Cesium Run and LY Extraction

DArT Analysis

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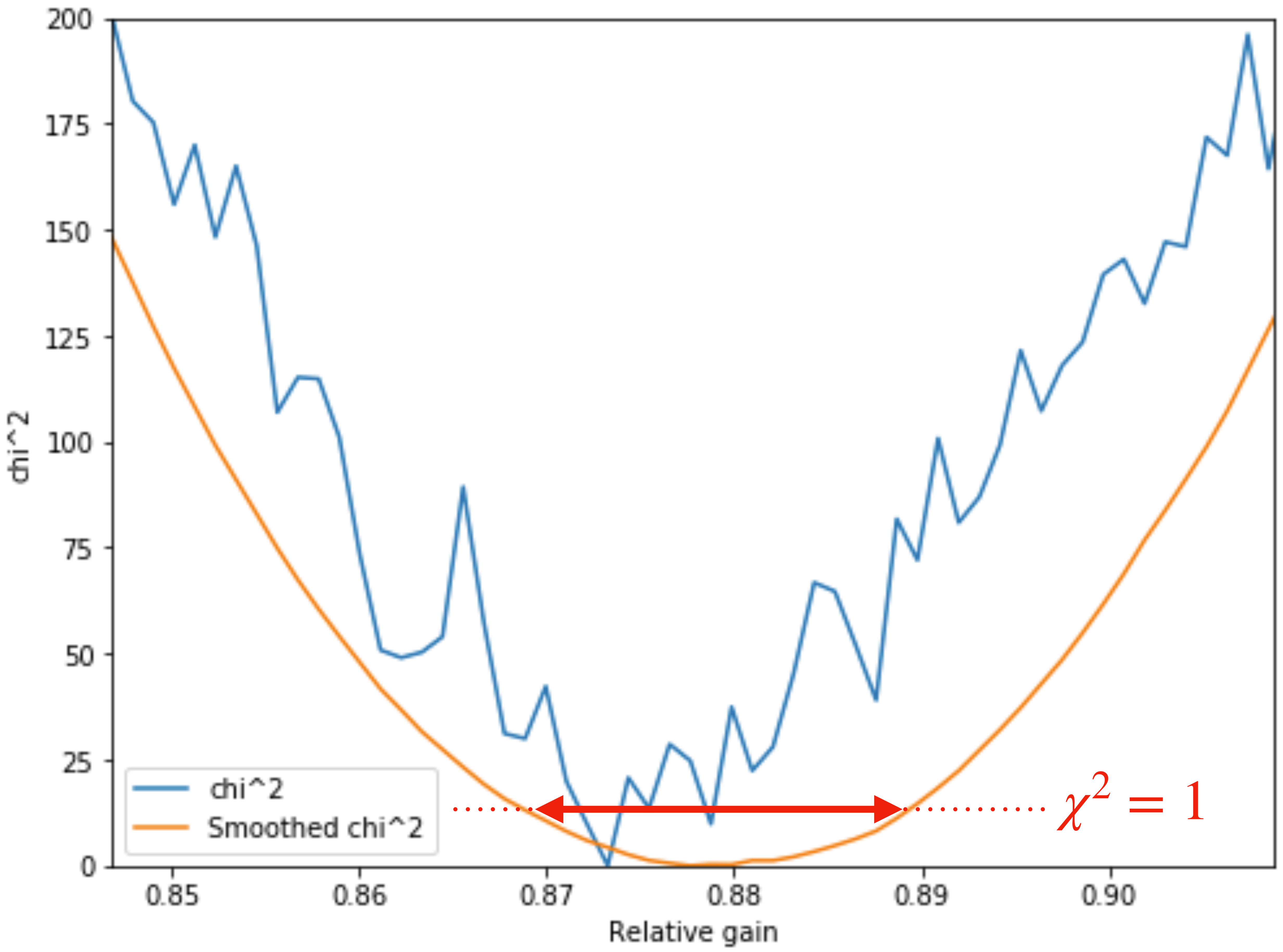
Summary

- Analysis on ^{137}Cs run
  - Relative gain calibration
  - Background subtraction
- Monte Carlo spectrum fit
  - Convolution model
  - Charge Yield (QY) and fano factor (F) measurement
- Effective Light Yield (LY) extraction
  - Gain and LY calculation
  - From the spectrum
  - From the α peaks

Analysis on ^{137}Cs run

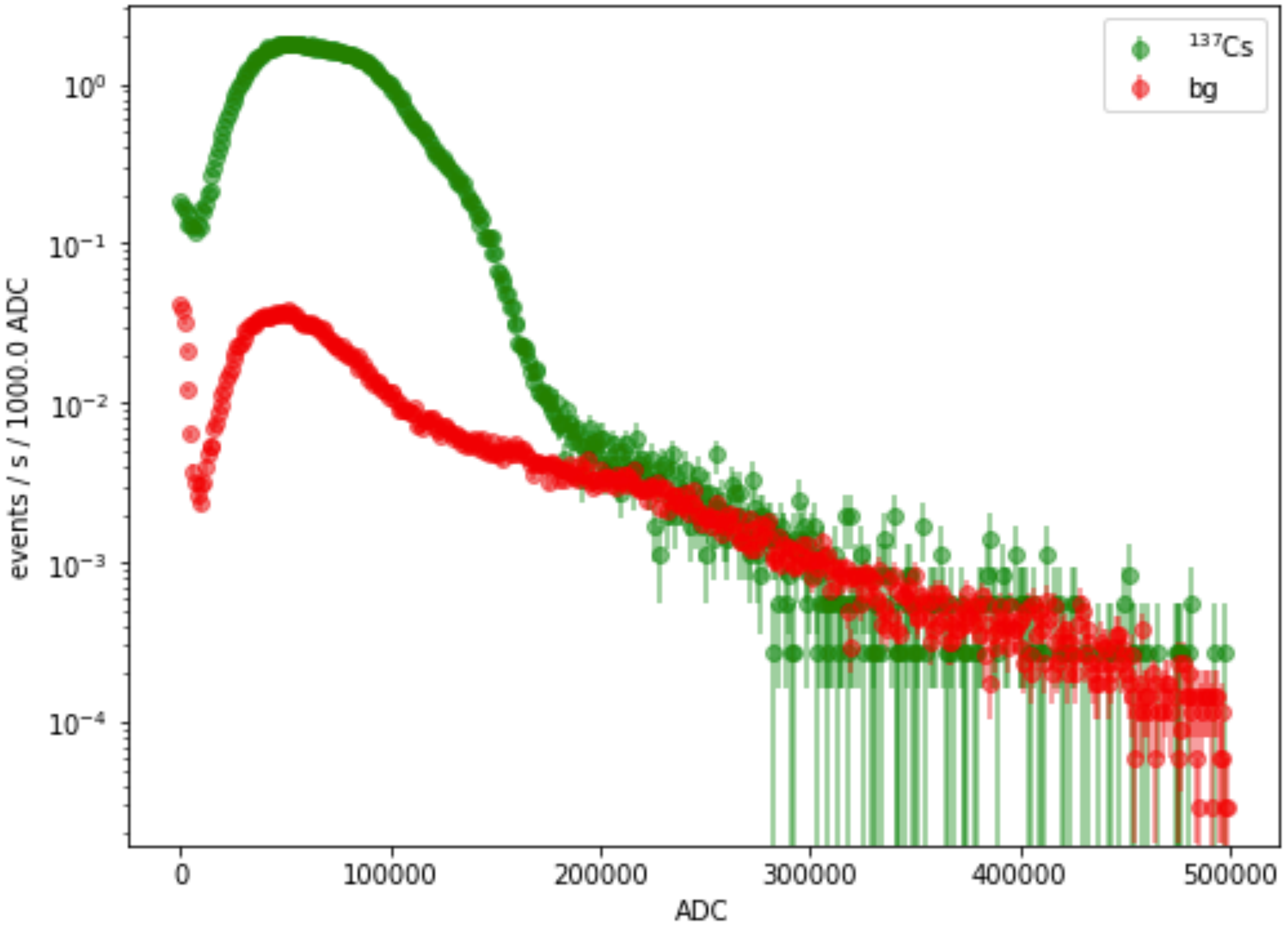
Relative gain calibration

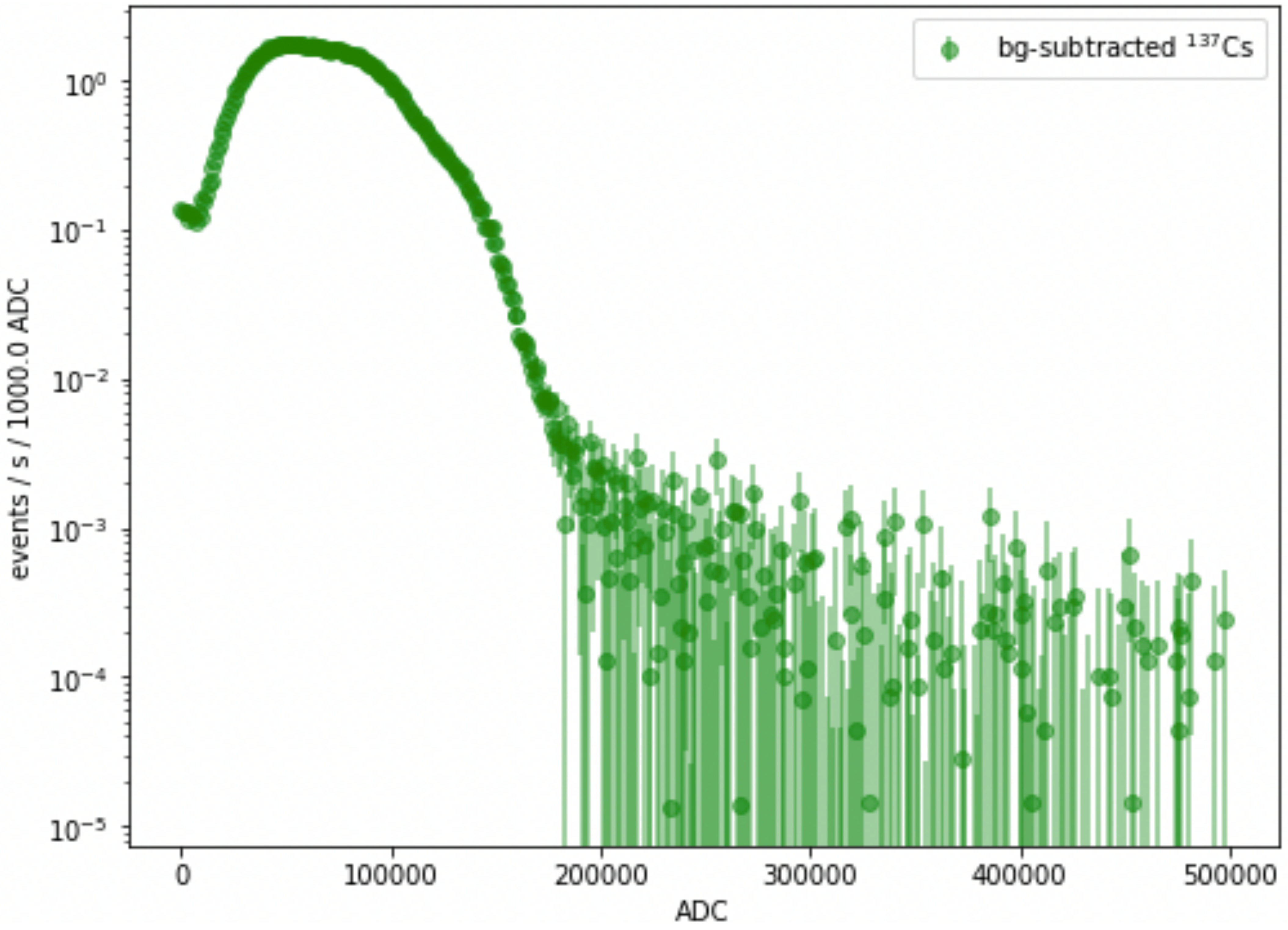
- Minimisation performed on background run of :
  $\chi^2 = ROI_0 - ROI_1 \times scale$
- Uncertainty obtained at intersection with $\chi^2 = 1$:
  $scale = 0.878 \pm 0.002$
- ^{137}Cs run presents some asymmetry. Therefore, this scale is applied to all spectra for consistence.



Analysis on ^{137}Cs run

Background subtraction





137Cs run n°104

Background run n°103 - Normalized by live-time

Monte Carlo spectrum fit

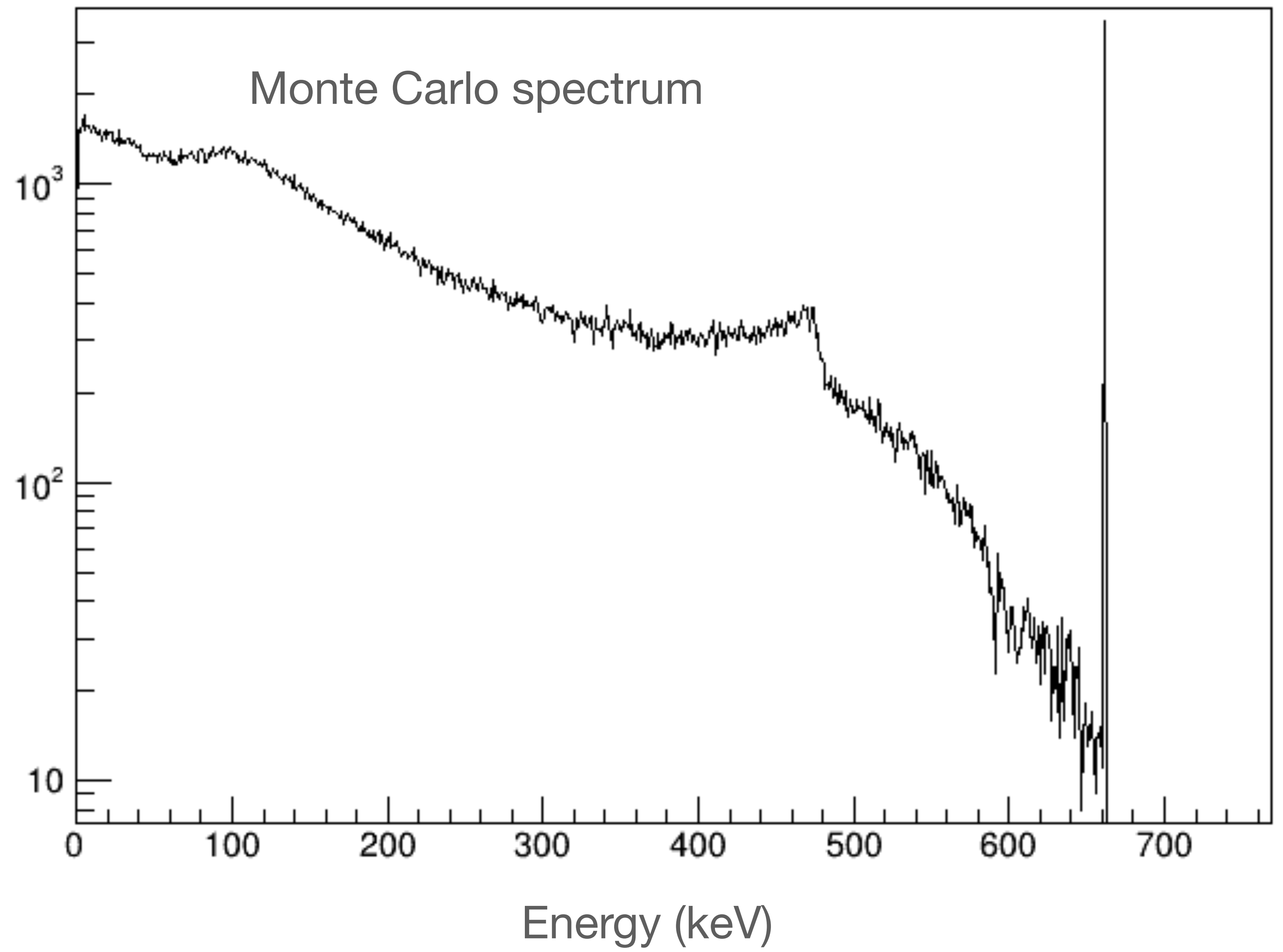
Convolution model

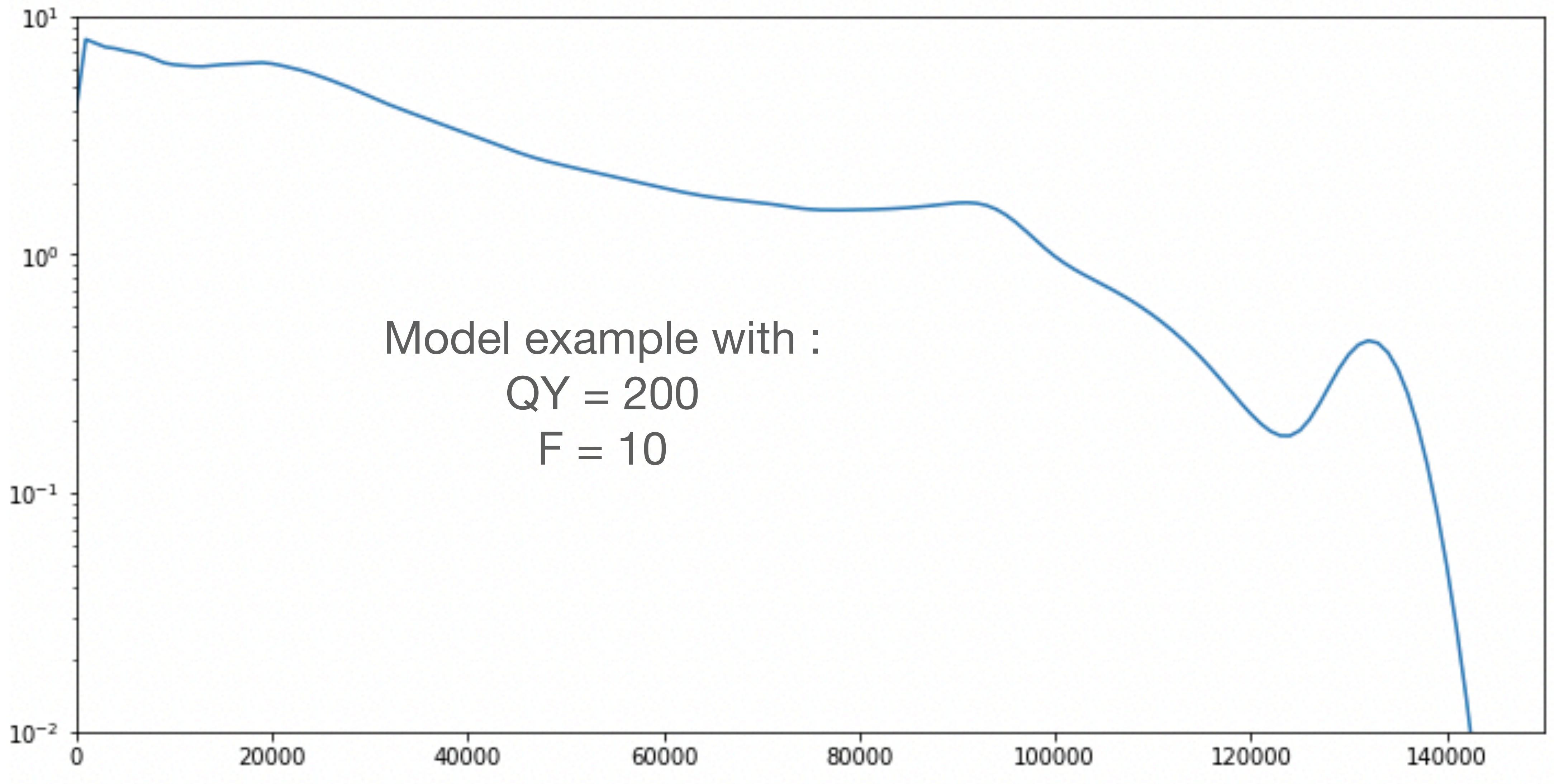
- The model is the convolution of the spectrum with a gaussian response function :

$$\int_{-\infty}^{+\infty} f(E)\, gaus(q - QY \times E, \sigma_q)\, dE$$

Where $\sigma_q = F\sqrt{q}$

- There are 2 parameters : QY and F

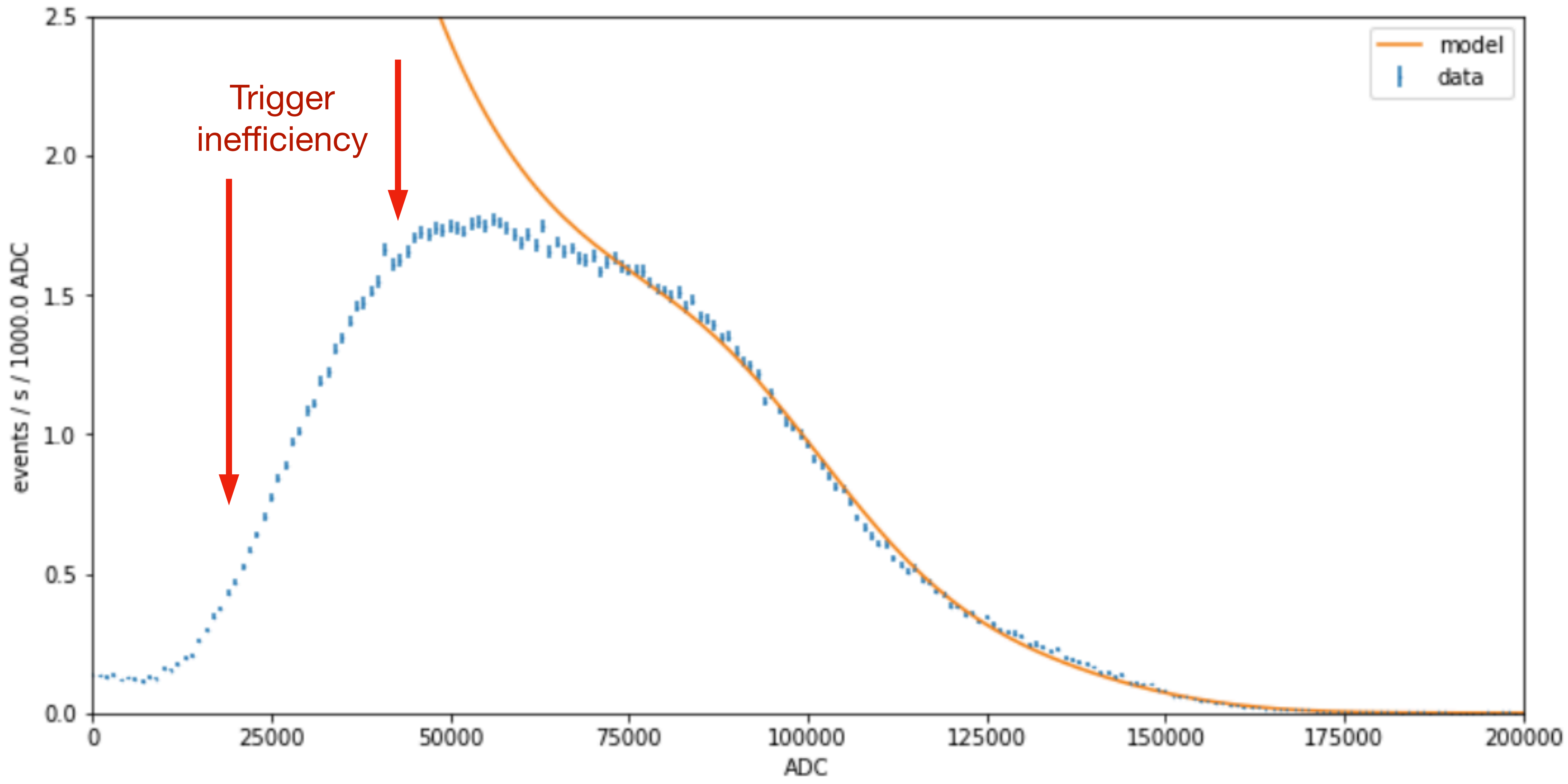




Monte Carlo spectrum fit

QY and F measurement

- Minuit minimisation of the data and the spectrum convoluted with the response.
- Fit range starts at 70000 ADC to avoid trigger inefficiency.



$$\begin{cases} QY = 200.4 \pm 0.4 \, ADC/keV \\ F = 47.2 \pm 0.7 \end{cases}$$

Effective Light Yield extraction

Gain and LY calculation

- From the charge yield QY, we want to extract the gain and the LY :

$$\sigma_q = F\sqrt{q} \Leftrightarrow \boxed{\frac{\sigma_q}{q} = \frac{F}{\sqrt{q}}}$$

$$gain = \frac{q}{N_{pe}} = \frac{QY}{LY}$$

- We require that the charge distribution is proportional to the PE distribution :

$$\boxed{\frac{\sigma_q}{q} = \frac{\sigma_{pe}}{N_{pe}} = \frac{1}{\sqrt{N_{pe}}}}$$

$$\Rightarrow F = \sqrt{\frac{q}{N_{pe}}} = \sqrt{gain} \Leftrightarrow LY = \frac{QY}{F^2}$$

Effective Light Yield extraction

From the spectrum

- From the fit parameters, the gain is extracted as : $gain = F^2$
- The equivalent Light Yield (LY) in the case of a poissonian distribution is given by : $LY = \frac{QY}{F^2}$

$$\begin{cases} QY = 200.4 \pm 0.4 \, ADC/keV \\ F = 47.2 \pm 0.7 \end{cases} \Rightarrow \begin{cases} gain = 2224 \pm 66 \, ADC/pe \\ LY = 0.090 \pm 0.003 \, pe/keV \end{cases}$$

We do not have access to the true LY but what we measure is the actual sensitivity of the detector.

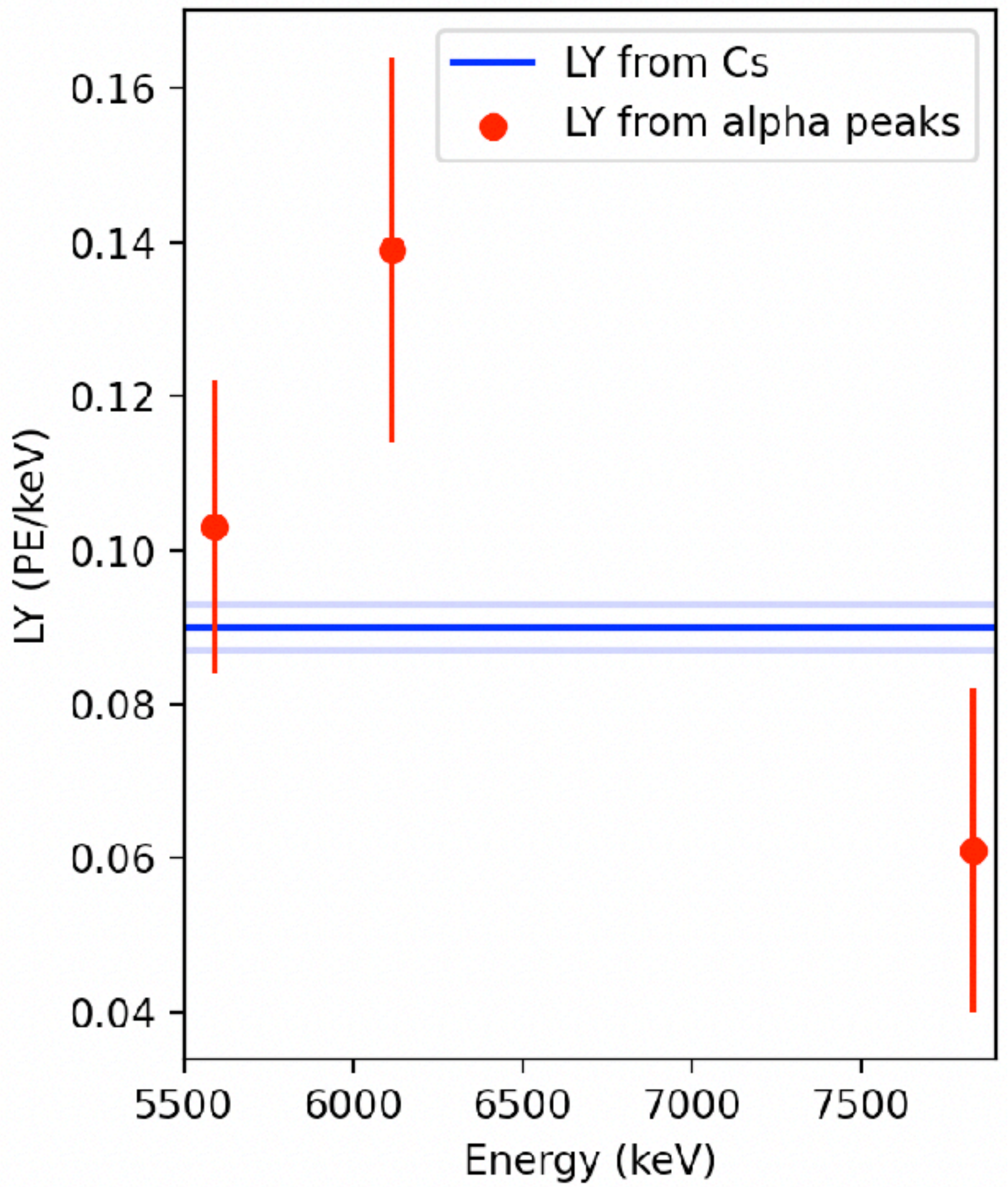
Effective Light Yield extraction

From the α peaks

$$LY = \frac{q^2}{\sigma^2 E}$$

Peak	Q-Value (keV)	Mean (ADC)	Mean uncertainty (ADC)	Standard Deviation (ADC)	Standard Deviation uncertainty (ADC)	Light Yield (pe/keV)	Light Yield uncertainty (pe/keV)
^{222}Rn	5590,3	8,276E+05	4,36E+03	3,45E+04	3,13E+03	**0,103**	**0,019**
^{218}Po	6114,7	9,121E+05	5,19E+03	3,13E+04	2,80E+03	**0,139**	**0,025**
^{214}Po	7833,5	1,164E+06	6,91E+03	5,31E+04	9,29E+03	**0,061**	**0,021**

The LY found with the Cesium run was : 0.090 ± 0.003 pe/keV



Conclusion

- The effective LY is very low at the moment
- The values from α peaks are compatible with the Cs spectrum
- The gain could be measure through the dark noise finger plot however :

  - There is too much noise at low VoV

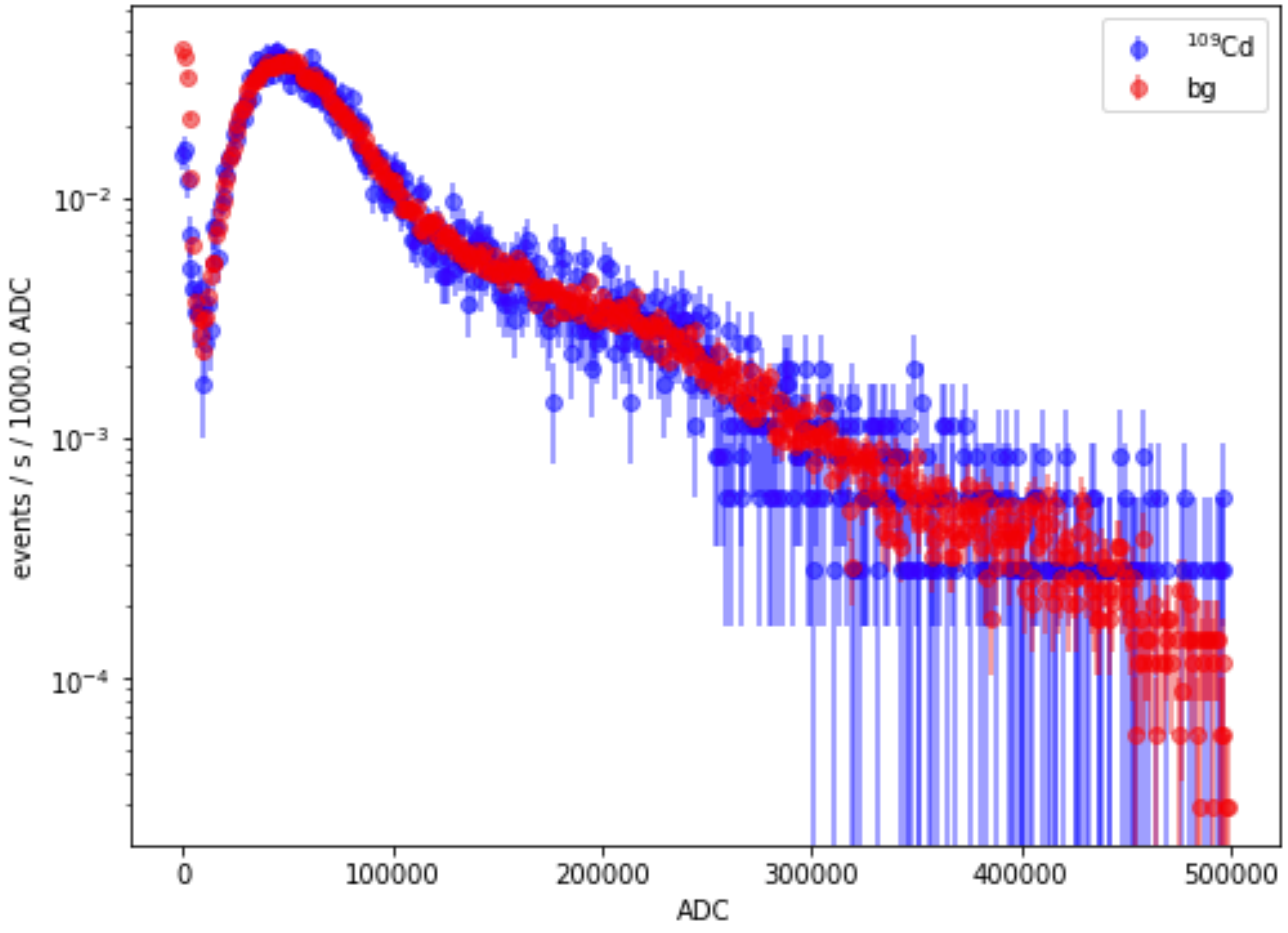
  - α peaks saturate at higher VoV

- The LY and the dark noise could be increased by adding more SiPM

Backup Slides

^{109}Cd run

Spectra comparison with live-time normalisation



- Background run n°103
- ^{109}Cd run n°105
- As expected, no excess in ^{109}Cd with respect to background.

Light Yield Calculation for α

Gain measurement

- For each peak, we fit σ_q and q knowing E
- We define F the deviation from a Poisson distribution such that $\sigma_q = F\sqrt{q}$
- We assume that the ADC count is proportional to an equivalent true Poisson distribution : $\dfrac{\sigma_q}{q} = \dfrac{\sigma_{pe}}{N_{pe}} = \dfrac{1}{\sqrt{N_{pe}}}$. This gives :

$$\frac{F}{\sqrt{q}} = \frac{1}{\sqrt{N_{pe}}} \Leftrightarrow F = \sqrt{\frac{q}{N_{pe}}} = \sqrt{g}$$

Light Yield Calculation for α

Effective LY computation

- $LY = \frac{N_{pe}}{E}$ and since $N_{pe} = \frac{q}{g} = \frac{q}{F^2}$, we have :

$$LY = \frac{q}{F^2 E} = \frac{q^2}{\sigma_q^2 E}$$

- Uncertainty propagation gives :

$$\delta LY = \frac{2q}{\sigma_q^2 E} \sqrt{\delta q^2 + \left(\frac{q}{\sigma_q} \delta \sigma_q \right)^2}$$

Channel relative calibration

Stability over runs