Cherenkov Telescope Array

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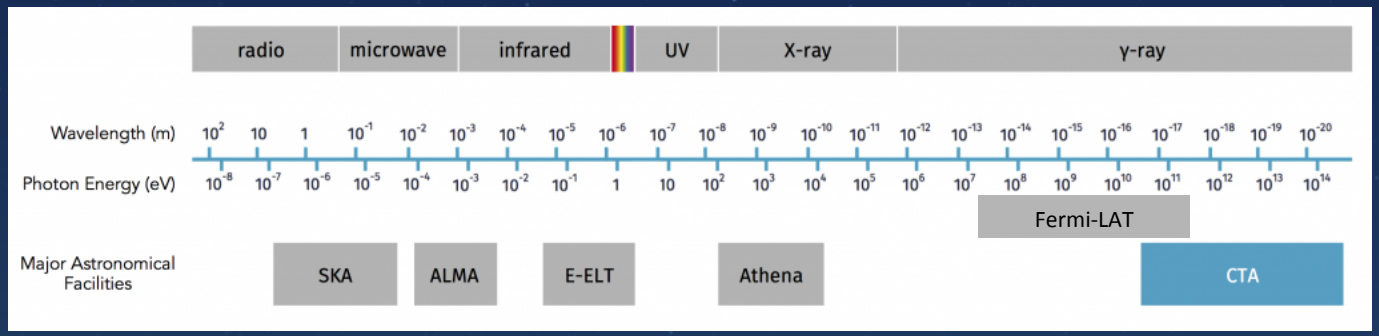
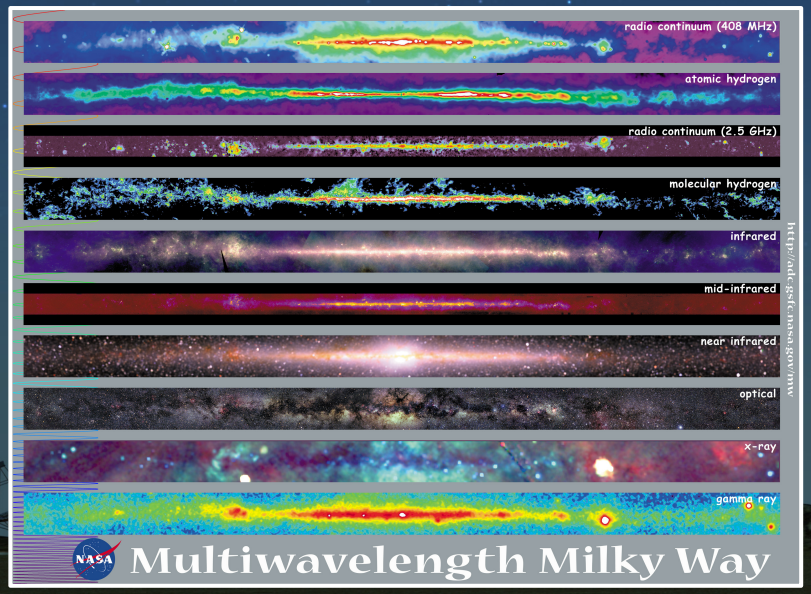
Particle Astrophysics in Poland, 20-21.05.2019

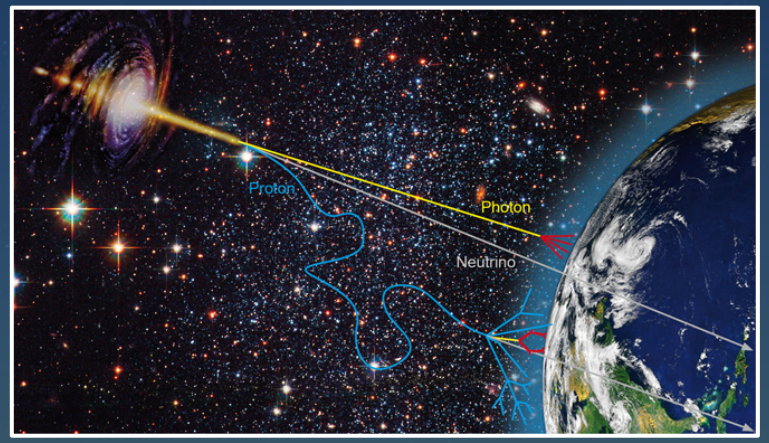
VHE gamma-ray astronomy



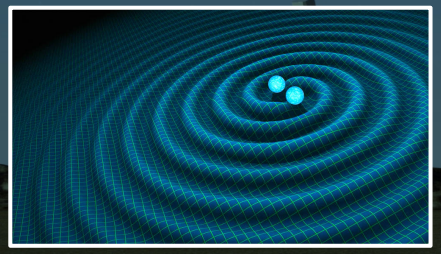
- Current instruments operating in 30 GeV – 100 TeV energy range
- Multi-wavelength and muliti-messenger approach



(NASA)



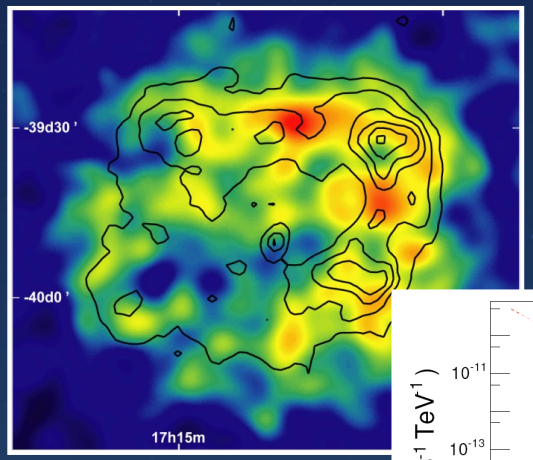
(DESY)



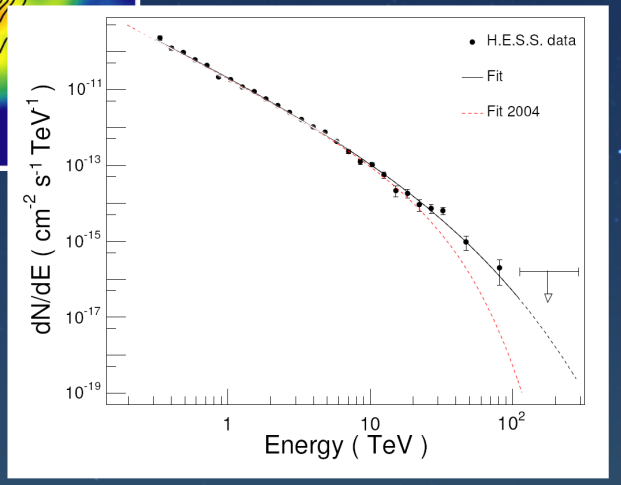
(R. Hurt/Caltech-JPL)

VHE gamma-ray astronomy today

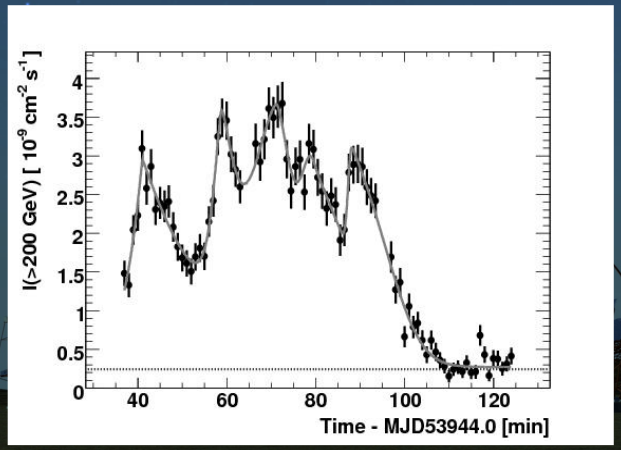
- Sky images and sky maps
- Dynamic range in gamma-ray flux:
  3 orders of magnitude
- Dynamic range in energy:
  3 decades
- Light curves on scales from
  minutes to years



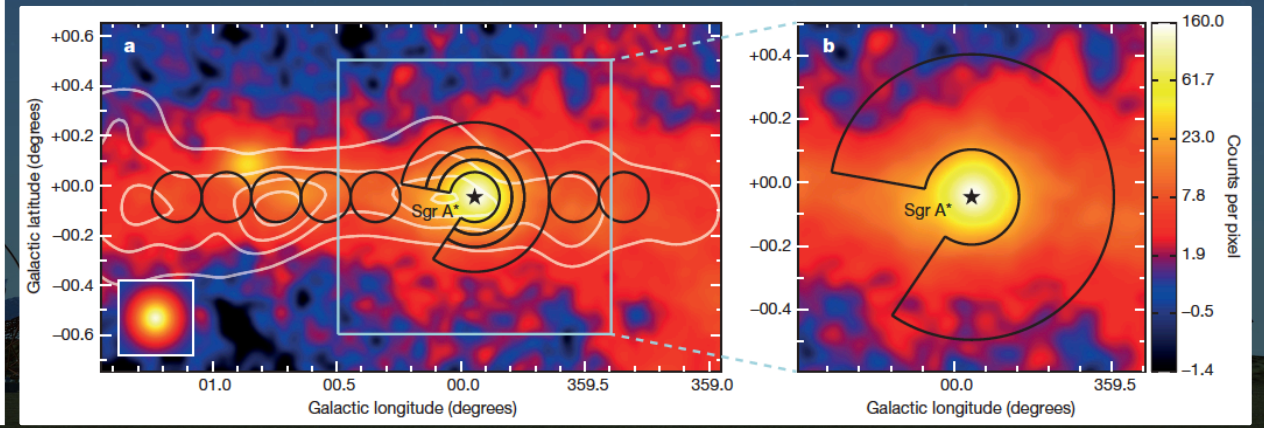
RXJ 1713.7-3946
[H.E.S.S.]



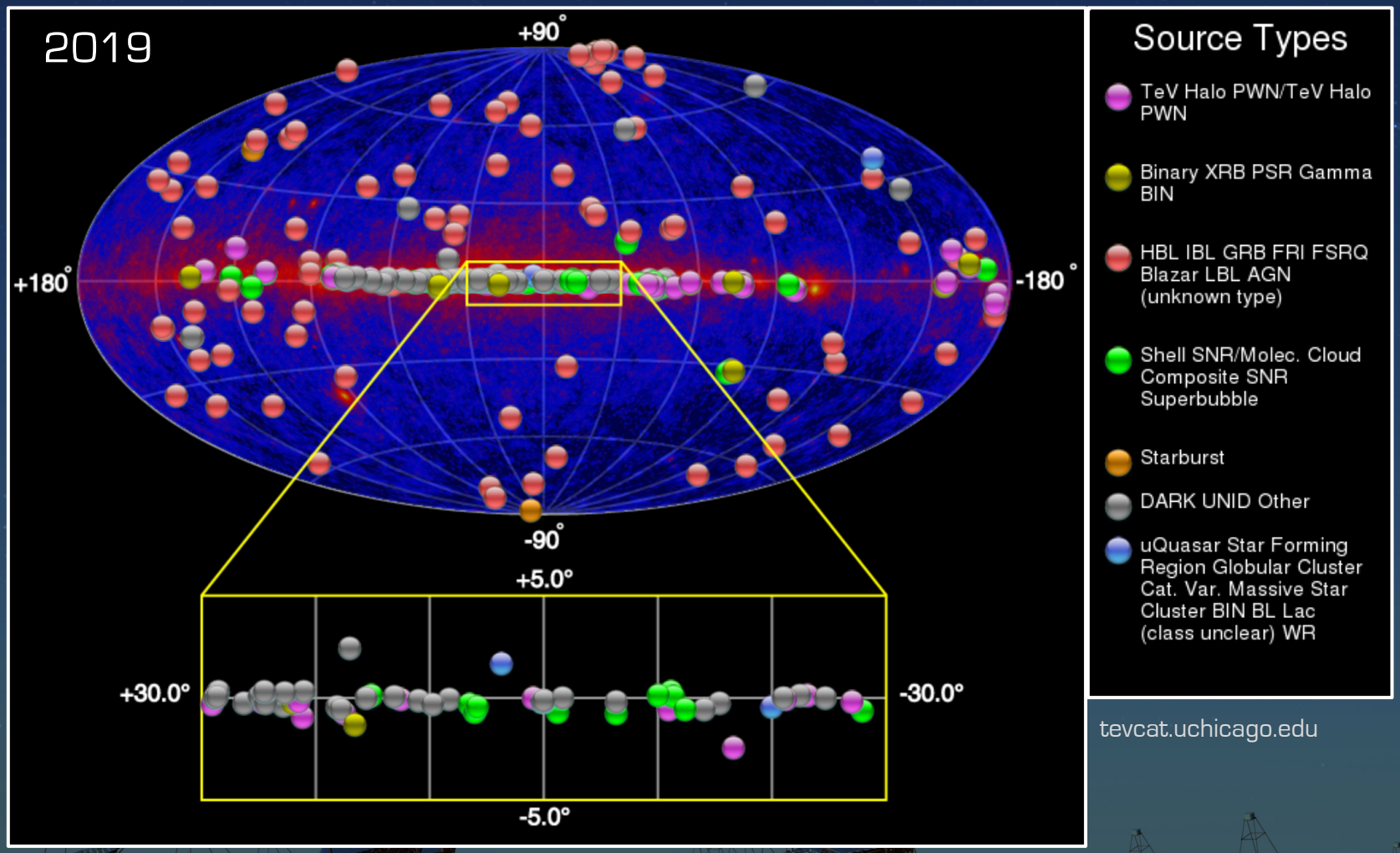
PKS 2155-304 [H.E.S.S.]



Galactic Center [H.E.S.S.]

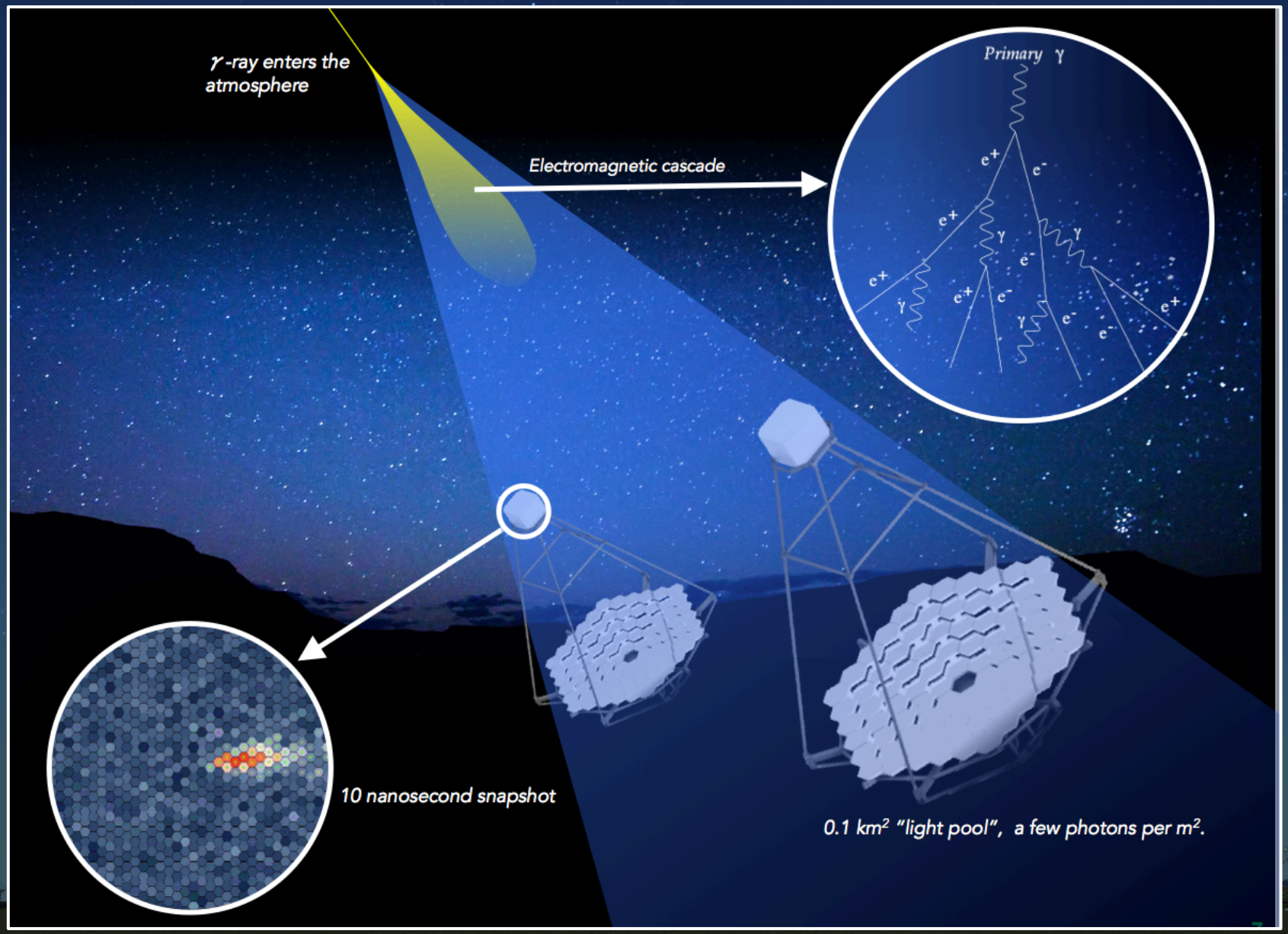


VHE gamma-ray astronomy today



More than 220 sources!

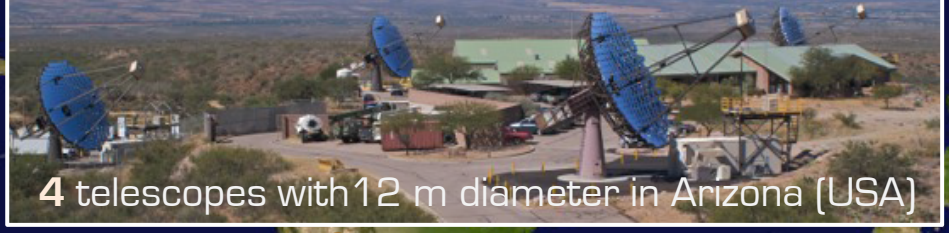
VHE gamma-ray astronomy with IACTs



(CTA)

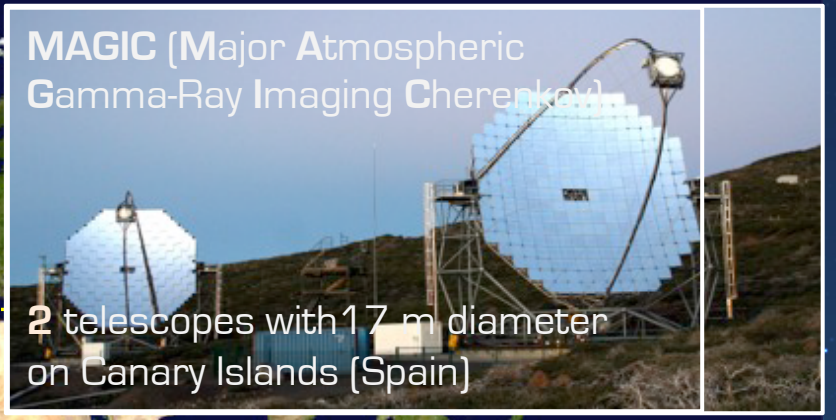
Current IACT gamma-ray observatories

VERITAS (**V**ery **E**nergetic **R**adiation **I**maging **T**elescope **A**rray **S**ystem)



4 telescopes with12 m diameter in Arizona (USA)

MAGIC (**M**ajor **A**tmospheric **G**amma-Ray **I**maging **C**herenkov)



2 telescopes with17 m diameter on Canary Islands (Spain)

+30º

-30º

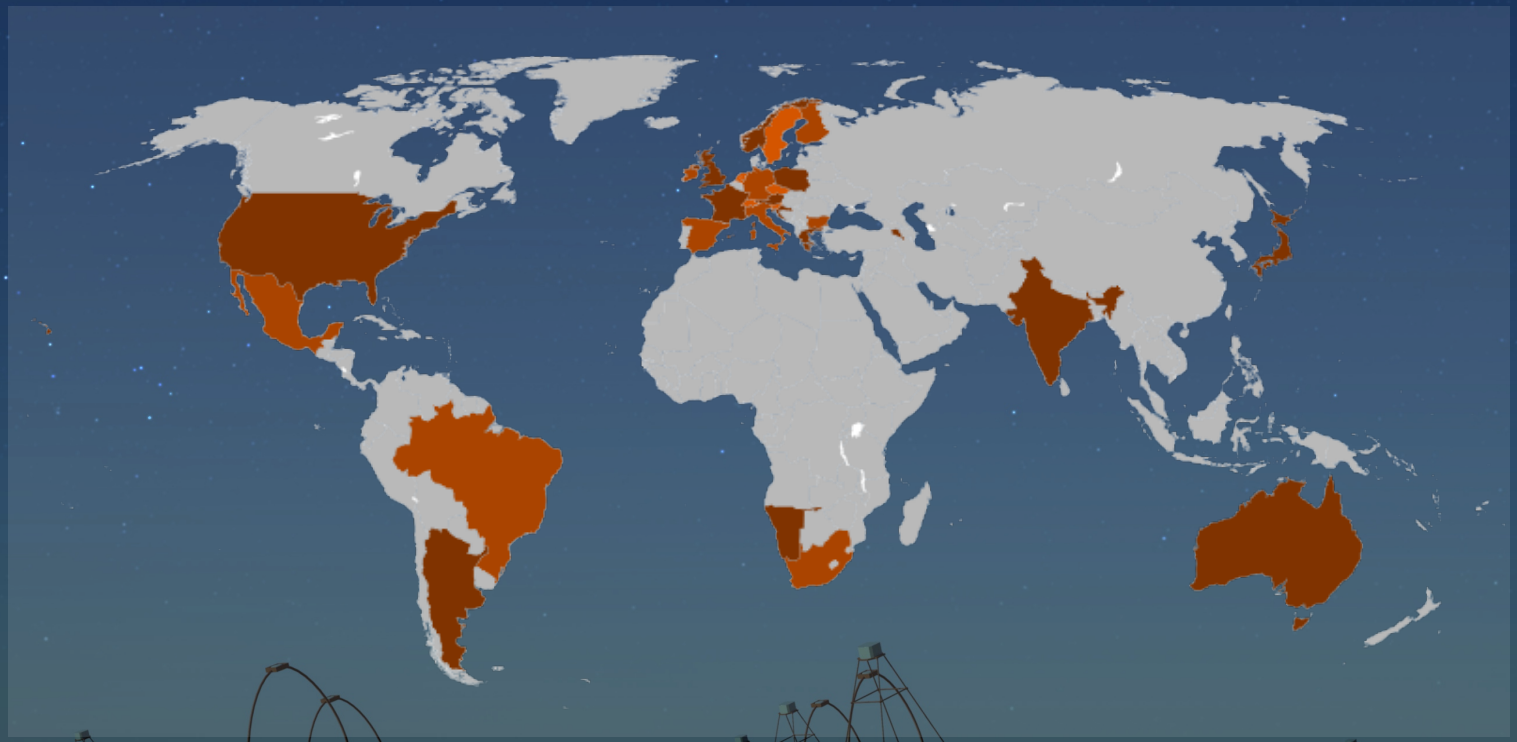
H.E.S.S. (**H**igh **E**nergy **S**tereoscopic **S**ystem)

4 telescopes with12 m diameter in Namibia, Additional 5th telescope with 28 m diameter

CTA: Cherenkov Telescope Array – the next generation project

cherenkov telescope array

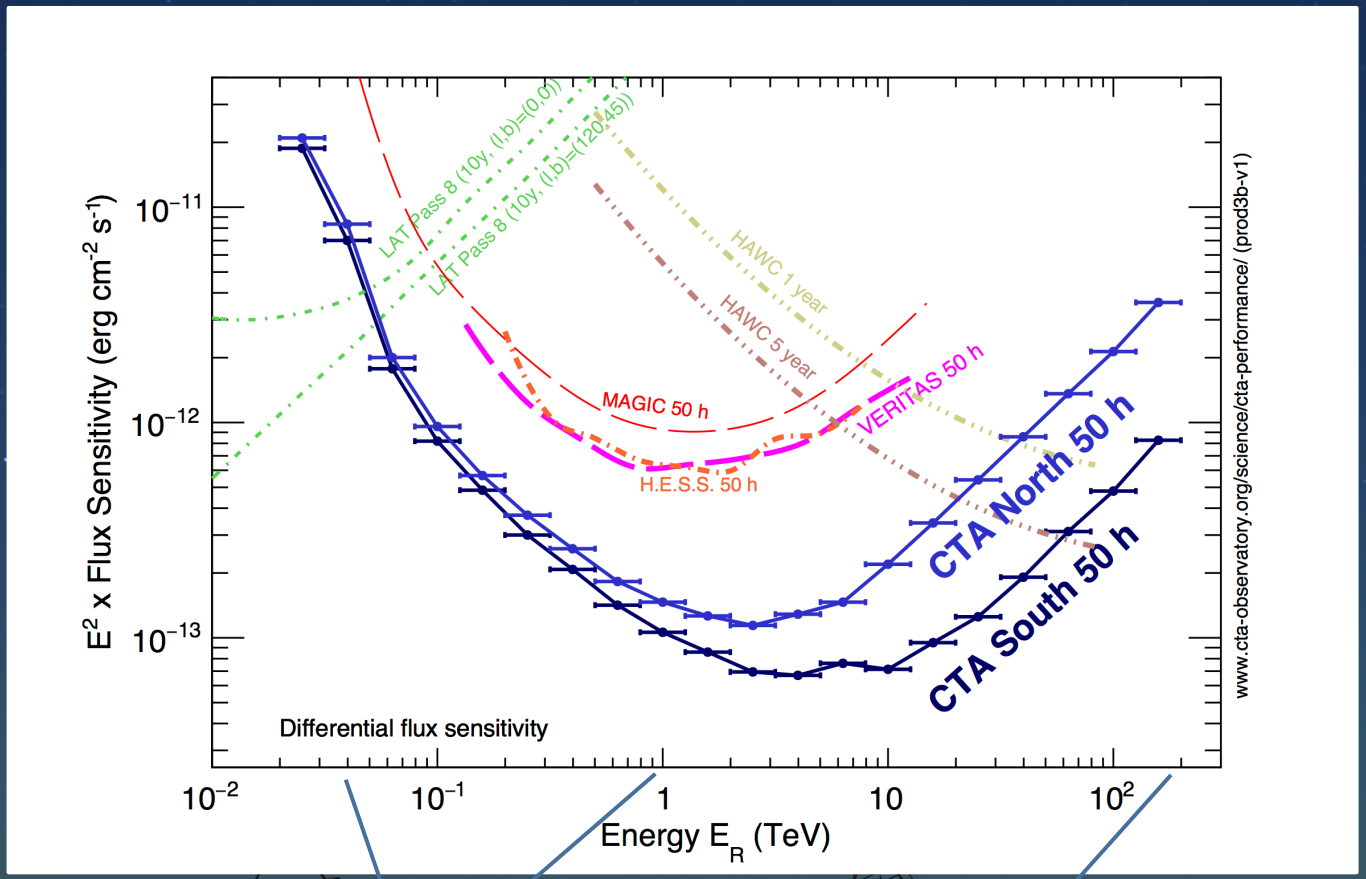
an observatory for ground-based gamma-ray astronomy



- 31 countries
- over 1400 members from over 200 institutions

CTA design drivers

- 10-fold increased sensitivity and wide energy range: 20 GeV – 300 TeV



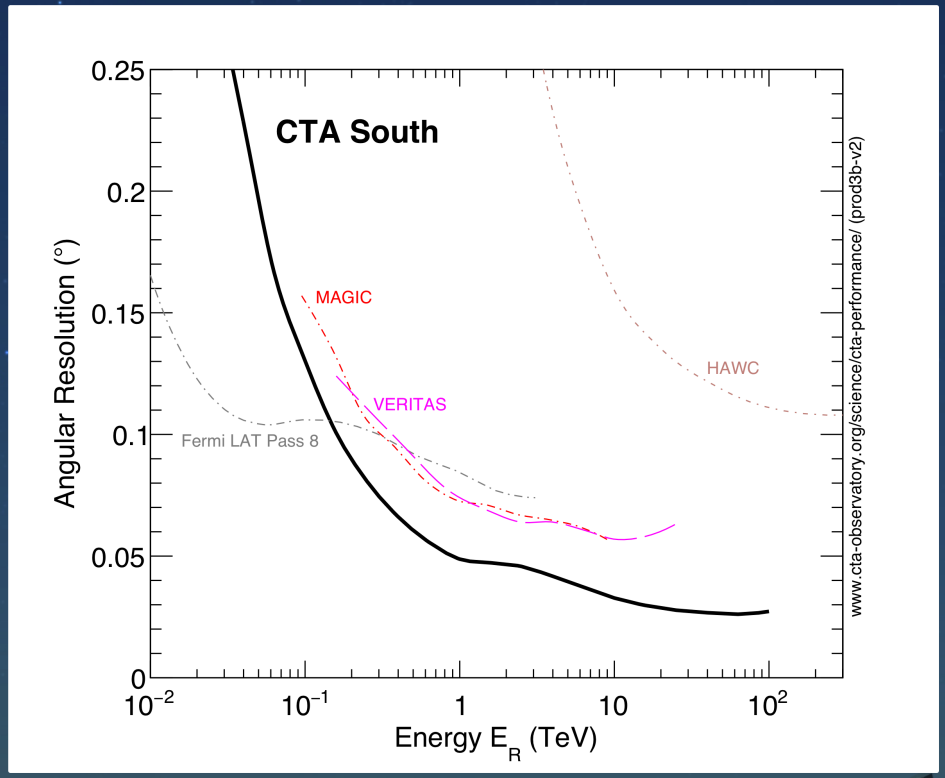
AGN, GRB, cosmology ++

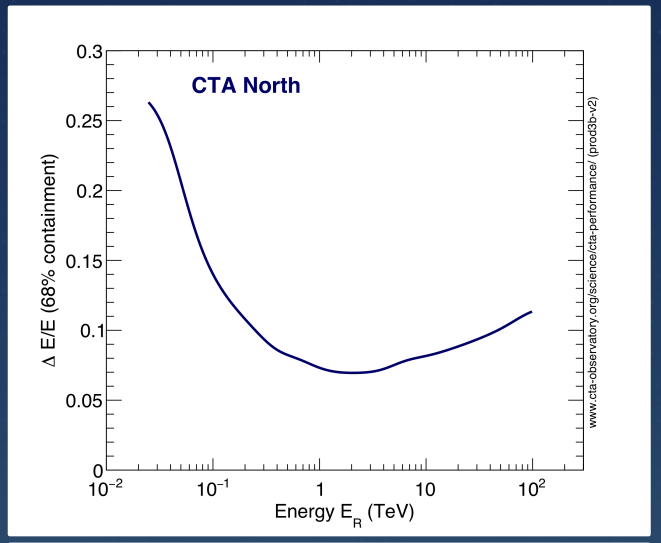
all science topics

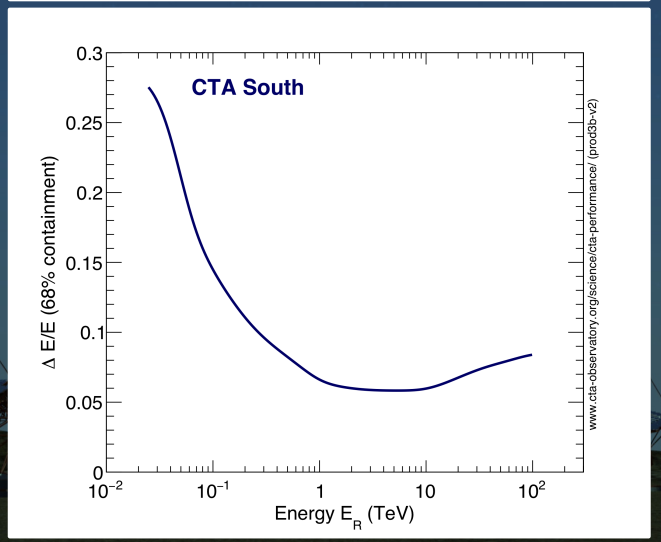
cosmic-ray origin

CTA design drivers

- large field of view, better angular resolution, energy resolution, and pointing precision

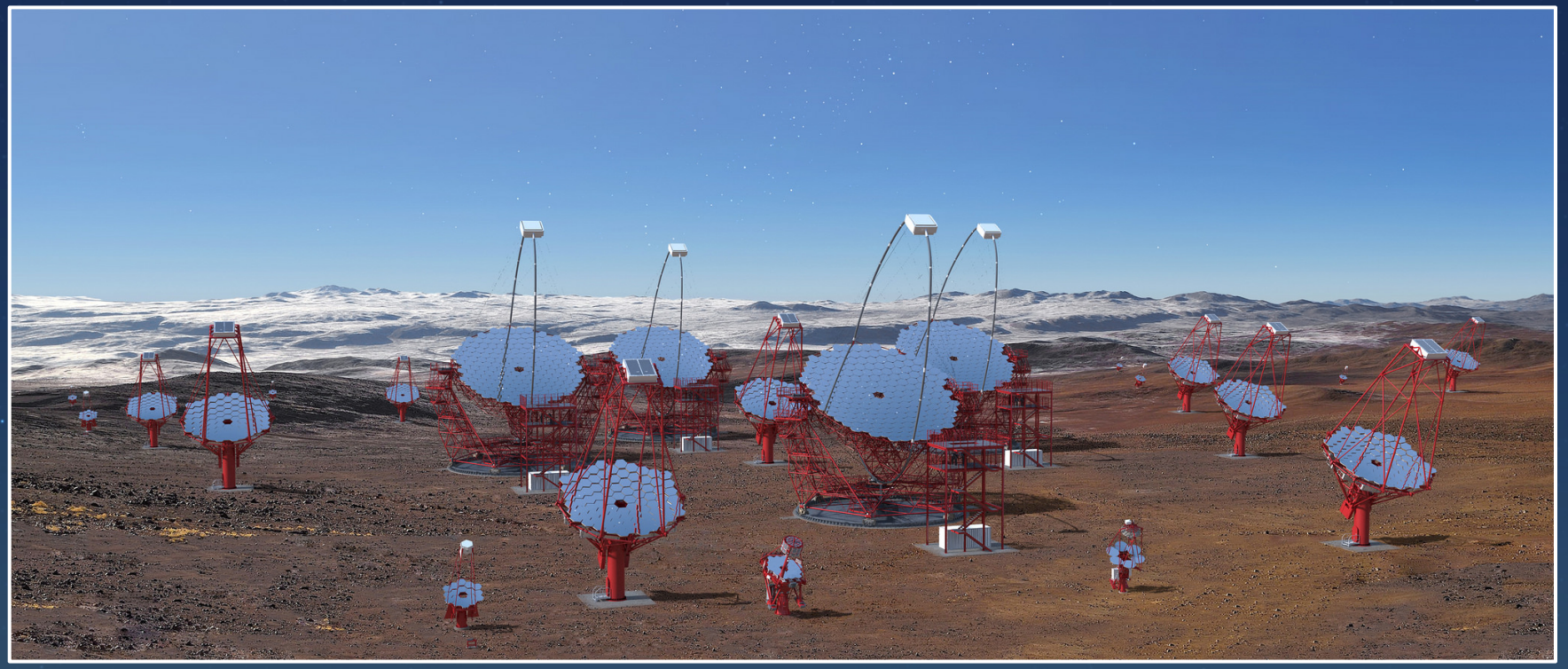






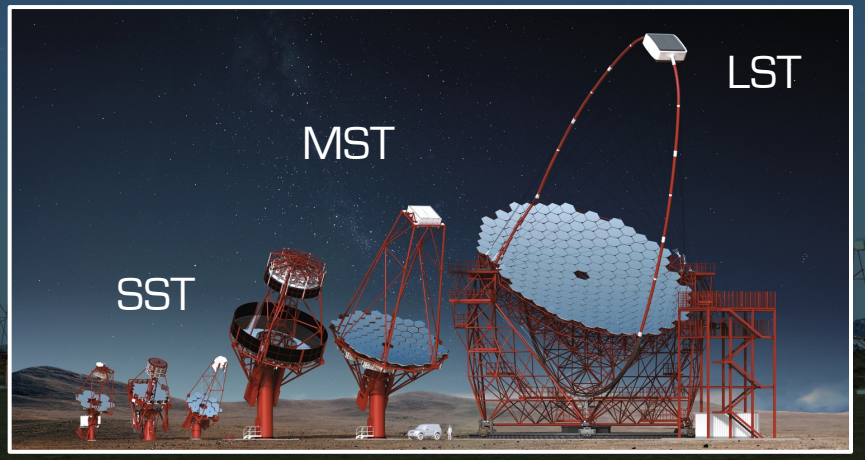
surveys, extended objects, detailed morphology, spectral features

CTA observatory design



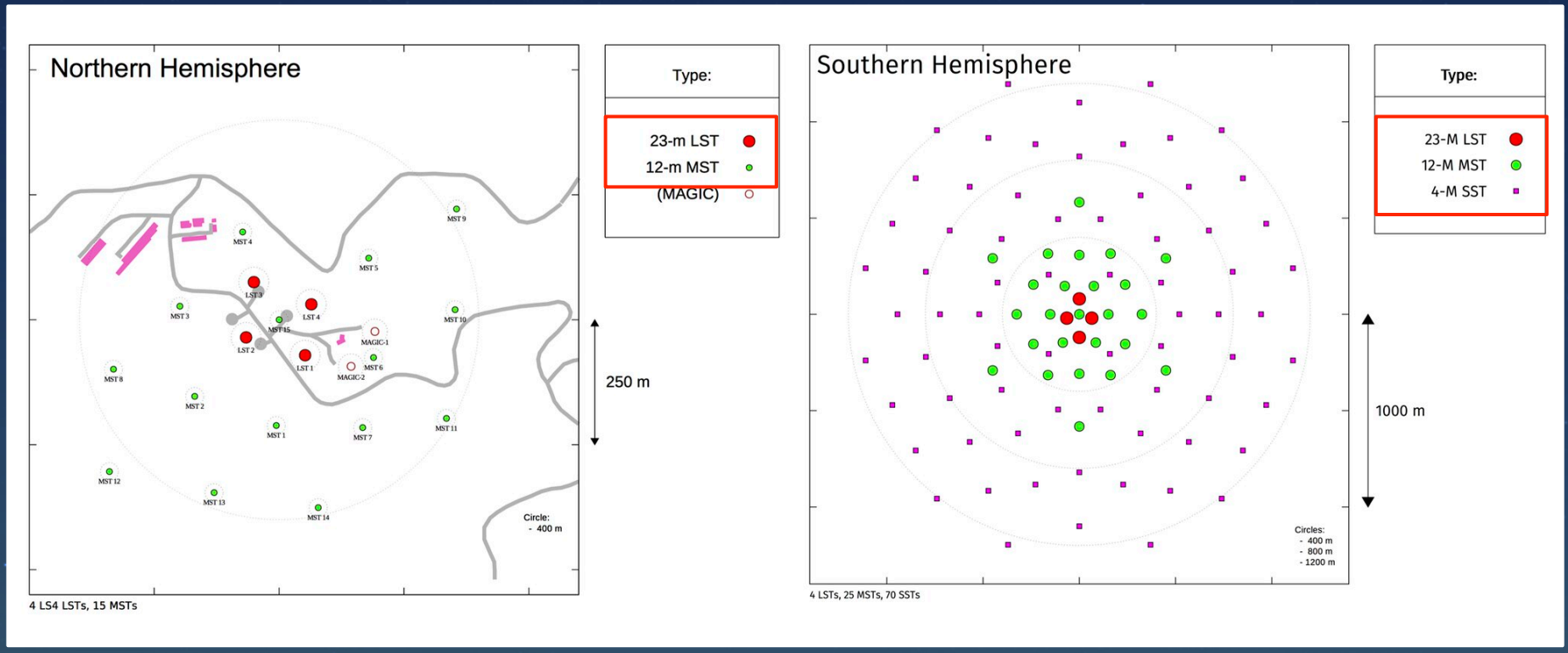
3 telescope types:

- large-size D=23 m (LST)
- medium-size D=12 m (MST)
- small-size D=4 m (SST)



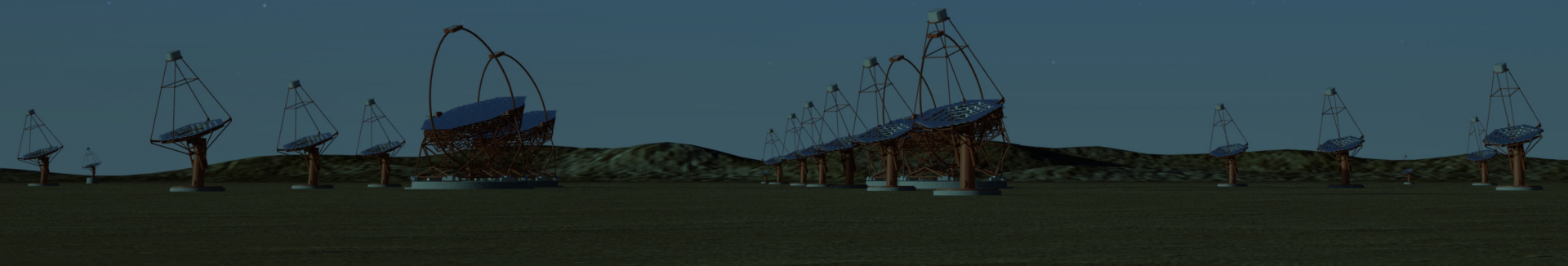
Northern and Southern Observatories

CTA observatory design – array layout



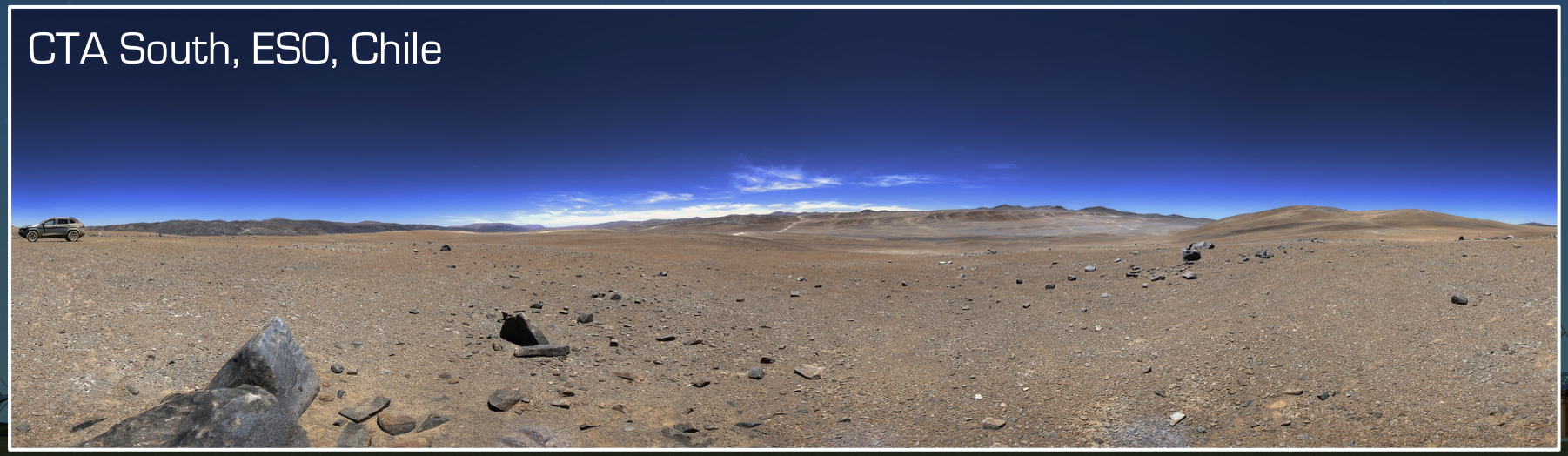
0.6 km^2

4 km^2



CTA observatory – a global collaboration

CTA observatory – selected sites



CTA – current status

Towards construction:

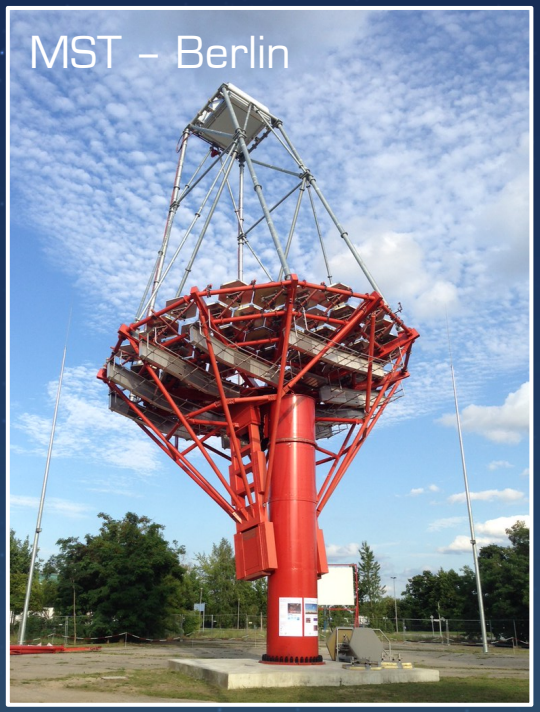
- Science vision & instrument concept
- Design phase
- Pre-construction/preparatory phase
- Construction phase
- Operation phase

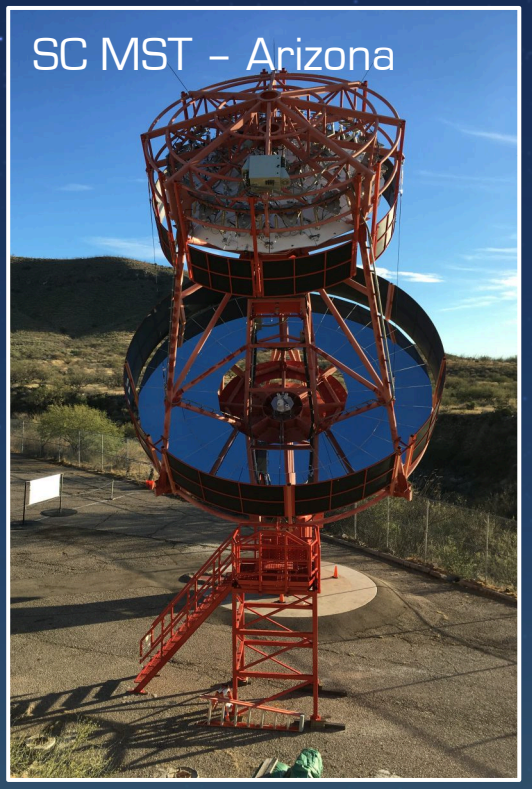
ESFRI 2018 Roadmap:
CTA as ESFRI Landmark

Legal orgnization:

- CTA Consortium & CTA Observatory – interim legal entity CTAO GmBH based in Heidelberg [11 shareholders + ESO, Poland as observer]
- Final legal entity – ERIC, in preparation
- MoU concerning the Funding of the Construction and Operation of the Cherenkov Telescope Array, in progress [Poland signed in October, 2018, 15 MEur contribution]

CTA telescope prototypes





Key Science Projects

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

- Processes close to neutron stars and black holes.
- Processes at relativistic jets, winds and explosions?
- Cosmic voids.

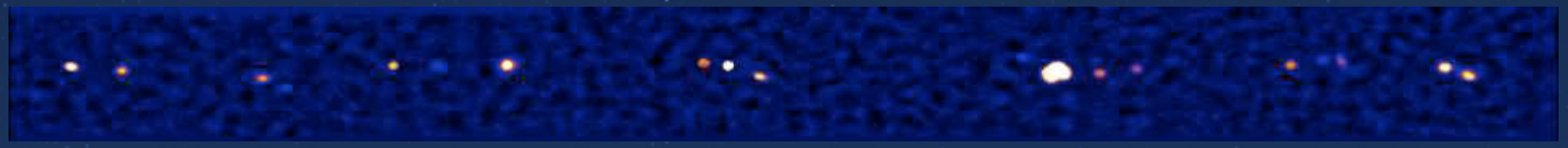
Theme 3: Physics Frontiers

- What is the nature of Dark Matter?
- Is the speed of light a constant?
- Do axion-like particles exist?

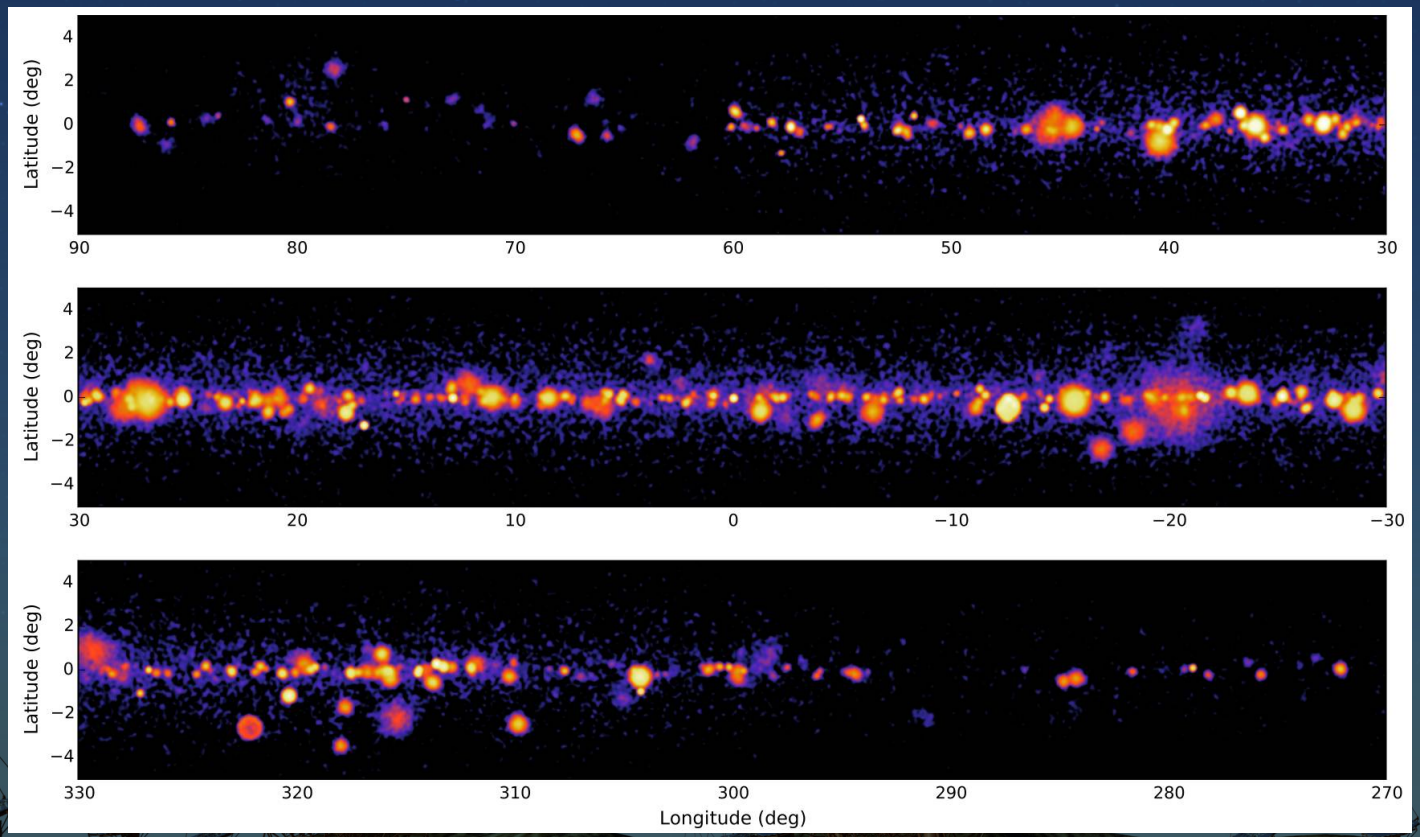
www.worldscientific.com/worldscibooks/10.1142/10986

CTA – venturing beyond the high-energy frontier

Galactic Plane – H.E.S.S.

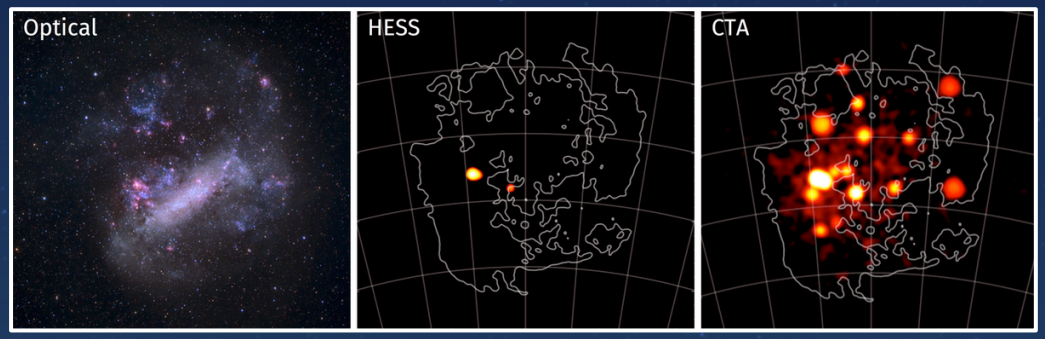


Simulated Galactic Plane Survey by CTA

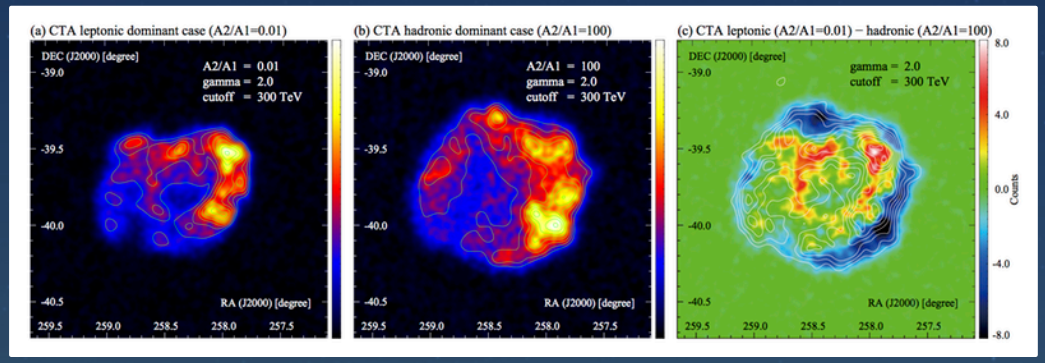


- Particle acceleration and transport – origin of cosmic rays

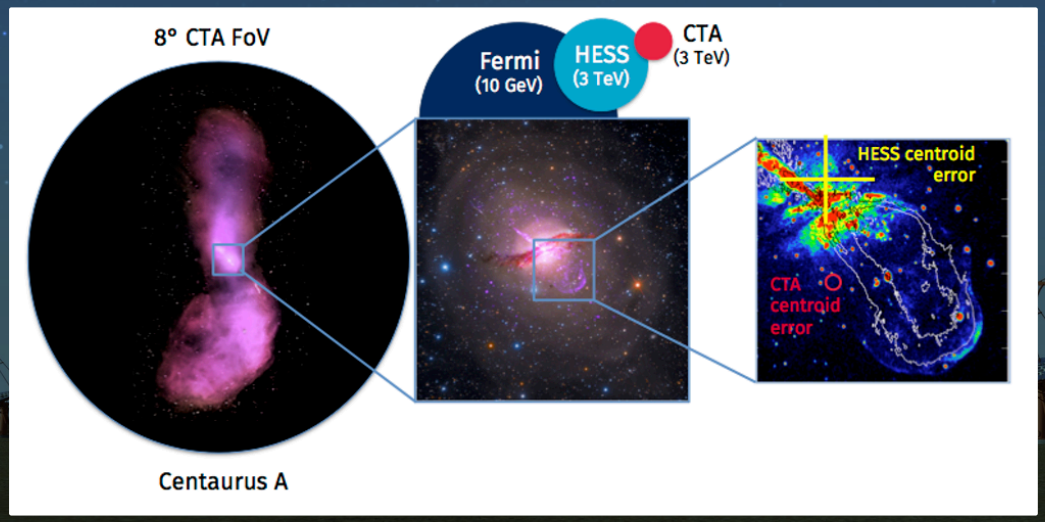
CTA – venturing beyond the high-energy frontier



LMC – sensitivity



RXJ 1713.7-3946 – extended source imaging and detailed morphology



Centaurus A – resolving power

Poland in CTA

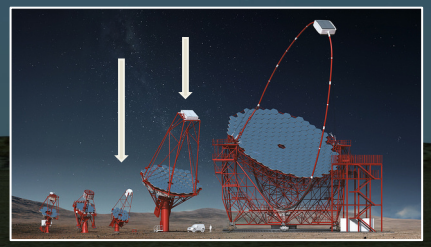
Polish Consortium of the CTA Project – 13 institutions, about 80 members (leader – Jagiellonian University in Kraków)

The main instrumental contributions:

- composite mirrors for MSTs developed at IFJ PAN
- Single-mirror SST – Polish-Swiss-Czech collaboration (leader – IFJ PAN)

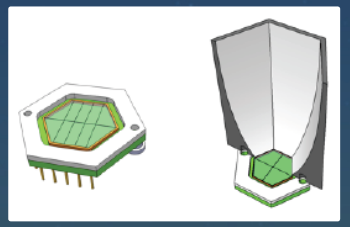
Glass-aluminum composite mirror for MST.
Size: 1.2 m (ftf), Focal length 16.14 m,
PSF < 20 mm

SST-1M; inauguration in June 2014 at the test site in IFJ PAN, Kraków.
Dish size: 4 m, Focal length 5.6 m, 18 spherical mirrors
Field of view 9,1°
Silicon photomultipliers based camera with fully digital readout electronics (DigiCam); 1296 pixels



SST-1M

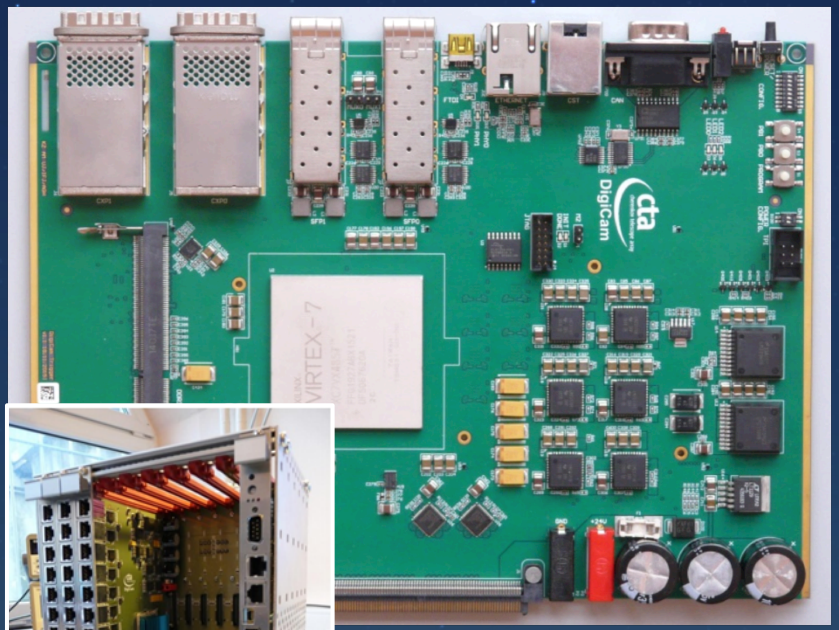

SST-1M prototype at IFJ PAN in Kraków

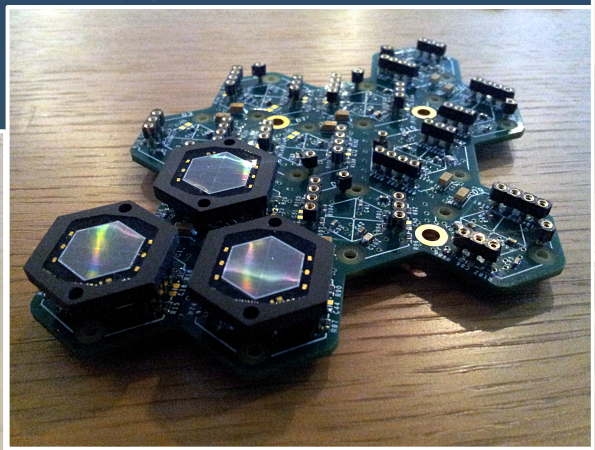


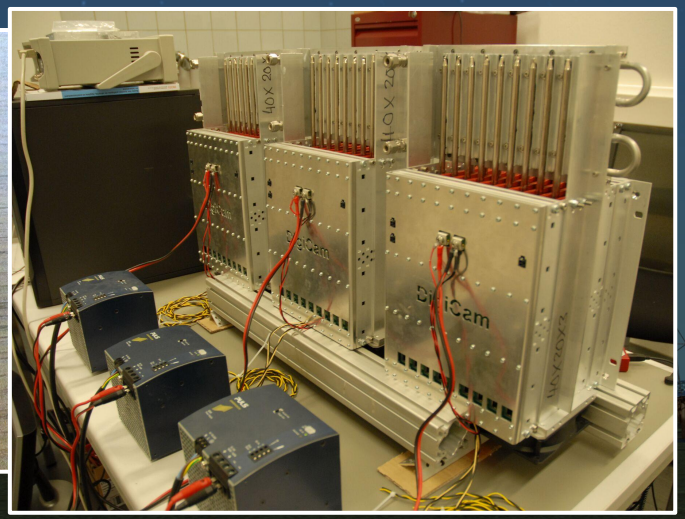
- Focal length 5,6 m
- Dish size 4 m
- 18 spherical mirrors (78 cm, f=5,6 m)

- 1296 pixels
- Camera field if view 9,1°
- Silicon-based haxagonal photomultipliers

SST-1M prototyping

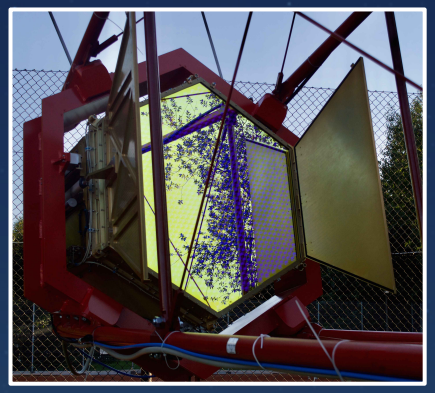




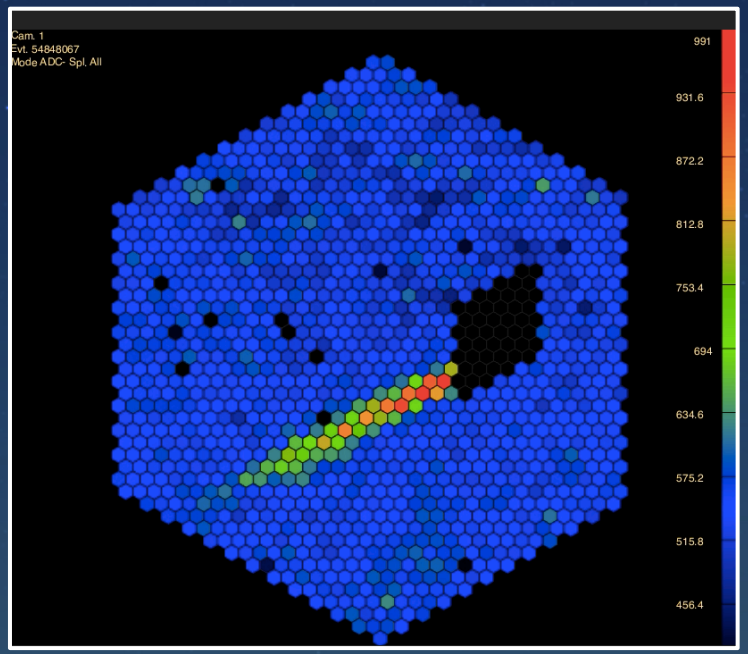


- Mechanical structure and drive system (IFJ PAN)
- Novel fully digital camera with silicon photomultipliers – DigiCam project (UJ, AGH, UniGe)
- Optical system, mirror alignment, telescope pointing (CBK PAN, FZU, CAMK PAN, IFJ PAN)
- Data aquisition system with central trigger system, computer modeling (CAMK PAN, CBK PAN, CYFRONET, UŁ, IFJ PAN, UniGe)

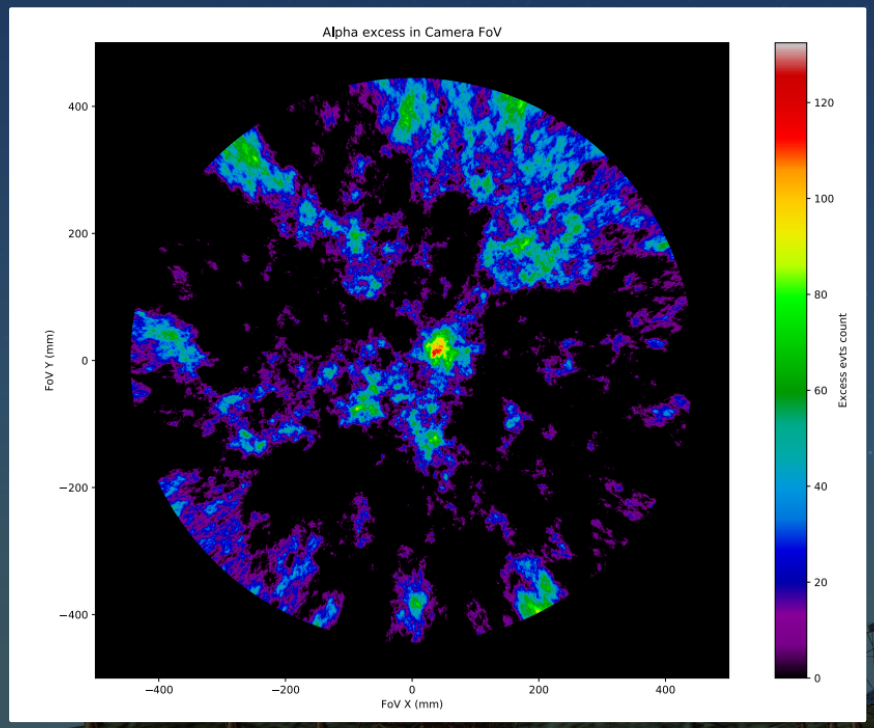
SST-1M project status



First light – September 2017



γ ray shower



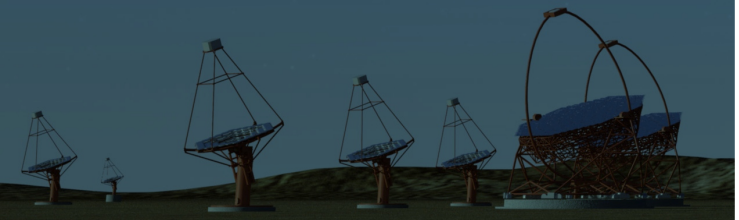
Crab Nebula detection

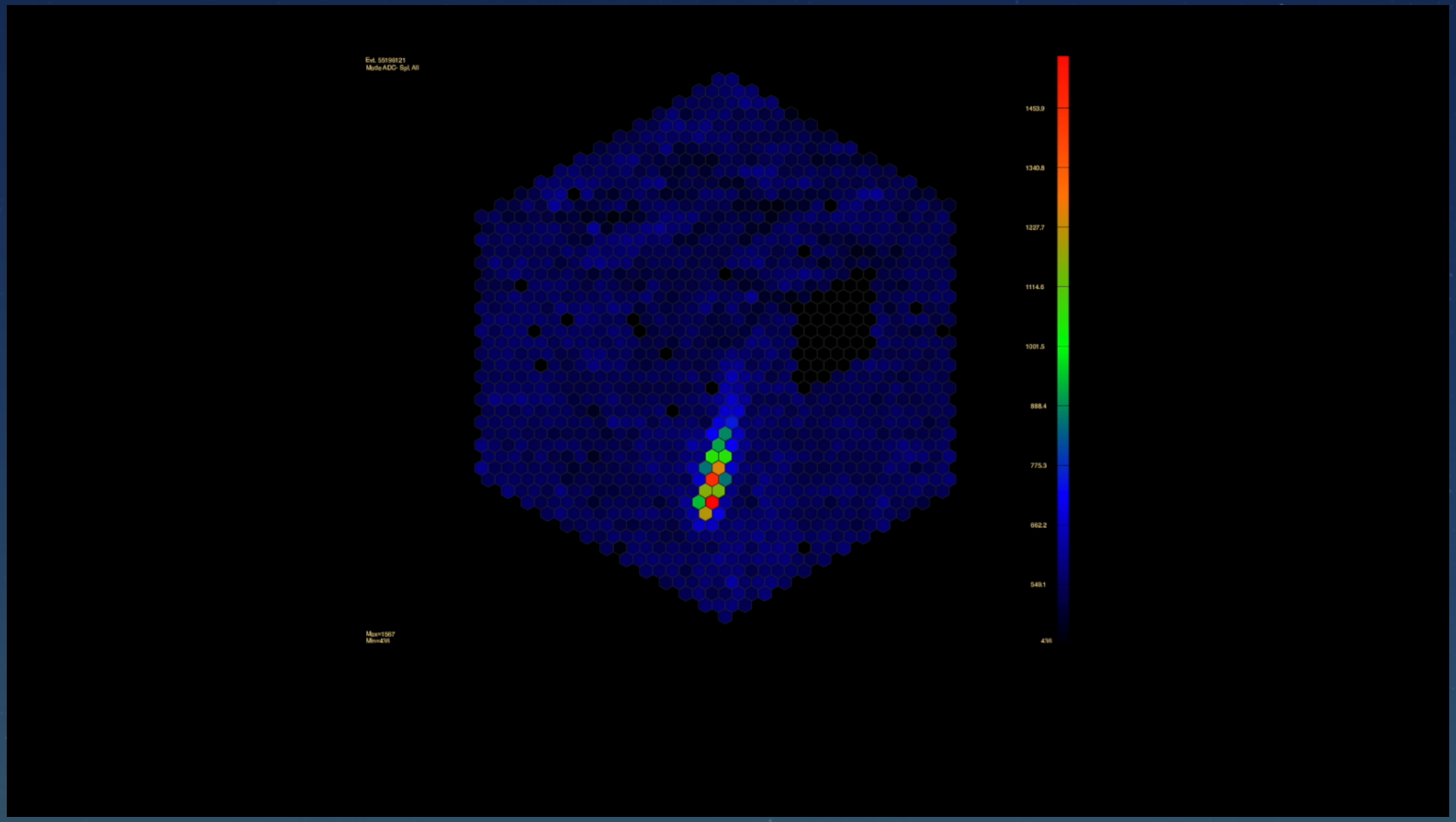
SST-1M project status

- Funding by MNiSW of the project: SST-1M Mini-array Construction and Testing as Technology Demonstrator for the Cherenkov Telescope Array
- Agreement between University of Geneva, Institute of Physics, Czech Academy of Sciences and IFJ PAN representing Polish Consortium of the CTA Project
- 6,87 mln PLN in years 2018-2019
- Executed by: IFJ PAN (coordinator), UJ, AGH, CAMK PAN
- Main goals:
  - completing the construction and testing of the SST-1M prototype
  - construction of the second prototype and mini-array installation at a test site in the Geneva Observatory
  - testing, validation of components and solutions, implementation of necessary design changes, calibration, verification against CTA requirements and specifications
  - science program (blazar monitoring, measurement of diffuse gamma-ray background, optical intensity interferometry)
- Project status – production of the second SST-1M telescope in progress

SST „harmonization”

- Only a single solution for the SST can be accepted by CTA
- Harmonization process started in the Spring of 2018
- Panel of external experts appointed by CTA Council in late 2018
- Review took place in Bologna in March 2019
- SST-1M evaluated as the best project
- Decision on the final selection of the SST telescope to be taken soon by the CTA Council





Thank you for your attention.

Jacek.Niemiec@ifj.edu.pl