Development of Low Temperature Detector with $CaMoO_4$ Crystal for Neutrinoless Double Beta Decay

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Neutrinoless Double Beta Decay

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

Candidates : ^{48}Ca, ^{76}Ge, ^{82}Se, ^{96}Zr, ^{100}Mo, ^{116}Cd, ^{128}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) : one of the most promising double beta decay candidate because of its high transition energy (Q = 3035 keV).

$CaMoO_4$ (calium 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	Scheelite
Wavelength of emission maximum (nm)	520

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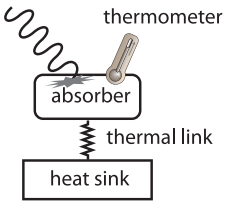
Calorimetric Detection

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



At low temperatures, the heat capacity of the detector becomes so small that even a low energy particle can sufficiently increase the temperature of the detector. Moreover, the thermal energy fluctuation can be significantly reduced.

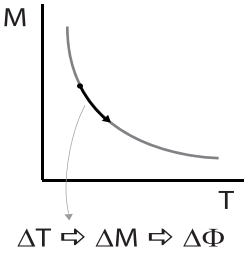
$$\Delta E = 2.35\xi(k_B T^2 C)^{1/2}$$

Metallic Magnetic Calorimeter (MMC)

Themometer : Au:Er (800 ppm)

- a dilute alloy of Er in Au

- paramagnetic material



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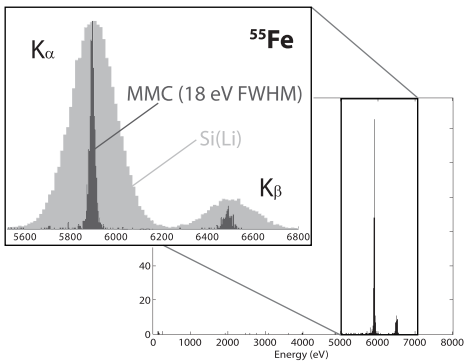
MMC Performance Compared with Si(Li)



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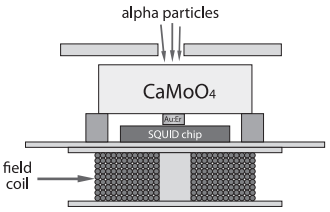
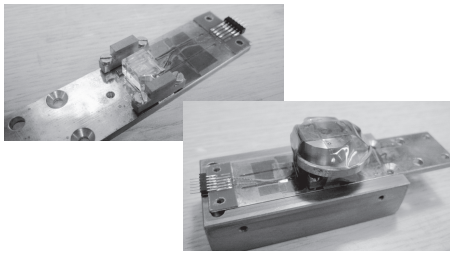
Experimental Setup





Crystal size : ~ 11 mm × 8 mm × 6 mm

Operating condition : 11 mK, 40 G

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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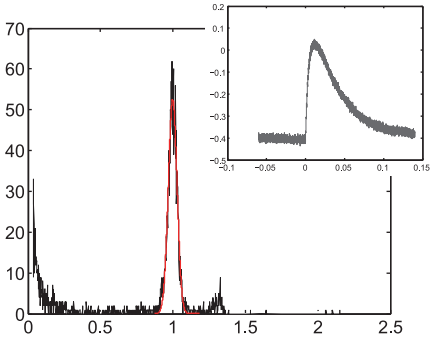
Results



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) ^4He 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-choon, Park