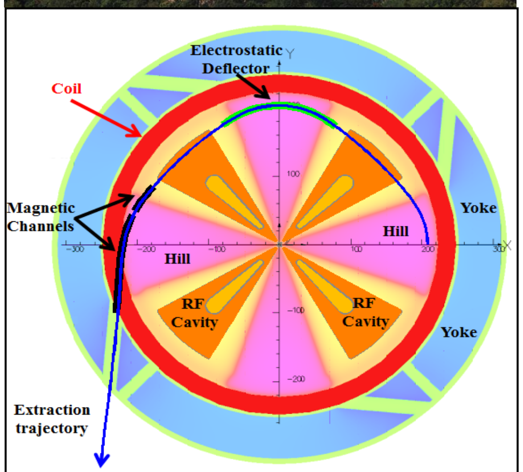
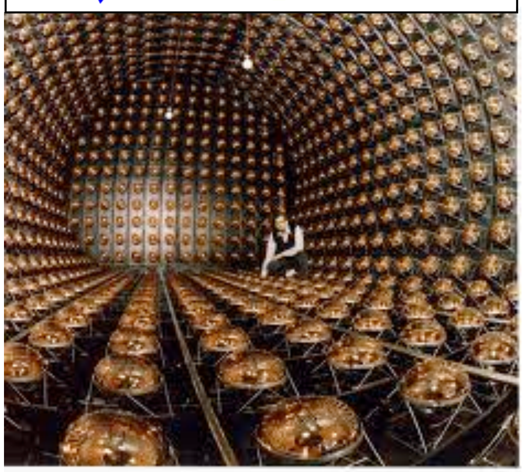




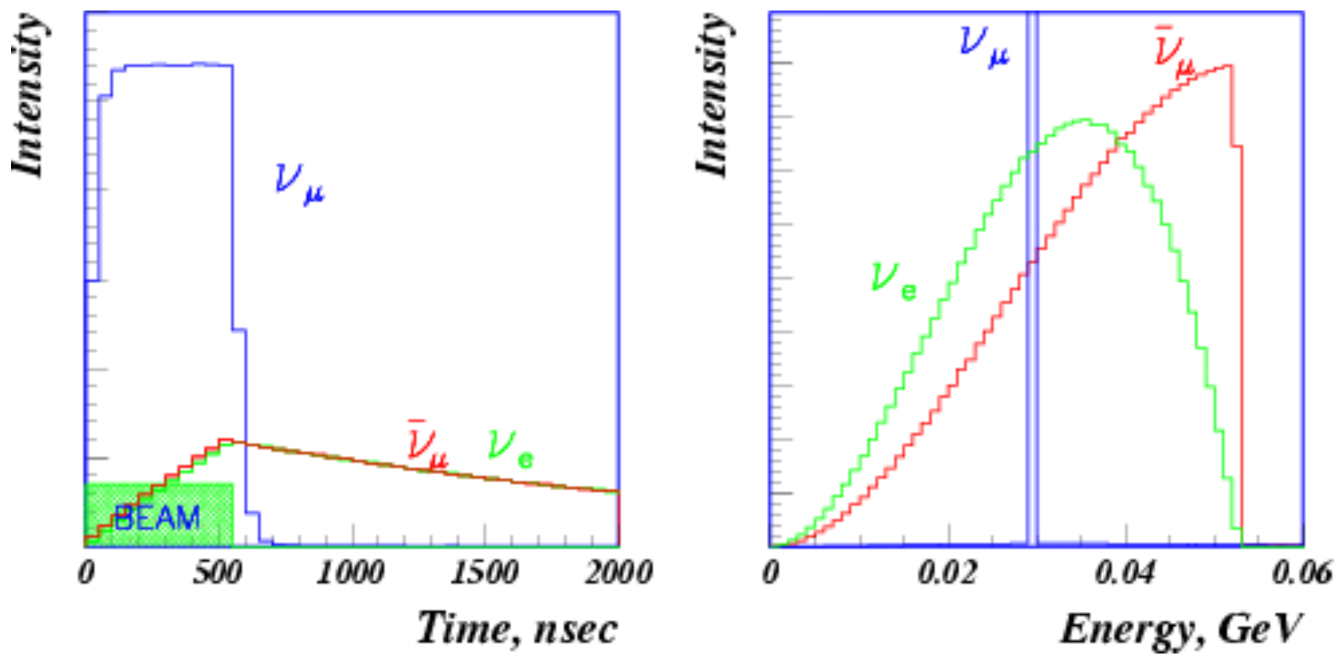
Review:
Decay at Rest Sterile Neutrino Searches

Lindley Winslow
University of California Los Angeles

Two Main Options:

- *Pion Decay-At-Rest*
  - Highlight: OscSNS
- *Isotope Decay-At-Rest*
  - Highlight: IsoDAR

Pion Decay-At-Rest

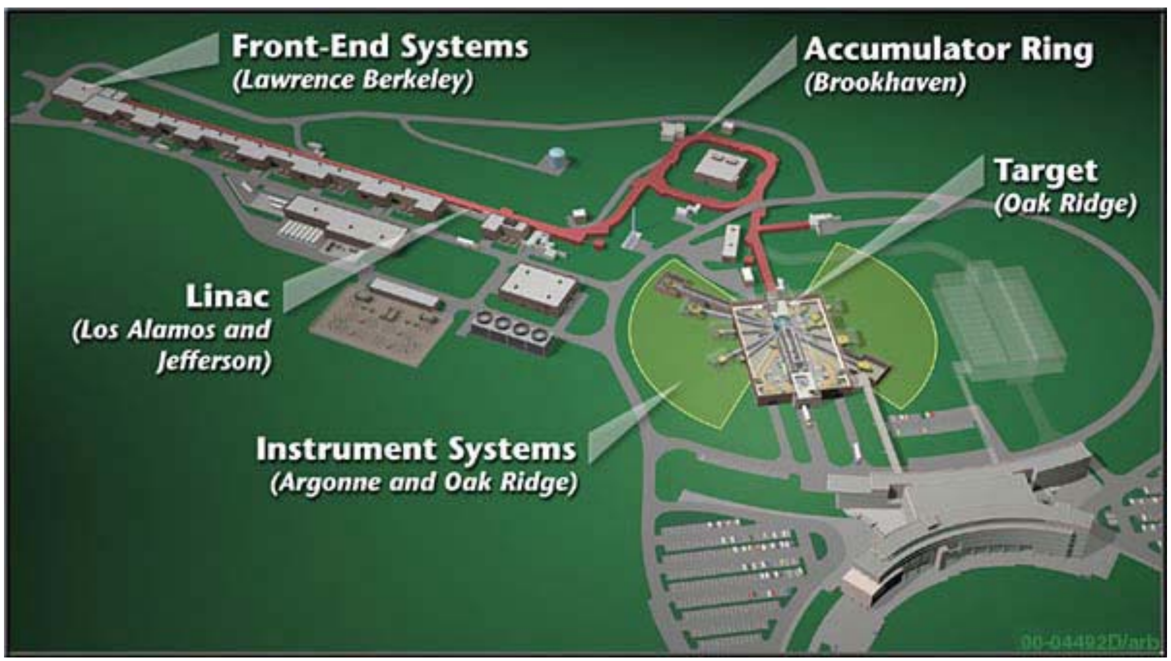


Simple beam dynamics well determined by the kinematics of the pions decaying at rest.

OscSNS

From:
W. Louis

- Make use of the "free" neutrinos being made at the Spallation Neutron Source (SNS).



The SNS is putting $2x10^{23}$ ~1GeV protons on a liquid Hg target per year (1.4MW).

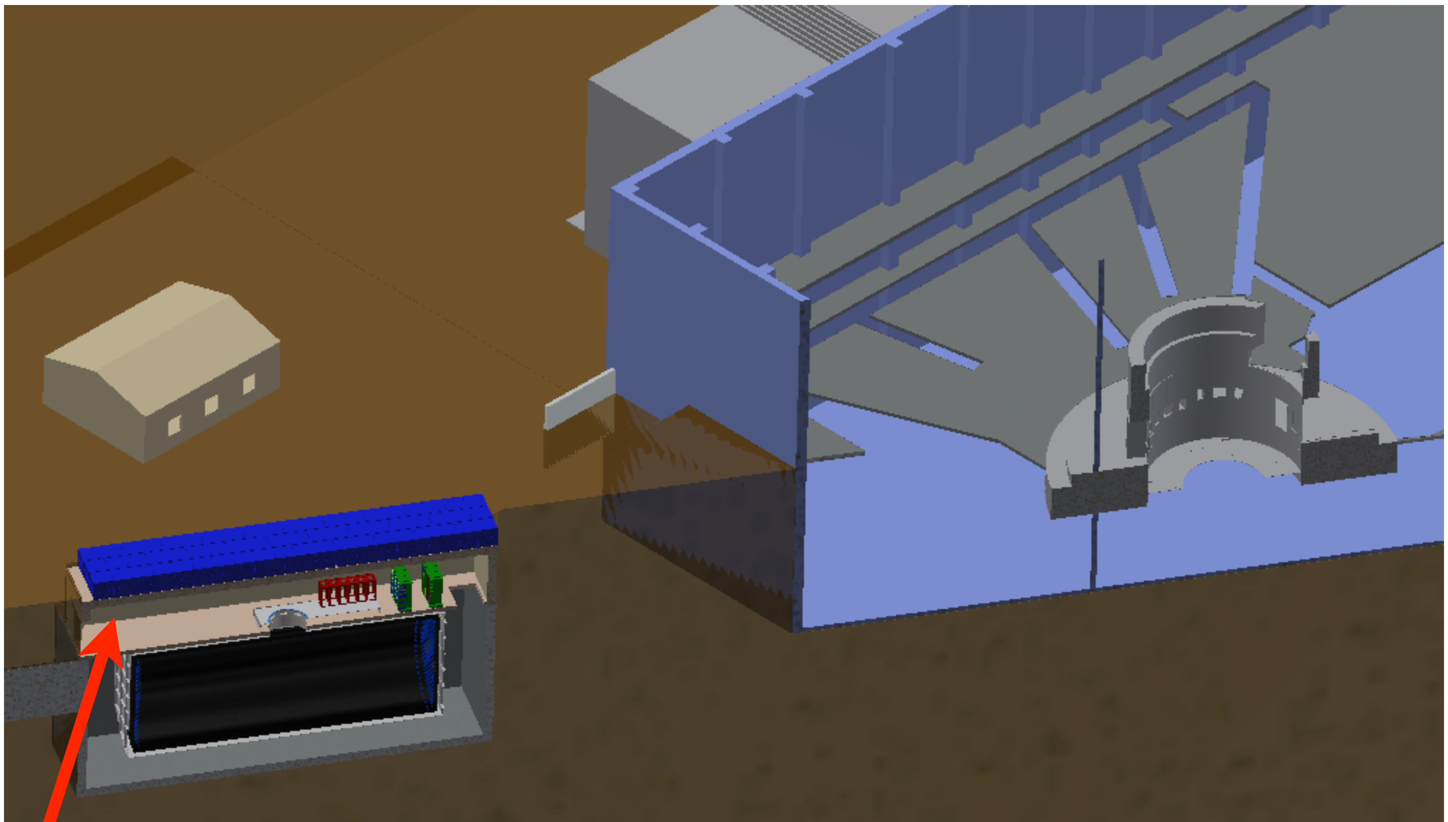
Pretty Picture:

The SNS at ORNL

Zooming In:

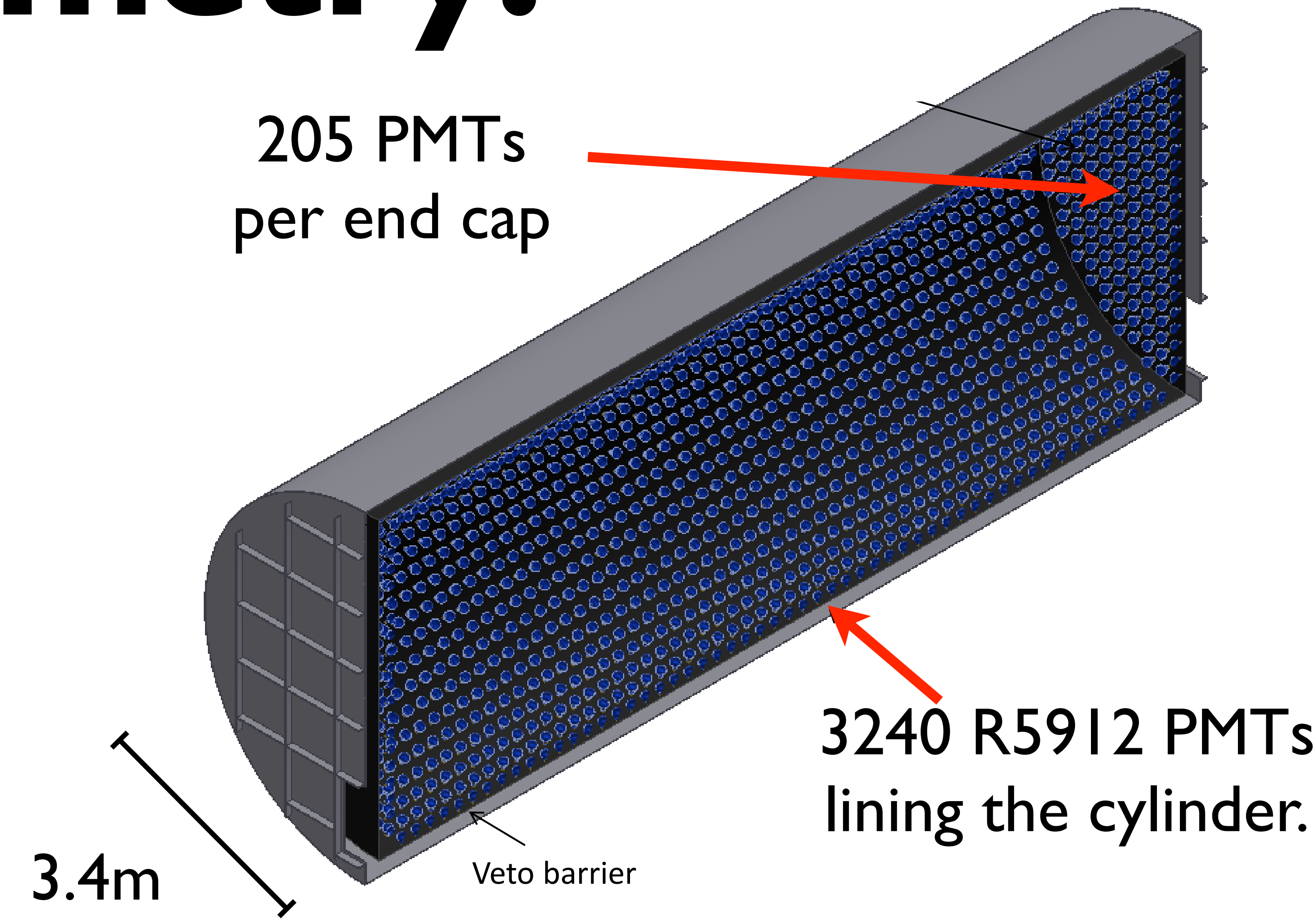
Assumed Detector Location

Detector Hall:



Steel Shielding

Detector Geometry:



Better Than LSND:

- Mass **5 x** Larger
- Neutrino Source Intensity **x 2**
- Lower Duty Factor **x 1000**

(less cosmogenic background)

- Separation of $\boldsymbol{\nu_\mu}$ & $\boldsymbol{\nu}_e/\boldsymbol{\bar{\nu}_\mu}$ with timing.
- Negligible Decay in Flight (backwards).
- Negligible neutrino background **x 2-4**

(60m vs. 30m)

Summary with LSND Parameters:

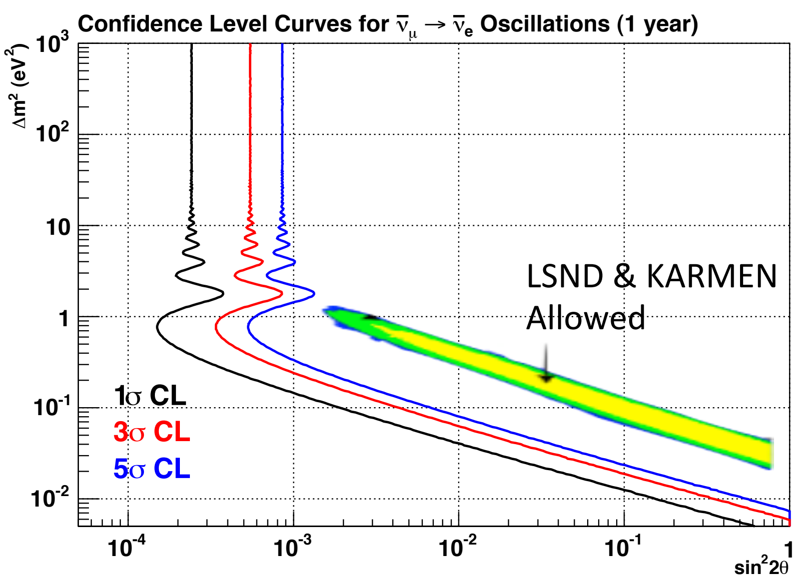
- 350 $\bar{\nu}_e$ oscillation events per year with 80 background events.
- Should also observe ν_e and ν_μ disappearance.

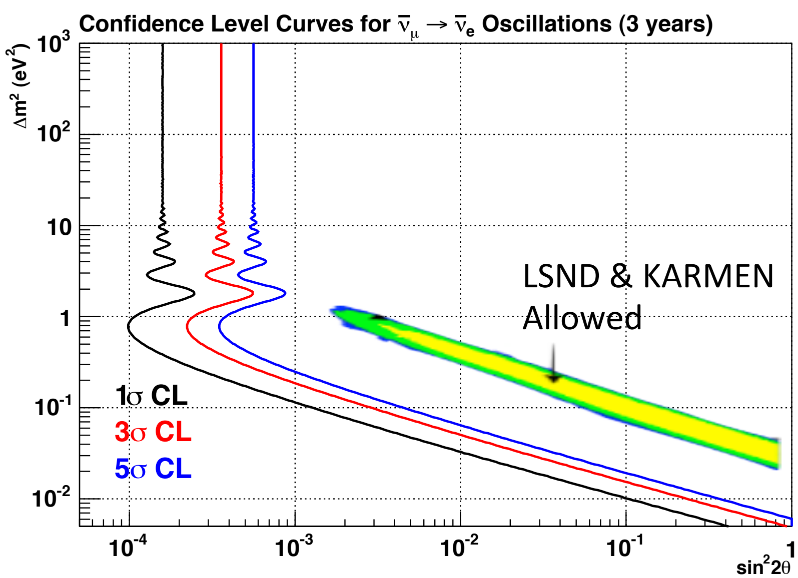
Should Also get cross section measurements and may be even a $\sin^2\theta_W$ measurement.

Let’s see what it can do!

$\bar{\nu}_\mu \rightarrow \bar{\nu}_e$ Appearance!

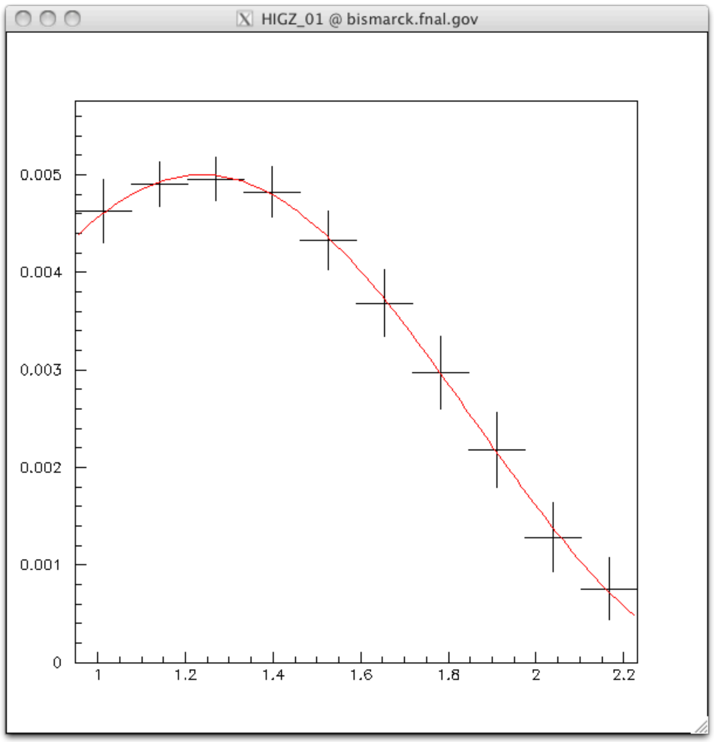
Sensitivity for 2 and 6 years of running



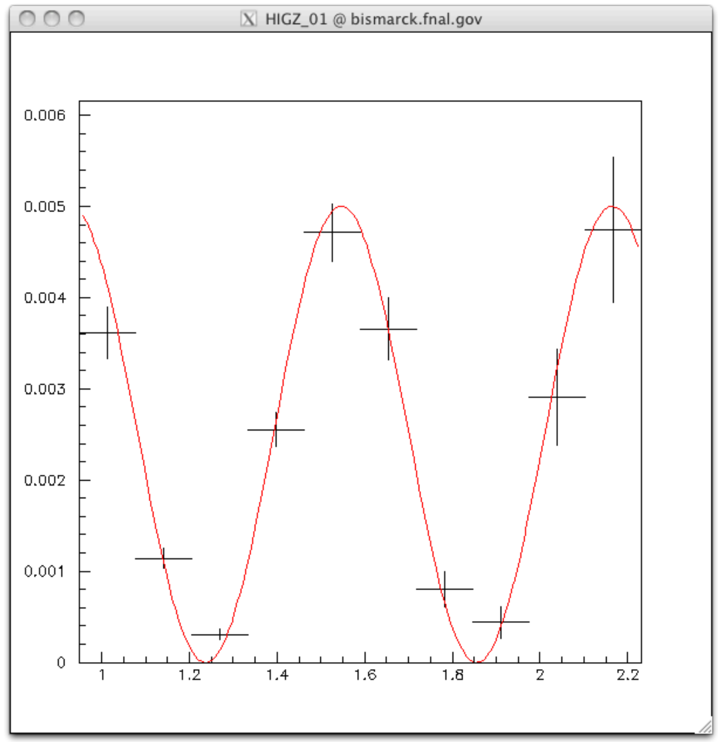


Can observe oscillation across the detector!

Assuming 10y of data & $\sin^2 2\theta$ = 0.005, Δm^2=1 eV^2



Assuming 10y of data & $\sin^2 2\theta$ = 0.005, Δm^2=4 eV^2

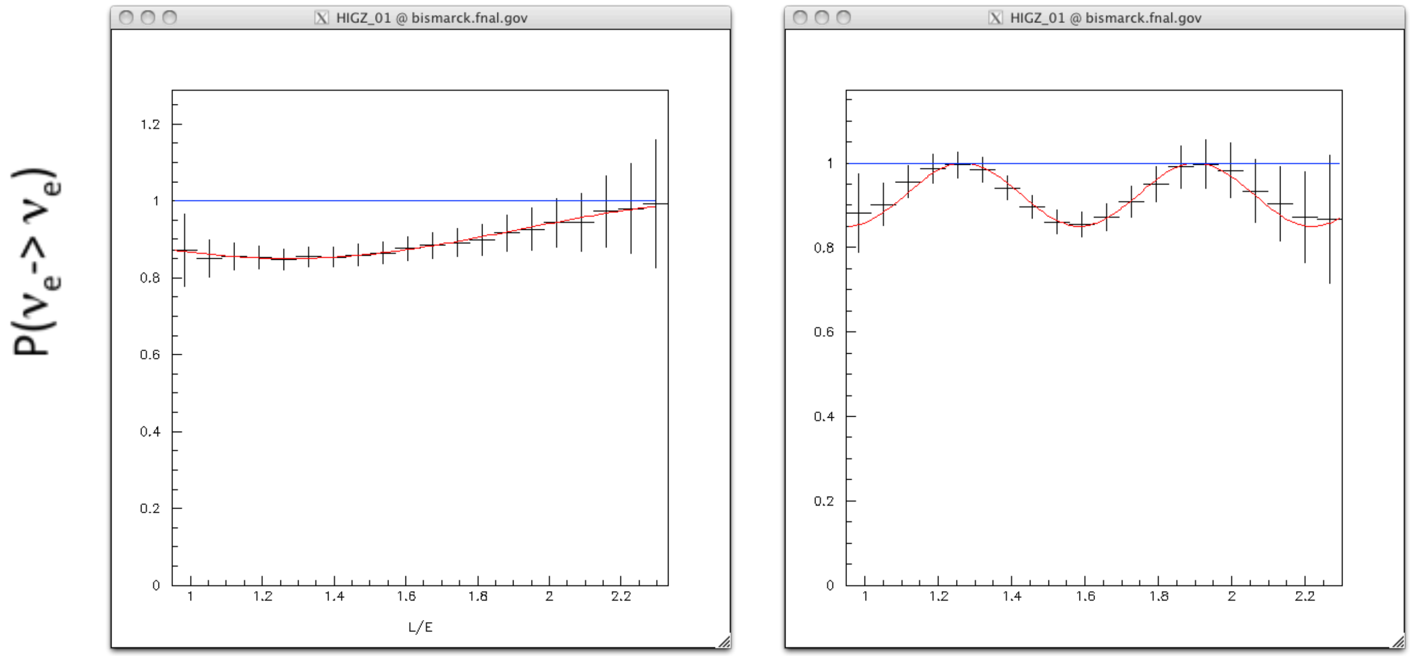


L/E (m/MeV)

Note the distinctive shape of the different possible parameters.

Disappearance in $\nu_e + C \rightarrow e^+ + N$ then $N \rightarrow C + e^+ + \nu_e$

Assuming 10y of data & $\sin^2 2\theta = 0.15$, $\Delta m^2 = 1\ eV^2$ Assuming 10y of data & $\sin^2 2\theta = 0.15$, $\Delta m^2 = 4\ eV^2$



L/E (m/MeV)

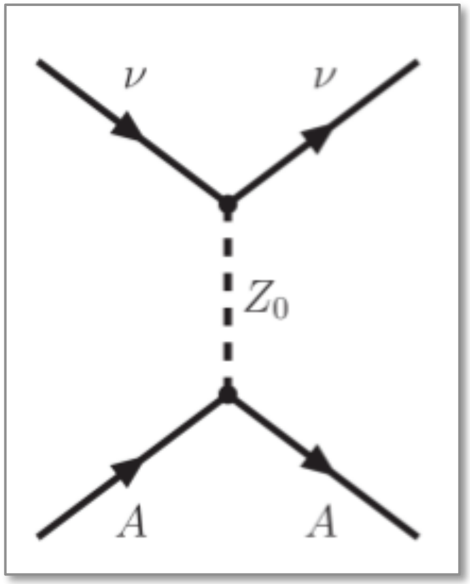
Once again the distinctive signature of oscillations across the detector.

For reference:

Channel	Events/2 years
ν_e C -> e^- N_{gs}	4705
ν_e C -> e^- N^*	2247
ν_μ C -> ν_μ C^*(15.11)	1490
ν C -> ν C^*(15.11)	7070
ν_e e^- -> ν_e e^-	1353
ν_μ e^- -> ν_μ e^-	450
100% ν_μ -> ν_e, ν_e p -> e^+ n	92,308
0.26% ν_μ -> ν_e, ν_e p -> e^+ n	240

Two quick variations:

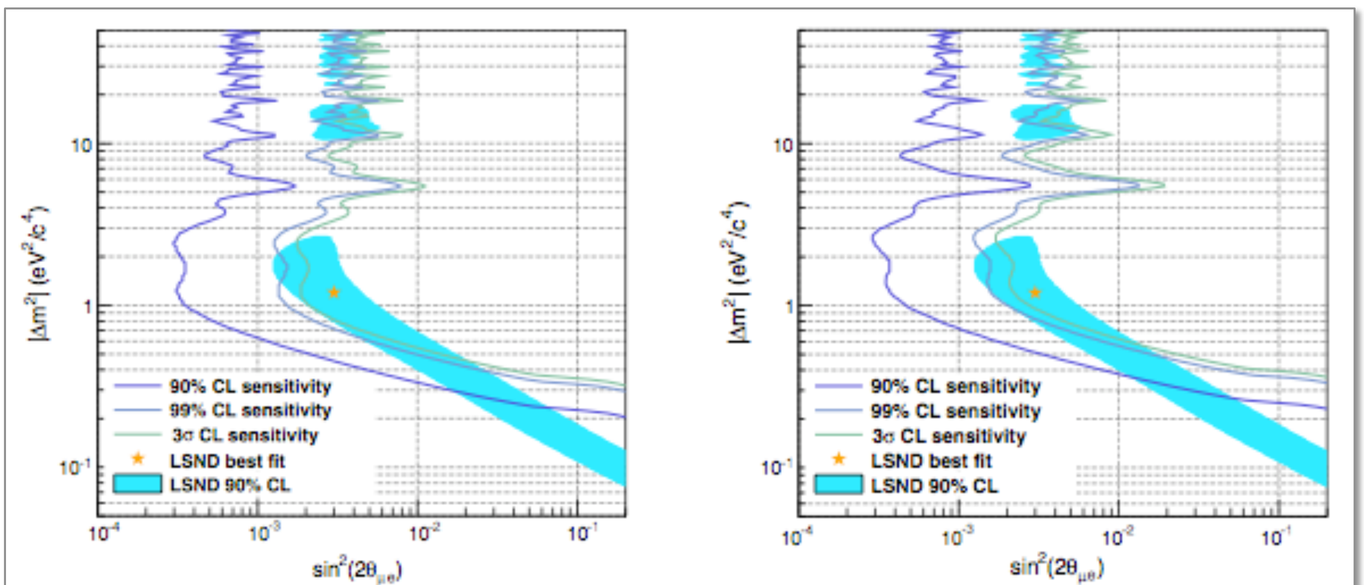
Coherent PiDAR



If we can observe coherent neutrino scattering then with either a Ge or Ar based detector.

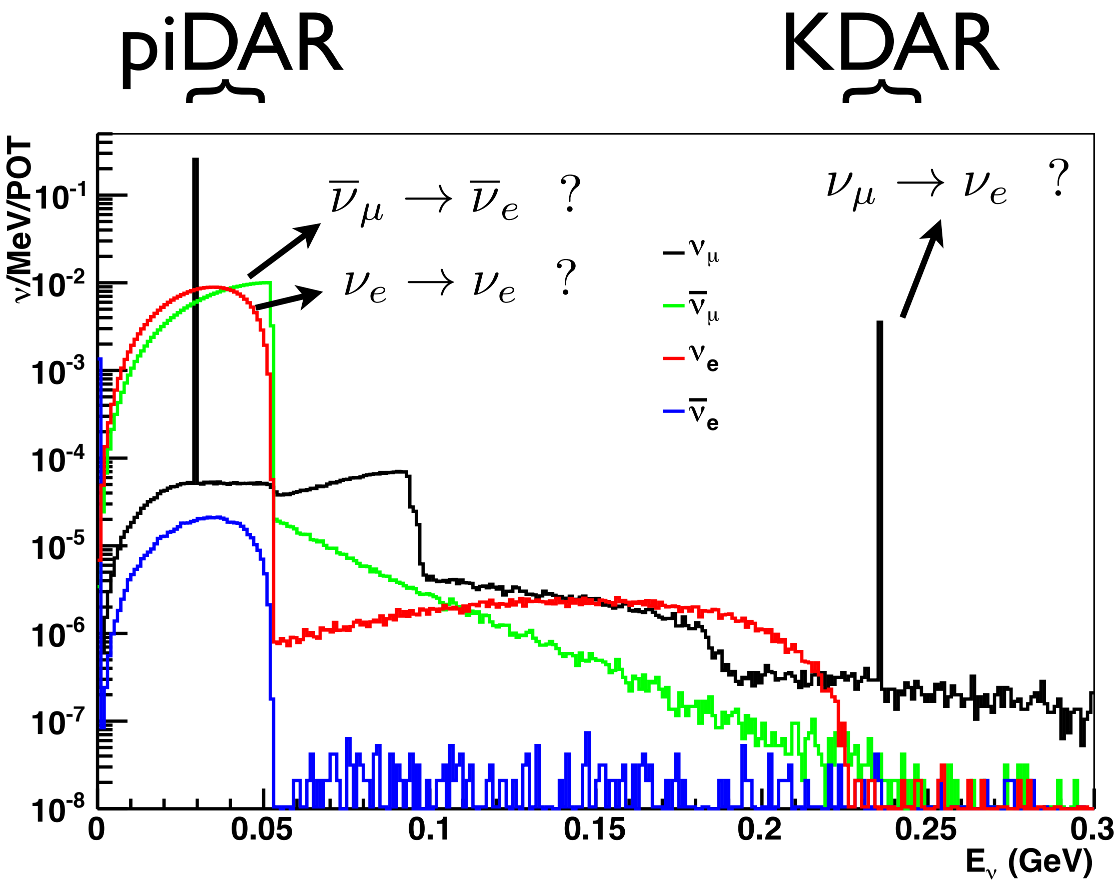
	^{76}Ge	^{40}Ar
Active mass	100 kg	456 kg
Efficiency	0.67 (flat)	0.50 (flat)
Threshold	10 keV	30 keV
$\frac{\Delta E}{E}$ at threshold	3%	18%
Radiogenic background	2/year	See text
Cosmogenic background	0.1/(10 kg · day)	0.1/(10 kg · day)
Beam-related background	0/year	0/year

PRD 86, 013004 (2012)



From: G. Karagiorgi

PiDAR and KDAR @ JPARC



- Spallation neutron source at JPARC's Material and Life Science facility provides 3 GeV protons at (eventually) 1 MW.
- Short beam window (~80 ns x2, 25 Hz).
  - Reduced steady-state background by 10,000 compared to LSND.
- Liquid scintillator detector; parameters (baseline, size, ...) are under consideration.
- Sensitivity to oscillations in multiple channels and with neutrino and antineutrino!
  - Provides discovery confidence.
  - If it exists, precision measurements of sterile properties.

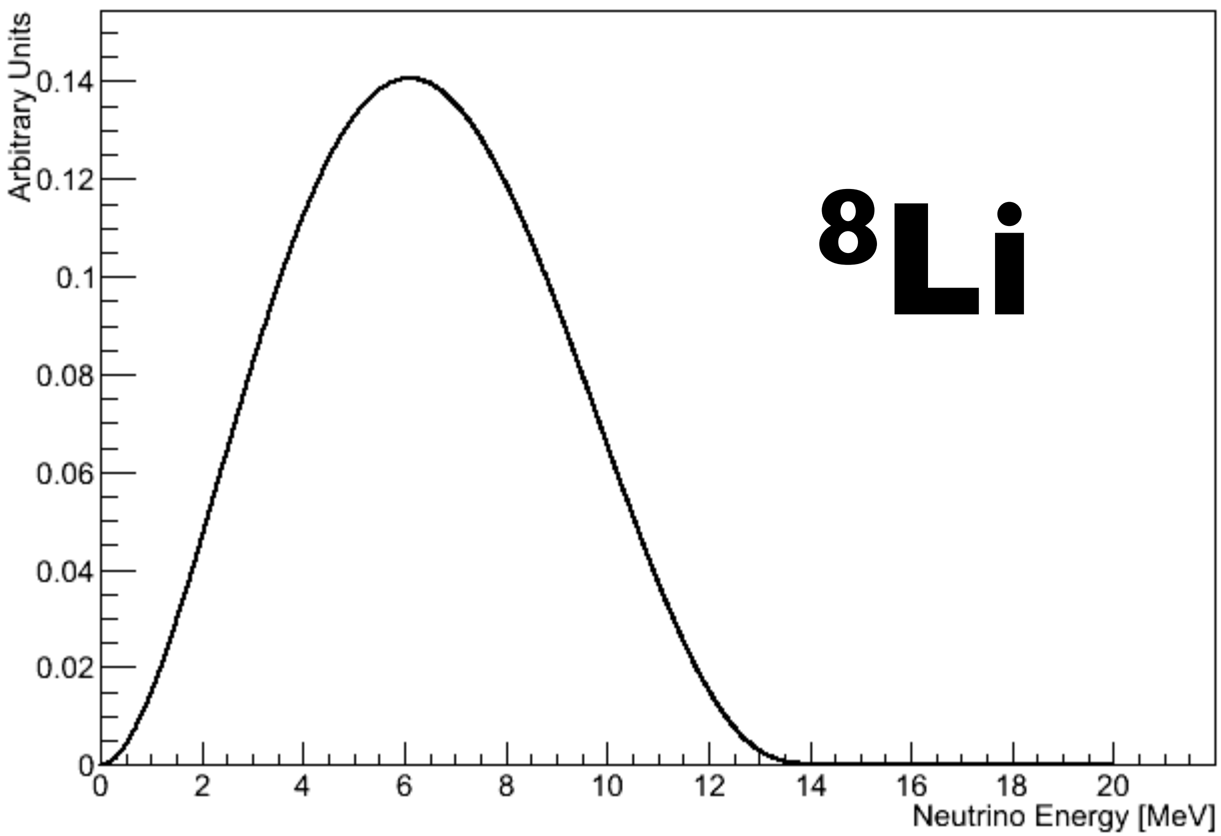
From:
J. Spitz

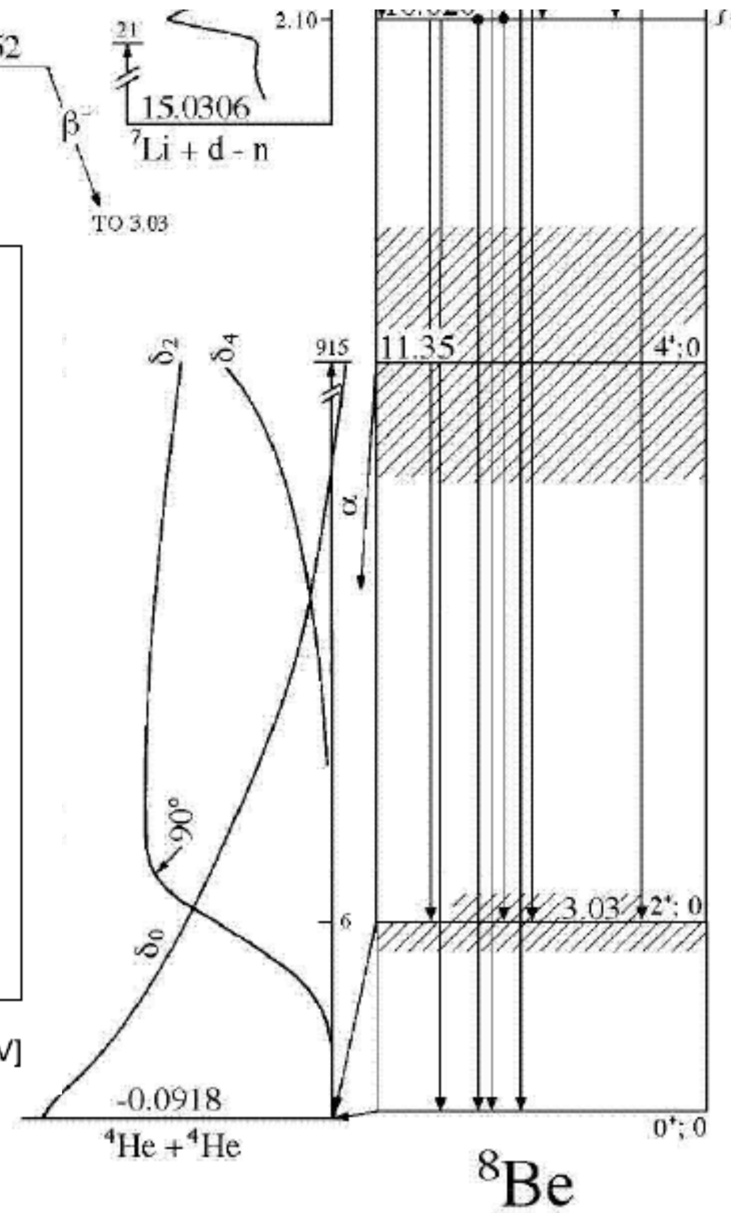
KDAR described in Phys.Rev. D85 (2012) 093020

Next Up:

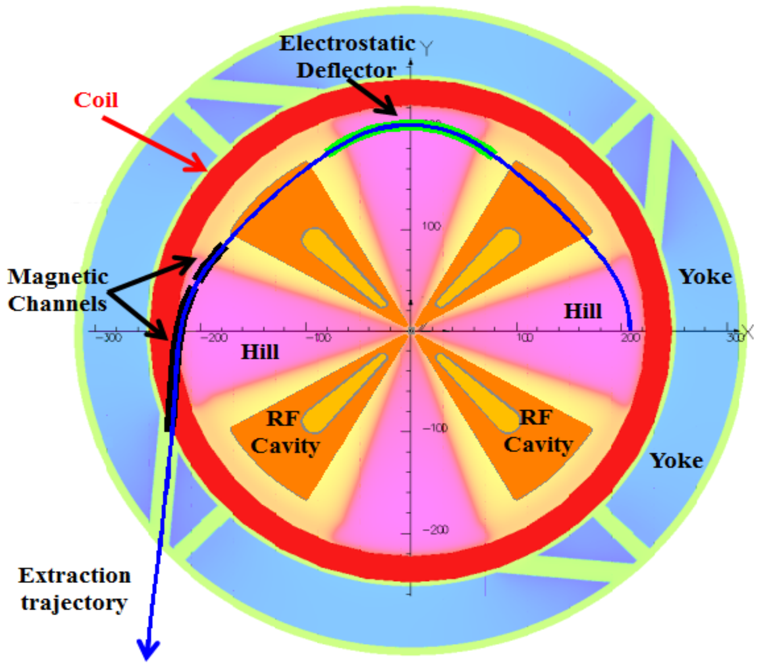
Isotope Decay-At-Rest

Even a complicated beta decay is well understood.

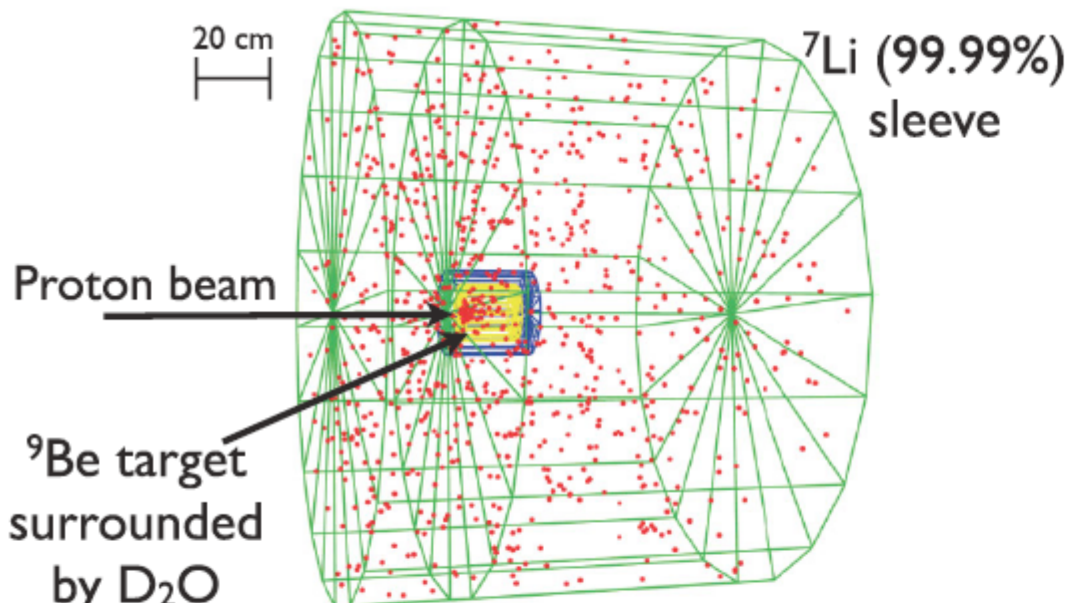




IsoDAR

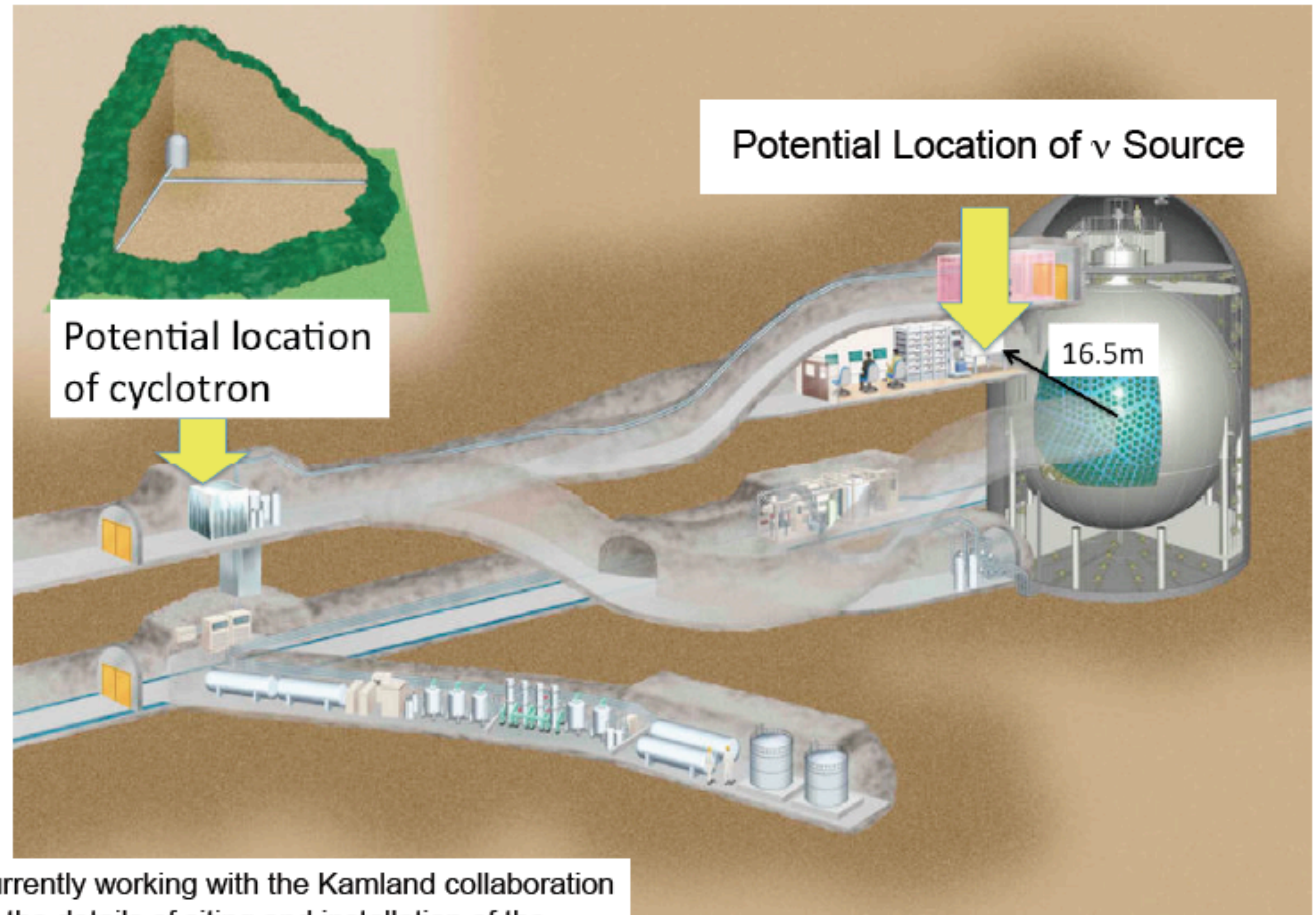


Neutrons capture on ^{7}Li to make ^{8}Li.



Accelerating H_2^+,
60MeV/n @ 5ma

Place Source Near Detector:



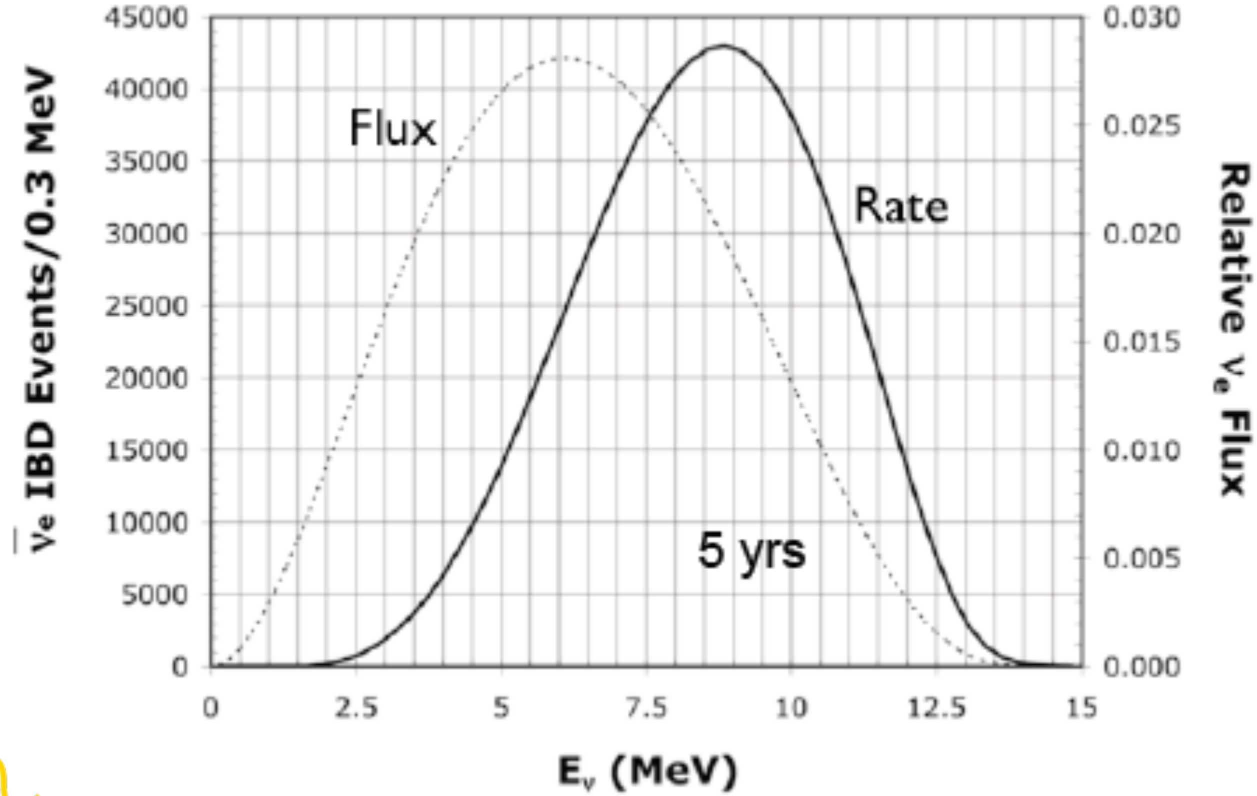
Currently working with the Kamland collaboration on the details of siting and installation of the cyclotron, beamline, and neutrino source.

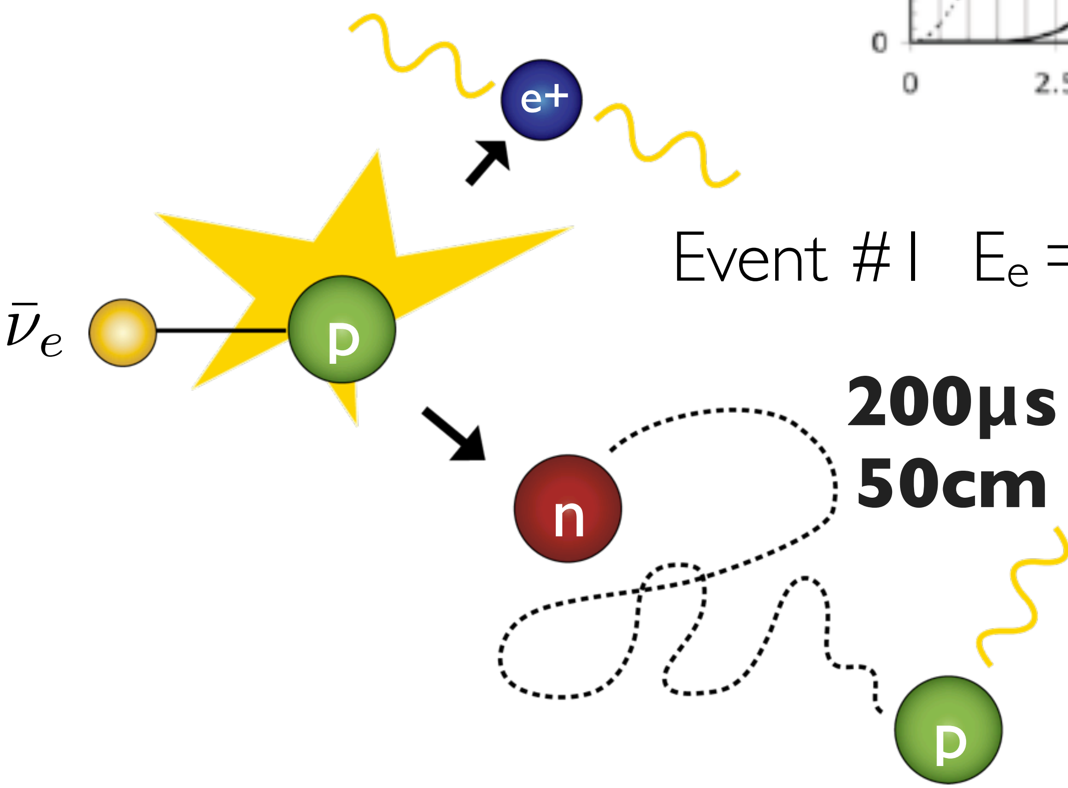
Make Disappearance Measurement:

- Look for $\bar{\nu}_e$ disappearance.
- Look for L/E dependence across detector.
- Sensitivity to LSND signal region and Reactor/Source anomalies.

For details see Phys.Rev.Lett. 109 (2012) 141802.

The Signal: *Inverse Beta Decay*



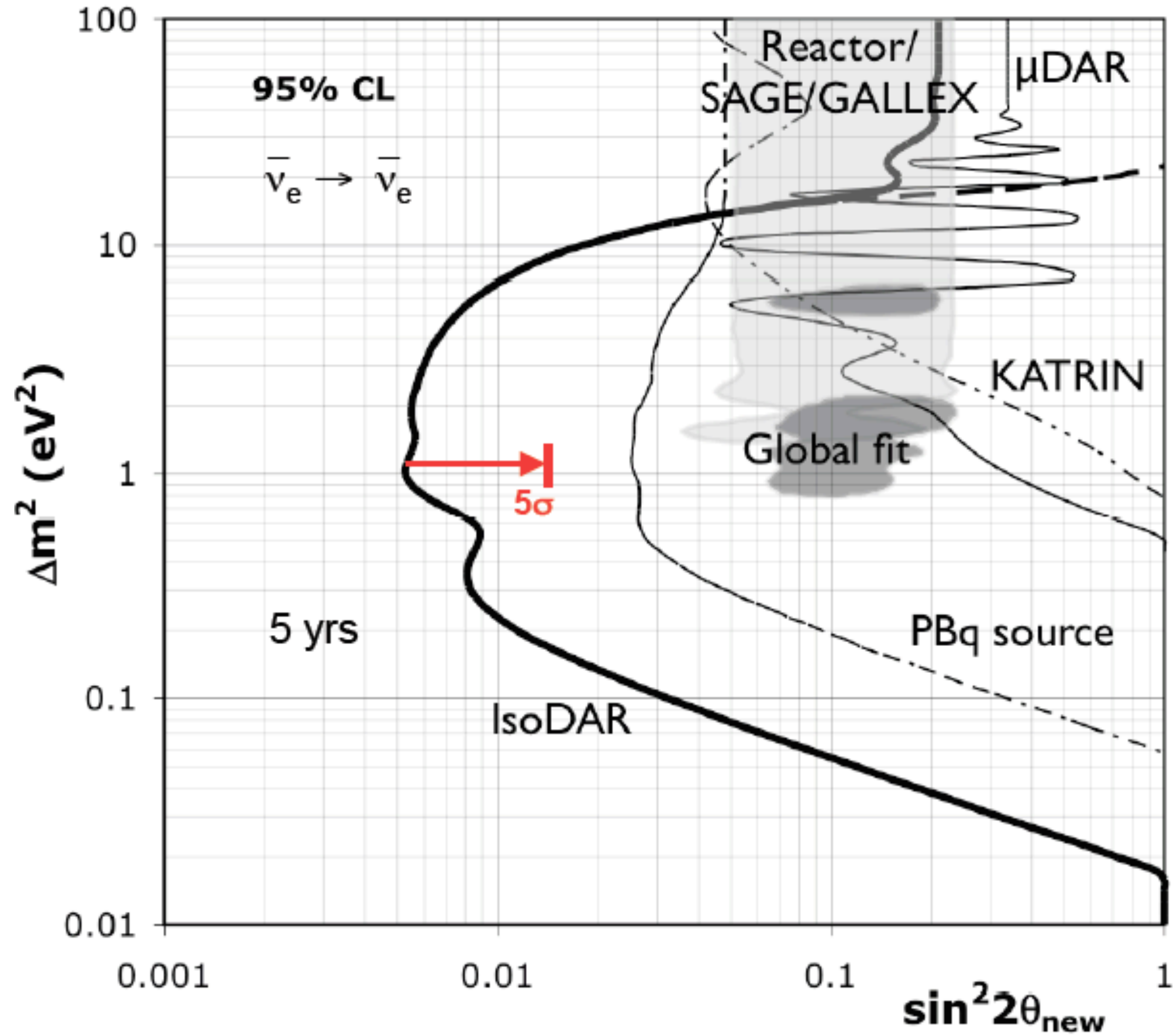


Event #1 $E_e = E_\nu - 0.8\text{MeV}$

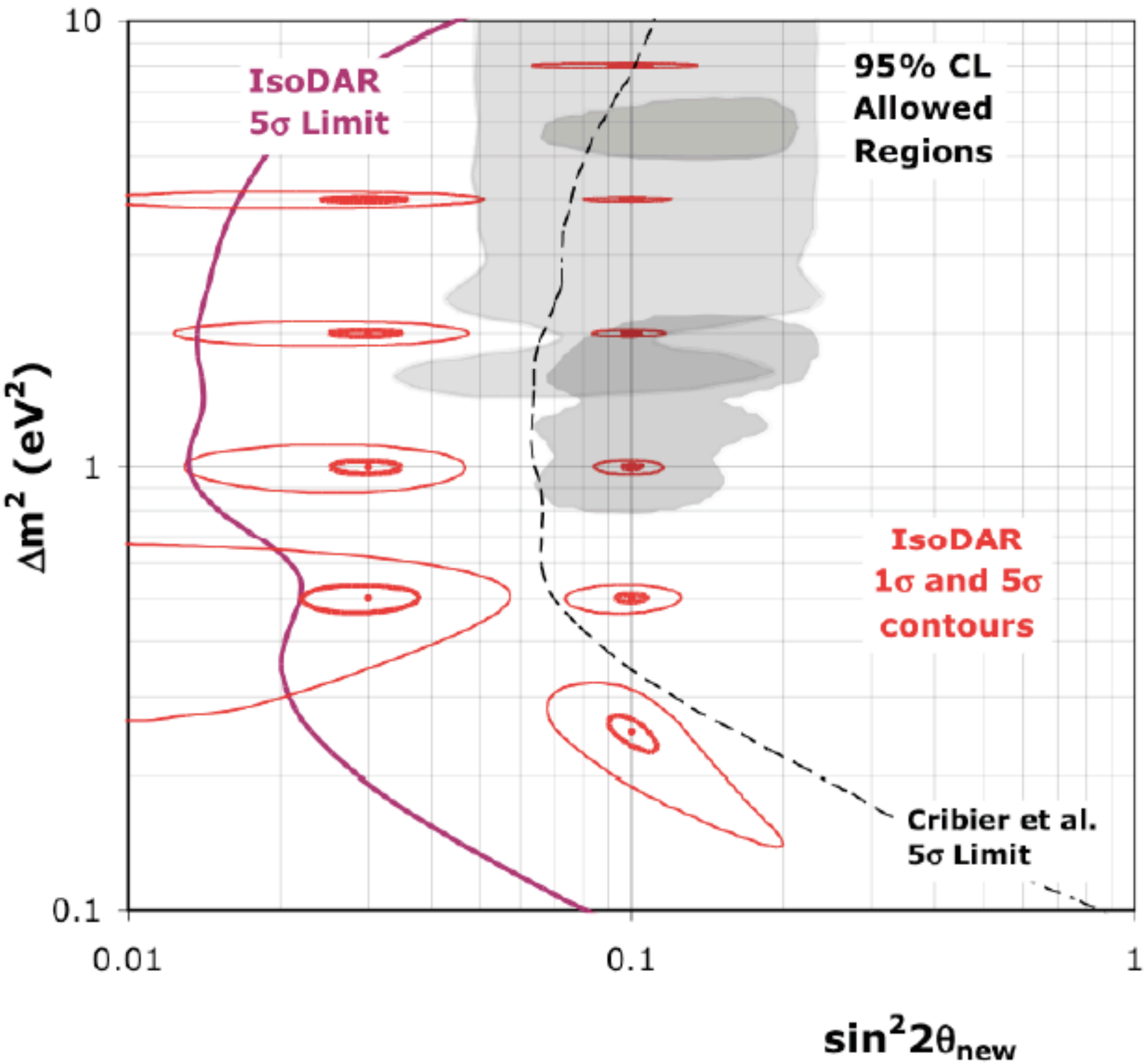
Event #2 $E\gamma \sim 2.2\text{MeV}$

~160,000 IBD reconstructed per year!

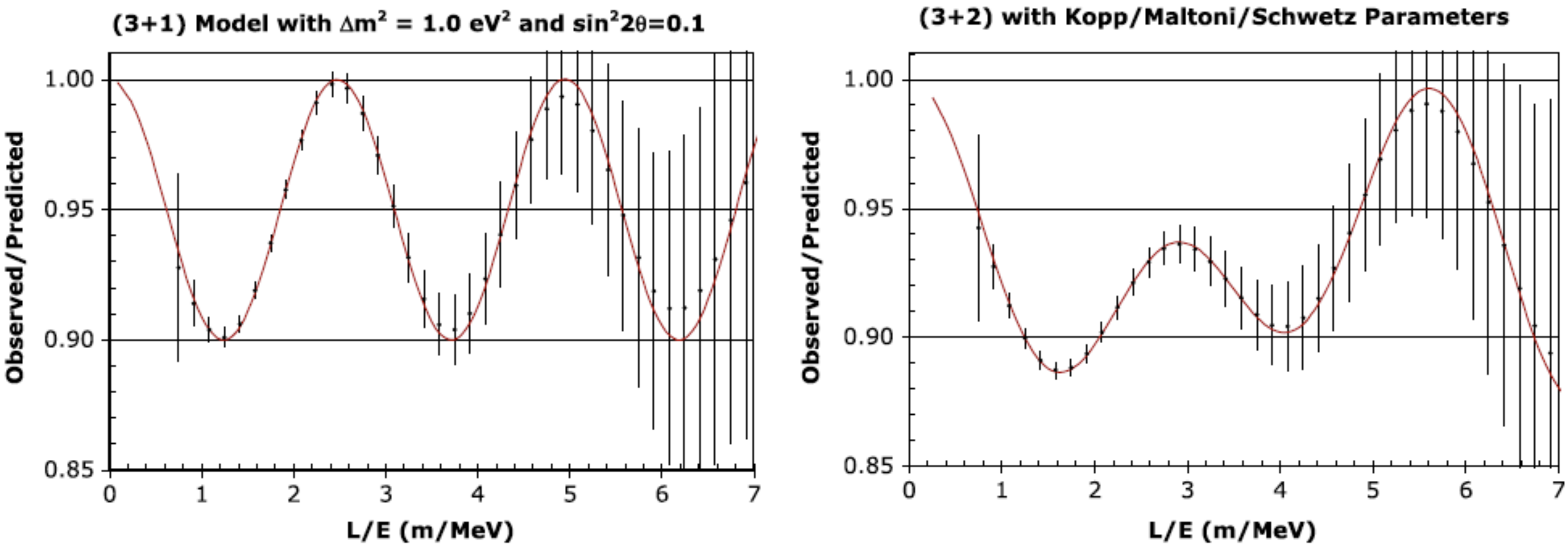
IsoDAR $\bar{\nu}_e$ Disappearance Oscillation Sensitivity (3+1)



IsoDAR Measurement Sensitivity

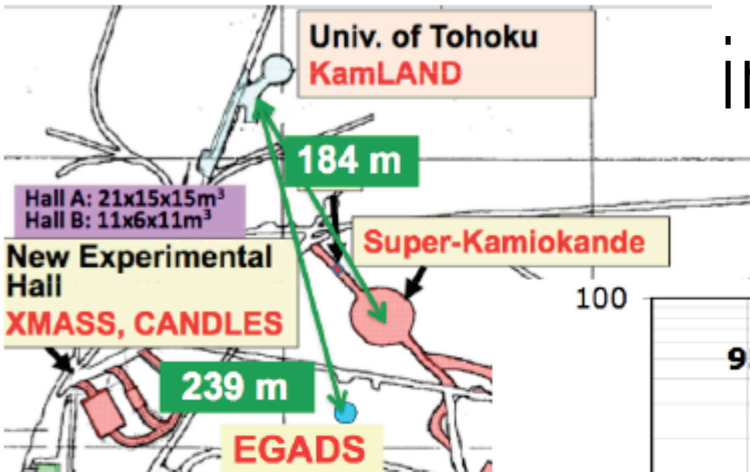


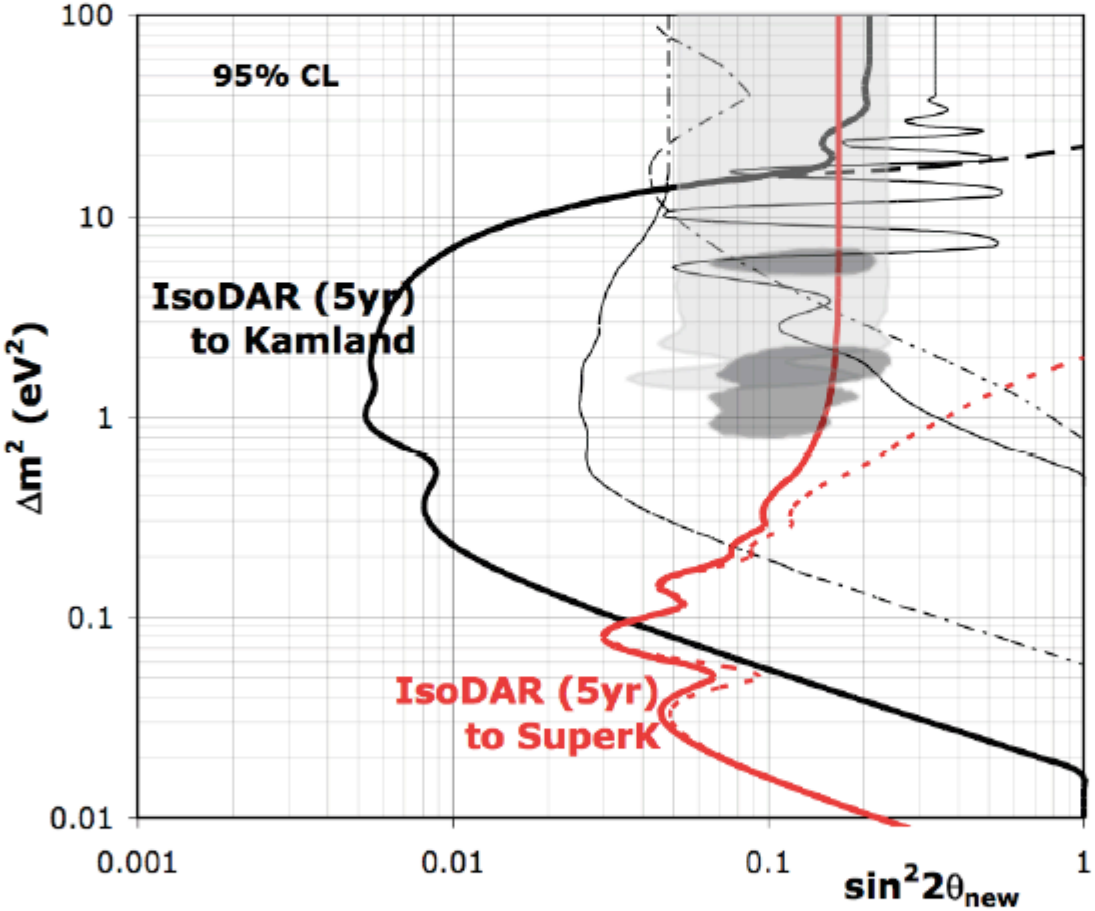
IsoDAR Oscillation in L/E



IsoDAR's high statistics and good L/E resolution has the potential to separate 3+1 and 3+2 models.

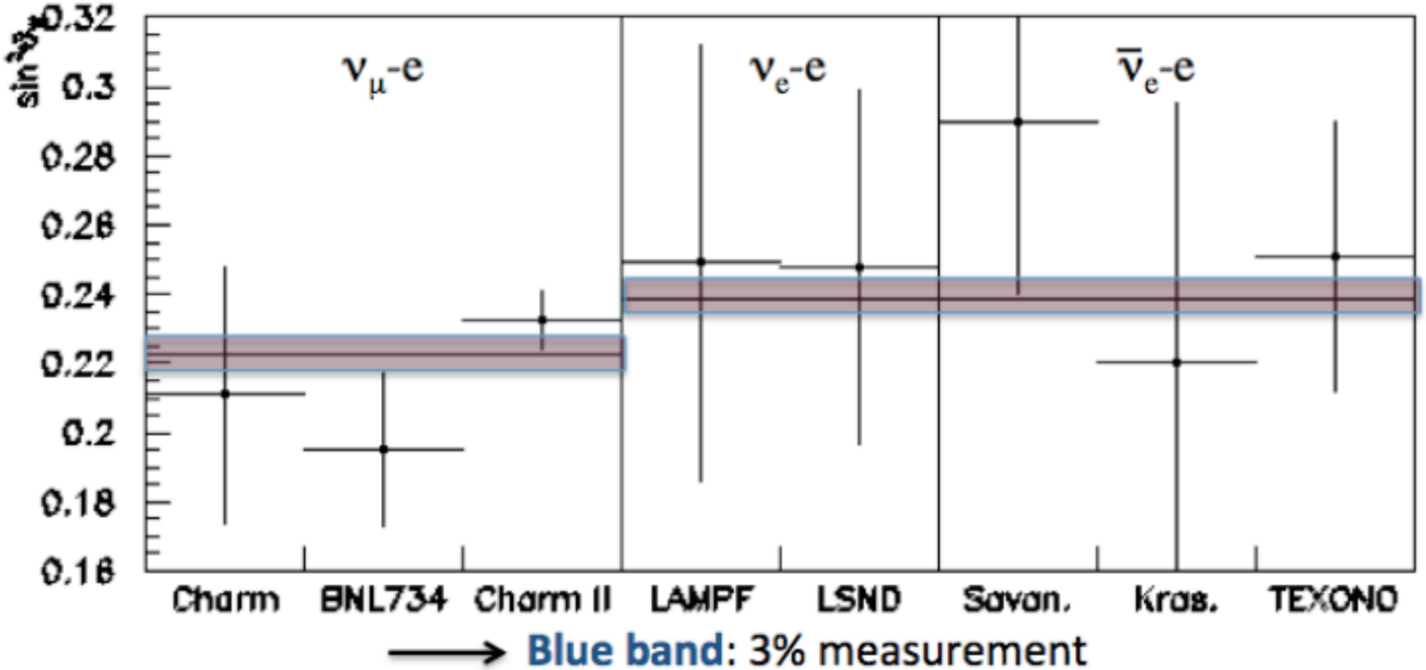
Possibility to probe lower in Δm^2 using Super-K.





Mass 22.5 kton
Enu > 5.5 MeV requirement
sig(E) -0.123+0.376sqrt(E)+0.0349E in Me
sig(L) 2.23m/sqrt(E(MeV))
L 185m
eff 0.402 = 60%*67%
DF fraction 90%
IBD Events (5yrs) 52,000

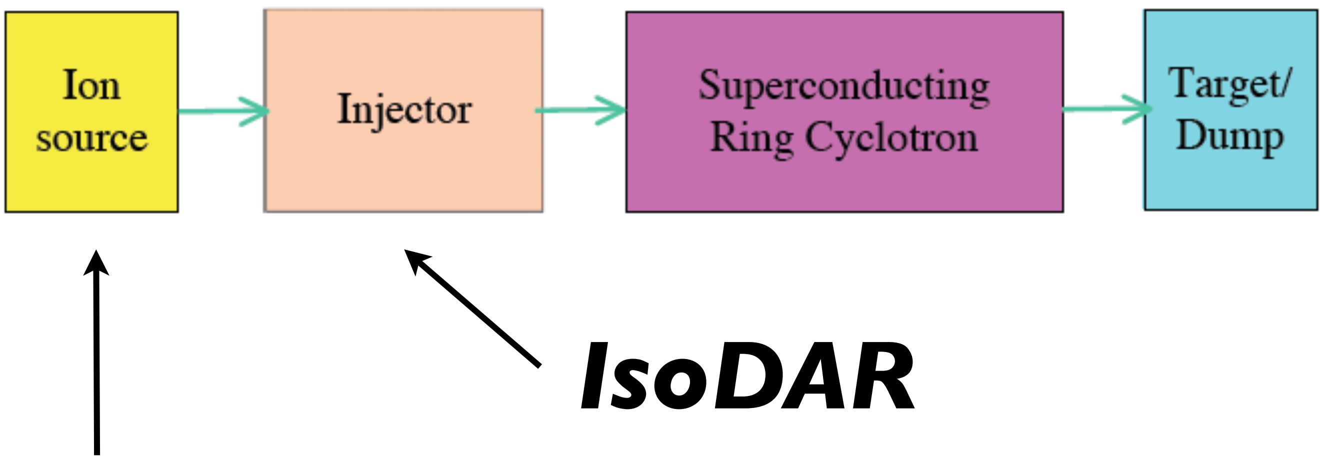
Can also do a scattering measurement...

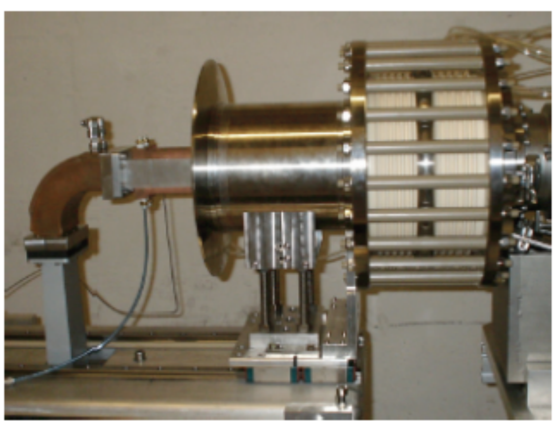


IsoDAR produces 7,200 events in five years allows a 3% measurement. This is not as good as NuTeV (0.7%) but would be the best $\bar{\nu}_e$-e measurement to date.

DAEδALUS

IsoDAR is part of the greater DAEdALUS program to develop multi-megawatt cyclotrons for a CP violation experiment.





Much work is underway including tests of the ion source at Best Cyclotrons, Inc in Vancouver this summer!

Summary:

Decay-At-Rest sources provide high flux and well characterized beams for sterile neutrinos searches. The high statistics allow these experiments to see the signature of oscillations, the L/E shape across a detector.

The End