Sterile Neutrinos as Mirror Matter

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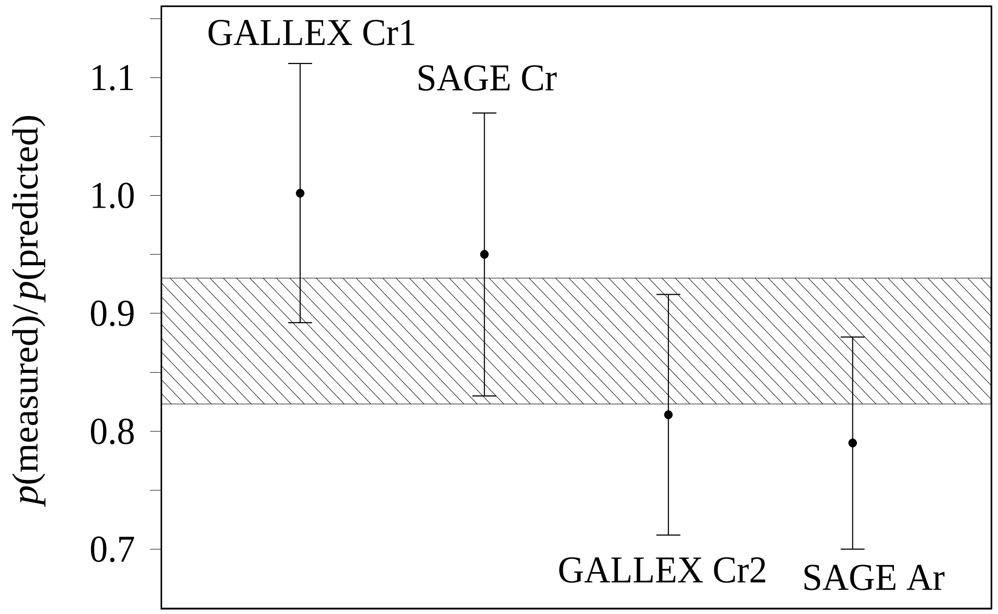
B-L Workshop - 21 September 2007

A phenomenological approach starting from Gallium 2 σ anomaly.



$R \equiv$ wheighted average value of the ratio of measured and predicted ^{71}Ge production rates (p) :

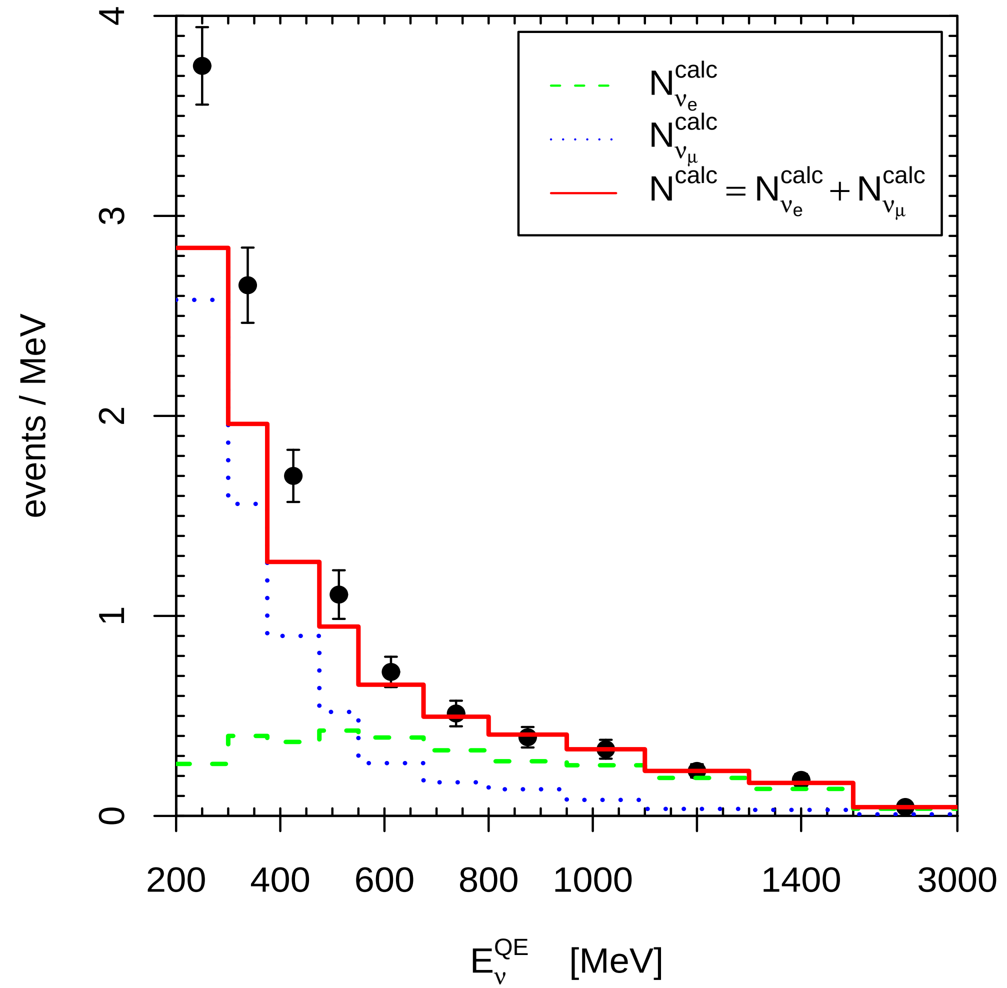
$$R \equiv \frac{\text{p(measured)}}{\text{p(predicted)}} = 0.88 \pm 0.05(1\sigma)$$

nucl-ex/0512041

Ga radioactive source exp. results may be interpreted as an indication of the disappearance of ν_e due to active-sterile oscillations!

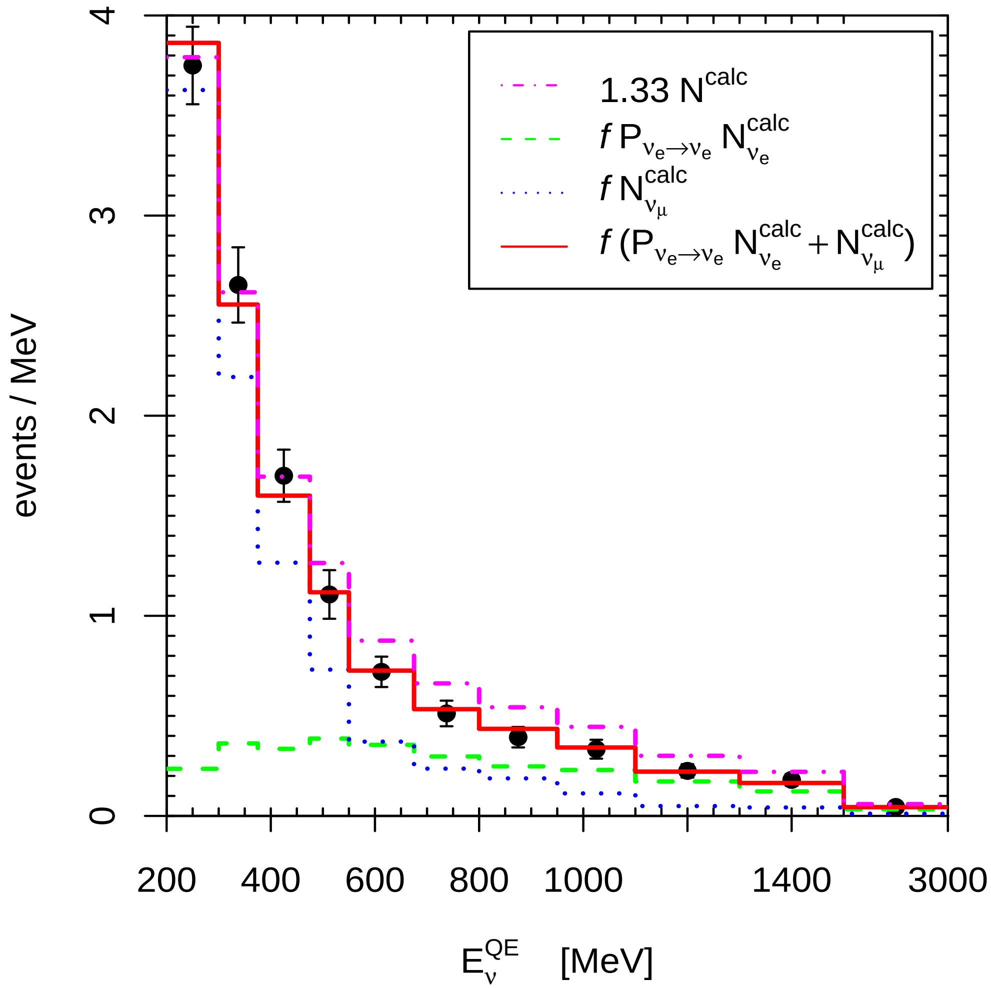
hep-ph/0610352 Carlo Giunti & ML .

Miniboone data : Low Energy Excess or ...



R.Tayle : Miniboone talk at LP07

ν_e Disappearance in Miniboone



0707.4593.v2 C.Giunti & ML

N.B. constant $P_{\nu_e\to\nu_e} \leftrightarrow \Delta m^2 \gtrsim 20\,\mathrm{eV}^2$

Baic idea: a renormalization of the absolute neutrino flux by a **constant factor f** with a simultaneous disappearance of the ν_e in the beam . This hypothesis is allowed by the large error on the absolute neutrino flux.

j	Energy Range [MeV]	$N^{\text{calc}}_{\nu_e,j}$	$N^{\text{calc}}_{\nu_\mu,j}$	N^{calc}_{j}	N^{meas}_{j}
1	$200-300$	26	258	284	375
2	$300-375$	30	117	147	199
3	$375-475$	37	90	127	170
4	$475-550$	32	39	71	83
5	$550-675$	49	33	82	90
6	$675-800$	41	21	62	64
7	$800-950$	41	20	61	59
8	$950-1100$	38	12	50	50
9	$1100-1300$	38	7	45	45
10	$1300-1500$	27	6	33	36
11	$1500-3000$	54	12	66	67

Table 1: $N^{\text{calc}}_{\nu_e,j}$: number of expected ν_e-induced events ; $N^{\text{calc}}_{\nu_\mu,j}$: number of expected ν_μ-induced events ; N^{calc}_{j}: total number of expected events ; N^{meas}_{j}: measured number of events .

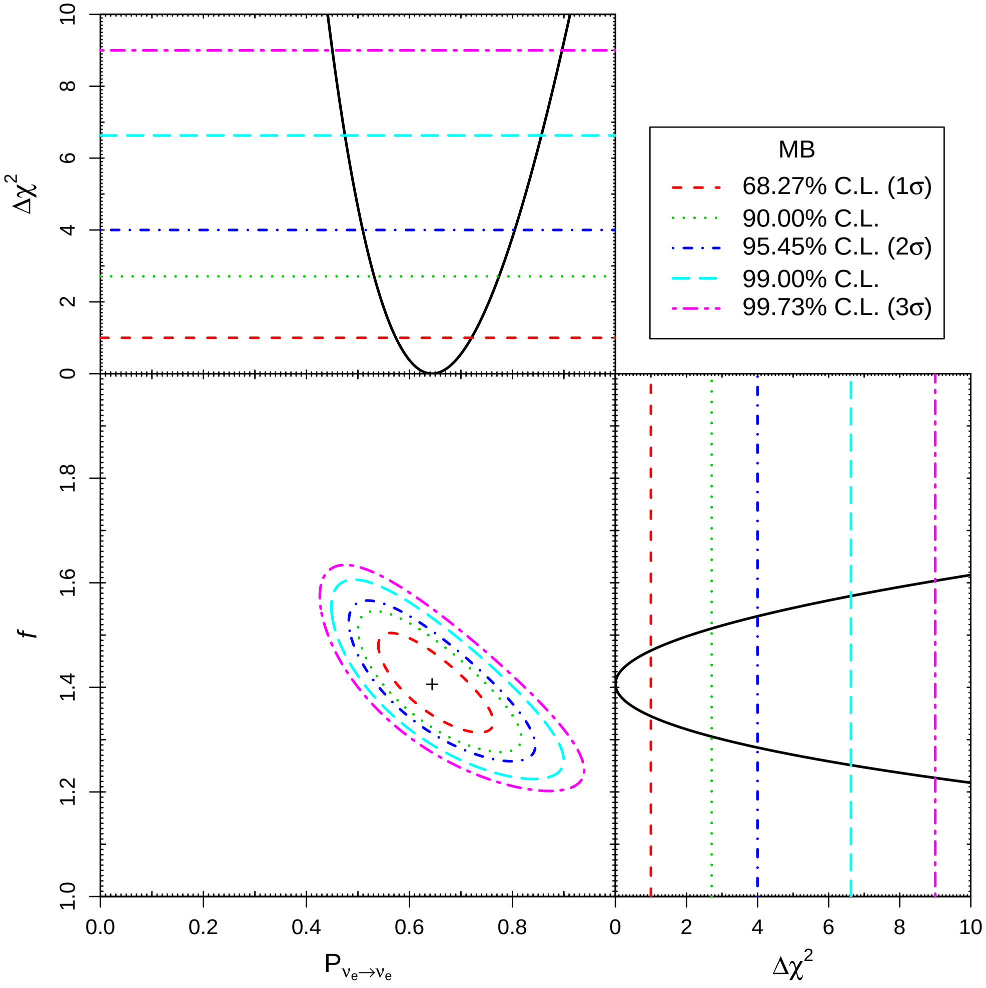
Under this hypothesis, the theoretical number of events in the jth energy bin is given by

$$N^{\text{the}}_j = f\left(P_{\nu_e\to\nu_e}N^{\text{calc}}_{\nu_e,j} + N^{\text{calc}}_{\nu_\mu,j}\right) ,$$

We tested the ν_e-disappearance hypothesis with the Pearson's chi-square

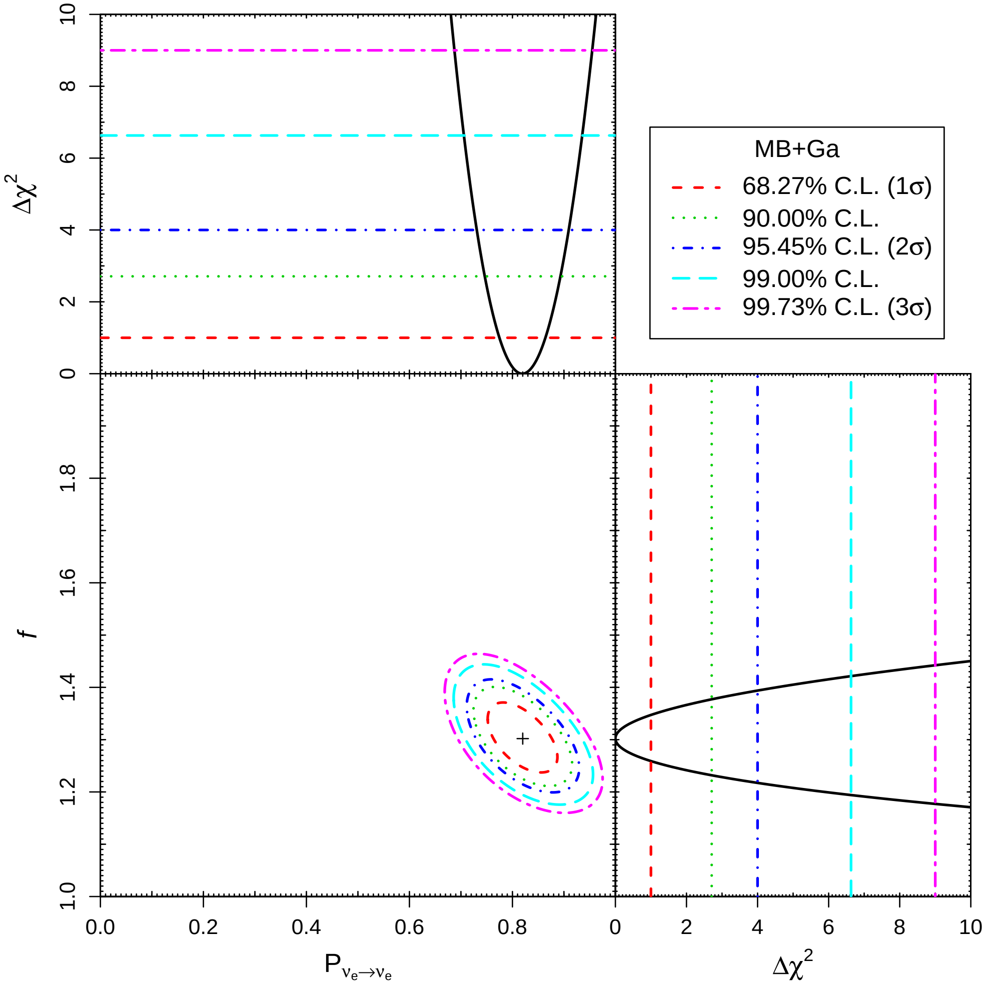
$$\chi^2_{\text{MB}} = \sum_{j=1}^{11}\frac{\left(N^{\text{the}}_j - N^{\text{meas}}_j\right)^2}{N^{\text{the}}_j} ,$$

Fit to Miniboone data



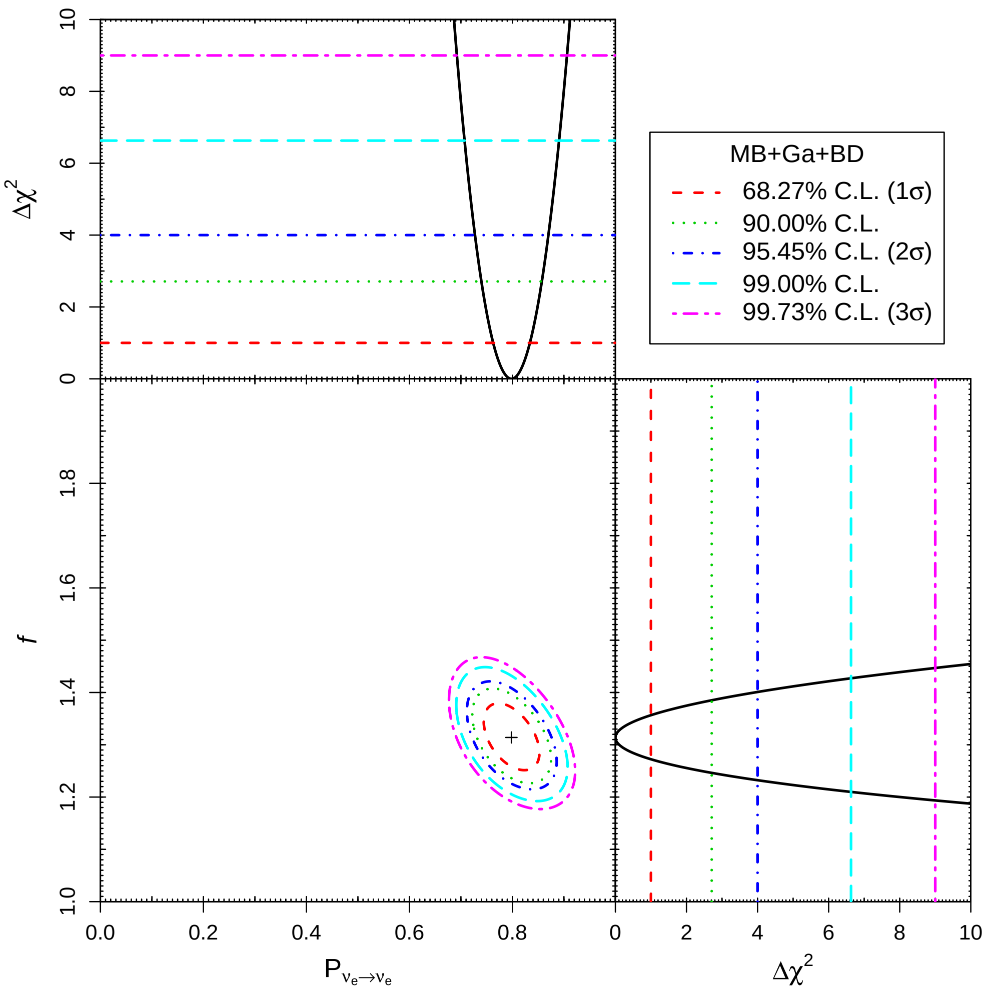
$\chi^2_{\rm MB} = 2.31/(9\,{\rm dof})$ $\quad gof = 98.6\%$ $\quad P_{\nu_e \to \nu_e} = 0.64^{+0.08}_{-0.07}$ $\quad f = 1.41 \pm 0.06$

Fit to Miniboone + Gallium data



$$\chi^2_{\rm MB+Ga} = 8.48/(10\,{\rm dof}) \quad gof = 58.2\% \qquad P_{\nu_e\to\nu_e} = 0.82 \pm 0.04 \quad f = 1.31^{+0.04}_{-0.05}$$

Fit to Miniboone + Gallium + Beam Dump data



$$\chi^2_{\mathrm{MB+Ga+BD}} = 9.11/(11\,\mathrm{dof}) \quad gof = 61.2\% \quad P_{\nu_e\to\nu_e} = 0.80^{+0.03}_{-0.04} \quad f = 1.32 \pm 0.04$$

Possible Interpretations of the results

We have considered here an old indication in favor of ν_e disappearance found from the analysis of the results of Beam-Dump (BD) experiments : $\sin^2 2\vartheta = 0.48 \pm 0.10 \pm 0.05$ for the large squared-mass difference $\Delta m^2 = 377 \pm 27 \pm 7\,\text{eV}^2$

[G. Conforto Nuovo Cim. A103 (1990) 751] .

In this case, the average ν_e survival probability is

$$P^{\text{BD}}_{\nu_e \to \nu_e} = 0.76 \pm 0.06 \,. \tag{1}$$

The large disappearance of ν_e found in this study may be due to oscillations into sterile neutrinos $\nu_e \to \nu_s$ with $\Delta m^2 \gtrsim 20\,\mathrm{eV}^2$, since

- $\nu_e \to \nu_\mu$ transitions are restricted by the results of CCFR , KARMEN , NOMAD and MINIBOONE ;
- $\nu_e \to \nu_\tau$ transitions are limited by the results of CHORUS and NOMAD .

Comparison with SBL reactor limits : Bugey 2 detectors

B. Achkar et al. / Nuclear Physics B 434 (1995) 503–532 527

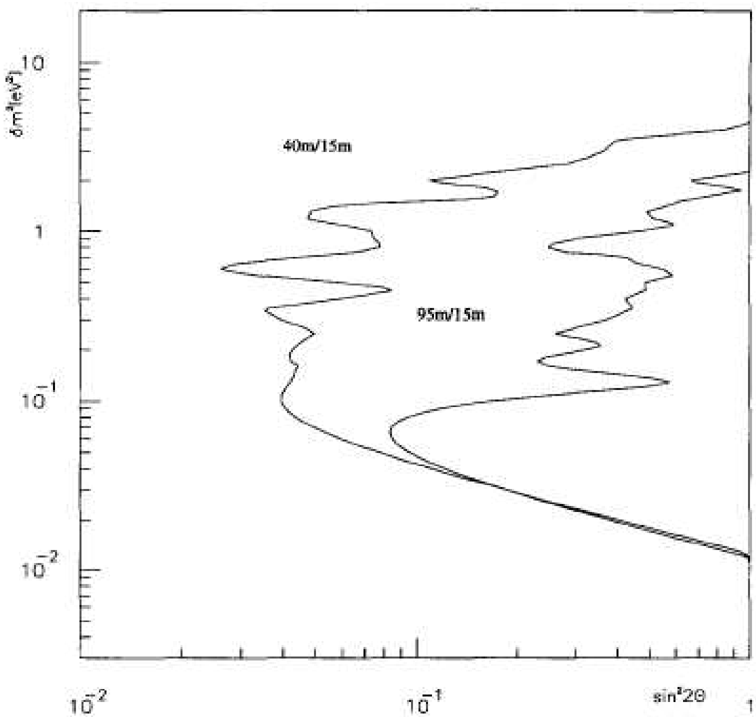


Fig. 16. 90% C.L. exclusion contours obtained from the ratios of the positron energy spectra measured at 40/15 and 95/15 meters.

2 detectors Bugey 90 % C.L. (raster scan) limits do not exclude active-sterile mixing with $\delta m^2 > 5\,\mathrm{eV}^2$

Bugey : high δm^2 limit

530 B. Achkar et al. / Nuclear Physics B 434 (1995) 503–532

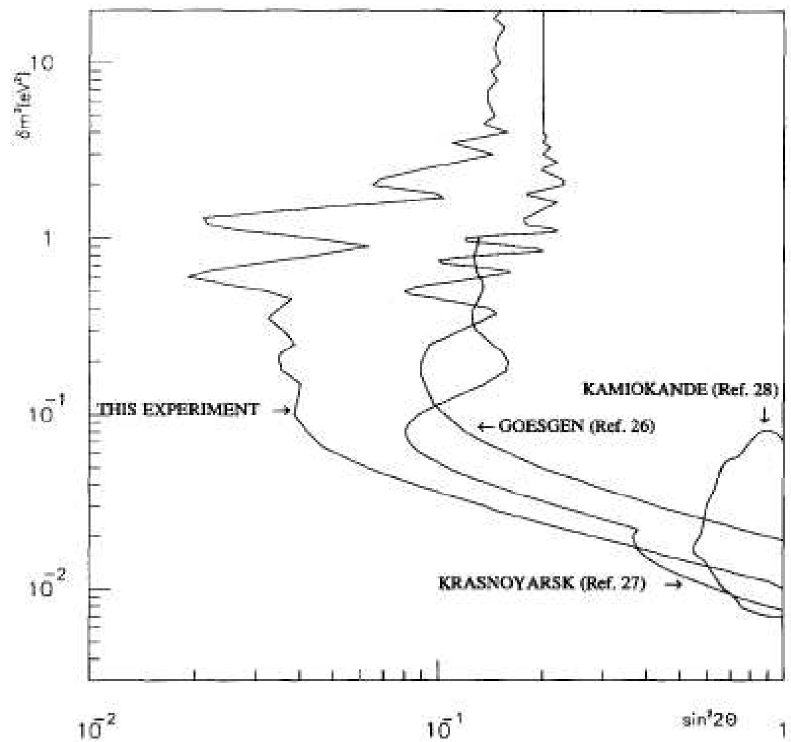


Fig. 18. The 90% C.L. exclusion contour obtained from the positron energy spectra measured at 40, 15 and 95 meters. Also shown is the hitherto excluded area in earlier reactor experiments with the region for a possible ν_e–ν_μ oscillation put forward by the KAMIOKANDE collaboration.

Bugey 90 % C.L. high δm^2 (raster scan) limit do not exclude active-sterile mixing with $\sin^2 2\theta \lesssim 0.15$ if the neutrino flux is **known with 2.8 % error**

ν_e versus $\bar{\nu}_e$ data tension

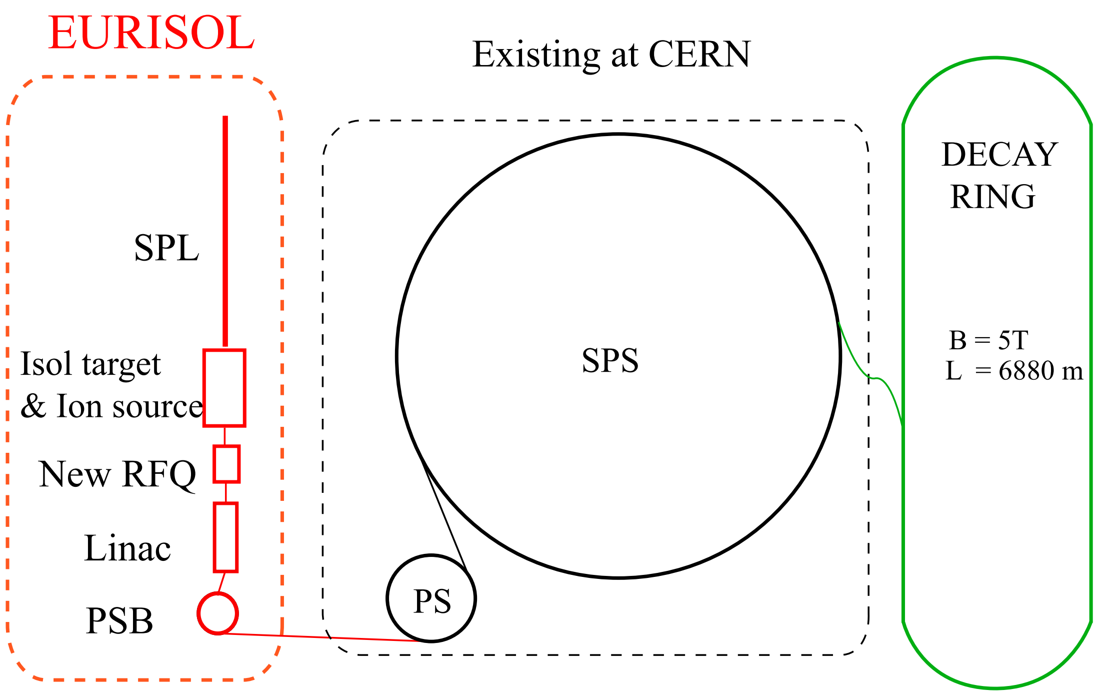
Taken the Bugey error as a reference value (5% error on $P_{\bar{\nu}_e \to \bar{\nu}_e}$) we face 2 possibilities

(3% is the error on $P^{\text{MB+Ga+BD}}_{\nu_e \to \nu_e}$) :

- The error in $\bar{\nu}_e$ data may be $> 5\%$ and therefore
  $(P^{\text{MB+Ga+BD}}_{\nu_e \to \nu_e} - P_{\bar{\nu}_e \to \bar{\nu}_e}) < 4\sigma$.
- The error in $\bar{\nu}_e$ data is $< 5\%$ and therefore
  $(P^{\text{MB+Ga+BD}}_{\nu_e \to \nu_e} - P_{\bar{\nu}_e \to \bar{\nu}_e}) > 4\sigma$.
  This possibility seems to need new physics that violates CPT.

In hep-th/0610252 R.Casalbuoni showed as the infinite component wave Majorana equation [E.Majorana Nuovo Cimento 9 (1932) 335], were no negative energy solutions are presents, violates CPT (... and therefore the spin-statistic theorem does not generally hold). This is a radical starting point but with interesting consequences on the role of ν in cosmology ... see [A.Dolgov hep-ph/0504238].

Future SBL experimental tests with β beams



Future SBL Beta-Beam experiments [P.Zucchelli PLB 532 (2002) 166]

with a pure ν_e or $\bar{\nu}_e$ beam from nuclear decay of accelerated ions have the potentiality to check the SBL disappearance of ν_e and $\bar{\nu}_e$ with high accuracy .

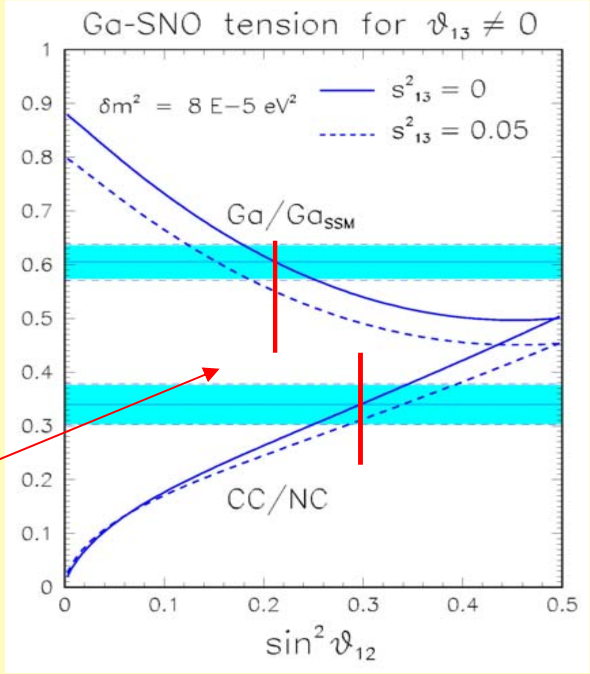
... if they are roses they'll flower...

... GOOD LUCK to ν physics & astrophysics !!!

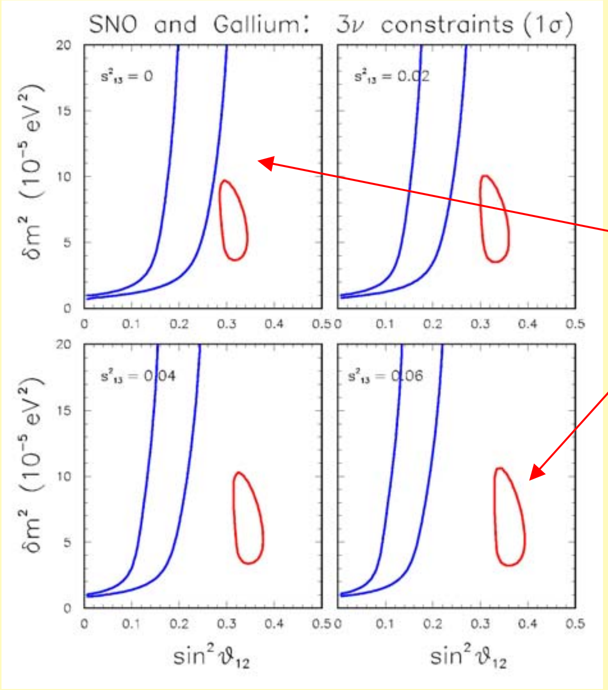
Backup slides

The situation with Ga cross-section renormalization (0.88±0.05 at LE), is that:

1) Ga and SNO data are no longer in good agreement with predictions for $\theta_{13}=0$ (Ga prefers lower $\sin^2\theta_{12}$)
2) The disagreement becomes rapidly worse for increasing θ_{13}, since the Ga and SNO allowed regions become even more separated in $\sin^2\theta_{12}$.
3) Thus, there is never a very good agreement between Ga and SNO constraints, in particular for nonzero θ_{13}.

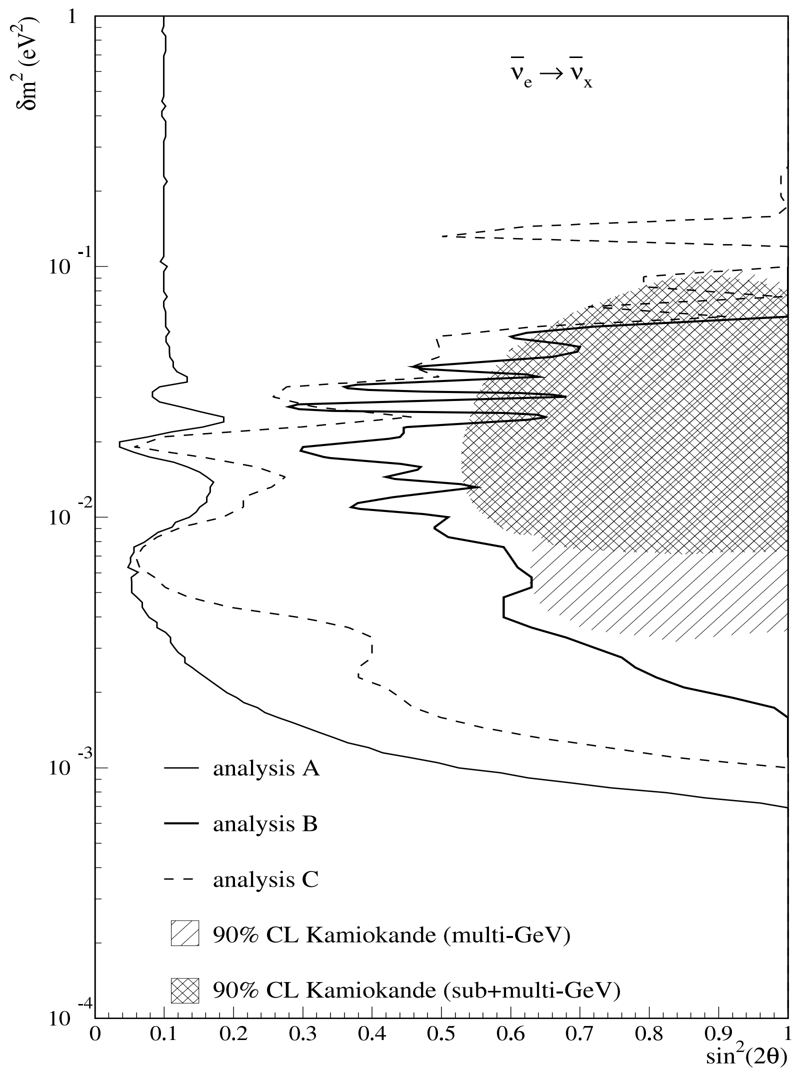


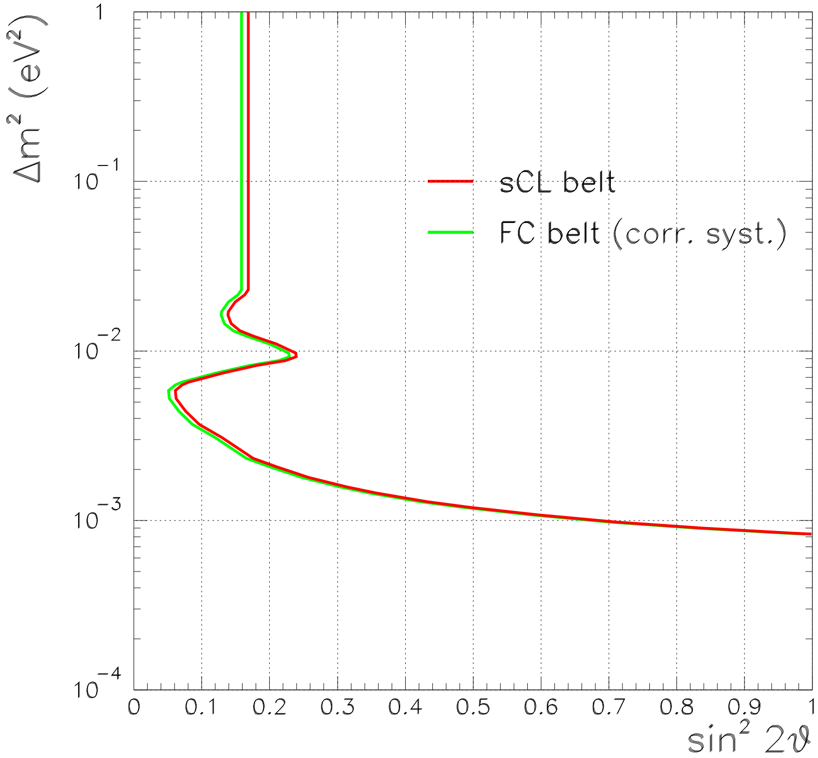
mismatch at $\theta_{13}=0$



mismatch at $\theta_{13}=0$, increasing mismatch at $\theta_{13}>0$

CHOOZ high δm^2 limits



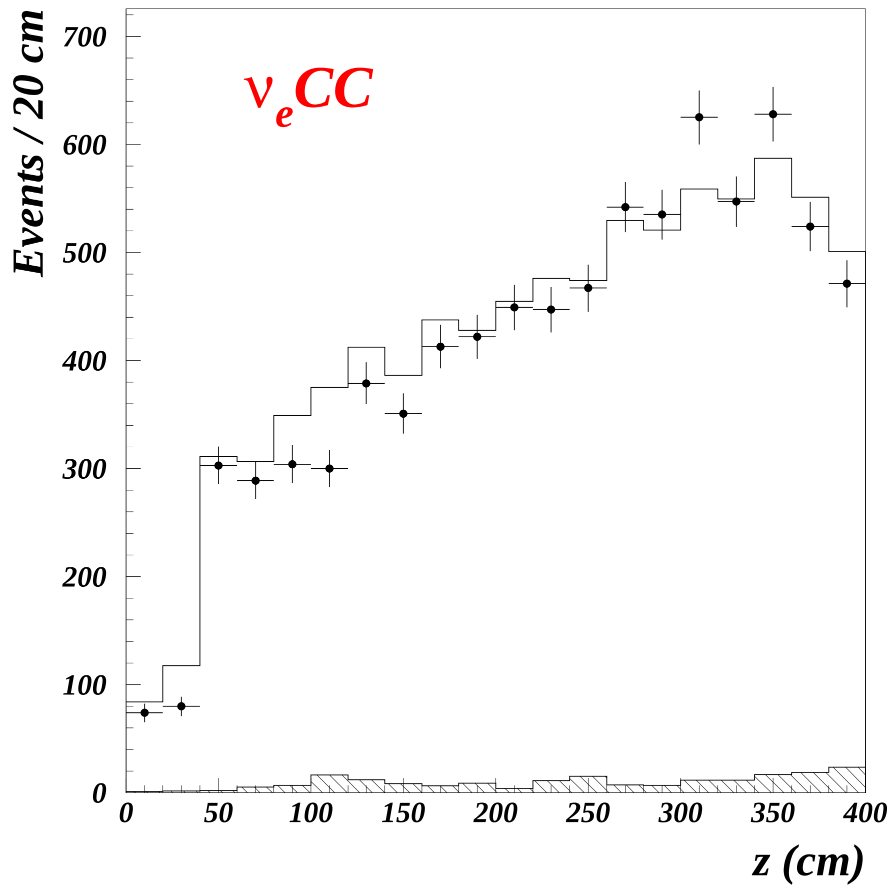


$90\% C.L.$ limit : $\sin^2 2\theta < 0.1$

FC limit: $\sin^2 2\theta < 0.16$

hep-ex/0301017

NOMAD ν_e measurement

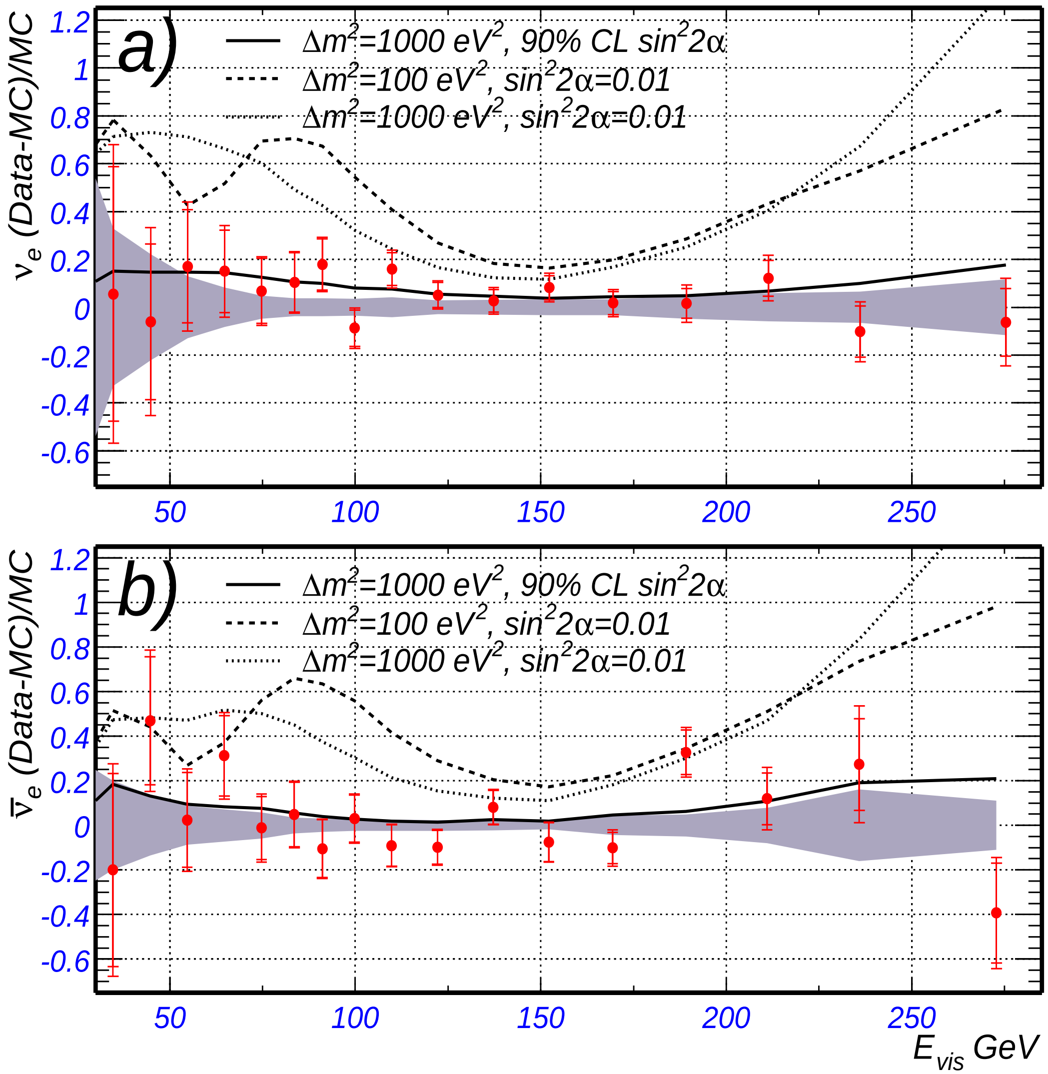


Before [$z_{VTX} > 184\,\mathrm{cm}$] cut : observed = 7969 ; predicted = 8329

(4% absolute normalization error) $\Rightarrow 1\sigma$ deficit

hep-ex/0306037

NUTEV ν_e , $\bar{\nu}_e$ measurements



hep-ex/0203018