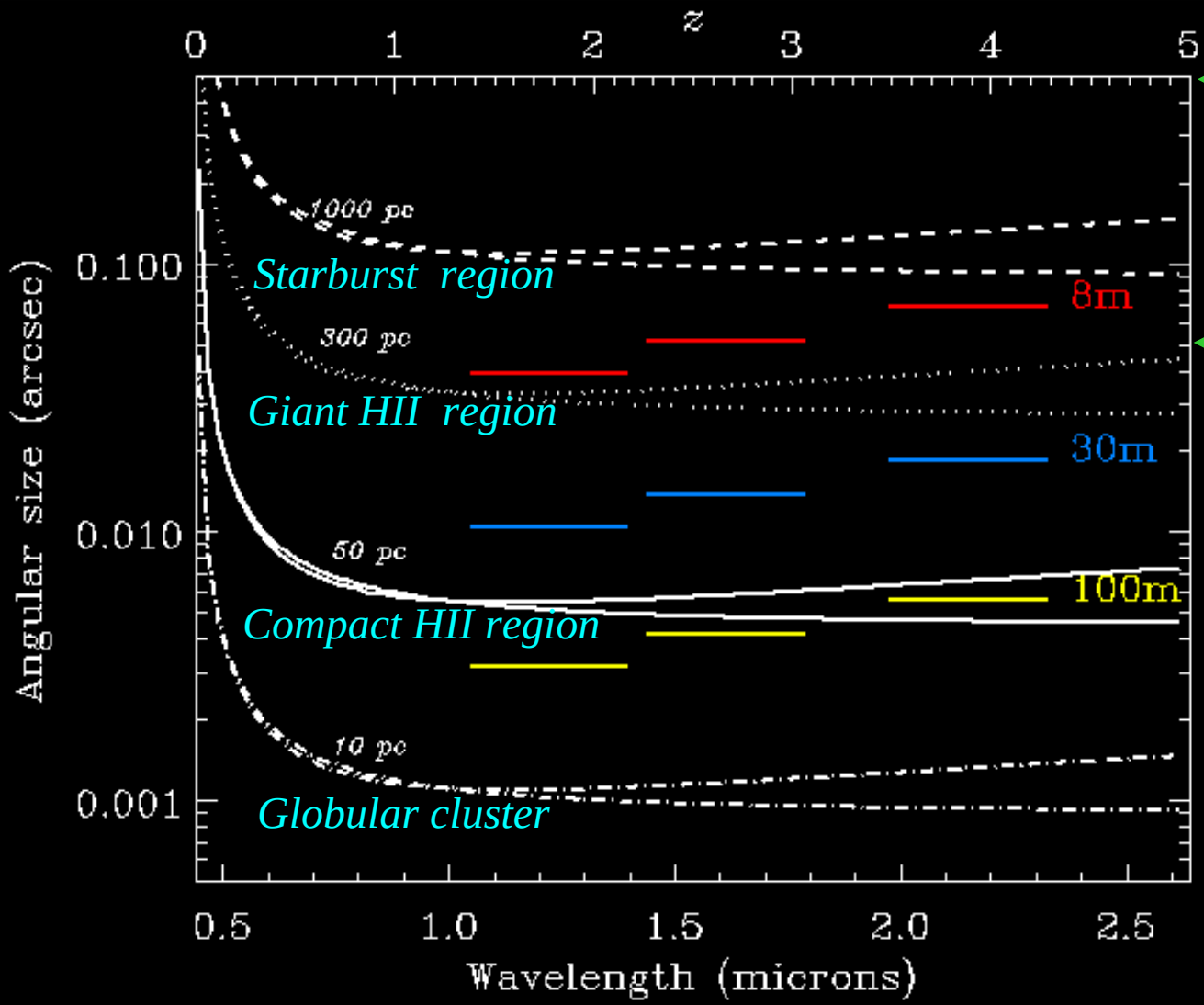
Overview of the Science case for a 50-100m Ground-based Telescope

Isobel Hook
University of Oxford

- Theoretical performance
- Work from the European ELT SWG

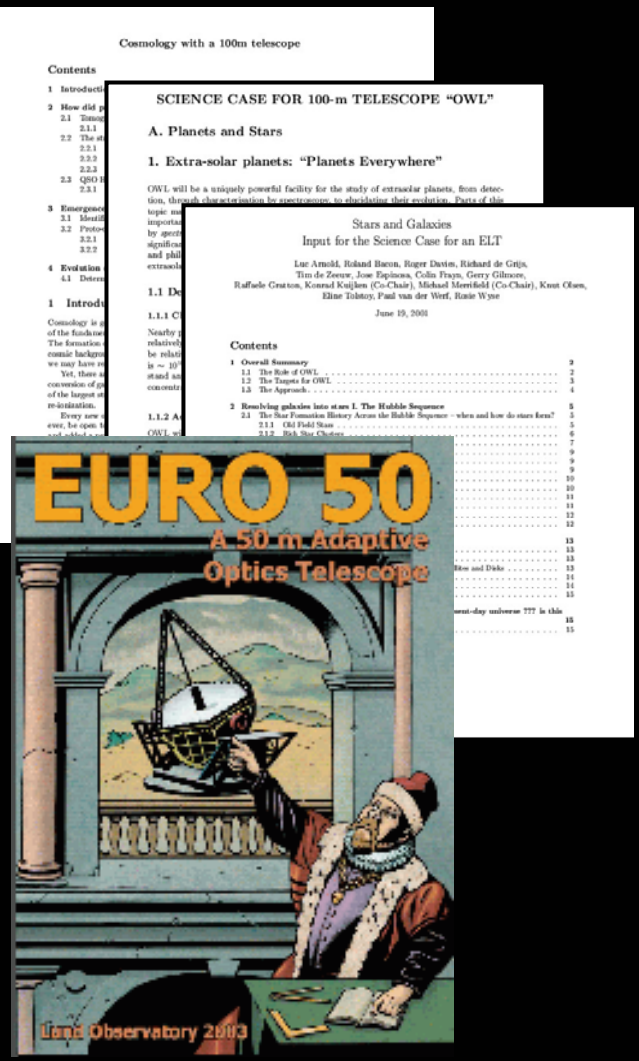
Near-IR Diffraction limits



+ dramatic improvement in point-source sensitivity

European ELT science WG

- Building on previous work for 100m (e.g. Leiden Documents) & Euro-50
- 3 working groups have been formed
  - Stars & Planets - *Hans Zinnecker & Rafael Rebolo*
  - Stars & Galaxies - *Mike Merrifield & Sergio Ortolani*
  - Galaxies and Cosmology - *Jacqueline Bergeron & Bruno Leibundgut*
- + ~100 volunteers from around Europe
- Work sponsored by OPTICON

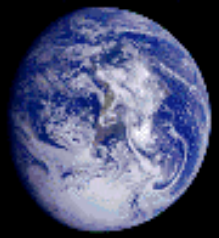


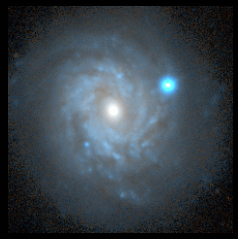
Marseille Meeting participants November 2003

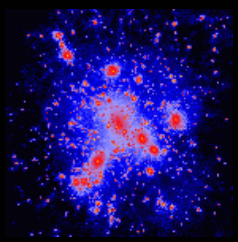
~50 participants

Goal: select science hightlights for a 50-100m ground-based telescope

European ELT Science Highlights
Marseille, Nov 2003







- **TERRESTRIAL PLANETS IN EXTRA-SOLAR SYSTEMS**
  - Direct Detection of terrestrial planets (and surrounding system)
  - Characterisation and search for bio-markers

  See talk by O. Hainaut
- **STELLAR POPULATIONS ACROSS THE UNIVERSE**
  - Resolve stellar populations in representative sample of the Universe (to Virgo)
  - Star formation rate to z~10 (via supernovae)

  See talk by M. Della Valle
- **BUILDING GALAXIES SINCE THE DARKEST AGES**
  - Spatially resolved studies of galaxies from z=1 to 5 (disk/bulge)

  See talk by M. Lehnert
  - Kinematics of galaxies and satellites in their DM haloes
- **THE FIRST OBJECTS AND RE-IONISATION STRUCTURE OF THE UNIVERSE**
  - Study IGM to z~15-20 using GRBs, QSOs, PopIII SNe(?) as background sources
  - Very high-z galaxies

  See talk by M. Bremer

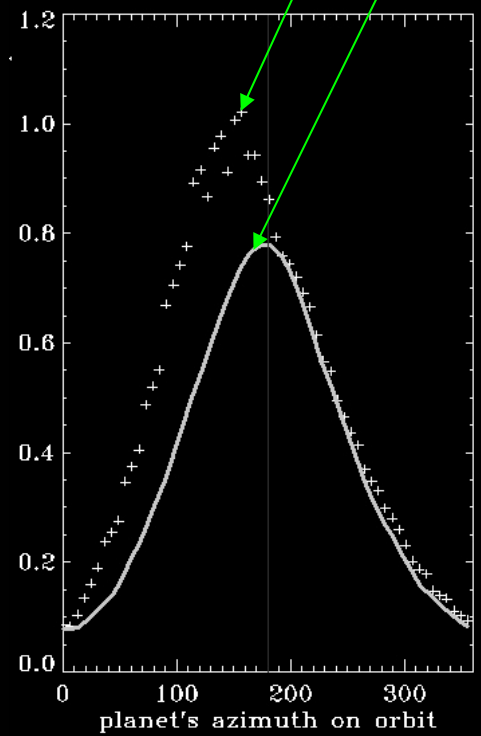
ELT terrestrial planet studies – are we alone?

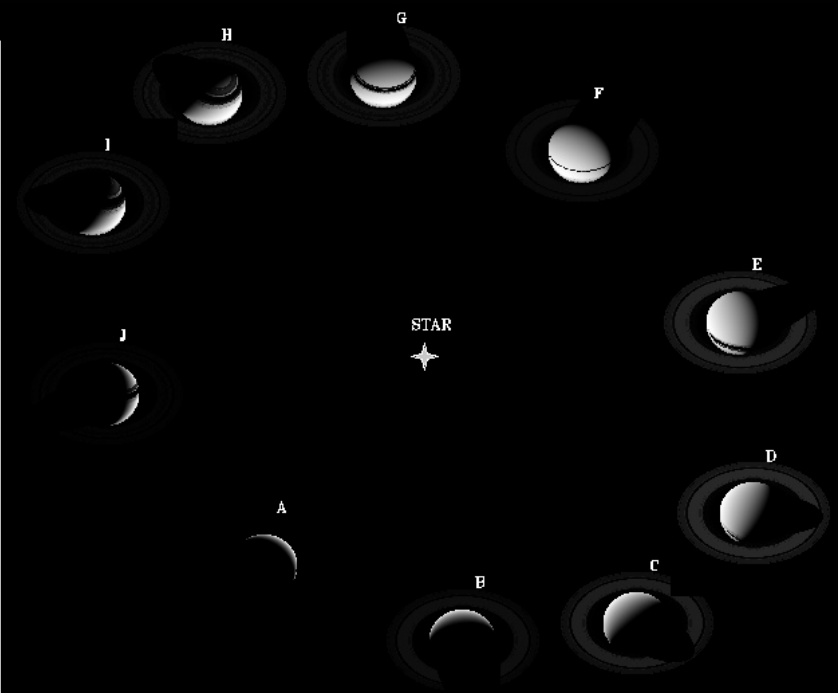
- To study exo-earths, need:
  - large sample (~1000 stars)
  - to reach ~30pc
  - resolution
  - > 50m
  - High supression
- Want to obtain:
  - SPECTROSCOPY
  - Orbits
  - Whole systems

Saturn Analogue:

With rings

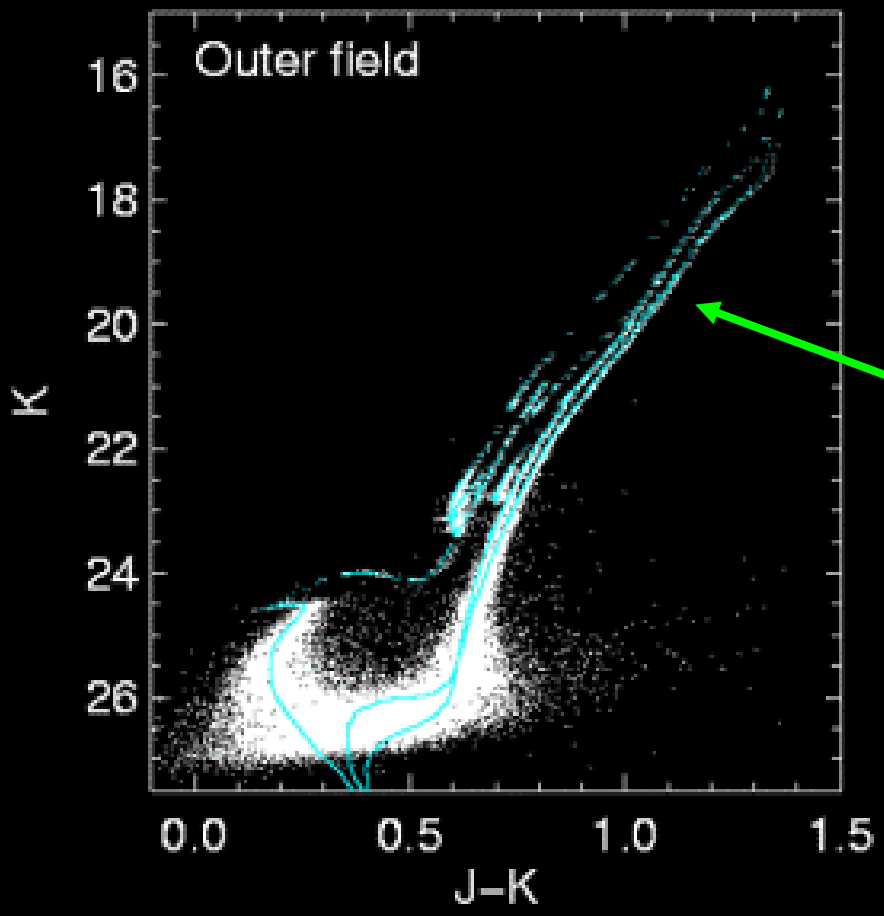
Without rings





Dyudina et al, Australian National University

Resolved Stellar populations and Galaxy Formation



- We can learn a lot about the formation and evolution of our nearby neighbours with a 30-m telescope

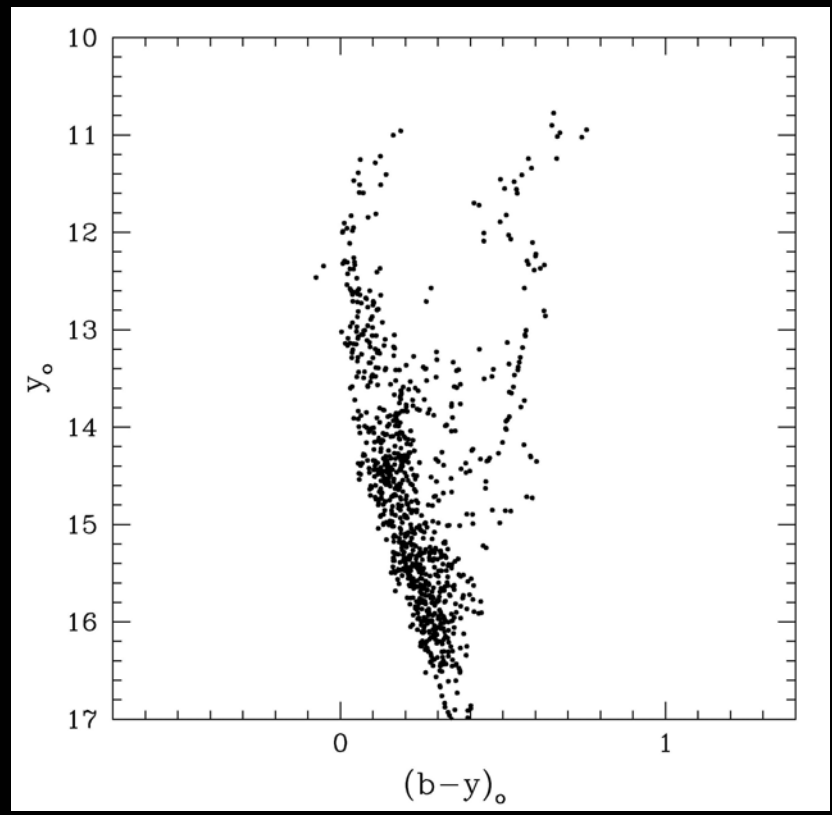
E.g. Colour-mag diagram reveals multiple stellar pops

- What about a more representative slice of the Universe?

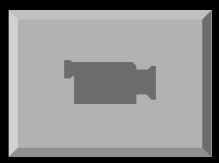
Simulated M32 CM Diagram Observed with 30-m Telescope *from GSMT study*

Formation of Galaxies and the role of dark matter

- Goal: to study the merger history of representative galaxies
- Need to measure ages and metallicities of individual stars

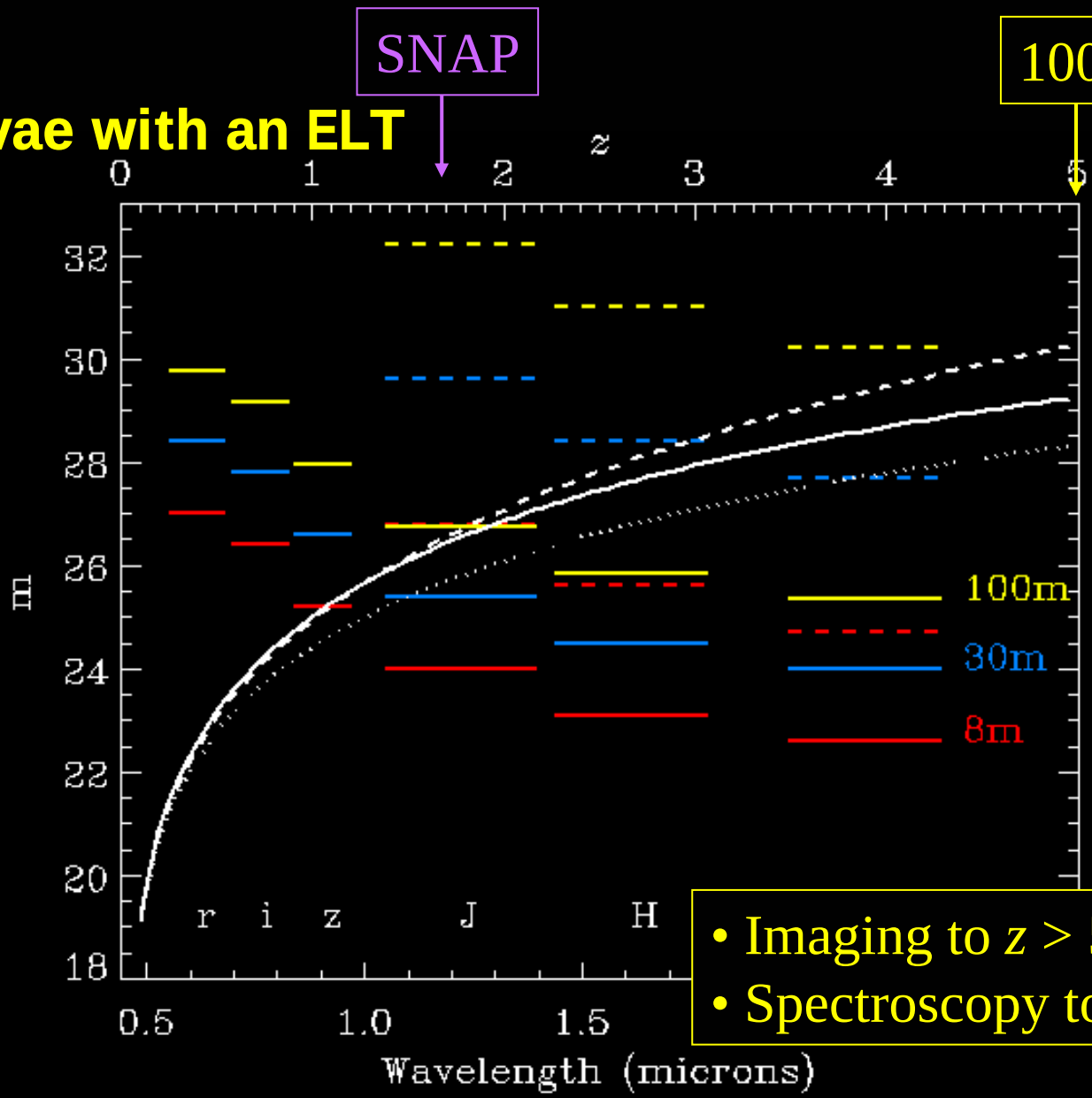


Simulated observations with a 50m *by Peter Linde*



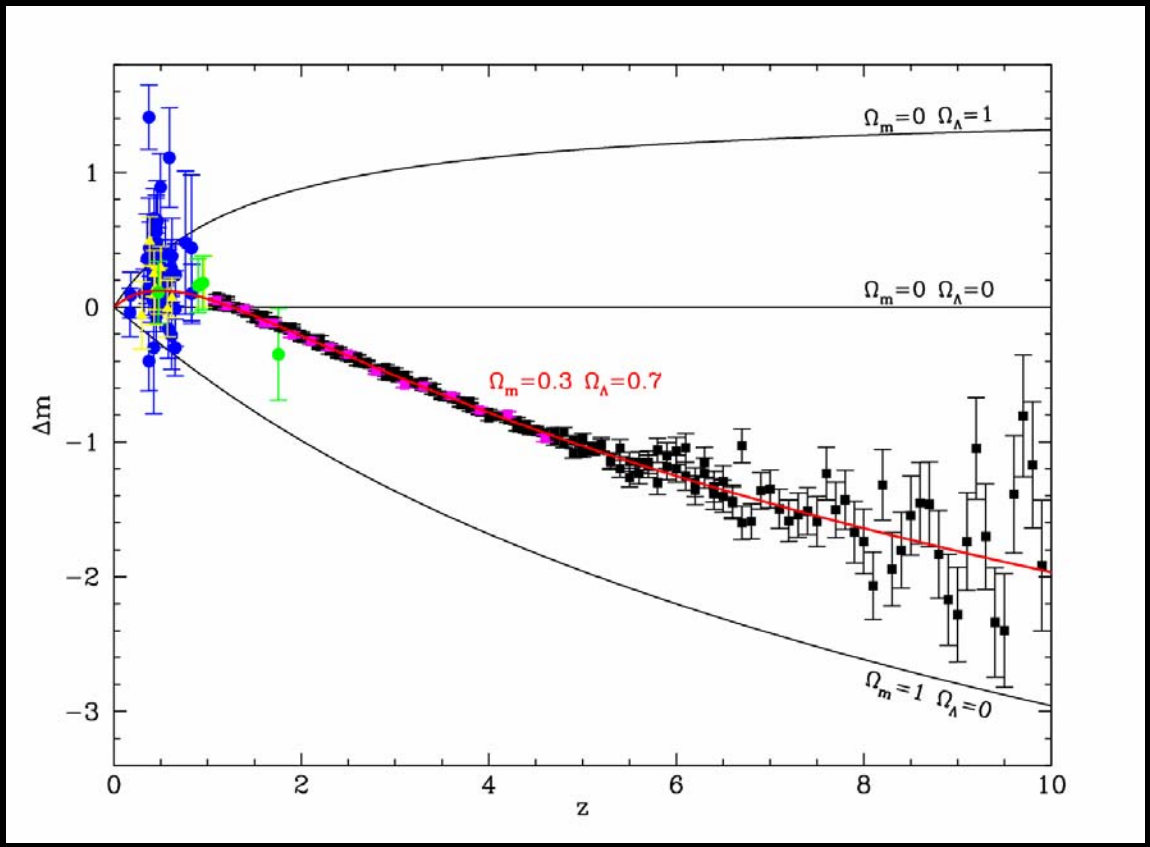
Need ~100m to reach Virgo

Supernovae with an ELT



- Imaging to $z > 5$ AT PEAK
- Spectroscopy to $z \sim 4$

The star formation history of the Universe



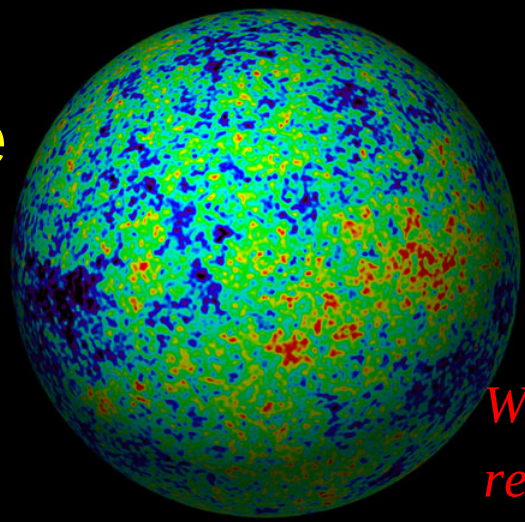
Simulated Hubble diagram for Supernovae with a 100m telescope

- SNe trace star formation

- SNeIa are standard candles:
  - Measure dark energy
  - Is it Λ ?

Massimo Della Valle & Roberto Gilmozzi

The Re-ionisation history of the Universe

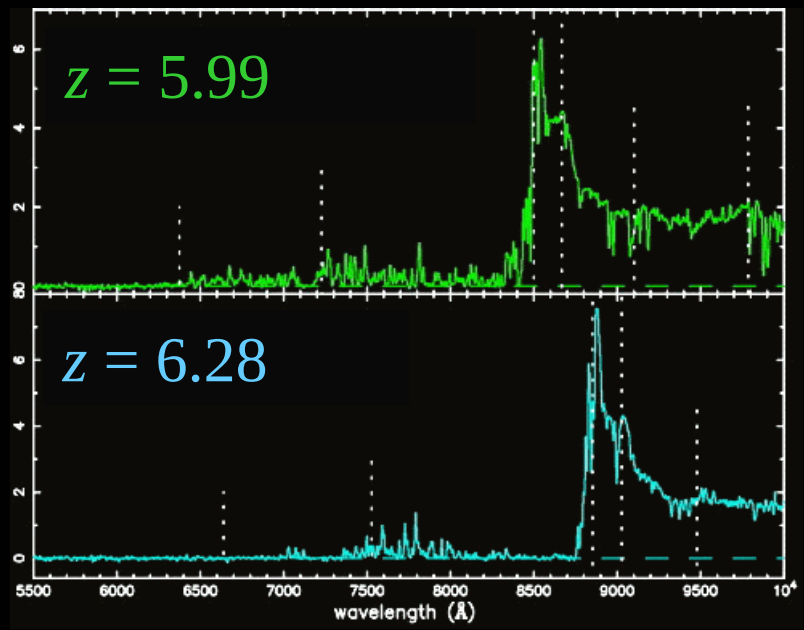


WMAP results

"Bright" objects at High-z can be used to probe IGM and its reionisation structure to very high redshift

- Point sources:
  - QSOs / AGN
  - GRBs
  - Supernovae
- IR (JHK) for z>9

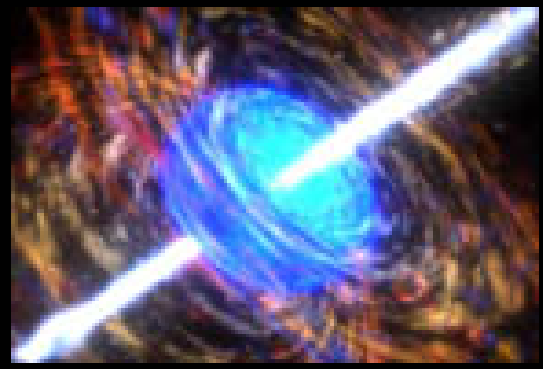
Detection limits estimated by J. Bergeron & M. Bremer



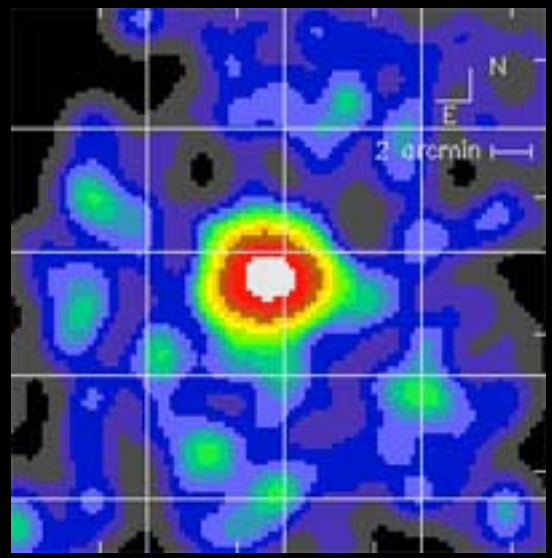
Becker et al. 2001

GRBs at z=10

- More luminous GRB afterglows should have fluxes at λ~2μm of
  - 30μJy 1 day after burst
  - 1.5 μJy 10 days after the burst
- Mean expected fluxes are (Lamb & Reichart 2000)
  - 1.5 μJy 1 day after burst
  - 0.04 μJy 10 days after the burst.
- Similar S/N can be obtained with 30 and 100m, BUT at different times after the burst.
- For R=10^4
  - 30m telescope could not observe the bulk of the GRB population at 10 days after the burst
  - could do very bright GRBs and/or within ~1 day



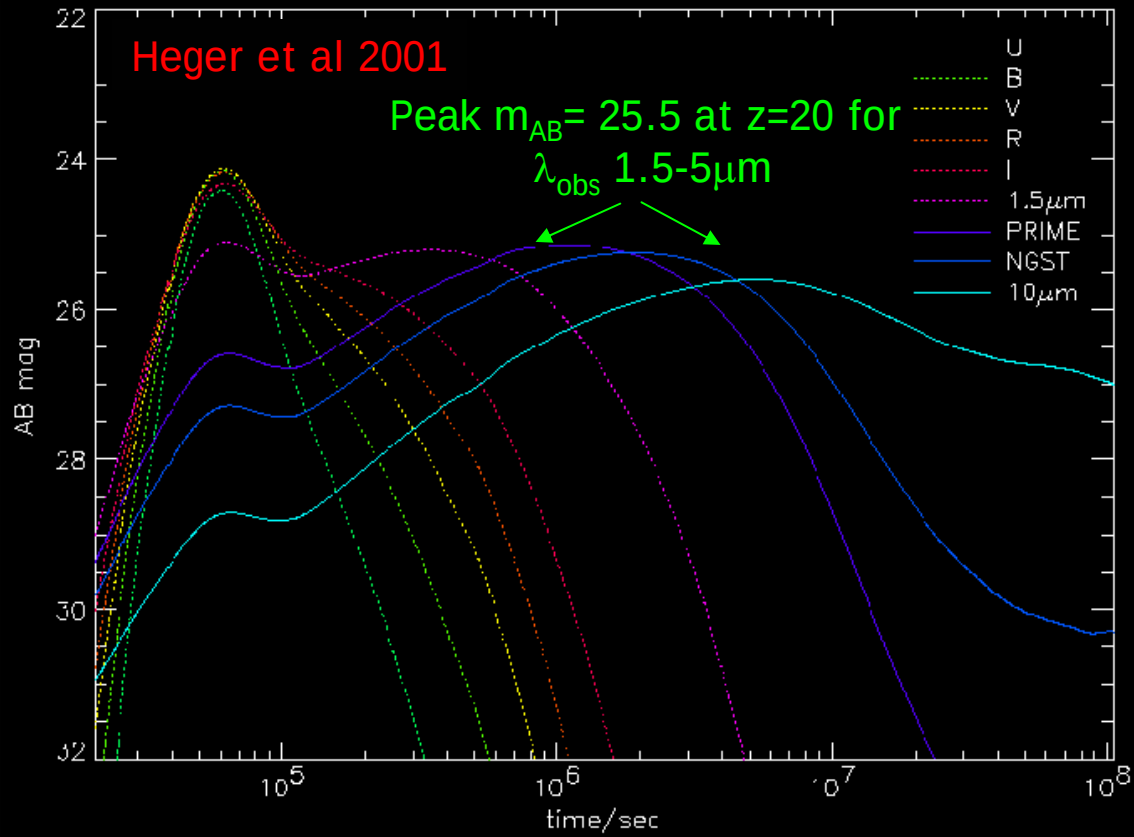
NASA / SkyWorks Digital



BeppoSAX image of GRB970228

Population III Supernovae

- Massive stars (140-260 M) should explode as very bright supernovae
- Detectable from the ground out to z~16 for ~one month



- R=10^4 needed to derive the physical properties of the IGM
- at z>10 this needs ELTs of 70-100m size

High-z QSOs

- Bright QSOs are rare
- More typical QSOs may be ten times less luminous than population III SNe.
- Need R=2x10^3 to explore e.g. the metal-enrichment of the IGM at early times from the study of the CIV forest.
- This could be done with 100m telescopes
- 100m detection limits (20σ, 50hr) correspond to black-hole masses of
  - J=29.1 1.5 x$10^5 M_{SUN}$ at z~9
  - H=28.2 5 x$10^5 M_{SUN}$ at z~12
  - K=27.6 13 x$10^5 M_{SUN}$ at z~16
- Such high mass at z~16 implies either
  - seed black-holes at z~25-30 with masses larger than $10^3 M_{SUN}$ or
  - efficient merging of black-holes in dense stellar clusters at early times

ELT - Mozilla

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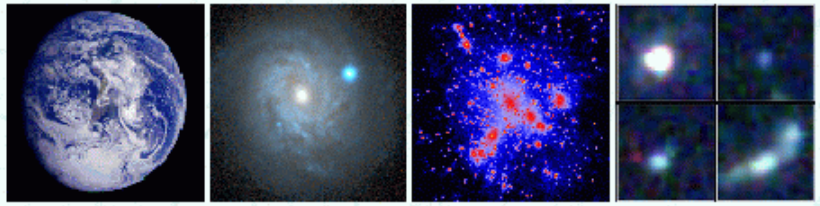
EUROPEAN LARGE TELESCOPE

SCIENCE CASE

These pages are a collection of ongoing work towards the science case for an Extremely Large Telescope (ELT). The goal of this work is to identify key science drivers for a telescope up to 100m in size, and develop the case sufficiently (through detailed calculations and simulations) to be able to drive the design of such a telescope.

This science case will include tradeoff studies, showing how science return is affected by the choice of key telescope design parameters such as size, wavelength range of operation etc. We aim to concentrate on developing the case for a 50-100m class telescope, while making use of the already well-developed case for a 30m class telescope (for example the GSMT and CELT cases linked below) when considering tradeoffs in telescope size.

ELT SCIENCE OVERVIEW



Click HERE for a summary of selected ELT science highlights

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Conclusions

- Very exciting prospects
- Many details to be worked out
  - Optimal aperture
  - AO system
  - Instrumentation (FOV vs pixel scale)
  - Balance of science drivers

For more info:
http://www-astro.physics.ox.ac.uk/~imh/ELT/

THE END