50 years from foundation of Department of Nuclear Physics

Resonant neutrinoless double-electron capture

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Muenster – Bratislava and TGV (Dubna, CTU Prague, Orsay, Bratislava) collaborations

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The process of the neutrinoless double-electron capture (0νECEC) has been revisited for those cases where the two participating atoms are nearly degenerate in mass. New 0νECEC transitions with parity violation to ground and excited states of final atom/nucleus were found. Selection rules for the 0νεε transitions were established. The explicit form of corresponding nuclear matrix elements was derived.

M.I. Krivoruchenko, F. Šimkovic, D. Frekers, and A. Faessler, Nucl. Phys. A 859, 140-171 (2011).

$$e^- + e^- + (A,Z) \rightarrow (A,Z\text{-}2)^{**}$$

0νECEC decay width:

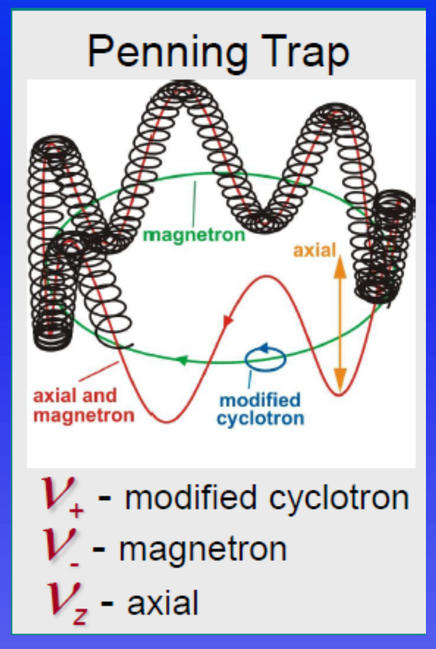
$$\Gamma^{0\nu ECEC}(J^\pi) = \frac{|V_{\alpha\beta}(J^\pi)|^2}{(M_i - M_f)^2 + \Gamma_{\alpha\beta}^2/4}\ \Gamma_{\alpha\beta}$$

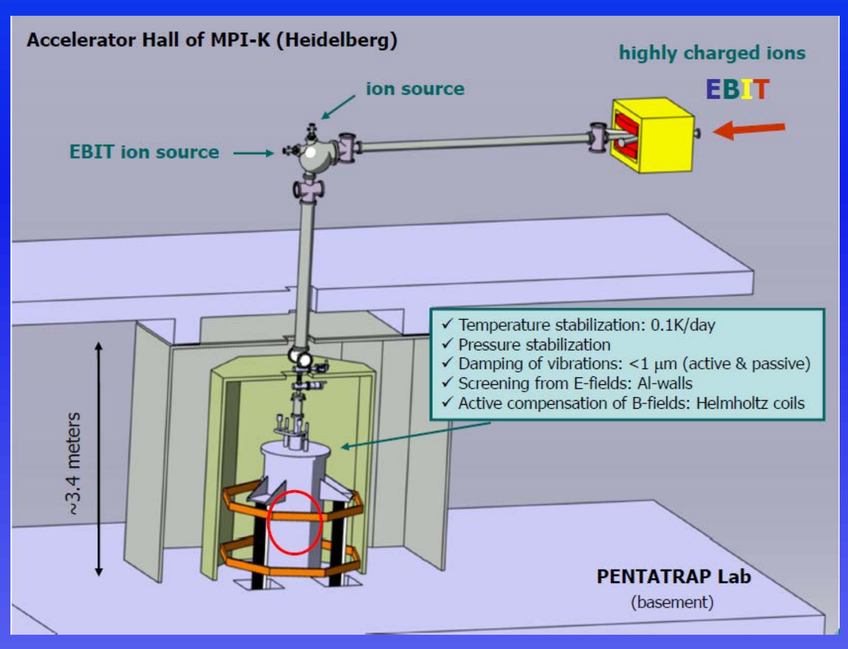
Calculations:

1. **Mass difference → Coulomb energy of electron holes.**
2. **Decay width $\Gamma_{\alpha\beta}$ → widths of the excited electron shells, Auger & radiative transitions.**
3. **V → L_T violating potential, electron wave functions & nuclear matrix elements.**

Atomic mass measurement at Penning trap (MPI-K): $T_{1/2}^{0\nu ECEC}(^{152}Gd) = 4\times10^{26}(1\,eV/m_{\beta\beta})^2$ years

Eliseev et al. (Šimkovic, Krivoruchenko), Phys. Rev. Lett. 106 (2011) 052504.



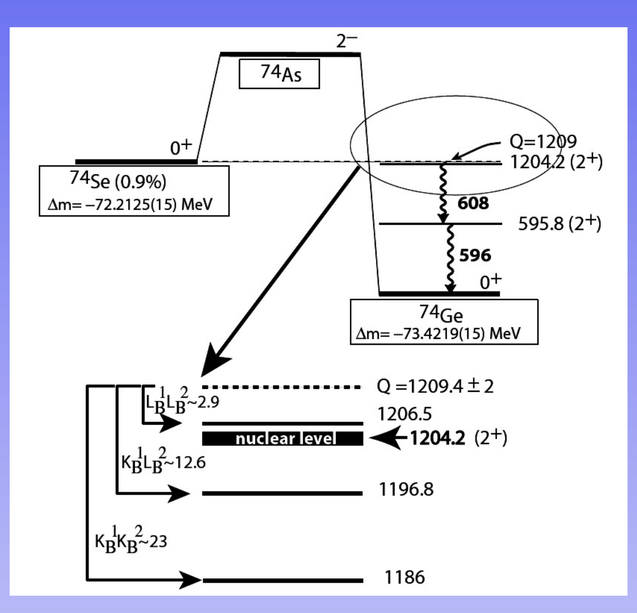


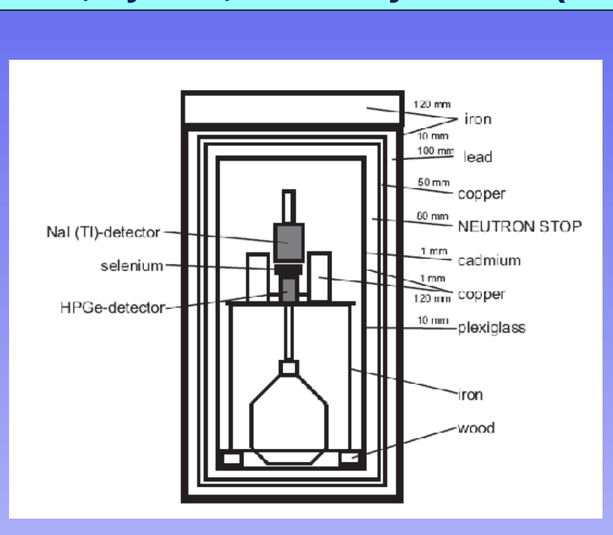
2EC-transition	*Q* (old), keV	*Δ* (old), keV	*Q* (new), keV	*Δ* (new), keV
$^{152}Gd \rightarrow {}^{152}Sm$	54.6(3.5)	-0.2(3.5)	55.7(0.2)	0.9(0.2)
			SHIPTRAP, PRL 106, 052504 (2011)	
$^{164}Er \rightarrow {}^{164}Dy$	23.3(3.9)	5.2(3.9)	25.07(0.12)	6.81(0.12)
			SHIPTRAP, paper submitted	
$^{180}W \rightarrow {}^{180}Hf$	144.4(4.5)	13.7(4.5)	143.1(0.2)	12.4(0.2)
			SHIPTRAP, paper submitted	

^{152}Gd is currently the most promising candidate for the search for resonant neutrinoless double-electron capture

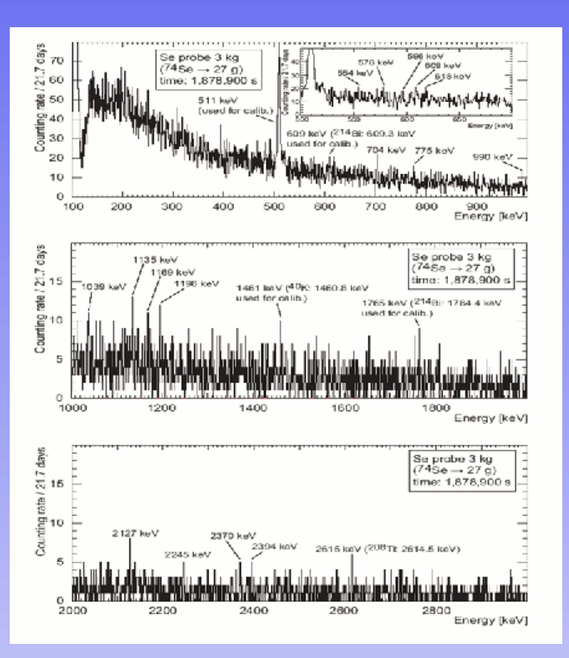
Bratislava-Muenster experiment: $T_{1/2}^{0\nu ECEC}(^{74}Se) > 4.3\ 10^{19}$ years

Frekers, Puppe, Thies, Povinec, Šimkovic, Staníček, Sýkora, Nucl. Phys. A 860 (2011) 1.



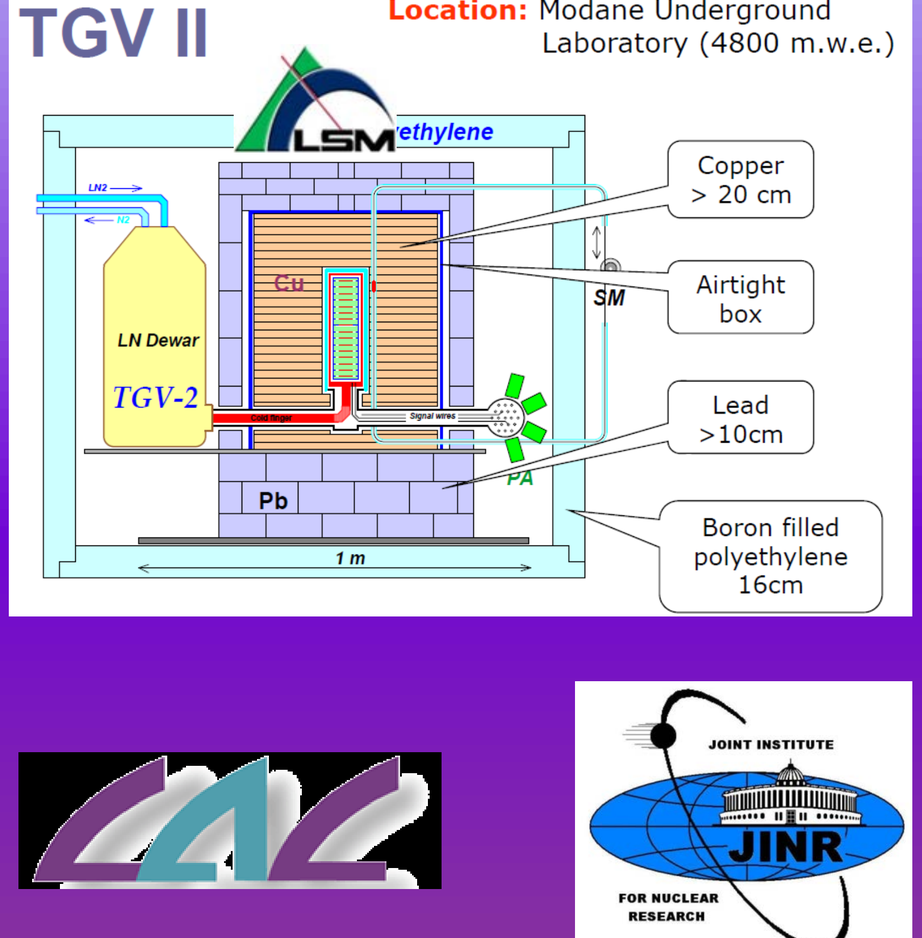


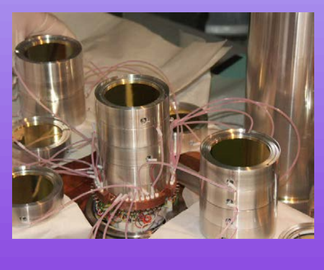
3 kg of natural selenium

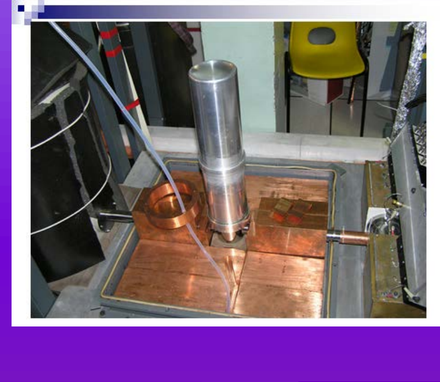


TGV (Dubna, Orsay, Prague, Bratislava) experiment: $T_{1/2}^{0\nu ECEC}(^{106}Cd) > 3.6\ 10^{20}$ years

Rukhadze et al. (Šimkovic), Nucl. Phys. A 852 (2011) 197.







- **32 HPGe planar detectors ø60 mm x 6 mm (active area 2040mm²)**
- **Total mass of samples: 10 - 15 g (maximum)**
- **E-threshold: ≈ 10 keV**
- **Samples: 12x ^{106}Cd foils (~10g in Phase 1)**