Very Large Telescope

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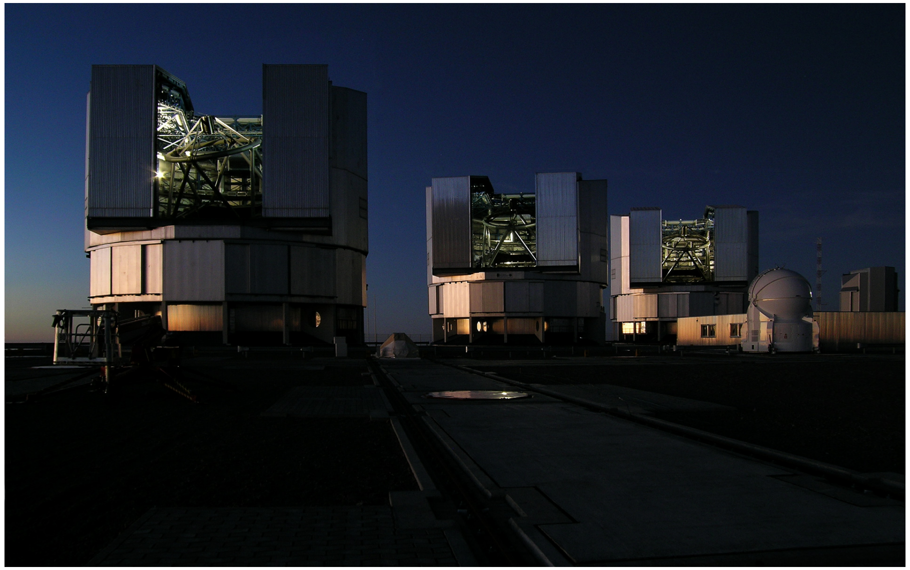
Outline

- What is VLT
  - Basic information
  - Main elements
  - VLTI
  - Comparison with LBT
- What has been done with VLT/VLTI
  - Fundamental sciences
  - Exoplanet detection
  - Cosmic evolution
- Summary

What is VLT

VLT Very Large Telescope

Full Name	Very Large Telescope
Observatory	Paranal Observatory
Location	Atacama Desert Chile
Coordinates	24.37.38S 70.24.15W
Organization	European South Observatory
Altitude	2,635m
First light	1998
Observing Time	340 nights per year
Wavelength coverage	300nm~20μm
Telescope style	Optical telescope
Diameter	four 8.2m mirrors and four 1.8m mirrors
Focal length	120m



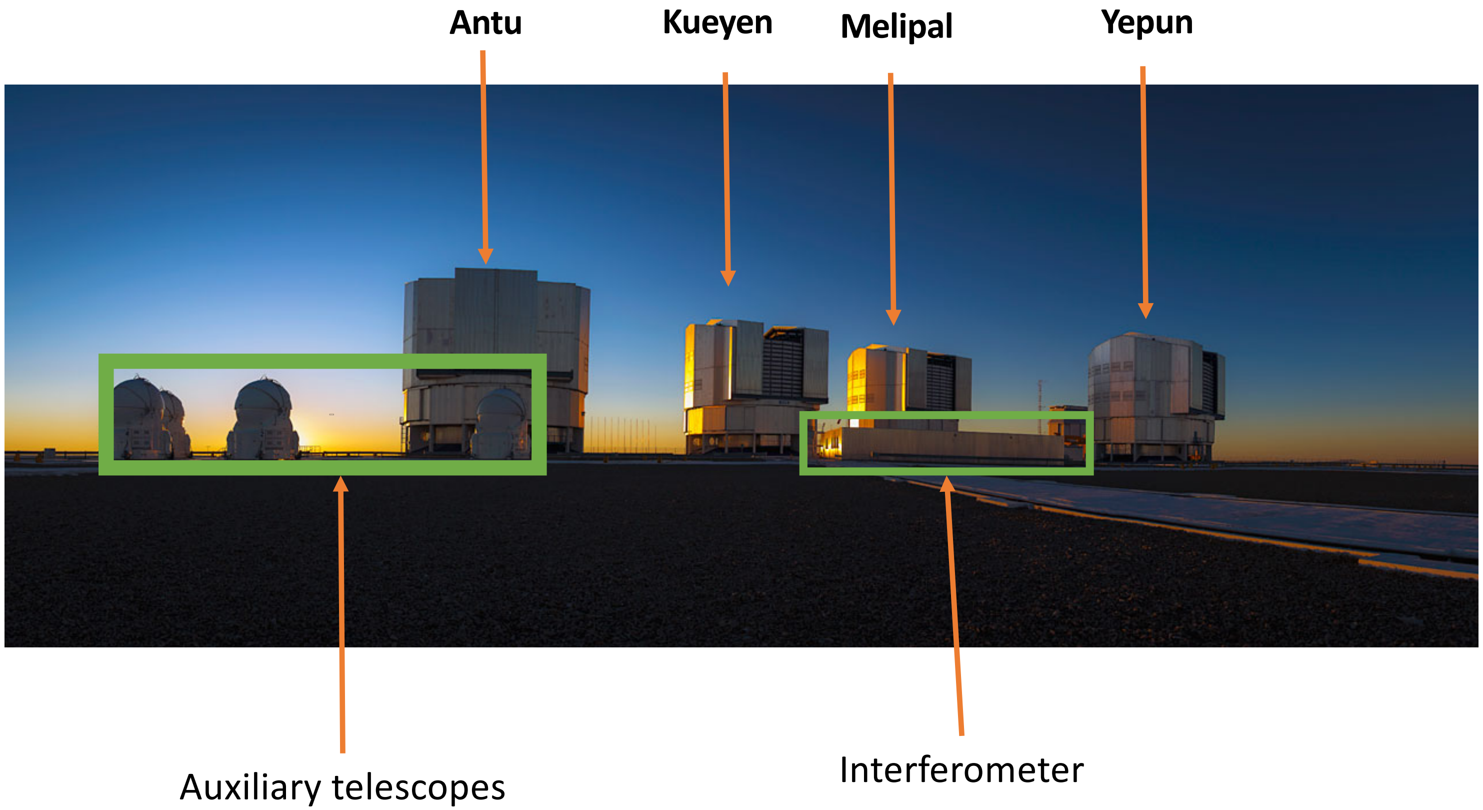
Main elements and Instrument of VLT

Main elements:

- Four 8.2m unit telescope
- Four 1.8m auxiliary telescope
- VLT Interferometer

3 modes:

- Independent telescope mode
- Combined coherent mode(VLTI)
- Combined Incoherent mode



Instruments

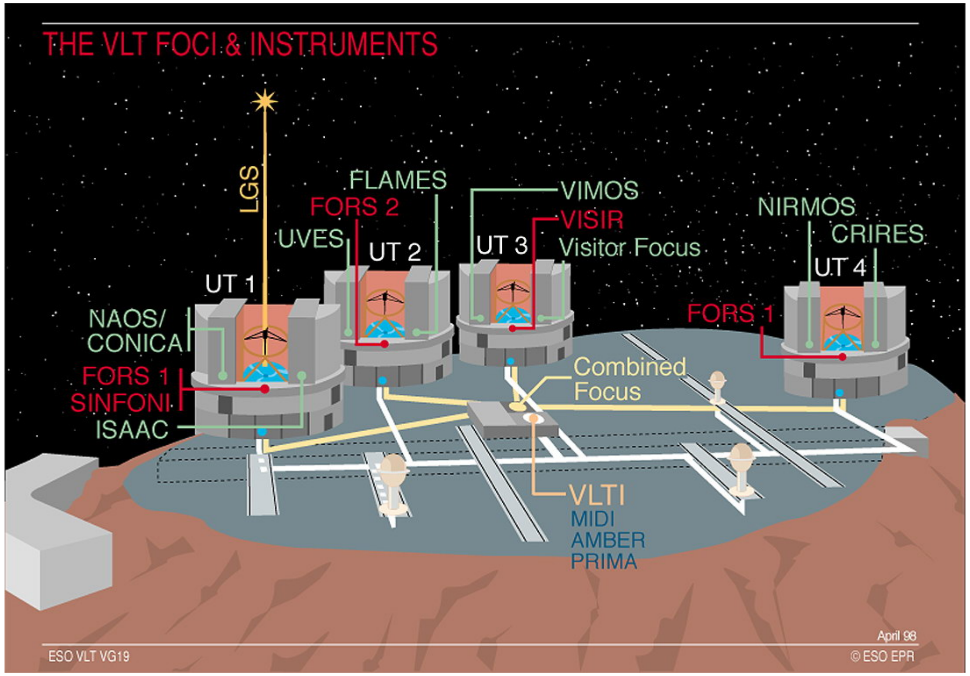
Multiobject spectrograph: **750 objects**

Widest FoV:4*7 arcmin*7 arcmin

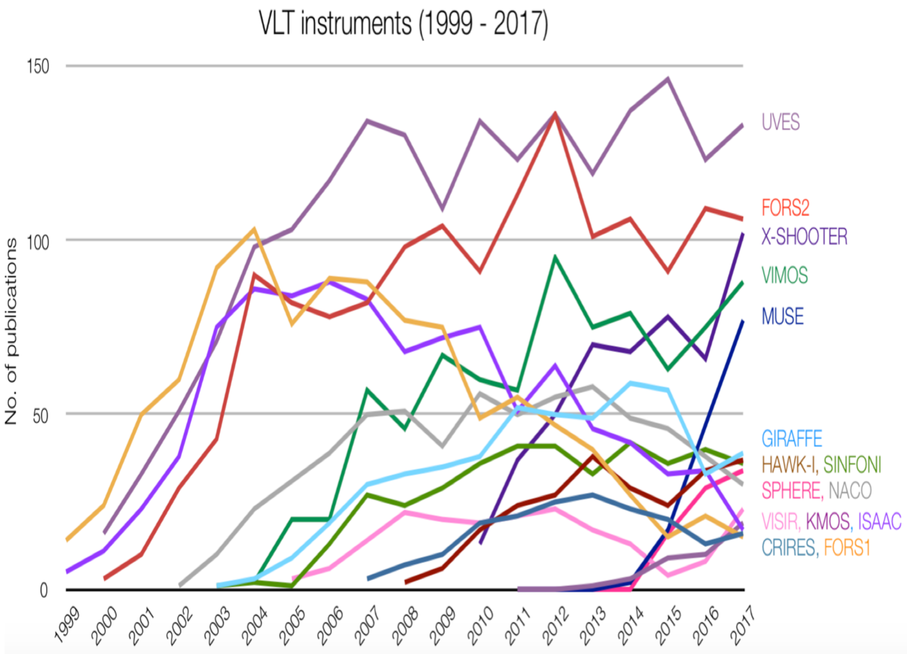
Wavelength coverage:300nm~25μm

Maximum spectral resolution:110,000

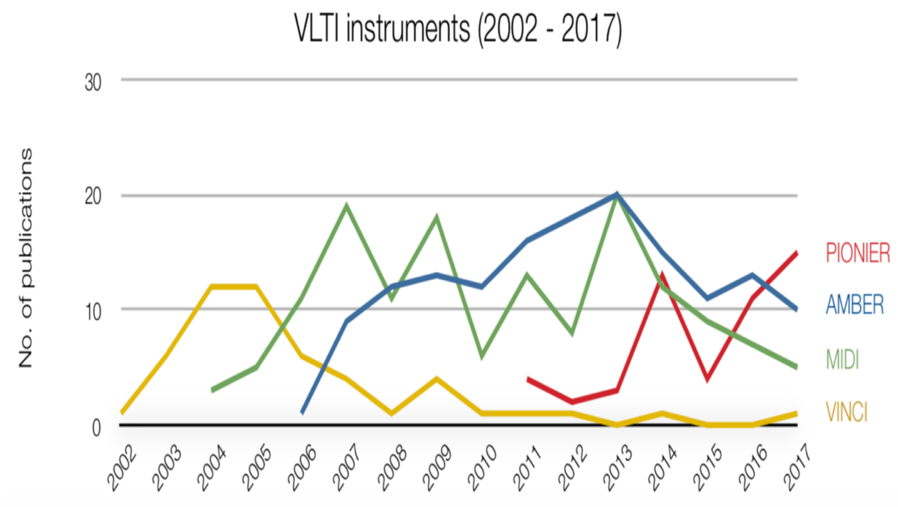
Optical Region(300-1000nm)	FORS
	UVES
	FLAMES
	VIMOS
Near-IR Region(1-5μm)	ISAAC
	CONICA
	CRIRES
	NIRMOS
	SINFONI
Mid-IR Region(8-25μm)	VISIR



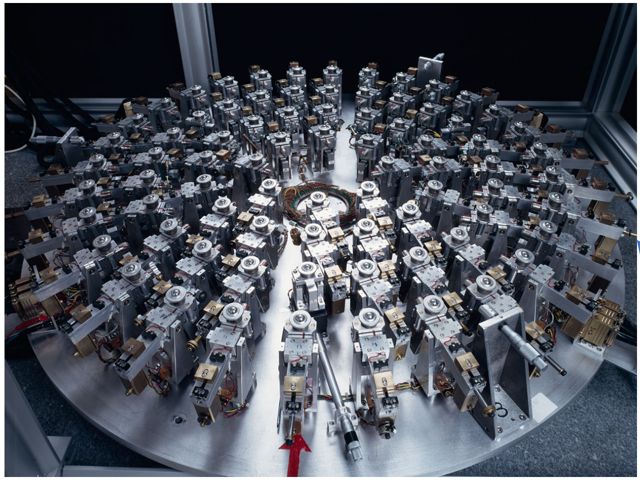
Publication of instruments

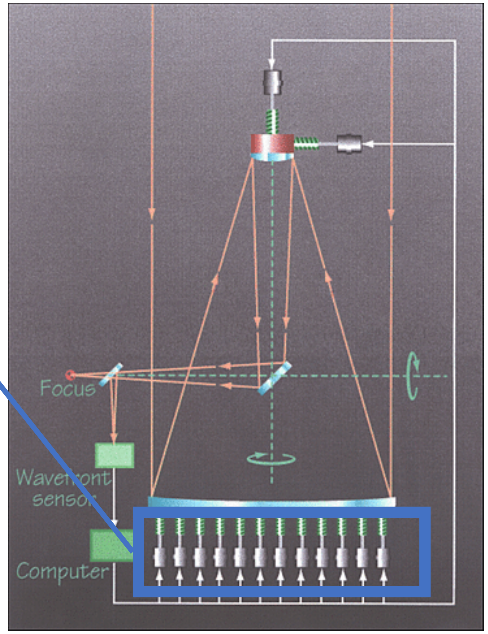


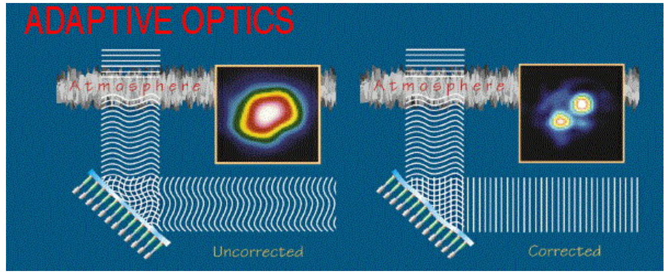
The overall trend of number of publication increased in recent years

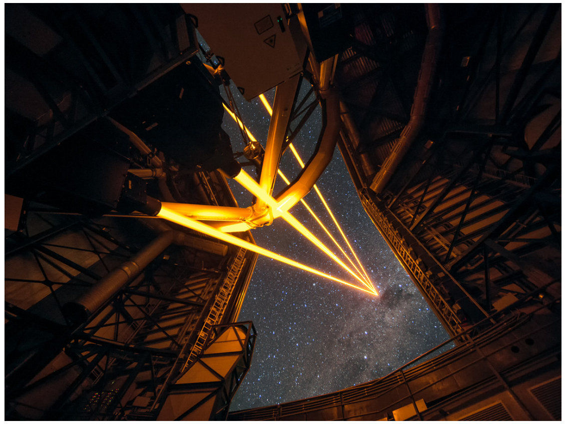


Active and Adaptive Optical Systems





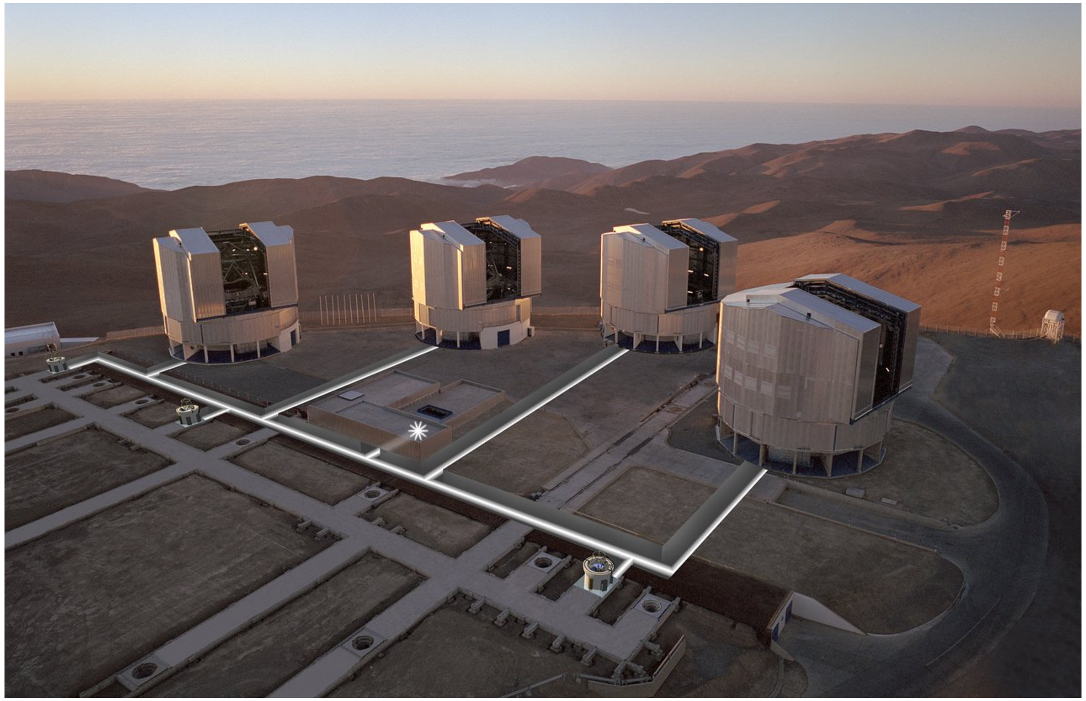


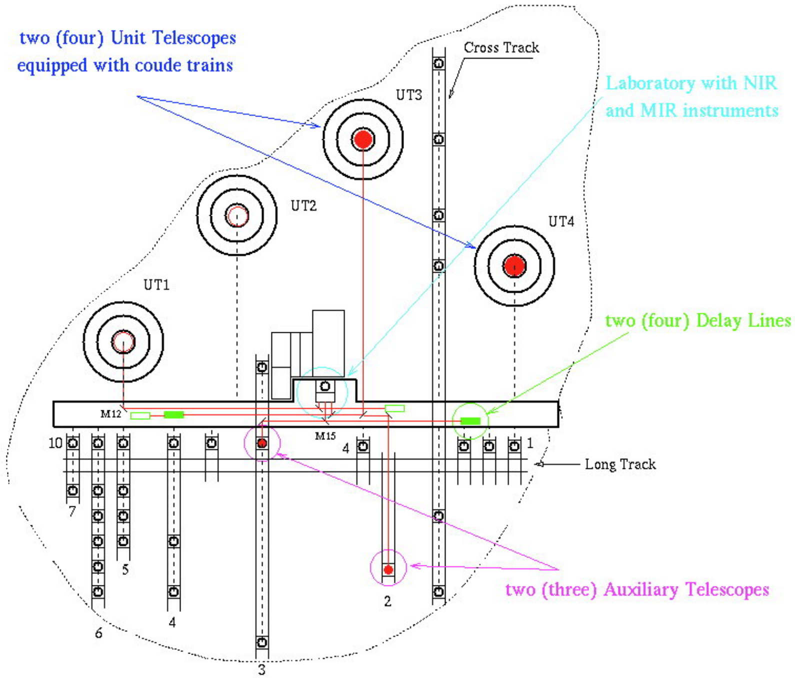


3 mode to satisfy different requirements

help VLT to achieve angular resolution of 1 milliarcsecond when works on VLTI mode

VLTI Very Large Telescope Interferometer





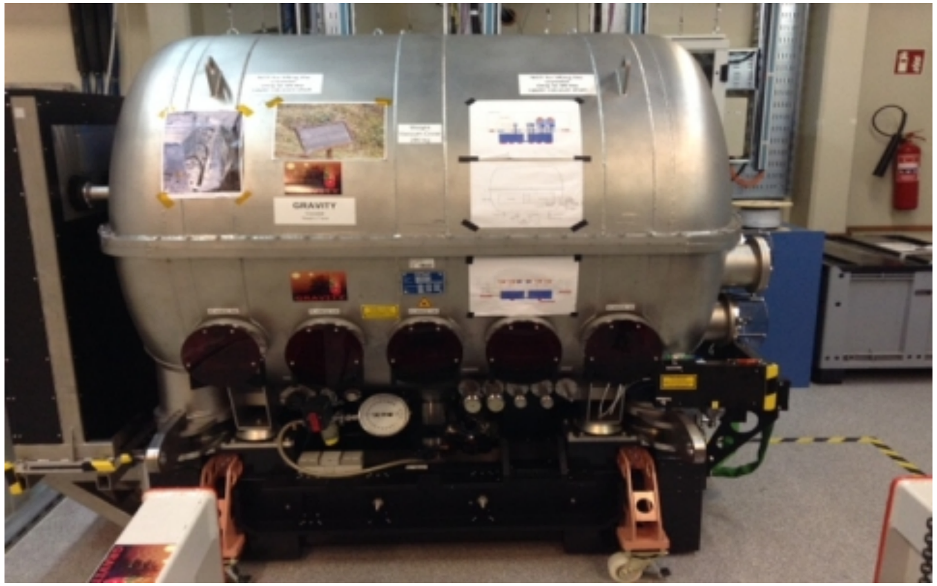
- **diffraction limit** with minimum of adaptive control
- **milliarcsecond angular resolution** at near infrared wavelengths.
- **Combine 2 UTs and 3 ATs simultaneously**

VLT vs LBT

	Large Binary Telescope	Very Large Telescope
time	2005-	1998-
instruments	two 8.4m wide mirrors	• four8.2m wide mirrors • four 1.8m auxiliary
Spectral resolution	270,000	110,000
coverage	320nm ~ 2.5μm	300nm ~ 25μm
cost	$120 million	$375million

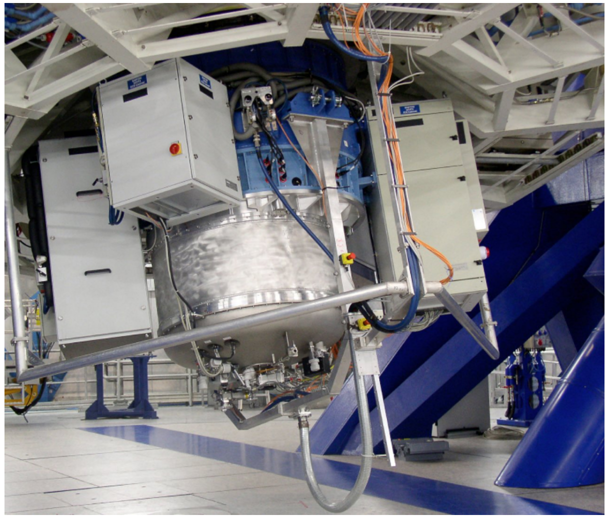
What has been done with VLT/VLTI

1. **Fundamental sciences**
   - Test general relativity
2. **Exoplanet detection**
   - Direct imaging
3. **Cosmic evolution**
   - Proto supercluster



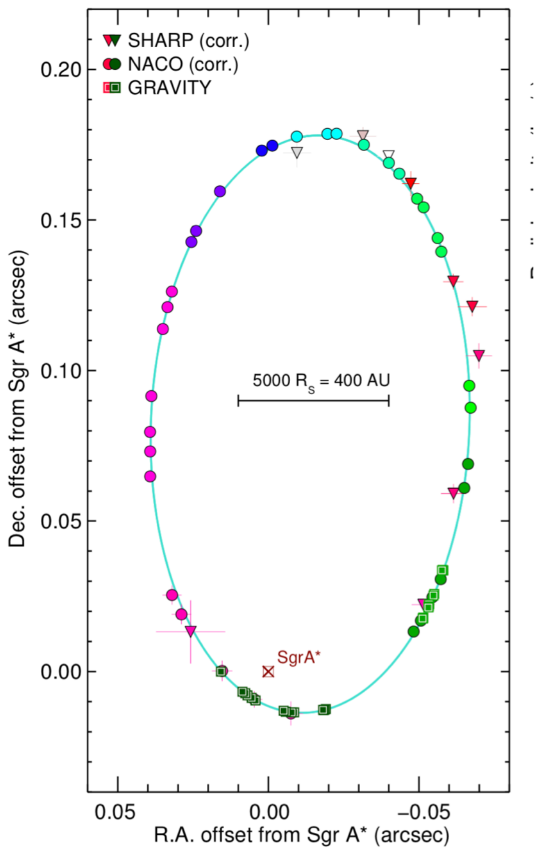
GRAVITY

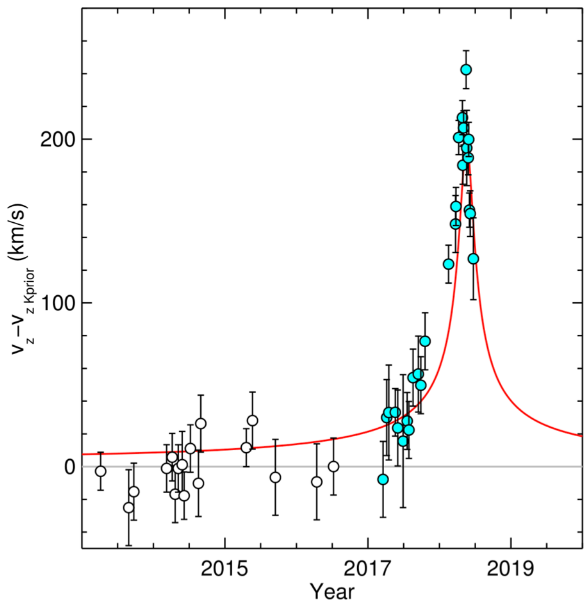
- Second-generation VLTI instrument for precision narrow-angle astrometry
- infrared astrometry with order 10 microarcsecond accuracy and phase referenced imaging with 4 milliarcsecond resolution
- Observe galactic central and central blackhole
- 4'' FoV for ATs and 2'' FoV for UTs

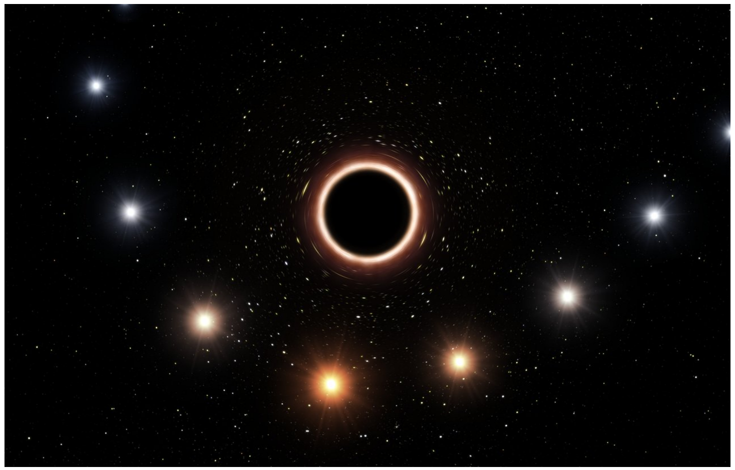


SINFONI

- Near-infrared integral field spectrograph
- UT4
- Infrared
- smallest pixel size is 0.025 arcseconds
- Spectal resolution: 1500–4000
- High spatial and spectral resolution studies of compact objects



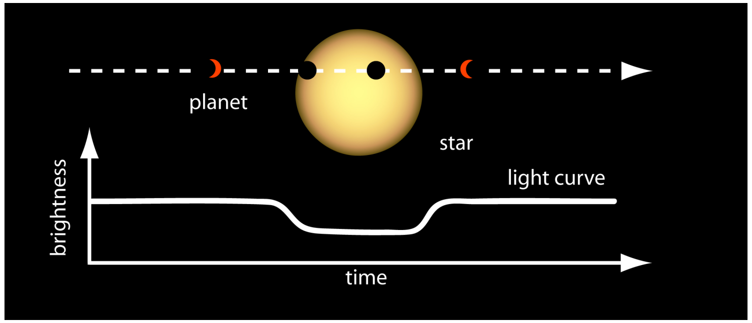




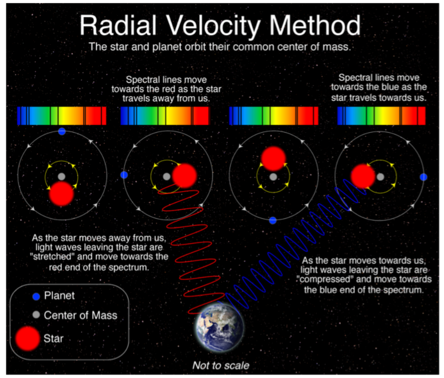
- **Observe S2 during May 2018 with GRAVITY, SINFONI and NACO when it reach the pericentre**
- **SINFONI is used to obtain the radial velocity while GRAVITY is used to detect proper motion**
- **Orbit velocity of S2 at pericentre is in excess of 25 million km/h (3% of the velocity of light)**
- **combined gravitational redshift and relativistic transverse Doppler effect for S2 of z = Δλ/λ ≈ 200 km/s/c**

1. **Fundamental sciences**
   -Test general gravity
2. **Exoplanet detection**
   - Direct imaging
3. **Cosmic evolution**
   - Proto-supercluster

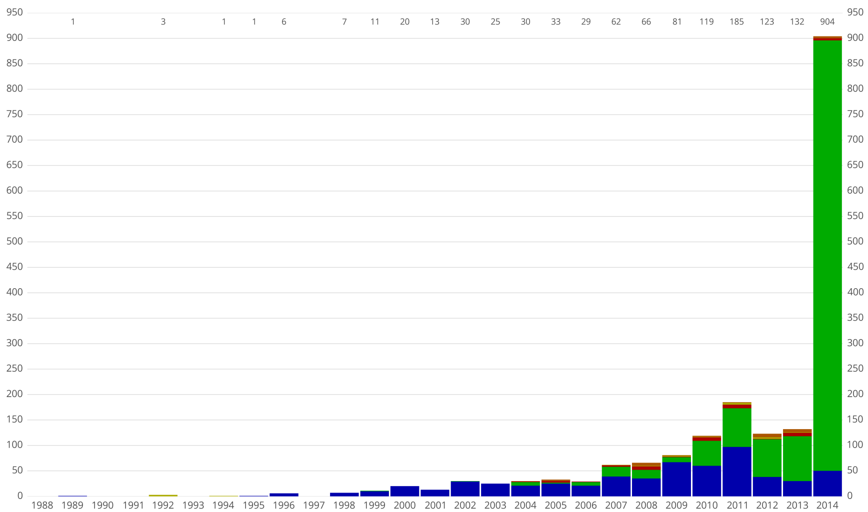
With VLT, high contrast and high angle resolution, direct imaging is possible



transit

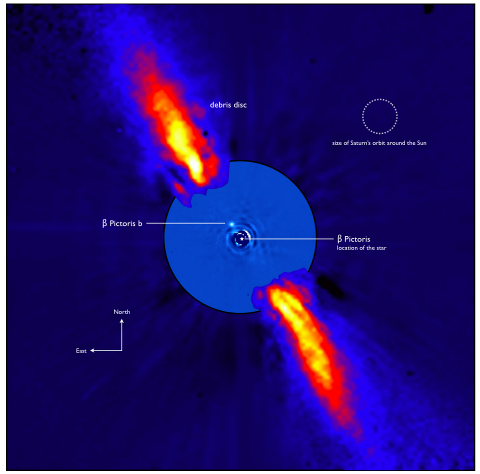


Radial velocity



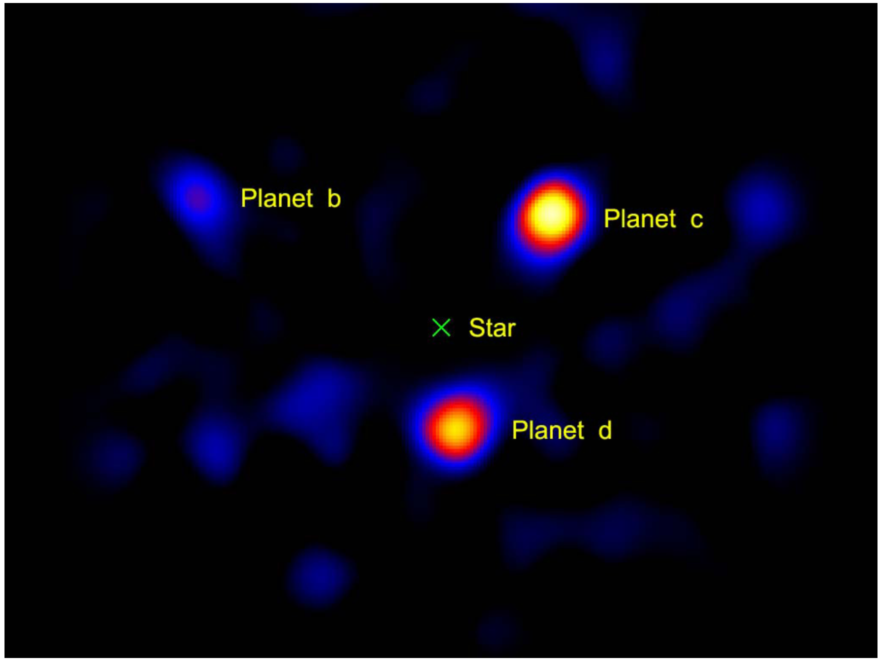
Statistic of method used for exoplanet detection

- Blue: radial velocity
- Green: transit
- Red: direct imaging
- Orange: microlensing



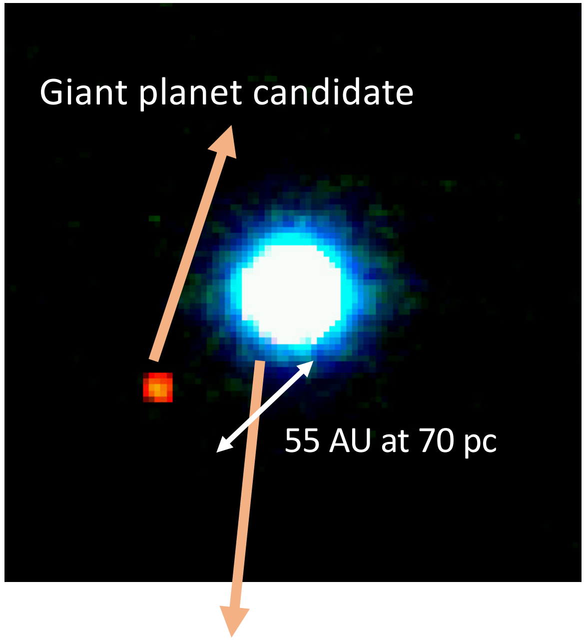
Direct imaging

Why Direct Imaging



- **Challenge 1: large ratio between star and planets flux**
- **Challenge 2: close proximity of planet to star**

- **Give constraints on planets' mass and radius simultaneously**
- **Determine chemical components of planet**
- **works better with planets with face-on orbits rather than edge-on orbits**



Source 2M1207(brown dwarf)

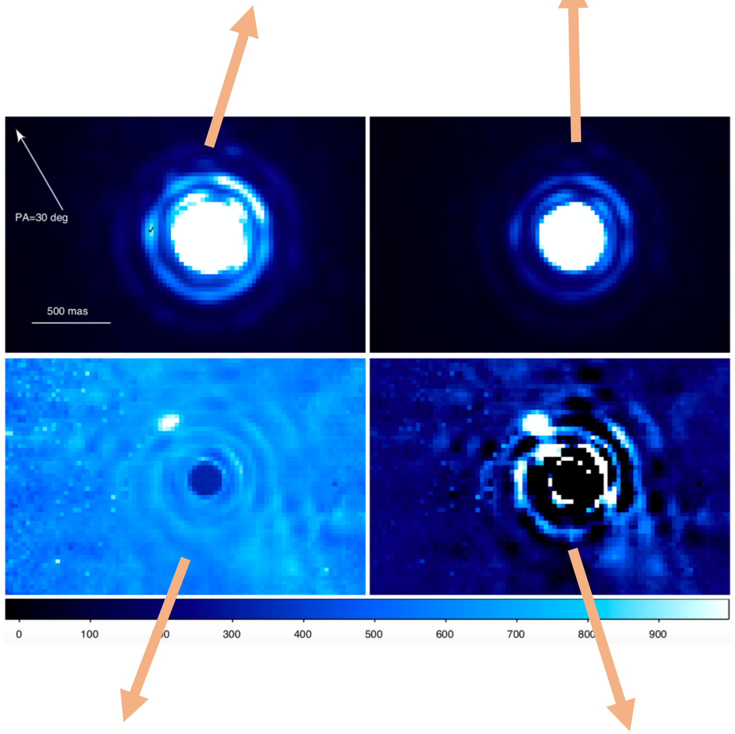
$Age{\sim}8^{+4}_{-3}Myr$

$Distance\ between\ the\ to\ object{\sim}55AU$

$Effective\ Temperature{\sim}1250 \pm 200K$

$M{\sim}5 \pm 2M_{Jup}$

β Pic HR 2435



Divide β Pic by HR 2435 Subtract background

This is a binary system, divide β Pic by HR 2435 to remove the PSF wings

The companion candidate point-like signal is clearly visible in the divided and subtracted images. The maximum of the signal is about 190 ADU

1. **Fundamental sciences**

   -Test general gravity

2. **Exoplanet detection**

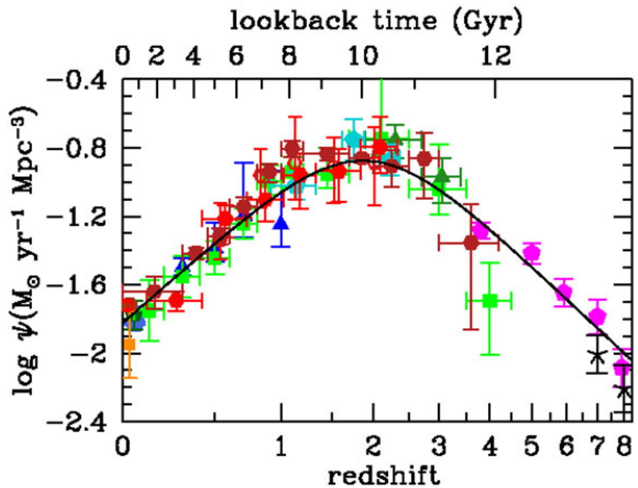
   - Direct imaging

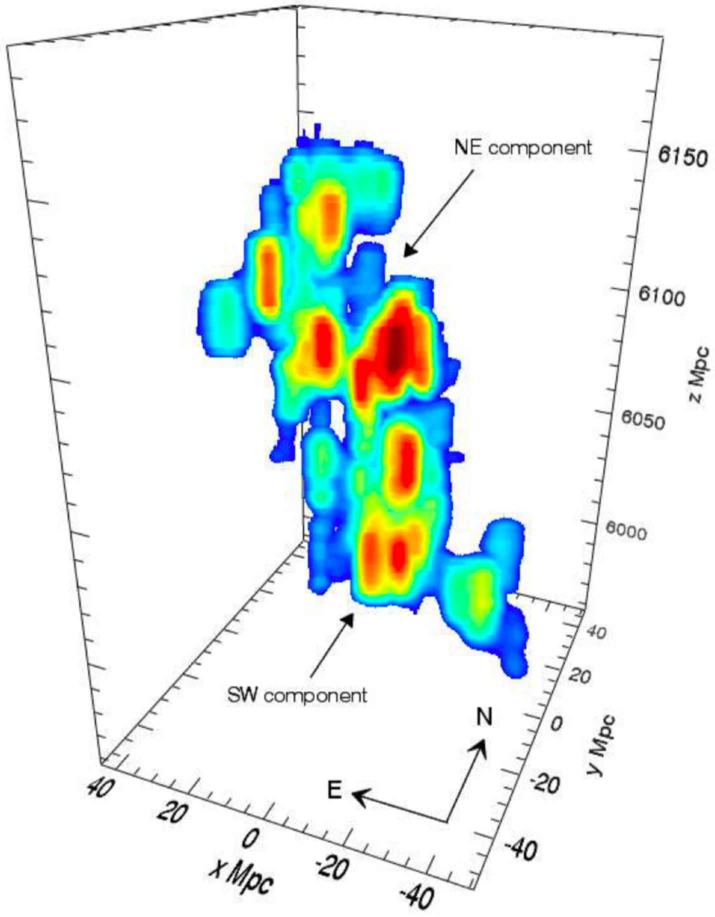
3. **Cosmic evolution**

   - Proto-supercluster

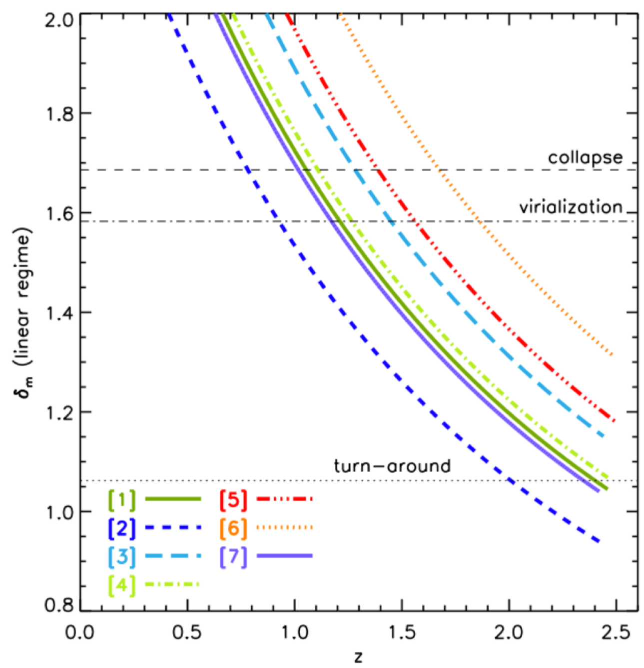
- What are proto-cluster
  - Diffused collection of halos that will merge into final halo
  - crucial sites for studying how environment affects galaxy evolution in the early universe

- How to find them
  - Unbiased tracer(star-forming galaxies, IR-luminous galaxies)
  - identification of large intergalactic medium reservoirs(Lyα forest absorption etc)
- Stellar formation rate peaks at z ~ 2





- **Construct 3D overdensity field over a volume of 100 × 100 × 150 comoving Mpc3 with VIMOS of VLT**
- **Identify proto-supercluster over a volume of 60 × 60 × 150 comoving Mpc3 whose total mass is** $\mathbf{4.8 \times 10^{15} M_{sun}}$
- **Seven density peaks in the range of 2.4<z<2.5 connected by filaments**
- **They will all be virialised at z ~ 0.8**



Summary

- VLT is the most powerful ground-based optical telescope with high performance. It has very high angular resolution which reaches to milliarcsecond.

- VIT is also a productive telescope and will play a important role in the future in many area for example, fundamental sciences, detection of exoplanet and understanding of the formation and evolution of galaxies.

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