

What can the CNO neutrinos flux measurement by Borexino say about ^{40}K geoneutrino flux?

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in collaboration with

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V International Conference on Particle Physics and Astrophysics, Moscow, Russia

Plan of the talk

- Introduction
- Potassium amount (estimations)
- ^{40}K geoneutrinos
- How to detect?
- Conclusion and outlook

Introduction

At Neutrino 2020 Conference Borexino collaboration announced the observation of CNO cycle solar neutrinos.

Expected value	4.9 ± 0.7 events per day/100 t
CA (7.4-8.5 MeV)	5.6 ± 1.6 (0.74 – 0.85 MeV)
MF (3.0-2.6 MeV)	$7.2 + 2.9 - 1.7$ (0.32 – 2.64 MeV)

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Very possible source is ^{40}K geoneutrinos.

- If this additional spectrum is from ^{40}K we can estimate its value. Difference between estimated and measured values is 2 ev./100 t per day.
- The value corresponds to 1-1.5% of potassium inside the Earth

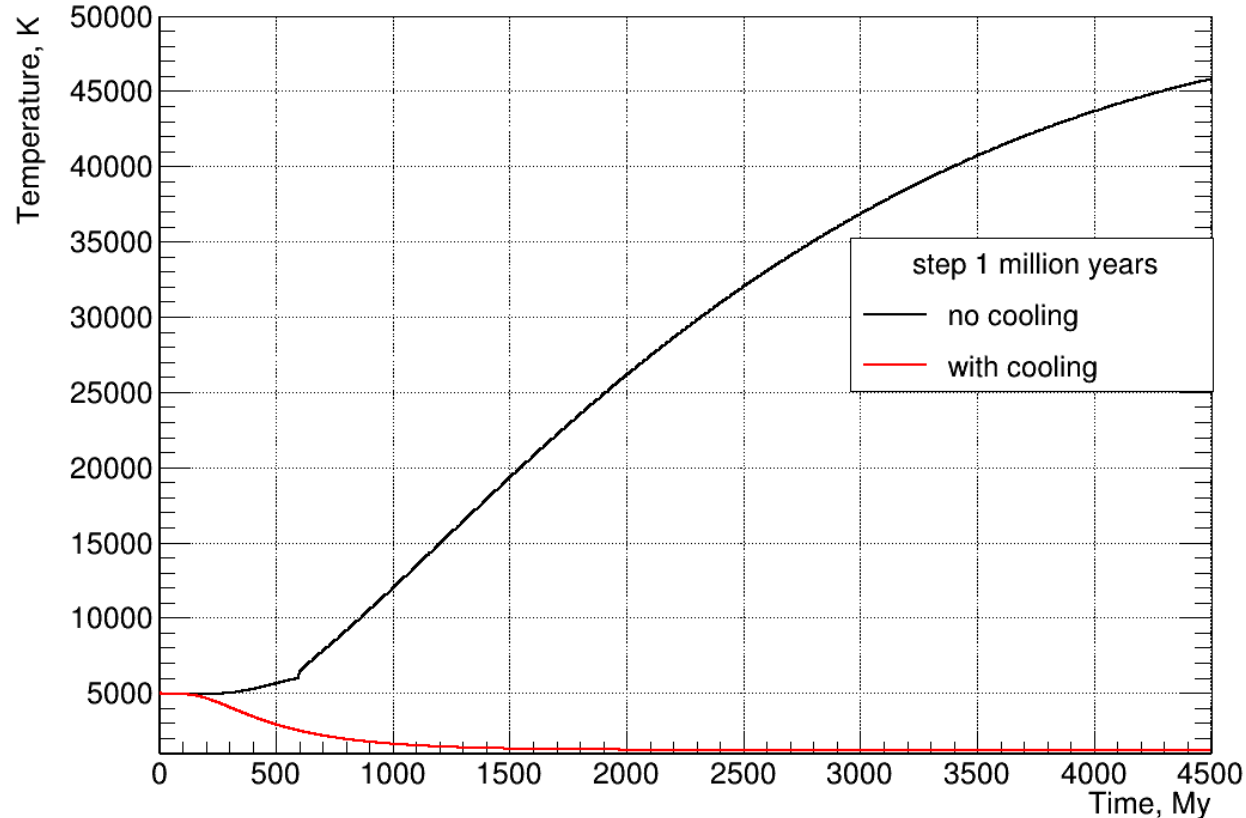
2004.02533 [hep-ex]

Reasonable argument in favor of low potassium
abundance

If to have **1%** of potassium in the Earth
it should be **melted** and be **liquid** up to
now !!!

Heat transfer calculations with 1% of potassium abundance in the Earth

Earth temperature in the centre



Thermal conductivity

$$K_{\text{crust}} = 1.5 \text{ W m}^{-1} \text{ K}^{-1}$$

$$k_{\text{m+c}} = 100 \text{ W m}^{-1} \text{ K}^{-1}$$

If **there is a cooling mechanism**
(fast heat removing from the Earth inner parts)
the Earth can be cold enough inside.

Potassium abundance

Potassium abundance in some reservoirs

<https://periodictable.com/Elements/019/data.html>

- in Universe 0.0003%
- in Sun 0.0004%
- in Meteorites 0.07%
- in Earth's Crust 1.5% - 2.6%
- in Oceans 0.042%
- in Humans 0.2%

in hole Earth – ?

Estimation of Earth K-abundance (1)

In hole Earth K-abundance is **0.024%**

according to

W.~F.~McDonough, Compositional models for the Earth's core, Carlson R. W. (ed.) Treatise on Geochemistry volume 2 The Mantle and Core, pp. 547–568 (Elsevier-Pergamon, Oxford) (2003)

This estimation is based on **2%** in the crust only and nothing inside the Earth interior.

Estimation of Earth K-abundance (2)

Ar containing in Earth's atmosphere (0.9%) consists of **99.6% of ^{40}Ar** – product of ^{40}K decay (branch $\sim 11\%$).

The Earth was melted and when crust was formed all K came to the crust (!)

Atmosphere mass $(5.1352 \pm 0.0003) \cdot 10^{18}$ kg

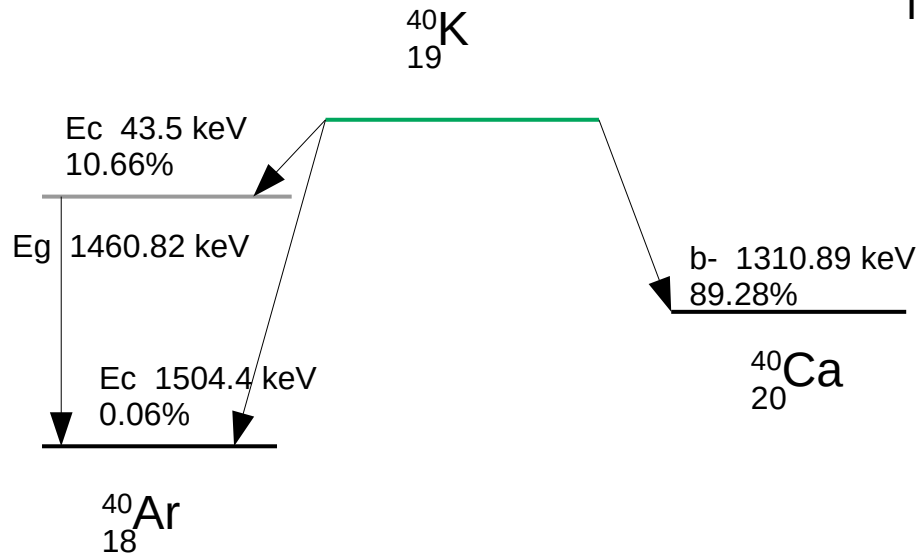
K mass (now) $4.97 \cdot 10^{20}$ kg abundance 0.008% (!) $< 0.024\%$

0.008 \rightarrow 0.08 \rightarrow 0.8%

depends on what part of ^{40}Ar came from the Earth to atmosphere.

^{40}K geoneutrinos

Natural isotopic abundance 0.0117%



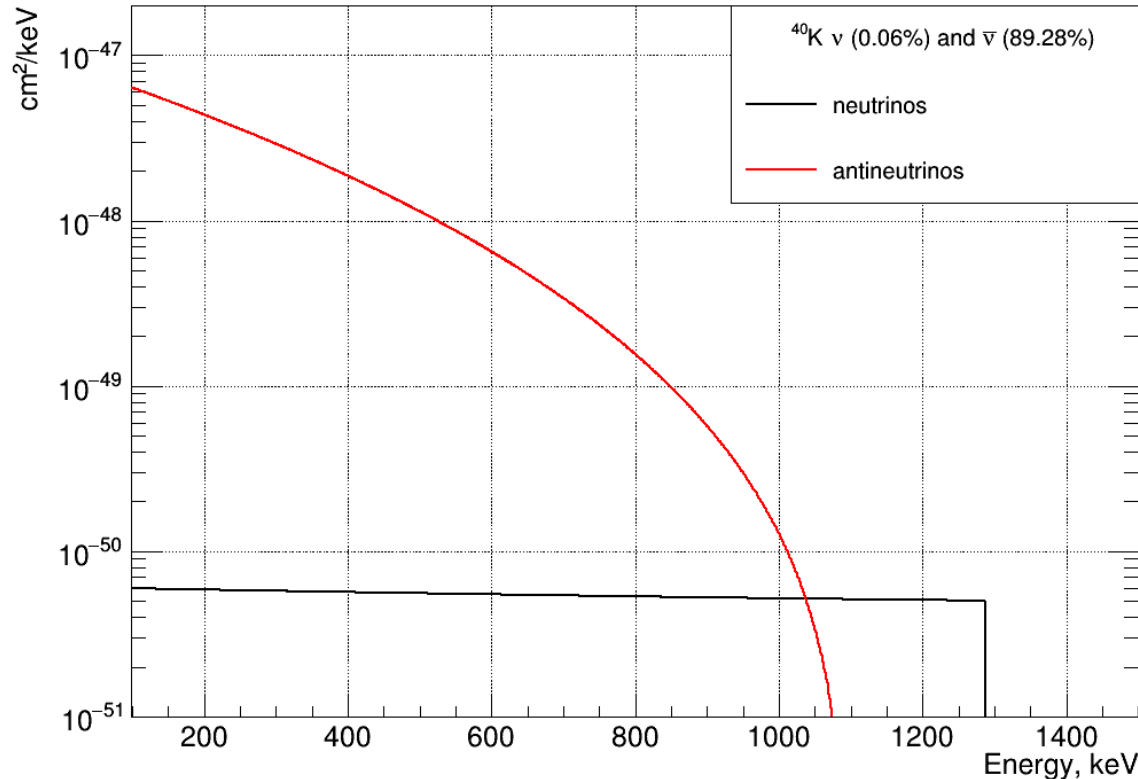
1% of potassium abundance
produce ~ 200 TW of heat

^{40}K emits:

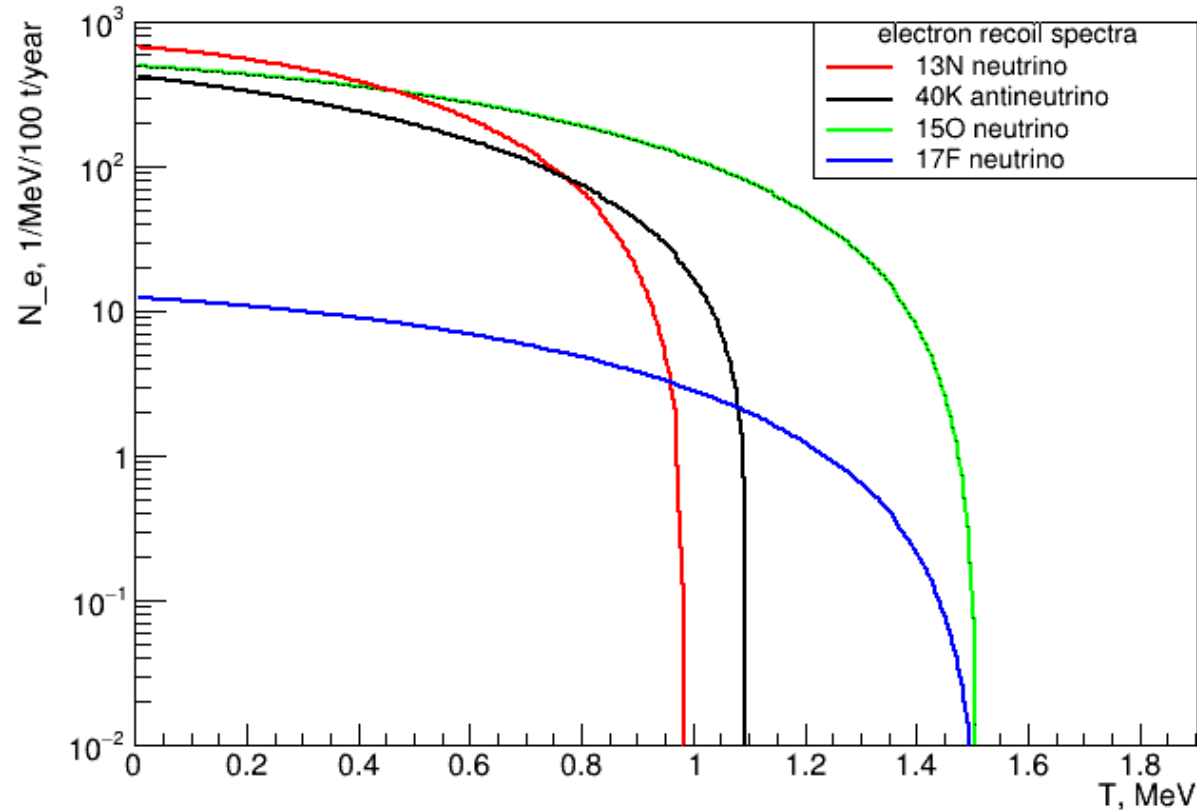
antineutrino with $E < 1.311$ MeV	(89%)
and neutrino $E = 0.044$ MeV	(11%)
$E = 1.504$ MeV	(0.06%)

Electron recoil spectra from ^{40}K

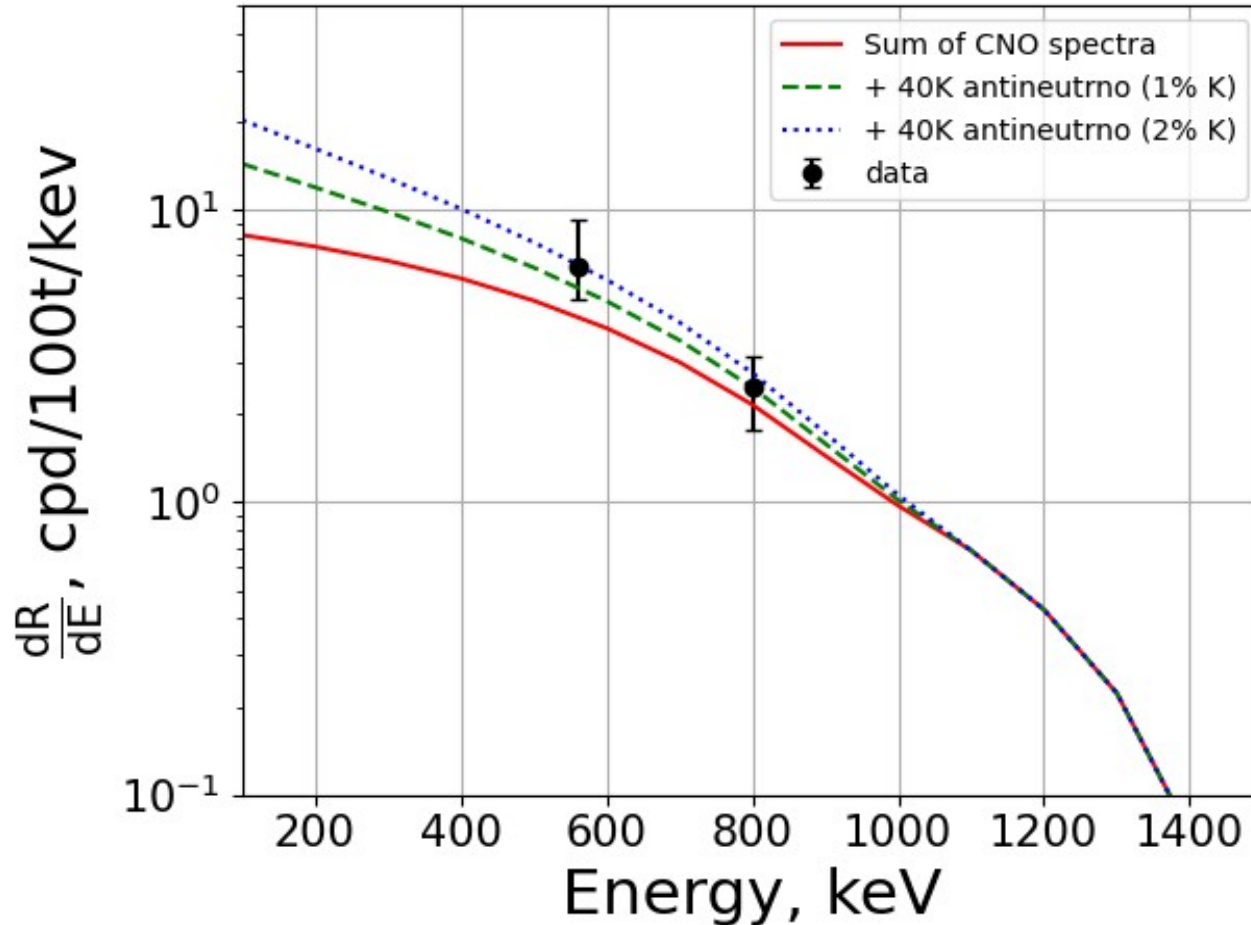
Cross sections for ^{40}K spectra



Comparison of recoil electrons spectra from ^{40}K and CNO neutrinos



CNO spectrum with admixture of ^{40}K flux



Experimental
Borexino points
recalculated by us for
effective energies.

Effective energies:

CA – 800 keV
MF – 560 keV

How to detect?

- Neutrino-electron elastic scattering (NES) (CNO+ ^{40}K)
– new detector Borexino type.
- IBD reaction on nuclei with $E_{\text{thr}} \sim 1 \text{ MeV}$ (^{40}K) –
detector LiquidO.
- Independent measurement of solar neutrino fluxes
and subtracting them from NES measurement. ^{115}In
proposed by Raghavan (CNO) - LENS.

Conclusion and outlook

- Recent CNO flux measurement by Borexino allows 1-1.5% of potassium abundance in the Earth.
- High (1-1.5%) potassium abundance can exist if there is an efficient mechanism of Earth cooling inside.
- To resolve the problem of potassium abundance a new detector is needed with characteristics better than Borexino ones.

Thank you for your attention

Extra slides

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- Heat from the Sun 118000 TW
- Man produced heat < 5 TW
- Inner Earth heat 50 - 200 TW