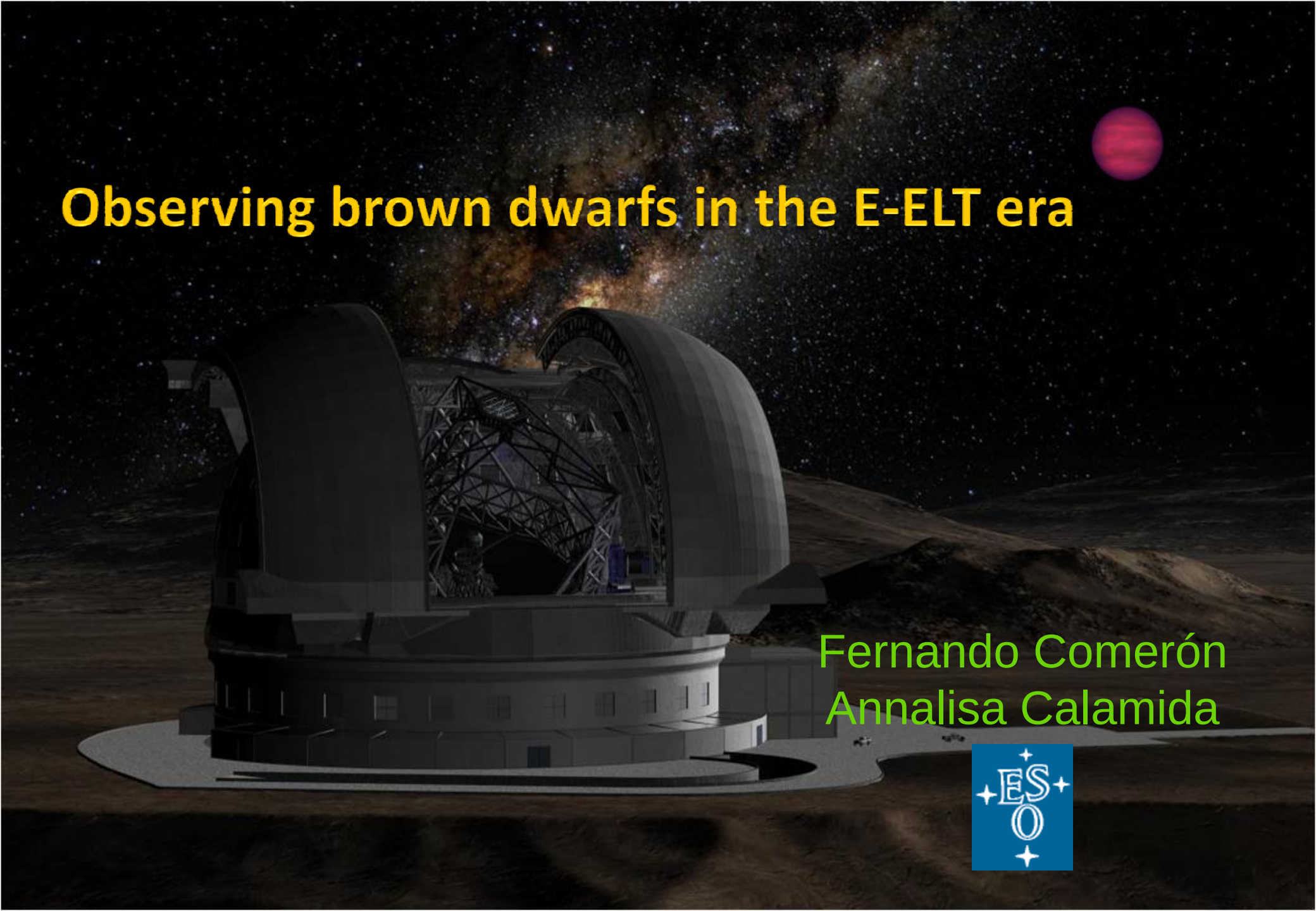
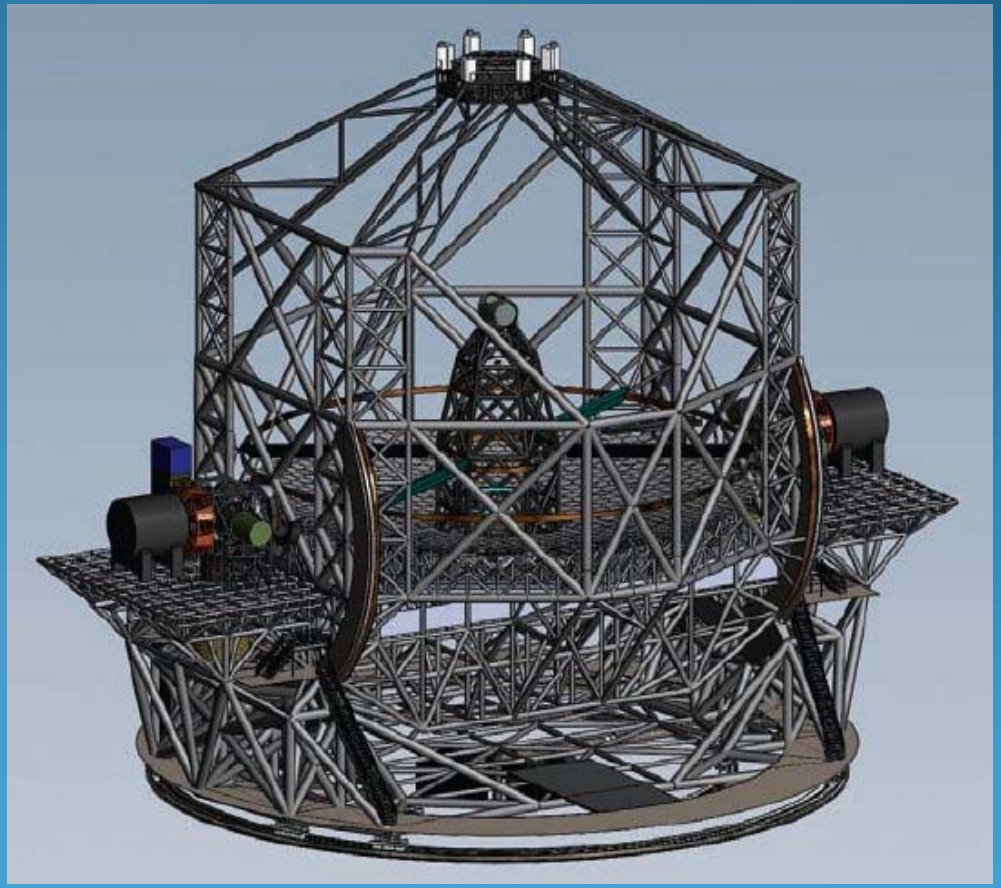

Observing brown dwarfs in the E-ELT era
Fernando Comerón
Annalisa Calamida
ESO

The European Extremely Large Telescope

The European Extremely Large Telescope being projected by ESO is Europe's proposal for the next generation of giant optical telescopes expected to operate by the end of the next decade

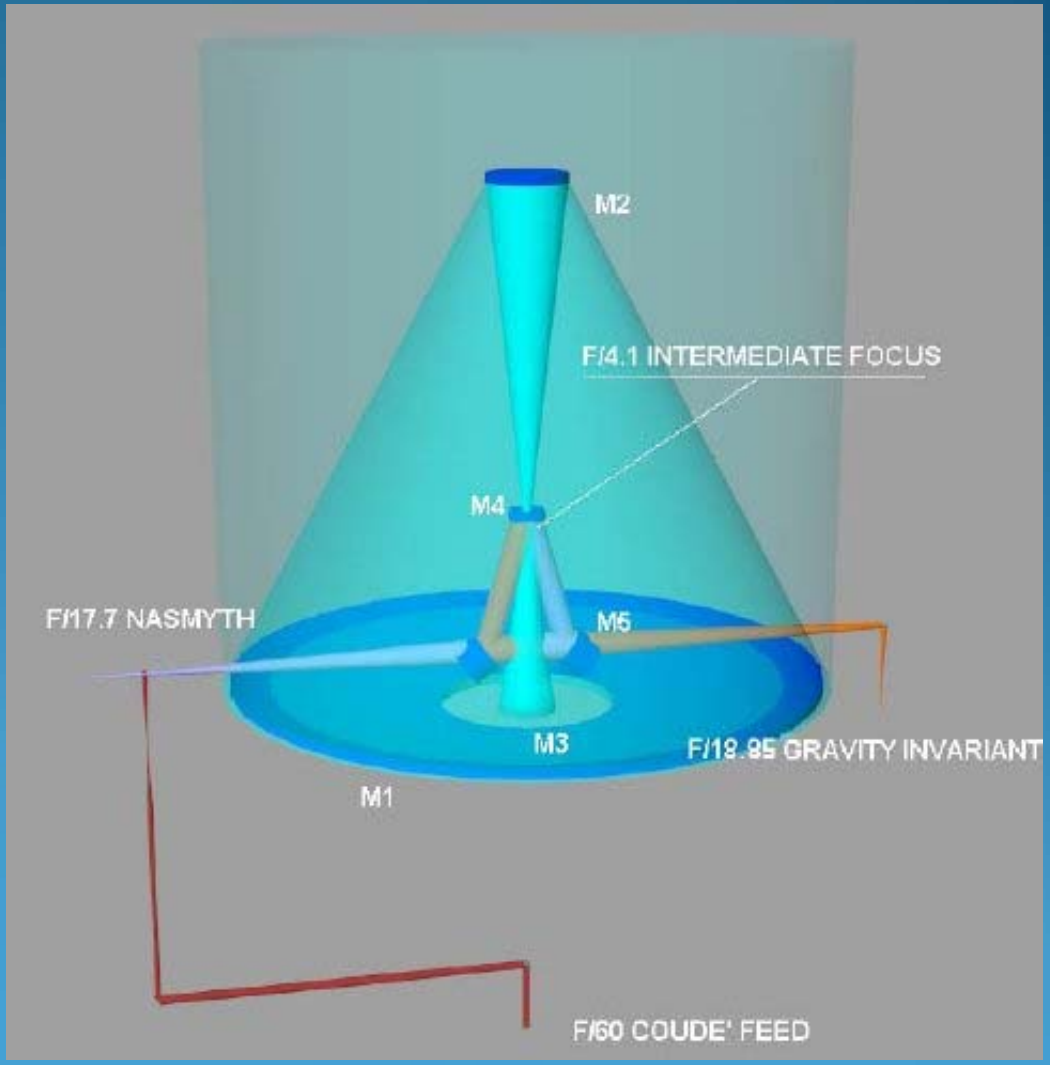
- A 42-m segmented mirror telescope for observations from the blue to the thermal infrared
- Aiming for a complement of instruments covering a large parameter space
- 5-mirror anastigmatic configuration (astigmatism, coma and spherical aberration corrected over a large FoV)
- Two multi-port Nasmyth foci, two gravity invariant foci, a coude focus
- Location still to be decided



An adaptive telescope

The E-ELT is designed as an *adaptive telescope*, with a deformable M4 and a tip-tilt M5.

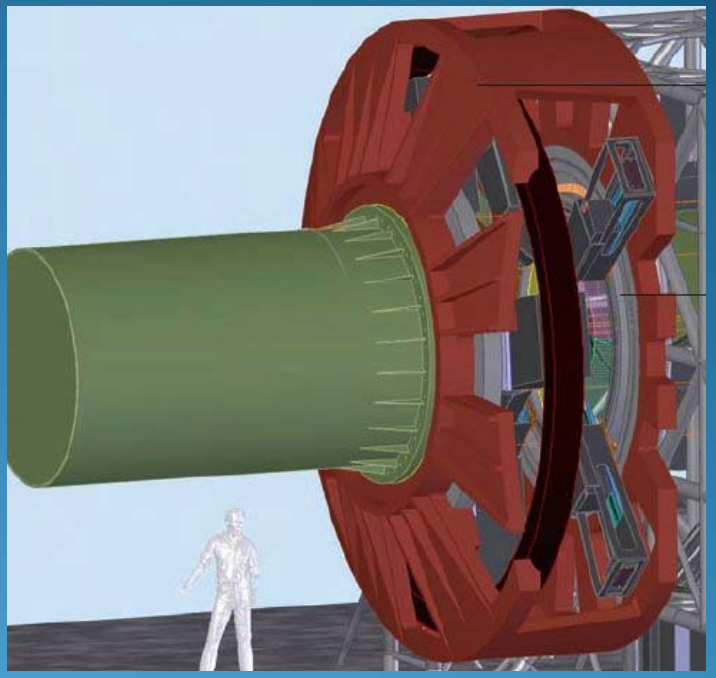
- Ground-layer AO (GLAO) correction provided by the telescope (3 Natural + 4 Laser Guide Stars)
- Multi-Conjugate AO (MCAO) or Laser Tomography AO (LTAO) provided by post-focal AO modules
- Multi-Object AO (MOAO) and Extreme AO (XAO) integrated in some of the proposed instruments



Instrumentation currently under study

Eight instruments are currently undergoing Phase A study:

- EAGLE, multi-IFU NIR spectrograph with MOAO
- CODEX, high resolution, ultrastable visual spectrograph using GLAO or seeing-limited
- MICADO, NIR camera using MCAO
- EPICS, high-contrast imager and spectrograph with XAO
- HARMONI, single-field, wide-band spectrograph, using GLAO, possibly MCAO/LTAO
- METIS, mid-infrared imager and spectrograph, using GLAO, possibly LTAO
- OPTIMOS, wide-field visual multi-object spectrograph, using GLAO, possibly MCAO
- SIMPLE, high-resolution NIR spectrograph, using GLAO, possibly LTAO

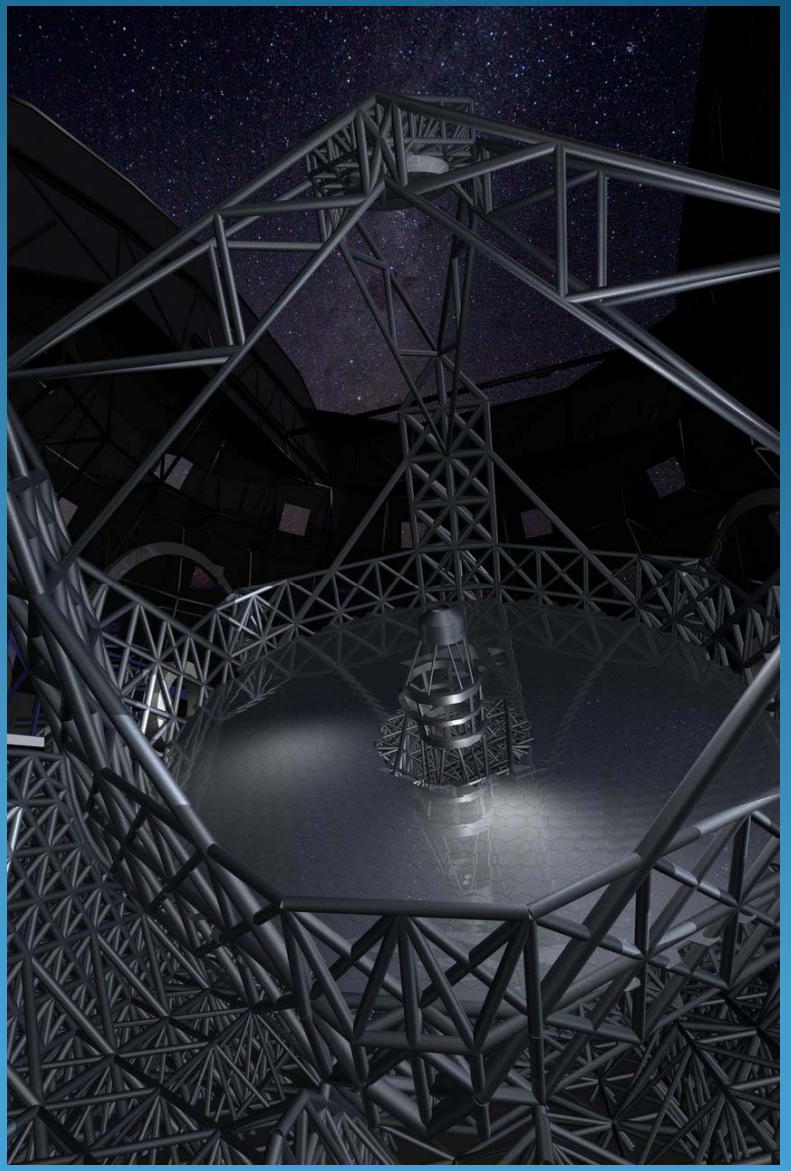


Even if only a few are built, this promises variety in wavelengths, techniques, AO modes…

Current status

Project currently undergoing Phase B development

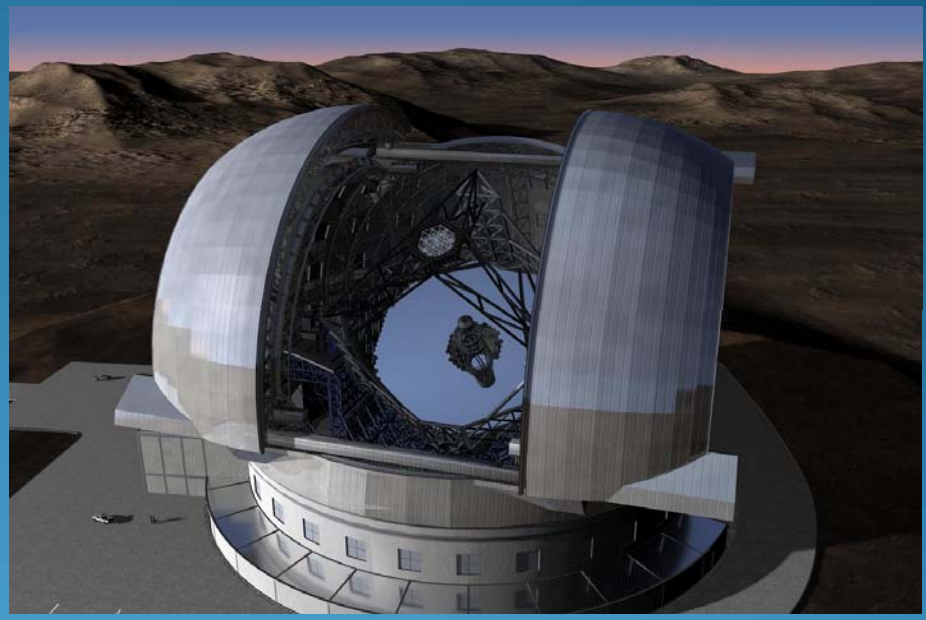
- Phase B budget 57.2 MEur, plus 6.1 MEur in FP7-funded project “Preparing for construction of the E-ELT”
- Cost to completion estimated to be somewhat below 1 GEur
- Site choice to be made in 2010
- Proposal for construction planned for end 2010
- Construction can start in early 2011
- Completion foreseen in 2018



How we will use it

A multi-purpose facility…

- Wide variety of science cases
- Reflected in instrumentation studies and community feedback
- Serving a broad community
- Offered under conditions similar to other current facilities
- “Easy” to use, based on known operations principles: “One more telescope”

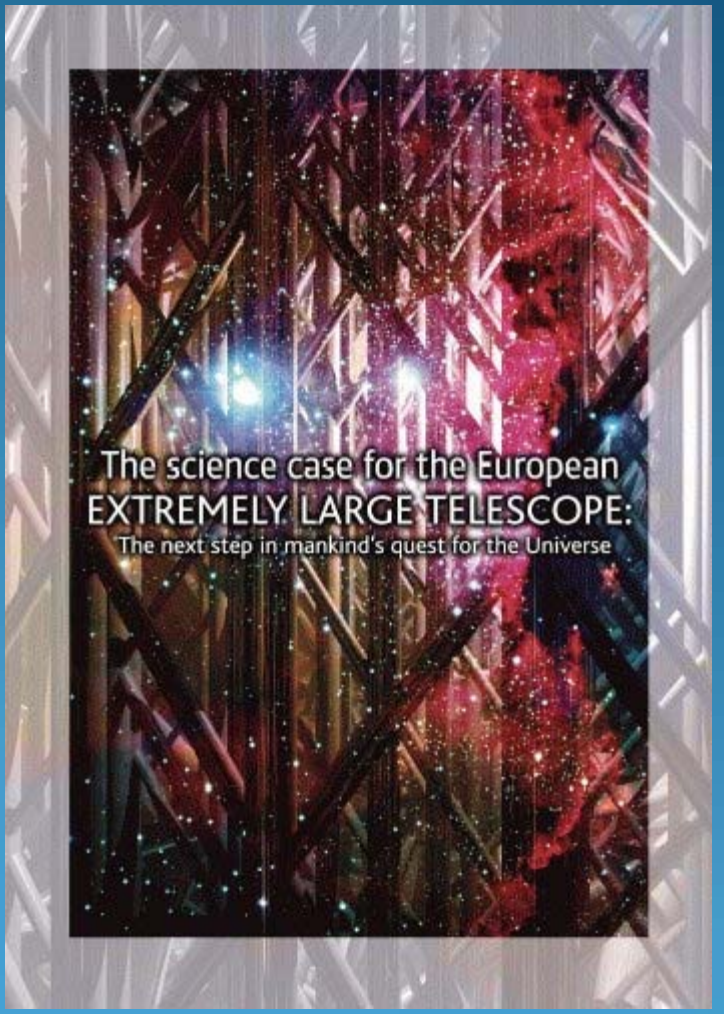


…operating at the limits

- Extremely demanding cases in terms of telescope and instrument performance

The case for brown dwarfs with the E-ELT

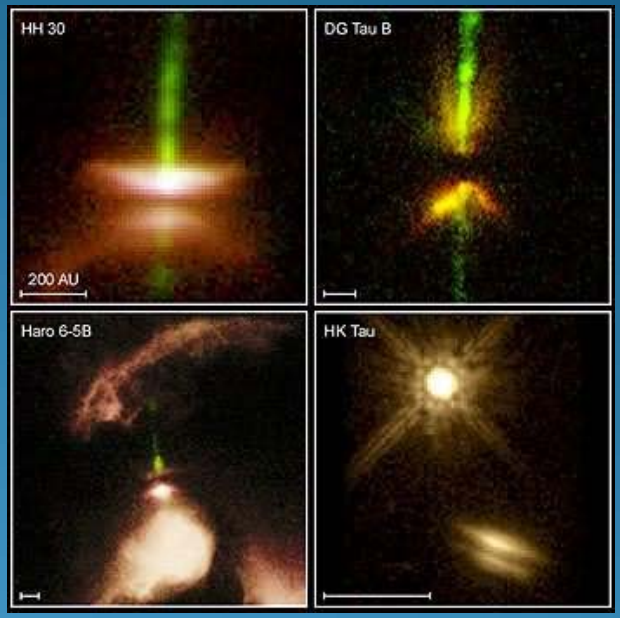
- Comprehensive cases presented at several conferences (a collection can be found at http://www.eso.org/sci/facilities/eelt/)
- OPTICON's science case of the E-ELT (April 2005) highlighted their interest for brown dwarf research
- Design Reference Mission (science cases developed within the E-ELT Science Working Group) includes brown dwarfs among the key cases 'Circumstellar disks' and 'Young stellar clusters and the initial mass function'
- Community interest expressed through the Design Reference Science Plan: brown dwarfs represented as main targets and within star formation studies

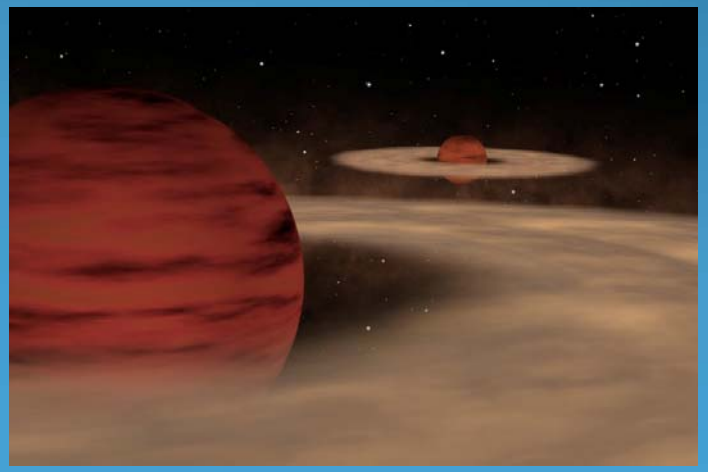


Sensitivity and spatial resolution

- Diffraction limit at 1 micron: 0’’006 (1 AU at 170 pc)
- Sensitivity: J~28 at 3-sigma in 1h if diffraction limited :
  - 10 Mjup at 5 Gyr at 100 pc
  - 10 Mjup at 1 Myr at 50 kpc (LMC!)

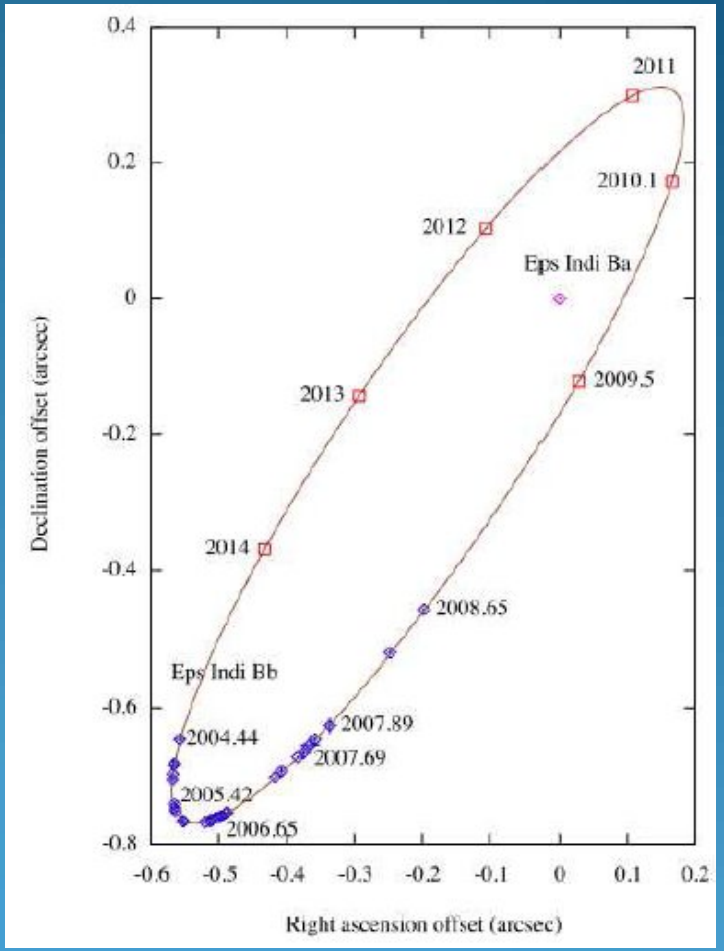
- Binarity, multiplicity (e.g. Joergens’ review)
- Planetary companions and formation timescales
- Disks and envelopes in scattered light, jets
- Dynamical masses
- …





Sensitivity and spatial resolution

- Dynamical masses can be determined in ~10 yr (~1/10 of the orbit) for binaries of >10 M_{Jup} separated by 5 AU at 150 pc (and lower masses and greater separations with more patience)
- Field binaries: within the ~1st year of operation, orbits can be determined for all pairs with separation ~1 AU and primaries with >0.05 solar masses within 30 pc.
- Field sample limited by identification with other facilities (E-ELT is not a survey telescope!); e.g. Zapatero Osorio's review

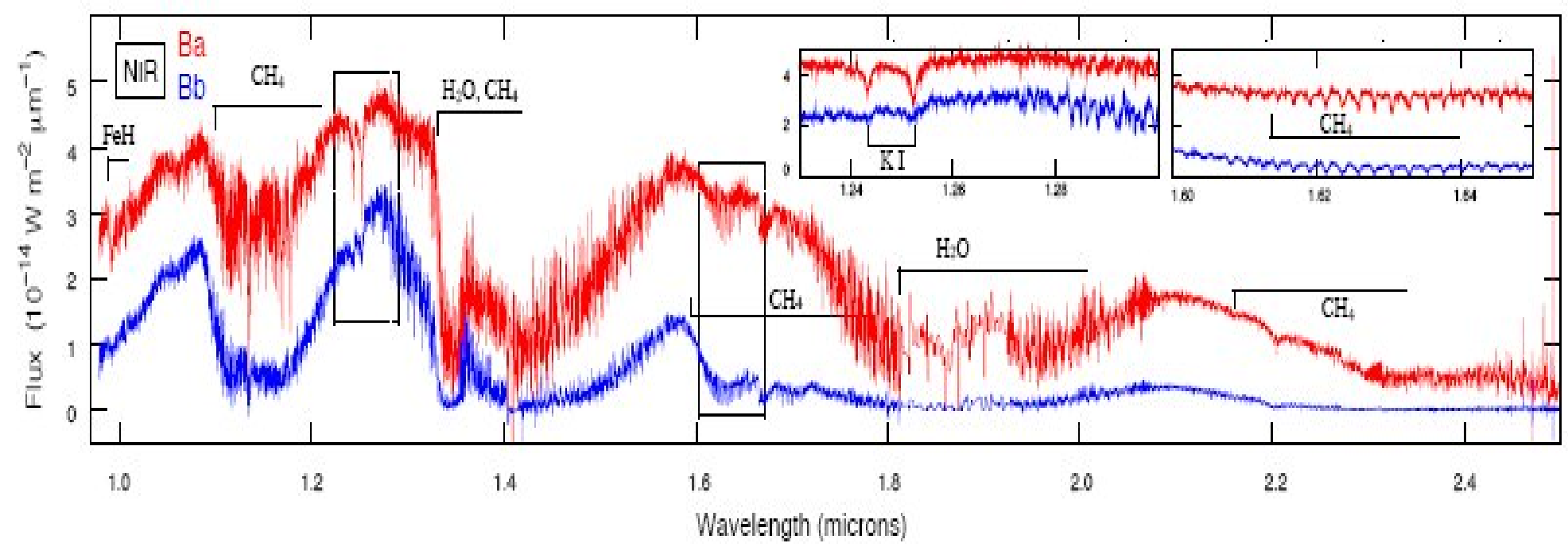


From Cardoso et al. 2009, 15th Cambridge workshop on Cool Stars, stellar systems and the Sun

Spectroscopic characterization

- Spectroscopic characterization and trigonometric parallax available for all of them

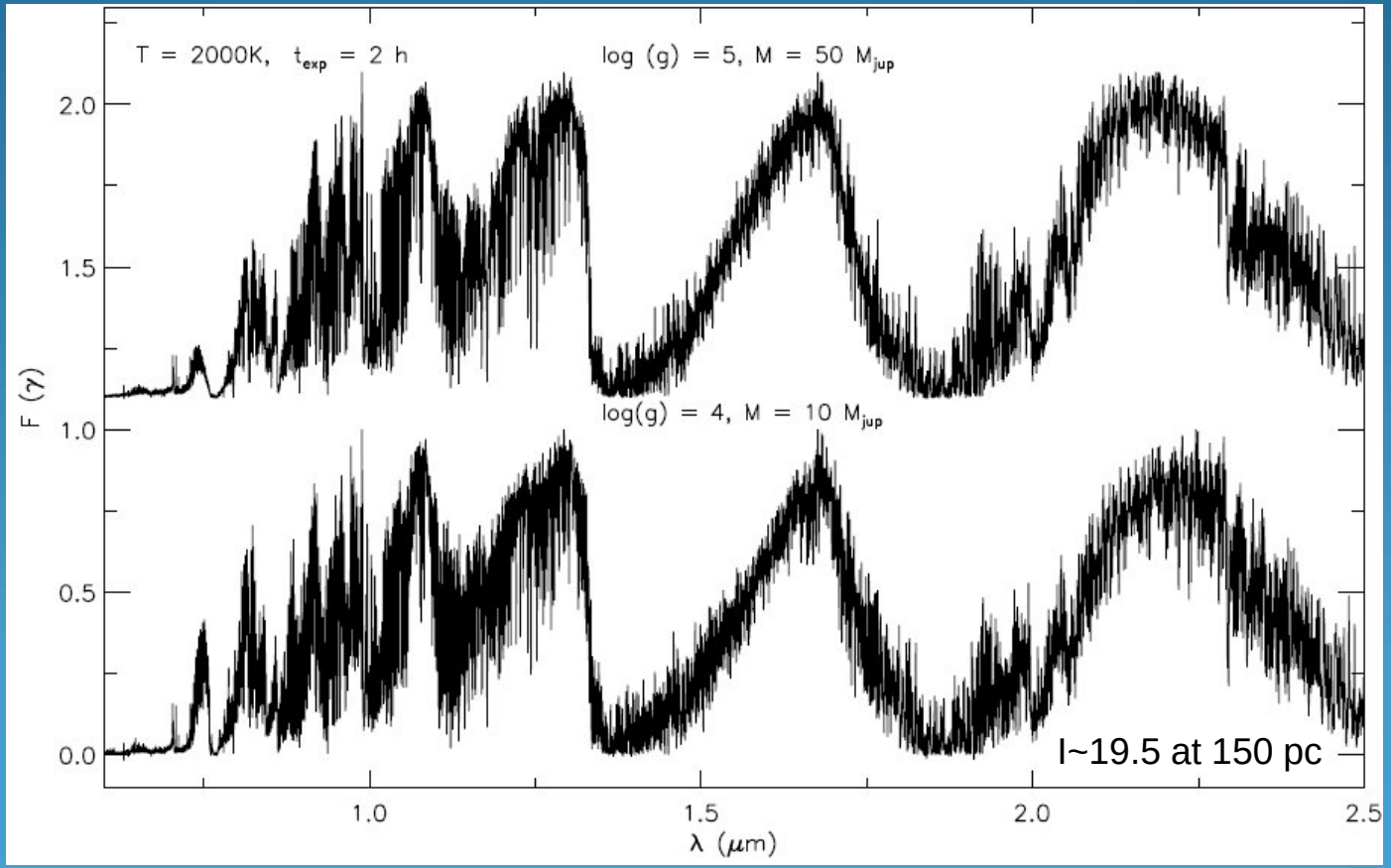
The field cool dwarf sequence will be placed on a sound physical basis (highly accurate M and L) within one year of operations



From King et al. 2009, 15th Cambridge workshop on Cool Stars, stellar systems and the Sun

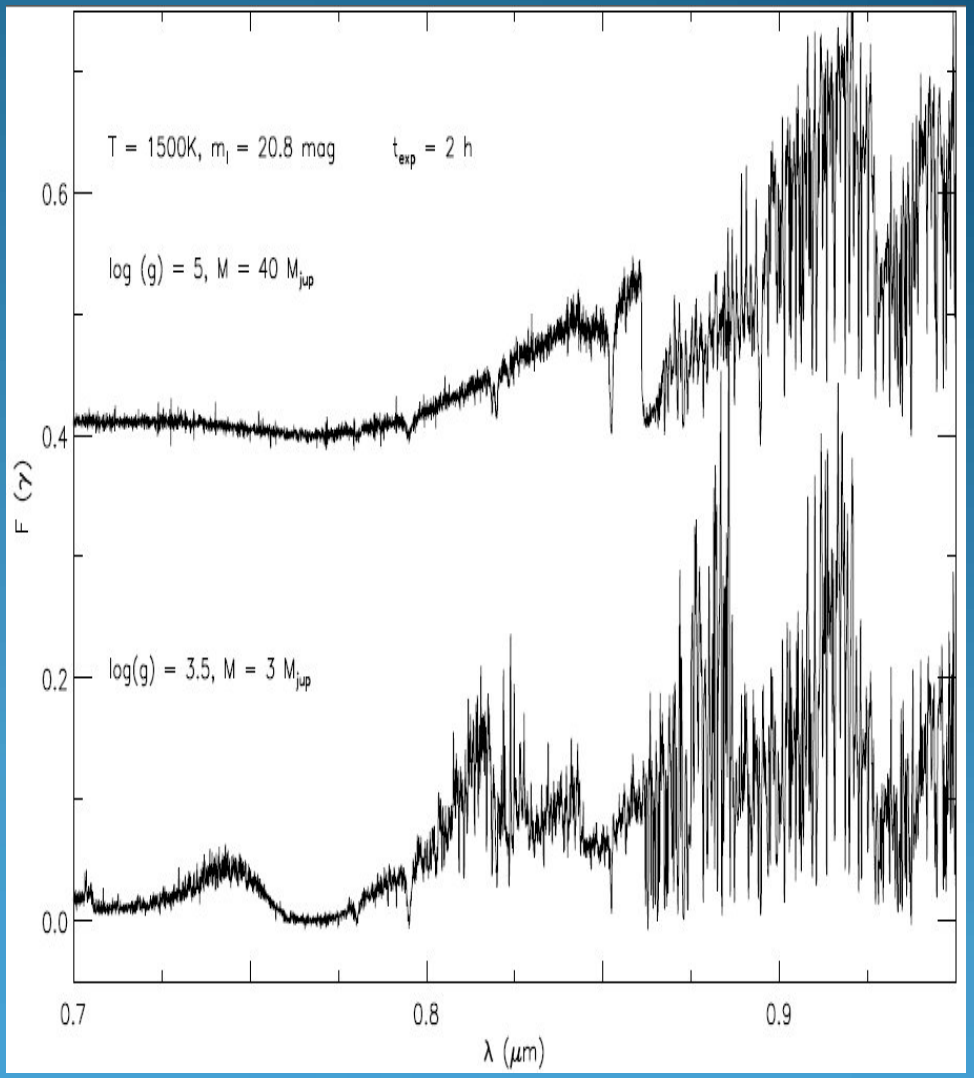
Spectroscopic diagnostics in young brown dwarfs

- Temperature, gravity, metallicity effects apparent in R~1000-5000 spectra



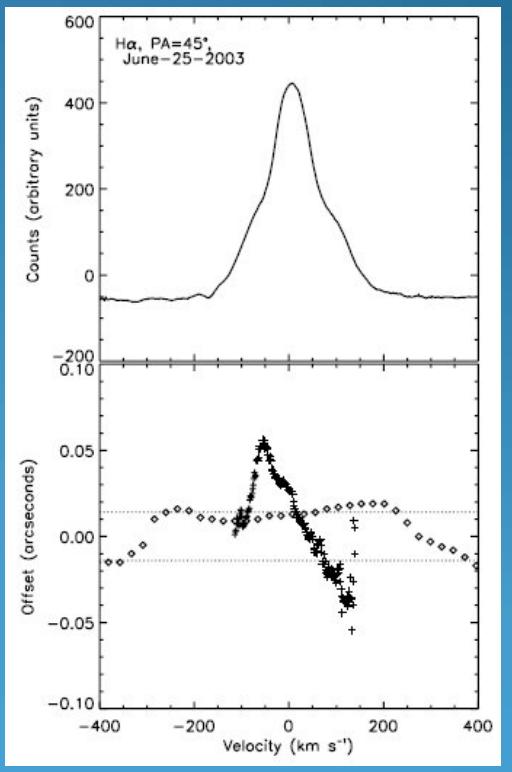
Spectroscopic diagnostics in young brown dwarfs

- I-band spectroscopy with R~1000 or higher needed (available at JWST only at R>100)
- Not very demanding at E-ELT: good project for nights with poor turbulence profile (simulations done assuming GLAO)



Spectroscopy with large collecting power

- High resolution still possible at such magnitudes: rotation, chemistry (e.g. capture of atomic species into molecules and grains)
- Resolving non-axisymmetric features (clouds) through Doppler tomography
- Magnetic fields through spectropolarimetry, if offered by instruments (hard with >5 reflections though)
- Extend radial velocity searches for planets to low-mass brown dwarfs
- Spectroastrometry



From Whelan et al. 2009, ApJ 691, L106

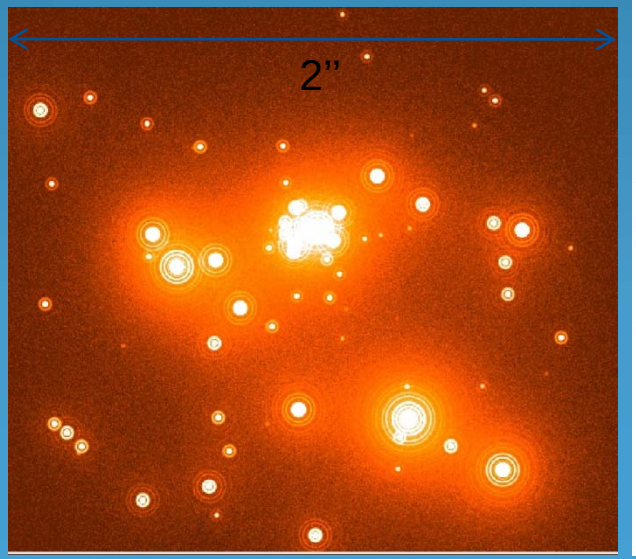
The IMF at the low mass and metallicities

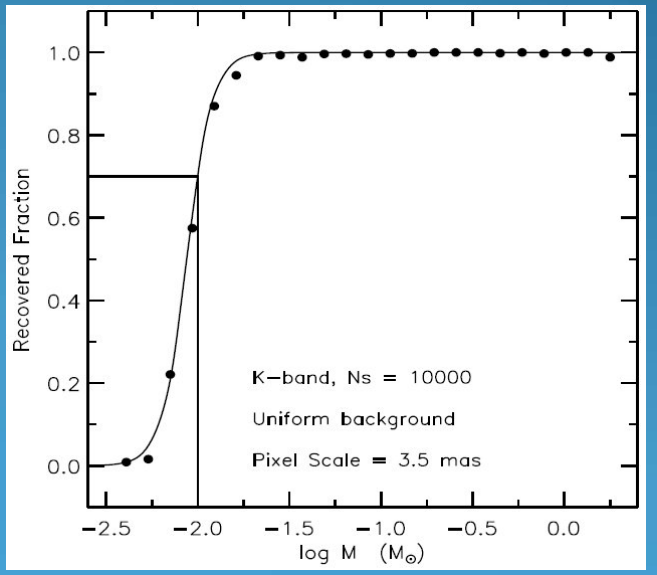
- Low metallicity brown dwarfs hard to observe: >5 Gyr-old field brown dwarfs with less than ~0.04 solar masses too faint to be picked up by surveys, might be found by chance in deep fields
- Brown dwarfs forming at low metallicities (~0.5 solar) may be found in the outer Galaxy: clusters fit in small field, good AO correction possible with MCAO, H~K~23 allows spectroscopy… but crowding.

Pushing to the limits: low-mass clusters in the LMC, SMC

- 10 M_{Jup} possibly reachable at 1 Myr

Opening observational extragalactic brown dwarf research!

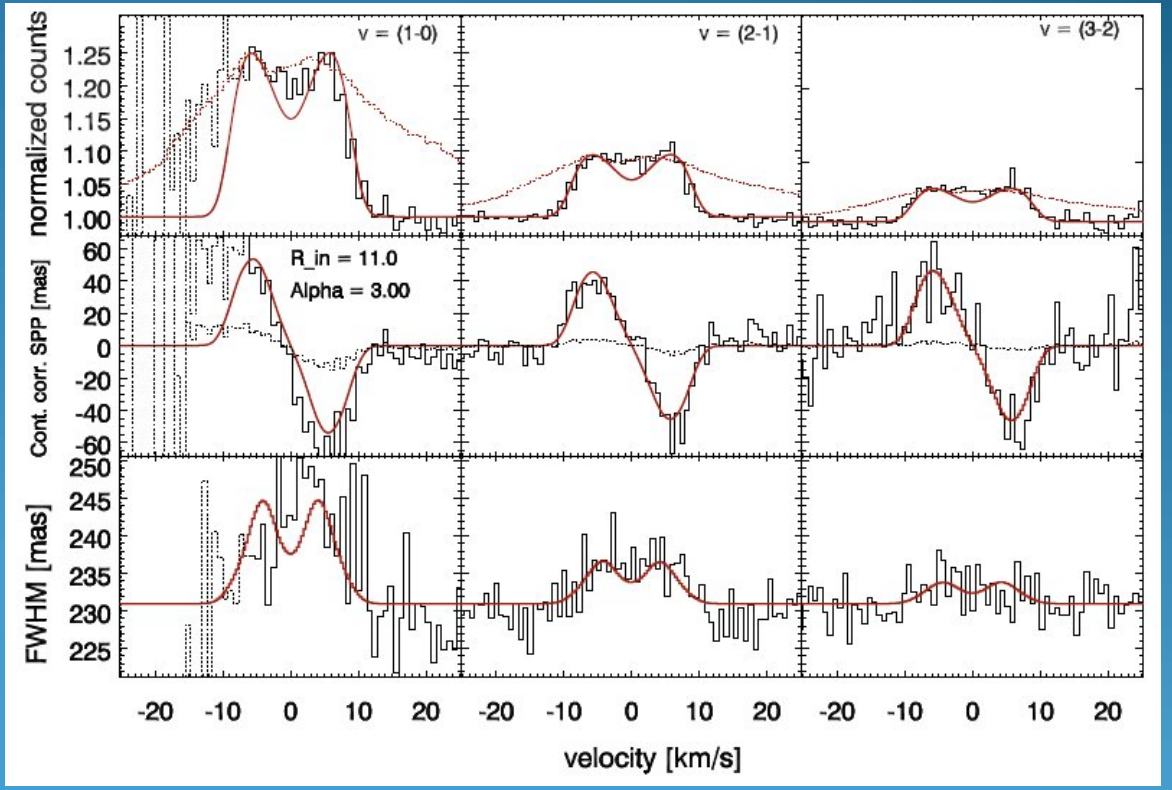




Infrared spectroscopy of brown dwarf disks

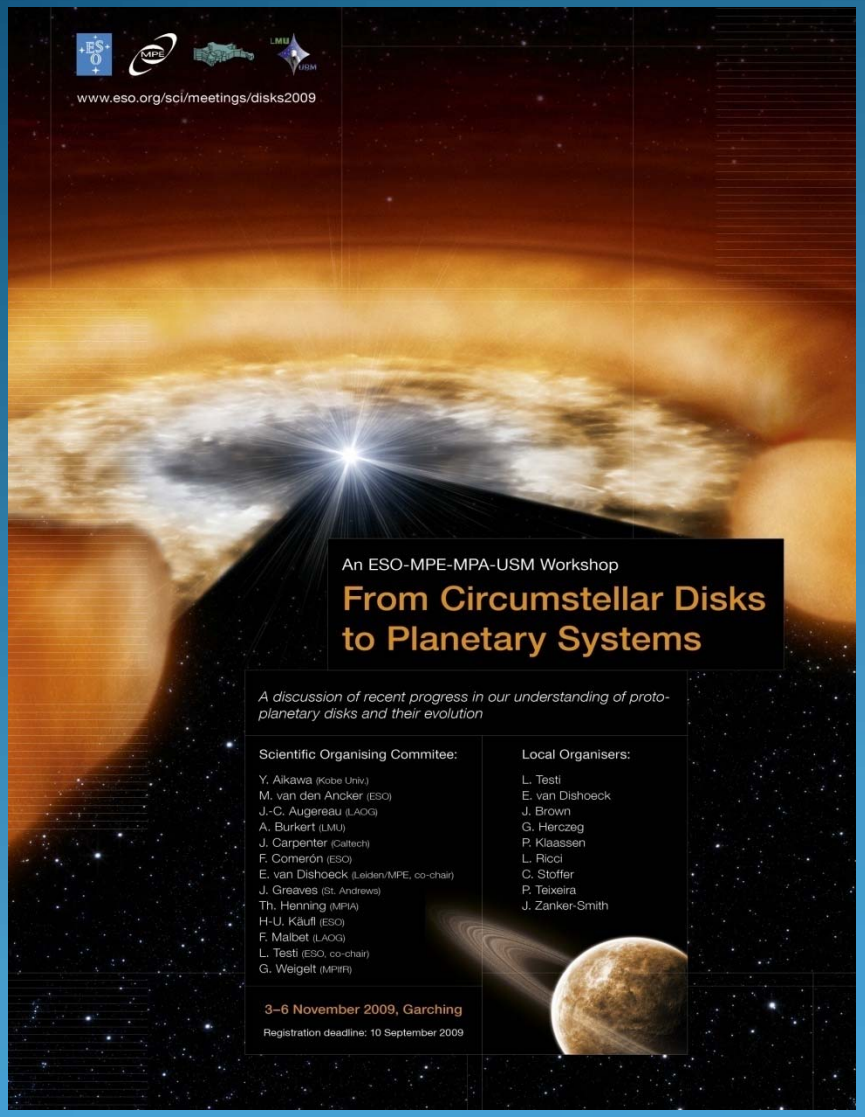
Near-infrared gas phase lines rich in inner-disk diagnostics of kinematics, chemical evolution, dissociation/ionization: CO bandheads, H_2, H_2O: complementary to ALMA

- May allow the detection of circum-proto-planetary disks
- X-ray and UV irradiation important in driving viscous and chemical evolution
- It must exist in brown dwarfs too, but little known thus far: high resolution infrared spectroscopy (e.g. CRIRES at the VLT) still limited to bright targets



From Van der Plas et al., 2009, A&A, 500, 1137

To know more…



JWST and the ELTs: An Ideal Combination

An ESA/ESO Workshop
Garching, April 13-16, 2010

This conference aims at exploring the scientific synergies between JWST and the up-coming giant optical/infrared telescopes (GMT, TMT, E-ELT).

For more information contact: jwstelt2010@eso.org

Latest News

- **The first announcement will be posted here September 1st, 2009.**

JWST and the ELTs: an ideal combination
ESO headquarters
Garching
13-16 April 2010

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