



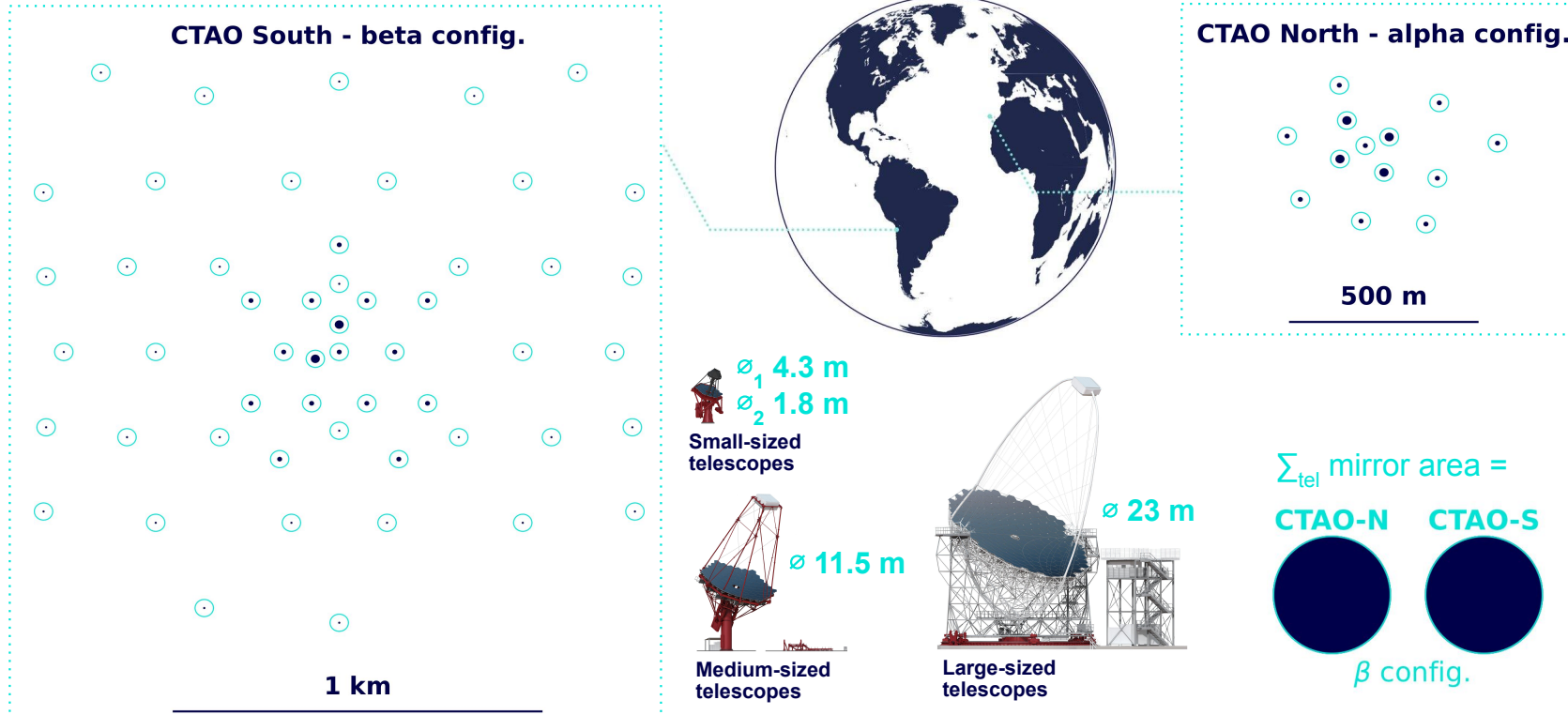
CONSORTIUM

Stellar intensity interferometry (SII) with the Cherenkov Telescope Array Observatory

Oct. 8 2026

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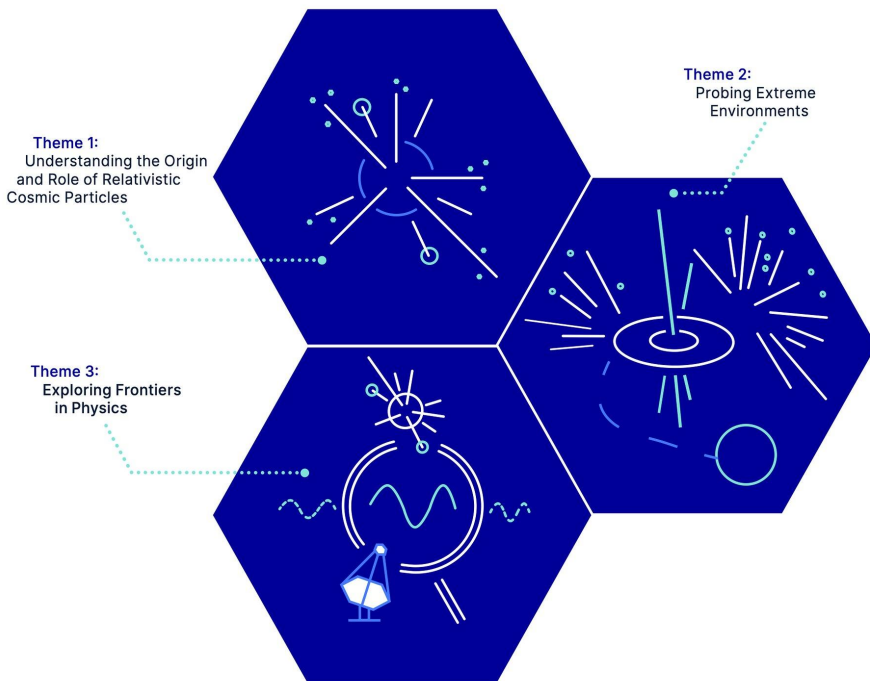
The two arrays of the CTAO



An observatory for γ -ray astronomy...

Targets: astrophysical plasmas and fundamental physics

- To be operated for 20+ years
 - Open observatory, with about half of the time spent on non-consortium proposals
 - Enhancements with respect to its precursors (HESS, MAGIC, VERITAS)
 - sensitivity $\times 5-10$
 - energy resolution $\times 1.5-2$
 - angular resolution $\times 1.3-1.4$
- see CTAO performance [here](#)

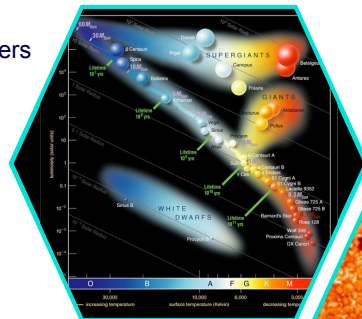


... proposed to be adapted for intensity interferometry

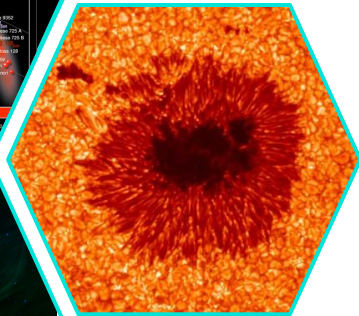
Target: high-resolution
astrophysics of hot stars

- Model-independent stellar radii, empirical calibration of the H-R diagram (T_{eff} , surface gravity), surface brightness color relations (impact on cosmic ladder?)
- Rotational oblatenesses, gravity darkening, dark spots, pulsation modes
- Equatorial disk geometry, stellar wind morphology, binary wind collision zones

Theme 1
Stellar parameters
and evolution



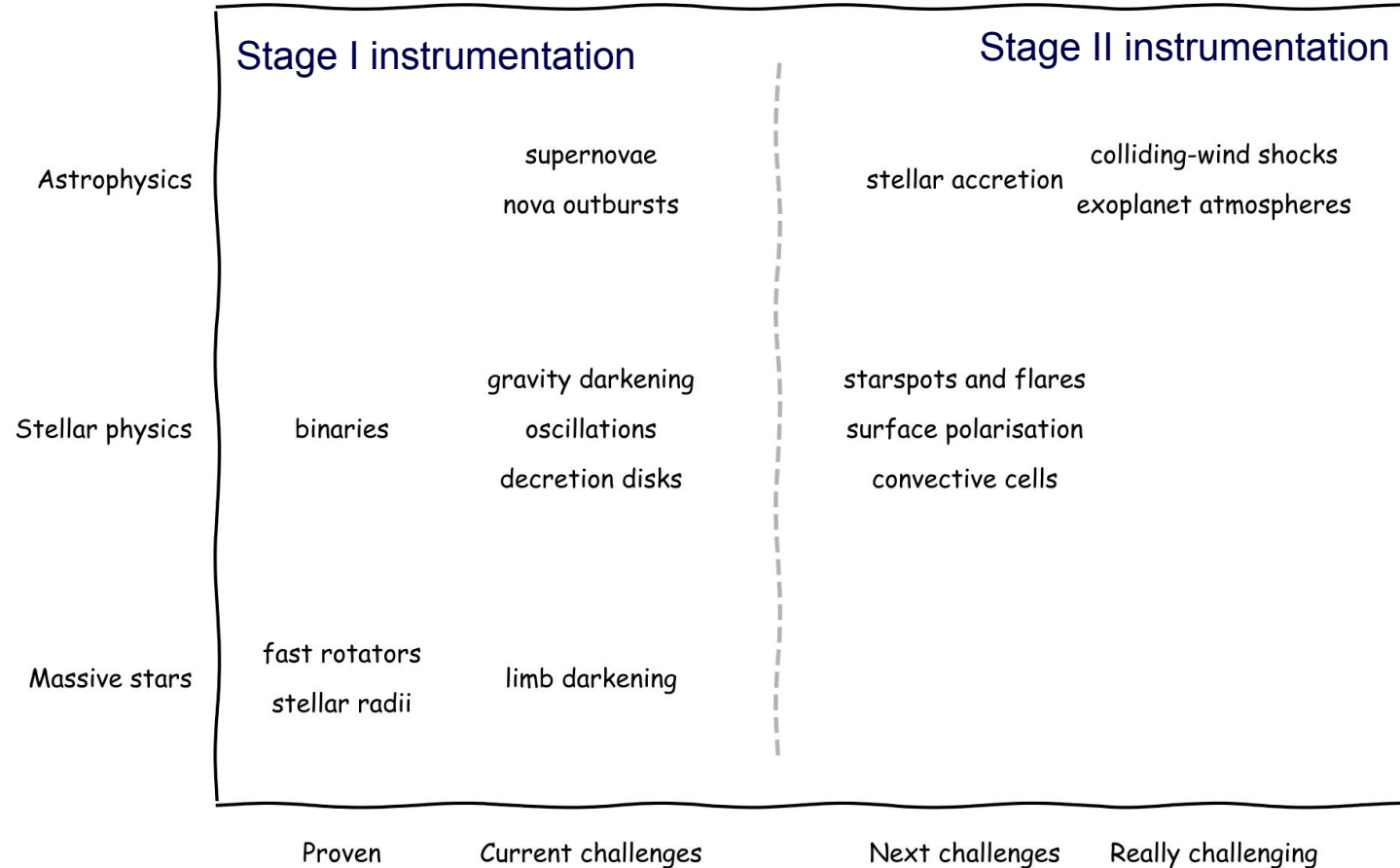
Theme 2
Surface distortion
and structure



Theme 3
Mass loss and
stellar winds



Credit: CTAO consortium (under internal review) / P. Saha

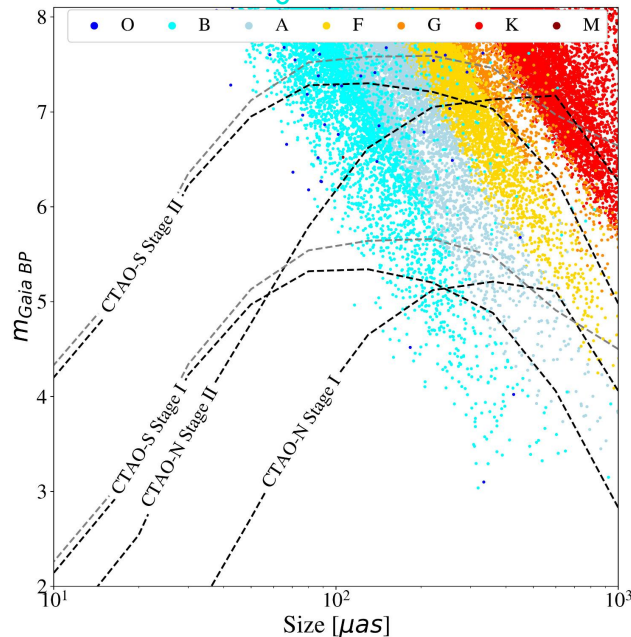




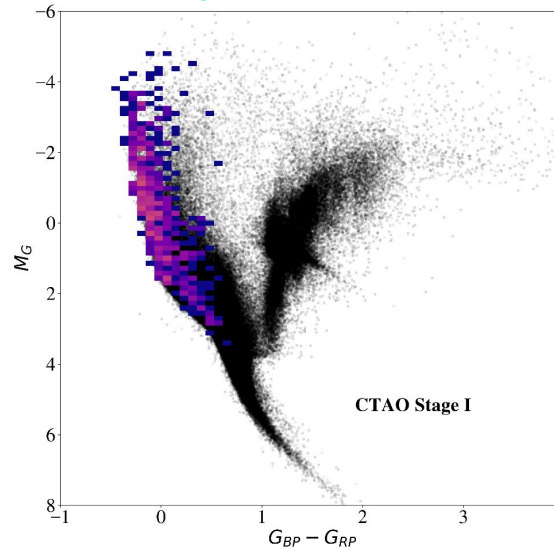
Science reach

Stellar populations within reach

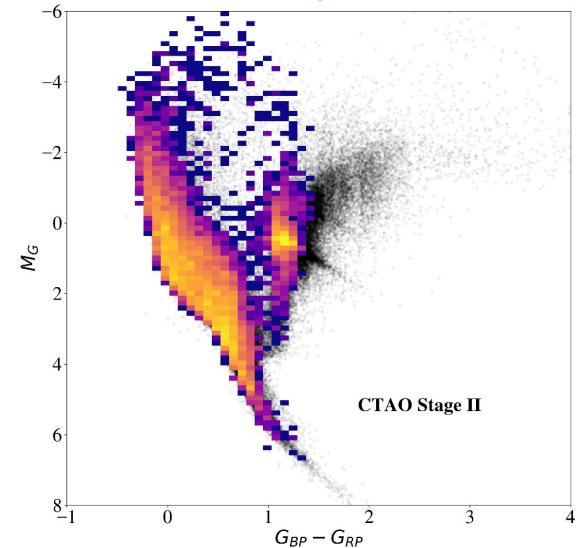
Stage I→II: $m_B > 5.5 \rightarrow 7.5$
 $T = 10h$, $\sigma_\theta = 3\%$, dark night



Stage I: 600
 OBA-type stars



Stage II: 10,000
 stars of all types

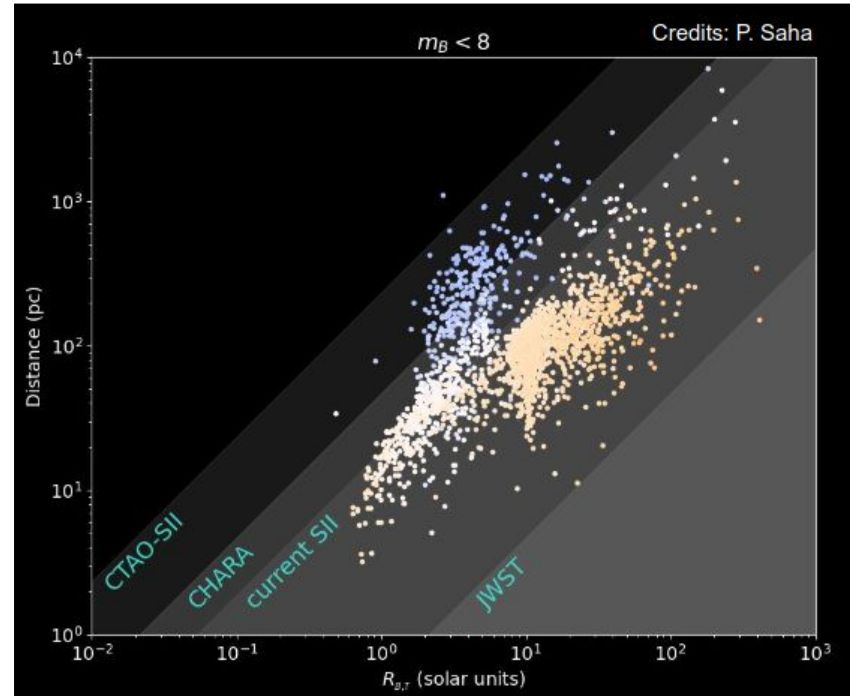
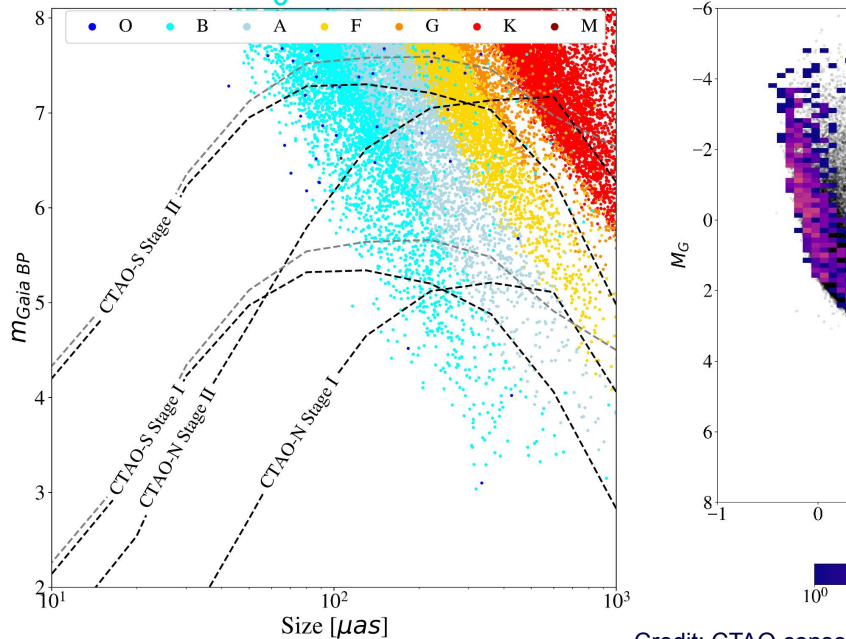


Credit: CTAO consortium (under review) / A. Cifuentes

Stellar populations within reach

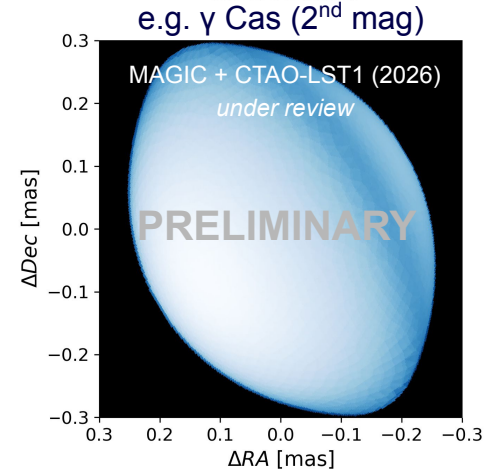
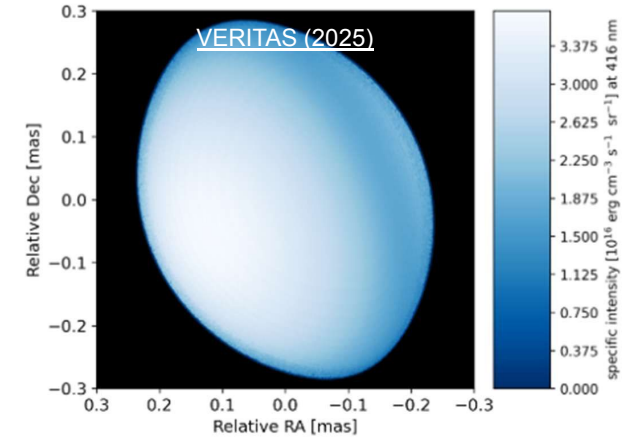
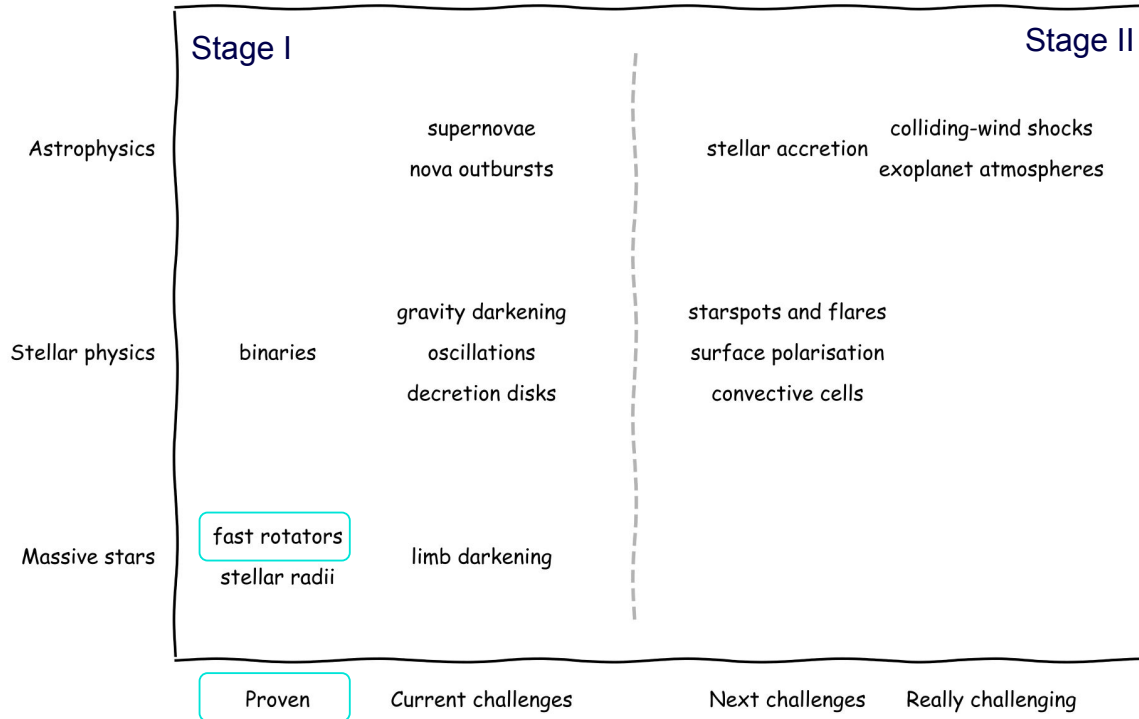
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 $T = 10\text{h}$, $\sigma_\theta = 3\%$, dark night

Stage
OBA-I

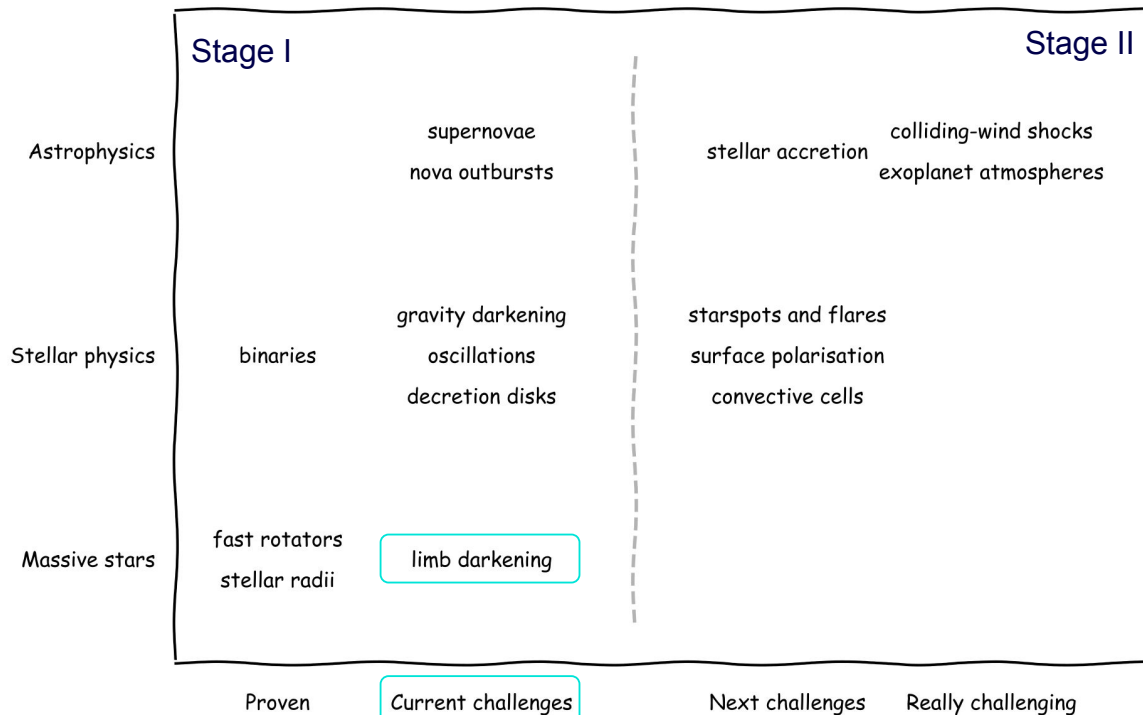


Credit: CTAO consortium (under review) / A. Cituentes

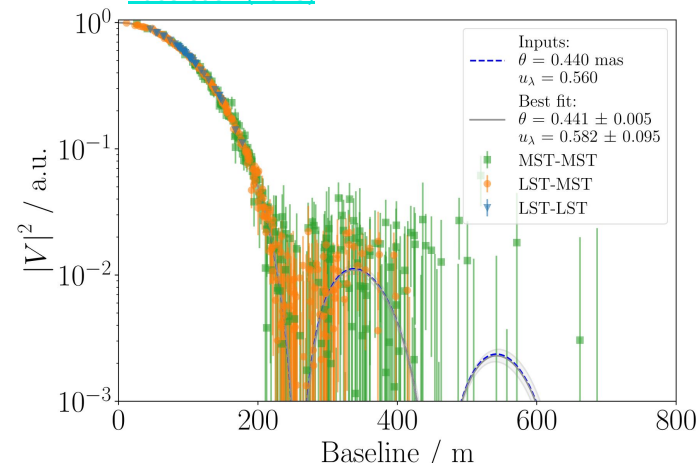
Science reach - Stage I



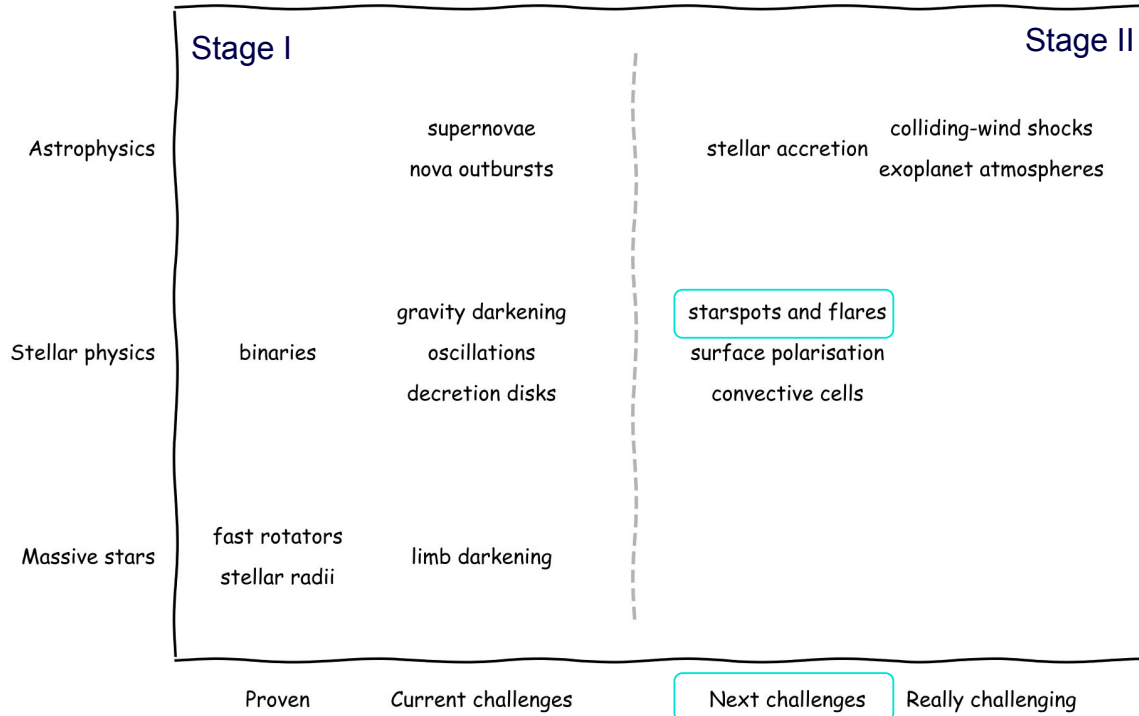
Science reach - Stage I



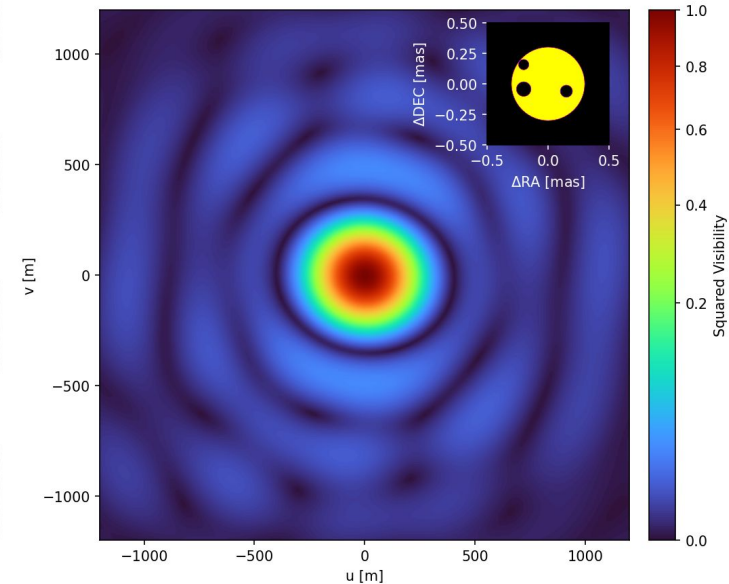
2nd mag. star simu. from CTAO-N
[Luce et al. \(2025\)](#)



Science reach - Stage II

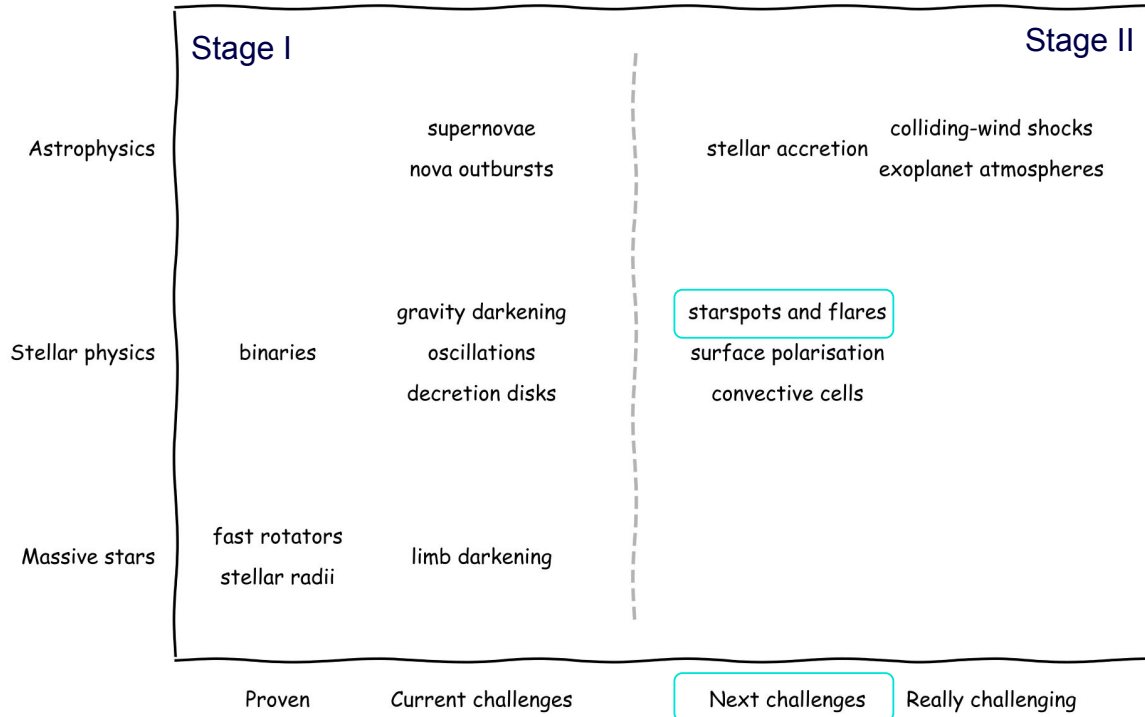


F-type star simu. ($V=4.5$) at $\delta=0^\circ$

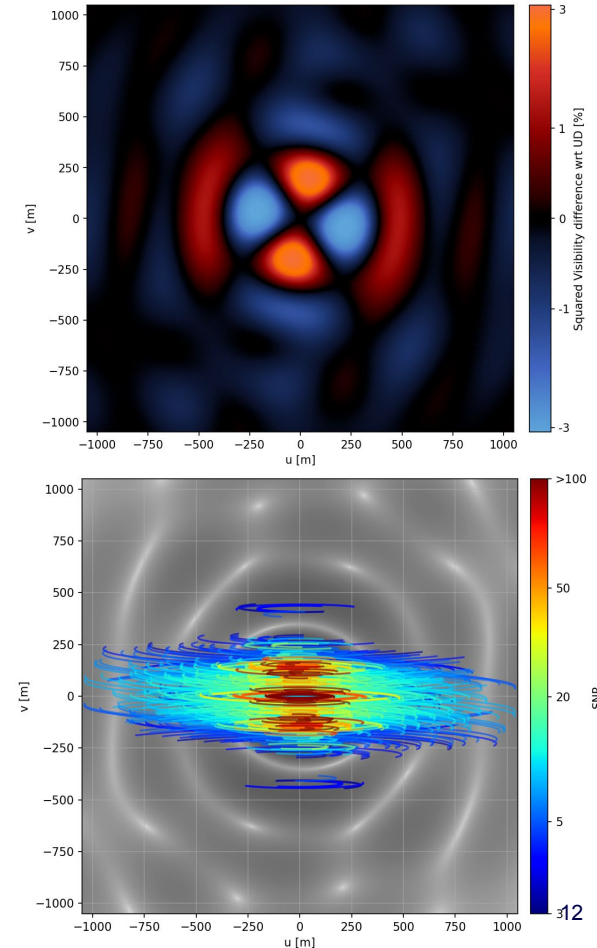


Credit: CTAO consortium (under internal review) /
M. Fiori & L. Zampieri

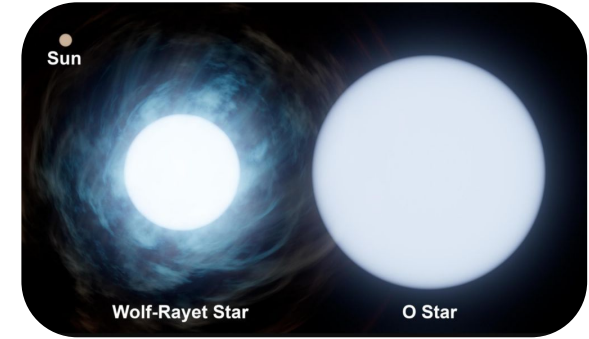
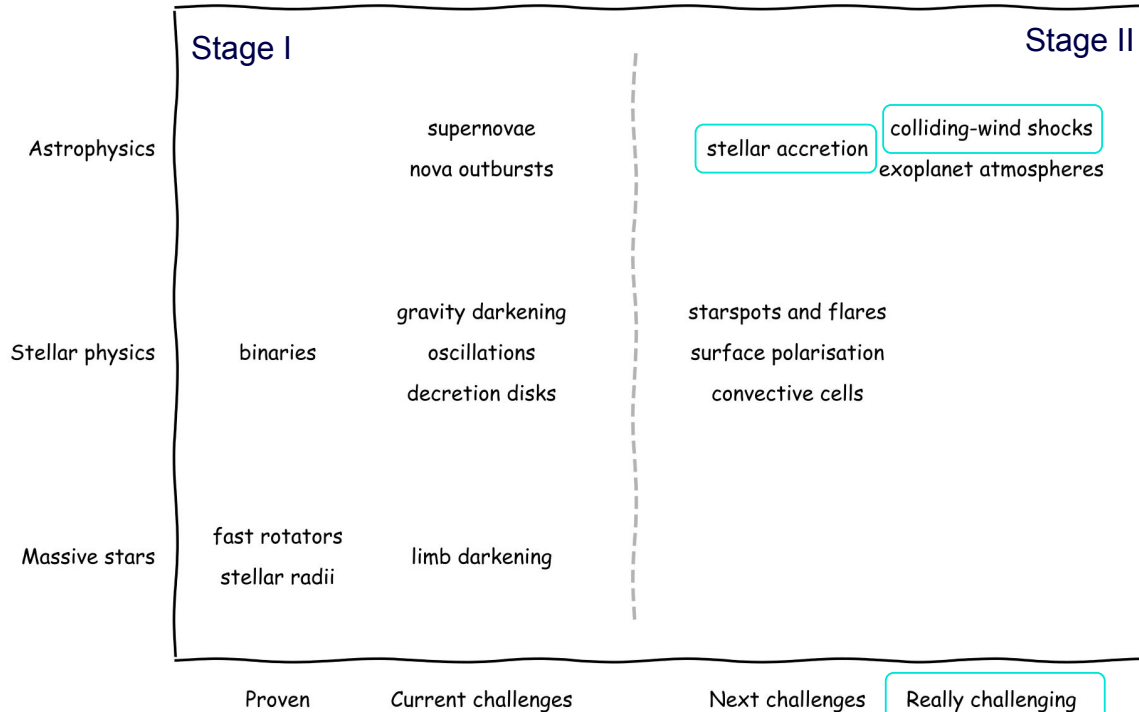
Science reach - Stage II



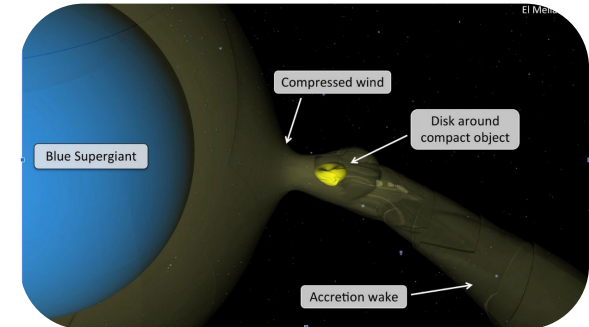
Credit: CTAO consortium (under internal review) /
M. Fiori & L. Zampieri



Science reach - Stage II



e.g. γ^2 Velorum (2nd mag)



e.g. Vela X-1 (7th mag)



Implementation

CTAO-SII Stage I

Minor adaptations to the arrays

- Robotic narrow-band optical filters
- Raw data streaming from one photodetector per camera
- High-bandwidth data transfer
- Correlator

$$\text{SNR} = \mathcal{L} \mathcal{B}^{-1} \times A \Phi |V|^2 \sqrt{b_\nu T/2}$$

$$\mathcal{L} = \alpha q \sigma \quad \mathcal{B} = F(1 + \Phi_{\text{ext}}/\Phi)$$

Loss factor Noise enhancement

	Stage I
photodetector QE (α)	0.40
Inverse time resolution (b_ν)	~ 400 MHz
Noise factor (F)	1.15
Filter bandpass	26 nm
Number of channels	1

CTAO-SII Stage II

Further adaptations to the arrays

- Dedicated photodetectors
- Focal-plane corrective optics + very narrow-band optical filters
- Multi-channel (λ) setup^(*)

$$\text{SNR} = \mathcal{L} \mathcal{B}^{-1} \times A \Phi |V|^2 \sqrt{b_\nu T/2}$$

$$\mathcal{L} = \alpha q \sigma \quad \mathcal{B} = F(1 + \Phi_{\text{ext}}/\Phi)$$

Loss factor Noise enhancement

	Stage I	Stage II
photodetector QE (α)	0.40	0.45
Inverse time resolution (b_ν)	~ 400 MHz	> 2 GHz
Noise factor (F)	1.15	1.05
Filter bandpass	26 nm	1 nm
Number of channels	1	10

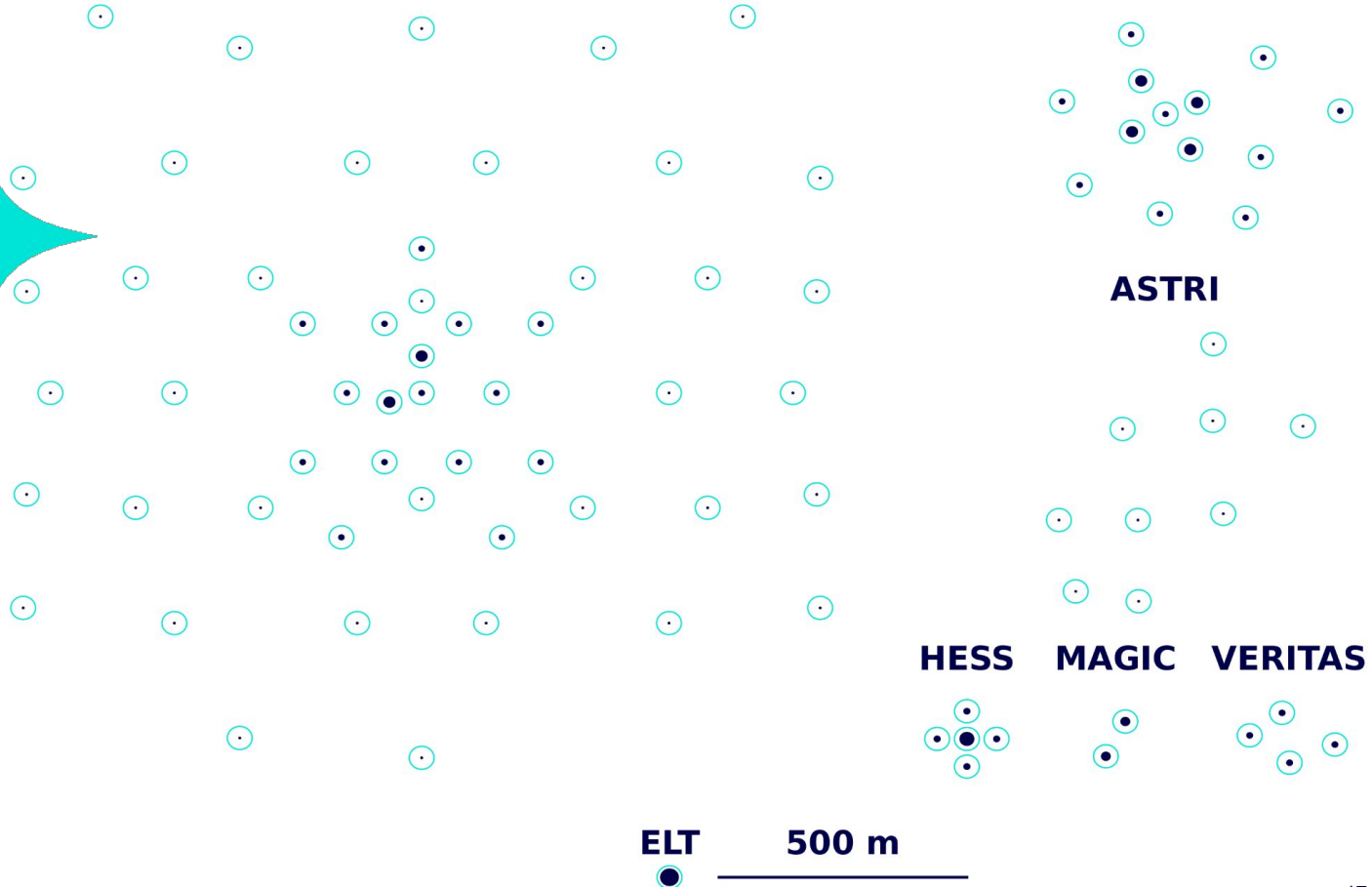
$$(*) \text{SNR} \propto (N_{\text{baselines}} N_{\text{channel}})^{1/2}$$

with $N_{\text{baselines}} = N_{\text{tel}}(N_{\text{tel}} - 1)/2$

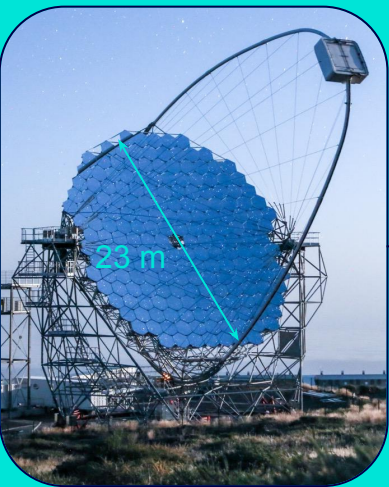
CTAO β config.

CTAO South - beta config.

CTAO North - alpha config.



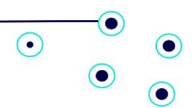
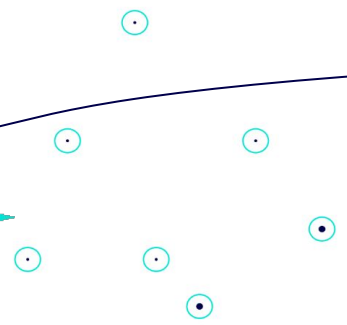
Credit: CTAO consortium (under review) / JB



CTAO
intermediate
config. '27

CTAO South - interm. config.

CTAO North - interm. config

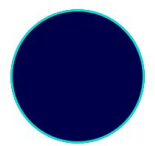


Mirrored Area

CTAO-N

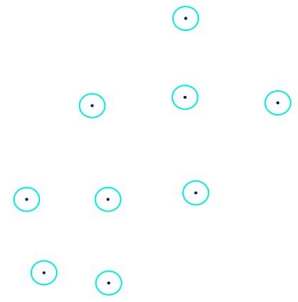
CTAO-S

ELT



interm. config.

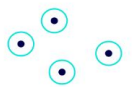
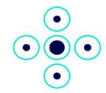
ASTRI



HESS

MAGIC

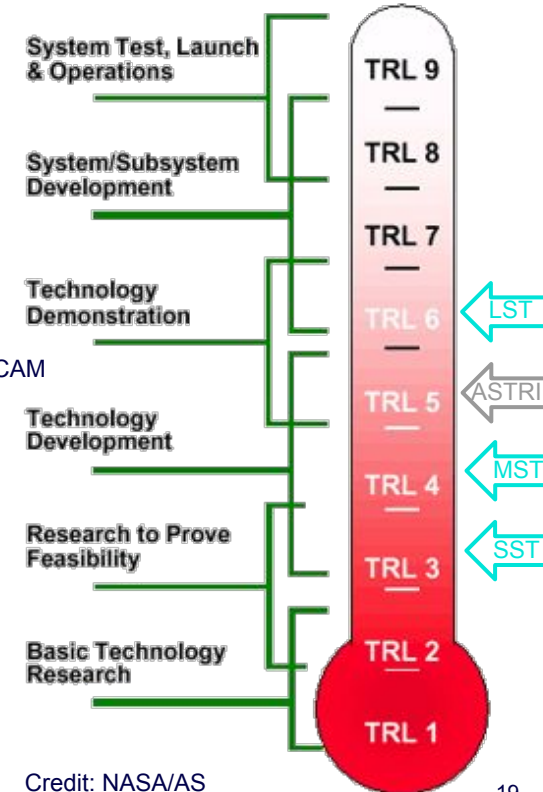
VERITAS



Technology readiness

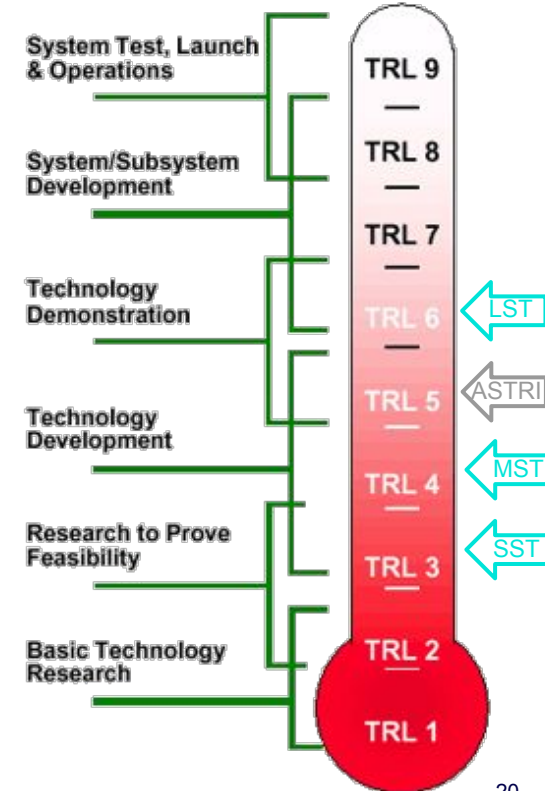
Stage I implementation

- Robotic narrow-band optical filters
 - deployed on LST-1 Cam (CTAO-N site)
 - validated in the integration hall of MST-NectarCAM
- Raw data streaming from one photodetector per camera
 - deployed on LST-1 Cam (CTAO-N site)
 - demonstrated in the integration hall of MST-NectarCAM
 - Optical design in progress for SSTs
- High-bandwidth data transfer
 - deployed on LST-1 Cam (CTAO-N site)
 - IDROGEN development for MST-NectarCAM
- Correlator
 - GPU-based correlator validated on LST-1+MAGIC



Technology readiness

Between TRL 4 and TRL 7:
the so called Valley of Death



How to overcome the valley of death in a sub project of a scientific observatory?

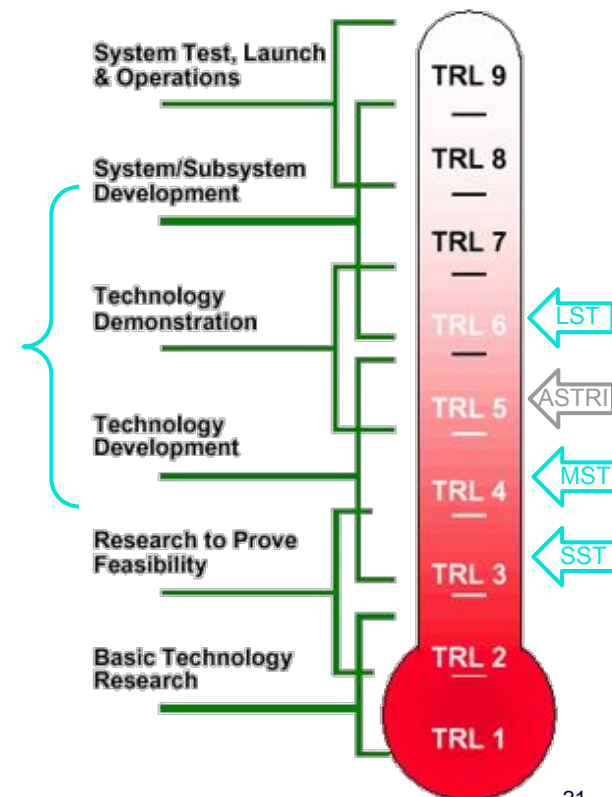
Overcoming the "Valley of Death" within a **sub-project of a scientific observatory** presents a highly specific operational and funding challenge. In big science (like astronomy, particle physics, or climate observatories), sub-projects often involve custom instrumentation, specialized sensors, high-throughput software, or cryogenic engineering.

Because these technologies are tailored for a single, massive facility, they lack a broad commercial market, making traditional venture capital irrelevant. The "valley" here is the brutal gap between a **working laboratory prototype (TRL 4)** and a **fully integrated, observatory-grade component qualified for operations (TRL 7/8)**.

More specifically implementing intensity interferometry for CTAO

Implementing Stellar Intensity Interferometry (SII) as a secondary observing mode within the Cherenkov Telescope Array Observatory (CTAO) is a major breakthrough. It exploits CTAO's massive light-collecting area and kilometer-scale baselines to achieve sub-milliarcsecond optical resolution. Crucially, it allows CTAO to conduct valuable stellar science during full-moon periods when high-energy gamma-ray observations are constrained.  Université de Genève +3

However, the "Valley of Death" for an SII sub-project lies in transitioning from a successful precursor trial (such as the recent **MAGIC + CTAO-LST1 joint observations**) to a highly automated, permanently integrated observatory-grade operation across the full array.  arXiv



So far we didn't learn so much from the AI mode...

🛡️ Specific Steps to Cross the Valley of Death

1. Leverage the Off-Site ACADA Test Clusters

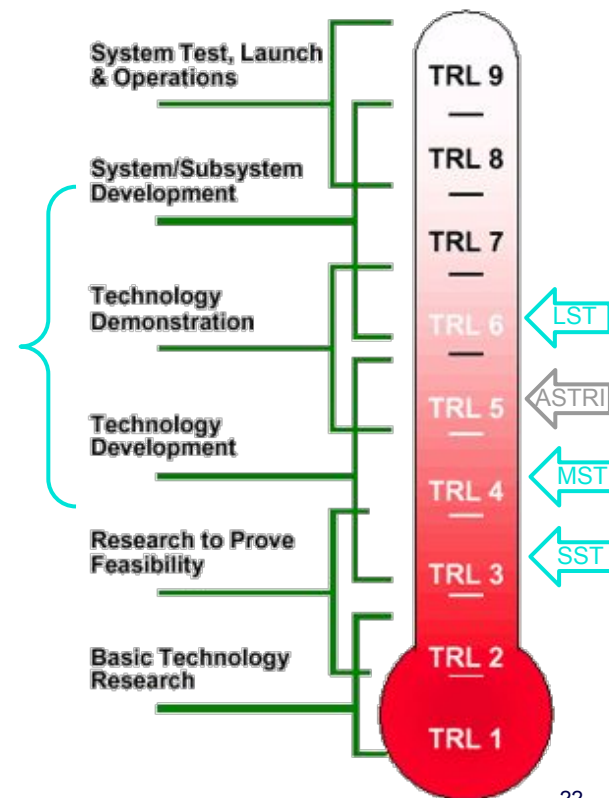
Do not try to debug your software integration on the actual telescopes in La Palma or Chile. Use the official **ACADA Test Cluster** and **Software Integration Cluster**. This dedicated environment allows you to simulate high-bandwidth data packages from your correlator and check for bugs alongside other integrated software packages before deployment.  Harvard University

2. Capitalize on Precursor Commissioning Data

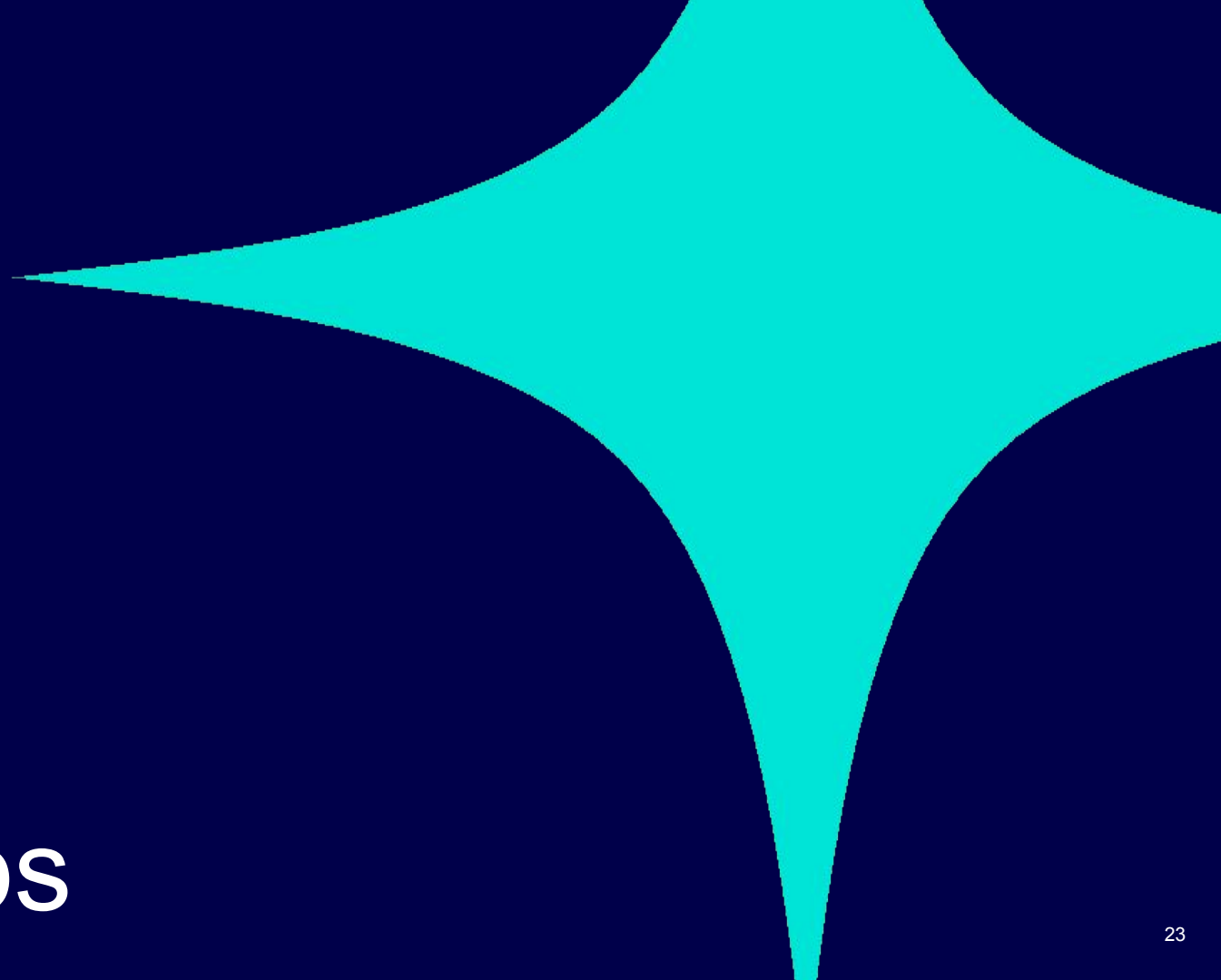
The joint runs between the **MAGIC telescopes** and the **LST-1 prototype** act as your ultimate TRL 6 environment. Use the data collected during these commissioning phases to refine your instrument response functions (IRFs). Proving that your pipeline can reliably map known stellar diameters (like those of massive stars or binary systems) will give the CTAO Steering Committee the risk assurance they need to support full integration across the rest of the array.  Université de Genève +2

3. Establish a Dedicated In-Kind Contribution (IKC) Framework

Because CTAO operates as an [ERIC \(European Research Infrastructure Consortium\)](#), the most effective way to secure funding for the TRL 5–7 engineering bridge is to formalize your sub-project as an official **In-Kind Contribution**. Frame the hardware modifications not as a niche science experiment, but as a critical infrastructure upgrade that expands the observatory's operational duty cycle into bright moonlit nights.  DFA Indico



More to the point.



Next steps

2026-27: pivotal years for CTAO



Deploy → Commission → Early γ -ray Science

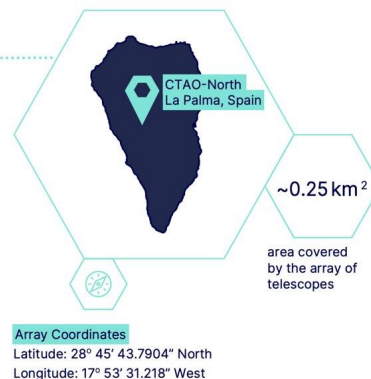
Looking to the future



- CTAO-South at Paranal (Chile)
→ 10-20 km away from VLT and ELT



- CTAO-North at La Palma (Spain, Canary Islands)
→ half a km away from GTC, WHT, NOT, TNG





The CTAO intensity interferometer

The CTAO is currently **under construction**.

With **kilometer-scale baselines** and an **unprecedented collection area**, the CTAO has the potential to be an exceptional interferometer in the 0.1 mas realm.

Busy and exciting path forward.