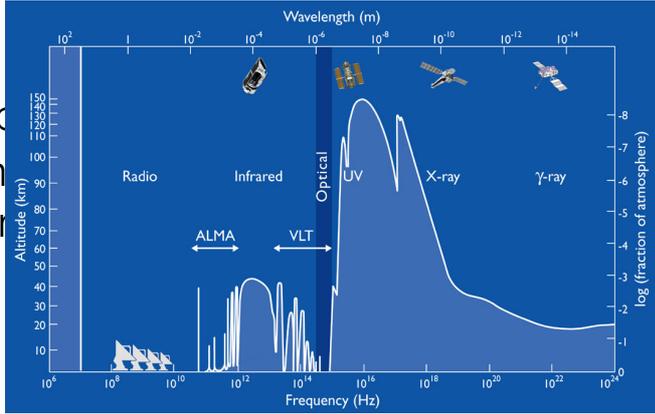




## Astrophysics in a Golden Age

- Full coverage of electro-magnetic spectrum  
MAGIC/HESS/VERITAS → Fermi/INTEGRAL → XMM/Chandra/Swift/Rossi XTE → Galex → HST/Gaia → ground-based optical/IR → ISO/Spitzer → Herschel → Planck → IRAM/JCMT/APEX/ALMA/NOEMA → radio telescopes
- Astrophysics
  - cosmology
  - dark matter



Brno | 2 September 2015 🇪🇺 🇩🇪 🇩🇰 🇫🇮 🇮🇹 🇯🇵 🇰🇷 🇸🇪 🇸🇰 🇨🇪 🇨🇯 🇩🇪 🇮🇹 🇸🇪 🇸🇰 🇨🇪 🇨🇯 🇩🇪 🇮🇹 🇸🇪 🇸🇰 🇨🇪 🇨🇯



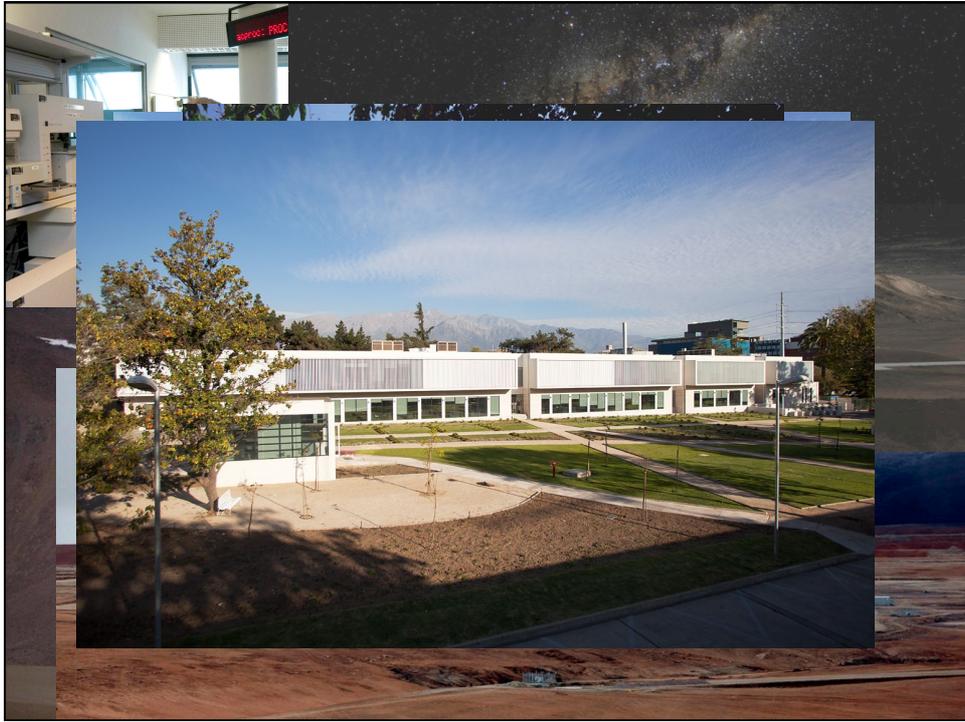
## Current ground-based facilities

- Large telescopes for a wide variety of investigations



Brno | 2 September 2015 🇪🇺 🇩🇪 🇩🇰 🇫🇮 🇮🇹 🇯🇵 🇰🇷 🇸🇪 🇸🇰 🇨🇪 🇨🇯 🇩🇪 🇮🇹 🇸🇪 🇸🇰 🇨🇪 🇨🇯







# Your entry to ESO

**Start with this page for the ESO science information**

www.eso.org/sci.html

European Southern Observatory

ESO — Reaching New Heights in Astronomy

Public Science User Portal Contact Site Map Search Go!

**Science Users Information**

- Observing Facilities
- Future Facilities and Development
- Observing with ESO Telescopes
- Science Software
- Data Handling and Products
- Science Archive Facility
- Science Activities
- Science Publications
- Science and Technical Meetings
- IT Services
- Libraries
- Vacancies

### Science Users Information

These pages are aimed at ESO community astronomers and contain all the information required in order to prepare, execute, process and exploit observations with ESO facilities. They also provide information on the scientific activities taking place at ESO. Details can be accessed via the navigation menu.

### ESO Science Announcements

**Call for Proposals for Period 97**  
**Published: 01 Sep 2015**

The [Call for Proposals](#) for observations at ESO telescopes in Period 97 (1 April - 30 September 2016) has been released. Please consult the [Call for Proposals document](#) for the main news items and policies related to applying for time on ESO telescopes. All technical information about the offered instruments and facilities is contained on ESO webpages that are linked from the Call. The deadline for proposals is **12:00 CEST 1 October 2015**.

[Go to Announcement](#)

**User Support Department Feedback Campaign**  
**Published: 31 Aug 2015**

The User Support Department (USD) invites principal investigators and their Phase 2 delegates to participate in a user feedback campaign. The survey is designed to provide USD with the opinions of the science community on a number of services, in particular related to service mode observation preparations, execution and follow-up. As such it is an important way for ESO and the USD to know where we are doing well, and where there is room for improvement.

### The Messenger

The [Messenger No. 160](#) is now available. Highlights include:

- C. Vlahakis et al. ALMA Extends to 15-kilometre Baselines: Submillimetre Science down to 20-Milliarsecond Resolution
- M. Gulleuzik et al. OmegaWINGS: A VST Survey of Nearby Galaxy Clusters
- R. J. Smith et al. The SINFONI Nearby Elliptical Lens Locator Survey (SNELLS)
- M. Rajulua et al. Report on the ESO Workshop: Barions at Low Densities: The Stellar Halos around Galaxies
- C. Vlahakis Report on the ESO Workshop: Dissecting Galaxies Near and Far

You can [subscribe](#) to the hardcopy of The Messenger or browse the [complete archive](#) of issues.

### The ESO Science Newsletter

The [September 2015 issue](#) is

[Go to Announcement](#)

Bm6 | 2 September 2015





# ESO Science Newsletter

■ Regular electronic newsletter with latest information

- Topics in September
  - Call for Proposals P97
  - User Support Feedback Campaign
  - ERC Starting Grants hosted at ESO
  - Data Reduction Packages as RPM for Linux
  - New GIRAFFE gratings characterised
  - GRAVITY integration
  - Data releases for VVV, VPHAS+ and PESSTO
  - ESO Fellowships

European Southern Observatory

**ESO Science Newsletter September 2015**  
01 Sep 2015



FORIS2 image of planetary nebula ESO 378-1

This newsletter is a summary of recent ESO Science Announcement items. Follow the links or visit [ESO Science Announcements](#) to read more.

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**Science Announcements**

**Call for Proposals for Period 97**

**01 Sep 2015:**

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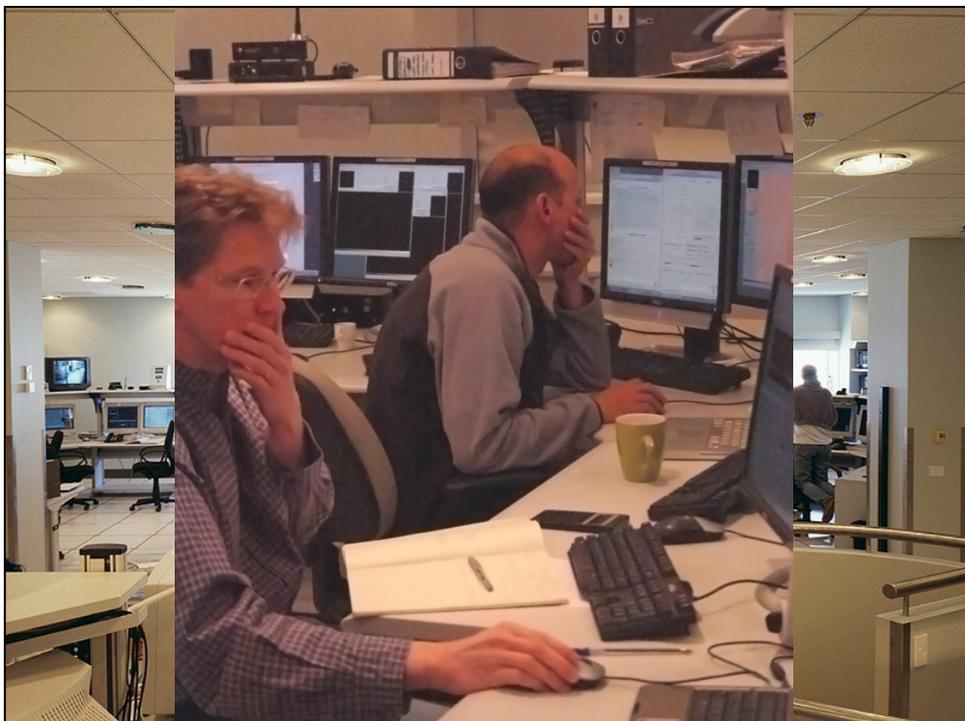
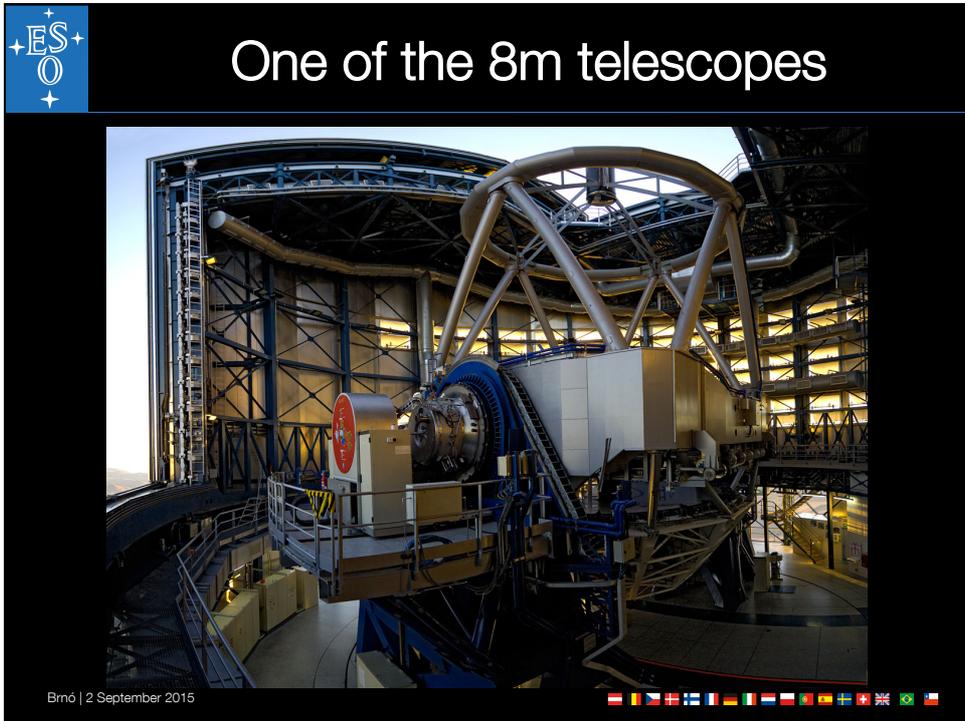


# Paranal and Armazonas



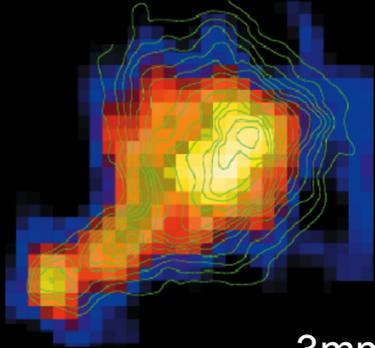
M. Tarengi

Brno | 2 September 2015



 Why telescopes and antennas?

- The strengths of black bodies
- Example: heat images



3mm

Brno | 2 September 2015







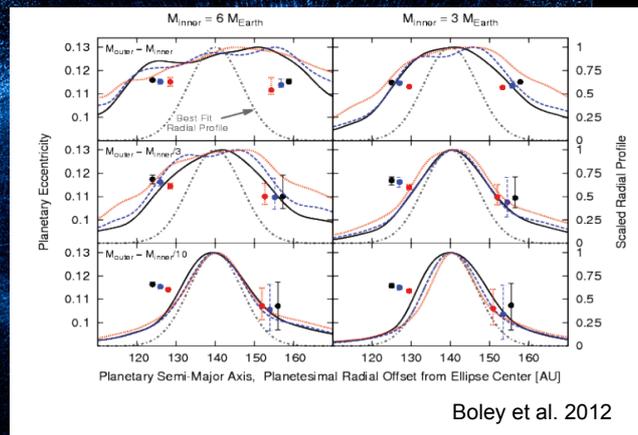
Brno | 2.9.





## Planet dust rings

- Dust ring around Fomalhaut
- Hints for two planets → a few Earth masses



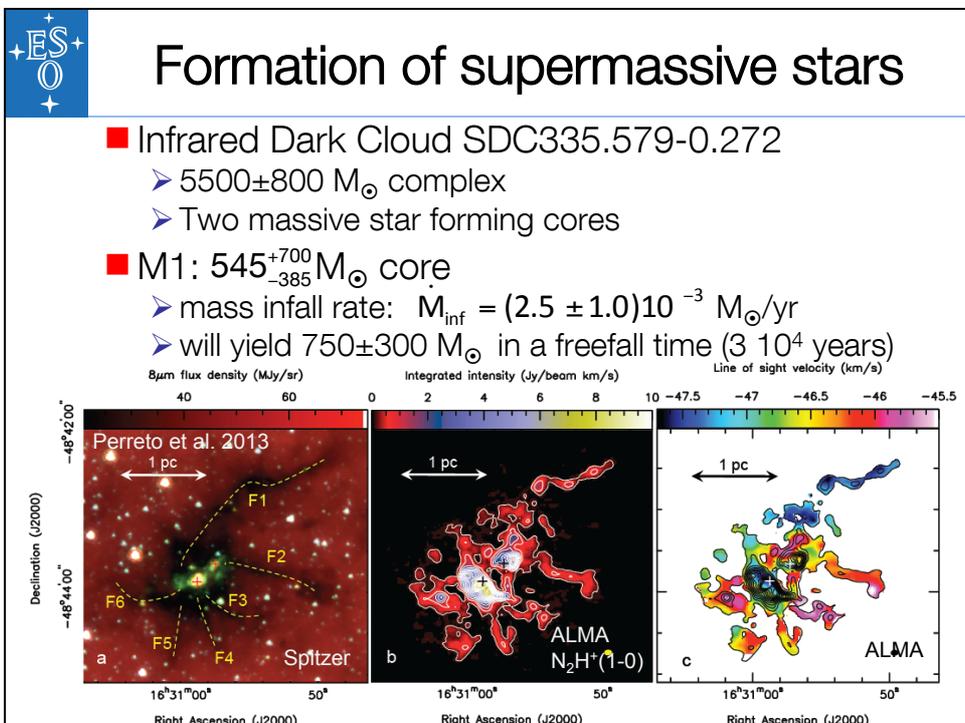
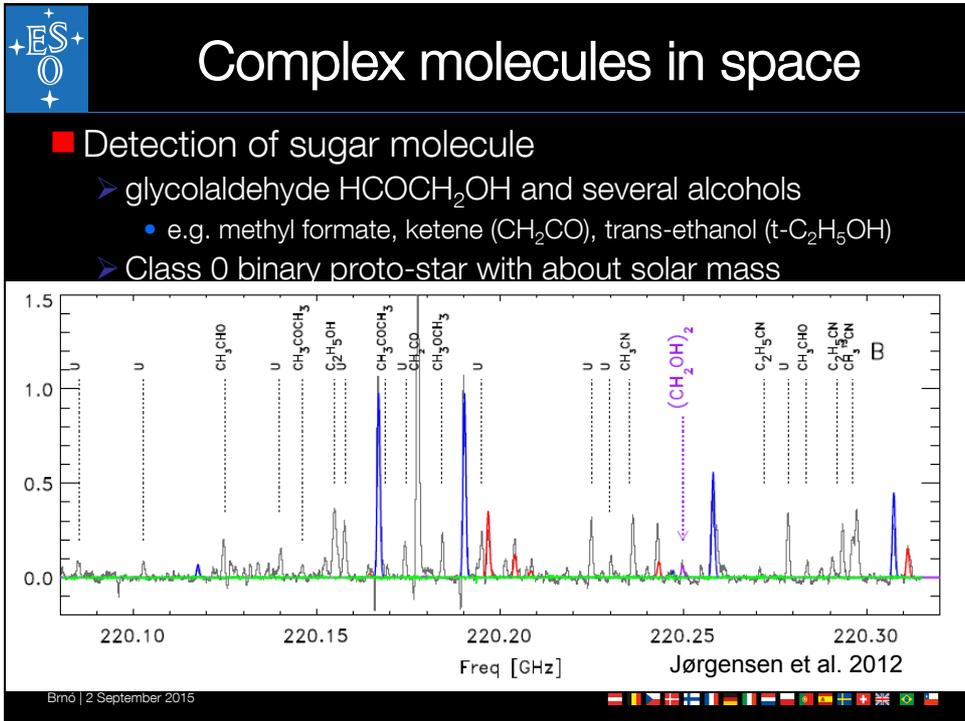
## HL Tau



ALMA

Brnó | 2 September 2015





**ESO**

## Lensed galaxy image

- Cold gas in a lensed galaxy observed with ALMA
  - source redshift:  $z_S=3.042$
  - lens redshift:  $z_L=0.299$

HST ALMA ALMA + Model

Brnó | 2 September 2015

**ESO**

## Lensed galaxy

- Detection of carbon monoxide

CO J=5-4 CO J=8-7 CO J=10-9  
2.0 mm 1.3 mm 1.0 mm  
B6&7 spectral index 1.14 mm (B6&7) H<sub>2</sub>O

Vlahakis et al. 2015

Brnó | 2 September 2015

## Distant galaxies with ALMA

- Follow-up of mm sources discovered with the South Pole Telescope (SPT)
  - Detected many high-redshift galaxies ( $\langle z \rangle = 3.5$ )
  - 860 $\mu\text{m}$  ALMA imaging (Cycle 0 – 16 antennas)
    - 47 candidates  $\rightarrow$  several clearly lensed sources
    - Integration times 1 minute
    - 2 objects at  $z=5.7$  with high star formation rate  $> 500 M_{\odot} \text{ yr}^{-1}$

Viera et al. Nature 2013; Hezaveh et al. ApJ 2013

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## Distant galaxies with ALMA

- Secure redshifts for many sources
  - ALMA 3mm spectroscopy
  - Integration times about 10 minutes
    - Lines detected of  $^{12}\text{CO}$ ,  $^{13}\text{CO}$ ,  $\text{Cl}$ ,  $\text{H}_2\text{O}$

Viera et al. Nature 2013  
Weiss et al. ApJ 2013

Bm6 | 2 Se





## The three modes of the VLT



**VLT**



**VLTI**



**VLT**

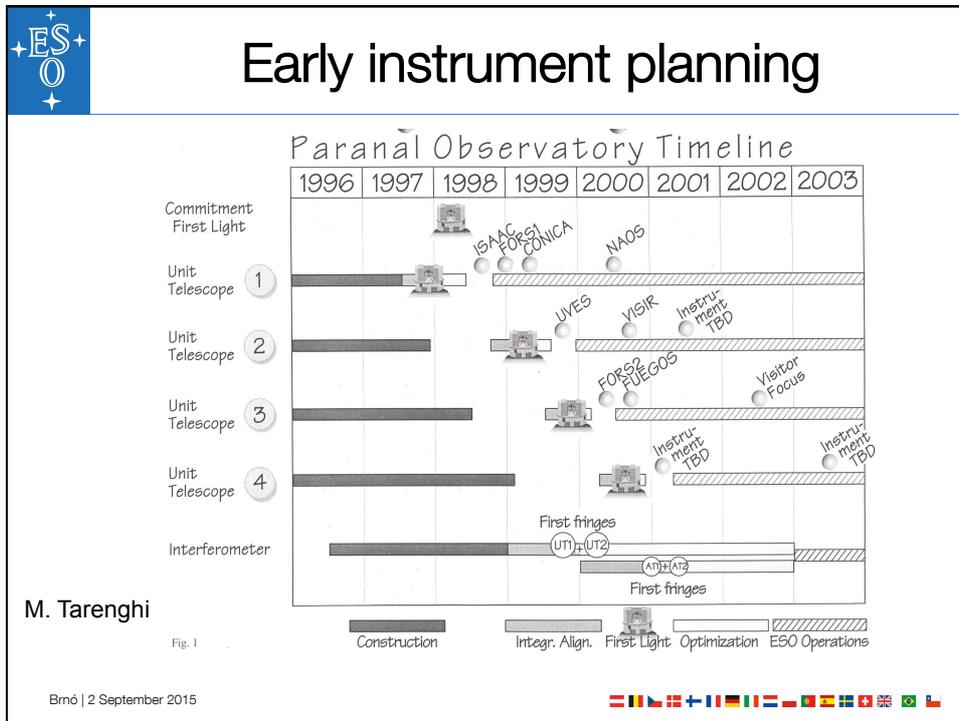
Incoherent combined focus  
(ESPRESSO)

Coherent combined focus  
Interferometry  
(PIONIER, GRAVITY,  
MATISSE)

Individual use of the  
unit telescopes  
(Cassegrain and  
Nasmyth foci)

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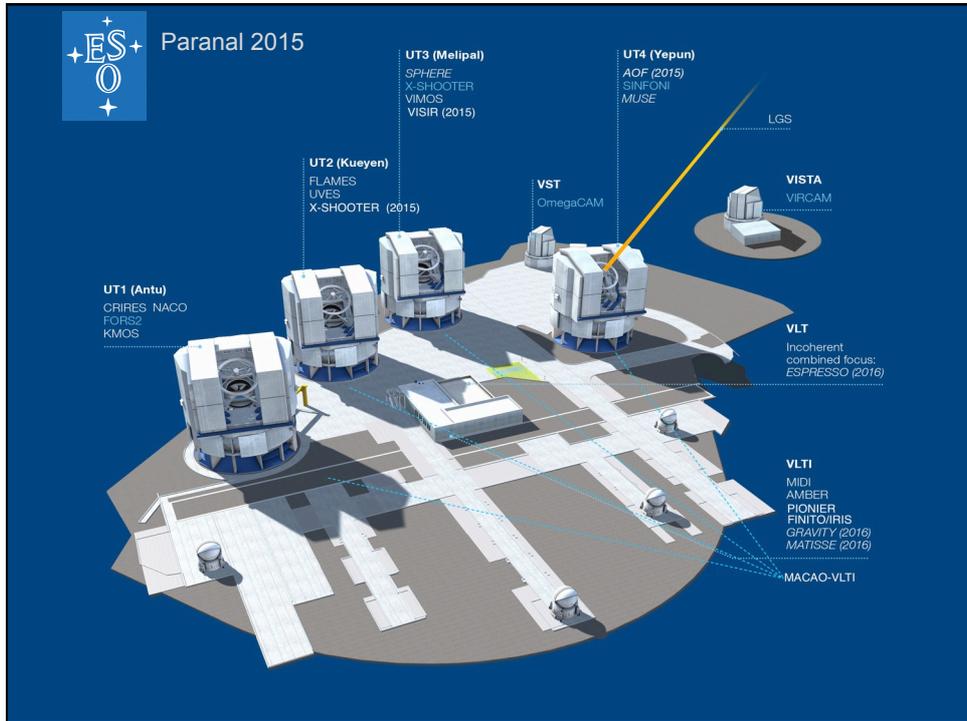




## Paranal Facilities

- VLT
  - 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, UVES, FLAMES, NACO, SINFONI, VISIR, HAWK-I, VIMOS, X-Shooter, laser guide star facility, KMOS, MUSE, SPHERE, Adaptive Optics Facility, CRIFES+, ESPRESSO, MOONS, ERIS**
- VLTI
  - **PIONIER, GRAVITY, MATISSE**
- VISTA
  - **VIRCAM, 4MOST**
- VST
  - **ΩCam**

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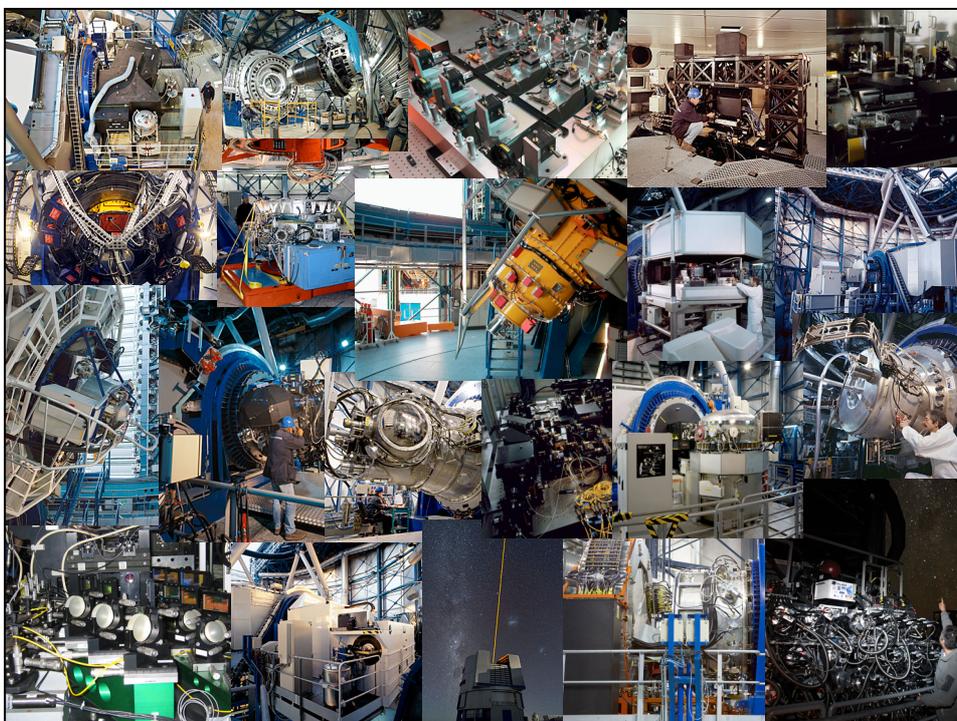




# VLT Opportunities

- Four 8m telescopes
  - flexibility
  - scientific throughput
    - 1200 observing nights/year
- Successful operational model
  - expand existing model to allow new modes
    - high time resolution photometry and spectroscopy
    - faster turnaround (currently DDT)
    - closer interaction with user, e.g. remote observing
- Telescope system
  - spatial resolution from 1 degree to 2 mas
  - wavelength coverage from 320nm to 20 $\mu$ m
  - spectral resolutions from a few to 100000

Birn6 | 2 September 2015 

 **VLT Instruments 2015**

<b>FORS2</b> 	<b>FLAMES</b> 	<b>VISIR</b> 	<b>SINFONI</b> 
<b>CRIRES</b> 	<b>UVES</b> 	<b>VIMOS</b> 	<b>MUSE</b> 
<b>KMOS</b> 	<b>X-shooter</b> 	<b>SPHERE</b> 	<b>HAWK-I</b> 

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# VLTI - Very Large Telescope Interferometry

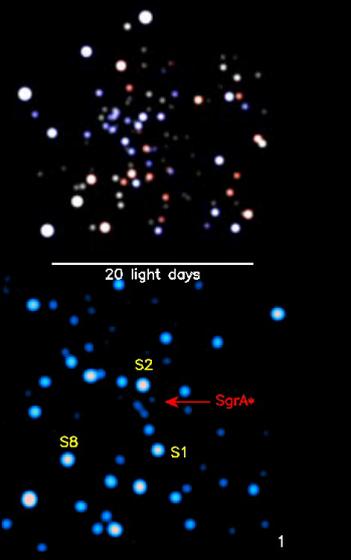
The VLTI is a virtual 100-Meter Telescope



**ESO**

## Our own black hole

- Mass determination through stellar orbits
  - about  $4 \cdot 10^6 M_{\odot}$
- Structure around the black hole revealed through flashes
- Testing General Relativity in the strong gravitational field



20 light days

S2

SgrA\*

S8

S1

1

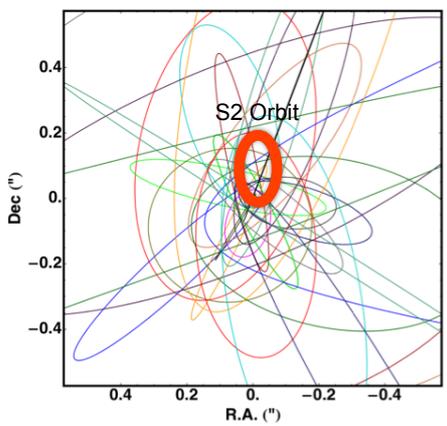
Bonn | 2 September 2015



**ESO**

## Galactic Center

- 40 orbits known



Dec. (")

R.A. (")

S2 Orbit

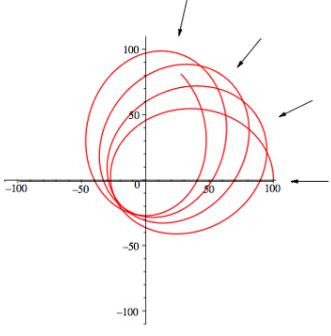
Bonn | 2 September 2015





## Galactic Center

- Pericenter shift probes the nature of the black hole
  - measure post-Newtonian effects



$$\Phi = -\frac{GM}{r} + f \frac{GMl^2}{c^2 r^3}$$

Higher order terms necessary to take into account GR in the strong gravity regime  
GRAVITY aims at constraining them

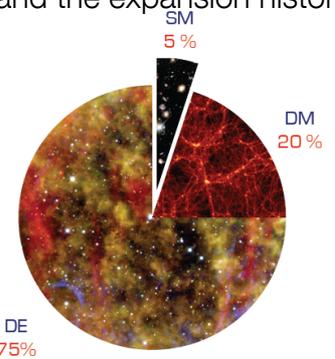
Brno | 2 September 2015





## What matters in the Universe?

- Characterisation of dark matter and dark energy
  - Requires large samples
    - sample a large fraction of the universe
  - Multi-year and (often) multi-telescope projects
  - Measure the distribution of matter and the expansion history of the universe
    - Baryonic acoustic oscillations
    - Weak lensing
    - Supernovae
    - Galaxy clusters
    - Redshift distortions



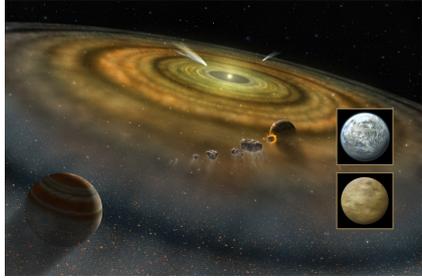
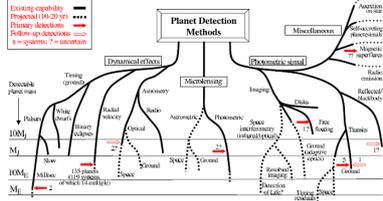
Brno | 2 September 2015





# Planets, planets, planets

- Planets everywhere
  - Radial velocities
  - Direct imaging
  - Transits
- Characterisation
  - Planetary systems, masses, chemical composition, temperatures

Brno | 2 September 2015





## A planet with $1.9M_{\oplus}$ and one in the habitable zone



Mayor et al. 2009

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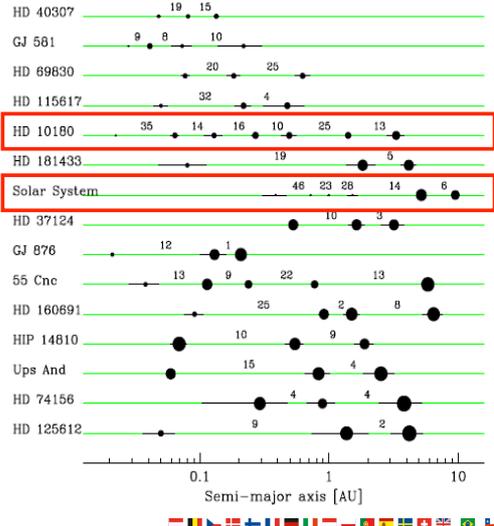


## Richest planetary system known

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

Lovis et al. 2010

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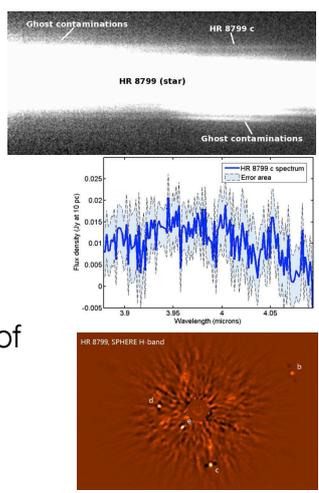




## The ESO exo-planet machinery

- HARPS at 3.6m telescope (NIRPS)
  - best radial velocity machine at a 4m telescope extremely stable spectrograph
  - ESPRESSO at VLT in the future
- NACO/SPHERE
  - 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
- CRRES+
  - spectroscopy of atmospheres

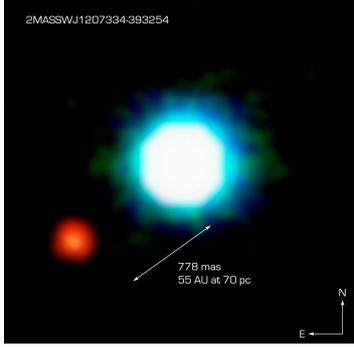
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## ESO results on exo-planets

- 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 ( $\beta$  Pic)
- Combination with transits
  - characterization of planets
    - mass, density, temperatures

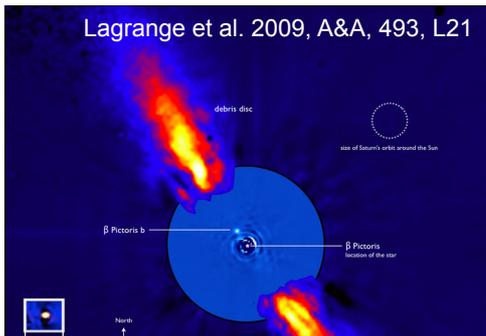


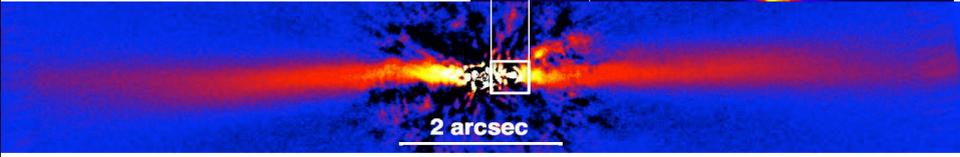
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## $\beta$ Pic planet

- Planet ( $\sim 10 M_{\text{jup}}$ ) within the massive dust disk
- Orbit only a few AU
- NACO imaging
- SPHERE imaging
  - planet – star separation
    - $\sim 350$  mas



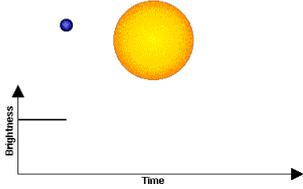


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## Exo-Planets

- **Emphasis is shifting**
  - most discoveries expected through transits
  - characterisation of atmospheres
  - discovery of Earth-like planets
  - characterisation of hot Jupiters
- **Requires different instruments**
  - Many global ongoing surveys
    - Next Generation Transit Surveys (NGTS – Paranal)
    - other hosted telescopes under discussion
    - future space missions (TESS, CHEOPS, PLATO)
  - Continued radial velocity surveys
    - masses through the combination with the transits
  - Atmosphere characterisation



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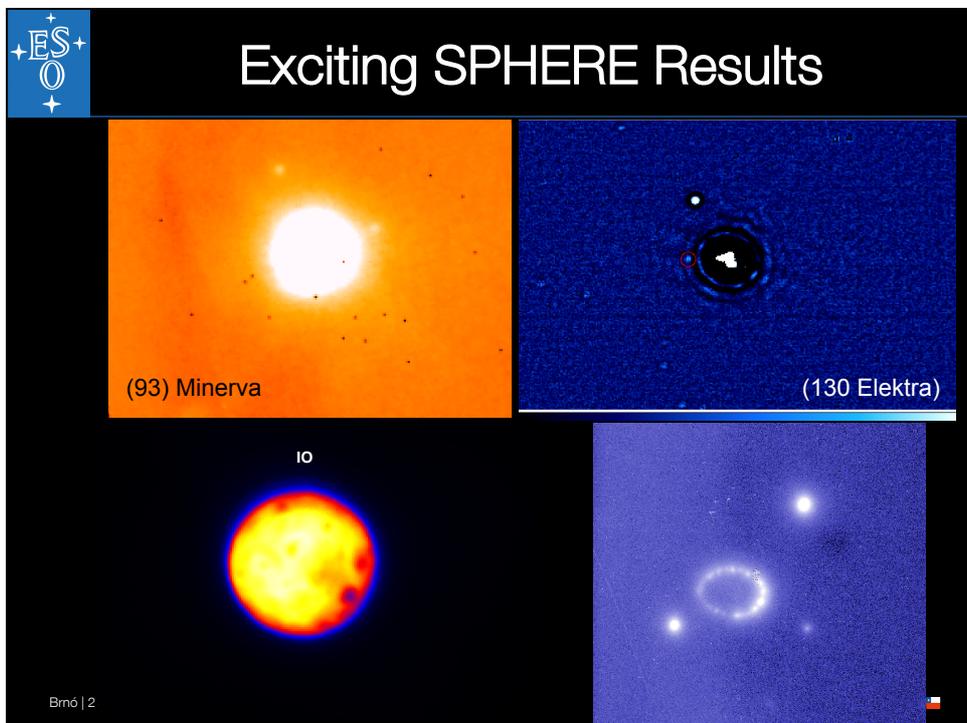
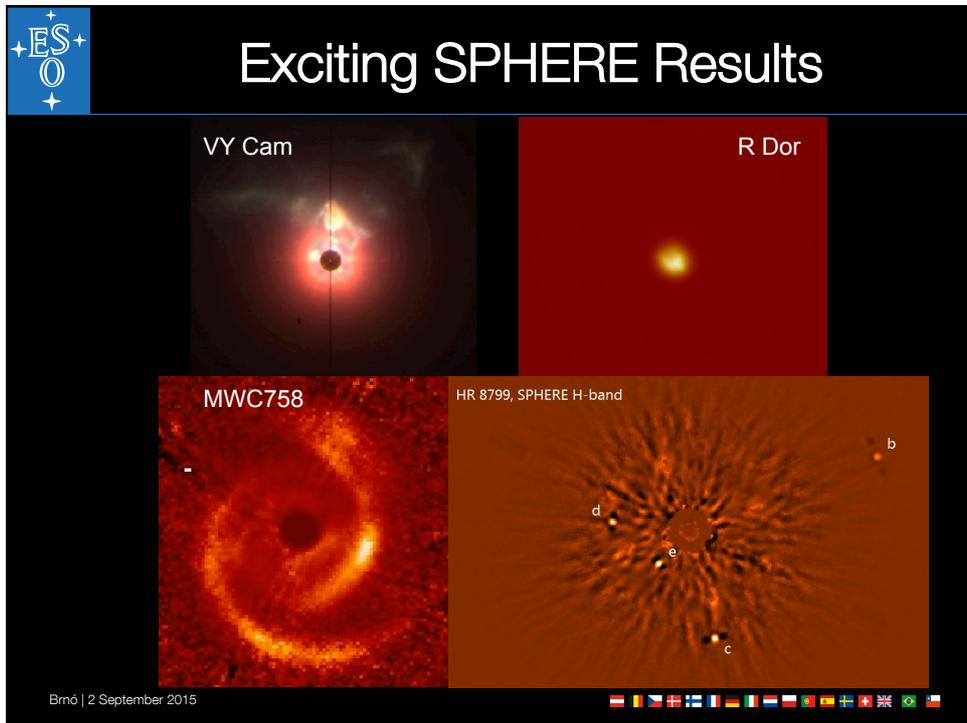


## Exo-Planets

- **Observational requirements**
  - continued long time series
    - radial velocities (HARPS, ESPRESSO, ELODIE/Euler)
  - long monitoring runs
    - transits to be covered over many hours at very specific times
    - dedicated instruments (NIRPS, dedicated hosted telescopes - ExTRa)
  - expect thousands of transiting planets
    - currently about 1000 known
    - (mostly in the Kepler field in the Northern Hemisphere)
    - many projects under way – global collaborations
      - WASP, HAT, MASCARA, NGTS
      - TESS, CHEOPS, PLATO

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# Transient Sky

- Changing sky – next frontier
  - Solar system objects
    - near-Earth objects
  - Exo-planets
  - Variable stars
    - window into stellar physics
    - distance indicators
    - VV, VMC, VIDEO, VST/SUDARE, (La Silla/QUEST), PESSTO
  - Gravitation
    - time scale depends on the strength of the gravitational field
      - X-ray binaries
      - black holes
    - electro-magnetic counterparts of sources of gravitational waves
      - merging white dwarfs, neutron stars, black holes

Brno | 2 September 2015 core-collapse supernovae 



# Transient Sky

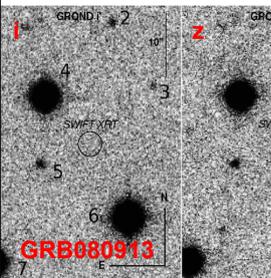
- Dedicated telescopes
- Dedicated operational modes
  - large Target of Opportunity fraction
  - flexible scheduling
  - variable timescales
- Database requirements
  - systematic archiving
  - time series
  - correlation analyses

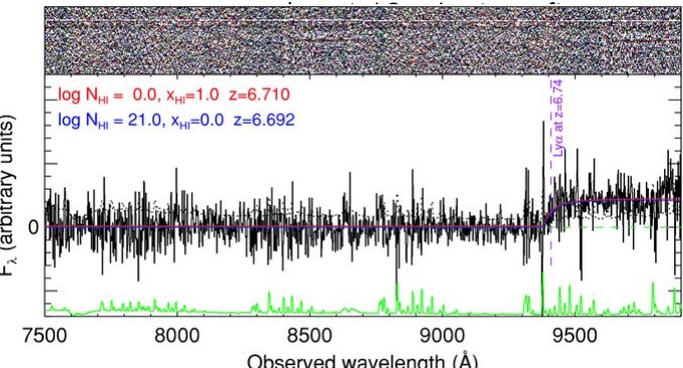
Brno | 2 September 2015 



# 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 to ol detection

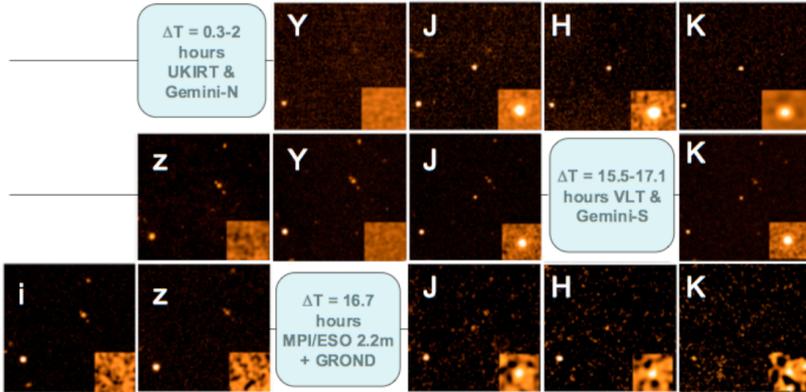






# Most distant stellar object yet observed – GRB 090423

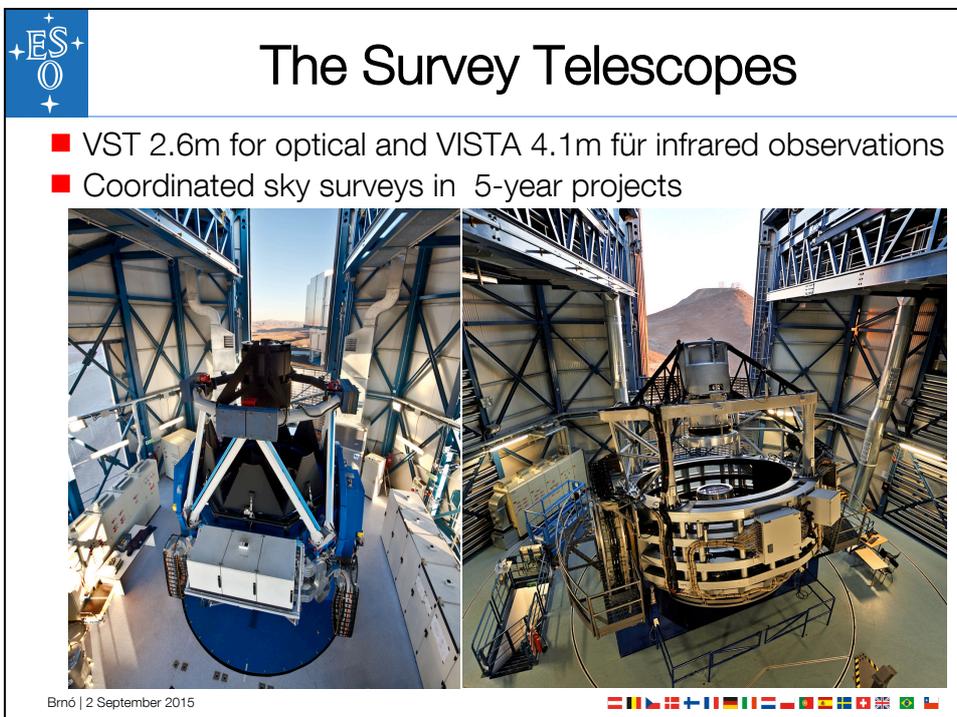
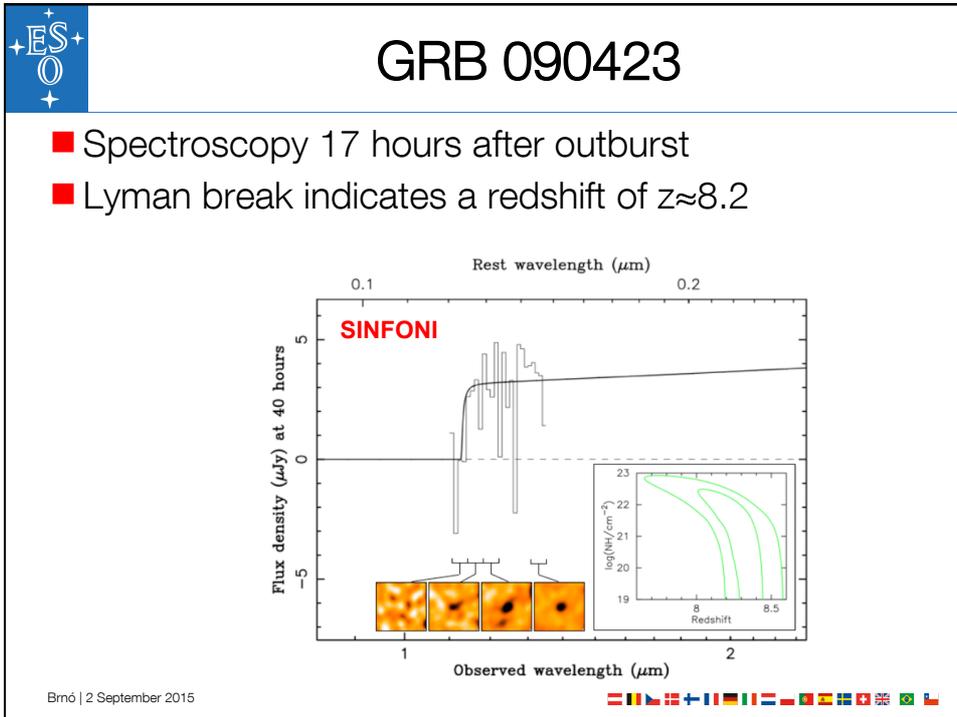
- Optical drop-out, bright in the near-infrared
- Rapid decline

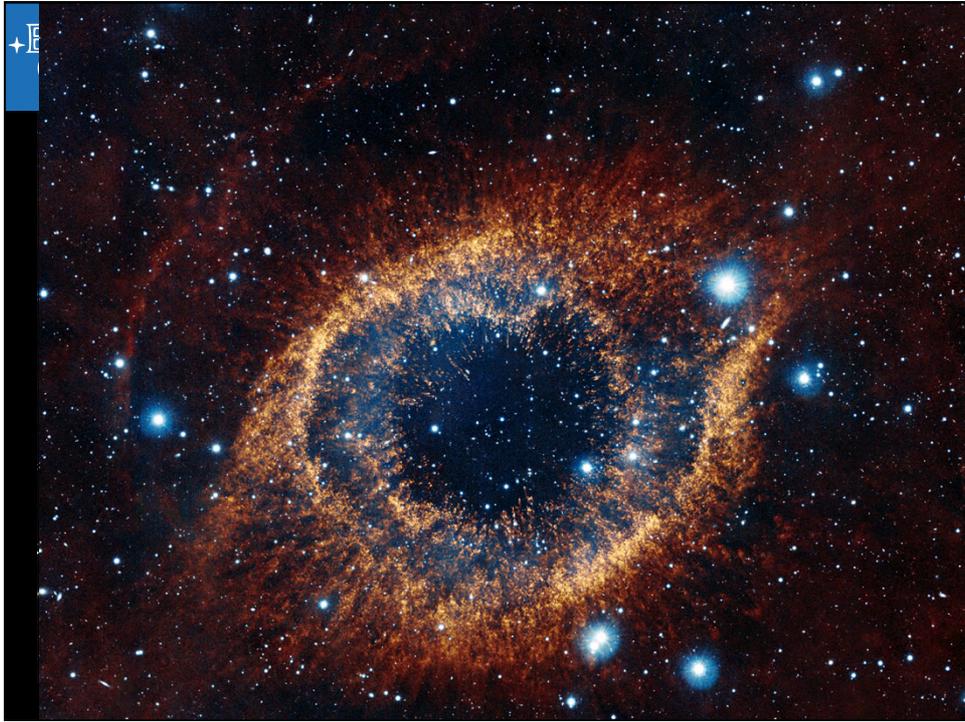


Tanvir et al., Nature submitted

Brnó | 2 September 2015







ESO

## Public Surveys

The diagram illustrates the Milky Way galaxy with several survey regions highlighted. KIDS-N (green outline) and ATLAS-N (blue outline) are located in the northern galactic hemisphere. KIDS-W2 (green outline) is a small region in the northern hemisphere. VPHAS+ (red outline) is a long, narrow region along the galactic plane. ATLAS-S (blue outline) and KIDS-S (green outline) are located in the southern galactic hemisphere.

Birmo | 2 September 2015

A row of small national flags representing the participating countries in the surveys, including Spain, the Netherlands, the United Kingdom, France, Germany, Italy, the United States, and others.

# ESO Science Archive

## Rich resource

ESO — Reaching New Heights in Astronomy

Public Science User Portal Intranet Contact Site Map Search Go!

Science Users Information > Science Archive Facility 01 Sep 2015

### Science Archive Facility

Welcome to the ESO Science Archive Facility

The ESO Science Archive Facility contains data from ESO telescopes at La Silla Paranal Observatory, including the APEX submillimeter telescope on Llano de Chajnantor. In addition, the raw UKIDSS/WFCAM data obtained at the UK Infrared Telescope facility in Hawaii are available.

The Principal Investigators of successful proposals for time on ESO telescopes have exclusive access to their scientific data for the duration of a proprietary period, normally of one year, after which the data becomes available to the community at large. Please read the [ESO Data Access Policy](#) statement for more information, along with the [relevant FAQs](#).

Browsing the archive does not require authentication, but to request and download data you have to log in to the [ESO User Portal](#). Please [acknowledge the use of archive data](#) in any publication.

### Latest News and Updates

- New Data Release of VVV Photometric Catalogues via the ESO Science Archive Facility (21 Aug 2015)
- New Release of PESSTO public survey data (06 Aug 2015)
- First release of the band merged catalogue for the VST Photometric H-alpha Survey of the Southern Galactic Plane (VPHAS+) (30 Jul 2015)

More news ...

To browse the archive

Currently, **raw data** and various types of **data products** can be reached via different interfaces:

Category	Access Point	Data collection	Data Type	Instruments
LPO Raw Data	Raw data query form (all instruments) Instrument specific query forms Direct retrieval of raw data by file name	All ESO raw data	Various	Many La Silla Paranal instruments
LPO Data Products	Phase 3 main query form Phase 3 imaging query form Phase 3 spectral query form Phase 3 VIRCAM-specific query form	Phase 3 Data Products (ESO public surveys; ESO pipeline-reduced products; Large programs: GOODS, zCOSMOS, etc.)	Currently, Imaging and Spectroscopy	Various Pipeline products for UVES, XSHOOTER, HARPS, and more to come.

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# Recent new VLT instruments

- SPHERE** – extreme adaptive optics system in the NIR and optical
- MUSE** – largest integral field unit available
  - see Dimitri's results yesterday
- KMOS** – multi-IFU system in the NIR
  - examples in Dimitri's talk yesterday
- X-shooter** – new workhorse instrument for individual objects
  - covers 400nm to 1.8 $\mu$ m simultaneously

Bm6 | 2 September 2015



## Planned new VLT instruments

- **ESPRESSO** – extremely stable high-resolution spectrograph
  - can use all four unit telescopes together
- **Adaptive Optics Facility (AOF)**
  - “seeing improver” for HAWK-I (ground-layer AO)
  - optical AO for MUSE
  - 4 laser guide stars
- **ERIS** – new NIR AO imager (NACO replacement)
  - includes SINFONI upgrade
- **4MOST (VISTA)** – high multiplex optical spectroscopy
- **MOONS** – high multiplex NIR spectroscopy
- **CUBES** – UV high-resolution spectroscopy

Birmó | 2 September 2015 



## New VLTI instruments

- (Existing) **PIONIER** – closure-phase NIR imager
- **GRAVITY** – highest angular resolution system in K-band
- **MATISSE** – highest angular resolution system in infrared

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