Trigger proposal

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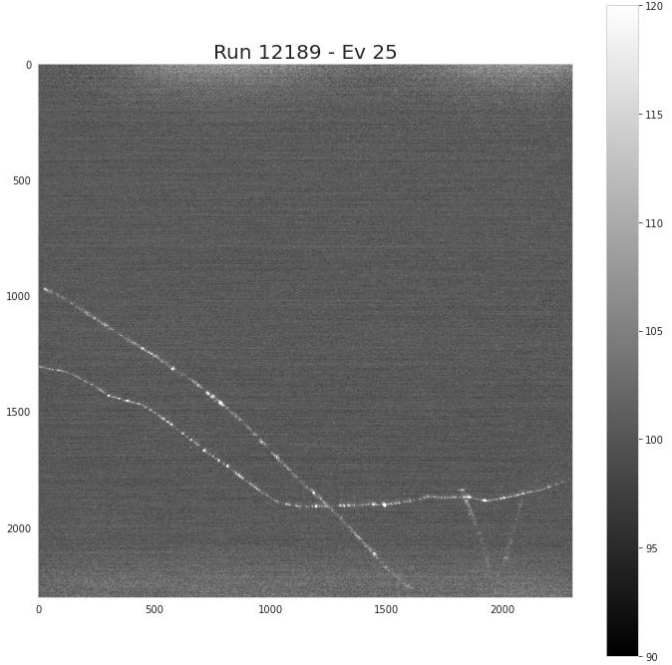
Analysis & reconstruction meeting

1.
Proposal

Proposal

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

Convolution



Raw image

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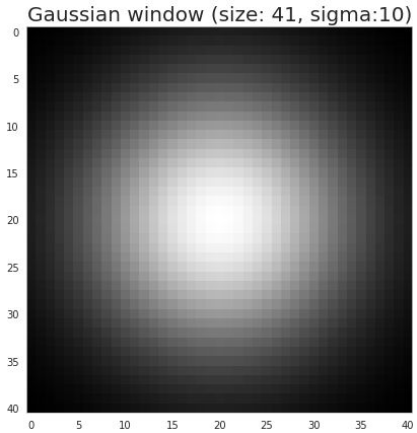

Normalized for area equal to 1.

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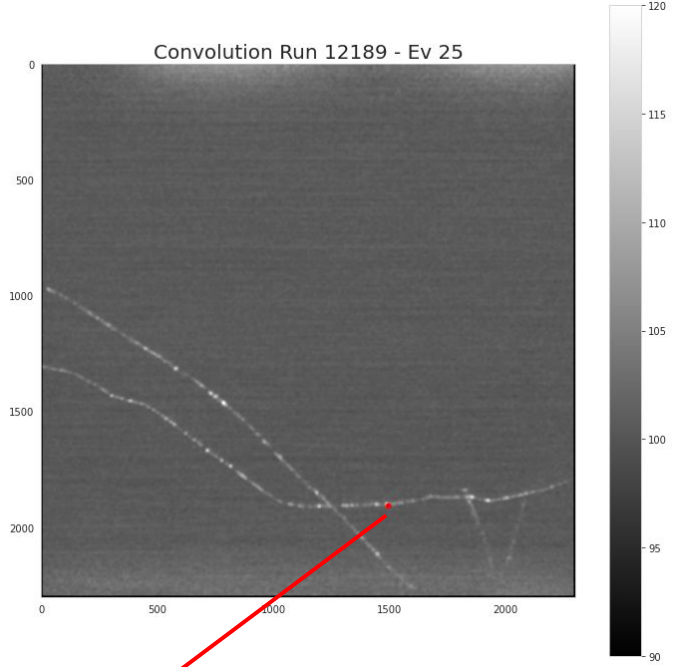


Pixel with highest correlation

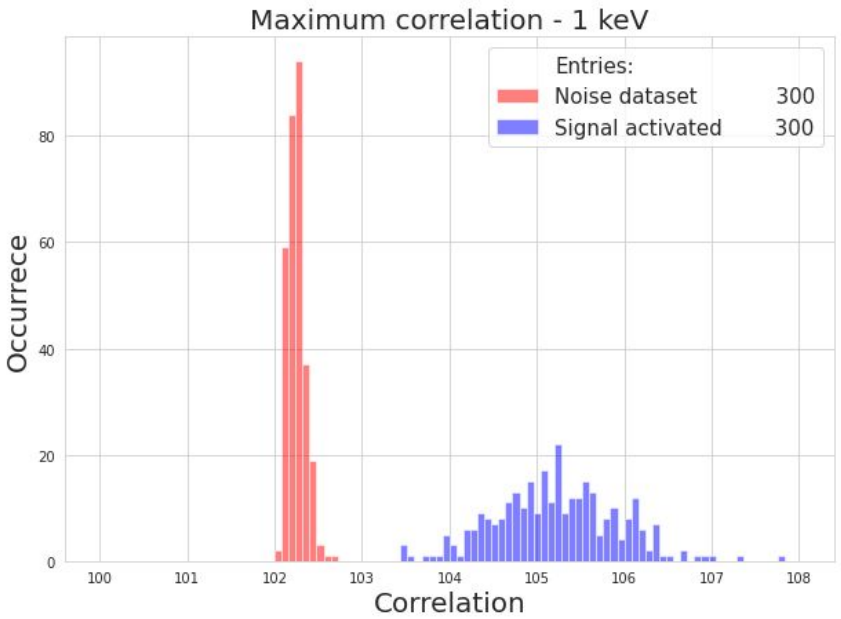
2.
Status

Status

- **Datasets used**
  - Signal simulation: 300 images with one signal in each one randomly displaced. Runs were created with the energy ranging from 0.5 to 5 keV.
  - Noise runs: 4 pedestal runs acquired on the LNGS (300 images used).
- **Analysis.**
  - Gaussian windows were created by changing the kernel size (from 3 to 41).
  - Sigma of the gaussian windows was kept at 10 for this initial analysis (selected by viewing ^{55}**Fe** spots).
  - The highest correlation (value and position) was stored for each image on the signal and noise datasets.
  - Time used for the algorithm.

3.
Analysis

Correlation distributions - Simulation

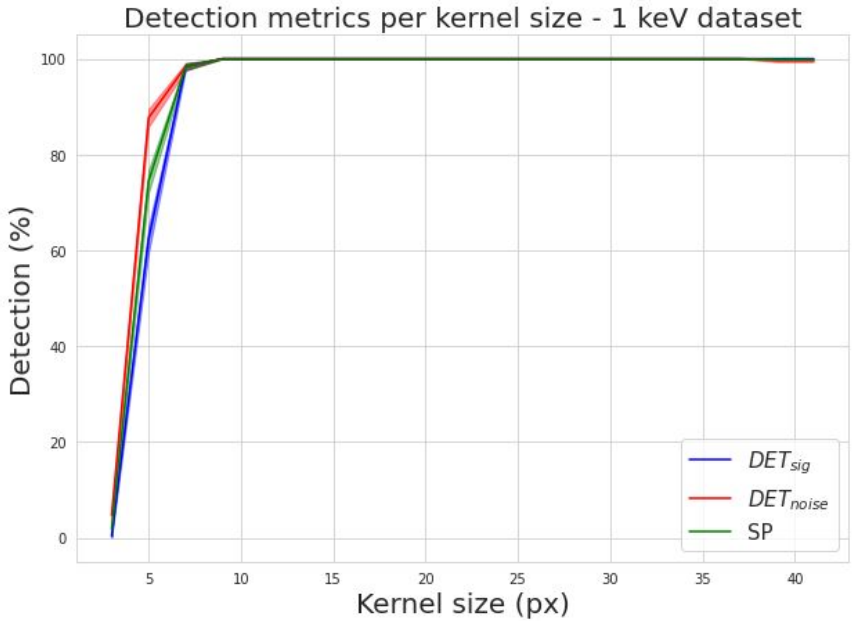


- Example of correlation distributions on the noise and signal (1 keV) datasets.
  - Kernel size equal to 15.
- The idea is to find a threshold that can discriminate noise from signal.
  - The criteria is the one that leads either to the maximum SP, DET_{sig} or DET_{noise}.

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

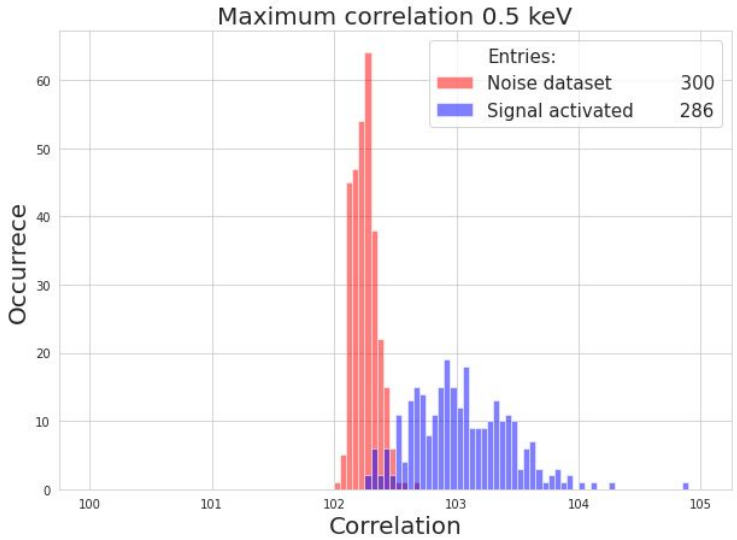
DET_{sig}: Percentage of signal elements above threshold.
DET_{noise}: Percentage of noise elements below threshold.

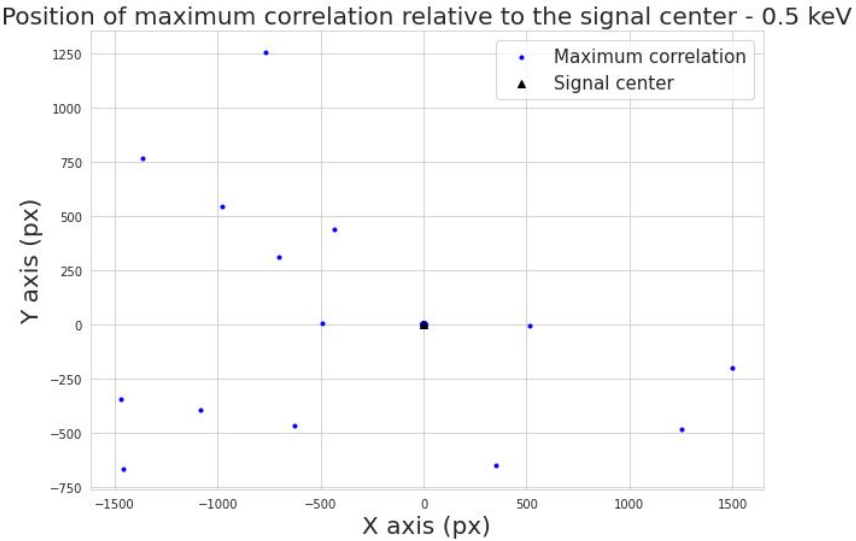
Kernel size scan



- It was possible to reach **100% SP** for most of the kernel sizes on the **1 keV dataset**.
- A great improvement compared to the subimage method (signal detection below 20% for 1 keV).

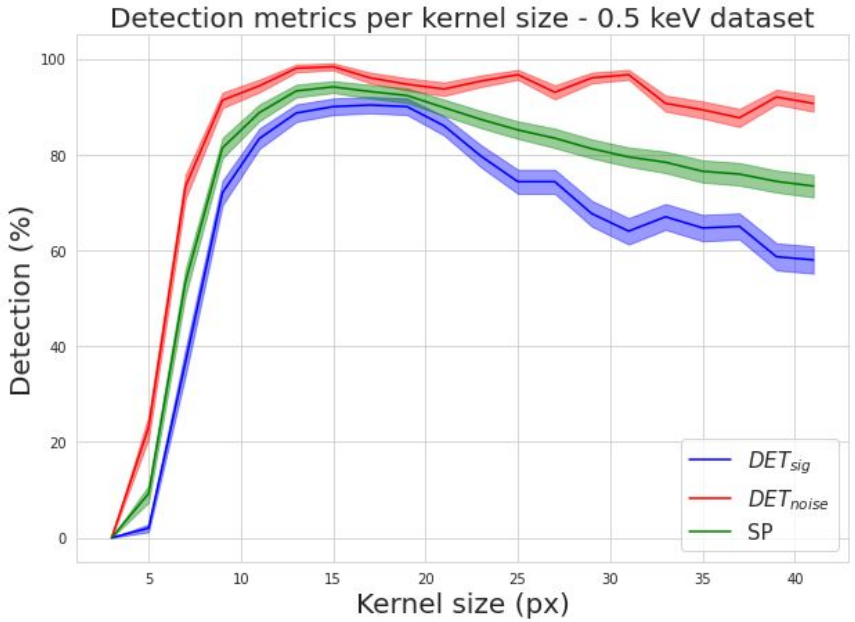
Correlation distribution - Simulation





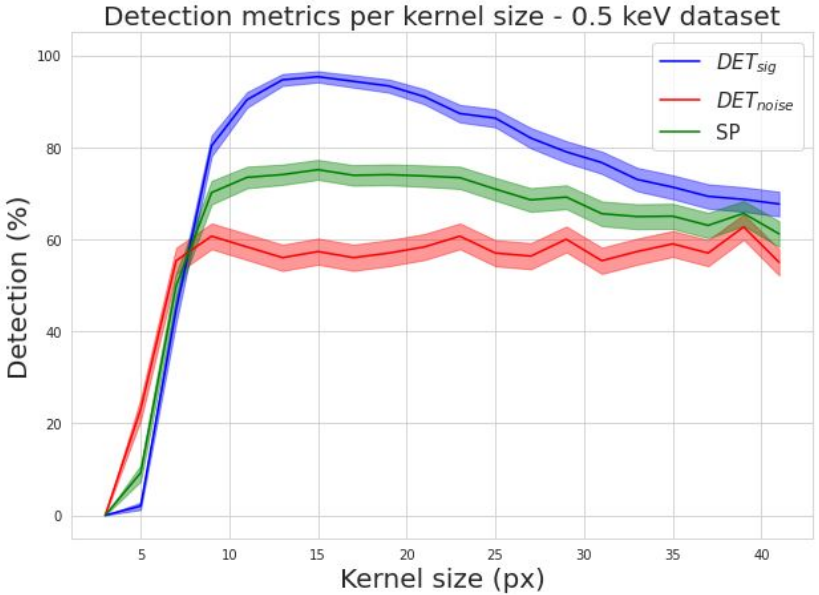
- Example of kernel size equal to 15.
- 14 out of the 300 images from the 0.5 keV dataset did not have the highest correlation close to the center of the event.

Kernel size scan - Highest SP



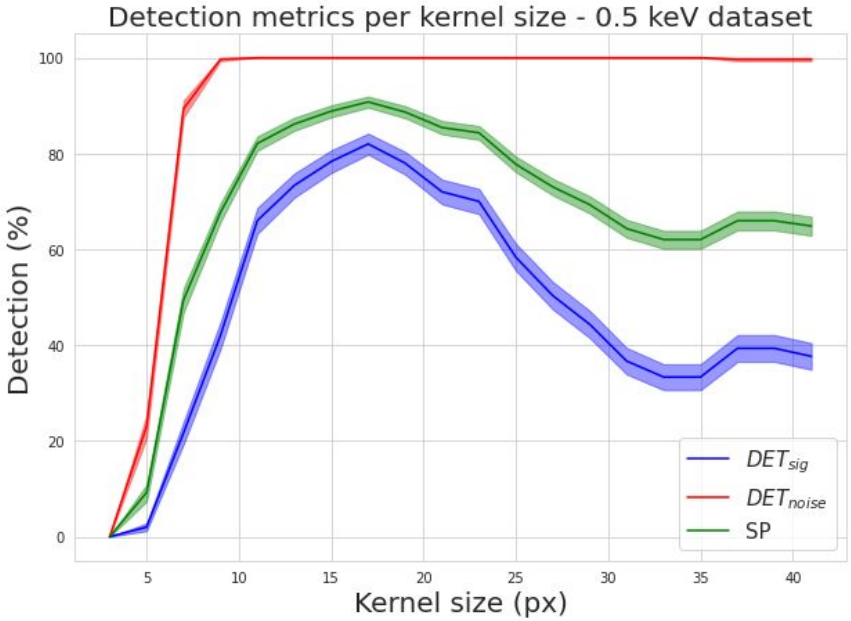
- It was possible to reach a **SP close to 94%** with kernel size equal to 15.
- **DET_{sig} = 90%** (detect 270 of the 300 signal events).
- **DET_{noise} = 98.3%** (reject 295 of the 300 noise images).

Kernel size scan - Highest DET_{sig}



- Another method to find the choose the threshold is to select either the DET_{sig} or DET_{noise} to be maximized.
- It was possible to reach a **DET_{sig} of 95.3%** (detect 286 of the 300 signal events) with kernel size equal to 15.
- **DET_{noise} = 57.3%** (reject 172 of the 300 noise images).
- **SP ≅ 75.1%**

Kernel size scan - Highest DET_{noise}



- Another method to find the choose the threshold is to select either the DET_{sig} or DET_{noise} to be maximized.
- It was possible to reach a **DET_{noise} of 100%** with most of the kernel sizes.
- **DET_{sig} = 82%** (detect 246 of the 300 signal events).
- **SP ≅ 90.8%**

Correlation distribution - Thresholds

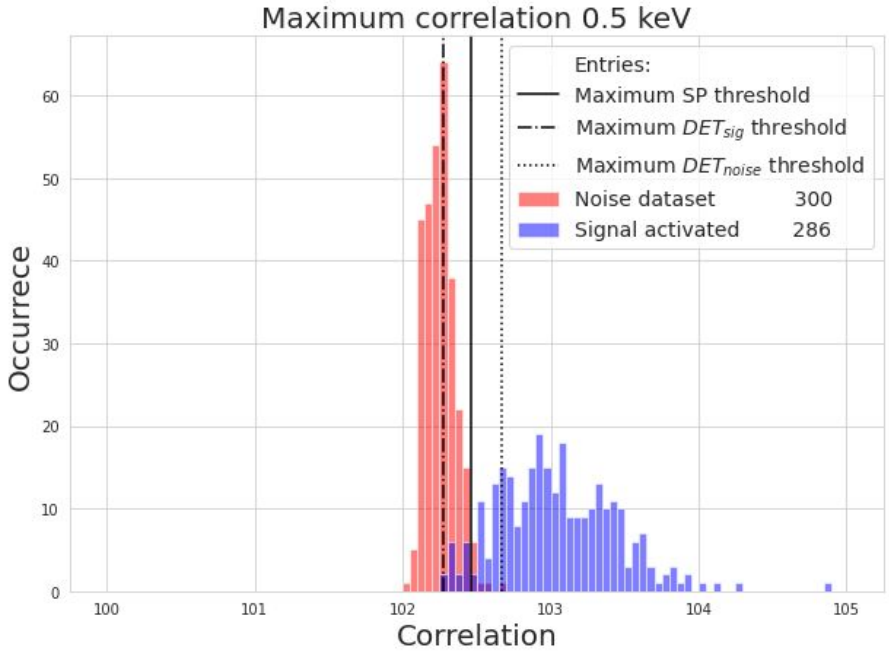
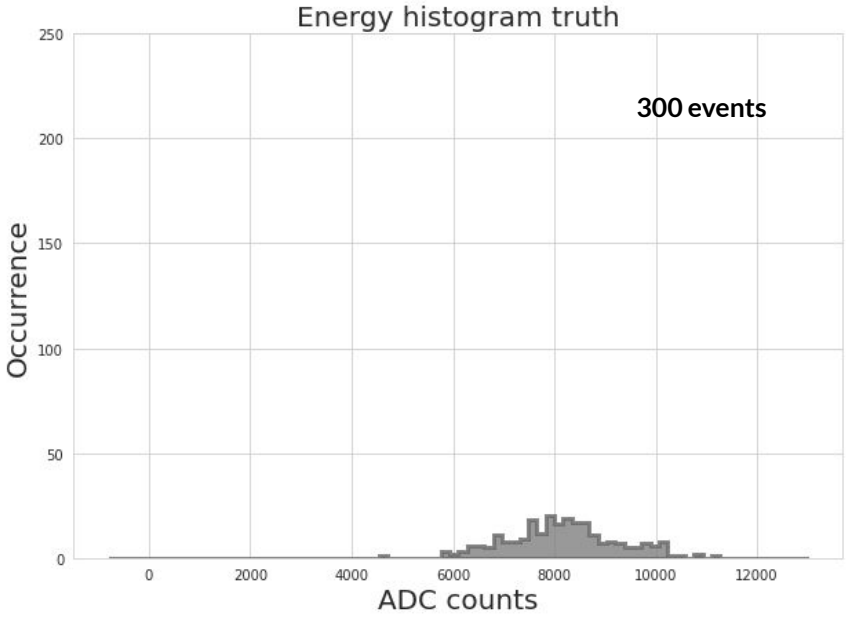


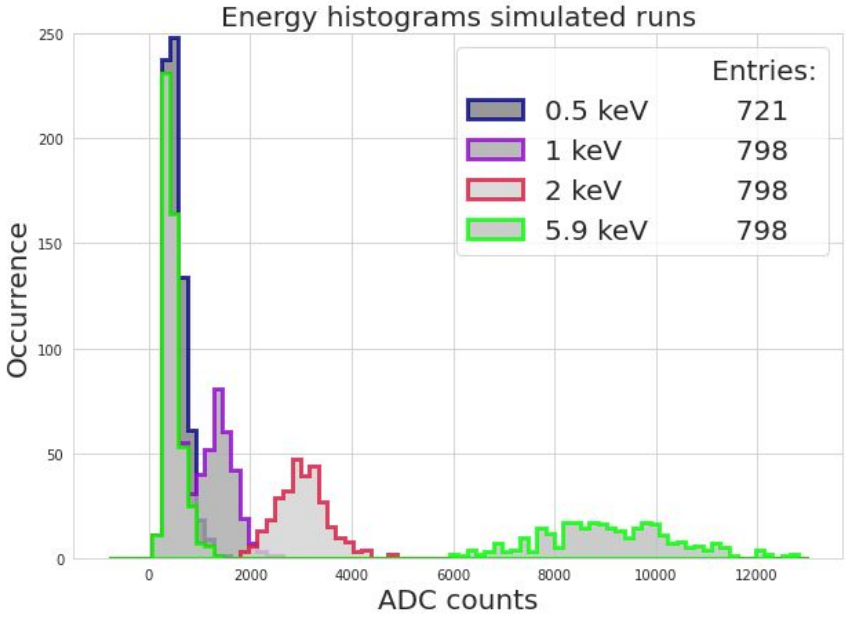
Table of highest achieved metrics based on the threshold criteria.

value \ criteria	SP	DET_{sig}	DET_{noise}
SP	**94%**	75.1%	90.8%
DET_{sig}	**90%**	95.3%	82%
DET_{noise}	**98.3%**	57.3%	100%

Example of thresholds based on criteria for the correlation distributions using kernel size equal to 15

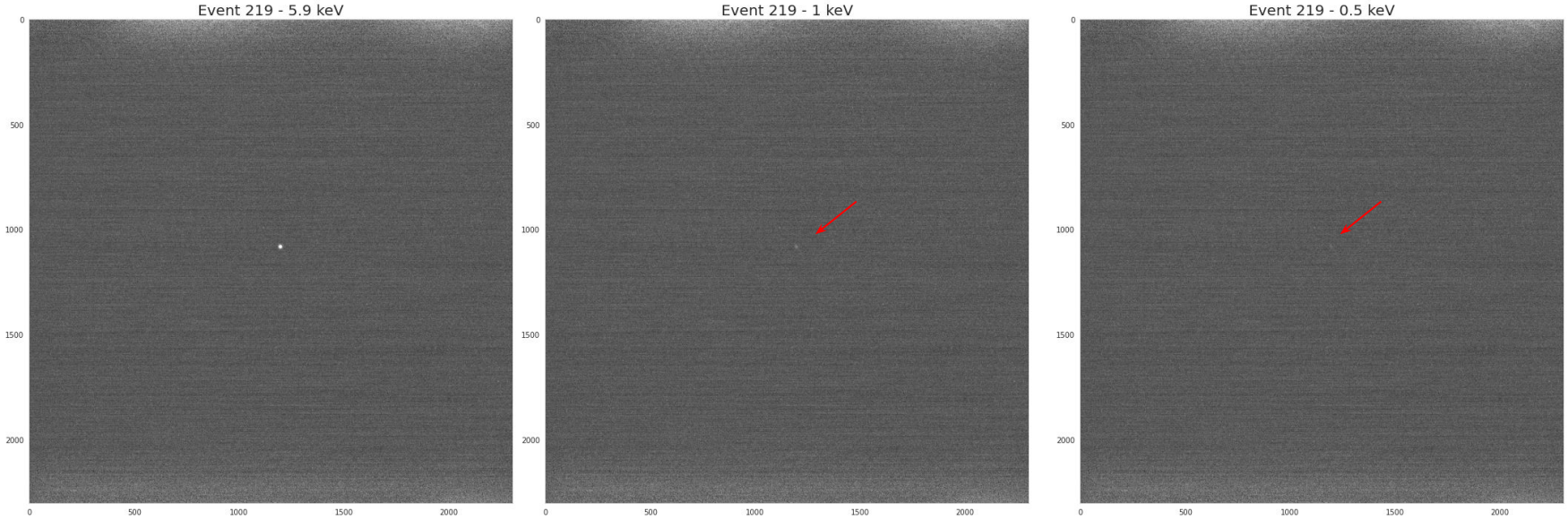
Reco files analysis





- The reconstruction code was not able to identify all the 300 events of 0.5 keV (77 were lost, almost 74% efficiency)
  - Most of the 0.5 keV reconstructed events are in the region dominated by the electronic noise.

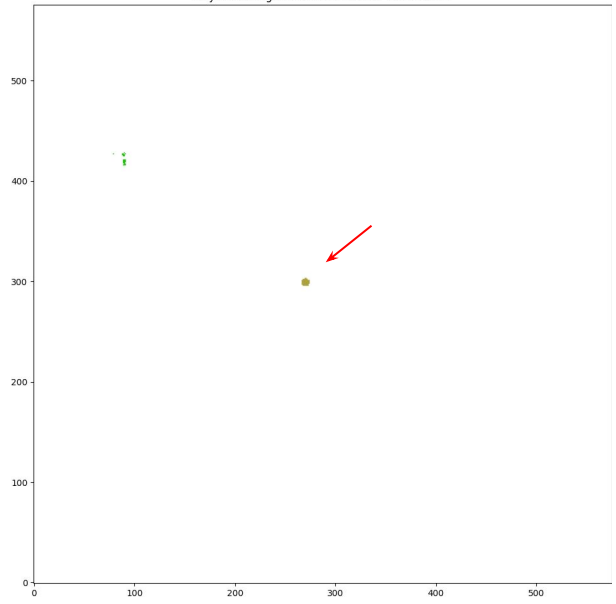
Reco files analysis - Lost event (both algorithms)



It is possible to see that as the energy decreases, the spot gets almost undetectable by eye.

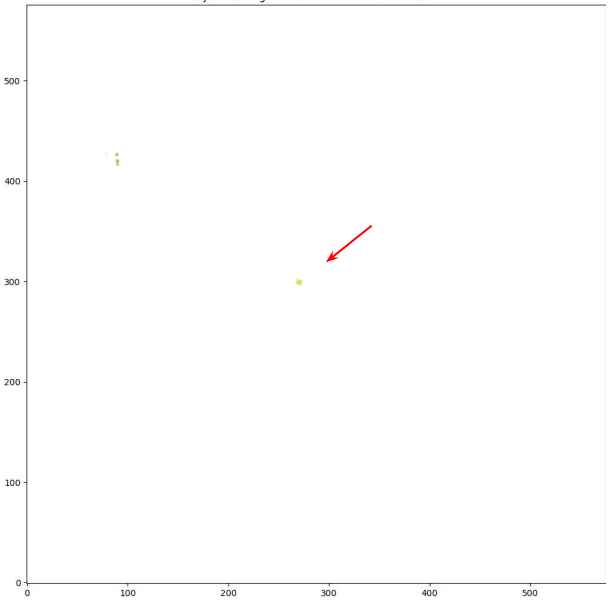
Reco files analysis - Lost event (both algorithms)

5.9 keV

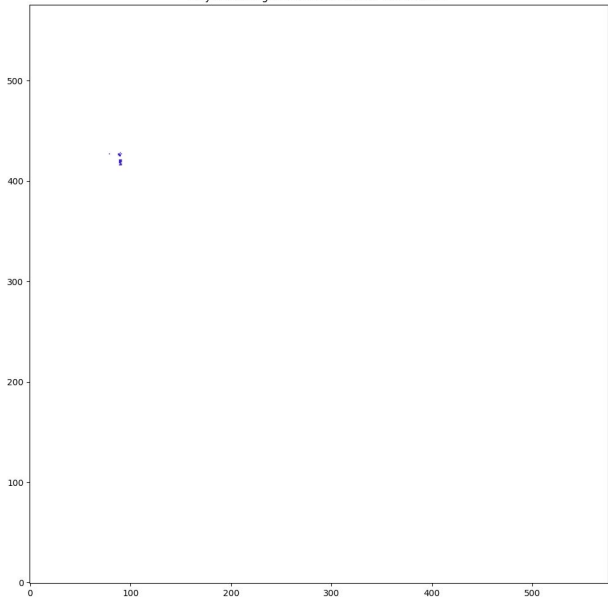


Same event of slide 16

1 keV

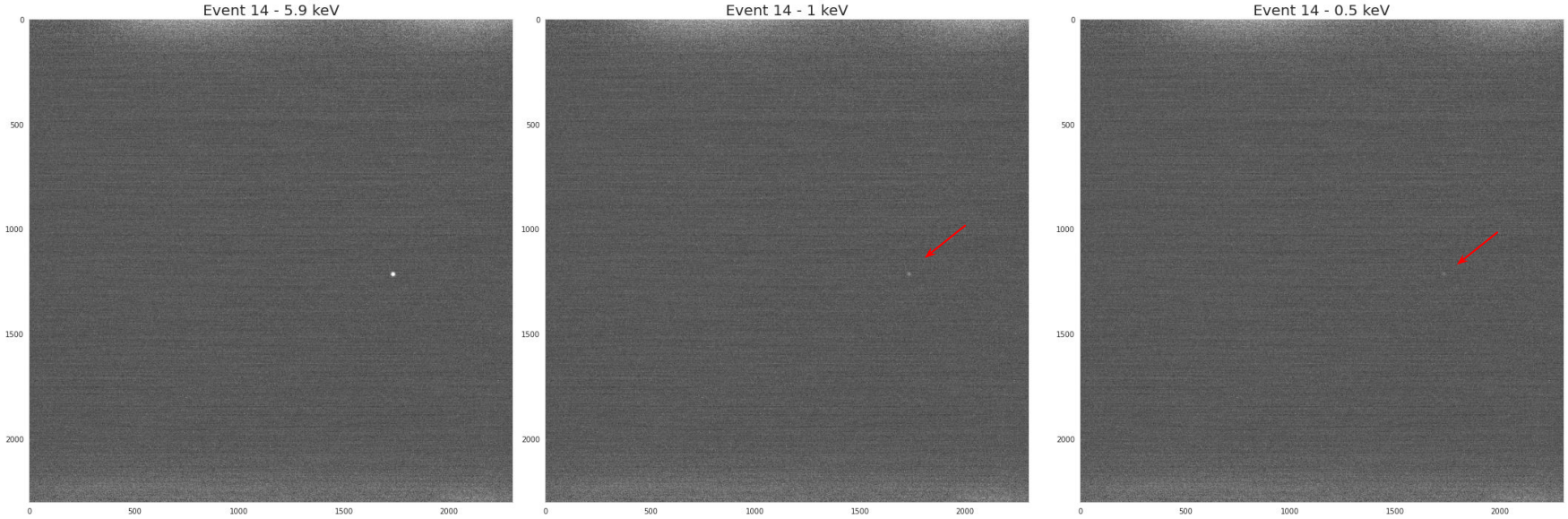


0.5 keV



- Reconstructed energies: (5.9 keV -> 6366.4 ADC counts); (1 keV -> 978.9 ADC counts); (0.5 keV -> Undetected)
  - This particular event (0.5 keV) have a correlation below the threshold found on slide 11 (kernel size 15).

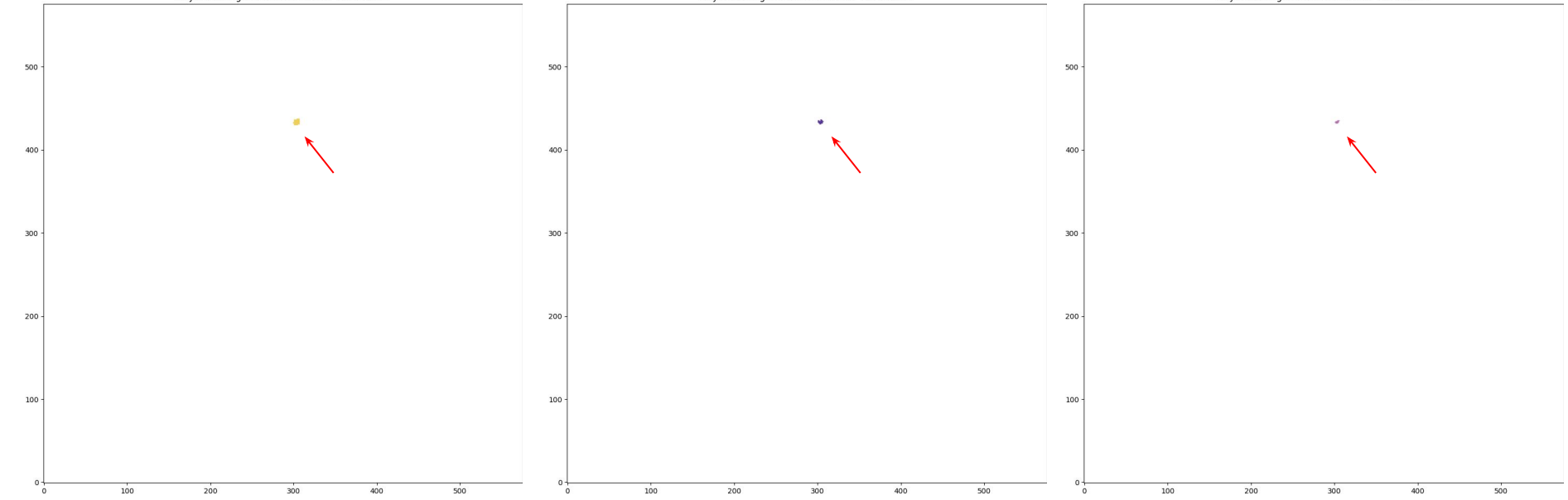
Reco files analysis - Detected event (both algorithms)



It is possible to see that as the energy decreases, the spot gets almost undetectable by eye.

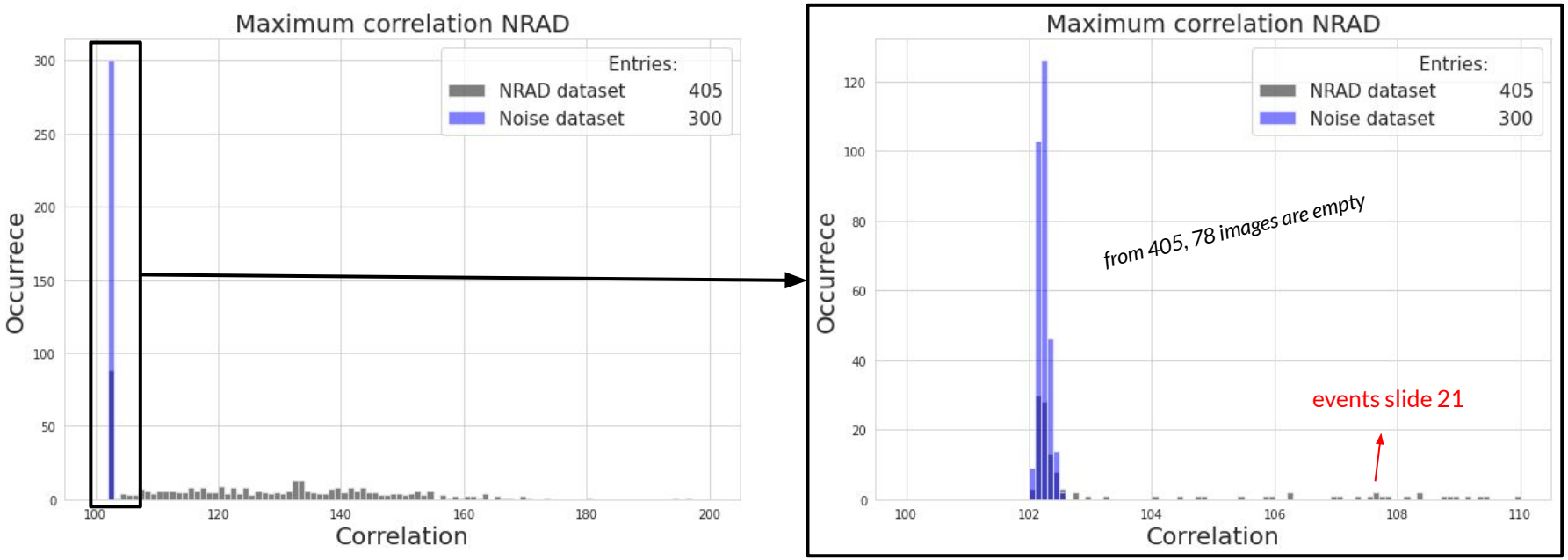
Reco files analysis - detected event (both algorithms)

5.9 keV Same event of slide 18 **1 keV** **0.5 keV**



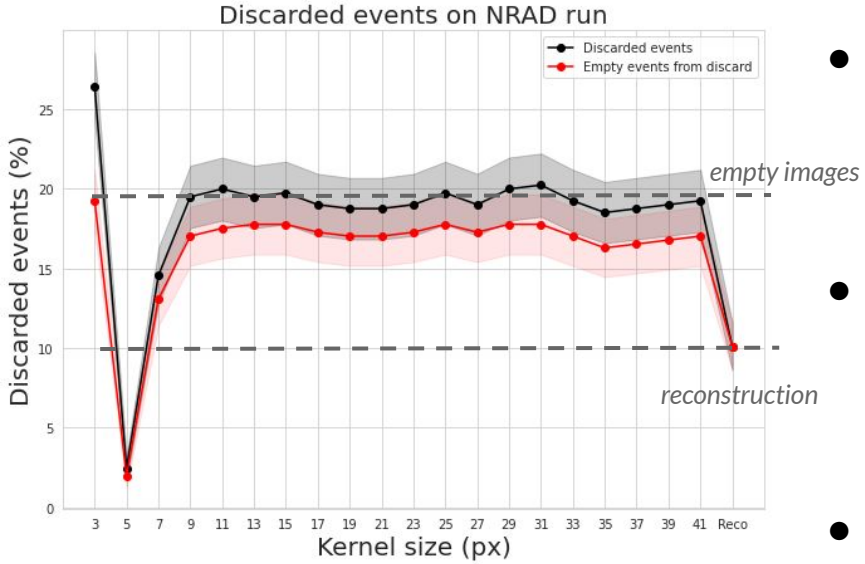
Reconstructed energies: (5.9 keV -> 8476.6 ADC counts); (1 keV -> 1483.1 ADC counts); (0.5 keV -> 670.1 ADC counts)

Correlation distributions - NRAD (12189)



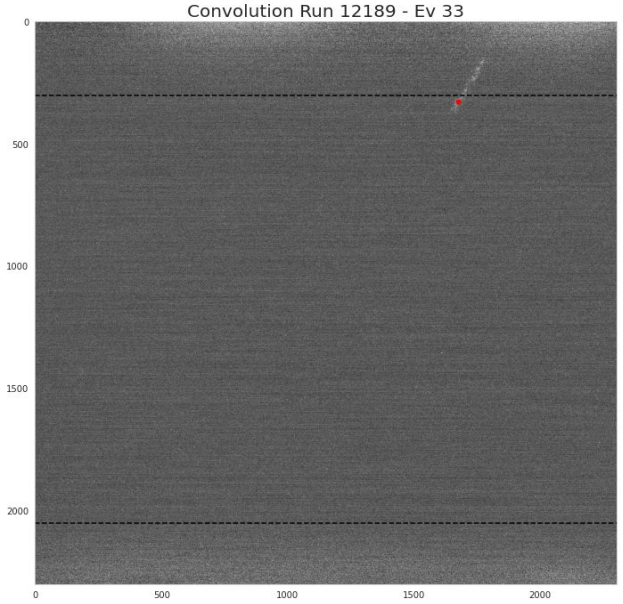
- The same procedure was done using the NRAD dataset (example of kernel size equal to 15).

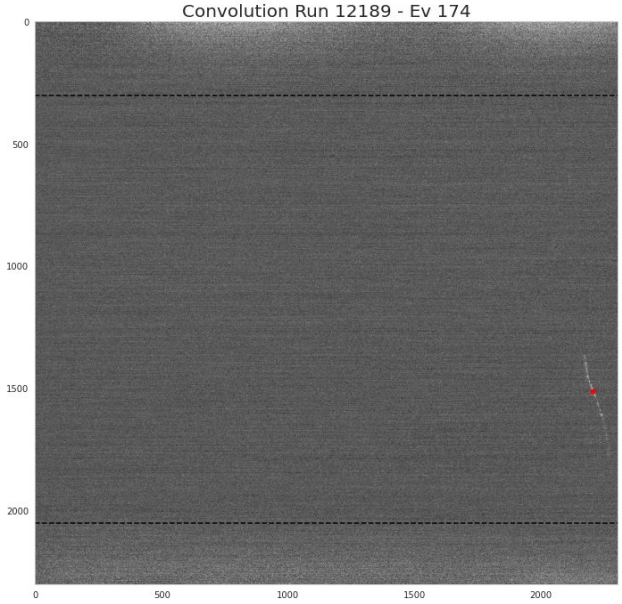
NRAD run (12189)



- An NRAD run containing 405 images was used to test the algorithm.
  - From those, 78 images were empty (~20%).
- It was possible to discard almost all of the empty images using the thresholds of highest SP (slide 11).
- The reconstruction was able to discard 41 images (almost half of the empty ones).

NRAD run - Signal detection

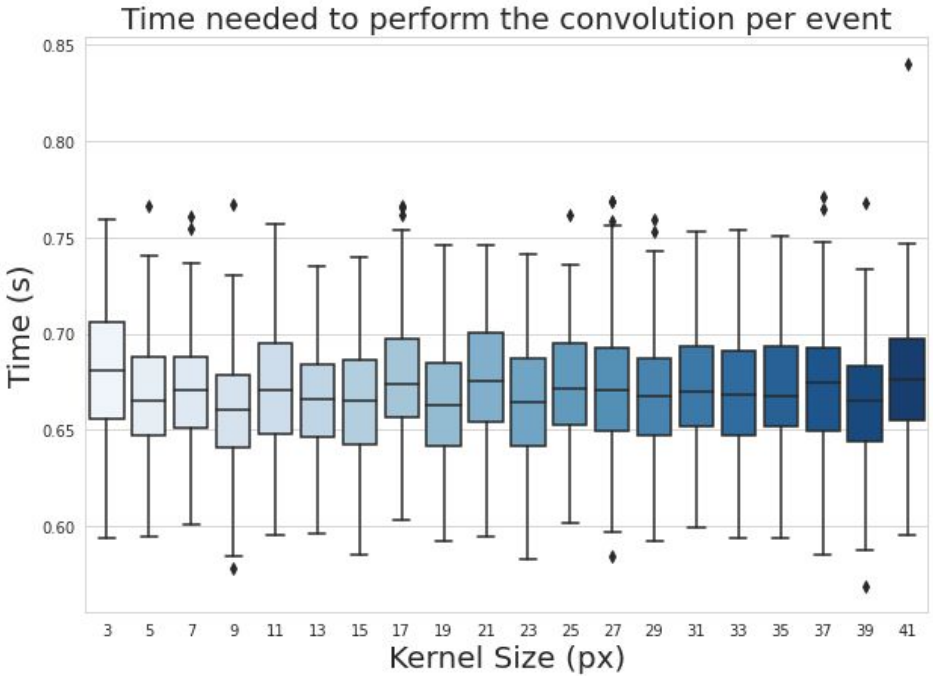




Maximum correlation (kernel size = 15)

- A complete analysis of signal detection on this dataset has not been done yet.
- Examples of images that contain cosmic tracks (maximum correlation is clearly on the track)

Time analysis



- The time needed to perform the convolution is close to 0.7 seconds per image.
- There seems to be no relation between time and kernel size (the function uses FFT and IFFT).
- There are some implementations in the literature of convolution using GPU (to be tested).

Reconstruction -> 7.44 ± 0.13 seconds per image on signal dataset.

Next steps

- Complete the analysis on the NRAD dataset.
  - Compare pixel information from the clusters to confirm the location of maximum correlation.
- Increase the complexity of the analysis.
  - Change the sigma from the gaussian window.
- Test multiple kernels and a CNN method.

Thanks!