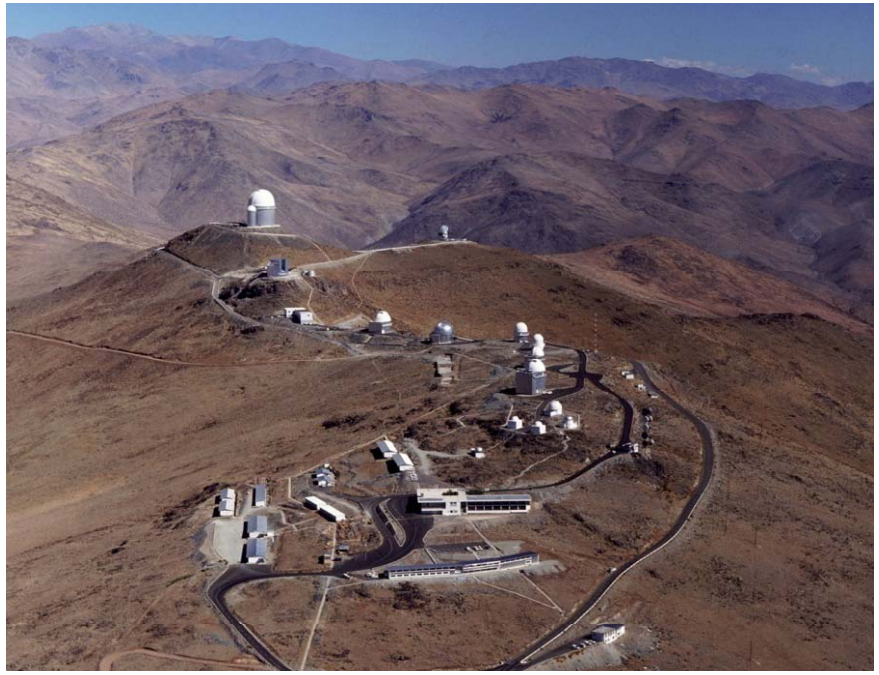
European Southern Observatory

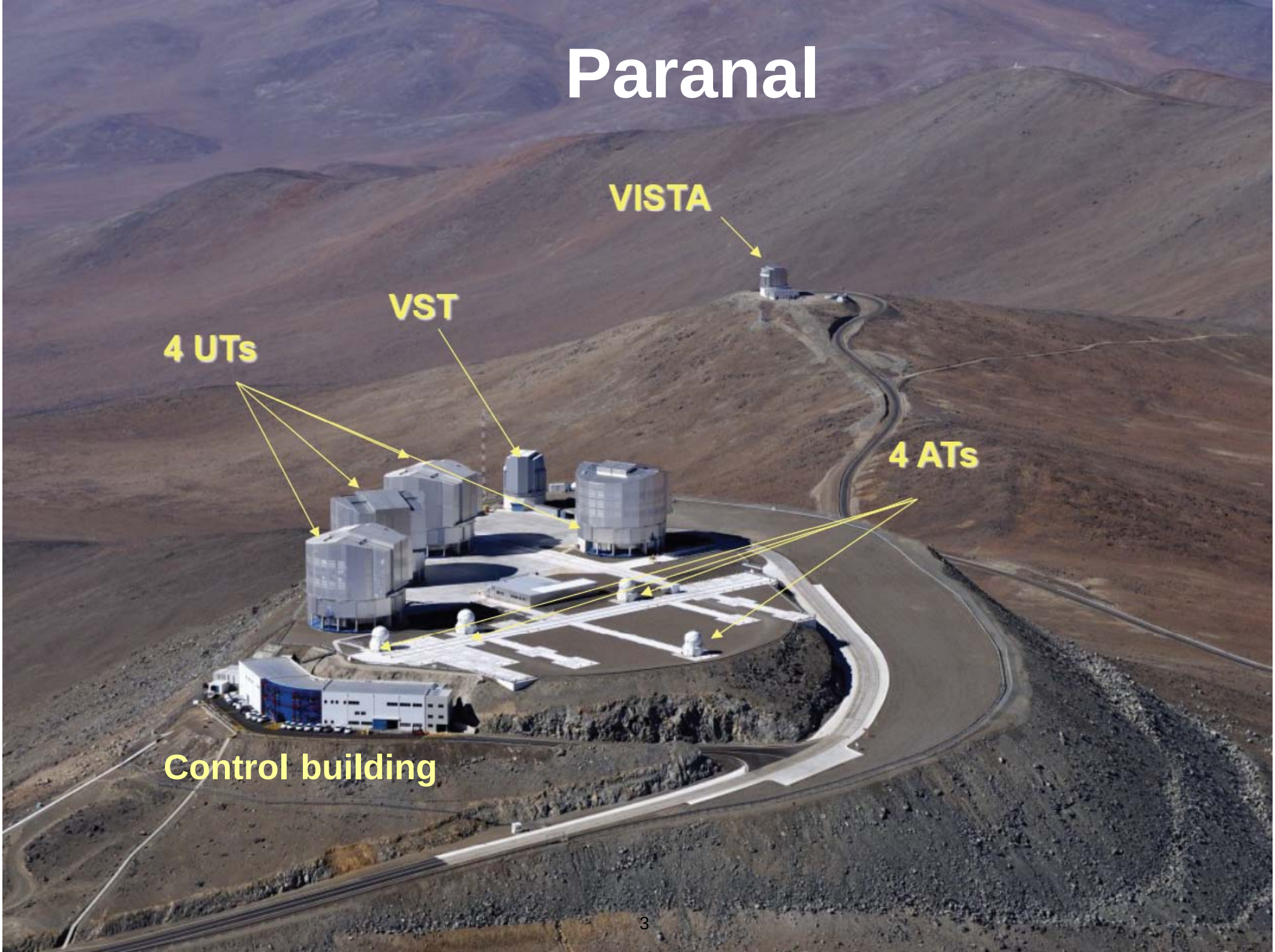
- 1962
  - ESO created by five Member States with the goal to build a large telescope in the southern hemisphere
    - Belgium, France, Germany, Sweden and The Netherlands
  - This became the 3.6m telescope on La Silla (1976)
- 2014
  - 14+1 Member States (~30% of the world's astronomers)
  - Paranal is the world-leading ground-based observatory
  - ALMA (in partnership) on Chajnantor almost completed
  - Construction of 39m E-ELT on Armazones started

La Silla

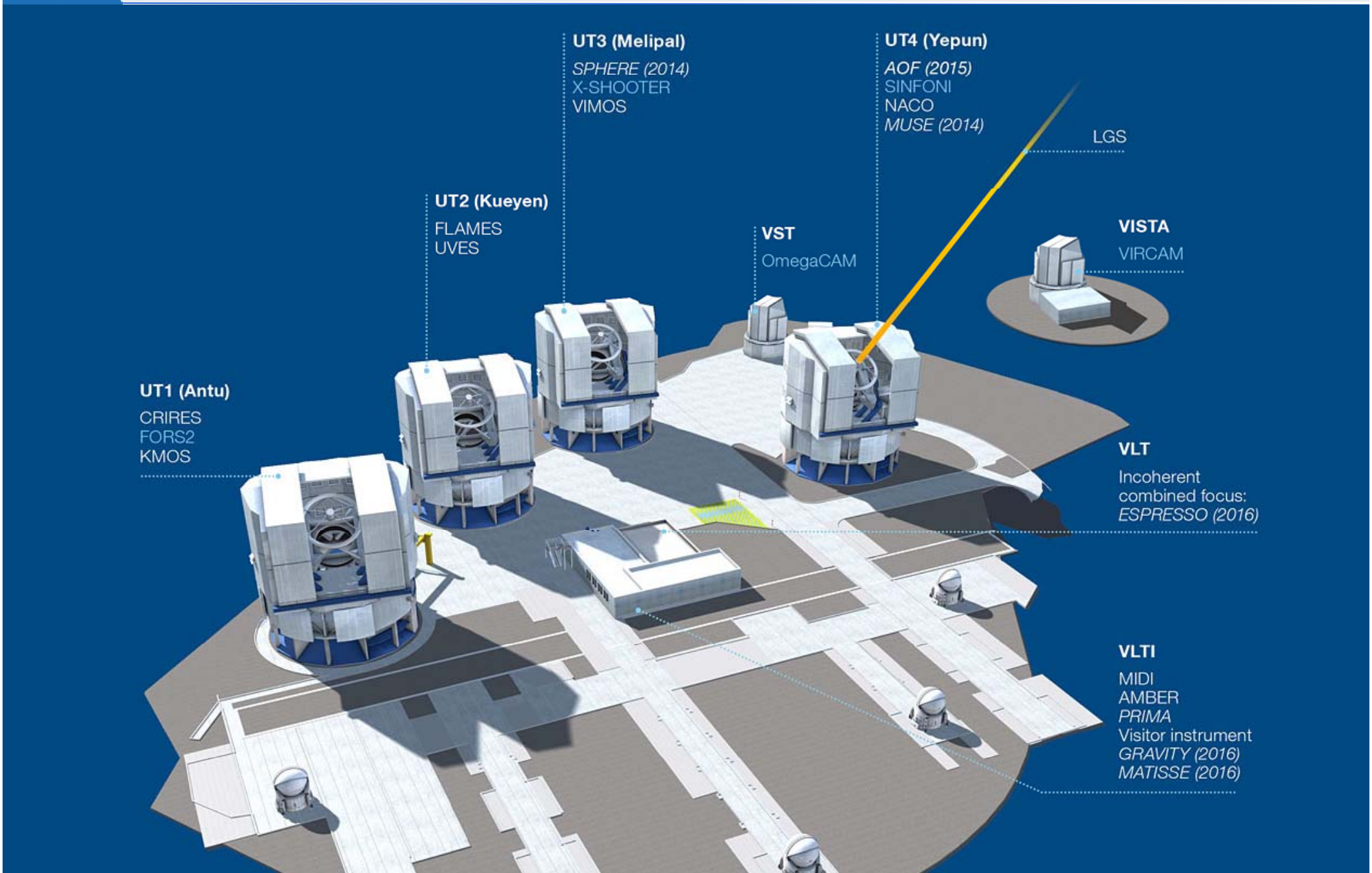
- Medium-size telescopes
  - 3.6m: HARPS
    - Exoplanet searches
  - 3.5m NTT: EFOSC2, SOFI
    - Incl. PESSTO public survey for follow-up of transients (60n/yr)
    - New instruments to come
  - Visitor mode only
    - Fewer than 20 staff members
- Small telescopes/robots
  - 2.2m MPG, Danish, Euler, QUEST, REM, Schmidt, TAROT-S, TRAPPIST, …
  - Operated by externally funded consortia



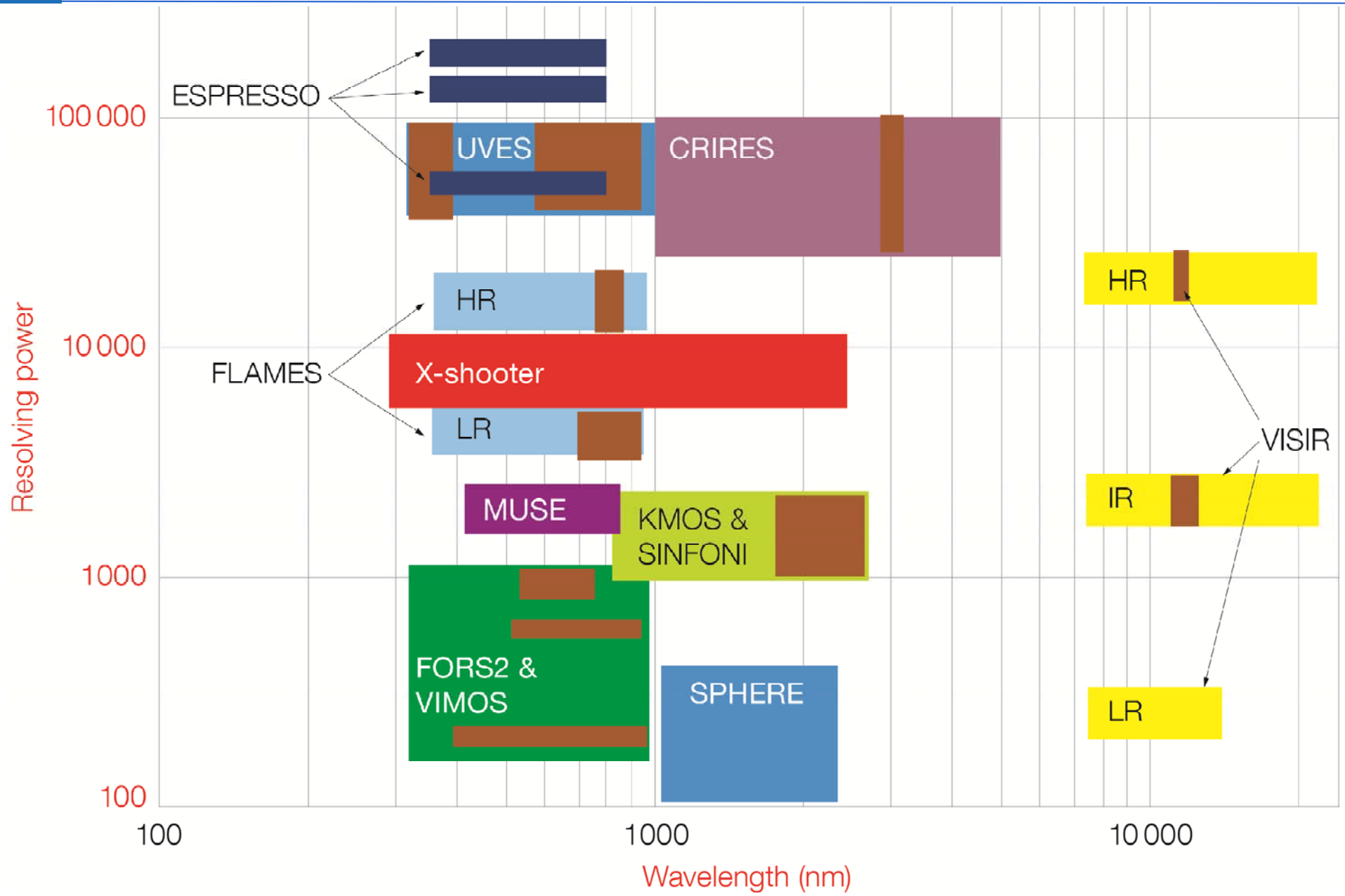
Paranal



Integrated System



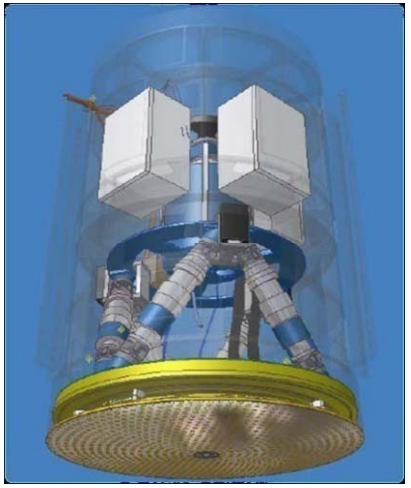
Resolving Power versus λ



Instrumentation Programme

- Long-range plan
  - Upgrades and new instruments in budget through 2030
- In-house development program
  - Detectors, controllers, edge-sensors
  - Adaptive optics systems
  - Innovative fiber lasers (patented)

- Infrastructure upgrades
  - Adaptive Optics Facility on UT4 in 2016
    - Four powerful lasers & deformable secondary
  - Key components for VLTI
    - NAOMI: Adaptive Optics units for ATs
  - Commissioning of incoherent combined focus allowing ESPRESSO to use 4 UTs

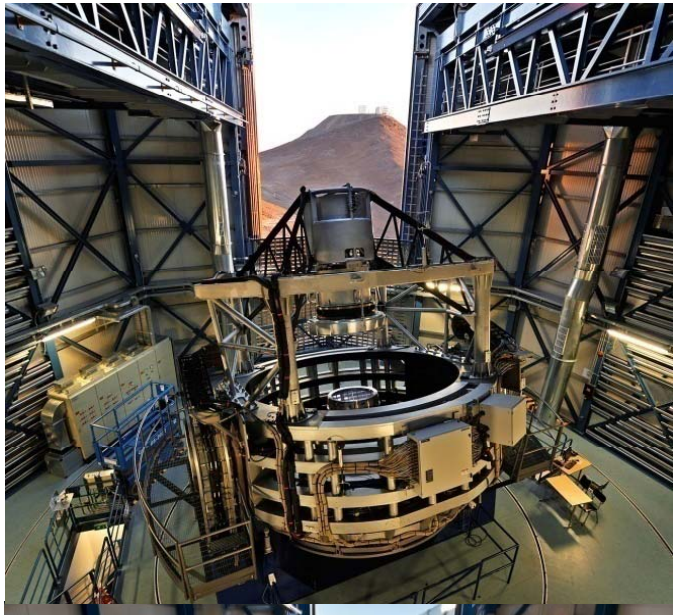


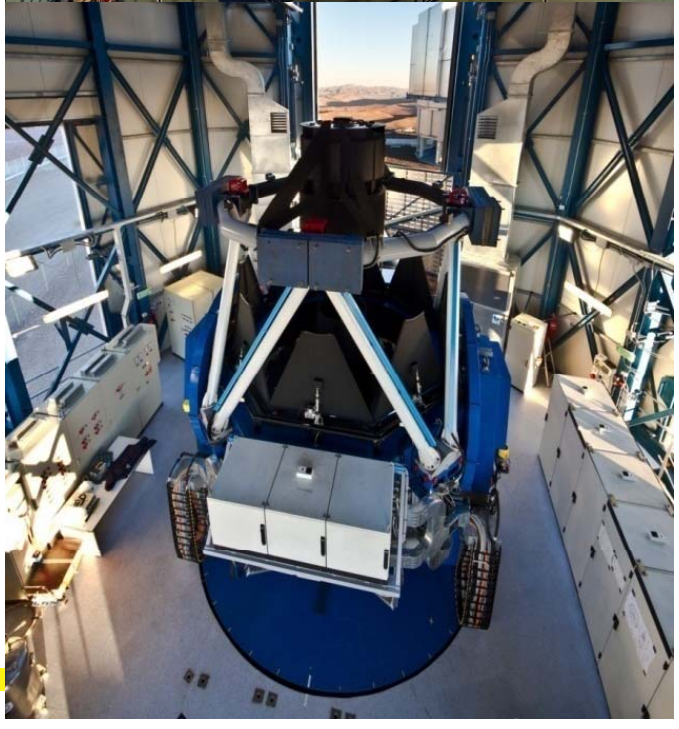
Partnership with Community

- Future VLT instruments
  - MUSE (2014), SPHERE (2014), ESPRESSO (2016), CRIRES^{+} (2017), CUBES (2018), ERIS (2020), MOONS (2020), …
- Future VLTI instruments
  - GRAVITY (2016), MATISSE (2016), …
- Most instruments built by *consortia of institutes*
  - ESO pays hardware (~1/3rd of total cost)
  - Consortia provide fte's; compensated in Guaranteed Time
  - This corresponds to up to ~250 nights per instrument
- Constitutes a very powerful support network

Survey Telescopes

- VISTA 4.1m for infrared
  - VIRCAM, 8k x 8k, FOV 1.6□
  - Wide-field MOS (4MOST)
    - Development to start in 2015
- VST 2.6m for optical
  - OmegaCAM, 16k x 16k, FOV 1□
- Dedicated to large *public* surveys
  - Carried out by community teams after open competition for time
  - Several 100 nights per programme
  - Data reduction done outside ESO
  - Reduced data to ESO archive





Observing Programs

- Observing proposals
  - ~900 proposals per semester (plus ~50 DDT)
    - La Silla, Paranal, APEX
    - Normal, Large and ToO programmes, and public surveys
    - Oversubscription 3 - 6, depending on requested mode
  - Time allocated on scientific merit
- Separate process for ALMA
  - ~500^{+} proposals for 33.75% ESO share of annual cycle
- Archive is open to the world
  - Includes advanced data products
    - UVES, X-Shooter, HARPS, FEROS, Large Programs, Public Surveys
  - Provides ~15% of all ESO-based refereed papers

APEX

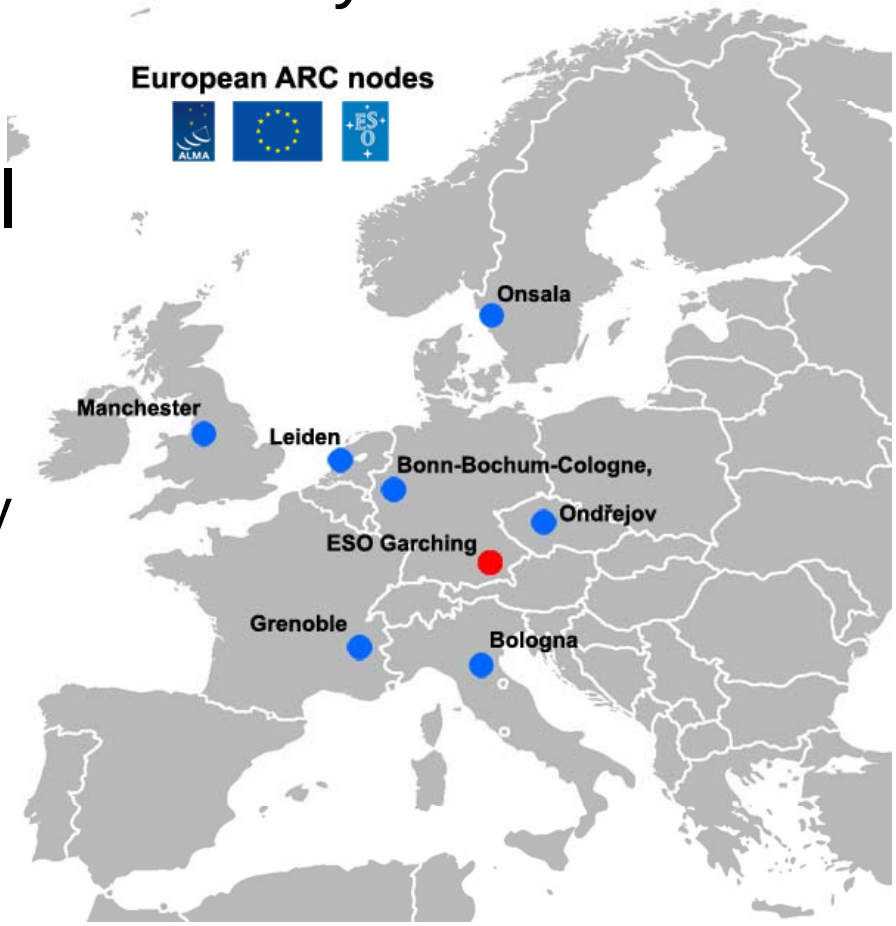
- Atacama Pathfinder EXperiment
  - 12m sub-millimeter antenna
  - Located on Chajnantor at 5050m
  - Partnership of MPIfR (50%), OSO (23%) and ESO (27%)
    - Agreed through 2017, consider extension after review in 2015
  - Operated by ESO @ Sequitor since 2007
    - As part of the La Silla Paranal Observatory

ALMA

- Atacama Large Millimeter/submillimeter Array
  - 54 x 12m + 12 x 7m antenna's on Chajnantor at 5050m
  - 7 – 0.35 mm (30-900 GHz) in 10^{+} atmospheric windows
  - World's most powerful radio interferometer
  - Cold Universe: formation of planets, stars and galaxies
- Global partnership
  - North America (37.5%), East Asia (25%) & ESO (37.5%)
  - In cooperation with Chile

ALMA Regional Support

- Each Partner supports an ALMA Regional Center
  - To provide support to the user community
  - In good global collaboration
- ESO ARC: distributed model
  - Core tasks at ESO
    - Support of proposal submission
    - Preparation of observations
    - Archive operations, data delivery
  - Additional support in seven externally funded nodes
    - Direct user support, f2f help
    - Advanced data analysis tools
    - Training, workshops
  - Helps develop strong community network



Scientific Productivity

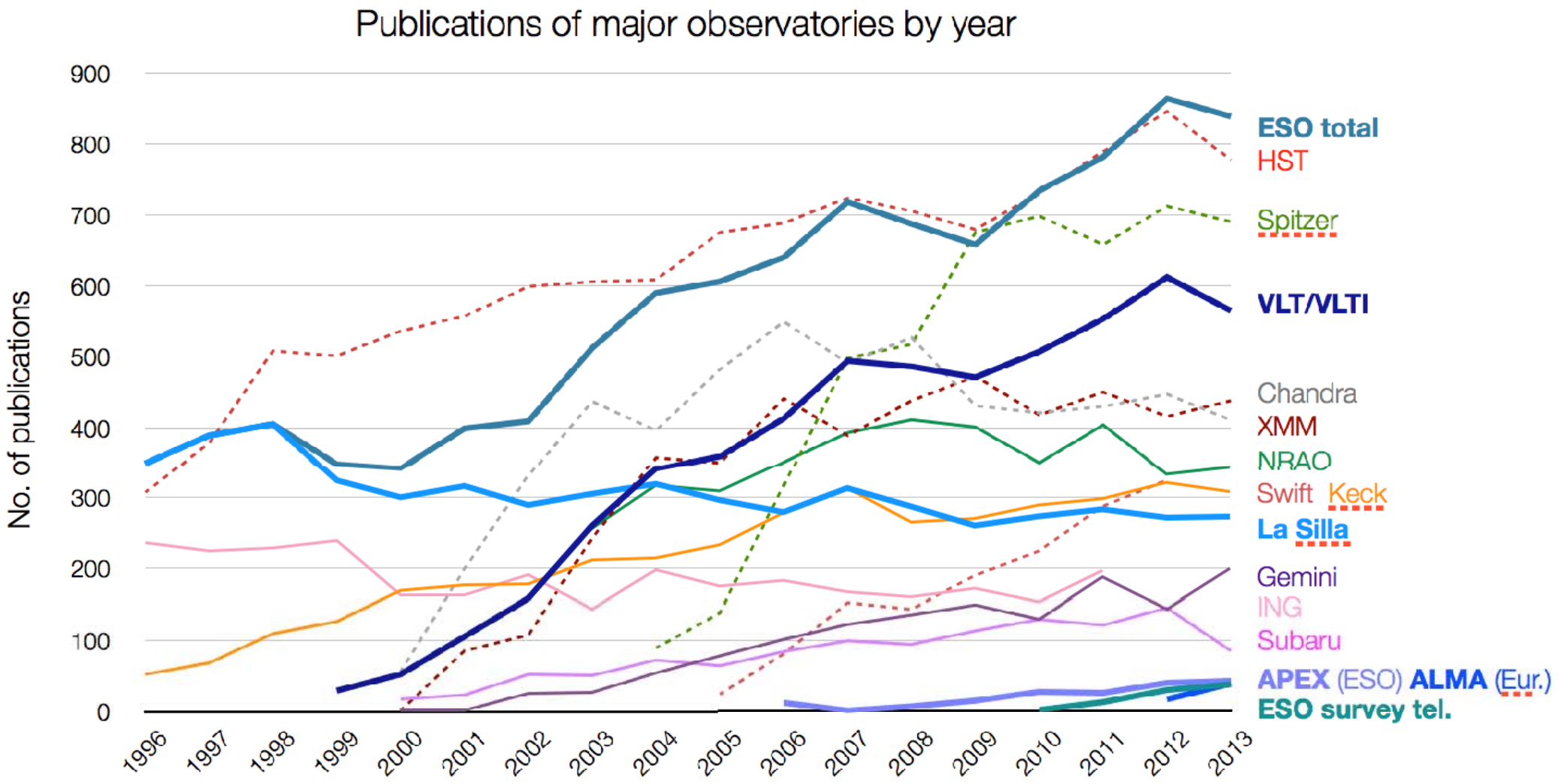
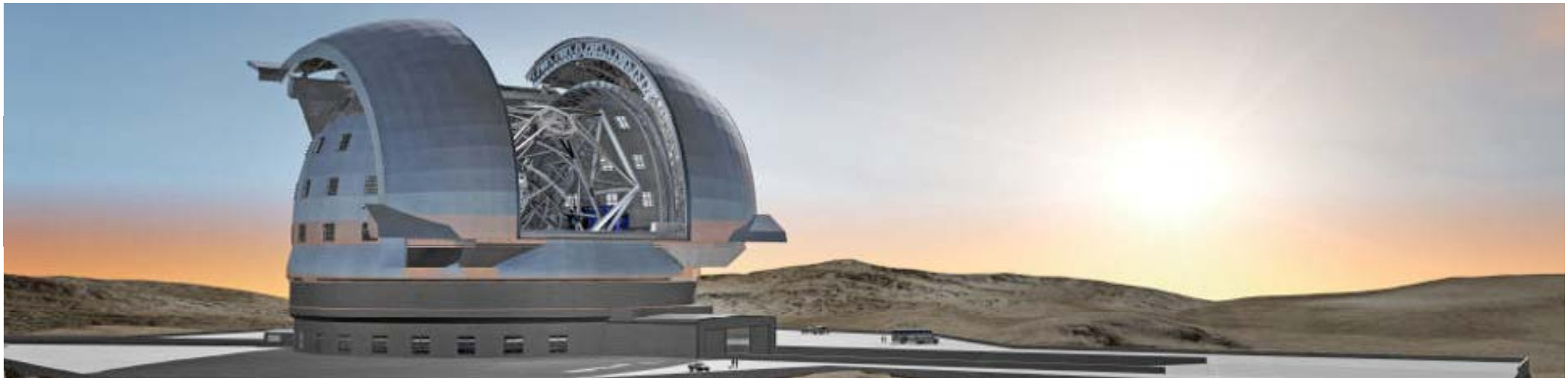


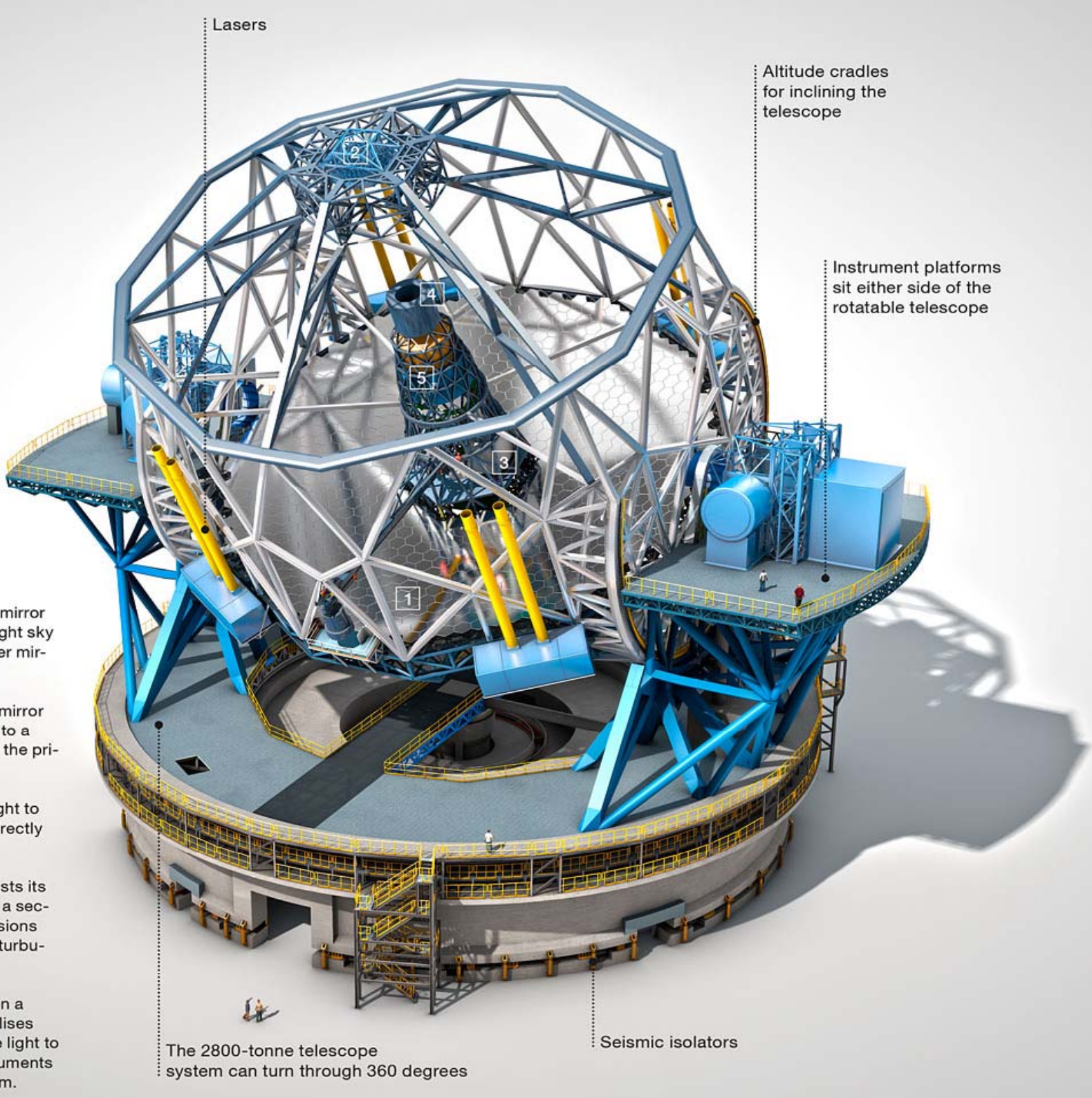
Fig. 3: Refereed publications by ESO and other observatories (as of Feb. 2014)
Thick lines: ESO facilities. Thin lines: other ground-based facilities. Dashed lines: space-based facilities.
Please note that selection criteria for inclusion or exclusion of papers vary among observatories

E-ELT

- Largest optical/infrared telescope in the world
  - 39m segmented primary mirror: transformational step
  - Science: exo-earths, deep universe, resolved populations
  - Design essentially complete, incl. instrumentation roadmap
- Project
  - Construction 2014-2024, on Cerro Armazones
    - As *integral part* of the Paranal Observatory (‘one more telescope’)
  - ESO cost: ~1100 MEUR incl. instruments and contingency



Armazones and Paranal



Five-mirror design

1. The 39.3-metre primary mirror collects light from the night sky and reflects it to a smaller mirror located above it.

2. The 4-metre secondary mirror reflects light back down to a smaller mirror nestled in the primary mirror.

3. The third mirror relays light to an adaptive flat mirror directly above.

4. The adaptive mirror adjusts its shape a thousand times a second to correct for distorsions caused by atmospheric turbulence.

5. A fifth mirror, mounted on a fast-moving stage, stabilises the image and sends the light to cameras and other instruments on the stationary platform.

E-ELT Program

- Funding comes from
  - Regular ESO income
  - Additional contributions from 14 Member States
    - ~30% increase of contributions; also secures operations funding
  - Accession of Brazil (entrance fee + annual contributions)
    - Ratification progressing in Chamber of Deputies
  - EIB guaranteed 300 MEUR borrowing capacity if needed
- Baseline procurement plan is being implemented
  - Contract for adaptive M4 ongoing (long-lead item)
  - Construction of road and platform started Mar 2014
    - Completion mid 2015
  - CfT for construction of Dome & Main Structure May 2014

E-ELT Instrumentation

- Instrumentation
  - Roadmap for seven instruments
  - Two first-light instruments
    - ELT-CAM (MICADO)
    - ELT-IFU (HARMONI)
    - Both in Phase B design
  - Next to Phase B
    - ELT-MIR (METIS)
  - Phase A studies
    - ELT-MOS
    - ELT-HIRES
- Construction philosophy
  - 'VLT model' of consortia working closely with ESO

Year	ELT-IFU	ELT-CAM	ELT-MIR	ELT-4 (MOS or HIRES)	ELT-5 (MOS or HIRES	ELT-6	ELT-PCS
2012	Decide science requirements, AO architecture.		VISIR start on-sky	Develop science requirements for MOS/HIRES			Call for Proposals for ETD
2013			TRL Review	Call for Proposals for MOS/HIRES			
2014							
2015				Selection ELT-MOS/HIRES		Call for Proposals	
2016							
2017							TRL check
2018							TRL check
2019						Selection	TRL check
2020							TRL check
2021							TRL check
2022 Tel. technical first light							
	Pre-studies taking the form of phase A or delta phase A work and/or ESO-funded Enabling Technology Development (ETD)						
	Decision point						
	Development of Technical Specifications, Statement of Work, Agreement, Instrument Start.						

The Organization

- Mission
  - Develop and operate world-class observing facilities for astronomical research
  - Organize collaborations in astronomy
- This is achieved by
  - Highly-skilled staff carrying out a multi-project program
    - ~390 staff in Garching at Headquarters
    - ~300 staff in Chile at Observatory sites and Vitacura Office
  - In-house science, engineering and support activities
    - Without these ESO becomes a management agency, the quality of the program will suffer and support by the MS will decline
  - Matched by additional effort in the Member States
    - In industry and in technical and scientific institutions
    - In good coordination with ESO

Contributions

- ESO income
  - Member States' annual contributions ∝ NNI*
  - Formulaic correction for annual cost variation
  - Current contribution level: ~165 MEUR/yr
    - Excludes additional income to come from Brazil
  - Has to support *all* operations and construction activities
    - E.g., half the income goes to E-ELT construction 2014-2024
- New Member State
  - Annual contribution ∝ NNI
  - Special Contribution ∝ overall ESO assets (by NNI)
  - Long-standing policy is to add new contributions to income to enable expansion of ESO's program
  - Poland on track to join in 2015

* Net National Income

Governance

- Council
  - Two delegates per MS government, plus President
  - At least one of the two an astronomer
  - Approves income and budget, and overall programme
- Advisory to Council
  - Finance Committee (FC), one delegate per MS
  - Science and Technical Committee (STC) (also to DG)
    - Three subcommittees: LSP, ESAC and ELT
- Advisory to Director General
  - Observing Programs Committee (OPC)
  - Users Committee (UC)

The ESO Model

- Partnership with community is key to support
  - Joint instrumentation development
  - Public surveys, advanced data products
  - Student and Fellowship program
  - Small telescope and experiments hosted on La Silla
- Multi-project programme is cost-effective
  - Re-use engineering skills, apply lessons learned
  - Experience in working effectively with industry
- Intergovernmental structure provides
  - Support at highest government levels
    - Ministerial level and above in Member States and in Chile
  - Budget stability and long-term planning ability

Long-term strategy for ESO

- Moderate further growth in membership
  - Countries with high-quality scientific communities that are keen to join, bring added value, and government support
- Continue to operate and build world-class facilities
  - Optical, radio and other ‘messengers’
  - Balance multi-purpose telescopes and experiments
  - Can be ‘all-ESO’ or in partnership