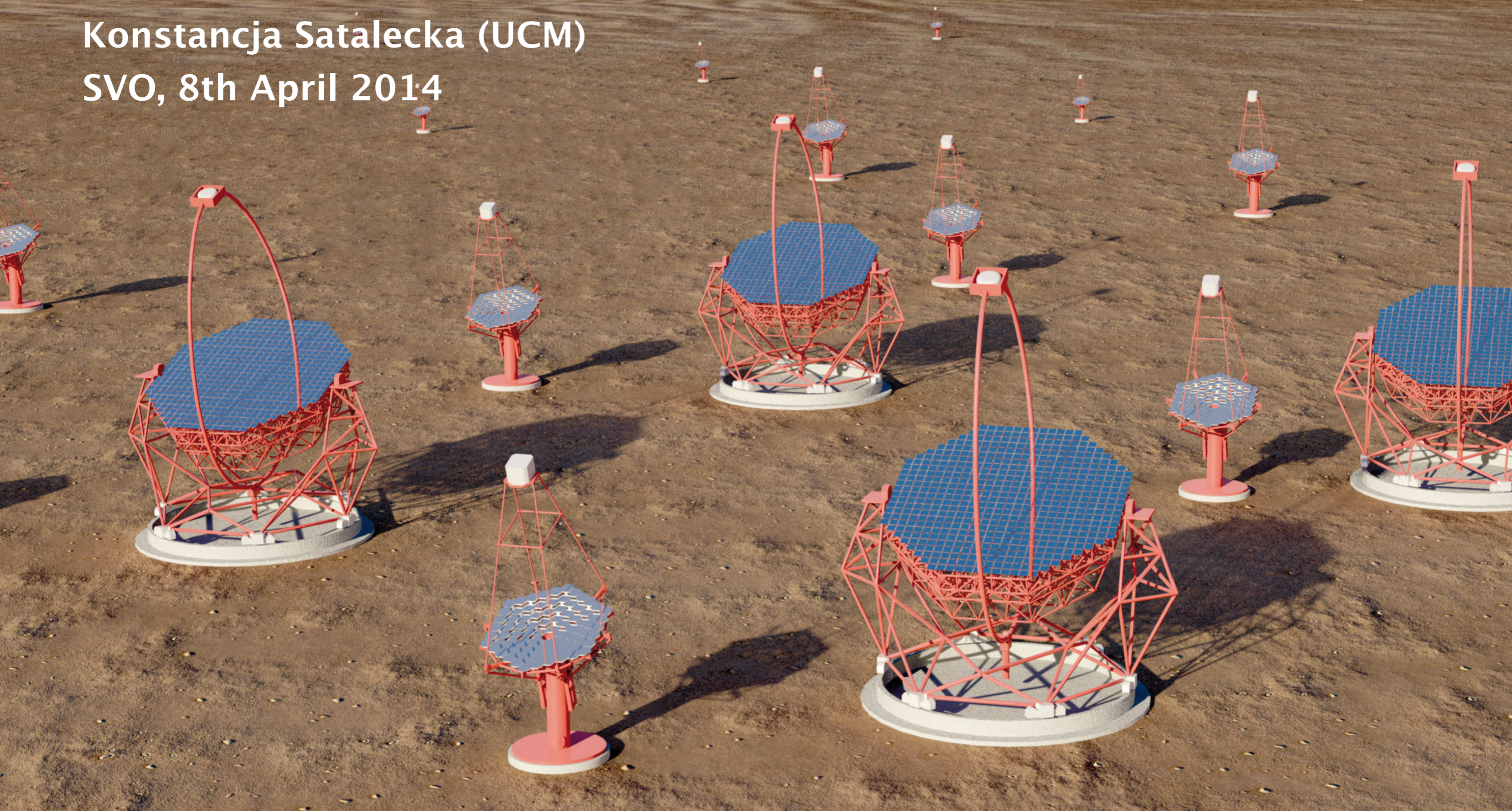


CTA in VO: needs and challenges

Konstancja Satalecka (UCM)

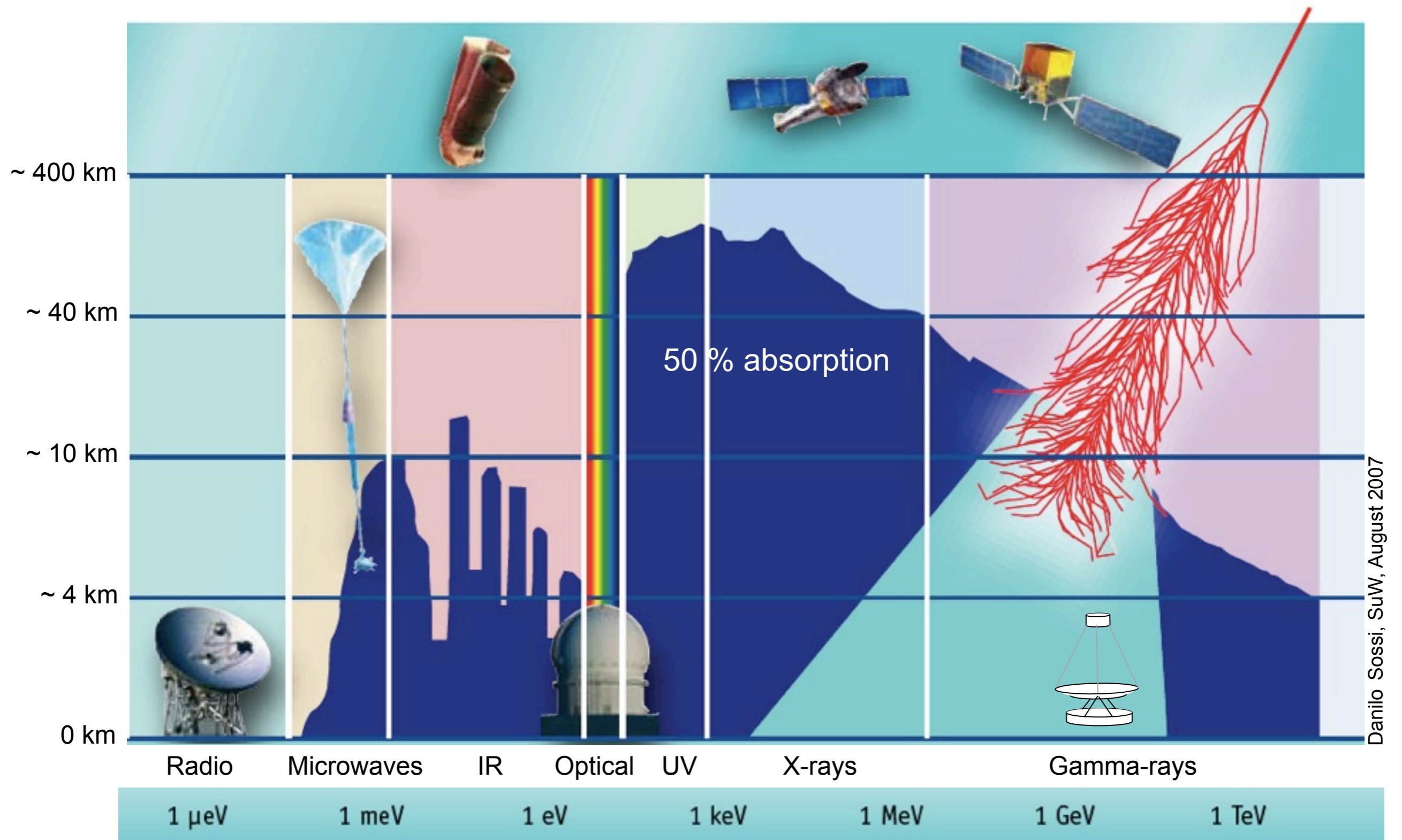
SVO, 8th April 2014



Outline

- 👁 Imaging Atmospheric Cherenkov Telescopes
- 👁 IACT data flow
- 👁 Future: CTA
- 👁 Summary

IACTs



Danilo Sossi, SuW, August 2007

IACTs



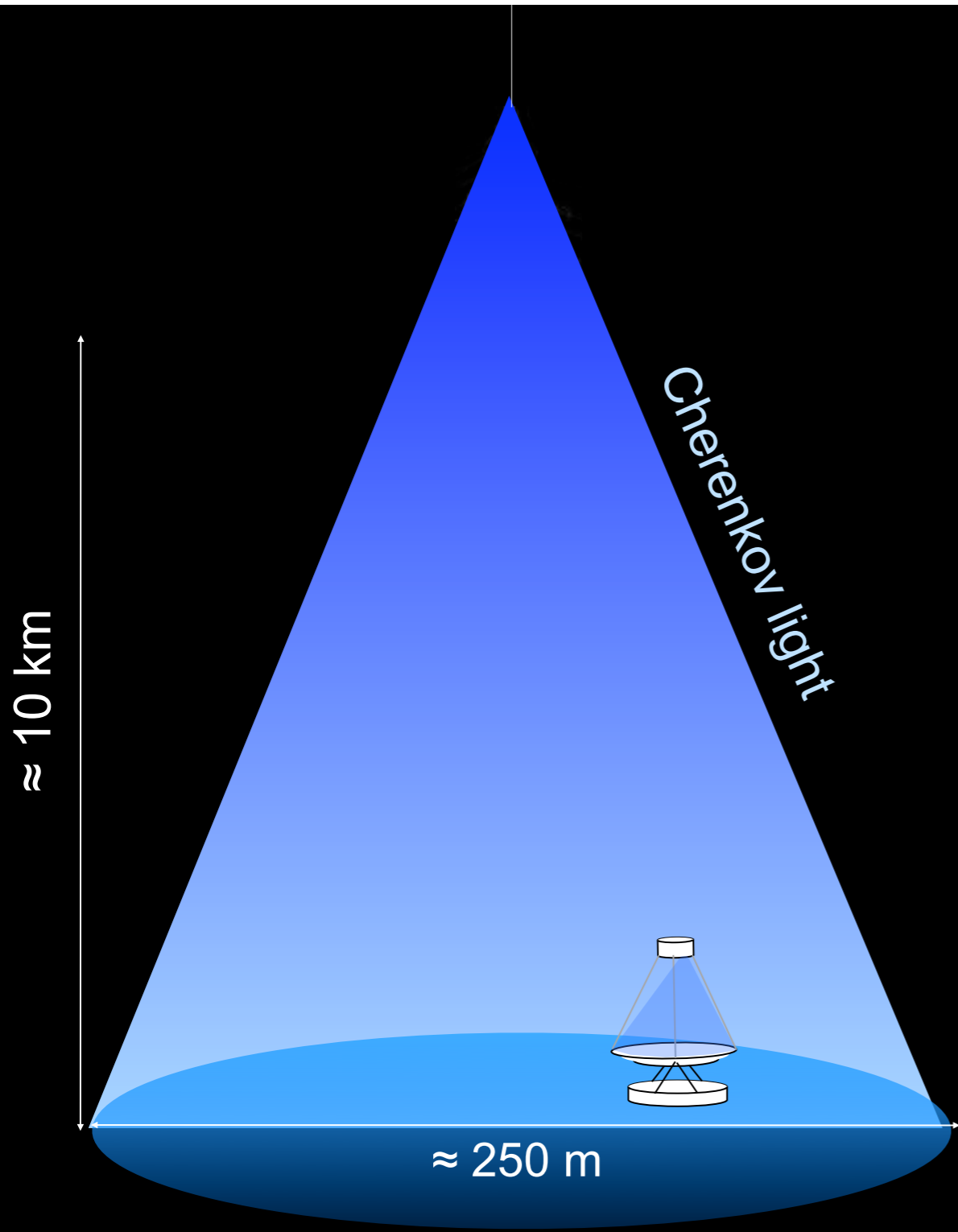
Very High Energy (VHE) γ -ray interacts with Earth's atmosphere and creates an electromagnetic cascade.

Cosmic Rays induce similar showers (hadronic) – main background for IACTs, isotropic.

≈ 10 km



IACTs



e^- and e^+ from the cascade
produce Cherenkov light

IACTs

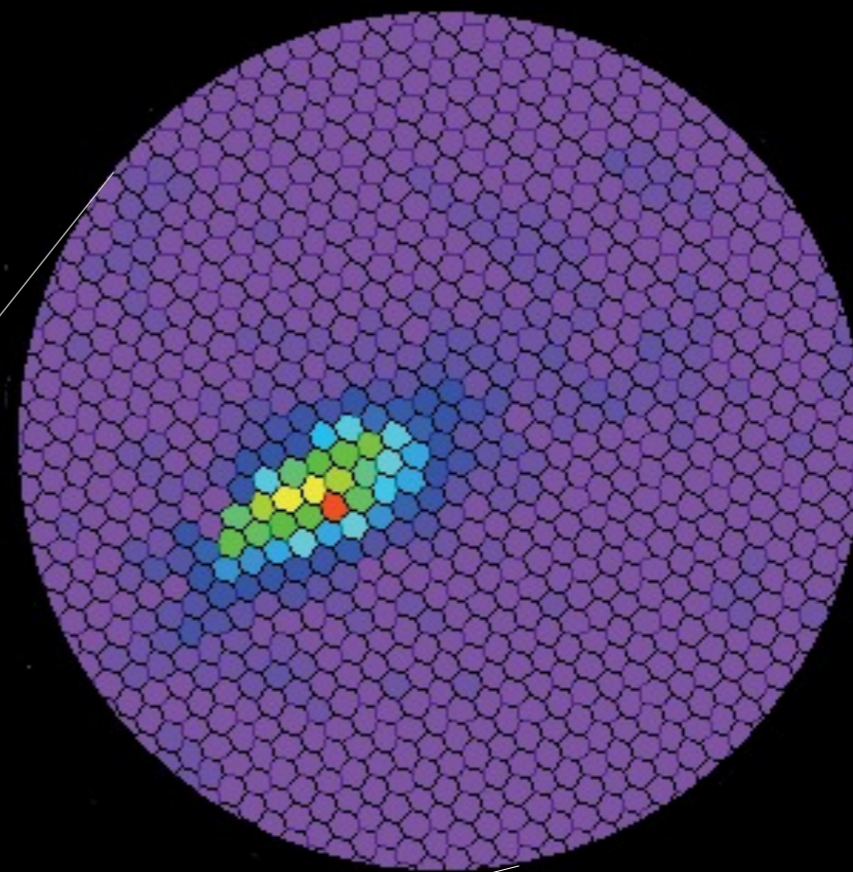
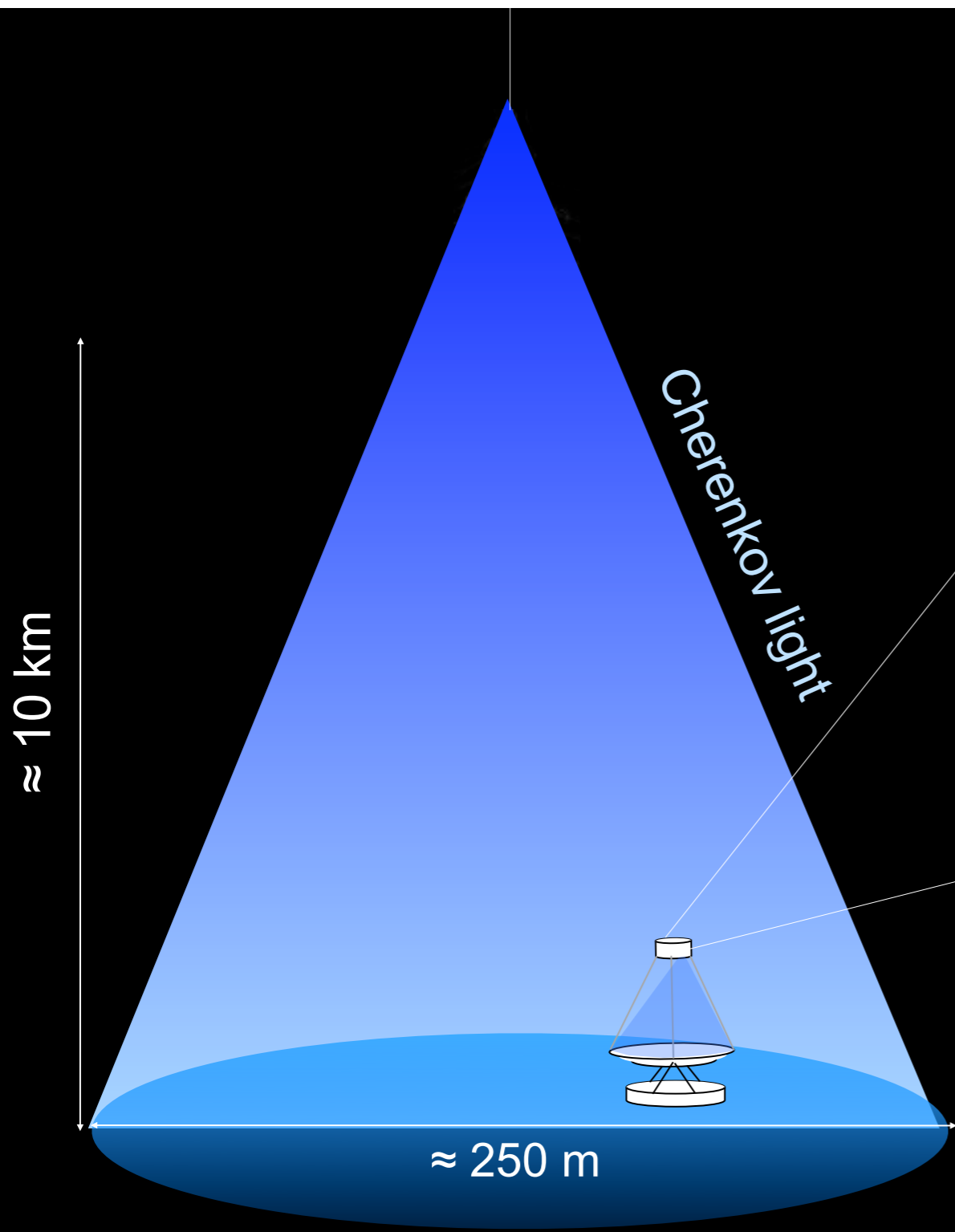
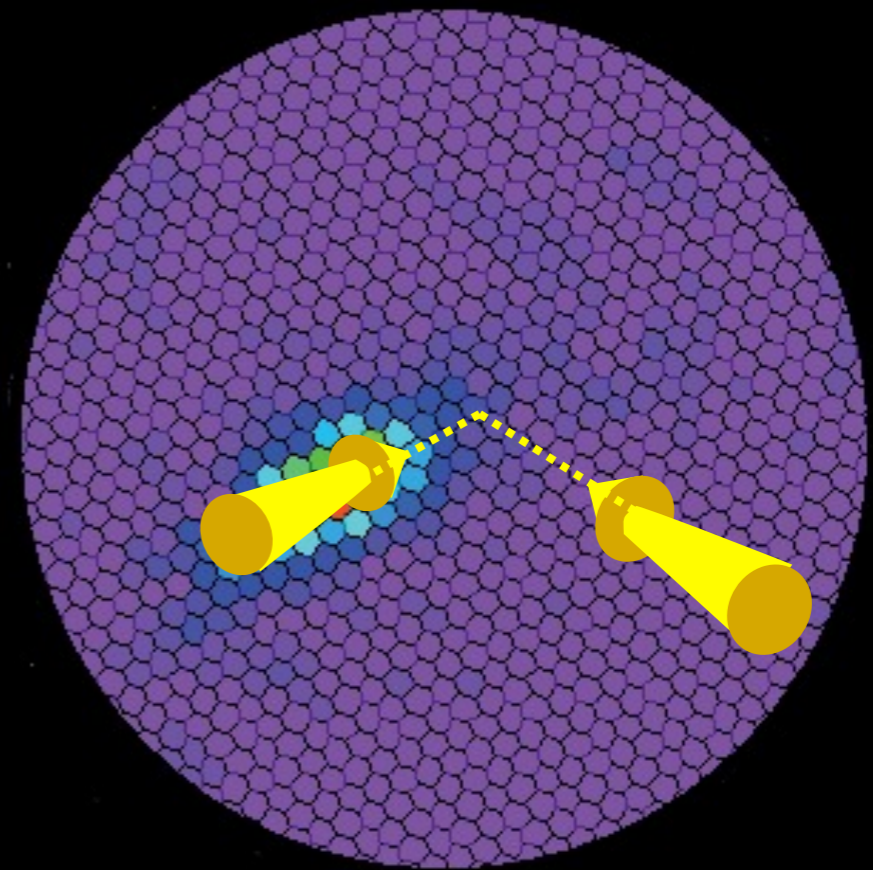
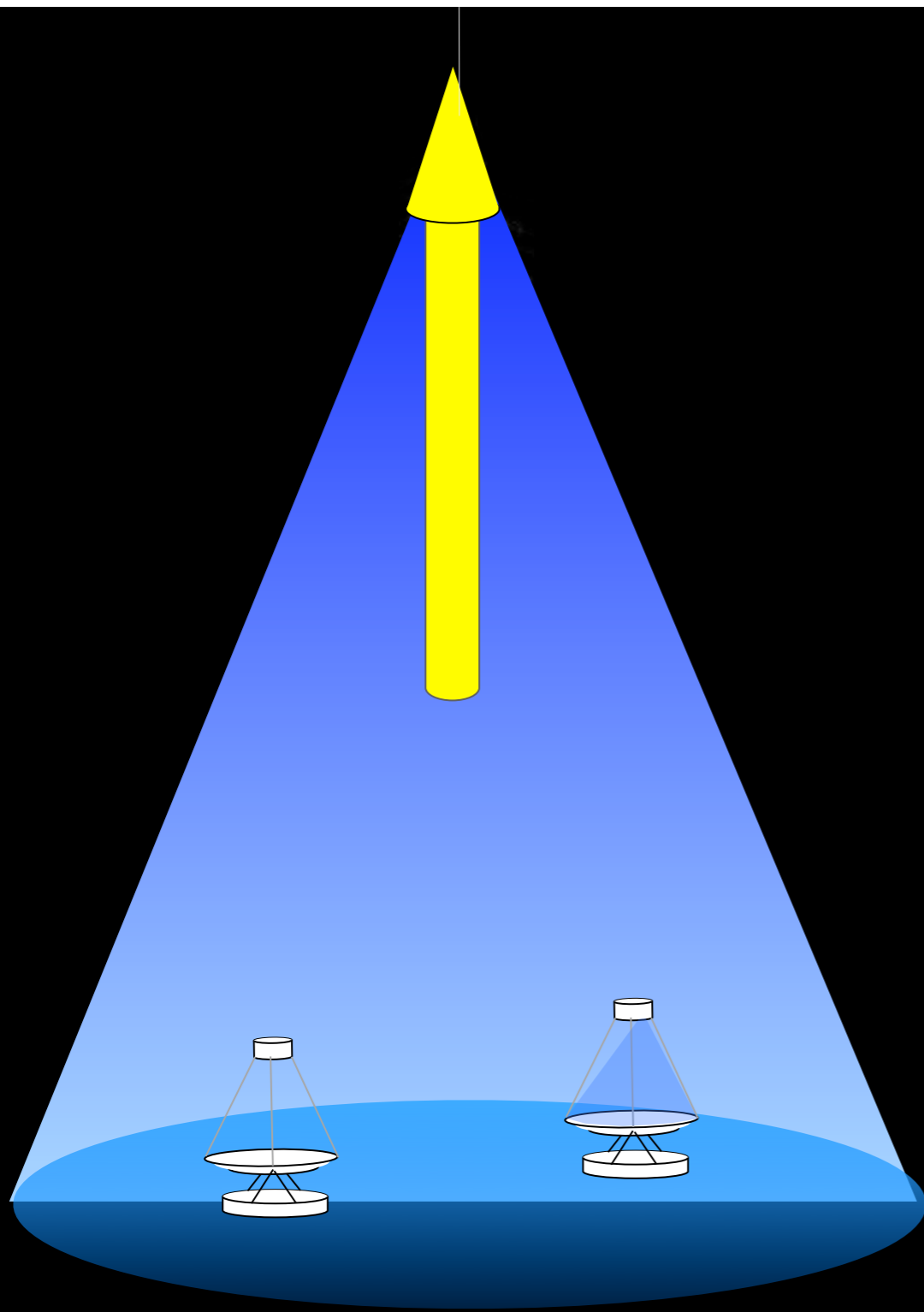


Image of the shower is recorded by the camera (PMTs).

Energy of a shower is roughly proportional to the number of recorded photons.

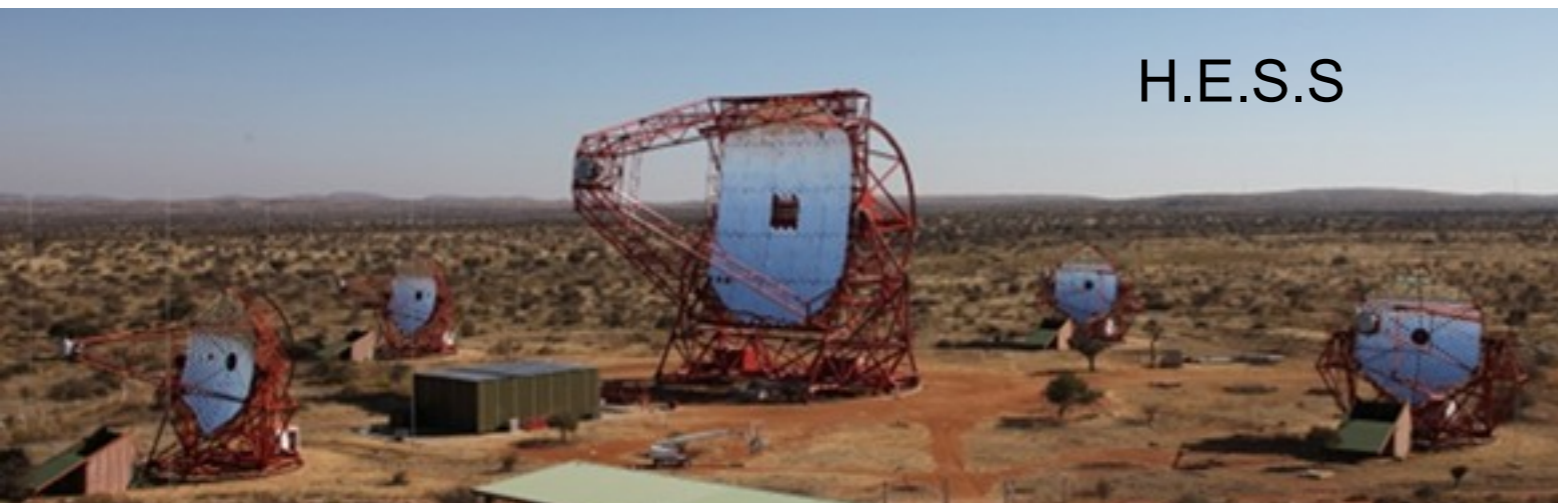
Shape of the image helps to discriminate signal from background (CR).

IACTs



- Stereoscopic view helps in:**
- reconstruction of γ -ray direction
 - energy reconstruction
 - background rejection

IACTs



H.E.S.S



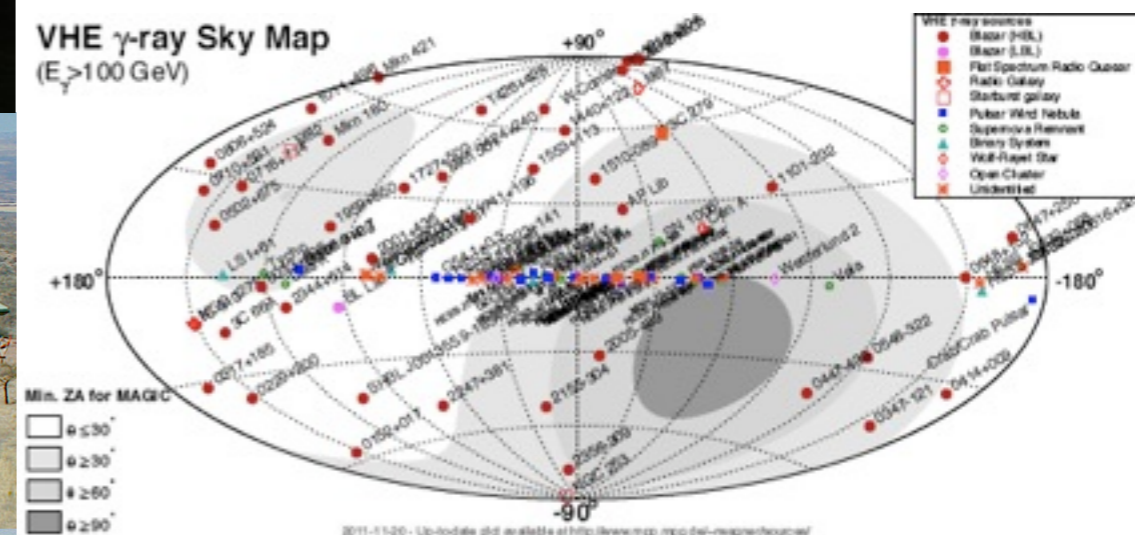
MAGIC



VERITAS

- ★ energy range 50 GeV – 50 TeV
- ★ energy resolution $\sim 15\%$ @ 1 TeV
- ★ angular resolution ~ 0.05 @ 1 TeV
- ★ physics: AGN, SNR, pulsars, GRBs, EBL, DM, LIV...
- ★ > 100 sources discovered so far

VHE γ -ray Sky Map
($E_{\gamma} > 100$ GeV)



Future: CTA

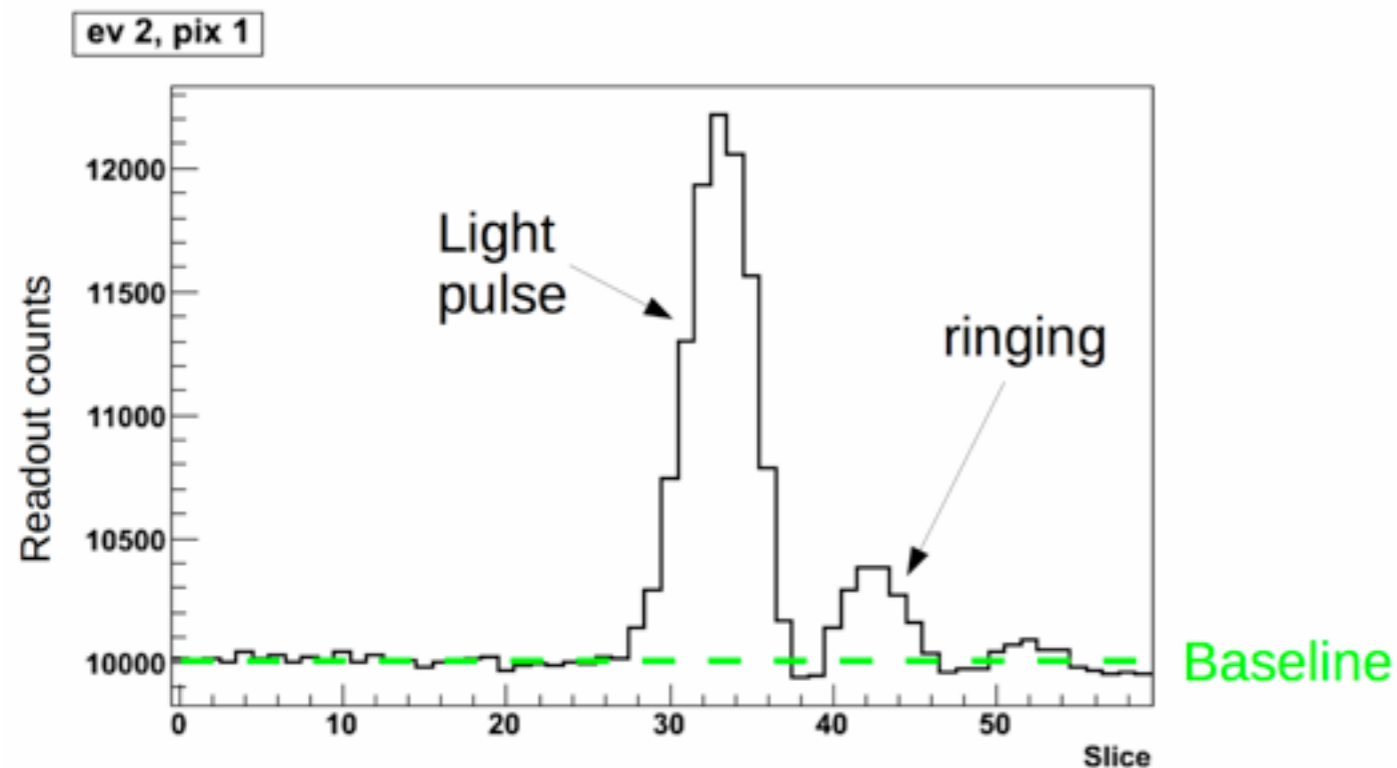
- ★ CTA = Cherenkov Telescope Array: few 10s of IACTs of 3 different sizes, Northern & Southern hemisphere observatories, area: several km²
- ★ improved sensitivity x10 in the entire energy range
- ★ extended energy range, improved energy resolution (10–15%)
- ★ increased FoV (~10 deg > 1 TeV) with homogeneous sensitivity
- ★ improved angular resolution (0.03 deg @ 1 TeV)
- ★ 1000 sources
- ★ expected raw data volume: 10–100 PB/yr (depending on scenario)
- ★ first IACT open observatory: external users will submit proposals and have to have an easy access to their data, analysis tools, simulations...



IACT data processing: DL0

- raw data:** readout counts in time-slices, for each event and pixel, for N telescopes
- MC raw data:** simulated readout counts in time-slices, for each event and pixel, for N telescopes
- technical data:** telescope monitoring & control, weather etc.

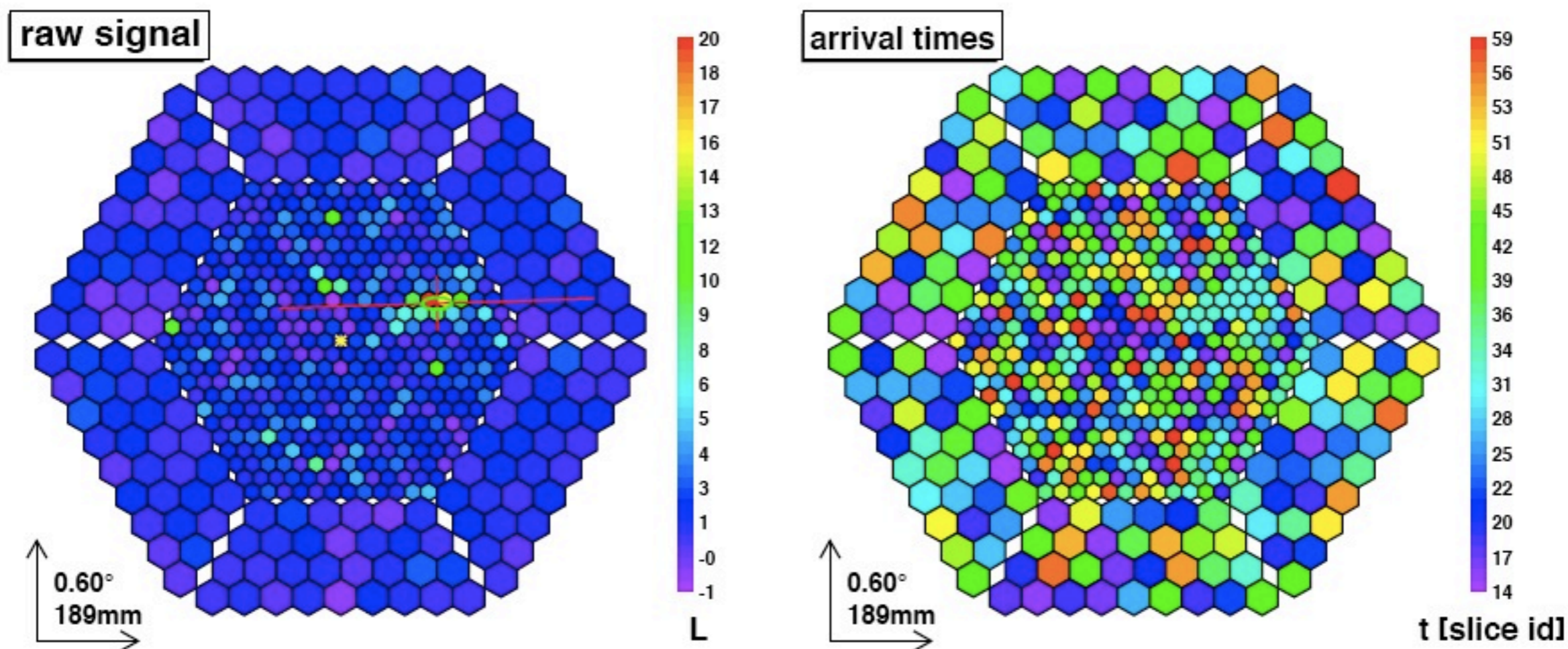
Access: only Privileged Users



IACT data processing: DL1

calibrated data: signal arrival time and charge for each event and pixel, for N telescopes
calibrated MC: same but for simulated events

Access: only Privileged Users

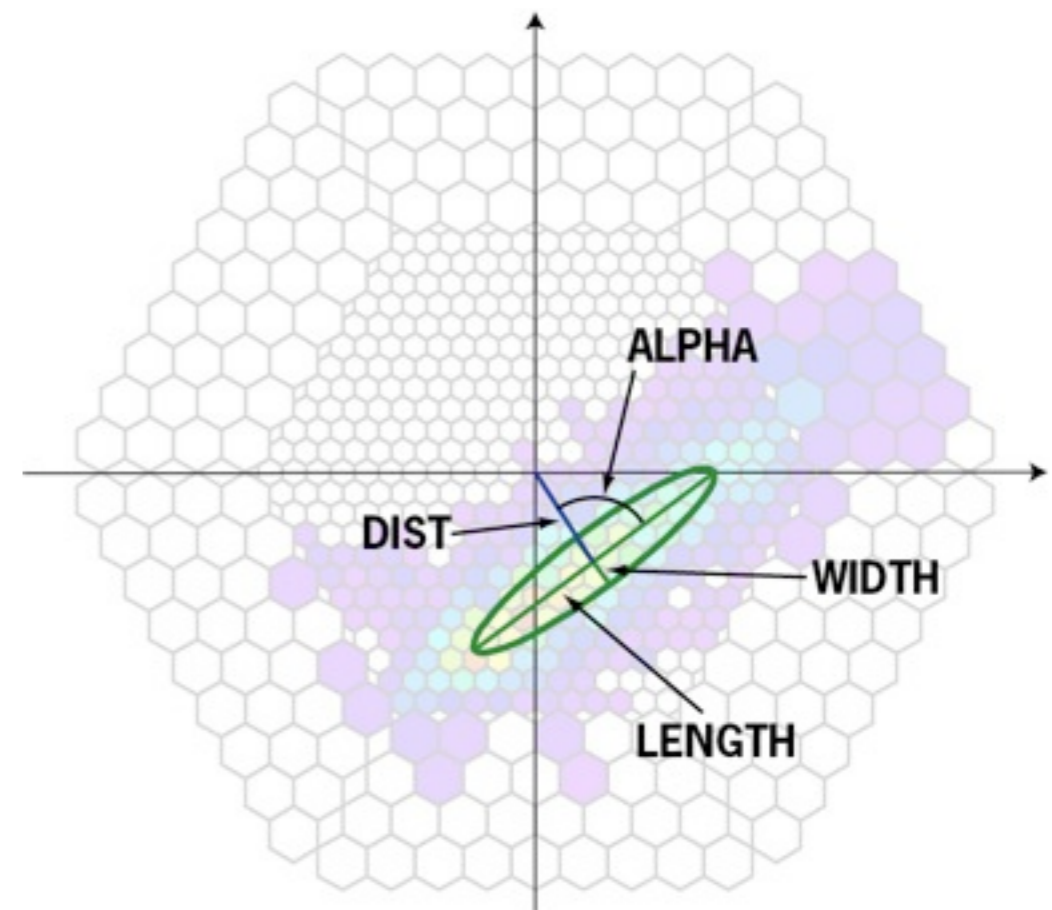
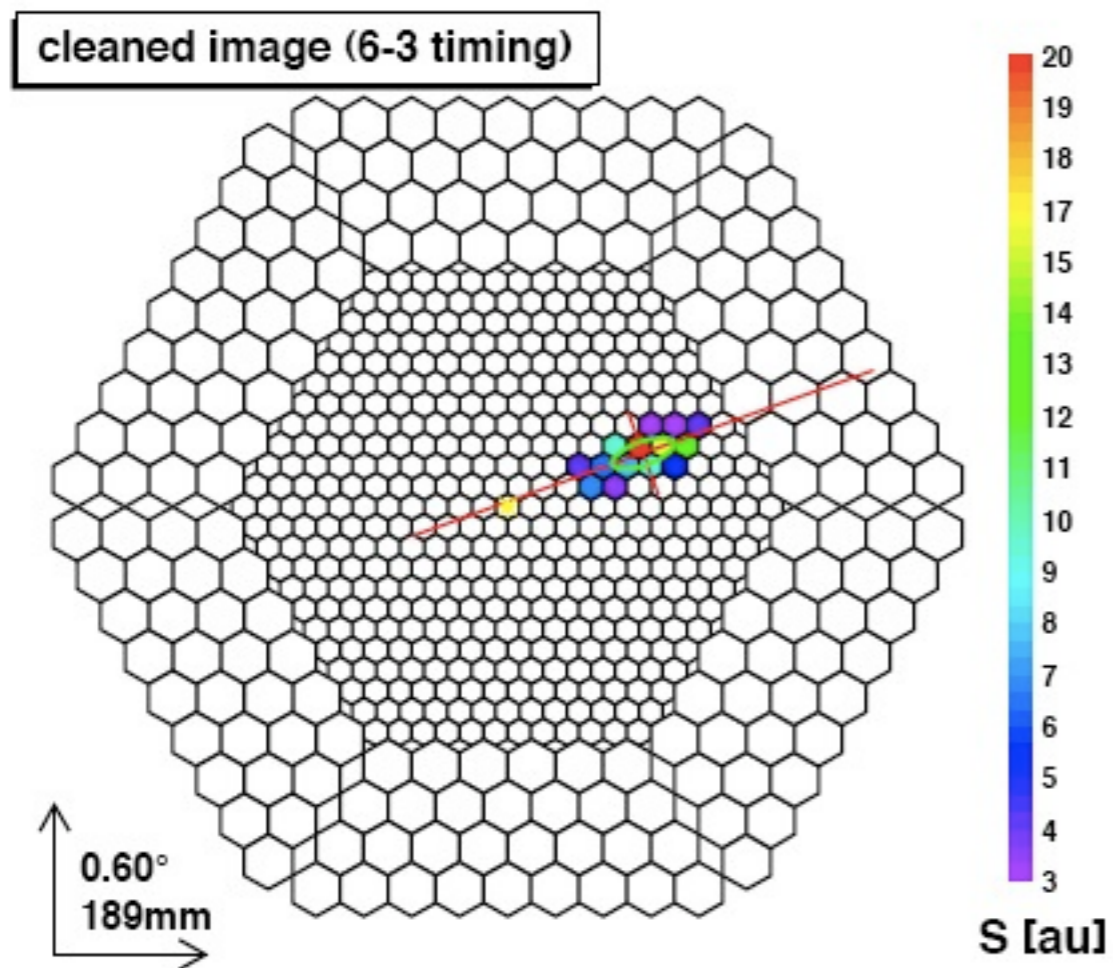


IACT data processing: DL2

reconstructed data: cleaned camera image, image parameters calculated, for each event, for N telescopes

reconstructed MC data: same for simulated

Access: only Privileged Users



IACT data processing: DL3

events lists (EL): gamma/hadron tag, reconstructed: energy, arrival direction, for each event

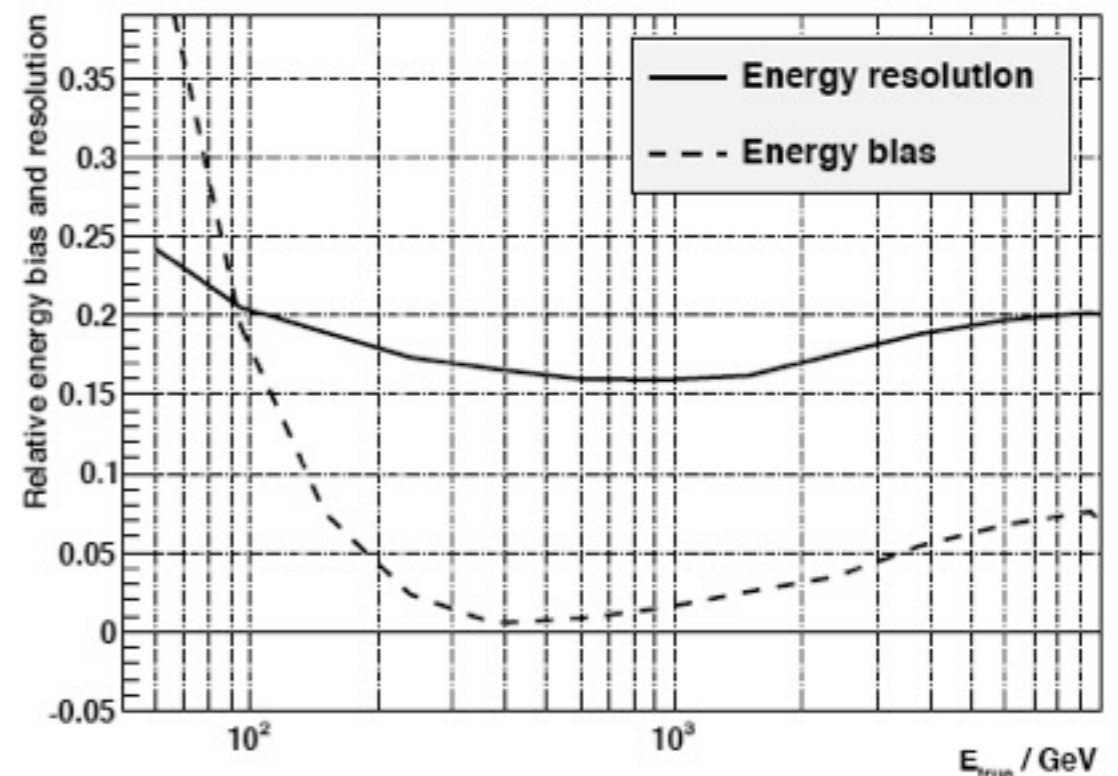
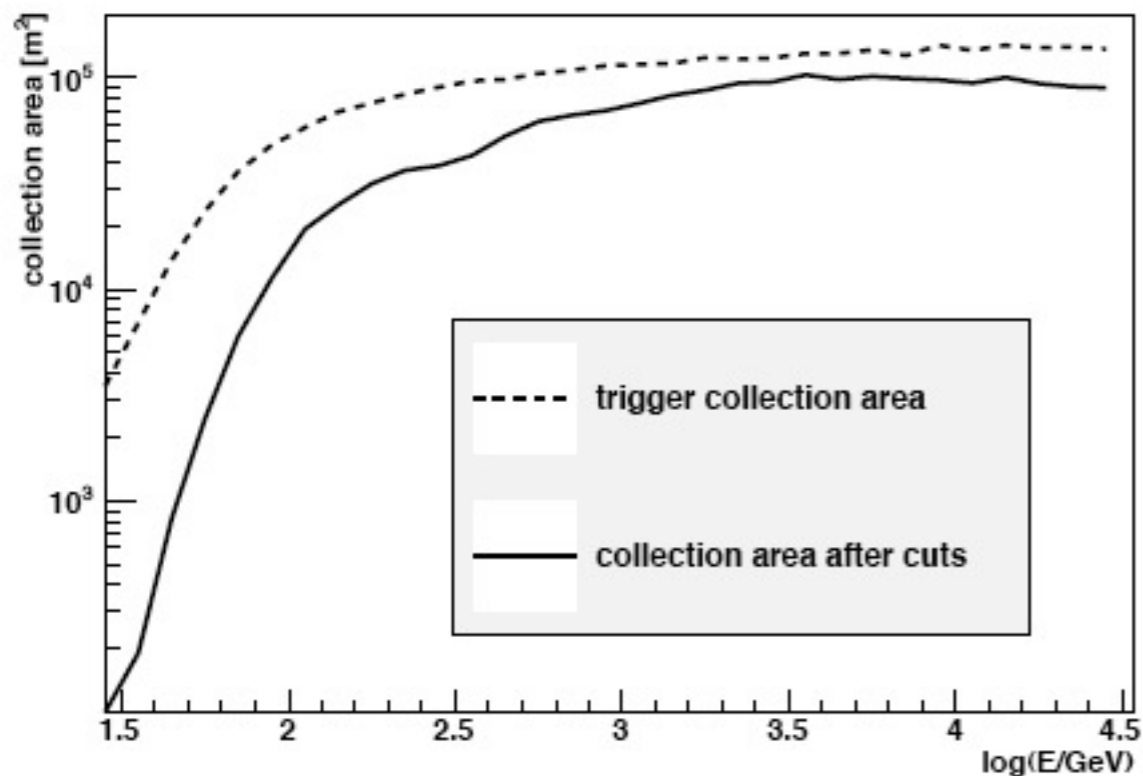
MC events list (MCEL): same for simulated events

Instrument Response Functions (IRFs): effective area, energy migration matrix, angular resolution

IMPORTANT:

- input from **MC** and **technical data** needed
- **EL** + **MCEL** + **IRF** come as a set with the same cuts, observational conditions etc.

Access: Privileged Users and Guest/Archive Users



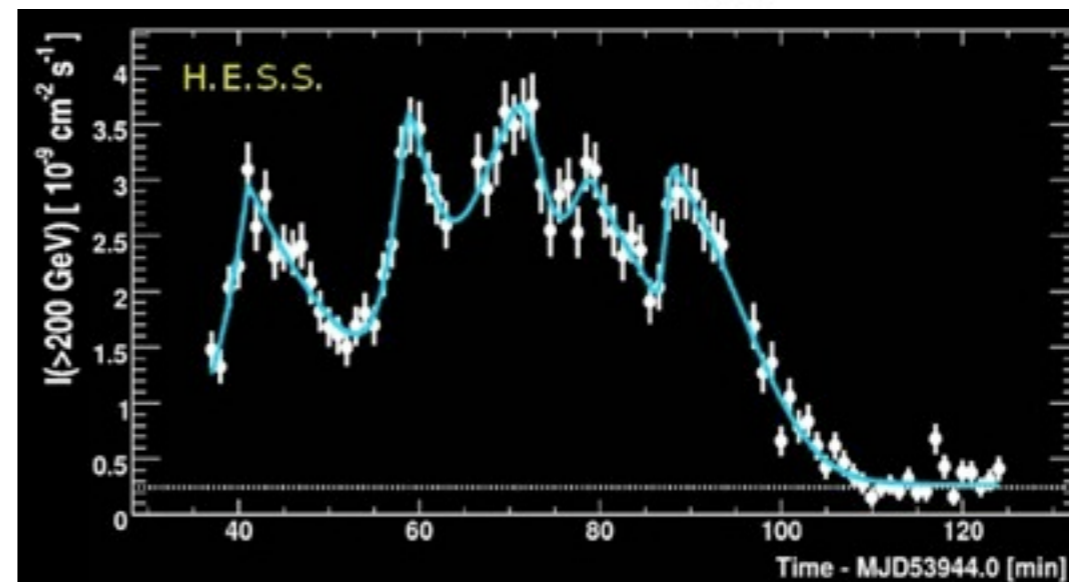
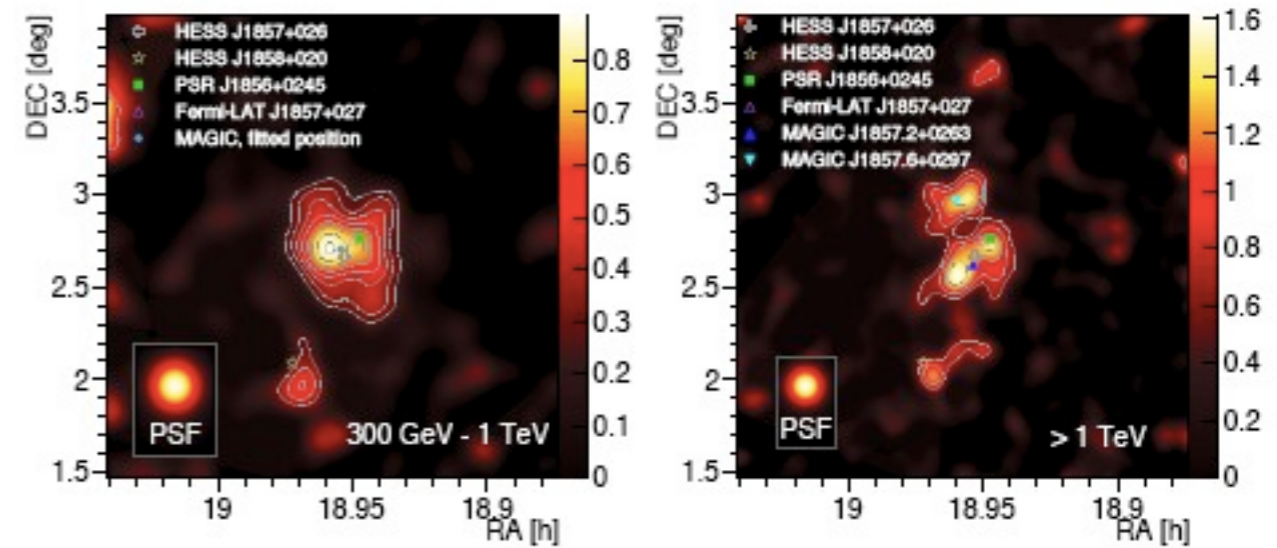
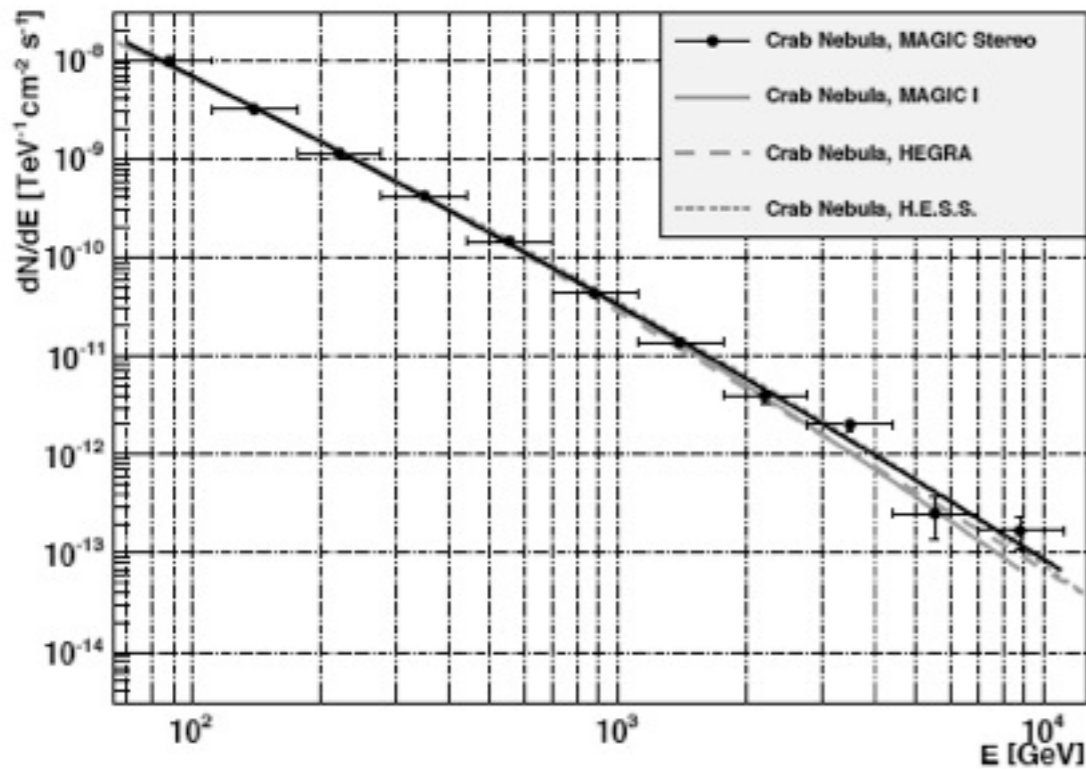
IACT data processing: DL4

high level data: light curve, spectrum, sky map for each source/observation

IMPORTANT:

- produced from L3 events list using the corresponding IRFs
- might be a combination of data from different observations

Access: Privileged Users and Guest/Archive Users



Privileged User

Guest/Archive User

DL0

DL1

DL2

DL3

DL4

Raw data

MC raw data

Technical data

Data reduction pipelines

Calibrated & reconstructed MC/data

Events List

MC Event List

IRFs

Technical data

Science tools

Image

Light Curve

Spectrum

Our VO needs for CTA

We would like to make accessible through VO:

- ★ DL4 data: light curves, spectra, sky maps
- ★ DL3 data: event lists, IRFs, technical data

Challenges:

- ★ Observations are long, but consist of many short time units (1–2 h) taken during various conditions: array/environment/processing (different IRFs!)
 - > DL4 products combination of data taken during different epochs
 - > We would like to combine data into sets including EL+IRF+MC
 - > We would like to include the history of the data set: environmental conditions, array configuration, processing pipeline...
- ★ We would like to publish “diffuse backgrounds” of gamma/electrons/hadrons
- ★ We have doubts, if the ObsCore model for spectra is enough for VHE data (what we see are counts/time unit – model (IRF) needed to convert them into flux)
- ★ We think some keywords (Utypes) are missing & some are not applicable (e.g. we would need PSF instead of aperture)
- ★ We use different units (e.g. spectral info given as a function of energy in [GeV] instead of wavelength in [m])

Our experience with VO: MAGIC

We offer VO services in two ways:

- via VO search tools (VOSED)
- via our own VO server (vobs.magic.pic.es), where you can fill out form or send a query through address line of your browser

- At the moment, we only support spectra and light curve protocols (SSA protocol)
- Access to sky maps in preparation...
- Results are returned in VOtable format, and as links referring to the generated results (in FITS format)
- Results expire after 24 hours
- Search is done over the public MAGIC results only

Our experience with VO: MAGIC

The screenshot shows a Firefox browser window displaying the 'MAGIC Data Virtual Observatory Search' page. The browser's address bar shows 'vobs.magic.pic.es'. The page features a search form with six sections: POSITION, SIZE, BAND, FORMAT, TIME, and TYPE OF DATA. Each section includes a description and a text input field. The 'POSITION' section has fields for 'Ra [deg]' and 'DEC [deg]'. The 'BAND' section has a field for 'Band [m]' with the value '1E-20/1E-16'. The 'FORMAT' section has a dropdown menu for 'Format' set to 'ALL'. The 'TYPE OF DATA' section has a dropdown menu for 'Search for' set to 'Spectrum'. A 'Reset' button is located at the bottom left of the form, and a 'Submit' button is at the bottom right. Below the form, there is a footer with contact information and a link to the MAGIC Fits Database.

MAGIC Data Virtual Observatory Search

POSITION:
The center of the region of interest. Coordinates are given in decimal degrees. If none are specified, "ALL" is assumed.
Ra [deg]:
DEC [deg]:

SIZE:
The radius of the region of interest. It is specified in the decimal degrees. If none is set, 1 deg is assumed.
Size [deg]:

BAND:
Spectral bandpass of the search. For MAGIC data, this value is always given as a 1e-20/1e-16 m range (corresponds to ~ 10 GeV / 100 TeV in energy).
Band [m]:

FORMAT:
The format in which the returned results will be in. Formats currently supported by MAGIC are listed below.
Format:

TIME:
The time coverage of the search. For MAGIC data, it does not make sense to constrain the search with this parameter.
Time [YYYY-MM-DD]:

TYPE OF DATA:
Type of Data the search is queried for. Currently supported by MAGIC are searches for Spectra and/or Light Curves.
Search for:

All coments, suggestions and requests send to jelena@ifae.es.

[Visit our MAGIC Fits Database](#)

Summary

- ★ CTA: first open IACT observatory - we have to publish the data for the whole astrophysics community
- ★ VO seems to be a good solution, but...
 - ★ our experience with VO is limited
 - ★ no standards yet for VHE data

