CTA in VO: needs and challenges

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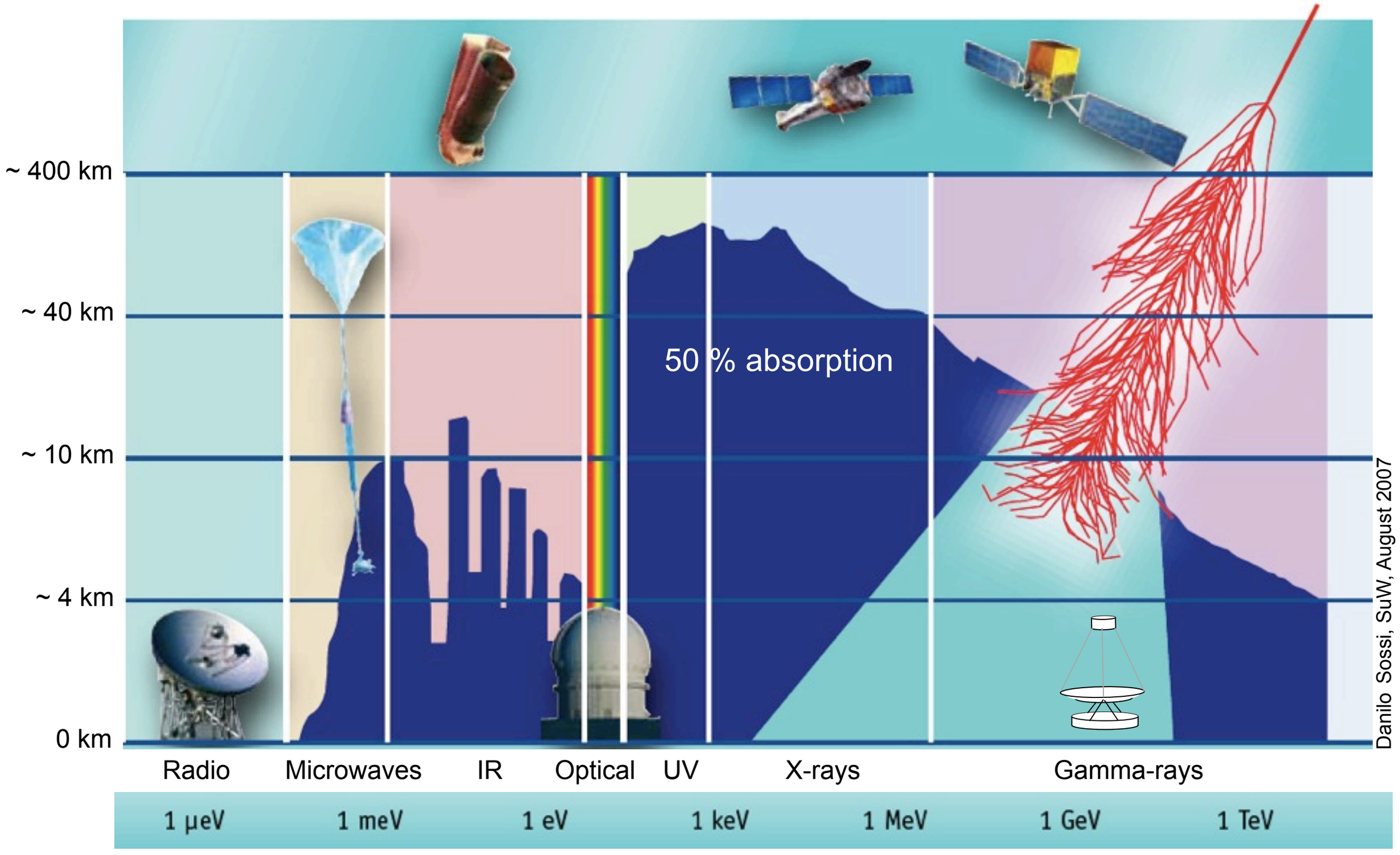
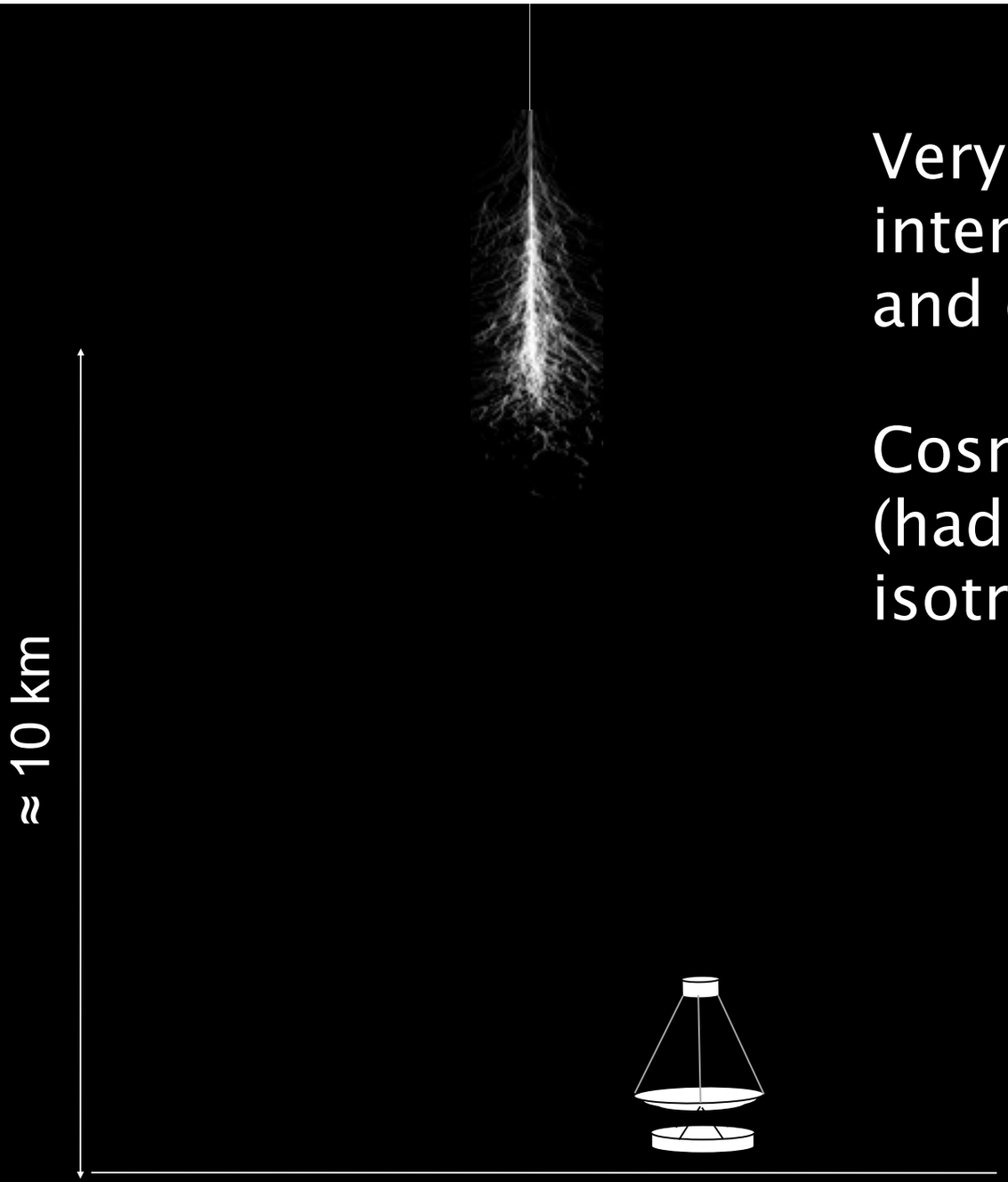
Outline

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

IACTs


~ 400 km
~ 40 km
~ 10 km
~ 4 km
0 km
50 % absorption
Danilo Sossi, SuW, August 2007
Radio
Microwaves
IR
Optical
UV
X-rays
Gamma-rays
1 μeV
1 meV
1 eV
1 keV
1 MeV
1 GeV
1 TeV

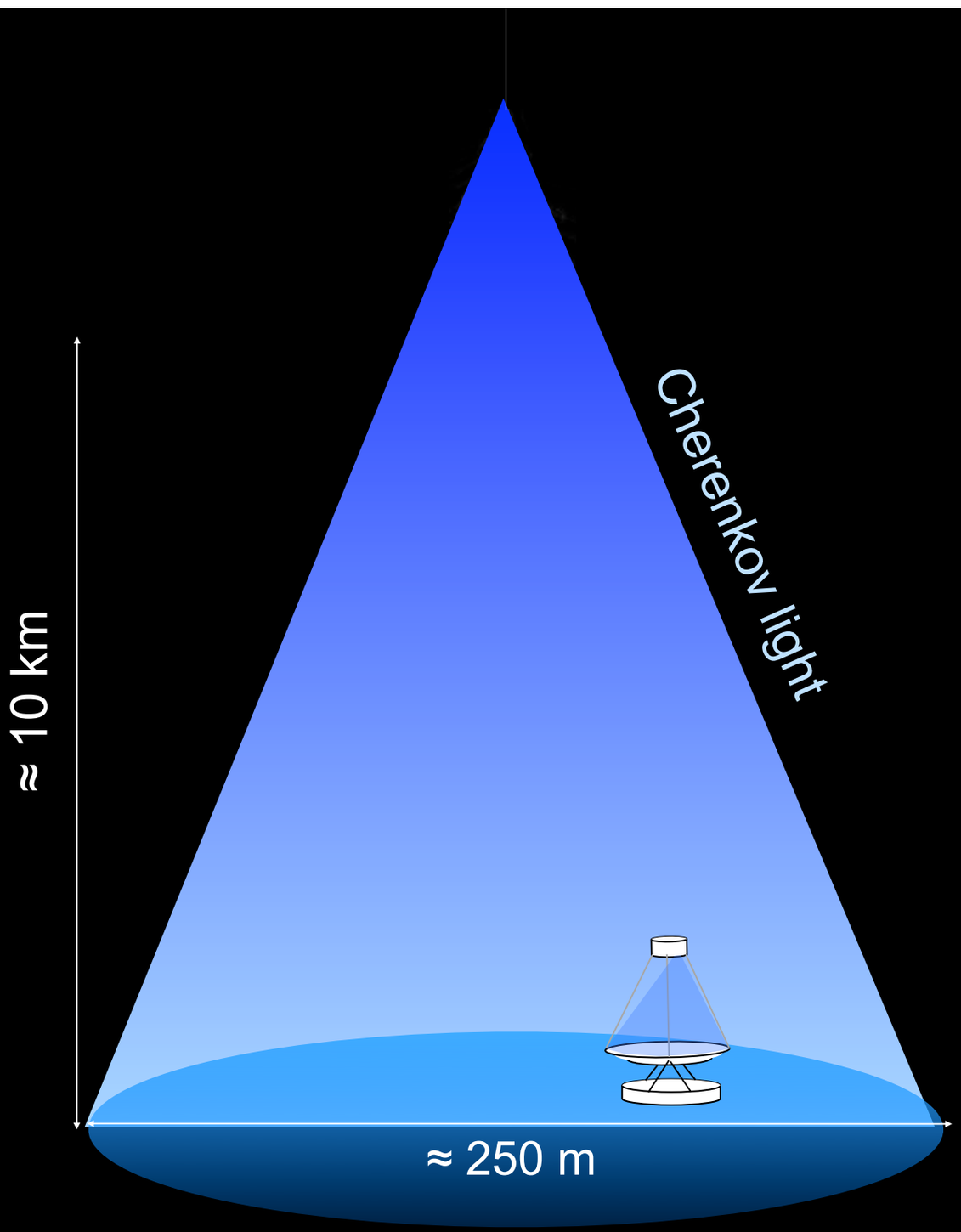
IACTs



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

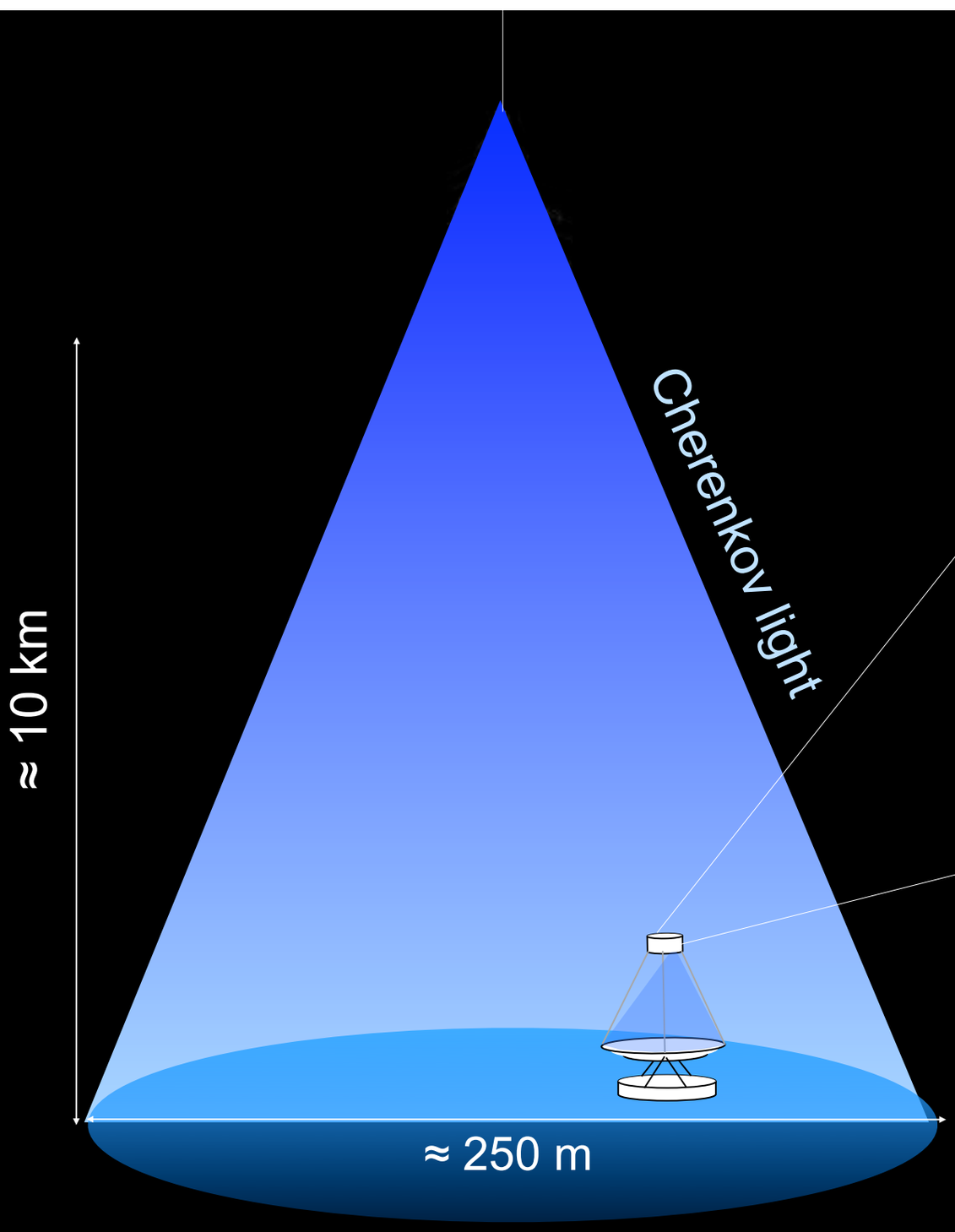
Cosmic Rays induce similar showers
(hadronic) - main background for IACTs,
isotropic.

IACTs



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

IACTs



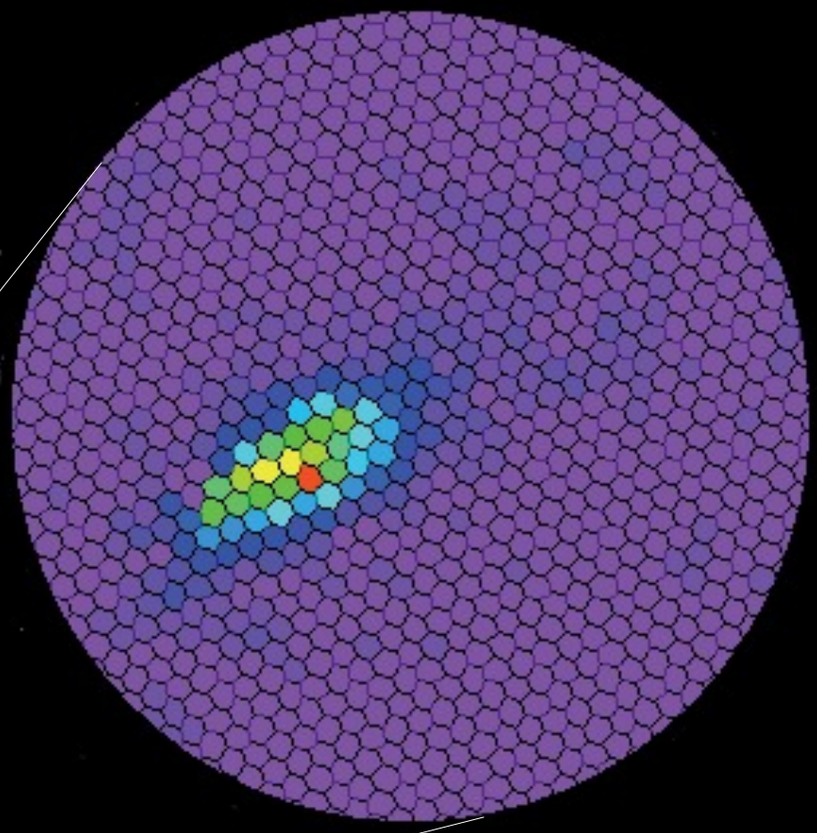
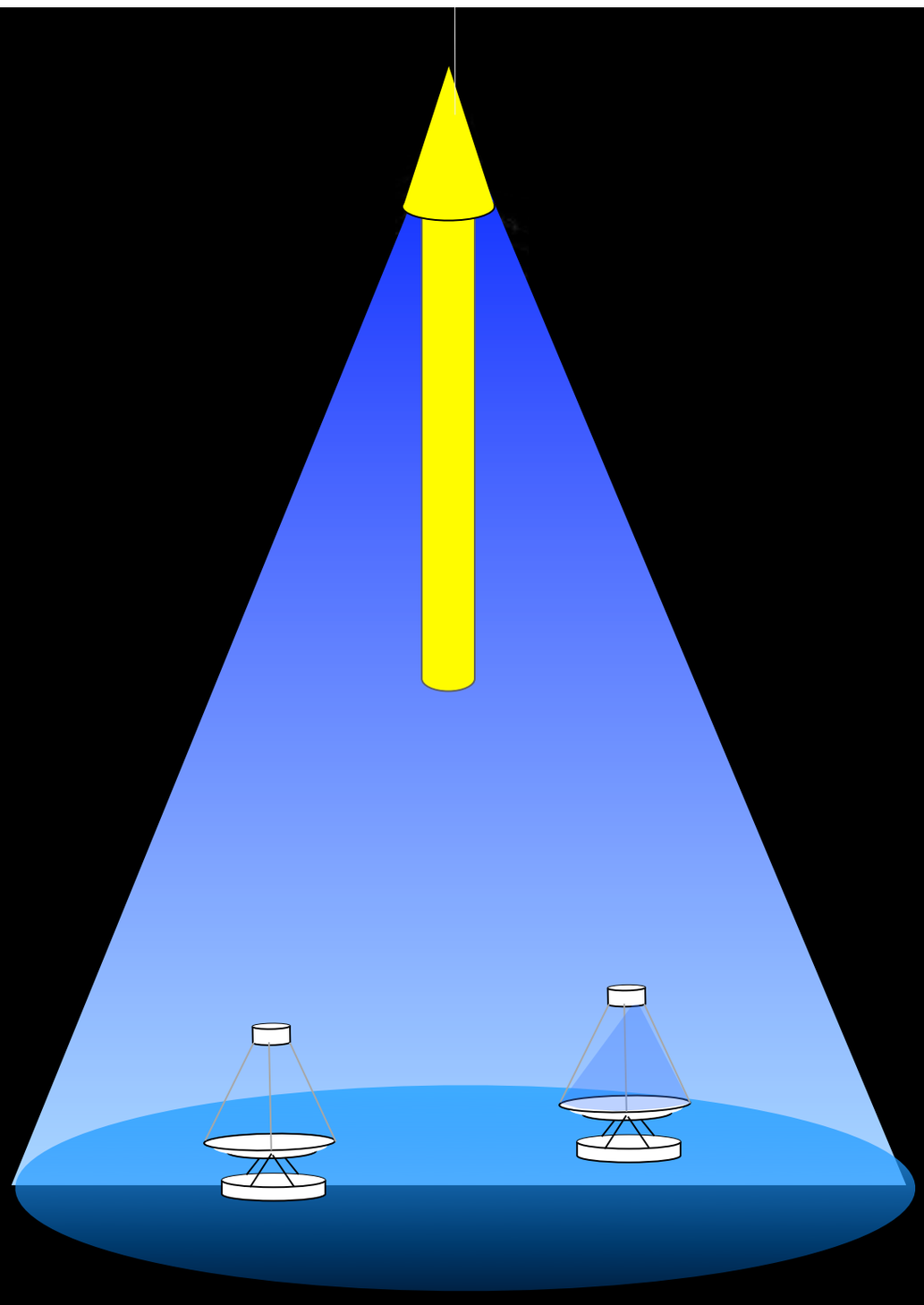


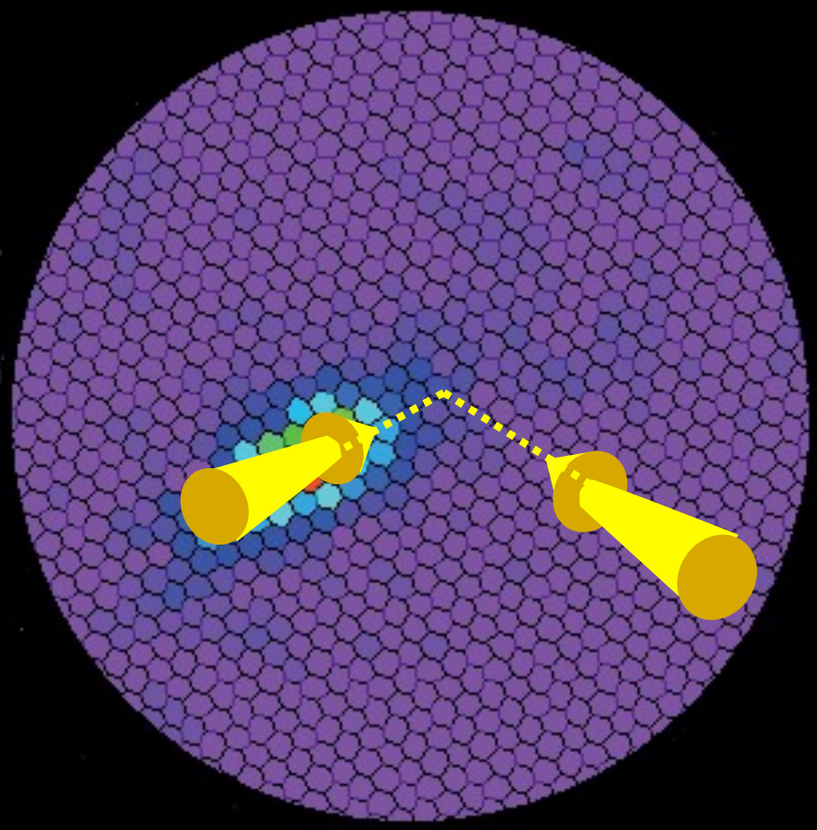
Image of the shower is recorded by the camera (PMTs).

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

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

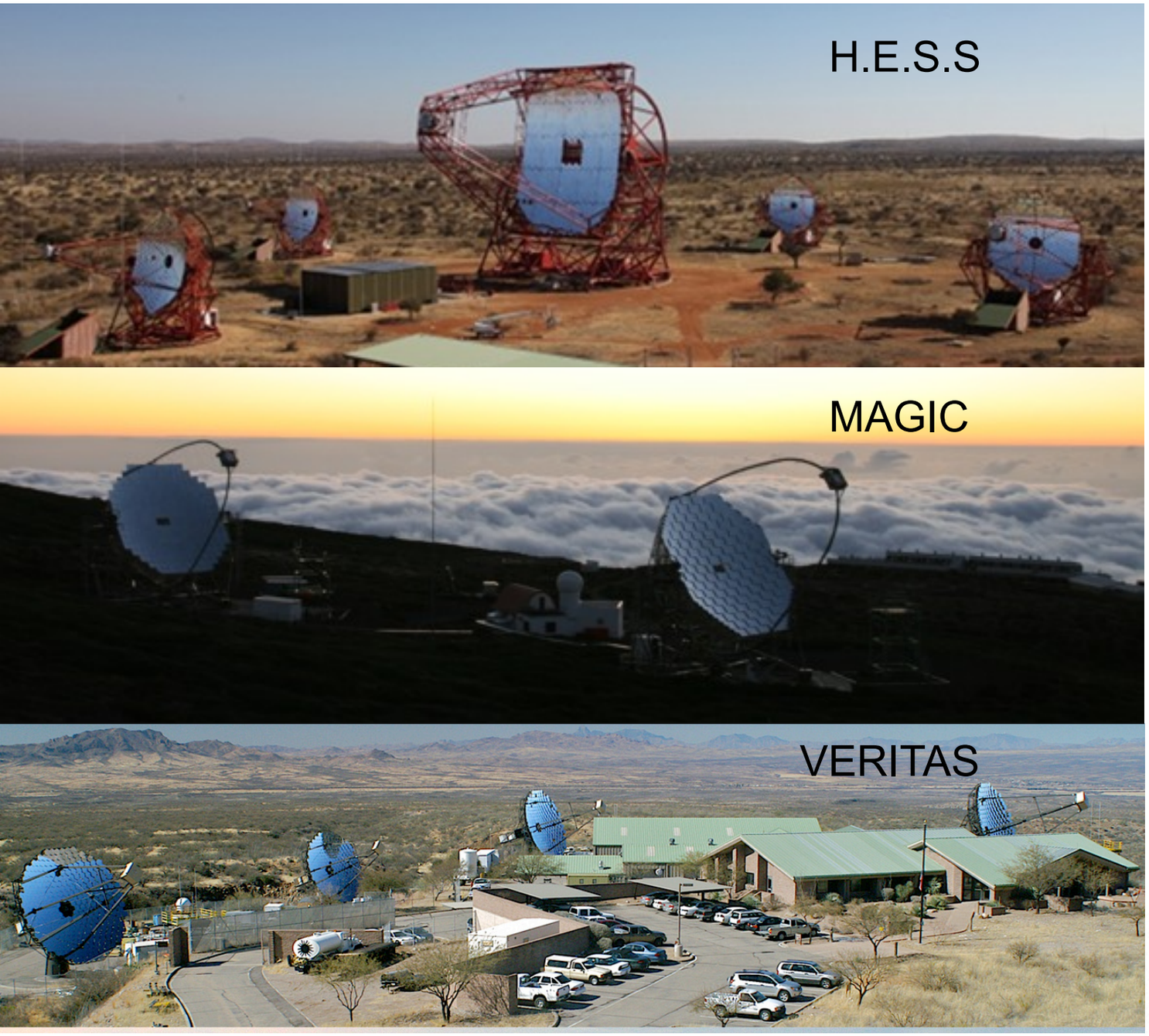
IACTs





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

IACTs



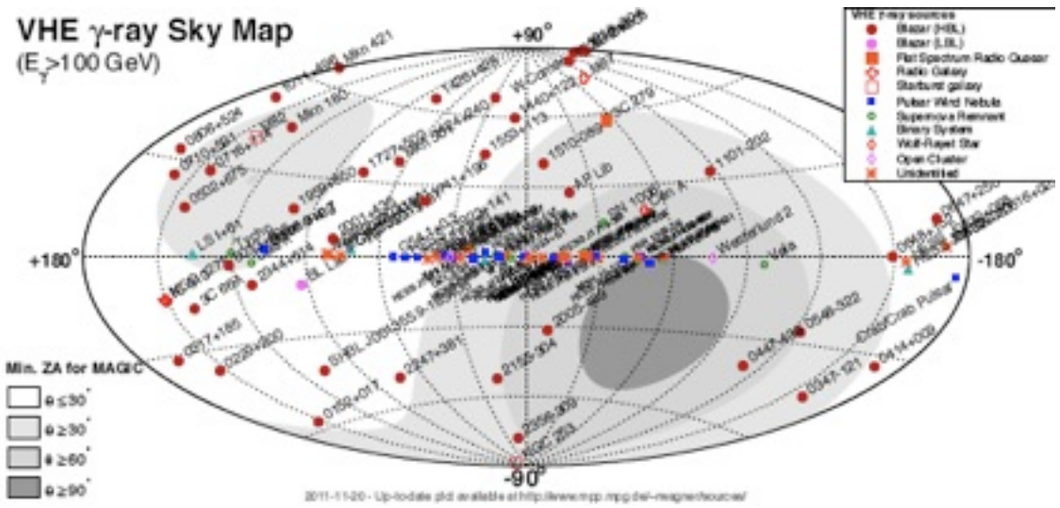
★ energy range 50 GeV – 50 TeV

★ energy resolution ~15% @ 1 TeV

★ angular resolution ~0.05 @ 1 TeV

★ physics: AGN, SNR, pulsars, GRBs, EBL, DM, LIV...

★ >100 sources discovered so far



Future: CTA

★ CTA = Cherenkov Telescope Array: few 10s of IACTs of 3 different sizes, Northern & Southern hemisphere observatories, area: several km^2

★ 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

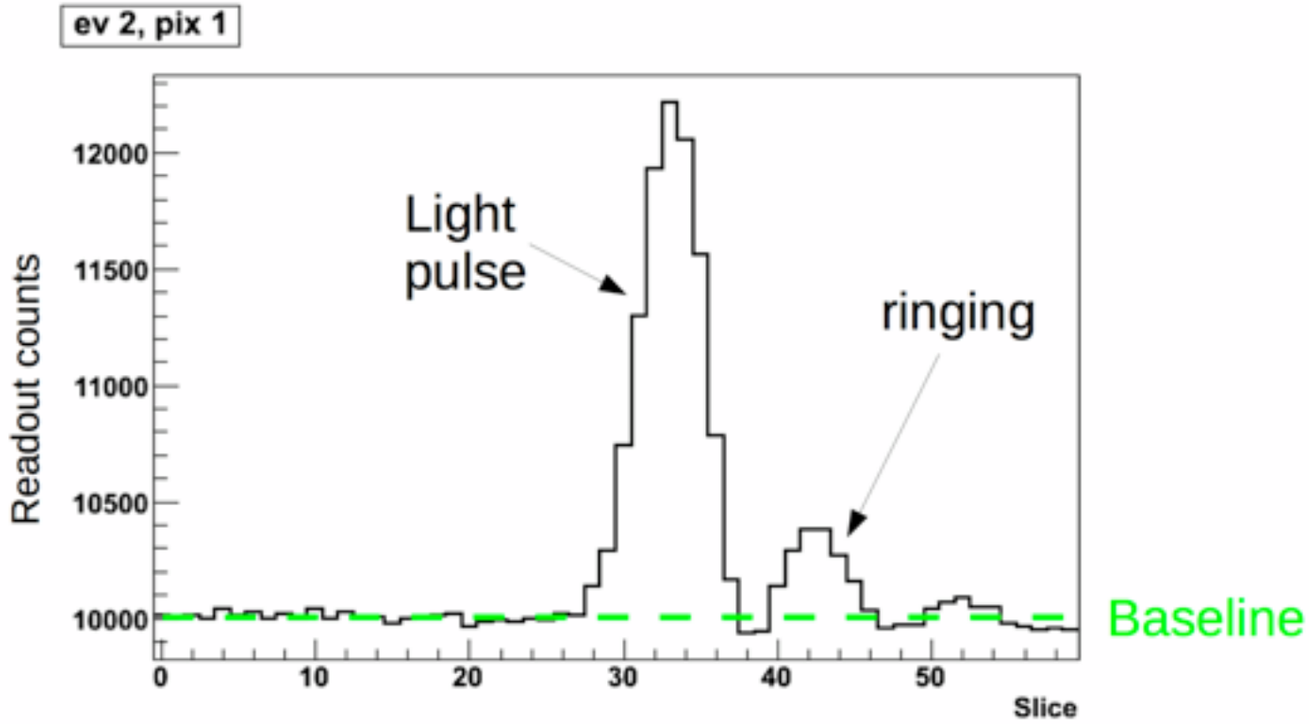
★ expected raw data volume: 10-100 PB/yr (depending on scenario)

★ 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.

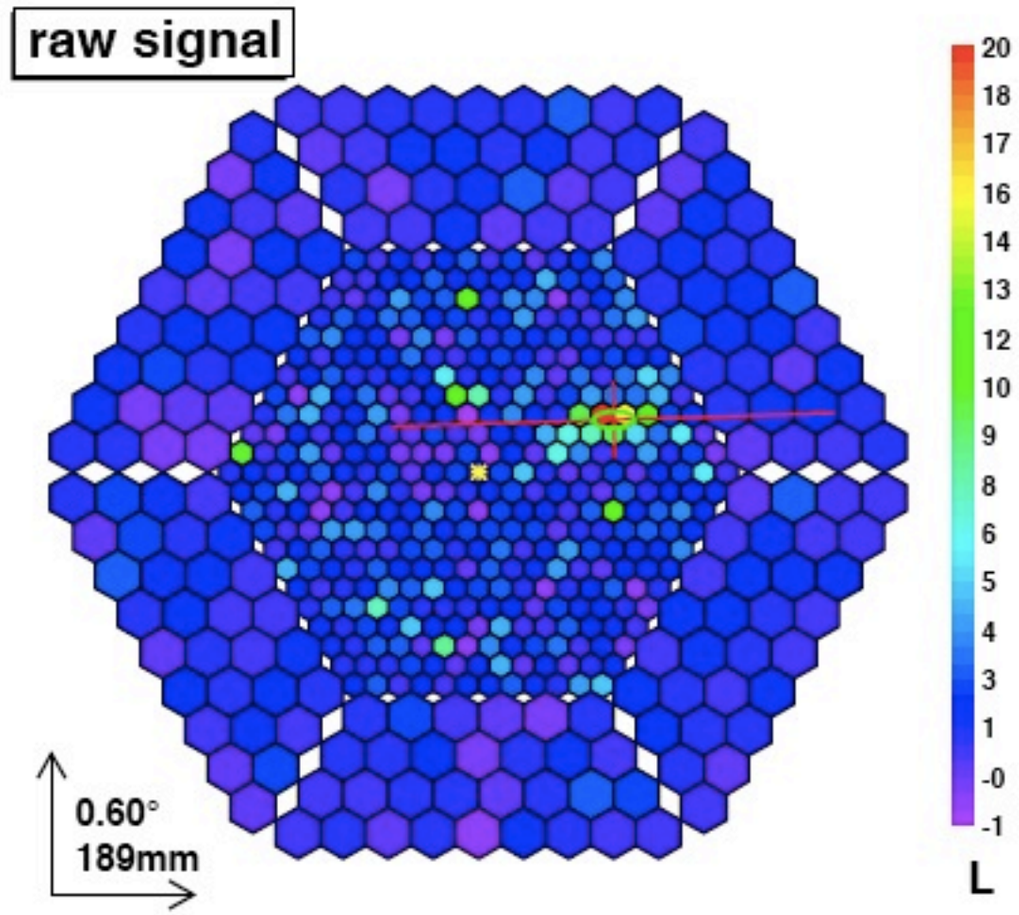
Access: only Privileged Users

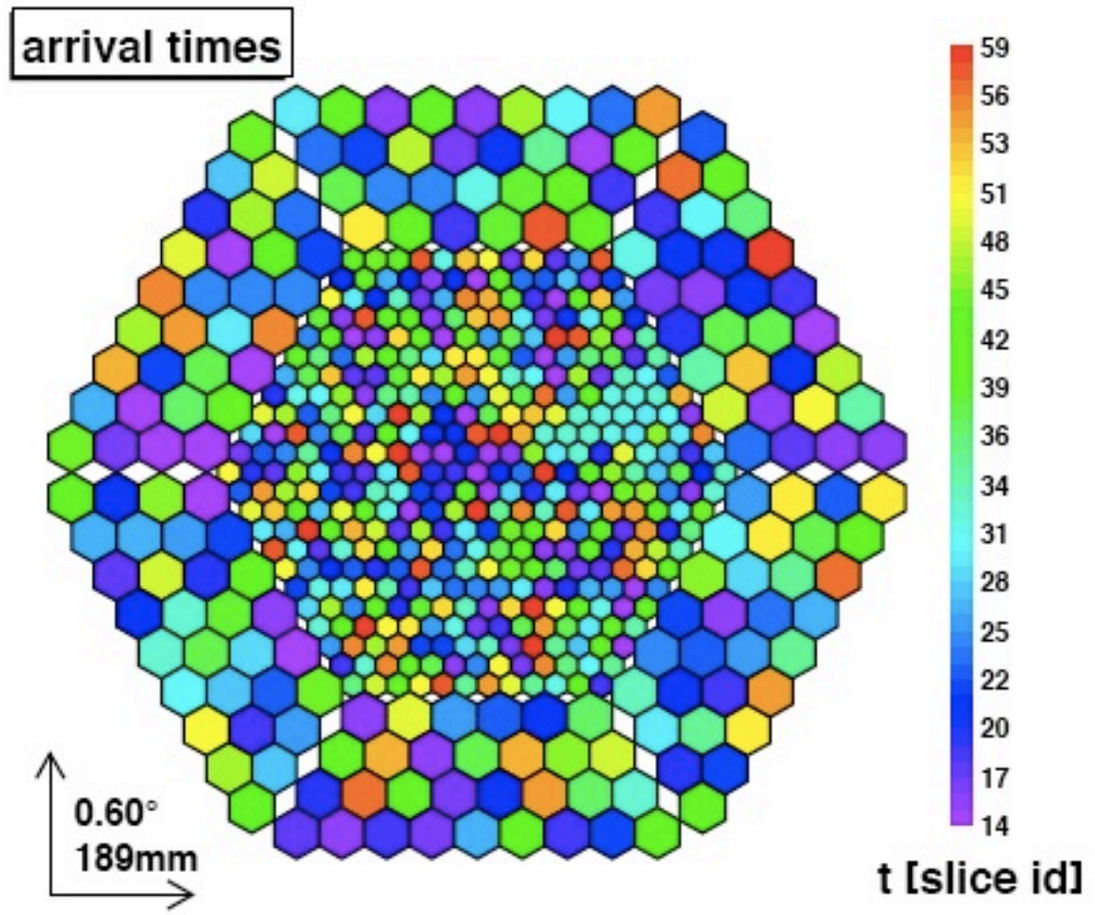


IACT data processing: DL1

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

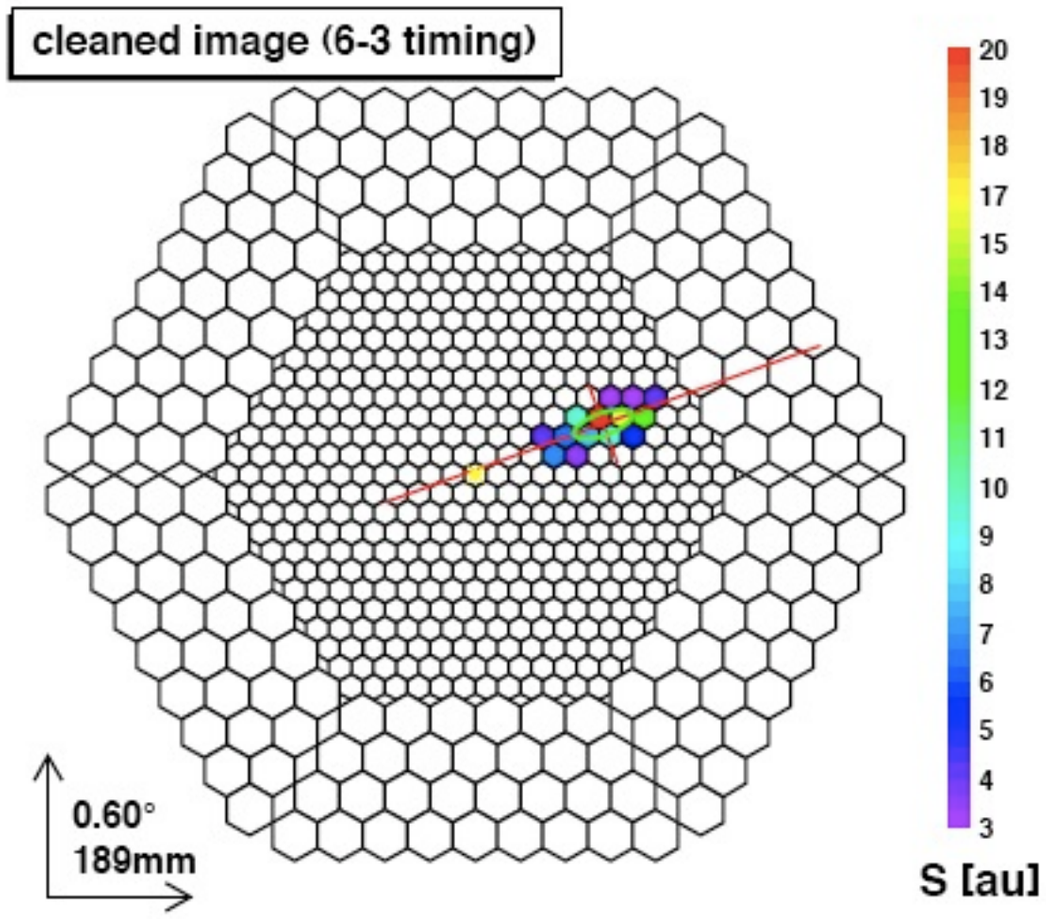


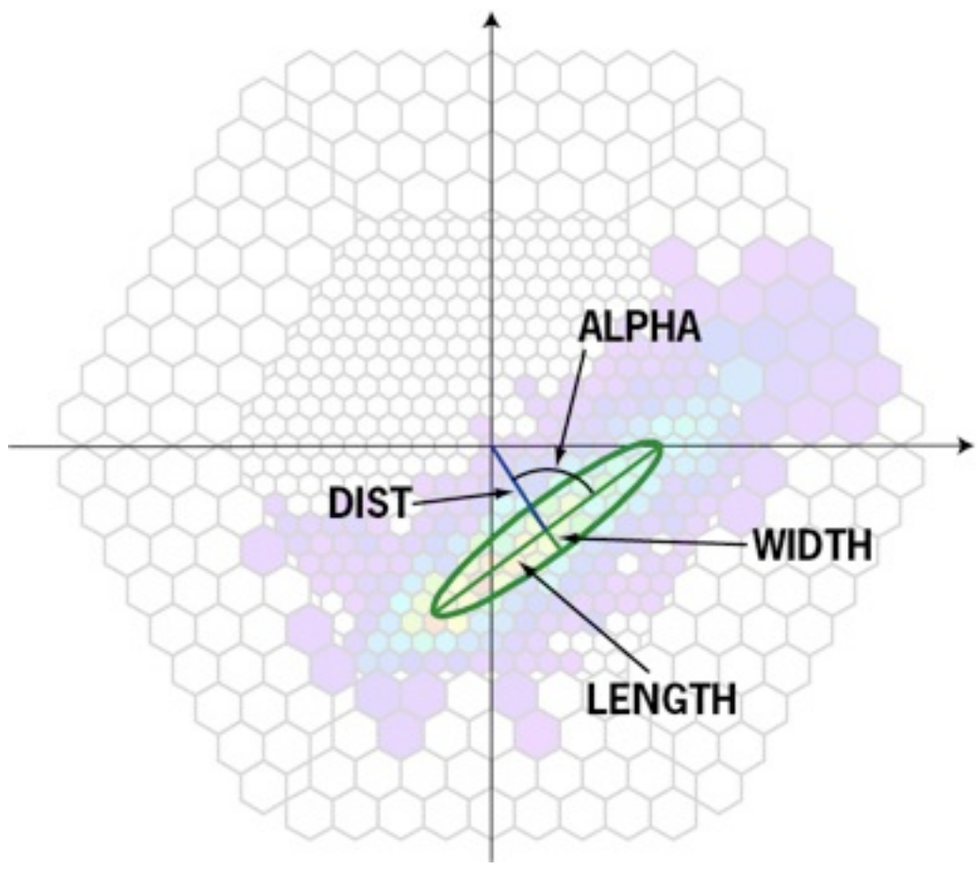


IACT data processing: DL2

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

Access: only Privileged Users



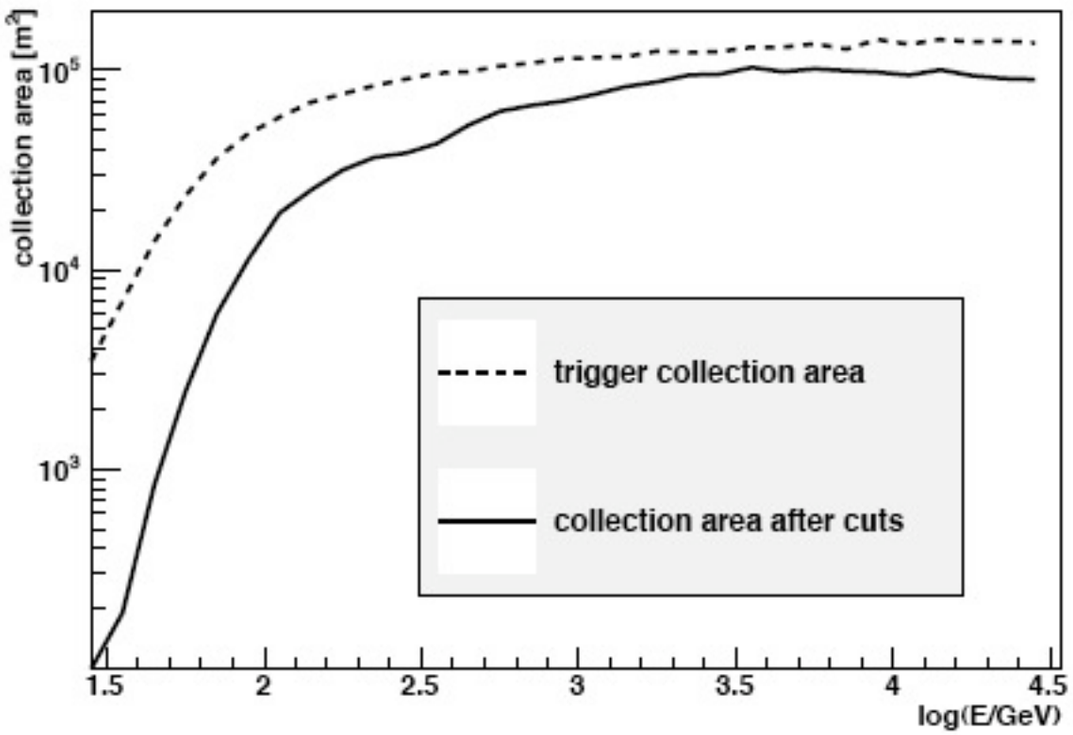


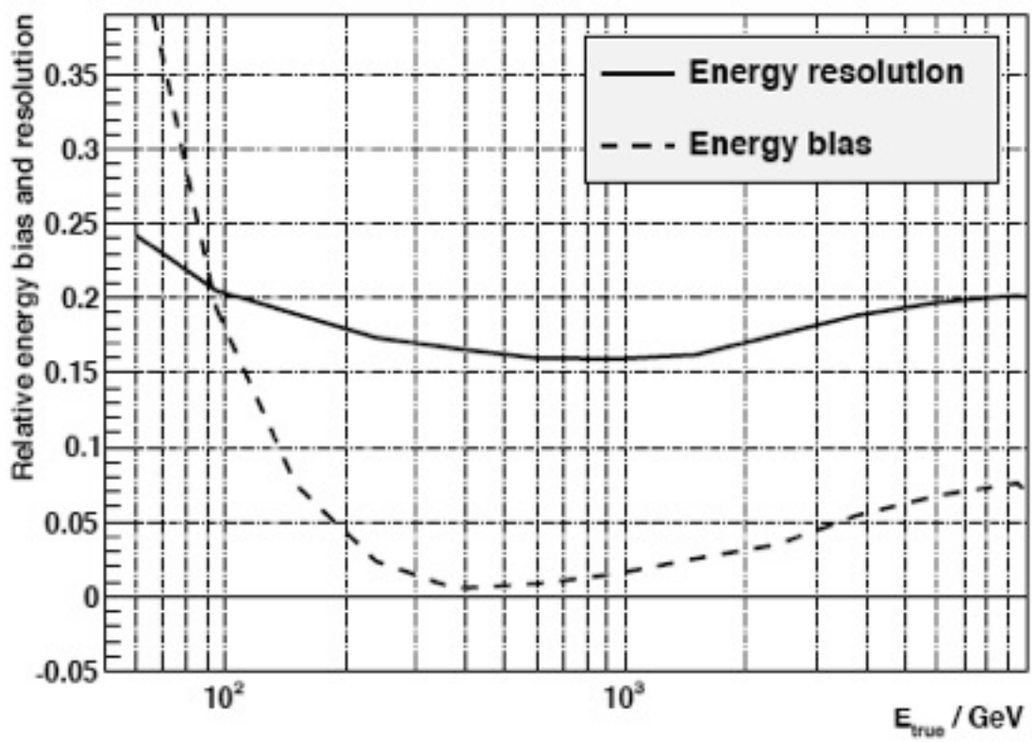
IACT data processing: DL3

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



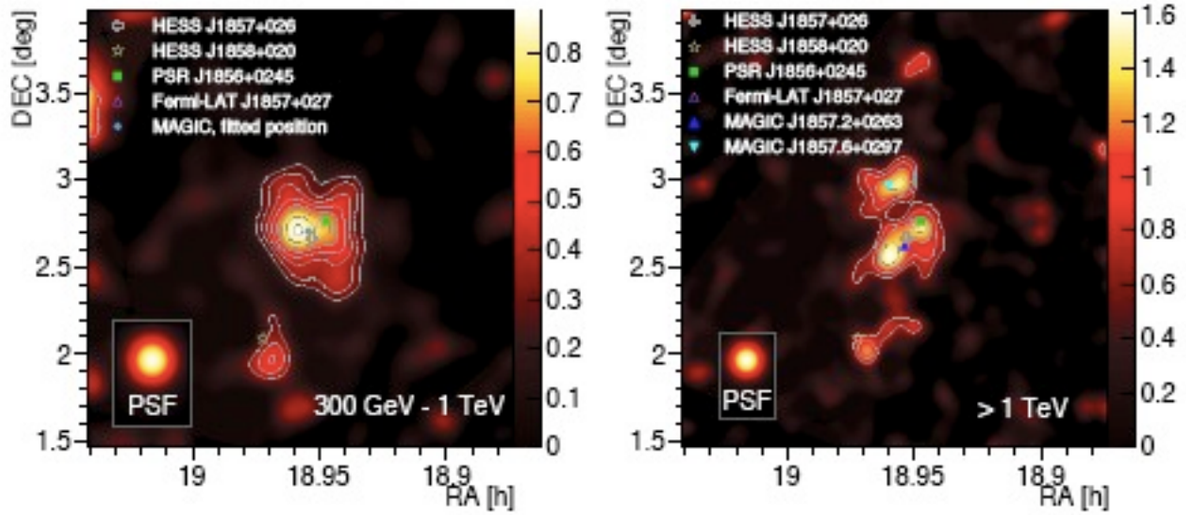


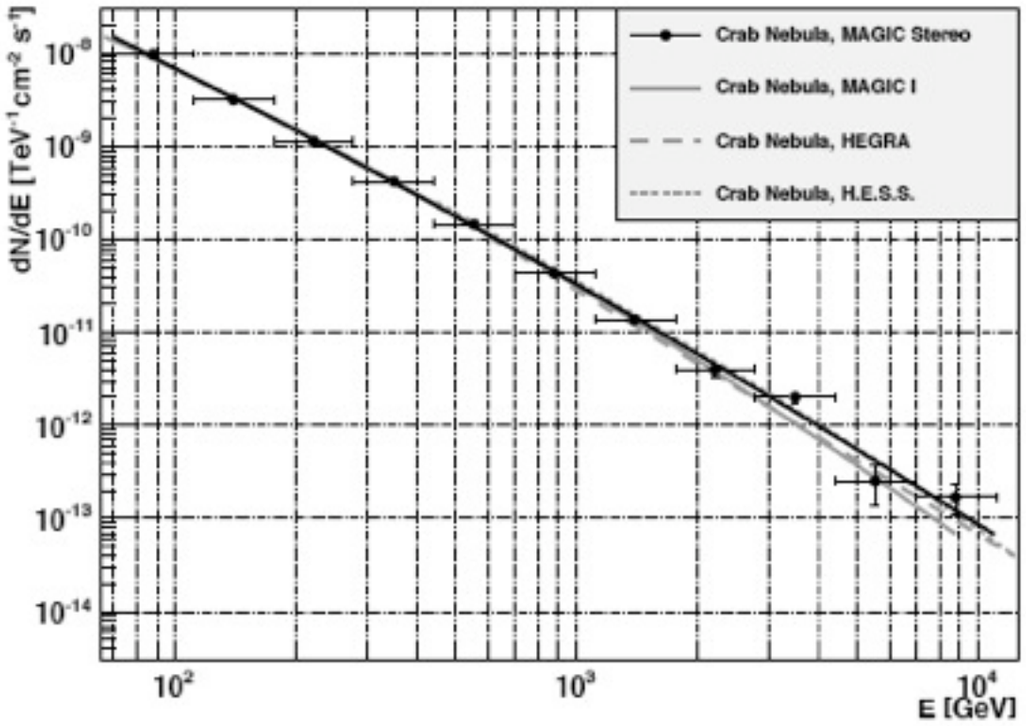
IACT data processing: DL4

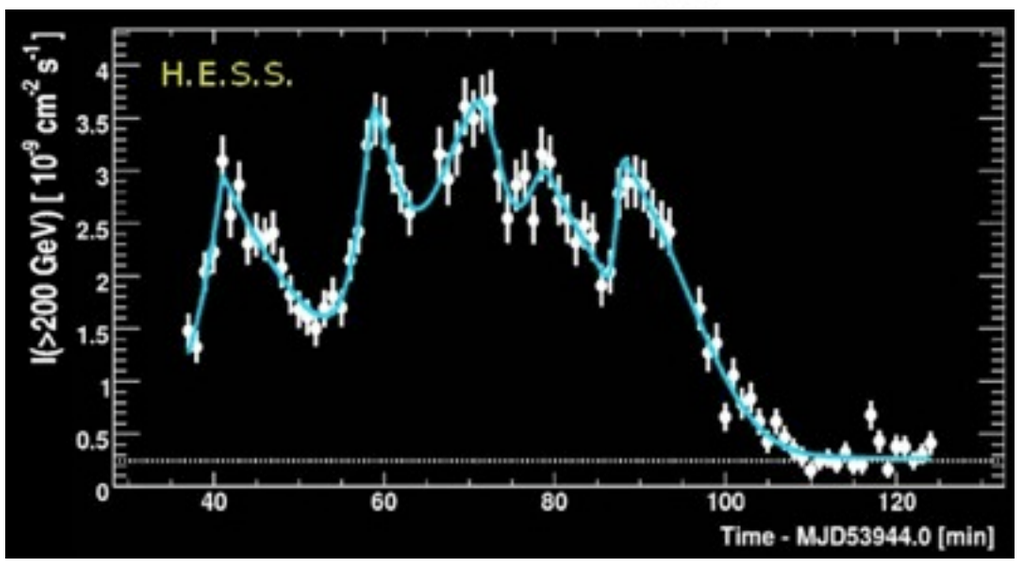
high level data: light curve, spectrum, sky map for each source/observation

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)

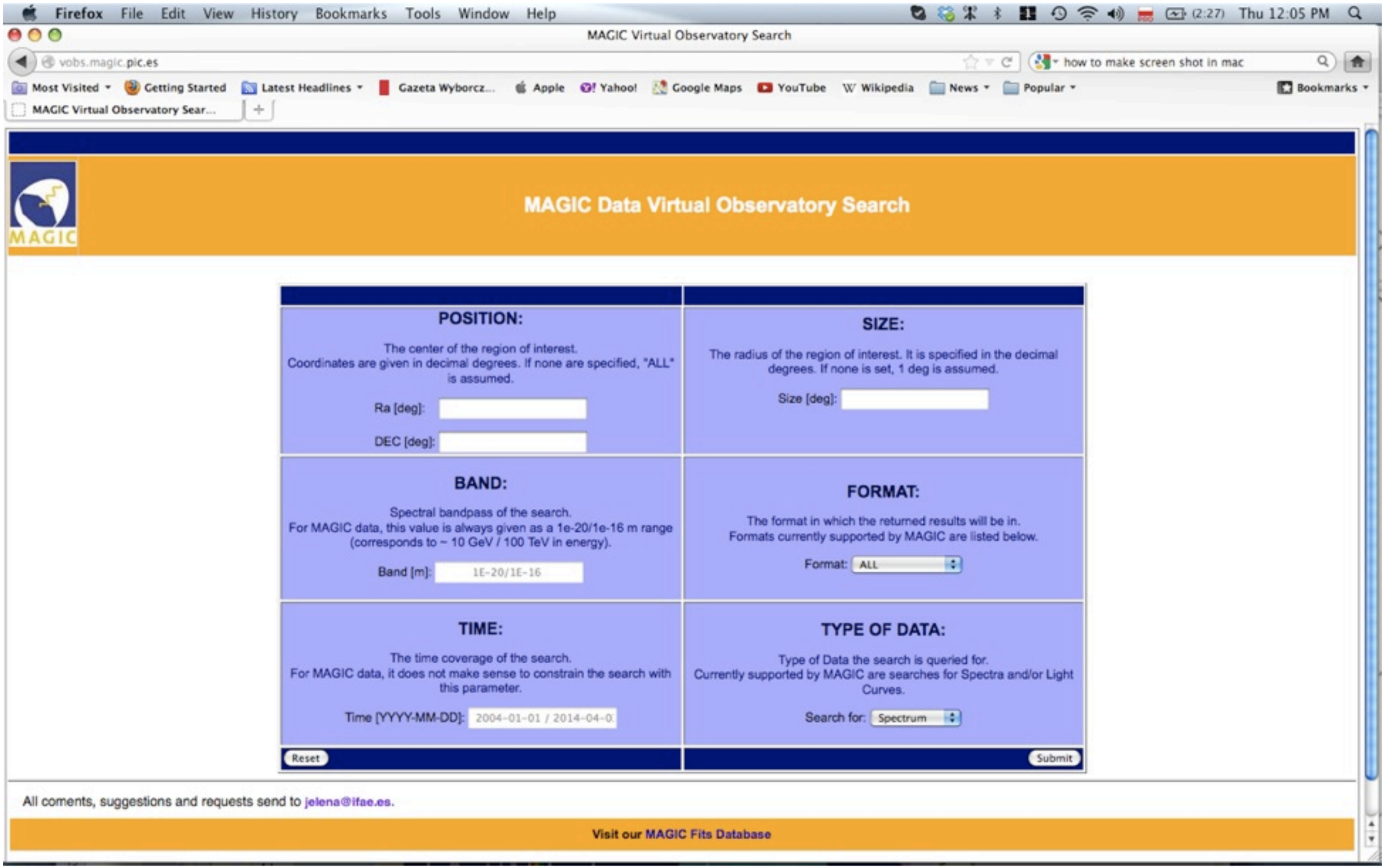
★ We use different units
(e.g. spectral info given as a function of energy in [GeV] instead of wavelength in [m])

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



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