Town hall meeting
Israeli Neutrino Input to the European Strategy for Particle Physics

Adi Ashkenazi
05/12/2018

The hanging Neutrinos

Many properties of the neutrino are still unknown.

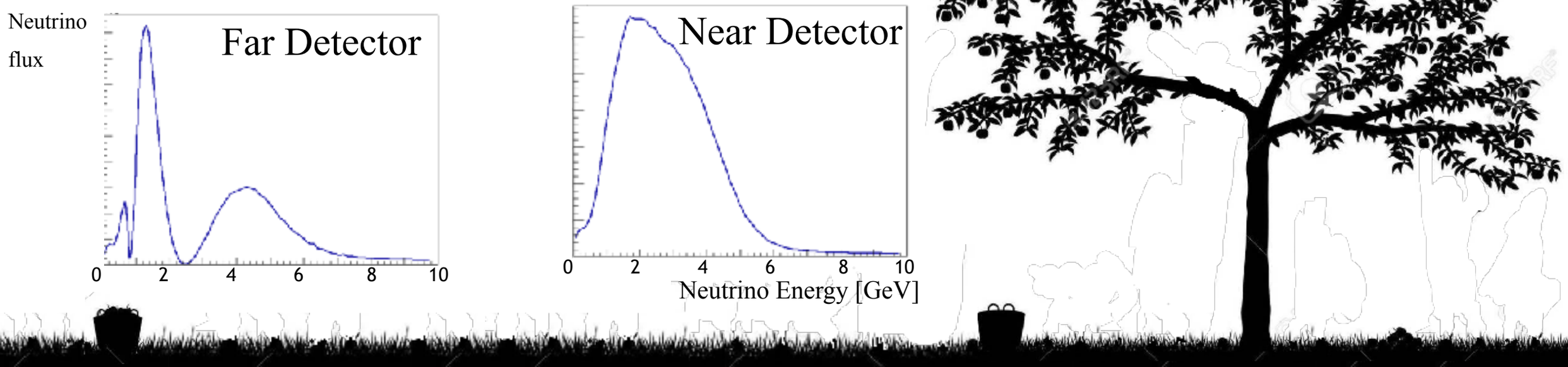
The known ones are very hard to explain using the SM.

Measuring neutrino properties became a popular tool to search for new physics beyond the standard model.

The hanging Neutrino Oscillations

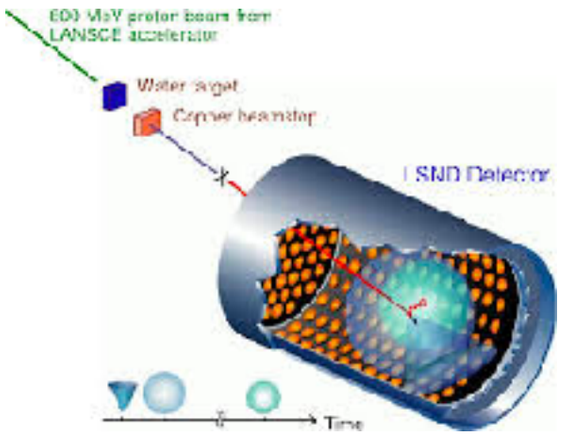
Oscillation precision measurements:

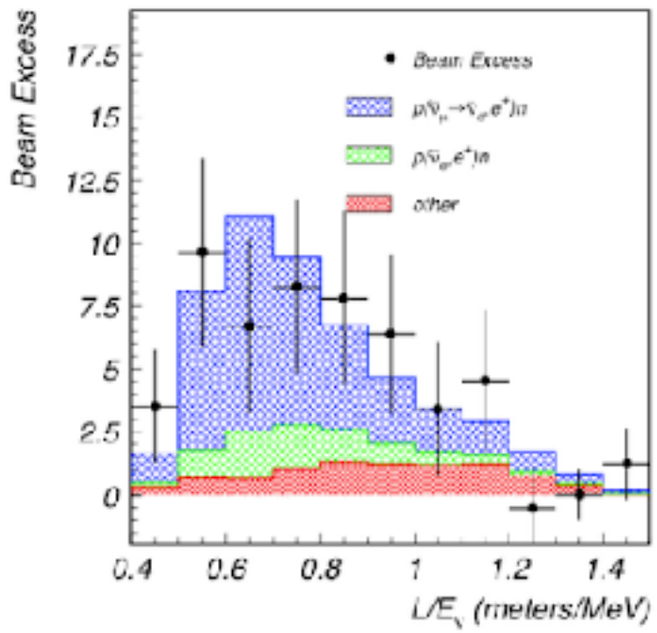
$$P\left(\nu_\mu \rightarrow \nu_x\right) = \sin^2(2\theta) \times \sin^2\left(\frac{\Delta m^2 L}{4E_\nu}\right)$$



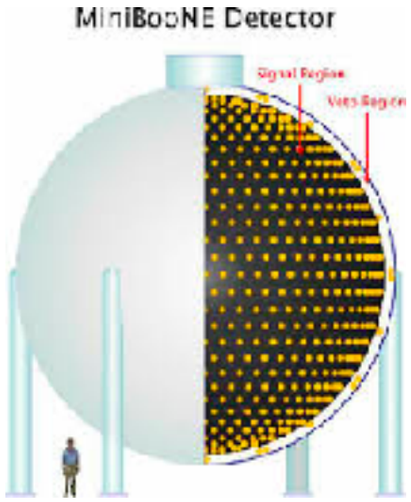
The hanging Neutrino Anomalies

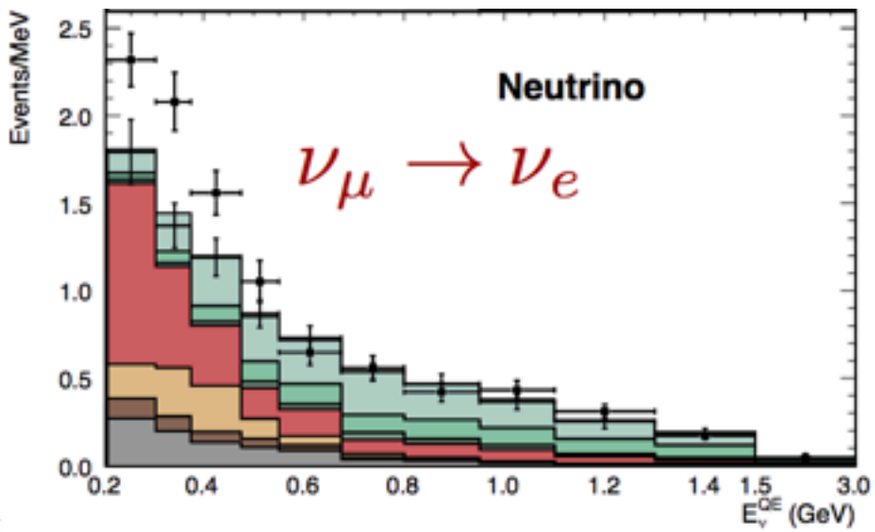
Current anomalies including the LSND and MiniBooNE low energy excess.





CCQE





NCπ^0

Current Plan

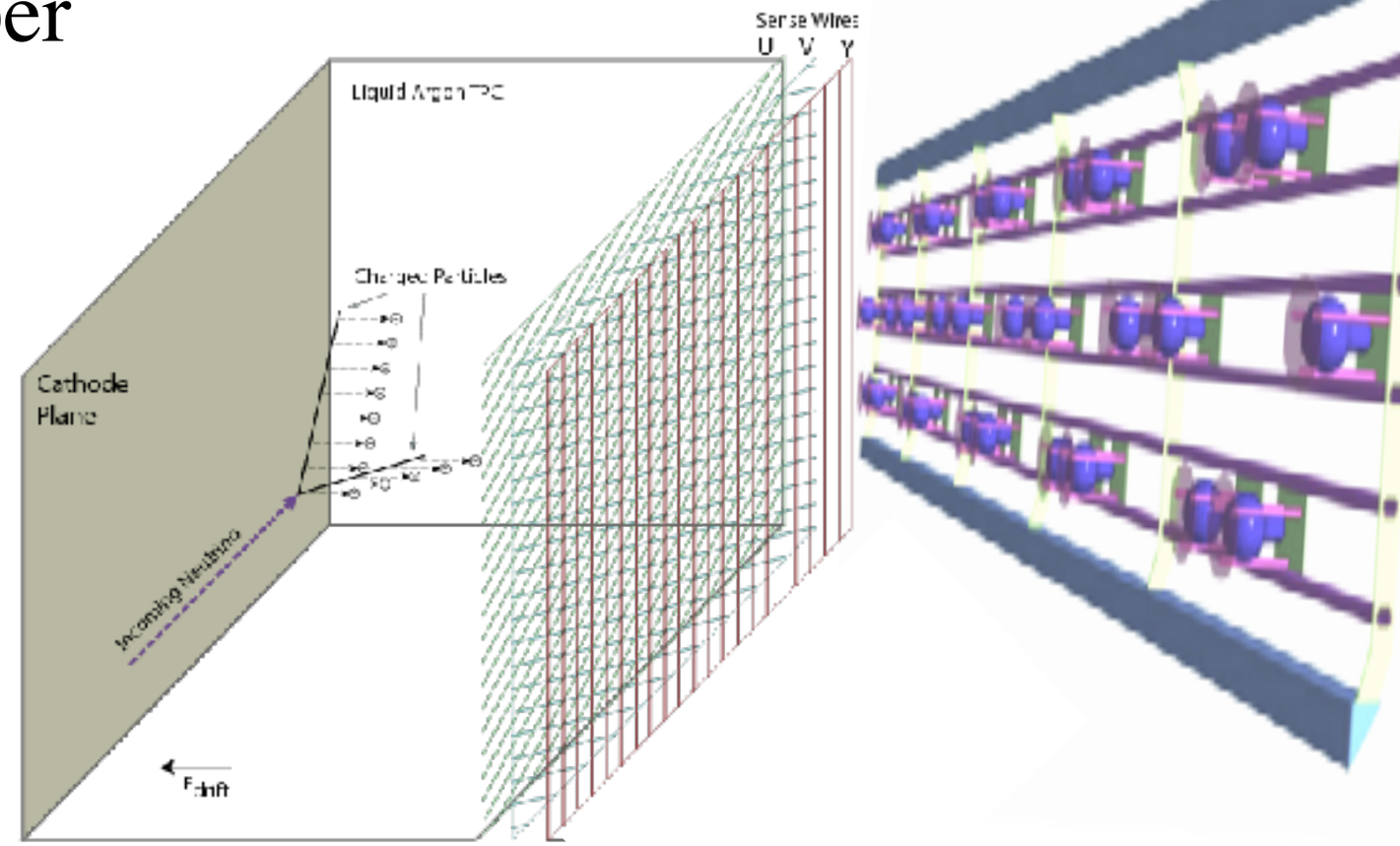
LAr TPC - MicroBooNE

LAr Time Projection Chamber

Near surface detector

Active mass : 85 tons

Triggered by PMTs



LAr TPC - MicroBooNE

Has 3 wire planes

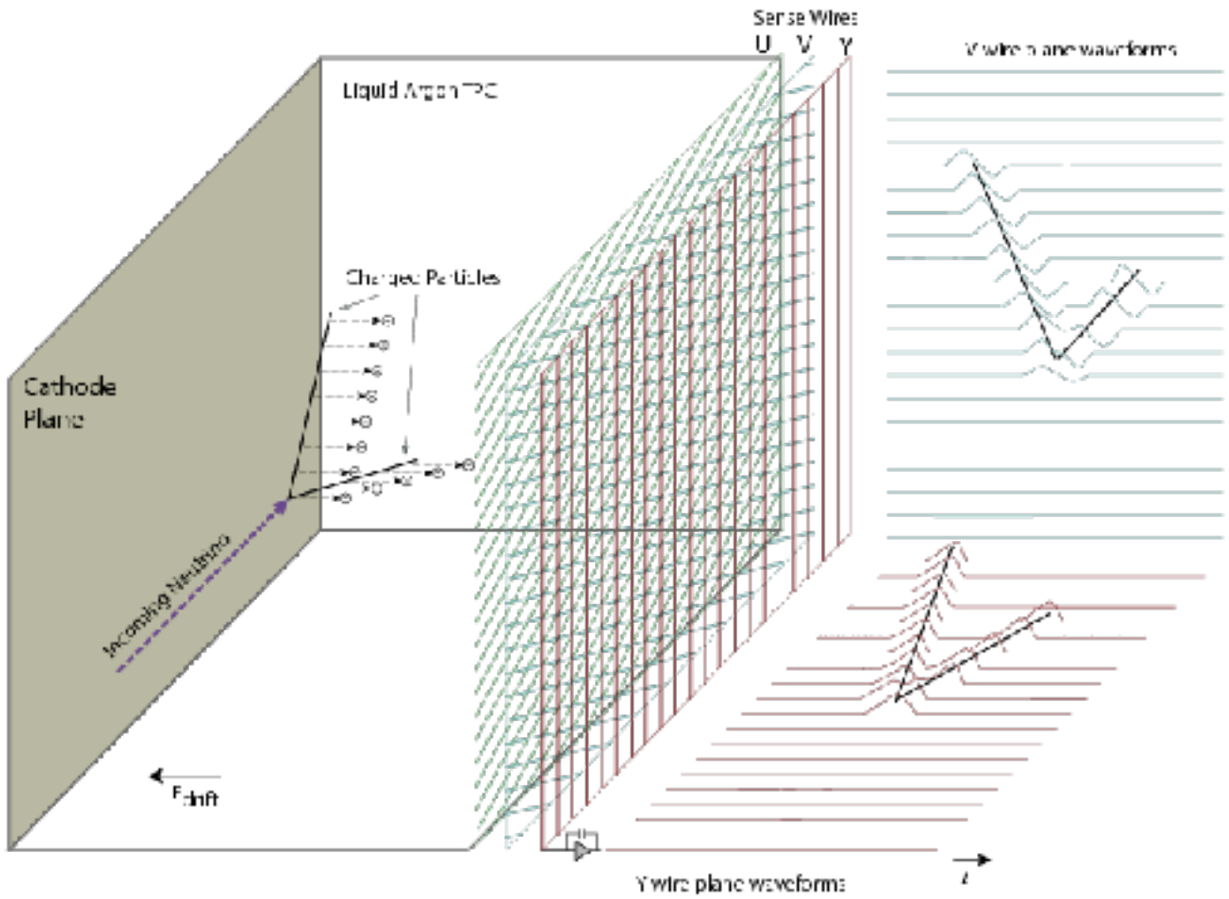
- 3 mm wire spacing

  giving impeccable spatial resolution

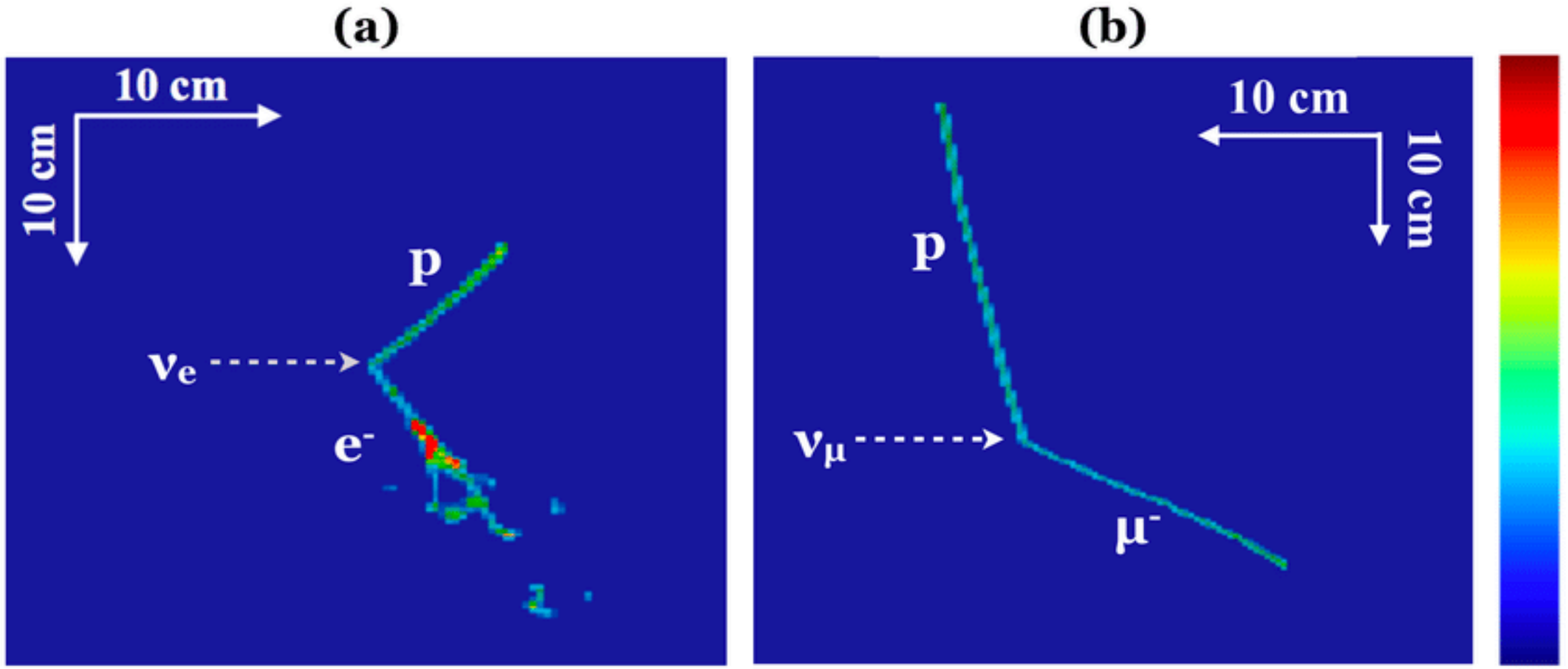
- Final plane collects charge

  giving calorimetric measurement

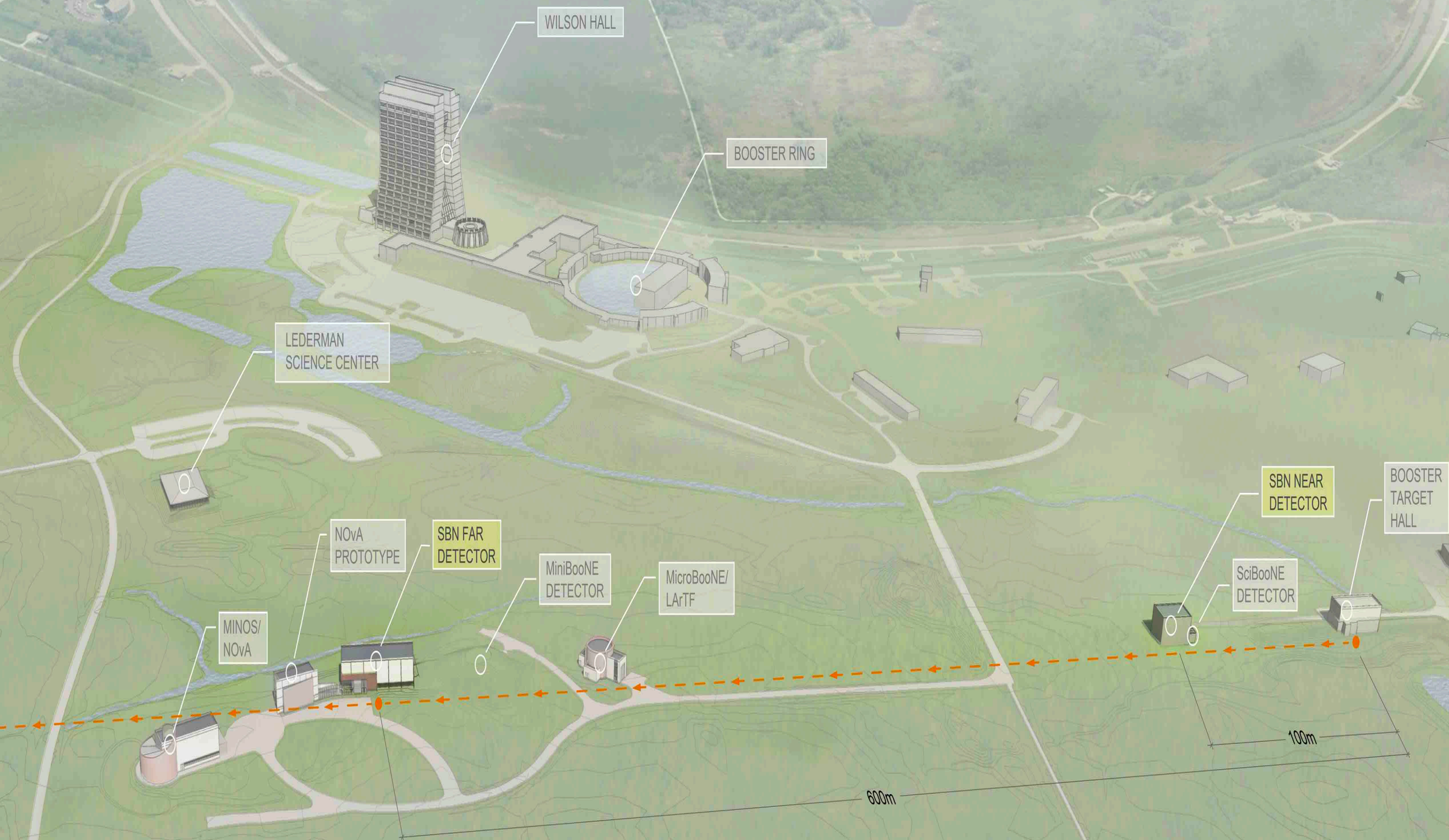
  Low tracking threshold



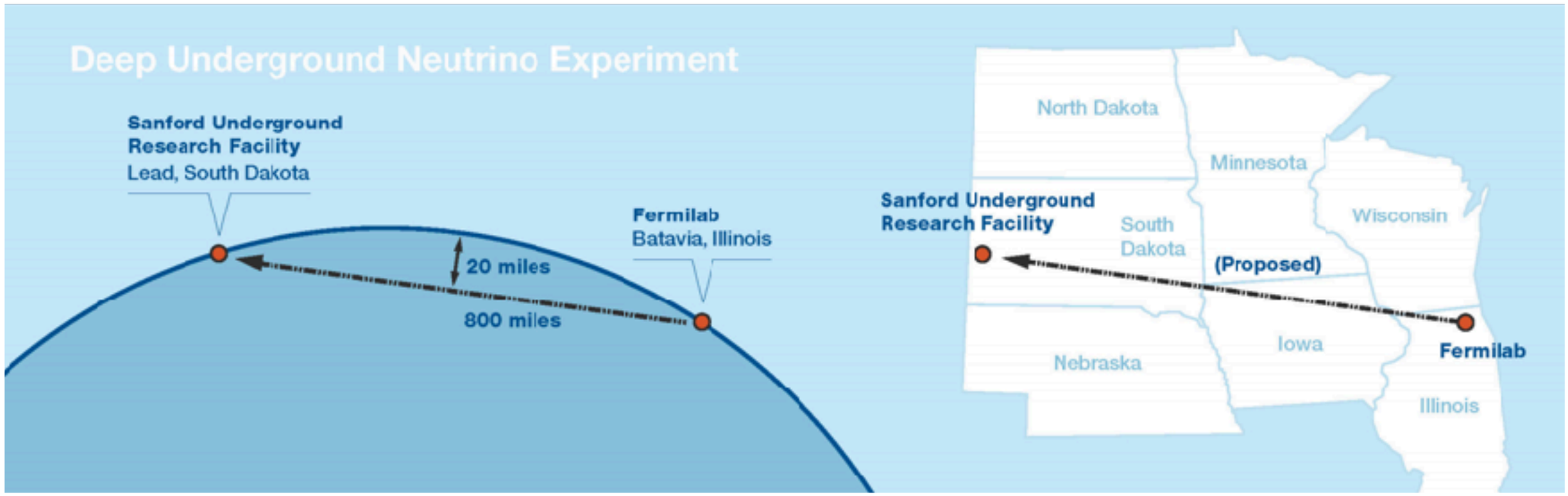
LAr TPC

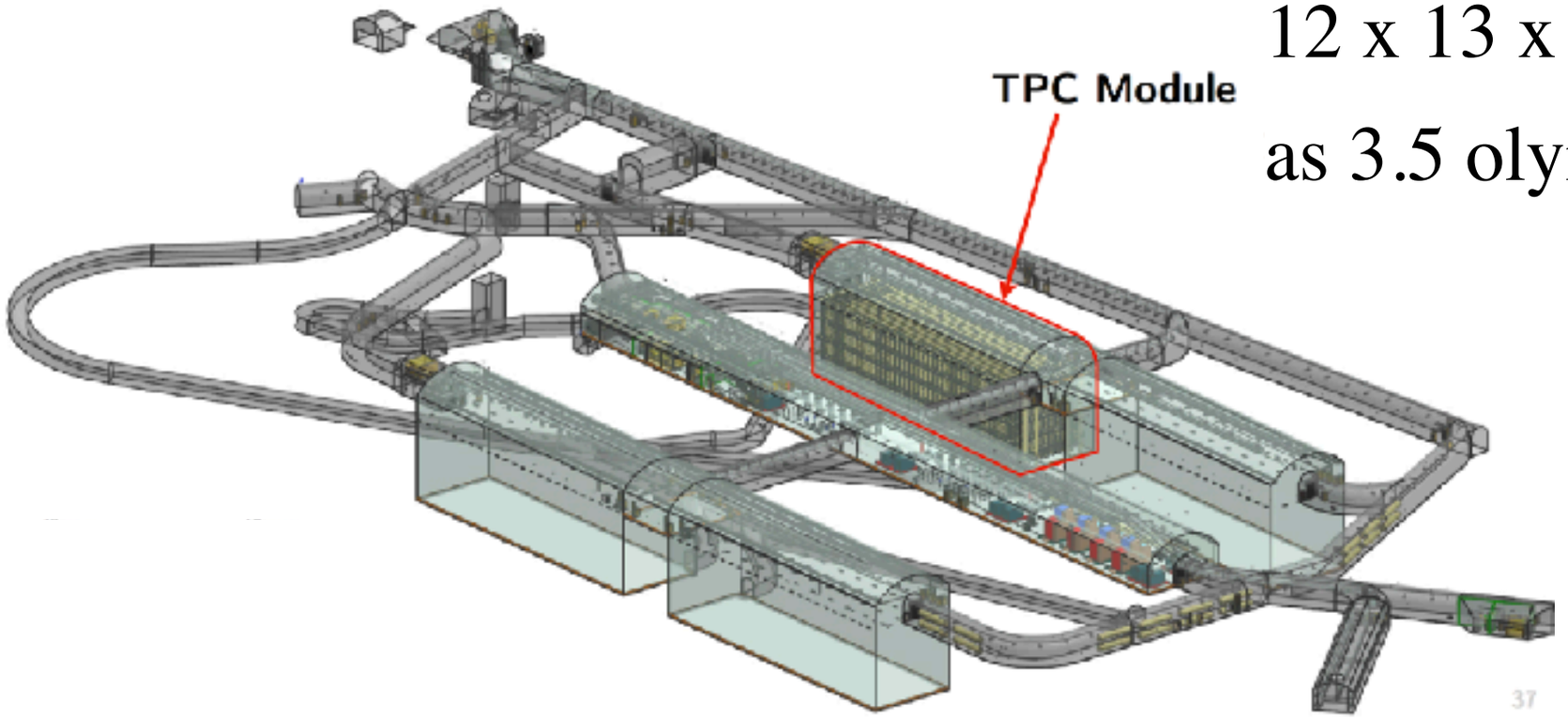


SBN - Short Base Line Program



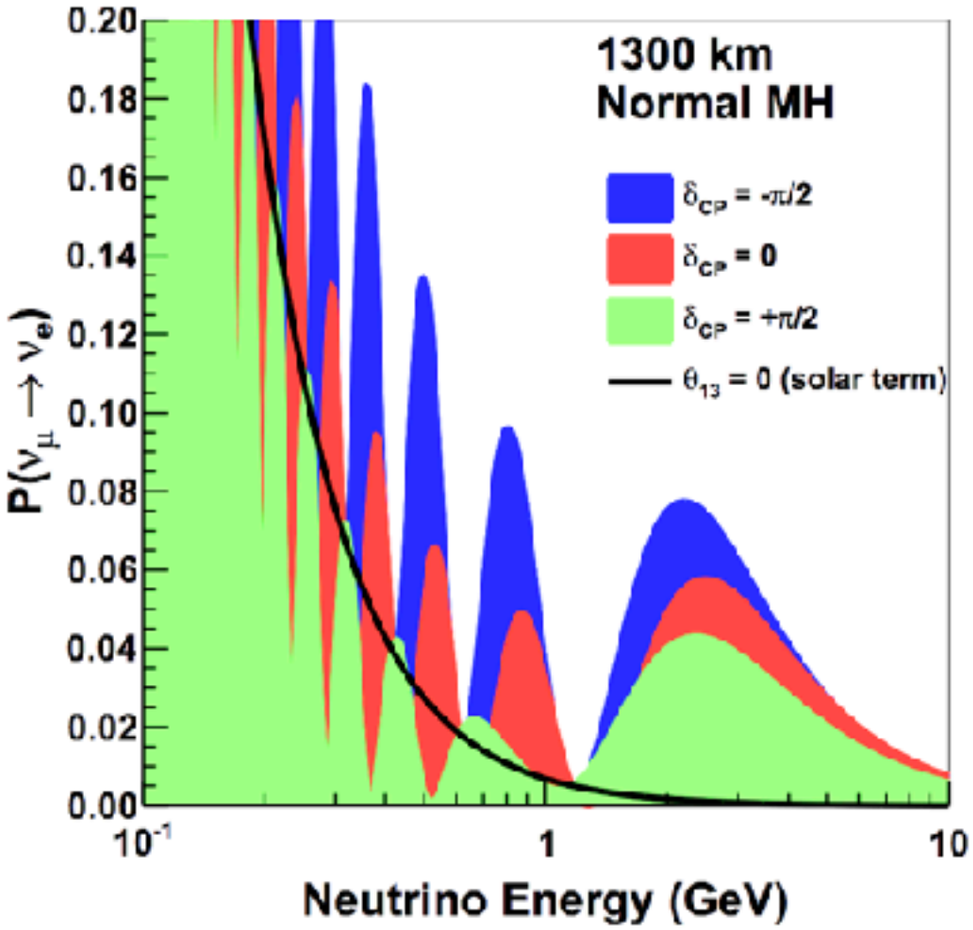
DEEP UNDERGROUND NEUTRINO EXPERIMENT

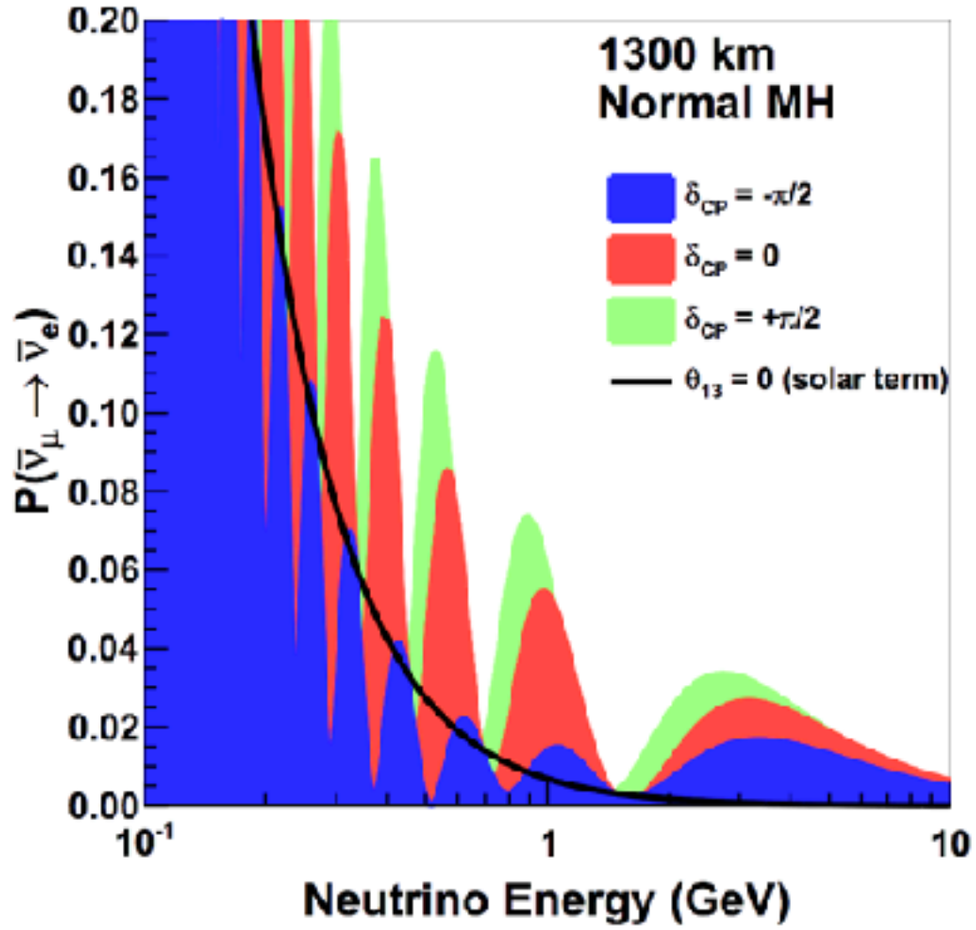




12 x 13 x 50 m

as 3.5 olympic pools


1300 km
Normal MH
$\delta_{CP} = -\pi/2$
$\delta_{CP} = 0$
$\delta_{CP} = +\pi/2$
$\theta_{13} = 0$ (solar term)
$P(\nu_\mu \rightarrow \nu_e)$
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
10^{-1}
1
10
Neutrino Energy (GeV)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Neutrino Energy (GeV)

Israel part

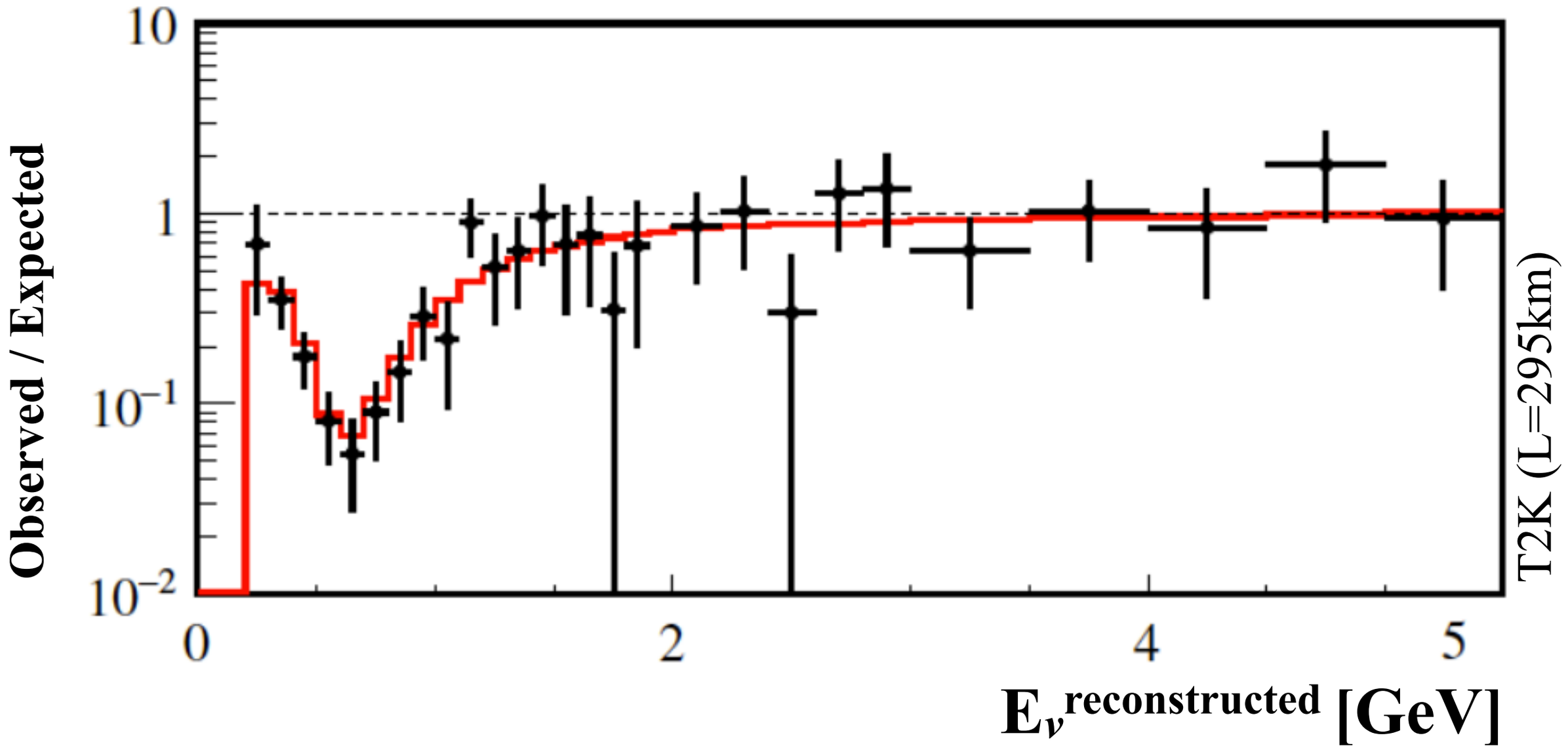
ISRAEL in MicroBooNE

Israeli group already part of MicroBooNE with an active control room at TAU

Leading the effort to a cosmic rejection method and CCQE analysis

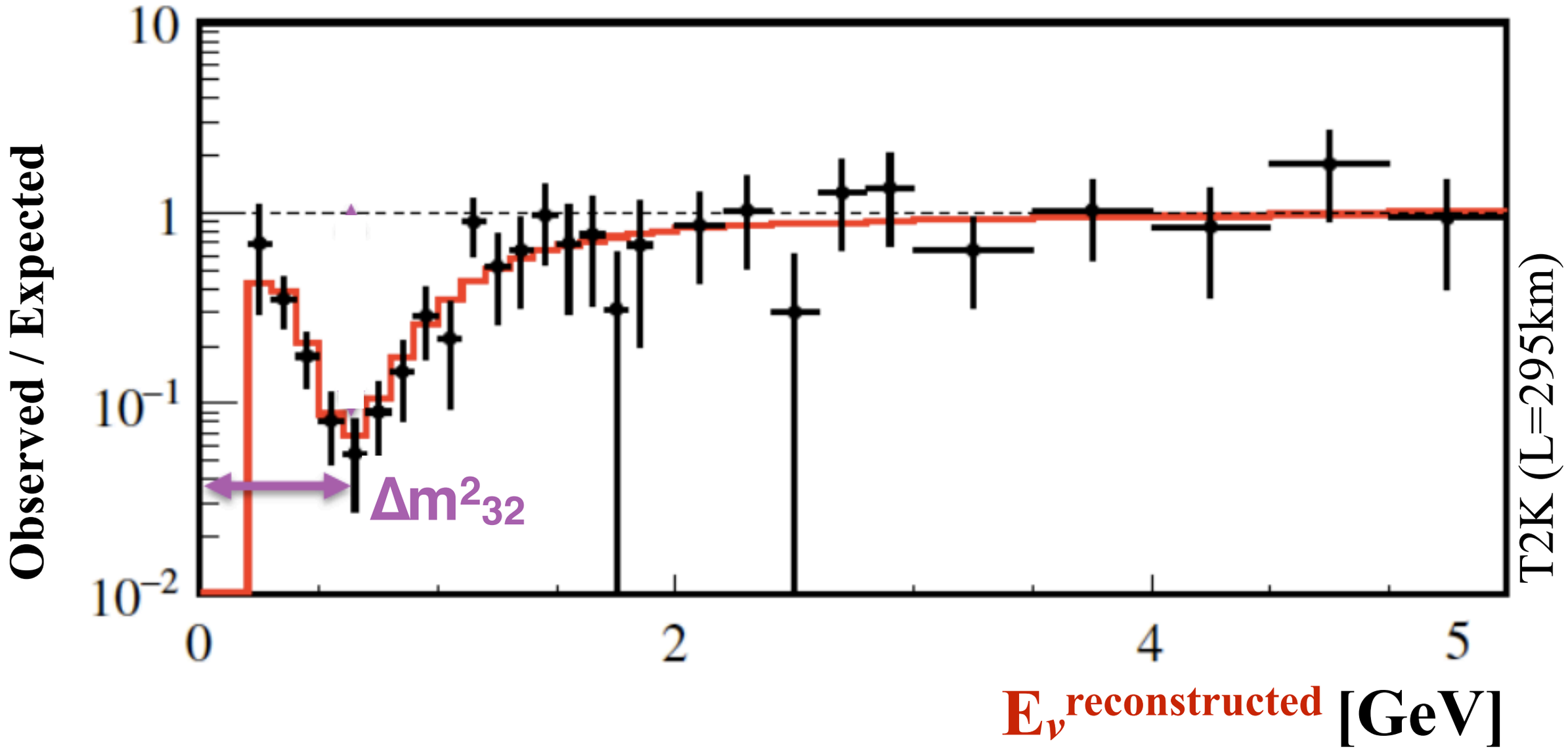
ISRAEL in e4v

$$P\left(\nu_\mu \to \nu_x\right) = \sin^2(2\theta) \times \sin^2\left(\frac{\Delta m^2 L}{4E_\nu}\right)$$



ISRAEL in e4ν

$$P\left(\nu_\mu \to \nu_x\right) = \sin^2(2\theta) \times \sin^2\left(\frac{\Delta m^2 L}{4E_\nu^{\textit{theoretical}}}\right)$$



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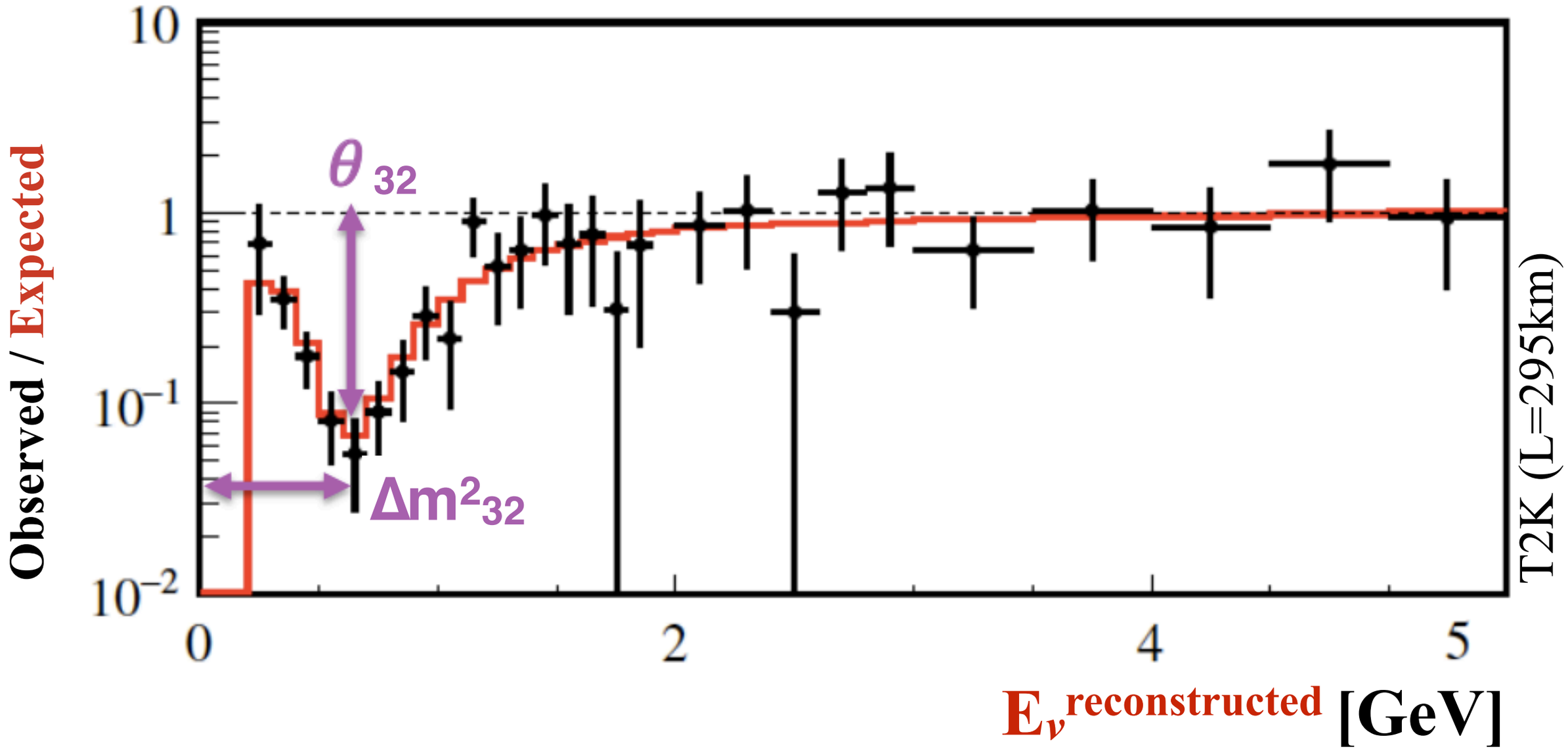


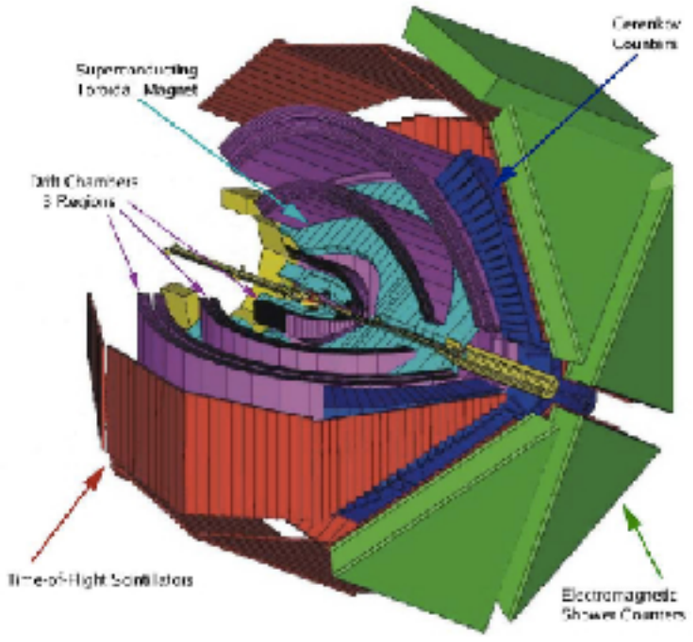
ISRAEL in e4v

GENIE

Event generator

CLAS

at JLAB



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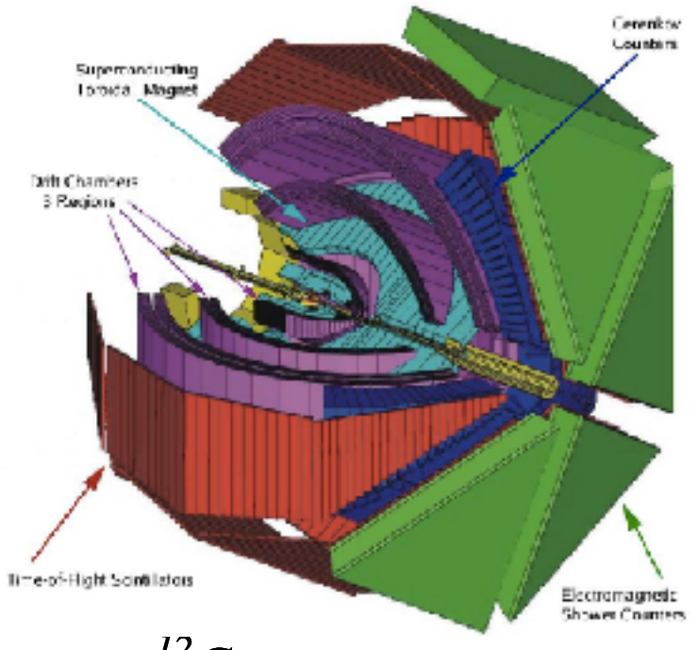
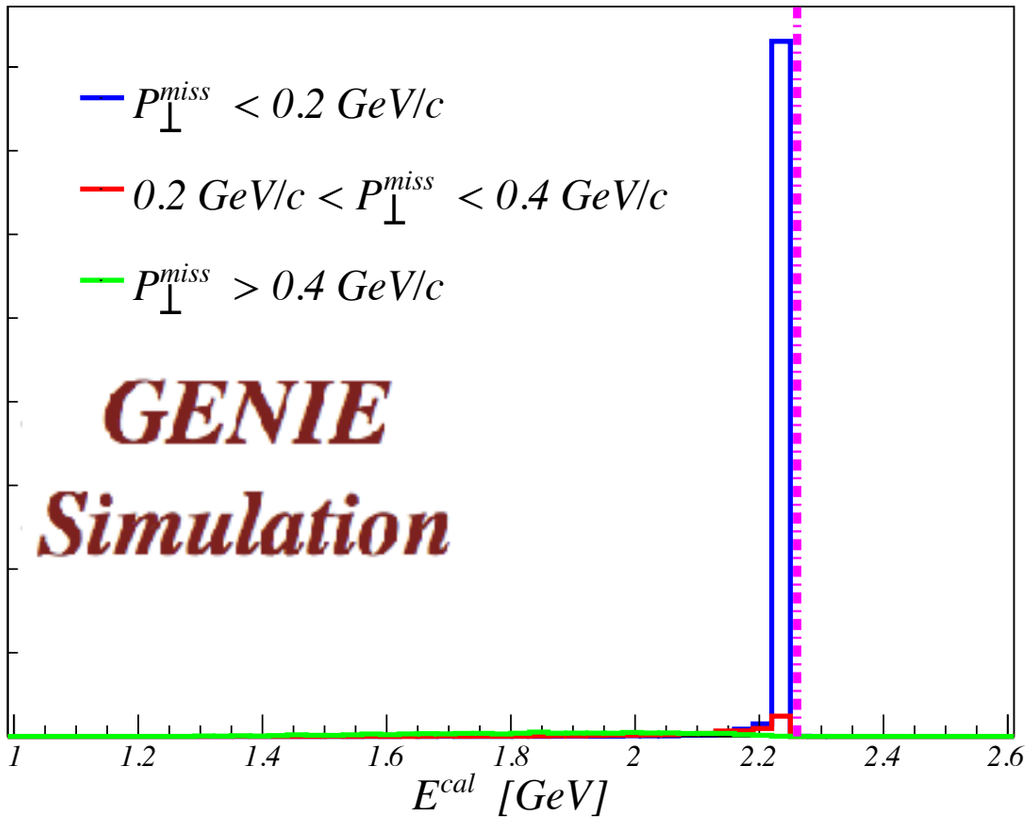
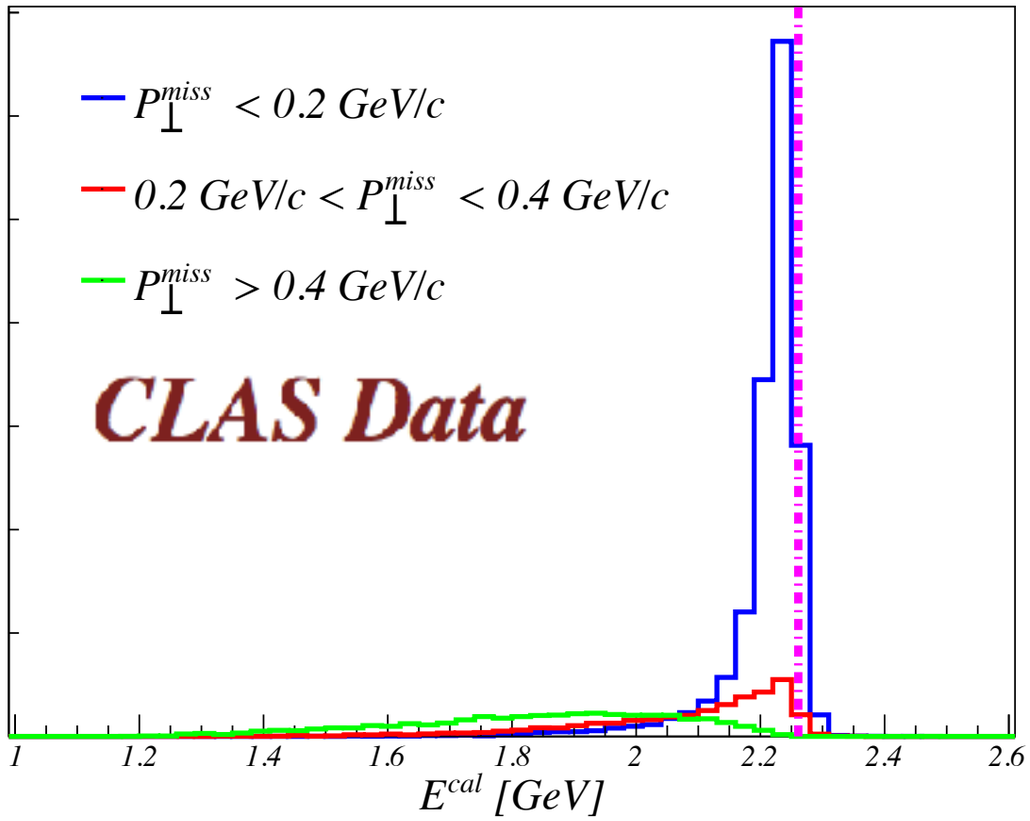


GENIE ^{12}C



DATA ^{12}C



What else can we do?

SBN & DUNE

Given Israel experience in:

- LHC data rate
- Trigger level analysis
- Machine learning
- Hardware experience with :
  - Gaseous chambers
  - TPCs
  - PMT
- and the close relations between nuclear and particle groups.

There no reason for it not to take a leading role in the short and long base line programs in the US along with Europe.

Israel based future effort

Neutrino sources:

- SNRC (Soreq)
- SARAF

Relevant to perform precision measurements of coherent neutron-nuclei and neutron-electron scattering

Israel can leverage the knowledge and experience in low energy detection methods for dark matter

Neutrino monitoring

Israel can establish its own WATCHMAN -

Water Cherenkov Monitor for Anti Neutrino

Summary

The next decade is going to be ground breaking for neutrino physics, no matter what the outcome of expected experiments will be.

Israel has a unique base of knowledge, expertise, great community, and great incentives to take a bigger part in the effort.

Thank you for your attention

Motivation

Inspired by IsoDAR 1307.5081, and Prof. Conrad visit:
a new suggestion to study neutrino-electron interaction in Israel.

Expected number of events per year:

flux x seconds per year x target electrons x cross section

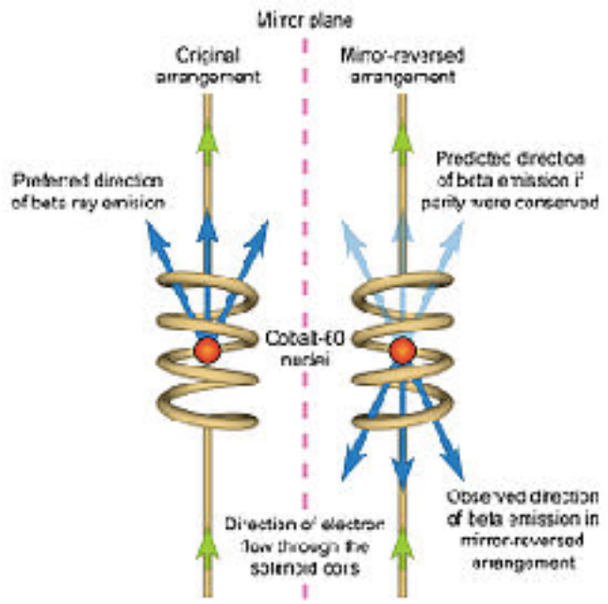
(m^3 scintillator)

$$\frac{10^{14}}{4\pi 400^2} \times 3\,10^7 \times 3\,10^{29} \times 10^{-44}\,\text{cm}^2 \sim 18 \text{ ev/year}$$

Idea: The rate of potentially detected neutrinos could be increased if the ^{8}Li in the sleeve around the neutron source would have been polarized.

Polarization and neutrino directionality

Chien-Shiung Wu

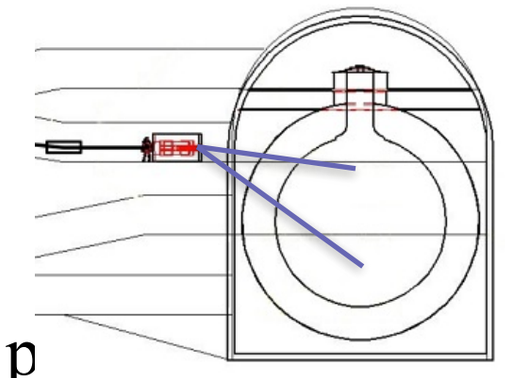


Motivation

For IsoDAR 1307.5081:

The rate of potentially detected neutrinos could be increased if the ^{8}Li in the sleeve around the neutron source would have been polarized.

Distance between face of target and center of detector R = 16.1 m
kamland fiducial radius r = 6.5 m
fraction of neutrinos arriving to Kamland: $\frac{\pi r^2}{4\pi R^2} = 0.04$



75 % ^{7}Li polarized with spin +3/2

a neutron with spin +1/2 will produce 100% polarized ^{8}Li
a neutron with spin -1/2 will have 25% probability to produce p
is it total of 62.5%

and so in total 0.75*0.625 = 0.46875

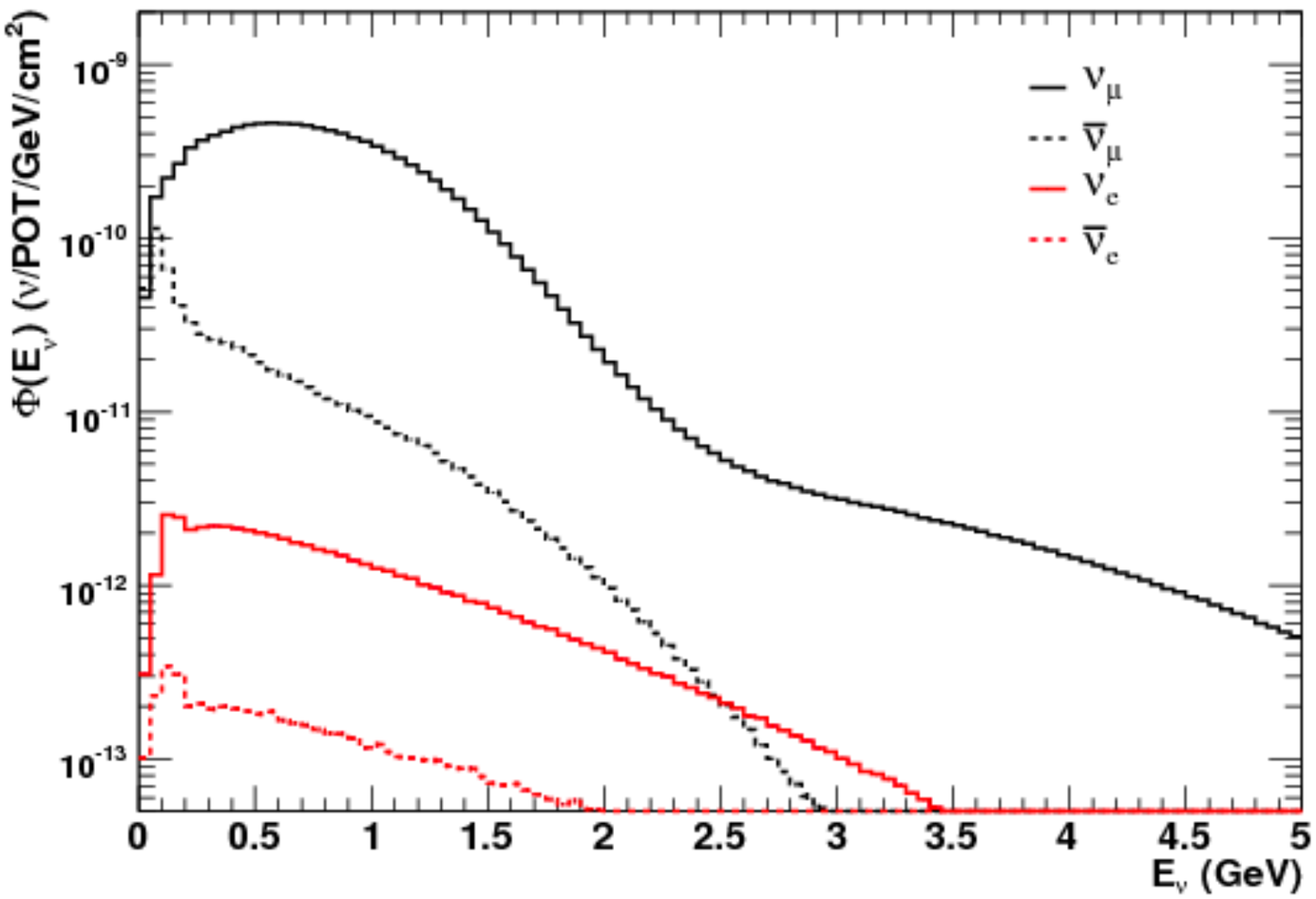
A potential order of magnitude improvement to the flux.

MicroBooNE Flux

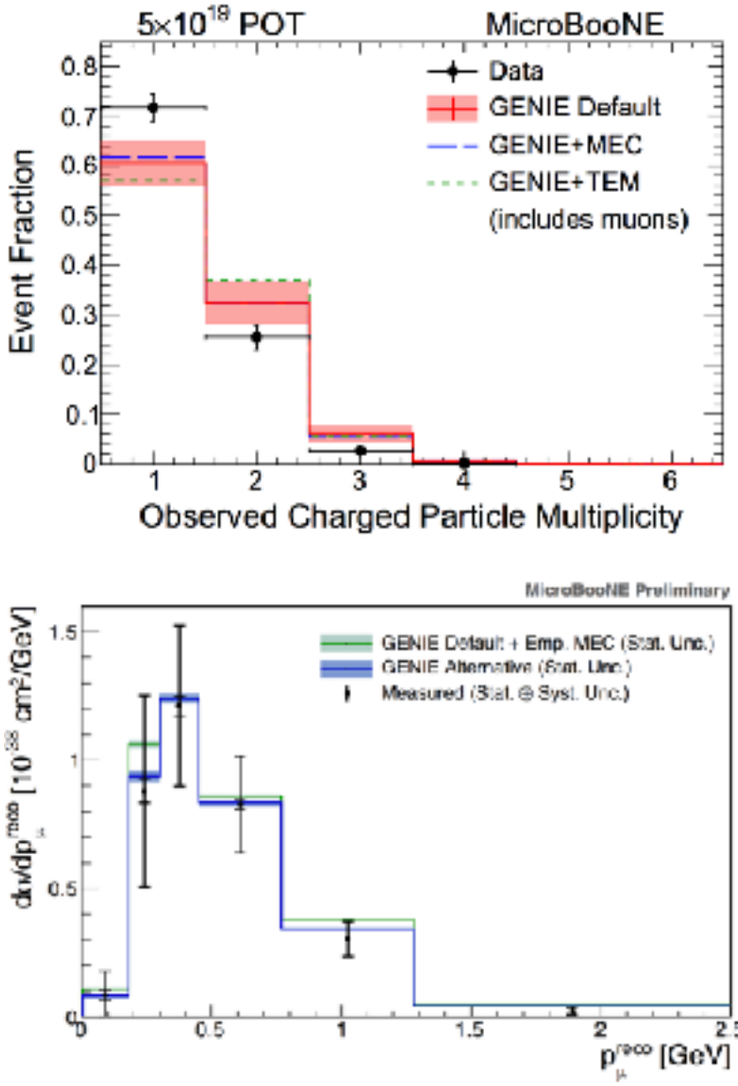
The Booster Neutrino Beam at Fermilab, a pure source of ν_μ

$E_\nu \sim 1$ GeV

Validated by MiniBooNE



MicroBooNE First Results



Charged particle Multiplicity

First detailed measurement testing GENIE models on Argon nuclei

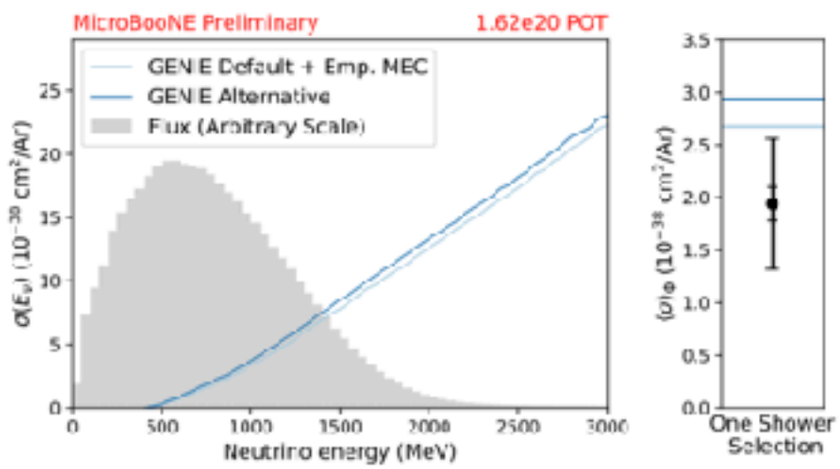
arXiv:1805.06887 (submitted to PRD)

CC inclusive

good cosmic rejection

model dependencies are negligible

MICROBOONE-NOTE-1045-PUB



CC π^0

Low statistics, lower cosmic background

Model dependent

MicroBooNE–Note–1032–PUB

Neutrino Interaction Modelling
GENIE

	Default Tune	Alternative Tune Theoretically driven	Future Possibilities
Nuclear Model	Relativistic Fermi Gas	Local Fermi Gas	Local Fermi Gas
CC QE	Llewellyn-Smith Dipole axial form factor	Nieves Dipole axial form factor	Nieves *z*-expansion
CC MEC	Empirical	Nieves	Nieves
NC MEC	Empirical	None	Empirical
NC Elastic	Ahrens	Ahrens	Ahrens
Resonance	Rein Sehgal	Berger Sehgal	Berger Sehgal
COH pion	Rein Sehgal	Berger Sehgal	Berger Sehgal
DIS	Bodek-Yang	Bodek-Yang	Bodek-Yang
Hadronization	AGKY	AGKY	AGKY
FSI	hA	hA2015	hA2018
Other Processes: Coherent rho, diffractive pion production, hyperon production	No	No	Yes

Andy Mastbaum