Trigger proposal

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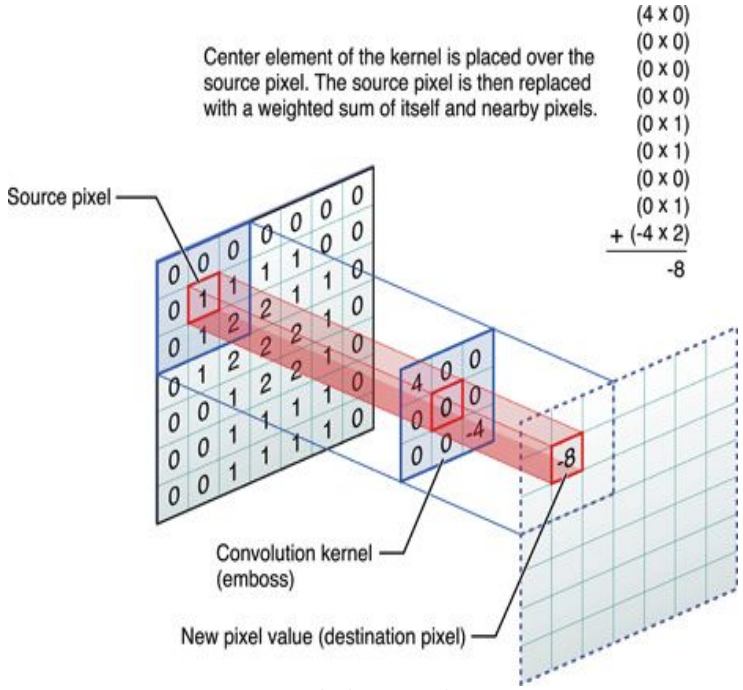
Analysis & reconstruction meeting

1.
Proposal

Proposal

- Develop algorithms to be tested as online trigger to decide whether to save or not images taken by the detector
  - Convolution of the image with a gaussian window: Look for high correlation points. Link of the last presentation

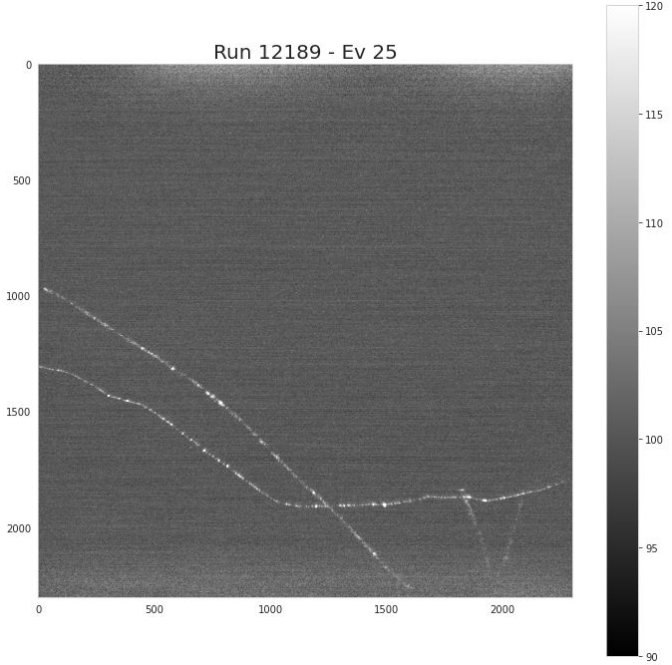
Convolution



compvisionlab.wordpress.com

- A convolution kernel (also called mask) passes through the image performing the convolution.
- A mask highly related to a desired signal may be used to detect it on an image (matched filter concept).
- The output image also shows the correlation between the input image and the mask.

Convolution



Raw image

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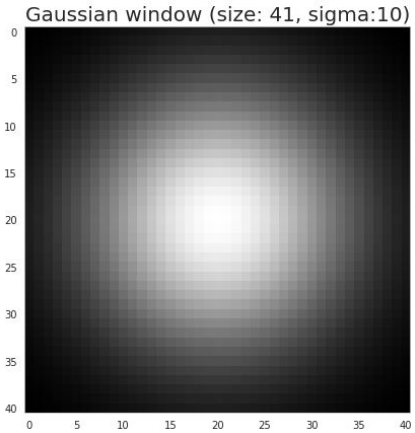

Normalized for area equal to 1.

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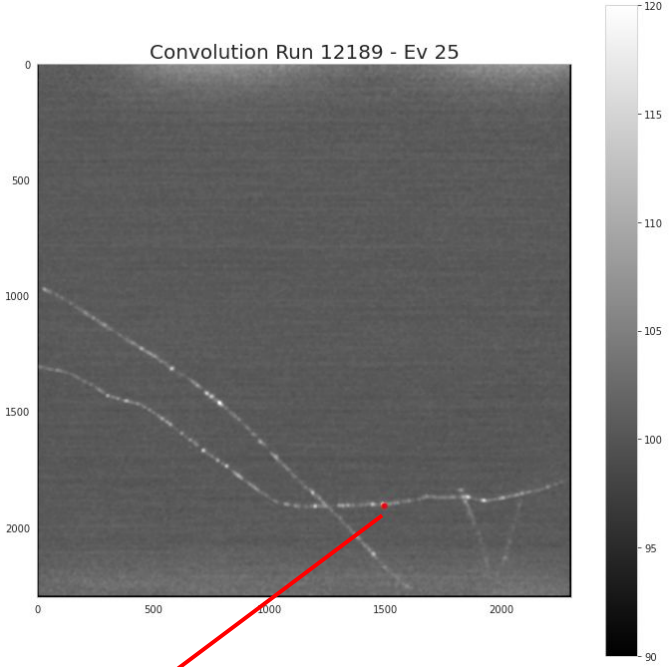


Pixel with highest correlation

2.
Analysis

Datasets

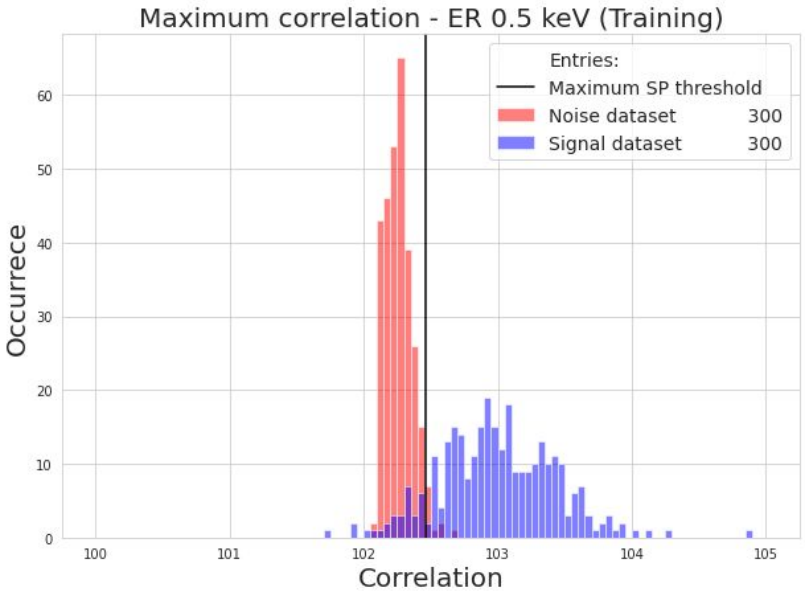
- **Datasets**
  - **Training:**
    - Noise dataset: 300 images from pedestal runs (Run 2 underground).
    - ER signal simulation: 300 images containing 0.5 keV signals (at random position) added to pedestal runs.
  - **Test (reconstruction was also used for comparison):**
    - Noise dataset: 300 images (different from train dataset)
    - ER signal simulation: 300 images containing 0.5 keV signals (at random position) added to pedestal runs.
    - NRAD run: 405 images (run 12189)
    - NR simulation: 219 images containing NR simulated signals added to pedestal runs.

Training

- The convolution was performed and the highest correlation was stored for each dataset.

- A threshold that best separates the two datasets was chosen (using the SP metric).

$$SP = \sqrt{\sqrt{DET_{sig} DET_{noise}} \left(\frac{DET_{sig} + DET_{noise}}{2} \right)}$$



DET_{sig}: (90±3.4) % (Percentage of signal elements above threshold)

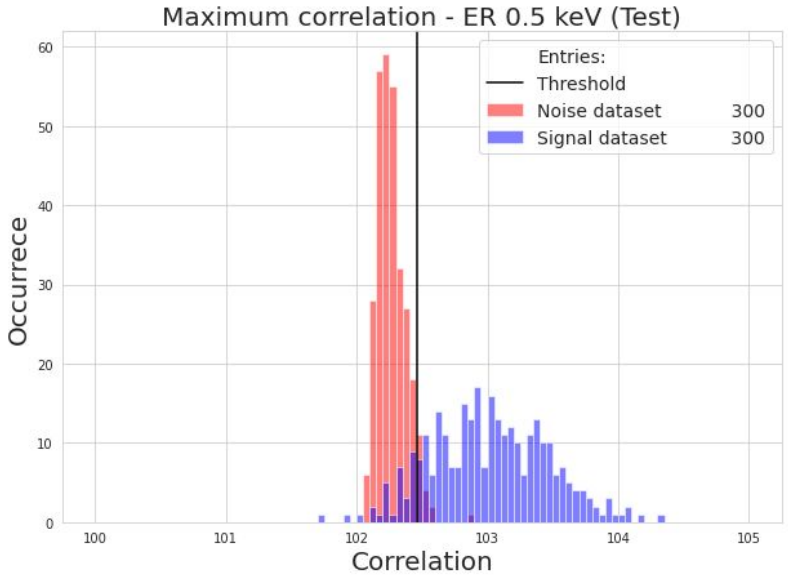
DET_{noise}: (98±1.6)% (Percentage of noise elements below threshold)

SP: (93.9±2.5)%

Kernel size = 15; sigma = 10.

Test (ER 0.5 keV)

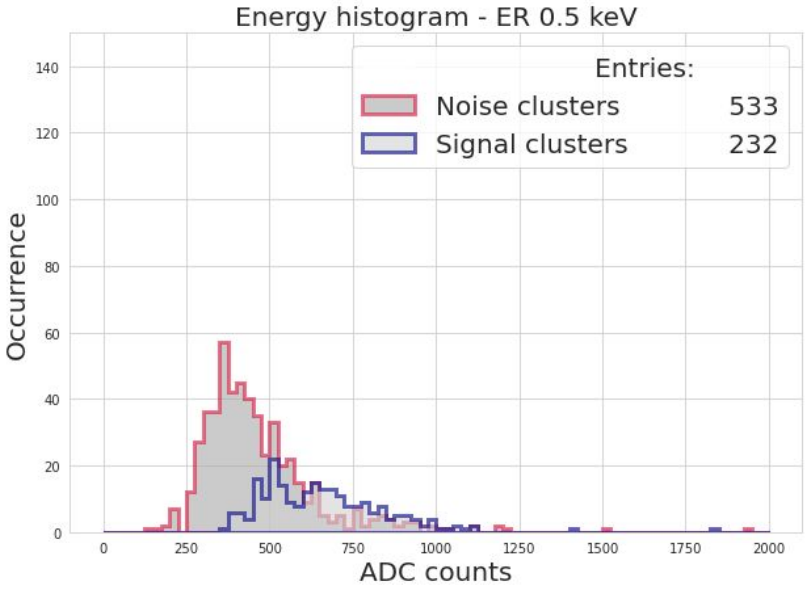
- The same procedure was used on the noise and signal datasets.
- The threshold found on training stage was used:
  - DET_{sig}: (89.7±3.8)%
  - DET_{noise}: (95.7±2.3)%
  - SP: (92.6±3.1)%



Kernel size = 15; sigma = 10.

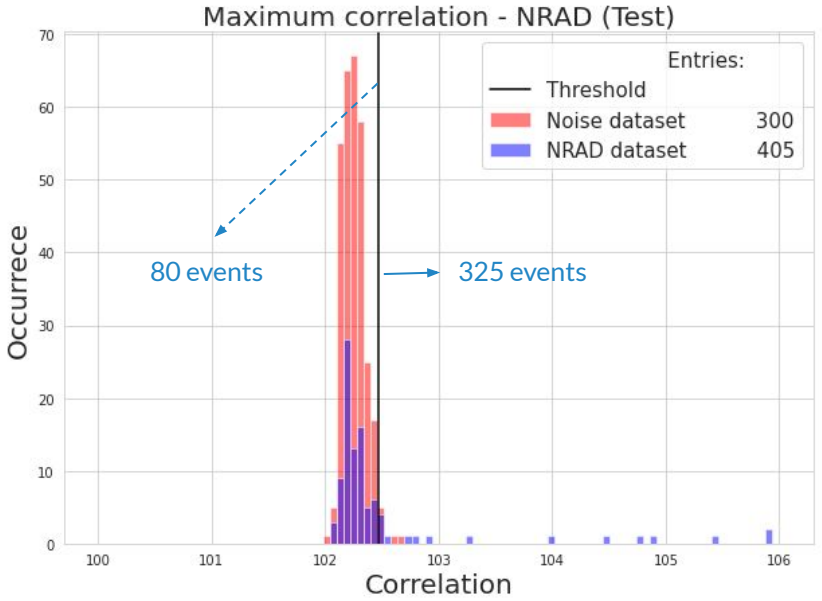
Reco file (ER 0.5 keV)

- The same run was used on the reconstruction code.
- The position of the clusters was compared with the truth information to check which clusters were actually signal.
- DET_{sig}: (77.3±4.7)%



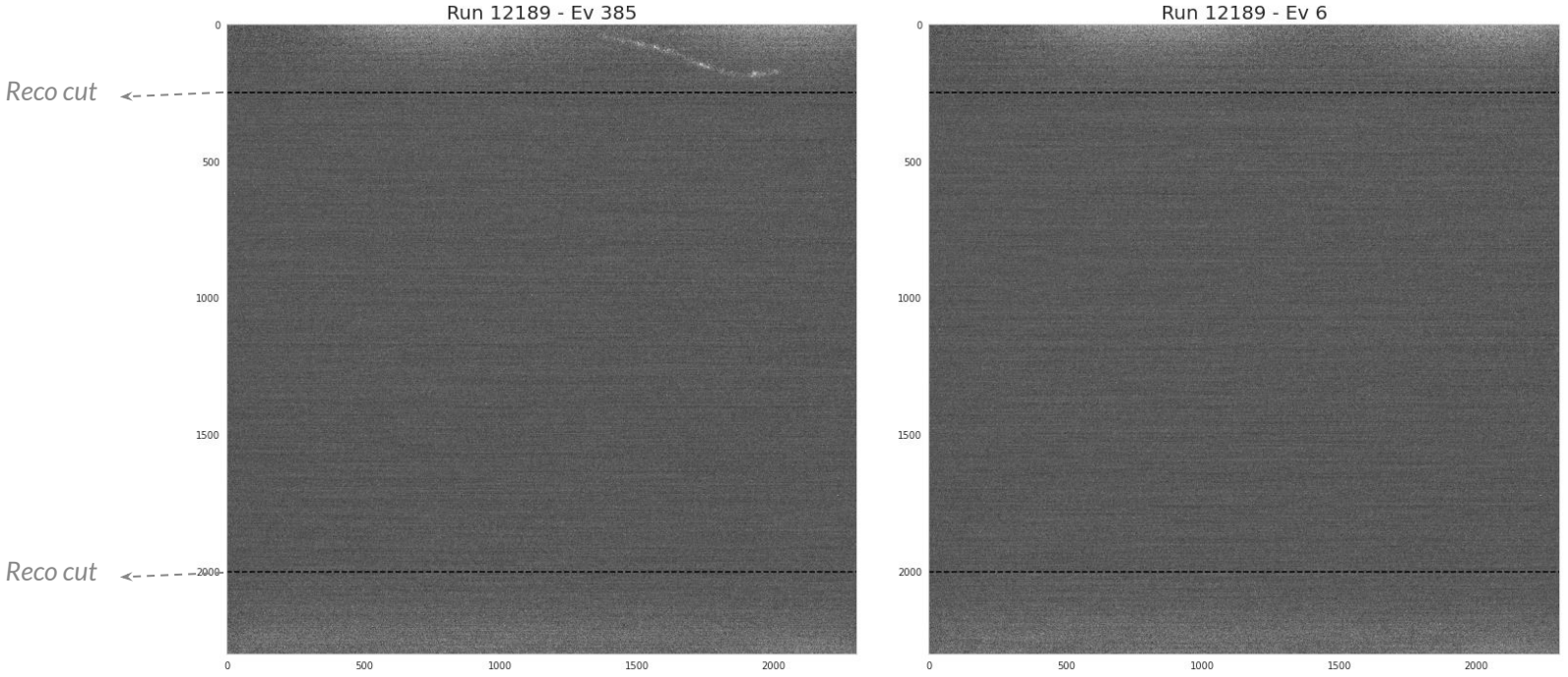
Test (NRAD 12189)

- The highest correlations on the NRAD dataset were also measured.
- This dataset contains some empty images.
- From the 325 events above the threshold, only 4 were not related to a cluster detected by the reconstruction code.



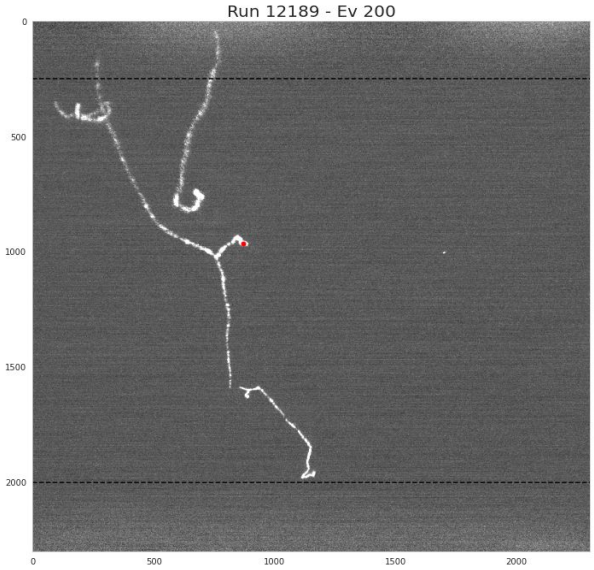
Kernel size = 15; sigma = 10.

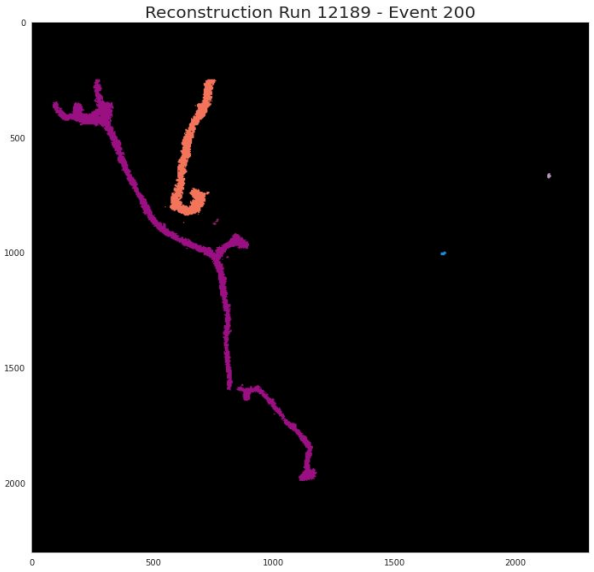
Test (NRAD 12189)

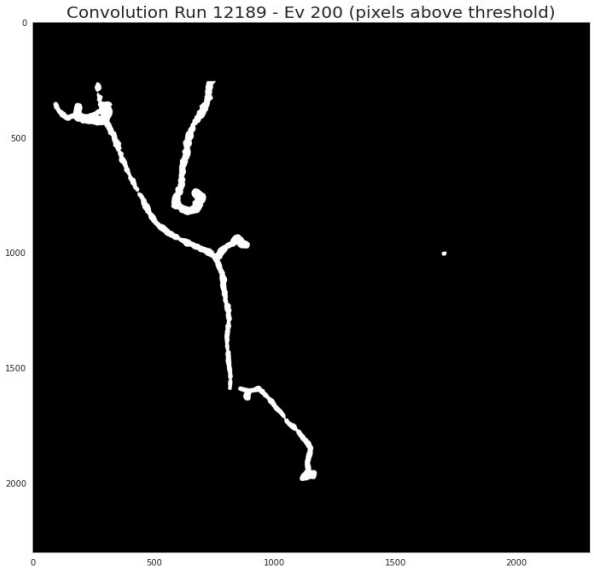


- Examples of images with correlation below the threshold.

Test (NRAD 12189)

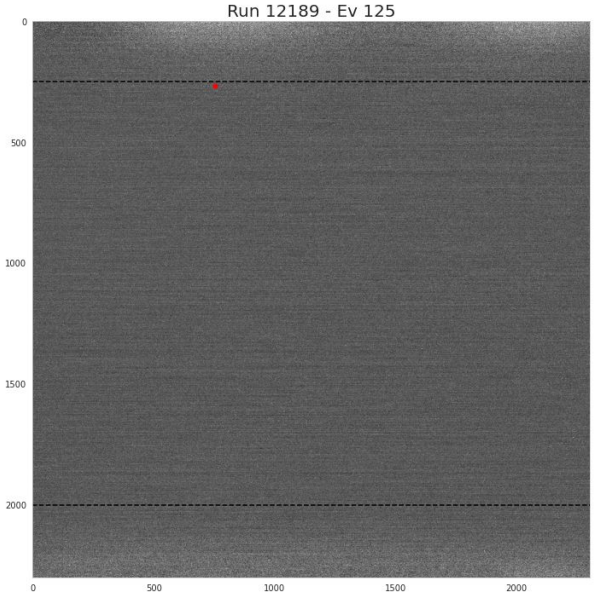


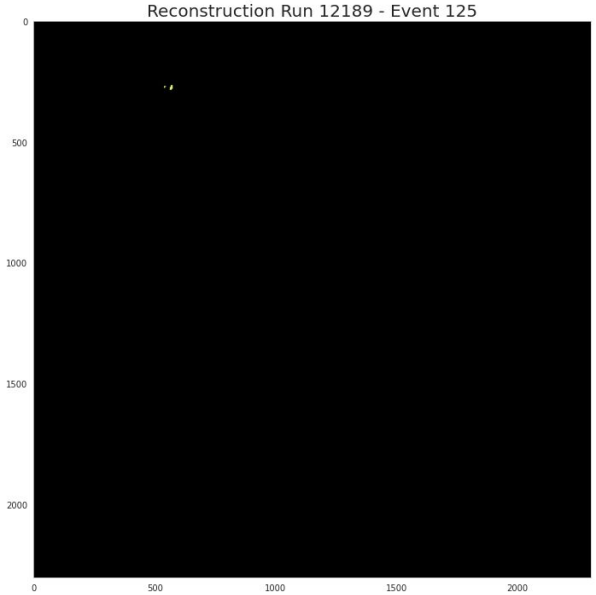


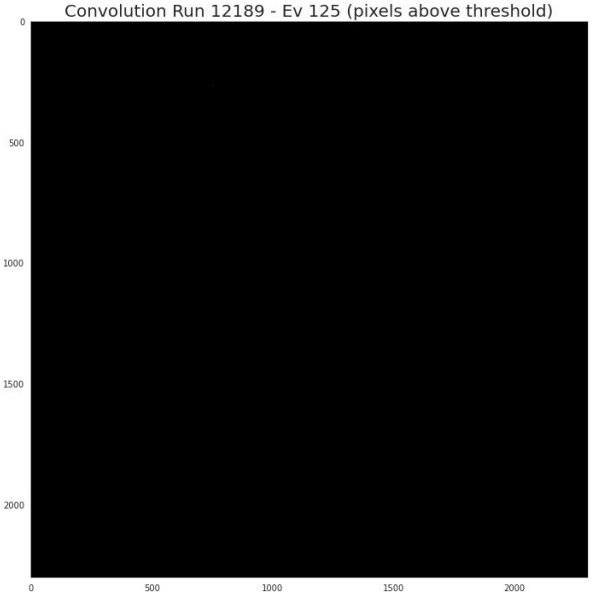


- Example of an event containing high energy tracks.
- The maximum correlation is at a pixel from the purple cluster.

Test (NRAD 12189)



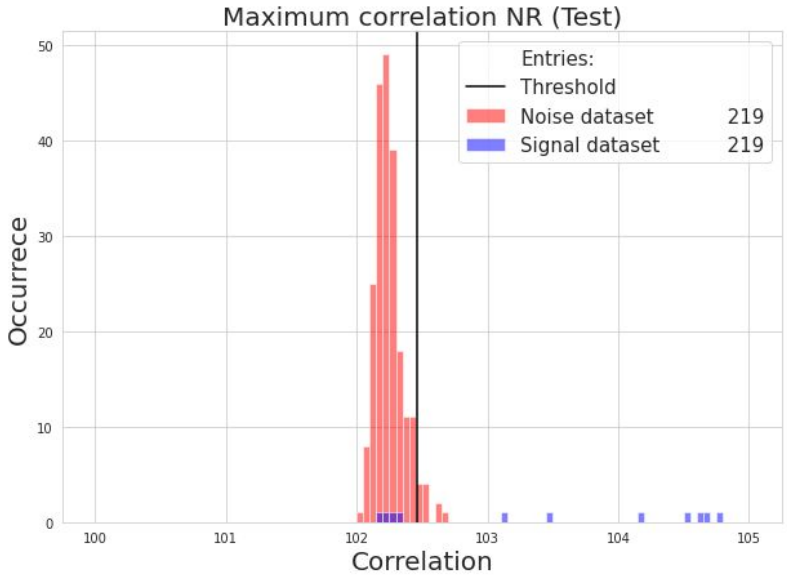




- Example of an event with no clear track.
- 4 pixels have a correlation that is above the threshold. (false alarm event)

Test (NR)

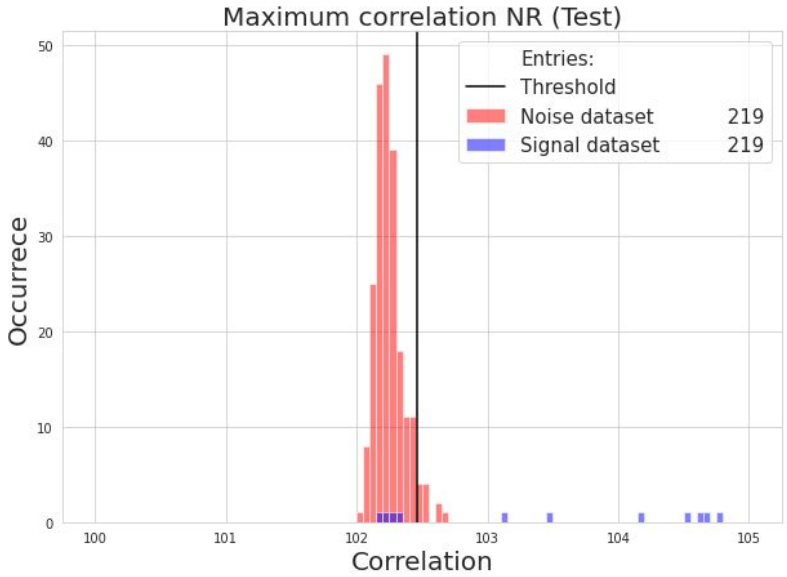
- This simulation contains events with various energies.
- The conversion factor (ADC -> keV) seems to be different from the ER tracks.
- The threshold found on training stage was used:
  - DET_{sig}: (98.2±1.7)%
  - DET_{noise}: (95.9±2.6)%
  - SP: (97±2.2)%



Kernel size = 15; sigma = 10.

Test (NR)

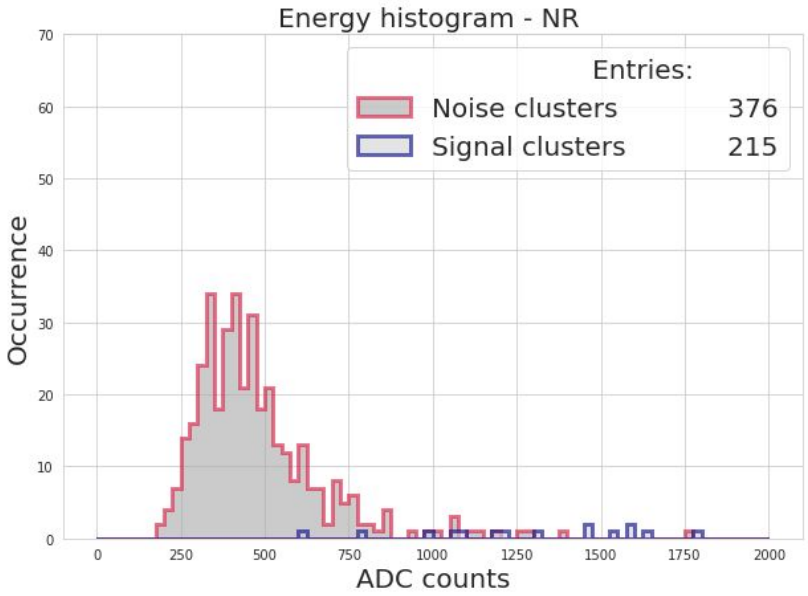
- Signals not detected had the following energies (type 9):
  - Event 6 : 1.889 keV (296 ADC counts)
  - Event 7: 2.099 keV (309 ADC counts)
  - Event 45: 1.871 keV (468 ADC counts)
  - Event 179: 1.885 keV (347 ADC counts)
- These signals would have around 0.25 keV if the ^{55}Fe conversion factor was used.



Kernel size = 15; sigma = 10.

Reco file (NR)

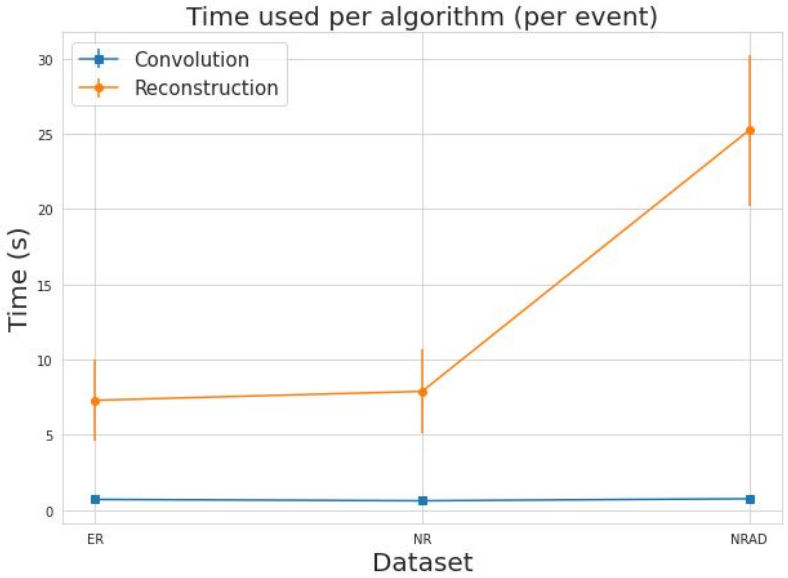
- Only the low energy region was considered for the right plot.
- The same procedure used on the ER dataset to distinguish noise and signal clusters was used.
- The same 4 events were lost on the reconstruction.



Time analysis

- The convolution method needs in average 0.7 seconds per image.

- The reconstruction code may need up to 25 seconds per image (depends on the occupancy of the image).



Conclusions

- The proposed method was able to reach a high noise rejection (~95%) and signal detection efficiency (~90%).

- It has a processing time smaller than 1 second. (independent of the number of tracks present on the image)
  - It also may be improved with GPU.

Next steps

- Test new masks.
- Compare the method with a CNN.
  - Last adjustments being made. (maybe will be presented on the next reco meeting)
- Test some of the preprocessing techniques of the experiment together with the convolution. (i.e pedestal subtraction)
- Test smaller energies (i.e 0.3 keV)? (Test low vgem runs)

Thanks!