

ESO: Telescopes and Instruments

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TOPICS



Summary of (for the beginners):

- ESO webpage (telescopes, instruments, and help)
- The call for proposals
- La Silla Observatory and Instruments
- Paranal Observatory and Instruments
- APEX
- Observing Modes and Proposal Types



ESO



European Southern Observatory

“ESO builds and operates a suite of the world's most advanced ground-based astronomical telescopes.”

- La Silla Observatory (2400 m) - telescopes up to 3.6m
- Paranal Observatory (2600 m) - VLT = four 8m UTs
- APEX @ Chajnantor (5000 m) - 1 antenna of 12m
- ALMA @ Chajnantor (5000 m) - 66 antennas (12 and 7m)

Calls for Proposals for observations are issued twice a year (beginning March and beginning of September)



How to find info?



- Call for proposals
- Proposal LaTeX package
- Instrument Information
- Instrument Manuals
- ETC
- Instrument Summary Table
- I looked everywhere and still have questions.
What do I do now?

www.eso.org



European
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Feeding Galaxy Caught in Distant Searchlight — ESO's Very Large Telescope probes growth of galaxies

Astronomers using ESO's Very Large Telescope have spotted a distant galaxy hungrily snacking on nearby gas. Gas is seen to fall inwards towards the galaxy, creating a flow that both fuels star formation and drives the galaxy's rotation. This is the best direct

Picture of the Week



29 July 2013 — potw1330

Messier 100 — Grand Design Splendour

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- 2
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- 4
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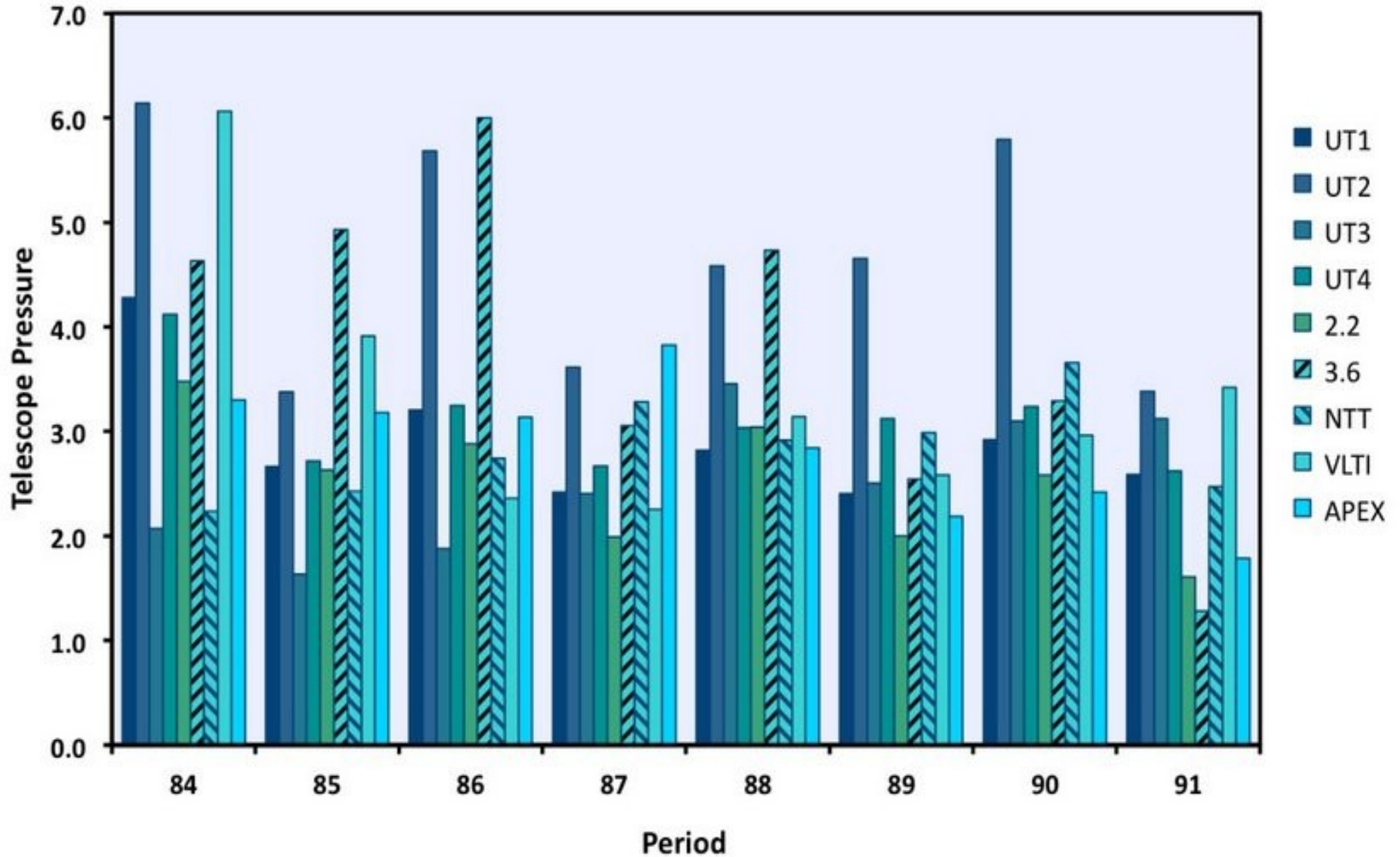


Links to useful information on the ESO website:

- **Phase 1 preparation:**
<http://www.eso.org/sci/observing/phase1.html>
- **Latest call for proposal (P92, deadline was april 2013):**
<http://www.eso.org/sci/observing/phase1/p92/proposalsclosed.html>
- **Instrument Summary Table**
https://www.eso.org/sci/observing/phase2/sm_overview/instrument_summary.html
- **User Support Department:**
<http://www.eso.org/sci/observing/phase2/USD.html>
- **Paranal instrumentation:**
<http://www.eso.org/sci/facilities/paranal/instruments/index.html>
- **La Silla Instrumentation:**
<http://www.eso.org/sci/facilities/lasilla/instruments.html>
- **User Portal**
<http://www.eso.org/UserPortal>
- **APEX**
<http://www.apex-telescope.org/>
- **Exposure Time calculators:**
<http://www.eso.org/observing/etc/>

Telescope Pressure

Telescope Pressure in Period 92





La Silla Observatory





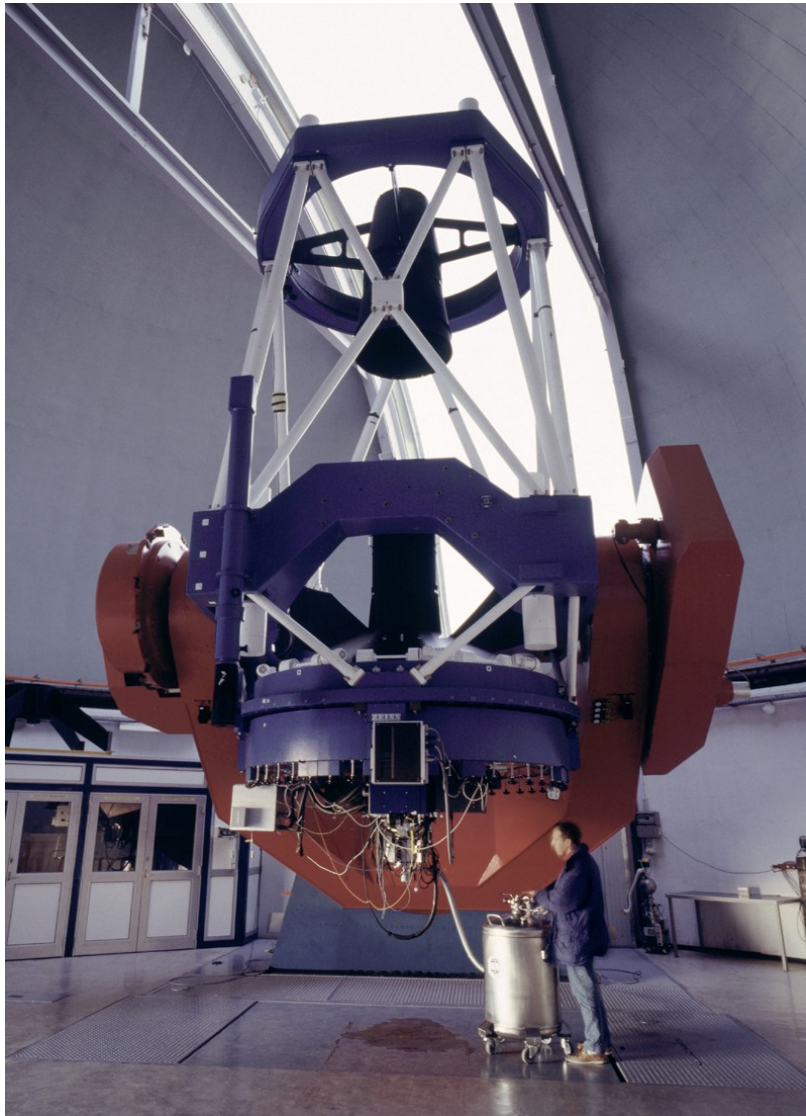
La Silla Observatory



- @ 2400 m on the Atacama desert
- Telescopes: many (up to 3.6 m)
- Median seeing: 0.8"
- Photometric sky: 70% of the time



2.2m MPG/ESO



- Time is no longer offered
- FEROS: spectrograph
- WFI: Wide Field Imager



NTT: 3.58m



- **First use of active optics**
- Alt-azimuth mount.
- Commissioned 1989
- Upgraded 1997
- ~40% observing time already committed
- Two Instruments:
SOFI and EFOSC2



SOFI

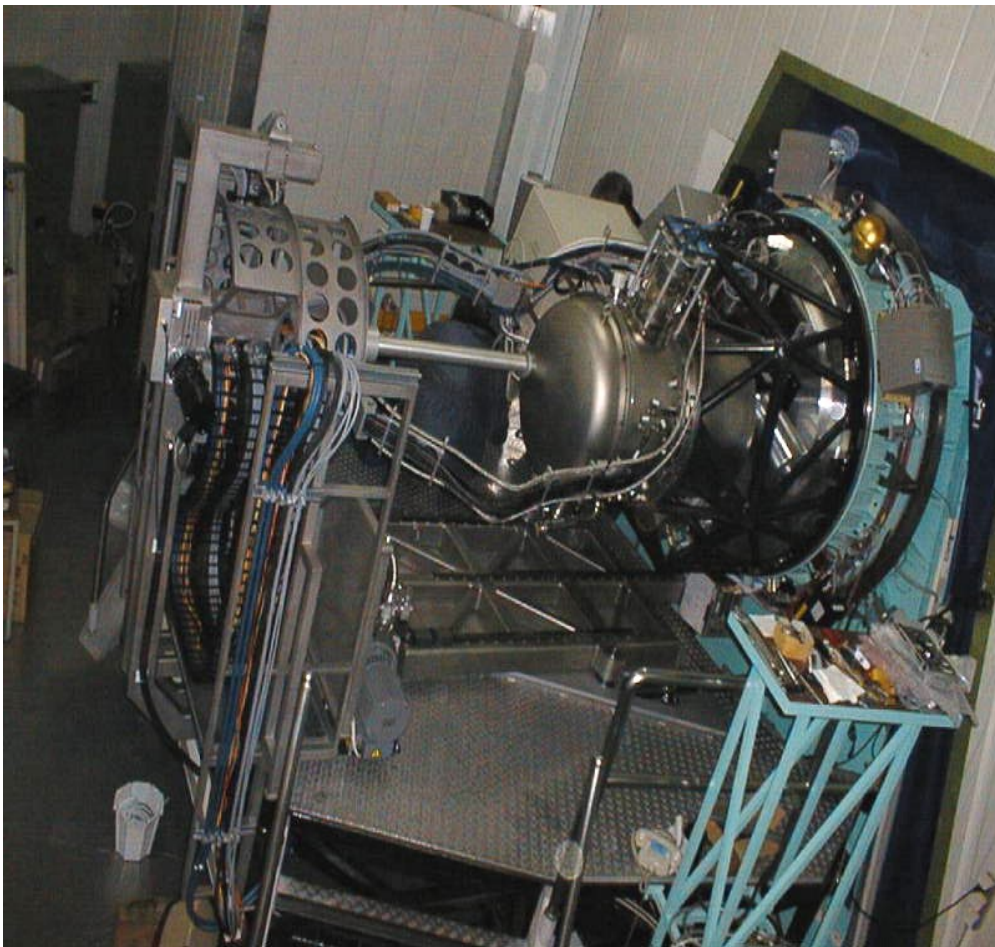


Son of ISAAC

- Infrared spectro-imager.
- ISAAC: Infrared Spectrometer And Array Camera (at the UT3/VLT).
- Questions about SOFI not to the USD, but to La Silla:
lasilla@eso.org
- Additional tools: IR standards, telluric lines, etc...



SOFI



- Provide La Silla with competitive IR capabilities at the VLT era.
- Wide-field surveys of high- z galaxies and low-mass stars, spectroscopy of galaxy nuclei, supernovae, and other IR sources (planetary nebulae, embedded stars, ...).

SOFI



Imaging:

- With plate scales of 0.144", 0.273" and 0.288"/pixel.
- Broad and narrow band filters.
- Wavelength range 0.9 to 2.5 microns.

High-time resolution imaging

- Integration time of few tens of milliseconds.
- Detector windowing.

Imaging polarimetry

- Wavelength range 0.9 to 2.5 microns.



SOFI



Spectroscopy:

- Low-resolution ($R \sim 600$).
- Medium-resolution ($R \sim 1500$).
- Combining 3 gratings with order sorting filters.
- Fixed width slits (0.6", 1.0", 2.0").
- 0.95 - 2.52 microns.



EFOSC2

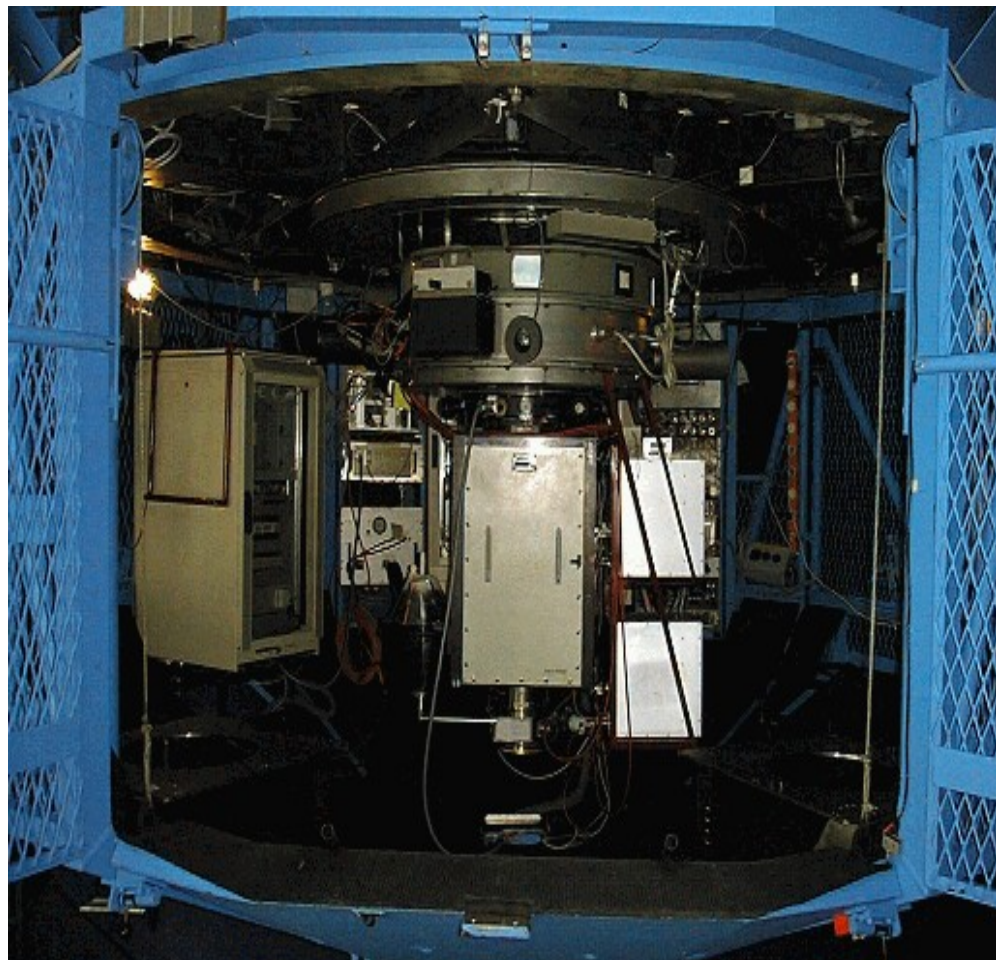


ESO Faint Object Spectrograph and Camera 2

- Low-resolution spectroscopy and imaging, in the visible and near UV.
- Wavelength range: 305nm and 1100nm.
- The field of view: 4.1'x4.1'.
- High-sensitivity of the CCD to UV photons.
- Questions about EFOSC2 not to the USD, but to La Silla:
lasilla@eso.org



EFOSC2



- Spectroscopy of faint objects and imaging of non-stellar objects
- Planetary nebulae, galaxy clusters, supernovae, GRBs, solar system planets



EFOSC2



Imaging:

- Broad and narrow band filters.
- Jittering option.

Coronagraphic imaging

- Inserting a coronagraphic mask on the light path.

Imaging polarimetry

- Some technical issues (effect of telescope pointing).



EFOSC2



Long slit spectroscopy

- Fixed slits of widths 0.3", 0.5", 0.7", 1.0", 1.2", 1.5", 2.0", 2.5", 5.0", 10.0", 15.0".
- Grisms: 318-1100nm, R~100 to 1000.
- Two VPHG: R ~4000.

Multi-slit spectroscopy

- Producing plates with many slits (15-25 slits/plate).

Slitless spectroscopy

- Spectropolarometry



ESO 3.6m



- Equatorial/Horseshoe mount.
- Commissioned 1977.
- Upgraded 1999.
- ~35% observing time already committed.

- One Instrument:
HARPS



HARPS

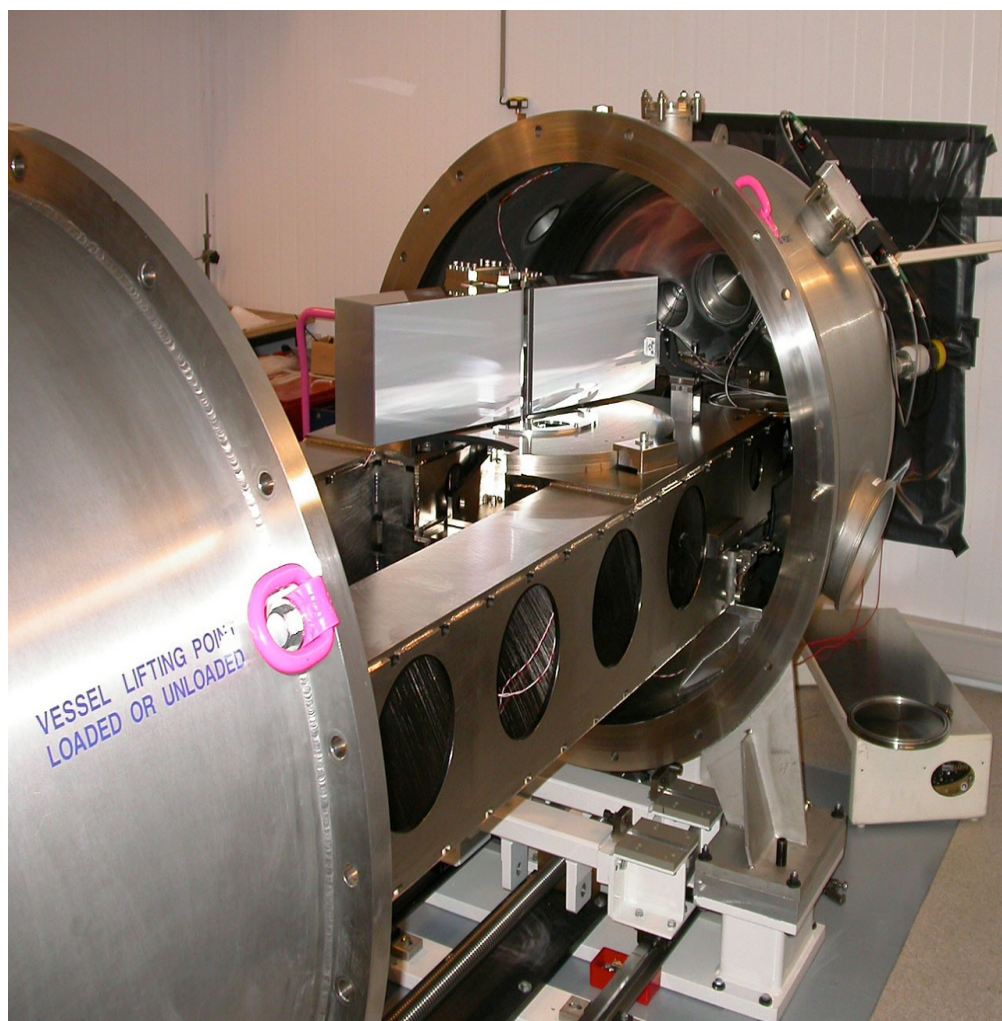


High Accuracy Radial velocity Planet Searcher

- Fibre-fed high resolution echelle spectrograph.
- Very-high radial velocity accuracy (~ 1 m/s).
- Two fibers and optimized for mechanical stability.
- One collects the star light, the second either simultaneous Th-Ar spectrum or background sky.
- $R \sim 115\,000$.
- Coverage: 378nm-691nm, in 2 CCDs, gap between 530-533nm.
- Questions about HARPS not to the USD, but to La Silla:
lasilla@eso.org



HARPS



- Planet-hunting machine
- Asteroseismology, stellar atmospheric dynamics, detailed chemical abundances, magnetic activity



HARPS



Simultaneous ThAr mode

- High-precision wavelength calibration.

Fabry-Perot Calibration System (FPCS)

- Laser source producing a uniform density of lines.
- Use instead of ThAr (for higher stability).
- Offered but still under characterization.

Polarimetry

- Both linear and circular polarization.



HARPS



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Paranal Observatory





Paranal Observatory



- @ 2600 m (12 km from the Pacific)

Telescopes:

- 4 x VLTs
 - 4 x ATs (for the VLTI)
 - VST
 - VISTA
-
- Photometric sky ~78% of the time
 - Median seeing: ~0.7"



Very Large Telescope



- **Four Unit Telescopes (UTs) of 8.2m**
- Alt-azimuth mount.
- First light 1998.
- Can work as an array (VLTI).
- ~40% observing time already committed.
- 11 Instruments + VLTI.



CRIRES



Cryogenic high-resolution IR Echelle Spectrograph

- Optics cooled to ~ 65 K, detectors to ~ 25 K.
- Wavelength range: 0.95 - 5.2 micron.
- $R \sim 100\,000$ (50 000).
- Fixed slit widths 0.2 and 0.4".
- Adaptative optics system (maximize spatial resolution and S/N).
- For wavelength settings see instrument manual.



CRIRES



- RV searches for extrasolar planets and direct spectroscopy (CO, CH₄).
- Solar system objects.
- Evolved stars (abundances, molecules, winds, mass loss, oscillations, magnetic fields).
- Young stellar objects.
- ISM chemistry.
- AGNs.



FORS2



Focal Reducer/low dispersion Spectrograph 2

- Multi-mode optical instrument.
- Wavelength range: 330 - 1100 micron.
- Two pixel scales: 1) 0.25"/px in 6.8' x 6.8' field, 2) 0.125"/px in a 4.25' x 4.25' field.
- 2 CCD choices: UV or Red sensitivity.
- Most requested instrument at the VLT.
- One of the most productive (8 of 10 most cited VLT papers).



FORS2



- Imaging, spectroscopy, and polarimetry.
- Deep imaging surveys, galaxy clusters, Lyman alpha in high-redshift, polarimetry of SNe, supergiants in nearby galaxies, white dwarfs, extra solar planets, TNOs.



FORS2



Imaging

- Broad and narrow band filters.
- Imaging with occulting bars (to mask bright objects).
- High-time resolution (few milliseconds to fractions of secs).

Long Slit Spectroscopy

- Normal gratings, holographic gratings, order separation filters.
- $R \sim 260-2600$ and different coverage.
- 9 slits with fixed widths (0.3" to 2.5").
- High-time resolution mode (Visitor Mode only!).



FORS2



Multi-object spectroscopy with slitlets (MOS)

- 19 movable slitlets (20" or 22" long).
- User defined widths.
- Wide slit (5") spectrophotometry.
- Slitless spectroscopy.

Multi-object spectroscopy with masks (MXU)

- Laser cut slit masks.
- Up to 10 masks of 470 slits can be mounted.
- 0.1" to 30" of width, up to 30" of length.
- Rectangular, circular or curved slits.



FORS2



Polarimetry

- Imaging.
- Slitless spectropolarimetry.
- Multi-object slitlets.
- All grisms can be used.



KMOS



K-band Multi Object Spectrograph

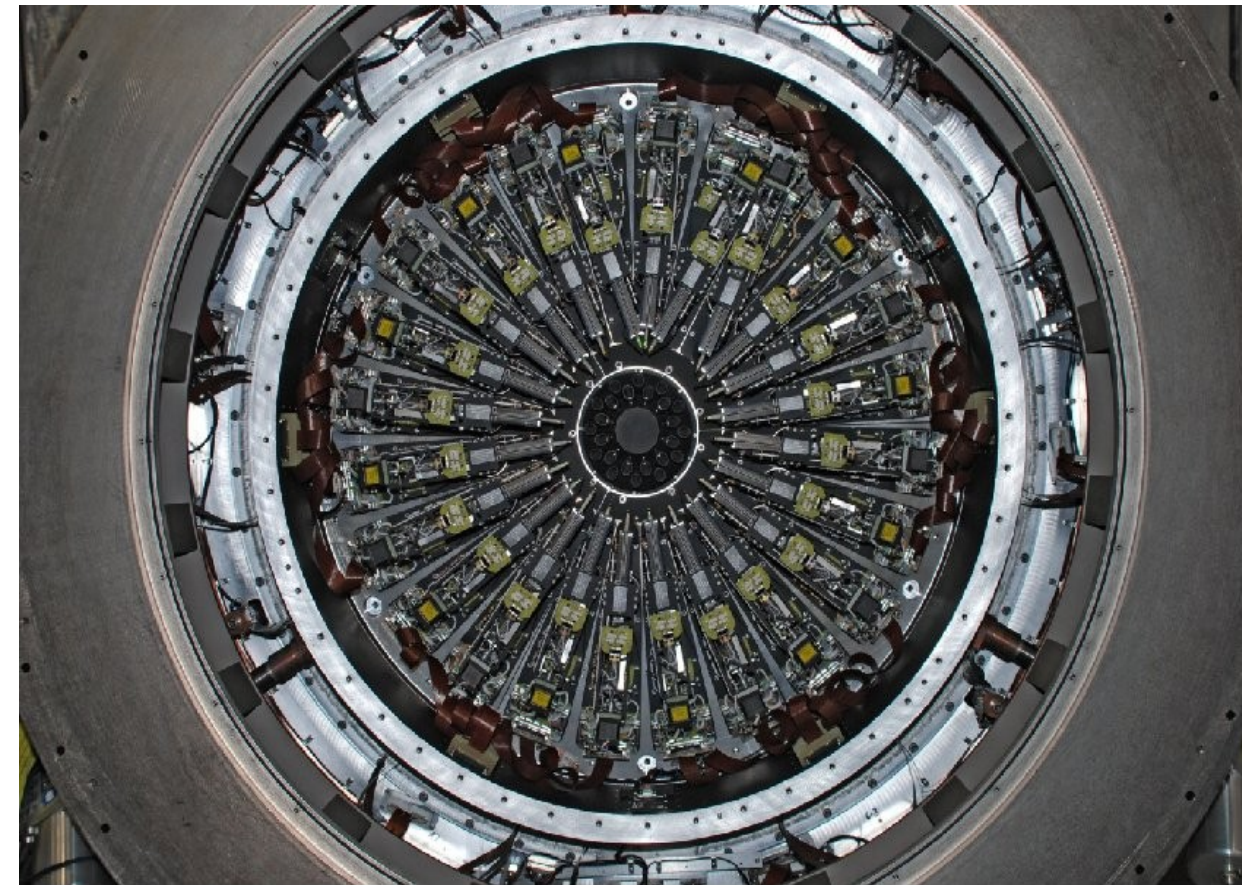
- Second generation instrument.
- Offered for the first time last semester.
- Spatially resolved multi-object spectra.

- 24 arms equipped with Integral Field Units.
- Each IFU field divided in 14 slices of 14 spatial pixels.

- Coverage: 0.8 to 2.5 micron.
- $R \sim 2000$ to 4000.
- 5 bands (IZ, YJ, H, K, HK).



KMOS



- Multi-object spectroscopy of high- z galaxies, resolve rotation curves of galaxies.



UVES

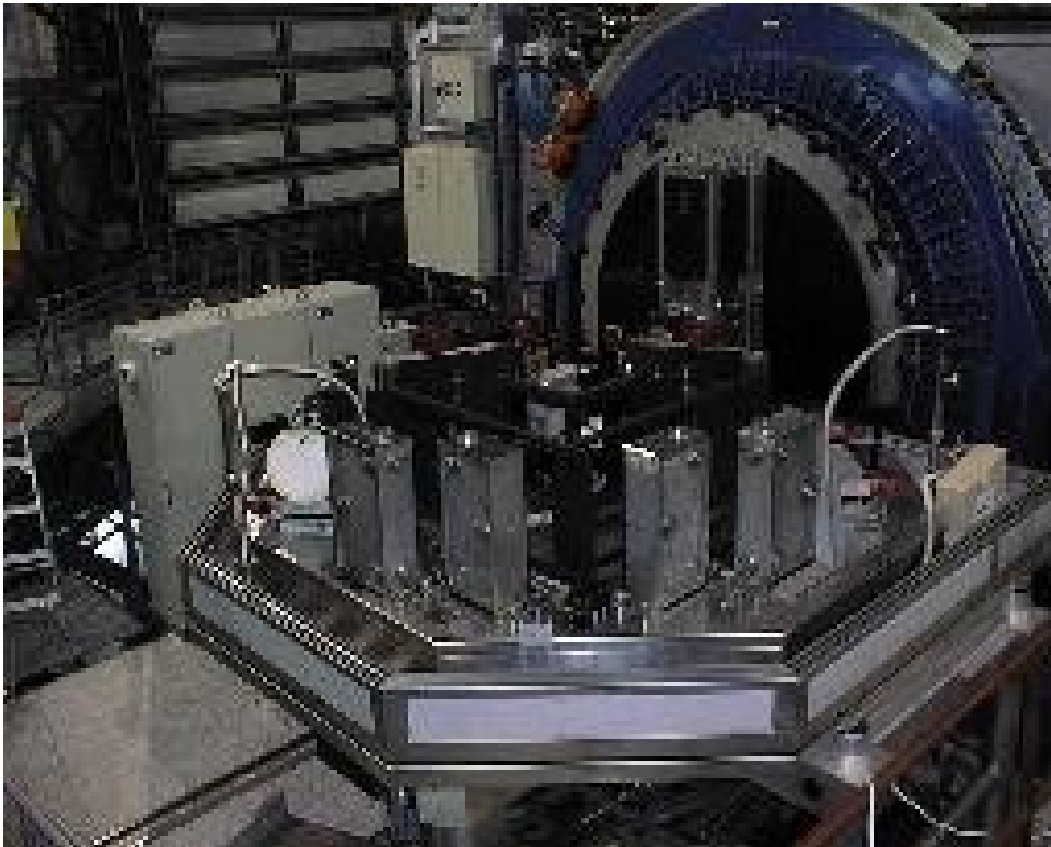


Ultraviolet and Visual Echelle Spectrograph

- High-resolution, high-coverage spectrograph.
- 300nm to 1100 nm (2 set ups to get full coverage).
- Use dichroics to split the light in two arms (blue + red).
- Blue and red optimized CCDs.
- up to $R \sim 80000$ (blue) and $R \sim 100000$ (red).
- Image slicers.
- Iodine Cell.



UVES



- Chemical abundances in stars, magnetic fields, pulsations, radial velocities, kinematics of stellar clusters, planet search.
- Stars (early- to late-type), ISM, young object, supernovae, QSOs.



FLAMES



Fiber Large Array Multi-Element Spectrograph

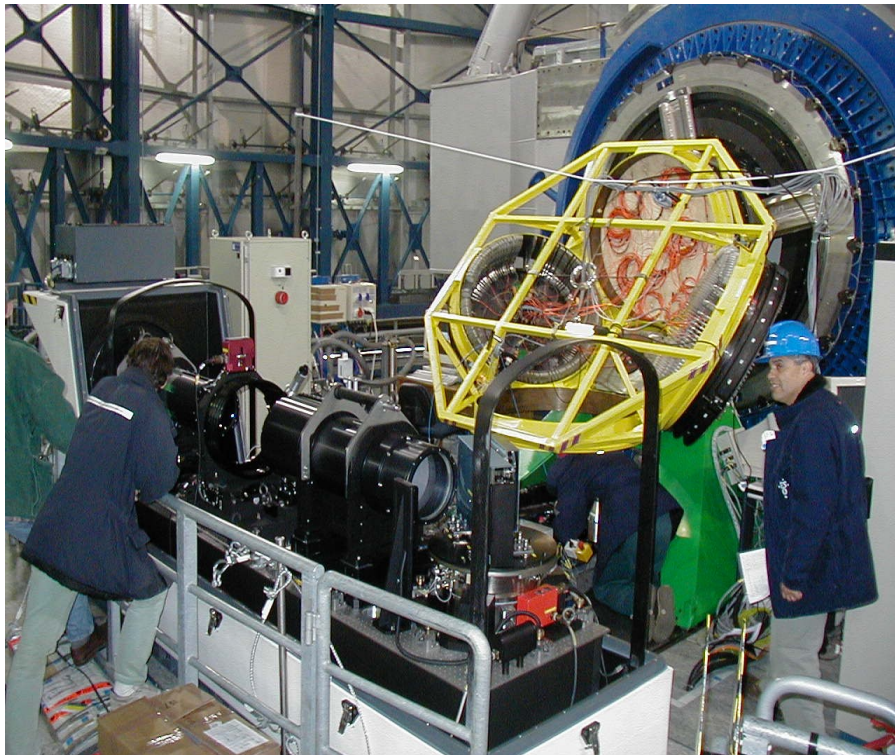
- Multi-object intermediate and high-resolution spectrograph.
- Field of 25 arcmin of diameter.
- Two plates for configuring targets.
- 132 individual fibers, 15 small IFUs, one large IFU.

Two spectrographs:

- Giraffe: $R \sim 5600$ -46000, 370-950nm.
- UVES: 8 fibers, $R \sim 47000$, red set ups.



FLAMES



- Multi-object spectroscopy of crowded/dense fields.
- Magellanic clouds, stellar clusters, bulge, dwarf galaxies, nearby galaxies.
- Kinematics, chemical abundances, radial velocities.



ISAAC



Infrared Spectrometer And Array Camera



Likely to be
decommissioned in
Dec. 2013



SPHERE



Spectro-Polarimetric High-contrast Exoplanet REsearch

- Main driver: direct imaging of extrasolar planets.
- Imaging, polarimetric imaging, long slit spectroscopy, integral field spectroscopy, differential polarimetric imaging.
- Imaging, long slit spec.: 0.95-2.32 micron ($R \sim 50-500$).
- IFS: 0.95 - 1.70 micron, $R \sim 30$.
- Diff. Pol. Imag.: 0.6-0.9 microns.



X-Shooter



Medium resolution multi-wavelength spectrograph

- Divides the light in 3 arms, each with separated detectors:
UVB arm: 300-560 nm ($R \sim 4000$ to 9900),
VIS arm: 560-1024 nm ($R \sim 5400$ to 18200),
NIR arm: 1024-2480 nm ($R \sim 3800$ to 10500).
- Each arm is a cross-dispersed echelle spectrograph.
- Each arm with a different slit (different resolutions) and different exposure times.
- IFU mode.



X-Shooter



- Brown dwarfs, star forming regions, close binaries, stellar remnants, SNe, GRBs, high-redshift galaxies.



VIMOS



Visible Multi Object Spectrograph

- Visible (360-1000nm).
- Wide field imager, multi-object spectrograph, and IFU.
- Field of View: four quadrants of 7'x8' separated by 2'.

Imaging

- 6 broad band filters UBVRIz.

MOS

- R ~ 180 to 2500 with 6 different grisms.
- Masks with up to 750 slits per quadrant.



VIMOS

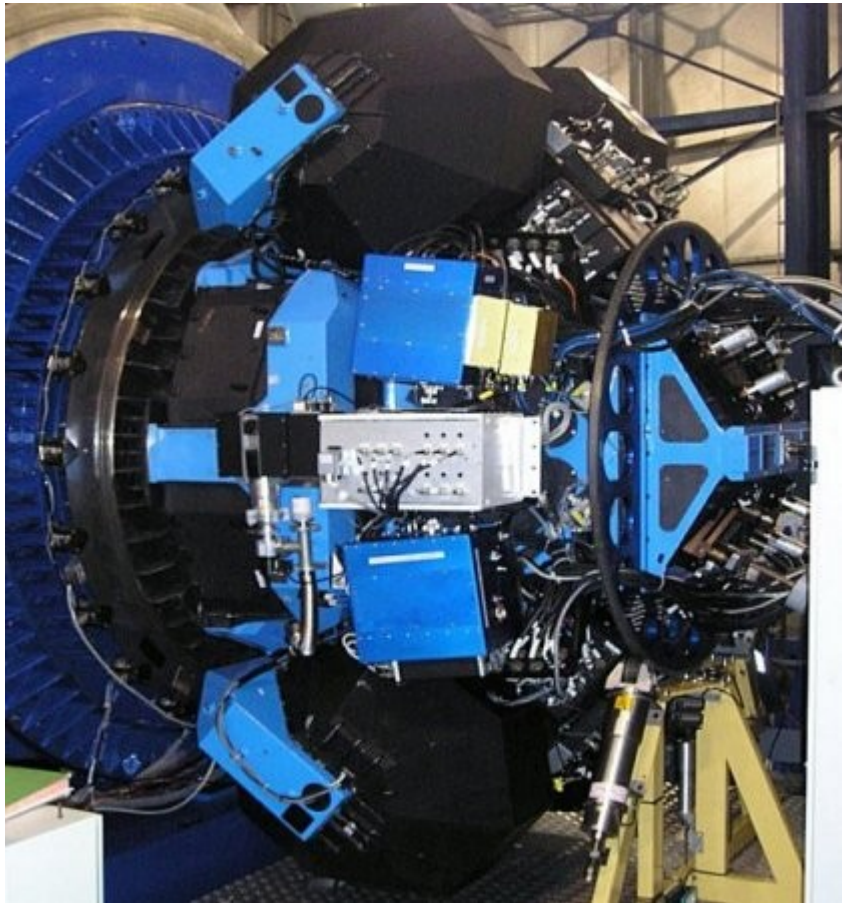


IFU

- 6400 microlenses coupled to fibers.
- Two spatial samplings: 0.67" per fiber or 0.33" per fiber.
- FoV in low resolution: 54" x 54" or 27" x 27".
- 1/4 of the field for higher resolutions.
- Same grisms as MOS .



VIMOS



- Kinematics of stellar populations in galaxies, globular clusters in nearby galaxies, high-z galaxies, imaging of galaxies.



HAWK-I



High Acuity Wide field K-band Imager

- Near infrared cryogenic wide-field imager (0.85-2.5 microns).
- 7.5' x 7.5' FoV in 4 detectors (15" gap).
- 4 Broad band filters (Y, J, H, K).
- 6 narrow band filters (Br. gamma, CH₄, H₂, 1.061, 1.187, 2.090 microns).
- 0.106"/px.



HAWK-I



- Surveys of faint sources: galaxies, emission lines in high-redshift objects.
- Embedded OB stars.
- Brown dwarfs.
- Solar system objects (ice bodies, comets, ...).



SINFONI

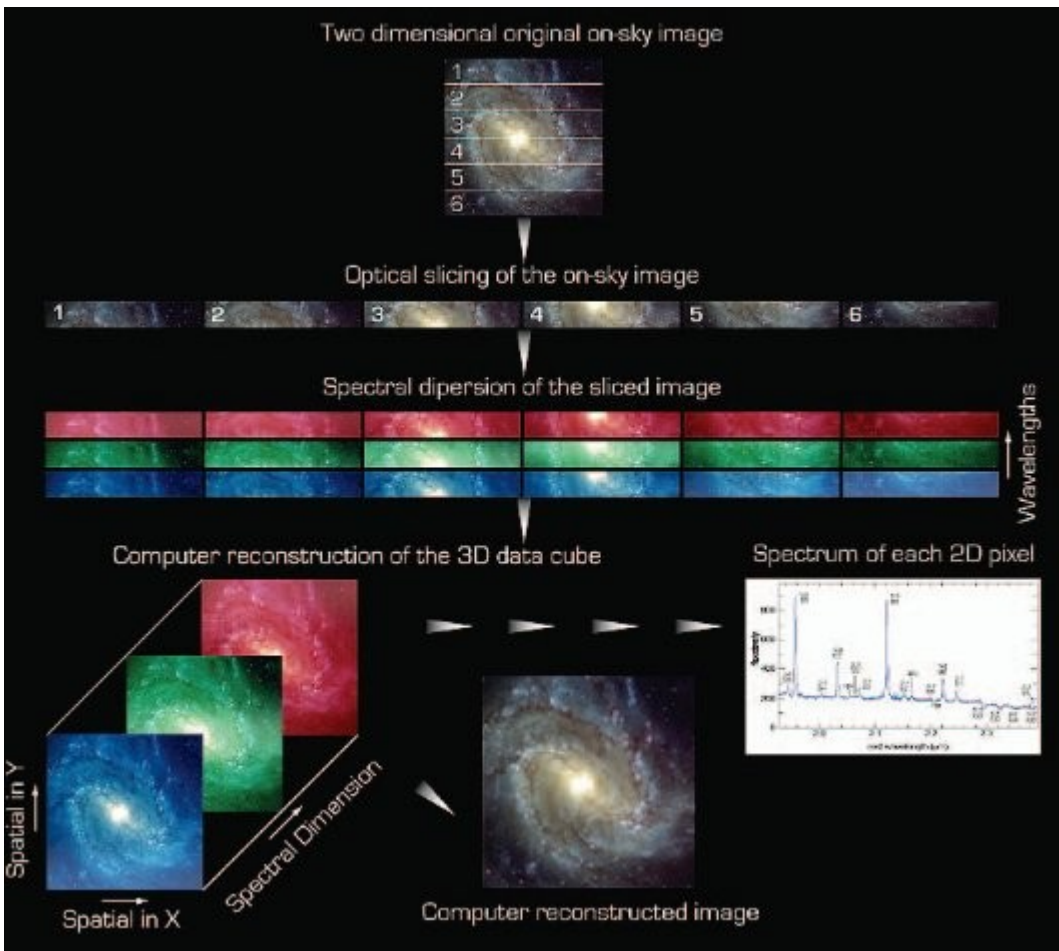


Spectrograph for INtegral Field Observations in the Near Infrared

- Near infrared (1.1-2.45 microns) integral field spectrograph.
- Fed by adaptive optics module.
- 32 slitlets imaged in 64 px each (32 x 64 spectra).
- Spatial resolution: 0.25", 0.1" or 0.025" per slice.
- FoV of 8"x8", 3"x3", 0.8"x0.8" divided in 32 slices.
- 4 gratings at J, H, K or H+K bands.
- R ~ 2000, 3000, 4000, 1500, in each band respectively.
- Can be used with the Laser Guide Star.



SINFONI



- Studies of the Galactic center
- Spectroscopy of AGNs
- Kinematics of high-redshift galaxies
- Super massive black holes
- Star forming regions
- Supernovae
- Obscured stellar clusters
- Small solar system bodies



NACO



NAOS - CONICA

Nasmyth Adaptive Optics System (NAOS)

Near Infrared Imager and Spectrograph (CONICA)

- Imaging, imaging polarimetry, coronagraphy, spectroscopy.
- Adaptive optics assisted.
- Can be used with the Laser Guide Star.

Is likely to be decommissioned in 2013



MUSE



Multi-object Spectroscopic Explorer

- 24 IFUs in a field corrected by adaptive optics.
- Fields: 1'x1' or 7.5"x7.5".
- Range: 465-930 nm.
- R ~ 2000 to 4000.

- Formation of galaxies, kinematics of nearby galaxies, dense stellar fields, solar system objects.



VLTI



The Very Large Telescope Interferometer



- Can use 4 UTs and/or 4 ATs.
- ATs have 1.8 m.
- UTs are fixed.
- ATs can be moved.

- Up to 3 tel. can be combined.

The VLT Array on the Paranal Mountain





AMBER



Astronomical Multi-BEam combineR

- The near-infrared/red focal instrument of the VLTI.
- Can use 2 or 3 beams.
- Operates in the J, H, K bands (1.0-2.4 microns).
- Angular resolution 2-50 mas (UTs) or 2-140 mas (ATs).
- Limiting H = 7 mag (UTs) or H = 5 mag (ATs).
- Measures visibility and closure phase.

Science examples:

- Circumstellar disks, multiple stars, AGNs, evolved stars.



MIDI



MID-infrared Interferometric instrument

- The mid-infrared instrument of the VLTI.
- Can use 2 beams (UTs or ATs).
- Measures visibility.
- Operates in the N-band, 8-13 microns.
- Limiting $N = 5.7$ to -0.44 , depending on mode and telescope.

Science examples:

- Circumstellar disks, multiple stars, AGNs, evolved stars.



VISTA



Visible and Infrared Survey Telescope for Astronomy



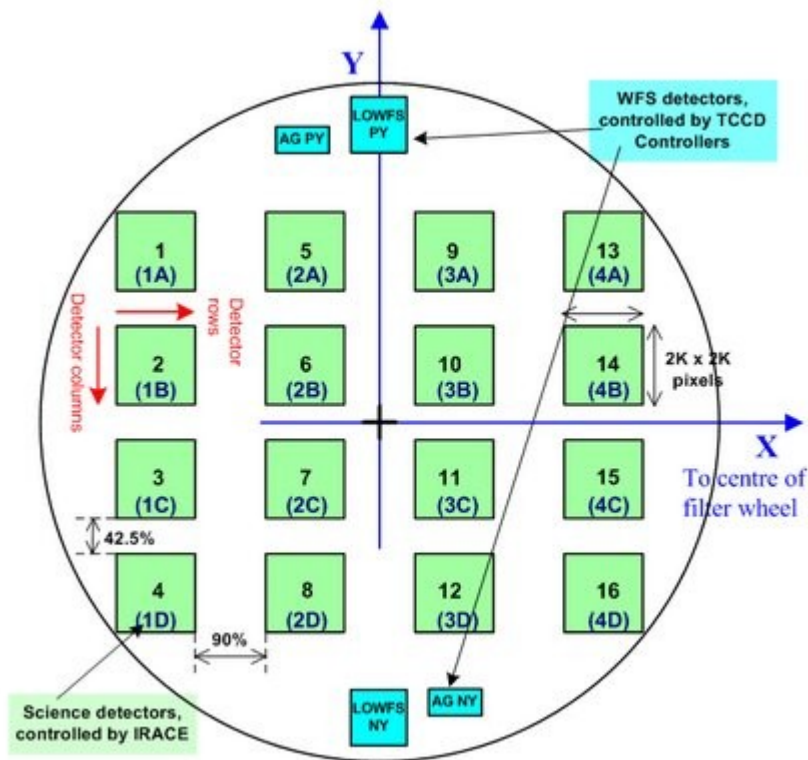
- 4m survey telescope.
- Alt-azimuth mount.
- Wide field (1.65 deg of diameter).
- Z, Y, J, H, Ks broad band filters.
- 3 narrow band filters.
- ~1500 m from the VLT.
- **Used for Public Surveys, limited time available.**



VIRCam



VISTA InfraRed Camera



- 16 detectors (2048 x 2048 px).
- 0.34"/px.
- Use has to be justified: Why your science can not be done with data collected by the public surveys?



VST



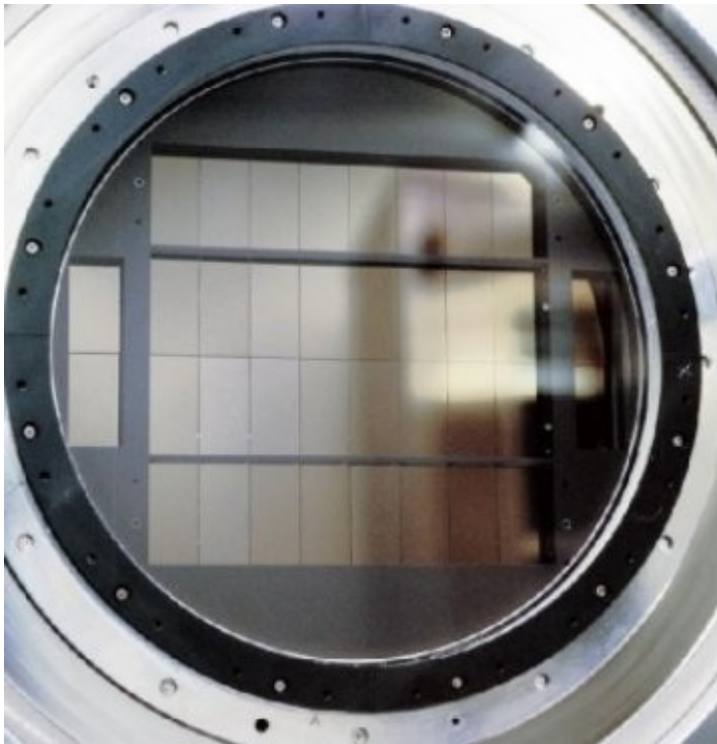
VLT Survey Telescope



- 2.6m wide field survey telescope.
- Alt-azimuth mount.
- Wide field (1x1 deg of diameter).
- ugriz (SDSS filters).
- BV Johnson, v Stromgren, Halpha.
- **Used for Public Surveys, limited time available**



OmegaCAM



- 32 detectors (2048 x 2048 px).
- 0.21"/px.
- Use has to be justified: Why your science can not be done with data collected by the public surveys?



APEX



Atacama Pathfinder EXperiment





APEX



- 12m radio antenna.
- APEX is a collaboration between Max Planck of Radio Astronomy, Onsala Space Observatory, and ESO.
- ESO has ~ 25% of the observing time.
- Important to check when ESO time is scheduled.
- Observes 24 hours a day.

- Has facility instruments but also PI instruments available for collaborations.

Facility instruments

Instrument	Type	Mode	Frequency [GHz]	HPBW [arcsec]	IF range [GHz]	# of beams	Location	Status	Comment
APEX-1 (SHeFI)	Heterodyne SIS	SSB	214 - 275	30 - 25	4 - 8	1	Nasmyth-A	✓	
APEX-2 (SHeFI)	Heterodyne SIS	SSB	267 - 378	23 - 17	4 - 8	1	Nasmyth-A	✓	
APEX-3 (SHeFI)	Heterodyne SIS	DSB	385 - 500	17 - 13	4 - 8	1	Nasmyth-A	✓	
APEX-T2 (SHeFI)	Heterodyne HEB	DSB	1250 - 1390	5	2 - 4	1	Nasmyth-A	✗	Science Verification pending
LABOCA	Bolometer array		345	19		295	Cassegrain	✓	
SABOCA	Bolometer array		850	8		39	Cassegrain	✗	warmed up

PI instruments

Apart from the facility receivers, PI instruments will be installed at APEX during longer or shorter time periods. Some of them can be used by the community in collaboration with people from the corresponding PI group. In case of the MPIfR instruments, contact Rolf Güsten (rguesten(at)mpifr-bonn.mpg.de) *before* submitting any proposals.

Instrument	Type	Usage	Frequency [GHz]	HPBW [arcsec]	# of beams	Location	Status	Comment
FLASH	Heterodyne SIS	PI (MPIfR)	272-377	17-22	1	Nasmyth-A	✓	
			385-495	12-14	1		✓	
CHAMP ⁺	Heterodyne SIS	PI (MPIfR)	620-720	9-7	7	Nasmyth-B	✓	
			780-950	7-6	7		✓	
ASZCA	Bolometer array	PI (MPIfR)	150	42	330	Cassegrain	✗	Decommissioned in December 2010
ARTEMIS	Bolometer array	PI (ESO)	670, 1500	9, 4	256	Nasmyth-A	✗	Available March 2013
PolKa	Polarimeter	PI (MPIfR)	345	19	295	Cassegrain	✗	Commissioning pending

Science with APEX: cold dust and gas in the Galaxy and in distant galaxies, structure and chemistry of planetary atmospheres, dying stars, regions of star formation, starburst galaxies, and comets.



Observing Modes



Service x Visitor Mode

Service: prepare “observing blocks” to be executed by the observatory. (~ 60% time in Paranal)

- Flexibility of schedule, do not need full nights, define observing conditions, calibration data taken by the observatory. (not possible VISTA, VST, APEX)

Visitor: travel to the observatory for the observations

- Real time decisions, specific instrument configurations, backup programme recommended, La Silla only in visitor mode (3 nights minimum).



Proposal Types



During P92 these types were available:

- Normal Programmes (those that don't fall under the other categories below)
- Monitoring Programmes
- Large Programmes
- Target of Opportunity
- Guaranteed Time Observations
- Calibration Programmes
- Director's Discretionary Time



Monitoring Programmes



- **Goal:** monitor targets over more than one period
- Minimum of 2 periods and up to 4.
- Service and visitor mode allowed
- Not for La Silla, VISTA or VST (and some VLT instr.)
- Less than 100 hours
- For APEX only possible in ESO time (roughly every 2 months)
- Targets of opportunity not possible



Large Programmes



- **Goal:** massive time allocation for major advance or breakthrough in the field of study.
- Minimum of 100 hours of observing time.
- Up to 30% of observing time can be allocated to LPs.
- Span from 1 to 4 periods at the VLT.
- Up to P97 in La Silla.
- Service and visitor mode allowed.
- Targets of opportunity not possible.
- Science data products returned to ESO (Phase 3).
- Not VST, VISTA and some VLT instruments.



Target of Opportunity



- **Goal:** observation of astronomical events that can not be predicted, or can be only poorly predicted
- Up to 5% of observing time allocated to ToO
- Observed usually during Service Mode (only under exceptional conditions overrides Visitor Mode)
- Depends on trigger activation
- Targets not known up to 1 week before observation



Target of Opportunity



- **Rapid Response Mode**
- Special type of ToO needing activation up to 4 hours after the event.
- Limited number of instruments accept RRM (FORS2, UVES, X-Shooter, SINFONI, HAWK-I)
- Upon receiving trigger, ongoing observations are aborted!
- Telescope can be on target ~6 min after trigger
- Override both service and visitor mode
- Restricted instrument set ups available



Calibration Programmes



- **Goal:** Calibrate some poorly calibrated instrument mode.
- ESO instruments are complex, not all modes have full calibration plans
- Community can request time to execute calibration blocks
- Up to 3% of observing time can be allocated
- Documentation requested from the proposer



DDT



- **Director's Discretionary Time**
- **Goal:** Flexibility

- Up to 5% of observing time can be allocated
- Accepted at any time
- Sudden and unexpected event
- Observations on highly competitive topic
- Quick follow-up of a recent observation that can lead to break-through results
- Risky proposal that need small amount of time to test feasibility



Other



Host state proposal (Chilean proposals)

- Has a PI with Chilean affiliation
- Up to 10% of observing time can be allocated
- VLT: At least half needs to be in collaboration with astronomers in ESO member countries

Non-member state proposal

- 2/3 or more proposers are not affiliated to ESO member state institutes
- Affiliation of the PI does not matter
- Nationality does not matter