What we found with Borexino

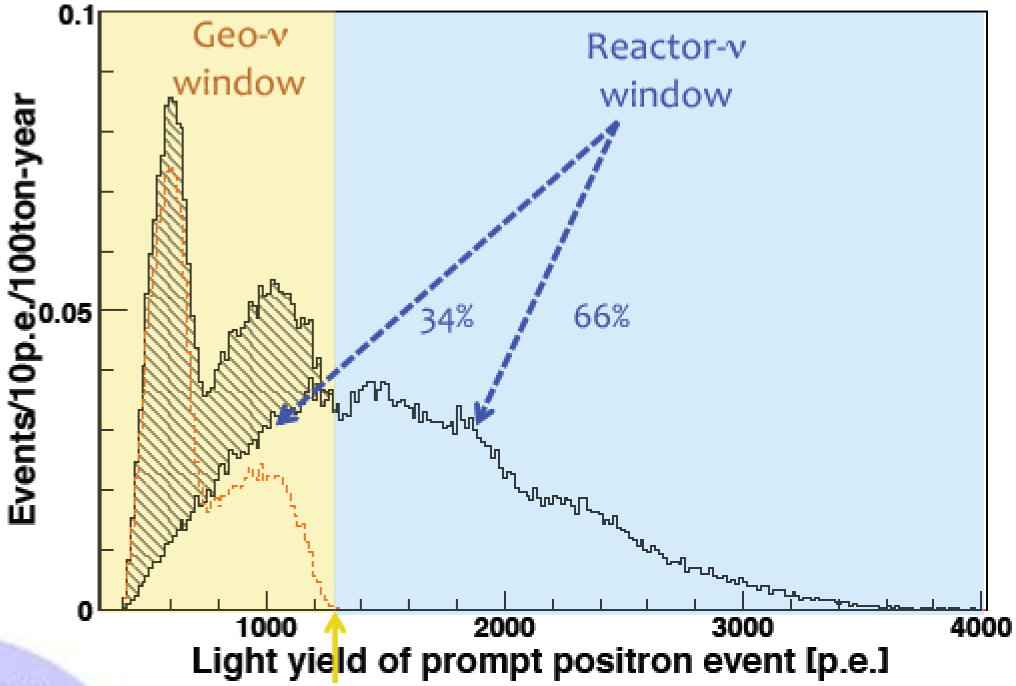
Stefano Davini
University of Houston
NMR-2013, Tokyo

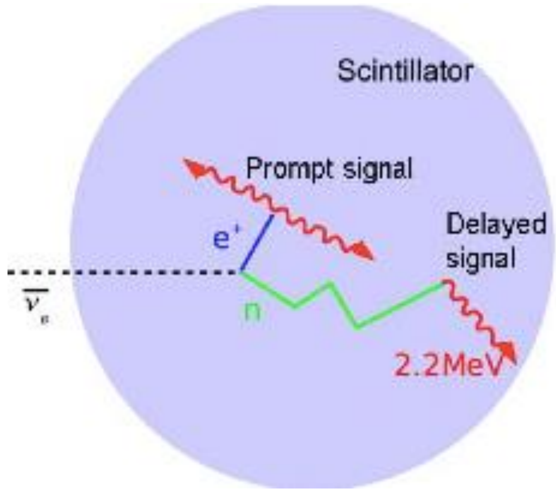
Outline

- Yesterday (Jul 25): Review of Geo-neutrinos and Borexino
  - review of **Borexino** detector
  - **antineutrino** analysis

- Today (Jul 26): What we found with Borexino
  - geo-neutrino **results** (2013)
  - **implications**

What we expect, and what the spectra means

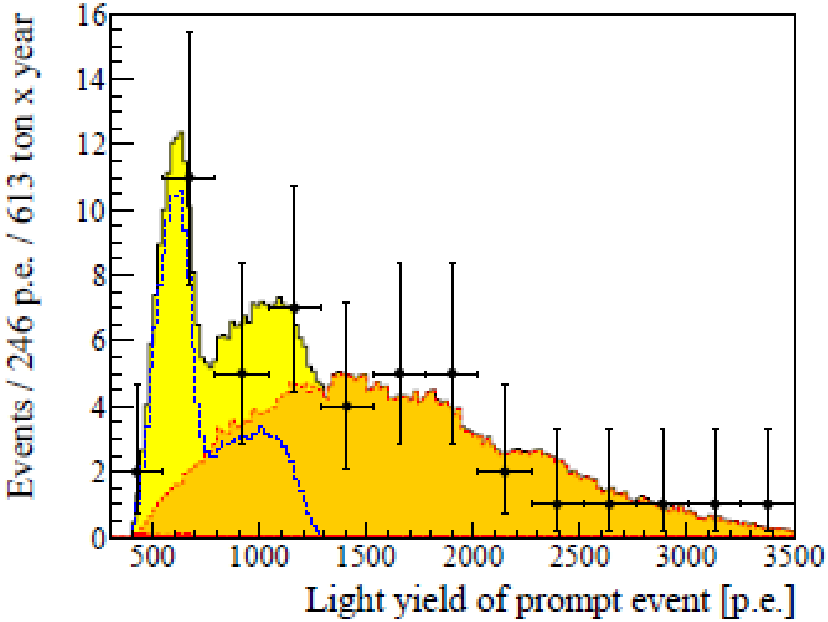




$$E_{\text{prompt}} = E_{\bar{\nu}_e} - 0.784\,\text{MeV}.$$

In Borexino
1 Mev ~ 500 **p**hoto **e**lectrons

What we found in Borexino (1)



46 anti-nu **candidates** in 613 tons * year

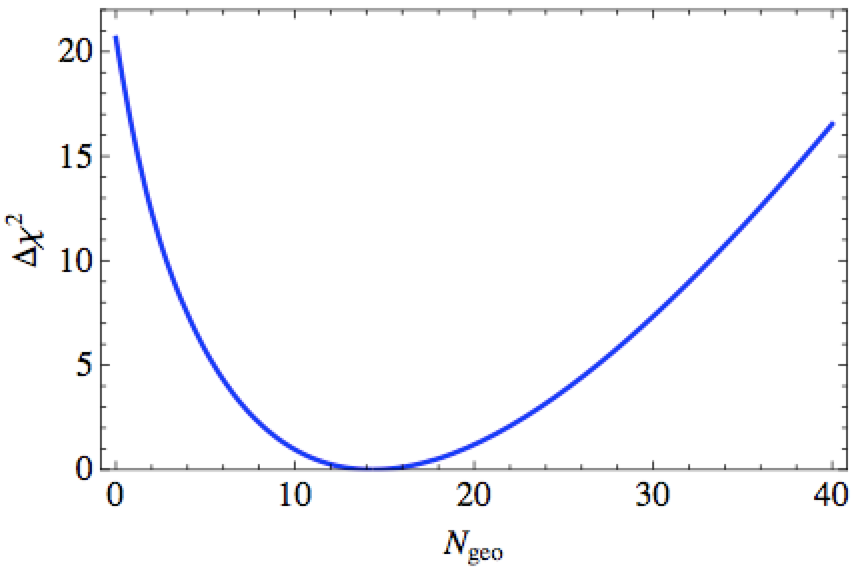
Unbinned Maximum Likelihood **fit** to **disentangle** geo and reactors anti-nu

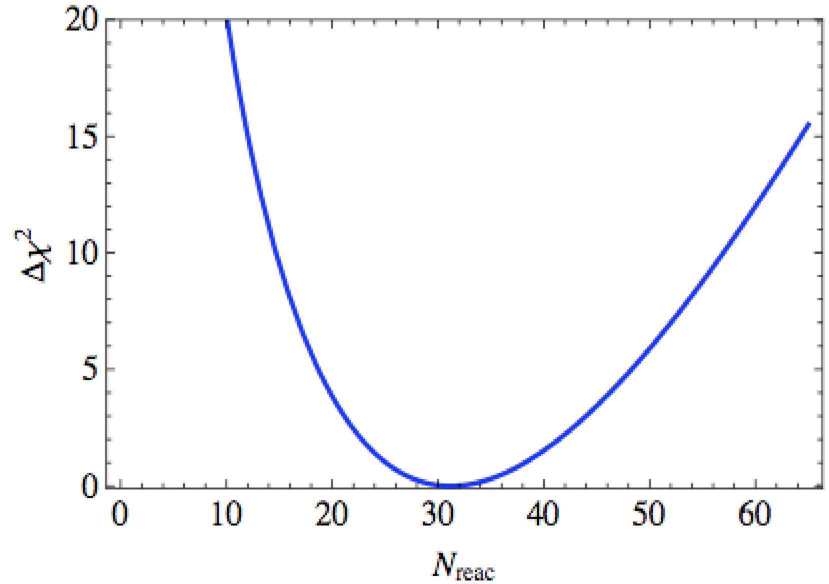
Fit with Chondritic ratio **fixed**: 3.9

Ngeo = (14.3 ± 4.4) events -> (38.8 ± 12) TNU

Nrea = $(31.2^{+7.0}_{-6.1})$ events -> $(84.5^{+19.3}_{-16.9})$ TNU

What we found in Borexino (2)

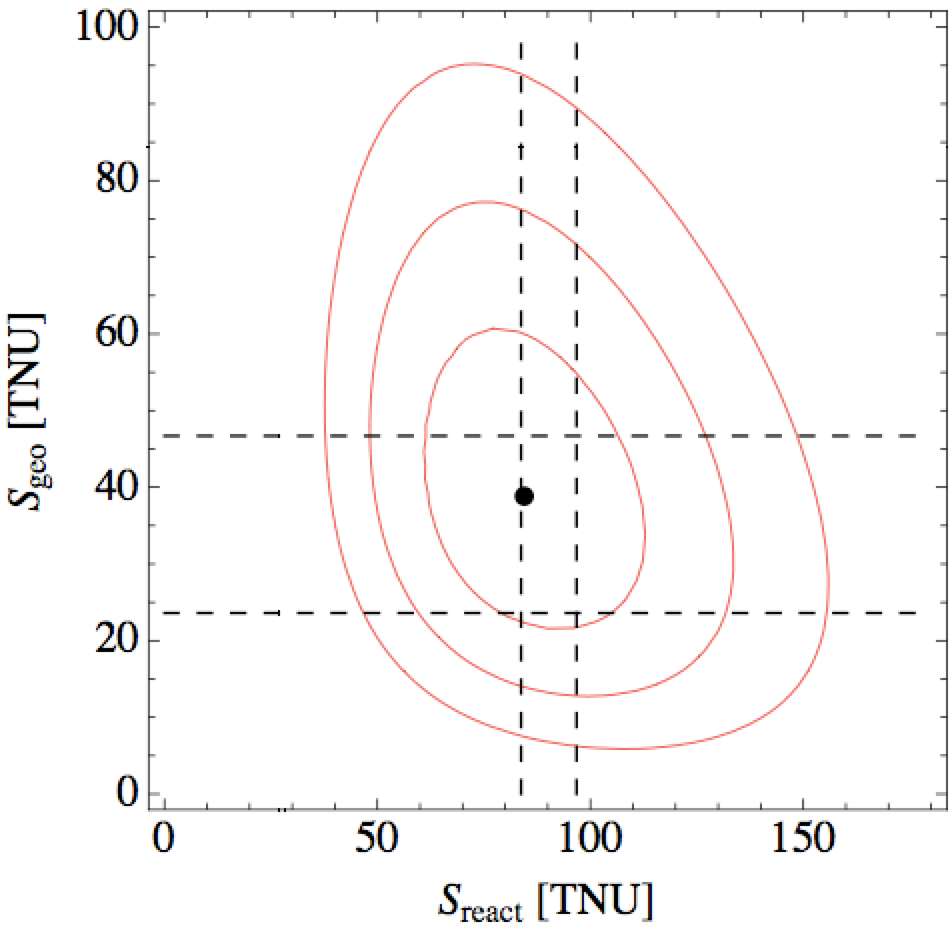




Null hyphotesis for geo-neutrinos (S geo = 0) has probability 6 $*10^{-6}$

Evidence for geo-nu measurement at **4.5 σ**

What we found with Borexino (3)



Contour Plot
for geo-nu
and reactor anti-nu

1σ expectation band
of S geo-nu = (26.3-46.6)TNU
for different models

1σ expectation band of S reactor : (83.2-97.3) TNU

Mantle contribution

Sgeo = S(Crust) + S(Mantle)

S^{BX} geo (Total) = (38.8 ± 12.0) TNU

S^{BX} geo (Crust) = (23.4 ± 2.8) TNU

M. Coltorti et al., Geo.Cosm. Acta 75(2011)2271
Y. Huang et al., arXiv:1301.0365

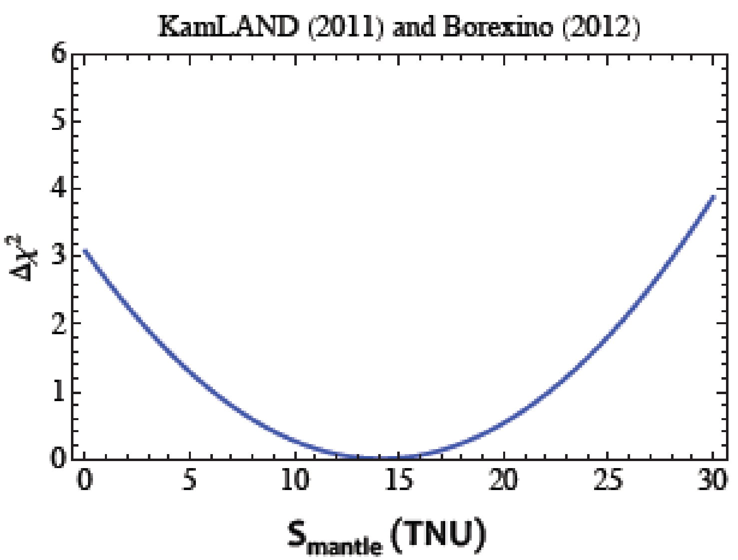
S^{BX} (mantle) = (15.4 ± 12.3) TNU

Combined analysis with KamLAND

S^{KL} geo(Total) = $(38.3\ ^{+10.3}_{-9.9})$ TNU

S^{KL} geo(Crust) = (25 ± 2) TNU

A. Gando et al. (KamLAND Collab.),Nature Geosci. 4 (2011) 647



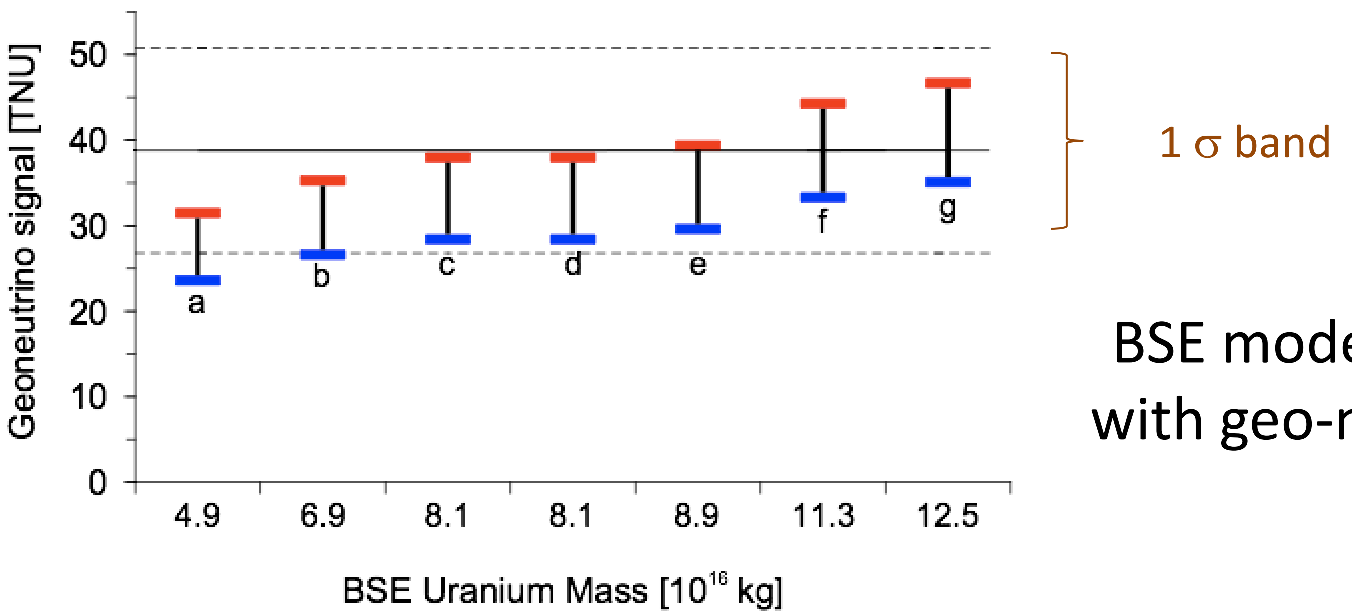
S(Mantle) = (14.1 ± 8.1) TNU

Comparison with BSE models

Total S_{geo} [TNU]		Model
low	high	
35.1	46.64	Turcotte & Schubert 2002 (g)
33.3	44.24	Anderson 2007 (f)
29.6	39.34	Palme & O'Neil 2003 (e)
28.4	37.94	Allegre at el. 1995 (d)
28.4	37.94	Mc Donough & Sun 1995 (c)
26.6	35.24	Lyubetskaya & Korenaga 2007 (b)
23.6	31.44	Javoy et al.2010 (a)

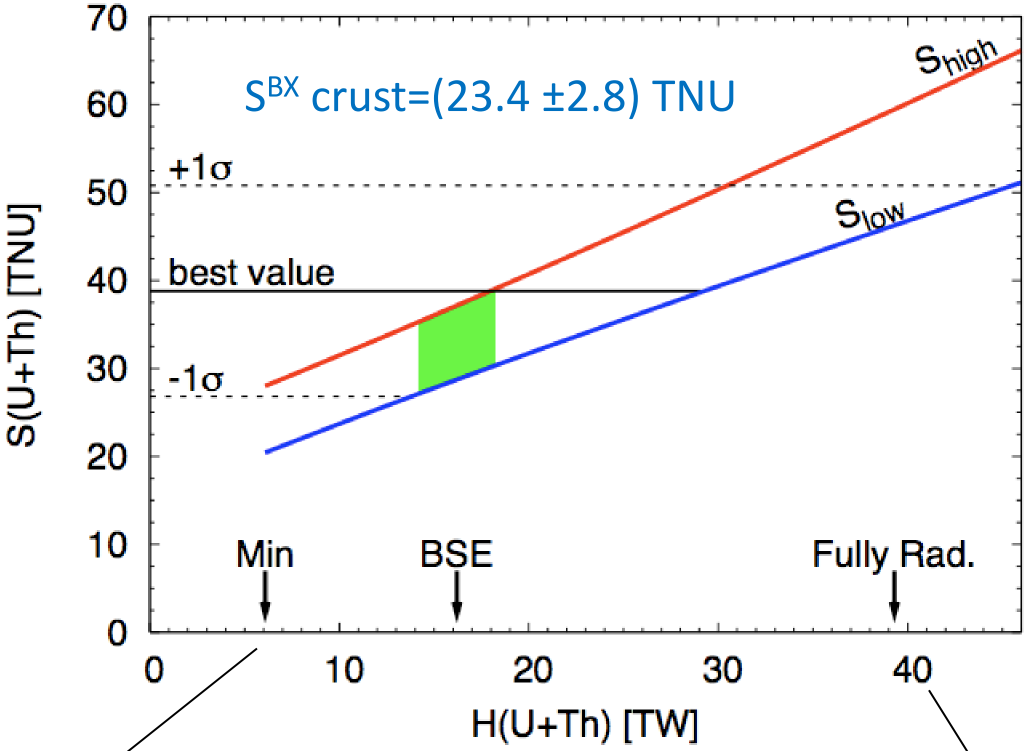
High= homogeneous mantle, crustal signal + 1 σ error

Low= HPE's concentrated close to the core-mantle boundary, crustal signal -1 σ error



BSE models in agreement with geo-nu measurement

Earth radiogenic power



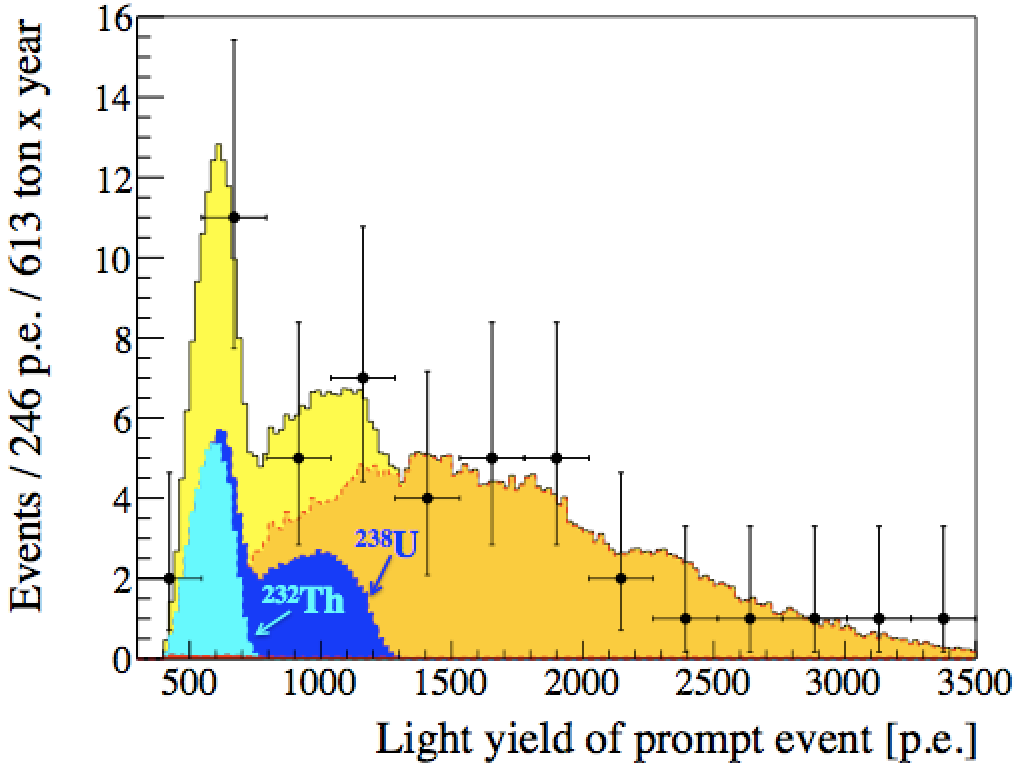
Red line: ROC+LOC +1σ, mantle homogeneous

Blue line: ROC+LOC -1σ, HPE's at mantle-core boundary

Min = only crustal HPE's

Full Rad: Tot Heat=(47 ± 2) TW => $H_U + H_{Th}$ = 39.3 TW

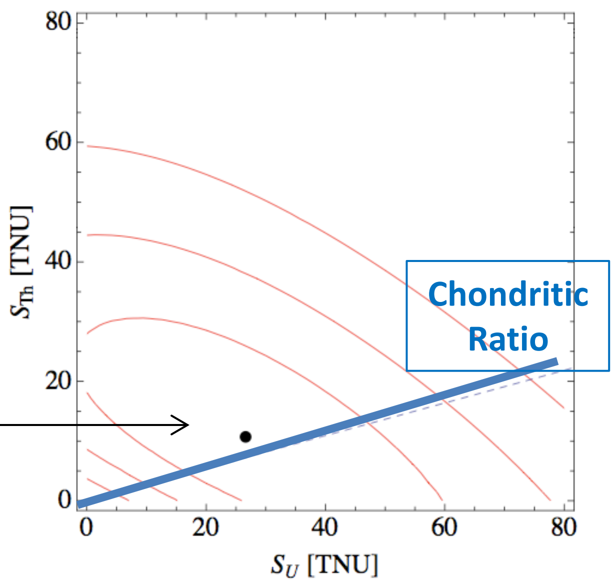
What we found with Borexino (4)



Fit with **separate** (**free**)
U and **Th** **contribution**

N **U** = 9.8 ± 7.2 events
N **Th**= 3.9 ± 4.7 events
N **react** = 31.7 $^{+7.2}_{-6.3}$ events

S U = (26.5 ± 19.5) TNU
S Th= (10.6 ± 12.7) TNU



Summary and Outlook

New **Borexino** result on geo-ν fluxes measured at **LNGS**,
fiducial exposure of 613 ton*year (3.69 *10^{31} N protons)

Measured **(14.3 ± 4.3) geo-ν**, **(38.8 ± 12) TNU**

BSE models in **agreement** with Geo-nu measurement

Signal for **mantle** deduced,
combined analysis with **KamLand**
S(mantle) = (14.1 ± 8.1) TNU

Spectroscopic **measurement** of U and Th,
obtained best value for **Th/U ratio** close to the chondritic one

Just one more step to attack models!