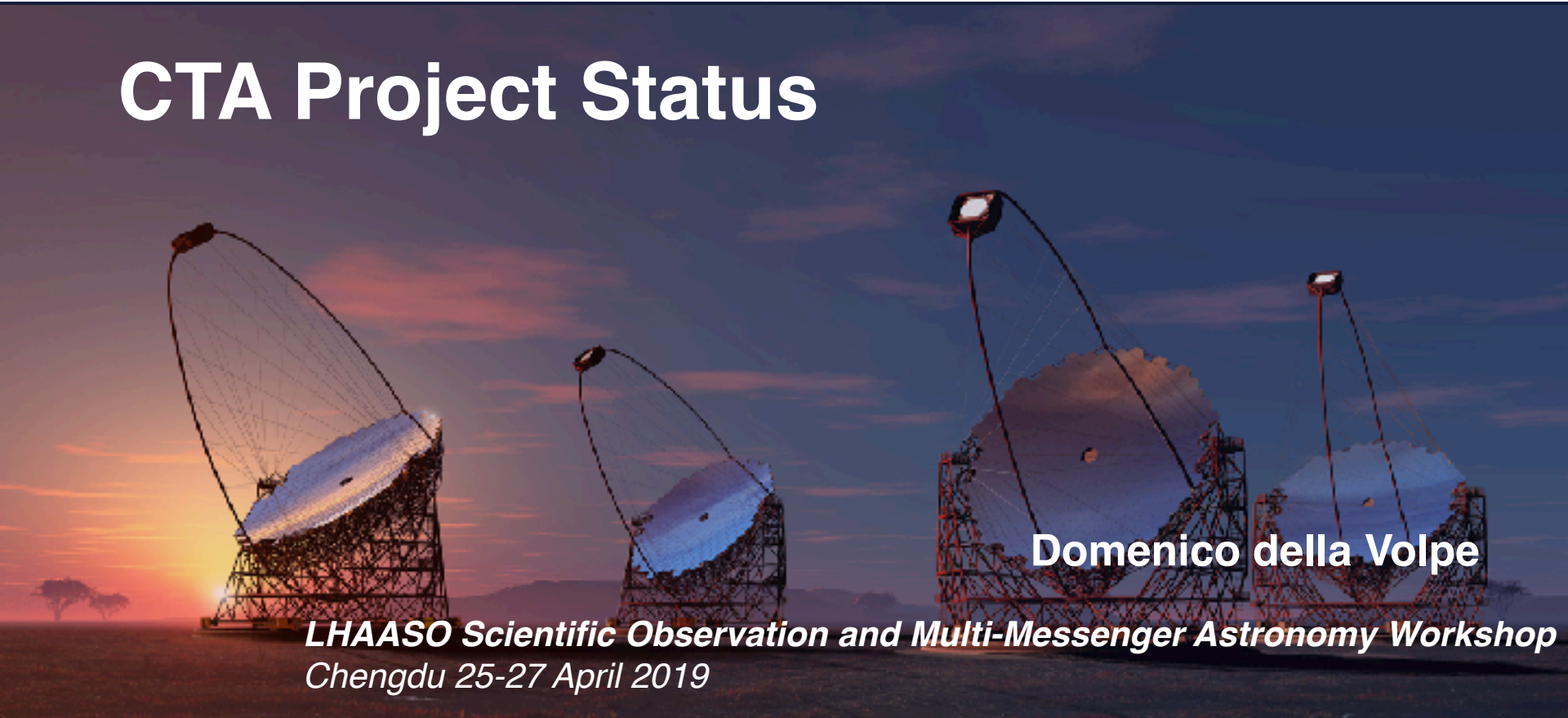
CTA Project Status



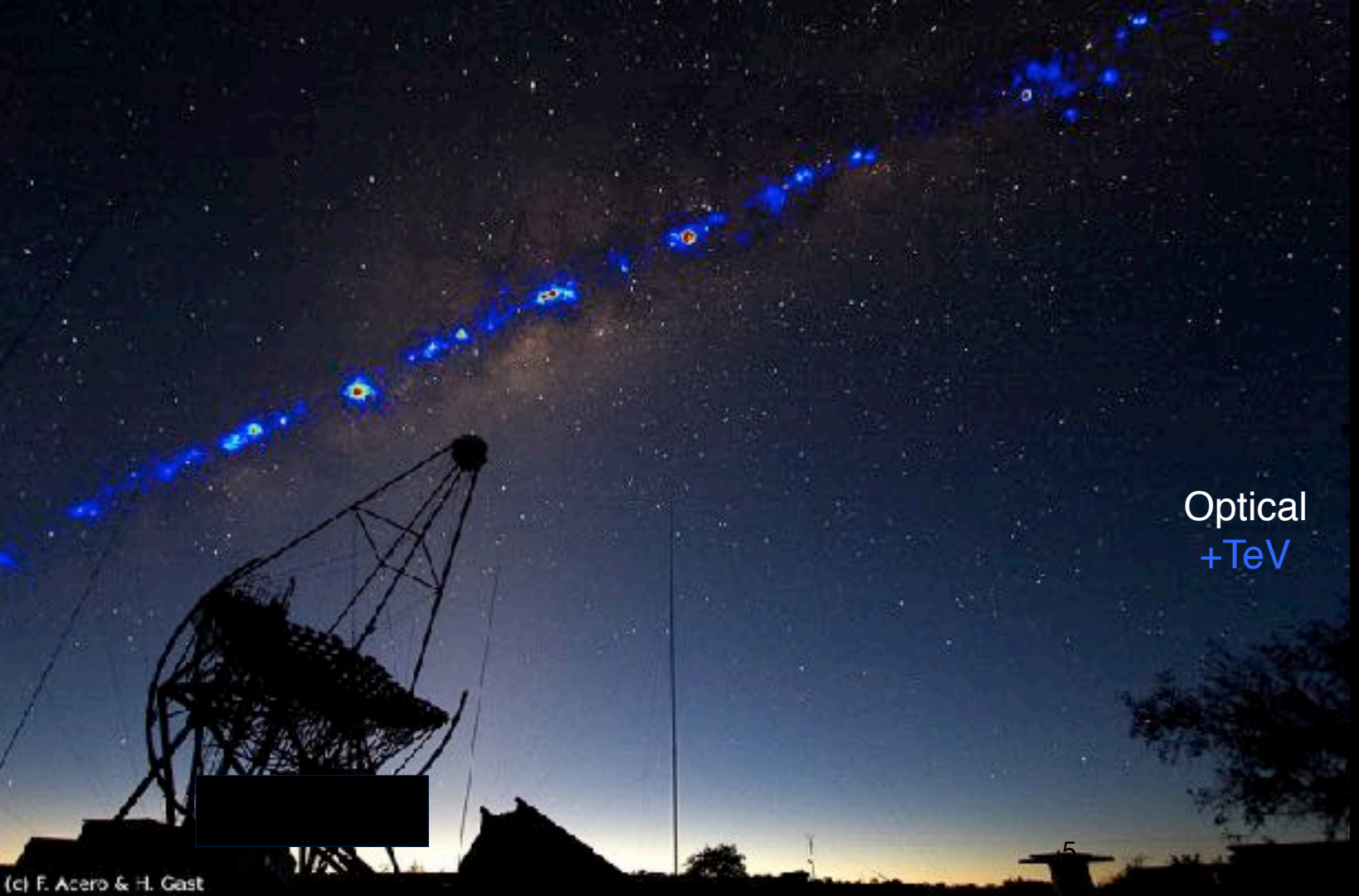
Domenico della Volpe

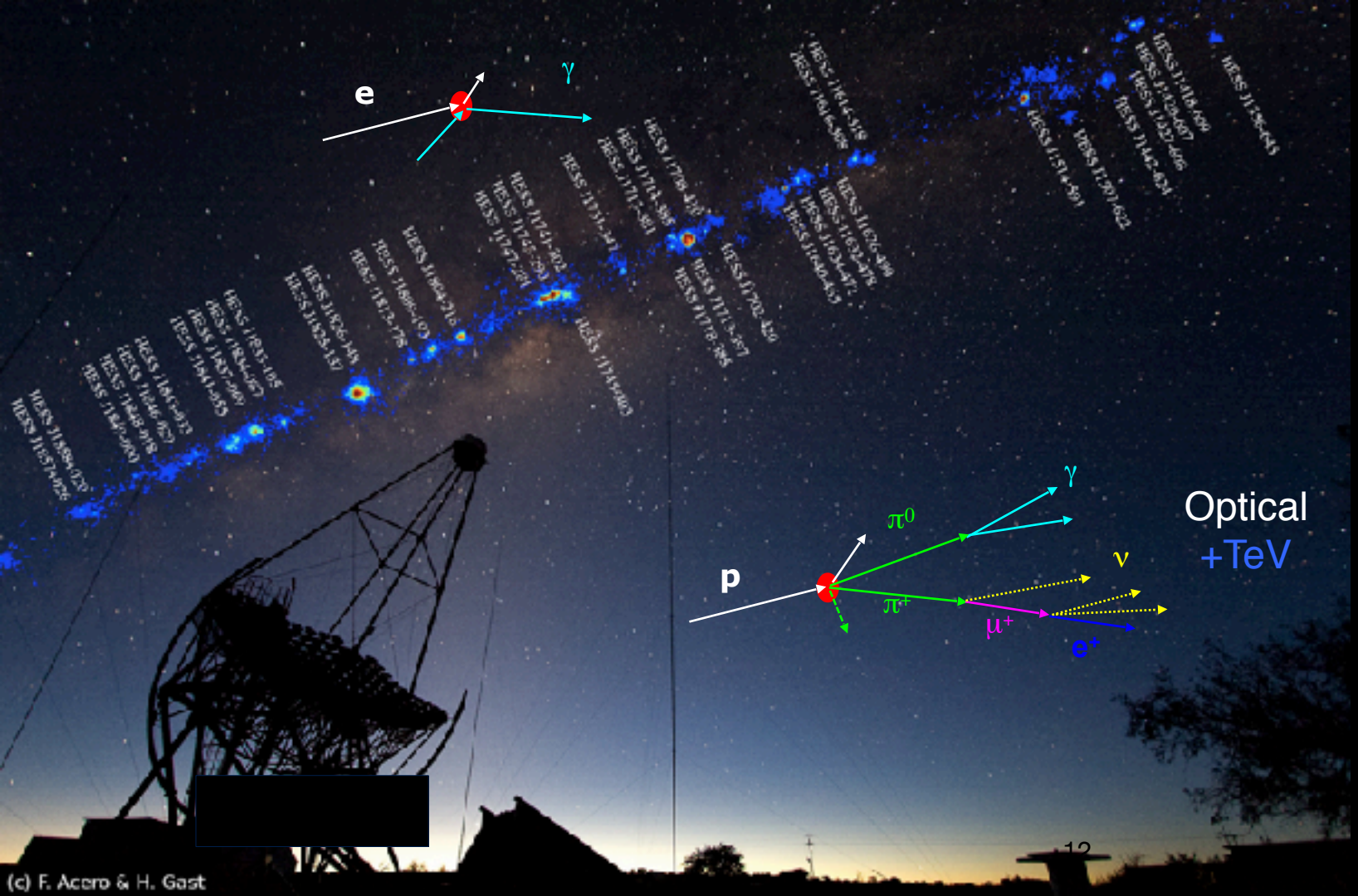
LHAASO Scientific Observation and Multi-Messenger Astronomy Workshop
Chengdu 25-27 April 2019

Why CTA

- CTA, the Cherenkov Telescope Array, is the next generation ground-based instrument for gamma-ray astronomy at very high energies
- It will have up to 118 telescopes on two sites in the North and South
  - Baseline configuration: 19 in the North, 99 in the South
  - Threshold configuration: 9 in the North, 65 in the South
  - Largest existing instrument has 5 telescopes
- It is designed and built in a large international collaboration
- It will be the first open gamma-ray observatory
  - Previous and existing instruments run as experiments

31 Countries
202 Institutes
1451 Scientist


Optical
+TeV
(c) F. Acero & H. Gast


e
γ
p
π0
γ
ν
π+
μ+
e+
Optical
+TeV
(c) F. Acero & H. Gast

CTA KEY TARGETS IN THE UNIVERSE

Active Galactic Nuclei

Galactic Plane

Galaxy Clusters

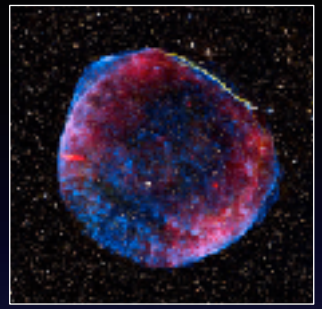
Galactic Centre

Transients

Star Forming Systems

Cosmic Ray PeVatrons

CTA KEY TARGETS IN THE UNIVERSE



Theme 1: Cosmic Particle Acceleration
- How and where are particles accelerated?
- How do they propagate?
- What is their impact on the environment?

Theme 2: Probing Extreme Environments
- Close to neutron stars and black holes
- Relativistic jets, winds and explosions
- Cosmic voids

Theme 3: Physics Frontiers
- What is the nature of Dark Matter?
- Is the speed of light constant?
- Do axion-like particles exist?

Download Full release

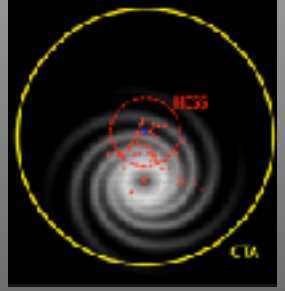
Contents

Sep 2017, 211 page volume, available at

https://arxiv.org/abs/1709.07997
and the CTA web site

Chapters and corresponding authors:

NASA

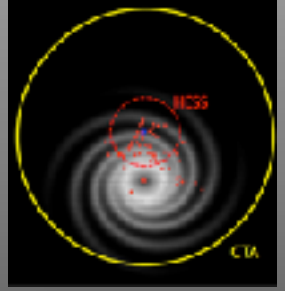


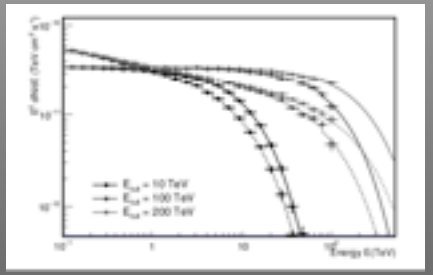
10 x Sensitivity, Large Collection Area

→ all topics

cta
cherenkov telescope array

NASA





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Energies up to 300 TeV

→ Pevatrons

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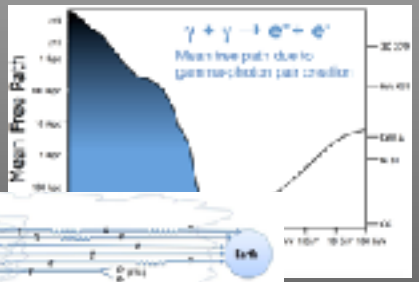

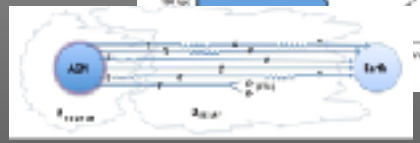

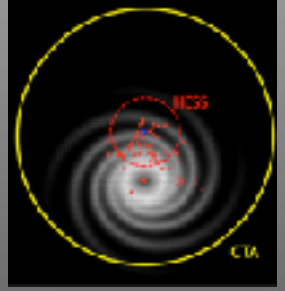

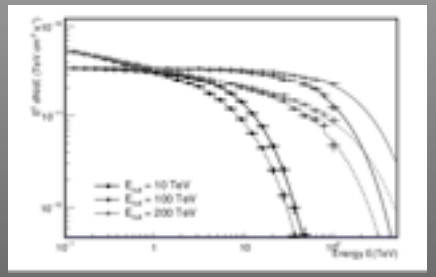

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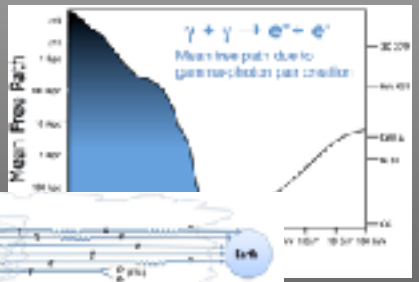

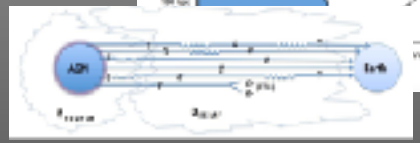

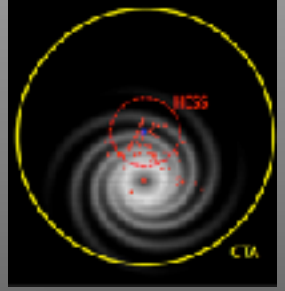

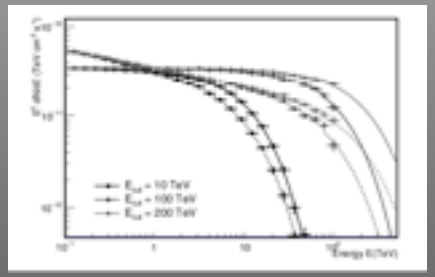

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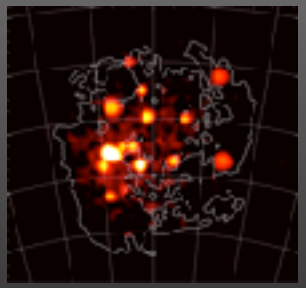


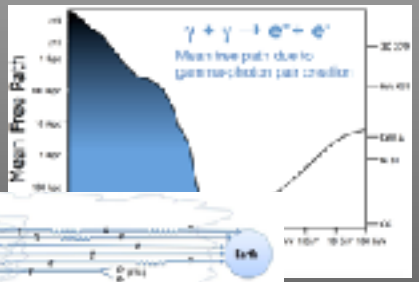
8º Field of View

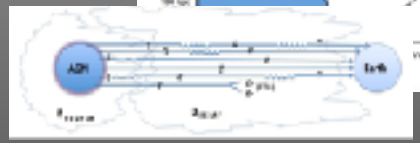
→ surveys, extended objects

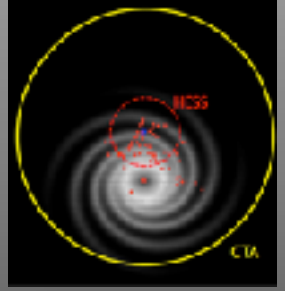
cta

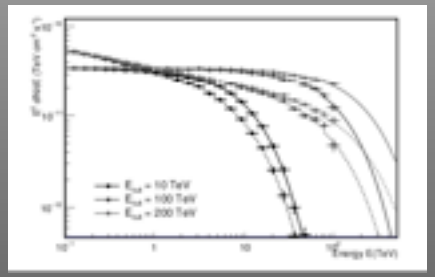
cherenkov telescope array

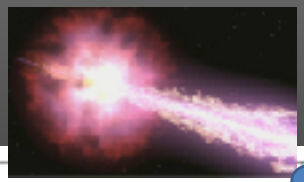
NASA

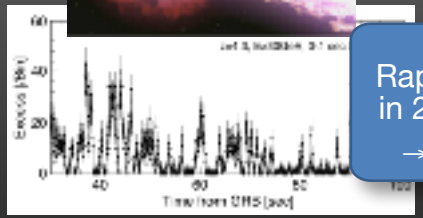












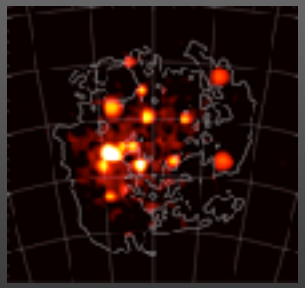
Energies down to 20 GeV
→ Cosmology++

10 x Sensitivity, Large Collection Area
→ all topics

Energies up to 300 TeV
→ Pevatrons

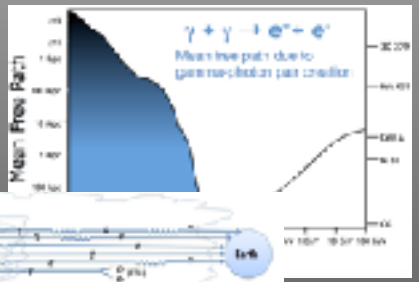
Rapid Slewing in 20 seconds
→ transients

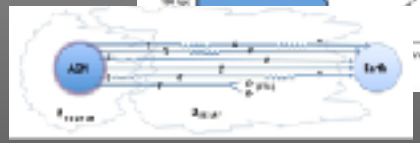
8º Field of View
→ surveys, extended objects

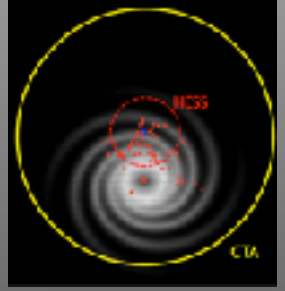


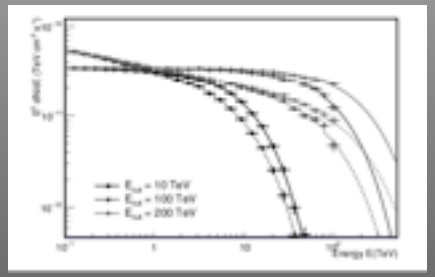
cta
cherenkov telescope array

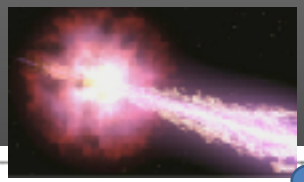
NASA

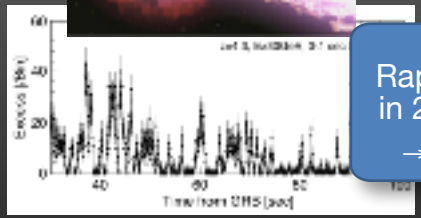


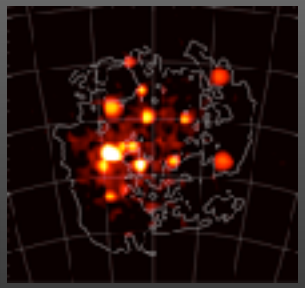


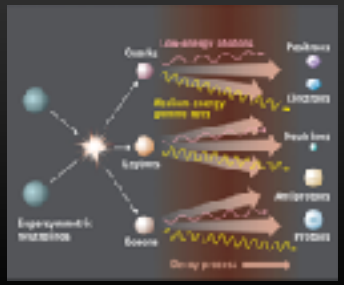












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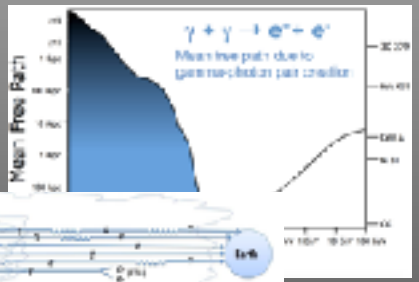
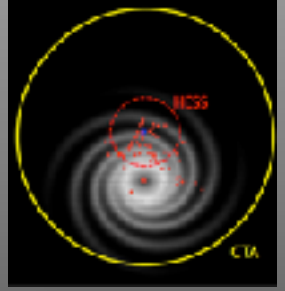
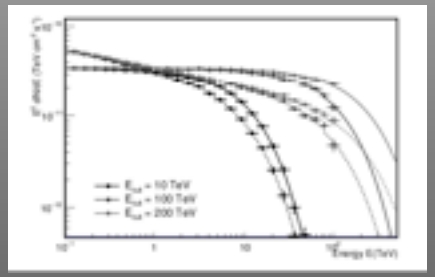
10% Energy Resolution
→ lines, features

cta
cherenkov telescope array







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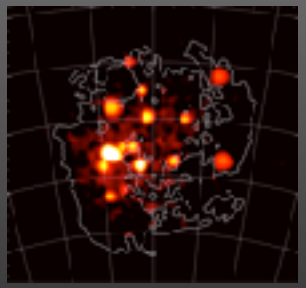

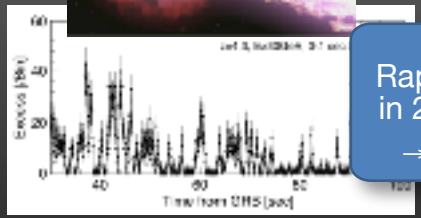

Rapid Slewing in 20 seconds
→ transients

8º Field of View
→ surveys, extended objects

cta
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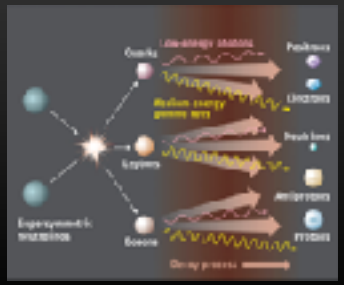
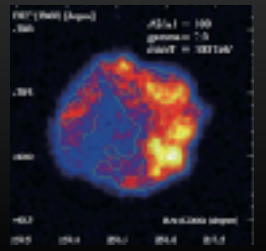


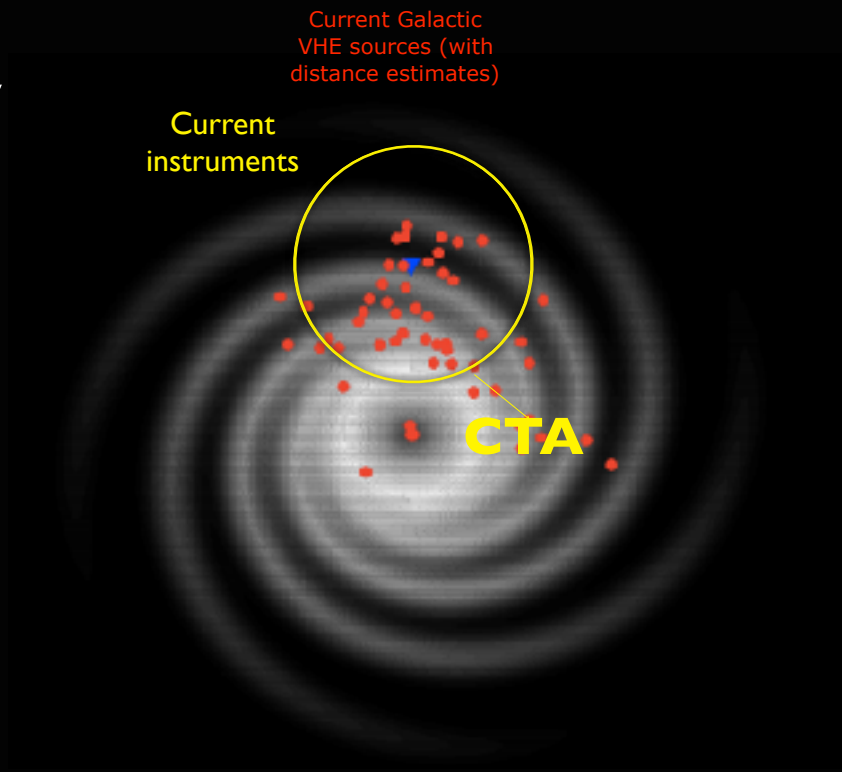
10% Energy Resolution
→ lines, features

Few ‘ Angular Resolution
→ morphology



Large Field of View + Sensitivity

- ***CTA can see the whole galaxy***
  - Galactic Plane survey~ 300 × HESS



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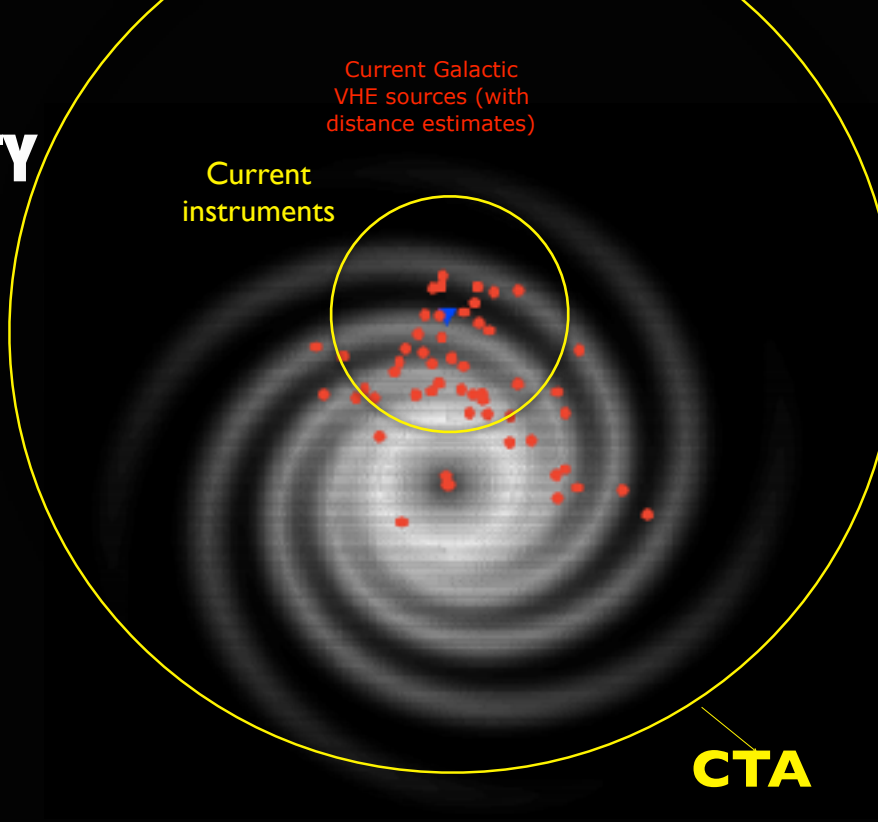

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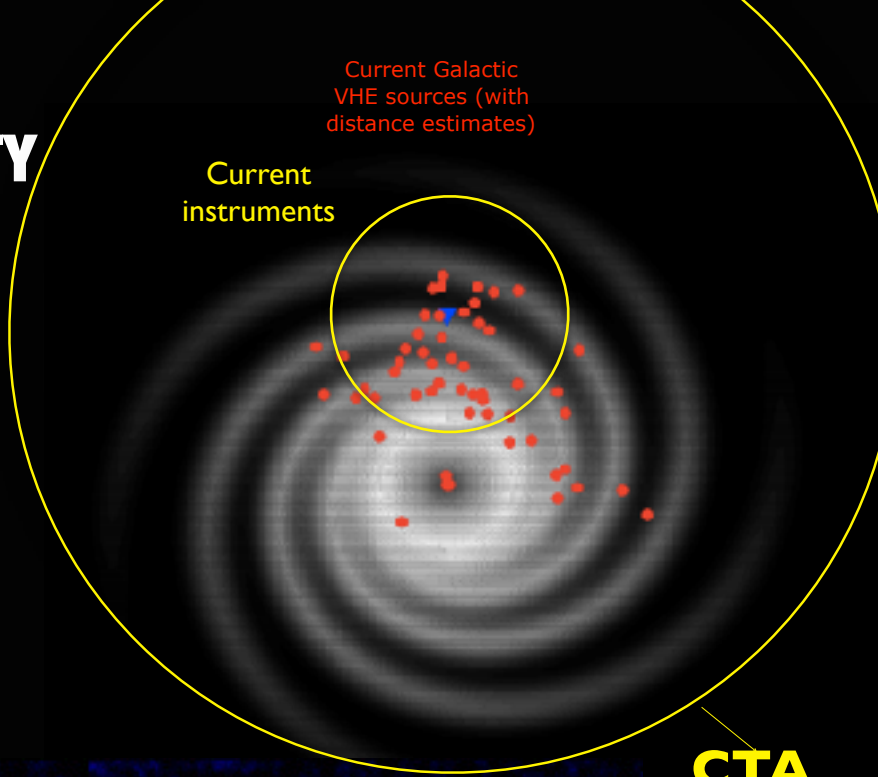
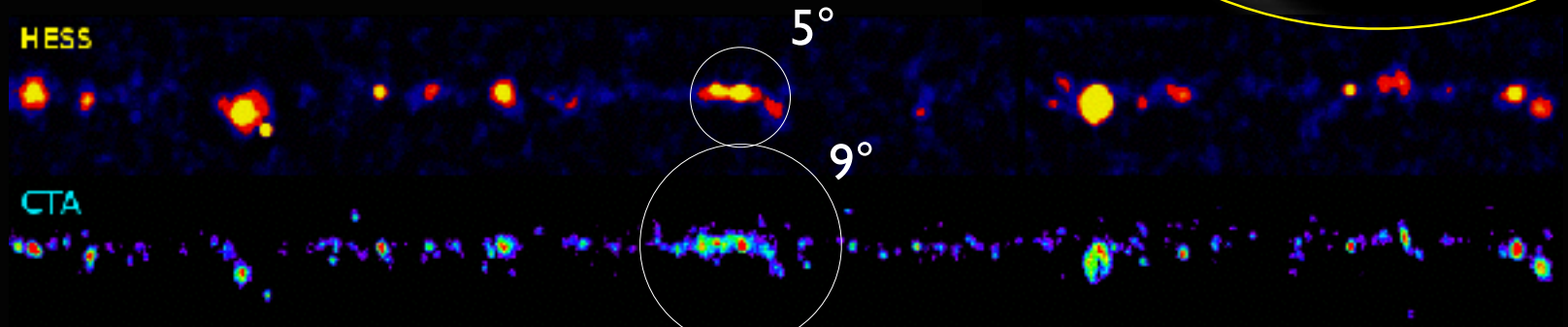
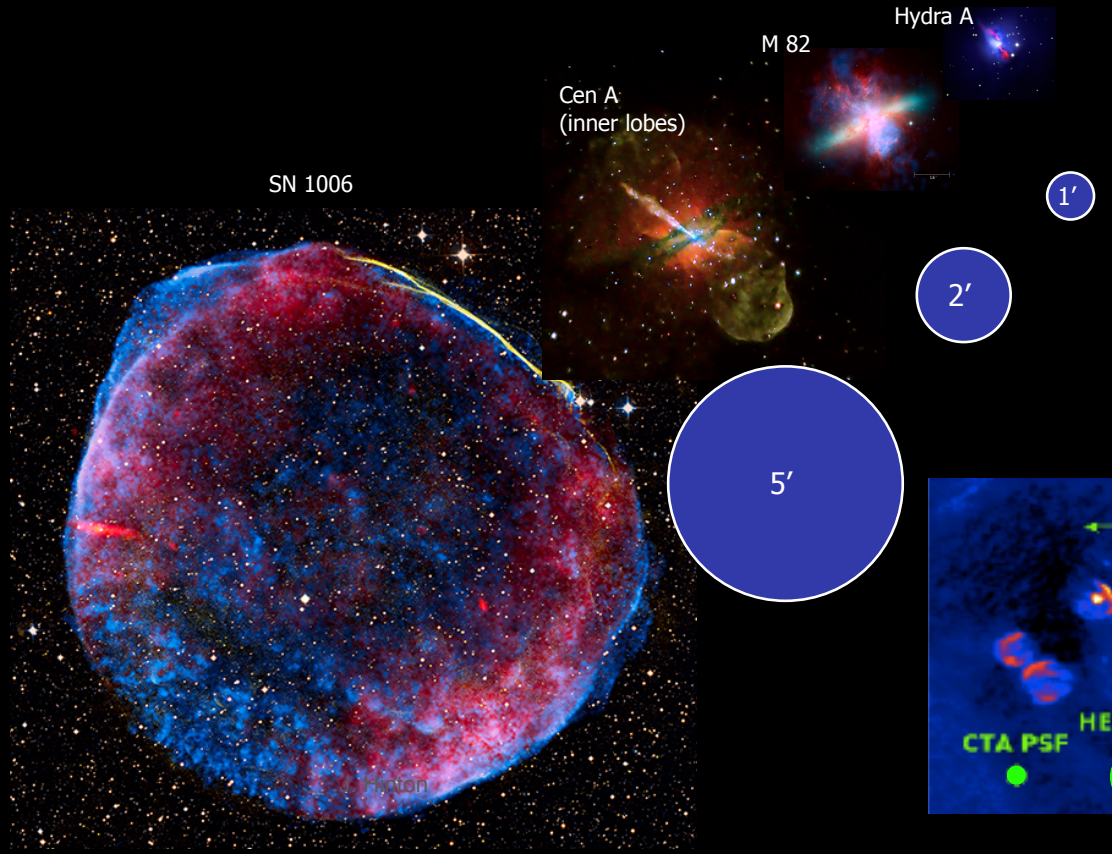
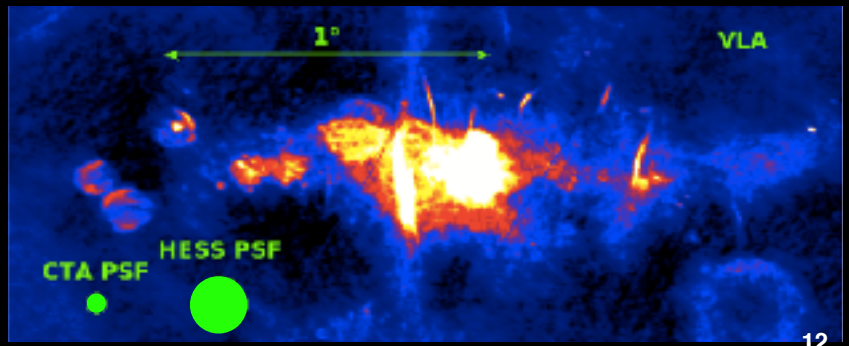




Improved angular Resolution





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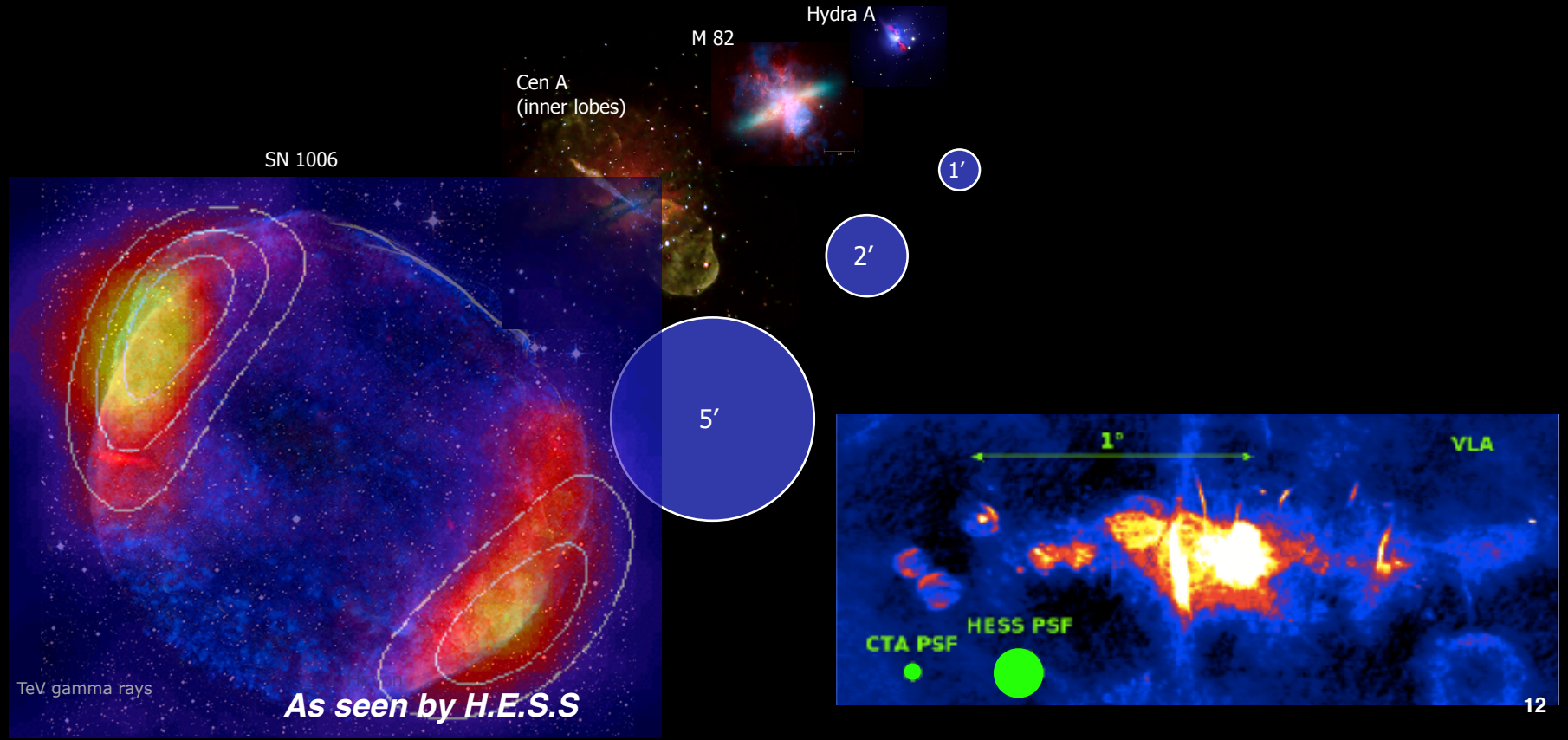

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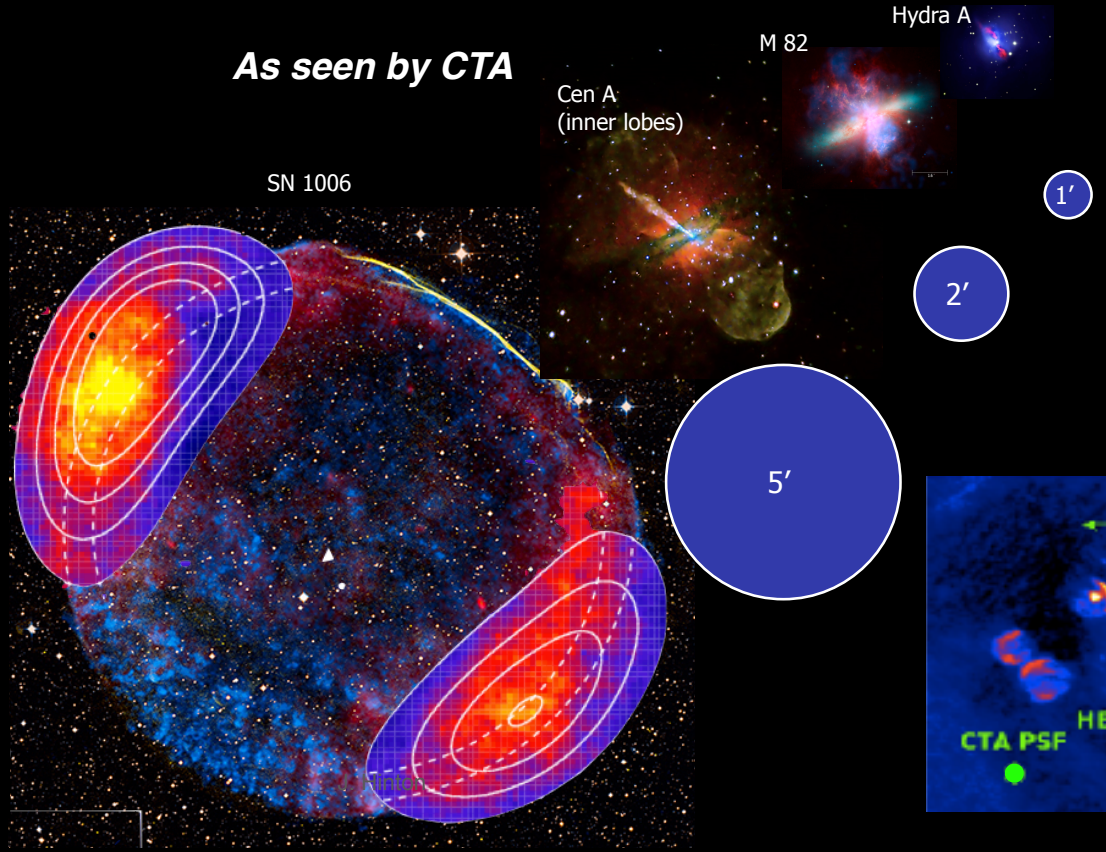
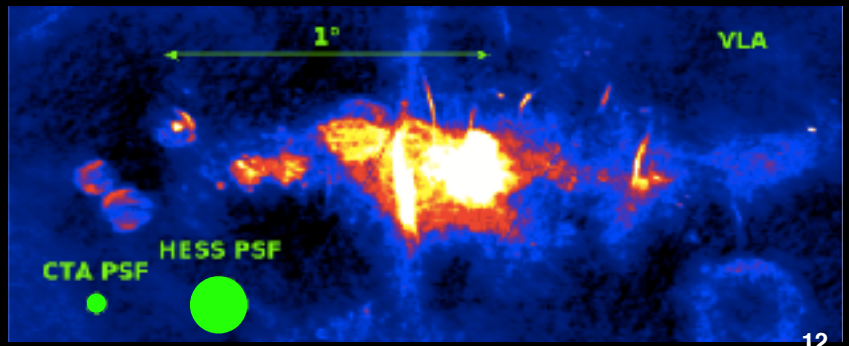
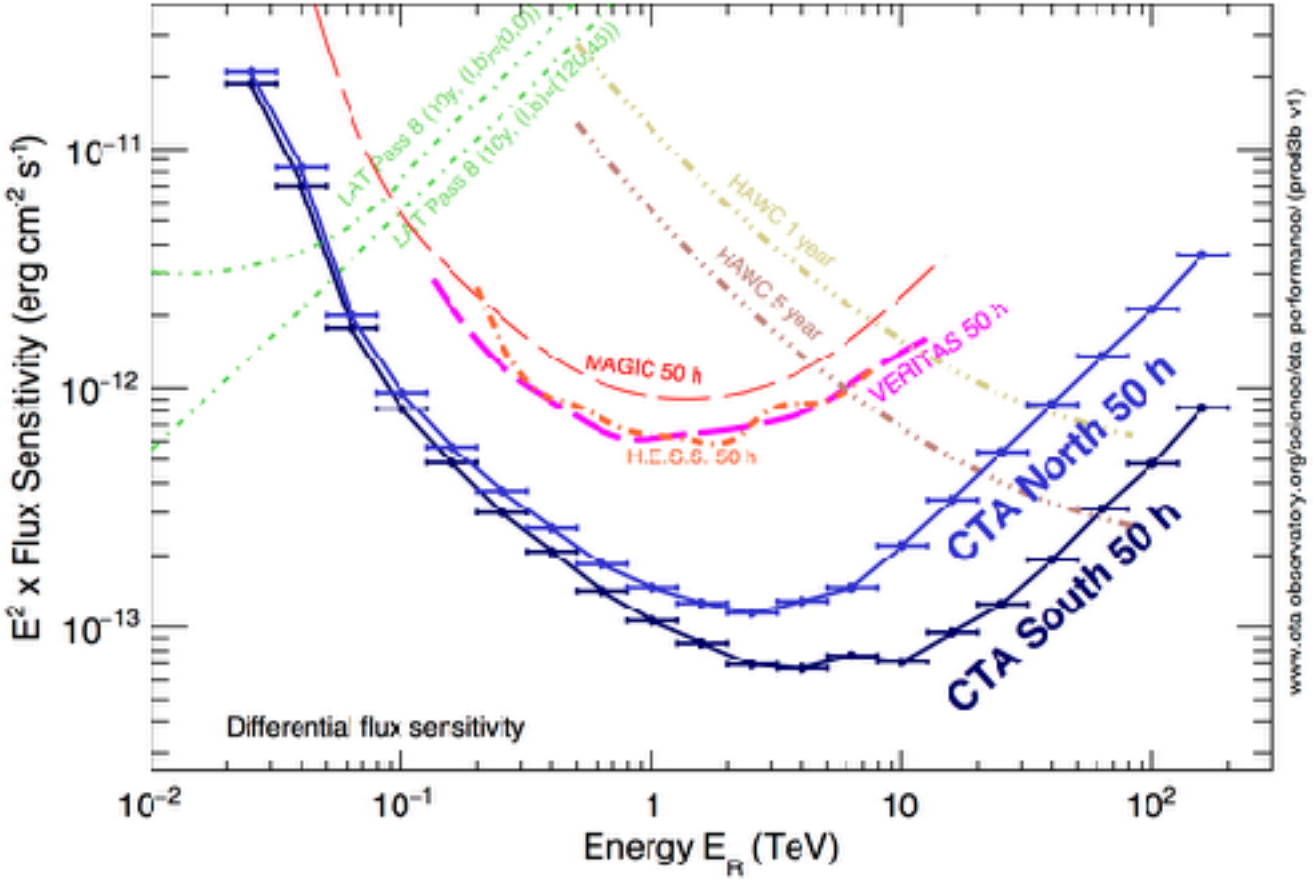




CTA Performances

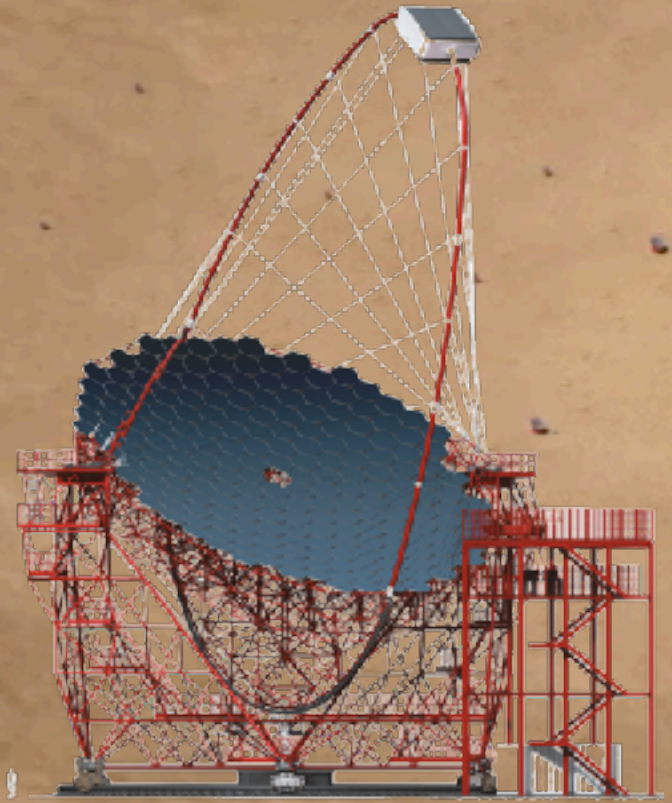



10 GeV
100 GeV
1 TeV
10 TeV
100 TeV
1000 γ/h·km²
10 γ/h·km²
0.1 γ/h·km²
Layout optimized using detailed simulations – tens of millions CPU-h
Southern array of Cherenkov telescopes - about 3 km across

10 GeV	100 GeV	1 TeV	10 TeV	100 TeV

1000 γ/h·km² *10 γ/h·km²* *0.1 γ/h·km²*

4S + 4 N: 23 m ∅ Large Size Telescopes (LST)

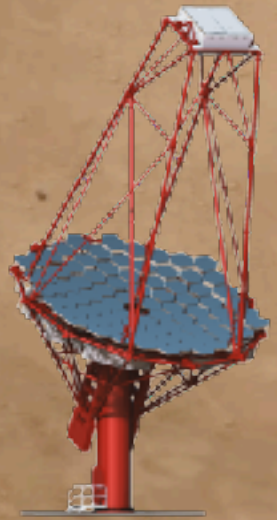


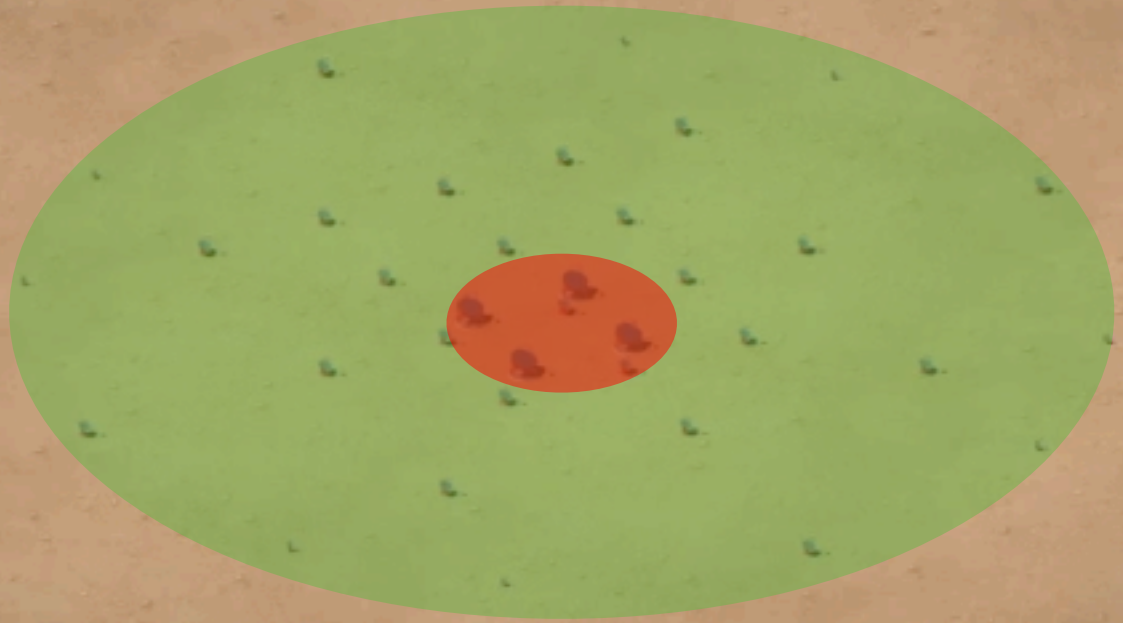
Southern array
of Cherenkov telescopes
- about 3 km across

10 GeV	100 GeV	1 TeV	10 TeV	100 TeV

1000 γ/h·km² *10 γ/h·km²* *0.1 γ/h·km²*

25 S + 15 N: 12 m ∅ Medium Size Telescopes (MST)



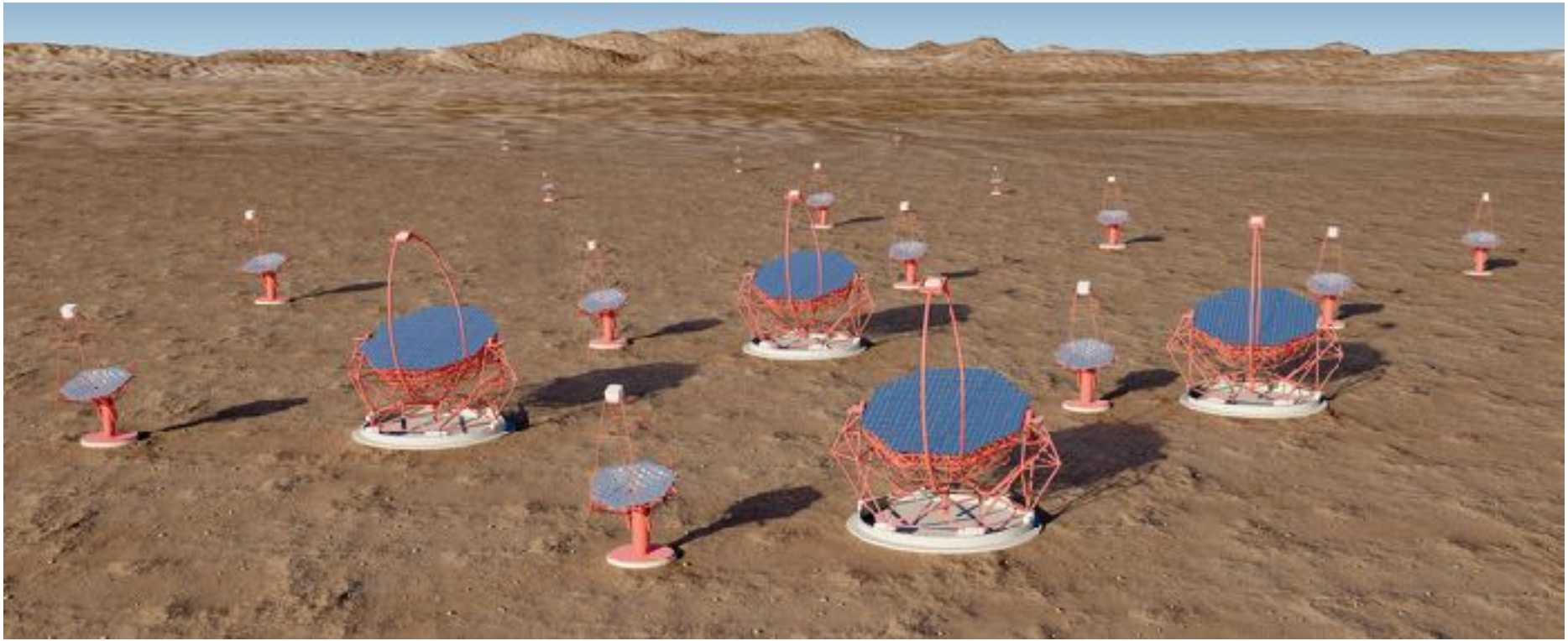


Southern array
of Cherenkov telescopes
- about 3 km across


10 GeV
100 GeV
1 TeV
10 TeV
100 TeV
1000 γ/h·km²
0.1 γ/h·km²
70 S: 4 m ∅ Small Size Telescopes (SST)
Southern array
of Cherenkov telescopes
- about 3 km across

CTA-South Site, ESO (Chile)

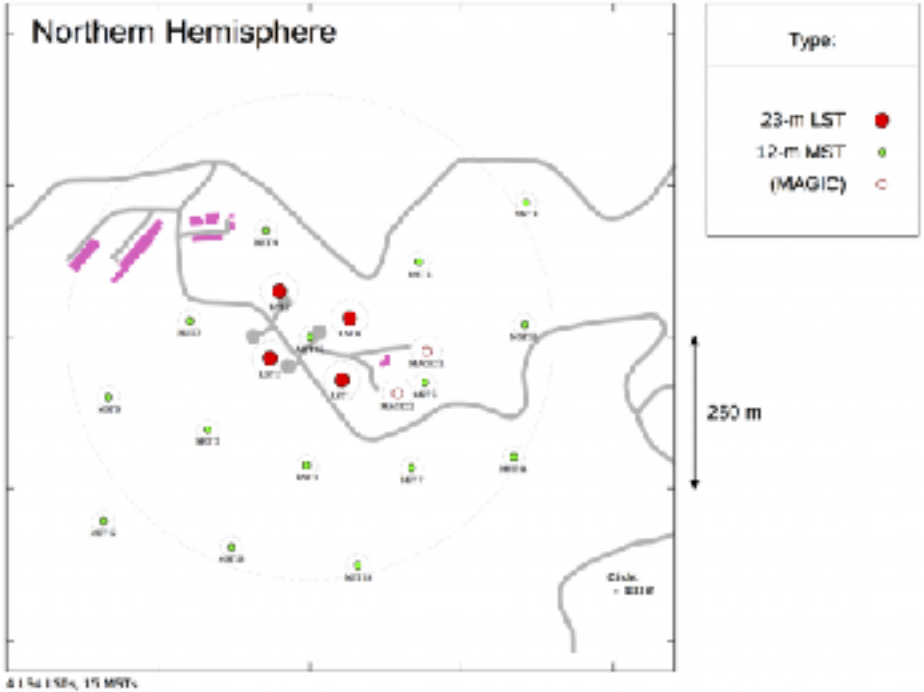
Rendering Atacama

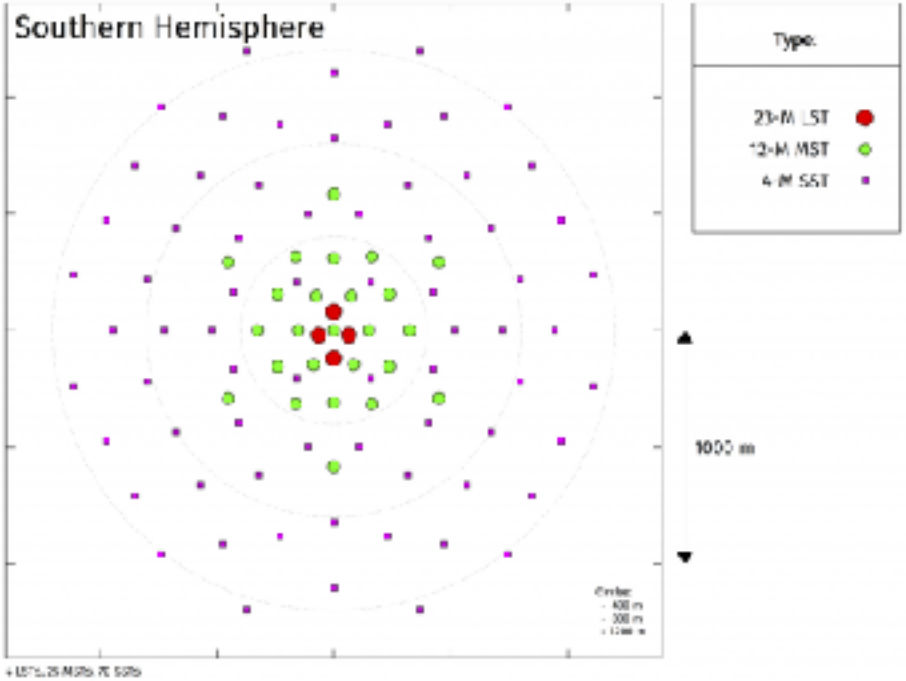


CTA-North Site (La Palma, Spain)

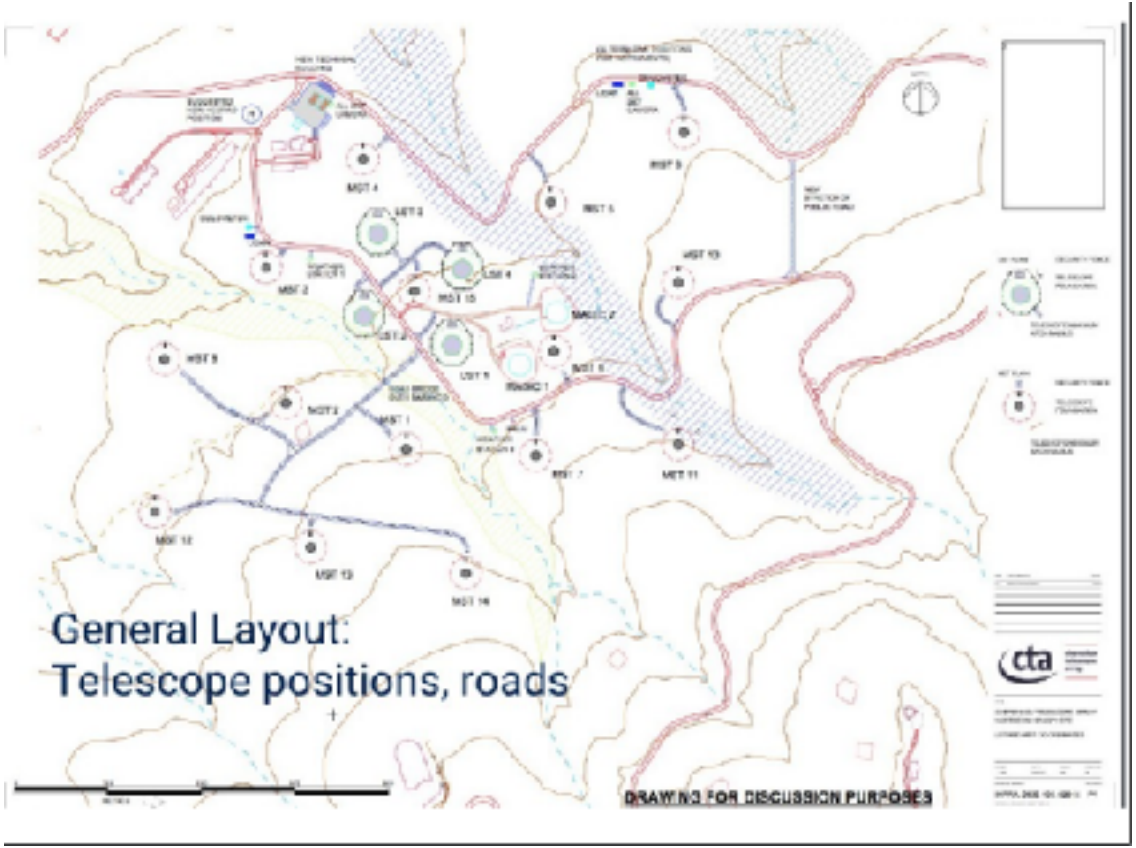
Observatorio Roque de los Muchachos,
IAC, La Palma, Canary Islands (Spain)

CTA Layout


Northern Hemisphere
Type:
23-m LST
12-m MST
(MAGIC)
250 m


Southern Hemisphere
Type:
1000 m

CTA-North Site (La Palma, Spain)



CTA technology – one page summary

Imaging of very faint nano-second long blue light (Cherenkov) flashes requires:

- Three telescope diameters to cover the CTA energy range from 20 GeV to 300 TeV
  - Large-Sized (23m), Medium-Sized (12m) and Small-Sized (4m) Telescopes
- Very sensitive cameras with many pixels (~10^3), using both photomultiplier tubes (PMTs) and silicon photomultipliers (SiPMs)
- Accurate timing & clock over the whole array
- Challenging calibration techniques and algorithms
  - Earth atmosphere is part of the detector !
- Substantial software development, “Big Data”
  - Expect 3.7 PB (reduced) raw data volume and ~4 PB of data products per year

CTA as an observatory

- A Guest Observer Facility
  - For the **first time** in this waveband
    - Existing instruments are run as experiments
  - Annual cycles, Time Allocation Committee (TAC) ranking, long-term schedule
  - Proposal preparation support, tracking, helpdesk +
  - Public science data archive
    - After proprietary period
- Two Telescope Arrays – one Observatory
  - Inter-site coordination
  - Uniform approach to science operations

Key science projects

Key Science Projects

- Ensure that important science questions for CTA are addressed in a coherent fashion and with a well-defined strategy,
- Conceived to provide legacy data sets for the entire community

Example: galactic and extragalactic surveys

- Deep investigation of known sources
- Follow-up of KSP discovered sources
- Multiwavelength campaigns
- Follow-up of ToOs
- Search for new sources
- …

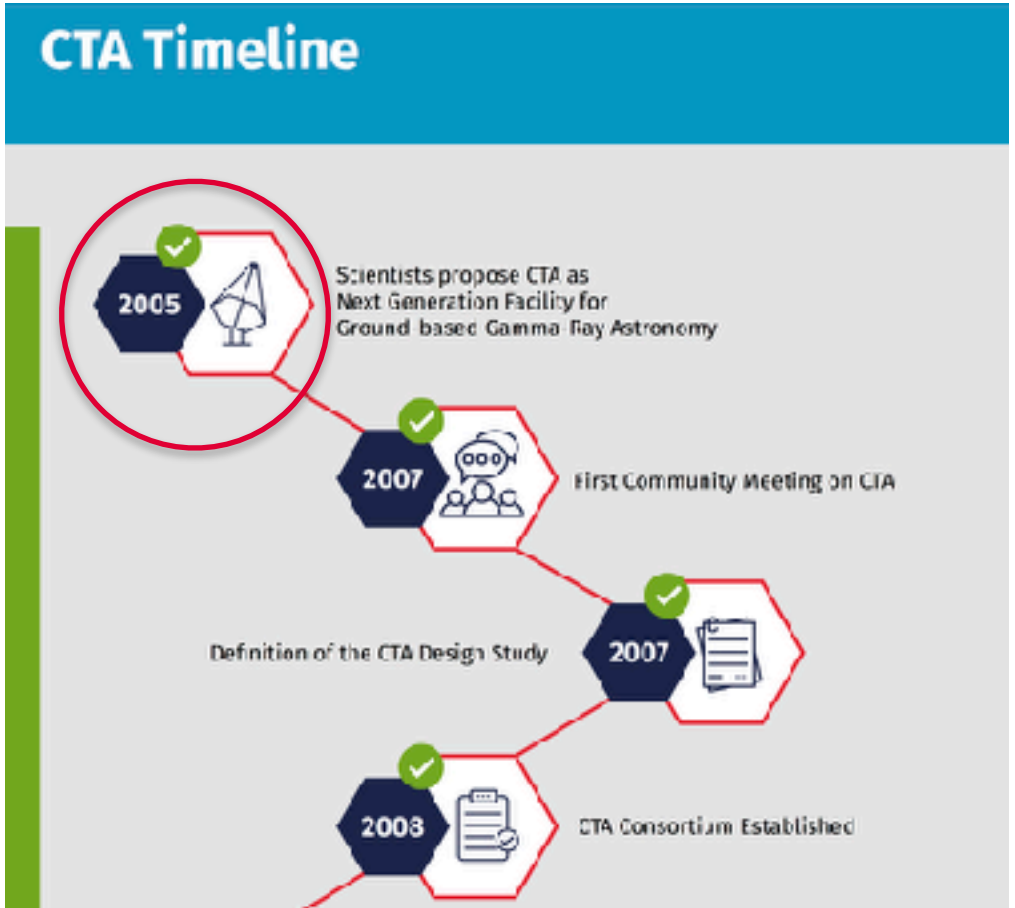
Proposal-Driven User Programme

The CTA Observatory (CTAO)

- In 2014, the CTA Observatory gGmbH was founded as interim legal entity, under German law
  - To prepare the CTA implementation (select and prepare two array sites + Science Data Management Centre)
- The final legal entity for full construction and then operation, a European Research Infrastructure Consortium (ERIC), is being set up under European Union law
- During 2017 the CTA Project Office moved to Bologna (Italy) and is still growing
- The Science Data Management Centre (SDMC) will be built up at DESY in Berlin-Zeuthen (Germany), in a new building

CTA TImeline

- 2005
  - Scientists proposes CTA
- 2008
  - Consortium established
  - CTA Included in the ESFRI Roadmap
- 2010-2014
  - Preparatory phase under a EU FP7 Project
- 2012
  - Funding Agencies sign a declaration of Intent
- 2016
  - North-site agreement signed
- 2018
  - CTA Become a LANDMARK of ESFRI
  - LST1
- 2025
  - End of construction



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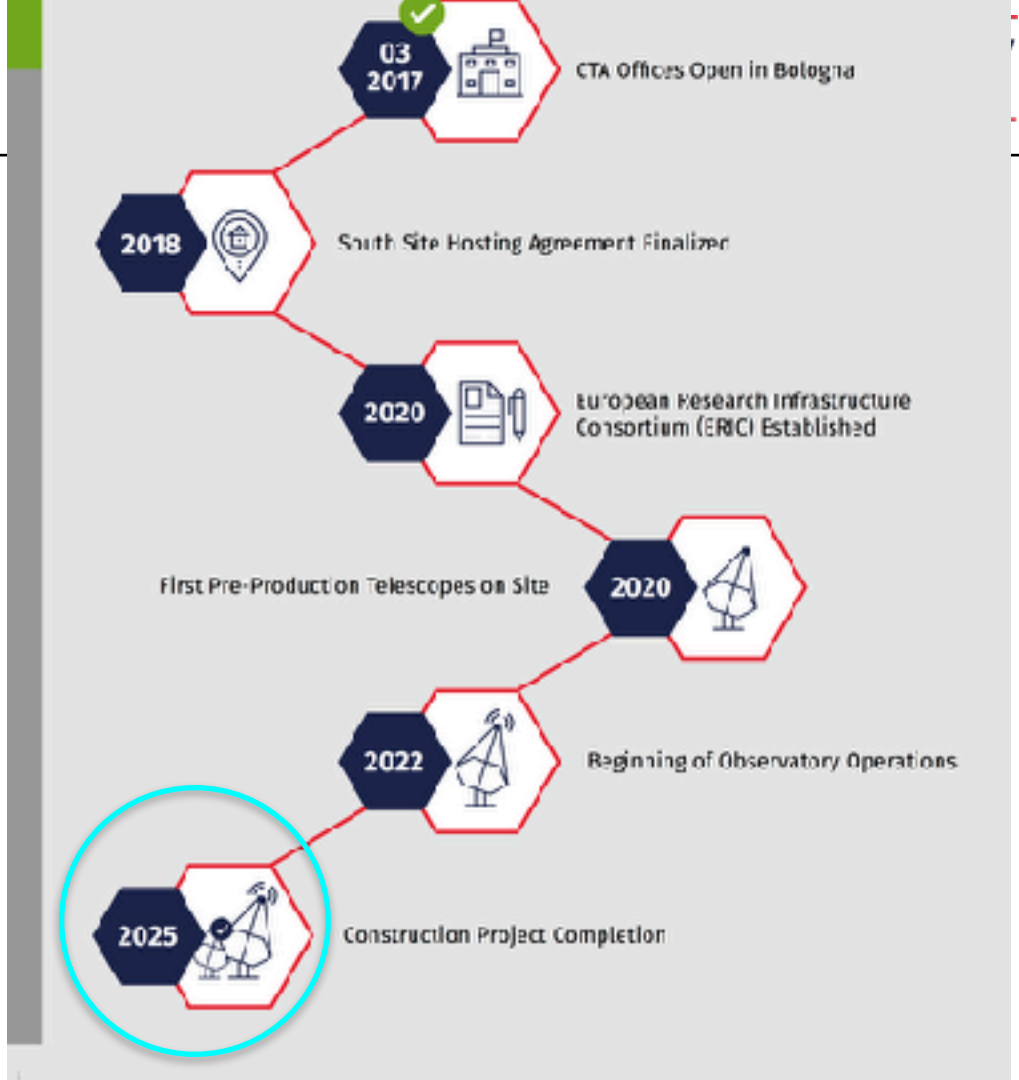
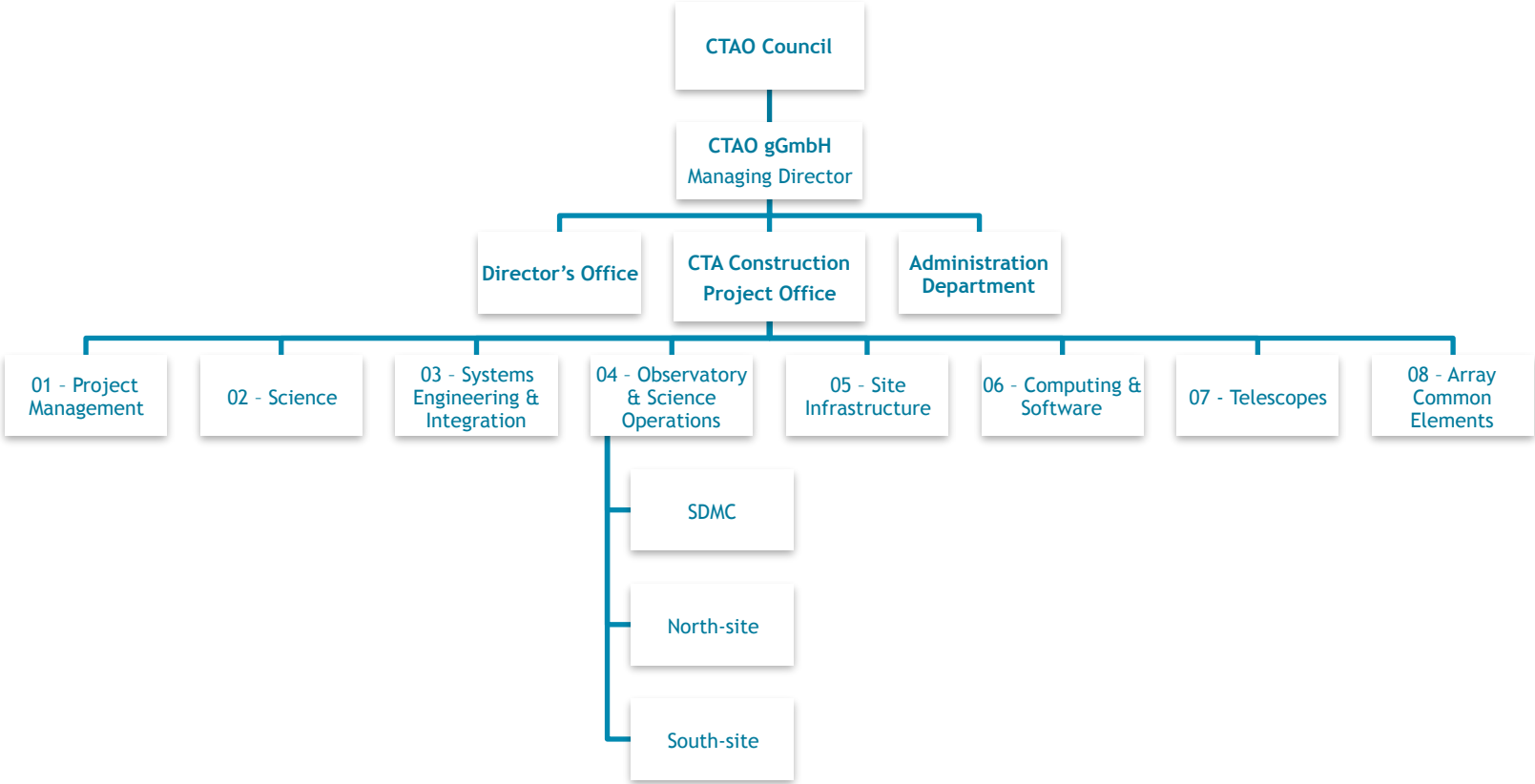


CTAO Organisational Chart



CTA construction status

- CTA design and prototyping
  - Multiple prototypes for telescope structures and cameras existing
  - System design being worked out
- CTA-North Site (La Palma, Spain)
  - LST1 completed – first light
  - Infrastructure phase 1: detailed design in progress, preparing Call for Tenders
- CTA-South Site (Chile)
  - Geotechnical study completed in 2017
  - Finalized negotiations of ESO - Chile - CONICYT - CTAO for hosting agreement
  - Will start with site infrastructure asap

Conclusions

- CTA planned as a major new international user facility
- Two array sites selected, North site being equipped, CTA HQ in Bologna, Science Data Management Centre in Berlin
- Currently in pre-construction phase, ramping up for construction
- CTA is a fascinating project with many challenges ahead – but also a lot of fun !
- We will address all of these challenges – with all the available expertise in CTA and existing and additional staff in the Project Office
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