Theoretical motivation for the Very Low Energy Neutrino Factory

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Short baselines anomalies

An intriguing accumulation of inconclusive hints . . .

The reactor anti-neutrino anomaly

- Recent reevaluation of expected reactor $\bar{\nu}_e$ flux is $\sim 3.5\%$ higher than previous prediction Mueller et al. arXiv:1101.2663 vs. Schreckenbach 1985
- Method: Use measured β-spectra from ^{238}U, ^{235}U, ^{241}Pu fission at ILL and convert to $\bar{\nu}_e$ spectrum
- Problem: Requires knowledge of Q-values for all contributing decays.

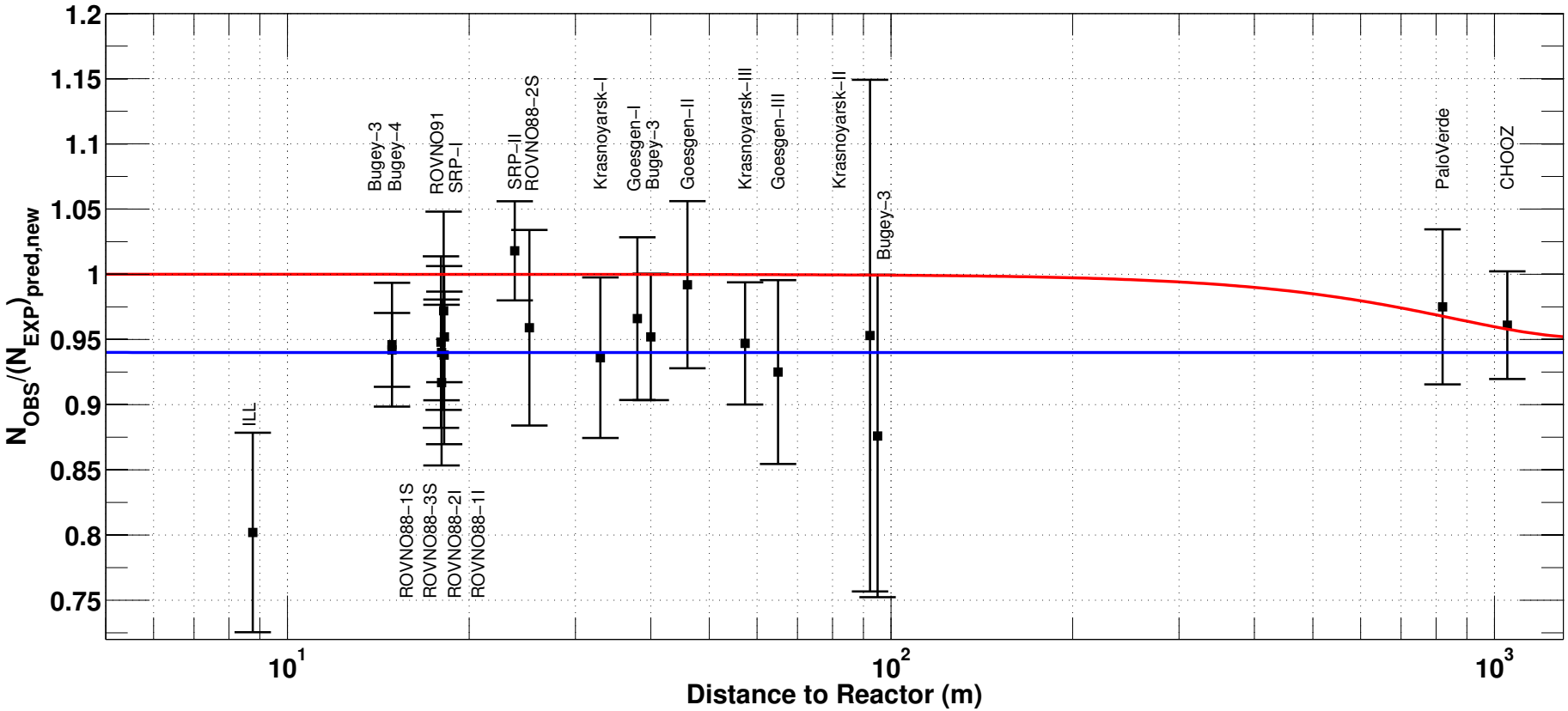
Old method Schreckenbach 1985	New method Mueller et al. arXiv:1101.2663
30 effective branches	Uses nuclear databases (90% of $\bar{\nu}_e$ flux)
	5 effective branches (remaining 10%)
	Error propagation, correlation matrix
	Off-equilibrium corrections (short irradiation time at ILL $\rightarrow$ not all β-branches in equilibrium

Mueller et al.'s results recently confirmed using independent method:
P. Huber, arXiv:1106.0687

. . . but also mentions possibly poorly understood nculear effects (weak magnetism) in nuclei with large log *ft* as a possible source of the anomaly.

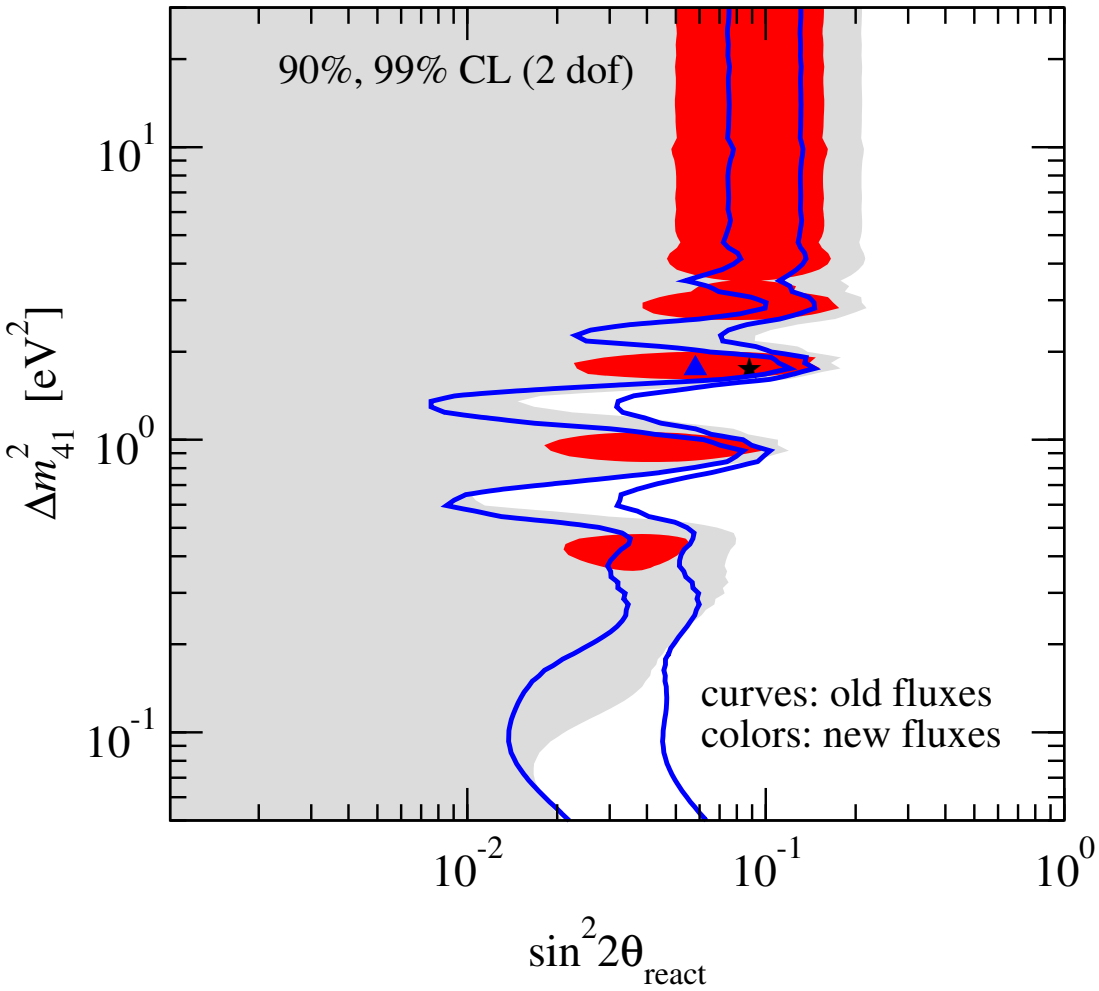
The reactor anti-neutrino anomaly (2)

- Have short-baseline reactor experiments observed a deficit?



Mention et al. arXiv:1101.2755

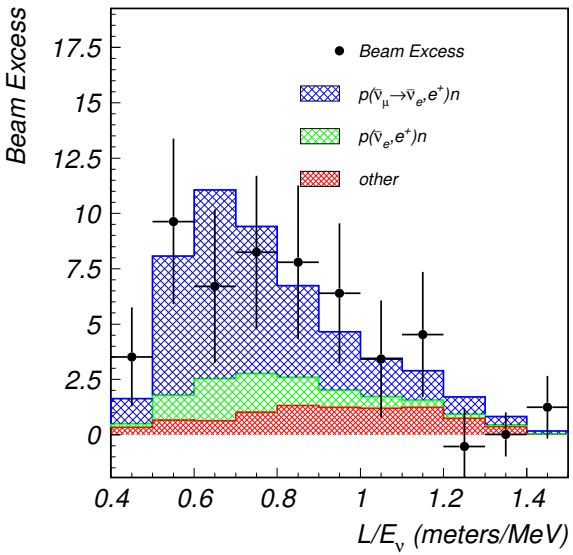
A sterile neutrino fit



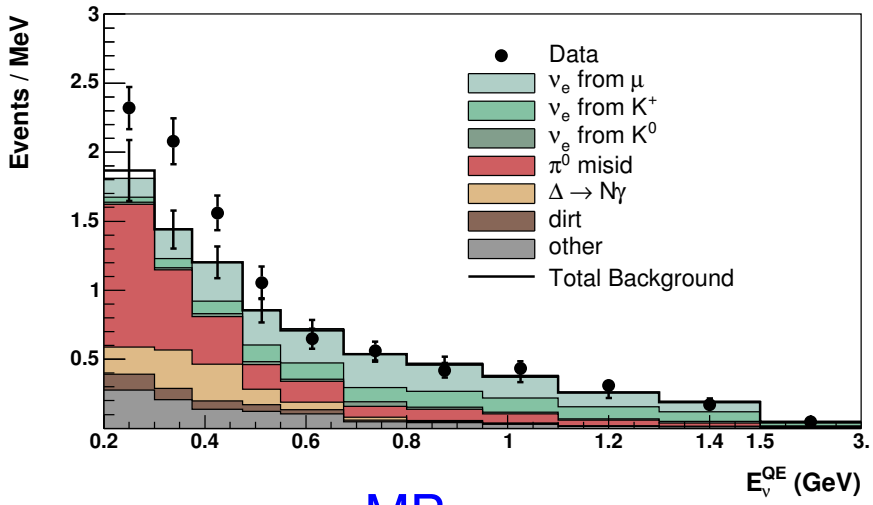
plot by Thomas Schwetz

LSND, KARMEN, MiniBooNE

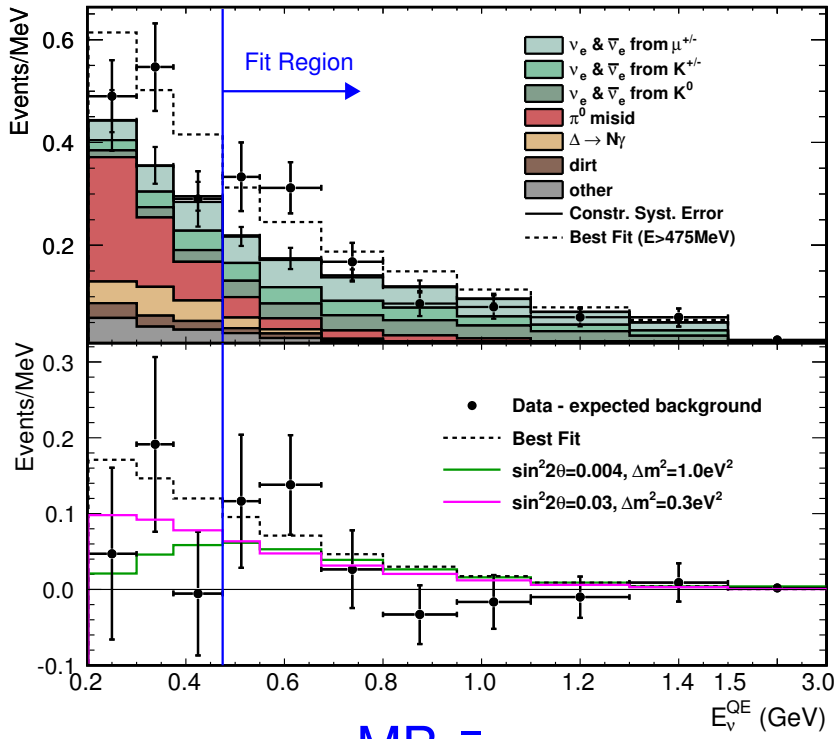
- LSND:
  - $\bar{\nu}_e$ appearance in $\bar{\nu}_\mu$ beam from stopped pion source
- MiniBooNE:
  - $\bar{\nu}_e$ appearance in accelerated $\bar{\nu}_\mu$ beam
  - No ν_e appearance in interesting energy region $\longrightarrow$ CP violation?
- KARMEN:
  - Very similar to LSND, but no excess



LSND $\bar{\nu}_e$



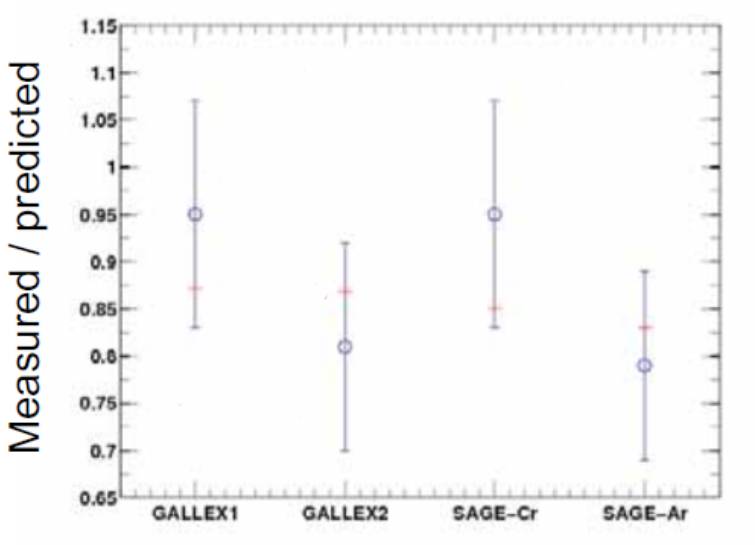
MB ν_e



MB $\bar{\nu}_e$

The Gallium anomaly

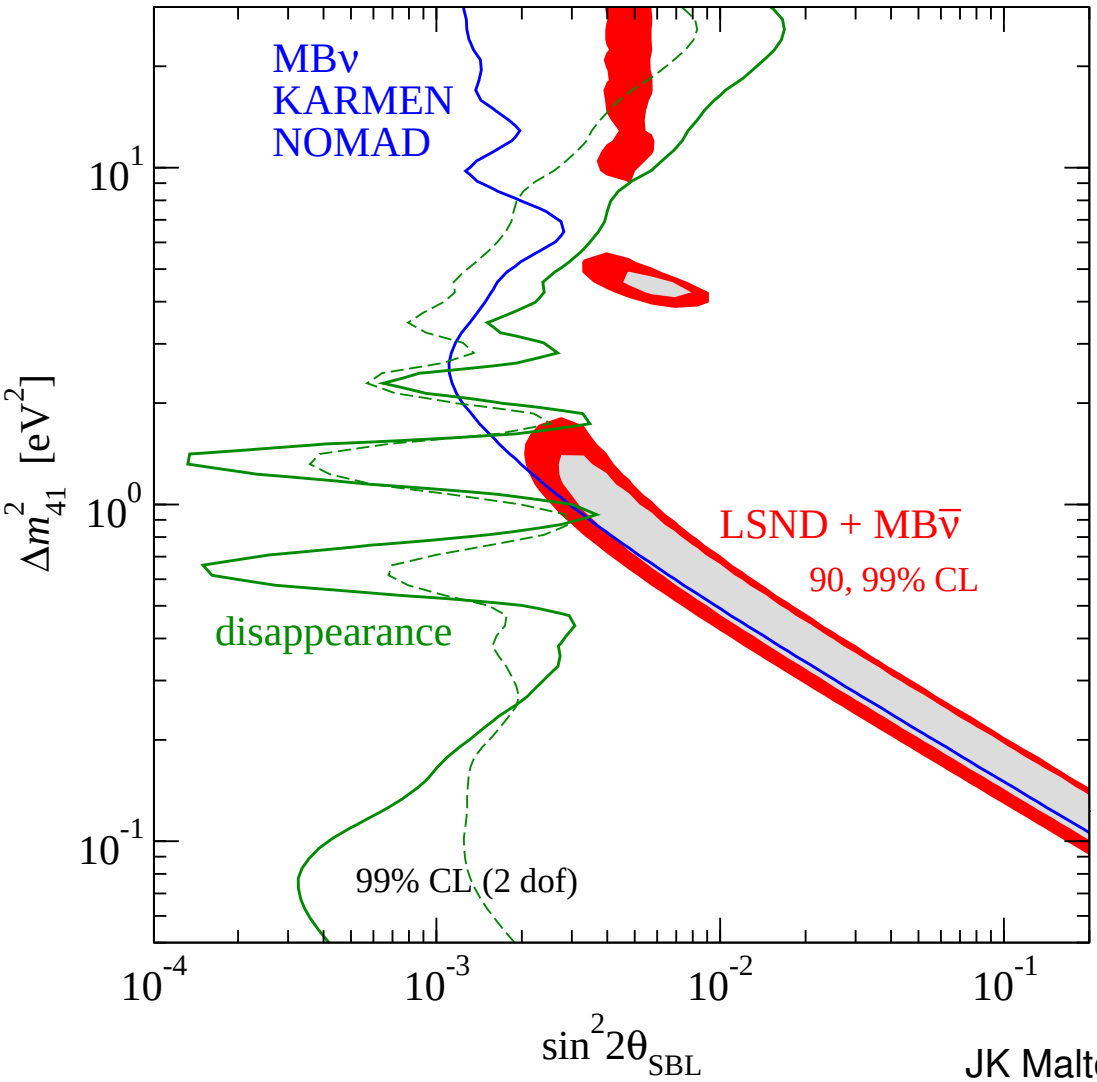
- Calibration measurements for the GALLEX and SAGE solar neutrino detectors using intense radioactive ν_e sources (^{51}Cr and ^{37}Ar)
- Neutrino detection via $^{71}\mathrm{Ga} + \nu_e \rightarrow {}^{71}\mathrm{Ge} + e^-$
- Result: Measurements consistently lower than expectation



Giunti Laveder arXiv:1005.4599, arXiv:1006.3244
Mention et al. Moriond 2011 talk

- Question: How well are efficiencies of the radiochemical method understood?

Another sterile neutrino fit



JK Maltoni Schwetz 1103.4570

Tension in the fit $\rightarrow$ 2 sterile neutrinos + CPV?

Searching for sterile neutrinos

- MiniBooNE / LSND suggest: $4|U_{e4}|^2|U_{e5}|^2 \sim \text{few} \times 10^{-3}$
- expect $4|U_{e4}|^2$, $4|U_{e5}|^2$ individually at the few–10% level
- Reactor and gallium anomalies suggest $4|U_{e4}|^2 \sim$ few–10%

$\Rightarrow$ A ν_e or ν_μ disappearance experiment with a sensitivity at the per cent level could likely clarify the situation

- Want to do this search in as many channels as possible.
- Ideally, want to see oscillation pattern
  difficult since straight section probably too long . . .)
- Possible synergy with MINOS+, NOνA, T2K neutral current searches, if beam energy/baseline in these appropaite for Δm^2.

Possible implications of VLENF results

If disappearance is found . . .

- Major step forward in neutrino physics
- But probably cannot claim discovery of sterile neutrino without observing oscillation dip.
- Far-reaching consequences for cosmology (ΛCDM *disfavors* $\sum m_\nu \gtrsim 0.5$–1 eV)
- New direction for building models of flavor

If no disappearance is found . . .

- Sterile neutrinos ruled out as explanation of LSND / MiniBooNE
- . . . but we know *something* is going on in MiniBooNE
  $\longrightarrow$ Measurement with clean beam in same detector might help resolve this

Important: Need CONCLUSIVE result!
No point in producing another $2.x\sigma$ . . .

Other short-baseline physics opportunities

- Cross section measurements. Help resolve MiniBooNE M_A anomaly?
- Search for CPT violation
- Test more exotic models?

(e.g. Gninenko 1009.5536, 1107.0279)

Upgrades?

- A magnetized detector $\longrightarrow$ appearance searches?
- A detector with lower backgrounds/systematics than MiniBooNE? $\longrightarrow \nu_e$ disappearance search?