# Cherenkov Telescope Array

An **observatory** for ground-based gamma-ray astronomy

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Asterics DADI
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# Based on known technology from precursors

H.E.S.S.

VERITAS

MAGIC

VHE gamma-ray astronomy with CTA is evolving towards the model of a public observatory where guest observers will submit observation proposals and have access to the corresponding data, software for scientific analysis as well as support services.

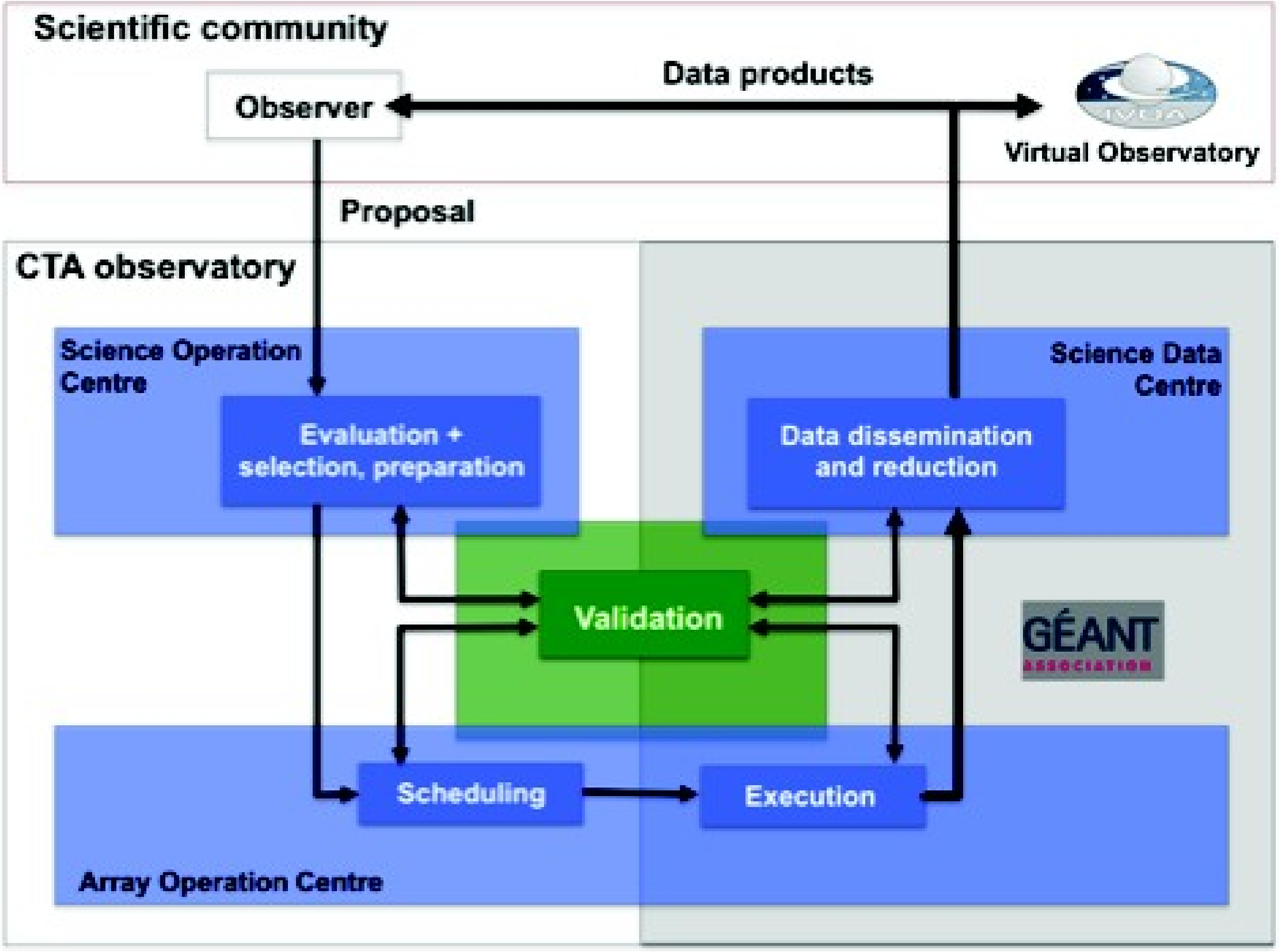
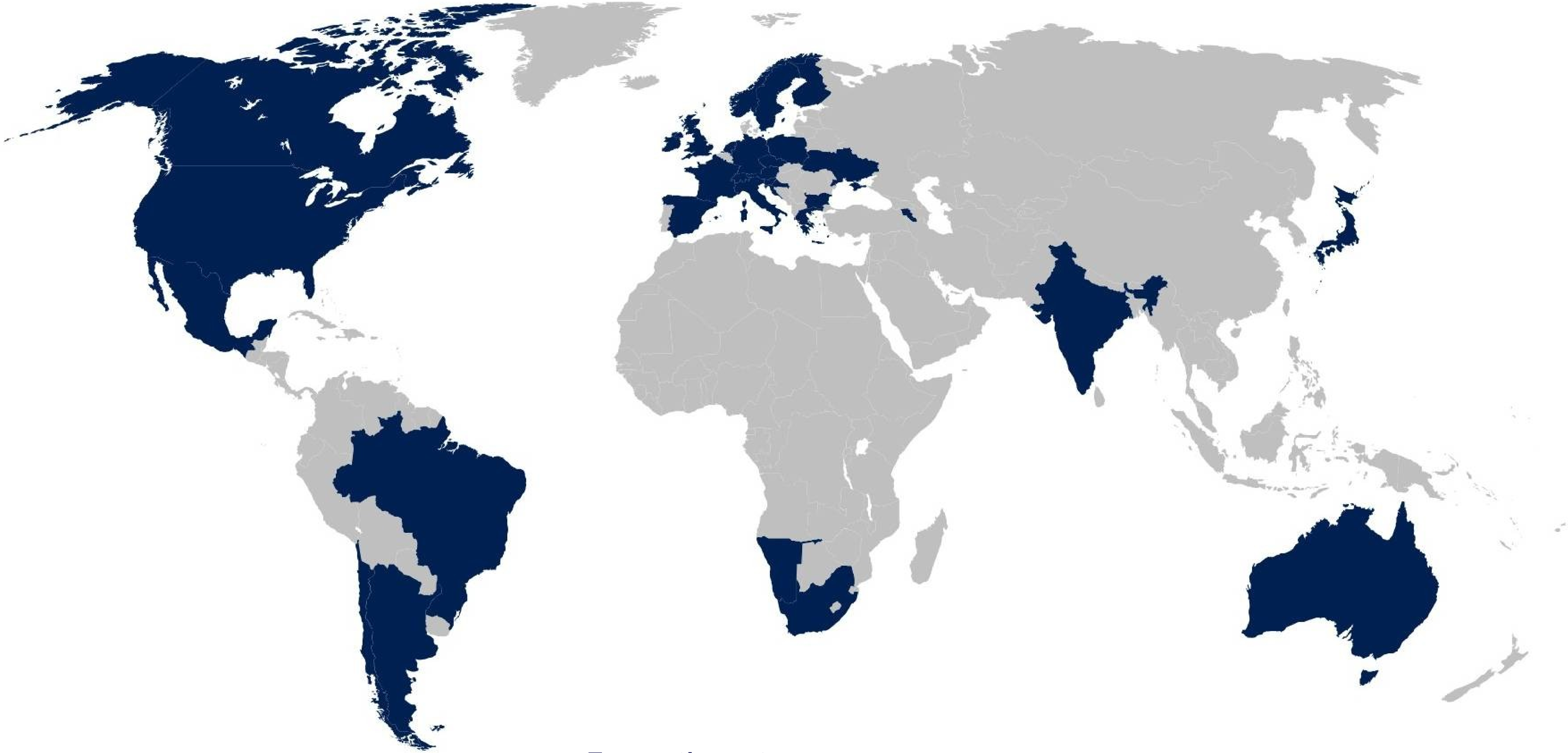
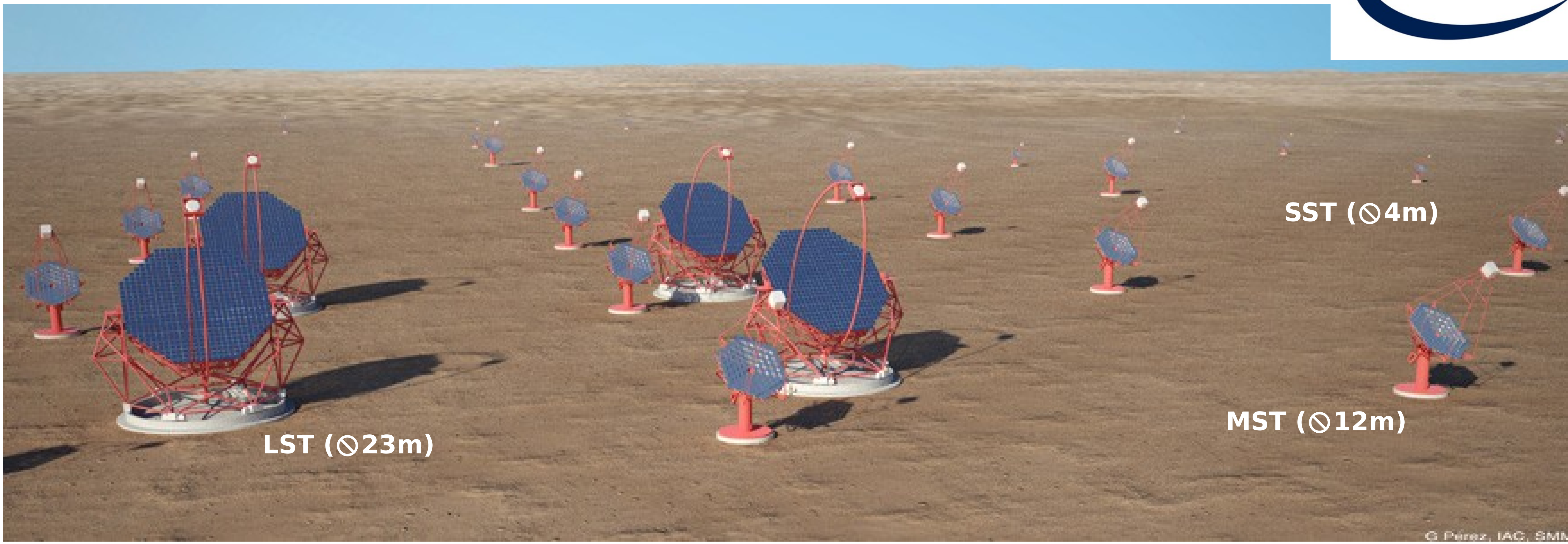



**Figure 1.1** – Logical diagram of the CTA Observatory functional Units.

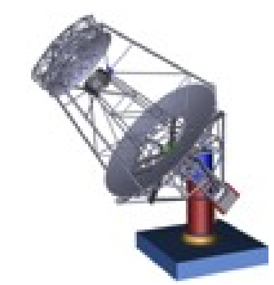
# Consortium



5 continents
31 countries
1270 members
424 FTE

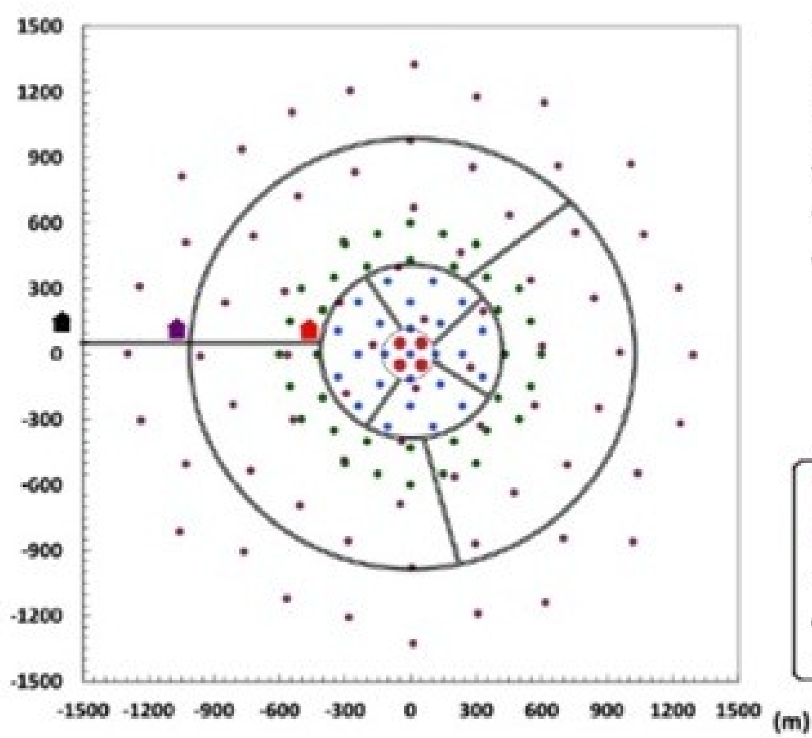



SCT (⦸10m)

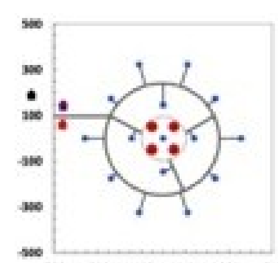


## South (Paranal, Chili)

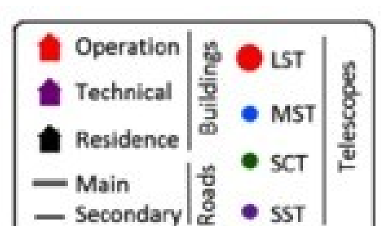
3 km




## North (La Palma, Spain)

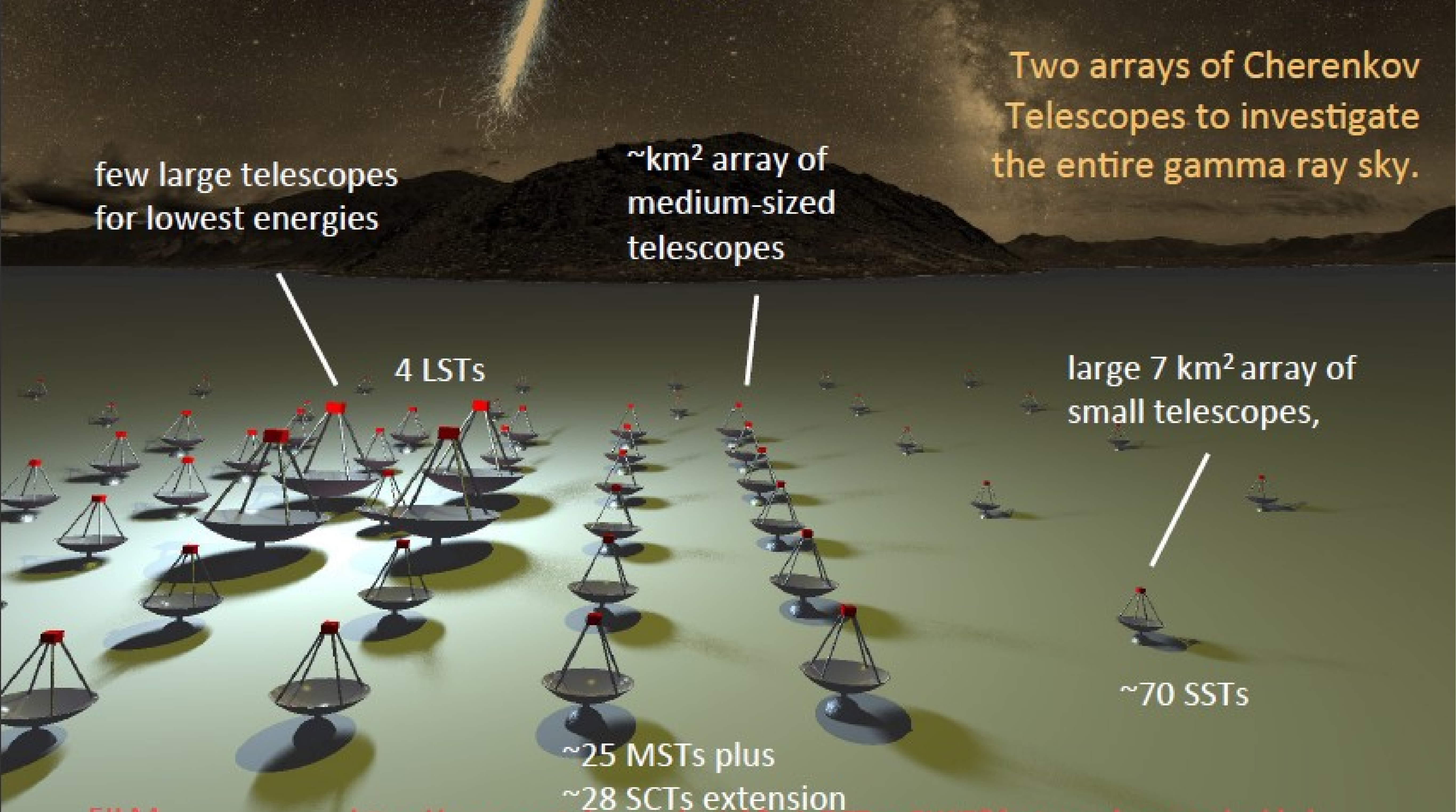


1 km



Science-optimization under budget constraints:

- Low-energy γ high γ-ray rate, low light yield
  ➜ require small ground area, large mirror area
- High-energy γ low γ-rate, high light yield
  ➜ require large ground area, small mirror area



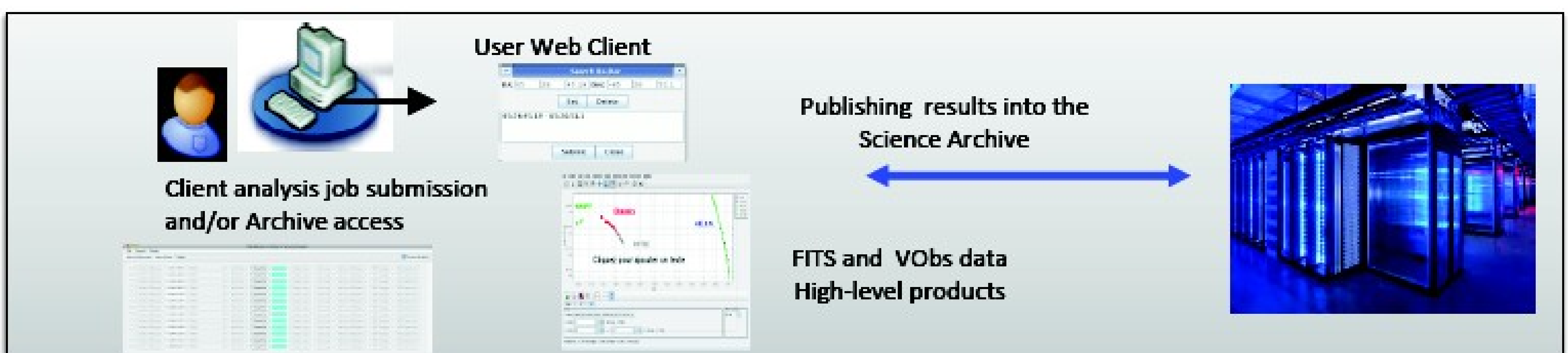

FILM https://www.youtube.com/watch?v=ioDGTowGLWE&feature=player_embedded

# Challenges

**Distant telescopes and a worldwide community:**
reliable high-bandwidth intercontinental connection

**Data rate, tens PB/year:**
challenges for streaming, on-site processing, archive, multithread pipelines processing, and long term sustainability


**Open access to Observatory data for a worldwide community:**
"Scientific Analysis System" integrating together Data Centre, Archive, Software and e-infrastructures

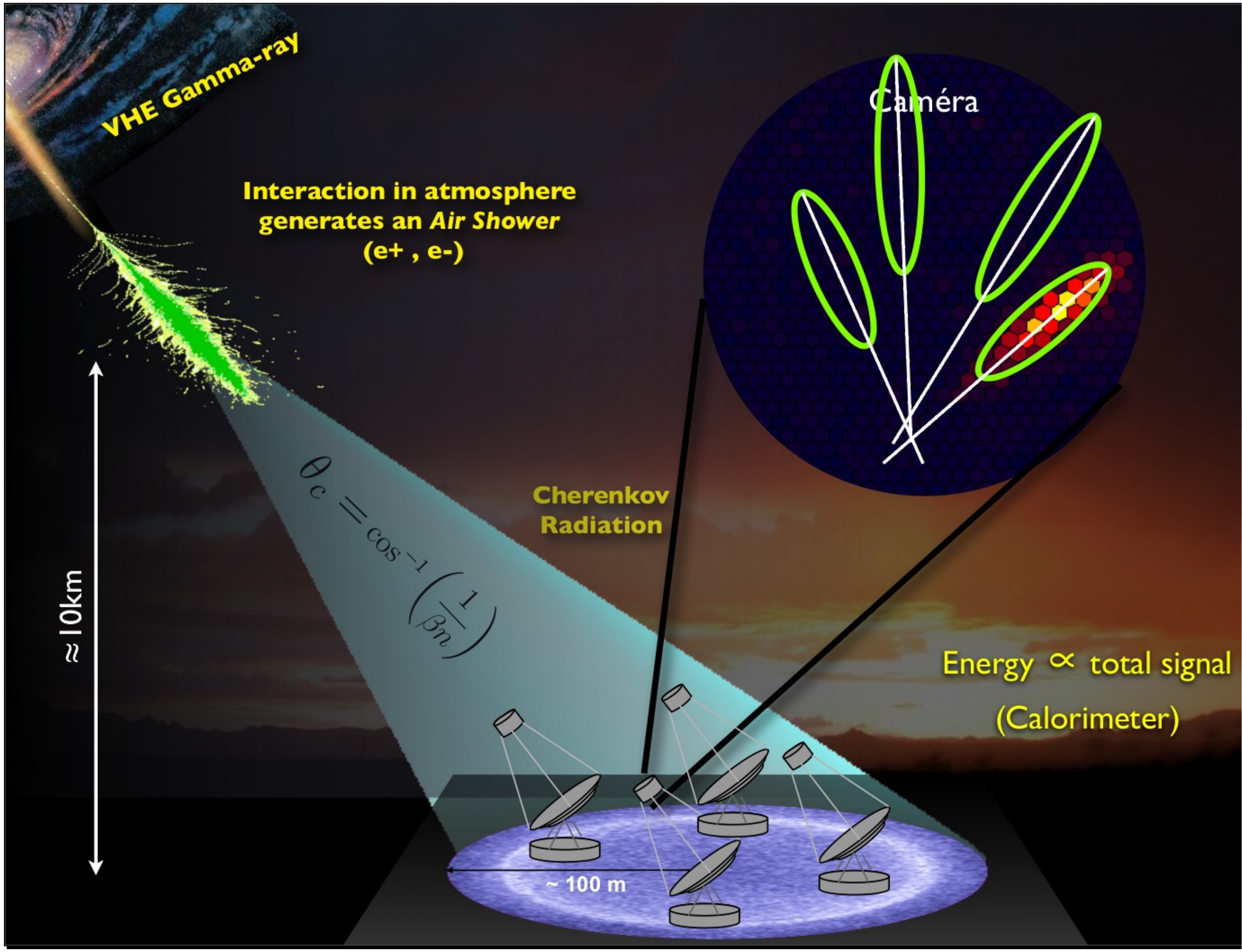


# Cherenkov astronomy

Event Reconstruction:
photon, particle shower,
Cherenkov light
(faint, few nanoseconds)

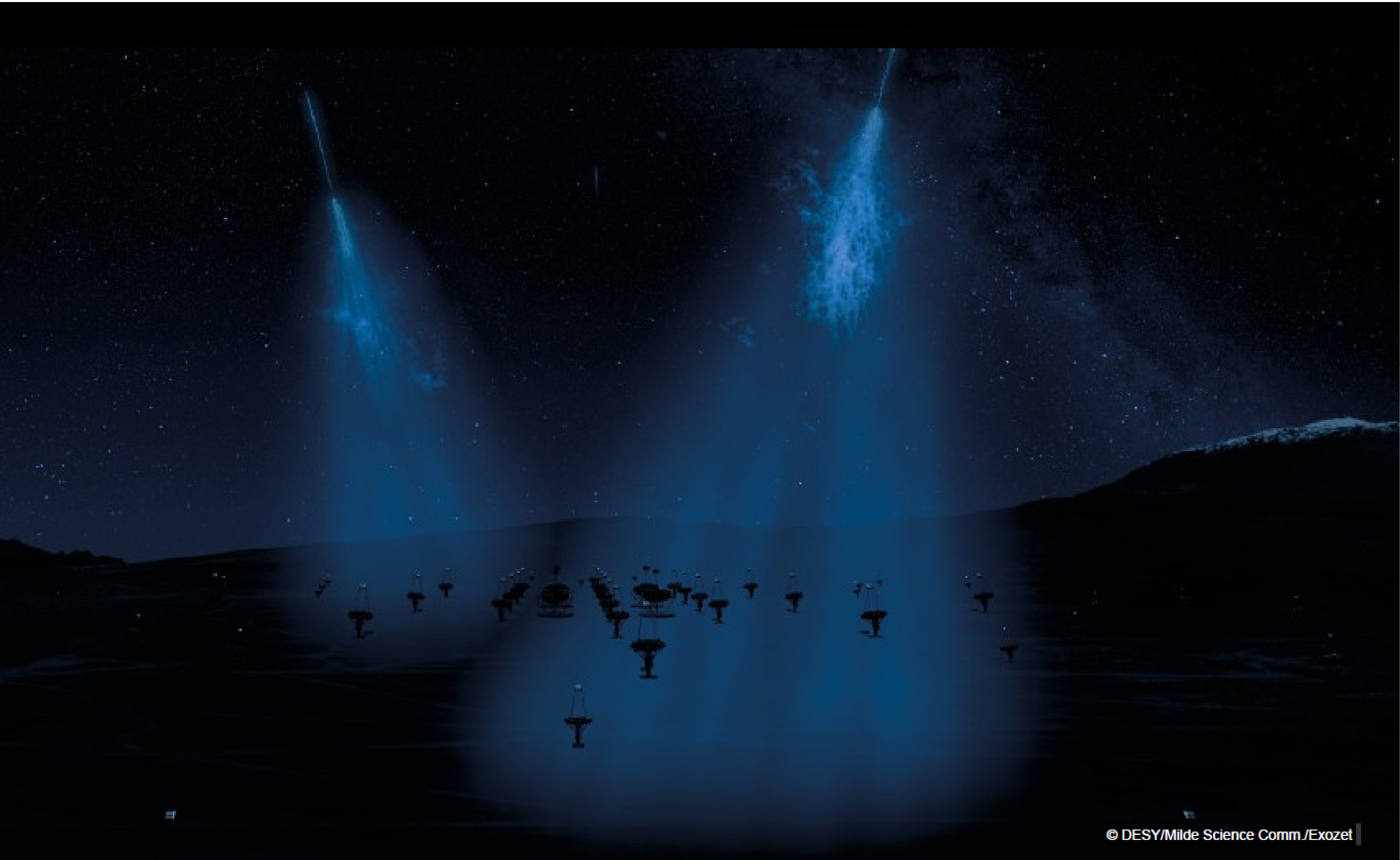
Atmosphere = calorimeter
→ simulations, assumptions

Complex Metada,
need to be structured

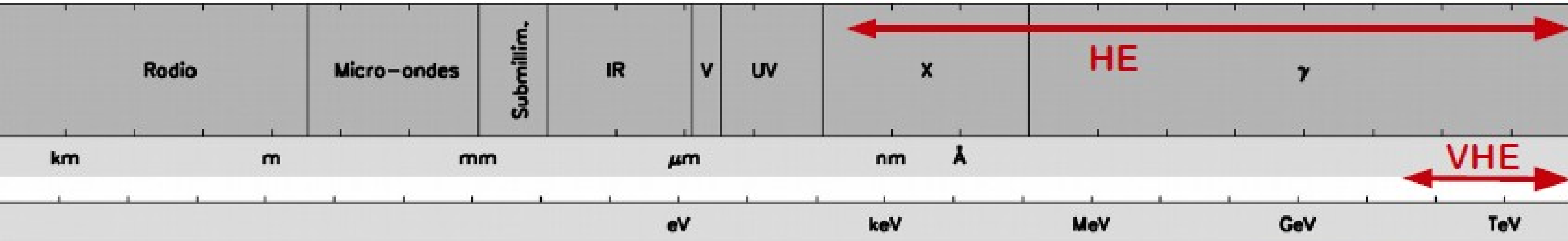



@ K. Kosack

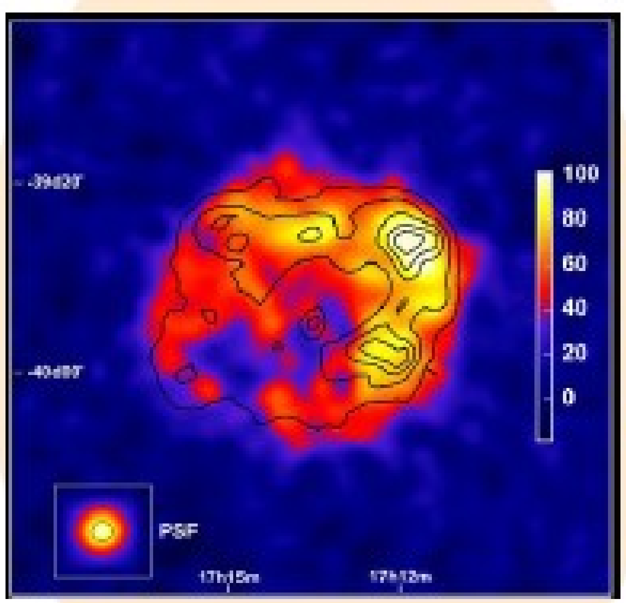
# Cherenkov astronomy : CTA



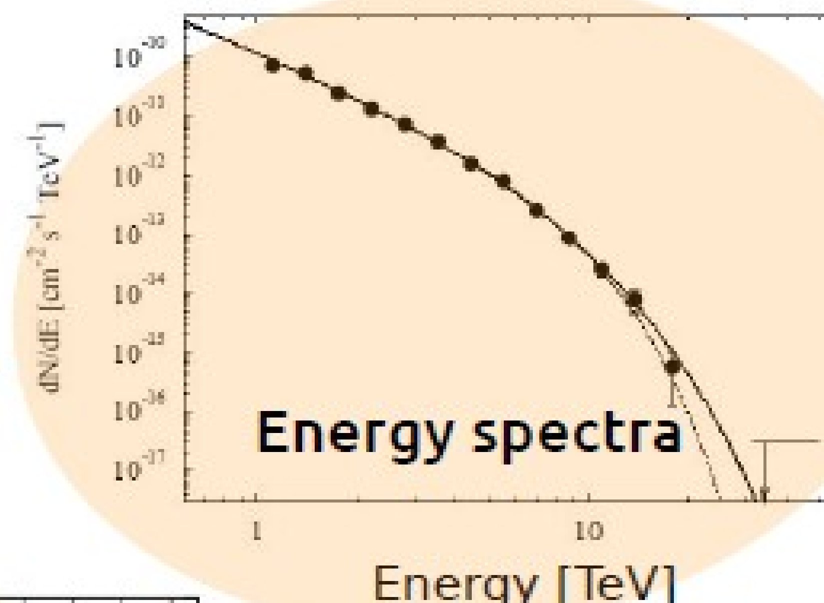
# Very High Energy



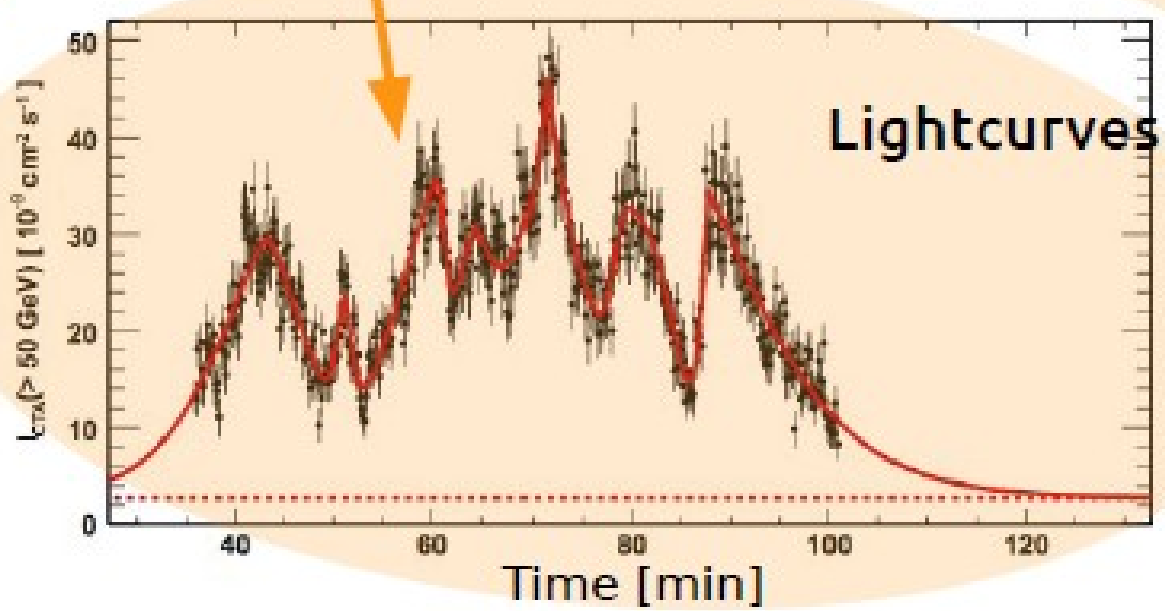

- Several orders of magnitude
- Photon counting
- Low count statistics, high background
- **Event lists** (coordinates, time, energy)




Images




Energy spectra




Lightcurves

@ M. Servillat

# H.E.S.S. AGN

Only a few useful hours of data summed over a long time

Close

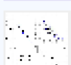
HESS J0152+017

| Observation | | | | | | | | | Curation | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| name | comments | pointing alpha | pointing alpha sys | pointing alpha stat | pointing delta | pointing delta sys | pointing delta stat | publisher | curation date | version | rights | contact name | contact email | title | creator | creation date | creation type |
| HESS J0152+017 | October to November 2007 summed data; significance | 1:52:33.500 | 1.3 | 5.3 | 1:46:40.300 | 20 | 107 | VO-Paris | 02-08-2008 | 1.0 | Public | C. Boisson | catherine.boisson@obspm.fr | Extragalactic | C. Boisson | 28-07-2008 | Archival |

Not pixel but assymetric energy bins

| Time Axis | | | Spectral Axis | Spectral Data (E in TeV) | Flux Data (dN/dE in cm-2.s-1.TeV-1) | |
|---|---|---|---|---|---|---|
| bounds start | bounds stop | livetime | energy threshold | value | value | stat error |
| 52412.075 | 53504.895 | 14.7 | 0.3 | 0.30847<br>0.484509<br>0.760992<br>1.19525<br>1.87731<br>2.9486 | 2.03399e-11<br>5.64448e-12<br>1.20326e-12<br>3.12378e-13<br>1.18592e-13<br>4.0974e-14 | 6.67404e-12<br>1.63425e-12<br>5.01844e-13<br>2.16144e-13<br>8.50016e-14<br>3.51122e-14 |

Data quality

| Segment | | | | | | | | | | Quality | Cuts | | Background | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| length | data type | imgfile | comments | background | hypothesis power law | hypothesis gamma | hypothesis ngamma | hypothesis chi2 | hypothesis dof | mean zenith angle | name | description | name | description |
| 6 | Spectrum |  | Aharonian et al., A&A 481 (2008) L103 | Reflected model | Single | 2.95 | 173 | 2.16 | 4 | 26.9 | Hillas soft cuts | Soft Cuts: as standard cuts but optimized for a 1% Crab flux (>100 GeV) source with a photon index of 5.0. * a 5/10 cleaning * a charge cut at 40 p.e. * a nominal distance cut at 2 degrees * a Mean Scaled Width between -2 and 0.9 * a Mean Scaled Length between -2 and 1.3 * a Theta^2 cut of 0.02 | Reflected model | Technique used in standard wobble observation mode. See Aharonian et al. (H.E.S.S. Collaboration), A&A 457, 899 (2006) |

Close

Complex info to be stored for high level data to be fully understood

# VO – Data Model & Provenance

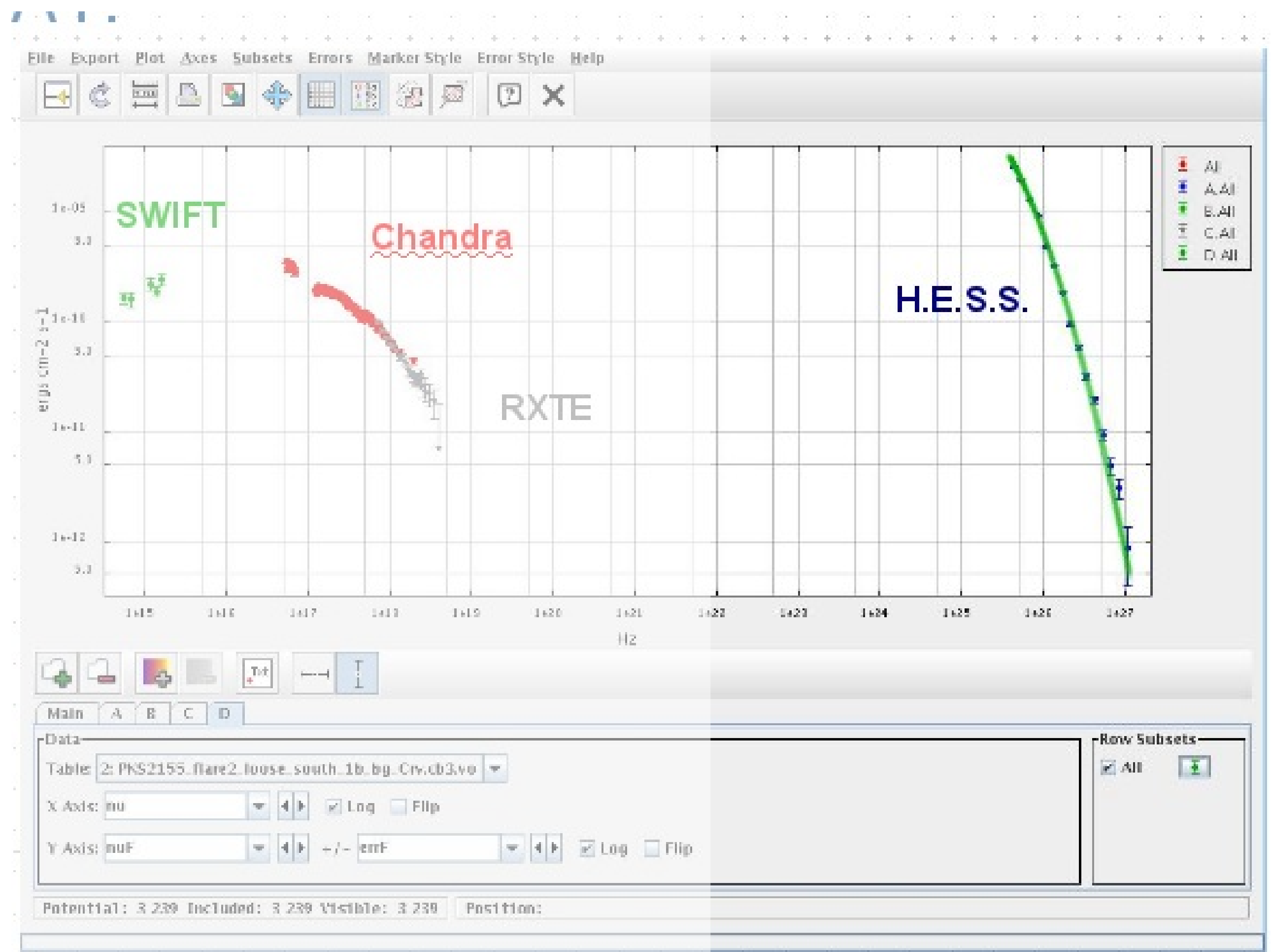
## Knowledge in Very High Energies and VO

H.E.S.S. and MAGIC experiments

High level **VO data access** prototypes - SSAP

ivo://vopdc.obspm/luth/hess

ivo://magic/ssa




## Not all necessary information fits in

## Need to adapt VO standards

→ Complex hierarchy of related products

→ Complex metadata for Provenance

→ Queryable metadata ?

FoV/PSF are energy dependant

Units and precision (m vs TeV)

# ASTERICS

To be published compliant with VO :
- event lists
- spectra, light curves, Images
- source catalogs

Data challenges proposed in DADI WP4 (and OBELICS WP3) are coherent with some of the key issues explored in the CTA Data Management project.

Opportunity for CTA to secure the Virtual Observatory developments for the future “data dissemination challenges” of the CTA Observatory.

True also for running Cherenkov “pathfinders”: H.E.S.S. and MAGIC

# VO (see Cosadie presentation)

**No standard yet to archive high energy astronomical data**

- SSAP protocol defines a uniform interface to remotely discover and access simple 1-dimensional spectra → OGIP standard PHA format of X-ray spectra not accepted, so difficult fo VHE

- Spectral Data Model does not describe completely the HE data

- HE spectra are not physical units but in instrument counts - calibration needed and a model should be assumed to obtain a spectrum in physical units

- ObsTAP - makes it possible to discover and access the whole dataset of the observation, but doesn’t access the calibration files needed for the analysis

- Units not adequate (e.g. meter) : problem of precision

# VO (see Cosadie presentation)

**No standard yet to archive high energy astronomical data**

- Missing keywords (Utypes) to the Spectral Data Model to describe High Energy astronomical data: e.g. calibration version, model used to extract spectrum, PSF instead of aperture model, time boundaries of observation together with live time

- Calibration DM : useful for x-calibration, changes flux value but here we have a fully new analysis (bkg, bin sizes, …)

- Partial data cubes : single exposure data cube access in different observations for better S/N and look to final results

- Light curves : need to talk to « time series » WG ?
  Not properly tackled yet.

# VO – publishing (see Cosadie presentation)

**Two kind of data to publish**

- Highest data products and catalogs where modeling is pre-defined
  → just define interface: DataLink? But still need to tell the history of the data set : Provenance ?

- Some more data with calibrations (on tool side: final post-processing, workflow system rather than a final product)
  → a complete DM

We have identified the need of an extension or combination of existent IVOA Data Models such as ObsCore & Characterisation (data products), SimDM & PDL (pipelines), DataLink (protocol), to take account of the particularities of HE Data Products. Provenance is another important block.

# Provenance (see Cosadie presentation)

**Describe the observational path from sky to the dataset**

Provenance right now too simplifies in ObsTAp

- Some kind of quality assesment
  - AmbiantConditions :altitude, weather, wind, pressure versus time, aerosol, moon phase...
    Create atm. sets ? Keep all metadata?
  - ObservingConfigurations : How was the telescope configured ? How many telescopes involved ?
  - DataProcessing : calibration, reconstruction and analysis pipeline

- Describe the previous steps and acces to « progenitors » if reprocessing of the data is needed

- Semantics for DataProcessing to be addressed