Simulation update

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CYGNO general meeting 12/03/20

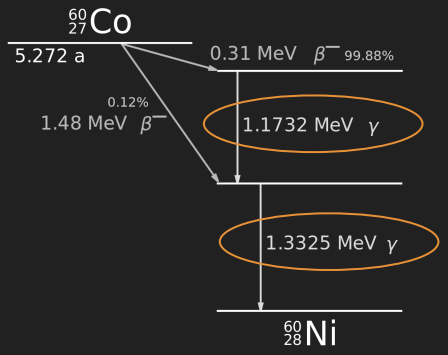
Outline

- Calibration sources for CYGNO
- Nuclear recoils with GEANT4
- Analysis and reconstruction

Calibration sources

(Slides from Flavio)

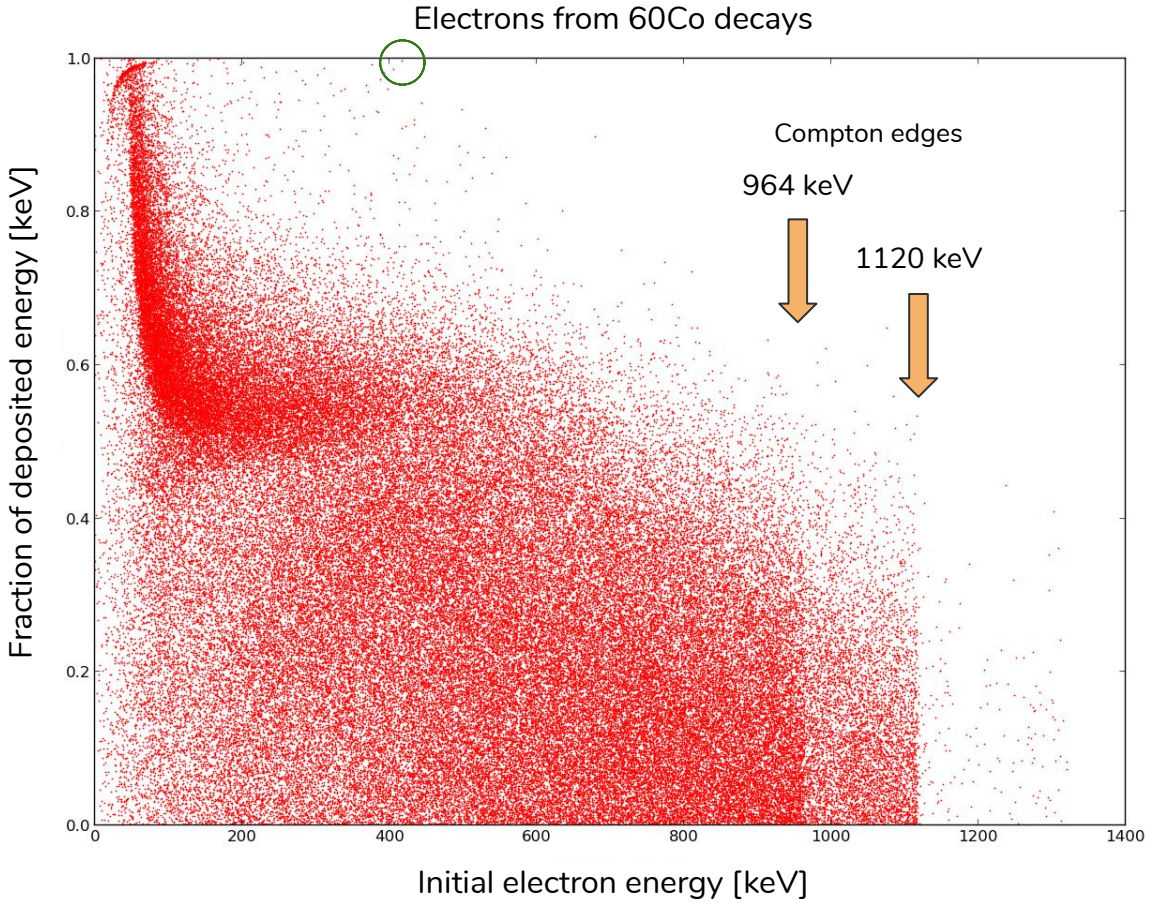
60Co



Problem: track containment

In general, only a fraction of the total energy carried by the particle is deposited inside the sensitive region

The maximum registered energy contained inside a 0.5m^3 region (between cathode and readout) is ~420keV



How our calibration source should be made

- X-ray emitter with E<100-150keV
  This is required to have tracks fully contained in the sensitive region, especially for side-cameras
- Good coverage of the cameras nearest to the one in which the source is
  The crucial point of the double-sided calibration is being able to calibrate the cameras in the center
- A sufficiently long half-life
  To make it simple to build the calibrated emission spectrum of the source

it is possible to carry out a systematic study of the detector response to the various isotopes suitable for our needs.

http://pdg.lbl.gov/2010/reviews/rpp2010-rev-commonly-used-radioactive-sources.pdf

55Fe (half life 2.7 y)

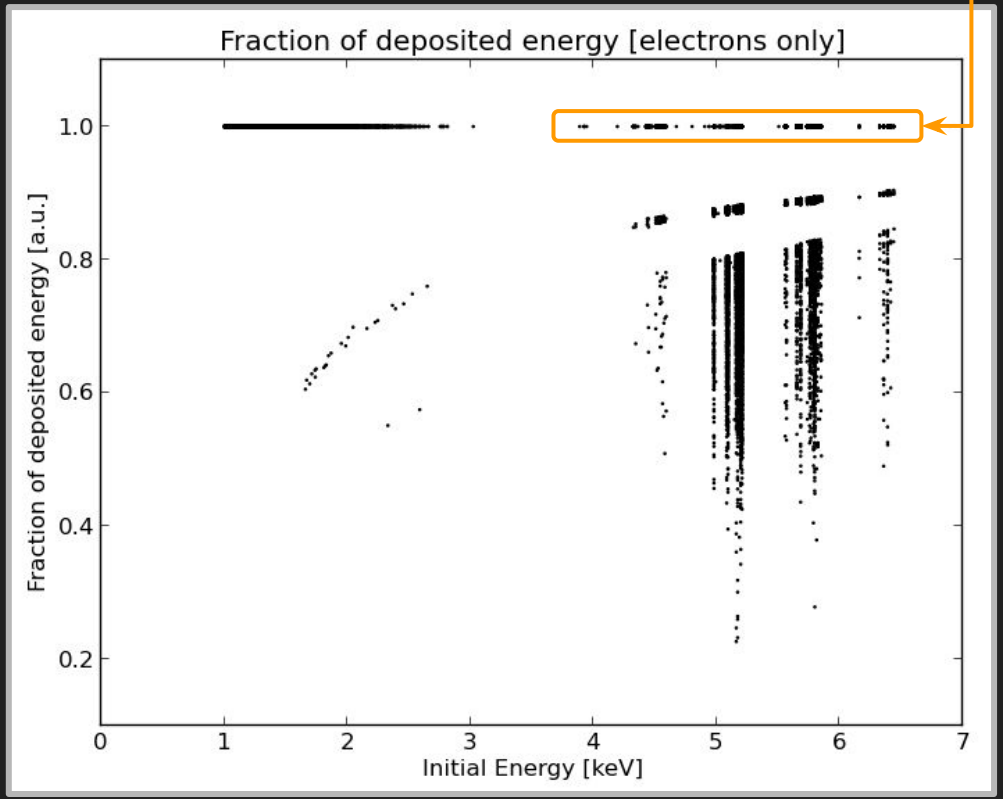
Low energy X-rays can deposit all of their energy

3.1.1 X Radiations

		Energy keV		Relative probability
X_K				
	$K\alpha_2$	5,88765		51
	$K\alpha_1$	5,89875		100
	$K\beta_3$	6,49045	}	
	$K\beta''_5$	6,5352	}	20,5
X_L				
	$L\ell$	0,556		
	$L\eta$	0,567		
	$L\beta$	0,649 – 0,721		

3.1.2 Auger Electrons

	Energy keV	Relative probability
Auger K		
KLL	4,953 – 5,210	100
KLX	5,671 – 5,895	27,2
KXY	6,370 – 6,532	1,85
Auger L	0,47 – 0,67	



55Fe

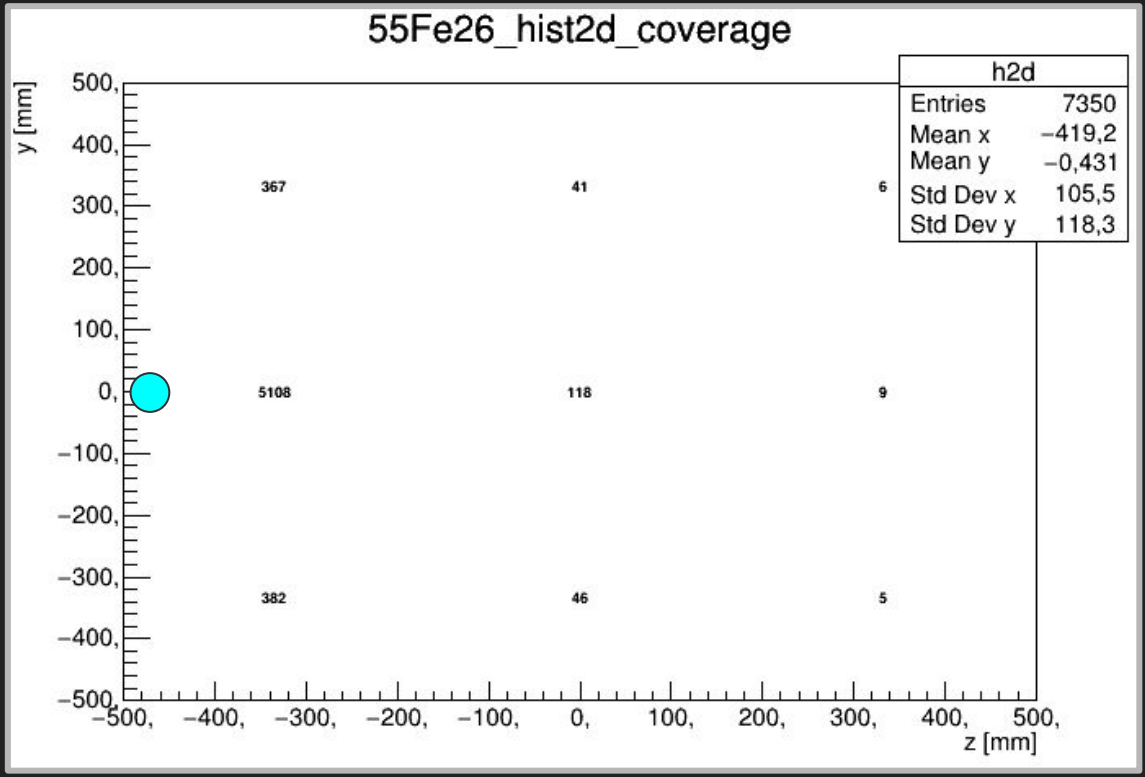
Problem: coverage area

We have a factor ~50 between the # of tracks in the side camera (in which the source is) and the # of tracks in the center camera.

How can we move the source?

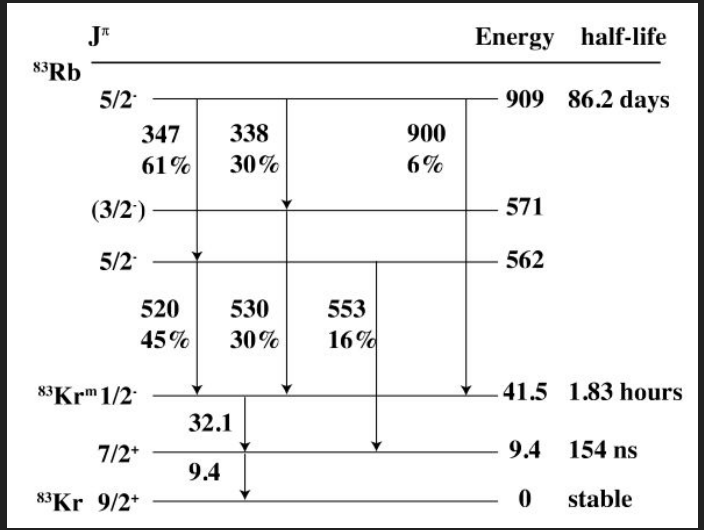
Can we swap cameras positions?

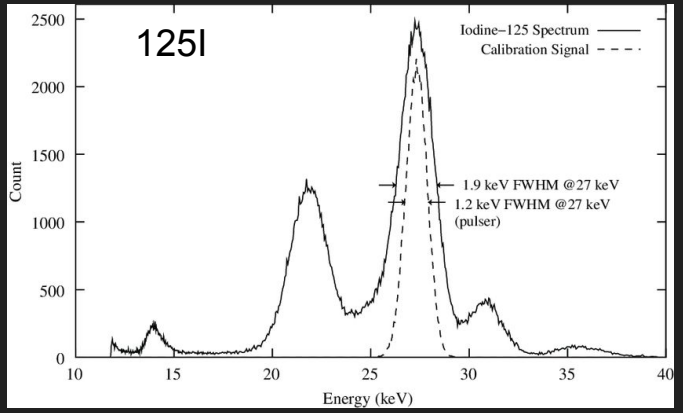
A “double-side” calibration would decrease the ratio by a factor 2

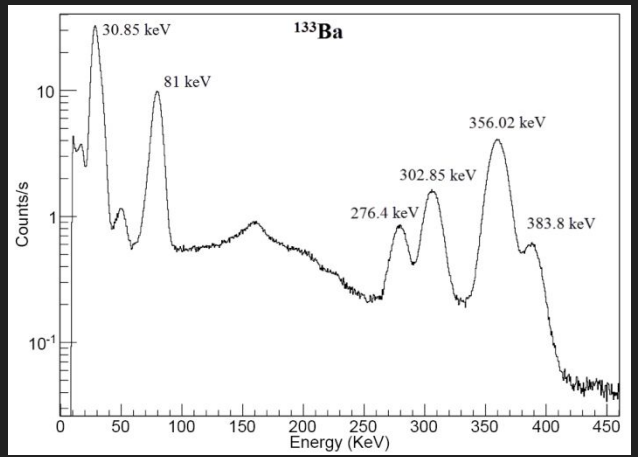


Other sources under study...

- ^{125}I (Half-life: 60d)
- ^{133}Ba (Half-life: 10.5 y)
- ^{83m}Kr (used in LXe see arXiv:0905.1766)
- others: 112Ag, 113Sn, 131I, 51Cr, 54Mn, 57Co, 60Co, 7Be



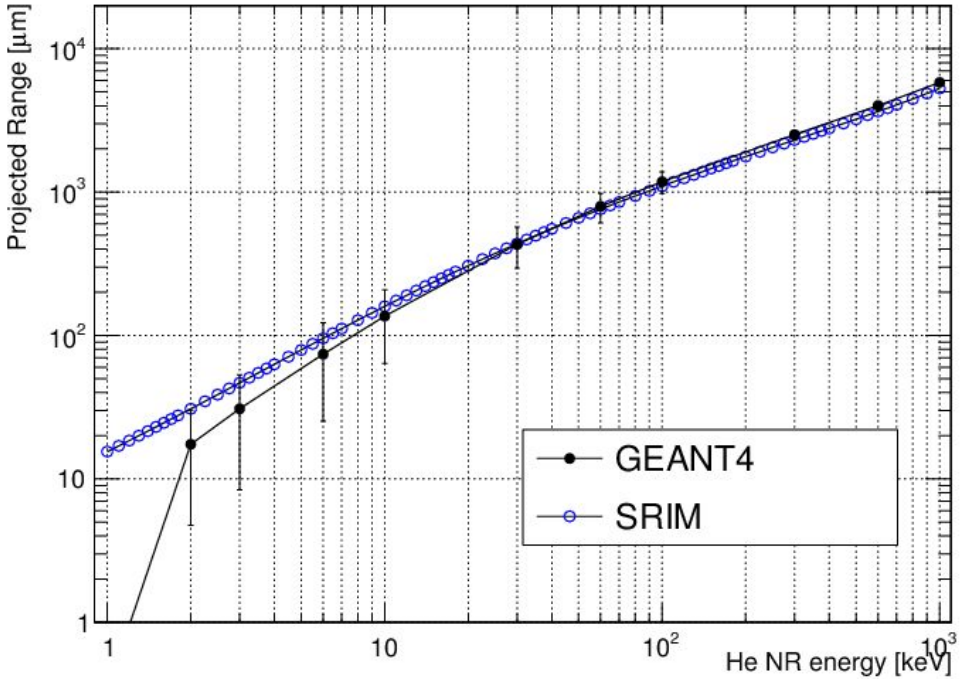




Nuclear recoils simulation

Comparison with SRIM

Range of He in 60:40 He:CF4 gas mixture



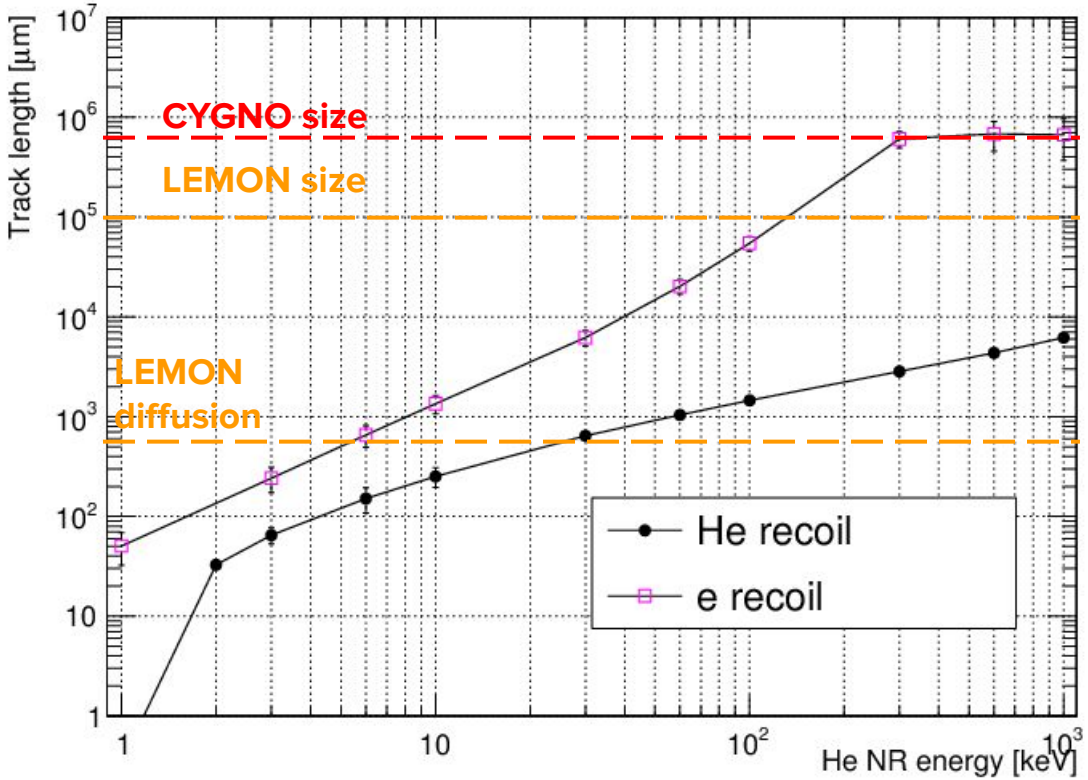
In reasonable agreement for E>2 keV

Used “projected range” definition by SRIM

Mean Projected Range

$$\equiv R_p = \sum_i x_i / N \quad = \langle x \rangle .$$

Nuclear vs electron recoils (GEANT)



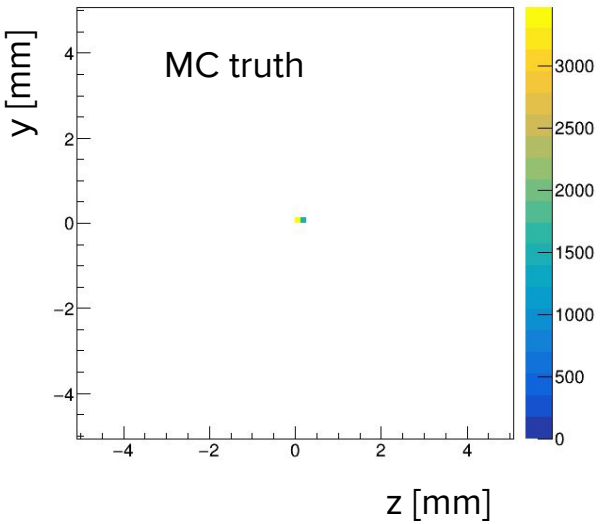
Limited by size of CYGNO detector ➜ 50 cm since the recoil is generated in the center

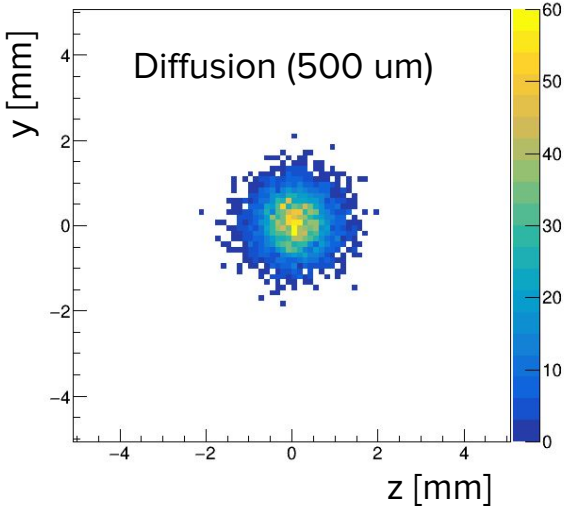
Expect ER tracks not fully contained in LEMON from E>100 keV

If diffusion ~500 um (LEMON) ➜ we should have some discrimination power for E>10 keV

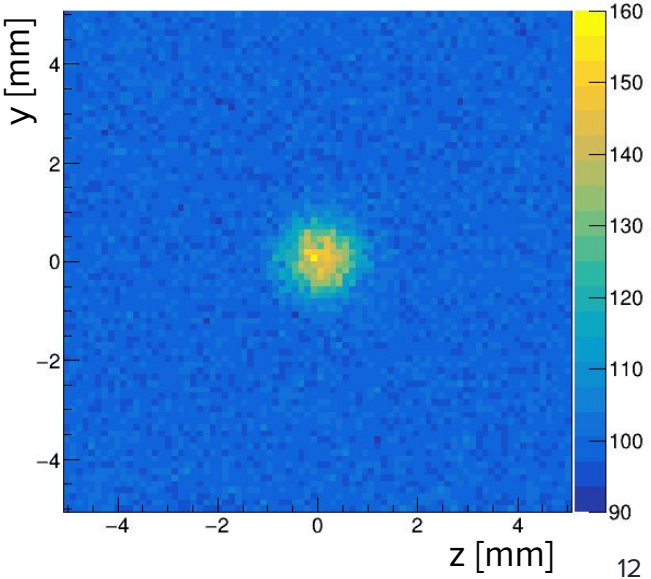
Digitization NR

- NR (He) of E= 10 keV with GEANT4
- generated in (y,z) = (0,0), direction (0,1)
- digitized with LEMON parameters





Diffusion and noise (2 photons)
Pedestals centered on 99



https://github.com/CYGNUS-RD/digitization/blob/master/ConfigFile_LEMON.txt

Digitization ER

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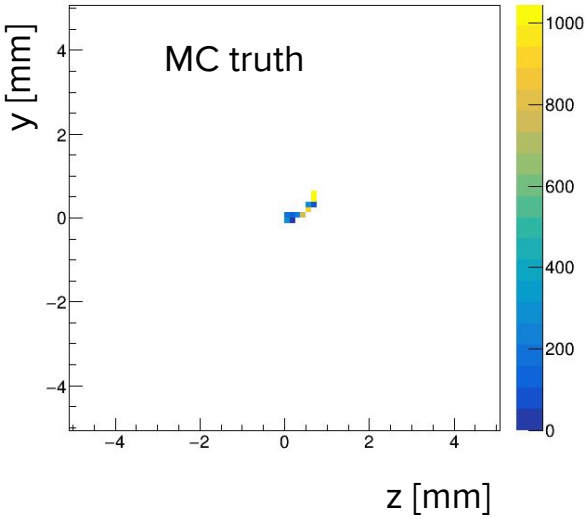

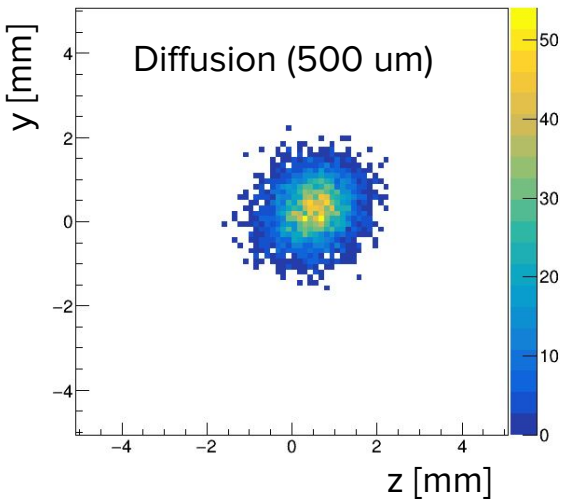

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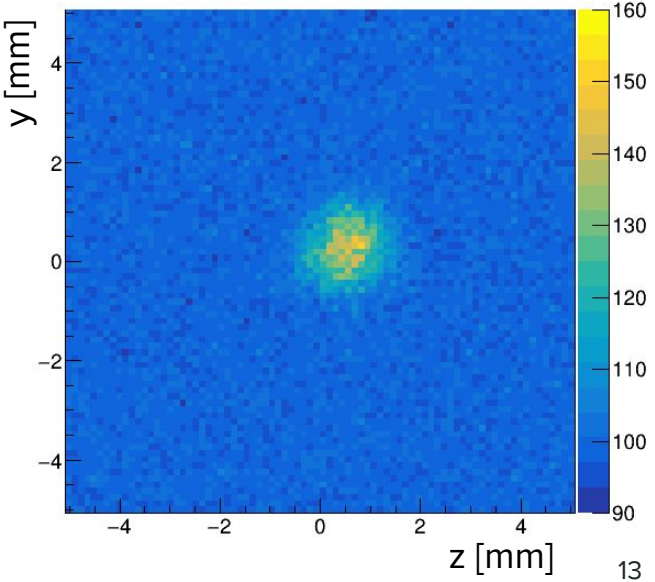

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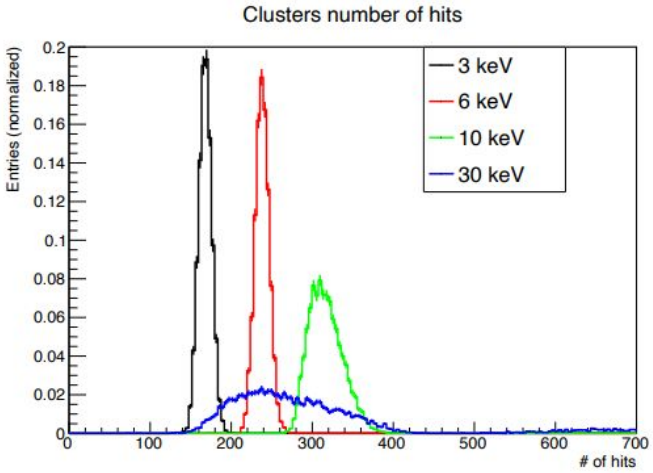
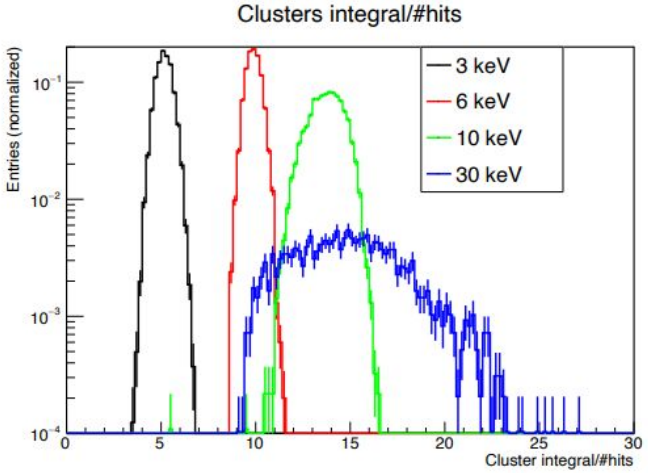
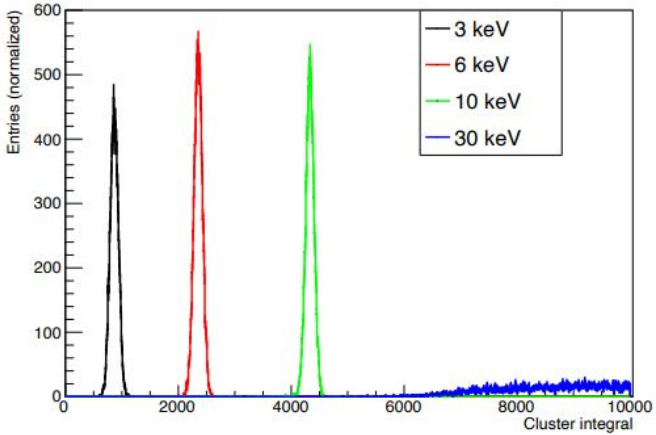
Analysis & reconstruction

(Slides from Fabrizio)

Examples of integral and nhits per cluster for ERs (the same applies to NRs)





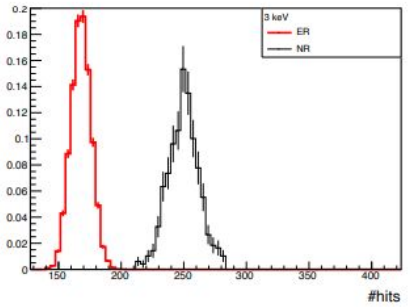


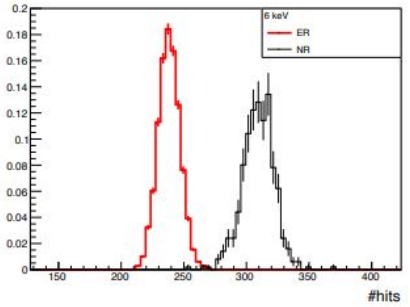
Sorry, this plot is cut @10k.
No time to regenerate it but it gives the idea anyhow…

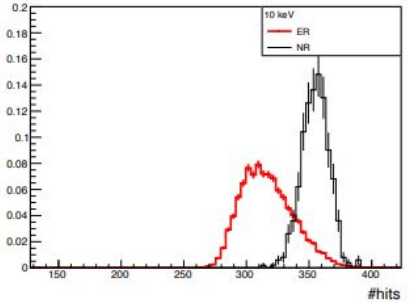
Number of hits per cluster

Can we distinguish ER from NR at the same energy looking at the number of active hits in a (S)cluster?

At very low energies the separations is reasonable.
Already @ 10 keV it is not.
Naively, we would expect the opposite behaviour…







Outlook & last remarks

- Issues with reconstruction:
  - 0 efficiency @ 1 keV;
  - Strange integral and nhits computation for E>=30 keV;
  - Stange number of cluster reconstructed for NR changing the 0-suppression parameter.

- Reconstruction parameters should be checked;
- I would also like to review the definition of some quantities (for example the integral, the lenght, …)

Longer term plans:

- It would be good to study the analysis at the different stages of the simulation to understand in details (separately) the effect of the diffusion and of the background superposition