

The Cherenkov Telescope Array

The project and the challenges

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On behalf of the CTA Project Consortium

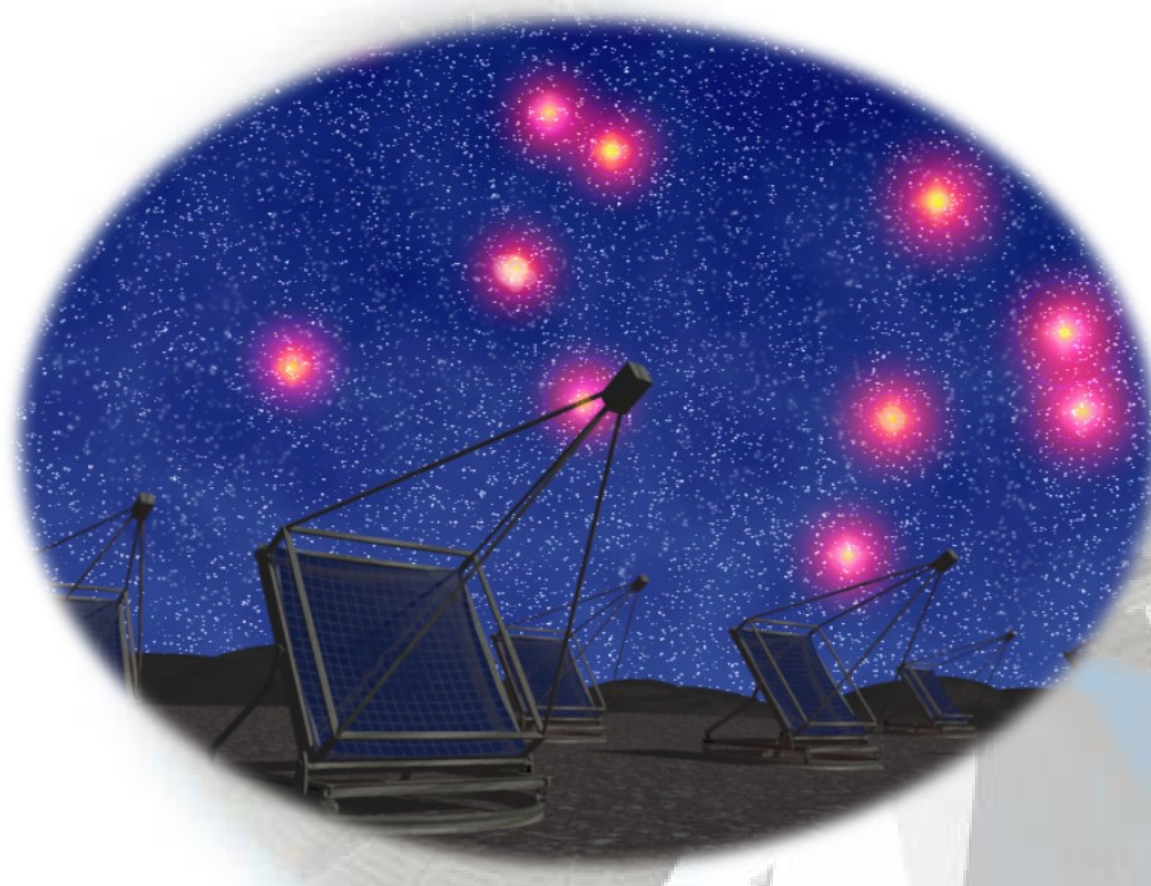
Astronomical Data Analysis Software and Systems

ADASS XX, 7-11 November 2010

Boston Massachusetts, USA

The Cherenkov Telescope Array

- Astronomy at very-high energy
- IACT instruments
- The Cherenkov Telescope Array
- Array configuration
- Open observatory concept
- The sites
- Timeline
- The challenges



What is very-high energy ?

What do we consider **Very-High Energy gamma-rays**?

0.1-1 MeV soft gamma-rays

INTEGRAL/IBIS

1-100 MeV gamma-rays

CGRO/COMPTEL

0.1-100 GeV High Energy gamma-rays (HE)

COS B, CGRO/EGRET, Fermi/LAT

>100 GeV **Very-High Energy gamma-rays** (VHE)

VHE gamma-rays are detected with **Imaging Atmospheric Cherenkov Telescopes (IACTs)** that image the Cherenkov light produced by the electromagnetic cascades they produce when entering the Earth atmosphere.

1st generation: **Whipple**

2nd generation: **Whipple, HEGRA**
(imaging and stereoscopy).

3rd generation: **CANGAROO-III, H.E.S.S., MAGIC, VERITAS.**





The catalogue

γ-ray astronomy: the only tool to explore the Universe at the highest energies

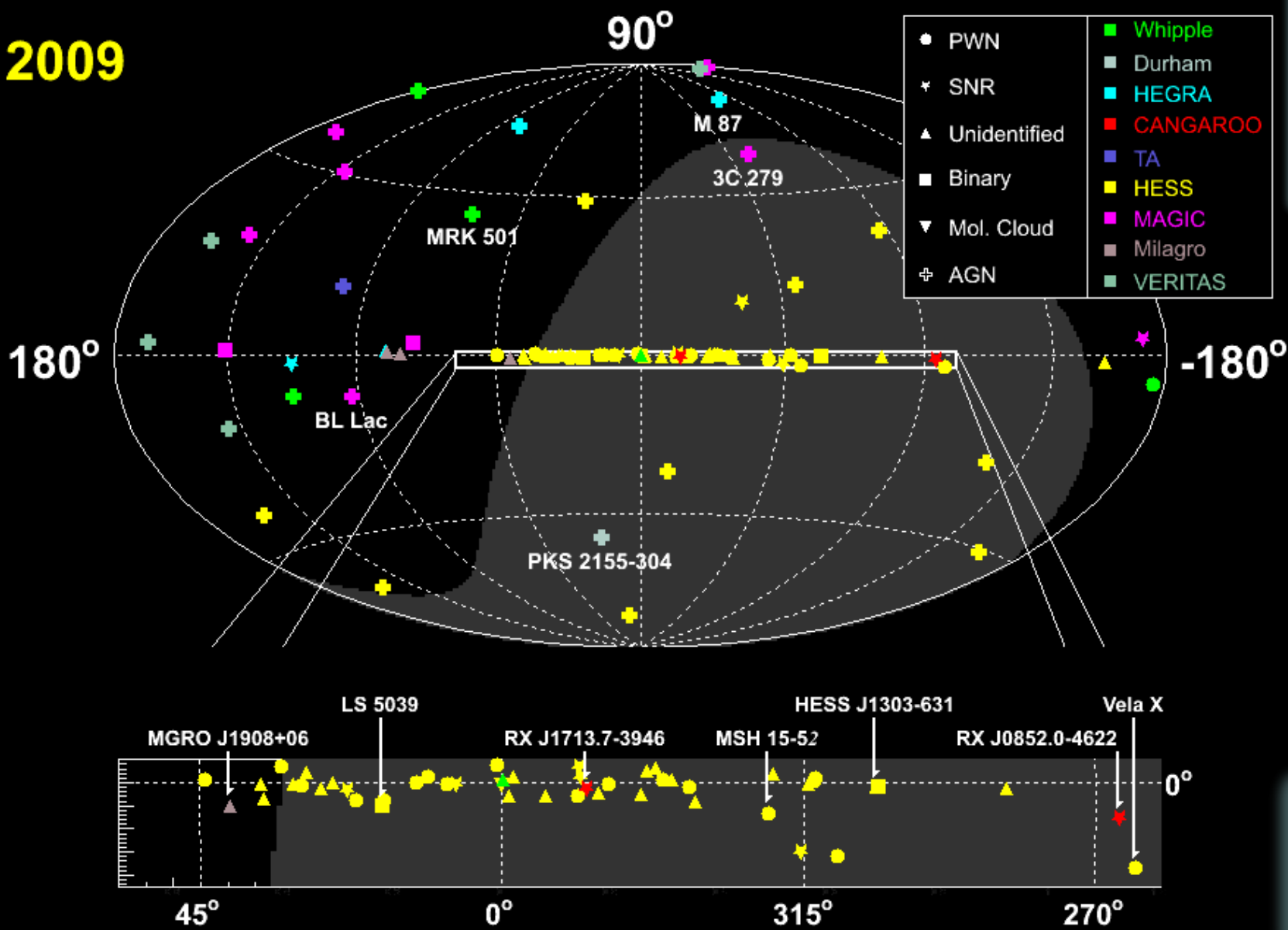
VHE Source Catalogue
(see e.g. <http://tevcat.uchicago.edu>)

As of 2010 June

- 110 sources
- 40 extragalactic
- 70 galactic

Cherenkov Telescopes: best instruments for γ-ray observation

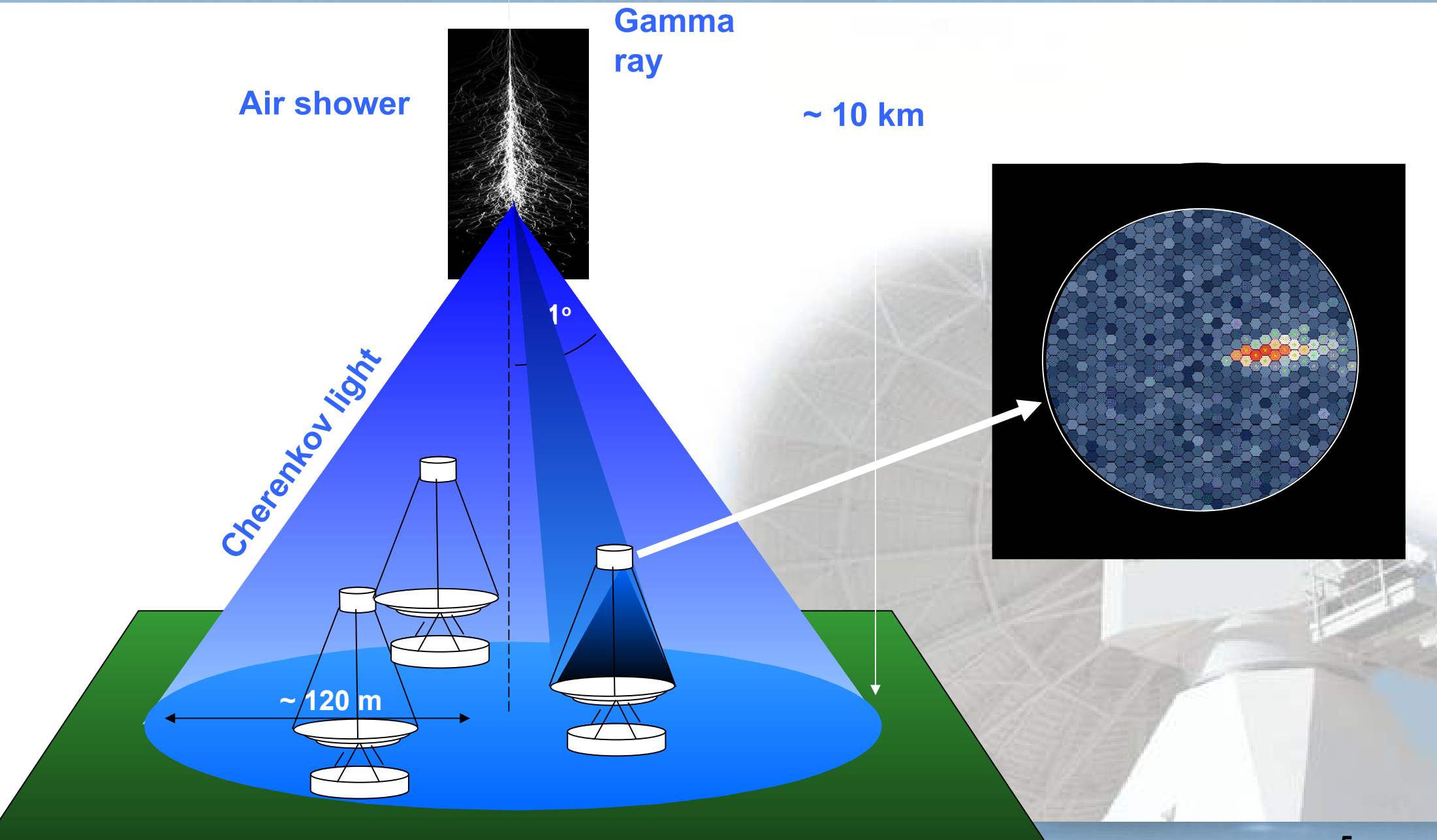
2009

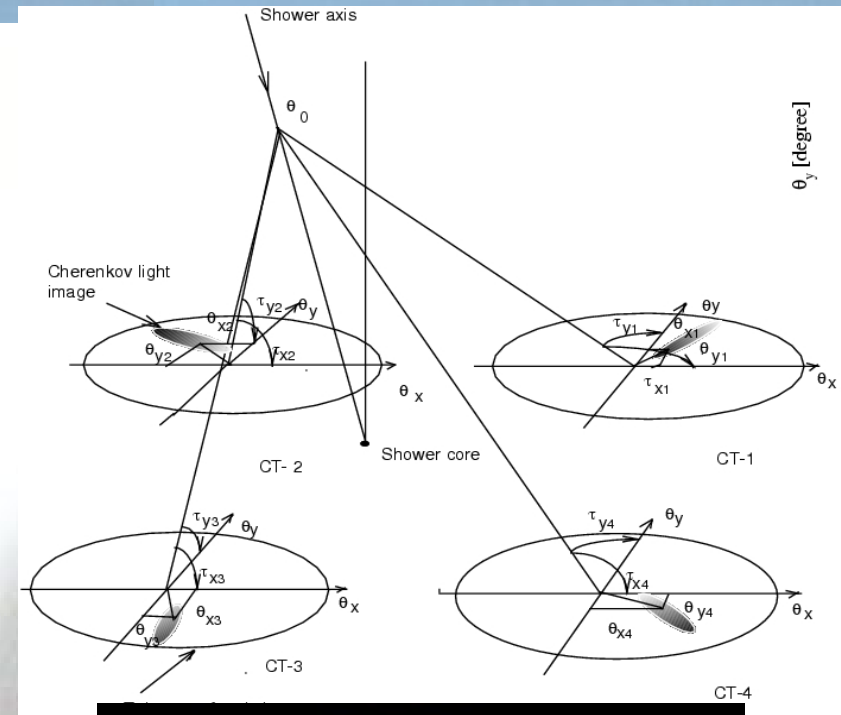
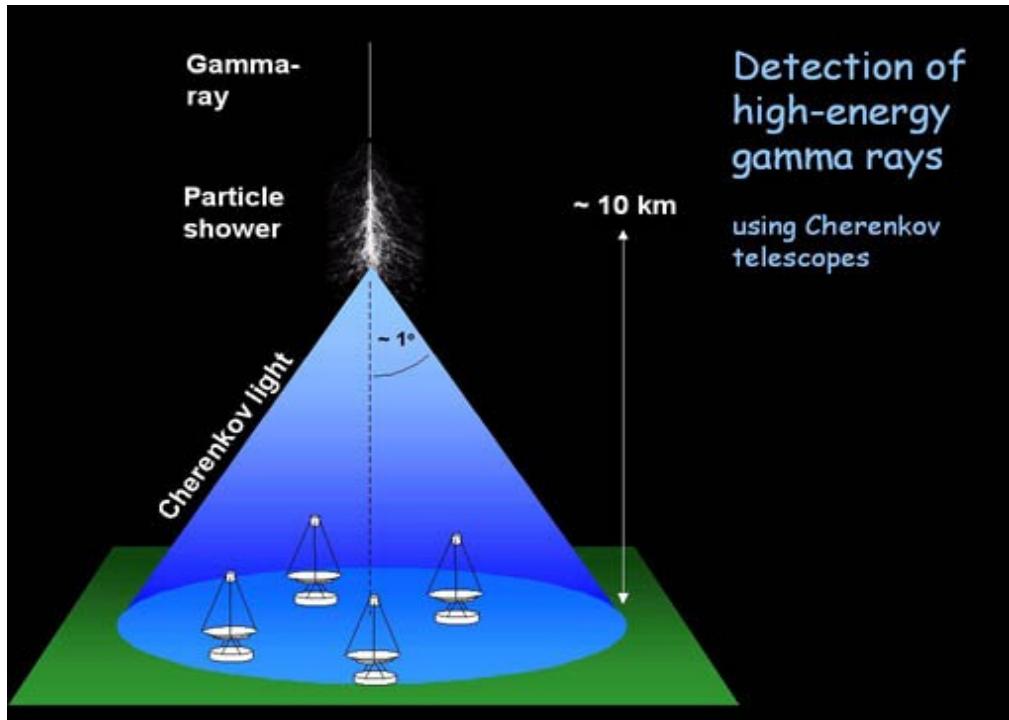


2010



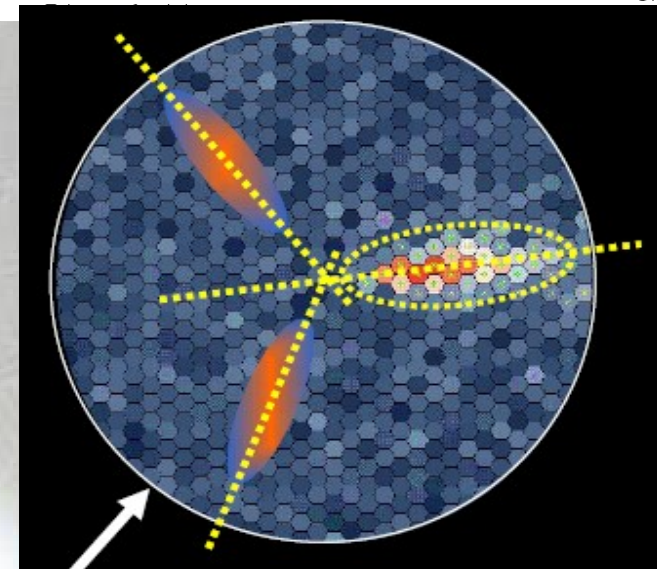
IACT gamma-ray detection





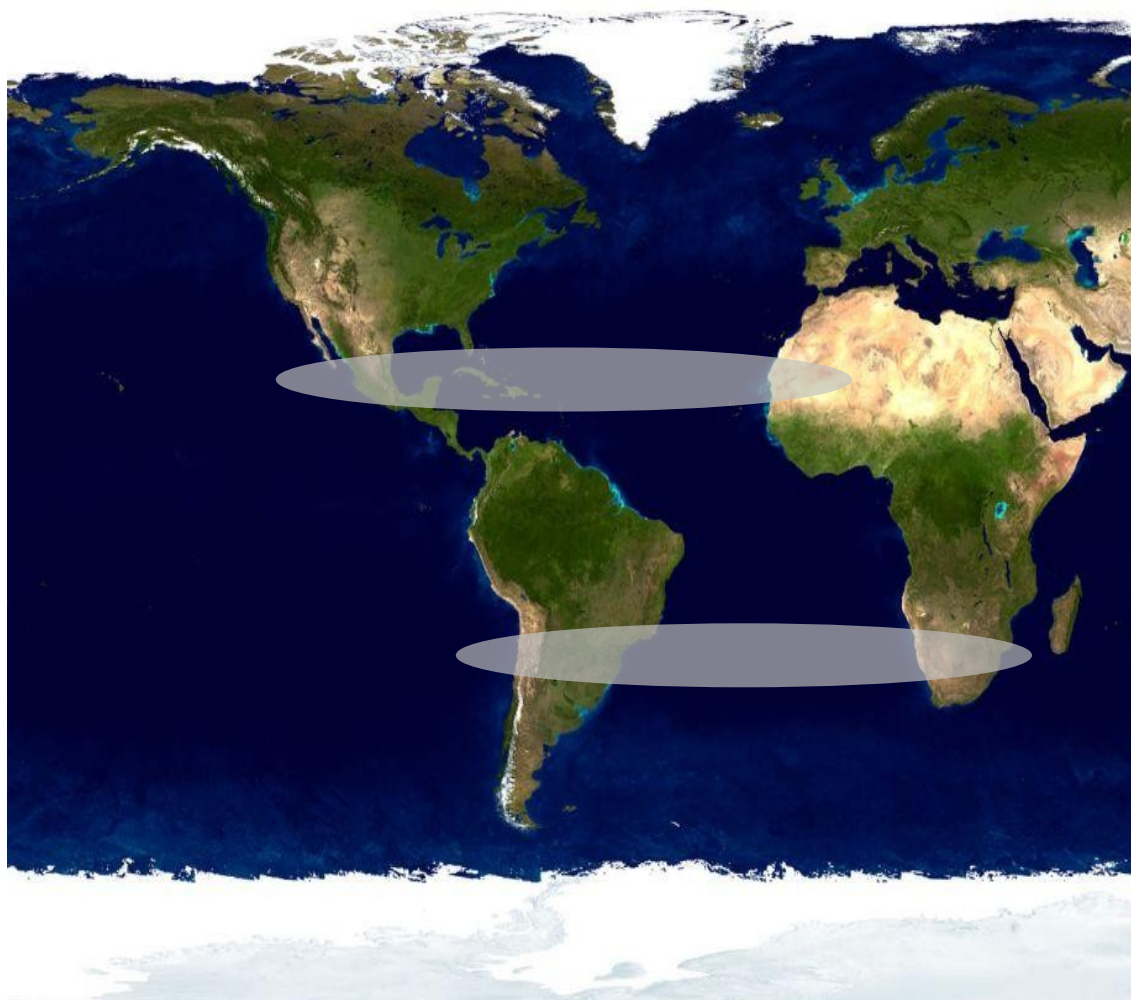
Stereoscopy provides better:

- Angular resolution.
- Energy resolution (distance).
- Background rejection.
- Sensitivity.



The Cherenkov Telescope Array

- One observatory with two sites for all-sky coverage
- Operated by one single consortium



Southern Array (100 M€)

- Full range: 10 GeV – 100 TeV
- Angular resolution 0.02 ... 0.2 deg
- Galactic + extragalactic sources
- Array area $\sim 10 \text{ Km}^2$

Northern Array (50 M€)

- Complements Southern Array for full sky coverage
- Energy range: 10 GeV – 1 TeV
- Mainly extragalactic sources
- Array area $\sim 1 \text{ Km}^2$

Builds on existing experience

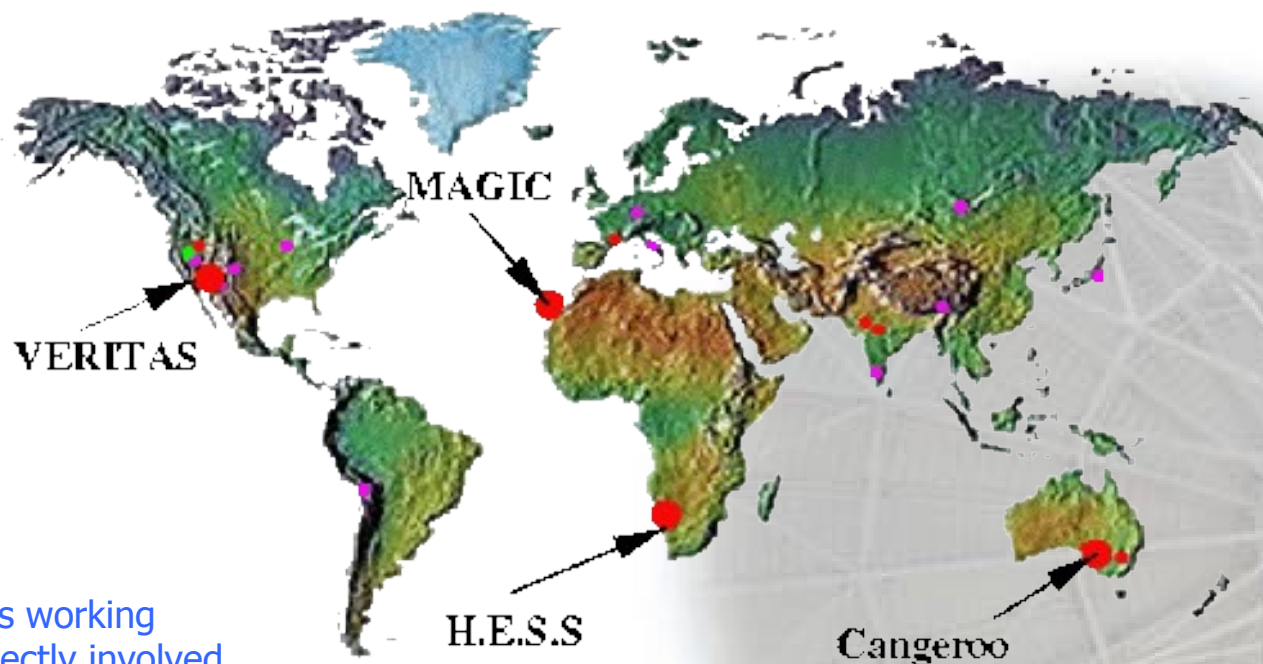
- MAGIC
- H.E.S.S.
- VERITAS
- CANGAROO

Several science communities:

- Astronomy and astrophysics
- Particle physics
- Fundamental physics

Scientists from

- Argentina
- Czech Republic
- France
- Germany
- Ireland
- Italy
- Poland
- South Africa
- Spain
- Switzerland
- UK



Approx. 600 scientists working in the field will be directly involved, with a user community significantly larger

Future participation

- USA
- Japan
- India
- Brazil



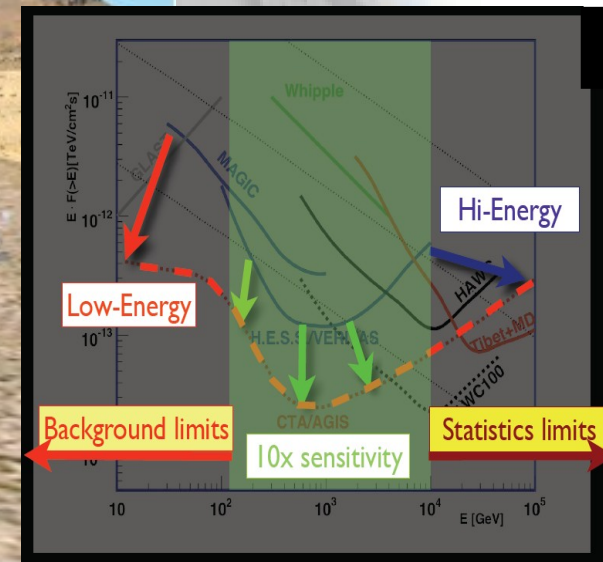
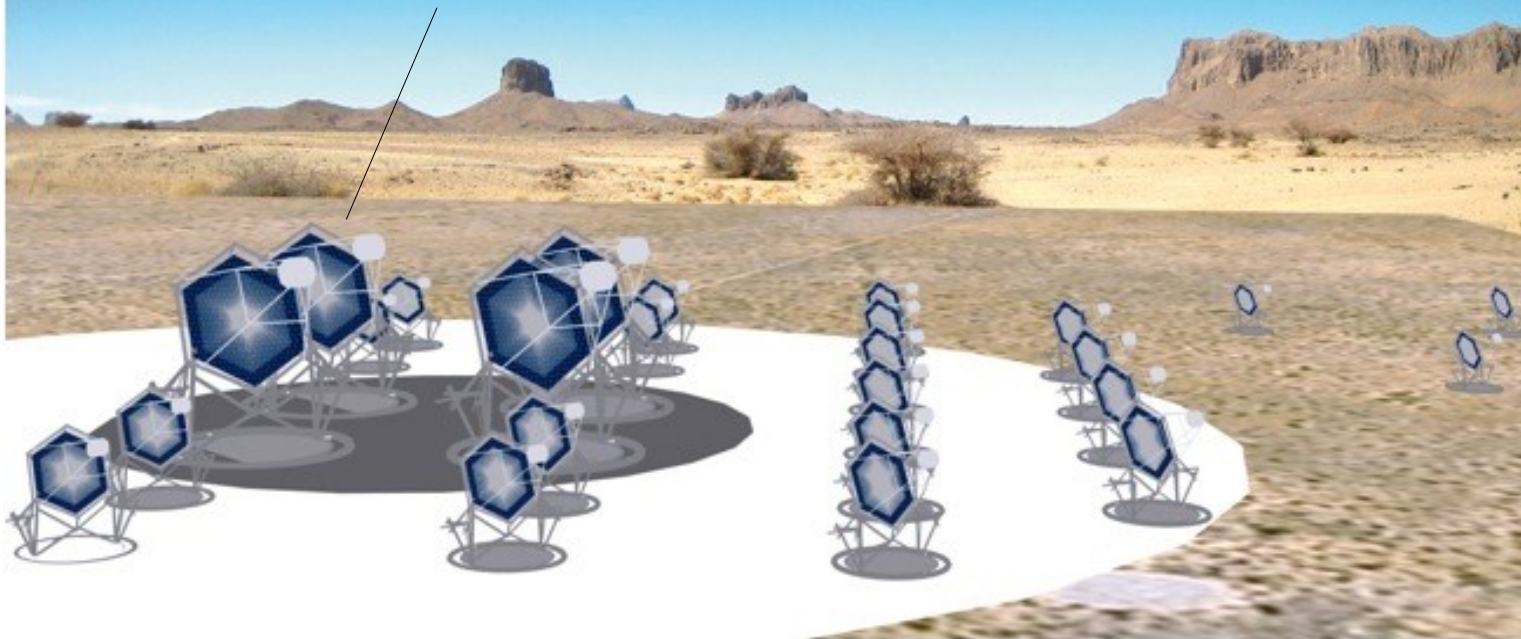
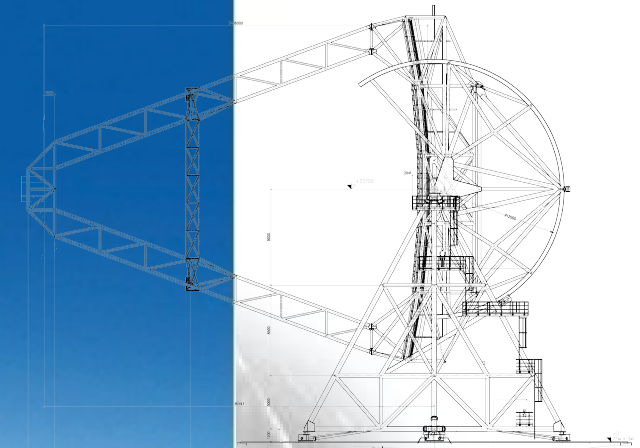
Low-energy section:

Large Size Telescopes (LST)

Array with a few O(24) m telescopes

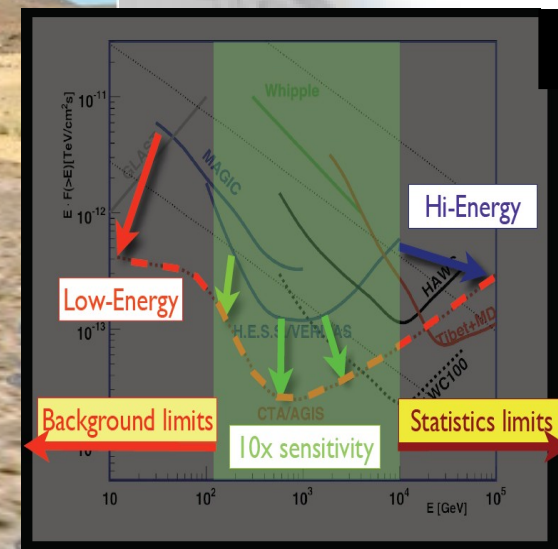
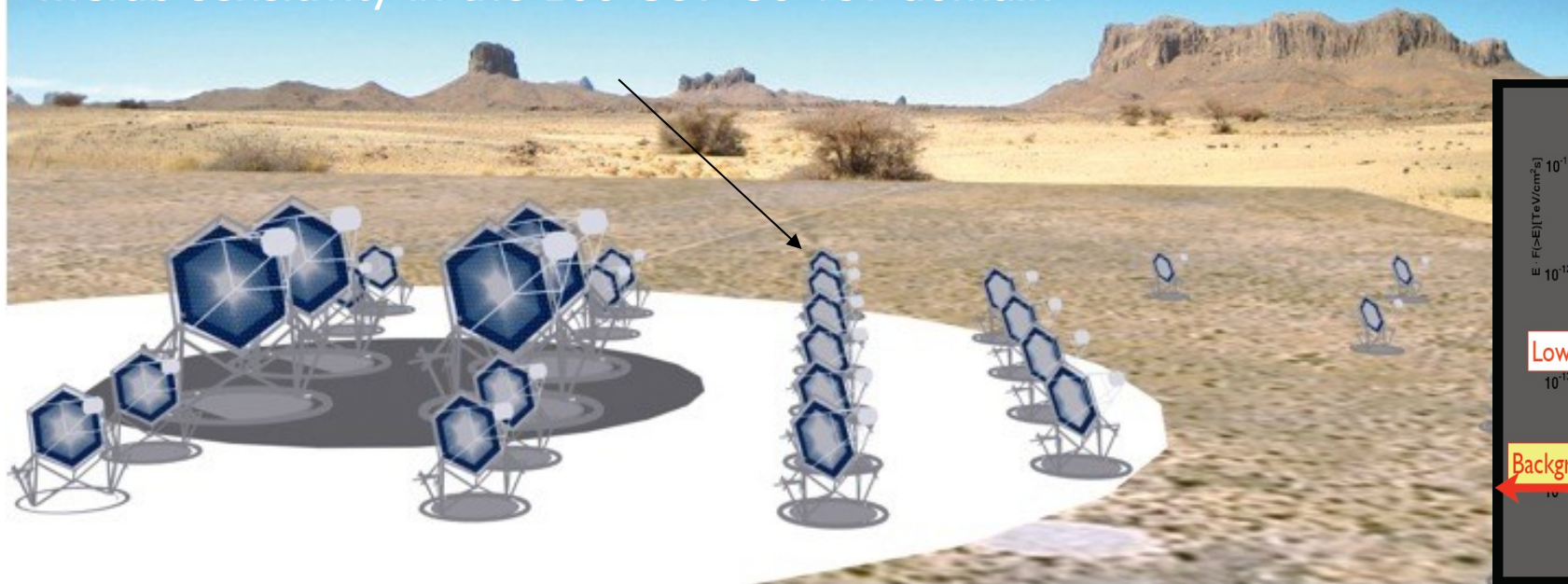
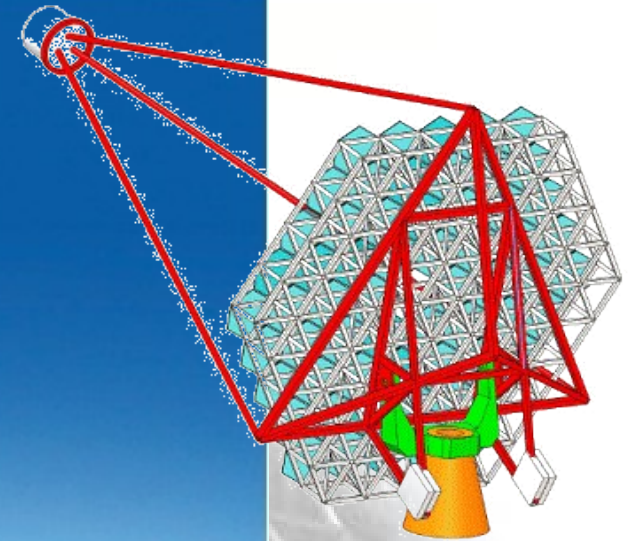
=> challenging technology on all sides

- Parabolic reflector - isochronous
- FOV: O(5) degrees
- O(0.09 deg/pix)
- f/d: O(1.2)
- sub-100 GeV photons



Core-energy array:

- Medium size telescopes (MST)
- Array with many O(12) m telescopes
 - => workhorse of CTA, push cost & reliability
- Davies-Cotton reflector
- FOV: O(8) degrees
- O(0.18 deg/pix)
- f/d: O(1.4)
- O(1 km²) area
- mCrab sensitivity in the 100 GeV–50 TeV domain



High-energy section:

Small size telescopes (SST)

Array with many O(6) m telescopes in Southern site

=> push low-cost, simple construction

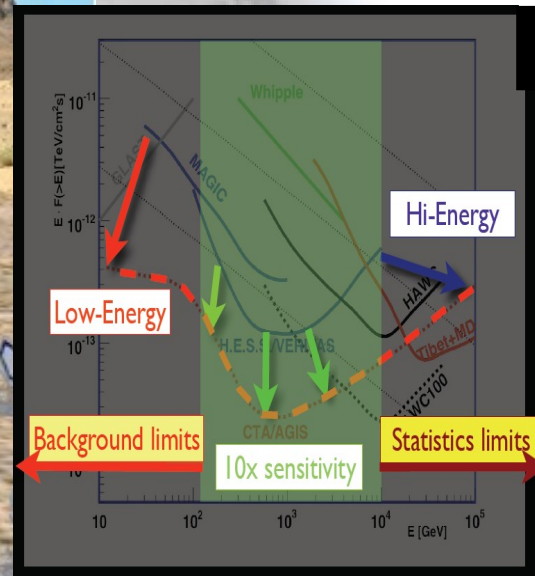
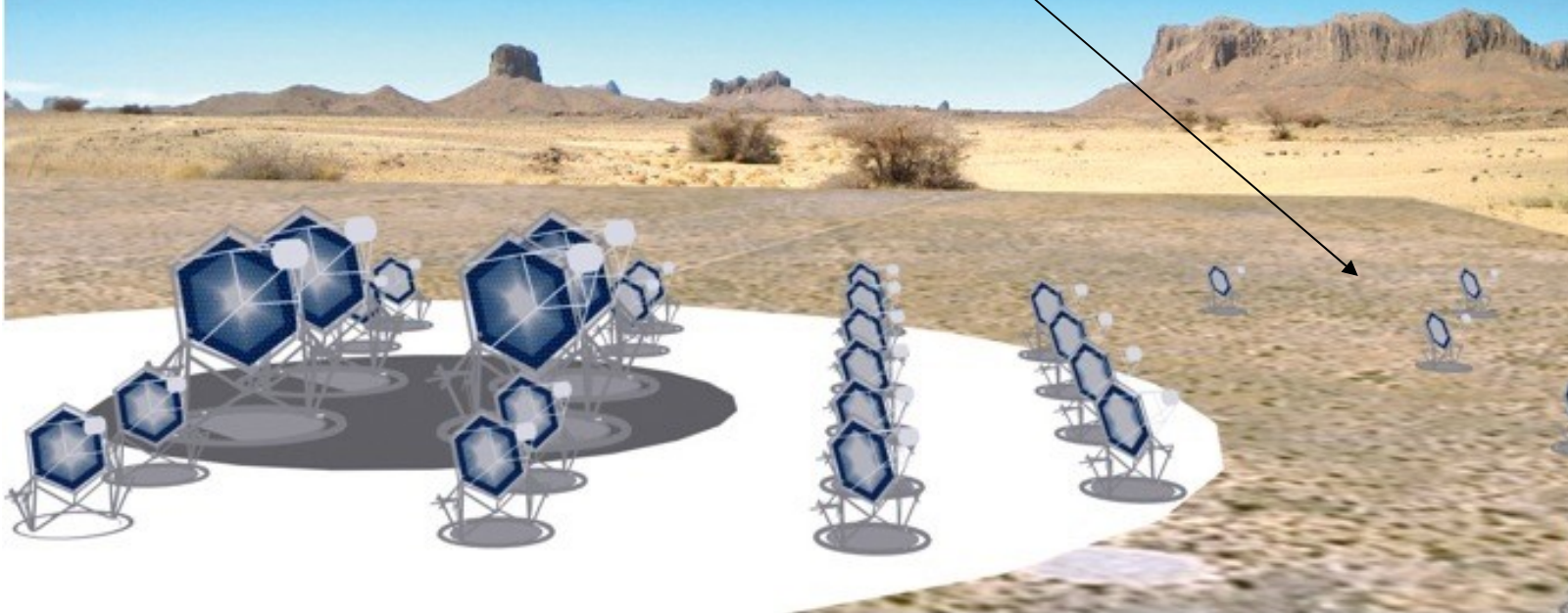
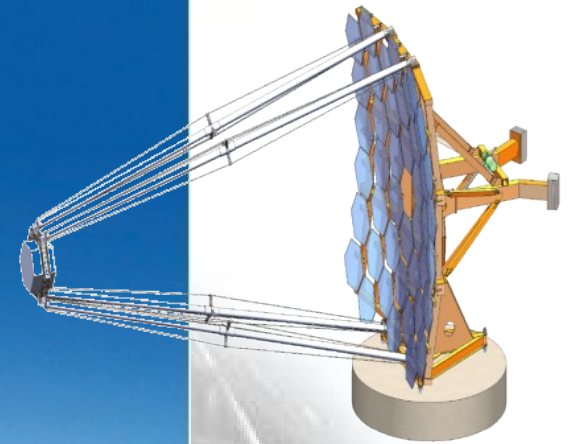
- Davies-Cotton reflector or Schwarzschild-Couder

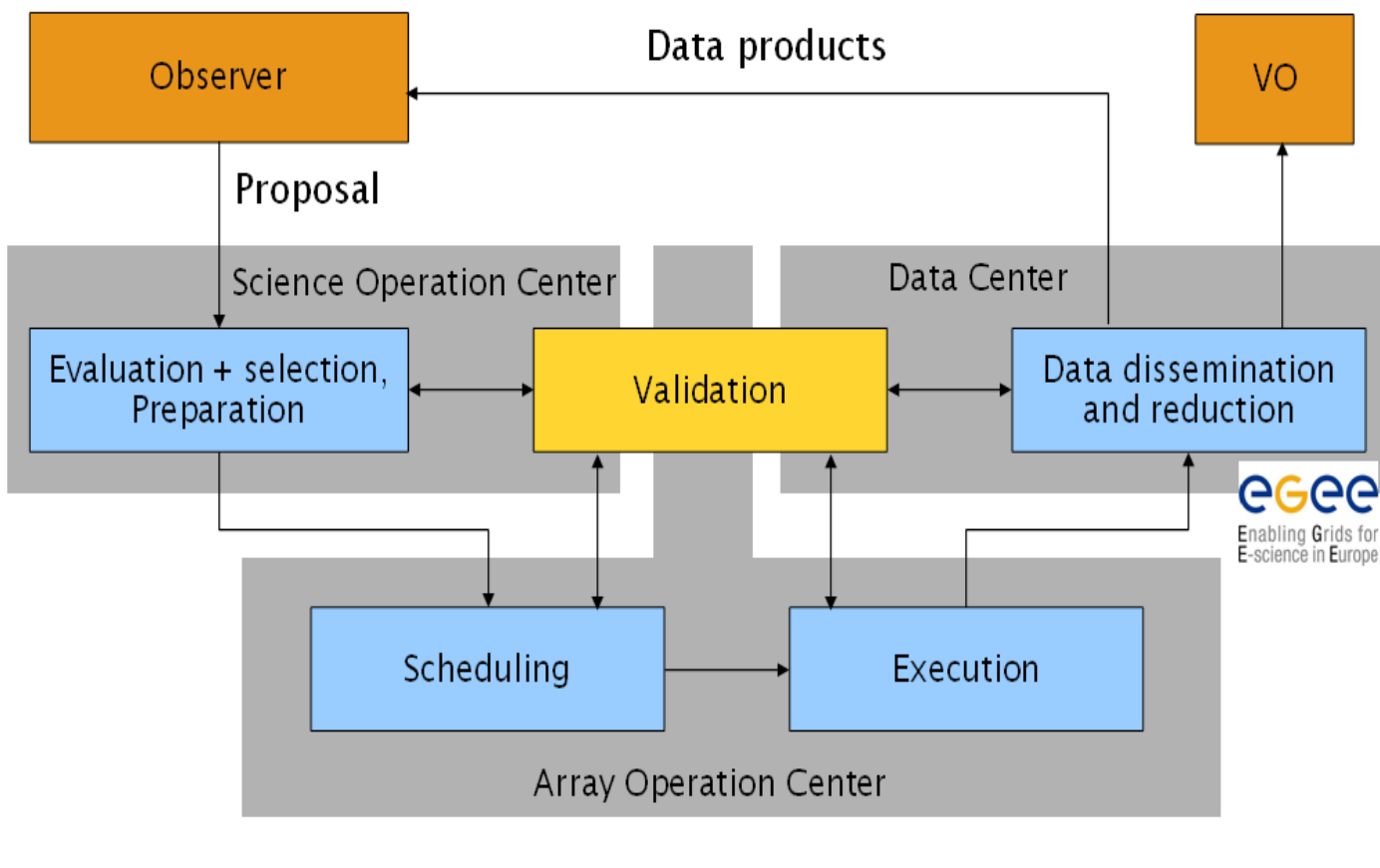
- FOV: O(10) degrees

- O(0.25 deg/pix)

- f/d: O(1.2-1.5)

O(10 km²) area at ultra 50-TeV energies





Data processing

- Open observatory concept
- Open standards
- Long-term lifetime maintenance
- Monte-Carlo core algorithms
- High processing rate
(10 TB/obs => few tens MB)

Science Operations Centre: Proposal handling, Science Planning, Science evaluation

Array Operations Centres: Scheduling, Execution (based on ALMA control system)

Data Centre(s): EGEE middleware, VO data archive and distribution

**Site requirements:**

- Latitude around 30° South / North
- Altitude between 1500 and 4000 m
- Flat area about 10 km² South, 1 km² North
- High number of clear nights (>80 %)
- Very good sky quality
- Adequate climate conditions
- Well-developed infrastructure and logistics
- Administrative / political stability

Southern site candidates:

Namibia: Khomas Highlands (23 S, 1800 m) H.E.S.S. observatory

Chile: North of La Silla (29 S, 2400 m),

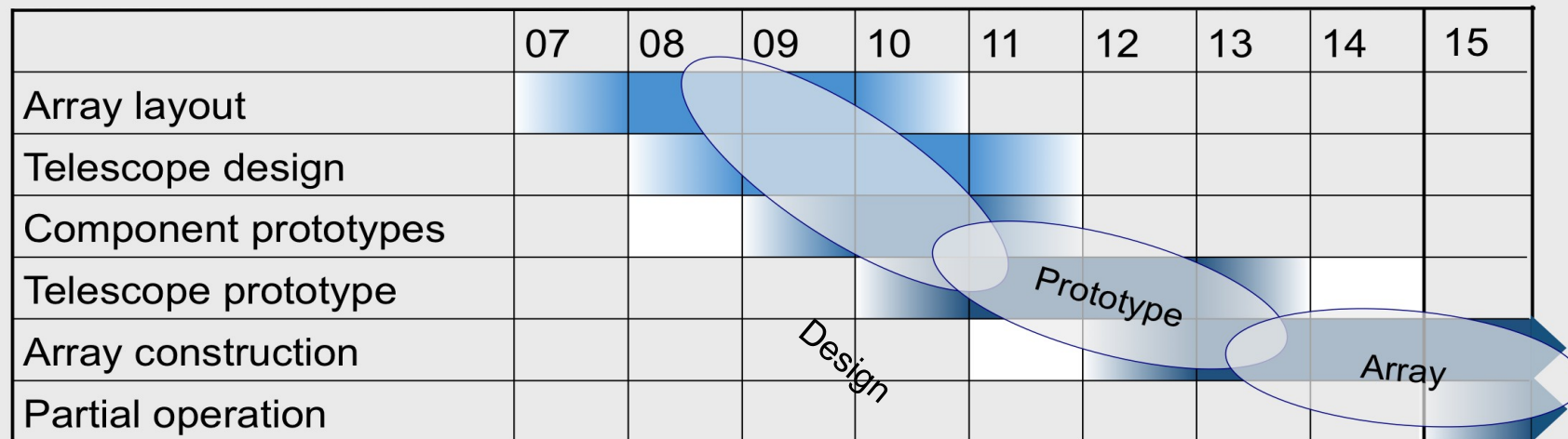
Argentina: El Leoncito (32 S, 2600 m), Puna Highlands (30 S, 3700 m)

Northern site candidates:

Canary Islands: La Palma / Teide observatories (26 N, 2400m)

Mexico: San Pedro Mártir, Baja California (31 N, 2800m)

Tentative timeline towards the CTA observatory



Design Study
2007-2010

Preparatory Phase
2010-2013

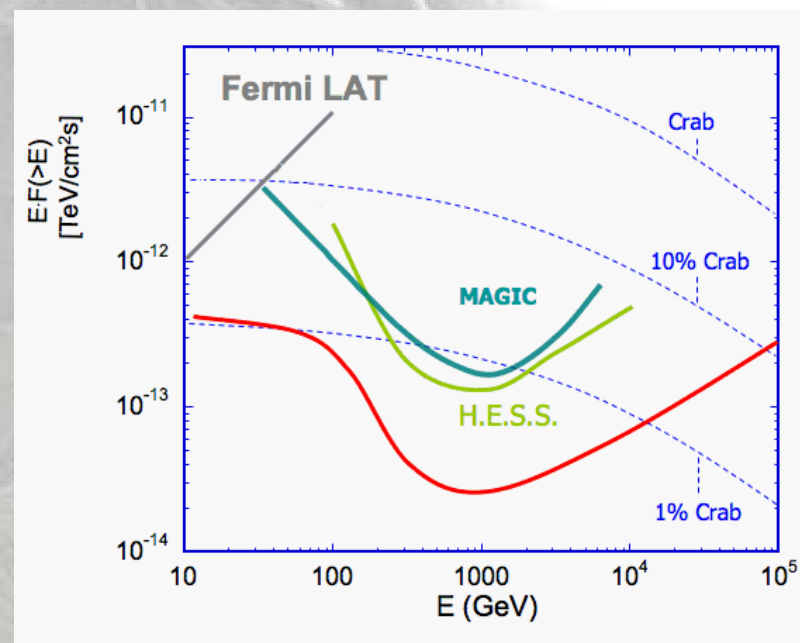
Array Construction
2013-2018

Preparatory Phase: EU-FP7 funding. **Project Office:** Landessternwarte, Heidelberg

Priority project in roadmaps: ASTRONET, ASPERA, ESFRI,
AstroParticle WG GSF (OECD),
US Decadal Report (NRC) Astro 2010 Report

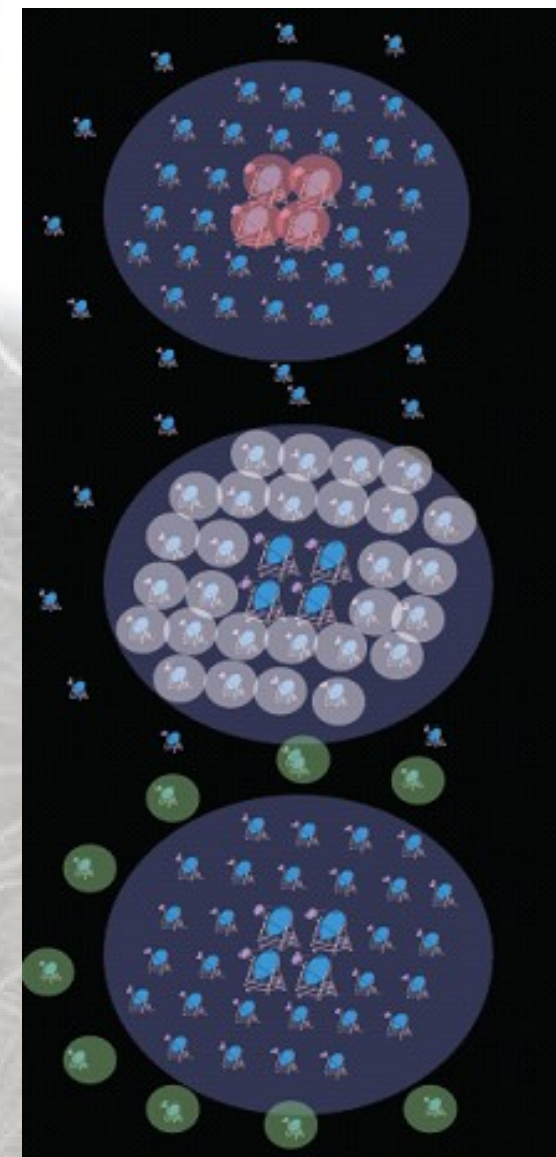
CTA is a new window to the universe

- Closer look to the physics of gamma-ray sources (SNR, PWNe, Binary systems, AGN)
- Understand origin and acceleration mechanisms of cosmic rays
- Extend the catalogue of VHE sources (survey of the Galactic Plane)
- Understand current “unidentified sources”
- New physics beyond the standard model (including the search for dark matter)



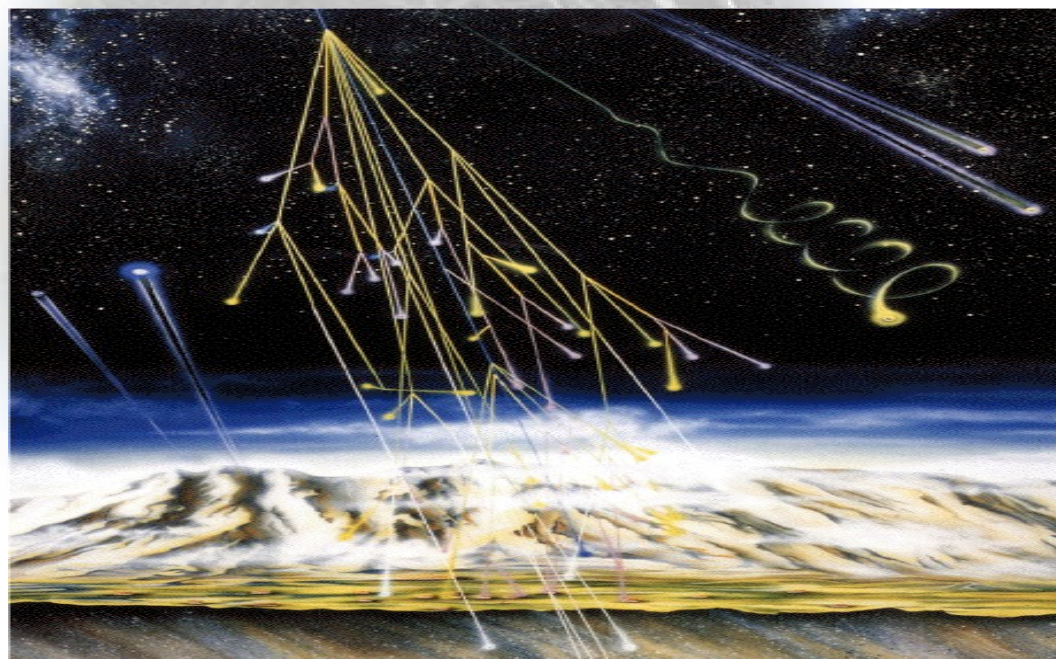
The project builds on existing experience

- Industrial production of the telescopes
- Optimal configuration of the telescope arrays
- Design of LST/MST/SST telescopes
- Sensitivity: factor of 10 more sensitive
milli-Crab sensitivity from 100 GeV to several TeV
- Angular resolution: factor of 5 (arc-min range)
- Reliable operations and maintenance
- Site selection
- Flexible scheduling of operations
- Processing performance: 50 TB/night
- Archive: 1 – 3 PB / year



Moving CTA from brainstorming phase towards an operational open observatory

- Open observatory concept: open proposals, open data access
- Integration of two science areas: astrophysics and high energy physics
- Coordination of the world-wide project: international scope
- New concepts in quality assurance
- Training ground for young scientists
- Public outreach
- Setup a large science project in current economic conditions ...



<http://www.cta-observatory.org/>

