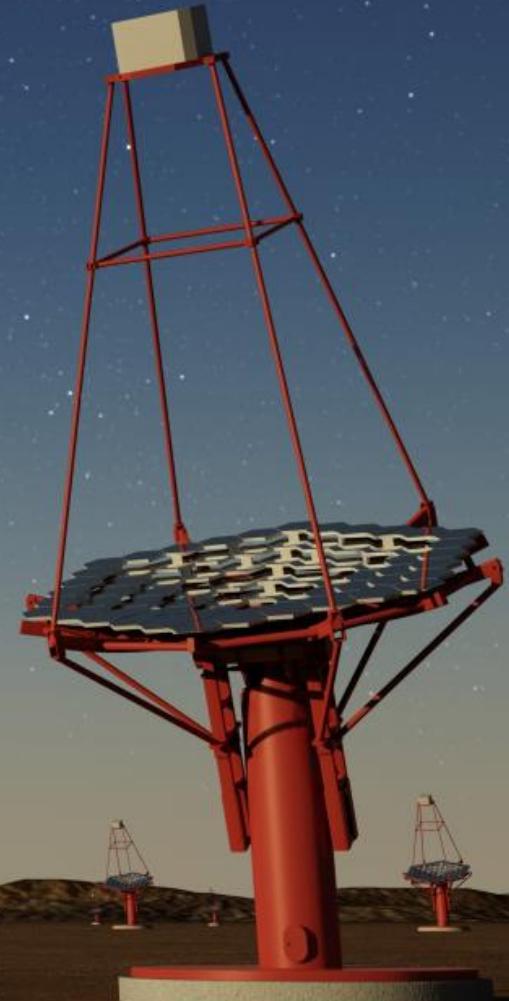


# Cherenkov Telescope Array (CTA)

## Project Status

The CTA Consortium<sup>†</sup>

represented by **Elisabetta Bissaldi\***



<sup>†</sup> see [http://www.cta-observatory.org/consortium\\_authors/authors\\_2019\\_03.html](http://www.cta-observatory.org/consortium_authors/authors_2019_03.html) for full author list

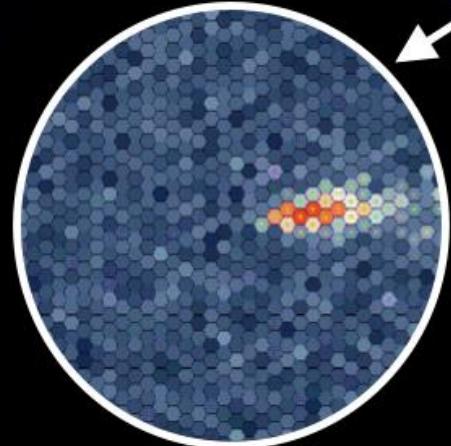
\*Politecnico & INFN Bari – [elisabetta.bissaldi@ba.infn.it](mailto:elisabetta.bissaldi@ba.infn.it)

$\gamma$ -ray enters the atmosphere

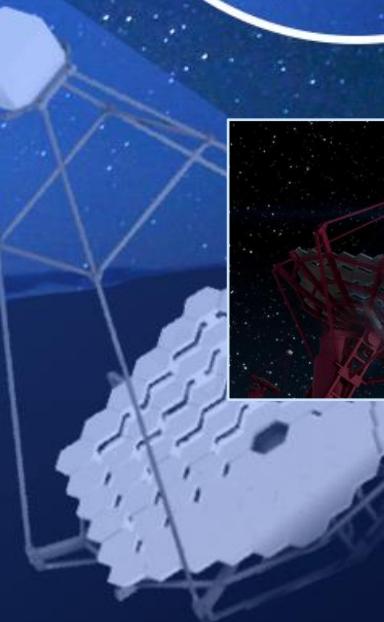
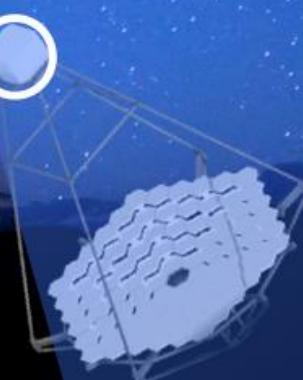
Electromagnetic cascade

Primary  $\gamma$

## Imaging Air Cherenkov Telescopes (IACTs)



10 nanosecond snapshot



0.1 km<sup>2</sup> "light pool", a few photons per m<sup>2</sup>.

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

# Currently operating major IACT systems



# Towards the next generation of IACTs

## The Cherenkov Telescope Array (CTA)

### 1420 members

from 200 institutes in 31 countries

Chair, CTA Council: Gabriel Chardin

Vice-Chair, CTA Council: Markus Schleier

Managing Director, CTAO gGmbH: Federico Ferrini

Spokesperson: Werner Hofmann

Co-Spokesperson: Rene Ong

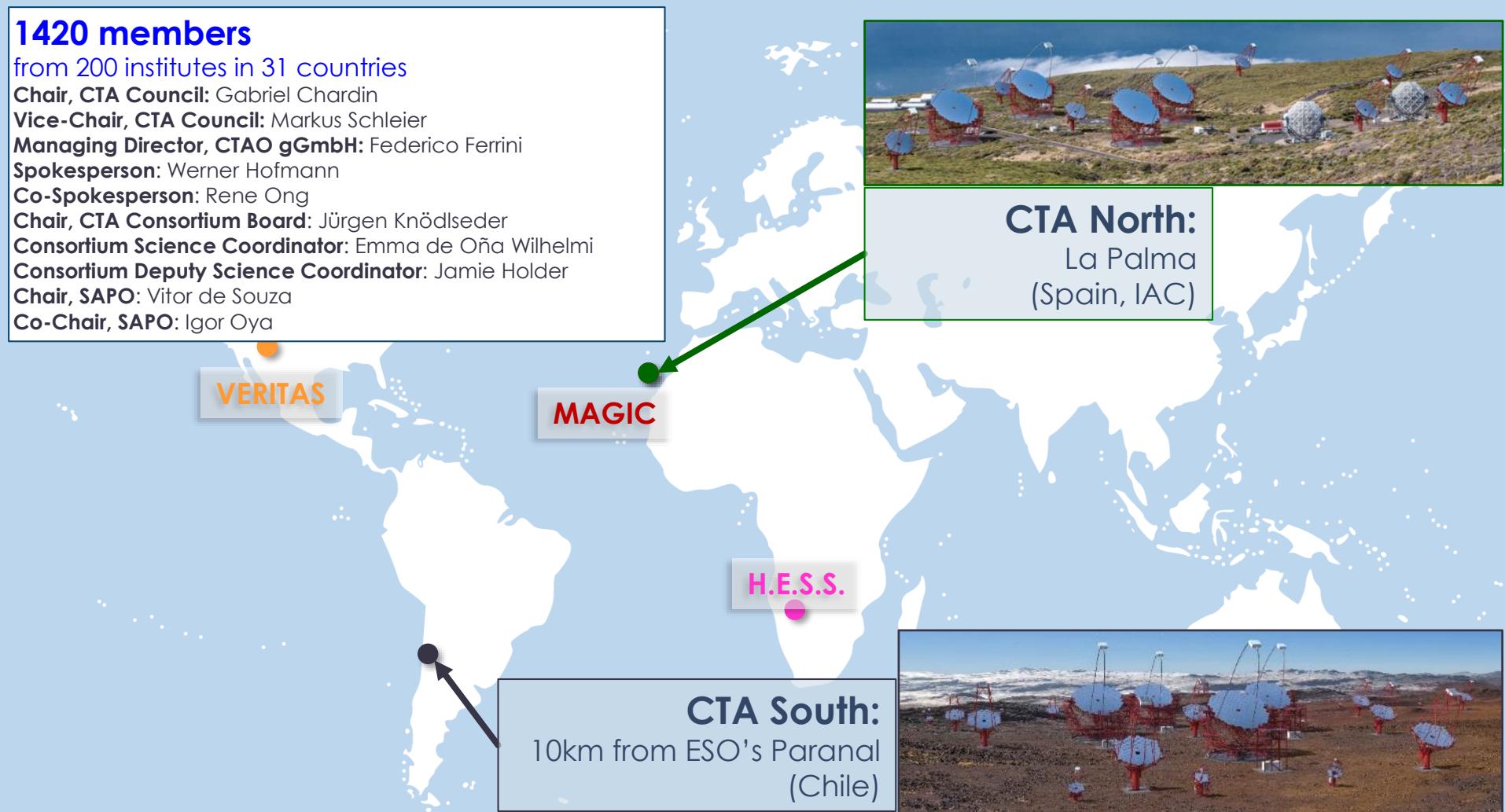
Chair, CTA Consortium Board: Jürgen Knöldseeder

Consortium Science Coordinator: Emma de Oña Wilhelmi

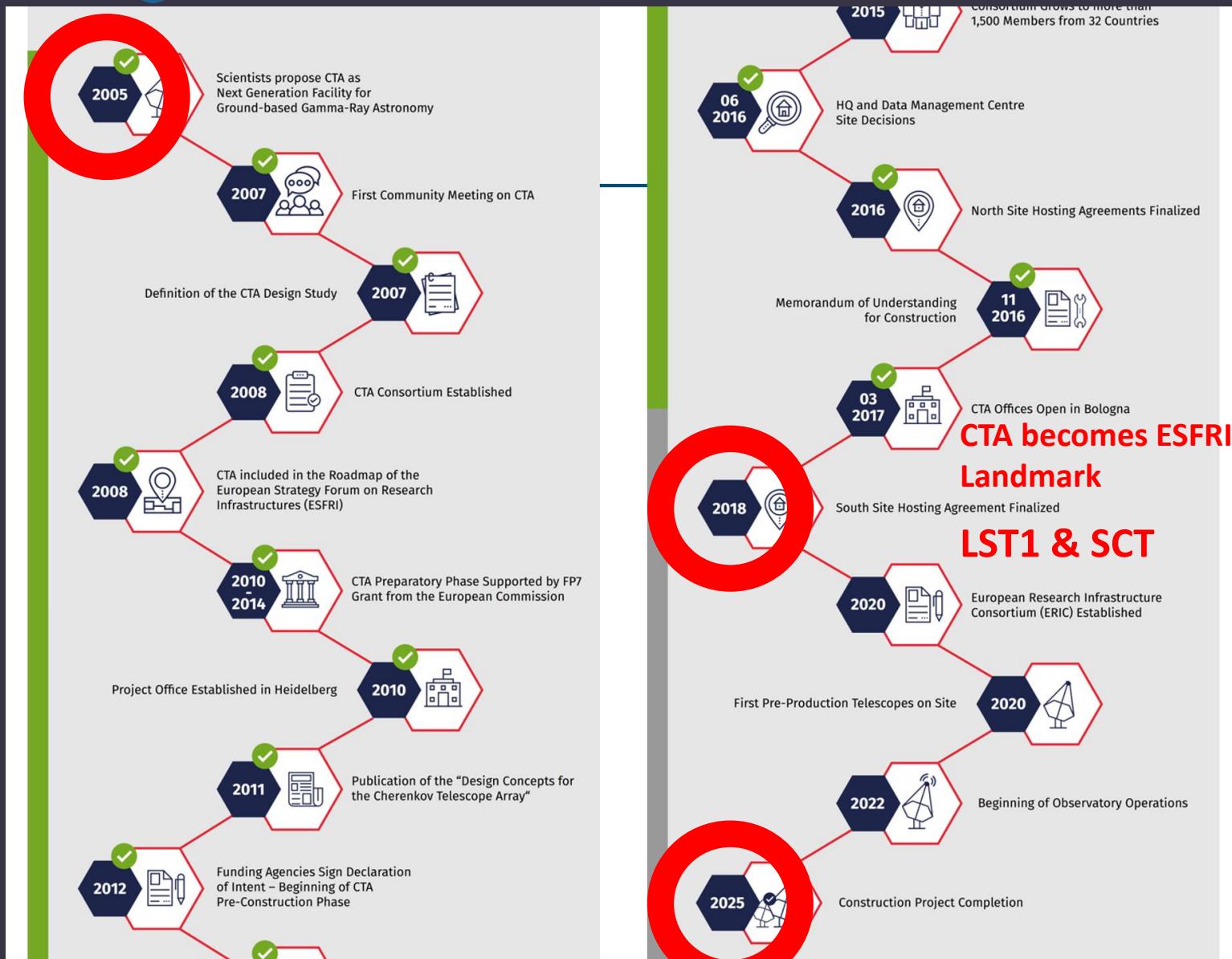
Consortium Deputy Science Coordinator: Jamie Holder

Chair, SAPO: Vitor de Souza

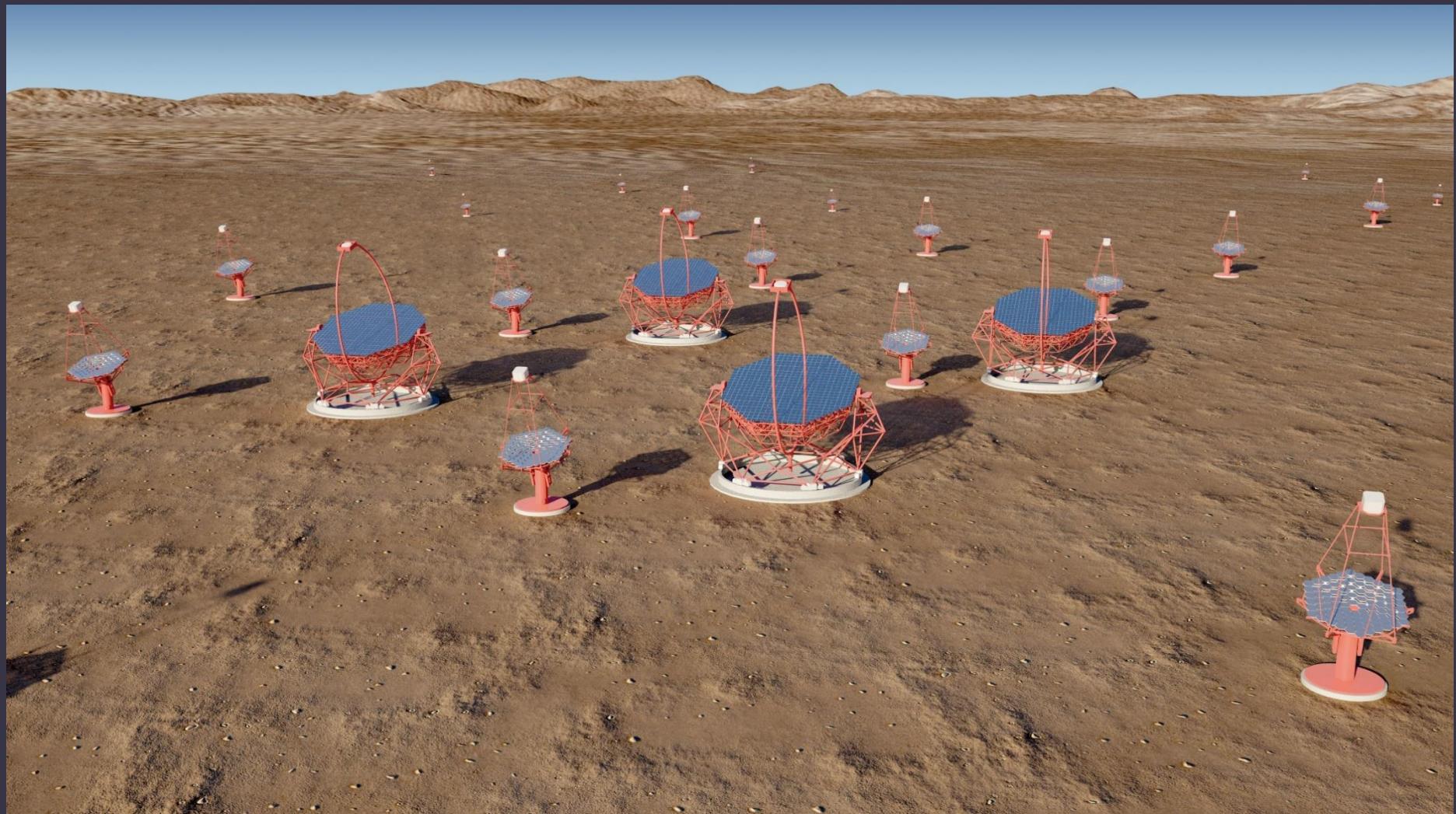
Co-Chair, SAPO: Igor Oya



# CTA timeline

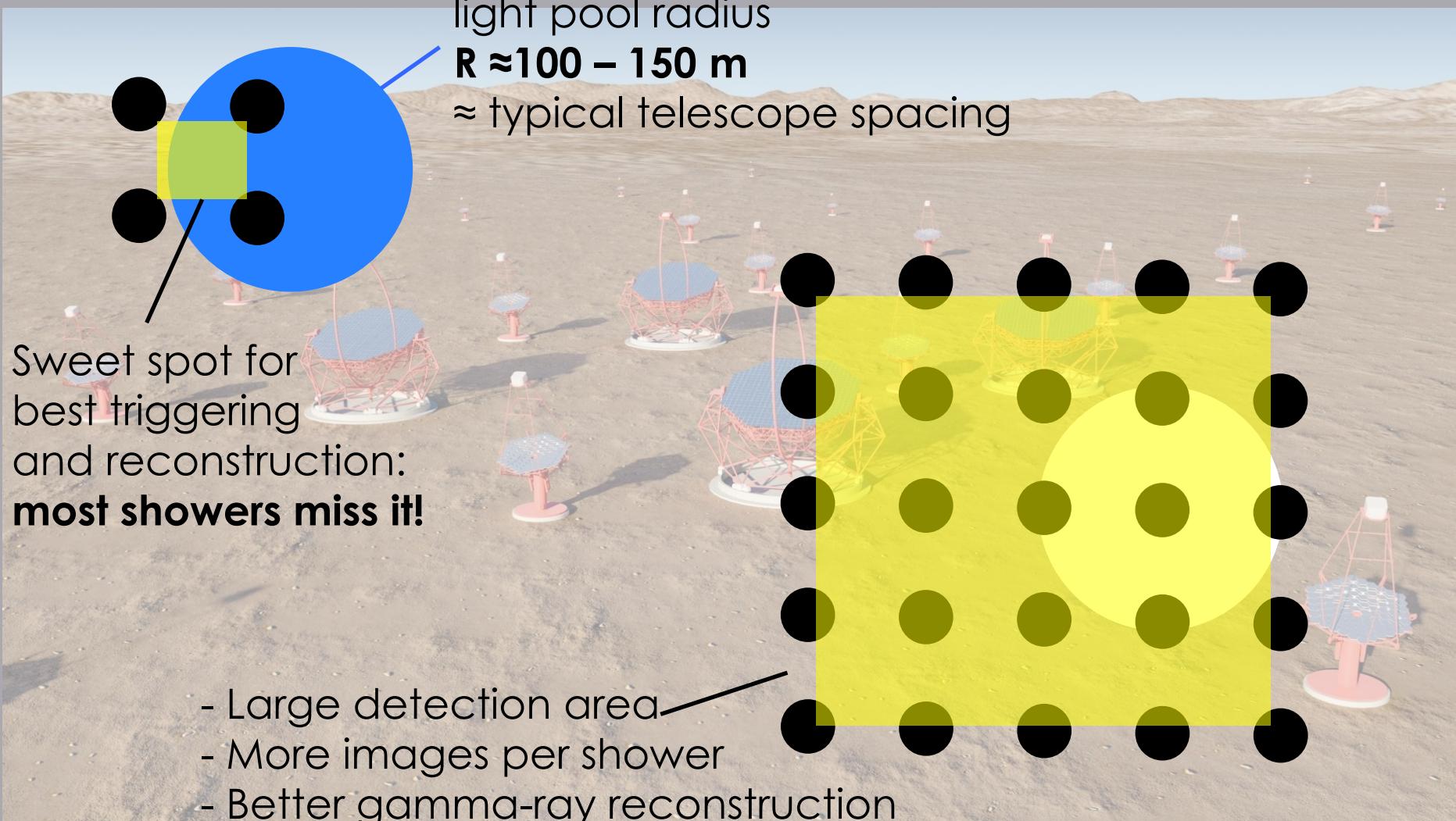


# The Cherenkov Telescope Array (CTA)



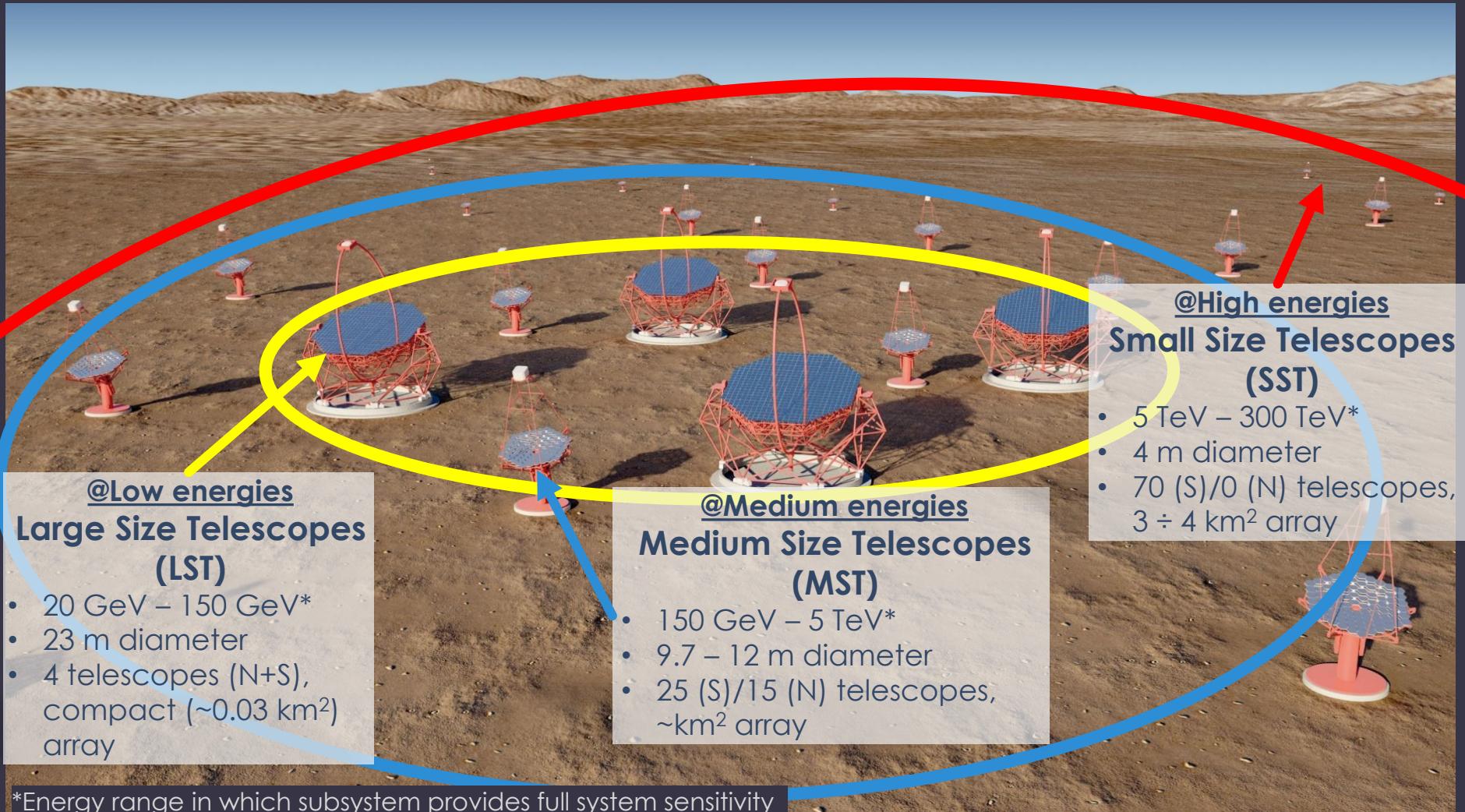
Artistic impression of the CTA, image courtesy G. Perez, SMM, IAC

# The Cherenkov Telescope Array (CTA)



Artistic impression of the CTA, image courtesy G. Perez, SMM, IAC

# CTA Requirements and Drivers



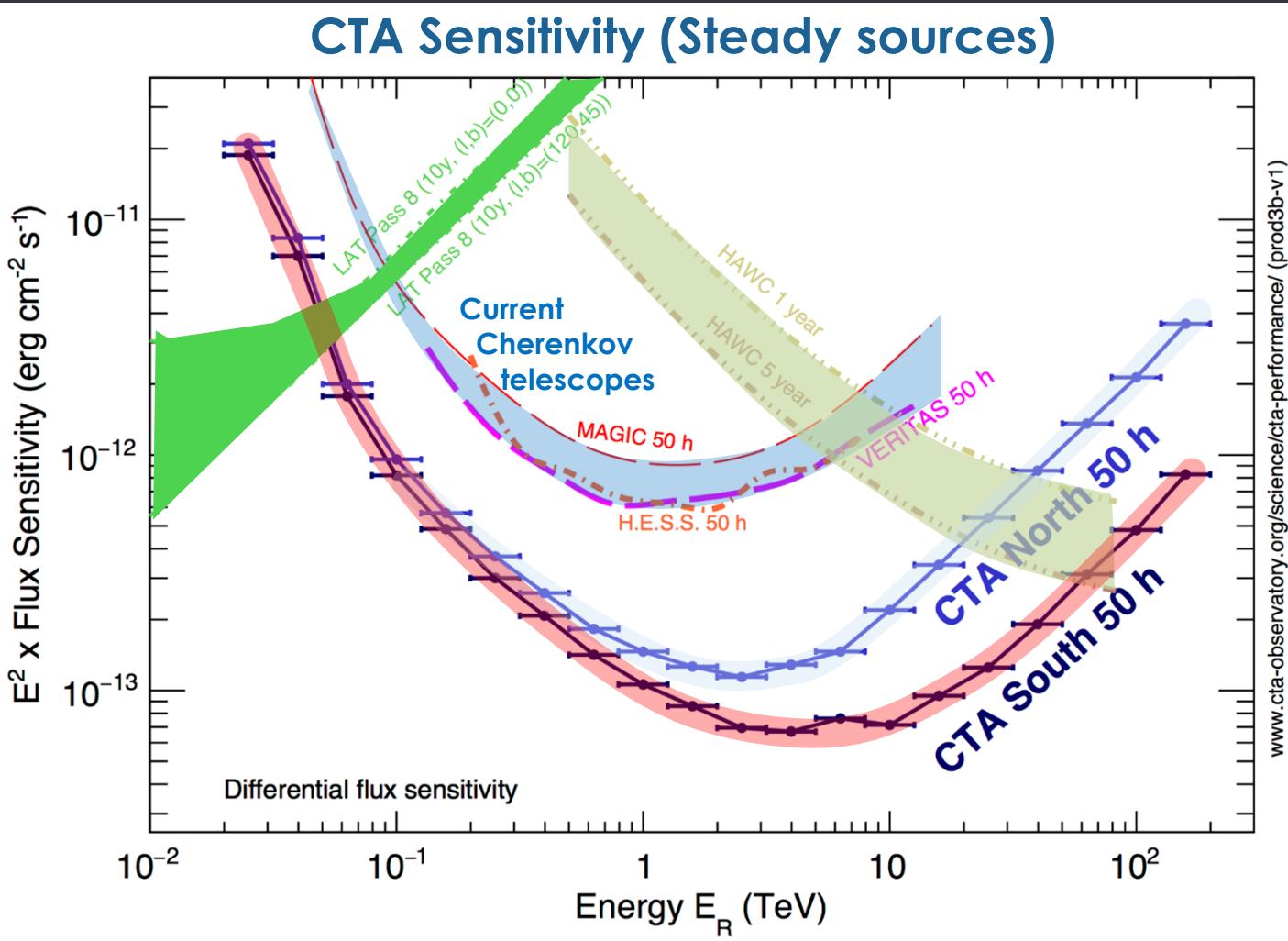
Artistic impression of the CTA, image courtesy G. Perez, SMM, IAC

# The Cherenkov Telescope Array (CTA)



Strongest emitters  
of very high energy  
gamma rays

Faint and  
distant  
objects



Integration time for steady sources: 50 h for CTs → years for Fermi, HAWC

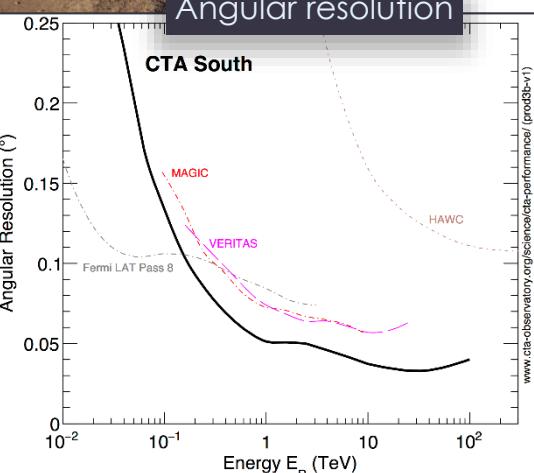
# The Cherenkov Telescope Array (CTA)



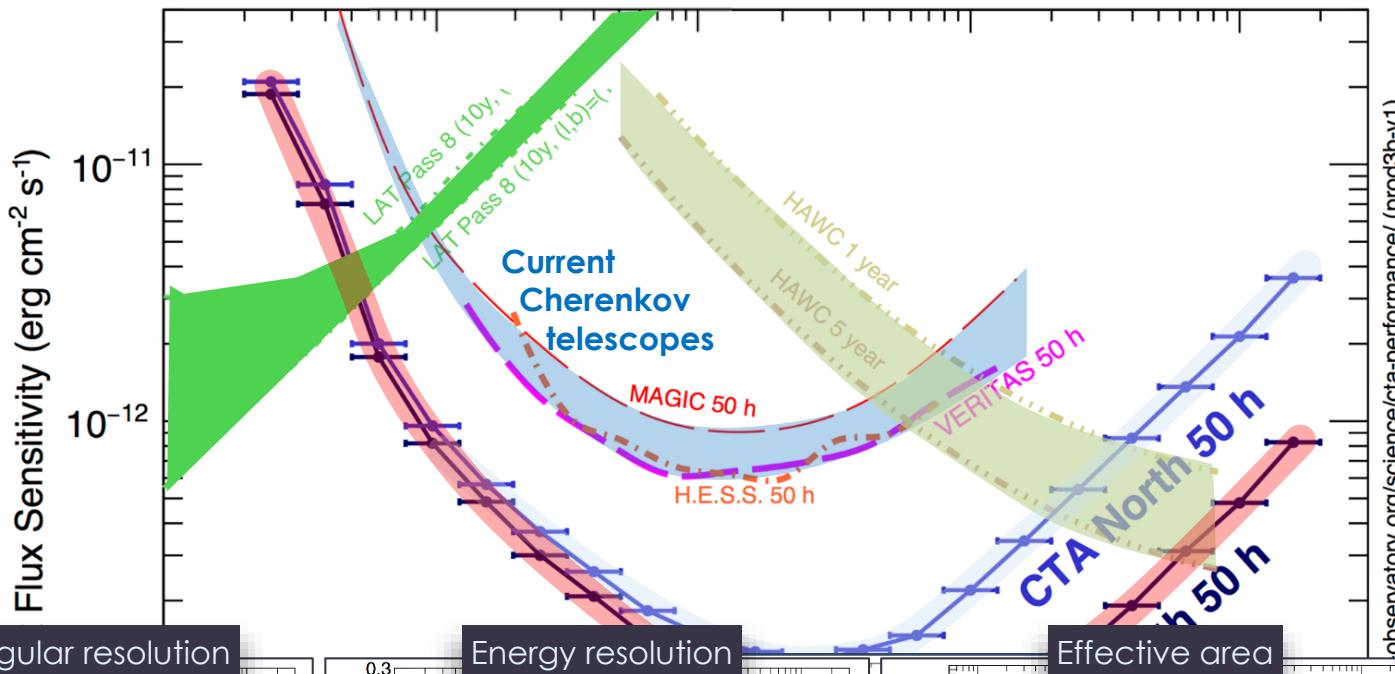
**Strongest emitters  
of very high energy  
gamma rays**



**Integral**



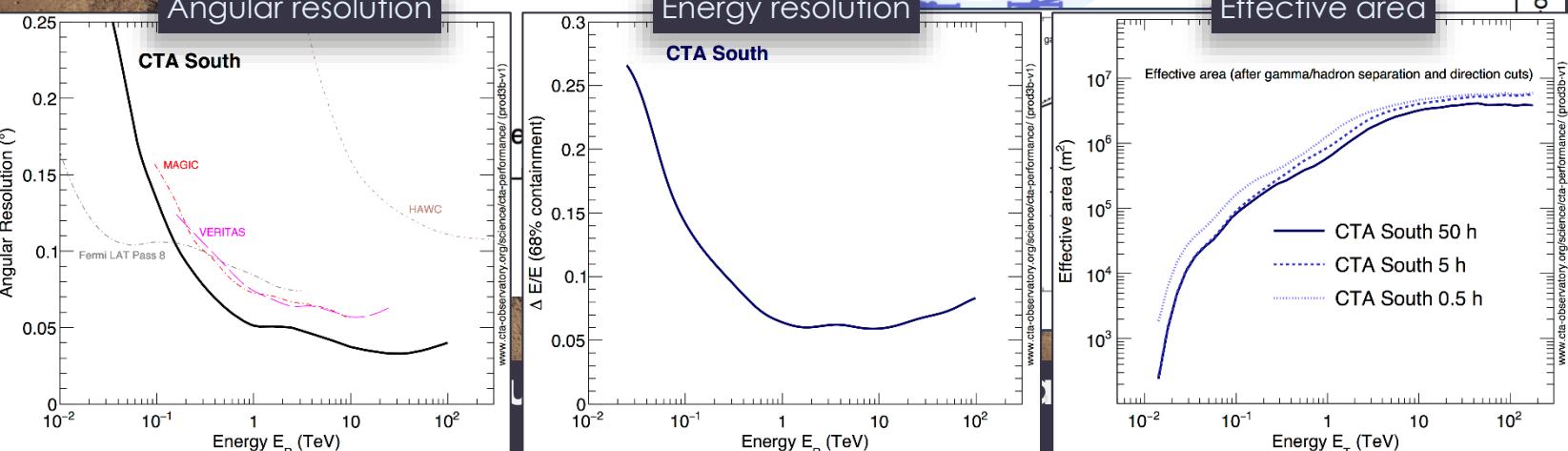
## CTA Sensitivity (Steady sources)



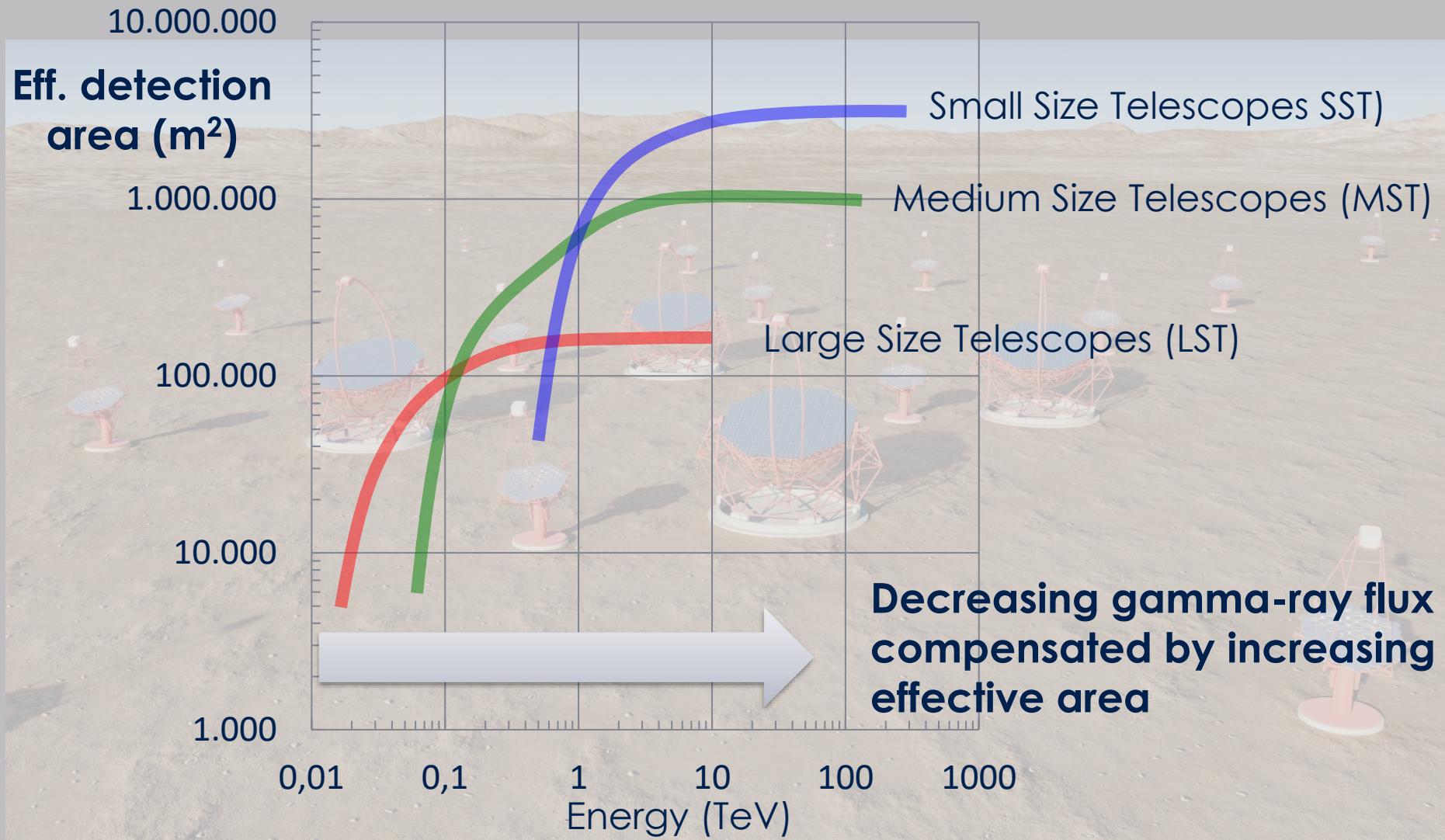
Angular resolution

Energy resolution

Effective area



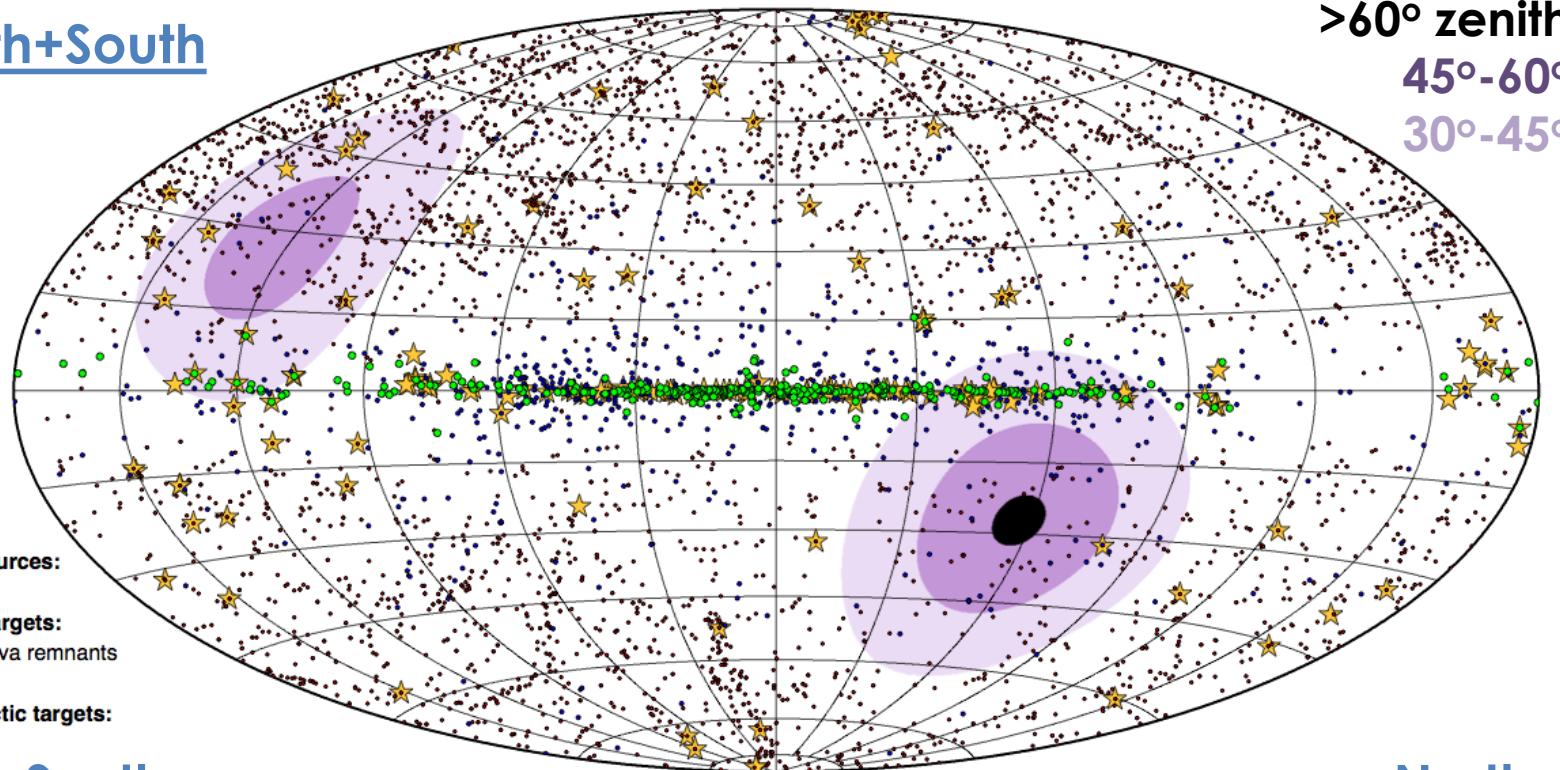
# The Cherenkov Telescope Array (CTA)



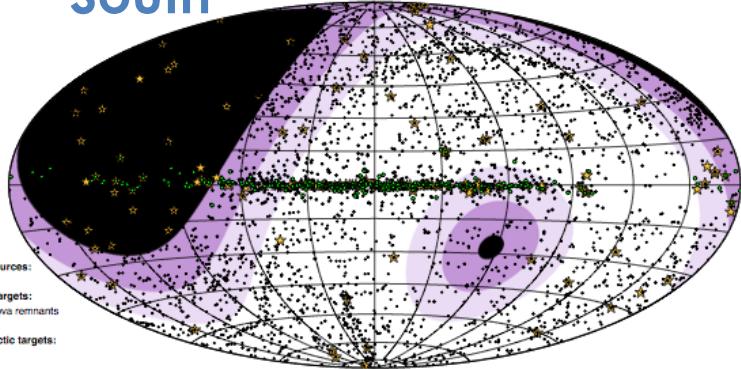
Artistic impression of the CTA, image courtesy G. Perez, SMM, IAC

# CTA sky coverage

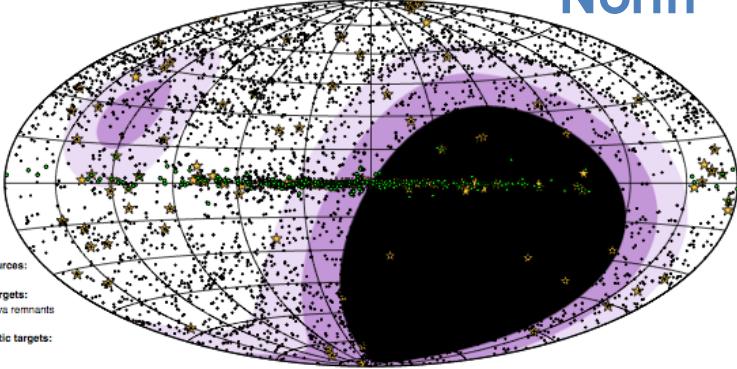
North+South



South



North



# CTA Sites: The North Site

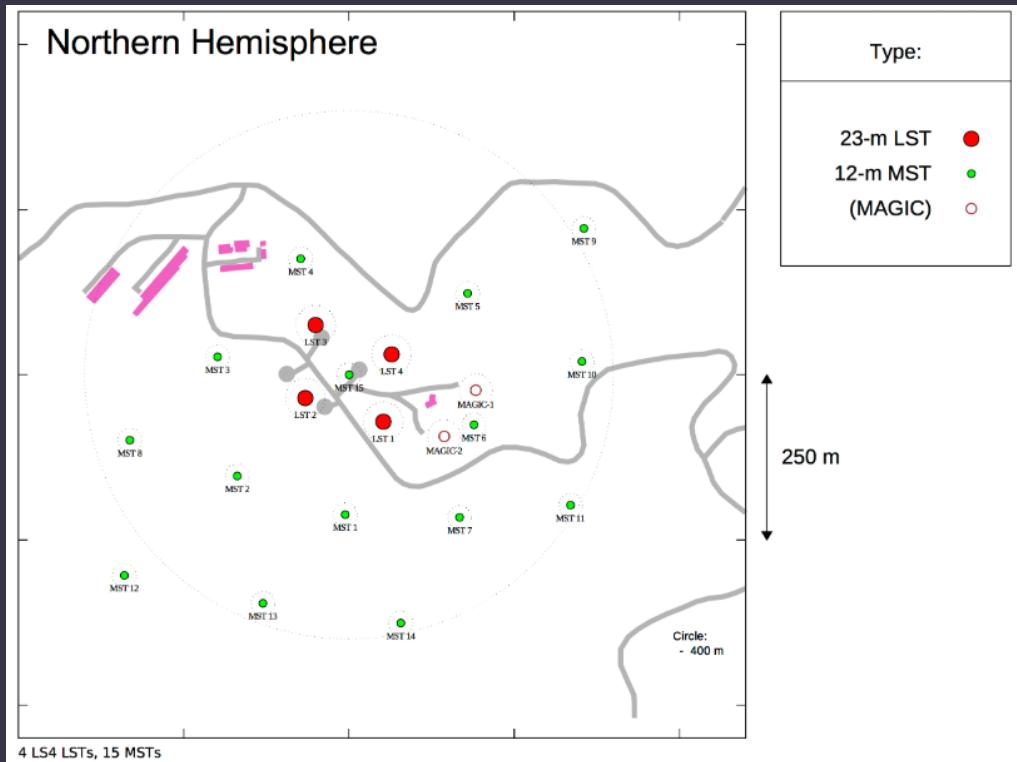


# CTA Sites: The North Site



## Observatory Roque de los Muchachos La Palma, Spain

- Selected July 2015
- Agreement signed Sept. 2016



## Deployment stages:

1. LST Prototype (LST1)
2. Remaining 3 LST + 1 MST
3. Remaining 14 MST
4. Infrastructure implementation being procured



# LST Inauguration ceremony

October 2018

<http://www.lst1.iac.es/webcams.html>



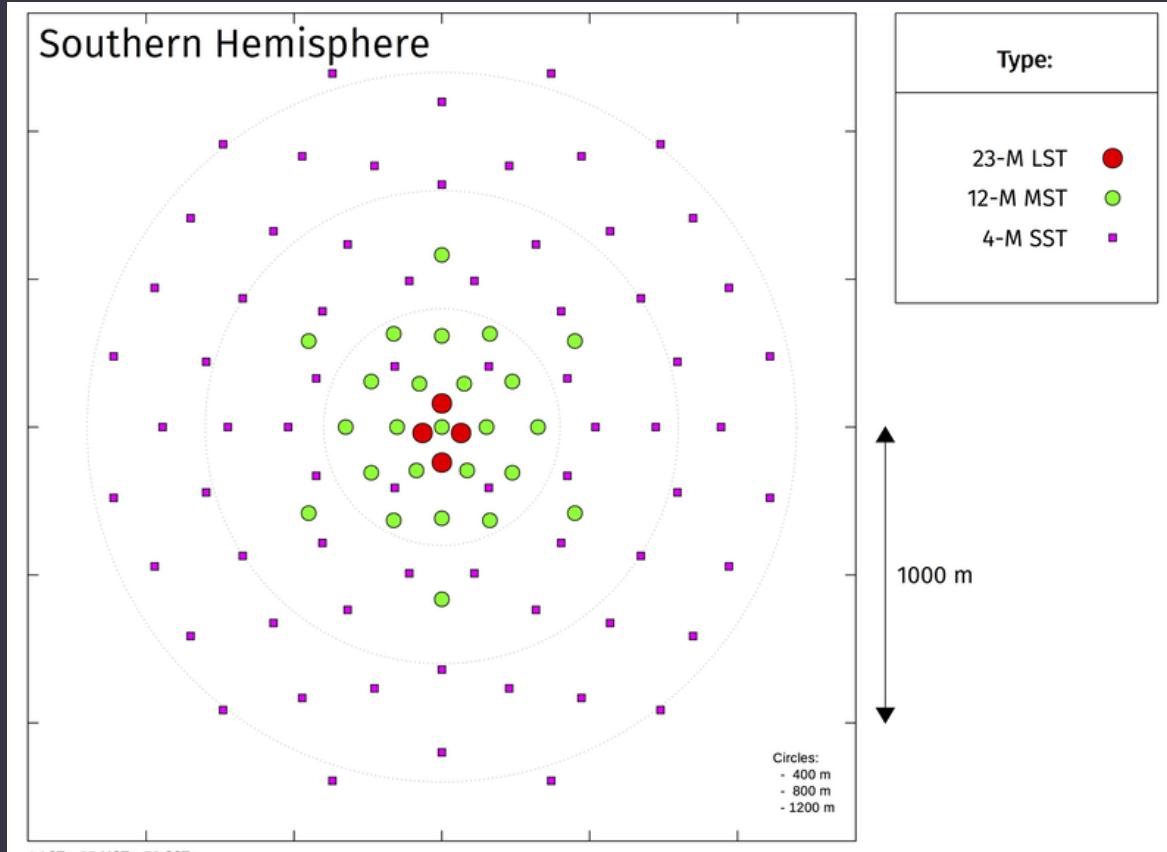
# CTA Sites: The South Site



# CTA Sites: The South Site

## ESO Chile

- Selected July 2015
- On 19 December 2018, CTAO and ESO signed the final agreements needed for CTA's southern hemisphere array to be hosted near ESO's Paranal Observatory in Chile.



# CTA – An Open Observatory



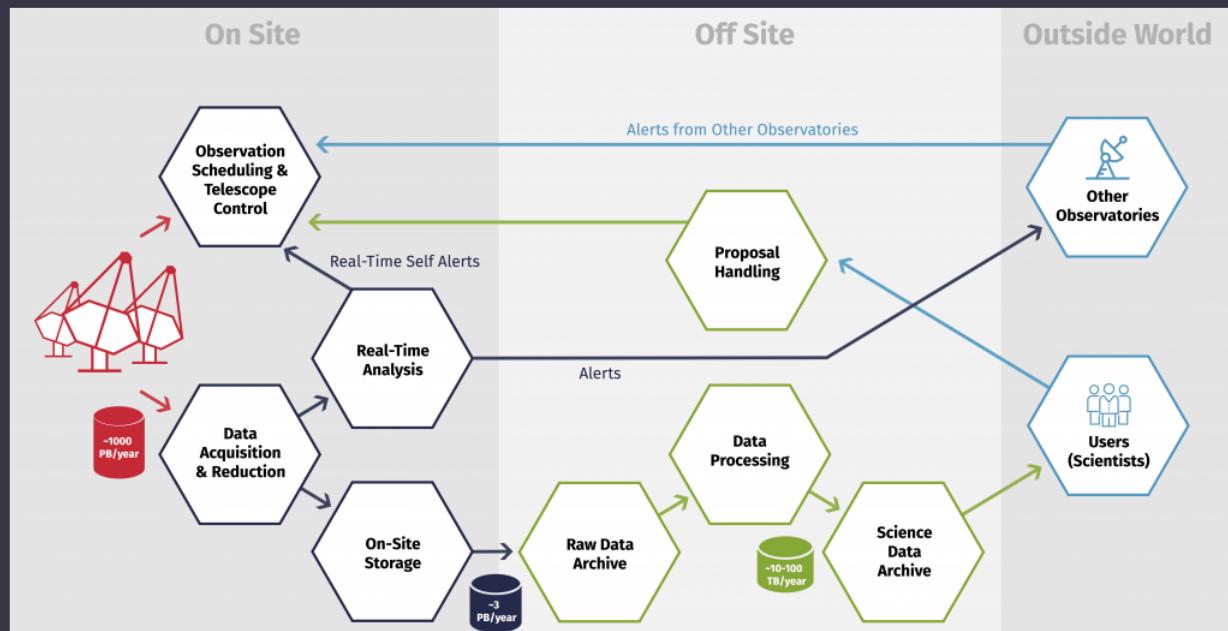
Separation between **CTA-Consortium (CTAC)** and **CTA-Observatory (CTAO)**

- **CTAC**: Scientific motivation, specifications/requirements, telescope design...
- **CTAO**: Sites construction, Science Data Management (time allocation)...

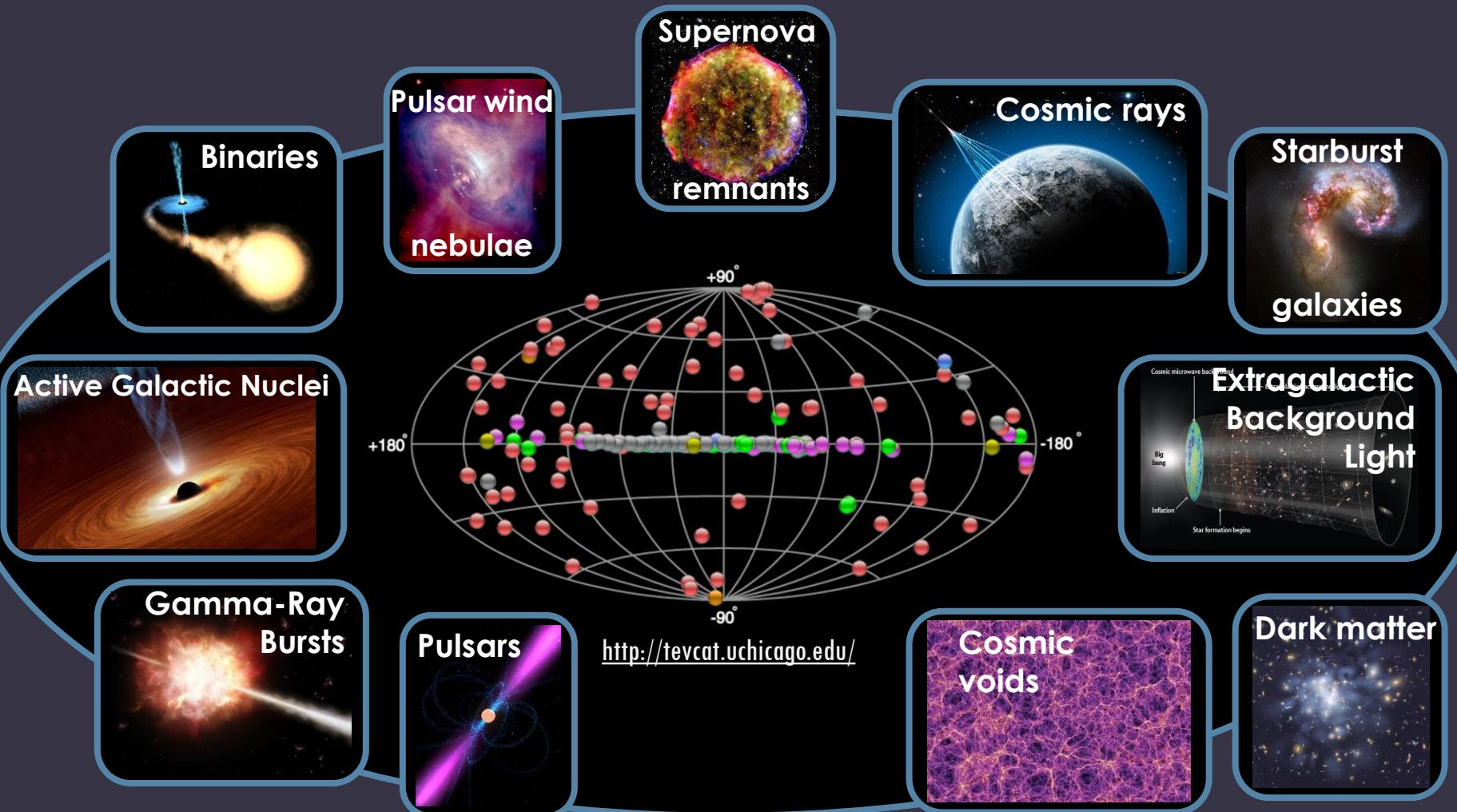
**CTA Observatory GmbH** founded in 2014 as interim legal entity, located at Heidelberg, under German law

- The final legal entity for full construction, a **European Research Infrastructure Consortium (ERIC)**, is being set up under European Union law (early 2020?)

- New Project Office HQ  
Bologna (Italy)
- Science Data Management Centre (SDMC)  
DESY in Berlin-Zeuthen (Germany)

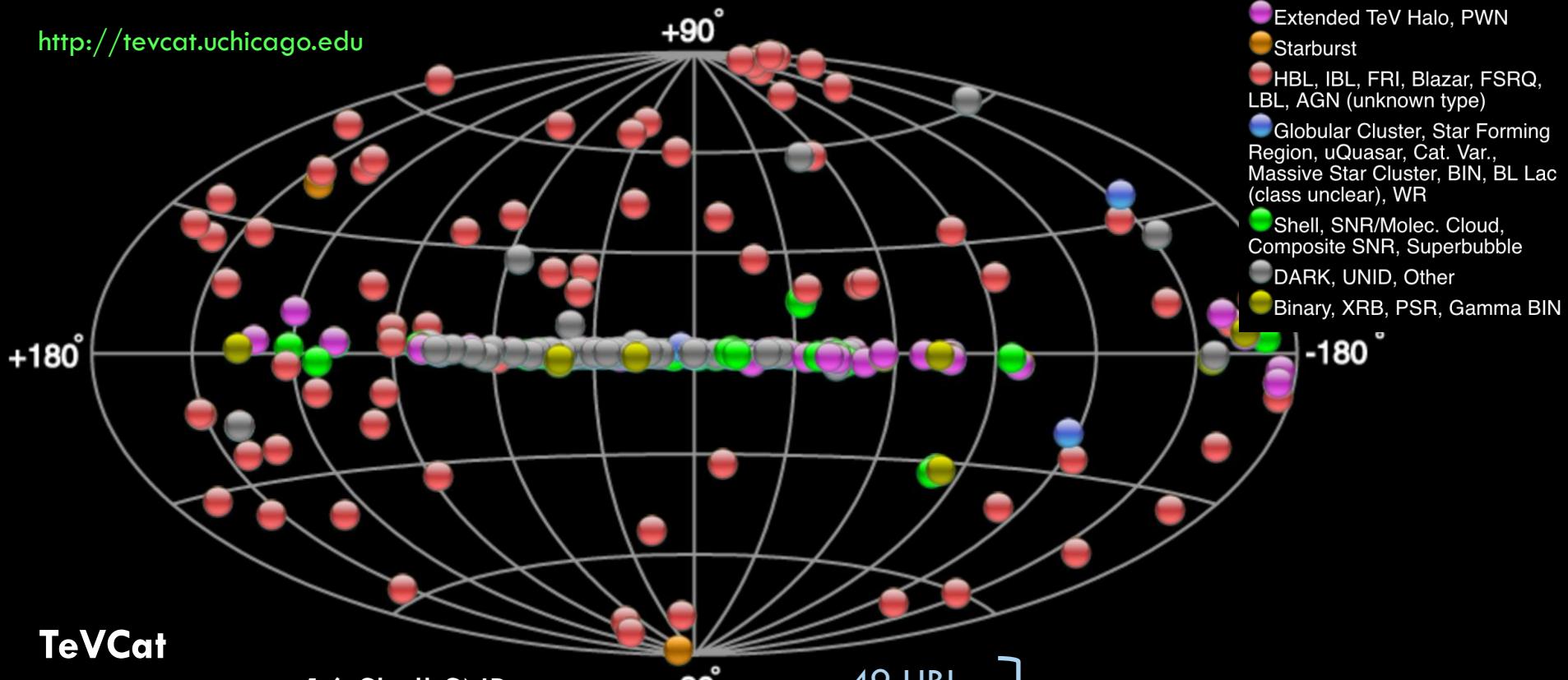


# Physics of IACTs



# The Gamma Ray Sky at Very High Energies

<http://tevcat.uchicago.edu>



## TeVCat

**212 Sources**

16 Shell SNR  
11 SNR/Cloud Interactions  
37 PWN  
7 Pulsars  
9 Gamma-Ray Binaries  
4 Star/Globular Clusters  
...

62 sources  
unidentified

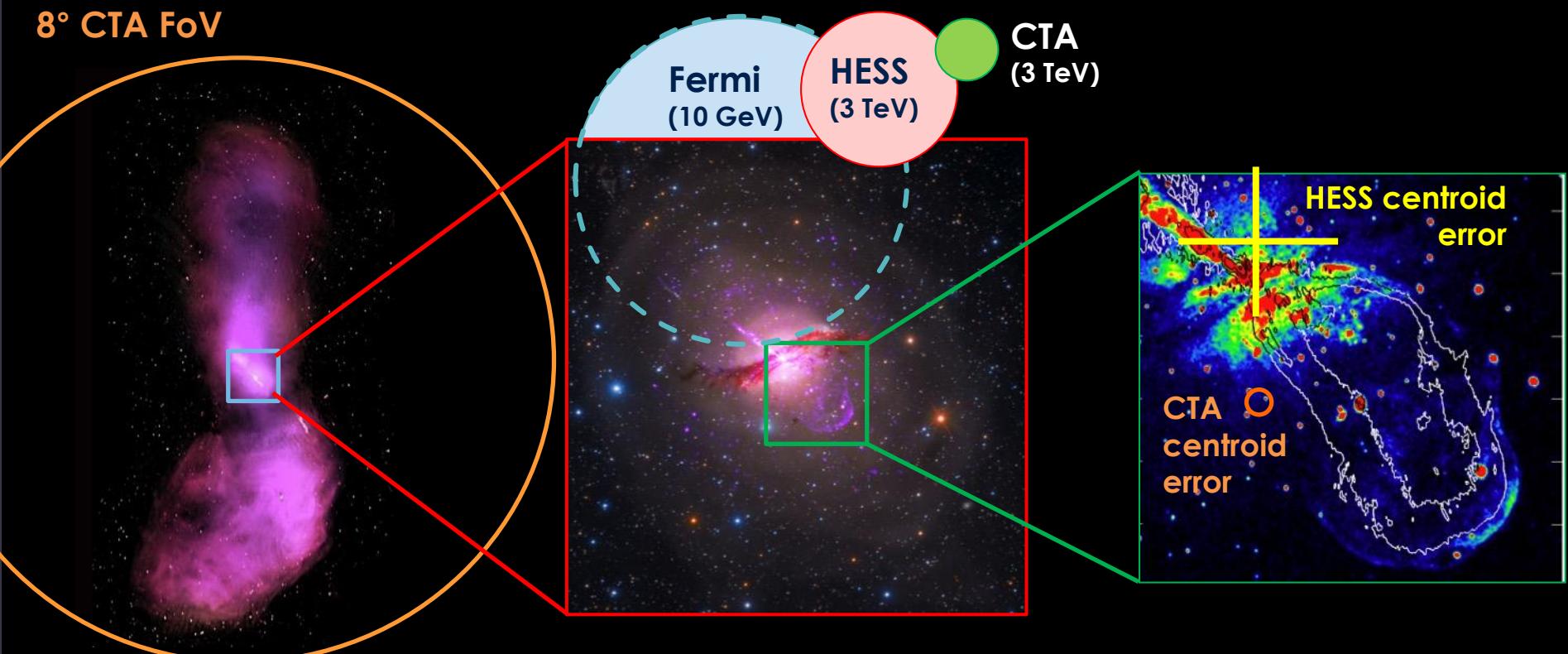
49 HBL  
8 IBL  
2 LBL  
3 FRI  
7 FSRQ

...  
2 Starburst Gal.

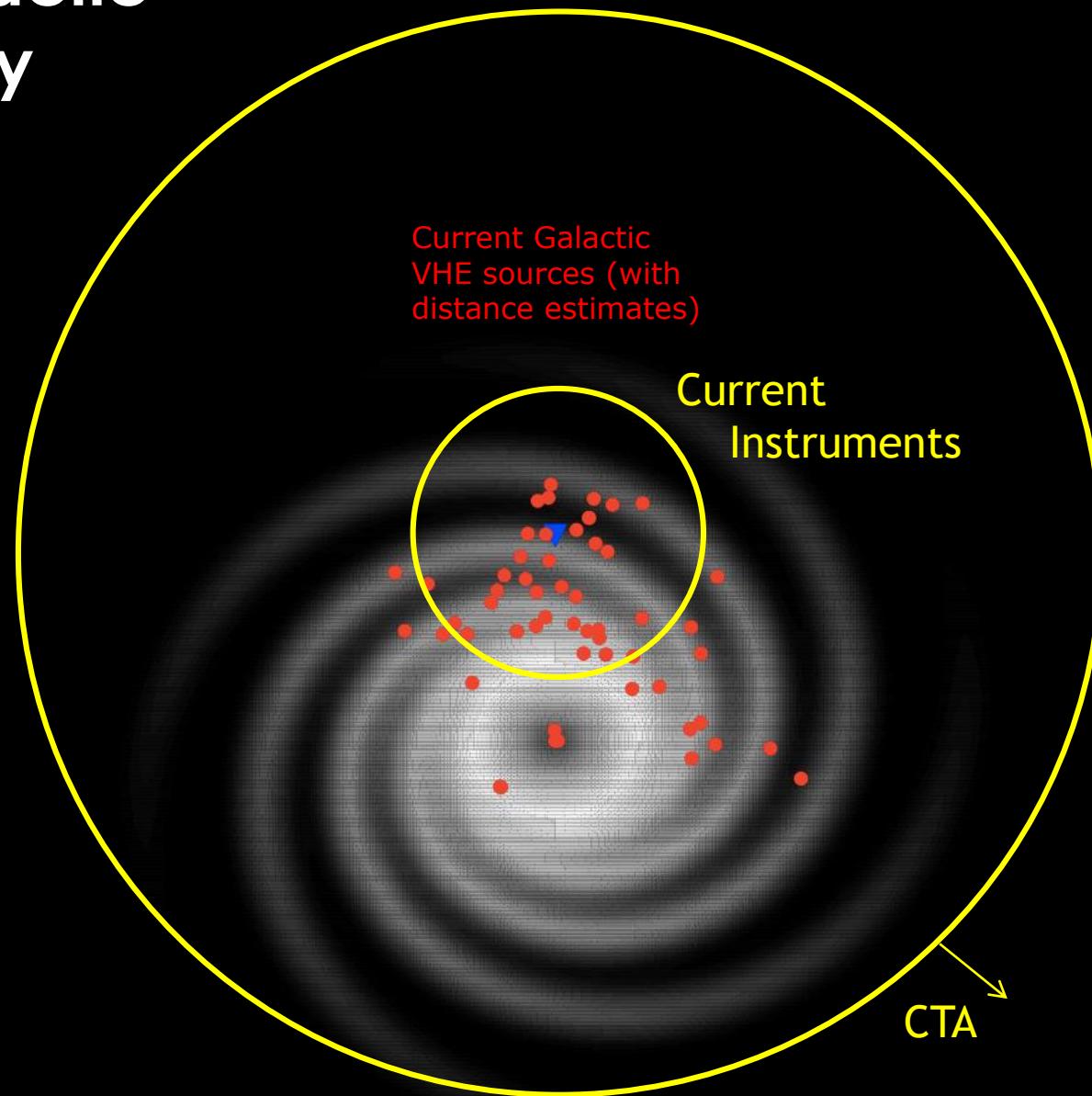
} AGNs with jets,  
differing in jet power  
and viewing angle of the jet

# CTA Resolving power

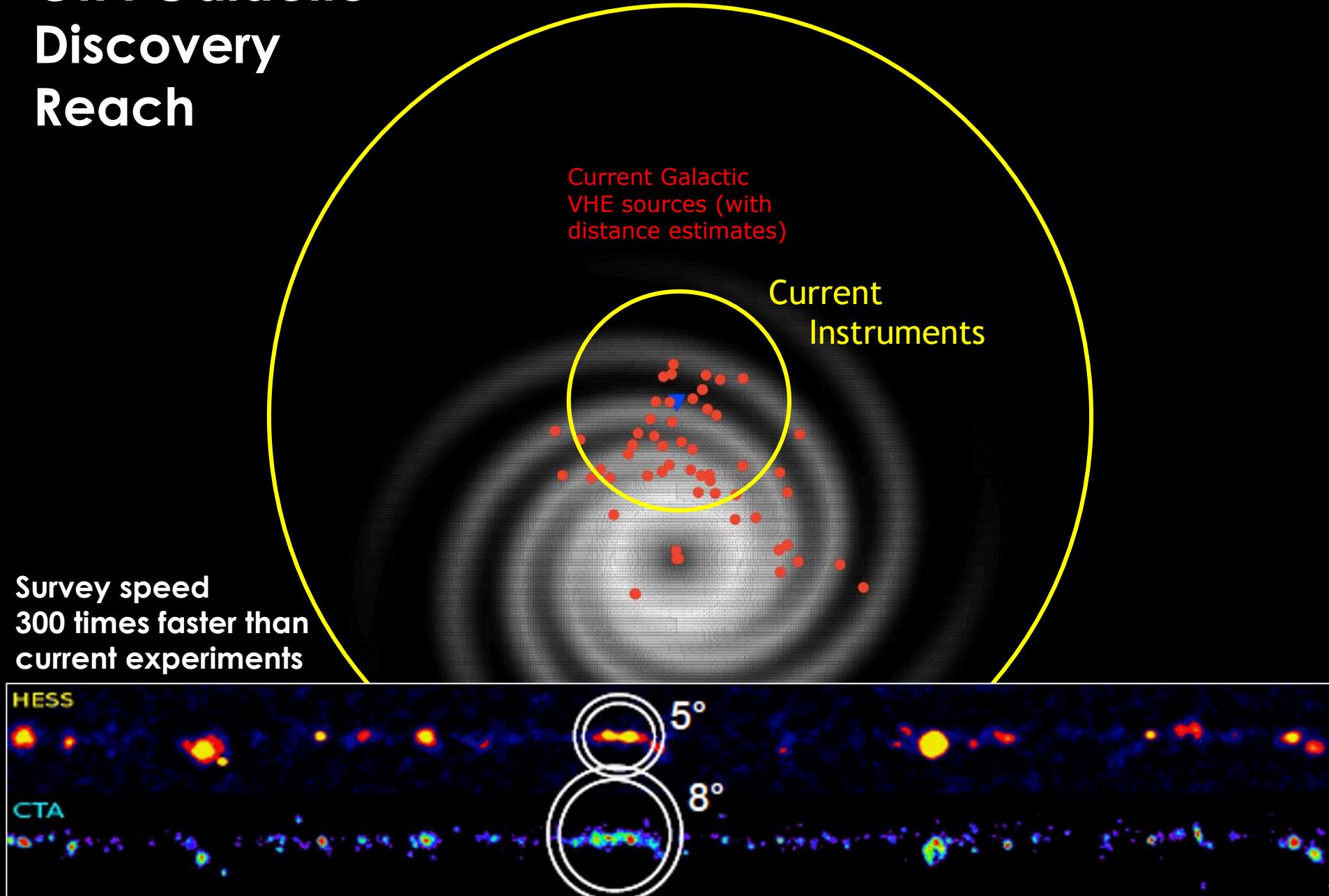
- Example: nearby active galaxy Centaurus A



# CTA Galactic Discovery Reach



# CTA Galactic Discovery Reach



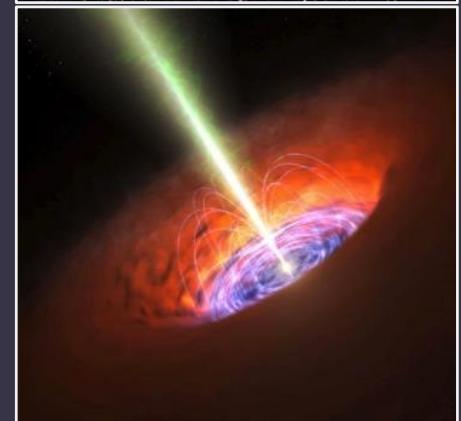
## Theme 1: Understanding the Origin and Role of Relativistic Cosmic Particles

- What are the **sites of high-energy particle acceleration** in the Universe?
- What are the **mechanisms for cosmic particle accelerations?**
- What role do accelerated particles play in feedback on **star formation and galaxy evolution?**



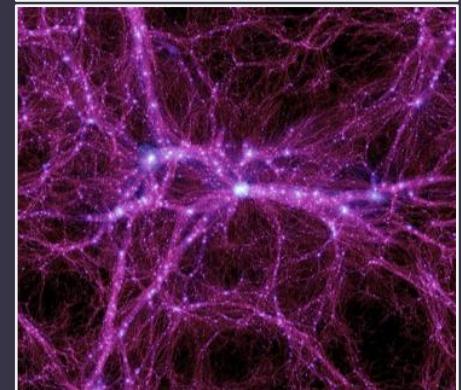
## Theme 2: Probing Extreme Environments

- What **physical processes** are at work close to **neutron stars and black holes?**
- What are the characteristics of **relativistic jets, winds and explosions?**
- How intense are **radiation fields and magnetic fields** in **cosmic voids**, and how do these evolve over cosmic time?



## Theme 3: Exploring Frontiers in Physics

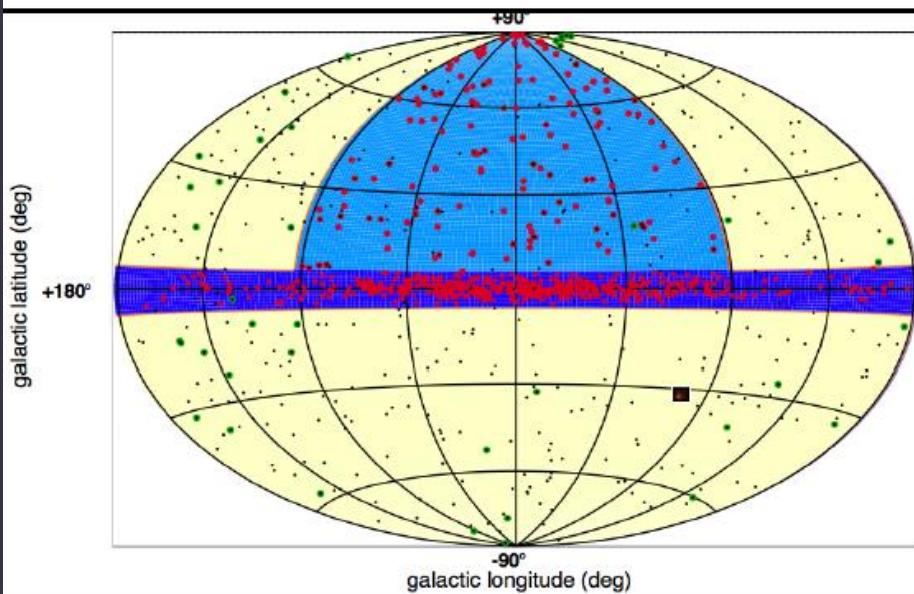
- What is the nature of **dark matter**? How is it distributed?
- Are there **quantum gravitational affects** on photon propagation?
- Do **axion-like particles** exist?



# CTA Large-scale surveys

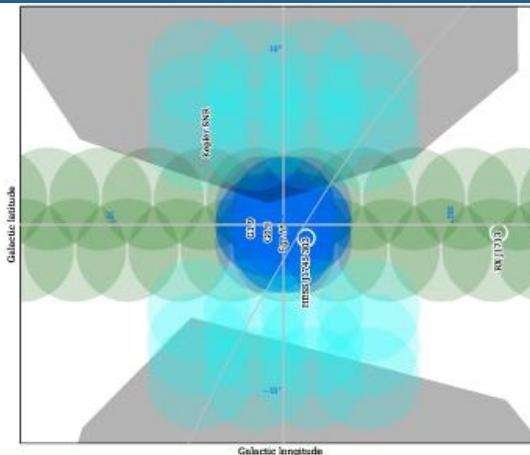
## Extragalactic Survey:

Unbiased survey of  $\frac{1}{4}$  sky to  $\sim 6$  mCrab  
VHE population study, duty cycle  
New, unknown sources; 1000 h



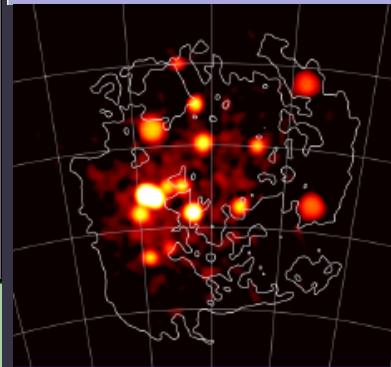
# Galactic Plane Survey:

Survey of entire plane to ~2 mCrab  
Galactic source population: SNRs, PWNe, etc.  
PeVatron candidates, early view of GC, 1620 h



## Galactic Centre Survey:

ID of the central source  
Spectrum, morphology of diffuse emission  
Deep DM search; base of the Fermi Bubbles  
Central exposure: 525 h,  $10^\circ \times 10^\circ$  : 300 h



# Large Magellanic Cloud Survey:

Face-on satellite galaxy with high SFR  
Extreme Gal. sources, diffuse emission (CRs)  
DM search; 340 h in six pointings

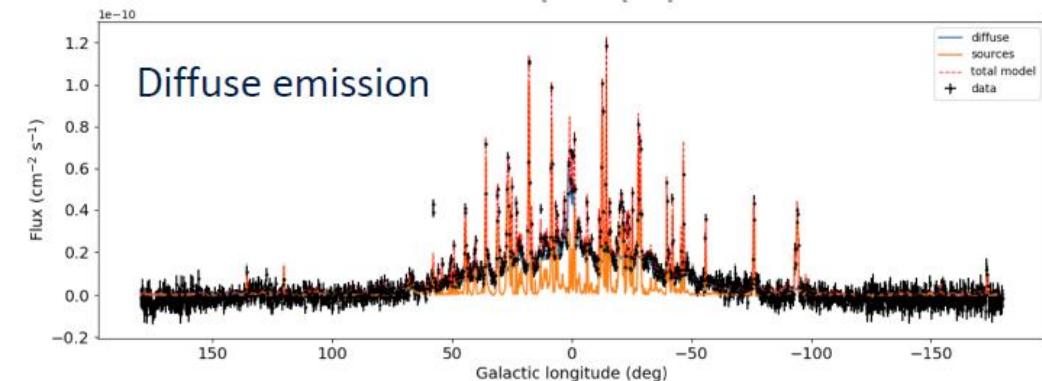
# CTA Science Case

- Latest iteration of **CTA's science case** published this month (March 2019) as a **book by World Scientific**:
  - <https://doi.org/10.1142/10986>
- **Key Science Projects** providing legacy data sets
  1. Dark Matter Programme
  2. Galactic Centre
  3. Galactic Plane Survey
  4. Large Magellanic Cloud Survey
  5. Extragalactic Survey
  6. Transients
  7. Cosmic-ray PeVatrons
  8. Star-forming Systems
  9. Active Galactic Nuclei
  10. Cluster of Galaxies
  11. Beyond Gamma Rays

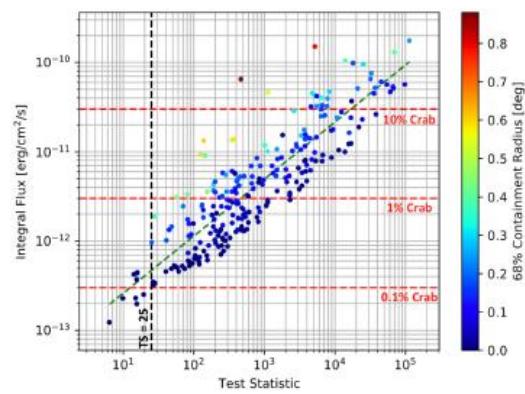


# CTA Data Challenge I

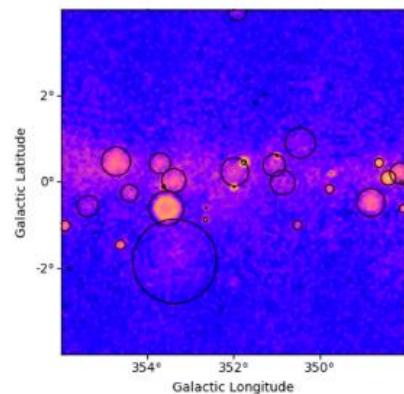
- Fermi-LAT + IACT input



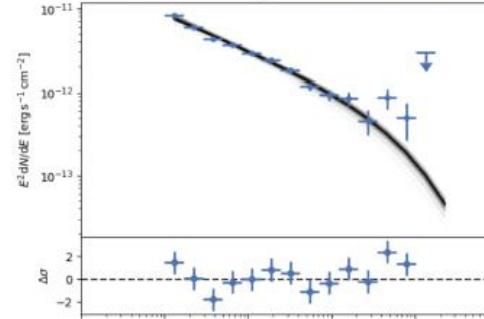
Galactic plane survey



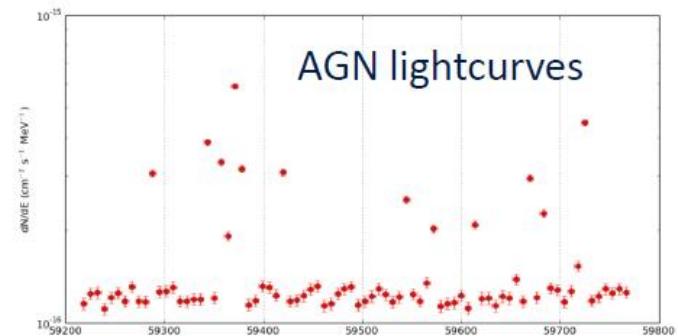
Catalogs



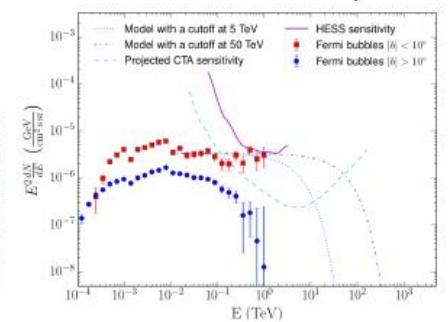
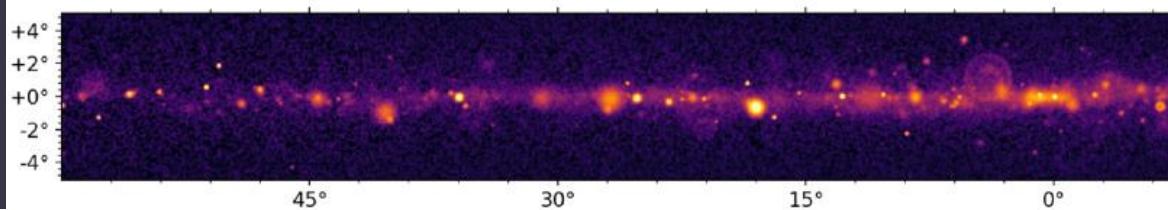
Supernova remnants

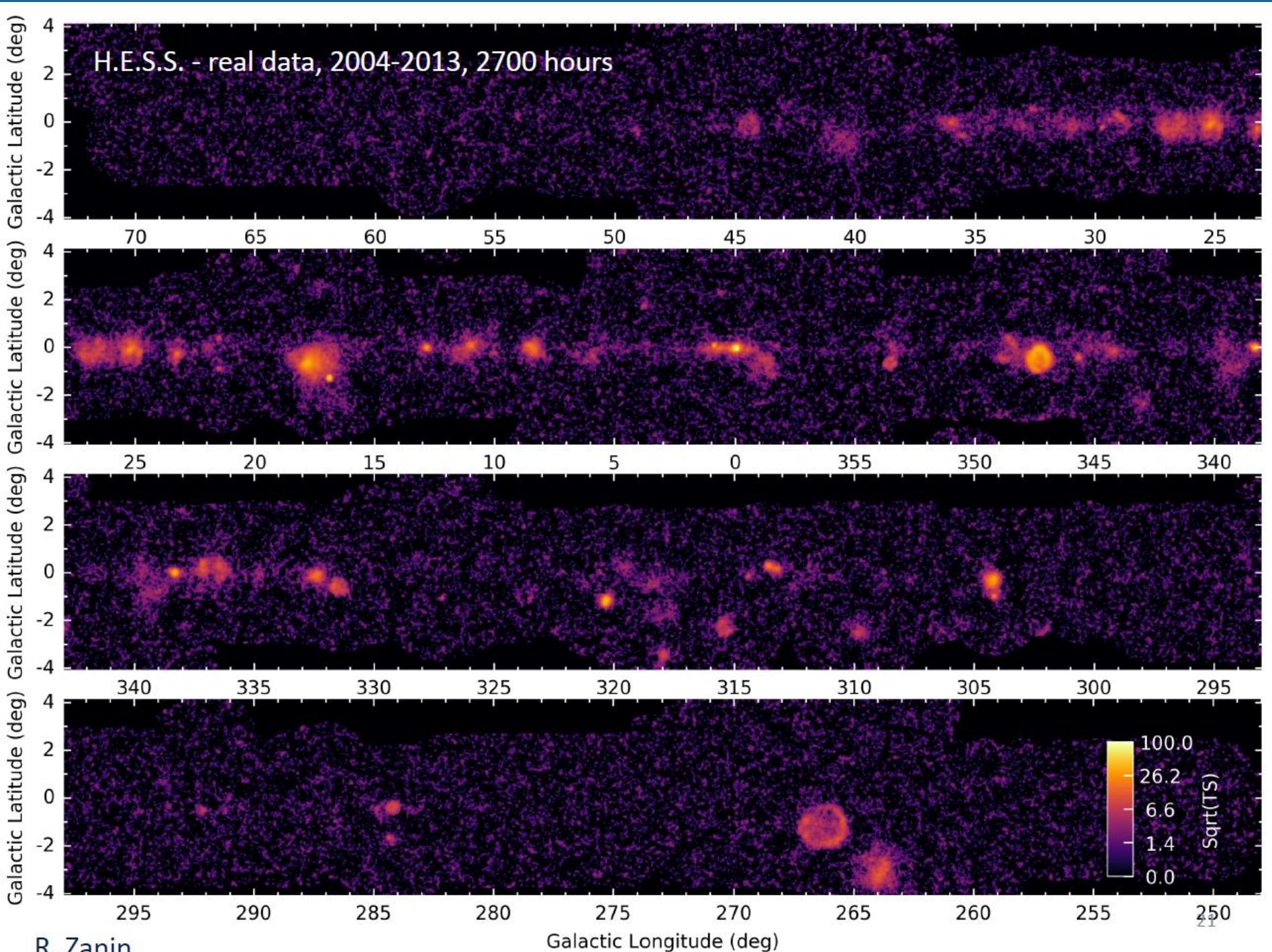


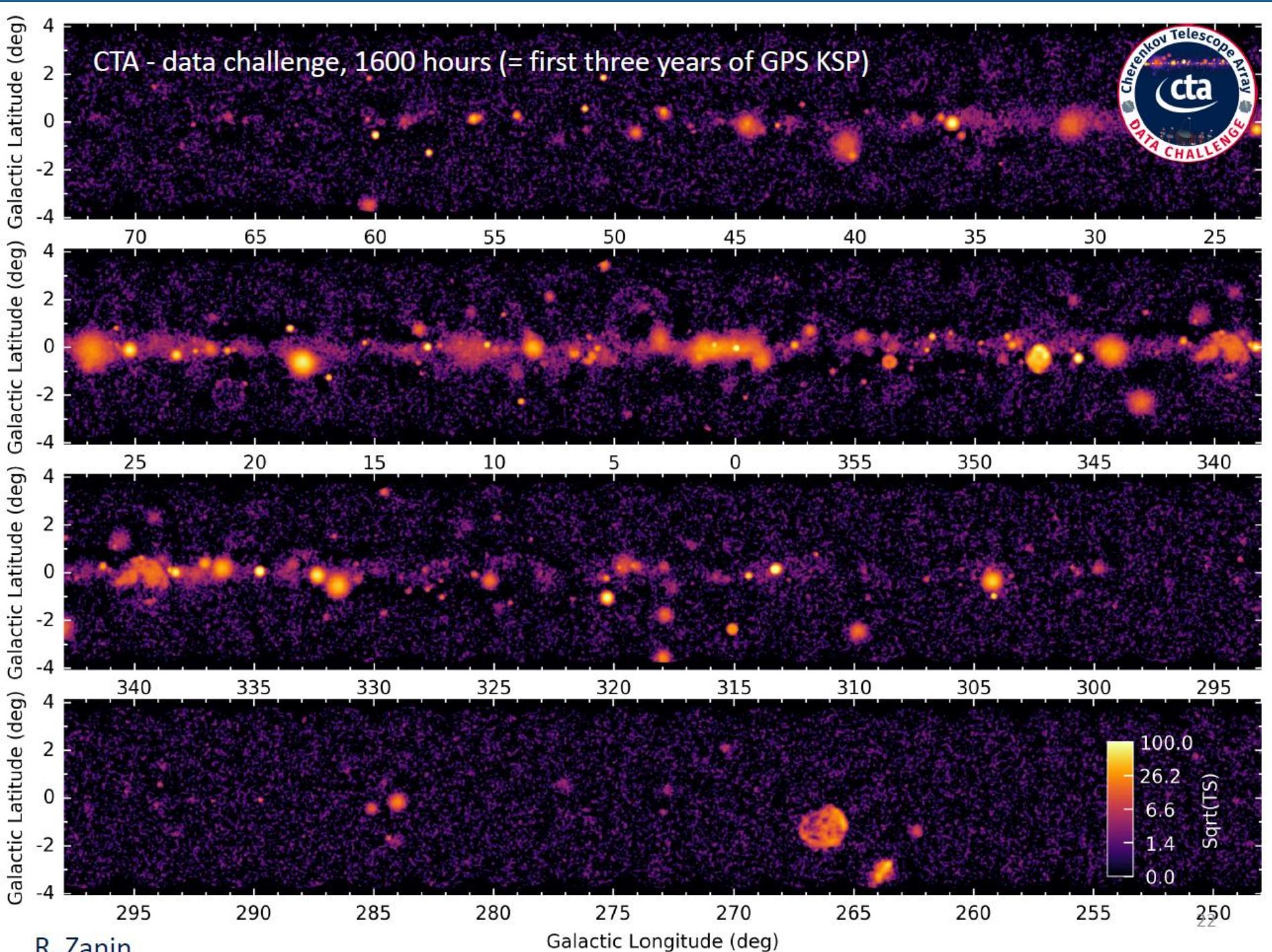
AGN lightcurves



Fermi Bubbles: D. Malyshev

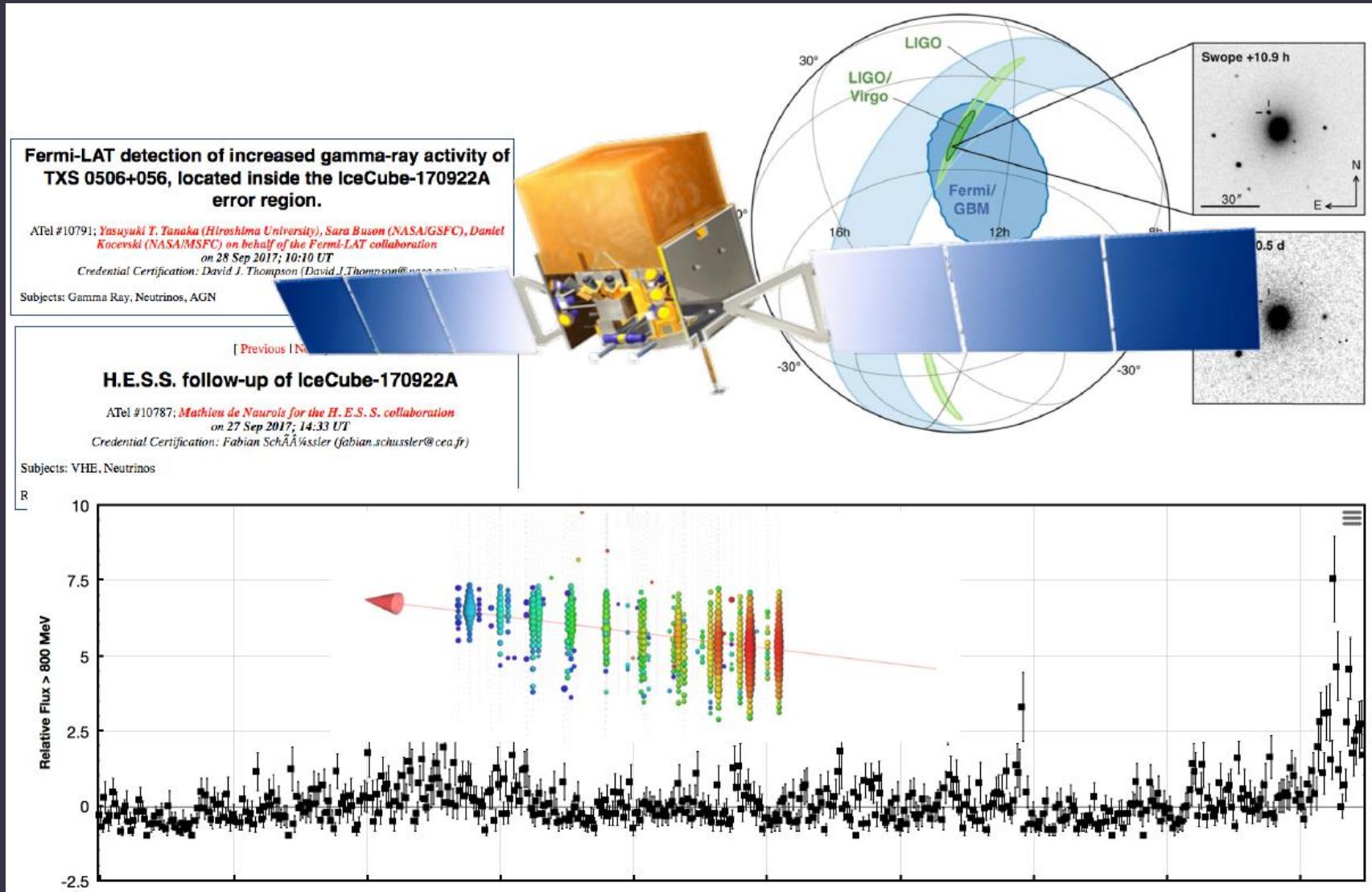






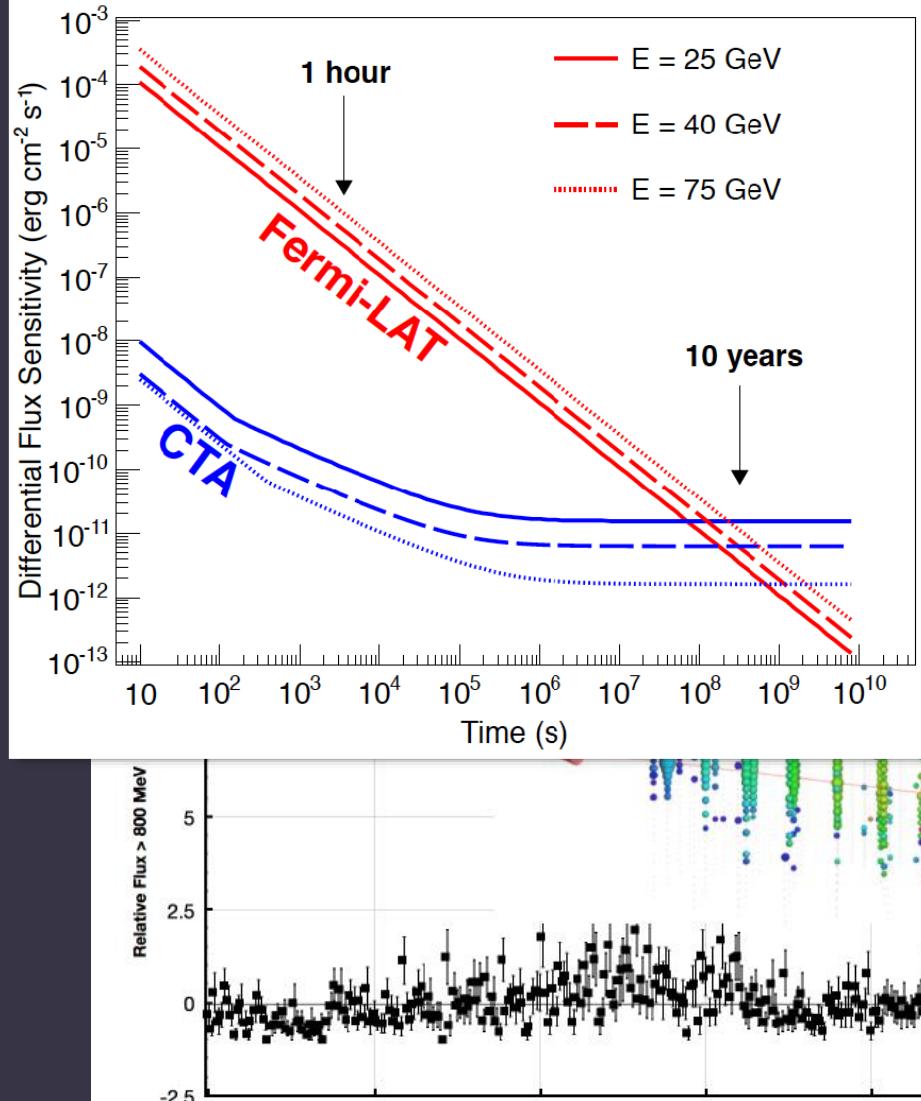
# CTA in the multimessenger context

- Recent joint GW and neutrino observations by many observatories



# CTA in the multimessenger context

- Recent joint GW and neutrino observations by many observatories

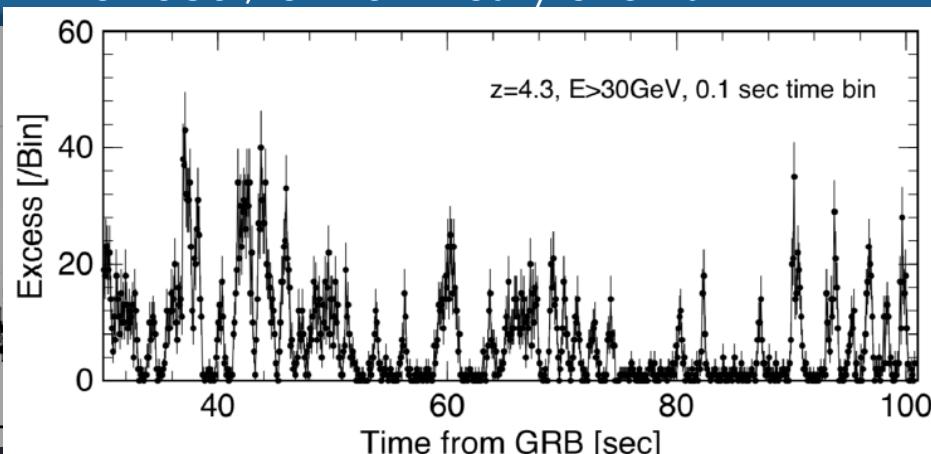


## Alerts and triggers to CTA

- For variable objects
  - Fermi-LAT, LVC, IceCube, optical transient factories, etc
- For GRBs
  - Swift, Fermi GBM, SVOM, etc

## Triggers from CTA

- Rate expected to be low – but identified events likely to be extremely important
- Serendipitous GRB detections possible, e.g. in divergent mode, huge potential for local, low-luminosity events



# CTA Technology

- Telescope prototype designs

**SST**

3 prototype designs



**MST**

2 prototype designs



**LST**



**GCT**



Paris

**SCT**



Arizona

**MST**



Berlin

**LST**



La Palma

**SST-1M**



Krakov



Sicily

ASTRI

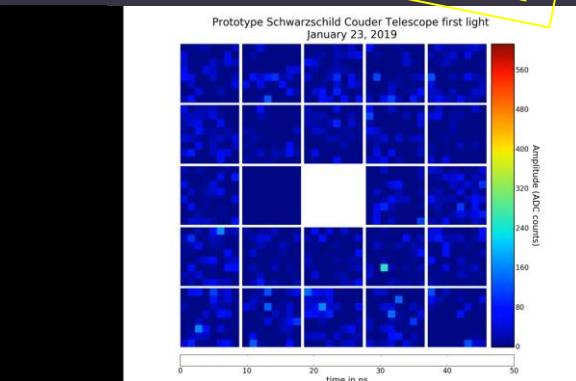
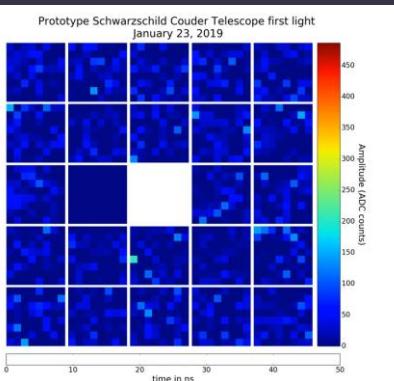


# The prototype telescope: pSCT

- **January 2019**

Inauguration of a prototype  
**Schwarzschild-Couder**  
**Telescope (pSCT)**  
 for CTA at the  
**Fred Lawrence**  
**Whipple Observatory**  
 in Amado, Arizona.

- A dual-mirrored Medium-Sized Telescope, the SCT is proposed to cover the middle of CTA's energy range (80 GeV – 50 TeV)

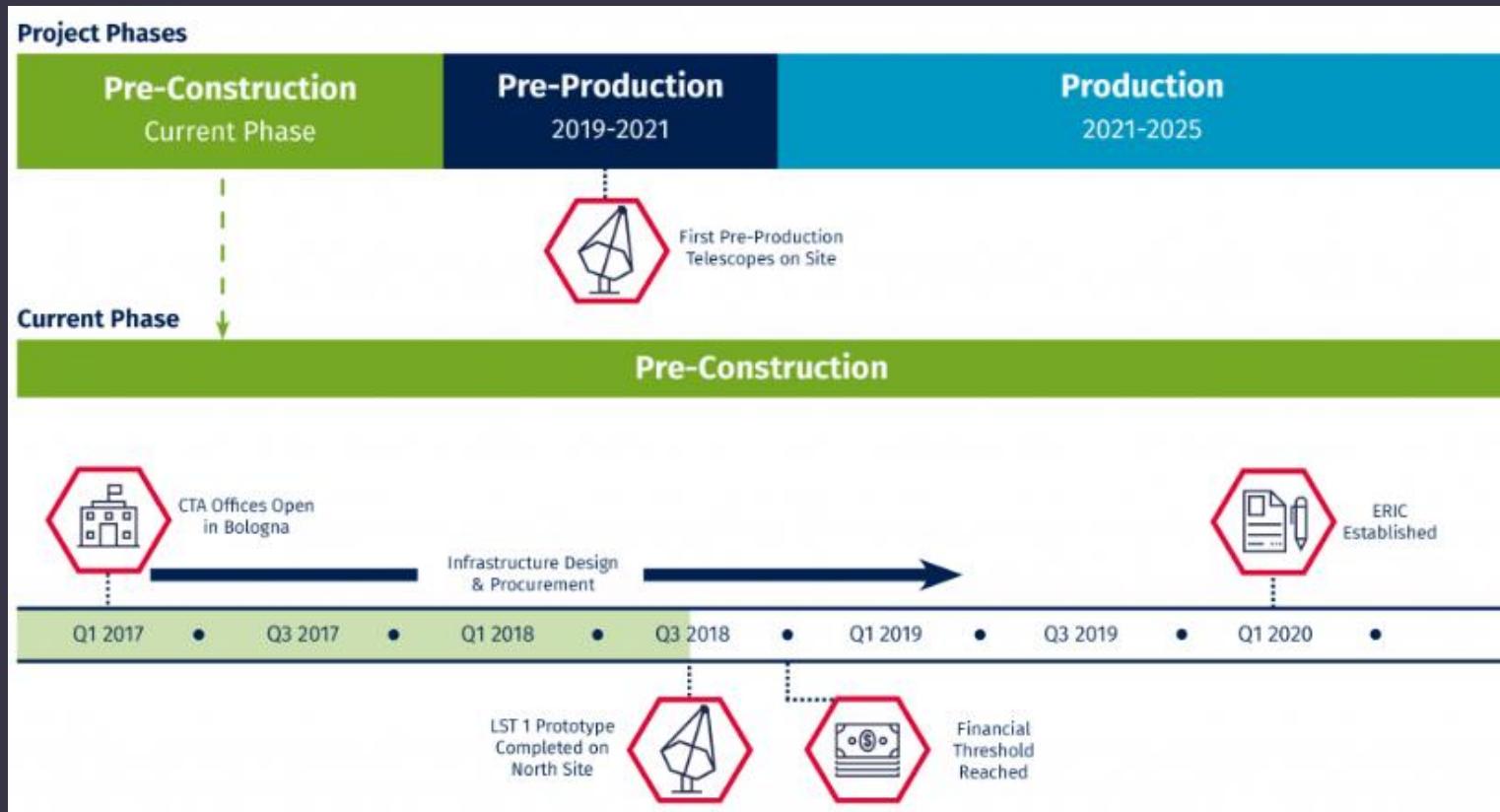


<http://cta-psct.physics.ucla.edu/>

# CTA Project status

- The project to build CTA is well-advanced

- The **Medium-Sized Telescope prototype** and **all three** proposed designs of the **Small-Sized Telescope** have achieved 'first light'
- The **Large-Sized Telescope prototype** was **inaugurated in October 2018**
- The **Schwarzschild-Couder Telescope prototype** was **inaugurated in January 2019**



# THANK YOU!

cta pSCT



# Backup

# The Schwarzschild-Couder Telescope (SCT)

- **Medium size telescope for CTA**
- **Dual mirror optics**
  - 9.7 m primary, 5.4 m secondary
  - 5.6 m focal length, f/0.58
  - 50 m<sup>2</sup> mirror dish area
  - PSF better than 4.5' across 8° FOV
- **SCTs can augment/replace MSTs in either the South or North Sites**
  - Increased gamma-ray collection area
  - Improved gamma-ray angular resolution

