Monoscopic analysis of LST1 data with ctapipe/cta-lstchain

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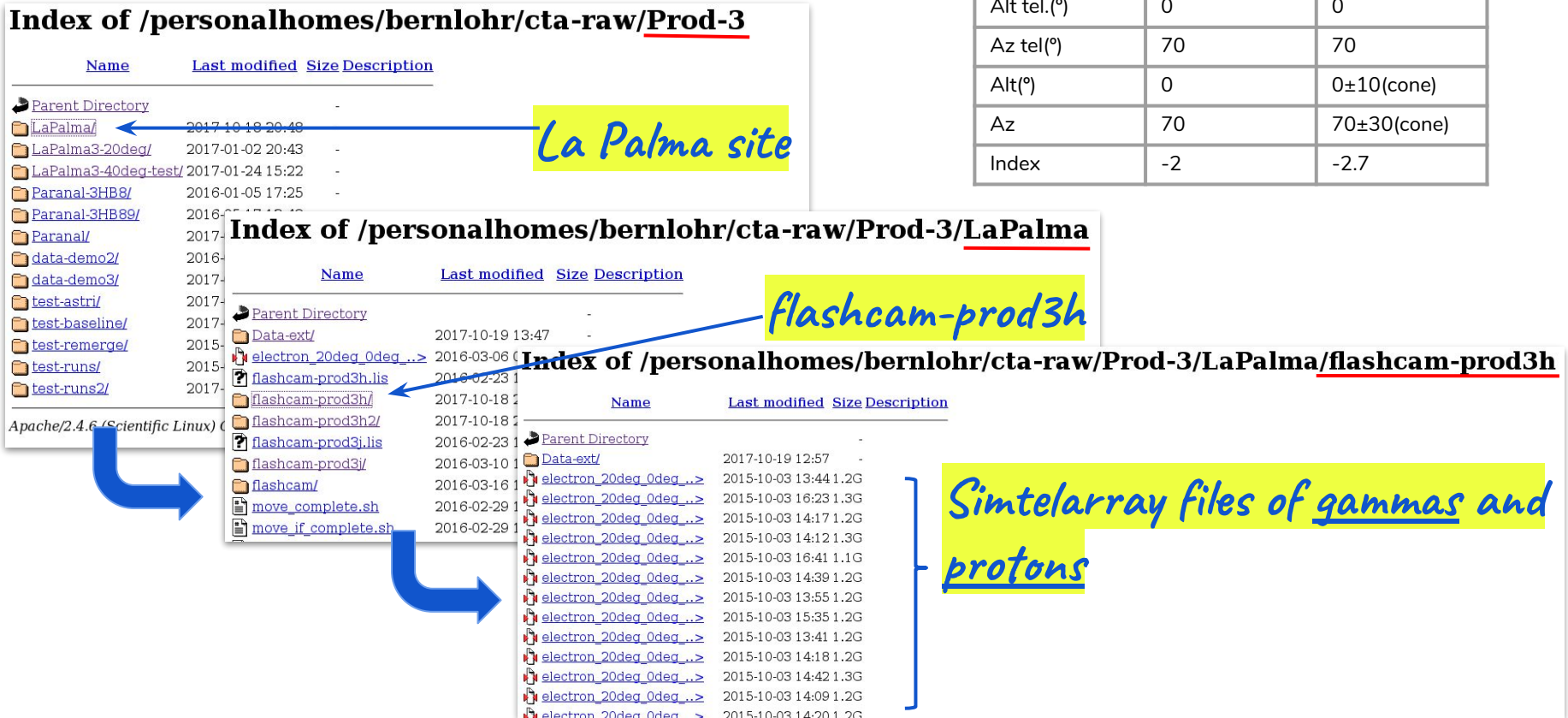
Overview

- **Datasets:**
  - Simtelarray files from K. Bernlohr webpage:
    - Pointlike gammas.
    - Protons
- **Analysis chain:**
  - Data reduction with ctapipe.
  - Reconstruction with Scikit learn Random Forests.
- **Results:**
  - Gamma/Hadron separation
  - Energy and direction reconstruction.
- **Future work:**
  - Diffuse gammas
  - Sensitivity curves
- **Conclusions**

Datasets:

The CTA MC repository at the MPIK Heidelberg
https://www.mpi-hd.mpg.de/personalhomes/bernlohr/cta-raw/

	Gammas	Protons
Alt tel.(°)	0	0
Az tel(°)	70	70
Alt(°)	0	0±10(cone)
Az	70	70±30(cone)
Index	-2	-2.7



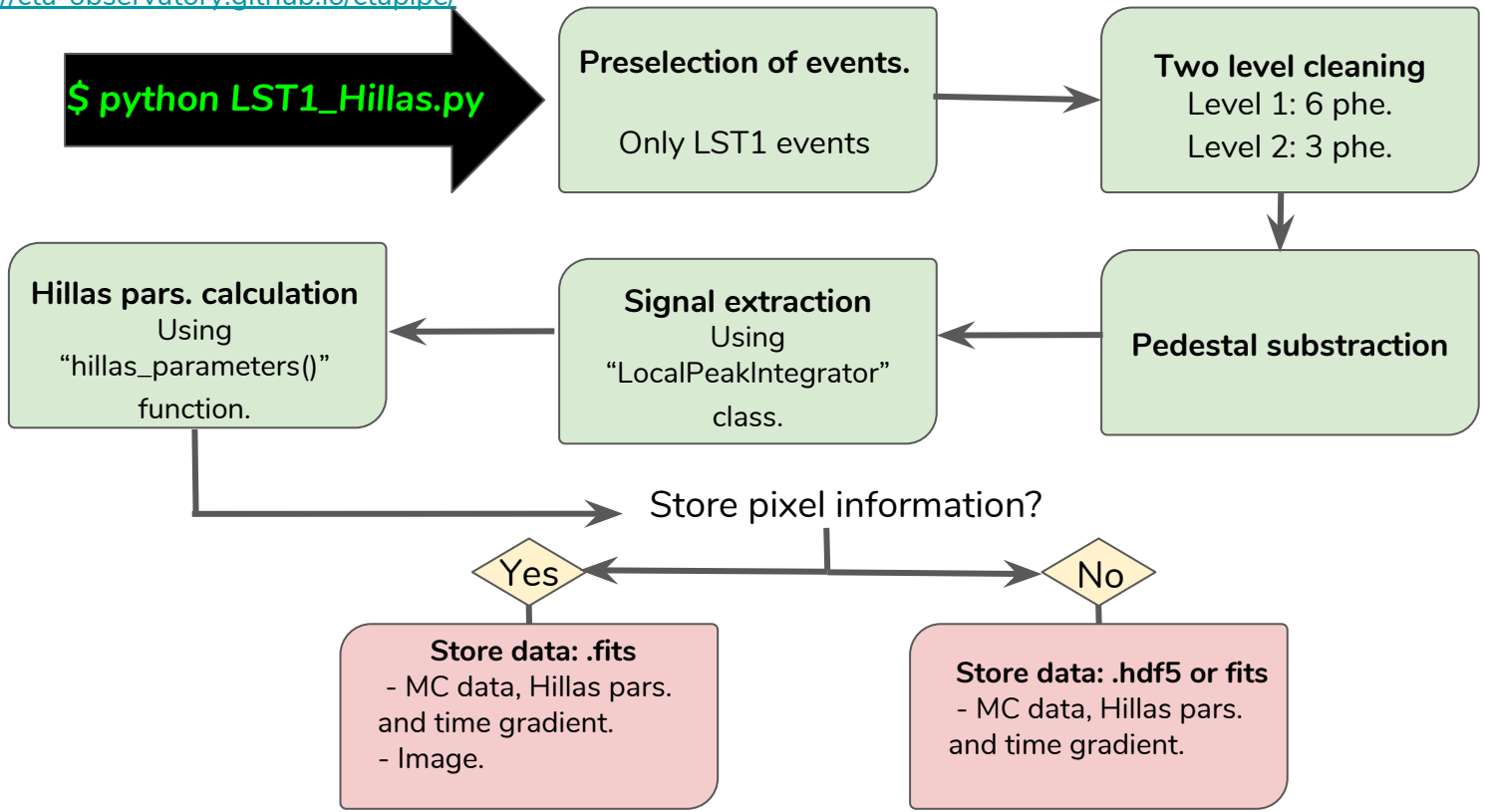
Analysis chain: cta-lstchain

GitHub repository: https://github.com/cta-observatory/cta-lstchain
For data storage: https://github.com/cta-observatory/cta-lstchain-extra

- **Data reduction:** *LST1_Hillas.py*,
  - Based on **ctapipe**: Cleaning at two levels, peak extraction, hillas parameters calculation.
  - Storage in HD5F files: MC data, Hillas parameters, time gradient.
  - Posibility of saving pixels information(images) in “fits” format for testing showers plotted in the camera (PlotDisp.py)
- **Energy reconstruction:** RFEnergy.py
  - Random Forest Regressor from *Scikit-learn*.
- **Source position reconstruction (Disp method):** RFDisp.py
  - Random Forest Regressor from *Scikit-learn*.
- **Gamma/Hadron separation:** RFGHseparation.py
  - First RF Regressor for Energy and Direction reconstruction.
  - The result is used in a Random Forest Classifier from Scikit-learn for G/H separation.
- **Auxiliar tools:** Disp.py
  - Convert source direction coordinates from AltAz to camera coordinates.
  - Calculate “Disp” distance from source position.
  - Calculate source position from “Disp” distance.

Data reduction: ctapipe

CTA Experimental Pipeline Framework
https://cta-observatory.github.io/ctapipe/



Scikit-learn

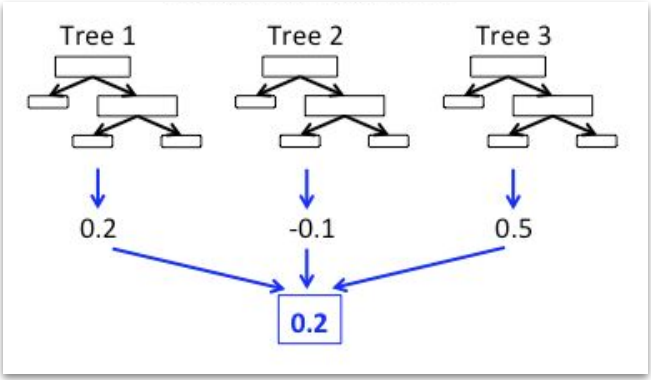
Machine Learning in Python
Built on NumPy, SciPy and matplotlib

Cuts in Data:

- Intensity > 60 phe.
- r < 0.8 Camera radius.

For Energy and Direction reconstruction:

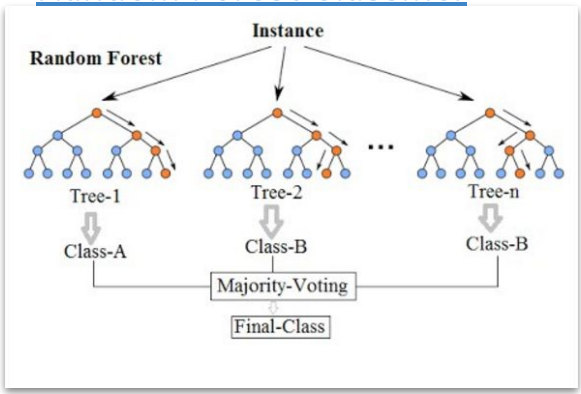
Random Forest Regressor



Features for training:
Width, Length, Intensity, Width/Length, Psi, Phi, Time gradient.

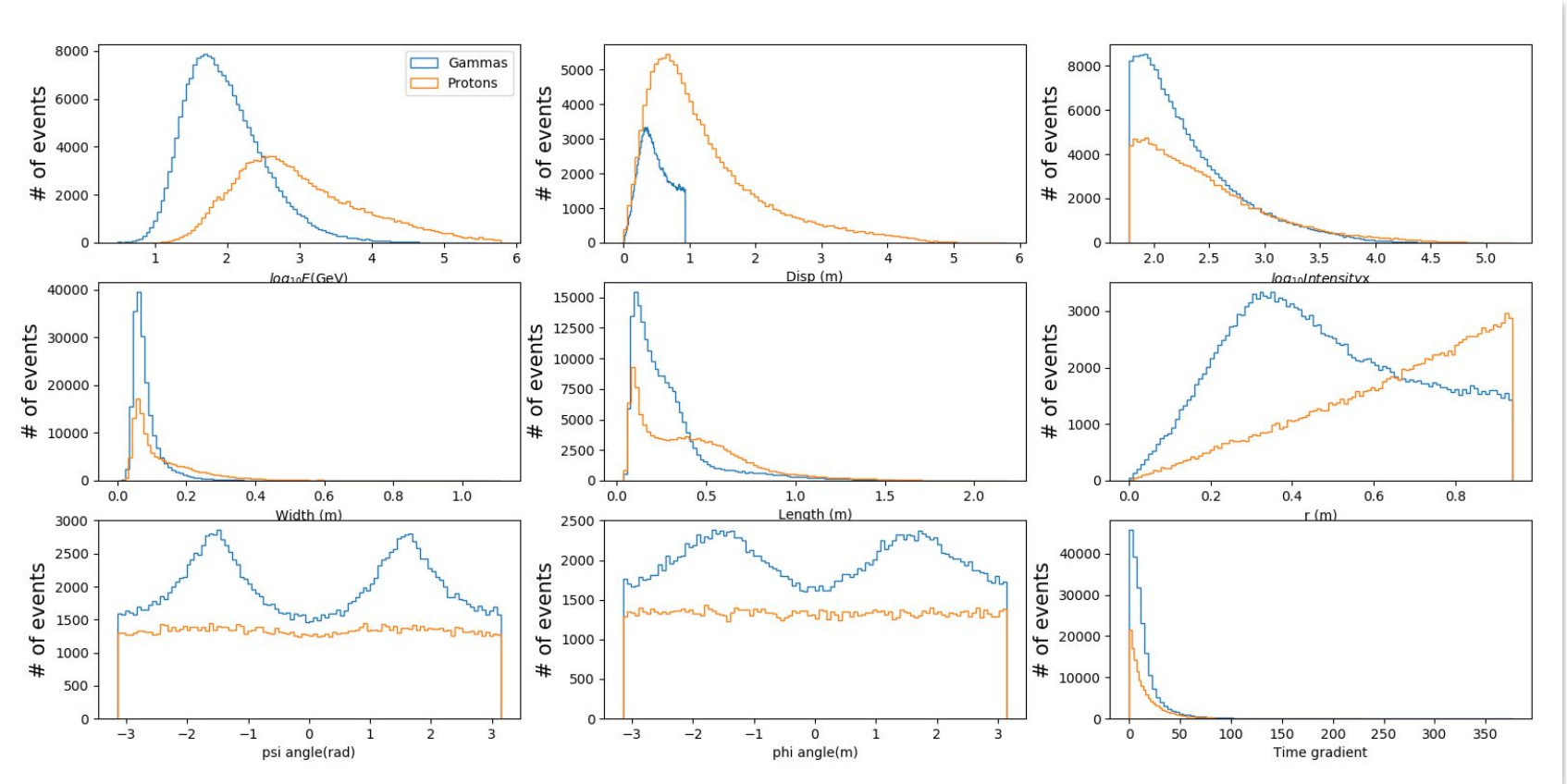
For Gamma/Hadron separation:

Random Forest Classifier

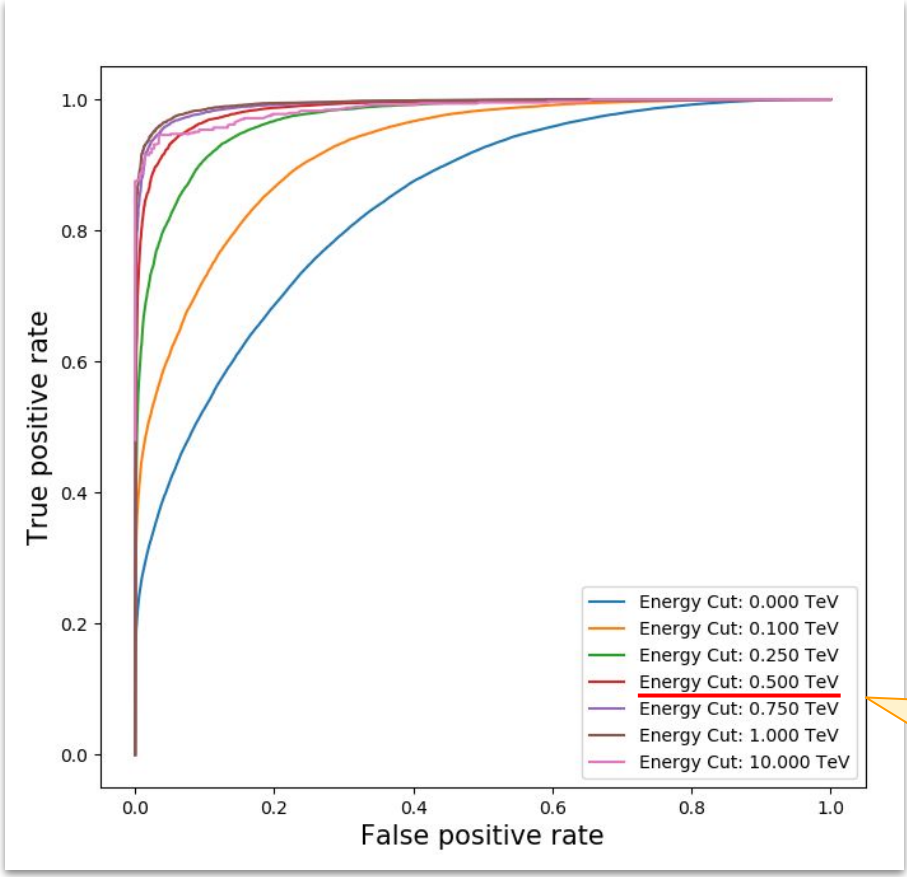


Features for training:
Width, Length, Intensity, Width/Length, Psi, Phi, Time gradient + $\mathbf{E_{rec}}$, $\mathbf{Disp_{rec}}$

Features

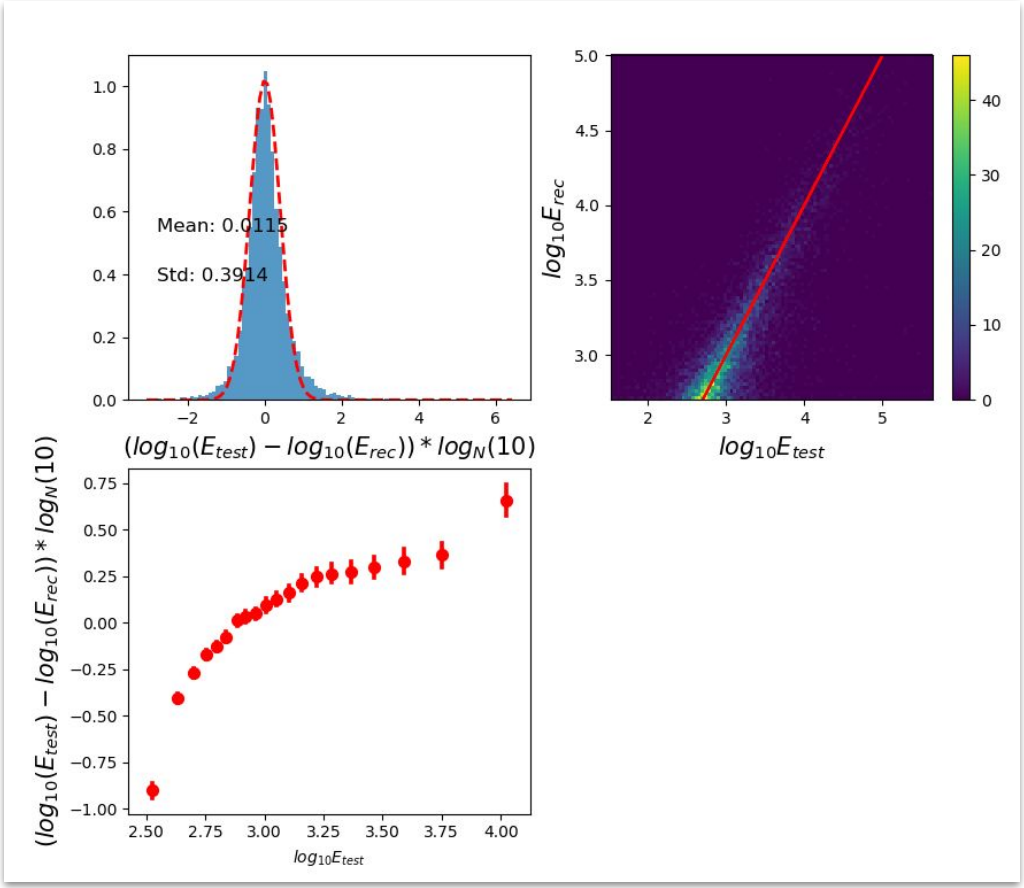

Gammas
Protons
# of events
log10E(GeV)
Disp (m)
log10Intensityx
Width (m)
Length (m)
r (m)
psi angle(rad)
phi angle(m)
Time gradient

Results: Gamma/Hadron separation

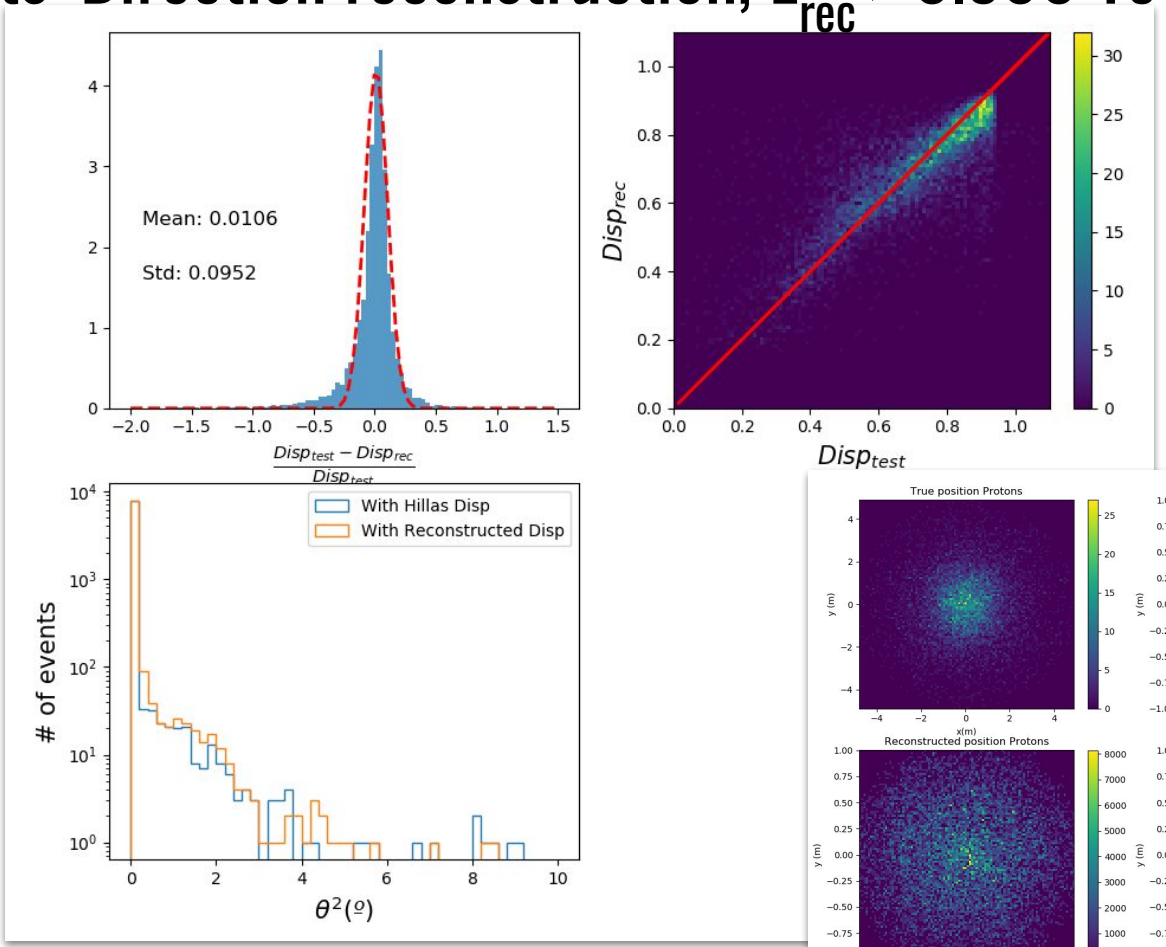


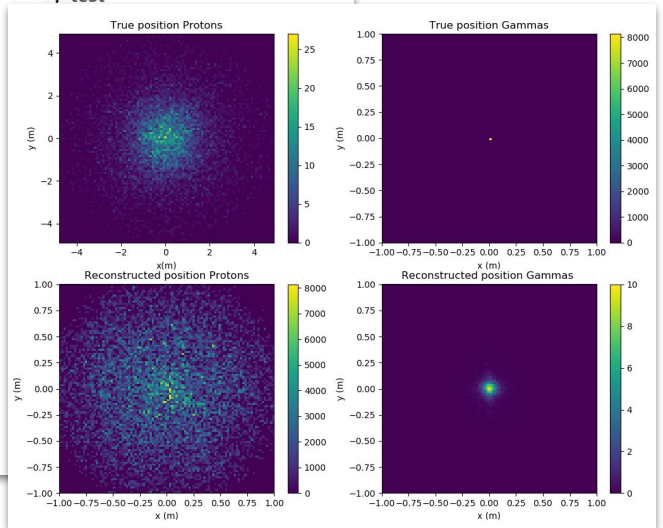
Cutting low energies for better because of limitations of monoscopic analysis.

Results: Energy reconstruction, E_{rec} > 0.500 TeV



Results: Direction reconstruction, E_{rec} > 0.500 TeV





Cut in Reconstructed energy > 0.500 TeV

Future work

- Use **CTA Grid** to run scripts in a (much) higher number of events.
- Perform the same analysis for **diffuse gammas**.
- Plot **sensitivity curves**
- Try **other reconstruction methods**?
- Merge cta-lstchain in **ctapipe**.

Conclusions

- We have started the development of a chain for the analysis of monoscopic data for LST1.
- The results for point sources are promising, for enegies over 500 GeV, with only a few thousands of events:
  - We need to retrieve more events for training!
- Still a work in progress: We are starting to use grid resources, to access easily to more data and be able to build sensitivity curves, add spectral weights to the data, try diffuse sources...
- See you in the LST1 analysis bootcamp in Padova!

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Thank You!