Recent Developments at ESO

Bruno Leibundgut

European Southern Observatory

European Southern Observatory

- Mission
  - Develop and operate world-class observing facilities for astronomical research
  - Organise collaborations in astronomy
- Intergovernmental treaty-level organization
  - Currently 14 member states
  - Some interest by other countries
- Observatories in Chile
  - La Silla Paranal: VLT, VLTI, 3.6m, NTT, VISTA, VST
  - Chajnantor: APEX and ALMA partnerships
- HQ in Garching and Office in Santiago

ESO's sites


Garching bei München
Chajnantor
Paranal
La Silla
Santiago
Earth at Night
More information available at:
http://antwrp.gsfc.nasa.gov/apod/ap001127.html
Astronomy Picture of the Day
2000 November 27
http://antwrp.gsfc.nasa.gov/apod/astropix.html

La Silla Paranal

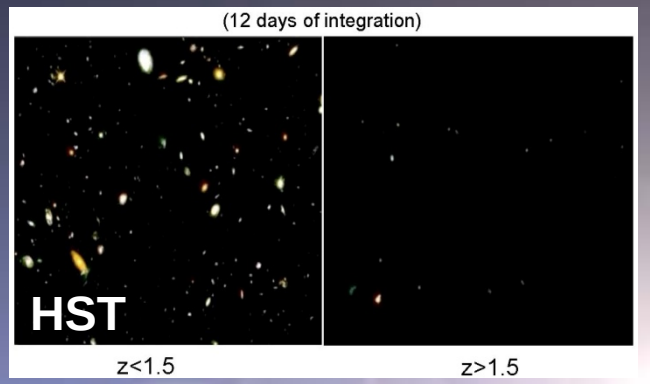
- VLT/I (Paranal)
  - Instrumentation operating, in assembly and planned
    - Covers the available optical infrared wavelengths 300nm to 20µm
    - Angular resolution from seeing limit to 50 µ-arcseconds
    - FORS2, ISAAC, UVES, FLAMES, NACO, SINFONI, CRIRES, VISIR, HAWK-I, VIMOS, X-Shooter, laser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

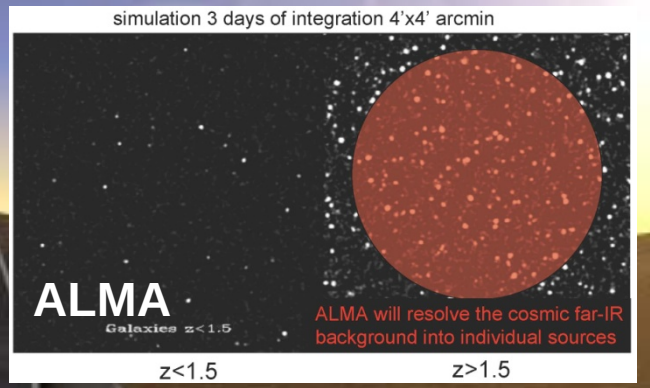
La Silla Paranal

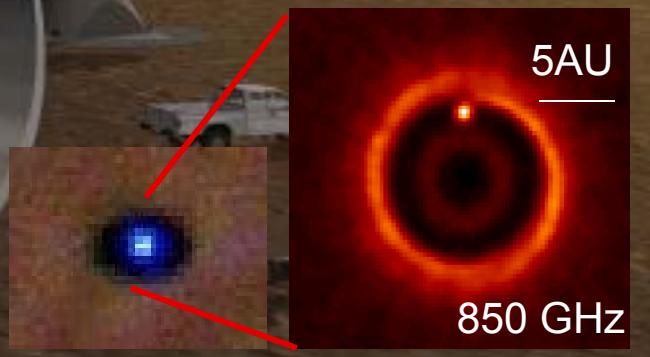
- La Silla
  - Continue operations with long-term programmes
    - HARPS, EFOSC2, SOFI, FEROS, WFI, visitor instruments
- APEX
  - Covers sub-mm and mm wavelengths 0.3 to 3 mm
  - SHFI (Swedish Heterodyne Facility Instrument), LABOCA, SABOCA, APEX-SZ, CHAMP+, Z-Spec

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)
  - 14km 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 studies finished
  - Industry strongly engaged
  - Construction proposal completed and under review
- Project
  - Builds on *entire* expertise at ESO *and* in the member states
  - Synergy: JWST/ALMA/SKA

Paranal

VLT Instruments

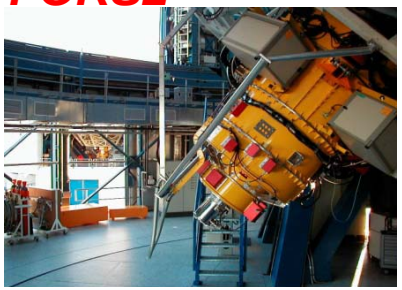
CRIRES

UVES

VIMOS

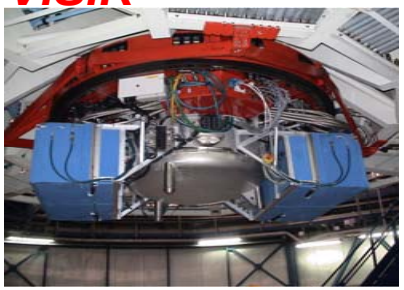
NACO

FORS2



X-shooter

VISIR



SINFONI

FLAMES

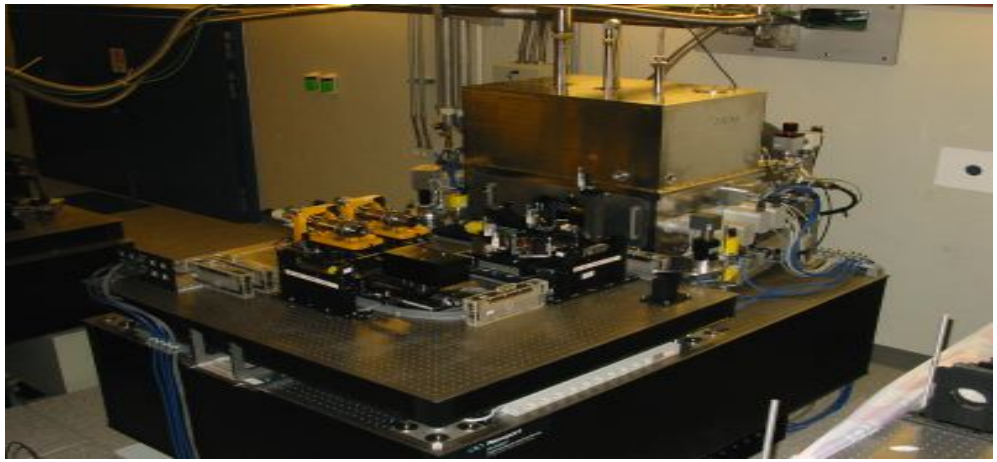
ISAAC

HAWK-I

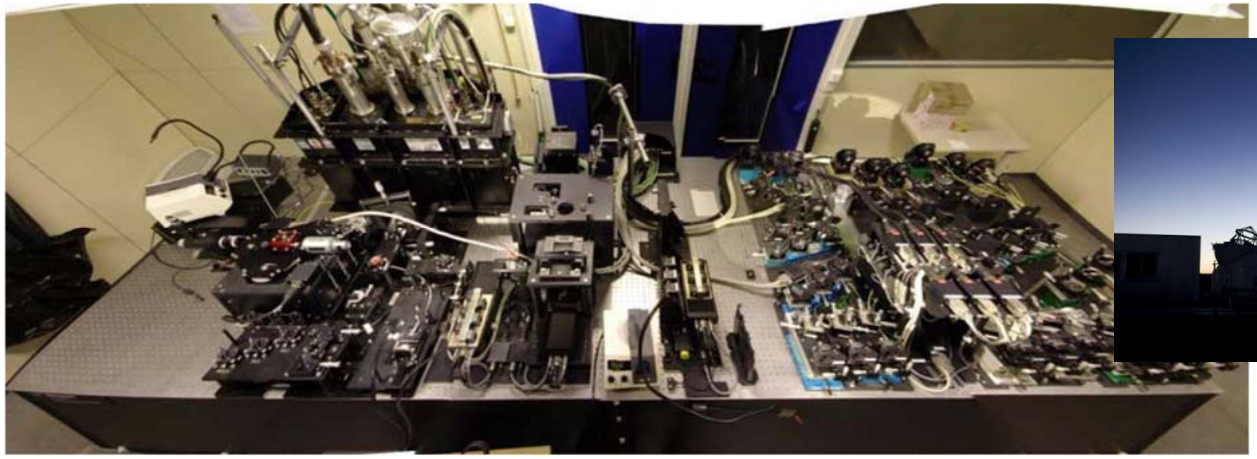
VLTI Instruments




MIDI



AMBER




VISTA

- VISTA in operations since April 2010
- Science Verification in late 2009
- Multi-year programme of large public surveys

More in Magda's presentation

VISTA

- Science Verification finished
  - NGC 253 and Orion
- Public Surveys started
  - VHS, VVV, VIDEO, VIKING, VMC, UltraVISTA

VST

- Final assembly and systems tests during the second half of 2010
- Surveys possibly will start in mid-2011
- Review of the public surveys in September 2010
  - surveys were originally selected in 2005

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

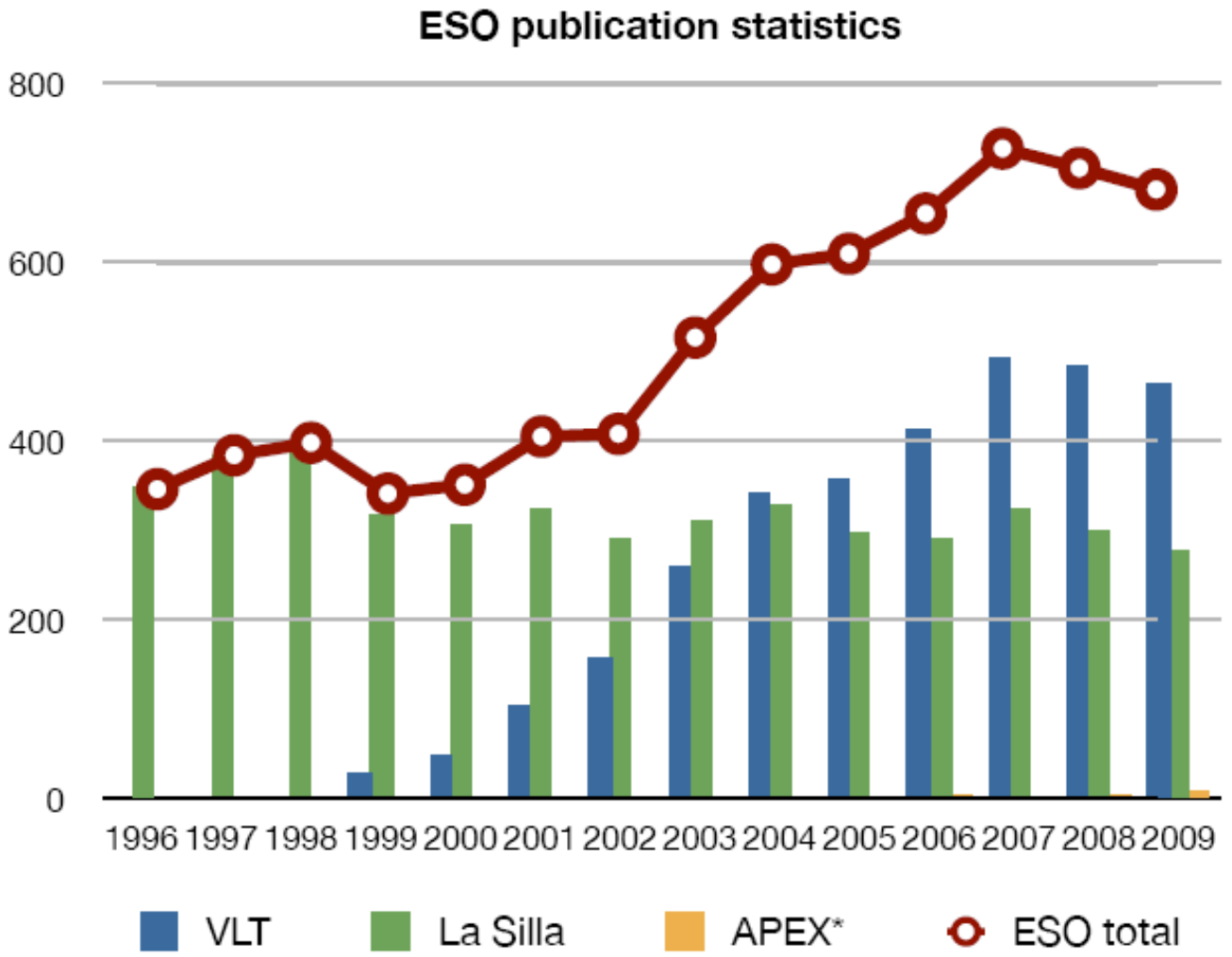
Other top science from ESO

- 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

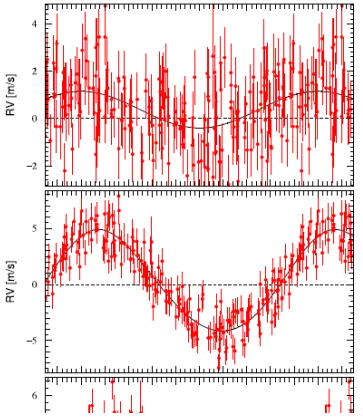
- Detecting and imaging the tori around AGN
- Measure the geometric shape of stars
- Determine the size of stars
  - E.g. Cepheids to calibrate the period-luminosity relation
- Star formation
  - Debris disks, chemistry in circumstellar disks
- Measure the structure of the Milky Way
  - Local spiral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

ESO Publication Statistics

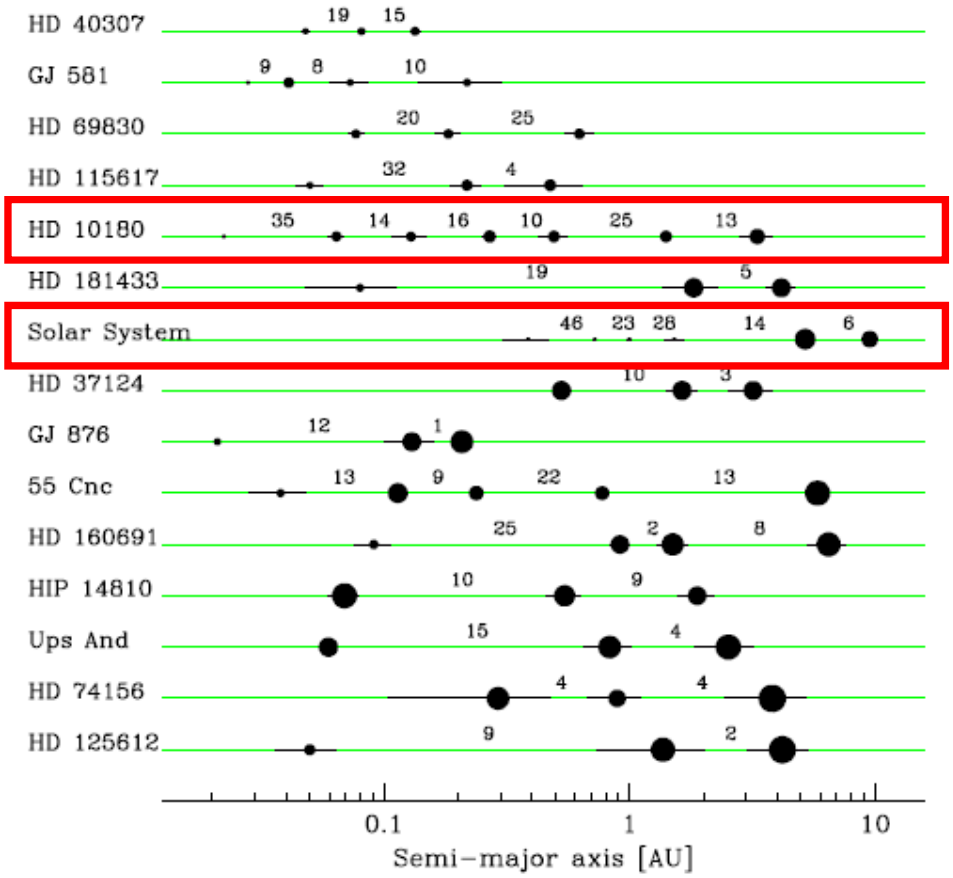


available at http://www.eso.org/sci/libraries/edocs/ESO/ESOstats.pdf

Richest planetary system

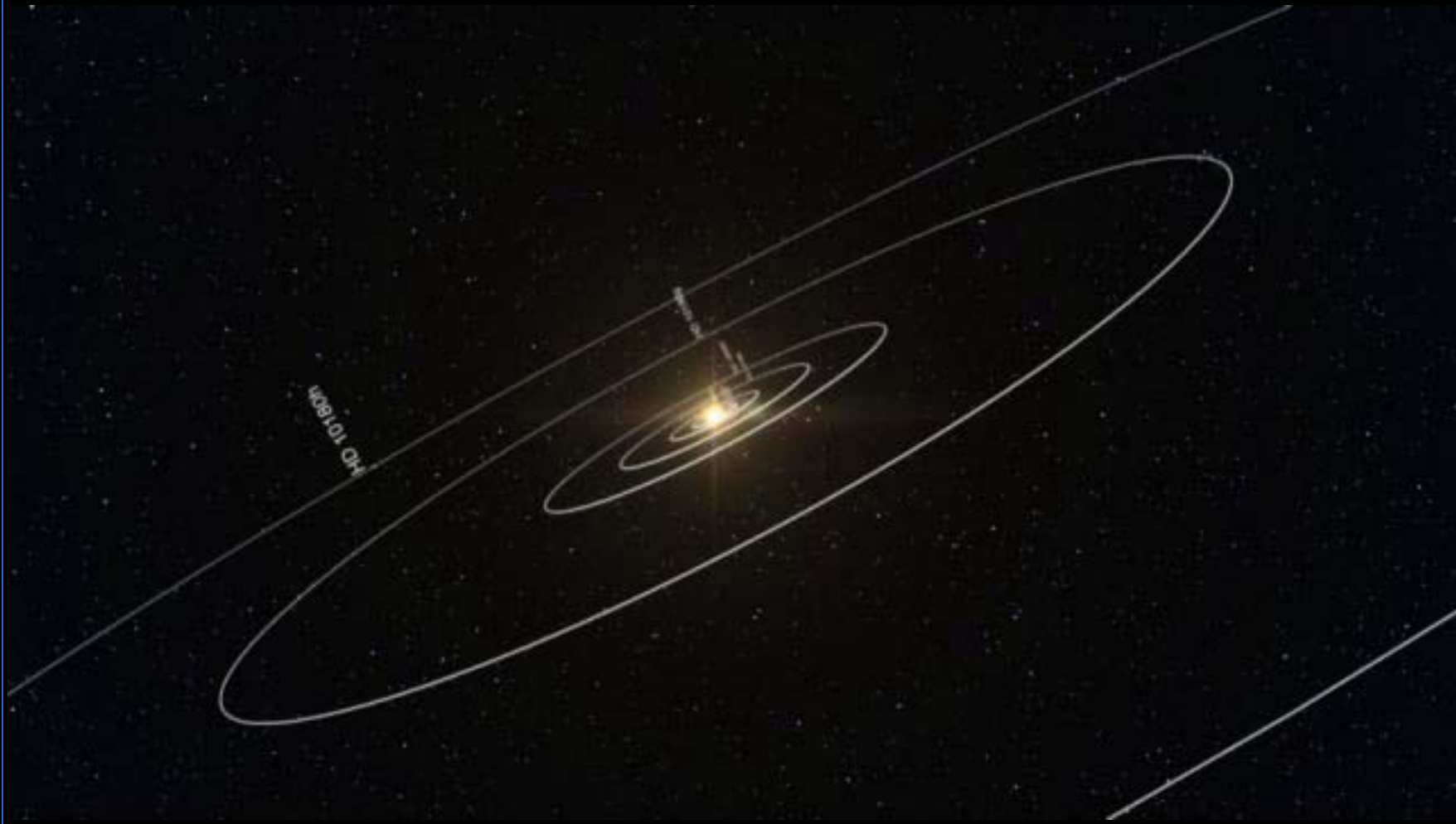


- Five planets with $12M_\oplus < M < 25M_\oplus$ $0.06AU < D < 1.4AU$
- One candidate with $M=1.4M_\oplus$ at $D=0.02AU$ and another with $M=65M_\oplus$ at 3.4AU
- HARPS detections



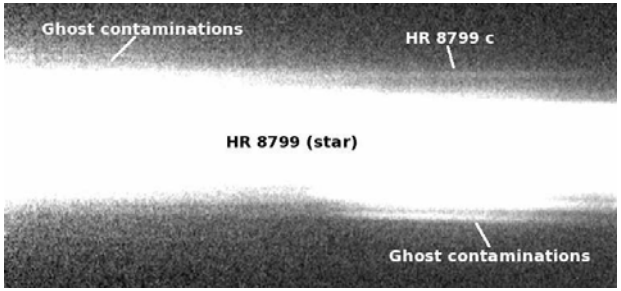
Lovis et al. 2010

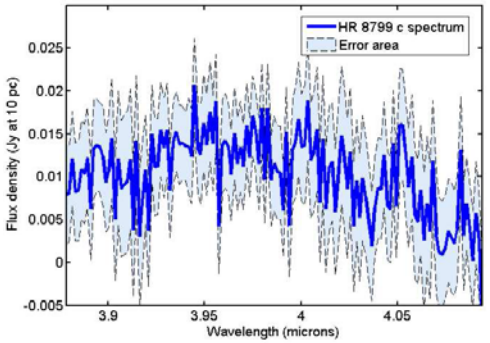
HD10180



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

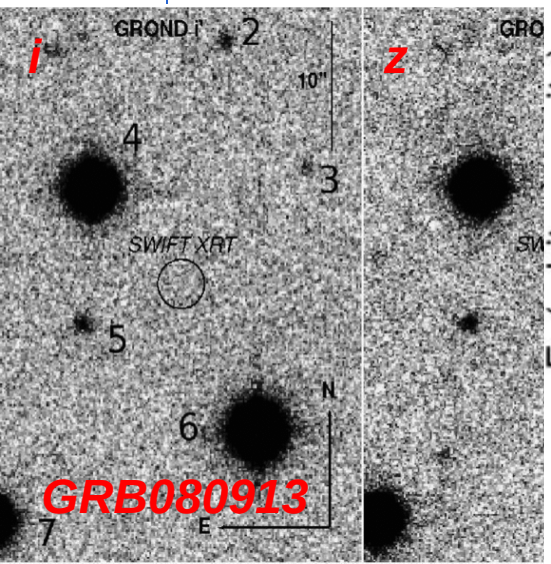


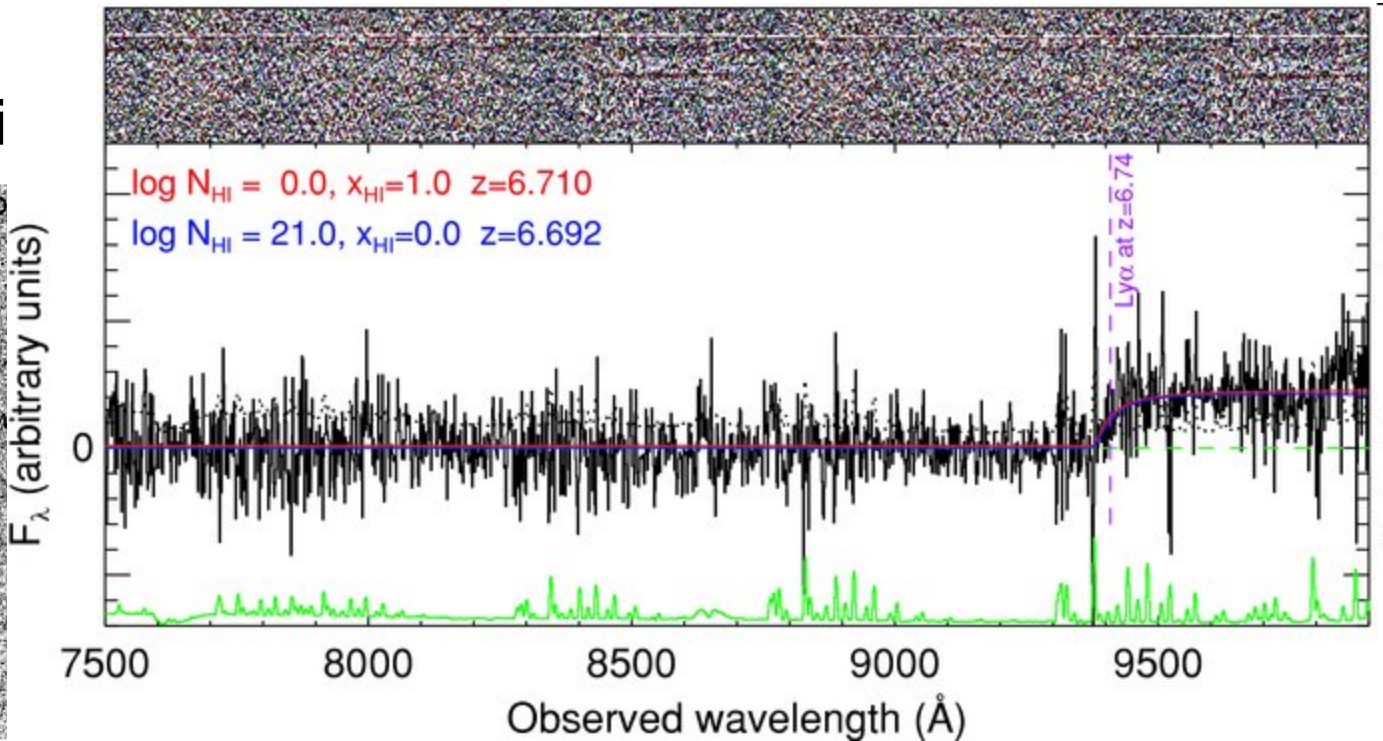


Janson et al. 2010

Gamma-Ray Bursts

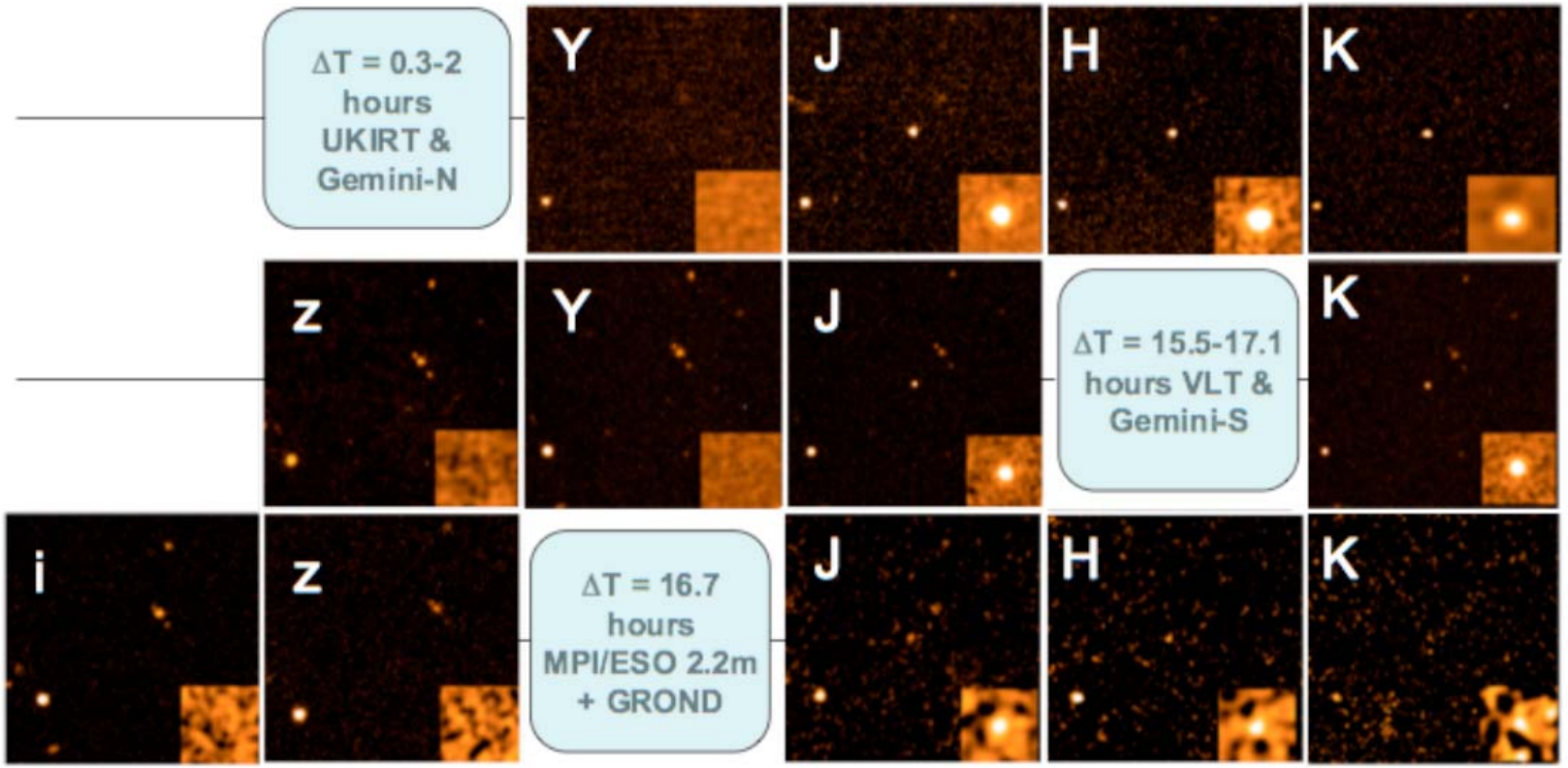
- Most distant stellar objects ever observed
  - redshifts 6.7 and 8.2 (tentative)
  - lookback time of nearly 12.5 billion years (or 95% of the age of the universe)
- VLT equipped with rapid response mode
  - allows detecti





Most distant stellar object yet observed – GRB 090423

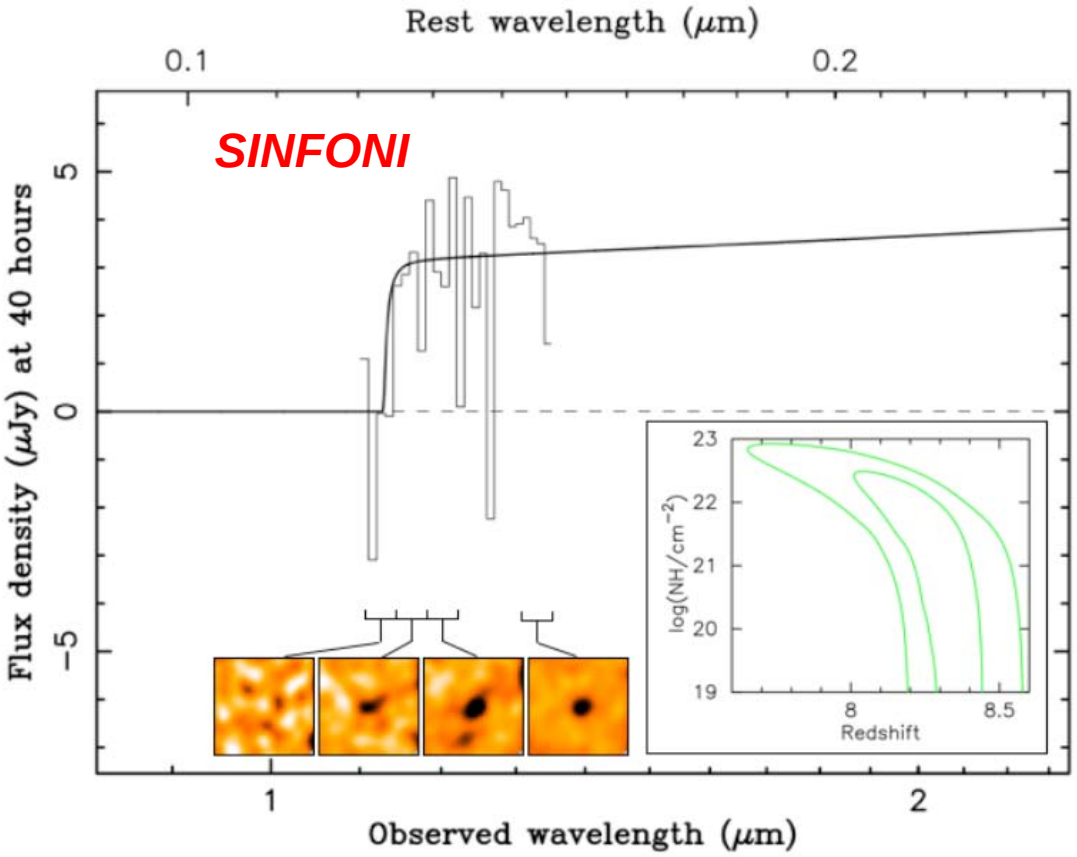
- Optical drop-out, bright in the near-infrared
- Rapid decline



Tanvir et al. 2009

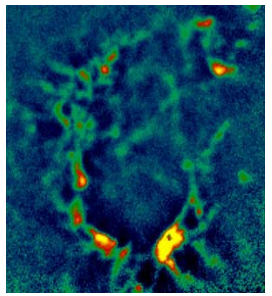
GRB 090423

- Spectroscopy 17 hours after outburst
- Lyman break indicates a redshift of z≈8.2



Chajnantor

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

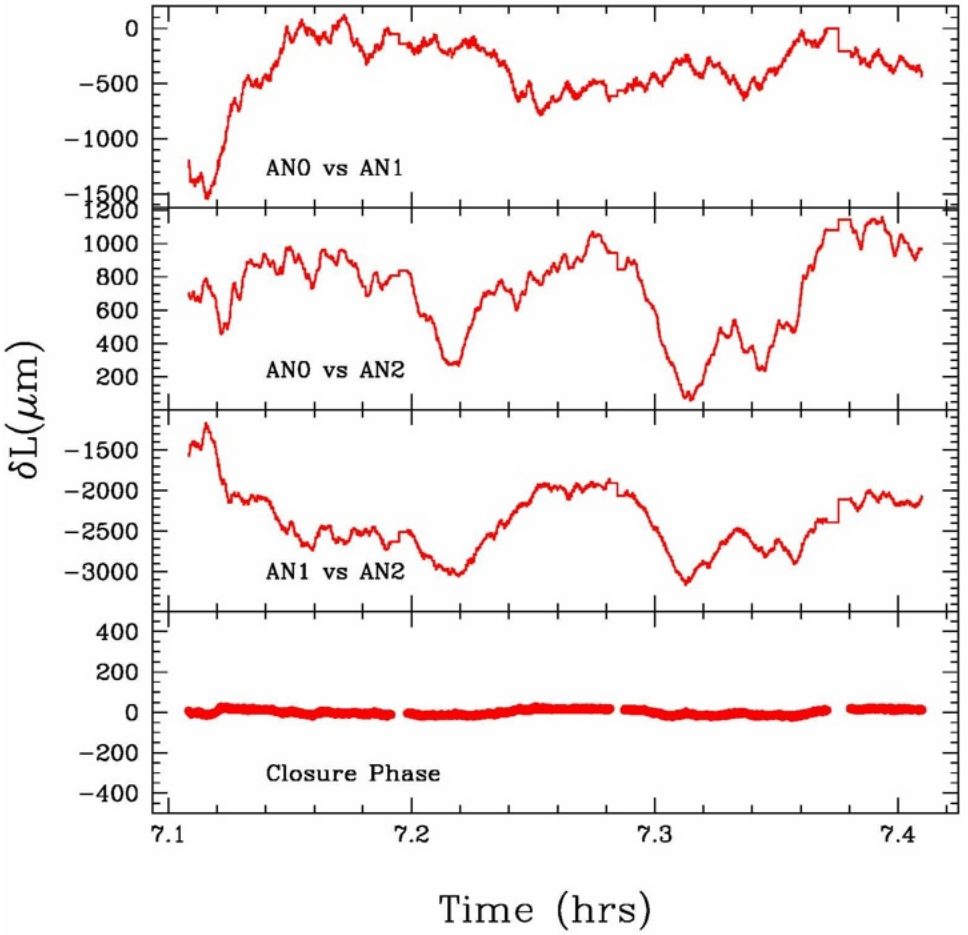


Chajnantor

- Three facility and three `PI` instruments on APEX
- Watch out for ALMA
  - early science in 2011
  - be prepared


nDVR Live Viewer
Directory View Camera Alarm Layouts Tools Help
Antena
10.198.16.213
9/9/2010
10:16:43 AM
Monitor 63
Tile 1
Camera 1
VERINT
Live Viewer
Iris
Focus
Preset
01 - ACA
Pattern
1 - Untitled
Auxiliary
1 - Untitled
Camara AOS - Enc (1)
VISTA GENERAL ALMA (4)
63
Current System Time: 4/9/10 09:
Network System Help
Last Refresh: 1
Reading Status Action
Normal
17 °C Normal
Current Date
Current Time
WeatherStation
Location
Humidity
Temperature
Dewpoint
Wind Direction
Wind Speed
Pressure
Status
UTC
percentage
celsius
celsius
degree
m/s
hPA
2010/09/04 14:11:03 Meteo1 AOS TB 3.11 -4.29 -43.06 262.00 12.60 555.04 OK
2010/09/04 14:11:03 Meteo2 AOS TB 3.13 -4.19 -43.00 266.00 11.90 555.03 OK
2010/09/04 14:11:03 Meteo3 OSF HG Tower#2 9.77 7.85 -22.09 206.00 1.50 721.27 OK
start
nDVR Live Viewer

Closure phase



- Commissioning and Science Verification started on 22 Jan 2010

ALMA Main Deliverables

IPT / Subproject	Europe	North America	East Asia
Site Development	ALMA Road to AOS OSF Technical Facilities OSF Residencia Santiago Central Office ALMA Power Supply 192 Antenna Foundations	Roads at AOS AOS Technical Facilities	Financial Contribution to Costs
Antennas	25 Antennas (12m) Two Antenna Transporters	25 Antennas (12m)	4 Antennas (12m) 12 Antennas (7m)
Front End	Band 7 (70) Band 9 (70) Cryostats (70) Water Vapour Radiom. (53) Calibration System (70) 26 Integrated Receivers	Band 3 Band 6 Monitor and Control 26 Integrated Receivers	Band 4 Band 8 Band 10 Integrated Receivers
Back End	Photomixers (hundreds) Digitizers Digitizer Clocks Multiplexers	Optical Transmitters Local Oscillators Digital Formatters Digital De-Formatters	
Correlator	Tunable Filter Boards	Correlator for 64 Ant	Correlator for 16 Ant
Computing	Software	Software	Software

ESO deliverables correspond to ~460 M€

ALMA

- Progress
  - Nearly all European deliverables on track
  - Closure phase with three antennas at the AOS
  - Santiago Central Office building completed – JAO moved in two weeks ago
  - Multi-fuel turbine being procured
  - First four European antennas mechanically integrated
    - two more in assembly
- Concern
  - Antenna delivery schedule: under close scrutiny

AEM Antenna #1

AEM Antenna #2

European antennas

ALMA Early Science

- 16 antennas with four frequency bands
- Baselines up to 1 km
- Up to 1/3 of the time used for this

Learn more about ALMA this afternoon in the special session

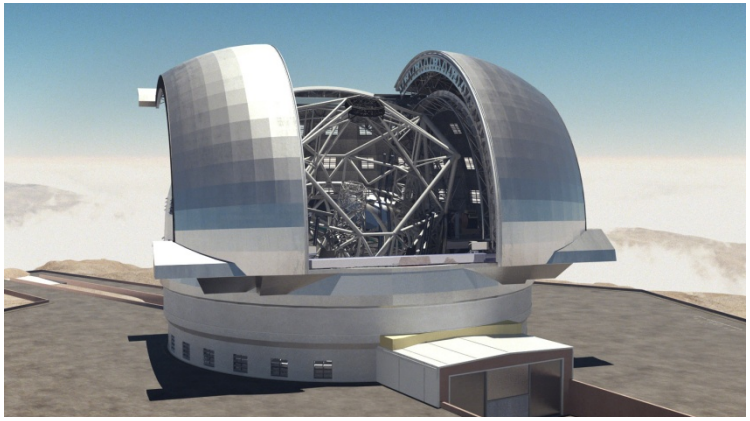
ALMA Band	Frequency Range (GHz)	Wavelength range (mm)
3	84-116	3.6-2.6
6	211-275	1.4-1.1
7	275-373	1.1-0.8
9	602-720	0.5-0.4

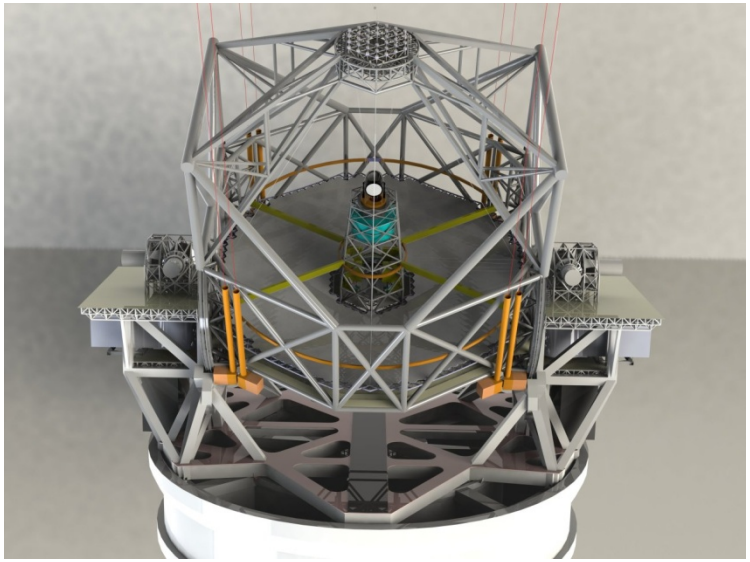
ALMA 2013

E-ELT

E-ELT Design

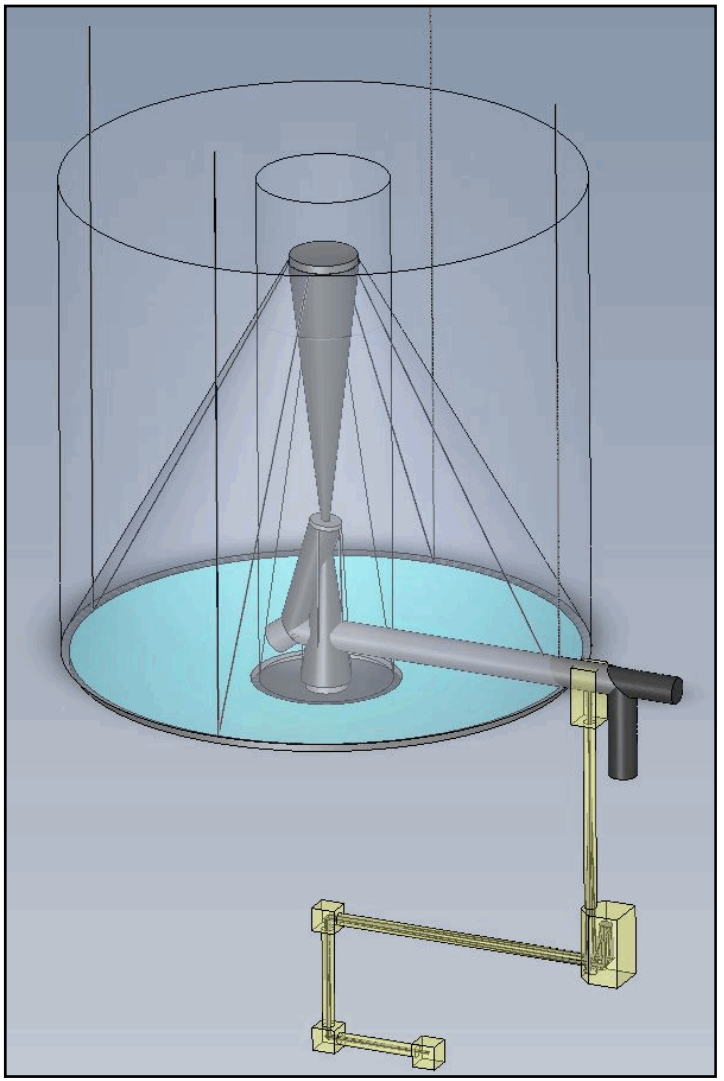
- Detailed design study
  - M1: ~1000 1.45m segments
  - Innovative five-mirror design ⇒ *adaptive* telescope
  - Suite of instruments
  - Industry strongly involved
  - Study cost: ~60 M€
  - Precursor work: ~40 M€, in part from EU programs
- Status
  - Construction proposal completed in Aug 2010
  - External review Sep 2010





Telescope

- Novel 5 mirror concept (3 mirror anastigmat + 2 flats)
- Diffraction limited over full 10′ field of view
- Flat, almost telecentric focal plane
- ‘Zoom’ capability (Nasmyth, gravity invariant, coudé foci)
- Laser “friendly” (very low aberrations even at zenith)



Instrument Studies

ACRONYM (P.I.)	INSTRUMENT TYPE
EAGLE	Wide Field, Multi IFU NIR Spectrograph with MOAO
EPICS	Planet Imager and Spectrograph with XAO
MICADO	Diffraction-limited NIR Camera- AO assisted
HARMONI	Single Field, Wide Band Spectrograph - AO assisted
CODEX	High Spectral Resolution, High Stability Visual Spectrograph
METIS	Mid Infrared Imager & Spectrograph –AO assisted
OPTIMOS	Wide Field , Visual, MOS (fibre or slit-based)- AO assisted?
SIMPLE	High Spectral Resolution NIR Spectrograph –AO assisted
	POST-FOCAL AO MODULES
MAORY	Multi Conjugate AO module (high Strehl, field up to 2')
ATLAS	Laser Tomography AO Module (high Strehl, narrow field)

STC recommendation on the first two instruments

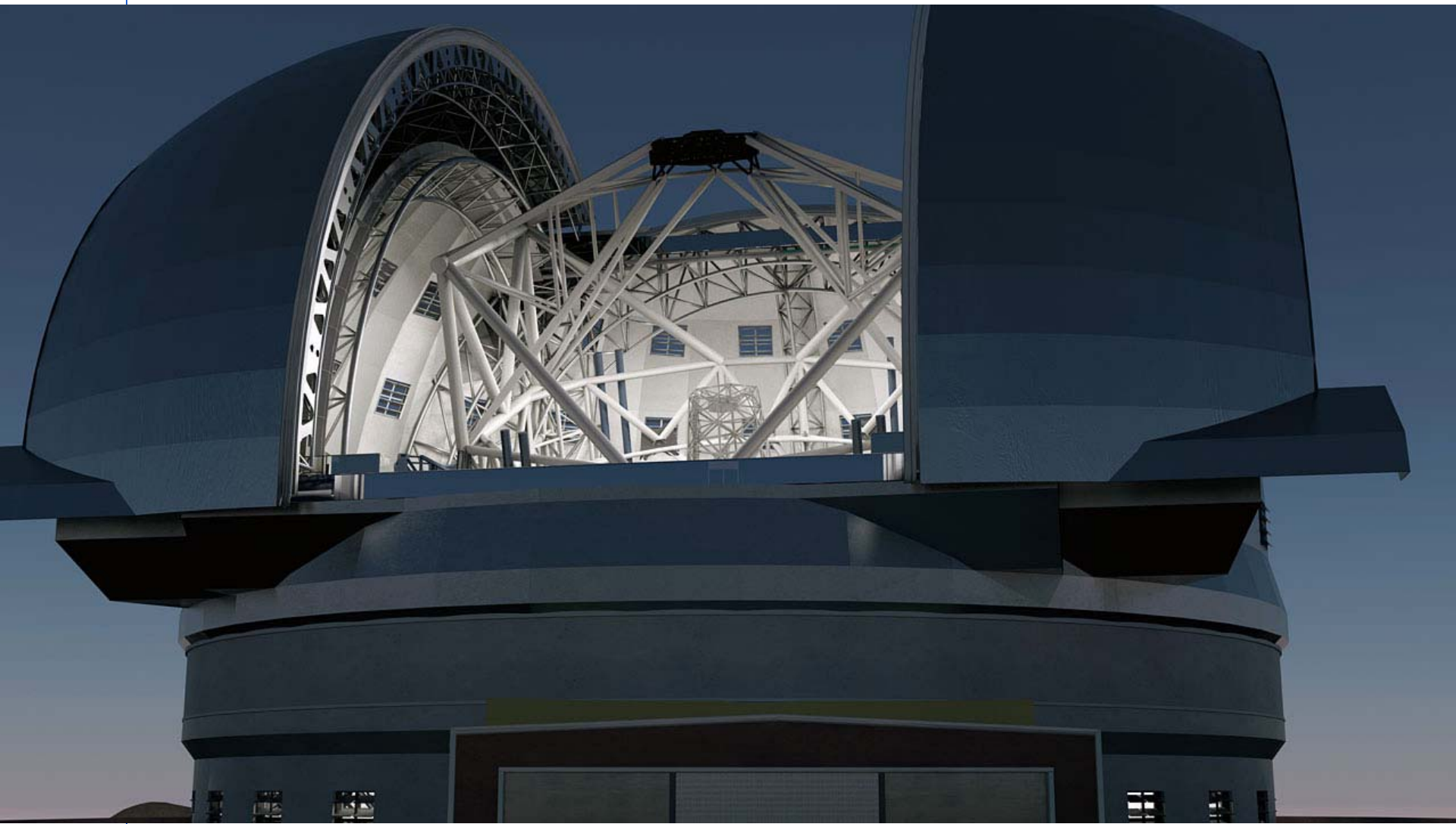
- imager and integral-field spectrograph to be pursued first
- make sure AO is developed at the same time

Site: Cerro Armazones

- Selection by ESO Council 26-04-2010
  - Paranal property will be extended through a generous donation by the Chilean government
- Cerro Armazones
  - Best overall atmospheric quality
  - Highest science return
  - Lowest cost for construction and for operations
  - Optimal scientific synergy with VLT, ALMA, LSST, SKA
- Overall program
  - Strengthening of Paranal with another unique capability, ensuring its long-term scientific future
  - World-leading ground-based observatory

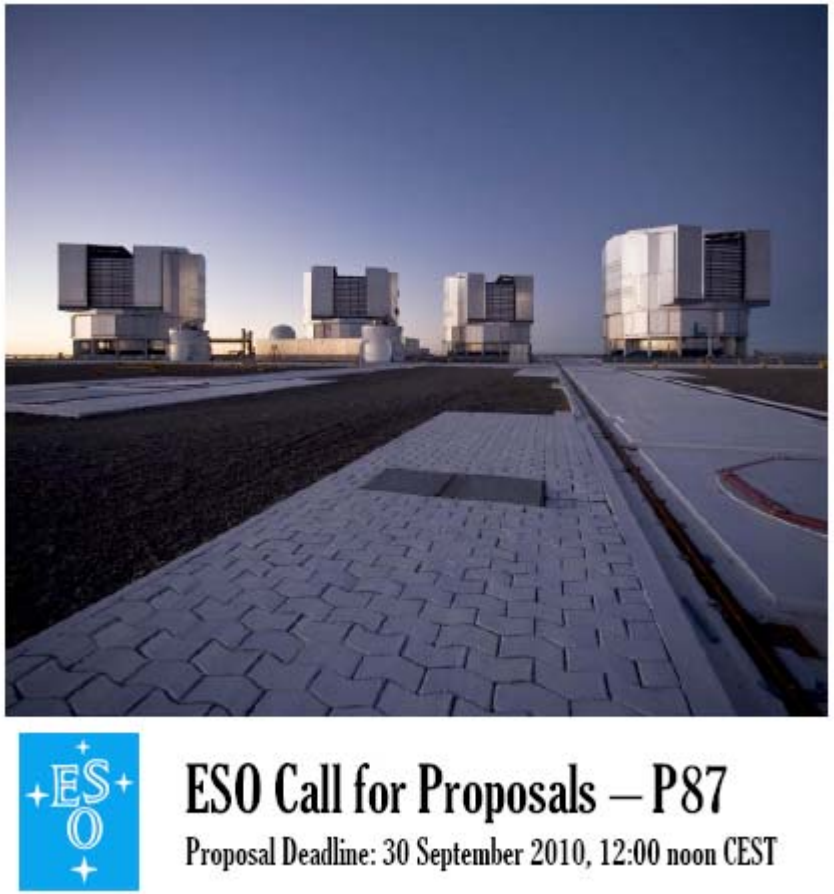
Armazones and Paranal

Time to turn of the lights and start observing

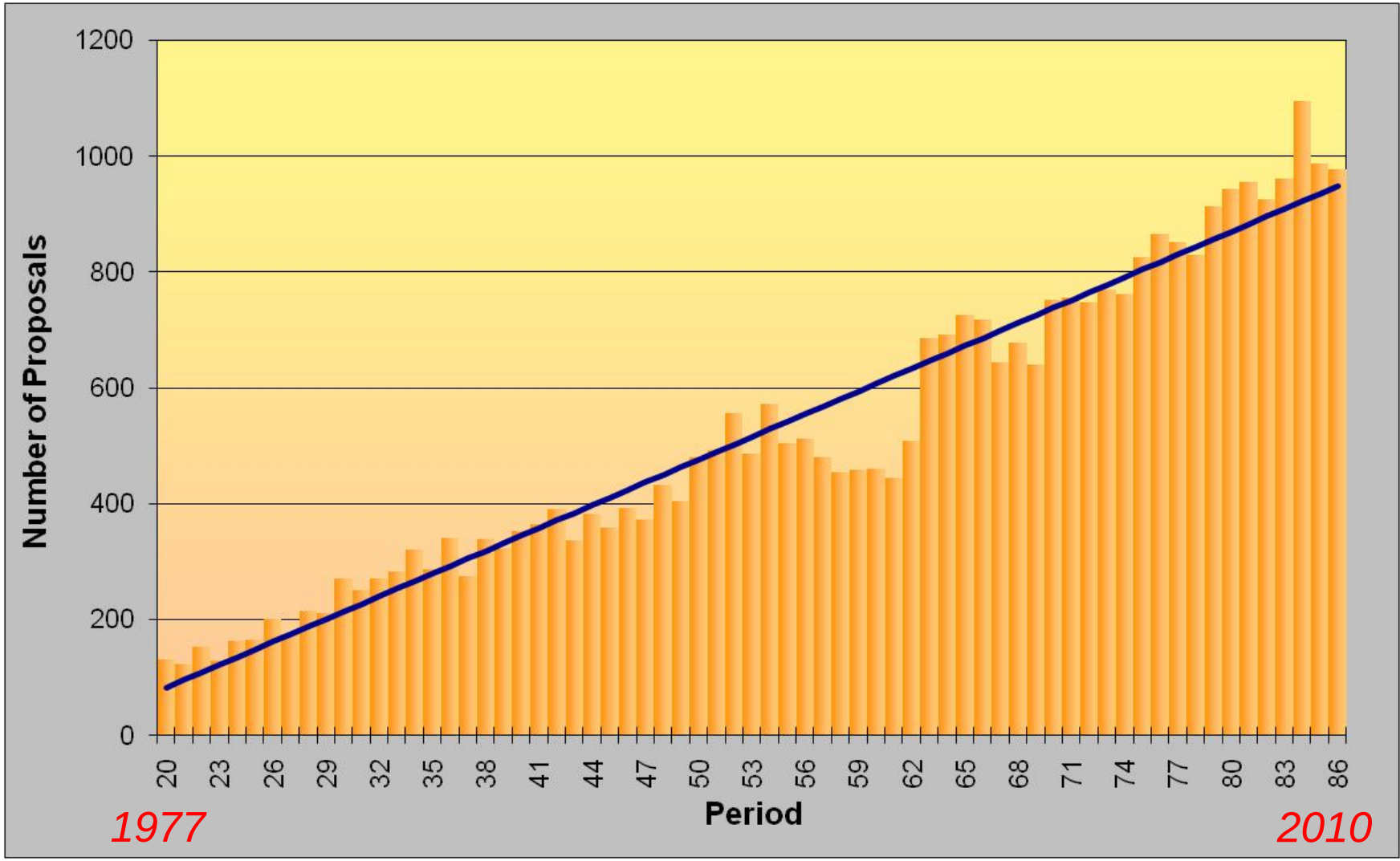


Proposing for ESO time

- Deadline for P87 proposals:
  30 September 2010



Proposal submission



OPC Working Group

- Composed by current OPC members, representatives of other observatories and ESO
- Chair: Elias Brinks (Hertfordshire)
- Evaluation of the current OPC process
  - efficiency in handling 1000 proposals twice per year
  - keep the load on panel members manageable
  - keep the process at ESO manageable
- Investigated ‘tweaks’ and alternatives
  - included some radical solutions
- Current process fairly good
  - any changes need to be accepted and trusted by the community

Public Spectroscopic Surveys

- Call for Letters of Intent issued
  - deadline: 15 October 2010
  - http://www.eso.org/sci/observing/proposals/Call_for_Public_Spectroscopic_Surveys_2010.pdf
- Pre-selection by a Public Spectroscopic Survey Panel
  - analogue to the public imaging surveys
- Proposals to be submitted for P88 (April 2011) for a start in October 2011
- no restriction on instrument or telescope

Wide-Field Spectrograph Study

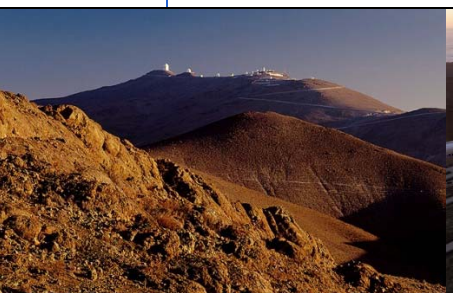
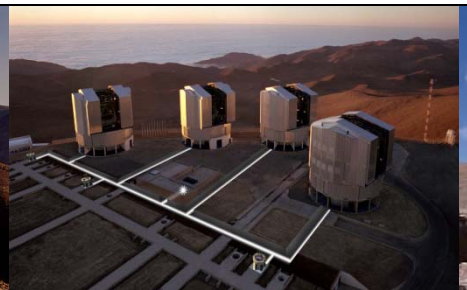
- Call for Letter of Interest issued
  - Deadline: 1 October 2010
  - http://www.eso.org/sci/announcements/MOS_final_combined.pdf
- Conceptual Design of a multi-object spectrographic facility
- no restriction on telescopes
  - change of UT top ends excluded
- Invitation for full proposal by end of October based on the received Letters of Interest
  - closing date for the proposals: 1 March 2011

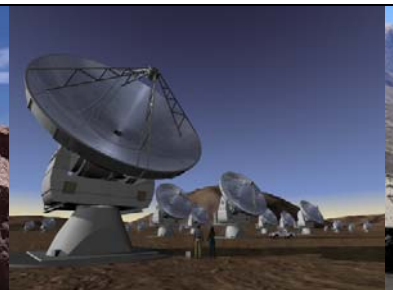
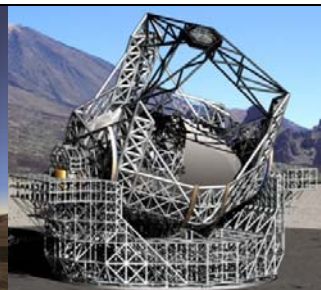
ESO Archive

- 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

ESO's goals for coming years

- Best science from La Silla Paranal Observatory
  - Second generation instruments (VLT/VLTI)
  - new instrument call
  - Key surveys with VST and VISTA
  - Public surveys (imaging and spectroscopy)
  - Long-term programs for unique science on La Silla
  - Prepare for ALMA science with APEX
- Deliver ALMA on time and in budget
- Secure funding for construction and operations of the world-leading E-ELT

How others see us

- US Decadal Survey:
  - The 14-nation ESO consortium is on track to become the undisputed leader in ground-based OIR astronomy with its planned construction of the 42m European Extremely Large Telescope (E-ELT) …
  - By concentrating most of its resources into a single international partnership, Europe has minimized duplication of capability between facilities, created a major international research center, and established a funding line for construction that is intended to lead from ALMA, to E-ELT …