Resolution studies update: z and HV scan

Pietro Meloni, Fabrizio Petrucci
27-06-2023

Update

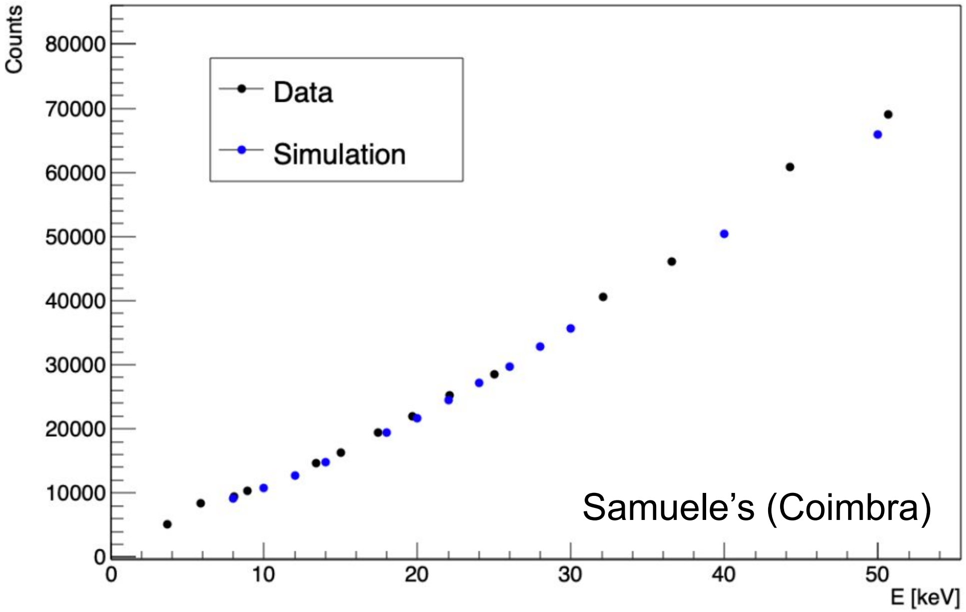
To better understand the energy resolution as a function of the energy in data and simulation, I studied the following:

- resolution as a function of z (data vs simulation);
- resolution as a function of GEM1 HV (data vs simulation);

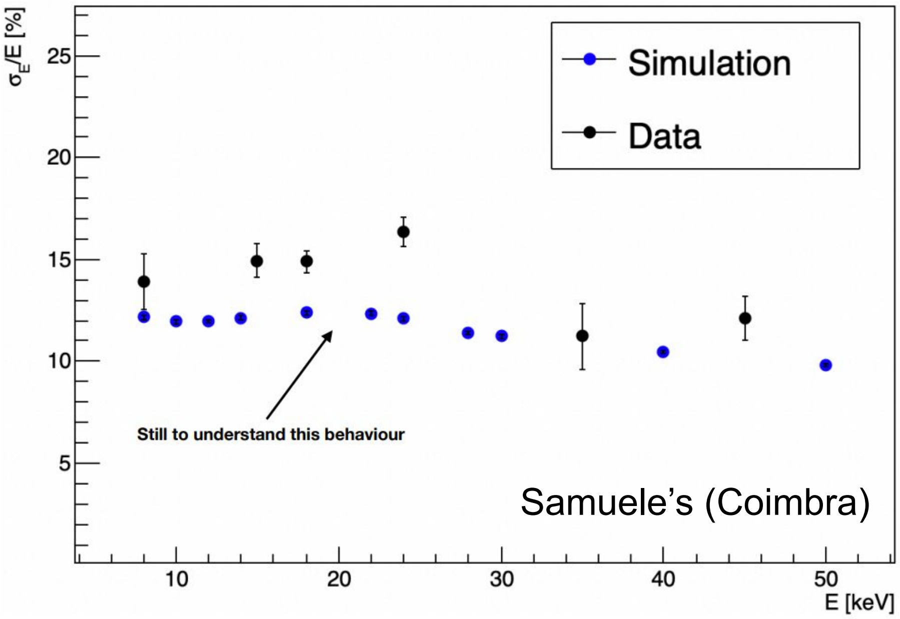
Spoiler: The accord between data and simulation is very good for resolution vs z (once z fluctuations are added!). And the accord between data and simulation is not very good for resolution vs GEM1 HV.

Where we left

integral vs E (@250 mm)



resolution vs E (@250 mm)



Resolution vs z

Simulation:
Digitized (in h5 *) 500 tracks (simulated by Giulia) at different z: 450, 400, 350, 300, 250, 200, 150, 100, 55 mm

Reconstructed winter23 branch (no memory leak with h5 format -> running with 4 GB on cygno queue)

Data:

LNF runs 5861-5911 (z scan with Fe55), already reconstructed by Emanule with winter22

Analysis (Data):

Cuts: integral>1000 && length< 500 && TMath.Hypot(sc_xmean-2304/2, sc_ymean-2304/2)<1000

Fitted the background with double exponential, and signal with a Gaussian

Analysis (Simulation):

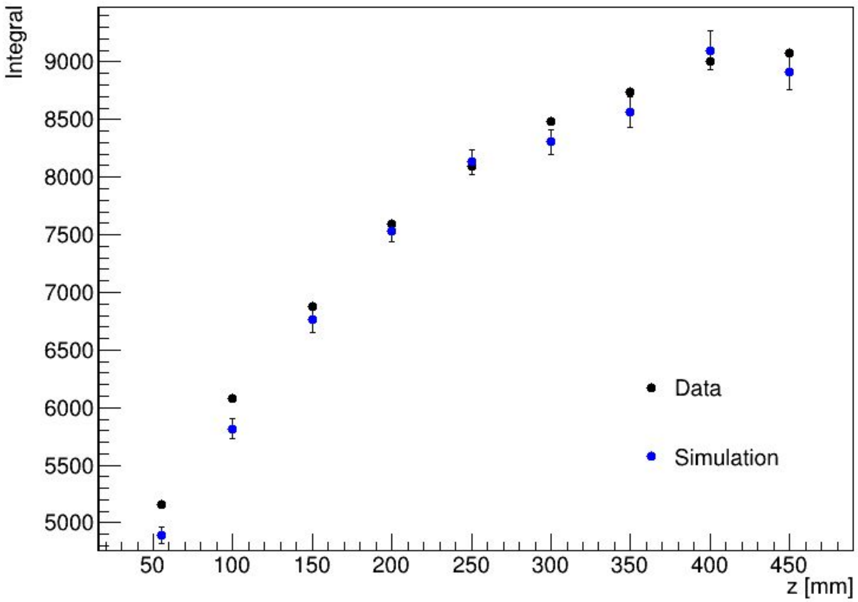
Cuts: integral>1000 && length< 500 && TMath.Hypot(sc_xmean-2304/2, sc_ymean-2304/2)<1000

Fitted the signal with a Gaussian

* h5 occupies 5 Mb per image (vs 4 Mb of ROOT)

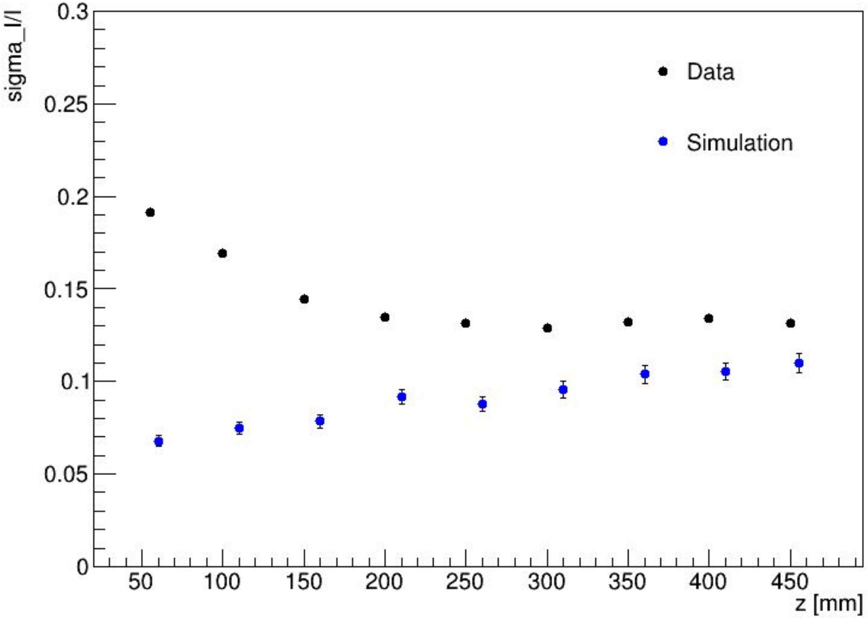
Results

Fe55 integral vs z (200 tracks)



Integral is ok (we tuned the simulation on it)

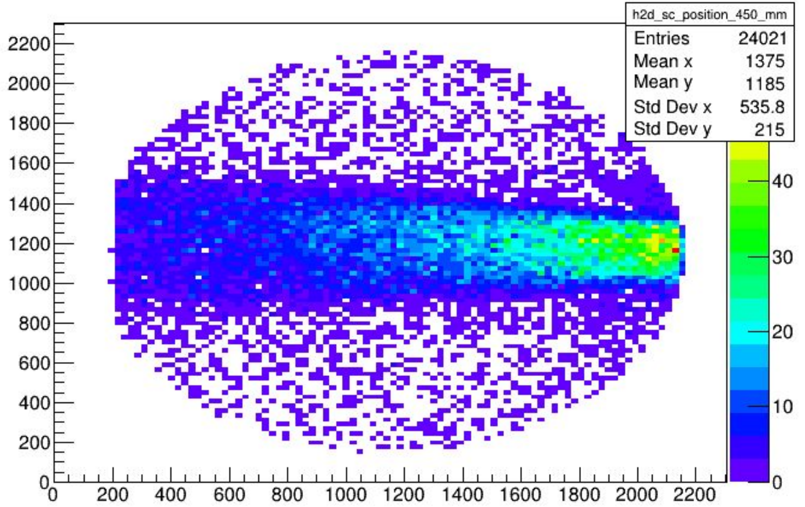
Fe55 resolution vs z (500 tracks)

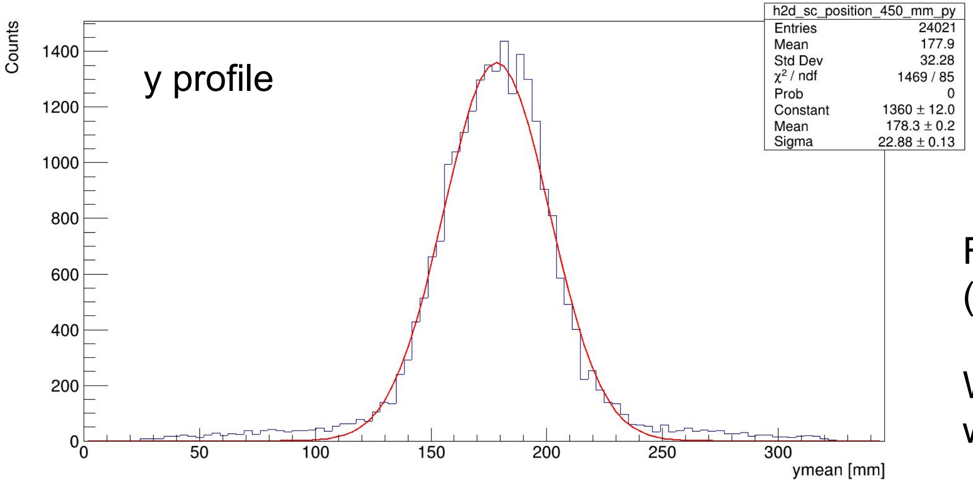


We've got a problem… **but we solved it!**

Adding z fluctuations

As we know, the Fe55 cone is not perfectly collimated.

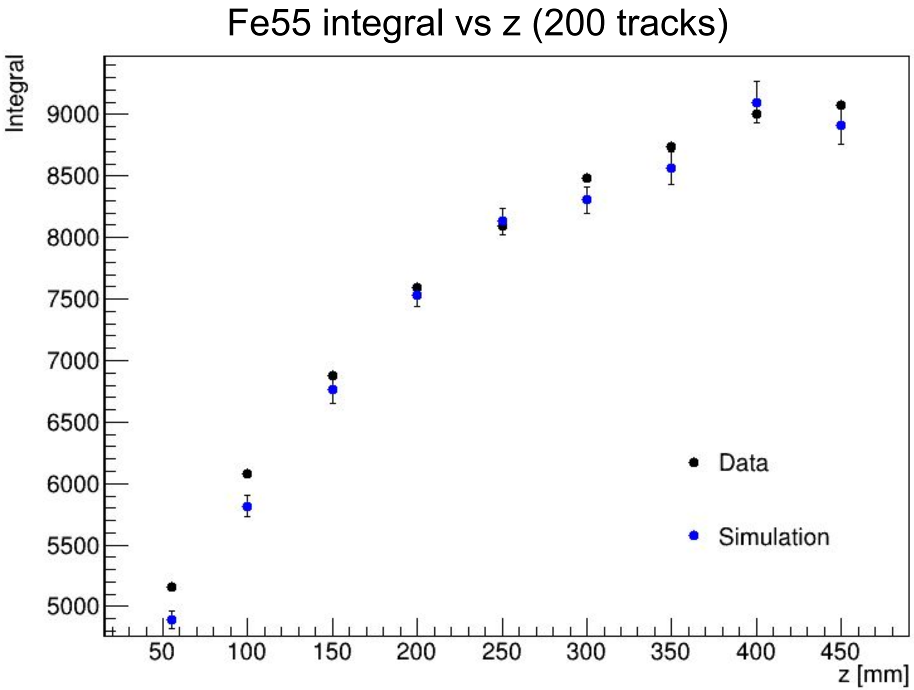


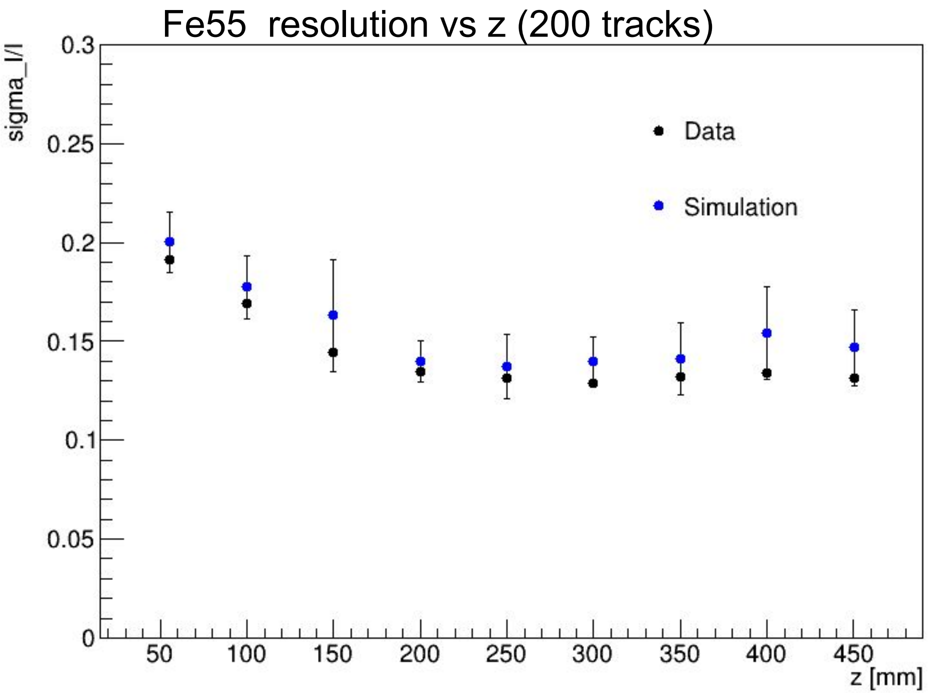


First, look at the fluctuations in x-y of data (looking images with source at 450 mm).

We decide to generate z from gaussian distribution with sigma 22 mm

Final result (with z fluctuations in simulation)





ERRATA CORRIGE (11/07/2023): in these plots we also added a flat gaussian fluctuation with sigma = 750 counts (add in quadrature)

Resolution vs GEM1 HV

Simulation:
Digitized (in h5 *) 300 tracks (simulated by Giulia) at different HV: 440 431 420 406 386 350 V

Reconstructed winter23 branch (no memory leak with h5 format -> running with 4 GB on cygno queue)

Data:

LNF runs 4455 – 4462 (HV scan with Fe55), already reconstructed by Emanule

Analysis (Data):

Cuts: integral>1000 && length< 500 && TMath.Hypot(sc_xmean-2304/2, sc_ymean-2304/2)<1000

Fitted the background with double exponential, and signal with a Gaussian

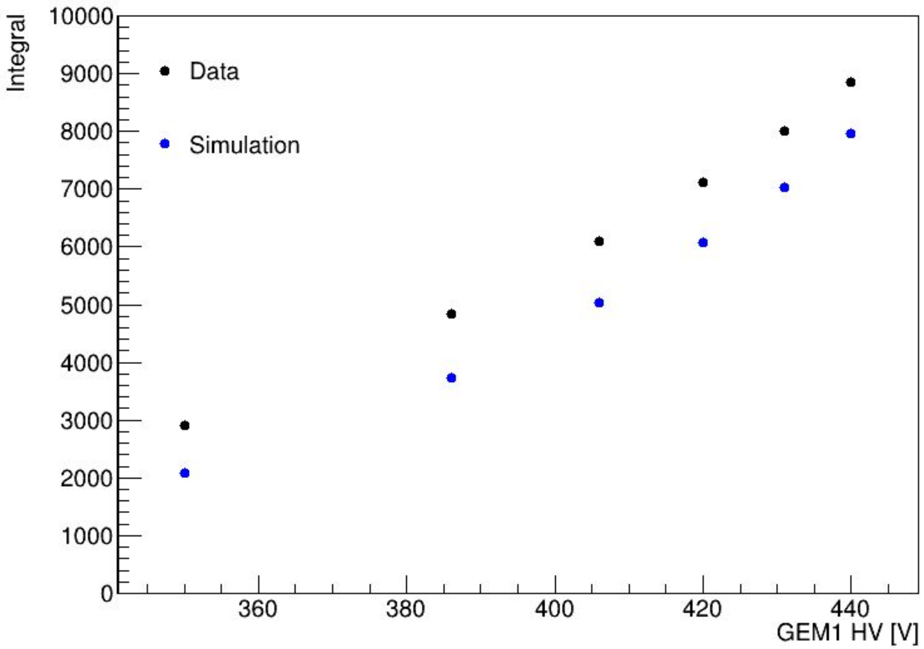
Analysis (Simulation):

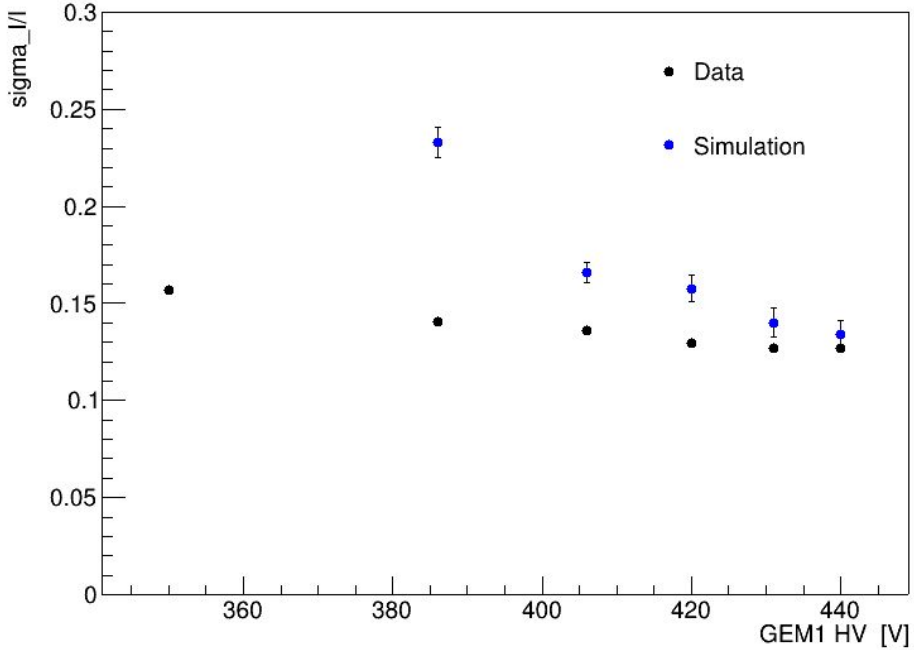
Cuts: integral>1000 && length< 500 && TMath.Hypot(sc_xmean-2304/2, sc_ymean-2304/2)<1000

Fitted the signal with a Gaussian

* h5 occupies 5 Mb per image (vs 4 Mb of ROOT)

Results





Note: the integral of runs 4455 – 4462 (these ones) is systematically higher than integral in runs 5861 – 5911. For this reason, we tuned the simulation on runs 5861 – 5911.

With lower integral in data, you would have worse resolution, as in simulation.

ERRATA CORRIGE (11/07/2023): in these plots we also added a flat gaussian fluctuation with sigma = 750 counts (add in quadrature)

Conclusions

The accord between data and simulation is very good for resolution vs z (once z fluctuations are added!).

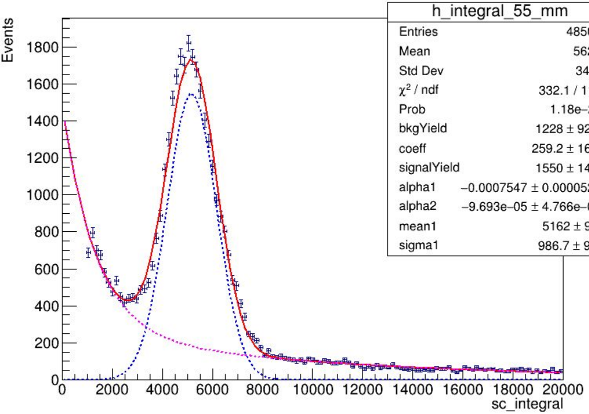
ERRATA CORRIGE (11/07/2023): to get a good agreement we also need to add a flat gaussian fluctuation with sigma = 750 counts (add in quadrature)

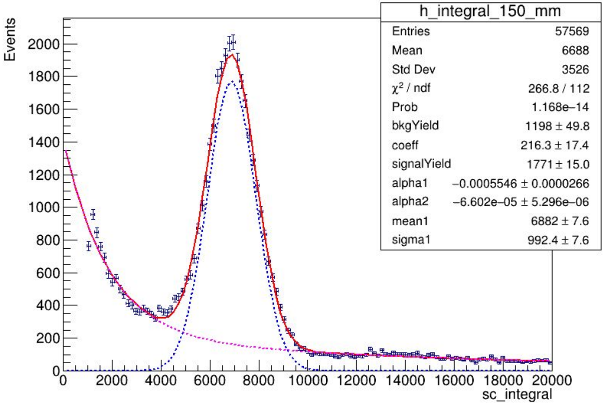
The accord between data and simulation is not very good for resolution vs GEM1 HV, but not that bad if we consider data might have problems.

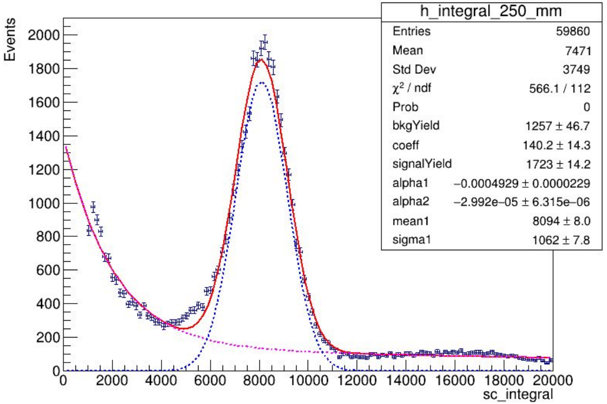
Other points related to the simulation:

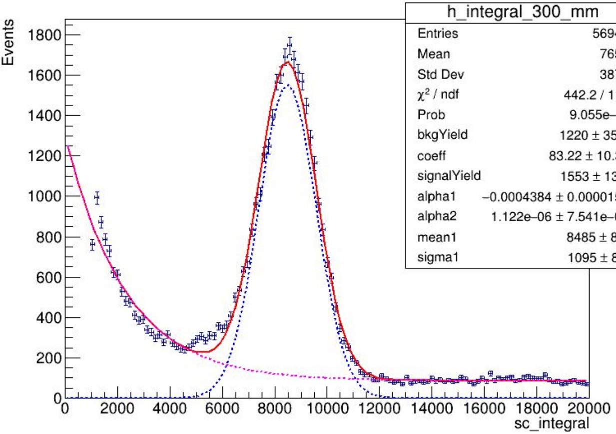
- Diffusion coefficient are now fixed in simulation: we can add the dependence on drift field
- Sensor noise simulation: can be used this code: https://github.com/ranobr/cygno-noise-simulation (we can see if the images are reconstructed well)
- PMT simulation: I invite committing to the main code, branch ‘pmt’: https://github.com/CYGNUS-RD/digitization/tree/pmt

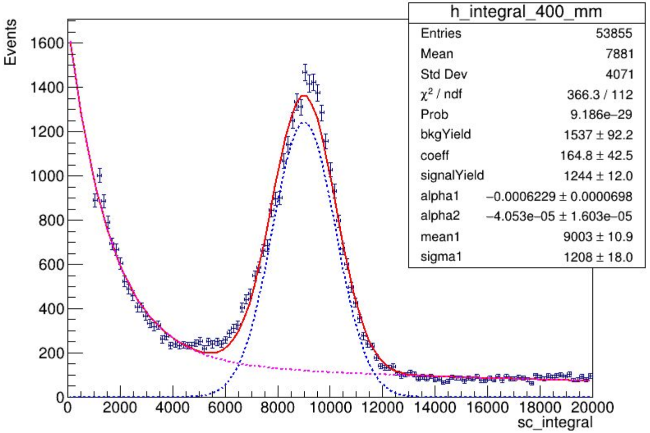
Fitting z scan (data)

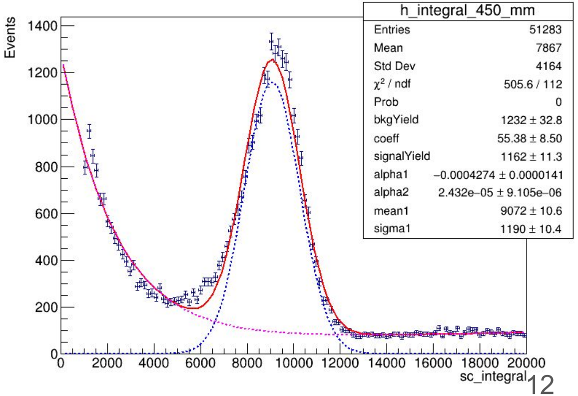












Fitting z scan (simulation) without z fluctuations