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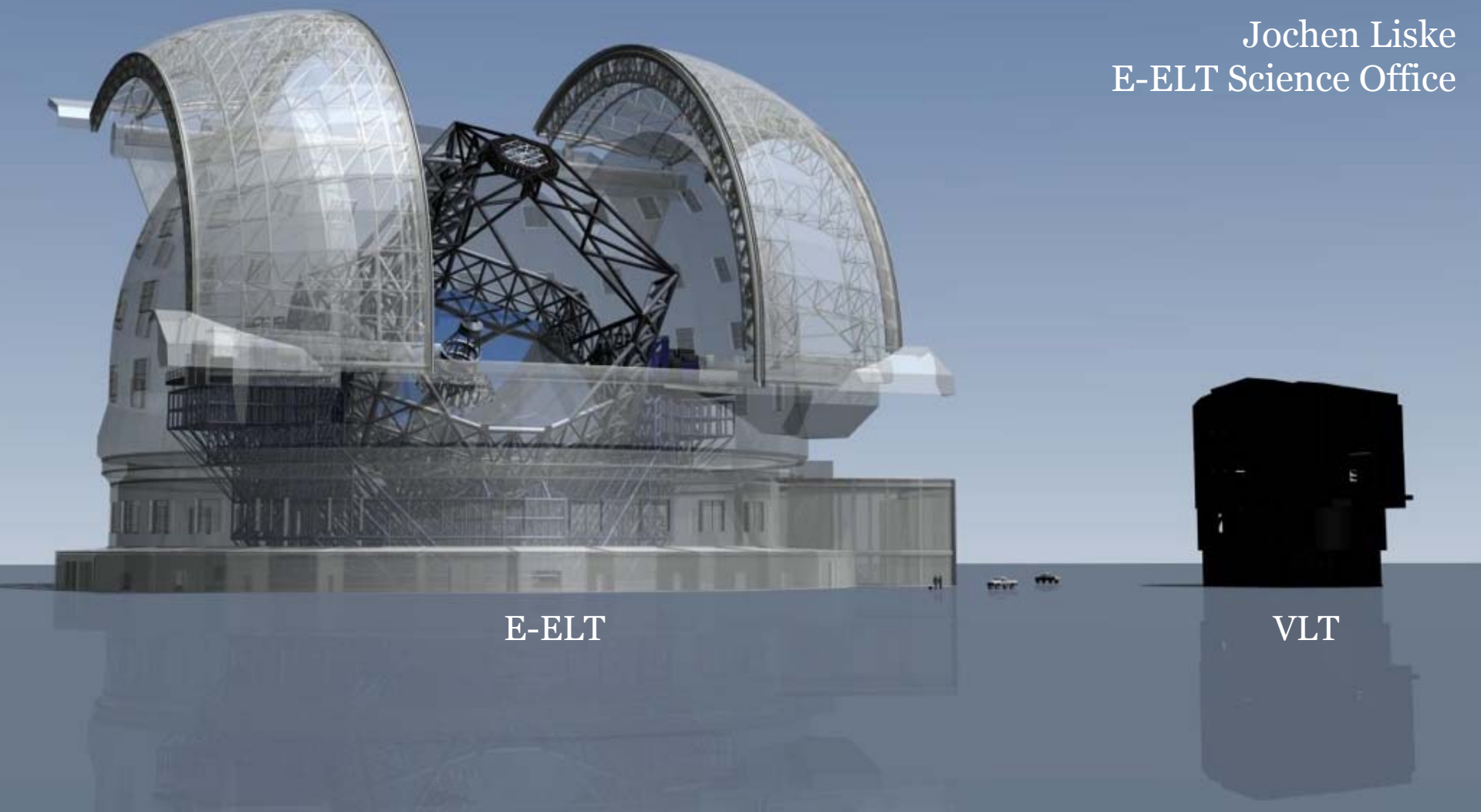
# The World's Biggest Eye on the Sky

## The European Extremely Large Telescope

Jochen Liske
E-ELT Science Office



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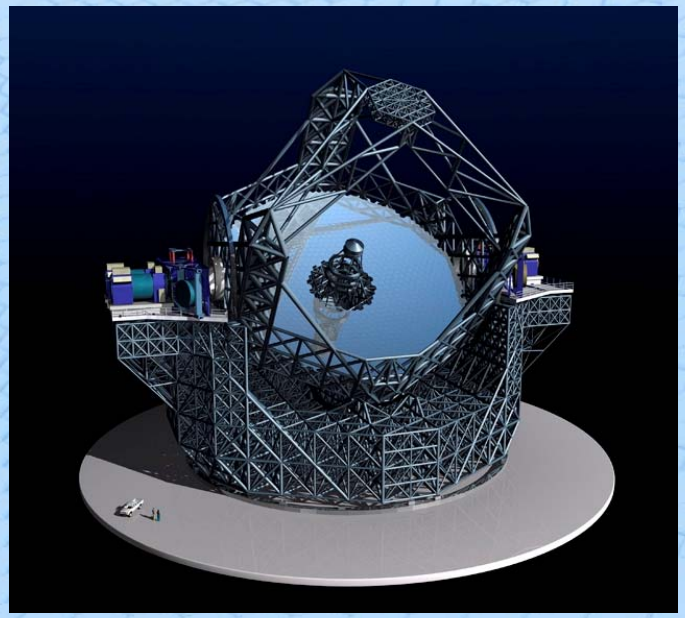
# Background

- In 2004 ESO Council resolved that:
  - ESO's highest priority strategic goal must be the European retention of astronomical leadership and excellence into the era of Extremely Large Telescopes…
  - the construction of an Extremely Large Telescope on a competitive time scale will be addressed by radical strategic planning … for fast implementation.



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# The story so far…

- ESO design activities on OWL concluded with design review at the end of 2005 with the following recommendations:
  - ELT activities to continue to phase B
  - 100-m feasible but risk to cost and schedule high
  - Risk mitigation recommended in the next phase of design, avoiding double segmentation, limiting complexity of functions and reducing schedule risk.
- 1st half of 2006 community wide consultations in 5 working groups with over 100 scientists and engineers directly contributing.
  - Site
  - Adaptive optics
  - Instrumentation
  - Telescope
  - Science
- 2nd half of 2006, formation of the ELT project office at ESO and consolidation of basic designs.
  - Baseline telescope design proposal presented to the ESO committees and community in Marseille (December 2006).
  - ESO Council gave a unanimous go-ahead (and 57.2 M€) to the project office to advance to phase B with a goal to present a construction proposal in 2010.

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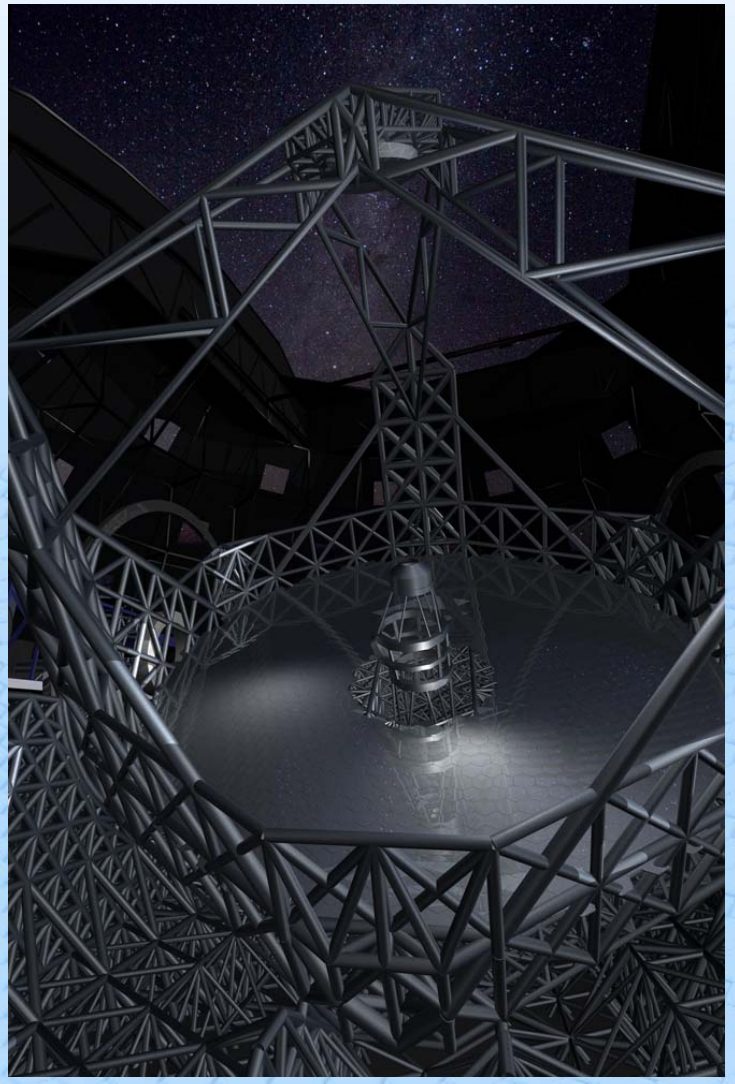
# E-ELT: General Characteristics

- Largest optical-infrared telescope in the World: 42m
- Adaptive optics assisted telescope
- Segmented primary mirror
- Active optics to maintain collimation and mirror figure
- Diffraction limited performance
- Fast instrument changes
- Wide field of view: 10 arcmin
- VLT level of efficiency in operations
- Mid-latitude site



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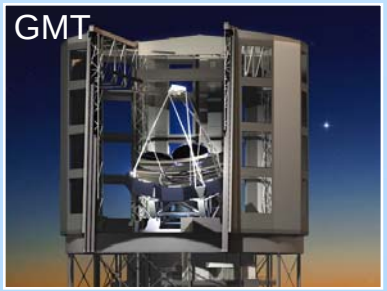
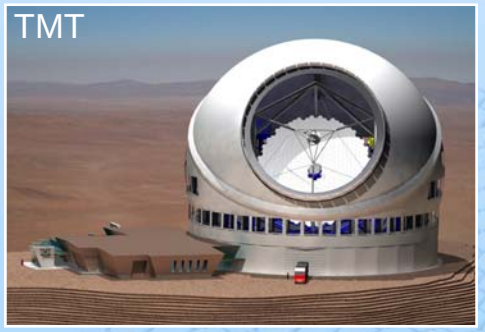
# The E-ELT compared to ELTs

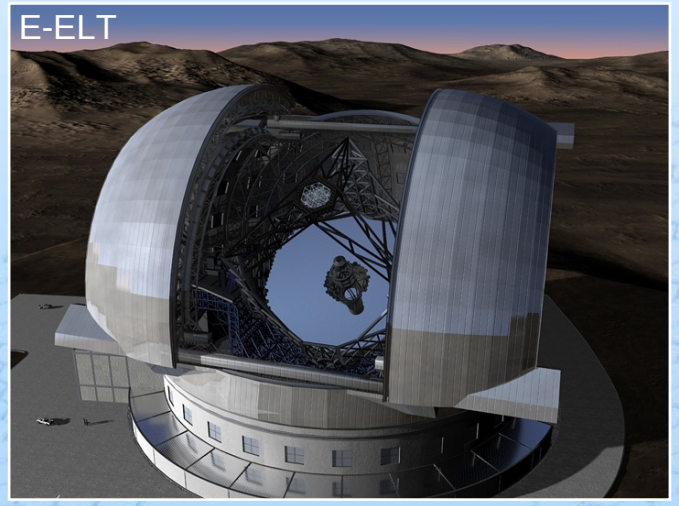
Largest

Larger

Large




| | | | | |
|---|---|---|---|---|
| Diameter: | 24 m | 30 m | 42 m | (JWST: 6.5 m) |
| Collecting area: | ~400 m² | ~600 m² | ~1200m² | (JWST: 25 m²) |
| Diffraction limit at 1μm: | 8.6 mas | 6.9 mas | 4.9 mas | (JWST: 34 mas) |

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# Current Status in a Nutshell

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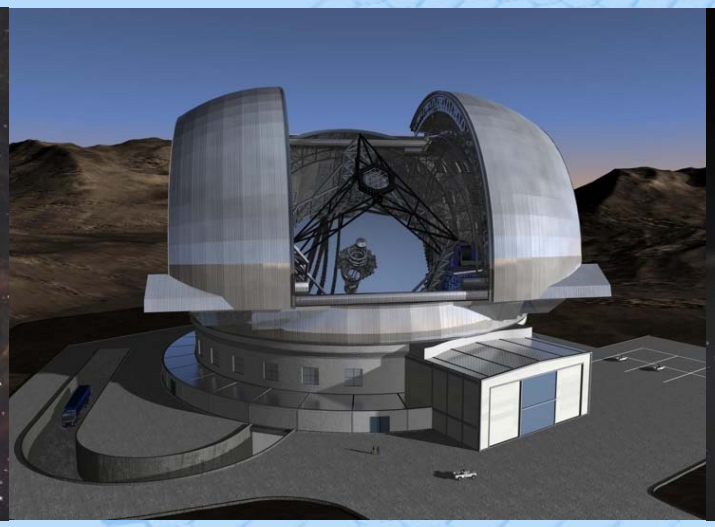
# Current Status in a Nutshell

- Top priority of European ground-based astronomy (on Astronet and ESFRI lists).
- Project (led by ESO) is in the detailed design phase (Dec 2006 - Dec 2010), with a total budget of 62 M€ from ESO + 35 M€ from EC Framework Programmes.
- Supported by community activities (FP7 activities).
- 8 instrument + 2 AO module concept studies in progress.
- Site not yet selected.
- Construction planned to begin in 2011. First light 7 years later: 2018
- Construction cost: ~950 M€ (incl. ~90 M€ for instrumentation)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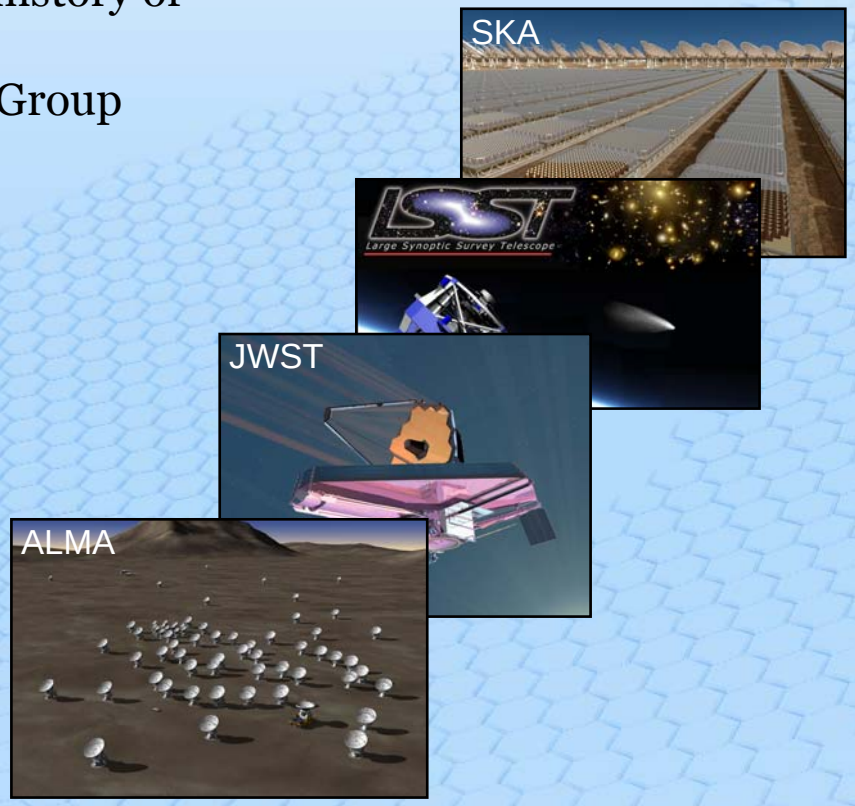
# The Science

Contemporary science:
Exo-planets: radial velocity detections (few cm/s), direct imaging (contrast of $10^{-9}$), proto-planetary disks (resolution of <1 AU),
Fundamental physics: GR in the strong field limit in the centre of the Milky Way (astrometry at 50-100 μas/year), variation of fundamental constants, expansion history of the universe (cm/s precision over a decade),
Resolved stellar populations: beyond the Local Group
The physics of high redshift galaxies
and many more...

Synergies with other top facilities:
ALMA (see www.eso.org/almaelt2009),
JWST (see workshop April 13-19, 2010),
LSST and other survey telescopes,
SKA (see workshop May 10-14, 2010), ...

Discoveries:
opening new parameter space in spatial resolution and sensitivity, ...



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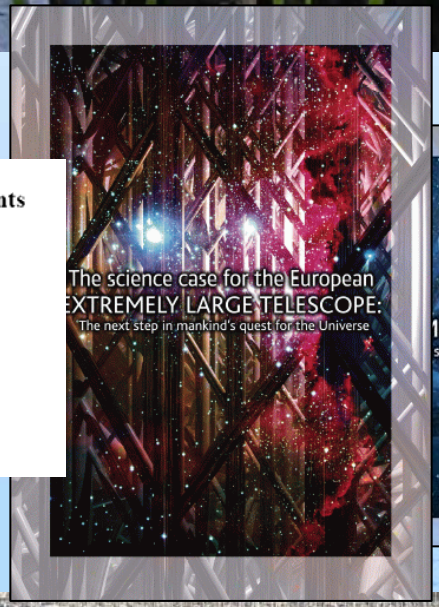
# Science Case Development

Florence 2004




Science Cases and Requirements for the ESO ELT

Report of the ELT Science Working Group

30 April 2006


Marseille 2003

Marseille 2006

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# E-ELT Science Working Group

Isobel Hook (Chair)
Arne Ardeberg
Andrea Cimatti
Fernando Comeron
Jose Espinosa
Sofia Feltzing
Wolfram Freudling
Raffaele Gratton
Hans-Ulli Kaeufl
Matt Lehnert
Christophe Lovis
Piero Madau
Mark McCaughrean
Michael Merrifield
Rafael Rebolo
Piero Rosati
Eline Tolstoy
Hans Zinnecker

With thanks to previous members:
Willy Benz
Robert Fosbury
Marijn Franx
Vanessa Hill
Bruno Leibundgut
Markus Kissler-Patig
Didier Queloz
Peter Shaver
Stephane Udry

Dec 2005: ESO SWG formed
Science case re-evaluated for 30-60m (April 2006)
ESO SWG merged with OPTICON activity

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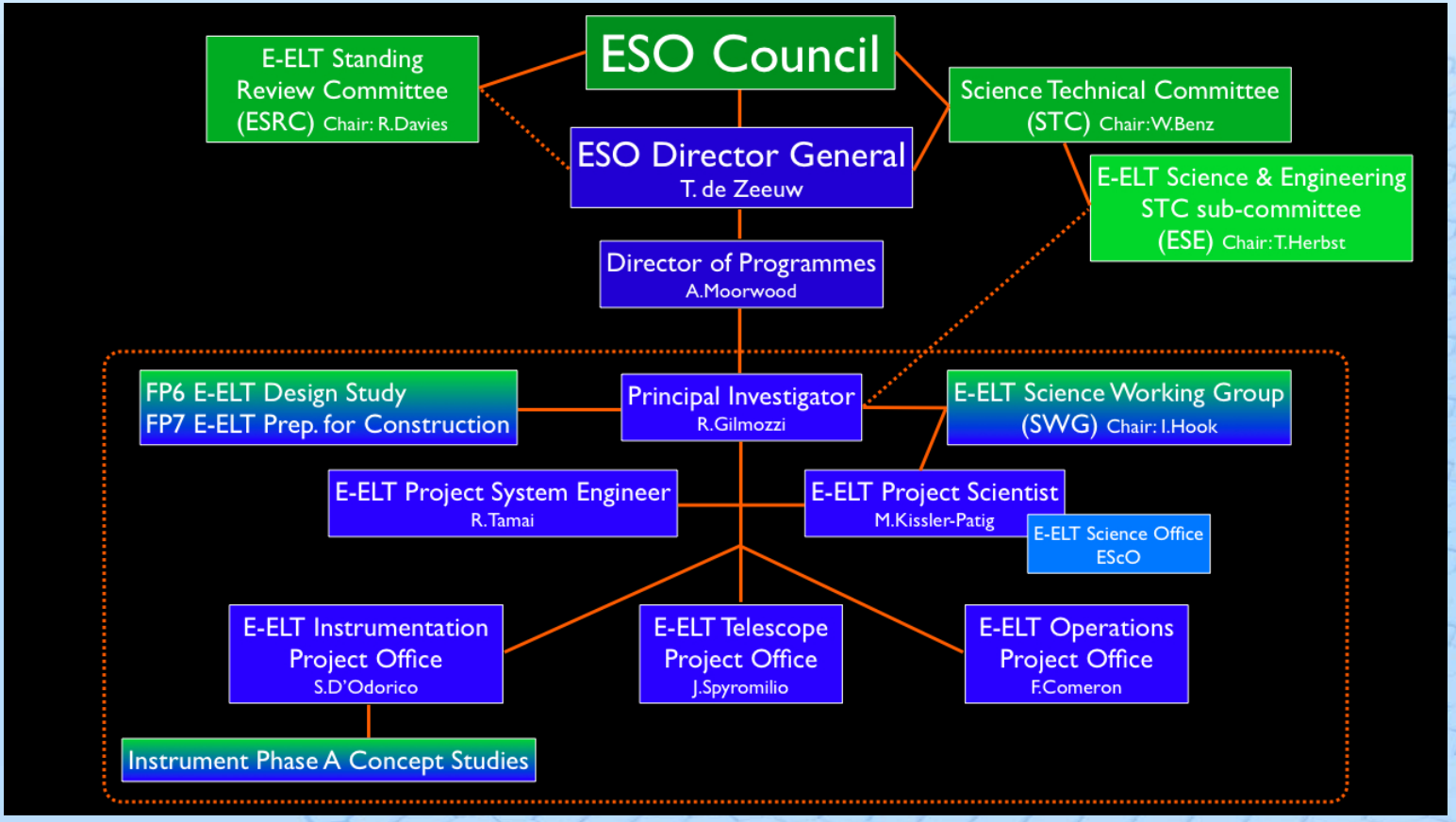
# Project Organisation

Project led by ESO on behalf on its 14 member states.

Strong involvement of member state industries and scientific communities.



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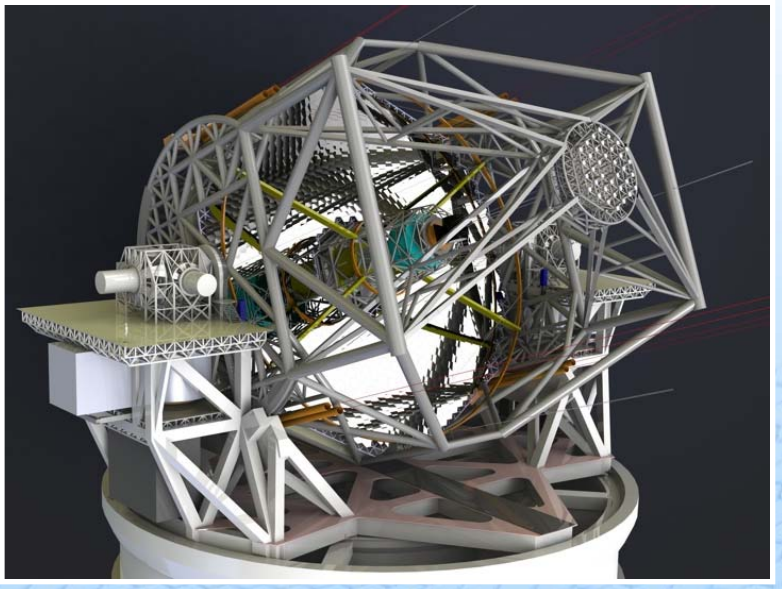
# The Telescope

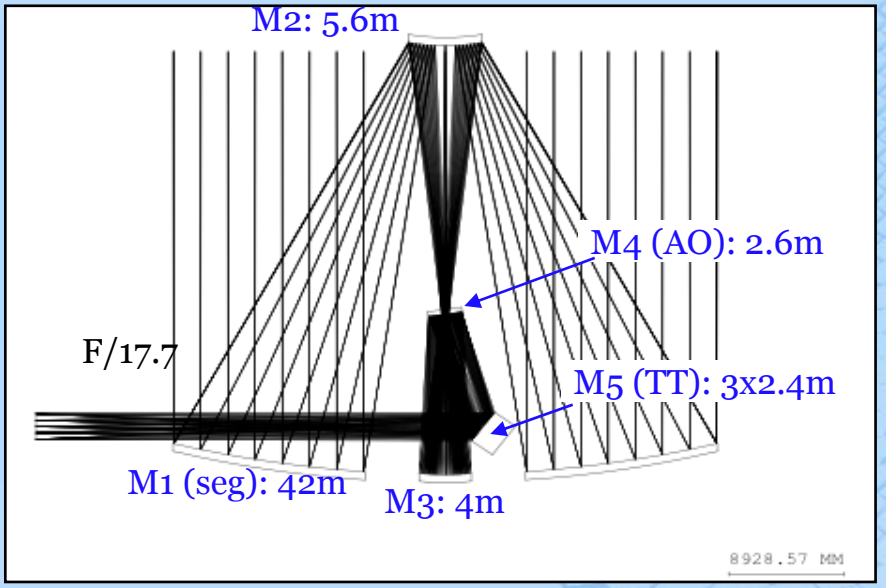
Nasmyth telescope with a segmented primary mirror of 42 m diameter.

Nearly 5000 tons of moving structure.

Two instrument platforms of the size of tennis courts can host 5 instruments each.

Six laser guide stars (provision for eight), launched from the side.

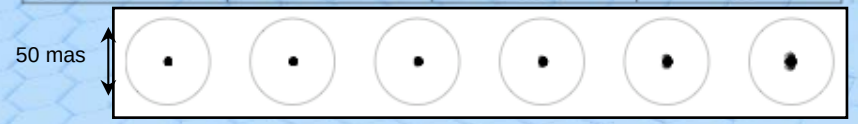





Novel 5 mirror design to include adaptive optics in the telescope

Classical 3-mirror anastigmat + 2 flat fold mirrors [M4,M5]

| Field of view (radius) | RMS Wavefront Error (nm) | Strehl ratio at wavelength 500 nm | Strehl ratio at wavelength 2000 nm |
|---|---|---|---|
| axis | 4 | 1.00 | 1.00 |
| 1 arc min | 4 | 1.00 | 1.00 |
| 2 arc min | 5 | 1.00 | 1.00 |
| 3 arc min | 7 | 0.99 | 1.00 |
| 4 arc min | 9 | 0.99 | 1.00 |
| 5 arc min | 13 | 0.97 | 1.00 |



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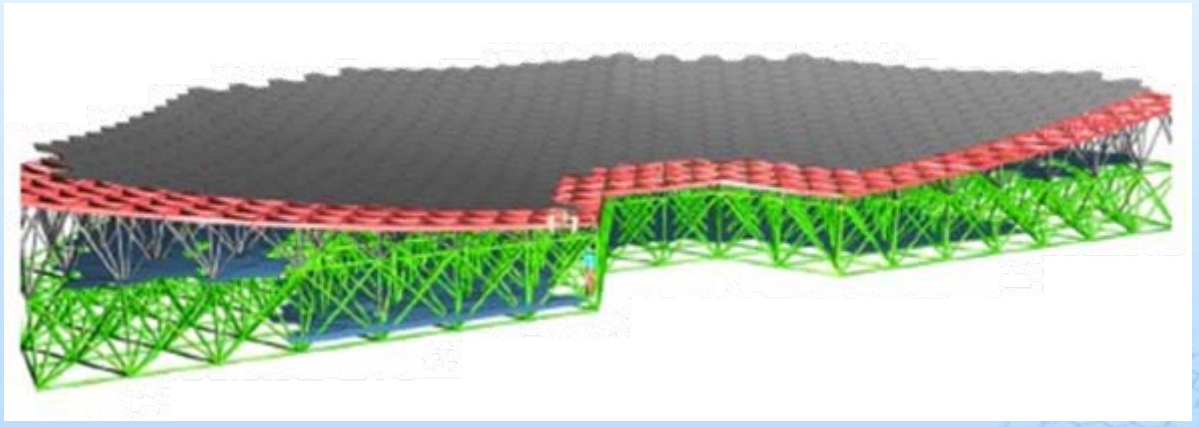
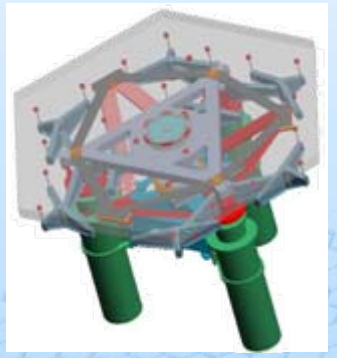
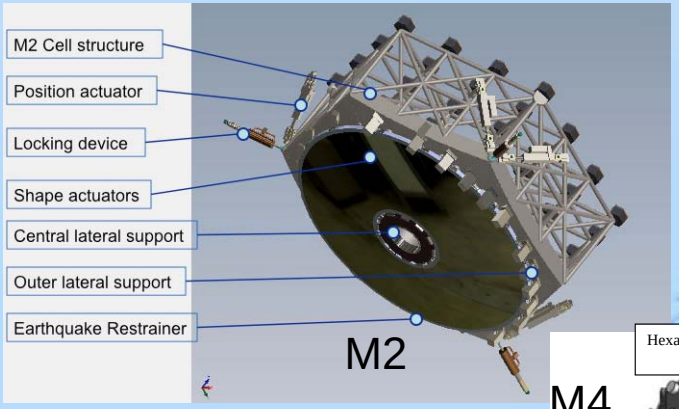
# The Mirrors

Primary mirror: 42m ∅, 984 hexagonal segments of 1.45 m tip-to-tip: 1200 m²

Contracted: 2 x seven segments, prototype segment support structures, edge-sensors, prototype position actuators, …





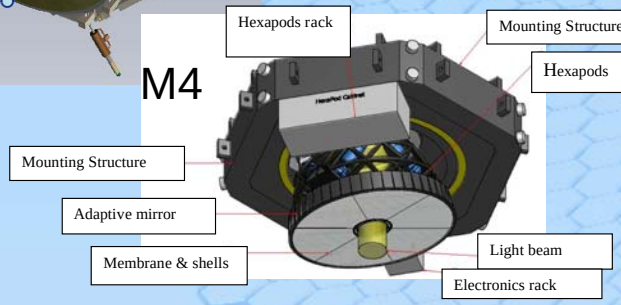



Secondary: 5.6m ∅, 156 axial supports

Contracted: polishing study, mirror cell design, actuator conceptual design, …

Tertiary: 4m ∅, controls f-ratio

Contracted: mirror cell design, …




M4: 2.6m ∅ flat, adaptive with 6000 to 8000 actuators

Contracted: two scale-1 functional prototypes

M5: 3x2.4m, flat, tip-tilt

Contracted: scale-1 electromechanical unit

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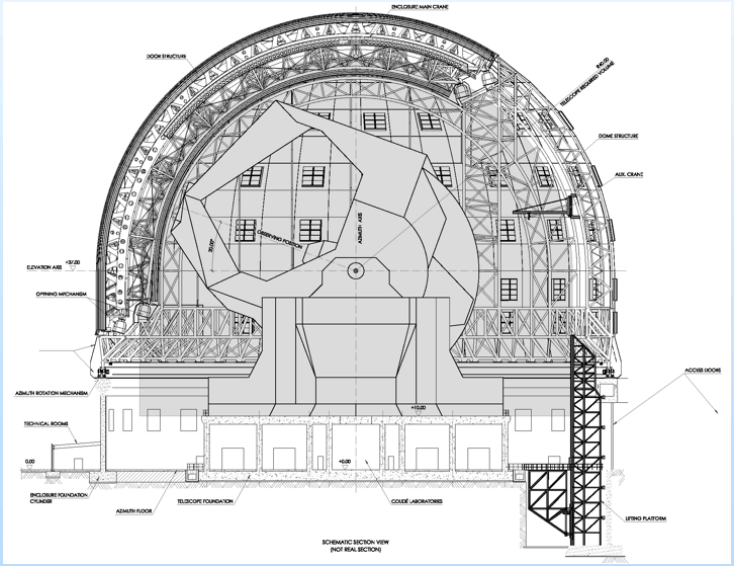
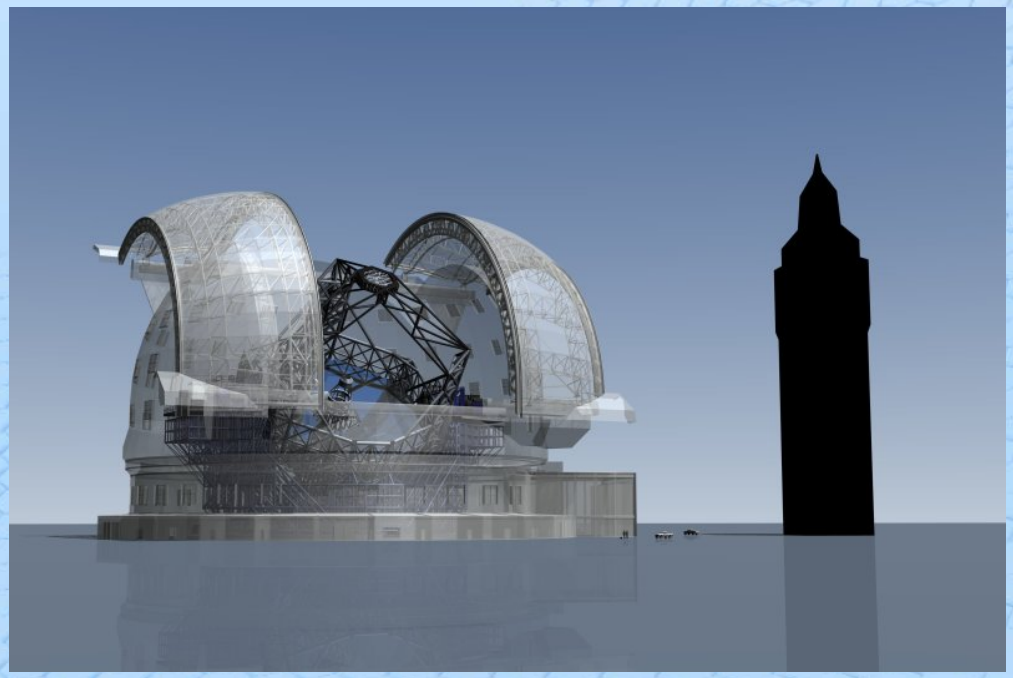
# The Dome



The E-ELT dome: base of 100 m diameter, and 80 m high.

The size of a football stadium.



Close to 4000 tons of steel.

Fully air-conditioned and wind shielded.

Equipped with several heavy duty cranes and a lifting platform for instruments.

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# Instrumentation

Instrument and AO modules Study Plan (April 2007):

- Goal: Definition of a *first generation instrument set*, to be included in the E-ELT construction proposal in 2010.
- Scope:
  - Carry-out a suitable number of instrument studies to verify that instruments can be built at an affordable cost and that they properly address the scientific goals of highest priority.
  - Work with the ESO community in studying 8 instruments + 2 AO modules and  to prepare for construction.
  - Work with telescope and operation POs to identify and define interfaces with the other subsystems and the observatory infrastructure.
- Budget: 2.3 M€ (2007-2010)

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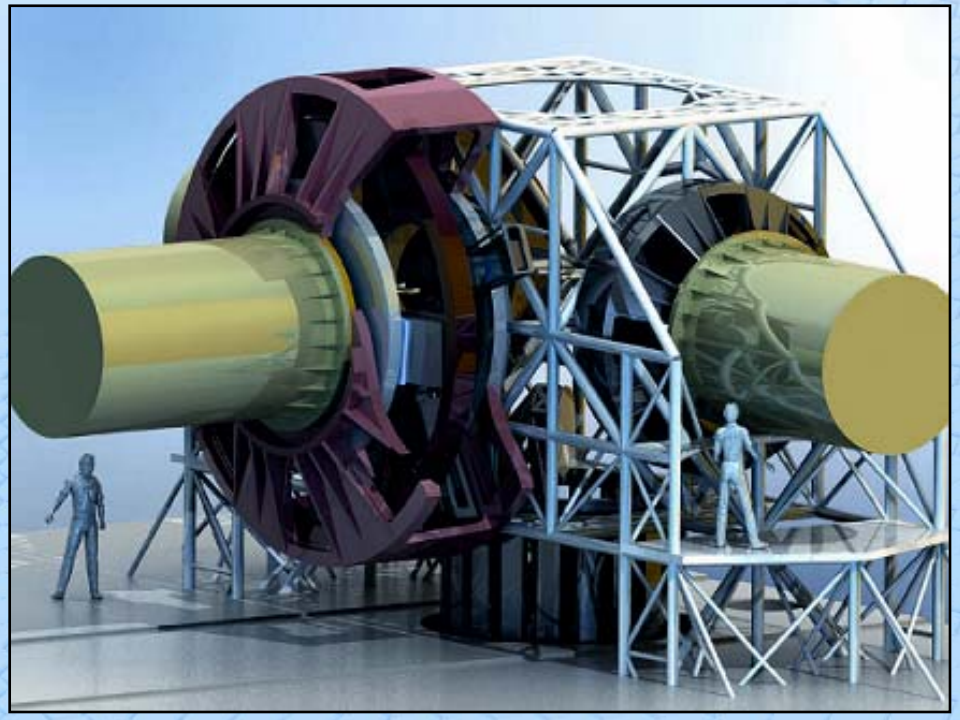
# The Instruments

- All 8 instrument concept (phase A) studies, and 2 post-focal adaptive optics modules studies are underway and will run until early 2010.

- Scope:
  - Detail the science case.
  - Finalize the instrument requirements.
  - Develop an instrument concept including cost and construction schedule.



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# The Instruments

| | |
|---|---|
| CODEX | High-resolution, high-stability optical spectrograph |
| EAGLE | Wide-field NIR multi-IFU |
| EPICS | Extreme AO planet imager and spectrograph |
| HARMONI | Single field NIR wide-band IFU |
| METIS | MIR imager and spectrograph |
| MICADO | Diffraction limited NIR imager |
| OPTIMOS | Wide-field optical MOS |
| SIMPLE | High-resolution NIR spectrograph |
| ATLAS | LTAO module |
| MAORY | MOAO module |

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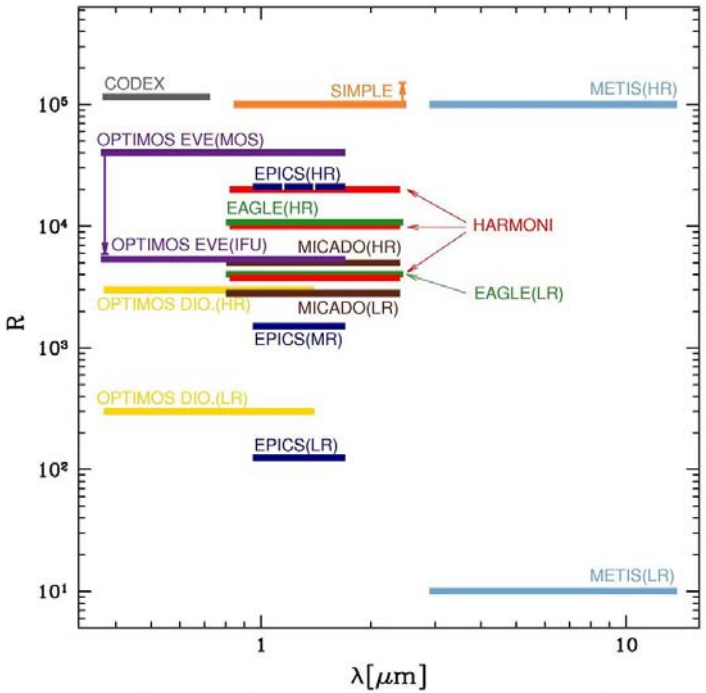
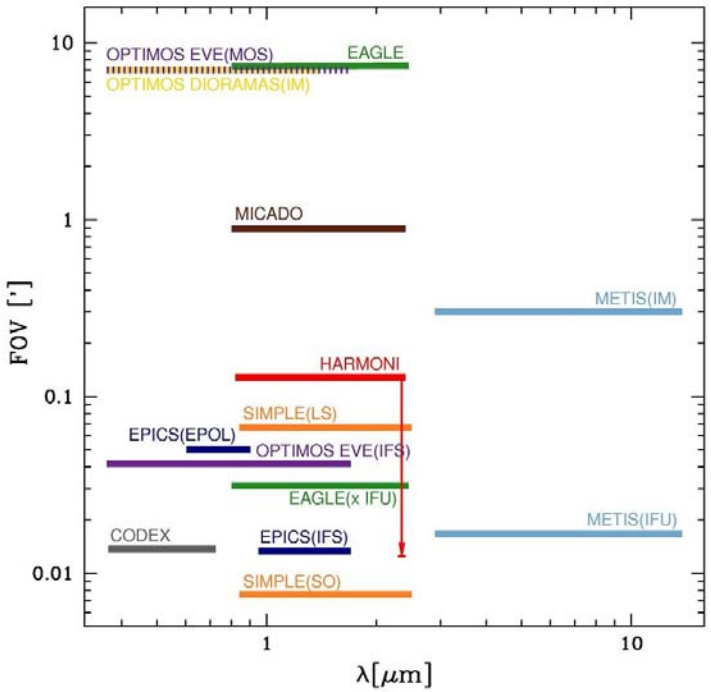
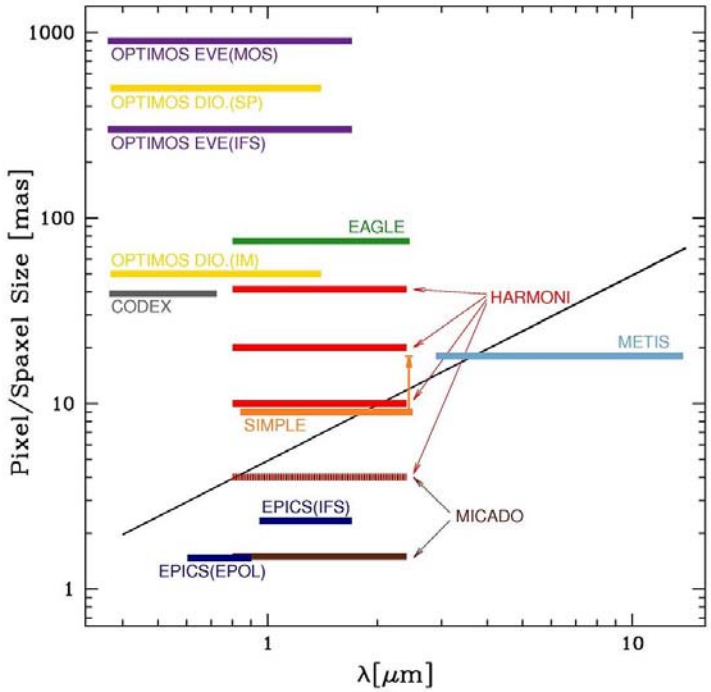
## Spectral resolution




## Field of View




## Sampling



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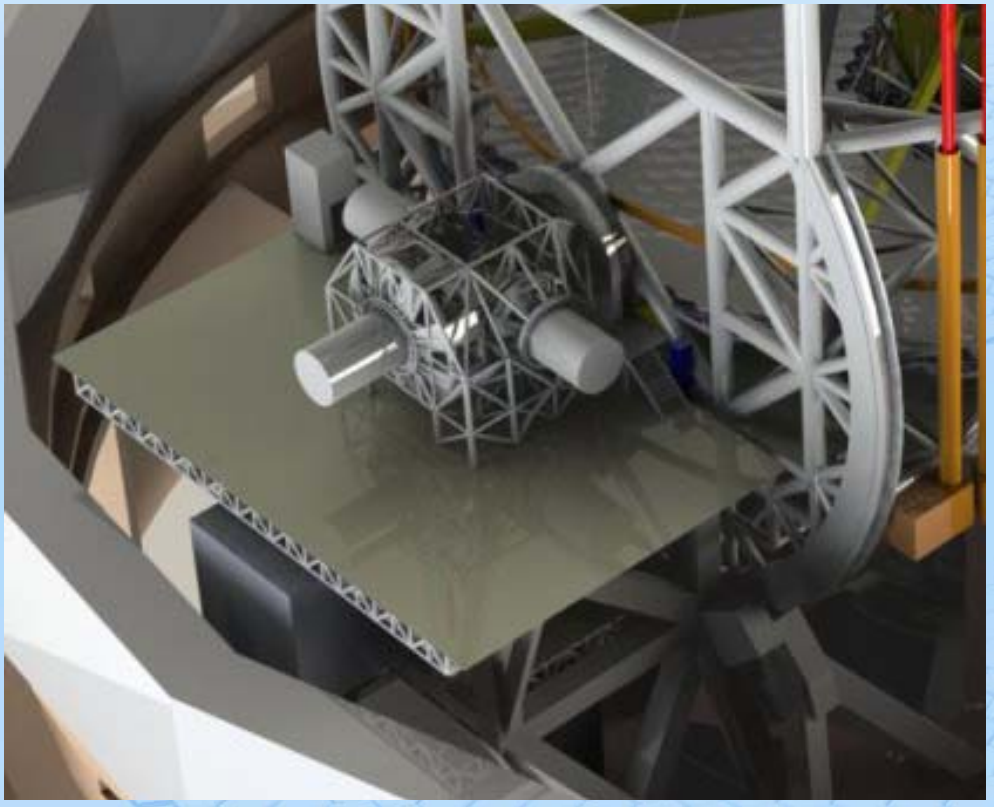
# The Instruments

In principle, the telescope can host up to 10 instruments (including two gravity invariant focal stations and a Coude lab).

Two to three first light instruments are foreseen and will be selected by mid-2010.



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# The Site(s)

Site decision expected by the end of 2009.

Several sites in Chile, Morocco, the Canary Islands, Argentina, Mexico, … have been intensively tested.

Selection criteria: impact on science, outstanding atmosphere, but also construction and operations logistics (roads, water, electricity, nearby cities, …).


Argentina


Atacama


Morocco


La Palma

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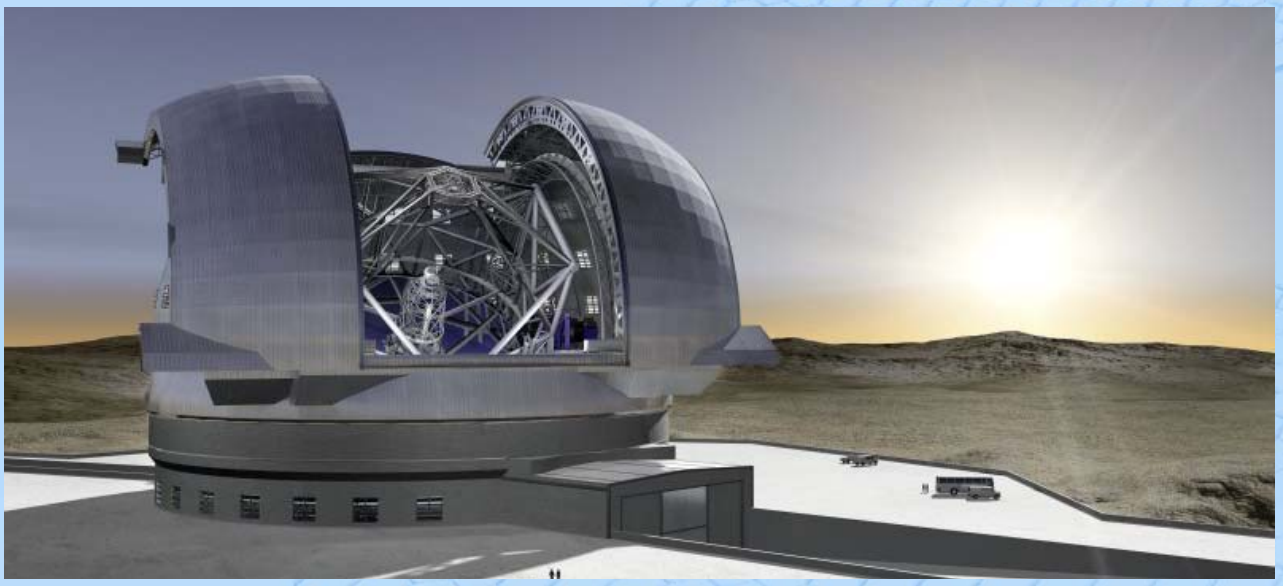
# The year ahead

- End of 2009: Site decision
- Early 2010: Decision on first-light instruments
- Mid 2010: Construction Proposal submitted to ESO committees
- End 2010: Construction Proposal submitted to Council



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# More information?

The public web pages:

http://www.eso.org/public/astronomy/projects/e-elt.html

The science users web pages:

http://www.eso.org/sci/facilities/eelt/

Brochures, Posters, etc:

http://www.eso.org/public/outreach/products/publ/brochures/index.html

Gallery:

http://www.eso.org/gallery/v/ESOPIA/EELT

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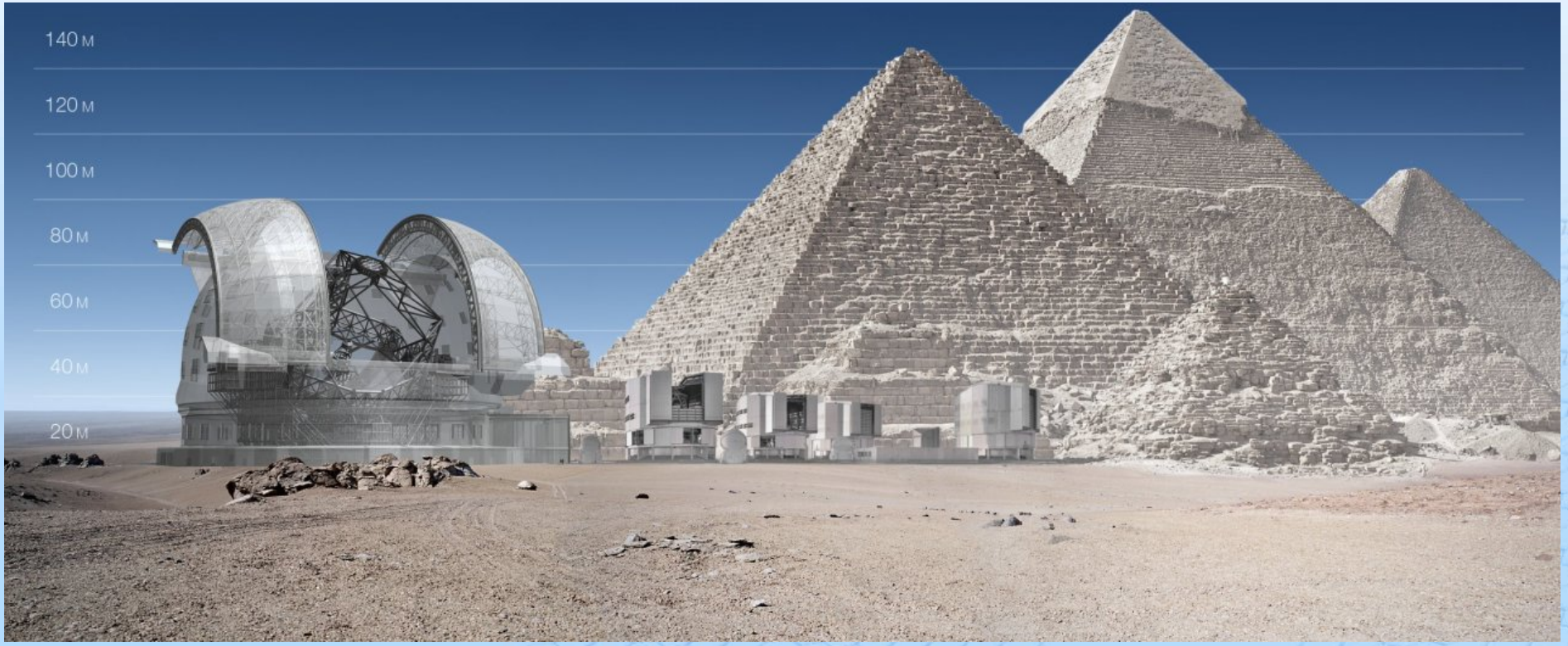


# Thank you