3ʳᵈ ASTERICS-OBELICS Workshop
23-25 October 2018, Cambridge, U.K..

Work on DL3 and Gammapy (IFAE & UCM)

J.L. Contreras

Open VHE γ-ray Astronomy

Work inside ASTERICs oriented towards CTA, and MAGIC,
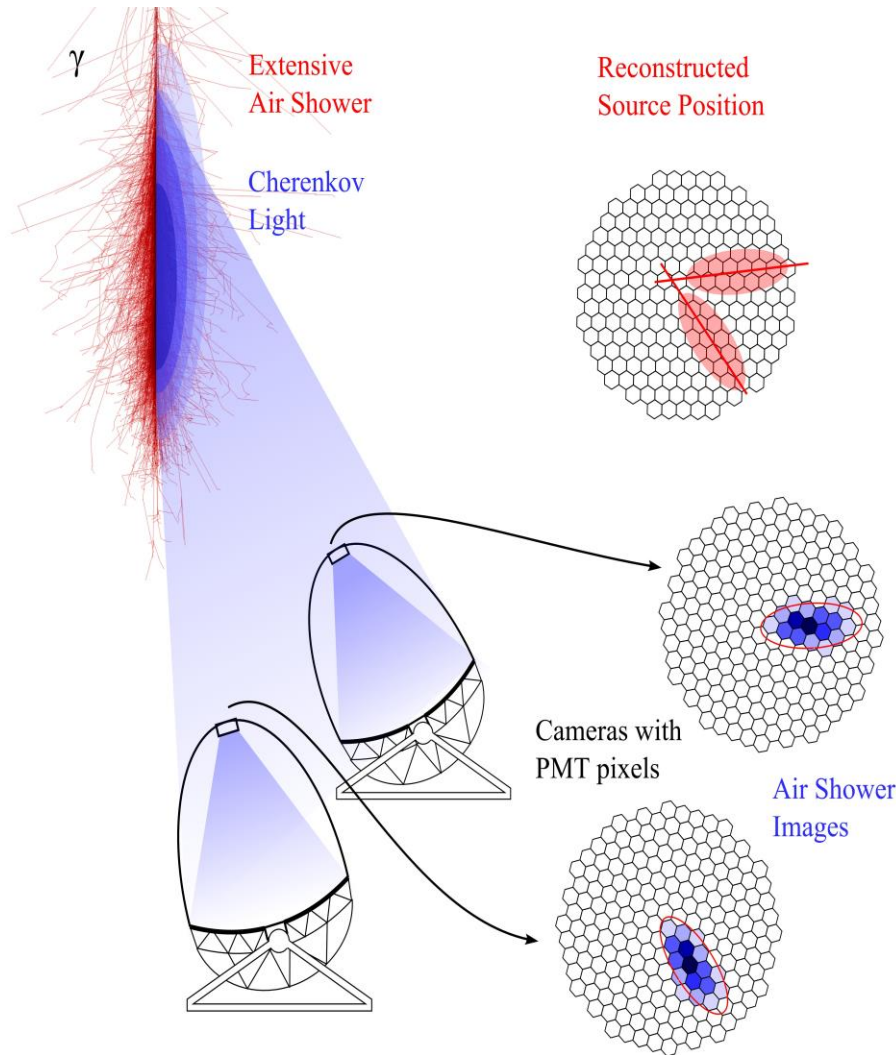
...but looking for applications into broader fields

LST-1 on MAGIC site

J.L. Contreras

Official inauguration last 10th October

Data processing in VHE

γ

Extensive
Air Shower

Cherenkov
Light

Reconstructed
Source Position

Cameras with
PMT pixels

Air Shower
Images

Christian Fruck

Compute a single γ-ray direction, energy & *hadronicity*

From many *videos*

And supress 1000 Cosmic Rays based on

"how they look like "

Data Levels in CTA

Data is reduced by factor 10^5 in several steps

Data Level	Description
DL0	Lowest level of data stored (videos)
DL1	Calibrated Data at telescope level
Dl2	Reconstructed data , showers
DL3	Lists of g-rays
DL4	Spectra, skymaps
DL5	Catalogs

Observatory Internal

Pipeline

User

Science tools

Open after proprietary period
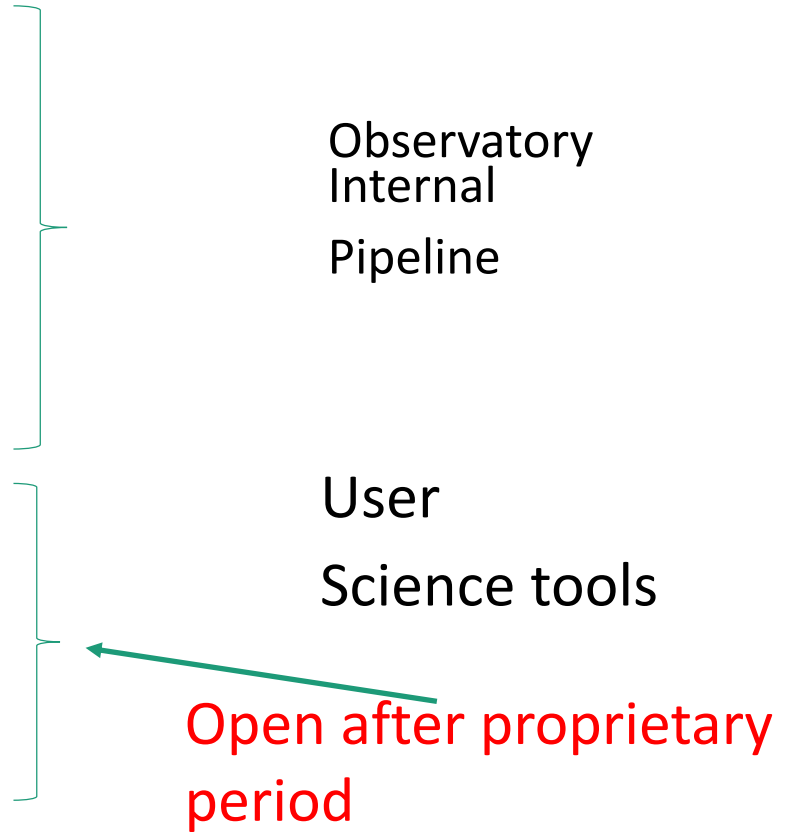
The two CTA data challenges

An open observatory

An enormous increase in sensitivity

Up to now VHE *experiments* =

propietary data and software

close to particle physics standards

CTA data will be open

User friendly, *universal* software

An enormous increase in data, concentrated in low level formats DL0

Pushing the limits of current

file formats

High Level Data

Under the simplification that DL3 production and analysis can be uncoupled

Science tools can operate on small samples of DL3 data, those events tagged as photons.

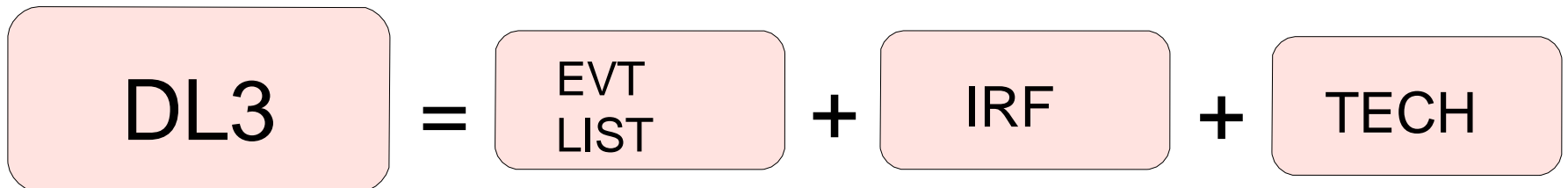This could need refinement when looking at special cases where high contamination is acceptable
.

DL3 Data format

DL3 is the high-level product of the pipelines containing:

Event lists (event-wise energy, RA, DEC, time...) of γ-like events **(from analysis of collected data)**

Instrument Response Functions (Effective Area, Backg. rate, PSF, Energy dispersion) **(from analysis of simulations)**

TECHnical data describing details of the observations (obs. conditions, etc..) **(fom auxiliary instruments)**
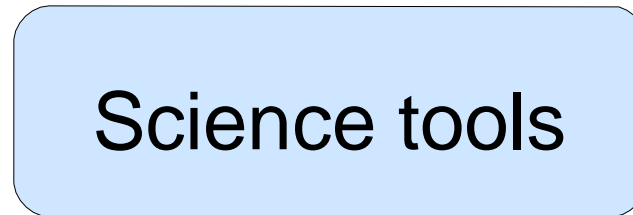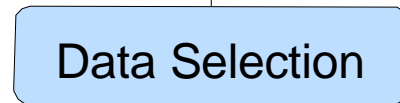
DL3 = EVT LIST + IRF + TECH

High Level Analysis in CTA

CTA pipelines $\longrightarrow$ DL3

ctools
cherenkov telescope array

By J. Knödlseder et al.

+

Science tools

By C. Deil et al.

Data Selection

Light Curves Counts Maps Spectra

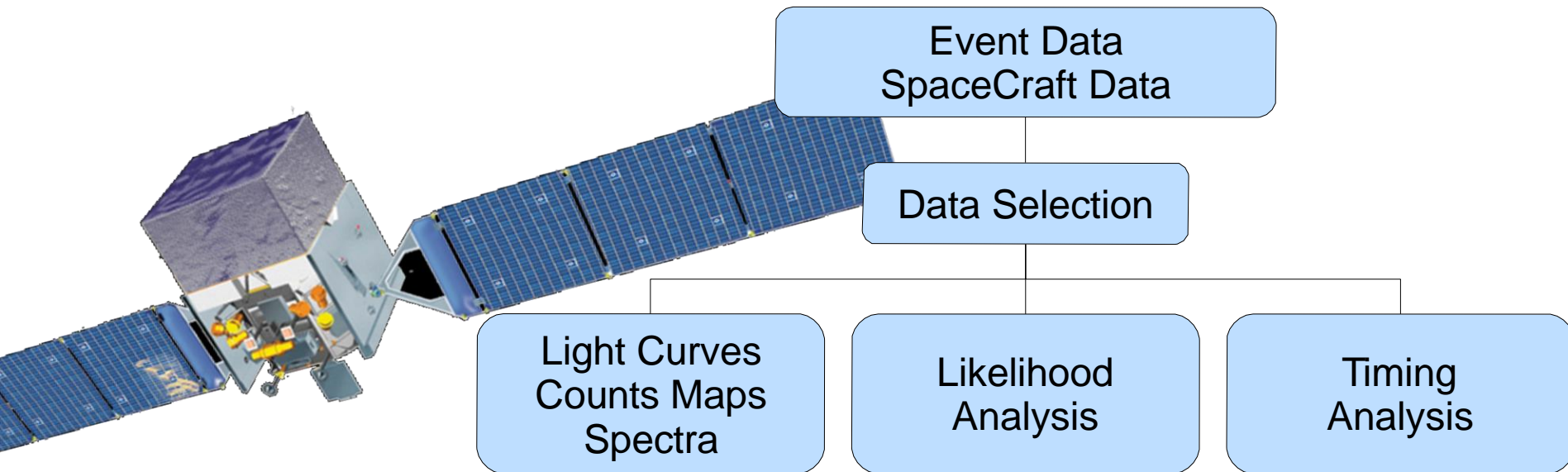**Likelihood Analysis**

Timing Analysis

Following Fermi-LAT steps

Scientists download event lists (EVT3) + spacecraft data (~TECH3)

Together with LAT IRFs (IRF3), gtools performs the high-level analysis

Format uses FITS tables

Event Data
SpaceCraft Data

Data Selection

Light Curves
Counts Maps
Spectra

Likelihood
Analysis

Timing
Analysis

Short history of DL3

- Definition of Data levels: G.Lamanna et al.   (2009?)

- DL3 Event Lists: K. Kosack, C. Boisson et al.   (2011)

- First DC in CTA: M. Raue, J. Knödlseder et al.   (2013)

- Generalization of format: C. Deil et al.   (2015)

since 2015 work inside ASTERICs

First approach to DL3 definition

FITS Data format for ACTs v1.0.0

Karl Kosack, CTA DAFA Working Package

2011-05-18

Contents

Data formats for gamma-ray astronomy

latest

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About
General
IACT events
IACT IRFs
IACT data storage
Sky Maps
Spectra
Light curves

About

In gamma-ray astronomy, a variety of data for used, often developed for one specific mission atmospheric Cherenkov telescopes (IACTs), da collaborations operating the telescopes. The n Telescope Array (CTA), will be the first ground open observatory with public observer access. for the data formats and software tools. Open a challenge on the implementation of services astronomy as accessible as any other wavebar

Present DL3 Standard in *readthedocs*

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DL3 Generalization

Extension of the open DL3 data format (C. Deil)

Common effort to define an open DL3 format by current IACT experiments: converters built

Combined IACT analysis
Cross-calibration
Data archive

List of particles →
Why not: HAWC,
KM3, Pierre Auger ?

Proposal, use cases
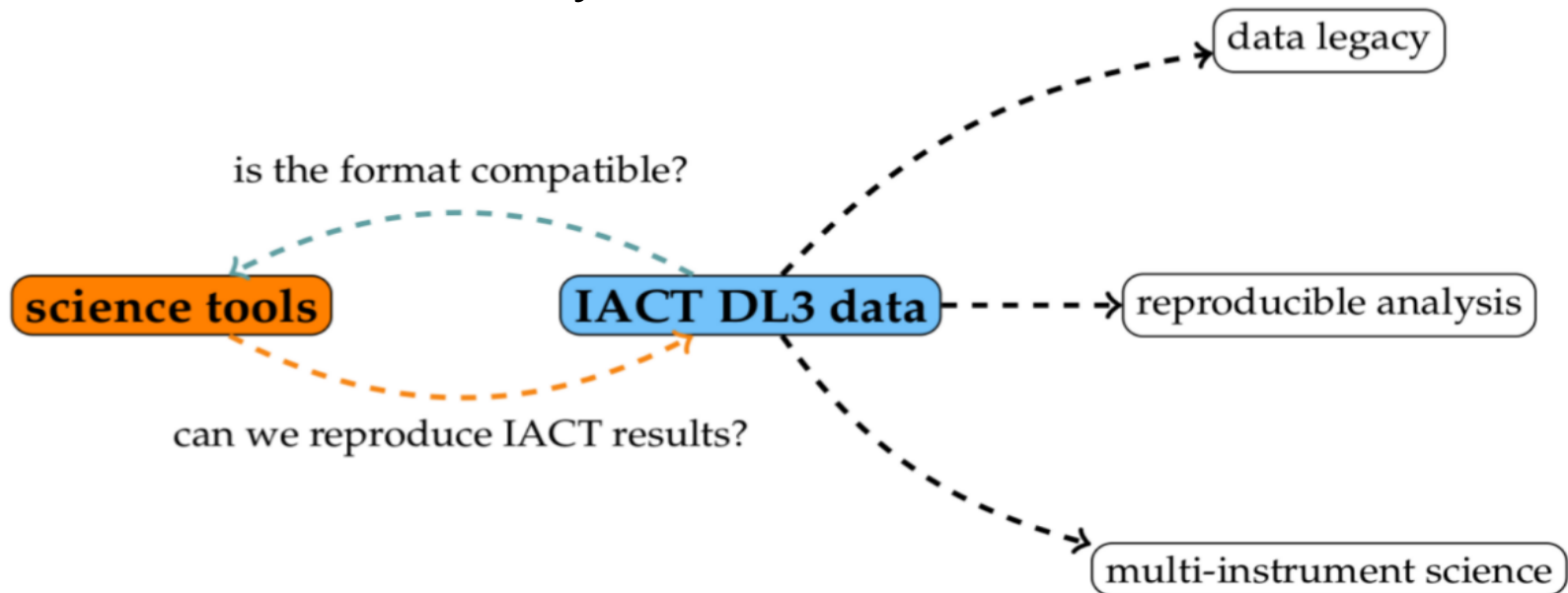 by J.L. Contreras, J. Rosado

DL3

Relevance for present IACTs

The DL3 files generated by current IACTs are necessary for:

CTA science tools validation

Legacy data that allow reproducible and multi-instrument analysis

Work @ IFAE I

Development of an open source C++ FITS IRF3 generator:

https://github.com/cta-observatory/flexIRF.git

- Served as prototype for the future CTA software
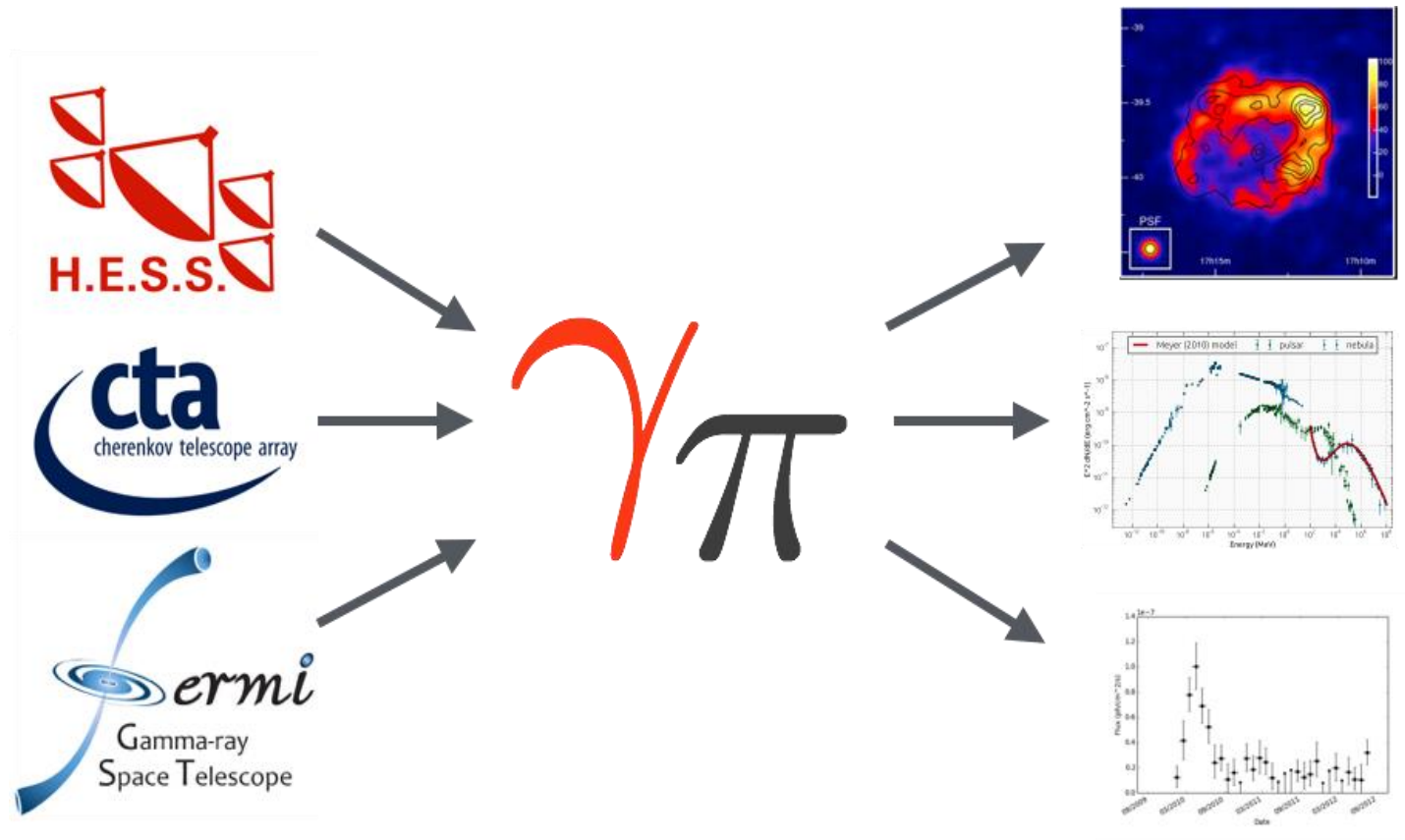 - Starting to test and validate science tools

May be used by any experiment generating DL3 data (currently used for MAGIC DL3 data)

MAGIC DL3 converter (private repo) (first versión @UCM)

Validated by MAGIC Software Board

C. Nigro, T. Hassan, J. Delgado, L. Jouvin J. Rico

Science tools: Gammapy

Gammapy history and characteristics

- Started in 2013 as an initiative in H.E.S.S.
- Written in Python
- Supported by researchers @ several Institutes:
  MPIK (Heidelberg), APC, ObsPM (Paris),
  IFAE(Barcelona), UCM(Madrid)…
- Collaborative
  - Development on Github
  - An Astropy-affiliated package
  - Contributes to related packages (healpix, regions, …)
- Active development: Weekly meetings, coding sprints…

Work @ IFAE - II

First MAGIC Crab spectrum using Gammapy (T. Hassan, C. Nigro)
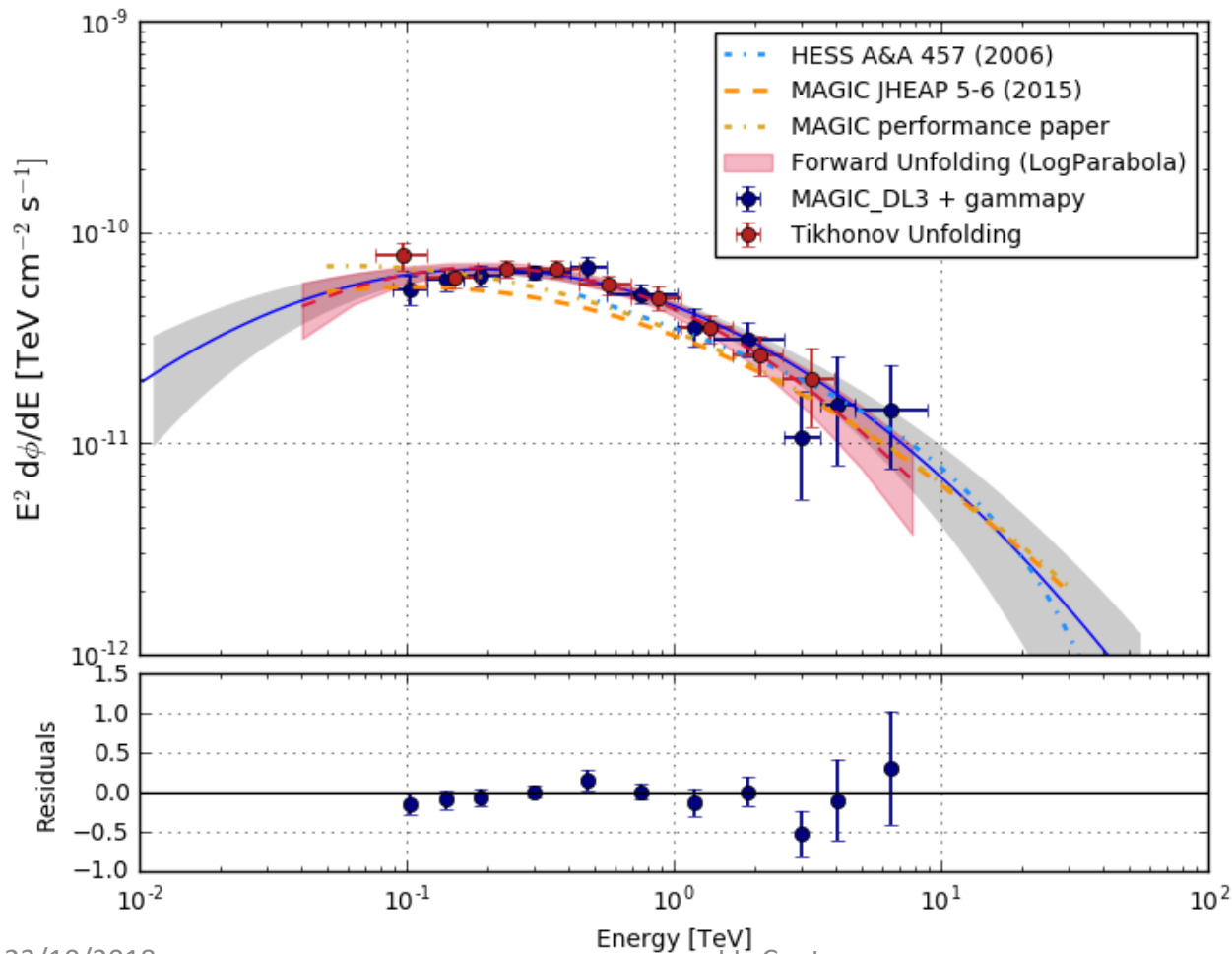
Work@IFAE and UCM

Currently collaborating on a *methods paper* to show the benefits of using the DL3 format:

Joint analysis of the Crab Nebula spectrum with data from several experiments

Goal: encourage the use of DL3 in other experiments, openly releasing the data used and allow a common, reproducible analysis with open source tools

C. Nigro , + (among others)
…. T. Hassan, ….J.L. Contreras,… D. Carreto-Fidalgo,… L. Jouvin, … J.Rico

Common Crab analysis

Preliminary results of the Common Crab analysis using Gammapy
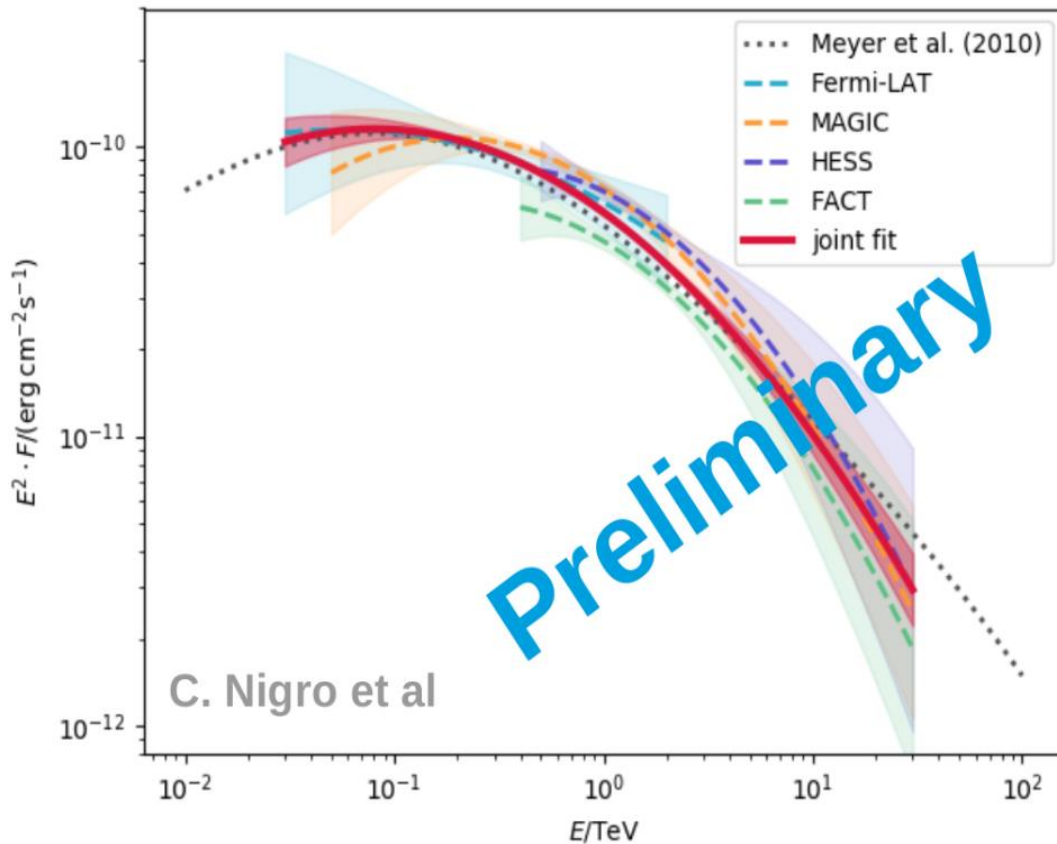
Common 1D likelihood spectral analysis using open source tools

DL3 samples will be released to the public, together with the required tools

Next goals I : *3D analysis*

- Morphology of the studied sources is more and more complex → have to be more precise

- This complexity will increase with CTA observations

- 3D analysis or cube analysis: fit simultaneously the morphology and the spectrum on a cube dataset → required to separate the different components of a same region of the sky

Work@UCM I

- Checking the code. Contributions to the binary and pulsar analysis of CTA Data Challenge using **Gammapy:** close-out document


2 Galactic Science in DC-1

Editors: R. Zanin and L. Tibaldo

LS161+303

The available data sample consists of 60 hr of observation of LS161+303, all clustered in two orbital phase bins (see Fig. 2.14). For this reason, we skip the production of the phase-folded lightcurve. The excess map and the energy spectrum obtained for this source are illustrated in Fig. 2.15. The latter shows the simulated true model for comparison, before and after the flux modulation correction. **do we want to explain it in detail?**.

Vela
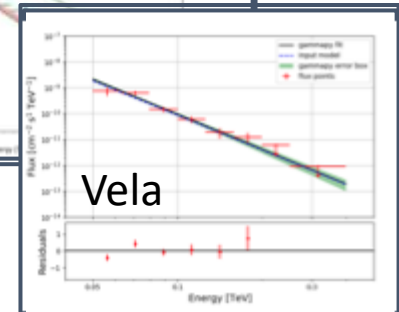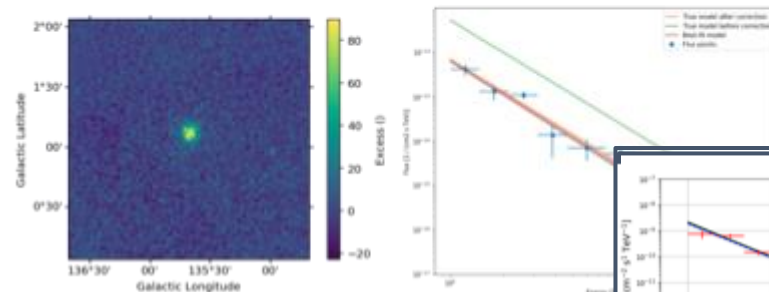
Work@UCM II

Two PIGs contributed (**P**roposal for **I**mprovement of **G**ammapy), work-in-progress …

PIG X – PIG Improvement for Computing Light Curves

- Author: David Fidalgo, ...
- Created:
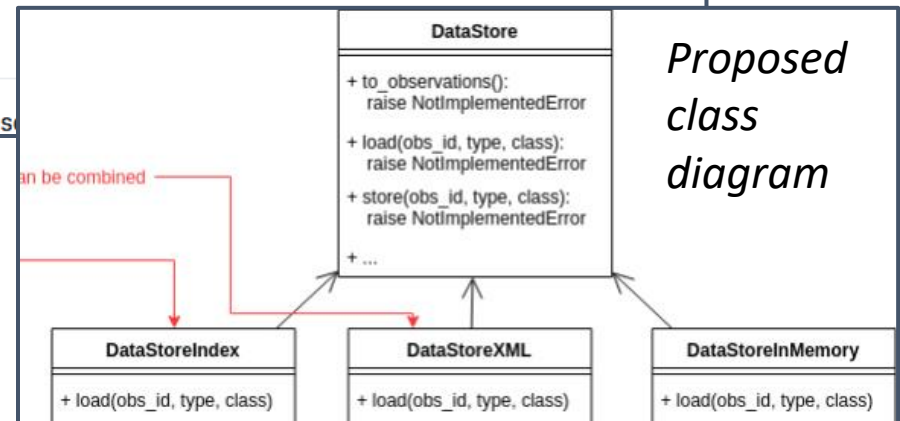- Accepte
- Status:
- Discussi

Abstract

In this PIG w
propose to p

PIG 6 – CTA observation handling in Gammapy

- Author: David Fidalgo, Christoph Deil, Régis Terrier et al
- Created: October 10, 2018
- Accepted: --
- Status: Being discussed
- Discussion: --

Abstract

In this PIG we want to outline an improvement of the CTA obs

Proposed class diagram

DataStore

+ to_observations():
  raise NotImplementedError

+ load(obs_id, type, class):
  raise NotImplementedError

+ store(obs_id, type, class):
  raise NotImplementedError

+ ...

an be combined

DataStoreIndex	**DataStoreXML**	**DataStoreInMemory**
+ load(obs_id, type, class)	+ load(obs_id, type, class)	+ load(obs_id, type, class)

Participation in coding sprints

- Gammapy team holds coding sprints around thrice/year.
- Last one held@Madrid 1-4 october

Acknowledgement