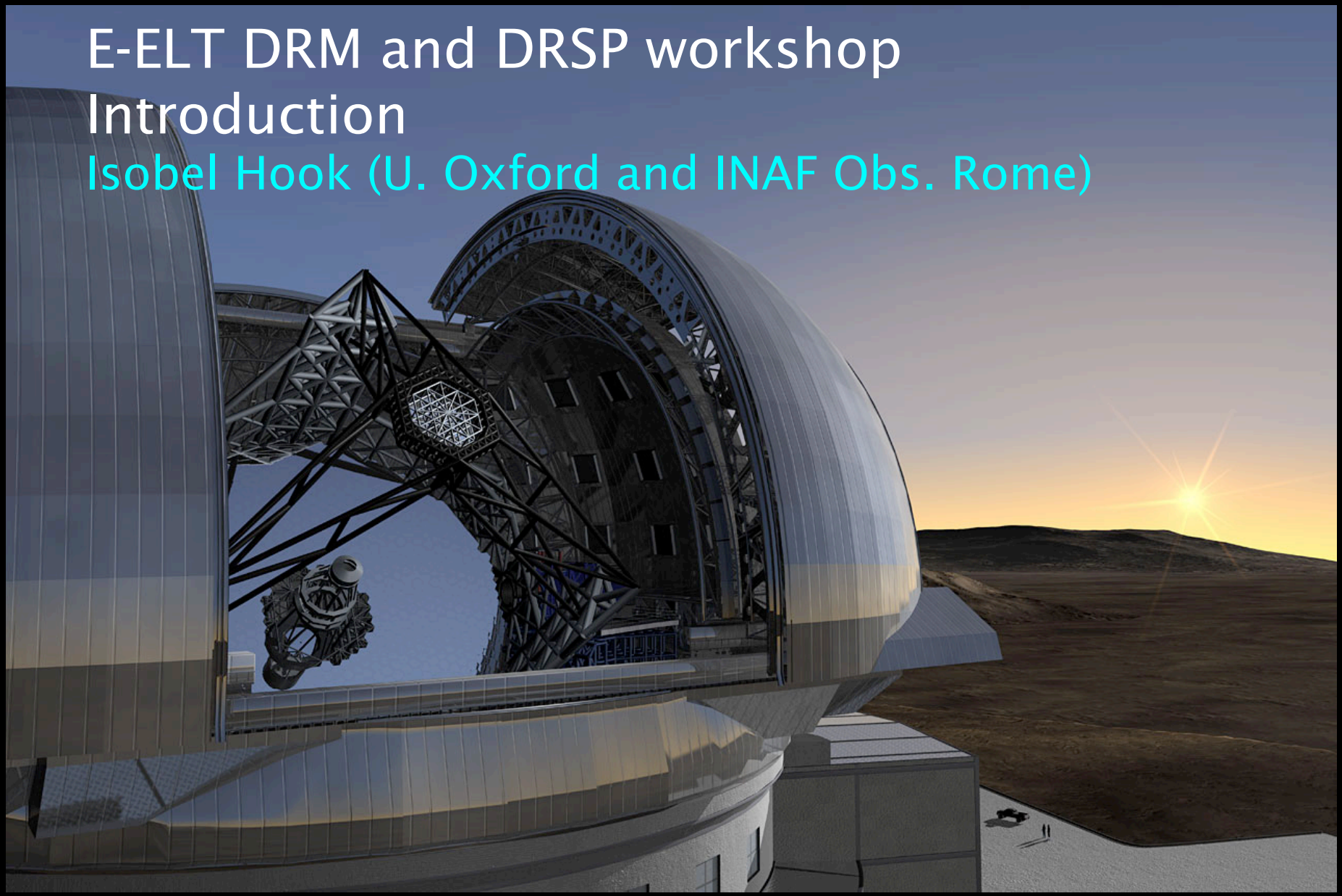
E-ELT DRM and DRSP workshop
Introduction

Isobel Hook (U. Oxford and INAF Obs. Rome)

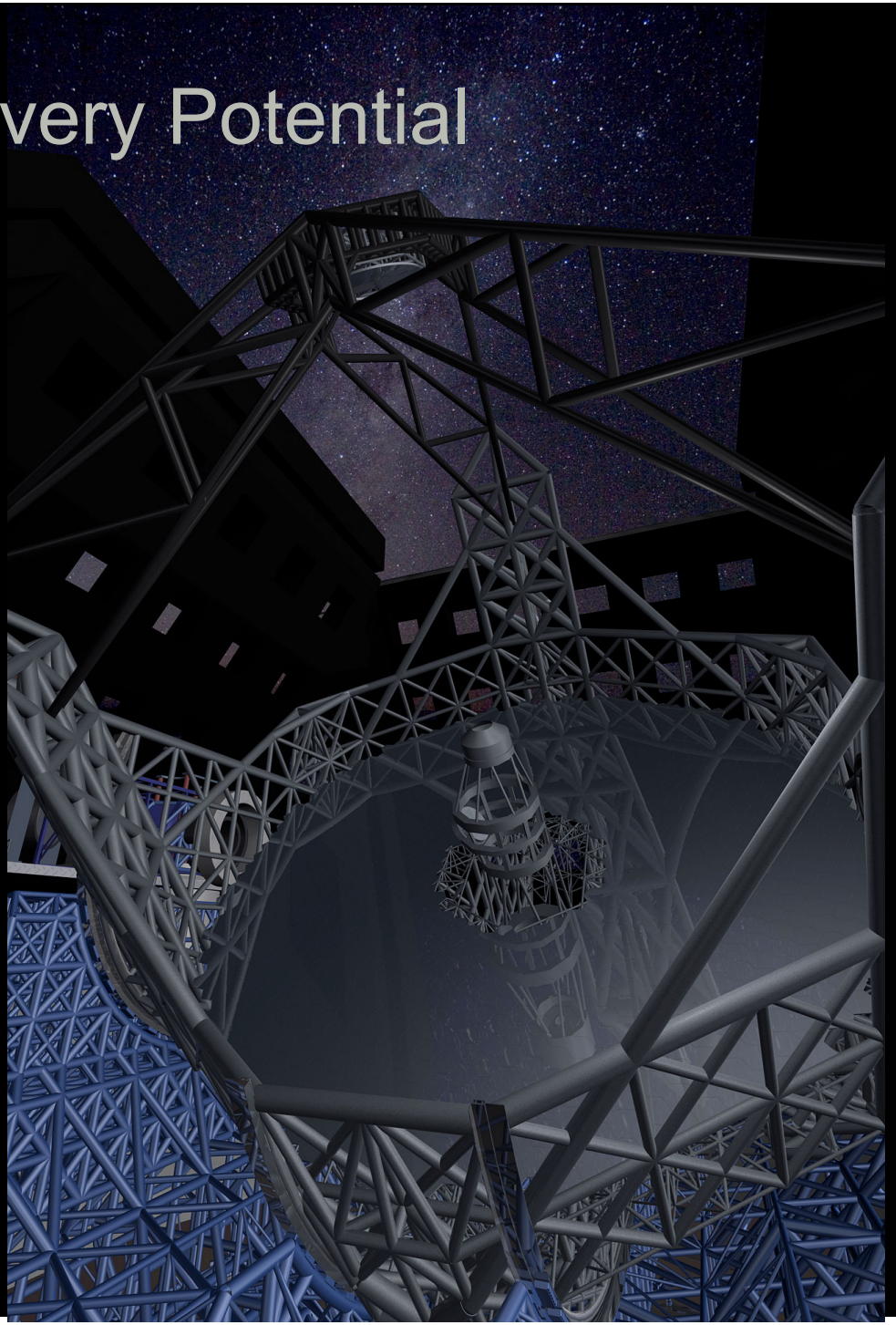


Outline

- Introduction to the E-ELT science case
- The Design Reference Mission
- This workshop
- What's next

European ELT Discovery Potential

- European ELT - a 42m diameter, adaptive telescope
- Start of operation - 2018
- Diffraction limited images 5x sharper than 8m or JWST
- Larger collecting area
- Enables spectacular new science, complements other flagship facilities



Other ELT projects

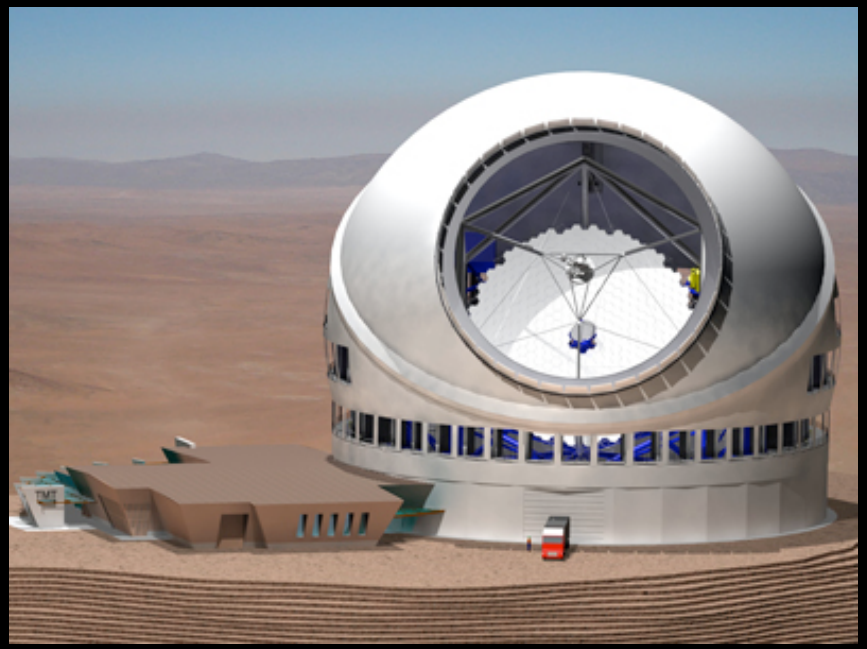
TMT

30m telescope

U. California, Caltech, Canada, + Japan as observers

Construction proposal complete

First light ~ 2018



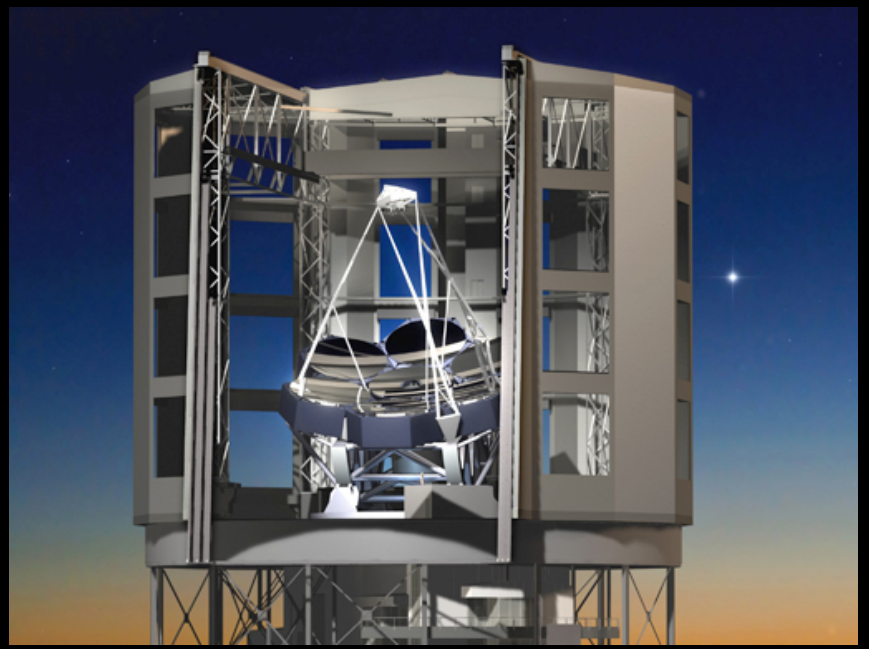
GMT

24m diameter (7x 8m segments)

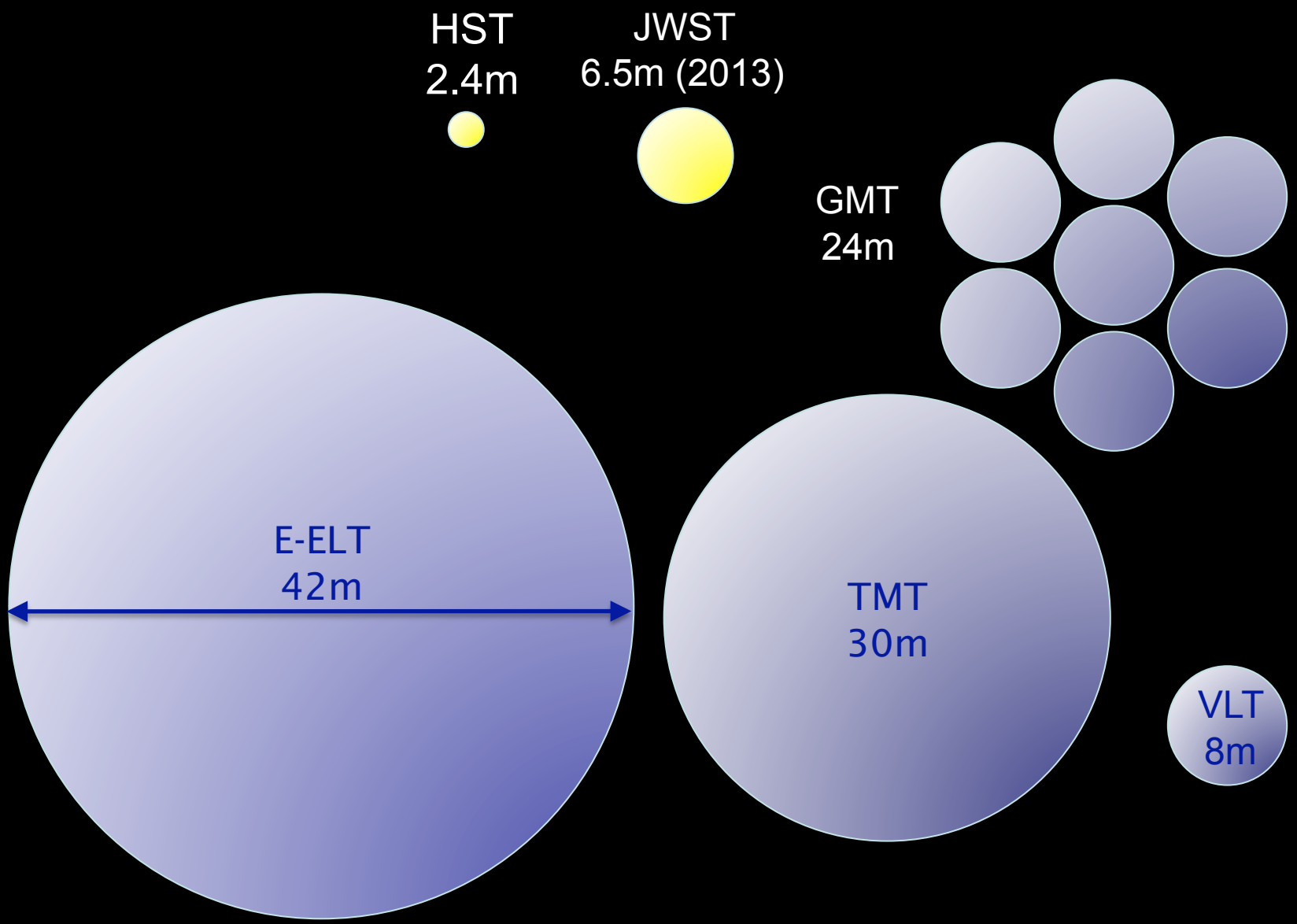
Collaboration of private US universities, Australia + Korea

First mirror cast

First light ~ 2018



Telescope primary mirrors



Diffraction limits (milliarcsec)

- Combination of resolution with collecting area gives enormous gains:
  - t~ D^{-4} in some cases
  - or ~6.5 mag gain vs 8m in natural seeing

Diameter /band	8m	42m
I	20.1	3.8
J	32.2	6.1
H	42.5	8.1
K	56.7	10.8

~ few mas in near IR
~ few 10s mas in Mid-IR

Science Working Group Report, April 2006

http://www.eso.org/sci/facilities/eelt/

Planets and Stars

Solar system comets

Extrasolar-system comets (FEBs)

Extrasolar planets:

- imaging

- radial velocities

Free-floating planets

Stellar clusters (inc. Galactic Centre)

Magnetic fields in star formation regions

Origin of massive stars

LMC field star population

Circumstellar disks, young and debris

Stellar remnants

Asteroseismology

Stars and Galaxies

Intracluster population

- Colour-Magnitude diagrams

- CaII spectroscopy of IRGB stars

Planetary nebulae and galaxies

Stellar clusters and the evolution of galaxies

Resolved stellar populations:

- Colour-Magnitude diagram Virgo

- abundances & kinematics Sculptor galaxies

- abundances & kinematics M31- CenA

Spectral observations of star clusters:

- internal kinematics & chemical abundances

- ages and metallicities of star cluster systems

Young, massive star clusters

- imaging

- spectroscopy

The IMF throughout the Local Group

Star formation history through supernovae

- search and light curves

- spectroscopy

Black holes/AGN

Galaxies and Cosmology

Dark energy: Type Ia SNe as distance indicators

- search and light curves

- spectroscopy

Dynamical measurement of universal expansion

Constraining fundamental constants

First light - the highest redshift galaxies

Galaxies and AGN at the end of reionization

Probing reionization with GRBs and quasars

Metallicity of the low-density IGM

IGM tomography

- bright LBGs and quasars

- faint LBGs

Galaxy formation and evolution:

Physics of high-z galaxies

- integrated spectroscopy

- high resolution imaging

- high spatial resolution spectroscopy

Gravitational lensing

Deep Galaxy Studies at z=2-5

ELT and the Astronet Science Vision

A. Do we understand the extremes of the Universe?

- Measure the evolution of the dark-energy density
- Test for a consistent picture of dark matter and dark energy
- Understand the astrophysics of compact objects and their progenitors

B. How do galaxies form and evolve?

- Map the growth of matter density fluctuations in the early Universe
- Detect the first stars, black holes, and galaxies
- Determine the evolution of the galaxy cluster mass function
- Make an inventory of the metal content of the Universe over cosmic time
- Measure the build up of gas, dust, stars, metals, magnetic fields, masses of galaxies

C. What is the origin and evolution of stars and planets?

- Determine the initial physical conditions of star formation
- Unveil the mysteries of stellar structure and evolution, also probing stellar interiors;
- Understand the life cycle of matter from the interstellar medium
- Determine the process of planet formation
- Explore the diversity of exo-planets in a wide mass range from giants to Earth-like
- Determine the frequency of Earth-like planets in habitable zones and push towards direct imaging

D. How do we fit in?

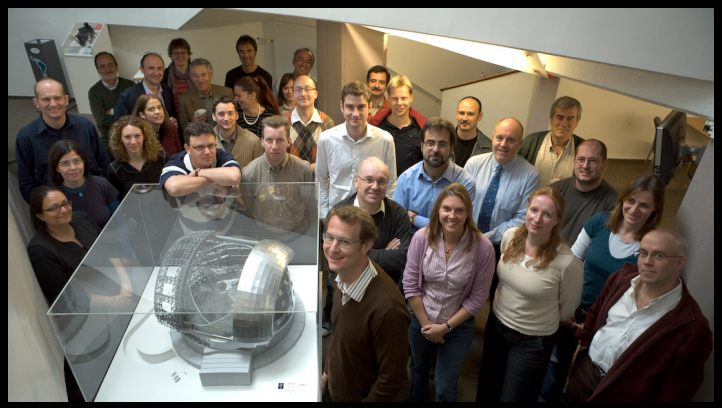
- Constrain the models of internal structure of planets and satellites
- Studies of Titan, Mars, Europa and other outer satellites.

Nov 2008: E-ELT ranked by Astronet as one of two top priorities for ground-based astronomy

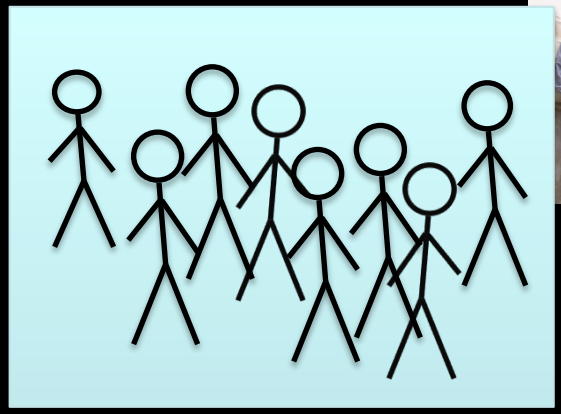
ELT science case development in Europe

Florence 2004

Marseilles 2003



Munich 2008



Munich 2009

Marseilles 2006

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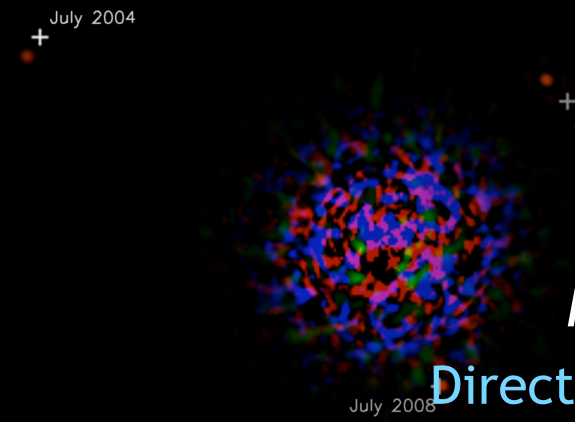
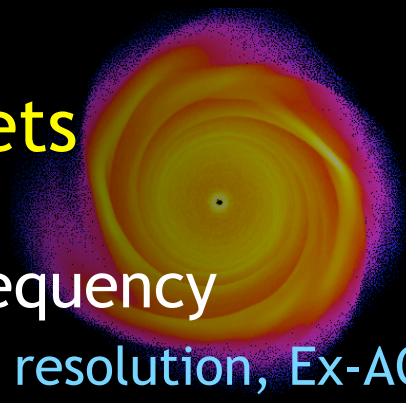
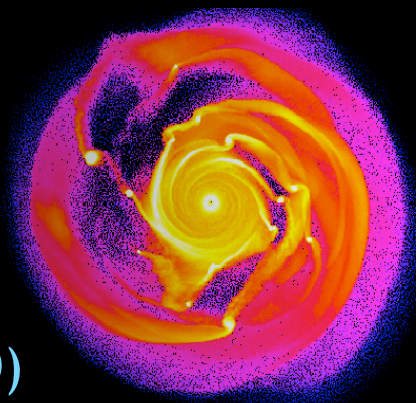


Exo-Planets





Mass, orbits, frequency

Direct detection (spatial resolution, Ex-AO)

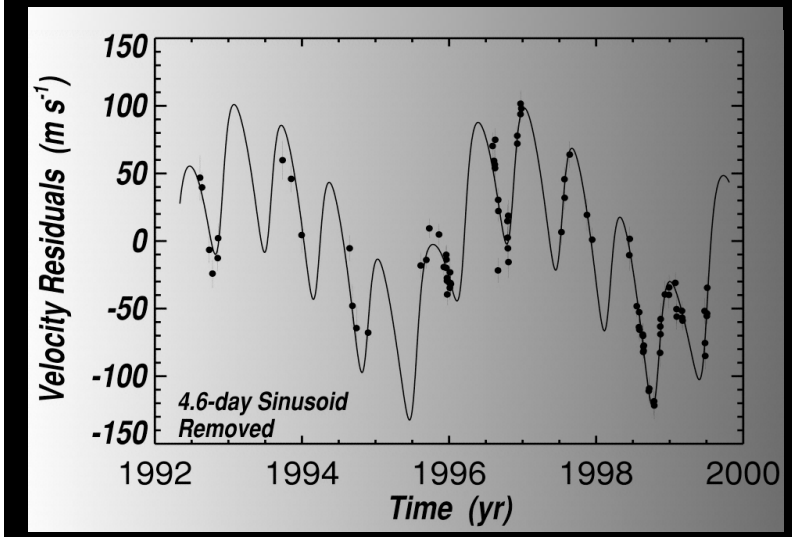
Radial velocity detection (to Earth Mass)

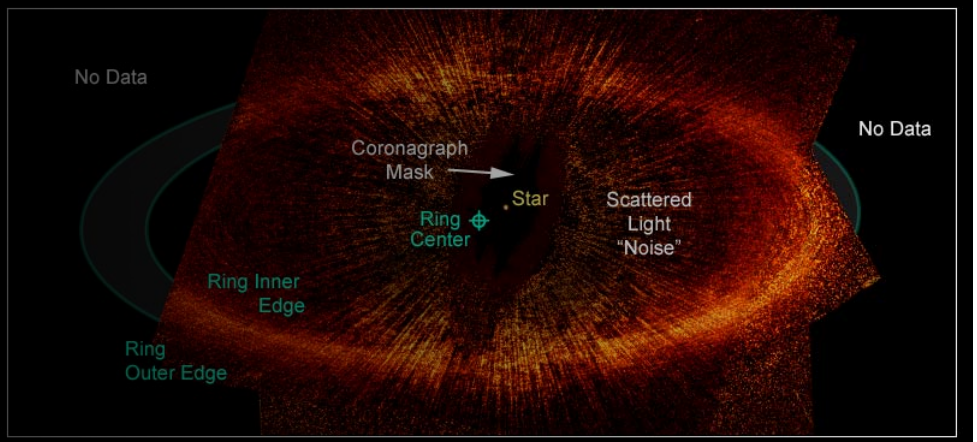
Exo-planet atmospheres (high-res spectroscopy)

Proto-planetary Disks: Formation mechanism

near-IR imaging of reflected light

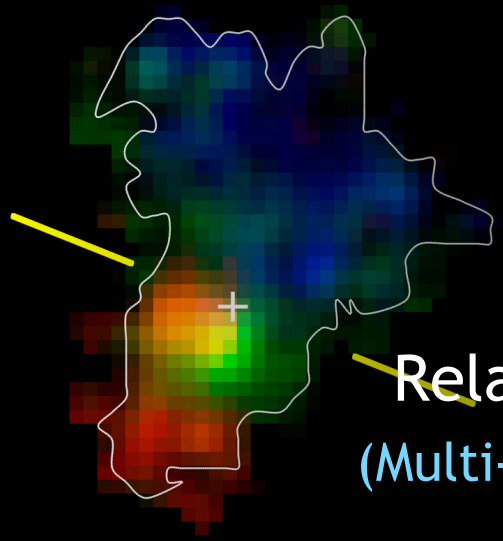
Mid-IR imaging/spectroscopy of dust



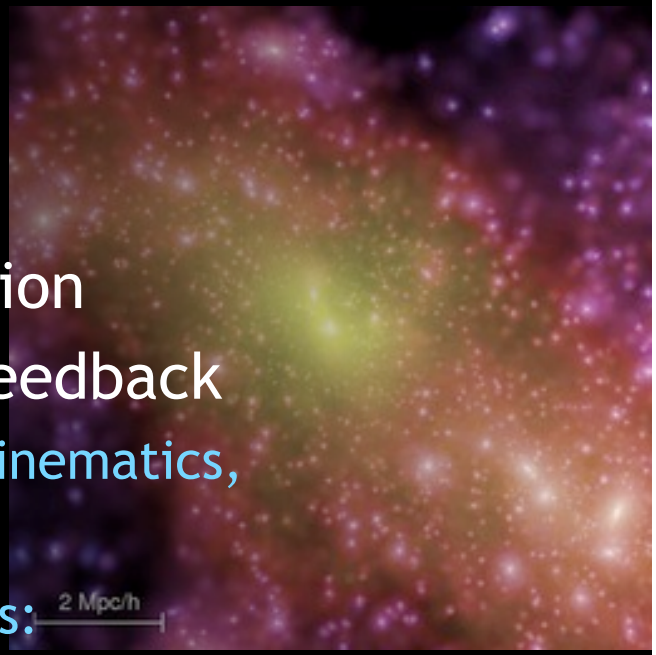


NASA, ESA, P. Kalas and J. Graham (University of California, Berkeley) and M. Clampin (NASA/GSFC)

STScI-PRC05-10



Galaxy Formation



Physics of galaxy formation

Relation to mass assembly, feedback

(Multi-) IFU observations: resolved kinematics,

SFR, mass 1< z < 6

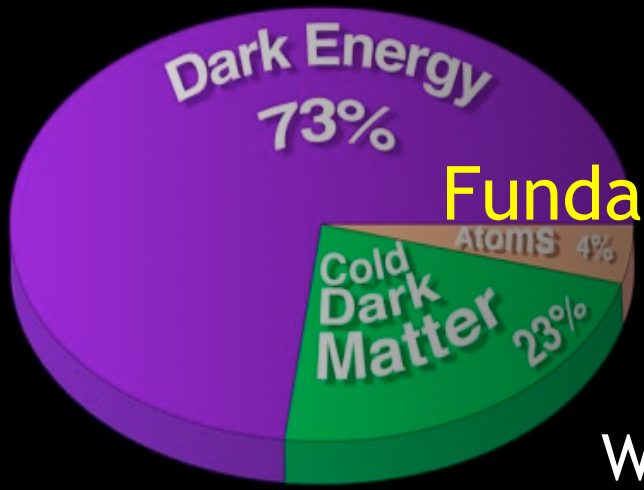
Resolved stellar populations:

merger history, detailed kinematics and abundances

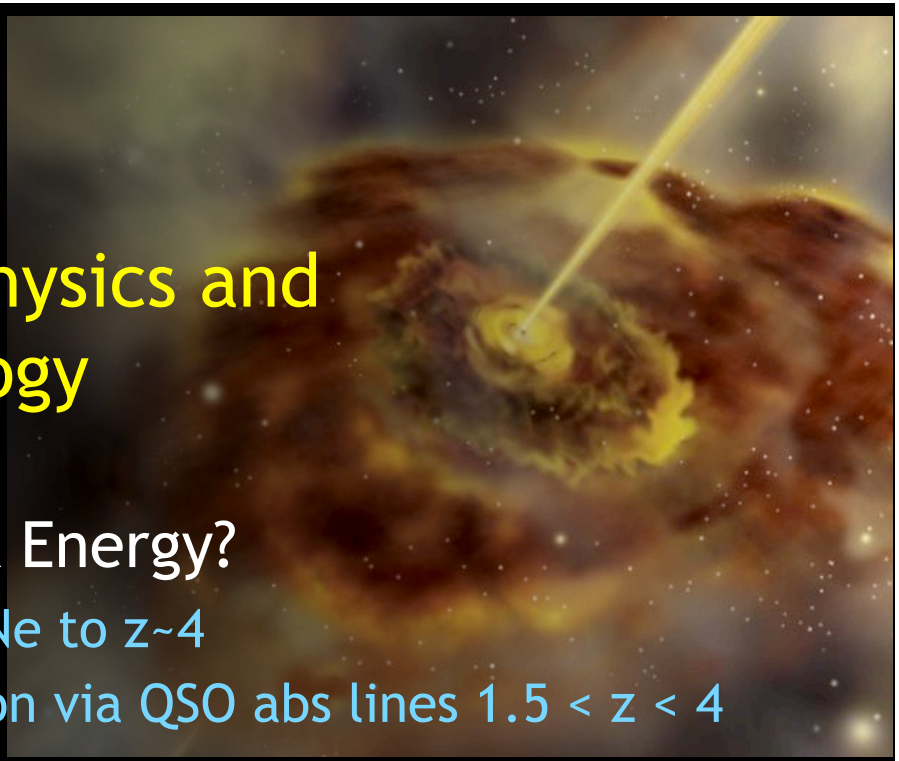
Highest redshift galaxies

Reionisation

Metal enrichment in the IGM



Fundamental Physics and Cosmology



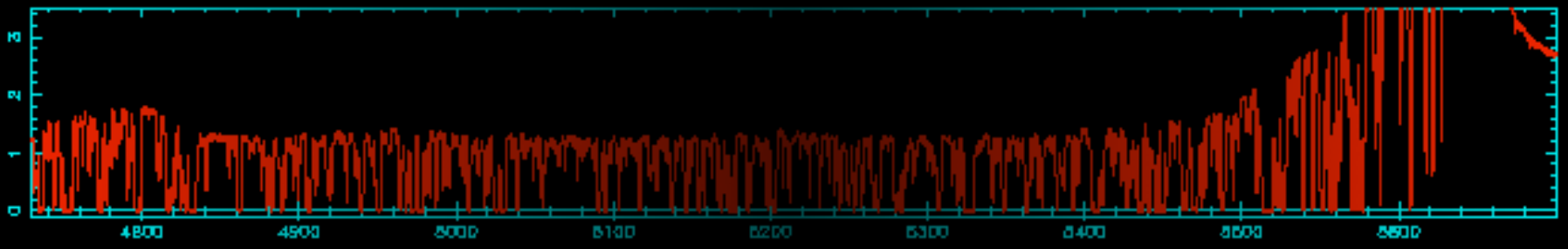
What is Dark Energy?

Type Ia SNe to z~4

Direct measurement of expansion via QSO abs lines 1.5 < z < 4

Variation of fundamental parameters

Physics in extreme conditions (Black holes)



The Unknown

Need a flexible system covering unique and broad parameter space

European ELT SWG
Prominent Science Cases

- Exo-planets
  - Direct detection
  - Radial velocity detection
- Initial Mass Function in stellar clusters
- Stellar disks
- Resolved Stellar Populations
  - Colour magnitude diagrams
  - Abundances and kinematics
  - Detailed abundances
- Black Holes
- The physics of galaxies
- Metallicity of the low-density IGM
- The highest redshift galaxies
- Dynamical measurement of the Universal expansion

- Setected from larger set
- Not complete!
- Input to Design Reference Mission
- See www.eso.org

The Design Reference Mission
(not to be confused with DRSP!)

- A set of observing proposals and corresponding simulations
  - SWG produced observing proposals based on prominent science cases
  - Simulations (by EScO) to assess feasibility
- Input to science case
- Assist with tradeoff decisions
- Working towards construction proposal, end 2010

E-ELT DRM Simulations

- Exo-planets
  - Direct detection
  - Radial velocity detection
- Initial Mass Function in stellar clusters
- Stellar disks
- Resolved Stellar Populations
  - Colour magnitude diagrams
  - Abundances
  - Detailed abundances and kinematics
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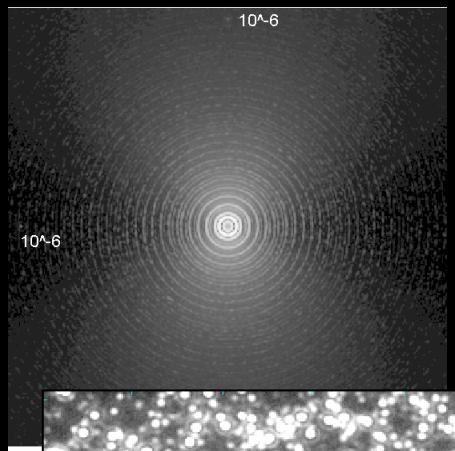

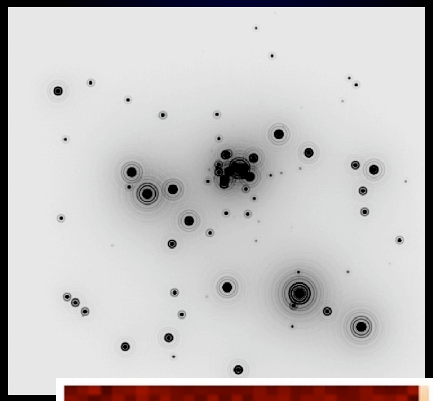

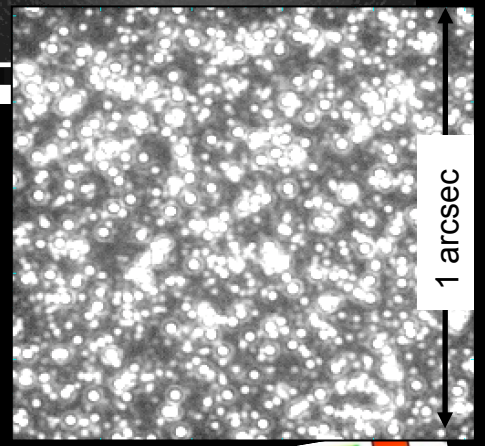

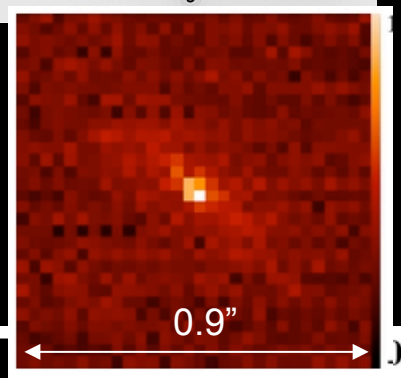

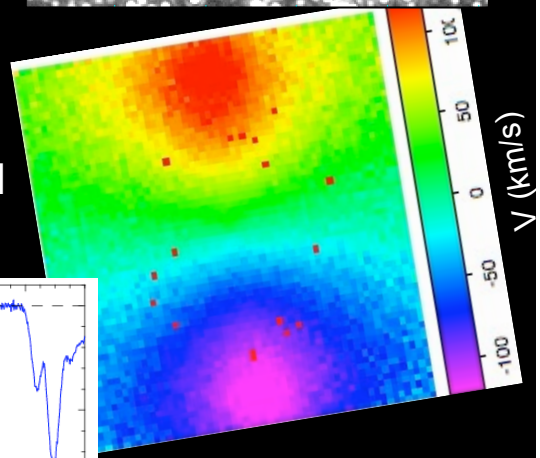

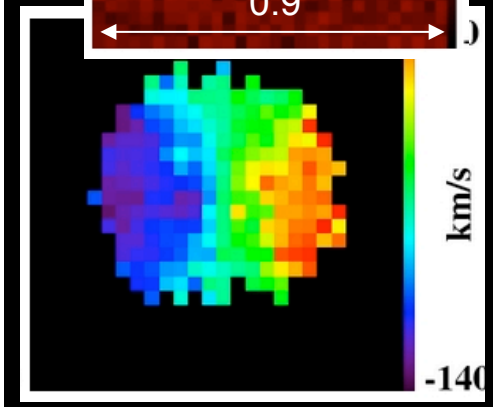

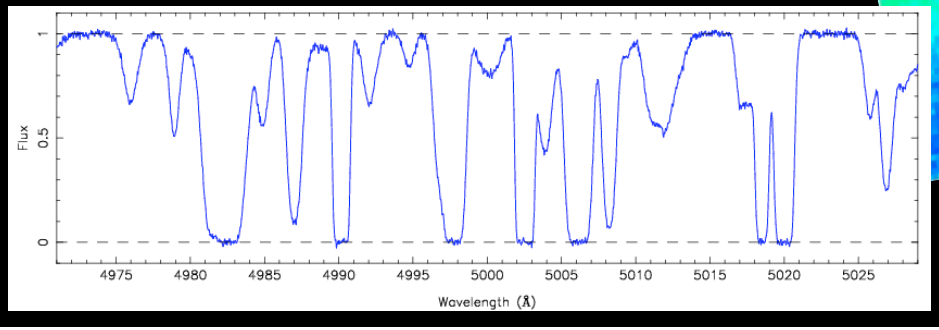

DRM feedback to project
e.g. Impact of site parameters on science

DRM science case		PI	Integrated seeing	AO friendliness			Atmospheric transmission	Background emission			Stability of conditions		Hemisphere	Number of clear nights	Comments
				AO generally	Ground layer /wide field AO	Lasers		Optical	Near-IR	Thermal-IR	time scale ~hours	time scale ~year			
Planets & Stars															
S3: From giant to terrestrial exoplanets: detection, characterization and evolution	Direct imaging of terrestrial and giant exoplanets	Rebolo	IQ critical	IQ critical (Ex-AO)	narrow field	Not required	systematic effects also important - not only photon noise		J band		Differential techniques may require stability	To obtain similar observations during planet's orbit	two out of three goals have a strong preference for the southern hemisphere		Check target Dec range. 3 exmaples given in proposal: from -80, +40
	Detection of New Earths	Udry - No proposal yet. Assuming ultra-stable RV observations.	IQ not critical	IQ not critical. No AO required?	IQ not critical. No AO required?	No AO required?	not photon starved	optical			stability required for ultra-stable line measurements? (but < 1hr?	stability required for ultra-stable line measurements?	preparatory work stronger in the South		Need to ask about target Dec range
	Rocky planets in the habitable zones of low-mass stars and brown dwarfs	No proposal. Similar requirements to above?													
	Physical properties of Earth-sized planets	No proposal. Similar requirements to above?													
S9: Circumstellar disks	Imaging the planet-forming regions of circumstellar disks (v1: 04 Mar 2008)	McCaughrean	IQ important	SCAO using central star? Or LTAO	Narrow fields only	possibly SCAO using central star. Or LTAO in near and mid-IR?			near and mid-IR (2-20um).	important, but resolution more critical than sensitivity? (cf JWST)	Can calibrate PSF within 1hr block (CHECK)	not critical	inner Galactic disk, synergy with ALMA - South preferred		No target positions given. Ask about distribution
	Dynamics and chemical evolution of circumstellar disks (v1: 04 Mar 2008)	McCaughrean	IQ fairly important for resolution and enhanced sensitivity to point sources	SCAO using central star? Or LTAO		possibly SCAO using central star. Or LTAO in near and mid-IR?			near and mid-IR (2-20um).	?	?	not critical	inner Galactic disk, synergy with ALMA - South preferred		IFU spectroscopy
S5: Young stellar clusters (incl. Galactic Centre)	Characterizing the lowest mass freely floating objects in star forming regions (v2: 21 Apr 2008)	Comeron	Proposal states that it can be carried out in non-optimal conditions	no AO		no lasers needed		0.6um - 4um but can tolerate poor conditions	0.6um - 4um but can tolerate poor conditions	0.6um - 4um but can tolerate poor conditions	can tolerate varying conditions even though monitoring?		suitable targets can be found in both hemispheres		Spectroscopy. Involves monitoring on hour-to-month timescales
	The Centers of Massive Dense Young Clusters: deep ELT infrared imaging and 3D spectroscopy (v1: 18 Mar 2008)	Zinnecker	IQ important, for sensitivity and resolution in crowded fields.	LTAO or SCAO		LTAO, or SCAO				2-5um, potentially 10 mu	need stability for photometric calibration but can be done in < 1hr block?	Need some stability for proper motion studies?	Targets not uniform. Galactic centre, LMC. Synergy with ALMA		astrometry and photometry in crowded fields. IFU spect. follow up less demanding
	Giant-planet-mass objects in the Large Magellanic Cloud (v2: 21 Apr 2008)	Comeron	IQ important, for sensitivity and resolution in crowded fields.	LTAO or SCAO		NGS should be available			1.1-2.4um		need stability for photometric calibration but can be done in <1hr block	not critical	LMC targets		Ask about target positions and reference to XAO.
Stars & Galaxies															

This workshop

- Part of EU FP7 “ELT Prep Phase” program, DRM WP
- Planned two workshops aiming to exchange information and ideas with the community
  - Inform community about E-ELT status
  - Collect community feedback
  - participants include Project Office, instrument teams, future users
- First Workshop - May 2008
  - Focus on tools and methods of simulations
- 2nd Workshop - May 2009
  - Focus on status and results of simulations (DRM)
  - Broader science case and observing techniques (DRSP)

Upcoming events

- Workshop on imaging with the E-ELT (29th May)
- DRSP input closes June 5th
- "Adaptive Optics for Extremely Large Telescopes"
  - 22-26 June, Paris
- "Towards Other Earths: Perspectives and Limitations in the ELT Era"
  - 19-23 October, Porto
- "Astronomy with Megastructures" conference
  - May (10-14?) 2010, Crete - Joint OPTICON + Radionet

www.eso.org/sci/facilities/eelt/

- Science case overview
- SWG membership, reports & resolutions
- DRM proposals and simulation results
- Tools for developing science cases
- DRSP form
- Summary slides on E-ELT

The End