Analysis of digitized NR tracks

CYGNO analysis and reconstruction meeting – 17/09/2021

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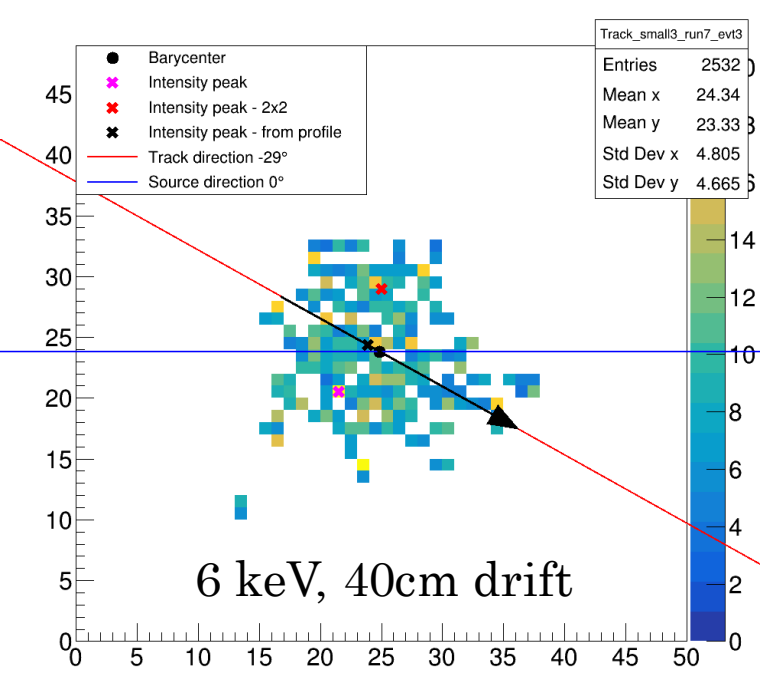
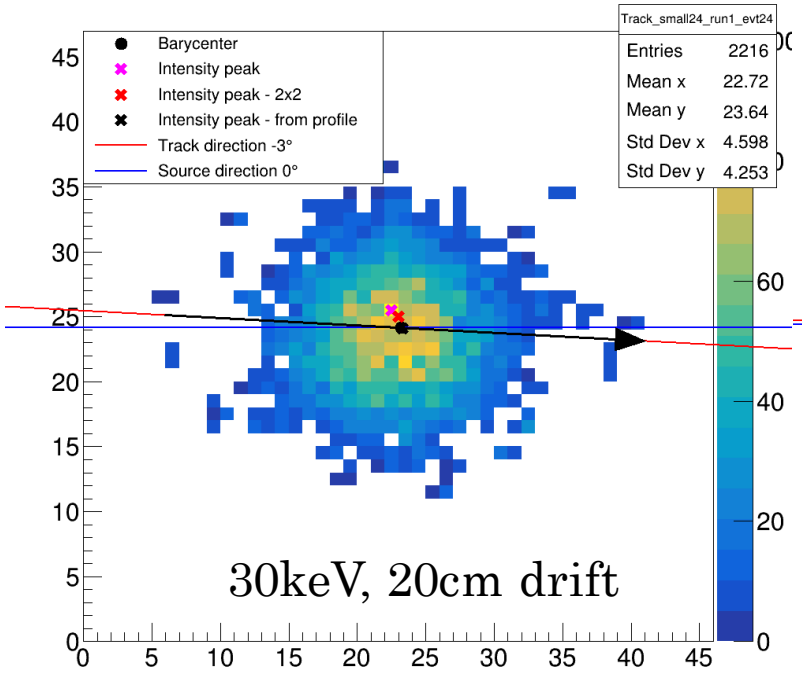
Sample production

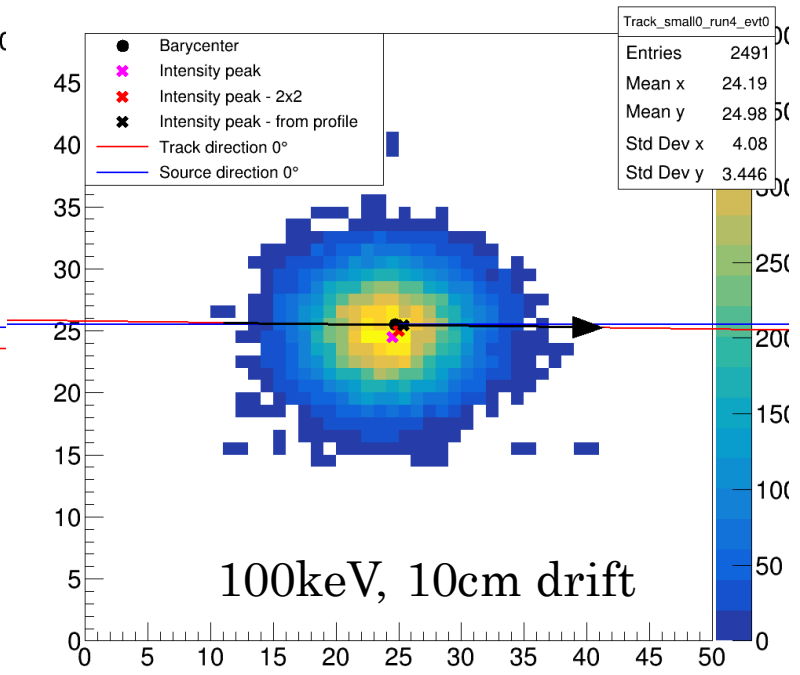
- Preliminary small sample of NR tracks: 1,3,6,10,30,60,100 keV of He, at 10cm, 20cm, 30cm and 40cm drift distance (2800 tracks total)
- Digitization code without saturation, LIME parameters:
  - Single GEM gain 123
  - Light yield 0.07 photons/electrons
  - Noise run 3944
  - ORCA fusion:
    - 2304×2304 pixels
    - Camera aperture 0.95
    - Sensor size 14.976 mm
    - Sensor calibration → 1 photon = 2 sensor counts
    - Active area: 35×35 cm^2
- Reconstruction using GAC

Direction and sense

- Direction determined from maximizing RMS line
- Sense of the track is found from the identification of the light intensity peak (we expect it to be in the first half of the track)
- Three definitions: max intensity single pixel, max intensity 2x2 macropixel, peak from projected longitudinal profile



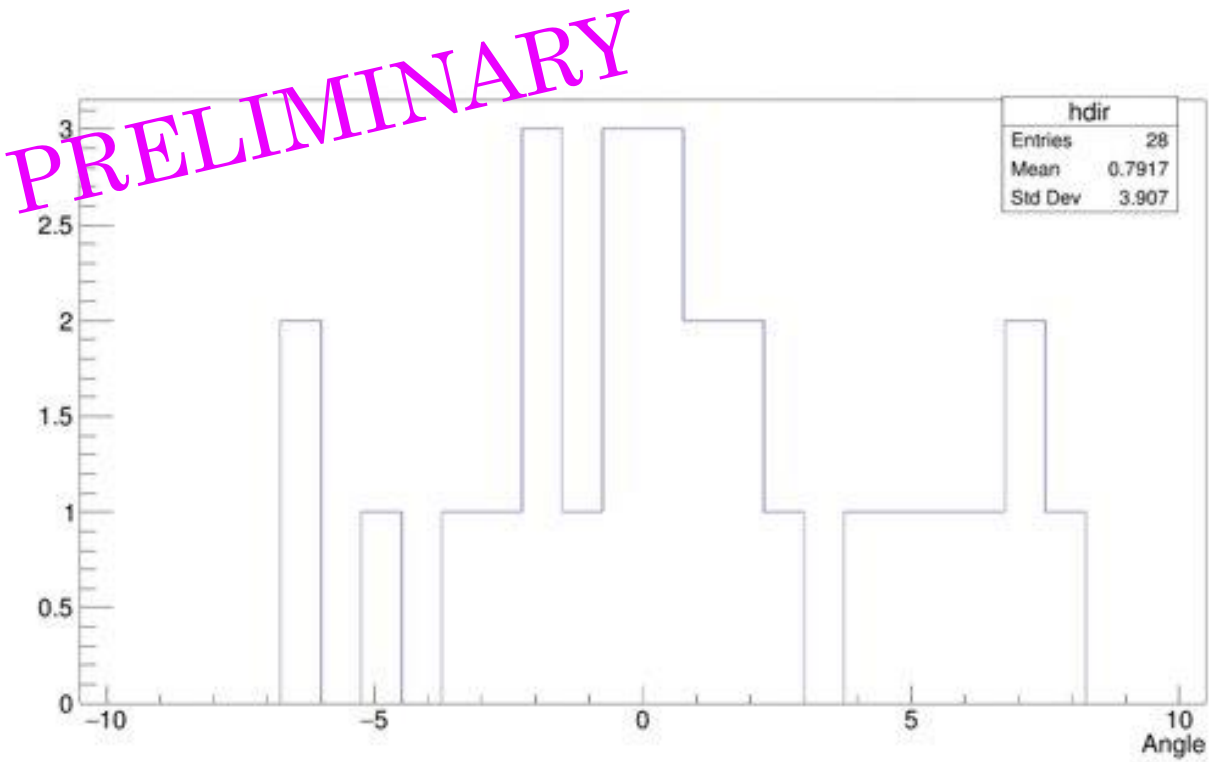




Angular distribution

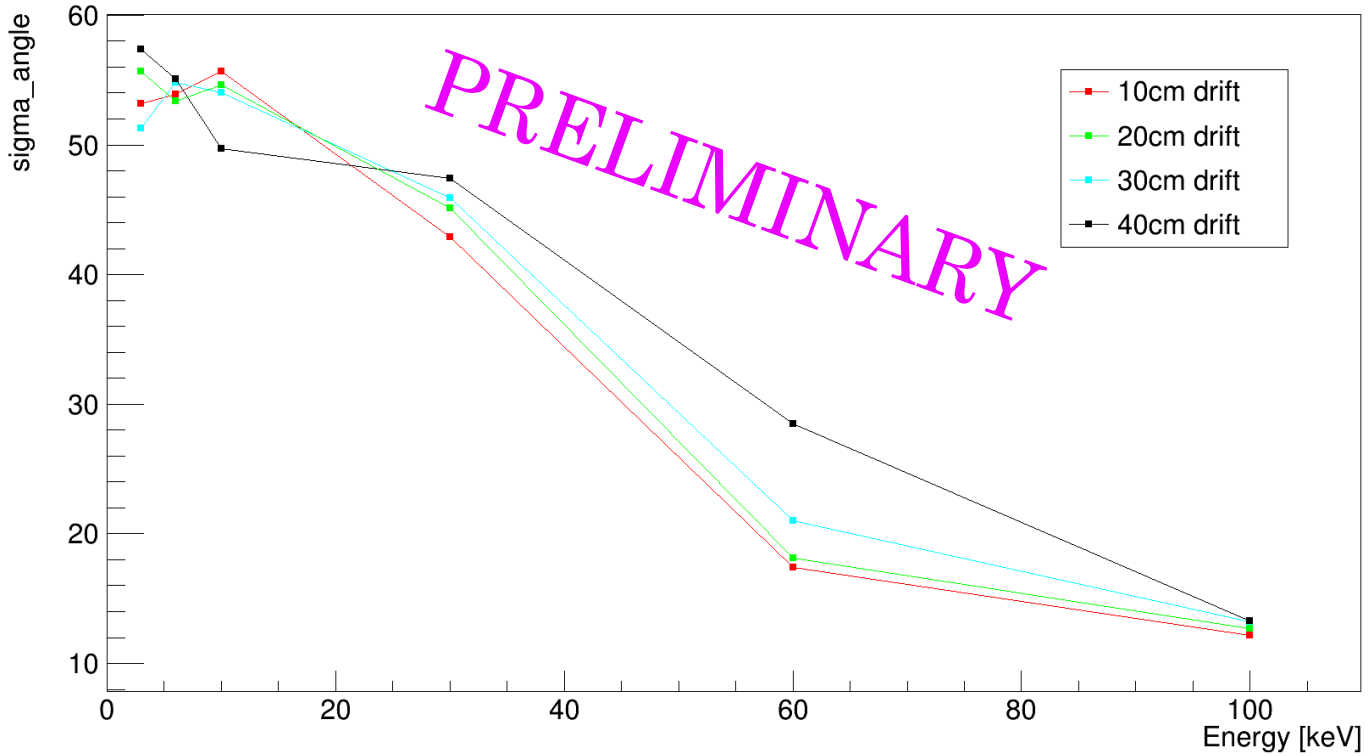
- Initial direction of all ions is (1,0,0), starting starting in the center of the image

- The distribution of the reconstructed direction is peaked around 0° with 3.9° of standard deviation
- This includes recoils of all energies and all drift distances



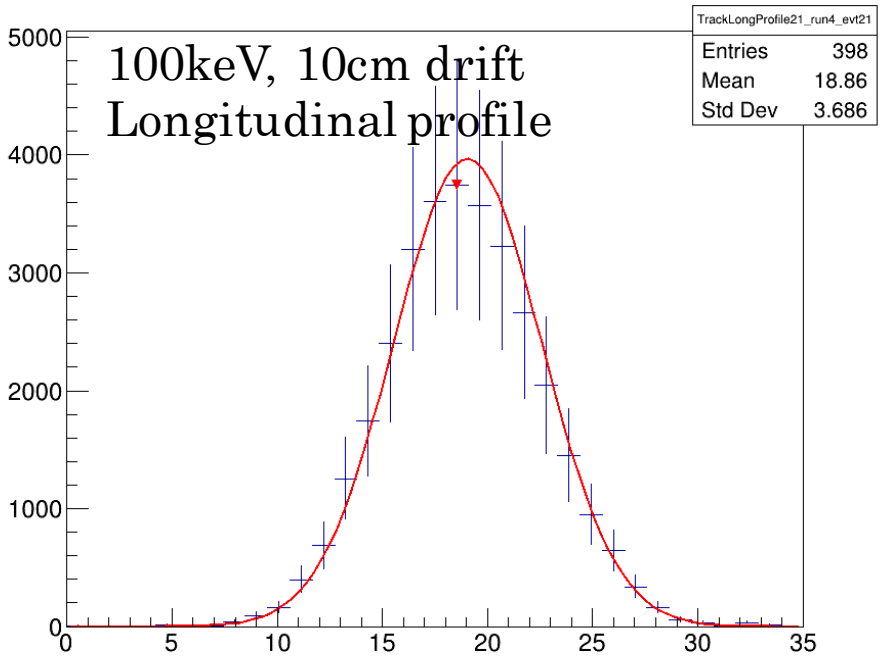
Angular resolution

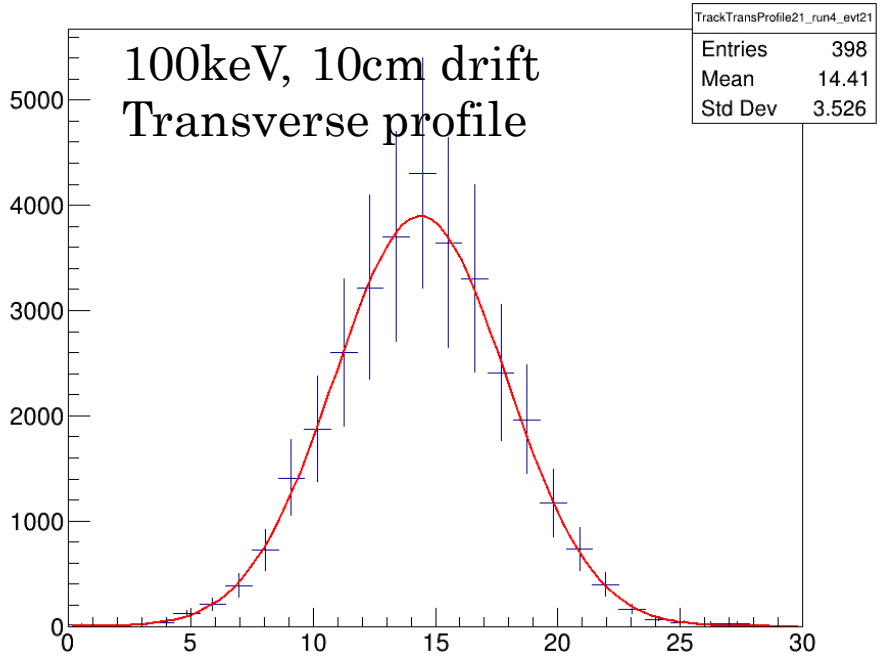
- Standard deviation of angular distribution
- From 30keV and above we start to have some directionality capability (worse with distance of the track from the GEMs)
- More energies and higher statistics is needed



Track projected profile

- Once the direction is identified, pixel intensity is projected along that line (longitudinal profile) and along the perpendicular direction (transverse profile)
- This represents the ionization charge profile of the track
- Low energy NR are almost round, and usually both profiles are (almost) gaussian
- This information can be used both to find the position of the intensity peak (for head-tail determination) and to distinguish NR and ER

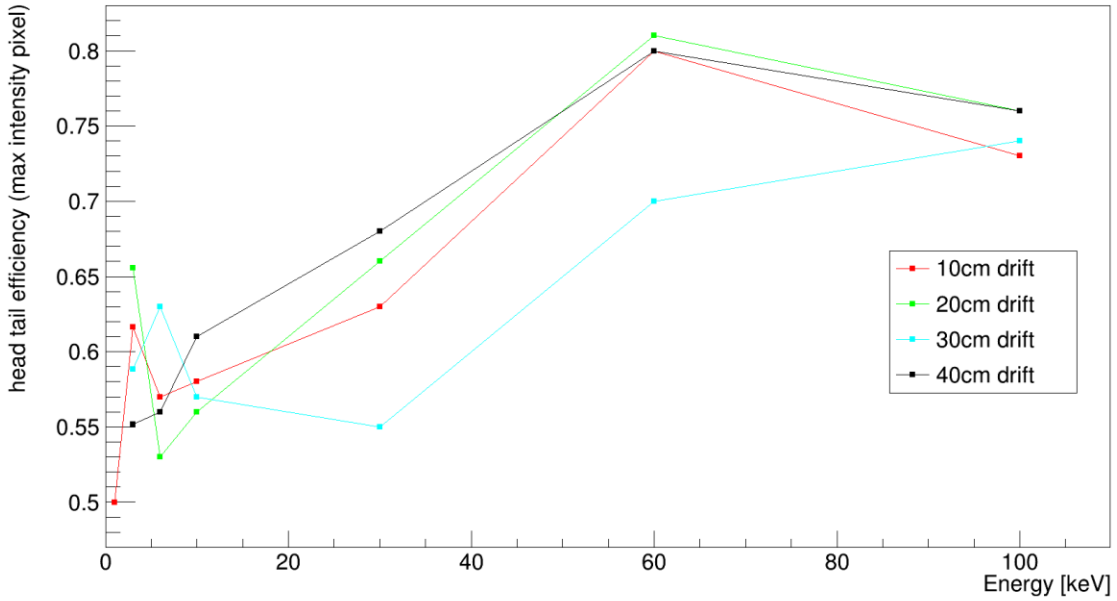




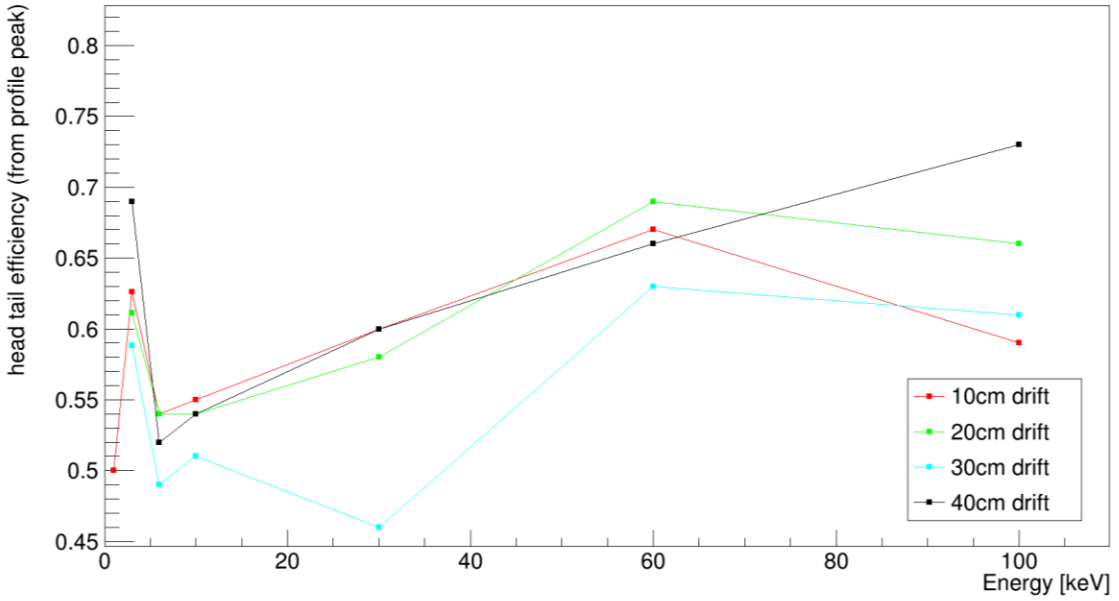
Head-tail identification capability

Defined as the number of tracks with direction correctly assigned in the range (–90°, 90°) (from left to right)

From position of maximum intensity pixel

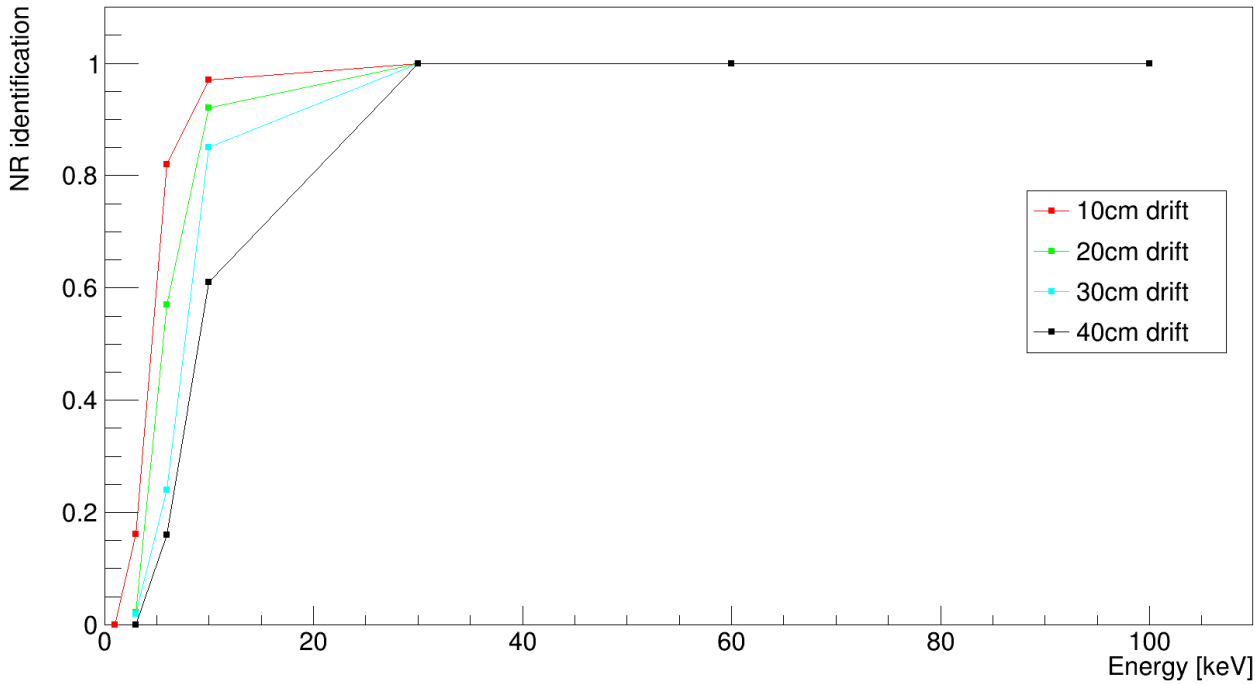


From position of peak from projected profile

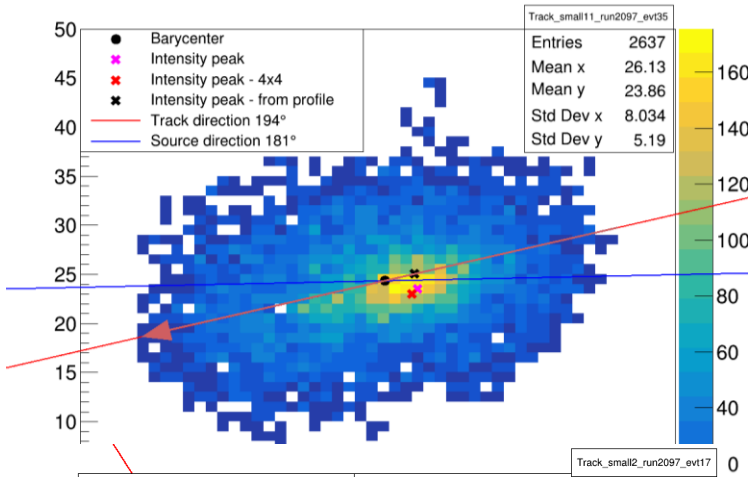


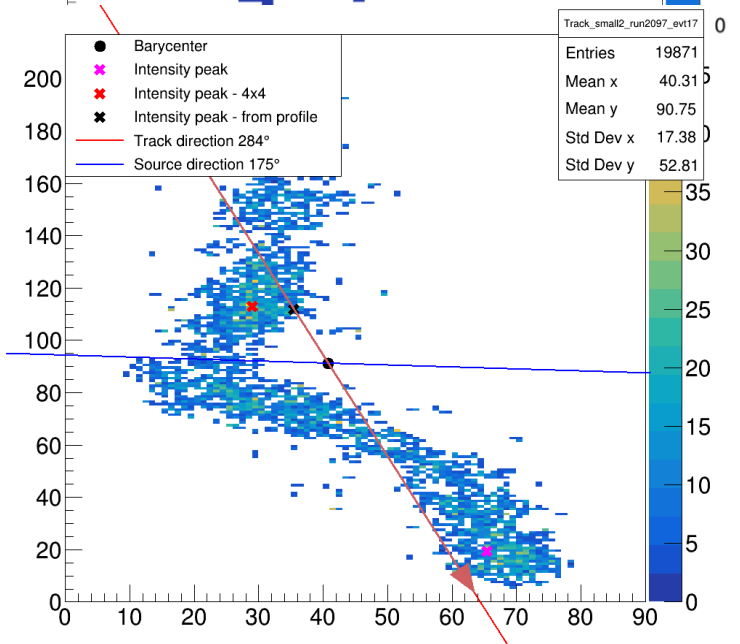
NR identification from profile

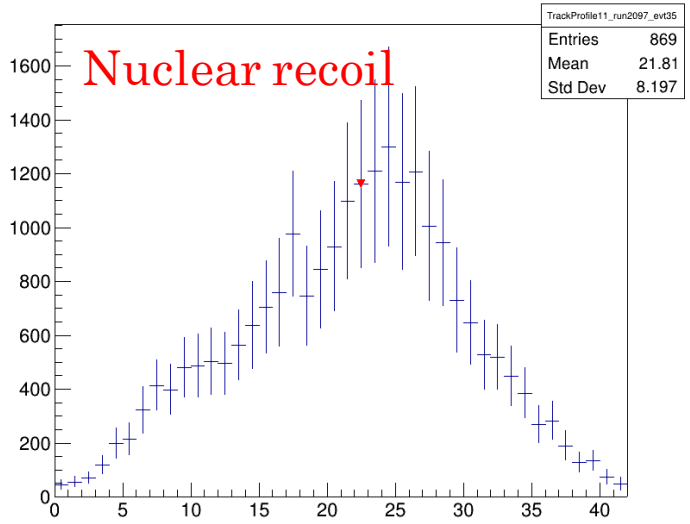
- Computed as fraction of tracks correctly identified as NR (number of tracks with only 1 peak in profile)
- NR are expected to have only one intensity peak, while ER have several (see https://agenda.infn.it/event/27224/contributions/137865/attachments/81887/107433/reco-meeting_27-05-21.pdf for details on the test on AmBe data)
- Efficiency of selection is 100% above 30keV, regardless of drift distance

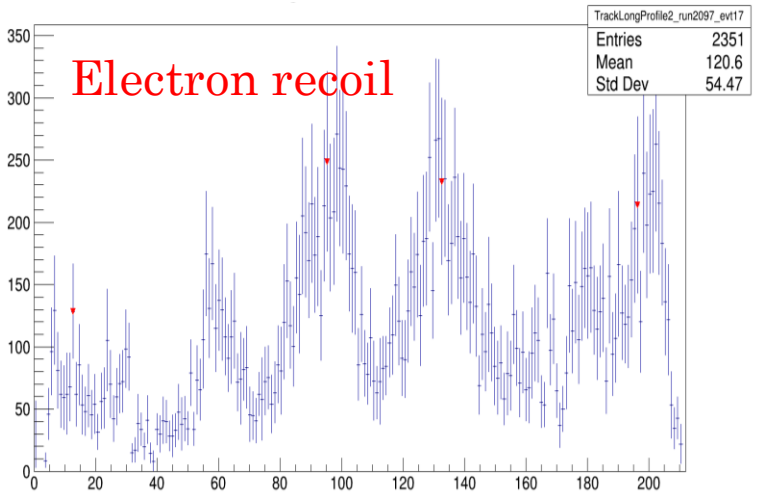


NR identification in AmBe data









- NR: only **one peak** found in longitudinal projected profile of the track
- ER: **multi-peak** structures are clearly visible
- The search is done scanning the profile looking for peaks with different sigma using the root TSpectrum class

NR identification in AmBe data

I applied this discrimination method to AmBe data after NR cuts:

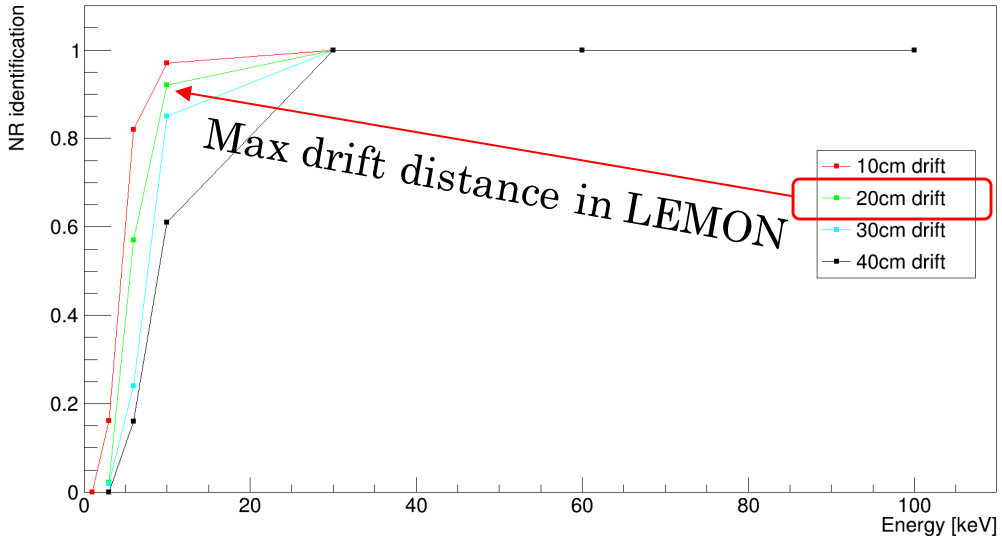
- 0.4 < width/length < 1
- length < 160 pixel (2cm)
- width < 53 pixel (6.54mm)
- density > 10

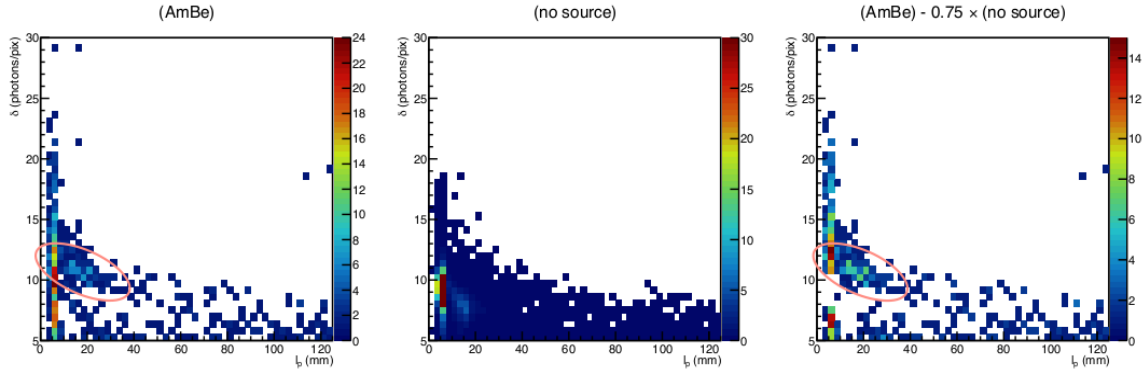
53.6% of tracks were identified as ER

After photon region cuts (59keV Am photons):

- width/length >= 0.3
- 120 < length < 250
- 9 < density < 12
- | density-y | < 2 (y = 14 – length/50)

100% of tracks were identified as ER

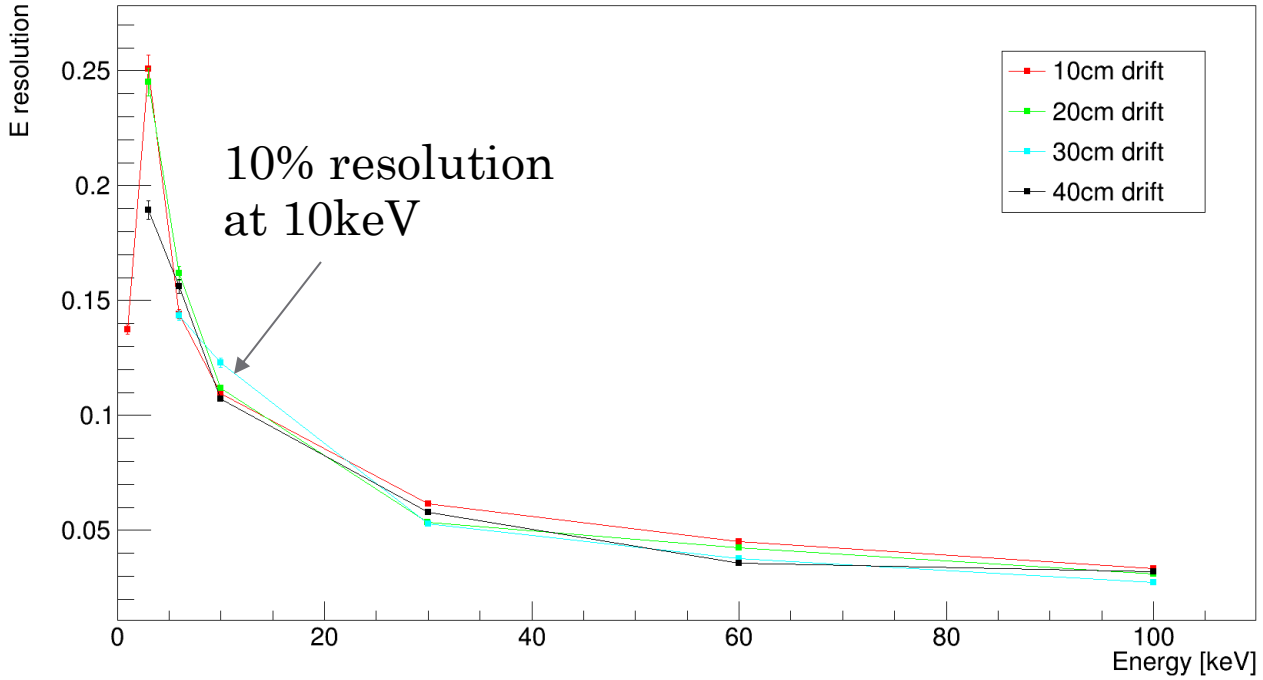




More tests on data would be interesting

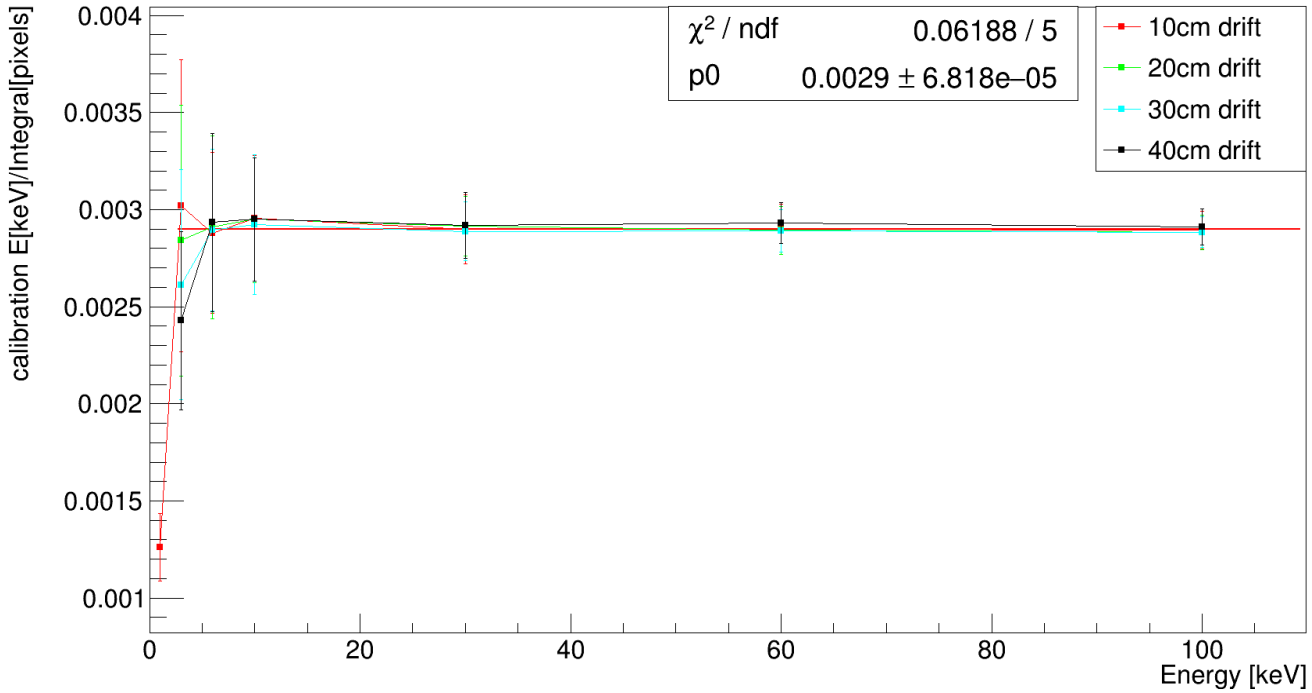
Energy resolution

Computed as the ratio between the standard deviation and the mean of the distribution of the integral of the reconstructed track (no fit)



Energy calibration

- Ratio between (visible) energy and cluster integral
- Tracks are not very well reconstructed below 6keV



Conclusions

- A *preliminary* analysis of NR simulated tracks has been done
  - Direction, head-tail, NR/ER discrimination, energy resolution
- A new – bigger – sample will be produced with random direction and random drift distance to simulate real data (with and without including saturation effects)
- AmBe data offer the possibility to test the direction/head tail algorithms, and also NR discrimination methods
  - Comparison of the NR identification efficiency between simulated NR and ER (using the profile peak structure)
  - Application of discriminating variables from Atul's study on AmBe data
  - Comparison of these methods with the cuts that were applied in the original analysis
- Angular resolution could be improved – with skeletonization?