Provenance for CTA data

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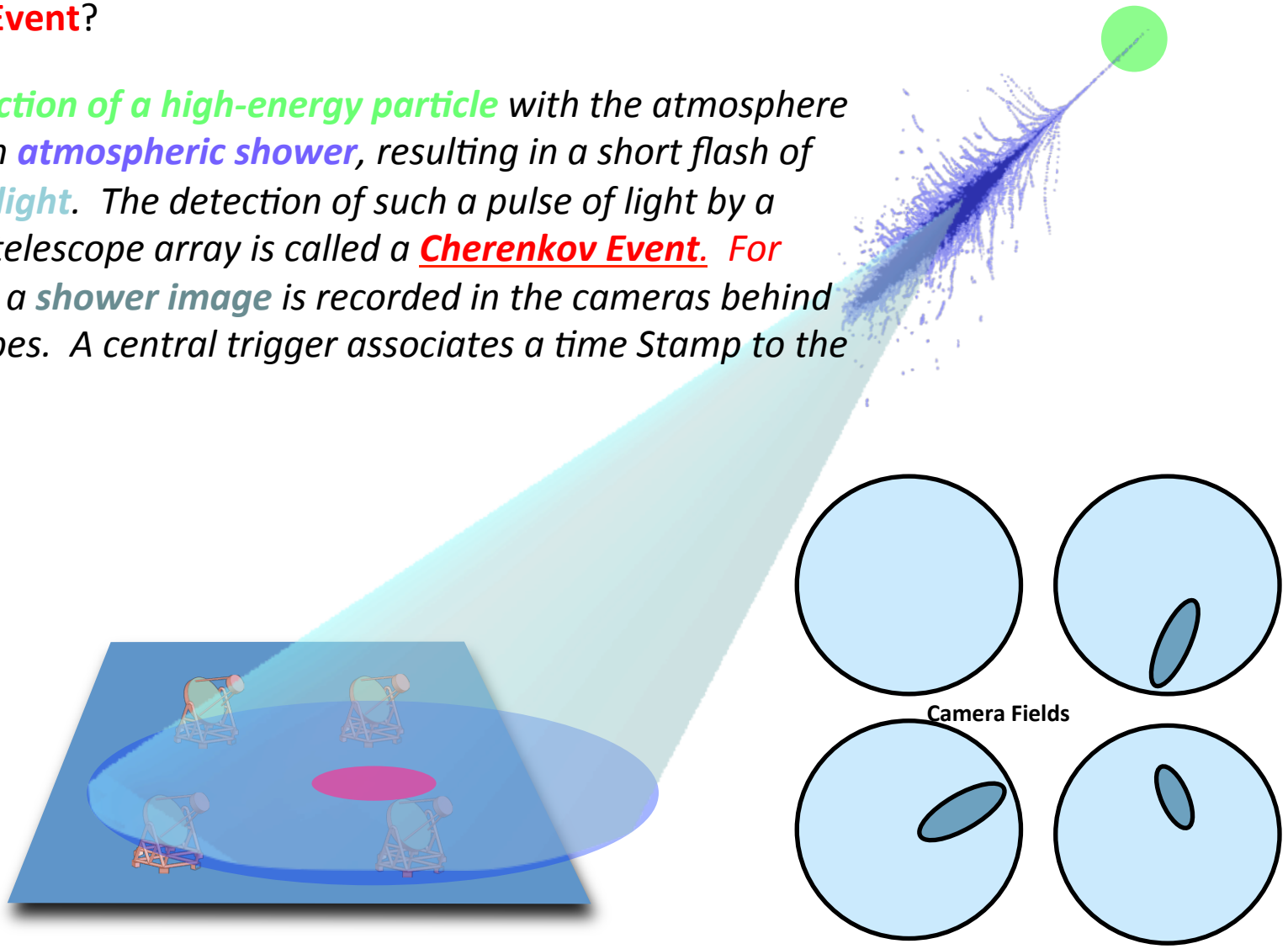
Atmospheric Cherenkov Telescopes Principle

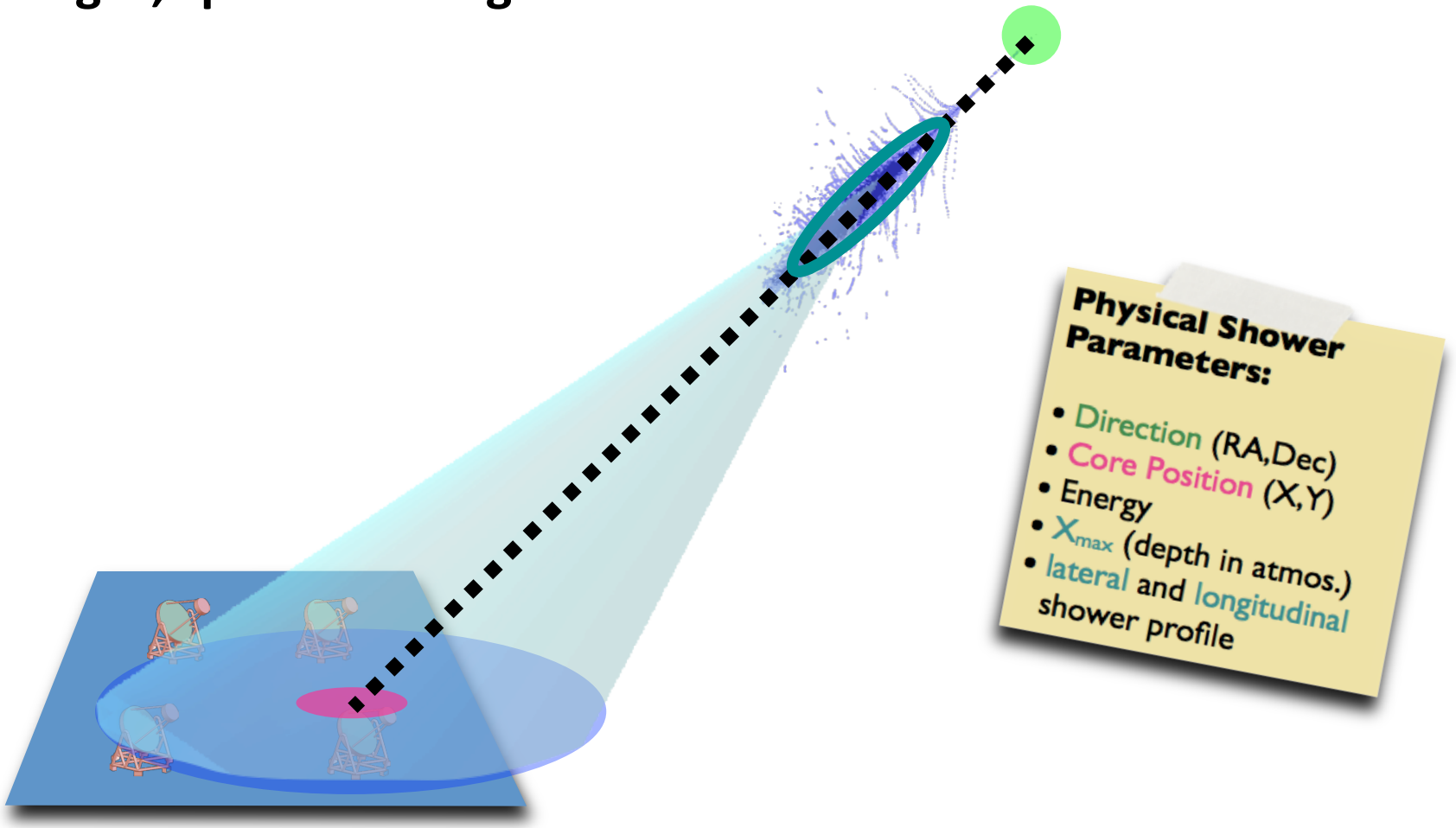
ACT Data are based on reconstructed **Events**.
What is an **Event**?

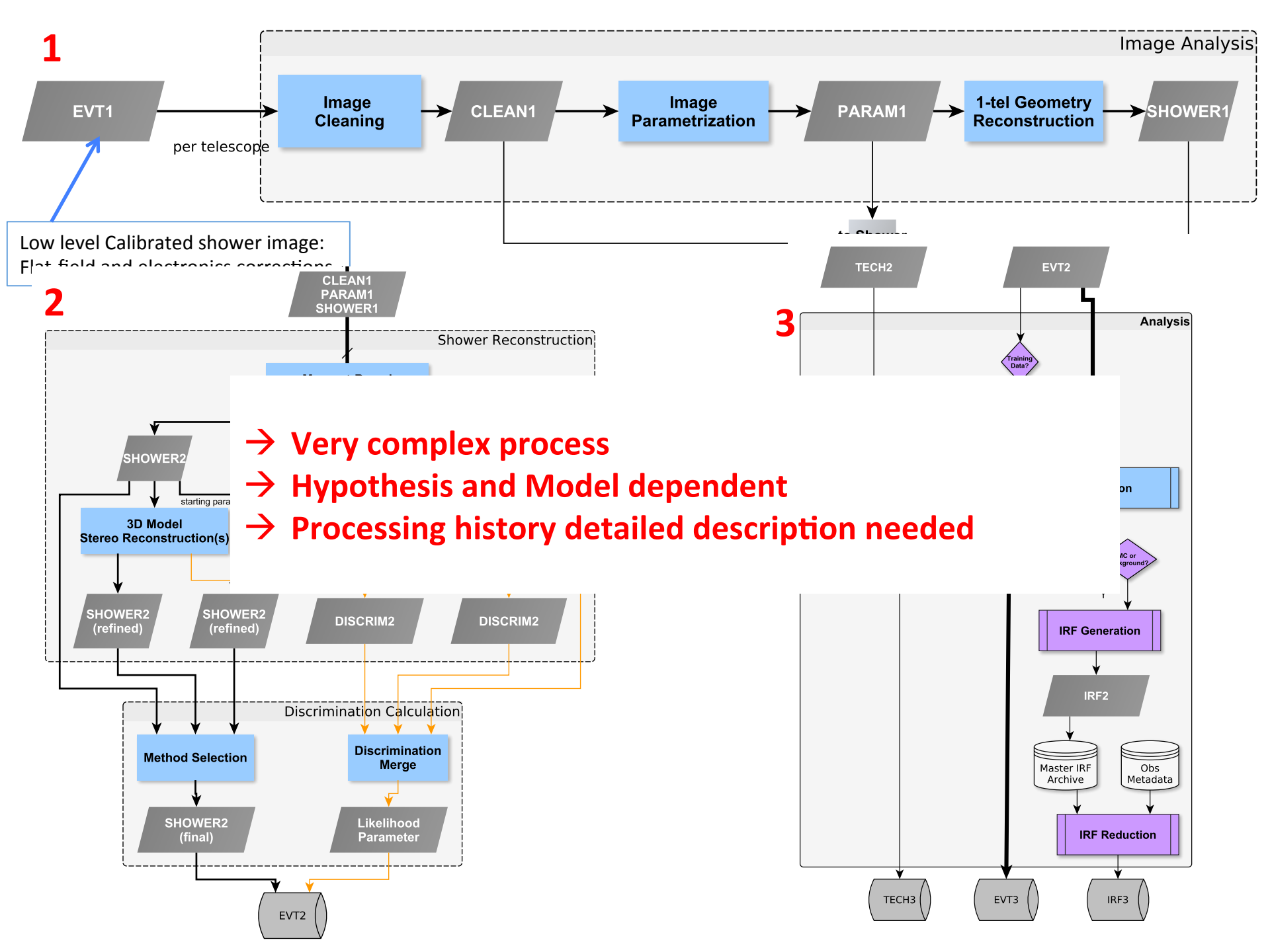
*"The **interaction of a high-energy particle** with the atmosphere produces an **atmospheric shower**, resulting in a short flash of **Cherenkov light**. The detection of such a pulse of light by a Cherenkov telescope array is called a **Cherenkov Event**. For each Event, a **shower image** is recorded in the cameras behind the telescopes. A central trigger associates a time Stamp to the Event"*



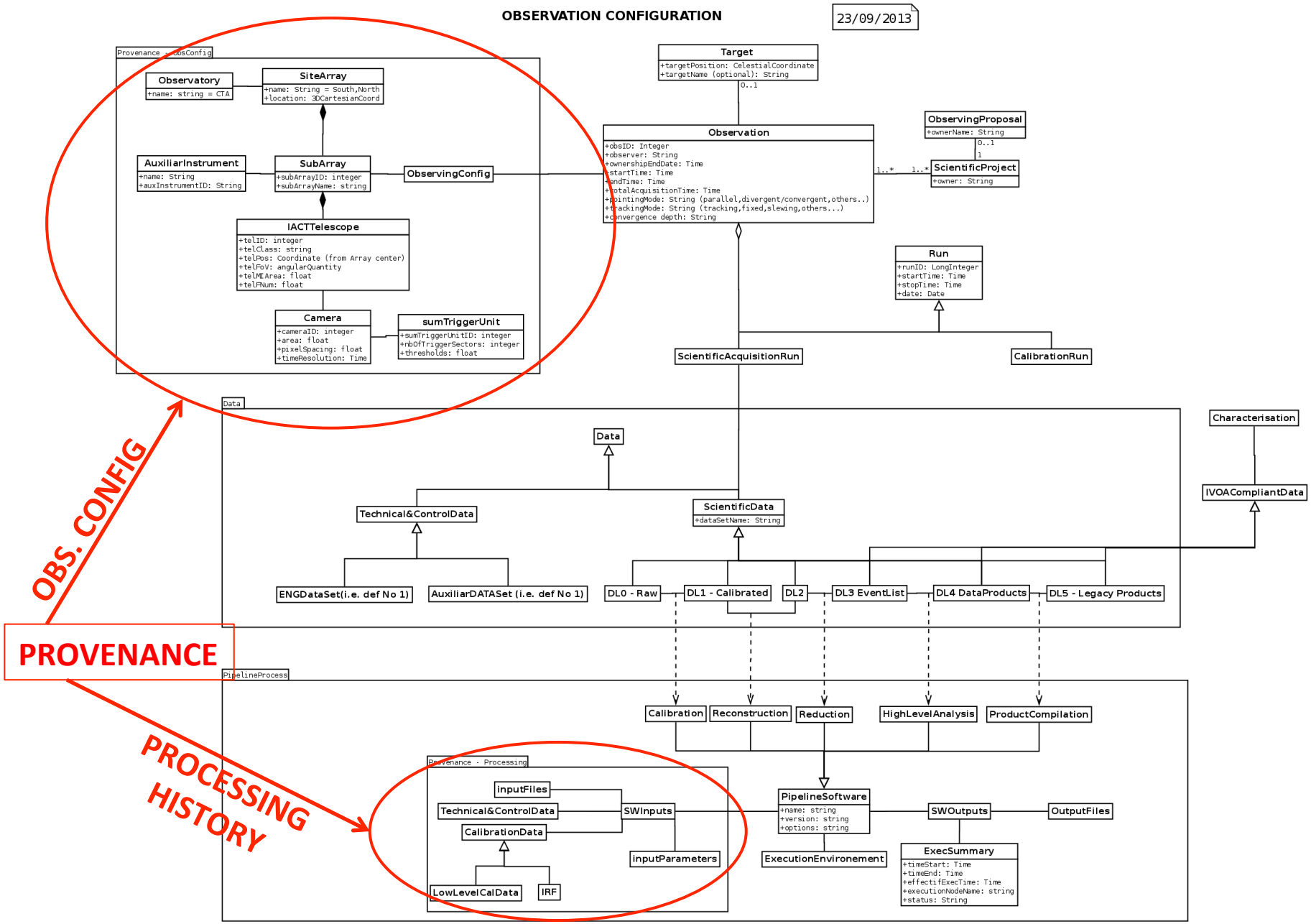
From shower footprints to astrophysical products…

- **Shower/Events parametrization and complex analysis**
- **Images, spectra and light curves are based on series of Events**

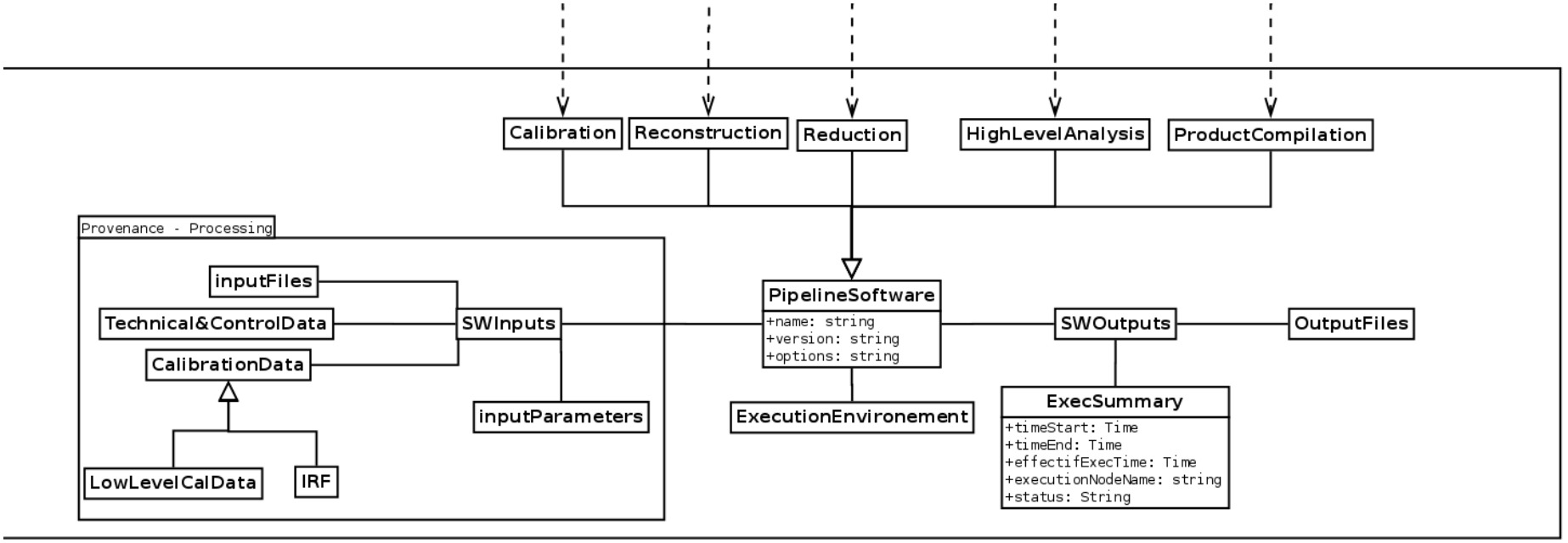



1
Image Analysis
EVT1
per telescope
Image Cleaning
CLEAN1
Image Parametrization
PARAM1
1-tel Geometry Reconstruction
SHOWER1
Low level Calibrated shower image:
2
CLEAN1
PARAM1
SHOWER1
Shower Reconstruction
SHOWER2
starting para
3D Model Stereo Reconstruction(s)
SHOWER2 (refined)
SHOWER2 (refined)
DISCRIM2
DISCRIM2
Discrimination Calculation
Method Selection
Discrimination Merge
SHOWER2 (final)
Likelihood Parameter
EVT2
TECH2
EVT2
3
Analysis
Training Data?
IRF Generation
IRF2
Master IRF Archive
Obs Metadata
IRF Reduction
TECH3
EVT3
IRF3
→ Very complex process
→ Hypothesis and Model dependent
→ Processing history detailed description needed

Pseudo-UML picture (Data & metadata included)



Processing history generic description



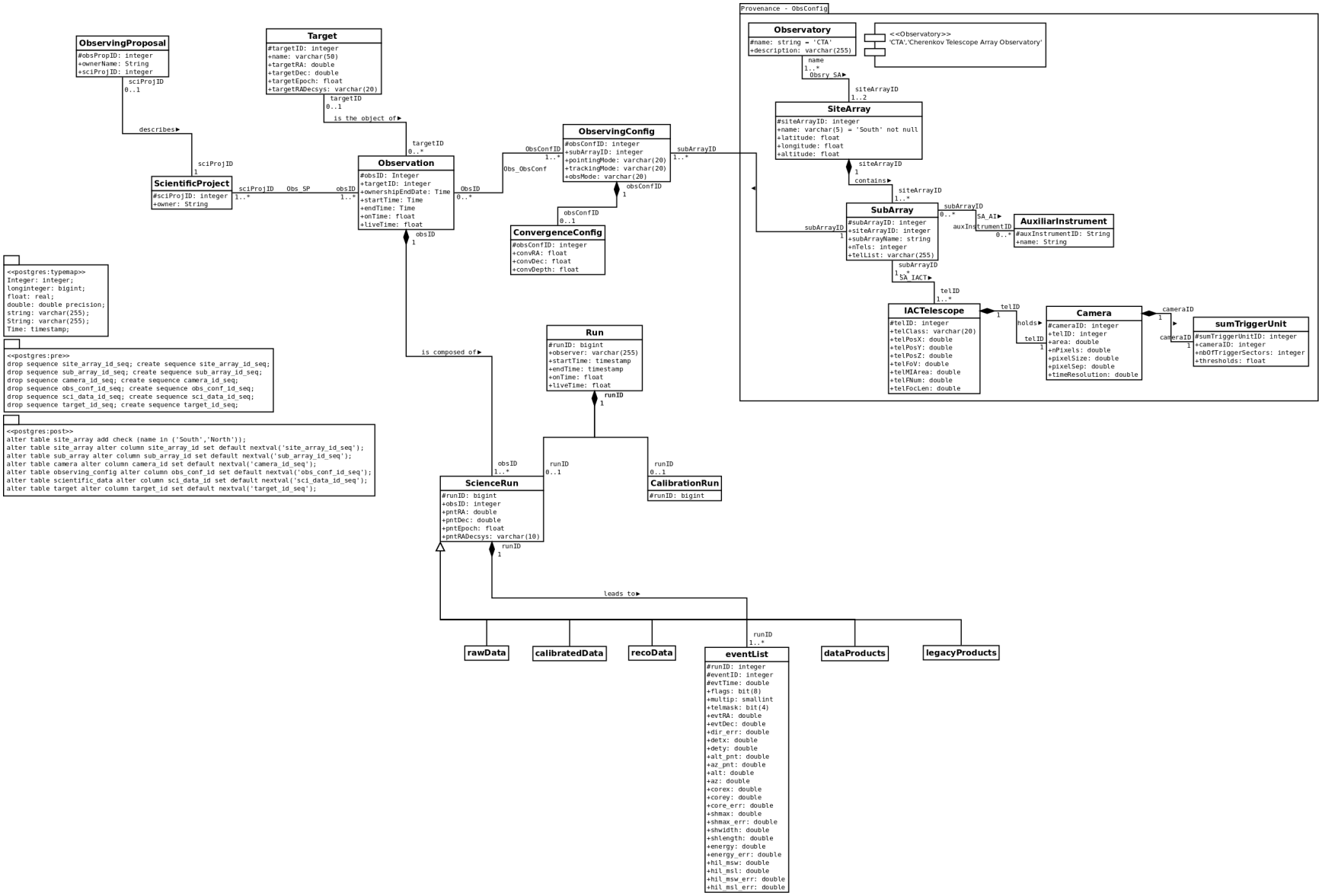
Must be rewritten to be fully UML compliant …

First efforts of implementation

- Bottom up approach:
  - Start implementing ObsCore
  - Evolve towards more complex DM: imageDM, spectralDM, dataLink for Provenance Info.

- Implementation of First CTA DataChallenge Data (CTA's ancestor's HESS Data)

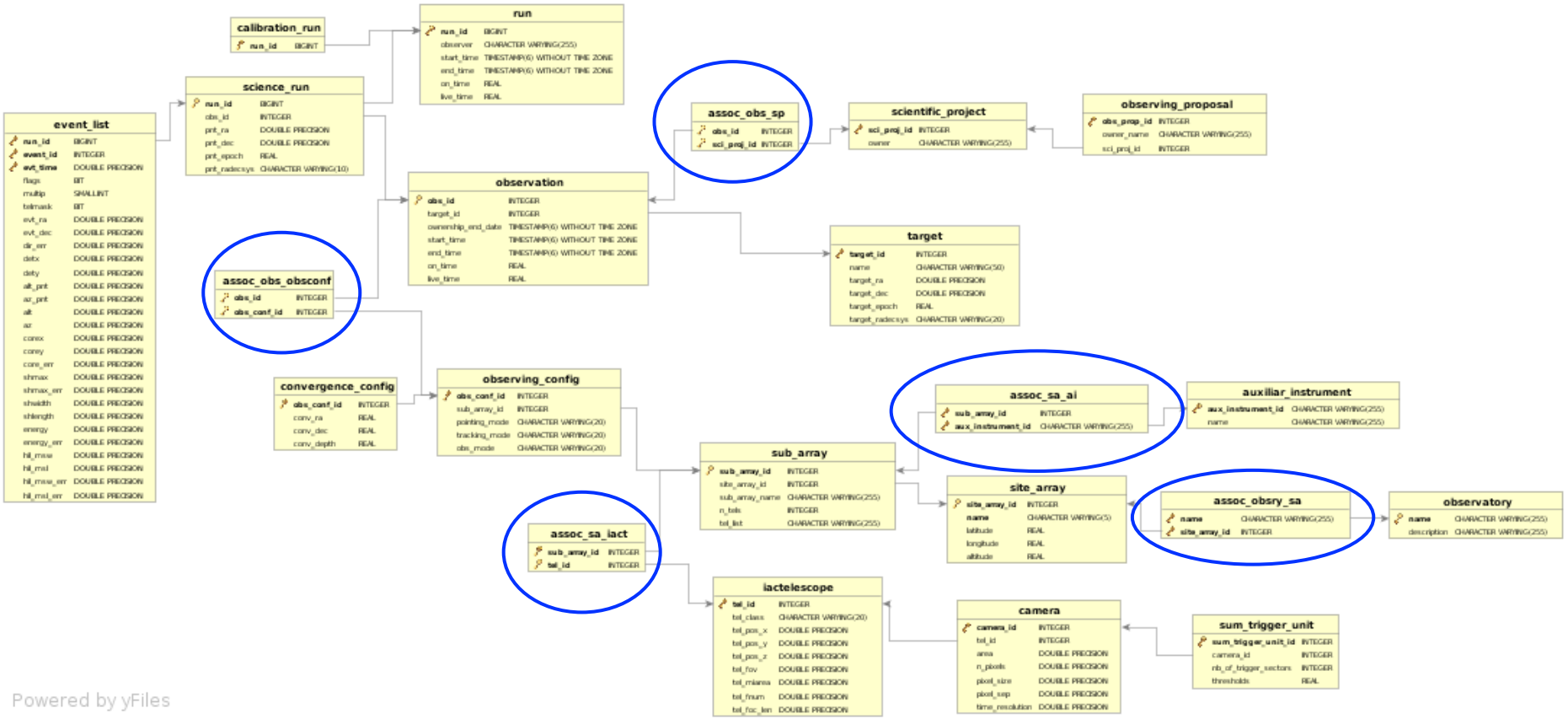
Section of the UML model using DIA



Data Model Implementation

- Automatic conversion **UML** to **SQL**
- Using DIA to create the UML diagram
- Scripts to generate the SQL code for PostgreSQL
- **Ingestion** of the CTA 1DC data files (Crab with HESS)
- **VO compatibility**: ObsCore data model view
- GAVO DaCHS to **expose** the ObsCore view
- **List of runs** accessible with VO protocols and services
- Support of **ADQL queries** through a web page
- TopCat with **TAP** (Table Access Protocol)

Structure of the PostgreSQL database after automatic conversion



(many to many associations in UML become association tables, encircled in blue)

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SQL code for ObsCore view

```
-- ObsCore view
CREATE OR REPLACE VIEW cta.vo_obscore AS
SELECT
   text 'eventlist' AS dataproduct_type
  ,integer '2' AS calib_level
  ,text 'CTA1DC_' || cast(o.obs_id as text) AS obs_collection
  ,cast(sr.run_id as text) AS obs_id
  ,text 'ivo://vopdc.obspm/cta#' || cast(sr.run_id as text) AS obs_publisher_did
  ,text 'http://cta/run_' || lpad(cast(sr.run_id as text),8,'0') || '_eventlist.fits' AS access_url
  ,text 'application/fits' AS access_format
  ,10000 AS access_estsize
  ,t.name AS target_name
  ,cast(sr.pnt_ra as double precision) AS s_ra
  ,cast(sr.pnt_dec as double precision) AS s_dec
  ,fov(o.obs_id) AS s_fov
  ,cast(scircle(spoint(sr.pnt_ra*pi()/180.0, sr.pnt_dec*pi()/180.0), fov(o.obs_id)*pi()/180.0) as text) AS s_region
  ,cast(0.1 as double precision) AS s_resolution
  ,cast(0.1 as double precision) AS s_resolution_min --optional
  ,cast(0.1 as double precision) AS s_resolution_max --optional
  ,tomjd(r.start_time) AS t_min
--  ,cast(r.start_time as text) AS t_min_iso
  ,tomjd(r.end_time) AS t_max
  ,r.on_time AS t_exptime
  ,cast(0.000001 as double precision) AS t_resolution
--  ,text 'em.energy' AS em_ucd --optional
--  ,text 'TeV' AS em_unit --optional
  ,cast(tev2meter(0.01) as double precision) AS em_min
  ,cast(tev2meter(100.) as double precision) AS em_max
  ,cast(null as text) AS em_res_power
  ,text 'em.energy' AS o_ucd
  ,cast(null as text) AS pol_states
  ,text 'CTA' AS facility_name
  ,text 'CTA' AS instrument_name
```

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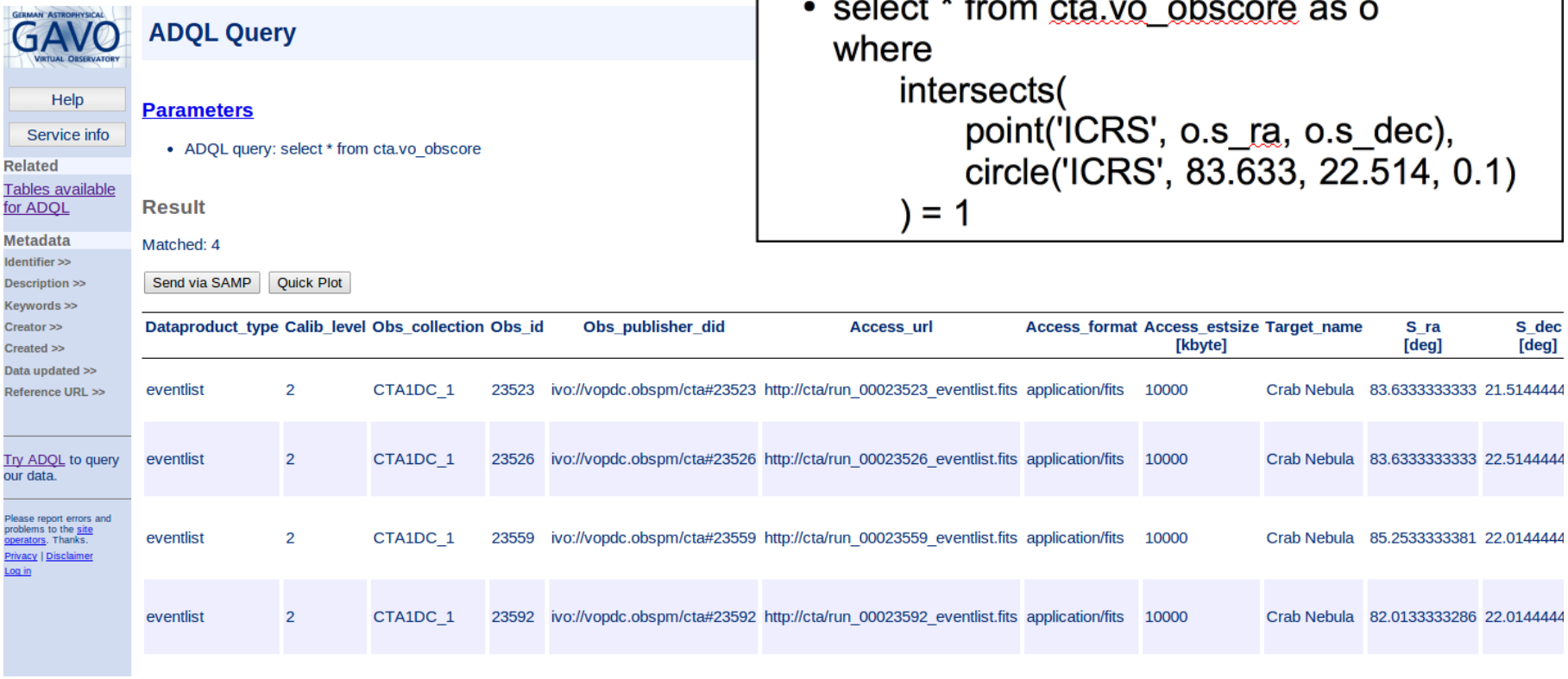
Now possible on a test server :
http://voparis-cdpp.obspm.fr/__system__/adql/query/form
Enter an ADQL query :

- select * from cta.vo_obscore
- select * from cta.vo_obscore as o
  where
  intersects(
  point('ICRS', o.s_ra, o.s_dec),
  circle('ICRS', 83.633, 22.514, 0.1)
) = 1



GAVO VIRTUAL OBSERVATORY

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Description >>
Keywords >>
Creator >>
Created >>
Data updated >>
Reference URL >>

Try ADQL to query our data.

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ADQL Query

Parameters

- ADQL query: select * from cta.vo_obscore

Result

Matched: 4

Send via SAMP | Quick Plot

Dataproduct_type	Calib_level	Obs_collection	Obs_id	Obs_publisher_did	Access_url	Access_format	Access_estsize [kbyte]	Target_name	S_ra [deg]	S_dec [deg]
eventlist	2	CTA1DC_1	23523	ivo://vopdc.obspm/cta#23523	http://cta/run_00023523_eventlist.fits	application/fits	10000	Crab Nebula	83.6333333333	21.5144444
eventlist	2	CTA1DC_1	23526	ivo://vopdc.obspm/cta#23526	http://cta/run_00023526_eventlist.fits	application/fits	10000	Crab Nebula	83.6333333333	22.5144444
eventlist	2	CTA1DC_1	23559	ivo://vopdc.obspm/cta#23559	http://cta/run_00023559_eventlist.fits	application/fits	10000	Crab Nebula	85.2533333381	22.0144444
eventlist	2	CTA1DC_1	23592	ivo://vopdc.obspm/cta#23592	http://cta/run_00023592_eventlist.fits	application/fits	10000	Crab Nebula	82.0133333286	22.0144444

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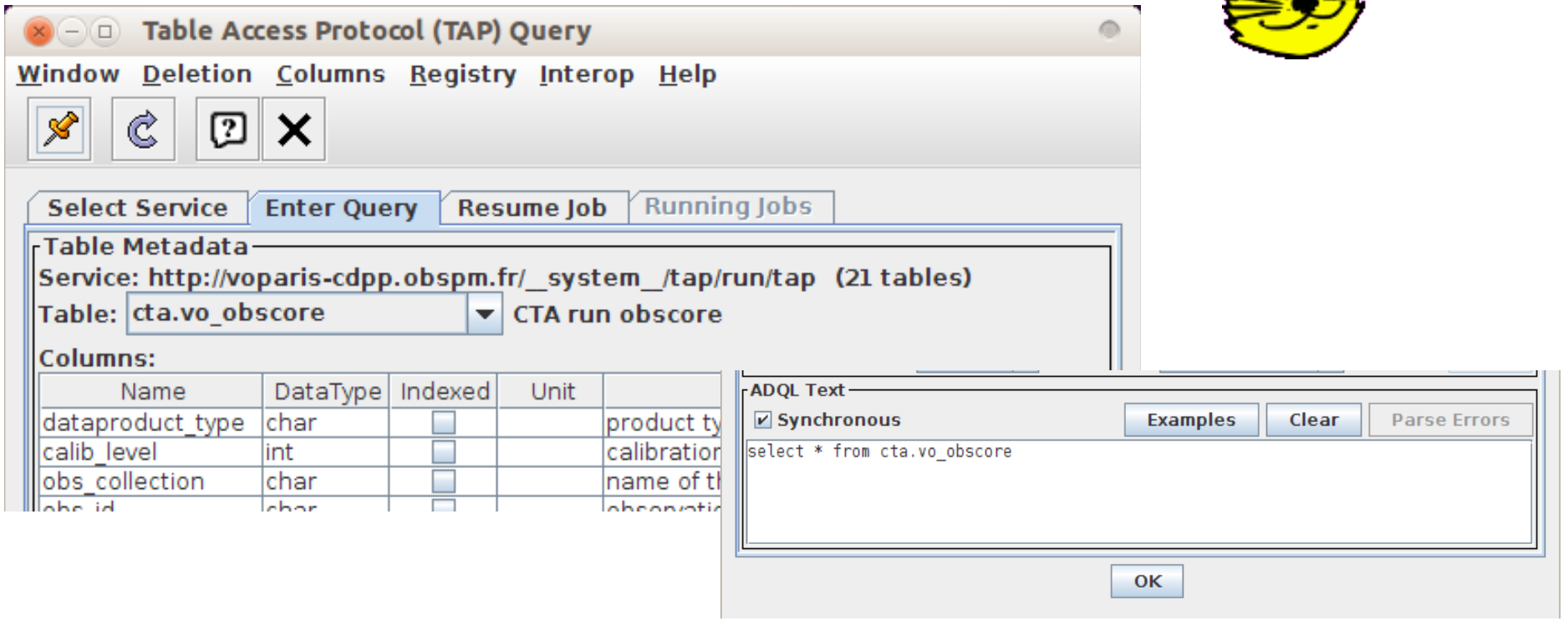
Query using Topcat

VO → Table Access Protocol (TAP) Query
In **Select Service**, enter **TAP URL** at the bottom :
http://voparis-cdpp.obspm.fr/__system__/tap/run/tap
Clic **Enter Query**
Select **Table** : cta.vo_obscore
Enter '**ADQL Text**' : select * from cta.vo_obscore, clic **OK**



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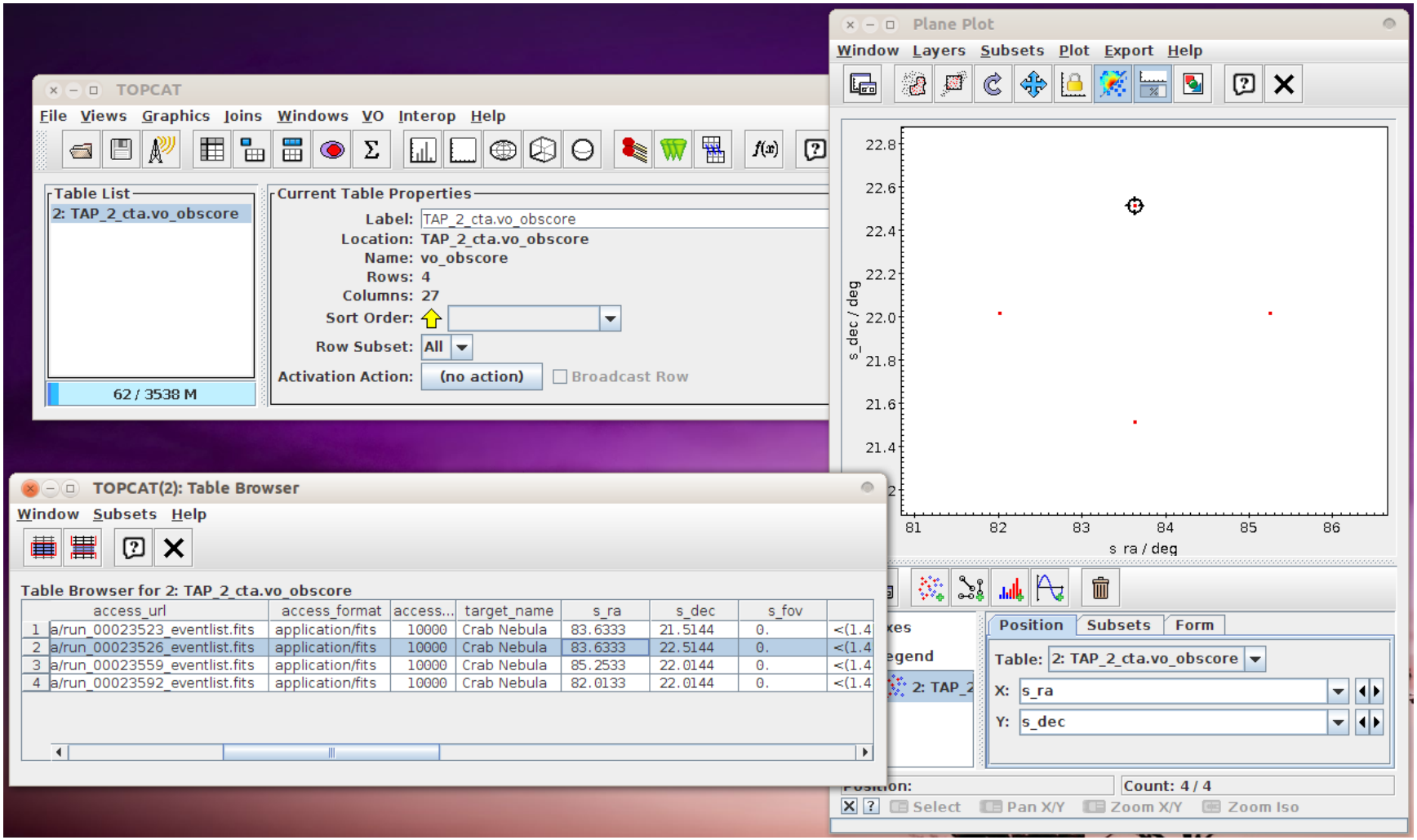
Query using Topcat



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Future work…

- Bottom up approach:
  - Start implementing ObsCore
  - **Evolve towards more complex DM:**
  - **ImageDM, SpectralDM,**
  - **Use of the Data Link data access layer specification for Provenance Info.**

- Implementation of First CTA DataChallenge Data (CTA's ancestor's HESS Data)