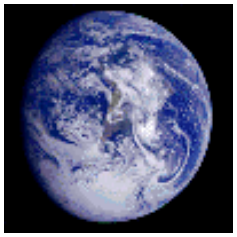
Florence 2004
Overview

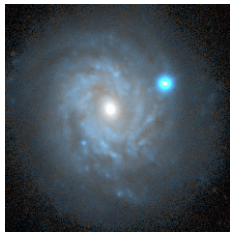
- Summary of the last meeting
  - Status of the science case for a 50-100m ELT
  - Quantitative simulations
- Progress since the last meeting
- Goals of this meeting
  - Science case document
  - Requirements document
- Some open questions

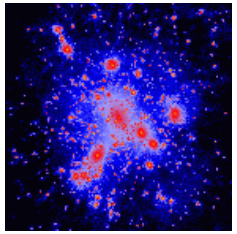
Marseilles 5-7 Nov, 2003

- 2.5 days – concentrated on identifying key science drivers for a 50-100m ELT

Marseilles 2003 - Highlights







- **TERRESTRIAL PLANETS IN EXTRA-SOLAR SYSTEMS**
  - Direct Detection of terrestrial planets (and surrounding system)
  - Characterisation and search for bio-markers
- **STELLAR POPULATIONS ACROSS THE UNIVERSE**
  - Resolve stellar populations in representative sample of the Universe (to Virgo)
  - Star formation rate to z~10 (via supernovae)
- **BUILDING GALAXIES SINCE THE DARKEST AGES**
  - Spatially resolved studies of galaxies from z=1 to 5 (disk/bulge)
  - 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

Planet detection models for OWL

O. Hainaut and R. Gilmozzi

- Simulated eX-AO-corrected psf
- Spectra of Sun, Jupiter, Earth
- Sky
- OWL efficiency simulator
- Photon noise
- cophasing errors

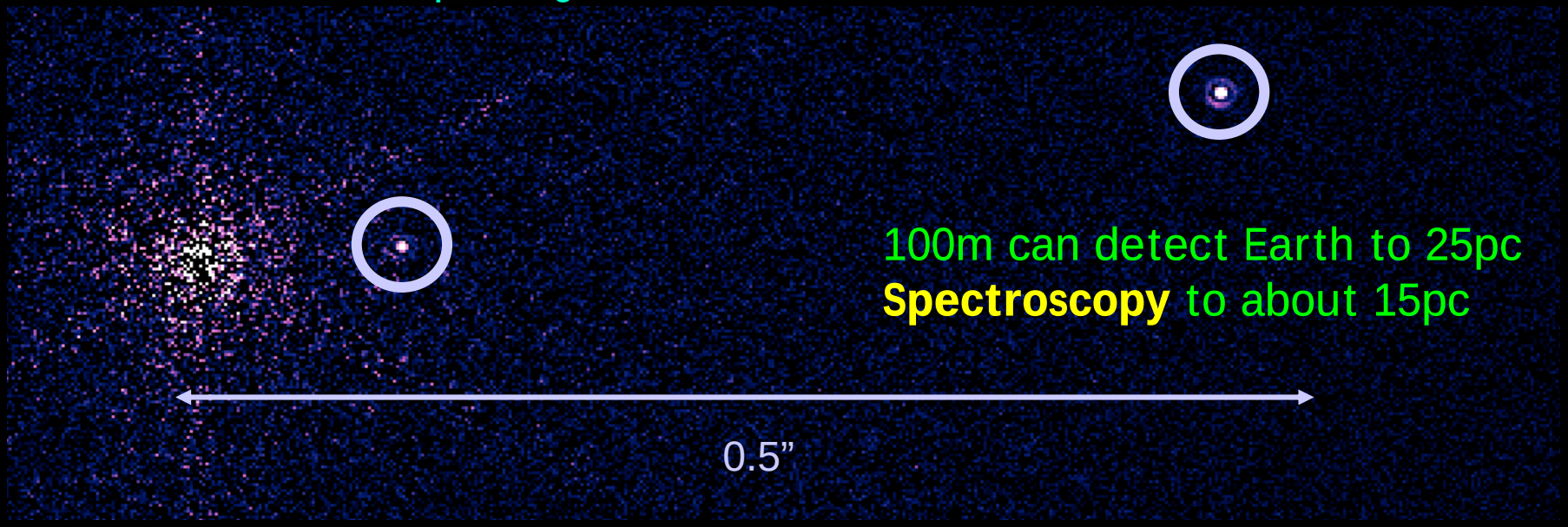
Filter R, t= 10ks

strehl=0.5

d = 10pc, D=100m

Jupiter: S/N=80

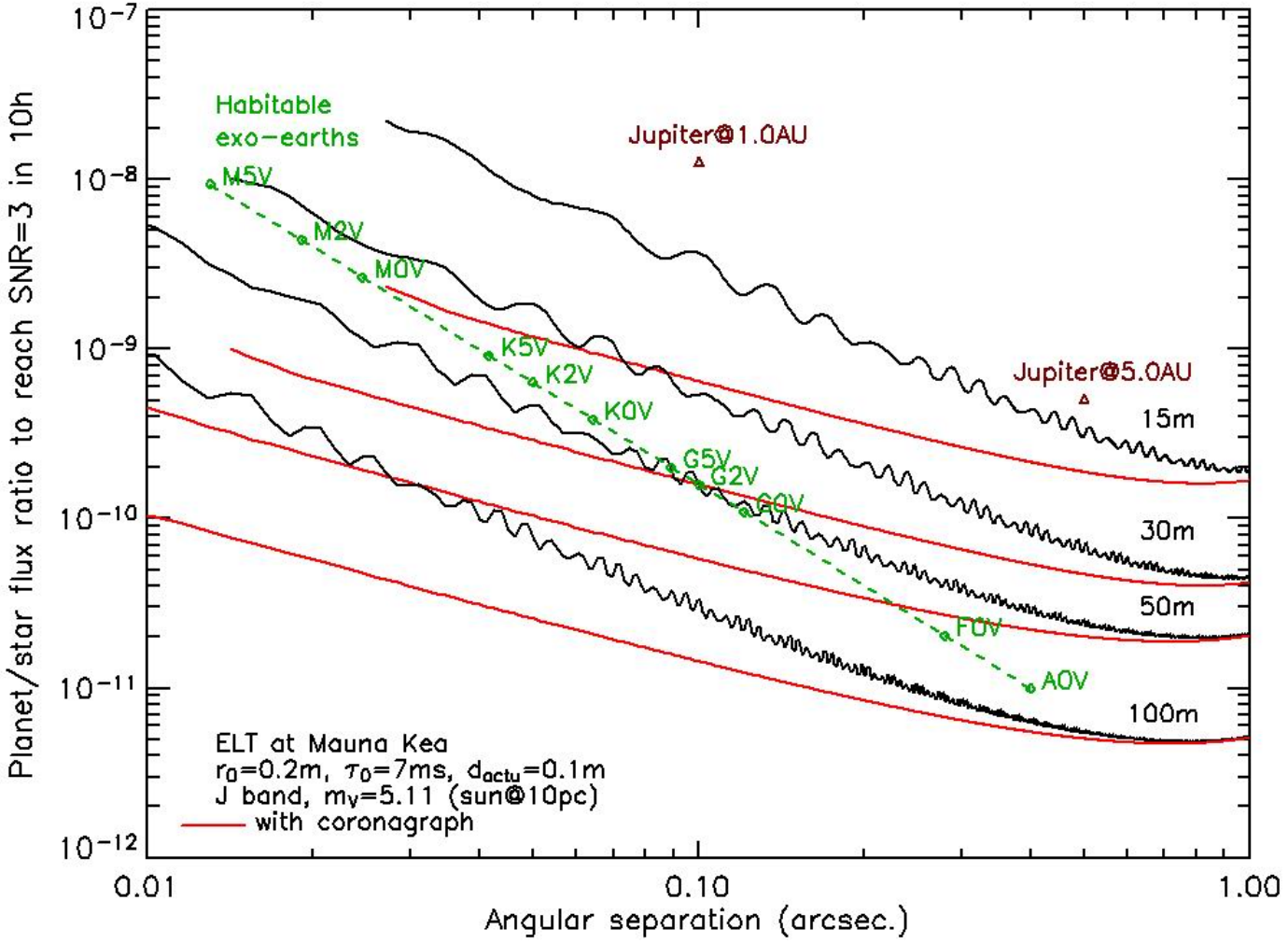
Earth: S/N=10



Planet Detection from the Ground
Lardiere et al 2003

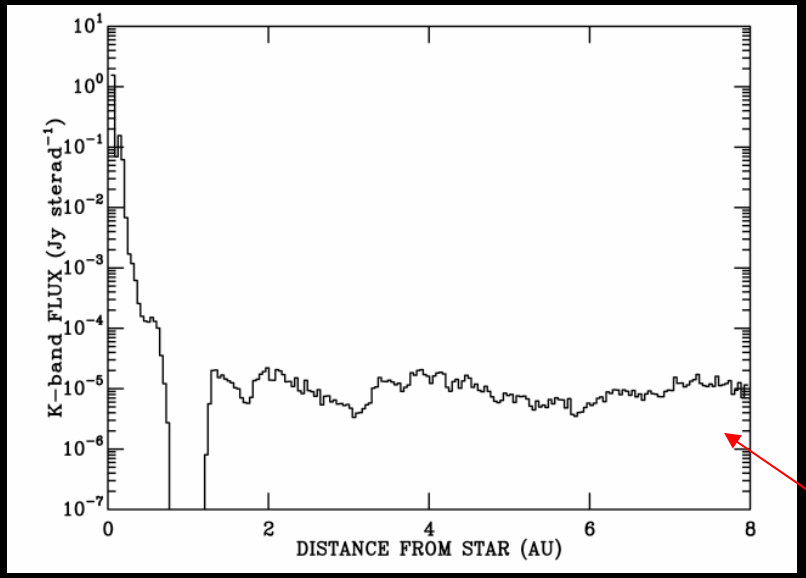
Assumes

- *System at 10pc*
- *S/N =3 in 10hrs in the J-band.*
- *Mauna Kea site*

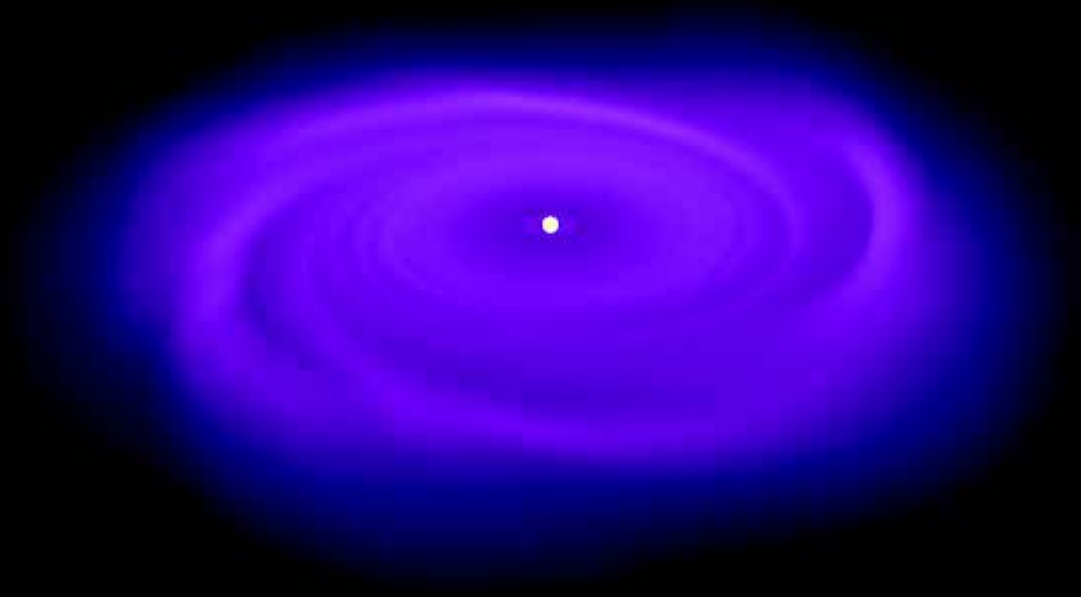


Protoplanetary Disks

- Can detect gaps in protoplanetary disks
- Requires high spatial resolution imaging in near IR
- Contrast needed ~10^6

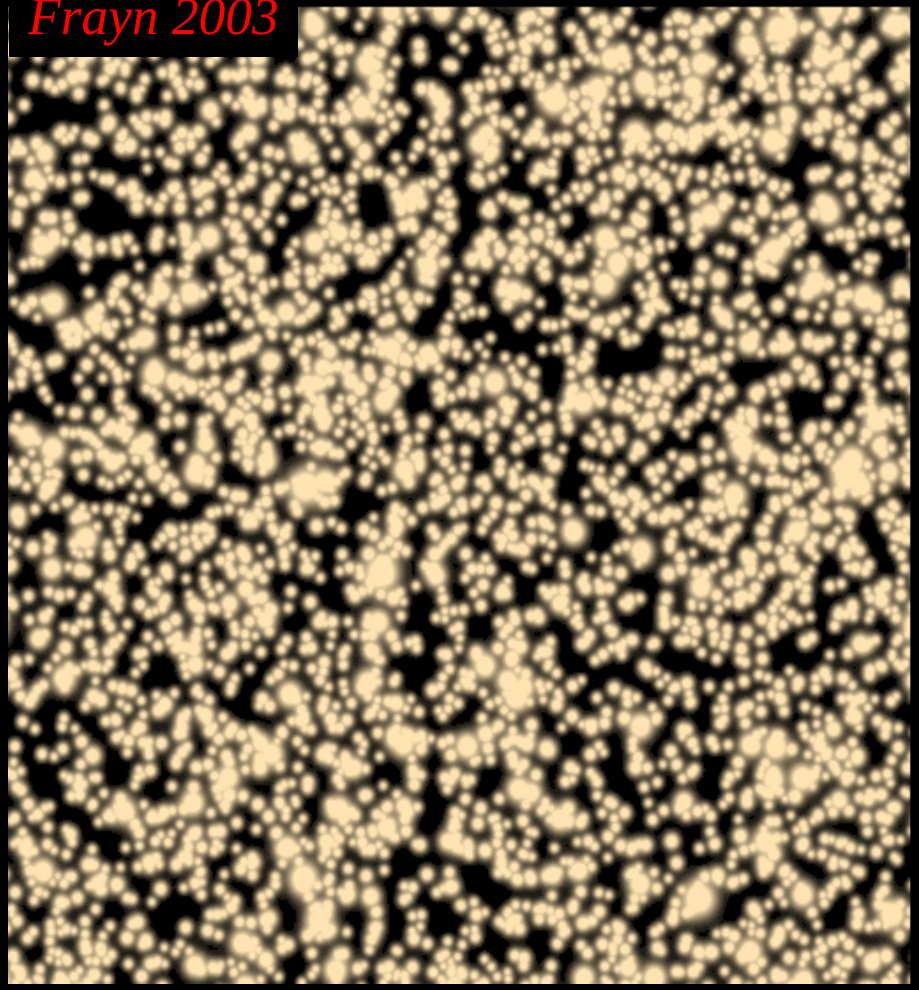


Model by Kurosawa, Harries and Bate (U. Exeter)

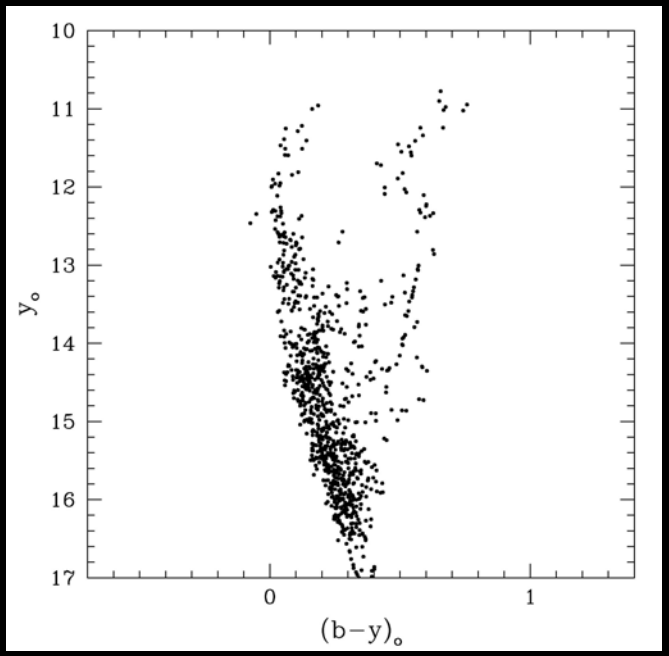


Simulation by Lucio Mayer
200 yrs of evolution in a growing proto-planetary disk

Frayn 2003



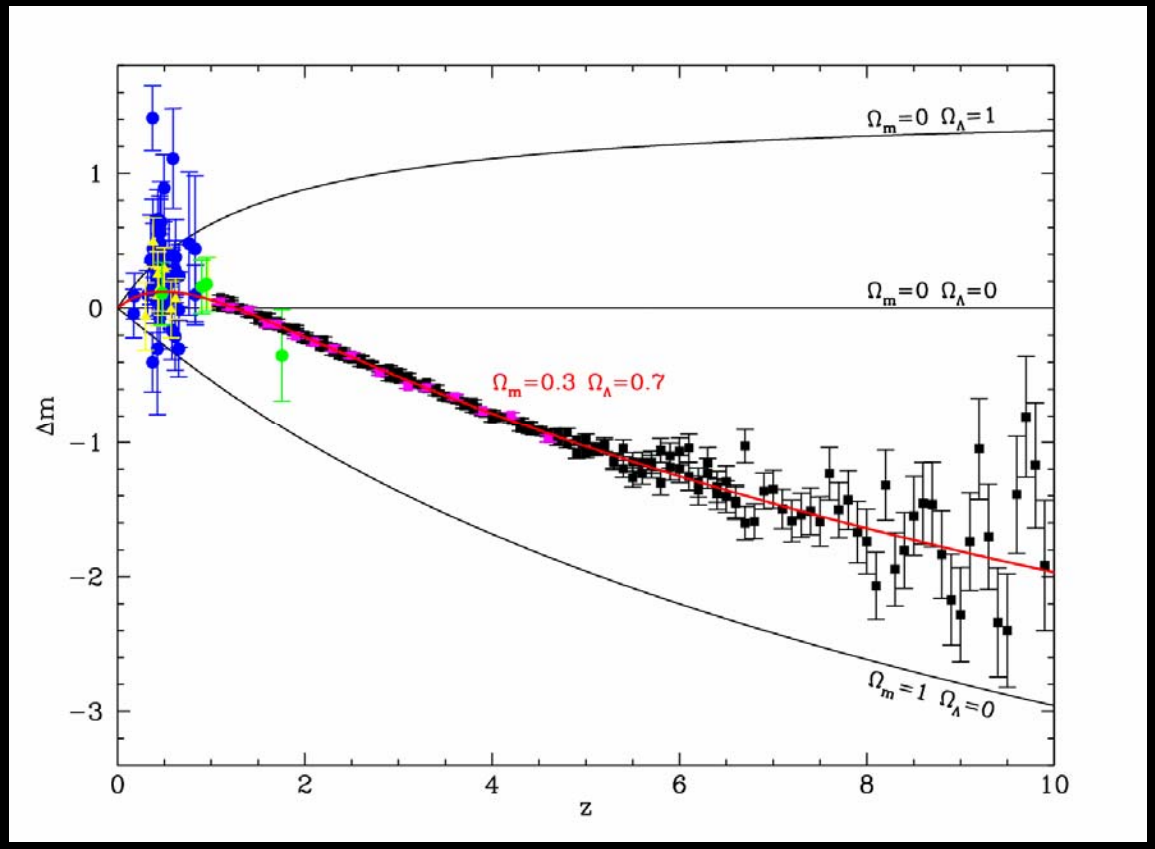
Simulated M87 field observed with 100-m telescope



Simulated observations with a 50m *by Peter Linde and Arne Ardeberg*

- 3 hour exposure
- Diffraction-limited observation
- Outer field (μI = 28)
- Realistic IMF plus population synthesis to two magnitudes below MSTO

The star formation history of the Universe



Massimo Della Valle & Roberto Gilmozzi

Simulated Hubble diagram for Supernovae with a 100m telescope

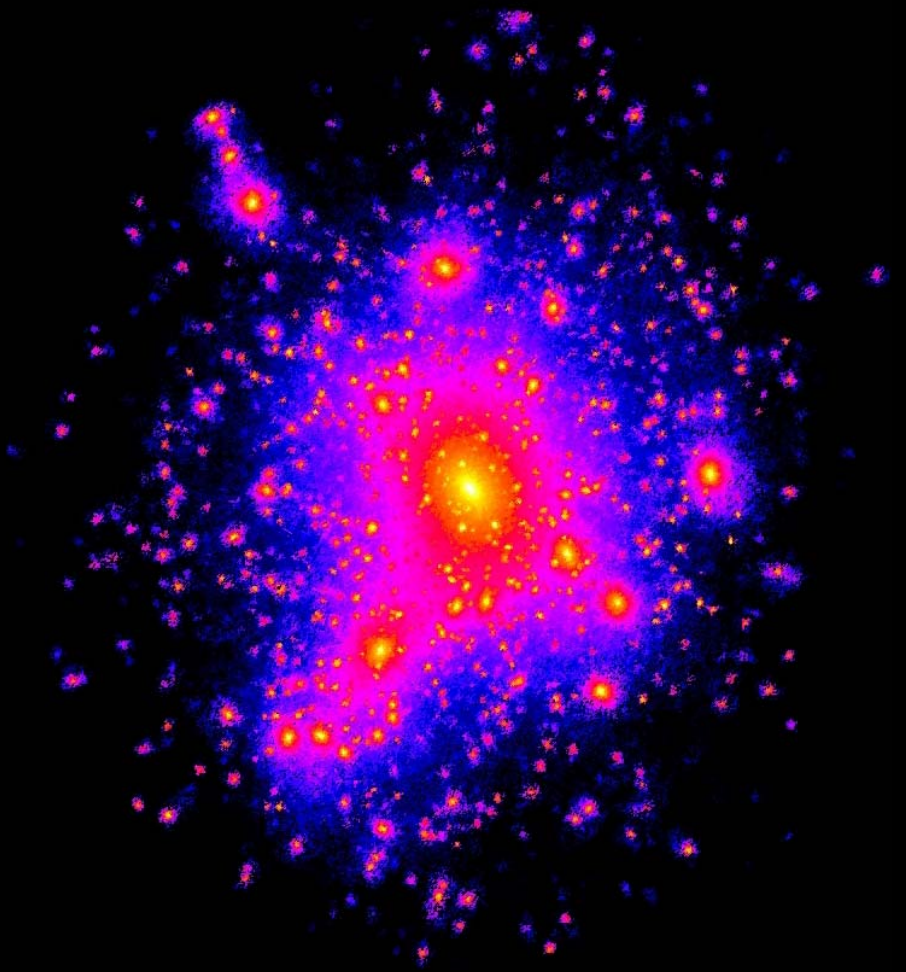
- SNe trace star formation

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

Galaxy Formation from 1< z < 5

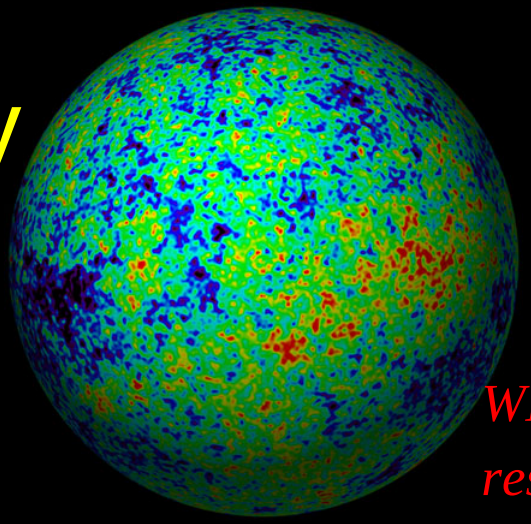
- Is our picture of hierachical galaxy formation correct?
- Goal: study growth of both baryonic and dark matter components of galaxy haloes from z=1-5
  - Resolved kinematics & abundances within central galaxy
  - Motion of satellites > t_{merge}
  - Lensed background objects > M

- multiple-IFU spectroscopy over ~10arcmin field
  - R~10,000 +/- 5000
  - Spatial sampling ~ 0.05”
  - **NEED quantitative depth estimates**



cD Galaxy formation simulation
Ben Moore

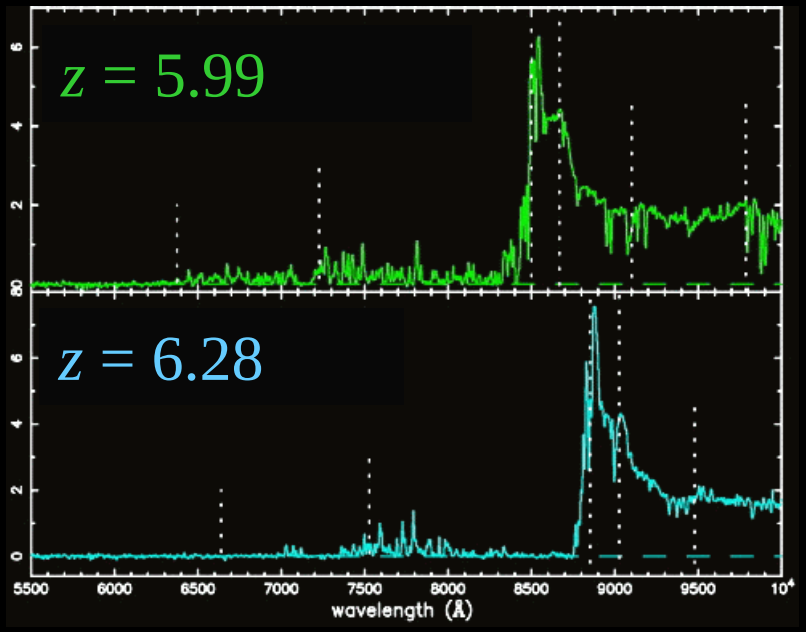
The Re-ionisation history of the Universe



WMAP results

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

- Point sources:
  - QSOs / AGN
  - GRBs
  - PopIII Supernovae
- IR (JHK) for z>9
- R=10^4 needed to derive the physical properties of the IGM
- ~100m needed for all but the brightest GRBs for z>10 at this resolution



Becker et al. 2001

Activity in the last year

- Nov 2003 Written highlights summary on the web
- Mar 2004 FP6 Design Study proposal submitted
  - With supporting science case
- May 2004 Meeting with GSMT (30m) science working group
  - General agreement on the main critical points in the science case
  - Aim to develop common set of assumptions
- May 2004 Berlin-04 “Exploring the Cosmic Frontier” meeting
  - Several presentations (and papers) by OPITCON ELT SWG
- Jun 2004 SPIE meeting (and written papers)
- Nov 2004 ELT “glossy” brochure – final draft stage
- Nov 2004 Florence meeting

Goals of this meeting

- Develop Science case –
- Compare with other planned facilities (30m, JWST, Darwin etc)
- Write the science case
  - State assumptions
    - Technical (assumed performance of telescope, instruments..)
    - Scientific (assumed brightness of sources etc)
- Write down the design requirements
  - FOV, wavelength etc
  - AO requirements

Science cases & Requirements Docs

- 20m
  - "Giant Magellan Telescope – Science Goals"
  - GMT web pages
- 30m
  - "Frontier Science enabled by a Giant Segmented Mirror Telescope"
  - GSMT web pages
  - TMT "Science based requirements document" – 50 pages (incomplete)
- 50m
  - Euro-50 book: 75 pages of science case
- 100m
  - Documents from Leiden 2001
    - 65 pages – needs some updating & formatting
  - Marseilles highlights, SPIE paper, draft "Glossy" brochure, Figures etc.
  - First attempt at requirements – on web

Comparison of 20-100m ELTs

Science Case	20m	30m	60m	100m
Solar System	**Y**	**Y**	**Y**	**Y**
Exo-Planets (direct detection): Gas Giants	**Y**	**Y**	**Y**	**Y**
: Exo-Earths	N	N	N?	**Y**
Proto-Planetary disks	**Y**	**Y**	**Y**	**Y**
Resolved Stellar Population: Local Group	N?	**Y**	**Y**	**Y**
: Virgo	N	N	N	**Y**
Massive Black Holes	**Y**	**Y**	**Y**	**Y**
Star formation History of the Universe	**Y**	**Y**	**Y**	**Y**
Physics of Galaxies and Dark Matter, z=1-5	**Y**	**Y**	**Y**	**Y**
Dark Energy	**Y**	**Y**	**Y**	**Y**
High-z Universe : Sources of re-ionisation	?	?	**Y**	**Y**
: $R=10^4$ at $z>10$	N	N	**Y**	**Y**
The Unexpected	**Y**	**Y**	**Y**	**Y**

Assuming a standard site (e.g. Mauna Kea, rather than Antarctica “Dome C”)

Science Requirements

- FOV
- Spatial Resolution – (or Strehl)
- Spectral Resolution
- Wavelength (range) of interest
- Observation type (e.g. absorbtion line spectroscopy)
- Target density
- Special Requirements (e.g. coronography, IFU)
- Dynamic range constraint (if any)
- Comparison of 30m,50m,100m & JWST [rank from 0 to 3]
- Observing time needed (assuming 100m):
- Date constraint (e.g. if program is dependent on other facilities, or will be done better by a future facility)
- Comments:

Some open questions for discussion

- Exo-Earths
  - What are the numbers of suitable stars available to survey?
  - Comparison with space-based missions and vs ELT size
- Resolved Stellar populations
  - What are the requirements on FOV & wavelength?
  - What are the requirements on AO (PSF ? Simulations?)
- Galaxies and Cosmology
  - Quantitative goals for 1<z<5 galaxies
  - First objects: How does a 50-100m compare to JWST and a 30m?
  - What can we really say about Dark Energy?

Plan of the meeting

- OPTICON ELT Science meeting - Florence 2004
- Monday AM: Introduction & Overview
- Monday PM: Parallel sessions

- Tuesday AM: Instrumentation, AO etc
- Tuesday PM: Parallel sessions cont.
  - Review Leiden documents & agree outline of science case document
  - requirements
  - DINNER !
- Wed AM : summary of parallel sessions + wrap up

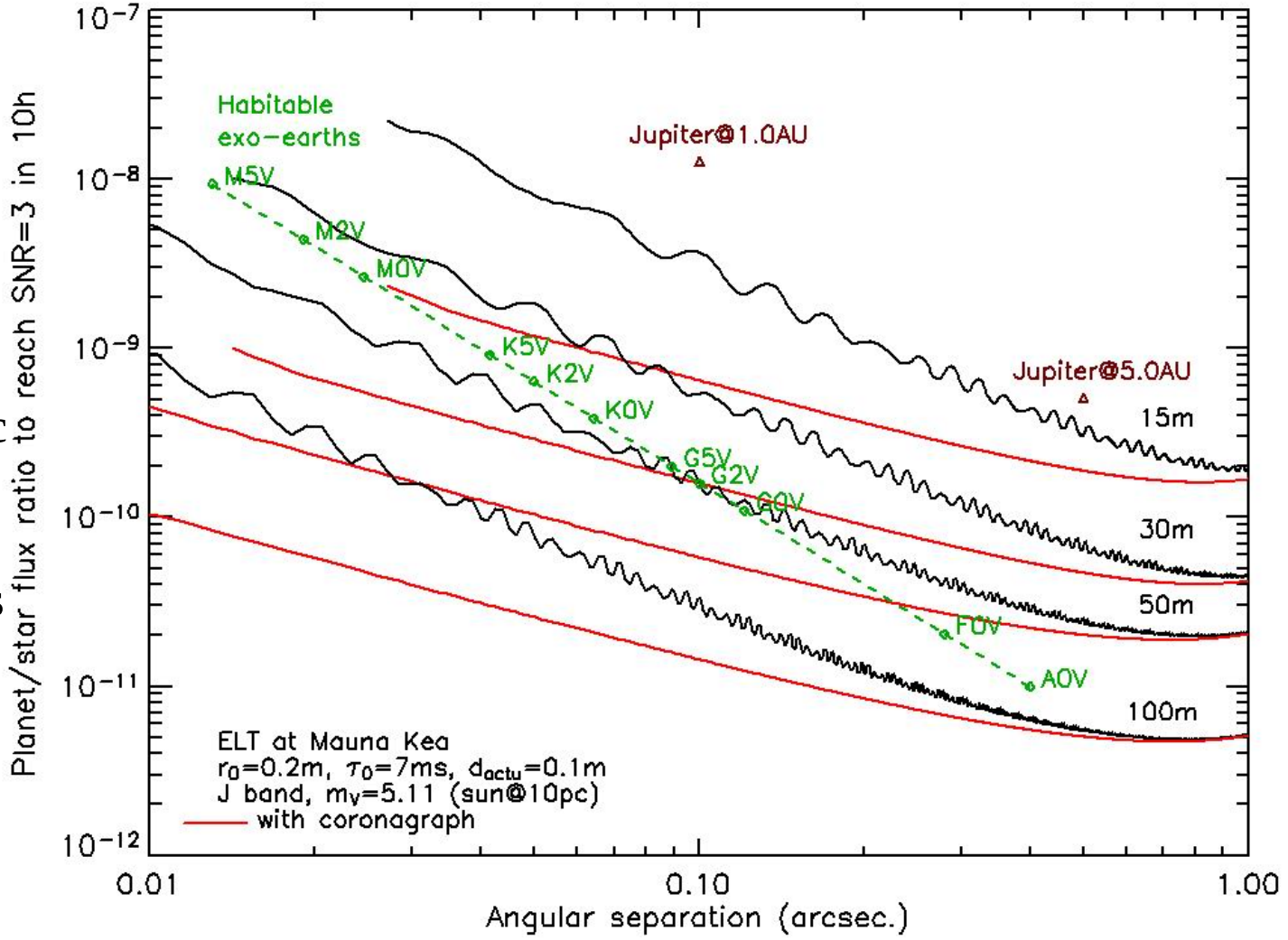
- Wed PM & Thurs AM : WRITING

The End

Planet Detection from the Ground
Lardiere et al 2003

Assumes
- *System at 10pc*
- *S/N =3 in 10hrs in the J-band.*
- *Mauna Kea site*

30m could perhaps detect earth at 10pc
But
- Not spectroscopy
- not enough targets at 10pc - need to reach ~30pc



Planet–Finding missions

- Kepler (NASA) — Launch 2007
  - photometric transits for earth-like planets
  - aim 50/185/640 planets with R=1.0/1.3/2.2 R_earth
- Eddington (ESA) — Launch 2009 if reinstated (was cancelled)
  - 1.2 m tel
  - objectives : photometric transits, astro-seismology:
  - 2000 earth mass terrestrial planets, ?? in habitable zone
- GAIA (ESA)
  - astrometric program (via transit observations) - few micro-arcsec
  - complete to 200pc
  - detection of 20-30,000 planetary systems (Jupiter mass)
- SIM (NASA)
  - astrometric (via interferom)
  - pointed.
- TPF (NASA) — Next 10-15 yrs
  - recently decided to start with coronograph and do interferometer later
  - direct detection of planetary systems
  - TPF-C is single visible telescope
  - TPF-I will be multiple telescopes for mid-IR interferometry
  - 32 stars full search/ 130 stars incomplete search
  - Interferom could be joint w/ESA Darwin, due before 2020.

Exo-earths Detection comparison (Angel, 2003)

Telescope	wave (mm)		mode	S/N* (earth@10pc, t=24h)	
space interf	4x2m	11	nulling	8.4	Darwin, TPF
space filled	7m	0.8	coron	5.5-34	JWST
Antarctic	21m	11	nulling	0.52	GMT
		0.8	coron	5.9	
ground	30m	11	nulling	0.34	Celt, GSMT
		0.8	coron	4.1	
ground	100m	11	coron	4.0	OWL
		0.8	coron	46	
Antarctic	100m	11	coron	17	BOWL=better OWL
		0.8	coron	90	

S/N is for detection of an Earth twin at 10pc
t=24hrs, QE=0.2, bandwidth $\Delta\lambda/\lambda=0.2$

Exo-Planet Detection

- GMT
  - Direct detection of Jovian Mass planets in wide orbits around nearby solar-like
  - Radial velocity search on fainter stars (Vol x200)
- TMT
  - Imaging young (t<10Myr) Jovian planets around stars in star-forming regions up to 200lt yrs away
  - Detect and classify mature Jovian planets (d<10-20pc)
- 100m
  - Survey of 1000 solar-like stars
  - Direct detection of Earth-like planets to 30pc
  - Time-resolved photometry of earth-like planets (albedo & weather)
  - Spectroscopy of earth-like planets
  - Study of entire exo-planetary systems

Stellar Populations

- GMT
  - Resolved stellar populations in magellanic clouds and LG dwarf spheroidals and Sagittarius dwarf
  - Resolve the brightest giant starts in galaxies in the Virgo cluster
  - Halo giants in Local Group galaxies (high-res spectroscopy)
- TMT
  - Measure age/metallicity of resolved populations in M31/M32 at ~750kpc (imaging)
  - star formation and chemical enrichment histories of galaxies out to Cen A (nearest active galaxy)
- 100m
  - Resolved populations in M87 (Virgo, 16Mpc)
  - Allows study of representative sample of Universe

Very High-z Universe

- GMT
  - Spectroscopy from 6<z<9 ?
  - Possibly detect z~10 objects (depends on their nature)
- TMT
  - Possibly detect z~10 objects (depends on their nature)
  - Spectroscopy of “earliest galaxies” found by JWST
  - NIR diffraction limit well-matched
- 100m
  - Should detect z>10 objects
  - spectroscopy of “galaxies” to z~20 (depending on nature). NB - may be resolved with 100m
  - Can do IGM studies at z>10 (GRBs, QSOs, PopIII SNe as background)