technische universität
dortmund

e5 experimentelle physik 5
astroteilchenphysik

Extending ctapipe image reconstruction using FACT methods

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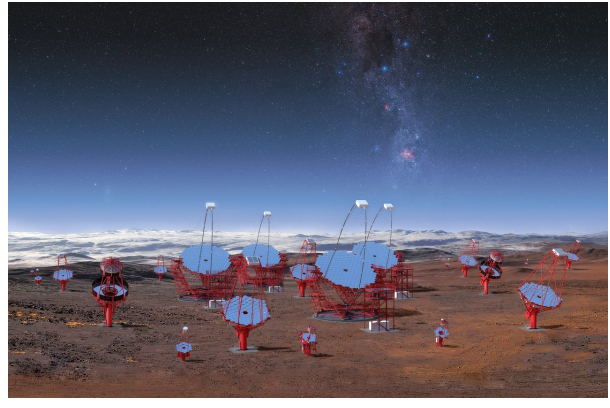
18. März 2019

E5b

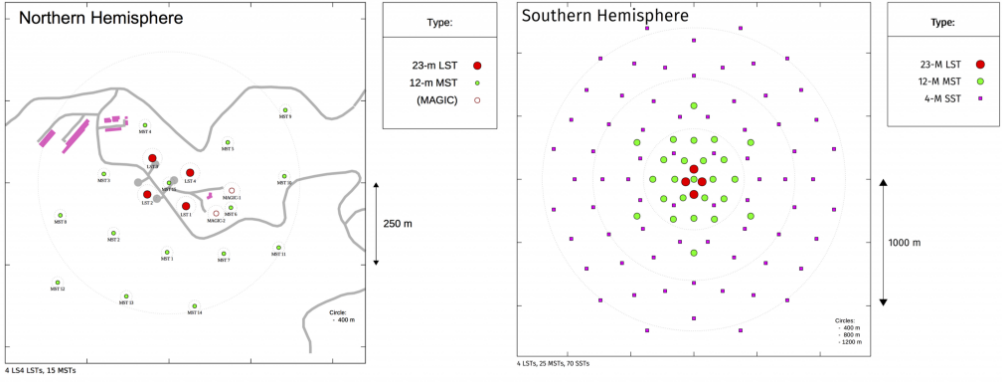
The Cherenkov Telescope Array

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

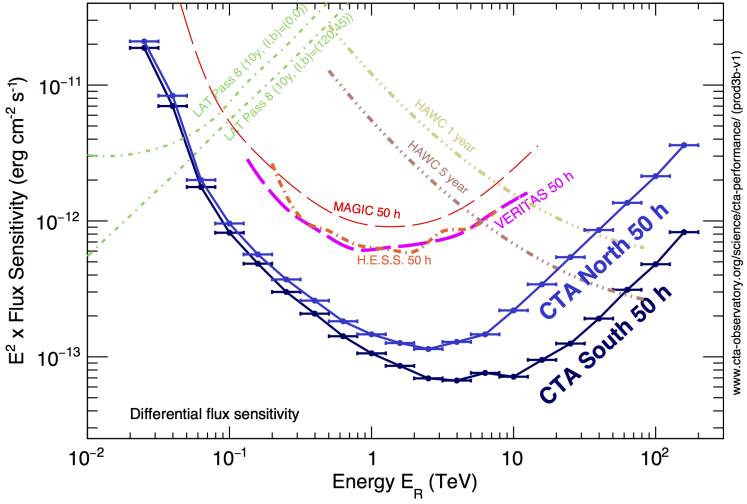


Visualization of the different telescope types. (*1*)

Planned Layout (2)

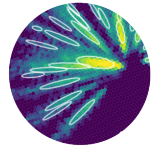


Expected Sensitivity (2)



ctapipe

- Pipeline for low level cta data
- Performs Transformation, Calibration, Cleaning, Hillas-Parameter, 3D-Reconstruction, Visualization
- Mainly **python** based
- Still in active development
- https://github.com/cta-observatory/ctapipe

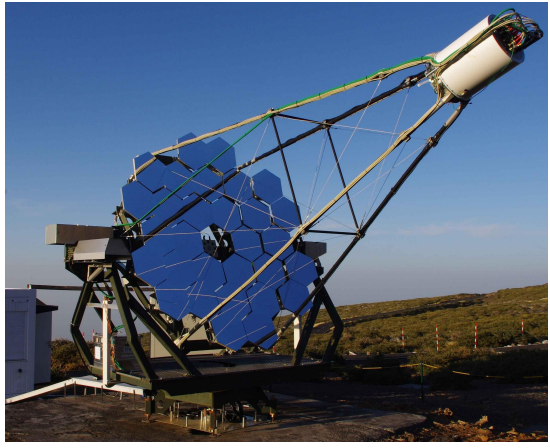


ctapipe

python™

The FACT Experiment

- "First G-APD Cherenkov Telescope"
- Operating in La Palma since 2011
- Monoscopic reconstruction only
- Advanced analysis pipeline
- What did we take a look at?
  - More advanced cleaning method
  - Distinction of "islands" in shower images
  - → Possible improvements for monoscopic reconstruction in ctapipe
  - → First use case: LST1



(*3*)

Image cleaning in FACT

Cleaning Methods

Tailcuts cleaning

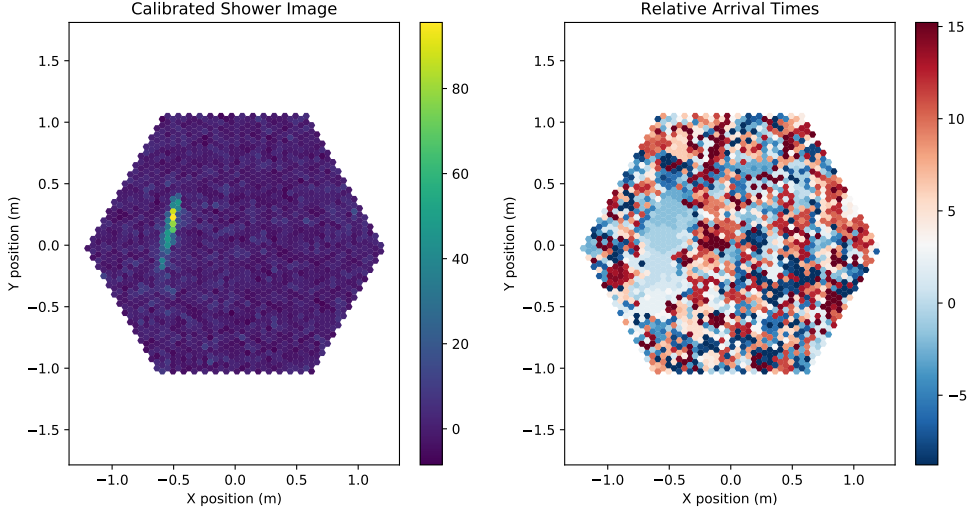
- ”Two treshold procedure”
- Pixels above upper threshold survive
- Signal pixels need at least N neighbors
- Add neighboring pixels above the lower threshold

”FACT image cleaning”

- Similar behaviour, but also uses information about the arrival times
- Pixels nedd to have a similar arrival time as their neighbors
- More steps removing ”lonely” pixels

→ Probably removes more pixels with the same intensity thresholds

Sample MC Event



Cleaning Results

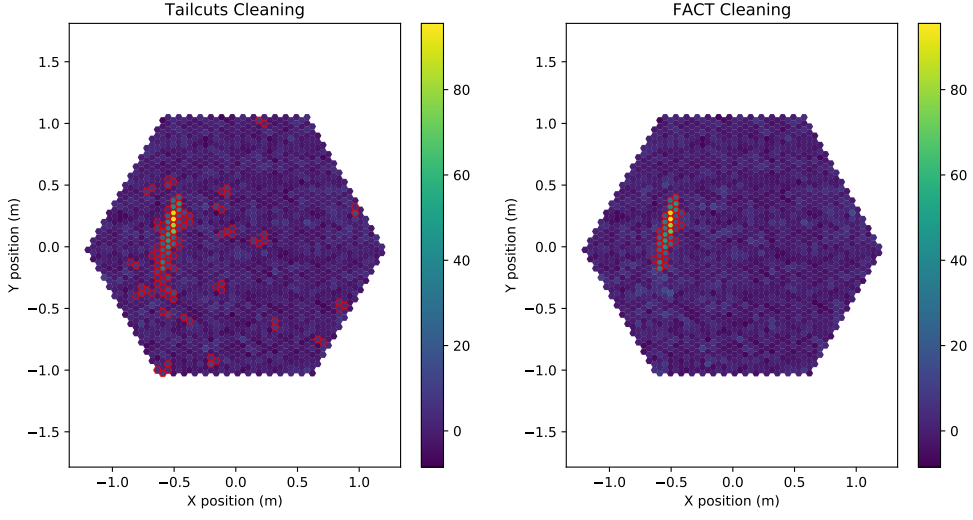
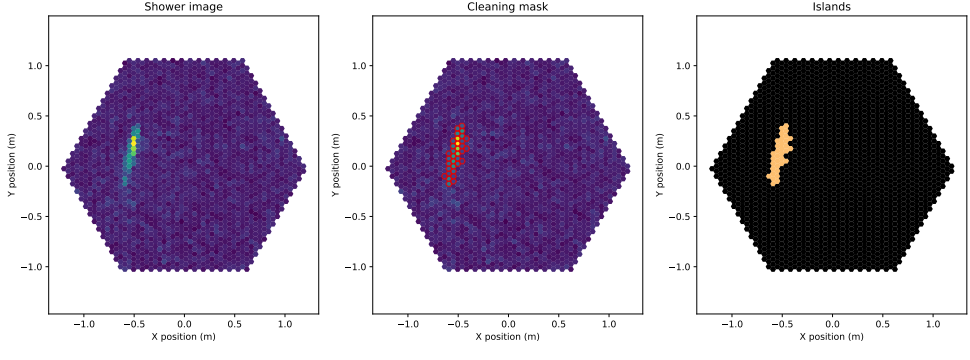


Image cleaning: Tailcuts vs. FACT

Finding islands

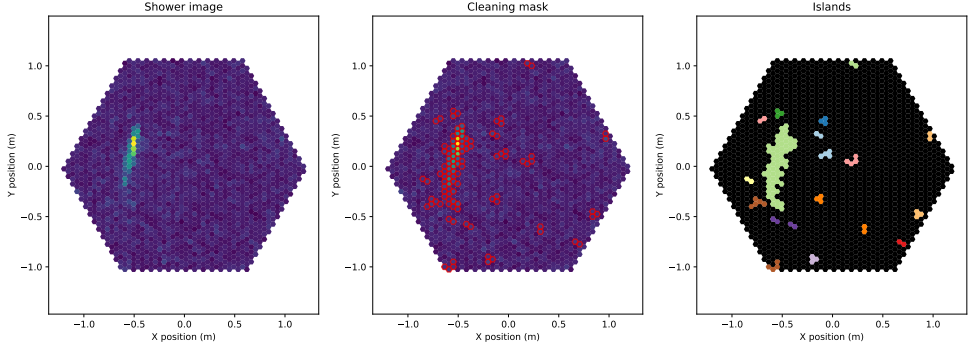
- Cleaning removed all but one cluster of pixels

→ Number of islands: 1



- Cleaning kept too many pixels

→ Number of islands: > 1



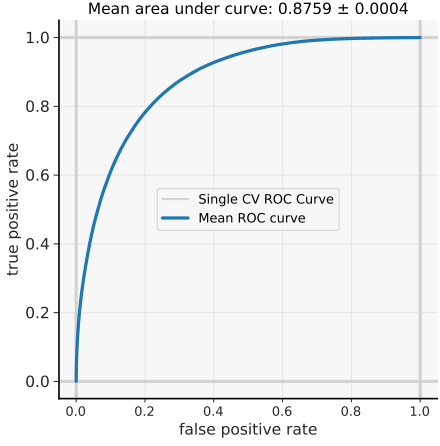
Machine learning impacts

Setup and expectations

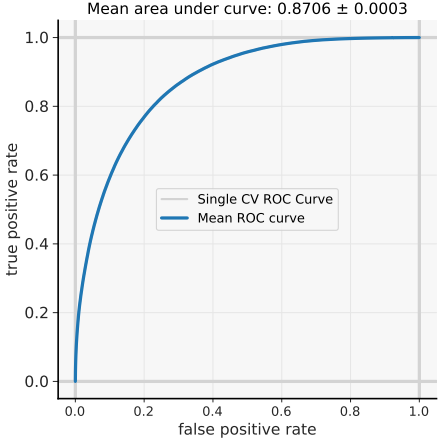
- A few 100 000 diffuse gamma and proton events
- Preprocessed with ctapipe, machine learning with aict-tools (*3*)
- Cleaning might affect separator performance
- Tailcuts cleaning should perform pretty well with the chosen parameters
- Number of islands might contribute to separator performance
- Number of islands will probably not constribute to gamma energy regression

Gamma/Hadron Separation - AUC

Tailcuts cleaning:

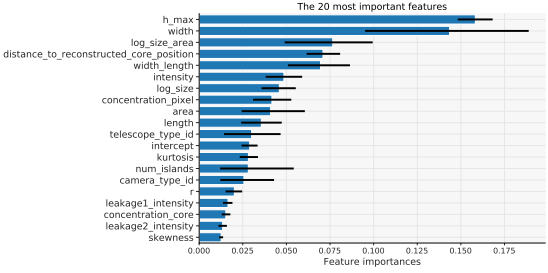


FACT cleaning:

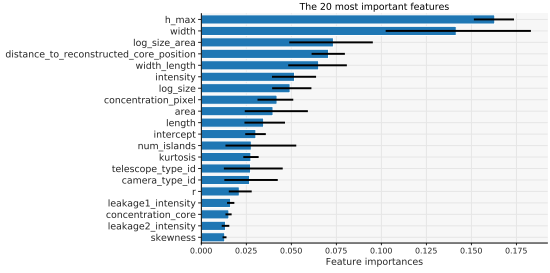


Gamma/Hadron Separation - Features

Tailcuts cleaning:

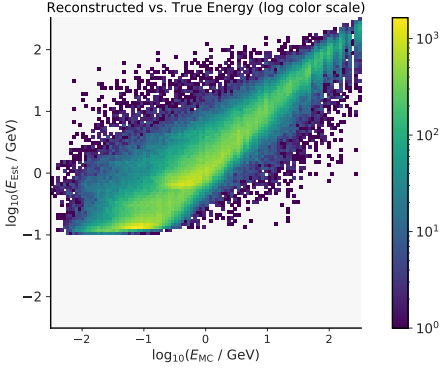


FACT cleaning:

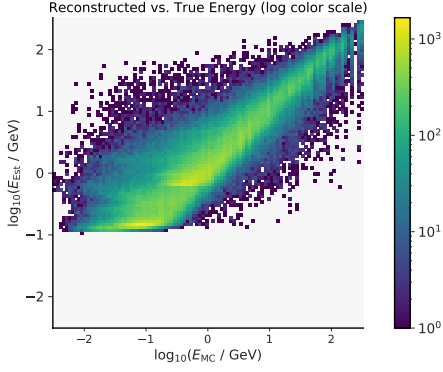


Energy Regression

Tailcuts cleaning:

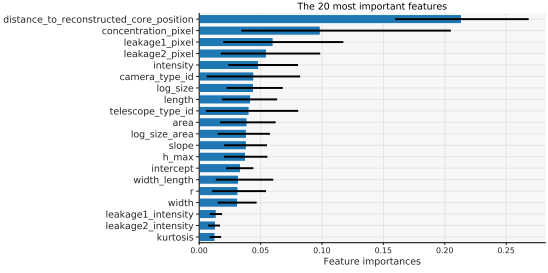


FACT cleaning:

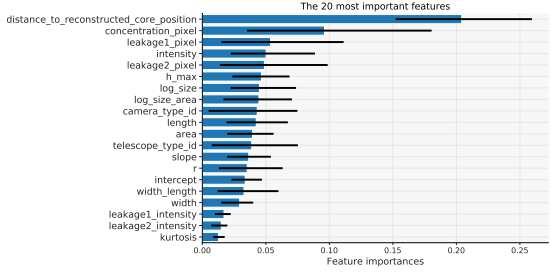


Energy Regression - Features

Tailcuts cleaning:



FACT cleaning:



Thank you for your attention!

C.-A. B. (Diaz)/ESO, (https://www.eso.org/public/germany/images/eso1841a/).

T. C. Consortium, *CTA's expected baseline performance*, (https://www.cta-observatory.org/science/cta-performance).

H. Anderhub *u. a.*, *Journal of Instrumentation* **8**, P06008–P06008, (https://doi.org/10.1088%2F1748-0221%2F8%2F06%2Fp06008) (Juni 2013).