Cryogenics for E ELT

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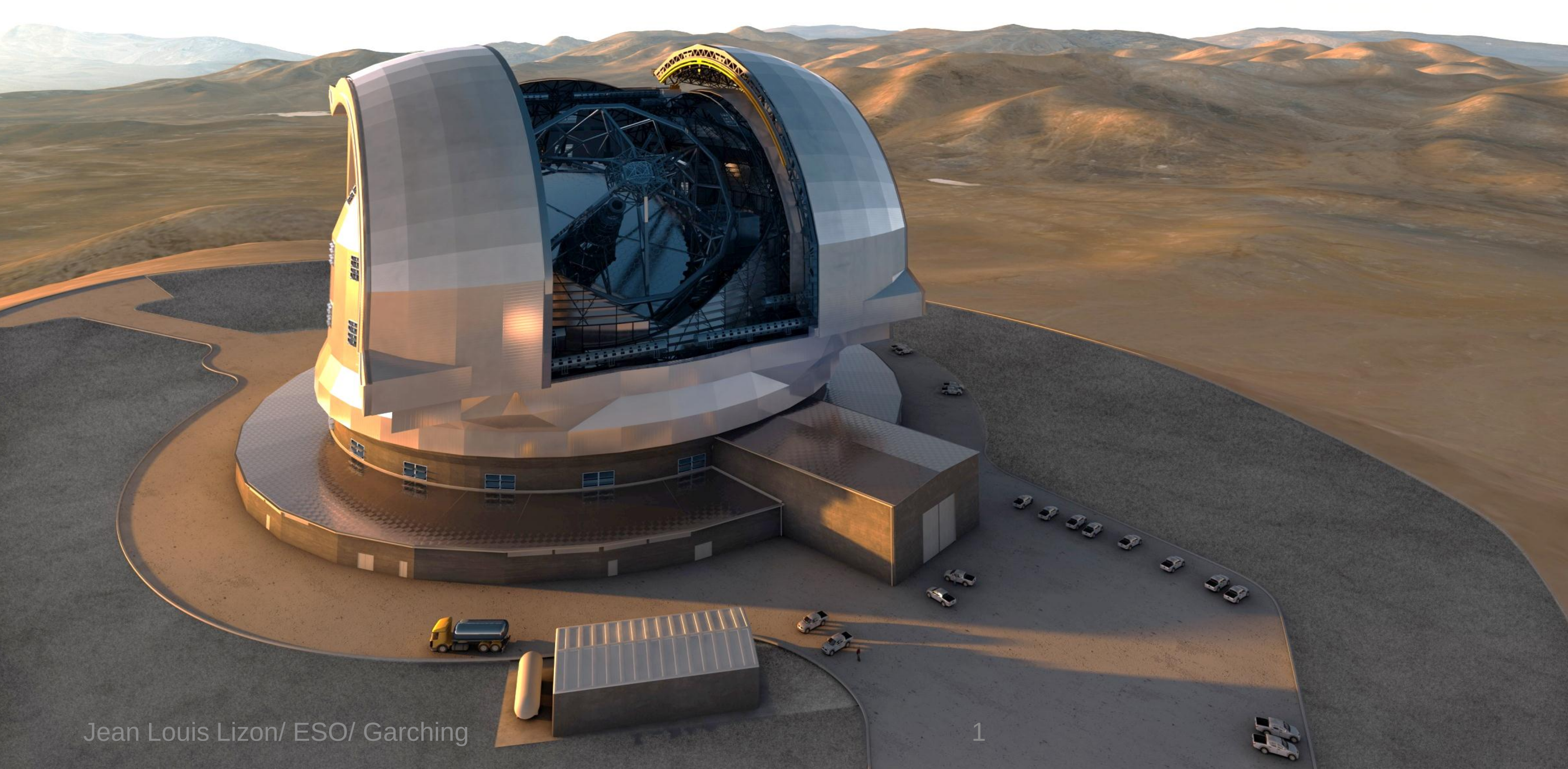
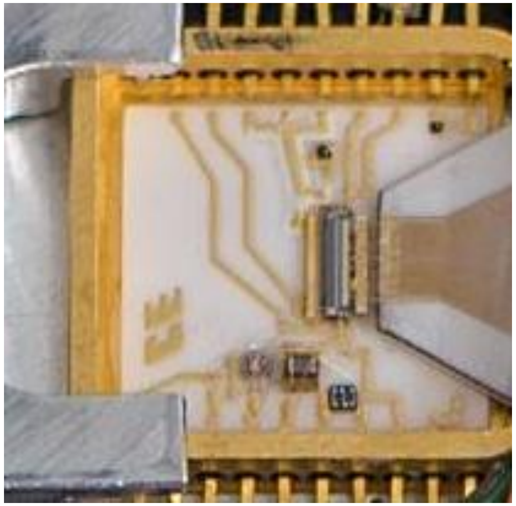
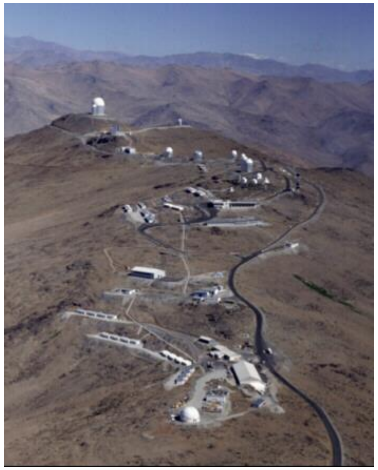
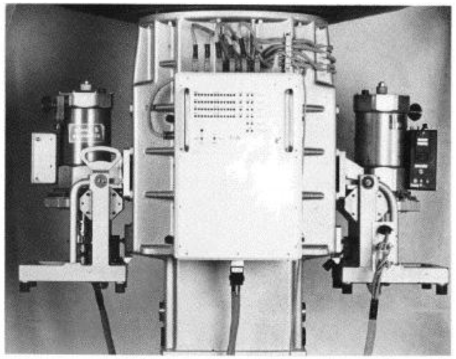


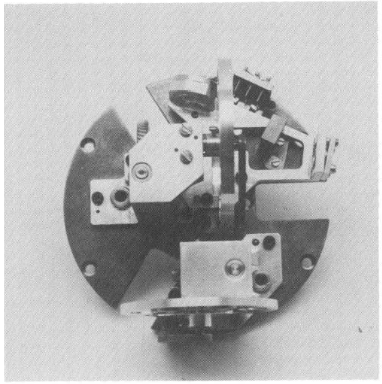
Cryogenics for E ELT

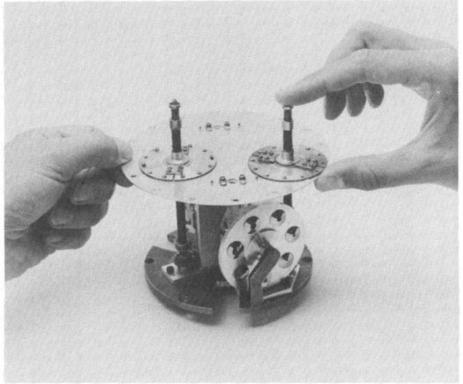
1980: Cryogenics enters in ground based astronomy
1st IR detectors 1x1 (LN2 and He cooled)
1982: Installation of the first large echelle spectrograph
Instrument LN2 cooled
Det: 32x1 He cooled

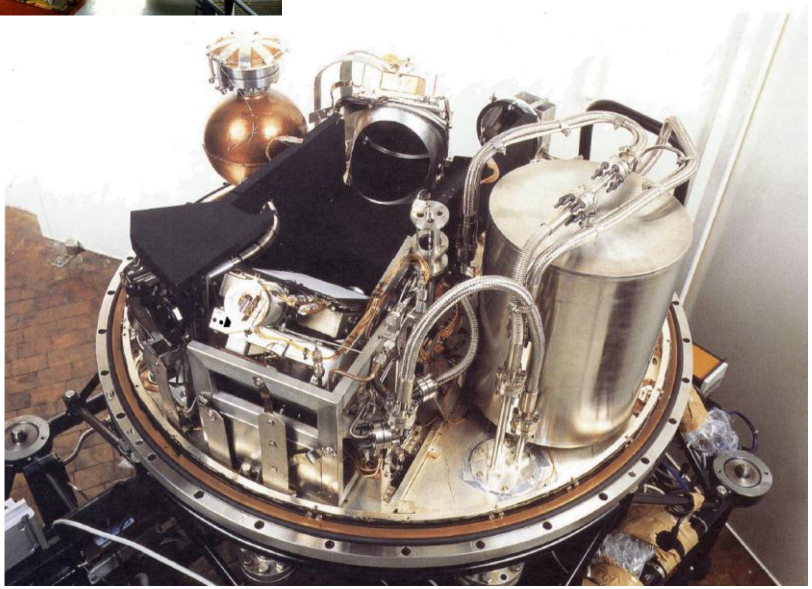






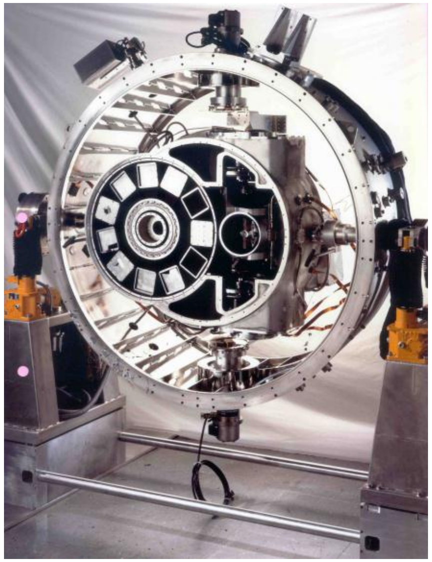






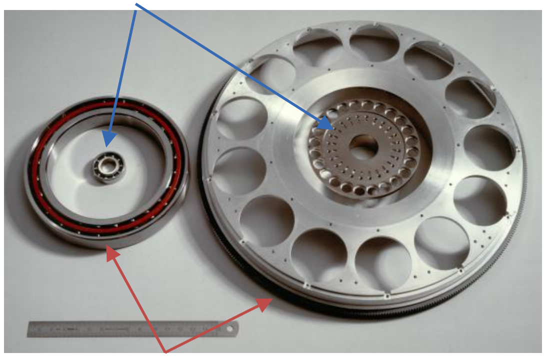
Cryogenics for E ELT

1992 Approval of the VLT

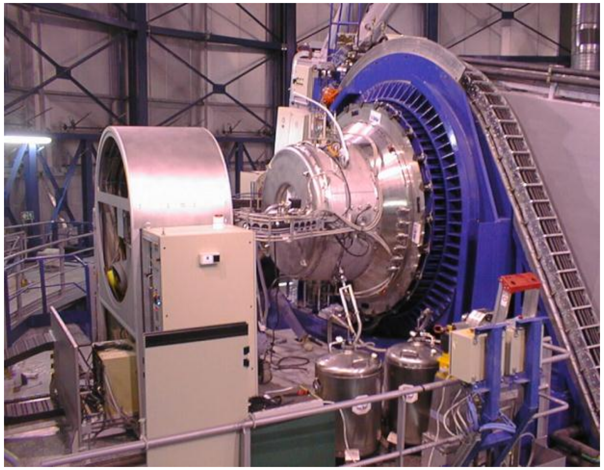


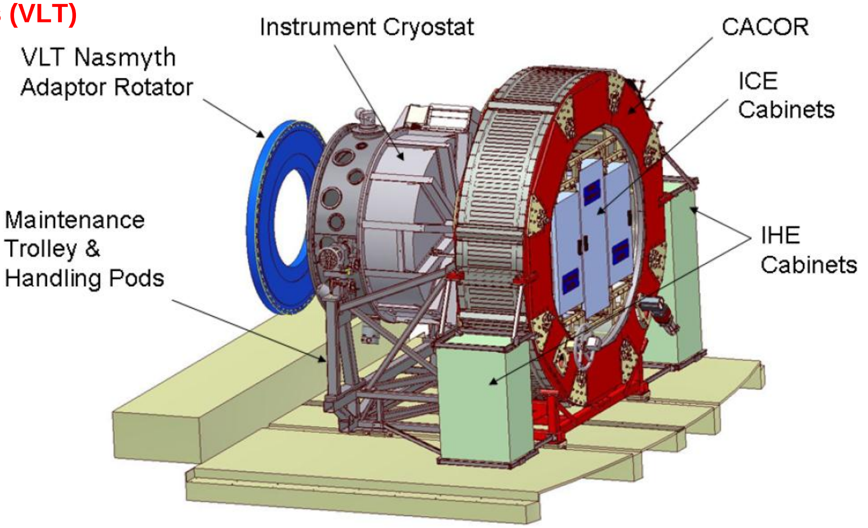
Telescopes: From 3.6m to 8m
Detector: Permanently growing

Filter wheel for instrument 80th



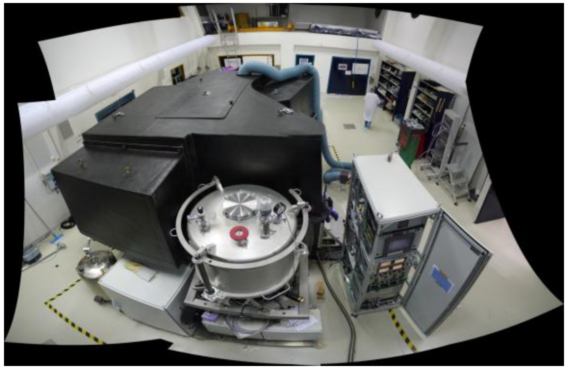
Filter wheel for instruments (VLT)

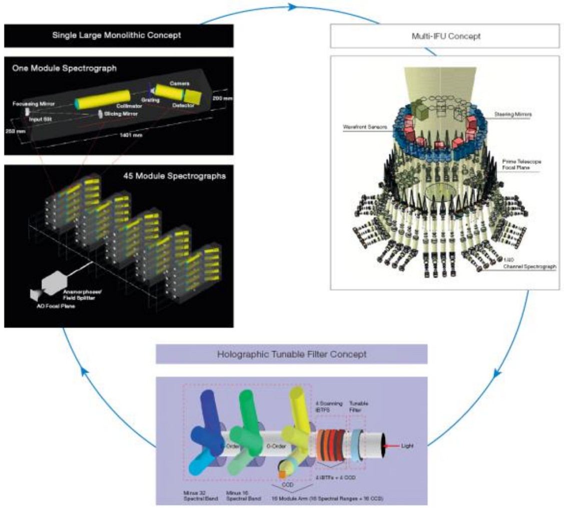


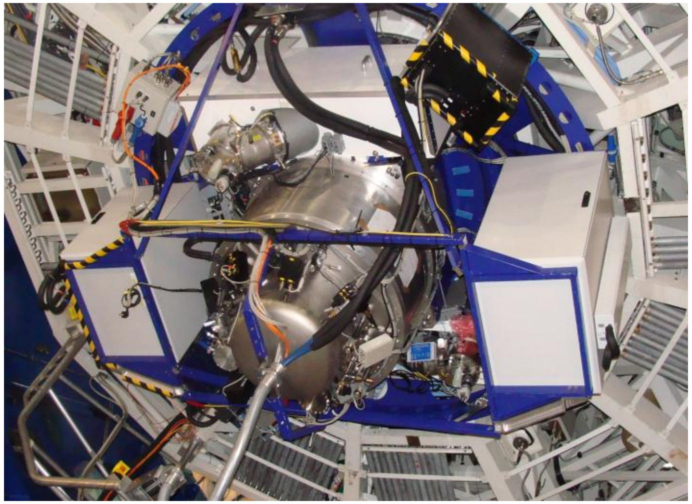


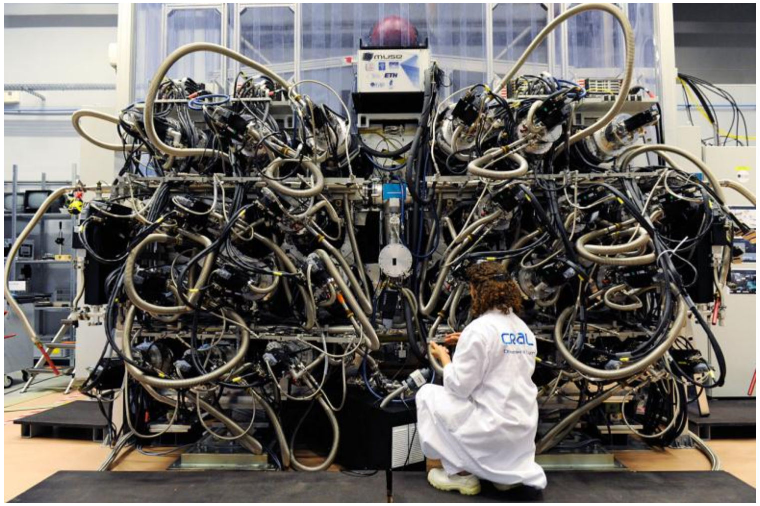
Cryogenics for E ELT

Mosaicking and clustering of Instruments and detectors

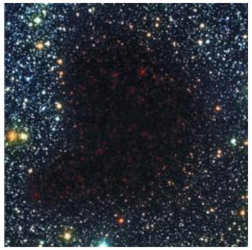








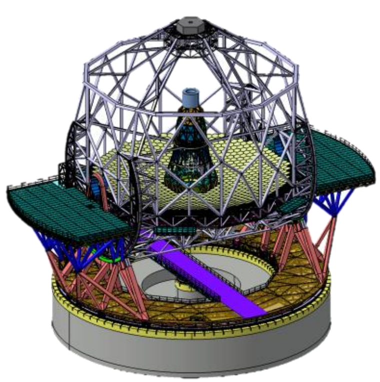
Visible Versus Infrared



Cryogenics for E ELT

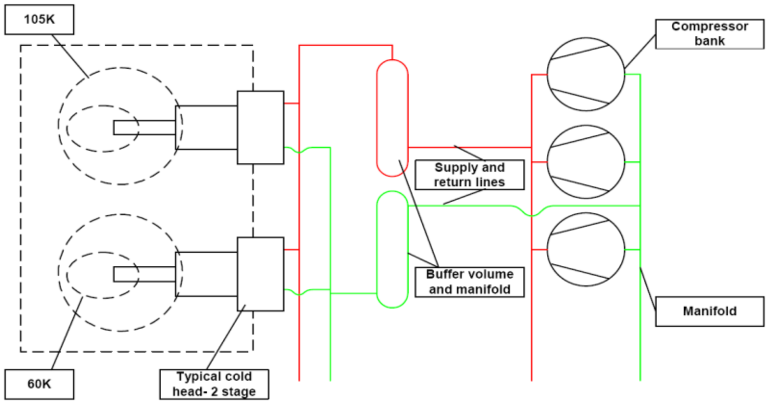
Requirements

Temperatures	Purpose	Power requirements	Locations (number) of duties		
			Nasmyth A	Nasmyth B	Coudé
230 K (T1)	Optical detectors	404 W	16	10	
105 K (T2)	NIR ins. optic	1579 W	3	28	1
65 K (T3)	NIR detectors	400 W	10	28	
27 K (T4)	MID IR optics	20 W		2	
5 K (T5)	MID IR detectors	35 W		2	

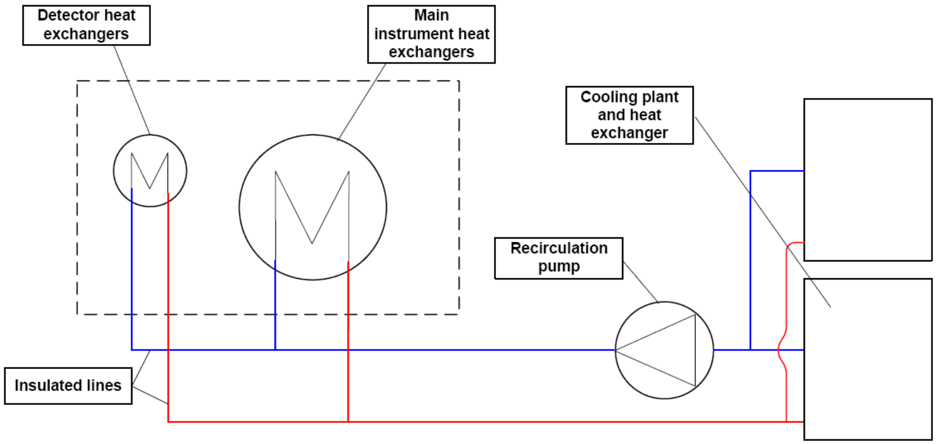


Cryogenics for E ELT

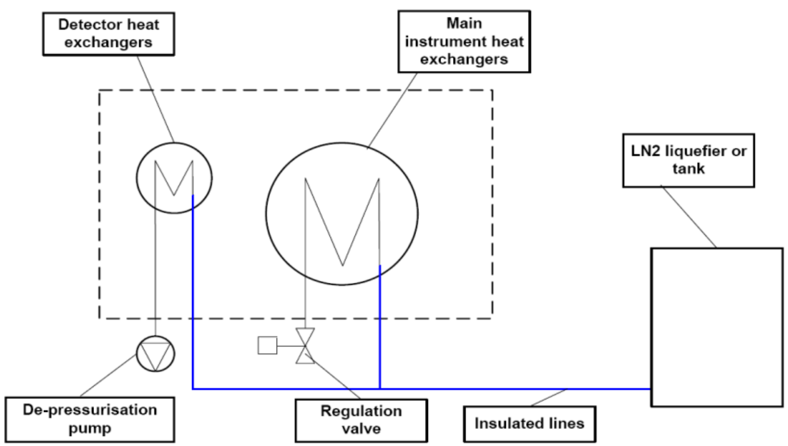
Tradeoff study to compare 3 different technology combinations



Schematic implementation of a forced flow cooling system



Schematic implementation of Mechanical Cooler



Schematic implementation of open loop LN2 cooling

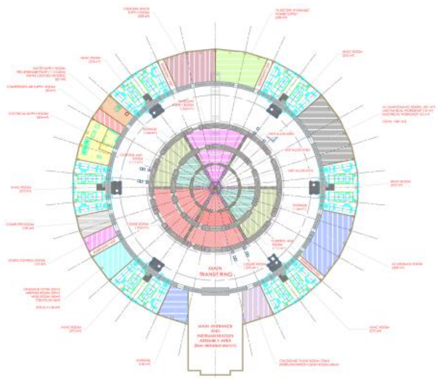
Cryogenics for E ELT

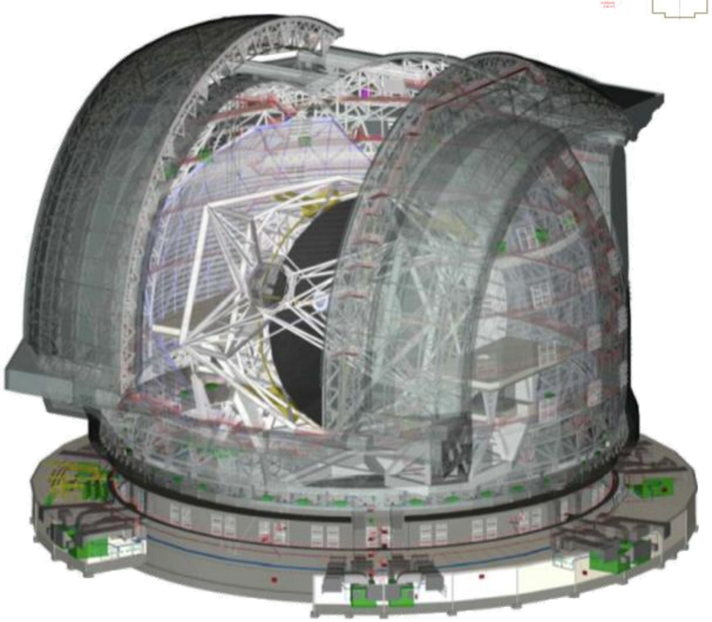
Result of the tradeoff study

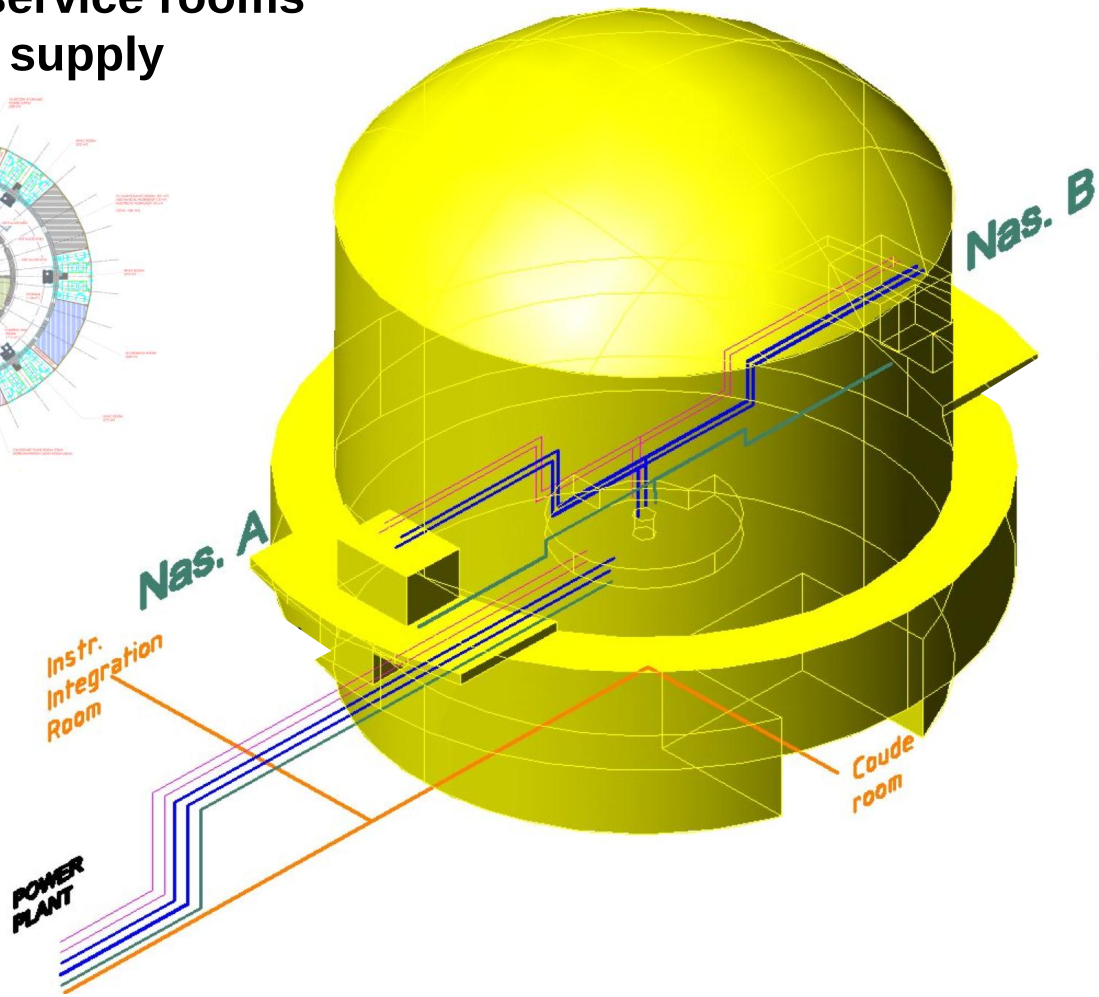
		Mechanical Coolers + LN2 pre-cool		Forced convection He + Mechanical Coolers		Open LN2 Cooling + Mechanical cooler	
Criterion	Weight (W)	Score (S)	Mark (S*W)	Score (S)	Mark (S*W)	Score (S)	Mark (S*W)
Vibration	5	1.5	7.5	4.25	21.25	4.25	21.25
Running cost	2	2.4	4.8	4.5	9	3.1	6.2
Power consumption	3	2.8	8.4	4	12	3.2	9.6
Capital cost	2	5.8	11.6	1.4	2.8	2.8	5.6
Installation effort	2	5.5	11	2.25	4.5	2.25	4.5
Technology readiness	4	4.25	17	1.5	6	4.25	17
Dome seeing, tel. perf.	3	1.5	5.5	5.5	16.5	3	9
Telescope service	1	5.5	5.5	1.5	1.5	3	3
Reliability	4	3.33	13.32	3.33	13.32	3.33	13.32
Failure mode	4	1.5	6	3	12	5.5	22
Scalability	3	5.5	16.5	1.5	4.5	3	9
Impact on instrument	3	1.5	4.5	4.25	12.75	4.25	12.75
AIV support	3	3	9	1.5	6	5.5	16.5
TOTAL			120.62		122.12		149.5

Cryogenics for E ELT

LN2 on site production in the service rooms
LN2 and Helium high pressure supply



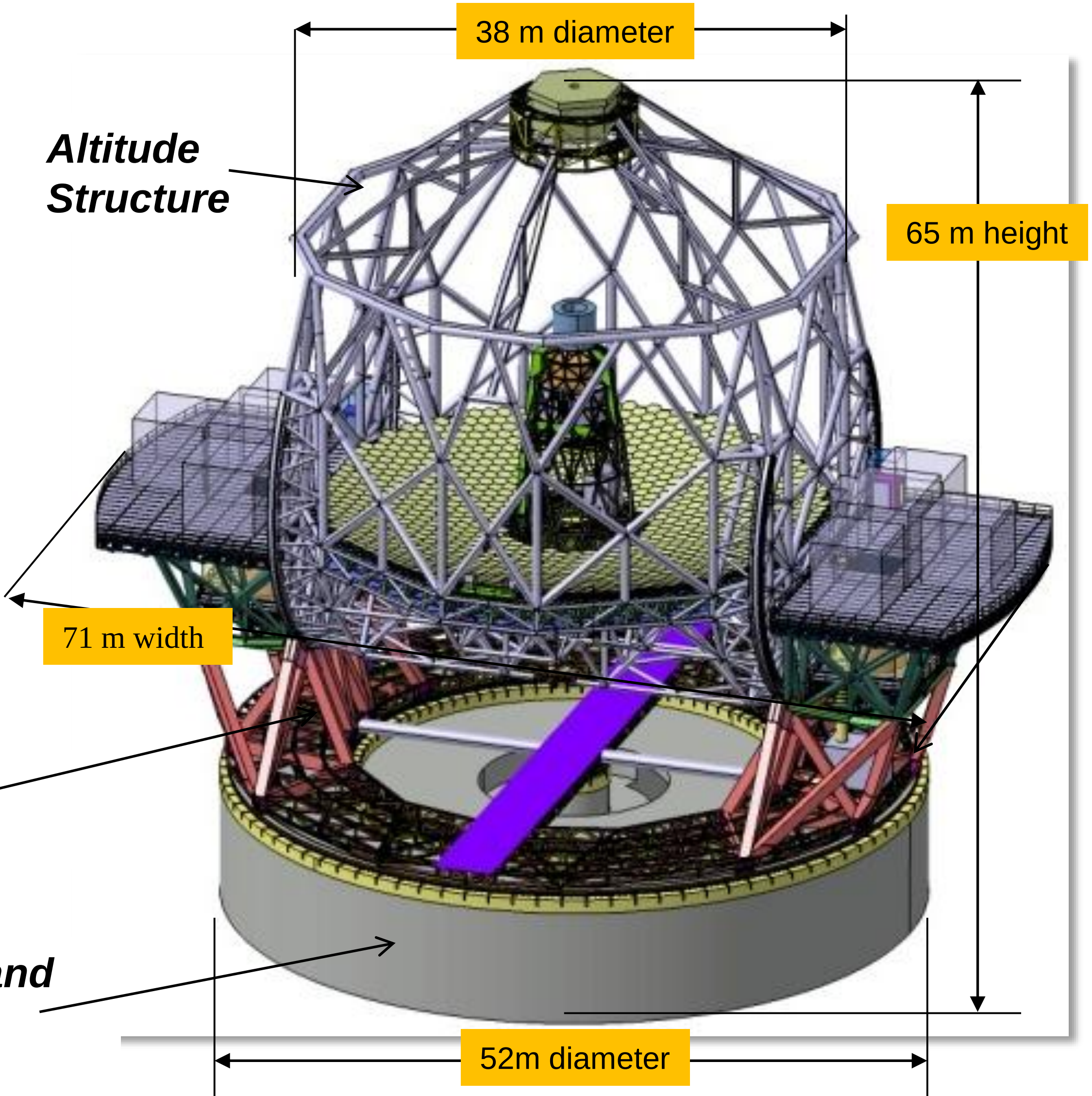




Cryogenics for E ELT

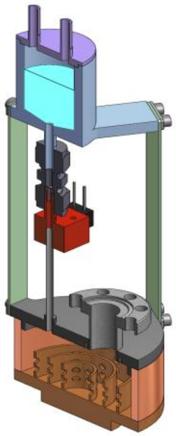
Main Structure ~ 2500 tons of steel moving 700 tons of opto-mechanics and electronics around two perpendicular axes (azimuth and altitude) Hydrostatic bearings driven by electrical direct drive motors with a precision of 0.3 arcsec under the maximum wind disturbance.

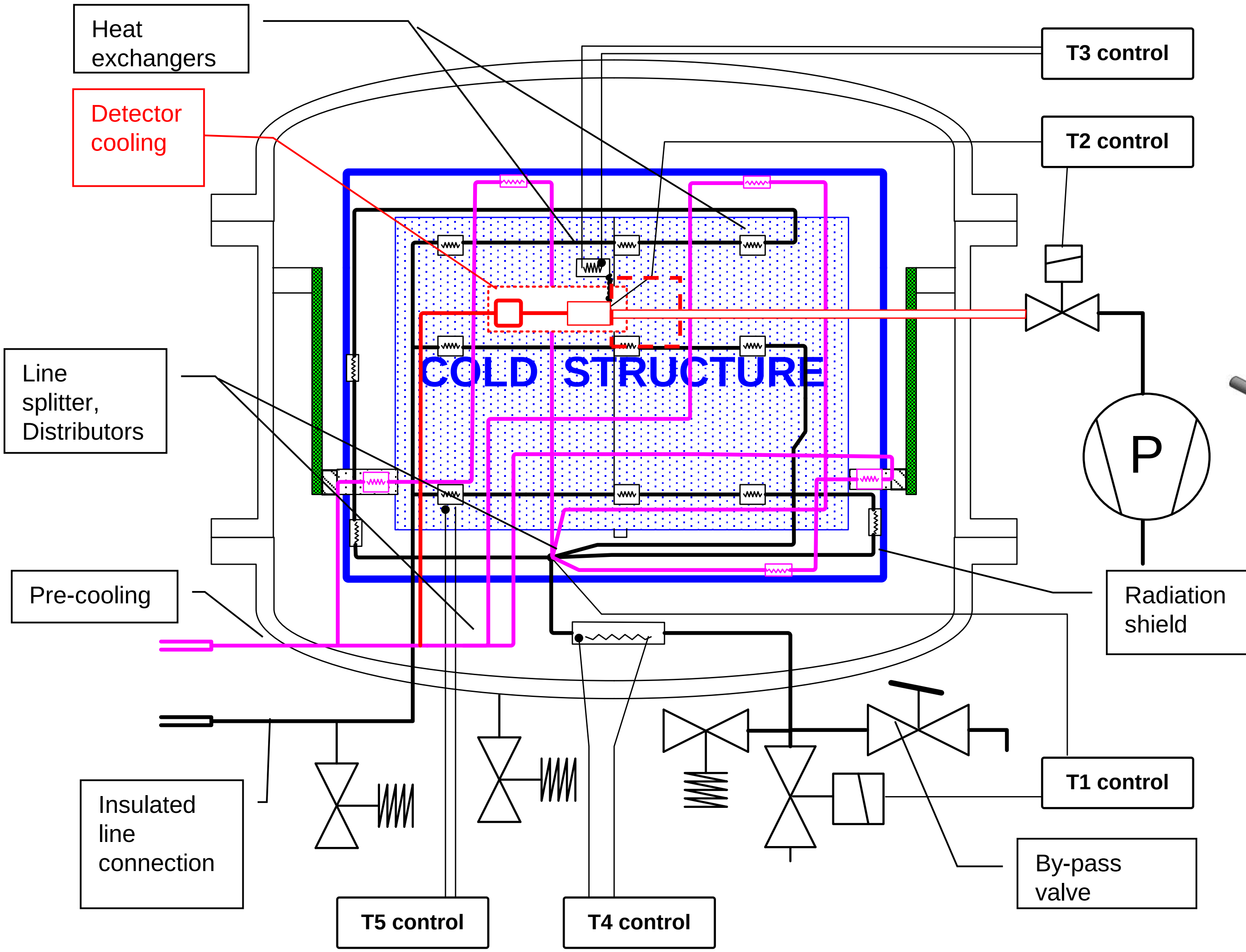
Instruments about 30 m above the ground

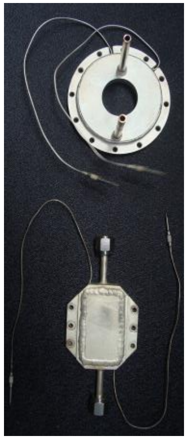


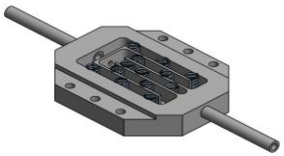
Cryogenics for E ELT

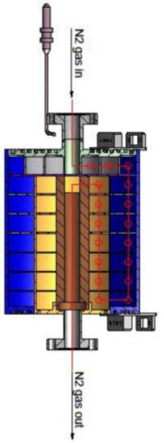
Base line solution for T1, T2 and T3





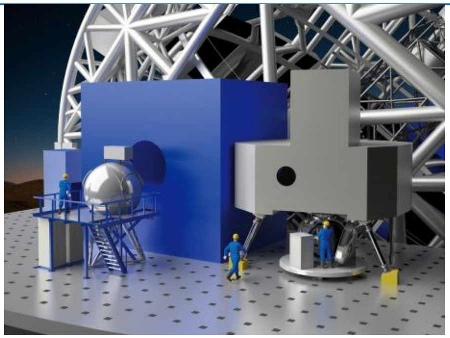


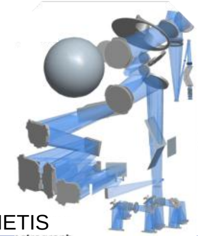




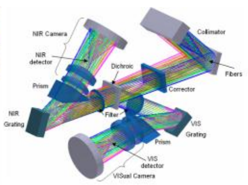
Cryogenics for E ELT

Examples of E ELT instruments
Difficulties to get optical quality at short wavelengths
→1st Generation mainly IR instruments



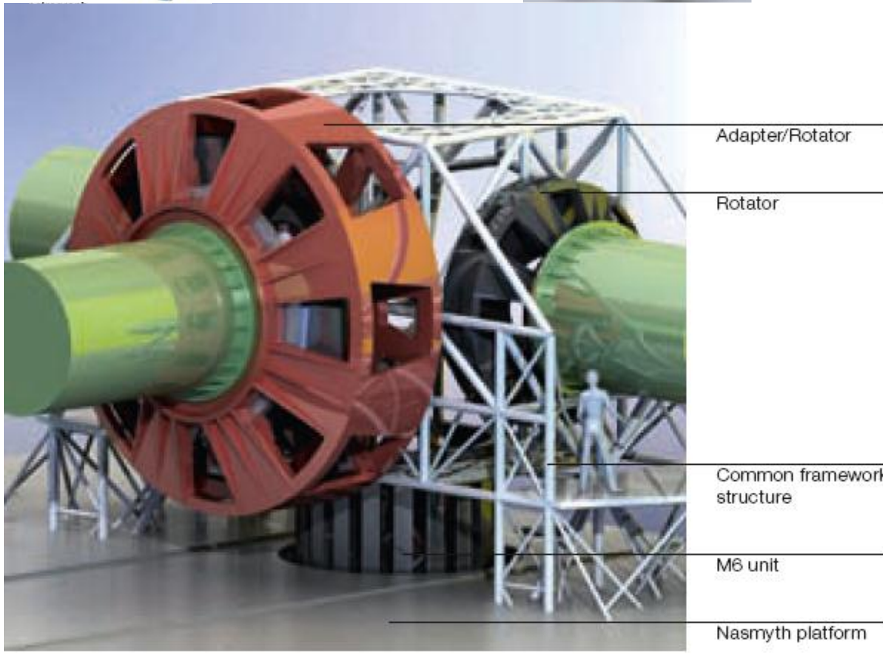


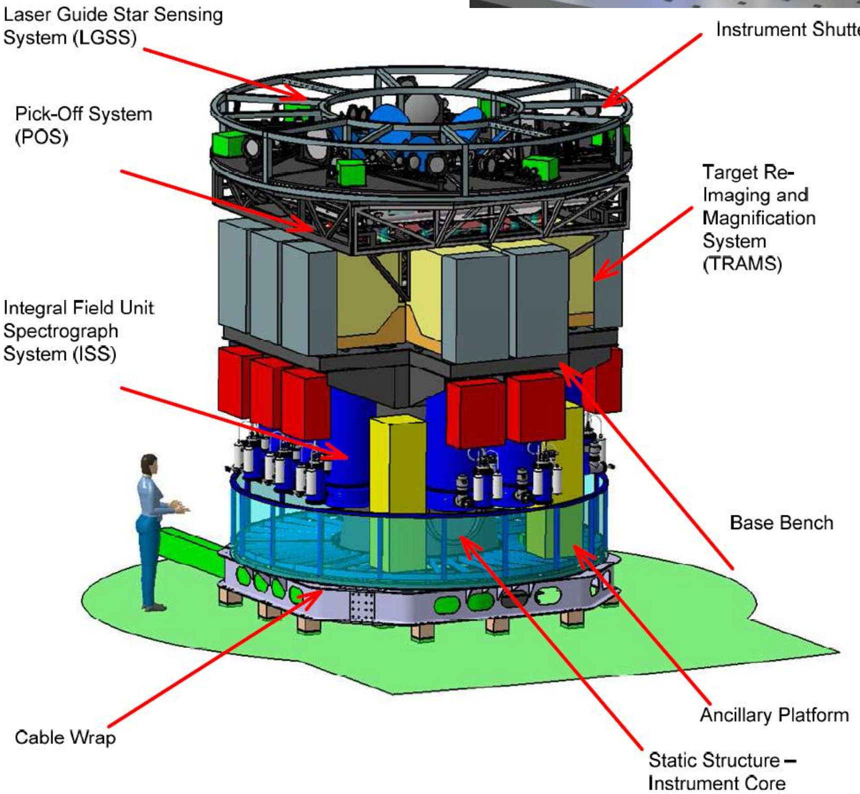
METIS



OPTIMOS/EVE

MICADO

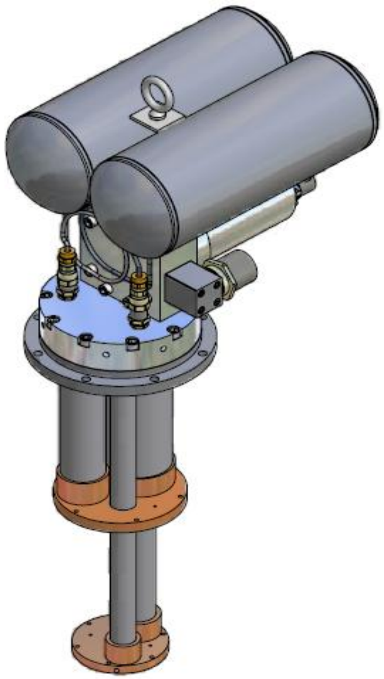




Cryogenics for E ELT

Base line solution for T4 and T5

Pulsed Tube (PT410) cooler from CryoMech

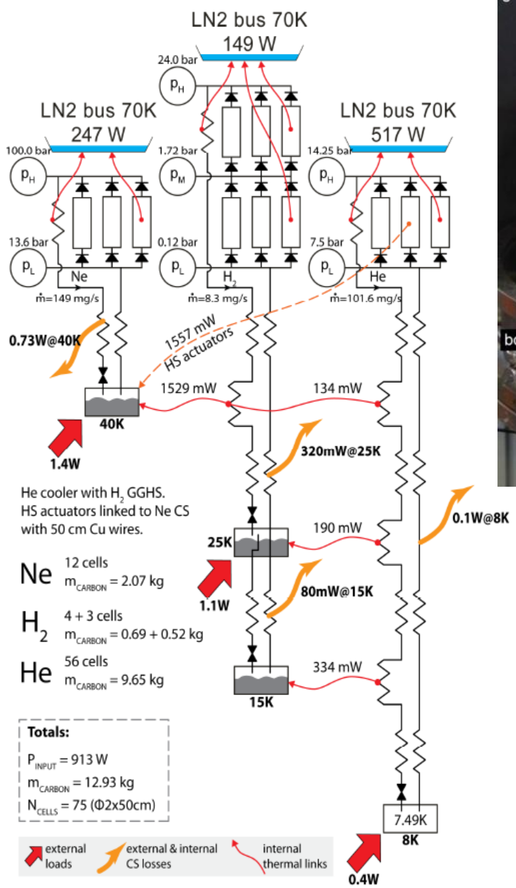


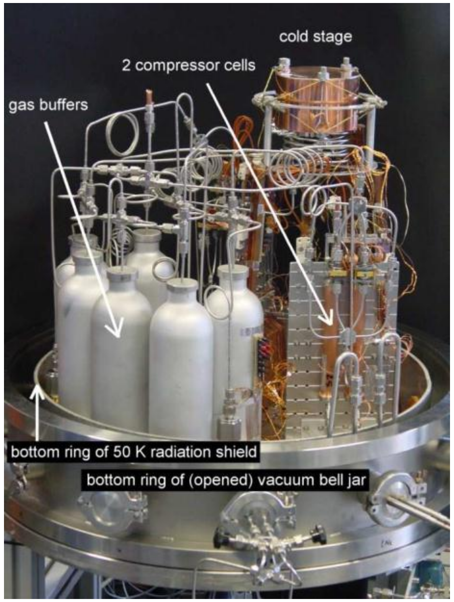
2nd stage and 1st stage combined power:	**1W @ 4.2K with 35W @ 45K (at 50 and 60 Hz)**
Lowest Temperature:	0W @ 2.8K
Cool down time to base temperature:	60 minutes to 4K
Input Power - Water Cooled:	8.4kW @ 60Hz, 7.9kW @ 50Hz

Cryogenics for E ELT

Alternative solutions for T4 and T5 and eventually other intermediate temperatures

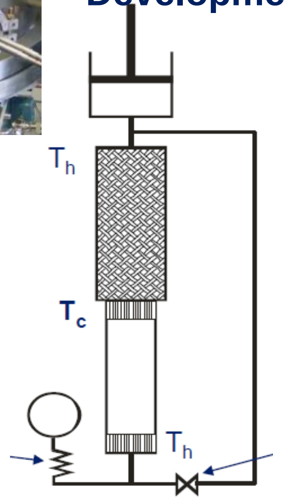
Sorption cooling:
Development from university of Twente



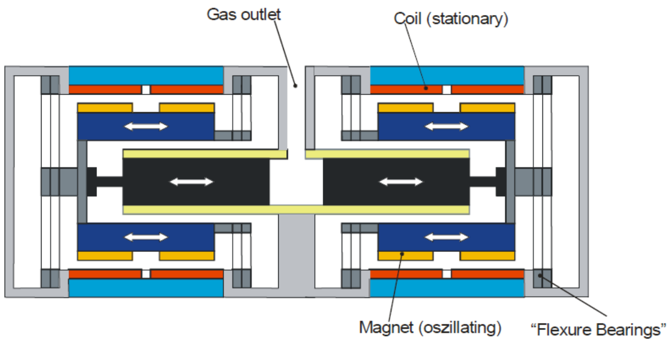


Thermal energy storage units using the Liquid-gas phase transition as energy storage (Neon for T4)

Pulsed Tube from 77K to 40K and other intermediate temperatures
Development from Giessen University



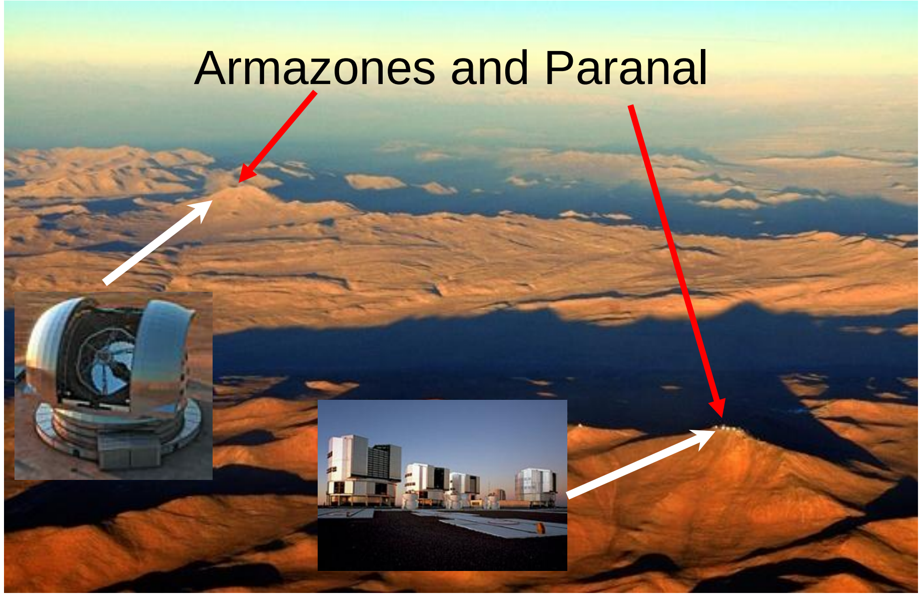
Inline



Oil-free, no rubbing (gas gap seal), high effciency: $\eta \approx$ 65 - 85%!
(Thales LPT9710 compressor: $\eta \approx$ 85 %)

Cryogenics for E ELT

Location and status of the project

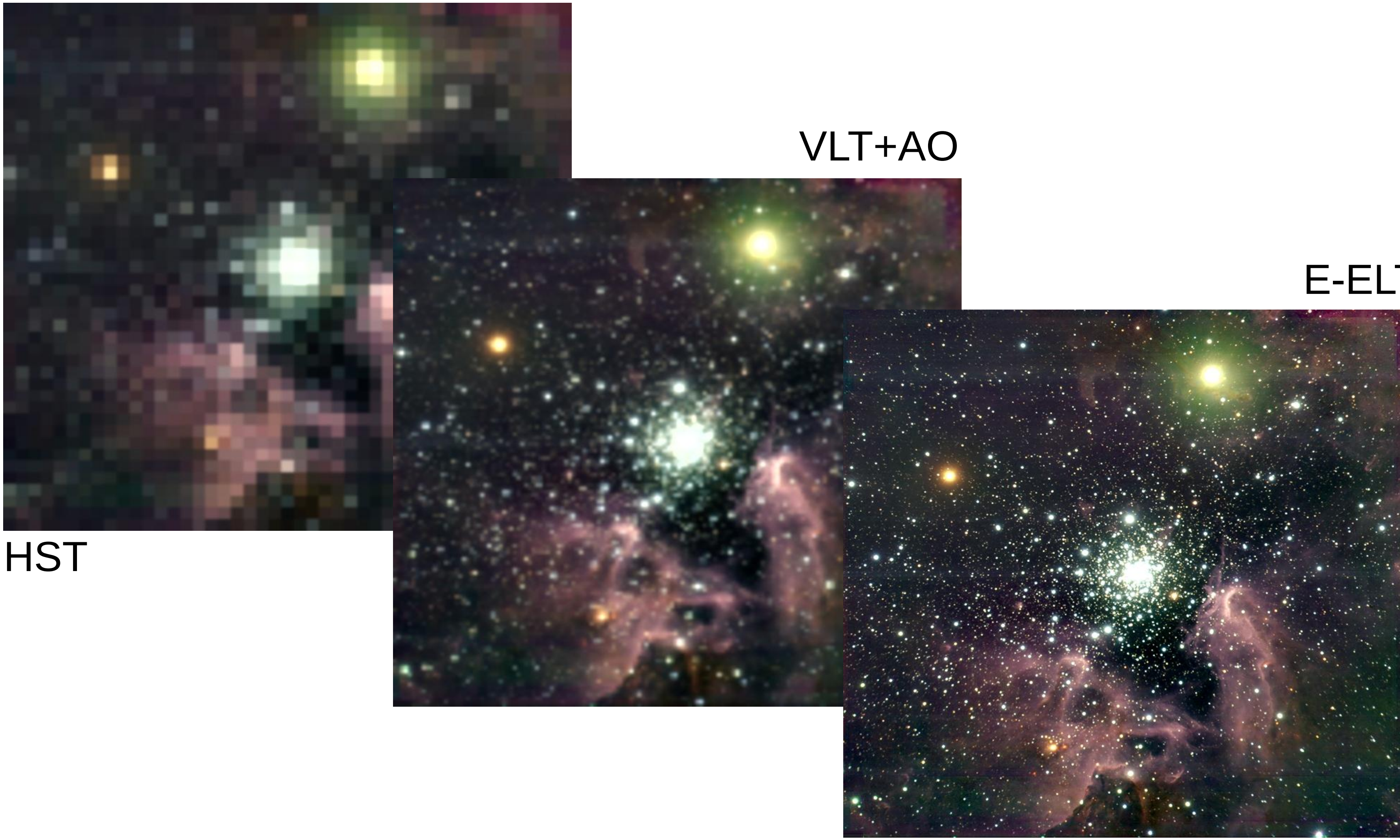


Construction 2014-2024, on Cerro Armazones (*3000 m above see level, Atacama desert*)

As *integral part* of the Paranal Observatory ('one more telescope')

ESO cost: ~1100 MEUR incl. instruments and contingency

Cryogenics for E ELT



Cryogenics for E ELT