Università degli Studi di Milano-Bicocca
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An array of scintillating bolometers of $ZnMoO_4$ in LNGS

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Second general meeting of the ISOTTA project

Orsay, June 24, 2013

Introduction - May 2012

First measurement with a large mass $ZnMoO_4$ crystal (330 g) at LNGS.

- Good bolometric performances.

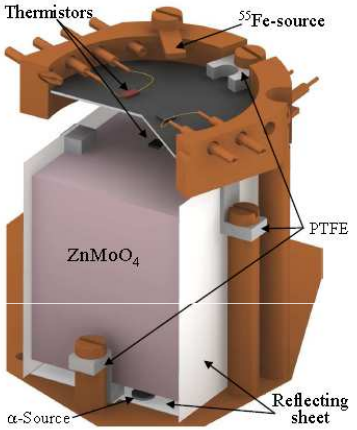

Table 2. FWHM energy resolutions of the $ZnMoO_4$ detecto evaluated on the two thermistors and on their sum.

	$ZnMoO_4$-1 [keV]	$ZnMoO_4$-2 [keV]	$ZnMoO_4$-Sum [keV]
583 keV	4.1±0.7	3.0±0.5	2.9±0.4
911 keV	4.9±0.4	4.7±0.5	4.0±0.4
1461 keV	4.9±1.5	5.4±1.2	4.9±1.0
2615 keV	6.8±0.4	6.6±0.6	6.3±0.5

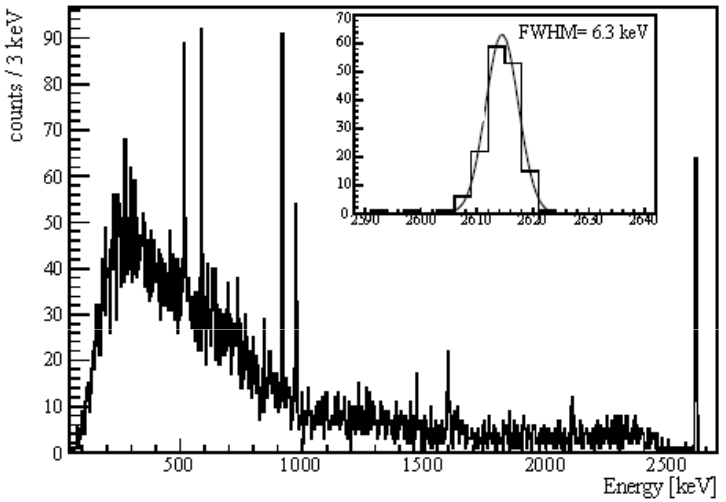

Fig. 2. Calibration spectrum obtained by exposing the $ZnMoO_4$ crystal to the ^{228}Th source for 80 h. The peak at 2615 keV of ^{208}Tl, magnified in the inset, shows a FWHM resolution of 6.3 keV.

J.W. Beeman *et al.*, **Performances of a large mass ZnMoO4 scintillating bolometer for a next generation 0vDBD experiment**, Eur. Phys. J. C (2012) 72: 2142

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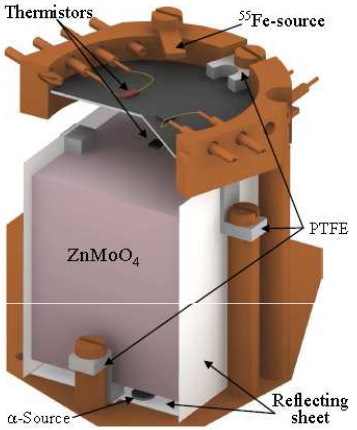
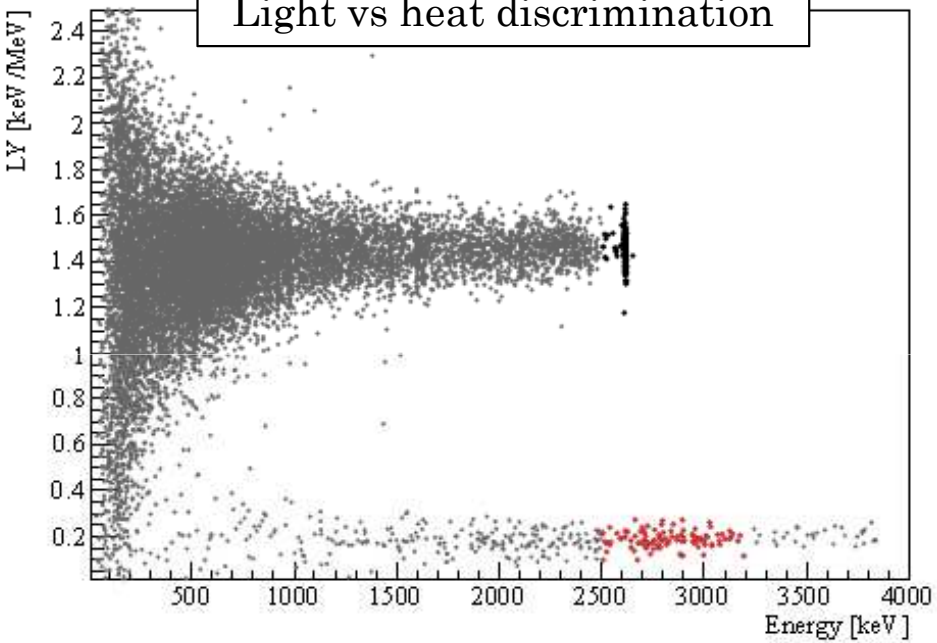
First measurement with a large mass $ZnMoO_4$ crystal (330 g) at LNGS.

- Good bolometric performances.
- Excellent discrimination power (α,ß/γ).

$$DP = \frac{\mu_{\beta/\gamma} - \mu_{\alpha}}{\sqrt{\sigma^2_{\beta/\gamma} + \sigma^2_{\alpha}}}.$$

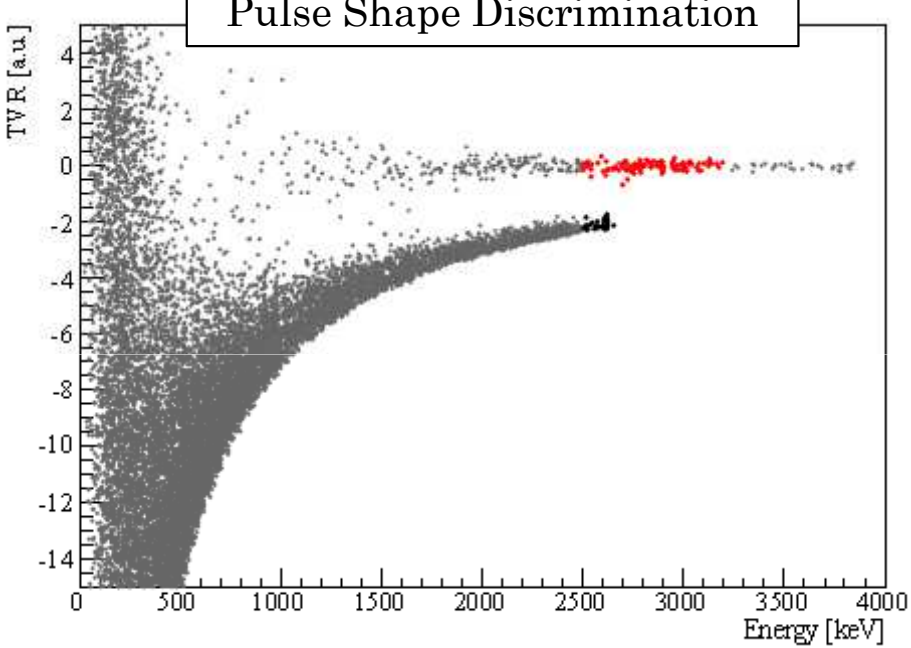


Light vs heat discrimination



DP~19

Pulse Shape Discrimination



DP~14

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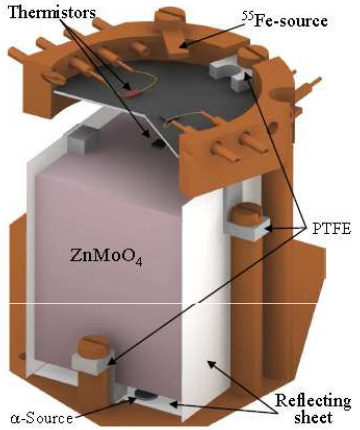
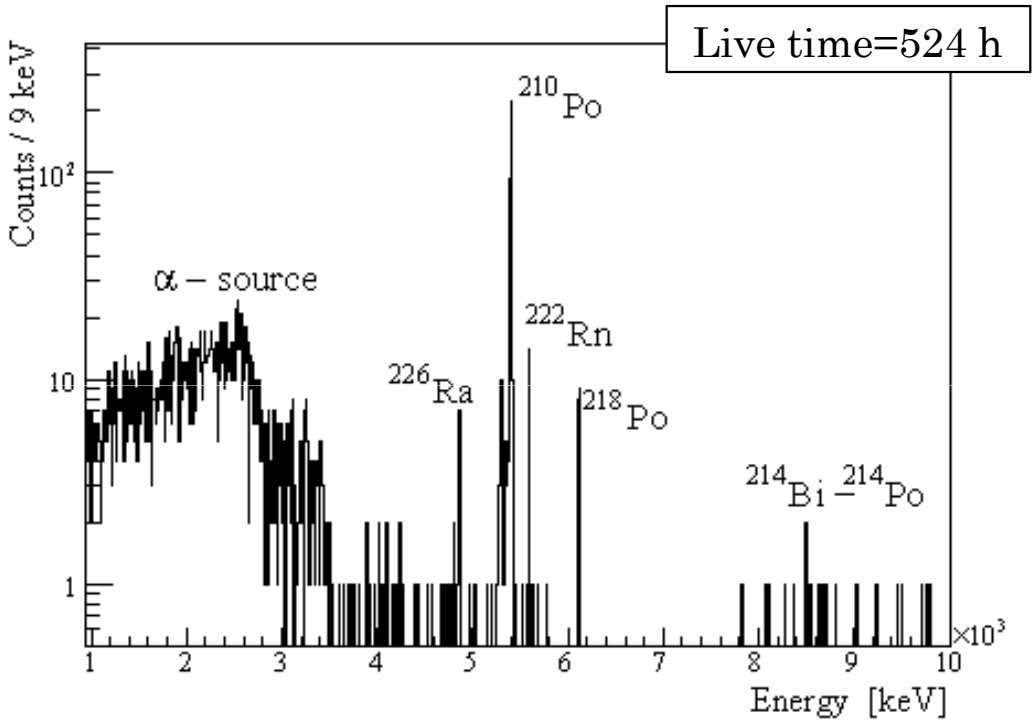
Introduction - May 2012

First measurement with a large mass $ZnMoO_4$ crystal (330 g) at LNGS.

- Good bolometric performances.
- Excellent particle discrimination.
- Low internal contaminations.





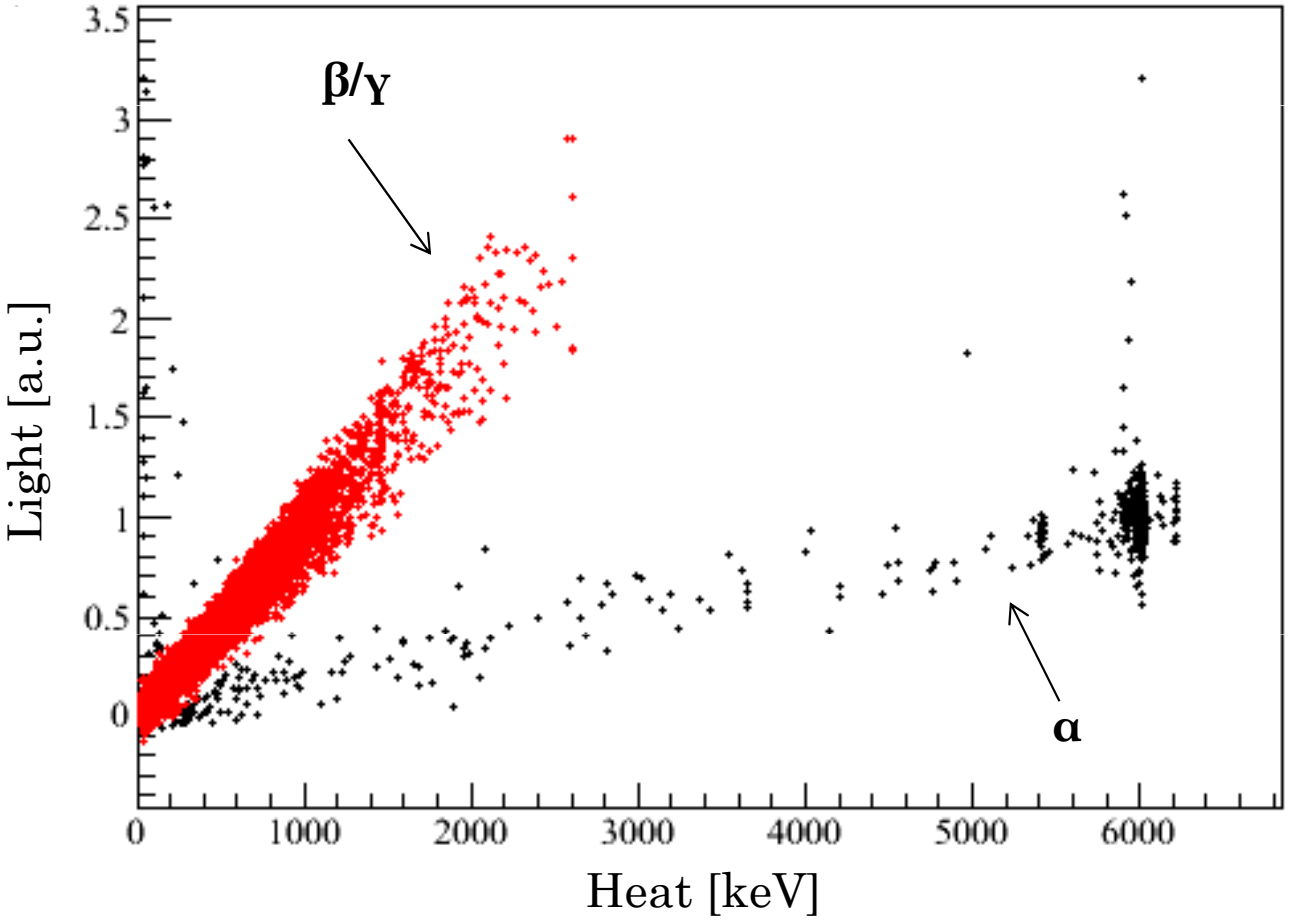
Chain	nuclide	activity μBq/kg
^{232}Th	^{232}Th	< 8
	^{228}Th	< 6
^{238}U	^{238}U	< 6
	^{234}U	< 11
	^{230}Th	< 6
	^{226}Ra	27±6
	^{210}Po	700±30

Table 3. Evaluated internal radioactive contaminations. Limits are at 90% CL.

J.W. Beeman *et al.*, **Performances of a large mass ZnMoO4 scintillating bolometer for a next generation 0vDBD experiment**, Eur. Phys. J. C (2012) 72: 2142

Introduction - August - September 2012

'High' statistics measurement in very low background conditions (LNGS hall C cryostat, external + internal lead shield).



Statistics = 6.27 kg*d

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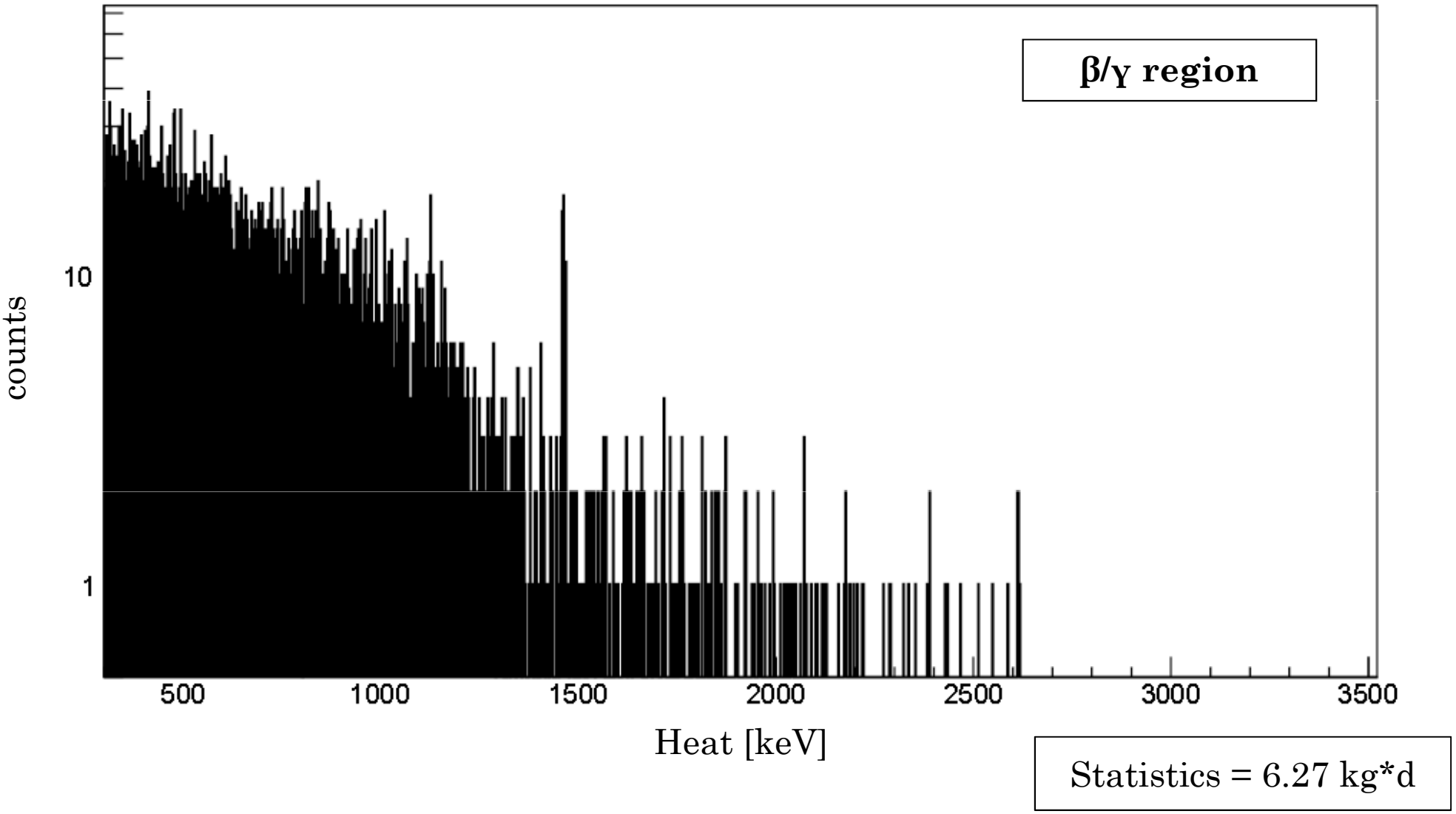

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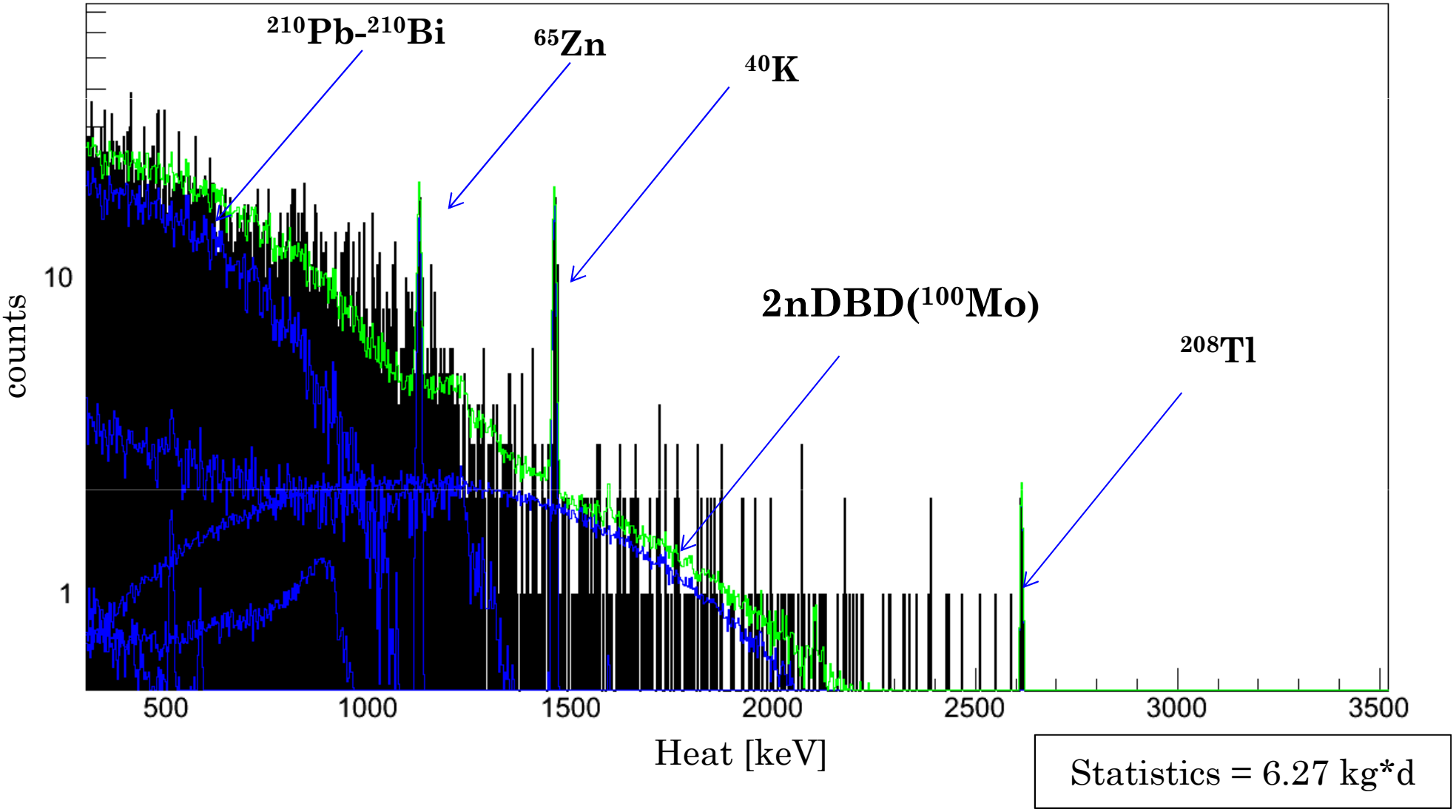
Background reconstruction (preliminary test....)



Statistics = 6.27 kg*d

Introduction - August - September 2012

Issue:

How to normalize the simulations to measurement?

$$\chi^2 = \sum_i^{N_{\text{bins}}} \frac{(c_i - F_i(\boldsymbol{\theta}))^2}{\sigma_{c_i}^2 + \sigma_{F_i(\boldsymbol{\theta})}^2},$$

c = measurement
F(θ) = sources of background

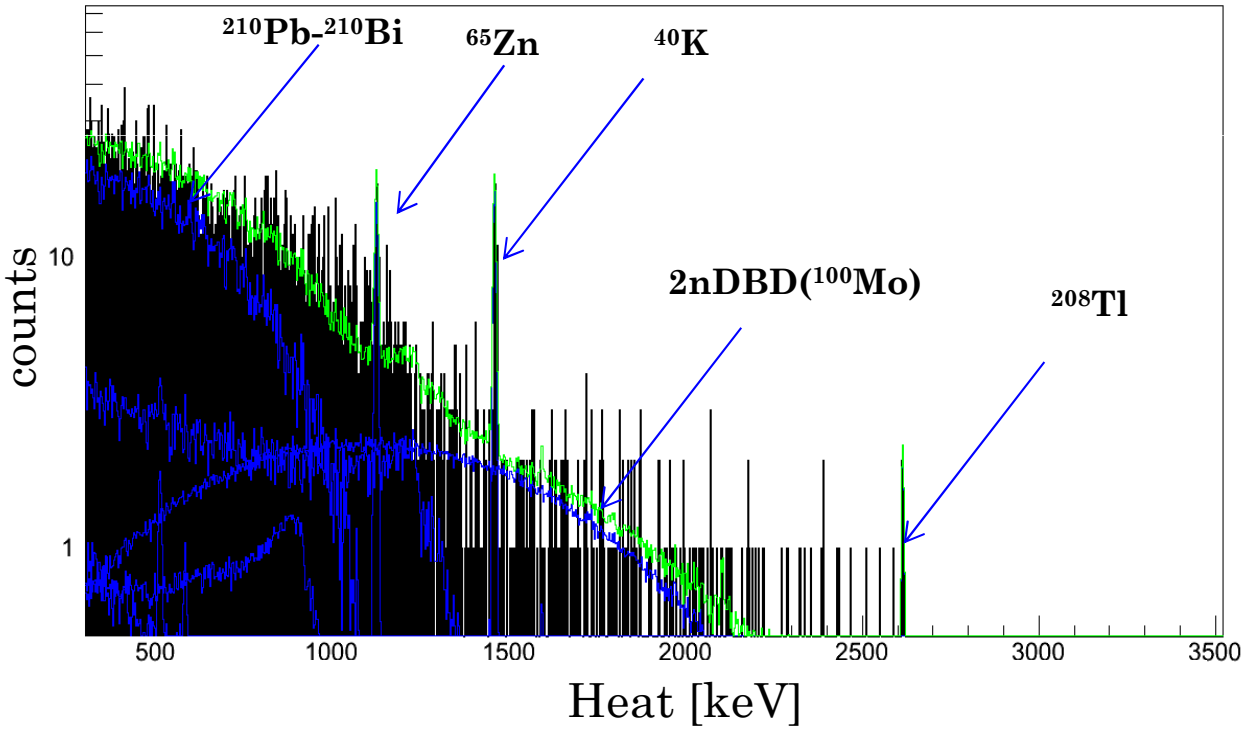
Very low number of events/bin

↓

Very difficult to normalize the simulations to the measurement

↓

High uncertainty on T_{2nDBD}



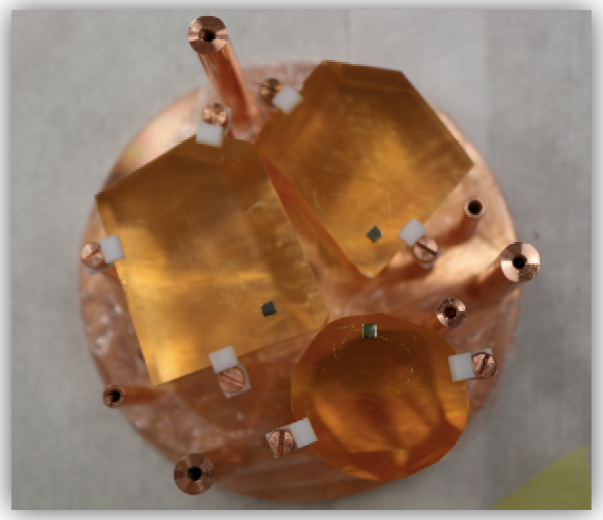
Number of 2nDBD expected for $T_{2nDBD} = 7.1 \cdot 10^{18}$

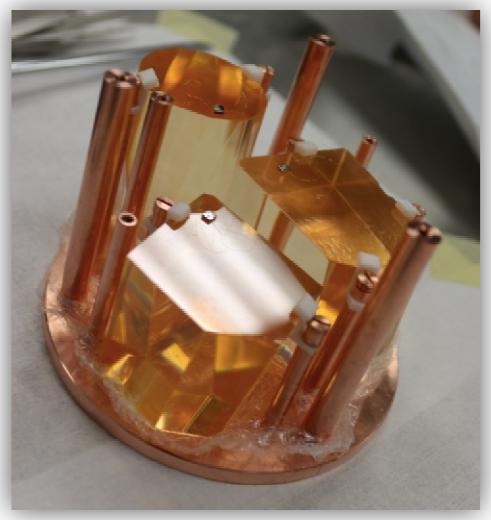
[0 - 3034 keV] = 625 counts
[1500 - 3034 keV] = 151 counts ⟶ measured 192 counts

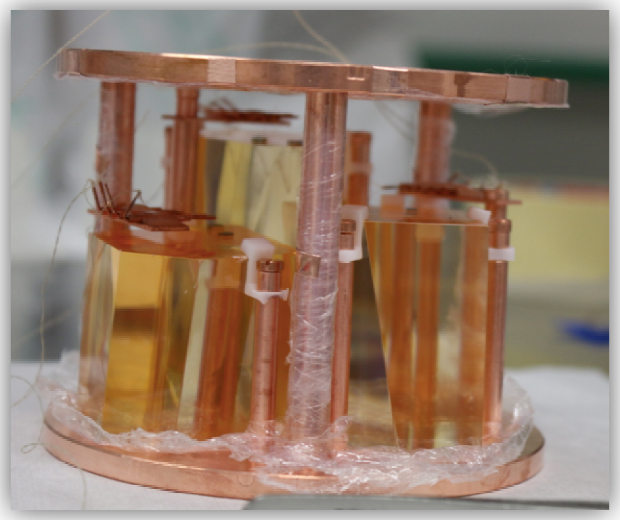
The $ZnMoO_4$ array

In May 2013 a measurement with 3 $ZnMoO_4$ crystals started.
Goals of the measurement:

- Increase the statistic
- Reduce the (Compton) background thanks to the anti-coincidences
- Better recostruction of the background thanks to the coincidences analysis





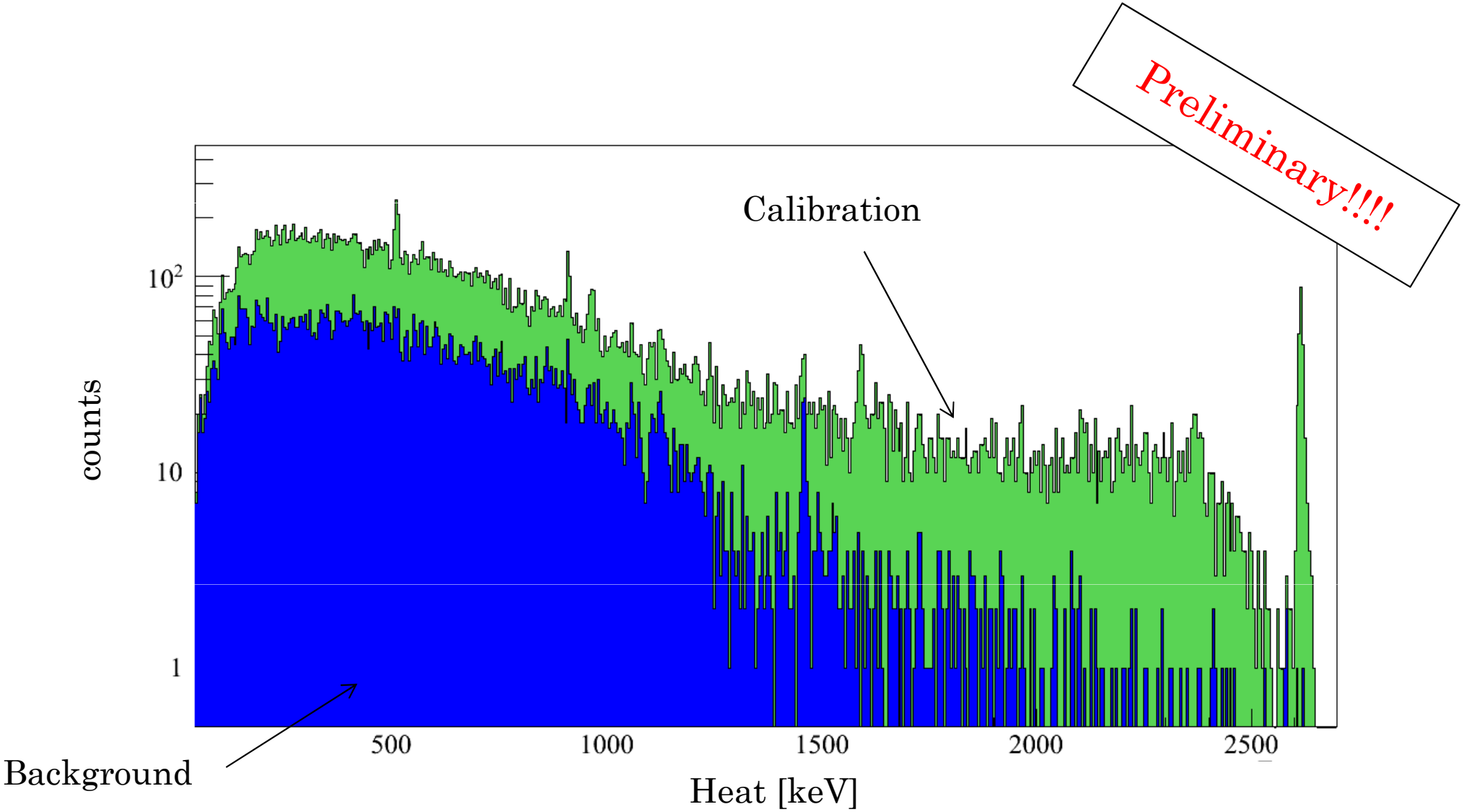


- Crystals surface polished
- No light detector

- $ZnMoO_4$ (1) = 328.8 g
- $ZnMoO_4$ (2) = 247.0 g
- $ZnMoO_4$ (3) = 235.2 g

The $ZnMoO_4$ array

In May 2013 a measurement with 3 $ZnMoO_4$ crystals started. The measurement is still ongoing.



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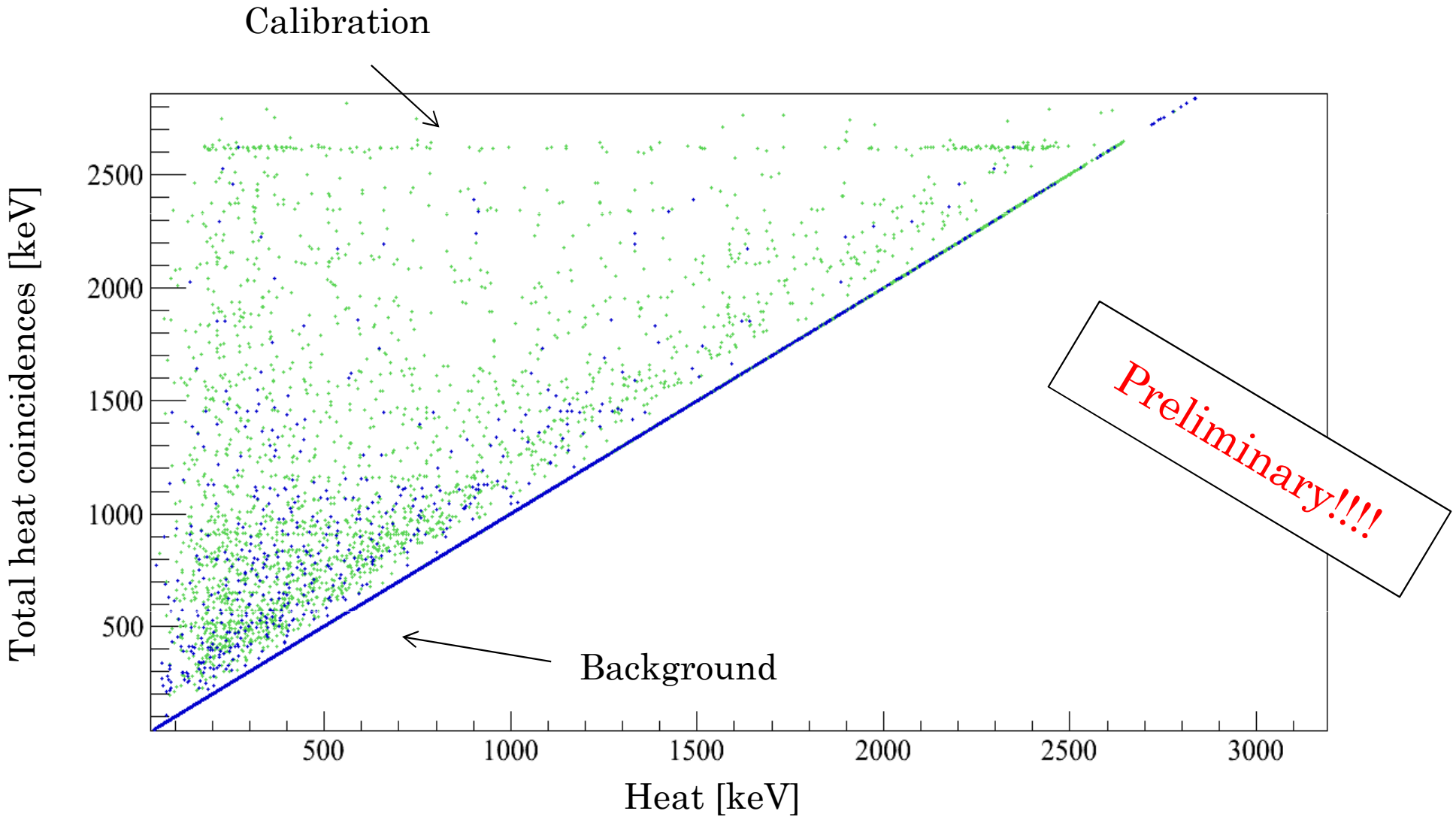

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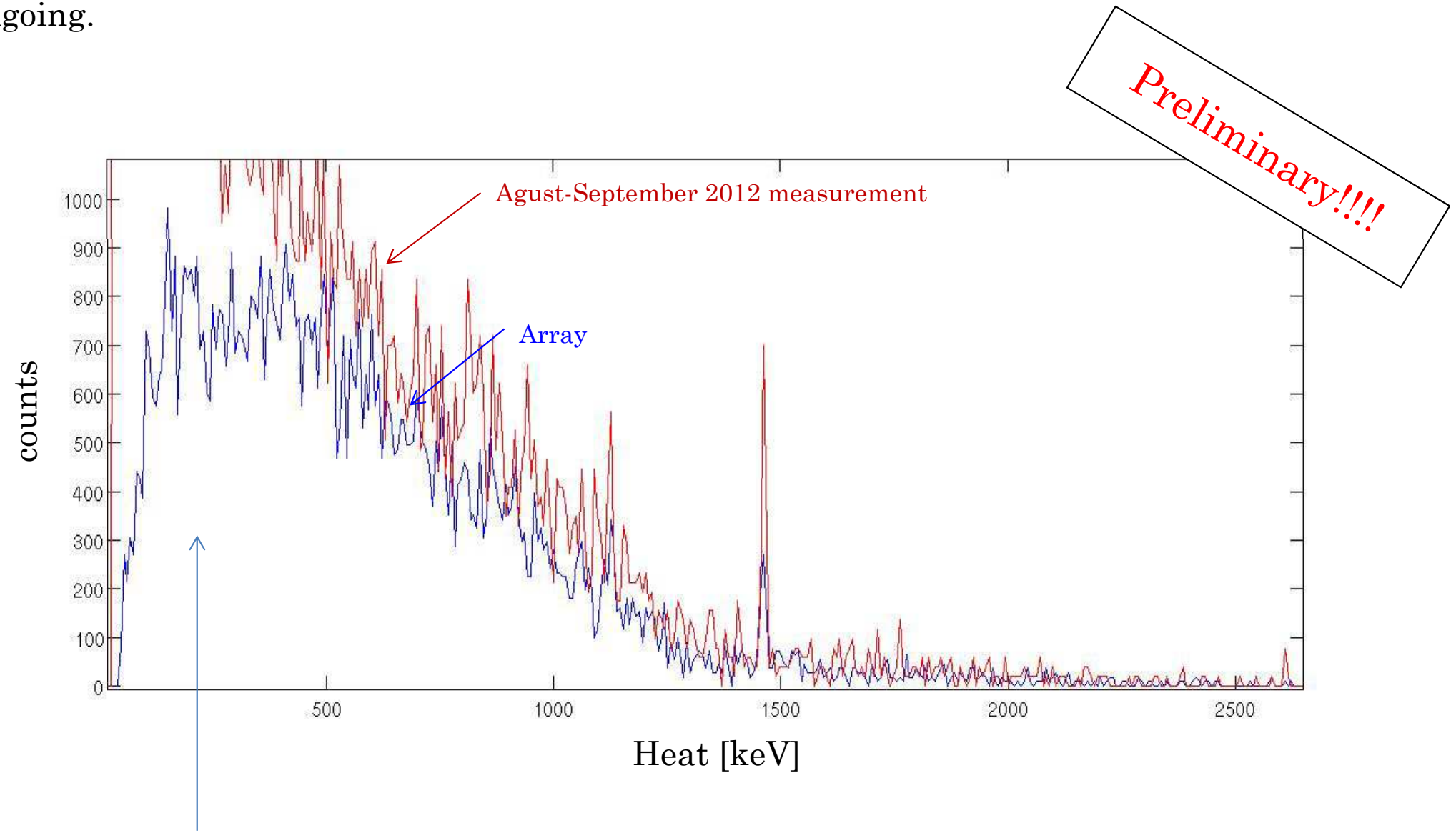

Different thresholds. The new measurement will be reprocessed to lower the energy threshold.

Statistics = 13.54 kg*d

Conclusions

- In May 2012 a first measurement with a large (330g) $ZnMoO_4$ was performed
  - Good bolometric performances.
  - Excellent particle discrimination.
  - Low internal contaminations
- A low background measurement (6.27 kg*d) performed in August – September 2012
  - Very low background in the energy region E>1460 keV
  - Low statistics -> very difficult recostruction of the background
- A new measurement with an array of 3 $ZnMoO_4$ is ongoing in hall C of the LNGS
  - Goals of the measurements
    - Increase the statistics
    - Reduce the (Compton) background thanks to the anti-coincidences
    - Better recostruction of the background thanks to the coincidences analysis