Detectors for Leptonic CP Violation at the Neutrino Factory

R. Bayes[1], A. Bross[3], A. Cervera-Villanueva[2] , M. Ellis[4,5], A. Laing[1] , F.J.P. Soler[1] , and R. Wands[3]

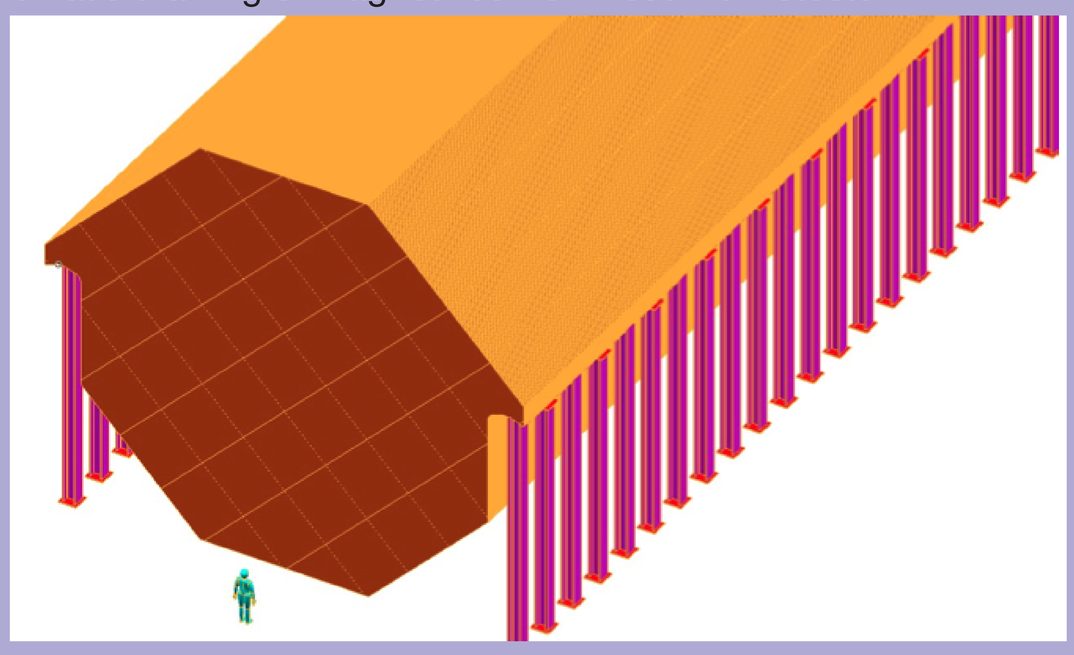
[1]University of Glasgow, [2]IFIC and Universidad de Valencia, [3]Fermilab, [4]Brunell University, [5]Westpac Institutional Bank, Australia,
on behalf of the IDS-NF collaboration

Introduction

- Proposed far detector for Neutrino Factory.
- To be used with a near detector for measurement of θ_{13} and δ_{CP}.
- Optimized to carry out "Golden Channel" measurements.
  - Looking for $\nu_e \rightarrow \nu_\mu$ or $\bar{\nu}_e \rightarrow \bar{\nu}_\mu$ oscillations.
  - Detects muon of sign opposite to that generated by neutrino beam.
- Simulation of detector needed to characterize parameter sensitivity

Conceptual Design for MIND

- Schematic drawing of Magnetized Iron Neutrino Detector

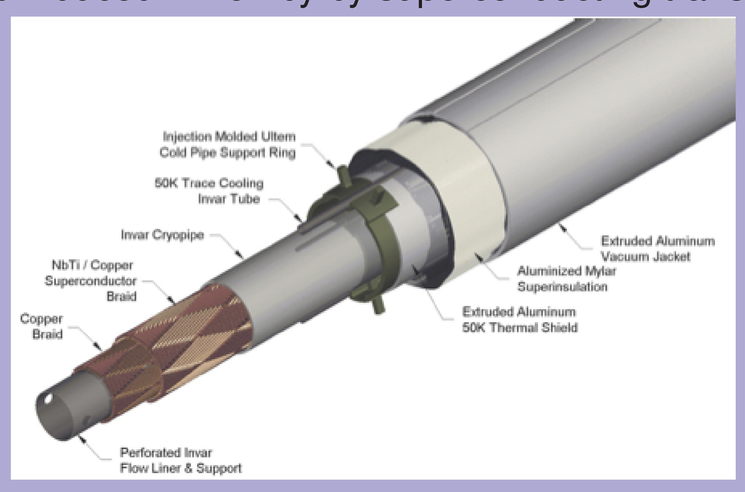


- Baseline parameters for MIND at two baseline distances

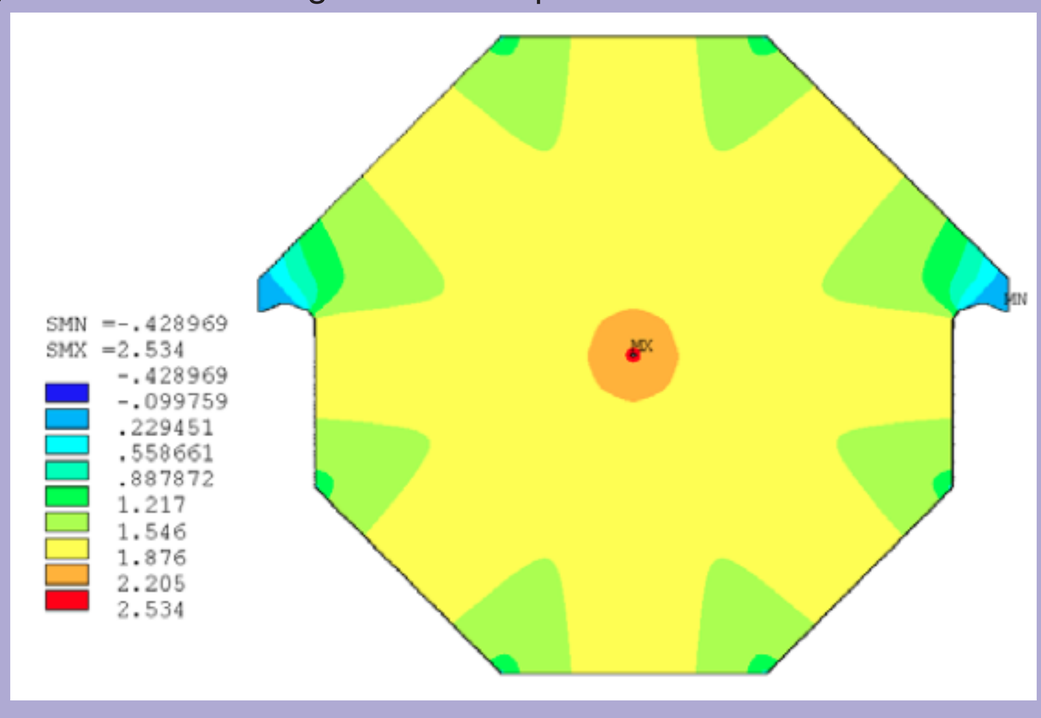
Parameter	MIND 1	MIND 2
Distance (km)	3000-5000	7000-8000
Fiducial Mass (kTon)	100	50
Iron Plate Dimensions (cm)	1500×1500×3	1500×1500×3
Length of Detector (m)	125	62.5
Number of Iron Plates	2500	1250
Scintillator Bar Dimensions (cm)	1500×3.5×1	1500×3.5×1
Number scinitillator bars per plane	429	429
Total number of scintillator bars	$\mathbf{2.14 \times 10^6}$	$\mathbf{1.07 \times 10^6}$
Total number of readout channels	$\mathbf{4.28 \times 10^6}$	$\mathbf{2.14 \times 10^6}$
Magnetic Field (T)	$> \mathbf{1}$	$> \mathbf{1}$

MIND Magnetic Field

- Required for identification of wrong sign muons.
- Magnetic field induced in iron by by superconducting transmission line

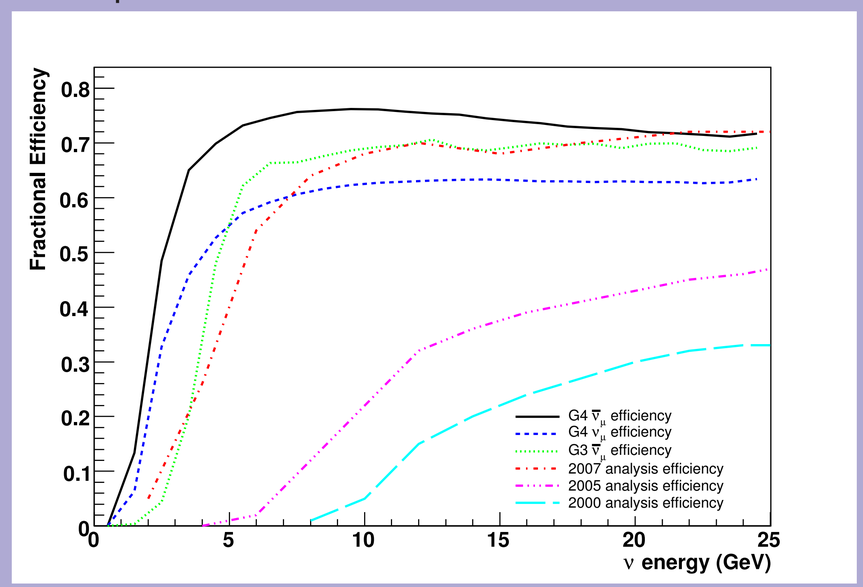


- Magnetic field in homogeneous iron plate

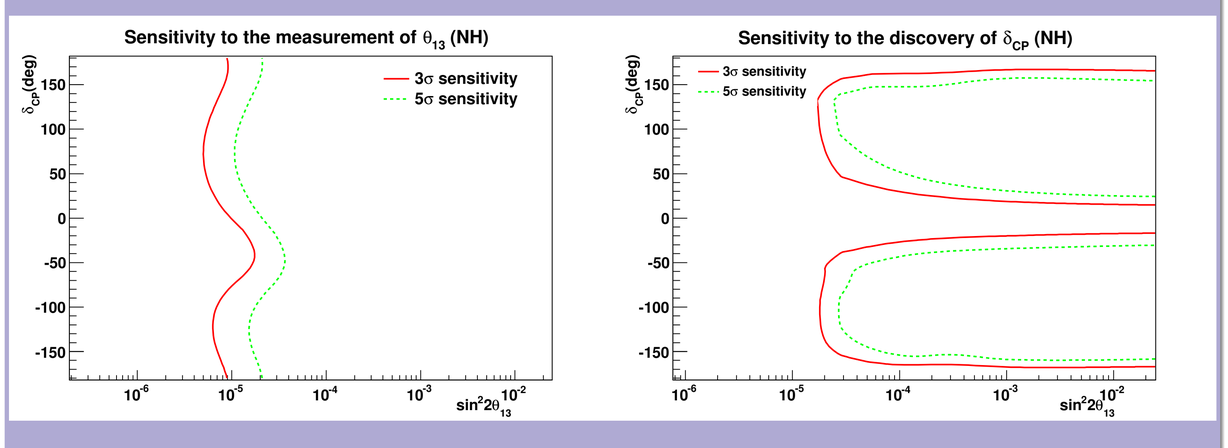


Simplified MIND Simulation

- Assumes a square cross section; 14 m×14 m×40 m.
- Uses a uniform, verticle, 1 Tesla Magnetic field.
- Alternating 3 cm iron and 2 cm scintillator planes used.
- Efficiency of simplified detector:

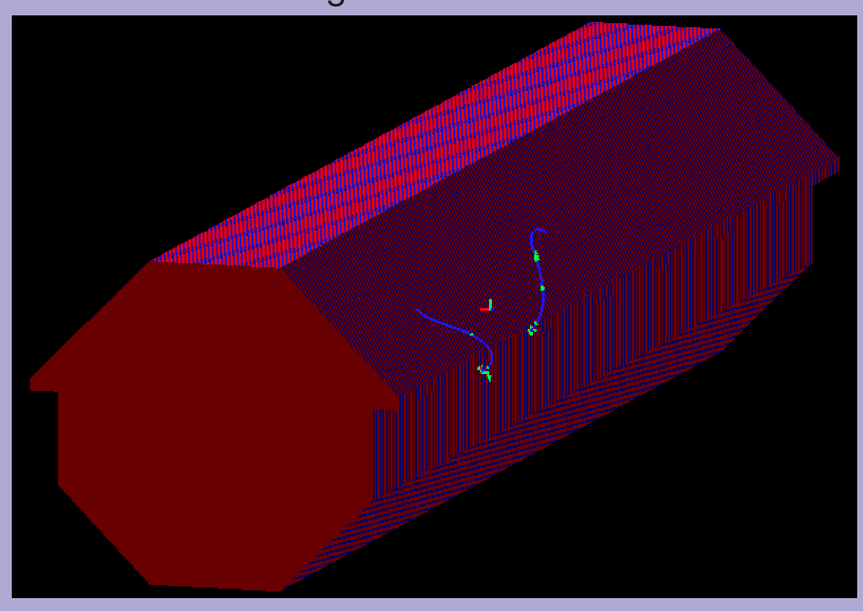


- Sensitivity of detector to δ_{CP} and θ_{13} in normal heirarchy:



Toward a Realistic MIND Simulation

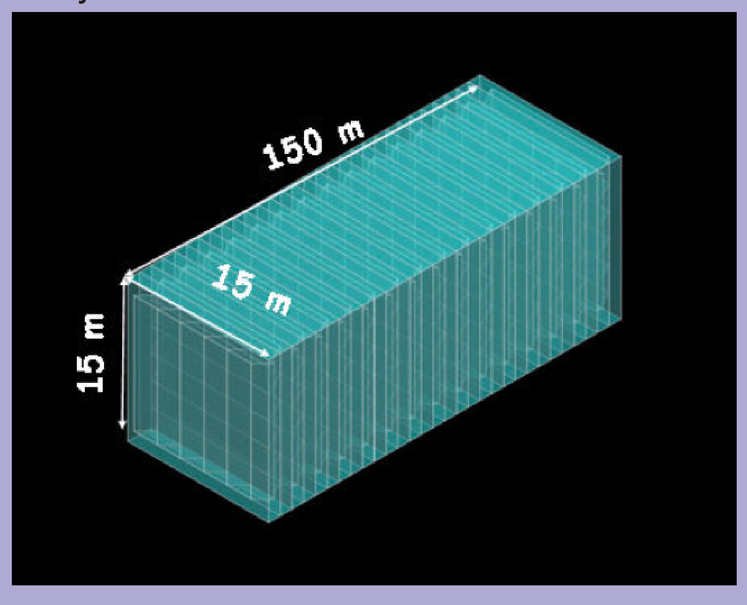
- Replaced NUANCE neutrino generater with GENIE.
- Adopted octagonal geometry in simulation.
- Introduced a realistic, toroidal field map.
- Simulation of two events using GEANT 4:



- Re-optimization of reconstruction for this environment in progress.

Alternate Far Detector: Totally Active Scintillating Detector

- Composed entirely of scintillator bars



- Can also measure $\nu_\mu \rightarrow \nu_e$ and $\bar{\nu}_\mu \rightarrow \bar{\nu}_e$ oscillations.
- Magnetic field must be generated external to the detector.