Background Levels in the Borexino Detector

Davide D'Angelo (TUM, INFN–Milano) and Michael Wurm (TUM)
for the Borexino Collaboration

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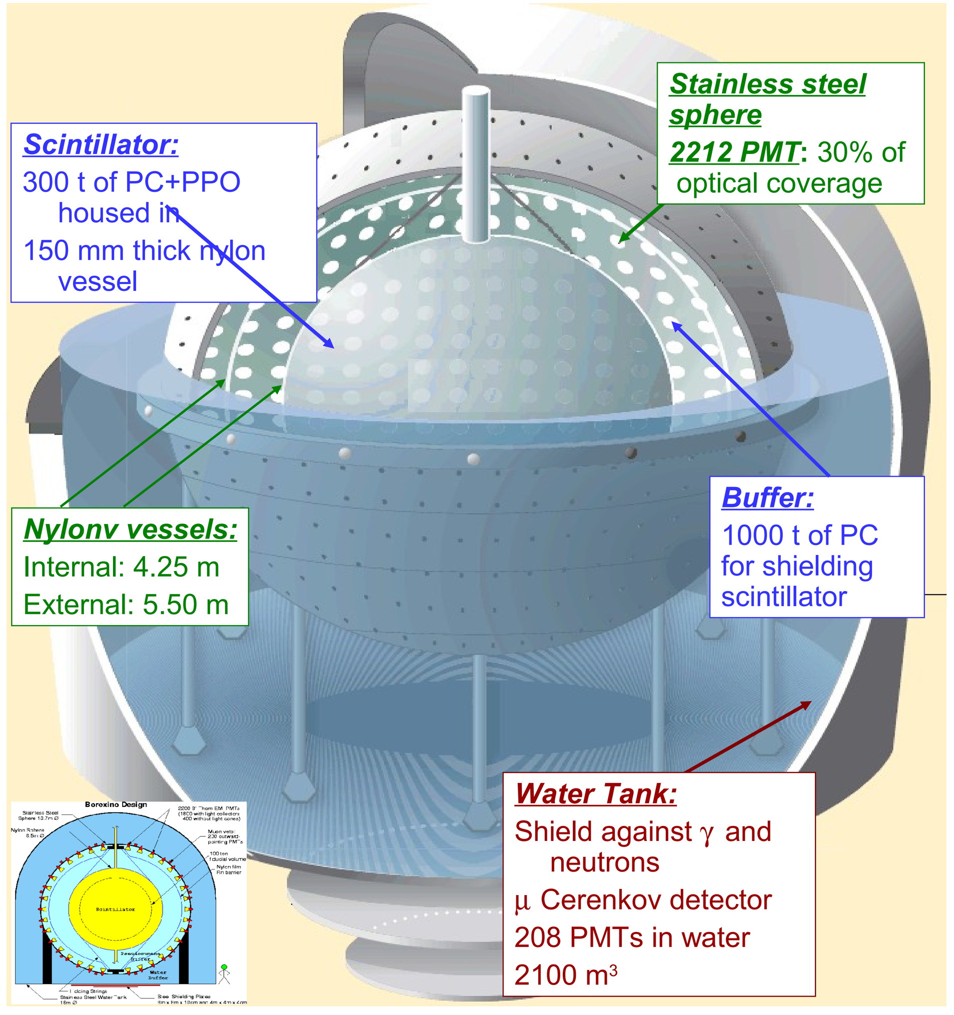
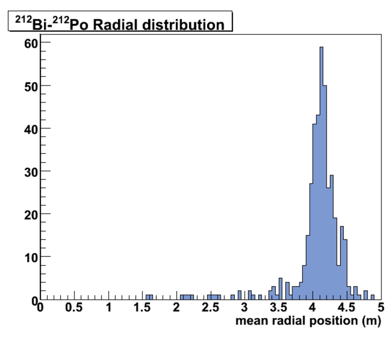
The Borexino detector, designed and constructed for sub-MeV solar neutrino spectroscopy, is taking data at the Gran Sasso Laboratory (Italy) since May 2007. The first data indicate the extremely low background levels achieved in the construction of the detector and in the purification of the target mass. Several pieces of analysis sense the presence of radioisotopes of the 238U and 232Th chains, of 85Kr and of 210Po out of equilibrium from other Radon daughters. Particular emphasis is given to the detection of the cosmic muon background whose angular distributions have been obtained with the outer detector tracking algorithm and to the possibility of tagging the muon-induced neutron background in the scintillator with the recently enhanced electronics setup.

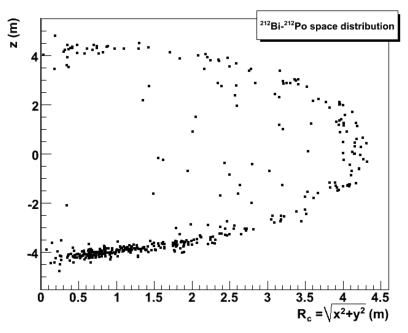


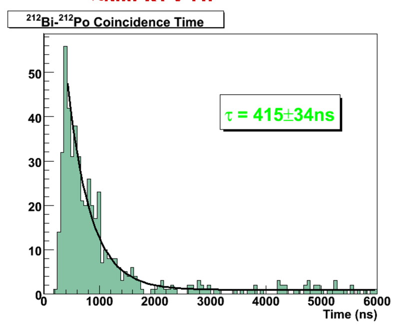
^{232}Th

Assuming secular equilibrium, ^{232}Th is measured with the delayed coincidence:

$^{212}Bi \xrightarrow[2.25\ MeV]{\beta} {}^{212}Po \xrightarrow[\sim 800\ KeV\ eq.]{\alpha} {}^{208}Pb$, τ = 432.8 ns







Events are mainly on the south vessel surface (probably particulate)

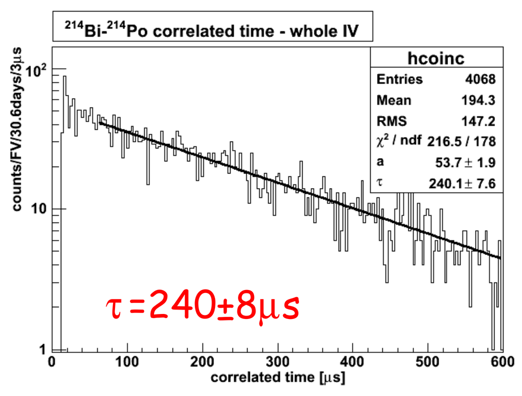
Specs: ^{232}Th: 1. 10^{-16} g/g
0.035 cpd/ton

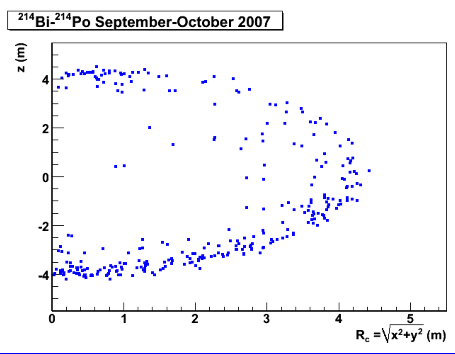
Results: From ^{212}Bi-^{212}Po correlated events in the scintillator:
0.00256 cpd/ton corresponding to
^{232}Th = $(6.8\pm1.5)\times10^{-18}$ g(Th)/g

^{238}U

Assuming secular equilibrium, ^{238}U is measured with the delayed coincidence:

$^{214}Bi \xrightarrow[3.2\ MeV]{\beta} {}^{214}Po \xrightarrow[\sim 700\ KeV\ eq.]{\alpha} {}^{210}Pb$, τ = 236 μs





Specs: ^{238}U: 1. 10^{-16} g/g
0.010 cpd/ton

Result: 2 cpd/100 tons
^{238}U = $(1.9 \pm 0.3)\times10^{-17}$ g(U)/g

^{85}Kr

^{85}Kr β decay :
$^{85}Kr \xrightarrow[687\ keV]{\beta} {}^{85}Rb$
τ = 10.76 y - BR: 99.56%

^{85}Kr tag:
$^{85}Kr \xrightarrow[173\ keV]{\beta} {}^{85m}Rb \xrightarrow[514\ keV]{\gamma} {}^{85}Rb$
τ= 1.46 μs - BR: 0.43%

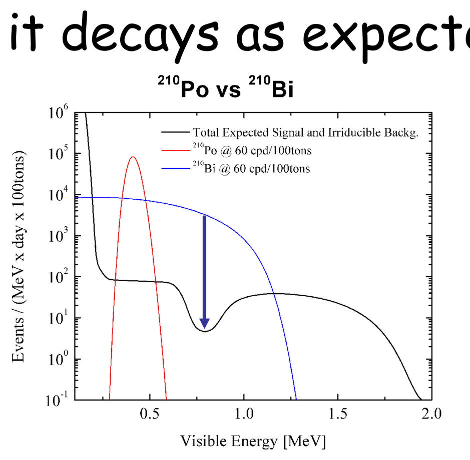
b decay has an energy spectrum similar to the ^{7}Be recoil electron

Only 10 events (β–γ) are selected in the IV in ~240 d.
2.3 events were expected from ^{14}C-^{210}Po random coincidences
the best estimate for ^{85}Kr contamination is 29±14 counts/(day·100 ton)

Due to low statistics it is left as free parameter in the total fit resulting in $25\pm2_{stat}\pm2_{syst}$ counts/(day·100ton).

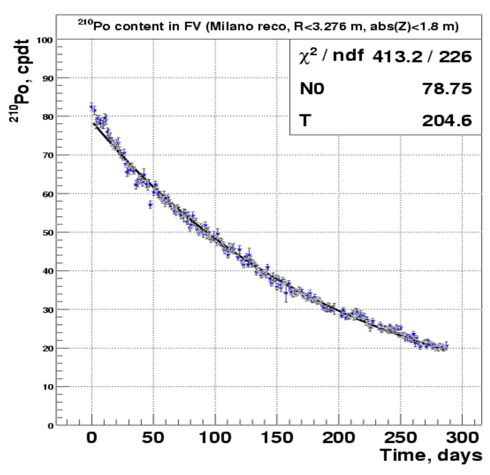
^{210}Po – ^{210}Bi

^{210}Po decays α with Q=5.41MeV (quenched about a factor 13)
Not in equilibrium with ^{210}Pb,
it decays as expected (τ=199.6d):



60 cpd/ton 1year ago

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



^{210}Po decay time: 204.6 d
Current contamination
14cpd/ton

^{210}Bi decays β with Q=1.16MeV:
no direct evidence --> free parameter in the total fit
It cannot be disentangled, in the ^{7}Be energy range, from CNO neutrinos. Combined result from fit: $23\pm1_{stat}$ cpd/100ton

Muons

Cosmic Muons in LNGS site are reduced by a factor 10^6 compared to surface.

Still a reduction of an additional factor 10^4 is required for Borexino

We achieve this with the Outer Detector (OD) and with Inner Detector Pulse Shape Analysis (IDF) based on the track-like nature of the muon event with a broader distribution (higher mean hit time, higher rise time to teh first peak) as compared to point-like scintillation events.

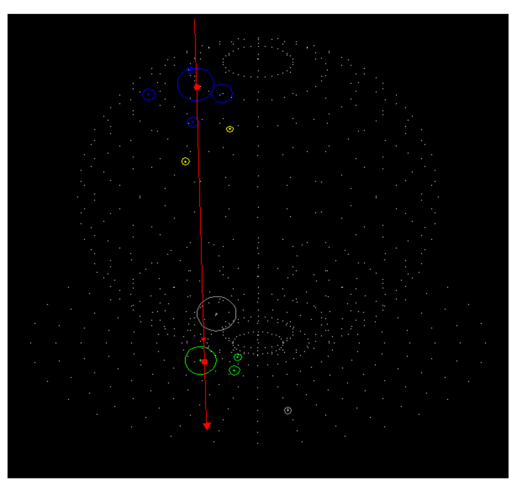
The inefficiency of the combined tagging is $7.6\cdot10^{-4}$ below 1MeV (corresponding to ~ $1\cdot d^{-1}\cdot100t^{-1}$) and ~$10^{-5}$ at higher energies.

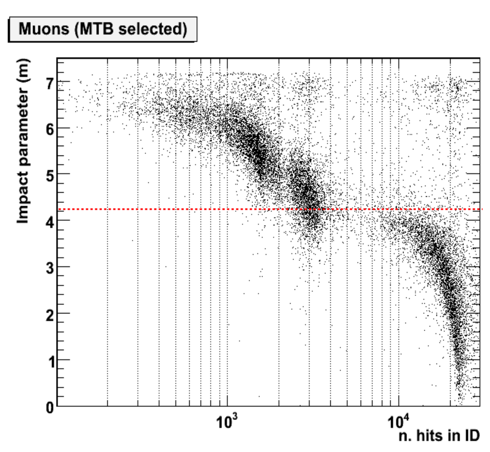
The measured muon rate is (with either sub-detector)

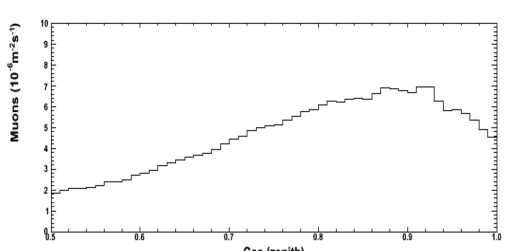
(1.21±0.05) $h^{-1}m^{-2}$

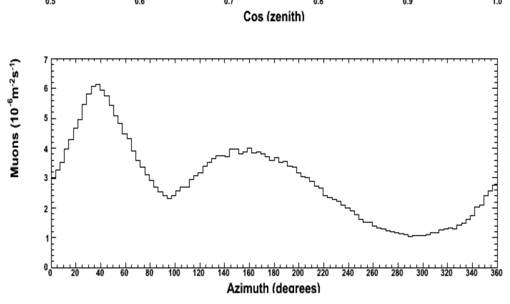
We have developed an algorithm to reconstruct muon tracks with OD, a parallel one with ID is under development, we currently reconstruct 86% of muons.

The rate and the measured angular distributions match those reported in [2].

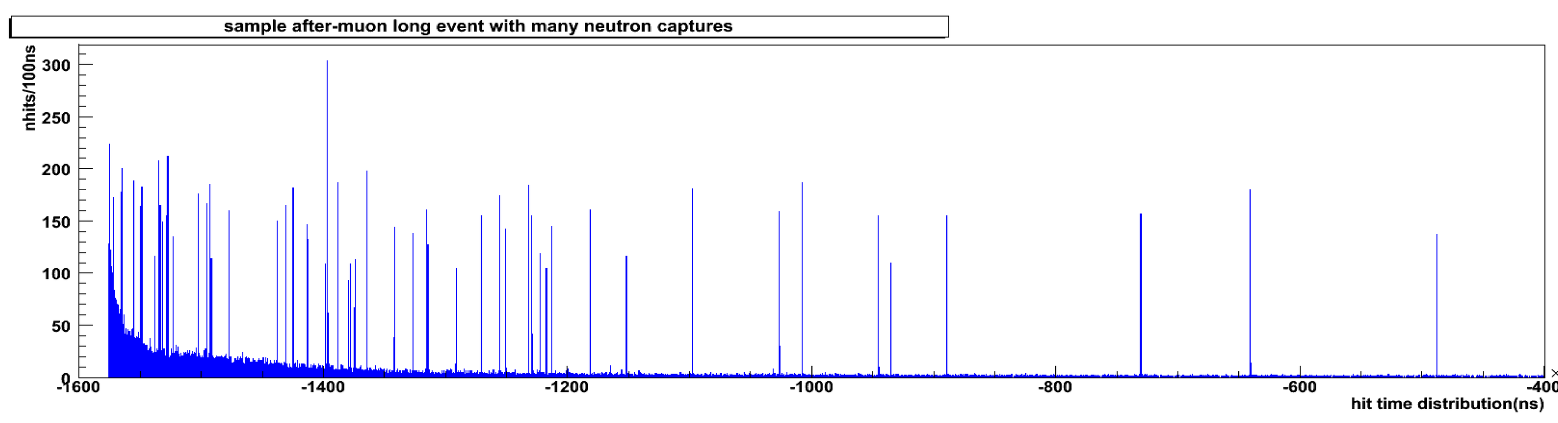








Neutrons



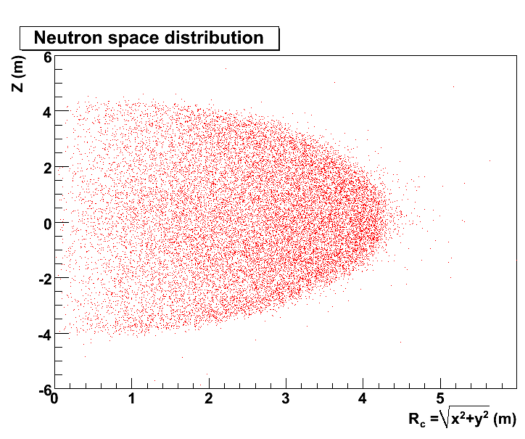
As a consequence of the interaction of cosmic muons in the detector's material neutrons may be produced.

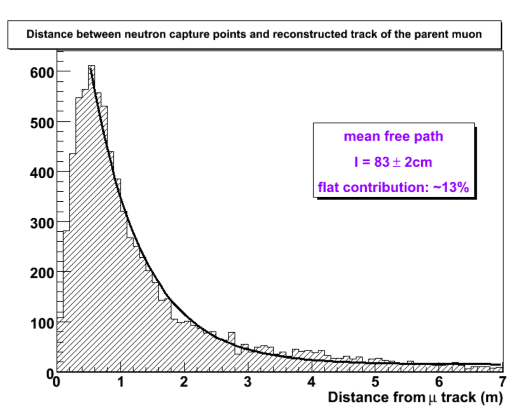
They are captured as n + p → d + γ (2.2MeV) in about 250 μs.

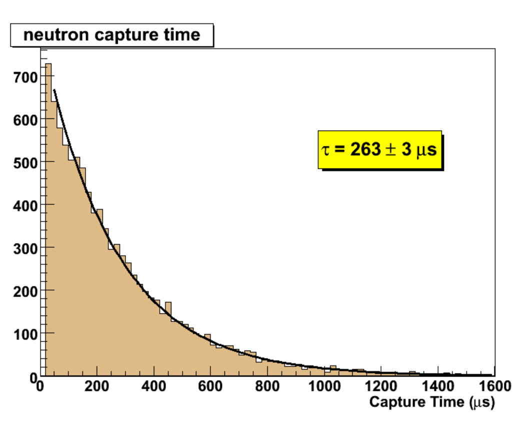
After Dec 16th 2007 we modified the daq in order to be sensitive to events with multiple neutrons produced after a muon in the scintillator: 1.6ms windows are acquired.

Preliminary efficiency checks indicate <u>> 90% neutrons detected</u>.

A parallel FADC multichannel system is under development to improve efficiency evaluation.







bibliography

- *First real time detection of Be-7 solar neutrinos by Borexino.* Borexino Collaboration, Phys. Lett. B658 101-108, 2008.

2. *Study of penetrating cosmic ray muons and search for large scale anisotropies at the Gran Sasso Laboratory.* By MACRO Collaboration, Phys. Lett. B249 149-156,1990.