Gallium and Reactor Neutrino Anomalies

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work in collaboration with Mario A. Acero and Carlo Giunti

Active-Sterile ν mixing ?

- Charged massive spin 1/2 particles can have only a Dirac mass term

- According to Majorana neutral massive spin 1/2 particles can coincide with their antiparticles having a Majorana mass term.

- Non-SM right-handed neutral particles can have both Dirac and Majorana mass terms.

- If these non-SM right-handed neutral particles are light (sterile neutrinos ν_s) can mix with ordinary active neutrinos.

- The observable effect is a disappearance of active neutrinos.

- We focus on Gallium (ν_e) and Reactors ($\overline{\nu}_e$) disappearance.
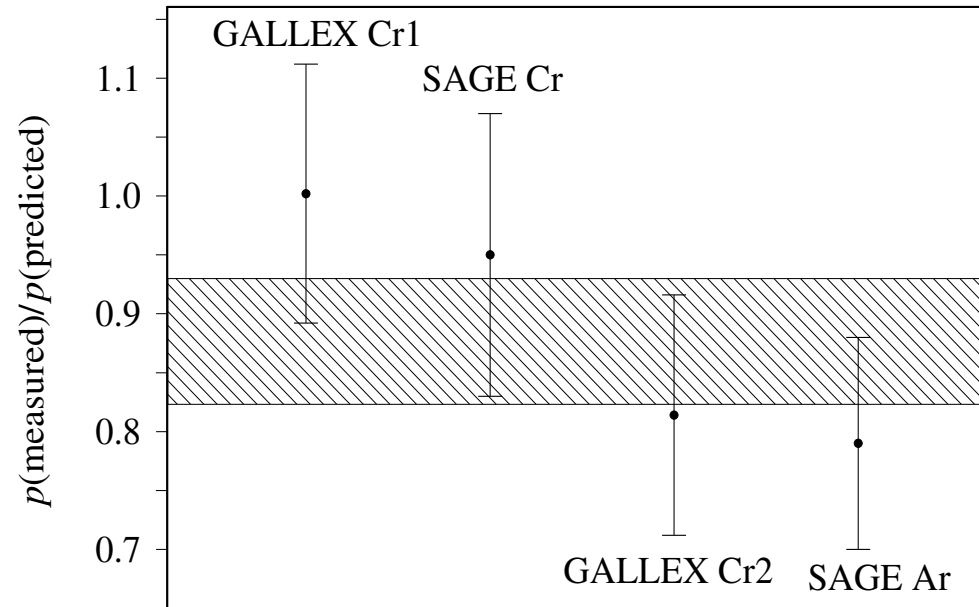
$R \equiv$ wheighted average value of the ratio of measured and predicted ^{71}Ge production rates (p) :
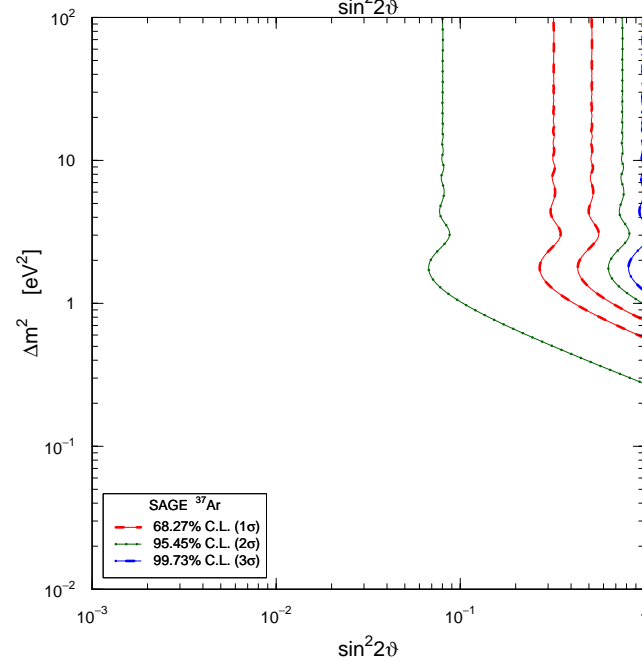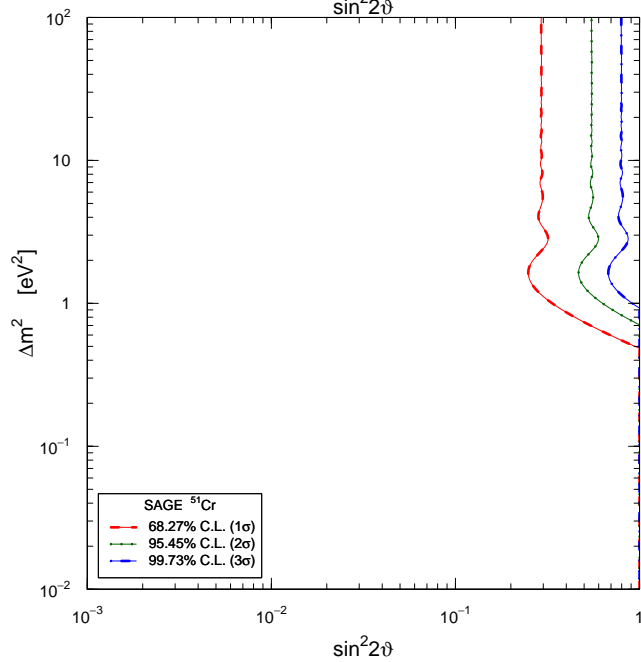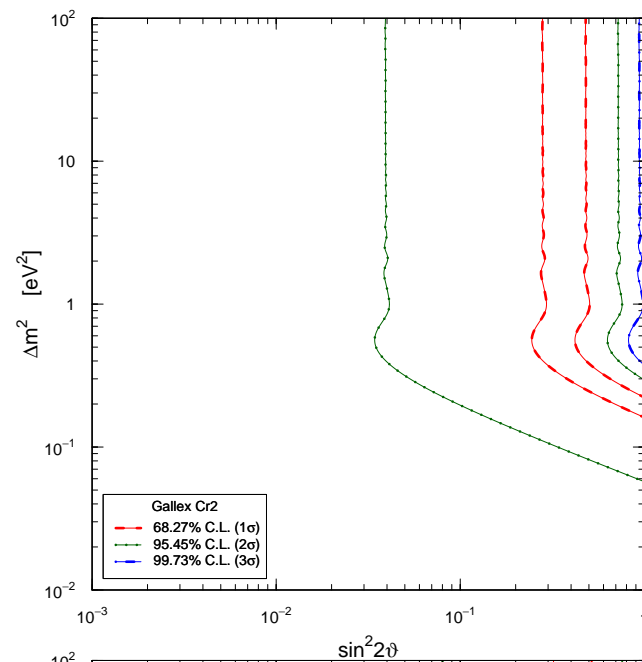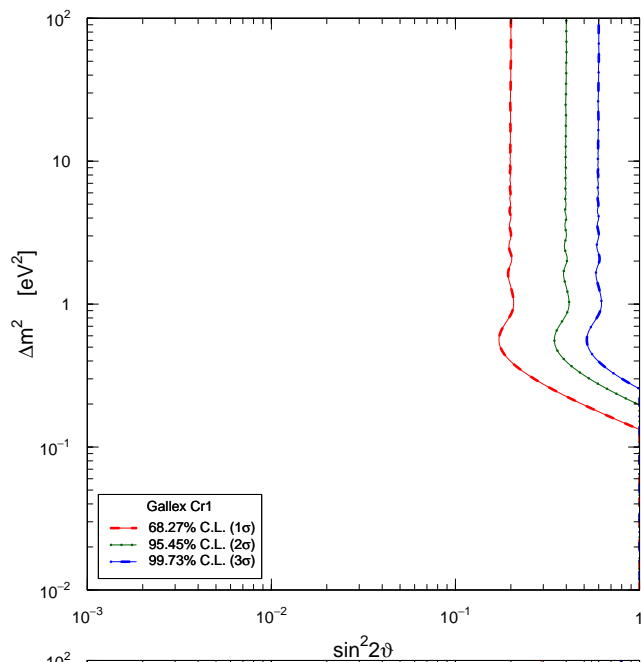
$$R \equiv \frac{\text{p(measured)}}{\text{p(predicted)}} = 0.88 \pm 0.05(1\sigma)$$
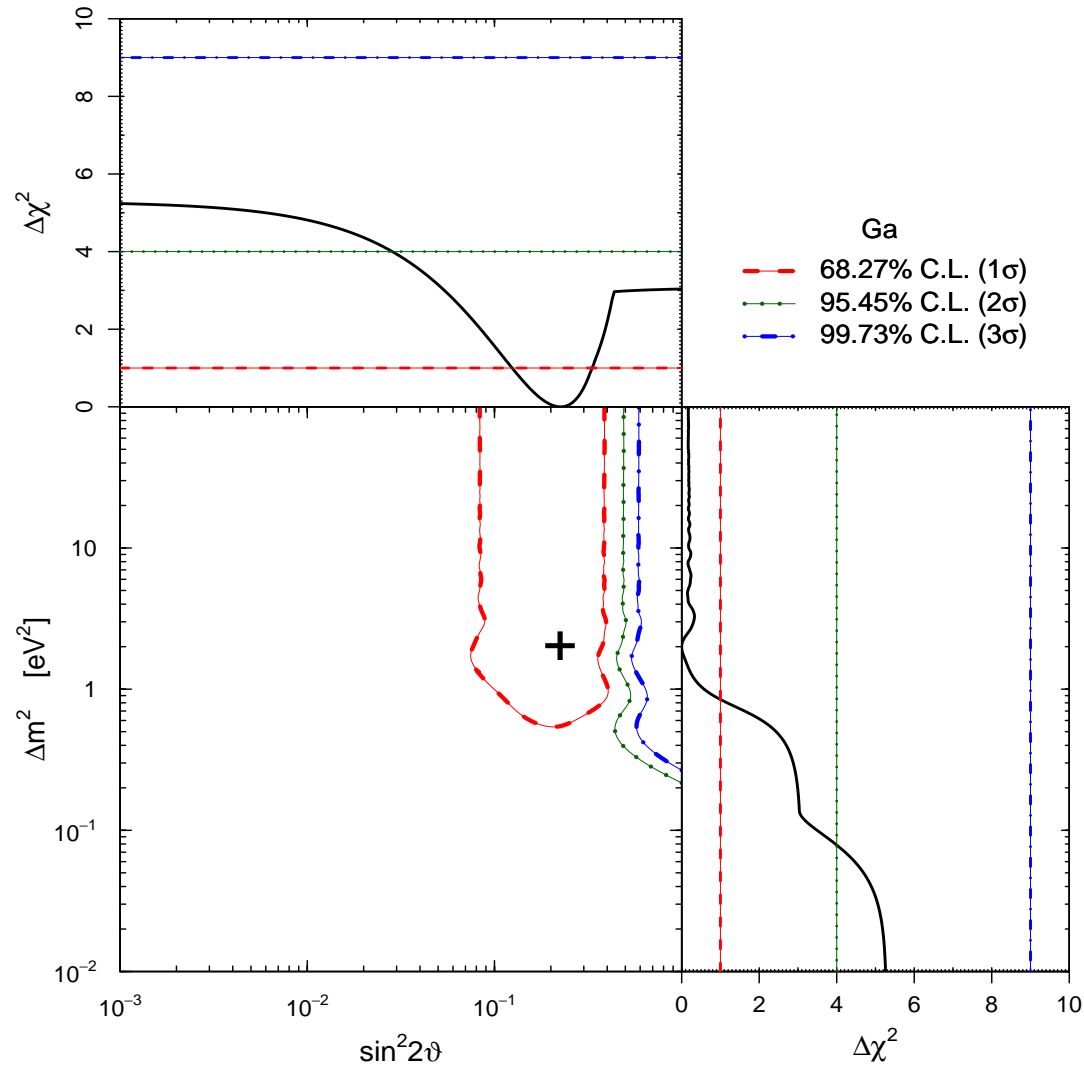
nucl-ex/0512041

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 .

Gallium anomaly : individual fits
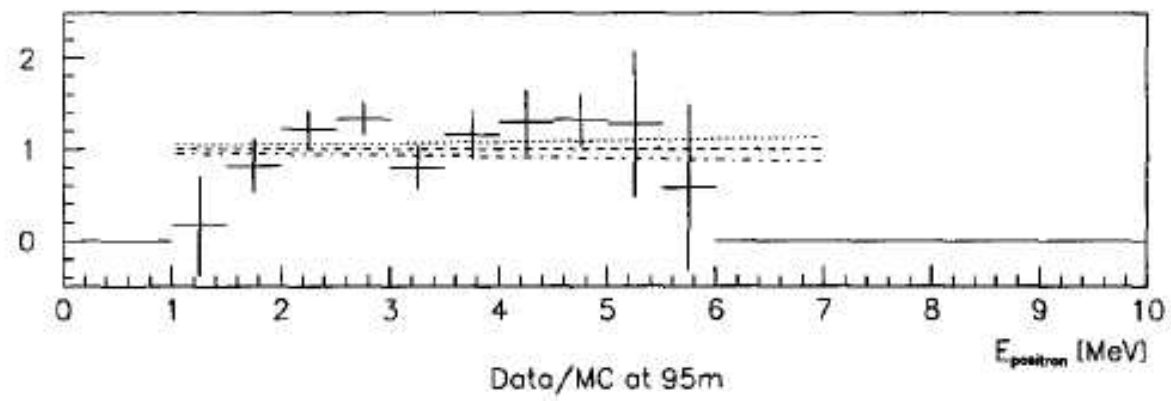
Gallium anomaly : combined fit

$$\chi^2_{\min} = 2.91/(2\,\text{dof}) \qquad GoF = 23\% \qquad \sin^2(2\theta)_{bf} = 0.22 \qquad \Delta m^2_{bf} = 1.98\,eV^2$$

Data/MC at 15m

Data/MC at 40m

Data/MC at 95m

Fit to Bugey data
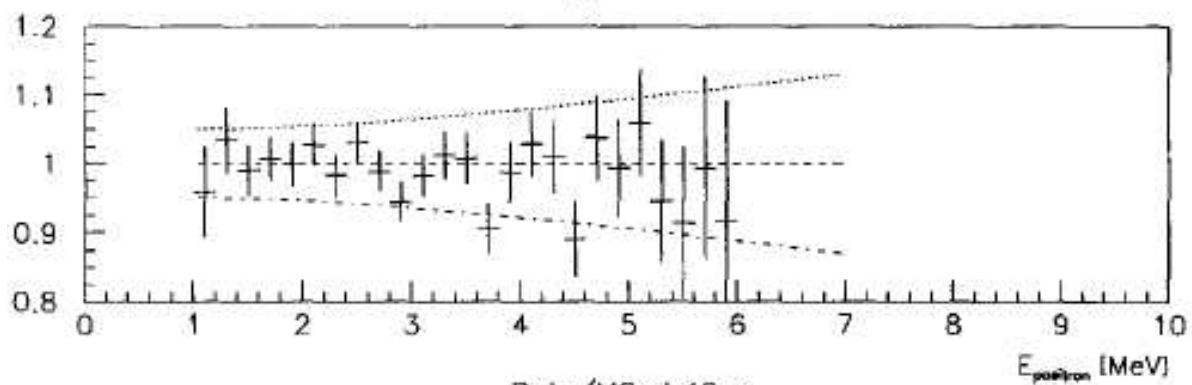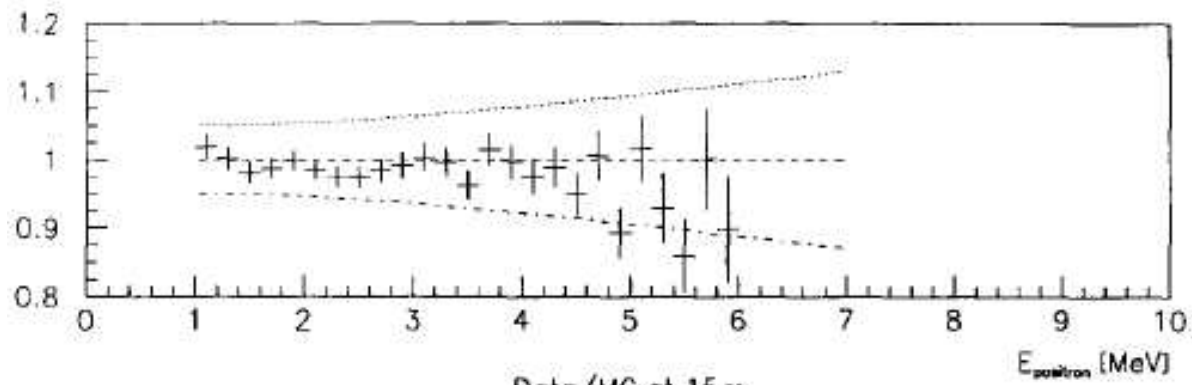
Bugey
- 68.27% C.L. (1σ)
- 95.45% C.L. (2σ)
- 99.73% C.L. (3σ)
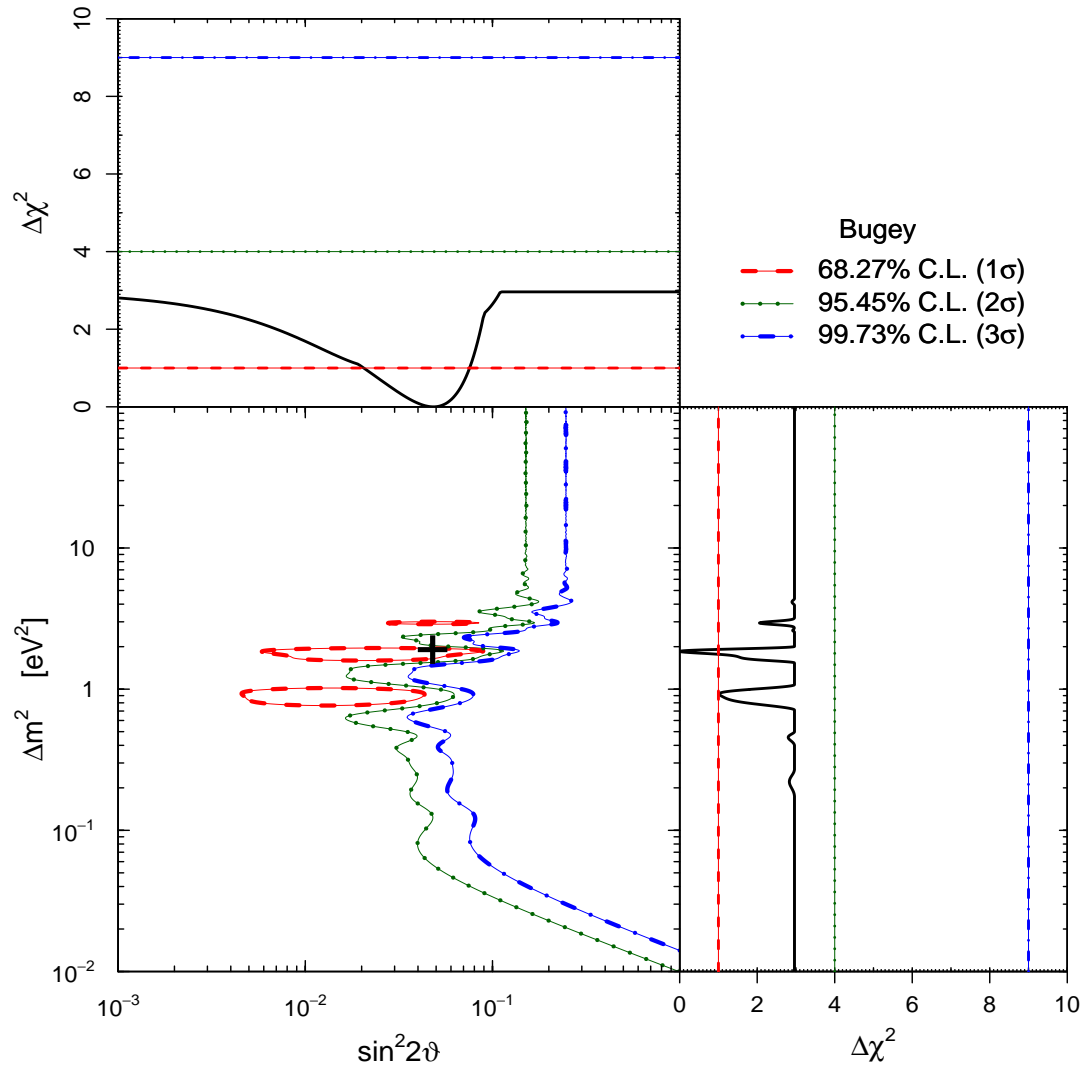
$\chi^2_{\min} = 47.97/(53\,\mathrm{dof}) \quad GoF = 67\% \qquad \sin^2(2\theta)_{bf} = 0.048 \quad \Delta m^2_{bf} = 1.85\,eV^2$

Best fit of Bugey data

L = 15 m

L = 40 m

L = 95 m

Combined fit to Gallium & Bugey data
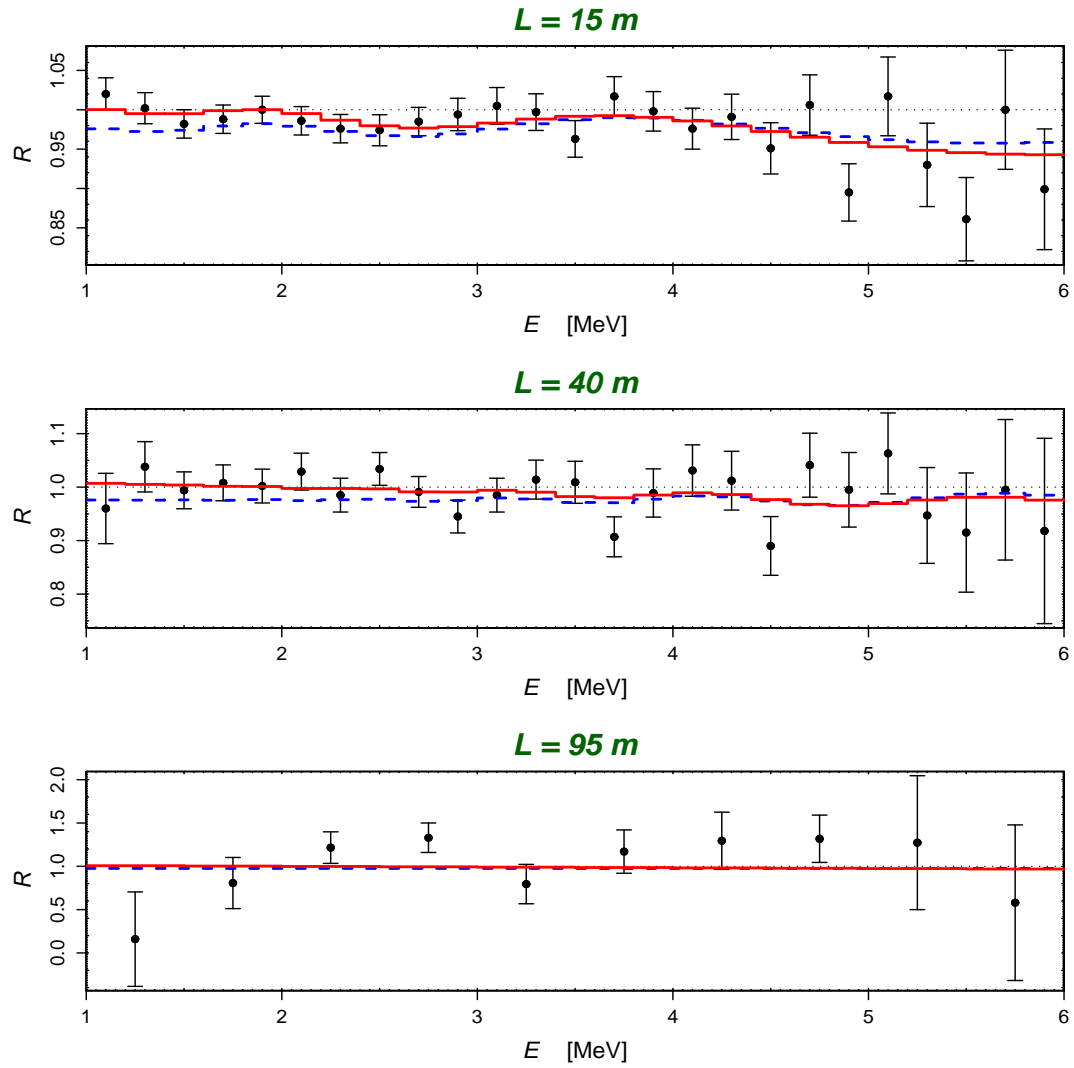
Ga + Bugey
- 68.27% C.L. (1σ)
- 95.45% C.L. (2σ)
- 99.73% C.L. (3σ)
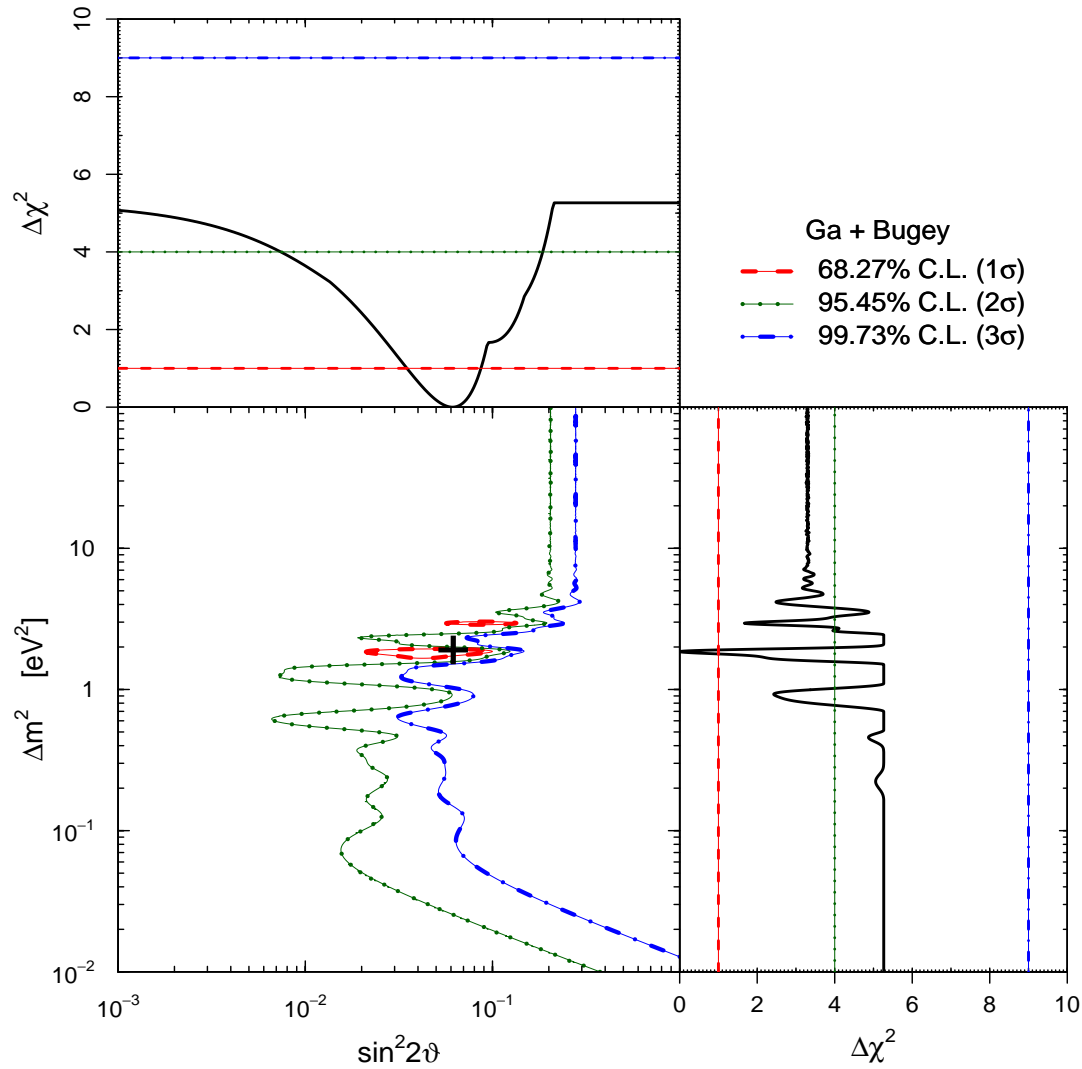
$\chi^2_{\min} = 53.87/(57\,\mathrm{dof})$ $GoF = 59\%$ $\sin^2(2\theta)_{bf} = 0.062$ $\Delta m^2_{bf} = 1.85\,eV^2$

Combined fit to Gallium   Bugey & Chooz data

Ga + Bugey + Chooz
- - - 68.27% C.L. (1σ)
······ 95.45% C.L. (2σ)
— - — 99.73% C.L. (3σ)
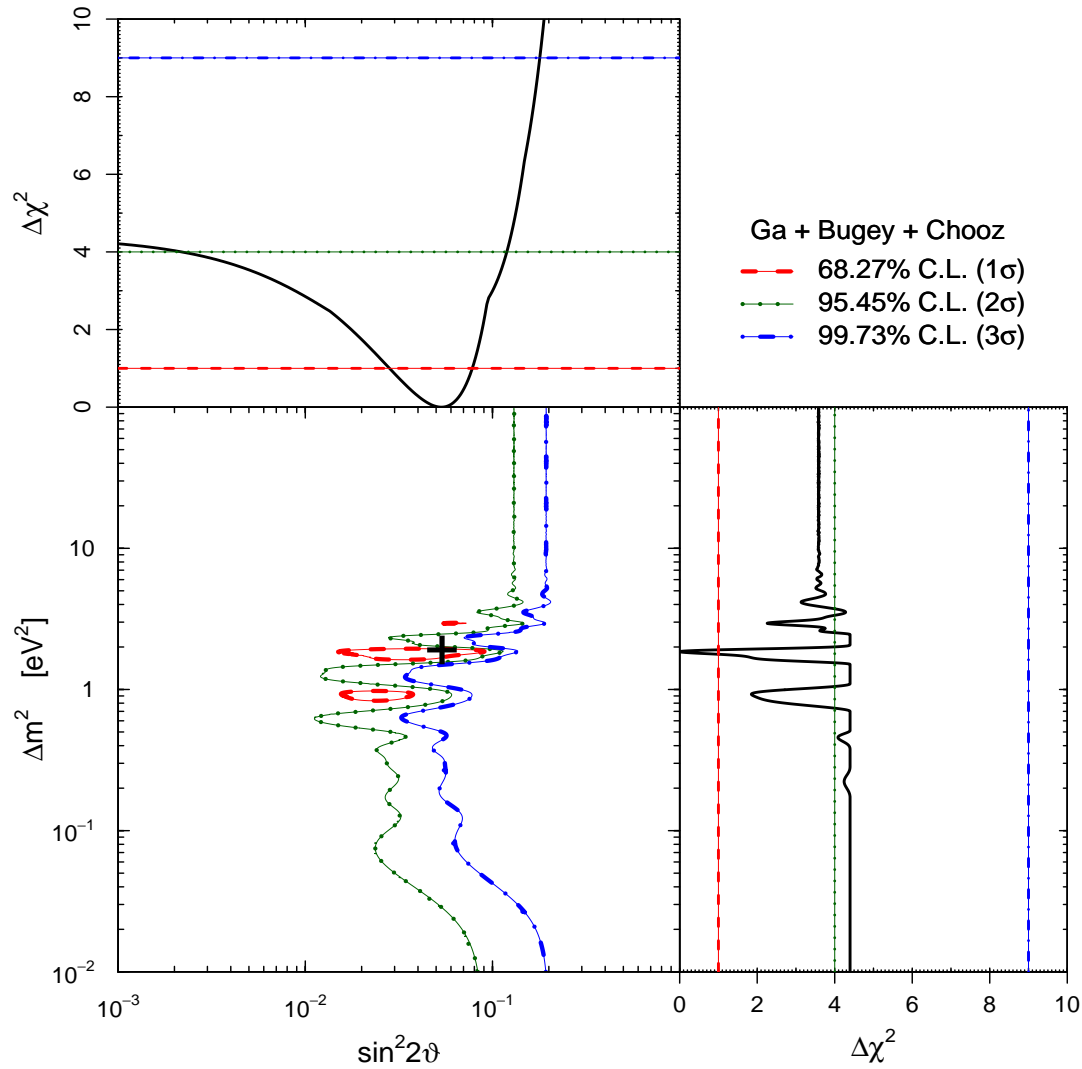
$\chi^2_{\min} = 54.80/(58\,\mathrm{dof})$ $GoF = 60\%$ $\sin^2(2\theta)_{bf} = 0.054$ $\Delta m^2_{bf} = 1.85\,eV^2$

		Ga	Bu	Ga+Bu	Bu+Ch	Ga+Ch	Ga+Bu+Ch
No Osc.	χ^2_{min}	8.19	50.94	59.13	51.00	8.26	59.19
	NDF	4	55	59	56	5	60
	GoF	0.085	0.63	0.47	0.66	0.14	0.51
Osc.	χ^2_{min}	2.91	47.97	53.87	48.63	6.60	54.80
	NDF	2	53	57	54	3	58
	GoF	0.23	0.67	0.59	0.68	0.086	0.60
	$\sin^2 2\vartheta_{bf}$	0.22	0.048	0.062	0.041	0.08	0.054
	$\Delta m^2_{bf}\,[\text{eV}^2]$	1.98	1.85	1.85	1.85	1.72	1.85
PG	$\Delta\chi^2_{min}$			2.98	0.59	3.63	3.85
	NDF			2	1	1	3
	GoF			0.23	0.44	0.057	0.28

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Active-Sterile ν mixing !

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- A hint in favor of short-baseline neutrino oscillations generated by $\Delta m^2 \gtrsim 0.1\,\mathrm{eV}^2$ is extremely interesting.

- This squared-mass difference is too large to be compatible with the three-neutrino mixing scheme inferred from the observation of neutrino oscillations in solar, very-long-baseline reactor, atmospheric and long-baseline accelerator experiments, in which there are only two independent squared-mass differences, $\Delta m^2_{\mathsf{SOL}} \approx 8 \times 10^{-5}\,\mathrm{eV}^2$ and $\Delta m^2_{\mathsf{ATM}} \approx 3 \times 10^{-3}\,\mathrm{eV}^2$.

- Our results indicate the possible existence of at least one light sterile neutrino ν_s.

- Future experiments which are well suited for finding small $\overset{(-)}{\nu_e} \rightarrow \overset{(-)}{\nu_s}$ transitions are those with a source producing a $\overset{(-)}{\nu_e}$ flux which is known with high accuracy.

- Beta-Beam experiments which have a pure ν_e or $\bar{\nu}_e$ beam from nuclear decay, Neutrino Factory experiments in which the beam is composed of ν_e and $\bar{\nu}_\mu$, from μ^+ decay, or $\bar{\nu}_e$ and ν_μ, from μ^- decay.
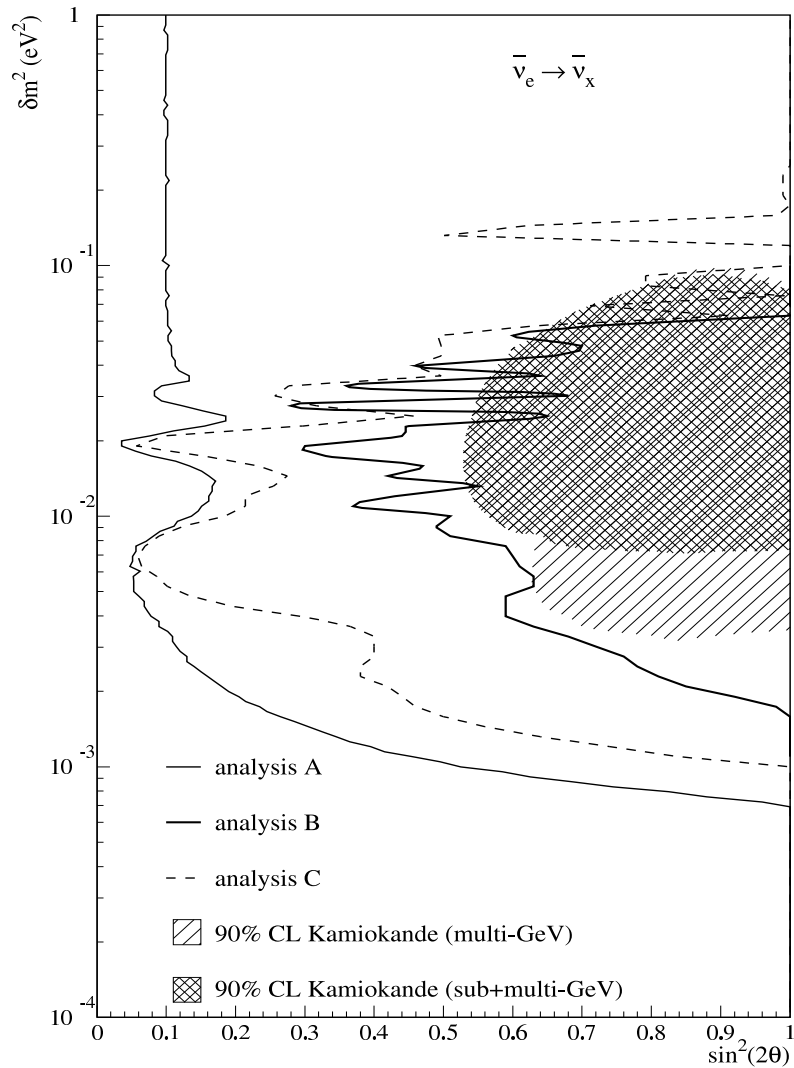
Se son rose fioriranno ...

... GOOD LUCK to MAJORANA ν PHYSICS !!!

Backup slides

CHOOZ high δm^2 limits

$\bar{\nu}_e \to \bar{\nu}_x$

--- analysis A

— analysis B

- - - analysis C

▨ 90% CL Kamiokande (multi-GeV)

▨ 90% CL Kamiokande (sub+multi-GeV)

sCL belt

FC belt (corr. syst.)

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

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

hep-ex/0301017