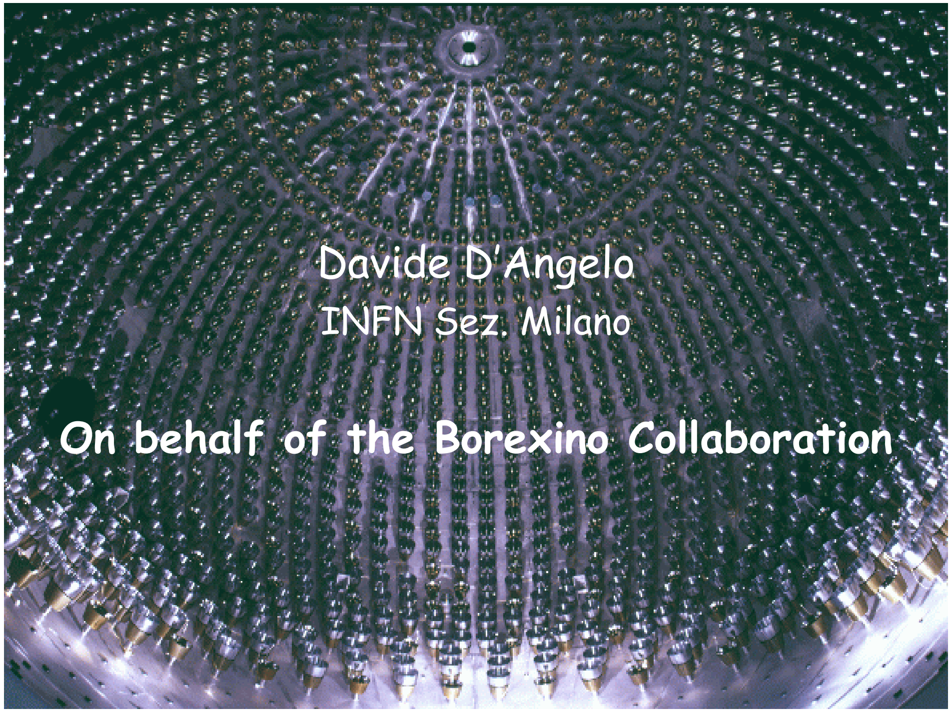
Results from the Borexino experiment after 192 days of data-taking



Borexino Collaboration

Milano

Genova

Virginia Tech. University

Kurchatov Institute (Russia)

Jagiellonian U. Cracow (Poland)

Heidelberg (Germany)

Dubna JINR (Russia)

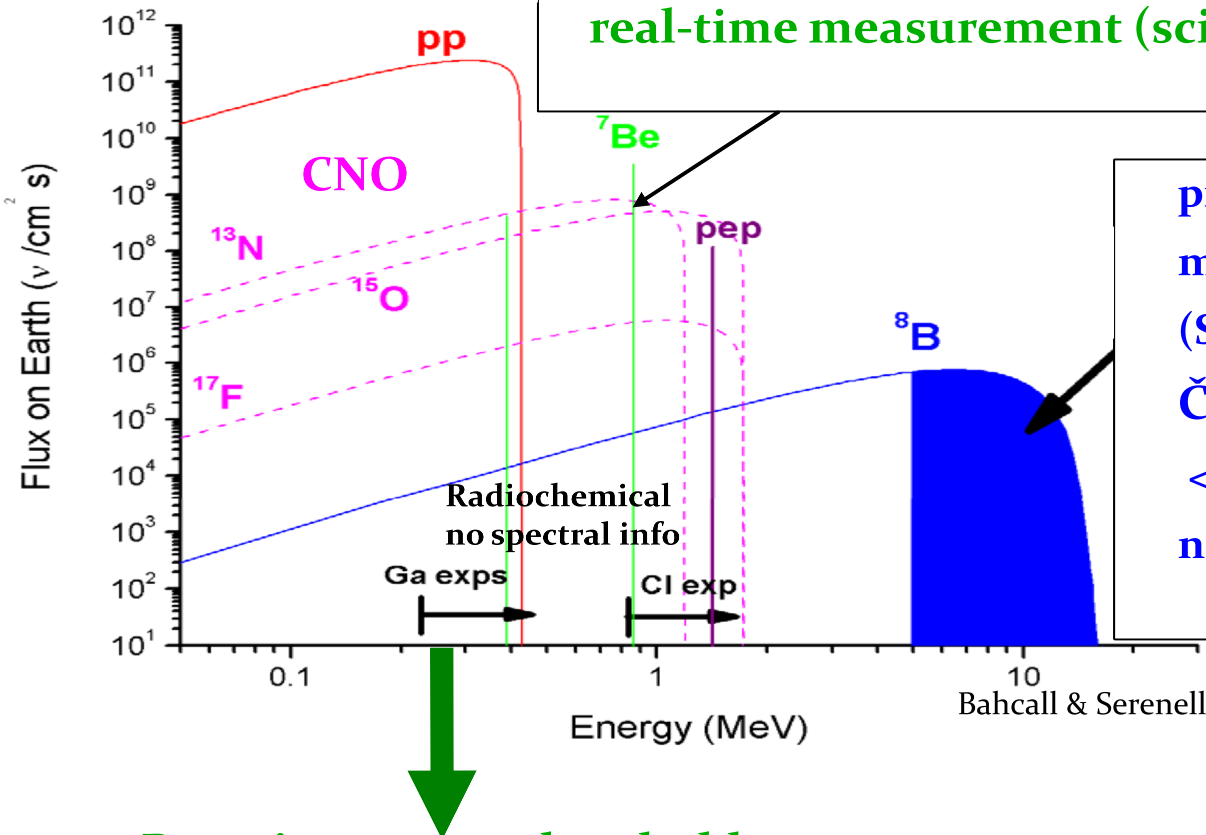
APC Paris

Munich (Germany)

Perugia

Princeton University

Solar neutrino energy spectrum



Bahcall & Serenelli 2005

mono-energetic 0.862 MeV ^{7}Be-ν

real-time measurement (scintillation light)

previous real-time measurements (SNO, SuperKamiokande)

Čerenkov radiation

< 1/10.000 of the total solar neutrino flux

Borexino energy threshold

Standard Solar Model:
Neutrino fluxes vs solar metallicity

(**metallicity:** abundance of the elements above Helium)

Φ ($cm^{-2}s^{-1}$)	pp ($\times 10^{10}$)	pep ($\times 10^{8}$)	^{7}Be ($\times 10^{9}$)	^{8}B ($\times 10^{6}$)	^{13}N:CNO ($\times 10^{8}$)	^{15}O:CNO ($\times 10^{8}$)	^{17}F:CNO ($\times 10^{6}$)
BS05 (1) GS 98 (2)	5.99	1.42	4.84	5.69	3.07	2.33	5.84
BS05 (1) AGS05(3)	6.06	1.45	4.34	4.51	2.01	1.45	3.25
Δ	+1%	+2%	-10%	-21%	-35%	-38%	-44%

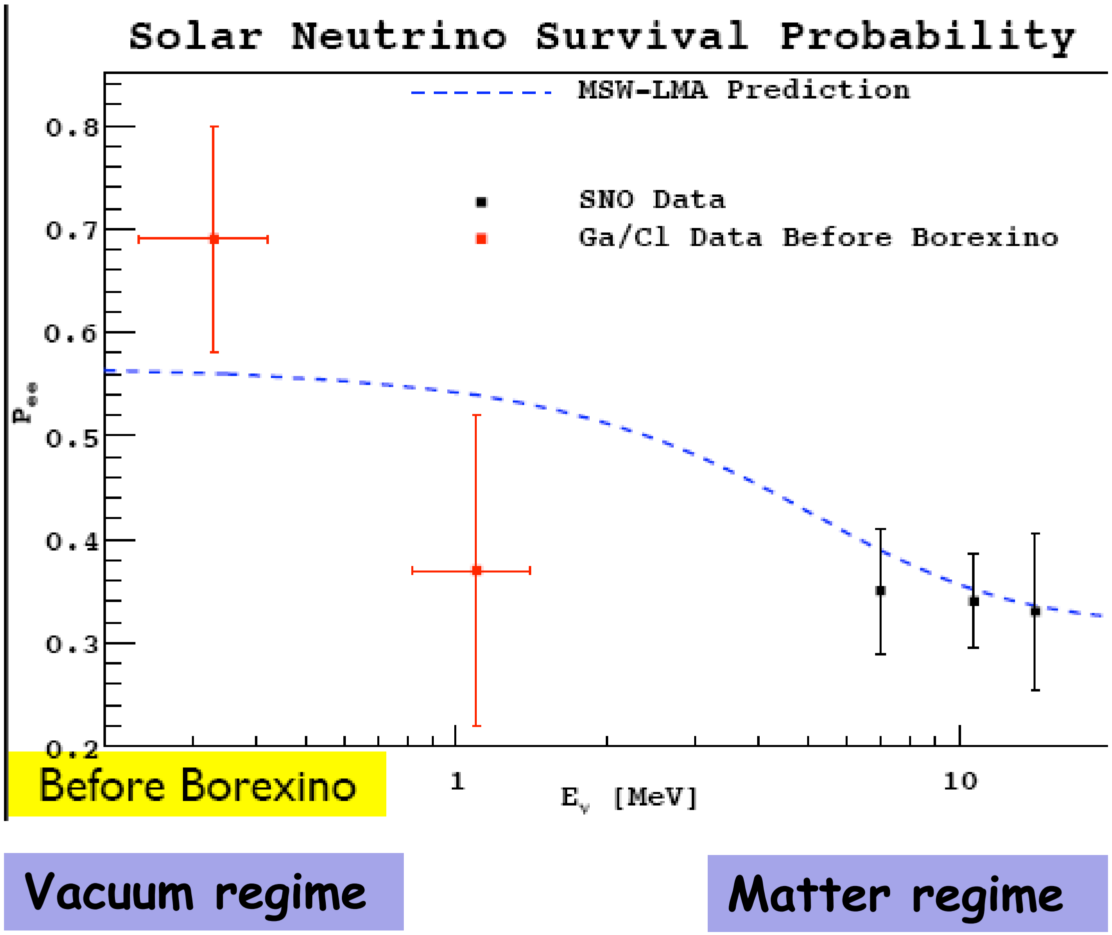
(1) BS05: Bahcall, Serenelli & Basu, AstropJ 621 (2005) L85

(2) Based on **high metalicity model** GS98: Grevesse & Sauval, Space Sci. Rev. **85, 161 (1998)**

(3) Based on new **low metalicity model** AGS05:
Asplund ,Grevesse & Sauval 2005, Nucl. Phys. A **777, 1** (2006).
BUT: incompatible with helioseismological measurements

MEASURING for the first time the CNO-neutrino fluxes would help to resolve the controversy!

Solar neutrino survival probability
BEFORE BOREXINO

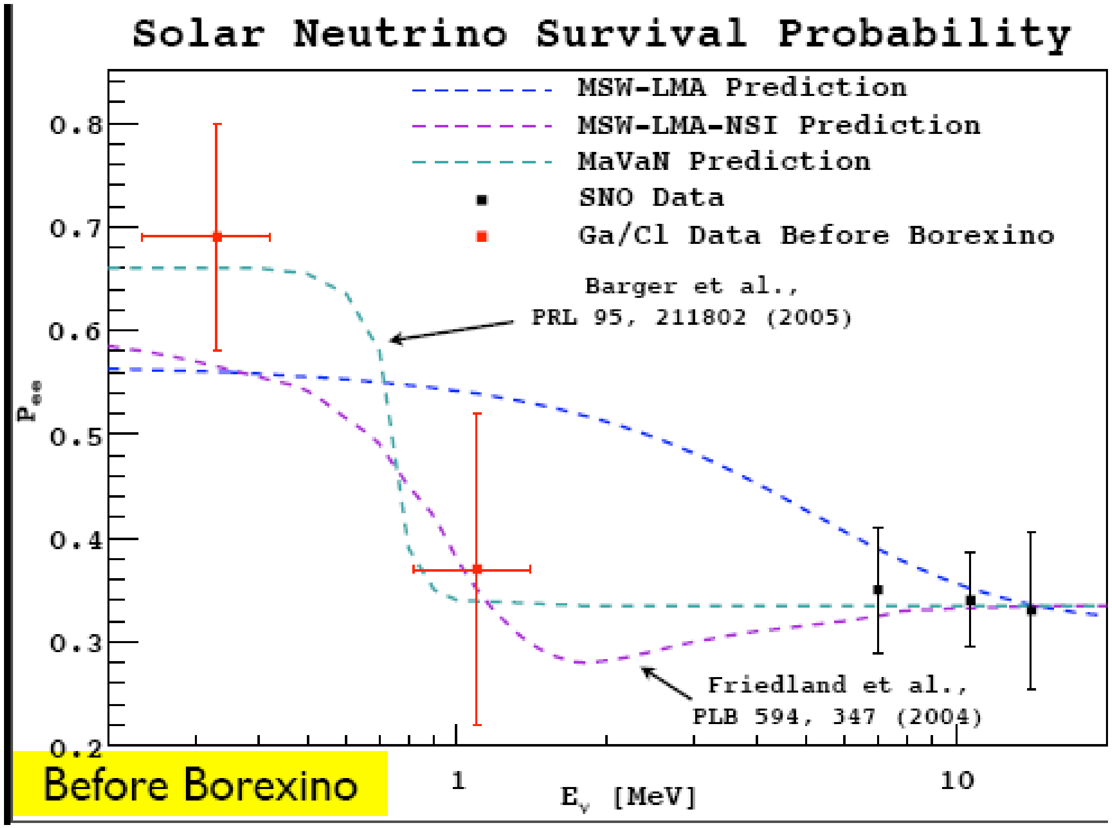


Low energy neutrinos:
flavor change dominated by vacuum oscillations;

High energy neutrinos:
Resonant oscillations in matter (MSW effect):
Effective electron neutrino mass
is increased due to the charge current interactions
with electrons of the Sun

Transition region:
Decrease of the ν_e survival probability (P_{ee})

Solar neutrino survival probability
BEFORE BOREXINO



Vacuum regime

Matter regime

Low energy neutrinos:
flavor change dominated
by vacuum oscillations;

High energy neutrinos:
Resonant oscillations in matter
(MSW effect):
Effective electron neutrino
mass
is increased due to the charge
current interactions
with electrons of the Sun

Transition region:
Decrease of the ν_e survival
probability (P_{ee})

Scientific goals of Borexino

- **The first real-time measurement of sub-MeV solar neutrinos;**
- The first simultaneous measurement of solar neutrinos from the transition region (^{7}**Be-**ν) and from the matter-enhanced oscillation region (^{8}**B-**ν).
- Precision measurement (at or below the level of 5%) of the ^{7}Be-ν rate to test P_{ee} :
  - the SSM and MSW-LMA solution of the Standard Solar Problem
  - indications of the mass varying neutrinos
  - indications of non-standard neutrino-matter interactions
- Test the balance between the neutrino and photon luminosity of the Sun;
- Check the 7% **seasonal variation** of the neutrino flux (confirm solar origin);
- Under study: first measurement of the **CNO** neutrinos (sun metallicity controversy);
- Under study: ***pep*** neutrinos – indirect constrain on the pp-flux;
- High energy tail of ***pp*** neutrinos ?
- Antineutrinos and **geoneutrinos**;
- **Supernovae** neutrinos and antineutrinos;

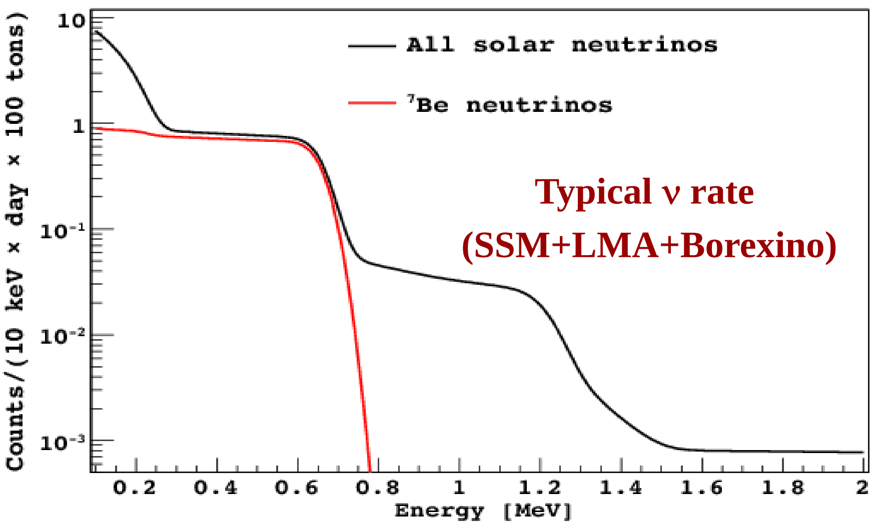
Detection principles and ν signature

- **elastic scattering on electrons** in **highly purified** organic **liquid scintillator**
  - ^{7}**Be ν** is the main design goal.
  - ^{8}B, pep, CNO and possibly pp ν are additional solar emissions that can be studied.

- Detection via scintillation light:
  - \+ Very low energy threshold
  - \+ Good position reconstruction
  - \+ Good energy resolution

  BUT…
  - – No direction measurement
  - – The ν induced events can't be distinguished from other β events due to natural radioactivity

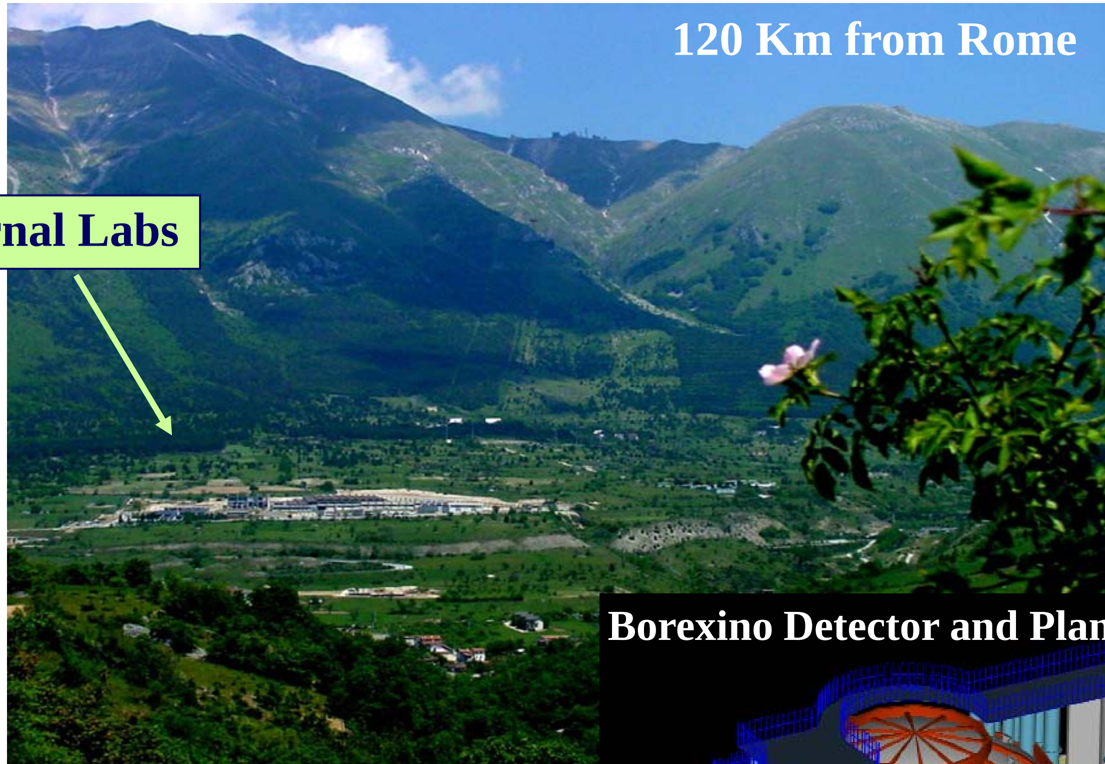
- **Extreme radiopurity of the scintillator is a must!**

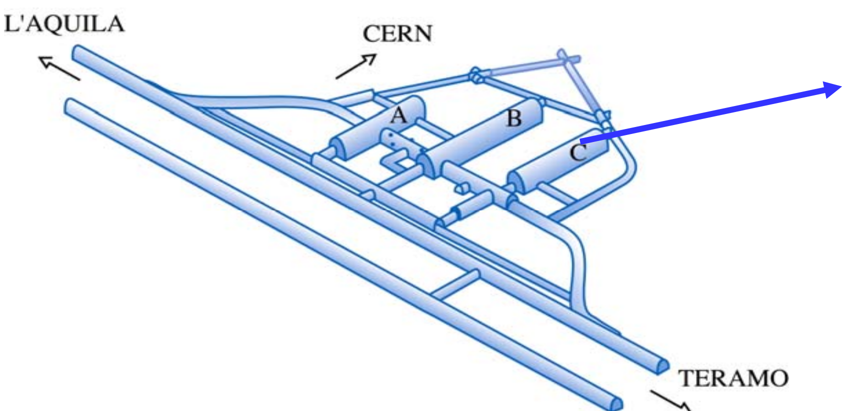


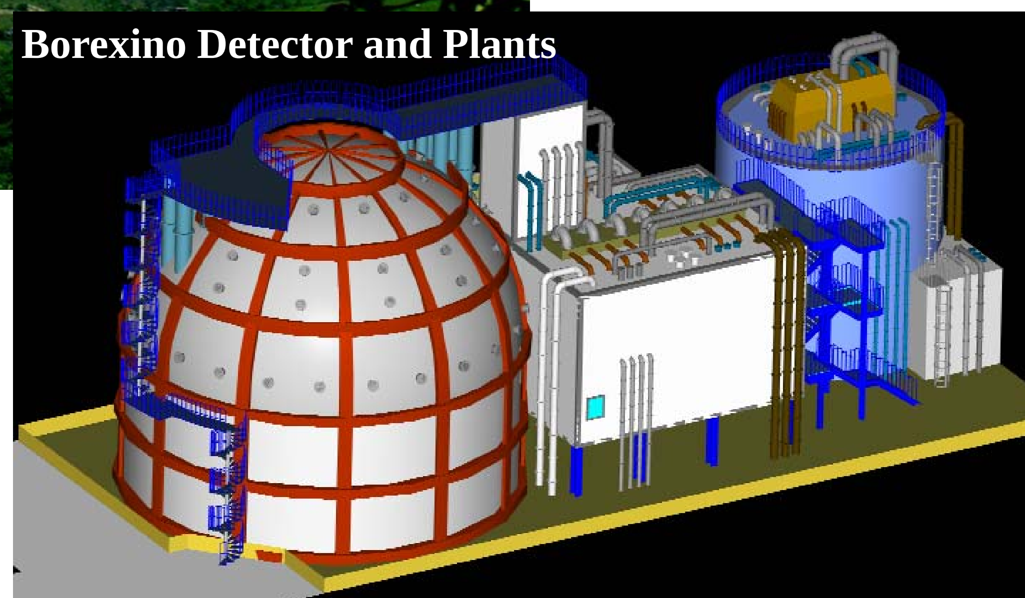
Experimental site

Laboratori
Nazionali del
Gran Sasso

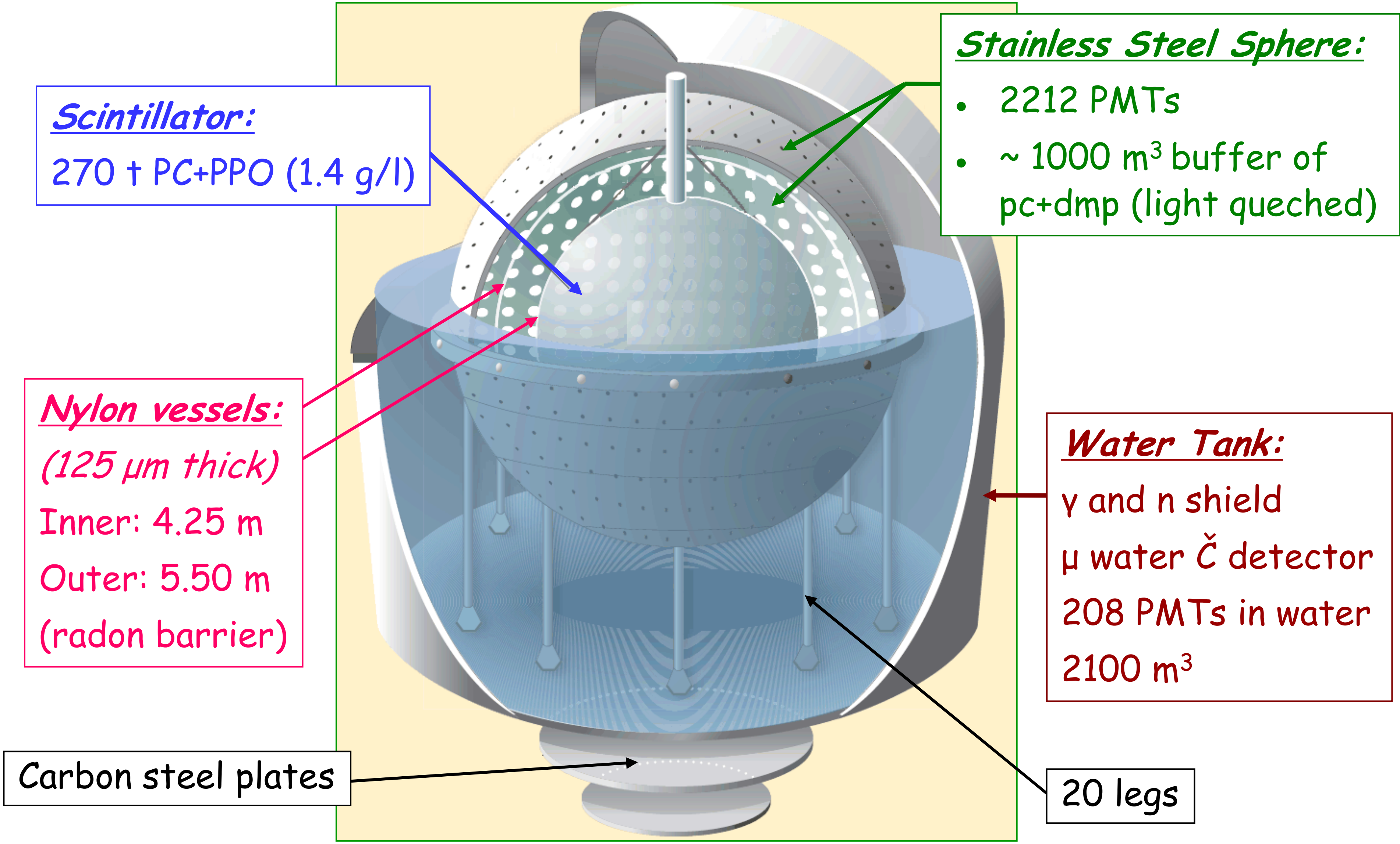
Assergi (AQ)
Italy
1400m of rock shielding
~3500 m.w.e.







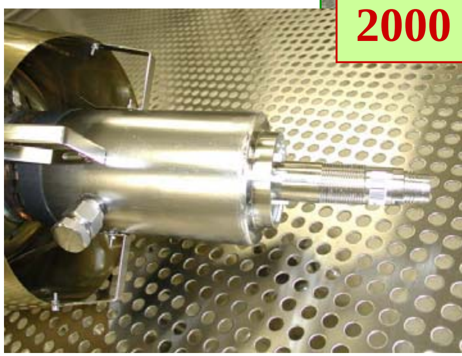
Detector layout and main features



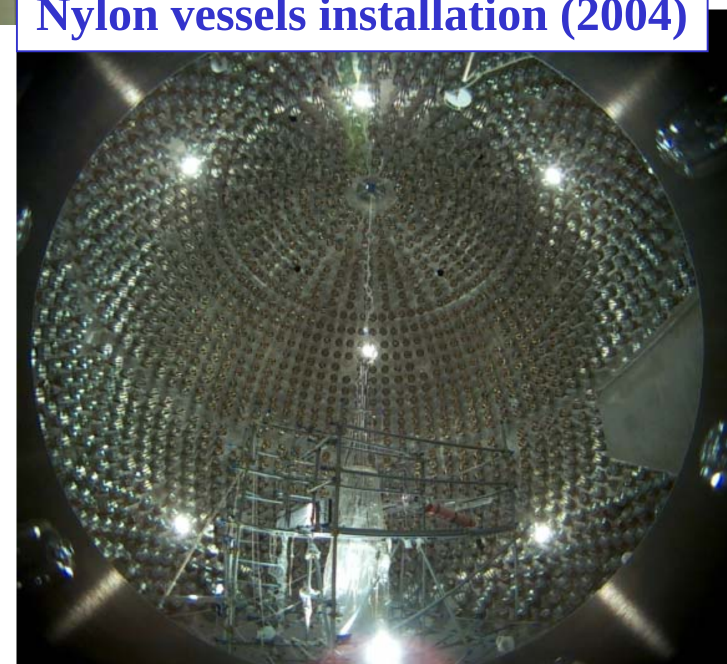
Picture gallery

Pmt sealing: PC & Water proof

2000

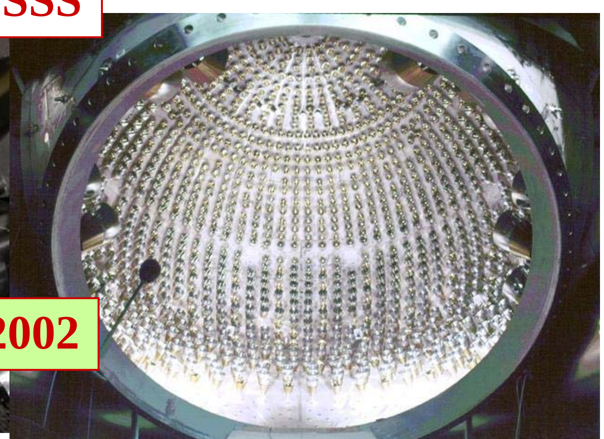


Nylon vessels installation (2004)



PMT installation in SSS

2002



Filling 1/3

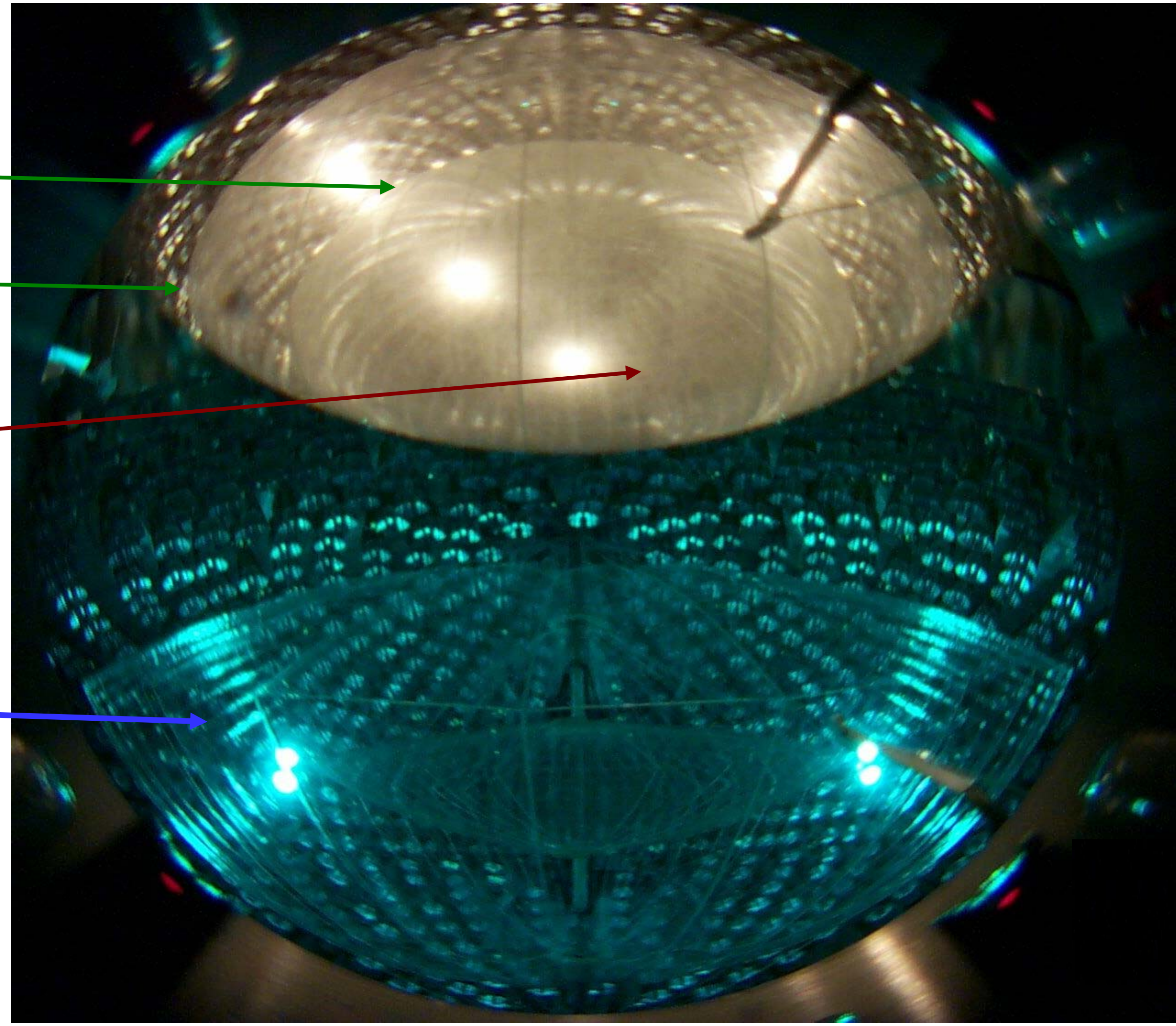
End October 2006

Nylon Vessels
Inner: 8.5 m
Outer: 11.0 m

LAKN – Low Argon and Krypton Nitrogen

Ultra-pure water

Foto taken with one of 7 CCD cameras placed inside the detector

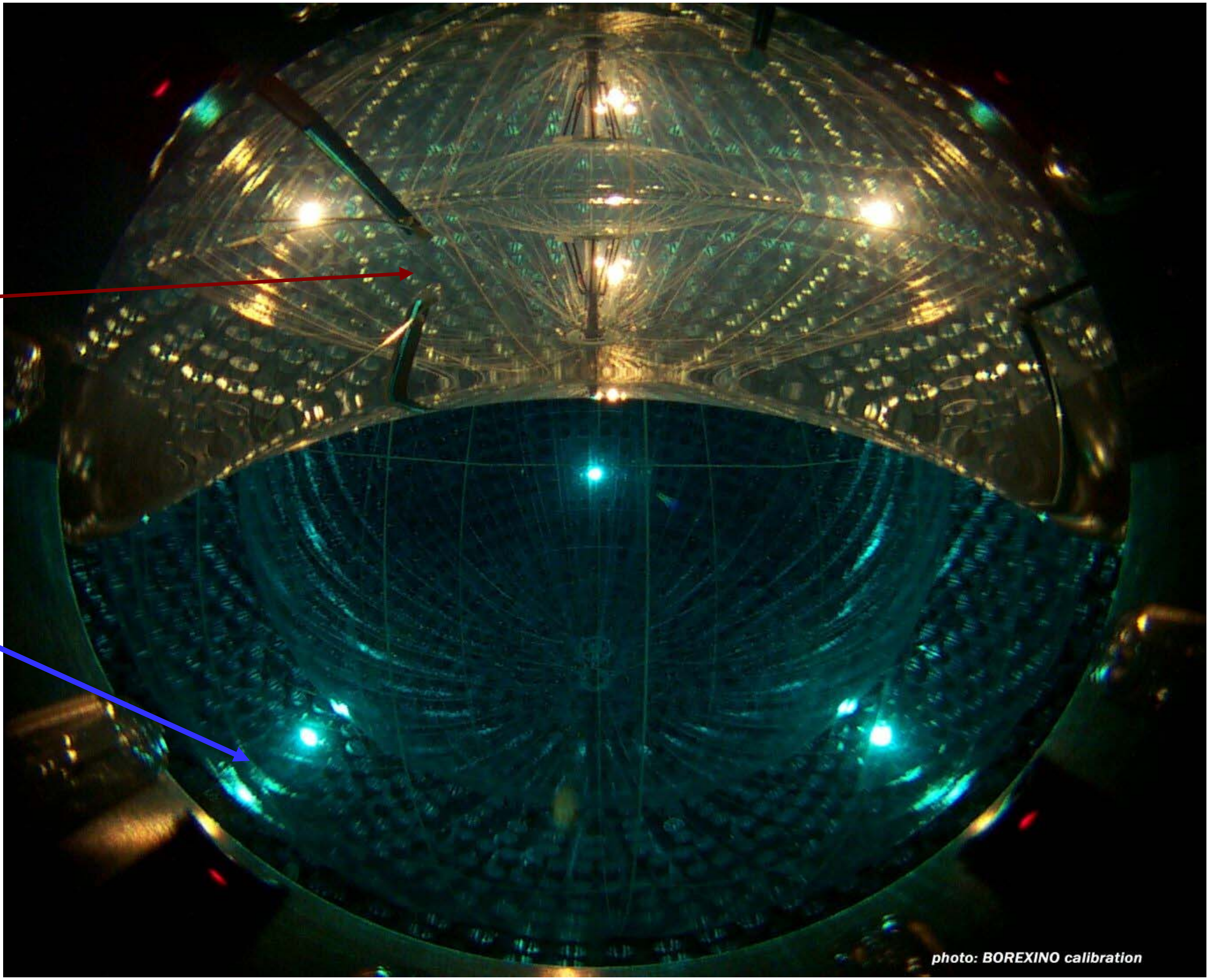


Filling 2/3

March 2007

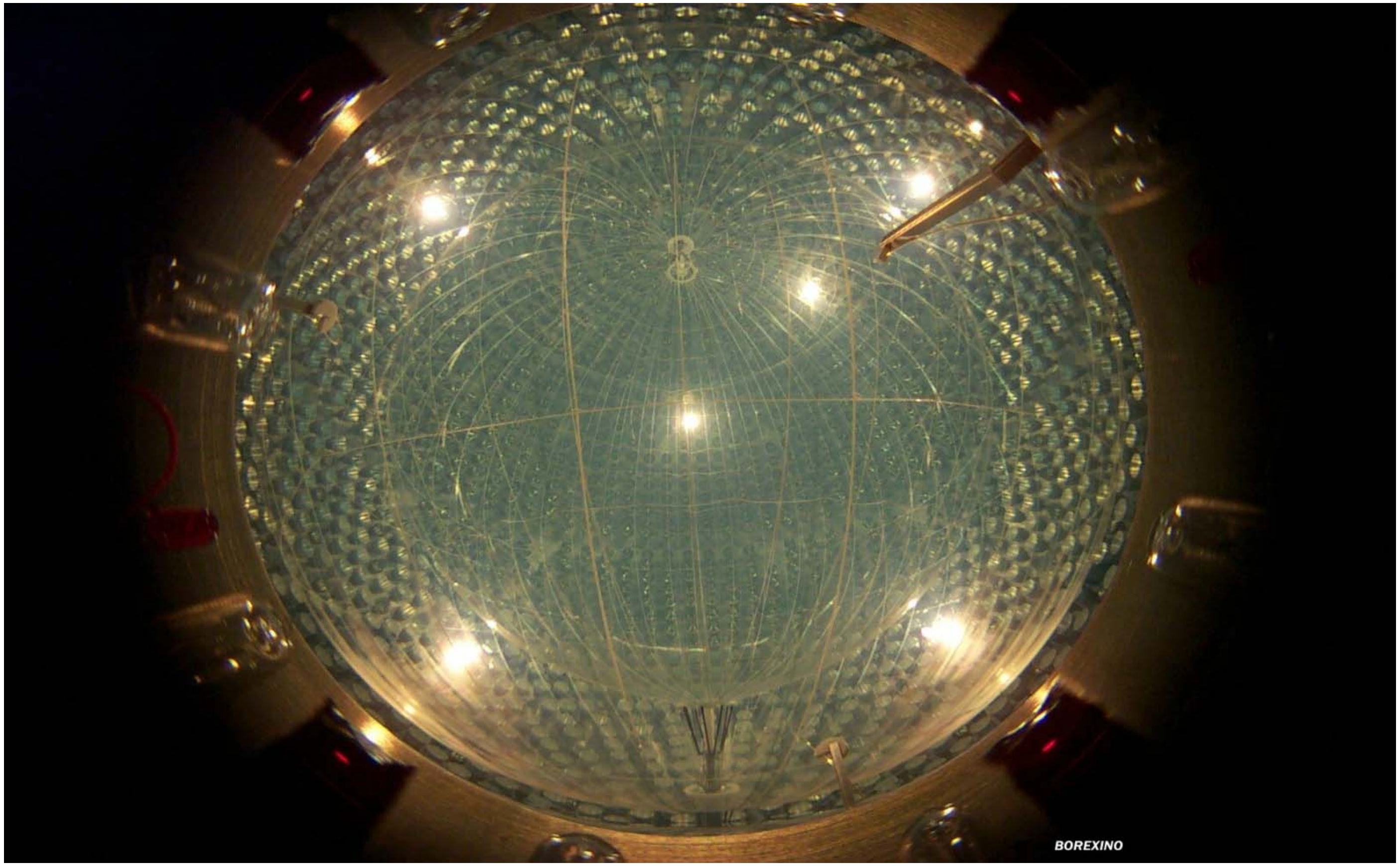
Liquid scintillator

Ultra-pure water



Filling 3/3

Detector fully filled on May 15th, 2007
DAQ STARTS



Detector performances

Lighth yield

1) ^{14}C spectrum, β^- decay 156 keV end point;
2) ^{11}C spectrum, β^+ decay 960 keV, triple coincidence with muon and neutron;
3) Global spectral fit (^{14}C, ^{210}Po, ^{7}Be edge);

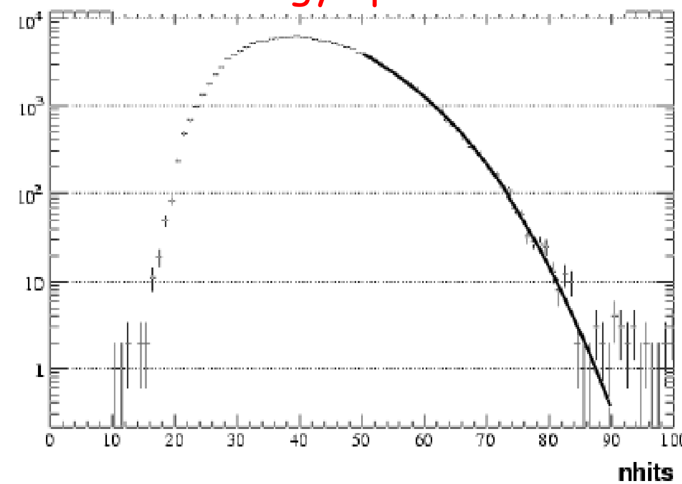
(500 ± 12) p.e./MeV

taking into account quenching factor

Energy resolution (σ): 10% @ 200 keV
8% @ 400 keV
6% @ 1000 keV

Spatial resolution: 35 cm @ 200 keV
(scaling as $N_{p.e.}^{-1/2}$) 16 cm @ 500 keV

^{14}C energy spectrum



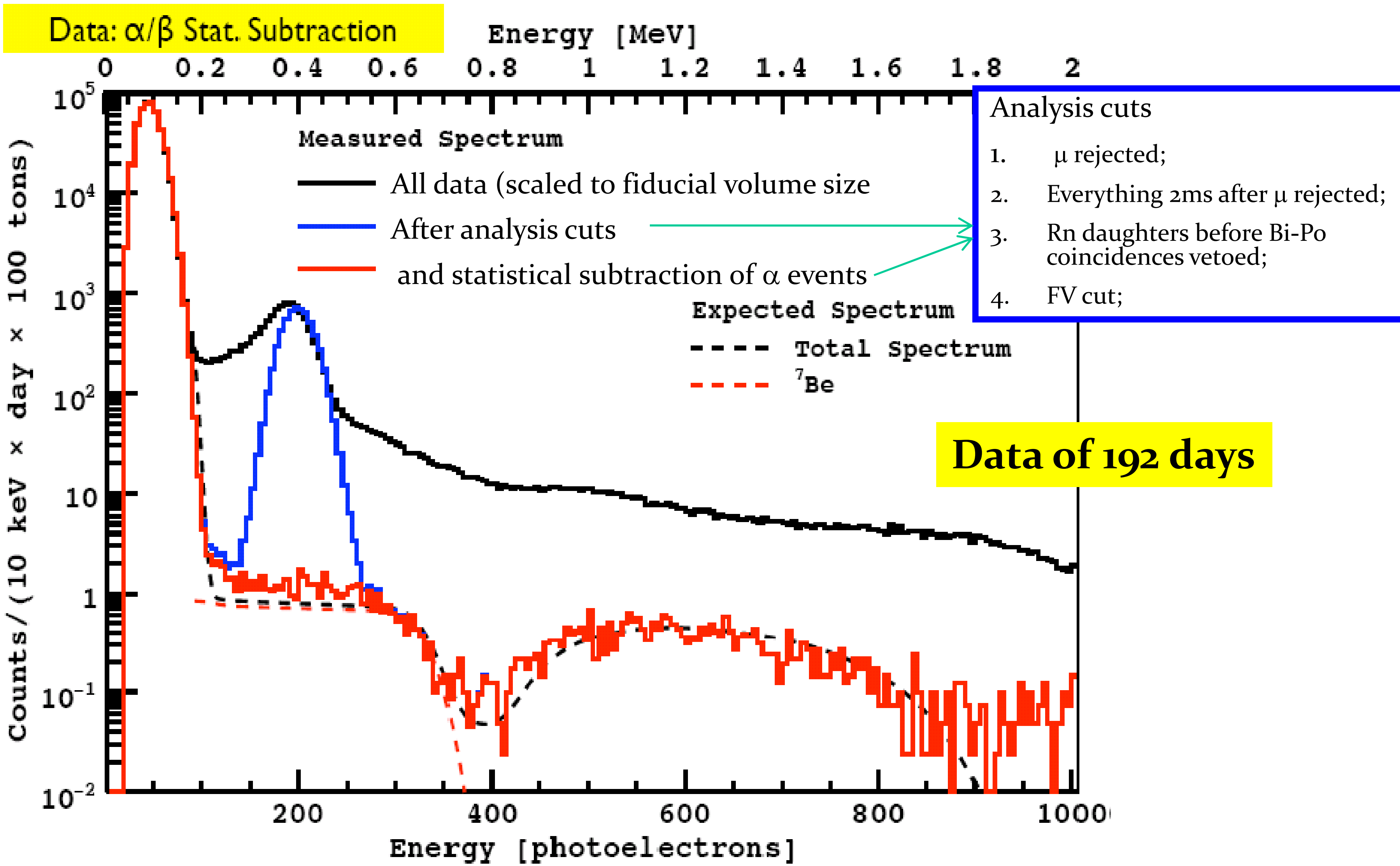
Fiducial volume definition

- the nominal Inner Vessel radius: 4.25 m (278.3 tons of scintillator)
- how to define fiducial volume of 100 tons?

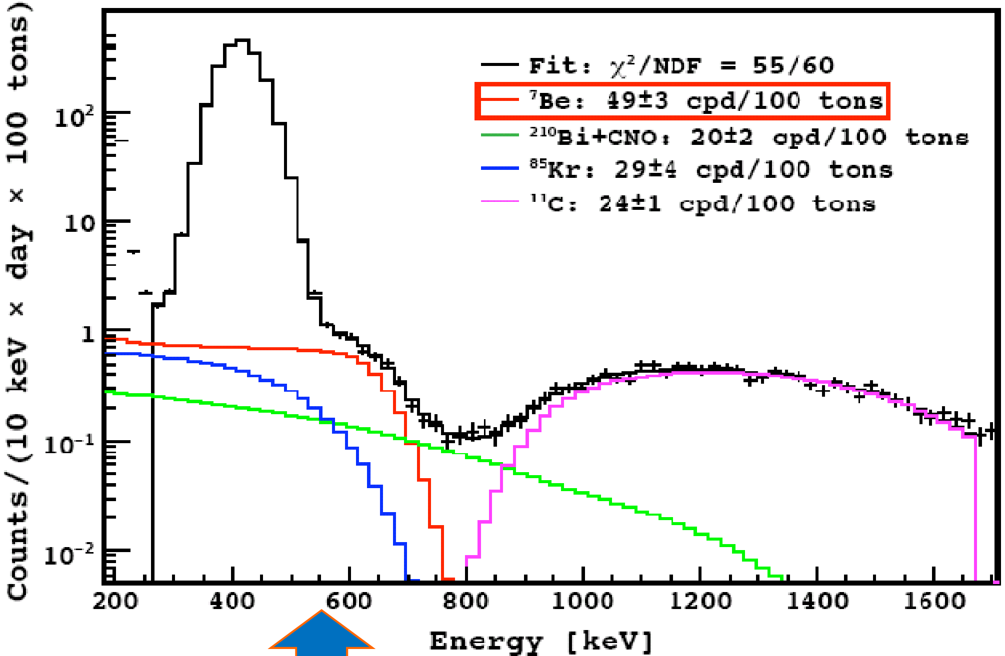
1) rescaling background components known to be uniformly distributed within the scintillator (^{14}C bound in scintillator itself, capture of μ-produced neutrons on protons)

2) using the sources with known position:
(Th emitted by the IV-nylon, γ external background, teflon diffusers on the IV surface)

Experimental spectrum

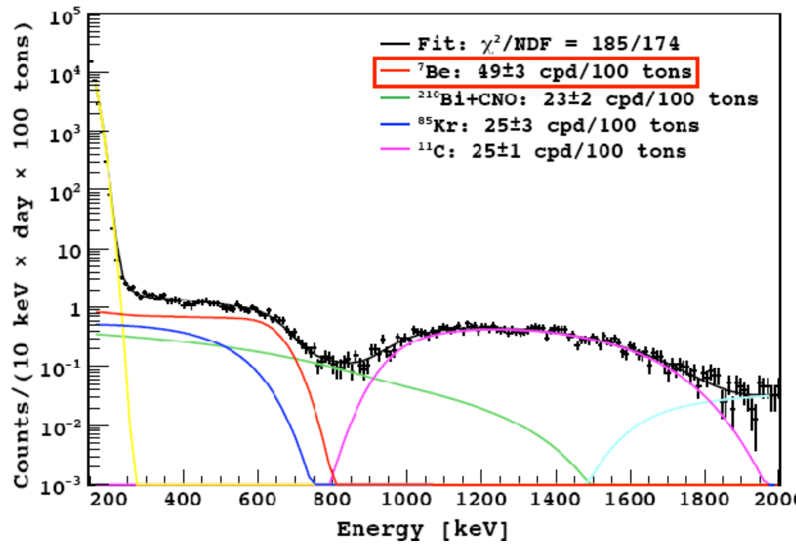


Spectral fit



- Fit between 100-800 p.e.
- Light yield: a free fit parameter
- Light quenching included [Birks' parametrization]
- ^{210}Bi/CNO, ^{11}C and ^{85}Kr free fit parameters

Fit to the spectrum **without** and **with** a-subtraction is performed giving consistent results



^{7}Be: (49 ± 3$_{STAT}$) cpd/100 tons

Systematic uncertainties

Source	Syst.error (1σ)
Tot. scint. mass	± 0.2%
Live Time	± 0.1%
Efficiency of Cuts	± 0.3%
Detector Resp.Function	± 6%
Fiducial Mass	± 6%
TOT	± 8.5%

$49 \pm 3_{stat} \pm 4_{sys}$ cpd/100 tons

	Expected rate (cpd/100 t)
No oscillation	75 ± 4
BPS07(GS98) HighZ	48 ± 4
BPS07(AGS05) LowZ	44 ± 4

To further reduce these errors
we need calibration!

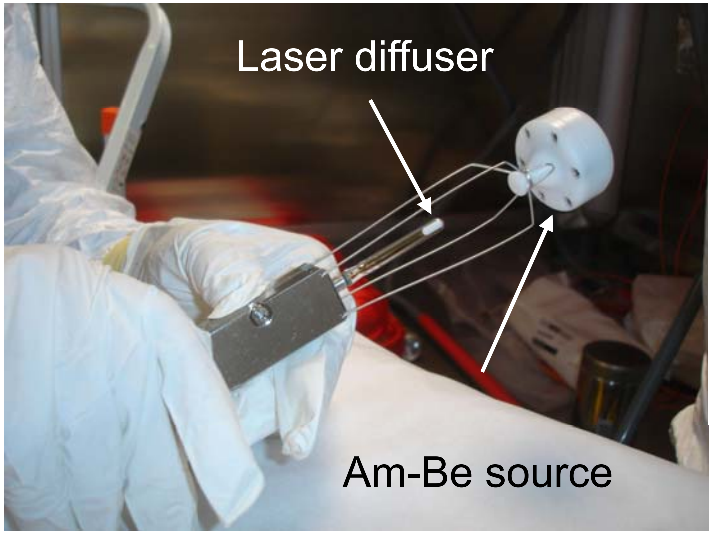
No-oscillation hypothesis rejected at 4σ level

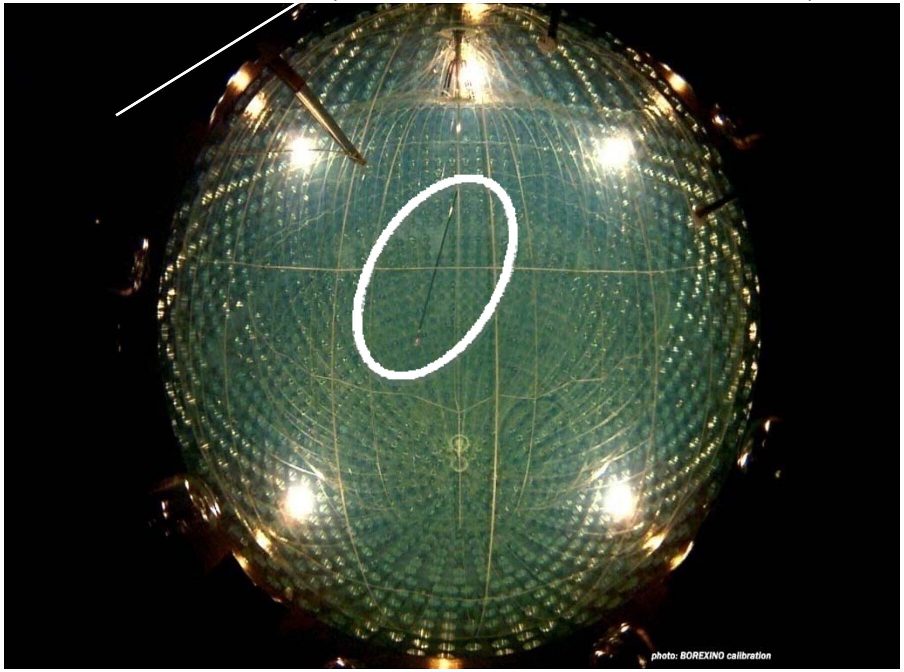
Calibration campaigns

3 calibration campaigns performed:

Oct 08 on axis / Jan-Feb09 on-off axis / Jun-Jul09 off axis

- accurate position reconstruction
- precise energy calibration
- detector response vs scintillation position



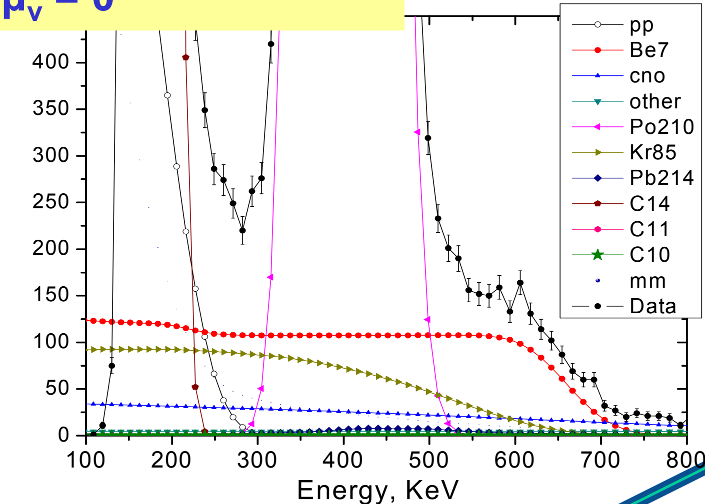


100 Hz $^{14}C + ^{222}Rn$ source diluted in PC:
115 points inside the sphere

β : ^{14}C, ^{222}Rn diluted in scintillator vial
α : ^{222}Rn diluted in scintillator vial
γ : ^{54}Mn, ^{85}Sr, ^{222}Rn in air
n : AmBe

Neutrino magnetic moment

$\mu_\nu = 0$



SM with $m_\nu = 0$: $\mu_\nu = 0$

T – kinetic energy of scattered *e*

E_ν – neutrino energy

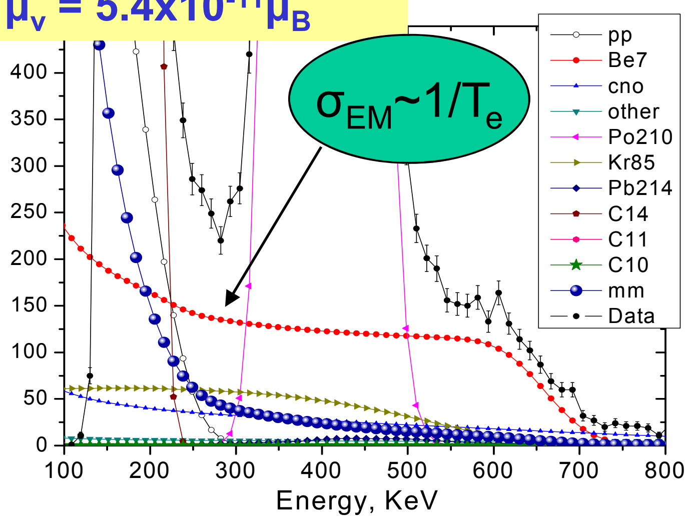
$$\left(\frac{d\sigma}{dT}\right)_W = \frac{2G_F^2 m_e}{\pi}\left[g_L^2 + g_R^2 + \left(1 - \frac{T}{E_\nu}\right)^2 - g_L g_R \frac{m_e T}{E_\nu^2}\right]$$

$$\left(\frac{d\sigma}{dT}\right)_{EM} = \mu_\nu^2 \frac{\pi\alpha_{em}^2}{m_e^2}\left(\frac{1}{T} - \frac{T}{E_\nu}\right)$$

Sensitivity enhanced @ low energies

$m_\nu>0$ $\mu_\nu>0$: additional EM term

$\mu_\nu = 5.4\times10^{-11}\mu_B$



Estimate	Method	90% C.L. 10^{-11} μ_B
SuperK [**D.W. Liu** *et al., Phys. Rev. Lett. 93, 021802 (2004)]*	^{8}B above 5 MeV	< 11
Montanino *et al.*	^{7}Be (Borexino early data)	< 8.4
GEMMA [**G. Beda** et al., Yad.Phys. 70, 1925 (2007)]	Reactor anti-ν	< 5.8
Borexino	**^{7}Be**	**< 5.4**

Currently the best experimental limit!

Constraints on *pp* & CNO fluxes

Combination of Borexino results on ^{7}Be flux with other experiments: constrain the fluxes of pp and CNO ν_e

- The measured rate in Clorine and Gallium experiments can be written as:

$$\mathbf{R_k = \sum_{i,k} f_i R_{i,k} P_{ee}^{i,k}}$$

$$f_i = \frac{\phi_i(measured)}{\phi_i(predicted)}$$

$$R_{i,k} = \text{expected rate of source "i" in experiment "k" (no oscill.)}$$

$$P_{ee}^{i,k} = \text{average survival probability for source "i" in experiment "k"}$$

$$k = Homestake, Gallex$$

$$i = pp, pep, CNO, {}^7Be, {}^8B$$

- $R_{i,k}$ and $P_{ee}^{i,k}$ are calculated in the hypothesis of **high-Z SSM** and **MSW LMA**, ;
- R_k are the rates actually measured by Clorine and Gallium experiments;
- $\mathbf{f_{8B} = 0.87 \pm 0.07}$, measured by **SNO** and **SuperK;**
- $\mathbf{f_{7Be} = 1.02 \pm 0.10}$ is given by **Borexino results**;
- Performing a χ^2 based analysis with the additional luminosity constraint;

$$f_{pp} = 1.005^{+0.008}_{-0.020} \ (1\sigma)$$

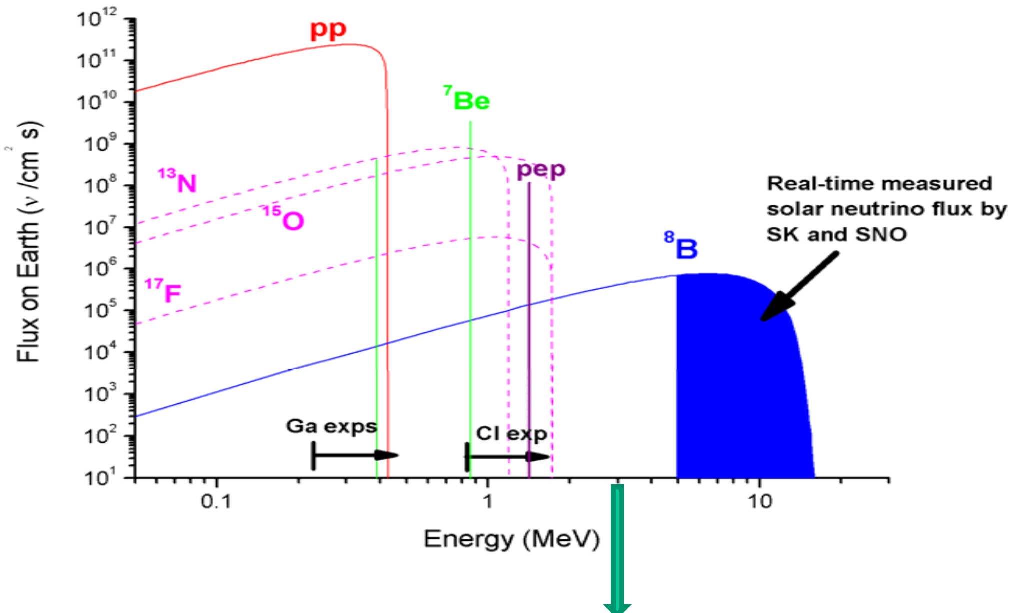
$$f_{CNO} < 3.80 \ (90\% \ C.L.)$$

Which is the best determination of *pp* flux (with luminosity constraint)

D. D'Angelo – Borexino coll.

^{8}B solar neutrino flux

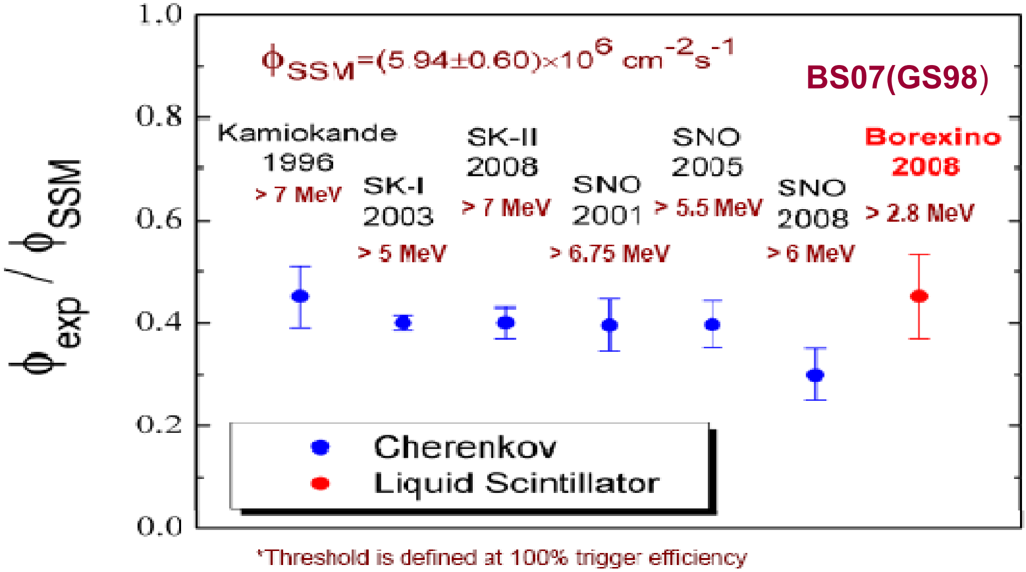
- The first simultaneous measurement of solar–ν from the **vacuum dominated region** (**^{7}Be-ν**) and from **the matter-enhanced** oscillation region **(^{8}B-ν);**
- The first measurement of **^{8}B-ν in real time below 5 MeV;**



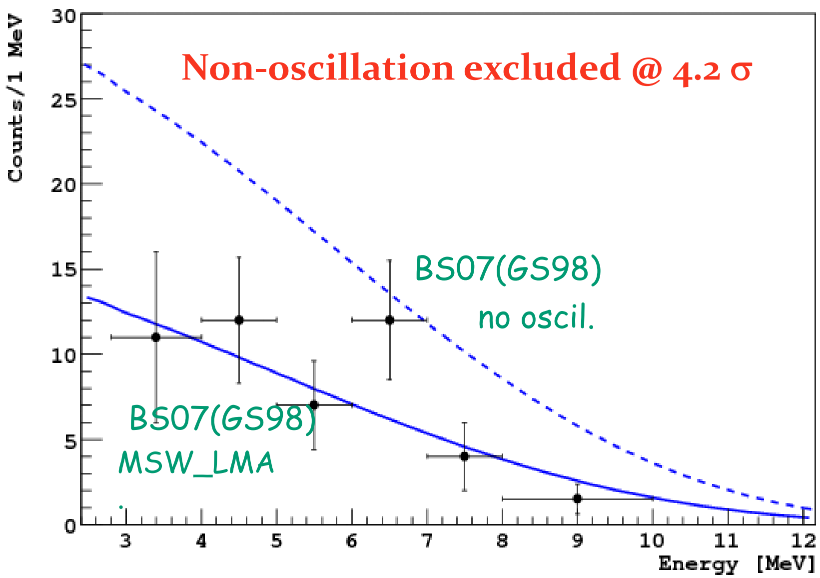
Borexino threshold for ^{8}B measurement

Major background sources:
1) Muons;
2) Gammas from neutron capture;
3) Radon emanation from the nylon vessel;
4) Short lived ($\tau < 2$ s) cosmogenic isotopes;
5) Long lived ($\tau > 2$ s) cosmogenic isotopes (^{10}C);
6) Bulk ^{232}Th contamination (^{208}Tl);

^{8}B solar neutrino flux



*Threshold is defined at 100% trigger efficiency



First real-time measurement down to 2.8 MeV:

$$Rate_{>2.8MeV} = (0.26 \pm 0.04 \text{ stat} \pm 0.02 \text{ sys}) \text{ counts/day /100 tons}$$

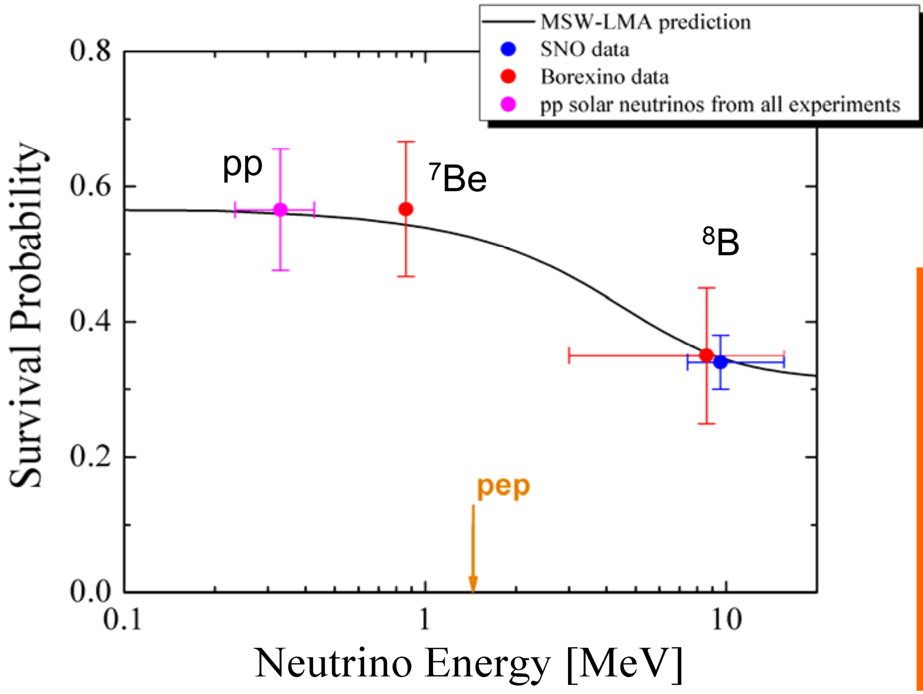
$$\left(\Phi^{ES}_{exp} / \Phi^{ES}_{th}\right)_{>2.8\,\text{MeV}} = (0.96 \pm 0.19)$$

Above 5 MeV in agreement with SNO and SuperK:

$$Rate_{>5MeV} = (0.14 \pm 0.03 \text{ stat} \pm 0.01 \text{ sys}) \text{ counts/day /100 tons}$$

$$\left(\Phi^{ES}_{exp} / \Phi^{ES}_{th}\right)_{>5\,\text{MeV}} = (1.02 \pm 0.23)$$

Survival probability after Borexino



Assuming high-Z SSM (BPS 07), the ^{7}Be rate measurement corresponds to

P_{ee} (^{7}Be) = 0.56 ± 0.10 (1σ)

which is consistent with the number derived from the global fit to all solar and reactor experiments (S. Abe et al., arXiv: 0801.4589v2)

P_{ee} (^{7}Be) = 0.541 ± 0.017

Assuming high-Z SSM (BPS 07) the ^{8}B rate measurement corresponds to

P_{ee} (^{8}B) = 0.35 ± 0.10 @ 8.6 MeV mean energy

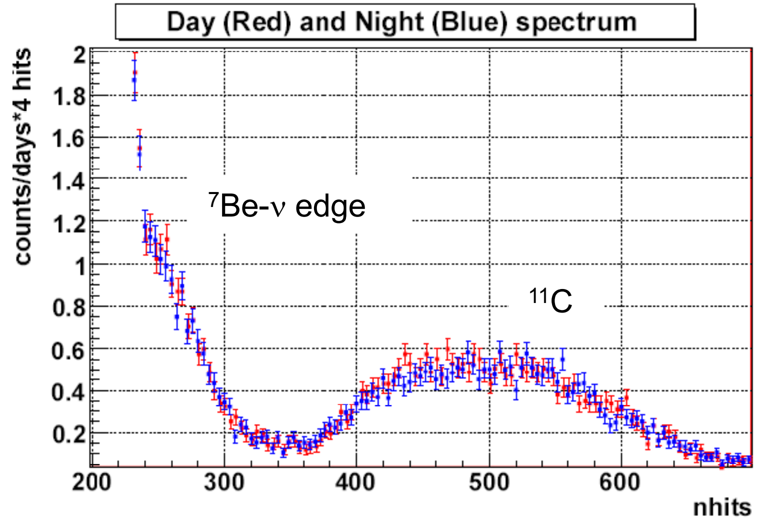
We determine the survival probability for ^{7}Be and pp-ν_e, assuming BPS07 and **using input from all solar experiments** (Barger *et al.*, PR (2002) 88, 011302)

P_{ee} (^{7}Be) = 0.56 ± 0.08

P_{ee} (pp) = 0.57 ± 0.09

Day/Night effects

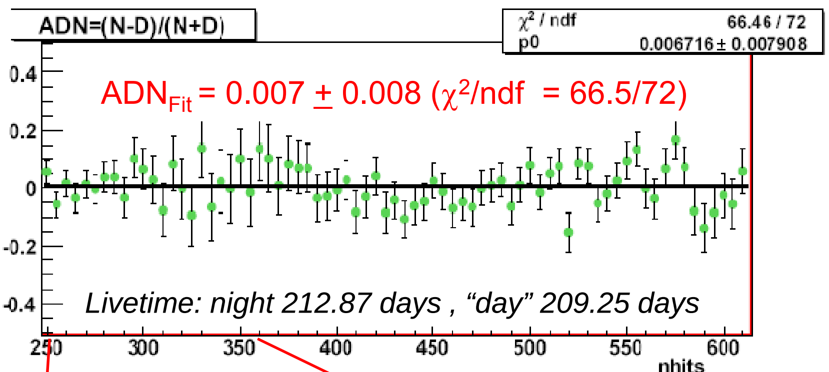
- **MSW mechanism:** possible ν_e regeneration at night: amplitude depends on latitude, E_ν and oscil. param. (θ, Δm^2)
- **LMA solution: no day/night effect**
- while LOW solution (already excluded by SNO, Kamland) and Mass Varying Models: a large effect
- **No observation in Borexino can confirm LMA solution at low E_ν**

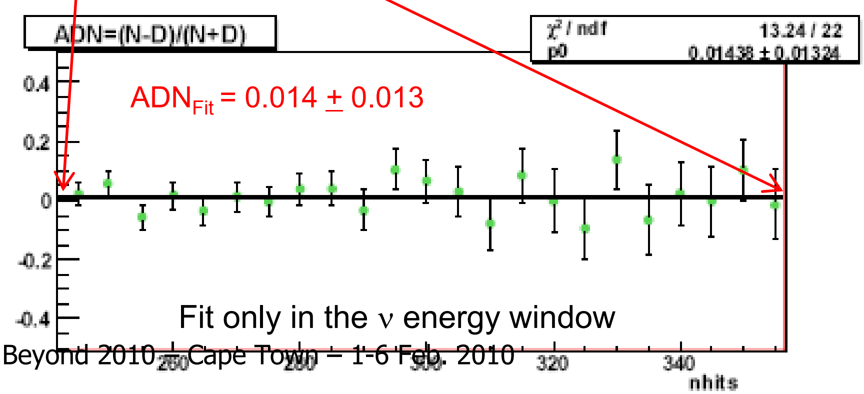


$$ADN = \frac{N-D}{N+D}$$

N = counts during night time in 1 year
D = counts during day time in 1 year

J. N. Bahcall et al. Phys. Rev C 56,5 2839 and JHEP04 (2002) 007





- ADN (ν signal + bkgr) is 0 within 1σ
- independent on the large systematic effects as FV definition and energy response function;
- ADN (ν signal only) = f (flux) => f(spectral fit):

$$\sigma_{ADN^{\upsilon}} \approx \frac{1}{\sqrt{2}} \frac{\sigma_{\Phi_{7Be}}}{\Phi_{7Be}}$$

$$ADN^{\upsilon} = 0.02 \pm 0.04_{stat}$$

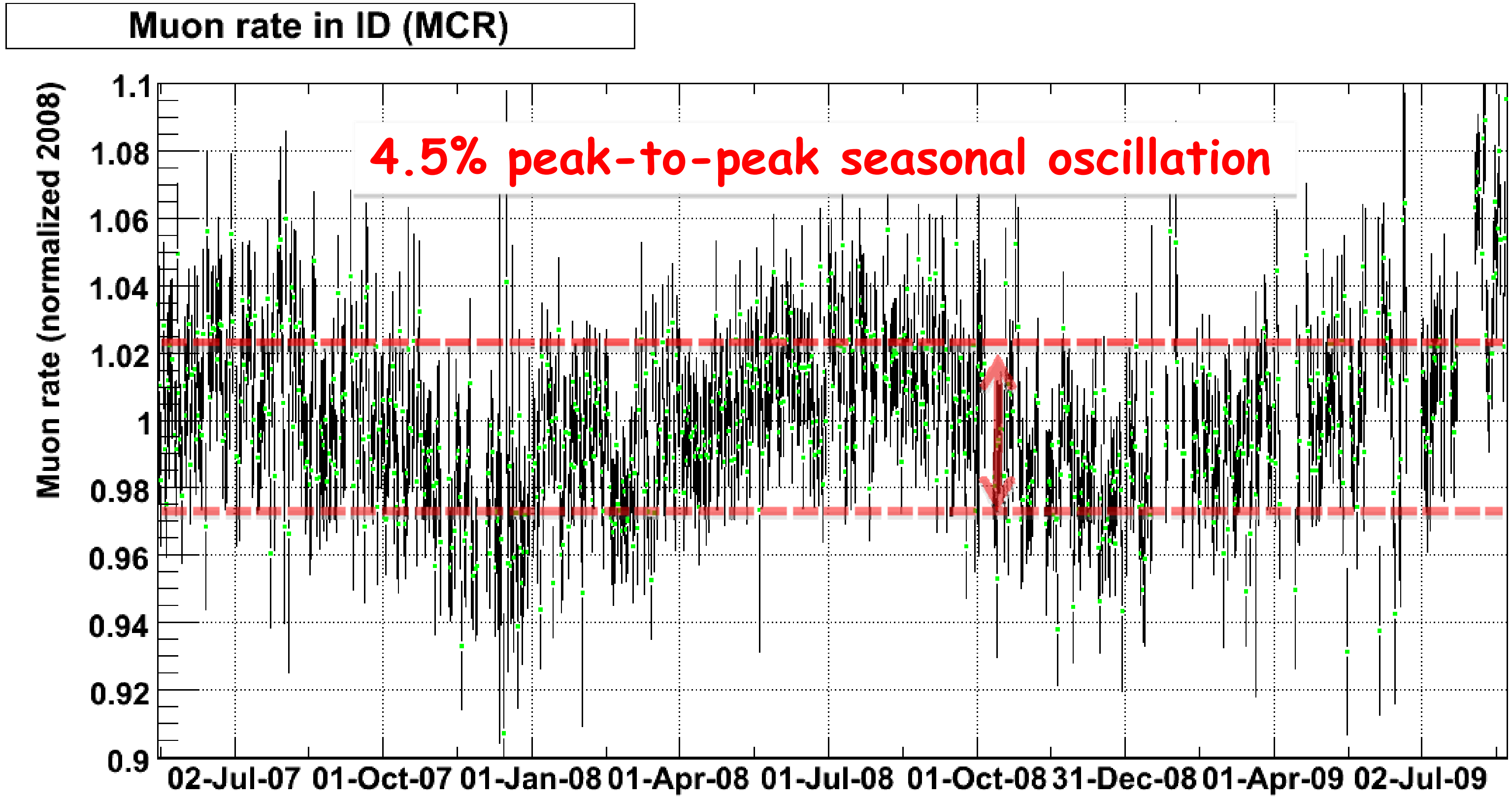
Systematic errors under study

PRELIMINARY

Cosmic muon flux

Muon rate: $(4312 \pm 4_{stat} \pm 4_{syst})$ cpd → $(1.22 \pm 0.01)\ h^{-1}\ m^{-2}$

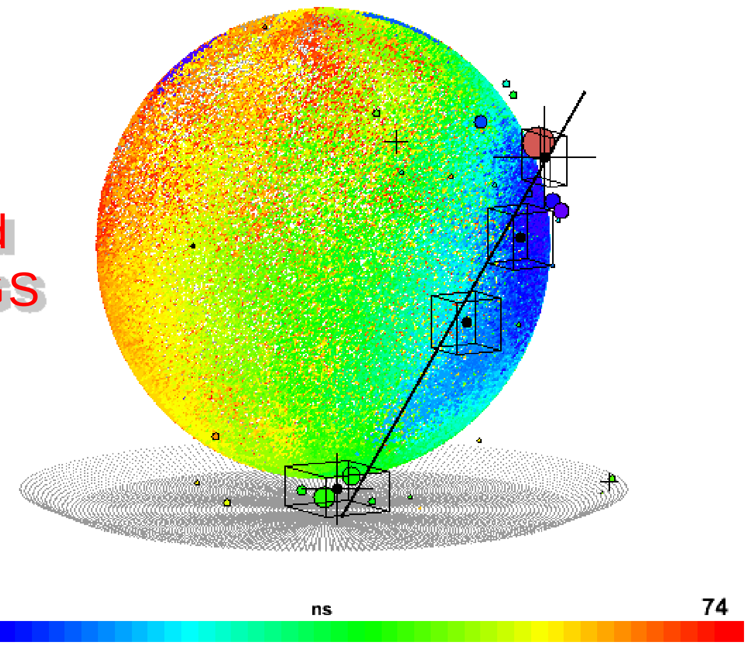
Macro rate: $(1.16 \pm 0.03)\ h^{-1}\ m^{-2}$, compatible at 2σ



PRELIMINARY

Muon Tracking

PRELIMINARY



Algorithms coverage: 99%

Uncorrelated tracks: 11%

Angular resolution (1σ):

~ 4° (θ)

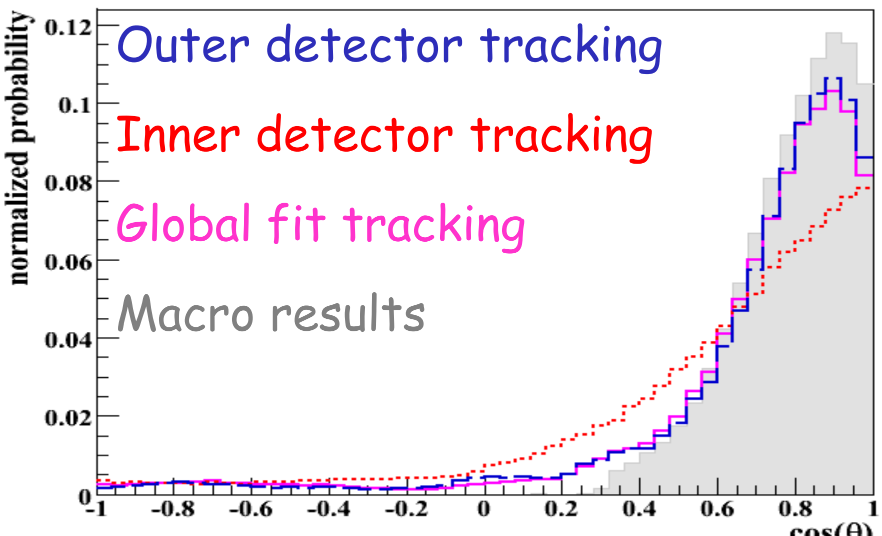
~ 9° (φ)

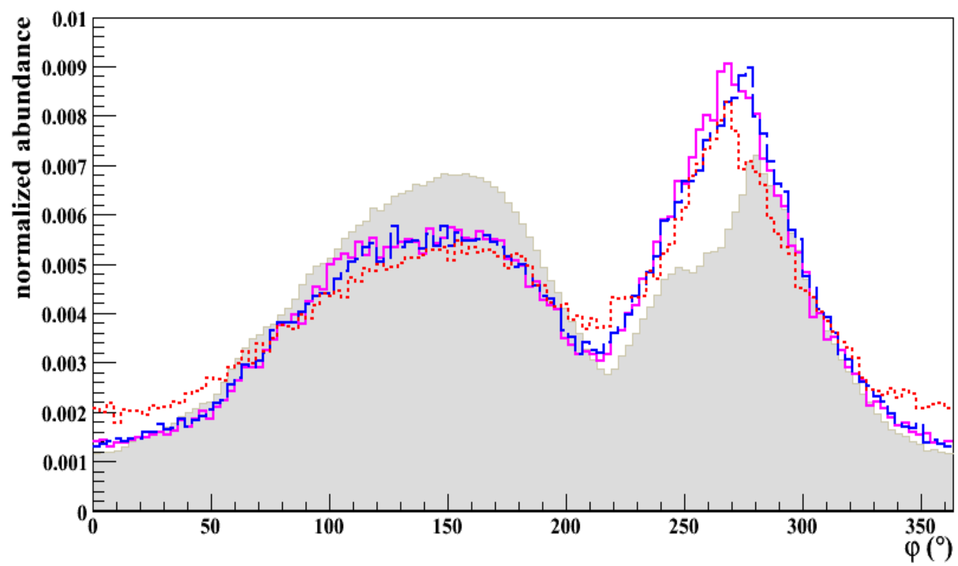
Lateral resolution: ~24cm

tested by CNGS

tested by cosmics

tested by neutrons





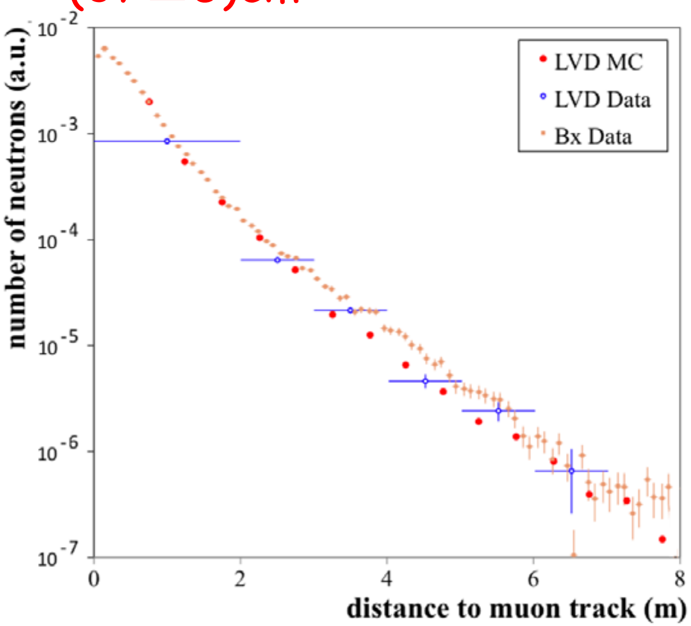
PRELIMINARY

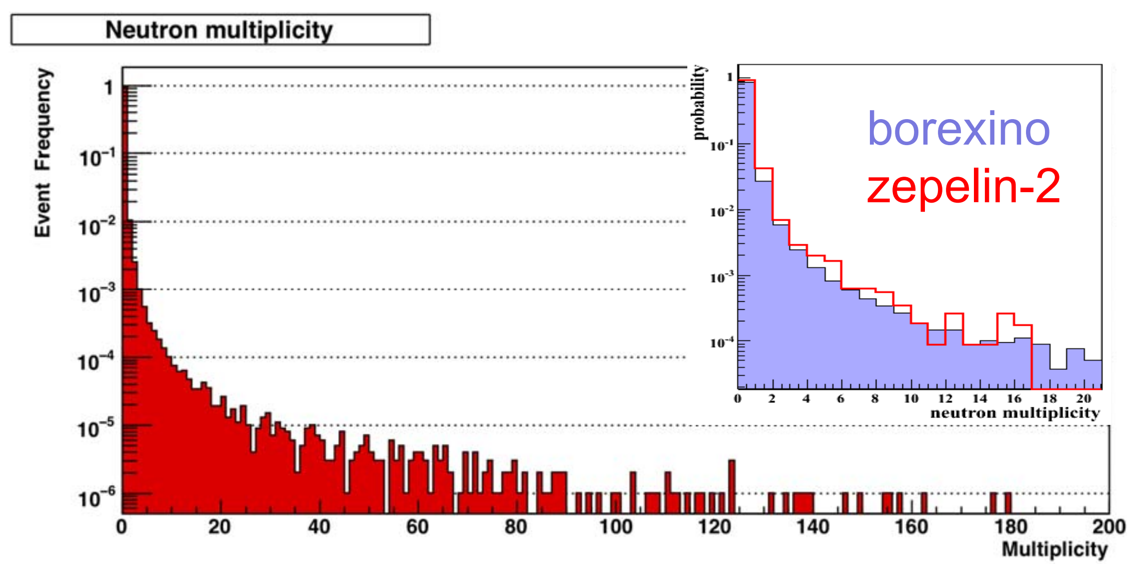
Cosmic Neutrons

What is observed is 2.2MeV-γ following capture on H

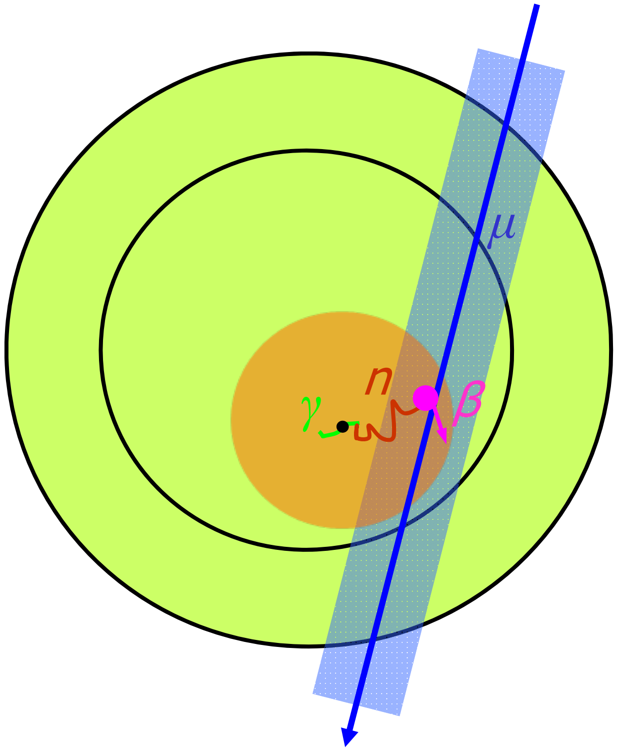
- Detection efficiency 92%
- Mean capt. time (258±2)μs
- Mean lateral dist. (37±5)cm

Experiment	Avg. E_μ	Target	10^{-4} n/(μ•g/cm^2)
Fluka/LVD	320GeV	C_nH_{2n}	2-3
KamLAND	260GeV	C_9H_{12}	2.8±0.3
Borexino	**320GeV**	**C_9H_{12}**	**$2.9_{-0.1}^{+0.3}$**





Going for *pep* and CNO: ^{11}C tagging



$$\mu + {}^{12}C \rightarrow \mu + {}^{11}C + n$$

τ (n capture): ~250µs

$$n + p \rightarrow d + \gamma_{2.2MeV}$$

$${}^{11}C \rightarrow {}^{11}B + e^{+} + \nu_e$$

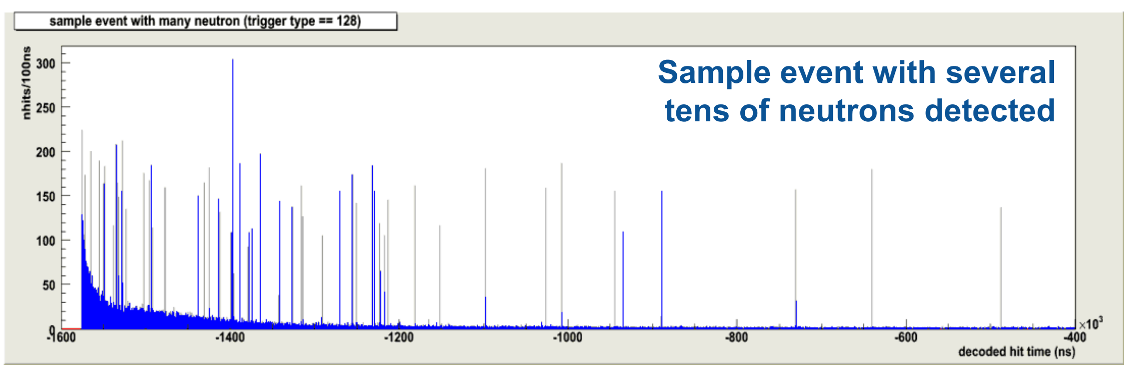
τ (^{11}C): ~30min

The main background for *pep* and CNO analysis is ^{11}C, a long lived (τ=30min) cosmogenic β^+ emitter with ~1MeV end-point (shifted to the 1-2MeV range)

^{11}C Production Channels:

[Galbiati et al., Phys. Rev. C71, 055805, 2005]

1. 95.5% with n: (X,X+n)
   - X = γ, n, p, $\pi^{\pm}$, $e^{\pm}$, μ.
2. 4.5% *invisible* :
   - (p,d); (π^+,π^0+p).

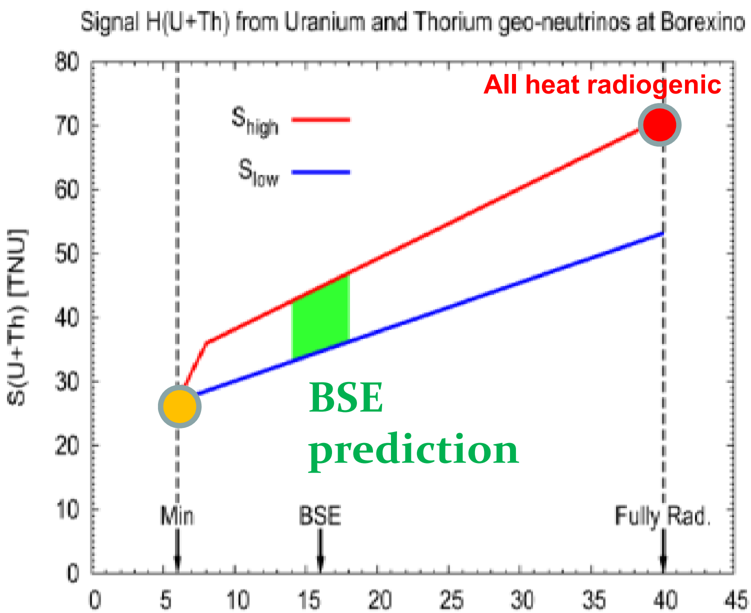


electronics improved in Dec 07 to be sensitive for this analysis:

1. after each muon **special 1.6 ms neutron gate opened**
2. FADC system in parallel

Borexino potential on geoneutrinos

(antineutrinos from the Earth, chains of U & Th, and K)



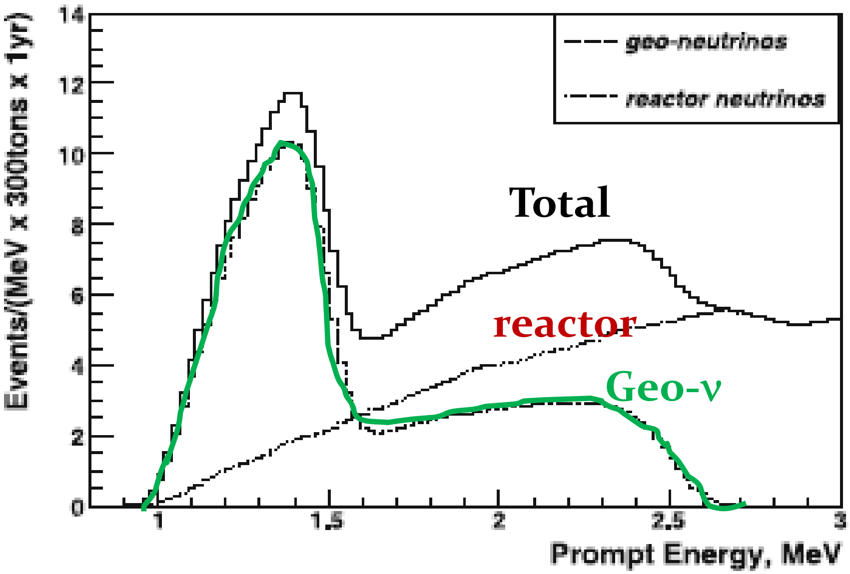
Heat (U+Th) [TW]

Mantovani et al., TAUP 2007

TNU = 1 event / 10^{32} target proton / year

Np (Borex) = 1.8 10^{31} target proton

Prompt signal energy spectrum (model)



5.7 events from reactors (in geo-ν E range)

BSE: 6.3 events from geoneutrinos

(per year and 300 tons, ε = 80%, 1-2.6 MeV)

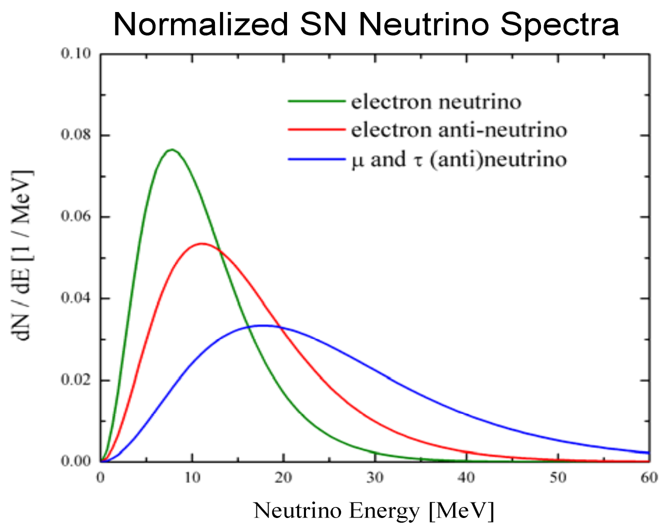
(Balata *et al.*, 2006, ref. model Mantovani *et al.*, 2004)

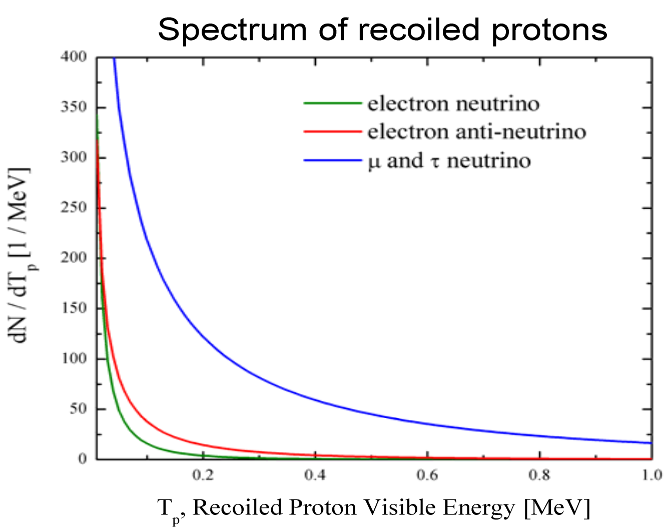
BSE: 3σ evidence of geoneutrinos expected in 4 years of data

Borexino potential on supernovae neutrinos

Standard galactic SN (10kpc, $3 \cdot 10^{53}$ erg)

Borexino:
E_{tresh} = 0.25 MeV
target mass = 300 t





Detection channel	# of events
ES (E_ν > 0.25 MeV)	5
Electron anti-neutrinos (E_ν > 1.8 MeV)	78
ν-p ES (E_ν > 0.25 MeV)	52
$^{12}C(\nu,\nu)^{12}C^*$ ($E\gamma$ = 15.1 MeV)	18
$^{12}C(\text{anti-}\nu,e^+)^{12}B$ ($E_{anti-\nu}$ > 14.3 MeV)	3
$^{12}C(\nu,e-)^{12}N$ (E_ν > 17.3 MeV)	9

Can be used as an early alarm

Borexino joined SNEWS in 2009

D. D'Angelo – Borexino coll.

Conclusions

DONE

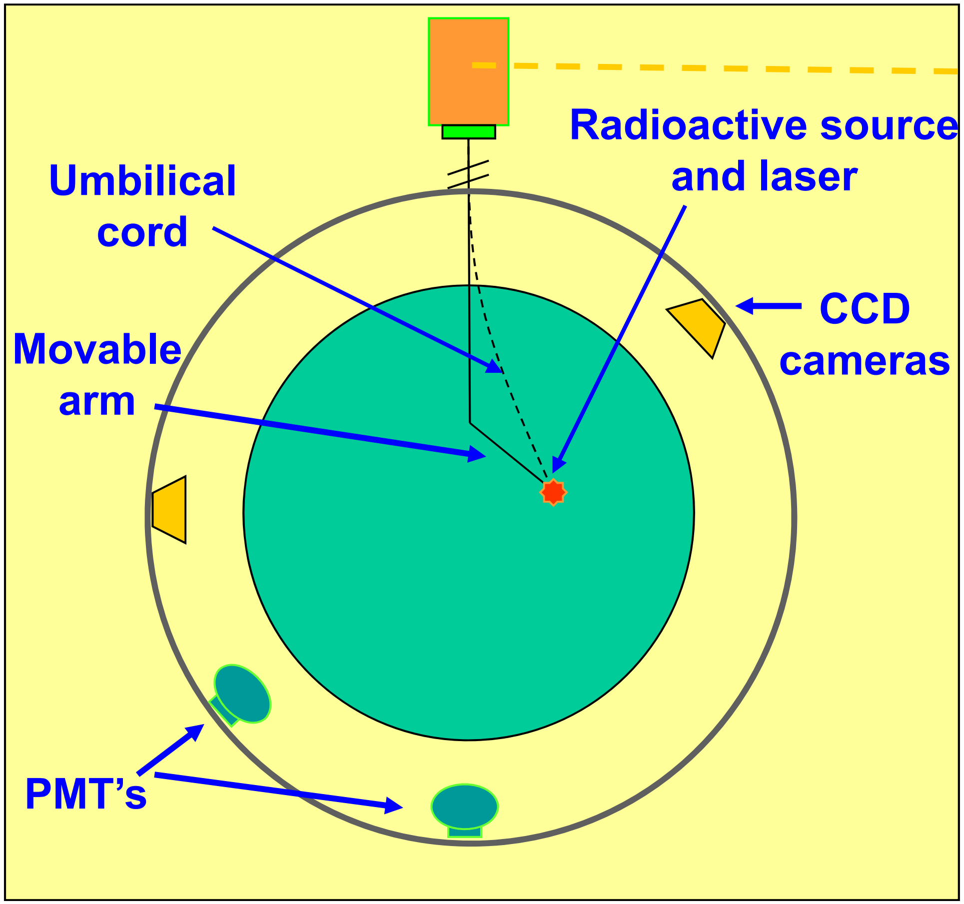
- First real-time measurement **of solar-ν below the barrier of natural radioactivity** (5 MeV) down to sub-MeV range
- The first real-time measurement of **^{8}B-ν above 2.8 MeV**
- The first **simultaneous** measurement of solar neutrinos from the **vacuum dominated region** (^{7}Be-ν) and from **the matter-enhanced oscillation region** (^{8}B-ν):
  - Confirmation for MSW-LMA solution
- **Best limits for pp- and CNO-ν,** combining information from all solar and reactor experiments
- Improve the limit of neutrino magnetic moment

TO BE DONE

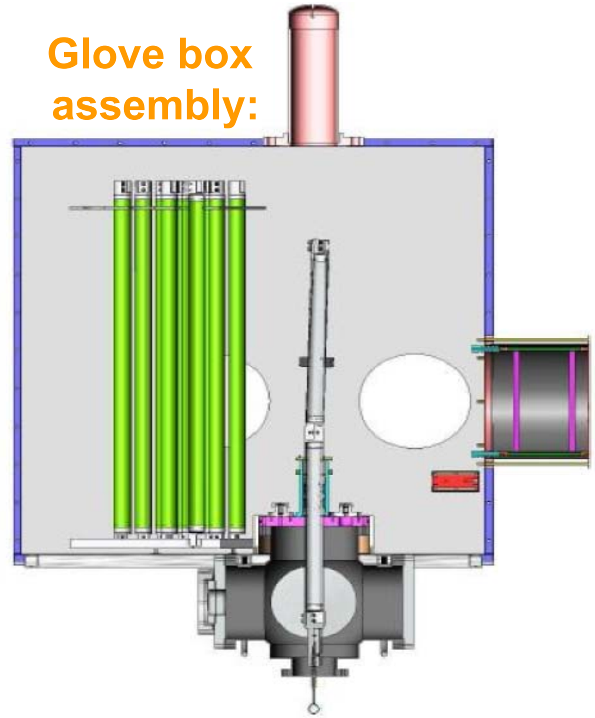
- Under finalization: precision measurement (at or below the level of 5%) of the ^{7}Be-ν rate;
- Check the 7% seasonal variation of the neutrino flux (confirm solar origin);
- Measurement of the CNO, pep and high-energy pp neutrinos;
- Strong potential in antineutrinos (geoneutrinos, reactor, from the Sun) and in supernovae neutrinos and antineutrinos;

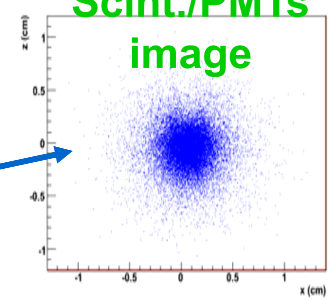
Additional slides

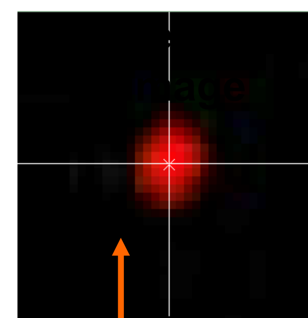
Source insertion system



Glove box assembly:



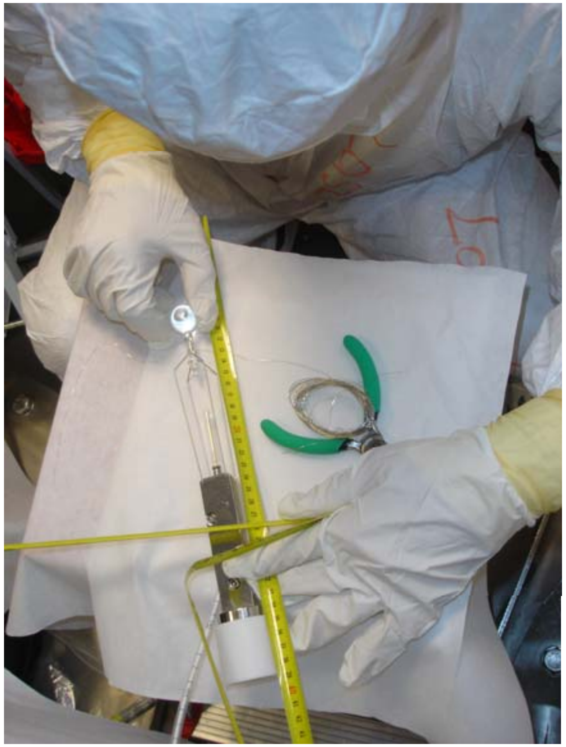


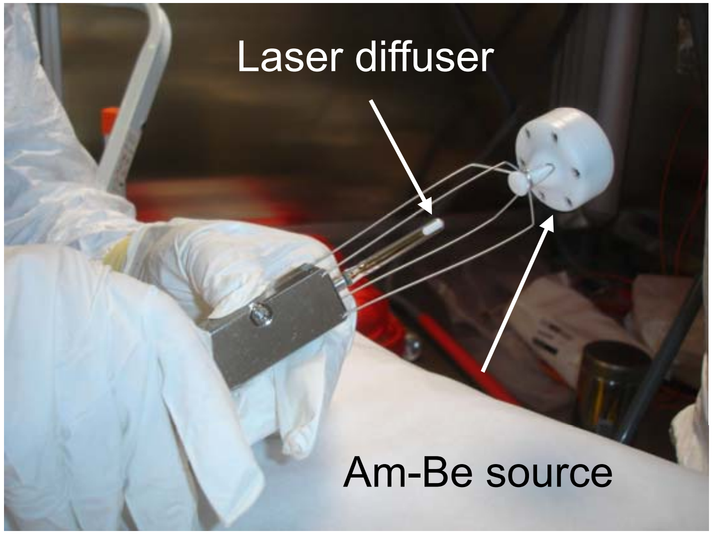


Source decays induced scintillation light/PMT's

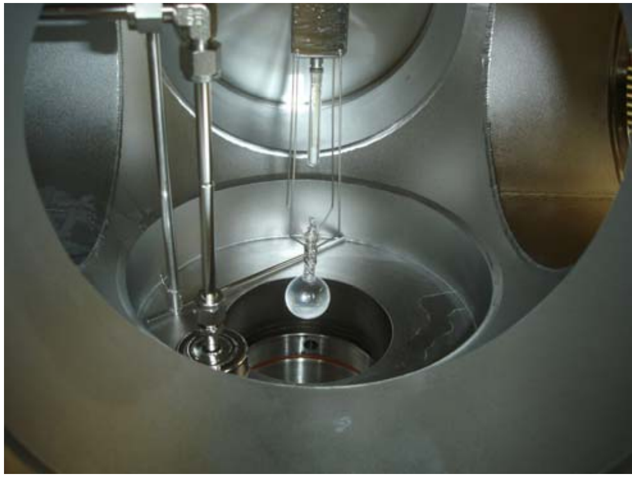
Red laser light/CCD cameras (accuracy: < 2 cm)

if you really like pictures…

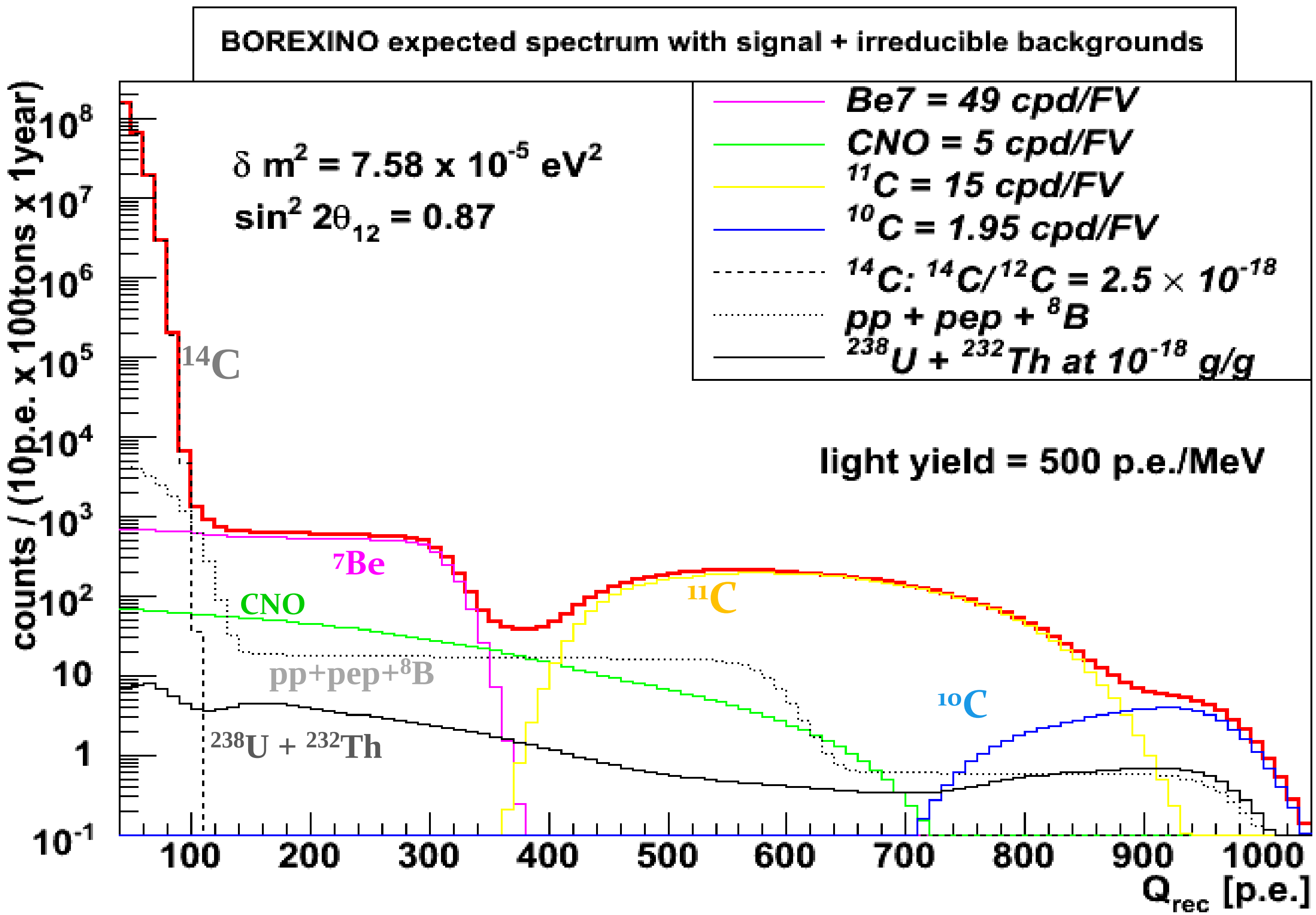




Source insertion in the cross



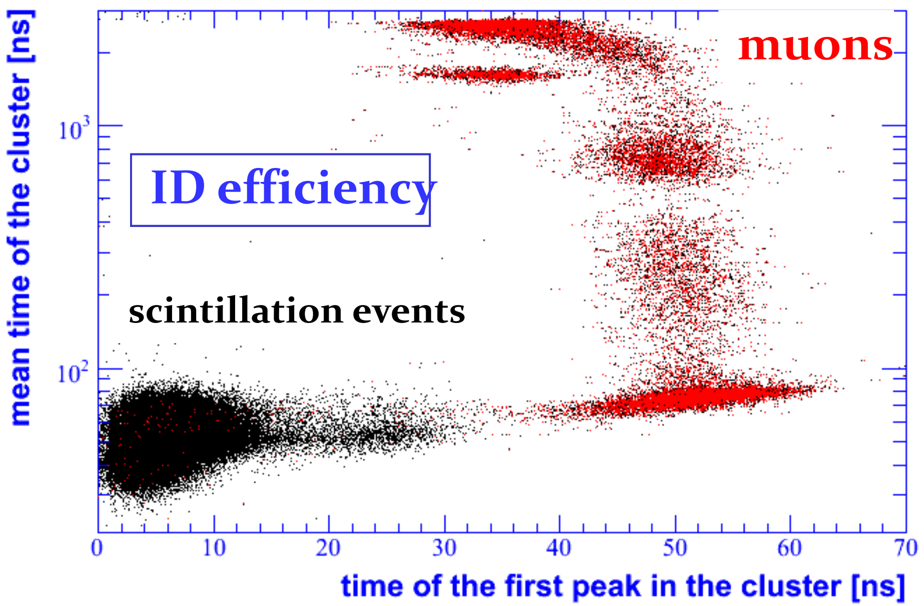
Expected Monte Carlo spectrum



D. D'Angelo – Borexino coll.

Muon identification

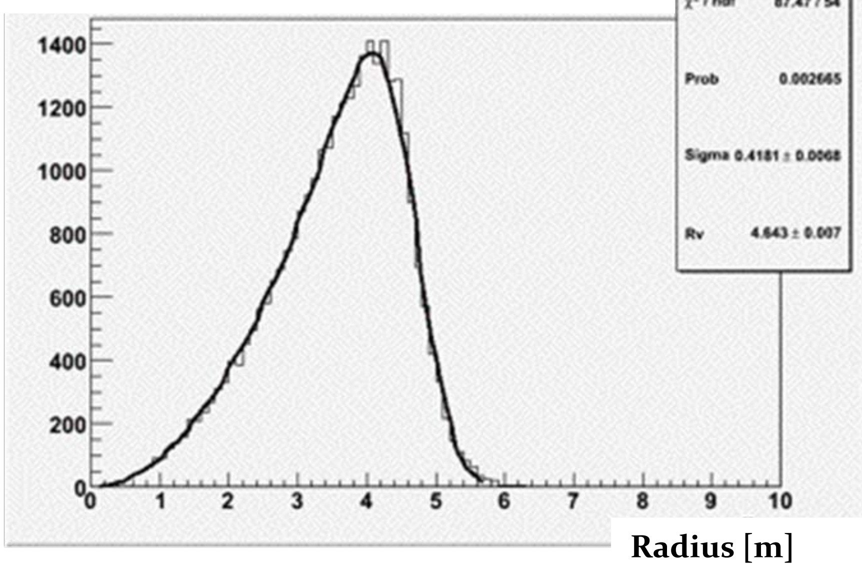
- μ **are identified by the OD and by the ID**
  - OD eff: ~ 99%
  - ID analysis based on pulse shape variables
    - Deutsch variable: ratio between light in the concentrator and total light
    - Cluster mean time, peak position in time
  - Estimated overall rejection factor > 10^4 (still preliminary)
- **After cuts, m not a relevant background for ^{7}Be**
  - **Residual background: < 1 count /day/ 1 00 t**

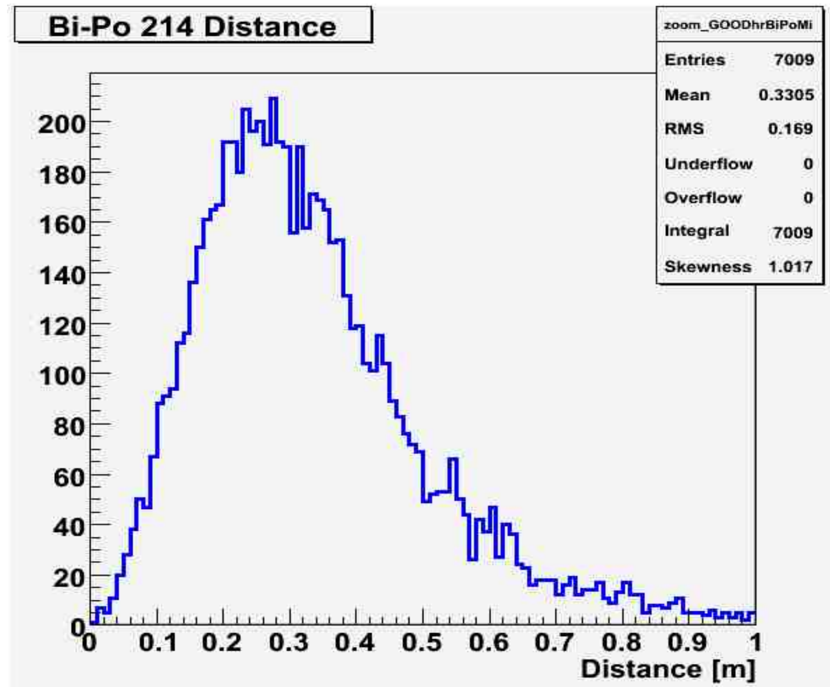


Position reconstruction algorithms

- Base on time of flight fit to hit-time distribution
- developed with MC, tested and validated in Borexino prototype CTF
- cross checked and tuned in Borexino on selected events (^{14}C, ^{214}Bi-^{214}Po, ^{11}C)

Radial distribution of ^{14}C events

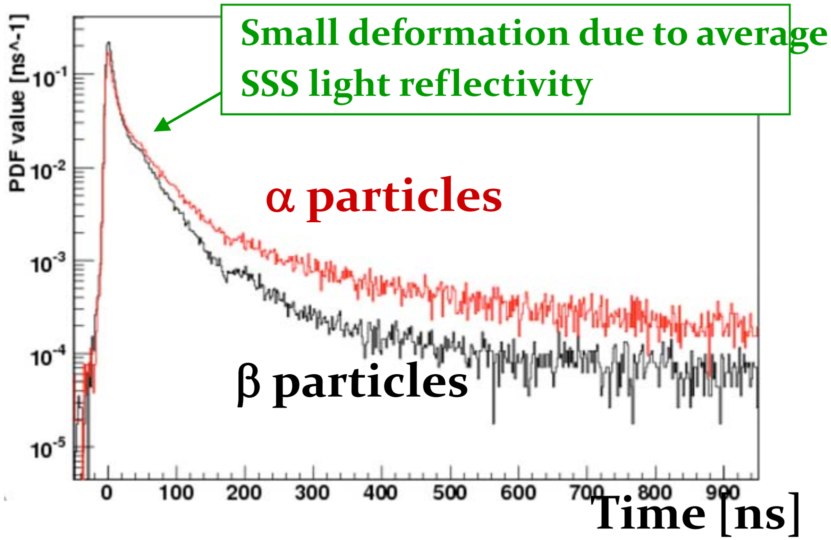


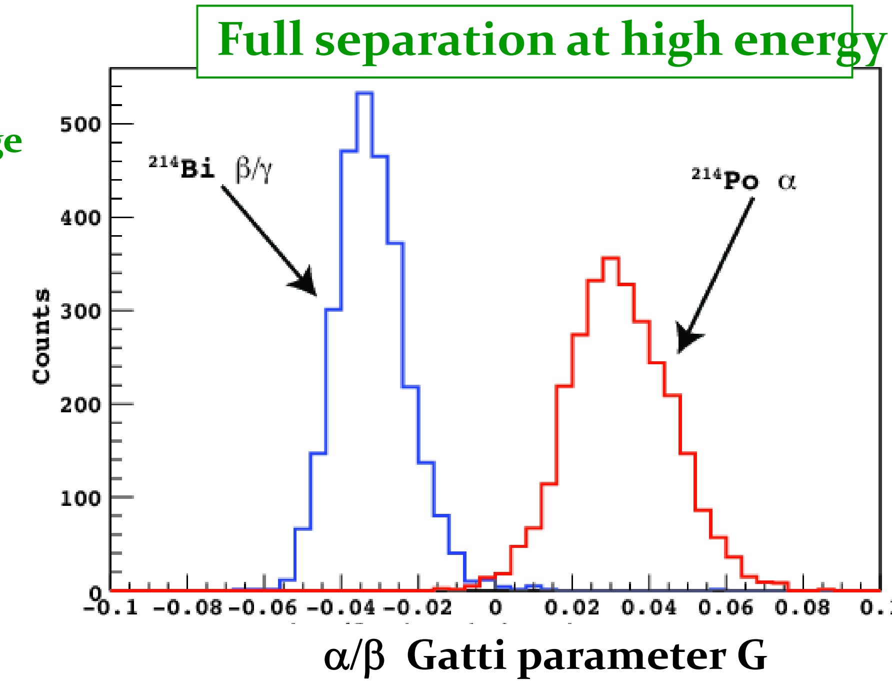


^{14}C "bound" in the scintillator: homogeneous
The fit is compatible with the expected
r^2-like shape with R=4.25m.

Spatial resolution:
35 cm at 200 keV
16 cm at 500 keV
(scaling as $N_{p.e.}^{-1/2}$)

α/β discrimination





$\overline{\alpha}_i, \overline{\beta}_i$ –> average pulse shapes

$$P_i = \frac{(\overline{\alpha}_i - \overline{\beta}_i)}{(\overline{\alpha}_i + \overline{\beta}_i)}$$ –> for i-time interval of 2 ns

$$G = \sum_i P_i S_i$$

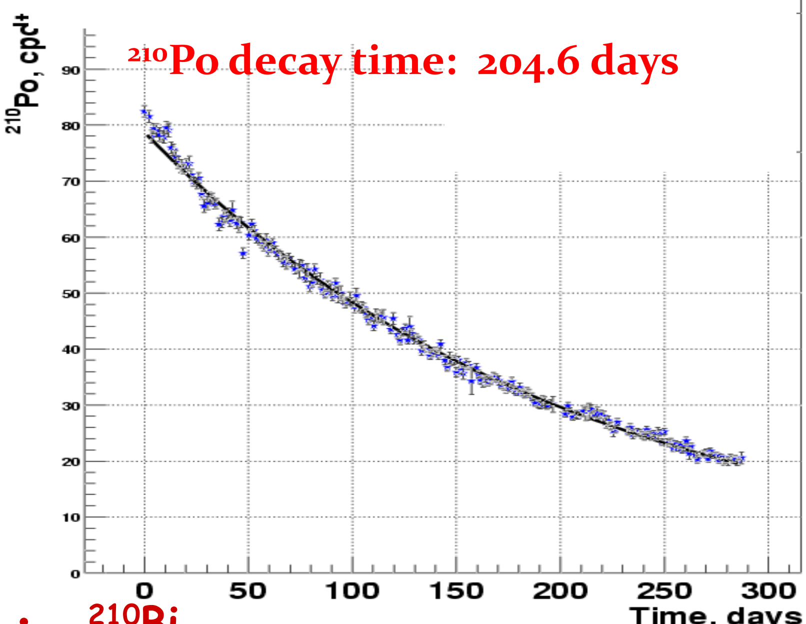
S_i –> signal shape within a given Δt (2 ns)

Background: ^{210}Po

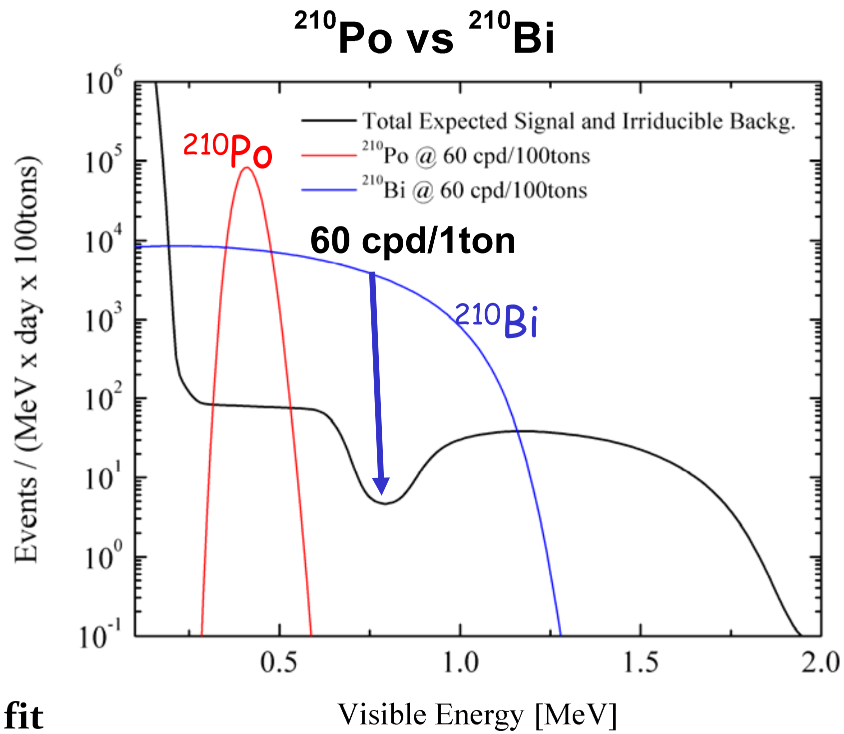
End of ^{238}U chain :

	β^-(61 keV)		β^-(1.2MeV)		α	
	^{210}Pb	->	^{210}Bi	->	^{210}Po	-> ^{206}Pb
$t_{1/2}$	22.3 y		5.01 d		138.38 d	stable

- Not in equilibrium with ^{210}Pb !
- ^{210}Po decays as expected



- The bulk ^{238}U and ^{232}Th contamination is negligible
- The ^{210}Po background is NOT related neither to ^{238}U nor to ^{210}Pb contamination

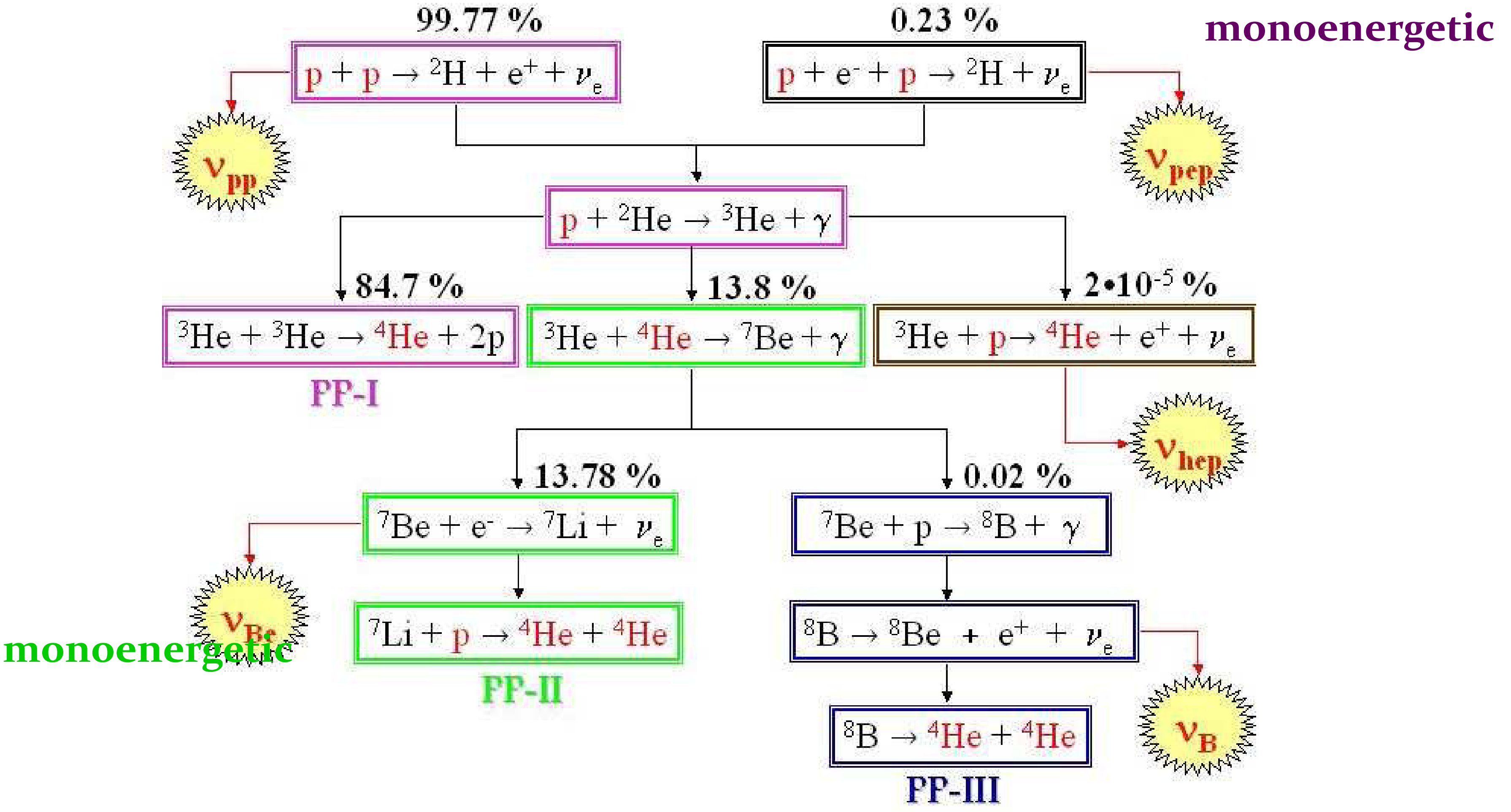


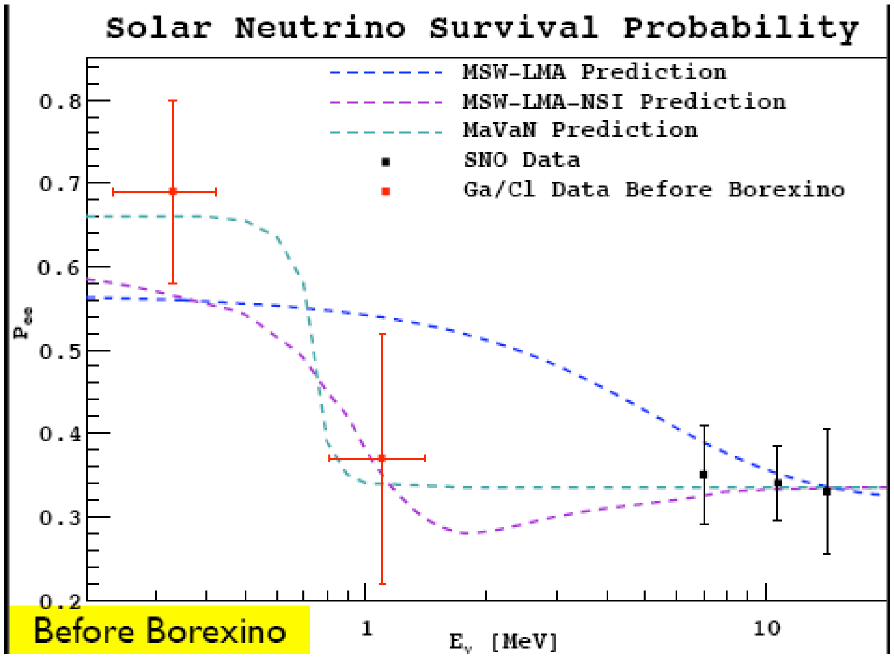
- ^{210}Bi

no direct evidence----> free parameter in the total fit

cannot be disentangled, in the ^{7}Be energy range, from the CNO

Proton-proton cycle: the main energy source in the Sun





Under the assuptions of High-Z SSM (BPS 07) the ^{7}Be rate measurement corresponds to

P_{ee} (^{7}Be) = 0.56 ± 0.1 (1σ)

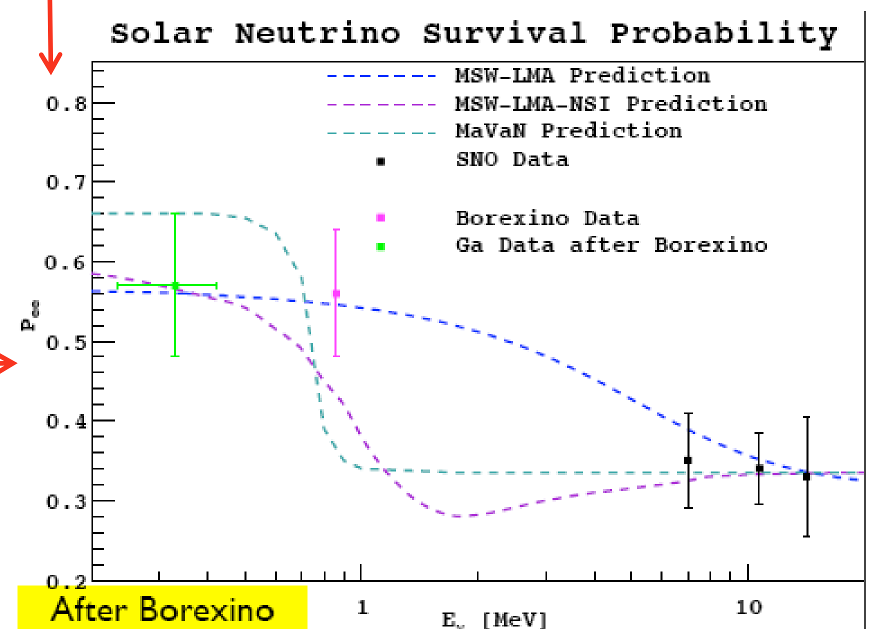
which is consistent with the number derived from the global fit to all solar and reactor experiments (S. Abe et al., arXiv: 0801.4589v2)

P_{ee} (^{7}Be) = 0.541 ± 0.017

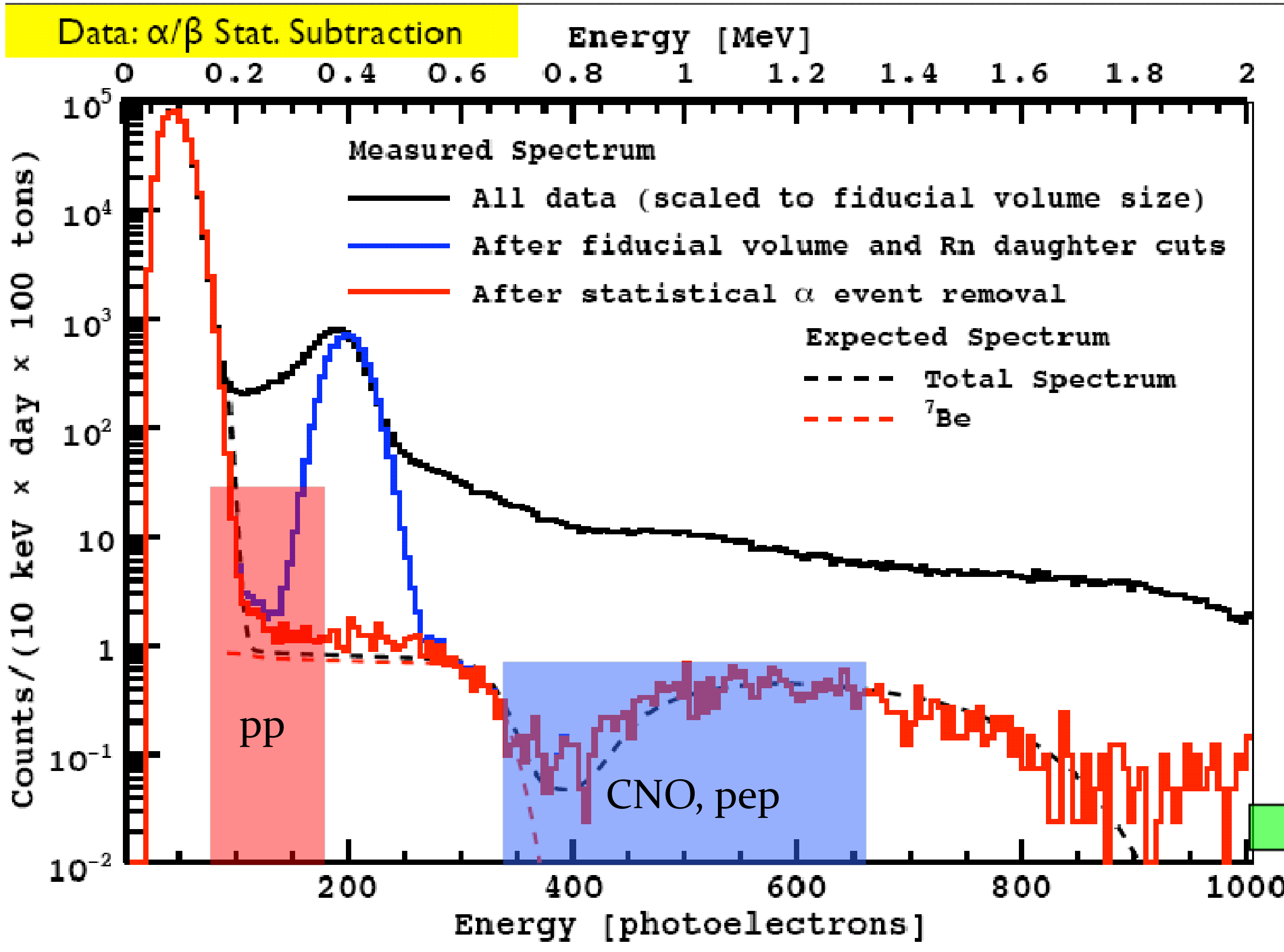
We determine the survival probability for ^{7}Be and pp-ν_e, assuming BPS07 and **using input from all solar experiments** (Barger *et al.*, PR (2002) 88, 011302)

P_{ee} (^{7}Be) = 0.56 ± 0.08

P_{ee} (pp) = 0.57 ± 0.09



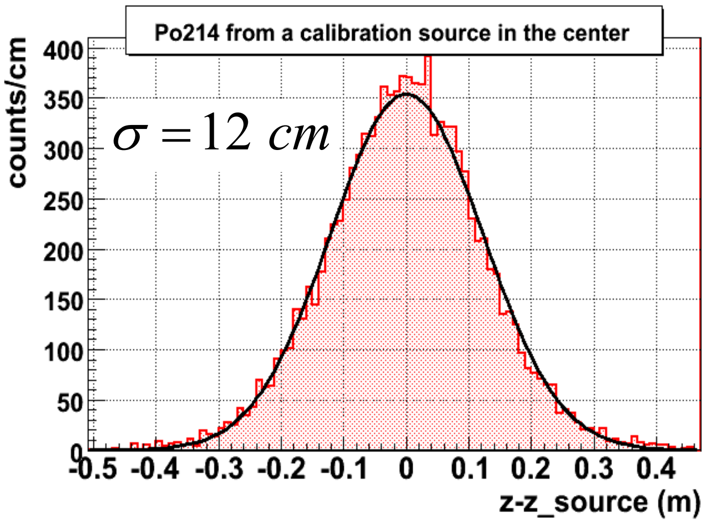
What can Borexino say about other solar ν sources?



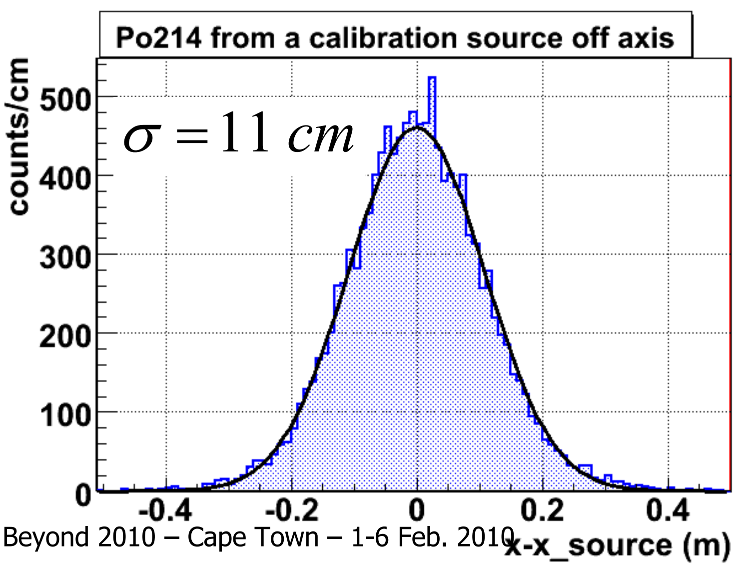
^{8}B above 2.8 MeV

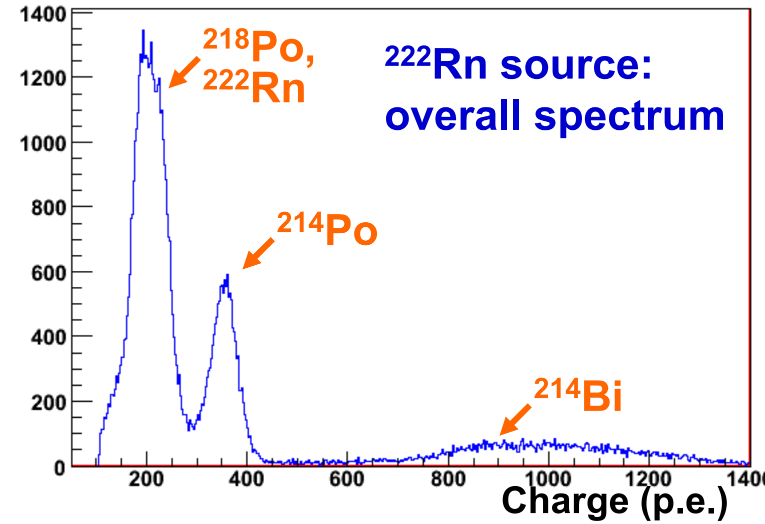
Example of calibration data

Source in the center



Source in (1.7, 0, 3) m





Overall analysis in progress : results in the next months

Background: ^{232}Th and ^{238}U content

assuming secular equilibrium:

^{232}Th chain

τ = 432.8 ns

^{212}Bi $\xrightarrow{\beta}$ ^{212}Po $\xrightarrow{\alpha}$ ^{208}Pb

2.25 MeV ~800 keV eq.

^{238}U chain

τ = 236 μs

^{214}Bi $\xrightarrow{\beta}$ ^{214}Po $\xrightarrow{\alpha}$ ^{210}Pb

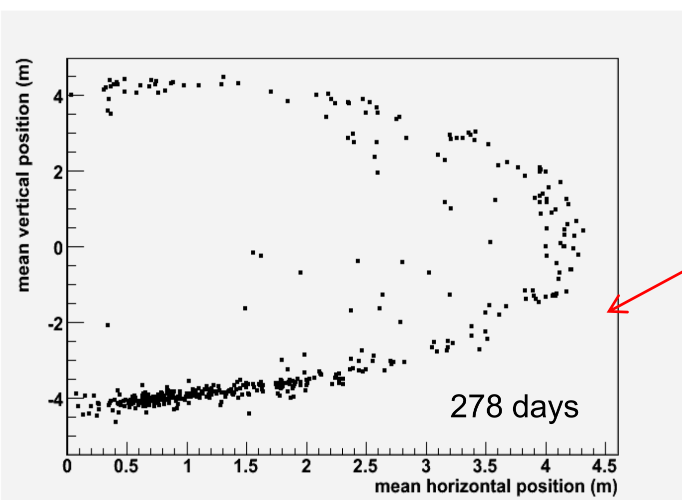
3.2 MeV ~700 keV eq.

(6.8±1.5) × 10^{-18} g(Th)/g

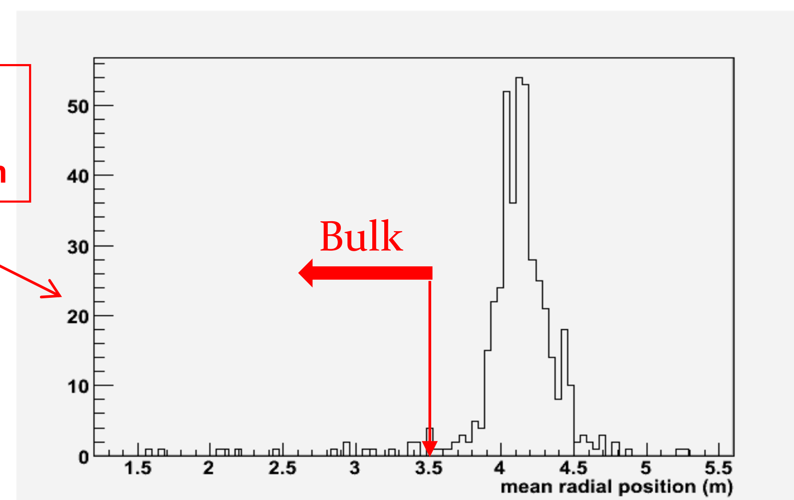
Bulk contamination

(1.6 ± 0.1) × 10^{-17} g(U)/g

Only few bulk candidates



^{212}Bi-^{212}Po centre of mass position distribution



Background: ^{210}Po and ^{85}Kr

^{210}Po: end of ^{238}U chain :

	^{210}Pb	$\xrightarrow{\beta^-\ (61\ \text{keV})}$	^{210}Bi	$\xrightarrow{\beta^-\ (1.2\ \text{MeV})}$	^{210}Po	$\xrightarrow{\alpha}$	^{206}Pb
$t_{1/2}$	22.3 y		5.01 d		138.38 d		stable

- The bulk **^{238}U and ^{232}Th** contamination is **negligible**
- The **^{210}Po** background is **NOT related** neither **to ^{238}U** nor to **^{210}Pb** contamination
- **May 2007 ~80 counts/day/ton, τ=204.6 days**
- **^{210}Bi no direct evidence** ---> free parameter in the total fit, cannot be disentangled, in the ^{7}Be energy range, from the CNO

^{85}Kr β-decay energy spectrum similar to the ^{7}Be recoil electron

$$^{85}\text{Kr} \xrightarrow[687\ \text{keV}]{\beta} {}^{85}\text{Rb}$$

τ = 10.76 y - BR: 99.56%

^{85}Kr is studied through :

$$^{85}\text{Kr} \xrightarrow[173\ \text{keV}]{\beta} {}^{85m}\text{Rb} \xrightarrow[514\ \text{keV}]{\gamma} {}^{85}\text{Rb}$$

τ = 1.46 ms - BR: 0.43%

Only 8 (β–γ) coincidences selected in the inner vessel in 192 days

the ^{85}Kr contamination **(29±14) counts/day/100 ton**

More statistics is needed → taken as a free parameter in the total fit