ESO: Present and Future

Tim de Zeeuw

Astronomy

Observationally-driven science

- Gamma & X-rays, optical, infrared, mm and radio waves

Technology now available to

- Study objects over 95% of the age of the Universe
- Detect and study planets around other stars

European Southern Observatory

- Mission
  - Develop and operate world-class observing facilities for astronomical research
  - Organize collaborations in astronomy
- Intergovernmental treaty-level organization
  - Founded in 1962, by 5 countries
  - Currently 14 Member States, may increase further
- Observatories
  - Optical/infrared: La Silla and Paranal
  - Submm: APEX and ALMA partnerships on Chajnantor
- HQ in Garching and Vitacura Office in Santiago

ESO Headquarters - Garching

- Since 1981
  - 230 persons, additional 220 elsewhere on campus
- HQ extension building to be completed late 2011

La Silla, Paranal & Chajnantor

Chajnantor

Paranal

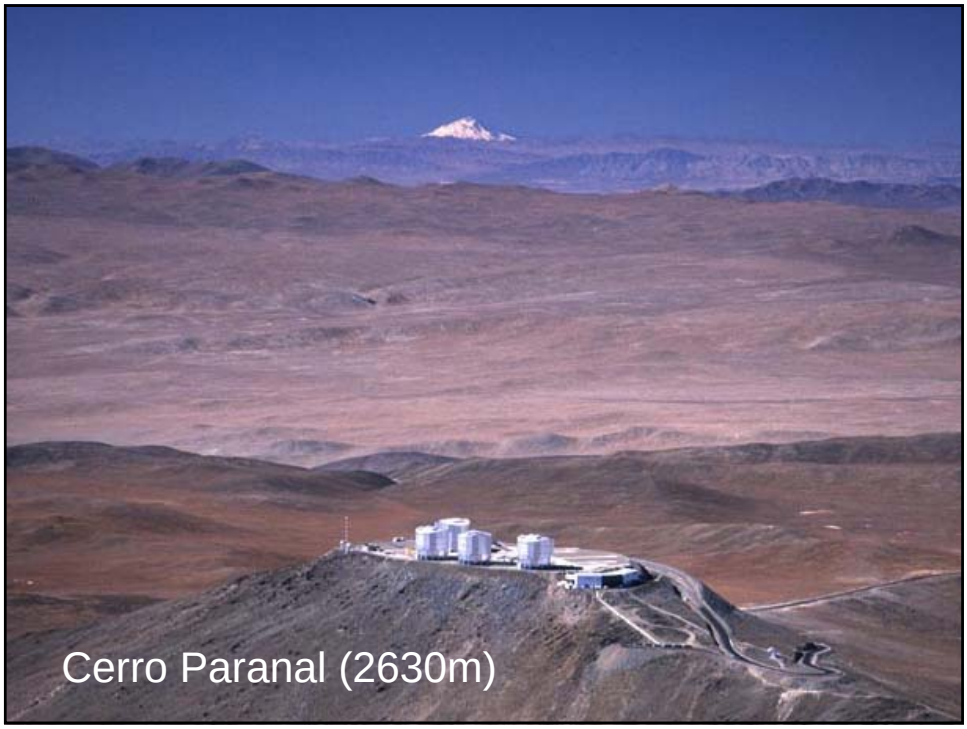
La Silla

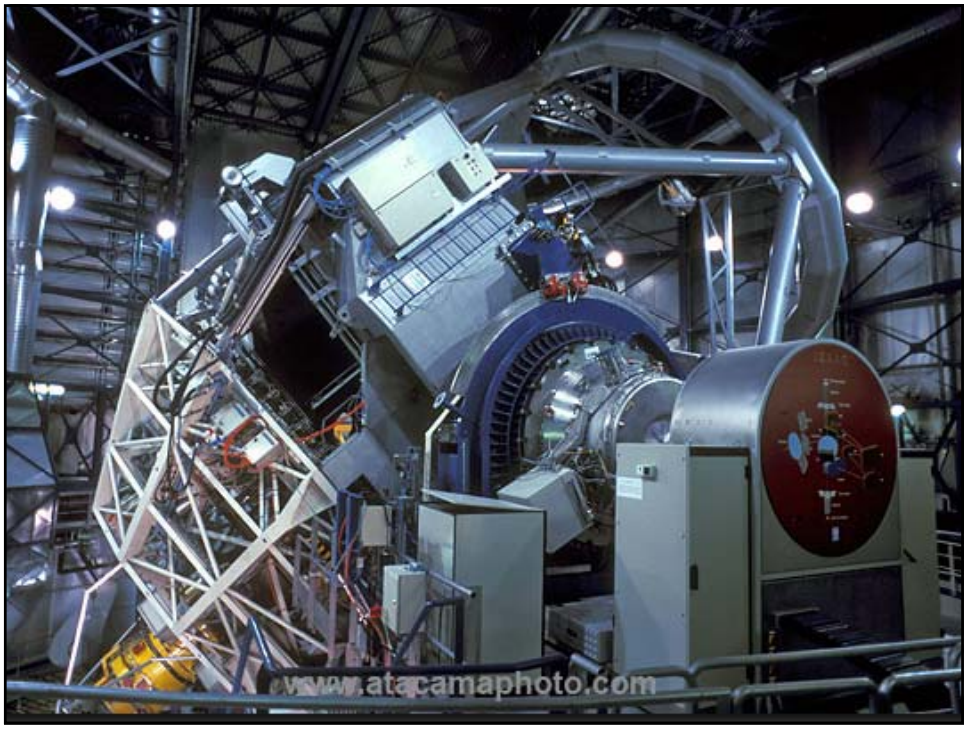
Santiago

La Silla

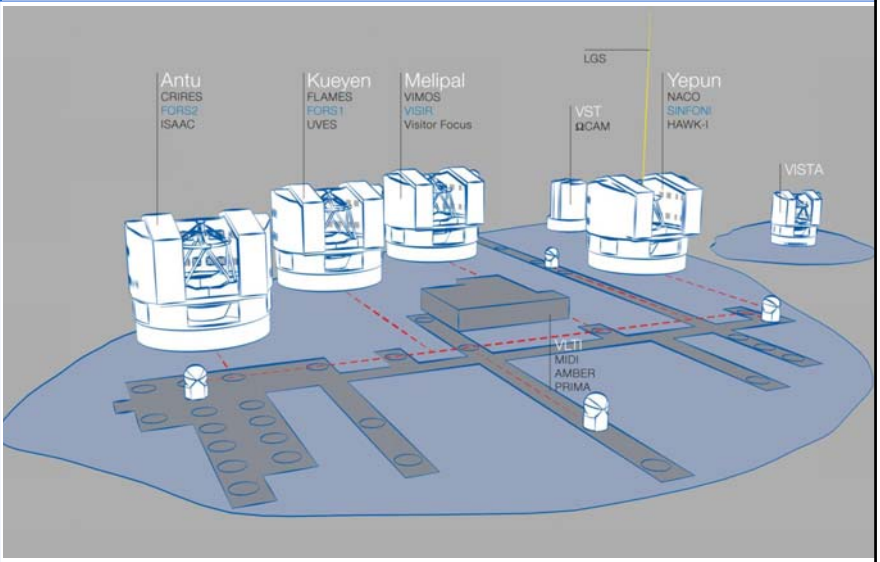
3.6m

3.5m NTT


Cerro Paranal (2630m)



Integrated System

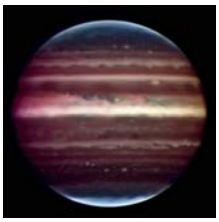


2nd Generation Instrumentation

- Approved VLT instruments in development
  - X-Shooter – Single object UV-IR spectrograph (2009)
  - KMOS – Near IR MOS, deployable IFUs (2010)
  - SPHERE – XAO + Near IR/Vis planet finder (2011)
  - MUSE – Visible IFU spectrograph (24 modules; 2012)
- New VLTI instruments
  - PRIMA: integration on schedule (10 μas accuracy)
  - MATISSE – L, M, N band, 4 telescope image/spec
  - GRAVITY – K Band, 4 telescope, astrometry near GC
  - VSI later (4-6 telescope near IR 'imager' spectrometer)
- One or more additional VLT instruments planned
  - High-resolution ultra-stable spectrograph (in Phase A)

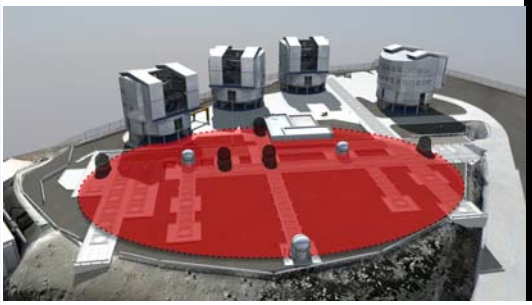
VLT/I Instrument Program

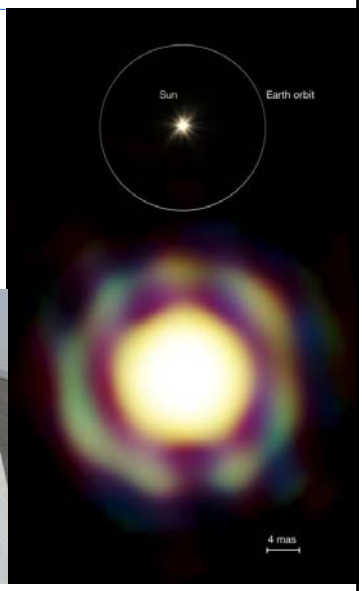
- Long-range plan
  - Upgrades and new instruments through 2020
- Most instruments built by consortia
  - ESO pays hardware costs (~1/3rd of total)
  - Consortia provide fte's; paid in Guaranteed Time
  - ~250 nights for 2nd generation instruments
  - Used for coherent science programs
- Development program
  - MCAO Demonstrator
  - Laser Guide Star Facility
  - Fully adaptive M2 for UT4, with 4LGS (2013)



Imaging with VLTI/AMBER

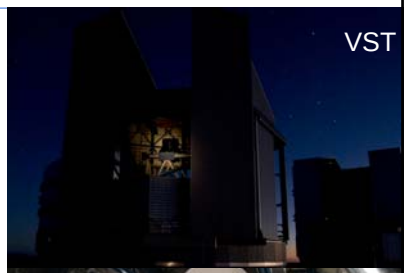
- Mira star T Leporis
  - 500 light years away
  - Surrounded by shell of molecular gas
- *Image* obtained using multiple AT configurations



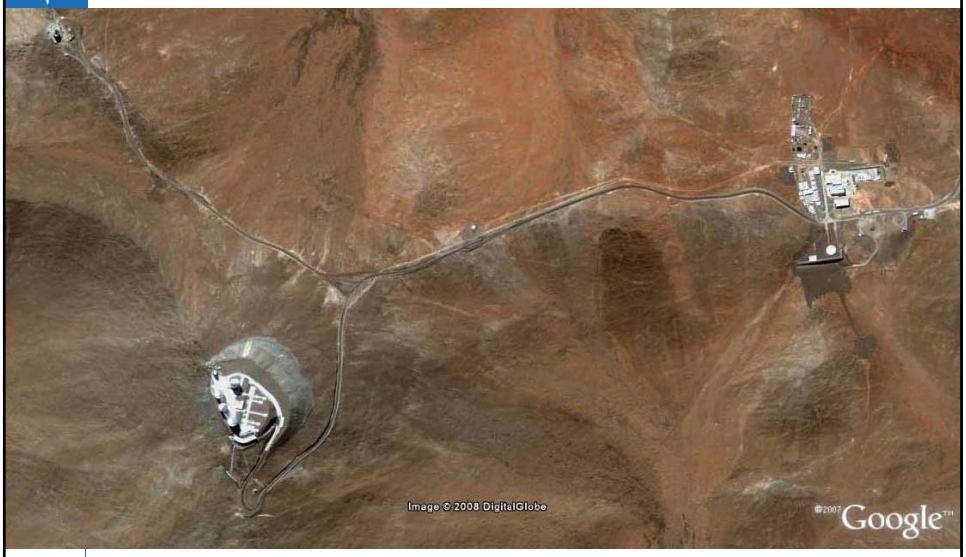


The Survey Telescopes

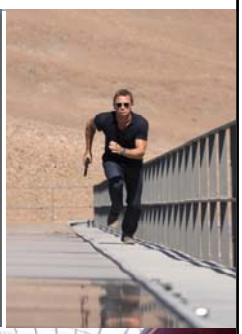
- Under construction
  - VST 2.6m for optical
  - VISTA 4.1m for infrared
  - Completion in 2009
- Science
  - Five-year program of large public surveys
  - Coordinated by ESO
  - Develops European survey capability



View from Space

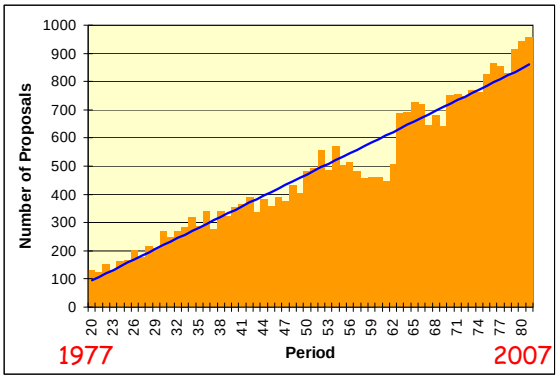


Perla de las Dunas



Observing Programs

- Observing proposals
  - Over 1000 proposals per semester
  - La Silla, Paranal, APEX
  - Over-subscription factor ~4-6 on VLT
- OPC
  - Meets twice a year
  - Over 70 members



End-to-end Operations Model

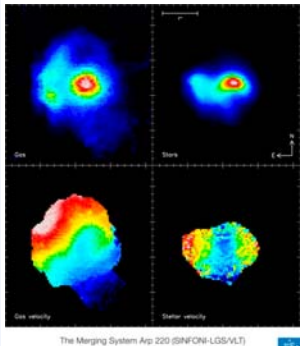
- User Portal
  - Single point of contact with ESO
  - Over 5300 registered users
- Operations
  - 70/30 in Service/Visitor mode; travel support by ESO
  - Maximize on-sky efficiency
  - 88% clear nights: >1300 UT nights every year
- Data products
  - Pipe-line reduction software developed in-house
  - Archive includes advanced data products, some developed by community; and Hubble archive

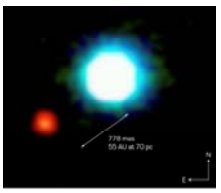
Science at ESO

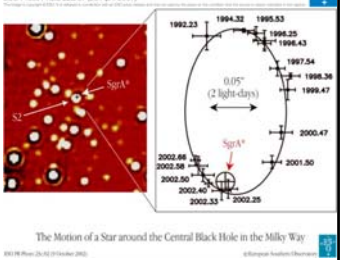
- 80 astronomers with up to 50% research time
  - Key to providing best instruments and support
- Fellowship program
  - 30 Fellows & 30 students (Garching & Vitacura)
  - Fellows have functional duties: improves skills
  - 92% of all ESO fellows still active in astronomy

- Seminars, colloquia, workshops, visitor program

Some O/IR Science Highlights

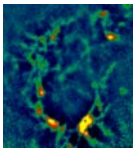






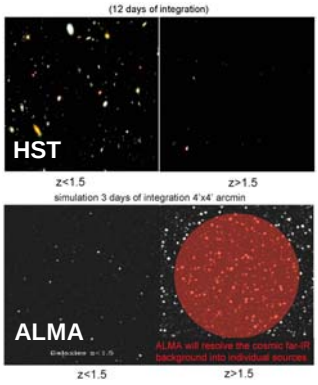
Chajnantor

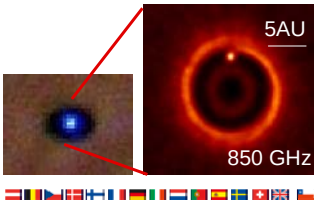
- APEX
  - 12m sub-millimeter antenna, operated by ESO @ Sequitor
  - MPG (50%), Sweden (23%) and ESO (27%)
- ALMA
  - Transformational science
  - 66 antennas at 5050m
  - Operations support at 2950m
  - Global partnership with North America East Asia & Chile



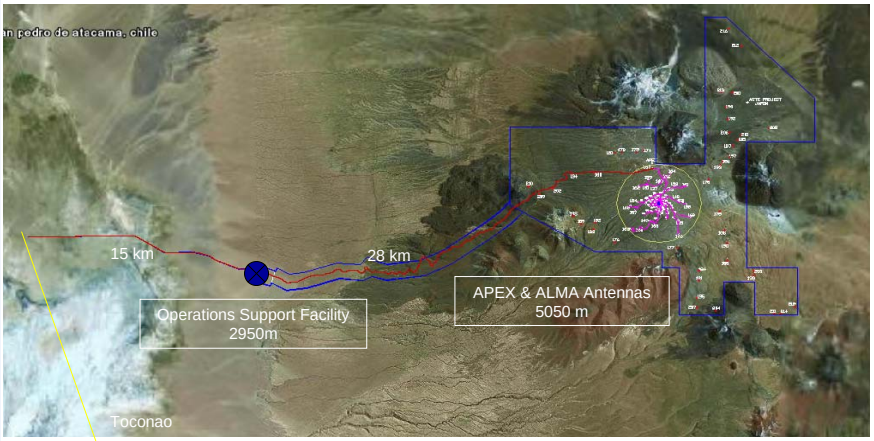
ALMA

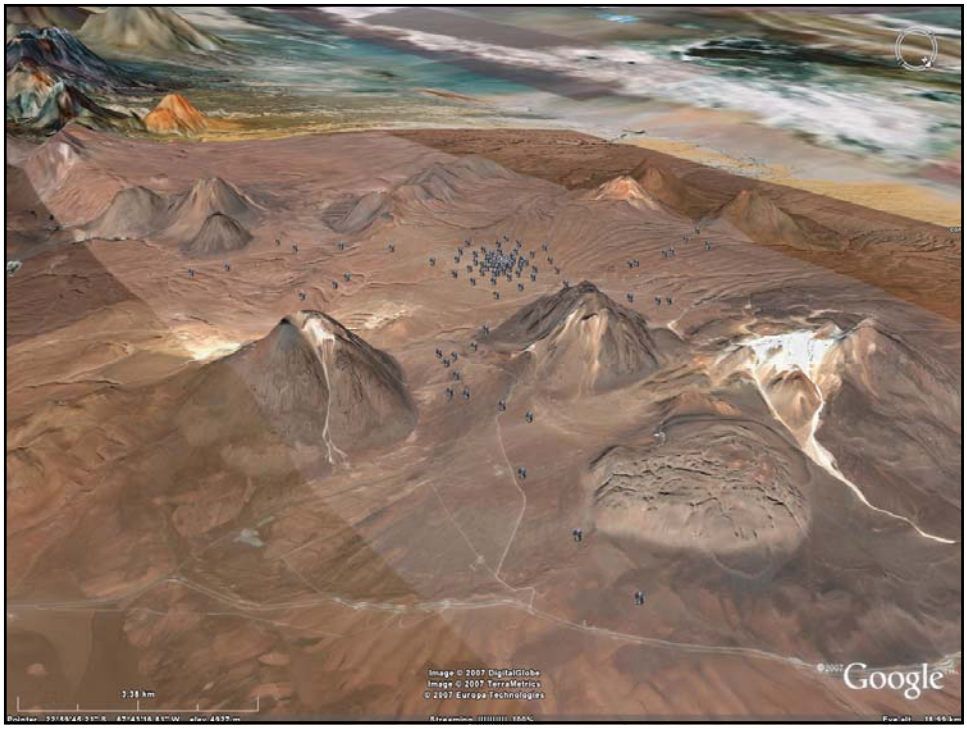
- Science requirements
  - Detect CO and [CII] in Milky Way galaxy at z=3 in < 24 hr
  - Dust emission, gas kinematics in proto-planetary disks
  - Resolution to match Hubble, JWST and 8-10m with AO
  - Complement to Herschel
- Specifications
  - 66 antennas (54x12m, 12x7m)
  - 14 km max baseline (< 10mas)
  - 30-1000 GHz (10–0.3mm), up to 10 receiver bands





ALMA: OSF and AOS





Llano Chajnantor (5050m)

View from Licancabur

ALMA 2009

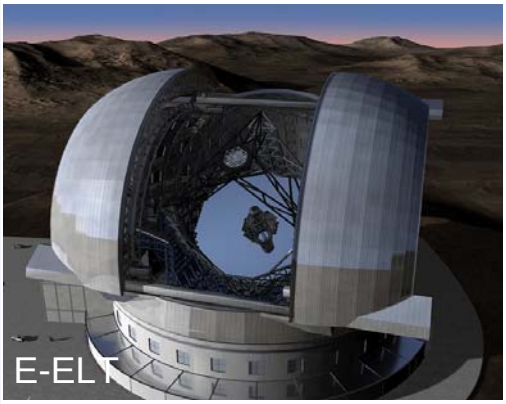


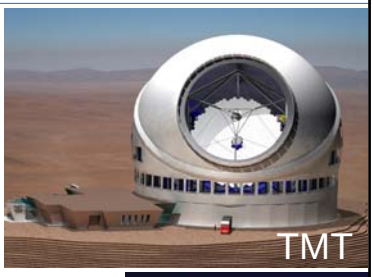


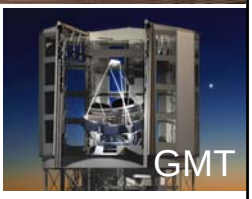


ALMA 2013

Giant Telescopes

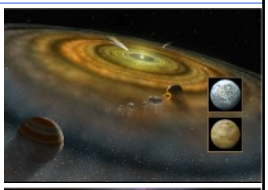


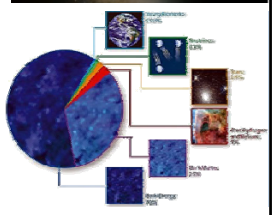




Science with the E-ELT

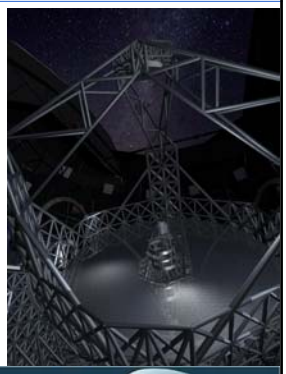
- Exo-planets
  - Imaging and spectroscopy
  - Earth-like planets accessible
- Stellar populations
  - Resolved out to Virgo cluster
  - To high redshift in integrated light
- Cosmology
  - The first stars and galaxies
  - Direct measure of expansion
  - Evolution of cosmic parameters
  - Dark matter, dark energy





E-ELT

- Detailed design study
  - Baseline 42m primary mirror
  - Adaptive optics built-in
  - Fully funded (~60⁺ M€)
  - Industry strongly engaged
  - Site selection late 2009
  - Study complete in 2010
- Project
  - Builds on *entire* expertise at ESO *and* in member states
  - Construction 2011-2018
  - Synergy: JWST/ALMA/SKA



World's Biggest Eye on the Sky

- Perspective
  - Highest-priority new O/IR program for ESO
  - ASTRONET Science Vision and Roadmap: ELT highest-priority ground-based astronomy project
  - One of two astronomy projects on list of high-priority research infrastructures for Europe
- Funding
  - Construction in 2011-2018 to be enabled by:
    - Additional contributions from 14 member states
    - Attract new member states, including outside Europe
    - If opportune, consider <30% partnership
  - Operations: covered by available annual income

Top-level ESO Goals

- Best science from La Silla-Paranal Observatory
  - Most advanced ground-based O/IR observatory
  - Continue to maintain & upgrade with new instruments
- Deliver ALMA
  - Within specifications & budget, on realistic time-line
  - Optimal preparation for scientific harvest
- Construct and operate the E-ELT
  - World-leading design; stunning science expected
  - Secure additional funding to construct in next decade