An event-type based analysis for LST-1

S. García Soto[1],
J. Bernete[1], T. Hassan[1], M. Strzys[2], I. Vovk[2], M. Linhoff[3]

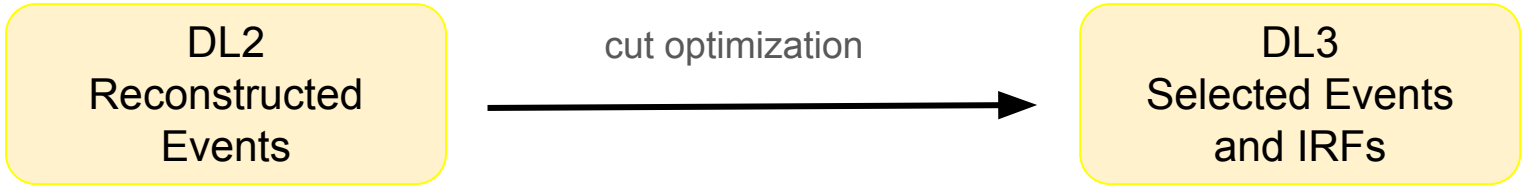
1: CIEMAT
2: ICRR, The University of Tokyo
3: CTAO, Science Data Management Centre

GOBIERNO DE ESPAÑA
MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES
Ciemat Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas
cfp CIEMAT física de partículas
TeV Particle Astrophysics TeVPA Valencia 2025

Contents

The event-type based analysis

Standard analysis

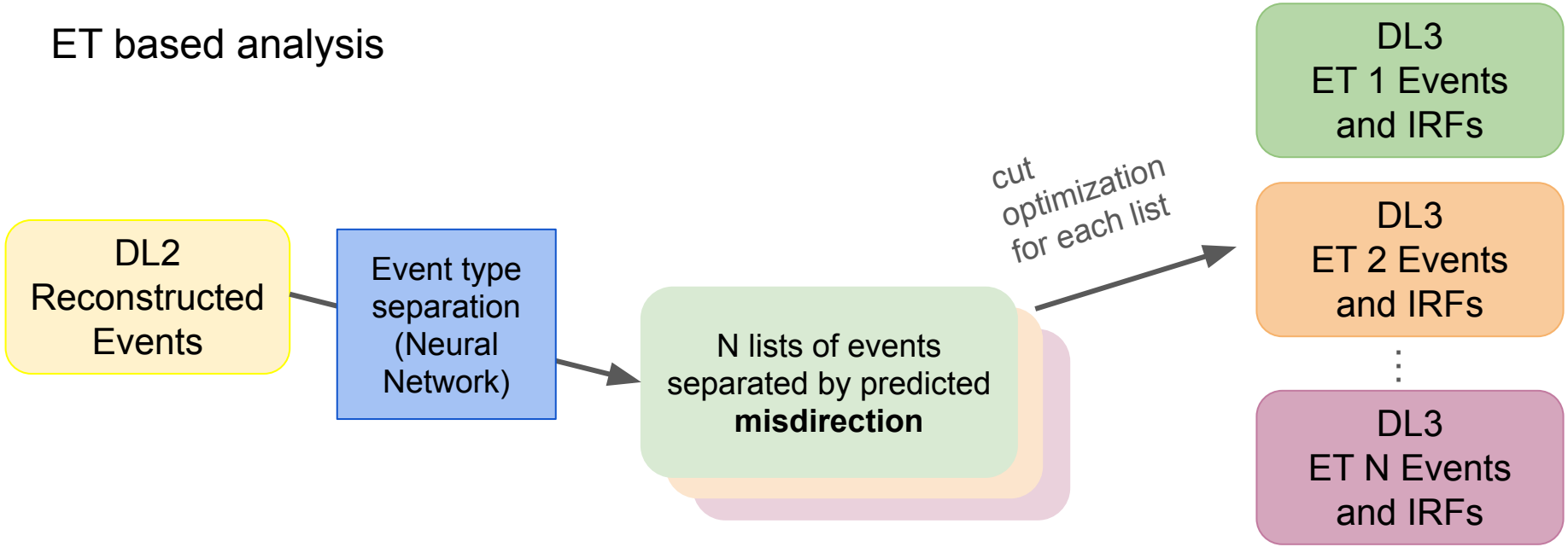


➔ All selected events are treated equally as if they had the same quality

Is there an alternative? ⇢ the event types approach is already successfully used by Fermi-LAT

The event-type based analysis

ET based analysis



Event-type analysis: separate events in subsamples according to their expected reconstruction quality and generate event-type-wise IRFs

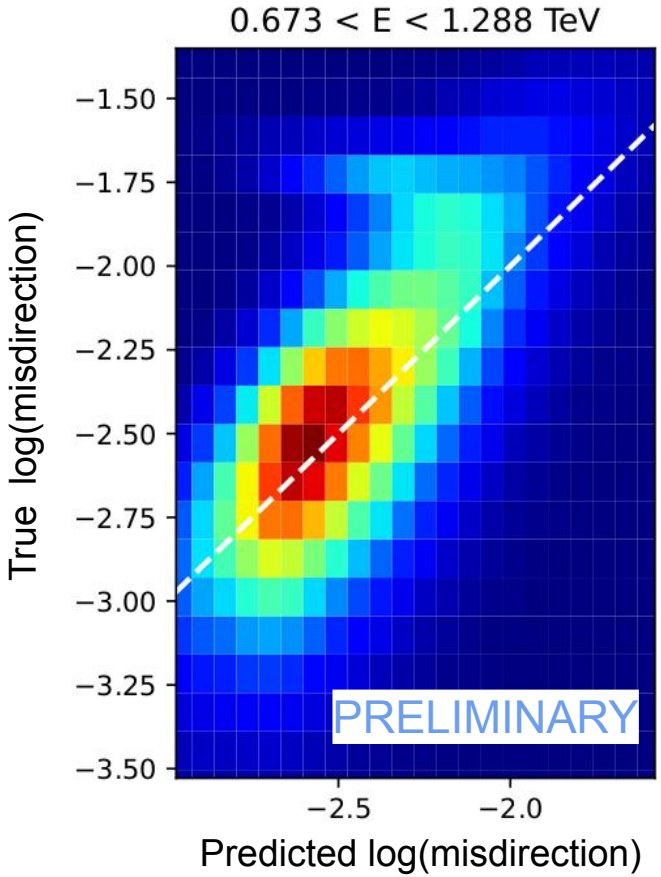
The event-type based analysis

- ET separation is done predicting the “misdirection” of events

  ⇢ angular difference between simulated and reconstructed events

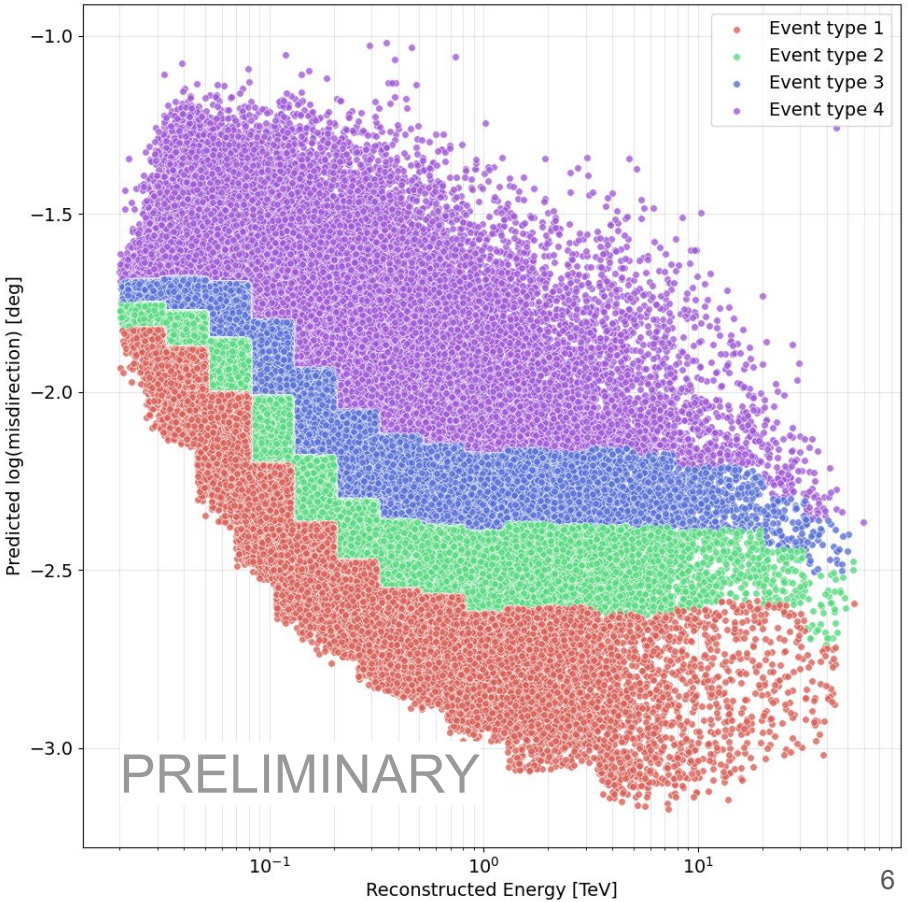
- Training/test statistics 25/75 %
- We use a regression algorithm

  ⇢ more flexibility and information about the quality is preserved



The event-type based analysis using real LST-1 data

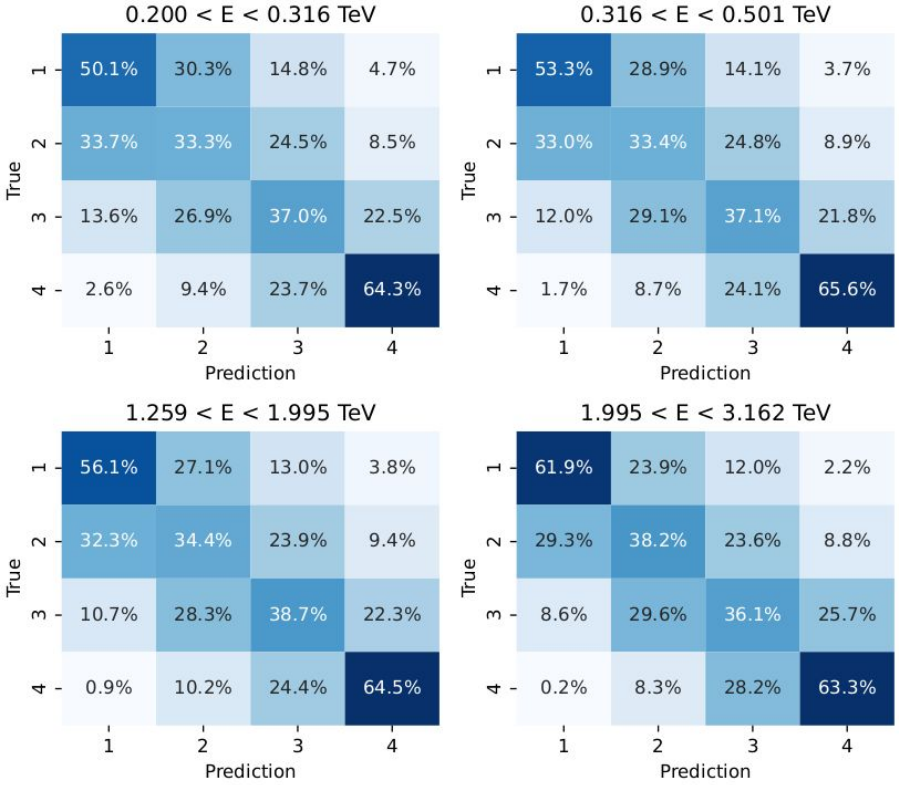
- Thresholds are defined in bins of reconstructed energy
- In this work, the events are partitioned into 15-15-30-40%*
- The Diffuse MC used are the corresponding ones for each run based on its nsb tuning, declination line and theta-azimuth node



*based on previous results by J. Bernete

The event-type based analysis using real LST-1 data

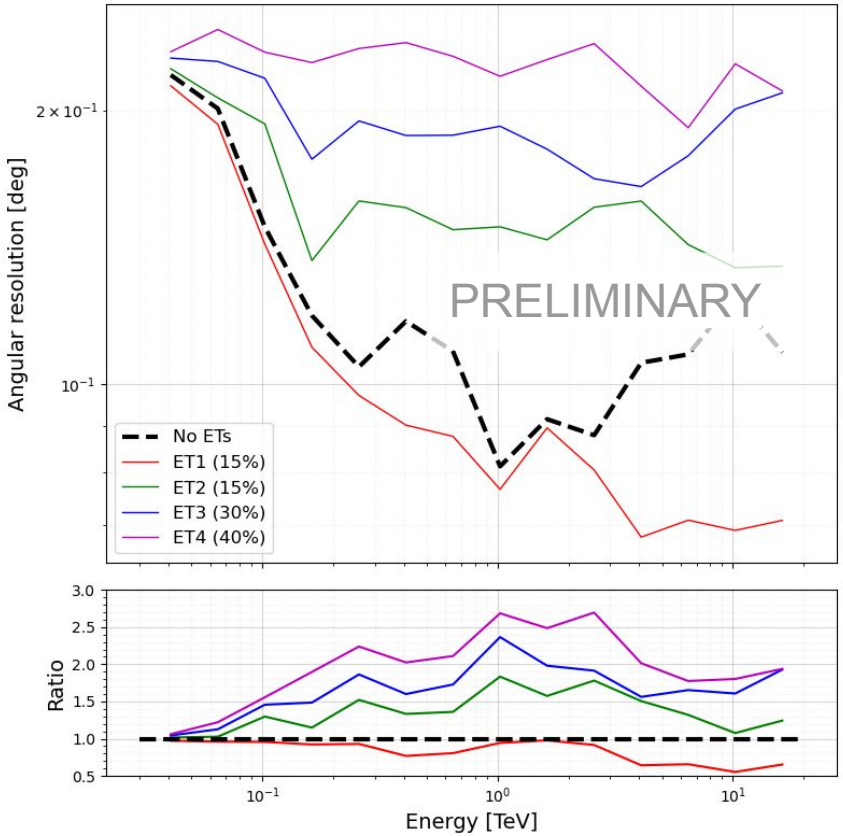
PRELIMINARY



Example of the performance for the theta_23.161_az_260.739 MC node

- Very few cases of confusion between the event type 1 (best 15% quality events) and event type 4 (worst 40%)

Instrument Response Functions

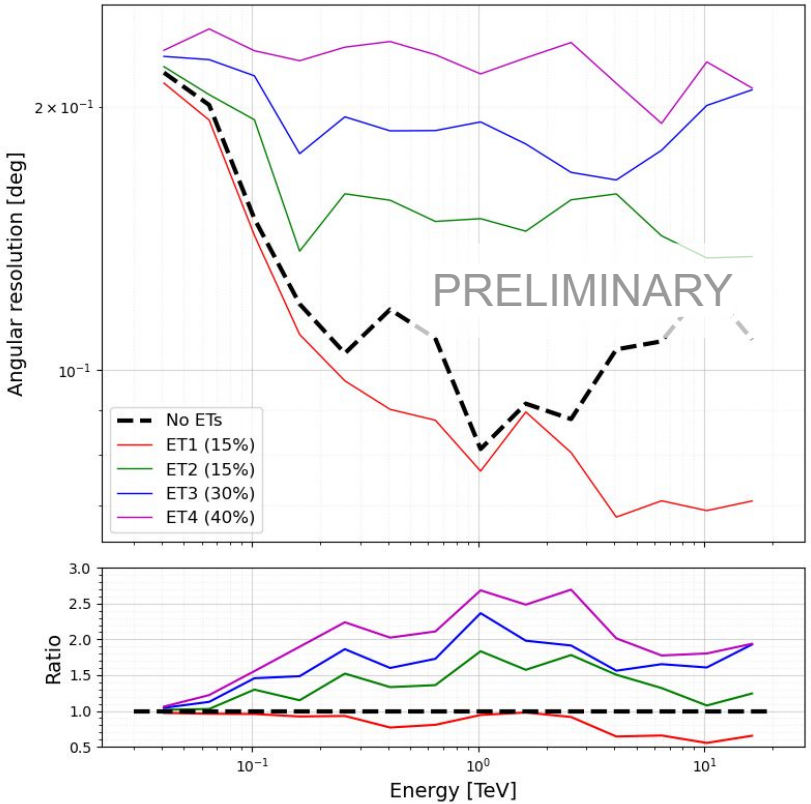


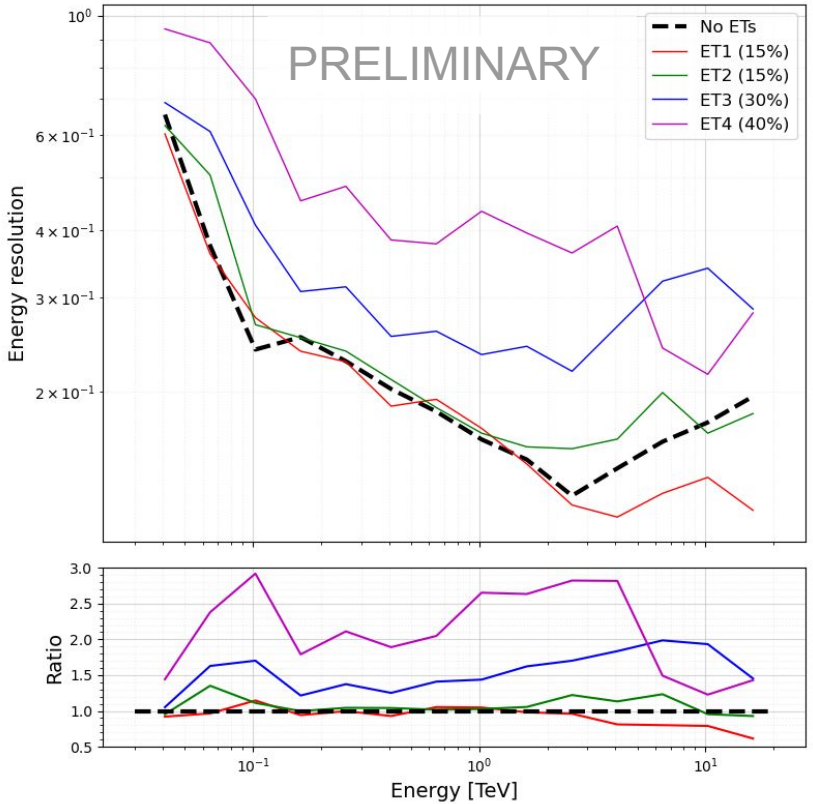
- Event-type-wise IRFs can be generated using optimized cuts
- Angular performance improves for the event types with better quality
- Events in the top 15% (ET 1) lead to a significant improvement with respect to the standard analysis

Example for the theta_23.161_az_260.739 node IRFs

Instrument Response Functions

➔ The 15% top events show better **angular <u>and energy</u>** resolution

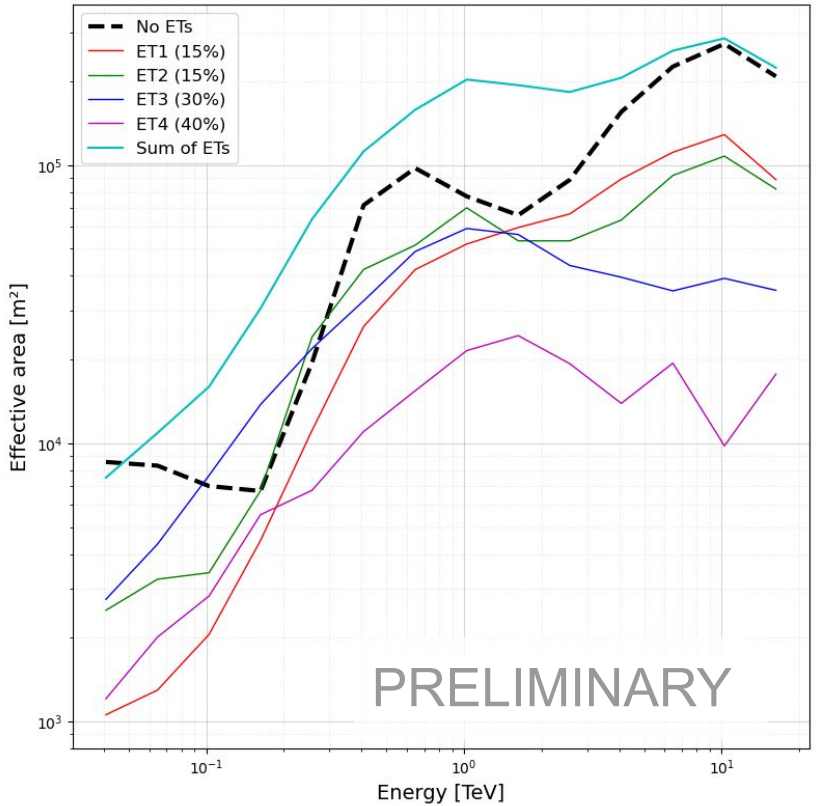


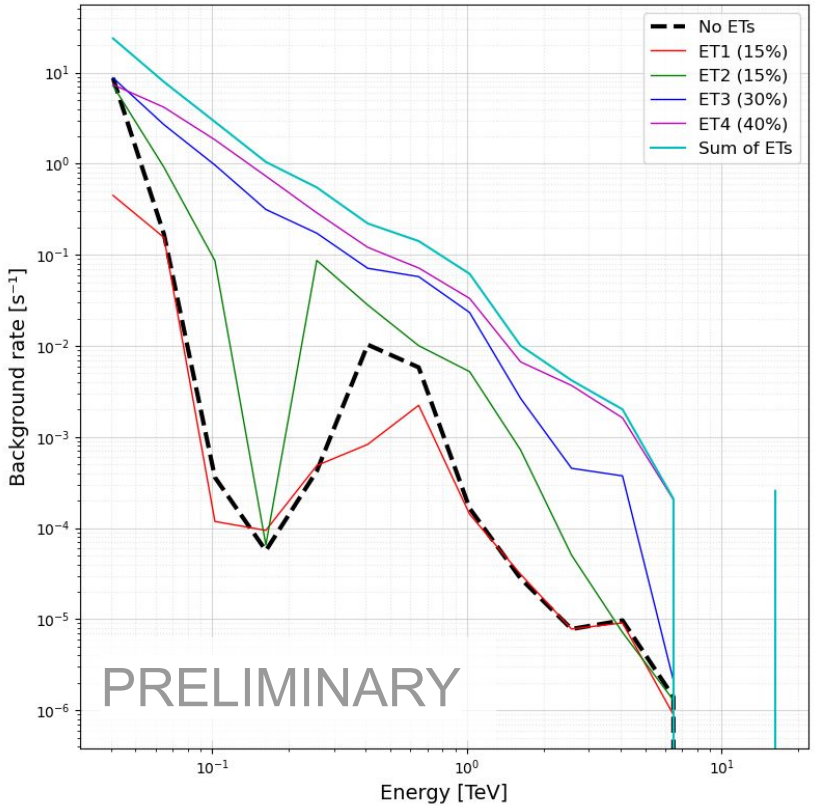


Example for the theta_23.161_az_260.739 node IRFs

Instrument Response Functions

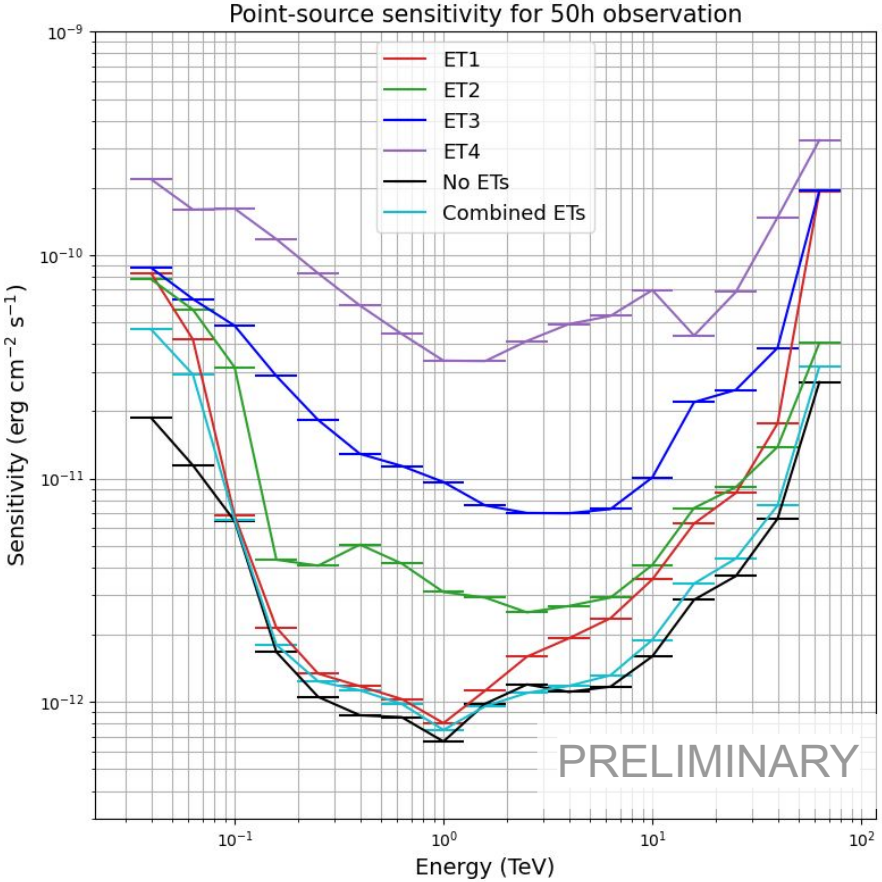
- Need for custom proton MCs to produce accurate bkg IRF



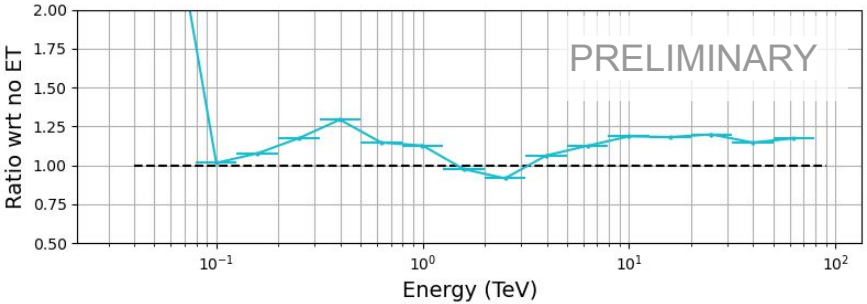


Example for the theta_23.161_az_260.739 node IRFs

Sensitivity Estimation



- Done using Gammapy's *FluxPointsEstimator* and simulating a 50h observation with a PWL spectrum with Γ=2.62
- Combined sensitivity compatible to standard analysis
- Next steps: decide proper sensitivity estimation method and apply directly to real data

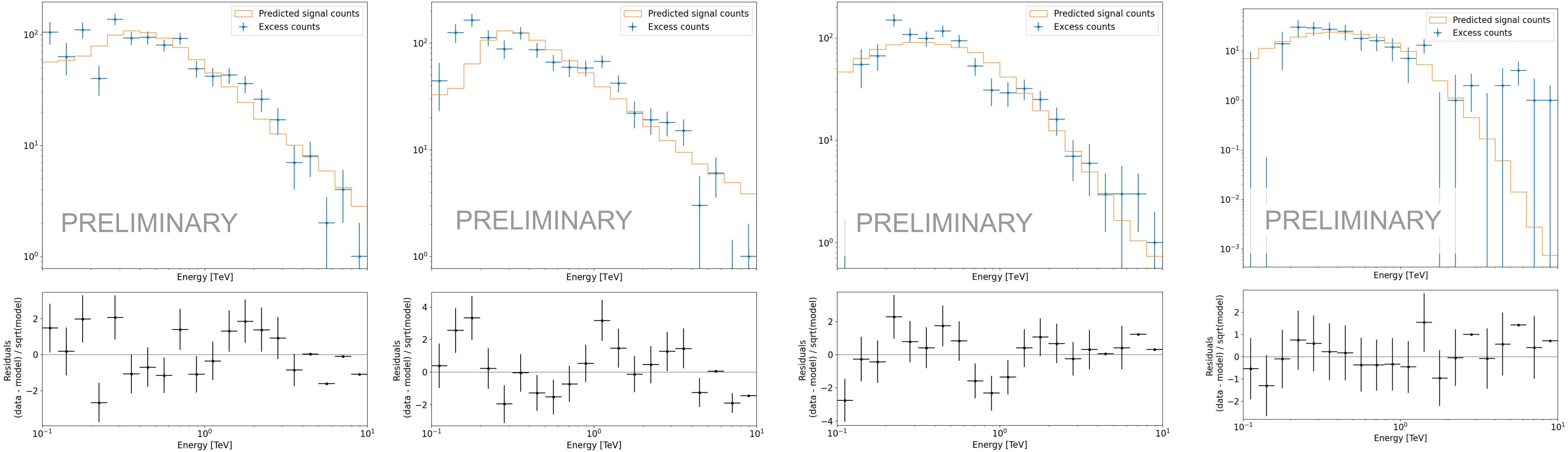


Example for the theta_23.161_az_260.739 node IRFs

The event-type based analysis using real LST-1 data

Crab Nebula dataset: 2.00h of observations taken on March 4th and 5th, 2022 (standard DL3 are publicly available[1])

➔ No clear trends when comparing the fit residuals of the 4 event types used in this work



[1]Morcuende, D. (2024). Crab Nebula DL3 example dataset from the LST-1 performance study [Data set]. Zenodo

Conclusions

- ➔ Preliminary event-type based analysis ready for LST-1 data analysis
- ➔ The current implementation of the NN used works with real data:
  - ◆ Partition ranking shows IRFs improving in resolution
  - ◆ High correlation between well-characterized events in energy and direction
- ➔ Next steps:
  - ◆ Optimize cuts to improve combined sensitivity
  - ◆ Evaluate the impact of ET-based analysis on spectral reconstruction systematics

Thank you!

An event-type based analysis for LST-1

S. García Soto[1],
J. Bernete[1], T. Hassan[1], M. Strzys[2], I. Vovk[2], M. Linhoff[3]

1: CIEMAT
2: ICRR, The University of Tokyo
3: CTAO, Science Data Management Centre

GOBIERNO DE ESPAÑA
MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES
Ciemat Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas
cfp CIEMAT física de partículas
TeV Particle Astrophysics TeVPA Valencia 2025