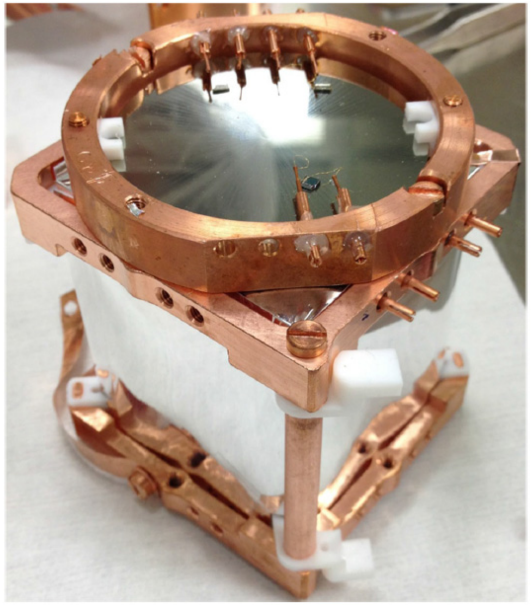
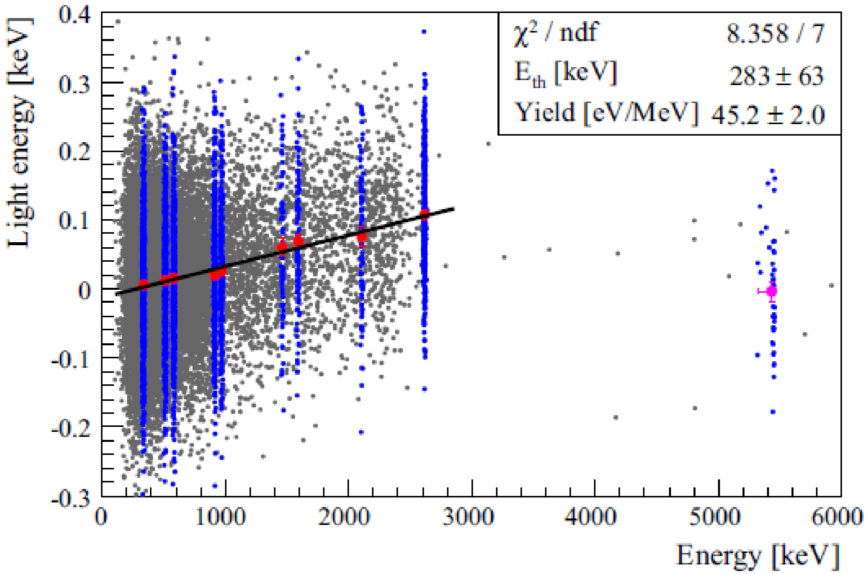
Test of a Ge-LD-“gravity”-on-LMO approach

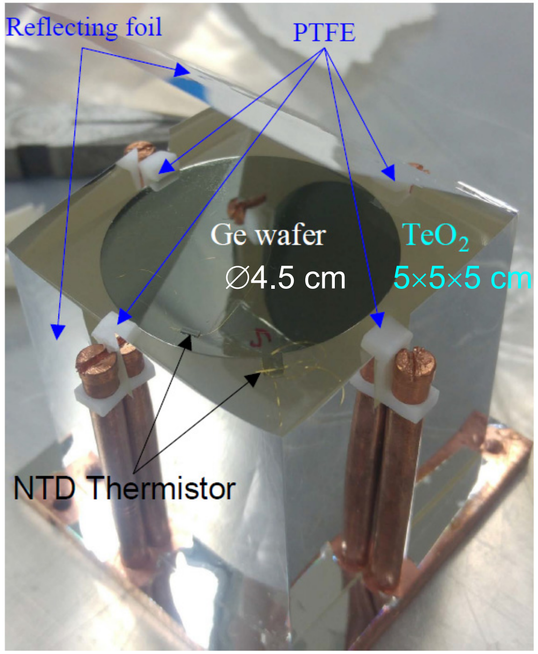
Denys Poda
on behalf of the IJCLab (Orsay, France) group

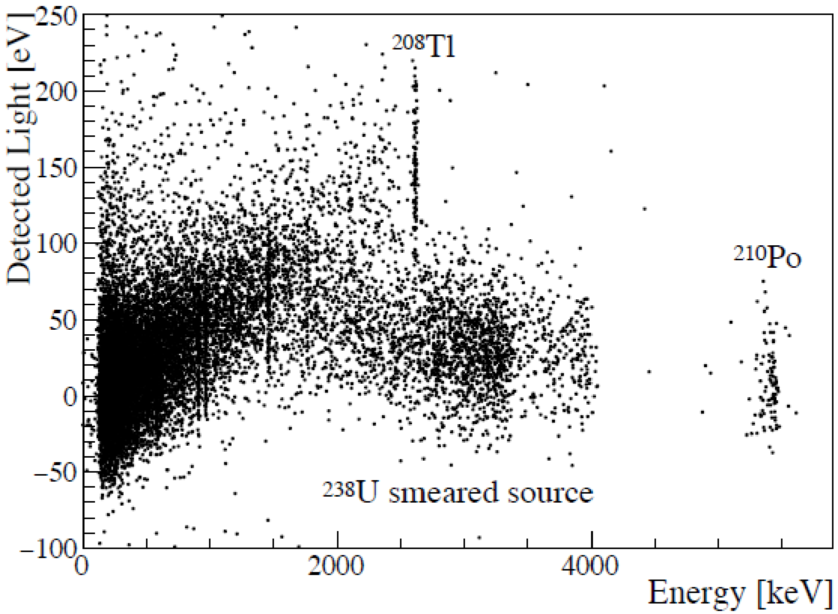
CUPID remote collaboration meeting, Detector WG parallel session
1 December 2020

Motivation (I)









Light @ 2.6 MeV:
0.09-0.1 keV
(∅44-50 mm Ge)

EPJC 75 (2015) 12
JLTP 184 (2016) 286

~50% gain in LY with LD-"gravity"

Light @ 2.6 MeV:
0.15 keV
(∅44 mm Ge)

LD performance:
R_{work} = 1.5 MΩ
S_A = 3.9 μV/keV
Noise = 20 eV RMS

NIMA 935 (2019) 150

Motivation (II)

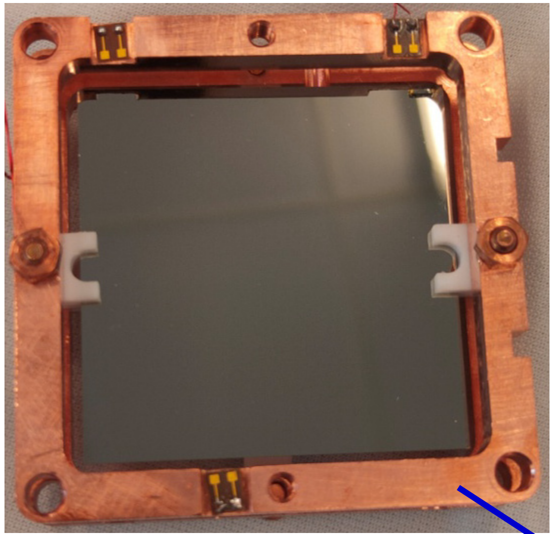
Characterization of cubic $Li_2{}^{100}MoO_4$ crystals for the CUPID experiment.

After validating the simulation framework, we used it to predict the improvement in light collection that could be obtained by using (i) a squared light detector that fully covers the LMO side and (ii) a light detector very close to the scintillator. In the current prototype, the distance between LMO and light detector is 6.5 mm. With a different mechanical structure we could narrow it down to 0.5 mm. The simulation suggests that these simple geometrical modifications will enhance the collected light by 60%.

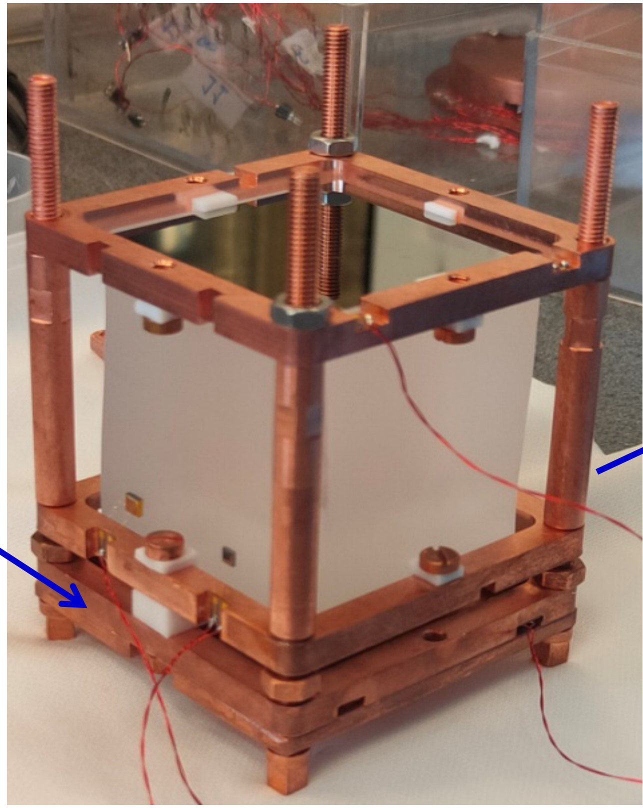
Preliminary works also proved that putting the light detector in contact with the main crystal allows to increase the light collection without affecting the bolometric performance of the device [82]. This experimental scenario cannot be described by a simulation, which would assume an ideal contact between the two surfaces. In reality, both surfaces feature micro-defects preventing an optical contact, which cannot be easily implemented in a simulation. For this reason, we believe it is important to repeat the studies performed in Ref. [82] with $Li_2{}^{100}MoO_4$ crystals, and determine if the direct coupling can further enhance light collection.

Test of a Ge-LD-"gravity"-on-LMO approach

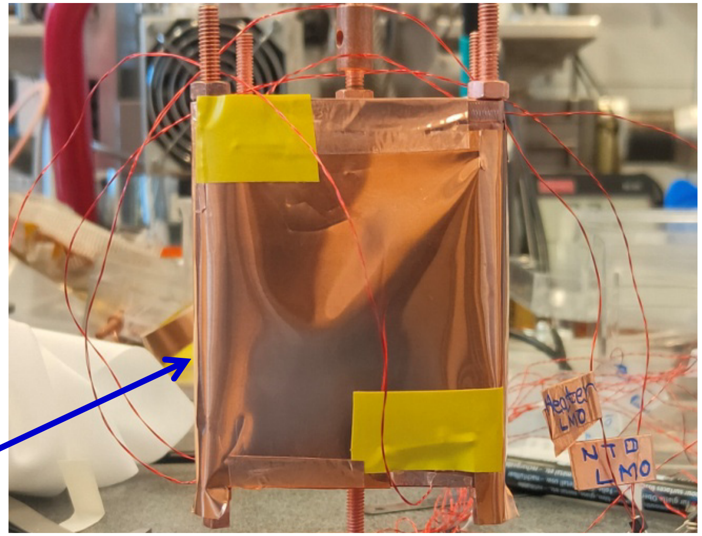
Ge LD "normal"



Ge LD "gravity" put on LMO

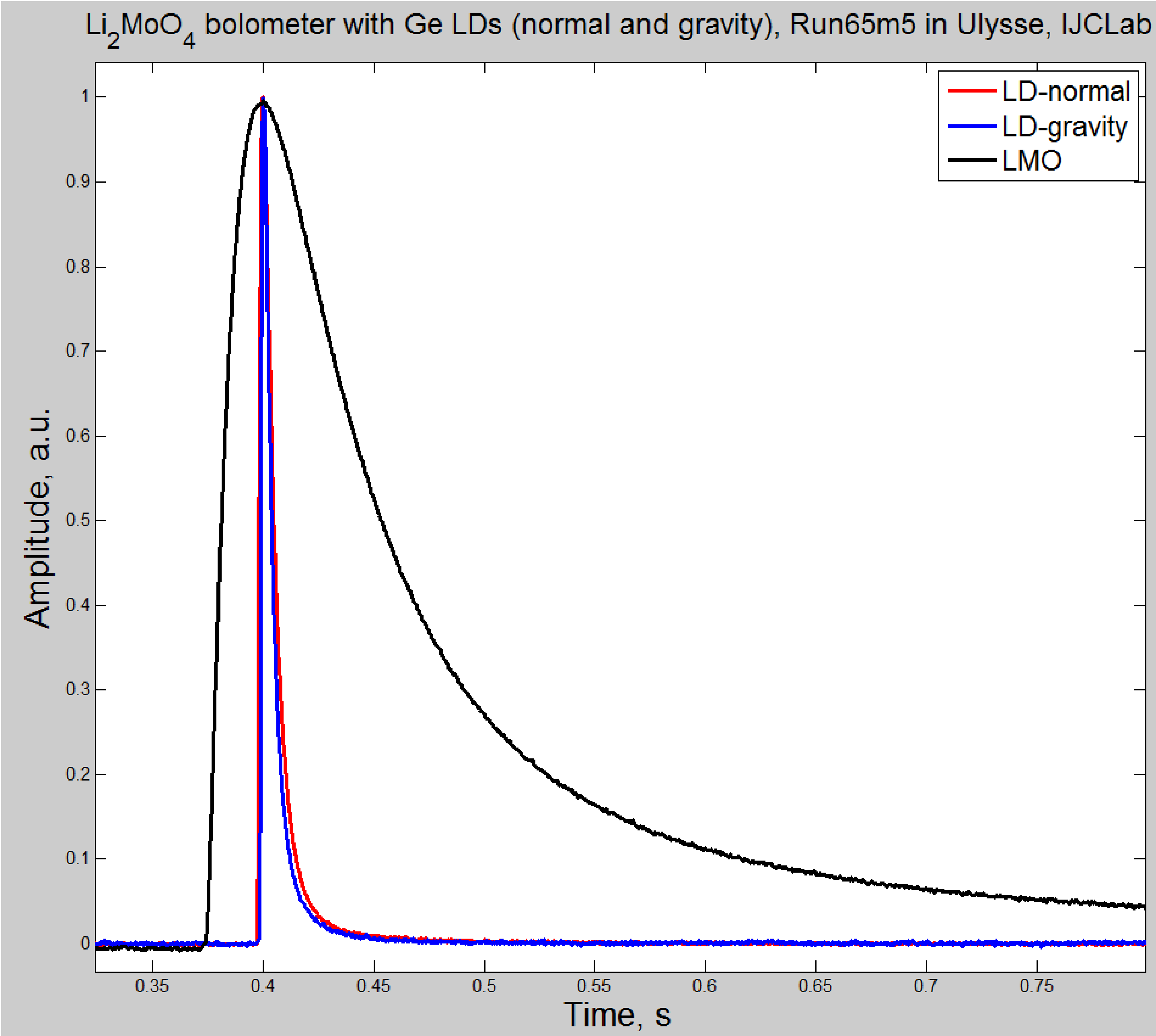


LMO with two Ge LDs

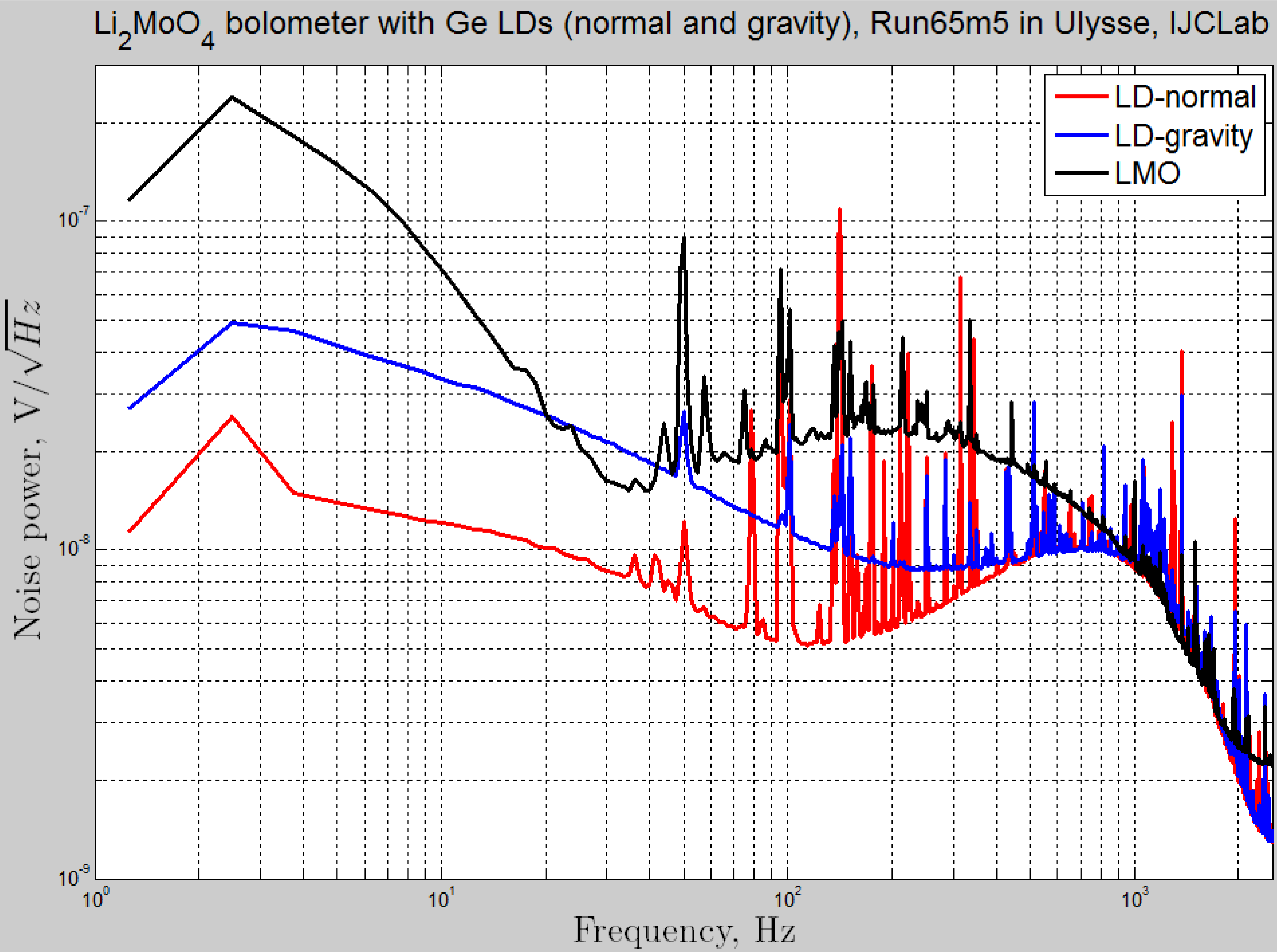


- **Li_2MoO_4 scintillating bolometer (LMO)** based on a 0.28 g sample (45×45×45 mm)
- **Two light detectors (LDs)** made of identical Ge wafers (45×45×0.3 mm), no SiO coating
- **Cu holder, PTFE supports, Cu reflecting cavity**; **NTDs** (LMO & LDs), **heater** (LMO)
- **Pulse-tube cryostat** "Ulysse" (Run65, measurement0005, 28-29/10/2020) at IJCLab
- **Regulated temperature of 15 mK**, stabilized on the sample holder
- **Stream data** (16 bit, 5 kHz sampling rate, ±5 V / ±1 V dynamic range for LMO / LDs)
- **^{232}Th calibration measurements** over 16 h

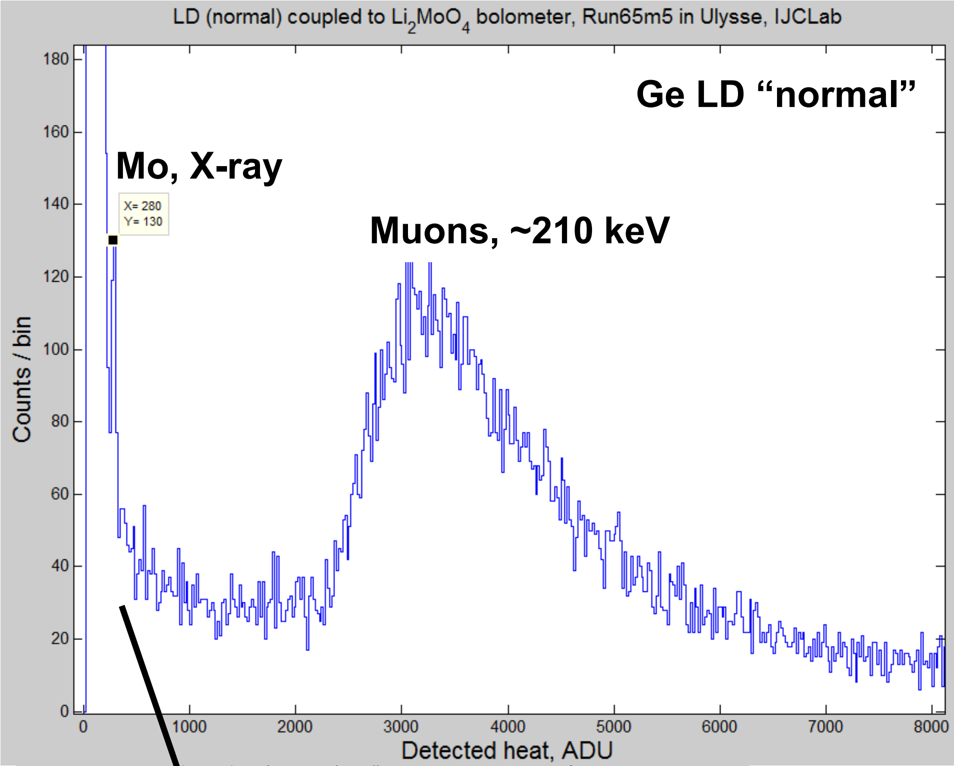
Detector response

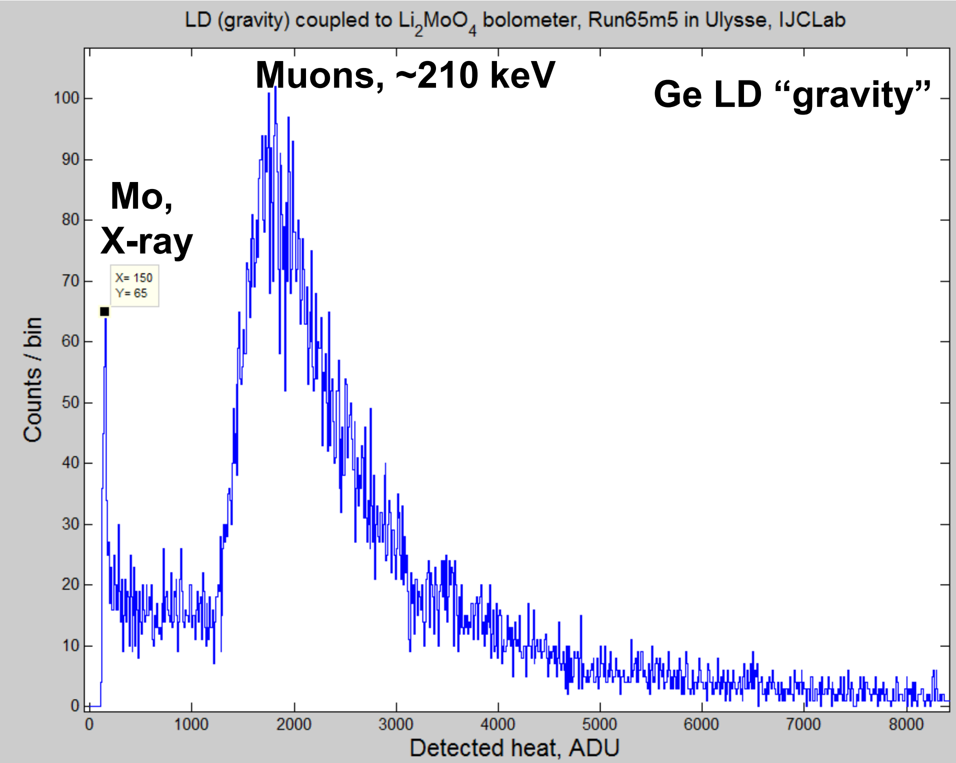


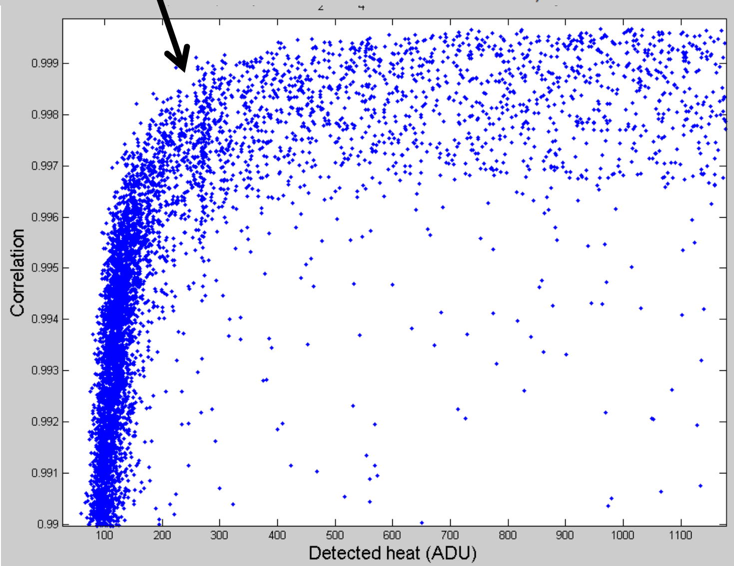
Noise power spectra



LDs calibration

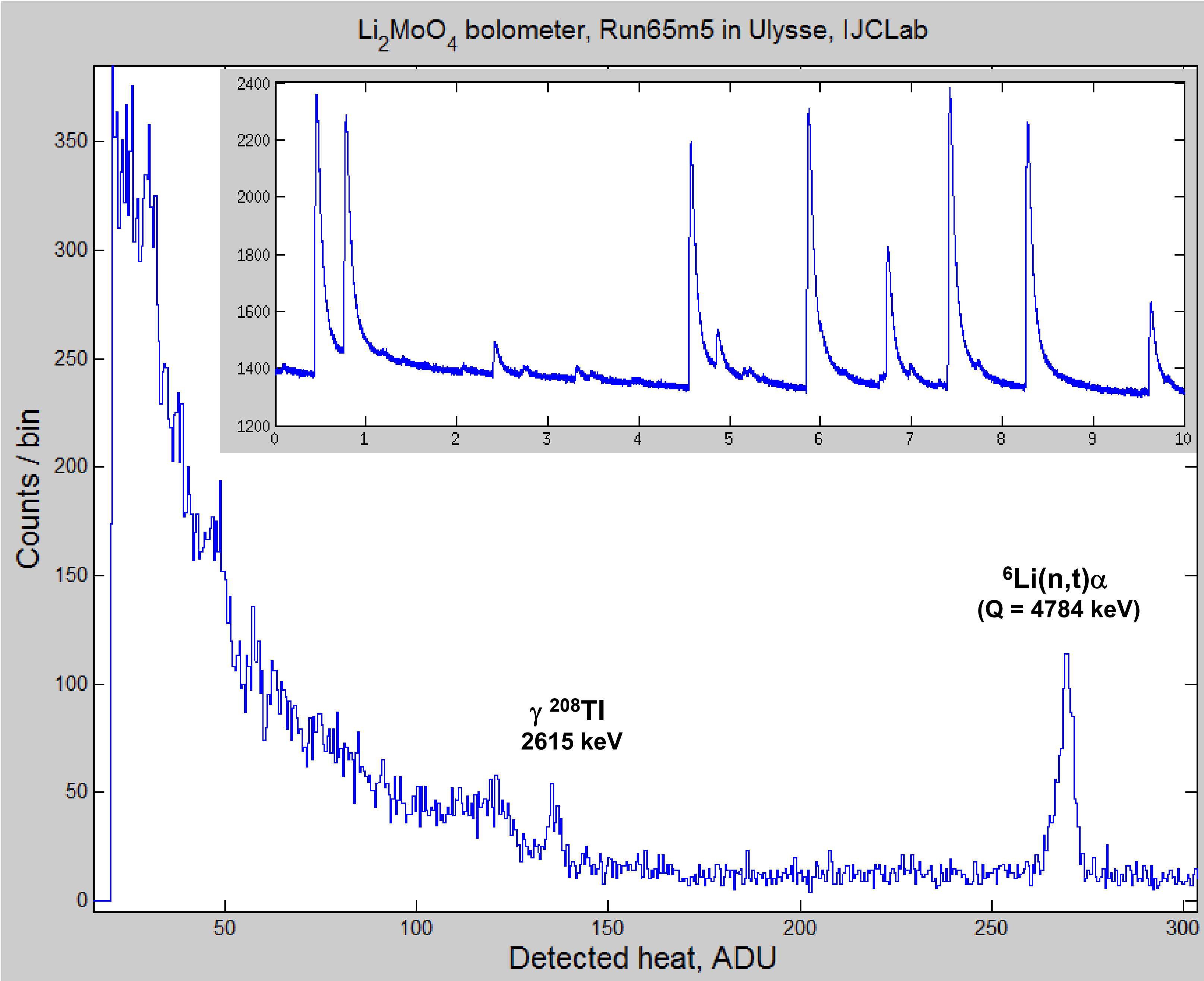






Assignment	E (keV)	Intensity per 100 vacancies in the K-shell
Mo K_{a3}	17,134	0.000470 *17*
Mo K_{a2}	17,374	22.4 *6*
Mo K_{a1}	17,479	42.7 *12*
Mo K_{b3}	19,590	3.42 *10*
Mo K_{b1}	19,607	6.63 *19*
Mo K_{b5}	19,771	0.0342 *15*
Mo K_{b2}	19,965	1.45 *4*
Mo K_{b4}	19,998	0.302 *13*

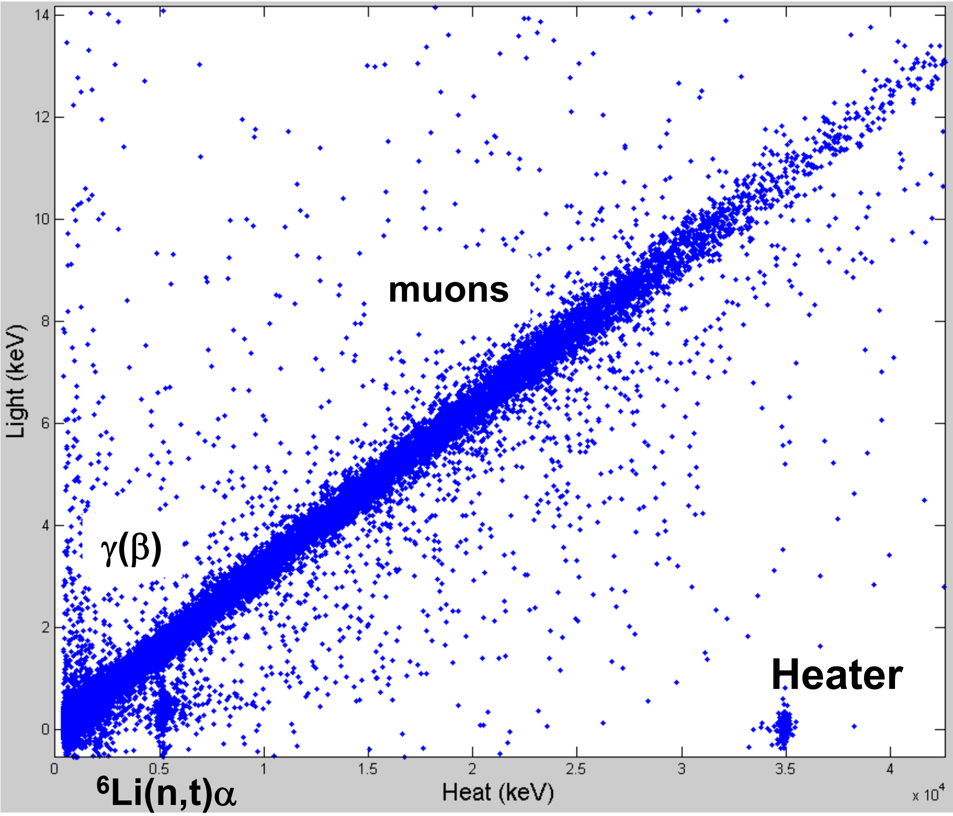
LMO calibration

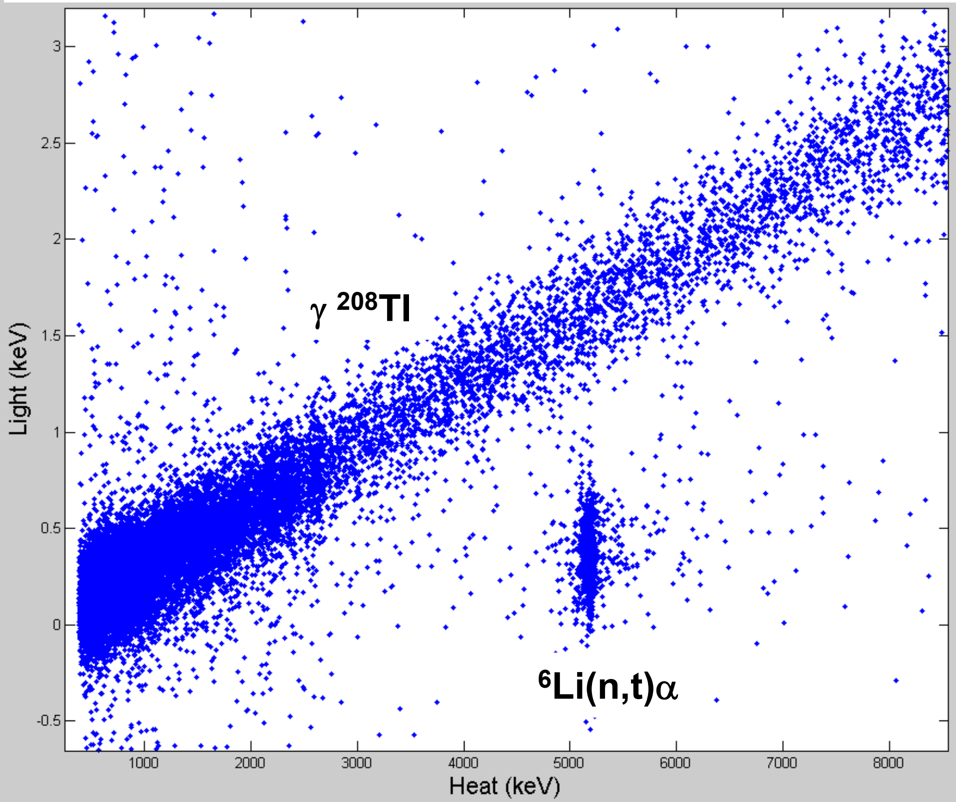


Detector performance

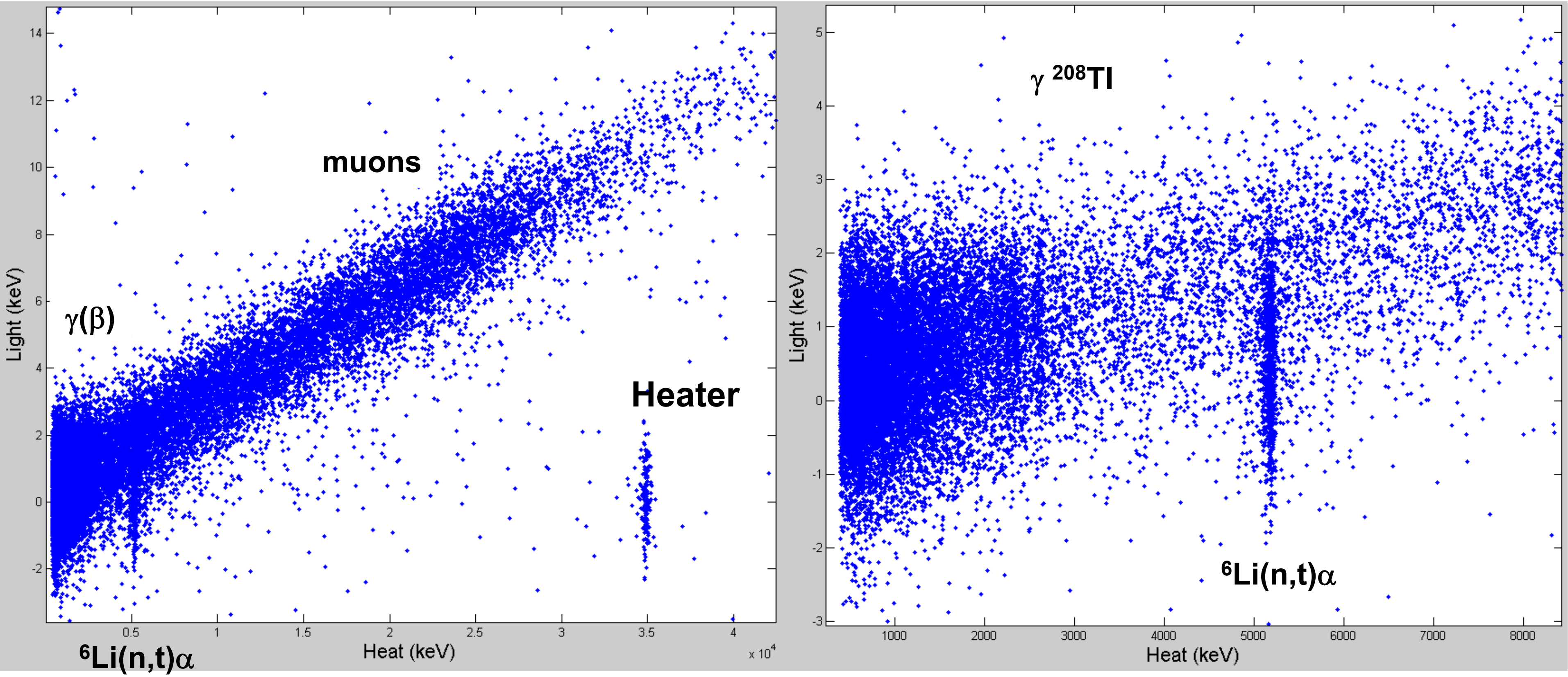
Channel	I_{NTD} [nA]	R_{NTD} [MΩ]	τ_{Rise} [ms]	τ_{Decay} [ms]	Signal [μV/keV]	$FWHM_{noise}$ [keV]	$FWHM_{noise}$ [μV]
LD "norm"	15	0.53	1.2	6.7	**0.48**	**0.31**	**0.15**
LD "gravity"	20	0.60	0.85	5.1	**0.24**	**2.0**	**0.47**
LMO	4	0.70	14	78	**0.008**	**52**	**0.42**

LD normal vs LMO

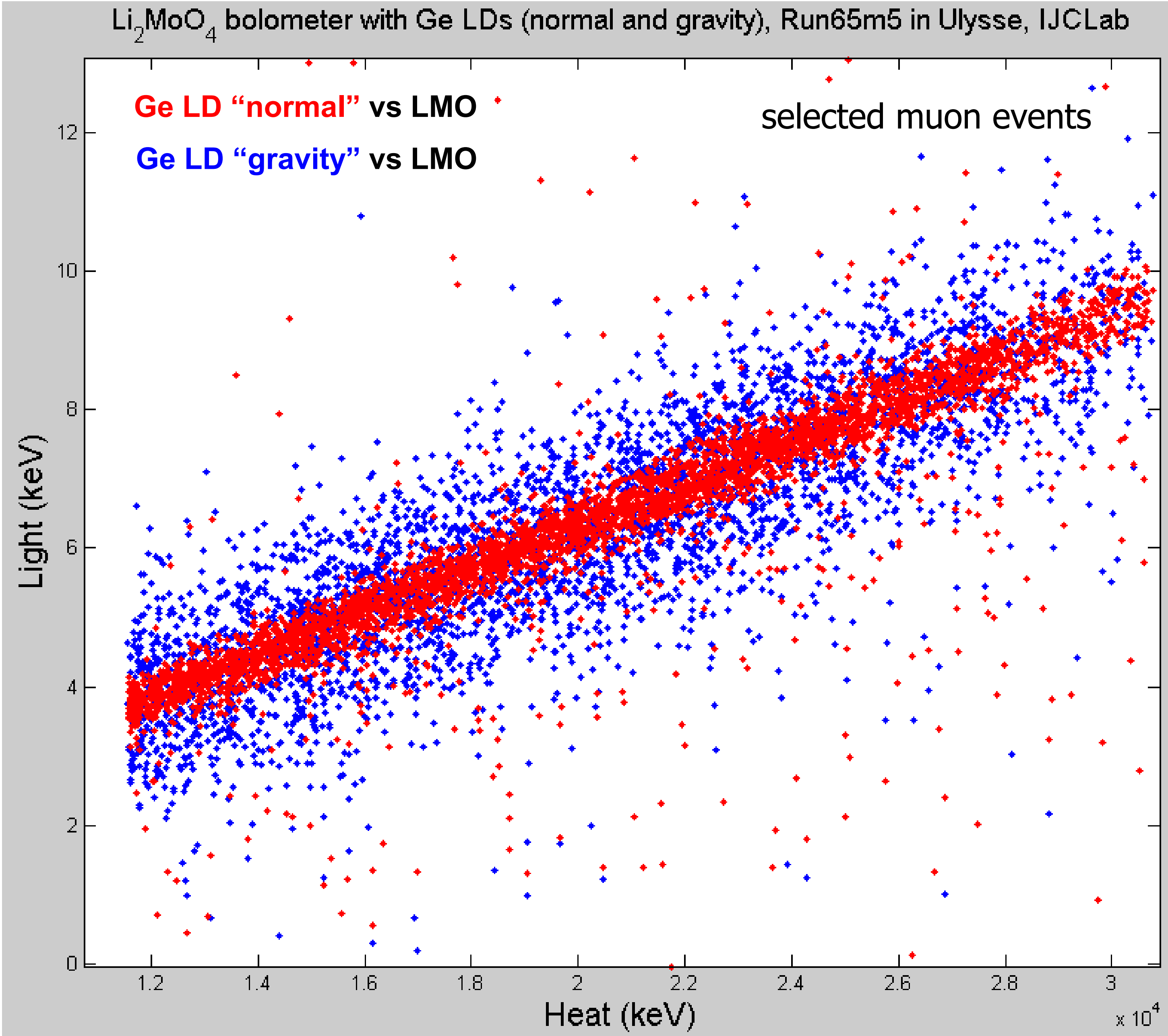




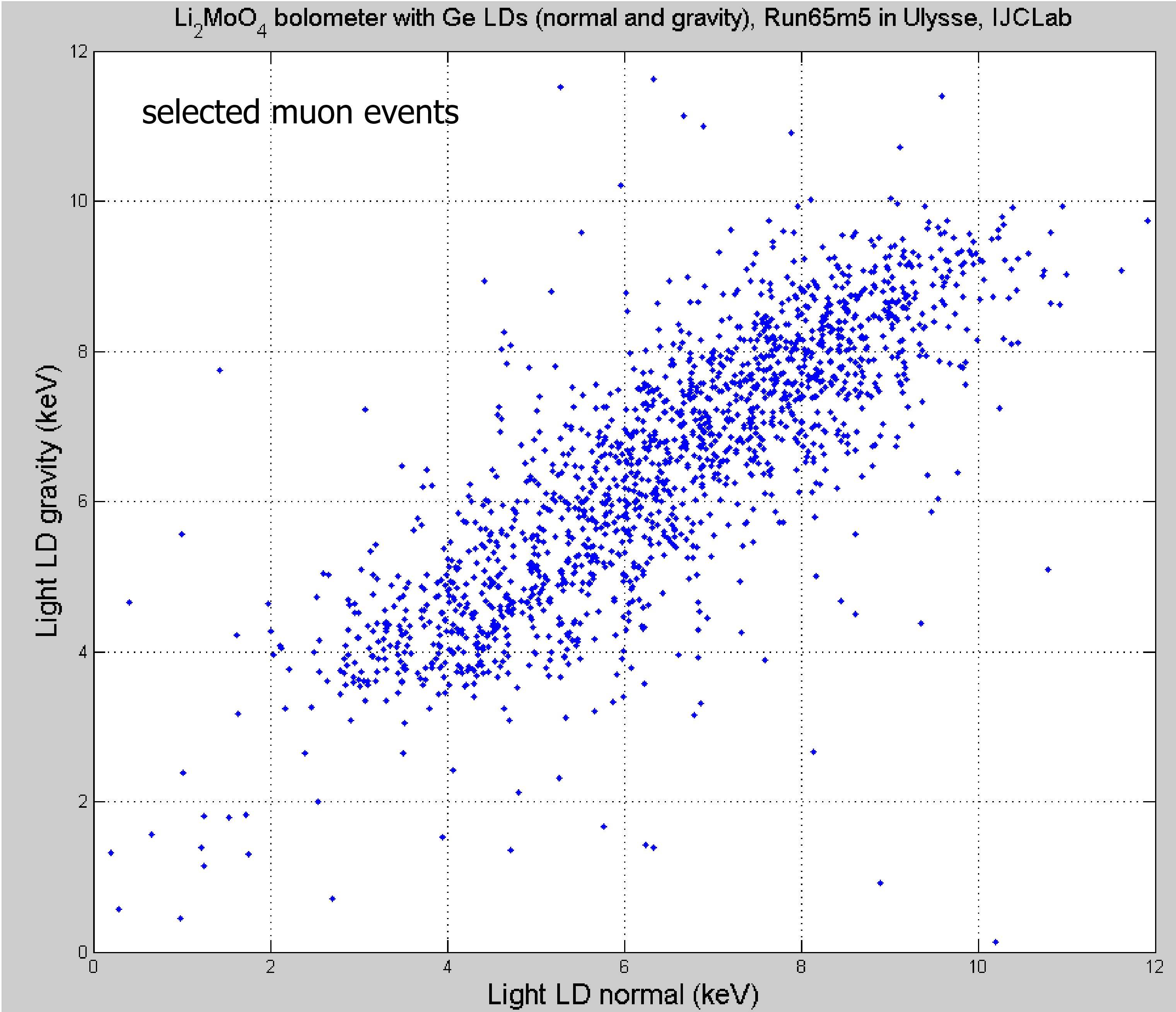
LD gravity vs LMO



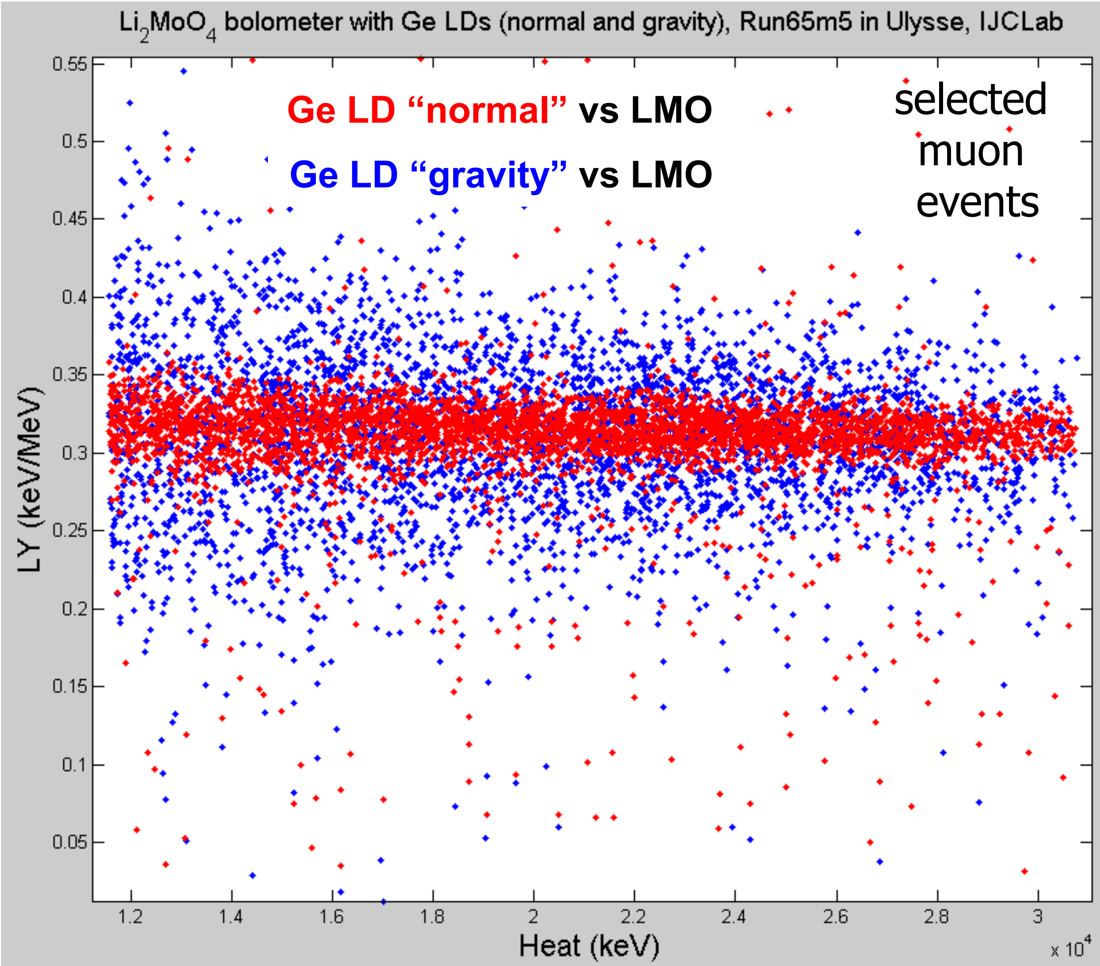
LDs vs LMO


Li_2MoO_4 bolometer with Ge LDs (normal and gravity), Run65m5 in Ulysse, IJCLab
Ge LD "normal" vs LMO
Ge LD "gravity" vs LMO
selected muon events
Light (keV)
Heat (keV)
x 10^4
0
2
4
6
8
10
12
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
3

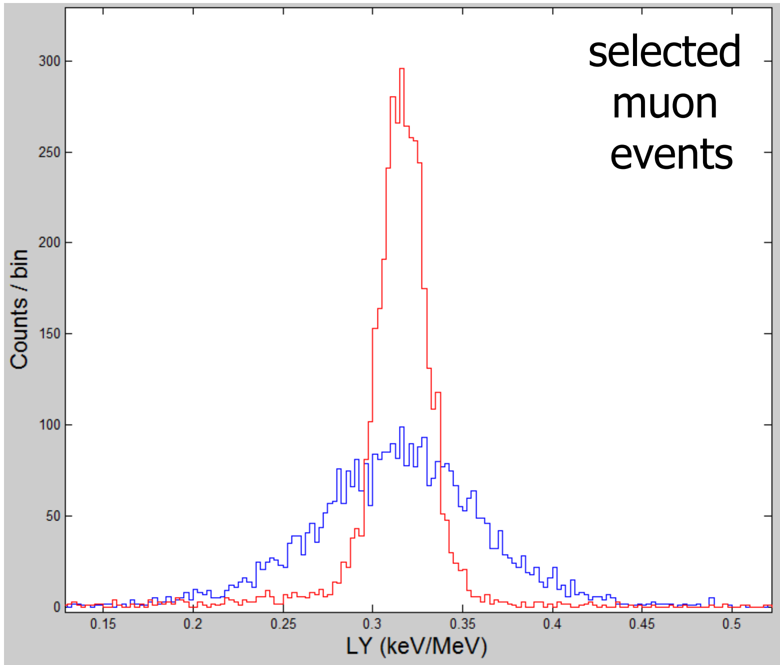
Light: "gravity" LD vs "normal" LD



LY vs Heat



Ge LD "normal" / "gravity" vs LMO



Summary

- The LD-gravity-on-LMO test has been realized at IJCLab (Orsay, France)

  ⇒ Li_2MoO_4 bolometer (LMO, 45×45×45 mm) viewed by two identical Ge light detectors (45×45×0.3 mm), "gravity" (on LMO) & "normal" (~5 mm from LMO)

- Detectors were operated in noisy conditions (detector construction issue ?)

  ⇒ LD "gravity" noise is ~7x worse than that of the "normal" LD

- No difference in the light yield measured by "gravity" vs "normal" LDs is observed

Backups

Baseline traces