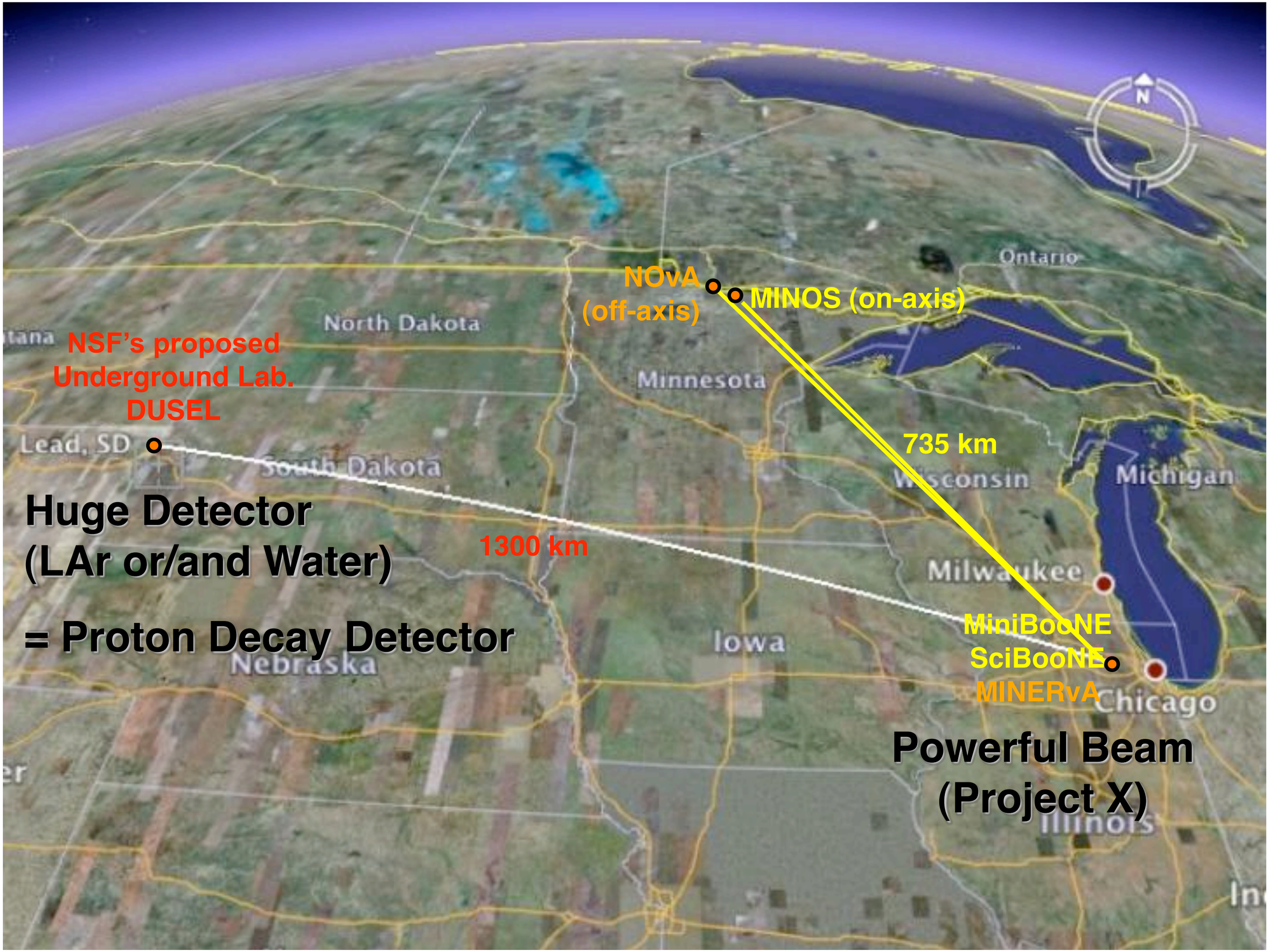
Fermilab to DUSEL and Non-Standard Interactions (NSI)

Stephen Parke
Fermilab

- Fermilab to DUSEL
- NSI


NOvA
(off-axis)
MINOS (on-axis)
NSF's proposed
Underground Lab.
DUSEL
Lead, SD
735 km
1300 km
Huge Detector
(LAr or/and Water)
= Proton Decay Detector
MiniBooNE
SciBooNE
MINERvA
Powerful Beam
(Project X)
North Dakota
Minnesota
Ontario
South Dakota
Wisconsin
Michigan
Milwaukee
Chicago
Iowa
Nebraska
Illinois
N

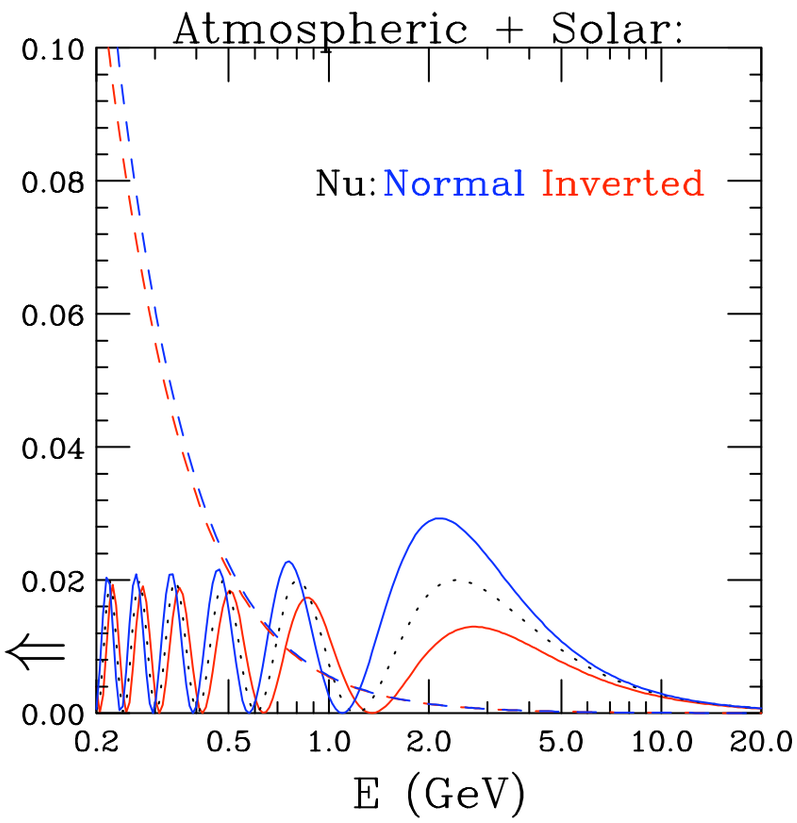
Narrow Band Beam: Same E, Longer L T2KK

Broadband Beam: Same L, Lower E Fermilab to DUSEL

In VACUUM the SAME but NOT in MATTER

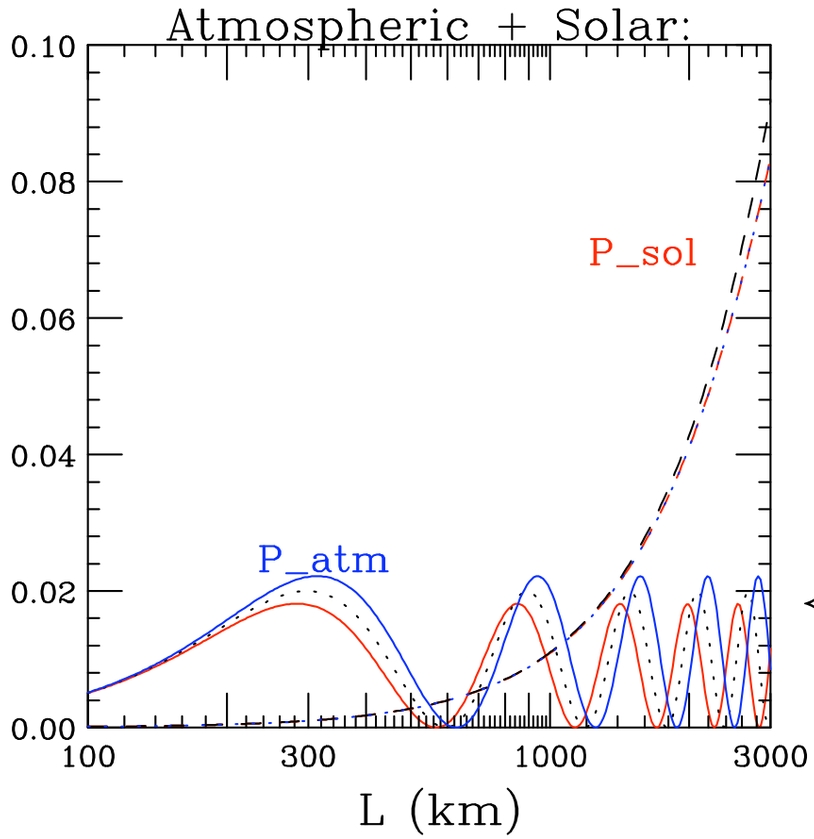
$$\sin^2 2\theta_{13} = 0.04$$

L=1200km



vacuum ⇐

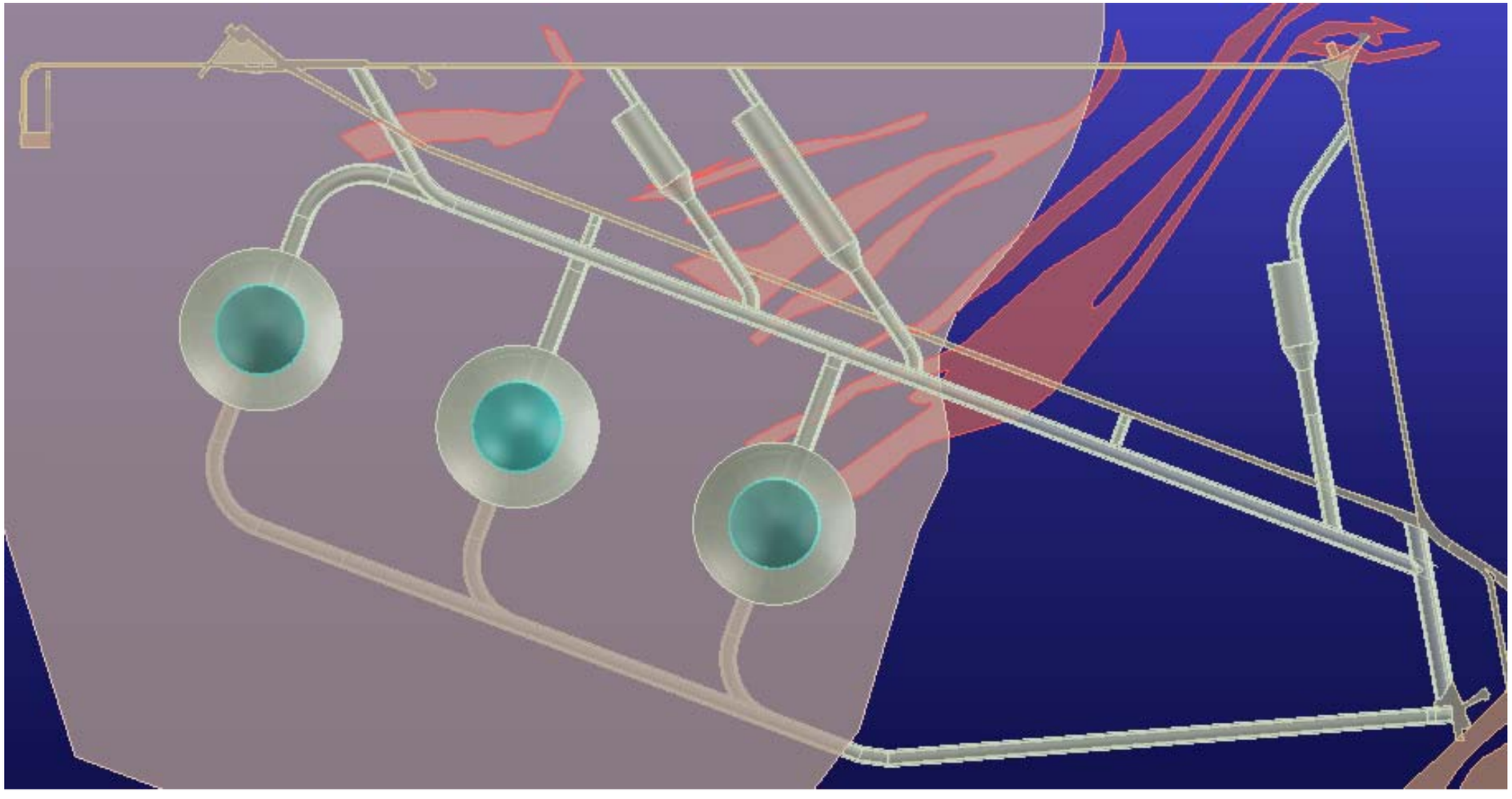
E=0.6 GeV

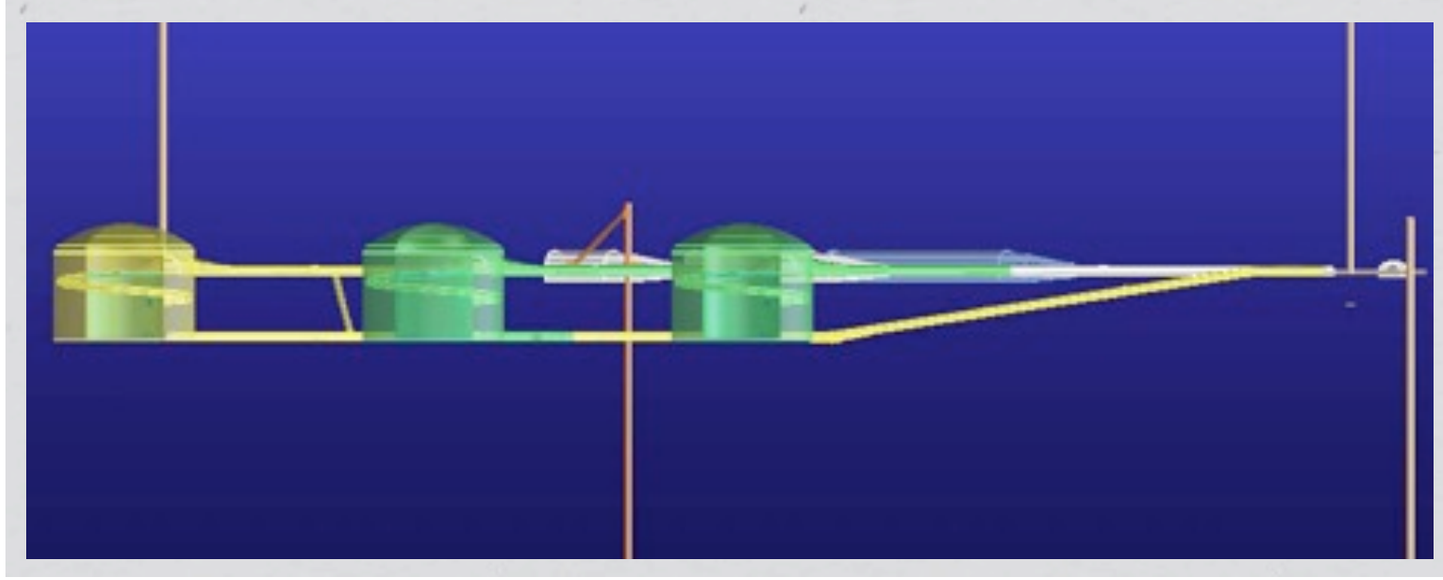


⇐ same height

$$P_{\mu\to e} \approx \left| \sqrt{P_{atm}}\, e^{-i(\Delta_{32} \pm \delta)} + \sqrt{P_{sol}} \right|^2$$

layout of 4850 level

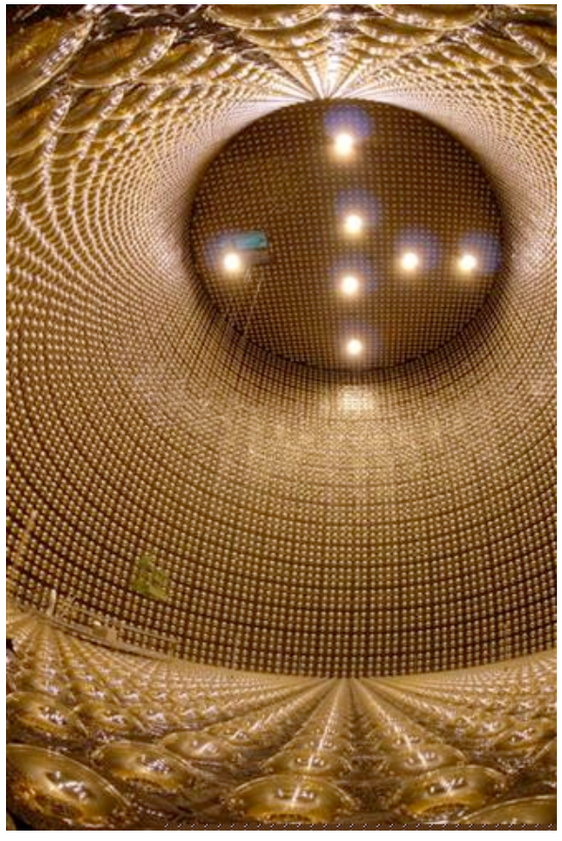




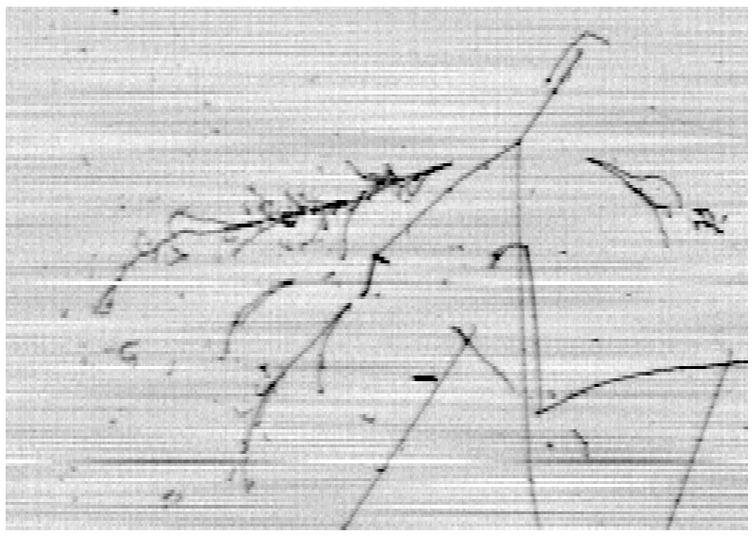
Intensity frontier: detector options

Options under consideration:
~300 kt WC, ~100 kt LAr, or some combination of the two.
Fermilab supports both technologies.

- Water Cerenkov
  - Known technology



- Liquid Argon TPCs
  - Great promise (x 3-4)

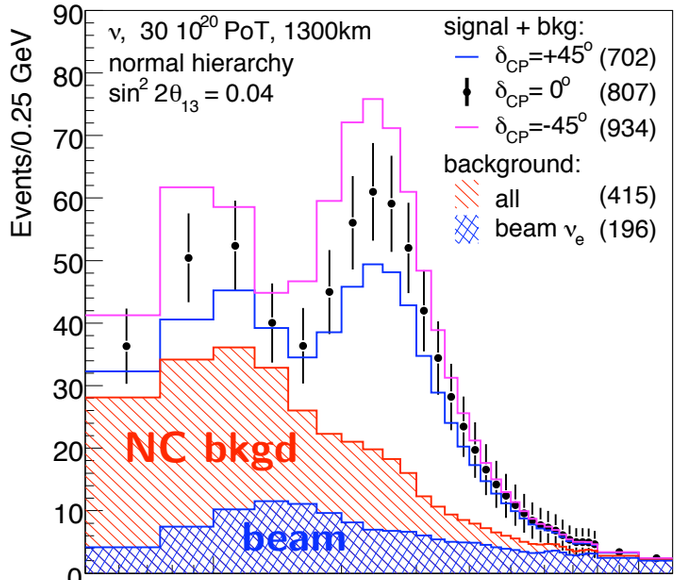


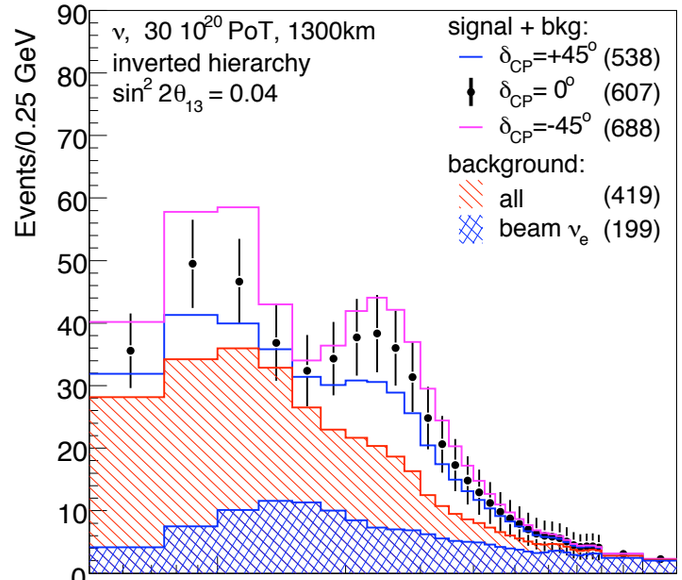
WATER CERENKOV: 300 KT

Normal

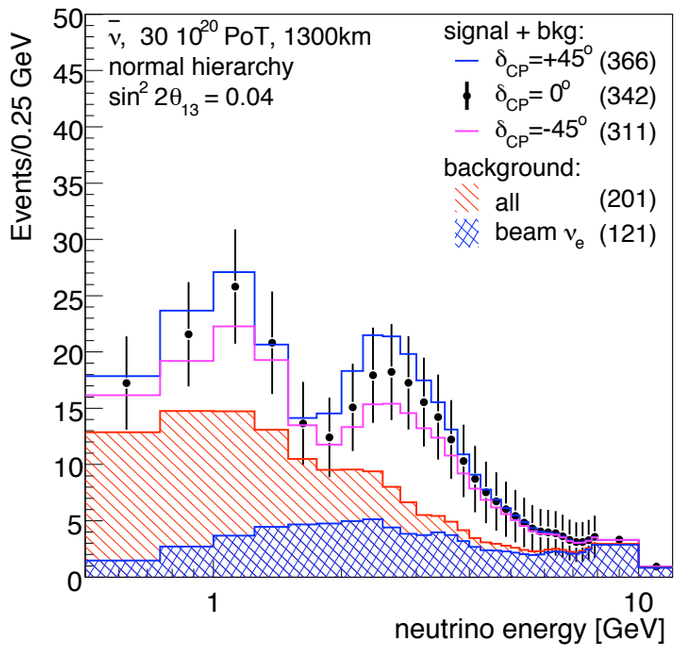
Inverted

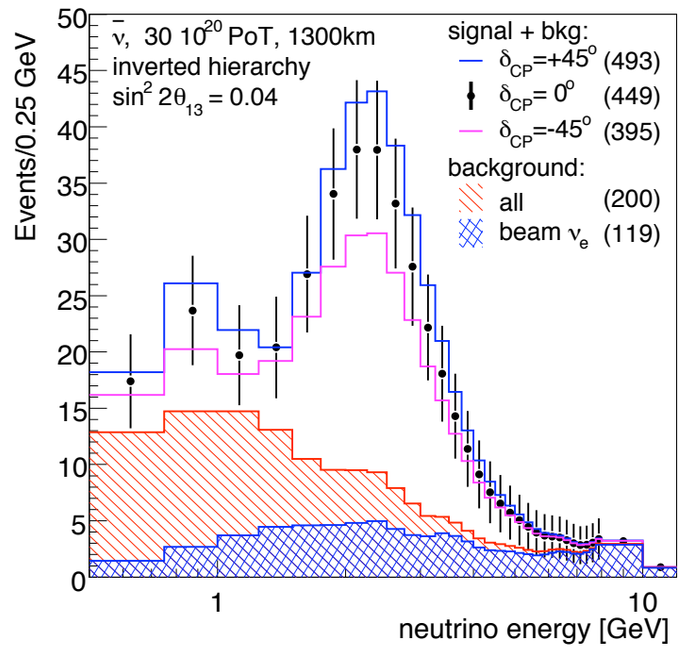
ν





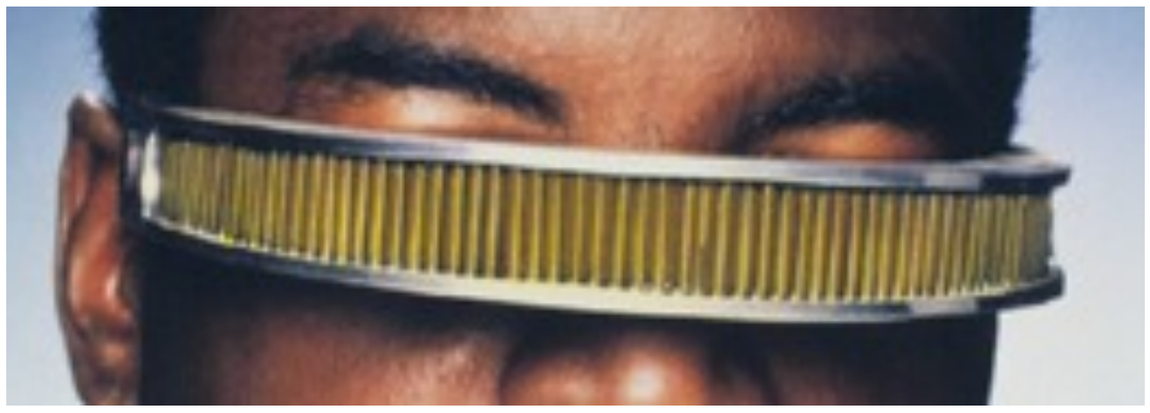
$\bar{\nu}$





arXiv:0705.4396

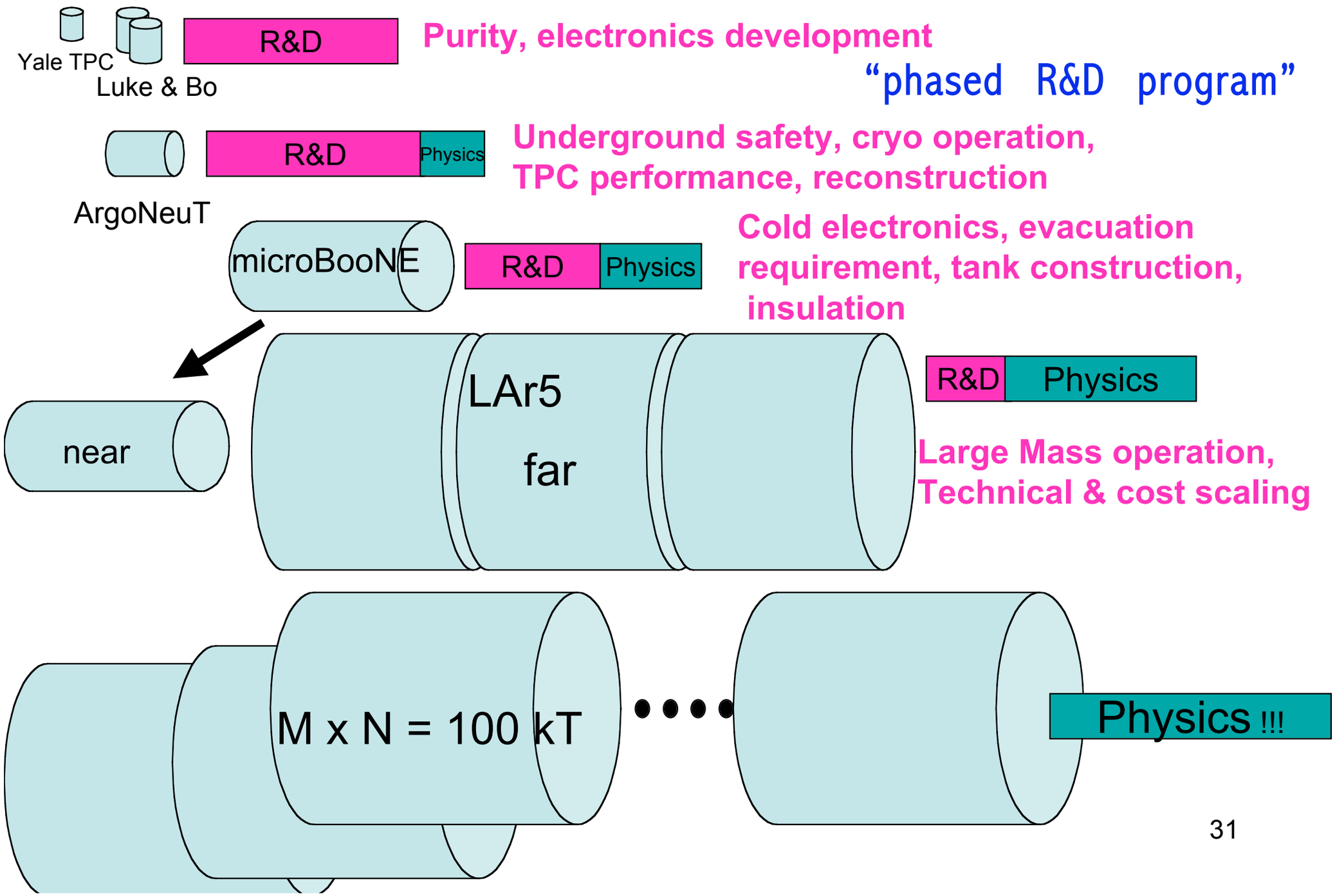
Star Trek: The Next Generation



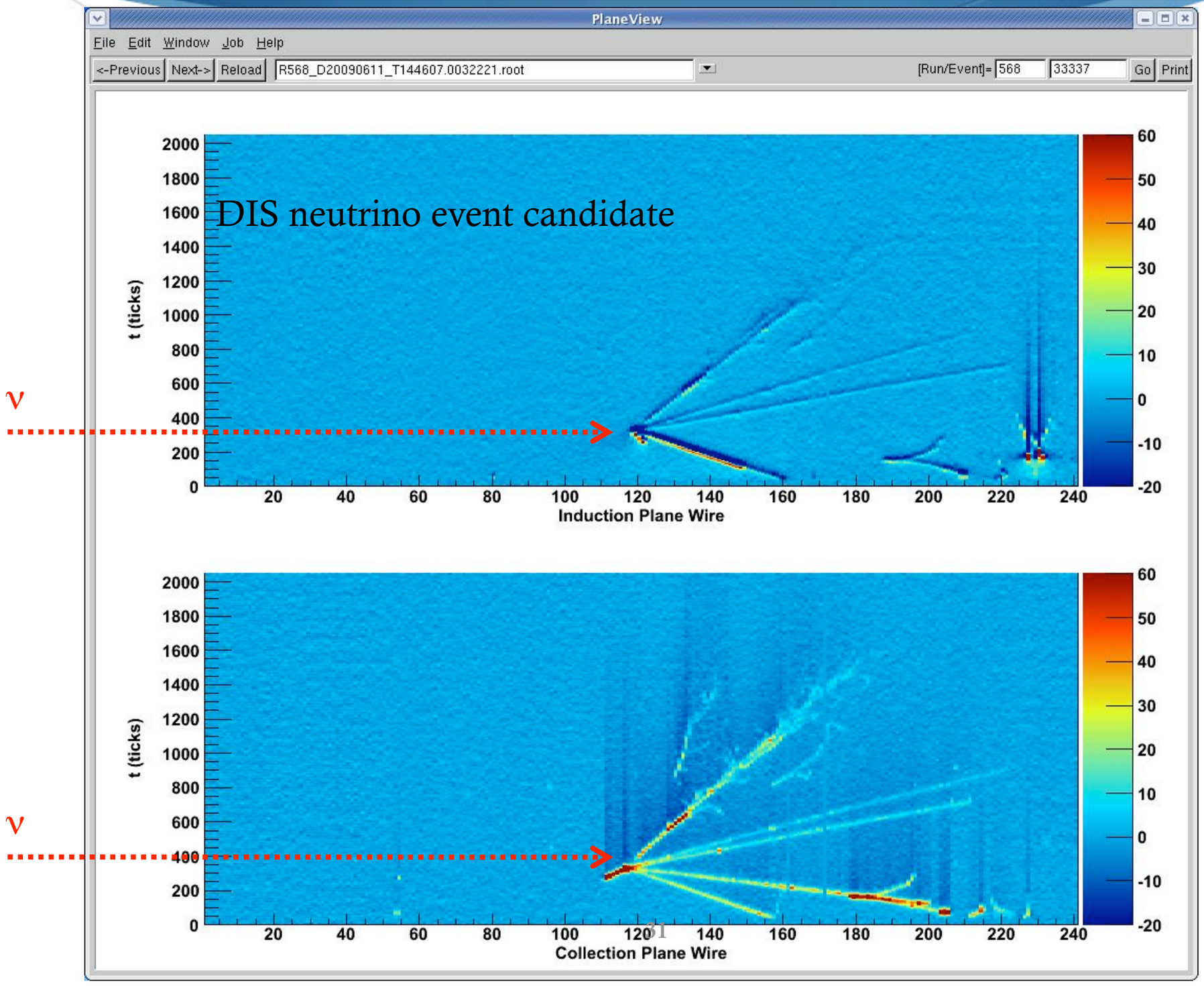
The visor “sees” Neutrinos!!!

Geordi La Forge: in “The Enemy”

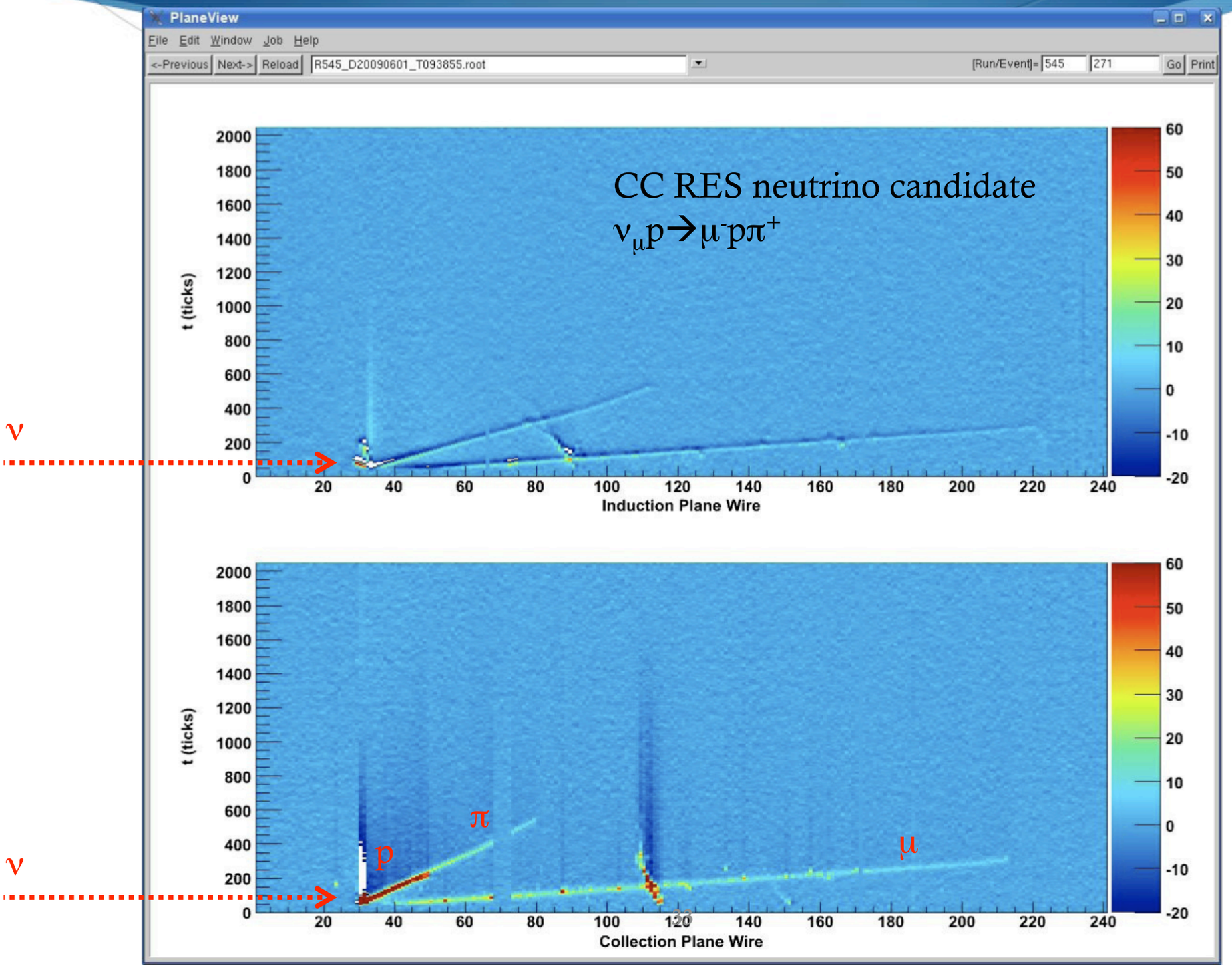
Evolution of the Liquid Argon Physics Program



ArgoNeuT Event Display: Raw Data



ArgoNeuT Event Display: Raw Data

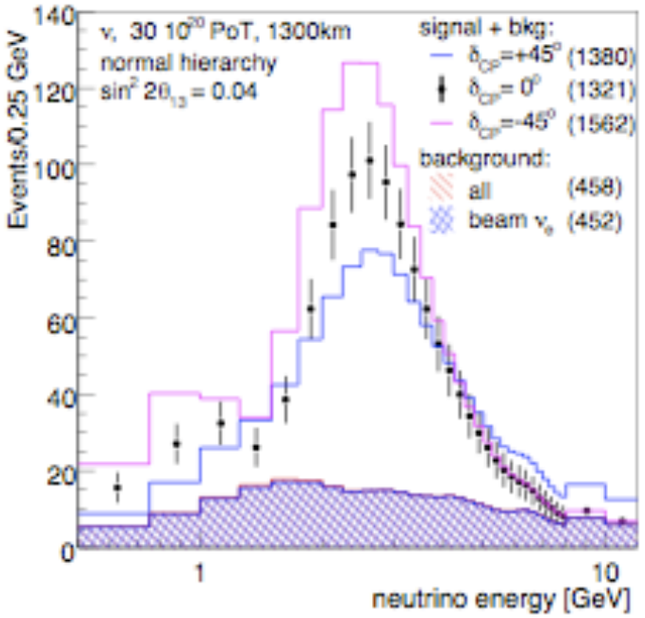


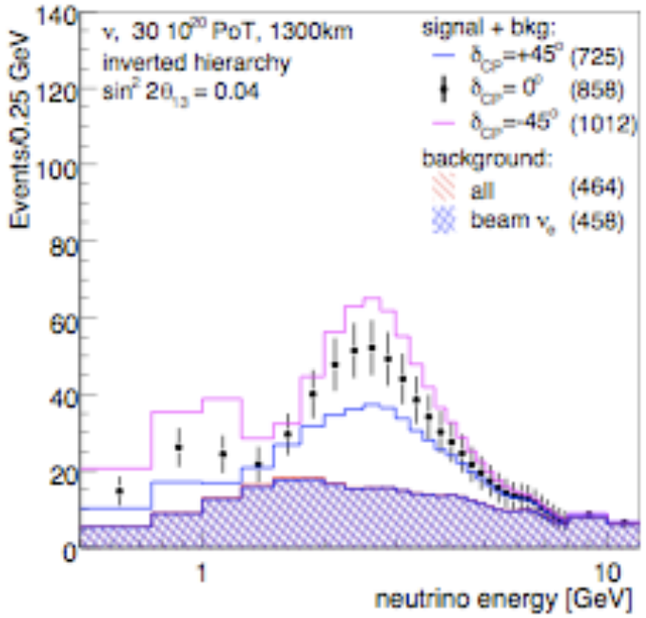
LIQUID ARGON: 100KT

Normal

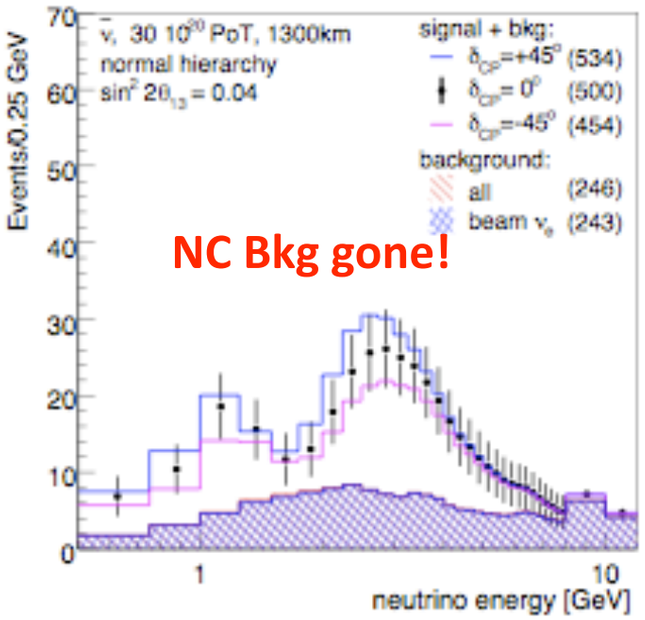
Inverted

ν

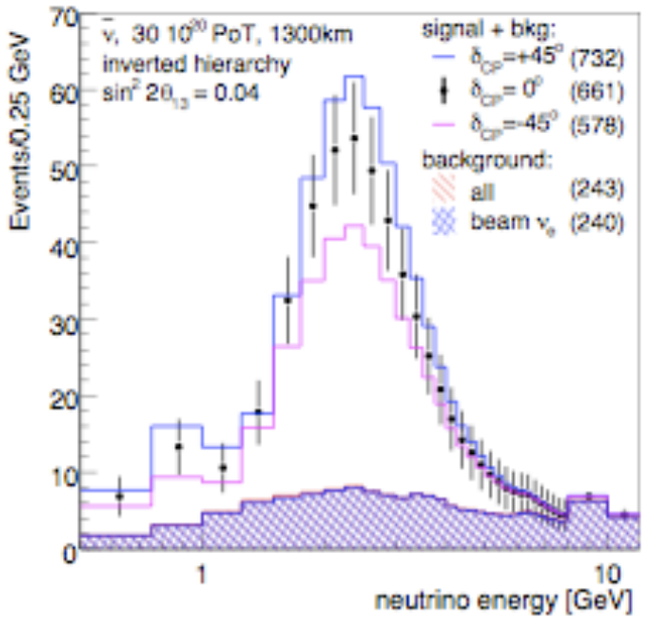




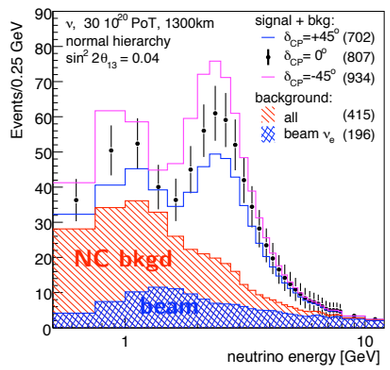
$\bar{\nu}$

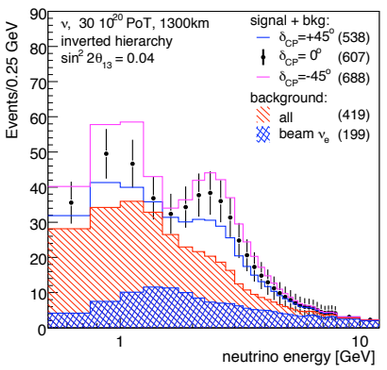


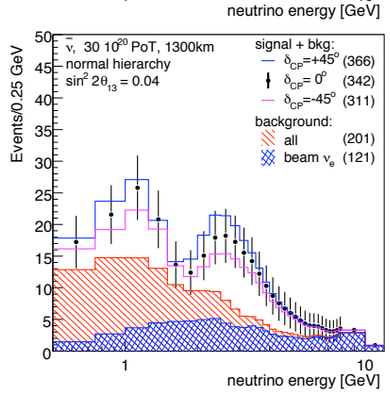
NC Bkg gone!

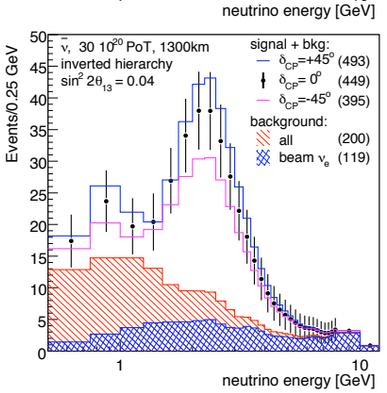


Studies suggest 100 kt LAR = 300kt WC

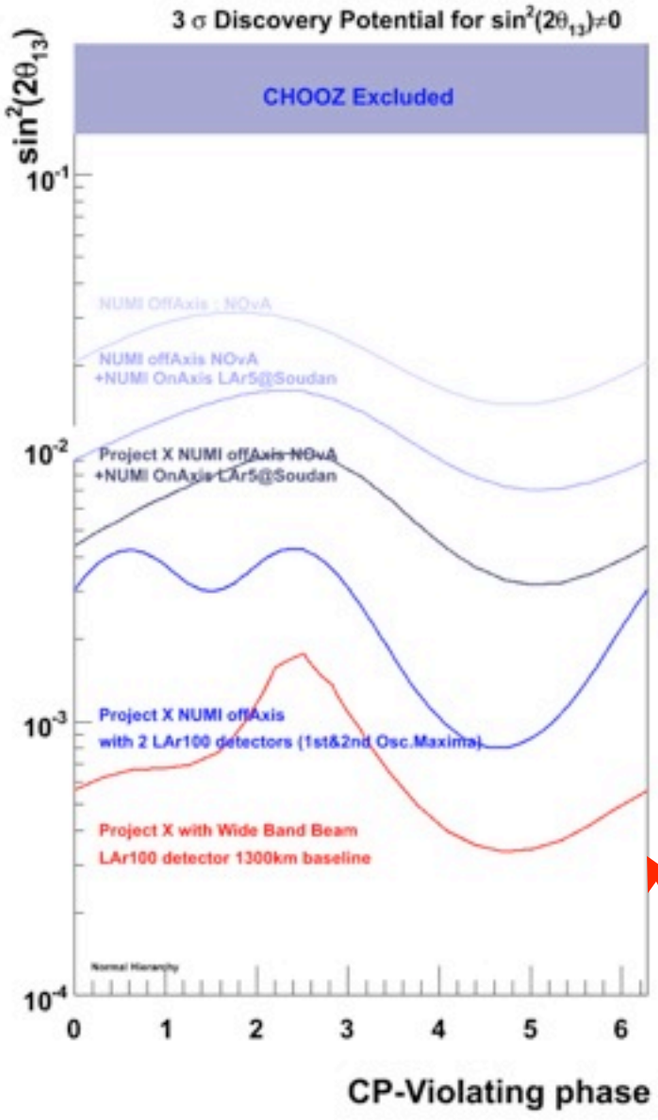


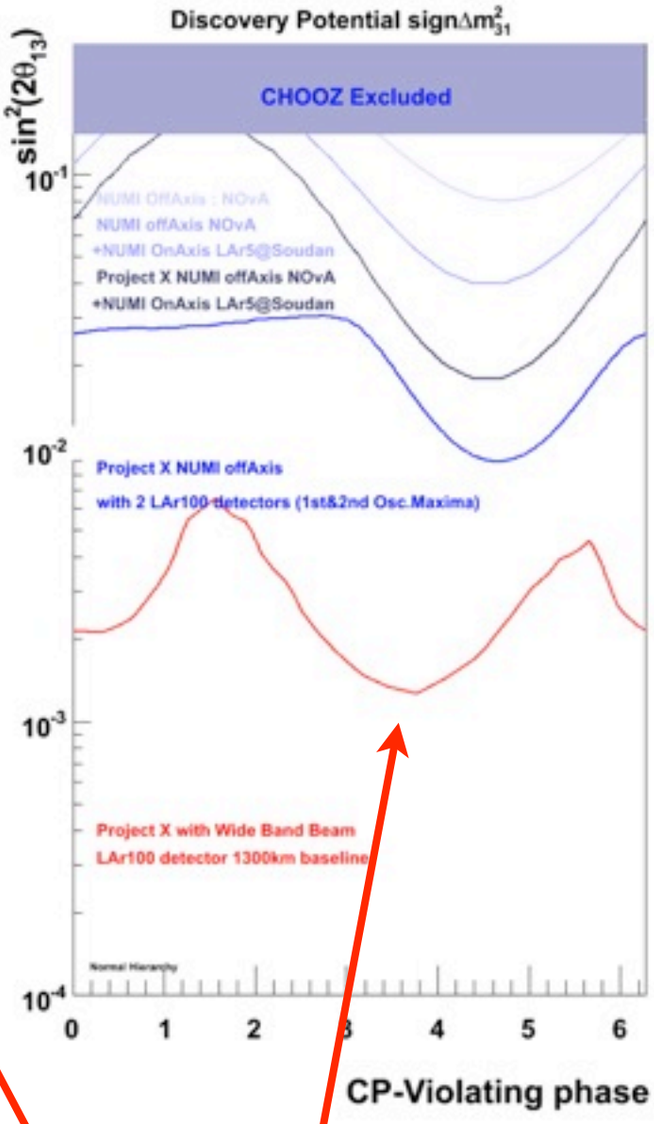


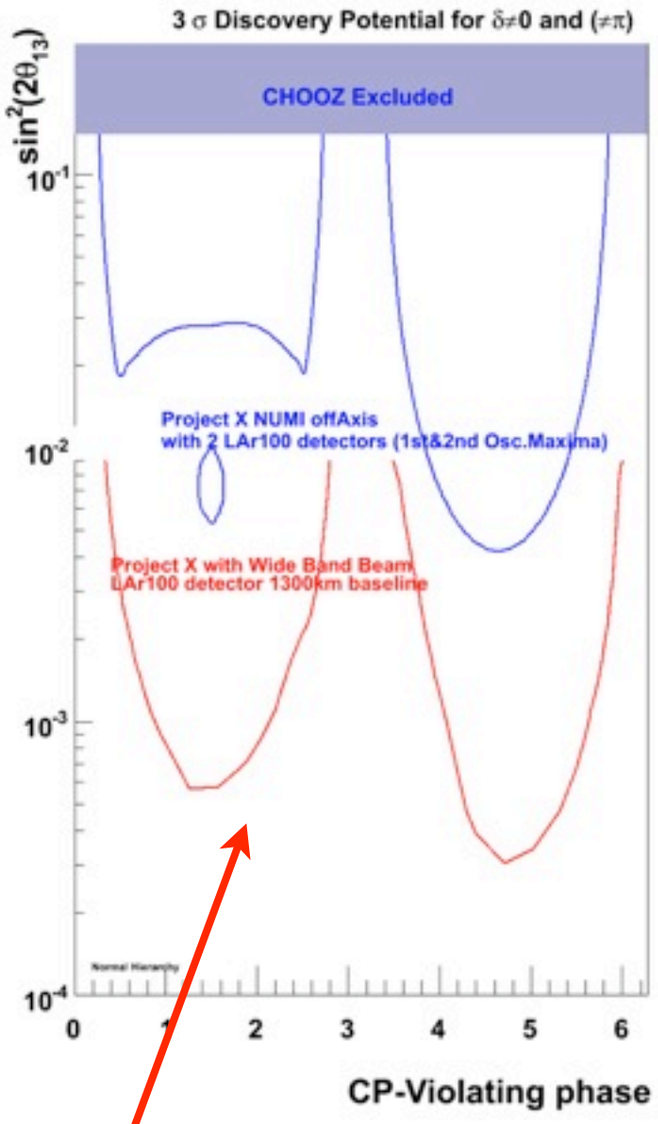




Sensitivity:







LAr 100kt 3+3 yrs 20e20 POT/yr

NSI

- First Propogation (Hiroshi Nunokawa, SP, Renata Zukanovich-Funchal)

- Source / Propogation /Detector (Joachim Kopp et al)

We concentrated on effects of NSI in ν propagation in matter

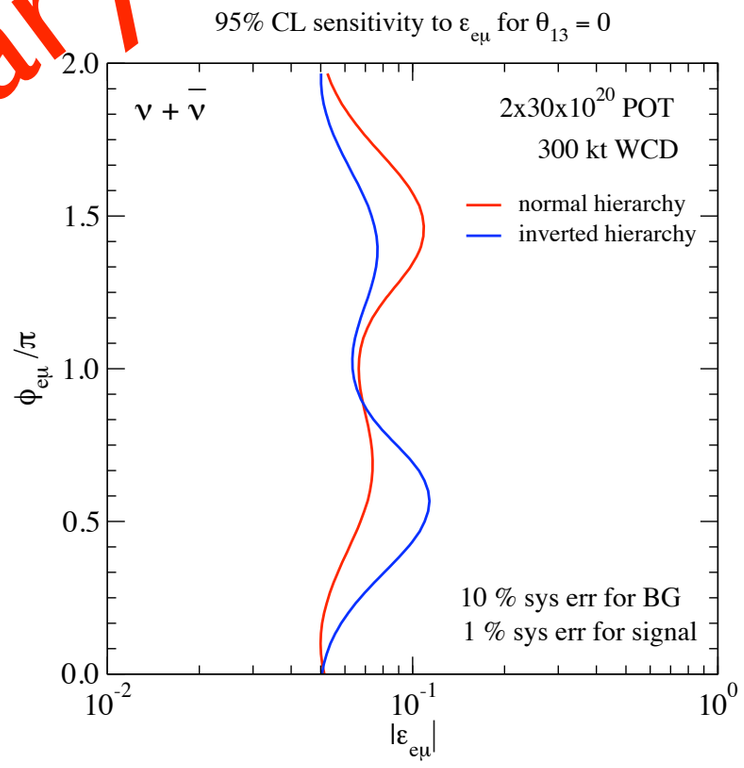
$$H = \frac{1}{2E}\left[U \begin{pmatrix} 0 & 0 & 0 \\ 0 & \Delta m^2_{21} & 0 \\ 0 & 0 & \Delta m^2_{31} \end{pmatrix} U^{-1} + \begin{pmatrix} 2\sqrt{2}G_F n_e E & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}\right]$$

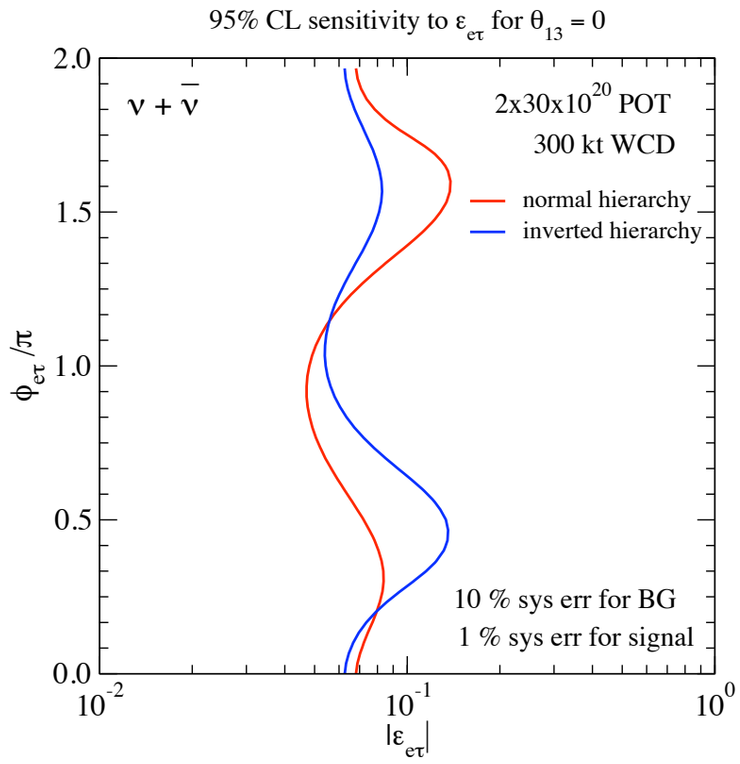
$$H = \frac{1}{2E}\left[U \begin{pmatrix} 0 & 0 & 0 \\ 0 & \Delta m^2_{21} & 0 \\ 0 & 0 & \Delta m^2_{31} \end{pmatrix} U^{-1} + 2Ea \begin{pmatrix} 1+\epsilon_{ee} & \epsilon_{e\mu} & \epsilon_{e\tau} \\ \epsilon^*_{e\mu} & \epsilon_{\mu\mu} & \epsilon_{\mu\tau} \\ \epsilon^*_{e\tau} & \epsilon^*_{\mu\tau} & \epsilon_{\tau\tau} \end{pmatrix}\right]$$

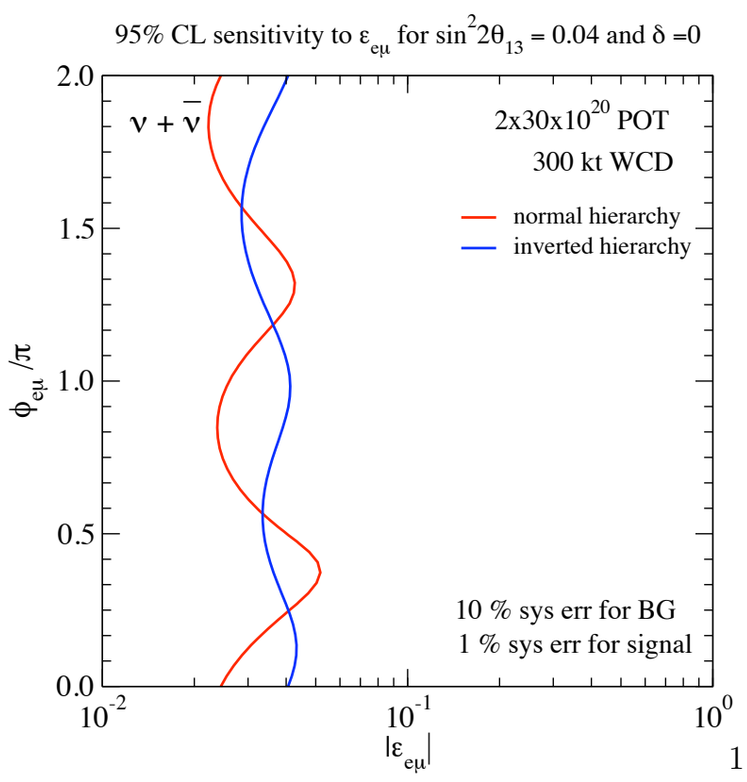
$$a \equiv \sqrt{2}G_F n_e$$

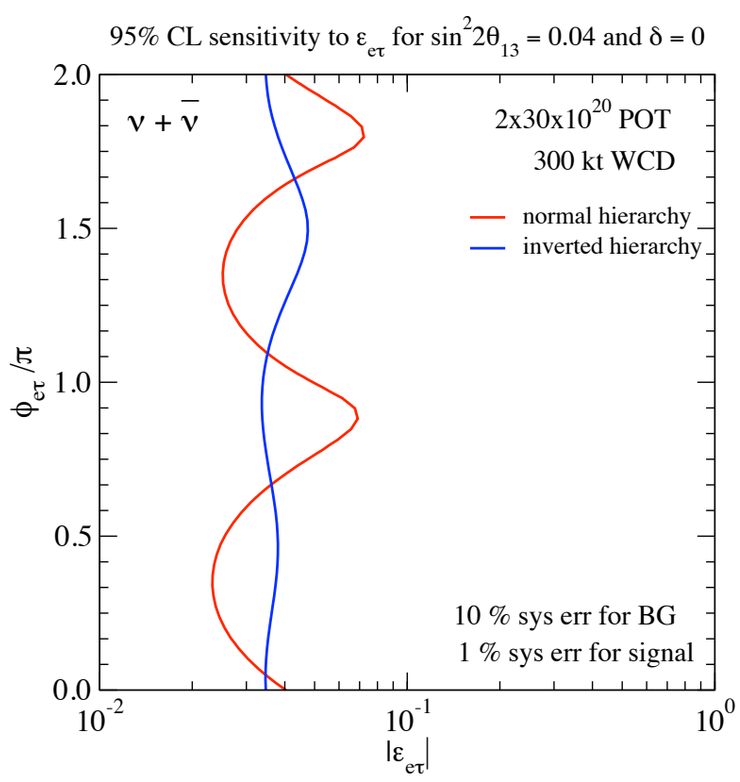
Valle, Gago-Guzzo-Nunokawa-Teves-Zukanovich Funchal

Preliminary





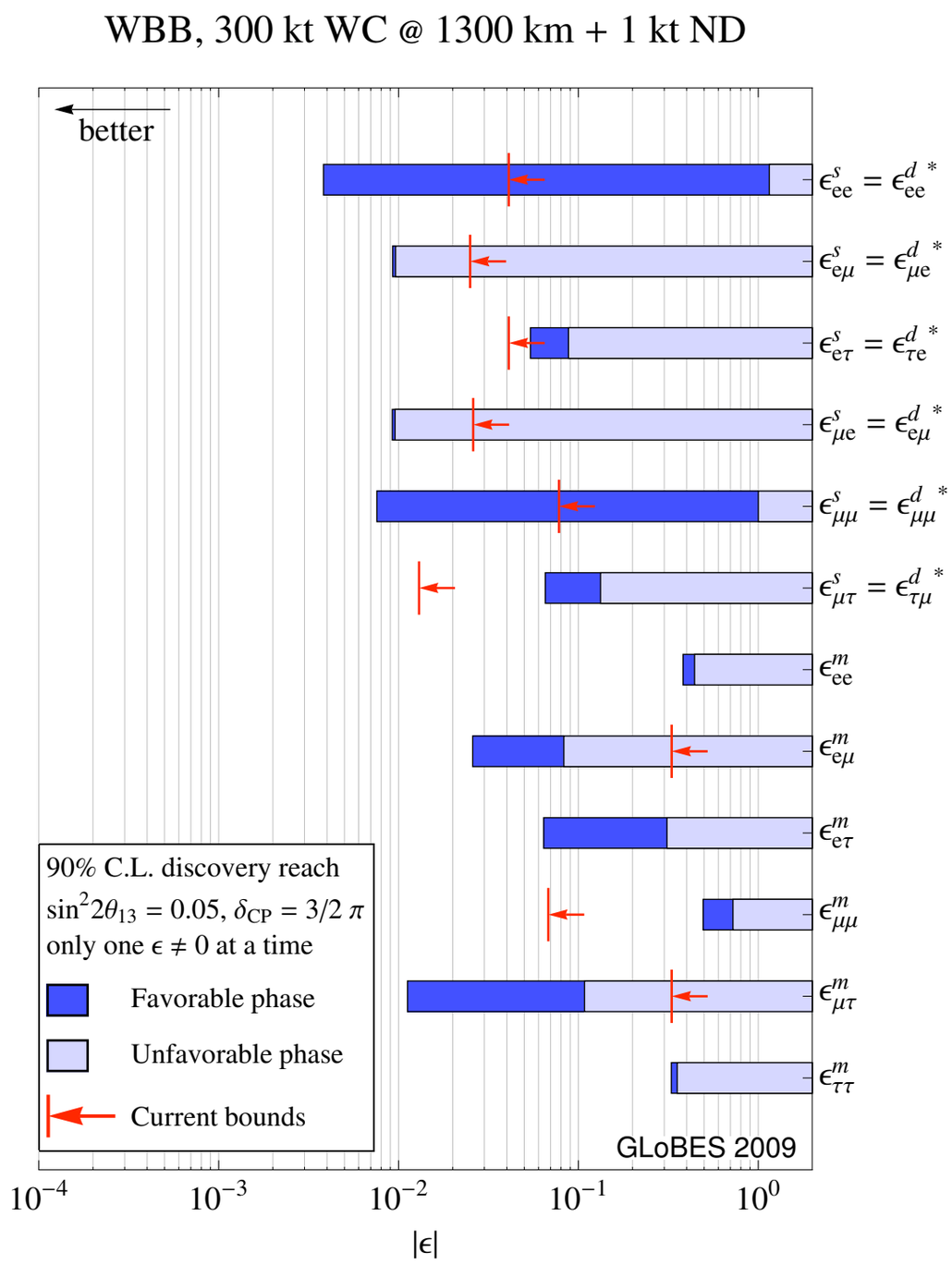




- Hiroshi Nunokawa, SP, Renata Zukanovich-Funchal

from Joachim Kopp

NSI sensitivity of FNAL-DUSEL wide band beam



GLoBES simulation:

- $\nu + \bar{\nu}$ running
  3×10^{21} p^+ on target each
- Far detector: 300 kt (fiducial) water Čerenkov @ 1 300 km
- Includes hypothetical 1 kt water Čerenkov near detector
- Includes 3-flavor treatment, systematical uncertainties, detector response function, parameter correlations, . . .

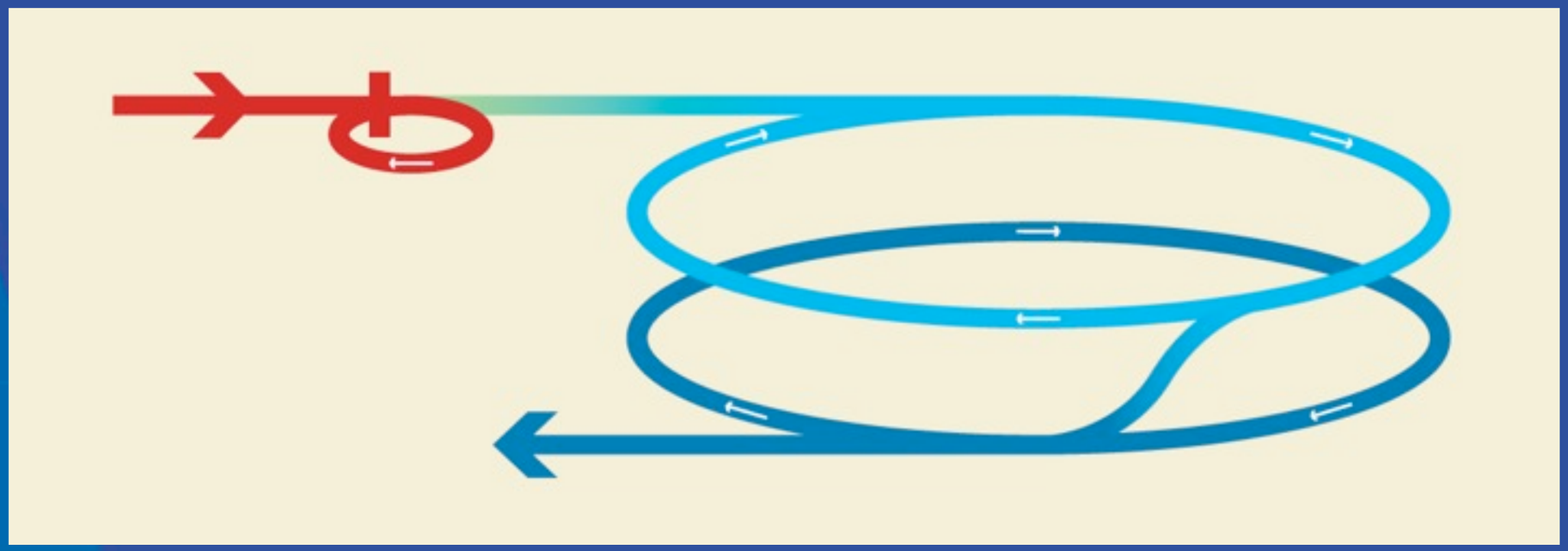
GLoBES experiment description based on work by Mary Bishai, Mark Dierckxsens, Milind Diwan, Christine Lewis, Patrick Huber
Current bounds from Biggio Blennow Fernandez-Martinez arXiv:0907.0097

Preliminary

Project X and LBNE to Homestake

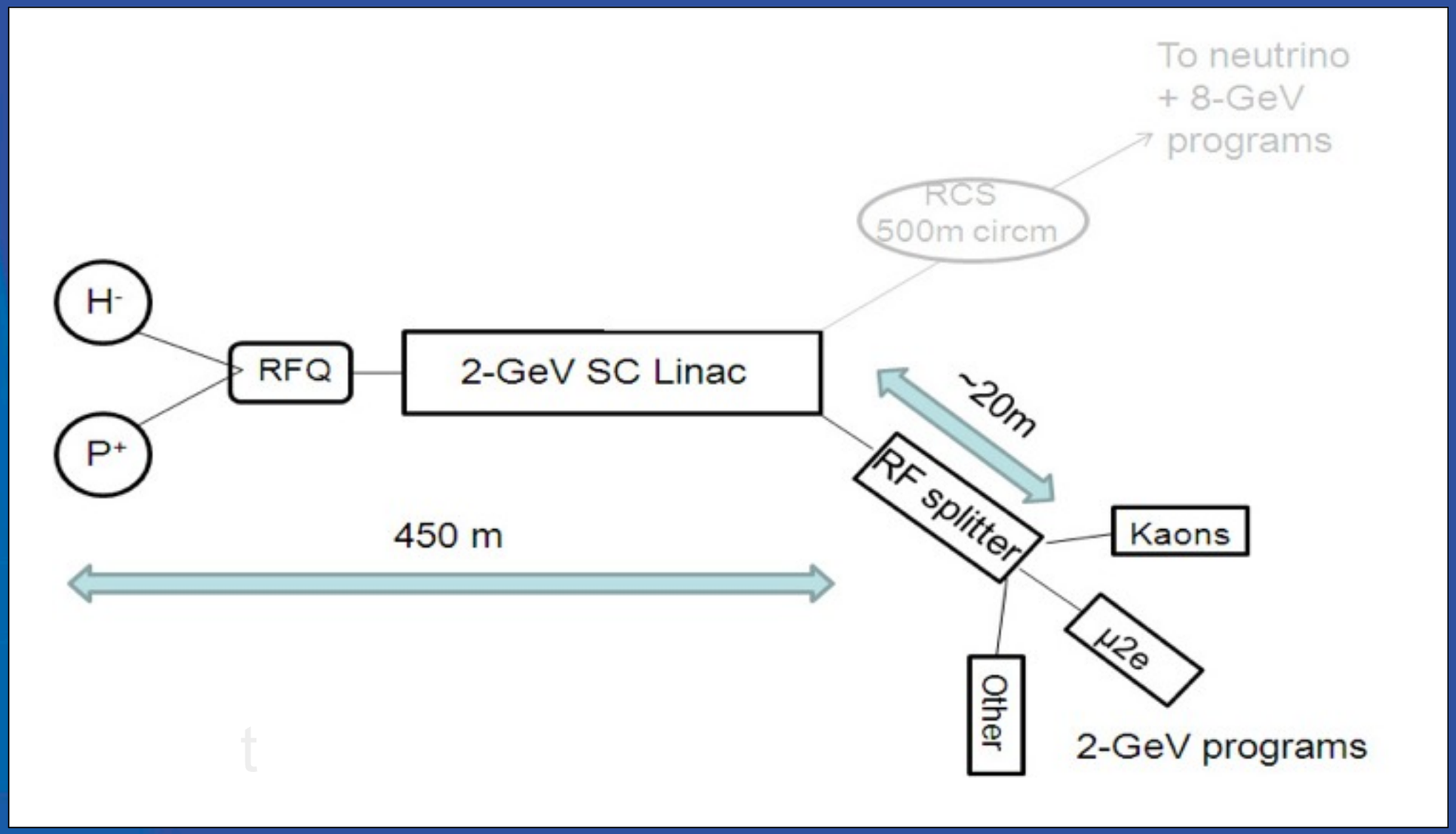
- 5% of the time line, the 2 GeV linac feeds a simple Rapid Cycling Synchrotron (RCS), 500m circumference, to strip, accumulate and boost the energy to 8 GeV

- Six pulses of the SAB are transferred to the recycler, filling the existing recycler, and every 1.4 sec transferred to the Main Injector for acceleration to high energies (60 GeV to 120 GeV)

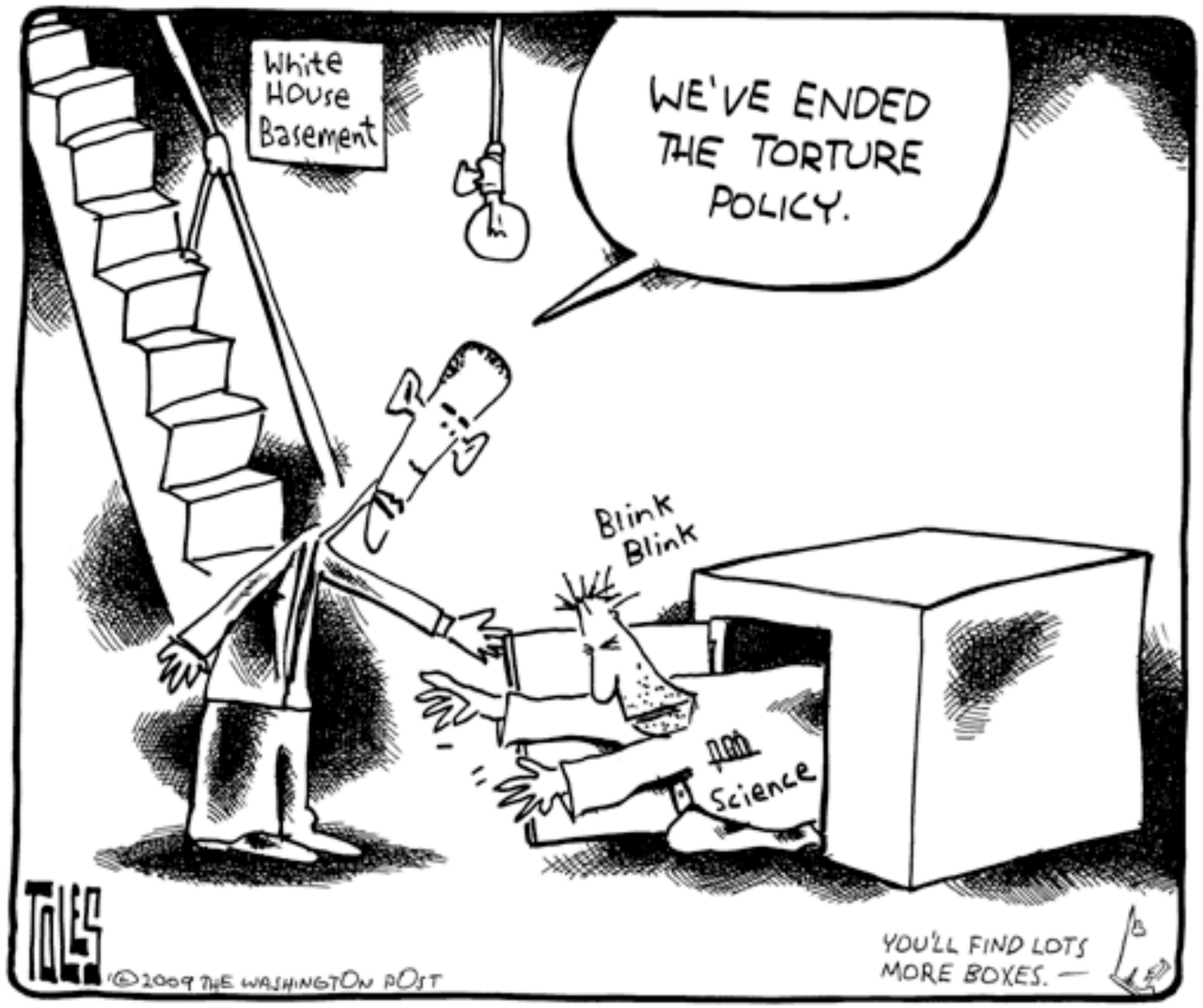


Project X and 2 GeV beams

- The greatest potential for rare processes comes from 2 MW continuous beam. Intensity experiments need continuous beam: pile up is the main limitation in pulsed beams



Washington Post 1/25/2009



http://www.washingtonpost.com/wp-dyn/content/opinions/tomtoles/?name=Toles&date=01252009