Background suppression strategies in BOREXINO for solar pep and CNO neutrino spectroscopy

Werner Maneschg

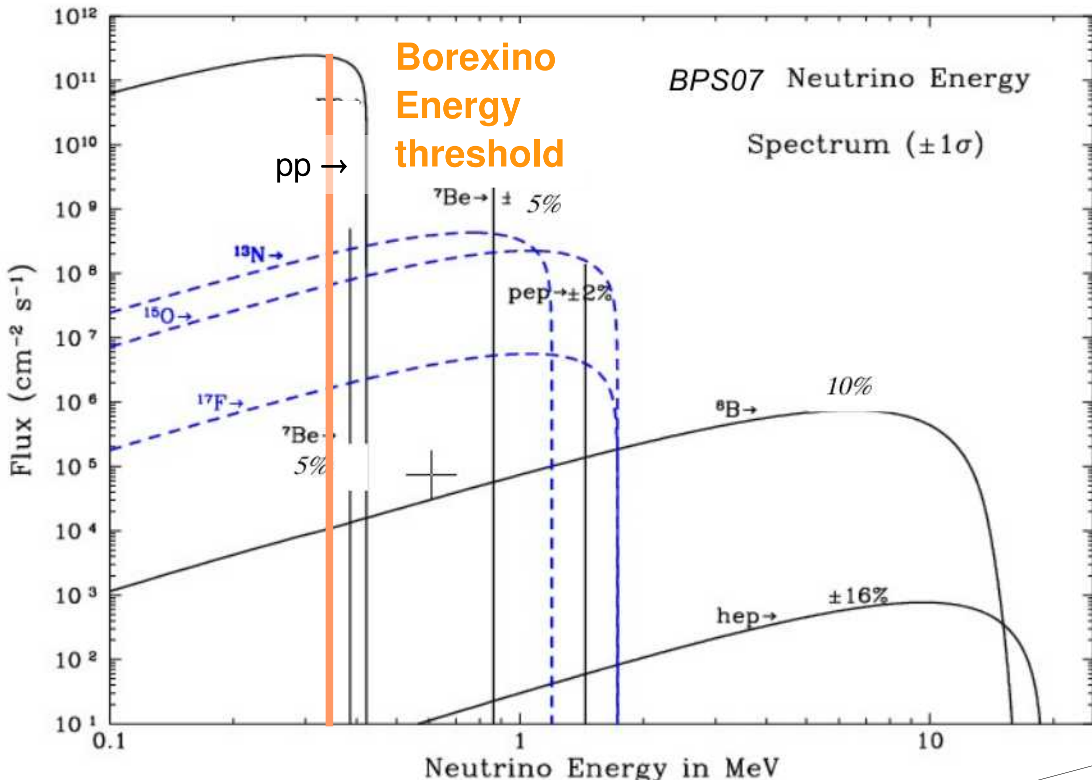
Max-Planck-Institut für Kernphysik - Heidelberg

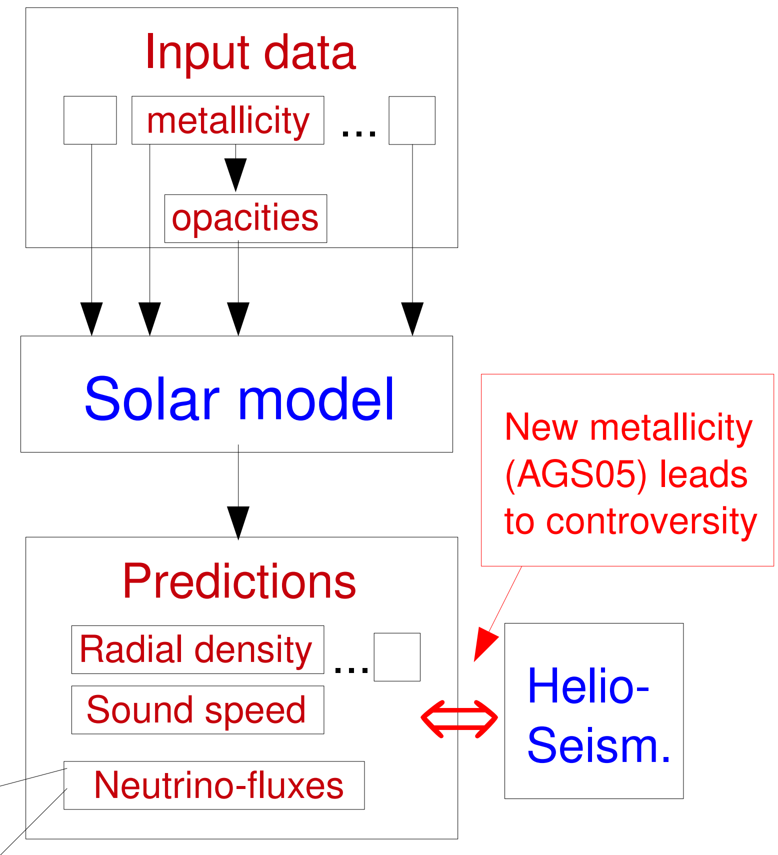
DPG Spring Meeting

Bonn - March 16th 2010

Measurement of solar neutrinos with Borexino

Predicted neutrino fluxes from SSM



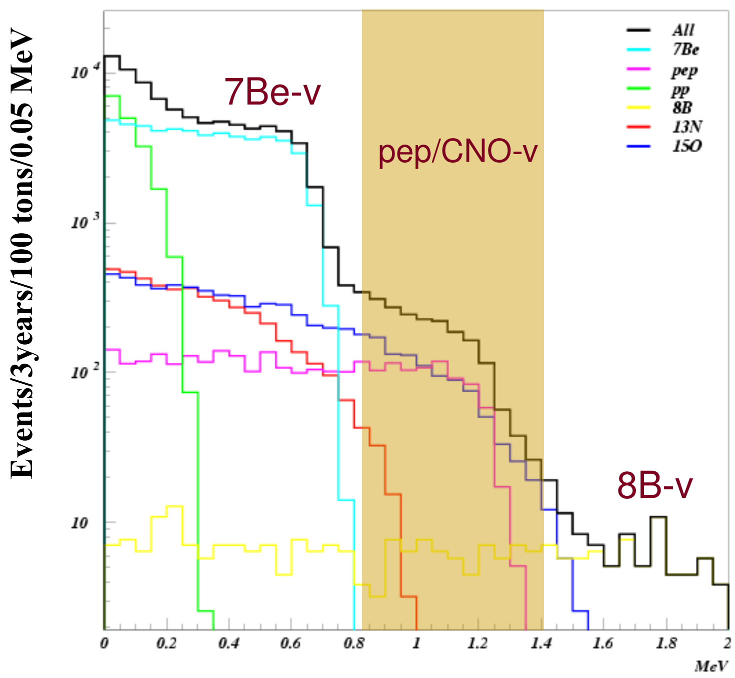


Neutrinos from nucl. fusion reactions	BS05(GS98) (high metallicity)	BS05(AGS05) (low metallicity)	(SSM1-SSM2)/SSM2
7Be	4.84 x 10^9	4.34 x 10^9	**- 10.3 %**
8B	5.69 x 10^6	4.51 x 10^6	**- 20.7 %**
13N	3.05 x 10^8	2.00 x 10^8	**- 34.4 %**
15O	2.31 x 10^8	1.44 x 10^8	**- 37.7 %**

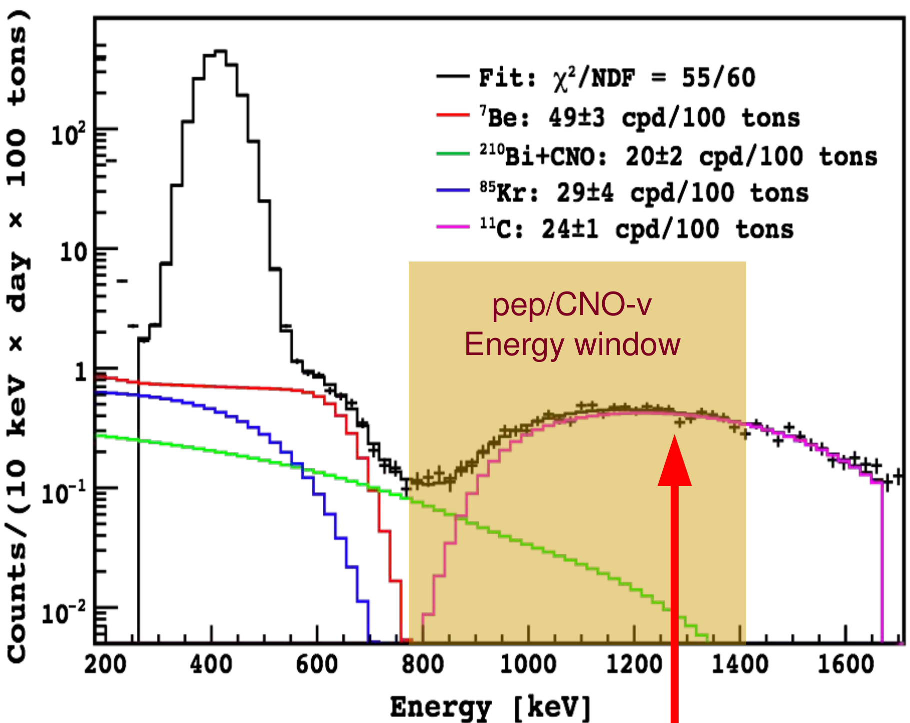
Measuring CNO-ν
→ help to discriminate
1 metallicity scenario

pep/CNO neutrino energy region in Borexino

Simulated energy spectrum from recoil-electrons scattered with solar neutrinos



Measured energy spectrum



Borexino measurements up to now:

7Be-neutrinos: arXiv:0805.3843v2 [astro-ph]
8B-neutrinos: arXiv:0808.2868v1[astro-ph]

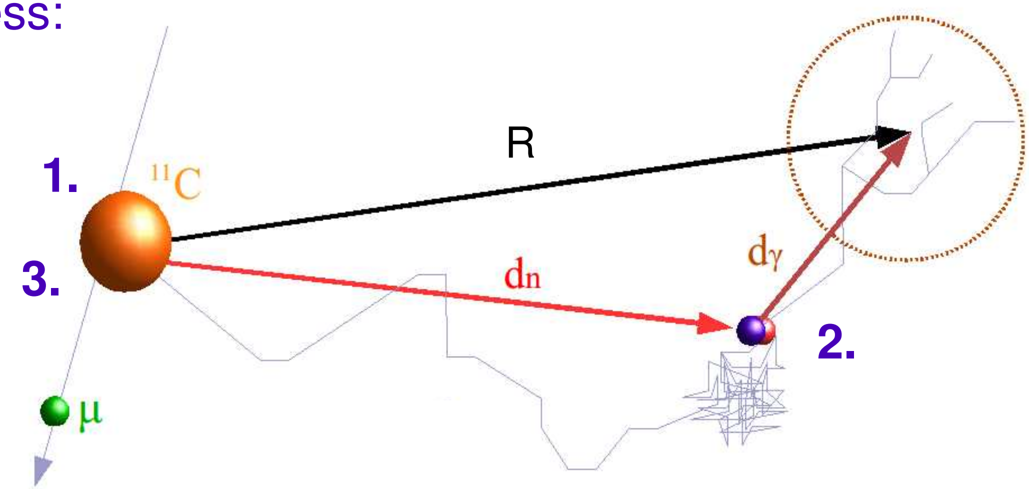
Main background:
Muon induced radioisotope ^{11}**C**

Expected ν-signal: ~1.5 cts/d/100ton
11C-rate: ~15 cts/d/100ton

S/B ~1:10

^{11}C identification & Threefold Coincidence Method

Process:

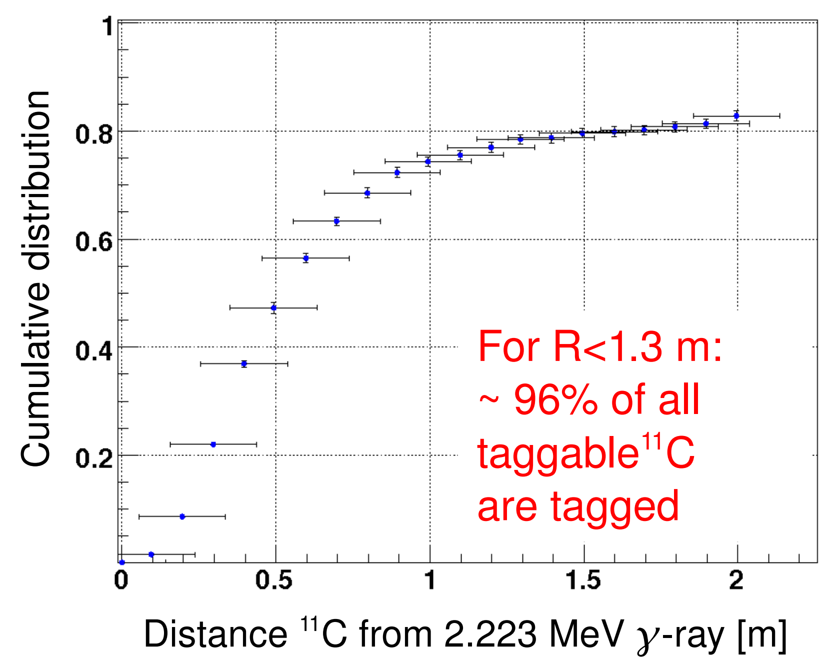


1. $\mu + {}^{12}C \rightarrow {}^{11}C + n + \mu$
2. $n + H \rightarrow D$ + 2.223 MeV γ-ray
3. ${}^{11}C \rightarrow {}^{11}B + e^{+} + \nu e$

Threefold Coincidence Method (TFC):

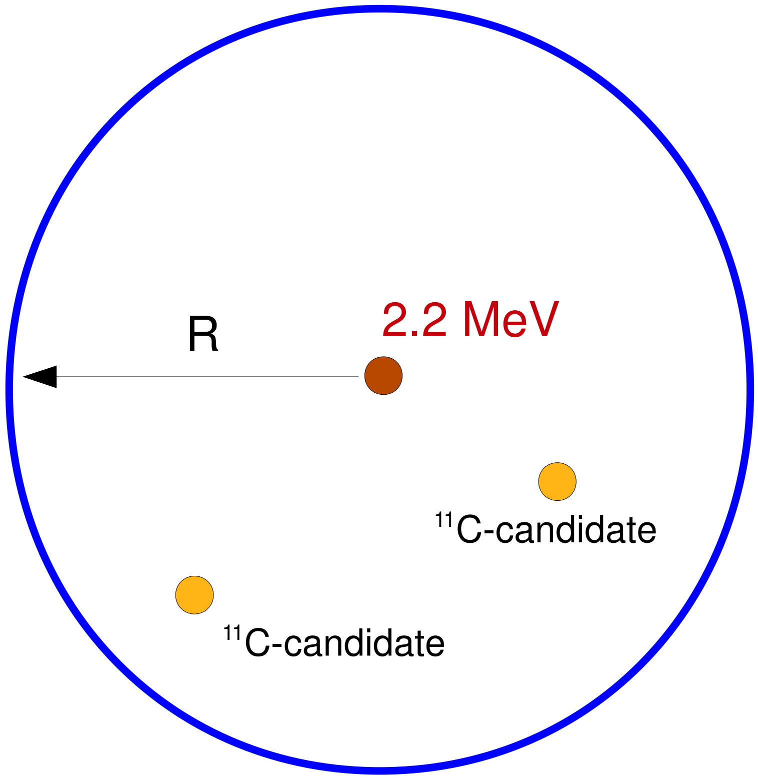
1. Prompt muon signal: **identification: y/n**
2. Delayed neutron capture: τ = 260 μs
   Position-reconstruction of characteristic 2.223 MeV γ-ray from neutron capture
3. Delayed ^{11}C decay: τ = 29.4 min
   Look for candidates within a **sphere of radius R** around the 2.223 MeV γ-ray in a **time interval** of typical 90-120 min.

Optimisation of TFC-cuts



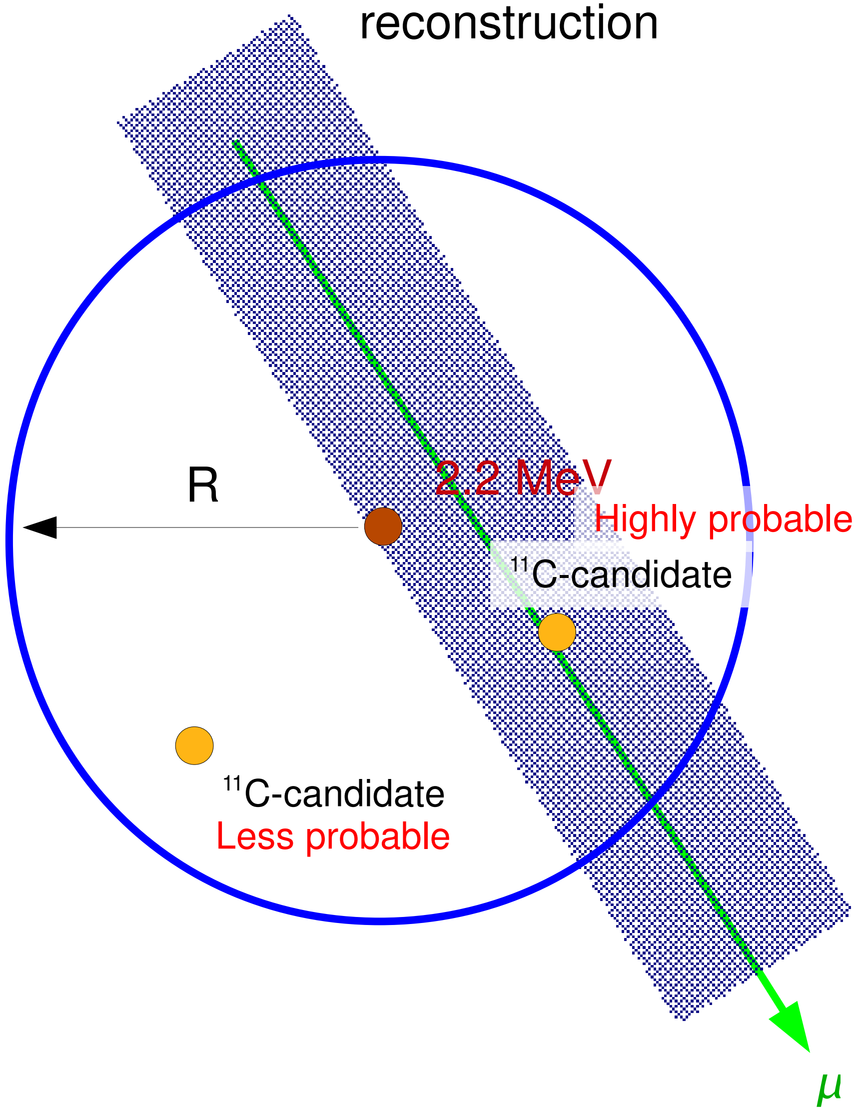
μ-track reconstruction & improved ^{11}C tagging efficiency

TFC: Up to now



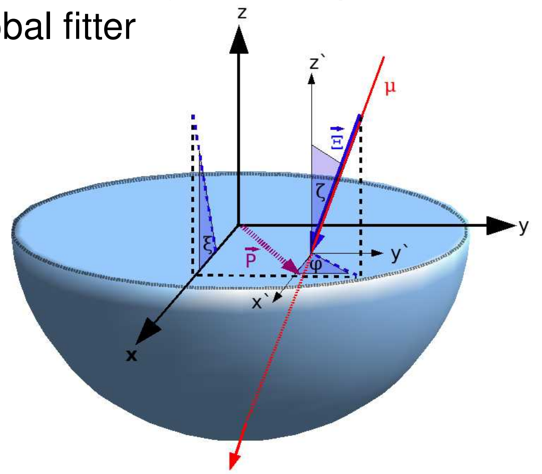
μ-track reconstruction & improved ^{11}C tagging efficiency

TFC: Including μ-track reconstruction

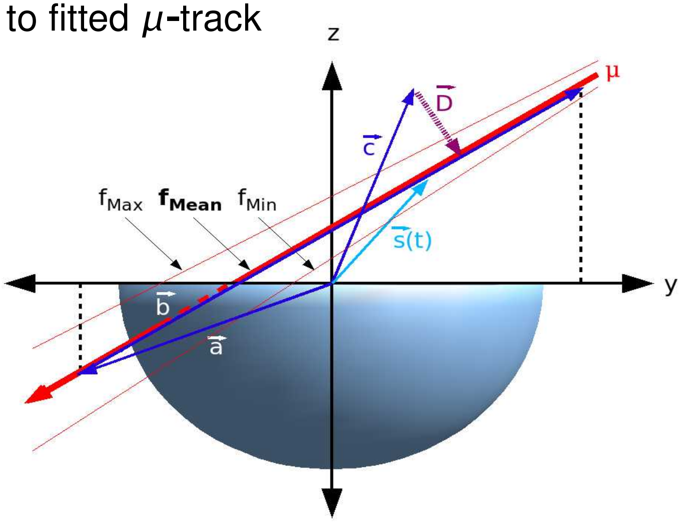


Reconstruction of μ-track

→ Estimate entry and exit point of μ-track
→ Global fitter



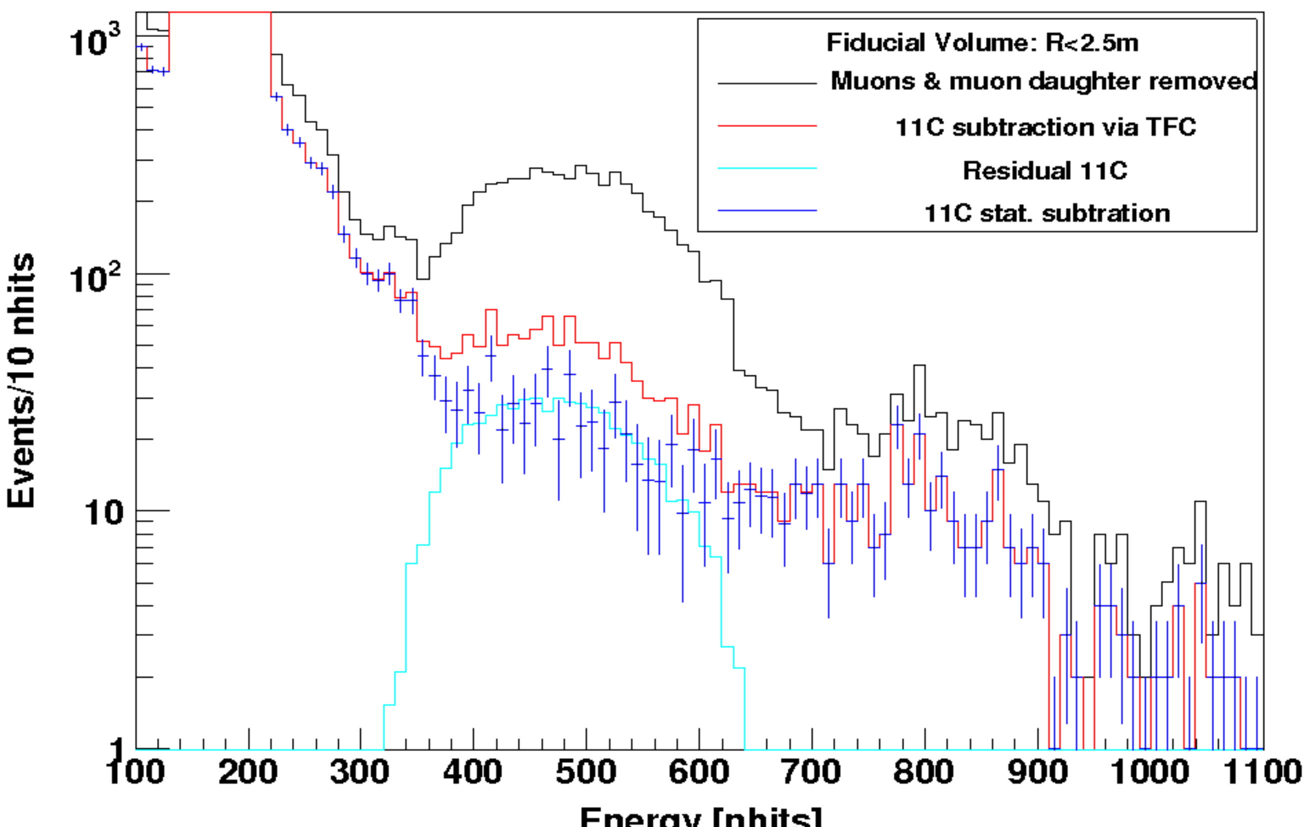
→ Estimate distance from ^{11}C candidate to fitted μ-track



^{11}C subtraction & residual ^{11}C

1. 11C-tagging via TFC method (R<1.3m; dt<120min);
→ ^{11}C subtraction event-by-event (removed ^{11}C: ~90%; loss of statistics: ~35%)

2. Estimation of spectral shape of ^{11}C peak via TFC method (R<0.5m; dt:(1,90)min)
Assuming a total 11C rate X: estimate residual amount of ^{11}C still present in data
→ Statistical subtraction of ^{11}C



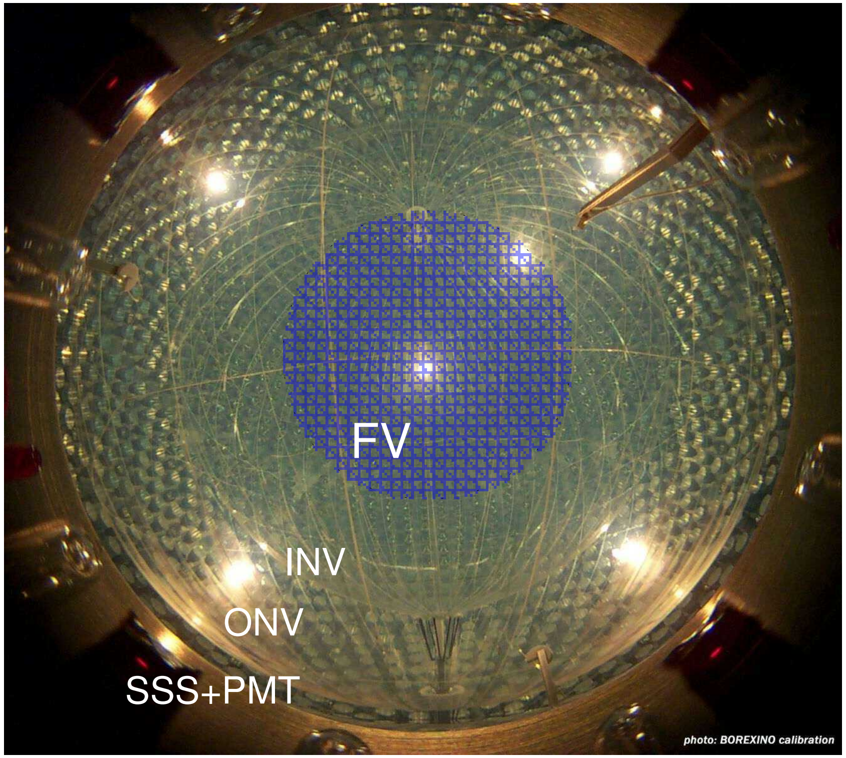
(320 nhits ~ 1MeV)

Other background components

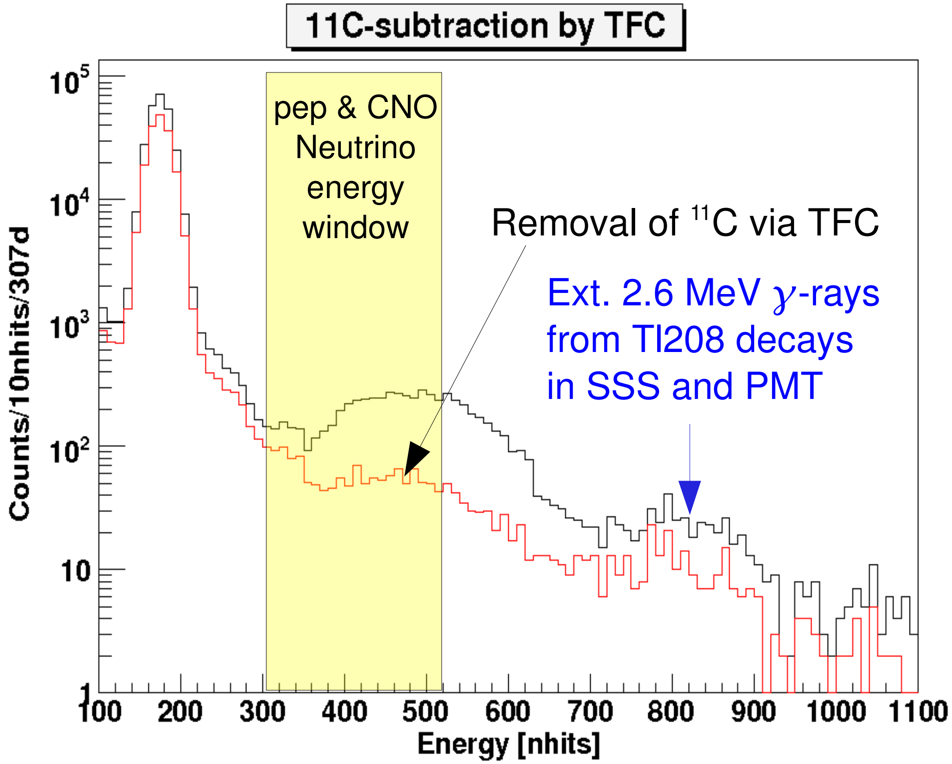
The external background from stainless steel sphere & PMTs

Stainless Steel Sphere (SSS): R<6.85m
Outer nylonvessel (ONV): R<6.25m
Inner nylonvessel (INV): R<4.25m

Fiducial Volume (FV): R<2.5 m
(4.35 m from SSS)

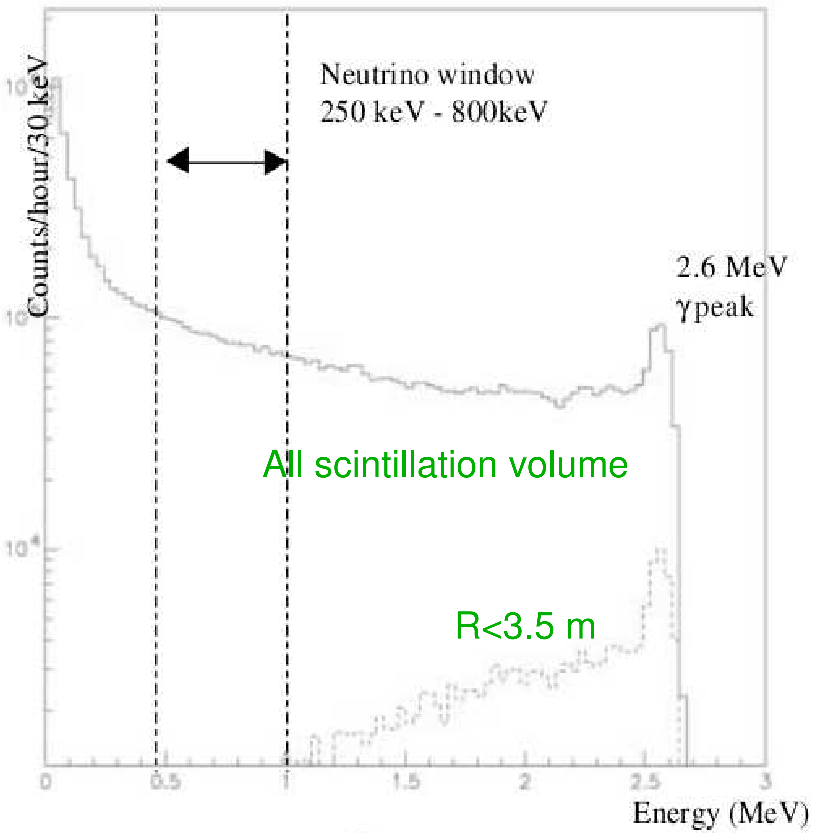


Rate of external 2.6 MeV γ-rays reduced, **BUT** still visible

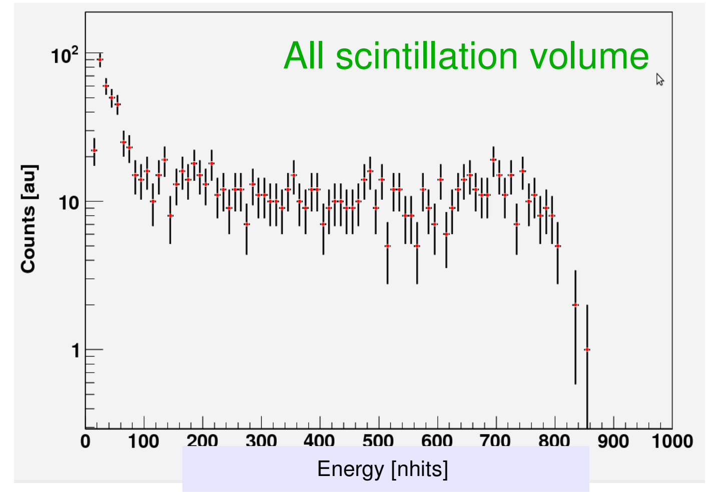


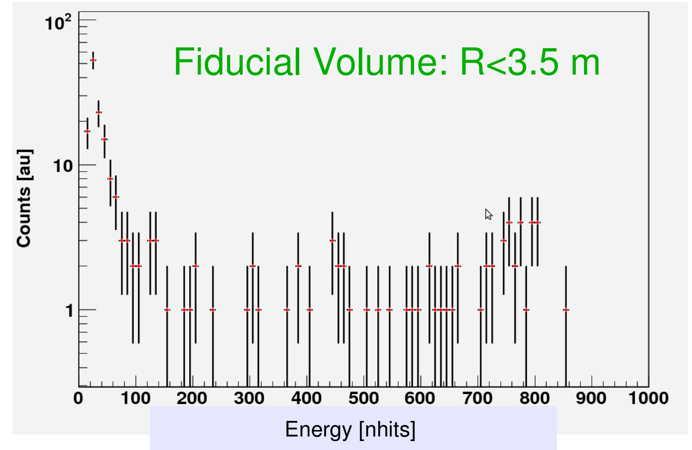
Spectral shape of the external background (E.B.)

MC simulations



Old MC (geneb-code)





New MC (Echidna c11, g4bx+bx_elec)

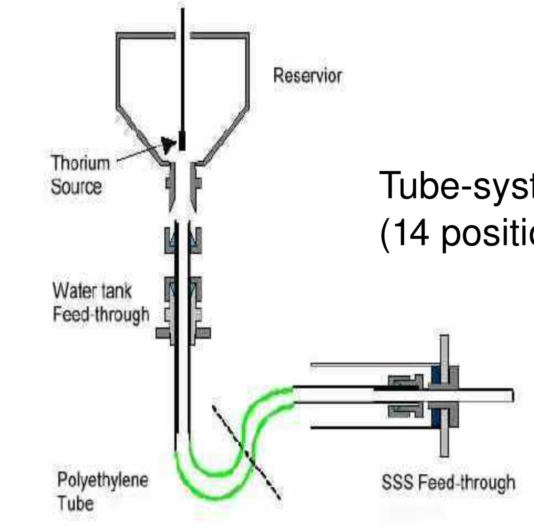
→ Spectral shape depends strongly on radius of F.V.

→ At smaller radii the continuum below the Full-Energy-Peak decreases, **BUT** it can still affect the pep/CNO ν energy region!

Measurement of spectral shape of E.B.

Calibration with external gamma source

Calibration system



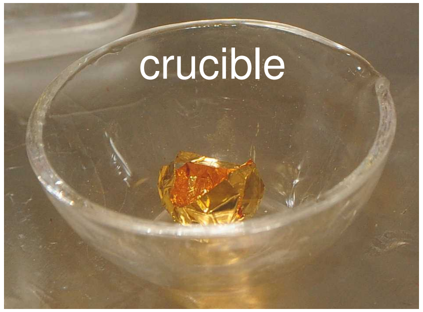
Tube-system
(14 positions)

Source-holder
attached to
fish-tap

Required source:
- Source emitting 2.614 MeV gamma-rays (from Tl208) with activity of several MBq
- Avoid indirect production of neutrons via (alpha,n) reactions in matrix-material

Procurement of custom-made source

Production:
- 6 MBq 228Th source
- gold as (alpha,n) resistive material
- chemical/thermal treatment



Next steps (March/April 2010):
- Sealing of custom-made source
- Characterisation of source
- Trasport to experimental side+calibration campaign

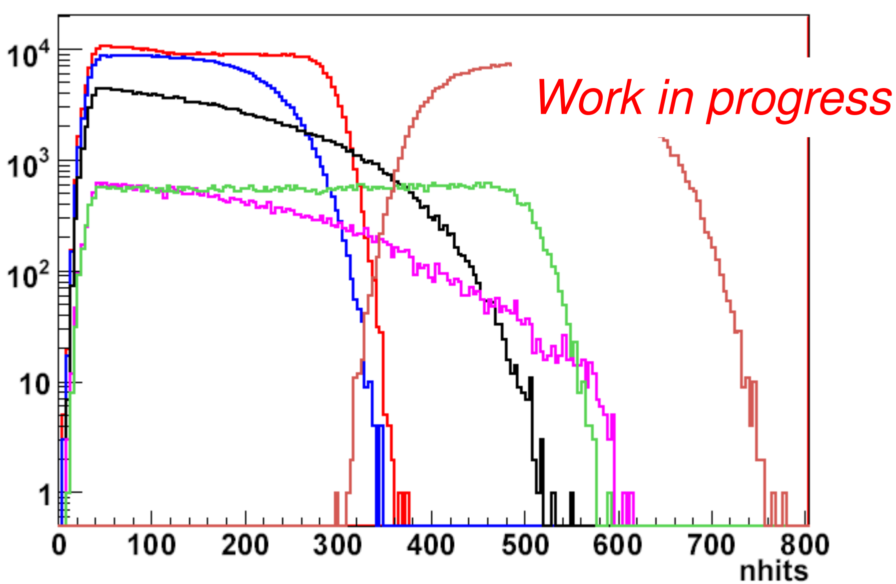
Spectral fit analysis of solar pep/CNO neutrinos

Strategy:

- Tagging ^{11}C via TFC-method
- 11C subtraction: 1. event-by-event; (2. statistically)
- Constrain on spectral shape of known residual contaminants
- Fit of energy spectrum: **2 possibilities:**

MC based fit

→ Full Implementation of detector and physics in Borexino-simulation package g4Bx (based on Geant4)
→ Tuning of MC-code via calibration sources: Energy (incl. kB and LY) and position reconstruction
→ Generation of all neutrino sources and contaminants



Analytical model fit

→ Use theor. expected energy spectra for neutrinos and background components
→ Required: estimation of detector response Function (analytical description)