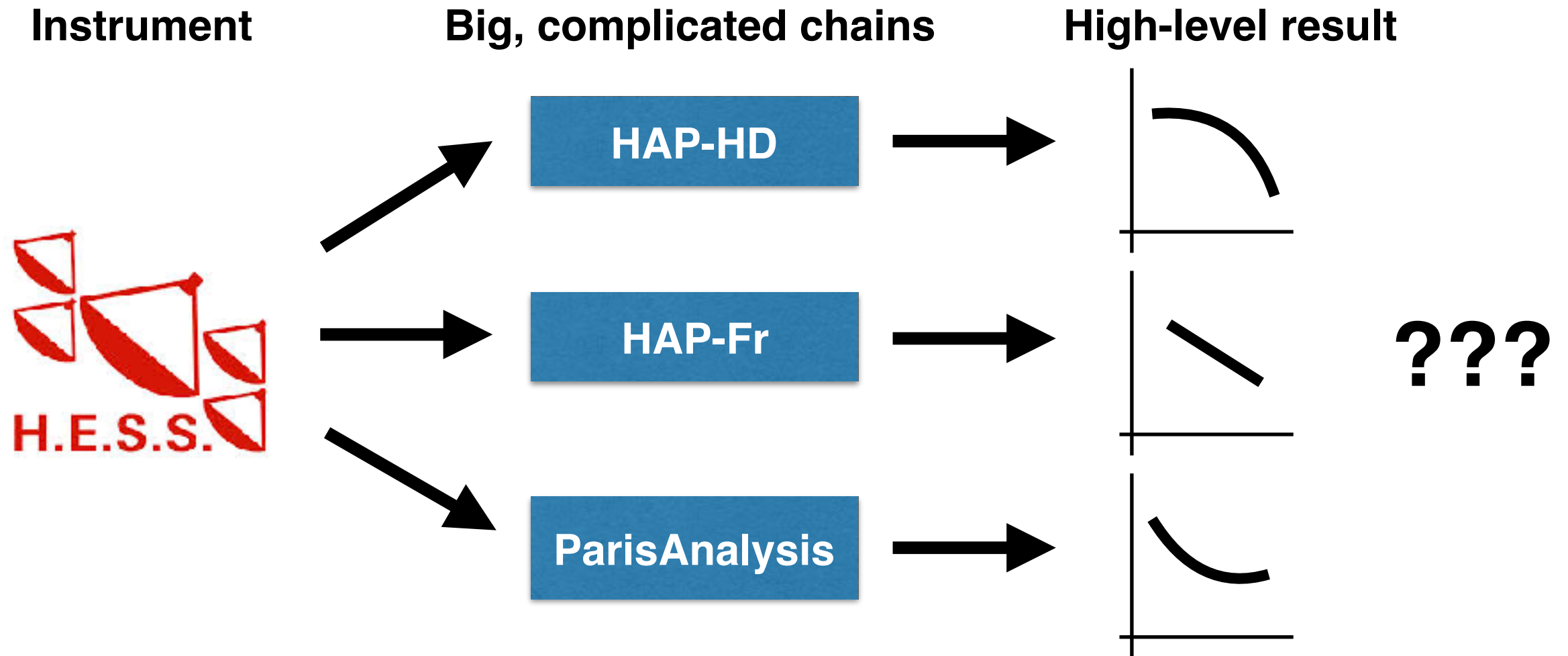


DL3 IN HESS

Christoph Deil
March 20, 2017

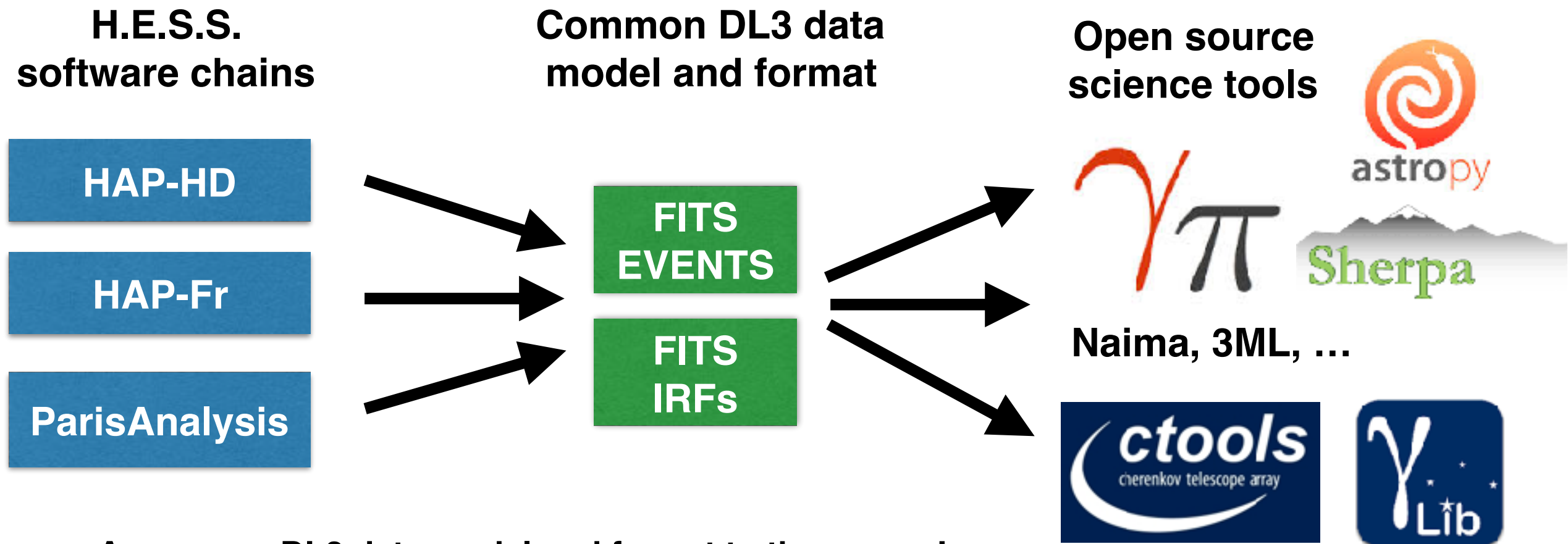
Mostly copy & paste of slides from previous presentations

H.E.S.S. data analysis with internal chains



- In H.E.S.S. we have 3 internal analysis chains (HAP-HD and HAP-Fr share some parts)
- DL1 to DL5 levels are mostly incompatible between the chains
- Lack of common data formats prevents mix & match of methods from different chains (e.g. calibrations, reconstructions, gamma-hadron separations, high-level analysis) and makes it hard to understand the differences in high-level results (e.g. source spectrum).

H.E.S.S. data analysis with open source tools



- **A common DL3 data model and format to the rescue!**
- Export events and IRFs at the DL3 level from each chain (after gamma-hadron separation, similar to Fermi-LAT public data)
- Makes mid-level (event energies, positions) and high-level (source position, morphology, spectrum) checks between the different chains, algorithms and open-source tools possible.
- Work on data formats, exporters, checks, open source tools ongoing in parallel ...

IN HESS: IRF GLOBAL DATABASE

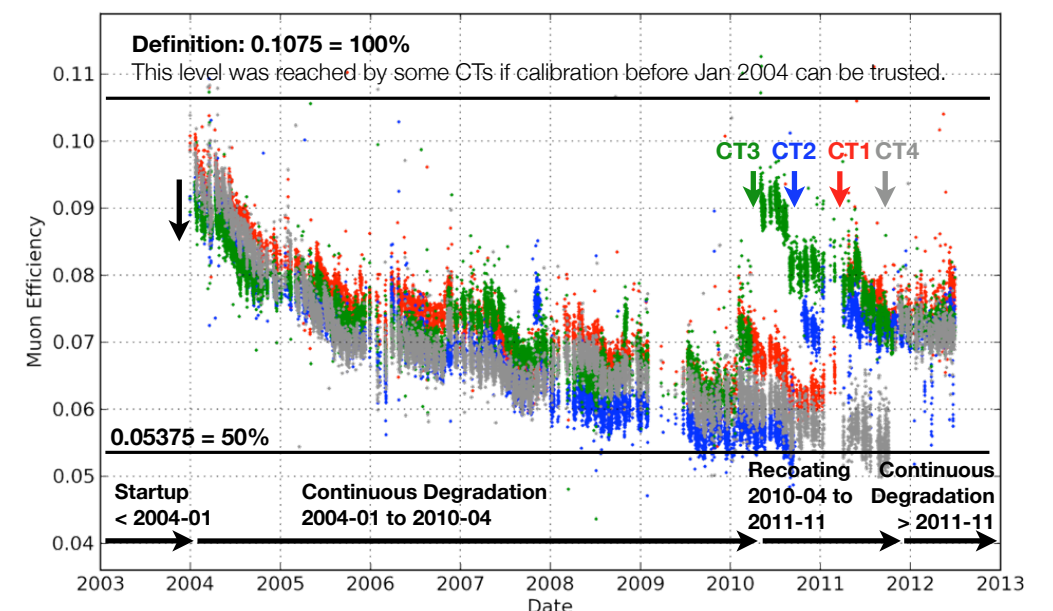
For HAP-HD, IRFs derived from MC events of gamma-ray point sources at given fixed parameters (zenith, azimuth, offset, ...) and power-law in energy. Other chains are different, e.g. ParisAnalysis has grid of fixed energies.

lookup file (.root)	histogram	parameters	x-axis	y-axis	z-axis
ScaleInfo	avg_length	opt,azm,zen,off	$\ln(\text{size}/p.e.)$	d/m	$\langle L \rangle / \text{mrad}$
	avg_width	opt,azm,zen,off	$\ln(\text{size}/p.e.)$	d/m	$\langle W \rangle / \text{mrad}$
	sigma_length	opt,azm,zen,off	$\ln(\text{size}/p.e.)$	d/m	σ_L / mrad
	sigma_width	opt,azm,zen,off	$\ln(\text{size}/p.e.)$	d/m	σ_W / mrad
EnergyInfo	MeanTrueEnergy	opt,azm,zen,off,tel	$\ln(\text{size}/p.e.)$	d/m	E/TeV
	SigmaTrueEnergy	opt,azm,zen,off,tel	$\ln(\text{size}/p.e.)$	d/m	$\sigma(E)/\text{TeV}$
EffectiveAreas	EffArea.TrueEnergy	opt,telp,azm,zen,off	$E_{\text{true}}/\text{TeV}$	$A_{\text{eff}}/\text{m}^2$	
	EffArea.RecoEnergy	opt,telp,azm,zen,off	$E_{\text{reco}}/\text{TeV}$	$A_{\text{eff}}/\text{m}^2$	
	EnergyBias	opt,telp,azm,zen,off	$\log_{10}(E/\text{TeV})$	$(E_{\text{reco}} - E_{\text{true}})/E_{\text{true}}$	
PSF	ThetaSq	opt,telp,azm,zen,off	$\log_{10}(E/\text{TeV})$	θ^2/deg^2	p.d.f. value
EnergyReconstruction	EnergyReconstructionPDF	opt,telp,azm,zen,off	$\log_{10}(E/\text{TeV})$	$(E_{\text{reco}} - E_{\text{true}})/E_{\text{true}}$	p.d.f. value
RadialAcceptance	RadialLookup	zen	$(\Delta\Psi)^2/\text{deg}^2$	acc/a.u.	

Table 1: Lookups used in hap. Here, d is the impact distance. L and W are the length and width of the shower in the camera respectively. $(\Delta\Psi)^2$ is the square of the angular distance to the centre of a source. Azm, zen, off angles, optical efficiencies, telescope ID, and tel

Muon Efficiency 2004 – 2012

CT1, CT2, CT3, CT4 (HD calibration, run-by-run)



HESS EXPORTED FITS FILES

.....

```
├── background
│   ├── bgmodel_alt7_az0.fits.gz
│   └── bgmodel_alt8_az0.fits.gz
├── hdu-index.fits.gz
├── obs-index.fits.gz
└── run23400-23599
    ├── run23523
    │   ├── aeff_2d_23523.fits.gz
    │   ├── edisp_2d_23523.fits.gz
    │   └── psf_king_23523.fits.gz
    ├── run23526
    │   ├── aeff_2d_23526.fits.gz
    │   ├── edisp_2d_23526.fits.gz
    │   └── psf_king_23526.fits.gz
    ├── run23559
    │   ├── aeff_2d_23559.fits.gz
    │   ├── edisp_2d_23559.fits.gz
    │   └── psf_king_23559.fits.gz
    └── run23592
        ├── aeff_2d_23592.fits.gz
        ├── edisp_2d_23592.fits.gz
        └── psf_king_23592.fits.gz
```

- Formats described in the open-astro-gamma-data spec (see previous presentation).
- On the left an example: files for 4 Crab runs from HESS.
- 1 observation = 1 GTI = 28 min
- Pre-computed IRFs
- IRF association currently via OBS_ID
- Obs index table for quick data selection and HDU index table for quick data localisation (HESS 1 has 20k obs and 80k HDUs)
- Background models are shared between many observations (~ 10 to 100 bg models only)

HESS EXPORTED DL3 FITS DATA

- All exporters use the formats from the open spec
- Gammapy and ctools used in HESS
- aeff_2d, edisp_2d, some chains bkg_2d or bkg_3d
- For PSF many things tried (psf_table, psf_king, psf_3gauss)
- IMO analytical PSFs (multi-Gauss and King profile) too hard to produce for all data (binning, steps, convergence) -> would suggest to focus on density estimation methods (e.g. histograms & smoothing)
- No checks yet if the “response time interval” of 28 min is too long in some cases, at the moment just compute IRF for mean run parameters (zenith angle, azimuth angle)
- Some people in HESS are working on run-wise IRF production. There will be an ICRC poster. But not connected to FITS effort.

H.E.S.S. PUBLIC TEST DATA RELEASE 1

➤ Idea

- A test data release to help the open spec and tools development.
- Not a science data release.
Very small sub-set of old HESS 1 data.
- First time real ground-based gamma-ray DL3 data (events and IRFs) are openly available.

➤ Status and timeline

- Release notes document 90% complete
(assuming we don't release analysis results)
- Hope to release in the coming months
(approval and some work on checks pending)

H.E.S.S. DL3 DR1 – RELEASE NOTES DOCUMENT



H.E.S.S. collaboration

DL3 public test data release 1

January 18, 2017

Abstract The H.E.S.S. collaboration is releasing a small data level 3 (DL3) dataset, event lists and instrument response information in FITS files. The motivation for the release is to make a contribution to on-going efforts to define a DL3 data model and formats for imaging atmospheric Cherenkov telescopes (IACTs) and open-source IACT science tool development. The data released consists of TODO hours of observations with the H.E.S.S. 1 array taken in the time span 2004 – 2008, i.e. is a very small subset of the 1000s of hours of H.E.S.S. observation taken in the past decade. The data set includes point sources (Crab nebula, PKS 2155-304) and extended sources (MSH 15-5 02, RX J1713.7-3946) and a variable source (PKS 2155-304). It was chosen to be a useful reference dataset for the development of the DL3 data model and formats as well as for open-source science tool testing and documentation examples and the development of new methods (e.g. TeV or multi-mission analysis).

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H.E.S.S. PUBLIC TEST DATA RELEASE 1 — TERMS OF USE

.....

H.E.S.S. DL3 public test data release 1 (HESS DL3 DR1)

H.E.S.S. collaboration, 2016

The data and documentation is publicly released by the H.E.S.S. collaboration as a contribution to the ongoing efforts to define a common open format for data level 3 of imaging atmospheric Cherenkov telescopes (IACTs) and IACT open-source science tool development, to enlarge the community involved in IACT data analysis.

No scientific publications may be derived from the data. Using the data for new claims about the astrophysical sources is not permitted.

When using this data, please include the following attribution:

This work made use of data from the H.E.S.S. DL3 public test data release 1 (HESS DL3 DR1, H.E.S.S. collaboration, 2016).

Alternatively, use the following shorter version, e.g. for presentations:

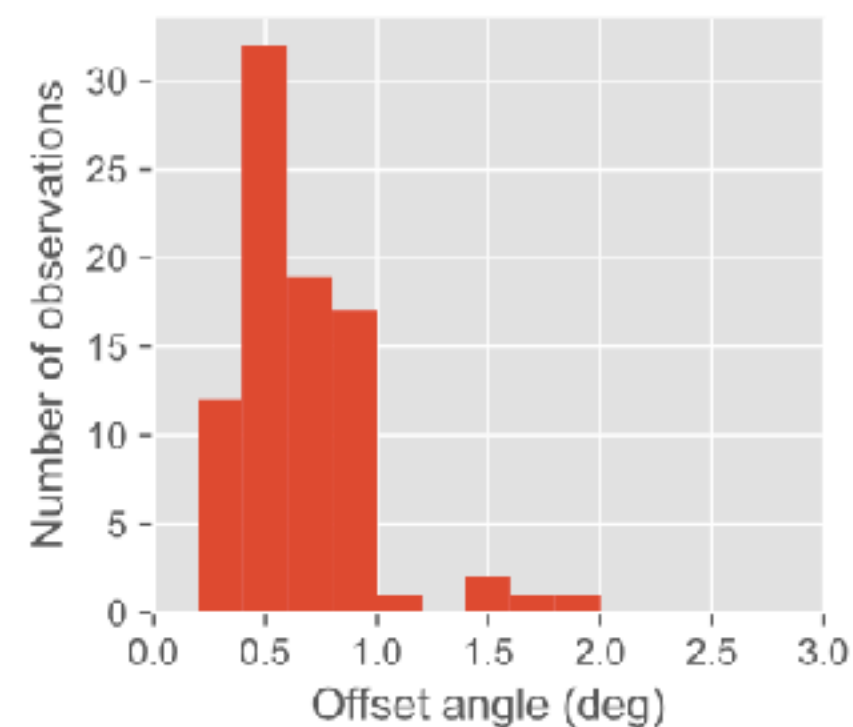
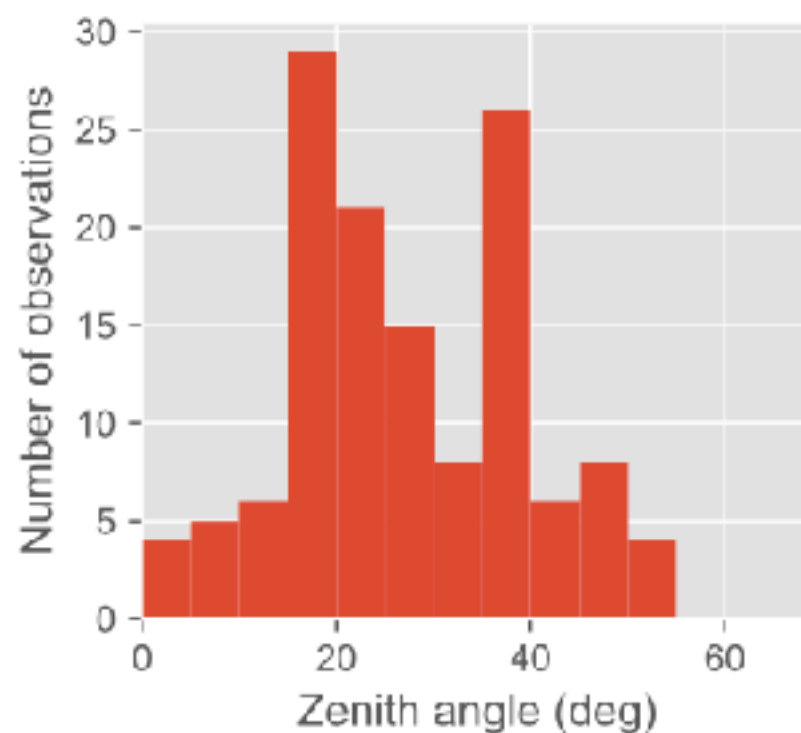
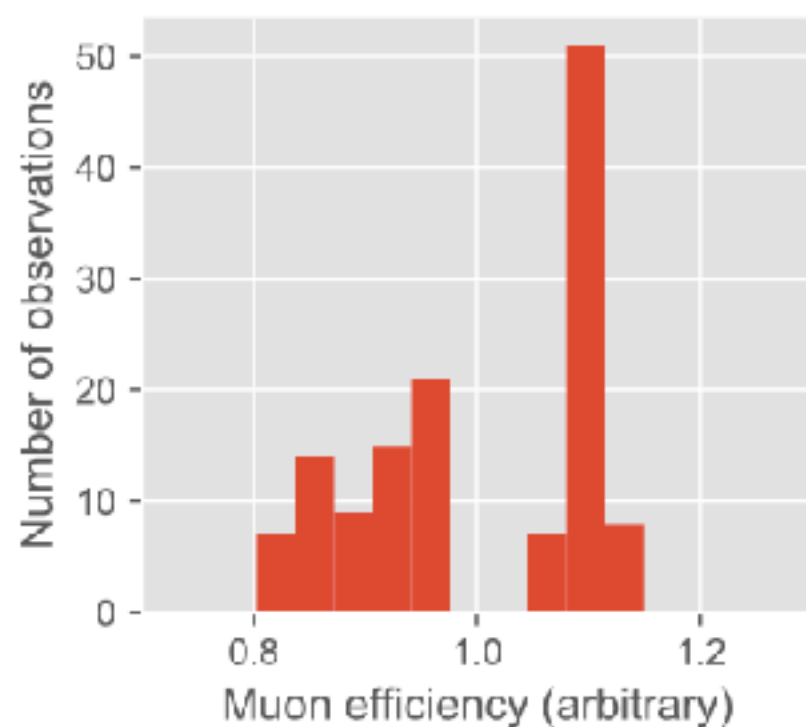
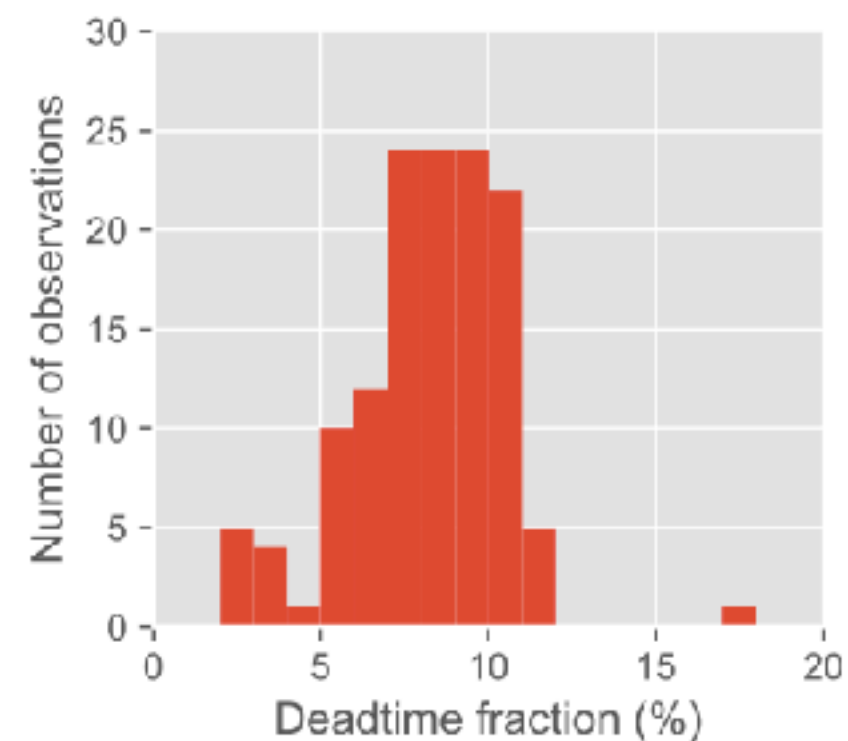
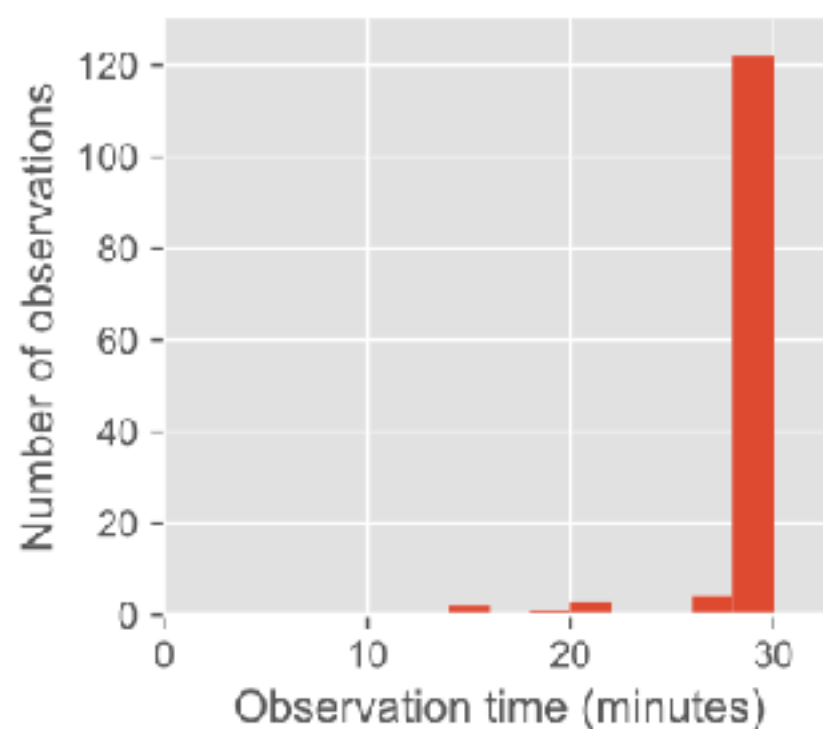
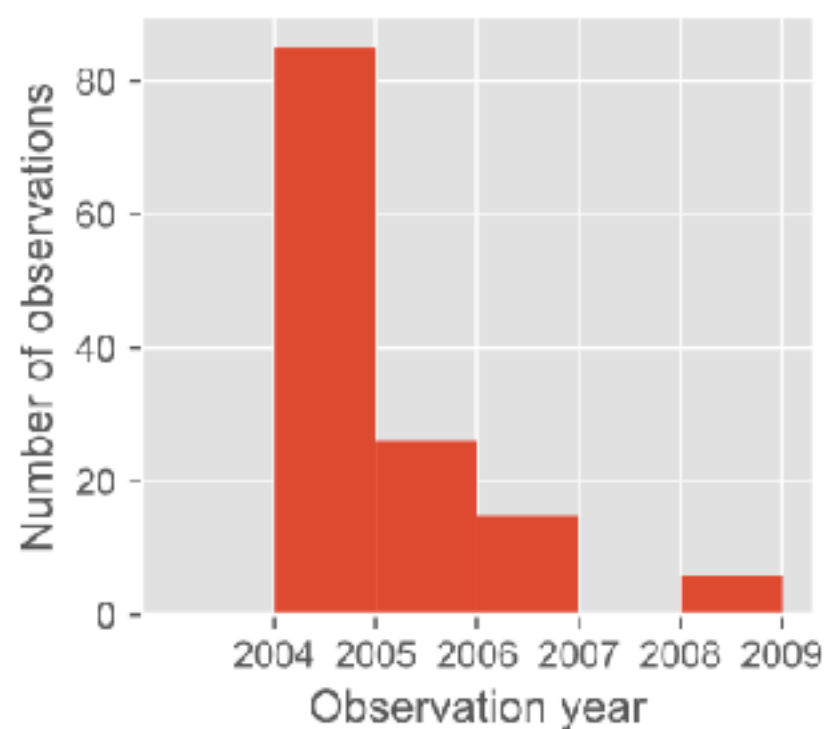
HESS DL3 DR1, H.E.S.S. collaboration

These terms of use must be included in all copies in full or part of the data.

For information on context, aims, use and contacts, as well as a description of the dataset, see the `hess_dl3_dr1.pdf` document.

DATASET

Summary: 100 decade-old good-quality HESS 1 runs (4 tel only)



H.E.S.S. DL3 DR1 – TARGET AND DATA SELECTION

Source name	Type	Size	H.E.S.S. publications
Crab nebula	PWN	Point-like	[5]
PKS 2155-304	AGN	Point-like	[6], [7], [8]
MSH 15-5 02	PWN	Small	[9]
RX J1713.7-3946	SNR	Large	[10], [11]

Table 2.1: Sources include in this release. The H.E.S.S. publications are only given for reference, the datasets from these publications do not match the ones released here.

Source Name	N _{obs}	Time (h)	Dates
Crab	4	1.9	2004-12-04 - 2004-12-08
PKS 2155-304 (steady)	6	2.8	2008-08-27 - 2008-08-28
PKS 2155-304 (flare)	15	7.0	2006-07-29 - 2006-07-30
MSH 15-52	20	9.1	2004-03-26 - 2004-04-19
RX J1713.7-3946	40	18.3	2004-04-16 - 2004-05-22
Off data	47	21.6	2004-03-16 - 2005-11-20

Table 2.2: Observation dataset summary. Time is the observation time in hours. N_{obs} is the number of observations. Observation dates is the time range when the observations took place. Information on the available event statistics in these datasets is given in Table 2.3.

DL3 IN HESS

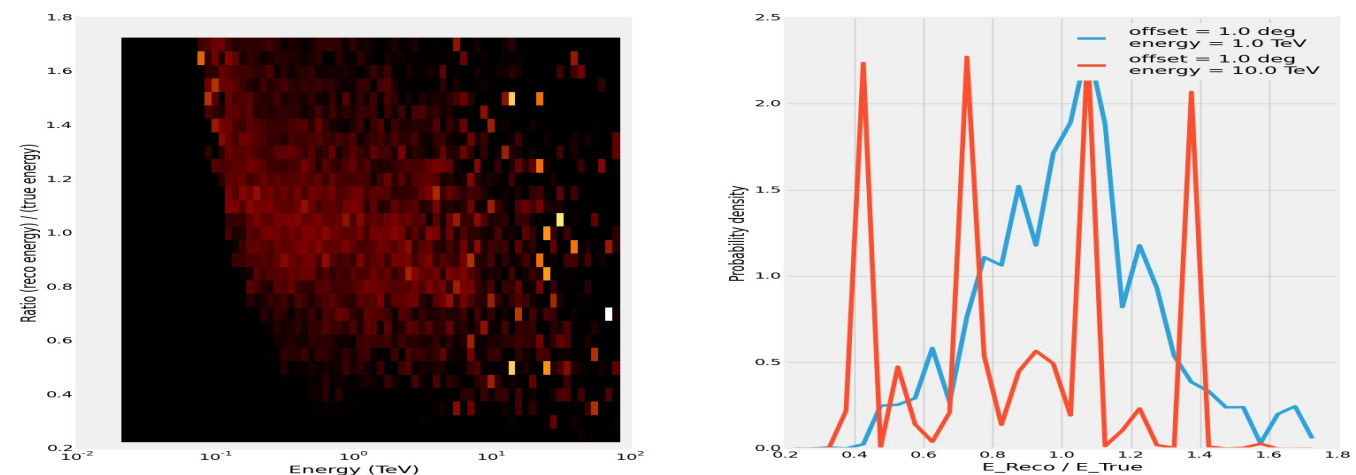
- FITS DL3 production and analysis has been a task in HESS for the past 5 years
- Limited by manpower, it's a large task and it's hard to get people to work on scripts & checks (e.g. ParisAnalysis chain was one person and now no-one).
- No paper based on HESS FITS data yet
 - What's the reason?
 - Data / tools weren't ready?
 - Picked wrong science analysis projects?
- Short term: focus on HESS test data release

BACKUP SLIDES

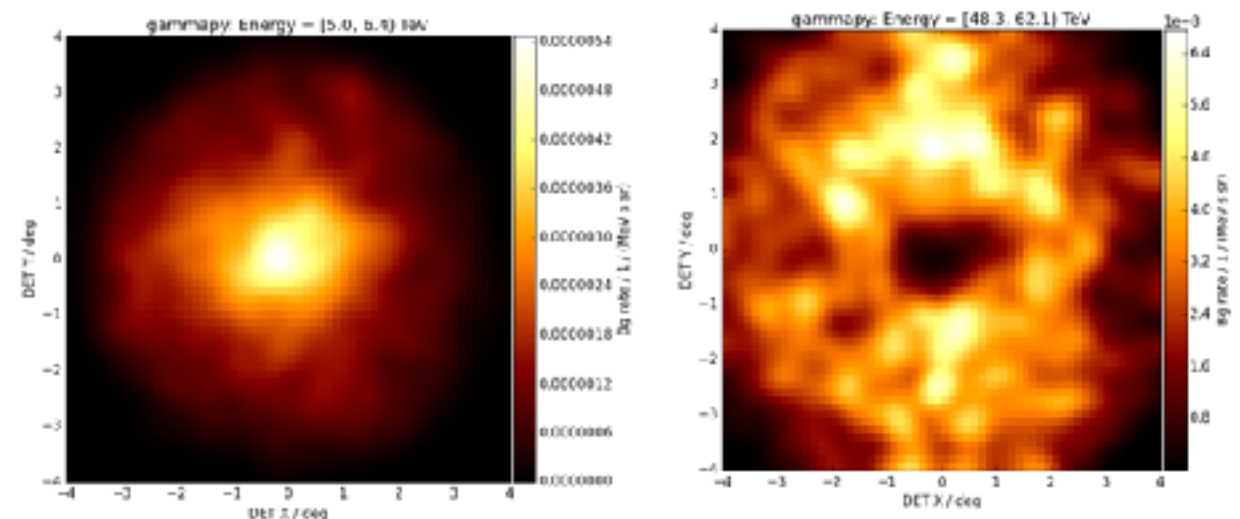
Issues with histogram IRFs

- In HESS we use histogram IRFs for energy dispersion (edisp2d) and background (bkg3d).
- As you can see on the right, these can become very noisy...
- Started investigating smoothing and analytical models for energy dispersion and background ...

Energy dispersion example



Background example



Low energy: stats OK!

High energy: low stats!

Issues with analytical IRFs

- In HESS we use analytical PSF models, such as `_psf_3gauss`.
- For some configs / observations / energy / offset bins, the analytical fit doesn't converge.
- Started investigating if 2-Gauss or King profile is good enough, or if smoothed histogram PSF would work better.

Incorrect PSF model because of non-converging triple-Gauss PSF analytical model fit.

