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DI RIPRESA E RESILIENZA



# CTAO

C. Aramo<sup>1</sup> for the CTA+  
Program, CTA-LST Project  
and CTAO Consortium

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## The Italian Program PNRR CTA+ for the Cherenkov Telescope Array Observatory South Site

## CTAO: next-generation Cherenkov Telescope Array facility

- Originally envisioned:  $\sim 100$  telescopes of 3 different sizes
- Alpha configuration (defined 2022): 64 telescopes
- Expected to improve sensitivity by  $\sim$  factor 10 compared to existing facilities (H.E.S.S., MAGIC, VERITAS)
- Extend energy coverage:  
 $\sim 10$  GeV -  $>100$  TeV





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Large-Sized Telescopes (LSTs): 23 m  $\varnothing$ ;  
PMT camera; 1855 pixels; 4.3° FoV  
see M. Teshima talk

Mid-Sized Telescopes (MSTs): 11.5 m  $\varnothing$   
PMT camera with 2 designs

- NectarCAM 1855 pixels; 7.7° FoV
- FlashCam 1764 pixels; 7.5° FoV

SCT Double mirror  
Schwarzschild-Couder  
9.66 m  $\varnothing$ ; ~ 12k SiPMs; 8° FoV  
see F.R.Pantaleo talk

Small-Sized Telescopes (SSTs): 4.3 m  $\varnothing$   
SiPM camera; 2048 pixels; 8.8° FoV

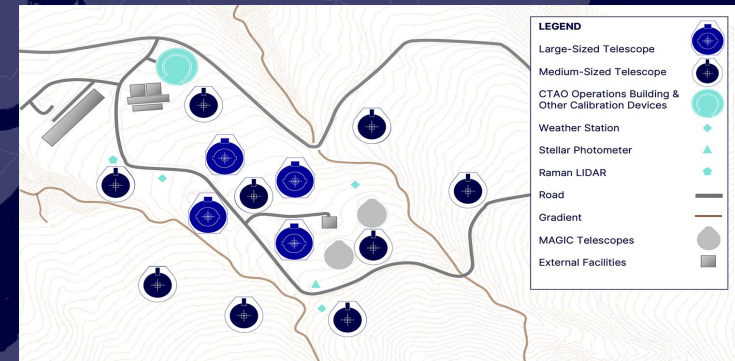
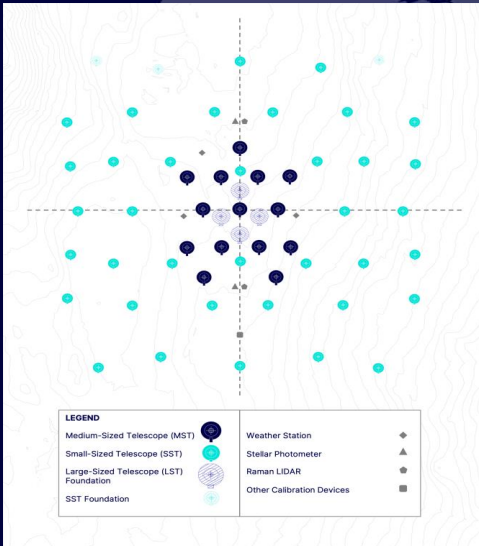
Science Data Management Centre  
Zeuthen, Germany

Headquarters  
Bologna, Italy

CTAO North  
La Palma, Spain

CTAO South  
Paranal, Chile

Current status:  
see talk by Alicia  
López Oramas





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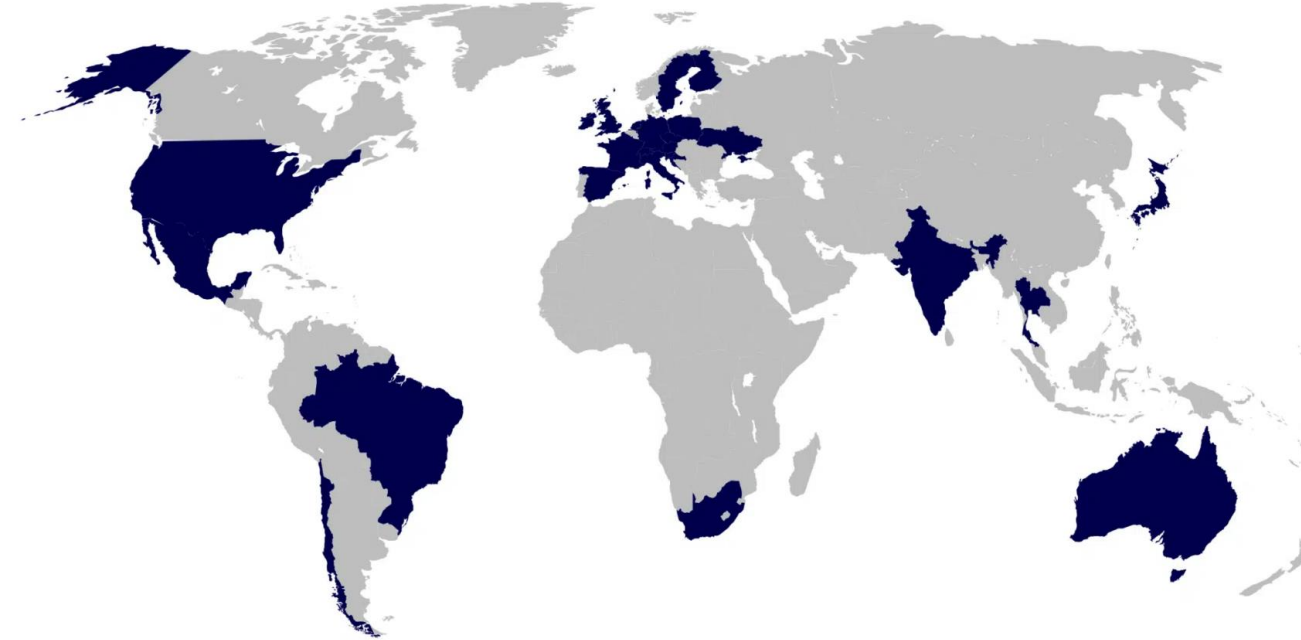
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# The CTAO Consortium

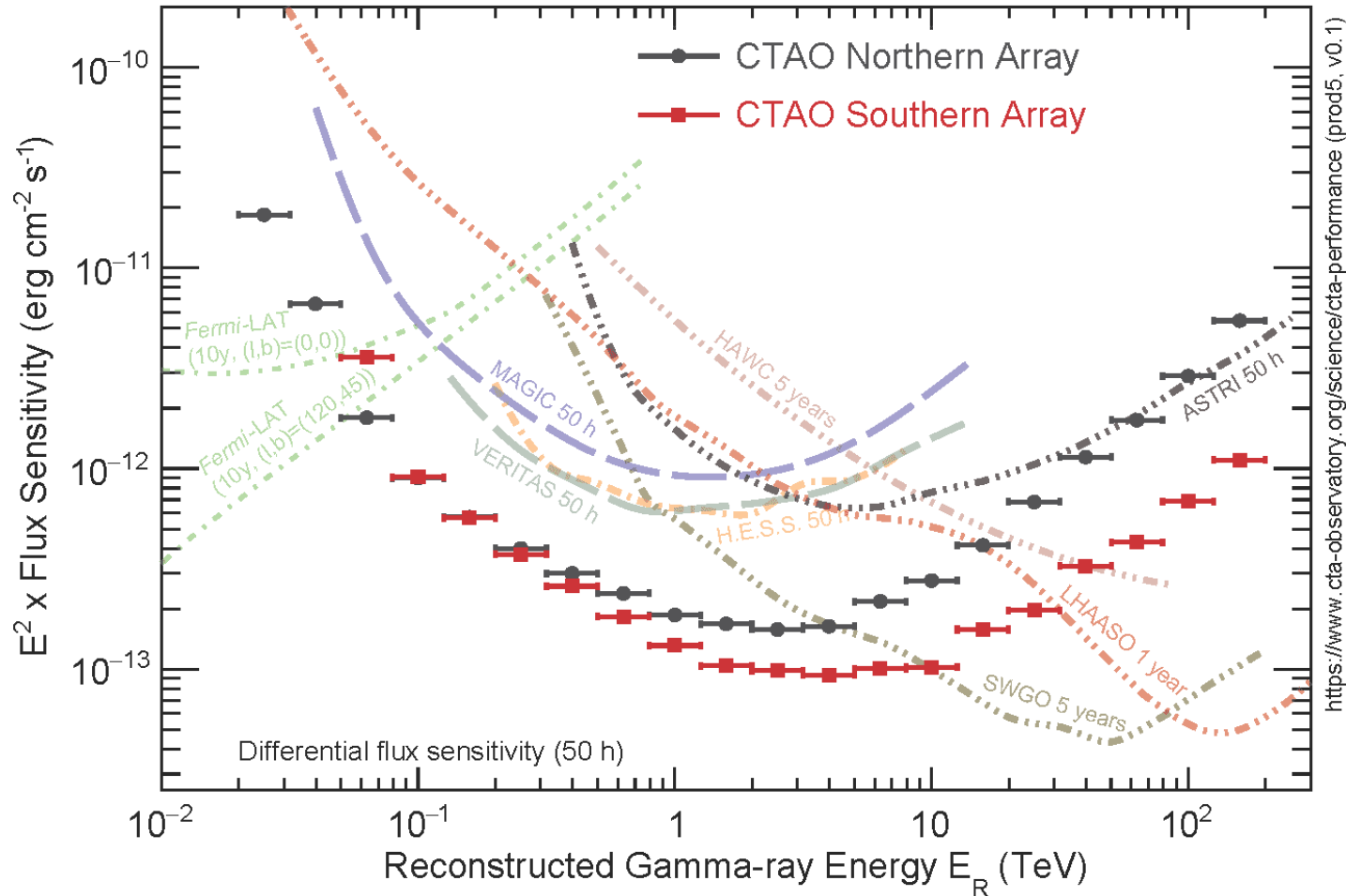


- More than 1500 scientists
- ~ 200 institutes
- 25 countries on 6 continents



Masahiro Teshima  
recently elected new  
spokesperson





**CTAO**

## Expected Sensitivity

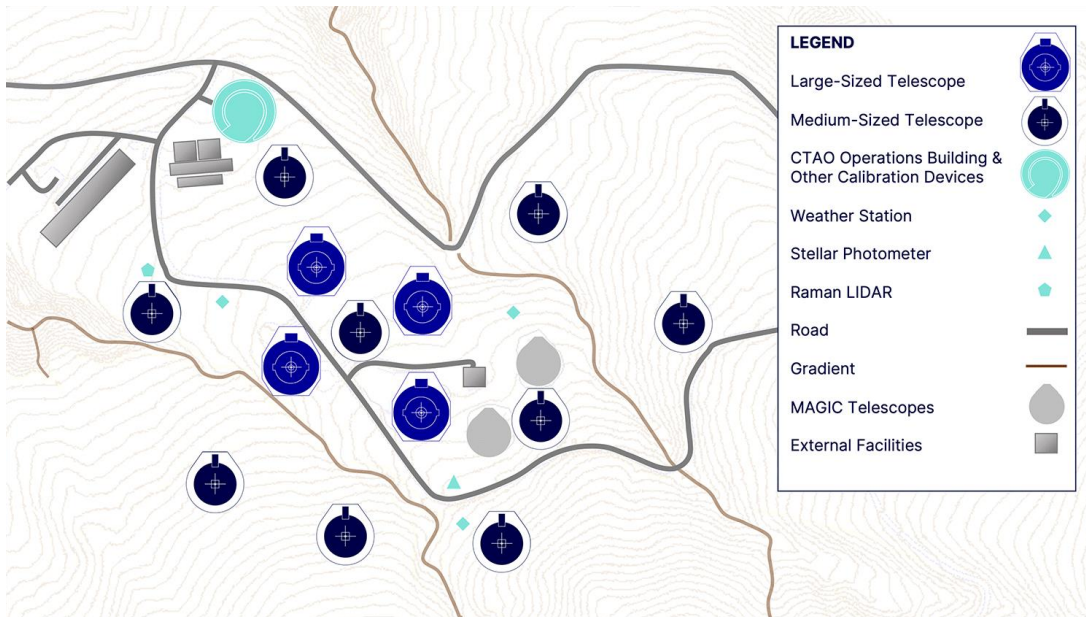
The first (open) Observatory in the TeV energy range

# CTAO Alpha Configuration + CTA+

## CTAO North

4 LSTs

9 MSTs



# CTAO

## CTAO South

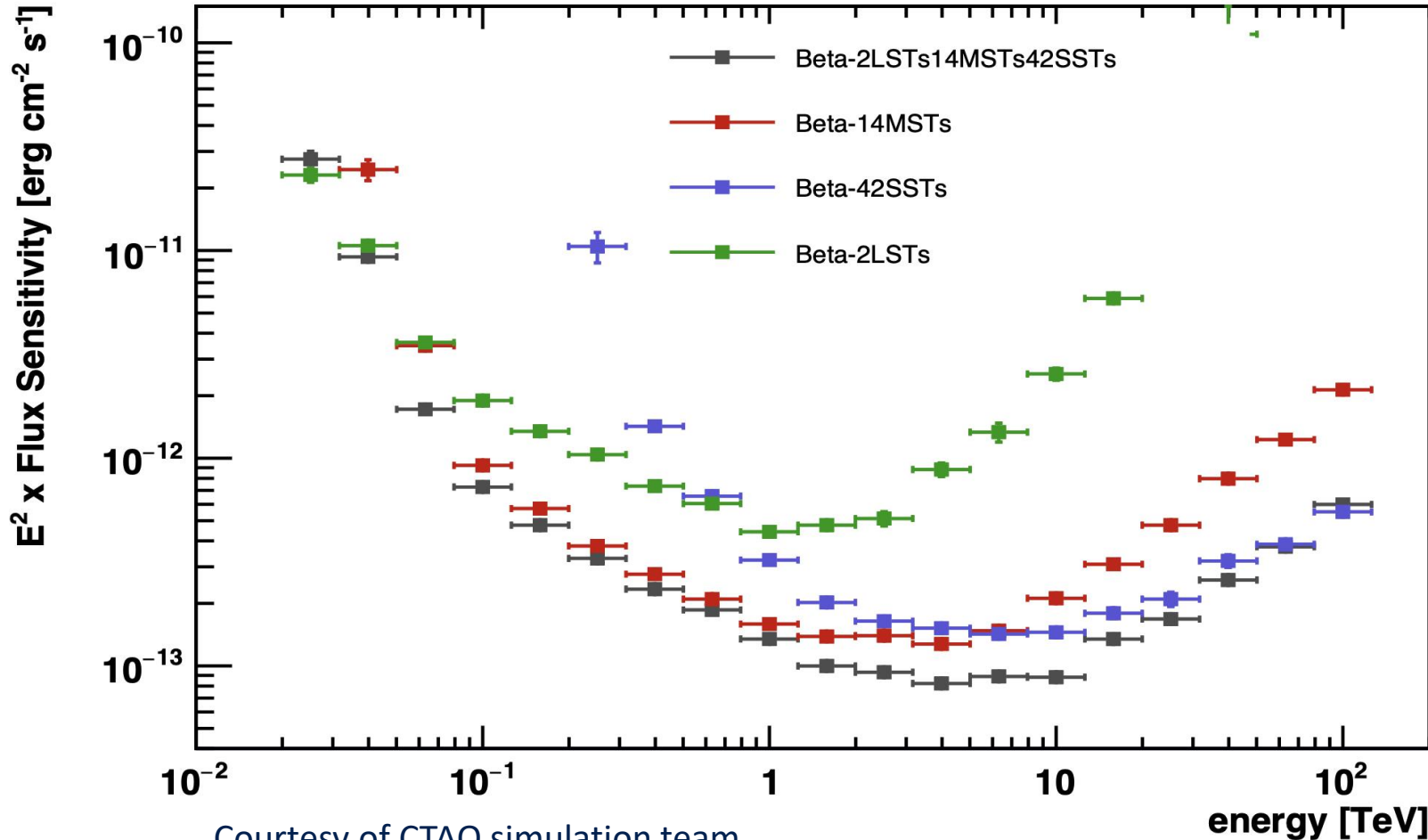
14 MSTs

37 SSTs

2 LSTs +  
5 SSTs



# The CTAO in context: **southern alpha** configuration performance



3 types of telescopes:

- LST (23m diameter)
- MST (12 m diameter)
- SST (4m diameter)

CTAO-S => 14 MST + 37 SST

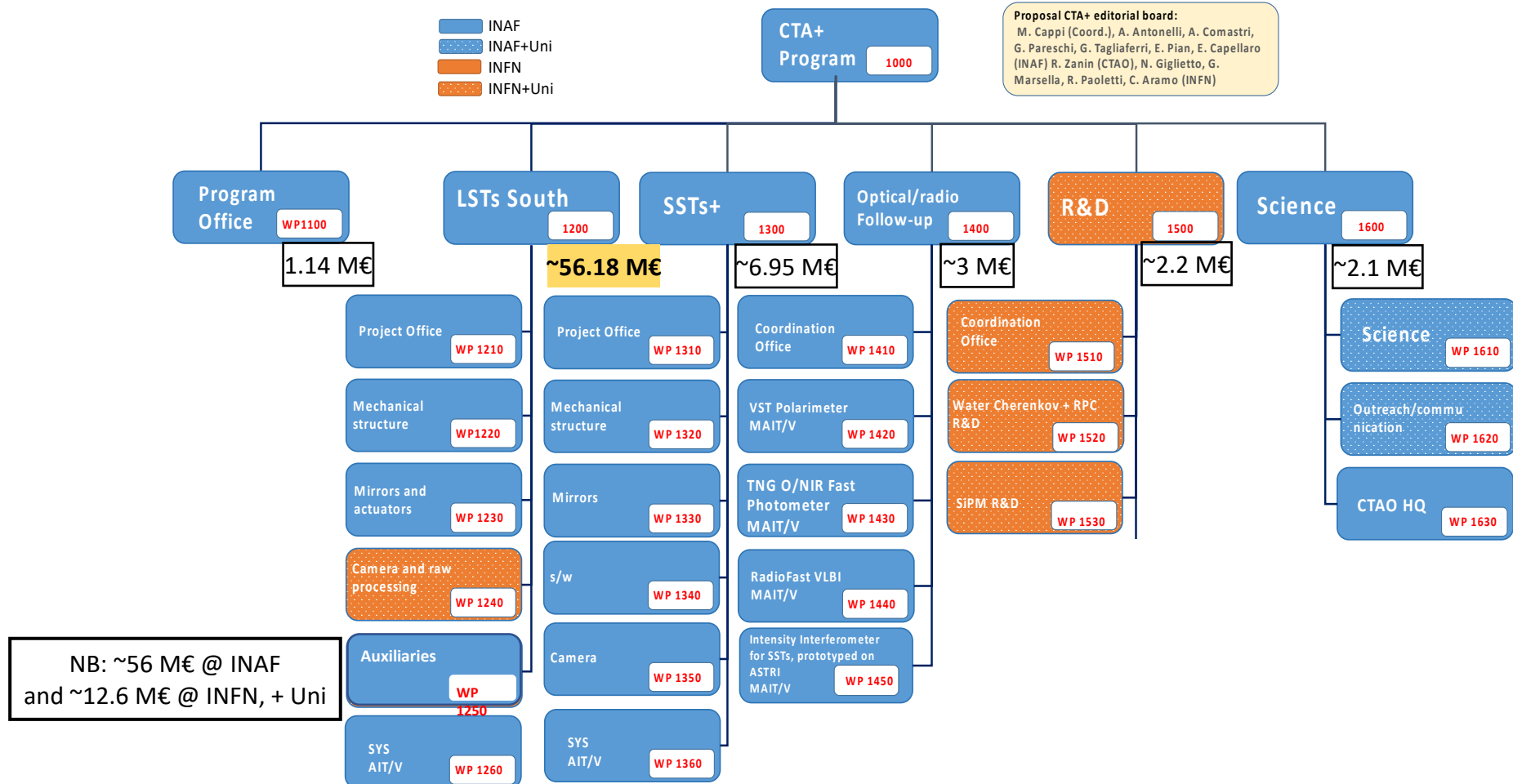
(from Italian PNRR: +2 LST + 5 SST)



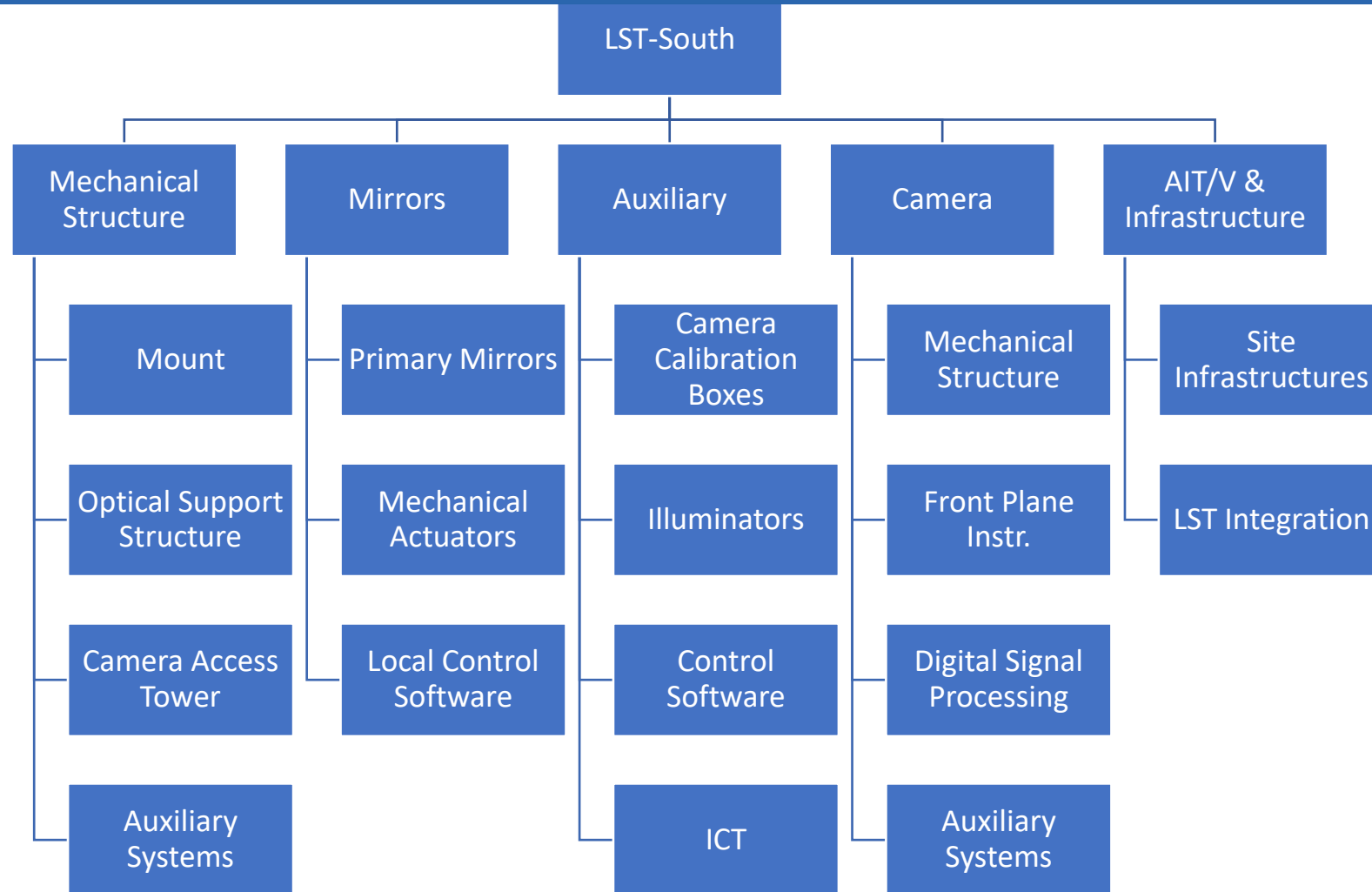


## The CTA+ Program in the PNRR context.

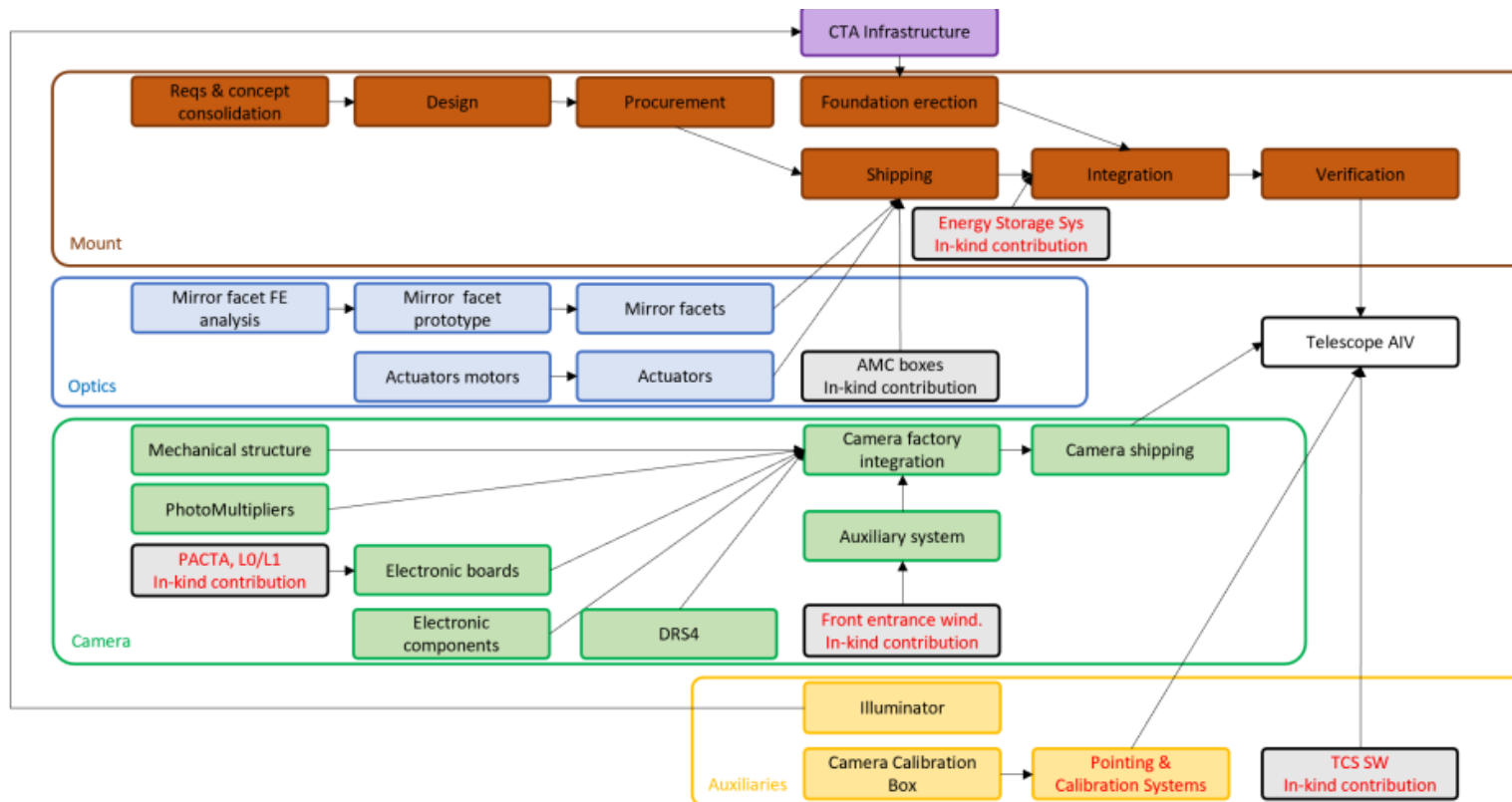
- PNRR Proposal approved in June 2022: 71.5M€ to be spent in 30 (+6) months (2023-25). Project KO on Jan. 1<sup>st</sup> 2023.
- Main contribution aimed at enhancing CTAO-S, opening/strengthening transient science in CTAO South i.e.:
  - a) **CTAO-S baseline + 2 LSTs** (CTA+ major effort) (*PI: Antonelli*)
  - b) **CTAO-S baseline + 5 SSTs** (*PI: Tagliaferri*)
  - c) + **Multi-wavelength follow-up enhancements**:
    - i. VST polarimeter (*PI: Schipani*)
    - ii. TNG fast photometer (*eSIFAP, PI: Ambrosino*)
    - iii. Fast vlbi radio (*PI: Giroletti*)
    - iv. Stellar Intensity Interferometry (*for ASTRI; PI: Zampieri*)
  - d) + R&D new detectors for Cherenkov telescopes or complementary (*PI: Marsella*)
  - e) + **science & outreach** in Italy and HQs (**Resp.: Zanin**)



# PBS



# LST-South workflow

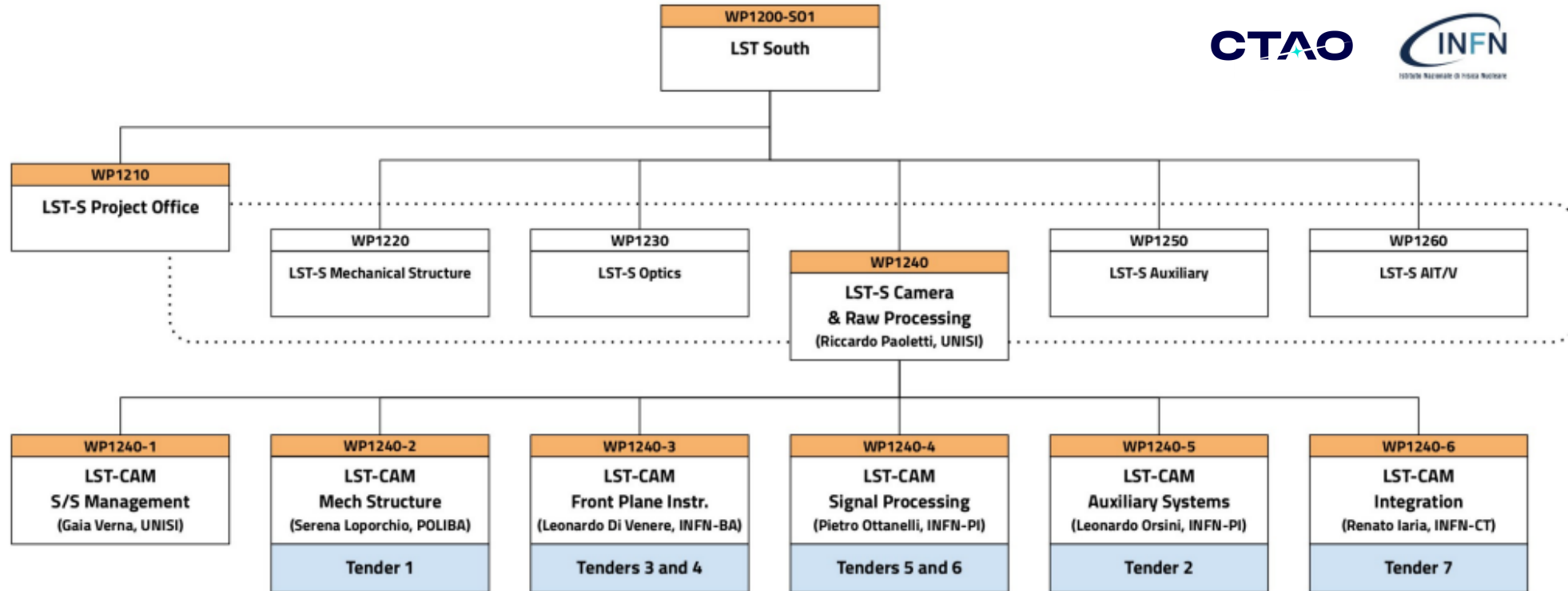


- Mount to be adapted to cope with CTAO-S site conditions
- Optics will keep LST-N overall concept (hexagonal mirror facets supported in very similar ways)
- Camera and auxiliaries will be as in LST-North

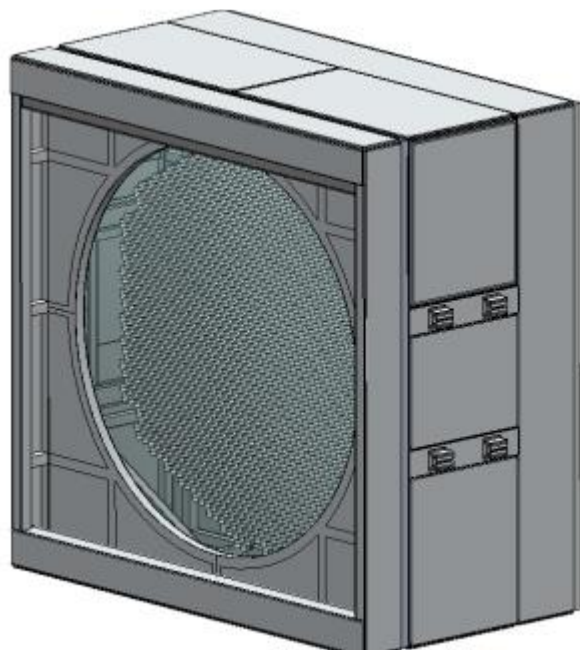
# LST South tenders strategy

- *The chosen strategy was to take an end-to-end approach with few tenders.*
- A fair approach was essential to ensure that all bidders were on a level playing field in the tenders.
- We used the CTAO requirements and specifications tailored for the southern site as mandatory parameters (in the sense of "applicable documents") and the openly available documentation as "reference documents".

# LST-South camera



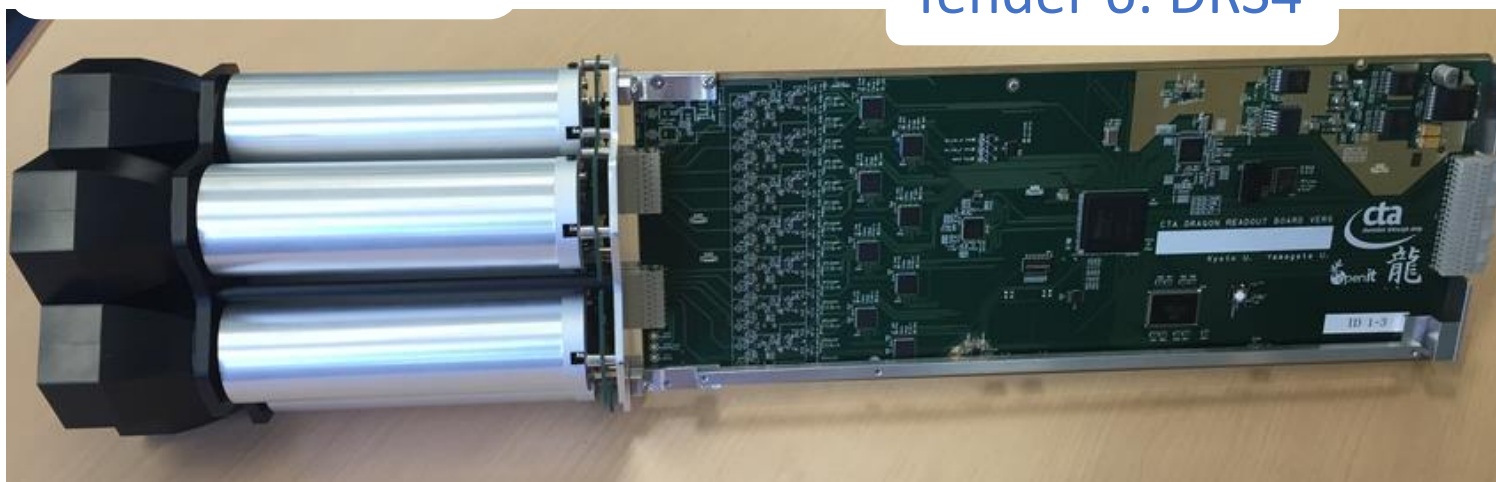
Tender 1: camera mechanics



Tender 3: PMTs procurement

Tender 5: Active components

Tender 6: DRS4



Tender 4: Cluster electronics production & assembly  
+ Tender 7: Integration facility in Catania

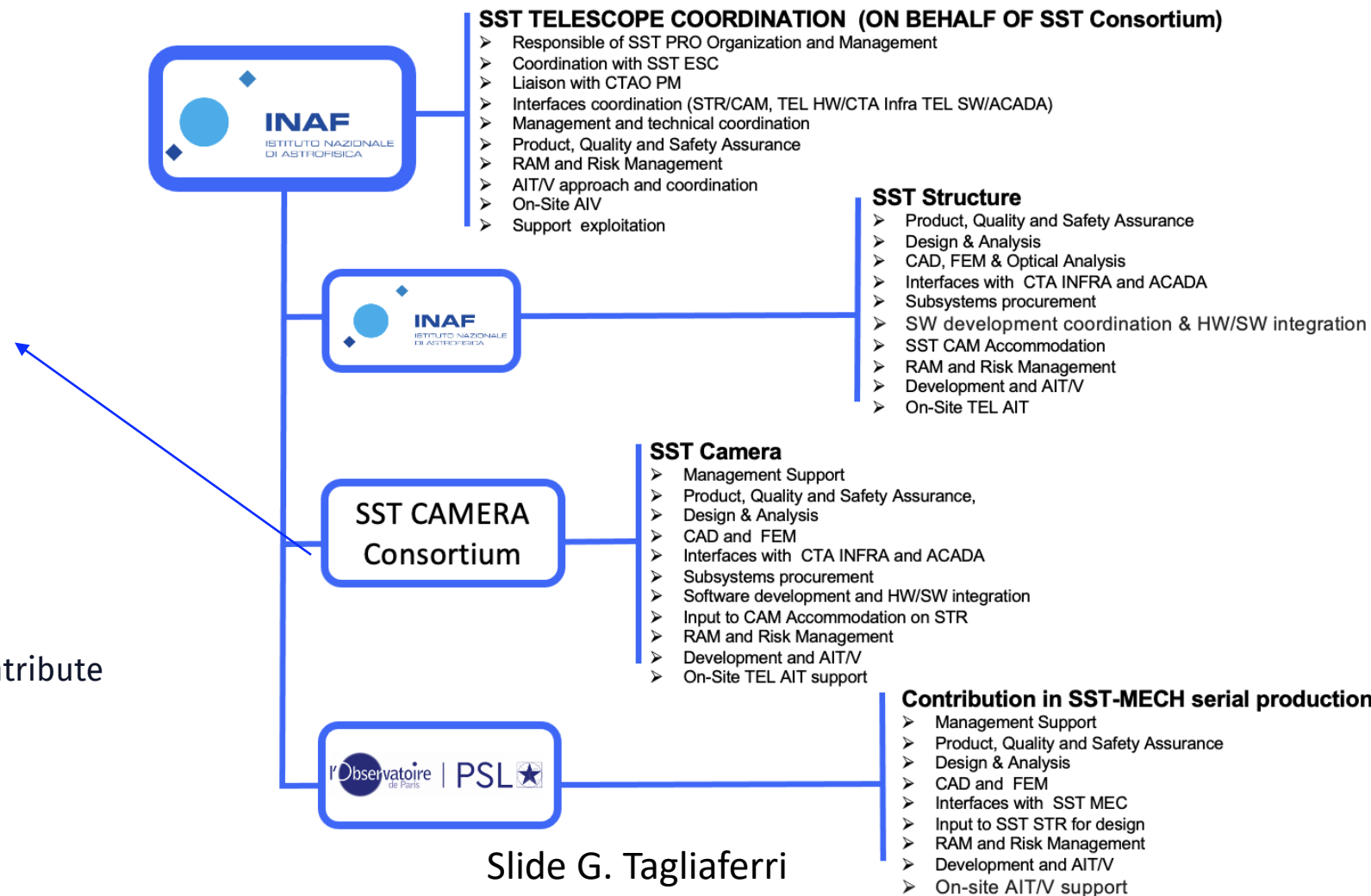
**Outcome: 2 fully equipped LSTs + 470 spare modules (PMT + readout + backplane) + 1 spare cooling unit**

# SST: the actors

## SST Camera Consortium

- **DE:** MPIK, DESY, ECAP
- **UK:** Universities of: Durham, Leicester, Liverpool, Oxford
- **NL:** UvA, Groningen
- **JP:** Nagoya
- **AU:** Universities of: Adelaide, Western Sydney, Sydney, Australian National, New South Wales, Monash, Curtin

The **IAG-USP** Institute from Brazil will contribute to the AIT/AIV activities in Chile



Slide G. Tagliaferri





# Industrial Contracts Status

**SST-MEC Tender #1: INAF 25 SST-MEC, the first 5 from CTA+ will be completed by 31/12/2025**

- selected the Dal Ben company
- The contract has been signed with Kick-Off on June 3<sup>rd</sup>, 2024, activities ongoing
- Next important milestone is the CDR (December 2024/January 2025)

**SST-MEC Tender #2: CNRS 12 SST-MEC + Telescopes Integration**

- call for tender to be issued by the end of 2024

**SST-OPT Tenders (INAF):**

- Primary mirrors (M1): selected the Media Lario Company, the activities have just started
- Secondary mirrors (M2): contract is on going (for the first five mirrors)

Slide G. Tagliaferri



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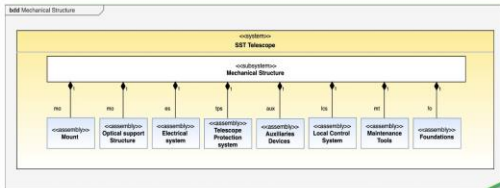


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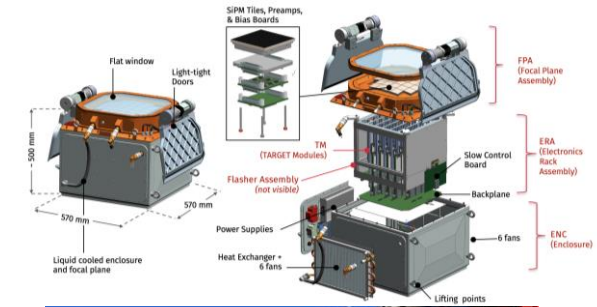
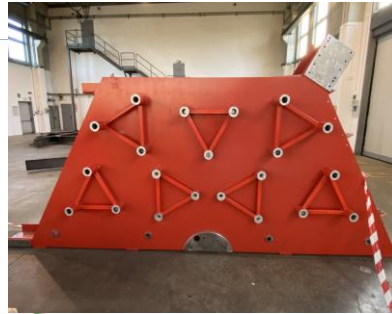
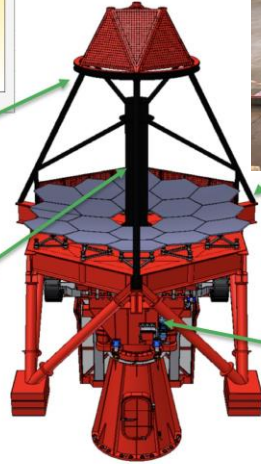


INAF  
ISTITUTO NAZIONALE DI ASTROFISICA

# SST: input from ASTRI, lessons learnt and solutions directly tested

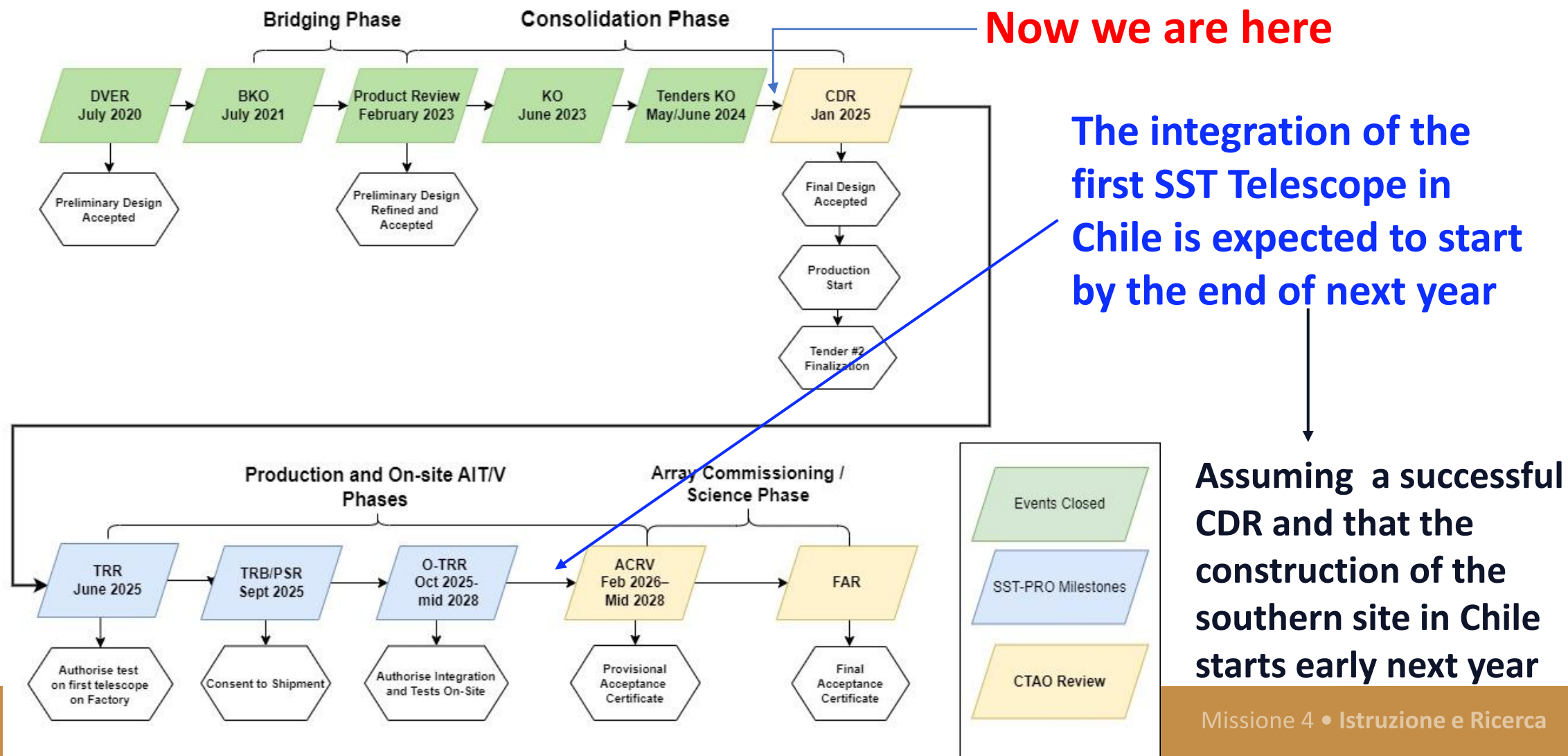


SST-STR decomposition



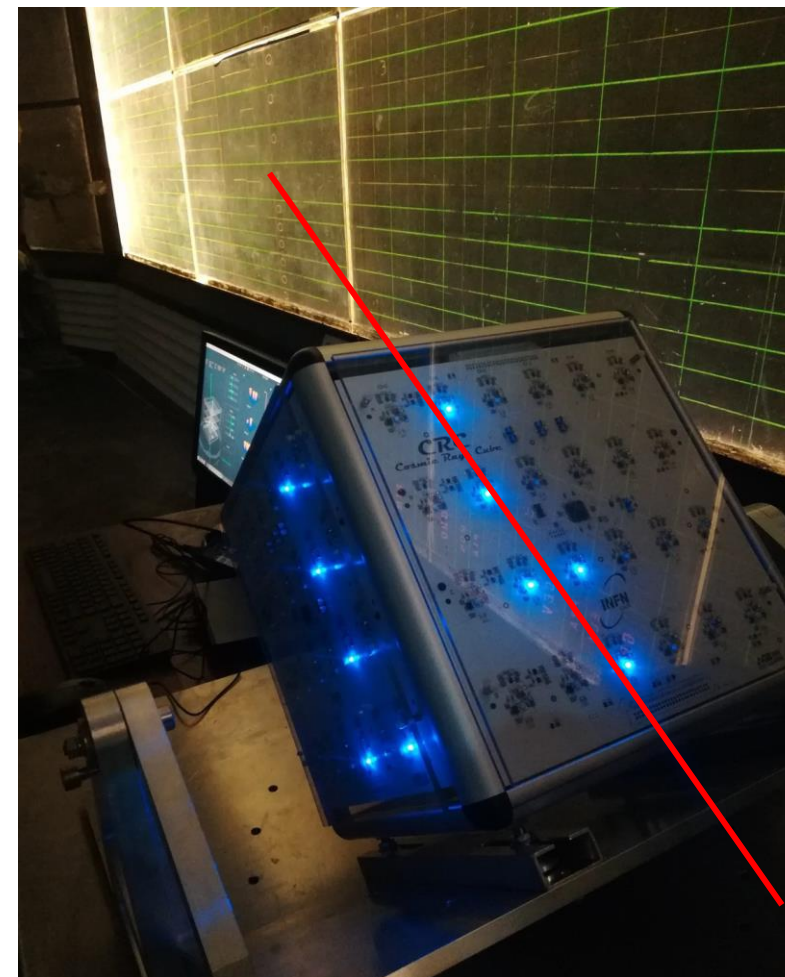
See talk by G. Pareschi

# SST Programme Status



## CTA+ outreach program

- The CTA+ program also includes many outreach and science communication activities, with events for the general public, but above all with activities for students and training for teachers to bring them closer to the fascinating world of gamma rays and astroparticle physics.
- Among all these activities, I will briefly describe two courses dedicated to Italian high school teachers, also using the Cosmic Ray Cube telescopes, founded by CTA+ program



## Discovering cosmic rays for in-service high school physics teachers

**From 10 to 13 December 2023**, 17 secondary school teachers from all over Italy attended the "Discovering Cosmic Rays" a course at the Gran Sasso National Laboratories.

The 2.5-days residential course was an opportunity to learn more about the fascinating topic of cosmic rays and gamma rays, the experiments that observe them and the messages they can bring us from space.



During the practical sessions, **participants were actively involved in building a muon telescope**, performing a muon flux measurement and analysing the data.



The aim of the course was to provide an overview of the subject matter, enabling participants to familiarise themselves with the activities, experience them first hand and build on their prior knowledge and skills, **thus facilitating immediate implementation of the activities in the classroom.**

## Second Teachers' Course INFN and Department of Physics and Astronomy, University of Padua.

- From September 9th to 11th, 30 physics teachers from secondary schools all over Italy participated in the course "Discovering the High Energy Universe".
- During the three days, seminars were held to deepen the knowledge of cosmic rays and the extreme events that produce them, such as blazars
- There was space for experimental activities through the use of astronomical portals to access data from astronomical observatories, perform data analysis activities, and develop educational pathways for use in the classroom.



The screenshot shows the INFN website's 'NEWS SCUOLA' section. The article title 'INSEGNANTI ALLA SCOPERTA DELL'UNIVERSO DELLE ALTE ENERGIE' is circled in red. The article text describes a course for secondary school teachers on high energy astrophysics, held from September 9th to 11th, 2024, at the University of Padua. It mentions that 30 teachers were selected from 180 candidates across Italy. The course includes seminars, data analysis, and experimental activities. The article also notes that the course is part of the INFN's outreach activities, specifically the 'OCRA - Outreach Cosmic Ray Activities' project, which is funded by the PNR Cherenkov Telescope Array Plus CTA+.



## Conclusions

- CTA+ will improve the performance and scientific output of the CTAO South Array
- The larger and most ambitious goal of the CTA+ programme is to implement two LSTs and five SSTs at the CTA South site in about three years, using an end-to-end approach.
- The two telescopes will be realised using the same basic design as the northern LSTs, with the exception of the modifications required to meet the environmental requirements of the southern site and to further reduce construction risks and costs.
- The production of the auxiliary instruments, cameras, mirrors and mechanical structures will be realised through large industrial contracts overseen by the CTA+ management with the support of the LST Collaboration and the CTAO.
- Some international partner countries of the LST Collaboration also provide in-kind contributions to the realisation of part of the telescopes.
- CTA+ is carrying out an R&D programme for future CTAO detectors and ancillary instruments.
- The science and outreach programme is well integrated and developed.



## Acknowledgements

This work has been realized with the EU funding program "Next Generation EU" in the context of the PNRR-IR "CTA+". The acknowledgements for CTA Consortium are listed here: [https://www.cta-observatory.org/consortium\\_acknowledgments/](https://www.cta-observatory.org/consortium_acknowledgments/) . We gratefully acknowledge financial support from the following agencies and organisations listed here: <https://www.lst1.iac.es/acknowledgements>.

## Questions?