CEA Status report

Tino Michael
on behalf of
CEA Saclay, Irfu/SAp

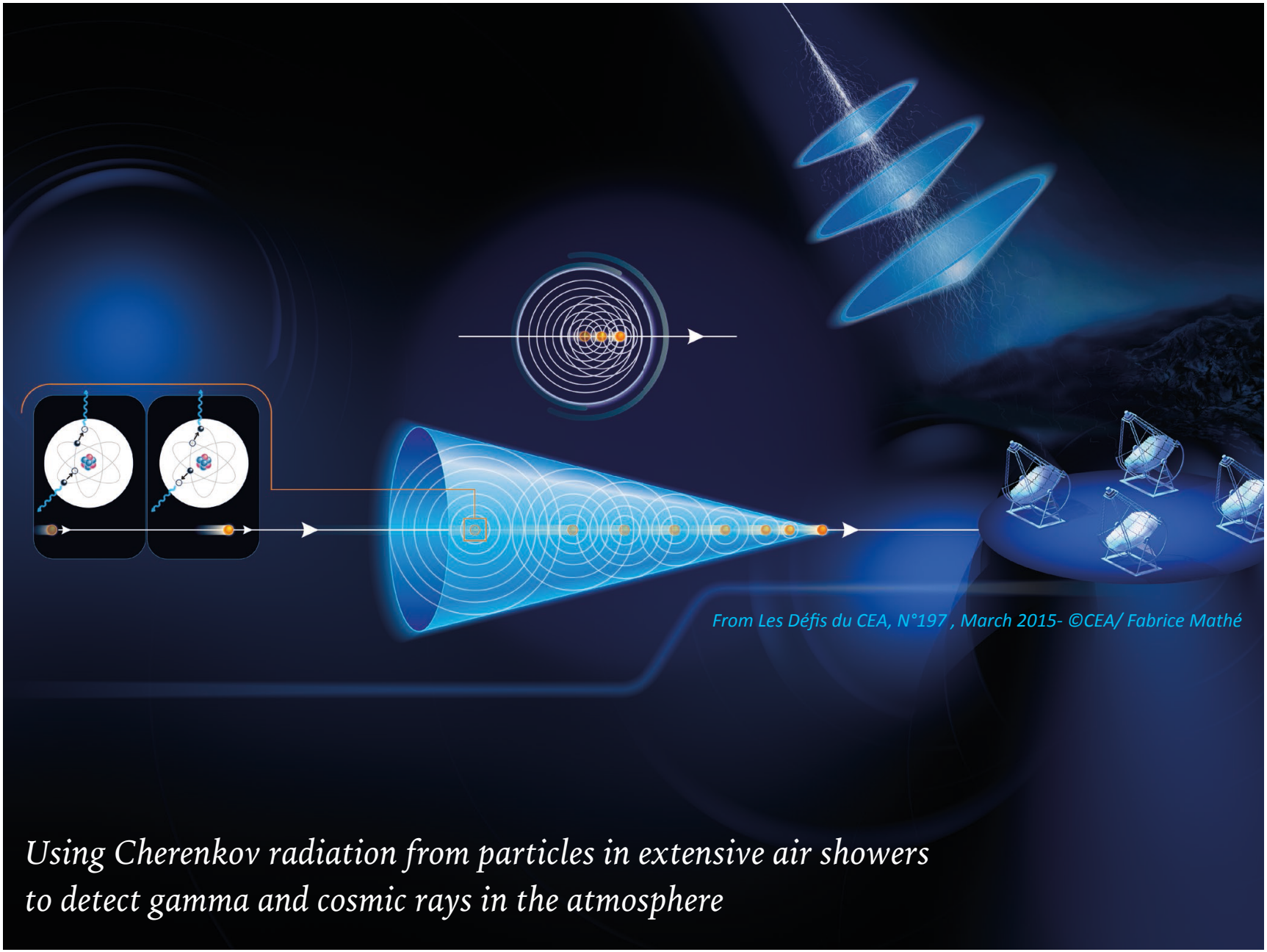
OBELICS Meeting Madrid
2016-09-15

CTA Group at CEA

- 12 People, working on CTA + other projects
  - HESS, Fermi, Integral, SVOM, XMM-Newton, Antares
  - Science : SNRs, X-Ray binaries, pulsars/PWNe, galactic diffuse flux, and GRBs
- 1 ASTERICS PostDoc since April 2016
- 1 Artificial Intelligence PostDoc
- Liaison between High-Energy Astro group and CosmoStat[a] Group for algorithm development
- CTA Data Pipelines coordination
- Detection of Transients in sky images

[a] http://www.cosmostat.org

CTA – Detection Principle



Using Cherenkov radiation from particles in extensive air showers to detect gamma and cosmic rays in the atmosphere

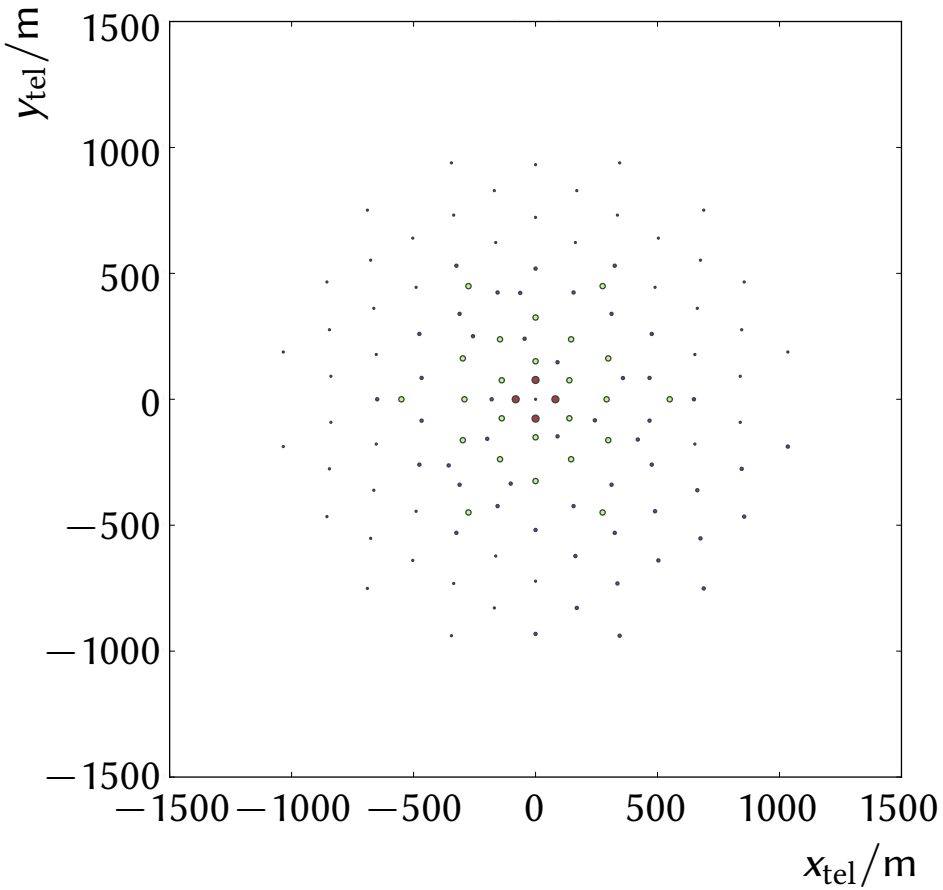
CTA – Detector

credit: DESY/Milde Science Comm./Exozet

CTA Location

2 Locations:
La Palma, Spain and Paranal, Chile

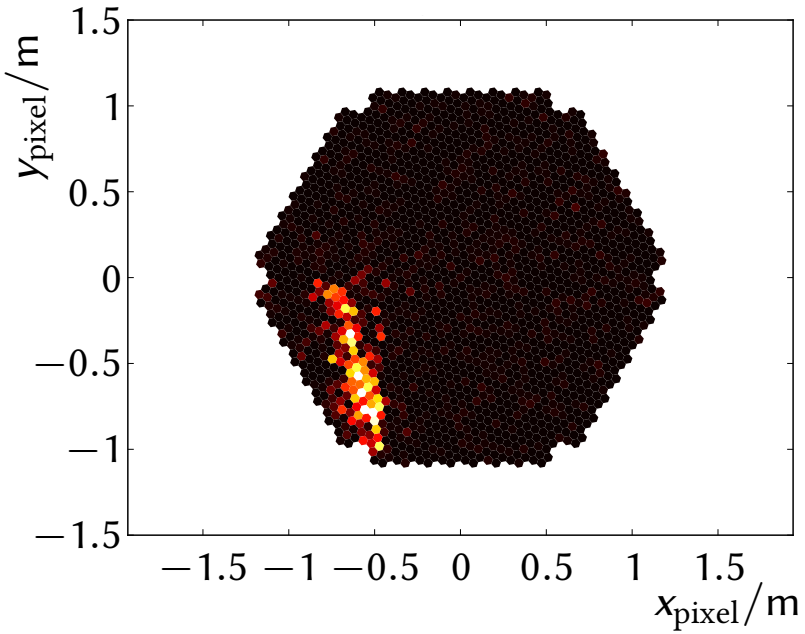
- Layouts not yet finalised
- here: possible implementation of Paranal Site to study performance of different telescopes
- 125 telescopes
- Large, Medium and Small Scale Telescopes (LST, MST, SST) optimised for different energy ranges

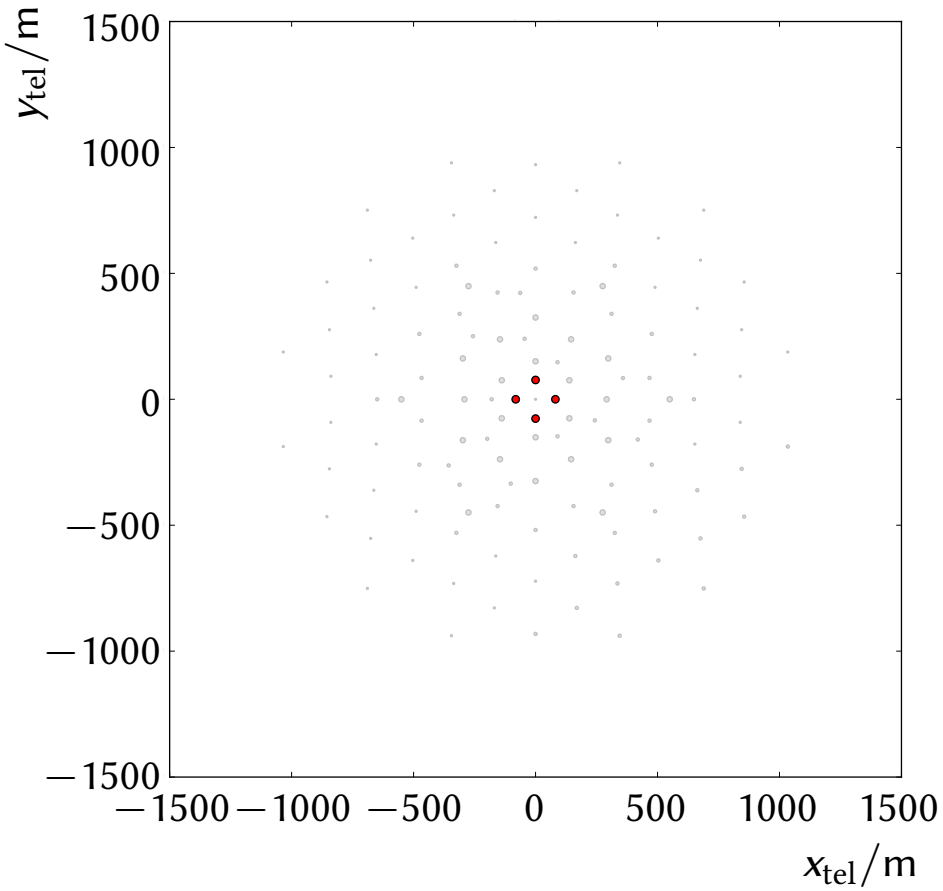


CTA South Layout

LSTCam

- Telescopes 1 to 4
- hexagonal pixels

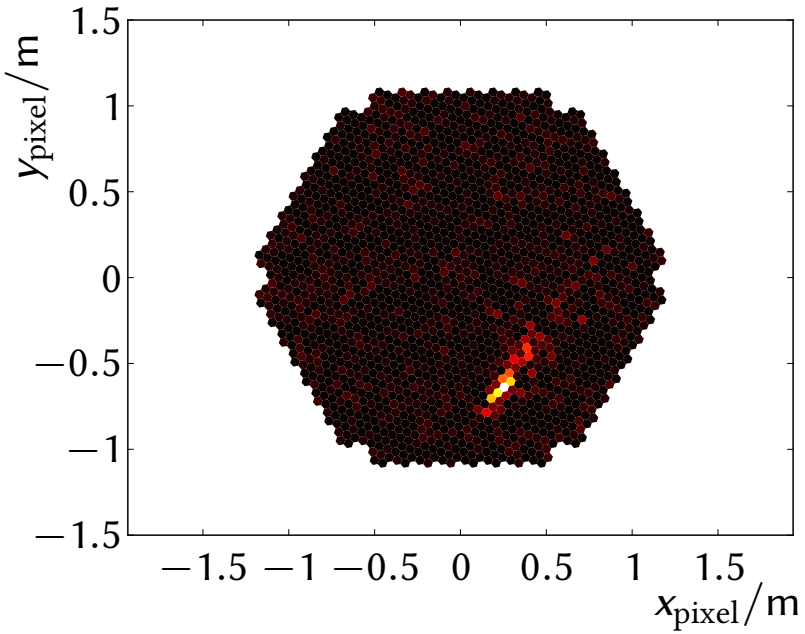


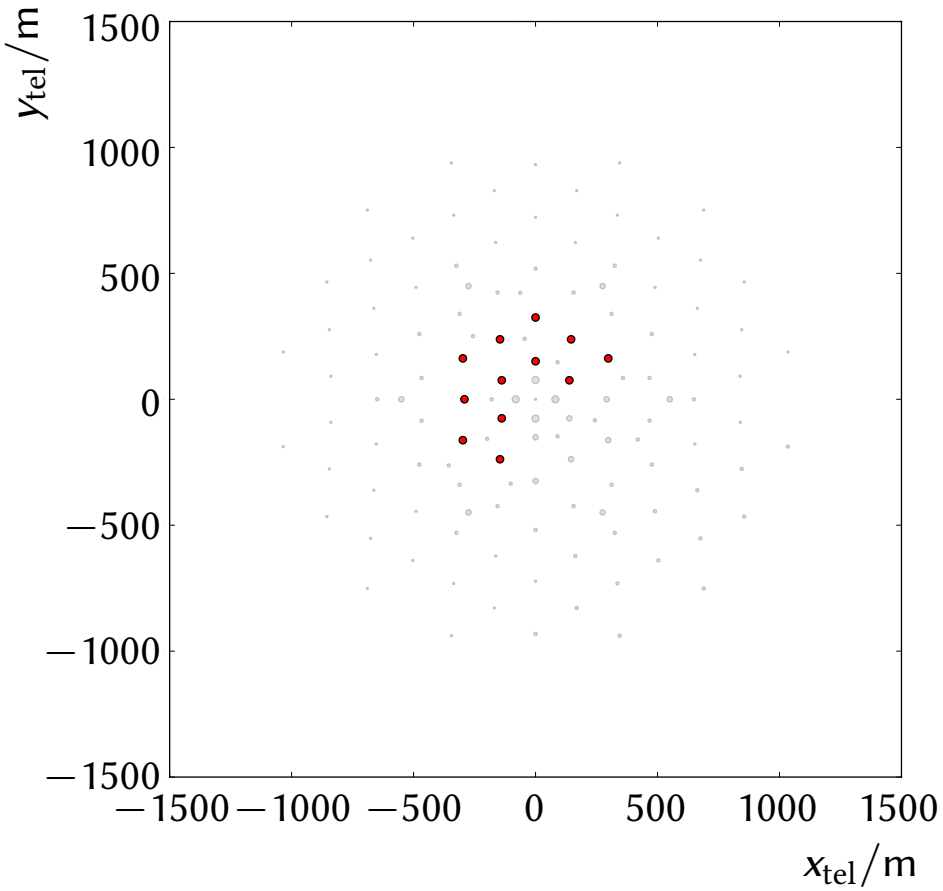


CTA South Layout

NectarCam

- Telescopes 5 to 16
- hexagonal pixels

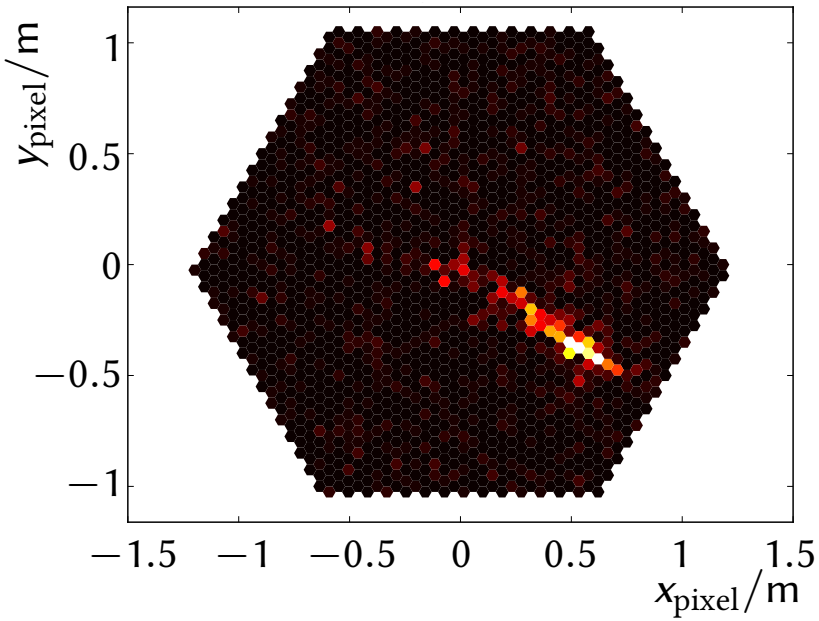


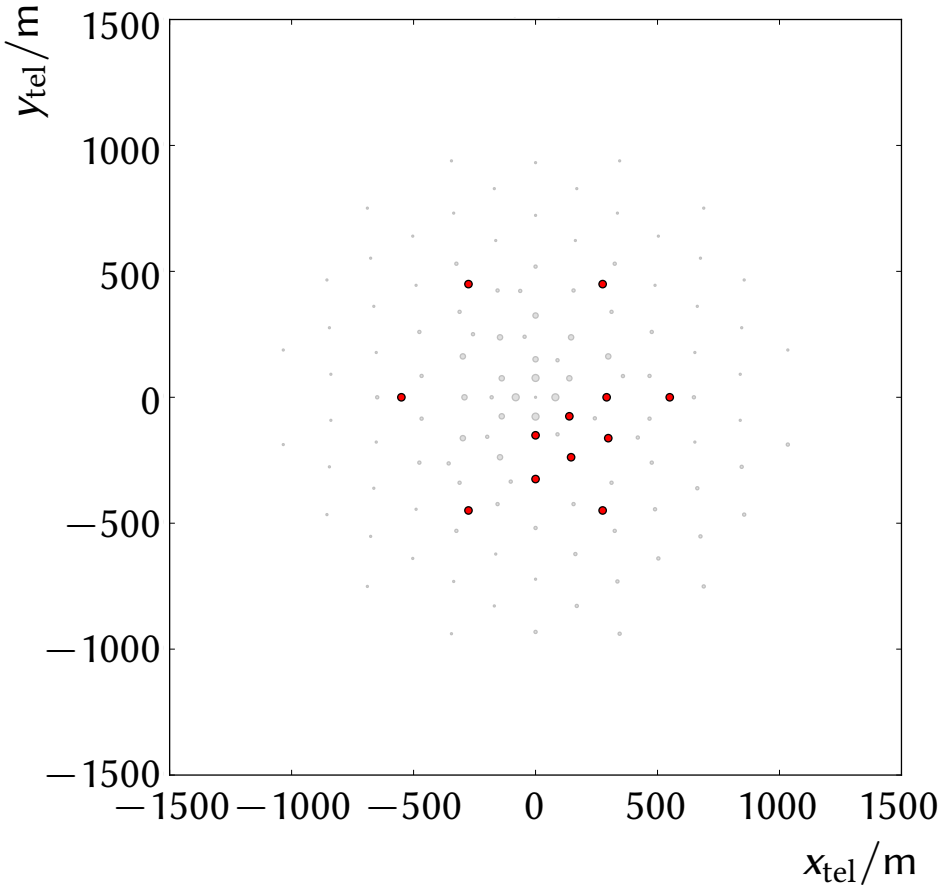


CTA South Layout

FlashCam telescopes

- Telescopes 17 to 28
- hexagonal pixels

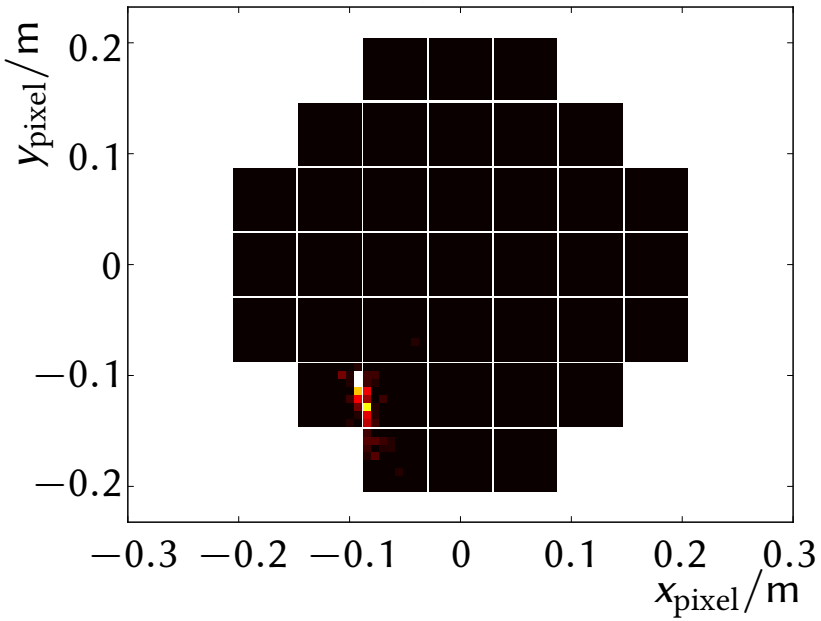


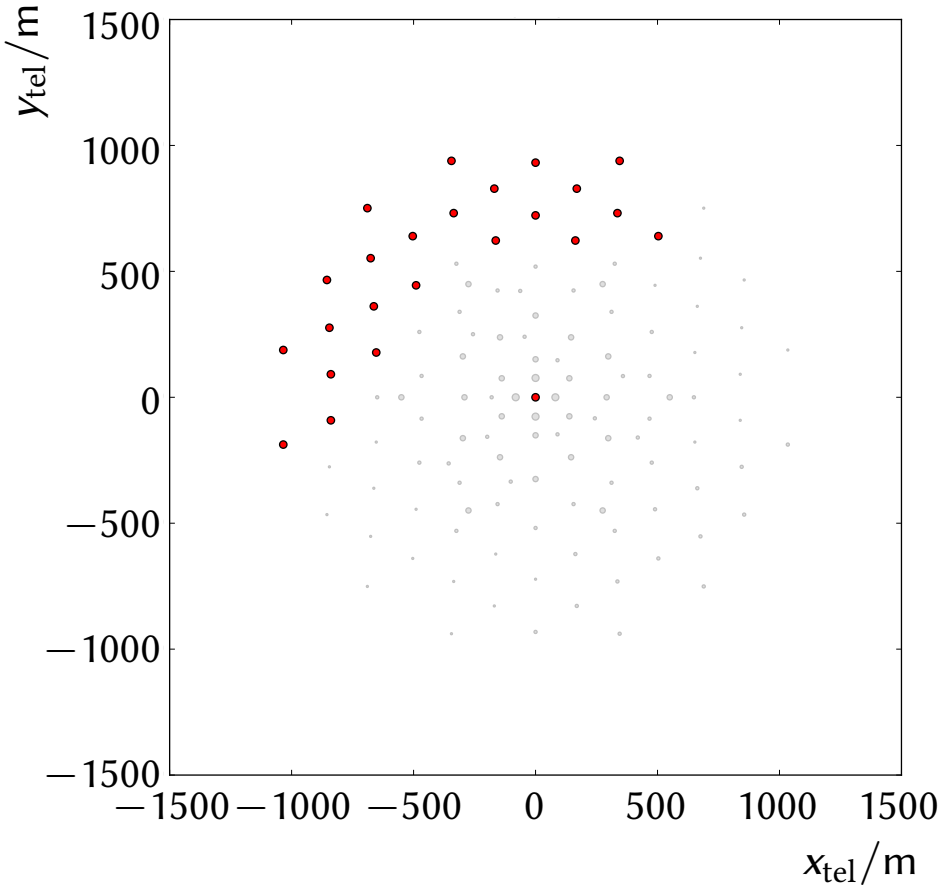


CTA South Layout

ASTRI telescopes

- Telescopes 29 to 52
- rectangular pixels

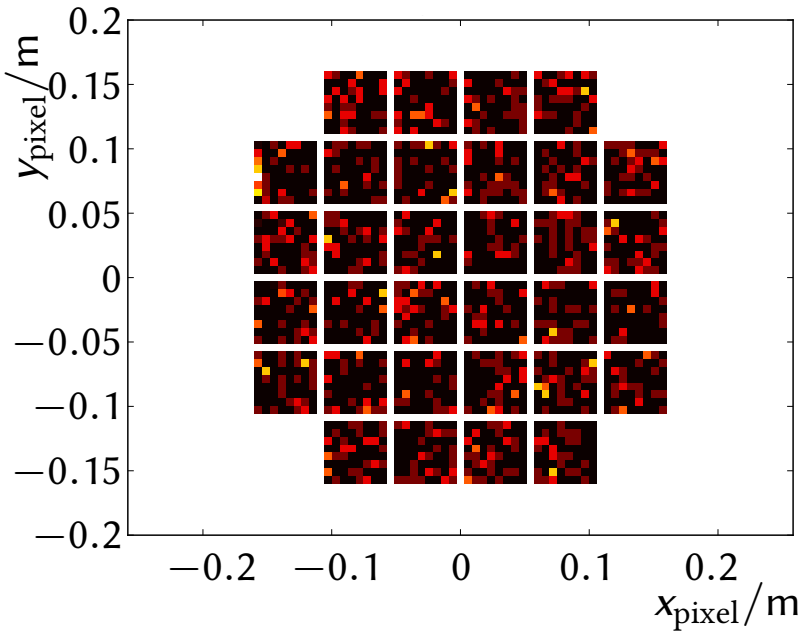


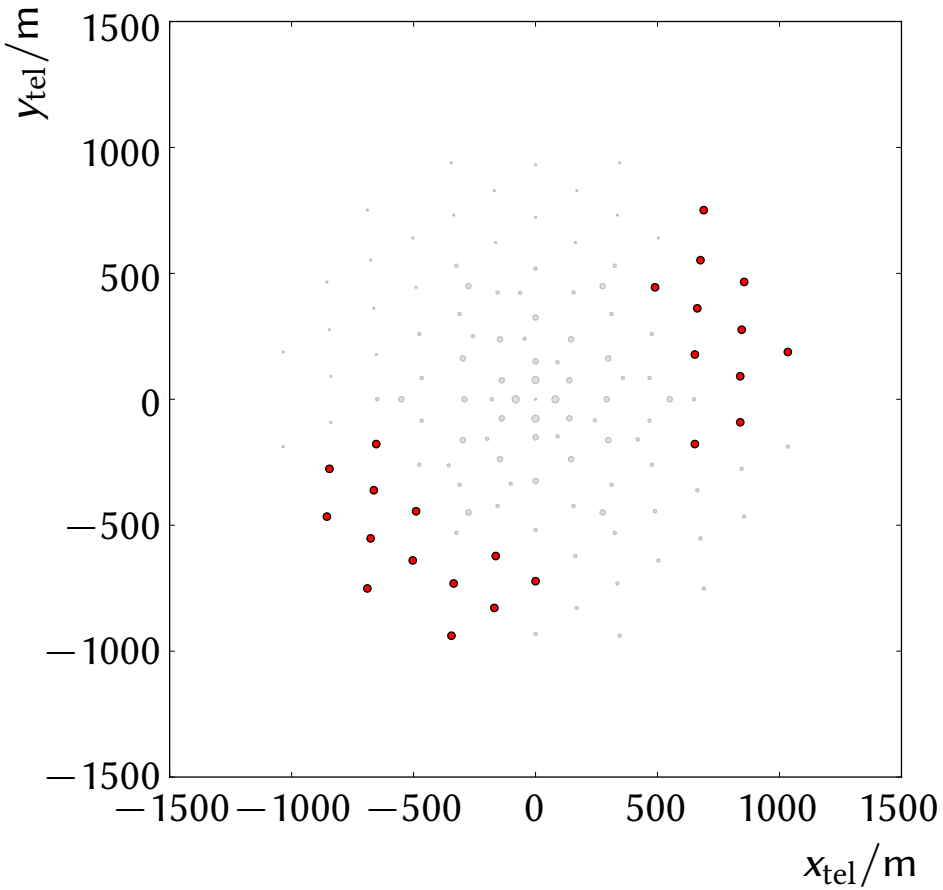


CTA South Layout

GATE

- Telescopes 53 to 76
- rectangular pixels

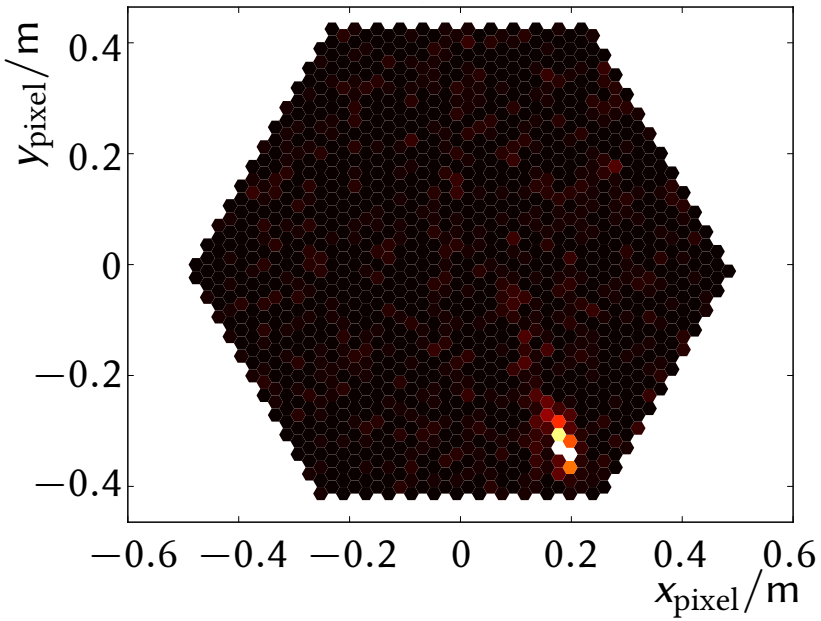


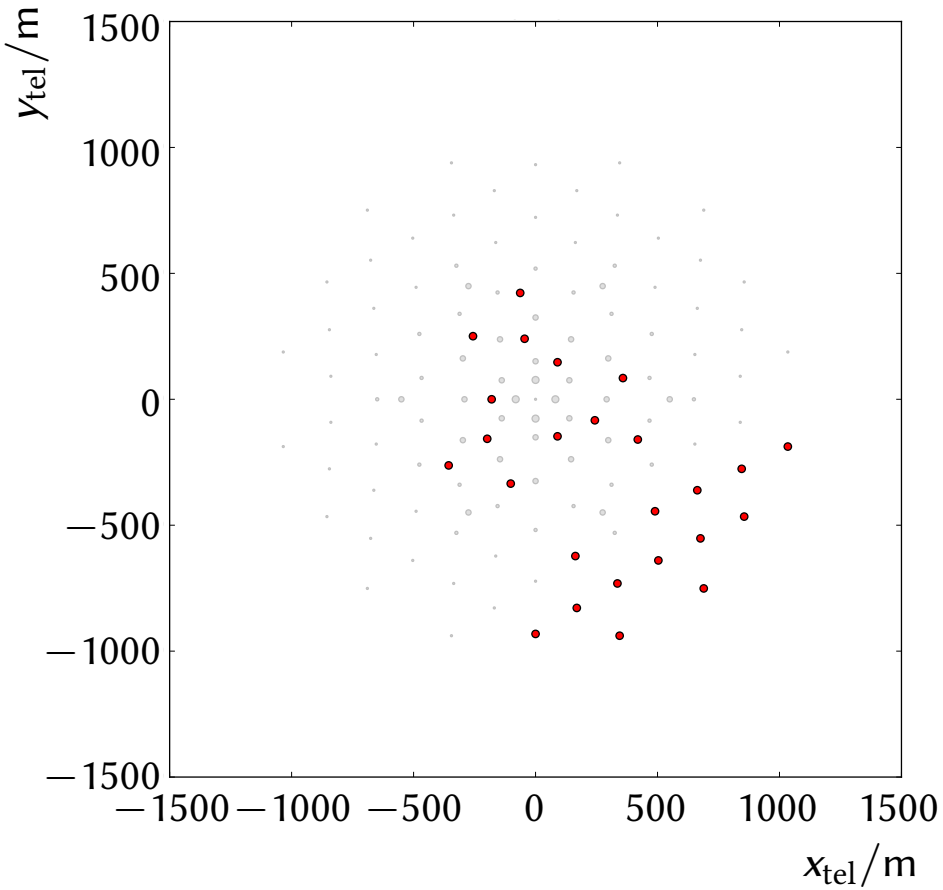


CTA South Layout

SST-1m

- Telescopes 77 to 101
- hexagonal pixels

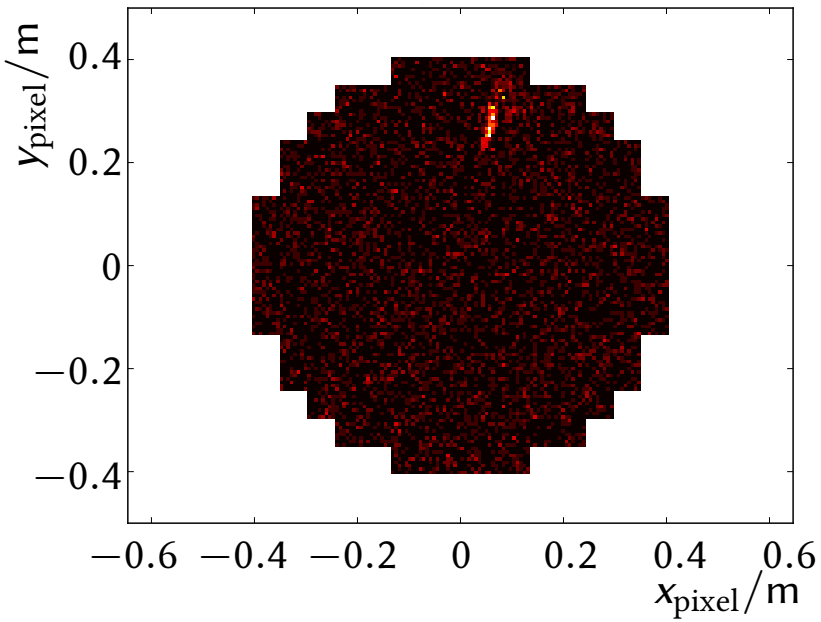


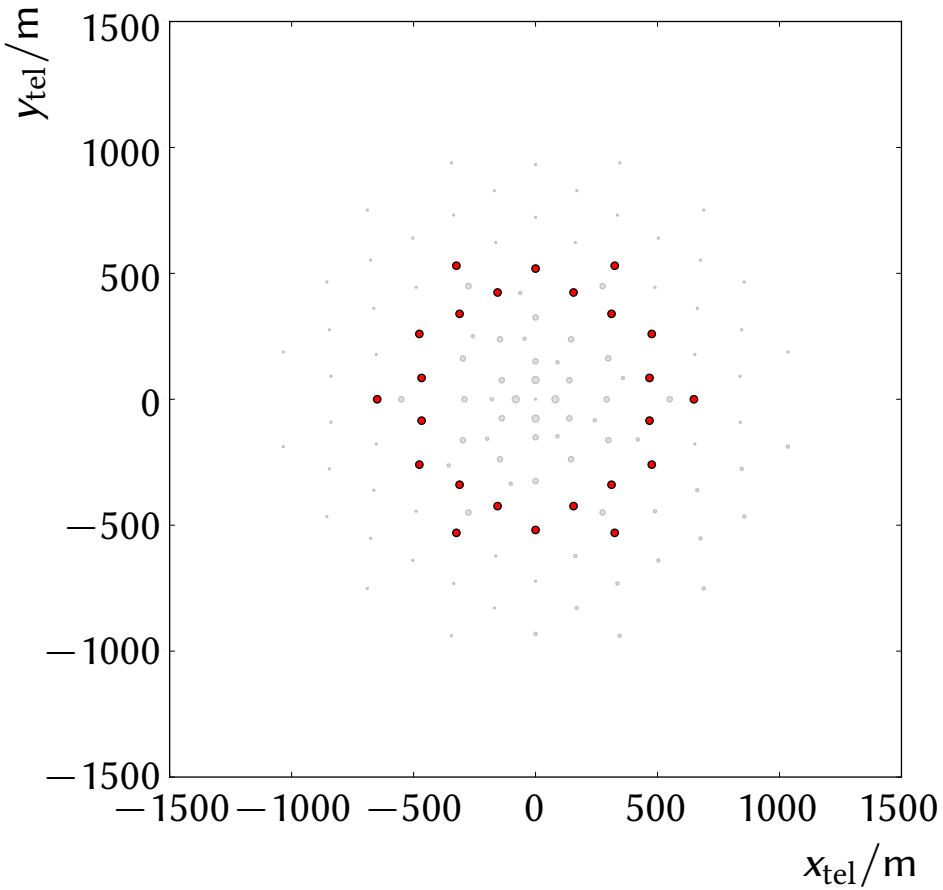


CTA South Layout

SCTCam

- Telescopes 102 to 125
- rectangular pixels

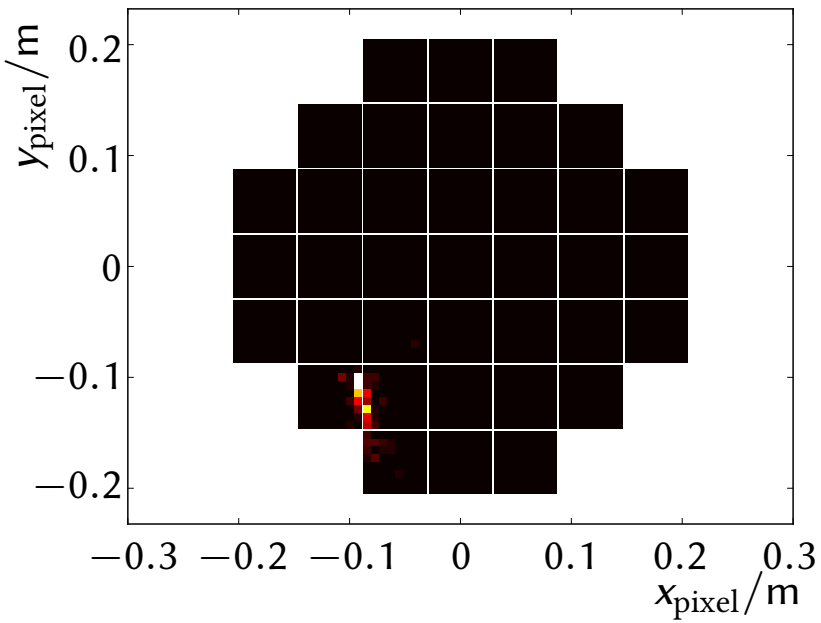


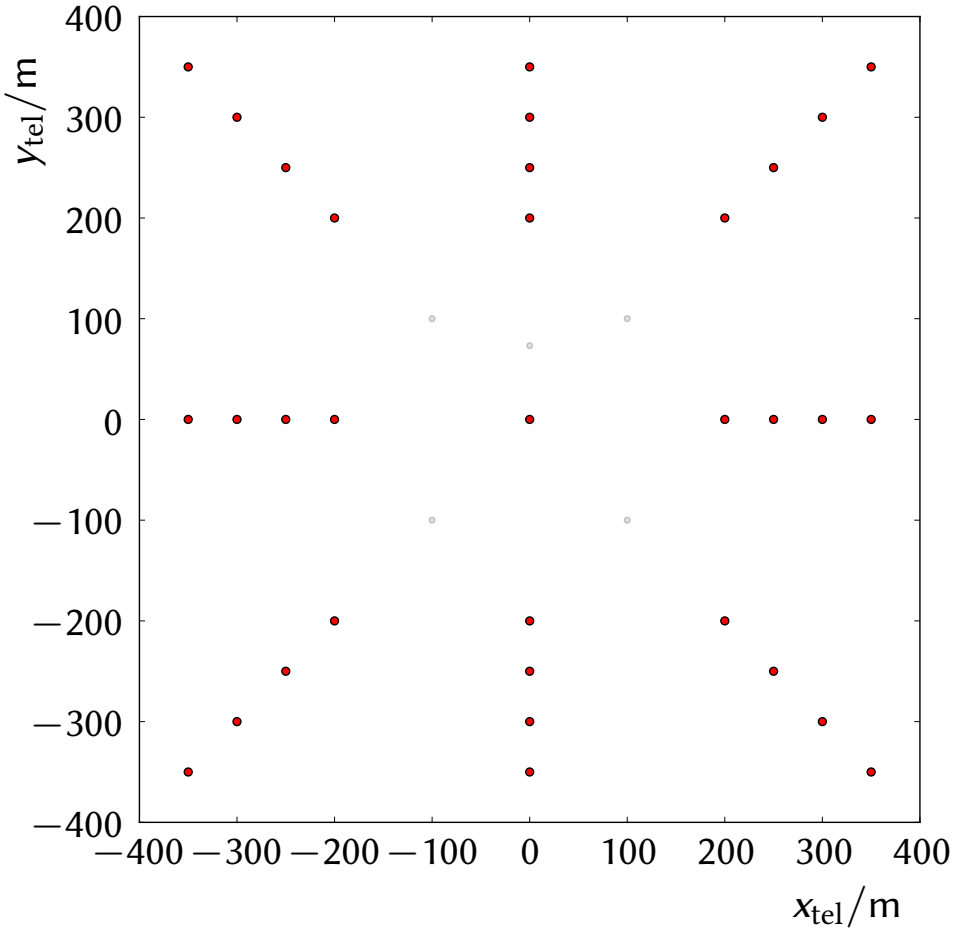


“ASTRI mini-array”

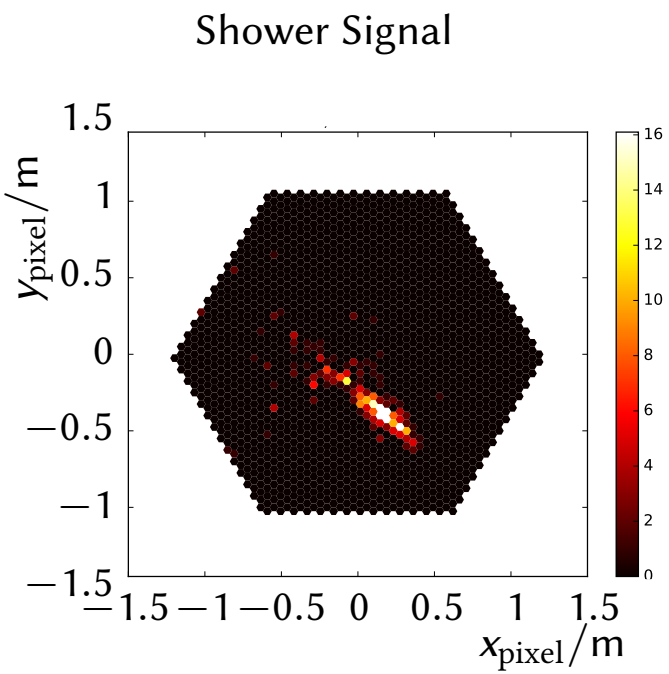
ASTRI telescopes

- 2368 rectangular pixels
- dedicated Monte Carlo with 33 Telescopes for spacing study for implementation in full array
- only using the central 3×3 here



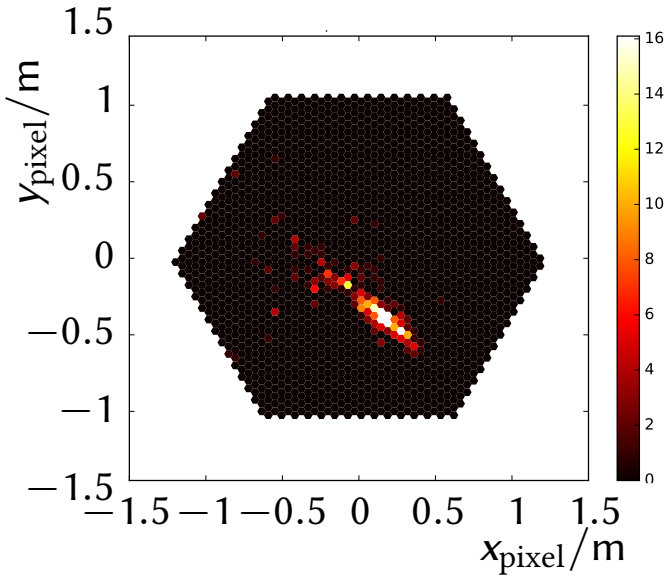


How the Signal looks like



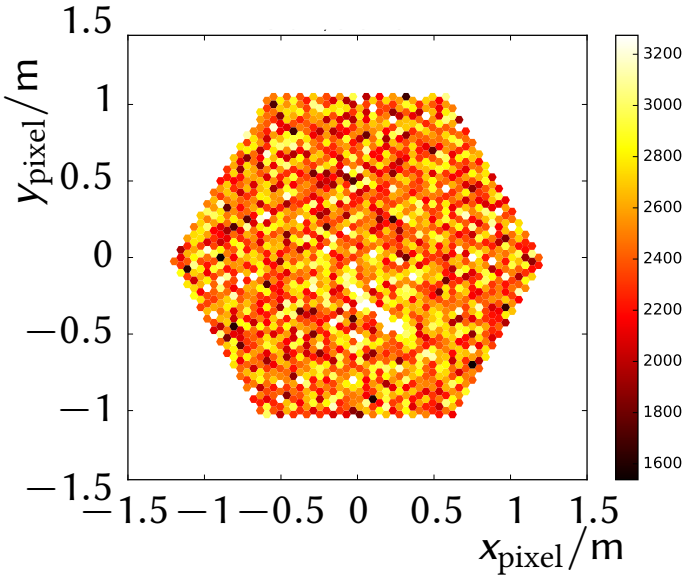
How the Signal looks like

Shower Signal



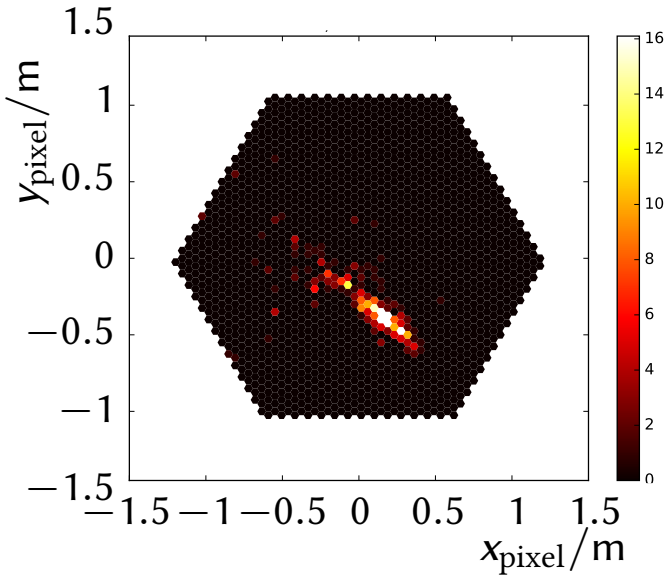
Stars, Clouds,
Electronics etc.
$\longrightarrow$

Detector Response



How the Signal looks like

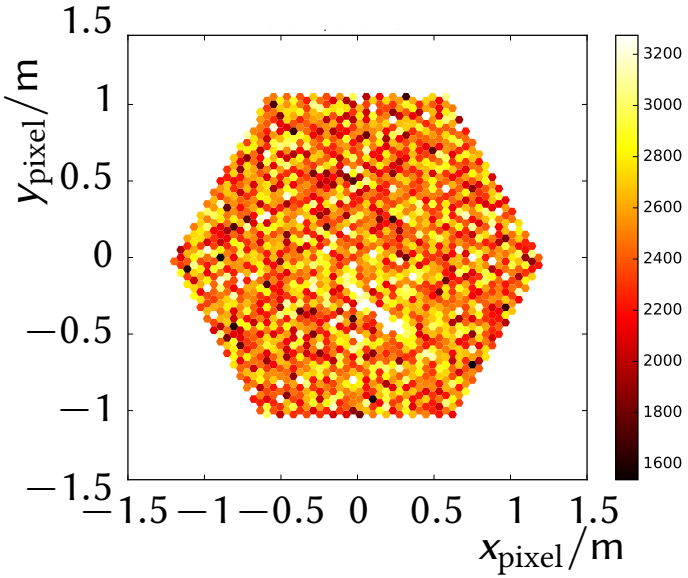
Shower Signal



Stars, Clouds, Electronics etc. $\longrightarrow$

$\longleftarrow$ How to get back?

Detector Response



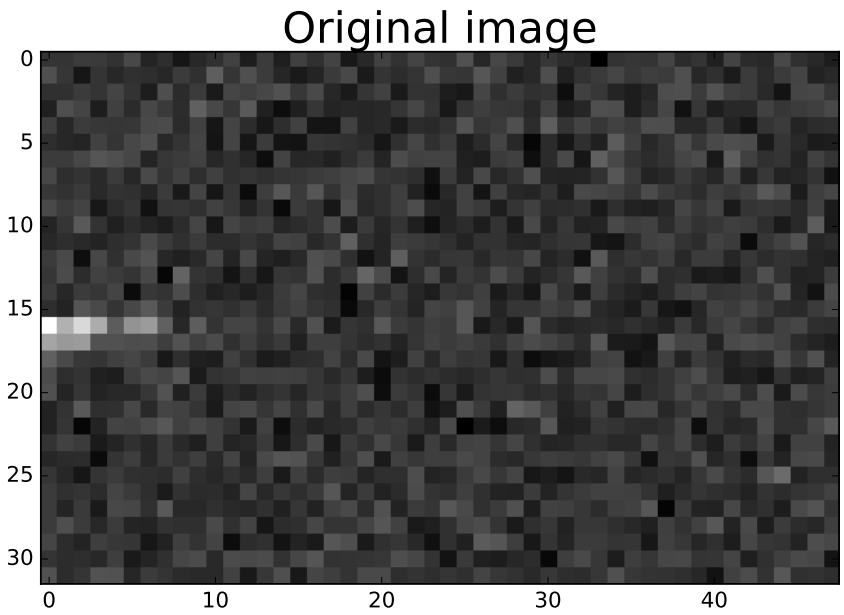
Suggested Solutions

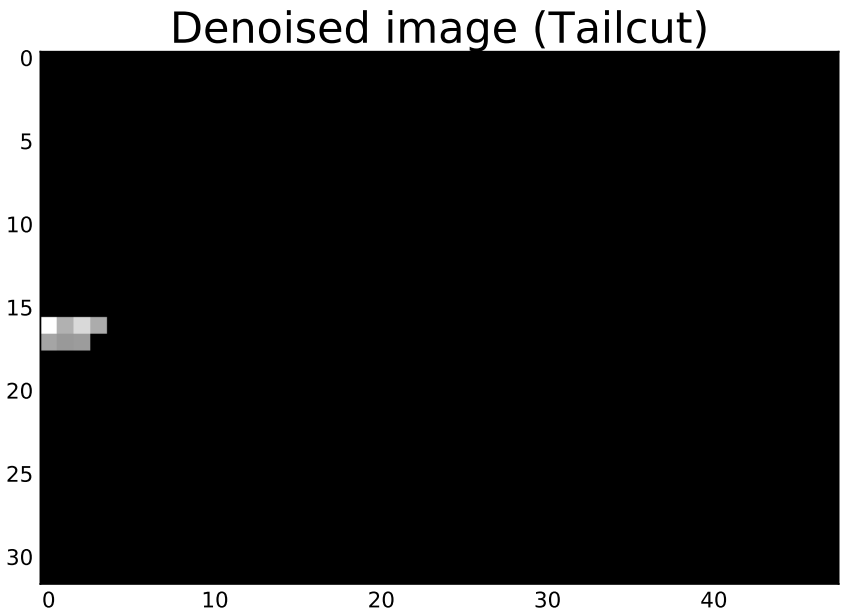
Tail-Cuts Used by H.E.S.S.: Cut away all pixels below a given threshold
– possibly recover neighbouring pixels through second, lower threshold.

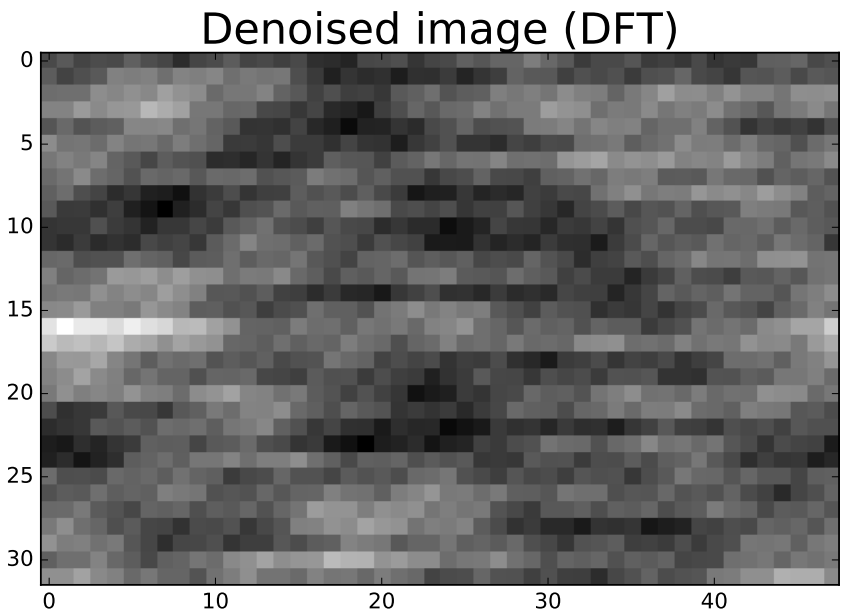
Fourier Trans. Decompose image into Fourier coefficients and cut in Fourier space.

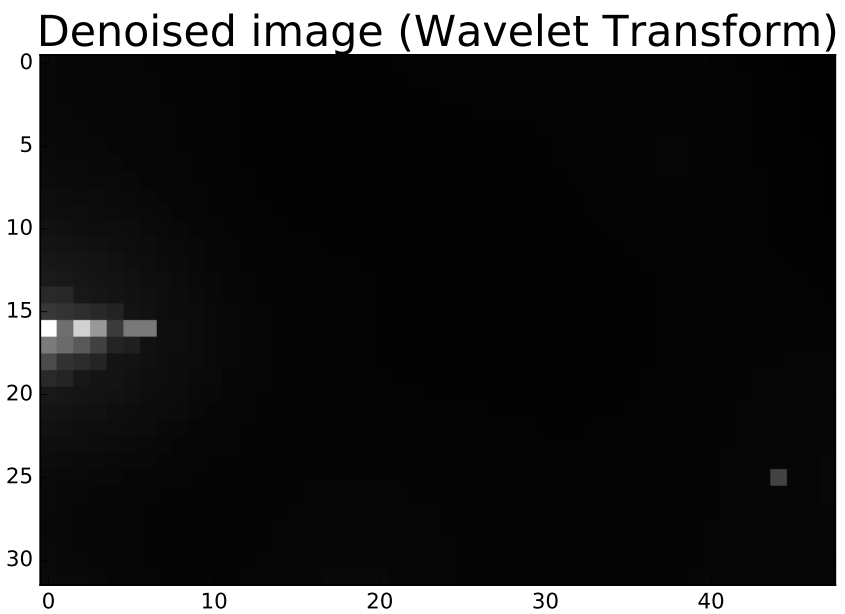
Wavelet Trans. Decompose image into waveletes (in contrast to waves) and cut there.

Comparing Methods







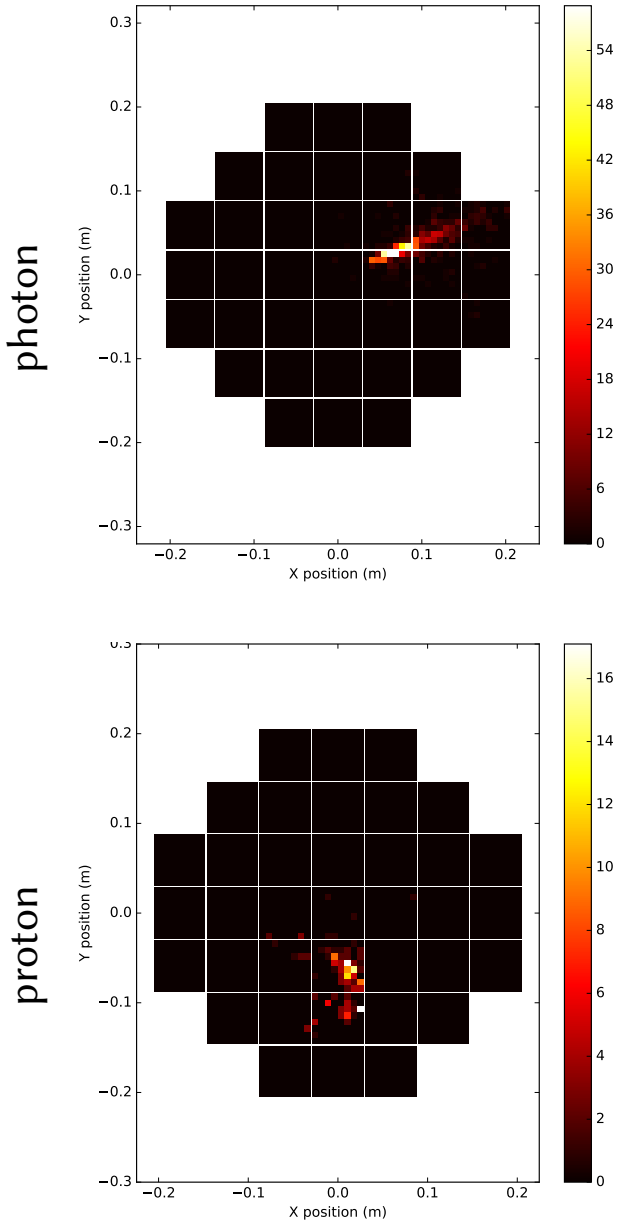


Next Steps

Photon / Proton Discrimination

- Protons pose major background
- Event rate about 10^5 times above Photons
- Discrimination with Random Forest Classifier fed with parametrisation of camera image (width, length, ... of a fitted ellipsis: Hillas parametrisation)

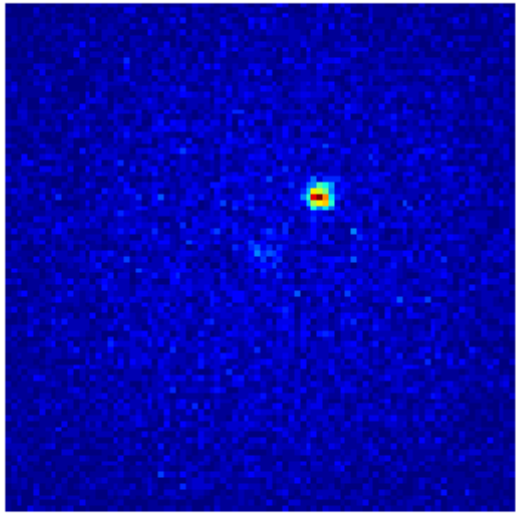
Classifier is implemented in ctapipe software framework. Quantitative results will follow soon.



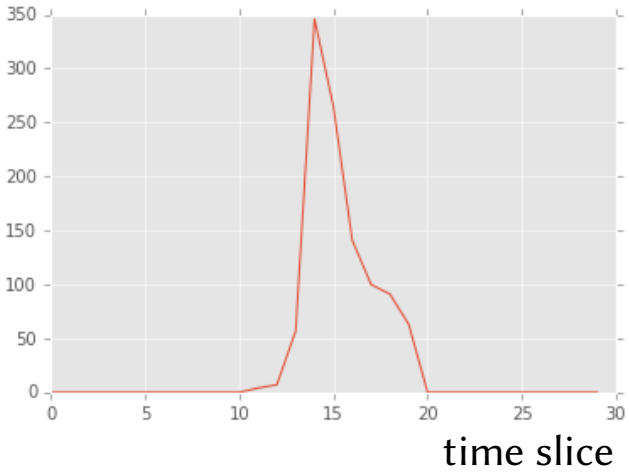
Sky Images – Transient Sources

- detect a transient outburst online
- focus on LST:
  → low energy
  → large field of view
  → always a steady source in view
- apply wavelet decomposition to 3D data cube (two angles and time)
- able to filter out steady source and background
  → transient now clearly visible

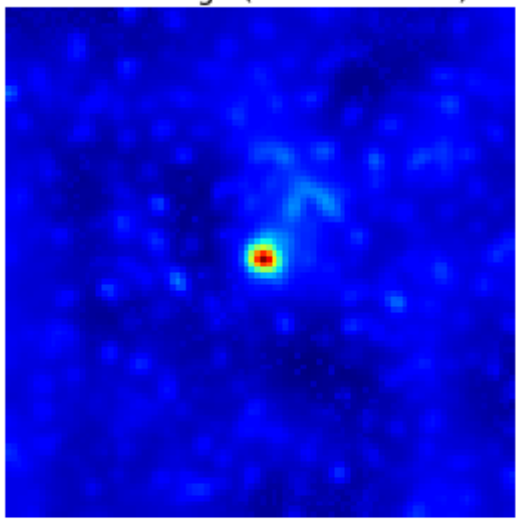
Original noisy image (summed cube)



- injected signal inspired by real Fermi GRB
- transient peaks at $\approx 2 \cdot \Phi_{\mathrm{Crab}}$
- steady source at 1 Crab
- each time slice is 10s of integration and $50 < E/\mathrm{GeV} < 500$



Clean image (summed cube)



To Do List

Showers

- optimise parameters for wavelet cleaning
- adapt wavelet algorithm for hexagonal image grid
- evaluate background rejection and shower reconstruction in light of wavelet cleaning

Sky Images

- continue to work on improving sensitivity to transient sources
- disentangle complex, large FoV