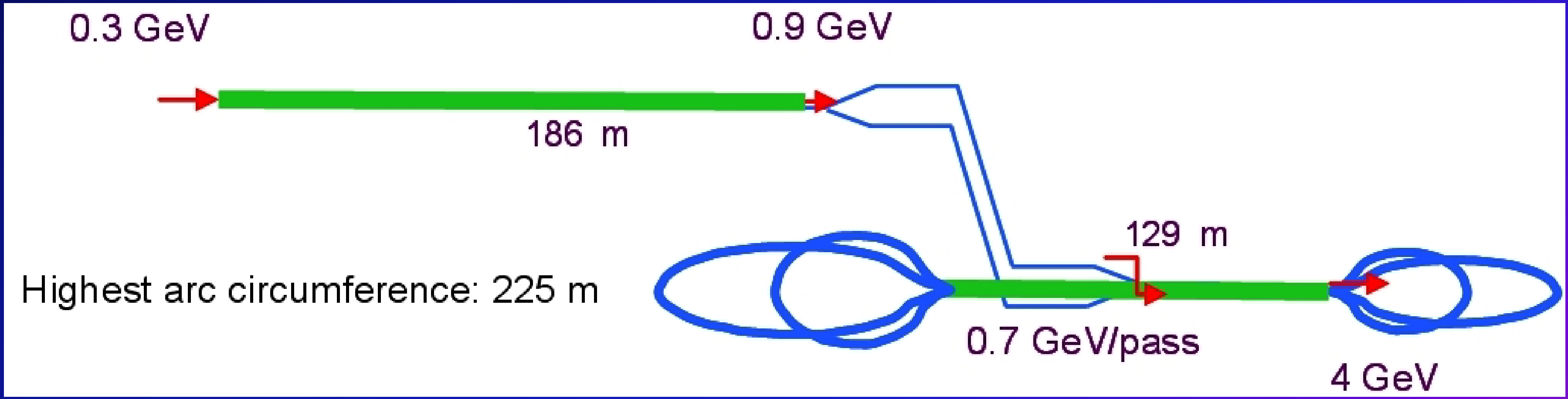
- New Design Study iteration*
  - Based on previous design, but
    - Improved bunching and phase rotation system
    - New acceleration system
    - Storage ring optimized for 4 GeV
      - Permanent magnet design
      - L $\approx$ 300 m (Fermilab $\rightarrow$ DUSEL beam line pitch = 6°)
- $\approx$ 1.4 X 10^{21} μ^+ (μ^-) decaying in straight/yr

*FERMILAB-PUB-09-001-APC

LENF Subsystems



μ/p within reference acceptance = 0.085 at end of cooler (75m)

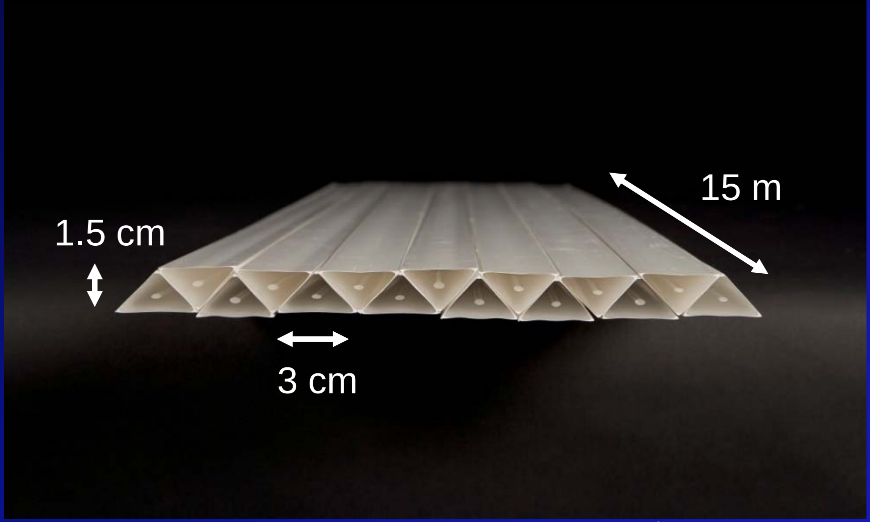


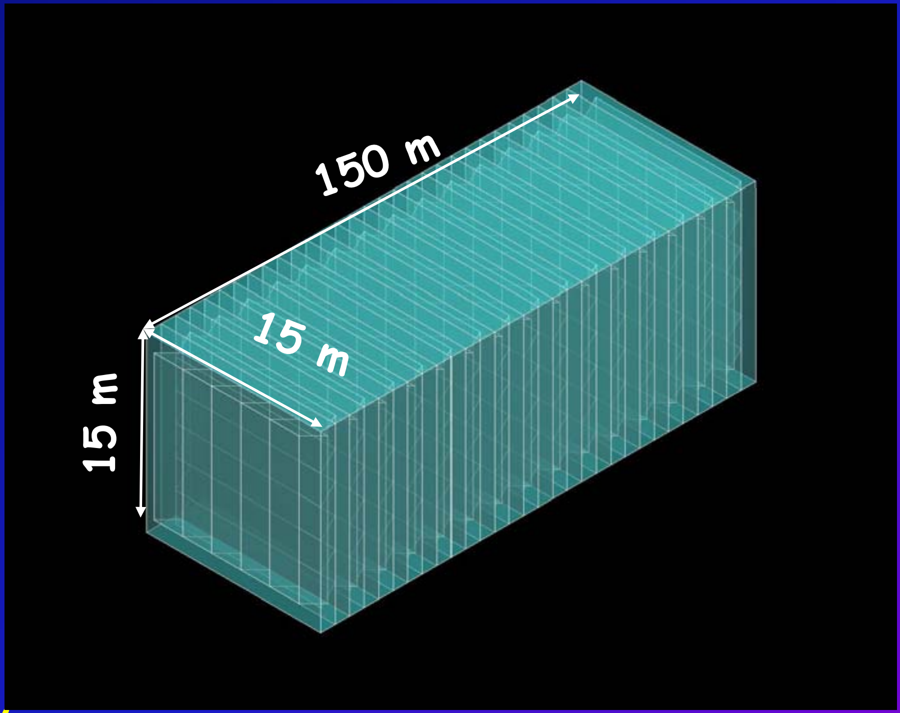
μ survival at 4 GeV ≈ 85%

Fine-Resolution Totally Active Segmented Detector

Simulation of a Totally Active Scintillating Detector (TASD) using Nova and Minerva concepts with Geant4

- 35 kT (total mass)
- 10,000 Modules (X and Y plane)
- Each plane contains 1000 cells
- Total: 10M channels



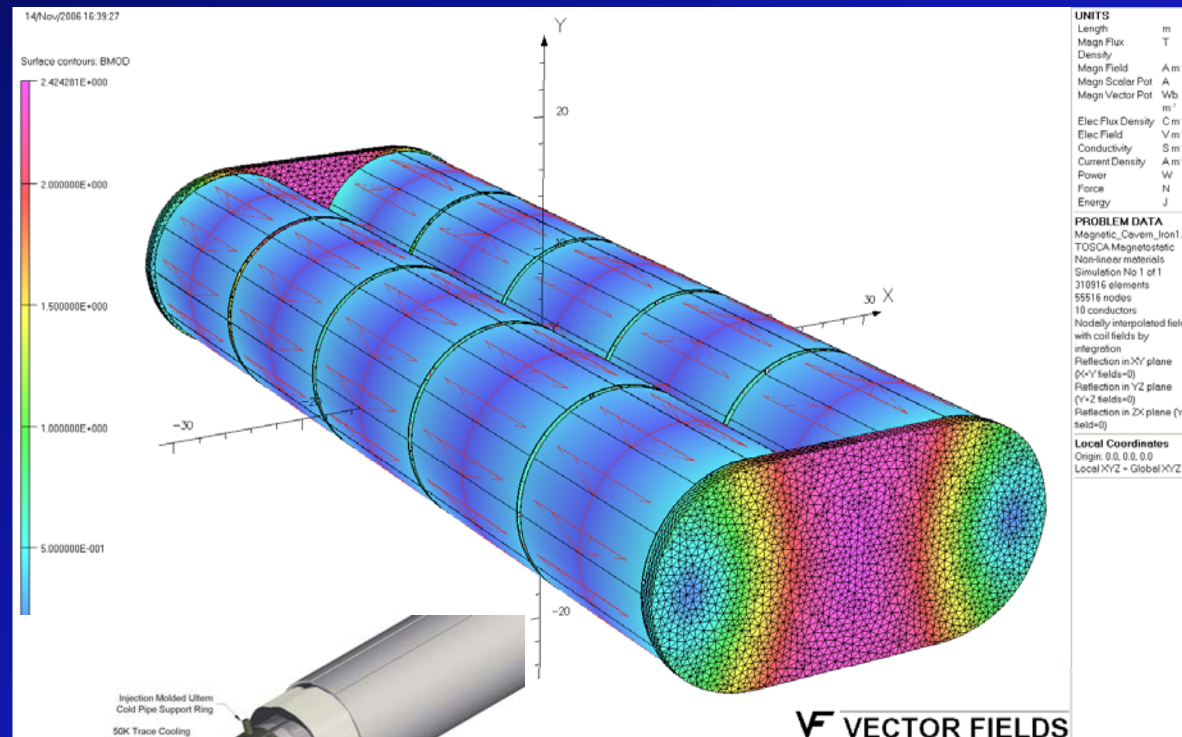


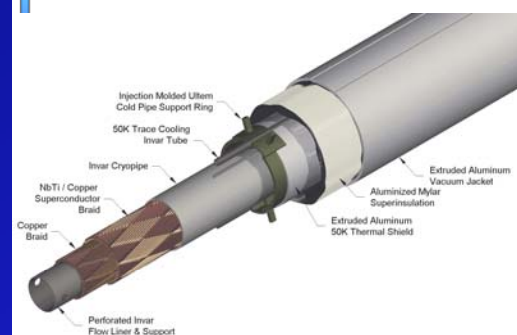
- Momenta between 100 MeV/c to 15 GeV/c
- Magnetic field considered: 0.5 T
- Reconstructed position resolution ~ 4.5 mm

B = 0.5T

Detector Has to be Magnetized

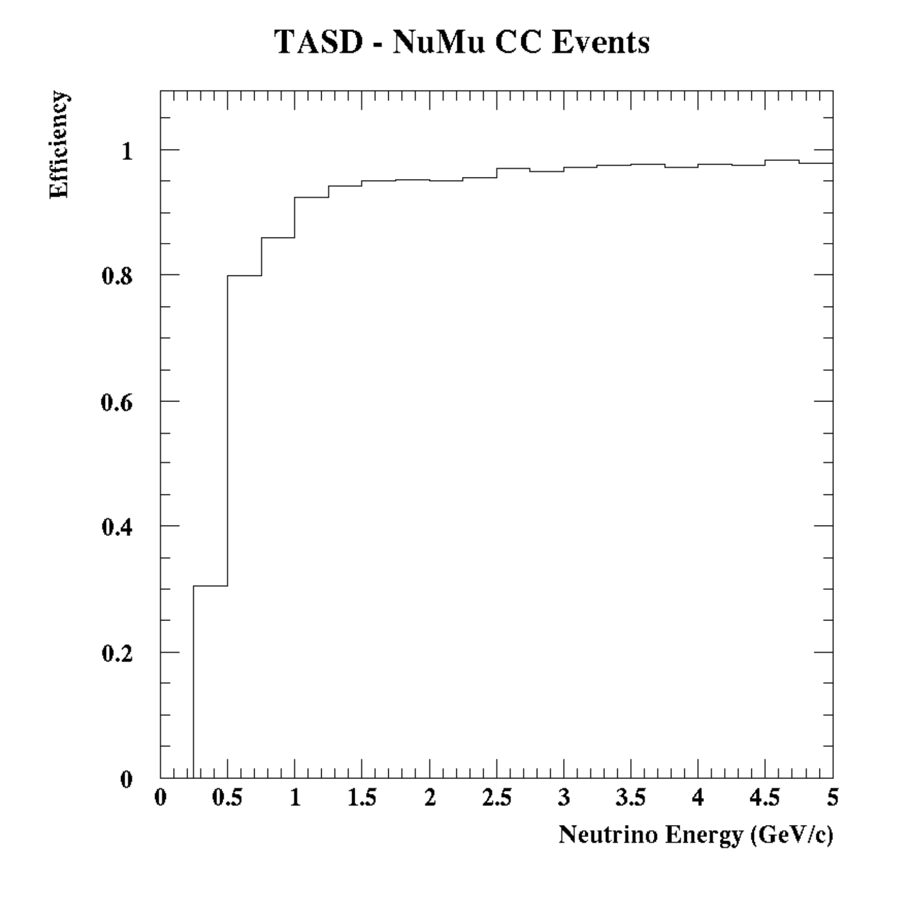
- Magnetized Totally Active Sampling Calorimeter 35kT
- Magnets
  - 15m ∅ X 15m long -0.5T
  - Times 10!
  - Cost estimate
    - $140-680M
      - Conventional SC
- New Ideas
  - High T_c SC
    - No Vacuum Insulation
  - VLHC SC transmission line
    - Technically proven
    - Might actually be affordable



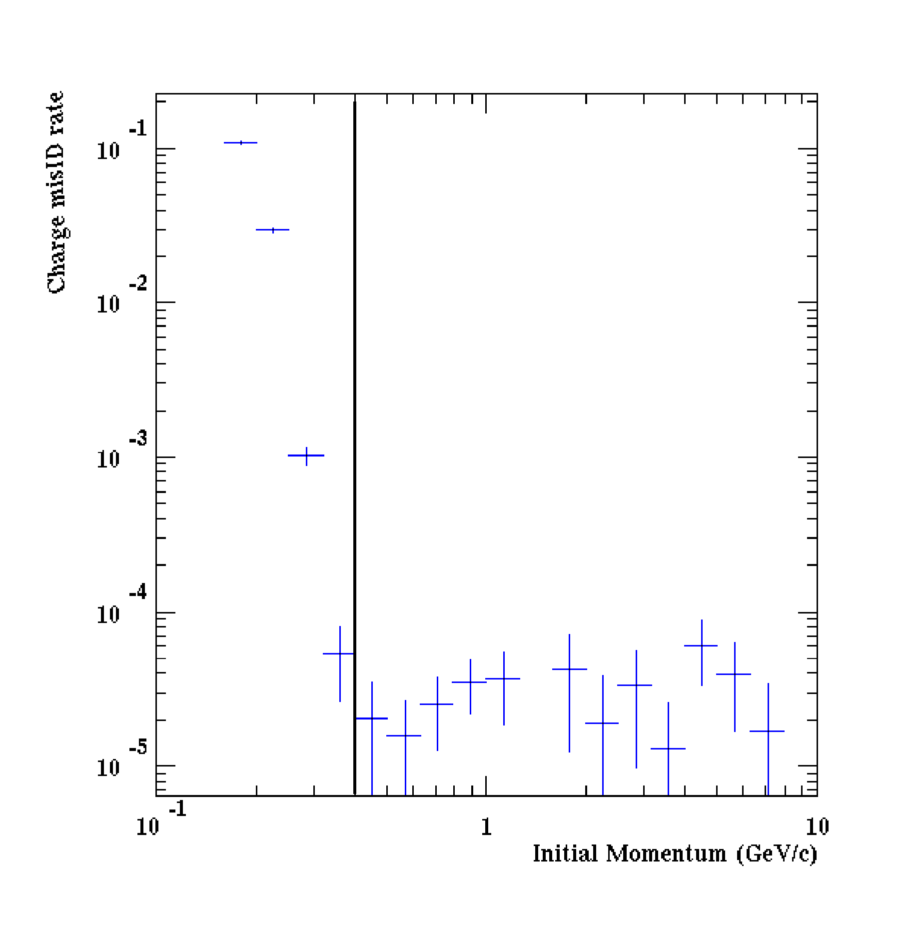


TASD Performance

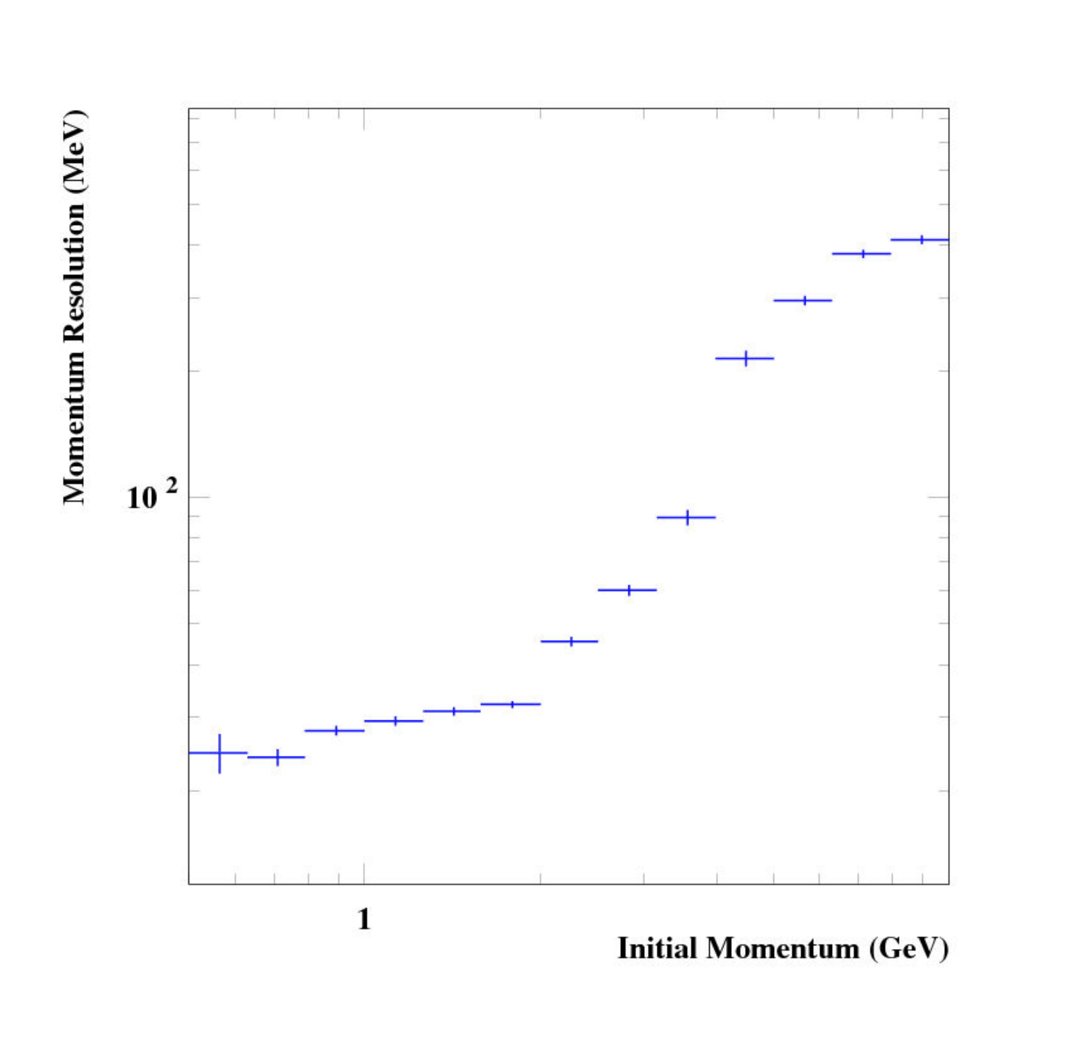
ν Event Reconstruction Efficiency



Muon charge mis-ID rate



TASD Performance II



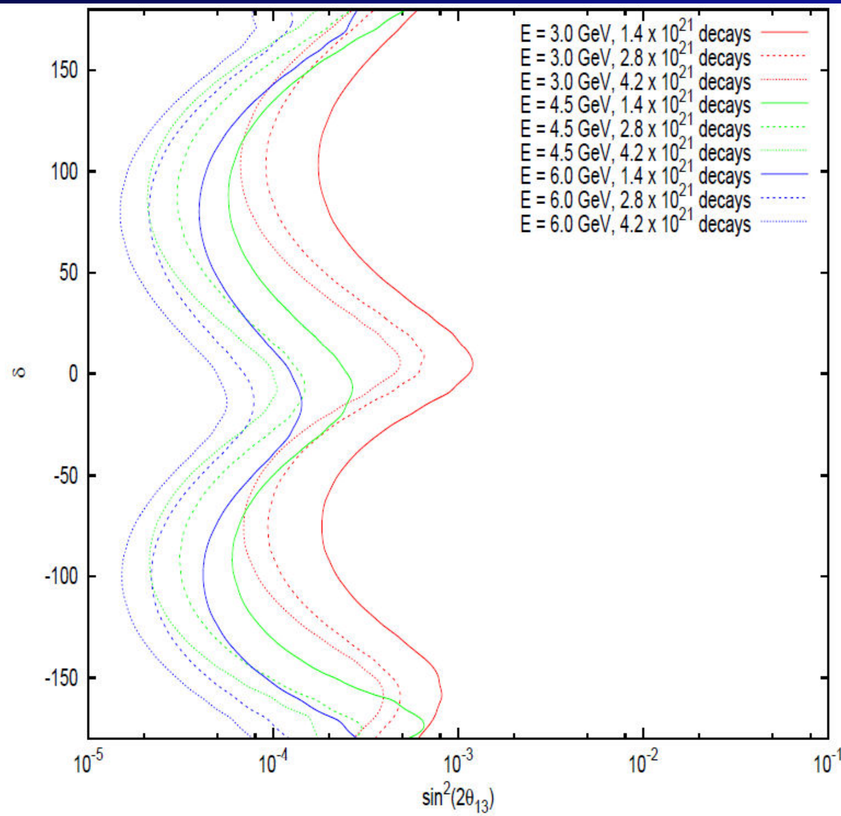
- Momentum resolution excellent
  - Neutrino Event energy reconstruction from tracking
  - EM component from hit counting possibly
- Simplifies electronics
  - No calibration needed
  - Hit efficiency is only consideration
- Expect
  - $\sigma(E_{evt}) \approx$ 5-10% @ 2GeV
    - Based on extrapolations from Nova simulations

The Physics Study*

- Baseline: 1480km (FNAL-Henderson)
  - Also did Homestake to Fermilab
- Choose NF Energy ~ 4 GeV (Actually 4.12 GeV). This is motivated by the realization that for baselines O(1000km), if θ_{13} is not very small, the oscillation pattern is extremely rich below ~4 GeV.
- Detector energy threshold of 500 MeV, $\delta E/E$ = 30%, ν CC event efficiency of 73%
- Central value assumptions
  - $\sin^2\theta_{12} = 0.29$, $\Delta m^2_{12} = 8\times10^{-5}\ eV^2$, $|\Delta^2_{31}| = 2.5\times10^{-3}\ eV^2$, $\theta_{23} = 40^o$
- δ = 0, 90, 180, 270
- High and Low statistics scenarios
  - 1×10^{23} and 3×10^{23} Kton-decays

* Phys.Rev.D77:093012,2008

Latest Results



(a) 3σ contour for θ_{13} sensitivity, using muon energies of 3, 4.5 and 6 GeV, and 1.4×10^{21}, 2.8×10^{21} and 4.2×10^{21} decays per year