New data taking with AmBe and background rejection

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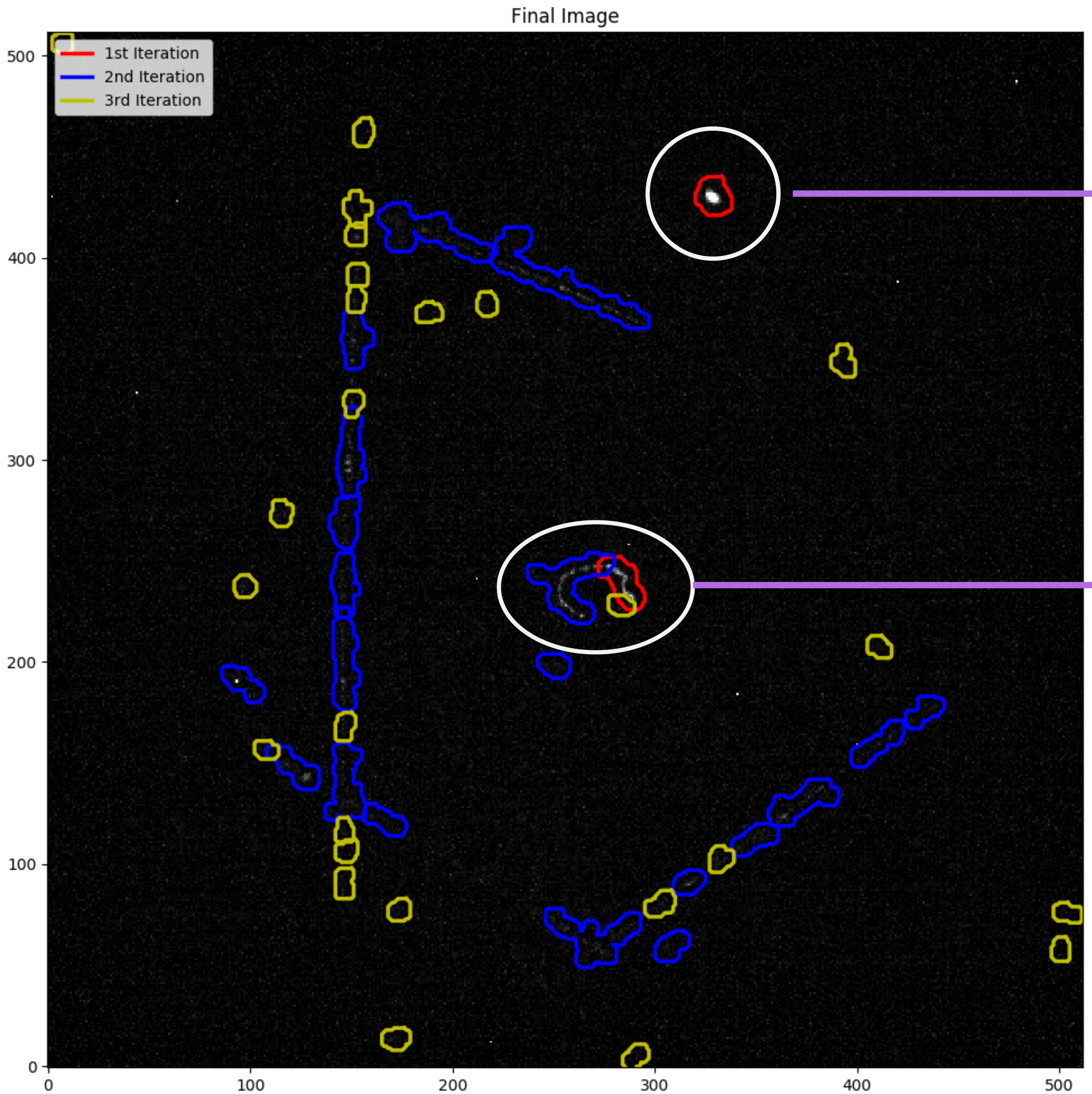
First look at AmBe (neutrons)

- Tuned the cluster reconstruction parameters to get efficiently α's and what seem nuclear recoils in iteration 1, and the rest into iteration 2
  - reminder: iteration 1 is made for "high-density" clusters
  - iteration 2 is made for medium/low-energy clusters (e.g. 5.9 keV spots from Fe55, typical ambient radioactivity, cosmics products…)
- Achieved:
  - all the Fe55 is well separate (checked with the energy peak) => go to iter-2
- Problem:
  - there are clusters, pieces of the ubiquitous cosmics, that go into iteration 1
    - **=> iter-1 is not a pure sample of recoils**
- Possible solutions:
  - these are pieces of longer tracks, so they could be rejected by the supercluster length
  - at the moment not done, because the supercluster runs on separate classes (iterations) of clusters
    - => need to run the superclustering on the OR of it1 + it2 clusters

example: clusters in AmBe run



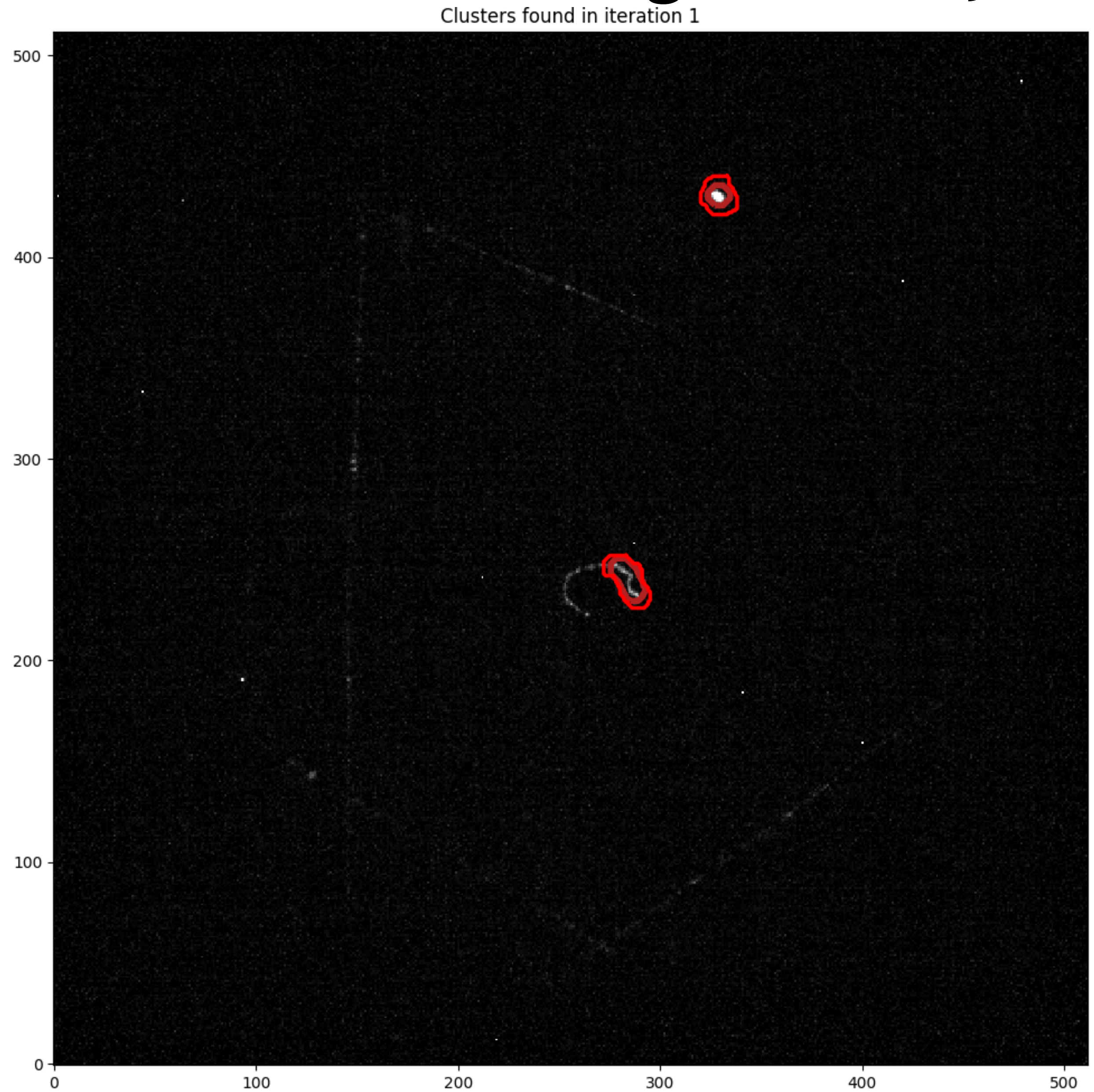
Good recoil?

Two clusters with different iterations clearly from the same track

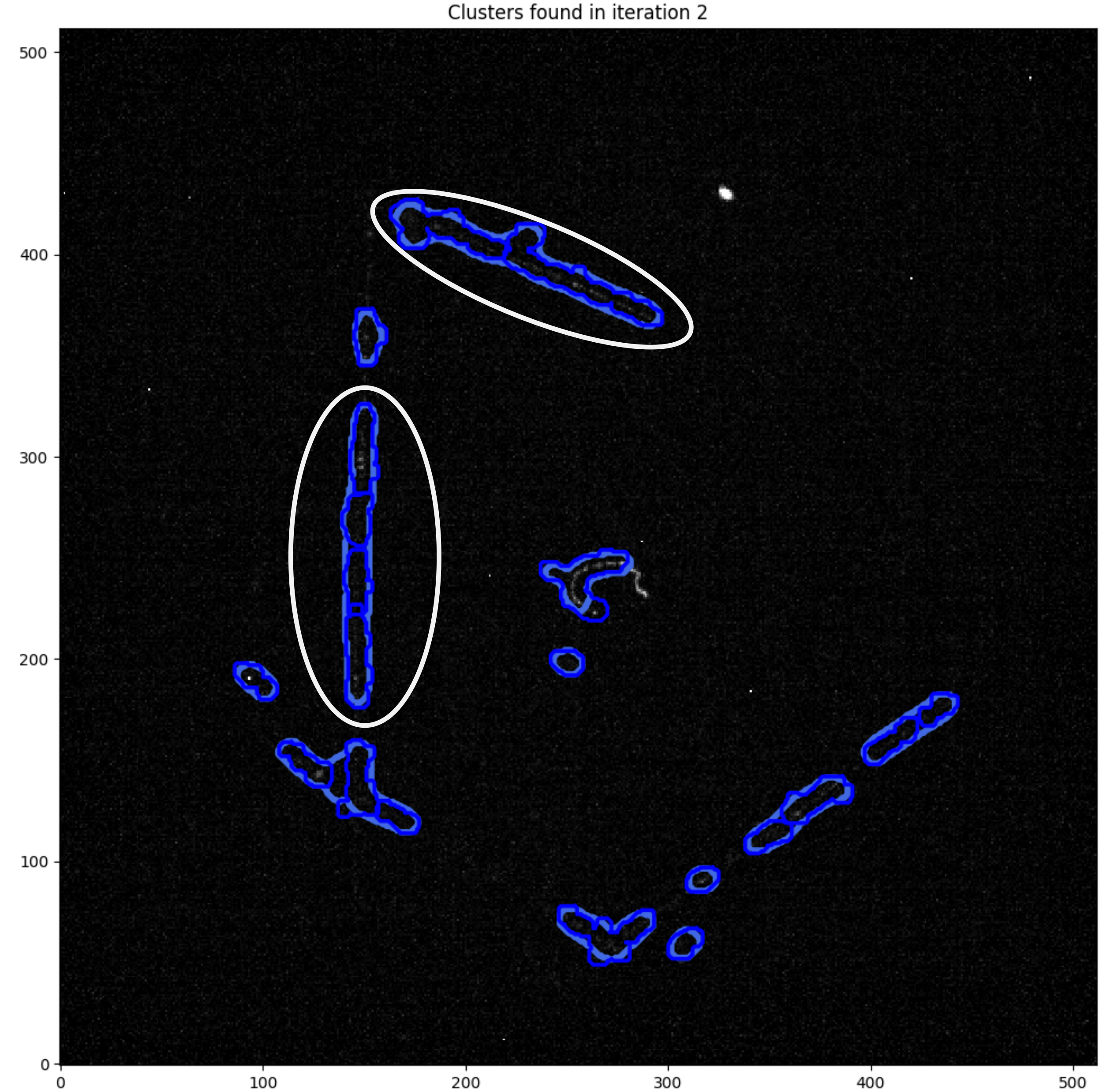
Clustering step

super-clusters in AmBe run

iteration 1: high density



iteration 2: medium density

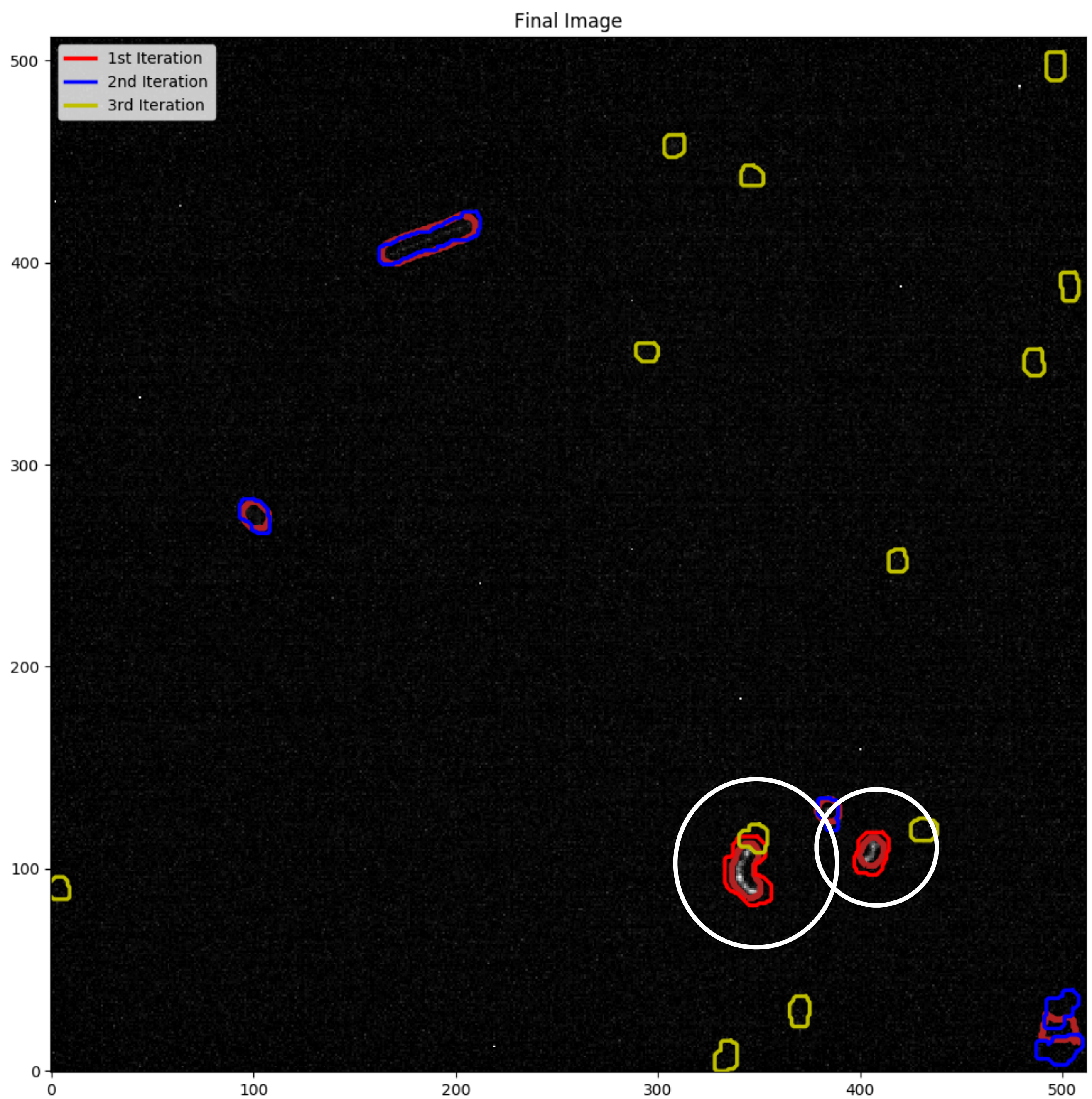


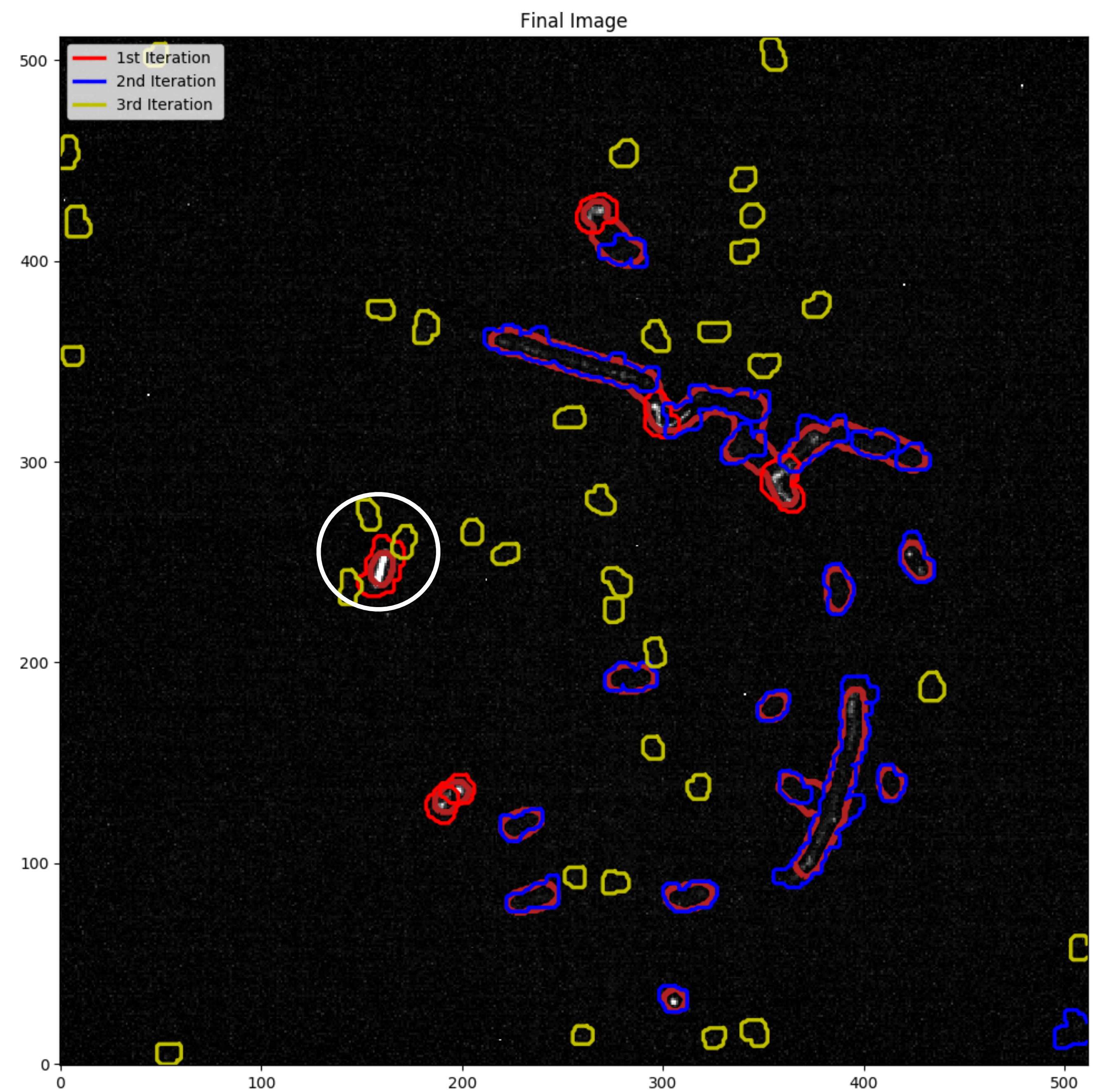
superclusters in it2 join pieces of tracks belonging to the same iteration, but by construction cannot join it1 + it2

Will change that to help the discrimination against "cosmics"

side note: not a big problem underground…

typical candidates

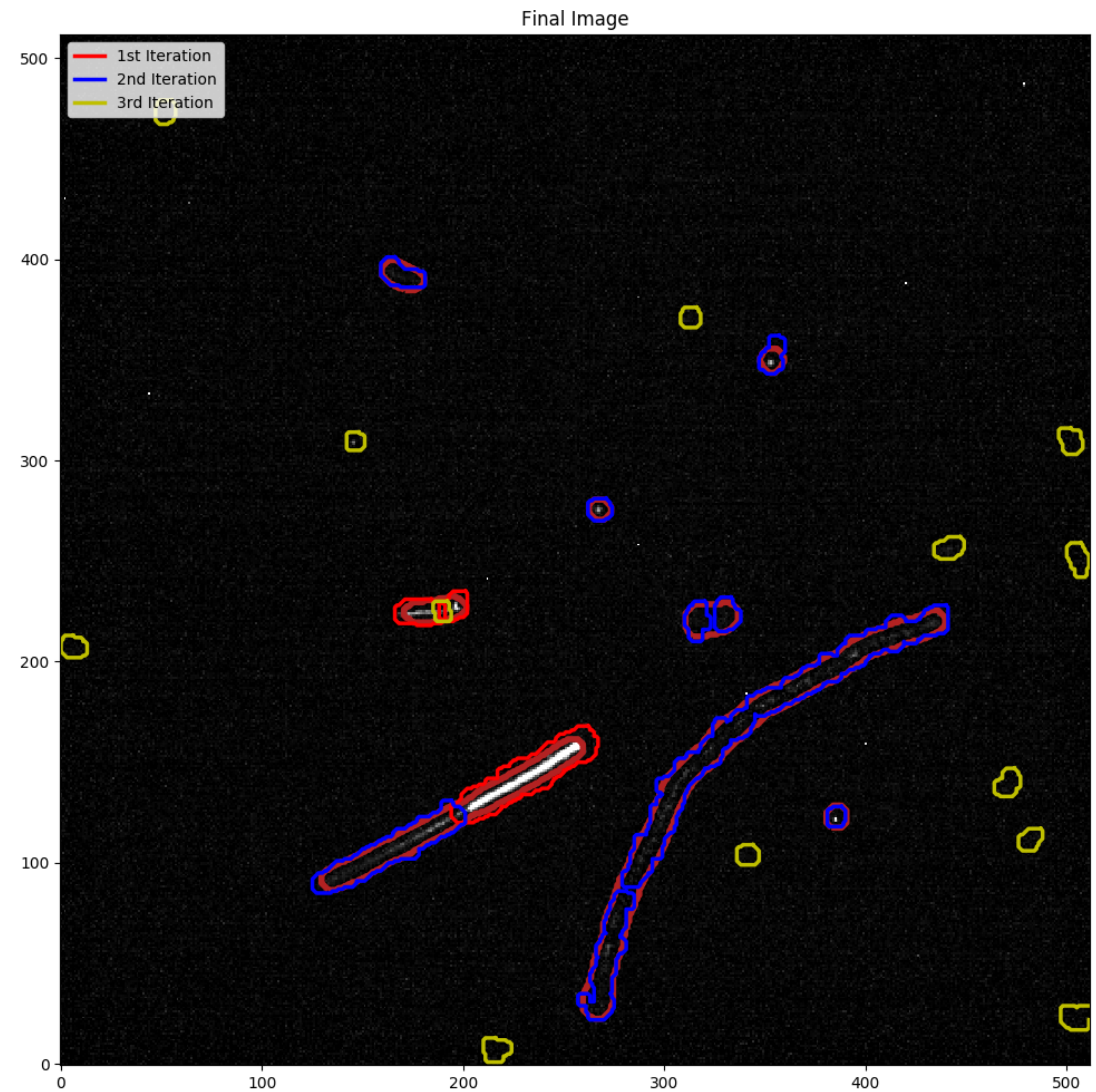




e.g. of 1 selected cluster

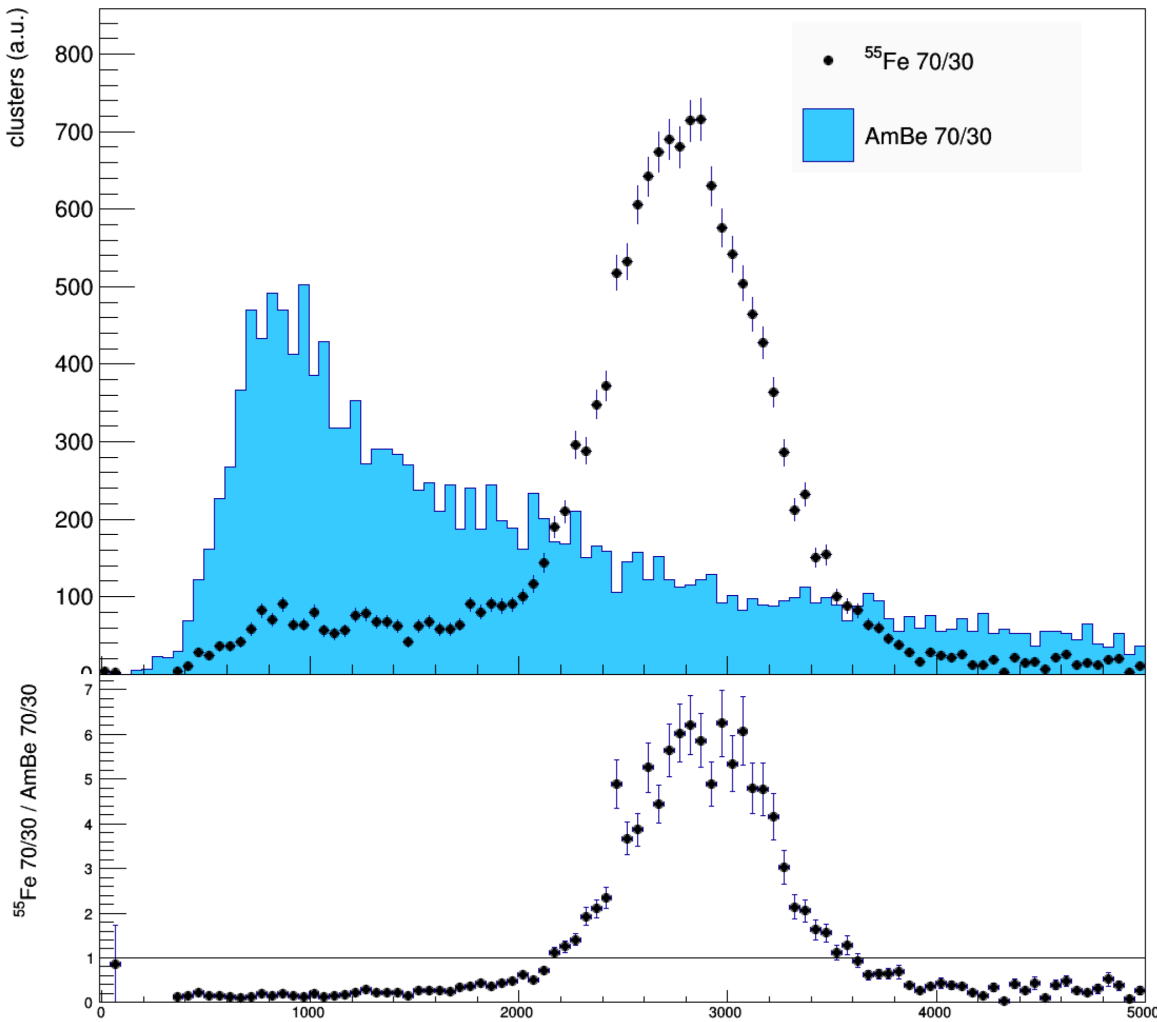
- One strange example with one **probably proton** track with two different “light-yield zones”

P.S. already implemented the supercluster inclusive wrt iterations

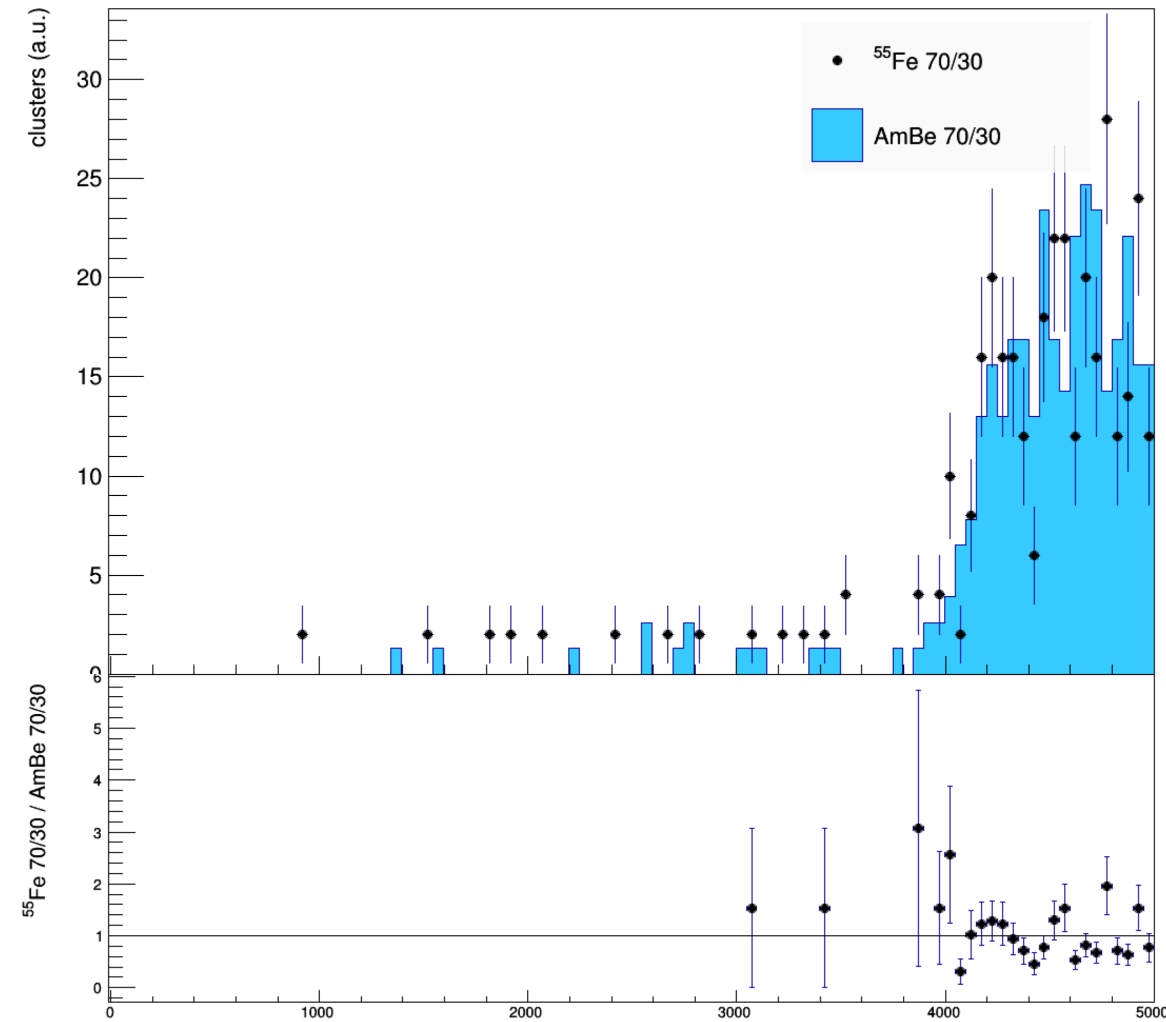


^{55}Fe vs AmBe: energy of the 2 classes

- Reconstructed Fe55 and AmBe with the same reconstruction parameters (runs of the same day)



photons



photons

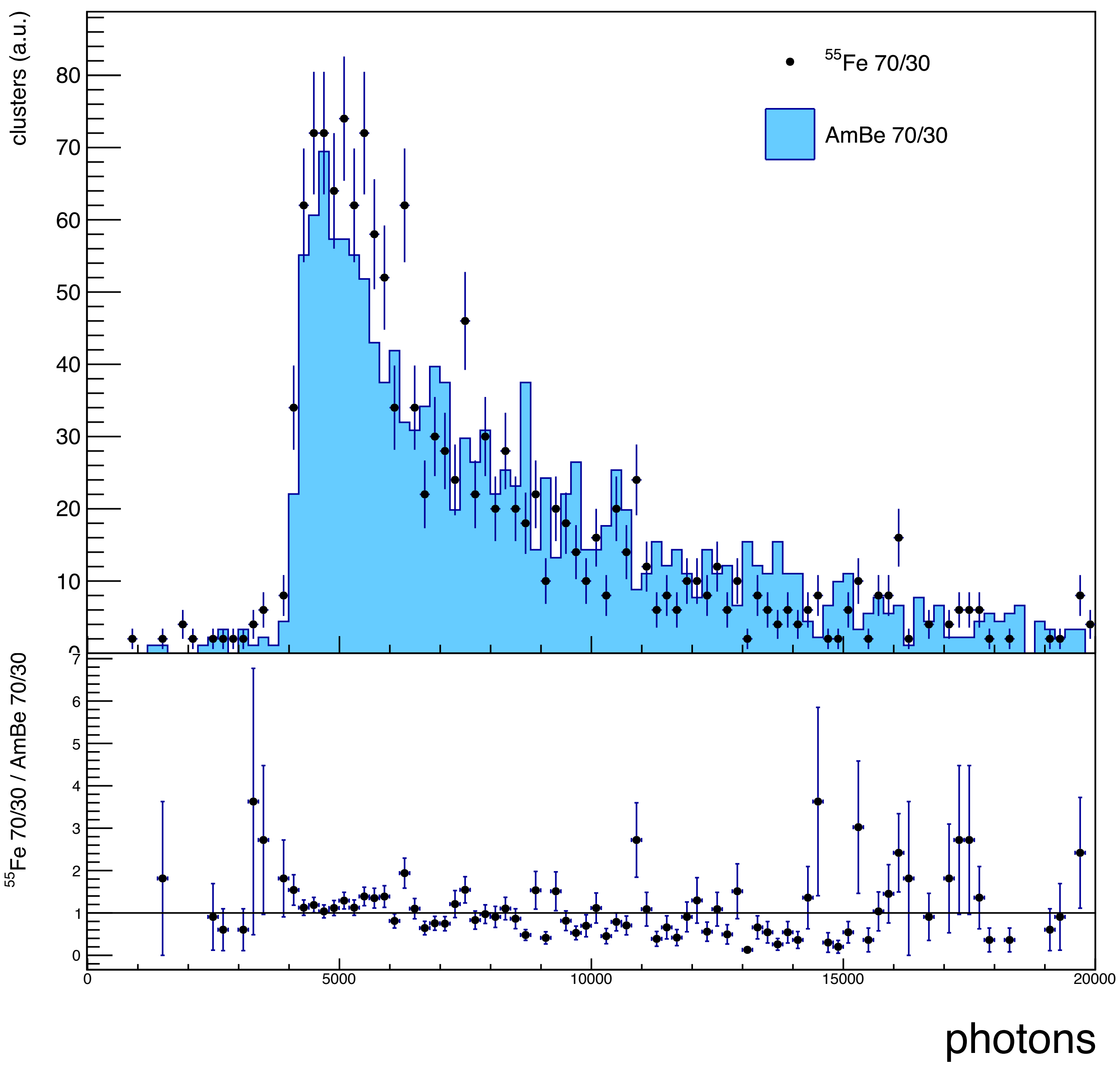
iteration 2:

- gets the Fe55 peak (~2.8k photons)
- gets the bkg (note: same shape in Fe and AmBe)

iteration 1:

- do not get any part of the Fe55 peak (i.e. it's a decent discriminator)
- gets higher energy (full spectrum later)

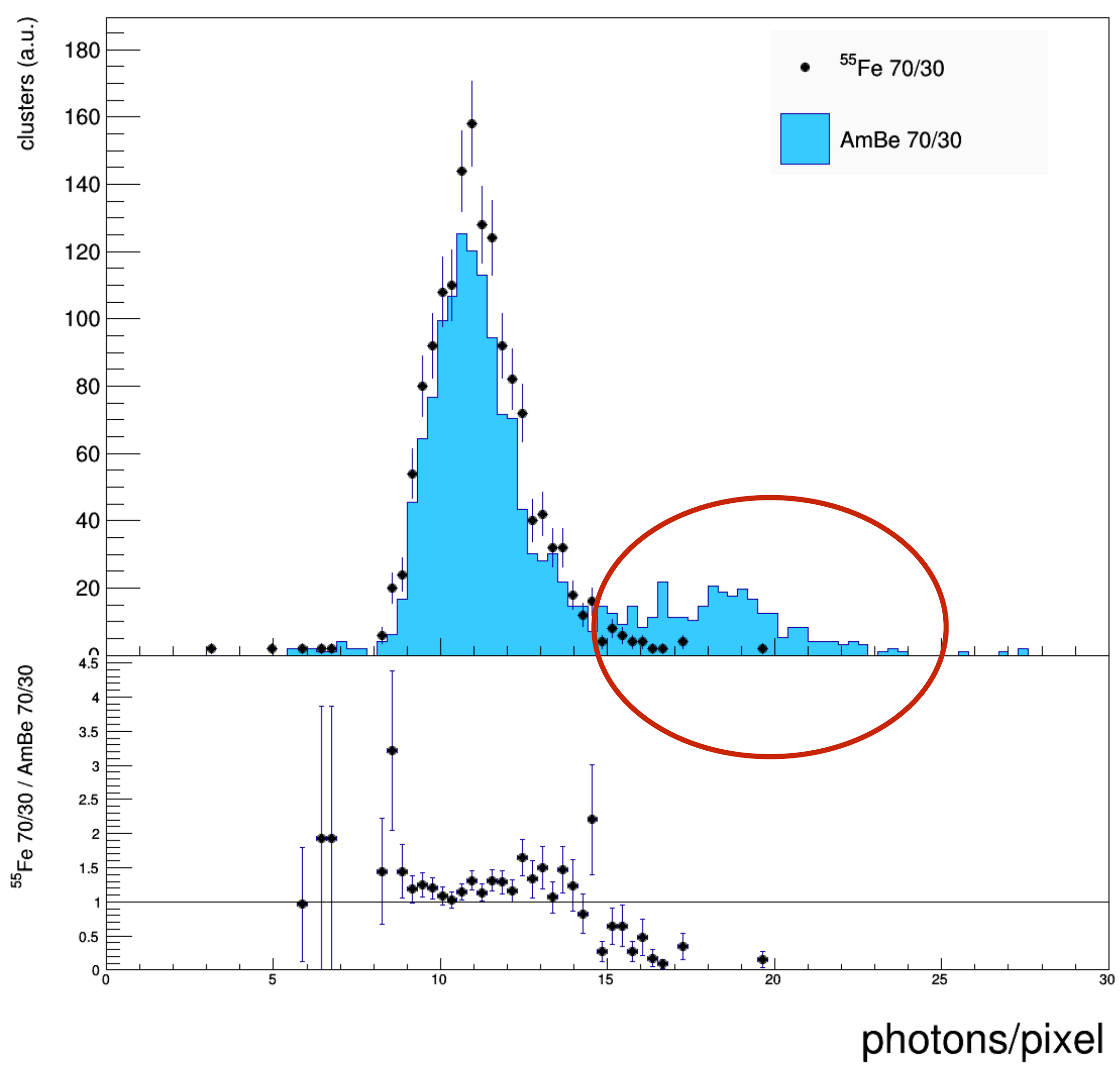
^{55}Fe vs AmBe: energy of iter-1



- The spectrum **in the mid-range** (calibrated energy in [10.3 - ~40 keV]) is very similar between the AmBe and Fe55 run
- **indeed these are MOSTLY pieces of cosmic-induced background, which are present both in Fe55 and AmBe runs**
- Also, the AmBe source was screened a lot, so it's a small contribution to this spectrum (if any, in the tails also, see later…)

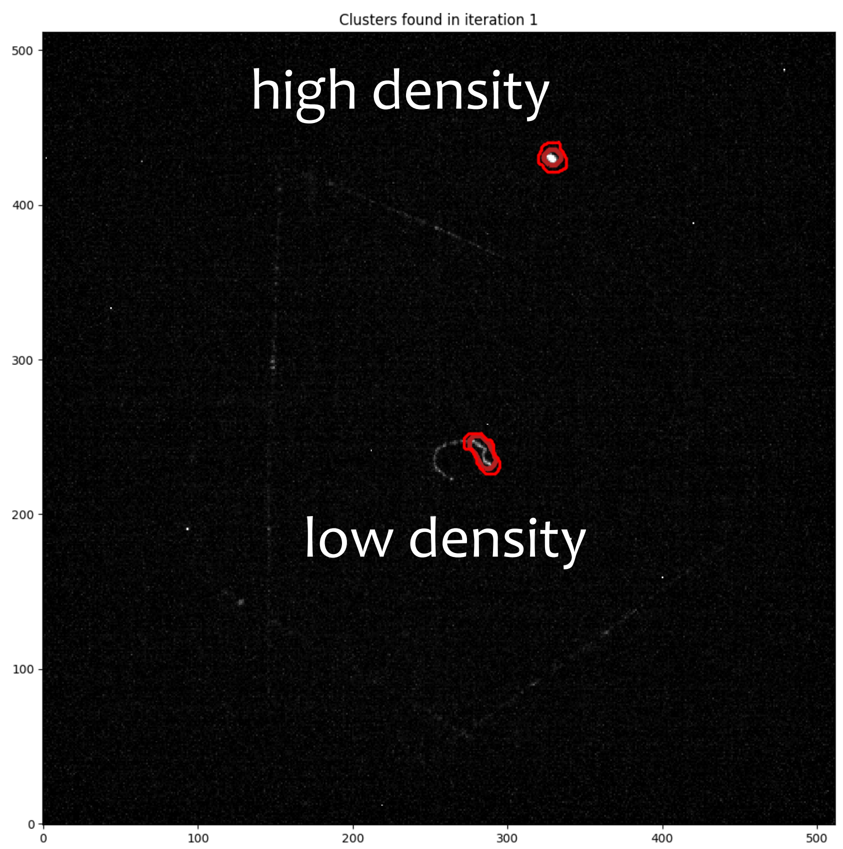
do we see anything?

- Length, width, slimness, etc. are all very similar (should be solved as said by “superclustering” the OR of it1 and it2)
- **apart the density: #photons/pixels in the cluster: the bump > 15 is only in AmBe runs**



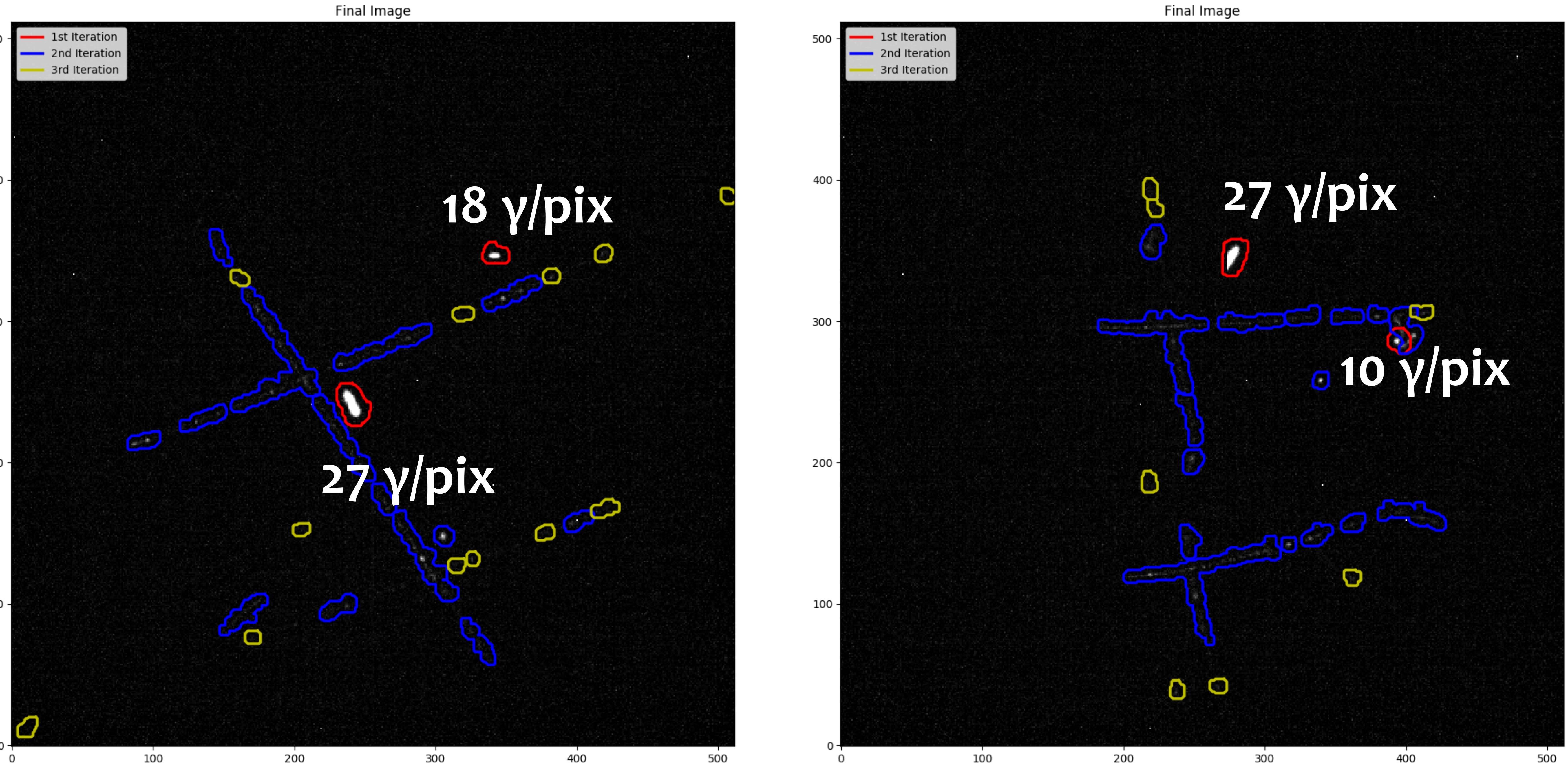
can try to select those

e.g. the two it1 clusters of the previous image were 1 high/1low density



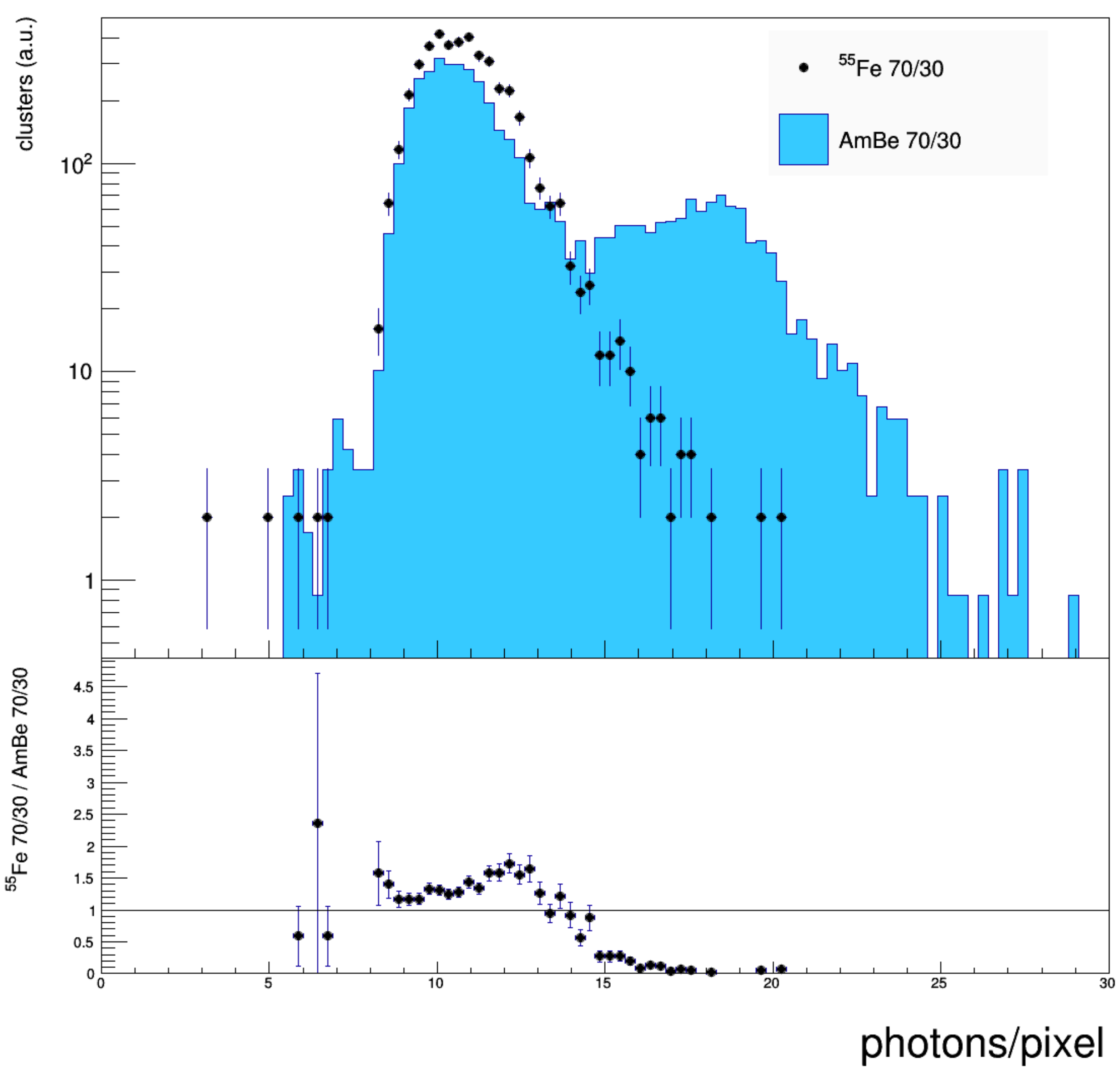
other examples

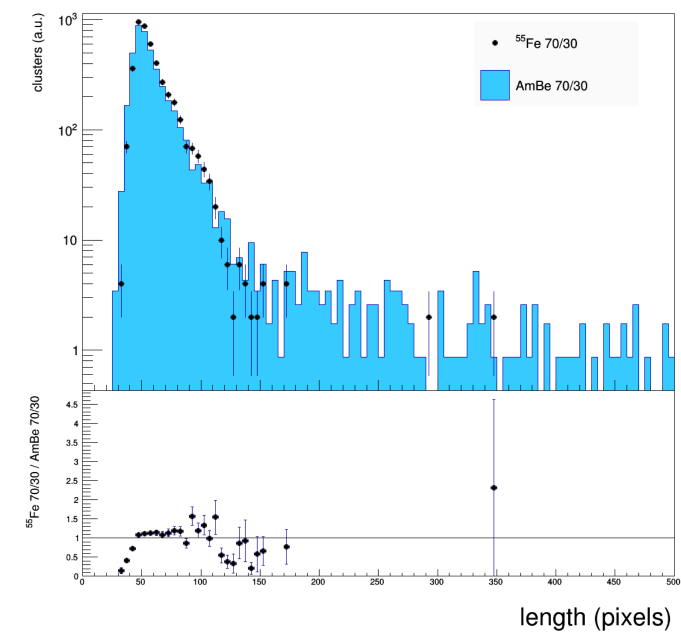
- looking at O(10) images, it seems that density>15 selects good recoil candidates



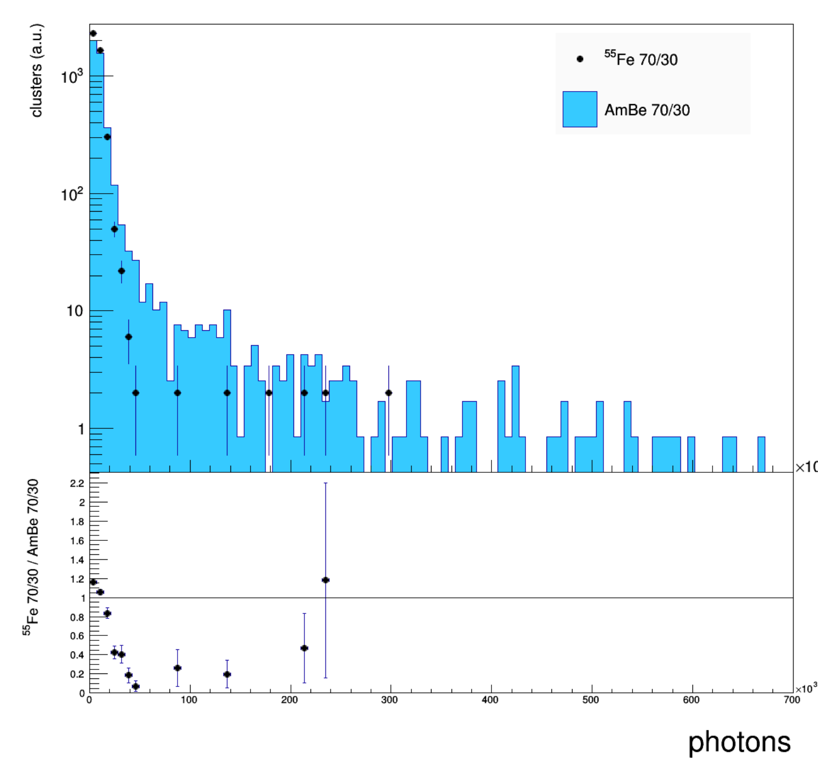
Very similar to α's

- N.B. The previous plots are cutting in the center of the FC ellipse (~1/2 of the area), to remove the protons coming from the interactions with the FC.
- Looking at the full volume the number of high-density clusters increases, as it should, because very long α tracks





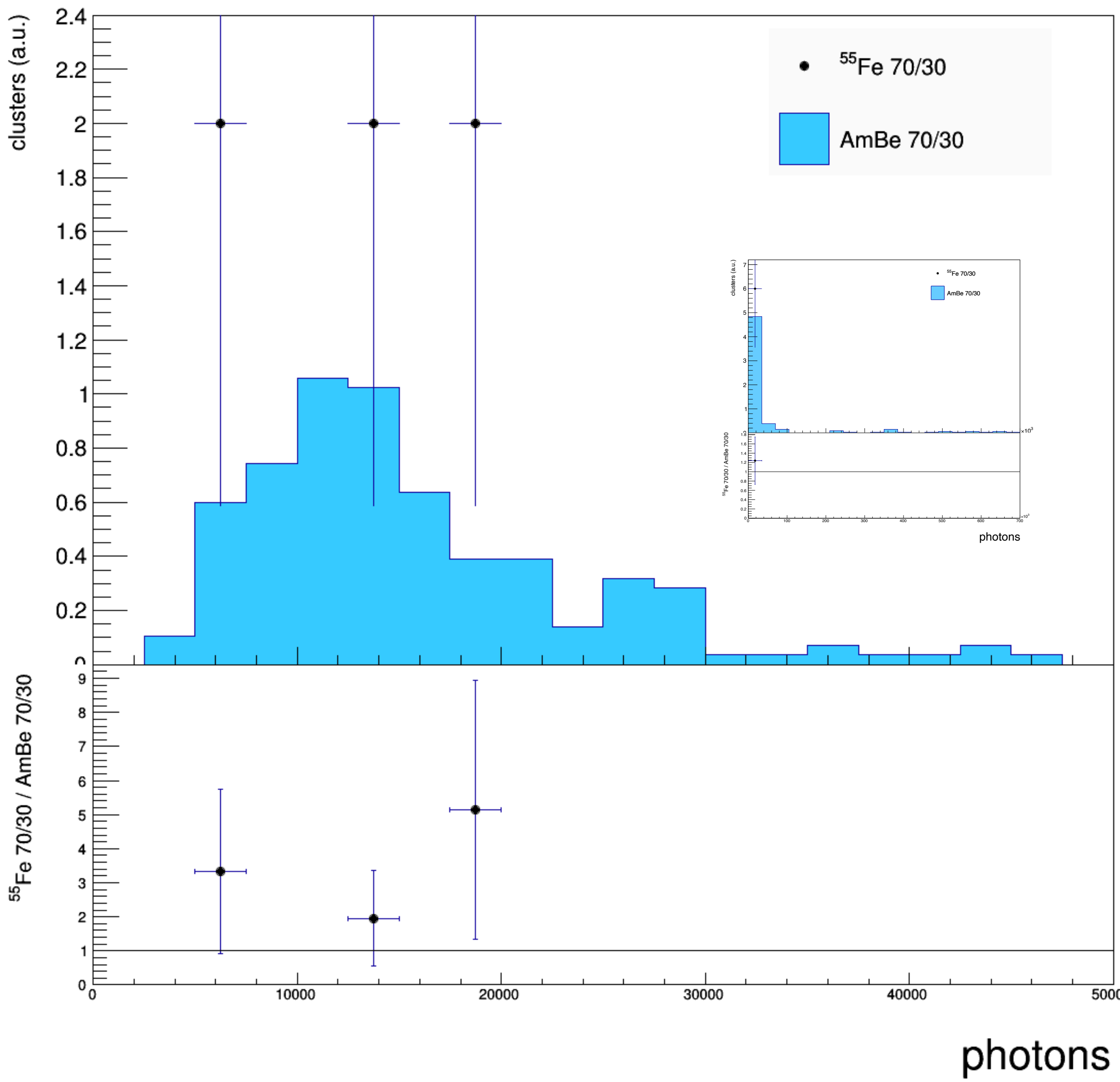
up to 10 cm long tracks

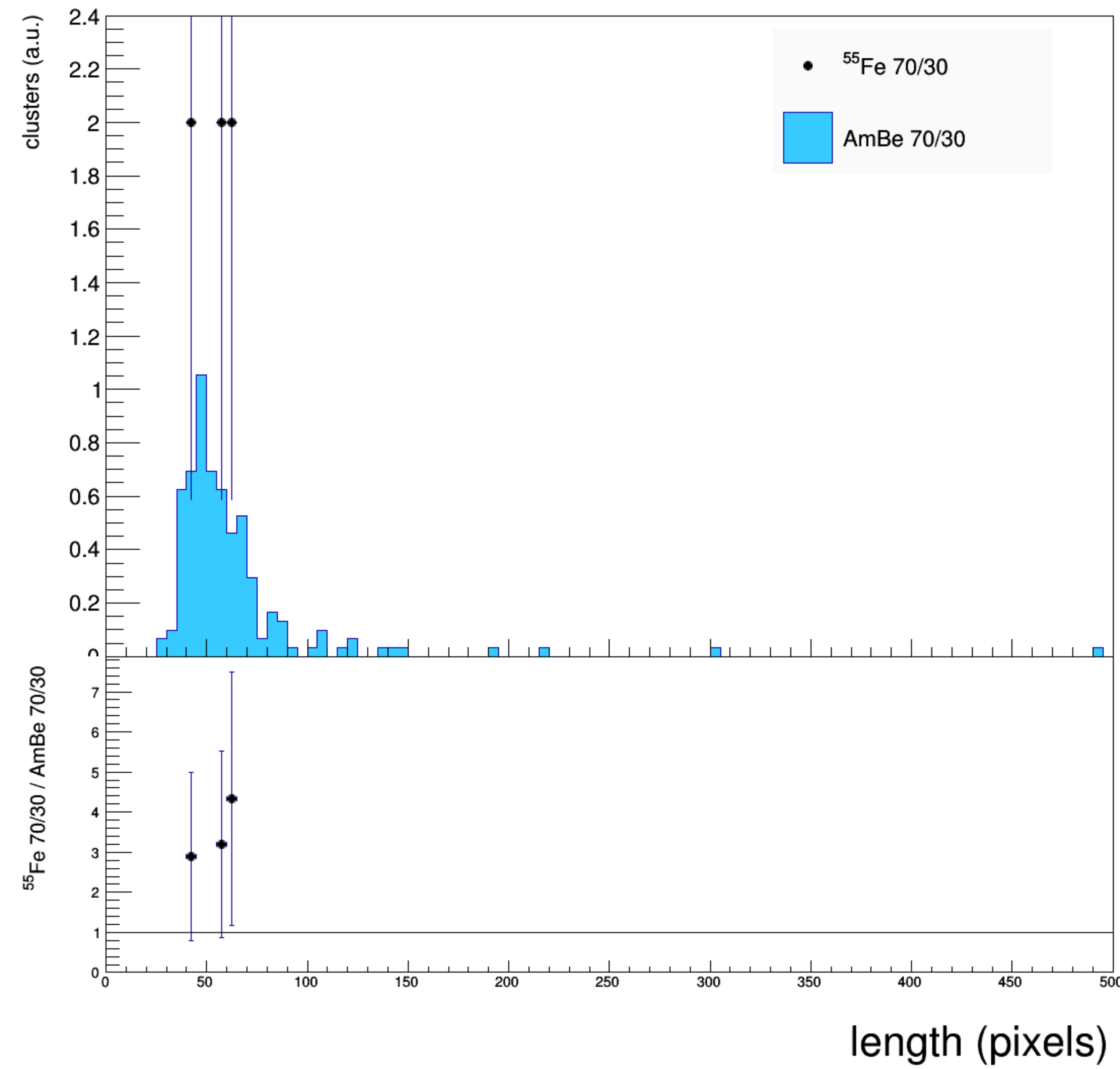


up to 1.5 MeV

neutron candidates

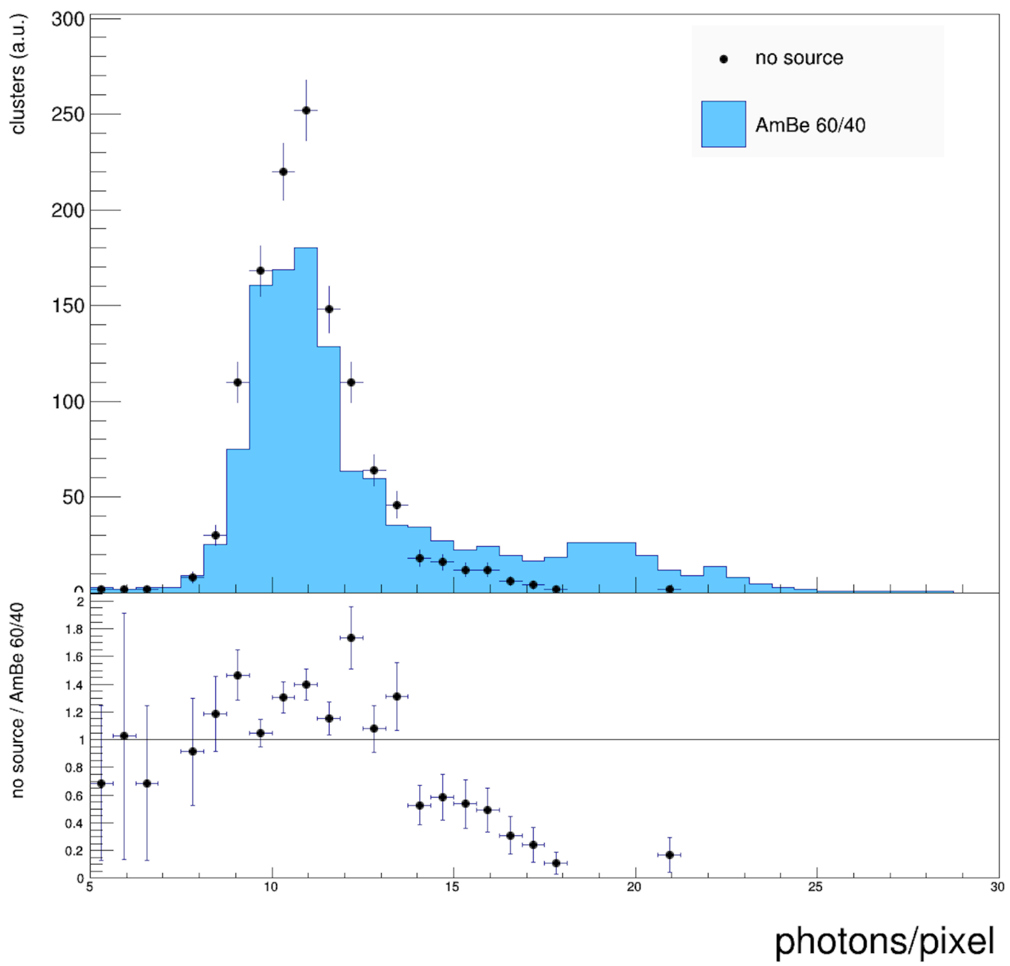
- I.e. iter1 superclusters with density >15 γ/pixel inside the center of the FC
- what remains are not many candidates, with mode energy ~20 keV, but with a tail up to 1.5 MeV
- length up to ~1cm (average 0.5 cm). ^{55}Fe "spots" are ~2.5 mm wide





Signal yield and efficiency

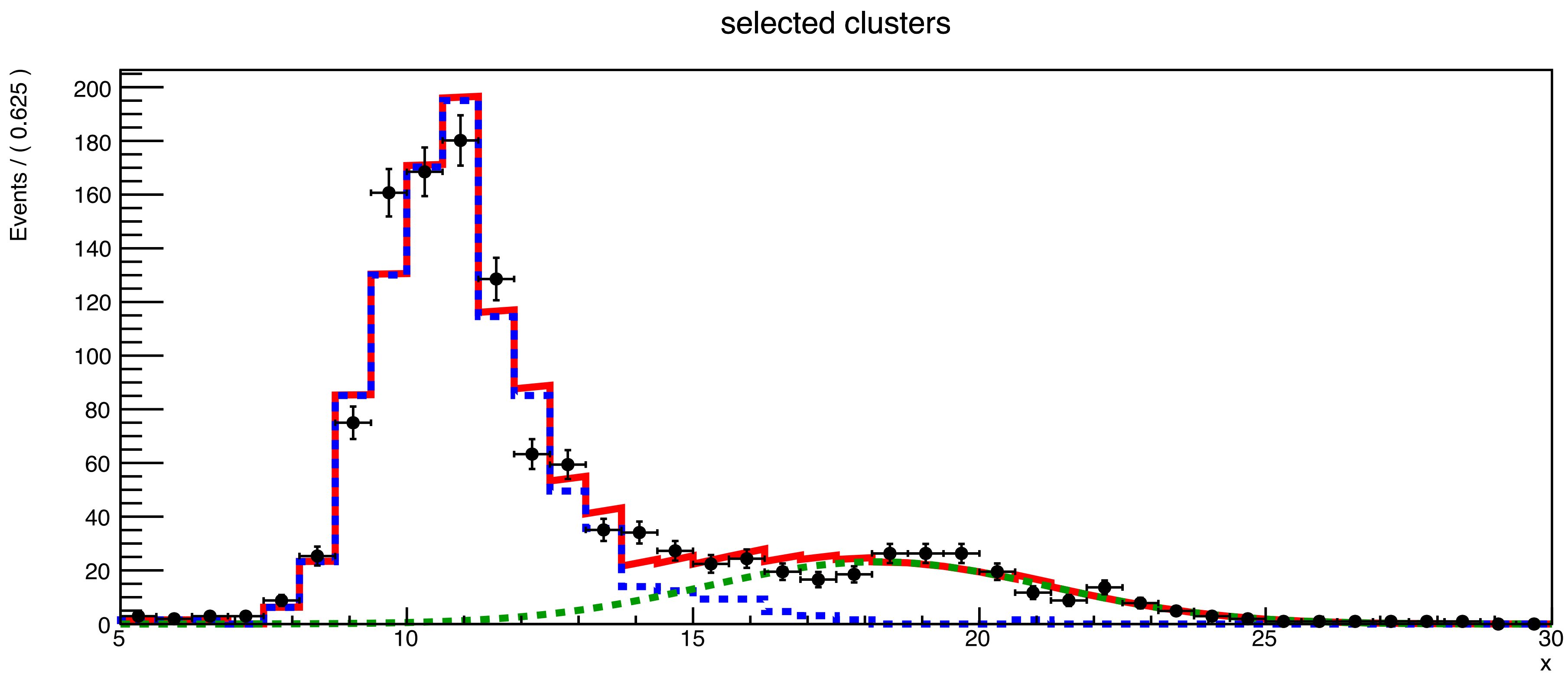
- Choose the “density” as sig/bkg separation variable
- Need to subtract the background statistically to get pure signal yield and shape
  - from the signal shape one can get an efficiency for a density > XX cut
- Make a simple likelihood fit
  - a run with no source (#2109 with 60/40 mixture) makes the PDF for the background
  - the “bump” around 19 ph/pix is modeled with a Gaussian (free mean/sigma)



The no-source data seems to model well the peak around 10 ph/pixel from pieces of cosmic-induced bkg

Template fit

- 2 components fit
  - bkg from the binned template from cosmic data
  - signal as a completely floating Gaussian (not a rock-solid choice)

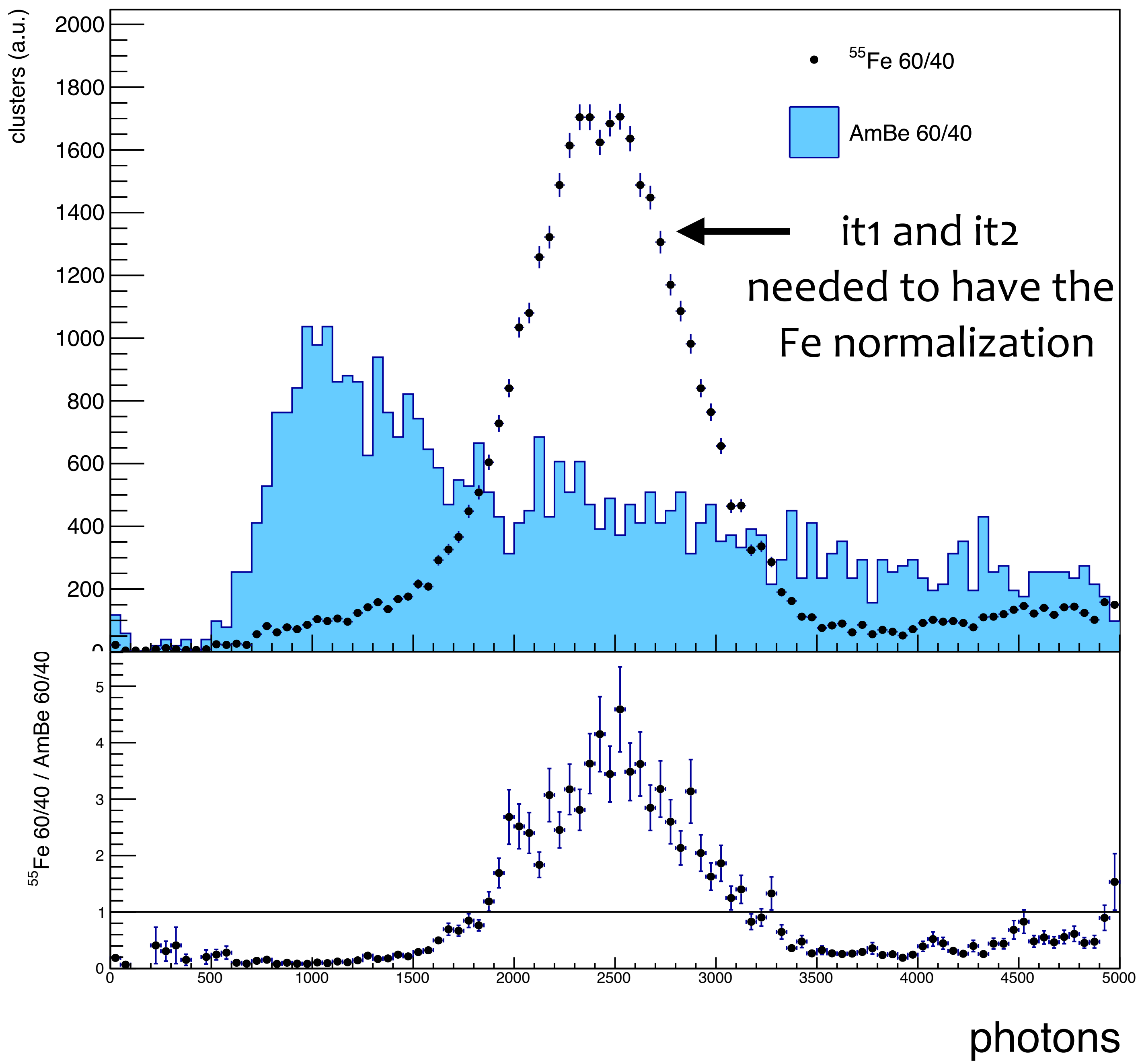


threshold	Signal efficiency	Bkg efficiency
>16	77%	1.5%
>17	66%	5.8e-3
>18	53%	1.9e-3
>19	40%	1.6e-3

signal/bkg efficiency obtained integrating the PDFs

Get bkg rejection for Fe at 6 keV

- not valid for recoils if there is saturation (because energy is shifted in non-linear way)



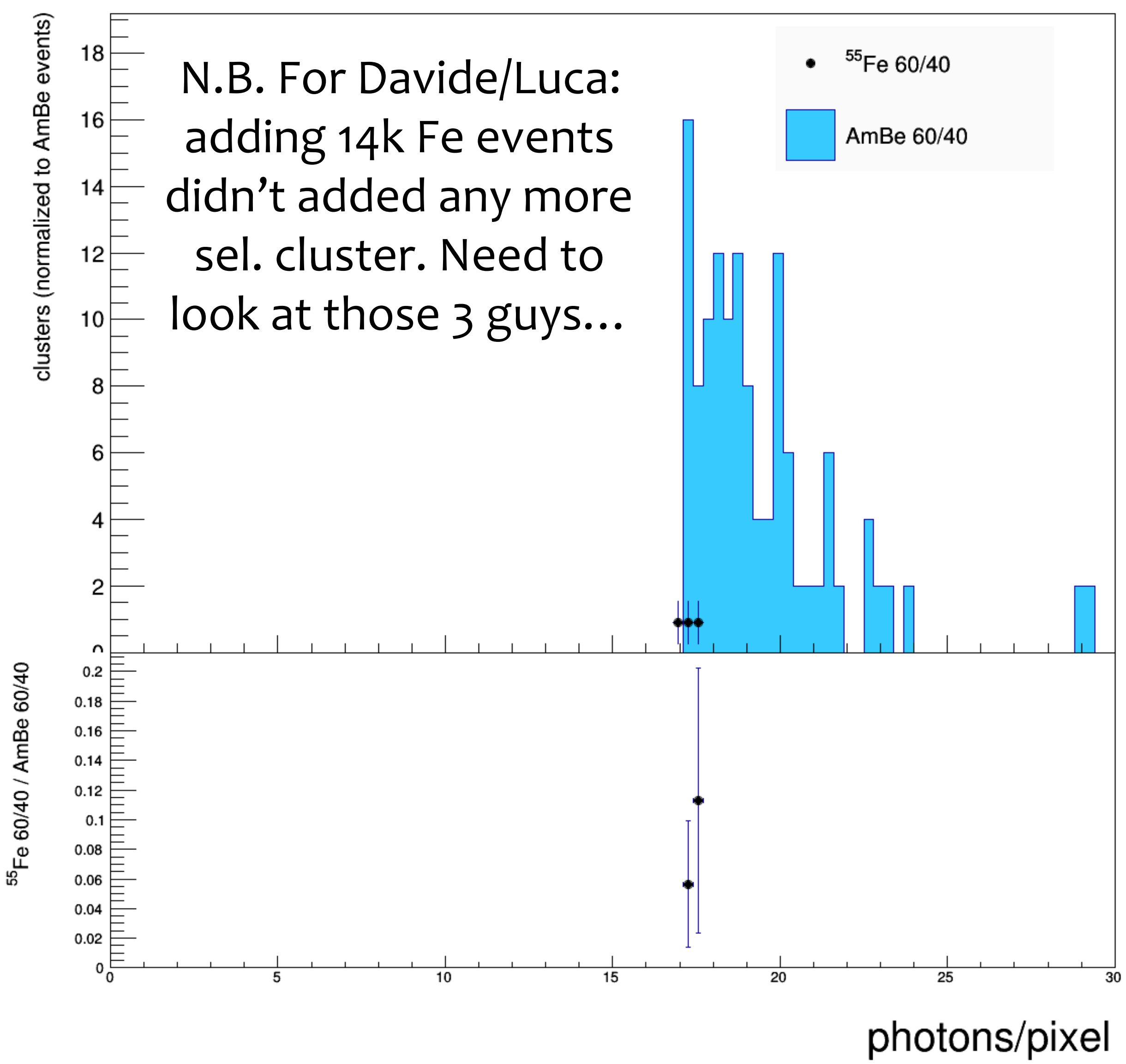
~3.5 Fe clusters/image within the strict fiducial region (reconstructed with iter1 OR iter2 to get ~100% efficiency on Fe)

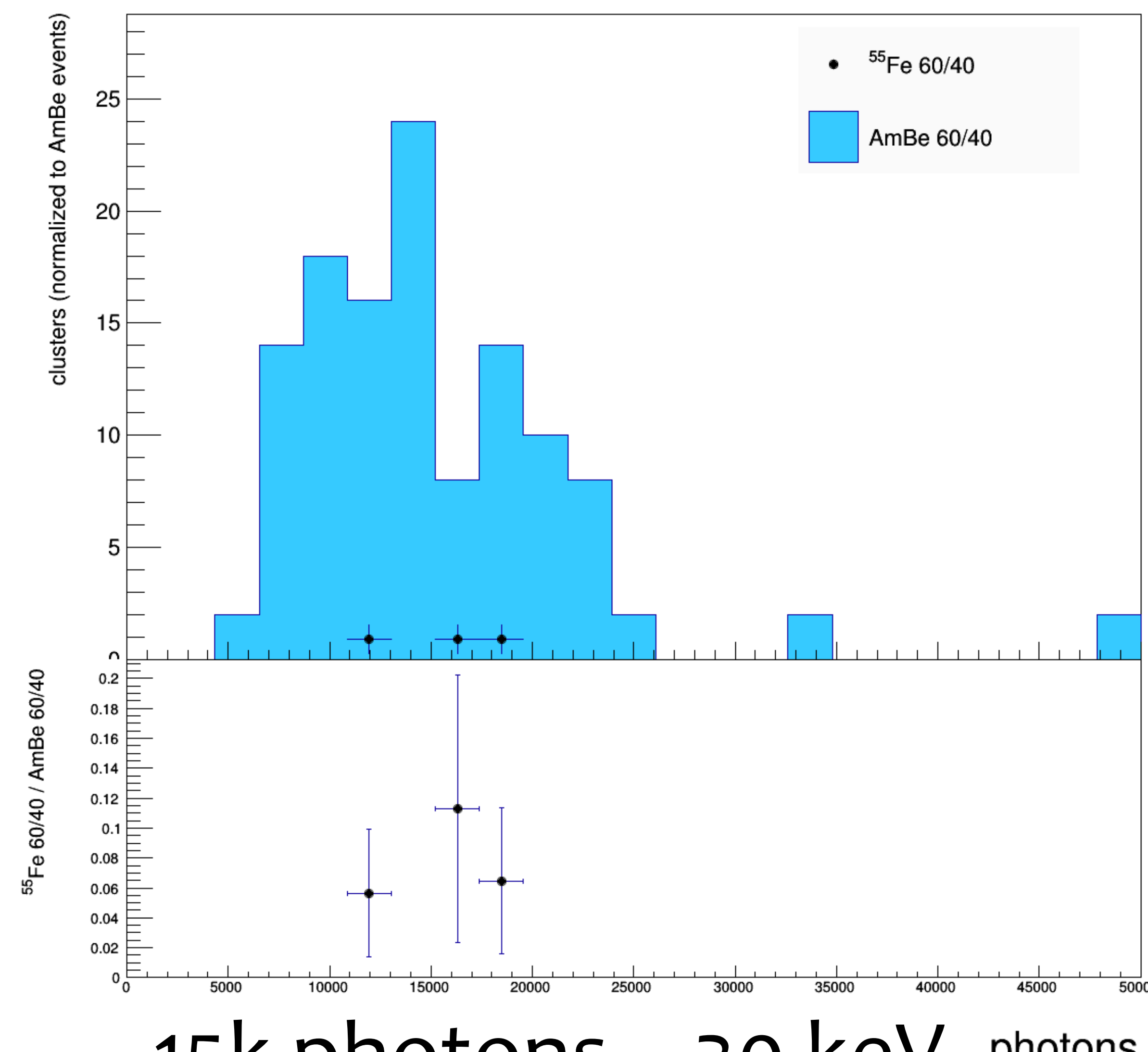
$$\text{bkg } \varepsilon = \frac{n(^{55}Fe)^{sel}}{n(^{55}Fe)^{fiducial}}$$

$n(^{55}Fe)^{sel}$ is the number of clusters selected with a cut on density > threshold

background rejection @ 6 keV

- Reconstructed 20k Fe images and 2900 AmBe images (…reconstructing more Fe…)
- applied the above selection with “density” cut > 17 photons/pixel.
  - 3 clusters surviving close to the boundary
    - efficiency = 3 clu /(2e4 ev * 3.5 clu/ev) = 4.3e-5
    - with a stat uncertainty of ~3.8e-3 (reconstruction of ALL Fe runs ongoing)





15k photons ~ 30 keV

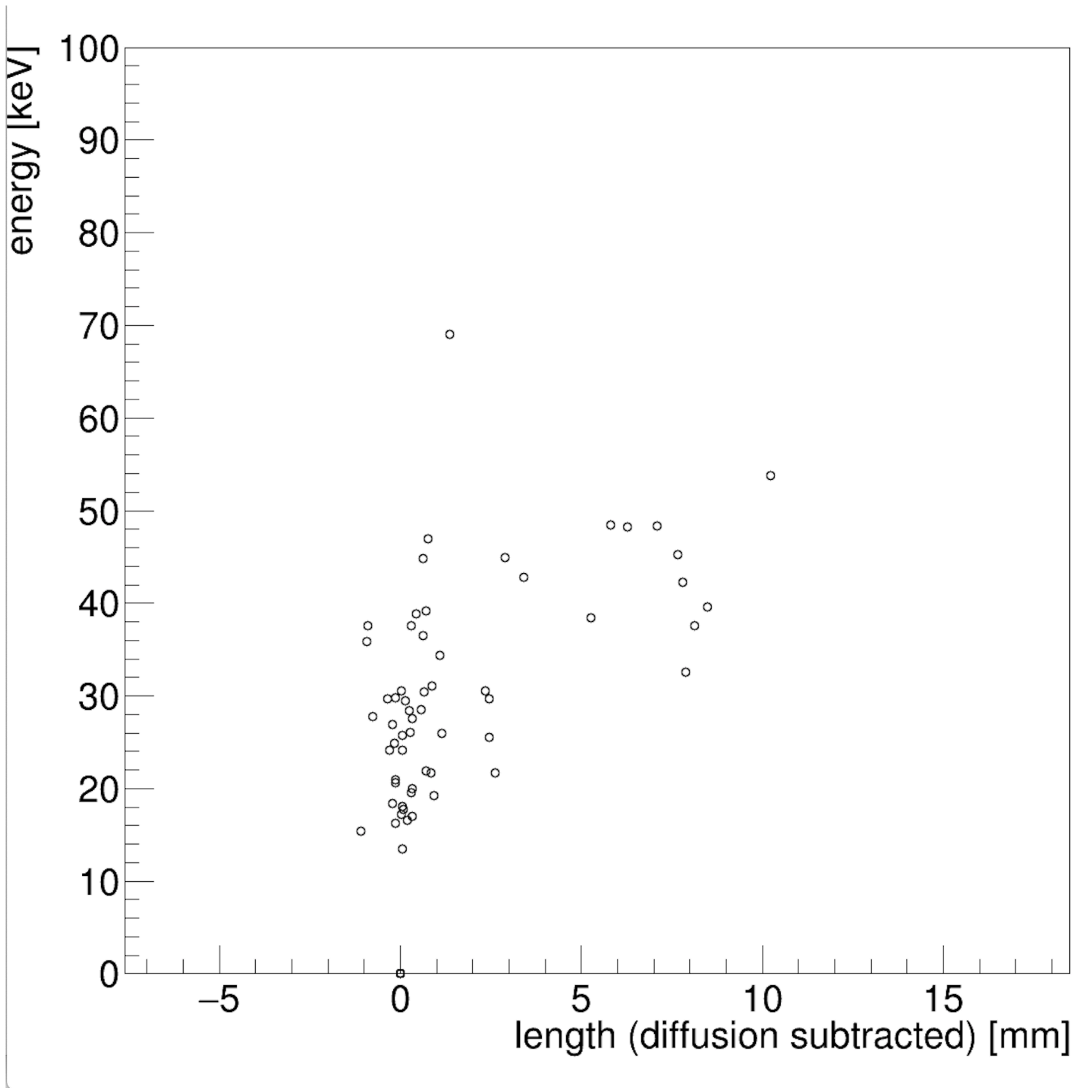
background rejection @ 6 keV

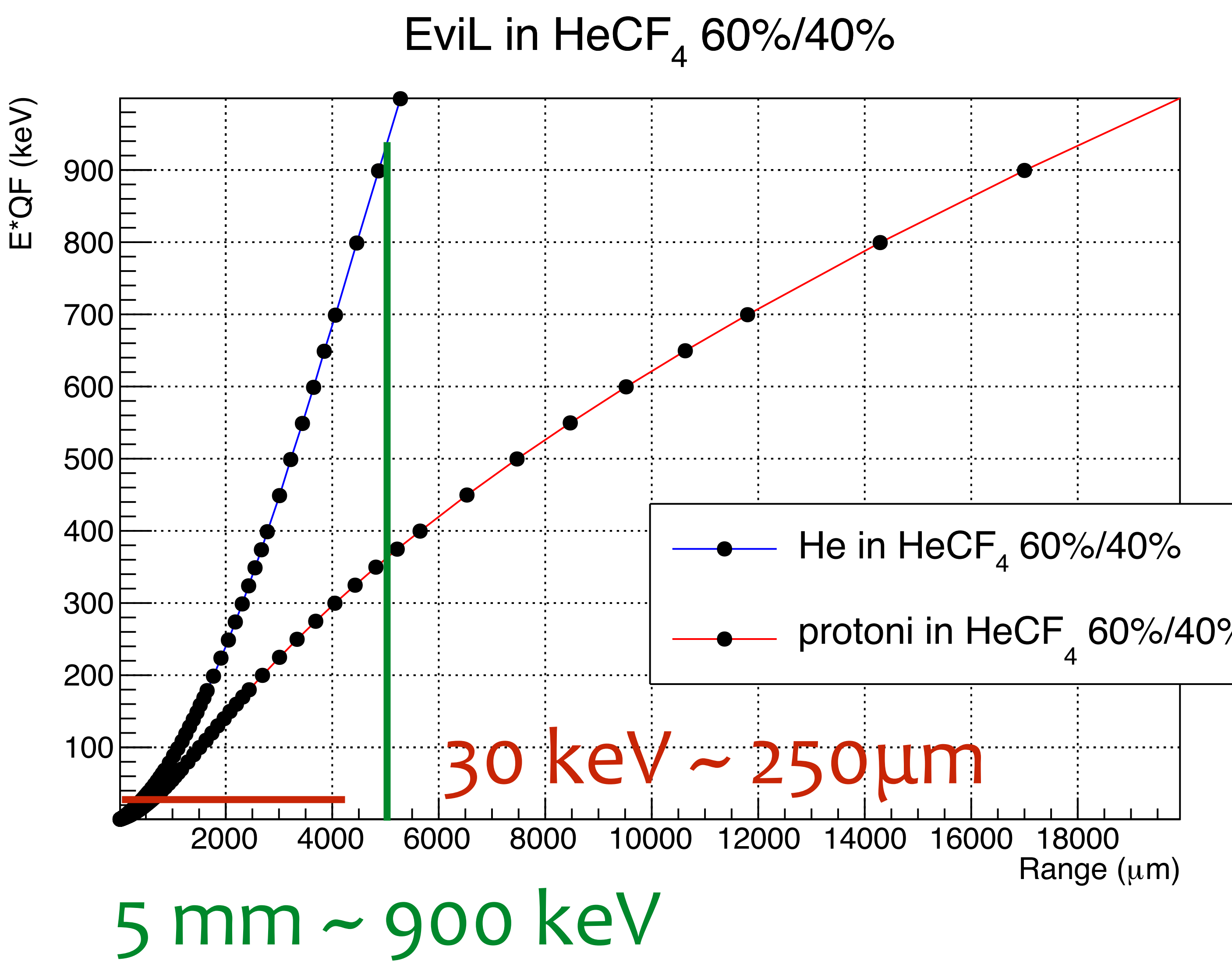
- Need to evaluate the total efficiency on signal (reconstruction, rest of the selection), not only the one from the density cut.
  - But presumably this is very high, looking at the images
  - so let's assume that Eff(Sig) ~ Eff(density cut)

threshold	**Signal efficiency**	Bkg efficiency of density cut	**Bkg rejection**
>16	**77%**	1.5%	**1.1e-4**
>17	**66%**	5.8e-3	**4.3e-5**
>18	**53%**	1.9e-3	**1.4e-5**
>19	**40%**	1.6e-3	**1.2e-5**

off-topic: Ev(i)L

Length "diffusion subtracted" = length - width (cluster-by-cluster)
since in the transverse direction it should be a delta, while it is ~<3 mm>



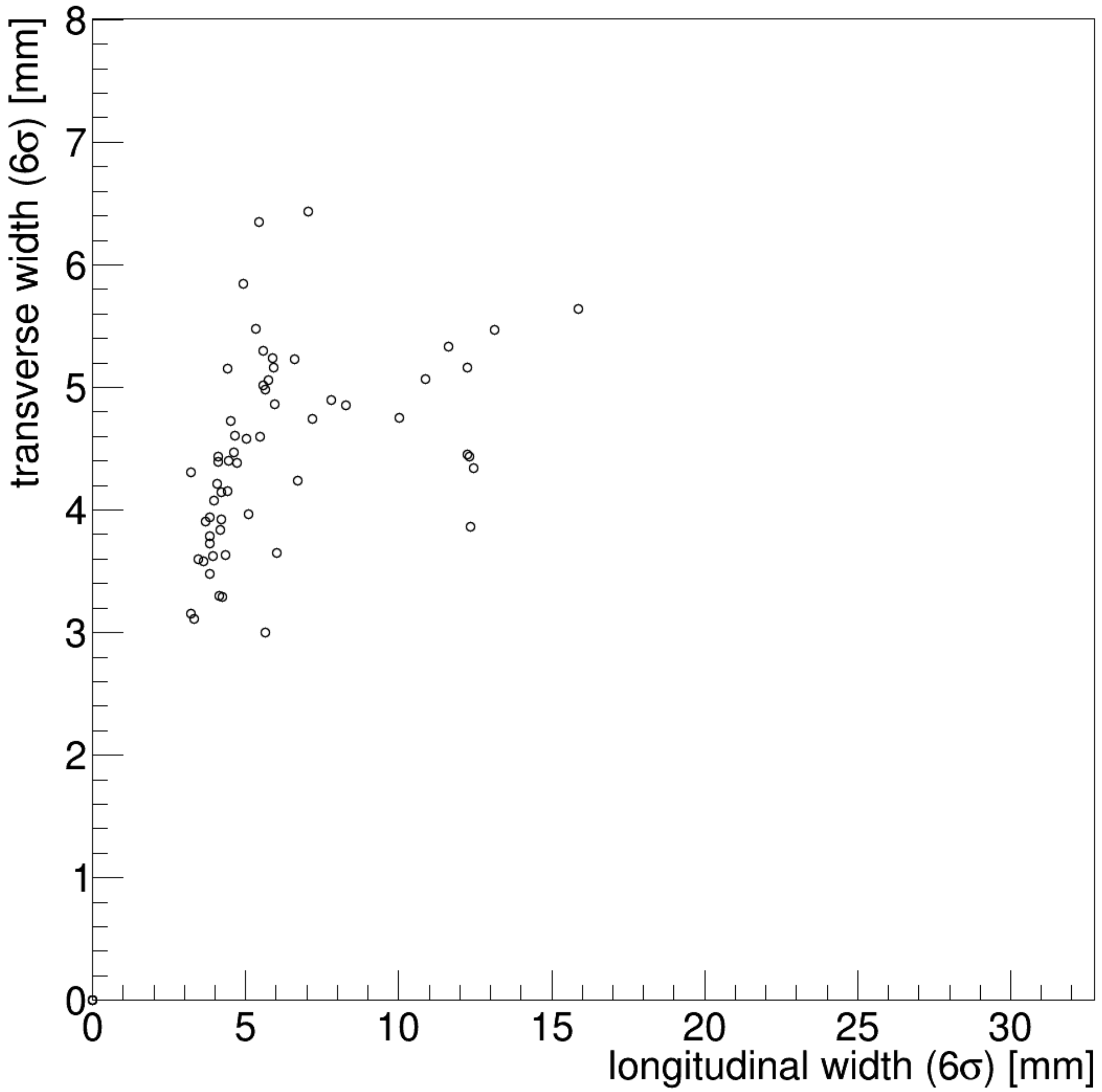


5 mm tracks from SIM should correspond to ~1 MeV
energy calibration @ 6keV is robust

may GEM **saturation** give **x10 Energy underestimate**?

diffusion

- transverse size of a track is 3 to 6 mm. This needs to be subtracted to the width…



The End