Study of solar ^{8}B neutrino with Borexino and radiopurity of the ^{144}Ce source for the SOX experiment.

under the supervision of D.Franco and T.Lasserre

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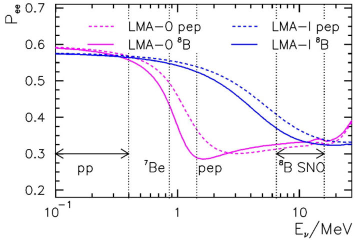
In the ν oscillation field, many open questions. Two of them are :

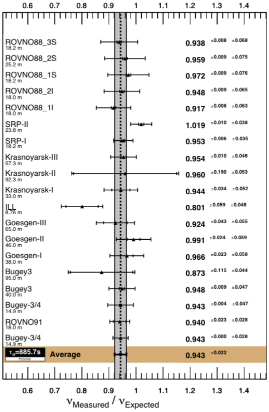
Solar ^{8}B ν_e rate in Borexino

Measuring the ^{8}Bν_e rate as a test for MSW effect as well as metallicity models inside the Sun.



$\overline{\nu_s}$ with SOX

Bringing a 144Ce source below Borexino in order to test the reactor antineutrino anomaly.



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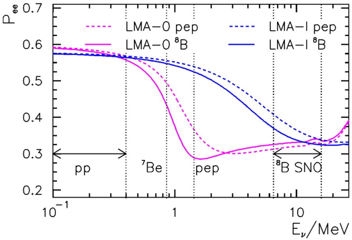

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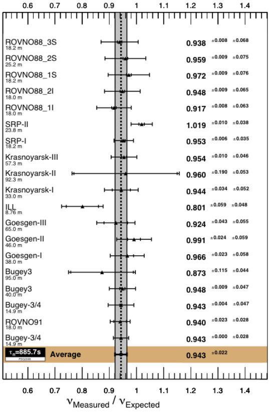
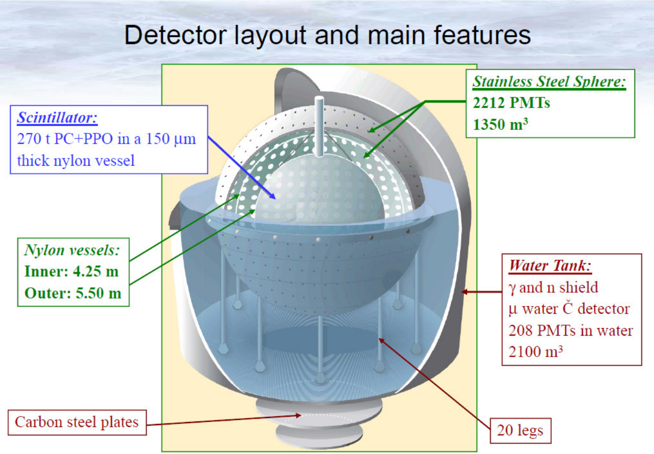


Borexino

Located at the underground Gran Sasso laboratory (3800 m.w.e.) for shielding against cosmic ray and muons (reduced by a factor 10^6). Running since 2007.



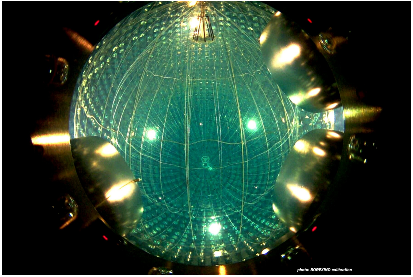
Borexino - Detection method

ν_e

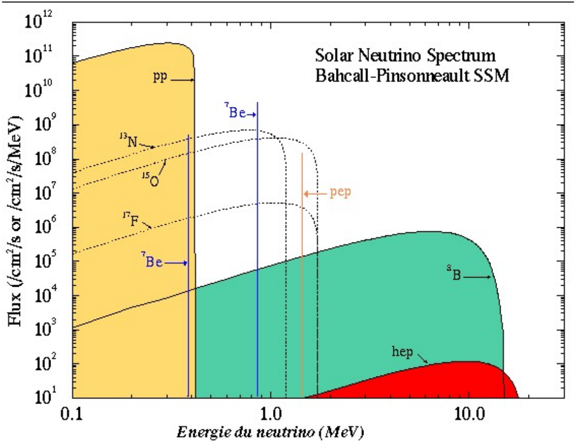
Elastic scattering interaction on the e^- of the organic liquid scintillator is producing light $\Rightarrow$

- very low energy threshold,
- good position reconstruction
- good energy resolution.

But a very high radiopurity is mandatory because every β contamination can mimic a ν_e signal.



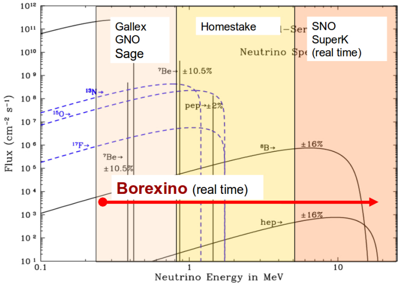
Production of ν_e in the Sun

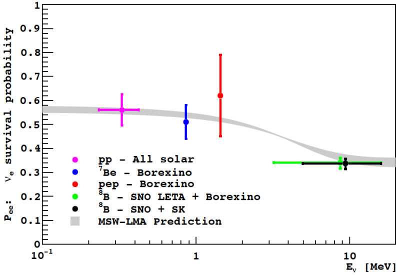


Energy spectrum of the ν_e produced in the Sun (pp chain +CNO).

Goals and results of Borexino

Borexino was designed for measuring the ^{7}Be monoenergetic rate.





^{8}B ν_e : Classical analysis

Analysis first done in 2010 on 2 years of data taking, redone with improvments in 2016 with 8 years of data taking.

Primary selection

- Energy > 3 MeV (to avoid the 2.6 MeV γ from ^{208}Tl)
- Radius < 3 m $\rightarrow$ 100 t of active target

We expect 0.25 cpd/100 t ^{8}B ν_e events above 3 MeV.

Background left

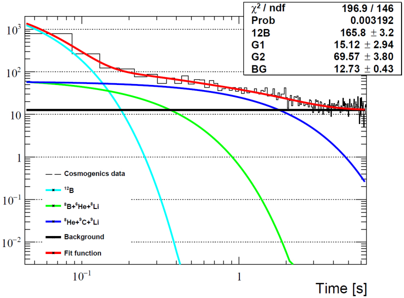
- muons (1550 cpd/100 t) $\rightarrow$ tagged by active veto,
- neutrons (25 cpd/100 t) $\rightarrow$ tagged by active veto,
- cosmogenics (2.1 cpd/100 t),
- radioactive background inside the vessel (1cpd/100 t),
- external background (0.05 cpd/100 t).

^{8}B ν_e : Cosmogenics

Cosmogenics : radioactive elements produced by muon spallation.

Cosmogenics above 3 MeV and their expected rate in the fiducial volume :

Isotopes	^{12}B	^{8}He	^{9}C	^{9}Li	^{8}B	^{6}He	^{8}Li	^{11}Be	^{10}C
lifetime (s) (t_i)	0.0291	0.17	0.19	0.26	1.11	1.17	1.21	19.9	27.8
Expected rate [cpd/100t] (r_i)	1.41	0.026	G1	0.071	0.273	G2	0.40	0.035	0.54
Fraction > 3 MeV (δ_i)	0.886	0.898	0.965	0.932	0.938	0.009	0.875	0.902	0.012



Cut 6.5 s after an internal μ :

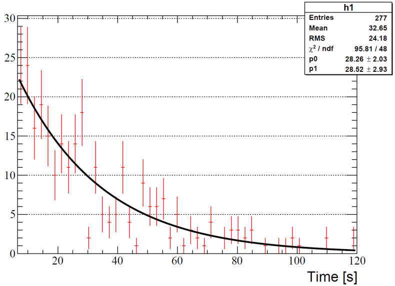
$\Rightarrow$ **27.5 % dead-time**

$\Rightarrow$ **Residue of (27.7 $\pm$ 1.5) $\times$ 10^{-4} cpd/100t**

^{8}B ν_e : Cosmogenics

What about long lifetime cosmogenics like ^{10}C ?

^{12}C -> ^{10}C +2n then ^{10}C decaying as β^{+} (27.8s, 3.6 MeV).



Looking for a triple coincidence :

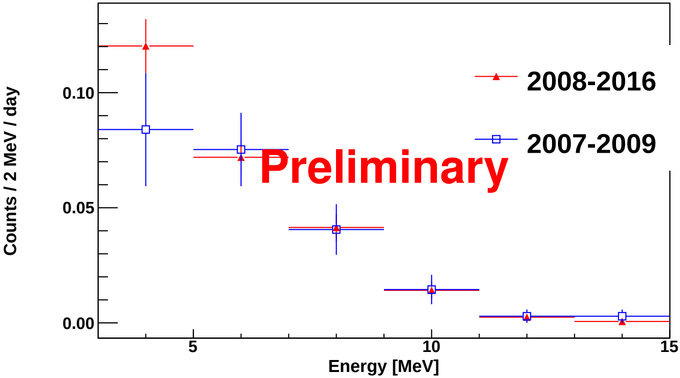
- a muon crossing the detector
- a neutron detected on the same time
- around the neutron point looking for the decay of ^{10}C

Cut 120 s after a (μ+n) coincidence in a 0.8 m sphere :

$\Rightarrow$ **0 % dead-time**

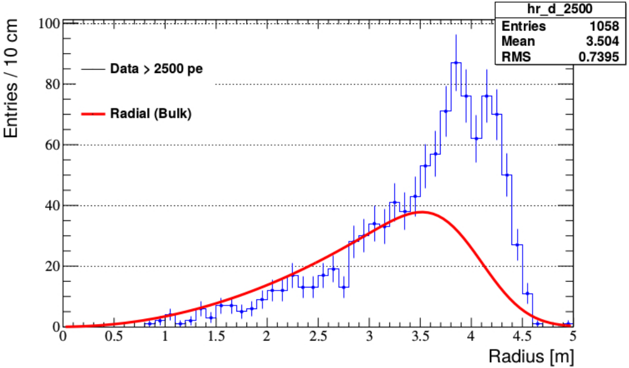
$\Rightarrow$ **Residue of (12.7 $\pm$ 2) $\times$ 10^{-4} cpd/100t**

^{8}B ν_e : Result of the classical analysis



^{8}B ν_e : New analysis above 5 MeV

The idea is to take the whole inner vessel volume in order to gain in statistics.

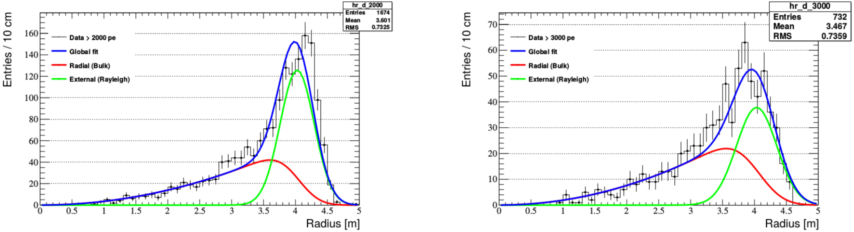


Trying to fit the radial distribution event with an uniform radial distribution.

Problem : **Contamination from outside, we have radially dependent background.**

^{8}B ν_e : New analysis

What are those events ? $\Rightarrow$ Those events are most probably γ from neutron capture.
How to take them into account ? $\Rightarrow$ Why not analytical functions : a **radial** component, and an **external** one for events coming from outside the vessel (mainly γ from PMTs).



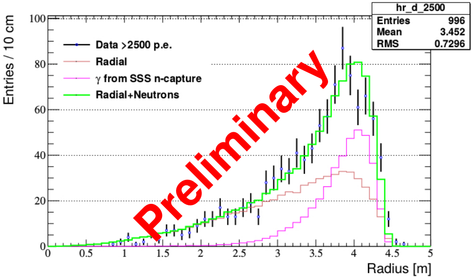
Here the radius fitted at two different threshold (respectively 4 and 6 MeV) is moving (from 4.11 to 3.88 m). Absurd.
Analytical functions are not working because the shape of the vessel is moving in time on long period analysis.

^{8}B ν_e : New analysis above 5 MeV

One needs to take into account the moving shape of the vessel.

Simulating events using on-time real shape

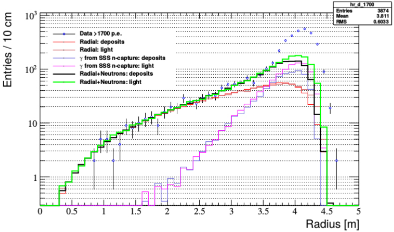
- Radial : e^- in the inner vessel,
- External : thermalized neutron inside the SSS,
- Averaging each of them for the shape measured every week.



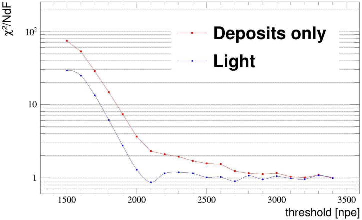
Comparison MC/data above 5 MeV

Conclusion

- The "classical" analysis is still pertinent and we handled the issue coming from a moving detector,
- A new perspective has been opened using the whole volume,
- Very promising results above 5 MeV but still to be confirmed below.



Comparison MC/data above 3 MeV



χ^2 evolution depending on the energy threshold