#### Status of the Large-Sized Telescopes





#### Martin Will for the CTA LST Project Max-Planck-Institut für Physik

This work was conducted in the context of the CTA-LST Project

### **Cherenkov Telescope Array**









- Northern site (baseline)
  - ORM, La Palma
  - 20 GeV to 20 TeV
  - ▶ 4 LST, 15 MST



- Southern site (baseline)
  - Paranal, Chile
  - 20 GeV to 300 TeV
  - ▶ 4 LST, 25 MST, 70 SST

## **Cherenkov Telescope Array**







- Northern site (Alpha)
  - ► LST 1-4 + MST 1 ongoing
  - ► MST 2 to 9 in coming years





- Southern site (Alpha)
  - 14 MST + LSTS!
  - 37 SST

Aiming to reach baseline (Omega) configuration at later stages of CTA

# Large-Sized Telescope (LST)



- Carbon fiber reinforced polymer (CFRP) / steel structure
  - Total moving weight: ~100 tons
  - Repositioning speed: 10 deg/s
  - Repositioning time: < 30 s</p>

- Energy range: 20–150 GeV (3 TeV)
- Camera: 1855 PMTs, FoV ~ 4.3°
- Focal length 28 m
- Parabolic mirror: 23 m, 400 m<sup>2</sup>
- Pointing precision: < 14 arcsec</p>



### **LST Collaboration**





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#### CTA Large-Sized Telescope – January 2024



# Organigram



### **Publications**



- Several ATels
  - Latest on detection of OP313
  - Various flaring sources
- Already published several papers
  - LST Performance
  - LHAASO J2108 MWL
  - Star Tracking for Pointing
  - SiPM Test Cluster
- Many papers in the pipeline
  - Image Correction, PMT Modules, Atmosphere Correction, ...
  - ▶ RS Oph, BL Lac, GRBs, ...

#160: Observations of the	Crab Nebula and Pulsar with the Large-Sized Telescope
Crab_Nebula_and_Pulsar_ob Abelardo	servations_of_the_Large_Sized_Telescope_prototype_of_the_Cherenkov_Telescope_Ar
Moralejo Olaizola	Published in ApJ
Accepted	
X Your	
content review is	
pending	
#161: Development of a Si Cherenkov Telescope Arra	PM Pixel Prototype for the Large Size Telescope of the y
≜ Davide Depaoli ✓ Accepted	Published in NimA
Your content review is pending	
#162: The optical calibration	on system for the Large Sized Telescope camera
A Maurizio Iori	Calibox_Paper_v3.pdf
~ To be corrected	
a Your coment review is pending	
#164: Star tracking for poi Telescopes. Application to Array	nting determination of Imaging Atmospheric Cherenkov the Large-Sized Telescope of the Cherenkov Telescope
A Mykhailo Dalchenko	Star_tracking_paper-final-draft-with-lst-and-SAPO-comments-v2.pdf
Submitted for reviewing Your content review is pending	Published in A&A
#165: Performance of the Nebula observations	joint LST-1 and MAGIC observations evaluated with Crab
💄 Julian Sitarek	diff_v3.4_to_v3.5.pdf 🖄
<ul> <li>Accepted</li> <li>Your content review is pending</li> </ul>	Published in A&A

# **LST-1 Mono Proposals**

- LST-1 Cycle II Mono Proposals
  - Internal only to LST members
  - 500 hours (dark time) dedicated to LST Mono observations
  - Observations must be achievable with LST-1 alone, MAGIC+LST requests go through MAGIC

#### Timeline

- Need to be discussed first within respective WGs
- Deadline February 2, 2024
- Cycle II begins March 27, 2024
- Email with relevant information was sent last November





### **Duties**



- Steering Committee approved introduction of duties (similar as MAGIC)
  - Everybody wants to do physics, but we have a telescope to finish and commission and 4-5 more on the way.
  - We run the telescope with about 5 FTE, compare to 20 FTE CTAO is planning to have for CTA North.
  - Need to strengthen onsite team with technical stays for commissioning
  - Close to 100 open duties identified in addition to shifts.
- Duties for new people
  - Daily Checks, Burst Advocates
  - Software Maintenance and Development
  - Hardware Projects
- Duties for experienced people
  - Deputies for several coordinators
  - Schedulers
  - Shift leaders

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#### CTA Large-Sized Telescope – January 2024

PBS	Level 1	Max number of Duties	Number of covered Duties	Number of Vacant duties
1	Boards	123	117	6
2	Operation	102	61	41
3	Maintenance Hardware	58	30	28
4	Maintenance Software	66	39	25
5	R&D	0	0	0
6	LST2-4 construction	0	0	0
7	LST South	0	0	0
	Summary	349	247	100

2024

### **Status of CTA North Site**





- 2018: LST1 inaugurated
- 2019: LST1 first light, commissioning
- 2020: Permit process for LST2-4 started, delayed in local administration
- 2021: Project re-submitted but volcano starts to impact everything in La Palma
- 2022: Permit issued, deployment power lines and civil works start
- 2023: Start of installation of LST2-4



### Schedule LST 2–4



				2024				2025				2	026		
			3rd Quarter 4th C	Juarter 1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	1st Quarter	2nd Quar	ter 3rd Qu	arter 4th	h Quarter 1	st Quarter	2nd C	
			Jul Aug Sep Oct	Nov Dec Jan Feb Ma	ar Apr May Jun	Jul Aug Sep	Oct Nov De	c Jan Feb Ma	Apr May	Jun Jul A	ug Sep Oo	ct Nov Dec J	an Feb Ma	r Apr I	
All permits granted	0 days	Tue 18/10/22													
Civil works start	0 days	Mon 24/10/22											IVI	<b>VVC</b>	orks
Civil works finish	0 days	Wed 22/11/23		22/11											
LST4 construction starts	0 days	Mon 04/09/23	• 04/09												
LST4 dish and structure united	0 days	Fri 14/06/24			<b>*</b>	14/06									<b>ST</b>
LST4 CSS installed	0 days	Wed 21/08/24				p 21/	/08								514
LST4 mirrors installed	0 days	Fri 17/01/25						• 17/01							
LST4 camera installed	0 days	Wed 14/05/25							· • •	14/05					
LST4 construction completed	0 days	Fri 06/06/25							•	<b>06/06</b>					
LST4 ready for acceptance	0 days	Fri 09/01/26										•	09/01		
LST3 construction starts	0 days	Mon 02/10/23	02 م	/10											
LST3 dish and structure united	0 days	Fri 04/10/24				6	04/10								CL3
LST3 CSS installed	0 days	Wed 11/12/24					<b>*</b>	11/12							015
LST3 mirrors installed	0 days	Fri 09/05/25							0 🔶 🛉	9/05					
LST3 camera installed	0 days	Wed 30/07/25								<b>*</b>	30/07				
LST3 construction completed	0 days	Fri 22/08/25								6	22/08				
LST3 ready for acceptance	0 days	Fri 27/03/26											•	27/03	
LST2 construction starts	0 days	Mon 06/11/23	4	06/11										_	
LST2 dish and structure united	0 days	Fri 18/10/24					<mark>▶</mark> ♠ 18/10								ST2
LST2 CSS installed	0 days	Mon 10/02/25						▶♠ 10/0	2						
LST2 mirrors installed	0 days	Wed 09/07/25								روں 🔶	07				
LST2 camera installed	0 days	Mon 22/09/25									22 🔶 ر	/09			
LST2 construction completed	0 days	Wed 15/10/25									-	15/10			
LST2 ready for acceptance	0 days	Wed 20/05/26												•	, 20/05

- Changed order: LST4, LST3, LST2
- Civil works started in December 2022, should finish end of January 2024 (delays due to missing work force)
- Some more delays in rail, central pin installation
- End of installation in 2025

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### **LST4 Installation Schedule**



	Duration	Start						2024						2025							
P I. M			larter		4	th Qua	rter	1st Quarter	2nd Quarter	3rd Qua	ter	4th Quar	ter	1st Quarter	2nd	Quarter	r	3rd Qua	rter	4t	th Qu
ask Name	40 days	Man 04/00/22	A			0	N	DJF	MAM		A S	0	N D	J F	MA	M	<u></u>		A	S	•
Rail LS14	40 days	Mon 04/09/23		1				ormonu[2E%]													
Camera Access Tower LST4	20 days	Mon 04/09/23		1 c		spaint	/3%]/G	ermany[25%]										str		<b>†</b> 1	Ire
Energy Container LST4	5 days	Mon 18/09/23		49	75	pan													44		
Bogies LST4	5 days	Mon 06/11/23				- 19	Spair	n C													
Central Pin LST4	35 days	Mon 13/11/23					<b>*</b>	Germany	-1-												
Lower Structure / Access Sys. LST	445 days	Mon 25/12/23						-> -> P	ain	L.											
Dish / Backarch LST4	80 days	Mon 26/02/24		_				+		Spain											<u> </u>
Installation Az. Cable Chain LST4	5 days	Mon 26/02/24	•					•	ermany												
Cabinets LST4	5 days	Mon 11/03/24	ł.,					9	France						Cal	hli	nc	1 8		)ri	i Vi G
Ground Cabling LST4	10 days	Mon 18/03/24	•						France						Vai		113	<b>, ,</b>			
Lower Structure Cable Ducts LST	4 5 days	Mon 17/06/24	ŧ.							Germany							1 7				
CSS Locking LST4	5 days	Mon 17/06/24	F							Germany											
Elevation Drive LST4	3 days	Mon 24/06/24	4							German	1										
Drive / Cabling LST4	15 days	Mon 24/06/24	1																		
Drive Container LST4	5 days	Mon 24/06/24	F							France 🖌											
Structure Cabling LST4	5 days	Mon 24/06/24	4							France											
Azimuth Motor LST4	2 days	Mon 01/07/24	ŧ.							France											
Ground Cabinet Cabling LST4	10 days	Mon 01/07/24	F.							Fran	e										
IT Installation Drive Container LS	T-5 days	Mon 15/07/24	F							😛 Jar	an										
Cabinets El. Drive Platform LST4	5 days	Mon 15/07/24	F							Ger	many										
Webcams LST4	5 days	Mon 22/07/24								G	ermany										
Structure Monitoring LST4	5 days	Mon 22/07/24								G	ermany						rq		Ω.	Λ	
CSS Assembly Area Prep LST4	5 days	Mon 17/06/24								Spain							60	$\mathbf{\nabla}$	X	7	.u/
CSS LST4	43 days	Mon 24/06/24								5	Franc	e									
Rotate Dish to Park LST4	2 days	Thu 22/08/24									Franc	e[50%]/Ge	many[509	6]							
ALS LST4	10 days	Mon 26/08/24	F.								S SI	pain									
ALS Roof LST4	5 days	Mon 09/09/24									1	Spain									
Removal of Assembly Area / Repaturalization LST4	40 days	Mon 09/09/24	•								•		pain								
Ducts in Dish/Elevation Chain LS	10 days	Mon 09/09/24	F									Germany									
Cabling Dish/CSS LST4	5 days	Mon 23/09/24									4	France									
Structure Cabinet Cabling LST4	10 days	Mon 30/09/24	l.									Franc	e								
Drive Test 1 LST4	10 days	Mon 14/10/24	L.									Fr	nce								
Central Dish Section LST4	5 days	Mon 28/10/24	4										roatia[259	6]/France[25	%]/Italy[25	%]/Gerr	many[25	%]			
Mirrors / AMC LST4	100 days	Mon 28/10/24	1								-++				-n		++				-
IF Plates / Actuators LST4	20 days	Mon 28/10/24	l.									L 1 4	Japan					1		4	
Mirrors LST4	40 days	Mon 25/11/24											4	Japan					Uμ	ווע	
AMC Boxes LST4	5 days	Mon 20/01/25												Japan					_ <b>∎</b> 1		
AMC Cabling LST4	15 days	Mon 27/01/25												C J	apan						
CMOS Cabling LST4	15 days	Mon 17/02/25													Czechia						
Xbee Antenna Alignment LST4	5 days	Mon 10/03/25													Japan						
Lightning Protection System LST/	10 days	Mon 20/01/25												Spai	n	++-	++				+
Tension Cables / Pretention LST4	10 days	Mon 17/03/25													Fra	nce		•			<u> </u>
Drive Test 2 LST4	10 days	Mon 31/03/25														France		d	ПE		лC
			_													TE-					
Camera I ST4	23 days	Mon 14/04/25															spain i				
Camera LST4	23 days	Mon 14/04/25 Thu 15/05/25													9	╡	Spain Fran	ce			244

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### **LST3 Installation Schedule**



	Duration	Start					2024							30	125								
	Duration	Start	arter	4th O	arter		1st Quarter	2nd Quart	er	3rd Quarter	4	th Ou	arter	19	t Ouart	er	21	d Ou	arter	3rd Oua	rter	4	4th Ou
Task Name			A	s o	N	D	J F M	AN	J	JA	s	0	N	D	J	F	м .	A	MJ	J	A	s	0
Camera Access Tower LST3	20 days	Mon 02/10/23		<b>&gt;</b>	Spain[	75%]/	Germany[25%]																
Energy Container LST3	5 days	Mon 16/10/23			apan																		
Rail LST3	20 days	Mon 30/10/23				Spain																	
Bogies LST3	10 days	Mon 25/12/23	1				Spain																
Central Pin LST3	25 days	Mon 08/01/24	1				Germany																
Lower Structure / Access Sys. LST	345 days	Mon 26/02/24	1					Spa	ain														
Dish / Backarch LST3	80 days	Mon 17/06/24										Spair	1										
Installation Az. Cable Chain LST3	5 days	Mon 29/04/24						, G	ermany														
Cabinets LST3	5 days	Mon 06/05/24						5	France														
Ground Cabling LST3	10 days	Wed 19/06/24								France													
Structure Cable Ducts LST3	5 days	Mon 07/10/24										Ger	many										
CSS Locking LST3	5 days	Mon 07/10/24			Щ					L L	-	Ger	many										
Elevation Drive LST3	3 days	Mon 14/10/24								4		Ge	rman	,									
Drive / Cabling LST3	15 days	Mon 14/10/24										Π÷-											
Drive Container LST3	5 days	Mon 14/10/24										fr	ance										
Structure Cabling LST3	5 days	Mon 14/10/24										. Fr	ance										
Azimuth Motor LST3	2 days	Mon 21/10/24										F	rance										
Ground Cabinet Cabling LST3	10 days	Mon 21/10/24										1	Fran	e									
IT Installation Drive Container I ST	5 days	Mon 04/11/24										11.	Jap	an									
Cabinets FL Drive Platform IST3	5 days	Mon 04/11/24										UĽ	Gei	many									
Webcams I ST3	5 days	Mon 11/11/24											G	rmany									
Structure Monitoring   ST2	5 days	Mon 11/11/24											G	rmany									
CSS Assembly Area Prep 15T3	5 days	Mon 07/10/24										Spa	ih										
CSS Assembly Area Frep ESTS	A2 days	Mon 14/10/24									1	-11		Franc									
Potate Dish to Park IST2	45 uays	Thu 12/12/24										11		Franc	e[50%]	1/Ger	many[5	0%1					
	2 udys	Mop 16/12/24												5	ain	" "	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,						
ALS Doof LST2	E daur	Mon 20/12/24													inain								
ALS ROOT LS13	5 days	Mon 30/12/24													·pan								
Renoval of Assembly Area / Renaturalization LST3	40 days	Mon 30/12/24														3	200						
Ducts in Dish/Elevation Chain LST	10 days	Mon 30/12/24													Germa	any							
Cabling Dish/CSS LST3	5 days	Mon 13/01/25												6	Fran	ce							
Structure Cabinet Cabling LST3	10 days	Mon 20/01/25												· · · ·	G LFI	rance							
Drive Test 1 LST3	10 days	Mon 03/02/25													T P	Fra	nce						
Central Dish Section LST3	5 days	Mon 17/02/25														C C	oatia[2	5%]/I	France[25%]	Italy[25	%]/Ger	nany	[25%]
Mirrors / AMC LST3	100 days	Mon 17/02/25															-	_		1		-	
IF Plates / Actuators LST3	20 days	Mon 17/02/25															Japa	n		•			
Mirrors IST3	40 days	Mon 17/03/25														1	d ·	C	Japan				
AMC Boxes LST3	5 days	Mon 12/05/25															1		Japan				
AMC Cabling I ST3	15 days	Mon 19/05/25														L			Japa	in			
CMOS Cabling LST3	15 days	Mon 09/06/25																		Czechia			
Xhee Antenna Alignment I ST3	5 days	Mon 30/06/25																		Janan			
Lightning Distostion System LCT2	10 days	Mon 12/05/25																	Snain	Tapa.			
Tension Cables / Protention LST3	15 days	Mon 26/05/25	-																	nce			
Drive Test 2 IST2	10 days	Mon 16/06/25																		France			
Camera LST2	22 days	Mon 20/06/25																		ance	Snain		
Camera LS13	23 days	Thu 21/07/25																	1	<u>ل</u> ے ا	Ero		
Bameric Mirror Course I CT2	13 days	Thu 31/07/25																		1 🥍		an	
Remove Mirror Covers LST3	2 days	mu 21/08/25										111		1 1						11	al	all	

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### **LST2 Installation Schedule**





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### **Foundation**





### **Foundation**





#### All 3 finished

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### **Camera Tower**





All 3 finished

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# **Energy Storage Container**





- All 3 UCs moved from LST1 site before top platform of camera tower was installed
- Electrically connected and running, monitored from remote
- Maintenance in coming months during construction through subcontractors











- Height of concrete under rail too high, company tried to flatten it as much as possible
- Flatness of rail in LST4 and LST3 fine adjusted, latest measurements still pending

### **Central Pin**





- All Central Pins installed, some issues with rail height solved
- Next steps: armoring, mortar, apply pretension, final fixation
- No further issues expected











Some rust found on rack, was removed and greased to allow fine adjustment of rack and pinion

### **Lower Structure**





- Height of rail was barely ok to install central pin, just enough length in threaded bars to apply pretension after installation
- Next steps: armoring, mortar, apply pretension, final fixation
- No issues with LST3, LST2 expected, cage installed slightly higher

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### **Lower Structure**





## coming soon...

LST4 structure ongoing, LST3 and LST2 can start right after

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### Outlook



#### LST2-4

- Production of most parts finished, ready for installation
- Cameras passing QC and verification in Tenerife
- Civil works almost finished, good progress in installation
- Road to CTA North
  - LST2–4 construction phase includes first MST, atmospheric monitoring
  - Prepare for acceptance review by CTAO in 2024
  - Operations Building permits soon
  - Training of CTAO Staff
- LSTs in the South becoming reality
- Performance, Technical, and Physics papers on the way

