

CTAO Overview



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on behalf of the CTA Observatory

γ - 2022– July 08, 2022



- The first ground-based gamma-ray observatory
 - Broadest energy range amongst IACTs: 20GeV to 300 TeV
 - Serve large user community data & science tools in fair way
 - Proposal-driven observatory
- 30 yrs of lifetime
 - Significant effort for maintenance and operations costs optimization
- One legal entity: CTAO GmbH became an ERIC with HQ in Bologna (Italy) and the Science Data Center in Zeuthen (Germany)
- Two telescopes arrays, one Observatory
 - Inter-site coordination
 - Uniform approach to scientific operations

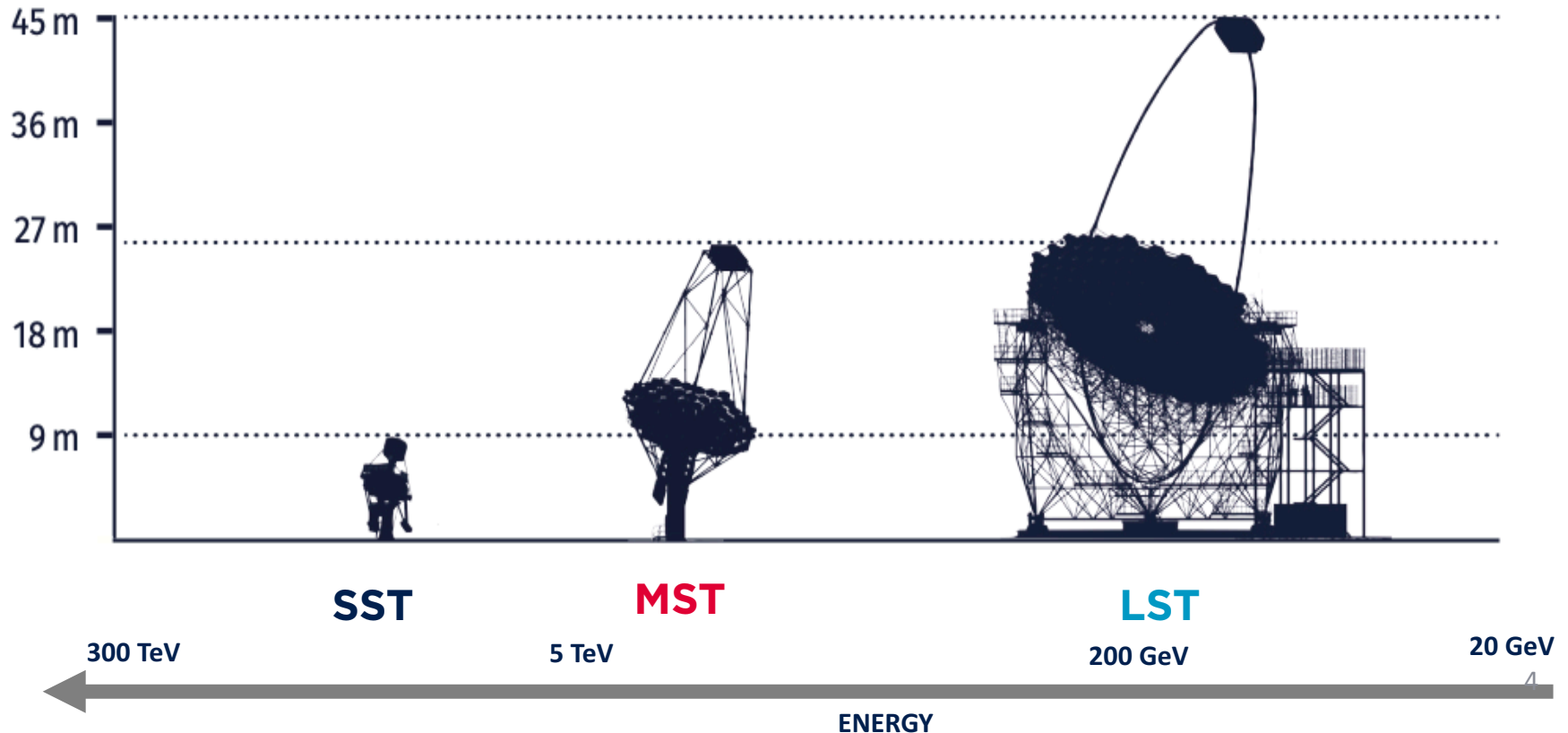
The CTAO sites



3 telescope designs



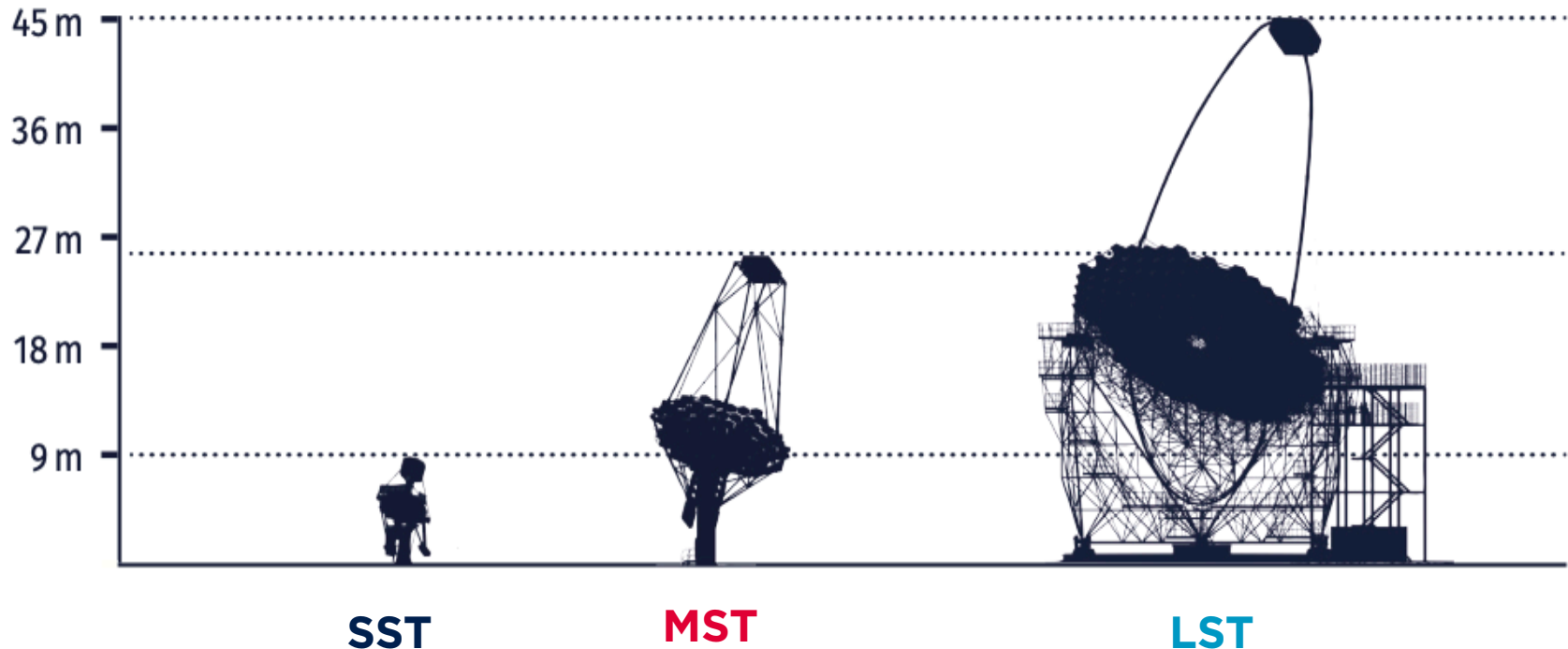
- 2-mirror Schwarzschild-Couder optical design
 - 4.3 m \varnothing primary reflective surface
 - SiPM camera: 2048 pixels (0.16°)
 - 8.8° FoV
 - 17.5 tonne
- Davies-Cotton optical design
 - 12 m \varnothing reflective surface
 - PMT camera – 2 designs:
 - NectarCam: 1855 pixels
 - FlashCam: 1764 pixels
 - $\sim 7^\circ$ FoV
 - 82 tonne
- Parabolic optical design
 - 23 m \varnothing reflective surface
 - PMT camera: 1855 pixels
 - 4.3° FoV
 - 100 tonne



Science cases and design



- Precision measurements in a still little explored energy range
- **100TeV range unexplored with IACTs**
- **Precision studies**
- **Deepest sensitivity ever**
- **Arcmin angular resolution**
- **Large FoV**
- **Surveys & precision studies**
- **Lowest energies (tens of GeV)**
- **Cosmological sources**
- **Deepest sensitivity for short timescales phenomena**
- **Time domain unexplored**

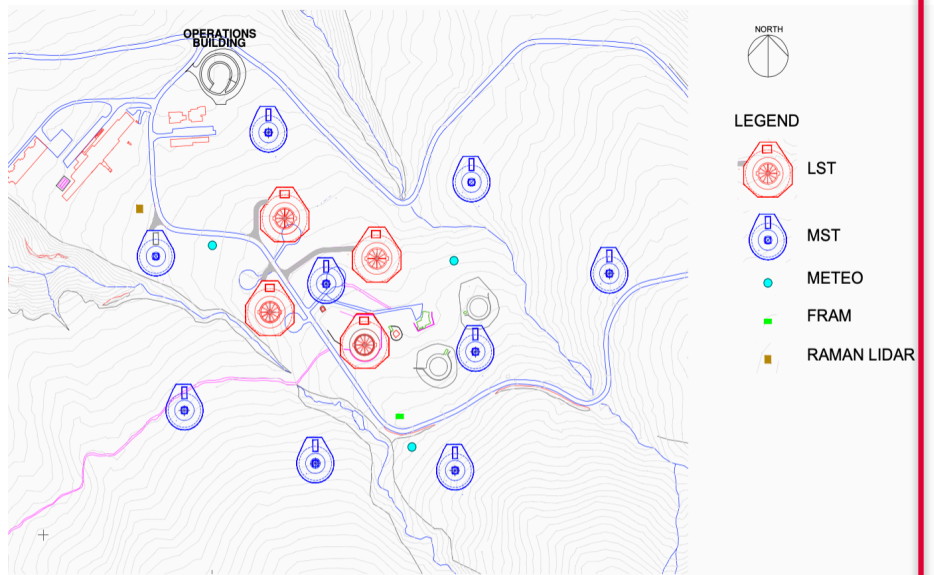


Arrays configuration



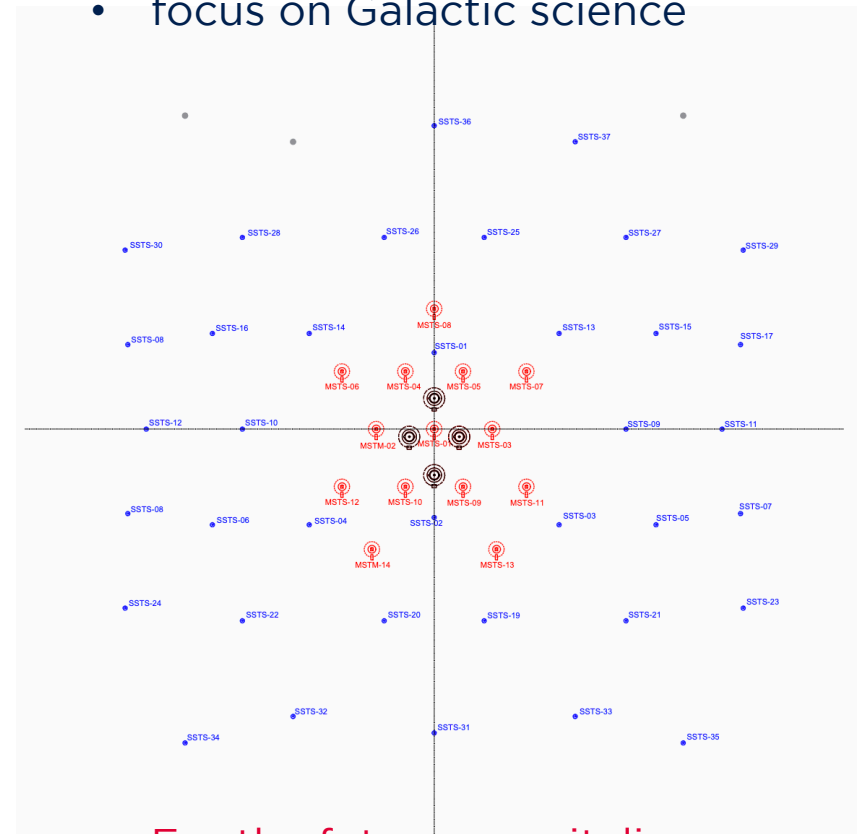
CTAO Northern Array

- 4 LSTs + 9 MSTs
- 0,25 km² footprint
- focus on extra-Galactic science



CTAO Southern Array

- 14 MSTs + 37 SSTs
- 3 km² footprint
- focus on Galactic science



- For the future: new italian foundings for **2 LST** and **5 SST**

Design drivers



Energy down to
20 GeV

Energy up
to 300 TeV

Rapid
slewing 20
sec

Full sky
coverage

10% energy
reconstruc
tion

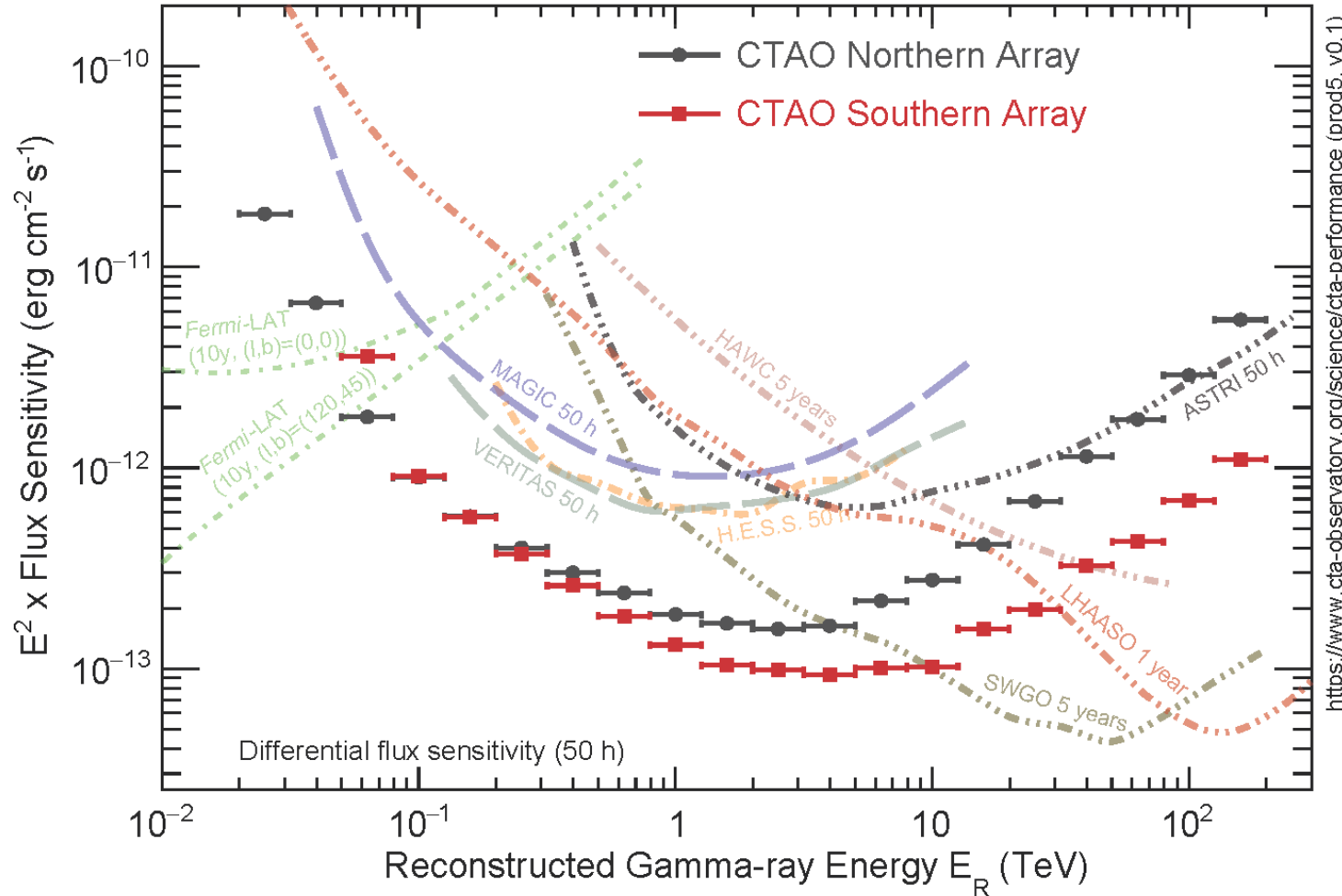
Arcmin
angular
resolution

$\sim 10^\circ$ FoV

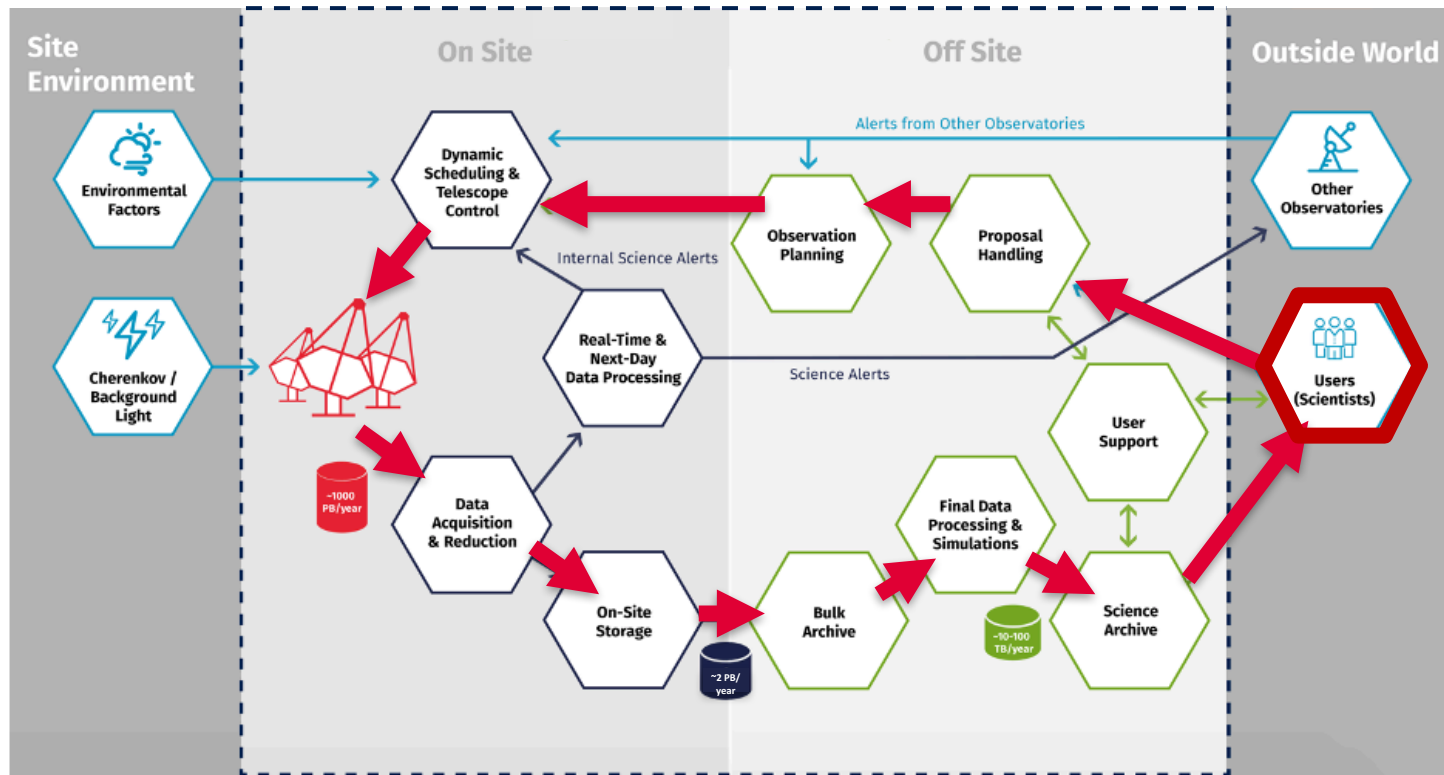
10x
sensitivity

30 sec
response

CTAO performance



CTA Observatory



- **Proposal-driven observatory:** standard proposals & long and large proposals (including Key Science Projects)
- **Proposals evaluated on scientific merits** by a Time Allocation Committee

CTAO Timeline



Pre-Construction

Current Phase

Pre-Production

2022-2023

Production

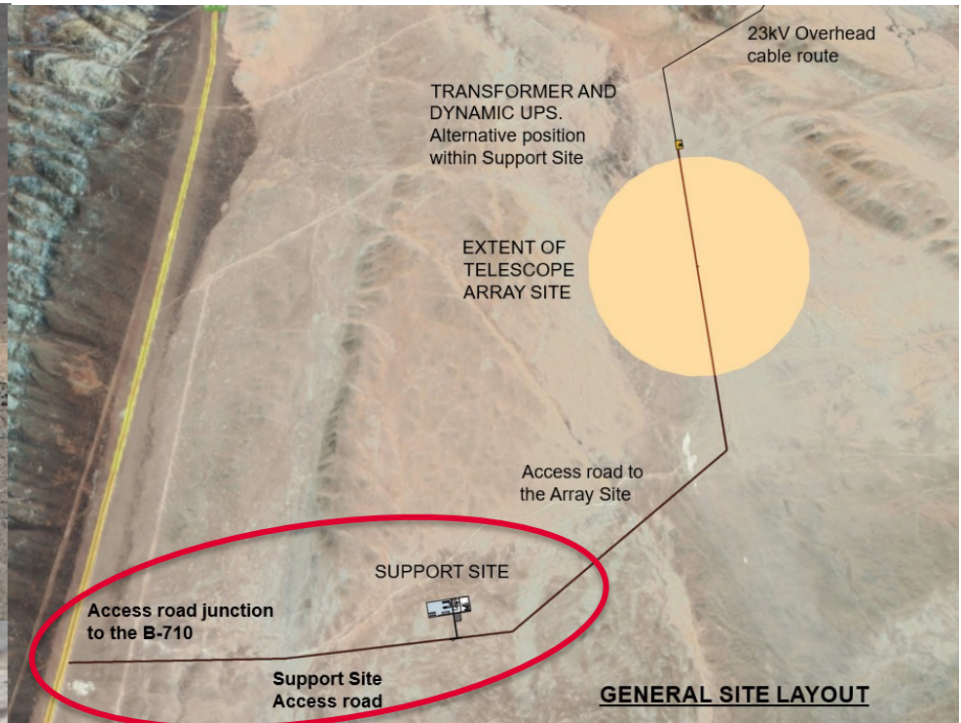
2023-2027

- **CTAO construction scope is agreed**
- The construction phase will start with the establishment of the final legal entity: CTAO European Research Infrastructure Consortium (ERIC)
 - Step 2 application submitted on end of May
 - ERIC operative beginning 2023
 - last about 5 yrs
- Early science operations foreseen during the construction phase

The present: South site



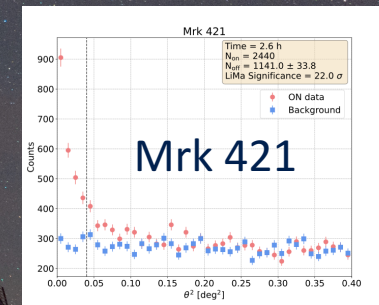
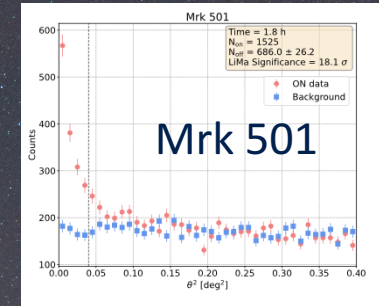
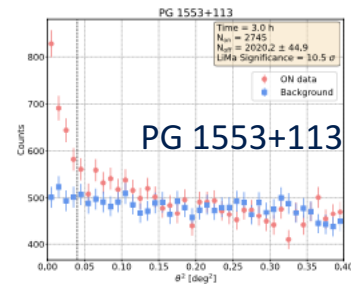
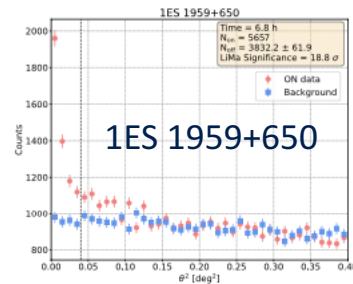
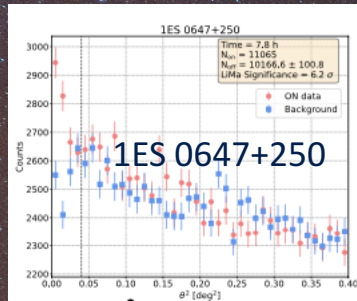
7 March 2022



The present: North site



Several known gamma-ray sources already detected, mainly AGNs



Detection of very-high-energy gamma-ray emission from BL Lac with the LST-1

ATel #14783; *Juan Cortina for the CTA LST collaboration*
on 13 Jul 2021; 21:03 UT
Credential Certification: Juan Cortina (Juan.Cortina@ciemat.es)

See Juan Cortina's talk

The present: Data Center



- On 2 March 2022, a ceremony was held at DESY Zeuthen for the laying of the SDMC ground stone



Credit and Copyright:
Heinle, Wischer und Partner, Freie Architekten, Berlin

(image rights: DESY / www.marco-urban.de)

The present: CTAO/CTAC general meeting



cherenkov
telescope
array

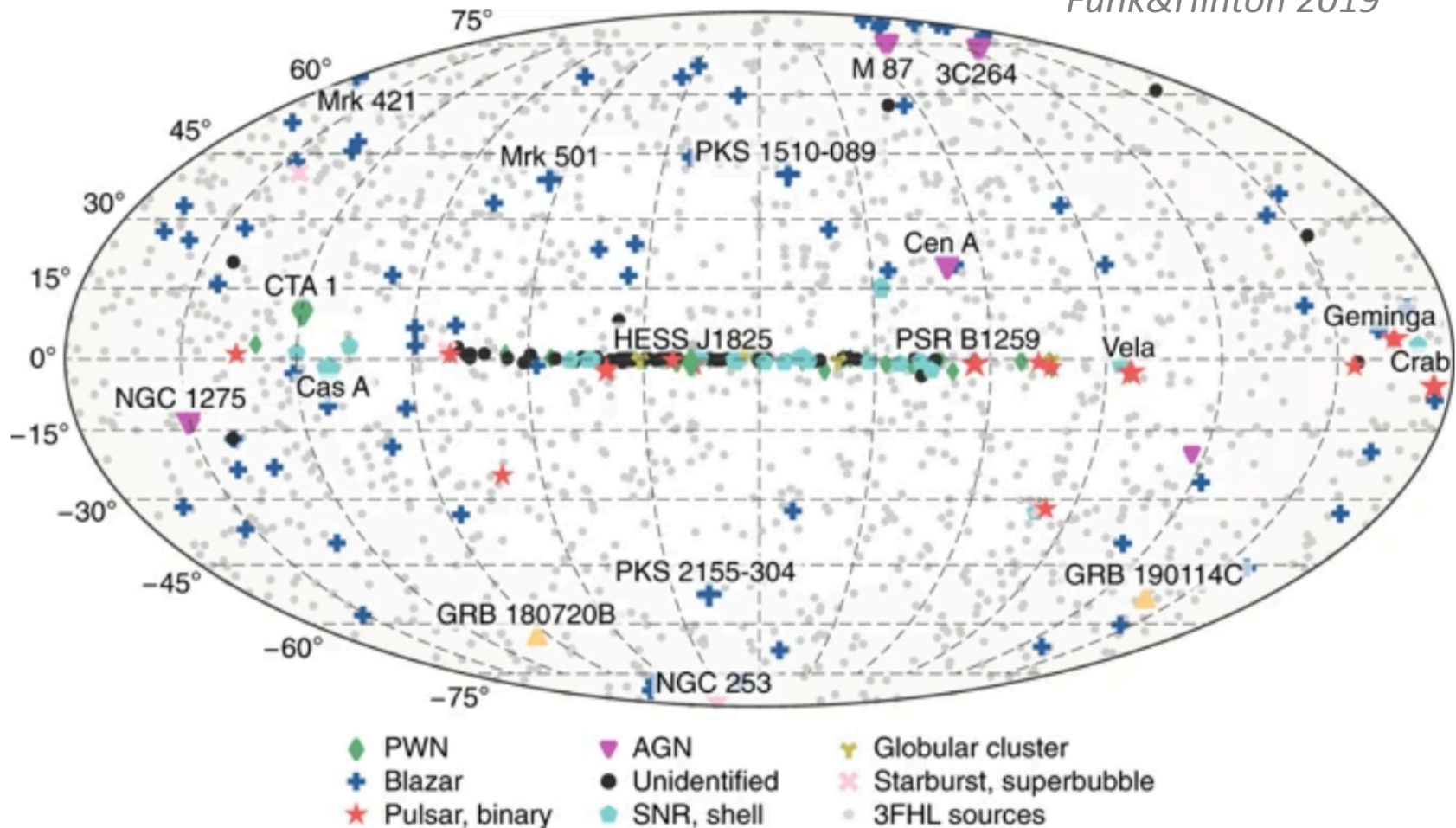
CTAO/CTAC General Meeting Bologna, Italy ~ 16 - 20 May 2022



The gamma-ray TeV catalogue



Funk&Hinton 2019



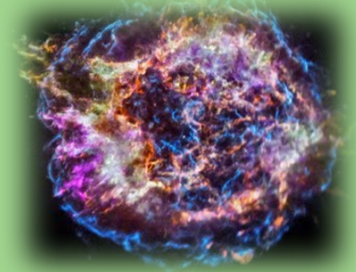
251 sources in the TeVCat

CTAO main scientific themes



COSMIC PARTICLE ACCELERATION

- How & where particles are accelerated?
- How do they propagate?
- What is their impact on the environment?



PROBING EXTREME ENVIRONMENTS

- Which are the processes close to neutron stars and black holes?
- Which are the processes in relativistic jets, winds and explosions?
- What are the cosmic voids?

PHYSICS FRONTIERS - BEYOND THE STANDARD MODEL

- What's the nature of the dark matter? How is it distributed?
- Do axion-like particles exist?
- Is the speed of light a constant for high-energy photons?

The science of CTAO



CTA will target major science questions in high-energy astrophysics, through a large observational programme.

Sky survey

MWL events

AGN monitoring

Deep targeted observations

Galactic Scan
Egal Scan
Dark matter programme
Magellanic clouds

Follow-ups of
transient and
MWL events

Study of
variability and
AGN environment

PeVatrons
Star forming Systems
Radio Galaxies &
Clusters
Source populations

CTAO surveys

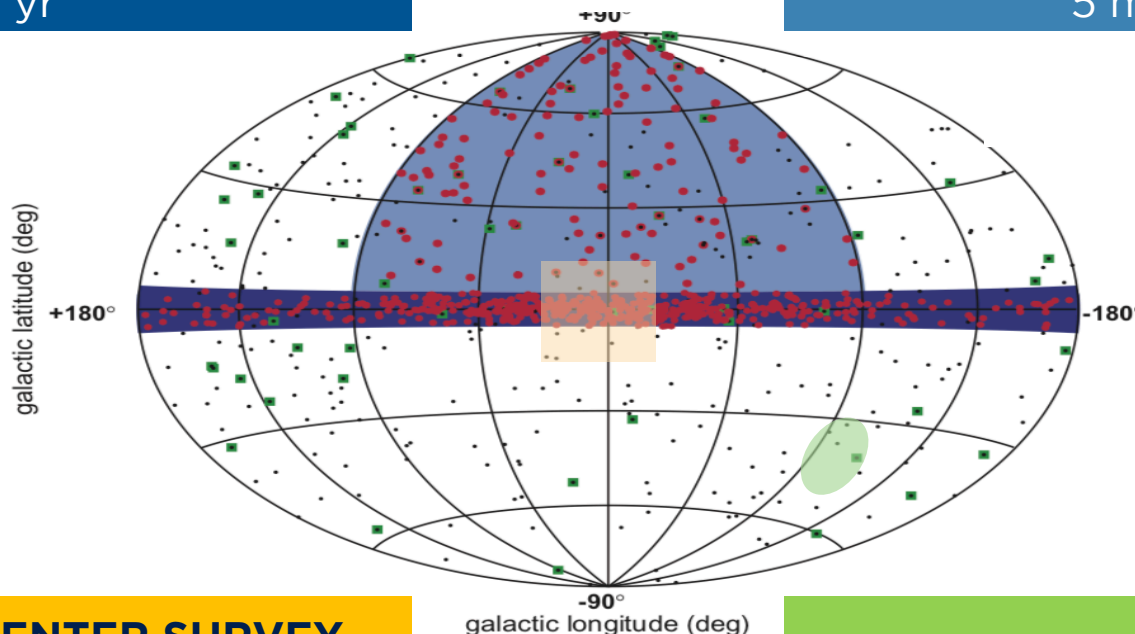


GALACTIC PLANE SURVEY

not uniform sensitivity across the plane
2-4 mCrab
pilot survey: first results after ~1 yr

EXTRAGALACTIC SURVEY

unbiased survey of VHE sky →
huge discovery space
25% of the sky
5 mCrab



GALACTIC CENTER SURVEY

deeper observations
around the GC
10° x 10°
2 mCrab

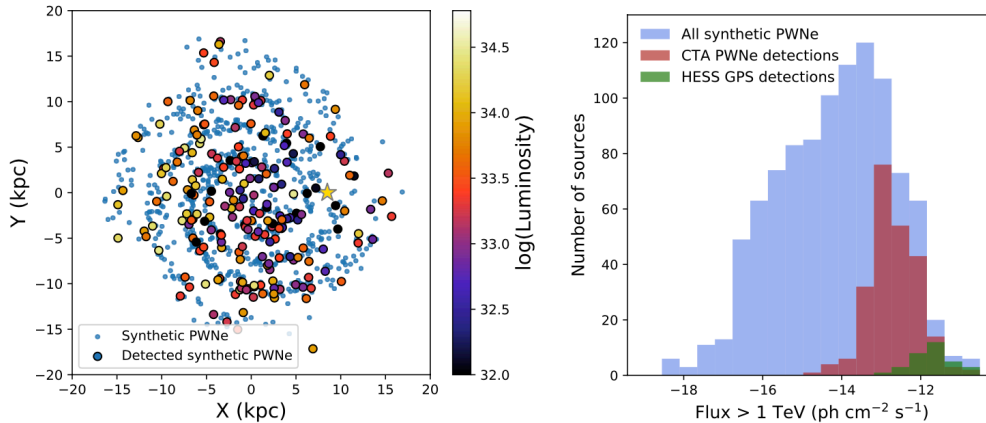
LARGE MAGELLANIC CLOUD SURVEY

1.5-2 mCrab

Source population studies

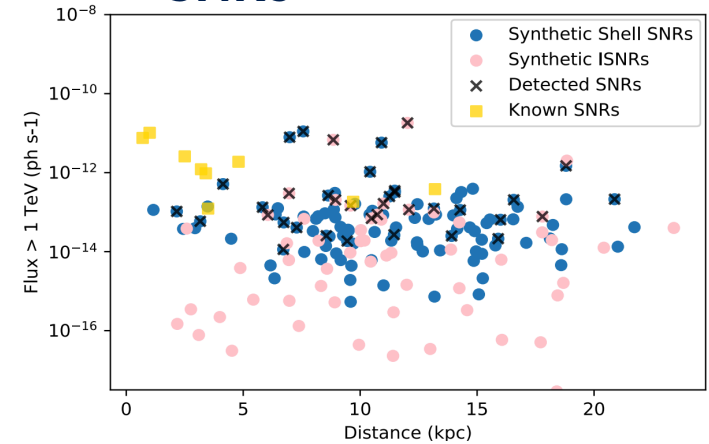


PWNe



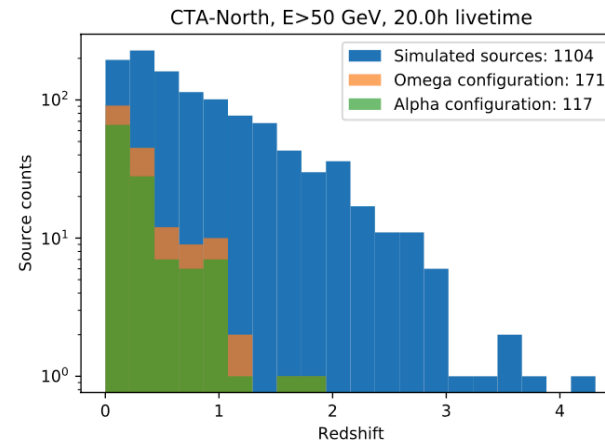
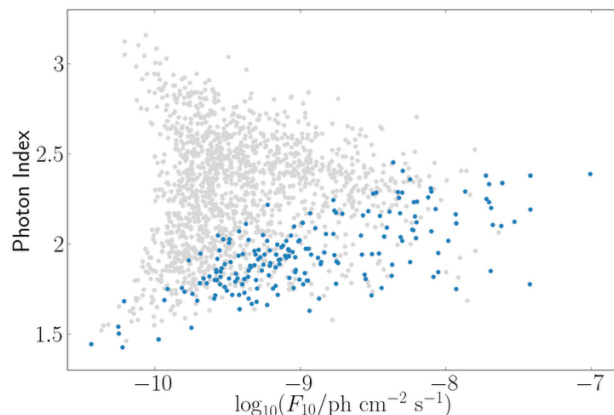
- transformational jump in population size to the PWNe field

SNRs



- SNRs up to other side of the Galaxy
- 5-10 times better flux sensitivity

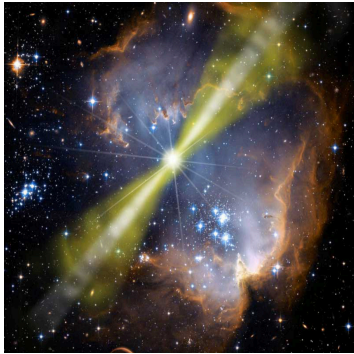
AGNs



- factor >2 more detected non-flaring AGNs
- enlarge the VHE horizon up to z ≈ 2

Transients in the multi-messenger era

GRBs

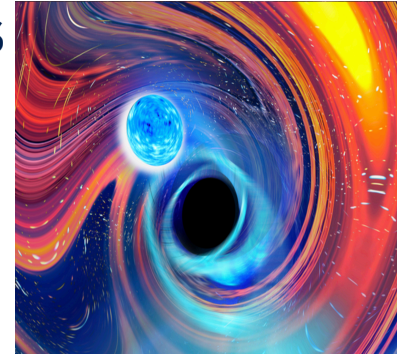


Q: How do the prompt and afterglow dynamics work?

See Monday talks

GW COUNTERPARTS

Q: What's the link between the progenitor event and the emerging GRB?



See Thursday talks

UHE NEUTRINOS

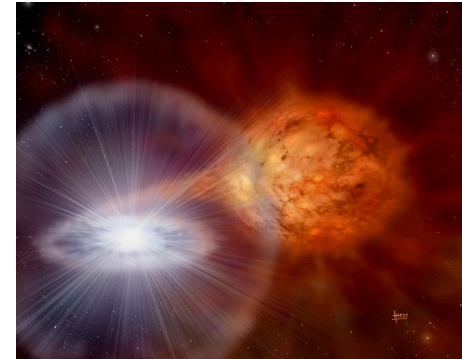


Q: What's the origin of the TeV-PeV cosmic neutrinos?

See Thursday talks

NOVAE

Q: Is there a population of VHE novae?



See Wednesday talks

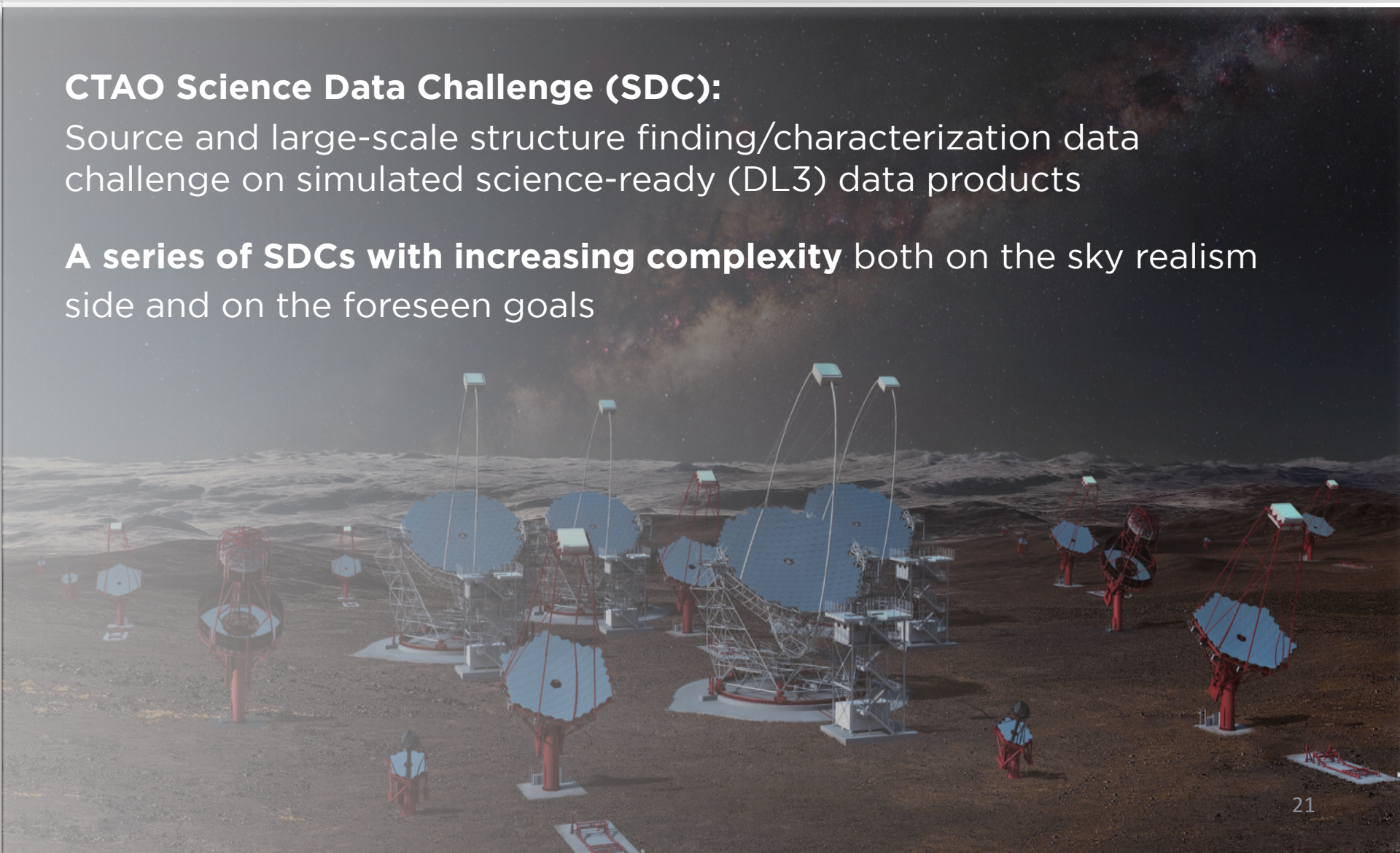
The 1st CTAO Science Data Challenge



CTAO Science Data Challenge (SDC):

Source and large-scale structure finding/characterization data challenge on simulated science-ready (DL3) data products

A series of SDCs with increasing complexity both on the sky realism side and on the foreseen goals



The 1st CTAO Science Data Challenge



- To allow the broad science community to **get familiar with the CTAO data products** and the CTAO Science Analysis Tools (SATs)
- **To serve as a test-bed for driving forward new algorithms and new technologies** (like machine-learning) for source and large-scale structure detection/identification in the context of the source confusion
- **To serve as intermediate step in the verification process of software packages** that will be used during Observatory operations and data models and formats
- **To foster the production of good documentation** to be used for user's support

Summary



- CTAO will be the first gamma-ray ground-based observatory, openly delivering data to the community
- CTAO will open a new era in VHE astrophysics
 - Rich science program answering many open questions
 - Large new discovery space
- ERIC approved: stay tuned for new updates!
- Science Data Challenge in preparation...

Stay tuned

