

ObsCore for High Energy Astrophysics



*IVOA Tucson
2023-11-11*

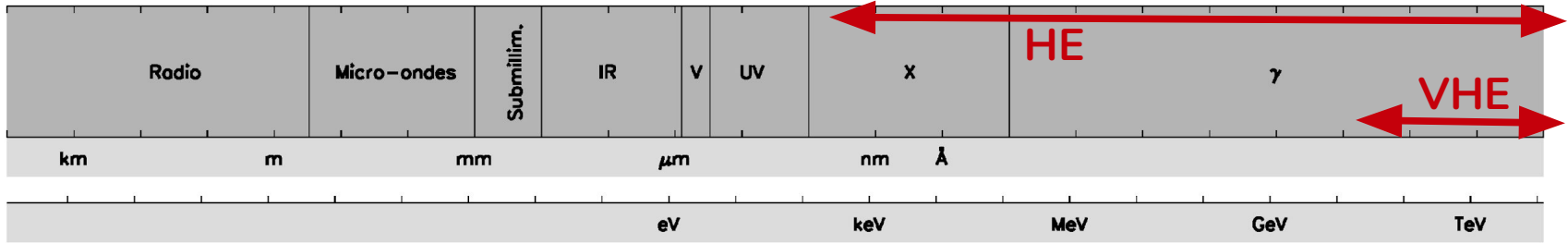


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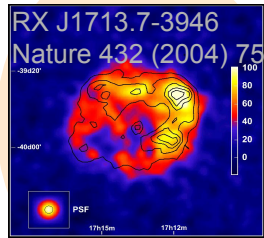


- ◆ Violent, transient, non-thermal phenomena
- ◆ Matter under extreme conditions
- ◆ Particle Acceleration
- ◆ Fundamental Physics
- ◆ Role of Black Holes in the structuration of the Universe

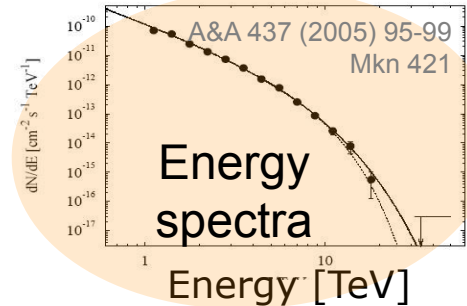
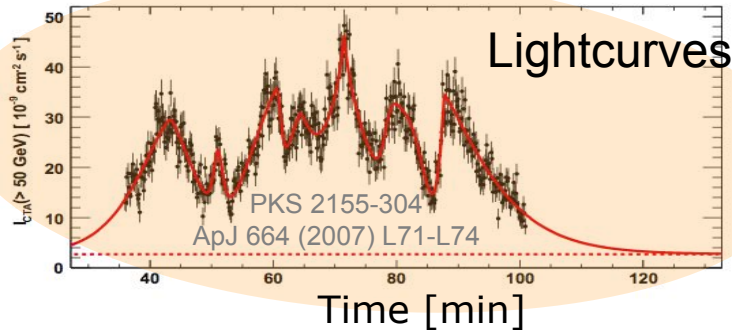
High Energy Astrophysics



Several orders of magnitude - Event **counting** - Low count **statistics** - High background
→ **Event lists** (coordinates, time, energy)



Images



+ **multi-messenger data** (photons, cosmic rays, neutrinos, gravitational waves...)

HE dedicated workshop at OV-France

- **October 2022 in Strasbourg**
 - <https://indico.obspm.fr/event/1489>
- Continue activities of the **ESCAPE European project** that focused on High Energy Facilities (**2019-2023** H2020 project).
- Bring together representatives of high energy observatories (VHE, HE, GW, neutrino)
- Presentations of HE observatory operations and data:
 - CTA (Mathieu Servillat)
 - Ligo Virgo Kagra (Pierre Chanial)
 - Neutrino (Damien Dornic)
 - XMM & SVOM (Laurent Michel)
 - GADF/VODF (Bruno Khelifi)

HE meeting at IVOA Interop

- In May 2023 at the IVOA Bologna
 - Dedicated talk at the DM session by M. Servillat:
 - https://wiki.ivoa.net/internal/IVOA/IntropMay3023DM/2023-05-11_IVOA_meeting_-_VOHE.pdf
 - Fruitful splinter IVOA meeting
- Creation of HE “club”
 - IVOA mailing list and wiki page
 - <https://wiki.ivoa.net/twiki/bin/view/IVOA/HEGroup>
 - Several online meetings
 - IVOA data models (cube, dataset)
 - Detailed of HE data, with a focus on Instrument Response Functions

Second OV-France workshop enlarged to IVOA

- **June 2023 in Paris**
 - *IVOA standards for High Energy Astrophysics*
 - <https://indico.obspm.fr/event/1963>
 - <https://etherpad.in2p3.fr/p/VOHE-2023-06>
- Review of previous notes and documents since 2021
- Focus on user scenarios in HE
 - Access and Analysis of HE data
 - IVOA used standards
 - What specific developments are needed
- Prepare an IVOA Note to justify a HE Interest Group
 - <https://share.obspm.fr/s/CFk7xGJKYRiNbaE>

Content of the Note

- Common practices and concept of event-list
 - **Lower level** dataset, used to generate images, lightcurves, spectra
 - Generally **reprocessed** from event lists for a dedicated analysis
 - Calibrated data, but instrument signature not totally removed
 - **Instrument Response Functions** (IRFs) are tightly connected
- Data Discovery
 - Is there missing information in an **ObsCore** record for a HE event list?
 - Possible extension for HE (see e.g. extension for radio astronomy)
- An Event List data model
 - Would describe the context of an event dataset
 - **Relations** to IRF and Instrument Configuration
- Modelling the content of an Event List
 - Cube and Dataset Data Model (see talk by MCD in this session)

HE “event” in the VO



a HE event is **not** a VOEvent

<https://www.ivoa.net/documents/ObsCore>

event: An event-counting (e.g. X-ray or other high energy) dataset *of some sort*. Typically this is instrumental data, i.e., "event data". An event dataset is *often a complex object* containing multiple files or other substructures. An event dataset *may contain* data with spatial, spectral, and time information for each measured event, although the spectral resolution (energy) is sometimes limited. Event data may be used to produce higher level data products such as images or spectra.

<http://www.ivoa.net/rdf/product-type> (Preliminary)

event-list: A collection of observed events, such as incoming high-energy particles. A row in an event list is typically characterised by a spatial position, a time and an energy.

ObsCore for Cherenkov event datasets

- Filling the ObsCore fields...
 - **dataprodct_subtype**
 - indicate a specific data format? (e.g. VODF) → data_format?
 - particle_type : e.g. expected particle in the event list (gamma, neutrino, protons, muons...)
 - **calib_level** = between 1 and 2... as IRFs needs to be applied
 - **obs_collection**
 - concept of **release**: analysis_type, software used and version calibration used, release description, docurl, doi...
 - **s_ra, s_dec** = telescope pointing coordinates, epoch? non-pointing telescopes?
 - **target_name**: several targets may be in a large field of view
 - **s_fov, s_region, s_resolution, em_resolution...** all those values are energy dependent
 - value at a given energy?
 - or range of values?
 - **em_min, em_max**: add fields expressed in TeV
 - **t_exptime**: ontime, livetime, stable time intervals... maybe a T-MOC would help
 - **facility_name, instrument_name**: minimalist, would be e.g. CTAO and a subarray
 - many fields are empty or null

Example of H.E.S.S. DL3 public data release

http://voparis-tap-he.obspm.fr/system/_/dc_tables/show/tableinfo/hess_dr.obscore

Table List

- 4: hess_dl3_dr1_obs_id_020343.fits.gz-3
- 5: hess_dl3_dr1_obs_id_020343.fits.gz-4
- 6: hess_dl3_dr1_obs_id_020343.fits.gz-5
- 7: hess_dl3_dr1_obs_id_023523.fits.gz
- 8: hess_dl3_dr1_obs_id_023523.fits.gz-2
- 9: hess_dl3_dr1_obs_id_023523.fits.gz-3
- 10: hess_dl3_dr1_obs_id_023523.fits.gz-4
- 11: hess_dl3_dr1_obs_id_023523.fits.gz-5

Current Table Properties

Label: hess_dl3_dr1_obs_id_023523.fits.gz
Location: https://hess-dr.obspm.fr/retrieve/hess_
Name: EVENTS-1
Rows: 7,613
Columns: 5

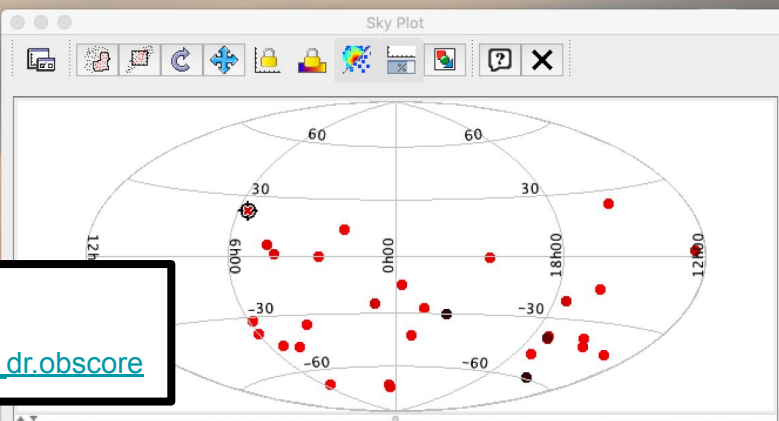


Table Browser for 1: TAP_2_hess_dr.vo.obscore

datapro...	datapro...	calib_le...	obs_colle...	obs_id	obs_	
47	event	events	2	HESS-DR	22593	ivo:/
48	event	events	2	HESS-DR	22997	ivo:/
49	event	events	2	HESS-DR	23040	ivo:/
50	event	events	2	HESS-DR	23077	ivo:/
51	event	events	2	HESS-DR	23143	ivo:/
52	event	events	2	HESS-DR	23246	ivo:/
53	event	events	2	HESS-DR	23523	ivo:/
54	event	events	2	HESS-DR	23526	ivo:/
55	event	events	2	HESS-DR	23559	ivo:/
56	event	events	2	HESS-DR	23573	ivo:/
57	event	events	2	HESS-DR	23592	ivo:/
58	event	events	2	HESS-DR	23635	ivo:/
59	event	events	2	HESS-DR	23651	ivo:/
60	event	events	2	HESS-DR	23736	ivo:/
61	event	events	2	HESS-DR	25345	ivo:/

Metadata

Find: hess

Service Capabilities

Query Language: ADQL-2.0 Max Rows: 200

ADQL Text

Mode: Synchronous

```
SELECT TOP 1000 * FROM hess_dr.vo.obscore
```

Run Query

Position: Count: 105 / 105

Sky Plot

Position: Count: 3,275 / 7,613

Additional ObsCore fields for HE

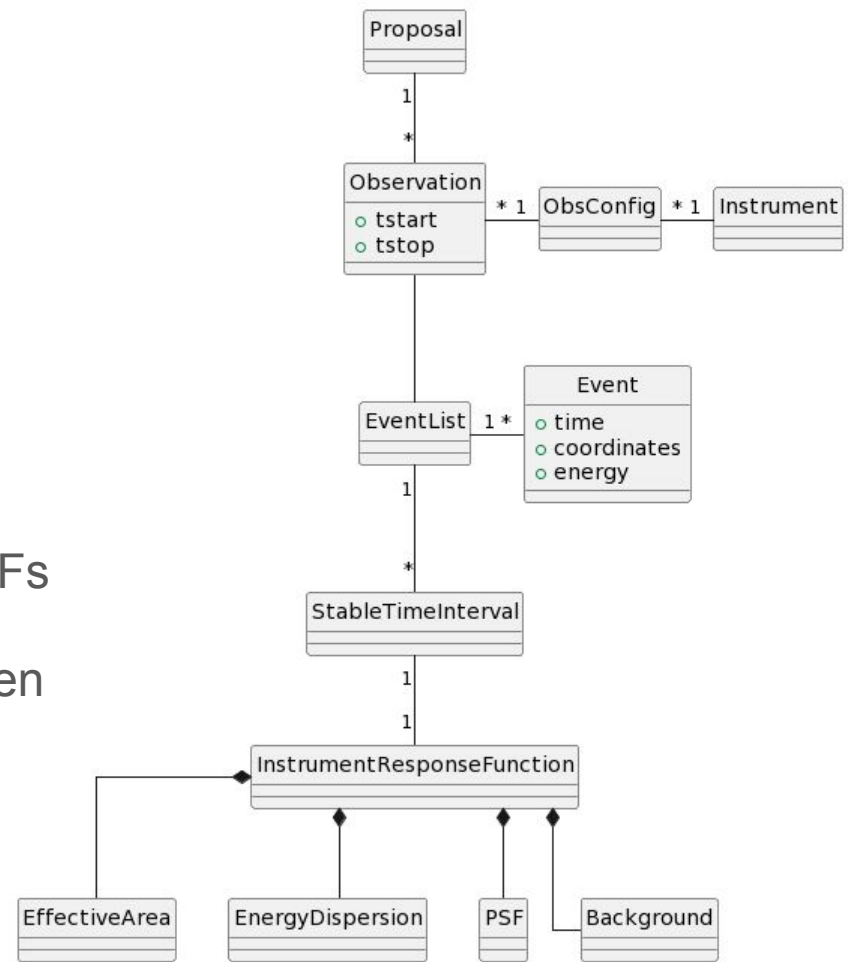
- Specific units
 - Use of keV, GeV, TeV in the HE domain... but **em_*** fields are in meters
 - Possible truncation of information if not stored as a double
 - Duplicate with dedicated fields? **em*_tev**?
- Related to the Observation Configuration
 - **obs/pointing/tracking_modes**? see scan mode for radio astronomy
 - New fields if relevant for data selection
- Related to the Instrument properties
 - Complex instrument, e.g. array of different Cherenkov telescopes
- Related to Provenance
 - Direct link to the detailed provenance (or DataLink?)
 - We could define a specific activity : “data release publication”
 - include an activity description, including a docurl

Event-list Data Model

- Issue
 - what is really in the event-list dataset?
 - does it include IRFs? only an event-list?
 - where can one find the corresponding IRFs?
- Mapping with ObsCore fields
 - dataproduct_subtype?
 - obs_collection?
- Need a way to link an EventList to its IRFs

→ Having a data model with relations between those elements would help

→ possible ObsCore extension fields would appear in this data model



Conclusion and discussion

- HE domain have specificities
- In particular the concepts of event-list and IRFs
- Limited number of VO services giving access to event-lists
- On the path to build an HEIG at IVOA

- Questions for the DM WG:
 - How to deal with several ObsCore extensions for different domains?
(few fields may be relevant fro several domains)
 - Should we add fields that duplicate information in different units?
 - Role of Datalink to connect event-list and IRFs?