New Limits on Axion-Photon Coupling Constant for Solar Axions

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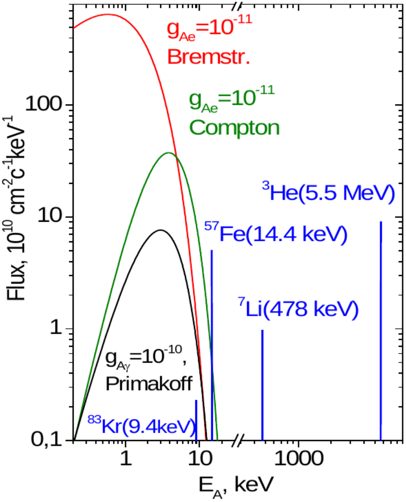
Axion Searches at PNPI

- Series of experiments devoted to Solar Axion Searches
- **Resonant absorption** by atomic nuclei:
  - ^{57}Fe: *A.Derbin et.al, Eur.Phys.J.C62:755-760, 2009*
  - ^{169}Tm: *A.Derbin et.al, Phys.Rev.D83:023505, 2011*
  - ^{83}Kr *Yu. Gavrilyuk et.al, JETP.Lett.107:10, p. 617, 2018*
- **Axio-electric effect:**
  - Si: *A. Derbin et.al, JETP Lett., 95, 379, 2012*
  - BiGeO: *Derbin et.al., Eur.Phys.J.C74:3035, 2014*

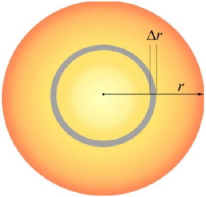
Solar Axion Production



- **Nuclear reactions:**
  - $^{7}\mathrm{Be} + e^{-} = Li^{*} + \gamma$; $Li* = Li + A$ (478 keV)
  - $p + d = {}^{3}\mathrm{He} + A$ (5.5 MeV)
- **Thermal excitation** of M1 nuclear levels
- **Primakoff effect**
- **A**xio-recombination **B**remmstrahlung **C**ompton

Flux of ^{83}Kr Solar Axions

- Axion flux $\mathbf{\Phi_A}$ depends on level energy $\mathbf{E = 9.4}$ keV, temperature distribution $\mathbf{T(r)}$, level liftime $\tau_\gamma = \mathbf{3.6\mu s}$, ^{83}Kr solar abundance $\mathbf{N(r)}$, and photon/axion emission ratio ω_A/ω_γ



$$\Phi_A = \int N(r) \frac{2\exp(-E_\gamma/kT(r))}{1+2\exp(-E_\gamma/kT(r))} \frac{\omega_A}{\tau_\gamma \omega_\gamma} dr$$

$$\Phi_A(E_{M1}) = 5.97 \times 10^{23} \left(\frac{\omega_A}{\omega_\gamma}\right) \mathrm{cm}^{-2} \cdot \mathrm{s}^{-1} \cdot \mathrm{keV}^{-1}$$

Experimental Setup

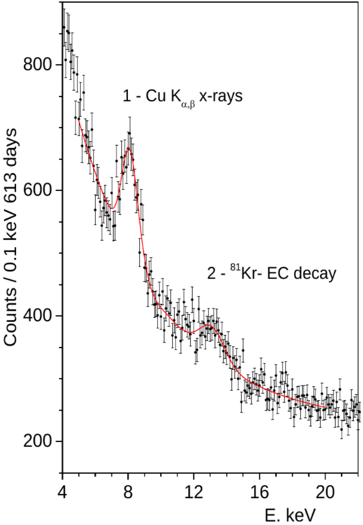
- Cylindrical proportional counter with **Cu** casing (13 mm).
- Inner diameter: 137 mm
  Length: 595 mm
  Volume: 8.77 l
- Pressure: 5.6 bar
  ^{83}Kr mass: 101 g
- Setup was equipped with passive shielding: Cu (20 cm), Pb (20 cm), polyethylene (8 cm)

BNO Facility (INR RAS)

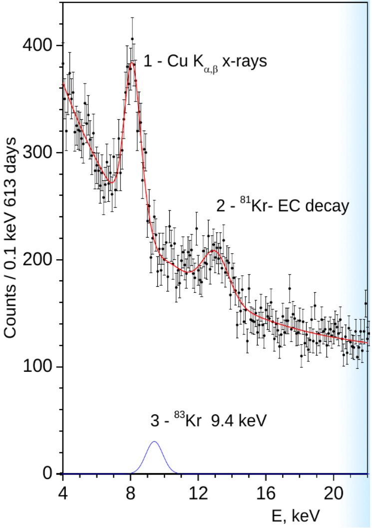
- Underground low-background facility (4200 m.w.e.)
- Muon flux $\mathbf{2.6\ m^{-2} \cdot d^{-1}}$ — reduced by $\sim 10^7$ times compared to surface rate.

Results from Phase II

Spectra obtained during **613 days** of measurements

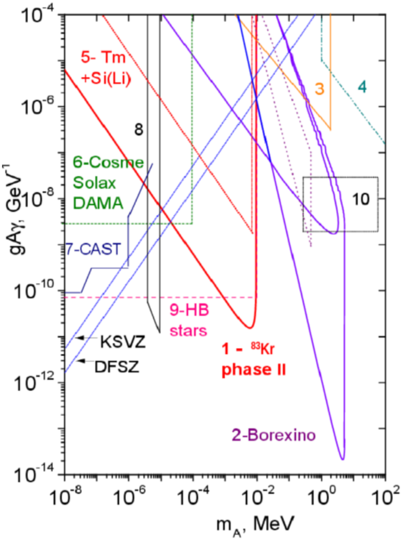


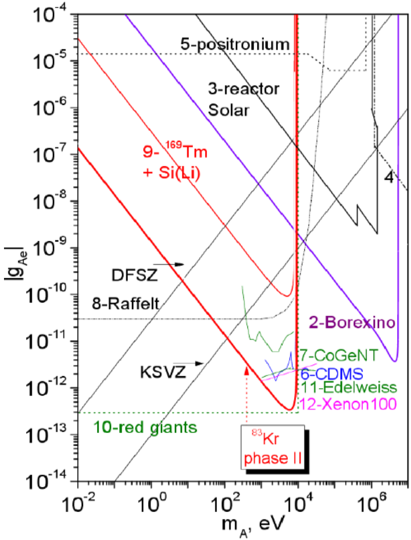
Full spectrum



Cuts applied

Obtained Limits (95% c.l.)





$$|g_{A\gamma} \times m_A| \leq \mathbf{6.26 \times 10^{-8}}$$

$$|g_{Ae} \times m_A| \leq \mathbf{1.38 \times 10^{-9}}$$