LSND reloaded

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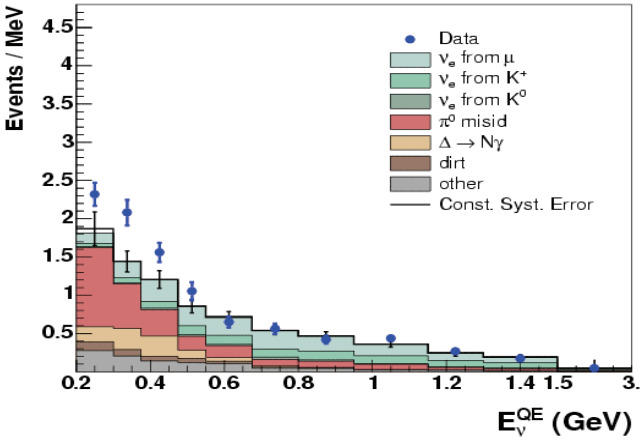
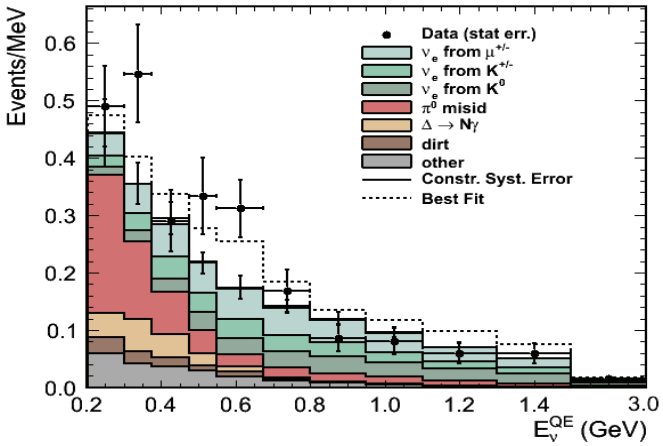
In this talk I will use Pions, Protons & Gadolinium to cook a definitive test of LSND

Based on S. Agarwalla, PH, Phys. Lett. B **696** (2011) 359.

An exotic animal

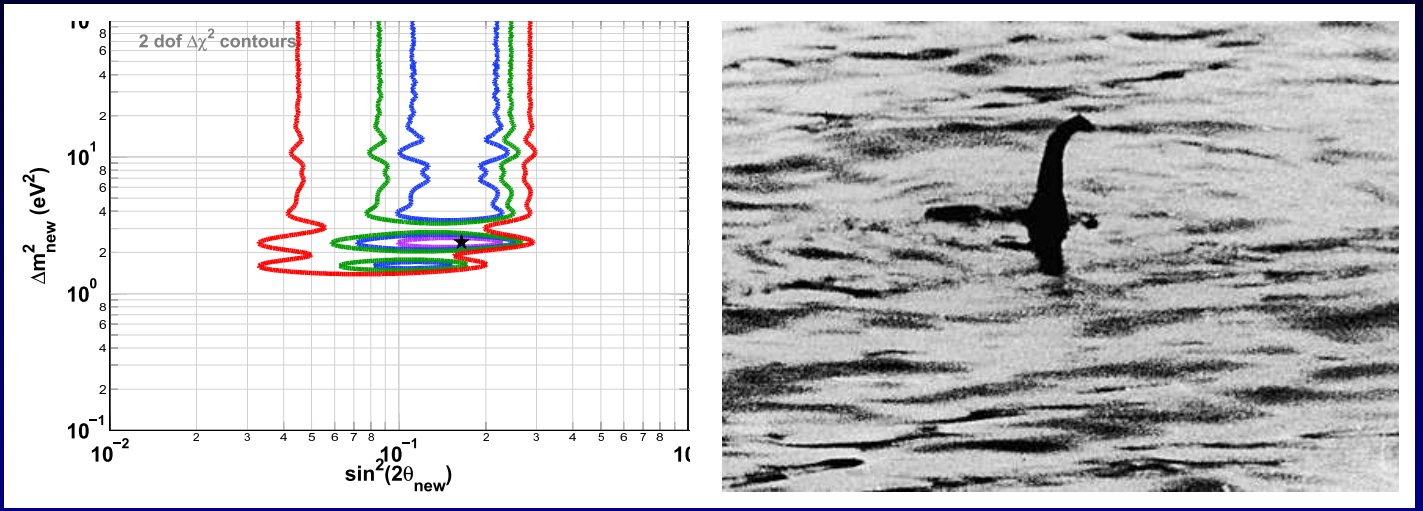




MiniBooNE

- LSND confirmed? refuted? both?
- Other oscillation data, cf. Bugey and CDHS?
- Low energy excess?
- 3+2 neutrinos + NSI?
- + a long list of proposals to finally hunt down this specimen

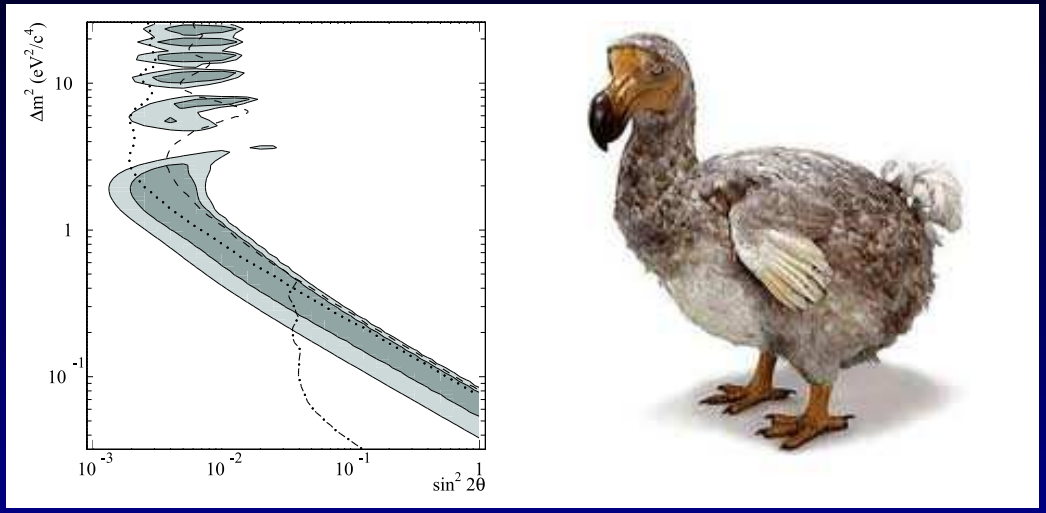
More additions to the Zoo



Short baseline reactor data

- Re-evaluation of reactor fluxes in Mueller *et al.*, arXiv:1101.2663 shows 2.5% upward shift in flux
- Mention, *et al.*, arXiv:1101.2755 concludes that there is a reactor neutrino deficit of several percent
- Schwetz *et al.*, arXiv:1103.0734 seems to confirm the deficit in global fits

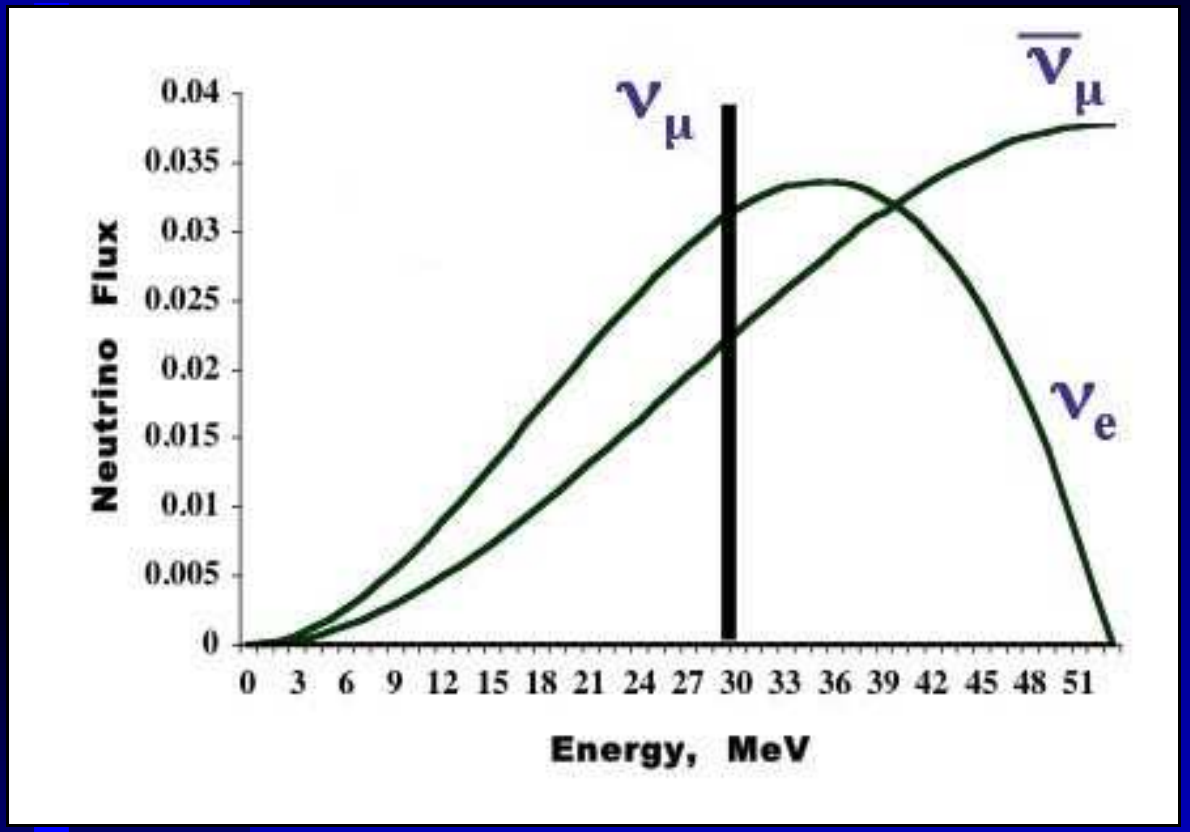
Long term exhibits



LSND

- Statistically quite significant, $> 3\,\sigma$
- Nearly tested by Karmen
- Oscillation interpretation not supported by global data – does the new reactor flux eliminate the Bugey constraint on a sterile neutrino interpretation of LSND?

Stopped pion neutrino source



$p + X \rightarrow \pi^{\pm} + X'$

π^- absorbed in thick, high-Z target

$\pi^+ \rightarrow \mu^+ + \nu_\mu$
mono-energetic ν_μ

$\mu^+ \rightarrow e^+ + \nu_e + \bar{\nu}_\mu$
Michel spectrum

With proper target design $\bar{\nu}_e$ contamination can be kept below 10^{-3}, we will use 4×10^{-4} (LSND value).

Proton source

Obviously, the technological bottleneck is the production of a sufficiently intense proton beam with an energy of 1-2GeV.

Traditional techniques, e.g. superconducting LINACs, can provide multi-MW beams, but they are multi-G$ facilities.

Conrad & Shaevitz PRL 104:141802 (2010) pointed out that alternative accelerator technologies may exist which can deliver muli-MW beams at 1/100 of the cost.

We take this assumption at face value and assume that a multi-MW proton beam is affordable.

GADZOOKS – part A

Inverse β-decay is flavor selective reaction

$$\bar{\nu}_e + p \rightarrow e^+ + n$$

and the positron energy is a direct measure of neutrino energy

In a water Cerenkov detector the positron is easily seen and its energy measured, but the neutron is invisible.

Adding about 0.1% in weight of Gadolinium with a neutron capture cross section of several 10,000barn will have a large fraction of neutrons capture on Gadolinium instead of capturing on protons.

GADZOOKS – part B

Why is capturing on Gd better than on p?

$$n + p \rightarrow^{2} \mathrm{H} + 2.2\mathrm{MeV}\gamma$$

versus

$$n + \mathrm{Gd} \rightarrow \mathrm{Gd} + 8\mathrm{MeV}\gamma's$$

Now, if your detector happens to have a threshold around 5MeV, you see the capture on Gd but not on p.

The essential ingredient is the availability of affordable Gd salts which dissolve very well in water.

Beacom, Vagins, PRL 93:171101, (2004).

Super-Kamiokande + Gd

The dimensions of SK's fiducial volume are so large, that LSND's whole source detector system would fit inside!

SK is deep and thus has only very small cosmic background rate

Event rates will be very large due large fiducial mass of 22.5kt vs 120t in LSND

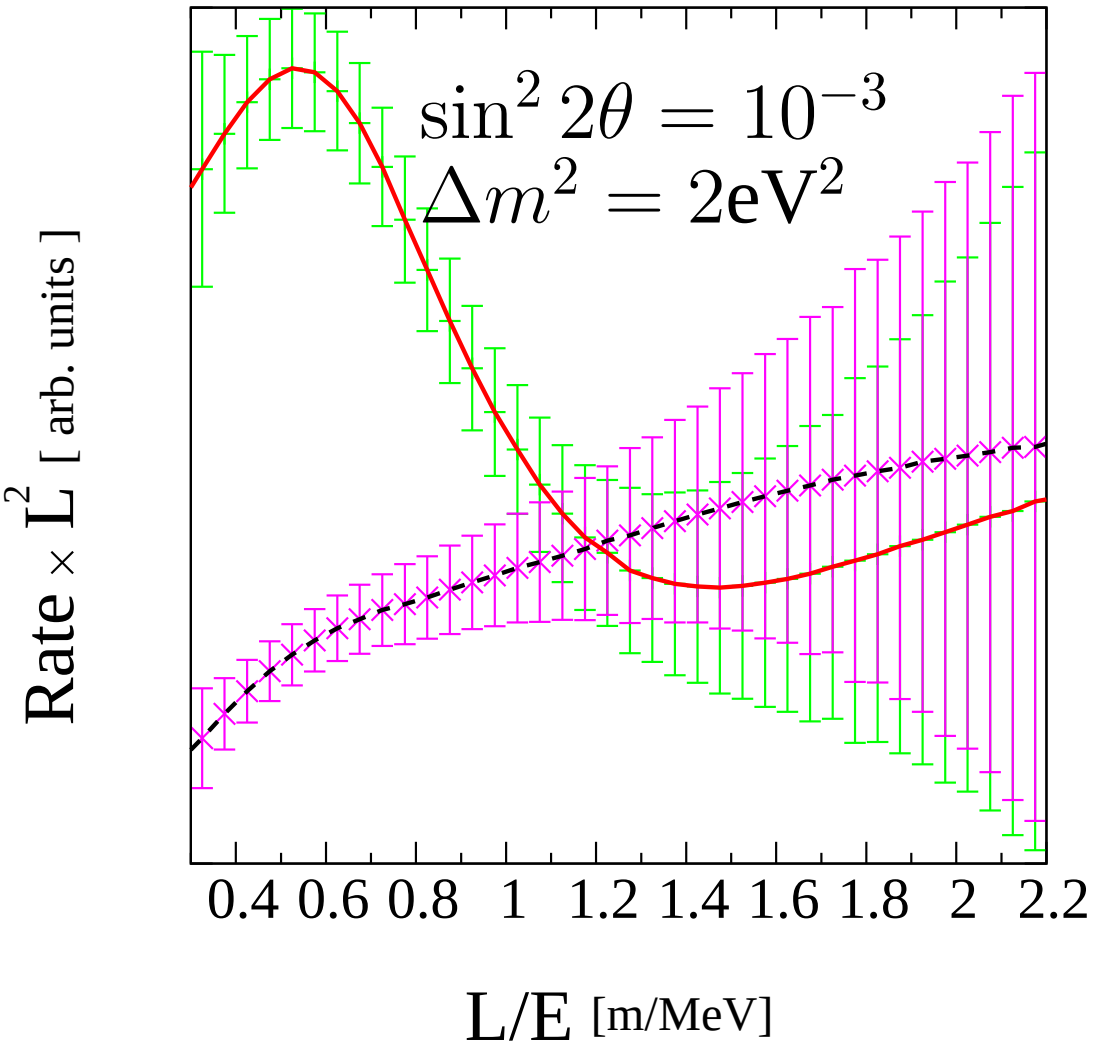
300kW proton beam power are sufficient

We assume the beam stop to be 20m away from the surface of SK, which should provide sufficient shielding against neutrons

Can one put Gd into SK? – subject of ongoing study

. . .

L/E pattern in SK

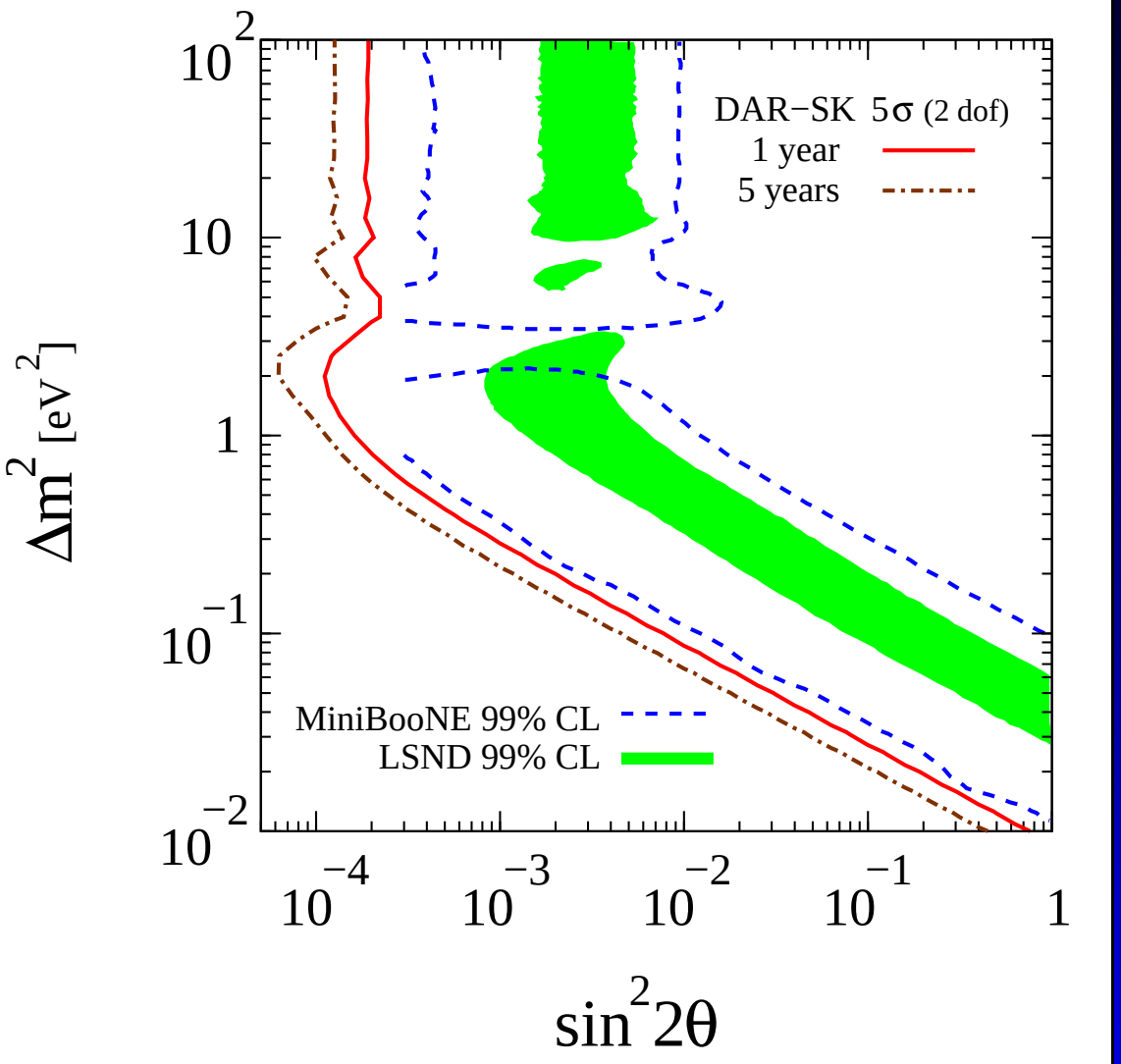


Beam stop size 0.5m & vertex resolution in SK 0.75m added in quadrature yields $\Delta x = 0.9$m. We use 1m bins.

Includes integration over the full beam spectrum from 20MeV upwards

Black: background
Red: oscillation signal

Sensitivity to sterile neutrinos



We cover the whole 99% CL region from both MiniBooNE and LSND at more than 5σ CL in one year

If a signal is seen, we know whether is oscillation or something else from L/E-dependence

Sterile Neutrinos at the Crossroads - SNAC11
September 26-28, 2011
Virginia Tech
Blacksburg

This workshop will be hosted by the Virginia Tech Center for Neutrino Physics.

For more information visit http://www.cpe.vt.edu/snac