

Monoscopic analysis of LST1 data with ctapipe/cta-lstchain

Mabel Bernardos Martín

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/bernlrohr/cta-raw/>

Index of /personalhomes/bernlrohr/cta-raw/Prod-3

Name	Last modified	Size	Description
Parent Directory		-	
LaPalma/	2017-10-18 20:48	-	
LaPalma3-20deg/	2017-01-02 20:43	-	
LaPalma3-40deg-test/	2017-01-24 15:22	-	
Paranal-3HB8/	2016-01-05 17:25	-	
Paranal-3HB89/	2016-02-15 12:40	-	
Paranal/	2017-01-02 20:43	-	
data-demo2/	2016-02-15 12:40	-	
data-demo3/	2017-01-02 20:43	-	
test-astri/	2017-01-02 20:43	-	
test-baseline/	2017-01-02 20:43	-	
test-remerge/	2015-10-03 13:44	-	
test-runs/	2015-10-03 13:44	-	
test-runs2/	2017-01-02 20:43	-	

La Palma site

Index of /personalhomes/bernlrohr/cta-raw/Prod-3/LaPalma

Name	Last modified	Size	Description
Parent Directory		-	
Data-ext/	2017-10-19 13:47	-	
electron_20deg_0deg_...	2016-03-06 16:41	1.2G	
flashcam-prod3h.lis	2016-02-29 16:41	-	
flashcam-prod3h/	2017-10-18 20:48	-	
flashcam-prod3h2/	2017-10-18 20:48	-	
flashcam-prod3j.lis	2016-02-29 16:41	-	
flashcam-prod3j/	2016-03-10 14:21	-	
flashcam/	2016-03-16 16:41	-	
move_complete.sh	2016-02-29 16:41	-	
move_if_complete.sh	2016-02-29 16:41	-	

flashcam-prod3h

Index of /personalhomes/bernlrohr/cta-raw/Prod-3/LaPalma/flashcam-prod3h

Name	Last modified	Size	Description
Parent Directory		-	
Data-ext/	2017-10-19 12:57	-	
electron_20deg_0deg_...	2015-10-03 13:44	1.2G	
electron_20deg_0deg_...	2015-10-03 16:23	1.3G	
electron_20deg_0deg_...	2015-10-03 14:17	1.2G	
electron_20deg_0deg_...	2015-10-03 14:12	1.3G	
electron_20deg_0deg_...	2015-10-03 16:41	1.1G	
electron_20deg_0deg_...	2015-10-03 14:39	1.2G	
electron_20deg_0deg_...	2015-10-03 13:55	1.2G	
electron_20deg_0deg_...	2015-10-03 15:35	1.2G	
electron_20deg_0deg_...	2015-10-03 13:41	1.2G	
electron_20deg_0deg_...	2015-10-03 14:18	1.2G	
electron_20deg_0deg_...	2015-10-03 14:42	1.3G	
electron_20deg_0deg_...	2015-10-03 14:09	1.2G	
electron_20deg_0deg_...	2015-10-03 14:20	1.2G	

Simtelarray files of gammas and protons

	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>

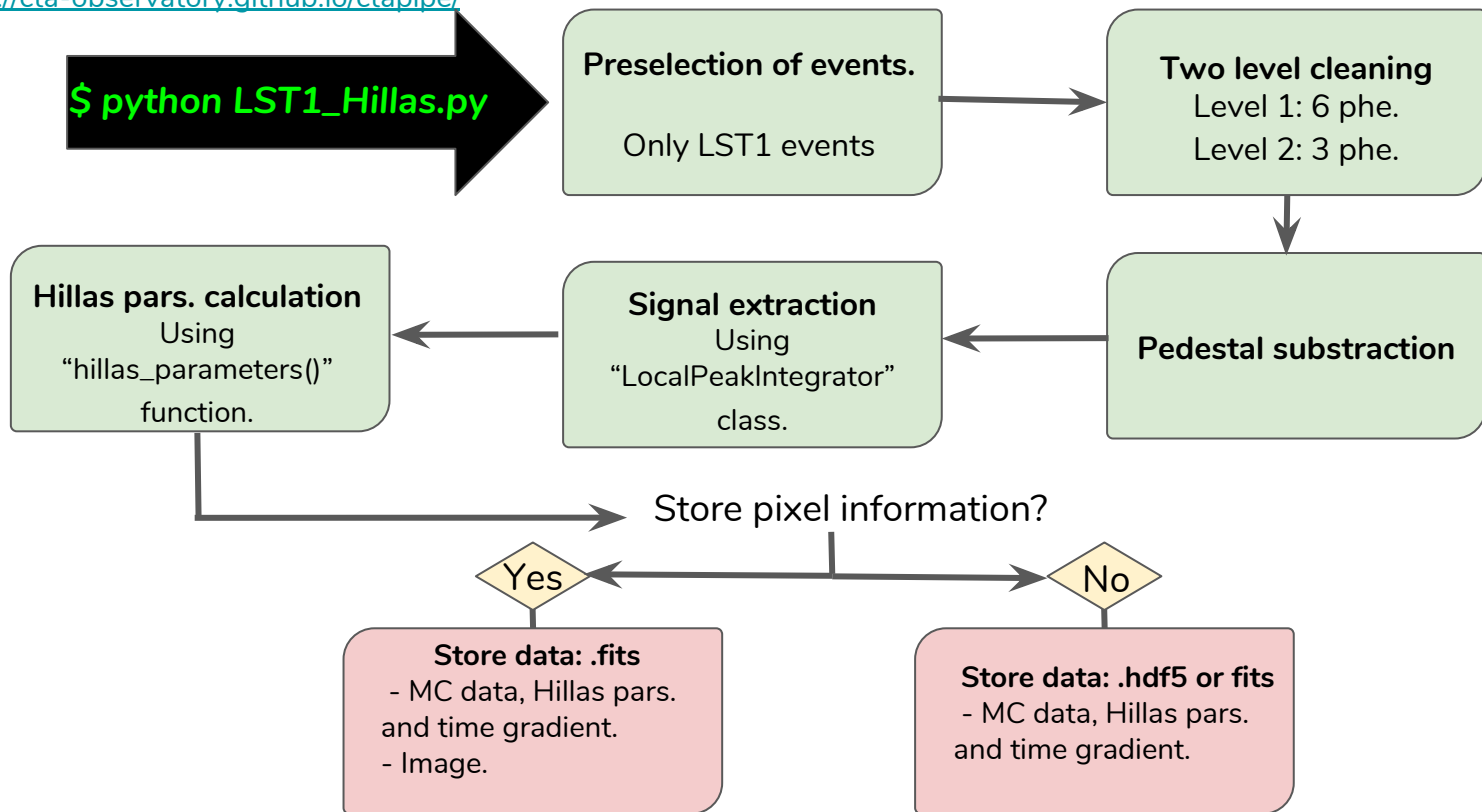
For data storage: <https://github.com/cta-observatory/cta-lstchain-extra>

- **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.
 - Possibility 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



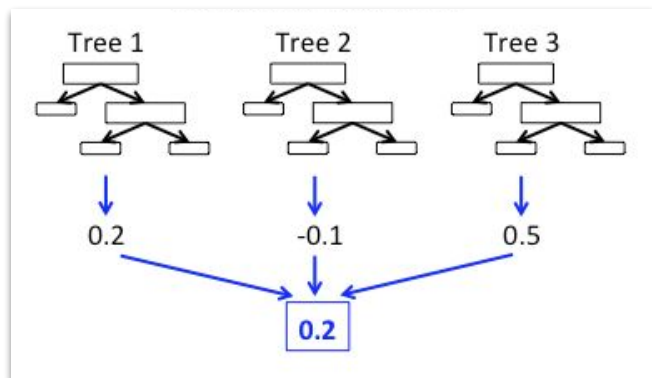
Cuts in Data:

Intensity > 60 phe.

$r < 0.8$ Camera radius.

For Energy and Direction reconstruction:

Random Forest Regressor

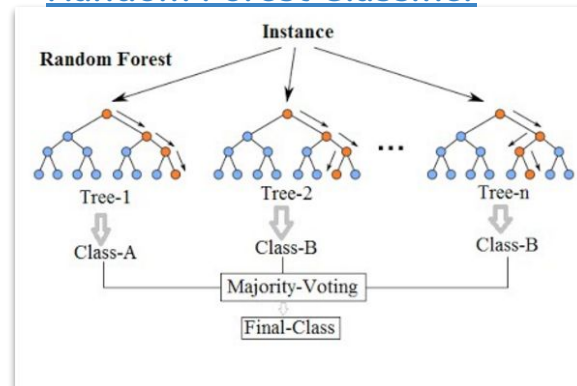


Features for training:

Width, Length, Intensity, Width/Length, Psi, Phi,
Time gradient.

For Gamma/Hadron separation:

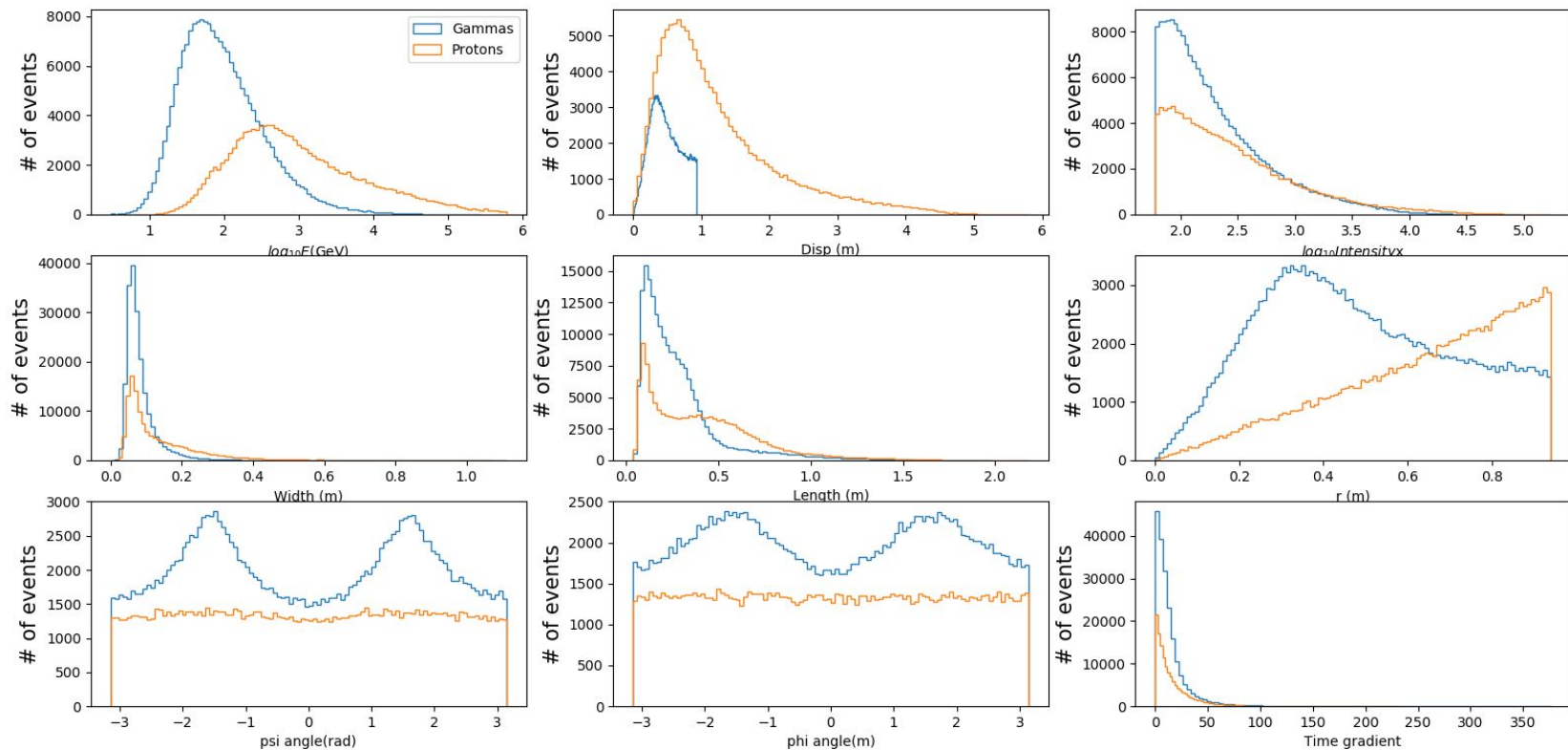
Random Forest Classifier



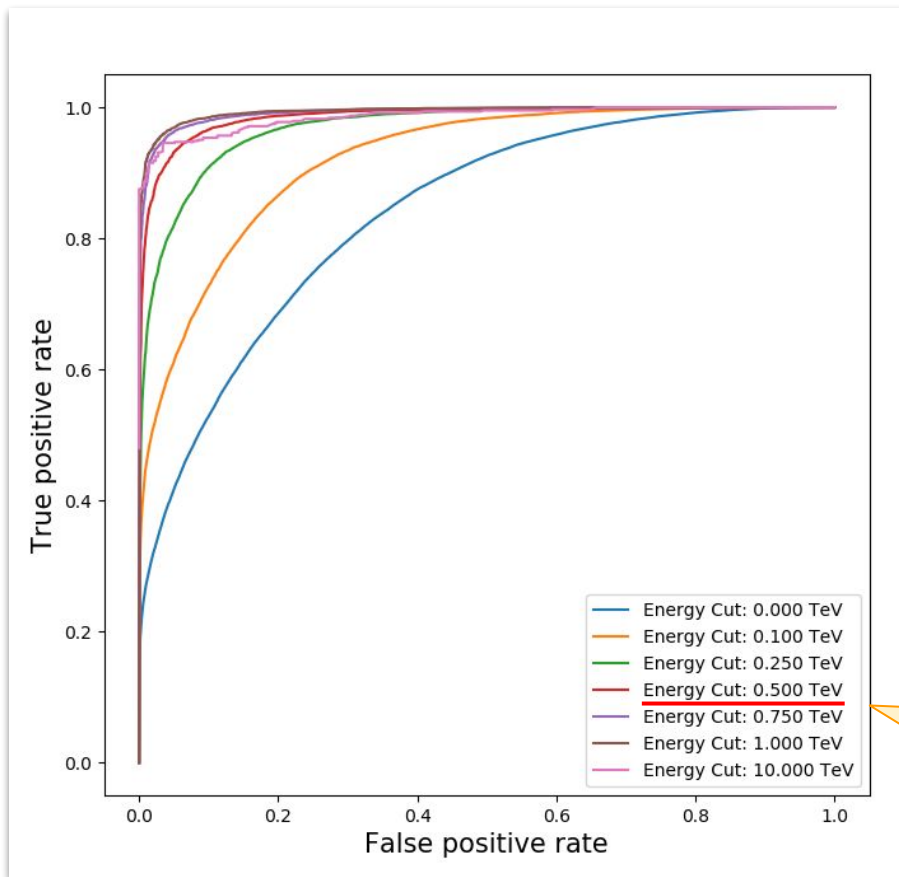
Features for training:

Width, Length, Intensity, Width/Length, Psi, Phi,
Time gradient + E_{rec} , $Disp_{rec}$

Features

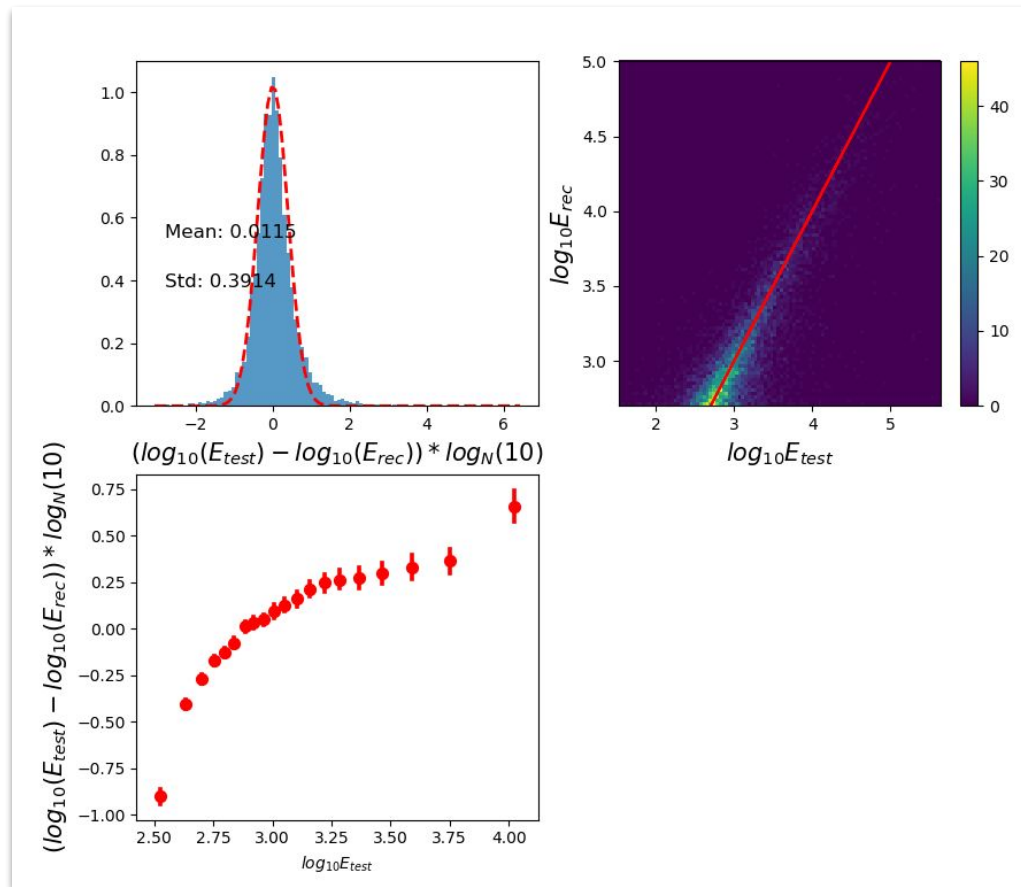


Results: Gamma/Hadron separation

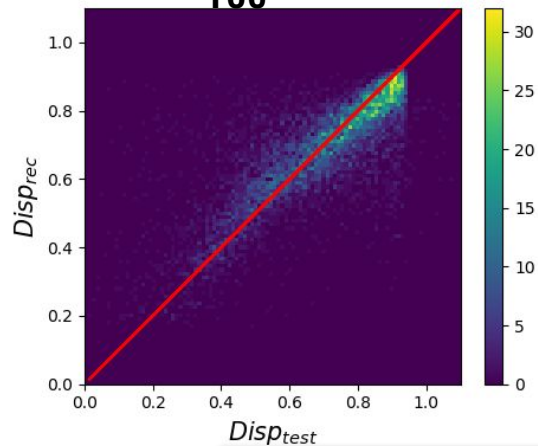
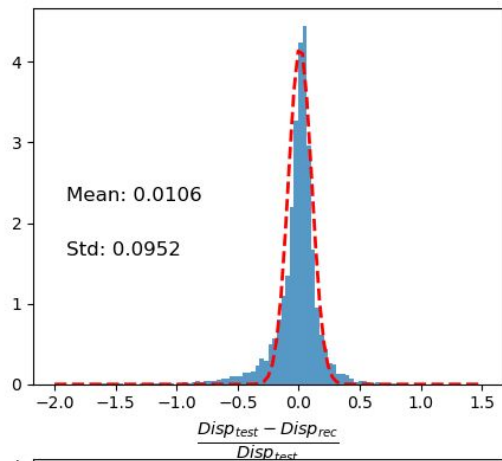


Cutting low energies for better because of limitations of monoscopic analysis.

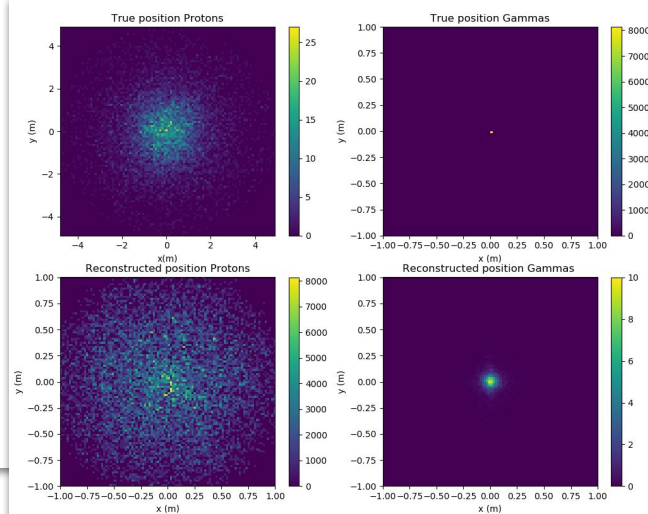
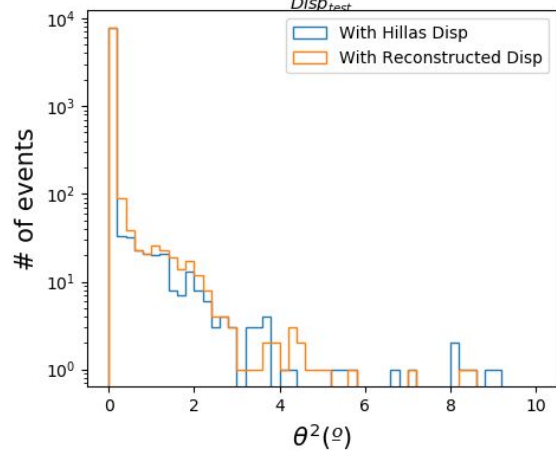
Results: Energy reconstruction, $E_{\text{rec}} > 0.500 \text{ TeV}$



Results: Direction reconstruction, $E_{\text{rec}} > 0.500$ 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 energies 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!

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 energies 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!

Thank You!