Extending ctapipe image reconstruction using FACT methods
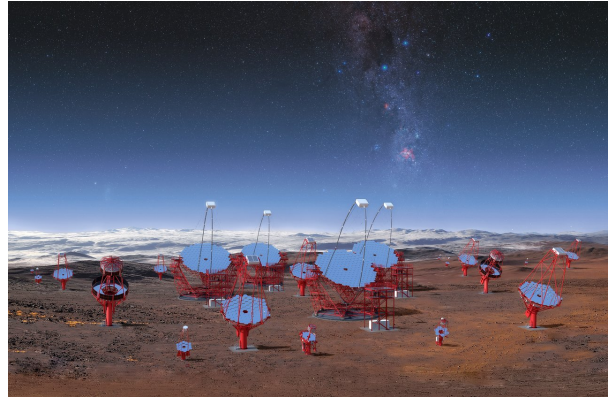
Lukas Nickel and Maximilian Nöthe

28. März 2019

E5b

The Cherenkov Telescope Array

- "Cherenkov Telescope Array"
- Proposed in 2005
- Currently in pre-production
- Status: First light on LST1
- Two arrays of multiple telescopes
- Three types of telescopes: LST, MST, SST
- Goals: Extend observable energy range, improve sensitivity, huge field of view
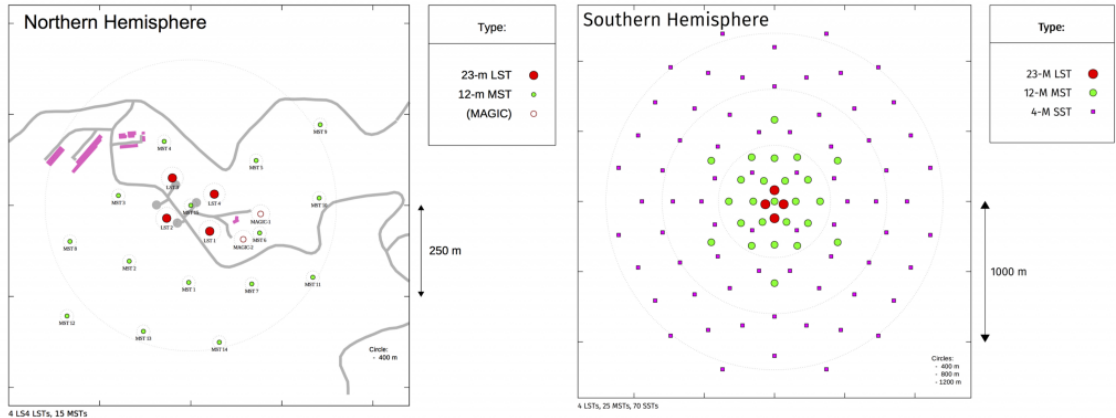

Visualization of the different telescope types.
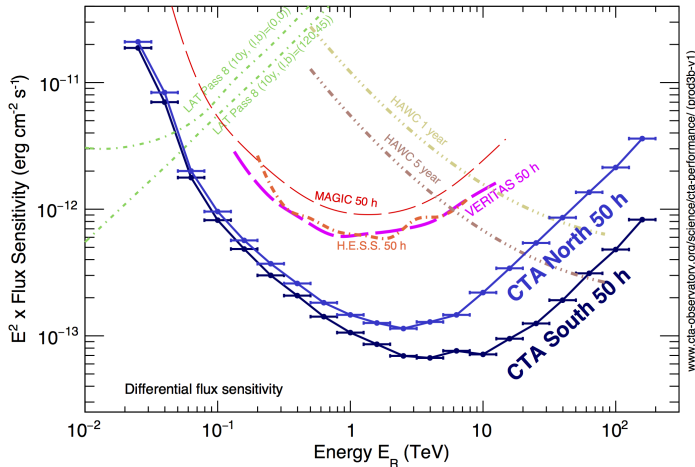CTA/M-A. Besel/IAC (G.P. Diaz)/ESO. 2018. URL:
https://www.eso.org/public/germany/images/eso1841a/

Planned Layout

Expected Sensitivity

The CTA Consortium, CTA's expected baseline performance

ctapipe

- Pipeline for lowlevel cta data
- Performs transformations, calibration, cleaning, hillas parameters, 3D-reconstruction, visualization
- Still in active development
- Mainly **python** based
- https://github.com/cta-observatory/ctapipe

The FACT Experiment

- "First G-APD Cherenkov Telescope"
- Single telescope
- → Monoscopic reconstruction only
- Operating on La Palma since 2011
- → Advanced analysis pipeline
- What did we take a look at?
  - More advanced cleaning methods
  - Distinction of "islands" in shower images
  - → Possible improvements for ctapipe

Image cleaning in FACT

Cleaning Methods

Tailcuts cleaning

- "Two treshold procedure"
- Pixels above upper threshold survive
- Signal with less N neighbors get discarded
- Neighboring pixels above the lower threshold get added

"FACT image cleaning"

- Similar behaviour, but also uses information about the arrival times
- → Pixels need to have a similar arrival time as their neighbors
- Multiple steps removing "lonely" pixels
- → Probably removes more pixels with the same intensity thresholds

Sample MC Event

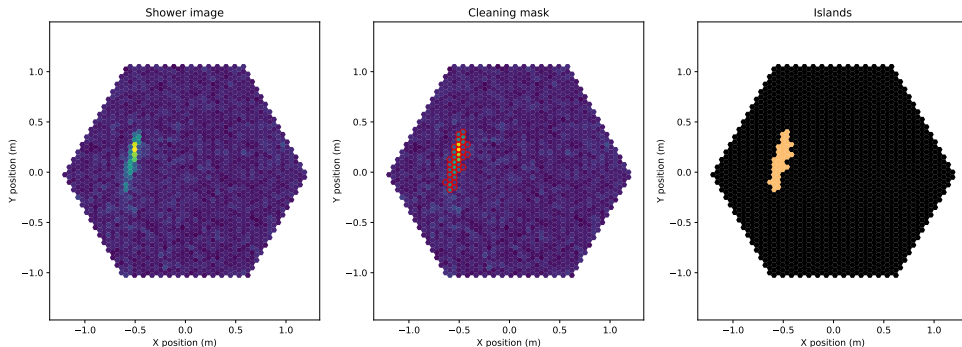Calibrated Shower Image
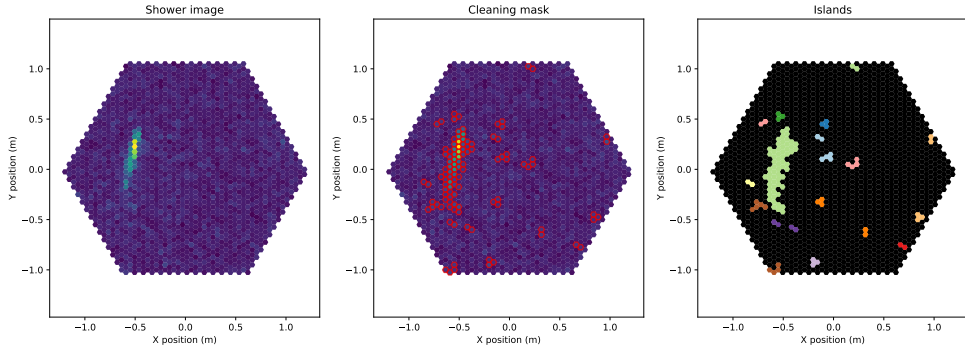
Relative Arrival Times
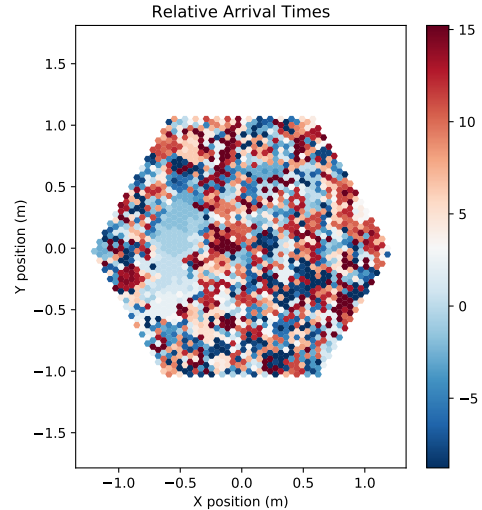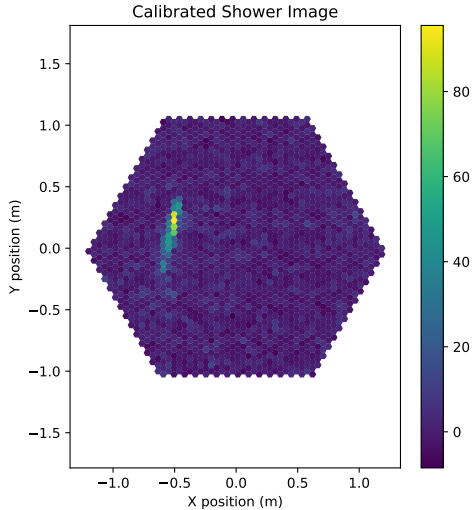
Cleaning Results
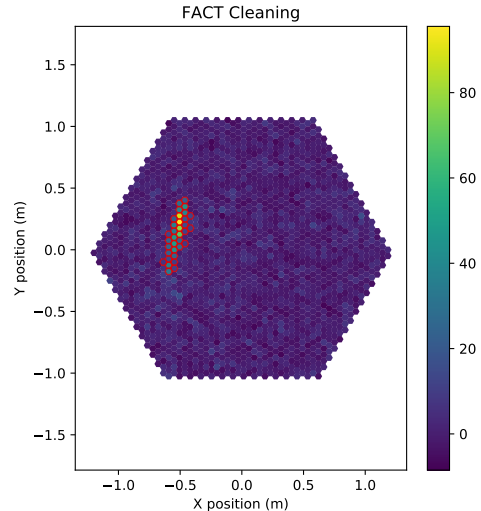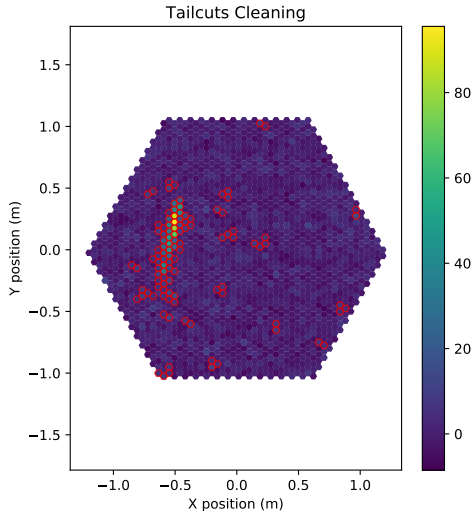
Finding islands

- Cleaning removed all but one cluster of pixels
→ Number of islands: 1

- Cleaning kept too many pixels
→ Number of islands: > 1

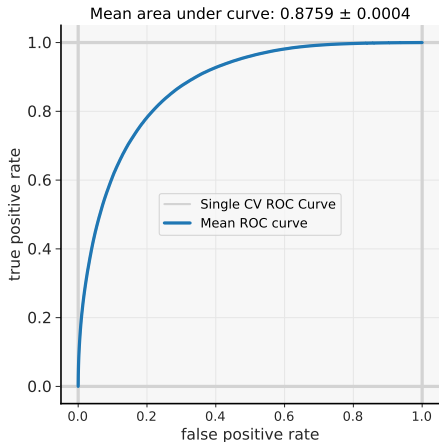Shower image   Cleaning mask   Islands

Machine learning impacts

Setup and expectations

- A few 100 000 diffuse gamma and proton MC events
- Preprocessed with ctapipe, machine learning with aict-tools

  aict-tools. URL: `https://github.com/fact-project/aict-tools`

- Tailcuts cleaning should perform pretty well with the chosen parameters
- Cleaning might affect separator performance
- Number of islands might contribute to separator performance
- Number of islands will probably not constribute to gamma energy regression
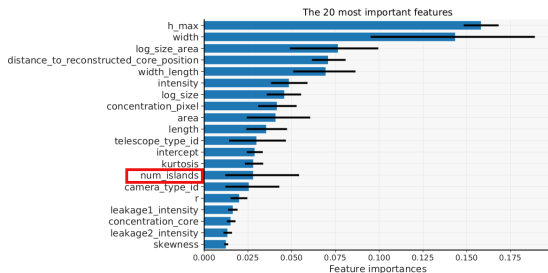
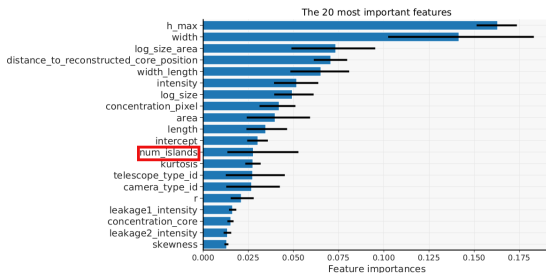## Gamma/Hadron Separation - AUC

Tailcuts cleaning:

Mean area under curve: 0.8759 ± 0.0004

FACT cleaning:

Mean area under curve: 0.8706 ± 0.0003
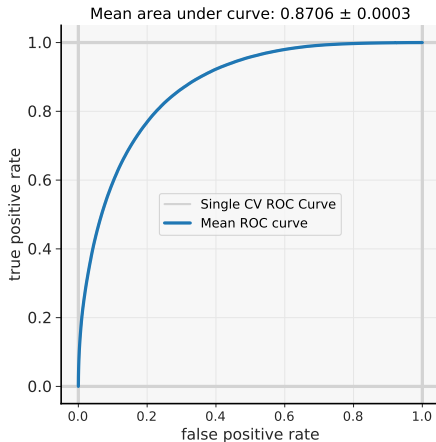
Gamma/Hadron Separation - Features

Tailcuts cleaning:

FACT cleaning:

Energy Regression

Tailcuts cleaning:

Reconstructed vs. True Energy (log color scale)

FACT cleaning:

Reconstructed vs. True Energy (log color scale)
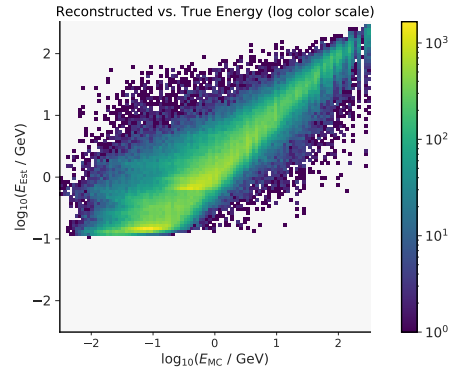
Energy Regression - Features

Tailcuts cleaning:
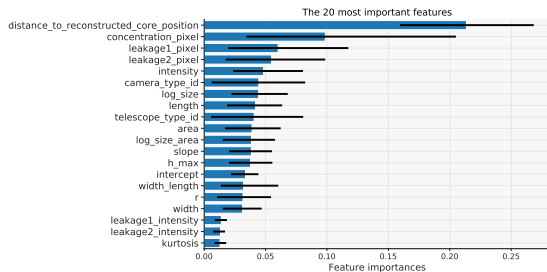
FACT cleaning:
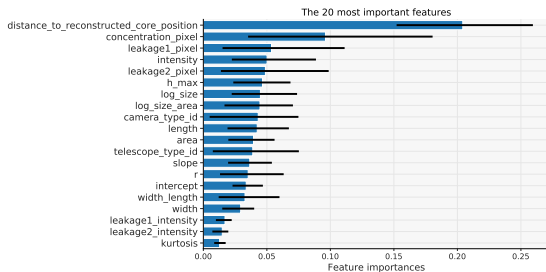
Thank you for your attention!

aict-tools. URL: https://github.com/fact-project/aict-tools.

Anderhub, H u. a. „Design and operation of FACT – the first G-APD Cherenkov telescope". In: *Journal of Instrumentation* 8.06 (Juni 2013), P06008–P06008. DOI: 10.1088/1748-0221/8/06/p06008. URL: https://doi.org/10.1088%2F1748-0221%2F8%2F06%2Fp06008.

Consortium, The CTA. *CTA's expected baseline performance*. URL: https://www.cta-observatory.org/science/cta-performance.

Diaz)/ESO, CTA/M-A. Besel/IAC (G.P. 2018. URL: https://www.eso.org/public/germany/images/eso1841a/.