The use case of the CTA data model

A test bed for a Provenance Data model

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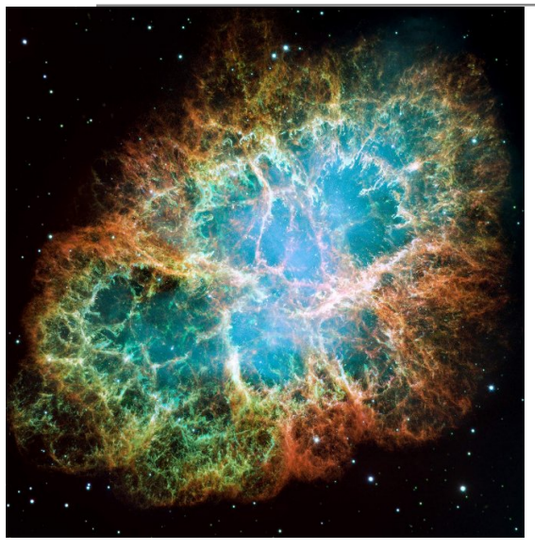
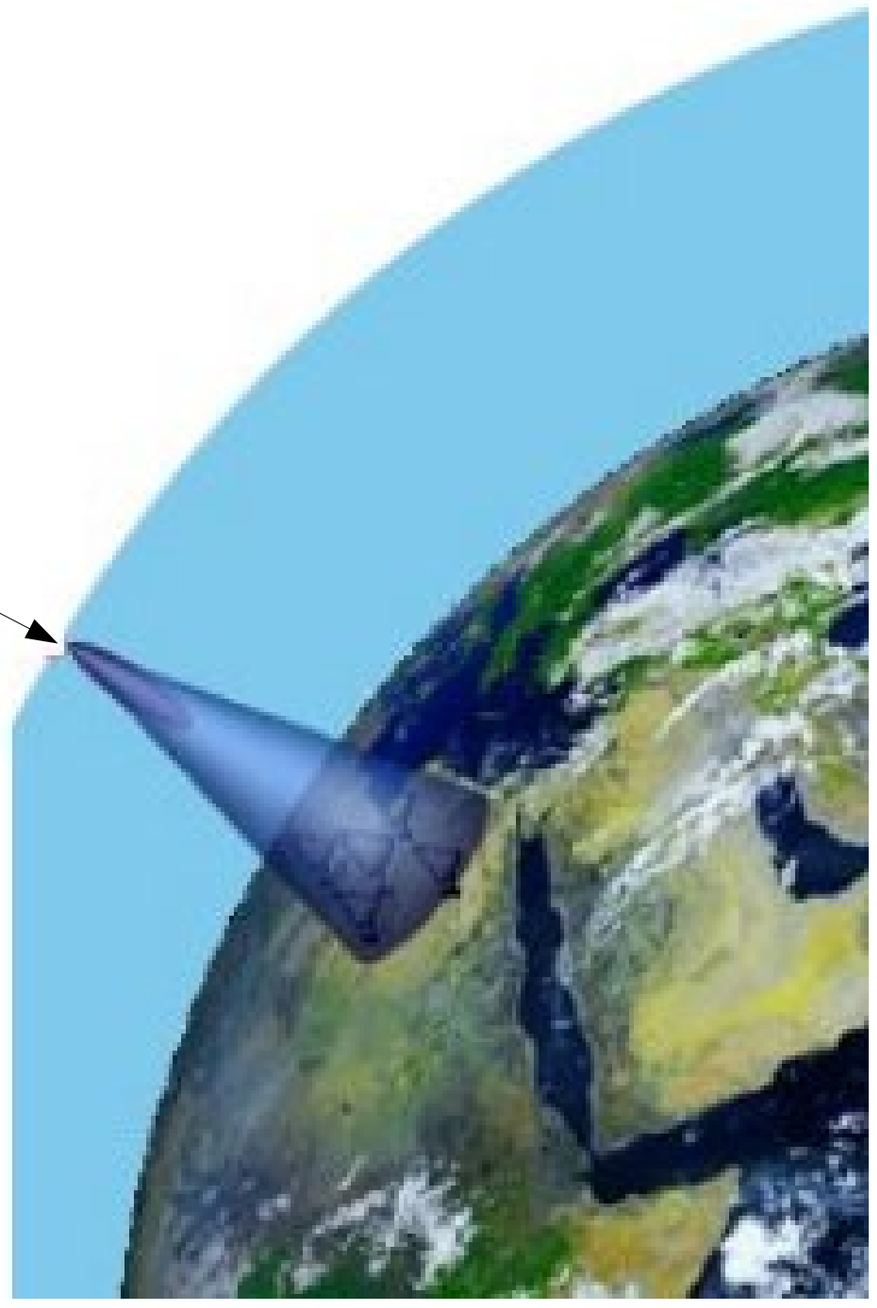
Spectrum and Light Curve: Energy Reconstruction



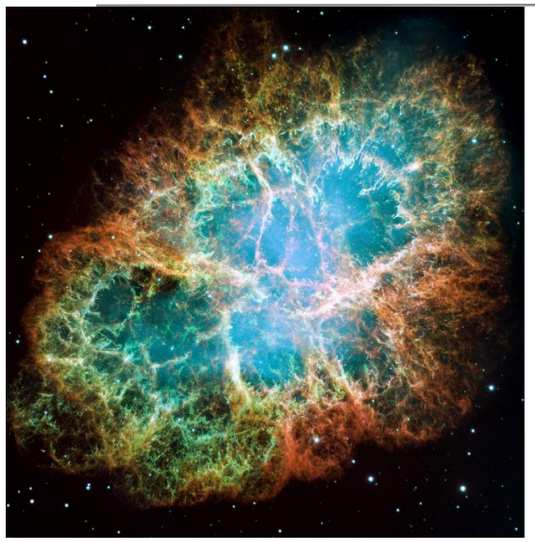
Gamma Rays

Which energy?



Problem is how to calibrate the detector in energy as atmosphere is part of the detector.

Spectrum and Light Curve: Energy Reconstruction



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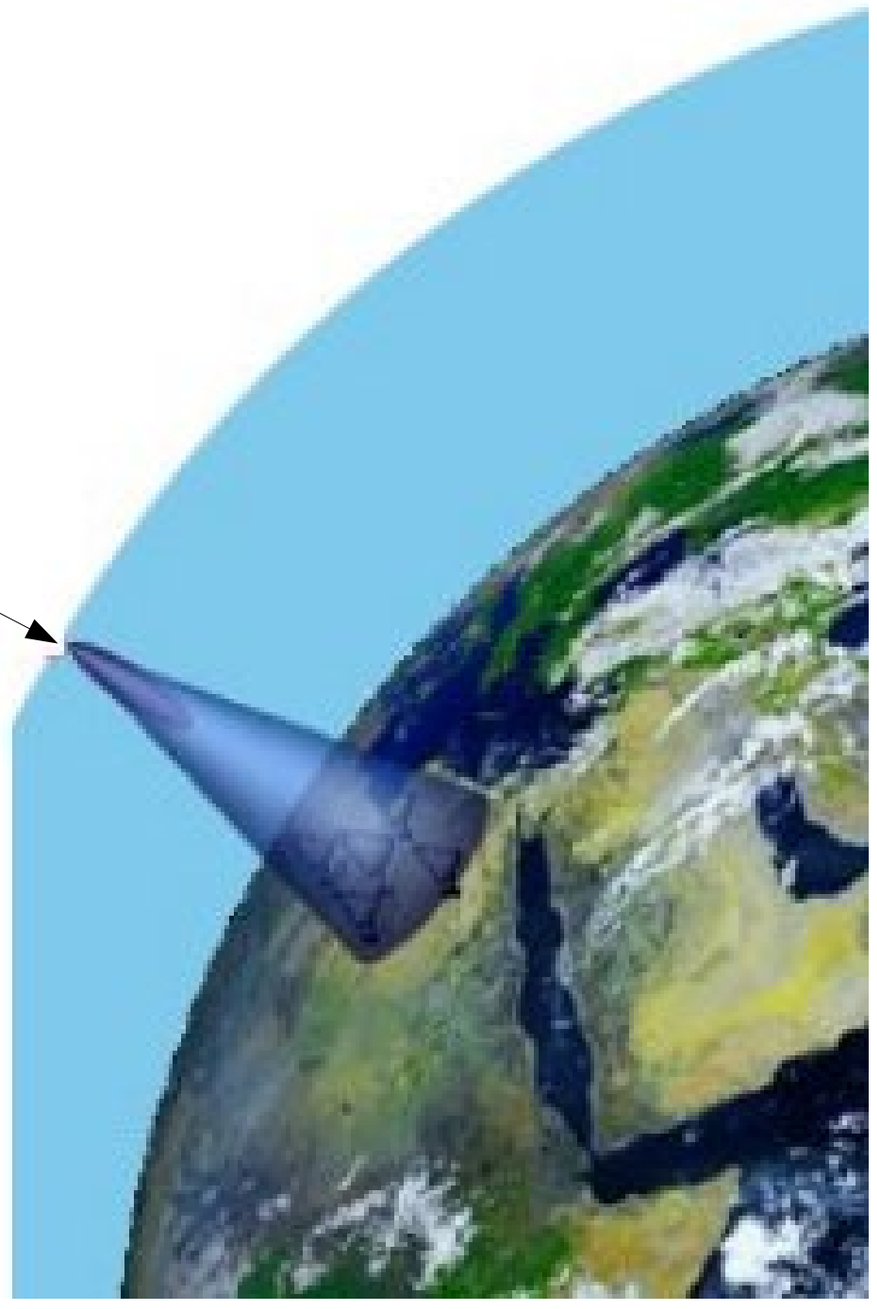
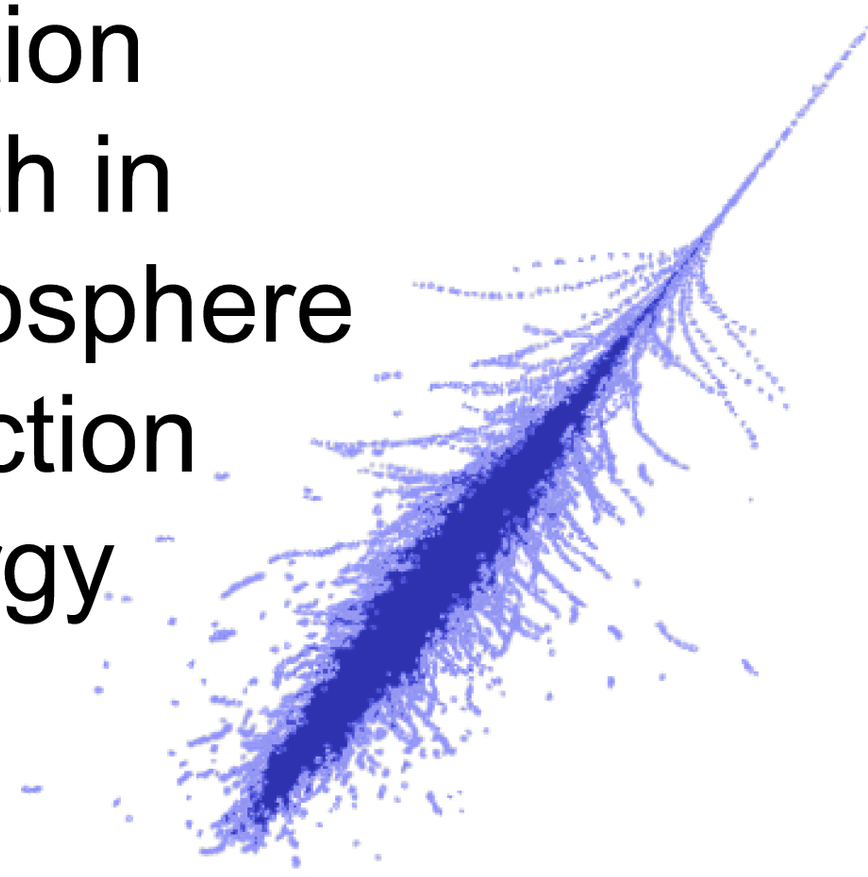


Problem is how to calibrate the detector in energy as atmosphere is part of the detector

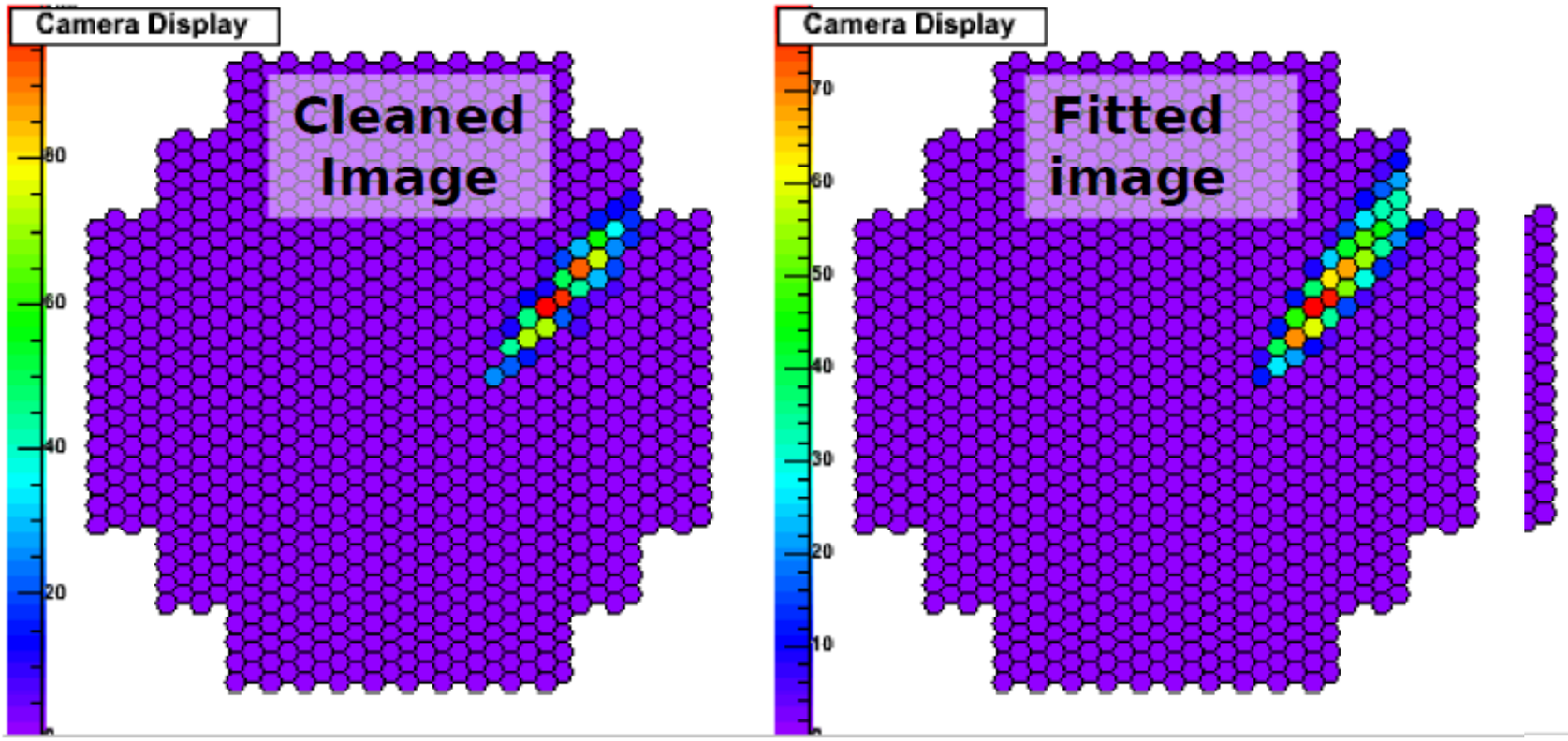
→ simulations are needed for energy reconstruction

- Given:
  - (cleaned) **image** of the shower in **N telescopes**
  - Geometry and pointing direction of telescopes
  - Current event time

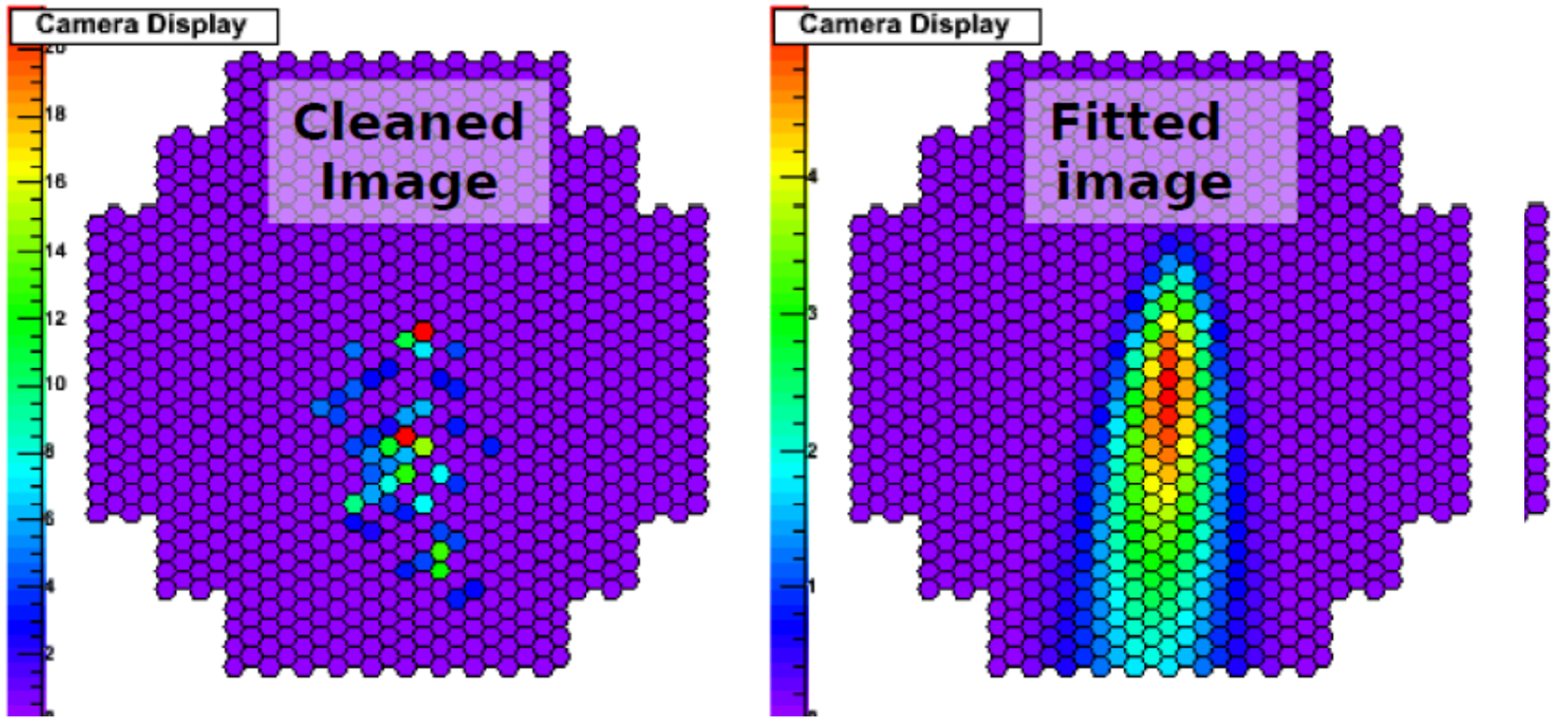
- Determine physical shower parameters:
  - Impact parameter/Core location
  - Depth in Atmosphere
  - Direction
  - Energy



Gamma Ray:

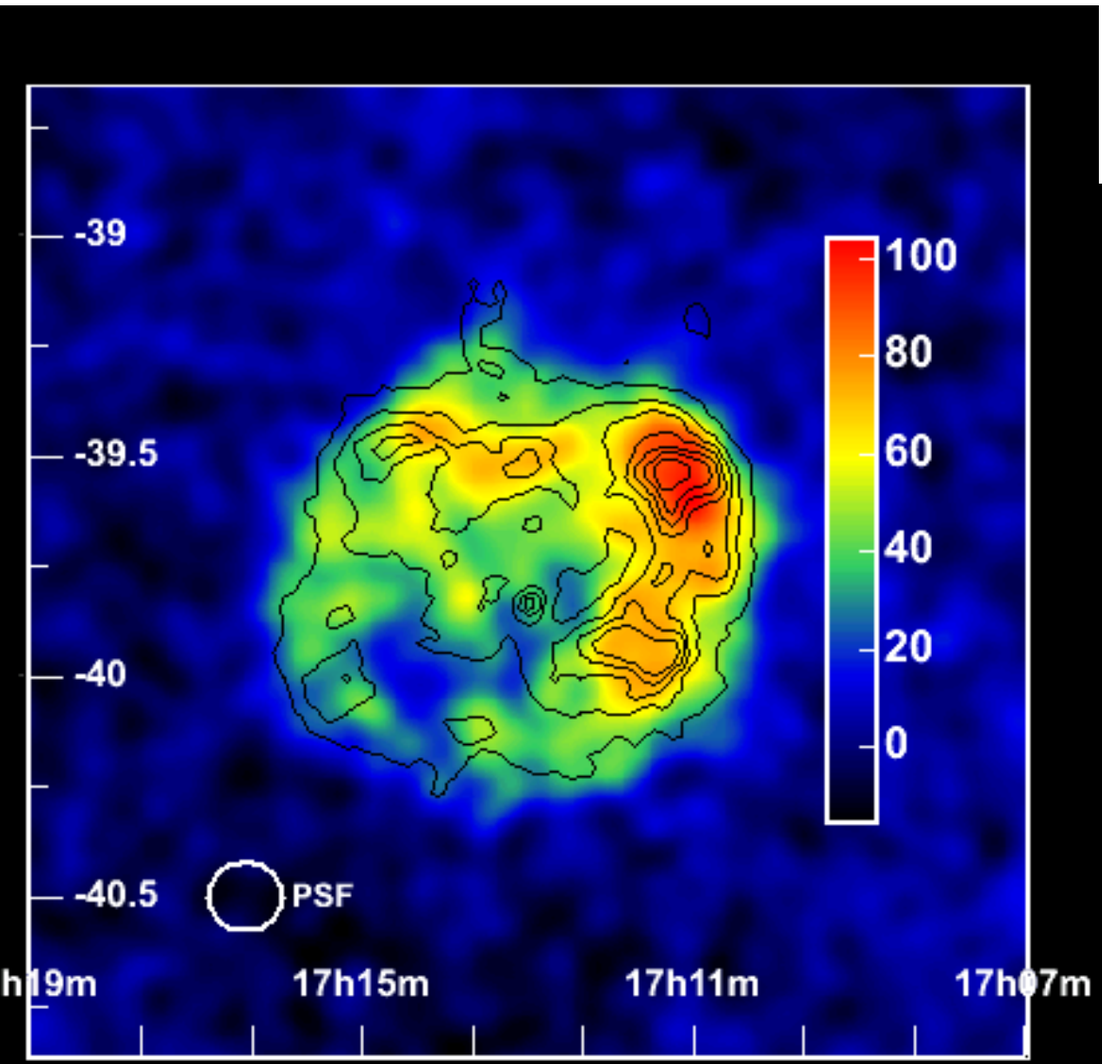


Hadron:

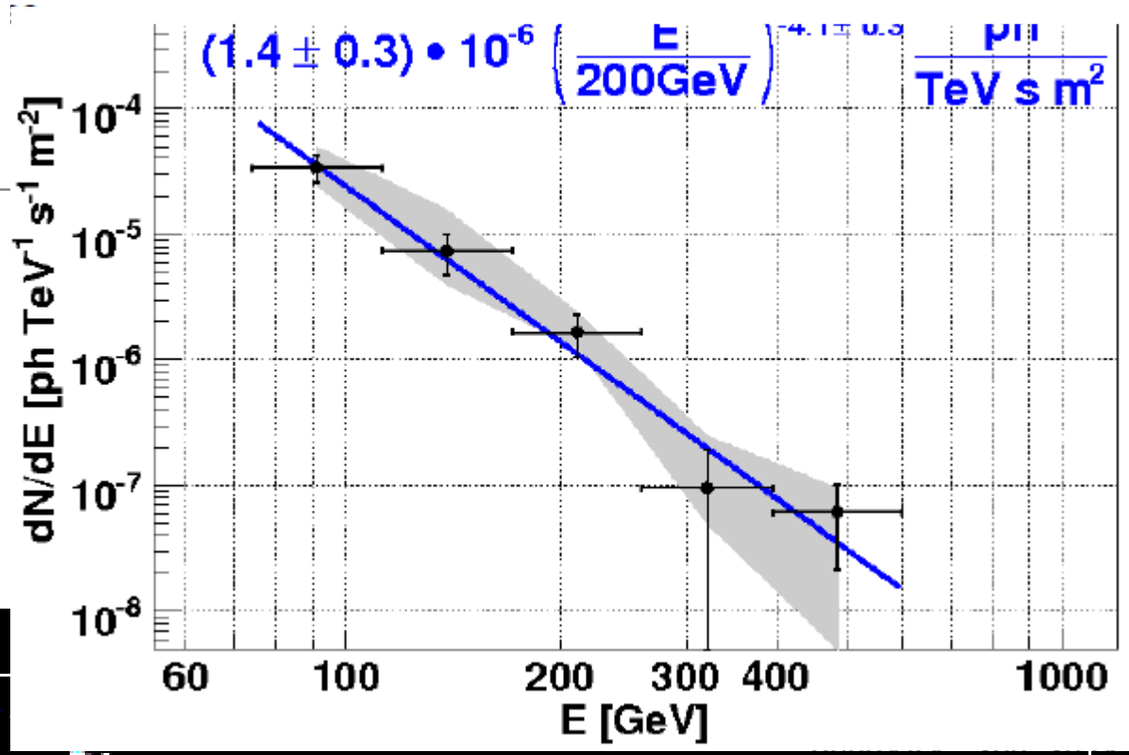


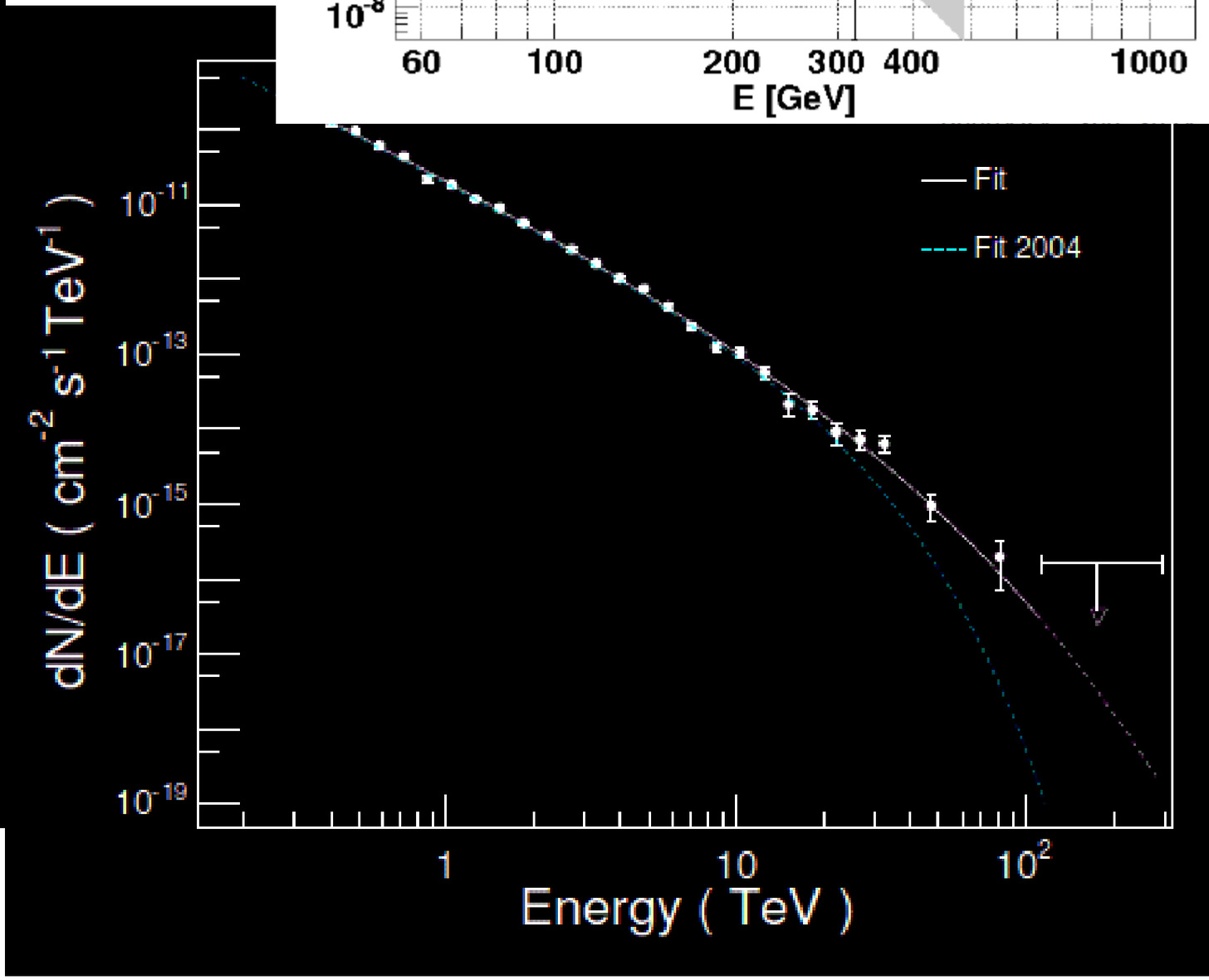
- Simulate processes in atmosphere
- Simulate telescope
- Compare shower images

→ reconstruct energy →

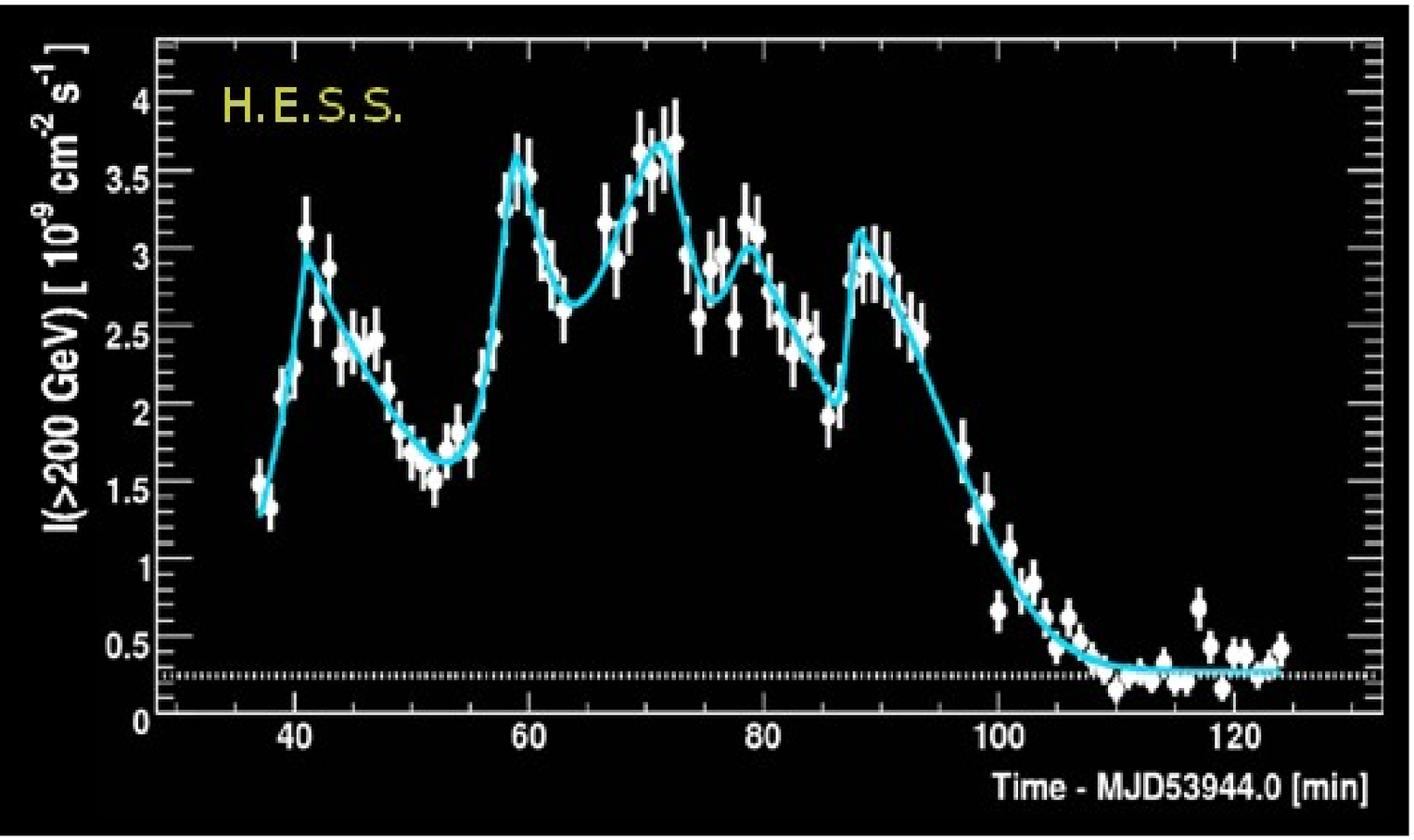


Aharonian et al., 2004, *Nature*, 432, 75



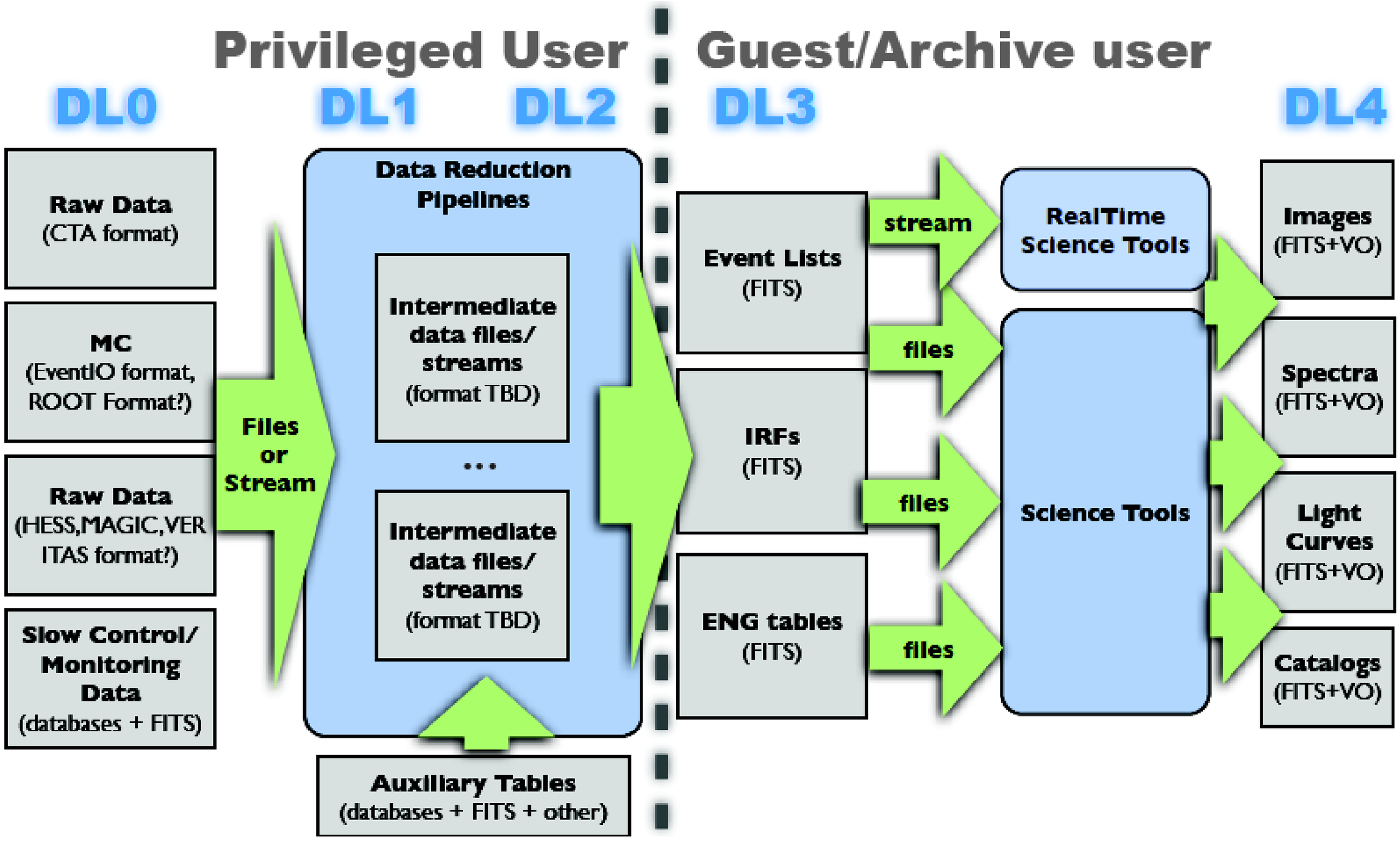


Resolved extended TeV source
Correspond with X-Ray morphology



- First major AGN flare for a source
- Variability on 5 min (or less) scales

Light curves at different timescale from months down to minutes


Privileged User
Guest/Archive user
DL0
DL1
DL2
DL3
DL4
Raw Data
(CTA format)
MC
(EventIO format,
ROOT Format?)
Raw Data
(HESS,MAGIC,VER
ITAS format?)
Slow Control/
Monitoring
Data
(databases + FITS)
Files
or
Stream
Data Reduction
Pipelines
Intermediate
data files/
streams
(format TBD)
...
Intermediate
data files/
streams
(format TBD)
Auxiliary Tables
(databases + FITS + other)
Event Lists
(FITS)
IRFs
(FITS)
ENG tables
(FITS)
stream
files
files
files
RealTime
Science Tools
Science Tools
Images
(FITS+VO)
Spectra
(FITS+VO)
Light
Curves
(FITS+VO)
Catalogs
(FITS+VO)

Kosack 2012

ICTA – Data

An observation – instrumental chain

Observations are “reconstructed” to get a list of event:
e(x,y,Ra,Dec,E,t, ambient conditions)

Observing time is not continuous → series of GTI exposures : run
Observation usually sum of 5 to 10hrs on source

Reconstructed position of the source → ROI, may be different from pointed Ra, Dec
Background(s), image response functions

Wide field → more than one source In the field

ICTA – Data

Products

- Excess maps
- Significance maps
- Exposure maps
- PSF variation (function of t, E, position across image)

- Skymaps in different energy bands
- Integrated spectra
- Light curves
- Photometry point when too low statistics

CTA – an Observatory

Data products

Data obtained will be systematically pipeline-processed to generate a range of **scientific and auxiliary data products**

Minimal data product to provide is *a list of events with the relevant quality informations, engineering data, required image response functions, as well as science data (images, spectra, light curves)*

But recall that products are only one **representation of the data**.
One may want to select another set of guess (hadron-gamma separation, bkg,...)

VO

No standard yet to archive high energy astronomical data

- SSAP protocol defines a uniform interface to remotely discover and access simple 1-dimensional spectra → OGIP standard PHA format of X-ray spectra not accepted, so difficult fo VHE

- Spectral Data Model does not describe completely the HE data

- HE spectra are not physical units but in instrument counts - calibration needed and a model should be assumed to obtain a spectrum in physical units

- ObsTAP - makes it possible to discover and access the whole dataset of the observation, but doesn’t access the calibration files needed for the analysis

- Units not adequate (e.g. meter) : problem of precision

VO

No standard yet to archive high energy astronomical data

- Missing keywords (Utypes) to the Spectral Data Model to describe High Energy astronomical data: e.g. calibration version, model used to extract spectrum, PSF instead of aperture model, time boundaries of observation together with live time

- Calibration DM : useful for x-calibration, changes flux value but here we have a fully new analysis (bkg, bin sizes, …)

- Partial data cubes : single exposure data cube access n different observations for better S/N and look to final results

- Light curves : need to talk to « time series » WG ?
  Not properly tackled yet.

VO – publishing

Two kind of data to publish

- Highest data products and catalogs where modeling is pre-defined
  → just define interface: DataLink? But still need to tell the history of the data set : Provenance ?

- Some more data with calibrations (on tool side: final post-processing, workflow system rather than a final product)
  → a complete DM

We have identified the need of an extension or combination of existent IVOA Data Models such as ObsCore & Characterisation (data products), SimDM & PDL (pipelines), DataLink (protocol), to take account of the particularities of HE Data Products. Provenance is another important block.

Provenance

How the observation is taken : ObservingConfiguration

- Ambiant Conditions :altitude, weather, wind, pressure versus time, aerosol, moon phase...
  Create atmospheric sets ? Keep all metadata?
- Observing Configurations : How was the telescope configured ?
  How many telescopes involved ?
-

How the observation is processed: Processing workflow descriptions

- Data Processing : calibration, reconstruction and analysis pipeline

Overview of the CTA Model

CTA Model 2013

Conclusions

Several aspects of provenance involved

Observing configuration

Processing

Multi types for data products

Towards a CTA IVOA Data Model... (3 : Processing)