

LST Project Status

D. Della Volpe on behalf the LST collaboration

12th of January 2022

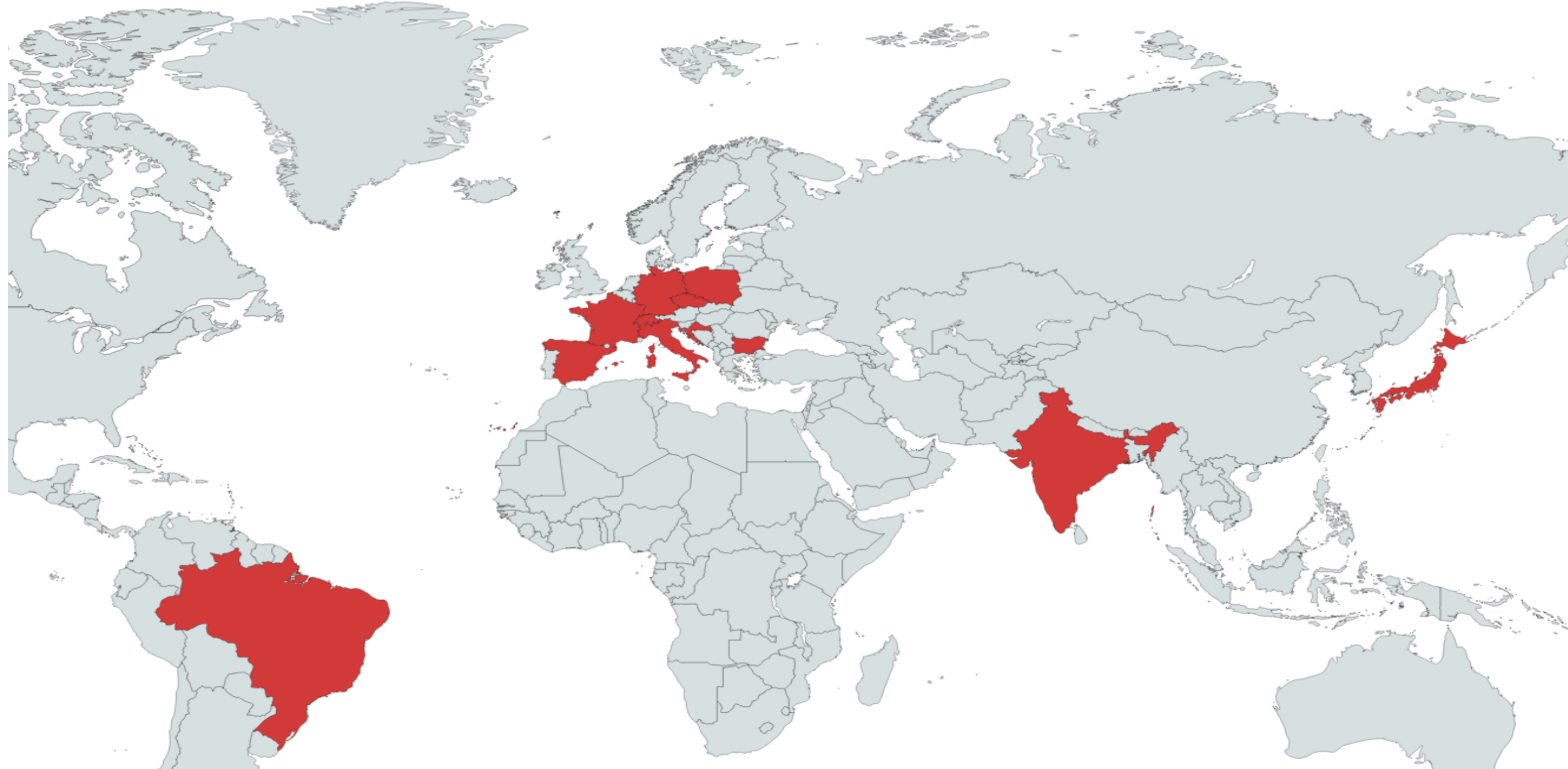
CTA Swiss Day



UNIVERSITÉ
DE GENÈVE

FACULTÉ DES SCIENCES

LST Collaboration



	Members	Scientist	Authors
Bulgaria	3	3	3
Brazil	3	2	2
Croatia	13	13	13
Czech Rep.	15	15	9
France	37	16	18
Germany	34	27	27
India	2	2	2
Italy	55	46	36
Japan	73	69	54
Poland	2	2	2
Spain	77	42	49
Switzerland	13	12	12
Total	327	249	227

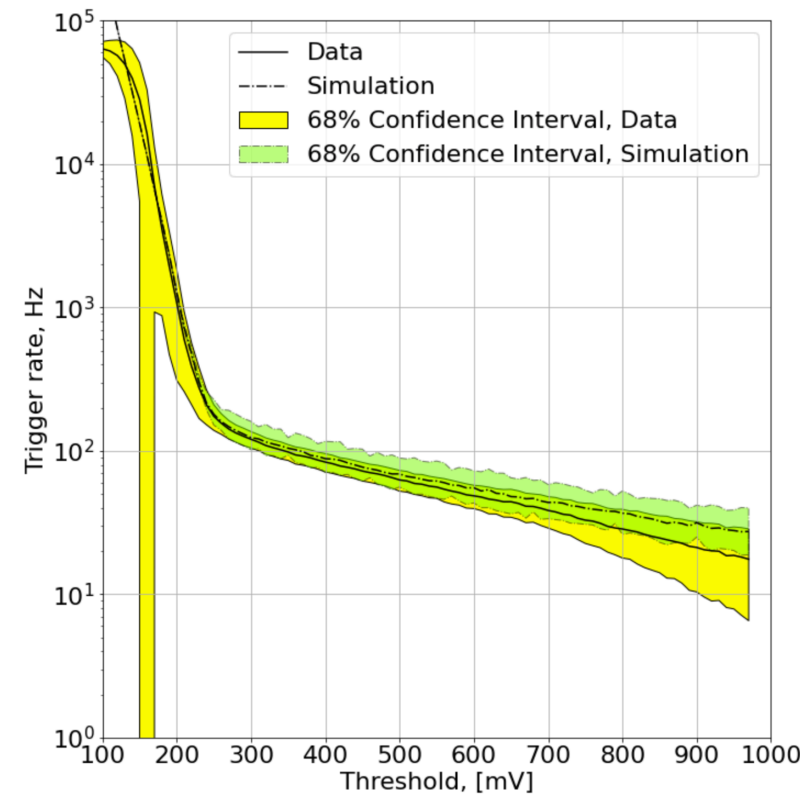


The Swiss scientists' role in LST



UNIGE DPNC

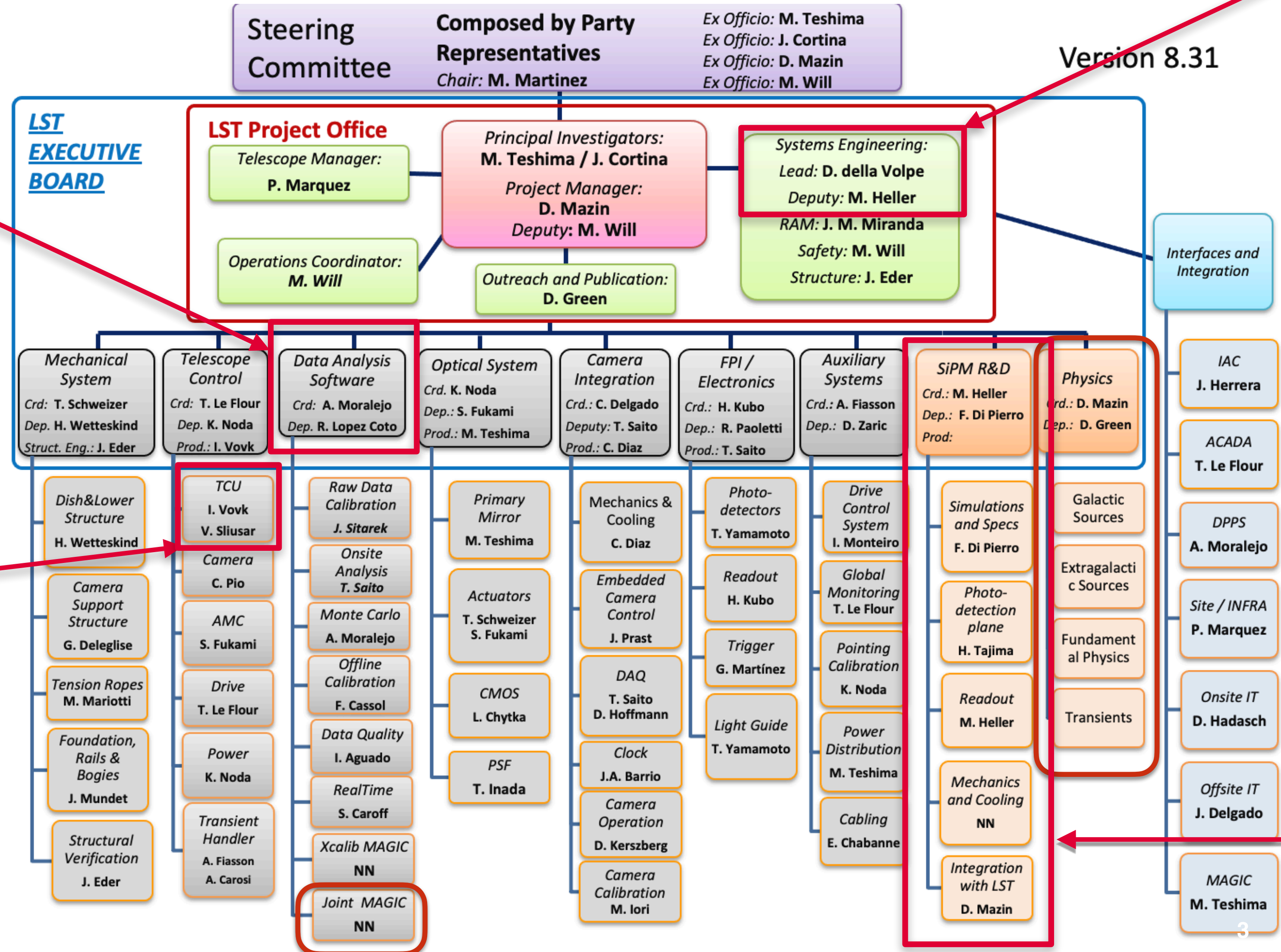
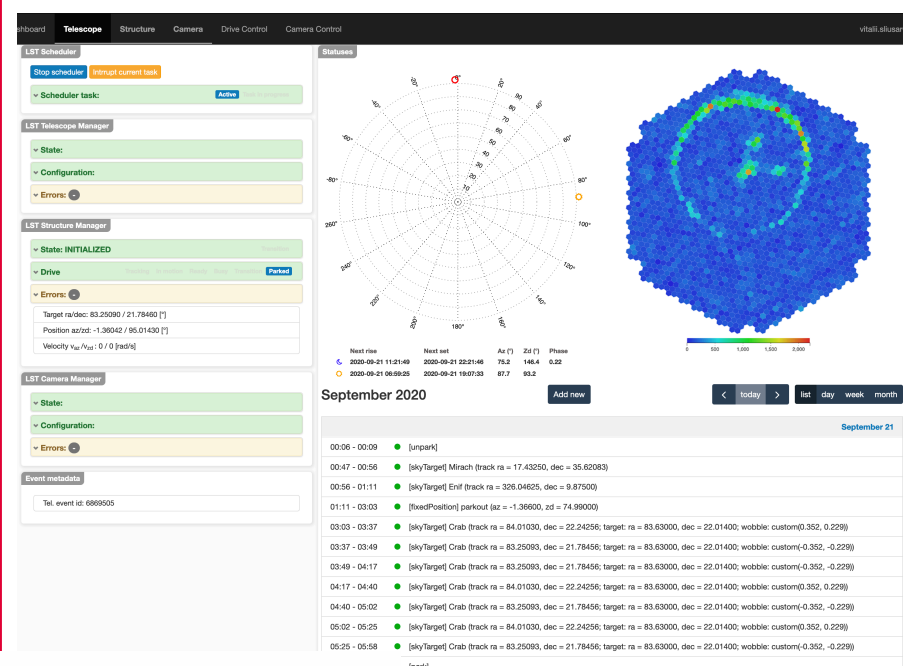
- Data analysis pipeline
- Data/Monte Carlo validation



L1 trigger rate data/MC

UNIGE ASTRO

- Telescope Control Unit
- Engineering GUI



UNIGE DPNC:

- System engineering with main focus on CDR follow-up



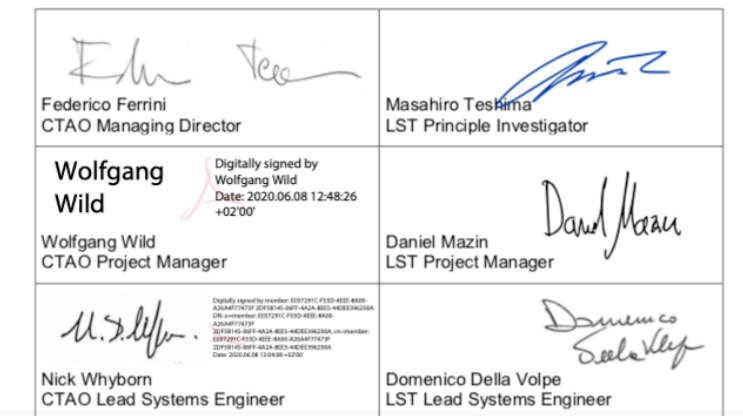
Declaration of CDR Pass

Following the criteria for passing the CDR given in Section 2 and the agreed work plan given in Section 3, the CTAO is pleased to confirm that the criteria are fulfilled to pass the CDR. Therefore,

CTAO declares the LST Critical Design Review as passed.

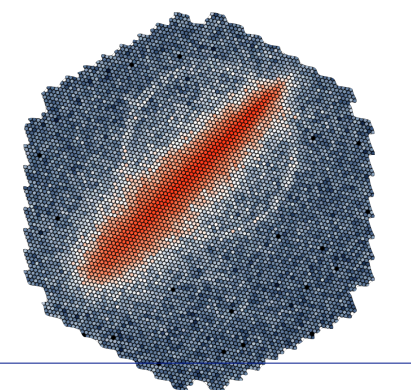
The CTAO is looking forward to the successful completion of all review related actions following the plan given in Section 3 and the acceptance of LST1 as the first CTA Observatory telescope.

The CTAO is also looking forward to the production of the LSTs 2, 3 and 4 by the LST Sub-Consortium and the acceptance and integration into the CTA-North Observatory array.



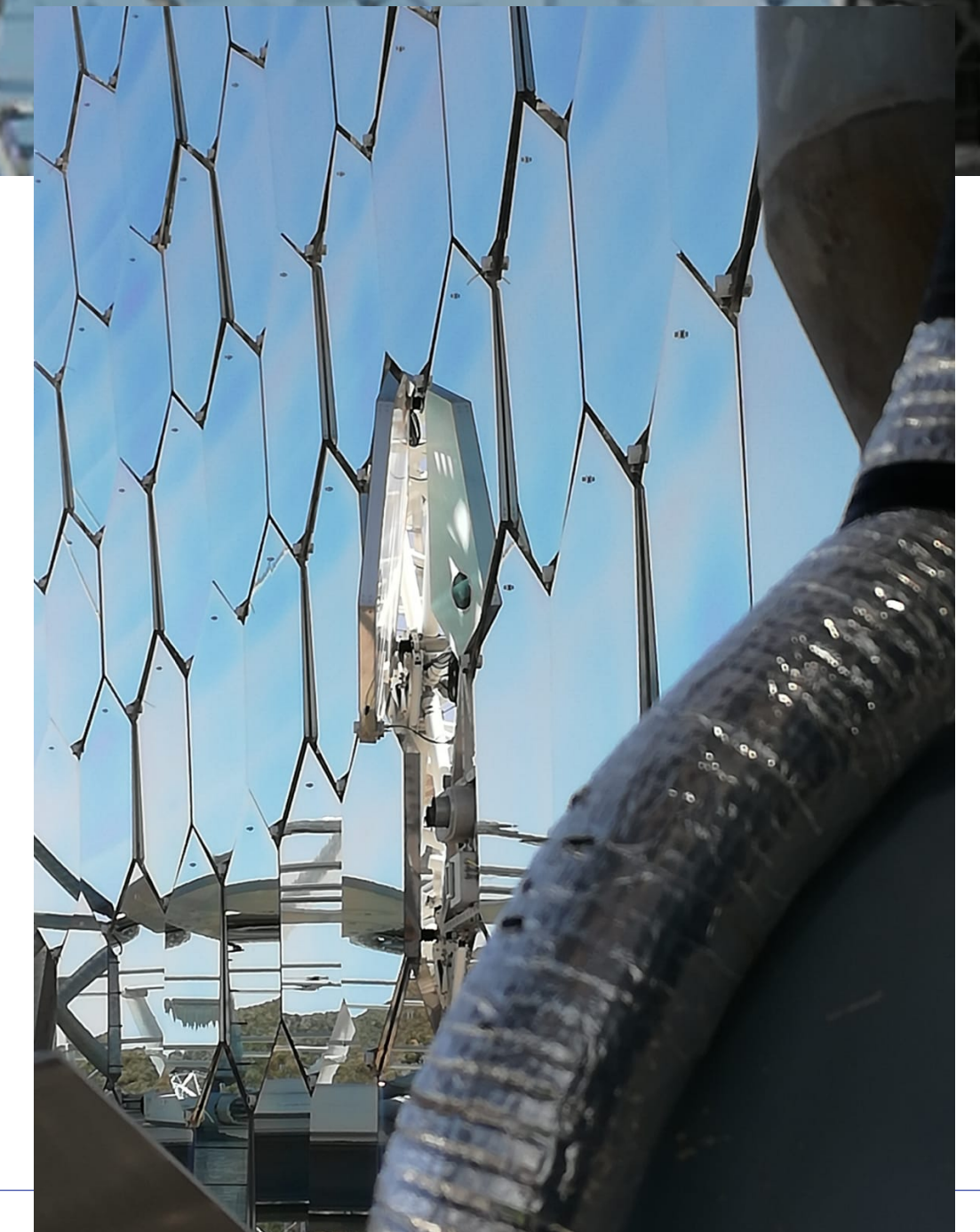
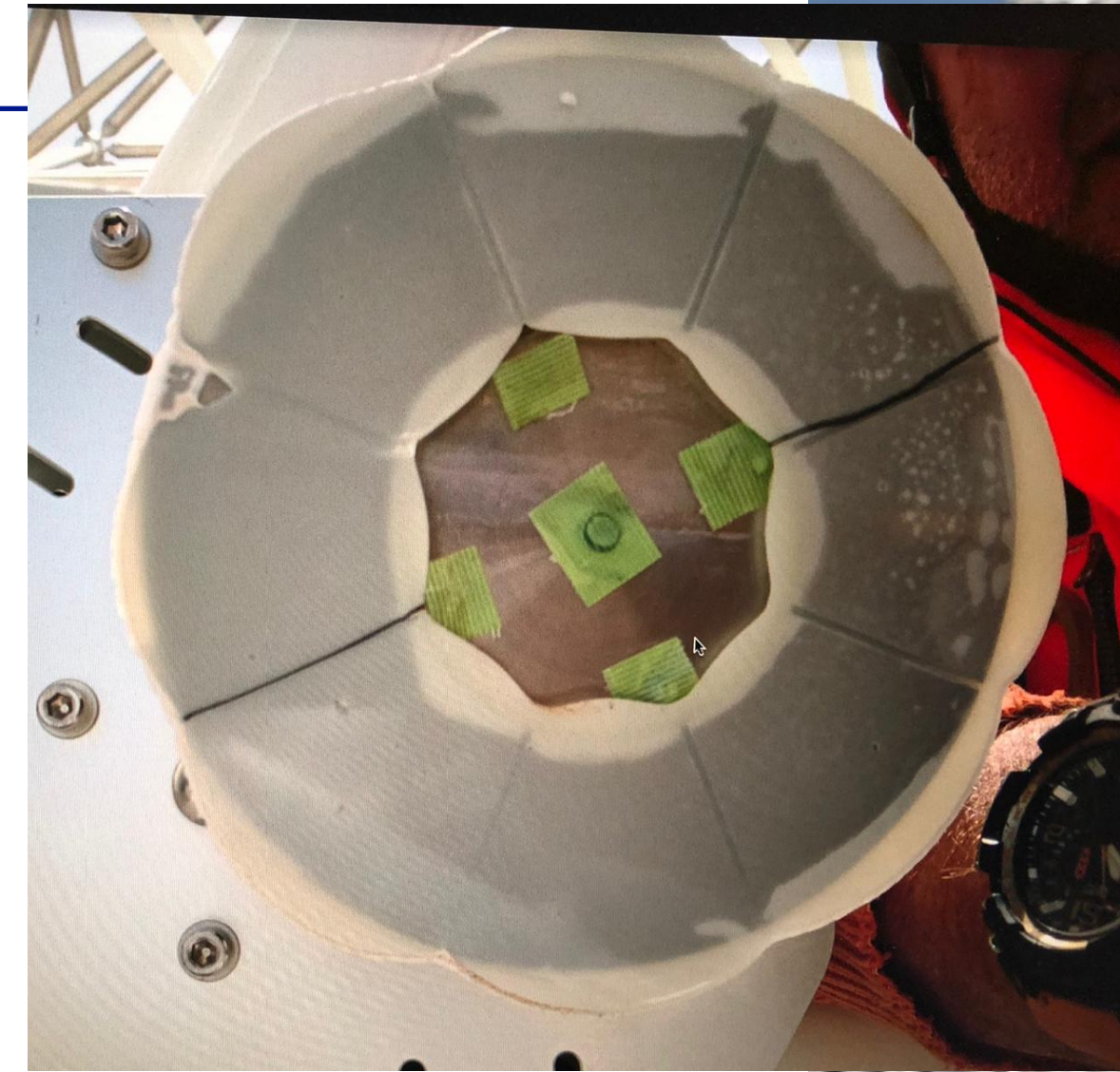
UNIGE DPNC/EPFL/ETHZ

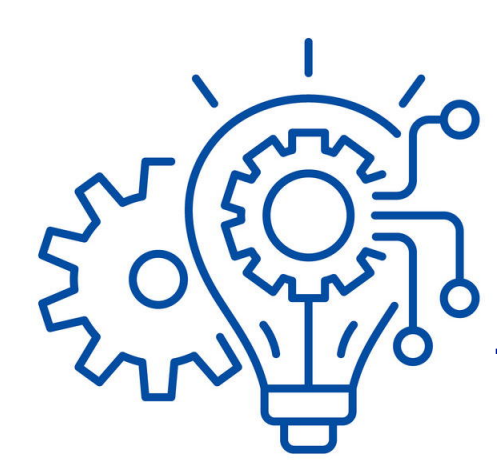
- Project coordination
- R&D activities on sensor, front-end electronics and digital readout



A tough Year

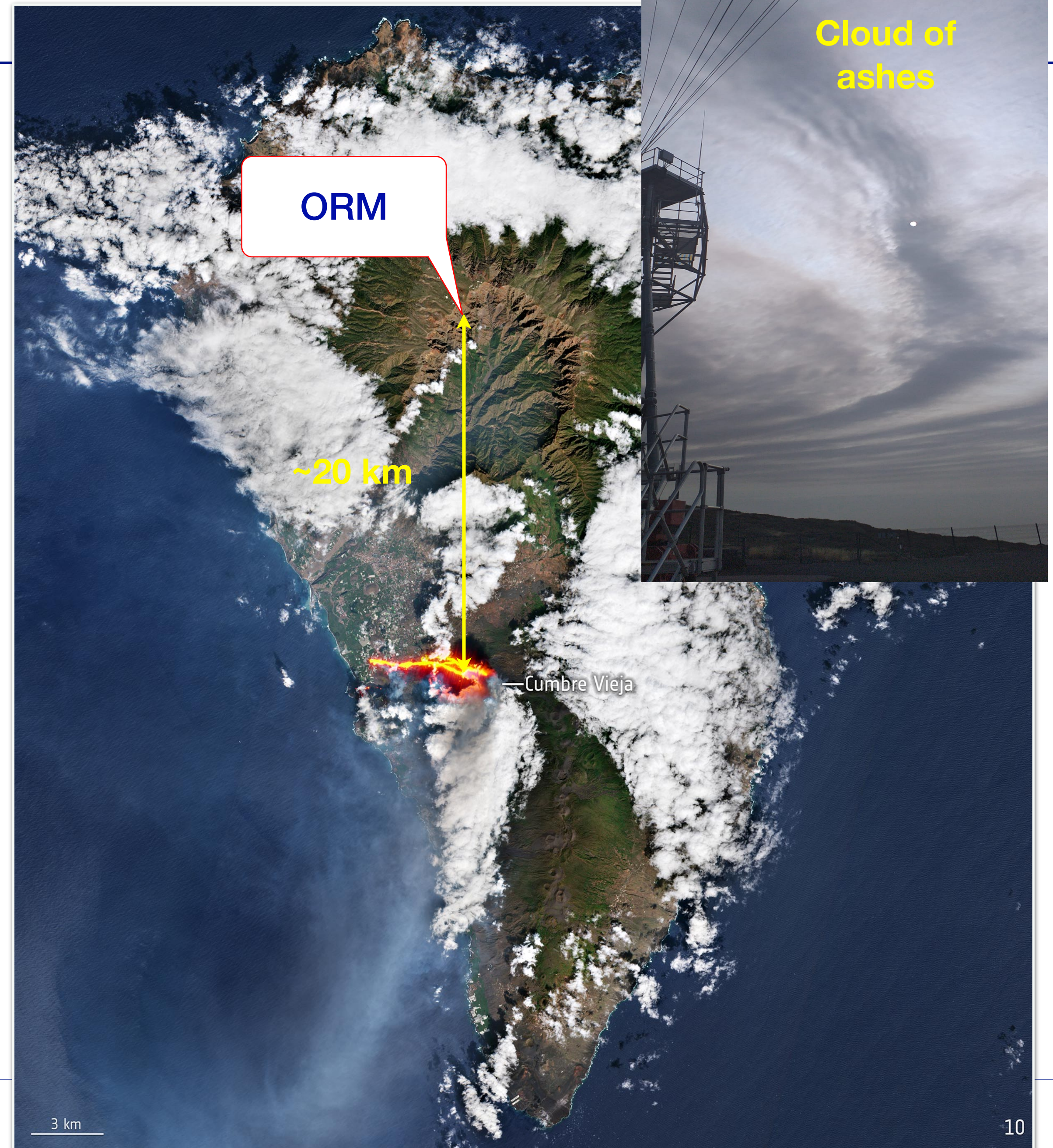
- ▶ COVID break-in
 - Need to react and re-adjust all activities
- ▶ A major incident: Mirror detachment
 - On March, a mirror in the middle of the dish, detached
 - The first analysis pointed to a single failure,
 - Later confirmed by a series of test performed by the optics group
 - Some identified non-conformity will be corrected
 - Silicon protection of the glue to be corrected
 - Change washer size for the safety bolt
- ▶ And in the end

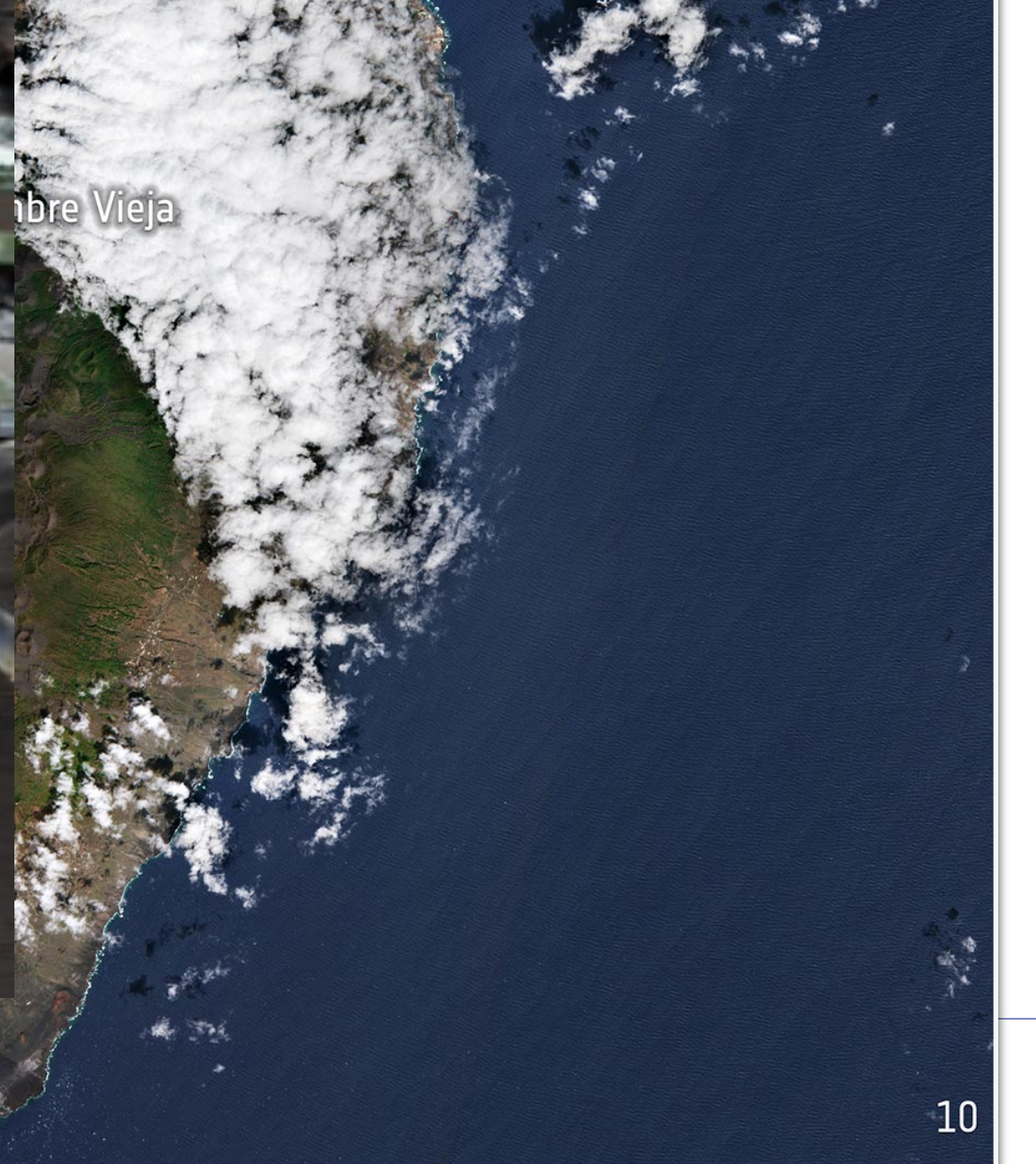




Volcano Eruption

- ▶ On 21st of September the volcano Cumbre Vieja erupted
- ▶ The longest eruption since last 700 years
 - Major damages to the island, thousand of house destroyed, road, infrastructure
 - Now people, can finally rebuild and recover
 - It will be a long process
- ▶ Significant ash fall-out
- ▶ In last days, high concentration of SO₂ in the air
 - Dangerous for people
 - With water can create acid - H₂SO₄









LST project status Overview



▶ CDR

- Progress in all area.
- An important Milestone was achieved with the visit by CTAO on site.
- The decision on last Software array trigger (SWAT) is shifting its closing - see ACADA matters

▶ Commissioning

- Many improvement but Volcano eruption imposed a substantial break
- Finally restoring the telescope these days
- ACADA release 1 integration in LST1 in preparation

▶ Operations

- Quite smooth and regular until Volcano eruption
- A good quantity of data recorded, most of which of very good quality
 - See analysis result delivered this year

▶ LST2-4 construction

- Steady progress on the tenders managed by IAC and contributors from the different countries
- Some delay introduced by the bureaucracy related to permits and licences

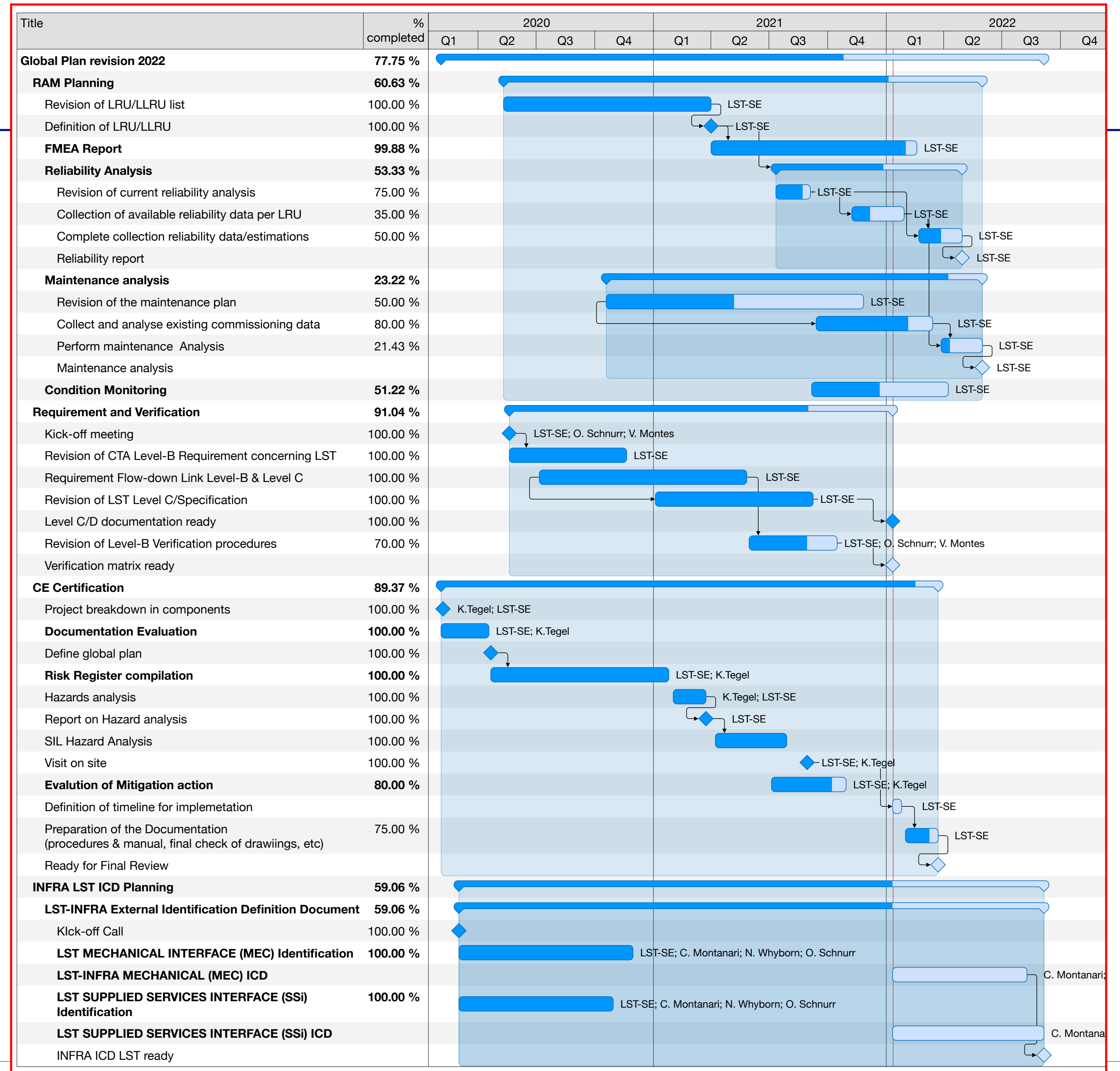
LST CDR

- ▶ Major progress in all areas
- ▶ Activities agreed could be completed by Q2 2022
- ▶ A meeting in coming weeks with CTAO SE to agree on the formal steps for closure

CDR is first step towards CTAO acceptance of LST

Most of the result of these activities, set the basis for IKC

- ▶ What is a product (Requirements)
- ▶ If it meets expectation (Verification, RAMS)
- ▶ How much will it cost to maintain it (RAMS, Maintenance)
- ▶ If it safe according to CE rules
- ▶ It will integrate correctly (Interfaces)



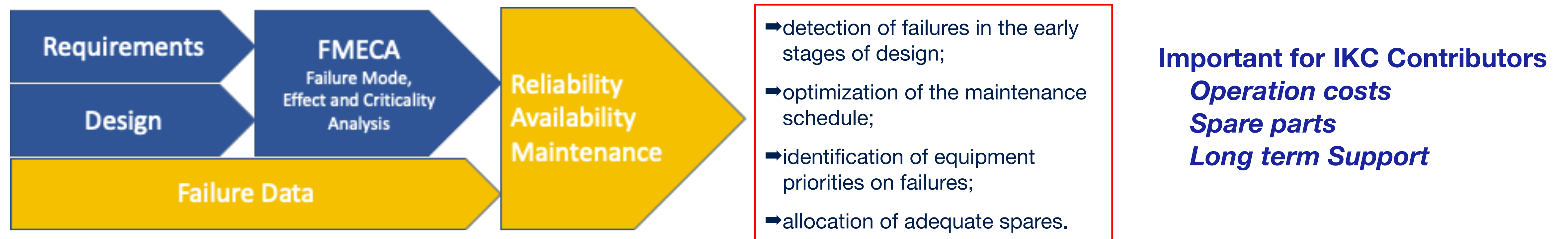
- ▶ An excellent and tremendous job done over the year by M. Heller and M. Will (now M. Stodulska will take over M. Heller)
 - More than 1000 of requirements and specification analysed
 - Flow-down of the requirement from Level-B up to Level-D
 - Delivered to CTA in the end of 2021, now under scrutiny
- ▶ A dedicated 2-days meeting will be organised by S. Stanghellini (CTAO) to go together through it and validate the work
- ▶ Next steps
 - Verification plans based on this revision of requirements
 - Discussions are already on-going with CTAO to define the format and template to be used
 - A big part of the verification methods have been already checked during last year's work

Requirements define what an LST product is

Verification checks that the design and realisation match.

RAM - Reliability, Availability & Maintenance

- ▶ This activity was behind schedule, suffering lacking of man power.
- ▶ Since the Hiring of M. Stodulska, on August, there was an impressive boost
 - Also another 0.5 FTE were provided by INFN/INAF with E. Giro, now part of the SE team.
- ▶ We are finalising the FMEA these days to be discussed with CTAO for its blessing and to close this deliverable.
- ▶ In parallel, reliability analysis is on going and its quite advanced.
- ▶ We are quite confident to complete this work before the end of Q2-2022





Conformity with European health, safety, and environmental protection standards



- ▶ Though this is a 'living' object and it is continuously revised, for CDR closing, the work done so far is considered finished.
- ▶ Few procedures to be written but the overall analysis is considered complete


#	Title	% completed	Expected End	Q1 / 2020		Q2 / 2020		Q3 / 2020		Q4 / 2020		Q1 / 2021		Q2 / 2021		Q3 / 2021		Q4 / 2021		Q1 / 2022		Q2 / 2022						
				01	02	03	04	05	06	07	08	09	10	11	12	01	02	03	04	05	06	07	08	09	10	11	12	01
0	CE Certification	89.37 %	23 Mar 2022																									
1	Project breakdown in components	100.00 %	6 Feb 2020	◆ K.Tegel; LST-SE																								
2	Documentation Evaluation	100.00 %	17 Apr 2020																									
3	Definition of the documentation for each subsystem	100.00 %	3 Feb 2020	◆																								
4	Provide Existing Documentation	100.00 %	21 Feb 2020	□ LST-SE																								
5	Evaluation by CTAO	100.00 %	17 Apr 2020	□ K.Tegel																								
6	Define global plan	100.00 %	20 Apr 2020	◆																								
7	Risk Register compilation	100.00 %	25 Jan 2021																									
14	Hazards analysis	100.00 %	24 Mar 2021	□ LST-SE; K.Tegel																								
15	Report on Hazard analysis	100.00 %	24 Mar 2021	◆ K.Tegel; LST-SE																								
16	SIL Hazard Analysis	100.00 %	28 July 2021	□ LST-SE																								
17	Visit on site	100.00 %	30 Aug 2021	◆ LST-SE; K.Tegel																								
18	Evaluation of Mitigation action	80.00 %	29 Oct 2021																									
19	Preparation of documentation	85.00 %	3 Sep 2021	□ LST-SE																								
20	Definition of the Mitigation action	75.00 %	29 Oct 2021	□ K.Tegel; LST-SE																								
21	Definition of timeline for implementation		21 Jan 2022	□ LST-SE																								
22	Preparation of the Documentation (procedures & manual, final check of drawings, etc)	75.00 %	23 Mar 2022	□ LST-SE																								
23	Ready for Final Review		23 Mar 2022	◆																								

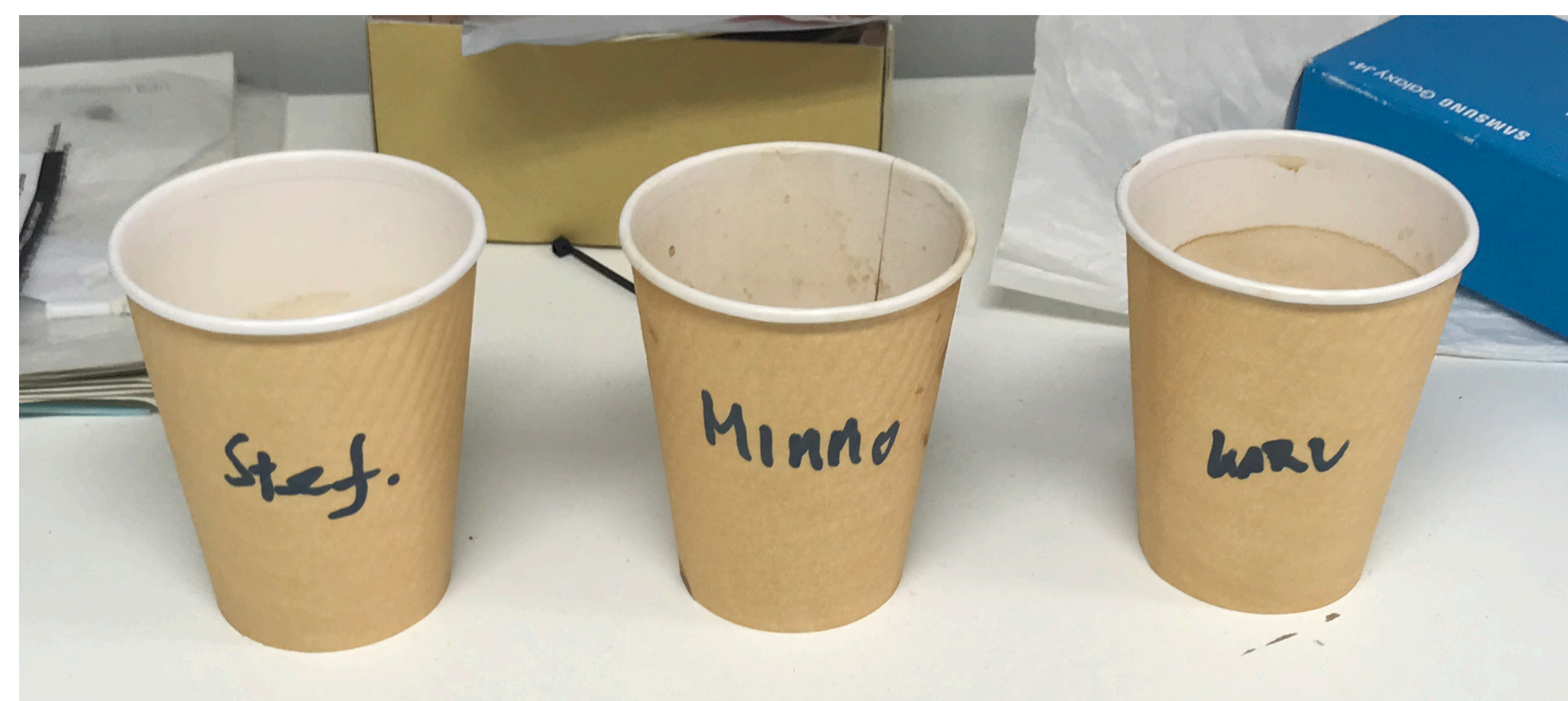
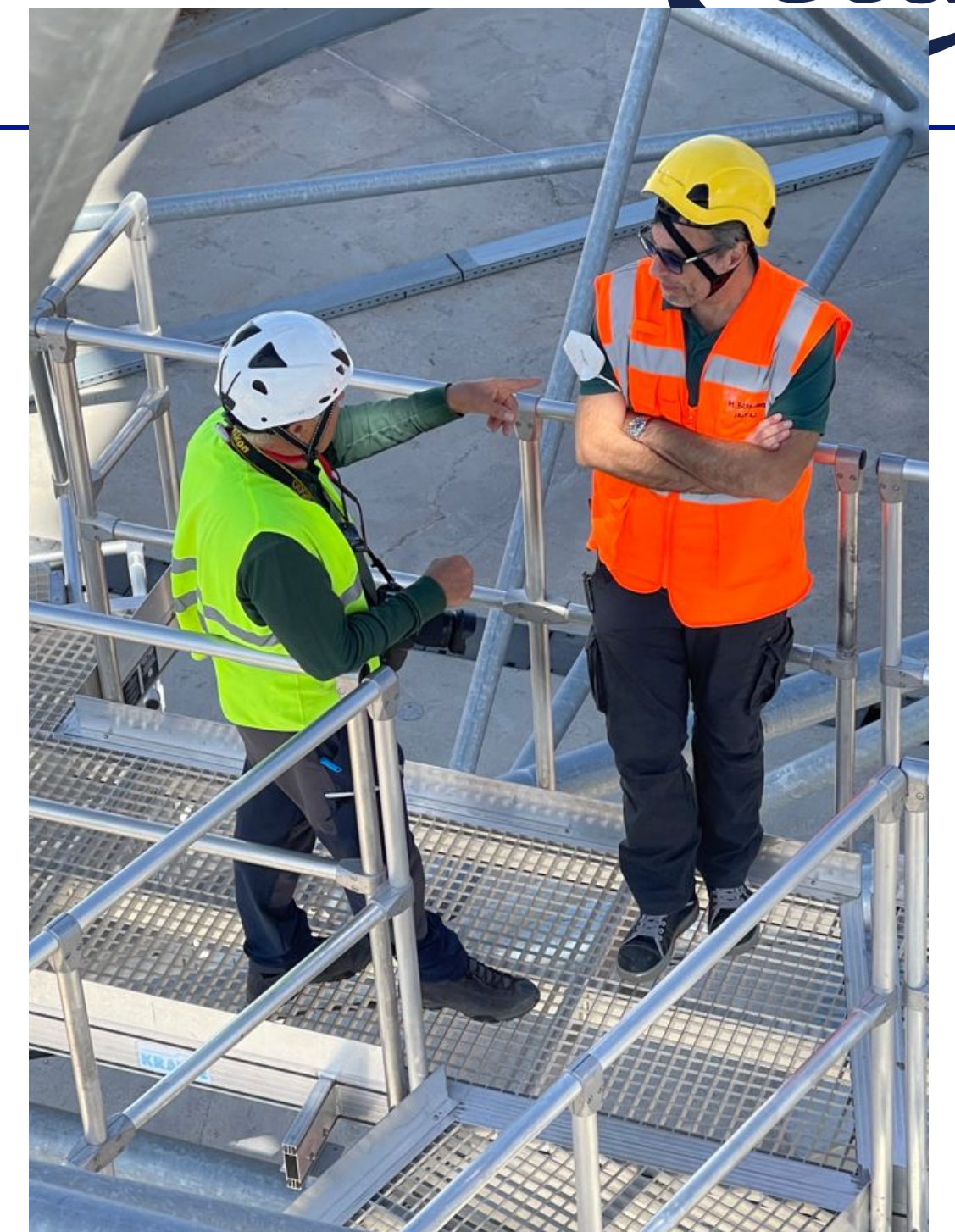
Based on LST2-4 Tender documentation

Living docs in EDMS ([link](#))

The last missing milestone was the visit on-site of CTAO, which happened in September 2021, few days before volcano eruption.

Visit at ORM 1-8 Sep. 2021

- ▶ .. it was very successful and prolific
- ▶ A deep inspection of the LST1 
 - CE compliance findings confirmed by K. Tegel
 - S. Stanghellini satisfied with the project status
 - Later S. Haid, CTAO Director of Administration
- ▶ Reaffirmed an optimal cooperation with CTAO



Visit at ORM 1-8 Sep. 2021

► also identify possible improvements on

- Foundation Crack
- Implementation of Lightning Protection system
- Cable routing in some places



- ▶ Spotted an incoherence between original Array trigger architecture (2017) and the Data model (2021)
 - LST & NectarCam build their Event Builder (EVB) according to the specification and design given by CTA in 2017 (**SWAT-2**)
 - The R1 Data model, recently approved, instead is not compliant with that original design and requires a different trigger scheme. (**SWAT-1**)
- ▶ No consensus was found to decide between the 2 schemes
 - For LST both trigger schemes are fine
 - For ACADA both implementation were fine,
 - start discussion with all project to compose this discrepancy
 - It was not possible to achieve a shared view (Flashcam and SST objected)
- ▶ A formal process was started
 - A memorandum was prepared from all projects with preferred option and impact term of time/money/performance
- ▶ CTAO decide to go for SWAT-1
 - EVB for NectarCam has to be changed
 - LST and NectarCam have the same EVB so we need to go together
 - The performance can be affected

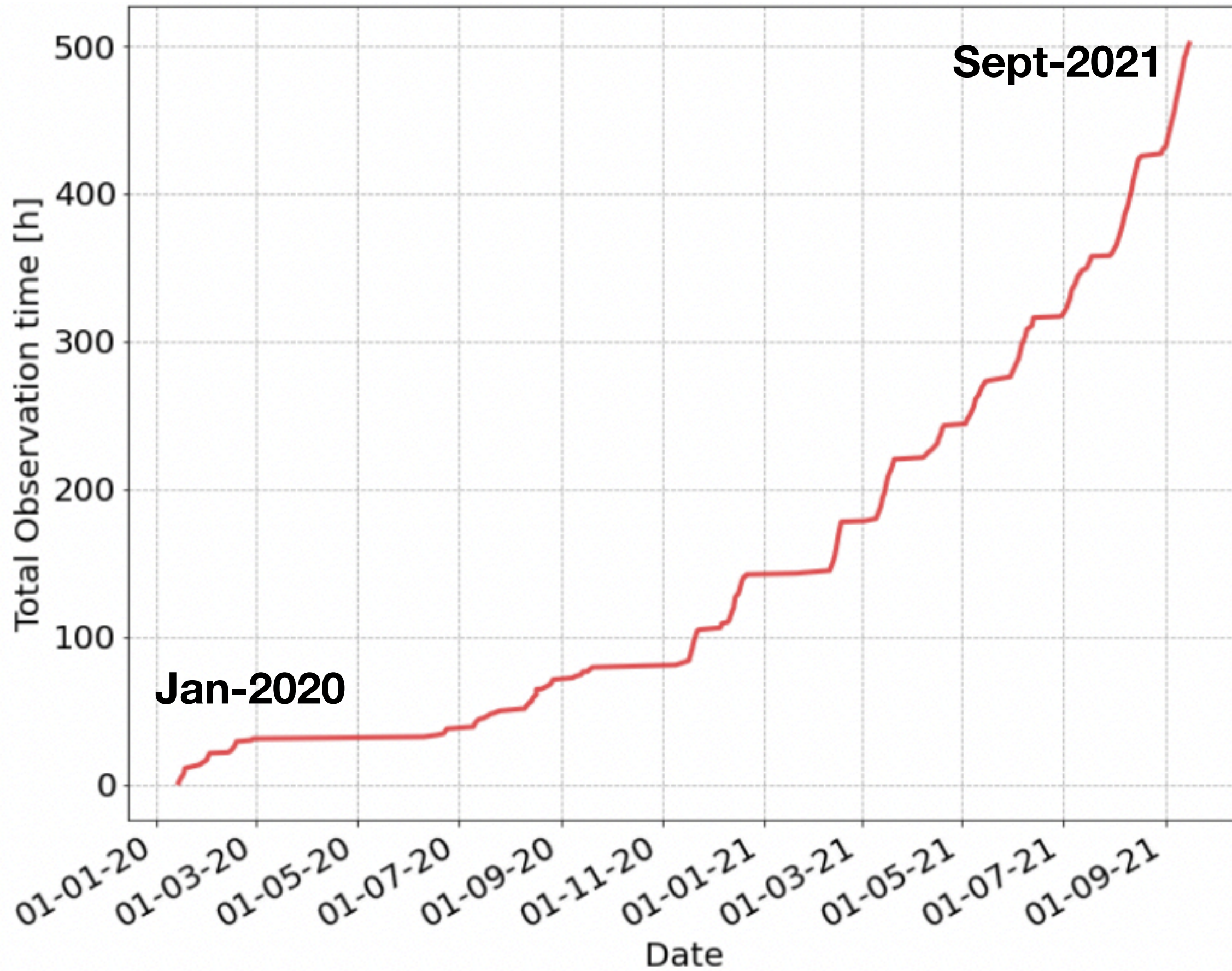
LST will evaluate the SWAT-1 solution with a new EVB.

If performance not achievable, or LST performance not fully exploitable re-discussion shall happen

- ▶ ACADA release 1 will be tested in LST in 2022
- ▶ Regular bi-weekly meeting between ACADA and LST developer team
 - It was agreed that SE will not follow this as being purely technical
 - Where decision is to be agreed, it will be discussed in the bi-weekly meeting between ACADA - LST SE
- ▶ The SWAT-1 decision impacts the timeline, but LST wants to test the final system (with new EVB) even if there could be performance issue.
- ▶ A detailed plan with deliverable and milestones is being produced in collaboration between ACADA and LST

LST-1 commissioning

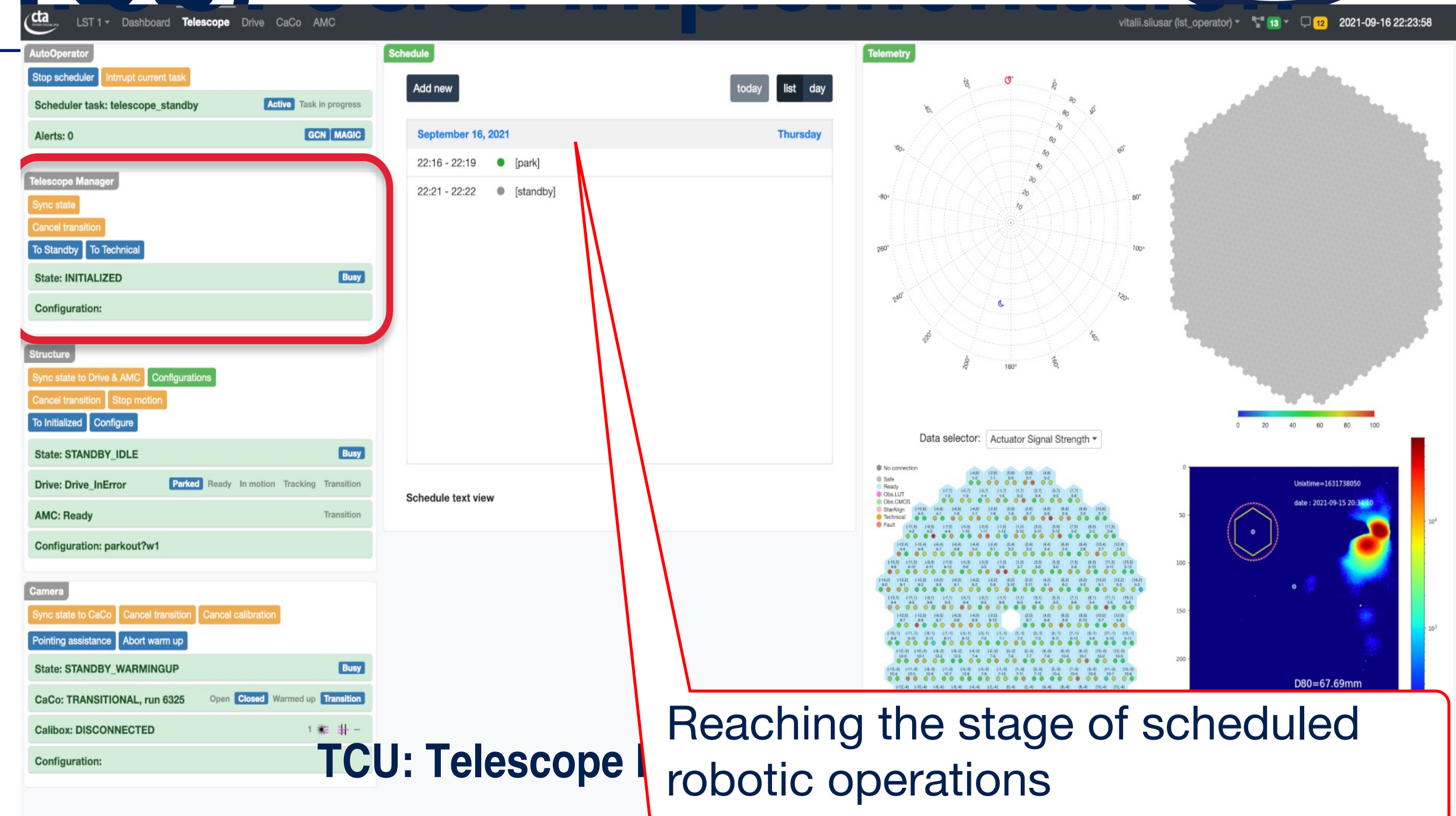
<https://pos.sissa.it/395/872>



- ▶ Implemented semi-remote operations, triggered by Covid-19 pandemic
- ▶ Telescope operated remotely, plus at least two people on-site
- ▶ Data processed at dedicated on-site IT center contributed by U-Tokyo

Telescope Control Unit (TCU)

- ▶ TCU became our main operator interface to control LST
 - Still many minor issues
 - Better error detection, including subsystems' health checks
 - Better handling of edge cases, automatic error resolution (if possible) and reporting



- ▶ These are not pure TCU software related issue

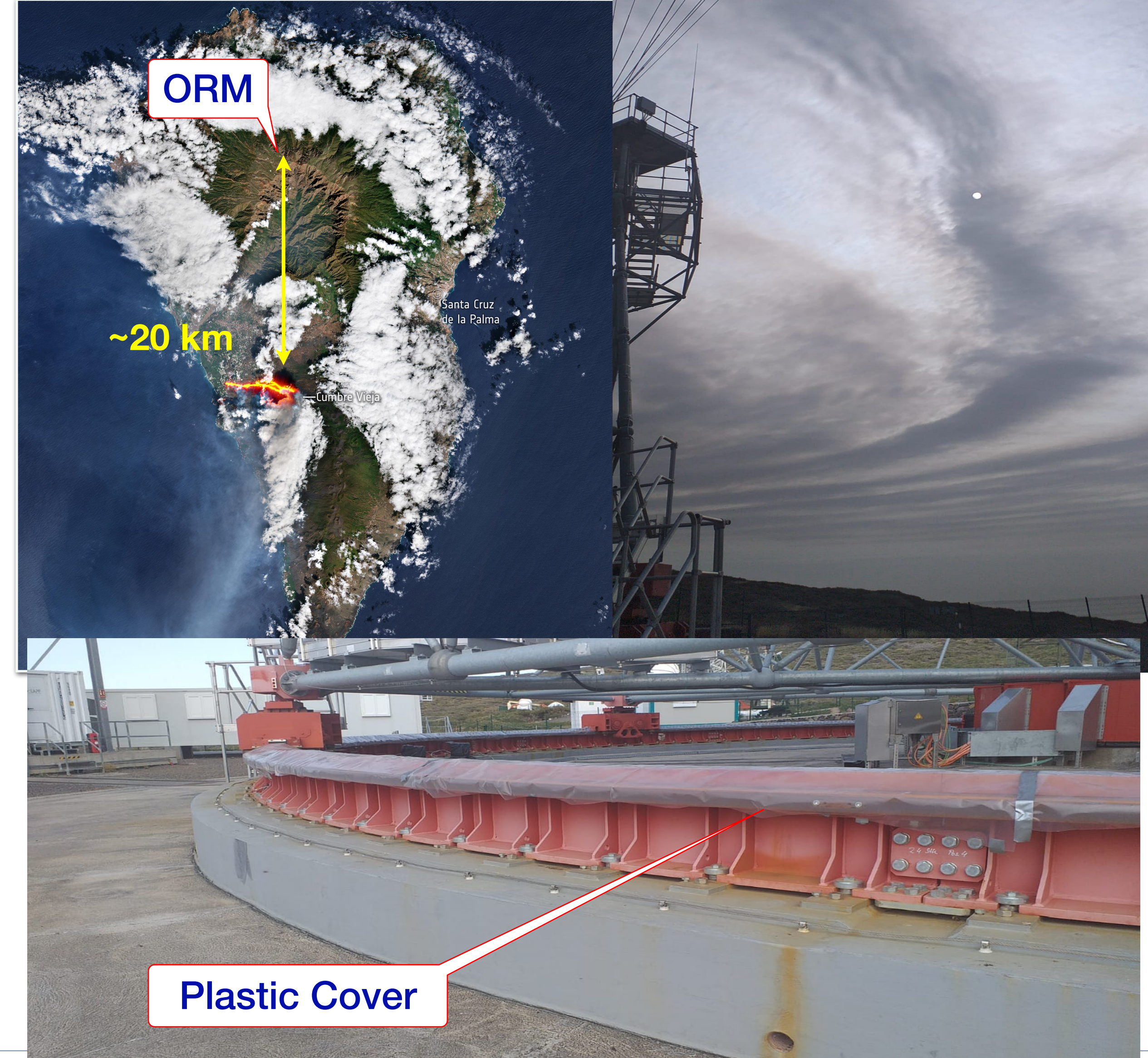
- Many software agents running providing information to TCU
- Error handling specific to each subsystem
- More harmonised approach among all evolved agents to reach the desired level of efficiency and stability

Reaching the stage of scheduled robotic operations

Operators fills in a schedule of observation, and it is executed accordingly by LST AutoOperator software using the TCU

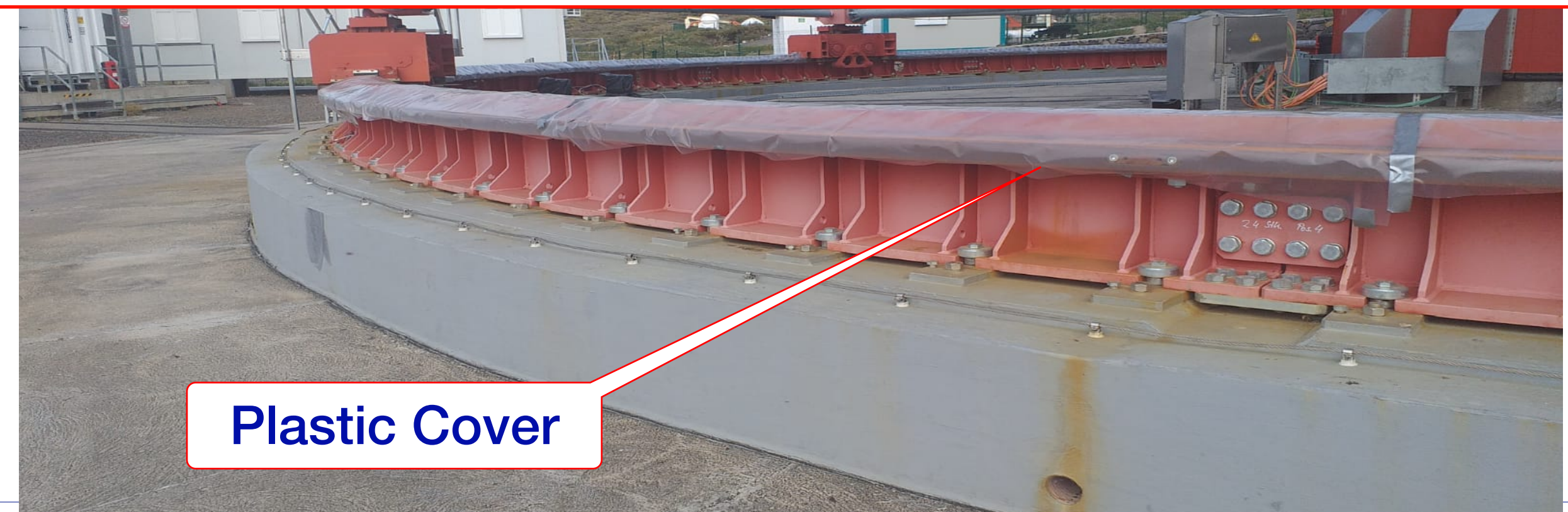
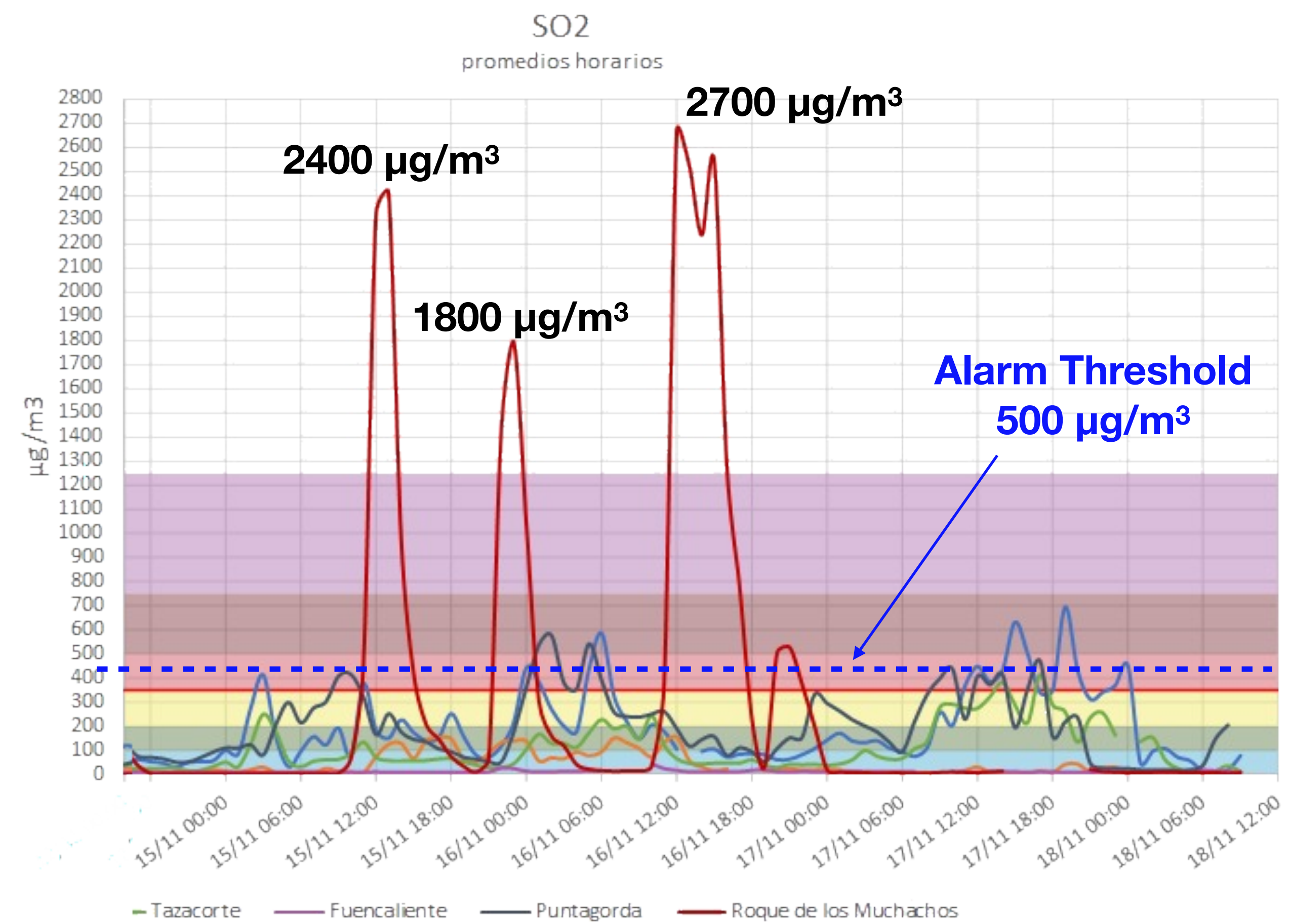
Volcano

- ▶ On 21st September the volcano Cumbre Vieja erupted
- ▶ Even if ORM is more than 20 km away and at higher altitude respect to eruption sites, we are affected by volcano activity
- ▶ Significant ash fall-out
 - Slightly paramagnetic (Motors, magnetised part)
 - Not highly volatile, cover is effective
 - No major problem of clogging of filters for chiller, air conditioning.
 - Greasing of elevation chain and azimuth rails affected
 - It will be needed to remove it and re-greased them
- ▶ Daily cleaning by Casana to avoid accumulation
- ▶ Since November, high concentration of SO₂ in the air.
 - Dangerous for people
 - With water can create acid - H₂SO₄



Volcano

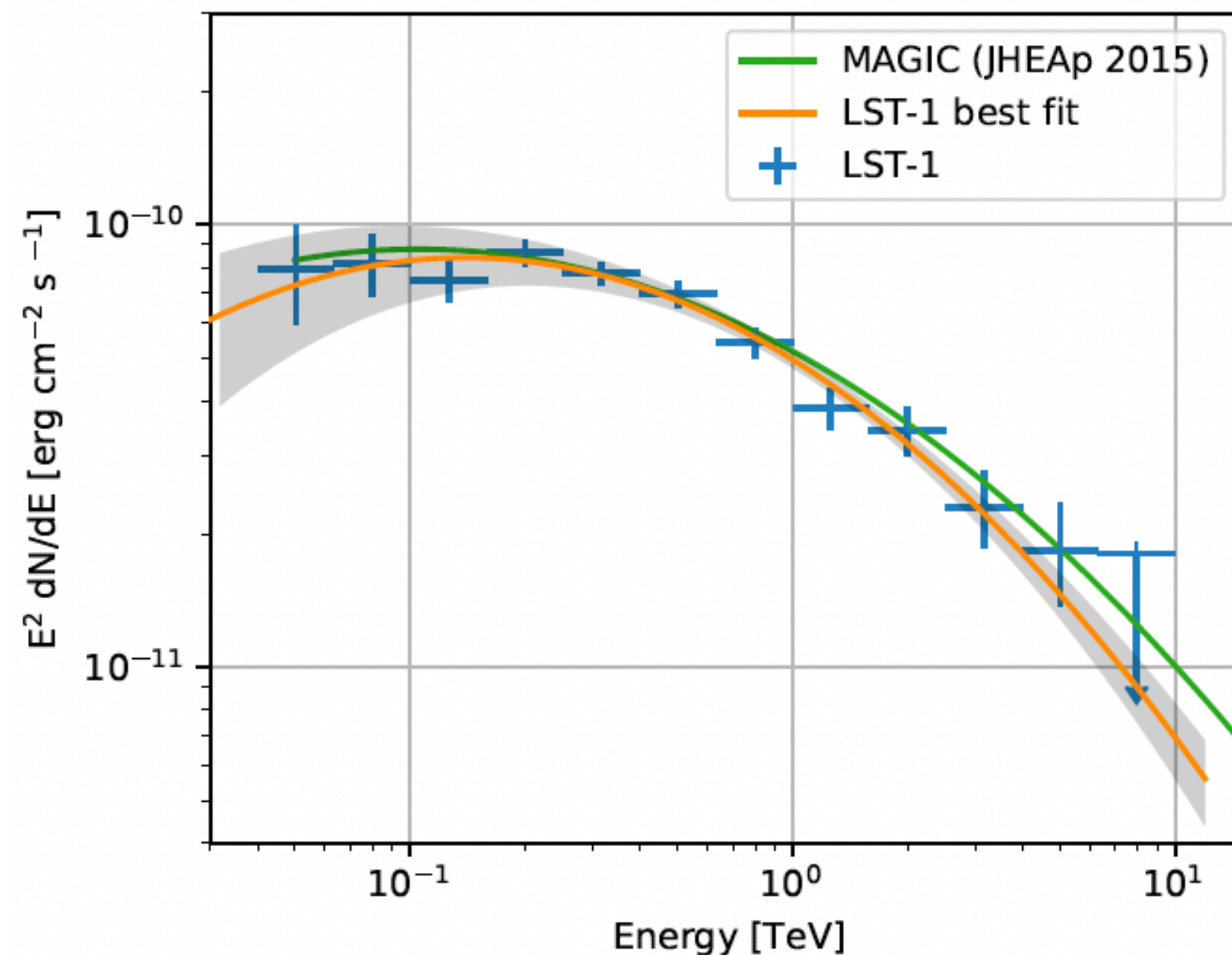
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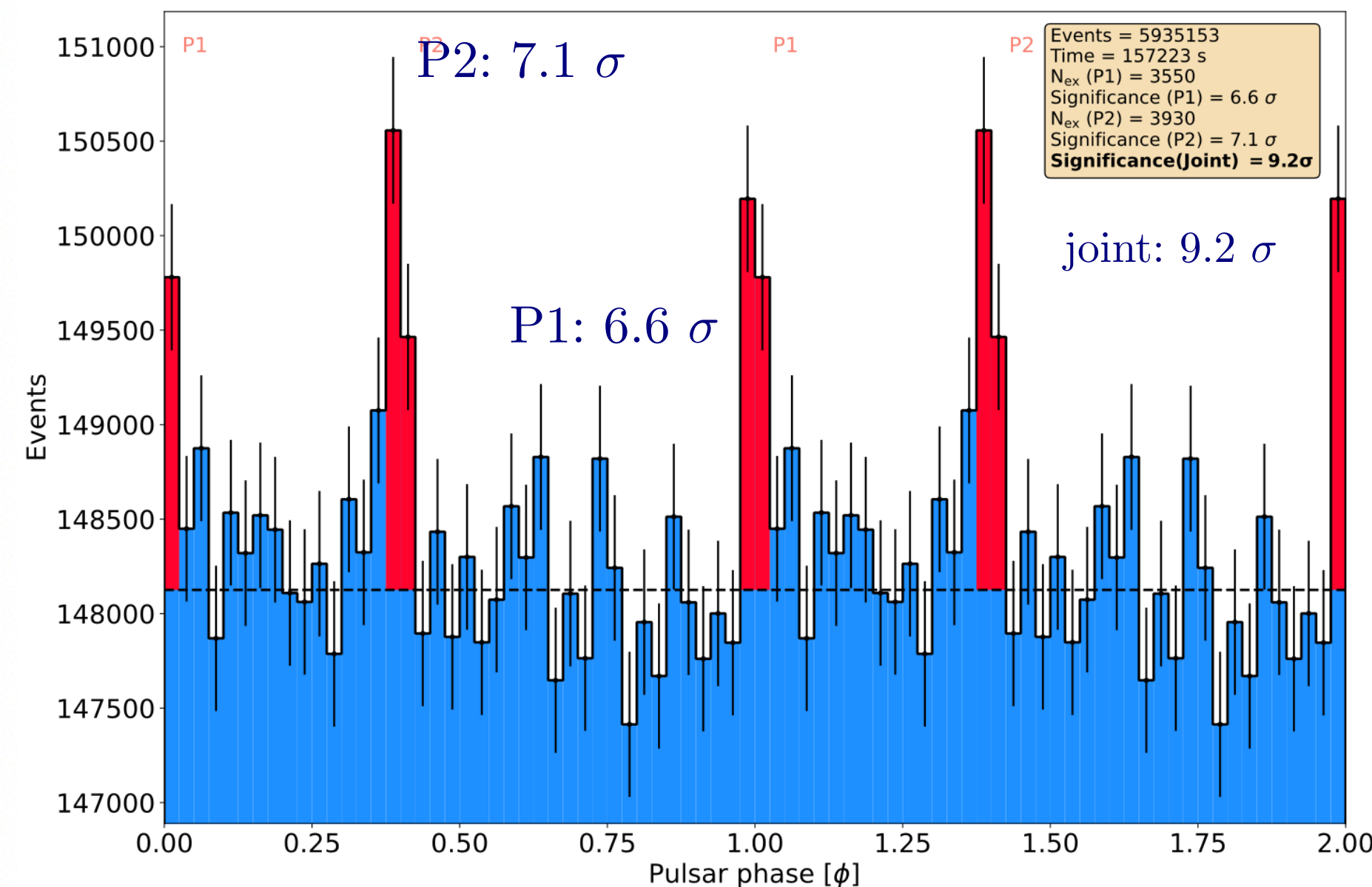
LST-1 early physics results

<https://pos.sissa.it/395/806>

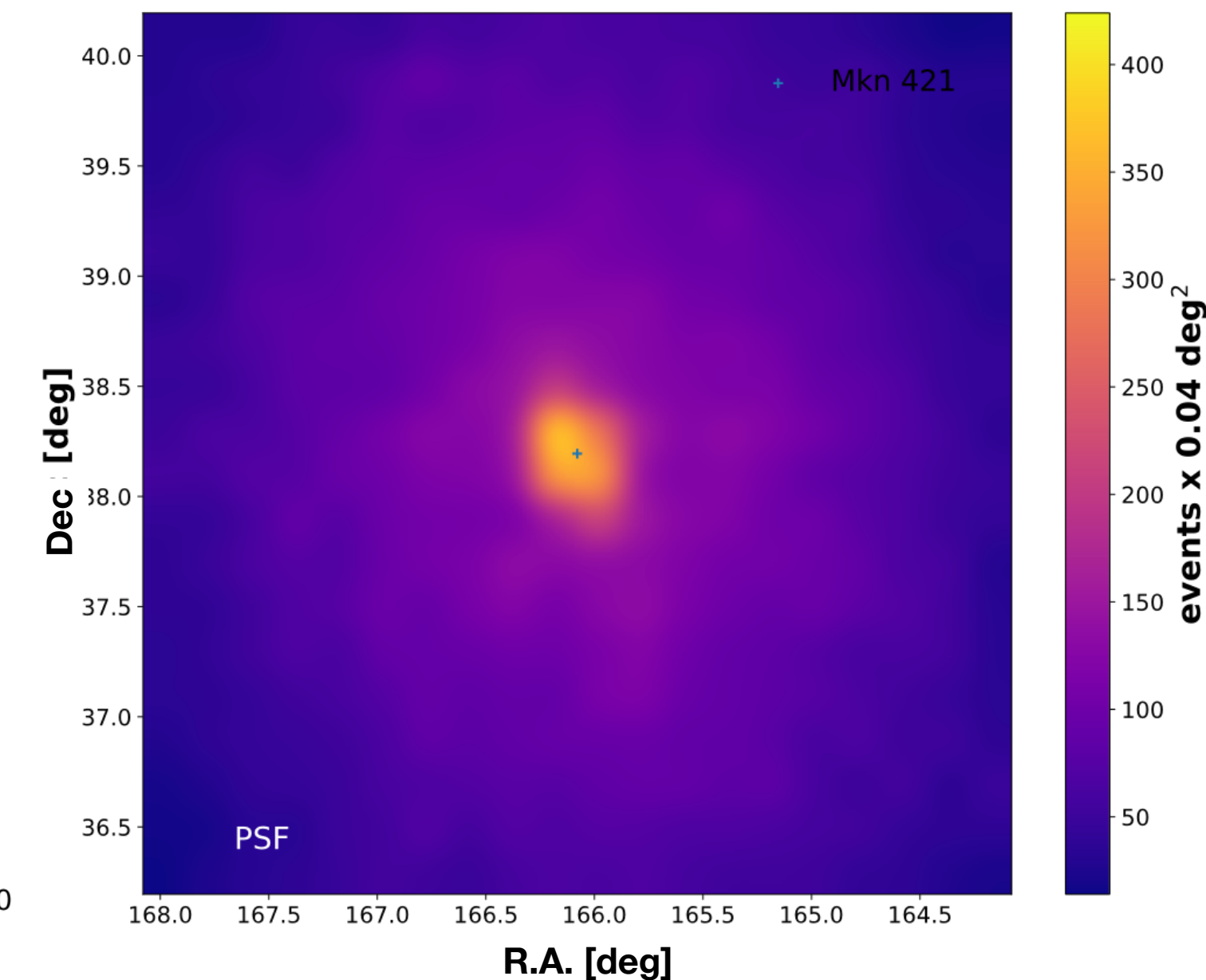
Crab nebula spectrum



Crab pulsar phaseogram

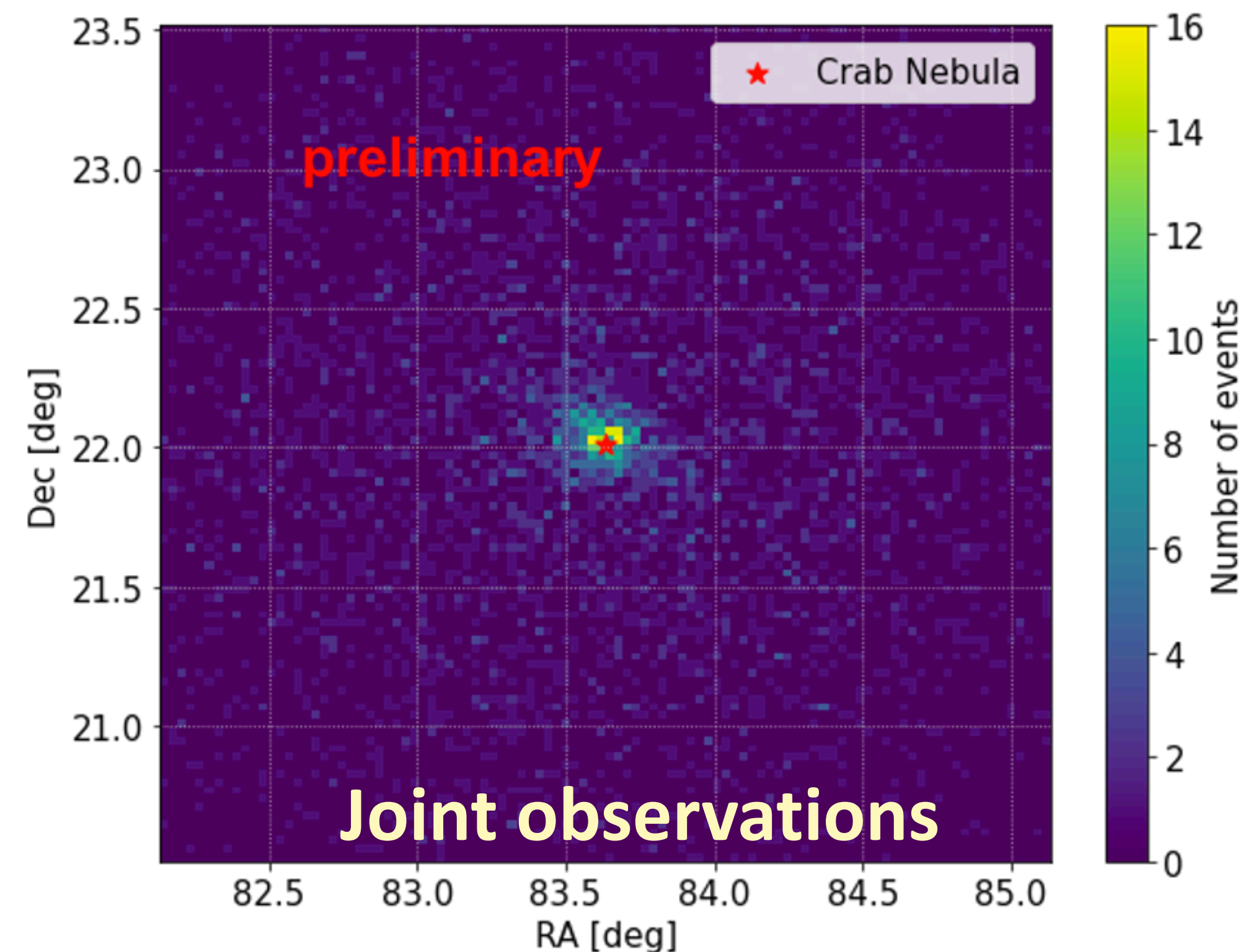
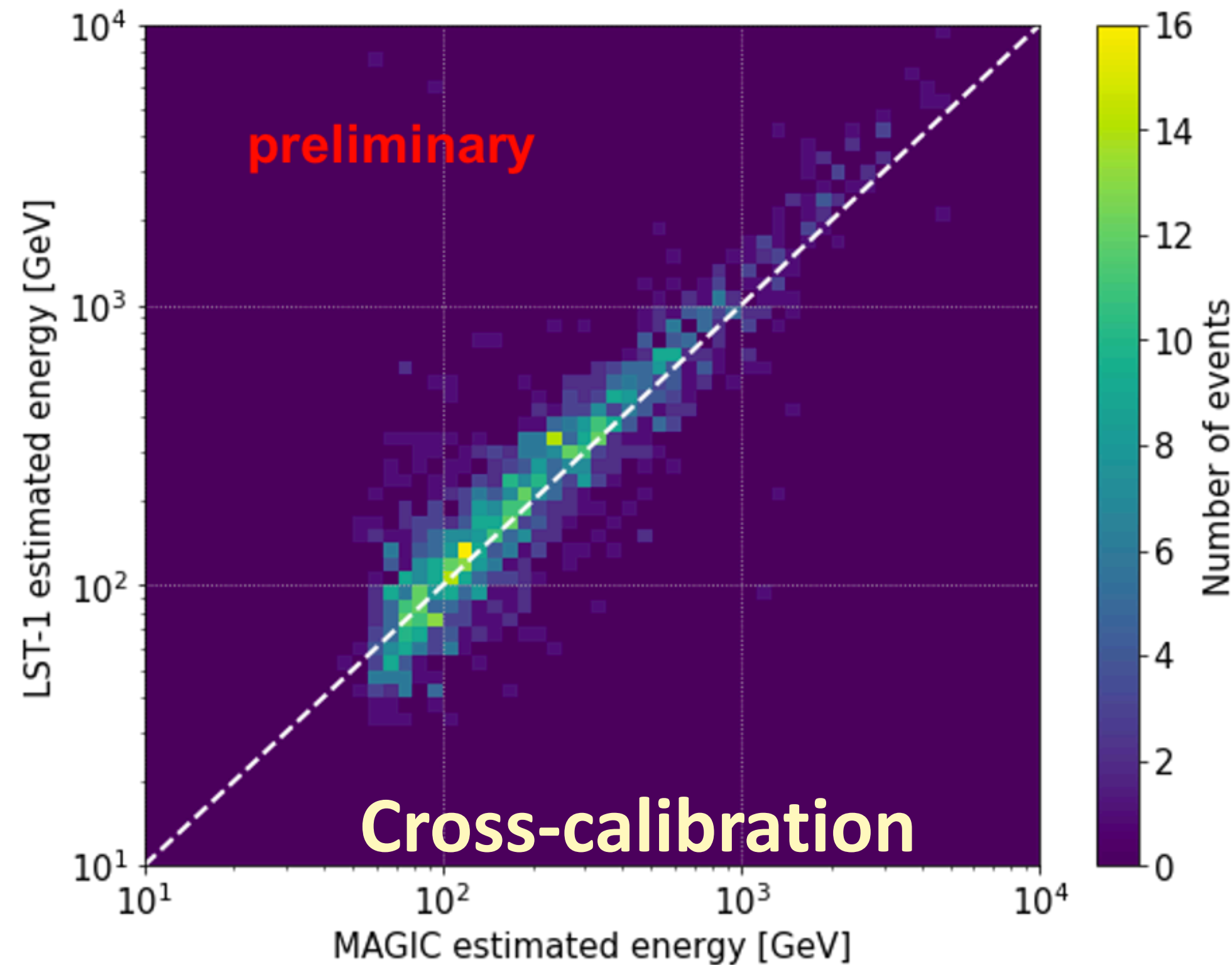


Mrk 421 significance map



- ▶ Detection of Crab nebula, Crab pulsar and several known AGN up to $z \sim 0.5$ (Mrk 421, Mrk 501, 1ES1959+650, 1ES0647+250, PG1553+113)
- ▶ First LST-1 ATel: BL Lac flare on July 11th 2021, [ATel #14783](#)
- ▶ Higher-level spectral analysis using Gammapy: gammapy.org

LST-1 and the MAGIC telescopes



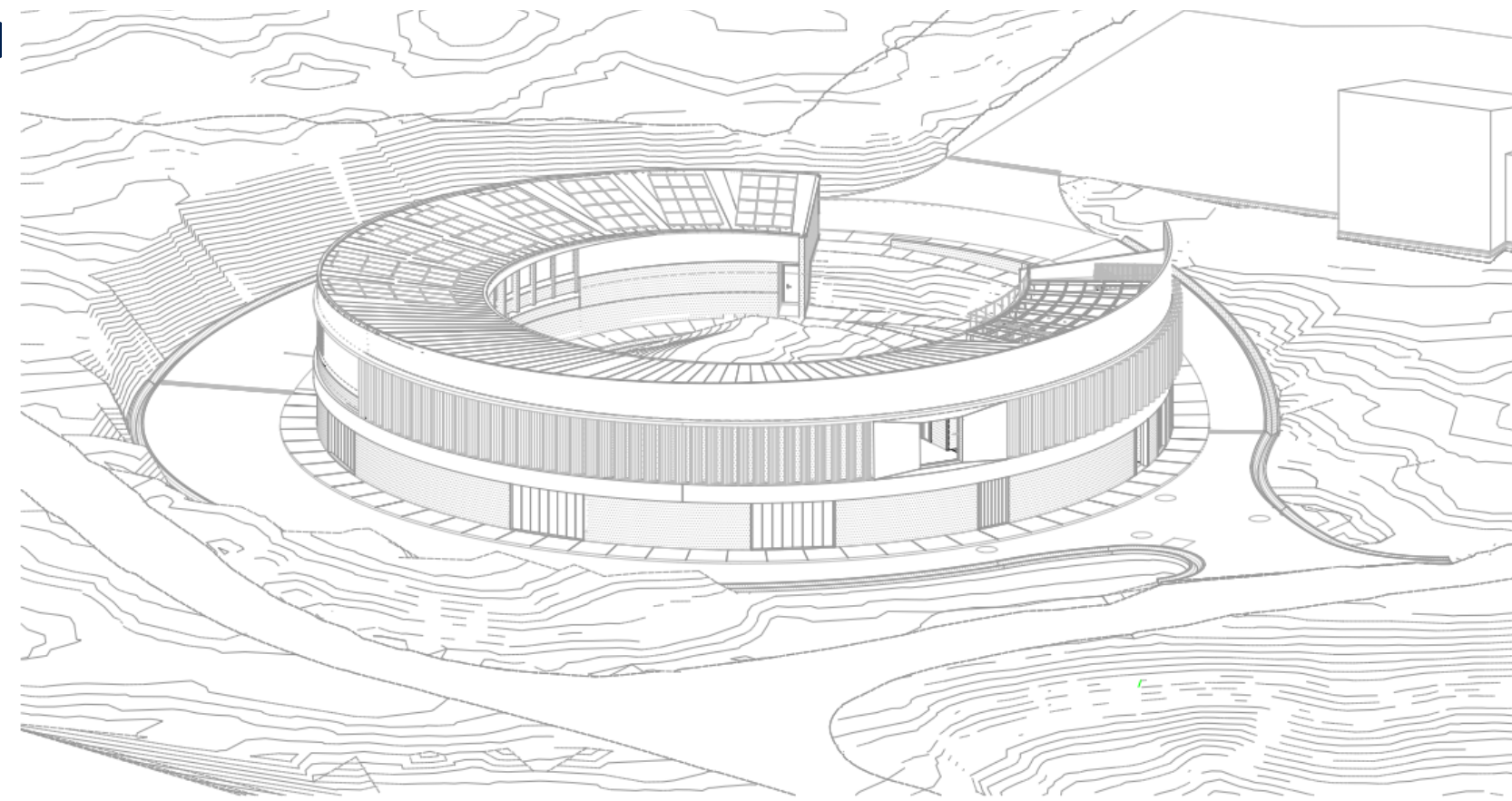
- ▶ Cross-calibration based on the observation of the same showers[‡]
- ▶ First joint stereoscopic observations ongoing (better shower reconstruction, but energy threshold driven by MAGIC's)

[‡]Events coincidence done with a software timing based on timestamps

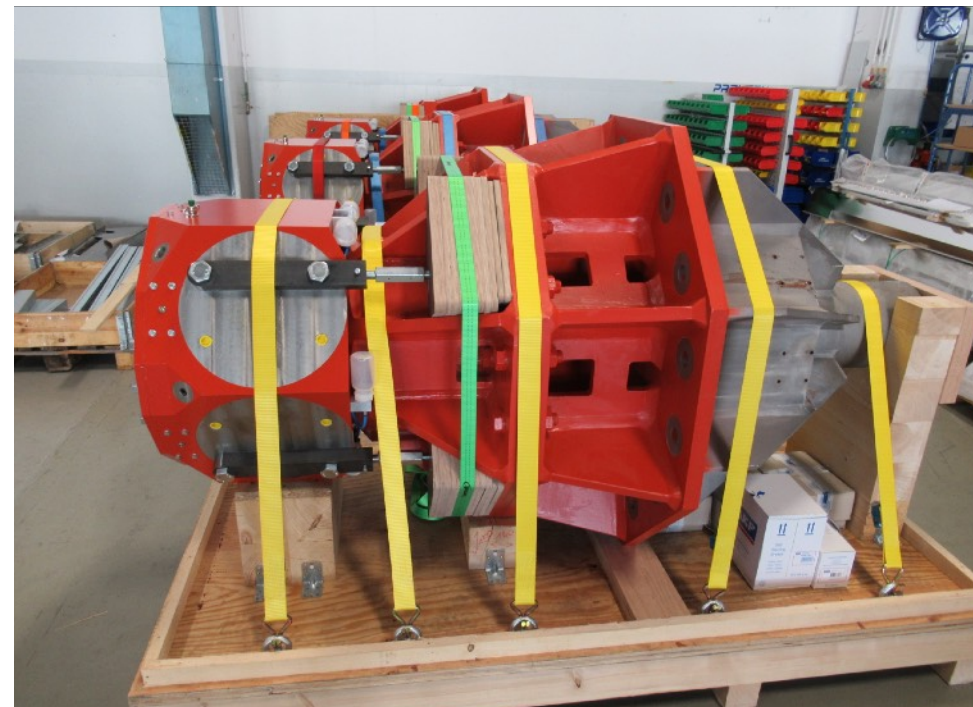
<https://pos.sissa.it/395/724>

LST2-4 Construction

► Excellent progress in Tenders and procurements



	<p>PROYECTO: PROYECTO DE EJECUCIÓN DEL EDIFICIO DE OPERACIONES DEL CHERENKOV ARRAY EN EL OBSERVATORIO DEL MONTE DE LOS MONTECROS, IBA DE ORMAIZTEGUI</p> <p>AUTORES DEL PROYECTO: UTE CTA 3000</p> <p>INGENIERO: CHAZAL & FERRAZ S.L.P.</p>	<p>UBICACIÓN: PASEO DE LAS MATHIAS, 18A DE GARDE, LA PALMA, ESPAÑA</p> <p>COORDENADAS UTM: 31T, 486, 71, 163, 0</p> <p>ESCALA: 1:100</p> <p>FORMATO: DWG</p>	<p>PLANO: ANOMÉTRICA</p> <p>PROYECTO: ARQUITECTURA</p> <p>ARQUITECTURA Y OBRAS CIVILES</p> <p>INGENIERO: CHAZAL & FERRAZ S.L.P.</p> <p>ARQUITECTO COLABORADOR: JORGE HERRERA Y TAYO</p>	<p>FECHA: 2022-01-12</p> <p>ESTADO: Proyecto Operativo</p> <p>ESCALA: 1:100</p> <p>FORMATO: DWG</p>	<p>07</p>
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cherenkov
telescope
array

FEDER Tenders*



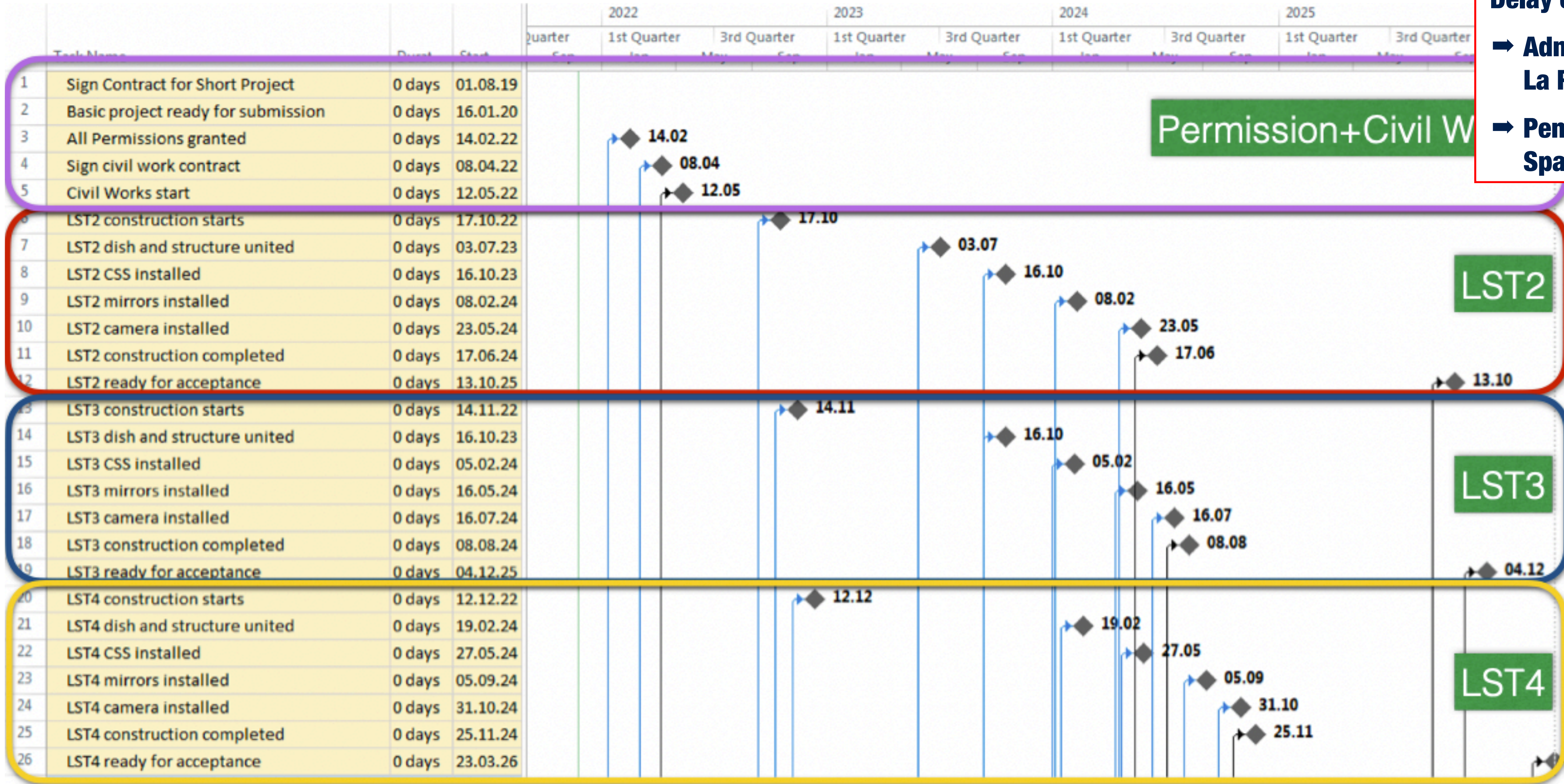
- Architects/Engineers LST2-4
- Azimuth Systems LST2-4 (rails + bogies)
- Cameras LST2-4 (mechanics + electronics + software)
- Mechanical Structures LST2-4
- Architects/Engineers Operations Building
- Elevation Back-Arches LST2-4
- Camera Access Towers LST2-4
- Access Systems LST2-4
- Azimuth Locking Systems LST2-4
- Weather stations ("contrato menor")
- Infrastructures LST2-4 (inc, earthing and grounding for lightning)
- Infrastructures LP-403
- Optical fibres LST2-4 ("contrato menor")
- Re-naturalization of LST1 and LST2-4 assembly areas
- Lightning Protection LST2-4
- Cabling LST2-4
- Operations Building

Contract running
Tender ongoing
Tender in preparation
Funds not 100% yet

* Only 4LST-CTAN FEDER agreement



LST2-4 Construction



Delay of 6-9 months due to

- ➔ **Administrative issues in La Palma**
- ➔ **Pending authorisation by Spanish ministry (MCINN)**

Permission+Civil W

LST2

LST3

LST4

This schedule has contingency, but there are also uncertainties that can impact

What's next?

- ▶ The project going well despite COVID and Volcano
 - Physics results are confirming the performance is very good!
- ▶ Missing manpower in SE team: filled by INAF/INFN and UNIGE!
- ▶ We have ahead a tough year
- ▶ Restarting activities after volcano stopped
 - Deep cleaning needed - Worries for Motors
 - Re-greasing of exposed parts
- ▶ SWAT-1 solution now will be setting the timeline
 - New EVB will Impact
 - CDR activities
 - Data taking
 - ACADA release integration
- ▶ Start discussing with CTAO a plan towards Acceptance
 - ↳ also a recommendation from STAC in this direction
- ▶ LST2-4 construction



Swiss contribution is in critical areas: SysEng, TCU, Analysis. It is well recognised in the collaboration