Neutrinoless Double Beta Decay

\[(A,Z) \rightarrow (A,Z+2) + e^- + e^-\]

Candidates: $^{44}$Ca, $^{76}$Ge, $^{82}$Se, $^{94}$Zr, $^{100}$Mo, $^{114}$Cd, $^{120}$Te, $^{130}$Te, $^{150}$Nd, and $^{238}$U

The observation of neutrinoless double beta decay will confirm the Majorana nature of the neutrino and will give information on the absolute neutrino mass scale.

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CaMoO$_4$ Crystal

$^{100}$Mo (9.63% natural abundance) is one of the most promising double beta decay candidate because of its high transition energy ($Q = 3035$ keV).

CaMoO$_4$ (calcium molybdate) scintillators were radiopurely fabricated from single crystals by the Czochralski method.

- Density (g/cm$^3$): 4.2-4.3
- Melting point (°C): 1445-1480
- Structural type: Schueelite
- Wavelength of emission maximum (nm): 520

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Metallic Magnetic Calorimeter (MMC)

Thermometer: Au:Er (800 ppm)
- a dilute alloy of Er in Au
- paramagnetic material

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MMC Performance Compared with Si(Li)

- $^{55}$Fe

- MMC (18 eV FWHM)

- Si(Li)

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Experimental Setup

Energy absorption of a photon or a particle by the absorber leads to temperature increase of the system.

\[\Delta E = 2.35 \xi (k_B T C)^{1.2}\]

Crystal size: ~ 11 mm x 8 mm x 6 mm
Operating condition: 11 mK, 40 G

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Radioactive Source

Electro-deposited monolayer $^{241}$Am alpha decay source from Ortec
- alpha energy (keV): 5388, 5443, 5486
- intensity (%): 1.4, 12.8, 85.2

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Results

- Trigger rate: ~ 1 Hz
- Energy resolution: ~ 6.1% FWHM for the major peak

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Discussion

Possible explanations for the poor energy resolution:
1) Cracks inside the crystal formed during photoresist process
   - Adopt stressless process
2) $^4$He attached on the surface of the crystal at low temperatures
   - Use gamma source for calibration

Future Plans:
1) Use bigger crystal
2) Measure scintillation light from the crystal at the same time using TES

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Dedicated to my mother So-cheon Park