Time optimization of the CYGNO reconstruction algorithm for the Trigger system

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Summary

- Motivation
- Time plots
- What we've concluded
- Optimization
- Conclusion

Motivation

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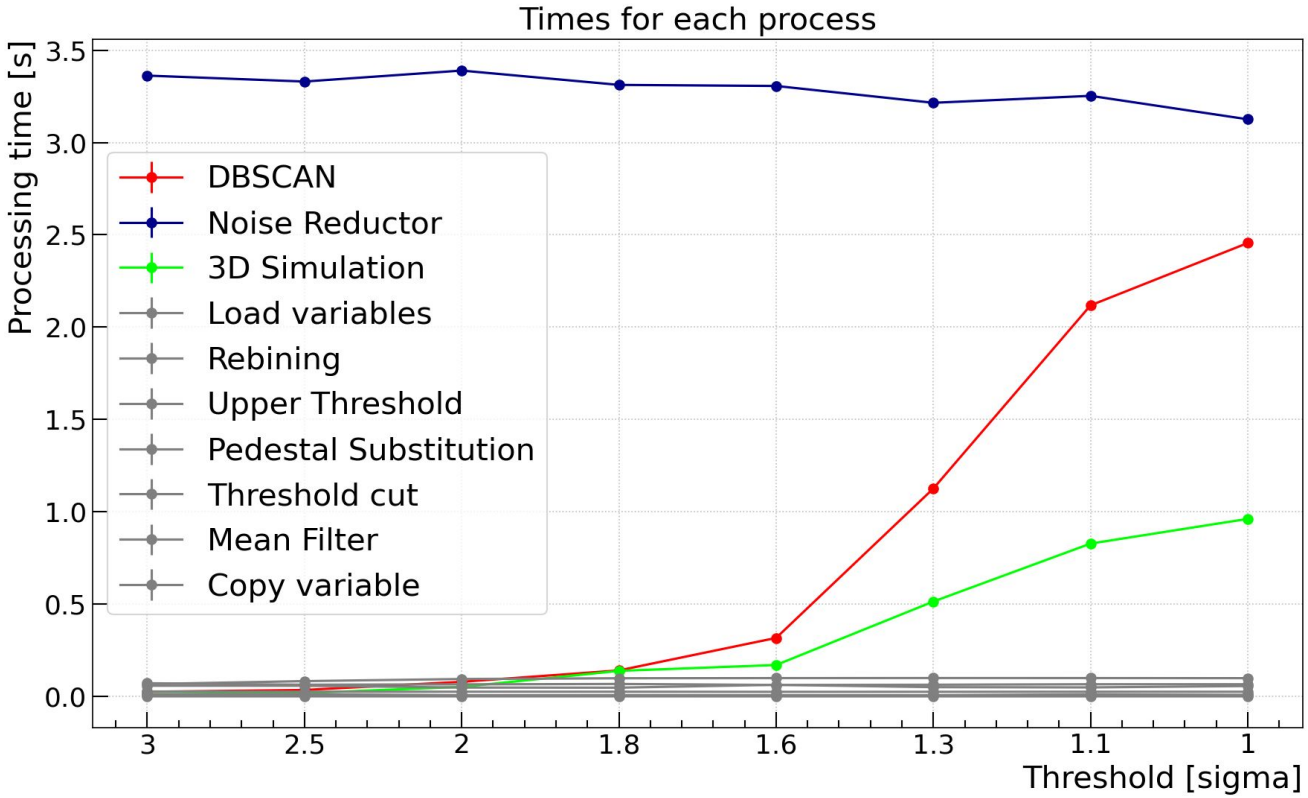
- As commented last meeting, pre-processing could be a more cumbersome process than clusterization itself;
- We've decided to time each process in order to find bottlenecks and places for possible improvement;
- **By knowing the time needed to run each process, it will be possible to choose the priorities in the search for an optimization of the processing time for the trigger system;**

All tests were made rebinning the image by a factor of 4.

Time plots


Times for each process
Processing time [s]
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
DBSCAN
Noise Reductor
3D Simulation
Load variables
Rebining
Upper Threshold
Pedestal Substitution
Threshold cut
Mean Filter
Copy variable
3
2.5
2
1.8
1.6
1.3
1.1
1
Threshold [sigma]

What we've concluded

- Both DBSCAN and Noise_reductor could take longer than 2s given the number of points;
    - DBSCAN time can be reduced using GPU
    - Noise_reductor optimization should be investigated
- 3D_simulation could also be a problem for bigger images;
- We should always consider that the process was done with rescaled images.

Our current work

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- Given our time problem we've looked into solutions to enhance timing of the more problematic processes;
- Some possibilities were to parallelize those processes or use other techniques;
- As of now, we've not found a satisfactory way to parallelize those processes, so we've looked into other optimization techniques;

Optimization

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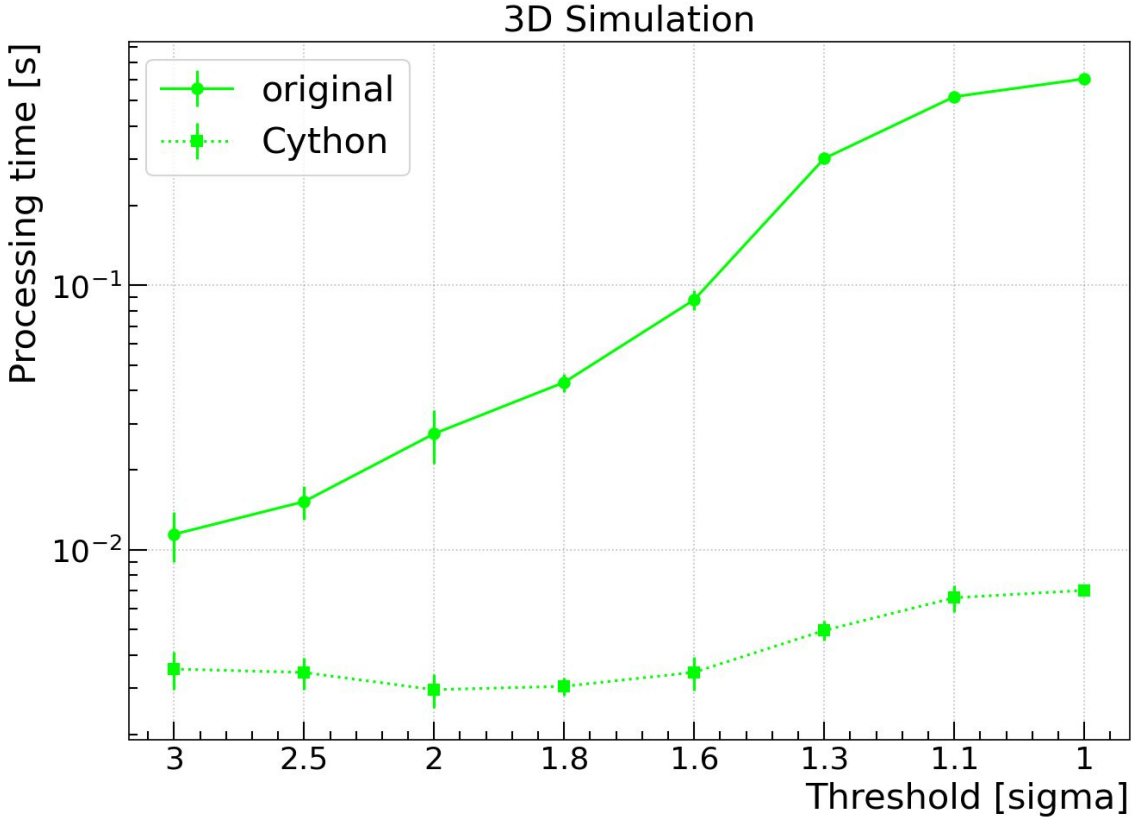
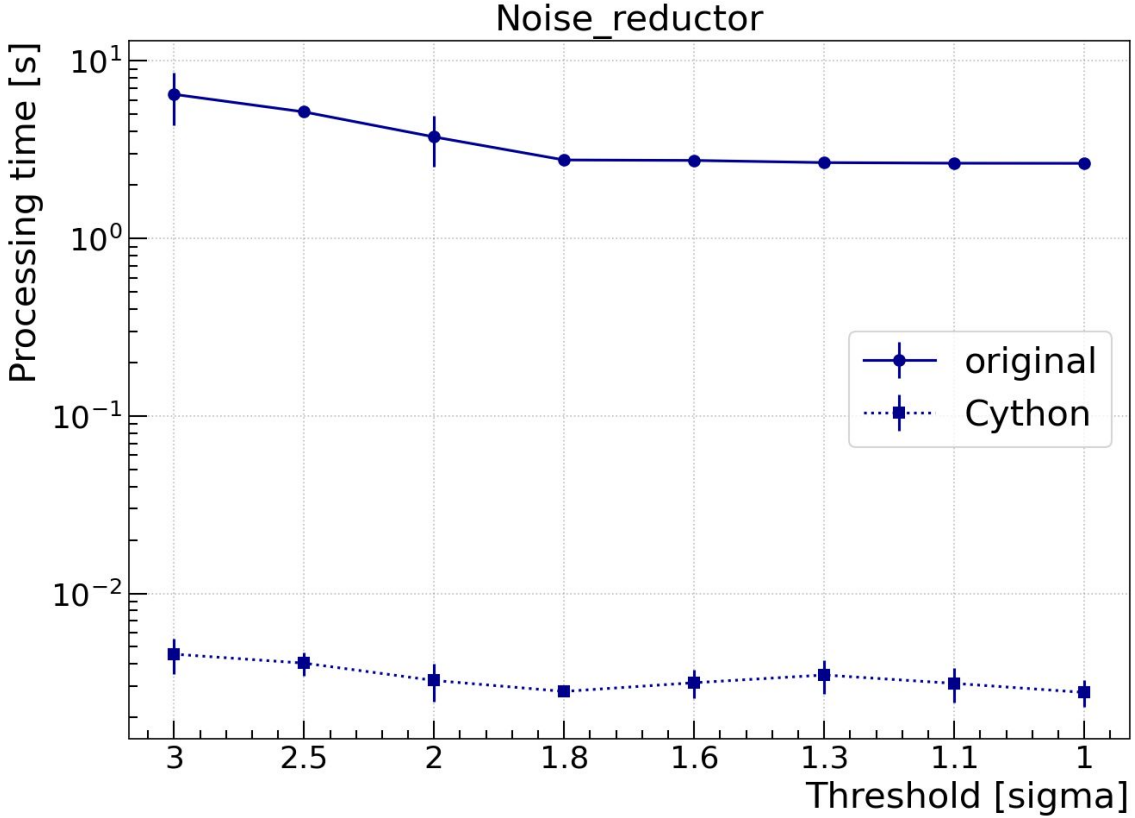
- In order to optimize both ‘3D Simulation’ and ‘Noise Reduction’ steps they were re-written in Cython
- Cython is a compiled version of Python that translate python calls to C/C++, then makes a compiled version with gcc
- Results in a much faster deployment of the same code just for skipping the interpretation step of python

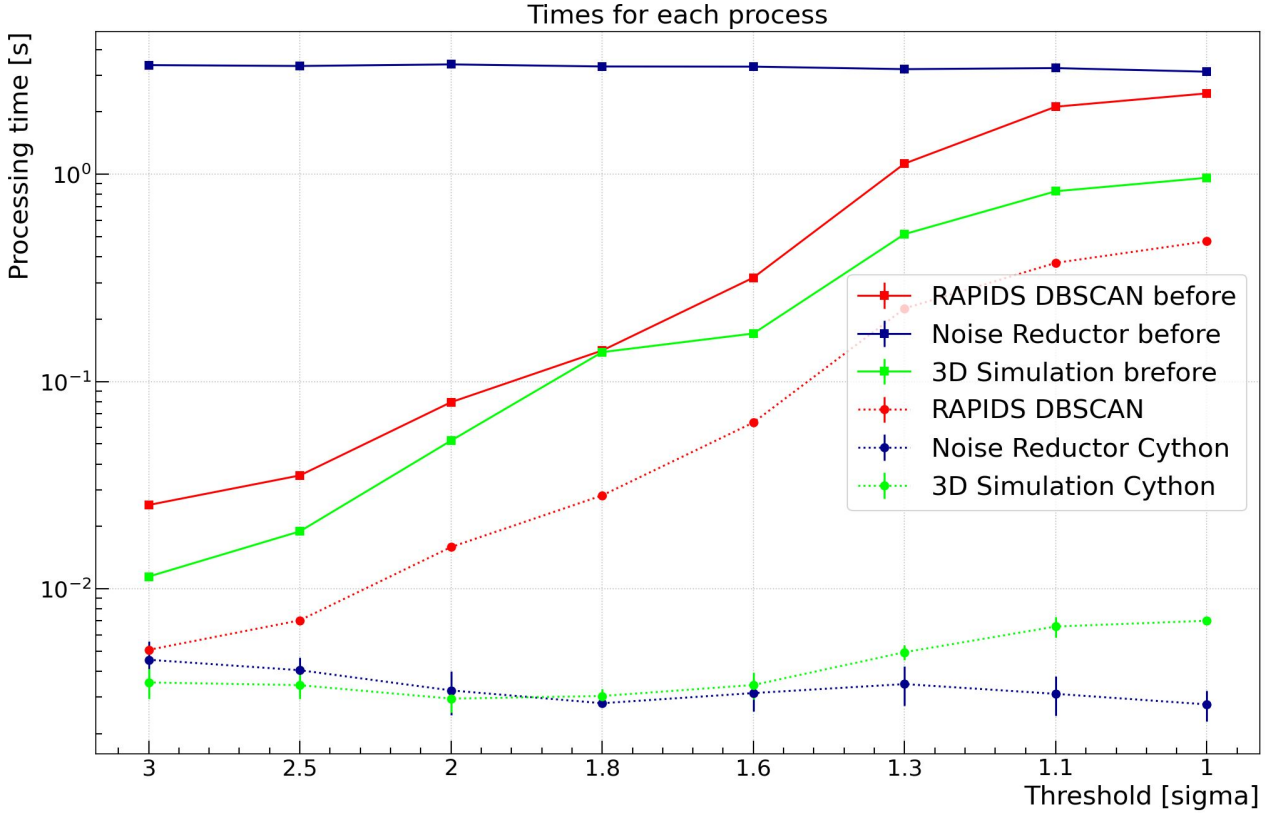
Optimization - 3D Simulation



Optimization - Noise_reductor



Optimization - Time comparison



The improvements using Cython could already be used by the collaboration to speed up the CYGNO on-going studies.

Optimization processes available

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Cython

- DBSCAN ✓
- Noise Reductor ✓
- 3D Simulation ✓
- Rebinning
- Upper Threshold
- Mean Filter
- Pedestal Substitution

CuPy

- Load Variables
- Rebinning
- Copy Variables
- Threshold Cut

CUDA

- DBSCAN ✓
- Upper Threshold
- Mean Filter
- Pedestal Substitution
- Threshold Cut

Conclusion

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- Our current reconstruction algorithm can be further optimized:
  - some improvements have already been tested as shown in this presentation;
  - other possibilities are under study;
- The idea is also to gain experience with the tools that can help in the timing optimization of the trigger algorithms;
  - speed gains can also make it possible to analyze images at full resolution;
- Other paradigms could also be explored as going further in C/C++ programming and porting the whole analysis to Cython;
- We'd like input for how to move forward from now on.