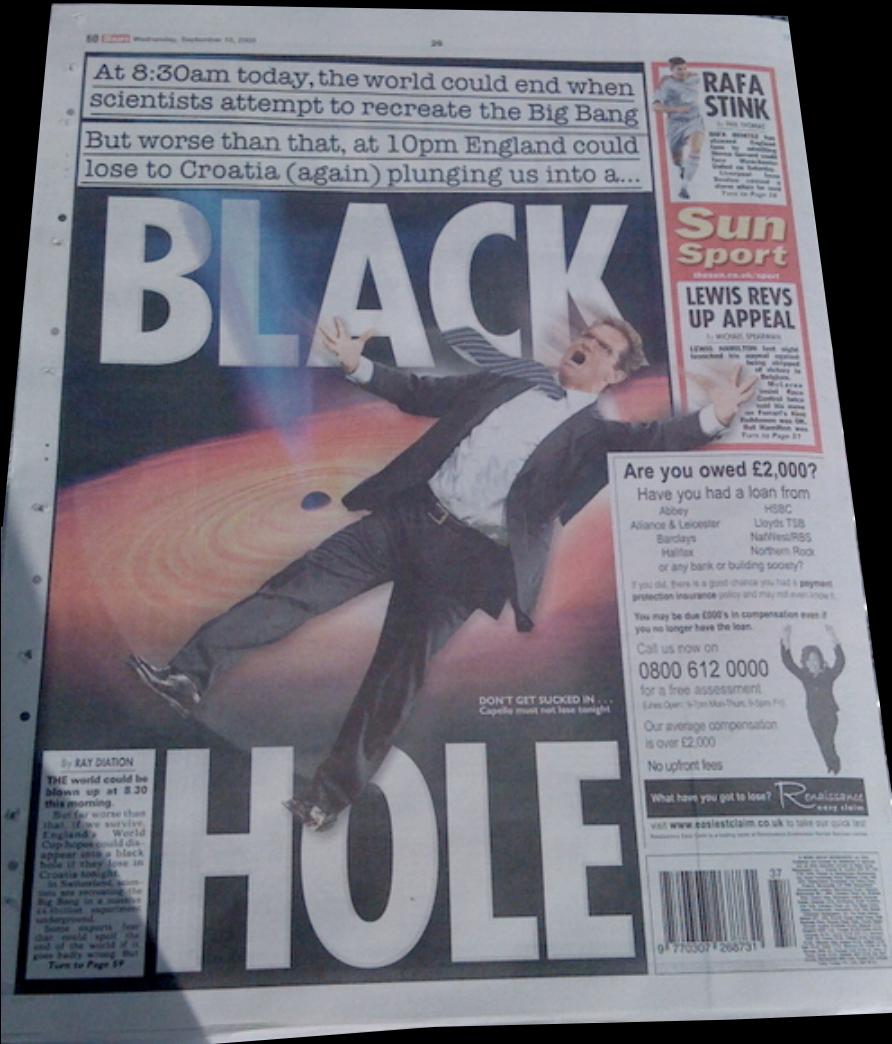




Still a
Popular
Source
of v's

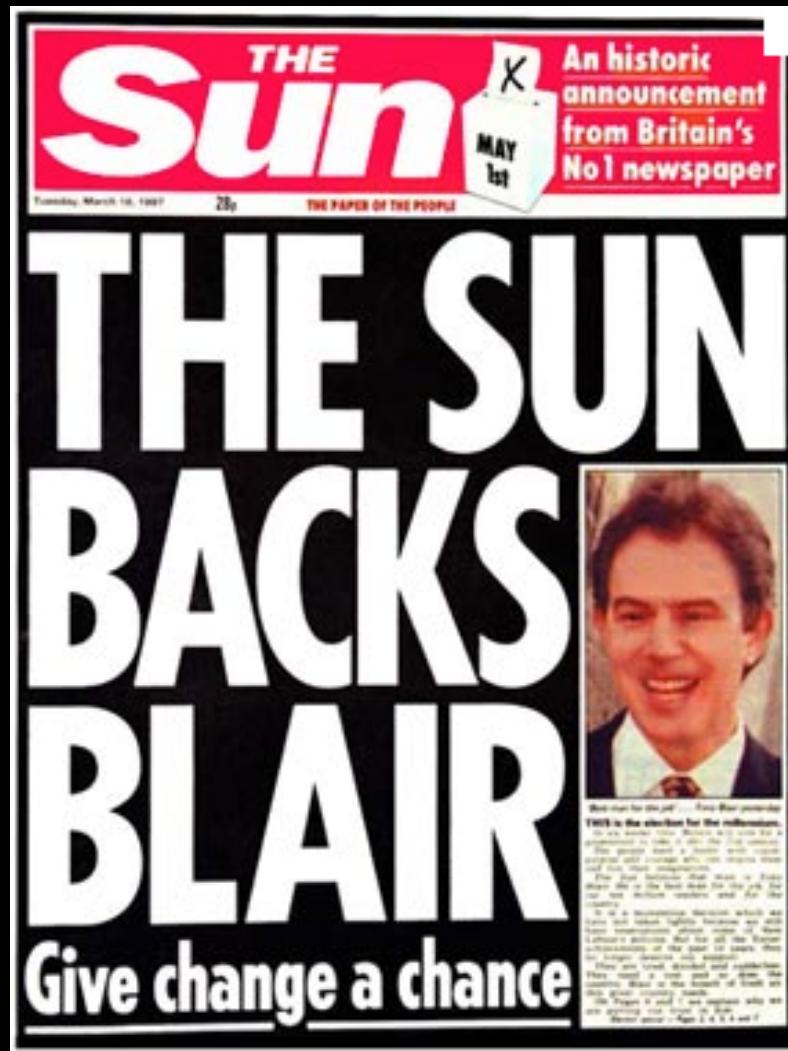
S. Biller
reporting for Oxford University

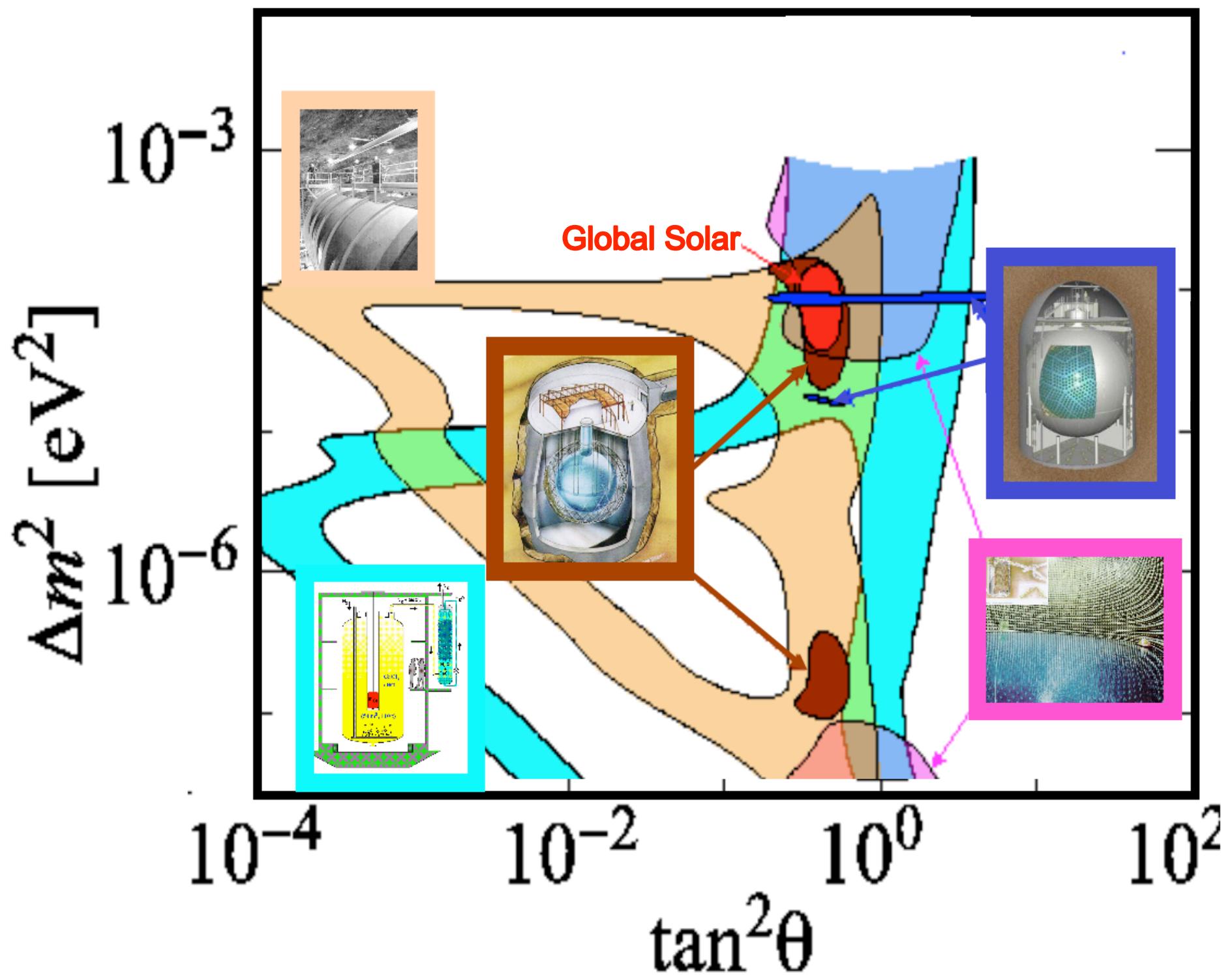
Back Page

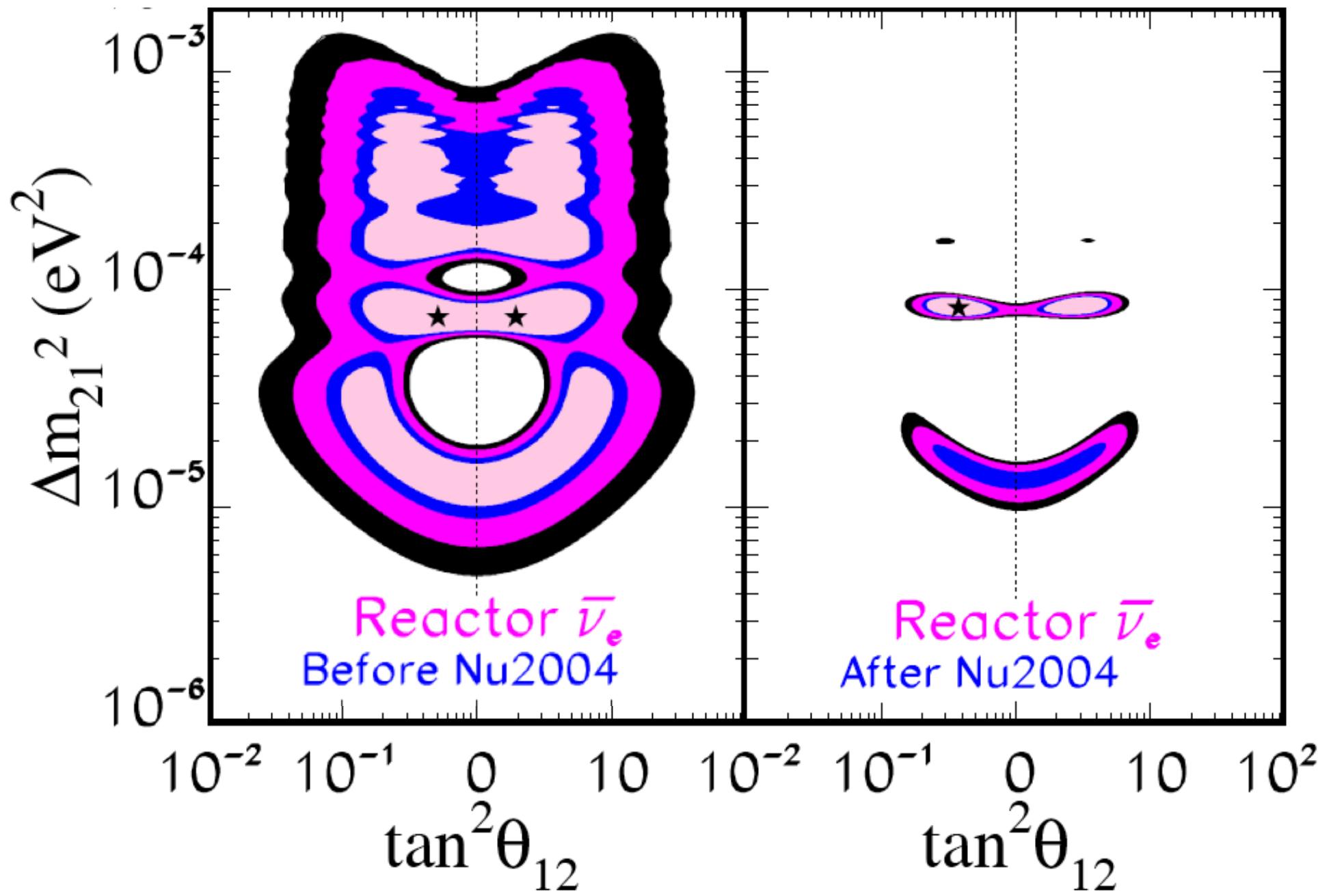


HELLAZ
HERON
LENA
LENS
MOON
etc.

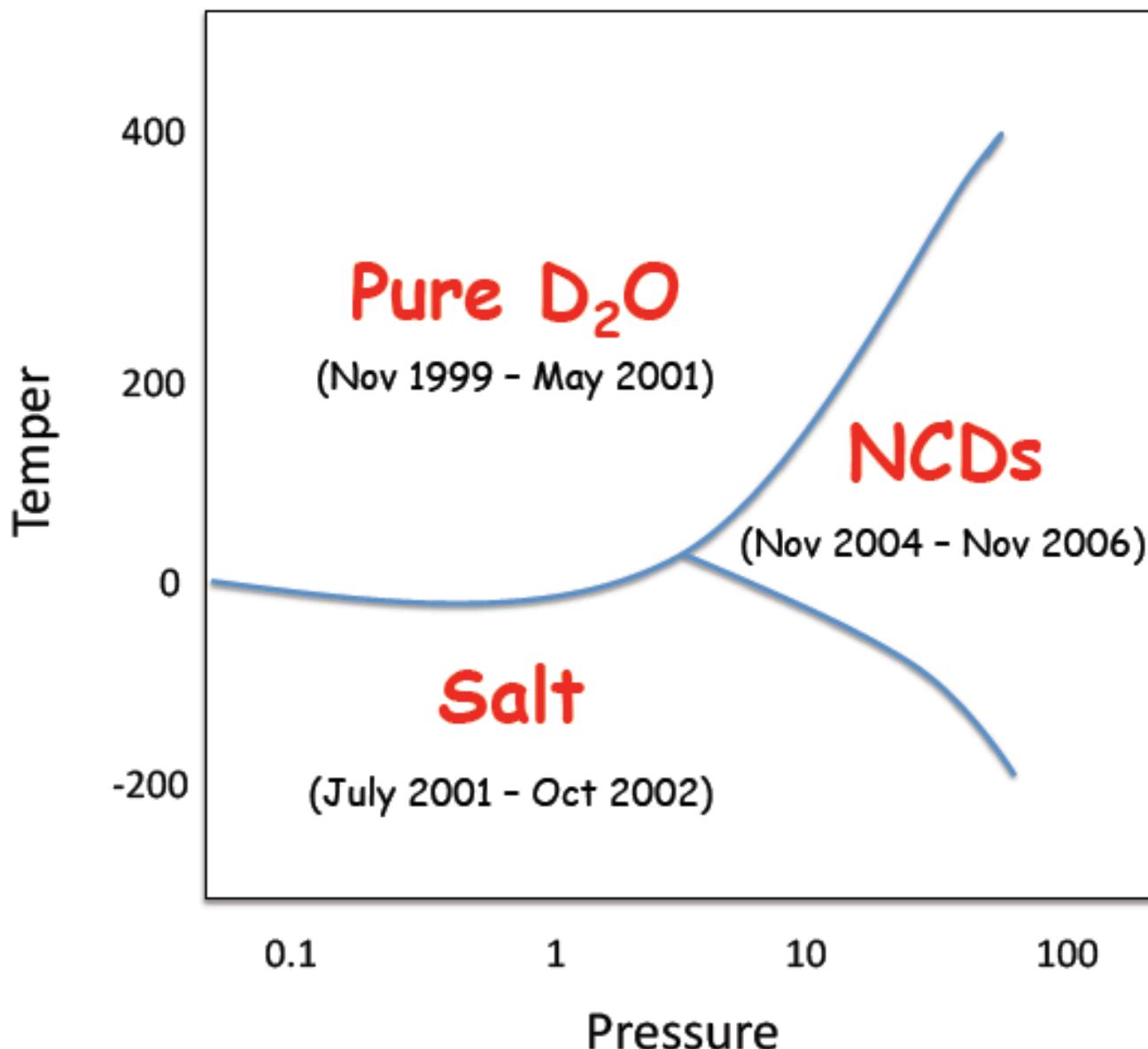
Old v's



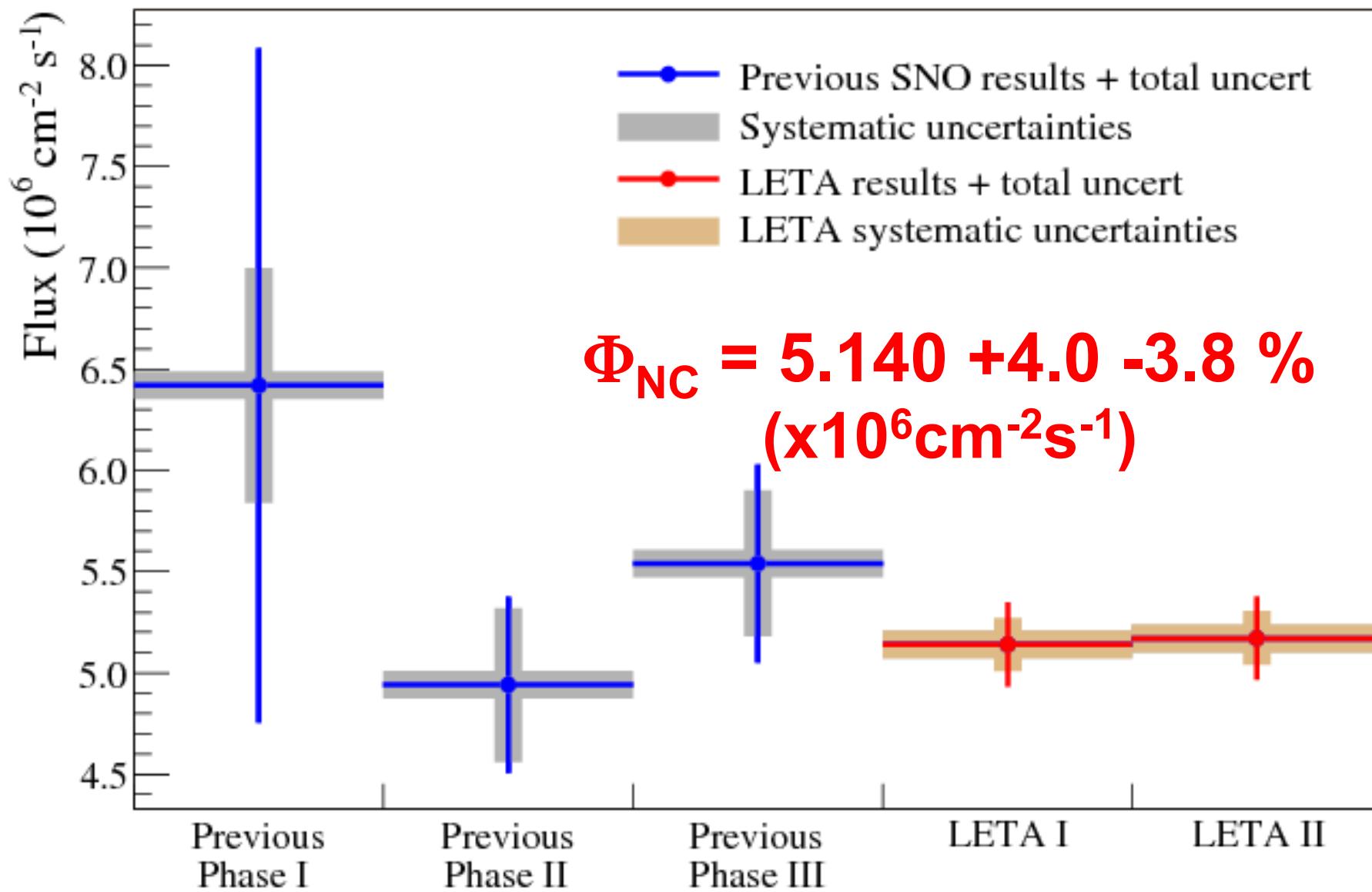




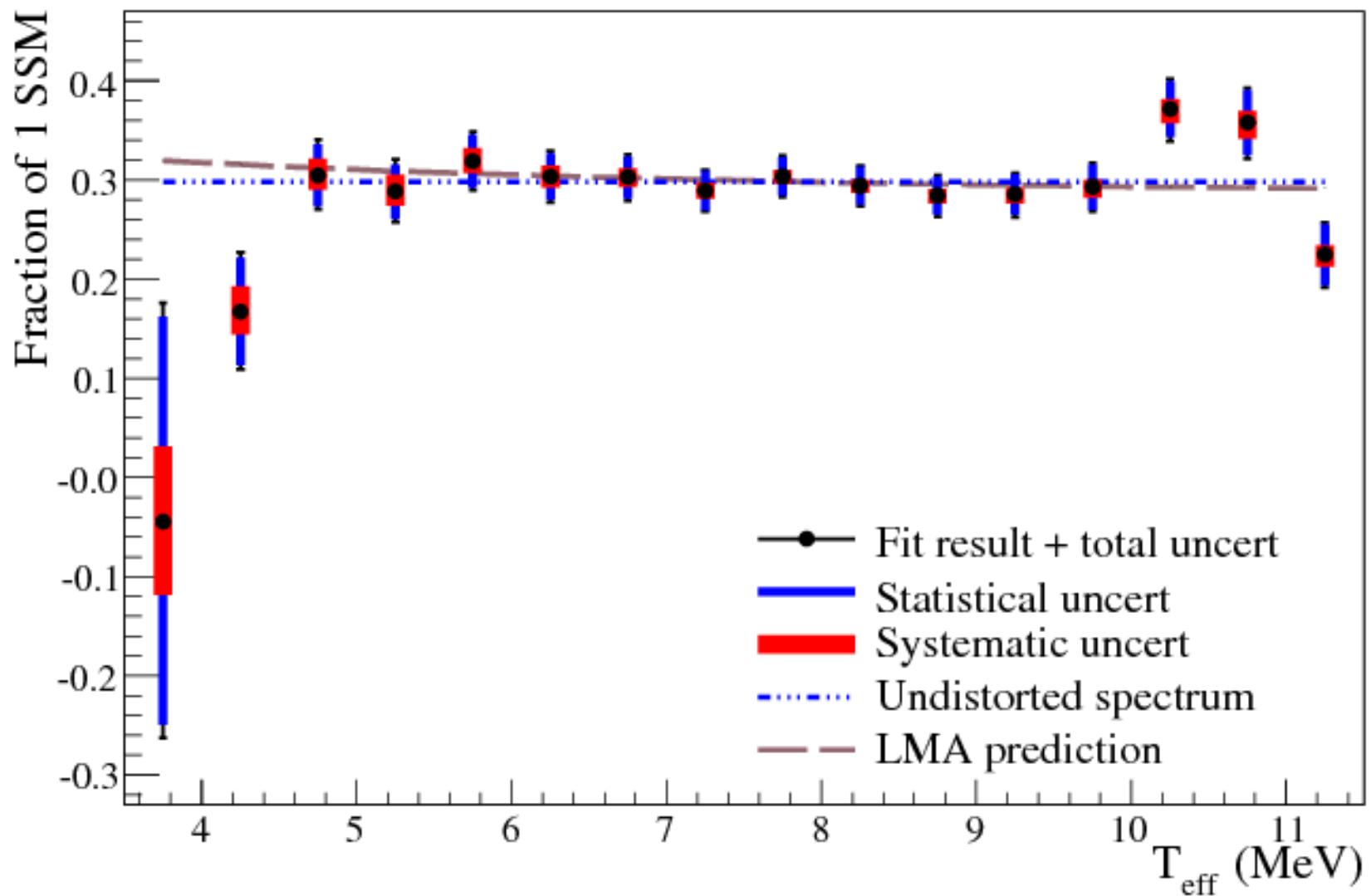
Phases of SNO:



${}^8\text{B}$ Flux Result

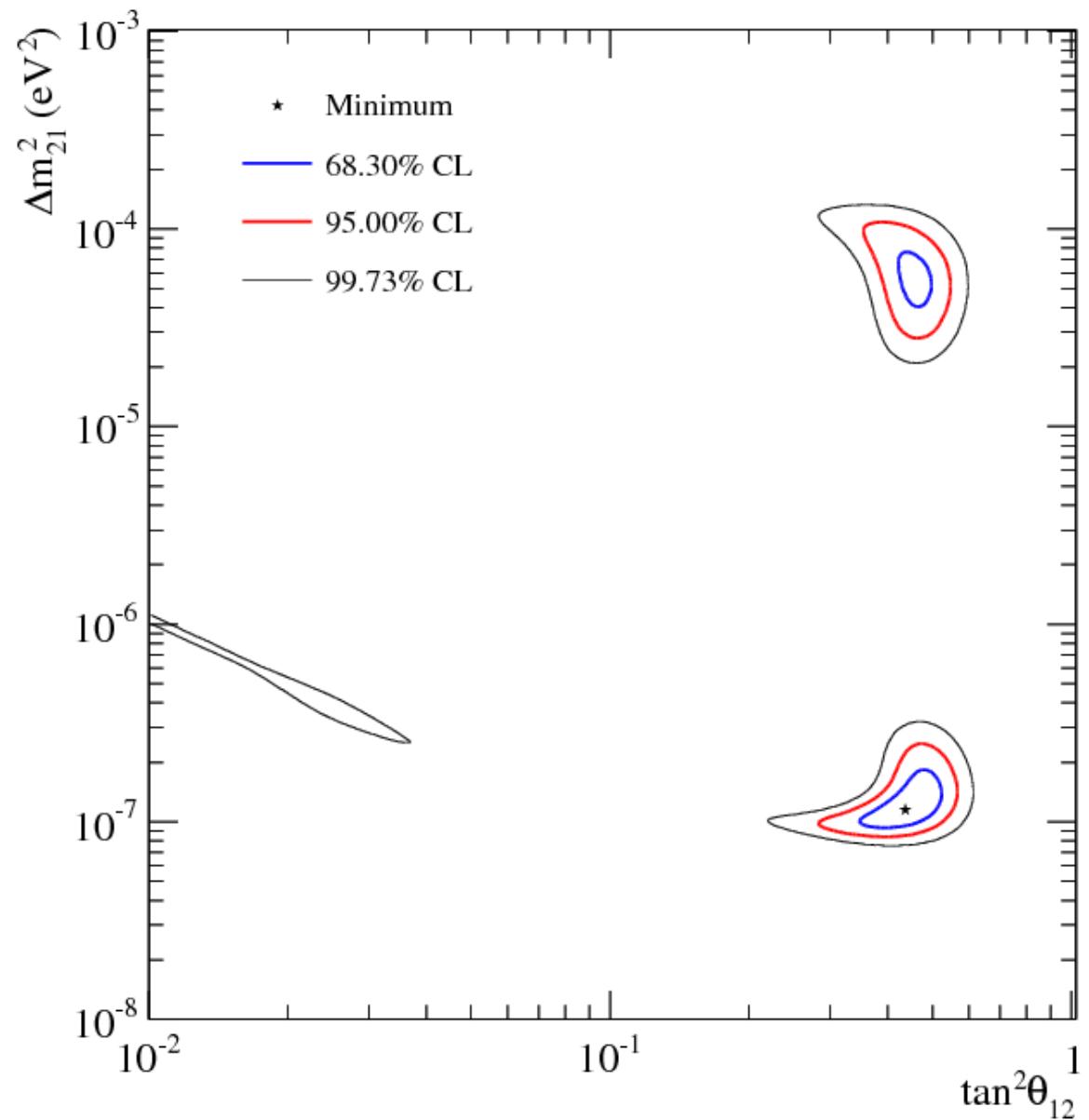


CC Recoil-Electron Spectrum



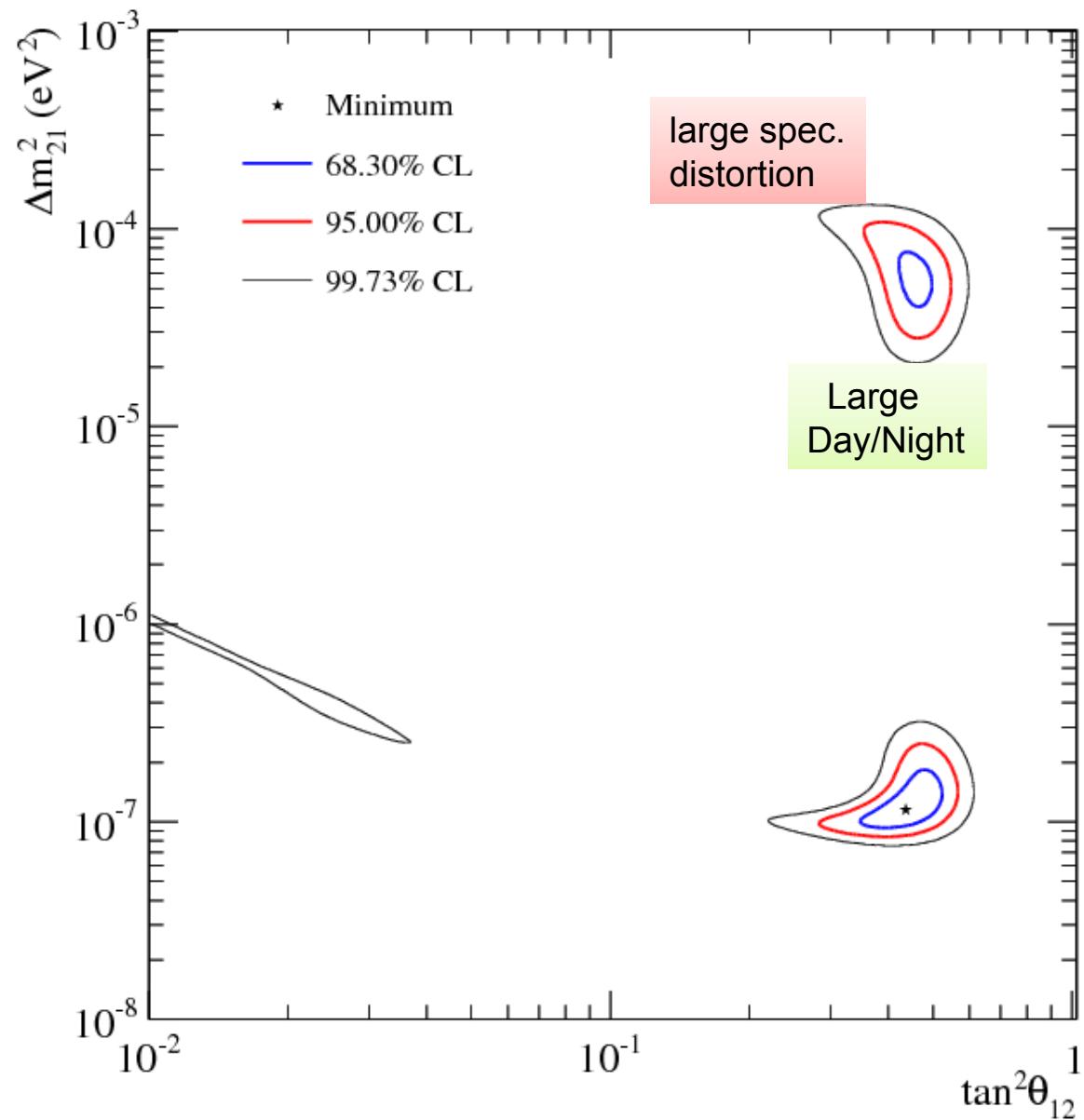
New Oscillation Analysis (LETA)

LETA paper 2010:
LETA joint-phase fit
+ Phase III



New Oscillation Analysis (LETA)

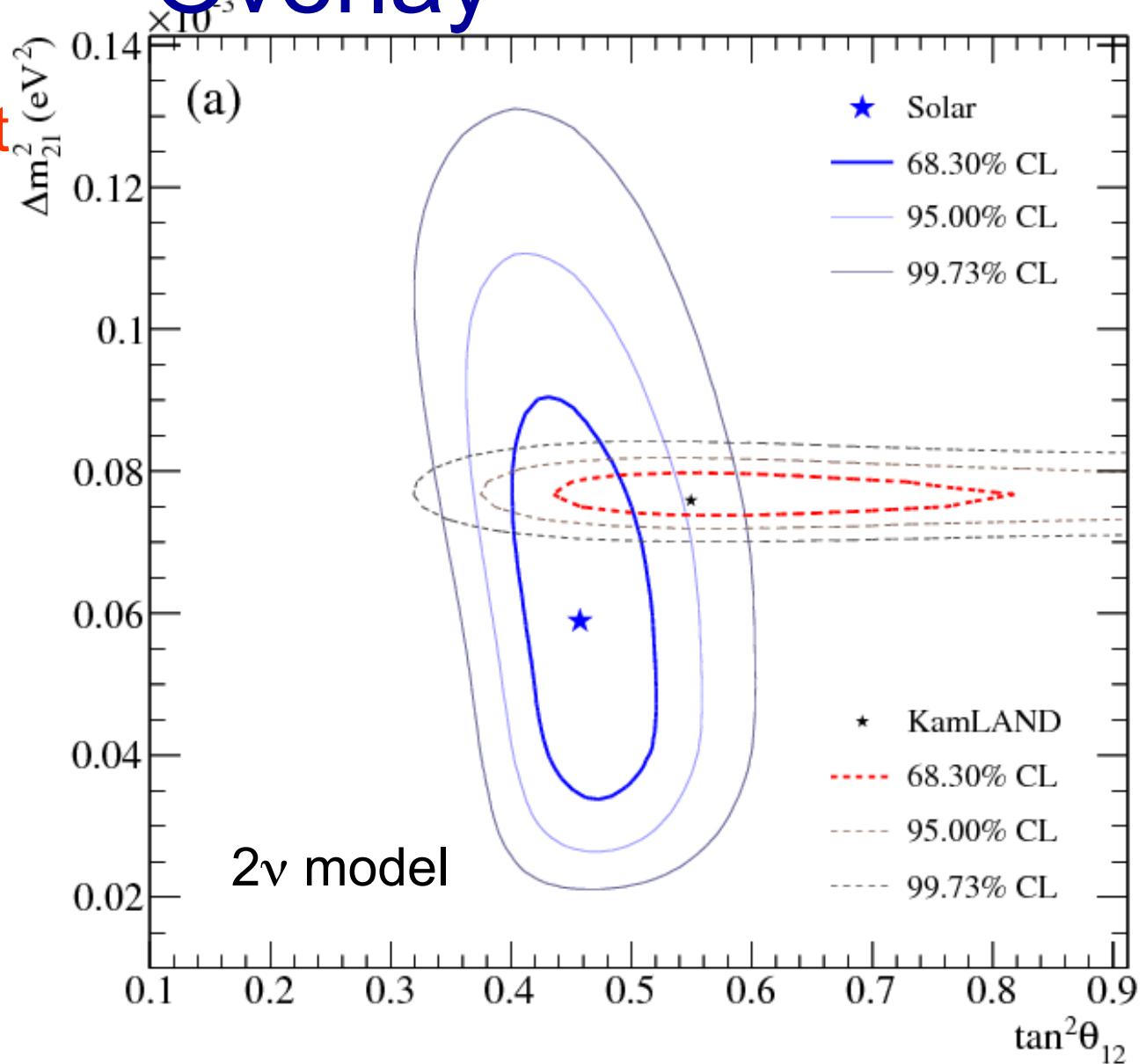
LETA paper 2010:
LETA joint-phase fit
+ Phase III



Solar + KamLAND 2-flavor Overlay

LETA paper 2010:
LETA joint-phase fit
+ Phase III
+ all solar expts
+ KamLAND

2-flavor overlay:



Solar + KamLAND 3-flavor Overlay

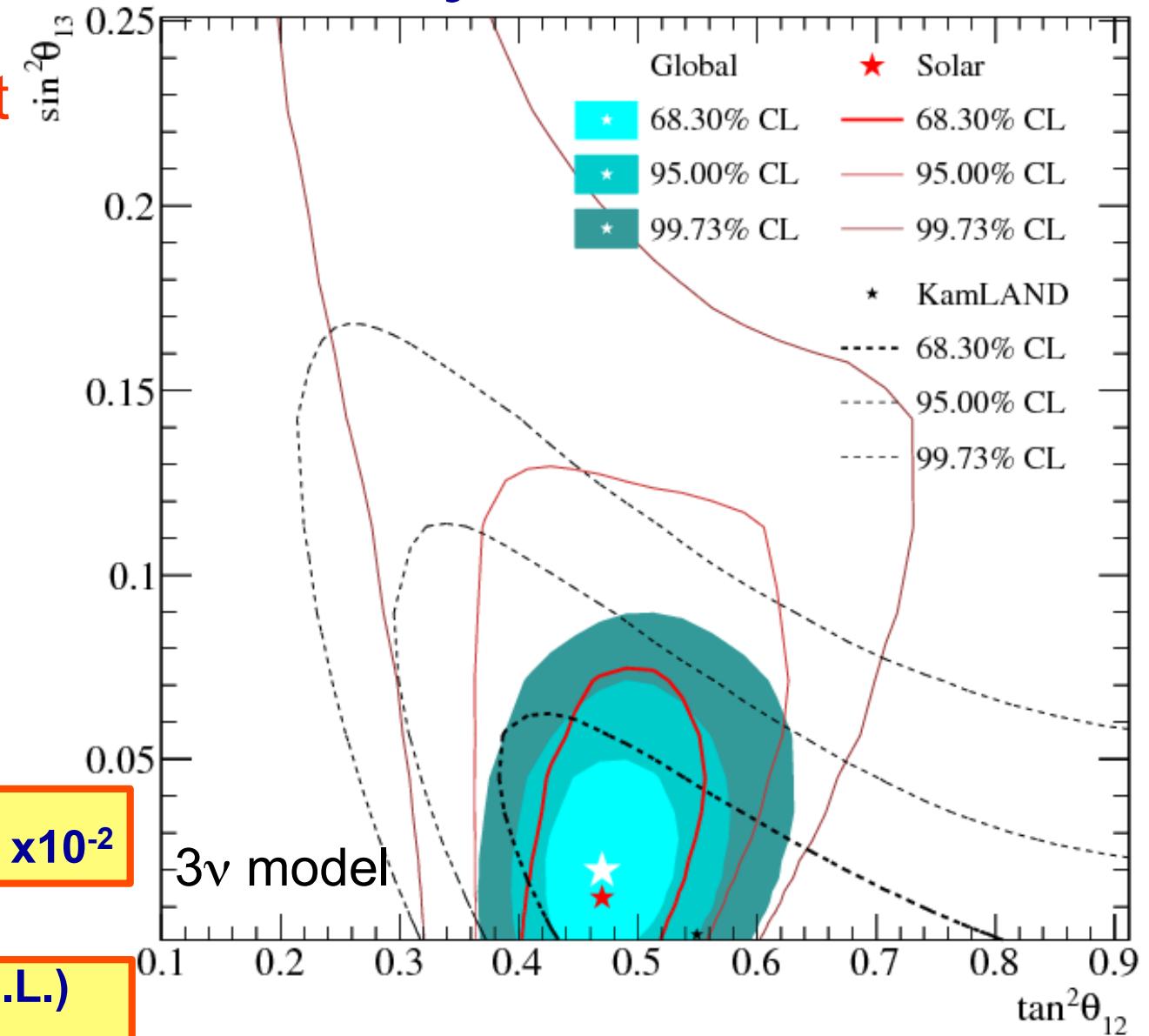
LETA paper 2010:
LETA joint-phase fit
+ Phase III
+ all solar expts
+ KamLAND

3-flavor analysis:

Best-fit:

$$\sin^2\theta_{13} = 2.00 + 2.09 - 1.63 \times 10^{-2}$$

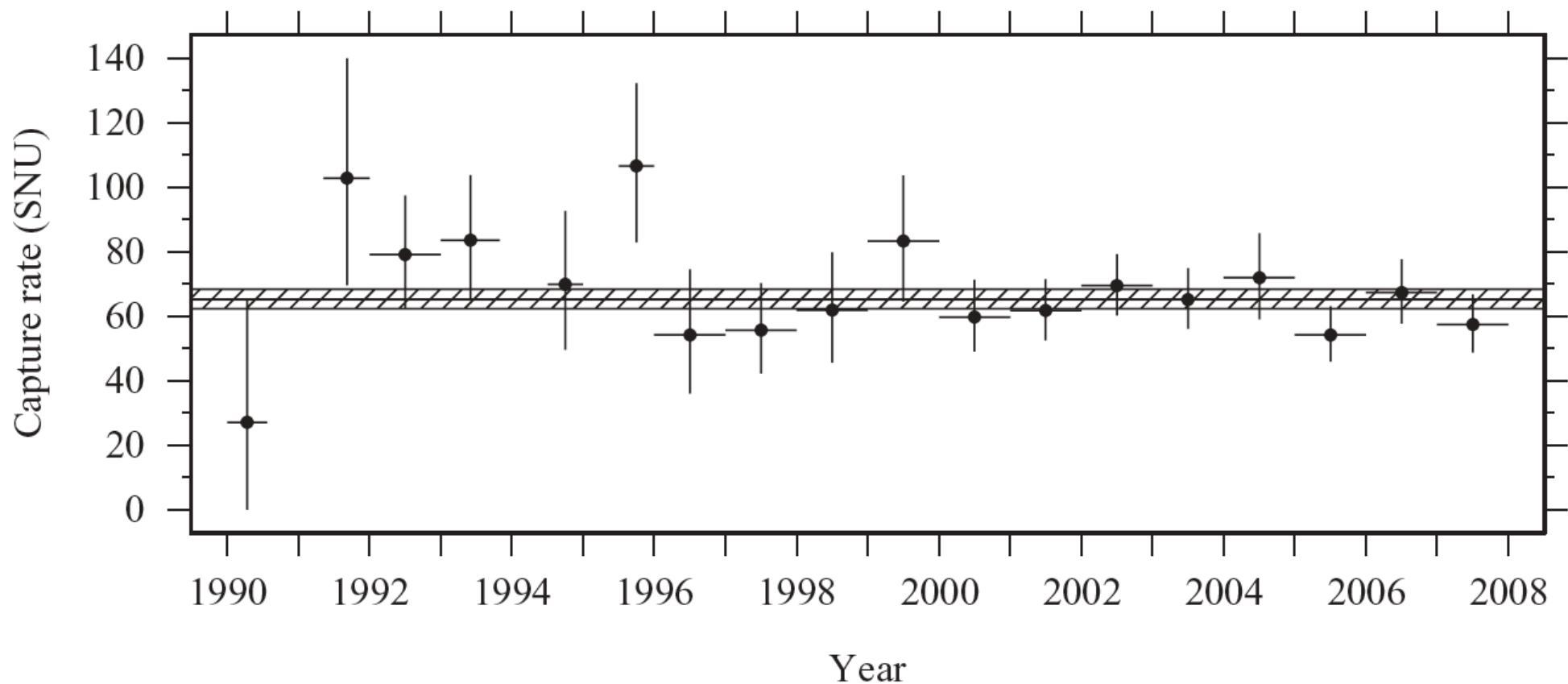
$$\Rightarrow \sin^2\theta_{13} < 0.057 \text{ (95% C.L.)}$$



SAGE

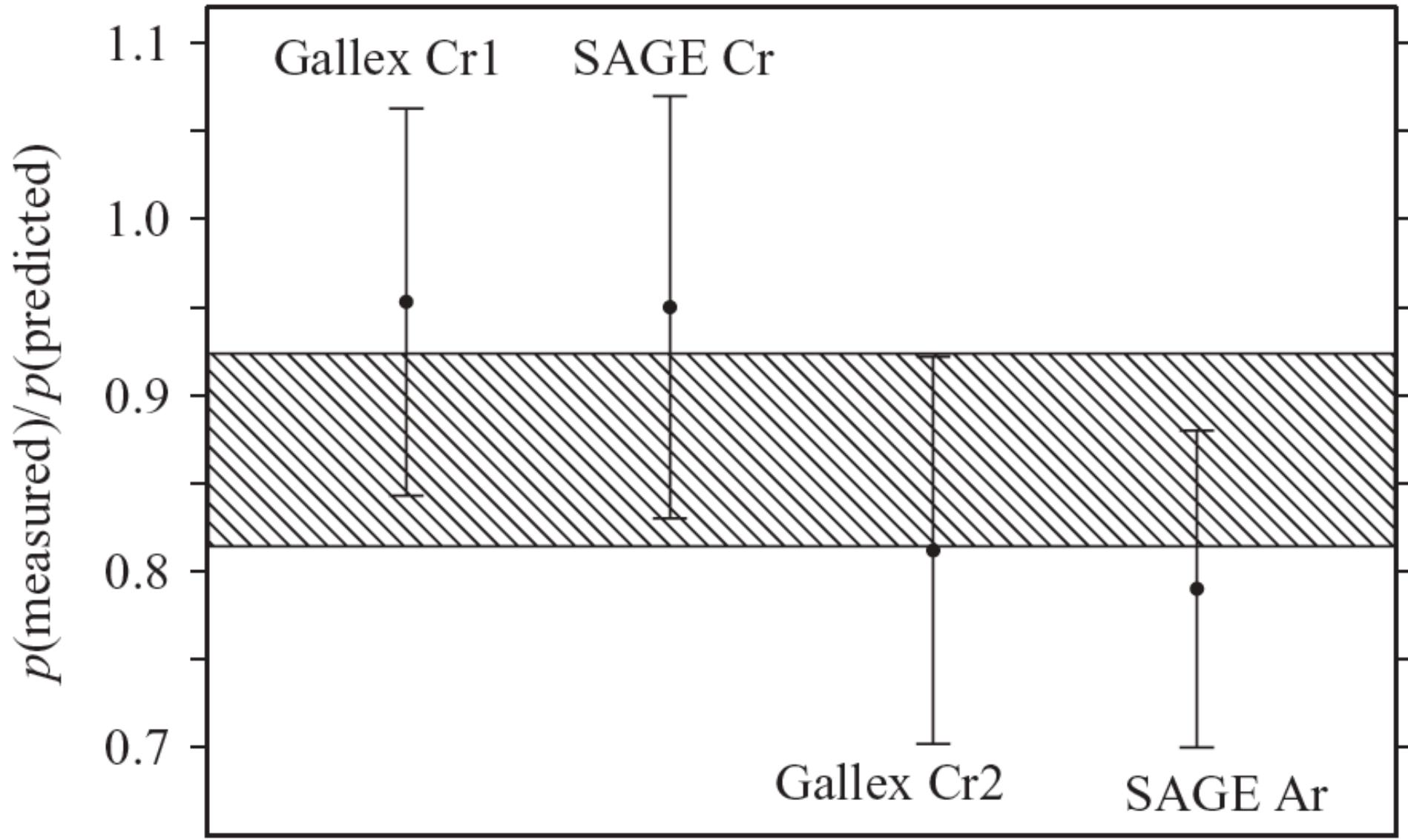
Russian-American Gallium Experiment





Spect. comp.	With GS98 composition						
	Cap. rate (SNU)	Percentage uncertainty in rate due to					Total unc. in rate (%)
		ϕ	σ	Δm_{12}^2	θ_{12}	θ_{13}	
<i>pp</i>	39.35	+0.6, -0.6	+2.4, -2.3	+0.0, -0.0	+2.2, -2.8	+2.0, -3.1	+3.9, -4.8
<i>pep</i>	1.43	+1.1, -1.1	+17.0, -2.4	+0.3, -0.3	+1.9, -2.3	+1.9, -2.9	+17.2, -4.6
^7Be	18.73	+6.0, -6.0	+7.0, -2.3	+0.1, -0.1	+2.1, -2.6	+2.0, -3.0	+9.7, -7.5
^{13}N	0.89	+15.0, -15.0	+9.8, -2.3	+0.1, -0.1	+2.1, -2.6	+2.0, -3.0	+18.1, -15.7
^{15}O	1.23	+17.0, -16.0	+12.9, -2.3	+0.2, -0.2	+2.0, -2.4	+1.9, -3.0	+21.5, -16.6
^{17}F	0.03	+19.0, -17.0	+12.9, -2.3	+0.2, -0.2	+2.0, -2.4	+1.9, -3.0	+23.1, -17.6
^8B	4.64	+11.0, -11.0	+31.8, -14.4	+0.5, -0.4	+5.4, -3.9	+1.8, -2.8	+34.1, -18.7
<i>hep</i>	0.02	+15.0, -15.0	+32.7, -15.4	+0.3, -0.3	+6.2, -4.5	+1.9, -2.9	+36.5, -22.2
Total	66.31	+1.9, -1.9	+3.3, -1.8	+0.1, -0.1	+1.5, -1.8	+1.3, -2.0	+4.3, -3.8

Spect. comp.	With AGS05 composition						
	Cap. rate (SNU)	Percentage uncertainty in rate due to					Total unc. in rate (%)
		ϕ	σ	Δm_{12}^2	θ_{12}	θ_{13}	
<i>pp</i>	39.81	+0.5, -0.5	+2.4, -2.3	+0.0, -0.0	+2.2, -2.8	+2.0, -3.1	+3.9, -4.8
<i>pep</i>	1.47	+1.0, -1.0	+17.0, -2.4	+0.3, -0.3	+1.9, -2.3	+1.9, -2.9	+17.2, -4.5
^7Be	16.81	+6.0, -6.0	+7.0, -2.3	+0.1, -0.1	+2.1, -2.6	+2.0, -3.0	+9.7, -7.5
^{13}N	0.58	+14.0, -13.0	+9.8, -2.3	+0.1, -0.1	+2.1, -2.6	+2.0, -3.0	+17.3, -13.8
^{15}O	0.77	+16.0, -15.0	+12.9, -2.3	+0.2, -0.2	+2.0, -2.4	+1.9, -3.0	+20.7, -15.6
^{17}F	0.02	+16.0, -15.0	+12.9, -2.3	+0.2, -0.2	+2.0, -2.4	+1.9, -3.0	+20.8, -15.6
^8B	3.68	+11.0, -11.0	+31.8, -14.4	+0.5, -0.4	+5.4, -3.9	+1.8, -2.8	+34.1, -18.7
<i>hep</i>	0.02	+15.0, -15.0	+32.7, -15.4	+0.3, -0.3	+6.2, -4.5	+1.9, -2.9	+36.5, -22.2
Total	63.16	+1.8, -1.8	+3.1, -1.8	+0.1, -0.0	+1.5, -1.9	+1.4, -2.1	+4.1, -3.8



Current V's

THE Sun Wednesday, 13 April 2011

B&Q MacAllister 165mm Laser Circular Saw ... £59.98 Shop now

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PAGE 3
Girls A-Z
Lodge

Kate Middleton has her wedding ring 'shrunk'

By RICHARD WHITE and DUNCAN LARCOMBE, Royal Editor
Published: Today

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SUPER-slim Kate Middleton is having her famous engagement ring shrunk to fit her finger.

The bride-to-be has asked Royal jewellers to fit two beads inside the £32million sapphire band - once worn by Princess Di - to stop it slipping.

Kate, 29, displayed the ring on slender hands on Monday during her last official outing before she weds Prince William.

Willowy Kate is having the ring made smaller because she is terrified it will fall off as she marries William.

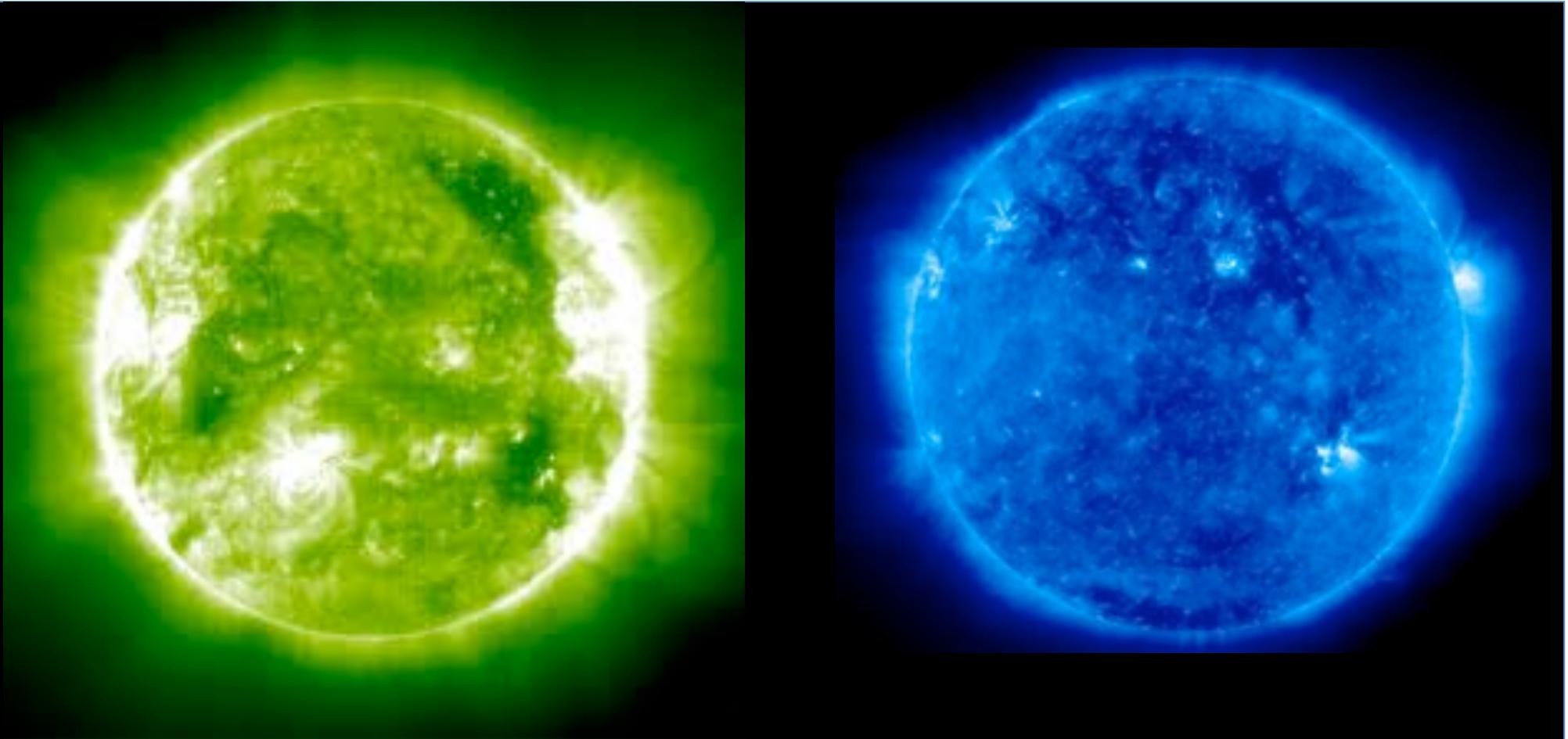
Kate, who seems to be slimming for her big day, has reluctantly accepted the dazzling sapphire and diamond band is too big for her size H finger.



Width this ring ... Kate Middleton is worried band will slip off

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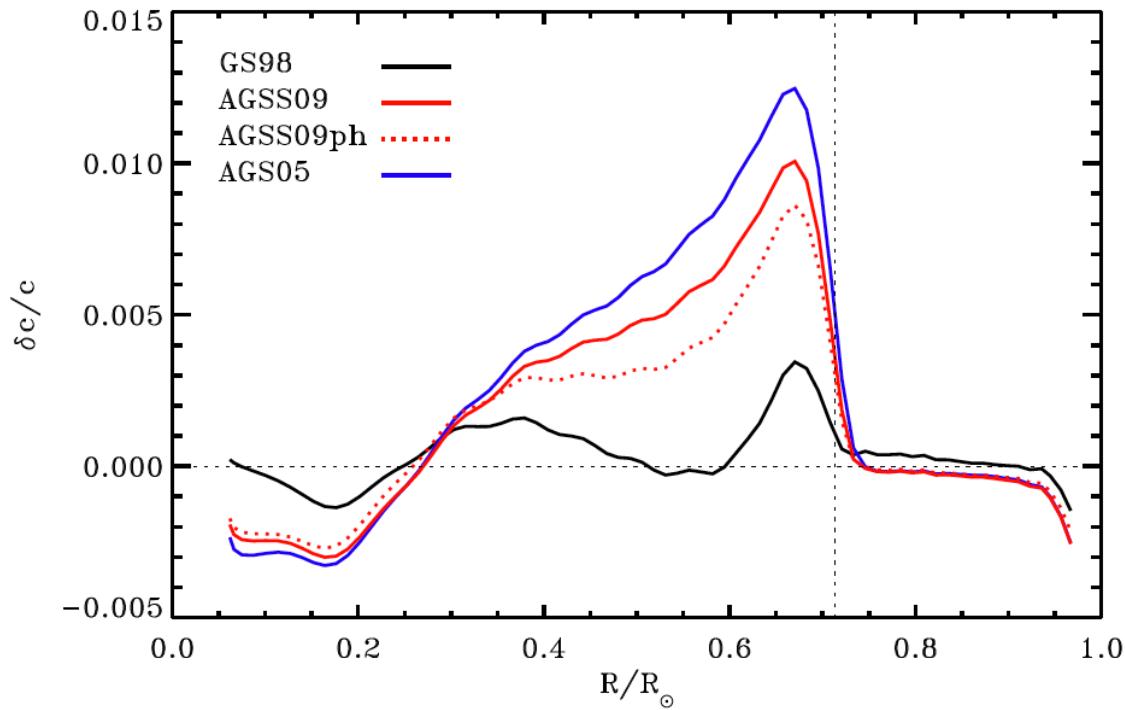




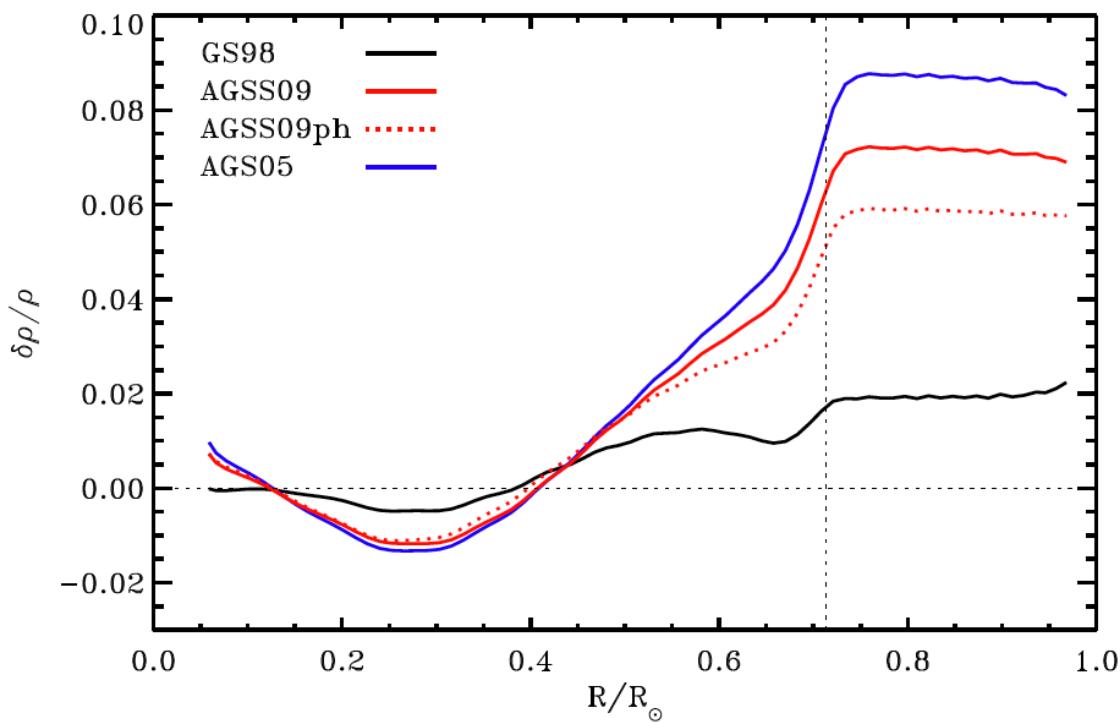
Improved solar spectral measurements and more detailed modeling yields an improved determination of solar photospheric composition that is ~25% lower in metallicity than values inferred over a decade ago

(Asplund *et al.*, 2005 & 2009)

Model - Data



Model - Data

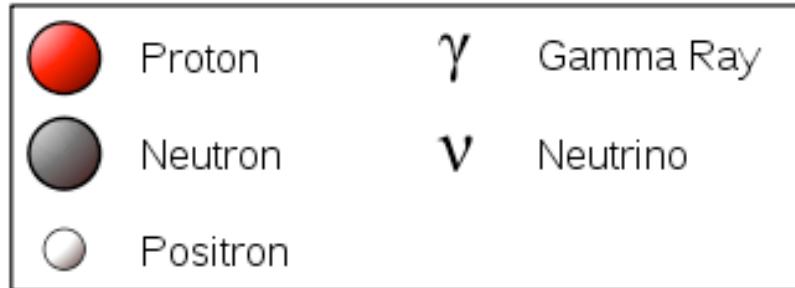
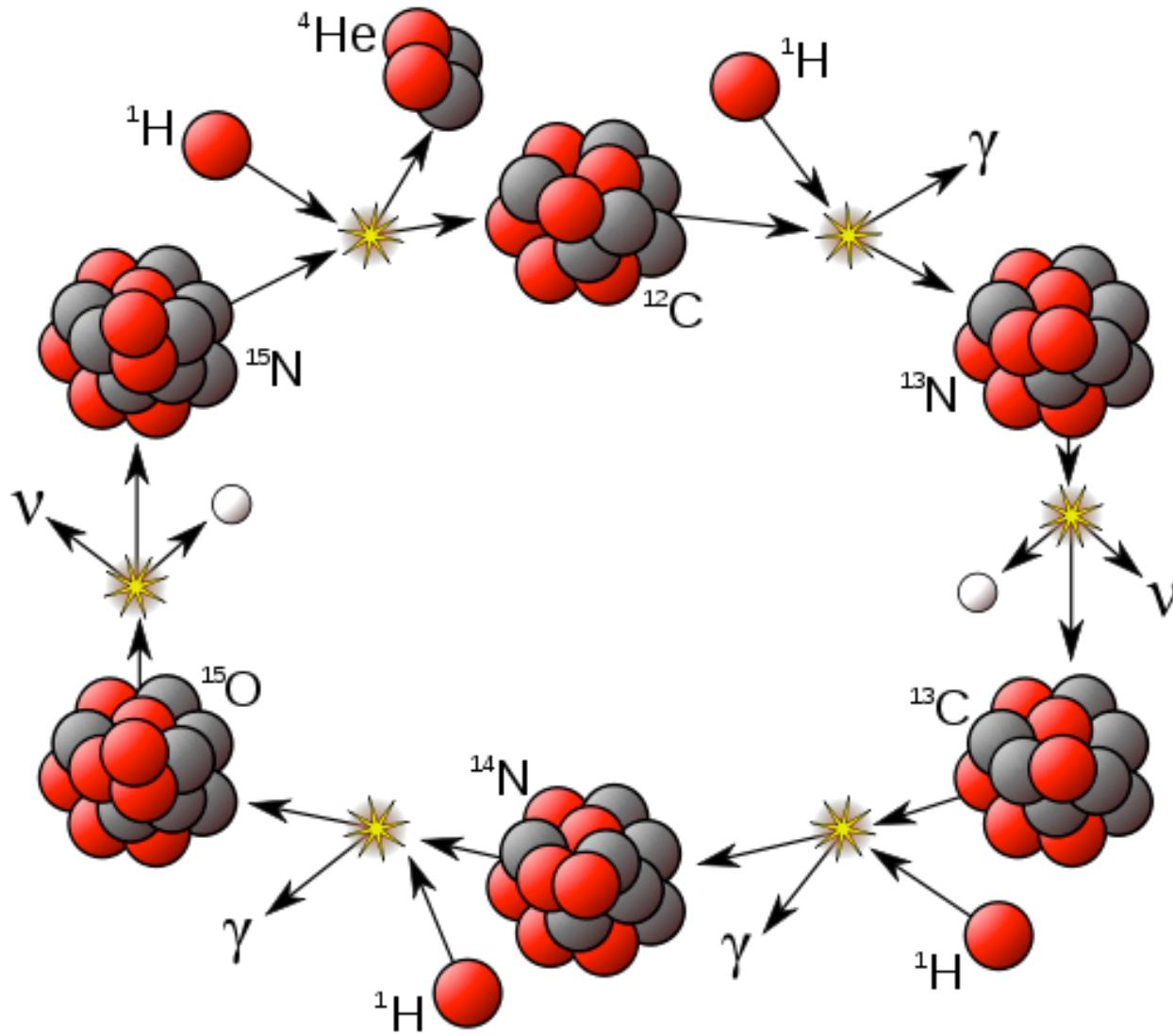


Contradiction with
Helioseismology !

Serenelli *et al.*, 2009

TABLE I: Predicted solar neutrino fluxes from solar models. The table presents the predicted fluxes, in units of $10^{10}(pp)$, $10^9(^7\text{Be})$, $10^8(pep, ^{13}\text{N}, ^{15}\text{O})$, $10^6(^8\text{B}, ^{17}\text{F})$, and $10^3(hep) \text{ cm}^{-2}\text{s}^{-1}$. Columns 2 and 3 show BPS08 for high and low metallicities; and column 4 the flux differences between the models.

Source	BPS08(GS)	BPS08(AGS)	Difference
<i>pp</i>	$5.97(1 \pm 0.006)$	$6.04(1 \pm 0.005)$	1.2%
<i>pep</i>	$1.41(1 \pm 0.011)$	$1.45(1 \pm 0.010)$	2.8%
<i>hep</i>	$7.90(1 \pm 0.15)$	$8.22(1 \pm 0.15)$	4.1%
${}^7\text{Be}$	$5.07(1 \pm 0.06)$	$4.55(1 \pm 0.06)$	10%
${}^8\text{B}$	$5.94((1 \pm 0.11)$	$4.72(1 \pm 0.11)$	21%
${}^{13}\text{N}$	$2.88(1 \pm 0.15)$	$1.89(1 \begin{array}{l} +0.14 \\ -0.13 \end{array})$	34%
${}^{15}\text{O}$	$2.15(1 \begin{array}{l} +0.17 \\ -0.16 \end{array})$	$1.34(1 \begin{array}{l} +0.16 \\ -0.15 \end{array})$	31%
${}^{17}\text{F}$	$5.82(1 \begin{array}{l} +0.19 \\ -0.17 \end{array})$	$3.25(1 \begin{array}{l} +0.16 \\ -0.15 \end{array})$	44%



Linger ing Issues

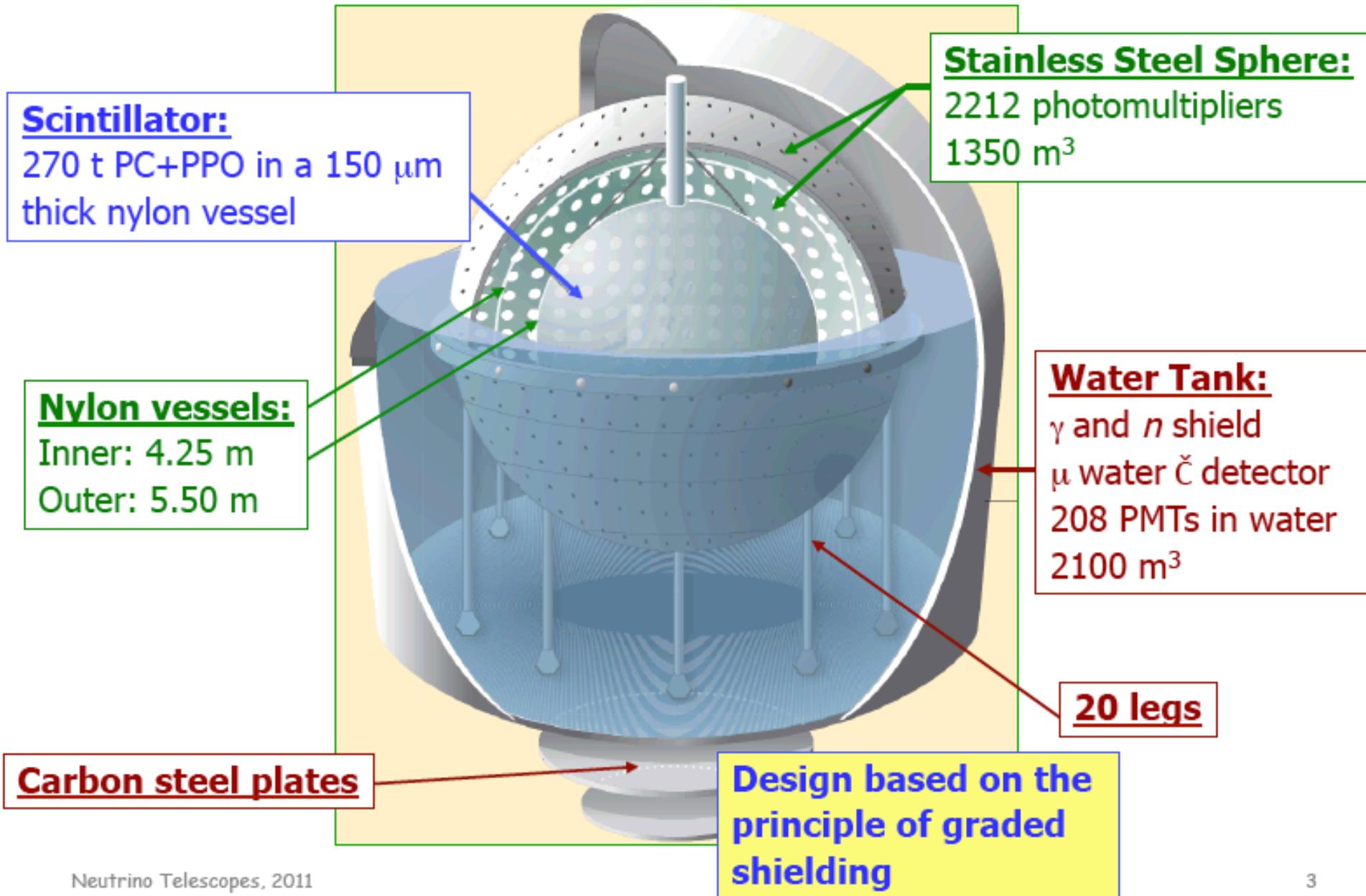
1. Solar Composition Problem

genuine mystery in need of resolution !

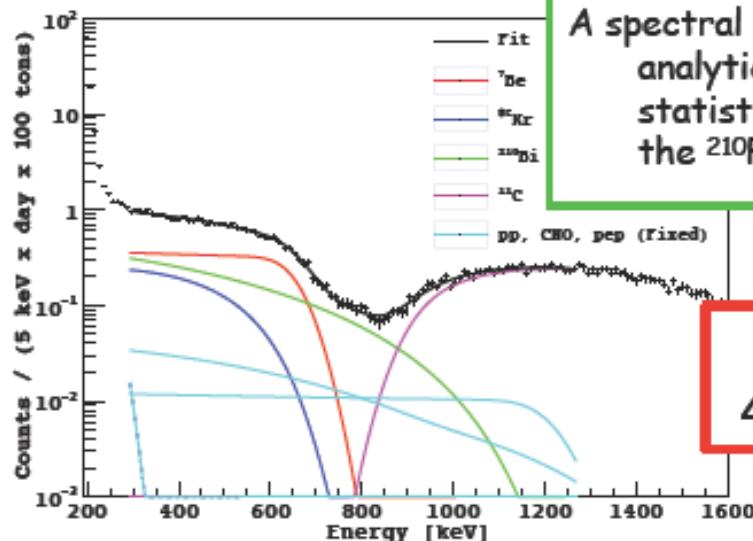
also want better understanding of CNO cycle

Detector design and layout

Borexino detector at LNGS



New result on ${}^7\text{Be}$ rate (preliminary)

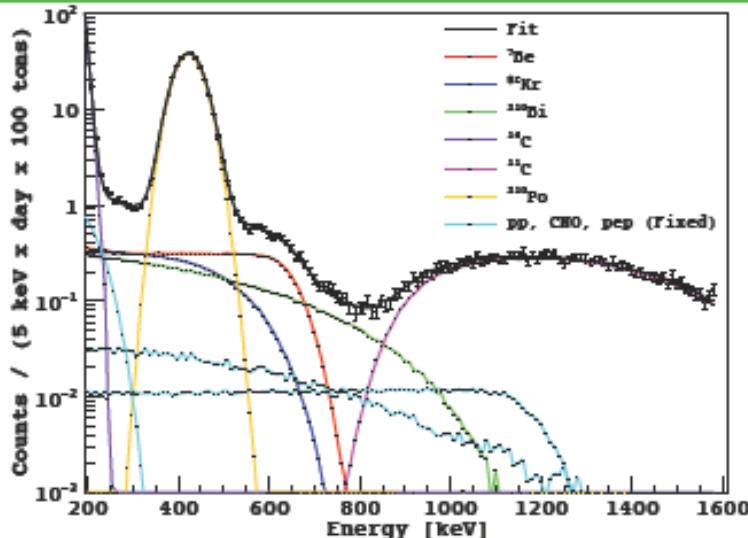


A spectral fit based on an analytical model with statistical subtraction of the ${}^{210}\text{Po}$ alpha component

~750 days of data

${}^7\text{Be}$ rate ($E=862$ keV line)
 46.0 ± 1.5 (stat) ± 1.3 (sys) counts/(day x 100t)

A spectral fit based on MonteCarlo



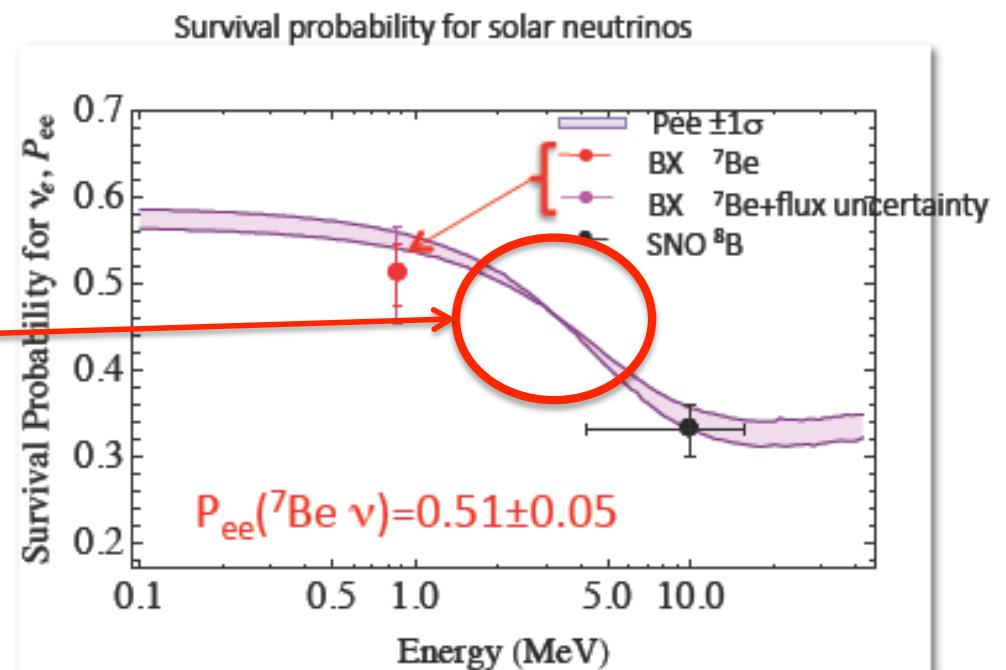
Source	Syst, error 1σ
Tot. Scint. mass	± 0.3 %
Live time	± 0.1 %
Fraction of good events removed by cuts	± 0.6 %
Energy scale	± 1.3 %
Fiducial mass	± 1.3 %
Fit method (α/β subtraction)	± 1.0 %
Fit assumption	± 1.7 %
Total syst. error	± 2.73 % ¹¹

Hypothesis	Expected rate (cpd/100t)
No oscillation + High Metallicity	74±4
No oscillation + Low Metallicity	67±4
Oscillation MSW + High Metallicity	48±4
Oscillation MSW + Low Metallicity	44±4

BX measurement confirms oscillations but cannot discriminate between High and Low metallicity

$46.0 \pm 1.5 \text{ (stat)} \pm 1.3 \text{ (sys)}$

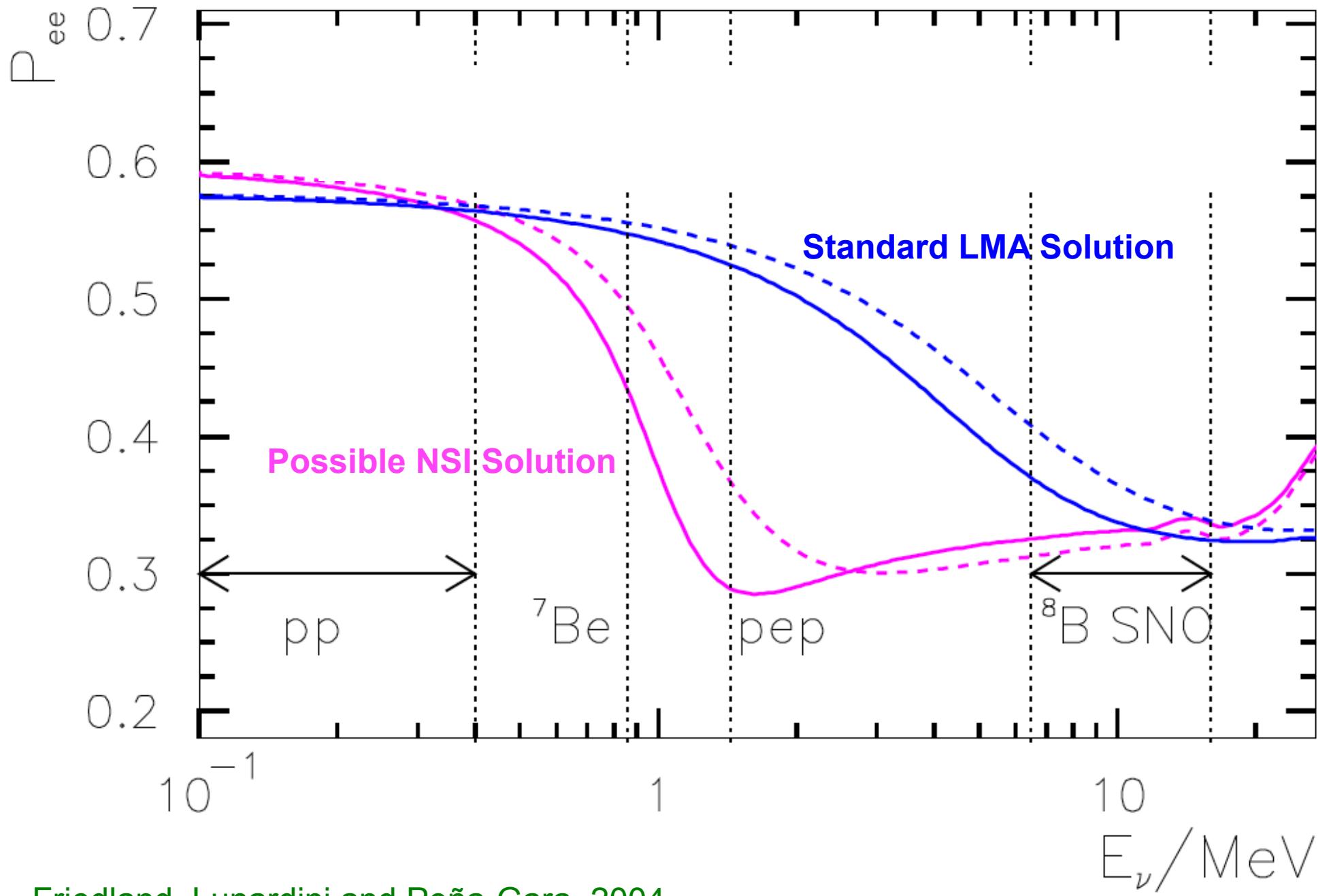
What happens here?

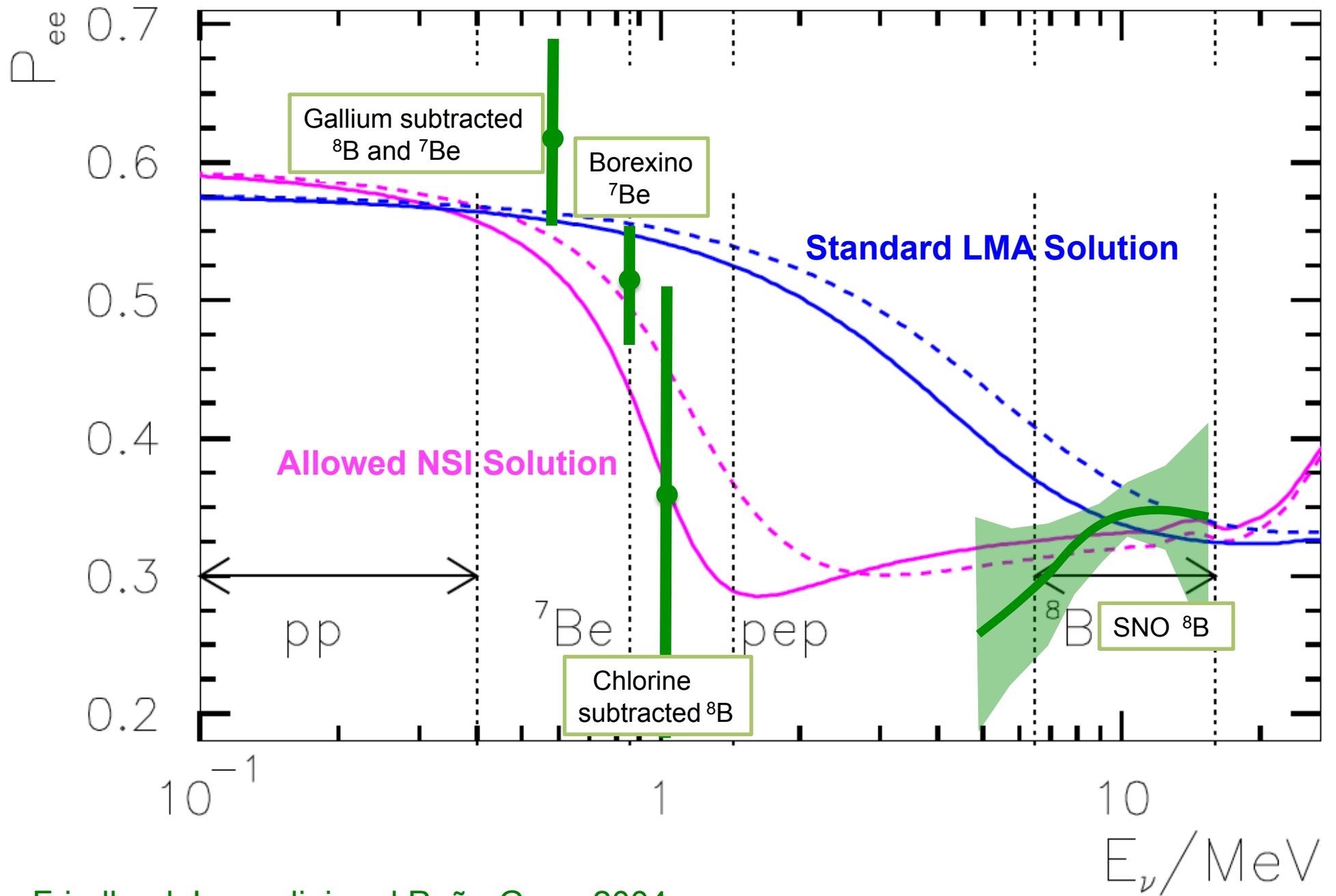


Observing change in ν_e survival probability over the transition region probes the nature of the neutrino-matter interaction

Possible New Physics Includes:

- Sterile neutrino admixtures
- Neutrino Decay
- Mass Varying Neutrinos
- Non-Standard Interactions





Friedland, Lunardini and Peña-Gara, 2004

Lingering Issues

1. Solar Composition Problem

genuine mystery in need of resolution !

also want better understanding of CNO cycle

2. Nature of MSW Transition

critical probe of neutrino/matter interactions

numerous alternative models tested

current data looks intriguing



$$\begin{bmatrix} |U_{e1}|^2 & |U_{e2}|^2 & |U_{e3}|^2 \\ |U_{\mu 1}|^2 & |U_{\mu 2}|^2 & |U_{\mu 3}|^2 \\ |U_{\tau 1}|^2 & |U_{\tau 2}|^2 & |U_{\tau 3}|^2 \end{bmatrix} = \begin{bmatrix} \frac{2}{3} & \frac{1}{3} & 0 \\ \frac{1}{6} & \frac{1}{3} & \frac{1}{2} \\ \frac{1}{6} & \frac{1}{3} & \frac{1}{2} \end{bmatrix}.$$

$$\theta_{12}=\sin^{-1}\left(\tfrac{1}{\sqrt{3}}\right)\simeq 35.3^\circ\quad \theta_{23}=45^\circ\\ \theta_{13}=0\hspace{1.5cm}\delta=0.$$

Lingering Issues

1. Solar Composition Problem

genuine mystery in need of resolution !

also want better understanding of CNO cycle

2. Nature of MSW Transition

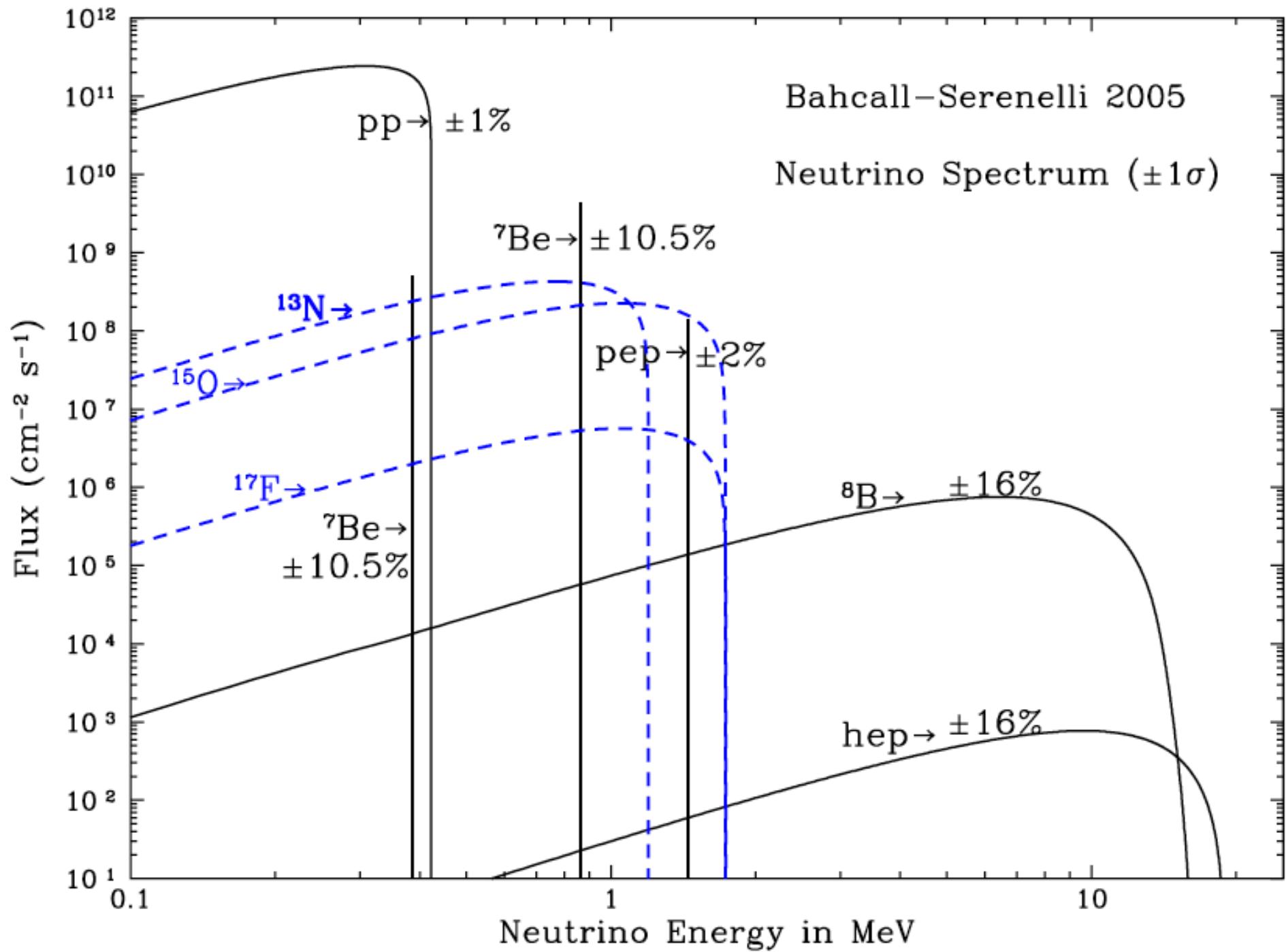
critical probe of neutrino/matter interactions

numerous alternative models tested

current data looks intriguing

3. Improve Precision on θ_{12}

test Tri-Bi-Maximal scenarios



Lingering Issues

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genuine mystery in need of resolution !

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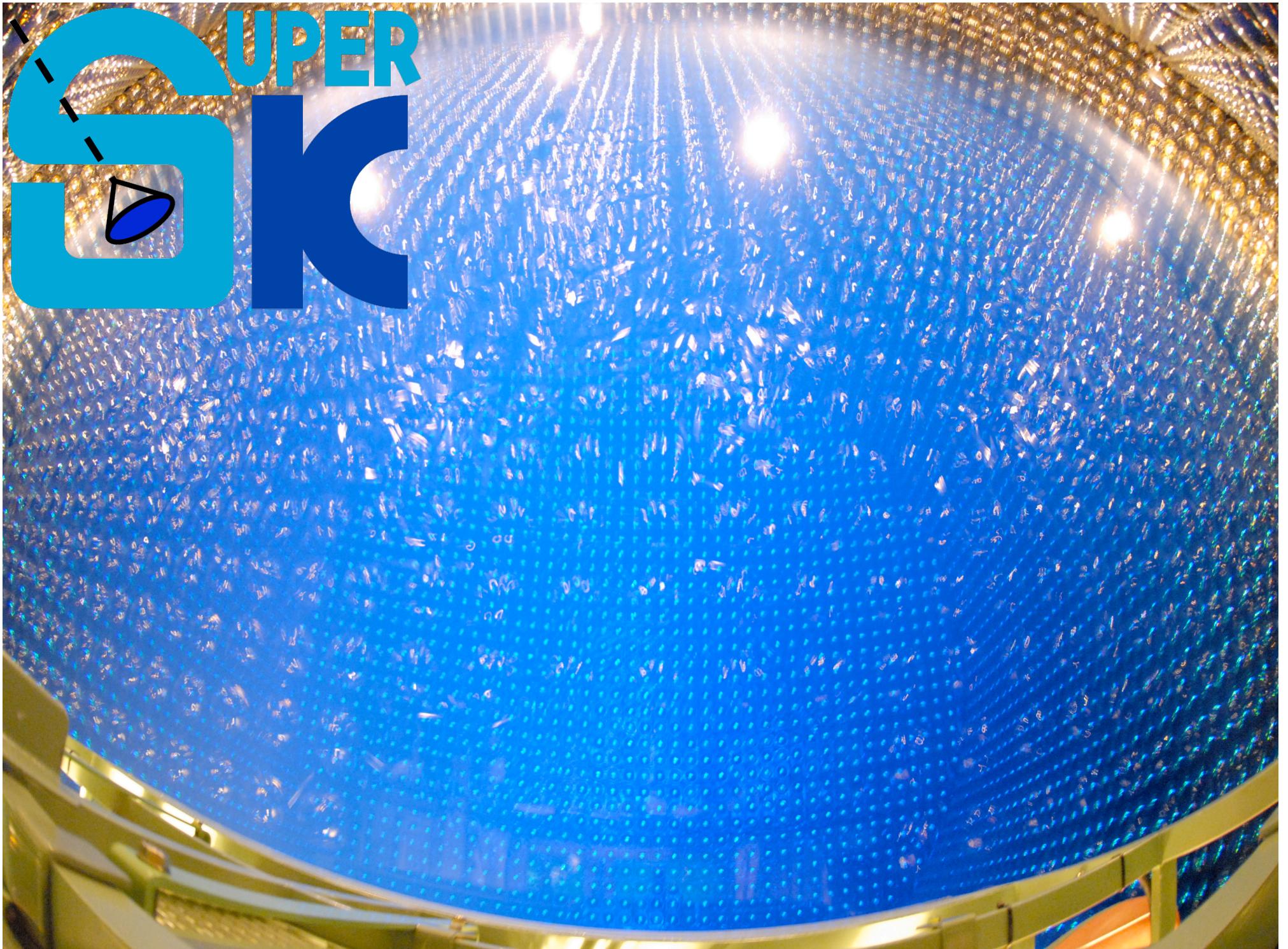
test Tri-Bi-Maximal scenarios

4. Check Fundamental Processes

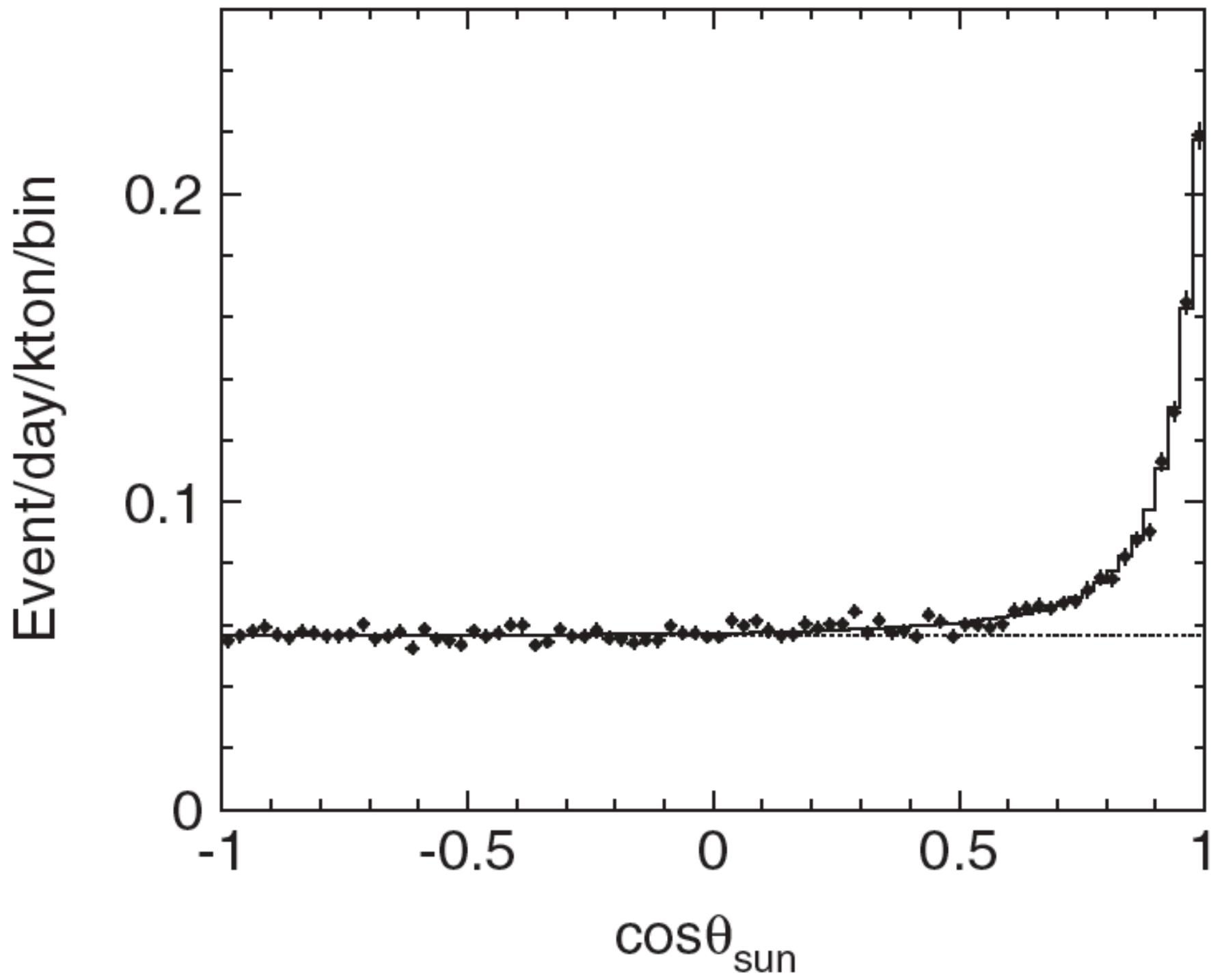
testing basic understanding is what we do!

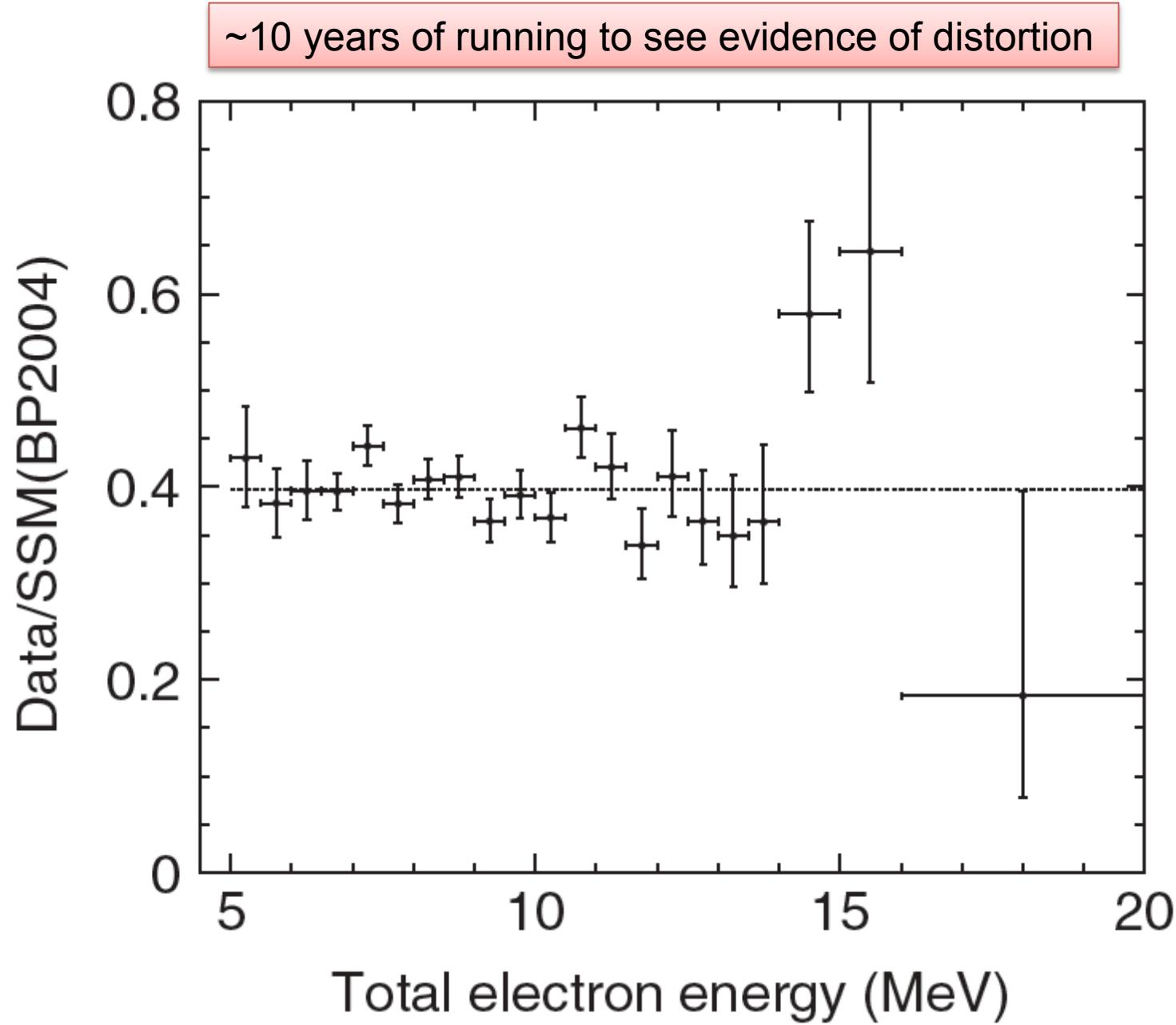
Tomorrow's V's



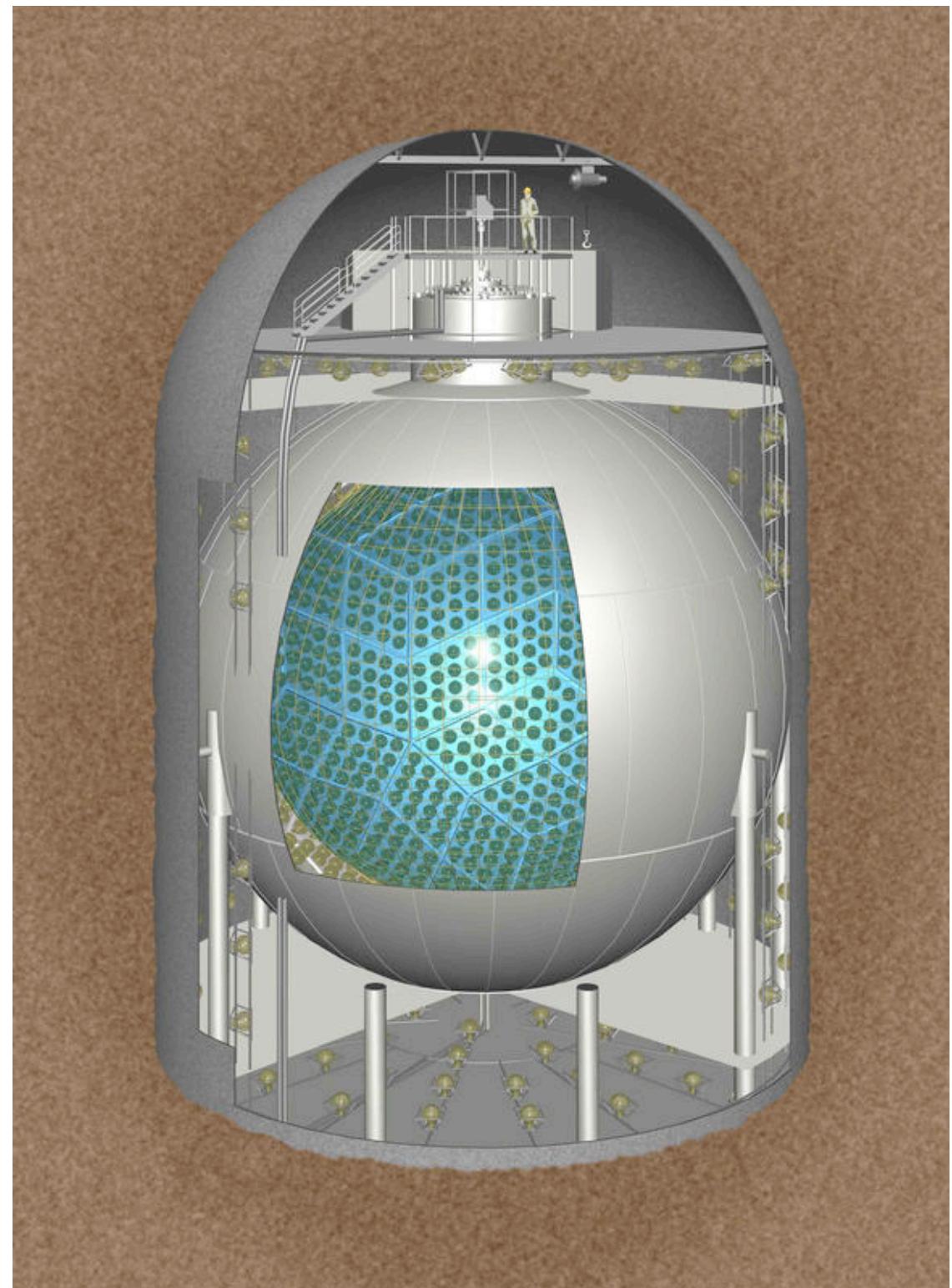


UPER
OK

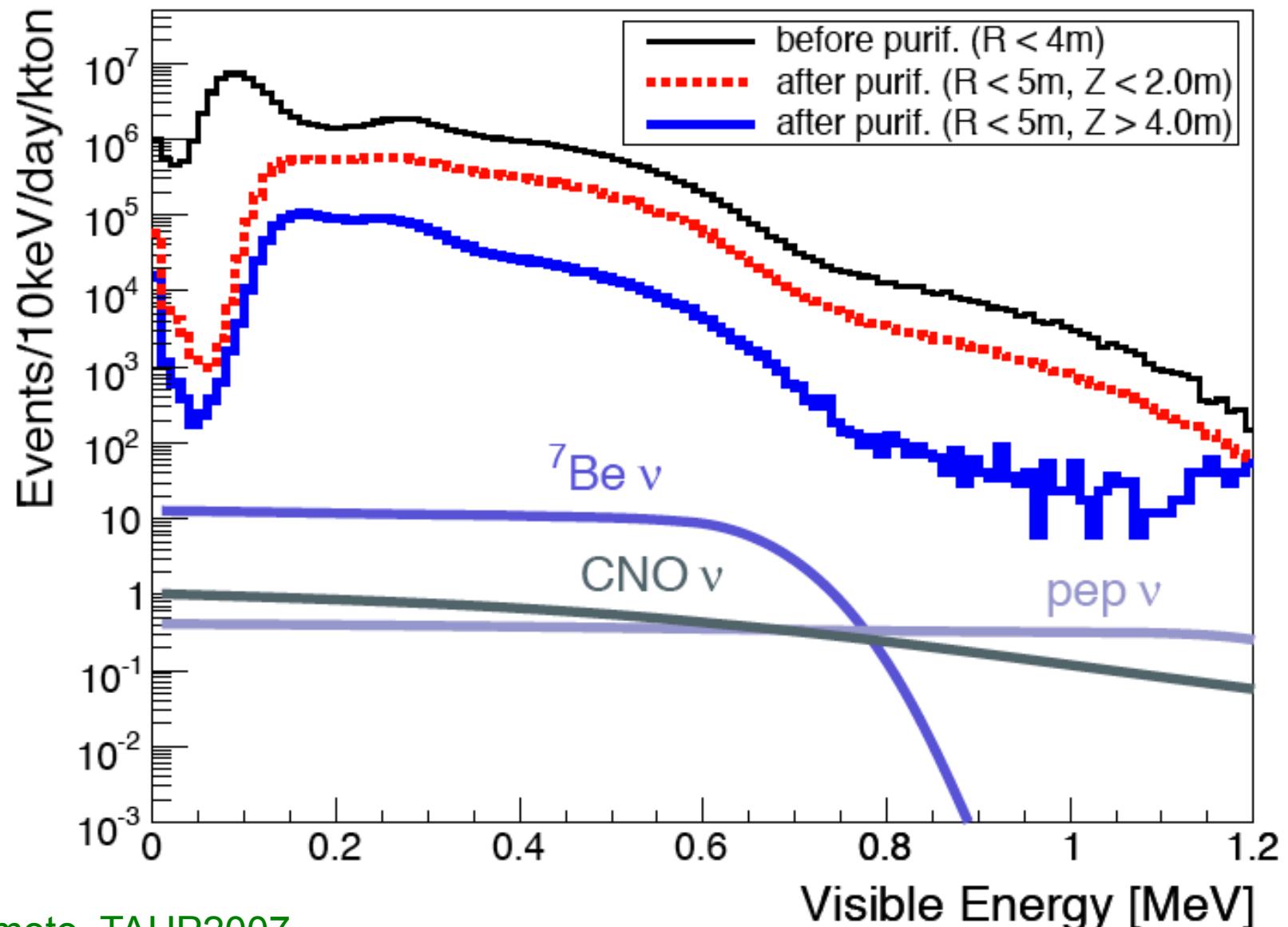


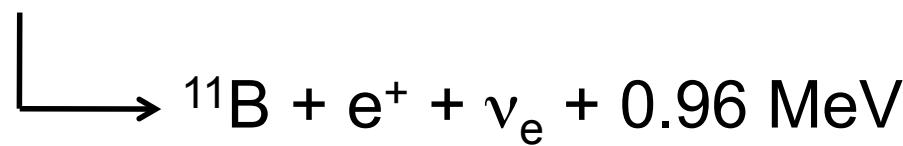
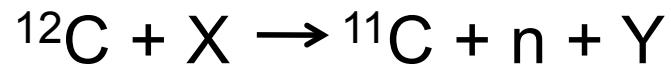


Abe *et al.*, PHYSICAL REVIEW D 83, 052010 (2011)



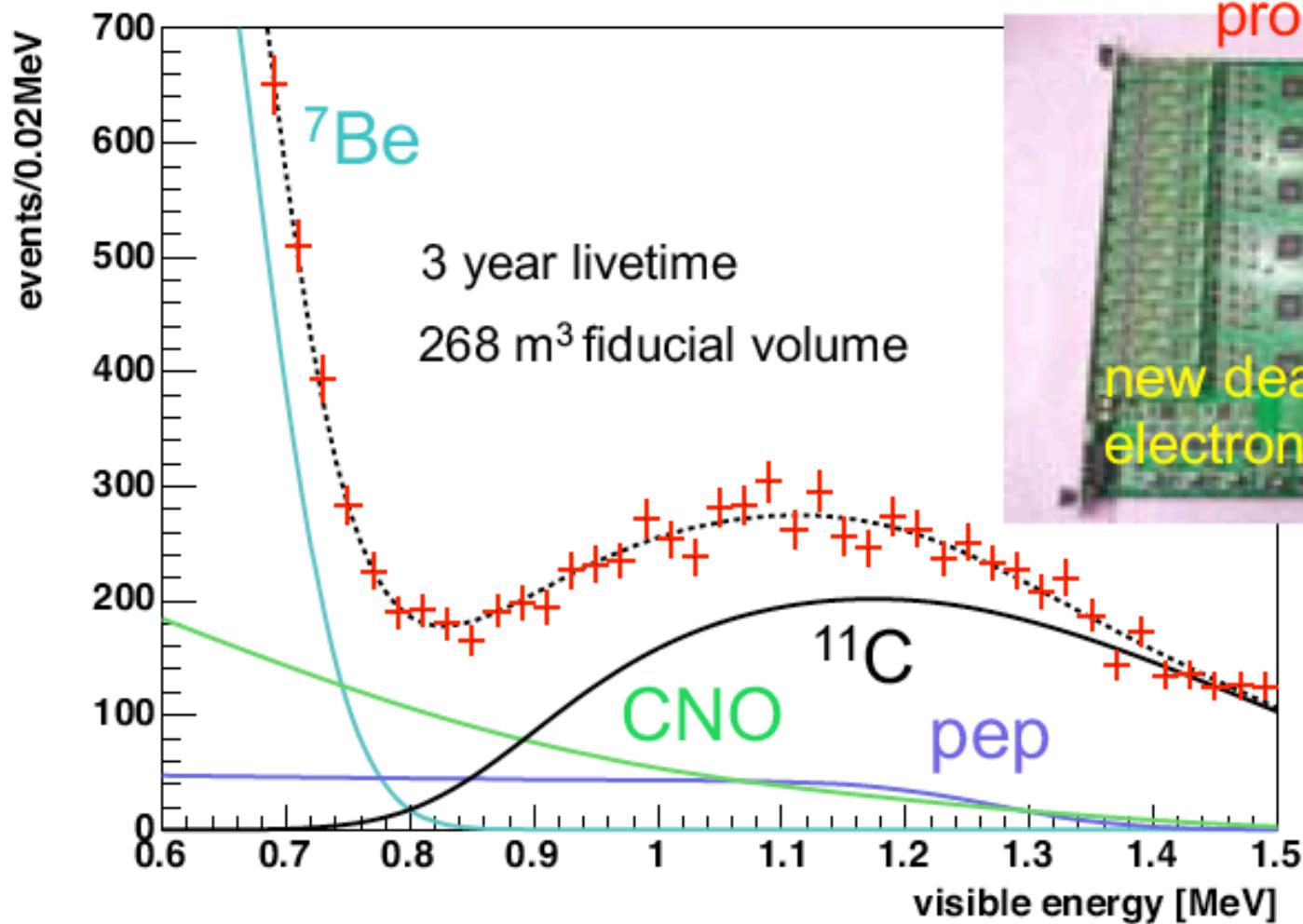
Isotope	Before [Bq/m ³]	After (Upper) [Bq/m ³]	After (Lower) [Bq/m ³]	Required [$\frac{\text{After}}{\text{Before}}$]
²¹⁰ Bi	$(4.2^{+0.8}_{-0.6}) \times 10^{-2}$	$(2 \pm 1) \times 10^{-4}$	$(1.0 \pm 0.1) \times 10^{-2}$	10^{-6}
⁴⁰ K	$(4.4 \pm 0.4) \times 10^{-5}$	NA	$(1.3 \pm 0.1) \times 10^{-5}$	10^{-6}
⁸⁵ Kr	$(5.1^{+0.2}_{-0.4}) \times 10^{-1}$	$(1.4^{+0.1}_{-0.2}) \times 10^{-2}$	$1.85^{+0.01}_{-0.02} \times 10^{-1}$	$10^{-5 \sim -6}$
²²² Rn	2.8×10^{-8}	1×10^{-4}	1×10^{-4}	$< 10^{-3}$

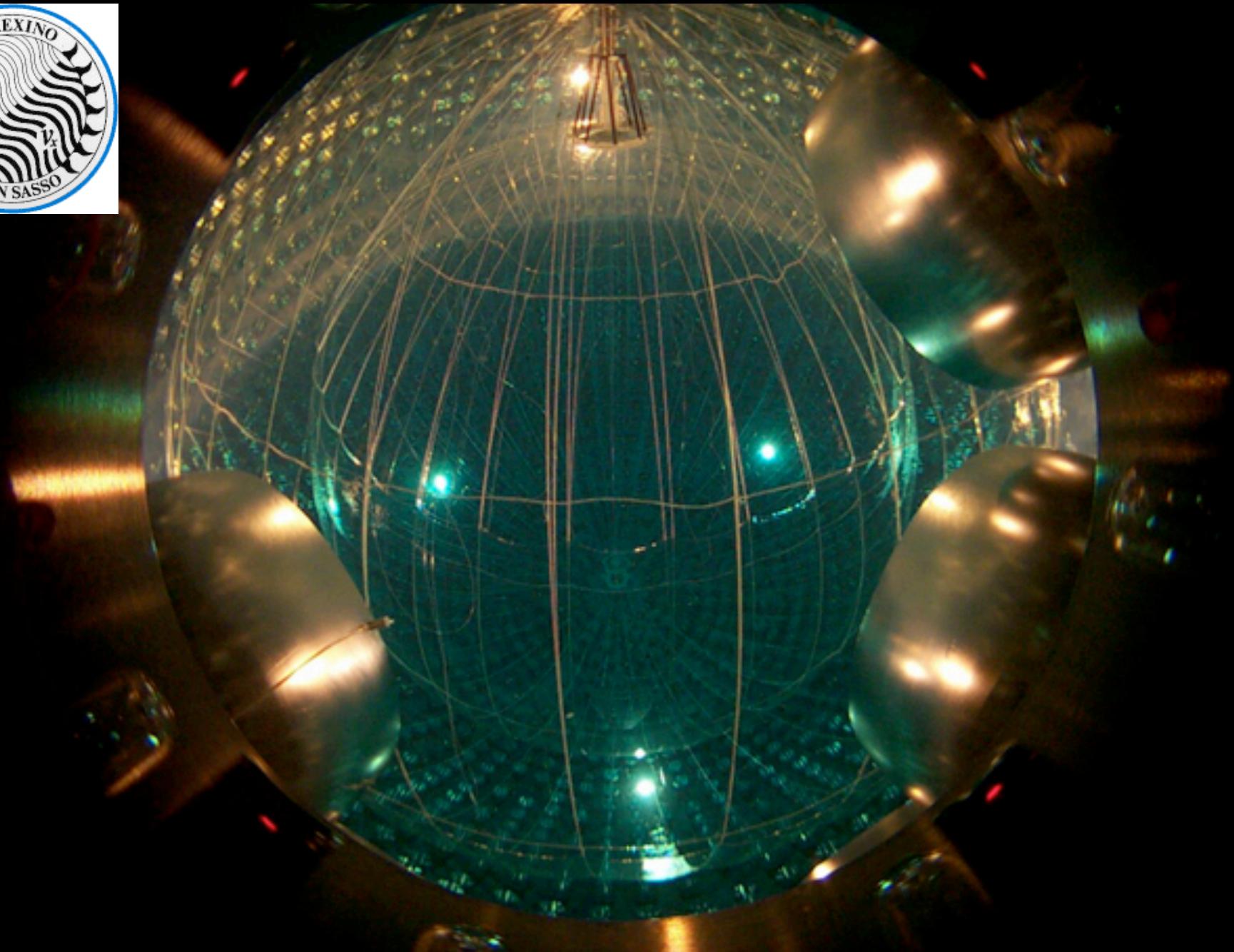




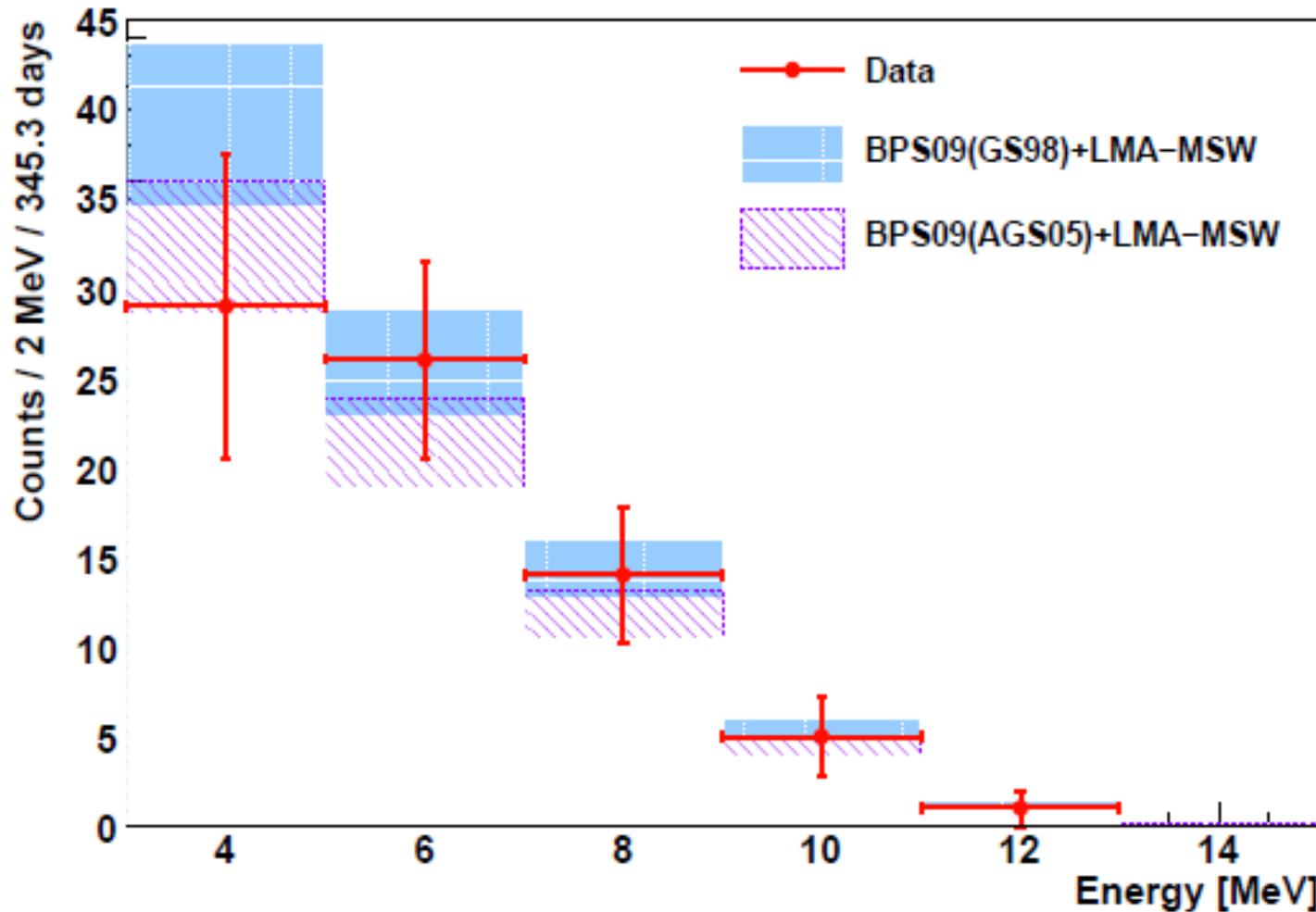
$$t_{1/2} = 20\text{s}$$

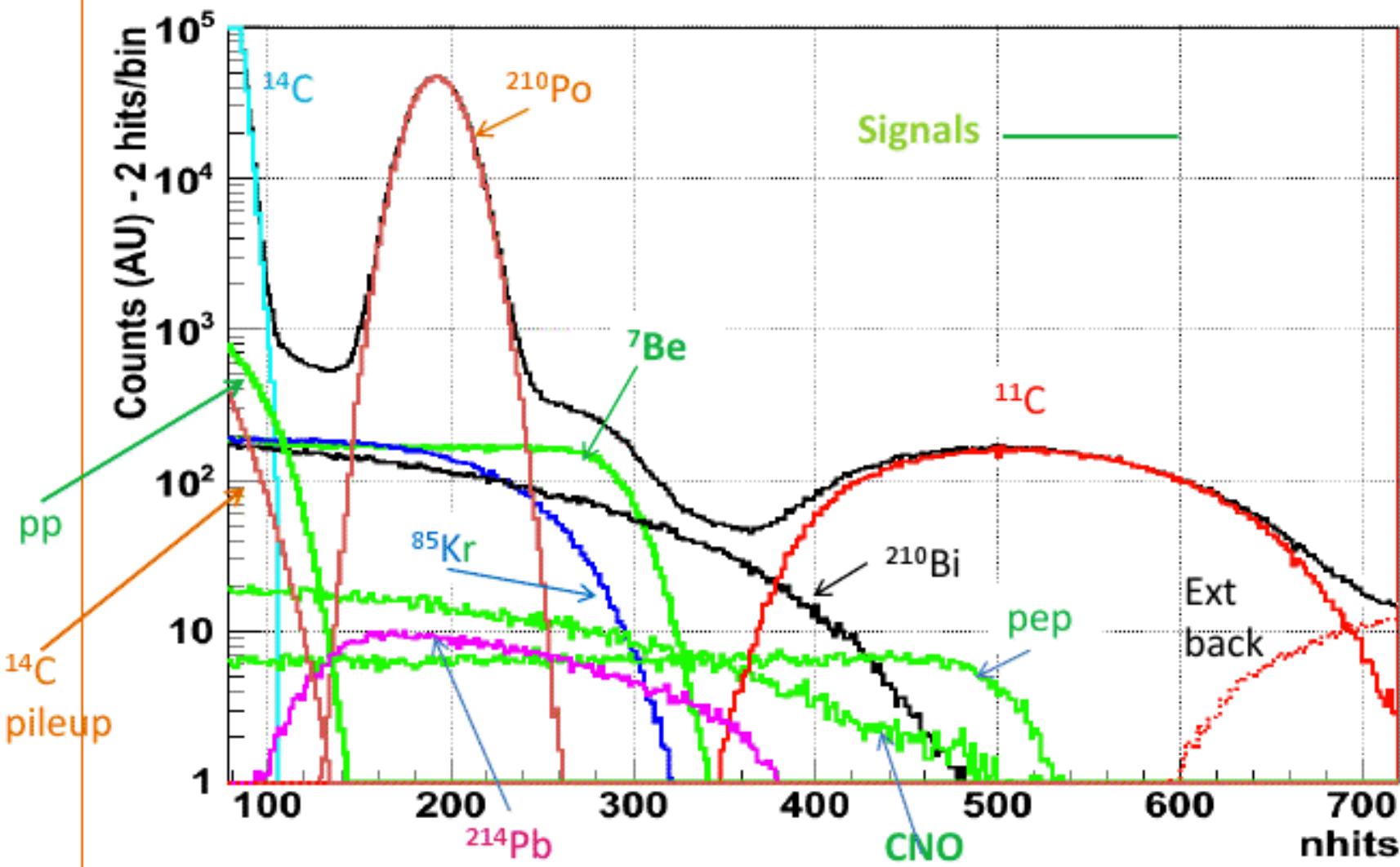
95% of ^{11}C is rejected by neutron tagging

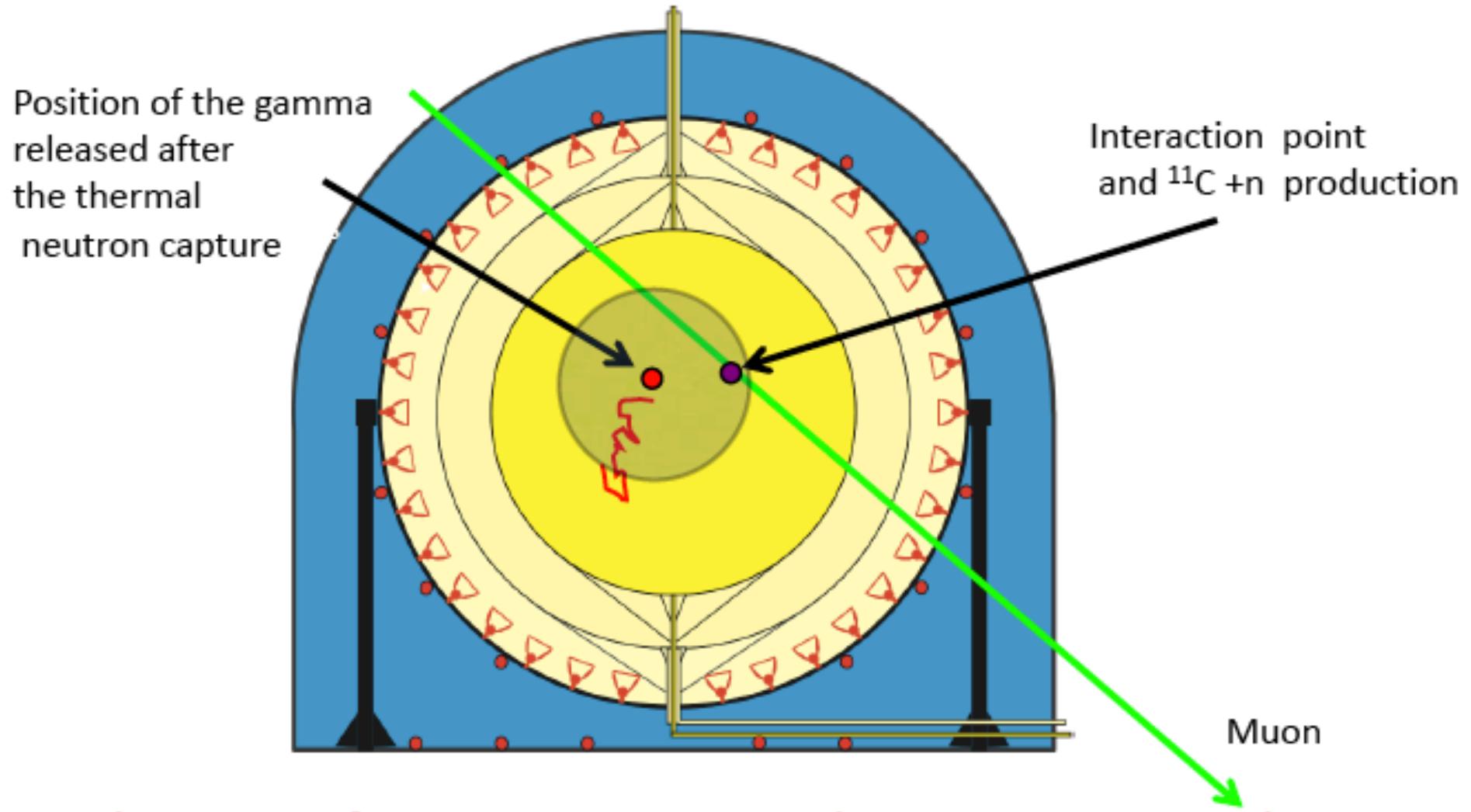




Borexino Elastic Scattering Measurement of ${}^8\text{B}$





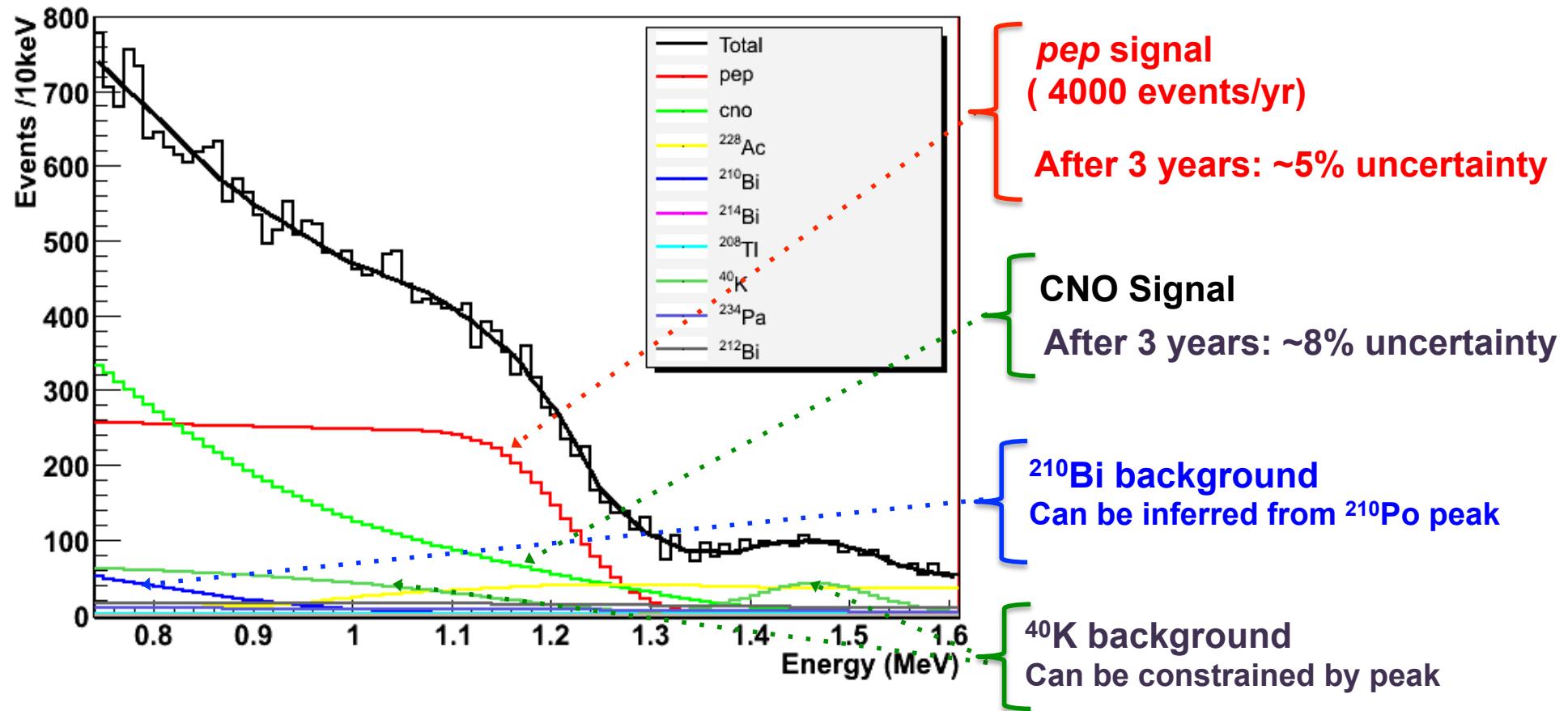


μ track+ gamma from neutron capture detection+ space and time cut



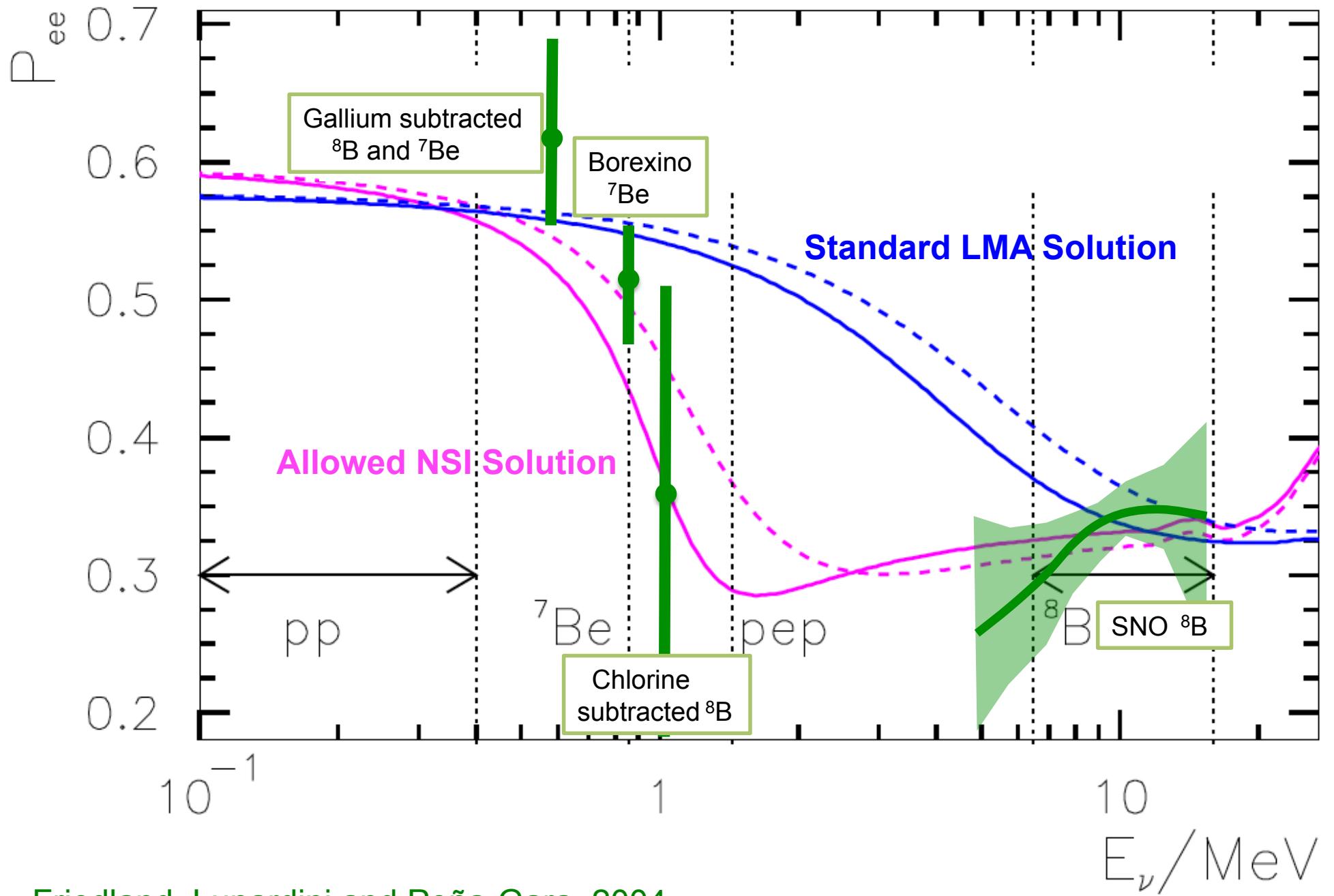
*A Diverse Instrument for Neutrino Research
within the SNOLAB Underground facility*

Simulated SNO+ Energy Spectrum

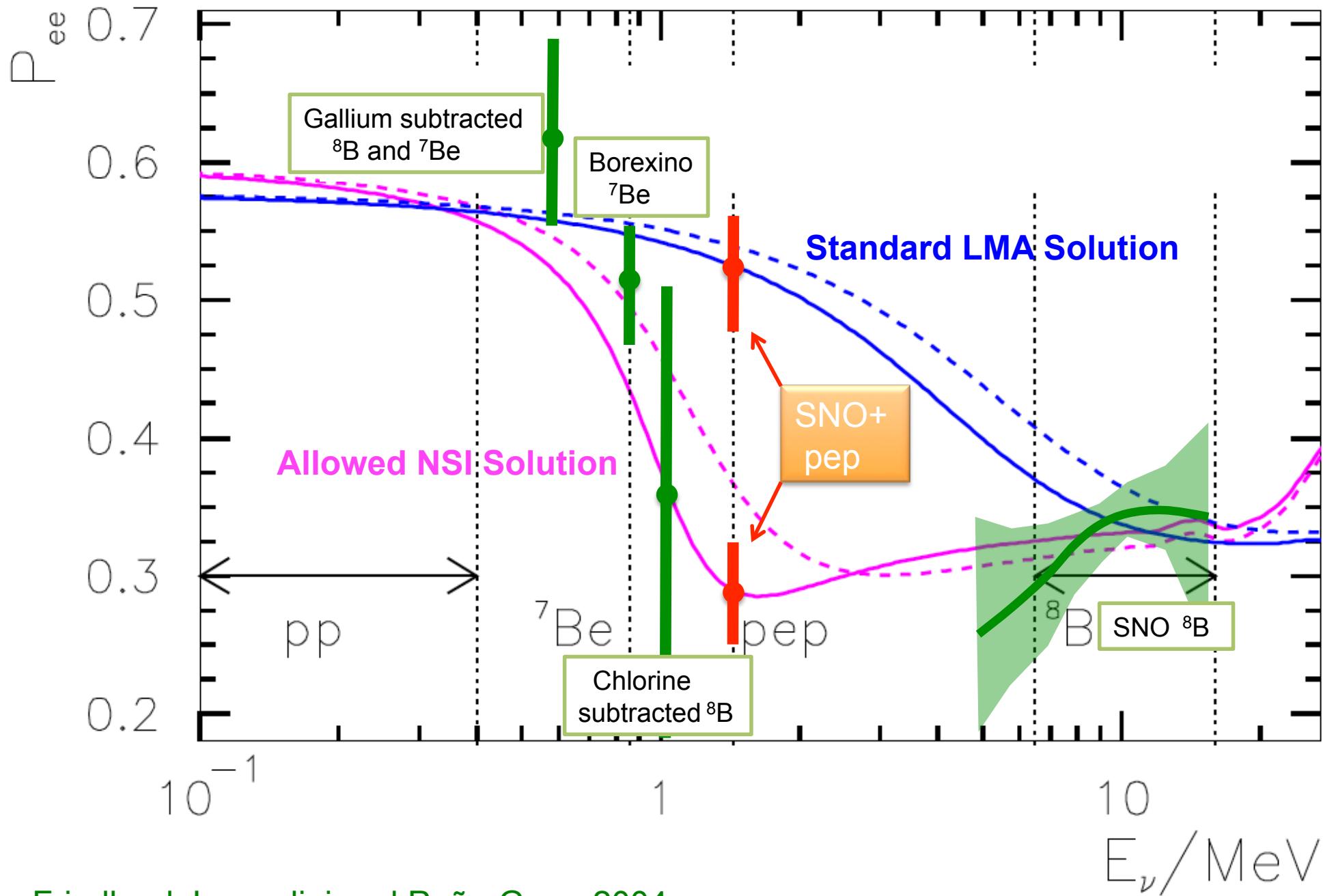


3600 *pep* events/(kton · year), for electron recoils >0.8 MeV

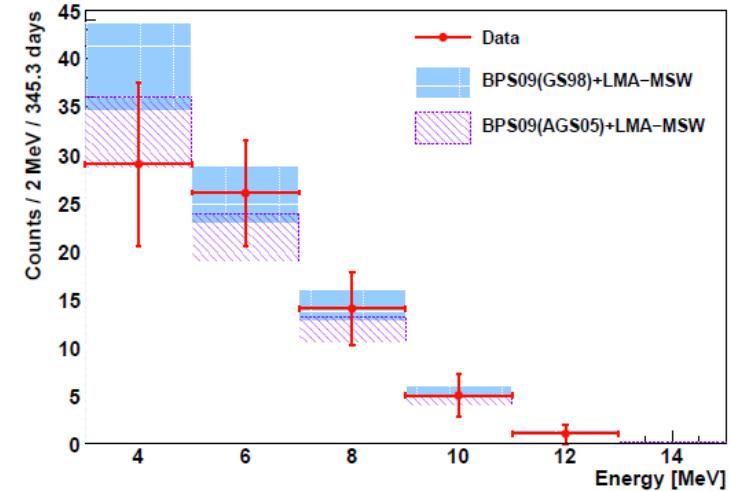
SNOLAB depth of 6000 mwe gives a muon flux 800 times less than KamLAND and virtually eliminates background from ^{11}C , making SNO+ uniquely sensitive for a precision measurement.



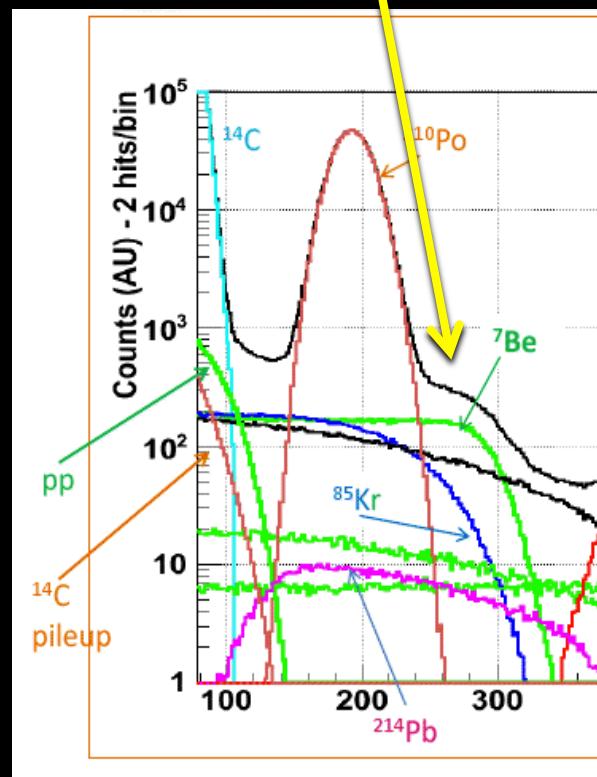
Friedland, Lunardini and Peña-Gara, 2004



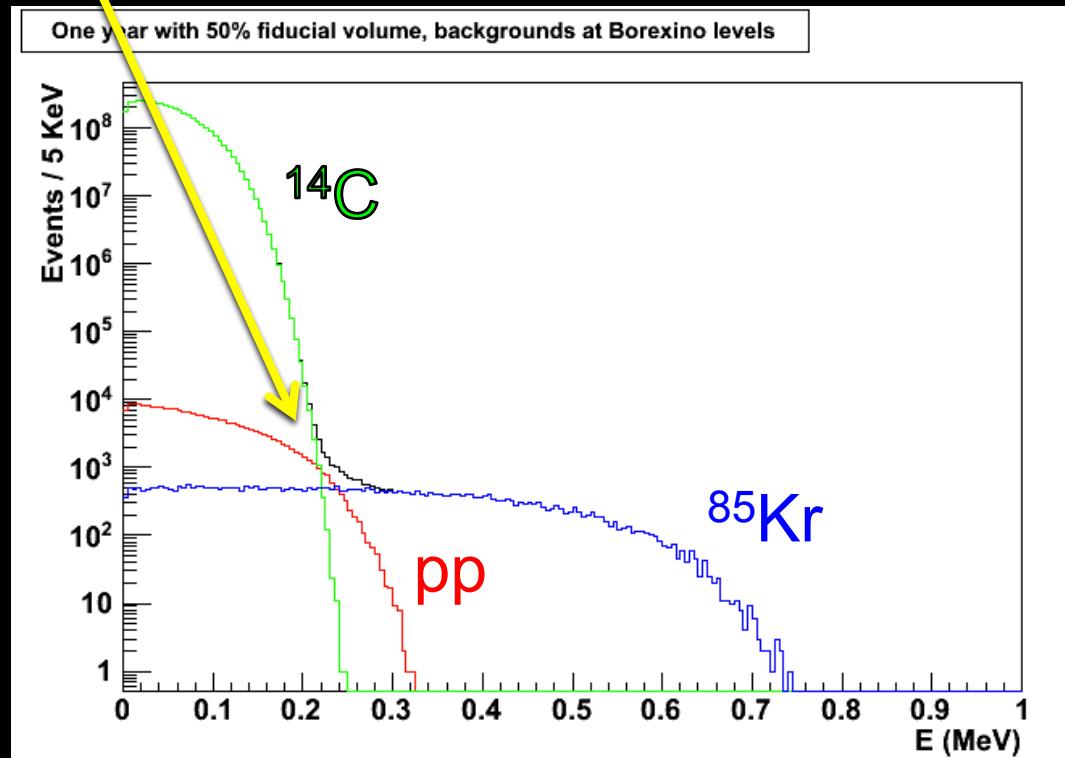
SNO+ will do better than
Borexino for low energy ^8B



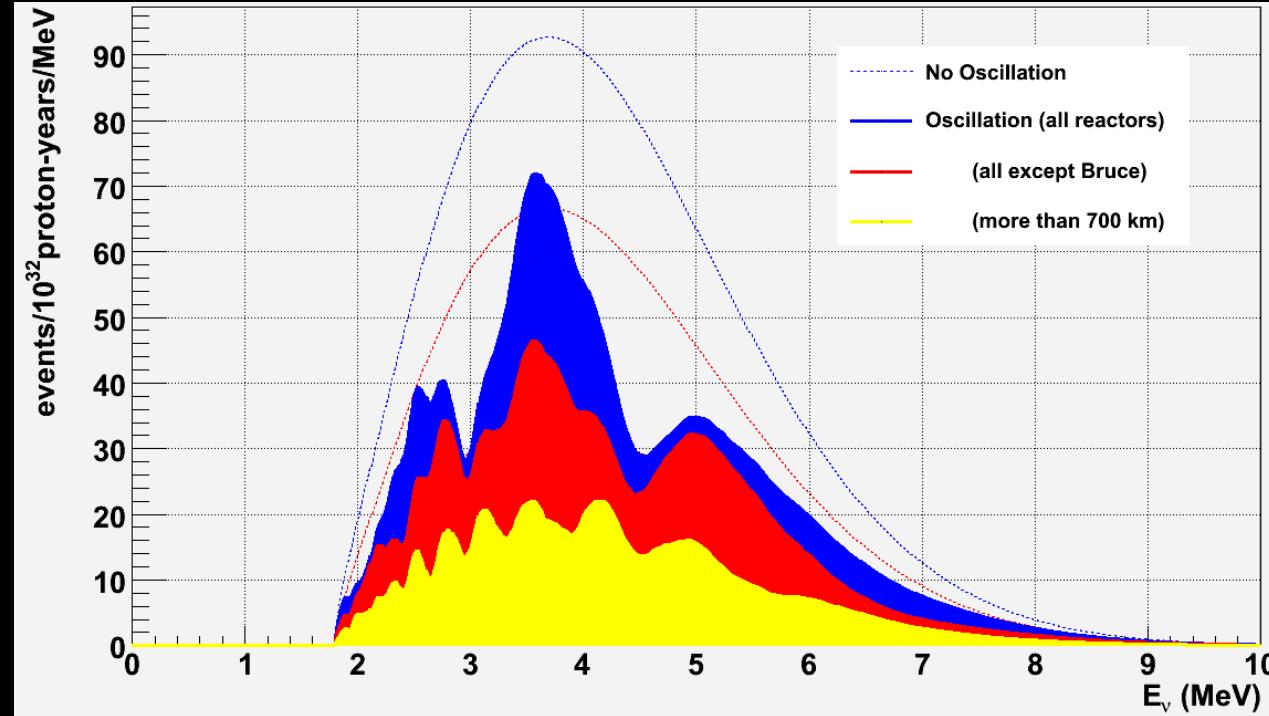
Potentially better for ^7Be



Possibly 1st real-time
measurement of pp

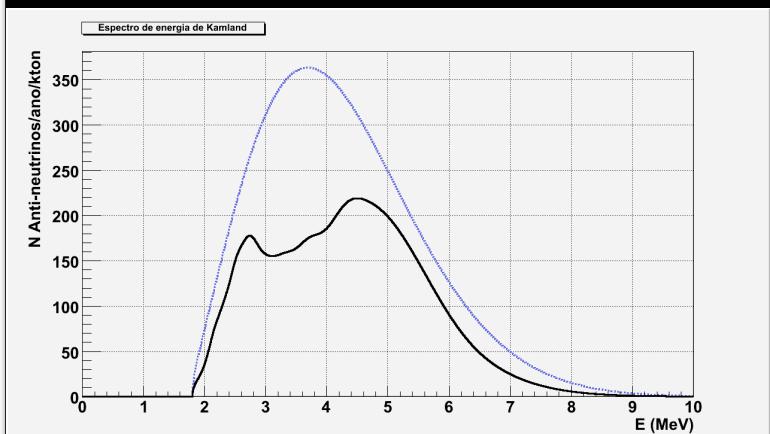


Reactors Contribution to the Spectrum



- Bruce reactor will contribute mainly to the central peak.
- We can take advantage from any “shut-off” period

L/E Analysis



Main Reactors
(distances smaller than
700km to the detector)

Reactor	d (km)	Th. Power (GW)
Bruce	281	10,32
Pickering	330	6,192
Darlington	340	10,572
R.E. Ginna	455	1,41
James A. Fitzpatrick	488	2,34
Nine Mile Point	488	5,07
Perry	530	3,1615
Enrico Fermi	559	3,255
Keweenaw	568	1,509
Davis-Besse	588	2,531
Point Beach	589	2,91
Palisades	617	2,34
Gentilly	648	1,914
Beaver Valley	657	4,929
Donald C. Cook	685	3,06



SNO+: First Data in 2012

Rough Order of Running:

H_2O ~ couple months

Pure Scintillator ~ several months

Nd-loaded Scintillator ~ few years

Pure Scintillator ~ few years

Follow-on Phase ~ ?

nucleon
decay

initial
solar study

Phase I
 $\beta\beta$

detailed
solar study

Phase II $\beta\beta$? Other ?

geo-neutrinos
reactor neutrinos

live for supernova running

Lingering Issues

1. Solar Composition Problem

genuine mystery in need of resolution !

also want better understanding of CNO cycle

2. Nature of MSW Transition

critical probe of neutrino/matter interactions

numerous alternative models tested

current data looks intriguing

3. Improve Precision on θ_{12}

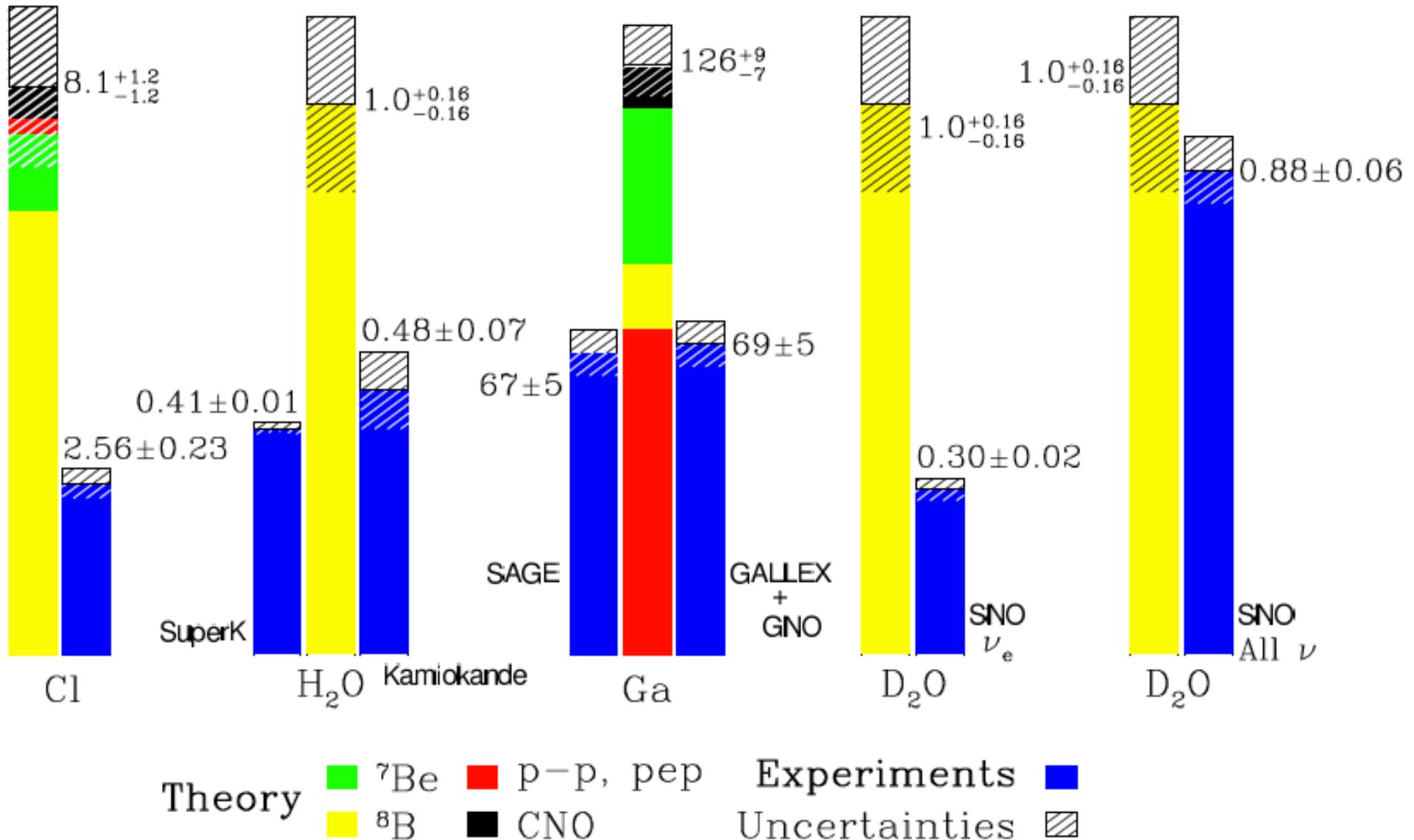
test Tri-Bi-Maximal scenarios

4. Check Fundamental Processes

testing basic understanding is what we do!

Total Rates: Standard Model vs. Experiment

Bahcall–Serenelli 2005 [BS05(OP)]



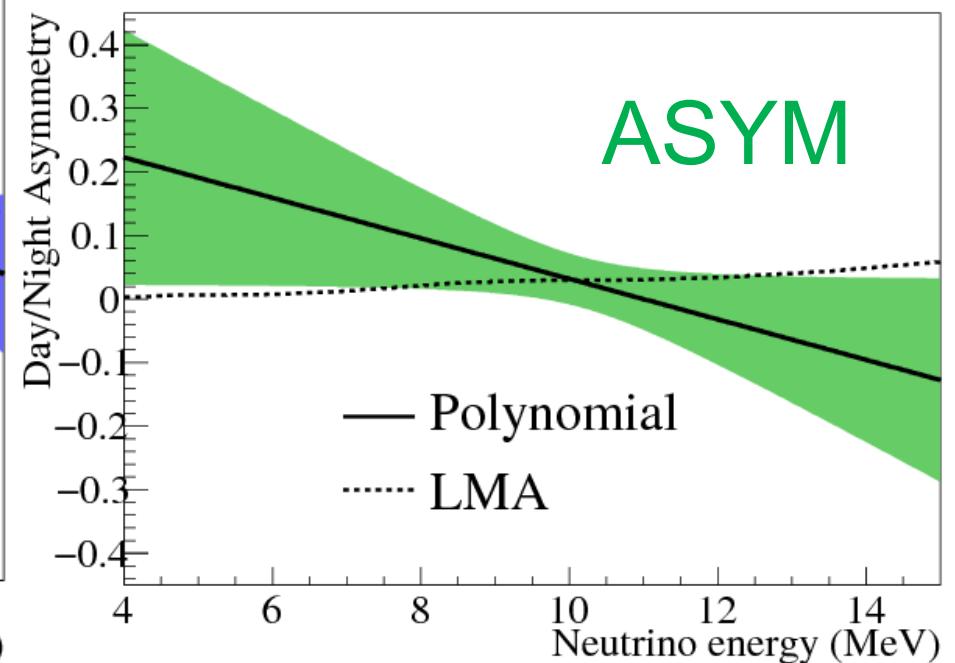
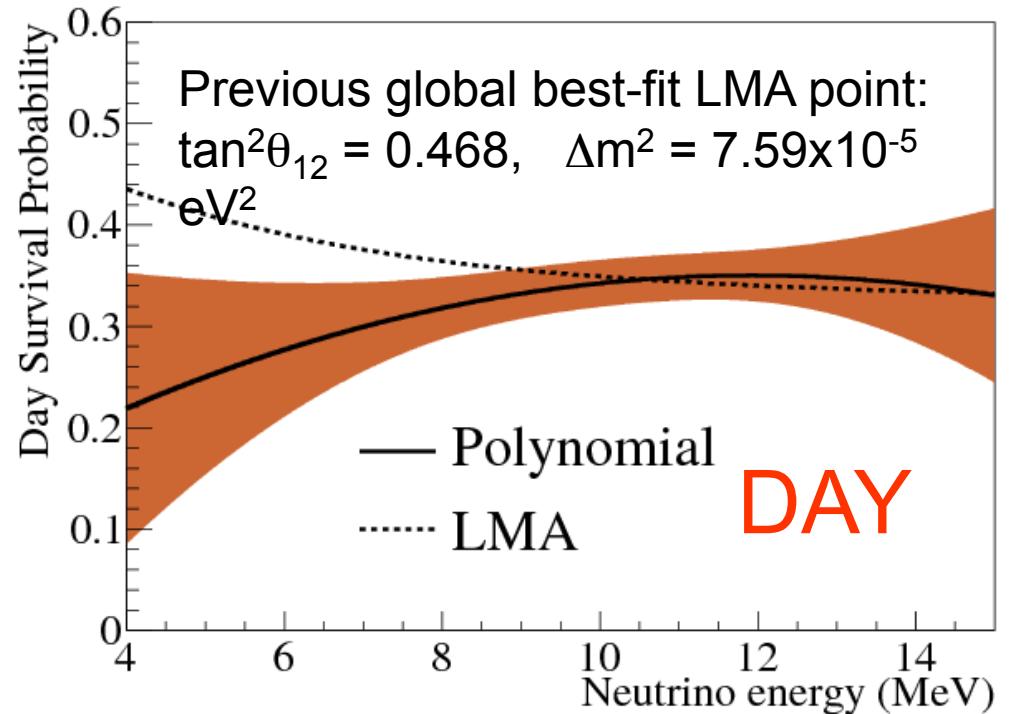
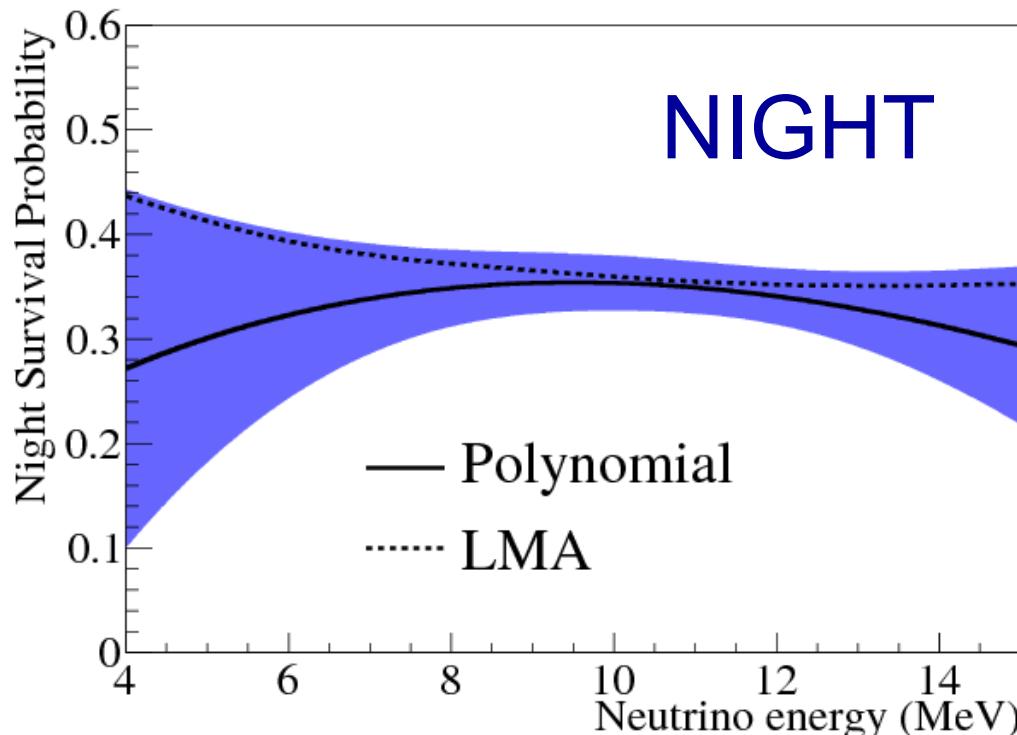
Direct Fit for Energy-Dependent Survival Probability

No distortion, no a/s:

$$\Delta\chi^2 = 1.94 / 4 \text{ d.o.f.}$$

LMA-prediction:

$$\Delta\chi^2 = 3.90 / 4 \text{ d.o.f.}$$



Solar + KamLAND 3-flavor Overlay

LETA paper 2010:
LETA joint-phase fit
+ Phase III
+ all solar expts
+ KamLAND

3-flavor overlay:

Best-fit LMA point:

$\tan^2\theta_{12} = 0.468$
 $(+0.042 - 0.033)$

$\Delta m^2 = 7.59 \times 10^{-5} \text{ eV}^2$
 $(+0.21 - 0.21)$

