Advanced Image Cleaning
LAPP/DAp Meeting

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CEA Saclay – Irfu/DAp

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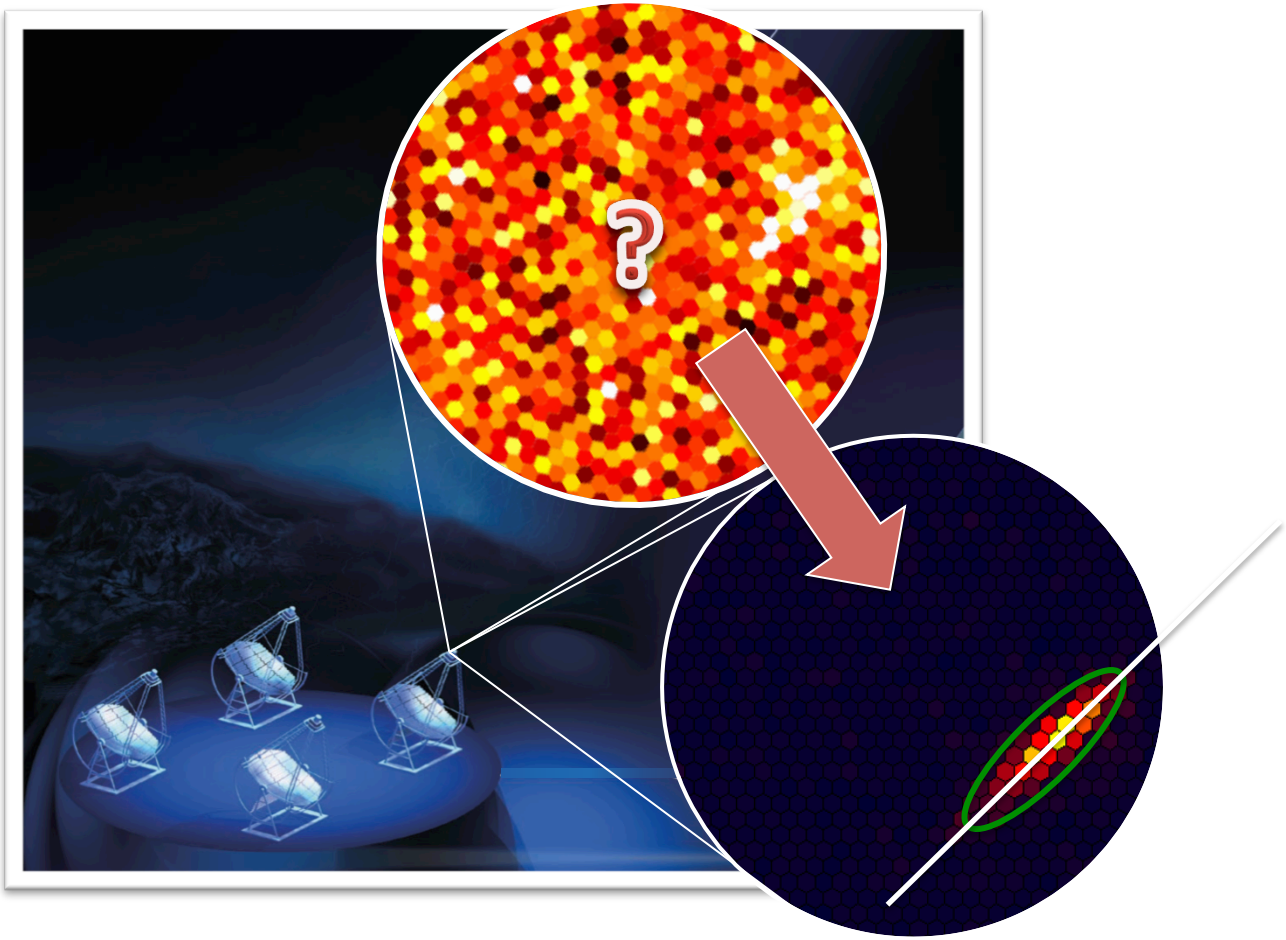
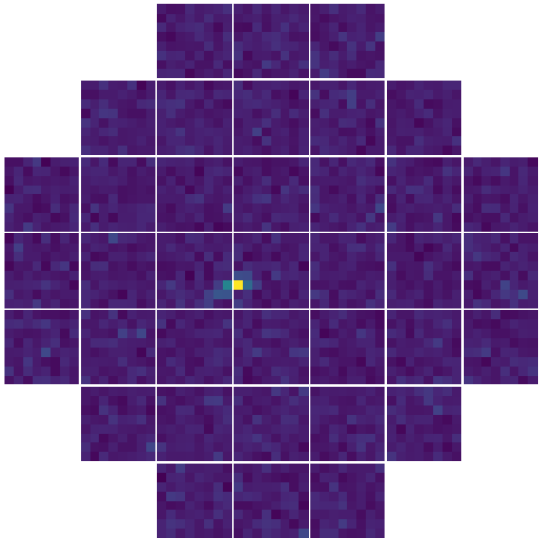
Subject: image cleaning

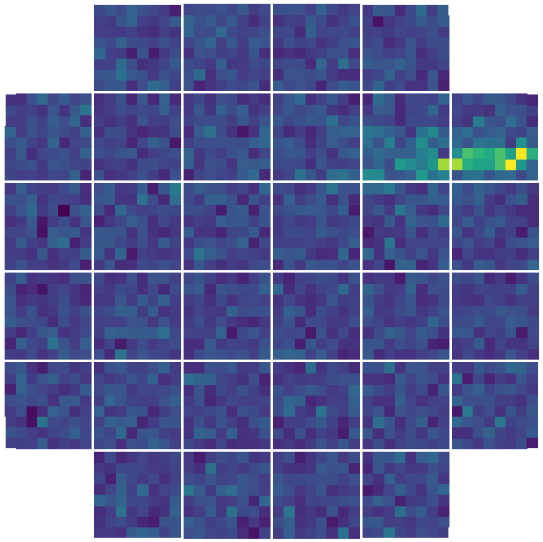


Examples

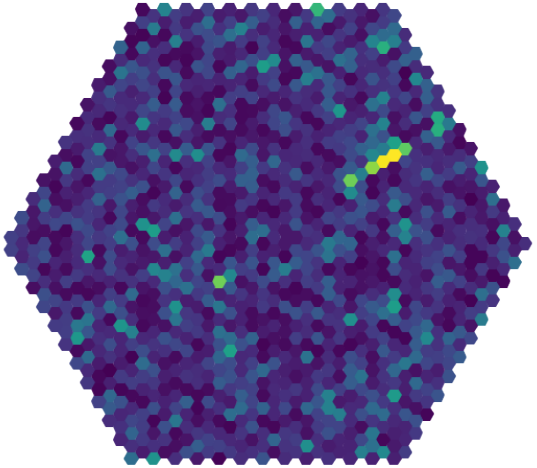
ASTRI



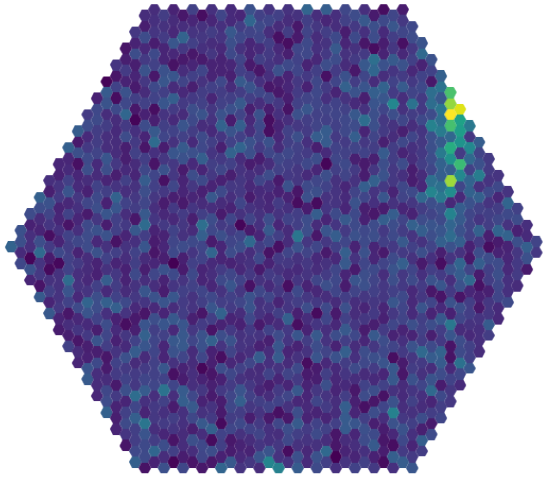
GCT



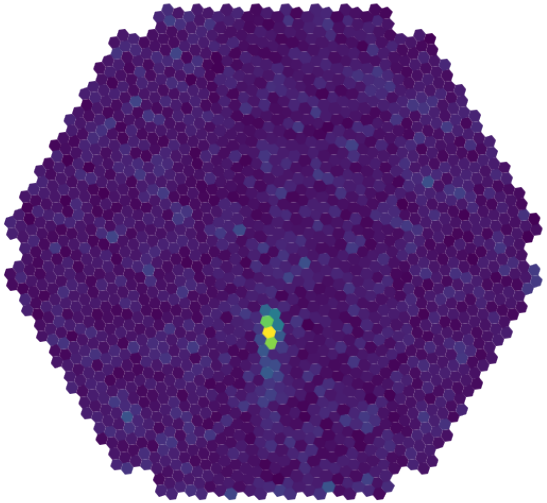
SST-1M



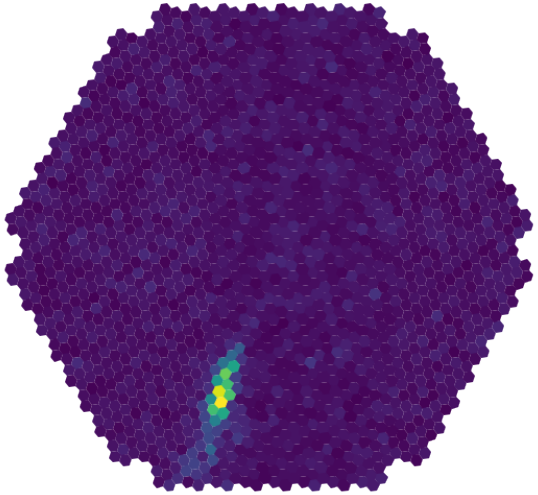
FlashCam



NectarCam



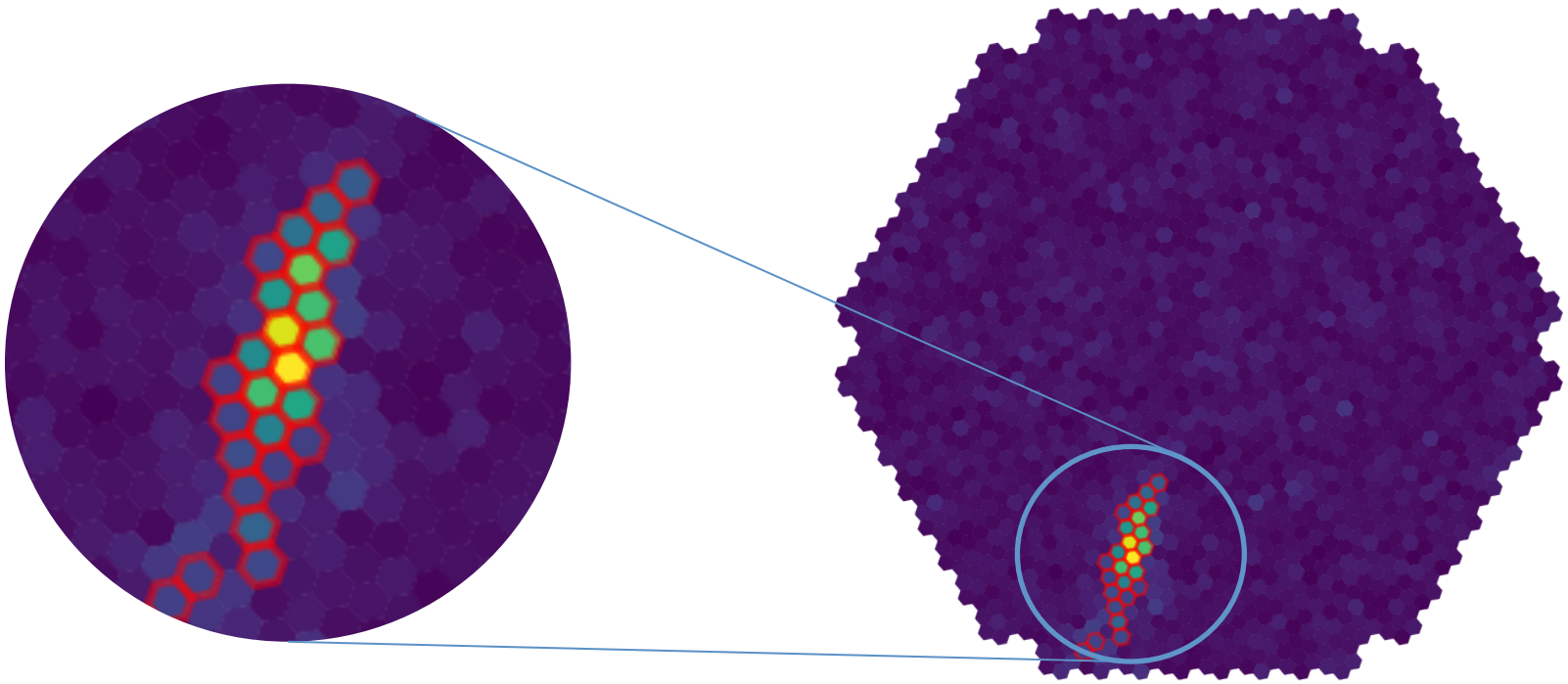
LSTCam



Methods currently used for gamma rays images cleaning (Tailcut)

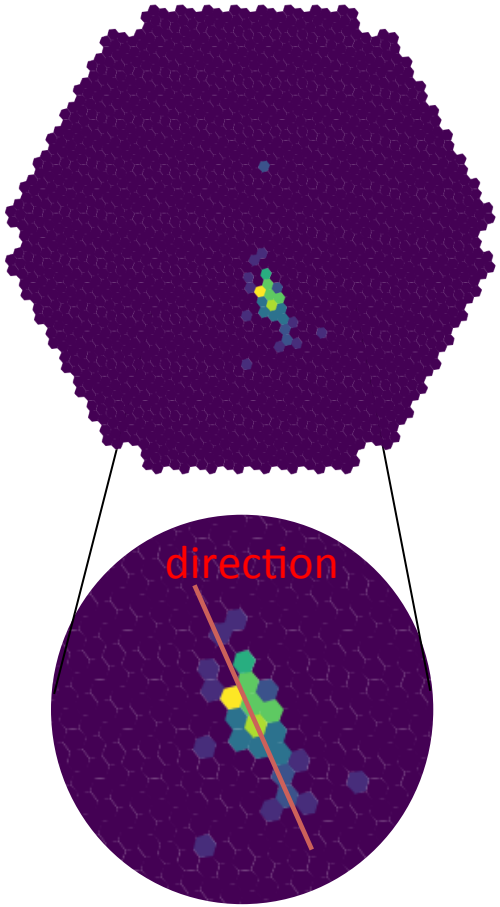
A very simple cleaning procedure (HESS setup):

- Keep pixels above a given threshold (10 PE)
- Keep some neighbors of these selected pixels:
  - those above a second (lower) threshold (5 PE)

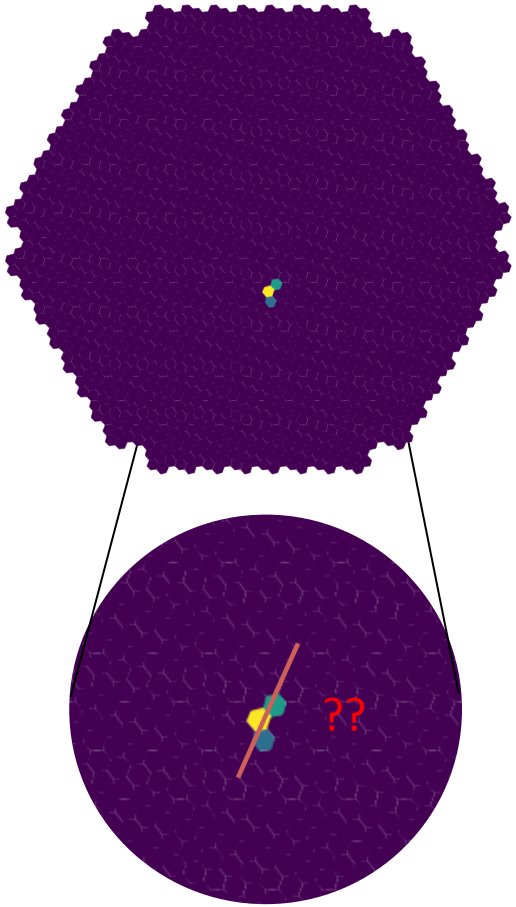


Issue with faint showers: Information loss

PE (truth)



After Tailcut cleaning



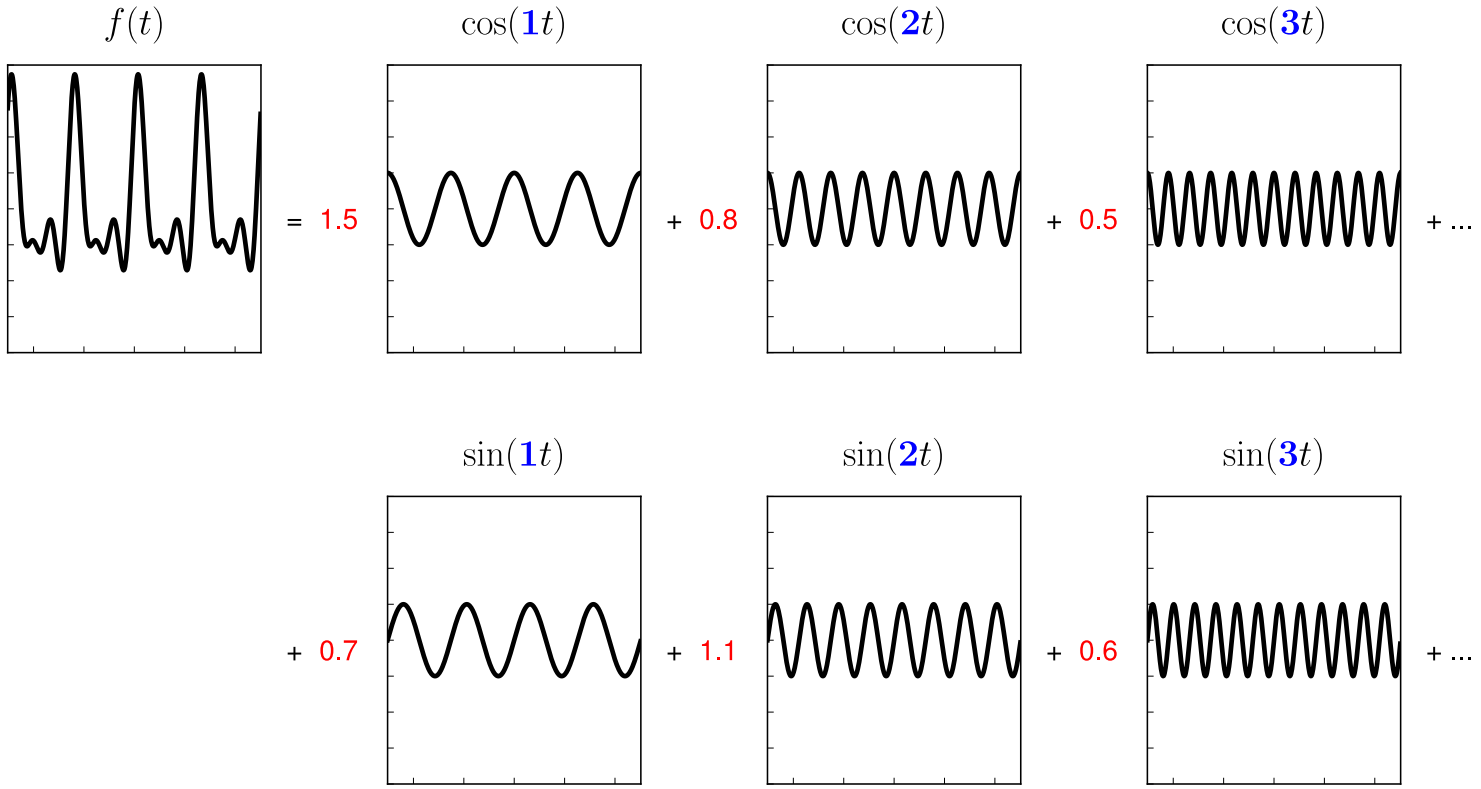
Basic idea to go beyond

- Tailcut method: thresholds in the main space
- Better idea: thresholds in a different space where signal and noise can be easily separated
  - Wavelet transform
  - Cosmostat tools (iSAP/Sparse2D)

    (http://www.cosmostat.org/software/isap/)

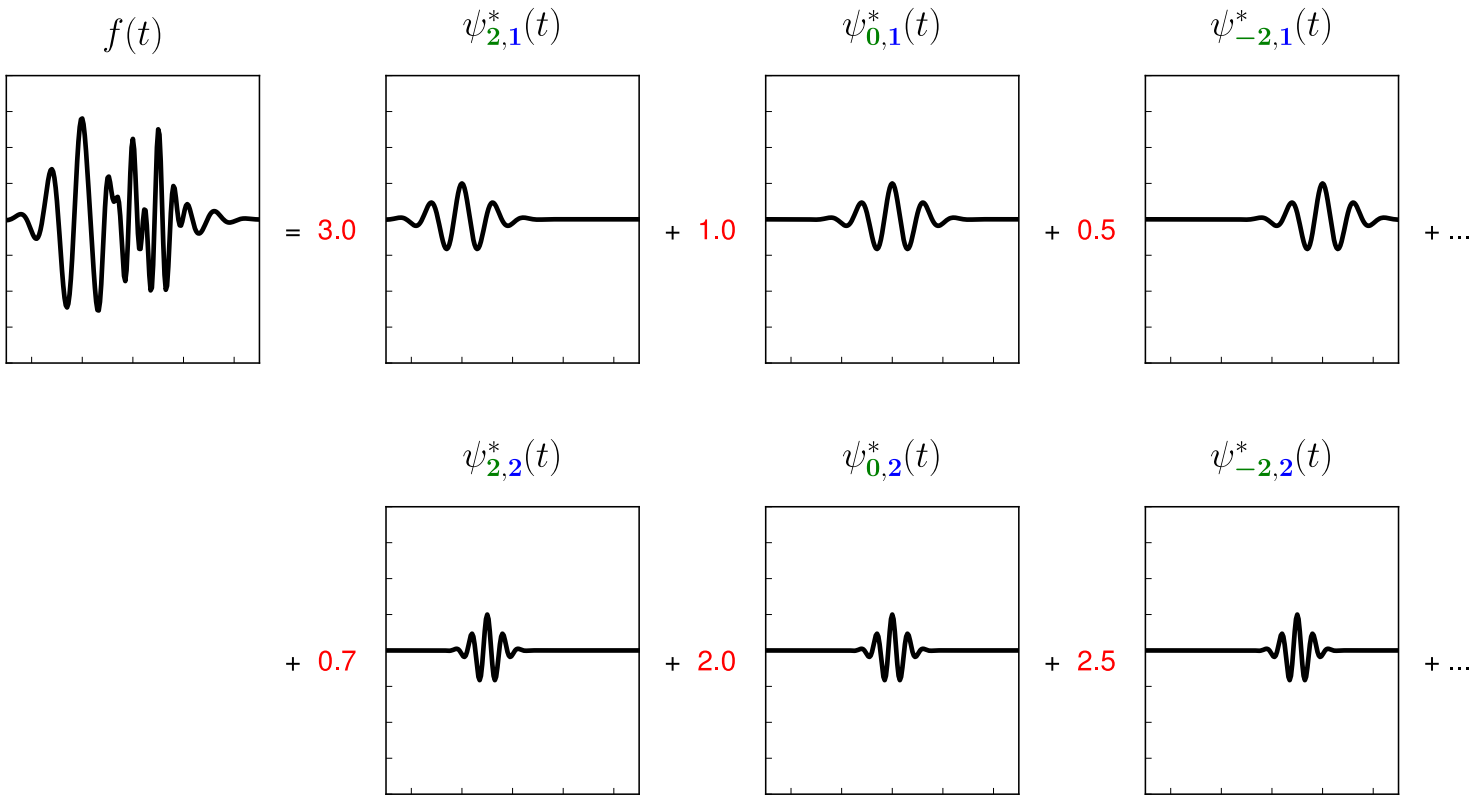
Cleaning procedure: general idea with Fourier Transform

- Input signal is converted to a weighted sum of sin and cos at different frequencies
- Threshold is applied on these weights to remove some frequencies in the input signal (e.g. high pass filter, low pass filter, ...)



Cleaning procedure: general idea with Wavelet Transform

- Input signal is converted to a weighted sum of these wavelet functions at different scales (dilate factor) and positions (translate factor)
- Threshold is applied on these weights to remove locally (in space or time) some frequencies (or scales) in the input signal



Wavelet transform on images

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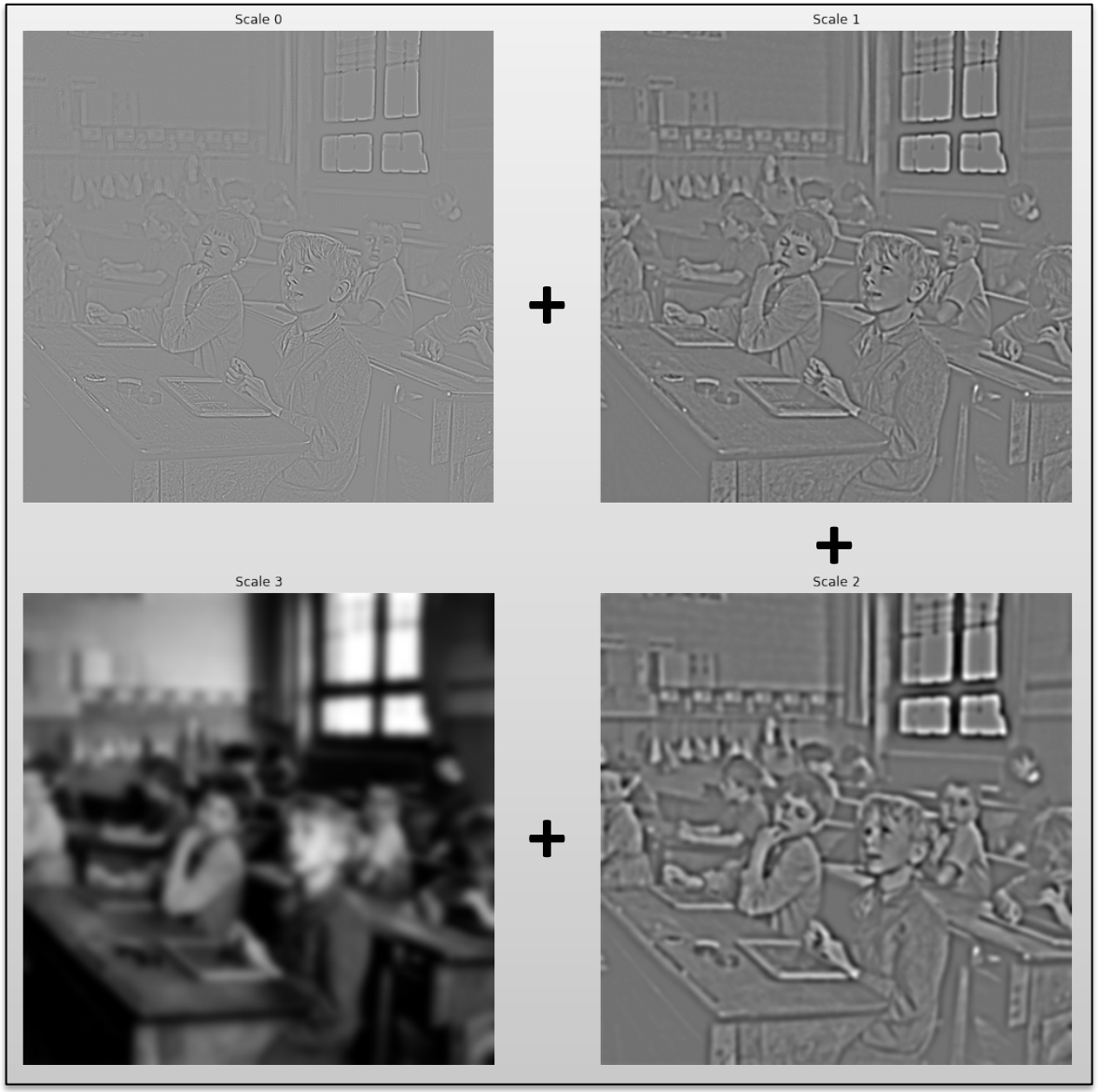
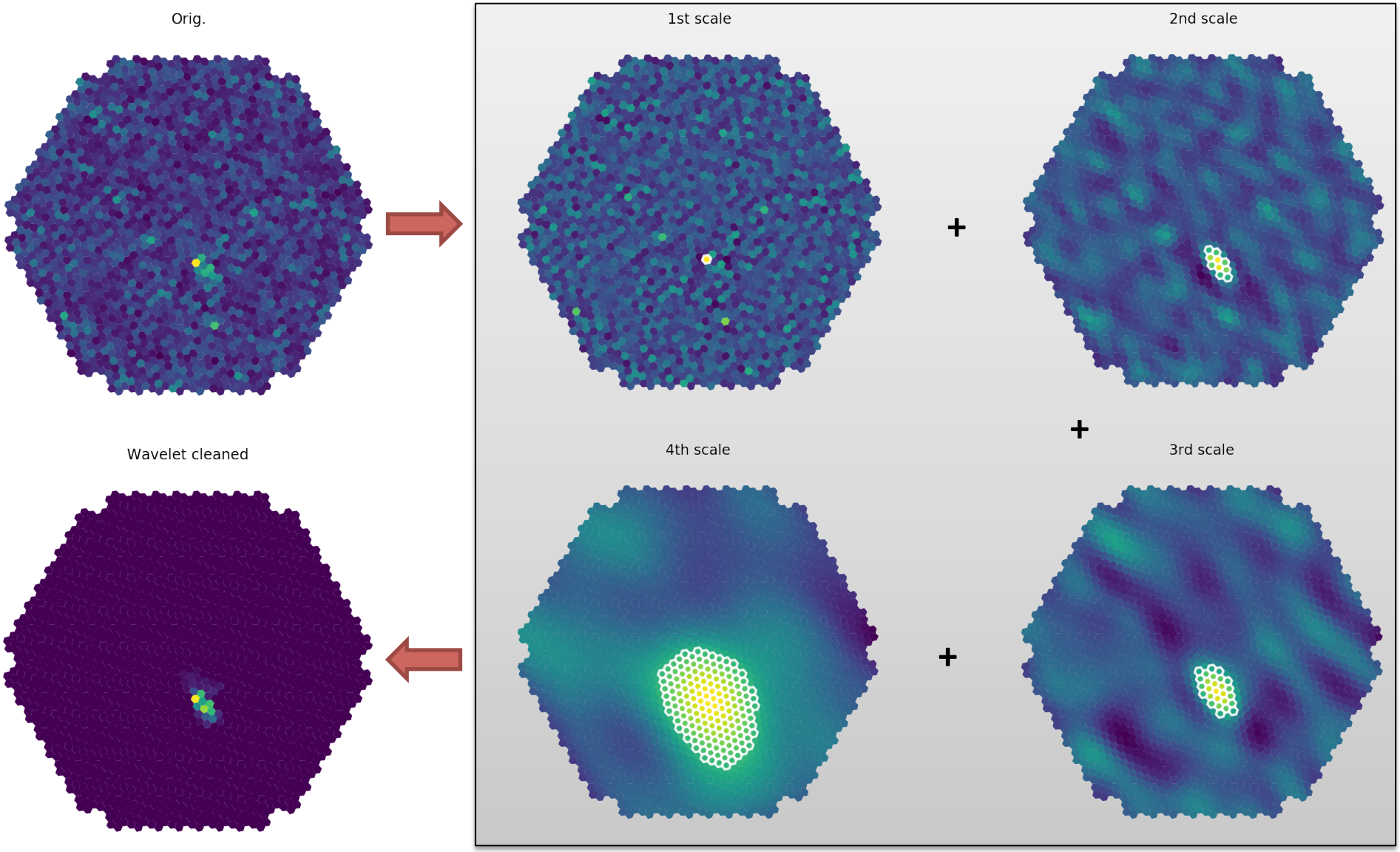
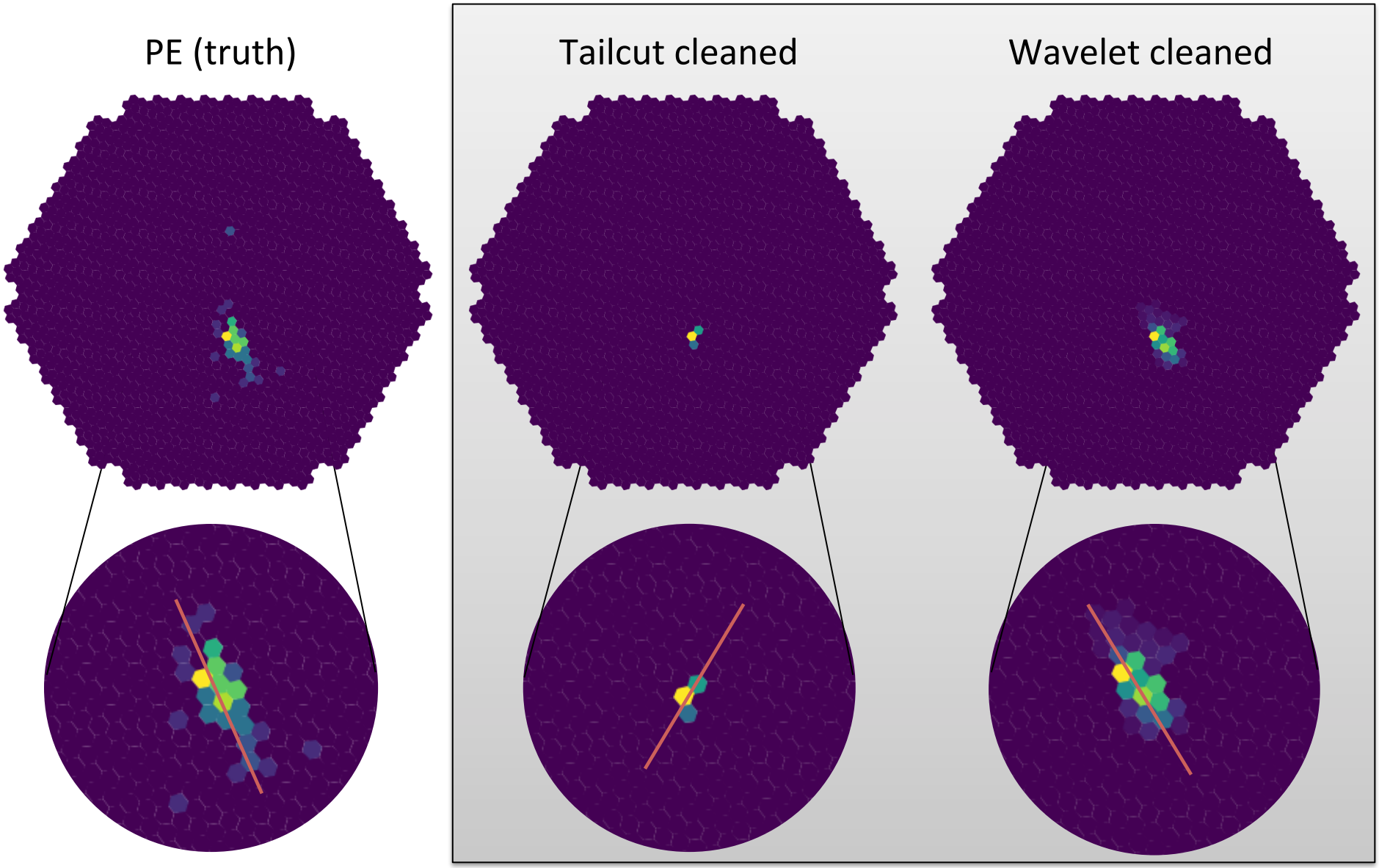


Wavelet transform for filtering

Wavelet filtering



Wavelet filtering



DOES IT WORK WELL ON LARGE STATISTICS ?

Experimental setting

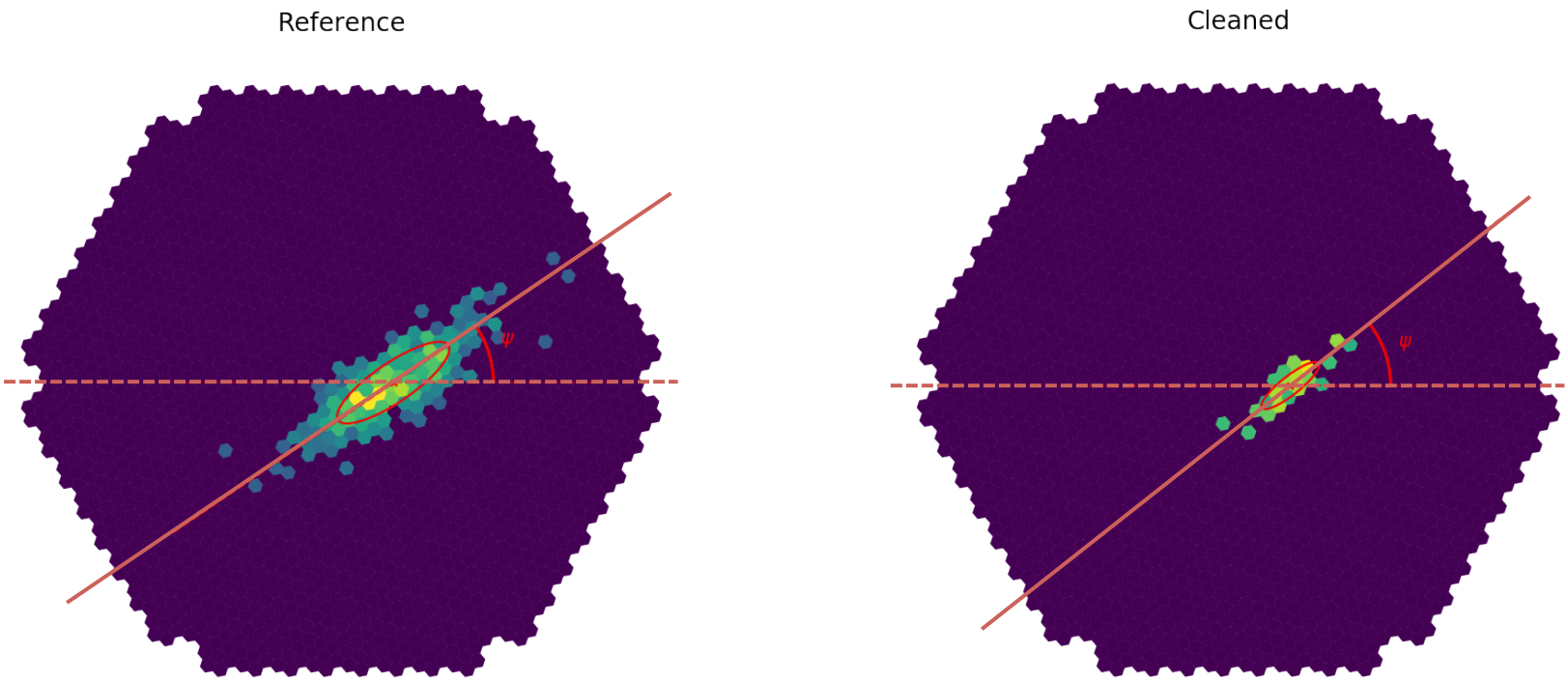
Pointing source (20° north)

- SSTs
  - **ASTRI** -> Inaf mini array + Konrad Bernloehr's mini array
  - **GCT** -> Konrad Bernloehr's mini array
  - **SST-1M** -> Konrad's mini array
- MSTs
  - **Flashcam** -> Inaf mini array + Prod3b North
  - **Nectarcam** -> Prod3b North
- LST
  - **Dragoncam** -> Prod3b North

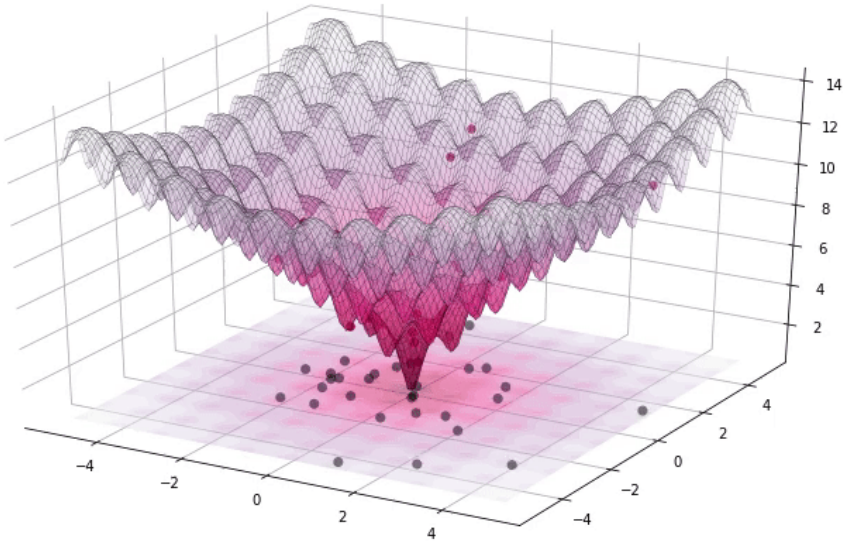
Many thanks to Konrad Bernloehr, Gernot Maier and the Inaf team for their help !

Evaluation procedure

“Δψ” : an estimator of performance at the level of images

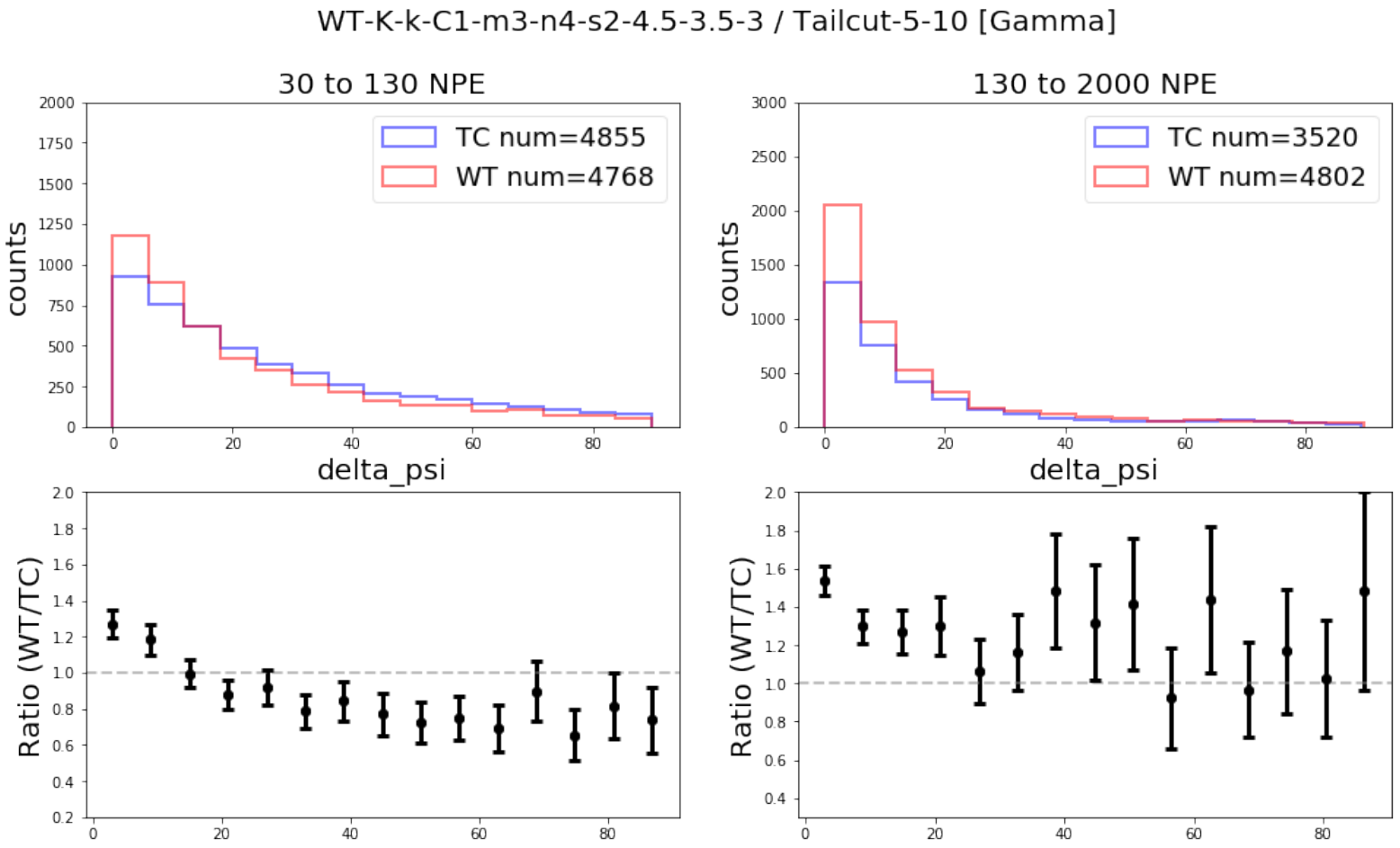


Finding the best thresholds

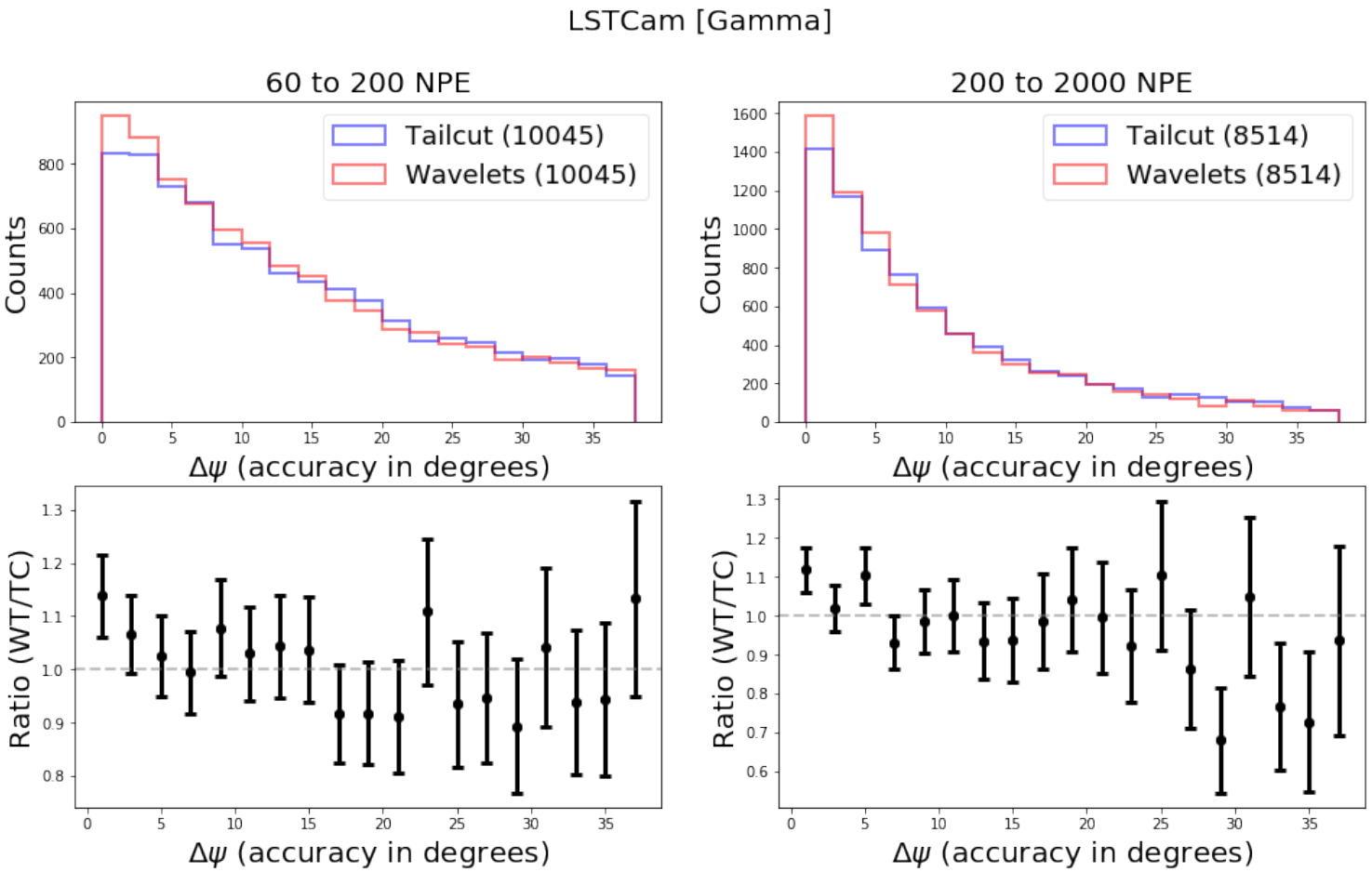


- Use a global optimizer
  - ➢ *Evolutionary Algorithms*
- Return the thresholds that minimize mean(Δψ)

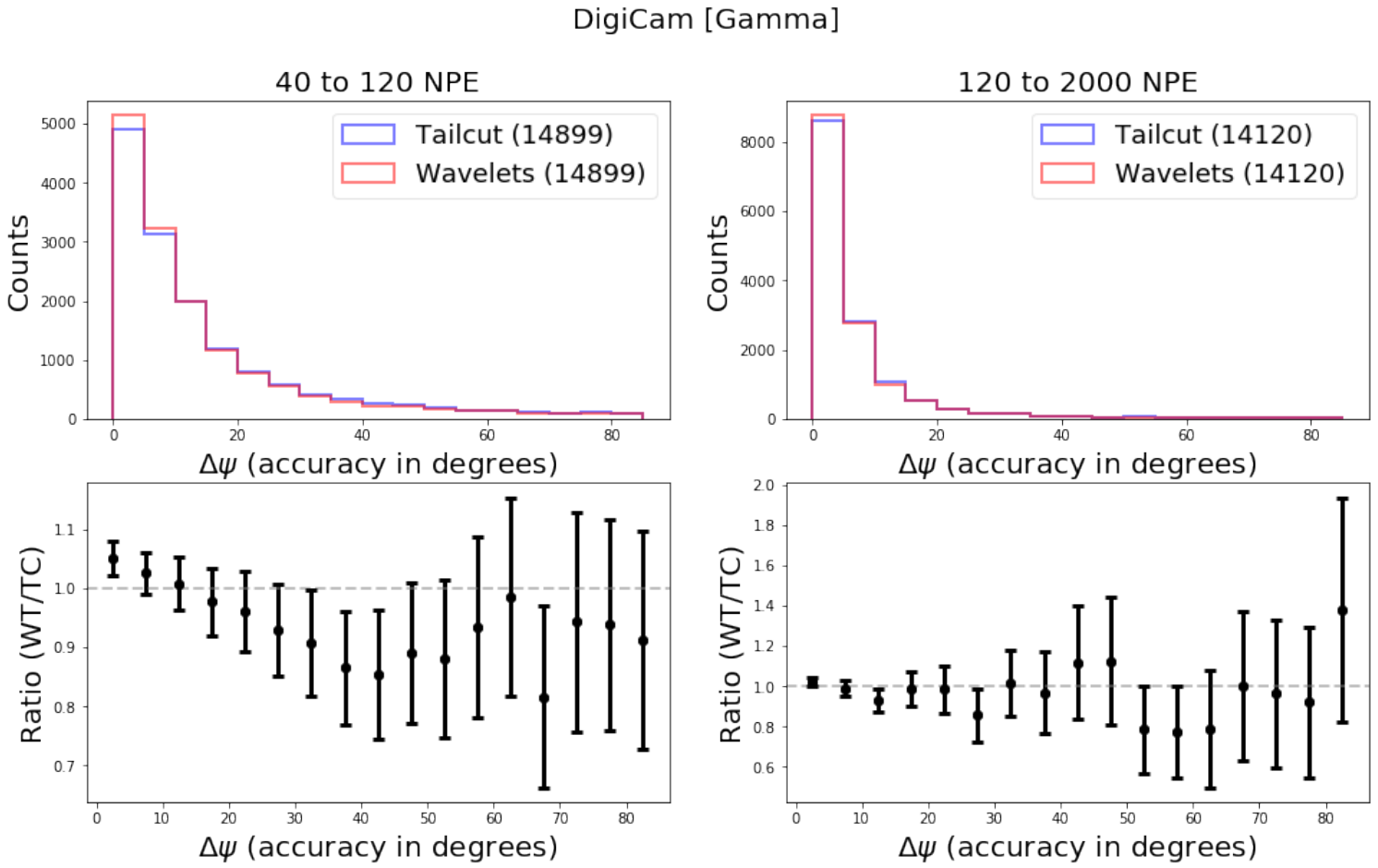
Shower axis reconstruction LSTCam (gamma) HESS setup



Shower axis reconstruction
LSTCam (gamma) optimized Tailcut



Shower axis reconstruction
SST-1M (gamma) optimized Tailcut

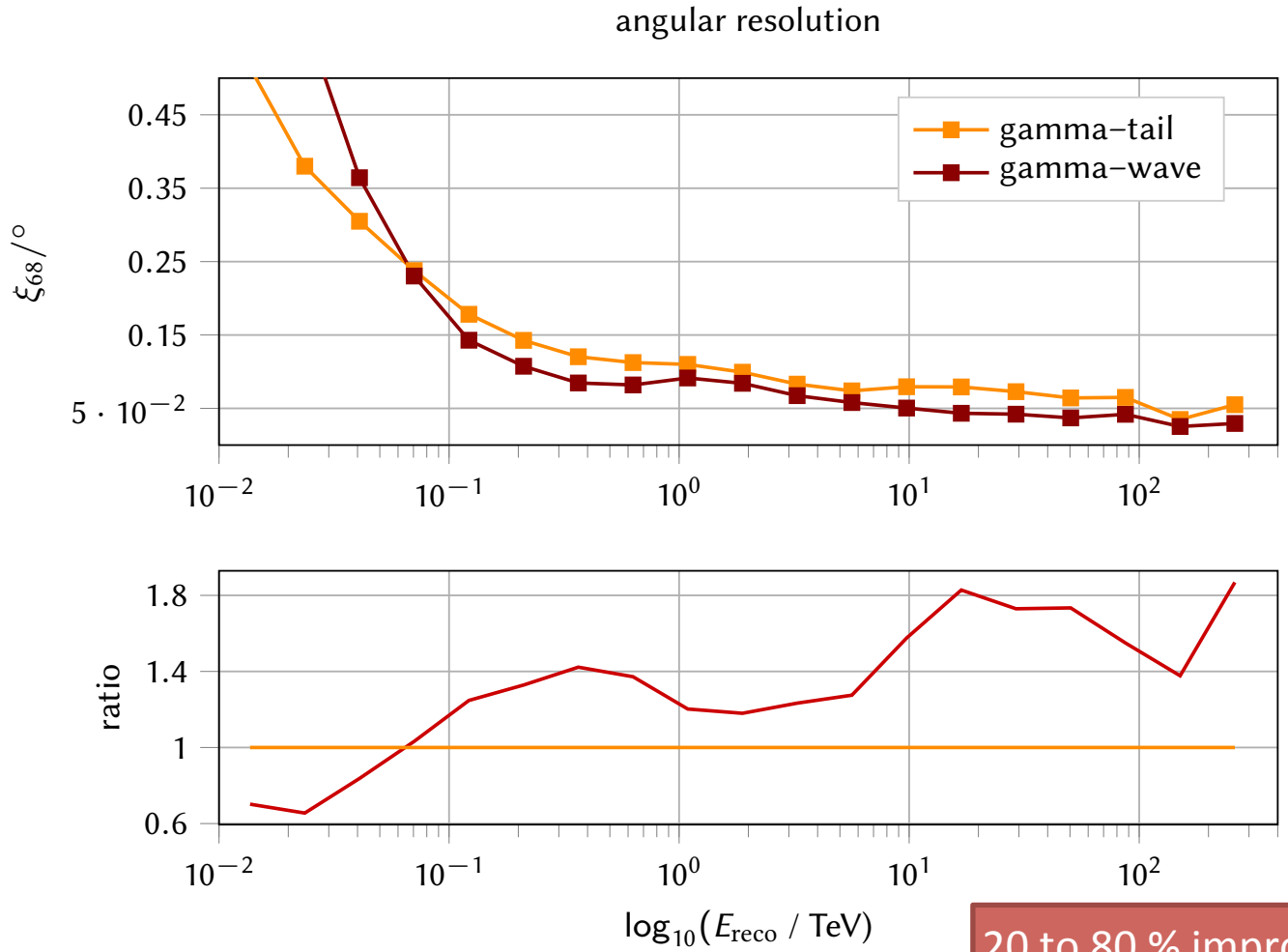


Progress in events reconstruction (Tino Michael)

- What about stereoscopy ?
- What about the actual sensitivity gain ?

Results from Full Reconstruction

Improvements to shower reconstruction direction
(angle between reconstructed and simulated direction)

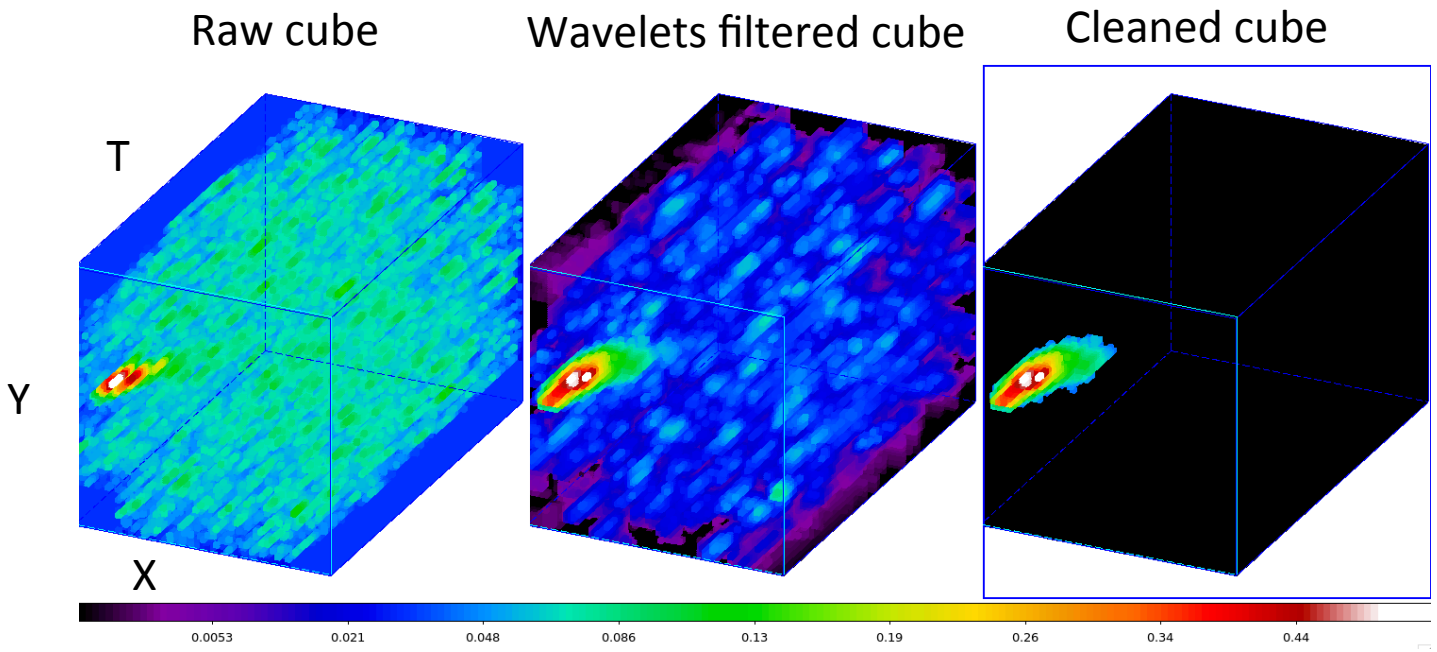


20 to 80 % improvement above 100 GeV

Next steps

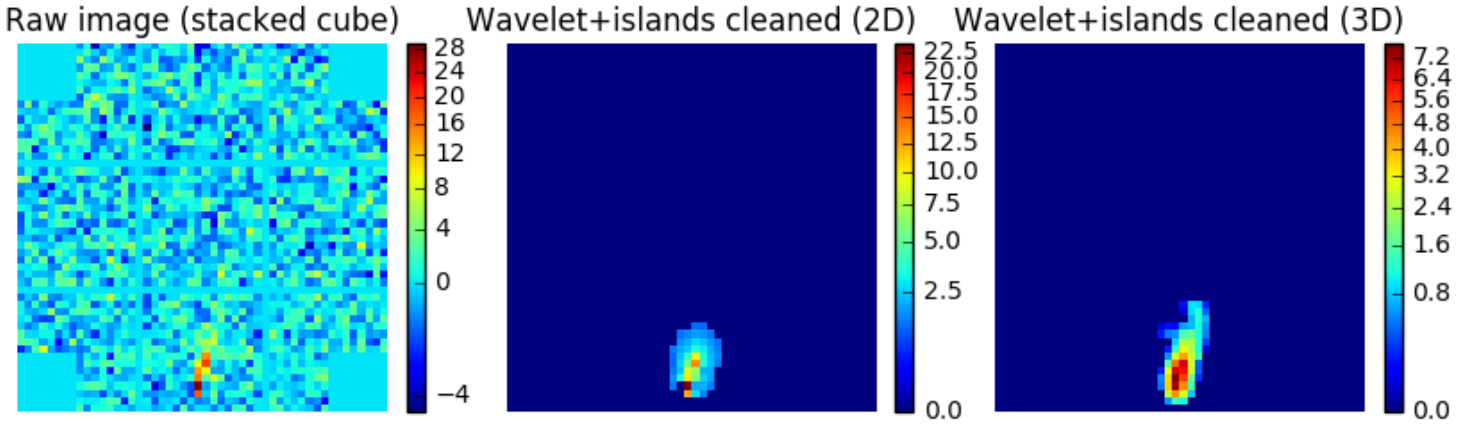
- Improve the filtering adding the time dimension
- Internal note

https://github.com/jdhp-sap/sap-cta-data-pipeline.git



Need to optimize

Impact on PSF ?



THANK YOU