

Active-Contour for Cherenkov shower detection

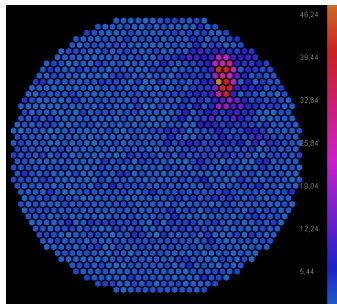
Dominik Baack

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dortmund





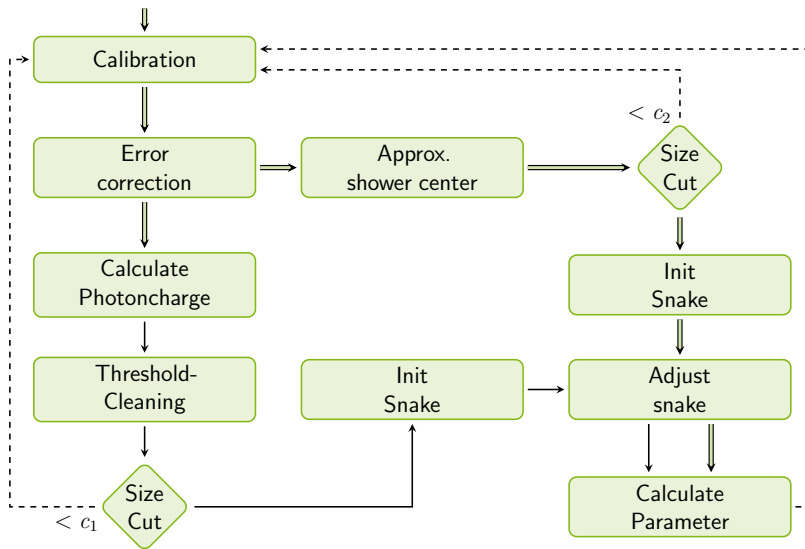
(a) FACT-Telescope [J. Buss]



(b) Shower image

FACT-Telescope

- Observation site: La Palma
- 300 Images, each 0.5 ns exposure time



→ Single image ⇒ Image sequence - -> Control flow

Active-Contour

Idea

Describe shower outline independent of resolution as continuous curve

Active-Contour model

- Assign to each possible contour an 'energy' with the help of a line integral
- Choose potential so that the energy becomes minimal when the contour is optimal
- Initialize the contour and vary it until the energy becomes minimal

Active-Contour

Optimization

- Derivate the potential in each point and move it in the direction of the minimum
- Iterative: Repeat until the contour doesn't change

Warning:

Contour can reach local minima and get stuck there

Discretization

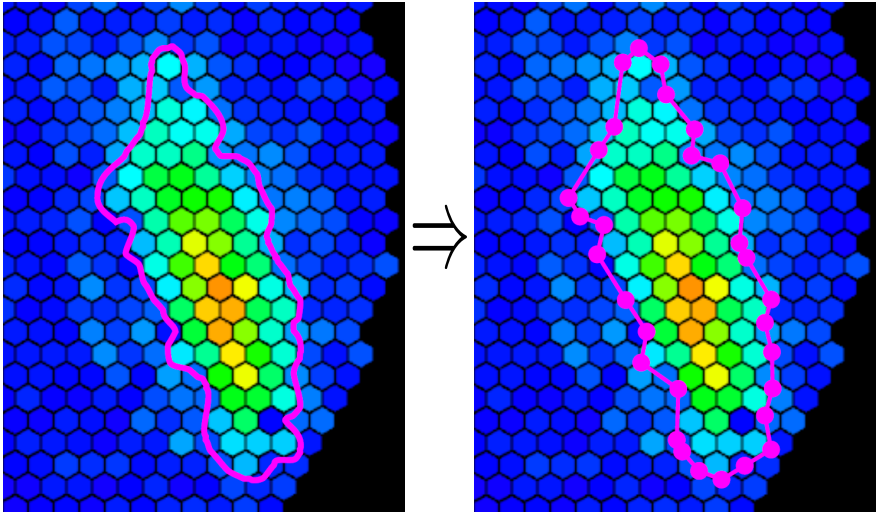
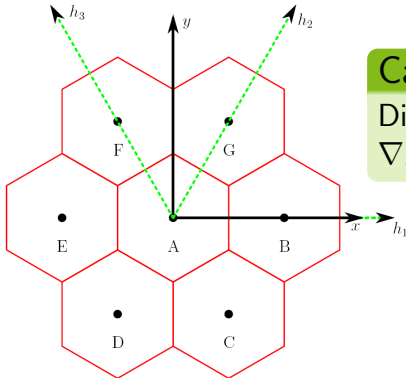


Image based force

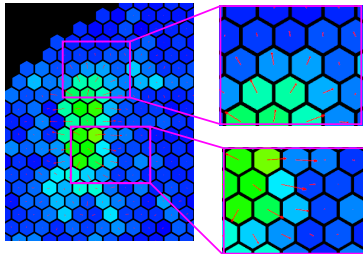


Calculation

Discrete gradient

$$\nabla A_x = (2B + G + C) - (2E + F + D)$$

Image based force

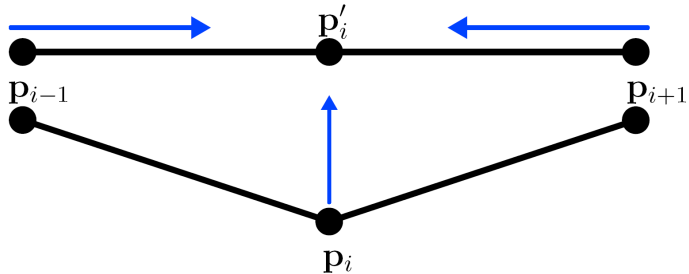


Calculation

Discrete gradient

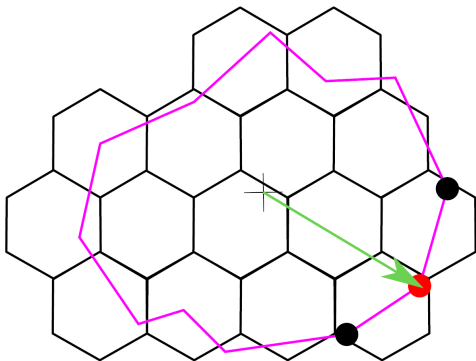
$$\nabla A_x = (2B + G + C) - (2E + F + D)$$

Internal force

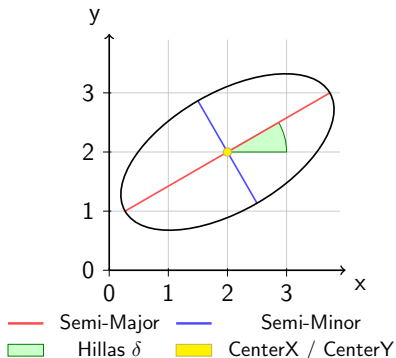


External force

$$\vec{F} = (I(\vec{p}) - \bar{I}) \cdot (\vec{c} - \vec{p}) \quad (1)$$

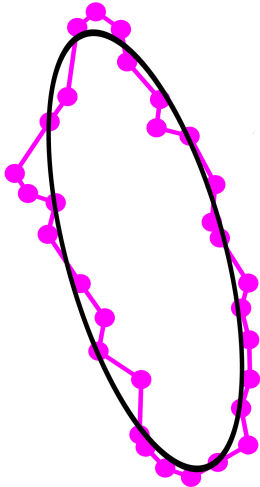


Hillas Parameter



- Shower in image nearly elliptical
- Good separation between hadron / photon

Additional parameter of the contour



Hillas like parameter

- Least-Square-Fit on Contour
- Account only outer shape
- Additional parameter which reflect the 'roughness'

Time parameter

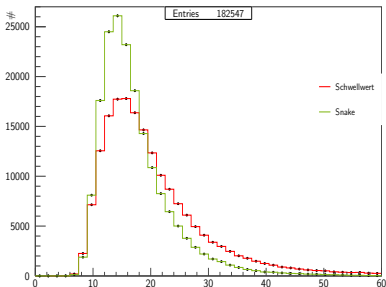
Parameter

- Calculate on single images of the video
- Conclusion to chronological development

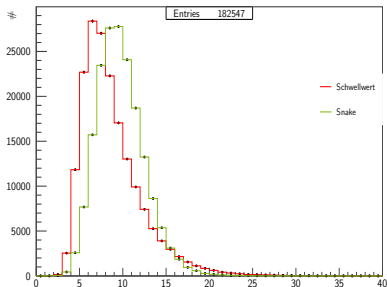
Calculation

The calculation of the time parameter can be done with the derivative or median over a fixed intervals

Hillas Parameter

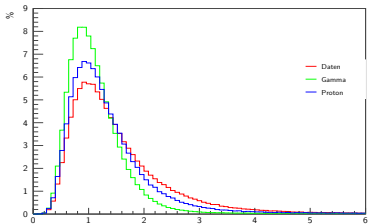


Length

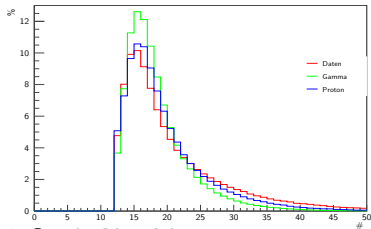


Width

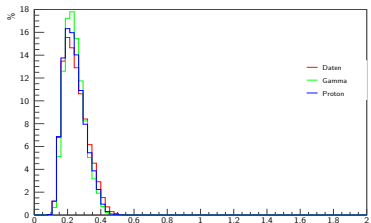
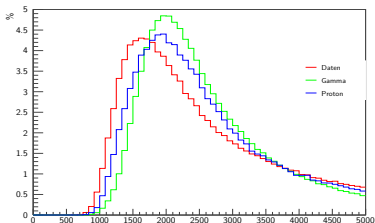
Additional parameter:



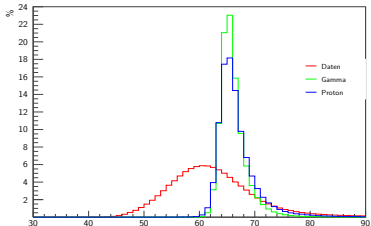
↑ SnakeErrorArea ↓



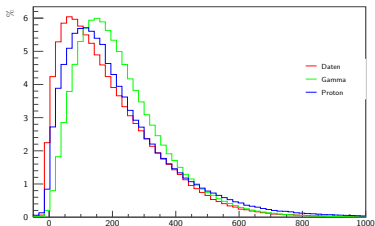
↑ SnakeNmrVerticesIn. Energy ↓



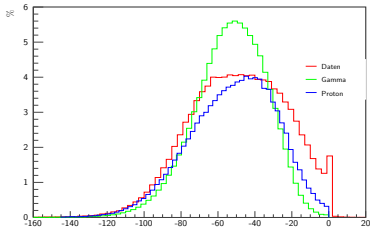
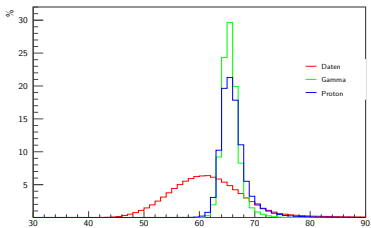
Time parameter



↑ Area | Size ↓



↑ Slope1 | Area | Slope2 ↓



Summary

Active-Contour

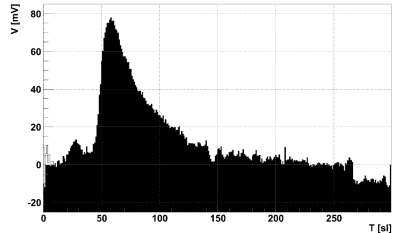
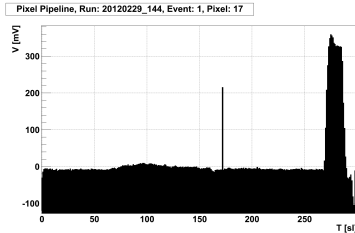
- Works as good as the threshold model

Optimization:

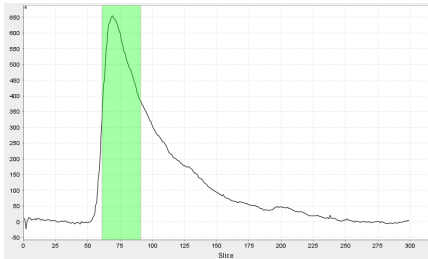
- Variation and different weighting of used forces
- Complete new forces for other image segments like a muon ring

Calibration and artefact removal

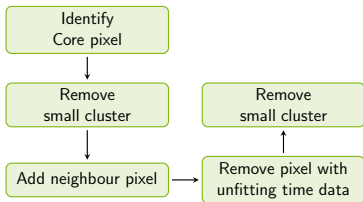
- Calibration and removal of known hardware oscillation
- Correction failed pixels
- Correction spontaneous spikes
- Correction jumps



Remove outlier and jumps [F. Temme]

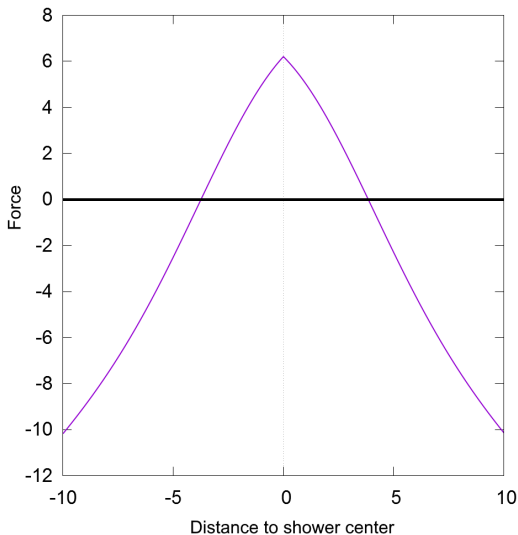


Calculate photoncharge
[FACT-Tools]



Threshold cleaning

Resulting force



- [1] F. Temme. Fact - data analysis: Analysis of crab nebula data using parfact a newly developed analysis software for the first g-apd cherenkov telescope. Diplomarbeit, Technische Universität Dortmund, Lehrstuhl E5, 2013.
- [2] J. B. Buß. Fact - signal calibration gain calibration and development of a single photon pulse template for the fact camera. Diplomarbeit, Technische Universität Dortmund, Lehrstuhl E5, 2013.