The (future) Cherenkov Telescope Array CTA

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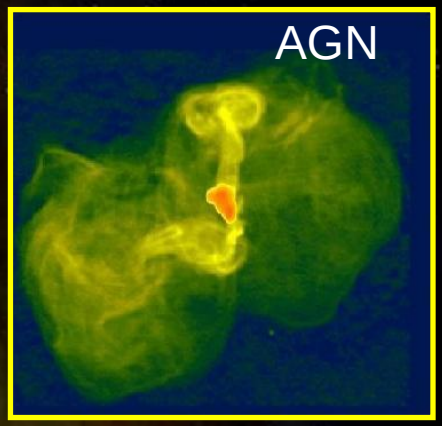
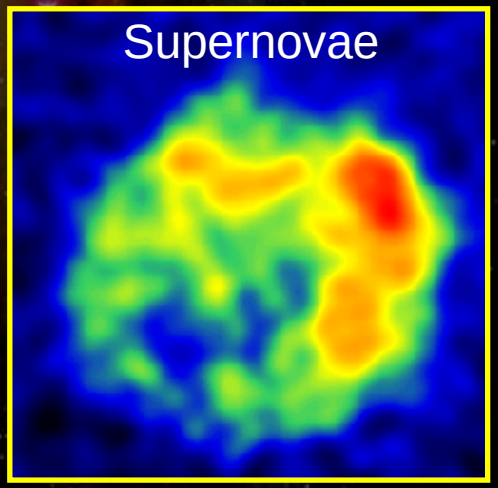
γ-Cherenkov telescopes - motivation

Access highest end of electromagnetic spectrum

- Galactic and extragalactic TeV γ-ray sources
  - AGN(blazars, radio galaxies), GRBs
  - pulsars, PWN, supernova remnants
  - binaries, microquasars...
  - *Multi-wavelength and multi-messenger*

- Search for new physics:
  - dark matter
  - quantum gravity
  - ...
- Surprise discoveries?

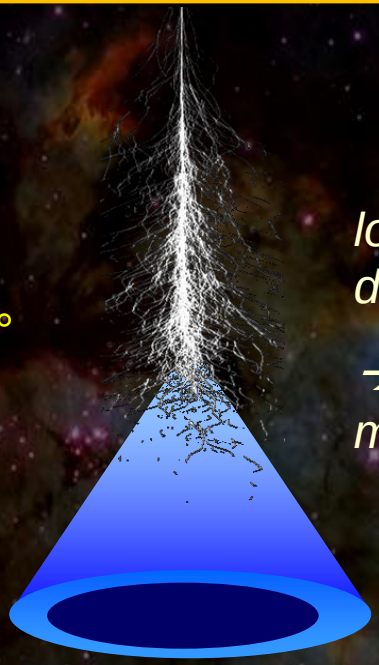




Technique

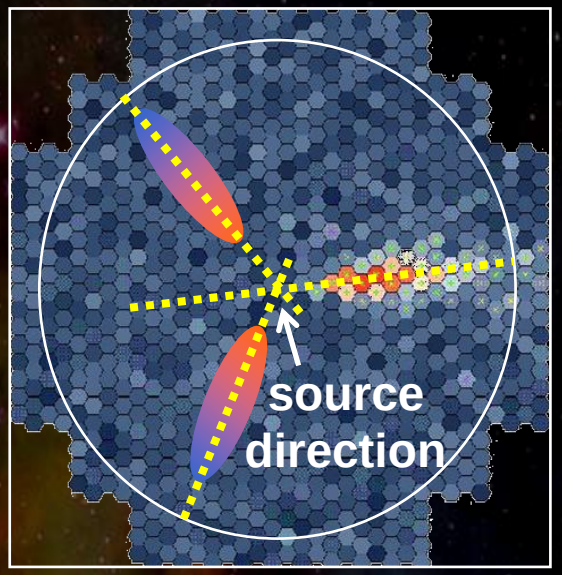
primary gamma ray **produces electro-magnetic shower** in atmosphere, h ~ 10km

→**Cherenkov cone** ~1°

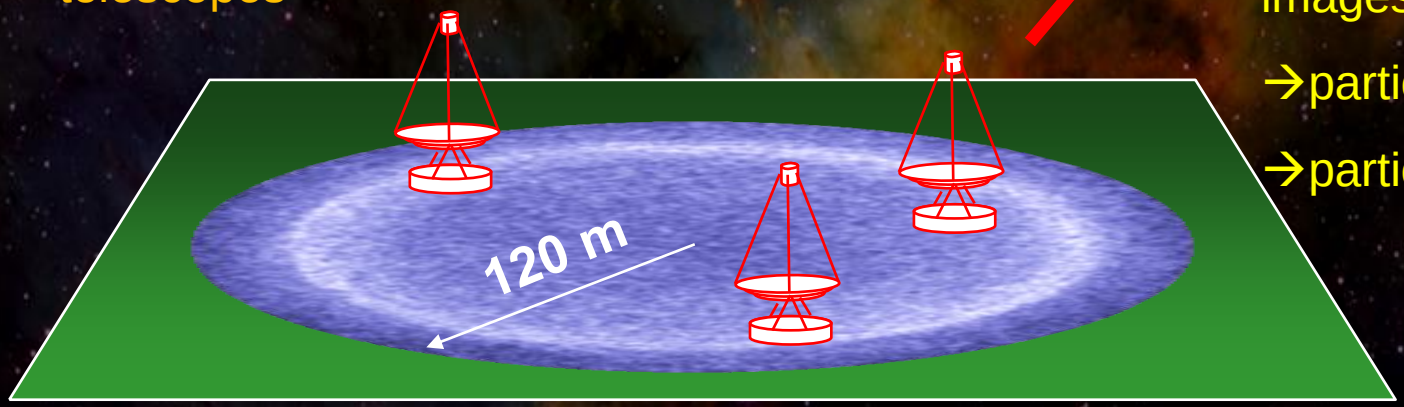


location: high, dry and dark

→*desert, mountains*



detection of light by array of Cherenkov telescopes

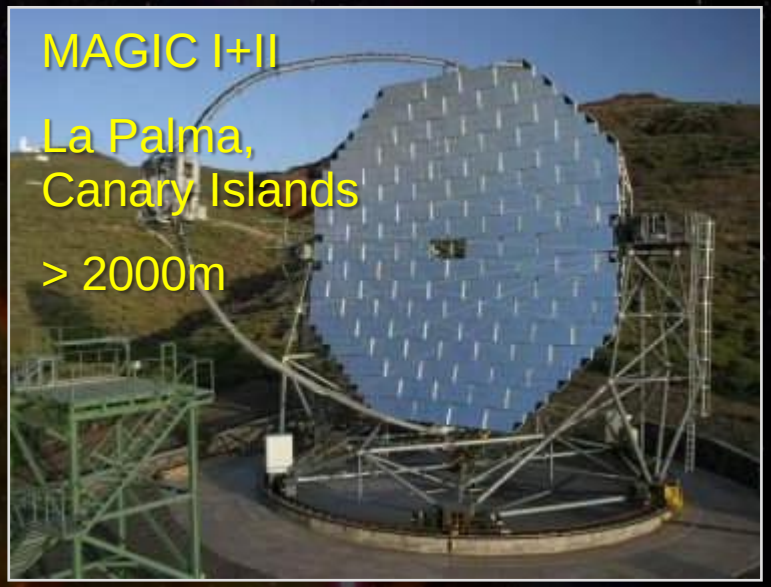


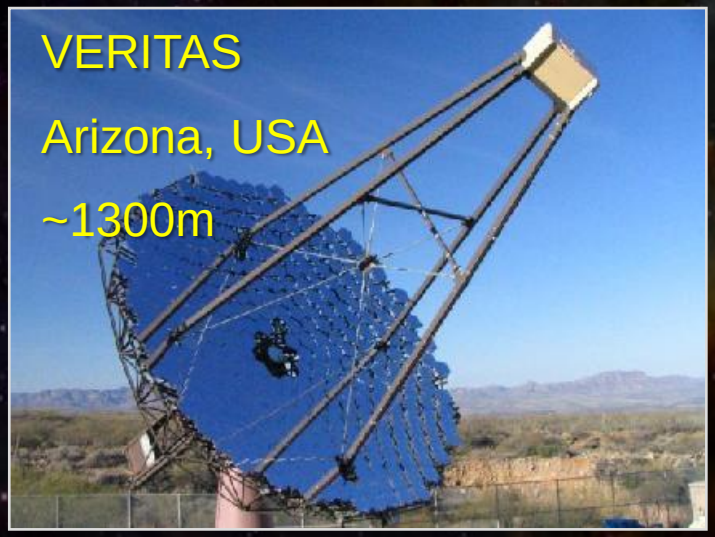
combination of multiple images = stereoscopy

→particle **direction**

→particle **type** and **energy**

Current generation Cherenkov telescopes

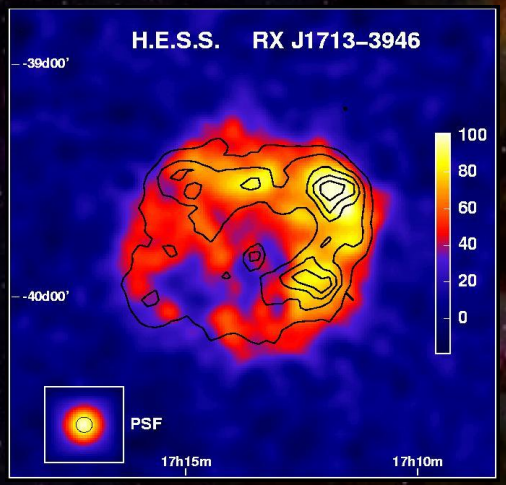




several telescope arrays currently in operation on Northern and Southern hemisphere

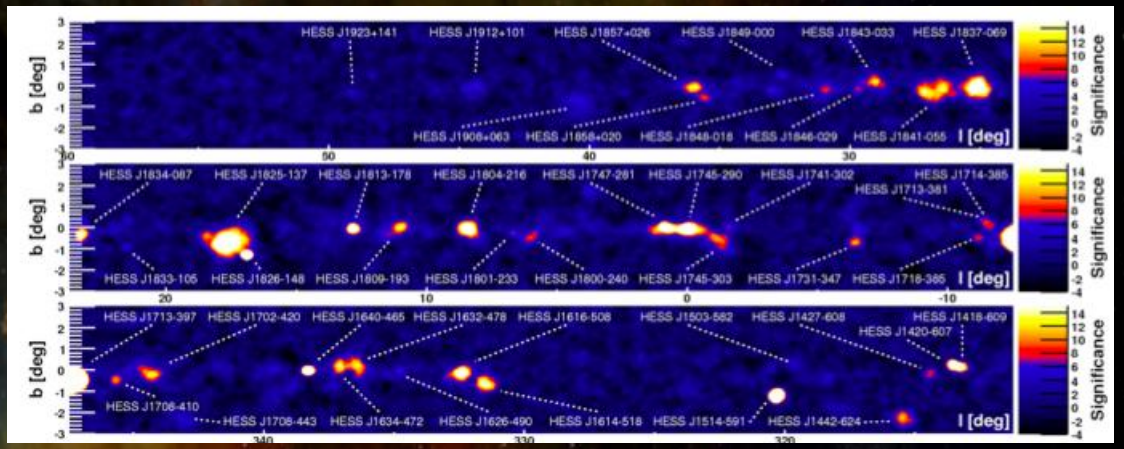
- spatially resolved images
- highly successful, huge scientific output
- system upgrades in progress (Magic 2, HESS-2, ...)

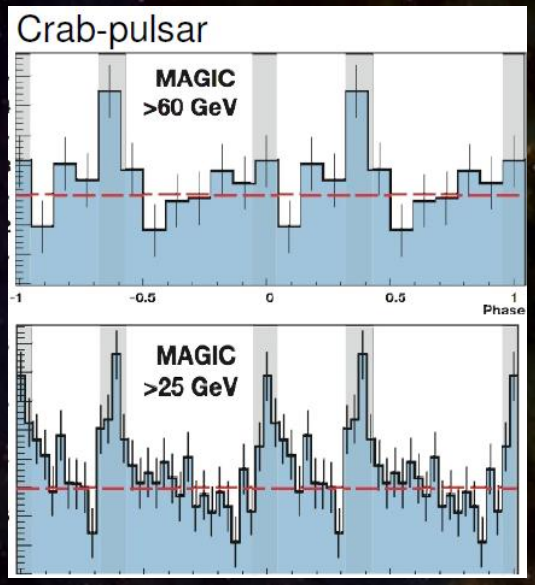
Cherenkov telescopes: Example results



morphology of shell-type supernova remnants and other extended sources

galactic surveys, detection of new sources with and without known counterpart





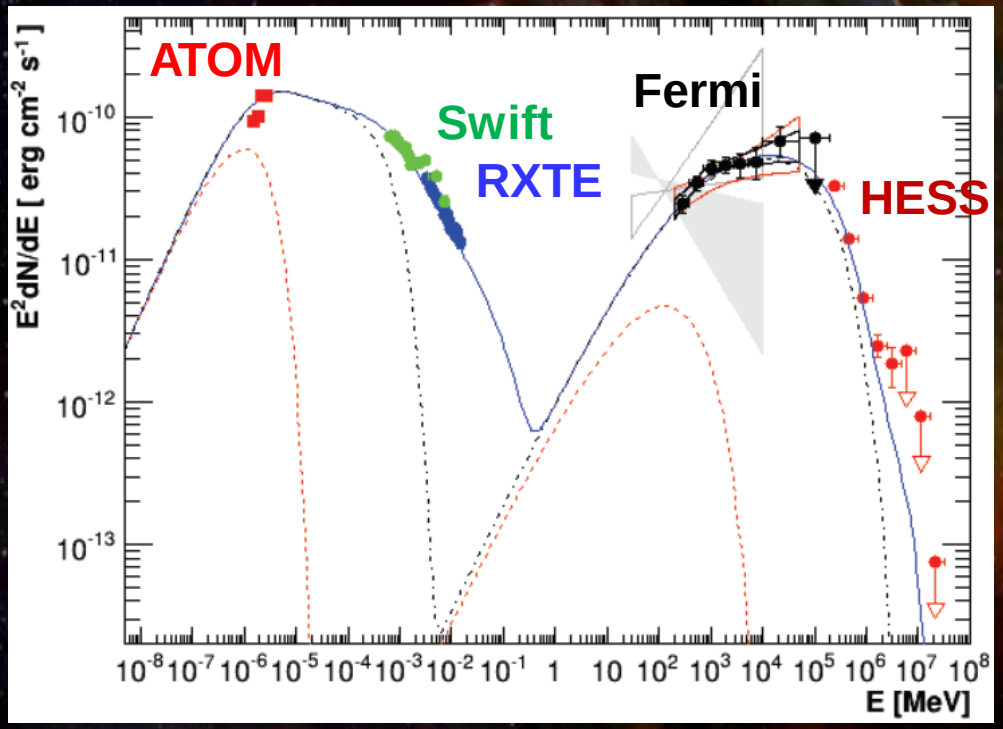
time dependent emission: flares, periodic transients

... and a lot more !

Example results - MWL

in addition to individual observations, also joint ***multi-wavelength campaigns*** with experiments in other energy ranges (satellites, telescopes)

Example: Optical (ATOM)-X-ray (Swift, RXTE)-Fermi and H.E.S.S. on the blazar **PKS 2155-304 (z=0.117) in a low state**



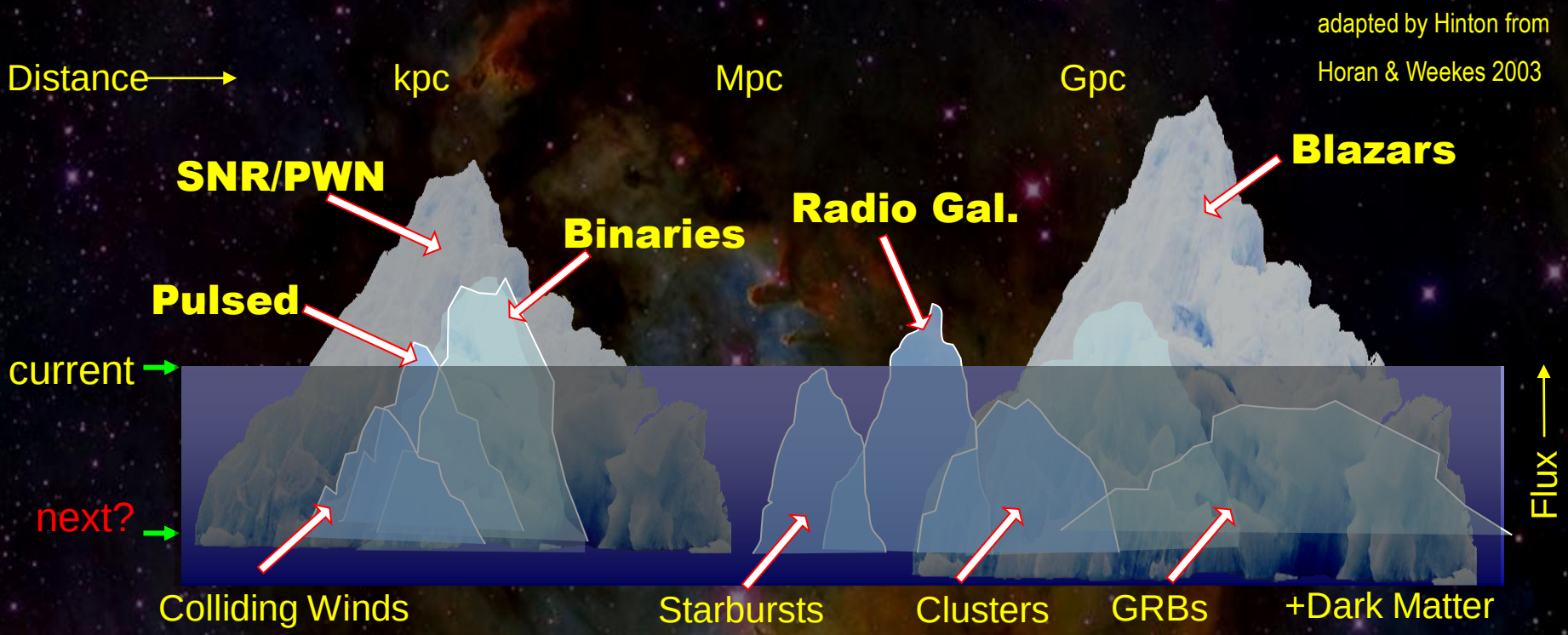
combined spectral data over nearly ***14 orders of magnitude***

→ very good **model constraints**

→ γ–CT's important role to determine HE cut-off (e.m. or hadronic ?)

also: *targets of opportunity:* CT observation of transient sources triggered by alerts from other experiments (e.g. GRB alert network)

The tip of the iceberg



current instruments have passed the discovery threshold... but

expect lots of more interesting physics “just around the corner” !

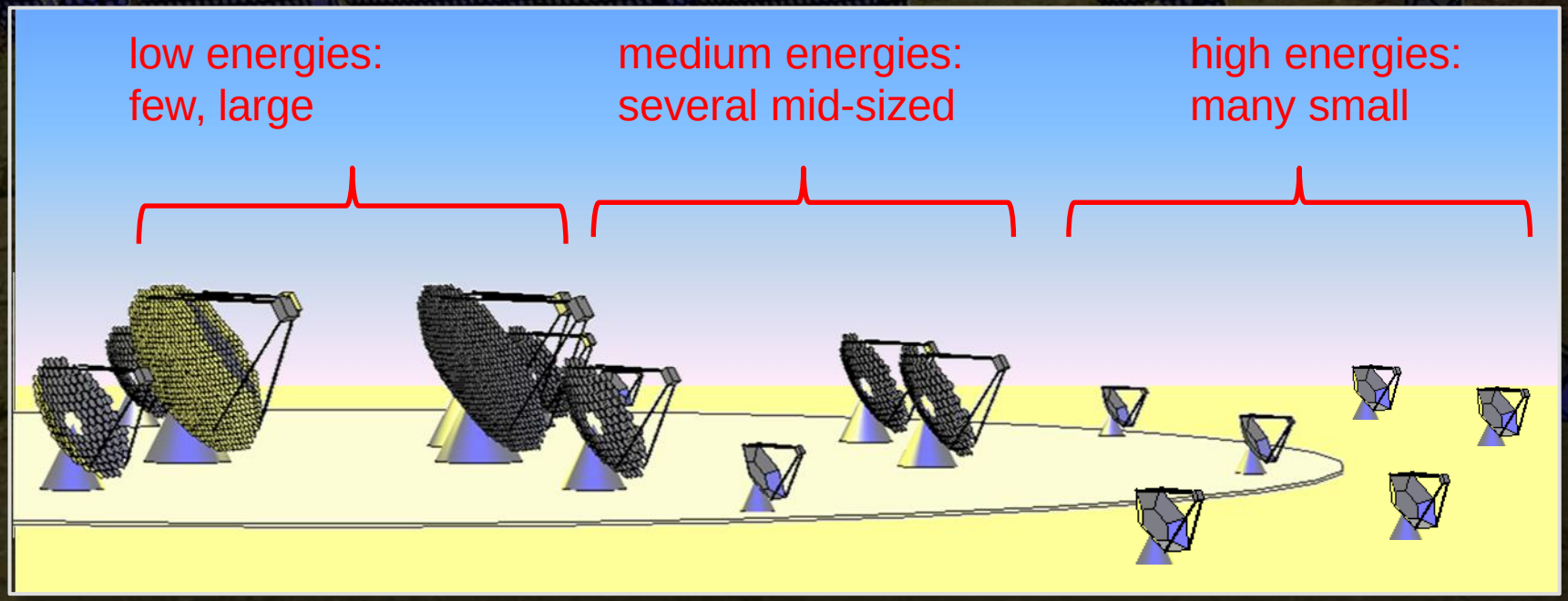
→ *uncover with next-generation instrument (remember LEP!)*

The Cherenkov Telescope Array

Large telescope arrays on Northern and Southern hemisphere:

10-100 telescopes each in 3 different sizes, spacing ~50-200m

- large (~24m): **low energy**, threshold ~10 GeV
- medium (~12m): core array for **milli-Crab sensitivity** in 100GeV-10TeV
- small (~7m): high energy section, ~10 km^2 at **multi-TeV energies**



The CTA project

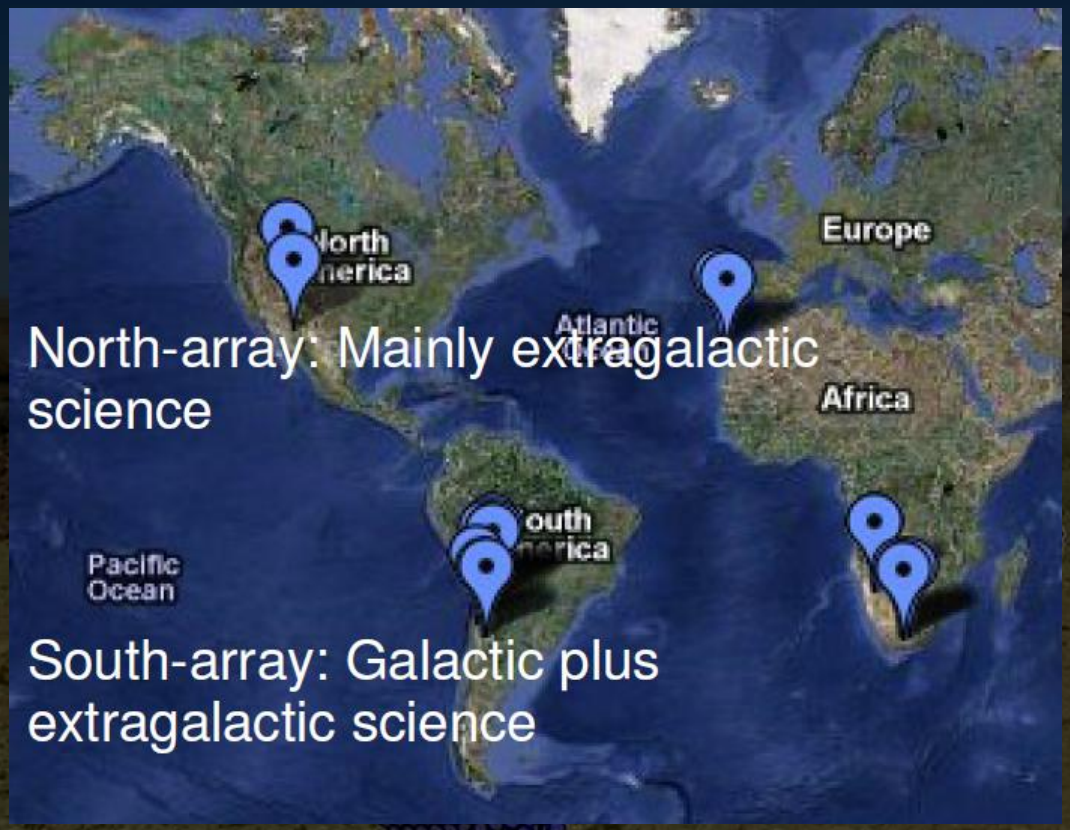
Design goals:

- higher sensitivity at TeV energies (x10)
- lower threshold (some 10 GeV)
- higher energy reach (PeV and beyond)
- better angular resolution (<<0.1 deg)
- wide Field of View

international consortium including HESS, MAGIC and VERITAS groups

- EU roadmap support
- design study finished 2010
- prototyping planned 2011-2012
- construction 2013+
- *start observing soon after*

Site search



several candidates for northern and southern site

criteria:

- atmospheric quality+altitude
- infrastructure + accessibility
- political stability and support

decision process based on scientific and political criteria

→ work package “SITE”

north and south array with different scientific aims (galactic or extragalactic)

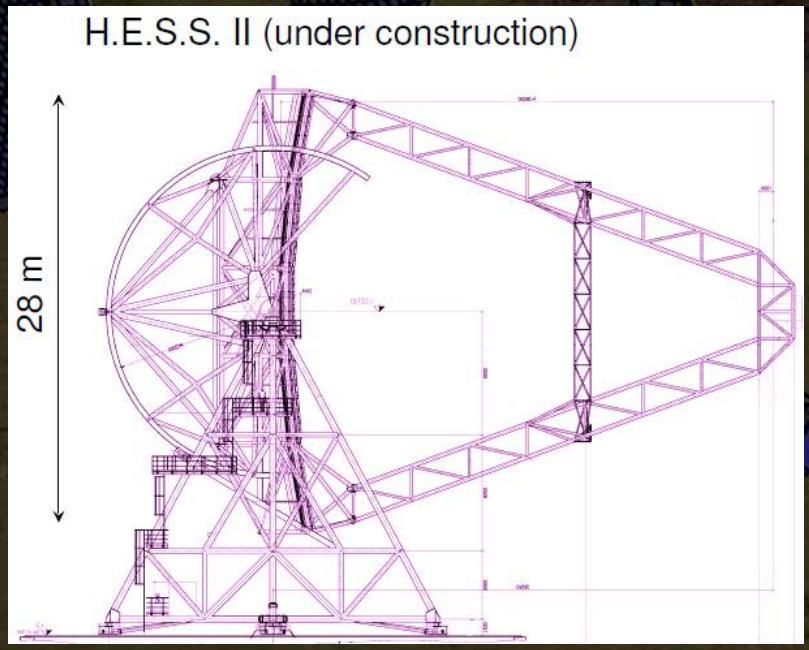
→ *different array layout and technology*

Towards the array

base technologies for different telescopes exist already

→optimise for cost-efficiency for large array

→need stable, low-maintenance system and efficient triggering and data-taking infrastructure



*work divided into many **work packages**, e.g. Telescopes, Monte-Carlo, Electronics, Site...*

Technology Development

novel readout schemes

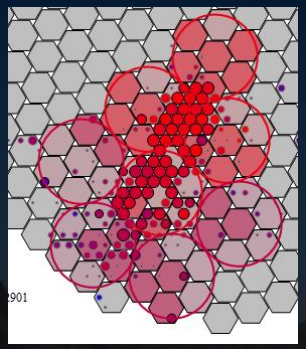
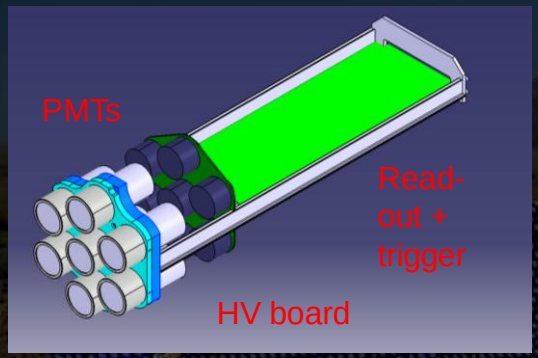


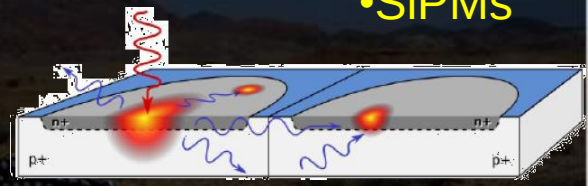
image analysis and reconstruction

front-end architecture



computing: hard- and software...

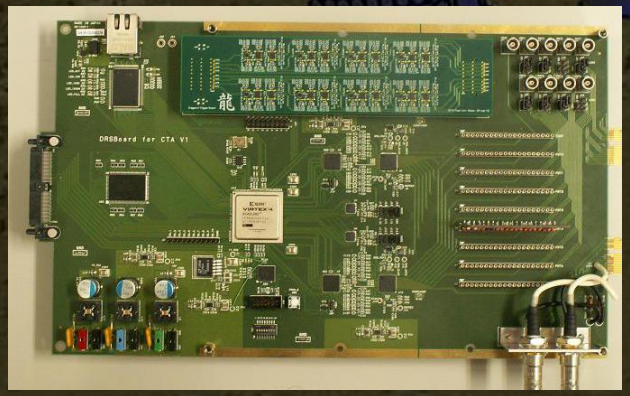
•SiPMs



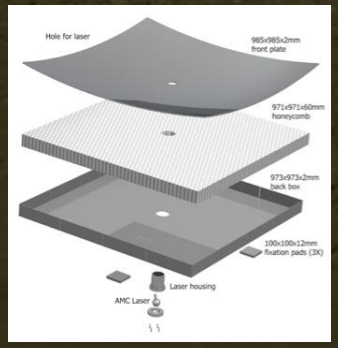
cherenkov telescope array

•“classical” PMTs

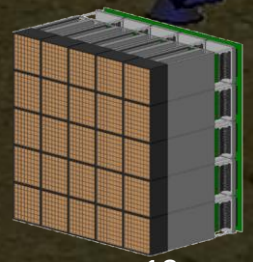
electronics, trigger designs, readout architectures



mirror design

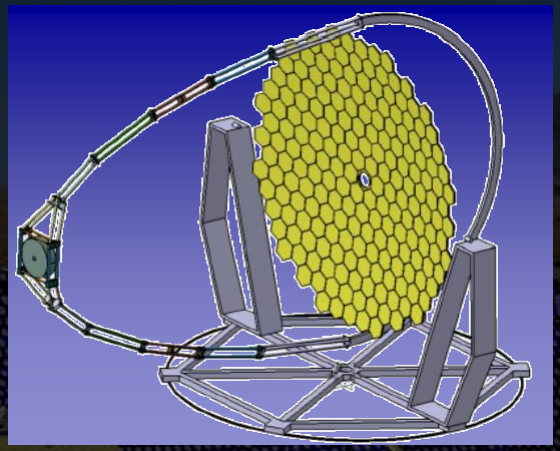


multi-anode PMTs



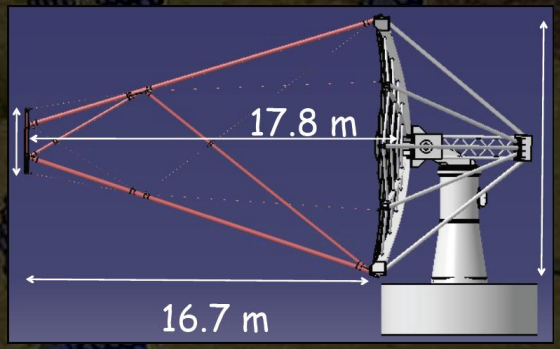
Telescope Mechanics

for each telescope size, several technical possibilities are pursued
→ studies, simulations, prototypes

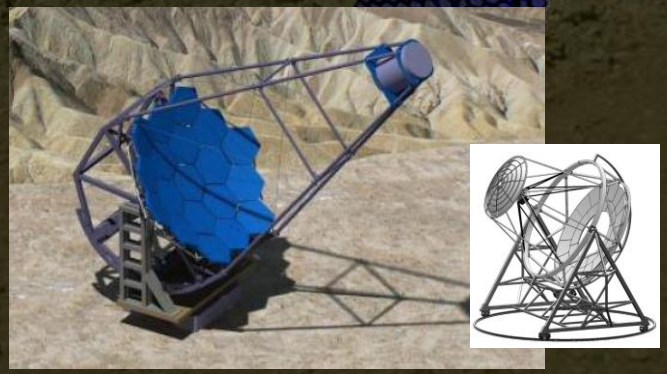


LST : weight, size

→ carbon fibre based structures, active mirror control...



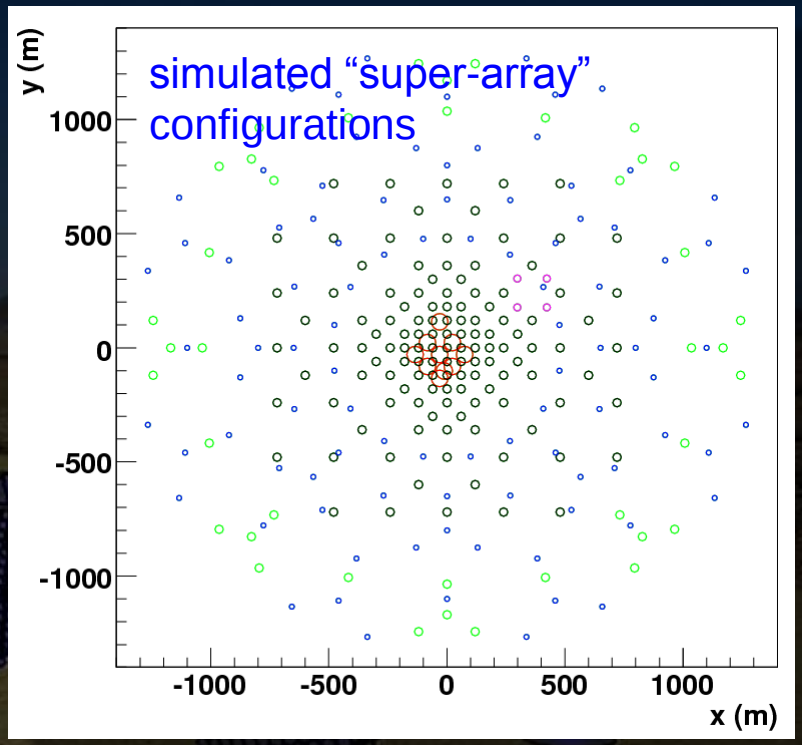
MST : different possible designs; cost and flexibility most important

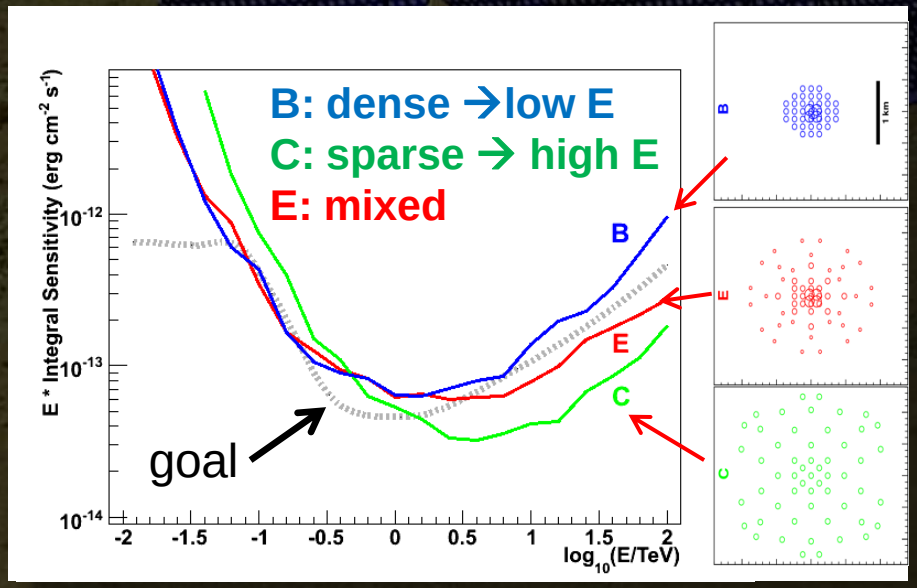


SST: single (Davies-Cotton) or dual mirror (Schwarzschild-Couder) options; small cameras (SiPMs, multi-anode PMTs)

Monte-Carlo Simulations

- Large scale simulation of arrays (different sizes, fields of view, distances, trigger systems...)
- Comparison of *candidate arrays* at *similar cost (~80 M€)*
- extensive use of **GRID technology**
- large library (~10^{11} showers) produced

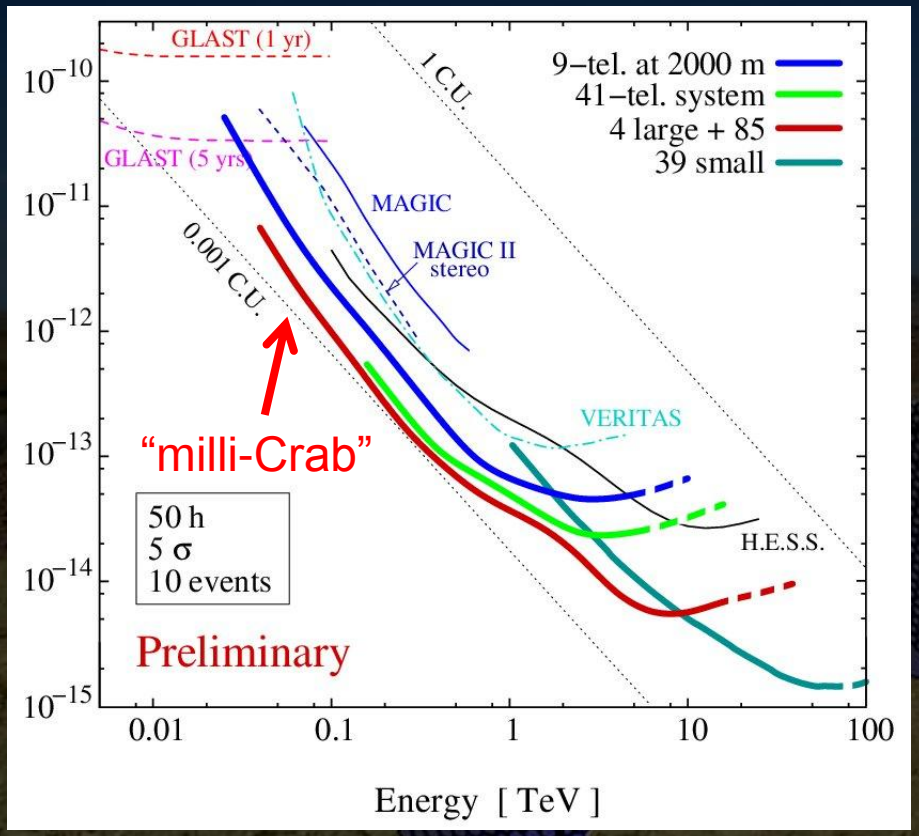




exemplary performance for different configurations

→ choice depends on physics goals!

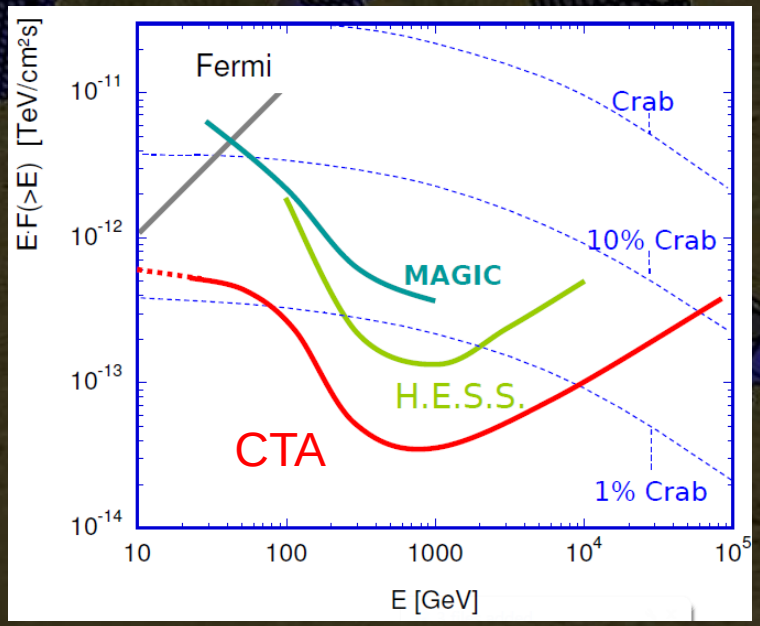
Expected performance



depending on configuration, milli-Crab sensitivity in focus region realistic

much more sensitive (~factor 10) than current experiments over much wider energy range

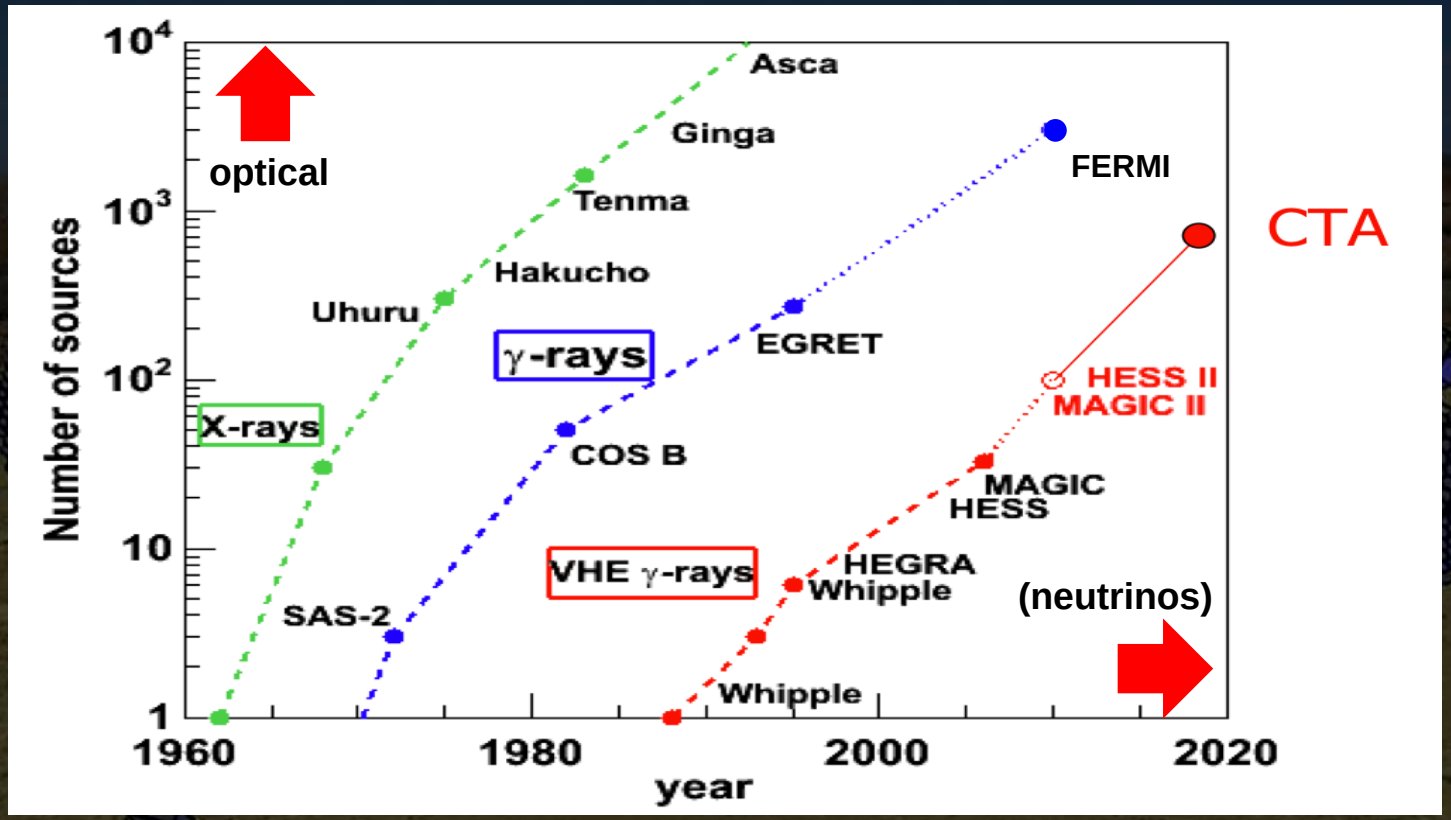
at low E, good overlap with satellites (Fermi !)



all goal specifications within reach of current designs!

The future of Photon detection...

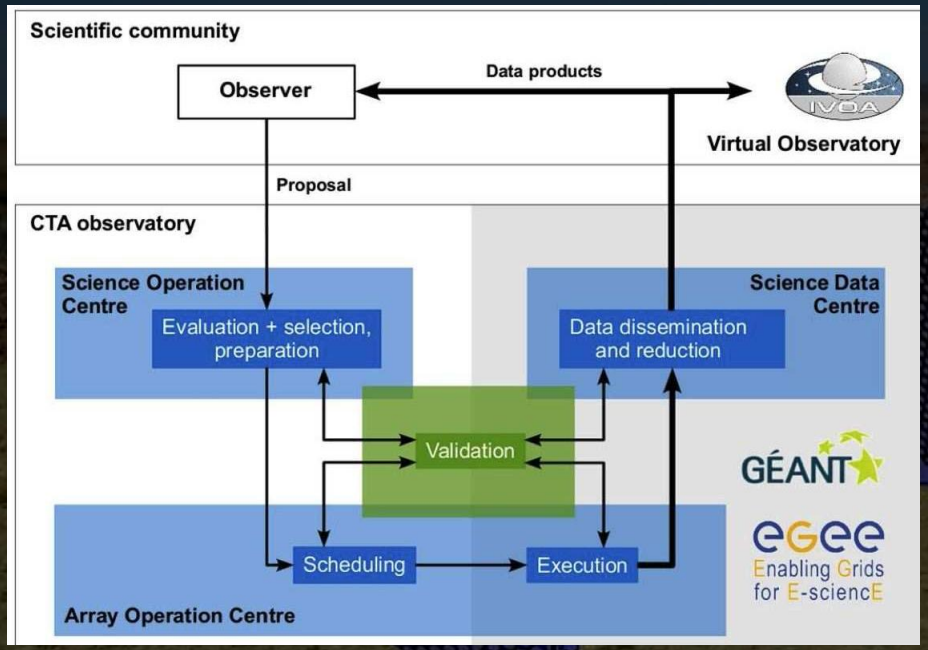
quite a lot has happened since Galileo Galilei pointed his telescope at the sky...



with CTA, will be able to “mass-produce” TeV gamma ray sources
→ will be on par with observations at lower energies

CTA as “Gamma Observatory”

operation as **open observatory** (unlike HESS, MAGIC,...)



external observation proposals

→peer-reviewed selection process

→operation by experts, data “on demand”

infrastructure:

- EGEE, GÉANT + VO
- data storage and access via GRID
- development of software for “black-box” analysis

also prepare public “legacy data” (galactic plane or full-sky scans)

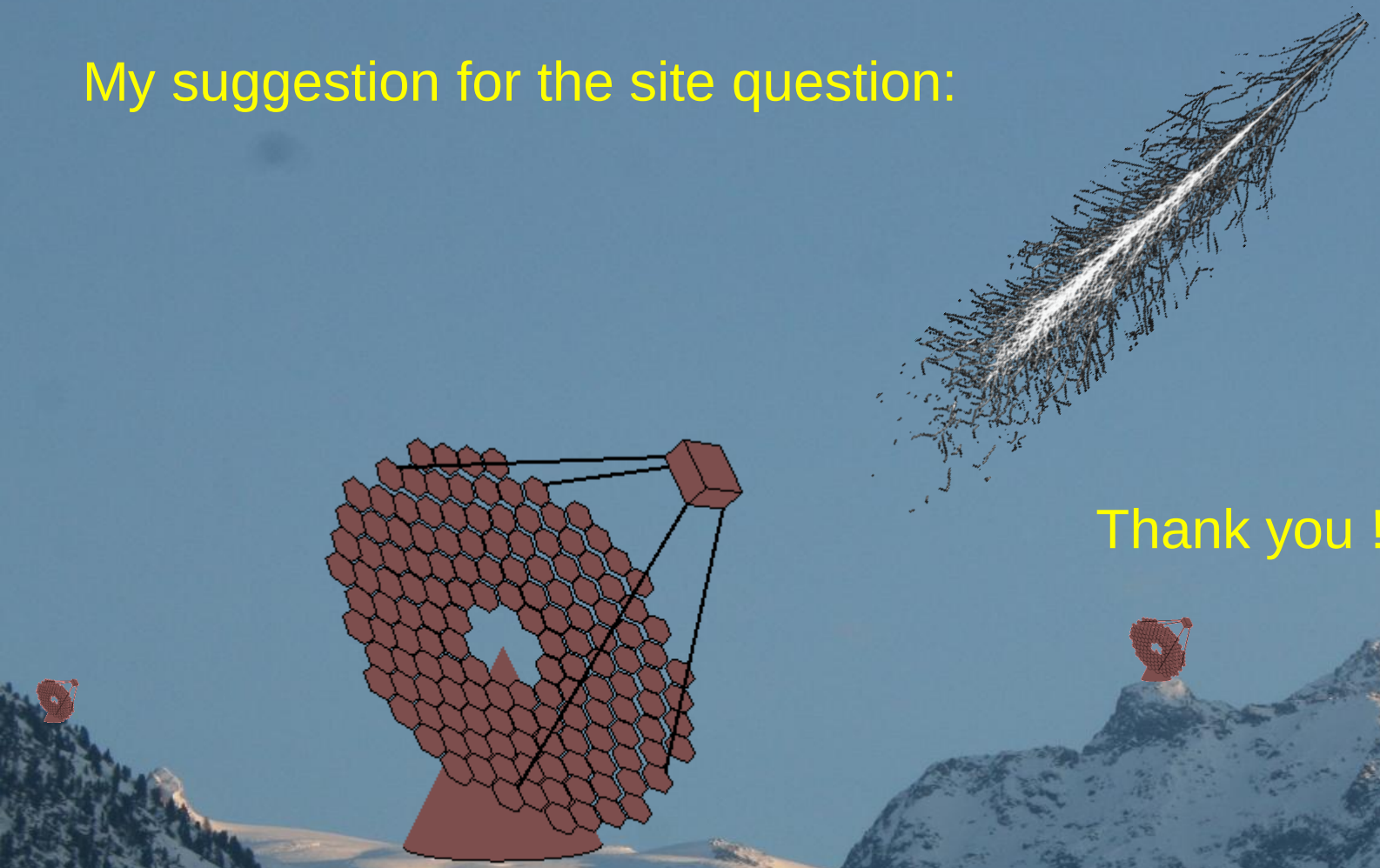
Summary and Conclusions

- Current gamma-Cherenkov telescopes have made important discoveries over last few years but are reaching their sensitivity limit
- joint successor project CTA: array(s) of 40-80 telescopes of different sizes to cover wide energy range with ~factor 10 superior sensitivity
- international consortium (25 countries, 132 institutes, > 700 people), European roadmap support

- Design study phase finished 2010 with publication of conceptual design report (**arXiv:1008.3703)**
  →all goal specifications in reach
- currently in Preparatory Phase, fixing of design, prototype work
- construction expected 2013+

→ expect exciting results ! (at La Thuile 2014?)

My suggestion for the site question:



Thank you !