CTA DADI Status
Cherenkov Telescope Array

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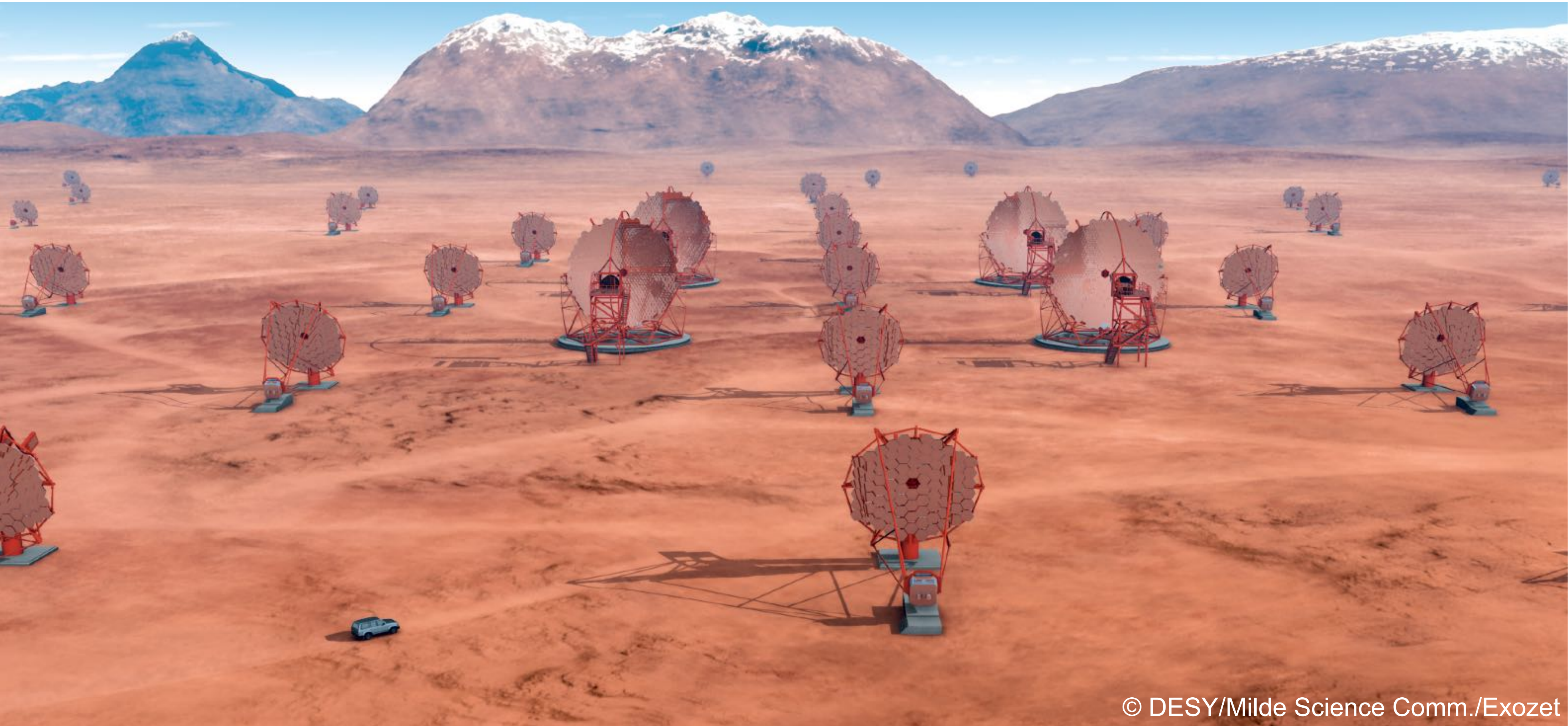
ASTERICS DADI ESFRI Forum 2
INAF - Osservatorio Astronomico di Trieste
13-14 Dec. 2017

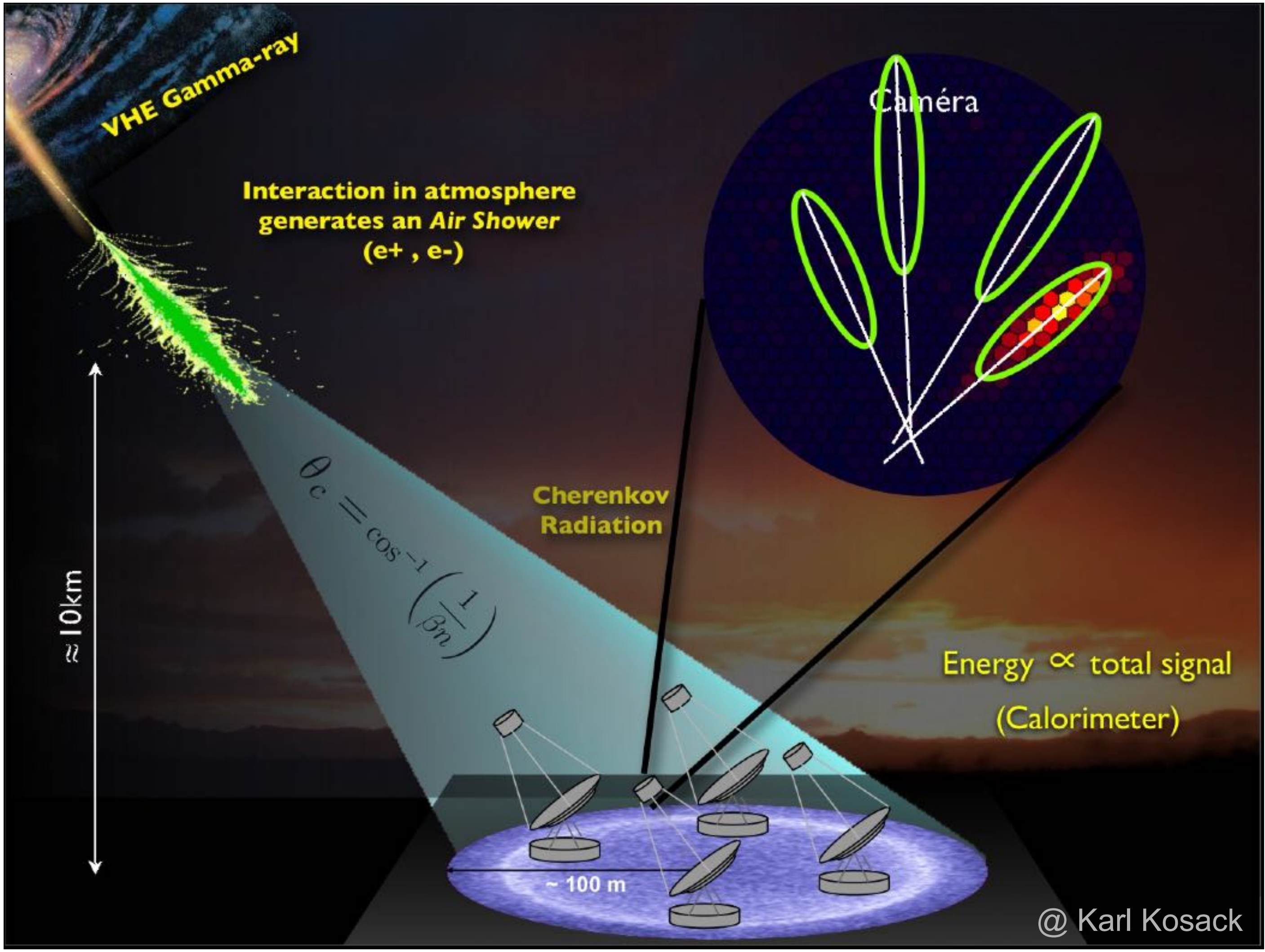
Observatory

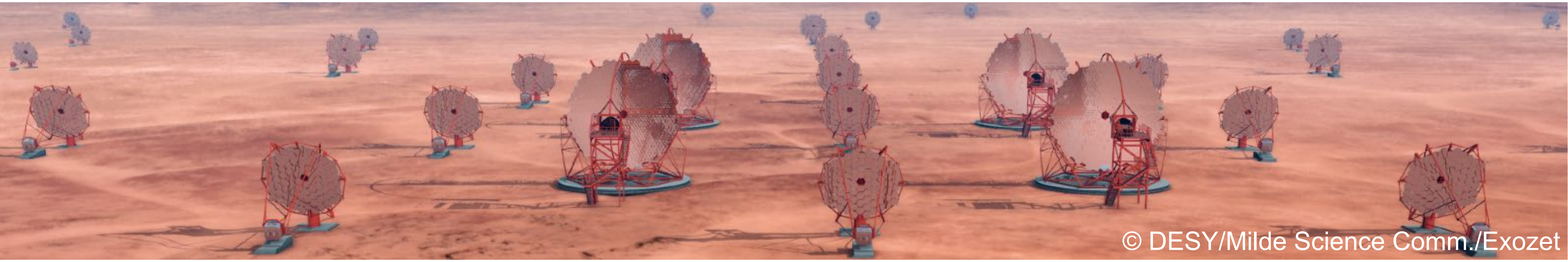
- Two arrays of **100 (South)** et **20 (North)** telescopes
- July 2015: sites selection, Chile (ESO) and La Palma
- 2016: pre-production phase
- 2018-2013: production phase
- Observatory **open** to the community



Cherenkov Astronomy Principles

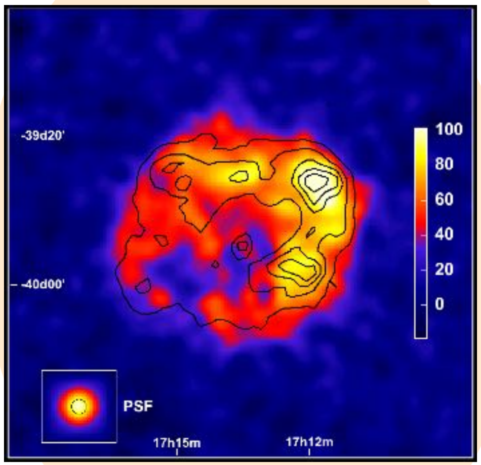
- **Dark nights** (small duty cycle)
- **Event Reconstruction**: photon, particle shower, Cherenkov light (faint, few nanoseconds)
- **Atmosphere** = calorimetre Simulations, assumptions
- **Complex Metadata**, need to be structured



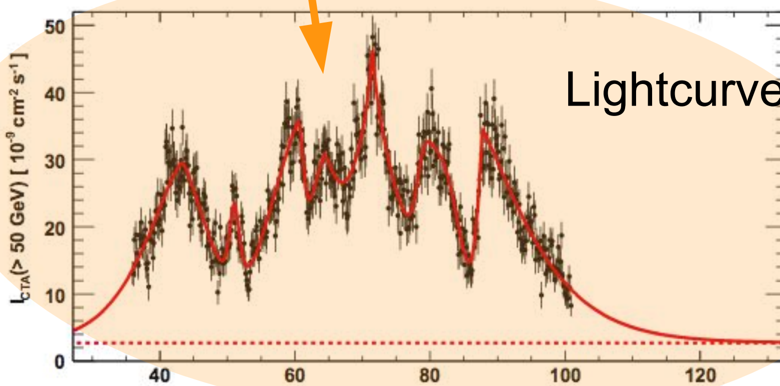


Multi-wavelength analysis

CTA Event lists
(coordinates, time, energy)

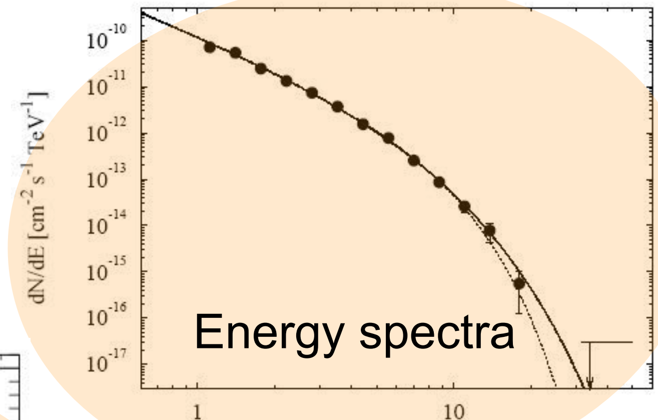


Images



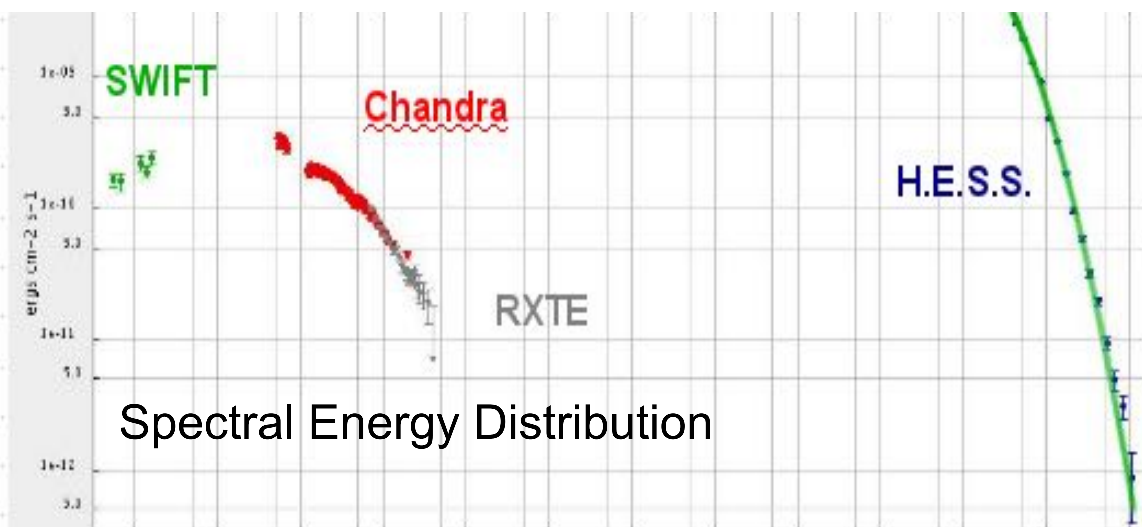
Lightcurves

Time [min]



Energy spectra

Energy [TeV]



Spectral Energy Distribution

Compatible data at other wavelength?

Simultaneous
Calibrated
Specific Processing?
Context?

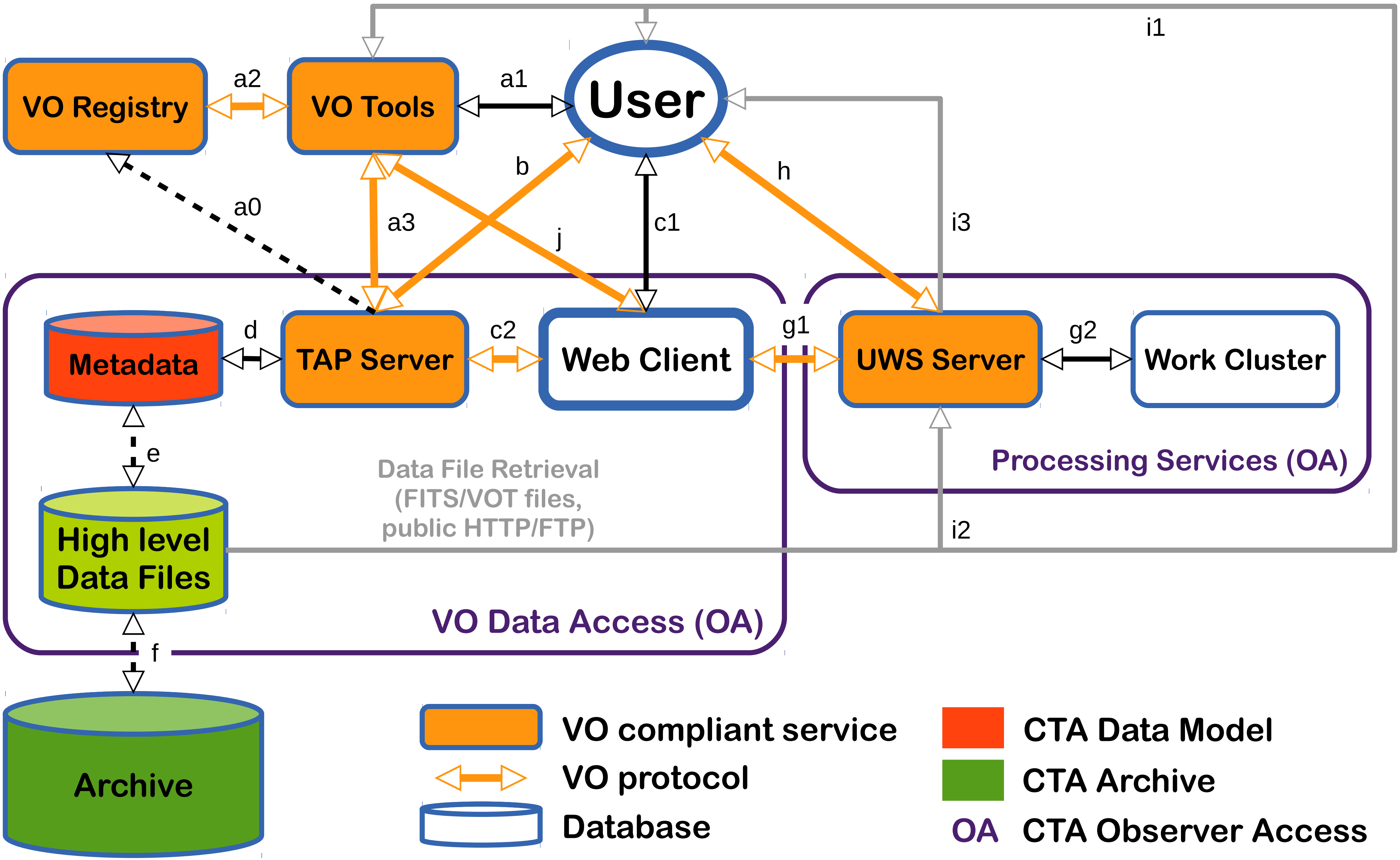
VO data access prototype

- **CTA Data Model (not complete, still evolving)**
  - **https://forge.in2p3.fr/projects/model/wiki/UML_models**
  - **Automatic** Conversion UML to SQL
  - Relational database implemented (PostgreSQL)
- **Data Ingestion**: CTA First Data Challenge (1DC)
- **VO Compliant**
  - IVOA ObsCore Data Model
  - GAVO DaCHS server: TAP, ADQL

  } ObsTAP
- **Web Client** (Django, jQuery, BootStrap)
- **Online Analysis**: UWS, SAMP
- **Single Sign On** solutions

► Complete solution based on VO standards/protocols

VO data diffusion prototype



CTA Data Distiller https://voparis-cta-test.obspm.fr

CTA Data Distiller | Search Form | Job List | Sign out **user**

☑ Cone Search

Target Name	Crab Nebula	Used to query Simbad with Sesame and set RA/Dec.
Source RA (deg)	83.633	
Source Dec (deg)	22.514	
Search radius (deg)	0.001	

Submit Reset

- Django, jQuery, BootStrap3
- Name resolver (Simbad through Sesame)
- Builds and Sends the ADQL query

ObsCore Search

proposal_id		Proposal ID
dataproduct_type	Nothing selected	Data product (file content) primary type
dataproduct_level	Nothing selected	DL0-5

CTA Data Distiller https://voparis-cta-test.obspm.fr

CTA Data Distiller | Search Datasets | ✔ Results | Job List | Selected Job | JS9 | Authentication: ✖ Sign out user

Search — Analyse — Visualisation

Results

show/hide query

SELECT * FROM cta.vo_obscore as o WHERE 1 = intersects(o.s_region, circle('ICRS', 83.63308333, 22.0145, 0.001))

Send

ADQL query

ObsCore fields

Search

	dataproduct_type	obs_collection	obs_id	target_name	s_ra (deg)	s_dec (deg)
☐	eventlist	1	23592	Crab Nebula	82.01333618164062	22.01444435119629
☐	eventlist	1	23559	Crab Nebula	85.25333404541016	22.01444435119629
☐	eventlist	1	23526	Crab Nebula	83.63333129882812	22.51444435119629
☐	eventlist	1	23523	Crab Nebula	83.63333129882812	21.51444435119629
☐	eventlist	3	5003499	CrabNebula	83.28087615966797	21.784133911132812

Showing 1 to 5 of 10 rows 5 ▴ records per page

<< < 1 2 > >>

SAMP

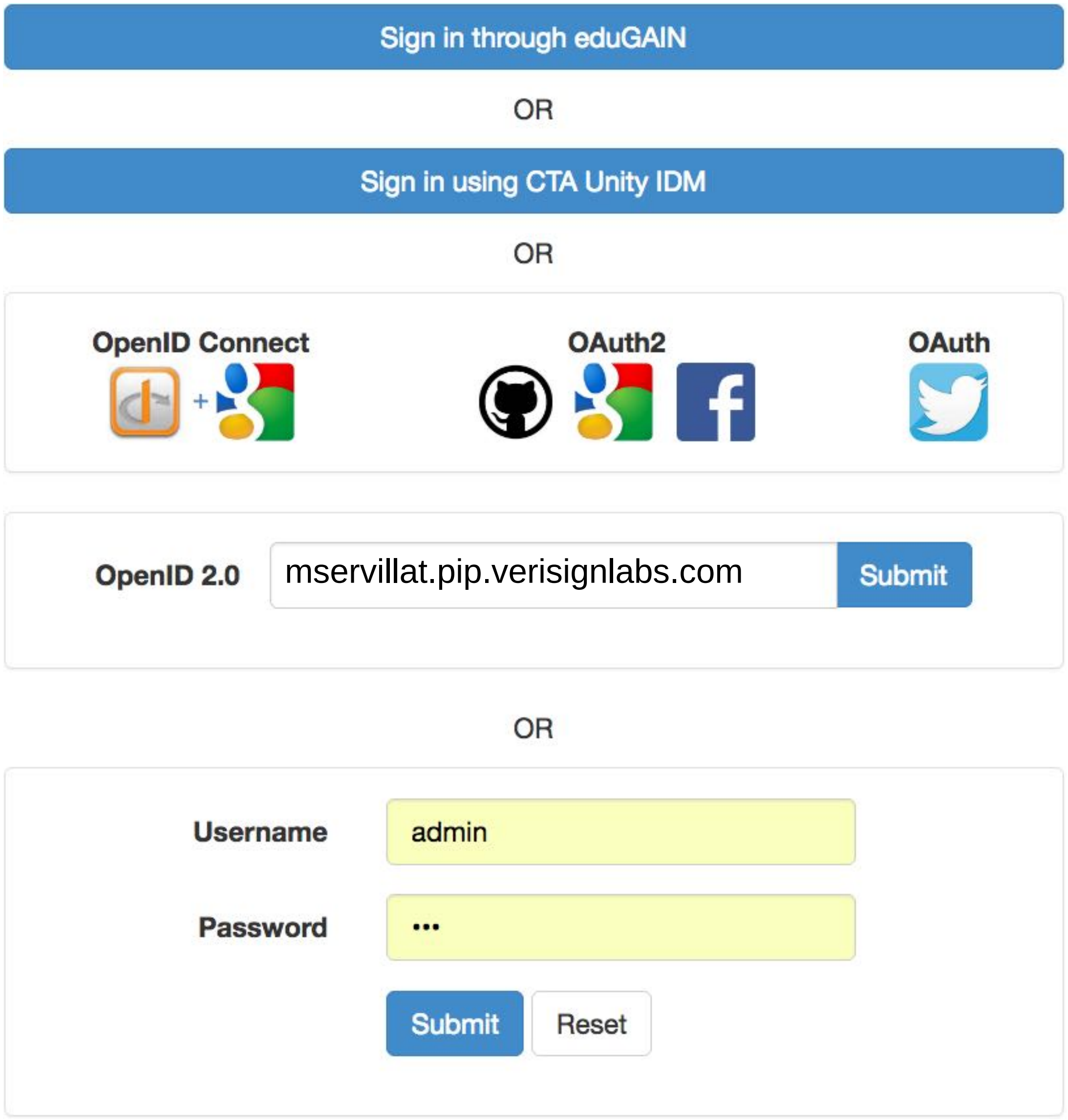
Interop (SAMP)
- Send Result Table
- Send Selected Data

UWS

Analysis tools
- Create Count Map(s)
- Extract Spectrum

Plotting tools
- TOPCAT
- Aladin
- VOSpec
- SPLAT

Authentication & Authorization

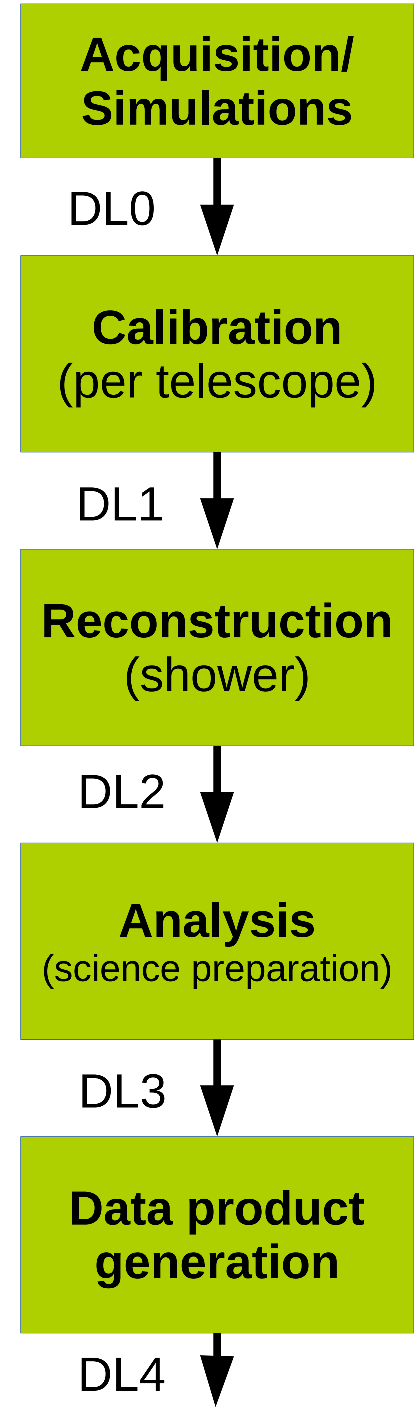


- Shibboleth+Grouper
  - EduGAIN federation
  - SAML2
- Unity IDM
  - Uses OpenID Connect
- OpenID Connect
  - Google as an IdP
- OAuth2
  - Github, Google, Facebook, ...
- OAuth
  - Twitter, ...
- OpenID 2.0 (deprecated)
- Local account

Pipeline Requirements

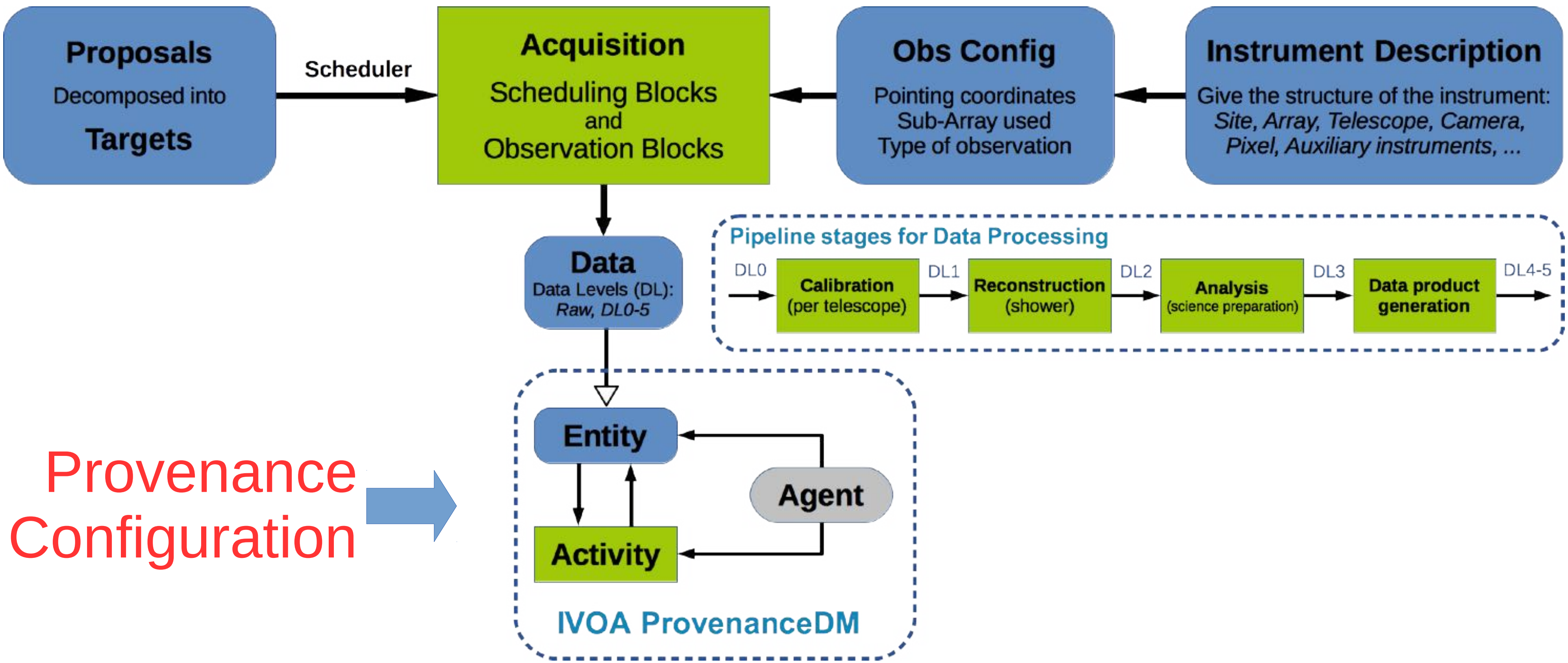
- **Open** observatory
- Must ensure that data processing is **traceable** and **reproducible** (A-USER-0110)
- **Inform** user on processing steps performed
- Link to progenitor to regenerate data (DL3 to DL4)

- Identify how a data product was produced
  ⇒ Provenance
- Identify what detailed options were used
  ⇒ Configuration



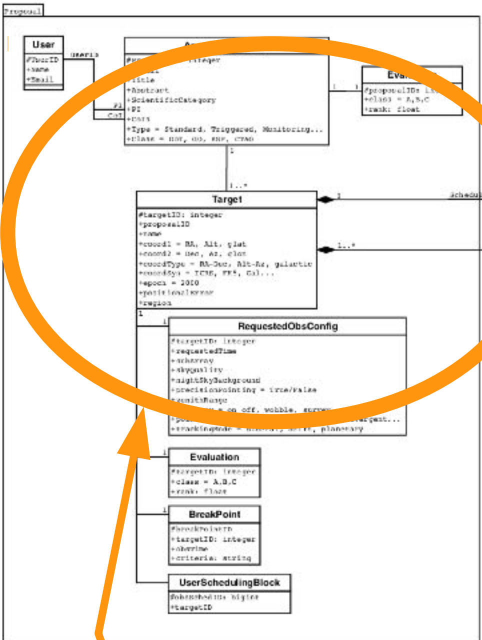
High level metadata model

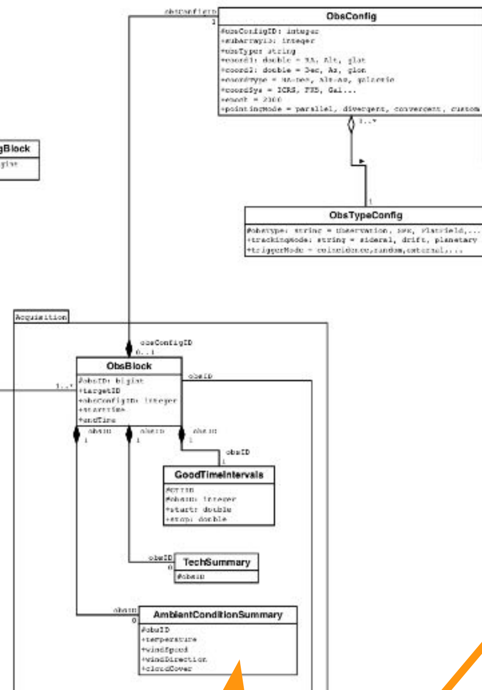
- Defines **structure** of services, content and context of data
- Can be seen as a **global interface**

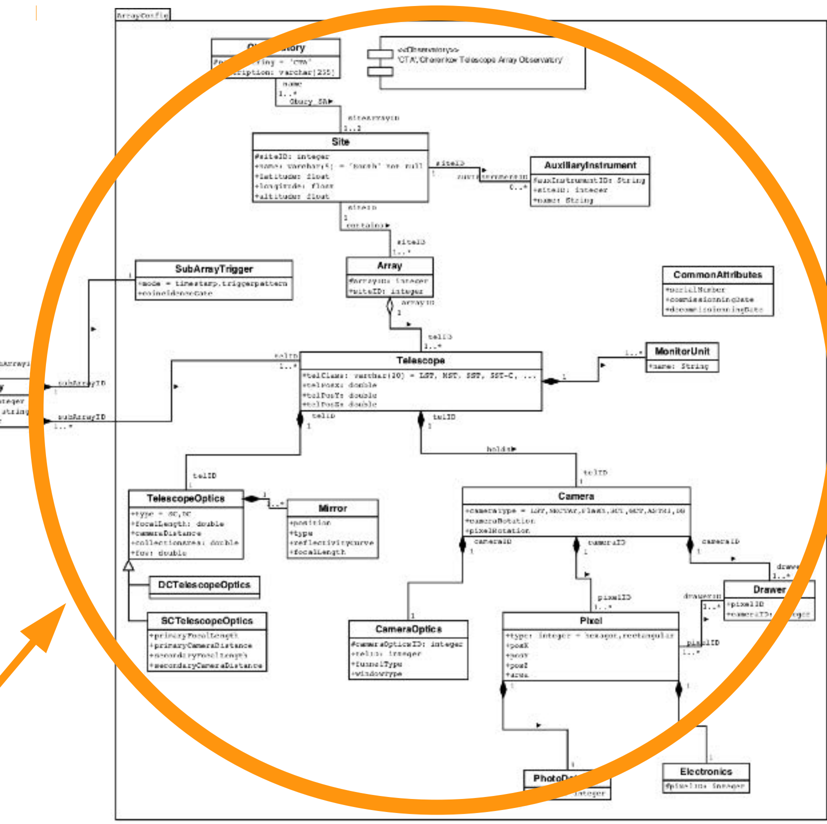


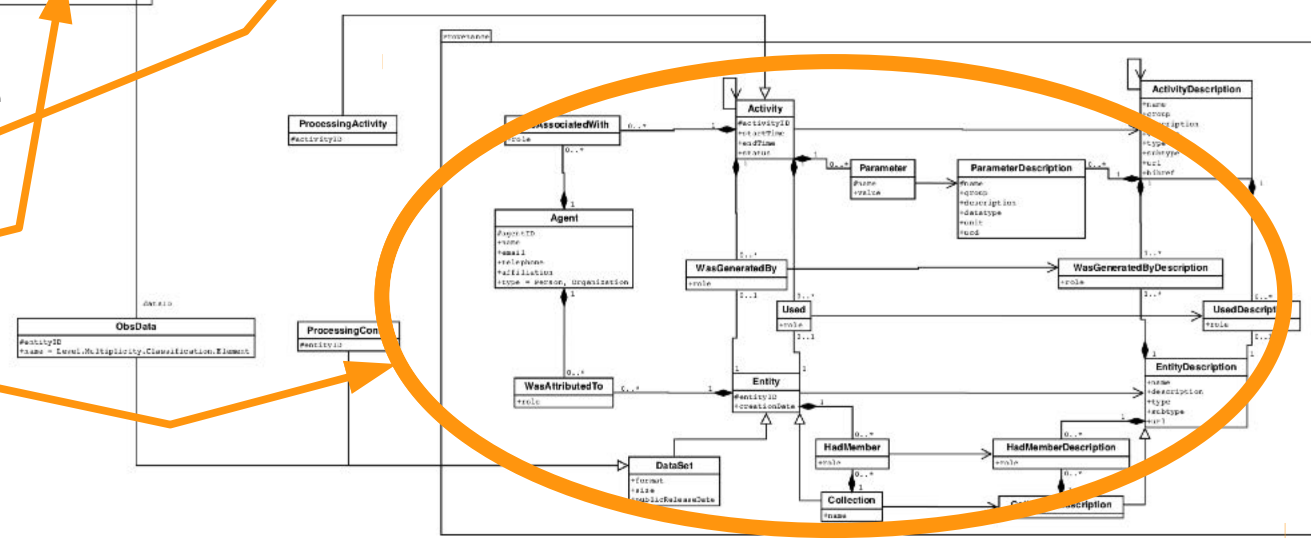
Servillat et al. 2017, ADASS Trieste

All you need is metadata!









"Extended" Provenance

- Proposal
- Observing Mode
- Ambient Conditions
- Processing History

IVOA Provenance Data Model

Version 1.0

IVOA Working Draft 2017-10-12

Working group
DM

This version
http://www.ivoa.net/documents/ProvenanceDM/20171012

Latest version
http://www.ivoa.net/documents/ProvenanceDM/

Previous versions
WD-ProvenanceDM-1.0-20170921.pdf
WD-ProvenanceDM-1.0-20161121.pdf
ProvDM-0.2-20160428.pdf
ProvDM-0.1-20141008.pdf

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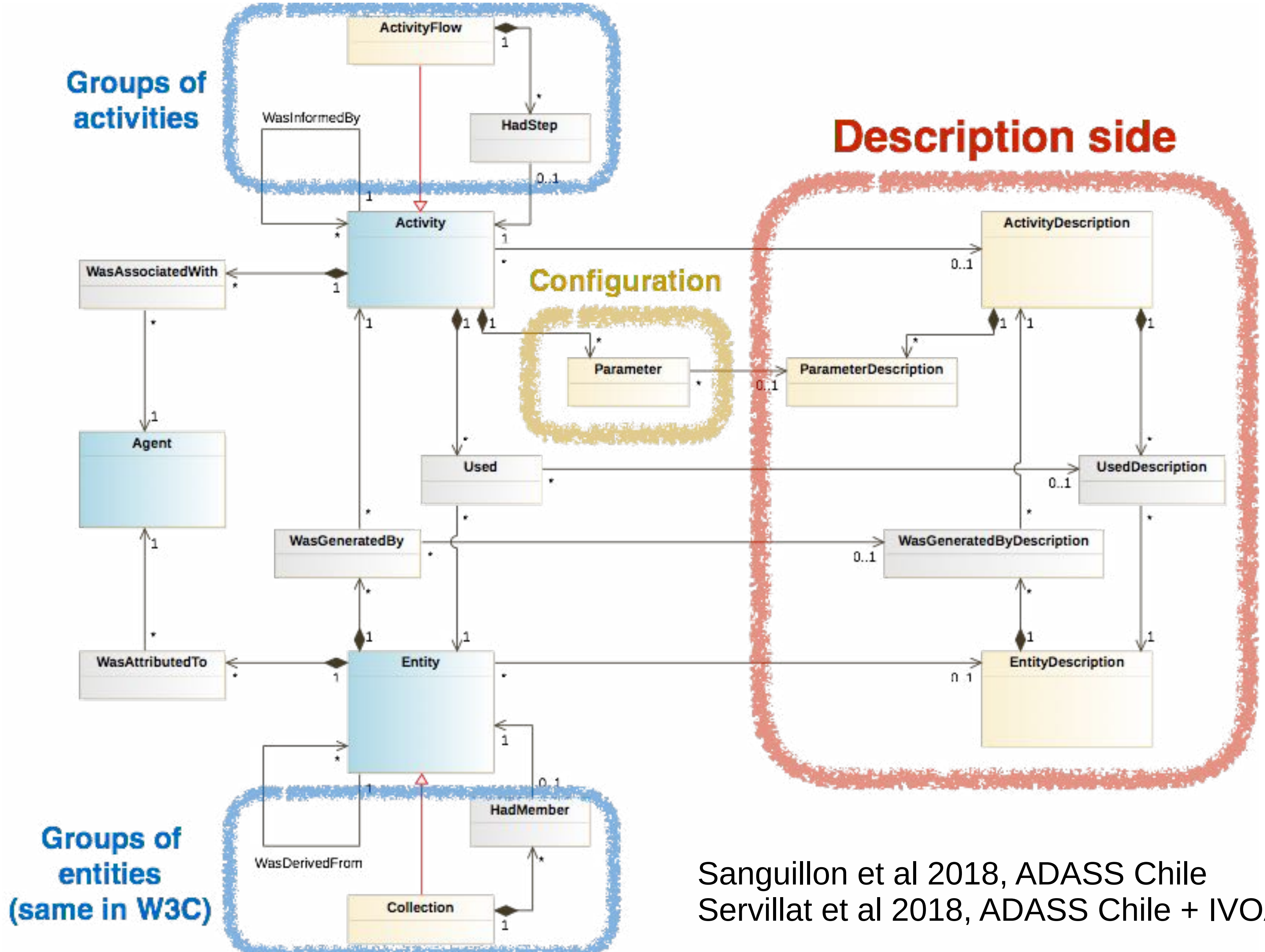
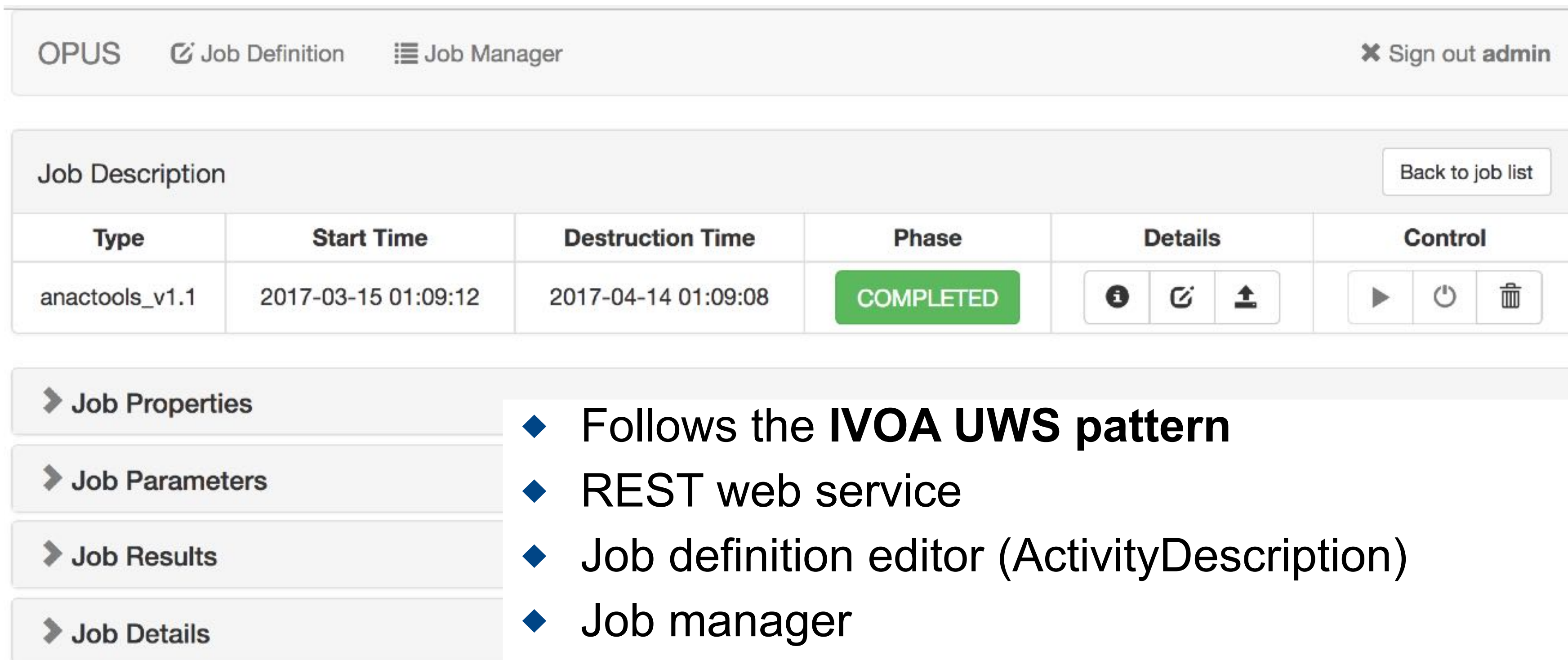
See presentation by M. Louys



Sanguillon et al 2018, ADASS Chile
Servillat et al 2018, ADASS Chile + IVOA

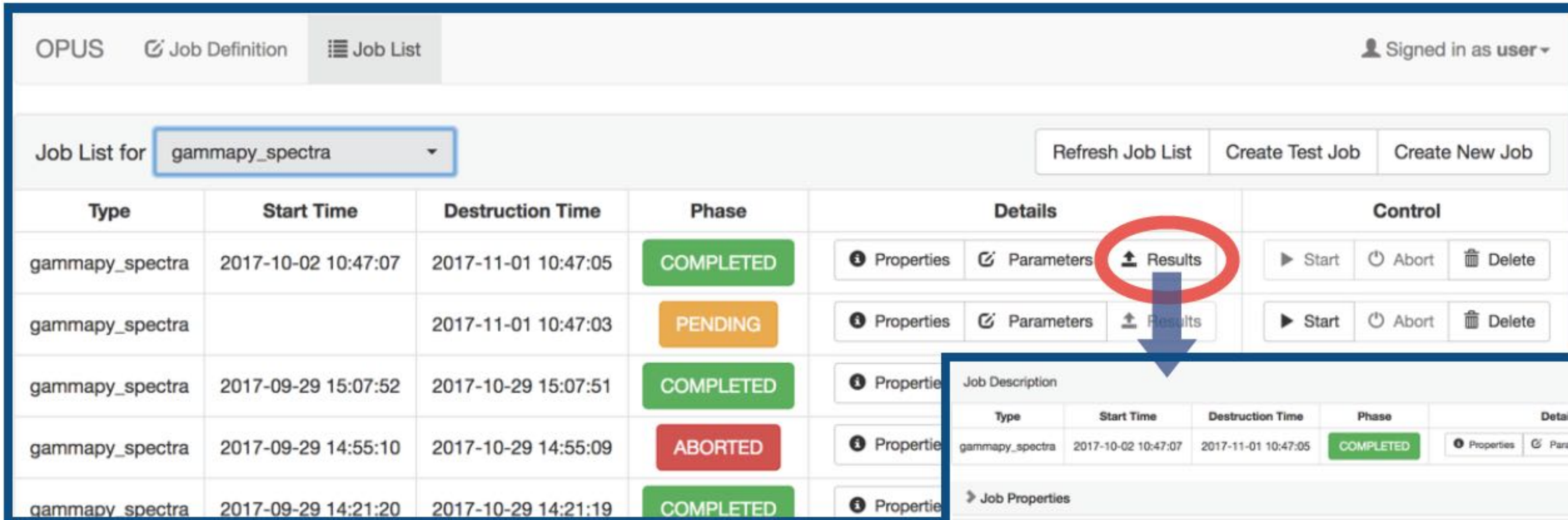
Provenance during a CTA analysis step

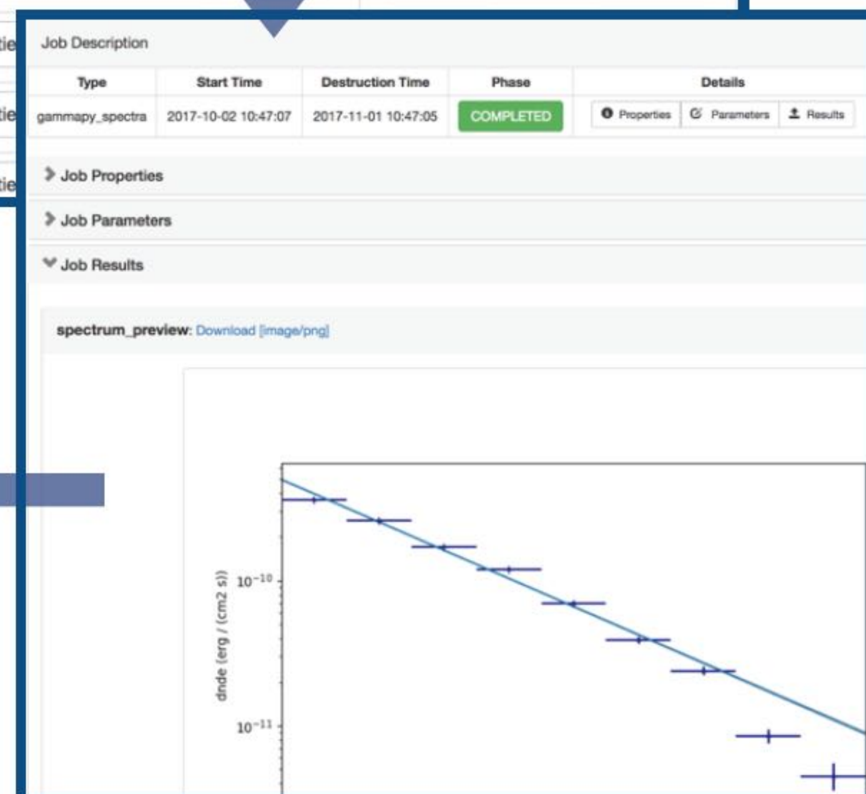
- **OPUS** (Observatoire de Paris UWS Server) is a light **job controller** for the Paris Observatory **work cluster** developped in Python: https://www.github.com/mservillat/OPUS



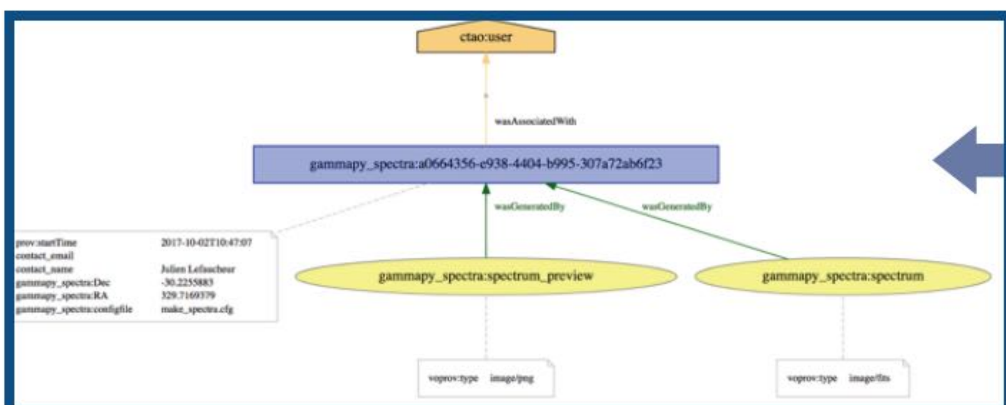
- Follows the **IVOA UWS pattern**
- REST web service
- Job definition editor (ActivityDescription)
- Job manager
  - Stores job **properties** (start, stop time…)
  - **Parameters** also kept
  - Access to **results**
  - Visualization of **logs** and **Provenance information**

From UWS to Provenance





Tracking of provenance information



https://github.com/mservillat/OPUS

Gammapy – An open source Python package for gamma-ray astronomy

J. Lefaucheur[1], C. Deil[2], A. Donath[2], L. Jouvin[3], B. Khélifi[3] and J. King[2]
[1]LUTH, [2]MPIK, [3]APC

MAX-PLANCK-INSTITUT FÜR KERNPHYSIK HEIDELBERG

l'Observatoire de Paris

APC, CNRS, FRANCE

Asterics
Astronomy ESFRI & Research Infrastructure Cluster

Context

- The current experiments (H.E.S.S., MAGIC and VERITAS) using the Imaging Atmospheric Cherenkov Telescopes (IACTs) technic can detect gamma-rays above a few dozen of GeV
- Data and tools for their analysis are private in the IACT community. The upcoming of the open observatory Cherenkov Telescope Array (CTA) slowly begins to change the mindset of the community
- Gammapy can be used to measure source properties such as morphology, spectrum and variability, using event lists as well as instrument response function (IRF) by taking into account IACT analysis methods' specificities

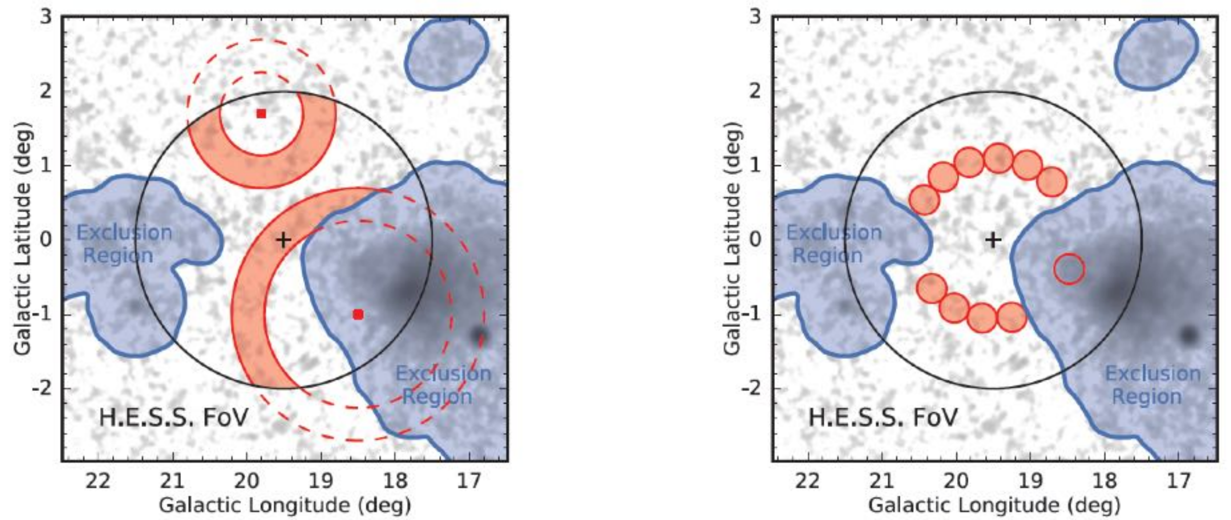
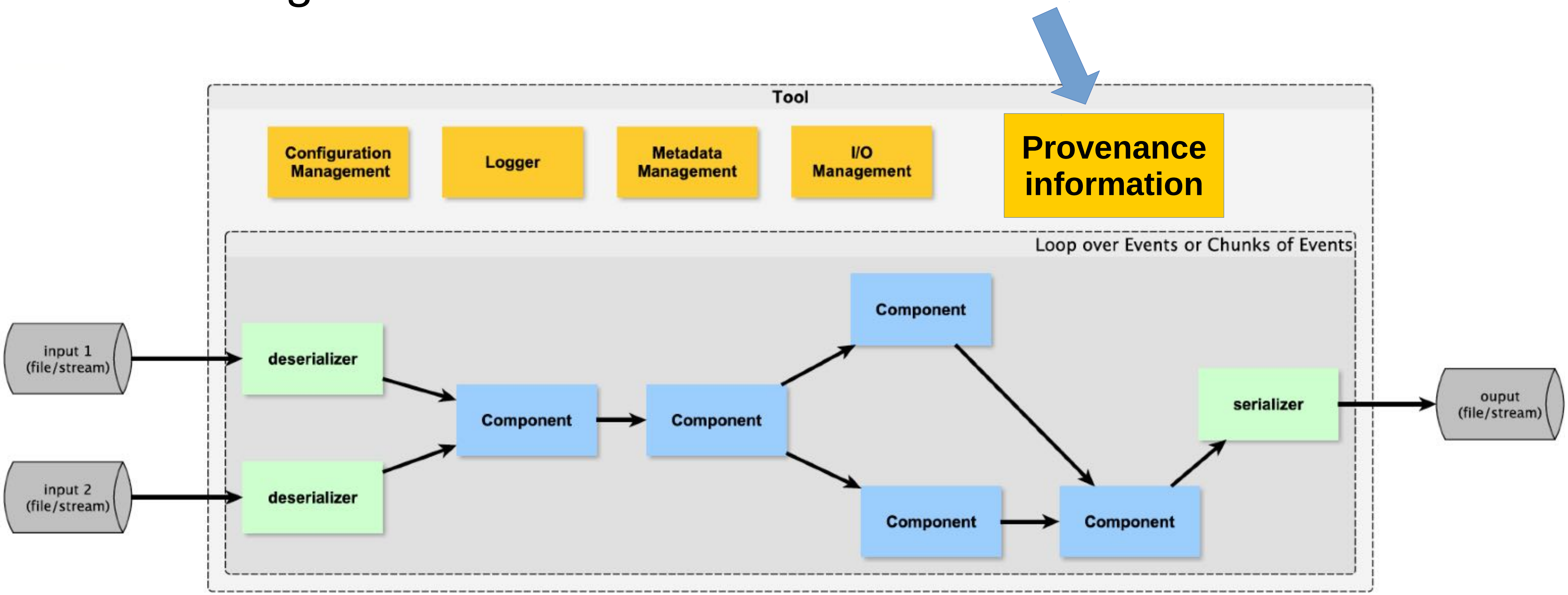


Figure 2: Illustration of classical method used to estimate the background implemented in Gammapy. The center of the field of view (FOV) is indicated with a black cross. Left, ring-background model used to reconstruct the morphology of a source. A ring (filled red regions) is used around a trial position (red squares) to estimate the background contamination. Right, reflected-region-background model used to reconstruct the spectrum of a source. The OFF regions (filled red circles) are used to estimate the background in the ON region (empty red circle). See Berge et al. 2007 for a detailed discussion.

Lefaucheur et al. 2018, ADASS Chile

Provenance in the Pipeline

- **Ctapipe**: a CTA data processing framework (prototype, not official, not recommended for use!) https://github.com/cta-observatory/ctapipe
- **Tool Python class** providing configuration, logger, I/O management… and **Provenance information**



@ Karl Kosack

Provenance class for ctapipe

```
from ctapipe.core import Provenance

prov = Provenance()
 # prov a singleton, so this gives you the same provenance class

prov.start_activitity("some_activity")

... # do things
prov.add_input_file("test.txt")
prov.add_output_file("out.txt")

prov.start_activity("some_sub_activity")

# do more things
prov.add_output_file("out2.txt")

prov.finish_activity() # finish some_activity
prov.finish_activity() # finish some_sub_activity
```

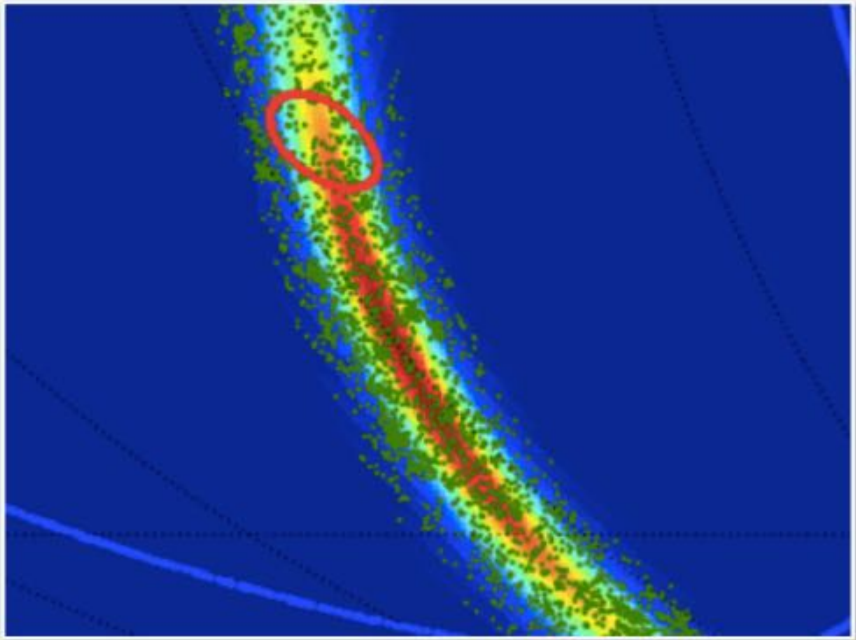
- Importance of **persistent identifiers**
- Also records **system configuration**, **state**, and **software versions**

VOEvent for MW/MM CTA science cases

see Transient Alert Mechanisms workshop, Amsterdam, 2017
https://indico.astron.nl/internalPage.py?pageId=5&confId=62

Example: Processing of GW alerts

- IACTs are part of EM GW follow-up efforts
- Large uncertainty regions make follow-up challenging
- Advantages of H.E.S.S.
  - rapid slewing
  - relatively large FoV
- dedicated algorithms to determine optimized scheduling
  - 3D-correlation with galaxy catalog (GLADE) vs. 2D coverage of GW uncertainty region
- running fully automated within VO system
- decision on event-by-event basis

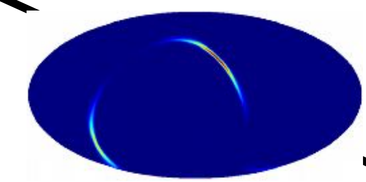


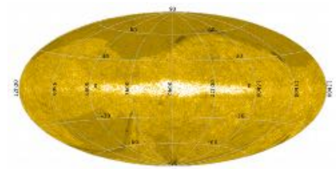
M. Seglar-Arroyo + FS, arXiv:1705.10138

@ Fabian Schussler

Gravitational Waves: follow-up strategy

Galaxy catalog(s)

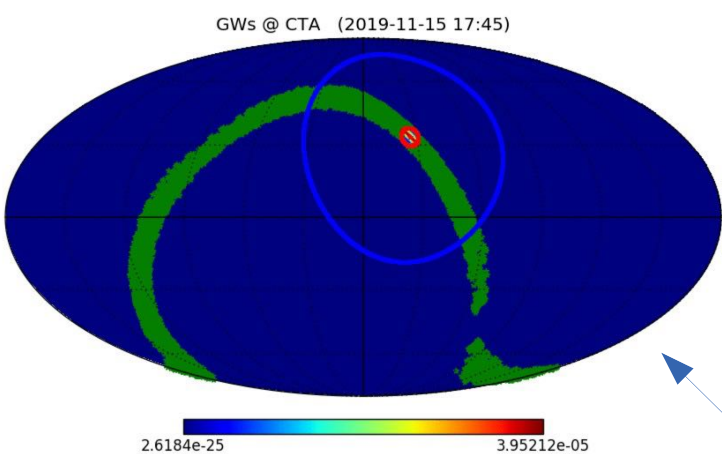




3D uncertainty region

GW-Scheduler

pointings, priorities, etc.

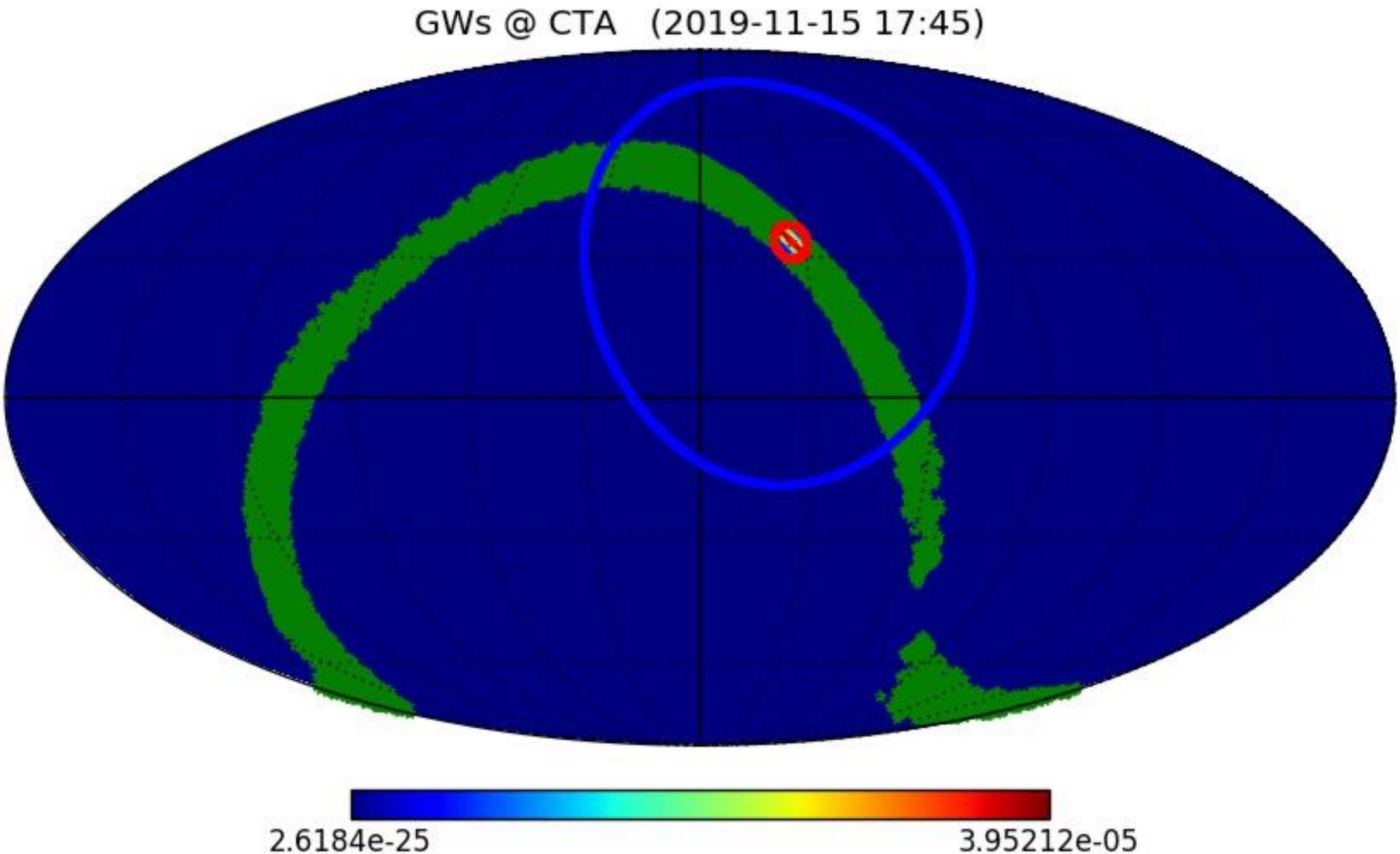


Blue rings : > 45° visibility N & S
Green points : galaxies compatible with GW map
Red : 8° CTA FoV

- **FULL CTA-ARRAY**
- Real-Time-Analysis searching for new/transient sources
- alert emission (internal/external)
- alert reception (EM counterpart)

simulated pointing strategy (worst case scenario: huge GW uncertainty)

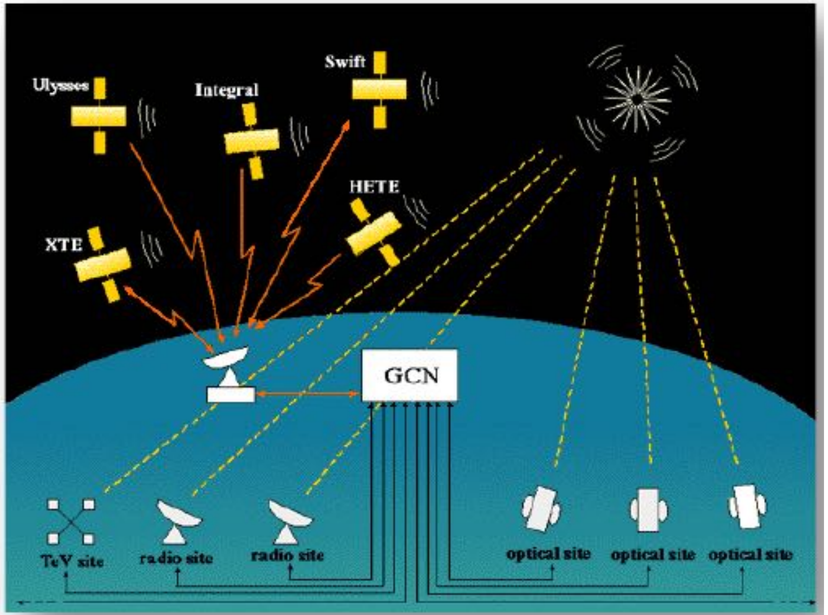
@ Fabian Schussler



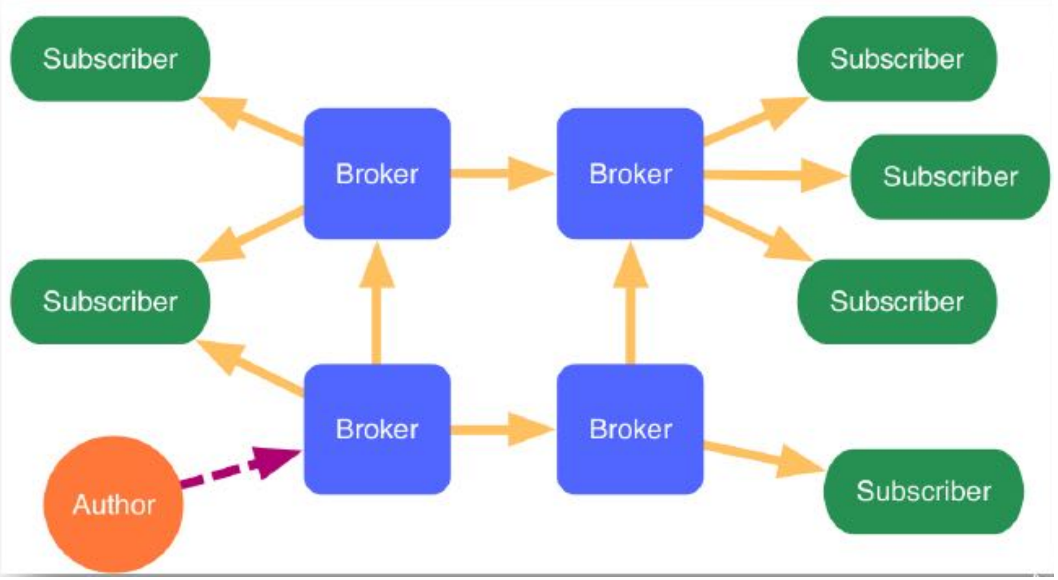
@ Fabian Schussler

VO Event concept

- GCN Socket System
  - Hosted at NASA
  - Centralised
  - → single point of failure
  - Can only select/deselect which packets to receive

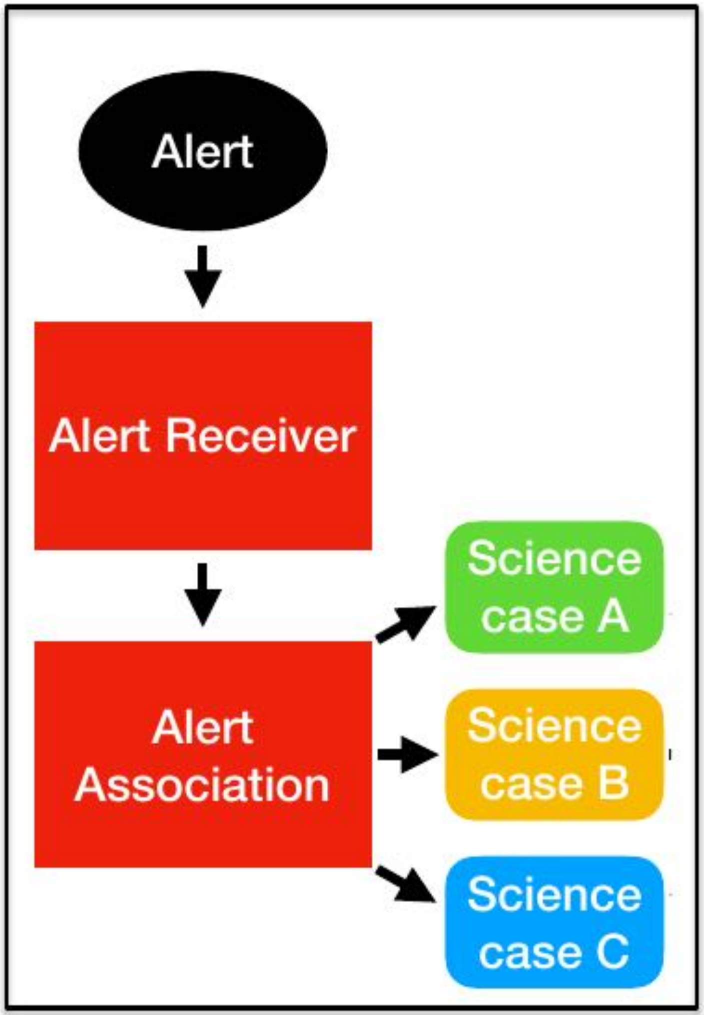


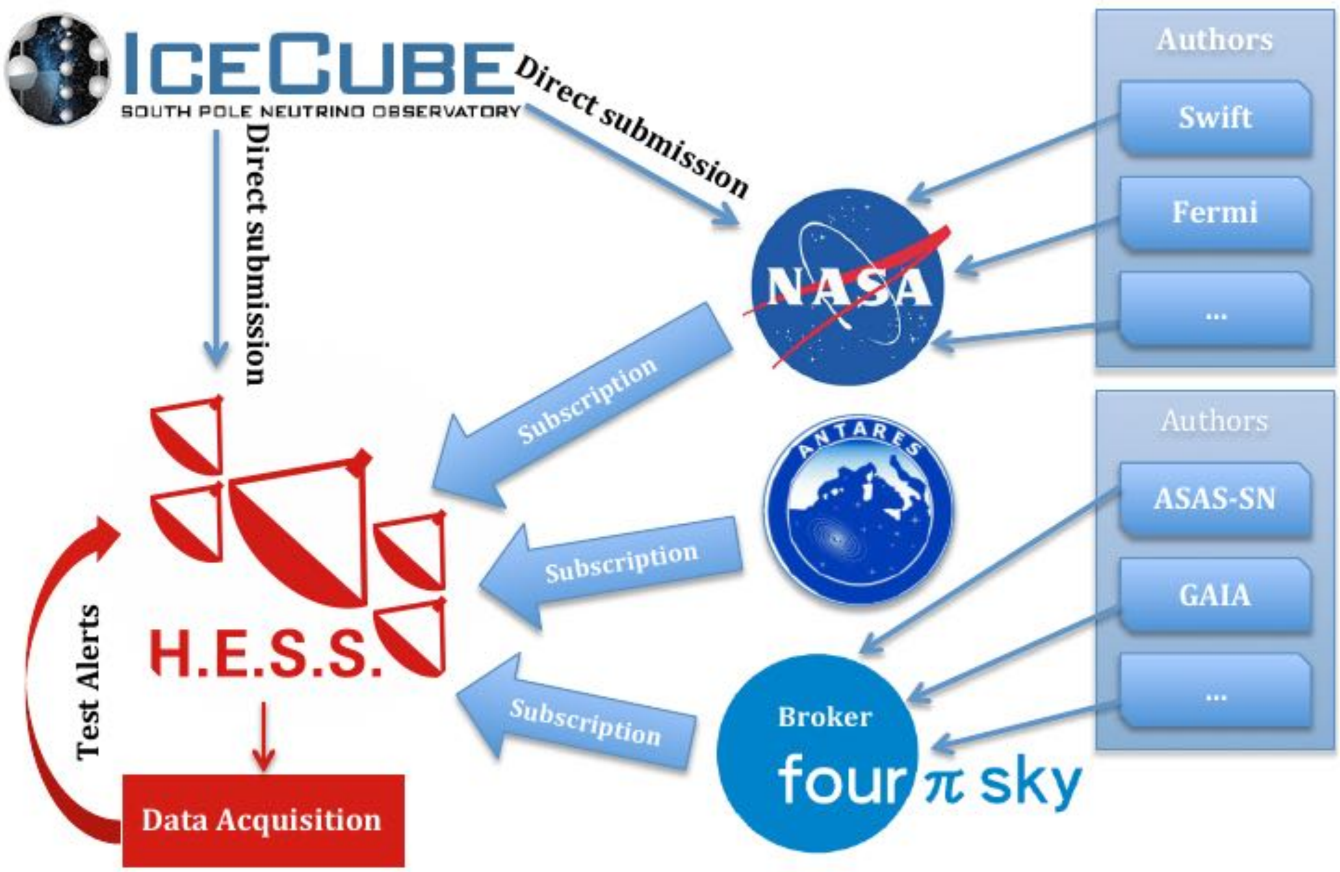
- VO Event System
  - Fully customizable setup
  - Distributed Broker system
  - Alerts can come from a variety of brokers
  - Feedback channels



@ Fabian Schussler

The H.E.S.S. transient system – alert reception and association





@ Stefan Ohm

ASTERICS Policy Forum – CTA document summary

	MW AGN & Transients	MM Campaigns	GP Transients
Physics Case	Flat spectrum radio quasars, BL Lacs, Radio galaxies, radio loud narrow line Seyfert 1 galaxies; prompt and afterglow emission in GRBs; FRBs	Gravitational waves and high-energy neutrinos from hadronic accelerators	Flaring pulsar wind nebulae, microquasars, pulsar binary systems, magnetars, novae, tidal disruption events, Galactic Centre, colliding wind binaries, and serendipitous source
Facilities	Monitoring facilities, SKA and precursors; AGILE, Fermi-LAT and X-ray satellites	SKA, ELT, GW second generation detectors: LIGO, VIRGO, KAGRA, I-LIGO, IceCube & KM3NeT, Baikal	Fermi-LAT, INTEGRAL IBIS, Swift BAT, eASTROGAM, XMM-Newton, Chandra, IXPE, XIPE, Athena, optical TLCs and SKA
Surveys/Time synchronisation	Monitoring and ToOs	Alerts of the order of secondsminutes following CTA observations	Simultaneous X-ray (similar timescale variability); ToO observations for MW follow-ups and shared time
VOTools / Archival Data	Fundamental to obtain information about light curves and SEDs	Crucial for localisation and identification	Fundamental for source identification and observation strategy optimisation
Modeling/Numerical Simulations	3D MHD & GRB modeling	VHE predictions; high-performance computing	SED and MHD simulations
Requested Time	~100 h/yr	~50 h/yr	~150 h/yr