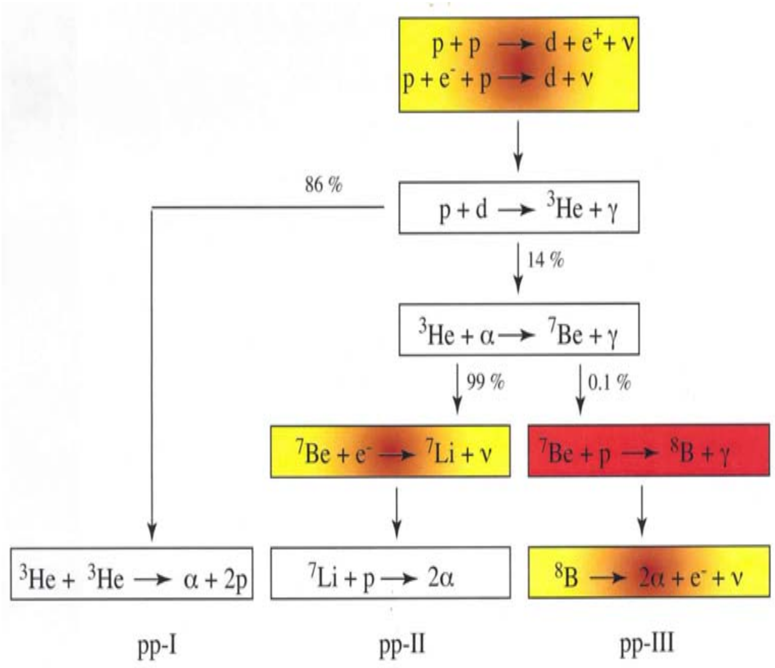

Results & Perspectives from SNO

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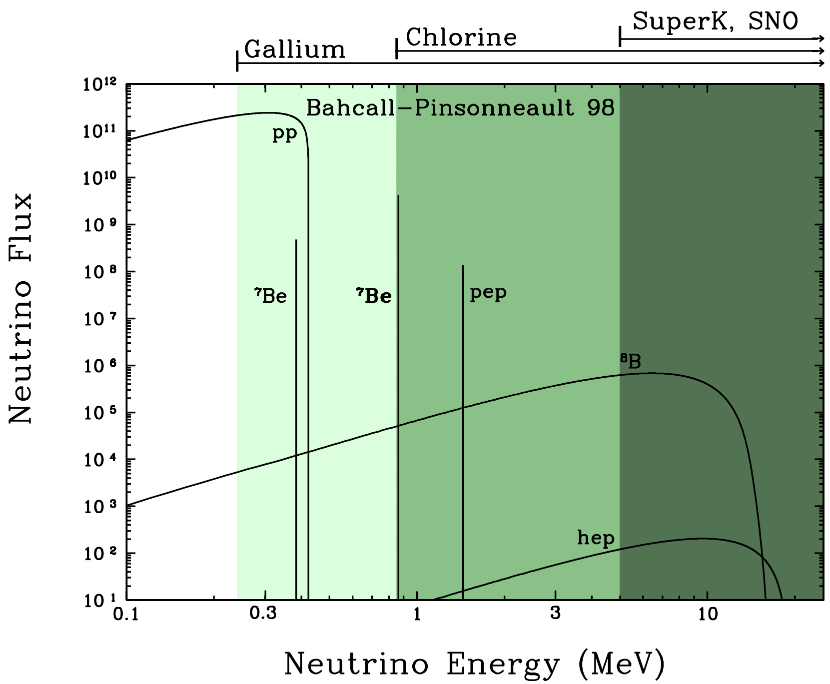
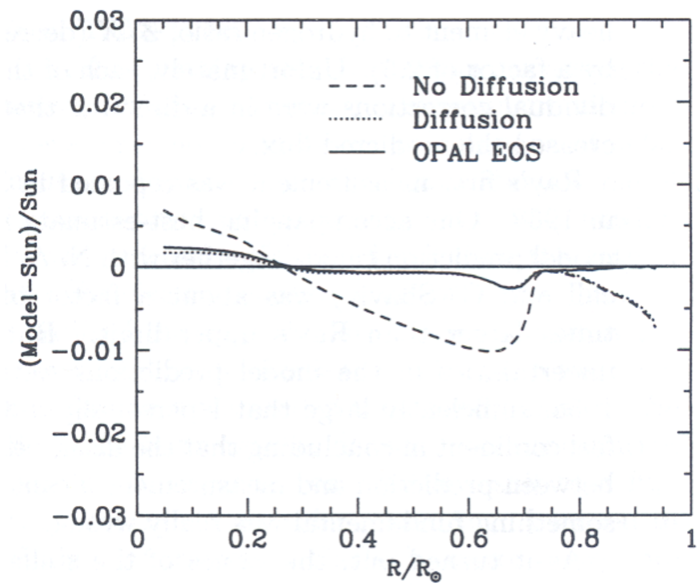
Les Rencontres de Physique de la Vallee D'Aoste

La Thuile, Aosta Valley, Italy, March 9-15, 2003

The Solar Neutrino Paradigm





			$\phi_{EXP}/\ \phi_{SSM}$	σ_{EXP}
Gallium:	GALLEX + GNO:	73.3 ± 4.7 ± 4.0 SNU	[0.58]	~ 8%
	SAGE:	70.8 ± 5.3 ± 3.5 SNU	[0.56]	~ 8%
Chlorine:	Homestake:	2.35 ± 0.23 SNU	[0.33]	~ 10%
H2O - ES:	SK:	2.35 ± 0.02 ± 0.06 x 10^6 $cm^{-2}s^{-1}$	[0.47]	~ 3%
{ D2O - CC:	SNO:	1.76 ± 0.06 ± 0.09 x 10^6 $cm^{-2}s^{-1}$	[0.35]	~ 6%
D2O - NC:	SNO:	5.09 ± 0.44 ± 0.45 SNU	[~ 1]	~ 12%

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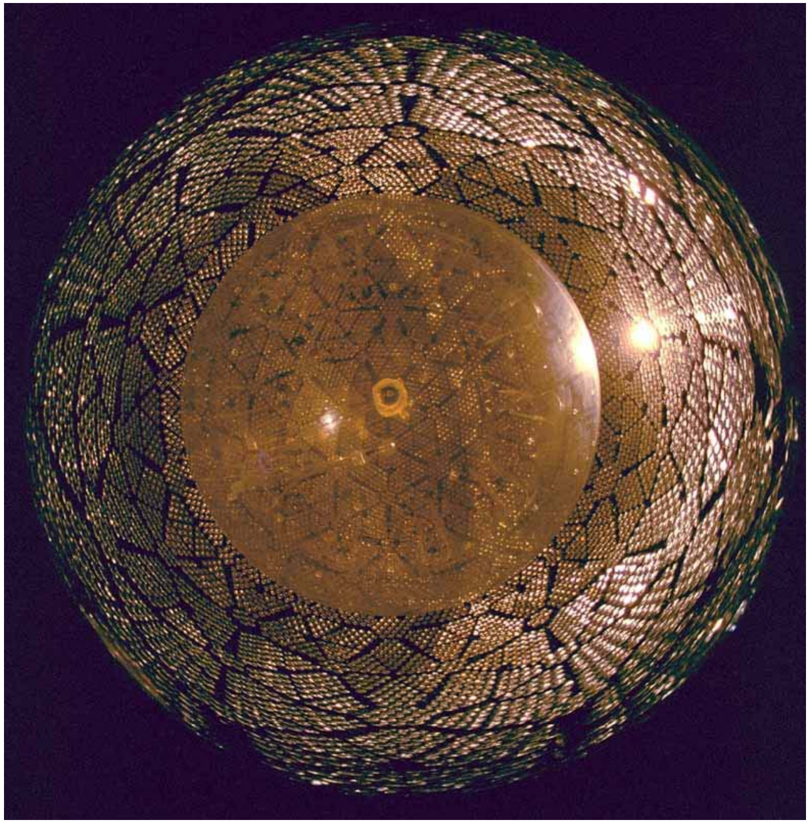

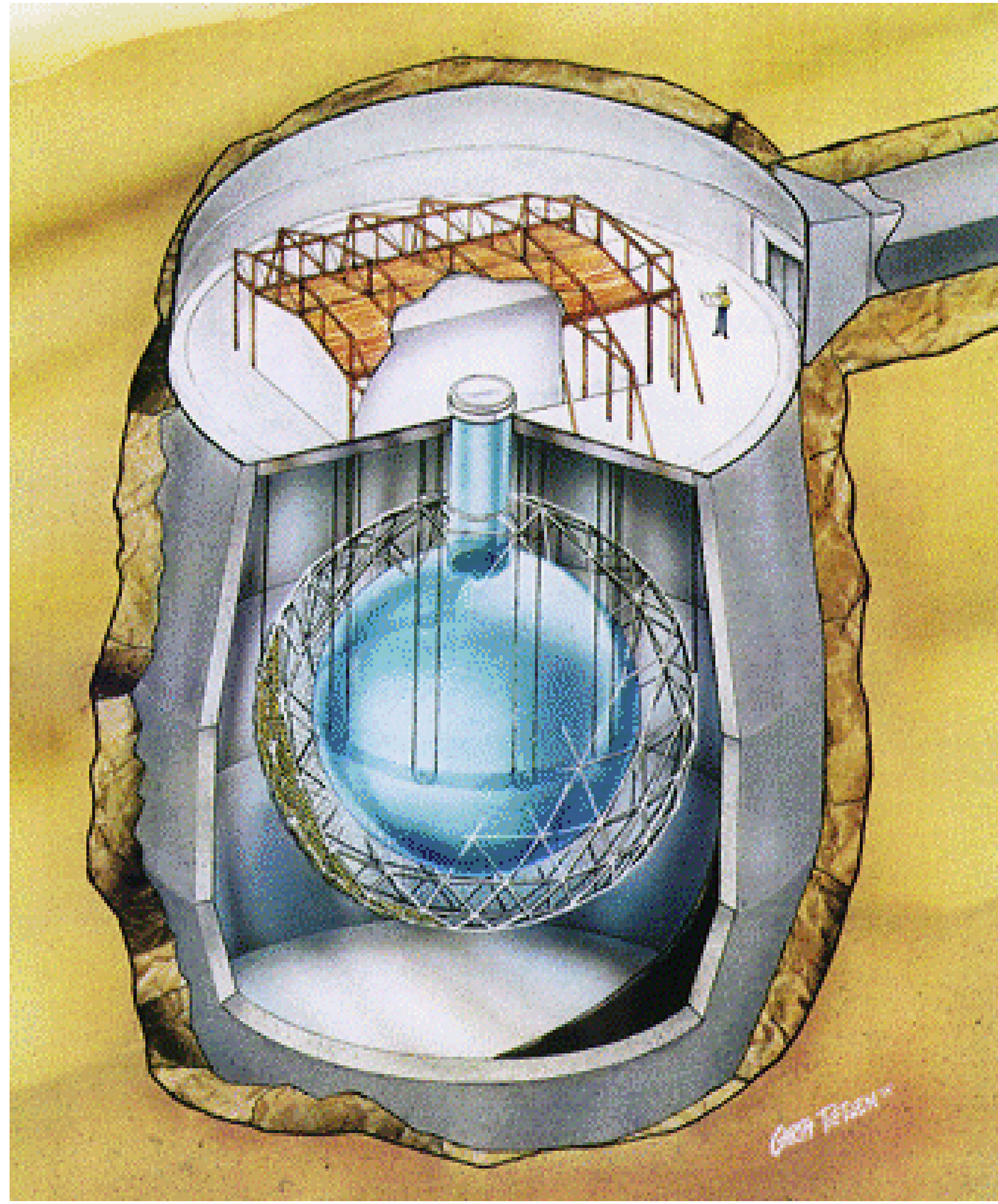

The Sudbury Neutrino Observatory

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Solar Neutrino Reactions

Charged Current Reaction (D_2O):

CC

$\nu_e + d \rightarrow p + p + e^-$ $E_{thres} = 1.4$ MeV

(Only ν_e)

- ν_e flux and energy spectrum
- Some directional sensitivity ($1 - 1/3\cos\theta_e$)

Neutral Current Reaction (D_2O):

NC

$\nu_x + d \rightarrow \nu_x + p + n$ $E_{thres} = 2.2$ MeV

(All ν types)

- Total active neutrino flux

Elastic Scattering Reaction (D_2O,H_2O):

ES

$\nu_x + e^- \rightarrow \nu_x + e^-$ $E_{thres} = 0$ MeV

(Mostly ν_e)

- Directional sensitivity (forward peaked)

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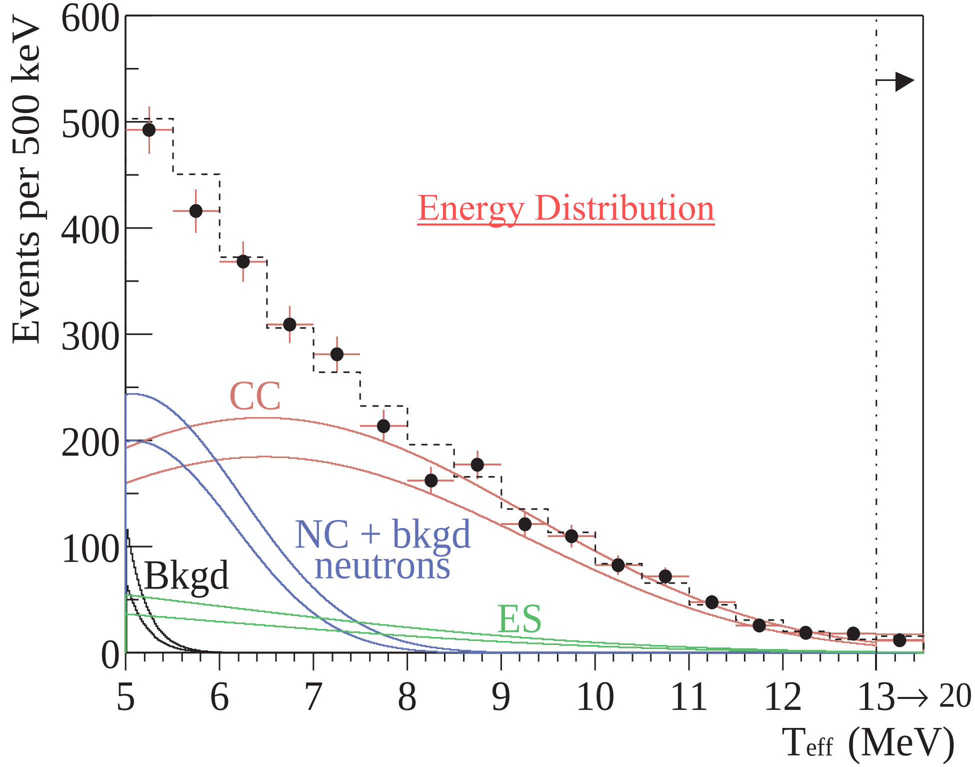
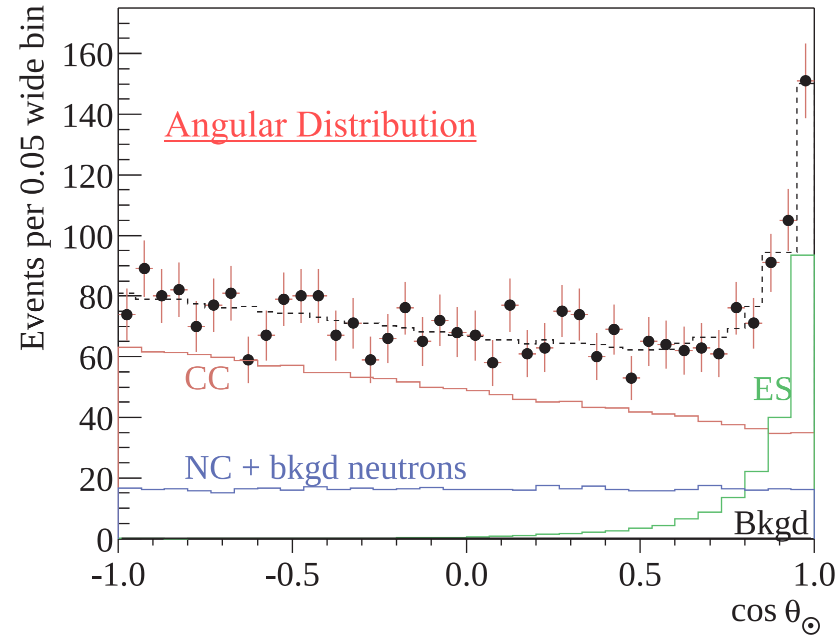
SNO Provides a Model-Independent Test of Neutrino Oscillations via ES/CC, NC/CC, and CC-Shape

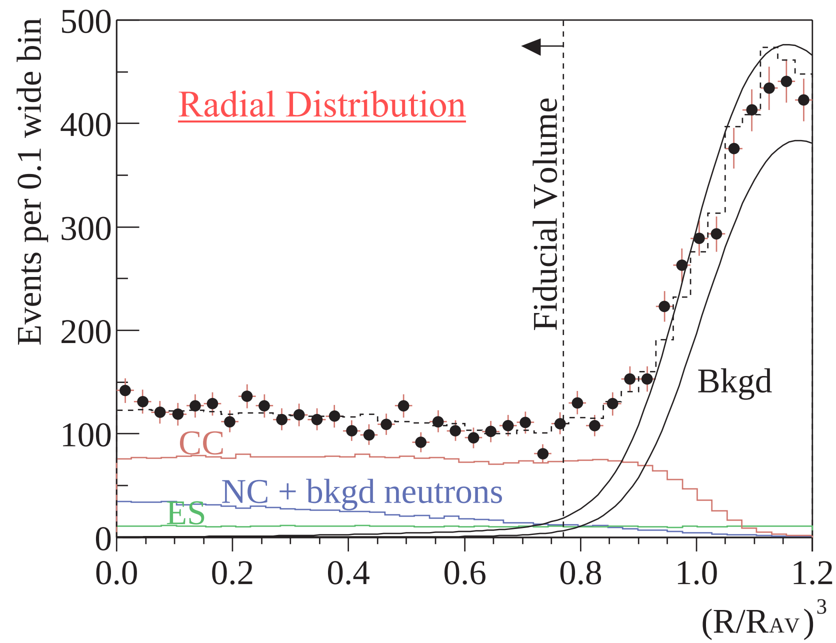
Signal Extraction in the Pure-D2O Phase of SNO

SNO Collaboration, Phys. Rev. Lett. 89, 011301 (2002)





#EVENTS		
CC	1967.7	+61.9 +60.9
ES	263.6	+26.4 +25.6
NC	576.5	+49.5 +48.9



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Results for Solar Neutrino Fluxes

In units of 10^6 neutrinos cm^{-2} s^{-1}

$$\phi_{CC}^{SNO} = 1.76 \pm 0.06 \pm 0.09 = 1.75 \pm 0.11$$
$$\phi_{NC}^{SNO} = 5.09 \pm 0.44 \pm 0.46 = 5.09 \pm 0.64$$
$$\phi_{ES}^{SNO} = 2.39 \pm 0.24 \pm 0.12 = 2.39 \pm 0.27$$
$$\phi_{ES}^{SK} = 2.35 \pm 0.02 \pm 0.06 = 2.35 \pm 0.07$$

Stat. Sys.

$$\phi_{CC}^{SNO} / \phi_{8B}^{SSM} = 0.347 \pm 0.022$$
$$\phi_{ES}^{SK} / \phi_{8B}^{SSM} = 0.465 \pm 0.014$$
$$\phi_{NC}^{SNO} / \phi_{8B}^{SSM} = 1.008 \pm 0.127$$

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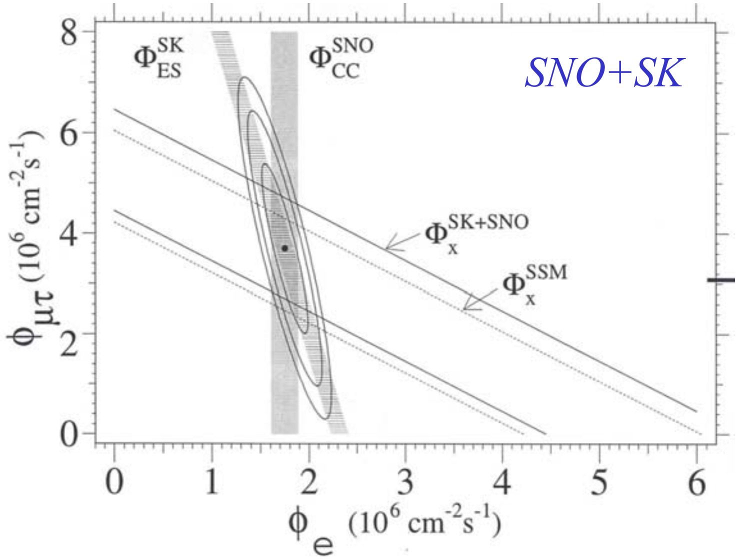
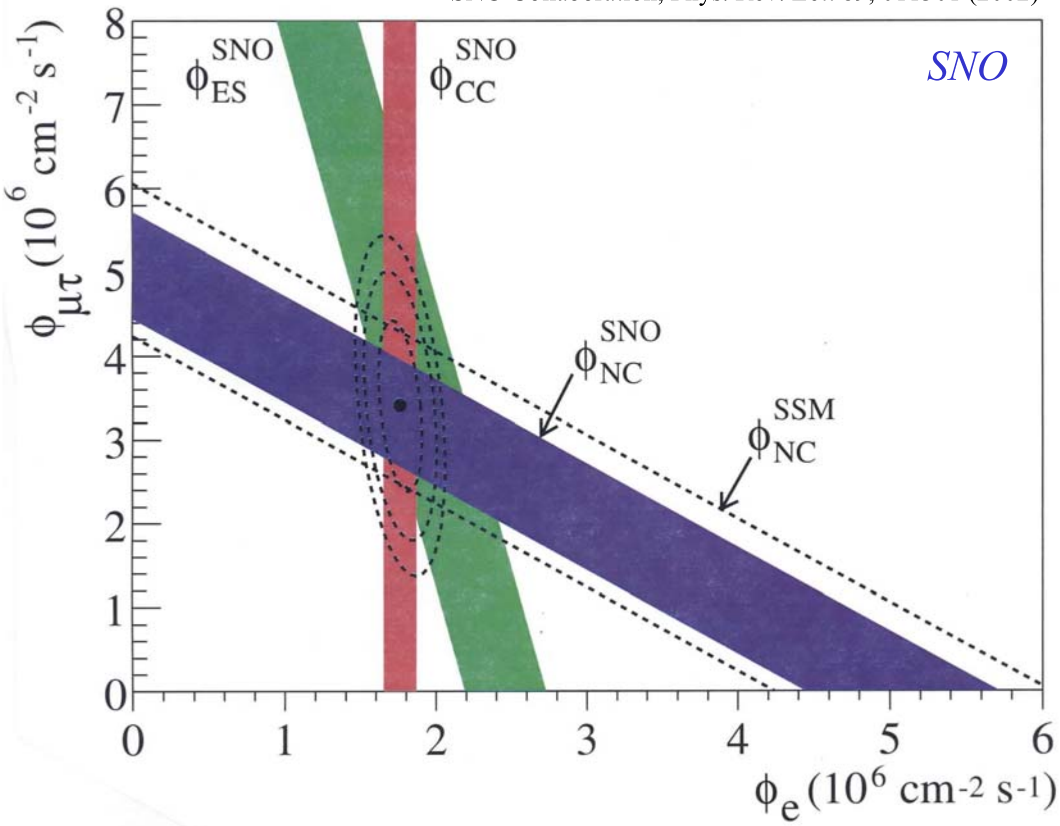
SNO Collaboration, Phys. Rev. Lett 87, 071301 (2001)



Flavor Content Analysis of the 8B Solar Neutrino Flux

SNO Collaboration, Phys. Rev. Lett 89, 011301 (2002)



$$\phi_{CC} = \phi_e$$
$$\phi_{ES} = \phi_e + \varepsilon\phi_{\mu\tau}$$
$$\phi_{NC} = \phi_e + \phi_{\mu\tau} = \phi_{Total}$$

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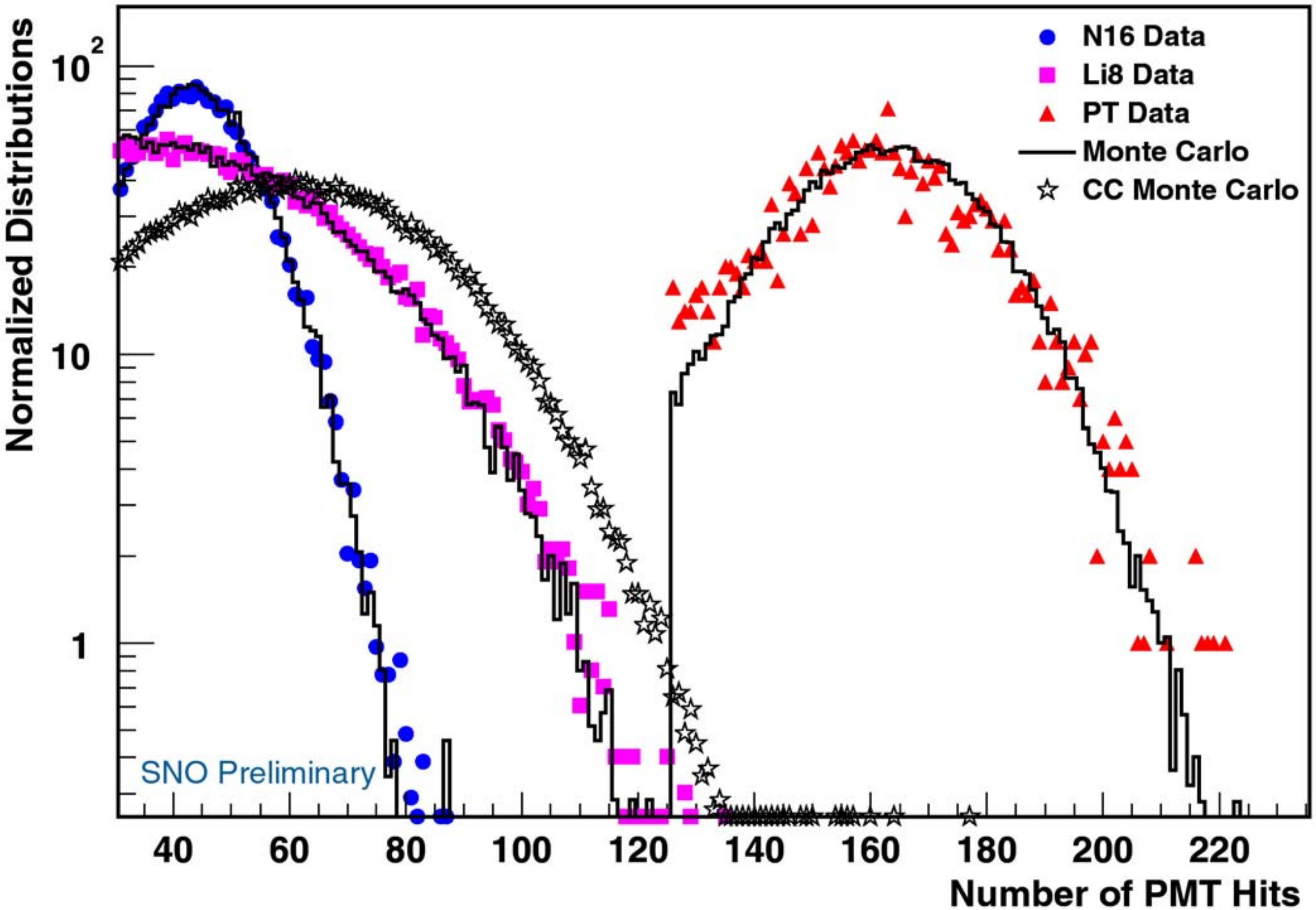
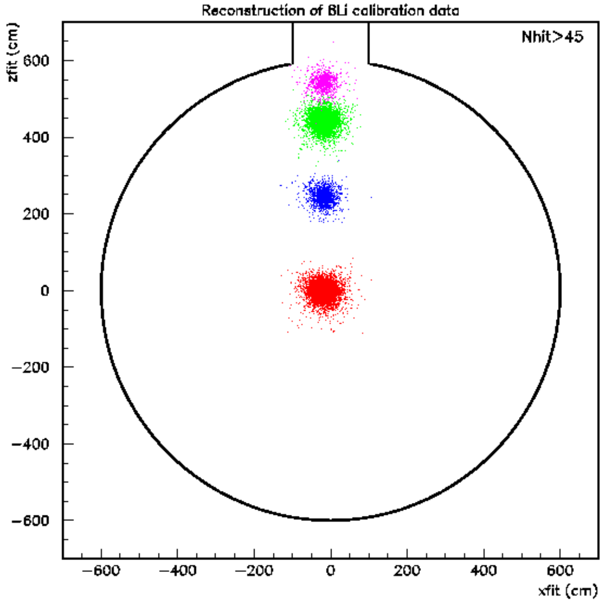
SNO Systematic Uncertainties

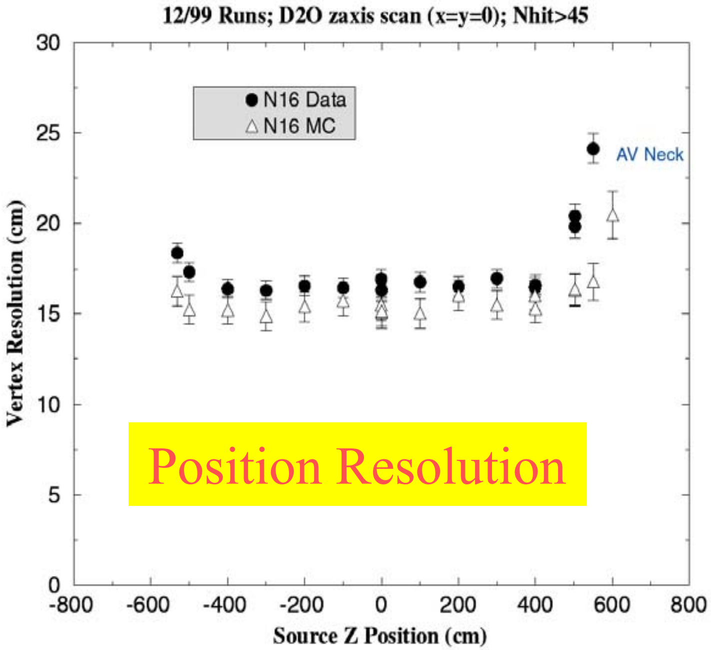
Source	CC Uncert. (percent)	NC Uncert. (percent)	$\phi_{\mu\tau}$ Uncert. (percent)
Energy scale †	-4.2,+4.3	-6.2,+6.1	-10.4,+10.3
Energy resolution †	-0.9,+0.0	-0.0,+4.4	-0.0,+6.8
Energy non-linearity †	±0.1	±0.4	±0.6
Vertex resolution †	±0.0	±0.1	±0.2
Vertex accuracy	-2.8,+2.9	±1.8	±1.4
Angular resolution	-0.2,+0.2	-0.3,+0.3	-0.3,+0.3
Internal source pd †	±0.0	-1.5,+1.6	-2.0,+2.2
External source pd	±0.1	-1.0,+1.0	±1.4
D_2O Cherenkov †	-0.1,+0.2	-2.6,+1.2	-3.7,+1.7
H_2O Cherenkov	±0.0	-0.2,+0.4	-0.2,+0.6
AV Cherenkov	±0.0	-0.2,+0.2	-0.3,+0.3
PMT Cherenkov †	±0.1	-2.1,+1.6	-3.0,+2.2
Neutron capture	±0.0	-4.0,+3.6	-5.8,+5.2
Cut acceptance	-0.2,+0.4	-0.2,+0.4	-0.2,+0.4
Experimental uncertainty	-5.2,+5.2	-8.5,+9.1	-13.2,+14.1
Cross section [7]	±1.8	±1.3	±1.4

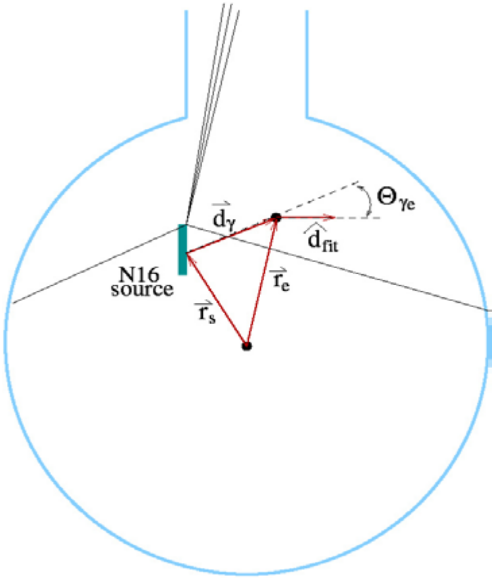
SNO's Energy Response

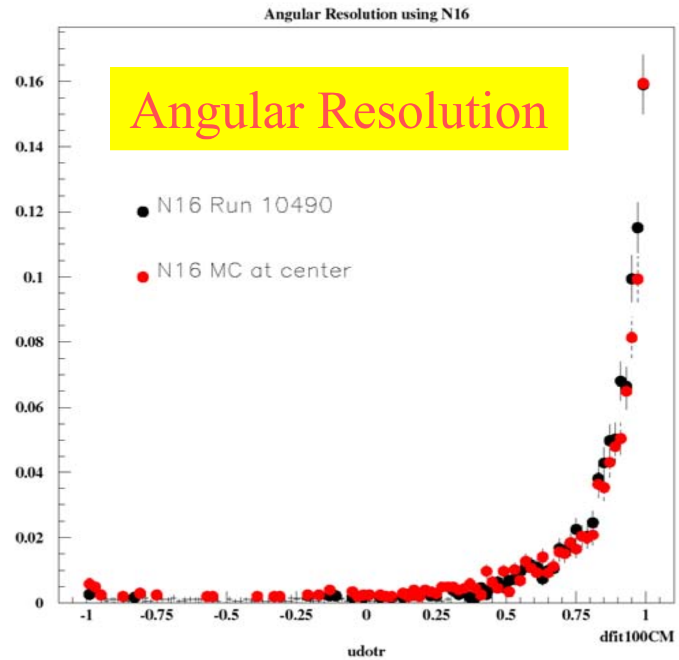
Energy Response at the Center of the Detector











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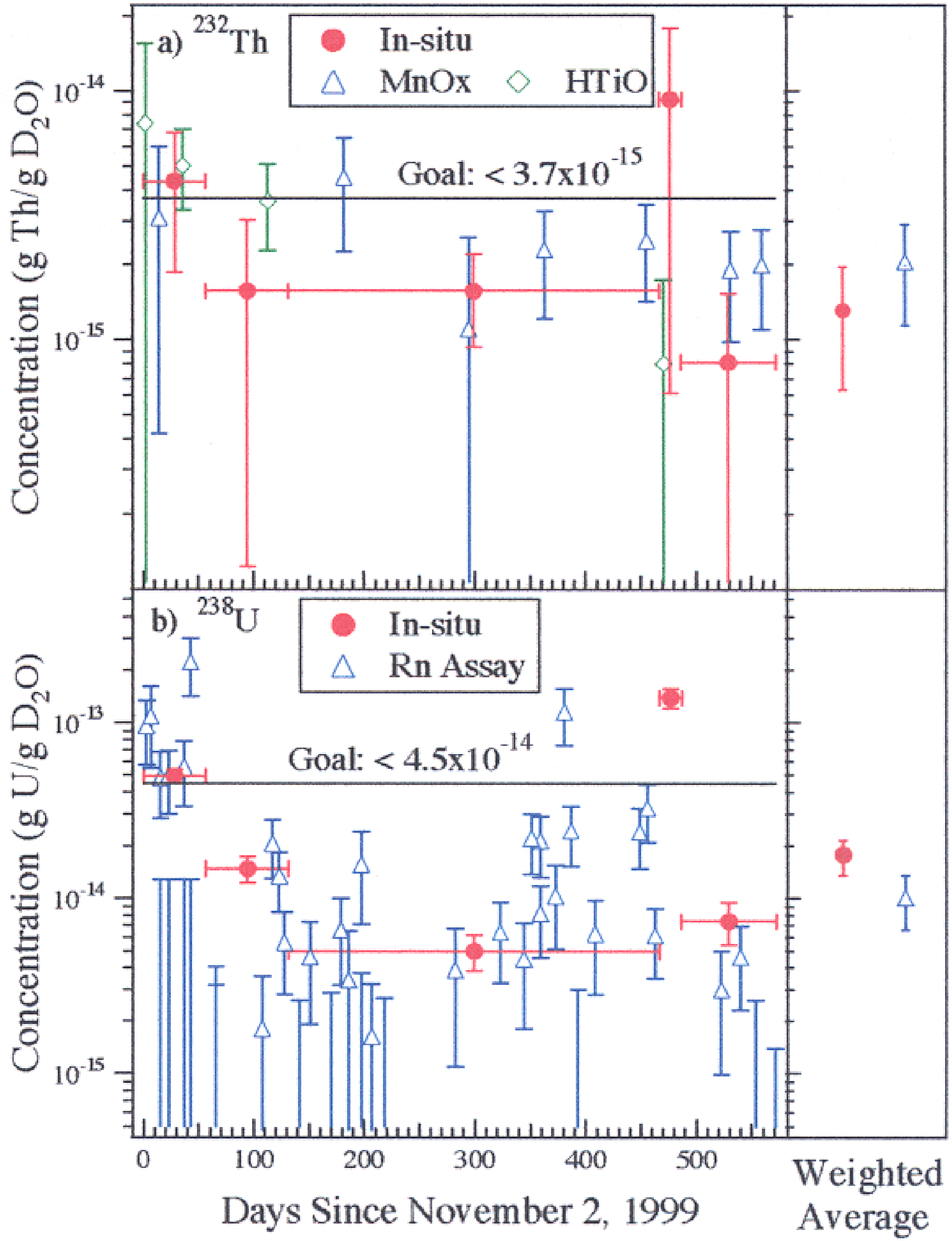
SNO Backgrounds



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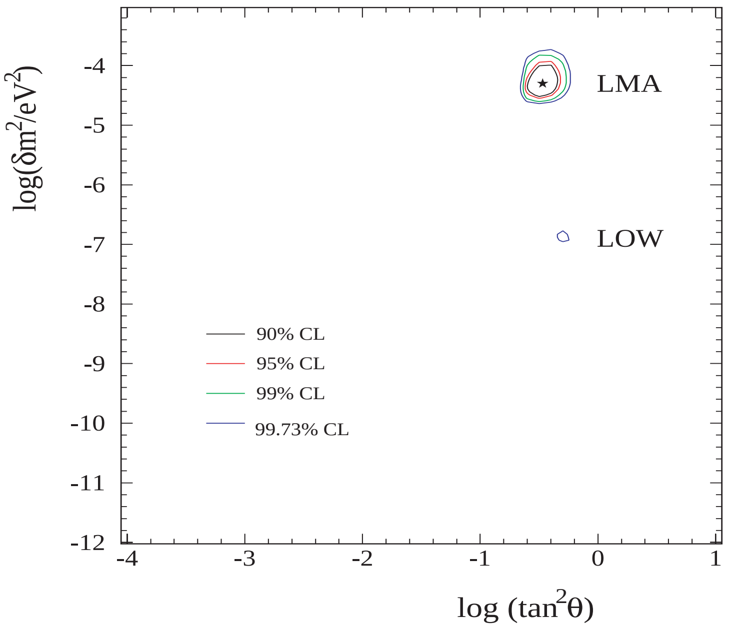
Life After SNO

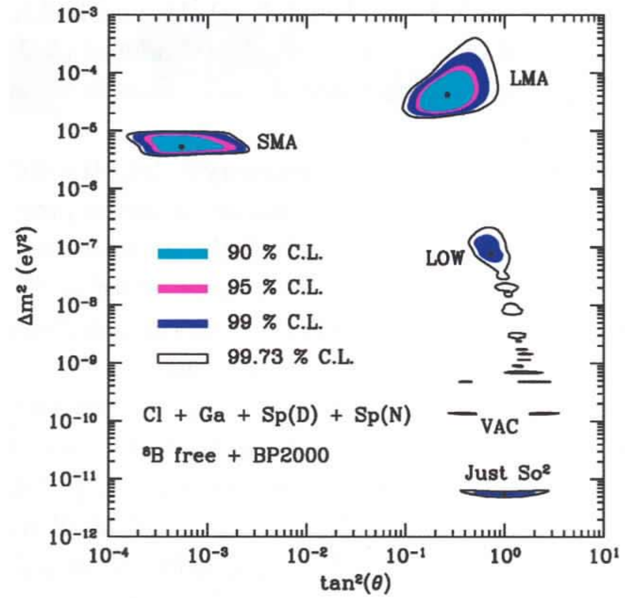
SNO Collaboration, Phys. Rev. Lett. 89, 011302 (2002)



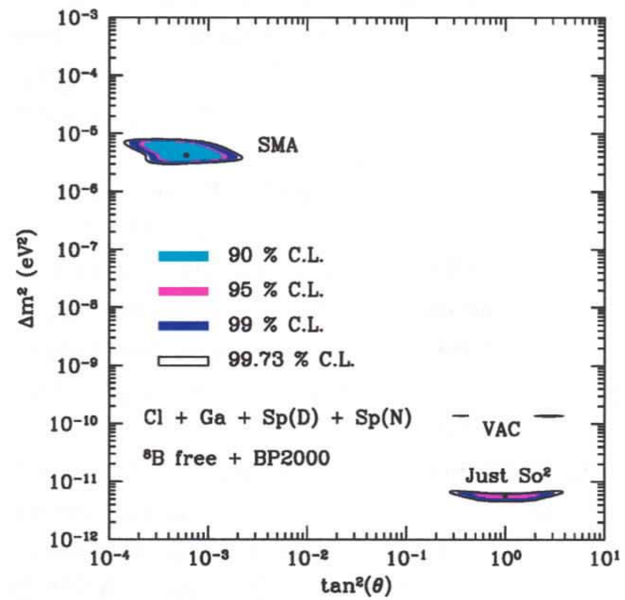
Life Before SNO

Bahcall, Krastev, Smirnov (hep-ph/0103179 v3)

Purely Active



Purely Sterile



Interpretation of flavor transformation as the result of non-zero neutrino mass and mixing in the lepton sector.

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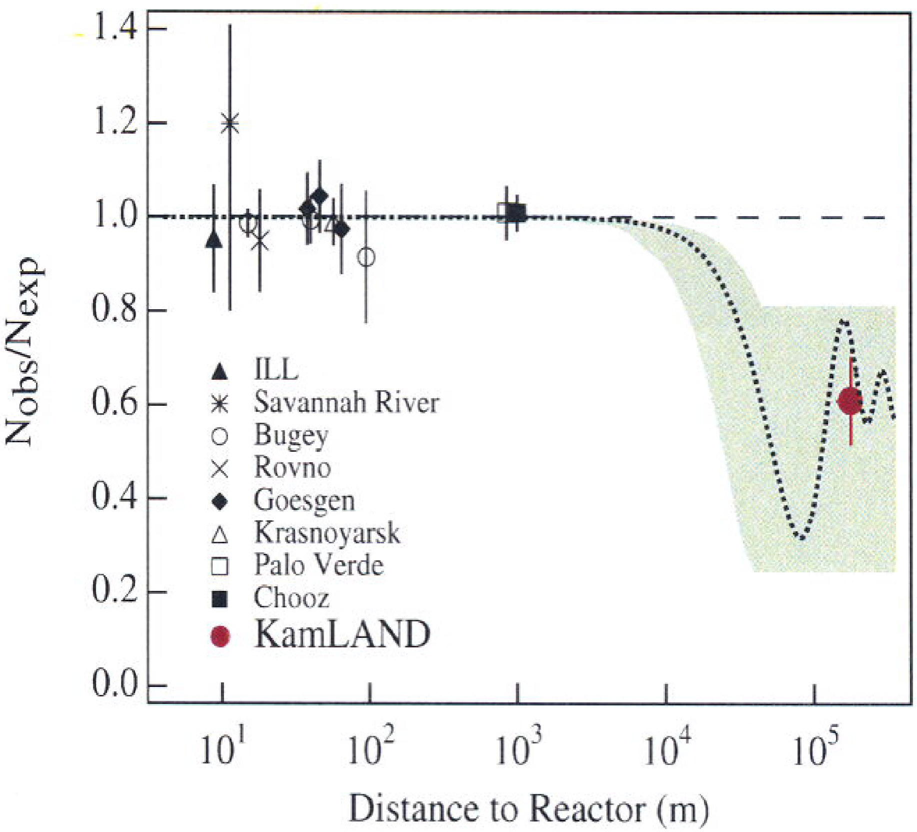
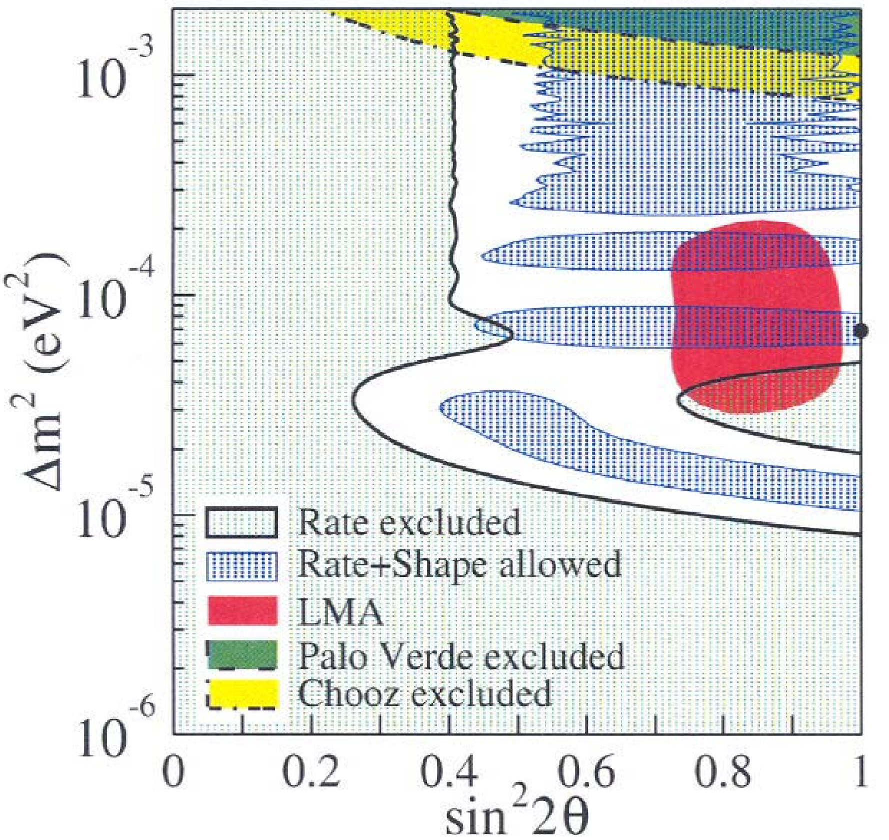
First Results from KamLAND

hep-ex/0212021





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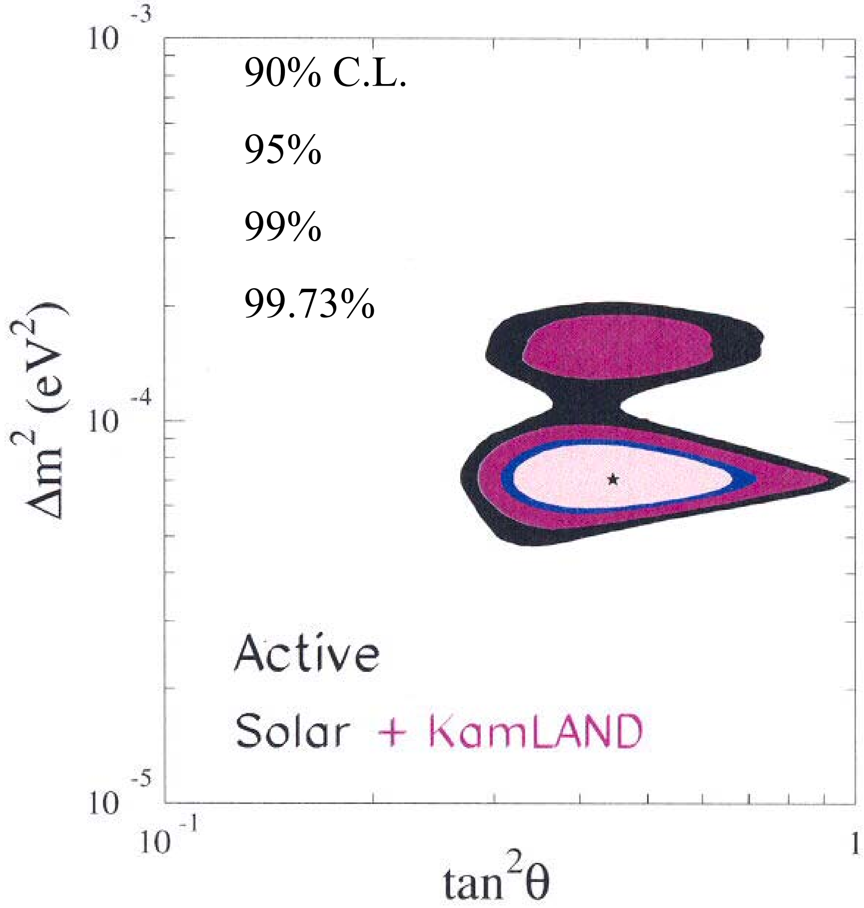
Active Neutrino Oscillation Parameters

J.N. Bahcall, M.C. Gonzalez-Garcia, and C. Pena-Garay hep-ph/0212147 v1



➔ LMA remains the only viable solution for solar neutrino flavor transformation.

➔ Δm^2 will improve with precision in KamLAND and D/N-asymmetry in SNO.

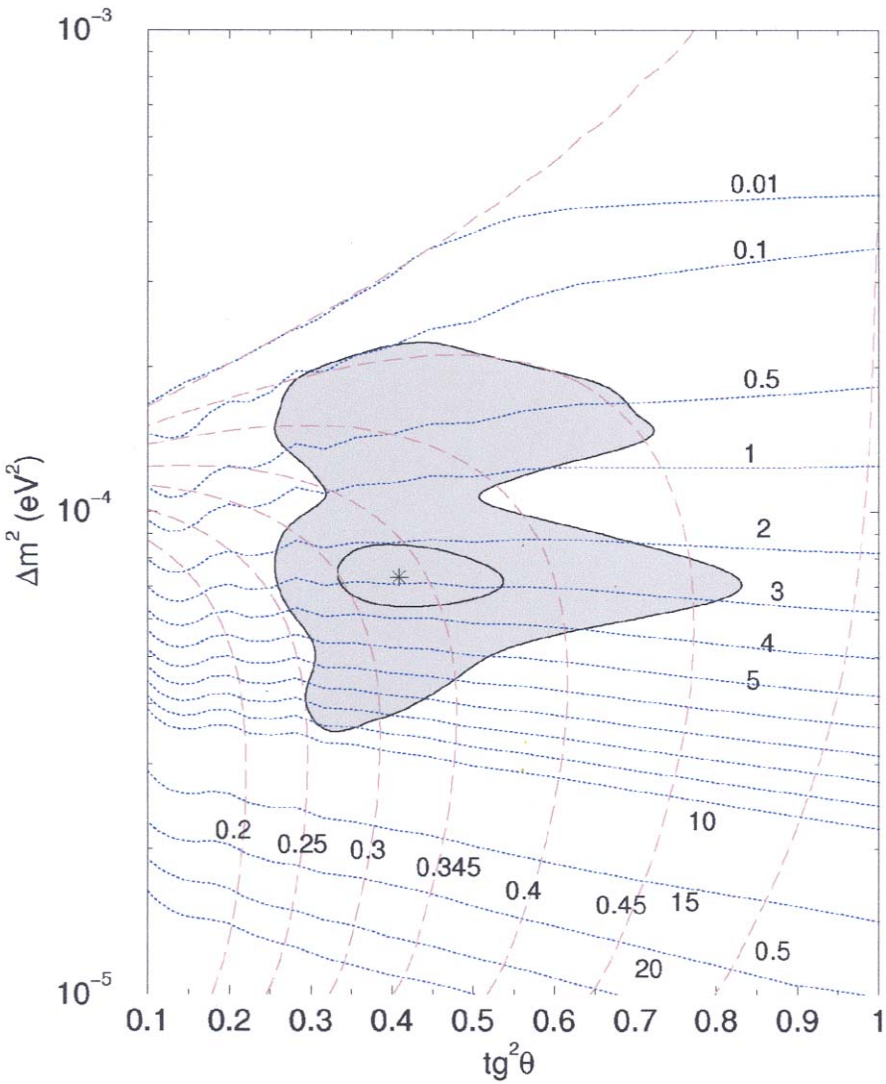
➔ Precision in $\tan^2\vartheta$ will improve with precision in CC/NC in SNO.

➔ $\Phi_{8B}^{Total} = (1.00 \pm 0.06)\ \Phi_{8B}^{SSM}$

Predictions for SNO

P.C. de Holanda and A.Yu. Smirnov

hep-ph/0212270 v2



Day/Night →

↑ CC/NC

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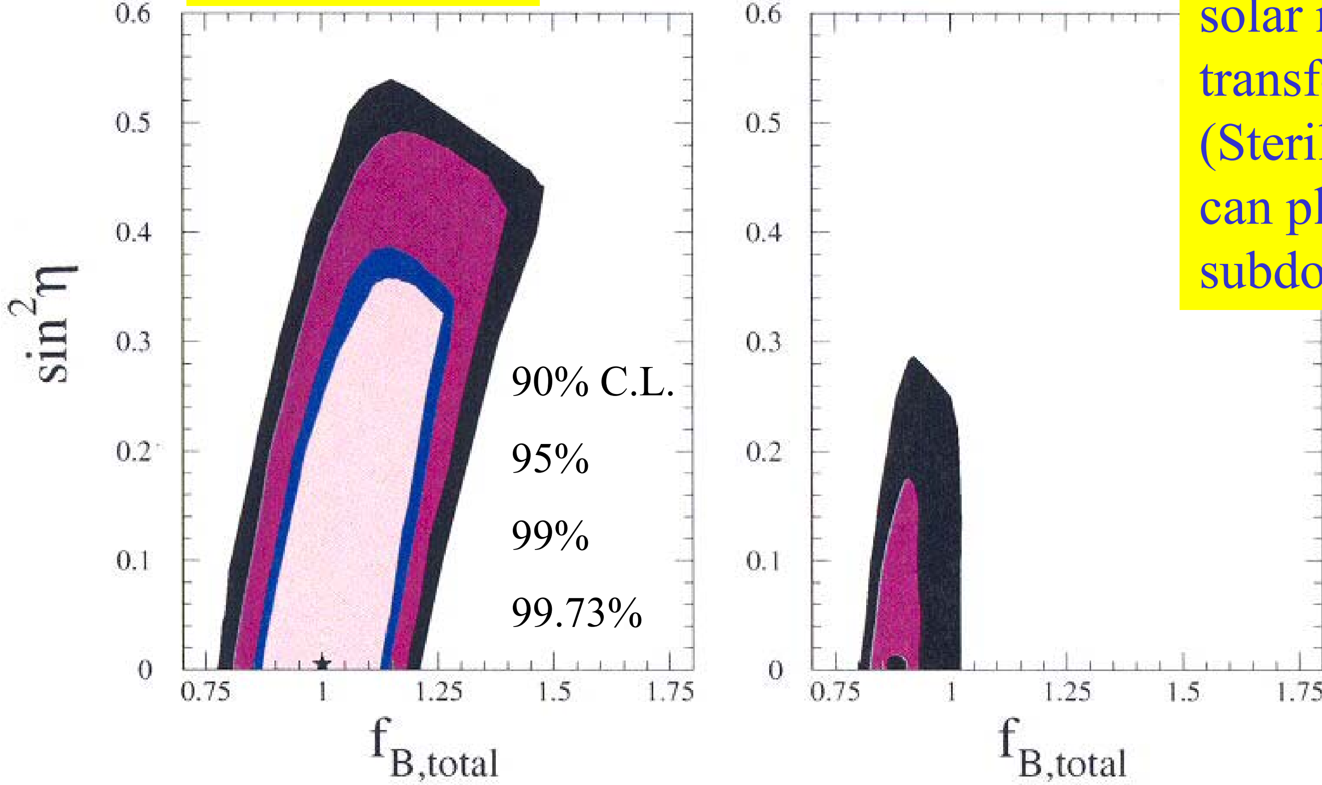
Total 8B Flux & Sterile Neutrino Admixtures

J.N. Bahcall, M.C. Gonzalez-Garcia, and C. Pena-Garay hep-ph/0212147 v1

$\sin^2\eta < 0.13$



➔ Other modes for solar neutrino flavor transformation (Sterile, RSFP, …) can play only a subdominant role.

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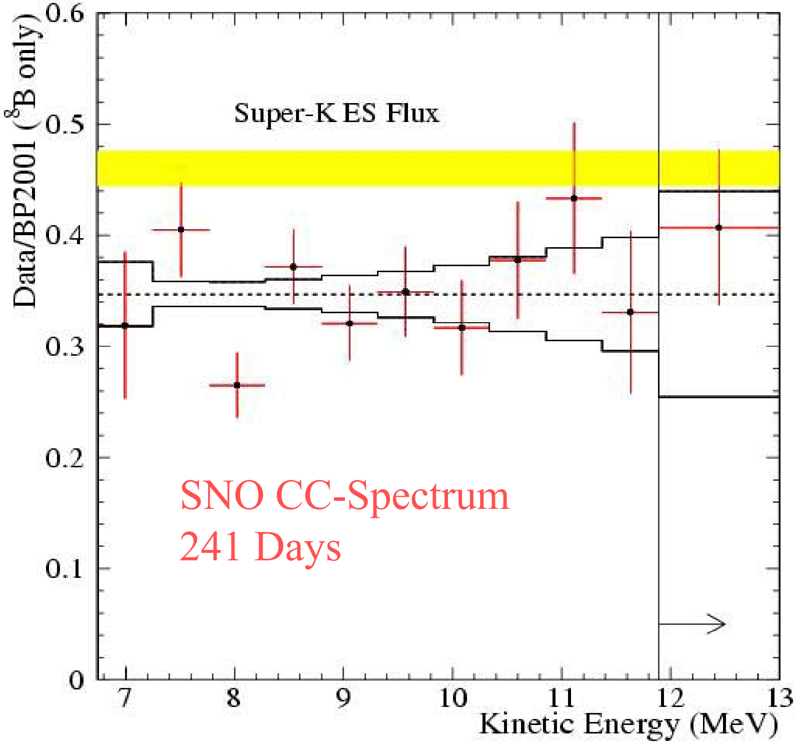
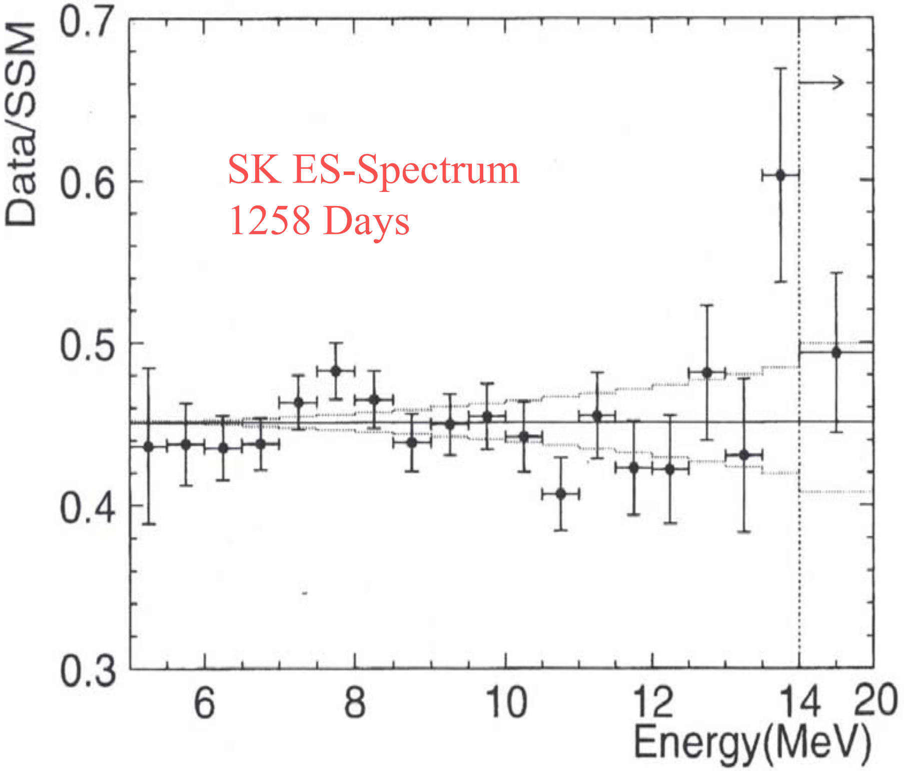
8B Energy Spectrum

PRL 87, 071301 (2001)



PRL 86, 5651 (2001)



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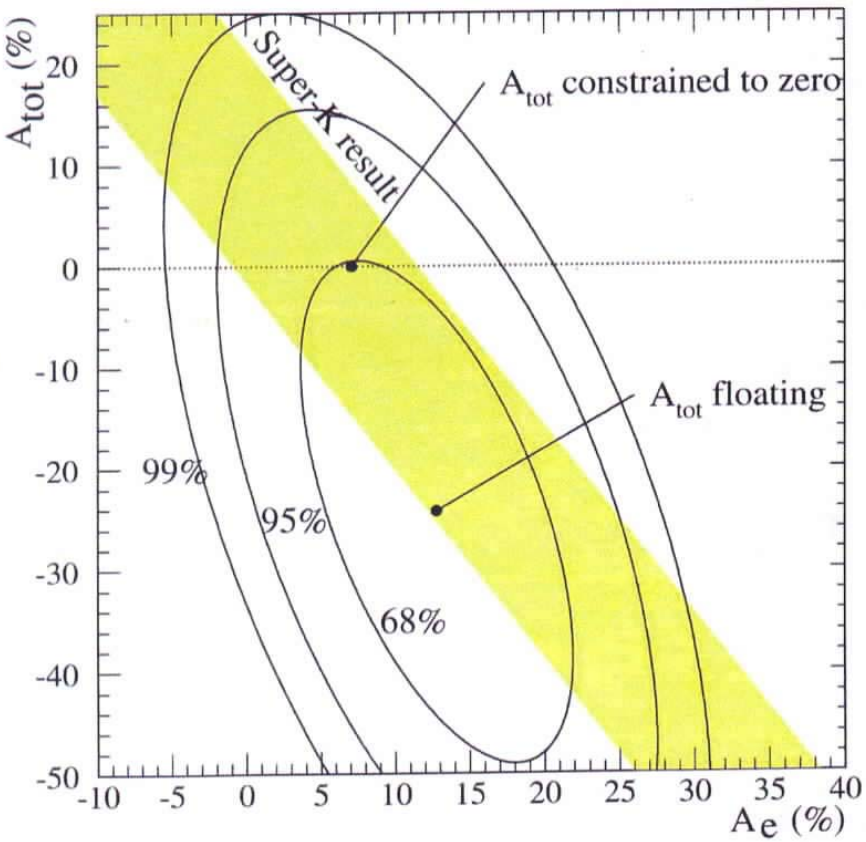
Day/Night Asymmetry

SNO Collaboration, Phys. Rev. Lett. 89, 011302 (2002)

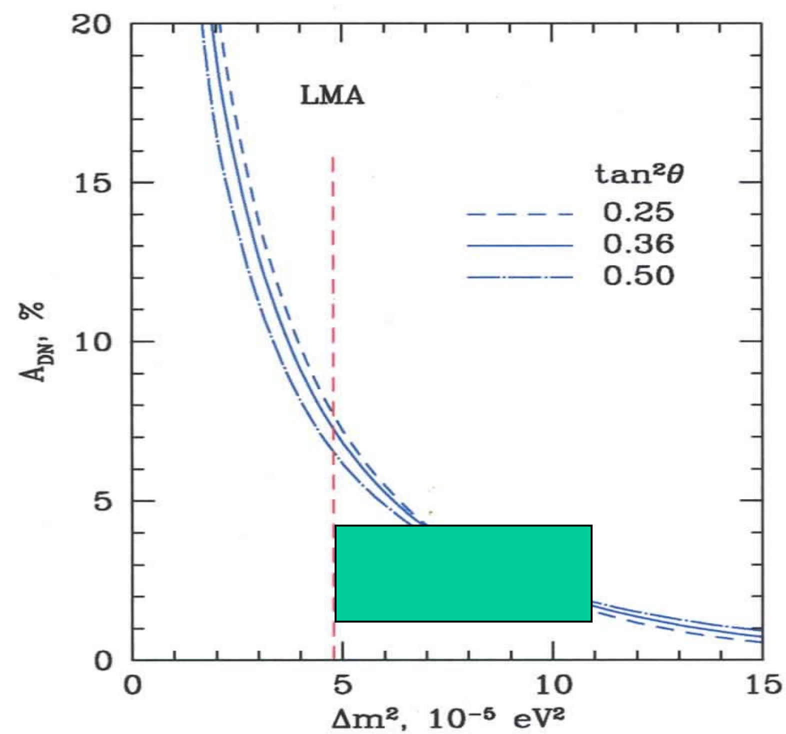


$A_e = 7.0 \pm 4.9^{+1.3}_{-1.2}$

$A_e^{sk} = 5.3 \pm 3.7^{+2.0}_{-1.7}$

$A_e = 12.8 \pm 6.2^{+1.5}_{-1.4}$

$A_{tot} = -24.2 \pm 16.1^{+2.4}_{-2.5}$



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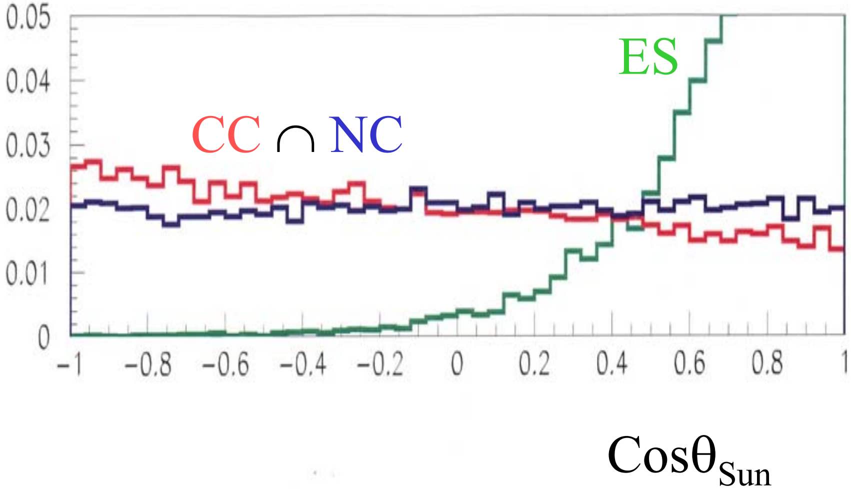
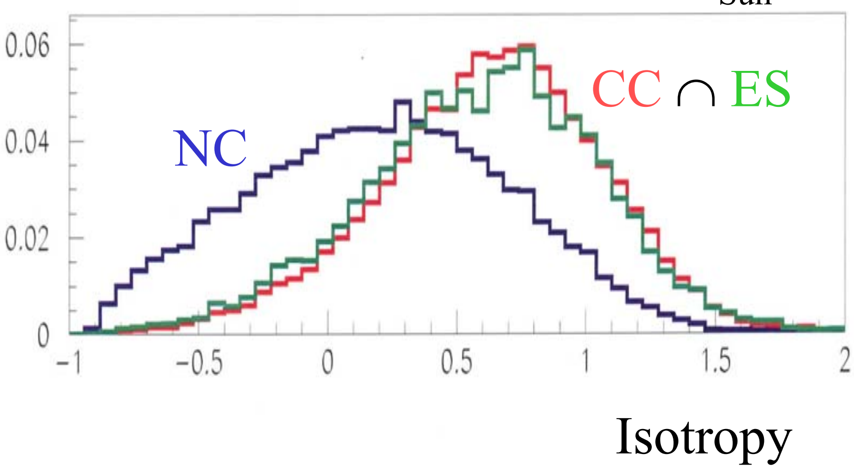
SNO with Dissolved Salt

SNO with Neutral Current Detectors (NCDs)

CC ∩ ES ∩ NC





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