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The Cherenkov Telescope Array Project

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INAF & ASDC

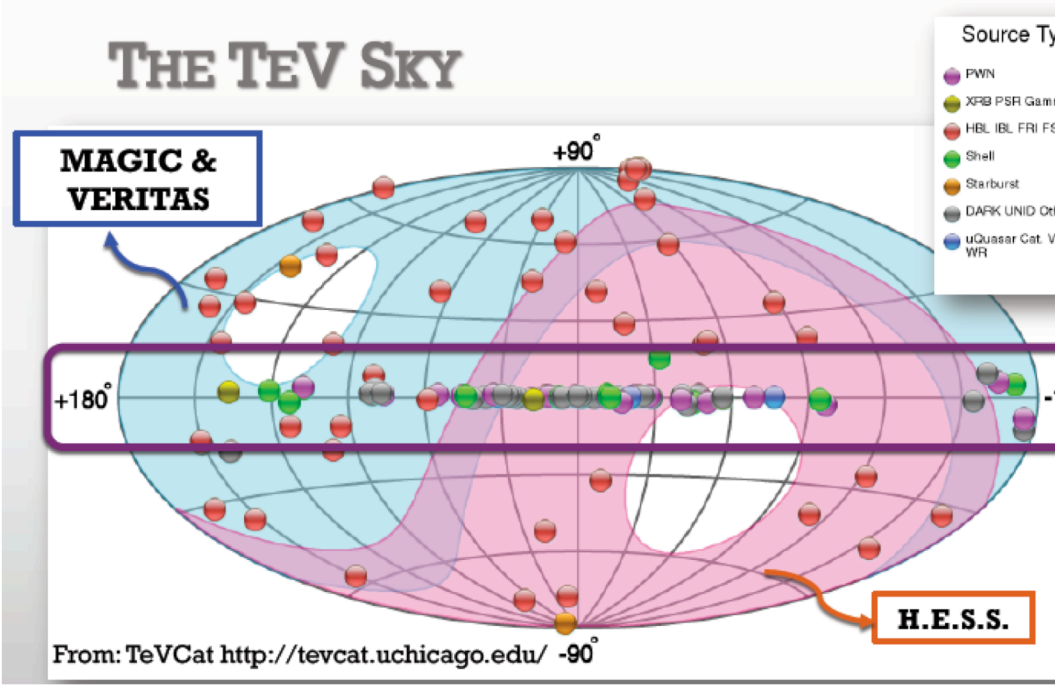
on behalf of the CTA Consortium

Overview

- What is CTA?
- What will CTA be for?
- How is CTA working?
- Who is CTA?
- Where will CTA be?
- When CTA will be?

What is CTA

The present generation of imaging atmospheric Cherenkov telescopes (H.E.S.S., MAGIC and VERITAS) has in recent years opened the realm of ground-based gamma ray astronomy for energies above a few tens of GeV.



What is CTA

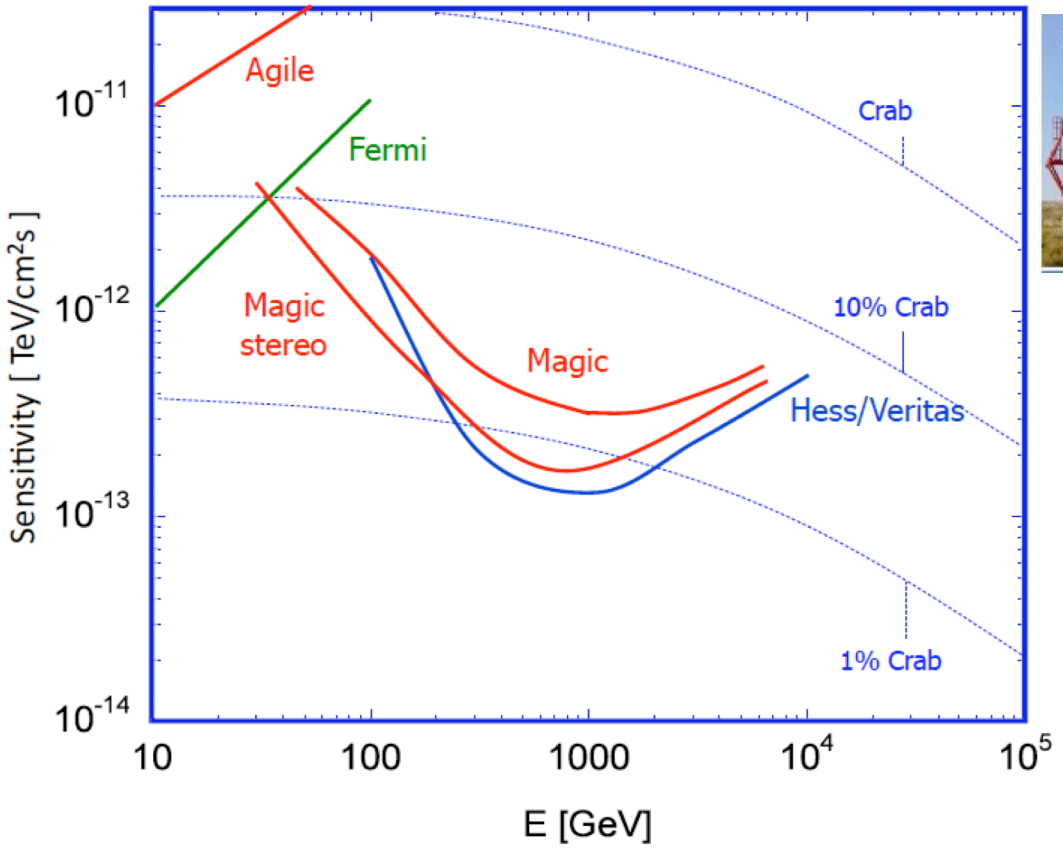
The Cherenkov Telescope Array (CTA) is a large project representing the next generation of IACT.

CTA will consist of two arrays of Cherenkov telescopes, which aim to:

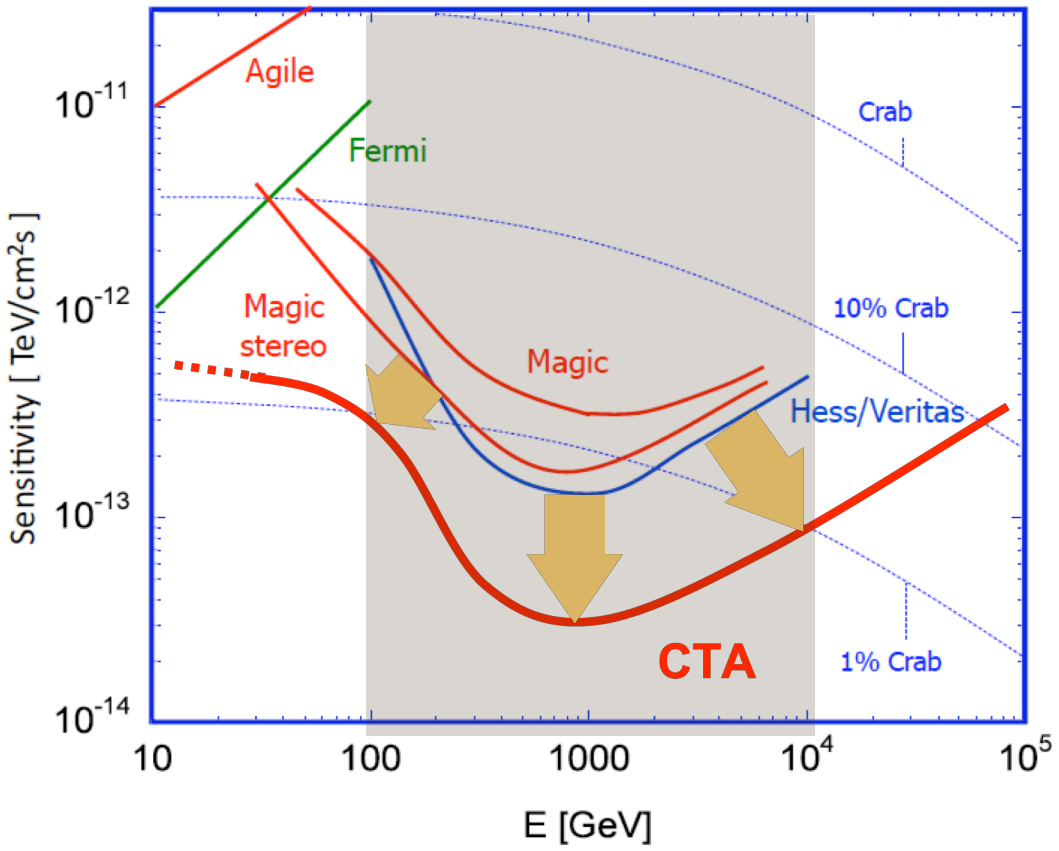
- increase sensitivity of one order of magnitude for deep observations around 1 TeV;
- boost significantly the detection area and hence detection rates, particularly important for transient phenomena and at the highest energies;
- increase the angular resolution and hence the ability to resolve the morphology of extended sources;
- provide uniform energy coverage for photons from some tens of GeV to beyond 100 TeV;
- enhance the sky survey capability, monitoring capability and flexibility of operation.

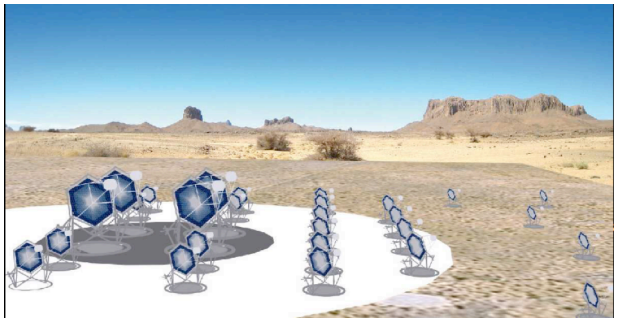
CTA will be operated as a proposal-driven open observatory, with a Science Data Centre providing transparent access to data, analysis tools and user training.

Improve sensitivity



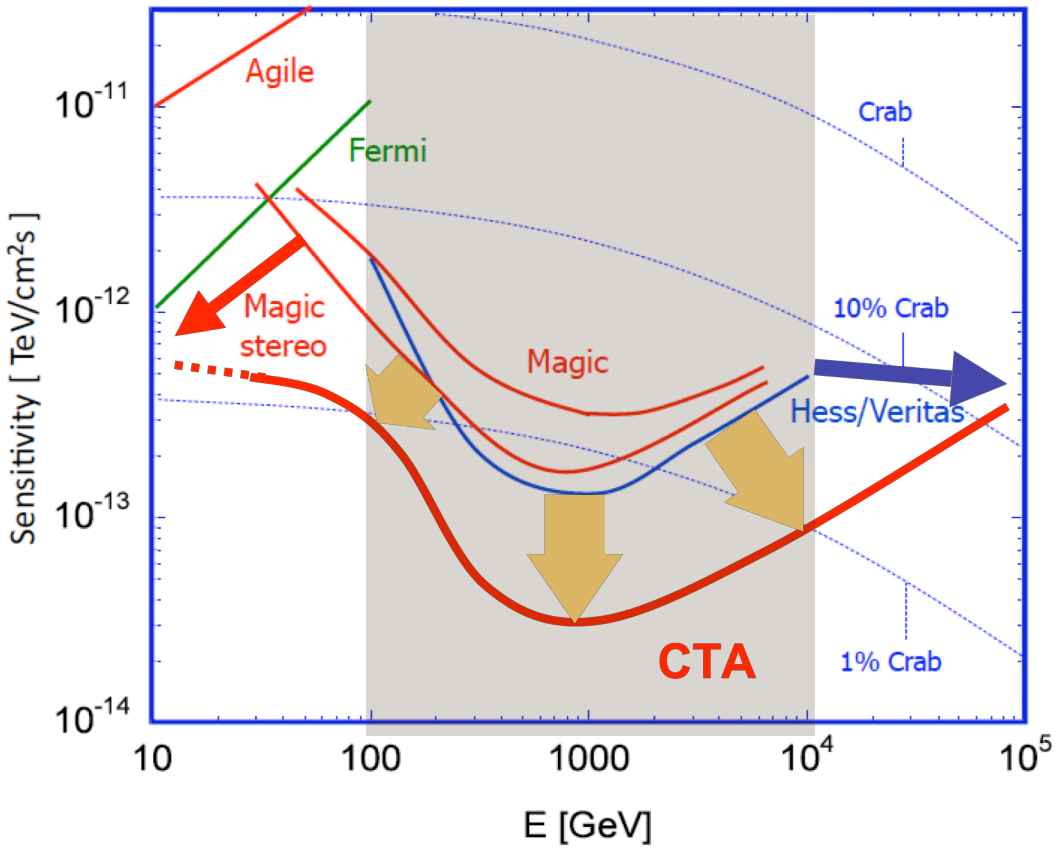
Improve sensitivity

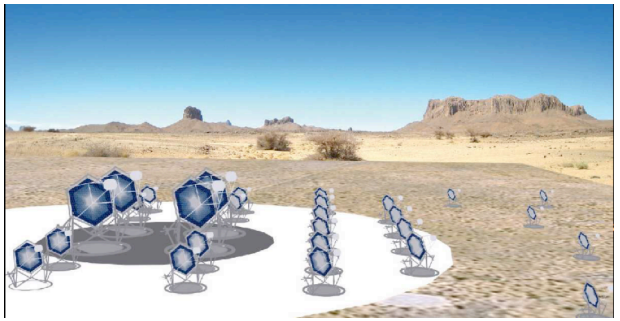




CTA will be about a factor of 10 more sensitive than any existing instrument in the 100 GeV-10 TeV energy band.

Improve sensitivity

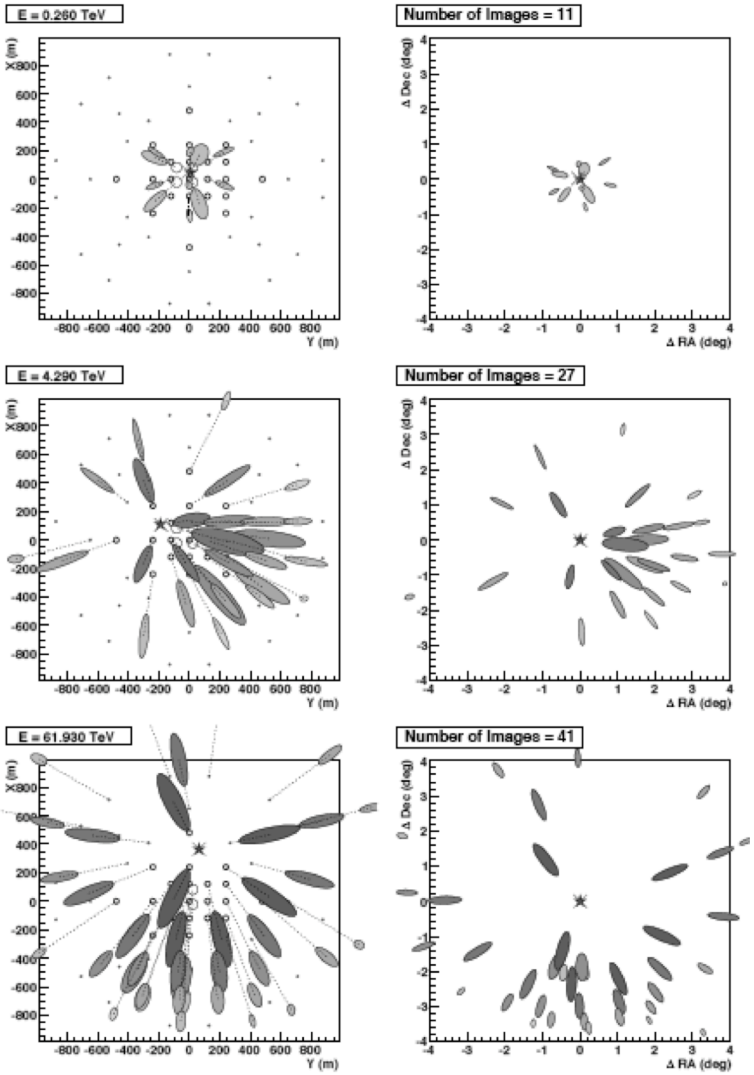




CTA will be about a factor of 10 more sensitive than any existing instrument in the 100 GeV-10 TeV energy band.

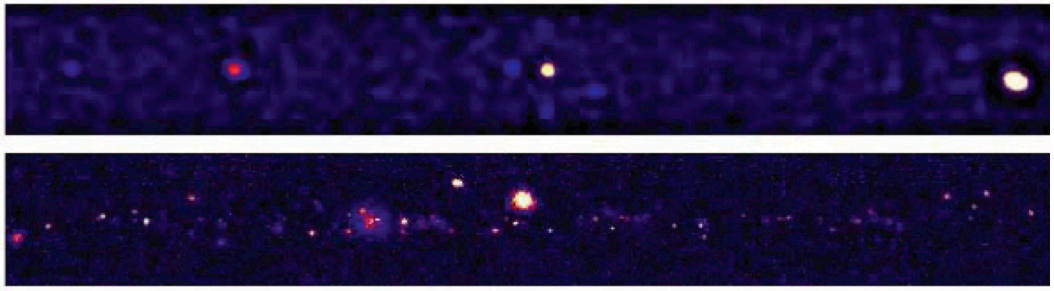
CTA will also extend the observed energy band reaching both the lower (10 GeV) and the higher (100 TeV) energies.

Improve angular resolution

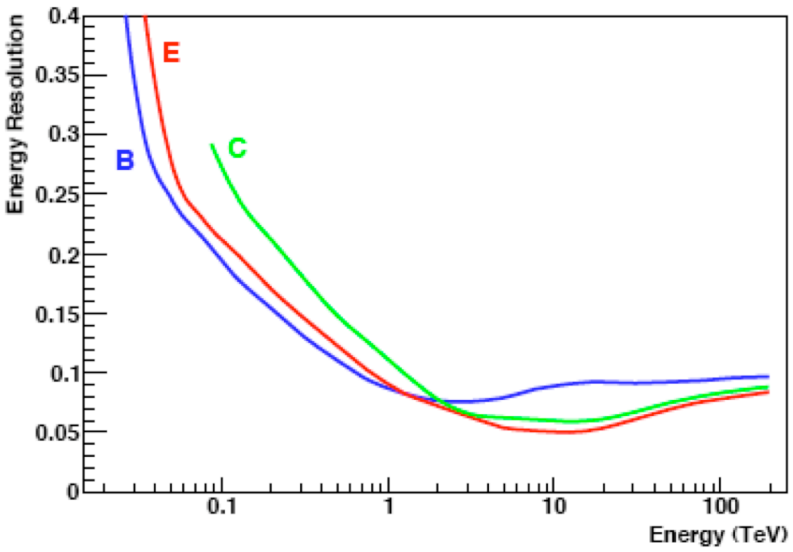


Both at the center and on the entire FOV.

- resolve galactic objects
- avoid source confusion due to the improved sensitivity.
- hadrons and leptons have different free-streaming lengths and gamma-emission is strongly shaped by local interactions. Improved angular resolution (arcsec scale) coupled with MW campaigns will give key information to discriminate acceleration mechanisms



Improve energy & time resolution



- 30% below 1 TeV
- 10% above 1 TeV

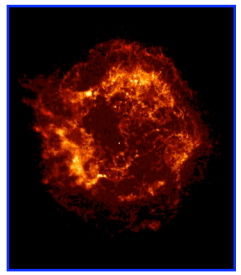
Increase capability to observe spectral features and cutoffs:

- Pulsar
- EBL-absorbed AGNs
- DM spectral features

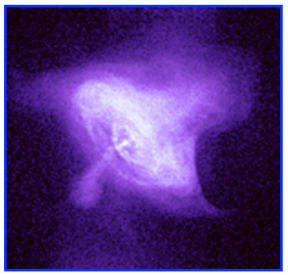
Thanks to its large detection area, CTA will resolve flaring and time-variable emission on sub-minute time scales, which are currently not accessible. This will allow to probe the size of the gamma-ray emission in proximity of Black Holes in both AGNs and galactic binary sources.

Scientific Objectives

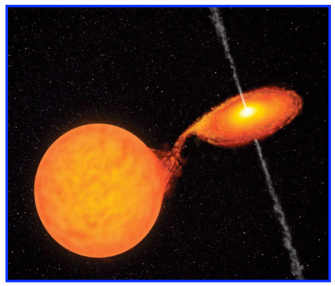
Galactic



SNRs

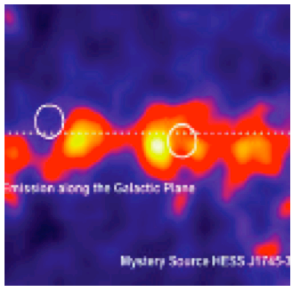


Pulsars and PWN



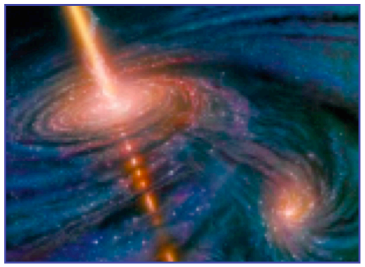
Micro quasars

X-ray binaries

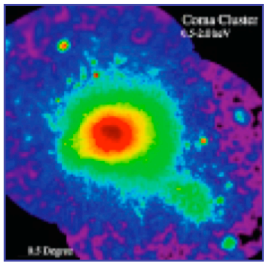


Galactic Center

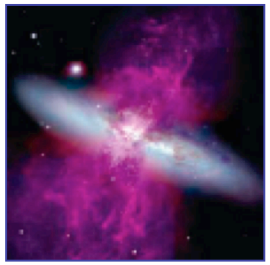
Extragalactic



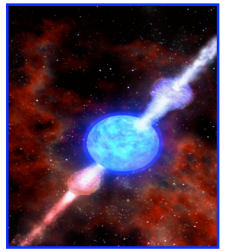
AGNs



Galaxy Clusters



Starburst Galaxies

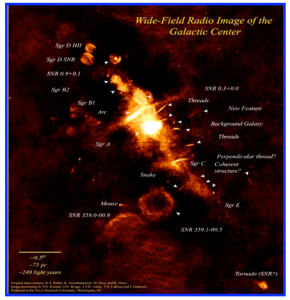


GRBs

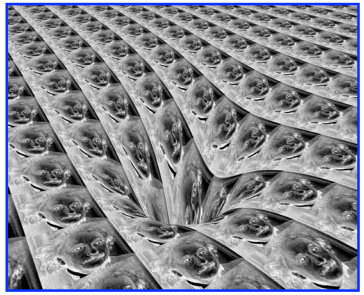
Fundamental Physics

Origin of

cosmic rays

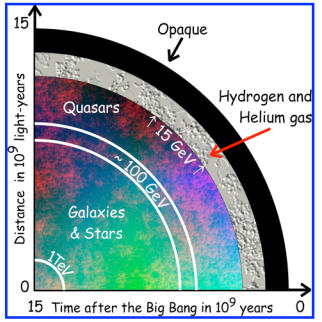


Dark matter



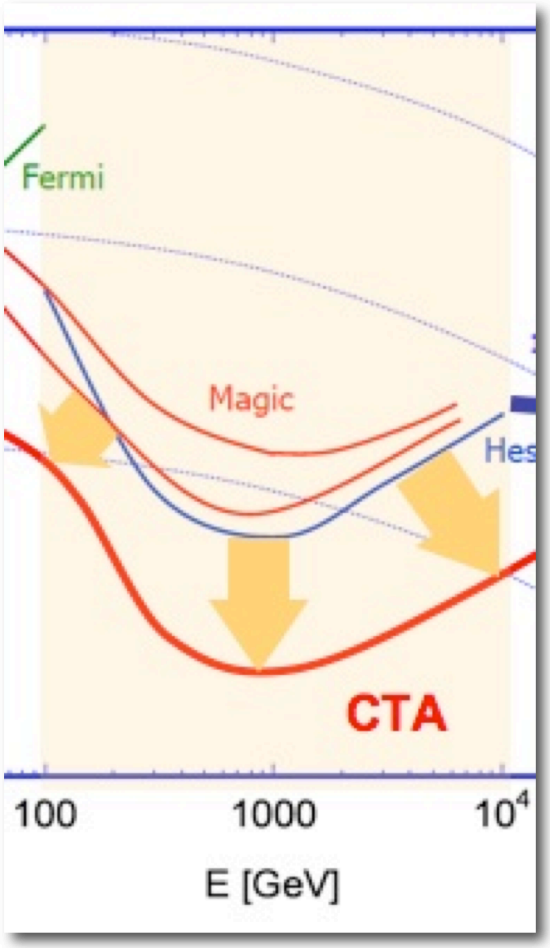
Space-time

& relativity



Cosmology

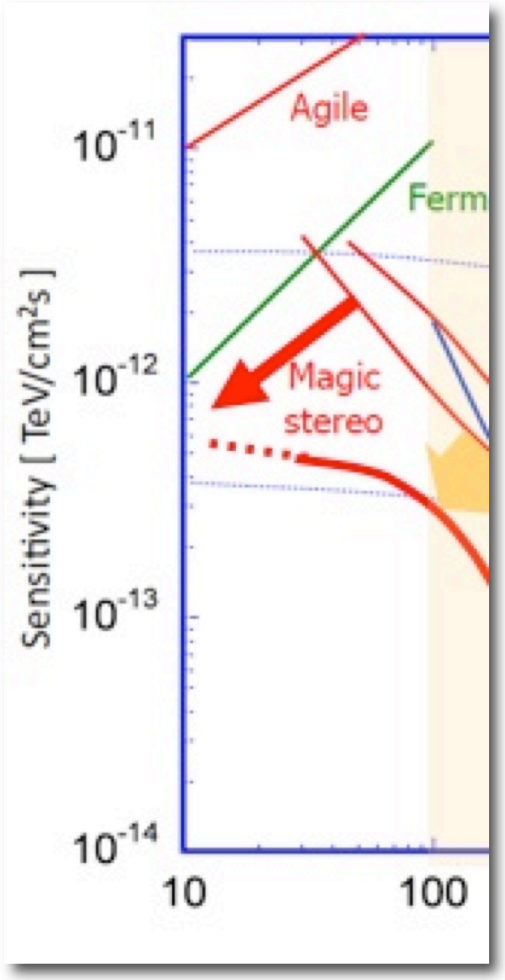
Improve sensitivity (100 GeV-10 TeV



A real VHE TeV astronomy:

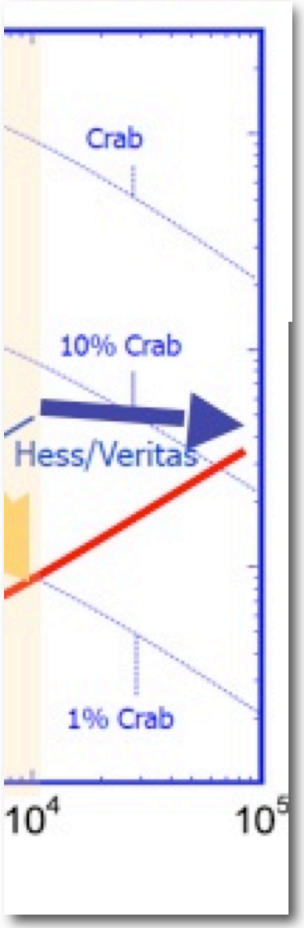
- Morphological studies on galactic targets
  - local interaction with gas/matter
  - discrimination hadronic/leptonic mechanisms
  - interaction with globular clouds
- Variability studies
  - sub-min scale variation (pulsar, binaries, AGNs,Lorentz invariance)
  - possibility to make follow-up obs. (binaries,blazar)
- Consolidate TeV astronomy
  - ~1000 new sources expected
  - acceleration sites of extragal. CRs (gal. merges, gal. clusters, IR gal., ...)
  - VHE model for AGNs
  - GRBs...

Low-energy physics (<50 GeV)

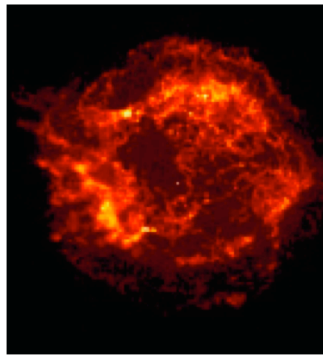


- Galactic objects
  - Investigate Pulsar models: pulsars may have different cutoffs according to acceleration close or far from surface.
  - Synchrotron emission from PWNs: PWNs emit synchrotron ~50 GeV gamma-rays from ultra-relativistic winds
    - Investigate acceleration mechanisms
  - hadronic/leptonic acceleration at SNRs: there are spectral differences below 100 GeV
- Extragalactic objects
  - Steep-spectrum blazars.
  - Complete Fermi catalog at VHE
  - GRBs
- Other
  - overlap with Fermi on all unidentified >GeV sources
  - increase probability of observation of low-mass DM candidates

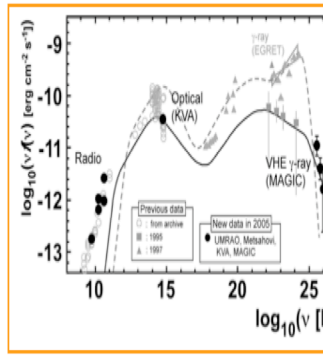
High-energy physics (>10 TeV)



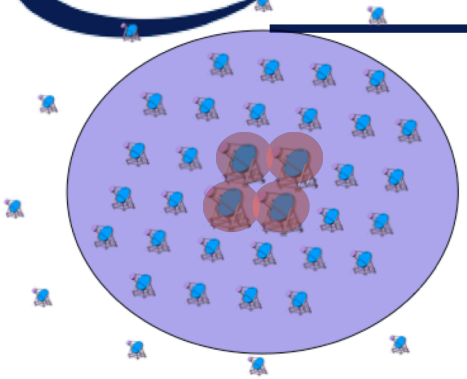
- Galactic objects
  - Acceleration mechanism in SNRs: above 50 TeV, hadronic/leptonic acceleration mechanism at SNRs differ.
  - the nature of ultra-relativistic jets of microquasars
  - the nature of binary-systems



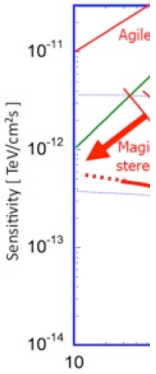
- Other
  - Probing the knee in cosmic-ray spectrum
  - Lorentz invariance between HE/LE photons



CTA concept



- Few Large Size Telescopes should catch the sub-100 GeV photons
  - Large reflective area
  - Parabolic profiles to maintain time-stamp
  - Contained FOV



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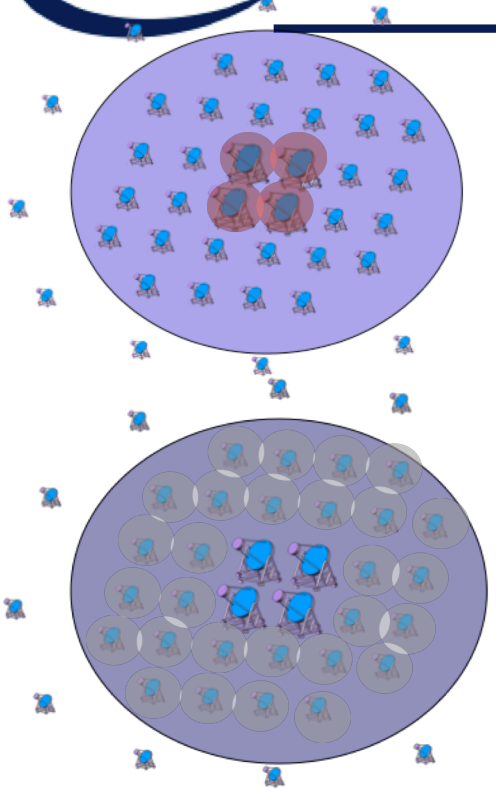

- Few Large Size Telescopes should catch the sub-100 GeV photons
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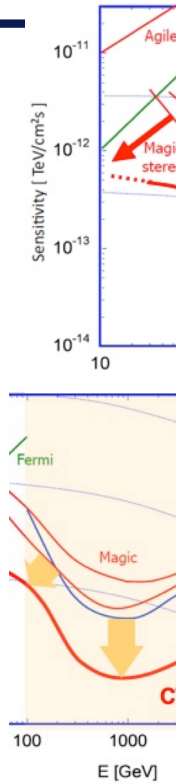
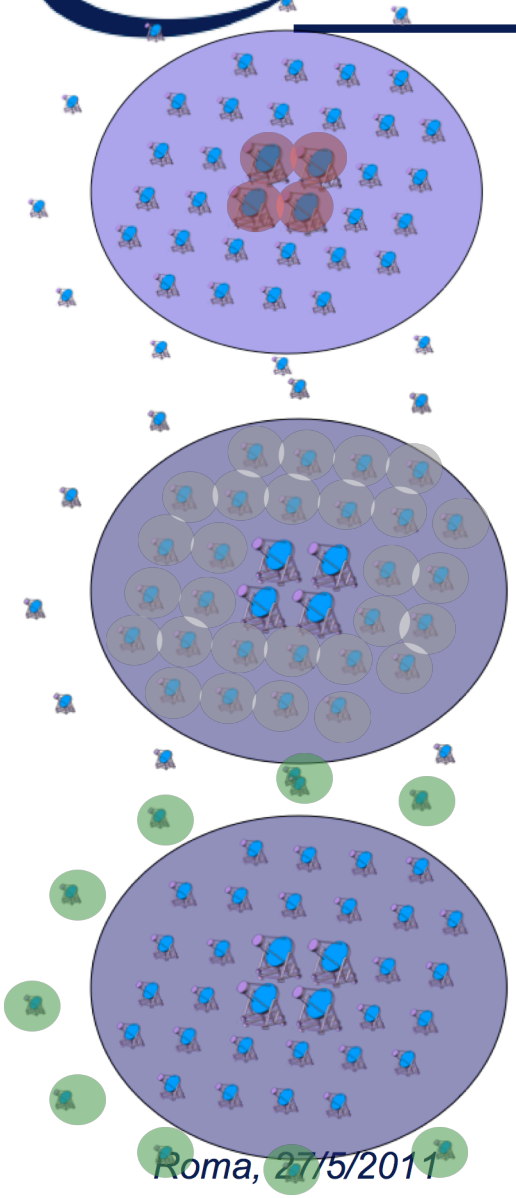
  - Contained FOV
- Several Medium Size Telescopes perform 100 GeV-50 TeV observation
- well-proven techniques (HESS, MAGIC)
- goal is to reduce costs and maintenance
- core of the array
- act as VETO for LSTs



CTA concept



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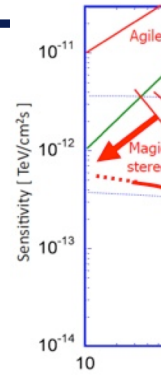
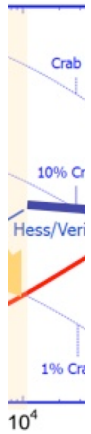
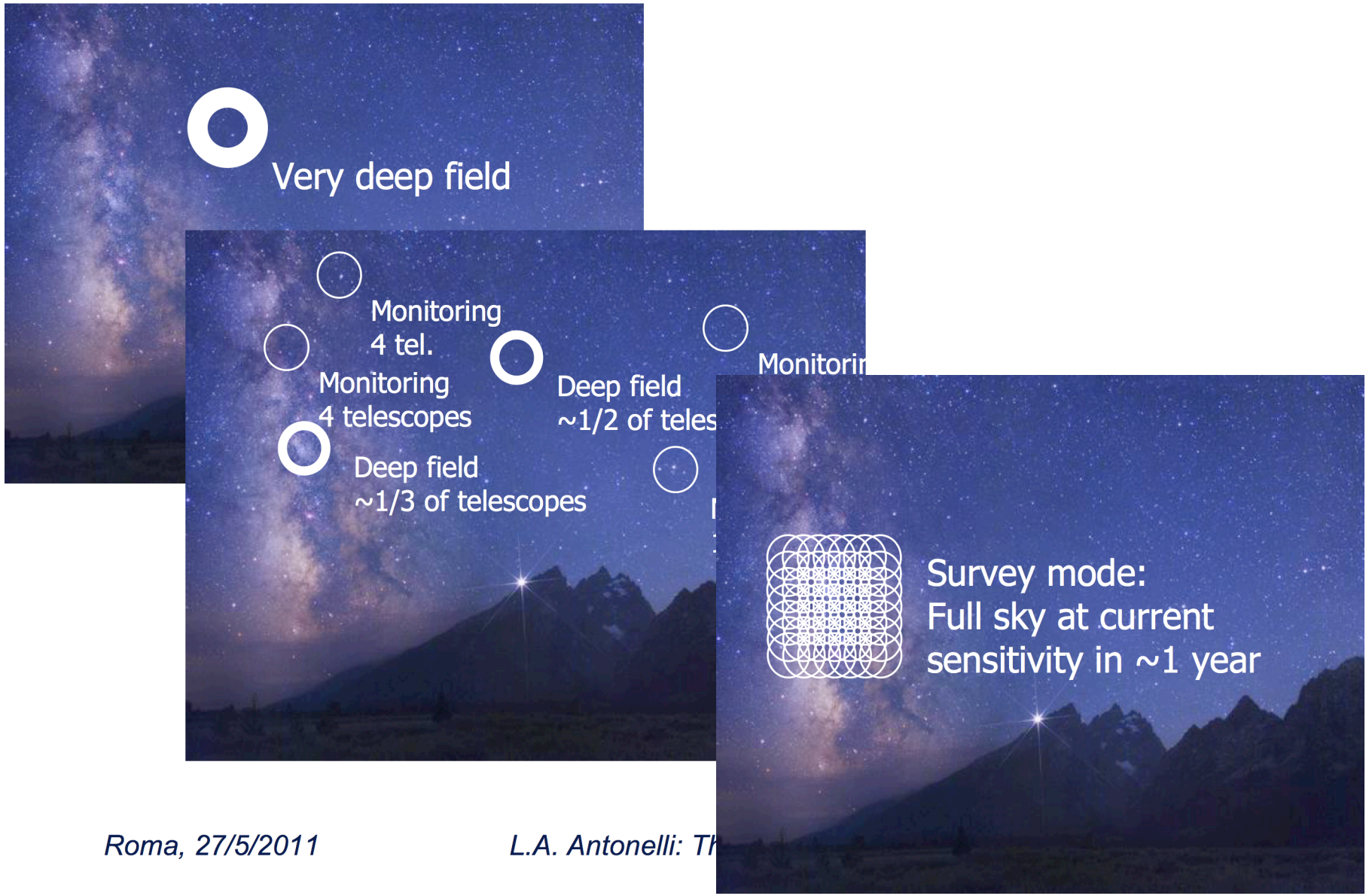
- Several Small Size Telescopes perform ultra-50 TeV observation
- challenging design
- Large field-of-view (8°)
- New camera technology

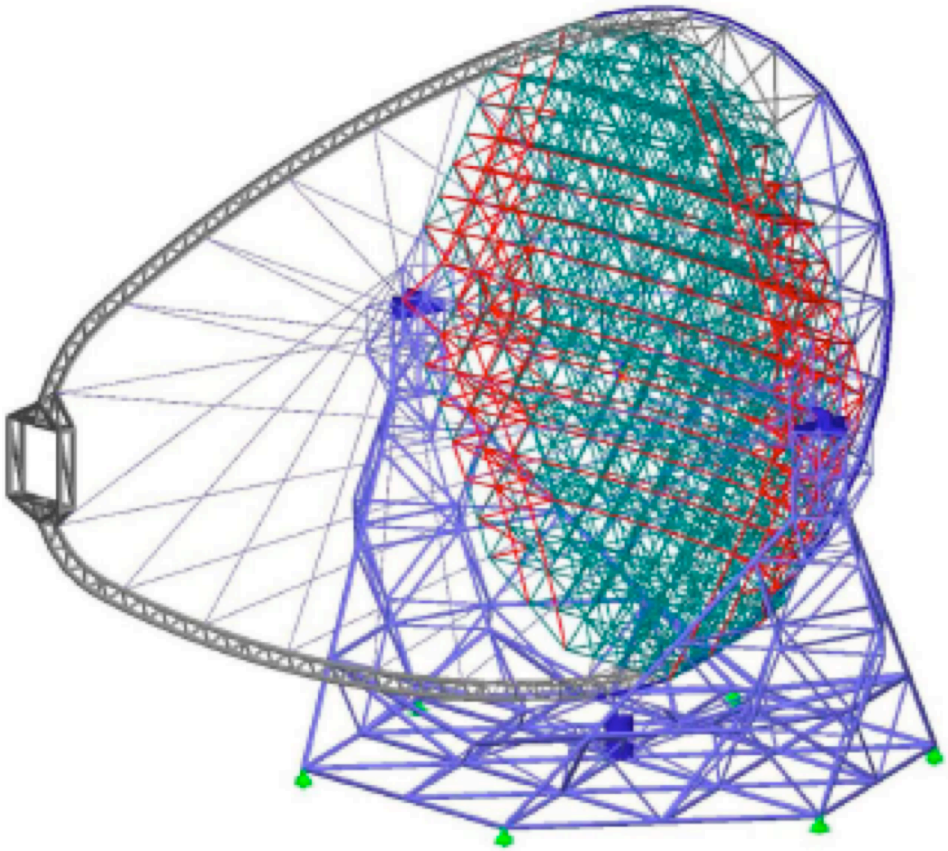




CTA observation modes

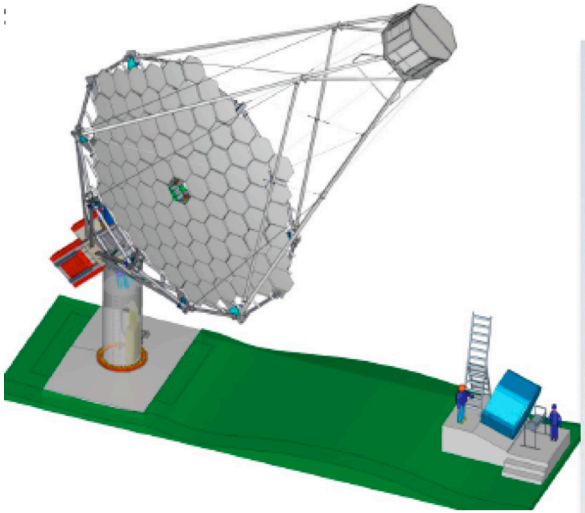


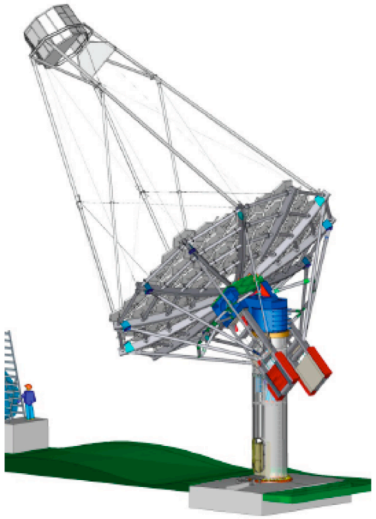
Large Size Telescope



- Dish Diameter D=23m
- Focal length F=28m
- F/D=1.2
- FOV=4.5 degrees
- Pixel size=0.1 degrees

Medium Size Telescope

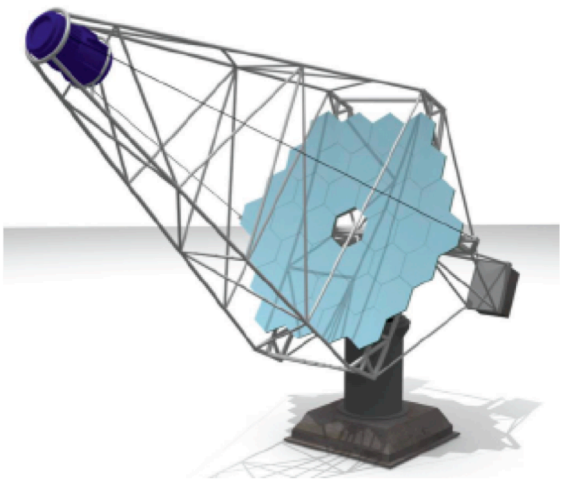




Focal length f	16m
Dish diameter	12m
Dish curvature radius	19.2m (= 1.2×f)
Camera Field of View – weight	8° – 2.5 tons
Mirror shape, size, weight, gaps	hexagonal 1.2 m wide, 8cm thick, 35 kg/m², 2c
Fast slewing speed	1min
Mechanics share to Point Spread Function	1mrad
Eigenfrequency	2.5 Hz
Displacement of camera	½ pixel
Tracking accuracy	1.2 arcmin
Environment: temperature, height, wind	-20...40°C, 3500 m 50, 65, 80, 180 km/h
Lifetime	30 years

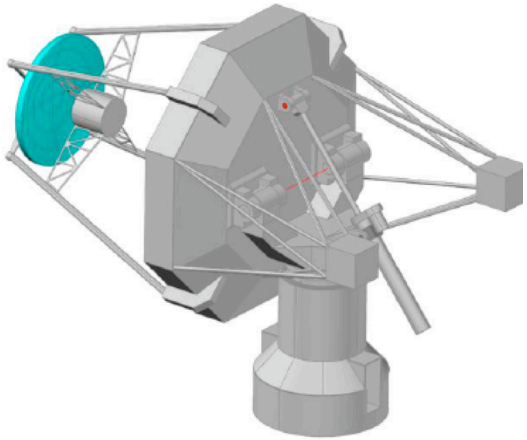
Mechanical prototype under construction

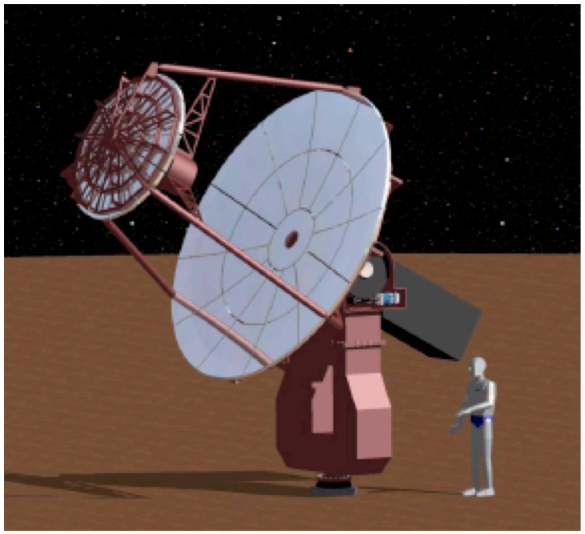
Small Size Telescope



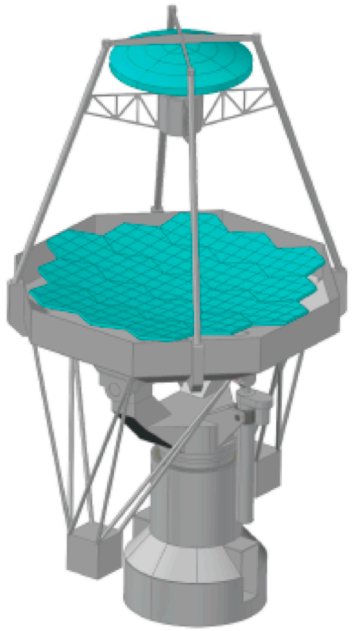
3 different designs:

-1 Polish D-C
-1 Italian S-C
-1 Anglo-French S-C

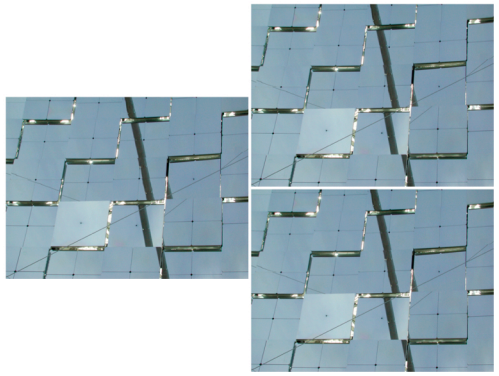




Primary Mirror diameter: 4.3 m (tessellated)
Secondary Mirror diameter: 1.8 m (monolithic)
F#: 0.5
Equivalent focal length: 2150 mm
FoV diameter: 9.6 degrees
Pixel: 0.16°

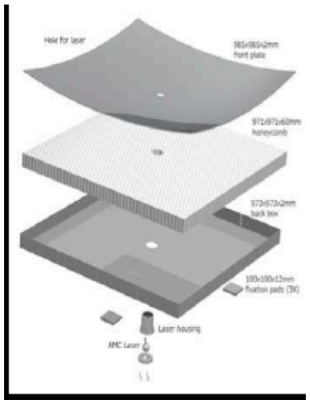


Mirrors

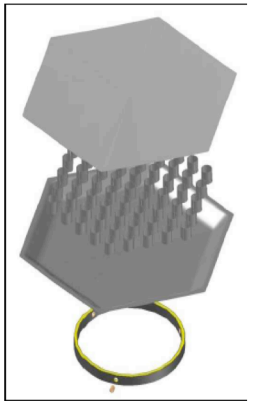


- Sizeable part of costs
- **Challenges**
  - 10,000 m^2 (to be produced in time!)
  - Replica techniques to be proven

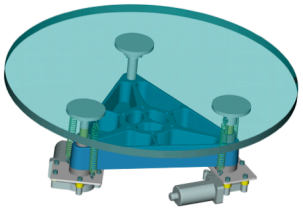
Some proposed technologies…



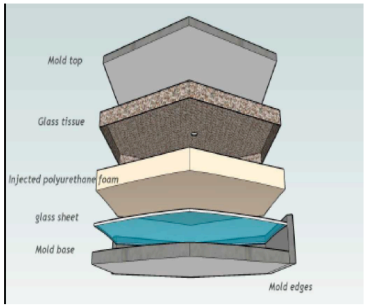
Diamond-milled Aluminum sandwich (MAGIC-I)



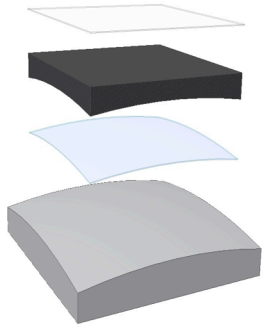
Composites (carbon-fibre epoxy)



Glass mirrors (H.E.S.S.)



Foam glass replica

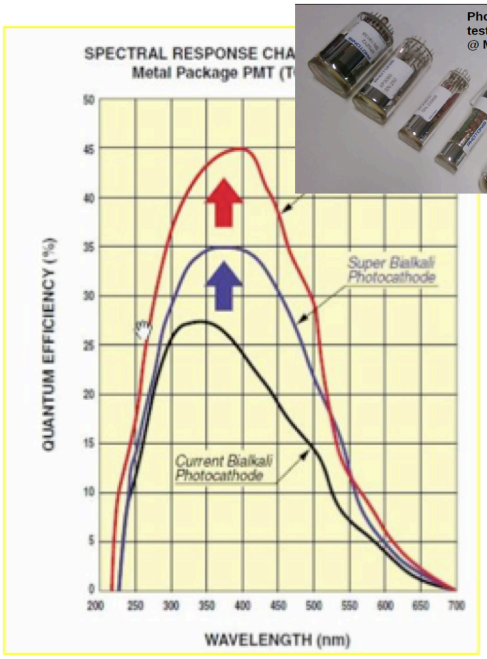


Cold-slumped glass replica (MAGIC II)

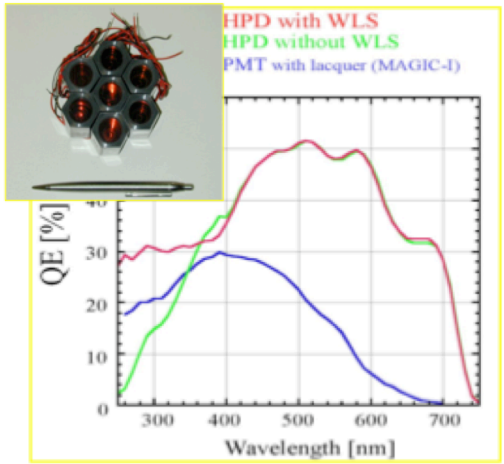
Cameras

- Expensive
- Camera composed of 1000-2000 pixels
- Electronic inside the camera
- Keep low weight

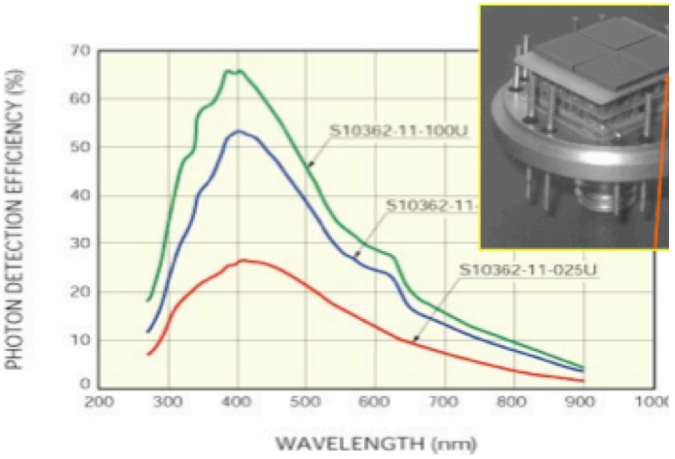
Use of PMTs is baseline design



PMT=40% PDE



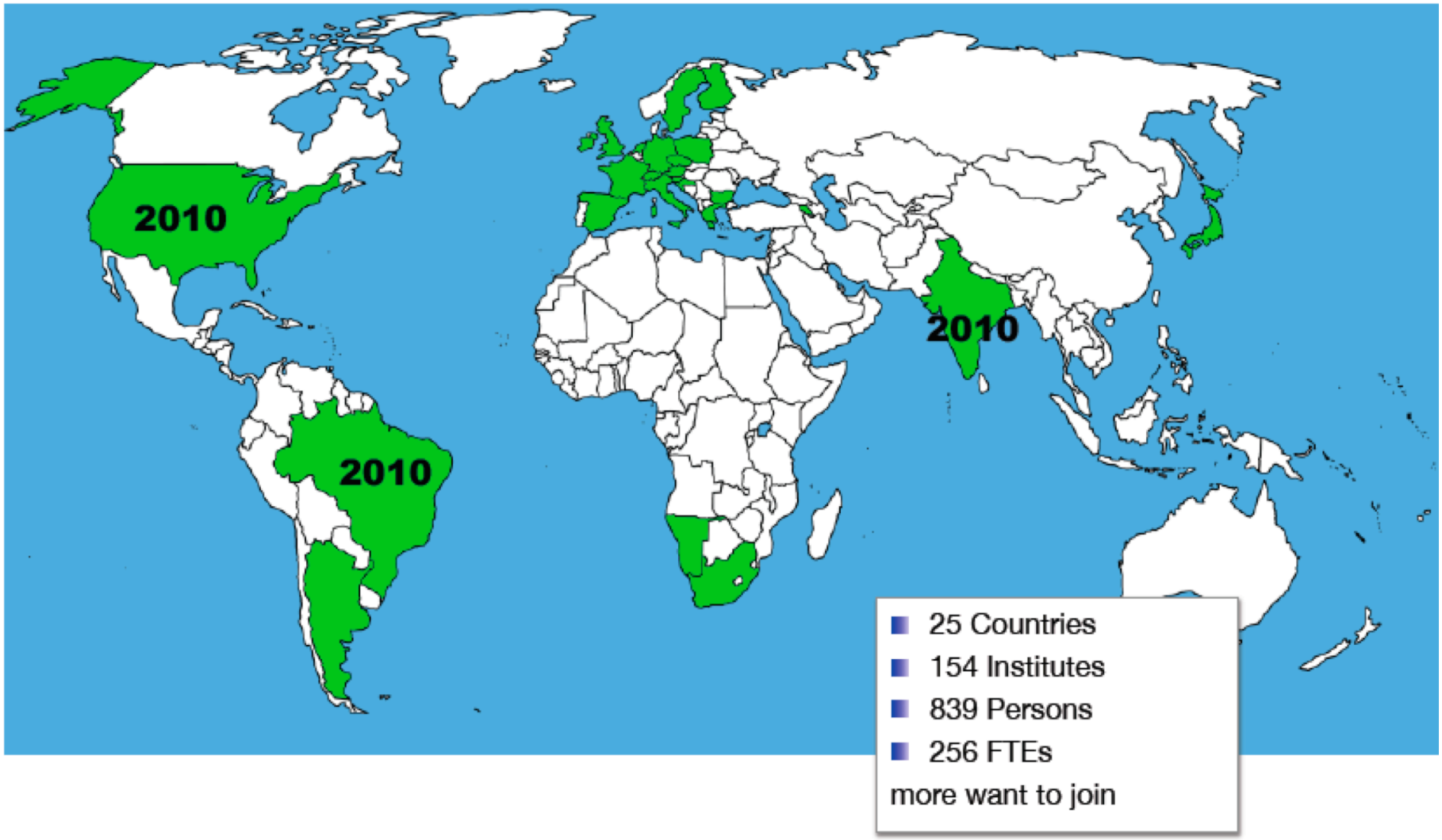
GaAsP HPD
50% PDE



SiPMT
60% PDE

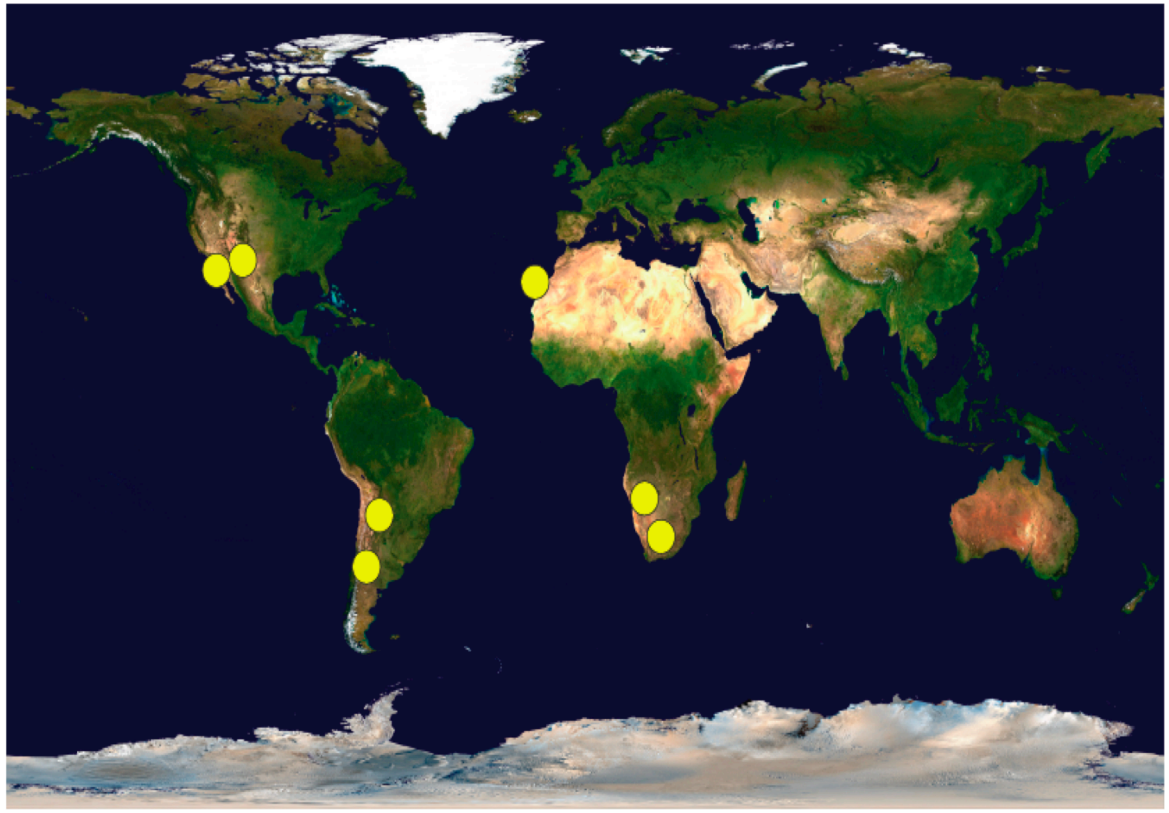
L.A. Antonelli: The CTA Project

Who is in CTA


2010
2010
2010
25 Countries
154 Institutes
839 Persons
256 FTEs
more want to join

CTA sites

One observatory with two sites for all-sky coverage operated by one consortium.



Northern Array (50 ME)

- → complementary to SA for full sky coverage
- → Energy range some 10 GeV .... ~1 TeV
- → Small field of view Mainly extragal. Sources

Southern Array (100 ME)

- → Full energy and sensitivity coverage some 10 GeV .... 100 TeV
- → Angular resolution: 0.02 ... 0.2 deg
- → Large field of view Galactic + Extragal. Sources

Who is supporting CTA

Unambiguously strong European support:

Project listed as priority in roadmaps of

- ASTRONET (Astrophysics)
- ASPERA (Astroparticles)

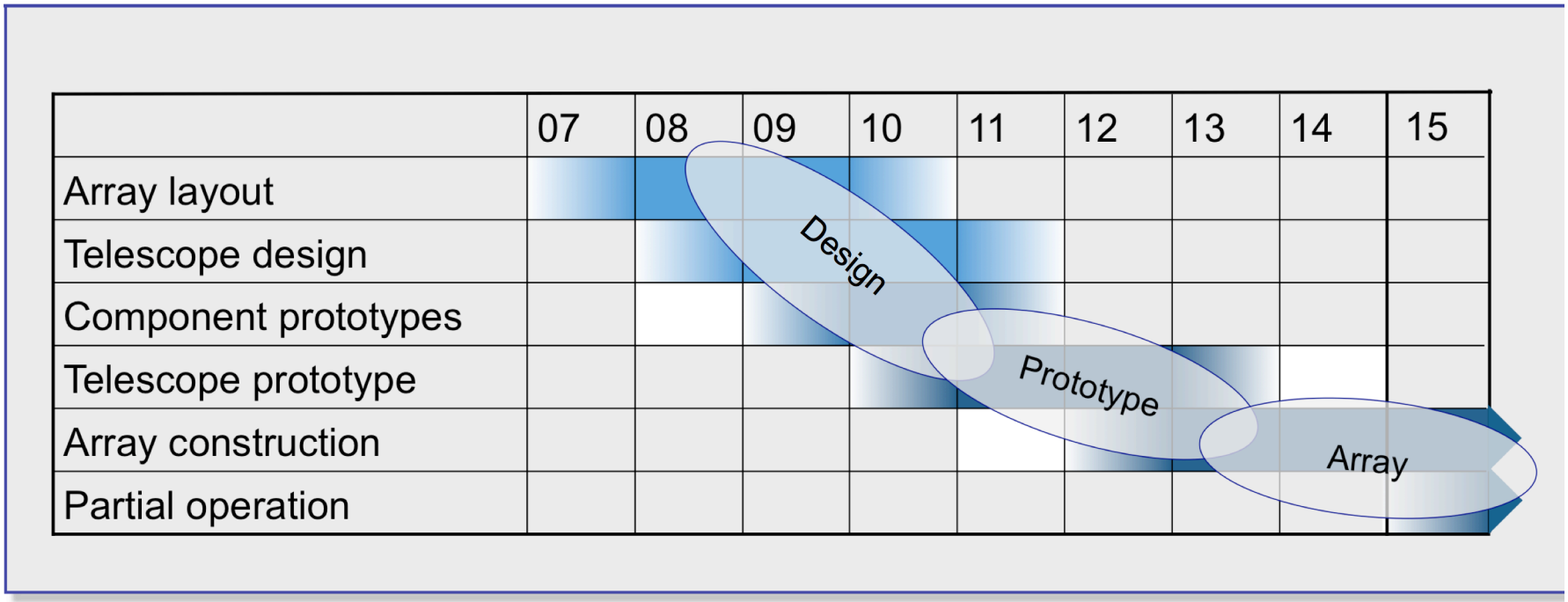
-> Targeted DS Common Call

- ESFRI (European Strategic Forum for Research Infrastructures)

-> FP7 Preparatory Phase approved

CTA Timelines

	07	08	09	10	11	12	13	14	15
Array layout									
Telescope design									
Component prototypes									
Telescope prototype									
Array construction									
Partial operation									

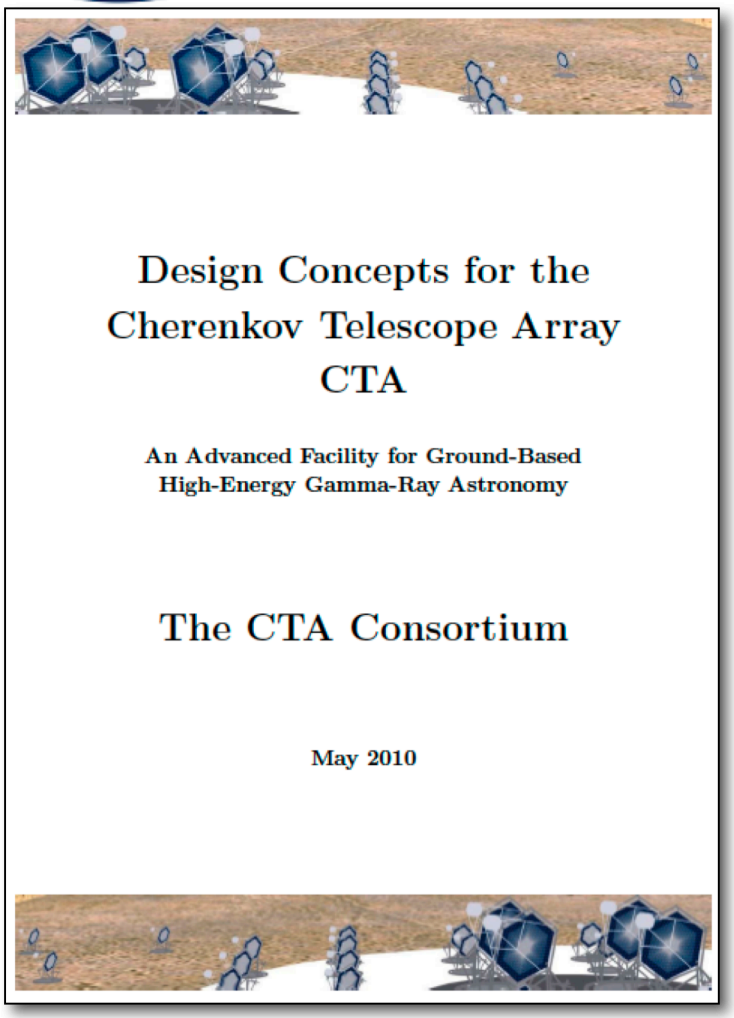


Design Study
2007-2010

Preparatory Phase
2010-2013

Array Construction
2013-2018

From Design Study to Preparatory Phase



arXiv:1008.3703

Thanks!