Recent results from Borexino

Alina Vishneva
(on behalf of the Borexino collaboration)
JINR, Russia

Baksan-50 session-conference, Nalchik, Russia
June 6-8, 2017

Outline

- Borexino experiment
- Neutrino program
- Antineutrino program

Outline

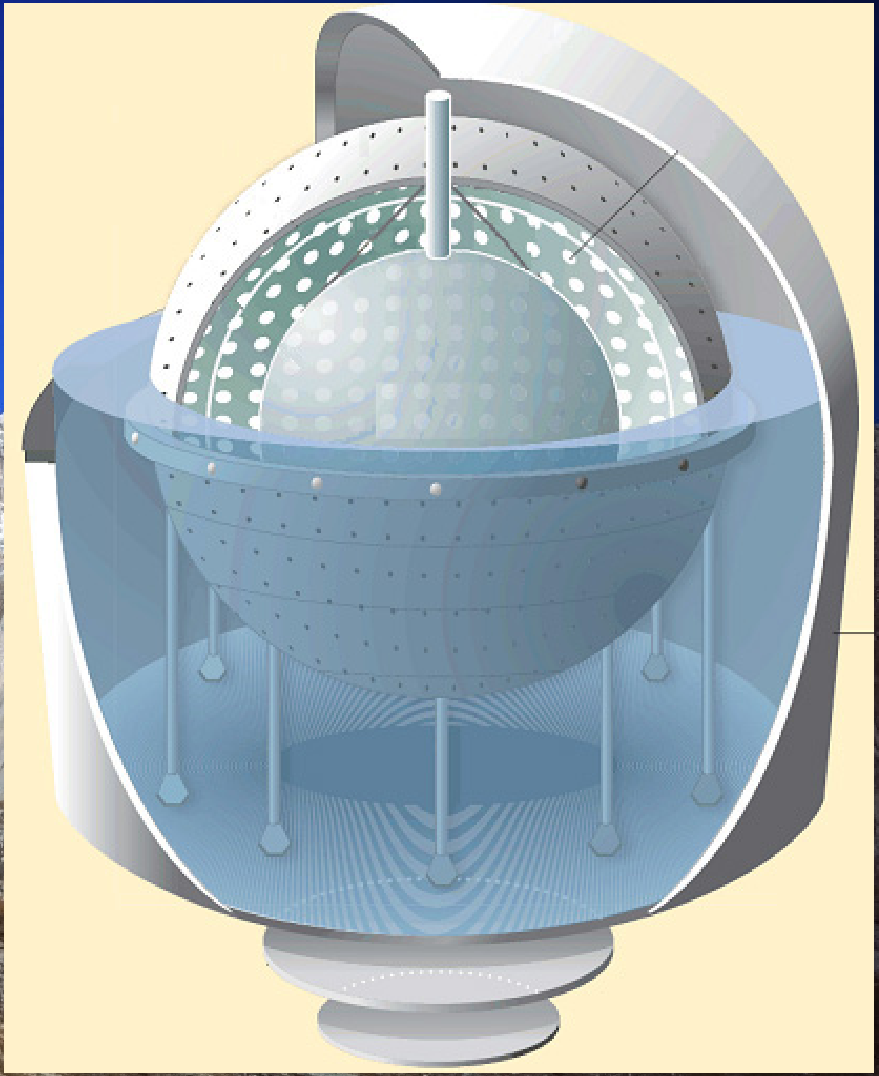
- **Borexino experiment**
- Neutrino program
- Antineutrino program

Borexino detector

- ☞ Location: LNGS, Italy
- ☞ Primary goal: low-threshold real-time solar neutrino detection (^{7}Be)
- ☞ Detection principle: elastic scattering on electrons, IBD (for antineutrinos)

Properties

- Scintillator: Pseudocumene + PPO (target), Pseudocumene + DMP (buffer)
- Mass: 278 t
- PMTs: 2212 (initially) + 208 external
- Radioactivity: ^{238}U and ^{232}Th contamination ~ 10^{-18} g/g
- Energy threshold: ~100 keV (on e^-)
- Energy resolution@1 MeV: ~5%



Phase 1: 2007 – 2010
Re-purification, calibrations: 2010-2011
Phase 2: 2011 – now

The most improtant Phase-1 results

- ✔ Measurement of ^{7}Be neutrino flux with 5% precision
- ✔ Absence of day/night assymmetry for ^{7}Be neutrinos => MSW-LMA solution singled out
- ✔ First observation of pep neutrinos
- ✔ The strongest limit on CNO neutrino flux
- ✔ Observation of annual modulations of ^{7}Be neutrino interaction rate => proof of the solar origin of neutrinos
- ✔ Low-threshold detection of ^{8}B neutrinos
- ✔ Searches for rare processes (Pauli principle violation, heavy sterile neutrino in ^{8}B flux, antineutrinos of solar origin)

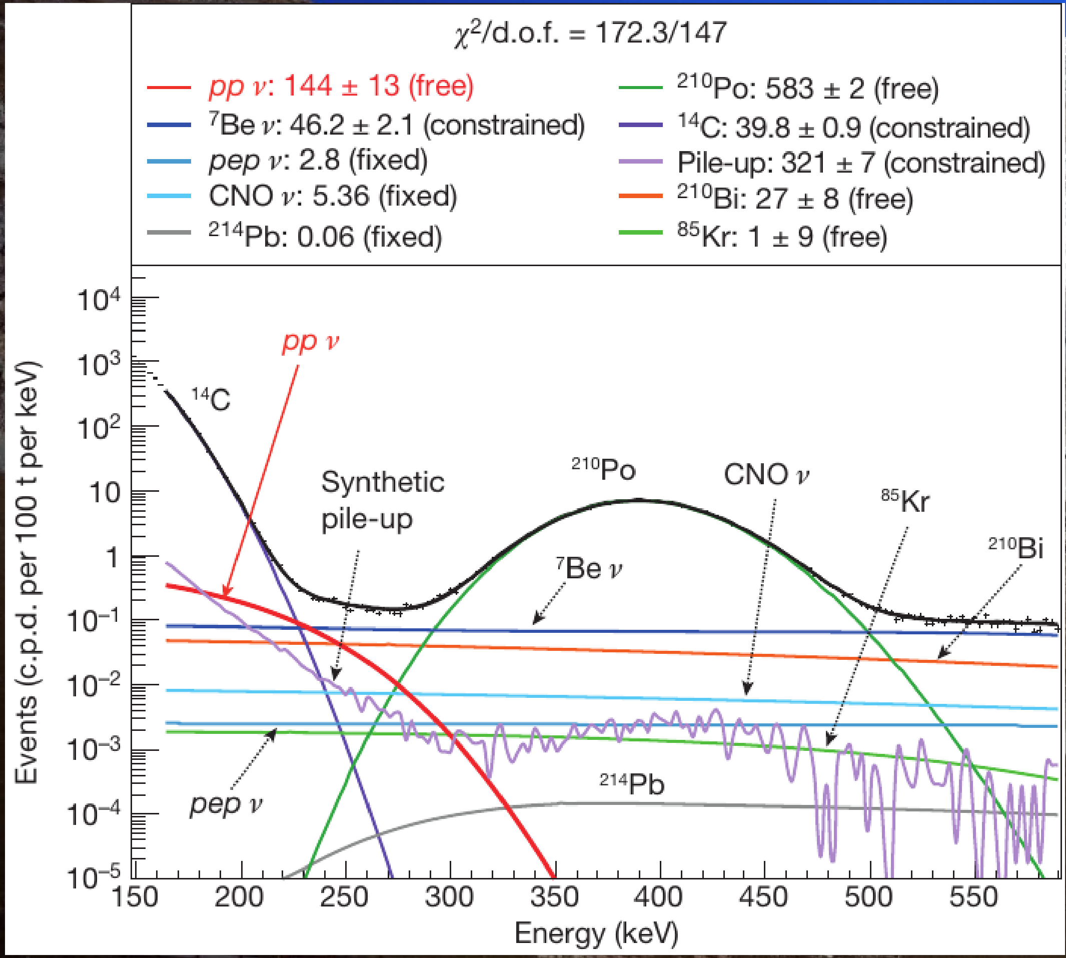
Outline

- Borexino experiment
- **Neutrino program**
- Antineutrino program

pp-neutrino flux measurement

Nature, **512**, 383-386 (2014)

Data set: January 2012 – May 2013 (408 days livetime)



Systematic uncertainties:

- Energy estimator
- Fit range
- Fiducial volume cut
- Pile-up evaluation methods

Measured flux: $(6.6\pm0.7)\times10^{10}$ cm^{-2}s^{-1}

SAGE flux: $(6.0\pm0.8)\times10^{10}$ cm^{-2}s^{-1}
Standard Solar Model prediction:
$5.98\times(1\pm0.006)\times10^{10}$ cm^{-2}s^{-1}

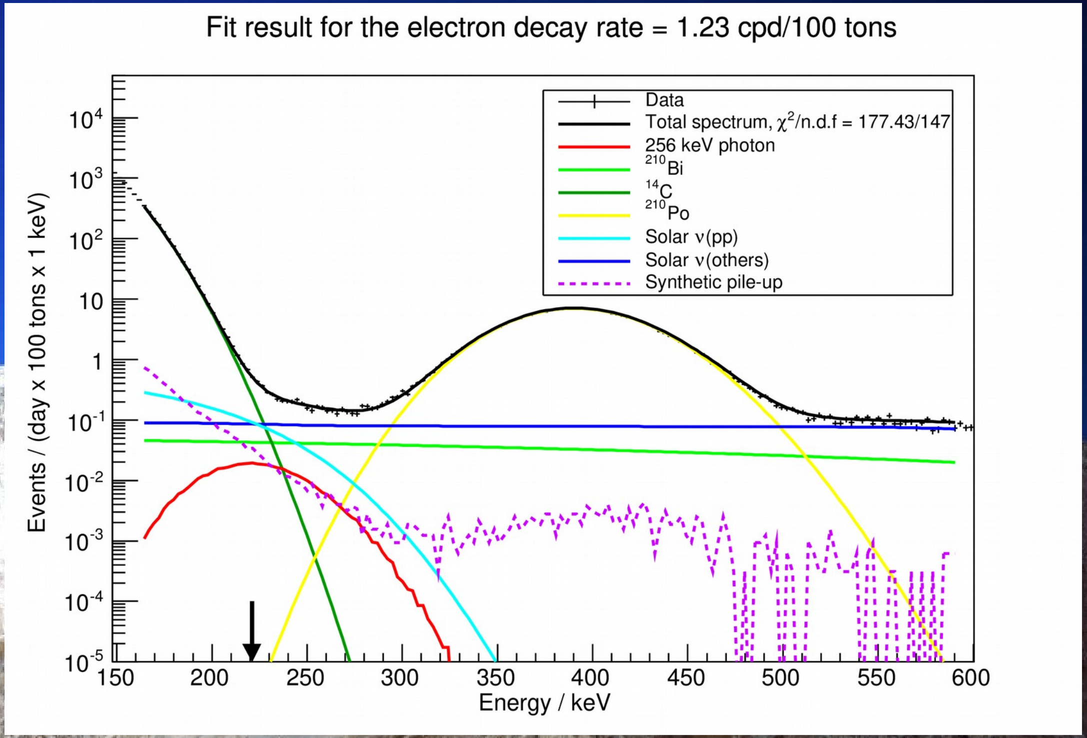
Electron lifetime limit

Phys. Rev. Lett. **115**, 231802 (2015)

- Decay mode: e→γν
- Analysis approach based on the pp-neutrino analysis
- Pp-neutrino rate is constrained according to results of radiochemical experiments

Systematic uncertainties:

- Quenching parameter
- Energy estimator
- Fiducial mass uncertainty



τ≥6.6×10²⁸ yr (90% C.L.)

The strongest electron lifetime limit!

14 Lepton Summary Table

LEPTONS

e

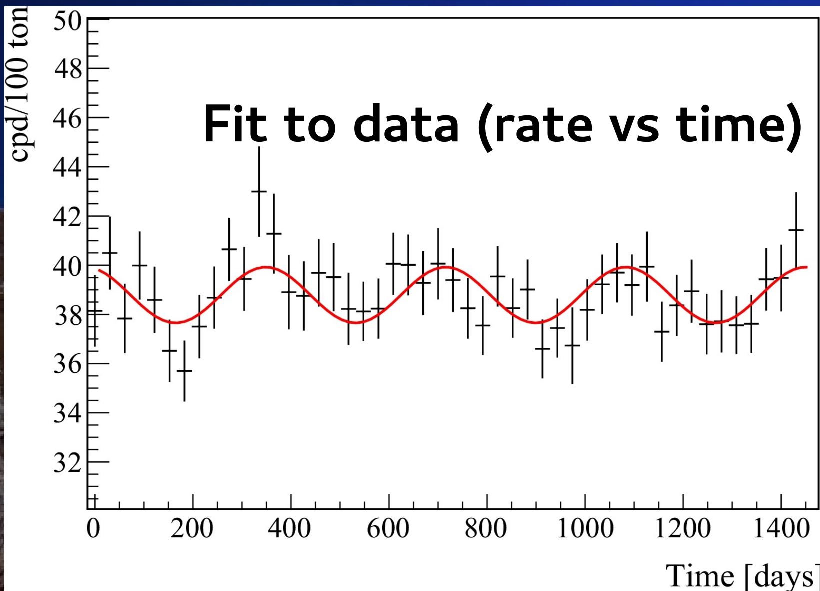
$J = \frac{1}{2}$

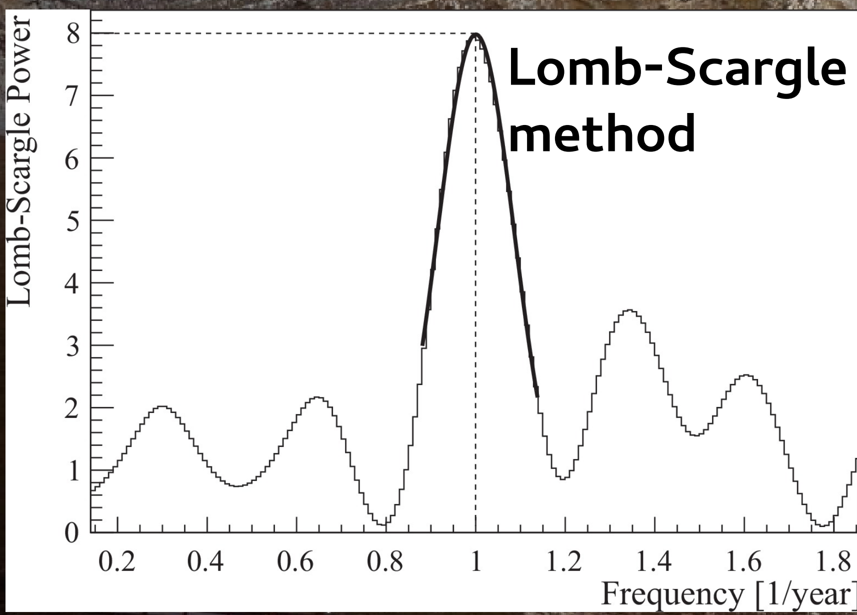
Mass $m = (548.579909070 \pm 0.000000016) \times 10^{-6}$ u
Mass $m = 0.5109989461 \pm 0.0000000031$ MeV
$|m_{e^+} - m_{e^-}|/m < 8 \times 10^{-9}$, CL = 90%
$|q_{e^+} + q_{e^-}|/e < 4 \times 10^{-8}$
Magnetic moment anomaly
$(g-2)/2 = (1159.65218091 \pm 0.00000026) \times 10^{-6}$
$(g_{e^+} - g_{e^-}) / g_{average} = (-0.5 \pm 2.1) \times 10^{-12}$
Electric dipole moment $d < 0.87 \times 10^{-28}$ e cm, CL = 90%
Mean life $\tau > 6.6 \times 10^{28}$ yr, CL = 90% [a]

Seasonal modulations

Astropart. Phys. **92**, 21-29 (2017)

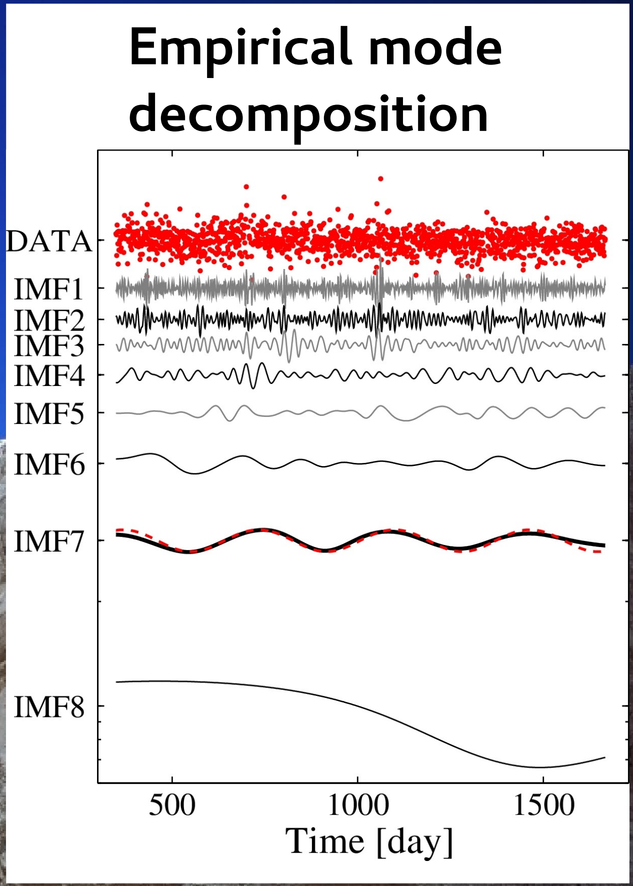
Data set: Dec 2011 – Dec 2015 (1456 days livetime)





Astronomical observations:
- T = 365.256 d
- ε = 0.0167

Borexino result:
- T = 367±10 d
- ε = 0.0174±0.0045



All approaches show consistency with the solar origin of ^{7}Be neutrinos.

The absence of seasonal modulation is ruled out at 99.99% C.L. (3.91σ)

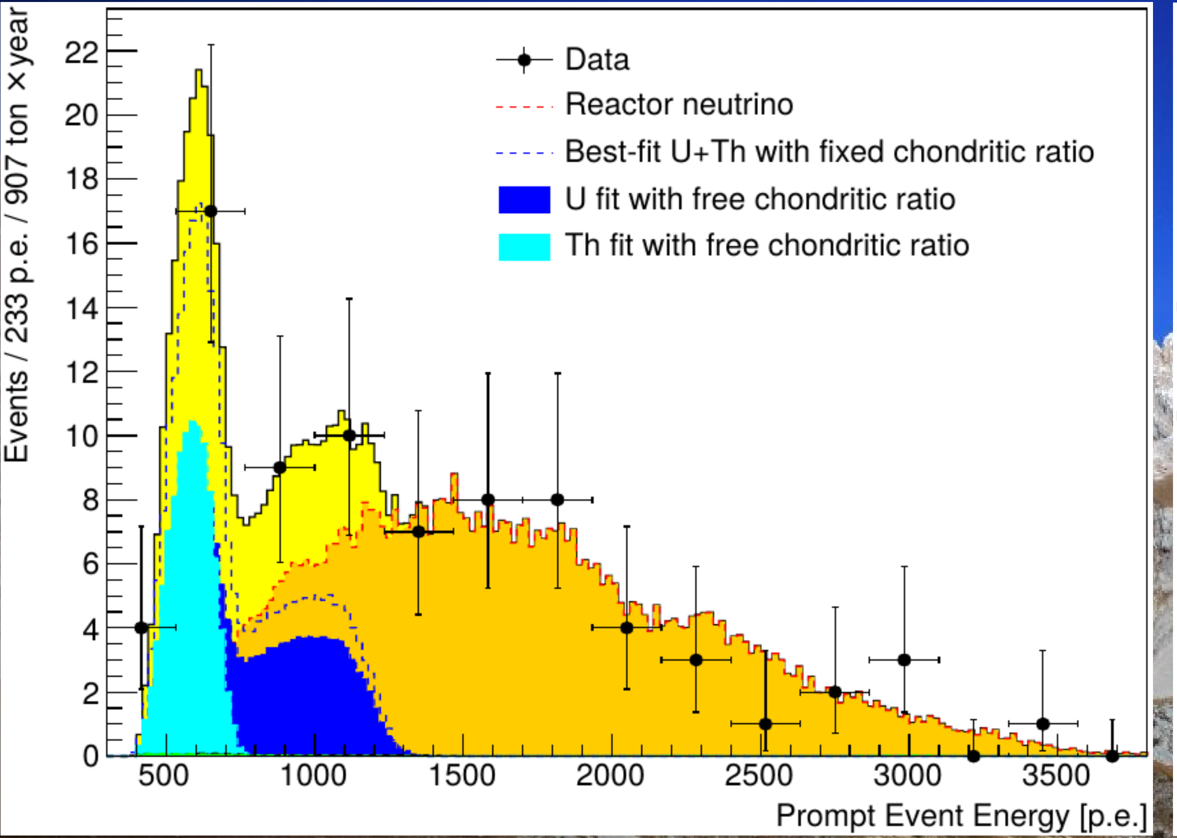
Outline

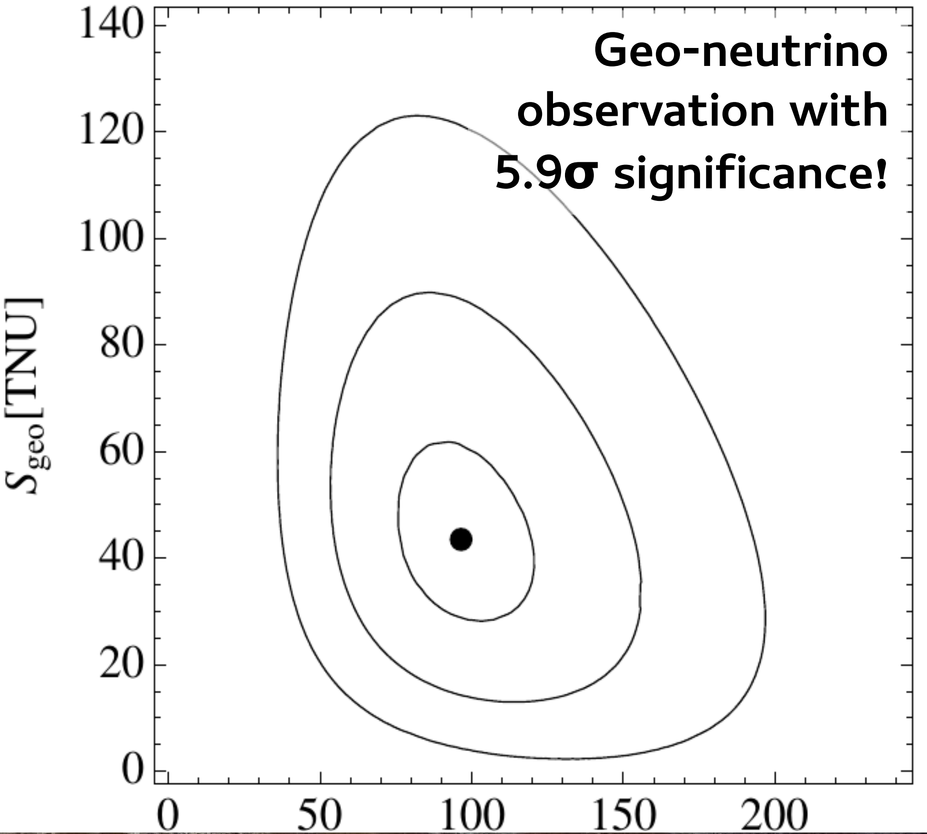
- Borexino experiment
- Neutrino program
- **Antineutrino program**

Geo-neutrino spectroscopy

Phys. Rev.D**92** no.3, 031101 (2015)

Data set: Dec 15, 2007 – Mar 8, 2015 (2056 days livetime)





Geo-neutrino observation with 5.9σ significance!

Geo-neutrino rate: $43.5^{+11.8}_{-10.4}$(stat)$^{+2.7}_{-2.4}$(sys) TNU

Geo-neutrino signal from mantle: $20.9^{+15.1}_{-10.3}$ TNU (98% C.L.)

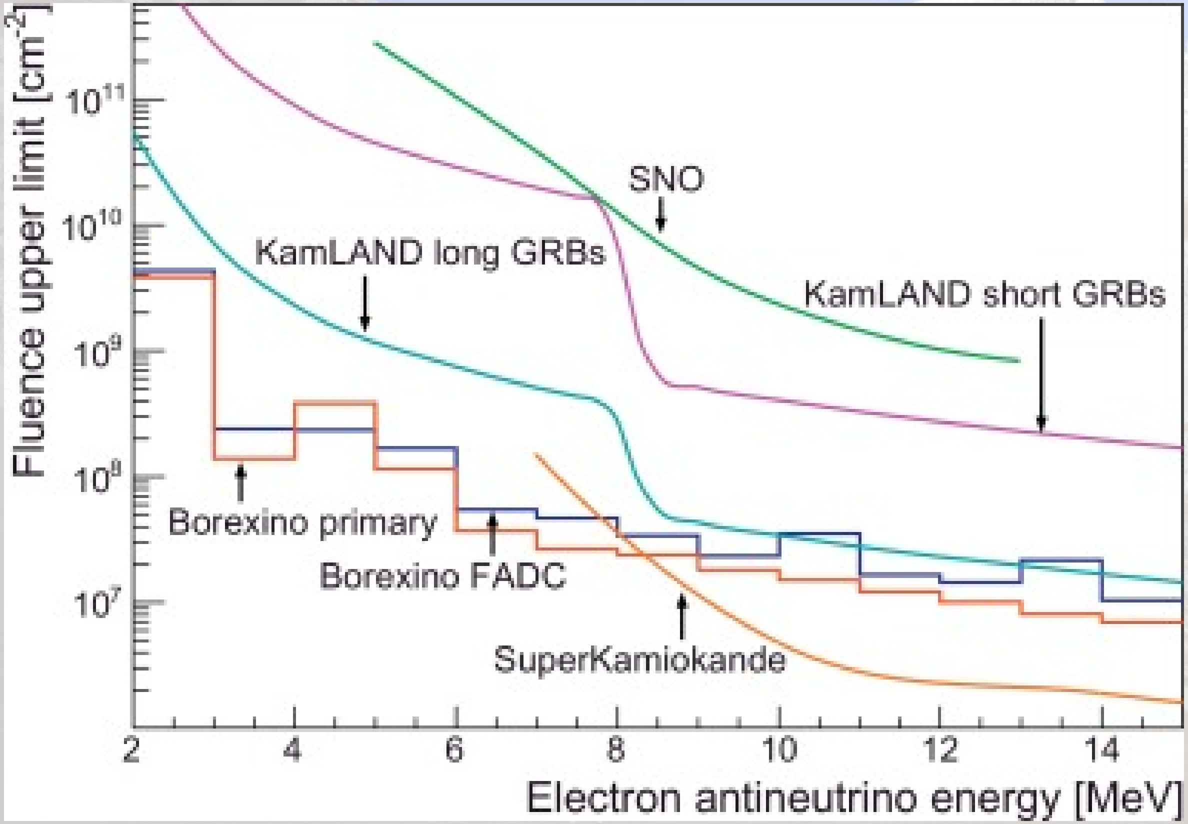
See talk by O. Smirnov

Antineutrino signal correlated with gamma-ray bursts

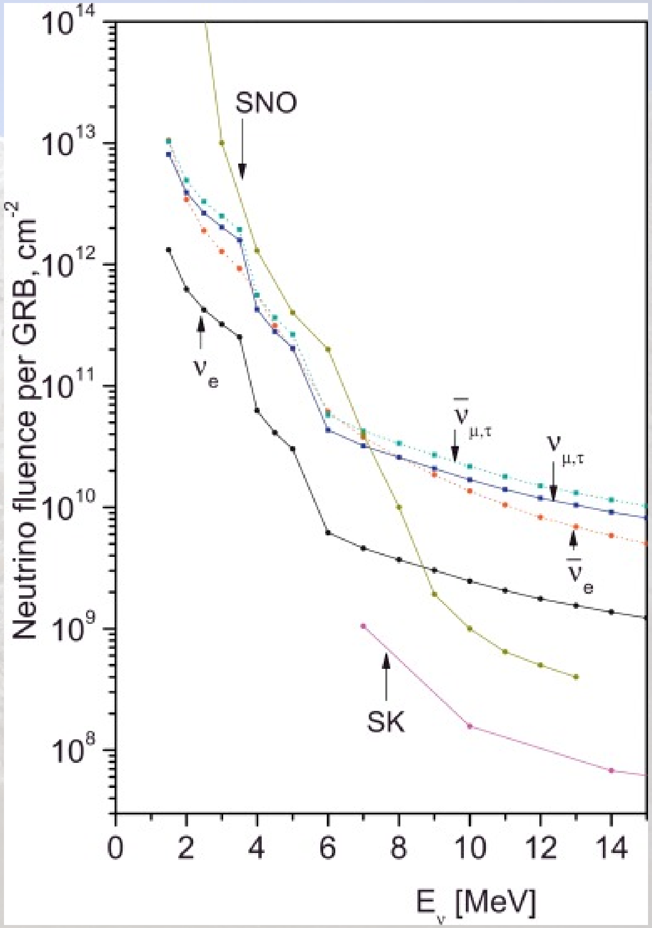
Astropart. Phys. **86**, 11-17 (2017)

Data set: Dec 2007 – Nov 2015 (Primary DAQ)
Dec 2009 – Nov 2015 (Flash ADC)

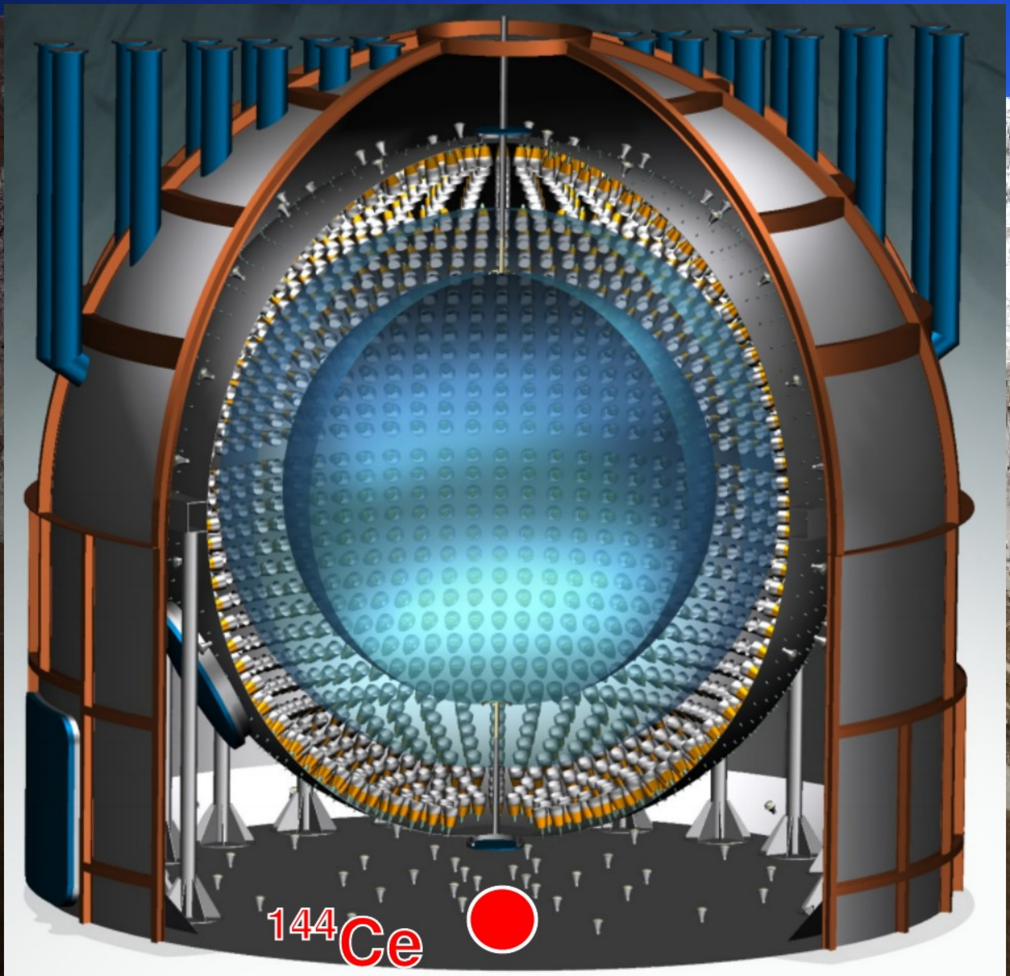
Inverse beta decay (electron antineutrinos)



(anti)neutrino-electron elastic scattering



Short-baseline sterile neutrio search: SOX project



- ☞ Source: ^{144}Ce-^{144}Pr, 100-150 kCi
- ☞ 10000 events in 1.5 yr
- ☞ Duration of data taking: 1.5 yr
- ☞ Start at the beginning of 2018

Approaches:

- ➢ Disappearance search
- ➢ Oscillometry

See talk by M. Gromov

Future plans

- "Global" solar neutrino fit in a wide energy range (made possible due to the improved tuning of the energy scale and the detector's response)
- More precise measurements of pp, ^{7}Be, pep-neutrino fluxes, CNO limit (will be presented at TAUP-2017)
- New limit on the neutrino magnetic moment (at the level of GEMMA's result)
- Search for non-standard neutrino interactions
- Sterile neutrino search (SOX)
- And more

Dear colleague

I am pleased to announce next workshop entitled "Recent Developments in Neutrino Physics and Astrophysics" that will be held in Assergi and L'Aquila (Italy) from September 4th to 7th, 2017.

The Borexino experiment —designed for world-class research in neutrino physics (especially, their oscillatory behavior), with particular emphasis on solar neutrinos and antineutrinos coming from Earth's interior (geo-neutrinos)— began its data-taking phase in May 2007.

2017 is therefore the 10th anniversary of Borexino's continuous data-taking: from September 4th to the 7th, physicists and astrophysicists will gather at LNGS and GSSI to discuss new perspectives on the many neutrino topics under active research.

The meeting is organized as a workshop, in order to allow wide discussions about all the diverse aspects of neutrino physics, the various neutrino sources and the approaches employed to probe them, as well as the models and approximations describing their behavior.

Please find enclosed poster of the event. You can find more detailed information on workshop webpage http://borexino10th.lngs.infn.it

Yours sincerely,

Gianpaolo Bellini
Chair of Local Organizing Committee