Light Detector development for CRESST Dark Matter Search

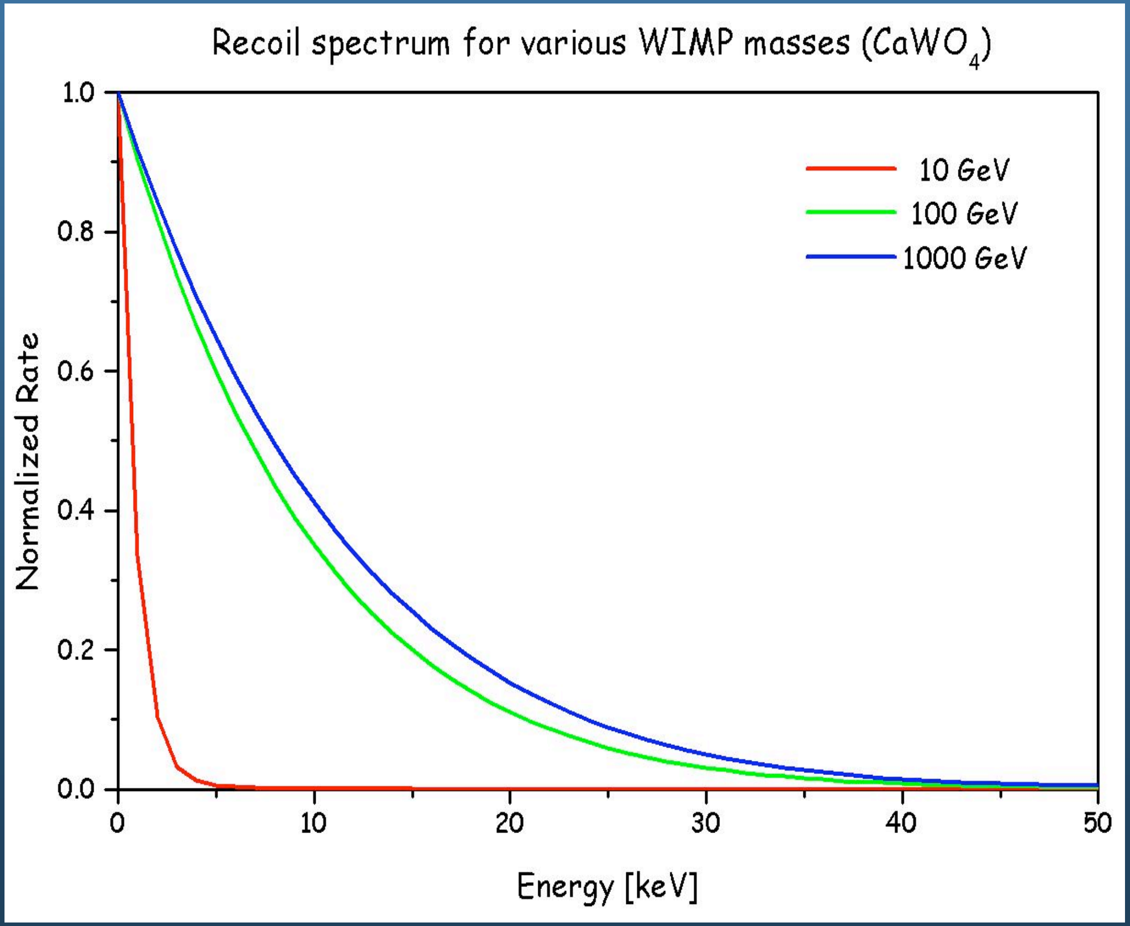
- CRESST light detector
- First results with silicon-on-sapphire light detector

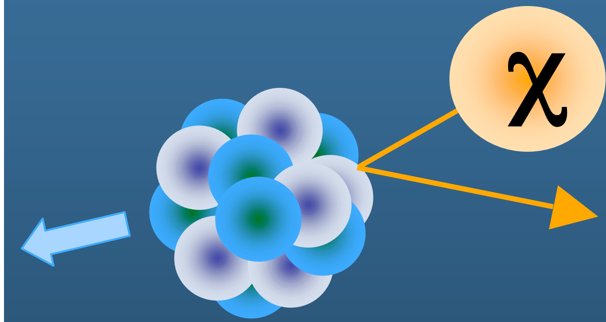
E. Pantic, I. Bavykina, A. Bento, D. Hauff, R. Lang, F. Petricca , F. Pröbst and W. Seidel

Max-Planck-Institut für Physik, Munich, Germany

WIMP Direct Detection

Low energy transfer (< 40 keV)

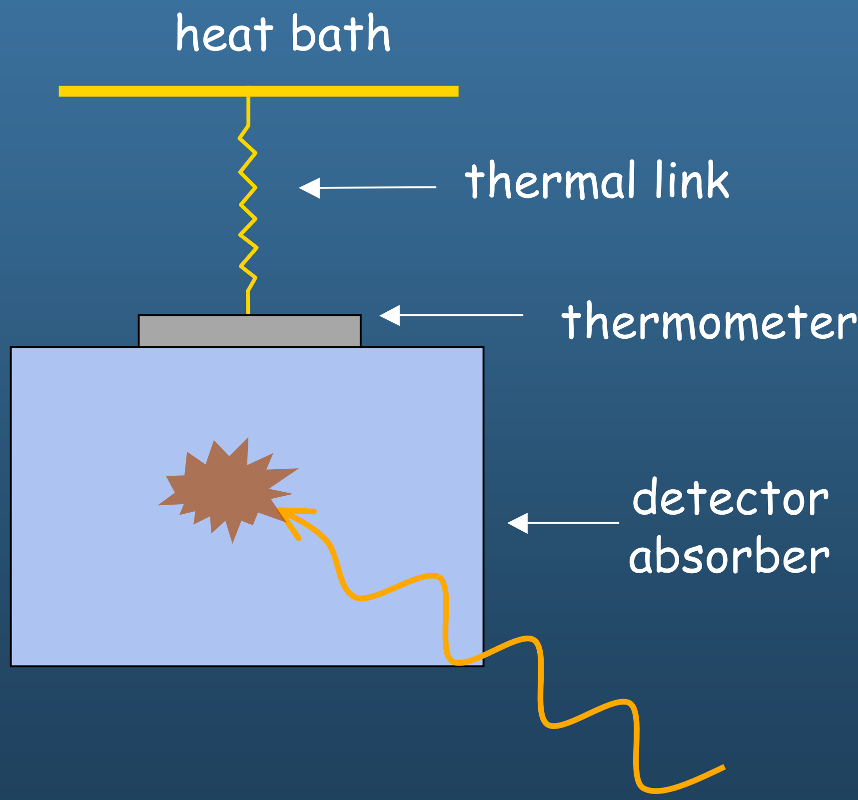


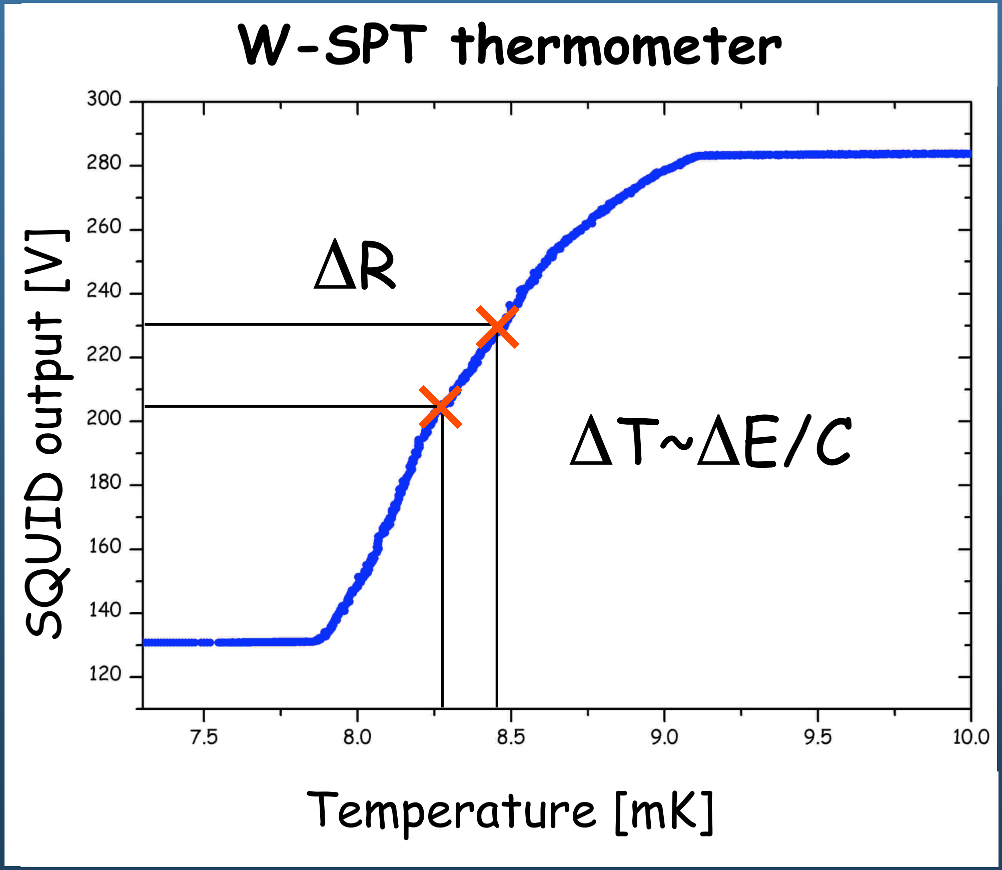


WIMP-nucleus scattering

Cryogenic detectors

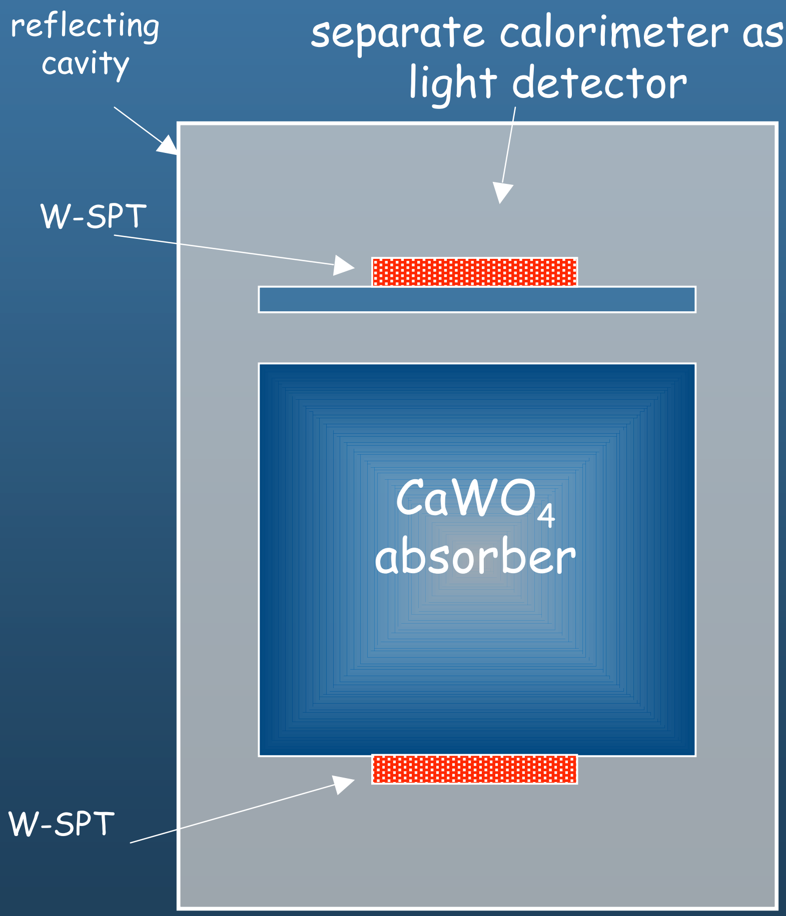
✓ Low energy threshold
✓ Excellent energy resolution

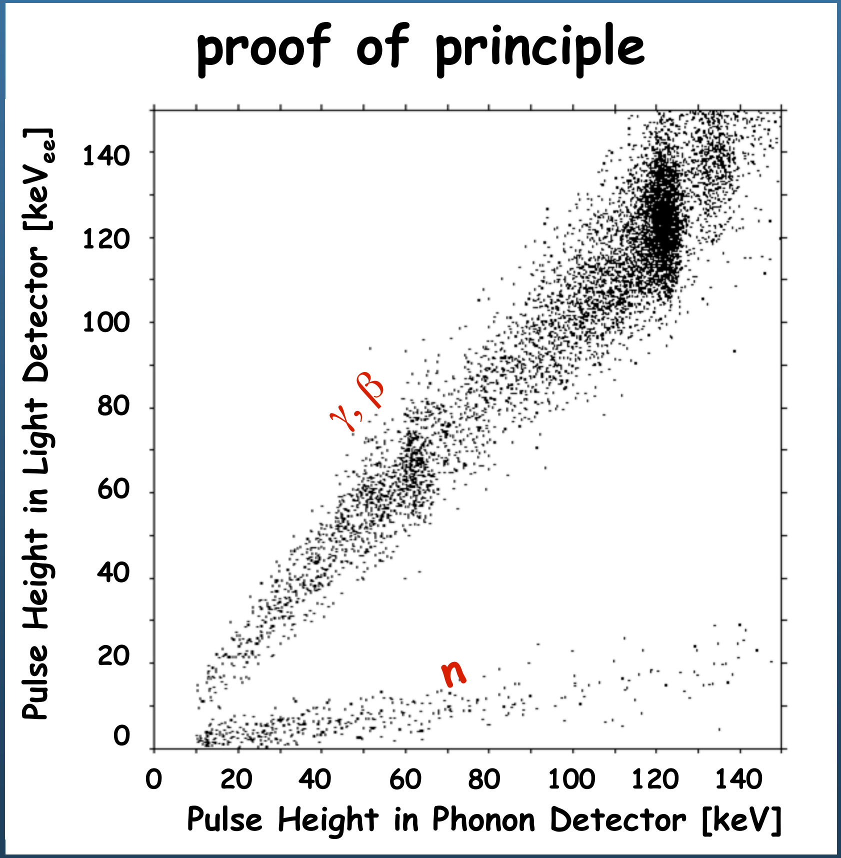




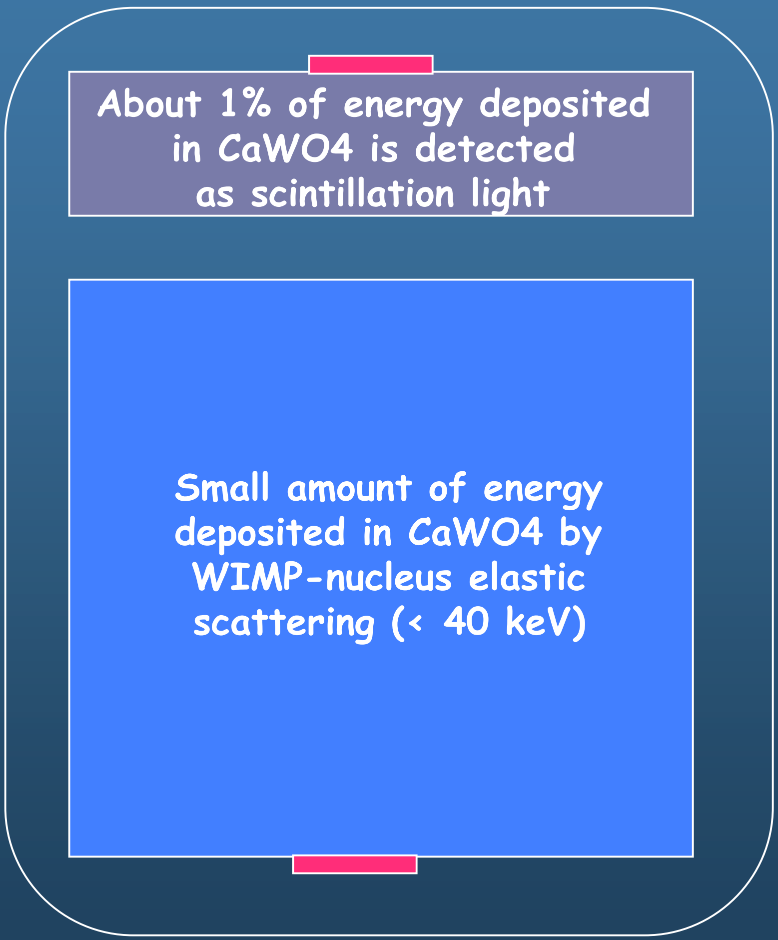
Detector module – background discrimination

Simultaneous measurement of phonons and scintillation light to discriminate nuclear recoil signals from radioactive background





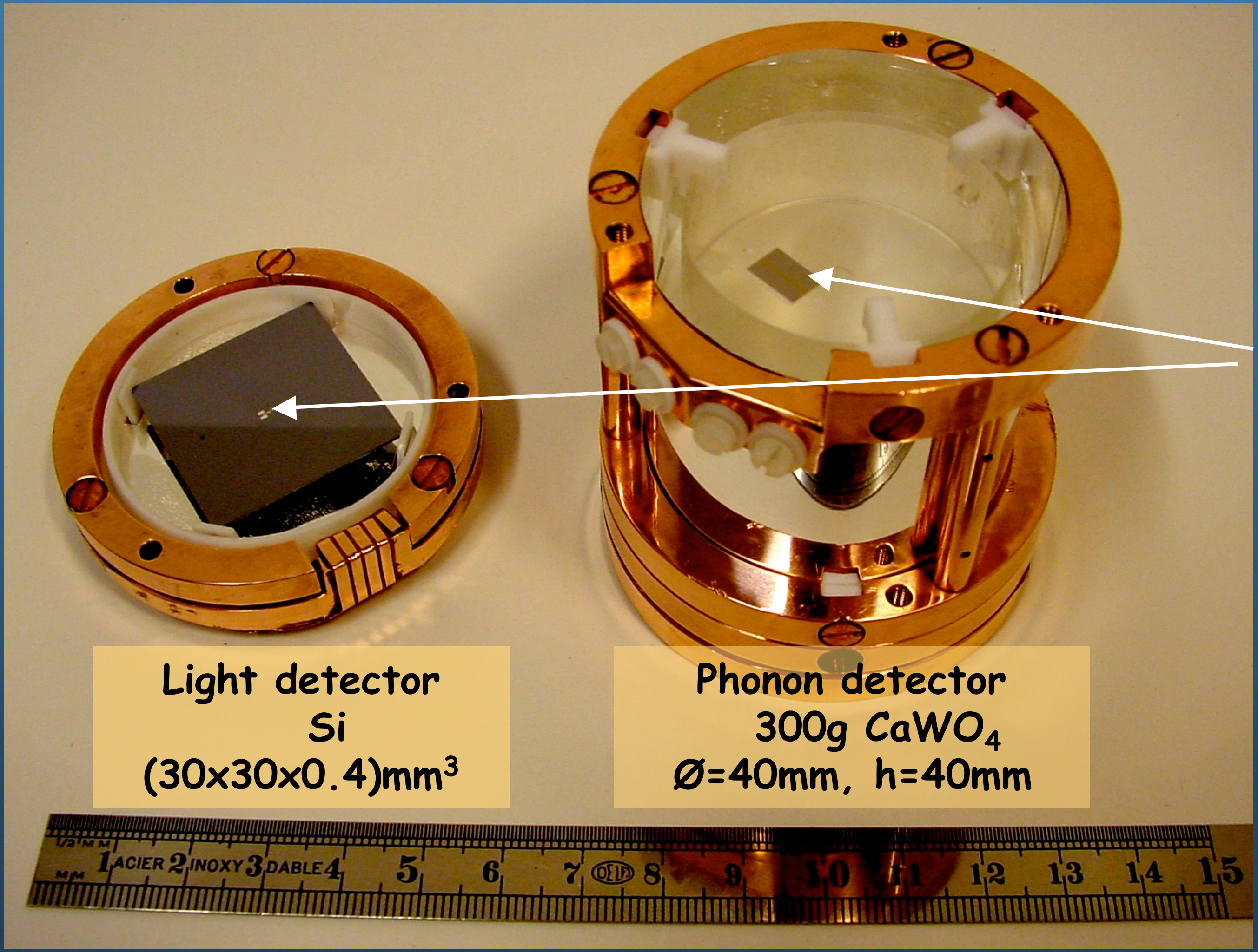
Challenges of the light detector



The sensitivity of the light detector is crucial for the background discrimination in the energy range relevant for WIMP search

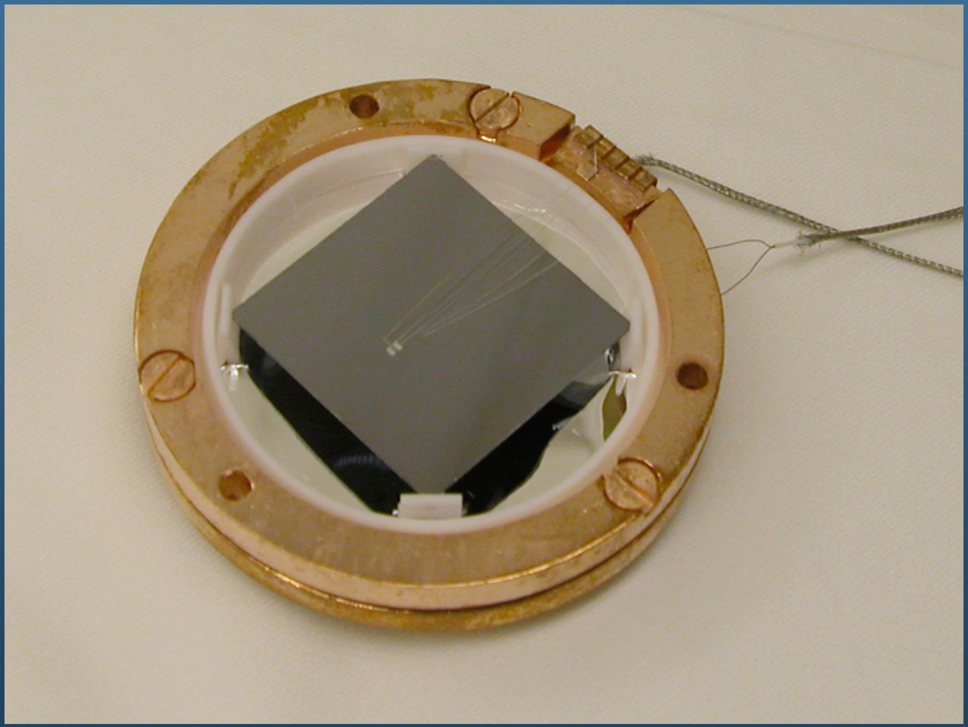
Light detector performance defines the discrimination threshold

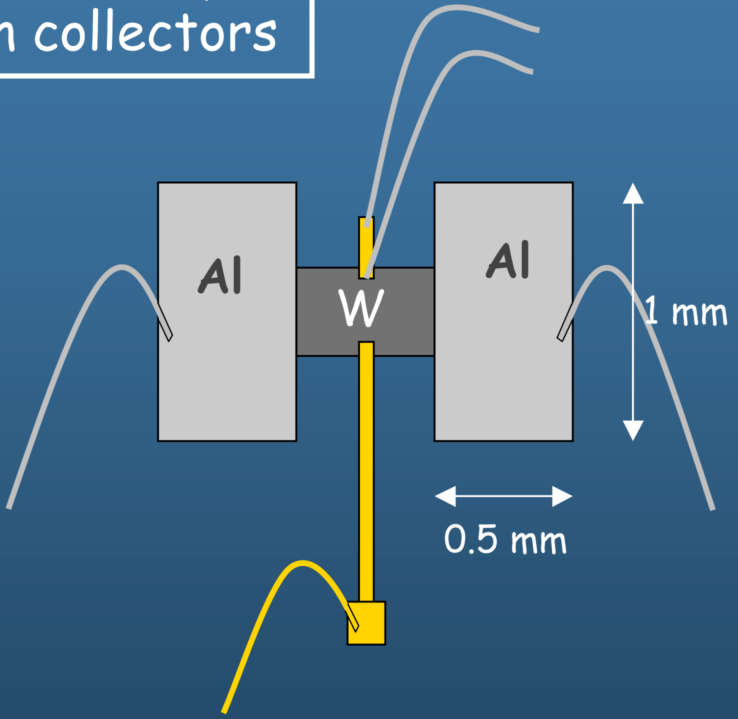
CRESST II prototyping phase detector module



Silicon light detector

Si wafer (30 x 30 mm^2) with 200Å SiO_2 layer
read out by W-SPT with Al-phonon collectors

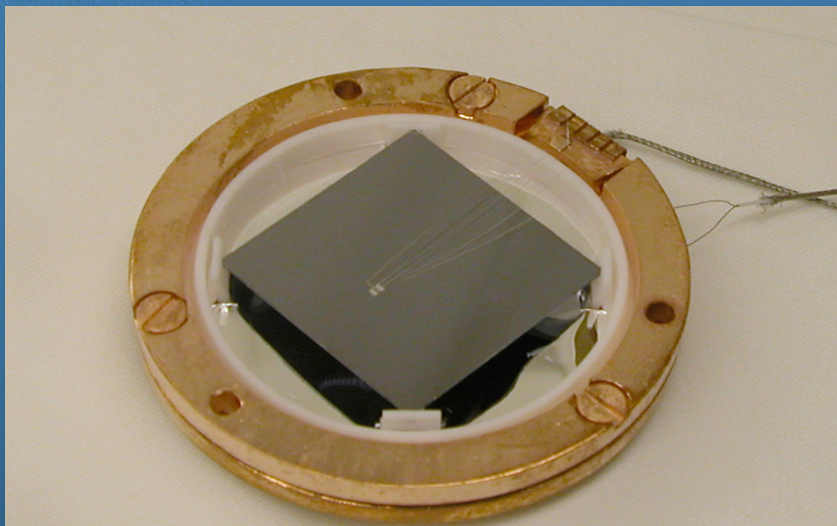


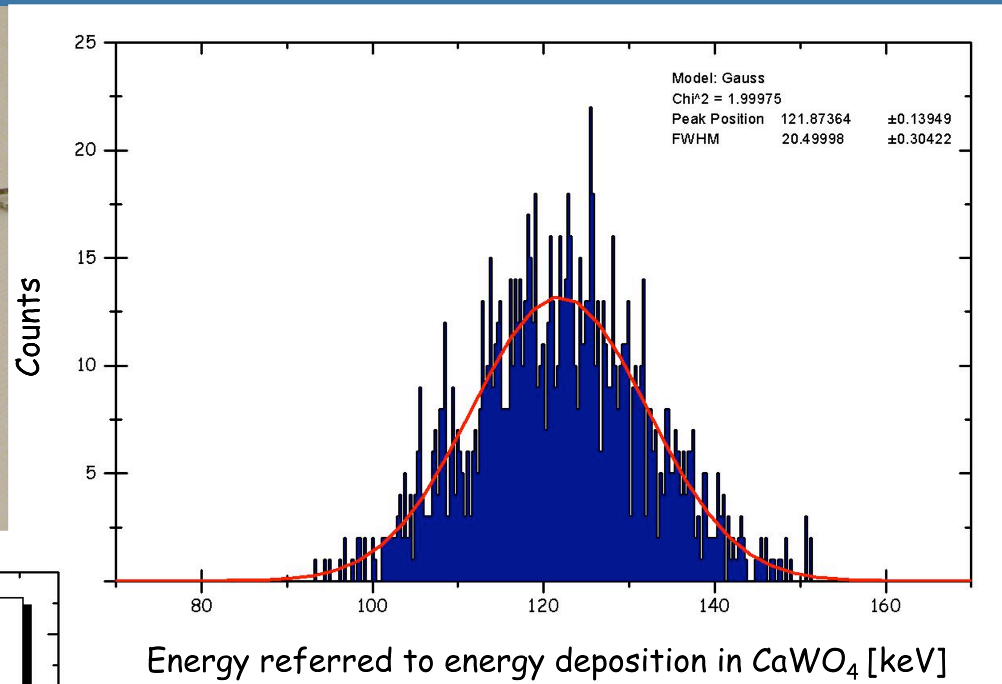


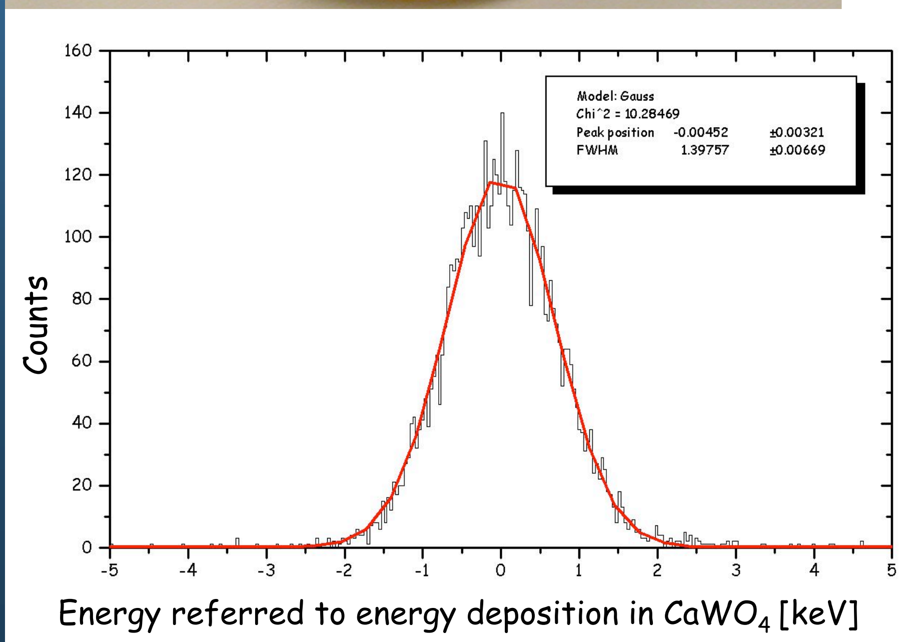
Al-phonon collectors

Thin film heater and thermal link

Silicon light detector - performance







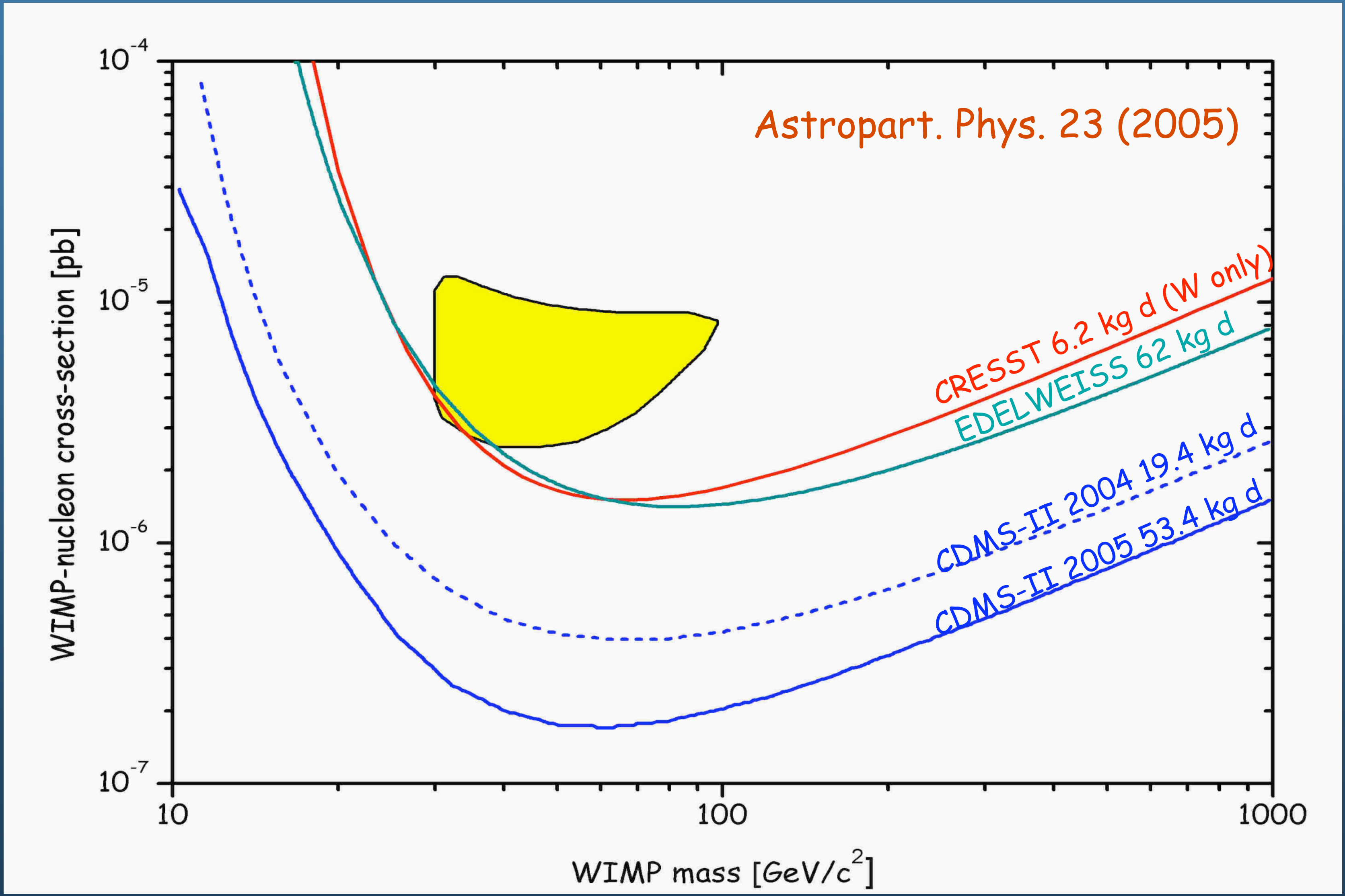
Energy resolution:

ΔE_{FWHM} = 20 keV_{ee} @ E = 122 keV_{ee}

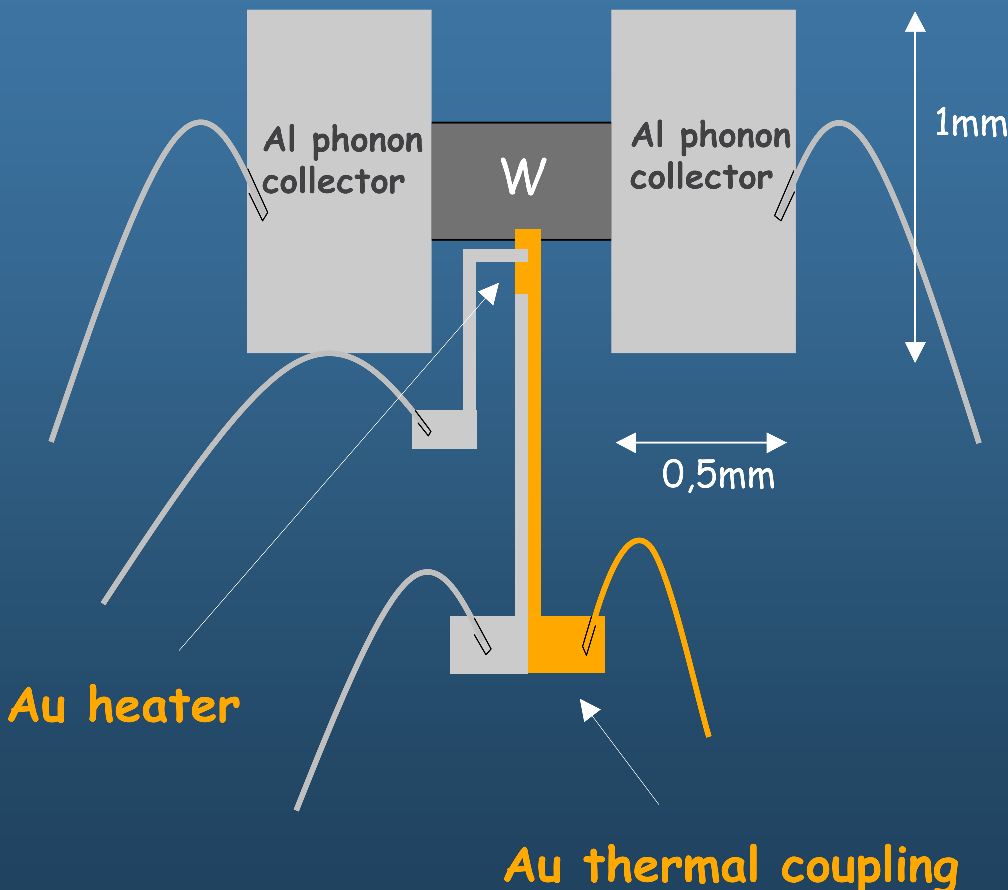
Energy threshold:

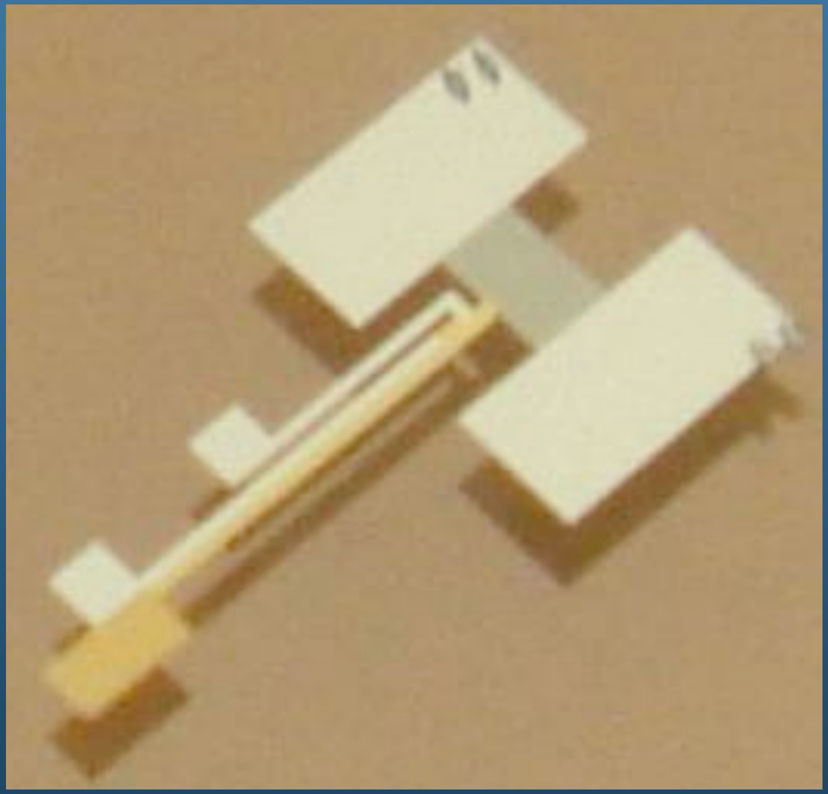
$E_{thresh} \approx 2.8\ keV_{ee}$ (5σ) (few photons)

Exclusion limits for spin independent WIMP-nucleon cross section



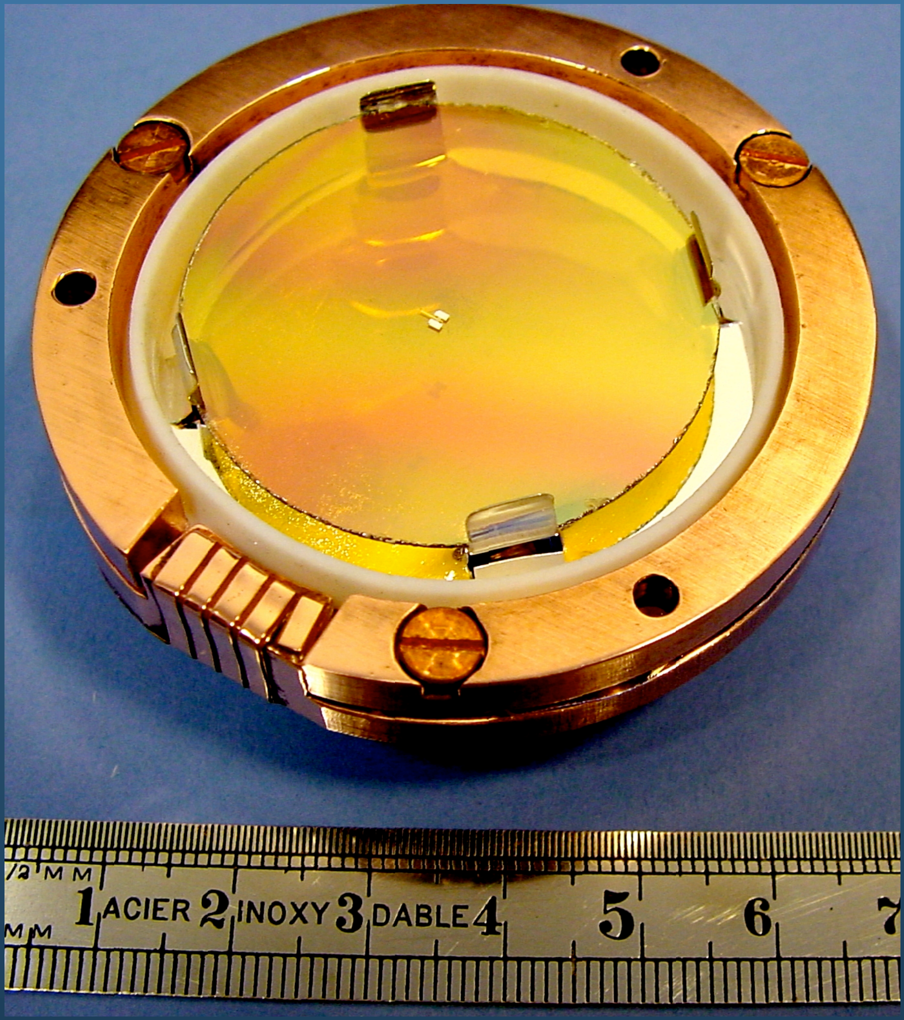
Light detector - design optimization





Light detector – material optimization

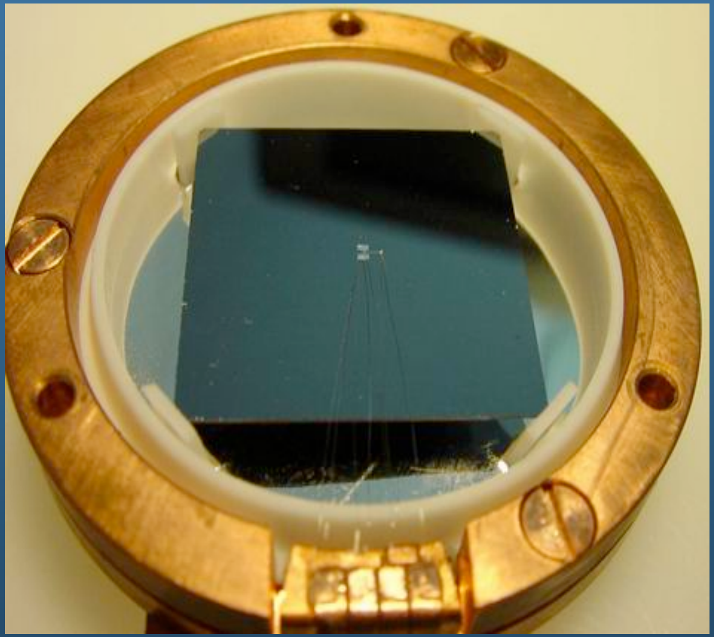
Silicon-On-Sapphire



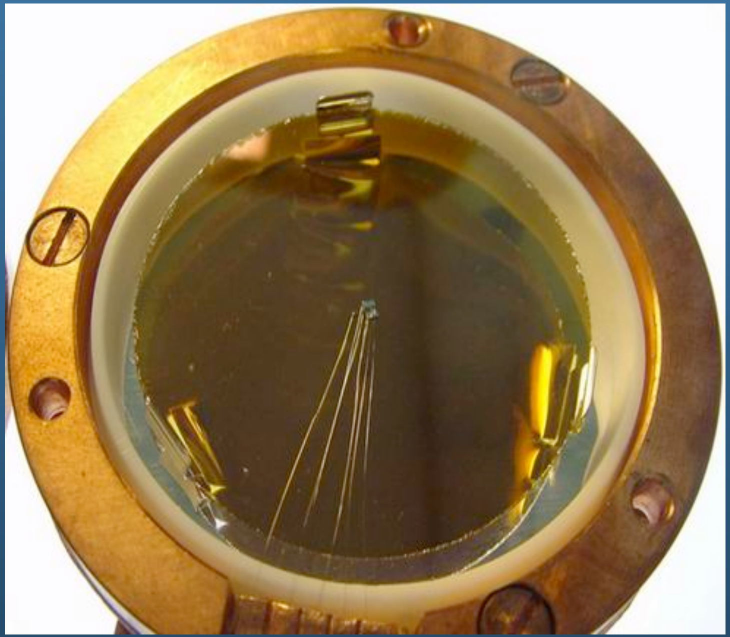
Silicon absorption properties
+
Sapphire transport properties

Absence of oxide layer on the sapphire side
↓
Reduced position dependence of the response

Light detector development - results

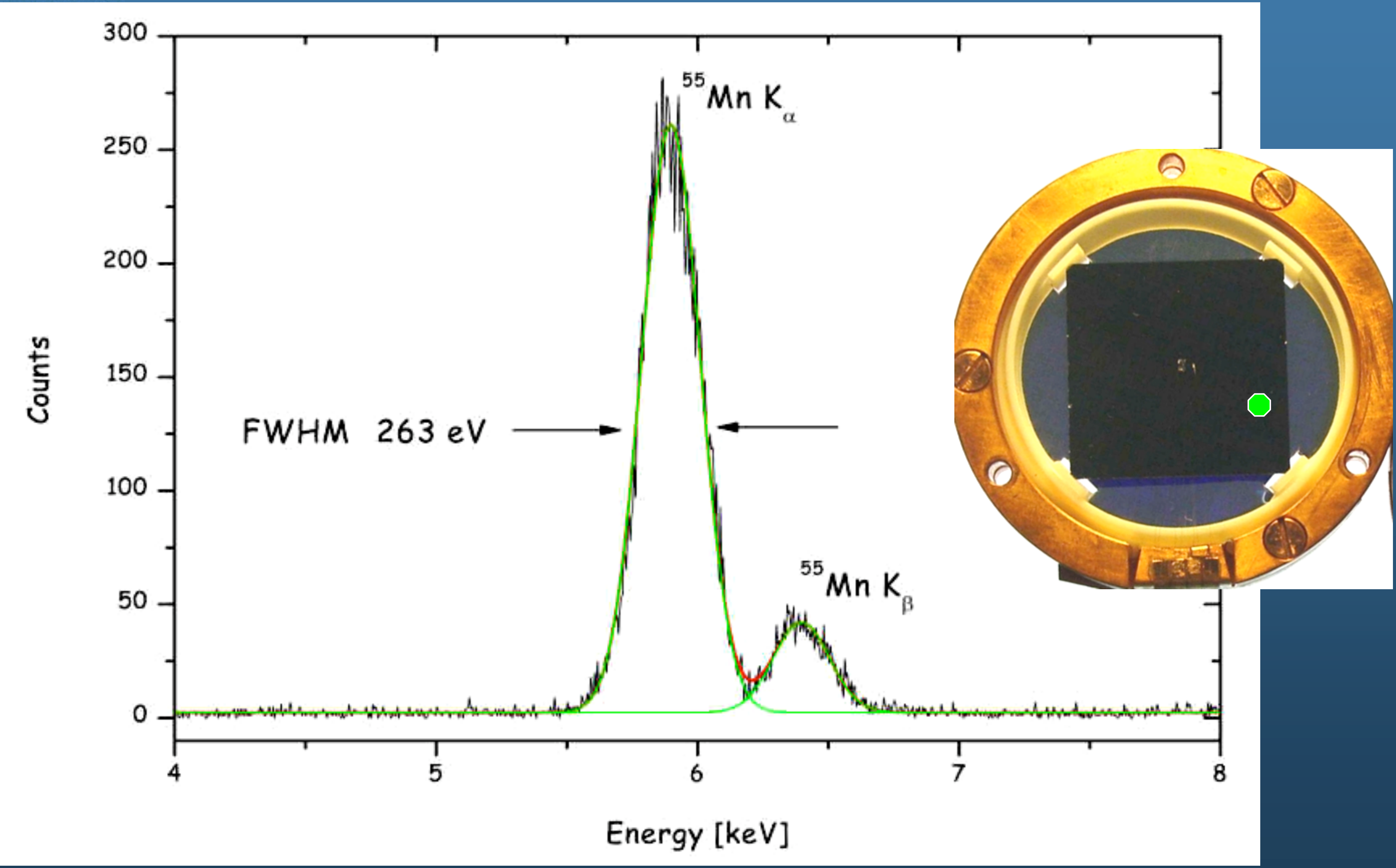


Silicon light detector

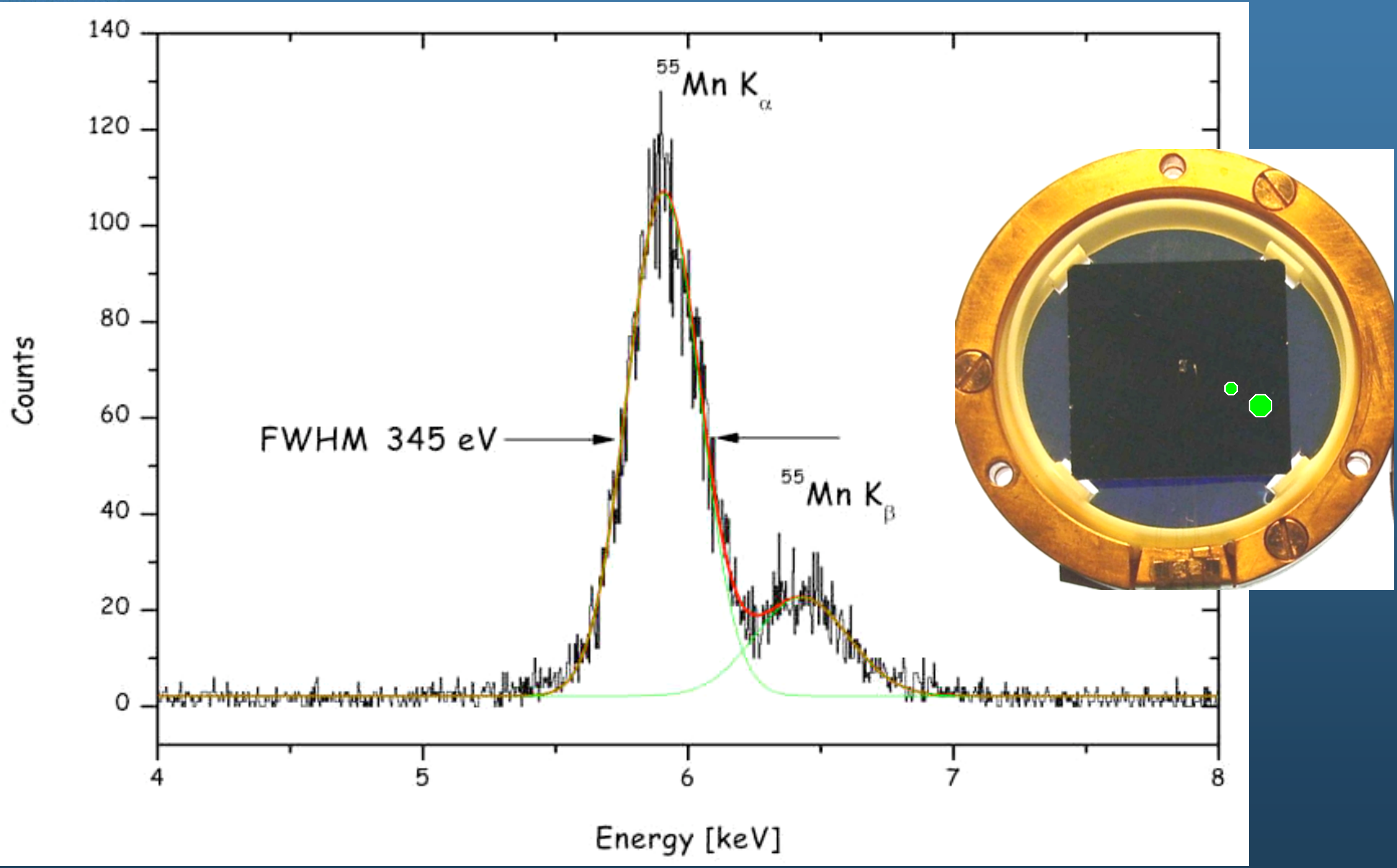


Silicon-On-Sapphire (SOS) light detector

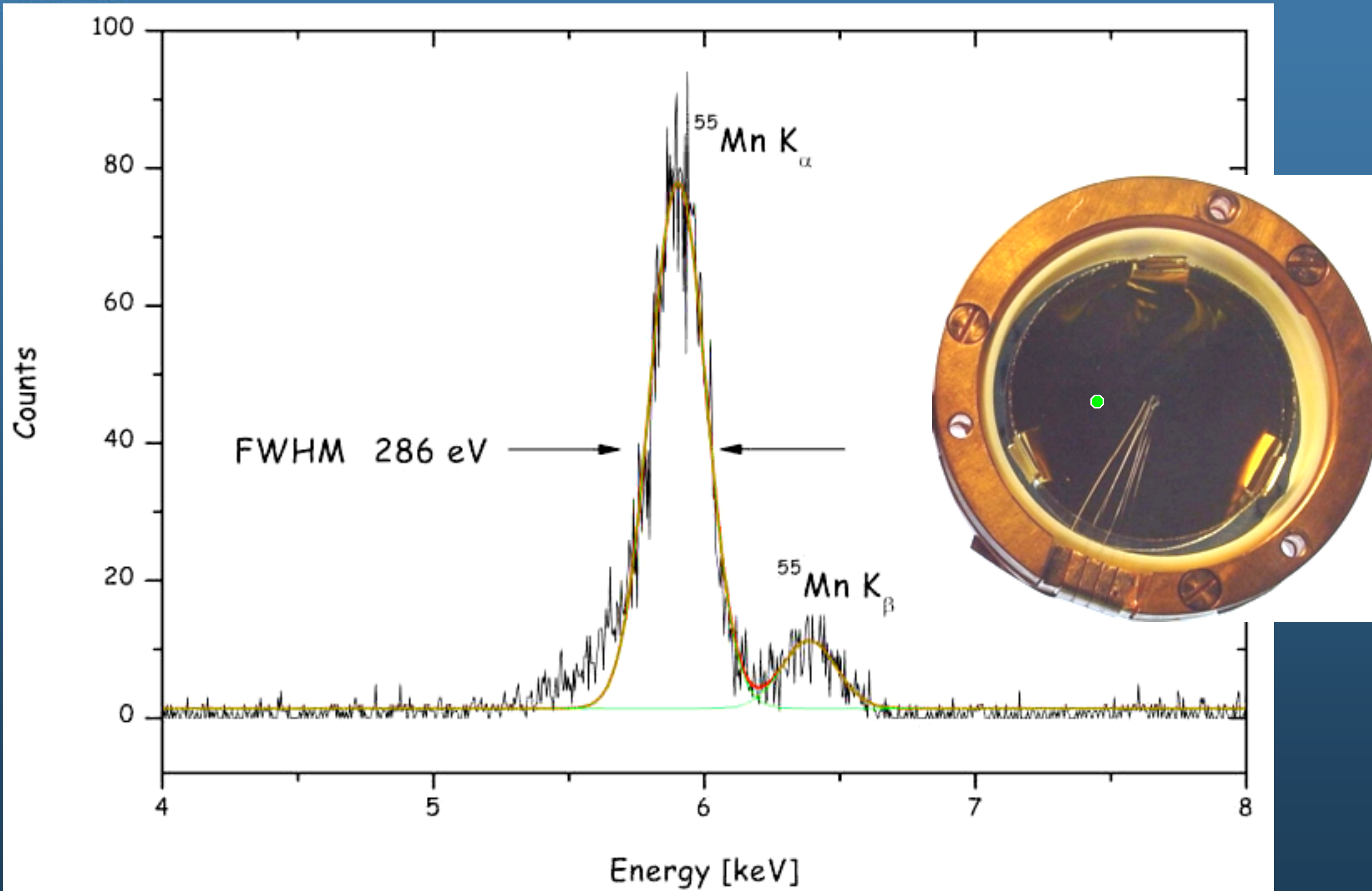
Silicon light detector resolution



Silicon light detector resolution



SOS light detector resolution



Silicon/SOS light detector

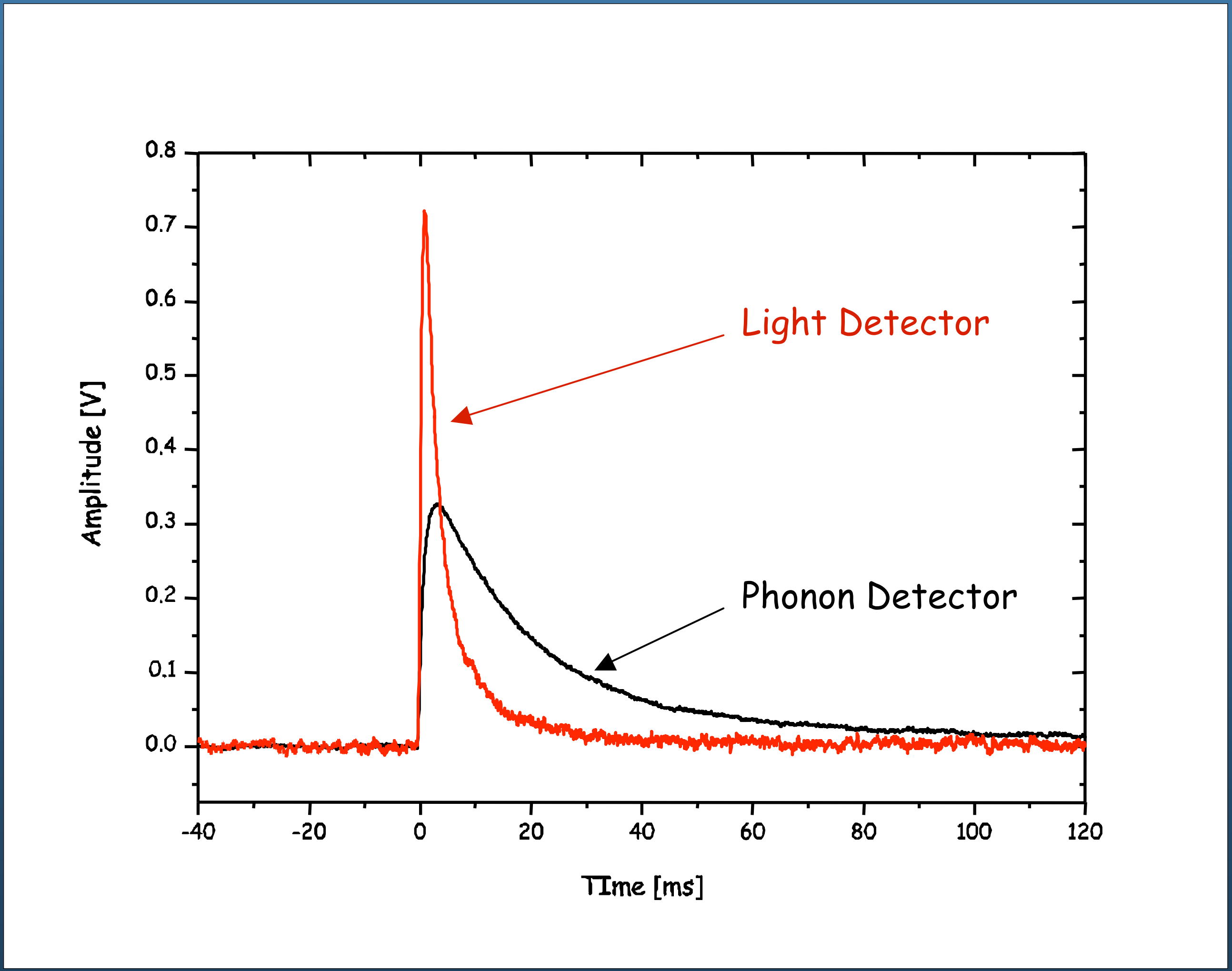
Deposited energy-ΔE= 6keV	equal		
Operating temperature-T_{op}	equal	✓	scaling
Heat capacity of thermometer-C_e	equal	✓	scaling

Silicon light detector ⟶ ΔT = ~39μK

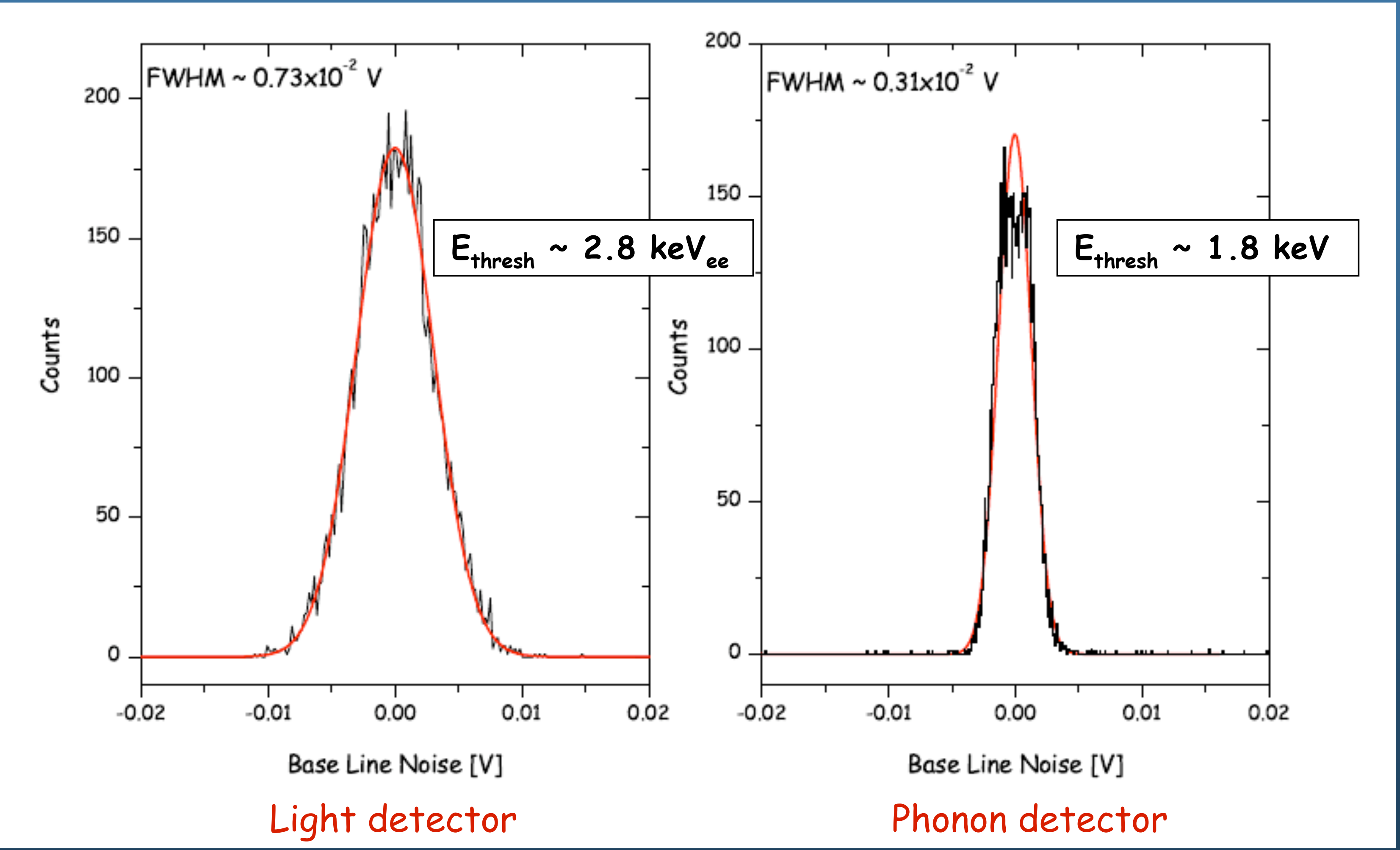
SOS light detector ⟶ ΔT = ~60μK

1.5x !

Noise considerations



Noise considerations



Next

Further investigation of:

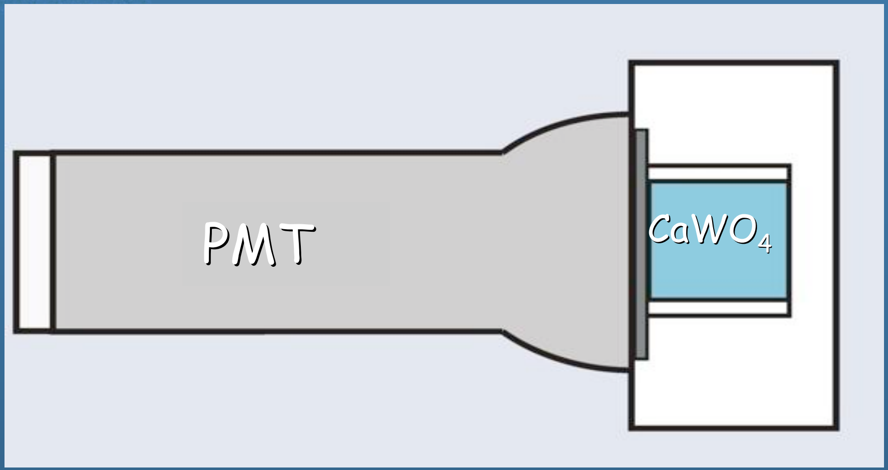
- the performance of SOS light detectors within CRESST-II detector module
- origin of noise in the light detector

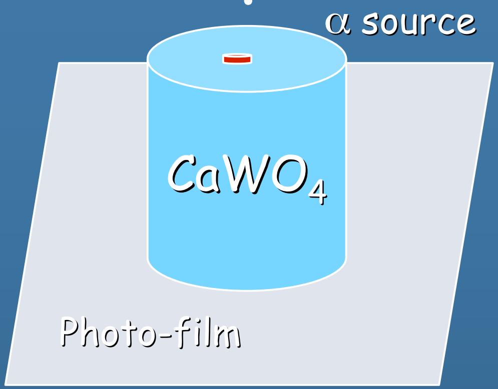
Further development of :

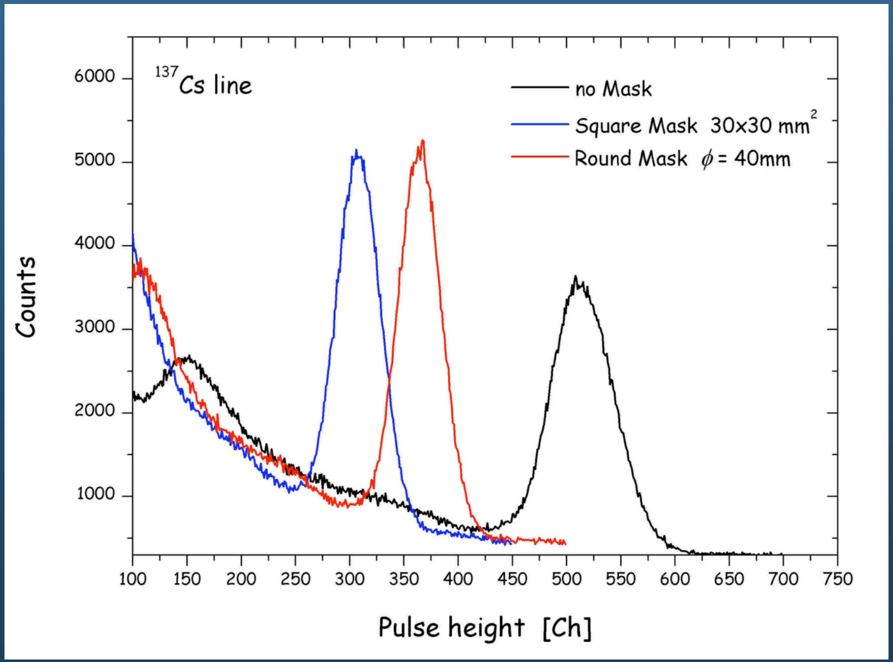
- the light detector thermometer geometry
- material for the light detector substrate

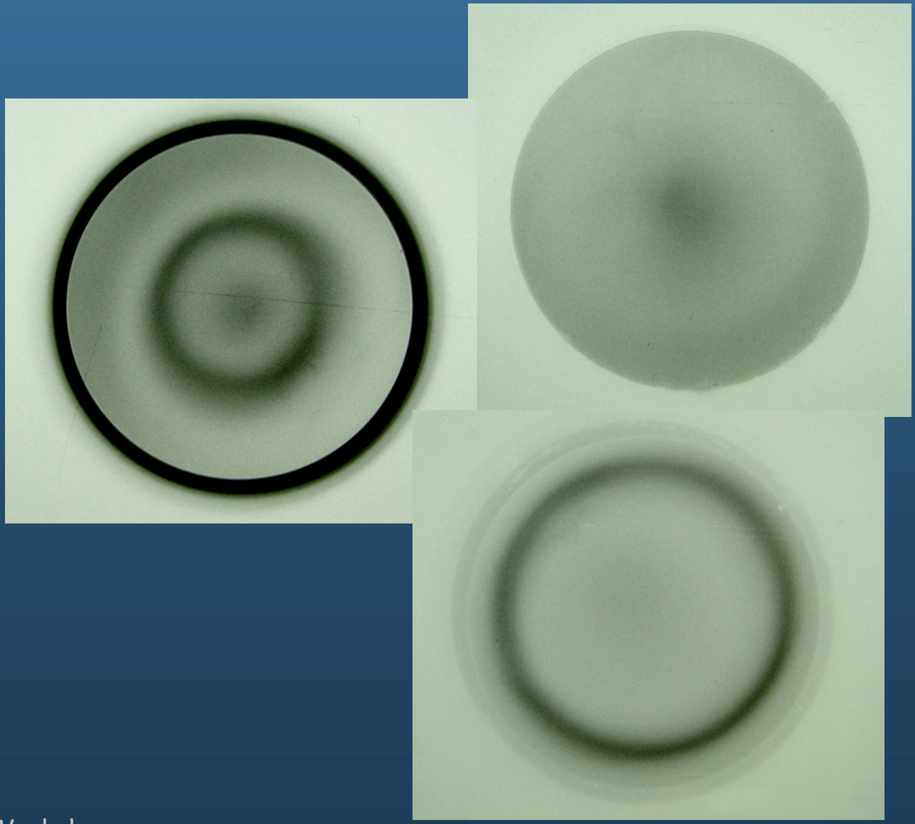
Additional slides

Light detector - dimensions optimization









Read out circuit