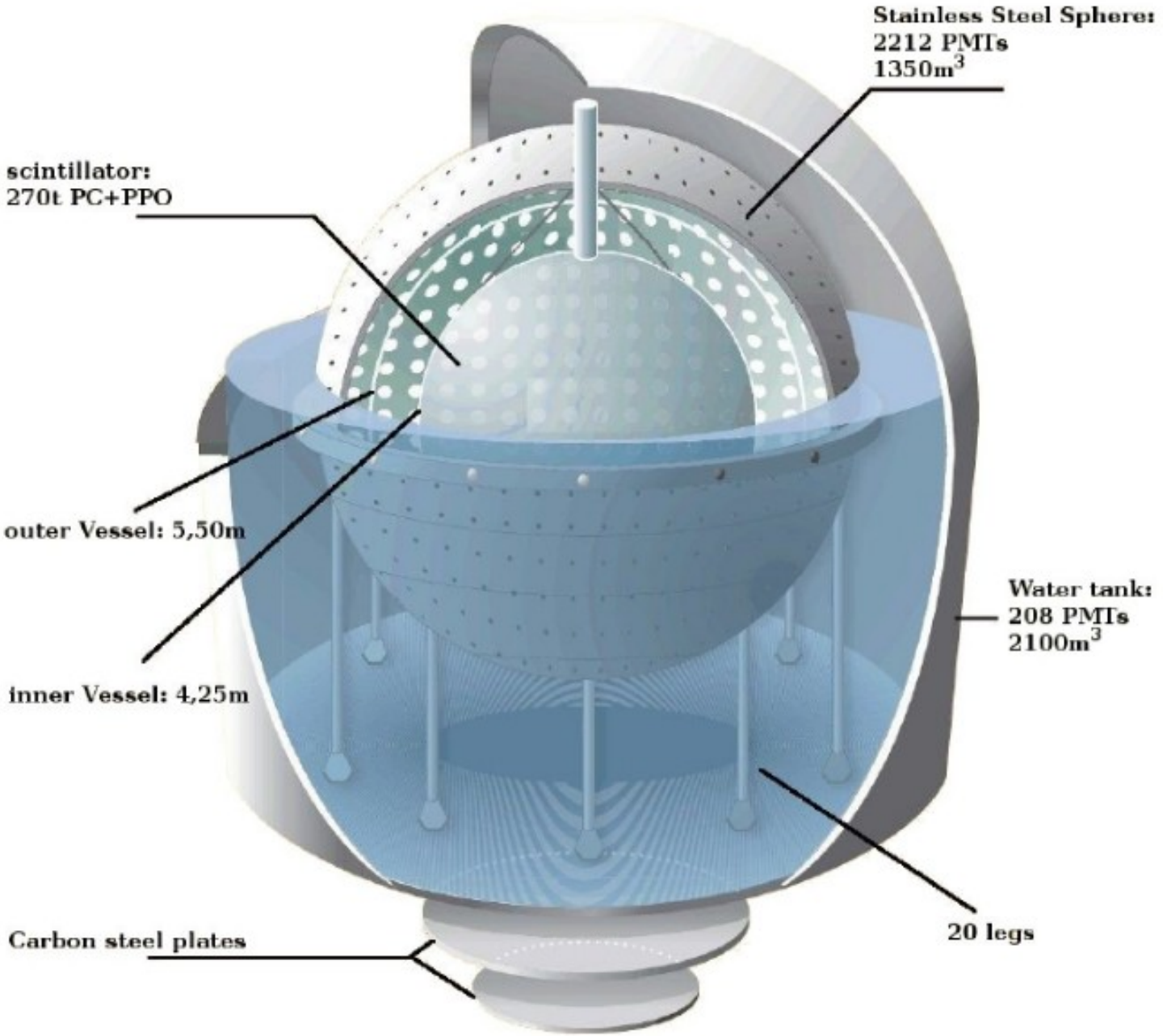
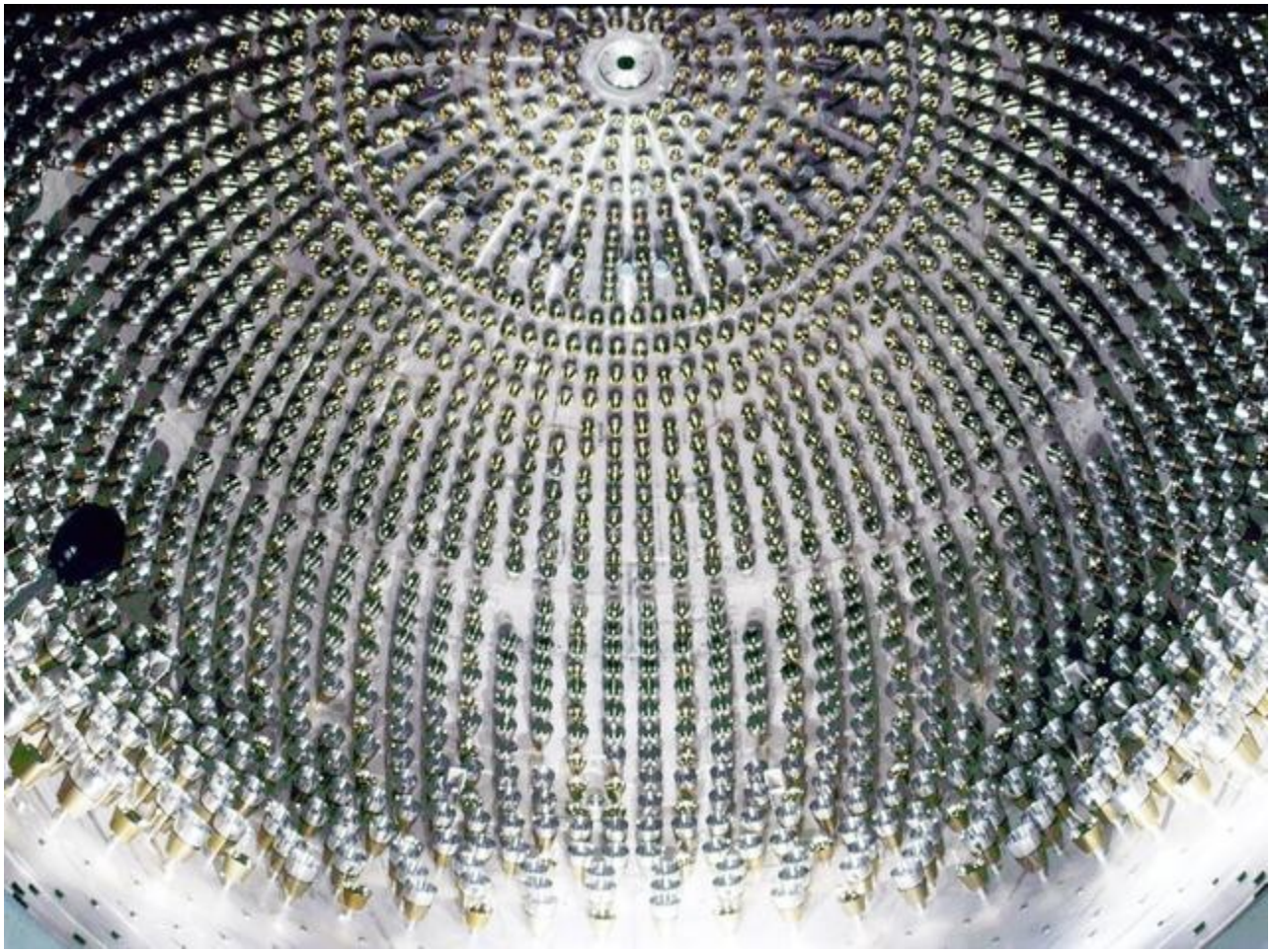


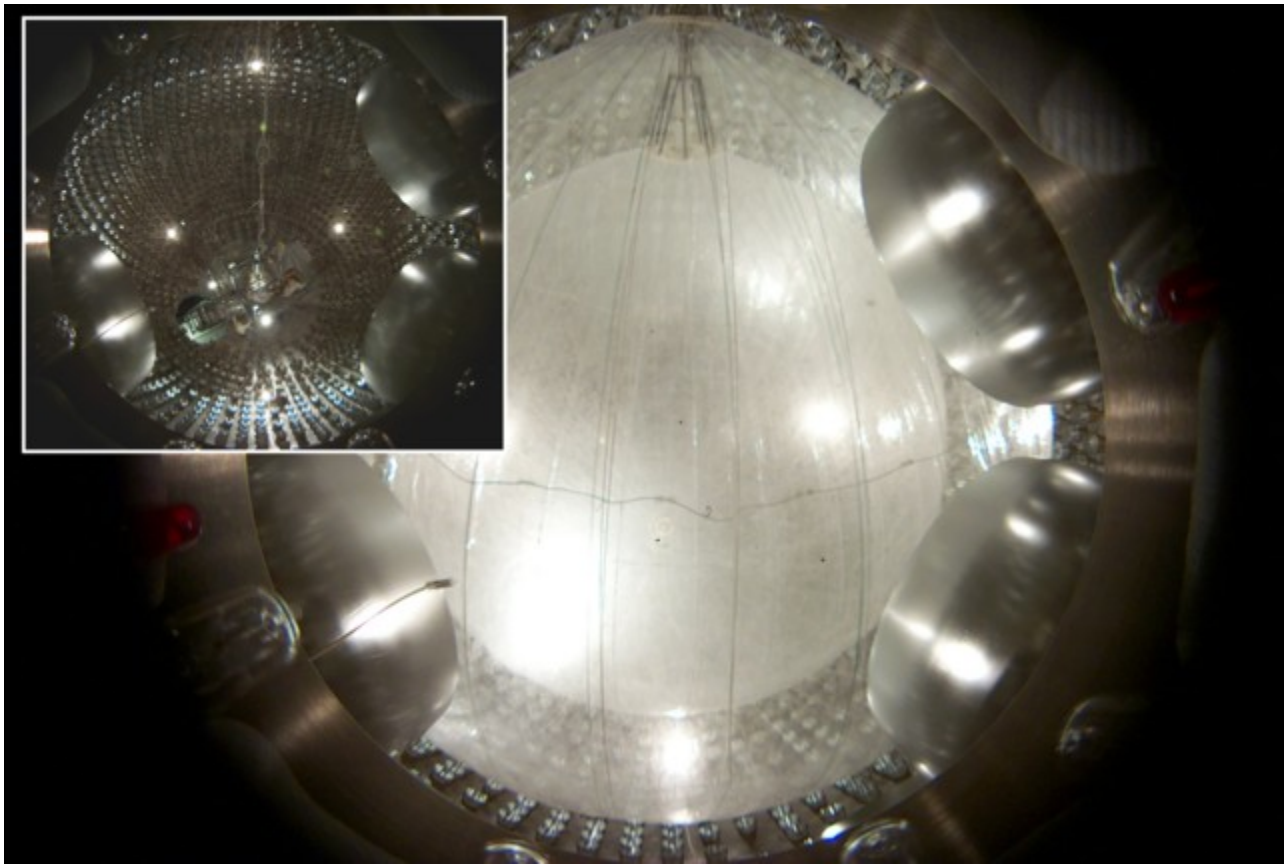
Figure 1. Sketch of the Borexino detector.

View of the internal of the Borexino Stainless Steel Sphere. PMTs installed, scaffoldings removed (2002).

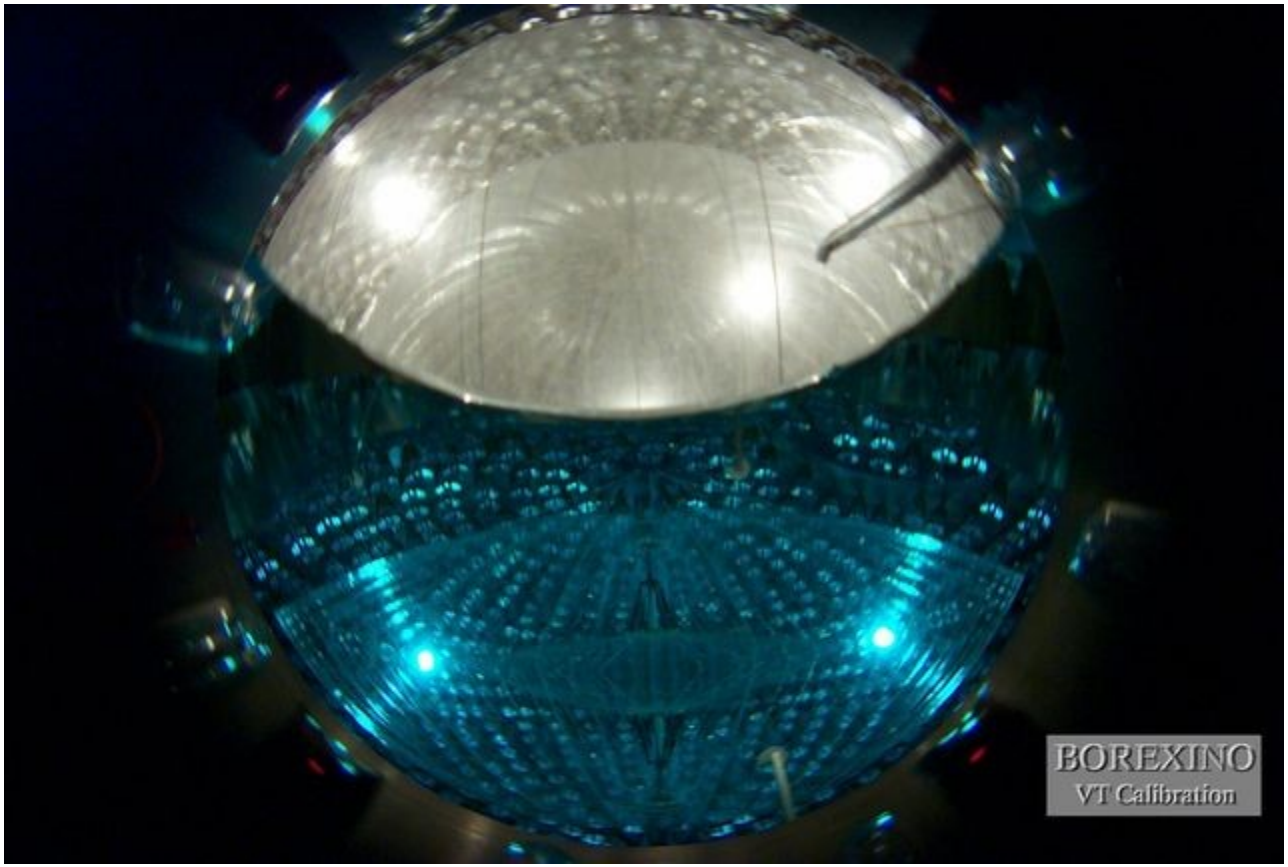


Test of the Nylon Vessels at Princeton University (August 2001)

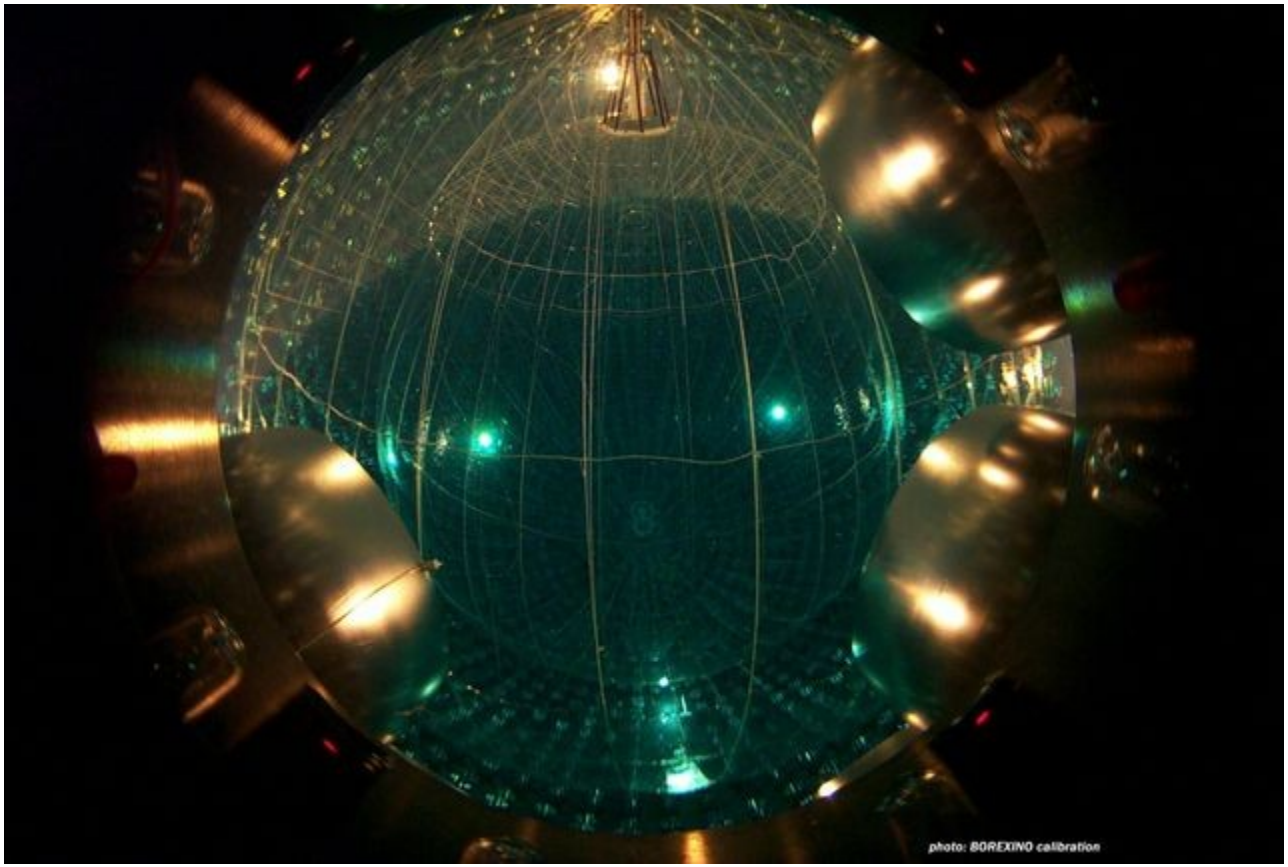
The Borexino vessels (gas) inflated. In the box, a view of the SSS before vessels installation (2004)



Borexino SSS partly filled with water
(viewed from camera #4) (Dec. 2006)



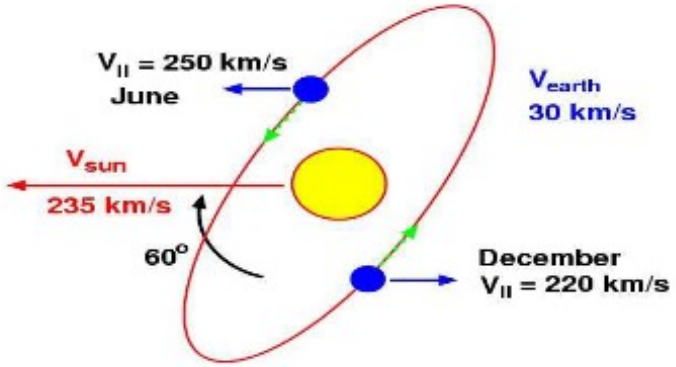
2007/01/29 - Inside view of the Borexino detector (camera #7). Water in the SSS (on the bottom) is being replaced by scintillator (on top). About 200t of scintillator in the SSS at this point



Fred Mayet (J-club 18/11/2011)

DAMA vs. the annually modulated muon background

Modulation annuelle

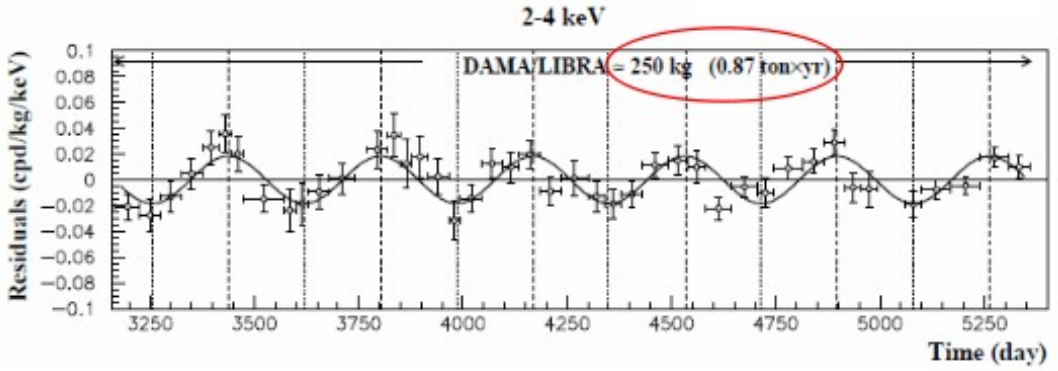


Drukier, Freese & Spergel *et al.* PRD 1986

$$R = \sigma \times \left(\frac{\rho_0}{m_\chi}\right) \times < v > \times \frac{1}{m_N}$$

Résultat DAMA/LIBRA

arXiv:1002.1028



- 8.9 σ CL
- période = 0,999 +- 0,002 an
- phase = 146 +-7 jour *(26 mai)*

Muons dans Borexino - arXiv:1202.6403

We have measured the muon flux at the underground Gran Sasso National Laboratory (3800 m w.e.) to be $(3.41 \pm 0.01) \cdot 10^{-4}$ m^{-2} s^{-1} using four years of Borexino data. A modulation of this signal is observed with a period of (366±3) days and a relative amplitude of (1.29 ± 0.07)%. The measured phase is (179 ± 6) days, corresponding to a maximum on the 28th of June [...]

$$I_\mu = I_\mu^0 + \Delta I_\mu = I_\mu^0 + \delta I_\mu \cos\left(\frac{2\pi}{T}(t - t_0)\right)$$

Fred Mayet (J-club 18/11/2011)

Pourquoi une modulation pour les muons ?

P.H. Barrett et al., Rev. Mod. Phys. 24 (1952) 133.

- muons atmosphériques proviennent des pions/kaons (15 km)

$\tau(\pi^{+-})=26$ ns

→Désintégration π versus Interaction π (pas de muon...)

→ si T ↗ la densité locale ↘

la proba d'interaction des π ↘ le flux de muons ↗

→Dans l'hémisphère nord : maximum en été, minimum en hiver...

→ Très forte corrélation avec la température de l'atmosphère à cette altitude

$$\frac{\Delta I_\mu}{I_\mu^0} = \alpha_T \frac{\Delta T_{\rm eff}}{T_{\rm eff}^0} \qquad \alpha_T = \frac{T_{\rm eff}^0}{I_\mu^0} \int_0^\infty dX W(X)$$

Muons dans Borexino - arXiv:1202.6403

[...] Using the most complete atmospheric data models available (`http://data-portal.ecmwf.int/`), muon rate fluctuations are shown to be positively correlated with atmospheric temperature, with an effective coefficient $\alpha T = 0.93 \pm 0.04$. This result represents the most precise study of the muon flux modulation for this site and is in good agreement with expectations.

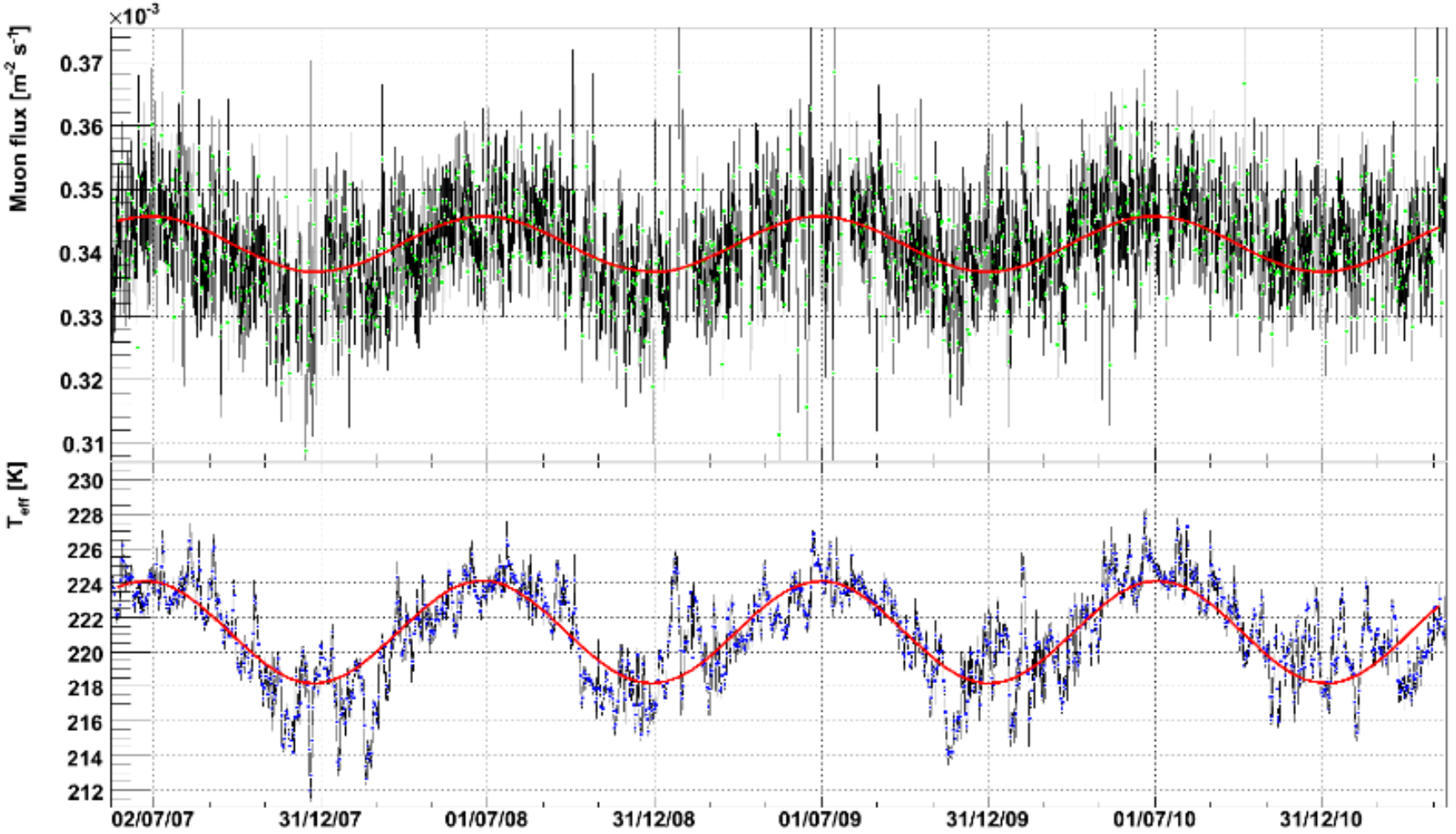


Figure 2. Upper panel: cosmic muon signal measured by Borexino as a function of time. Lower panel: effective temperature, $T_{\rm eff}$, computed using eq. 5.2 and averaging over the four daily measurements. Daily binning is used in both panels. The curves show the sinusoidal fit to the data (see text).

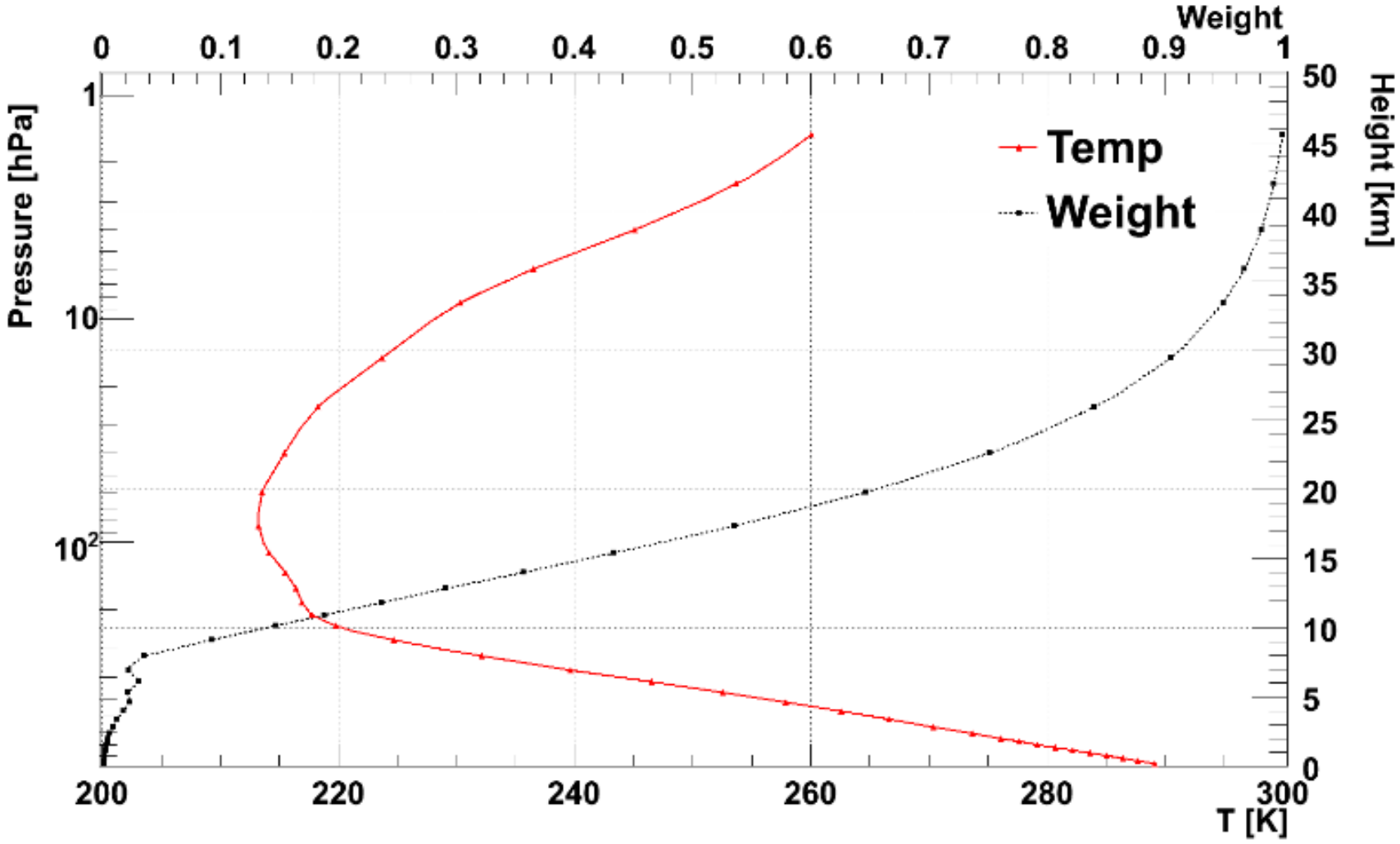


Figure 4. Average temperature (solid red line) [13] and normalized weight $W(X)$ (black dashed line) as a function of pressure levels computed at the LNGS site. The right vertical axis shows the altitude corresponding to the pressure on the left vertical axis.

Lomb-Scargle analysis

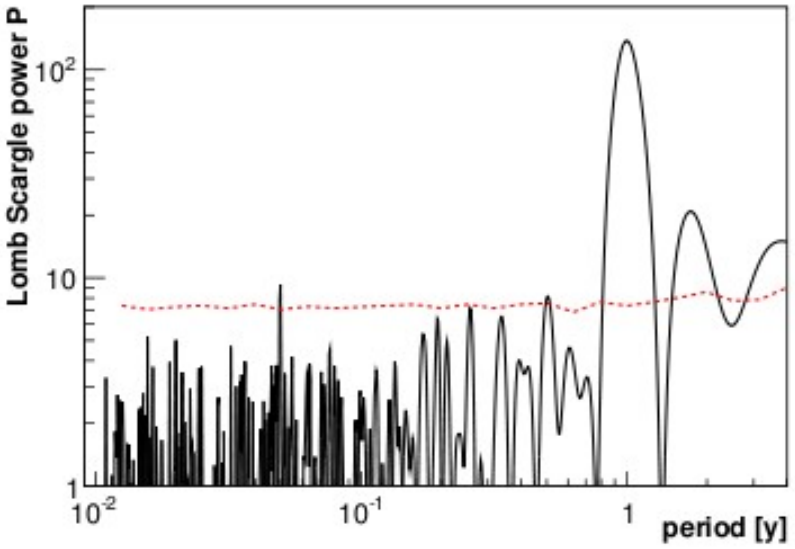


Figure 5. LS periodogram of the muon data. The dashed line indicates the detection threshold (3σ).

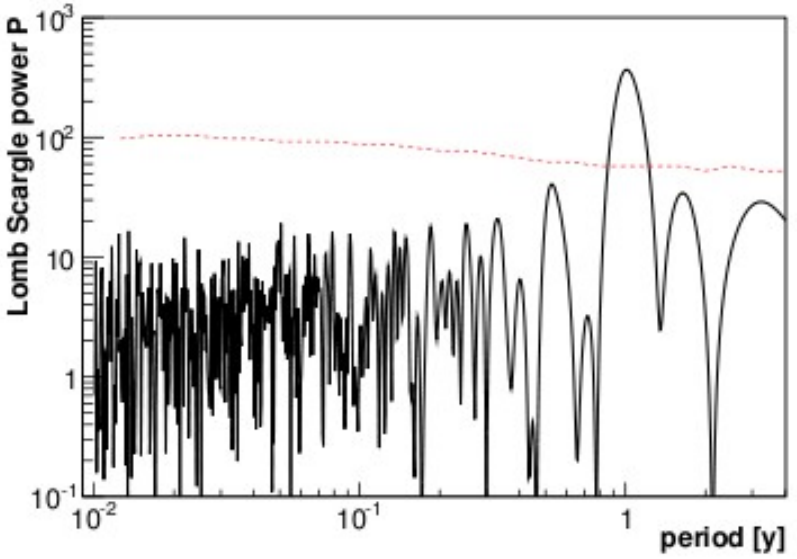


Figure 6. LS periodogram of the temperature data. The dashed line indicates the detection threshold (3σ).

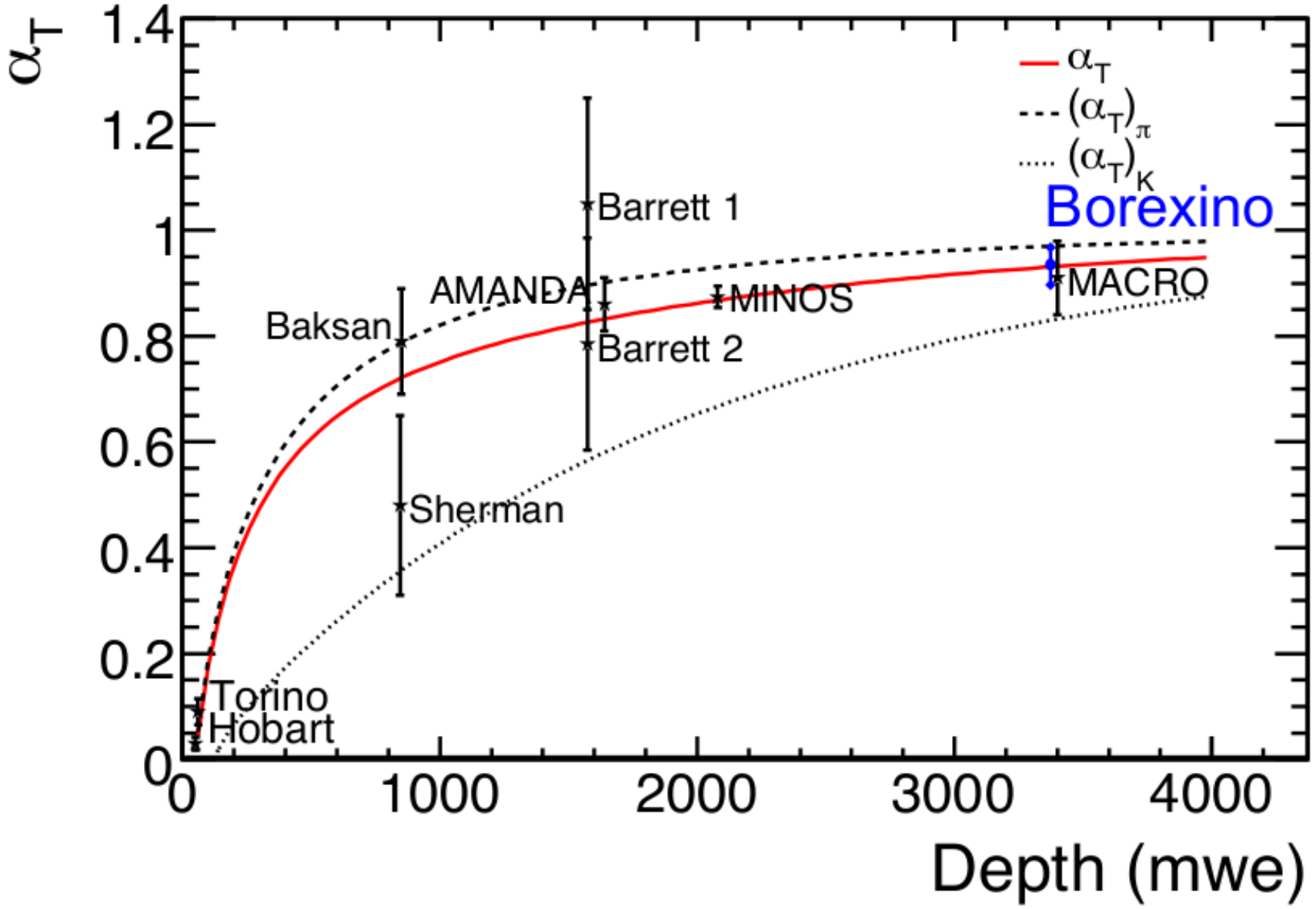
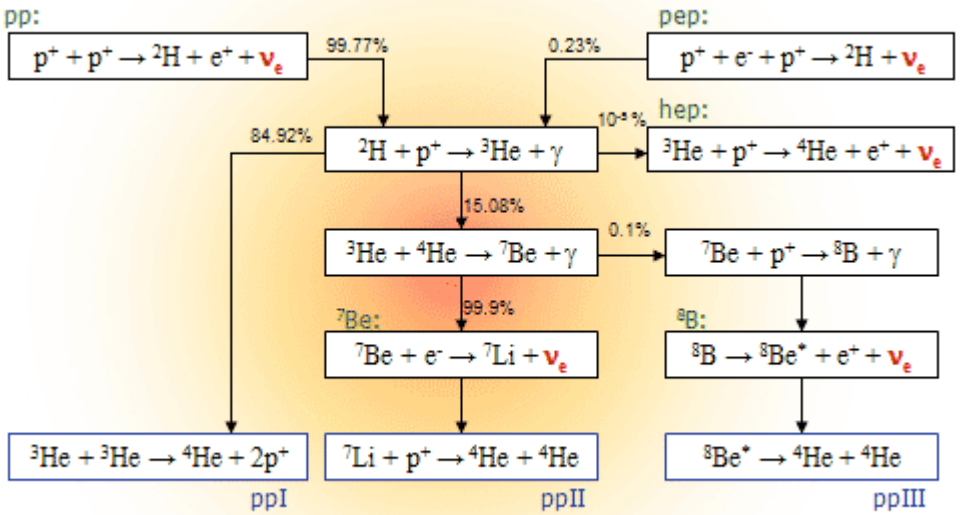


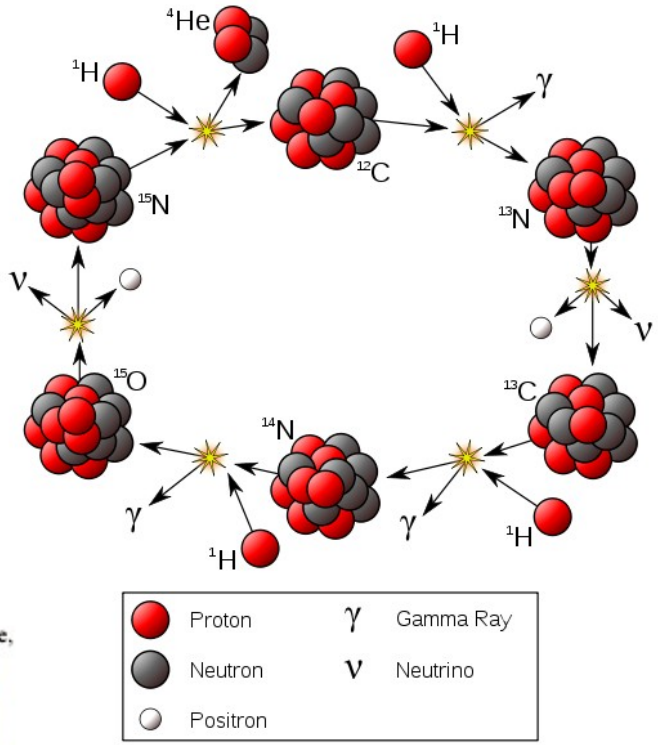
Figure 8. Measured values for the effective temperature coefficient, α_T, at varying site depths. The results from this analysis (in blue) as well as those from different experiments are presented. The red line is the value predicted including muon production by pions and kaons. The dashed lines account for one production mechanism only. See [6] and refs therein for details.

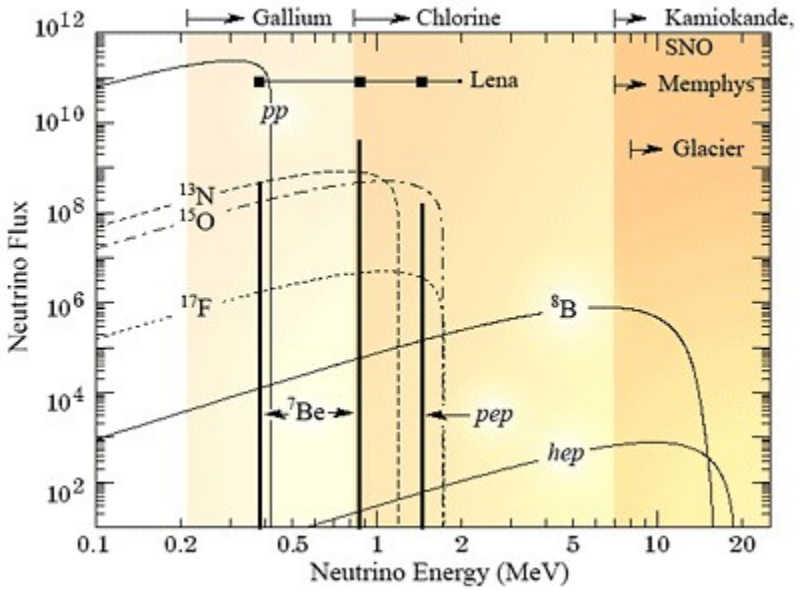
Neutrinos solaires dans Borexino - arXiv:1202.6403

pp cycle



CNO cycle





Measurements - arXiv:1202.6403

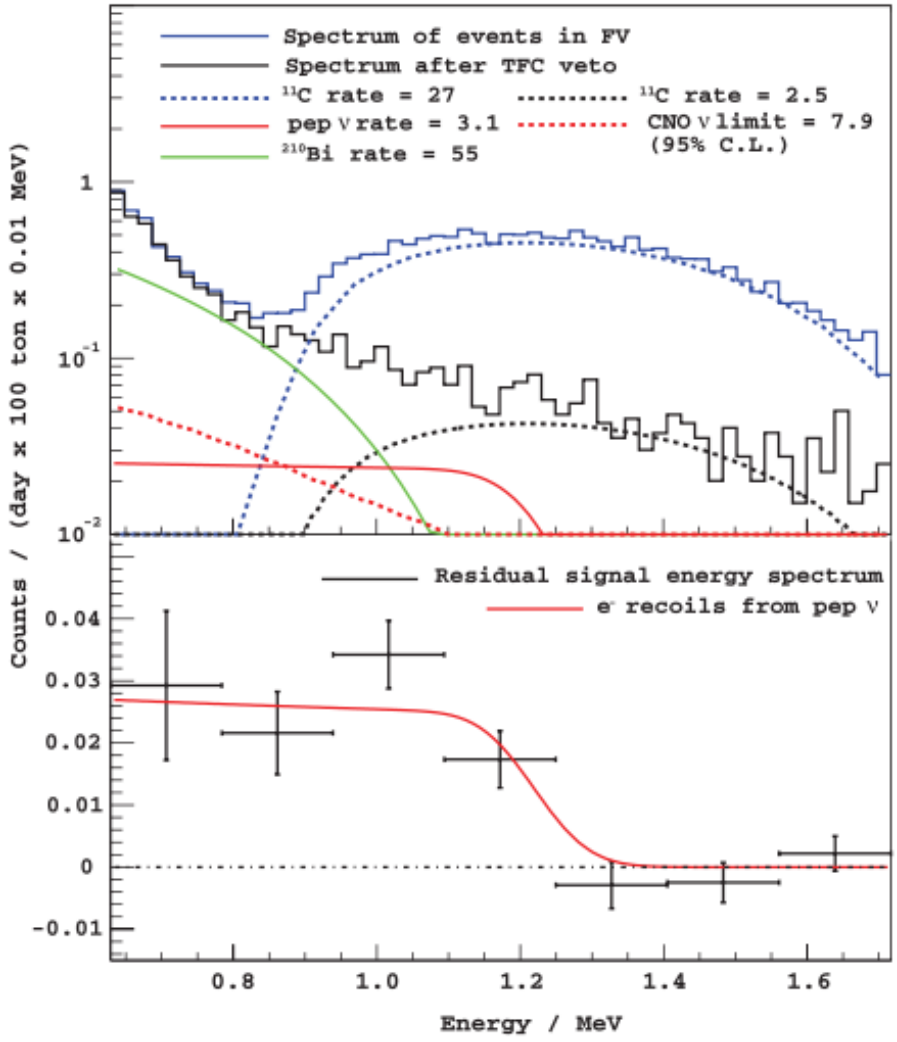


FIG. 1 (color). Top: energy spectra of the events in the FV before and after the TFC veto is applied. The solid and dashed blue lines show the data and estimated ^{11}C rate before any veto is applied. The solid black line shows the data after the procedure, in which the ^{11}C contribution (dashed black line) has been greatly suppressed. The next largest background, ^{210}Bi, and the e^- recoil spectra of the best estimate of the pep- rate and of the upper limit of the CNO- rate are shown for reference. Rate values in the legend are integrated over all energies and are quoted in units of counts=/ (day x 100 metric ton). Bottom: residual energy spectrum after best-fit rates of all considered back-grounds are subtracted. The e^- recoil spectrum from *pep-ν* at the best-fit rate is shown for comparison.

Background rates - arXiv:1202.6403

TABLE II. The best estimates for the total rates of the background species included in the fit. The statistical and systematic uncertainties were added in quadrature. The expected rates for the cosmogenic isotopes ^{11}C, ^{10}C, and ^{6}He have been obtained following the methodology outlined in [25]. The expected ^{234m}Pa rate was determined from the ^{214}Bi-^{214}Po measured coincidence rate, under the assumption of secular equilibrium. External γ includes the estimated contributions from ^{208}Tl, ^{214}Bi, and ^{40}K external γ rays.

Background	Interaction rate [counts/(day · 100 ton)]	Expected rate [counts/(day · 100 ton)]
^{85}Kr	19^{+5}_{-3}	30 ± 6 [5]
^{210}Bi	55^{+3}_{-5}	...
^{11}C	27.4 ± 0.3	28 ± 5
^{10}C	0.6 ± 0.2	0.54 ± 0.04
^{6}He	<2	0.31 ± 0.04
^{40}K	<0.4	...
^{234m}Pa	<0.5	0.57 ± 0.05
External γ	2.5 ± 0.2	...

arXiv:hep-ph/0411002

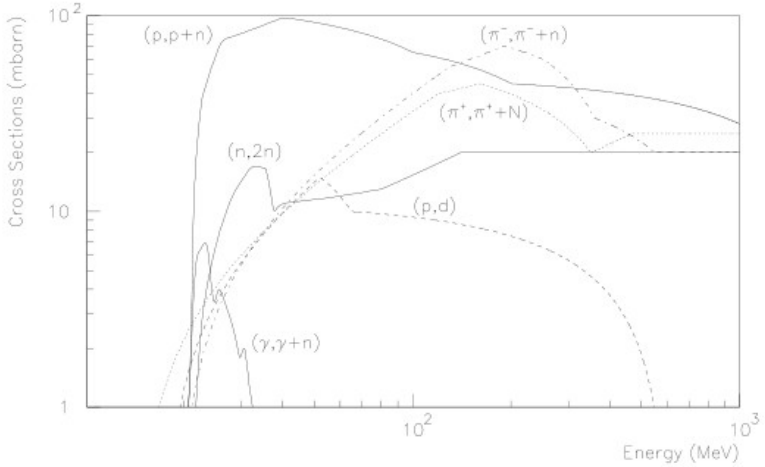


FIG. 2: Cross sections for ^{11}C production from ^{12}C as a function of energy.

Pep vs CNO rates - arXiv:1202.6403

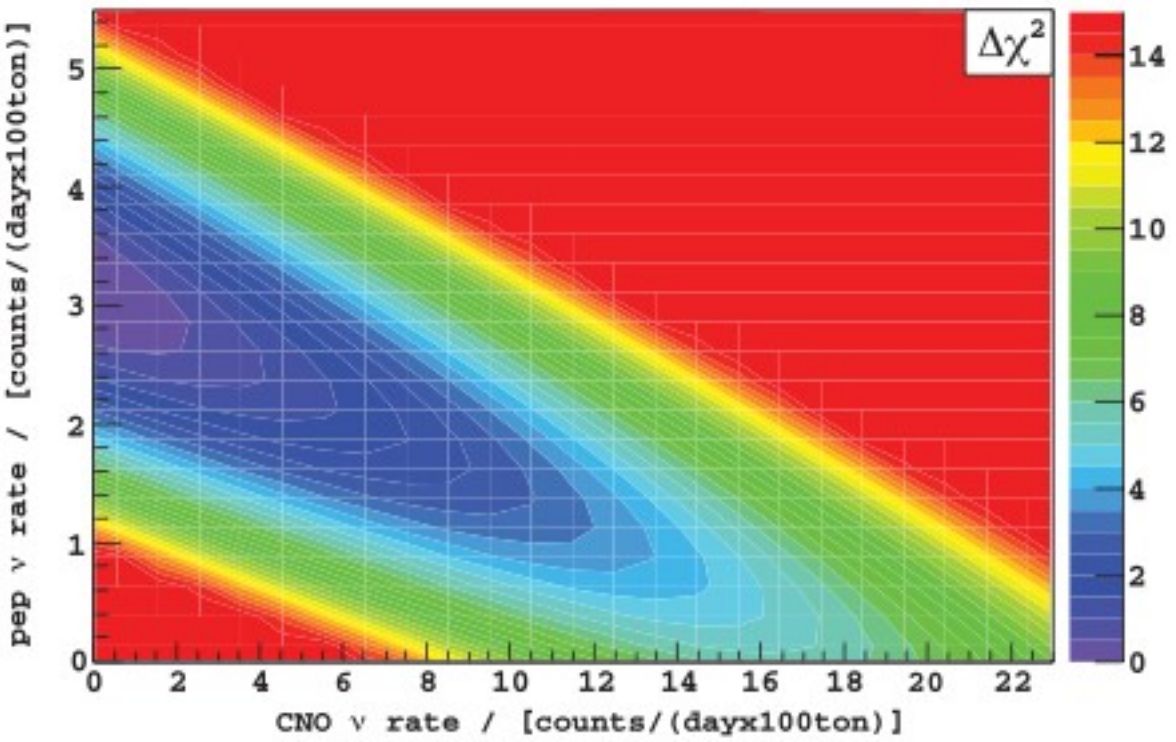


FIG. 4 (color). $\Delta\chi^2$ profile obtained from likelihood ratio tests between fit results where the *pep* and CNO neutrino interaction rates are fixed to particular values (other species are left free) and the best-fit result.

Disparition de ν_e vs E - arXiv:1202.6403

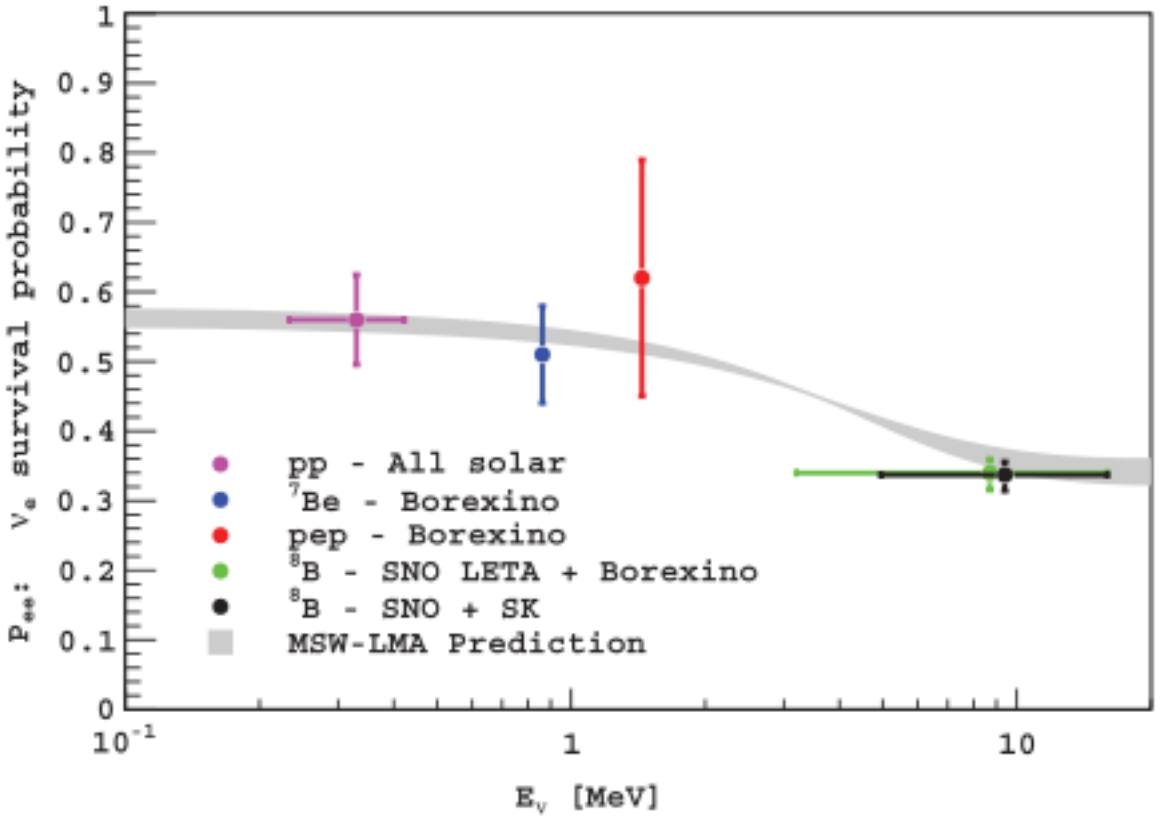


FIG. 5 (color). Electron neutrino survival probability as a function of energy. The red line corresponds to the measurement presented in this Letter. The *pp* and ^{7}Be measurements of P_{ee} given in [5] are also shown. The ^{8}B measurements of P_{ee} were obtained from [3,4,25], as indicated in the legend. The MSW-LMA prediction band is the 1σ range of the mixing parameters given in [22].