Trigger proposal

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Analysis & reconstruction meeting

1.
Introduction

Introduction

- Motivation: reduce data to manageable levels by selecting only events of interest, saving storage and processing resources.
  - Each run may need up to 2 Gb to be stored after the compression.
    - ~1 Tb per day considering the current frequency.

Proposal

- ▷ Develop algorithms to be tested as online trigger to decide whether to save or not images taken by the detector.
  - *on going* → ○ Convolution of the image with several kernels: look for high correlation points. [Link of the last presentation]
  - ○ Explore Machine Learning methods
- ▷ Redo the analysis considering various energies below 1 keV.

2.

Dataset

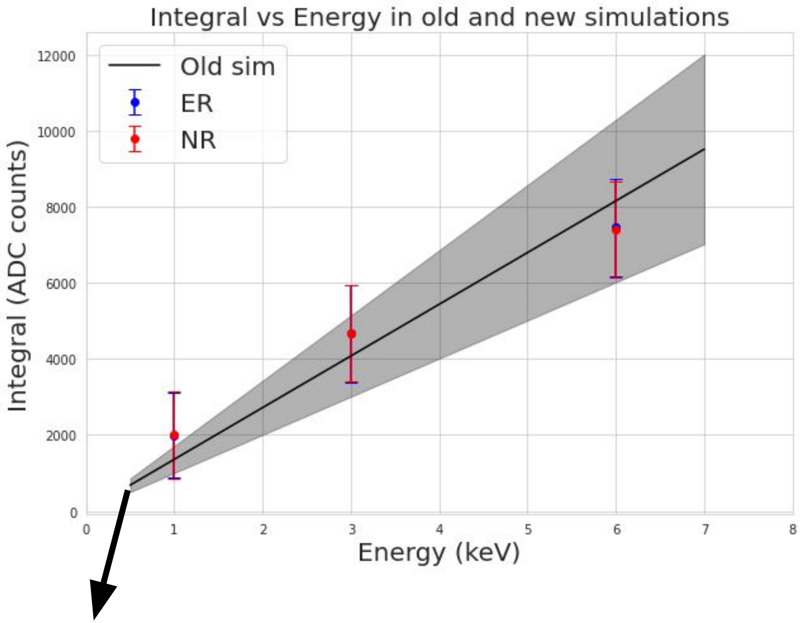
Simulation

- We started using Pietro's simulation, which contains:
  - ER events with 1, 3, 6, 10, 30 and 60 keV (1k each)
  - NR events with 1, 3, 6, 10, 30 and 60 keV (1k each)

- The smaller energies were compared to the simulation used on the previous work.
  - The old simulation had 300 events with 5.9 keV ER signals.

Simulation

- It's possible to observe that the linearity supposed in the previous dataset underestimates the smaller energies.
  - The performance of both reconstruction and trigger tends to be higher than the results shown before.
- This imprecision may be reduced if we use the 1 keV dataset to estimate the smaller energies.

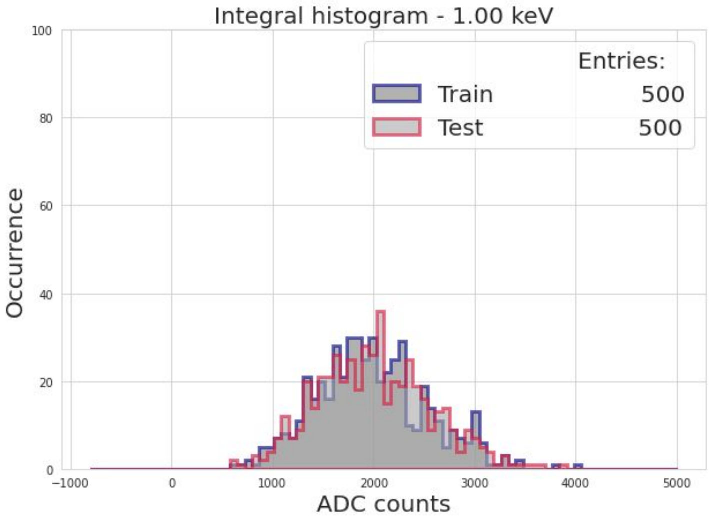


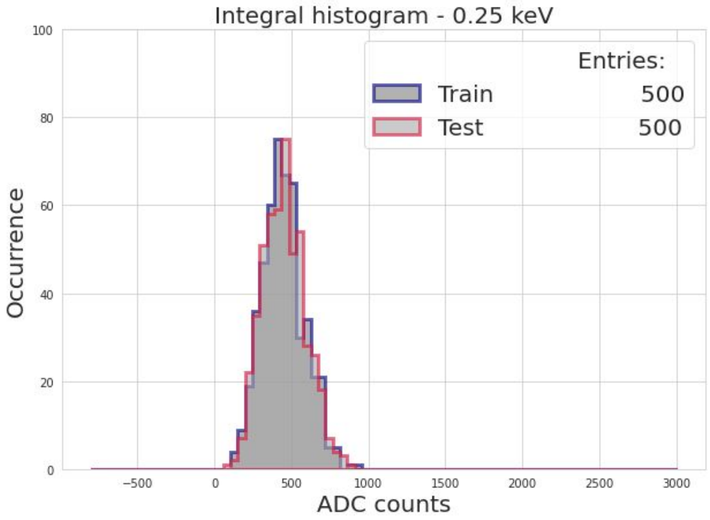
Last results

Datasets

- **Datasets**
  - **Training (reconstruction was also used for comparison):**
    - Noise dataset: 500 images from pedestal runs (Run 4 underground).
    - ER signal simulation: 500 images containing 0.25, 0.5, 0.75 and 1 keV signals added to pedestal runs.
    - NR signal simulation: 500 images containing 0.25, 0.5, 0.75 and 1 keV signals added to pedestal runs.
  - **Test (reconstruction was also used for comparison):**
    - Same numbers of training, but different signals and noise.

Simulation



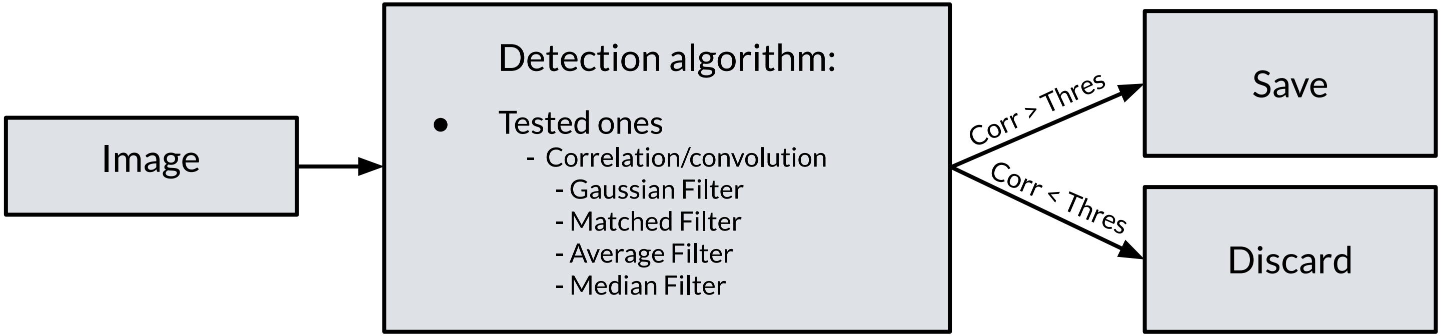


The train and test datasets were split in a way that both have similar distributions

3.

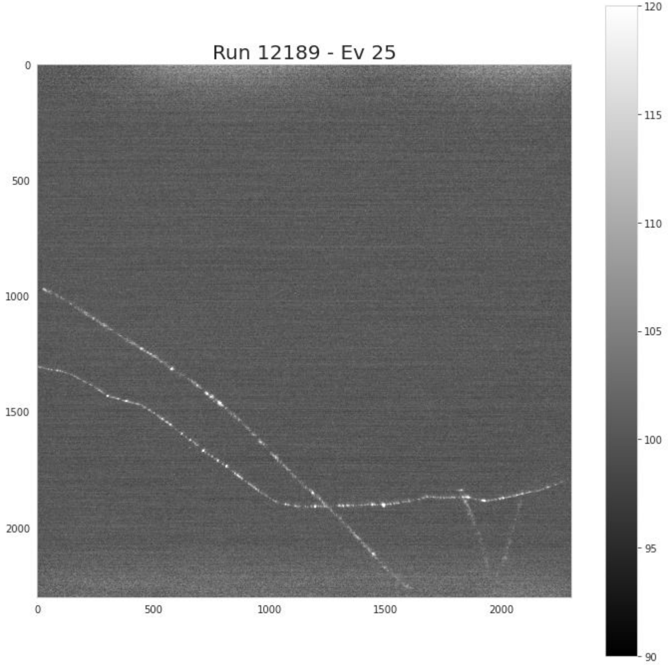
Analysis

Methodology



- A large set of parameters was used during the training for each filter (window size and sigma if needed)
- The filters had a slightly better performance using pedestal subtraction method.

Correlation/Convolution



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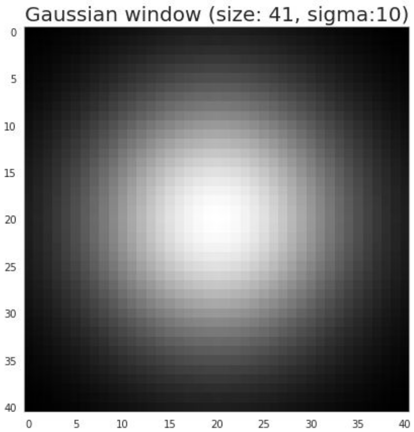

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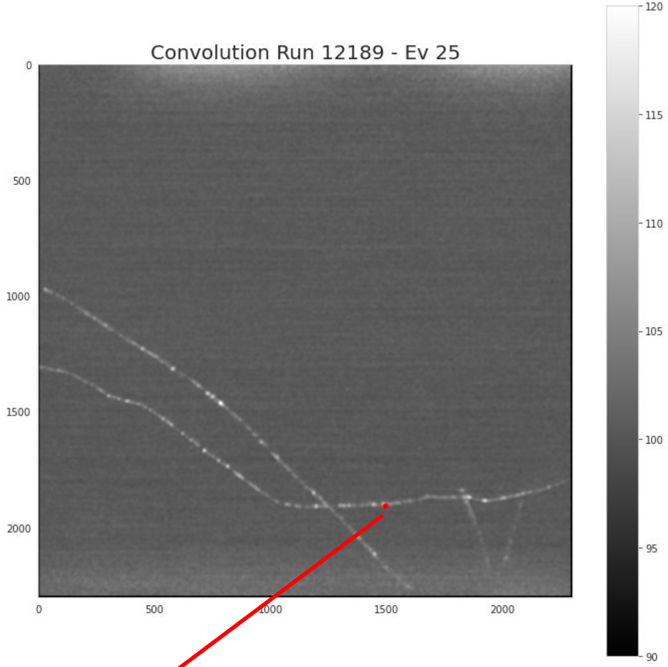


Raw image

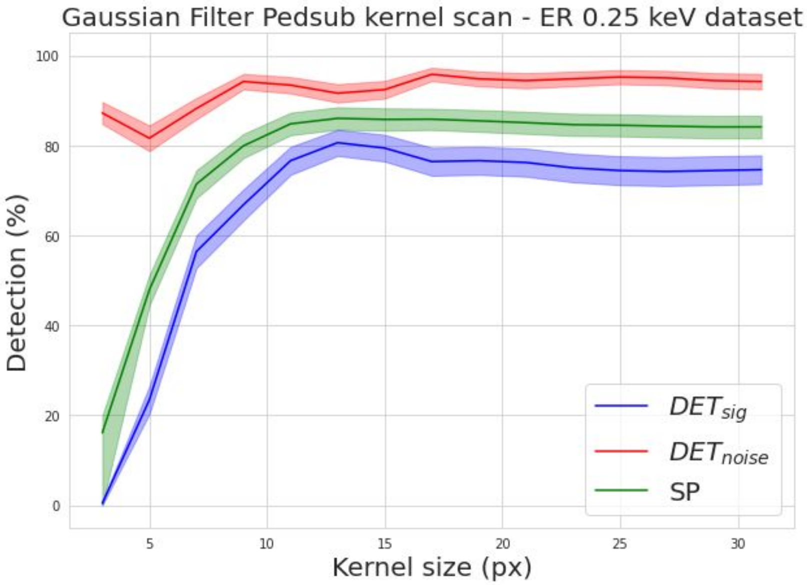
Normalized for area equal to 1.

Pixel with highest correlation

Training - ER

- The operation point is selected by testing the parameters aiming for the maximum SP.

- In this example, the gaussian filter on images after pedestal subtraction achieved the maximum SP with kernel size equal to 13.

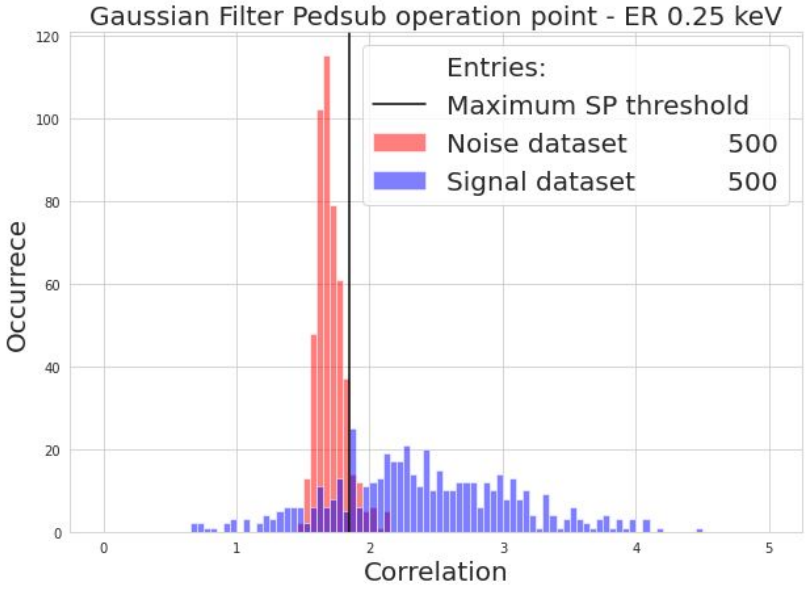


Sigma = 5

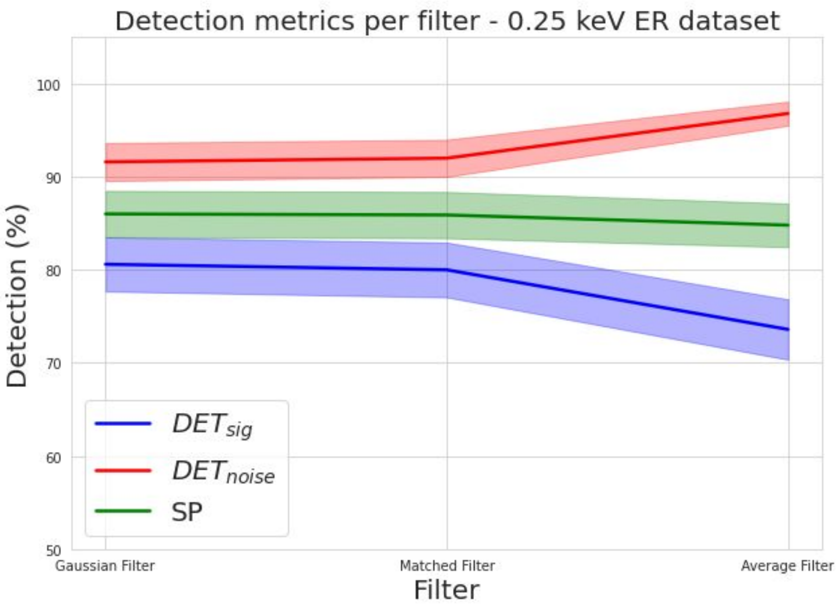
Training - ER

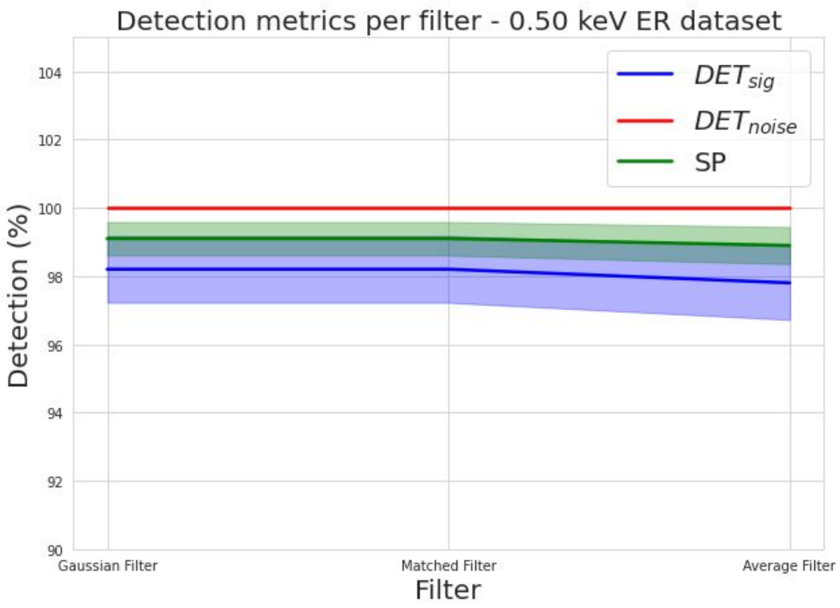
- The operation point is selected by testing the parameters aiming for the maximum SP.

- In this example, the gaussian filter on images after pedestal subtraction achieved the maximum SP with kernel size equal to 13.
  - DET_{sig}: (80.6±2.9)%
  - DET_{noise}: (91.6±2.0)%
  - SP: (86.0±2.5)%



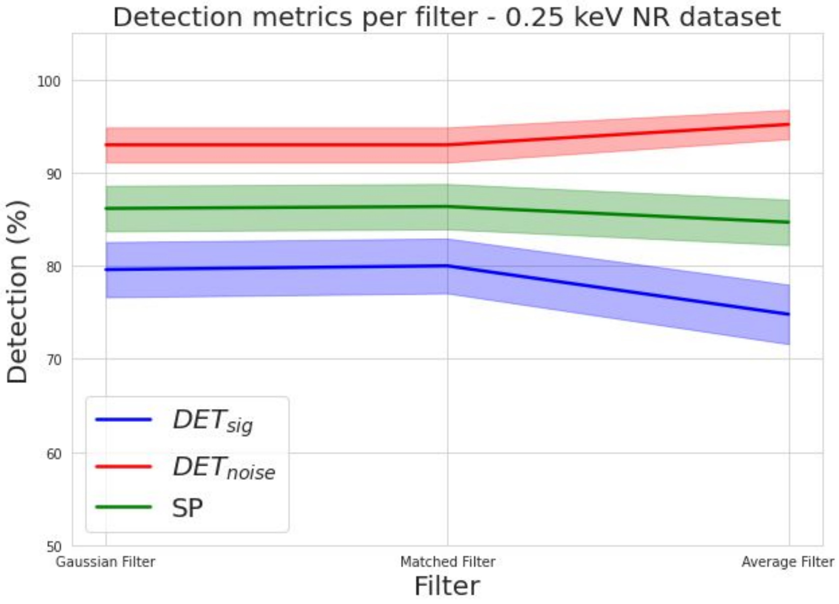
Training - ER

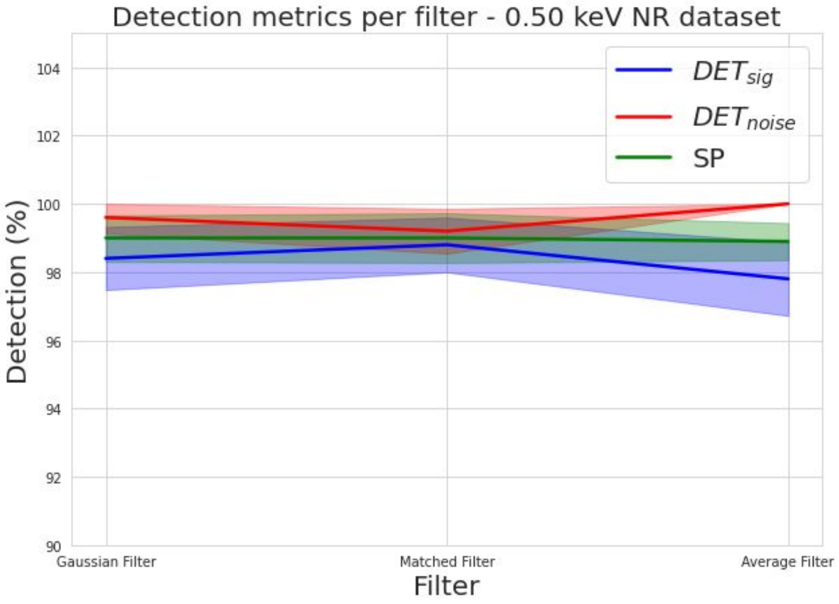




The 0.5 keV ER signal is almost fully separable

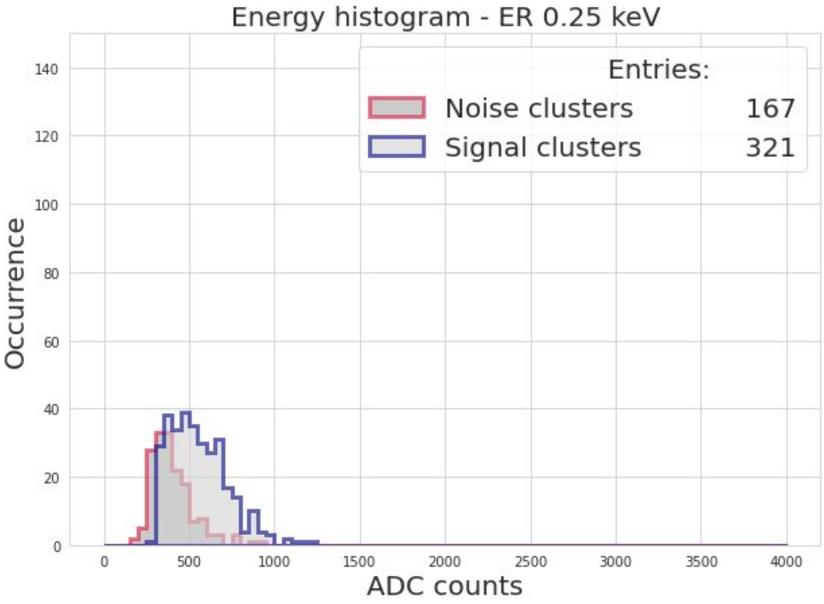
Training - NR

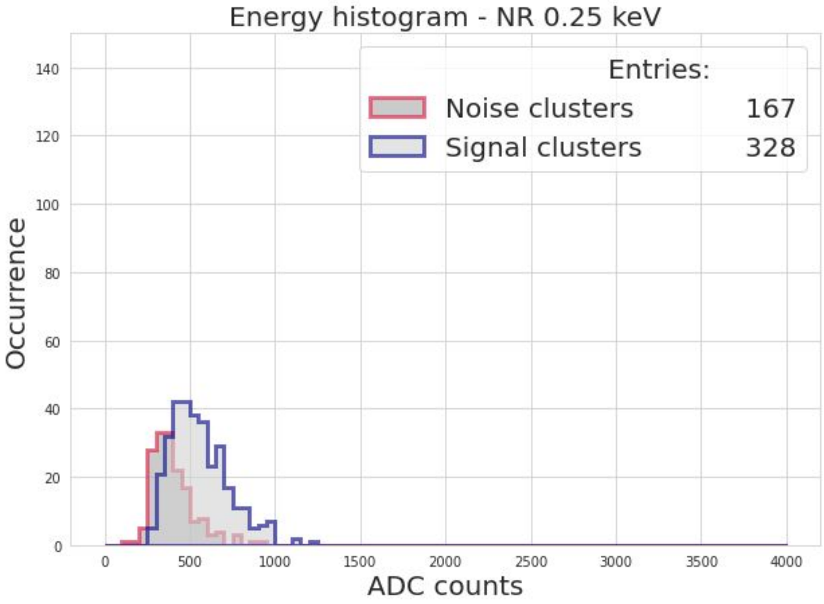




The NR simulation had almost the same results of ER (operation points were equal).

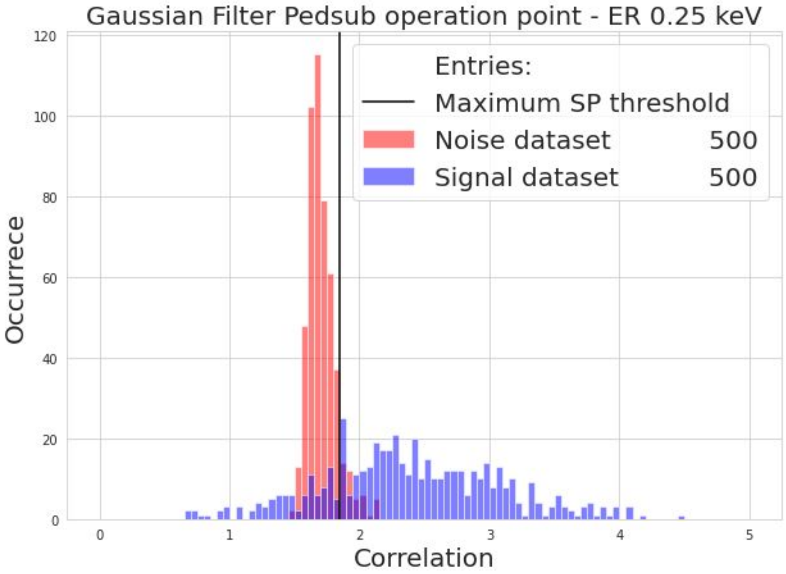
Reconstruction

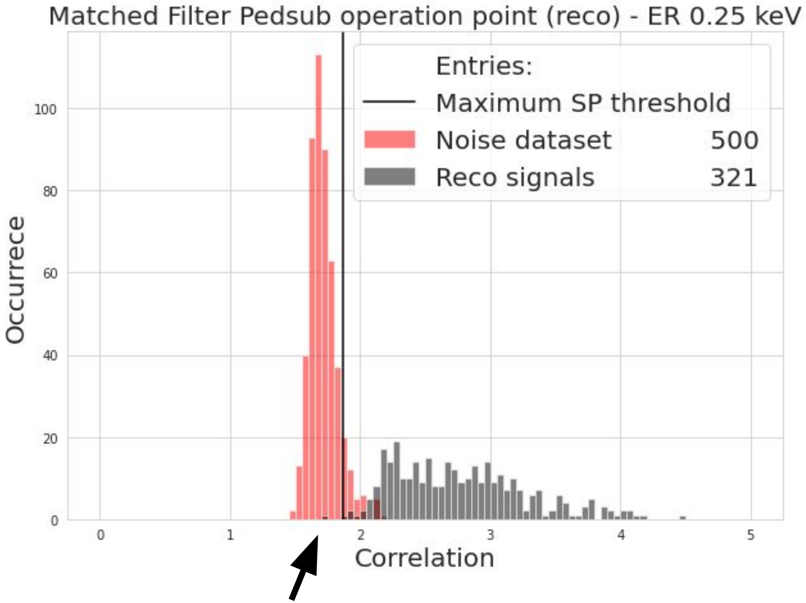




The reconstruction was able to detect 64.2% and 65.6% of the ER and NR signals respectively, while having a 66.6% noise rejection.

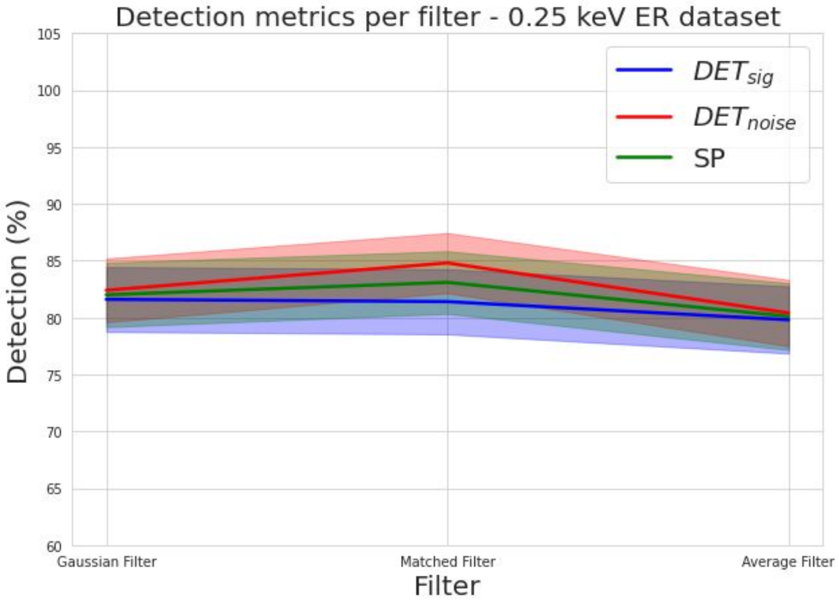
Reconstruction correlations ER

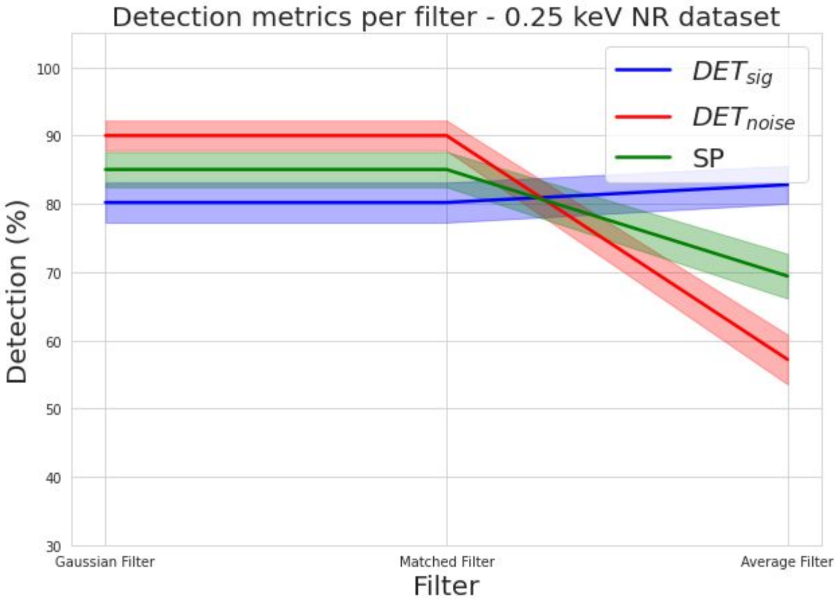




- If we compare the correlations in all events detected by the reconstruction, some of them may not be detected by this method, although the overall signal detection is higher.

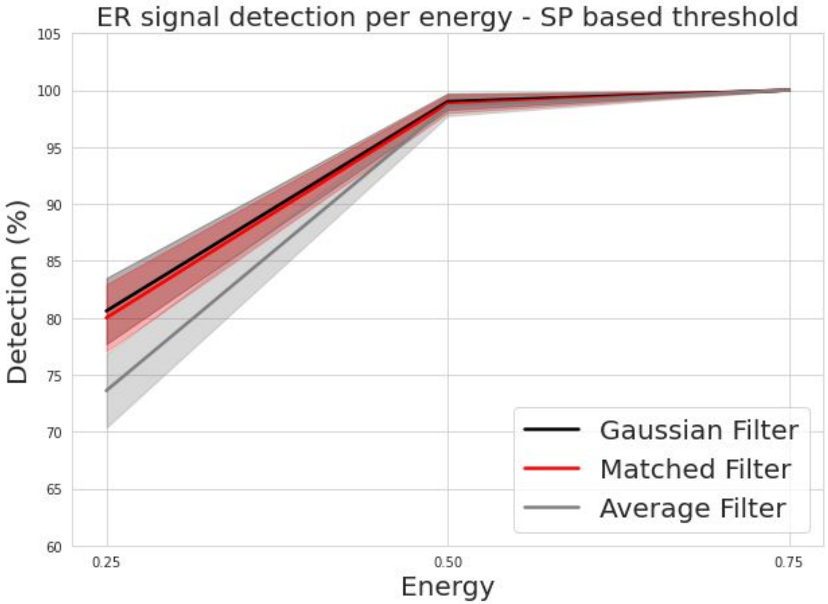
Training Reco Threshold

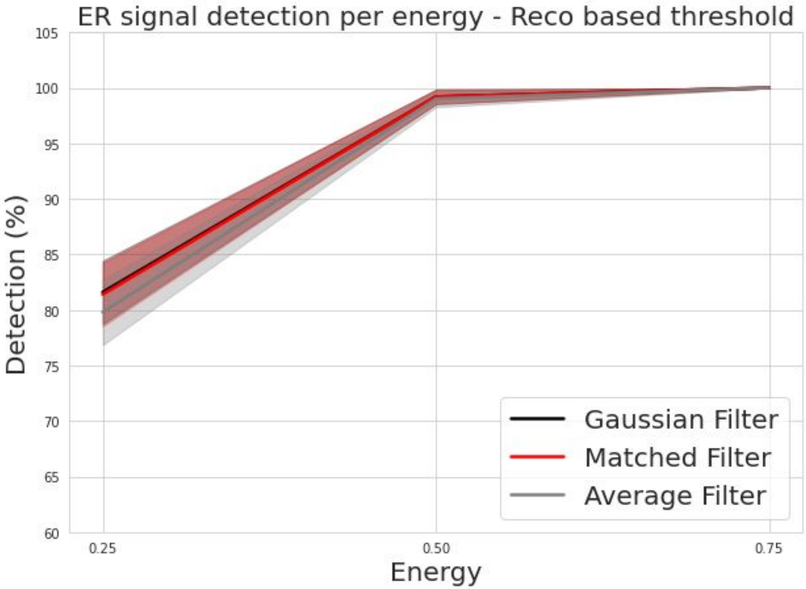




- Another way to select an operation point would be to select a threshold capable of triggering all events detected by the reconstruction while also maximizing the SP.

Energy performance - ER

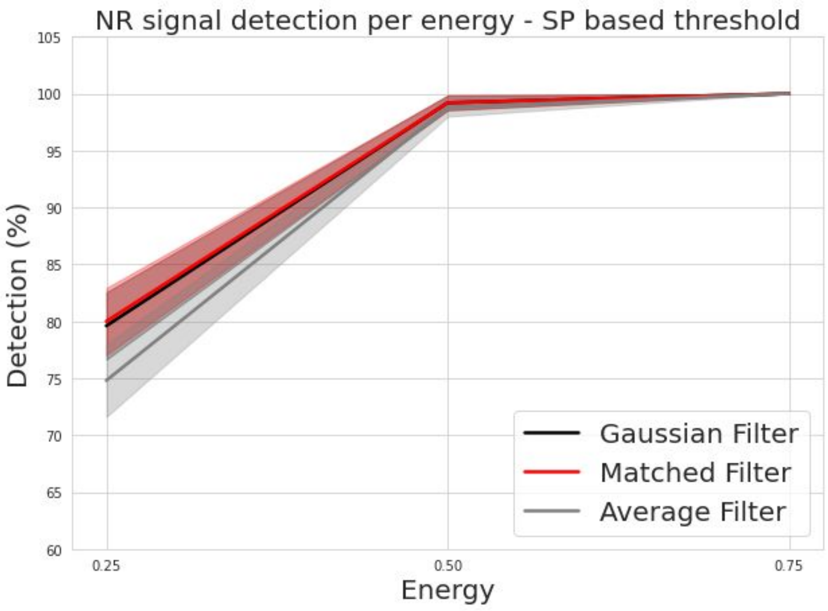


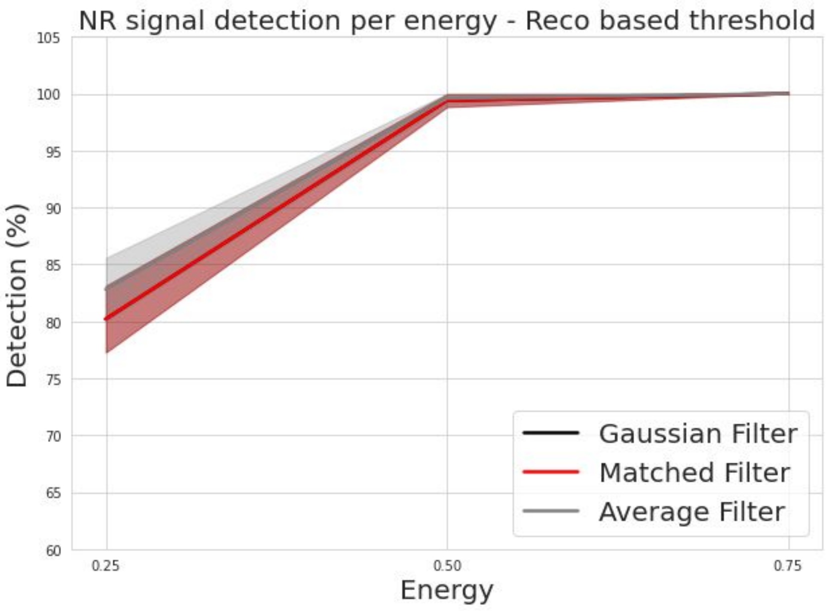


Gaussian Filter noise rejection = 91.6%
Matched Filter noise rejection = 92.0%
Average Filter noise rejection = 96.8%

Gaussian Filter Noise rejection = 82.4%
Matched Filter Noise rejection = 84.8%
Average Filter noise rejection = 80.4%

Energy performance -NR



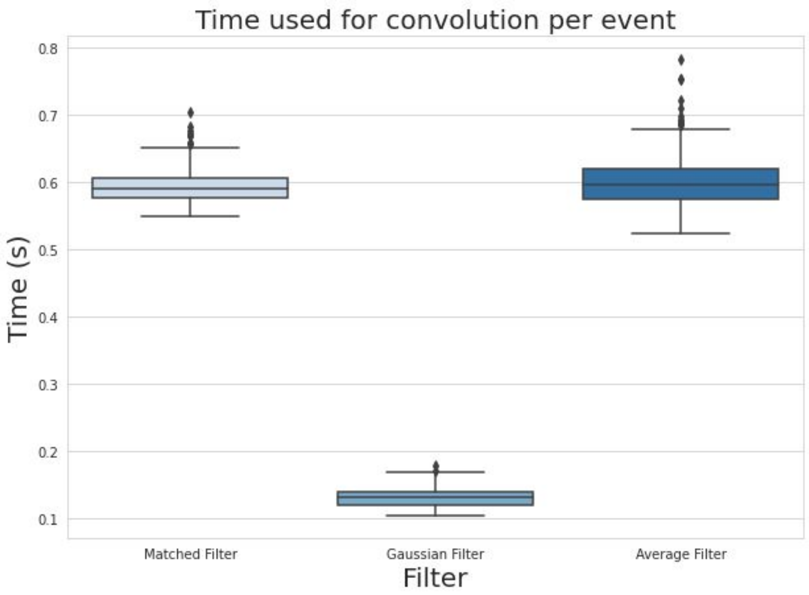


Gaussian Filter noise rejection = 93.0%
Matched Filter noise rejection = 93.0%
Average Filter noise rejection = 95.2%

Gaussian Filter Noise rejection = 90.0%
Matched Filter Noise rejection = 90.0%
Average Filter noise rejection = 57.2%

Time analysis

- The Gaussian Filter outperforms by far the other filters in speed.
  - Gaussian filter has a dedicated function that uses the its symmetry characteristic to speed up the convolution.
  - Average and Matched filters were applied via FFT and IFFT.



Conclusions

- The proposed method was able to reach a high noise rejection and signal detection at 0.25 keV (over 80% depending on the operation point).
    - Old simulation had 90% detection on 0.5 keV whereas the new has almost 100%.
    - ER and NR with very similar results at the low energy region.

- It has a processing time smaller than 1 second. (independent of the number of tracks present on the image)

Next steps

- Finish the analysis on the Test dataset.
- Compare the method with a CNN. (Guilherme’s work)
- Check if the actual simulation of energies below 1 keV follow a linear behavior as it was assumed.
- Test the method on low vgem runs.

Thanks!