The ECHo neutrino mass experiment

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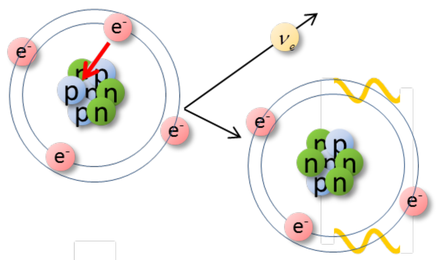
Electron capture – electron neutrino mass - ^{163}Ho



Calorimetric measurement

$$\frac{dW}{dE_C} = A(Q_{EC} - E_C)^2 \sqrt{1 - \frac{m_\nu^2}{(Q_{EC} - E_C)^2}} \sum_H B_H \varphi_H^2(0) \frac{\frac{\Gamma_H}{2\pi}}{(E_C - E_H)^2 + \frac{\Gamma_H^2}{4}}$$

$$^{163}_{67}\mathrm{Ho} \rightarrow {}^{163}_{66}\mathrm{Dy}^* + \nu_e$$

$$^{163}_{66}\mathrm{Dy}^* \rightarrow {}^{163}_{66}\mathrm{Dy} + E_C$$

- $Q_{EC} \cong$ 2.3 - 2.8 keV
- $\tau_{1/2} \cong$ 4570 years

^{163}Ho source :

- >10^6 Bq → >10^{17} atoms

charged particle activation — **Low cross-section**

^{nat}Dy(p,xn) ^{163}Ho
^{nat}Dy(α, xn) ^{163}Er (ε) ^{163}Ho
^{159}Tb(^{7}Li, 3n) ^{163}Er (ε) ^{163}Ho

Few radioactive contaminants

(n,γ)-reaction on ^{162}Er — **High cross-section**

Rradioactive contaminants

Er161 3.21 h 3/2- EC	Er162 0+ 0.14	Er163 75.0 m 5/2- EC	Er164 0+ 1.61	Er165 10.36 h 5/2- EC	Er166 0+ 33.6
Ho160 25.6 m 5+ * EC	Ho161 2.48 h 7/2- * EC	Ho162 15.0 m 1+ * EC	Ho163 4570 y 7/2- * EC	Ho164 29 m 1+ * EC,β-	Ho165 7/2- 100
Dy159 144.4 d 3/2- EC	Dy160 0+ 2.34	Dy161 5/2+ 18.9	Dy162 0+ 25.5	Dy163 5/2- 24.9	Dy164 0+ 28.2
Tb158 180 y 3- * EC,β-	Tb159 3/2+ 100	Tb160 72.3 d 3- β-	Tb161 6.88 d 3/2+ β-	Tb162 7.60 m 1- β-	Tb163 19.5 m 3/2+ β-

Thermal neutron flux (Φ): 1.3x10^{15} cm^{-2}s^{-1}

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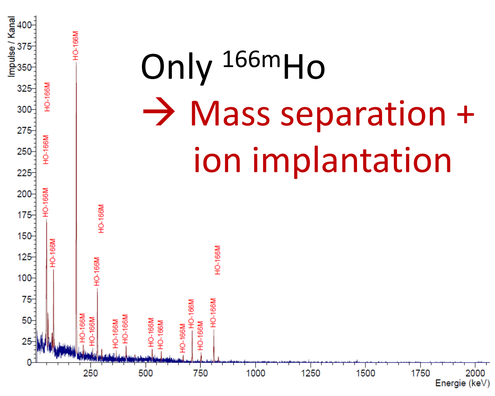
June 2012 : one irradiation at BER II Berlin

-5 mg Er for 11 days ⇒ 1.5•10^{16} atoms ^{163}Ho

Summer 2013: Two irradiations at ILL

- Treatment of Er prior to irradiation:
- Treatment of Er after irradiation:

- 30 mg for 55 days ⇒ 1.6•10^{18} atoms ^{163}Ho
- 7 mg for 7 days ⇒ 1.4•10^{16} atoms ^{163}Ho

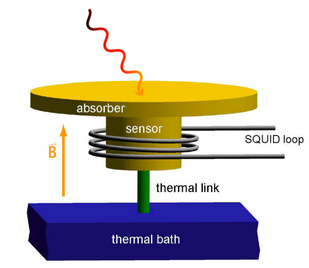


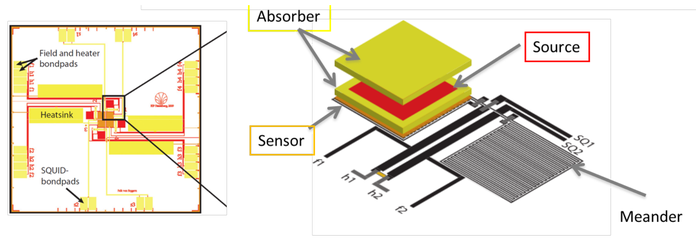
Only ^{166m}Ho
→ Mass separation + ion implantation

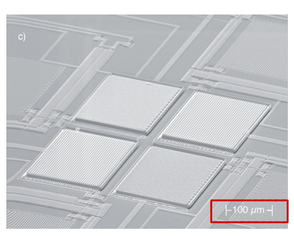
Calorimetric measurement:

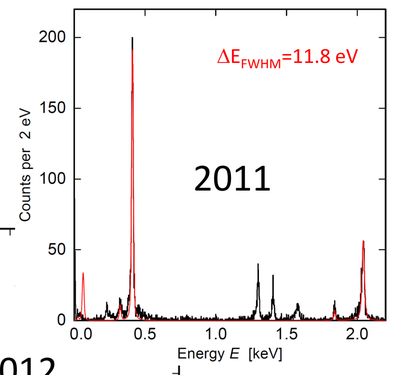
Low temperature metallic magnetic calorimeters

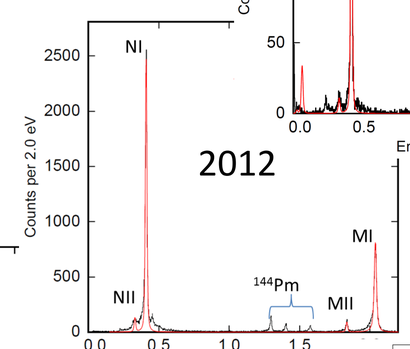
$$\Delta\Phi_S \propto \frac{\partial M}{\partial T}\Delta T \rightarrow \Delta\Phi_S \propto \frac{\partial M}{\partial T}\frac{E}{C_{sens} + C_{abs}}$$

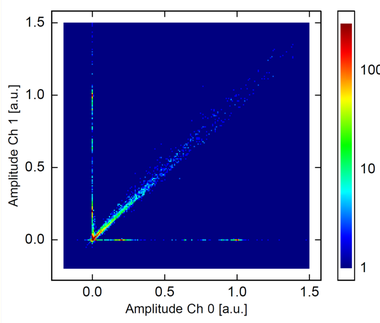


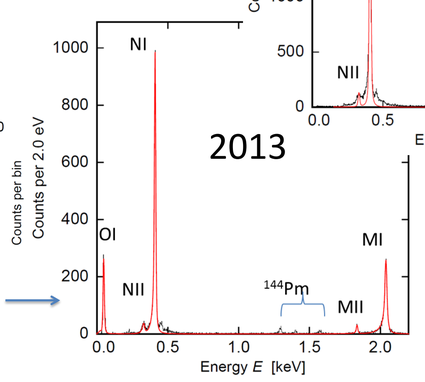


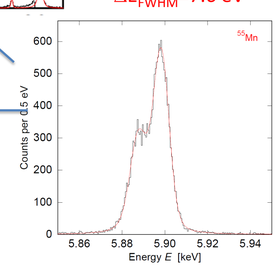


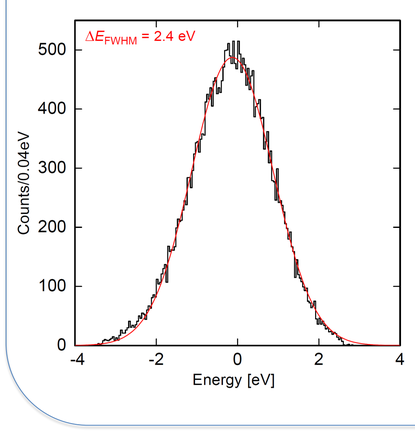


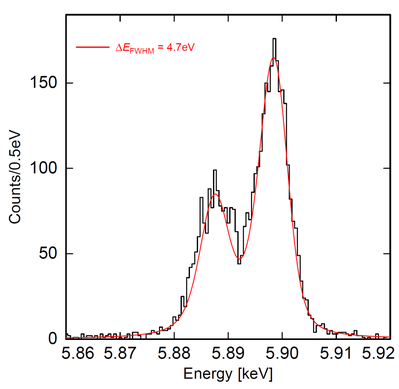


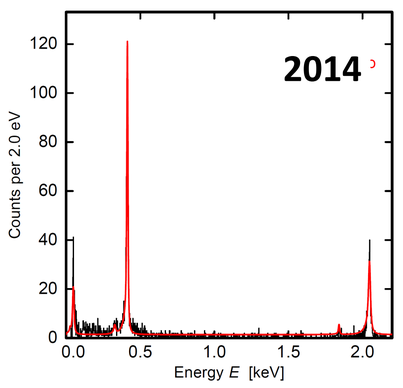






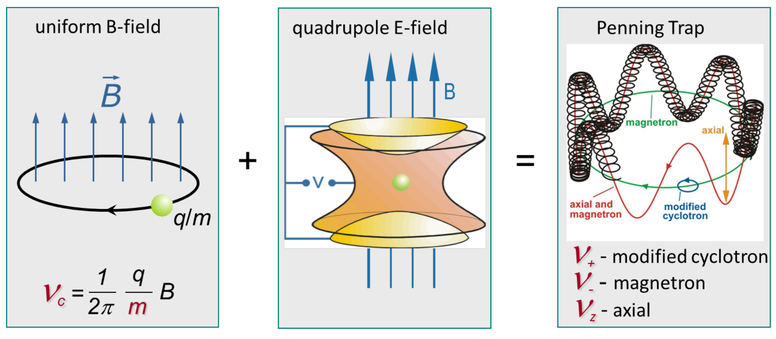






Q_{EC} independent measurement

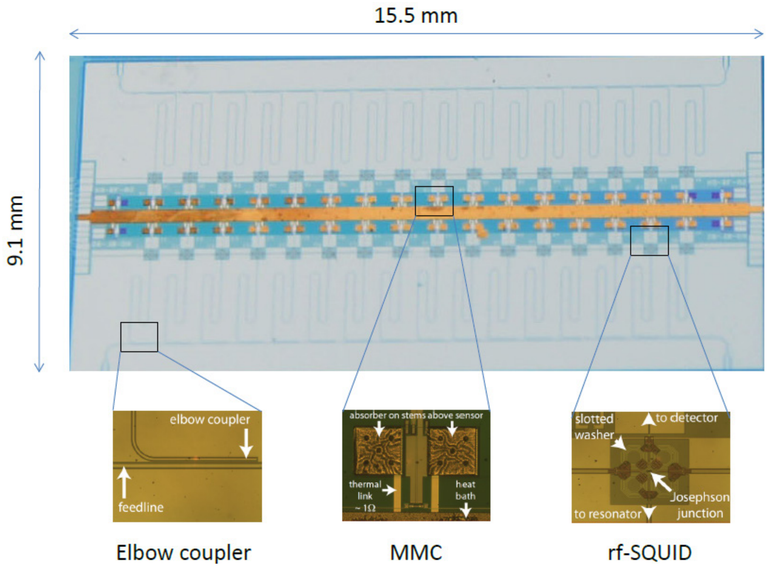
Penning Trap
mass spectroscopy



2014: TRIGATRAP - SHIPTRAP (GSI) → Q_{EC} determination within 30 - 100 eV

In few years: PENTATRAP (MPI-K HD) → Q_{EC} determination within 1 eV

Microwave multiplexing technique



1 HEMT amplifier
+ 2 coaxes
= 100 - 1000 detectors