

# *Cryogenics and vacuum systems at ESO – overview and future challenges*

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**40-m class**

**Extremely Large Telescope  
ELT at Cerro Armazones (3046m)  
2027**

**8-m class**

**Very Large Telescope  
VLT at Cerro Paranal (2635m)  
1998**

**4-m class**

**VISTA / VST  
at Cerro Paranal  
2009 / 2011**

**NTT / 3.6m Telescope  
at La Silla (2400m)  
1989 / 1977**

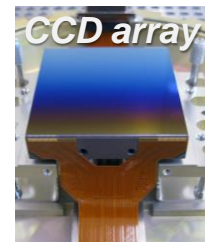
**APEX and ALMA  
at Chajnantor (5000m)  
2005 / 2011**

**12-m class  
radio telescopes**

**All of them require cryogenics!**

# Cryogenics and vacuum systems at ESO – overview

- Telescopes operated at ambient temperature
- Optics, detectors and low noise electronics of scientific instruments cooled as low as 3 Kelvin
  - Increased sensitivity, reduced thermal background, minimized dark current
- Cryogenic cooling based on Liquid Nitrogen (LIN) and cryo-coolers
- Cryostats require vacuum systems for thermal insulation
- Aiming for standardization and COTS products
- Instruments have own local cooling systems
- Observatories providing cryogenic infrastructure

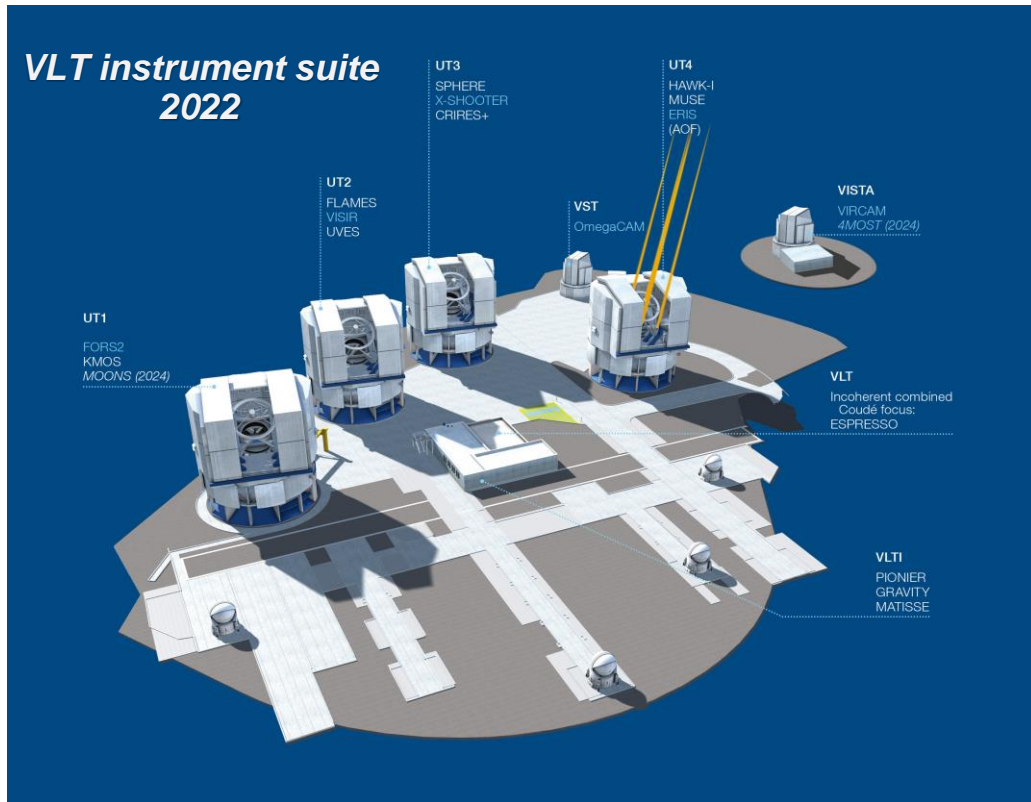




# Cryogenic instruments at VLT

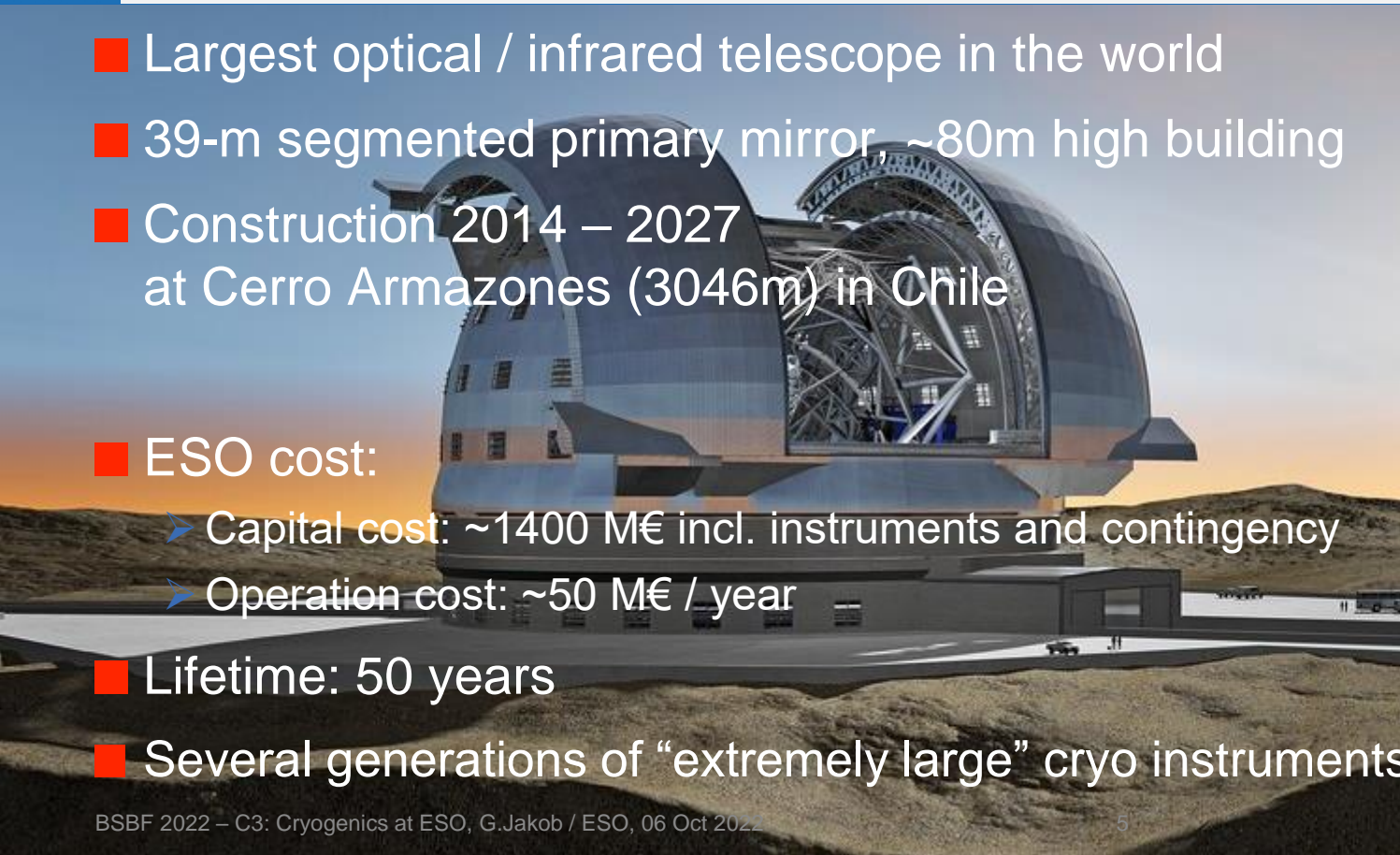
- ~ 20 cryogenic instruments in 24/7 operation
- Designed for a life cycle of 10 - 15 years
- ~ 1 - 2 new instruments every year; now 3<sup>rd</sup> generation of instruments
- Typical cold mass ~500 kg / 2500 L vessel / 3 t weight
- Ongoing developments, procurements, construction
- LIN supply of instruments via portable dewars labour-intensive

➤ ELT aims for fully automated LIN system

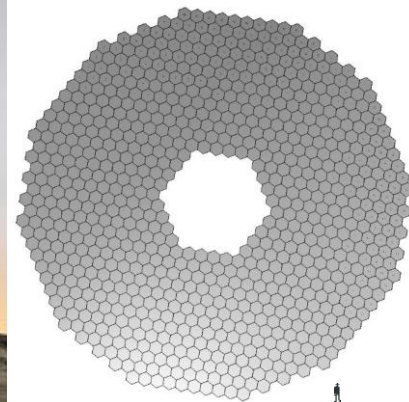


# ELT – The world’s biggest eye on the sky

- Largest optical / infrared telescope in the world
- 39-m segmented primary mirror, ~80m high building
- Construction 2014 – 2027 at Cerro Armazones (3046m) in Chile
- ESO cost:
  - Capital cost: ~1400 M€ incl. instruments and contingency
  - Operation cost: ~50 M€ / year
- Lifetime: 50 years
- Several generations of “extremely large” cryo instruments



**ELT – M1**



39-m diameter  
 6x133=798 segments (1.4-m)  
 +1x133 spare segments  
 Total: 931 segments



# ELT cryogenic instruments – future challenges

- Proven concept of LIN cooling and local cryo-coolers adopted from VLT
- LIN on-site delivery service refilling main storage tank (e.g. 42000 L)
- Distribution to instruments via fixed piping system (lesson learned VLT)
  - Advanced LIN infrastructure required
- Selected COTS cryo-coolers standardized at ESO
  - 2-stage cryo-coolers 1W @ 4K (15W @ 20K) / 50W @ 60K, ~9 kW input power
  - Up to 36 compressors in ELT; 4 cryo-coolers per instrument
  - Long Helium flex lines required (~100 m)
  - Low vibration versions required (PTC, etc.)
  - Very demanding vibration requirements
  - Advanced vibration isolation systems required

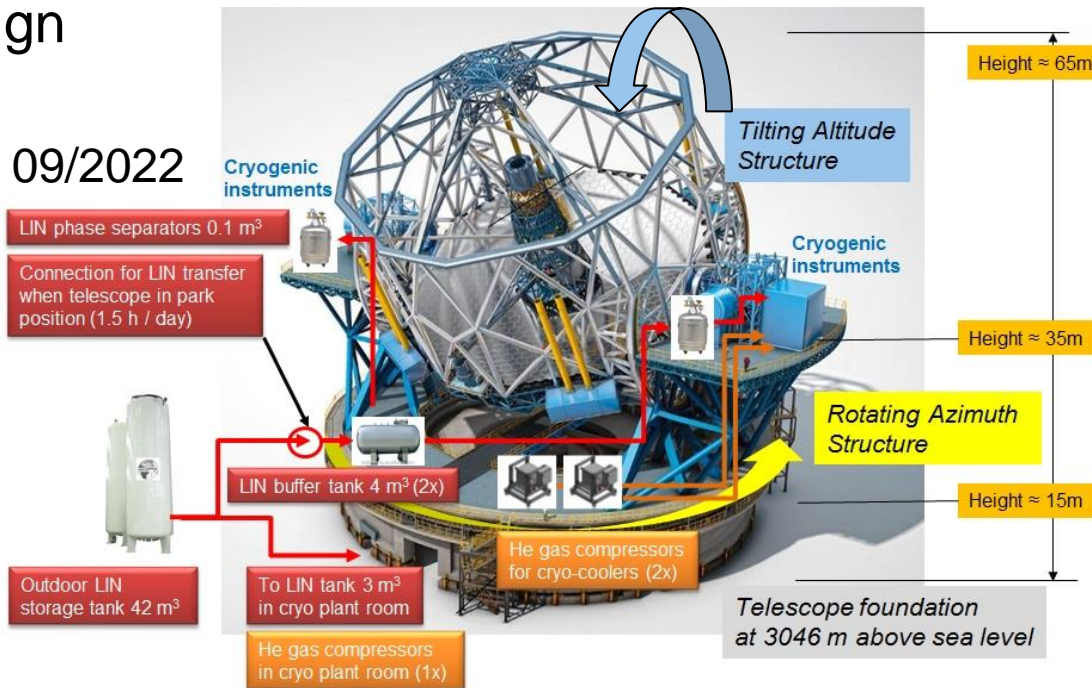
Unit	Frequency Range [Hz]		
	1 – 4.45	4.45 - 56	56 - 110
Nasmyth Instruments (RSS of force (x,y,z) [N] rms per one-third octave frequency bands)	1	0.4	2

*Vibration requirements for ELT instruments*



# ELT cryogenic concept (under development)

- ELT LIN infrastructure design specifications in progress
  - Preliminary Inquiry released 09/2022
  - CFT end of 2022
- Small scale LIN infrastructure at ESO HQ
  - CFT end of 2023
- Cryo-cooler infrastructure procurements 2022-2027
- Vacuum systems infrastructure 2022-2027



Principal concept of the ELT cryogenic infrastructure





# Selected investments in cryo-vacuum at ESO

#	Description	Contract type	Placed by	Start	End	Company type
1	ELT LIN distribution system infrastructure: design, construction, on-site installation	industrial contract (PI released recently)	ESO	2023	2026	specialized in large LIN infrastructures
2	ESO HQ LIN distribution system infrastructure: design, construction, on-site installation	industrial contract	ESO	2023	2025	specialized in LIN infrastructures
3	LIN delivery service LaSilla-Paranal-Observatory (La-Silla & VLT), Chile; 30000 L/month	frame contract, recurring every 3-5 years	ESO	2025	2028	LIN supplier
4	LIN delivery service on-site Armazones, Chile; for ELT FL instruments; 30000 L/month	frame contract, recurring every 3-5 years	ESO	2026	2030	LIN supplier
5	LIN delivery service on-site Armazones, Chile; for ELT 1 <sup>st</sup> and 2 <sup>nd</sup> gen. instr.; 60000 L/month	frame contract, recurring every 3-5 years	ESO	2030	2035	LIN supplier
6	LIN delivery service on-site ESO HQ, Germany; 4000 L/month	frame contract, recurring every 3-5 years	ESO	2024	open	LIN supplier
7	portable LIN dewars 120L / 200L	hardware procurement	ESO	2022	open	LIN dewar supplier
8	customized LIN transfer lines	hardware procurement	ESO + consortia	2023	open	LIN transfer line supplier
9	cryo-coolers for ELT instruments according ESO requirements and standards	hardware procurement	ESO + consortia	2022	open	cryo-cooler supplier
10	ELT cryo-cooler infrastructure: compressors, He piping, thermal enclosures, anti-vibration mount	hardware procurements and industrial contracts	ESO	2023	2030	supplier for cryo-coolers, instr. protection, welding
11	cryo-coolers for VLT 3 <sup>rd</sup> generation instruments according ESO requirements and standards	hardware procurement	ESO + consortia	2022	open	cryo-cooler supplier
12	vacuum components: pumps, valves, gauges, fittings, He leak detectors, mass spectrometers	hardware procurement	ESO + consortia	2022	open	vacuum hardware suppliers

# Expected investments in cryo-vacuum at ESO

Year of investment	2023	2024	2025	2026	2027	2028	2029	2030
k€ - cryo-vac*	800	1000	1600	1600	1600	800	800	800

\*all amounts non-binding

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*End of presentation – many thanks for your attention*