TECHNISCHE UNIVERSITÄT DRESDEN

iktp

Fakultät Mathematik und Naturwissenschaften, Institut für Kern- und Teilchenphysik

Neutrino nuclear interactions and forbidden beta decay for double beta decay

H. Ejiri, J. Suhonen, K. Zuber, Phys. Rep. 797,1 (2019)

Kai Zuber, TU Dresden

DRESDEN concept

Introduction

- The 2019 Physics Report is considered to be the Guideline book
- consider this talk is informal

So here are some updates (where I am involved in)
Dominated by collaboration with Joel Kostensalo and Jouni Suhonen (from now on KSZ)

- Final GERDA results on DBD of Ge-76
- Hence updates/new work are presented (Cd-113)
- A few solar neutrino issues
- Detection of the CNO neutrinos
- Summary

GERDA -experiment

- Double beta decay at LNGS based on Ge-76 HPGe-detectors
- Aim is an exposure of 100 kg yrs (127.2 kg yrs)

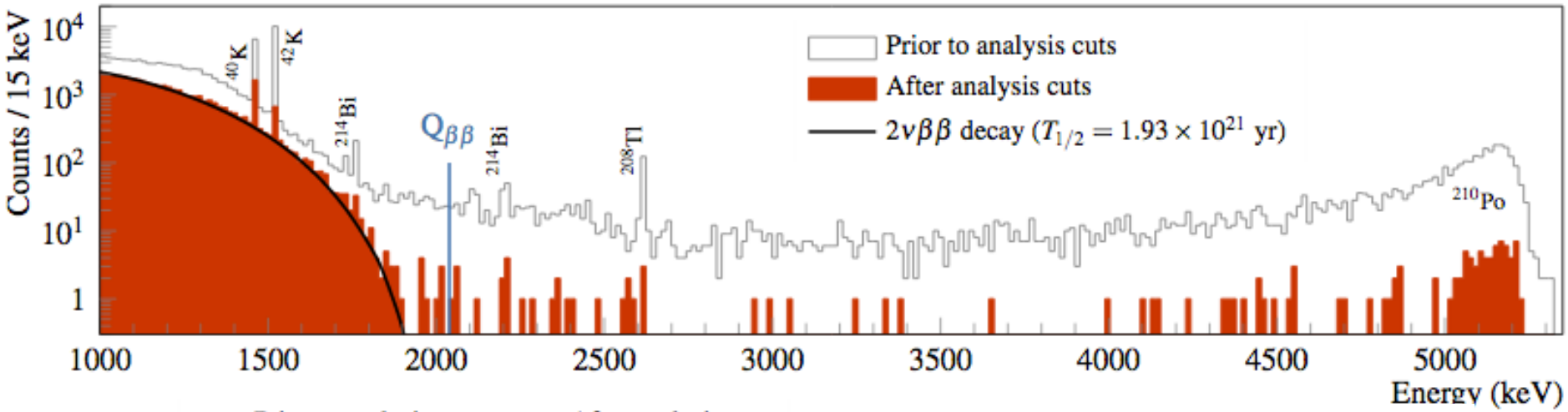
No evidence for a peak
Half-life limit

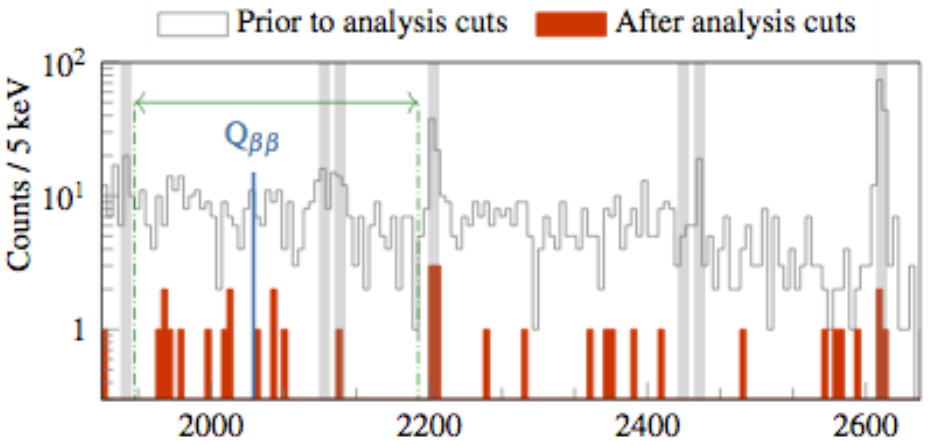
$T_{1/2} > 1.8 \times 10^{26}$ years
(90 CL)

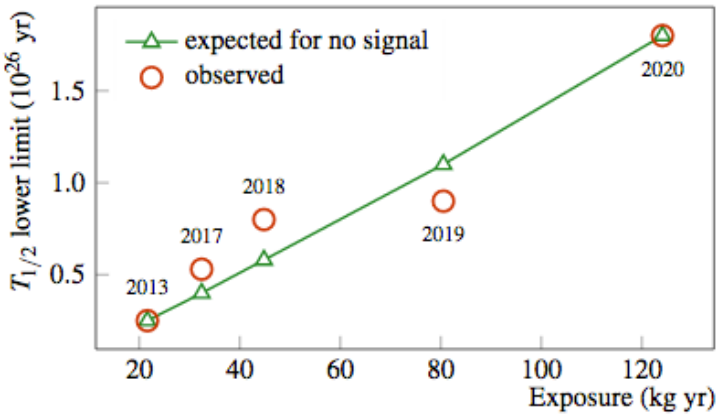
arXiv:2009.06079

GERDA

❖ Doube beta decay at LNGS based on Ge-76 HPGe-detectors





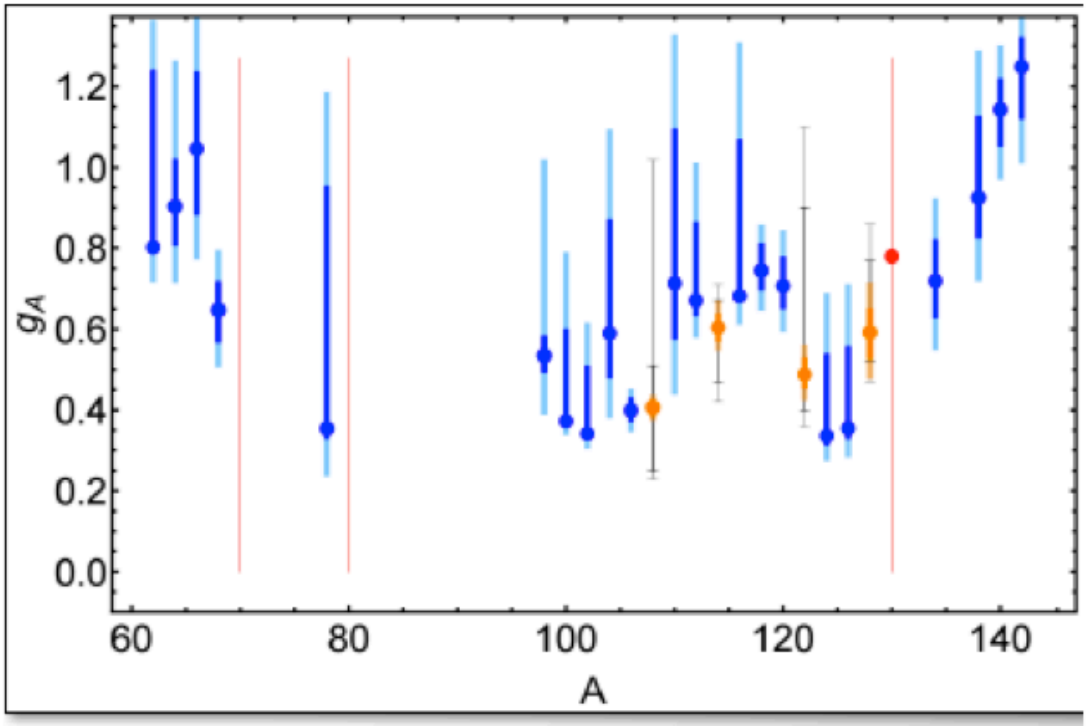


Quenching of g_A

- Free g_A value is 1.27 (PDG)
- In nuclei this might be different (effective g_A)
- Highly forbidden beta decay are very sensitive on g_A
- Double beta decay half-live depends on g_A^4

Quenching of g_A

$$(T^{0\nu}_{1/2})^{-1} = G^{0\nu} g_A^4 \mid M^{0\nu} \mid^2 \left(\frac{\langle m_{ee} \rangle}{m_e} \right)^2$$



Free value: $g_A = 1.27$

F. Deppisch, J. Suhonen, PRC 94, 055501 (2016)

Quenching of g_A – COBRA -experiment

Spectral shapes of highly forbidden beta decays are very sensitive on g_A

J. Suhonen, Phys. Rev. C, 96:055501 (2017)

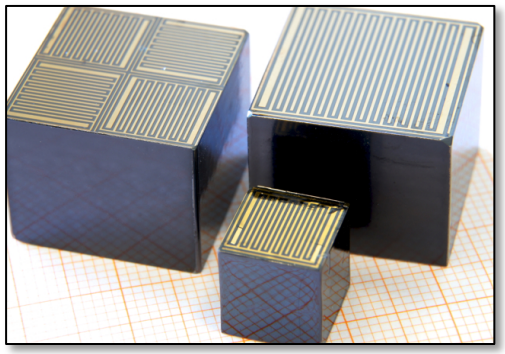
COBRA-Experiment: 64 CdZnTe room temperature semiconductors

K. Zuber, Phys. Lett. B 519,1 (2001)

Here: Cd-113 (half-live about 10^{15} yrs): $\frac{1}{2}^{+} \rightarrow \frac{9}{2}^{+}$ transition

COBRA performed special run fo row energy

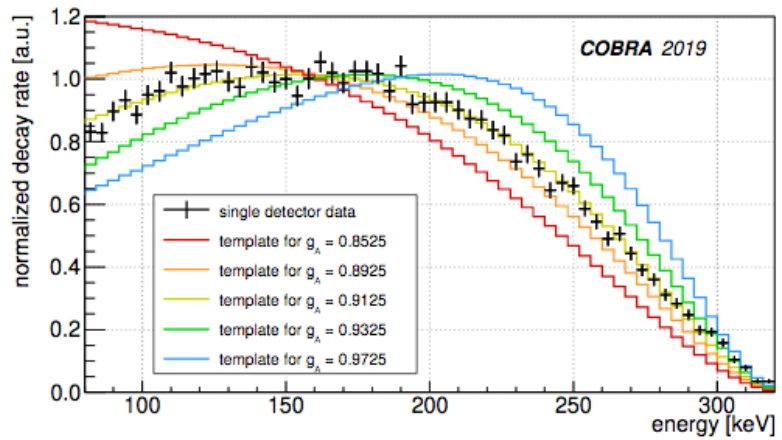
After selection 44 detectors are used



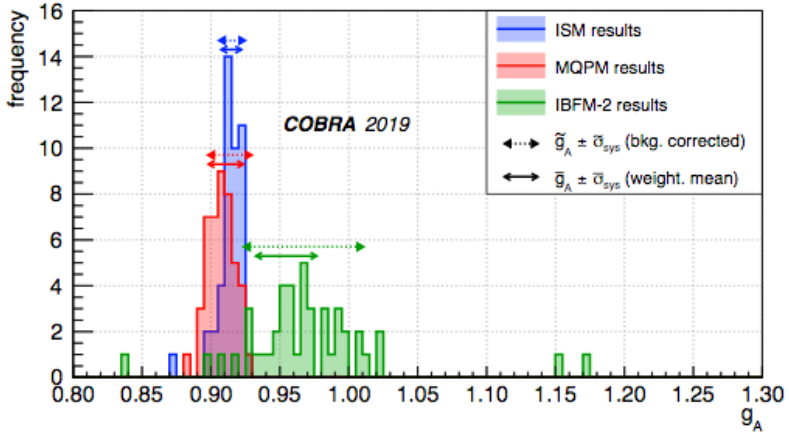
Quenching of g_A

$$(T^{0\nu}_{1/2})^{-1} = G^{0\nu} g_A^4 \mid M^{0\nu} \mid^2 \left(\frac{\langle m_{ee} \rangle}{m_e} \right)^2$$

One selected detector



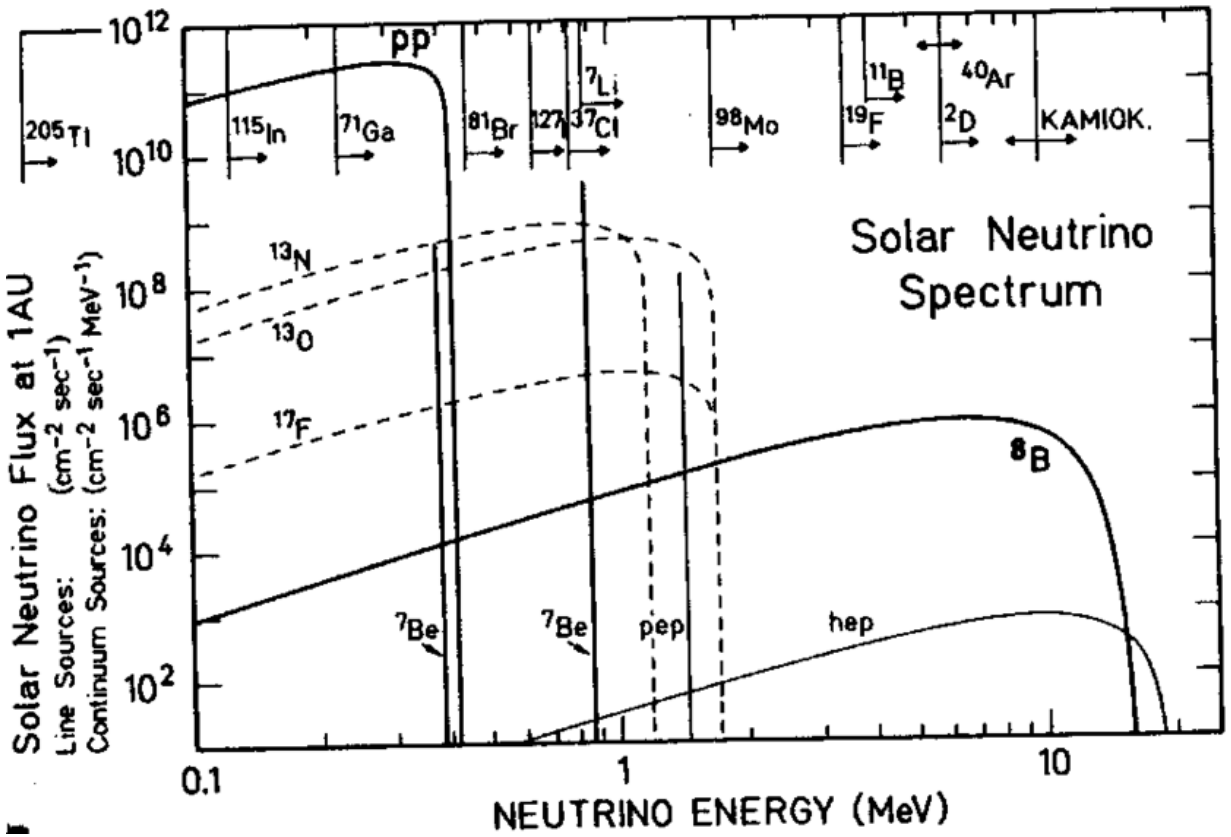
Frequentist



$$\begin{aligned} \bar{g}_A(\text{ISM}) &= 0.915 \pm 0.007, \\ \bar{g}_A(\text{MQPM}) &= 0.911 \pm 0.013, \\ \bar{g}_A(\text{IBFM-2}) &= 0.955 \pm 0.022. \end{aligned}$$

Bodenstein-Dresler et al., PLB 800,135092 (2020)

Solar neutrinos

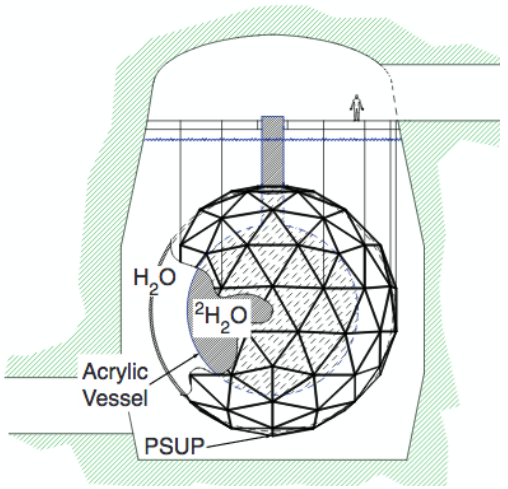


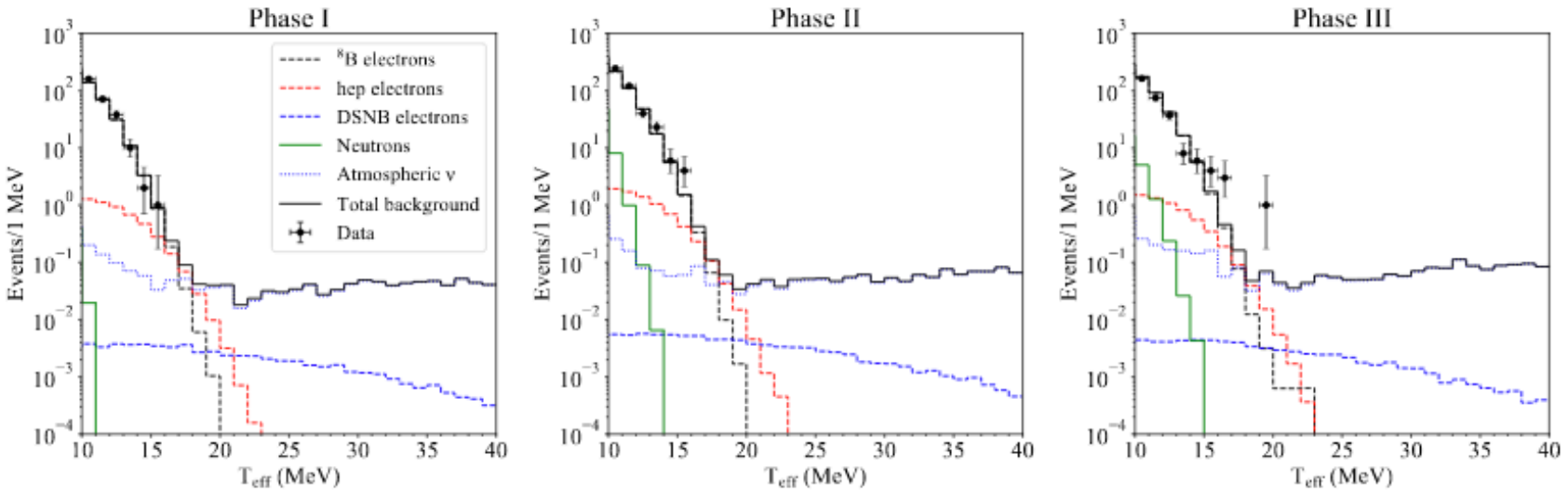
All branches observed except hep, still a lot to do

Hep neutrinos

Good old SNO made a new attempt

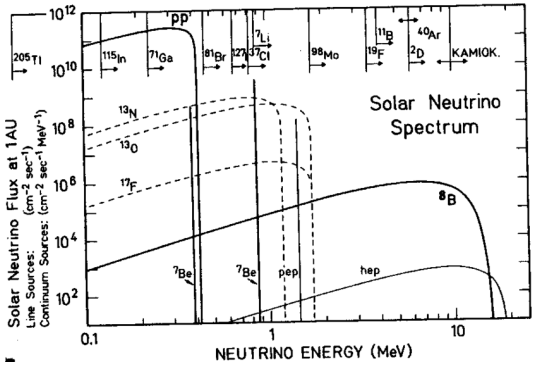
$$\Phi_{hep} < 30 \times 10^3 \text{ cm}^{-2} \text{ s}^{-1} \text{ (90\% CI)}.$$





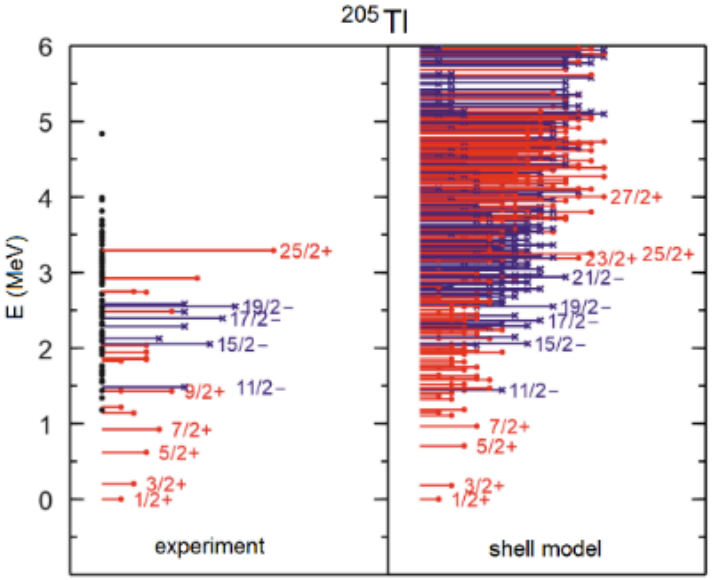
B. Aharmim et al., PRD 102, 062006 (2020)

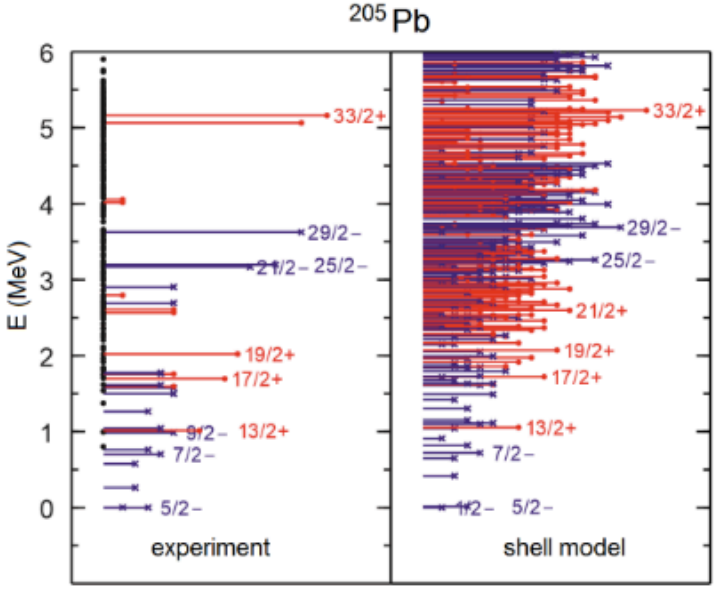
Solar neutrinos



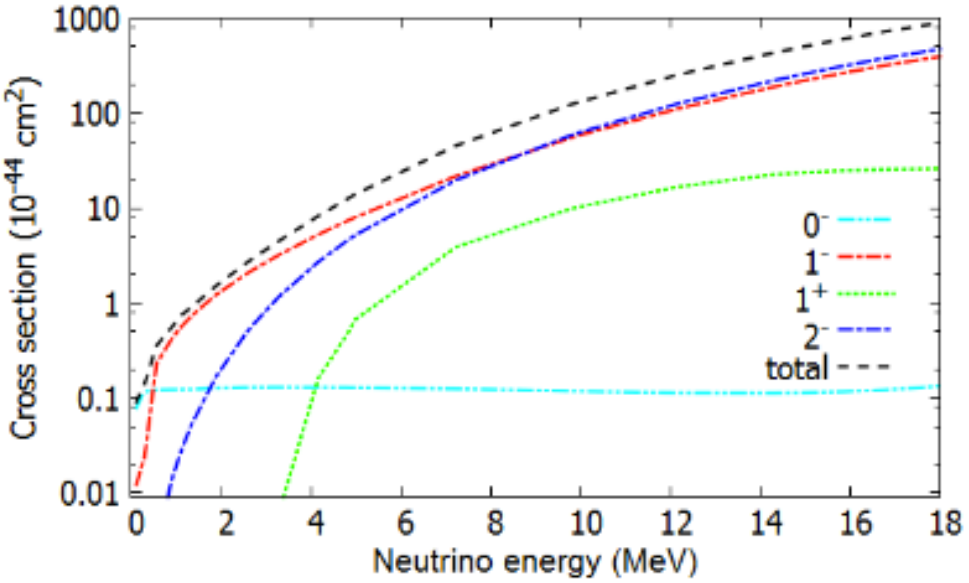
Radiochemical issues

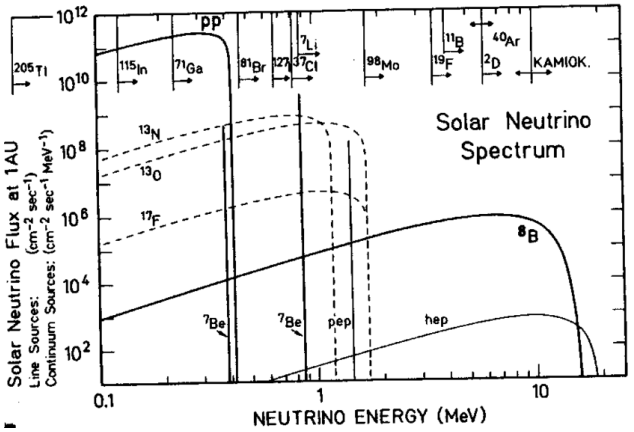
Tl-205 -> Pb-205 hase the lowest threshold of all radiochemical approaches (50 keV)





Tl-205 solar neutrinos





New cross section calculation for Tl-205 (asuming g_A=1.0)

Expected about 68 SNU, much less than before (KSZ, PRC 101,031302 (2020))

Big difference to Bahcall, Ulrich (1988), which has 263 SNU!

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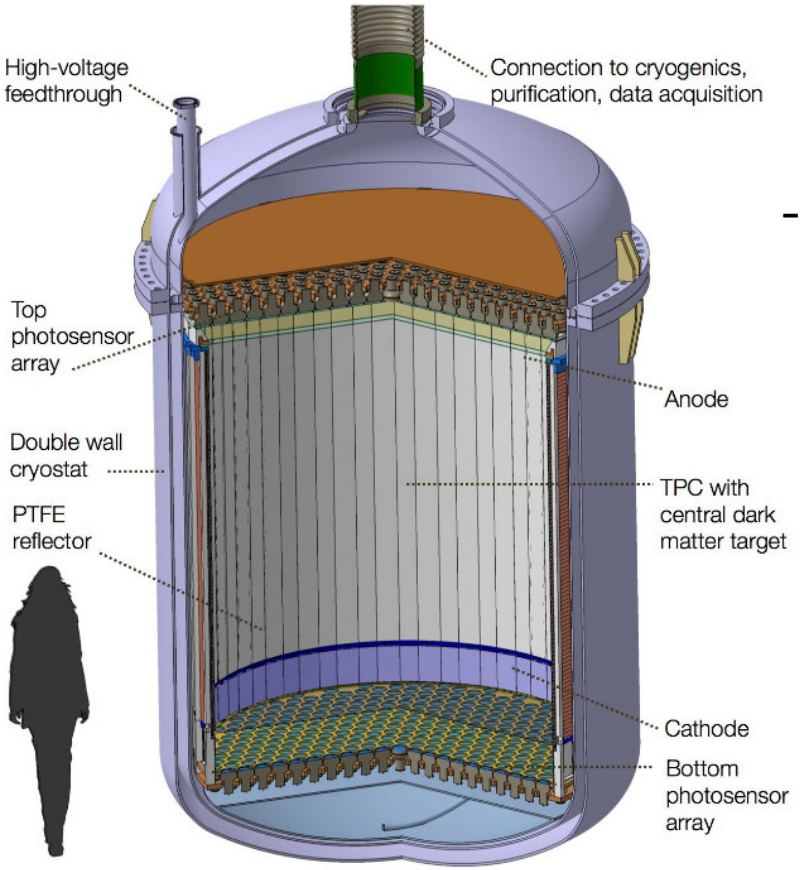
DARWIN - 50 tons LXe dark matter detector at LNGS



- Sensitivity for Xe-136 double beta decay

F. Agostini et al., Eur. Phys. J. C,80,808 (2020)

- Solar neutrions detection by electron recoil

F. Aalbers et al., arXiv:2006.03114

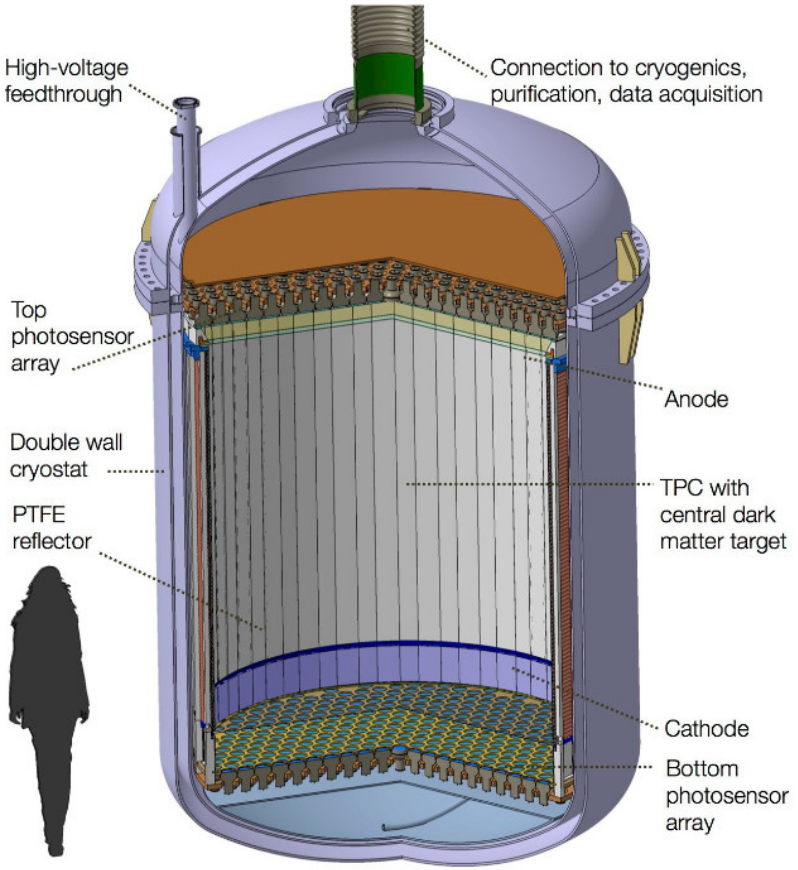
-Solar pp neutrino detection by Xe-131

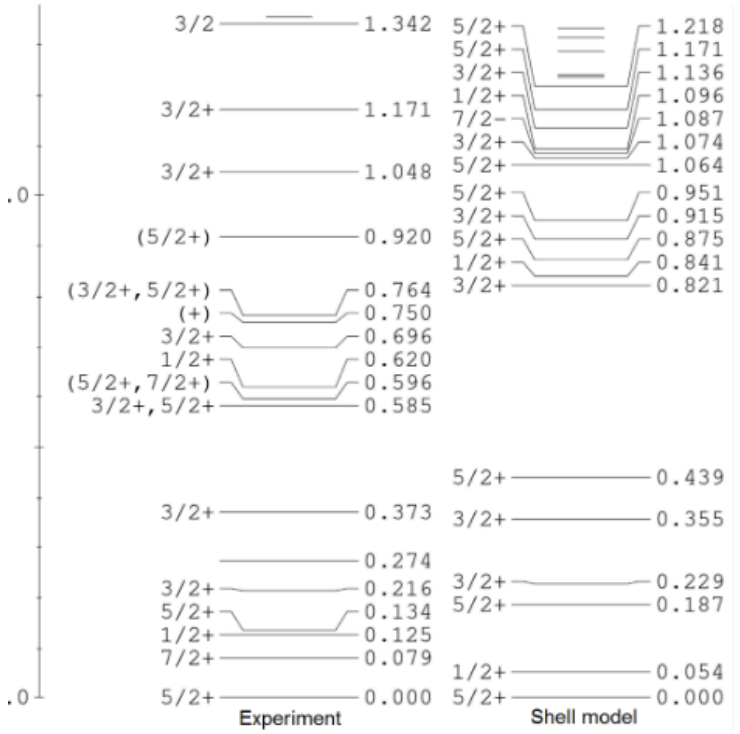
KSZ, arXiv:2009.01164

Added another 81 SNU

Also 3 new japanese groups joint DARWiN

DARWIN - 50 tons LXe dark matter detector at LNGS





Shell model

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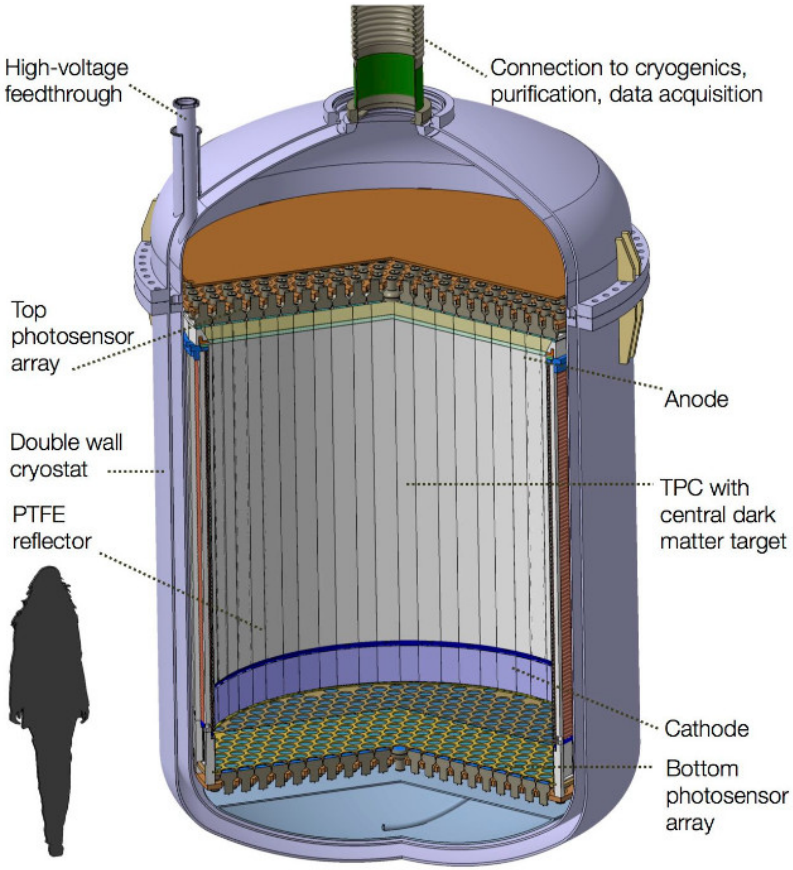
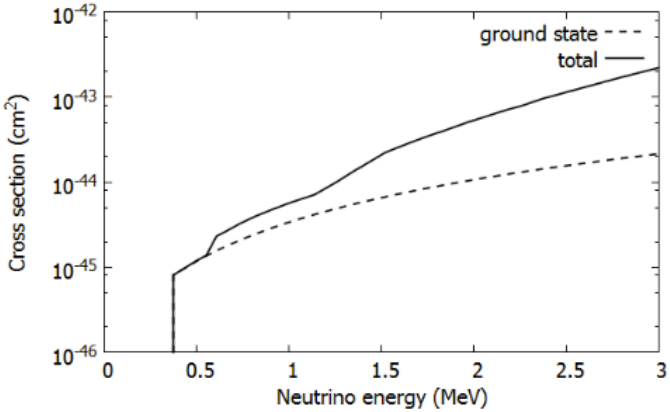
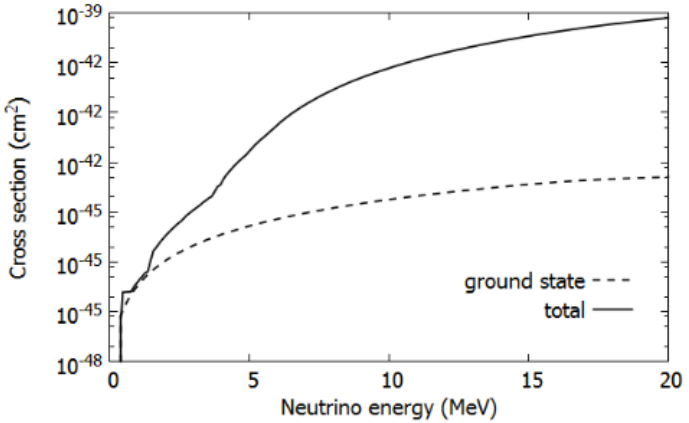


Shell model



MQPM
for higher E



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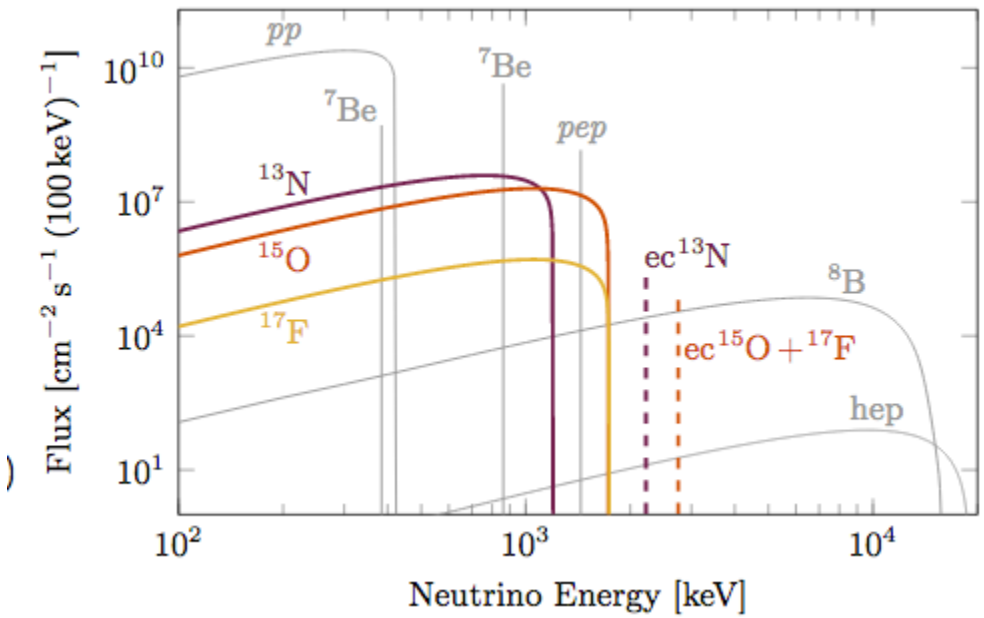
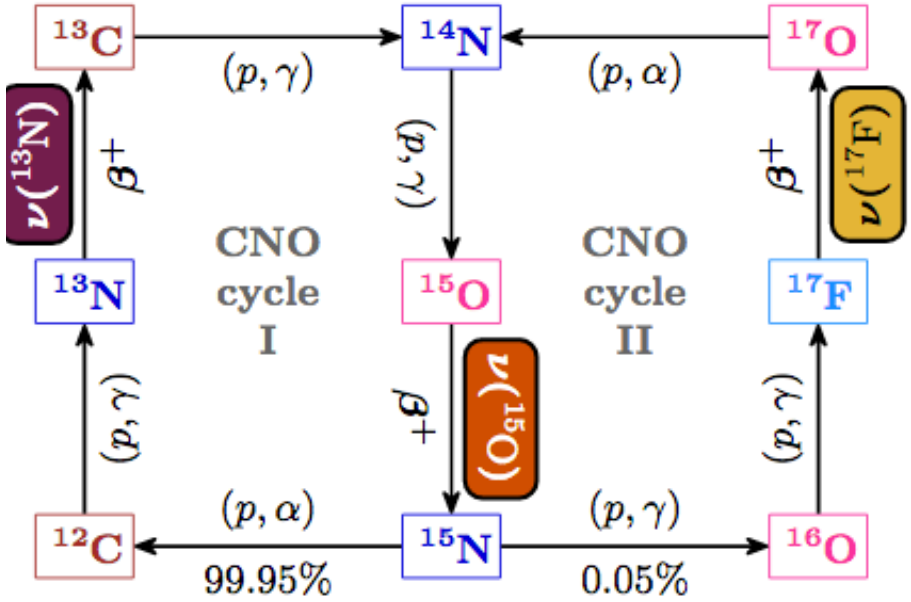
First detection of CNO-neutrinos by Borexino

Solar fusion by pp-chain reactions and CNO cycle





All pp-chain neutrinos have been observed except hep

CNO neutrinos never detected in the 80 years of prediction

Borexino @LNGS Underground

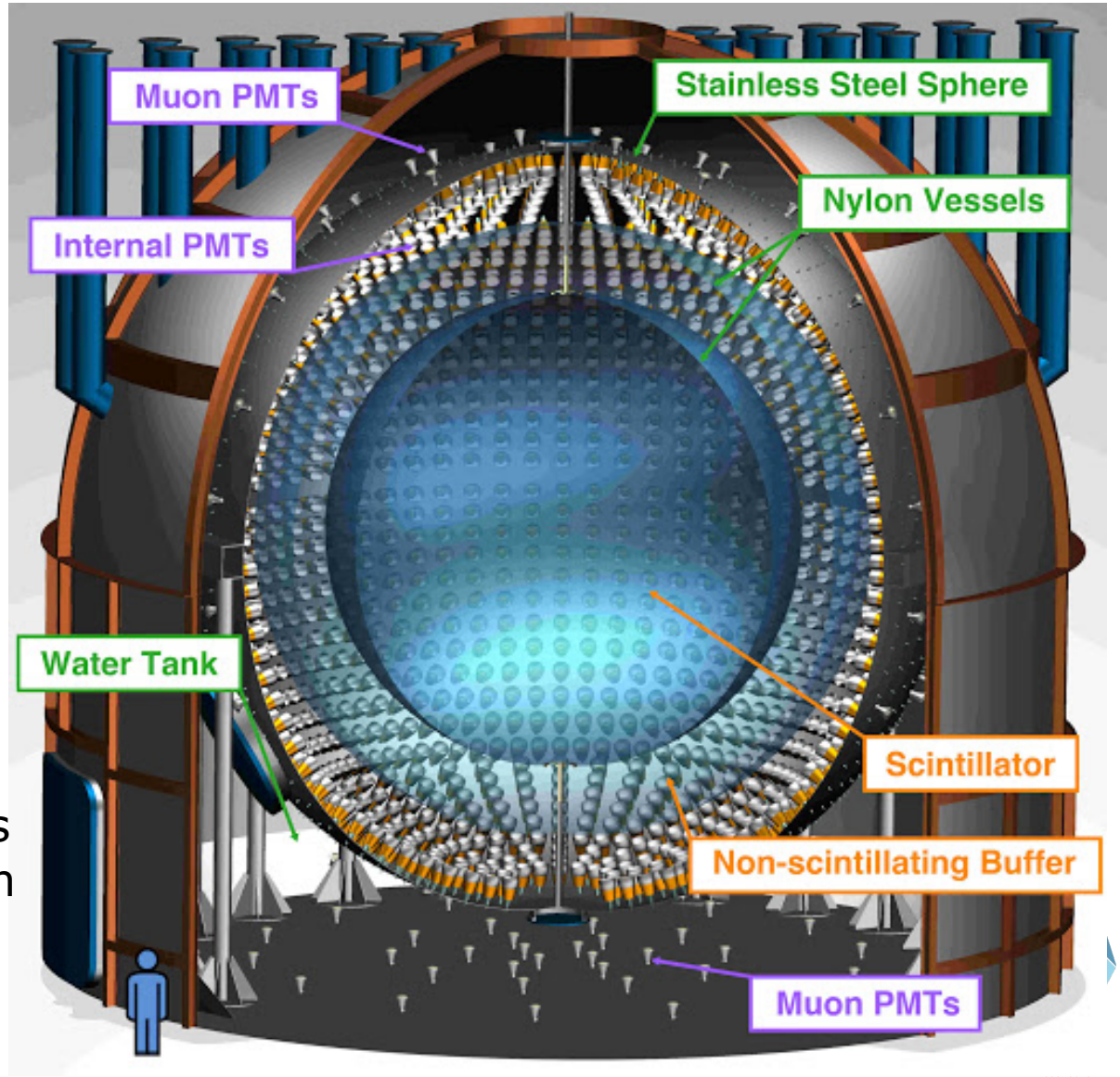
- Liquid scintillator detector (about 300t)

-Detection by neutrino electron scattering

-Running since many years

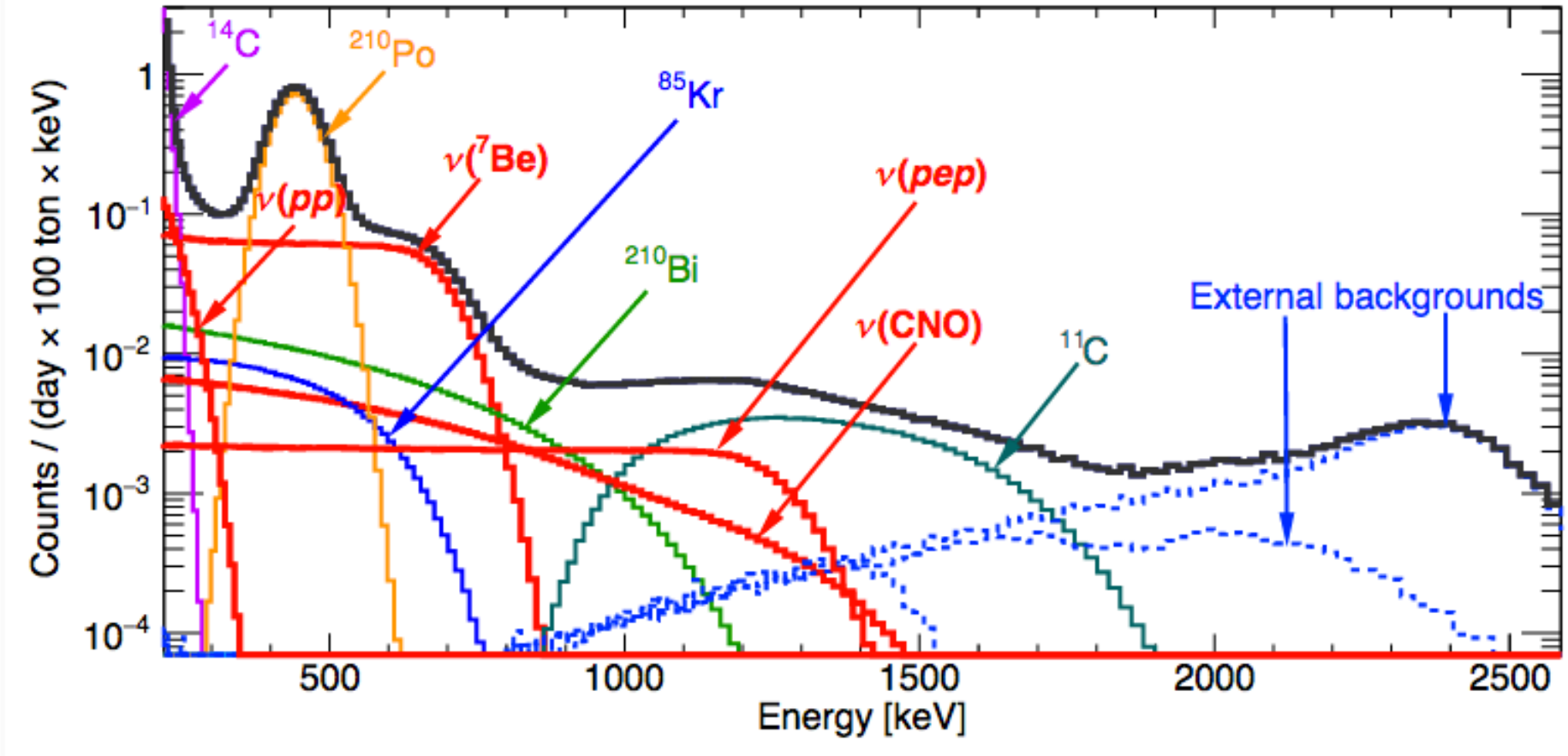
- Constantly improving the experiment

- C14 level is 6-7 orders of magnitude lower than normal

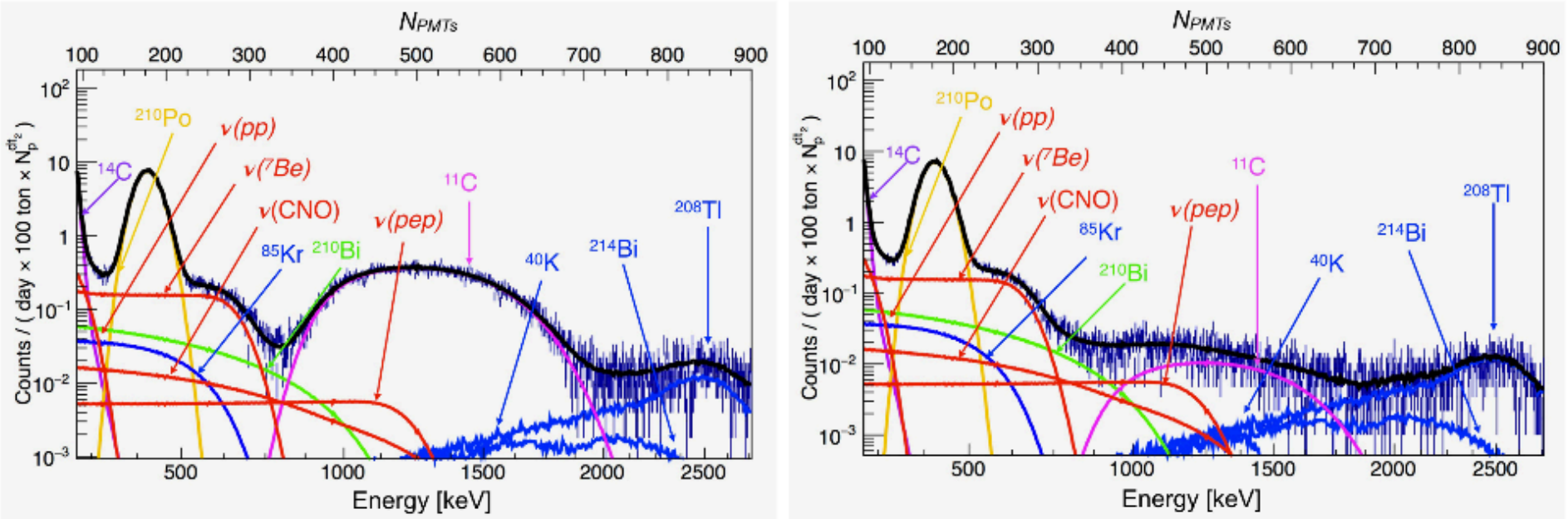


A typical period of data taking

Detection via electron-neutrino scattering



A Bi-210 beta spectral shape might show a slight difference from neutrino-electron scattering events of CNO neutrinos like in Borexino (LSc in general)



Borexino, Z. Bagdasarian et al. 2020 (TAUP 17)

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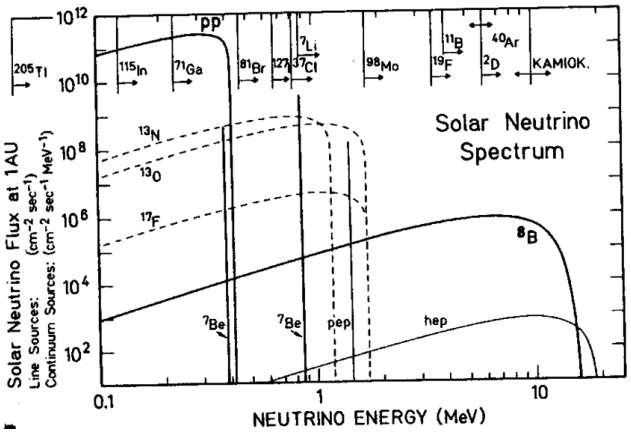
Further complication and predictions



Borexino phase-II

Solar ν	B16(GS98)-HZ cpd/100 ton	B16(AGSS09)-LZ cpd/100 ton	Borexino Results cpd/100 ton
pp	131.1 ± 1.4	132.2 ± 1.4	$134 \pm 10^{+6}_{-10}$
^{7}Be	47.9 ± 2.8	43.7 ± 2.5	$48.3 \pm 1.1^{+0.4}_{-0.7}$
pep	2.74 ± 0.04	2.78 ± 0.04	$2.43 \pm 0.36^{+0.15}_{-0.22}$(HZ)
			$2.65 \pm 0.36^{+0.15}_{-0.24}$ (LZ)
CNO	4.92 ± 0.78	3.52 ± 0.52	< 8.1 (95% C.L.)

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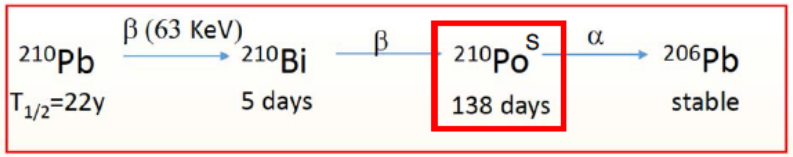
Two BG issues: Bi-210 and convection



Acc. By Nature