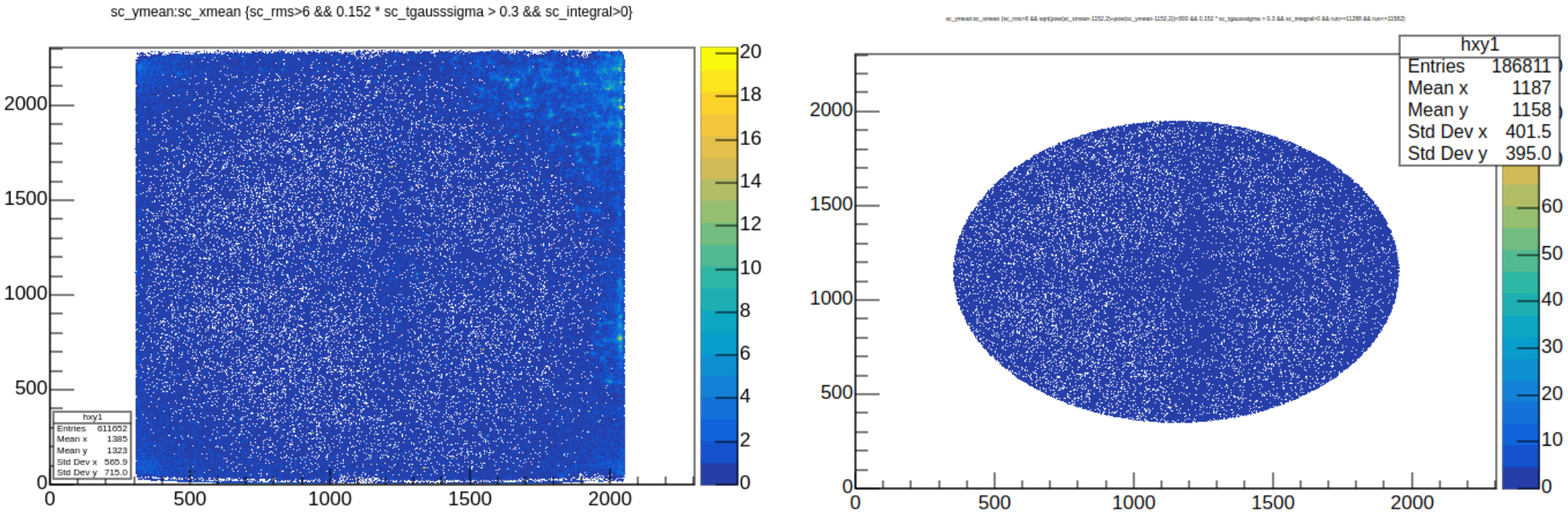
Energy spectra of LIME background in run2 and MC comparison

F. Di Giambattista, Analysis Meeting, Coimbra, 7-8 June 2023

Background simulation chain

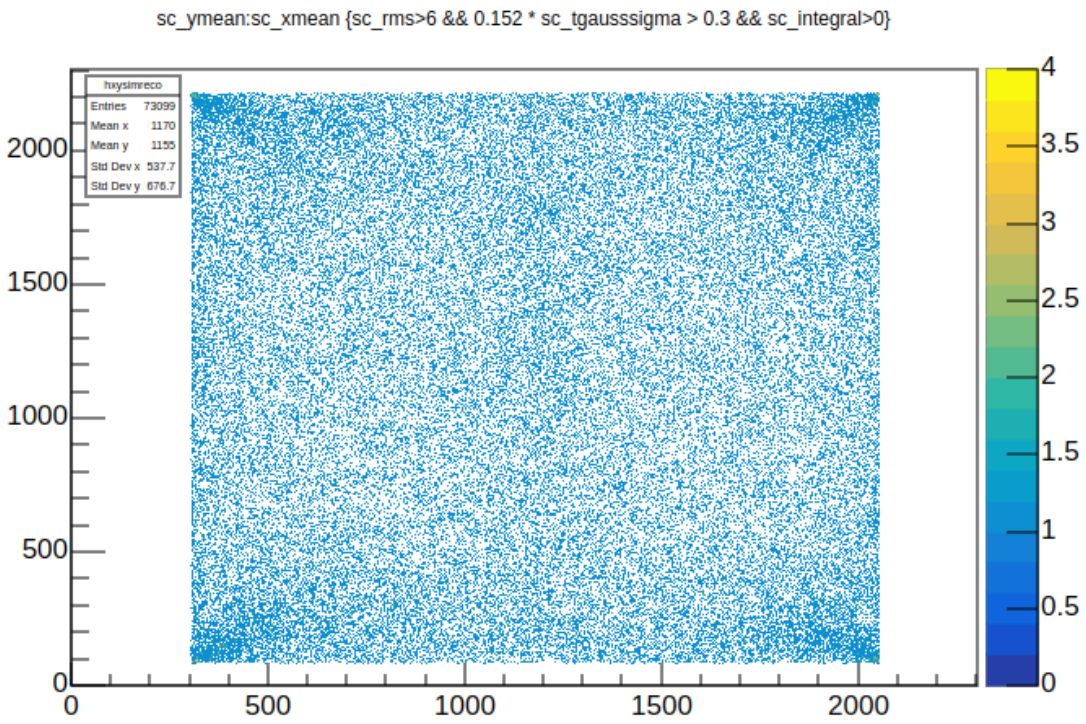
- Monte Carlo (MC) simulation of expected background in LIME underground with GEANT4
  - Main contributions:
    - External gammas produced in the lab rock
    - Radioactivity of LIME materials (field rings, cathode, acrylic box, GEMs, field cage resistors, camera)
- Digitization is applied
  - Energy deposits in the sensitive volume of gas are diffused, charge amplification and saturation are applied, vignetting effect is included, and images with the same granularity of real data are produced
  - Energy and spatial distribution of simulated events are retained, and the images are comparable with data
- Events are reconstructed with Winter23 version of the code (same as the one used for run2)

X-Y distribution – data

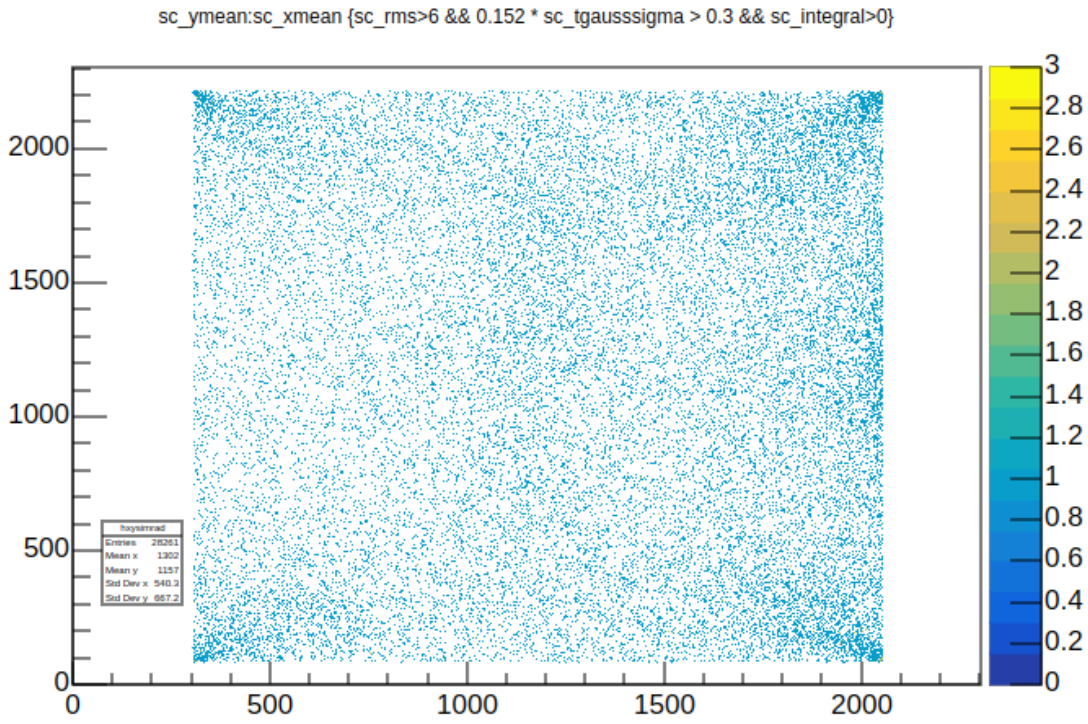


Excess of clusters in corners – cut a central circle in the center with 800px radius

X-Y distribution – simulation

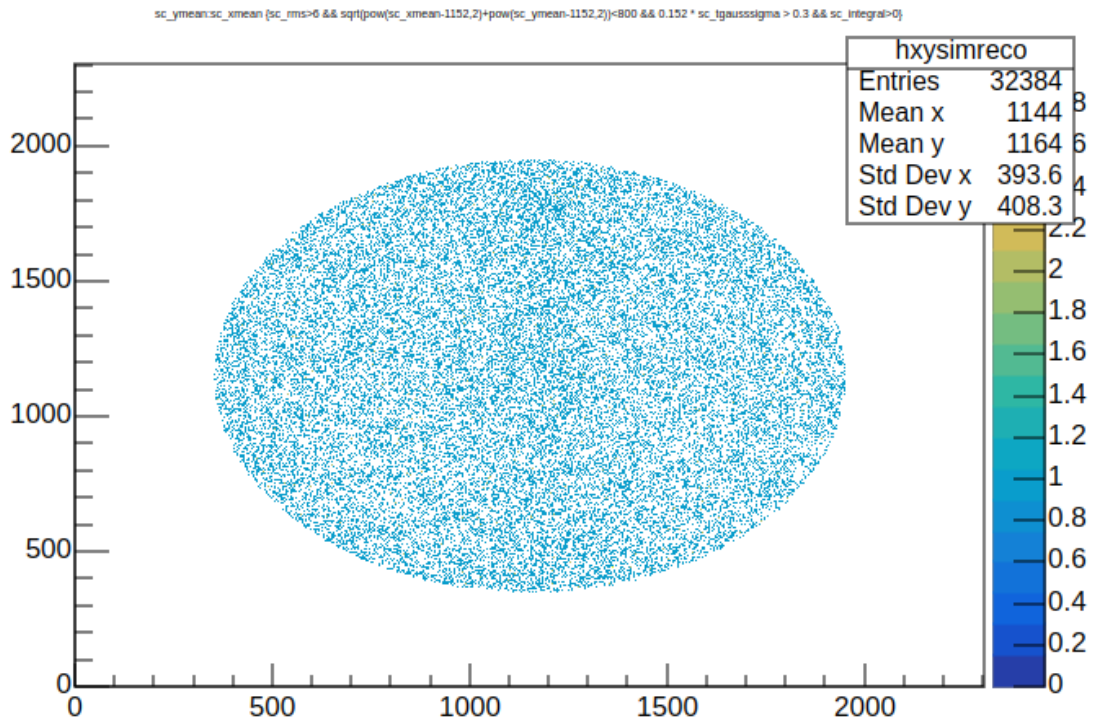


External gammas

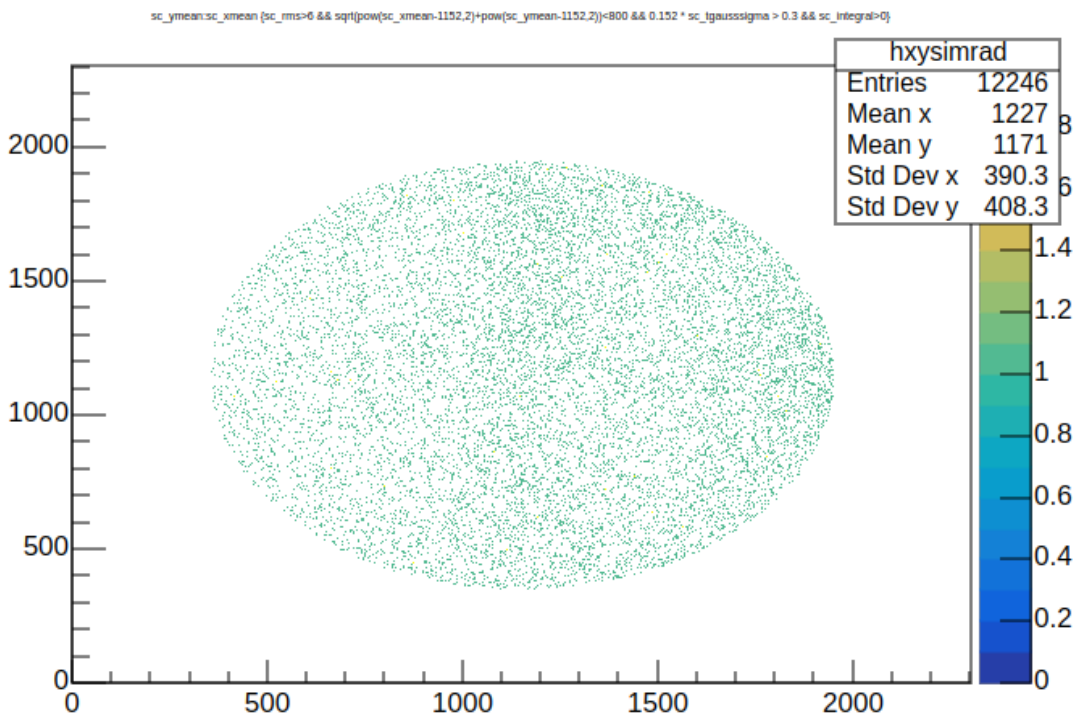


Internal radioactivity

X-Y distribution – simulation



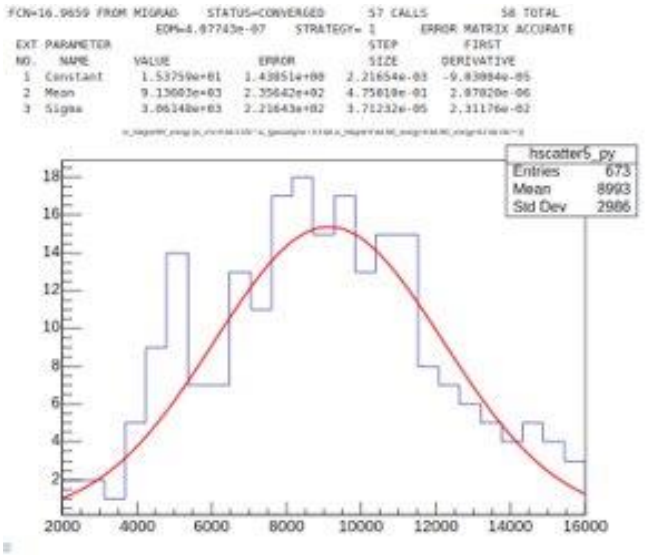
External gammas

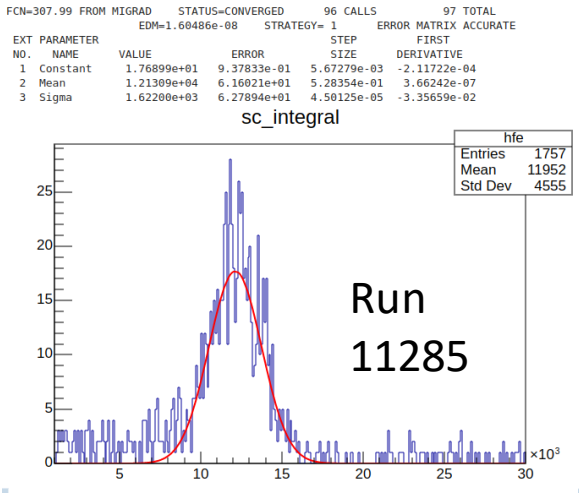


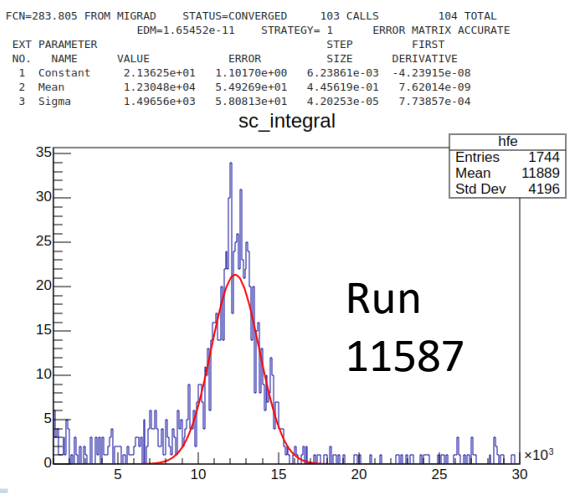
Internal radioactivity

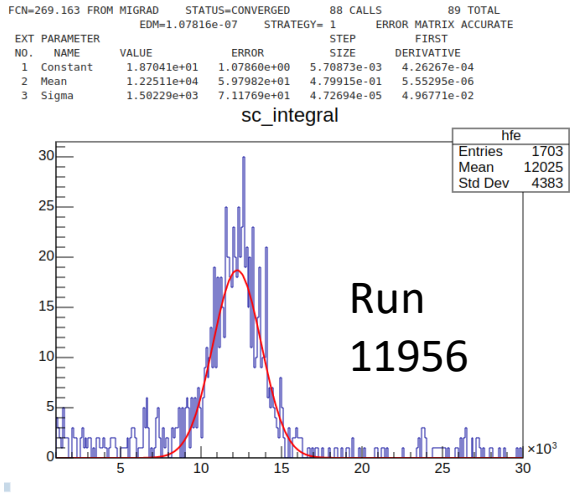
Energy calibration

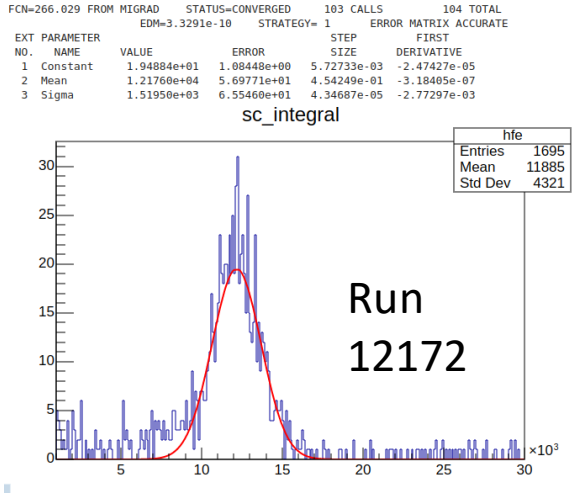
- For the simulation I used a peak at 8 keV (Cu X-ray)
- For data I used the Fe55 runs to calibrate the reconstructed data from background runs
- In both cases I did a simple Gauss fit



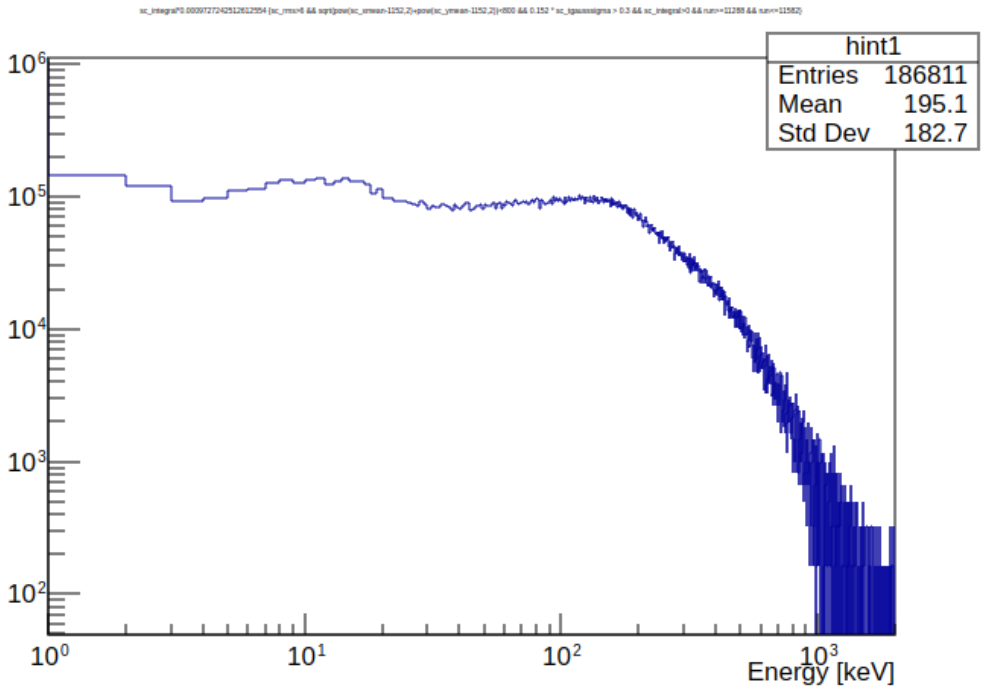


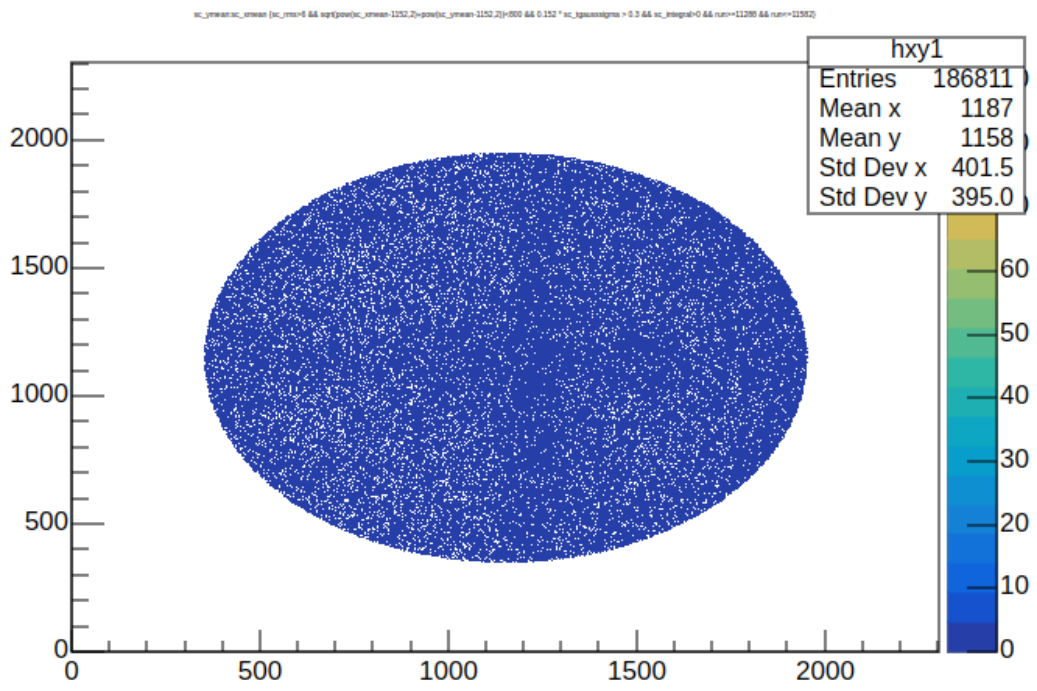






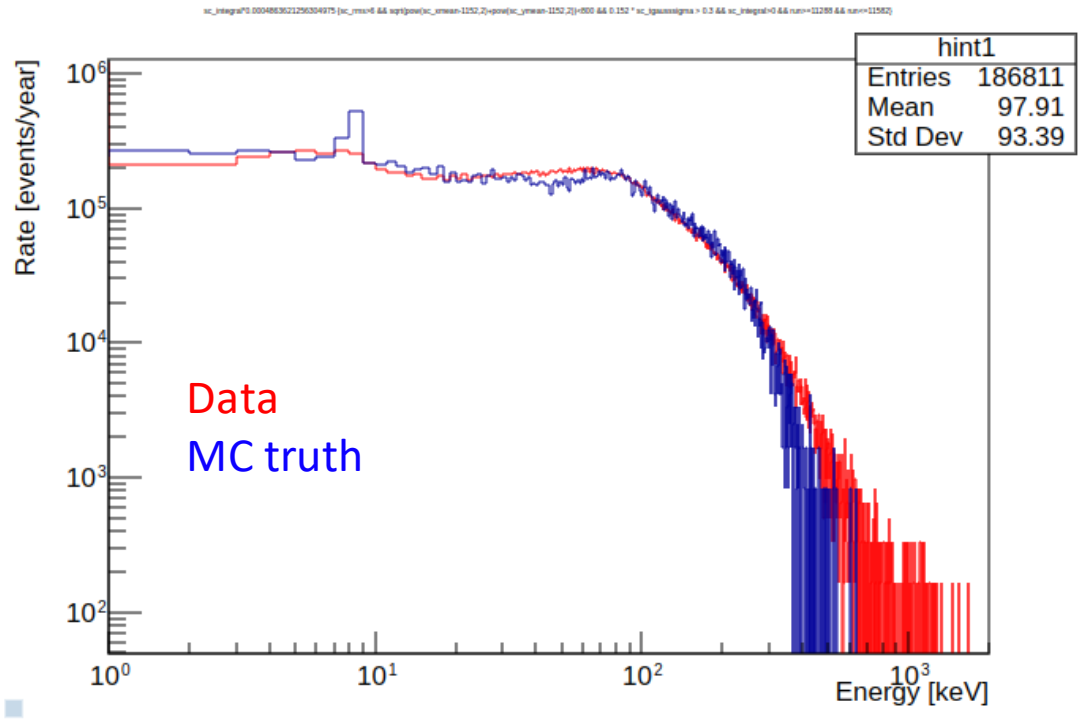
Energy spectrum – data run2





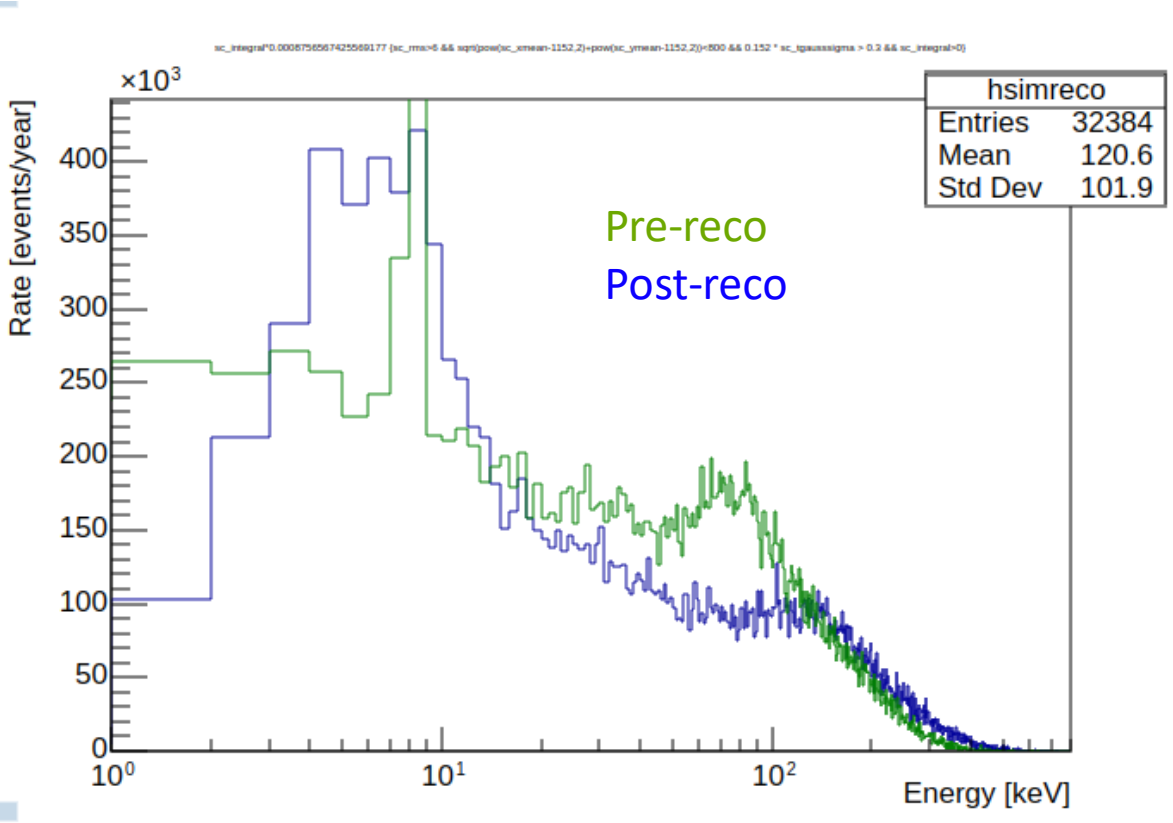
- Cuts applied: **sc_rms>6 && sqrt(pow(sc_xmean-1152,2)+pow(sc_ymean-1152,2))<800 && 0.152 * sc_tgausssigma > 0.3 && sc_integral>0**
- Normalized to the total real time of the runs (stop_time-start_time)

Energy spectrum comparison pre-reco



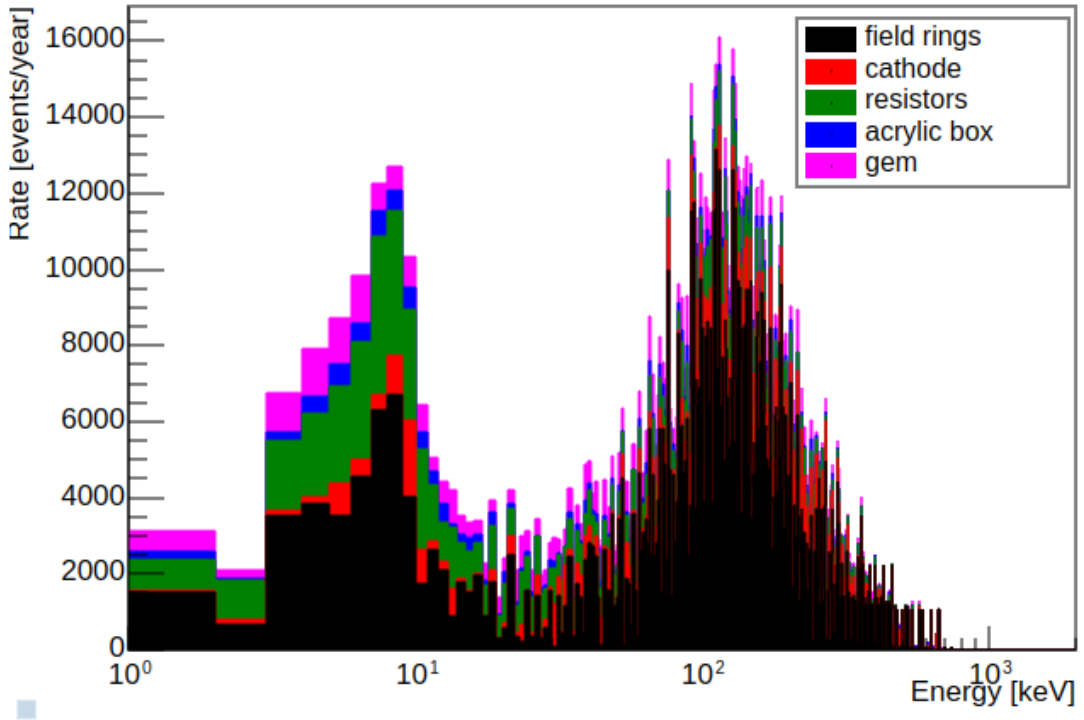
- Pre-reconstruction comparison
- External gammas only (it's the main contribution)
- Geometrical cut applied also to MC

Energy spectrum – MC simulation

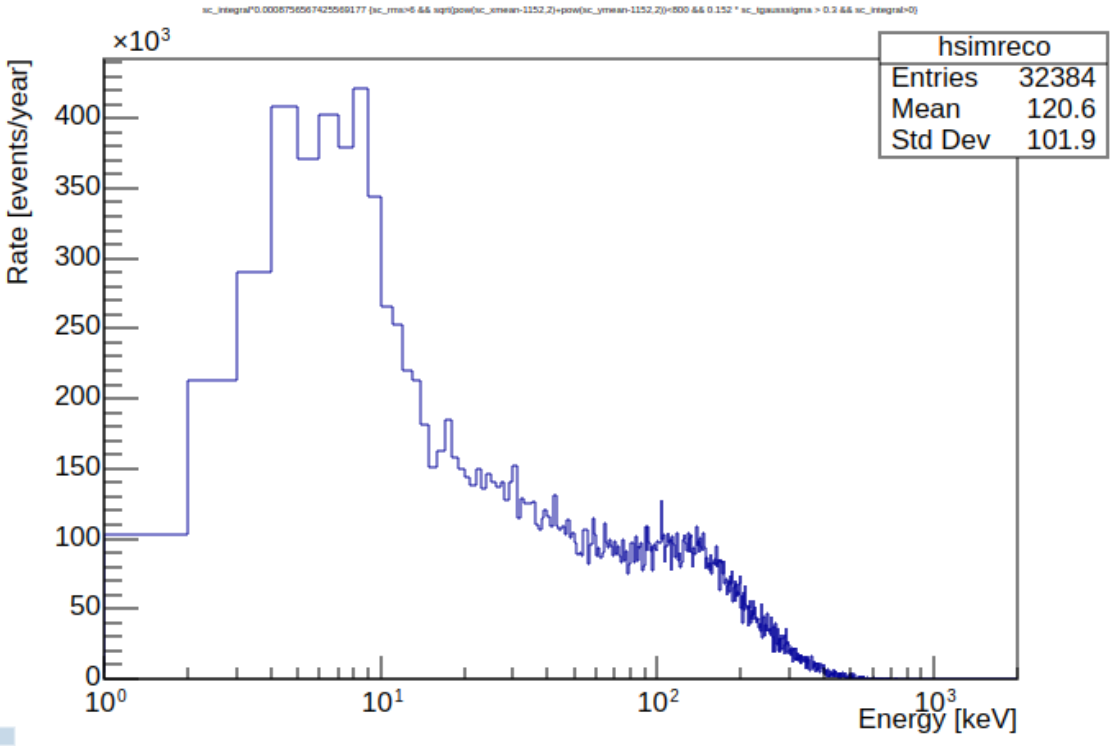


Pre-reco (MC truth) and **post-reco** energy spectrum of external gamma simulation comparison

Energy spectrum – MC simulation

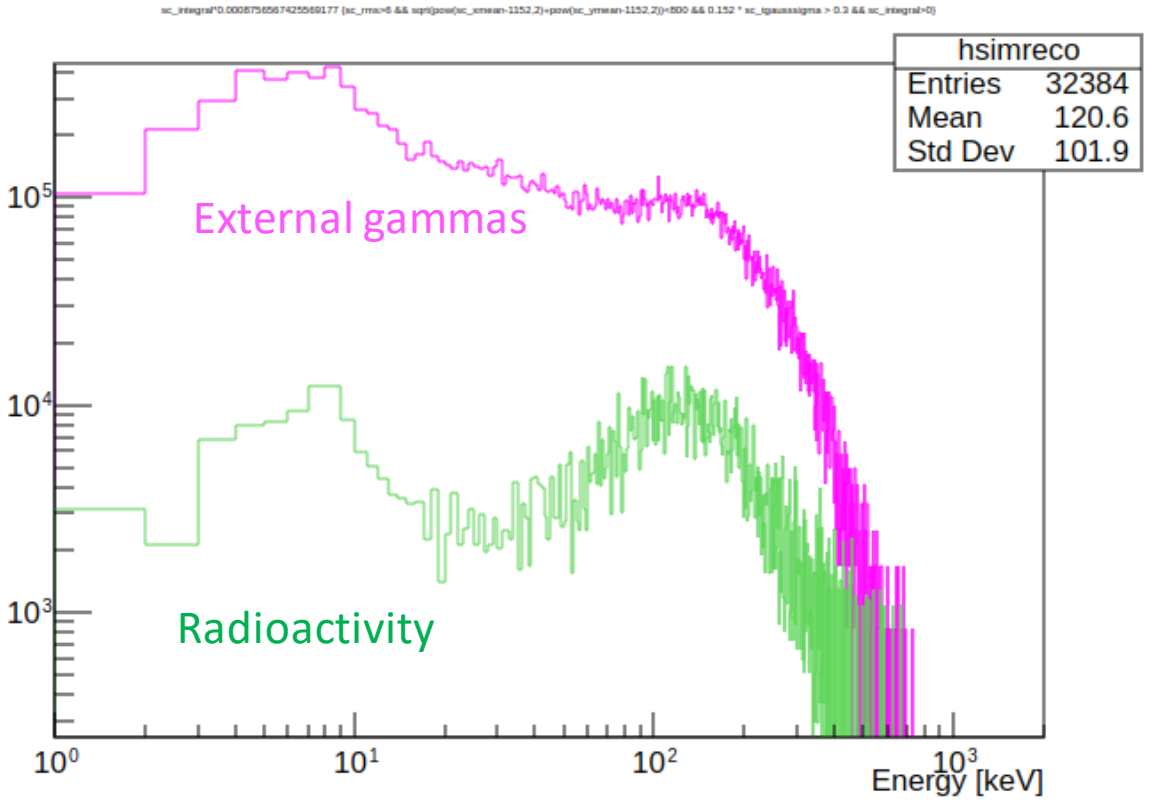


Internal radioactivity



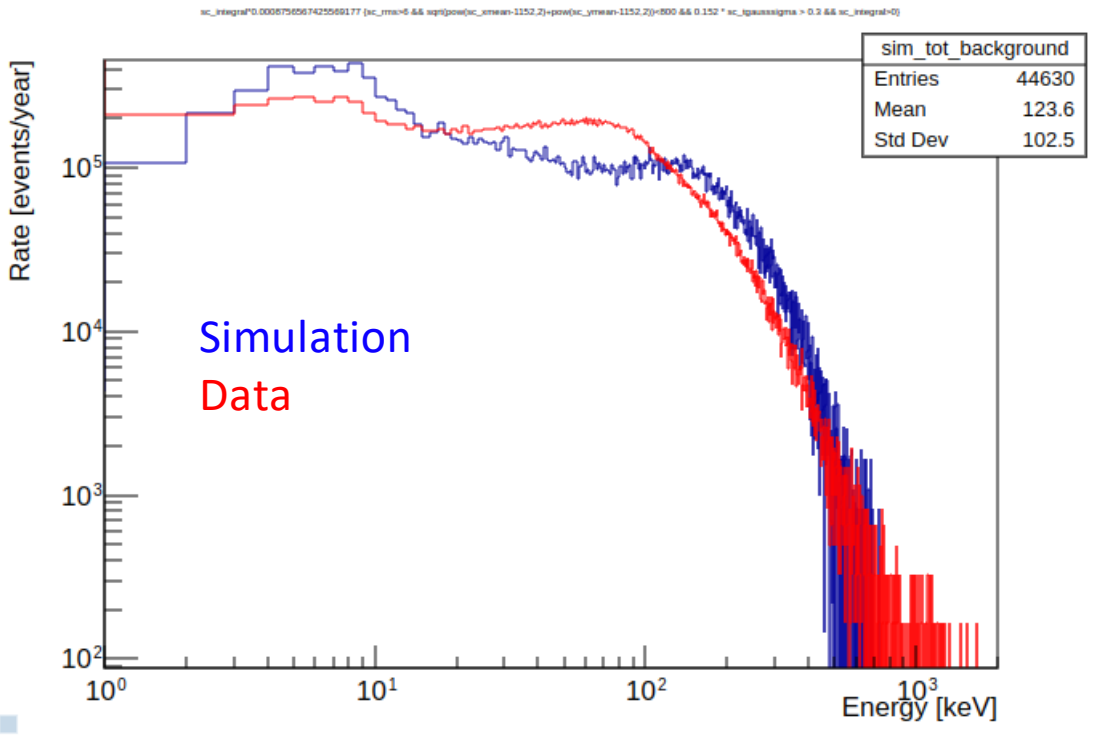
External gammas

Energy spectrum – MC simulation



- Same cuts as the data
- Normalization:
  - External gammas: 0.56 $cm^{-2}s^{-1}$ flux in Hall C (from Sabre), starting from a surface containing the whole setup
  - Radioactivity: for each detector component, each isotope simulation is normalized with the activity that was *measured* by M.Laubenstein underground

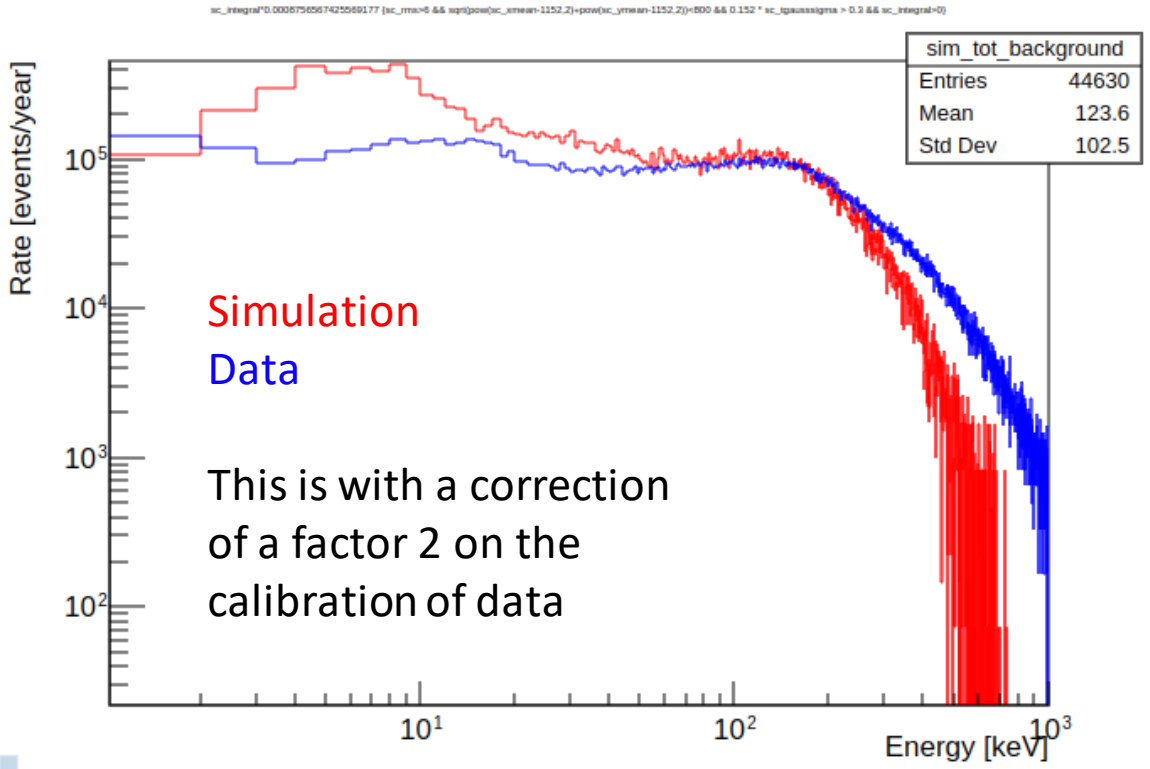
Energy spectrum comparison



Integral rates

- **Data**: 2.95x10^7 events/yr (0.93 Hz)
- External gammas simulation: 2.70x10^7 events/yr (0.86 Hz)
- Radioactivity simulation: 2.04x10^6 events/yr (0.065 Hz)
- **Total rate from simulation**: 2.90x10^7 events/yr (0.92 Hz)

Energy spectrum comparison



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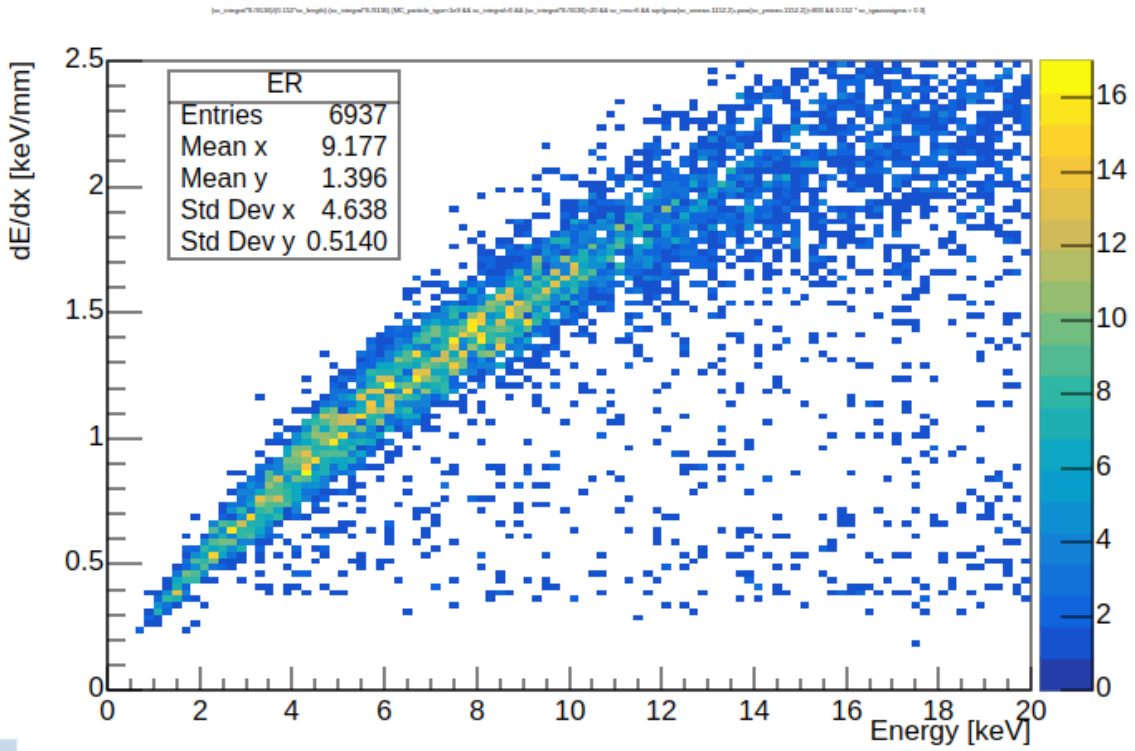
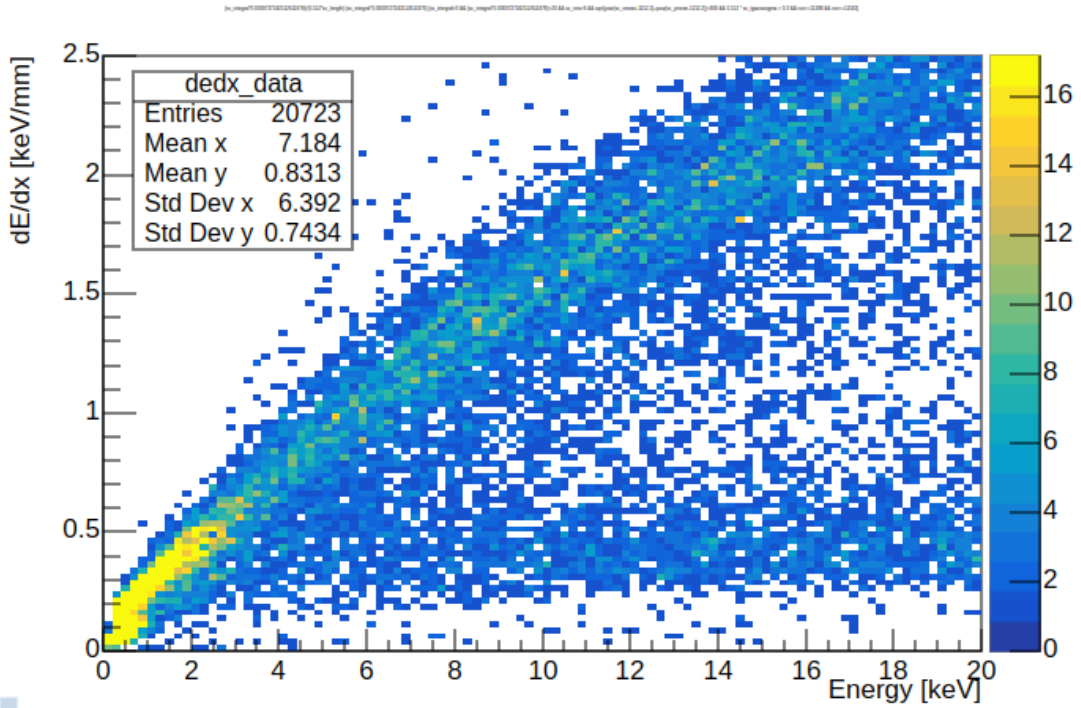
dE/dx vs energy

Simulation



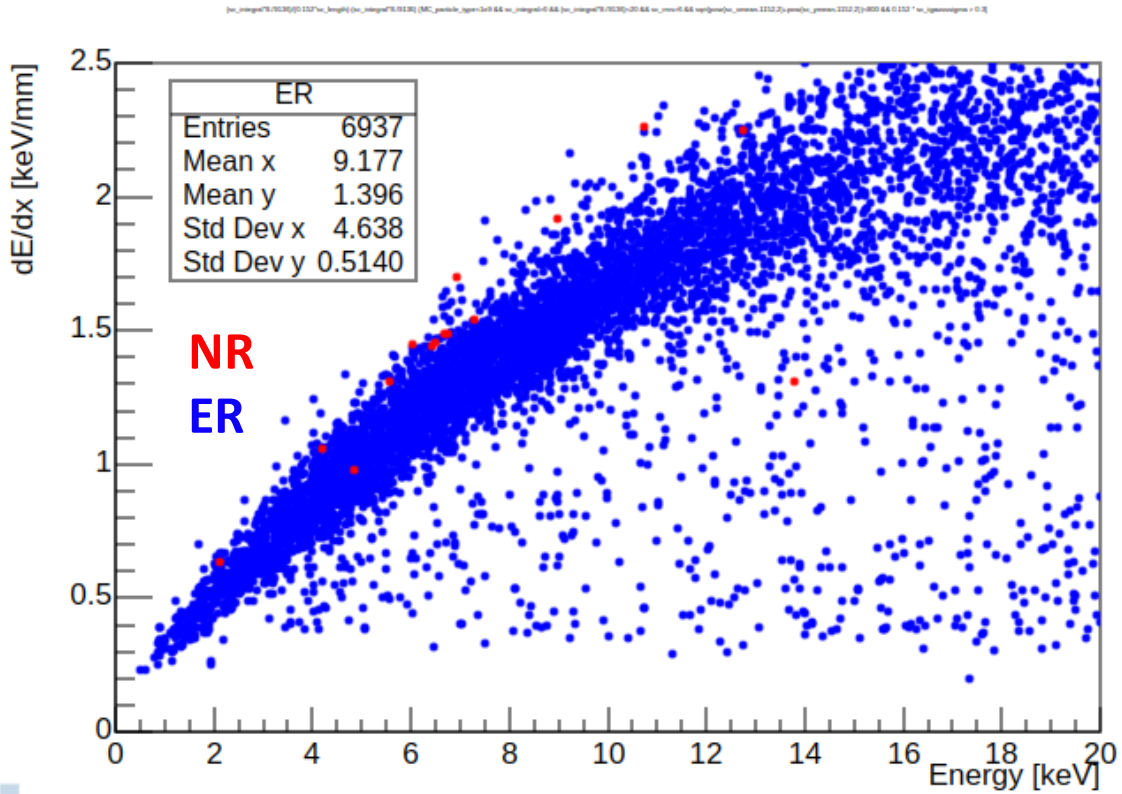
Data



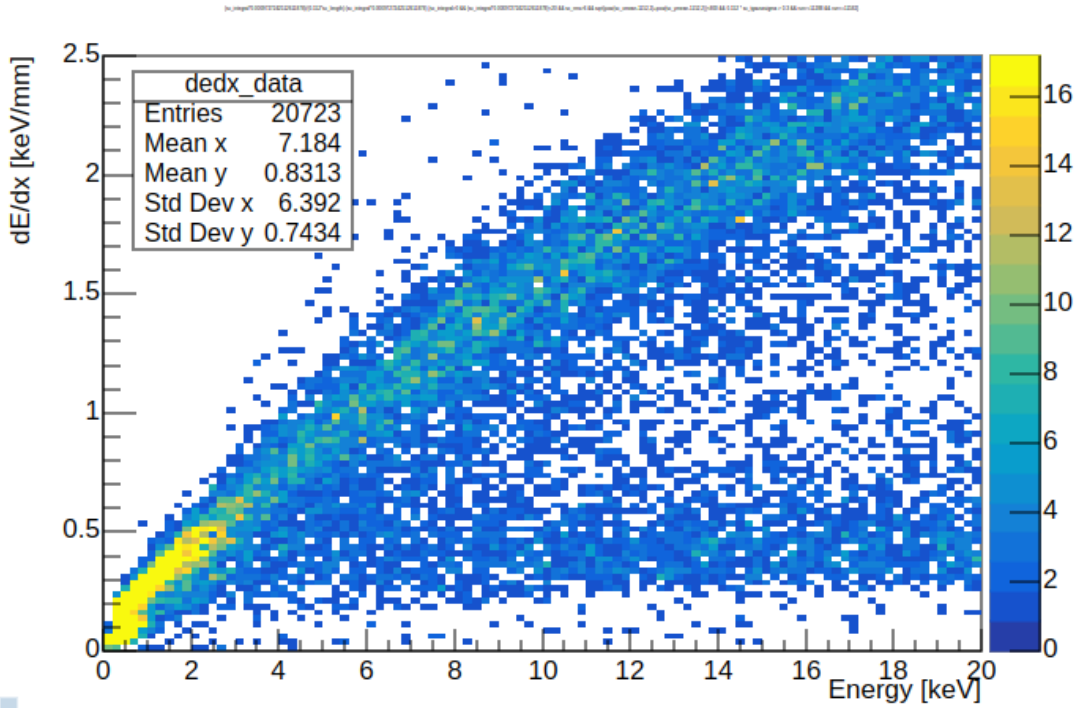
Calibration corrected

dE/dx vs energy (ER/NR separation)

Simulation

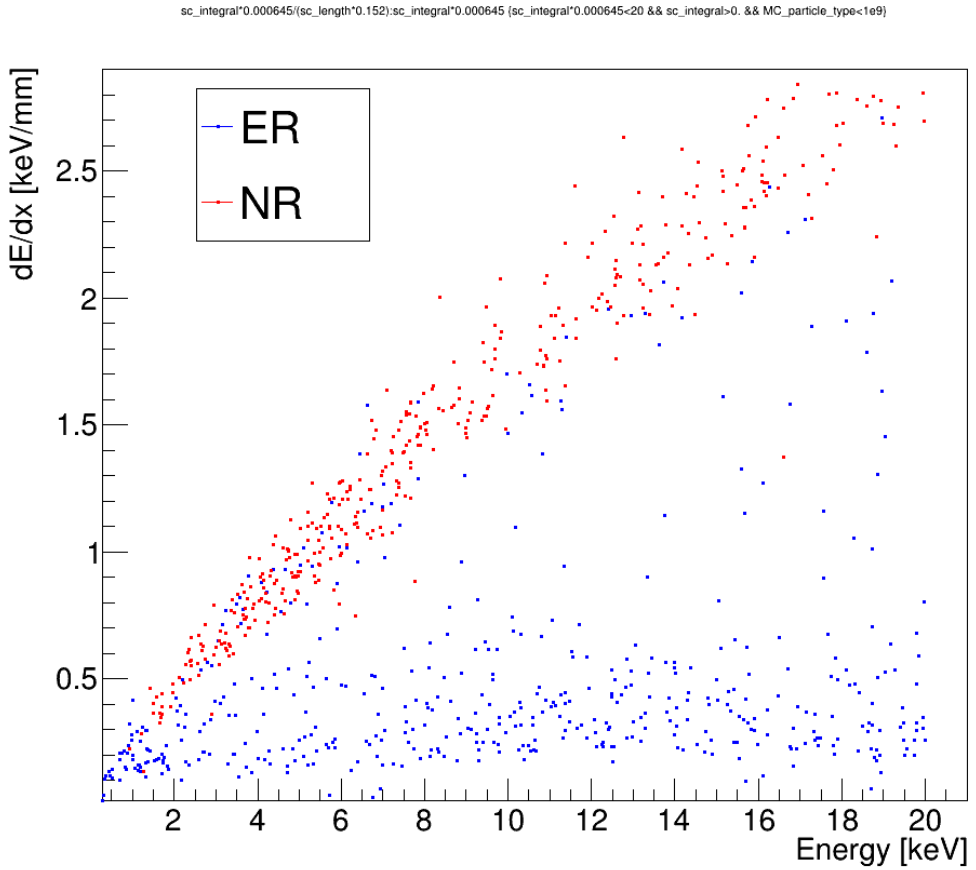


Data



Calibration corrected

Another example: AmBe simulation



- Geant4 simulation of the AmBe neutron source, in this case both ER and NR are produced in the sensitive gas and can be more easily compared
- NR and ER are divided in two bands

Next steps

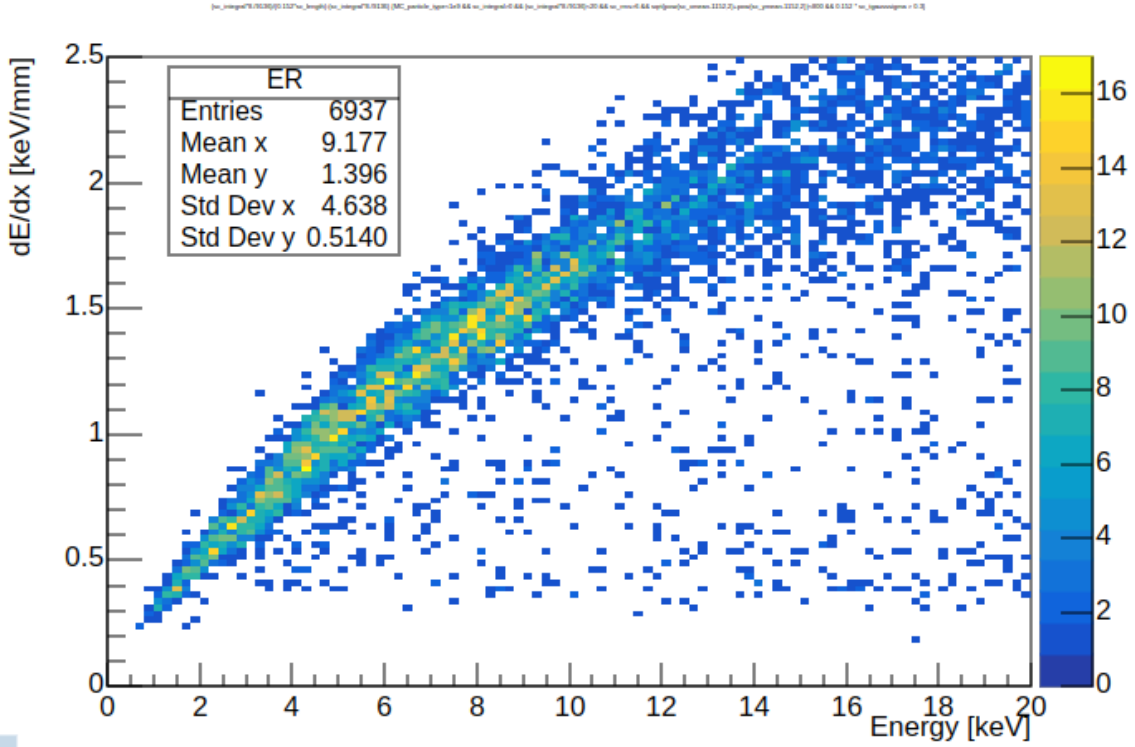
- Correct the calibration of data
- Compare MC to data after energy regression applied
  - Apply regression to simulation

Images
2D and 3D Event maps;
Evaluate detection efficiency vs E, x, y and z
Produce distributions of: E, length, angles
dE/dx vs E (2D, z, 3D)

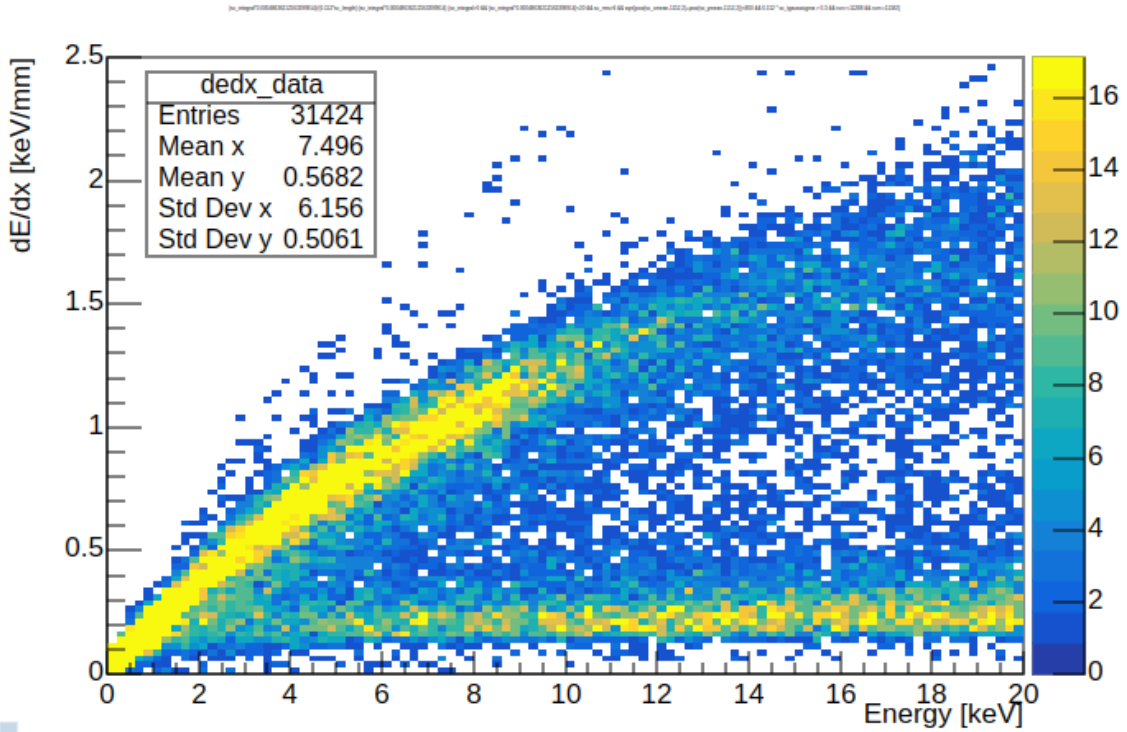
backup

dE/dx vs energy

Simulation



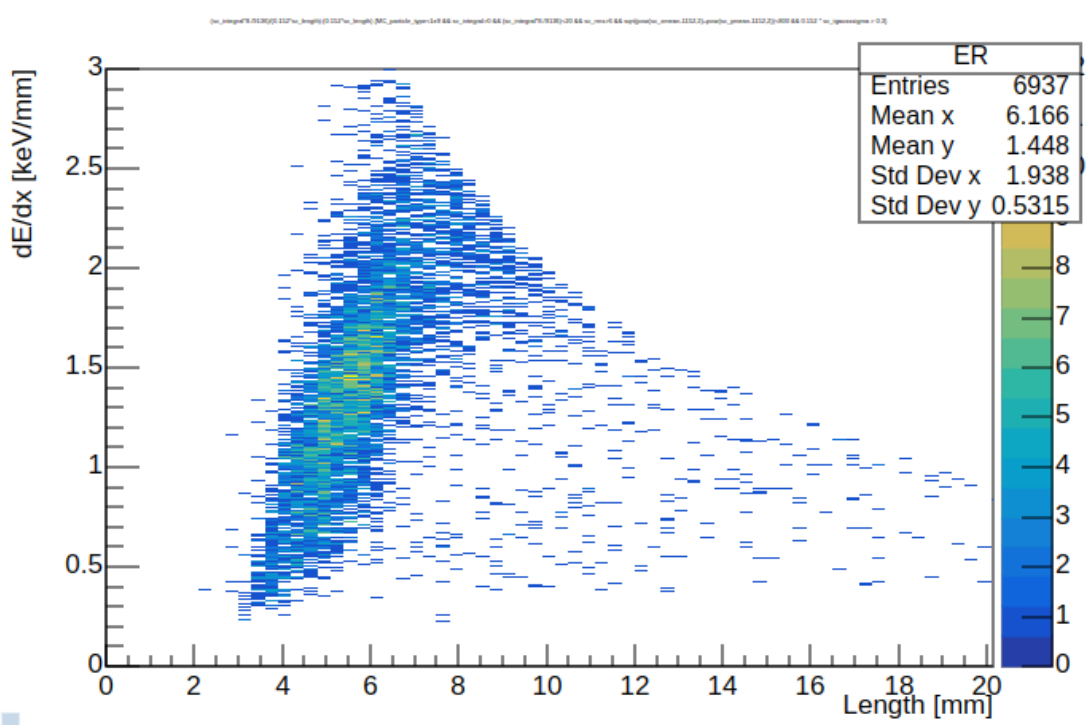
Data



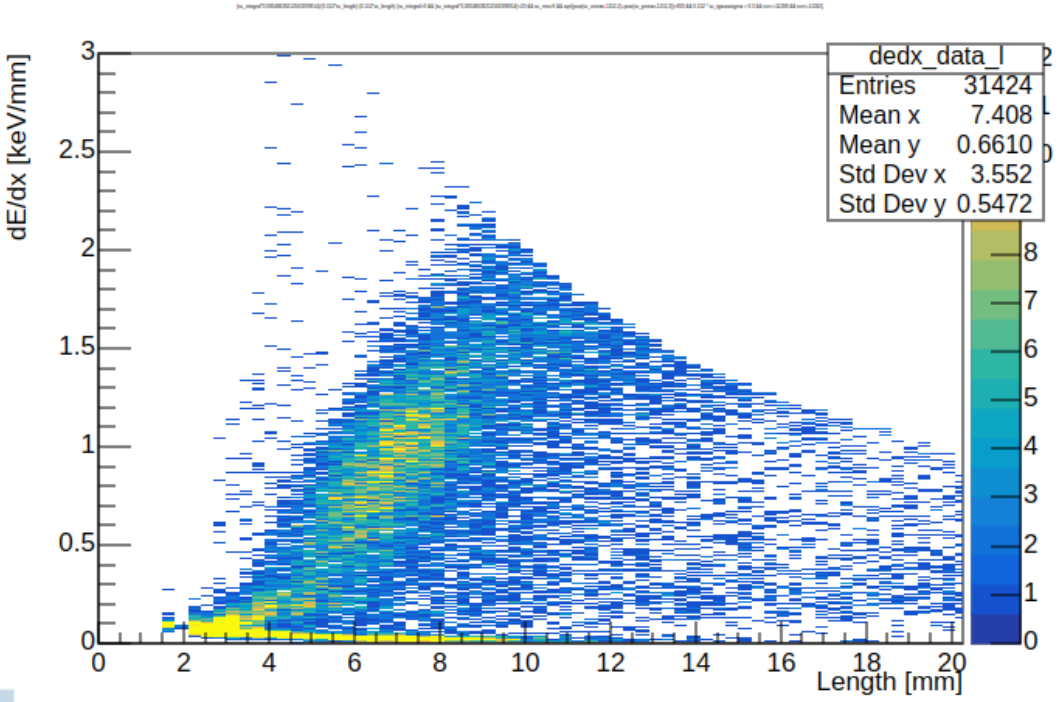
Calibration **not** corrected

dE/dx vs length

Simulation



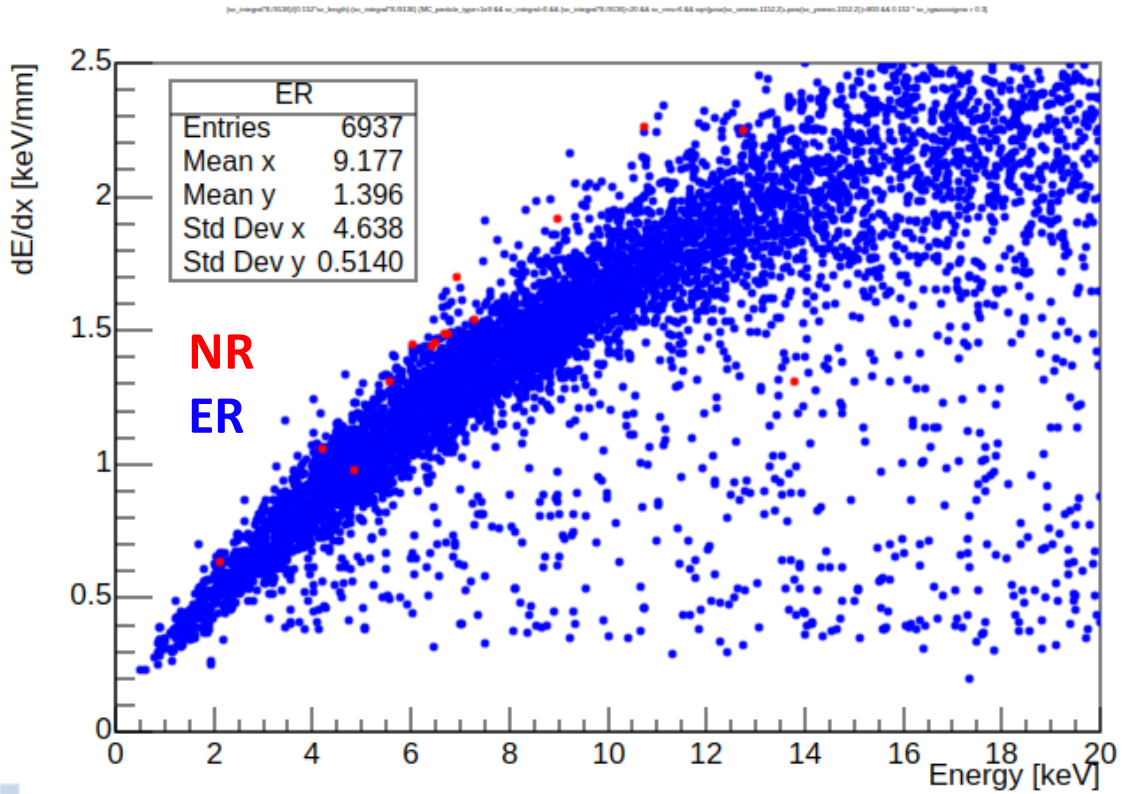
Data



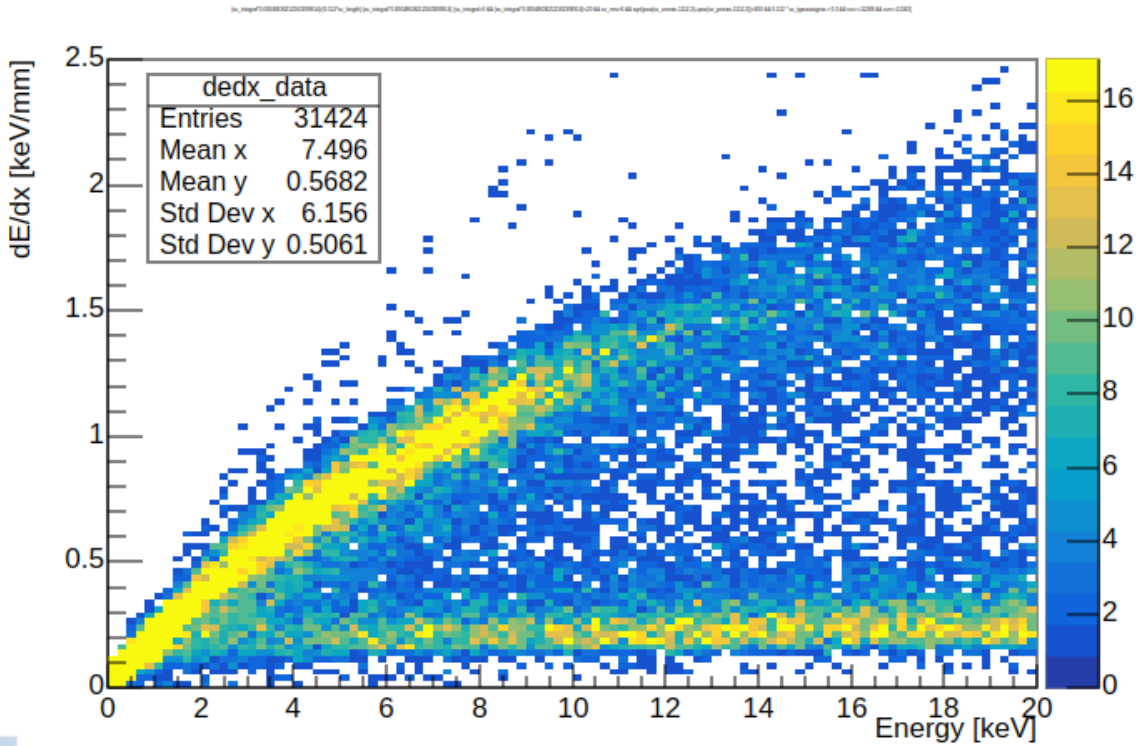
Calibration **not** corrected

dE/dx vs energy (ER/NR separation)

Simulation



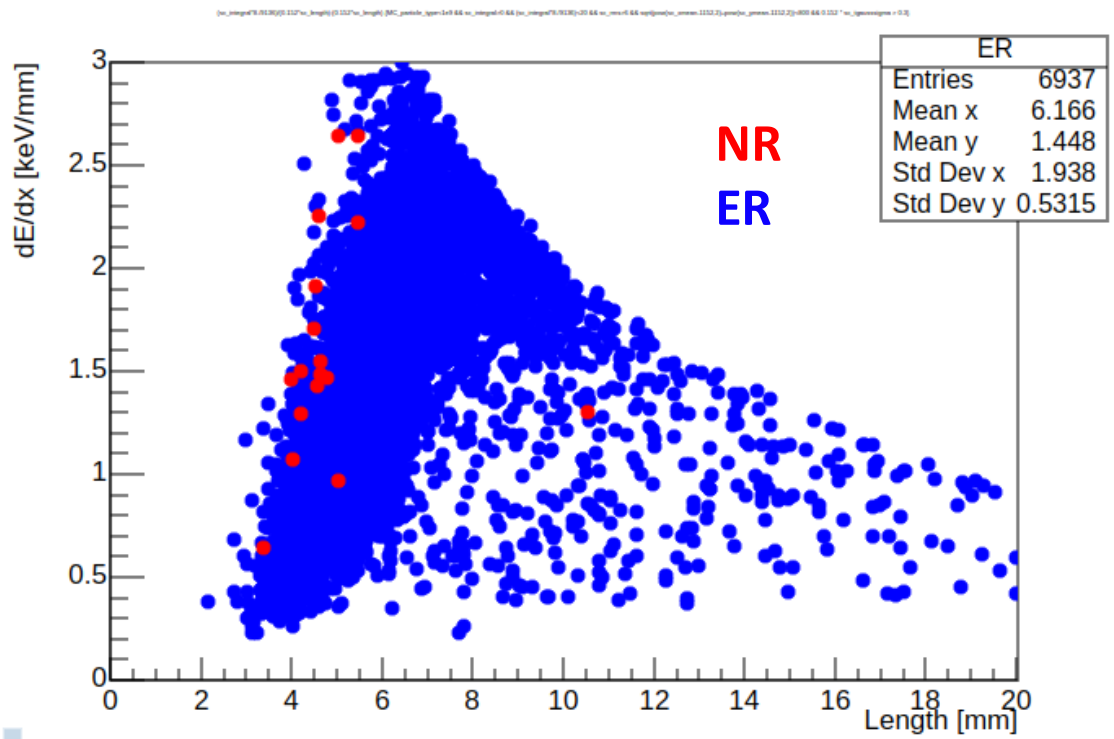
Data



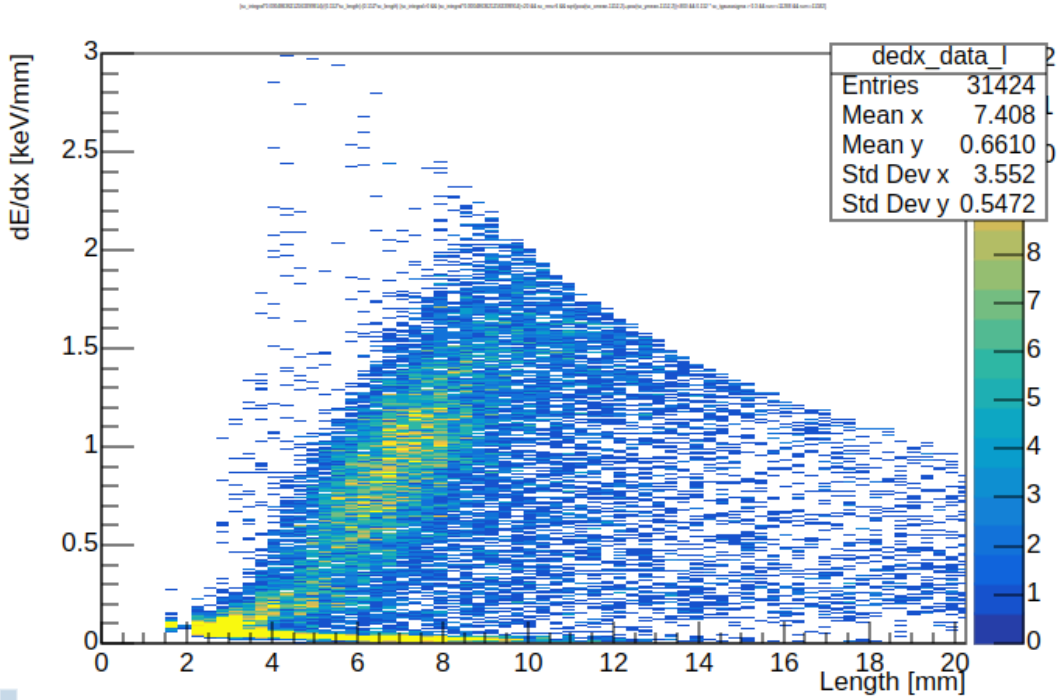
Calibration **not** corrected

dE/dx vs length (ER/NR separation)

Simulation



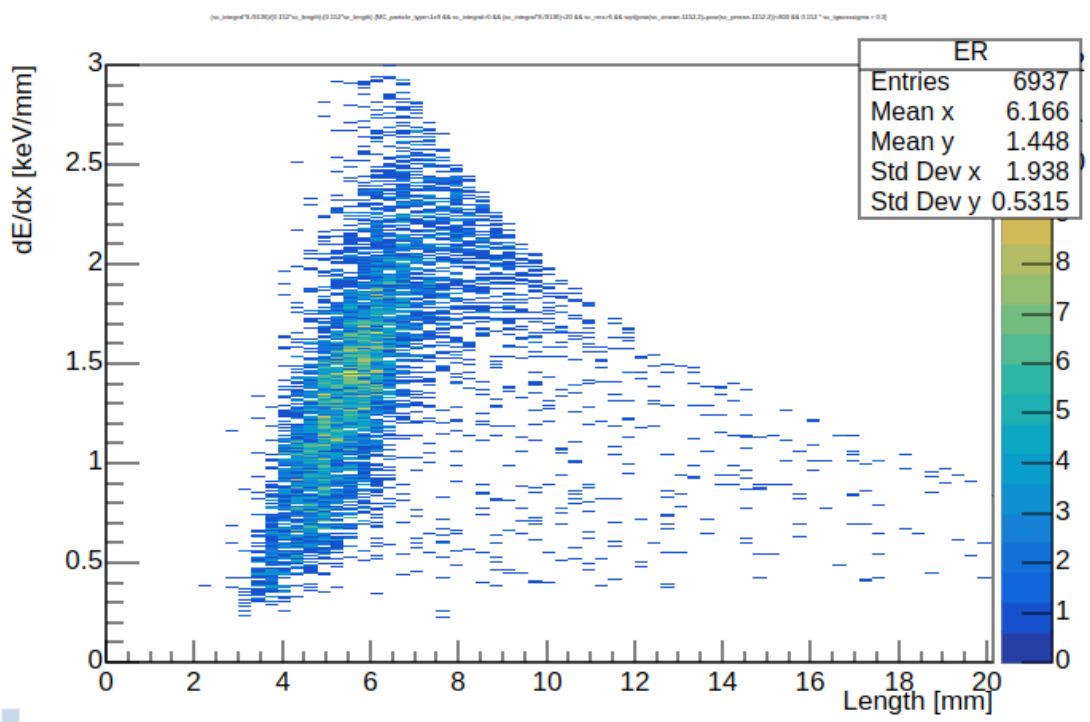
Data



Calibration **not** corrected

dE/dx vs length

Simulation



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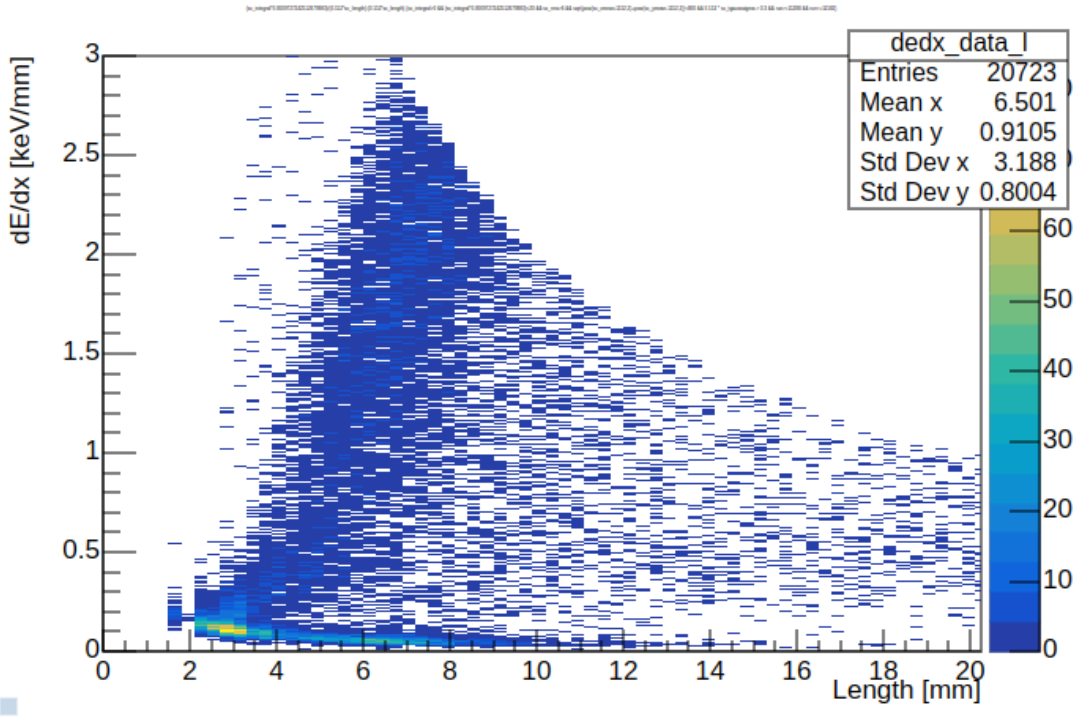
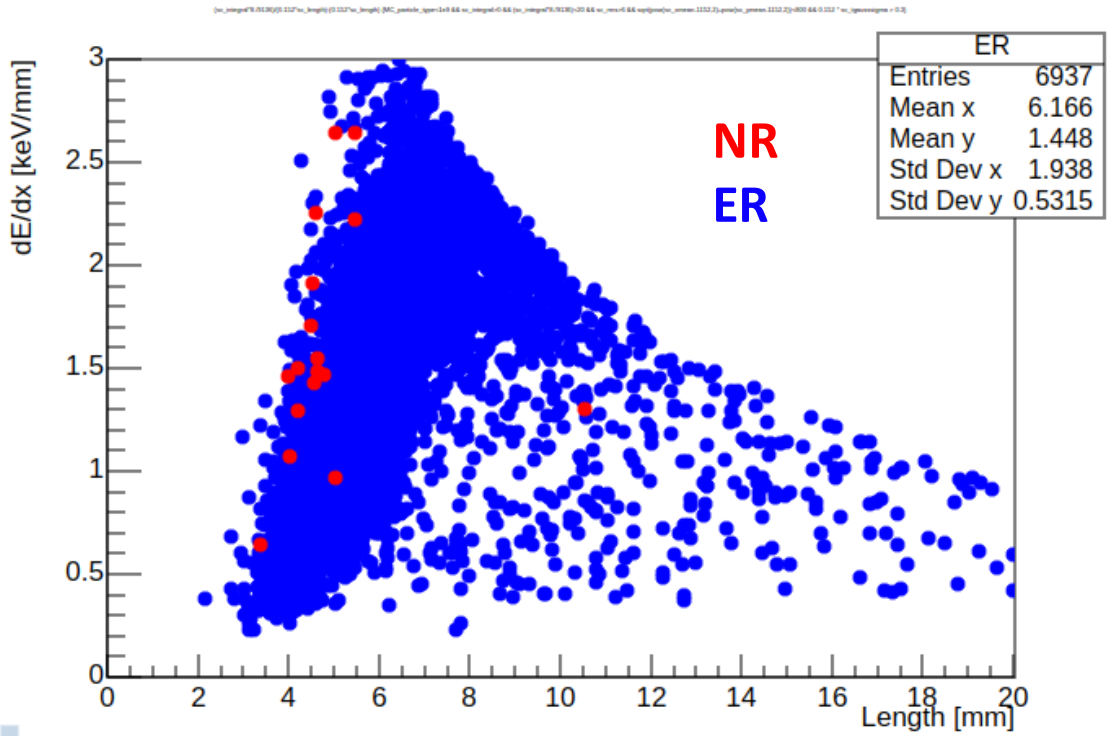


Calibration corrected

dE/dx vs length (ER/NR separation)

Simulation



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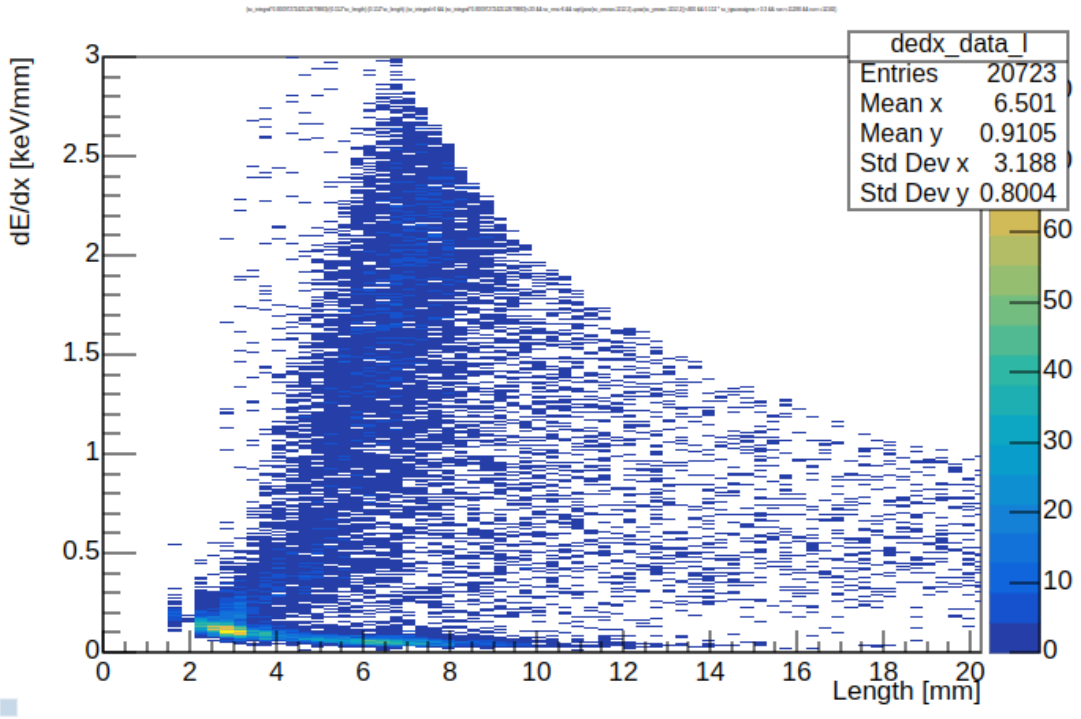

Calibration corrected