

High Energy Astrophysics in the Virtual Observatory



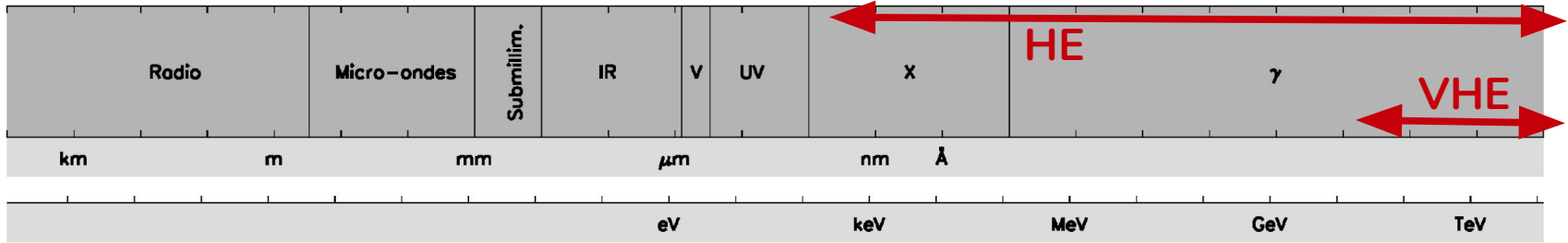
*IVOA Bologna meeting
2023-05-11*

Mathieu Servillat (LUTH - Observatoire de Paris / CNRS)

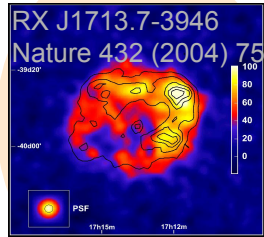


- ◆ Violent, transient, non-thermal phenomena
- ◆ Matter under extreme conditions
- ◆ Particle Acceleration
- ◆ Fundamental Physics
- ◆ Role of Black Holes in the structuration of the Universe

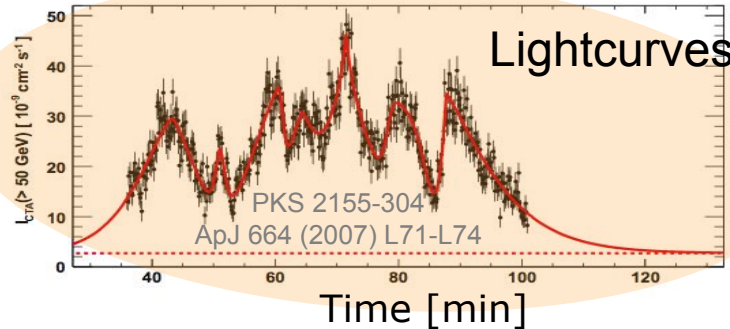
High Energy Astrophysics



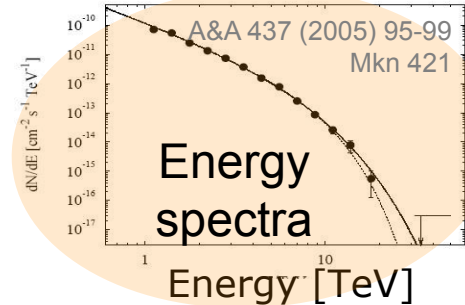
Several orders of magnitude - Photon **counting** - Low count **statistics** - High background
→ **Event lists** (coordinates, time, energy)



Images



Lightcurves



Energy spectra

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

A HE “event” in the VO

<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.



a HE event is **not** a VOEvent

ASOV dedicated workshop

- October 2022 in Strasbourg - <https://indico.obspm.fr/event/1489>
- *The aim was to bring together representatives of high energy observatories (GW, neutrino, VHE, HE) in order to share practices for the distribution and analysis of their data and to improve interoperability. In particular, we want to assess the need to define a common model of a high energy event (detection probably associated with a photon or a high energy phenomenon) and its dependencies (instrumental response, ...).*
- Presentations of HE observatory operations and data:
 - CTA (Mathieu Servillat)
 - Ligo Virgo Kagra (Pierre Chaniel)
 - Neutrino (Damien Dornic)
 - XMM & SVOM (Laurent Michel)
 - GADF/VODF (Bruno Khelifi)

Next meeting in Paris - 28-29 June 2023

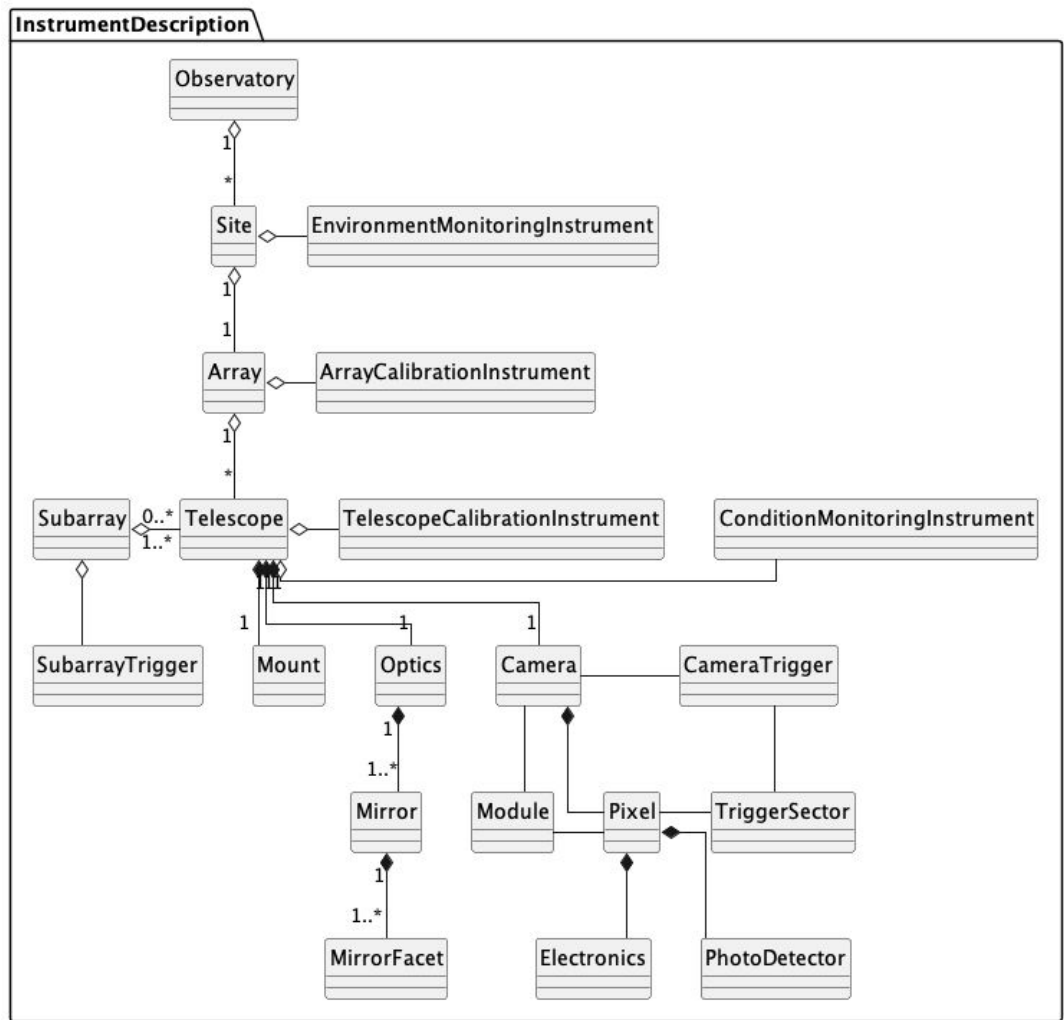
Main topics of interest

- Event list properties
 - **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 (see ObsCore calib_level... between 2 and 3)
 - **Instrument Response Functions** (IRF) are needed
- 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

ObsCore for Cherenkov event datasets

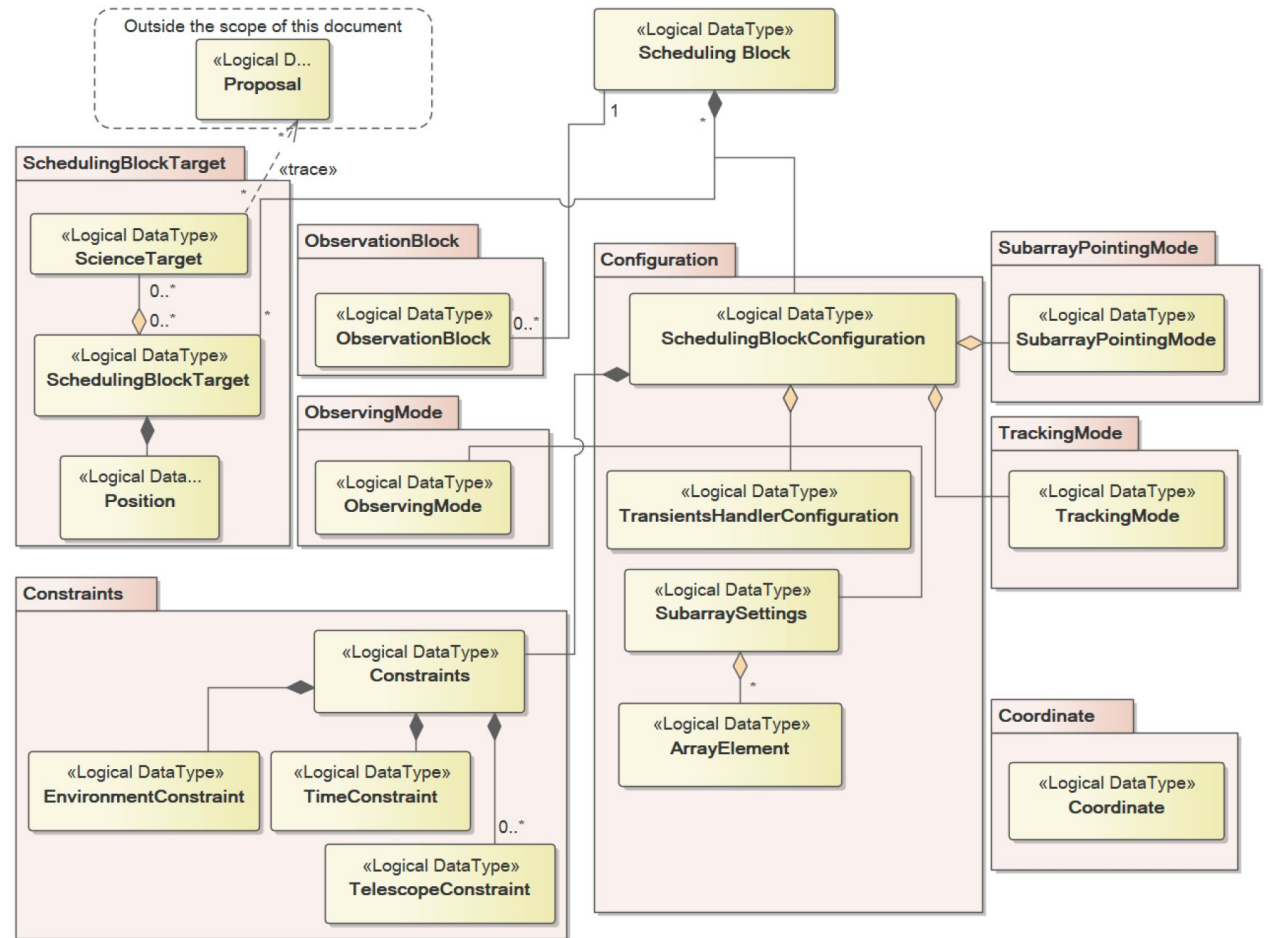
- Example of H.E.S.S. DL3 public data release
 - http://voparis-tap-astro.obspm.fr/_system_/dc_tables/show/tableinfo/hess_dr.vo_obscore
- Filling the ObsCore fields...
 - **dataprodct_subtype** = DL3, maybe specific data format (VODF)
 - **calib_level** = between 2 and 3...
 - **obs_collection** could contain many details : obs_type (calib, science), obs_mode (subarray configuration), pointing_mode, tracking_mode, event_type, event_cuts, analysis_type...
 - **s_ra, s_dec** = telescope pointing coordinates
 - **target_name** : several targets may be in the field of view
 - **s_fov, s_region, s_resolution, em_resolution...** all those values are energy dependent
 - value at a given energy?
 - 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

CTA Instrument Description



CTA Scheduling Block DM

class Scheduling_Block_Overview



TOPCAT

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

SAMP
 Messages: Clients:

109 / 1821 M

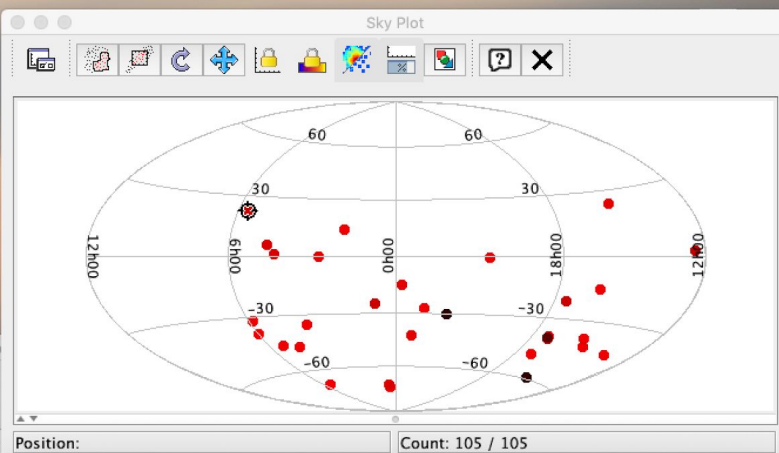


Table Access Protocol

TOPCAT(1): 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

Name Descrip Or

HESS DL3 DR1 (1/18)

- hess_dr (1/1)
 - hess_dr.vo_obscore

Tables: hess_dr (1)

Description: The releas response f for observ

Service Capabilities

Query Language: ADQL-2.0 Max Rows: 200

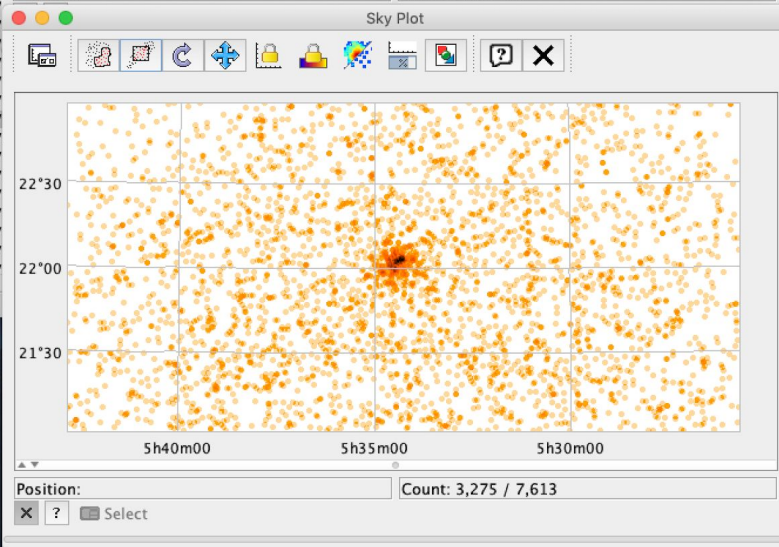
ADQL Text

Mode: Synchronous

SELECT TOP 1000 * FROM hess_dr.vo_obscore

Examples Basic 1/6: Full table

Run Query



EventList Data Model

- Issue
 - what is really in the event dataset?
 - does it include IRFs? only an event list?
 - where can one find the corresponding IRFs?
- Related 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

