Trigger proposal

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13/04/2023
Analysis & reconstruction meeting

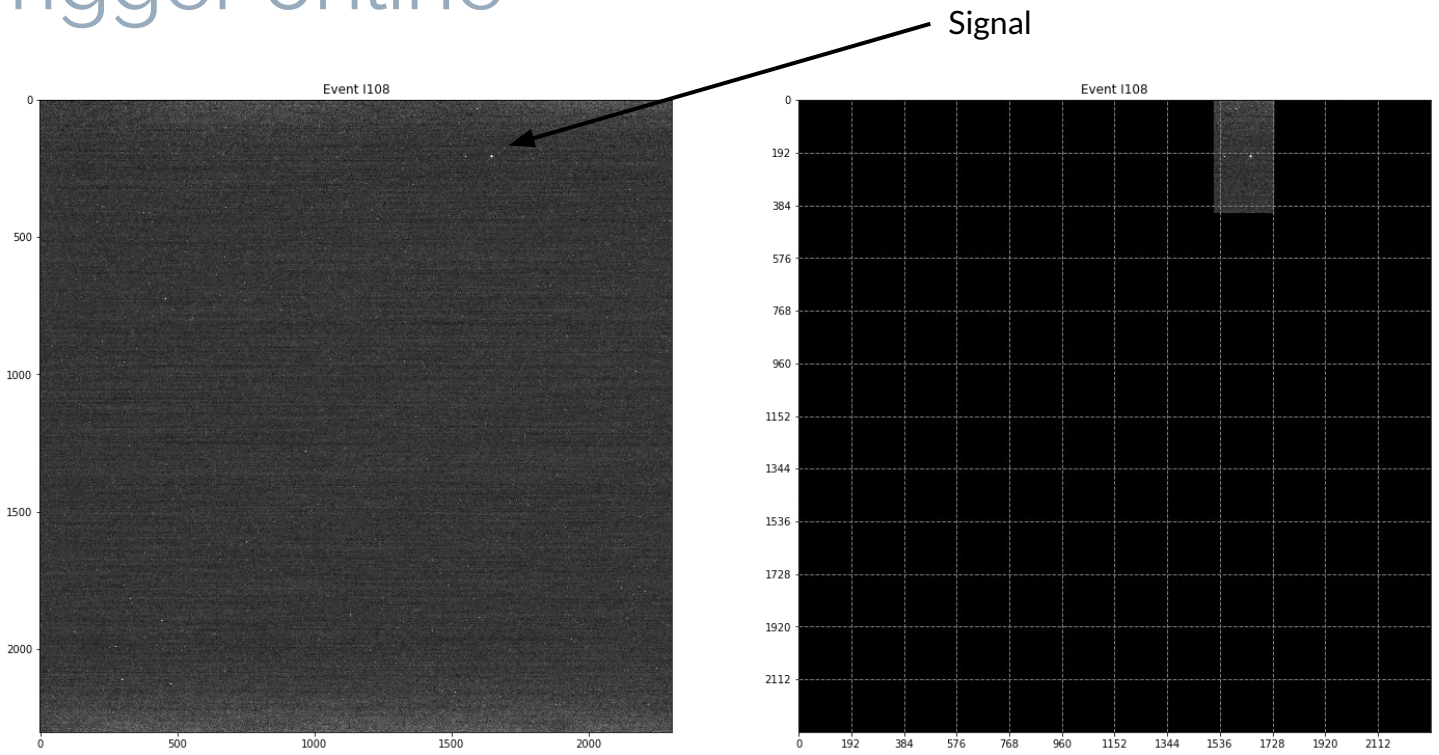
1.
Proposal

Proposal

- Develop algorithms to be tested as online trigger to decide whether to save or not images taken by the detector
  - **Simple algorithm based on subimage metrics: mean, std**
    - We are starting from the simplest possible case to then:
      - gradually increase complexity following up the performance evolution (efficiency, false alarm and response time) and
      - optimize computing processing issues
  - **Convolutional Neural Network**
    - on training stage (not tested yet)

Link of the full presentation

Trigger online



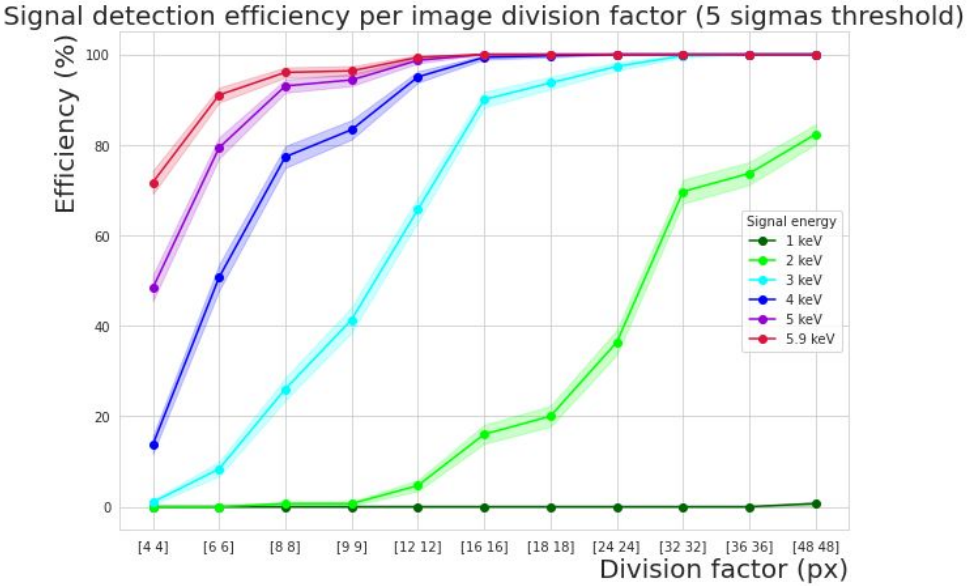
Example of the online trigger algorithm used on a LNF run taken on 15/12/2022.

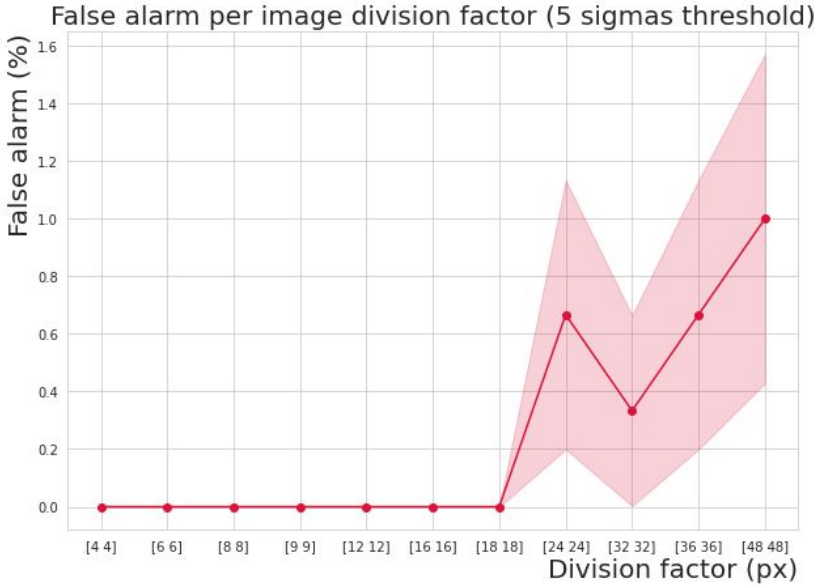
2.
Updates

Status

- **New datasets created.**
  - Signal simulation: 300 images with one signal in each one randomly displaced. Runs were created with the energy ranging from 1 to 5 keV.
  - Noise runs: 4 pedestal runs acquired on the LNGS (415 images).
- **Expanded analysis.**
  - Image divisions up to 48 in each axis.
  - The threshold on the training stage was done using from 3 to 5 sigmas from the mean on the std distribution.
  - Reco files used for comparison.
  - Time used for the most recent algorithm.

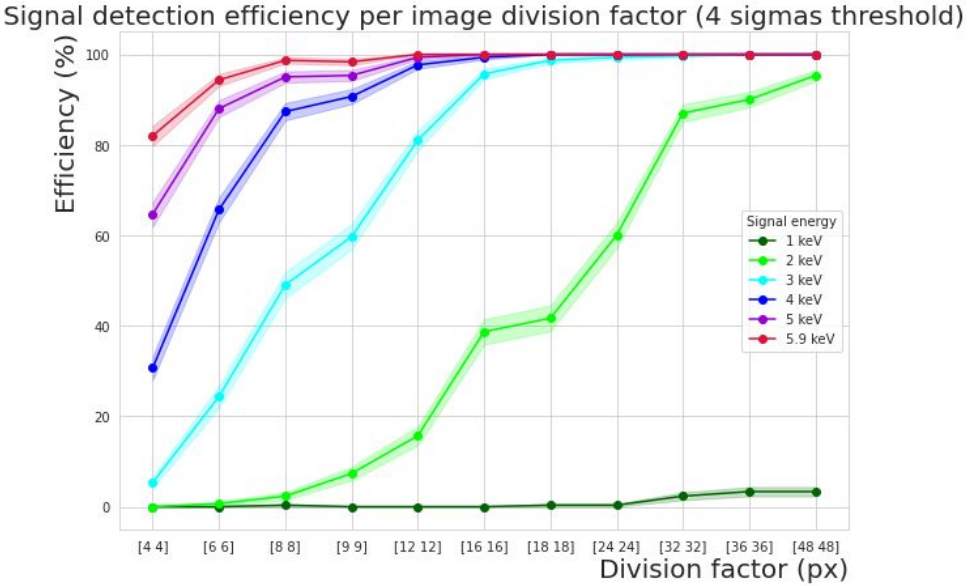
5 sigmas threshold

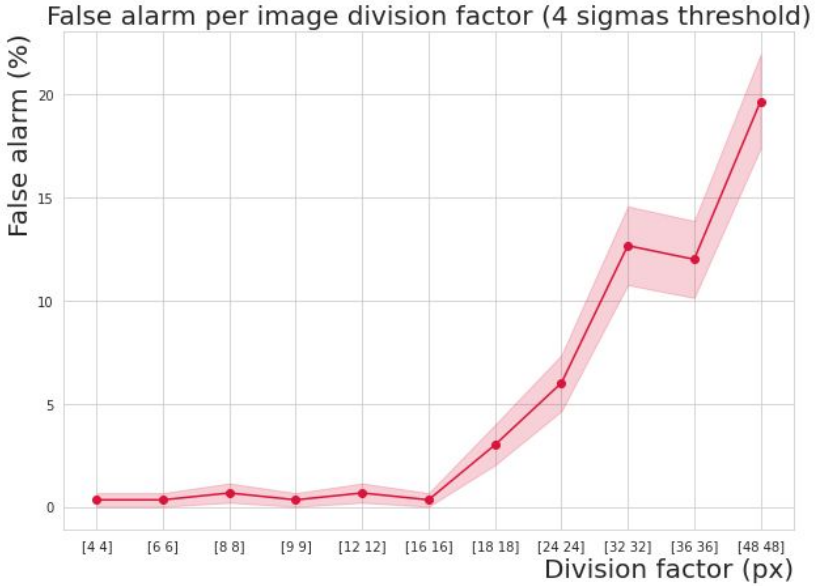




- The algorithm can easily detect signals starting from 3 keV with a close to 0% false alarm ratio.

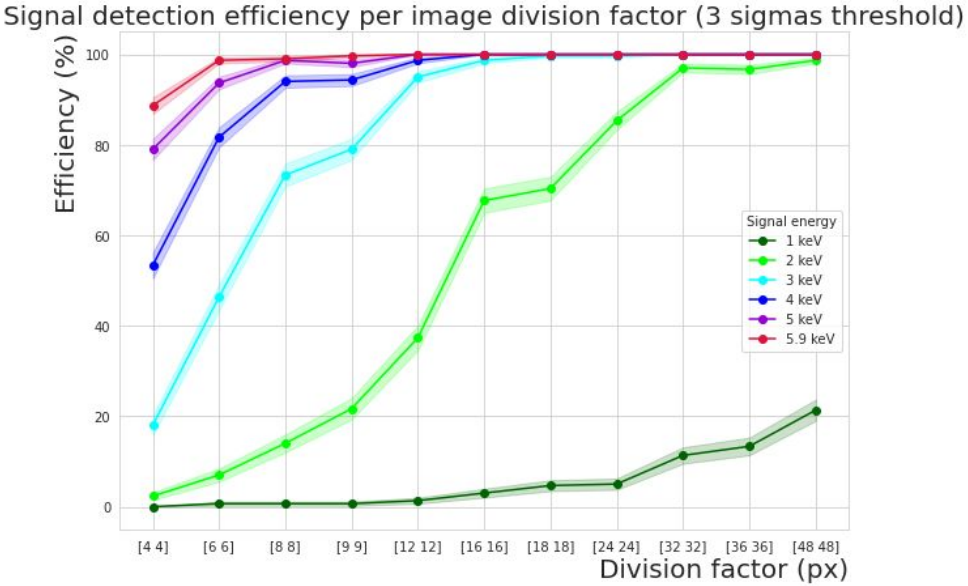
4 sigmas threshold

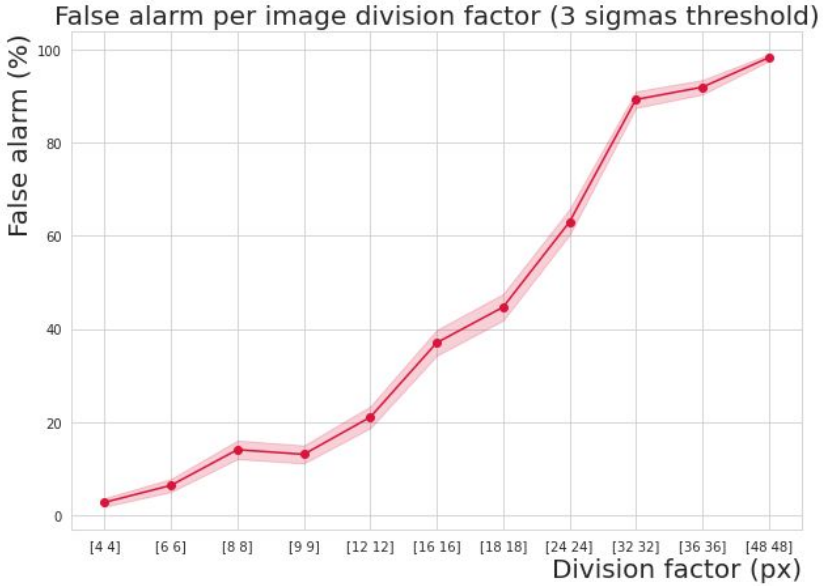




- Signal detection for signals with 2 keV improved, but false alarm ratio also increased.

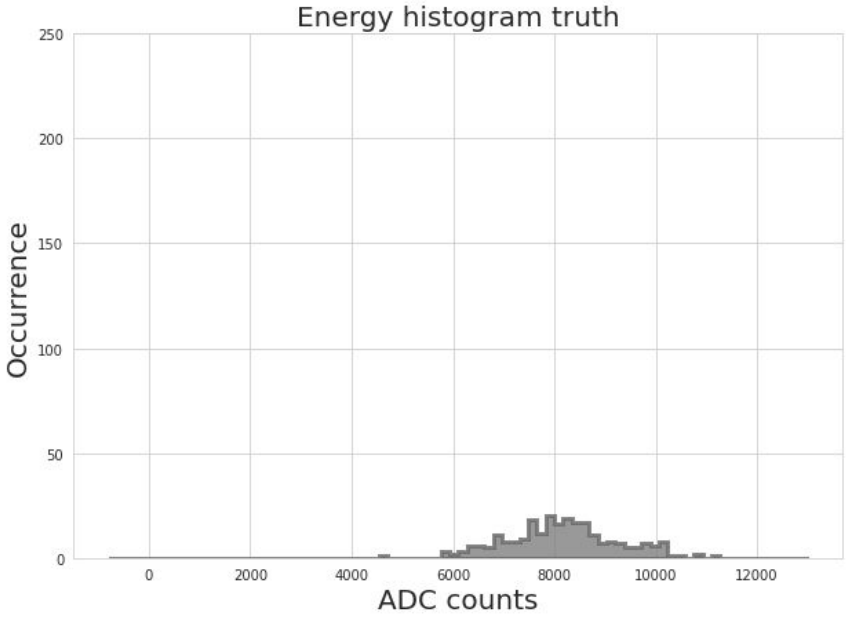
3 sigmas threshold

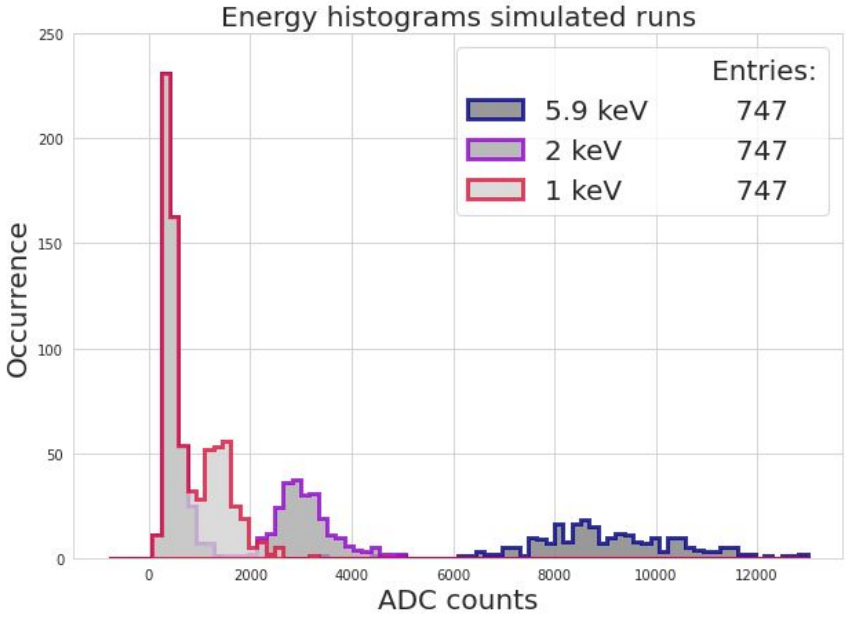




- Overall signal detection improved, but false alarm is high.

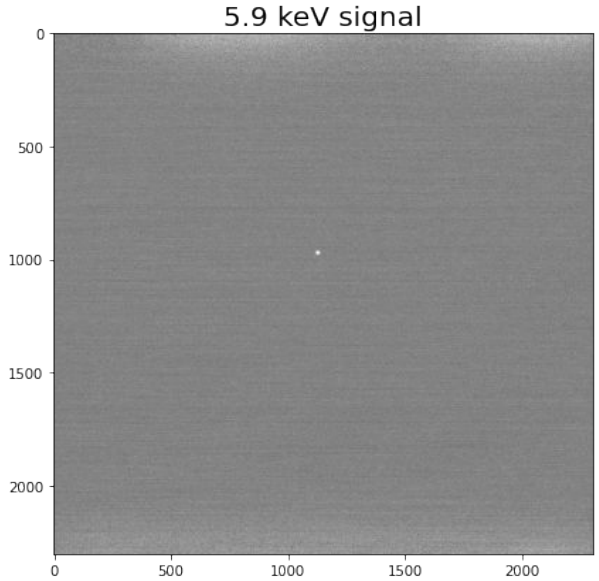
Reco files analysis

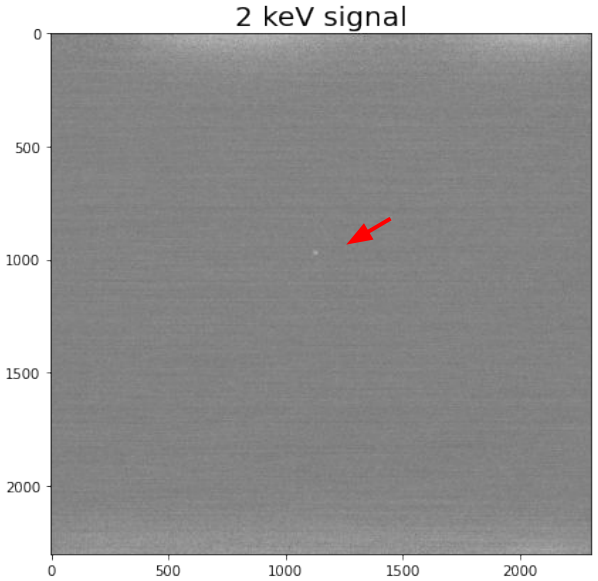


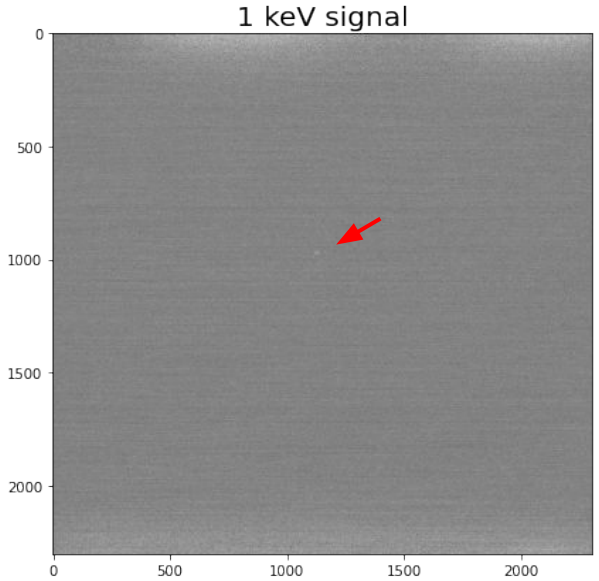


- The reconstruction code is able to identify all the tracks.
- As energy decreases, the signal starts to invade the electronic noise region.

Signal simulation example

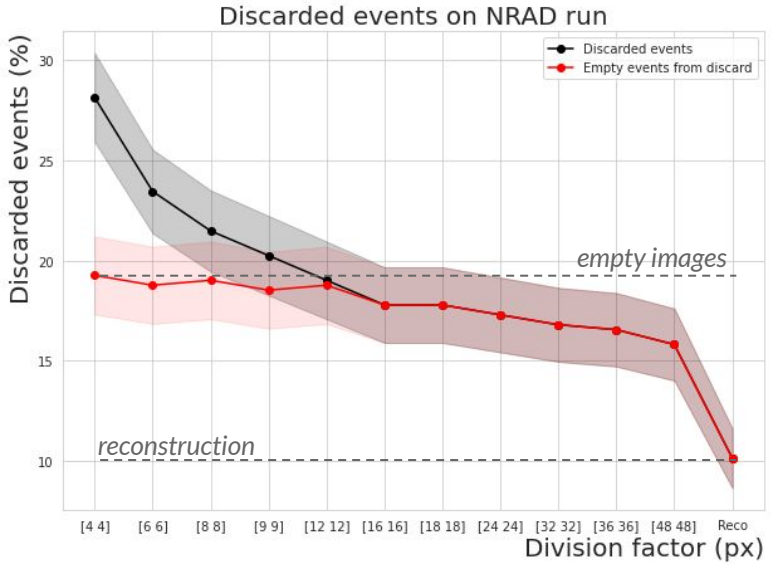






- As energy decreases, the contrast between signal and background is smaller.

NRAD run (12189)

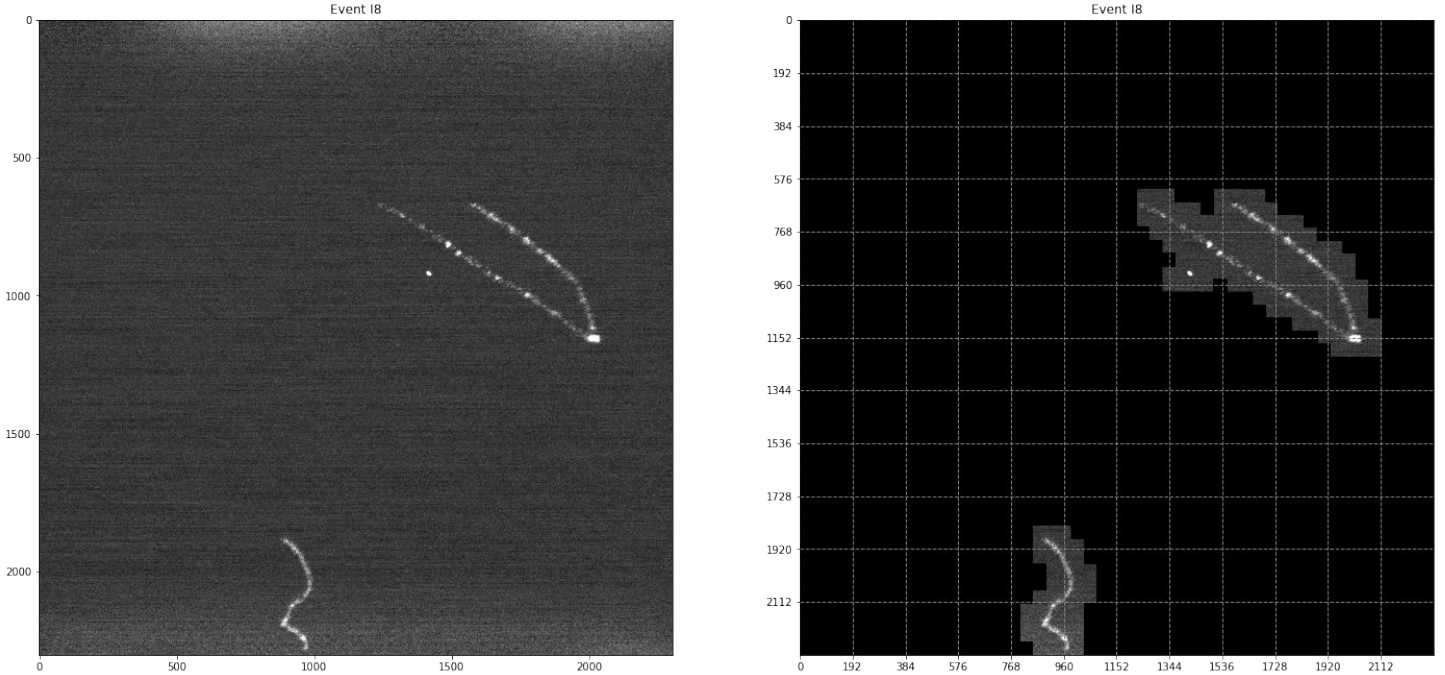


5 sigmas threshold

- An NRAD run containing 405 images was used to test the algorithm.
  - From those, 78 images were empty (~20%).
- The trigger algorithm was able to discard almost all of those images.
- The reconstruction was able to discard 41 images (almost half of the empty ones).

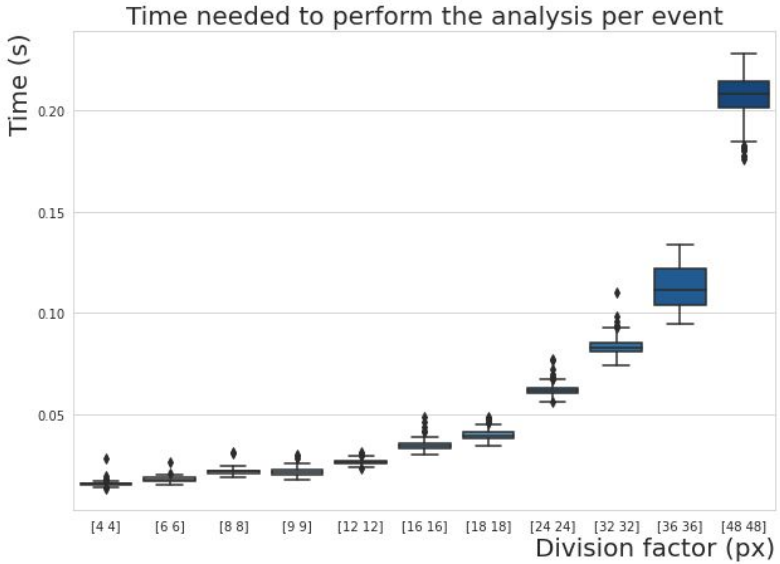
NRAD run (12159)

Operation point
- 2 keV → 80%
- FA → 1%



- Example of the algorithm working on an NRAD event (using [48,48] divisions and 5 sigmas as threshold).

Time analysis

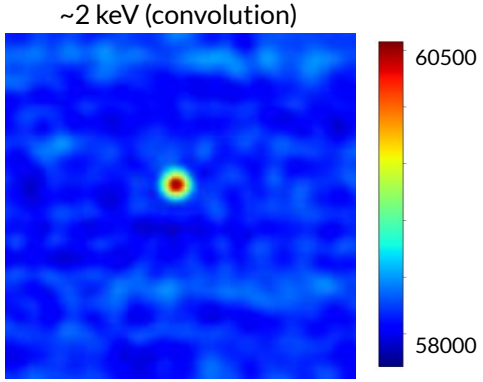


- The last division factor is almost 10 times slower than the first one.
- The reconstruction code needed, in average, 7.44 ± 0.13 seconds per image to analyse the simulated runs.

On going activities

- Framework to test and compare different trigger algorithms.
- STD based trigger algorithm.
  - GPU test on DAQ machine to be done.
- Trigger alternatives under construction
  - Convolution
  - CNN

(increasing trigger performance e.g. 1 keV)



- Test with GPU using different implementations - CUDA, CuPy, Numba.
  - Being studied by a new student from our group **(Augusto)**.

Thanks!