ESO
Today and Tomorrow
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
  - Finland joined in 2004
  - Currently 14 member states

- **Observatories in Chile**
  - Optical/infrared: La Silla and Paranal
  - Sub-mm: APEX and ALMA partnerships: Chajnantor

- **HQ in Garching and Office in Santiago**
European Southern Observatory
Tampere, 3 June 2010

La Silla and Paranal Observatory in full operations (8 telescopes in 2010, plus four telescopes for interferometry)

APEX operating on Chajnantor
ALMA under construction (early science in 2011, full operations in 2013)

Operational data archive
European Extremely Large Telescope in design phase
Headquarters in Garching, Germany
Representation in Santiago, Chile
La Silla Paranal

VLT/I (Paranal)

- Instrumentation operating, in assembly and planned
  - Covers the available optical infrared wavelengths 300nm to 20μm
  - Angular resolution from seeing limit to 50 μ-arcseconds
  - FORS2, ISAAC, UVES, FLAMES, NACO, SINFONI, CRIRES, VISIR, HAWK-I, VIMOS, X-Shooter, laser guide star facility KMOS, MUSE, SPHERE, Adaptive Optics Facility
  - MIDI, AMBER, PRIMA, GRAVITY, MATISSE
  - VISTA/VIRCAM
  - VST/ΩCam
La Silla Paranal

- **La Silla**
  - Continue operations with long-term programmes
    - HARPS, EFOSC2, SOFI, FEROS, WFI, visitor instruments

- **APEX**
  - Covers sub-mm and mm wavelengths 0.3 to 3 mm
  - SHFI (Swedish Heterodyne Facility Instrument), LABOCA, SABOCA, APEX-SZ, CHAMP+
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
E-ELT

- Detailed design study
  - Baseline 42m primary mirror
  - Adaptive optics built-in
  - 8 instrument studies and 2 adaptive optics modules studied
  - Industry strongly engaged
  - Study complete in 2010

- Project
  - Builds on entire expertise at ESO and in the member states
  - Construction 2011-2018
  - Synergy: JWST/ALMA/SKA
La Silla

- **Medium-size telescopes**
  - 3.6m: HARPS for exo-planet searches
  - 3.5m NTT: EFOSC2, SOFI & visitor instruments
  - 2.2m: WFI & FEROS in partnership with MPG

- **Small telescopes**
  - Closed/funded externally
<table>
<thead>
<tr>
<th>3.6m</th>
<th>NTT</th>
<th>2.2m</th>
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<tbody>
<tr>
<td>HARPS</td>
<td>SOFI</td>
<td>WFI</td>
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<tr>
<td>EFOSC2</td>
<td>FEROS</td>
<td>GROND</td>
</tr>
</tbody>
</table>
Paranal
VLT Instruments

- CRIRES
- UVES
- VIMOS
- NACO
- FORS2
- X-shooter
- VISIR
- SINFONI
- FLAMES
- ISAAC
- HAWK-I

Tampere, 3 June 2010
VLTI Instruments

AMI

AMBER

MIDI
Monikäyttöiset instrumentit

- Teleskoopeilla laaja tieteellinen käyttöalue
  - samoilla instrumenteilla havaitaan oman
    aurinkokuntamme kohteita, mutta myös
    maailmankaikkeuden kaukaisimpia kohteita
  - kohteet kuumista kylmiin, tiheistä
    harvarakenteisiin
  - hiukkasten havainnointi ja karakterisointi

- tähtitieteen laboratorio on maailmankaikkeus
Top list of ESO science

- Galactic Centre
  - Supermassive black hole

- Extrasolar planets
  - First images of exo-planets
  - Lightest known planets
  - First direct spectrum of an exo-planet

- Accelerating Universe
  - Spectroscopy of distant supernovae

- Gamma-Ray Bursts/Supernovae
  - Explosion physics
  - Tracers of the distant universe
Other top science from ESO

- Metal-poor stars
  - Tracing the chemical enrichment
  - Finding the oldest known stars
- Stellar populations in nearby galaxies
  - Measuring stars beyond the Local Group
- Massive galaxies in the distant Universe
  - Puzzles in galaxy formation
- Varying physical constants?
  - Measure the fine-structure constant over time
- Testing the cosmological model
  - Cosmic background temperature
More top science

- Detecting and imaging the tori around AGN
- Measure the geometric shape of stars
- Determine the size of stars
  - E.g. Cepheids to calibrate the period-luminosity relation
- Star formation
  - Debris disks, chemistry in circumstellar disks
- Measure the structure of the Milky Way
  - Local spiral arm
  - Bulge, disk and halo, run-away stars
- Solar System objects
  - Comets, asteroids, weather on Titan
ESO Publication Statistics


Tampere, 3 June 2010
ESO and other Observatories

Publications of major observatories by year

- ESO total
- HST
- VLT
- Chandra
- La Silla
- Keck
- Gemini
- Subaru

No. of publications

Black hole at the Galactic Centre

- Mass determination through stellar orbits
- Structure around the black hole revealed through flashes
- Coordinated studies with other wavelengths
- Multi-year study
  - use of AO instruments (SHARP on NTT, ISAAC NACO, SINFONI on VLT)
The ESO exo-planet machinery

- HARPS at 3.6m telescope
  - best radial velocity machine at a 4m telescope (supported by UVES on VLT)
  - extremely stable spectrograph

- NACO
  - adaptive optics supported imaging and spectroscopy

- VLTI
  - highest spatial resolution for follow-up observations of known systems

- NACO/SINFONI/FORS2
  - transit measurements, atmospheres of exo-planets
ESO results on exo-planets

- Most radial velocity detections through HARPS
  - lowest-mass planets known so far
    - rocky planets, earth-mass planets
  - planetary systems

- First direct image of a planet
  - around a brown dwarf
  - now innermost planet directly imaged (β Pic)

- Combination with transits
  - characterization of planets
    - mass, density, temperatures
A planet with $1.9M_\oplus$ and one in the habitable zone

- **Gliese 581**
β Pic planet

- Planet within the massive dust disk
- Orbit only a few AU
- NACO imaging

Gamma-Ray Bursts

- Identification relies on optical data
  - redshifts, explosion energies, explosion physics

- Cosmological probes
  - the most distant observable stars
  - light houses to measure the intergalactic medium
  - tracers of chemical enrichment?

- Very short duration
  - required special instrumentation and software to observe adequately
SN/G

- Spectral signatures of supernovae appear in Gamma-Ray Bursts.
- GRB 030329/SN2003dh / GRB 980425/SN 1998bw

UVES spectrum found $z = 0.1685$, i.e. second closest known GRB – “cosmological” GRB

FORS1 and 2 observations of afterglow (starting April 3 until May 1)

Hjorth et al. 2003, Nature, 423, 847

SN1998bw after 33 days

Observed wavelength (Å)
Rapid Response Mode (RRM)

UVES observations of GRB 060418
10 minutes after the initial Swift trigger

Many metal line systems at 3 redshifts.
[Zn/Fe] >> QSO abs.

Tampere, 3 June 2010
Gamma-Ray Bursts

- Most distant stellar objects ever observed
  - redshifts 6.7 and 8.2 (tentative)
  - lookback time of nearly 12.5 billion years (or 95% of the age of the universe)

- VLT equipped with rapid response mode
  - allows detection
Most distant stellar object yet observed – GRB 090423

- Optical drop-out, bright in the near-infrared
- Rapid decline

Tanvir et al., Nature submitted
GRB 090423

- Spectroscopy 17 hours after outburst
- Lyman break indicates a redshift of $z \approx 8.2$
The Survey Telescopes

- VISTA in operations since April 2010
- VST still in construction
  - Expected completion end 2010
- Science
  - Multi-year program of large public surveys
  - Coordinated by ESO
  - Develops European survey capability
Science Verification finished
- NGC 253 and Orion

Public Surveys started
- VHS, VVV, VIDEO, VIKING, VMC, UltraVISTA
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
Chajnantor

- Three facility and three `PI` instruments on APEX
- Watch out for ALMA
  - early science in 2011
  - be prepared
Progress
- Nearly all European deliverables on track
- Closure phase with three antennas at the AOS
- Santiago Central Office building nearing completion
- Multi-fuel turbine being procured
- First two European antennas mechanically integrated

Concern
- Antenna delivery schedule: under close scrutiny
Commissioning and Science Verification started on Jan 22, 2010
ALMA Early Science

- 16 antennas with four frequency bands
- Baselines up to 1 km
- Up to 1/3 of the time used for this
- Call for proposals towards the end of 2010
- Deadline probably around February 2011
- Observations start September 2011

<table>
<thead>
<tr>
<th>ALMA Band</th>
<th>Frequency Range (GHz)</th>
<th>Wavelength range (mm)</th>
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<tbody>
<tr>
<td>3</td>
<td>84-116</td>
<td>3.6-2.6</td>
</tr>
<tr>
<td>6</td>
<td>211-275</td>
<td>1.4-1.1</td>
</tr>
<tr>
<td>7</td>
<td>275-373</td>
<td>1.1-0.8</td>
</tr>
<tr>
<td>9</td>
<td>602-720</td>
<td>0.5-0.4</td>
</tr>
</tbody>
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Tampere, 3 June 2010
E-ELT

- **Design study**
  - First prototype mirror segments produced
  - ESO M1 phasing method tested successfully on GTC

- **Instrument studies**
  - Final reviews of 8 instrument studies and two adaptive optics modules complete
  - Results and SWG input presented to STC in April
  - Extraordinary STC Meeting on 16 June to discuss the first generation of E-ELT instruments

- **Site selection**
  - Council selected Armazones as baseline site
Proposing for ESO time

- Deadline for P87 proposals:
  30 September 2010
Structure of the ESO OPC

Observing Programmes Committee

- 4 scientific categories
  - Cosmology (A)
  - Galaxies and Active Galactic Nuclei (B)
  - Interstellar Medium, Star Formation and Planetary Systems (C)
  - Stellar Evolution (D)

- 13 panels
  - 3 for category A
  - 2 for category B
  - 4 each for categories C and D
Proposal types

- 5 proposal types all handled by OPC
  - normal programmes
  - short programmes
  - large programmes
  - Coordinated VLT/XMM projects
  - Target of Opportunity
  - calibration programmes
    - all considered by the OPC

- Director Discretionary Time
  - submission any time
  - decided by ESO Director General
ESO proposals

Pressure factor typically high

- typical oversubscription for ESO telescopes is >3
  - often reaching 5 and in certain periods/RA ranges 8 or higher
- Large Programmes have an acceptance rate of about 20% or less
- Pressure on ToO proposals is extremely high
  - GRBs, supernovae, novae, stellar occultations by TNOs, microlensing,
Finnish proposals

- Only few proposals received
  - P86: 13 proposals requesting 37 nights
    - FORS2, NACO, VISIR, UVES, X-shooter; SOFI, EFOSC2
  - P85: 13 proposals (1 LP) asking for 40 nights
    - FORS2, SINFONI, NACO; LABOCA, SABOCA, SFHI; HARPS, SOFI, EFOSC2

- 1.3% of the total time requested!

- Success rate fairly high
  (comparable and/or higher than for other countries)
What makes a proposal successful?

- **Exciting science**
  - providing a clear progress in our understanding of some phenomenon

- **A neat idea**
  - unusual method, new idea, new approach, unique observation or experiment

- **Clear language**
  - presentation of an exciting story, which is interesting for many people
  - cover all questions somebody may have
  - information to the point
What makes a proposal successful?

- A consistent story
  - the proposal is complete and provides all information
  - quantitative arguments for the amount of time requested
- Good Luck!
ESO Archive

- The ESO data archive
  - is a rich source of excellent data
  - abstracts of previous proposals available
  - data public one year after they have been delivered to the PI
  - great way to compete with your competitor, if they got observing time
  - easy retrieval and selection of calibration data
Get involved

- Participate in OPC
- Participate in other ESO activities
  - get to know the organisation better
  - active interactions with ESO people
- Have a lively scientific exchange with the (European) astronomical community
  - conferences, workshops
  - regularly publish your results
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ESO’s goals for next five years

- Best science from La Silla Paranal Observatory
  - Second generation instruments (VLT/VLTI)
  - Key surveys with VST and VISTA
  - Long-term programs for unique science on La Silla
  - Prepare for ALMA science with APEX

- Deliver ALMA on time and budget

- Design the world-leading E-ELT and secure funding for construction and operations