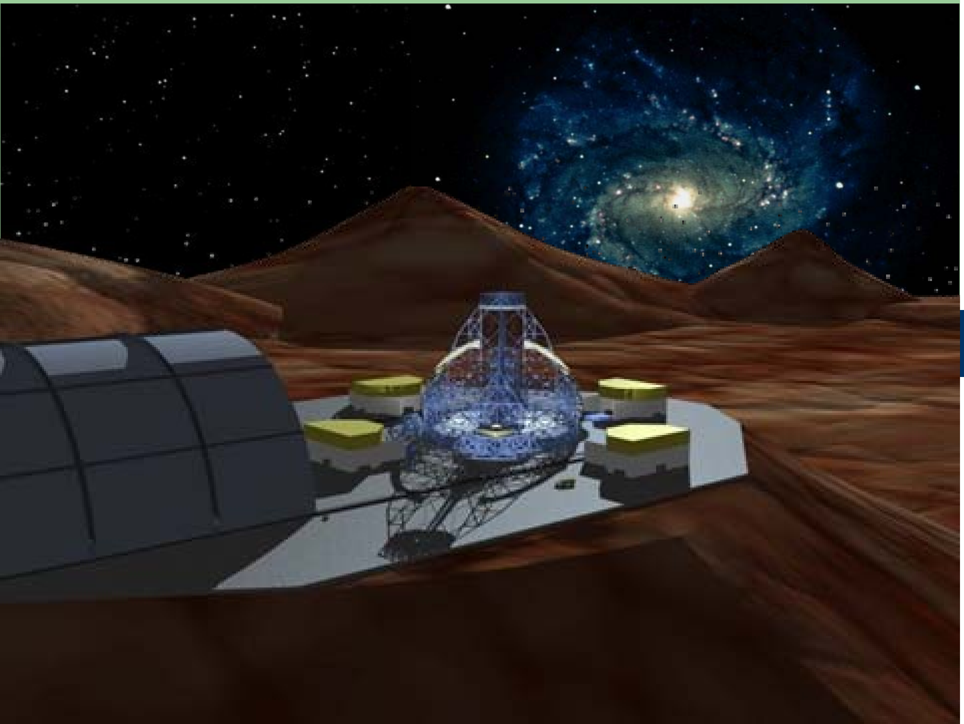
European Perspective: Stellar Populations with an ELT



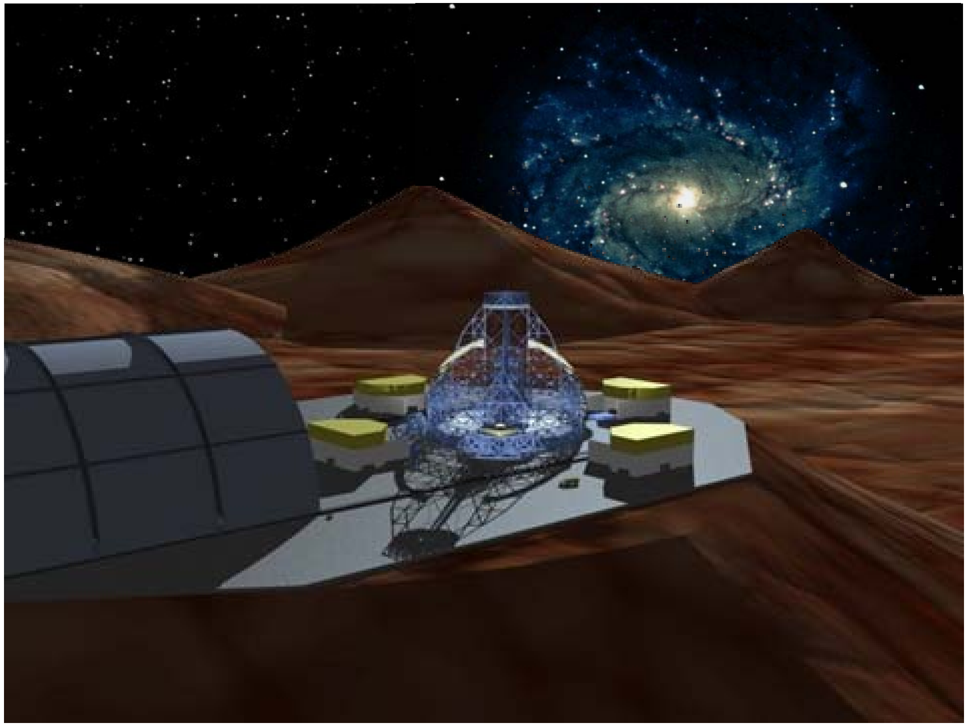
Richard de Grijs

(University of Sheffield, UK)

On behalf of the European ELT working group on "Stellar Populations"

The usual suspects

- Mike Merrifield (co-chair)
- Sergio Ortolani (co-chair)
- Andy Adamson
- Massimo Della Valle
- Raffaele Gratton
- Mark Hughes
- Peter Linde
- Richard de Grijs



The starting point

Where does a bigger, ELT-type telescope win?

1. For surveys, efficiency $\propto D^0$
2. For resolved sources, efficiency $\propto D$
3. For unresolved sources, efficiency $\propto D^2$

4. We can escape "photon starvation" to:
   - Work at very high dispersion
   - Obtain very high S/N spectra

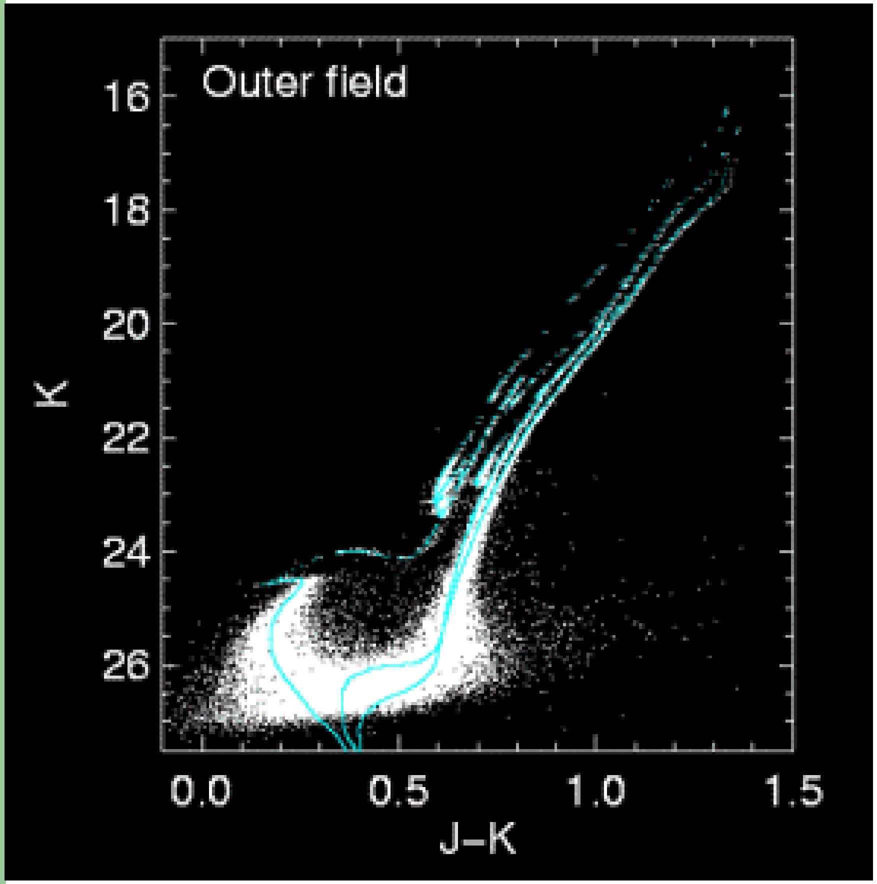
The fundamental questions

- ***How do stars form in galaxies?***
- ***How are galaxies formed from stars?***

… or, alternatively …

- ***When were stars formed?***
- ***Where are they now?***

The key contributions of an ELT



(from GSMT study)

- Extend detailed resolved stellar population studies from the Milky Way to our nearby neighbours (at Virgo or Fornax-cluster distances)

- Understand their formation, evolution, and kinematics (dynamics) ...

- ... of a more representative slice of the Universe

- Need to reach the main sequence turn-off, however.

~100-metre limiting magnitude

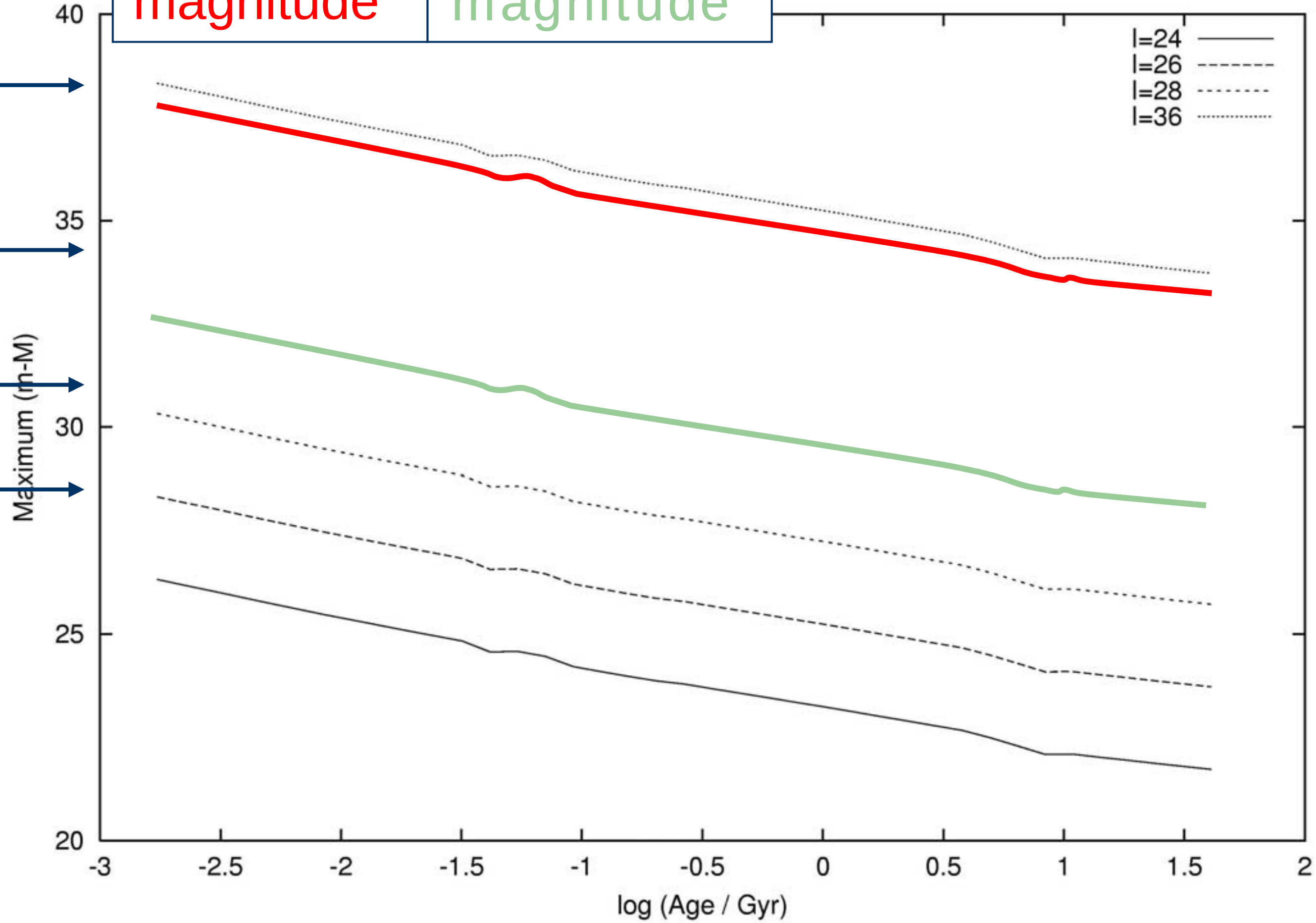
~30-metre limiting magnitude

z ~ 0.1

Coma

Virgo

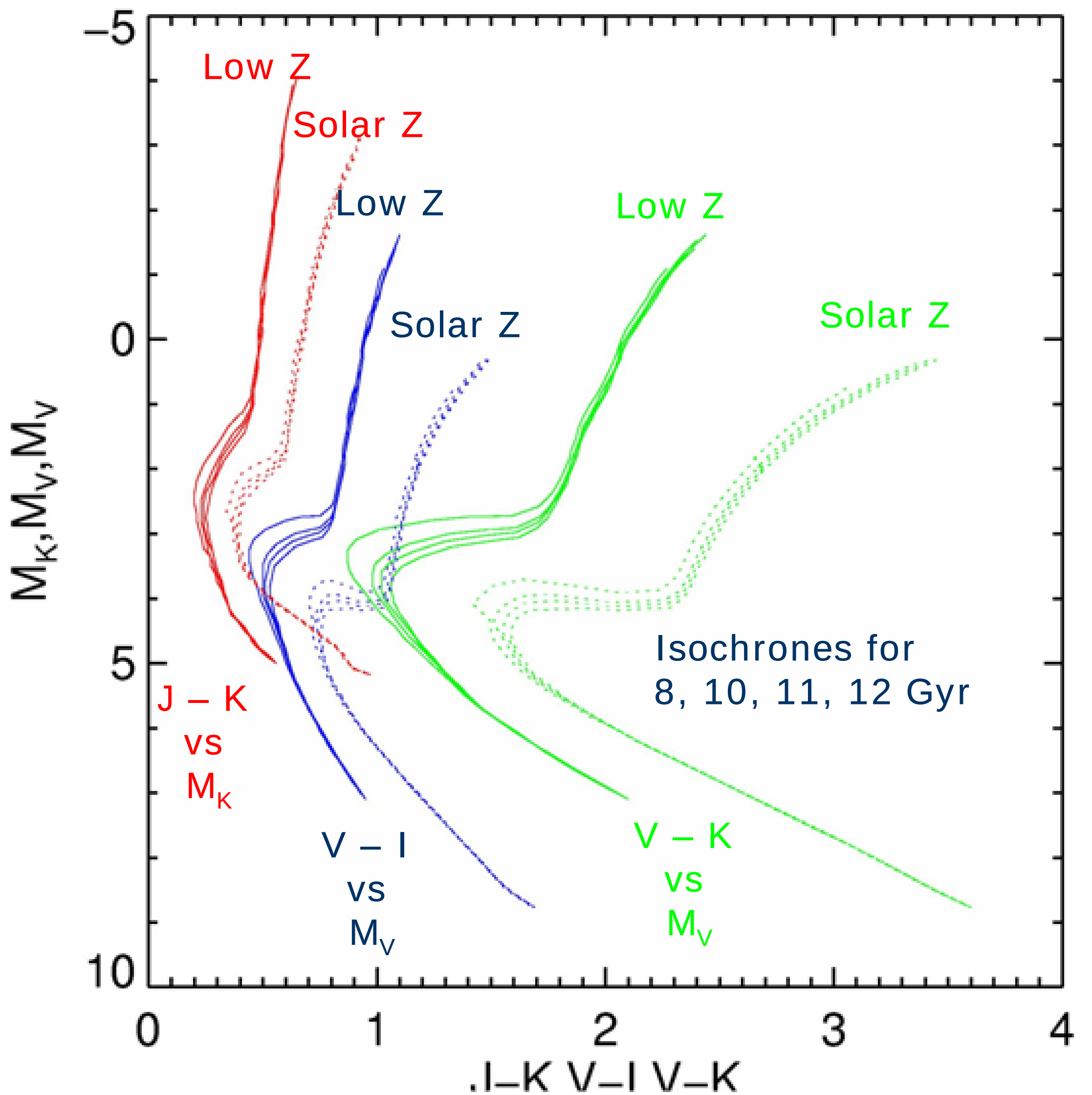
M82



Maximum (m-M)

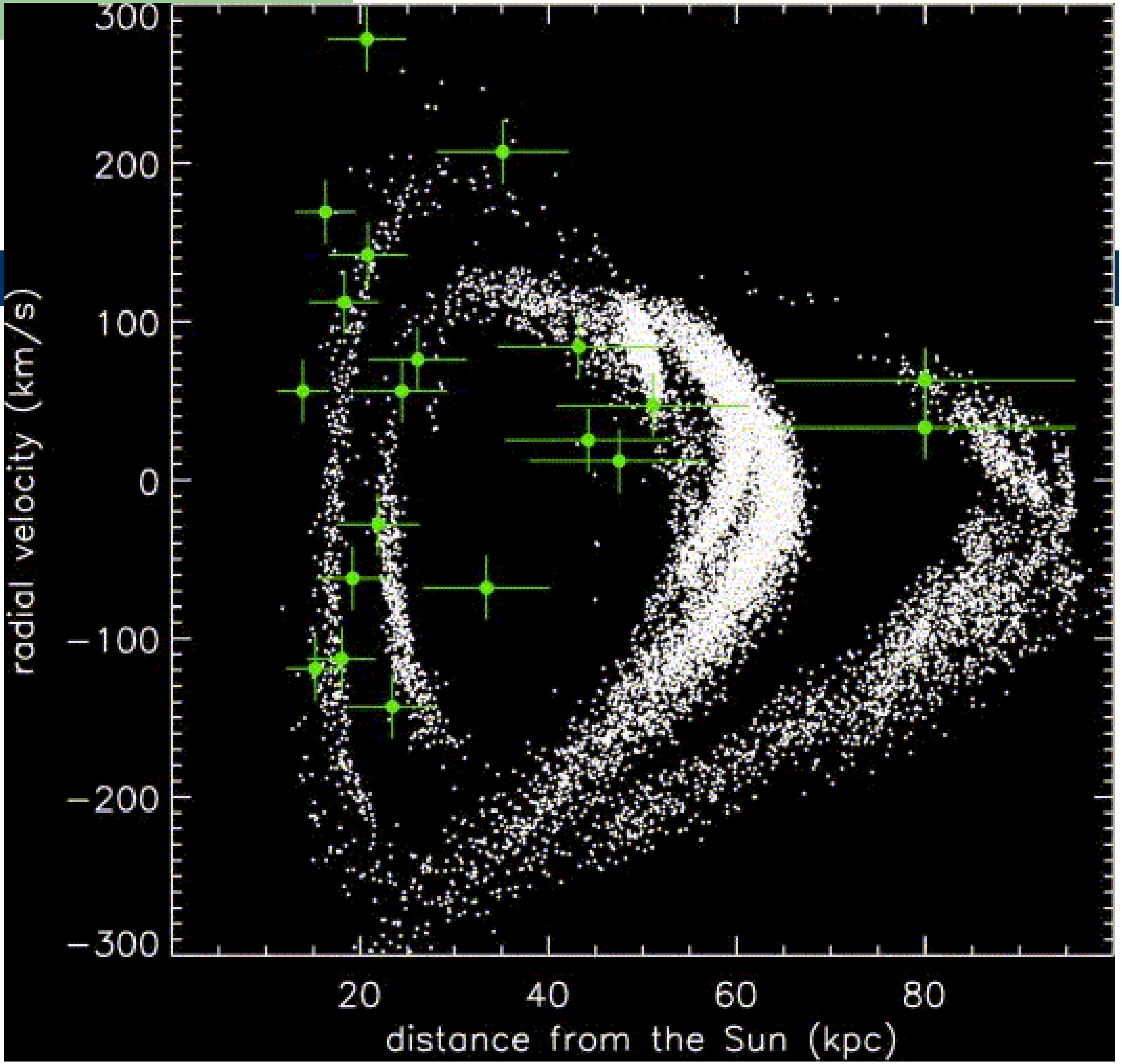
Log (Age / Gyr)

(from Frayn 2003)

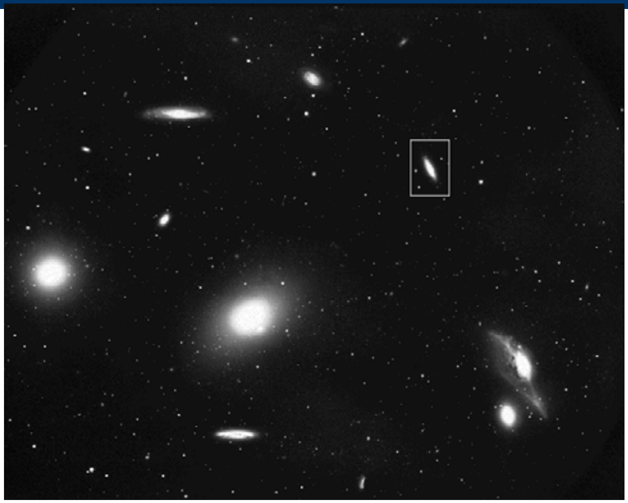


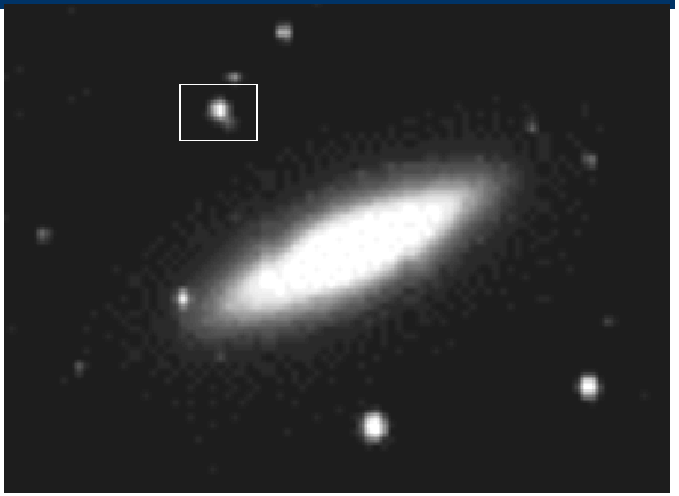
(from Rosie Wyse)

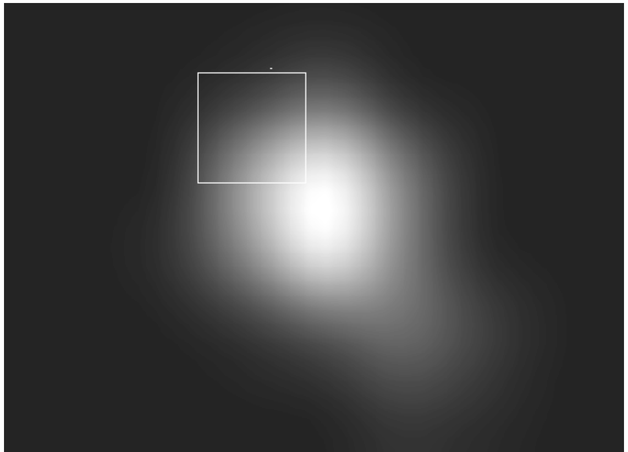
(*Spaghetti Survey*; *Helmi 2002*)

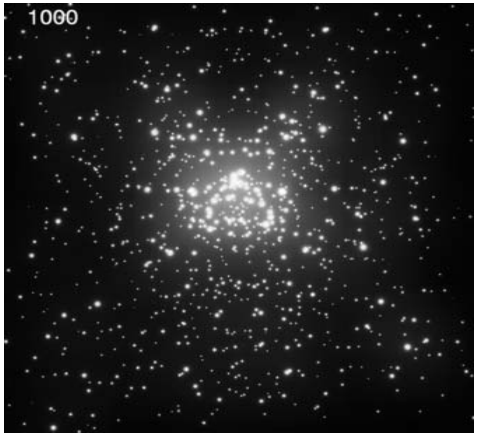


Zooming in on the Virgo Cluster









The key contributions of an ELT - 2

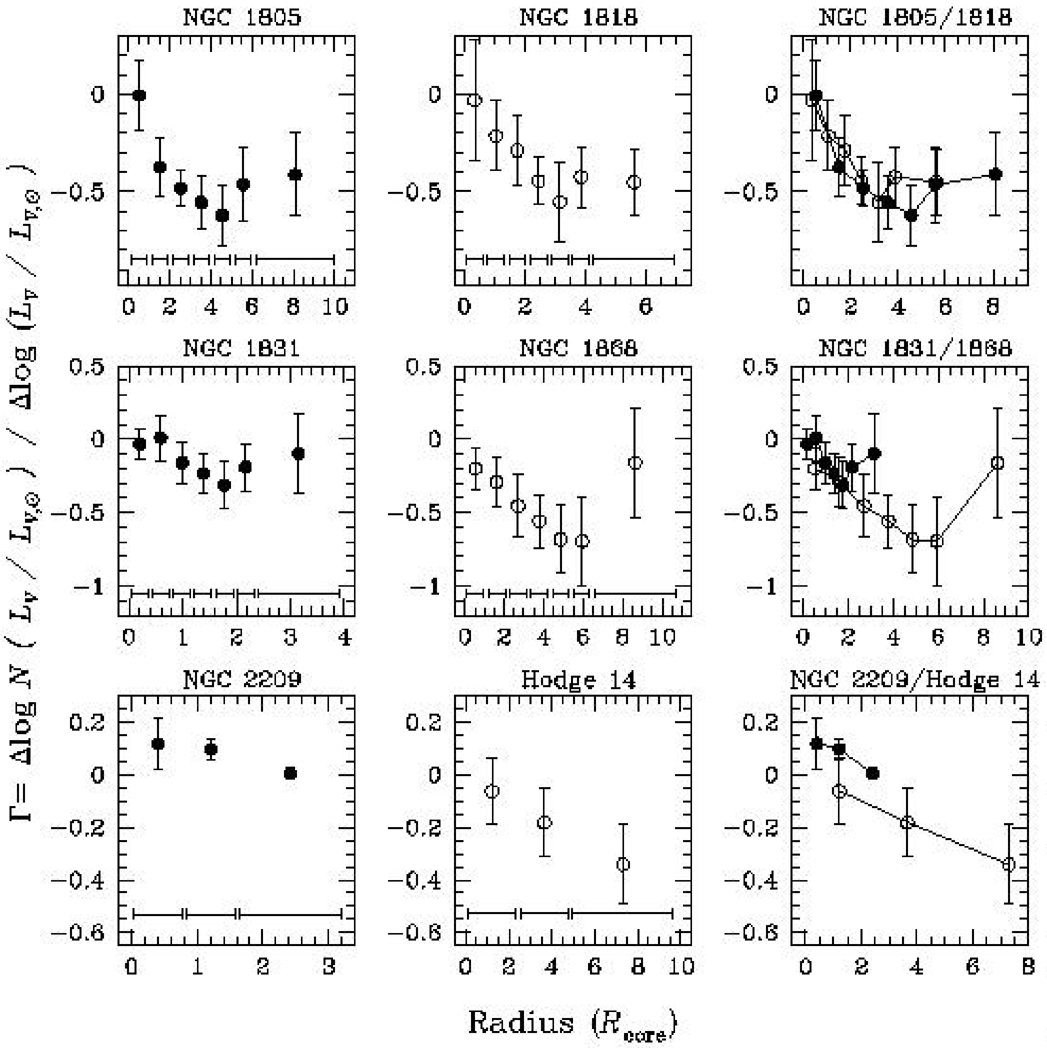
- *We will be able to spatially and spectrally resolve the stars in even compact star clusters and HII regions throughout and beyond the Local Group ...*

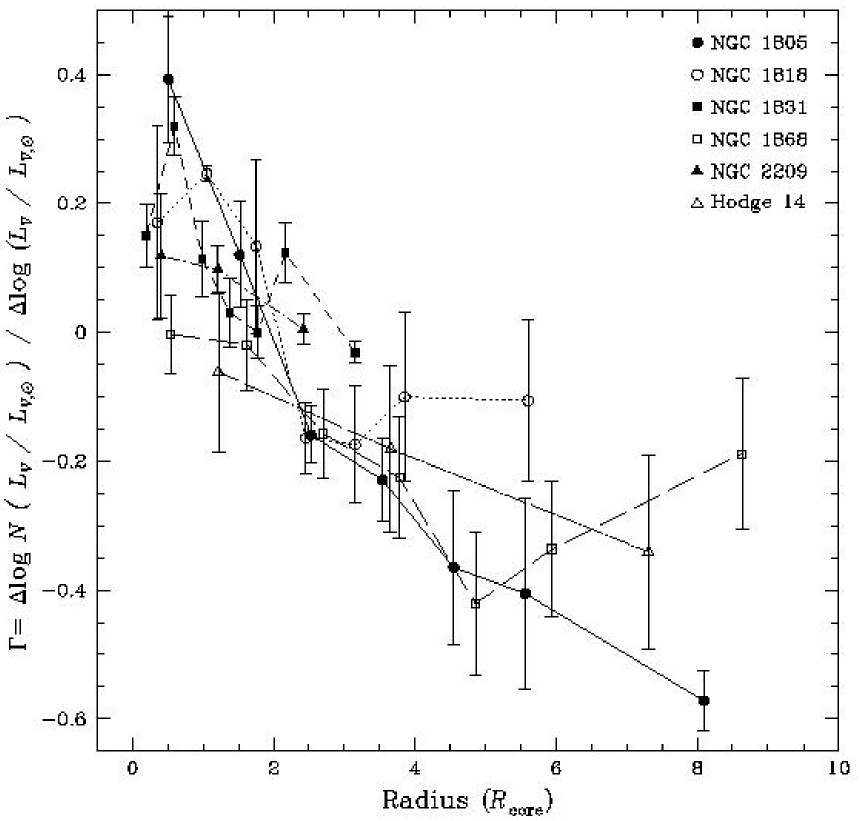
- *... in a variety of environments (normal galaxies, starburst and post-starburst systems) ...*

- *... and thus test the universality of the IMF as a function of environment (density);*

- *... and also calibrate SFR measures*

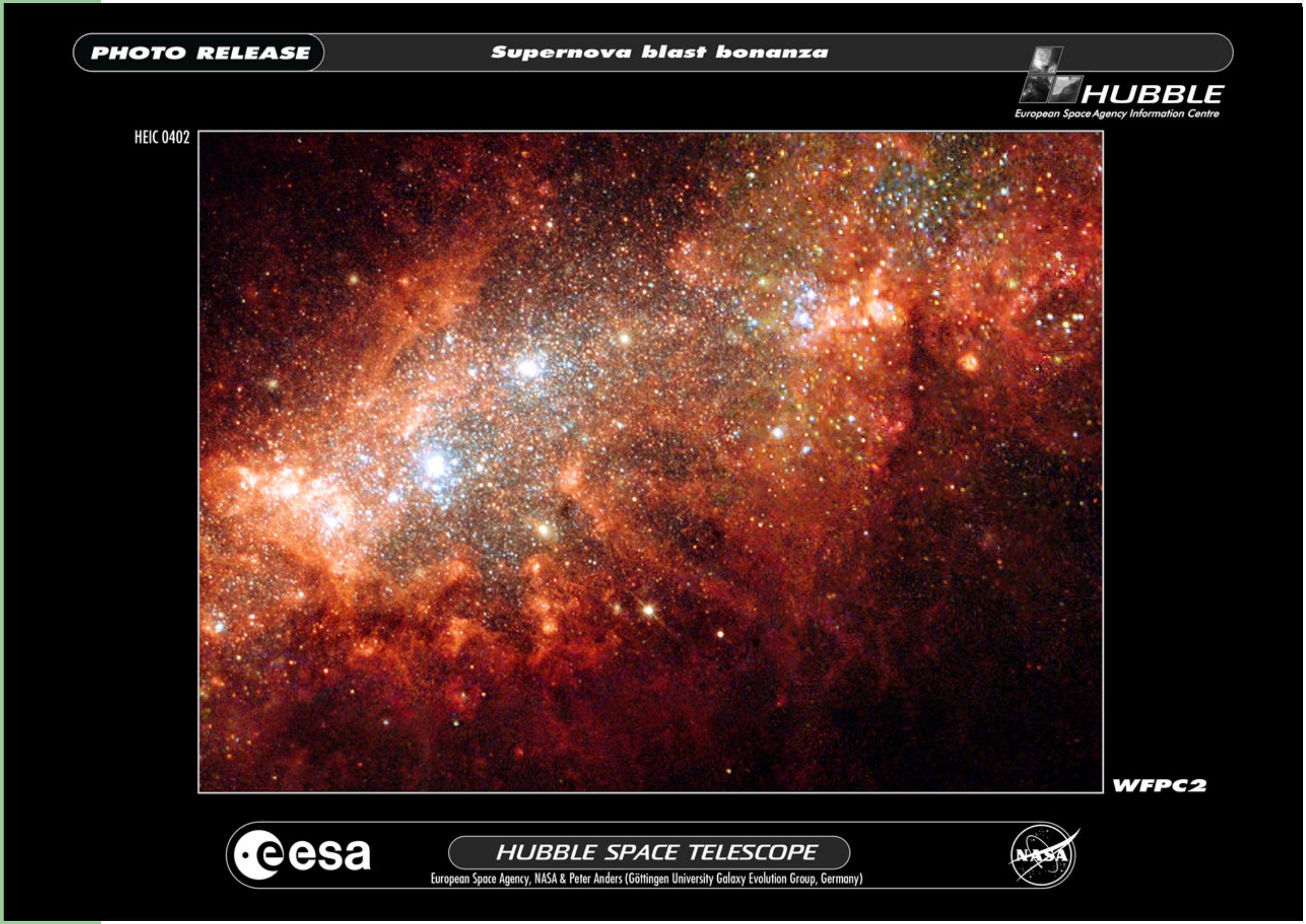
Mass segregation in LMC clusters





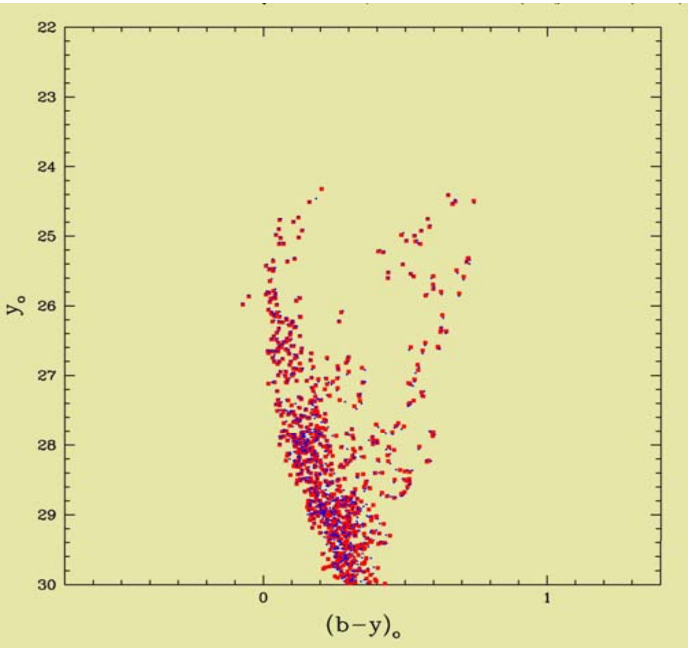
(from de Grijs et al. 2002)

NGC 1569 (Anders et al. 2004)



Simulating a 50m telescope

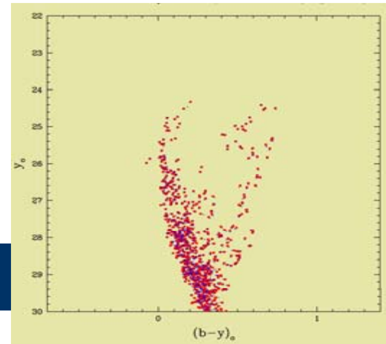
- *50 metre telescope*
- *Strömgren vby images simulated*
- *Exposure time: 200 000 sec / passband*
- *Strehl ratio: 0.7*
- *Circular aperture PSF*
- *0.”003 arcsec resolution*
- *0.”3 arcsec seeing-limited PSF*
- *Image size: 2048x2048 pixels*
- *Image scale: 0.”001 / pixel*
- *FOV: 2”x2”*

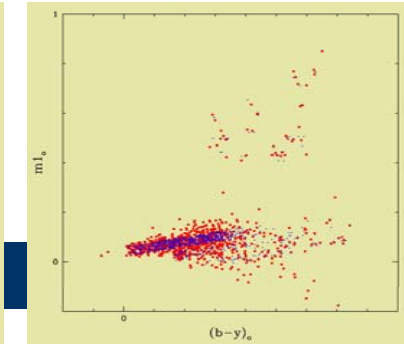


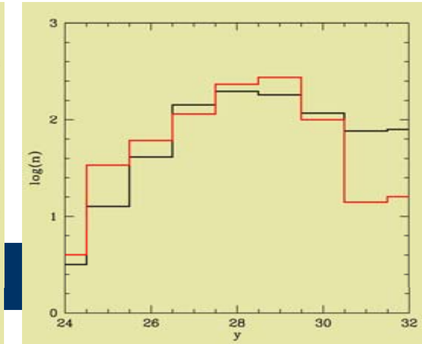
NGC6192	CMD	m_1	Luminosity function
Image size: 2048X2048 pixels pixel size: 1 milliarcsec	Blue dots original data, red dots measured data	Blue dots original data, red dots measured data	Black curve background population, red curve cluster population

1 Mpc

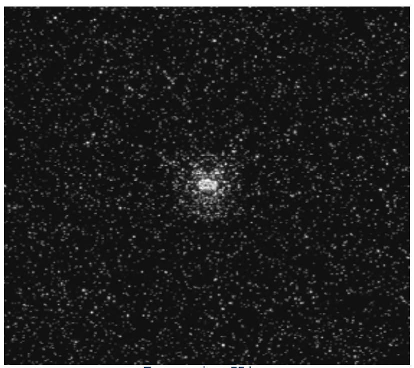
Exposure in y: 3 hours



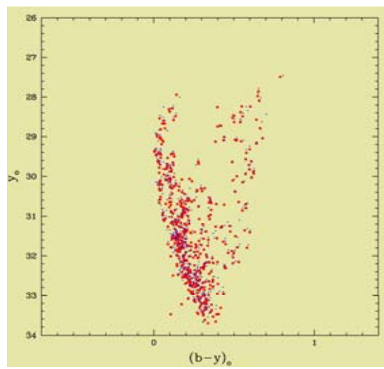


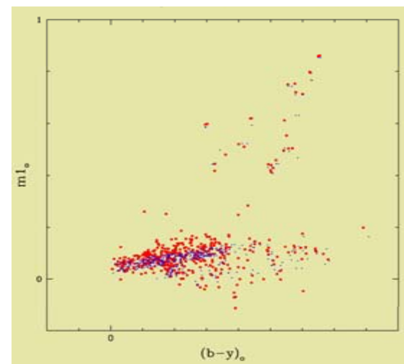


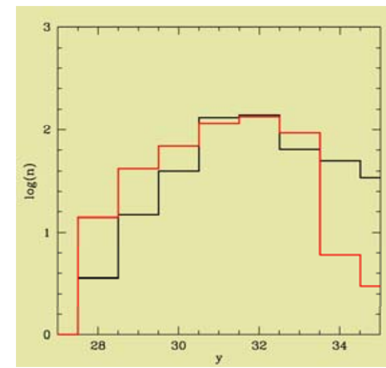
5 Mpc



Exposure in y: 55 hours

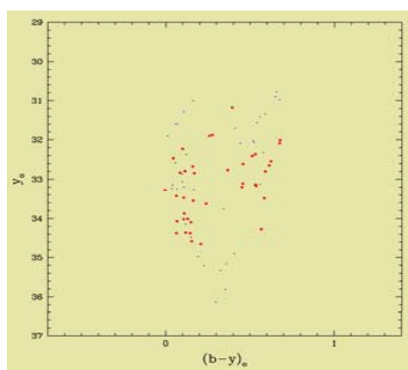


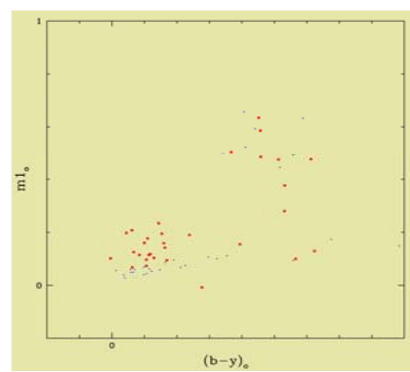


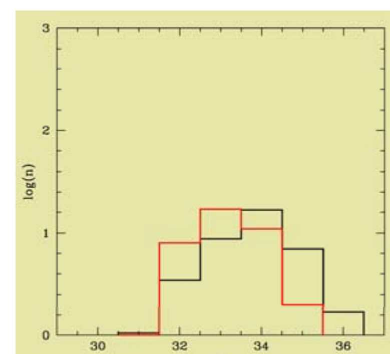


20 Mpc

Exposure in y: 55 hours







Star formation rates across the Universe

- *UV and Hα fluxes are not robust indicators of star formation:*

  - *Significant ionising flux is only produced by the most massive stars, with $M > 40\ M_{\odot}$ ...*

  - *... so this requires a significant (and uncertain) extrapolation to lower masses!*

  - *On the other hand, all stars more massive than $8\ M_{\odot}$ contribute to the Type II supernova rate;*

  - *SNe are good indicators of star formation*

  - *and visible at all redshifts!*

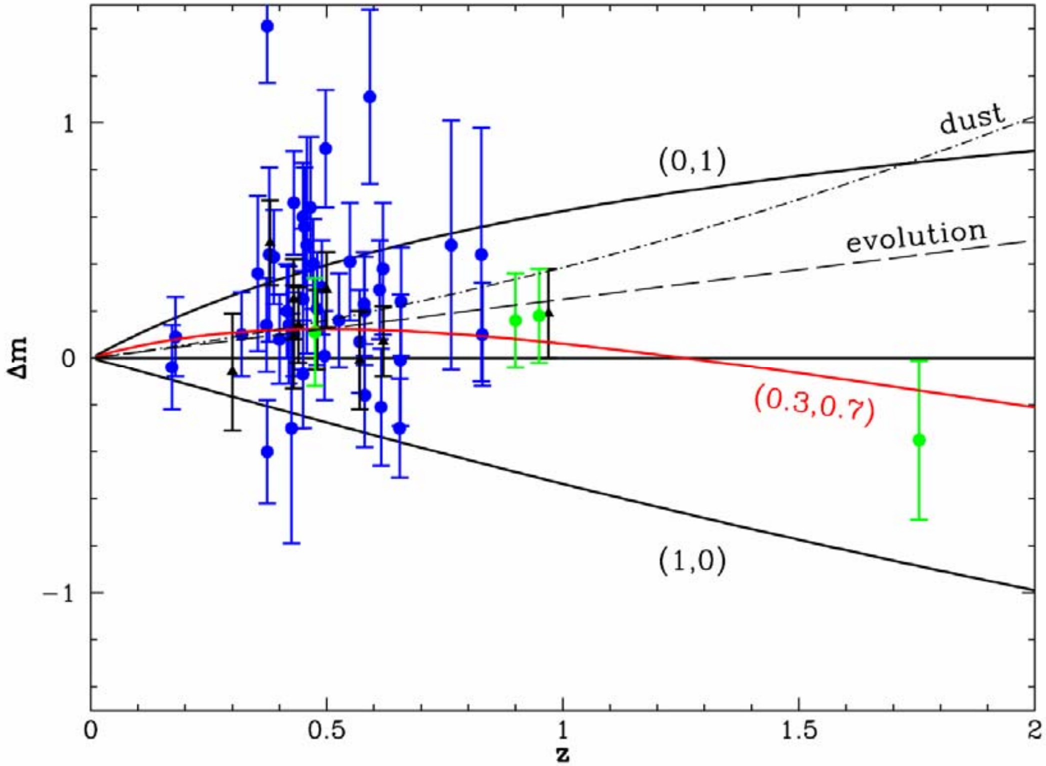
Supernovae from *z = 0* to *z = 10*

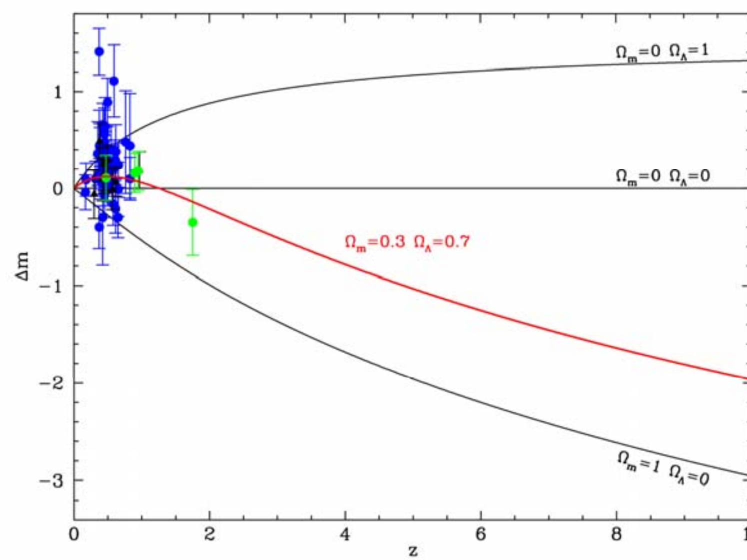
We plan to image 50 fields in the J, H and K bands (1h each) at 4 different epochs (="SN search")

+ 3 epochs in the *K* band for the photometric follow-up (i.e. seven *K* photometric points for each SN)
+ 4h for each SN ($z < 4.5$-5) to get the spectroscopic classification

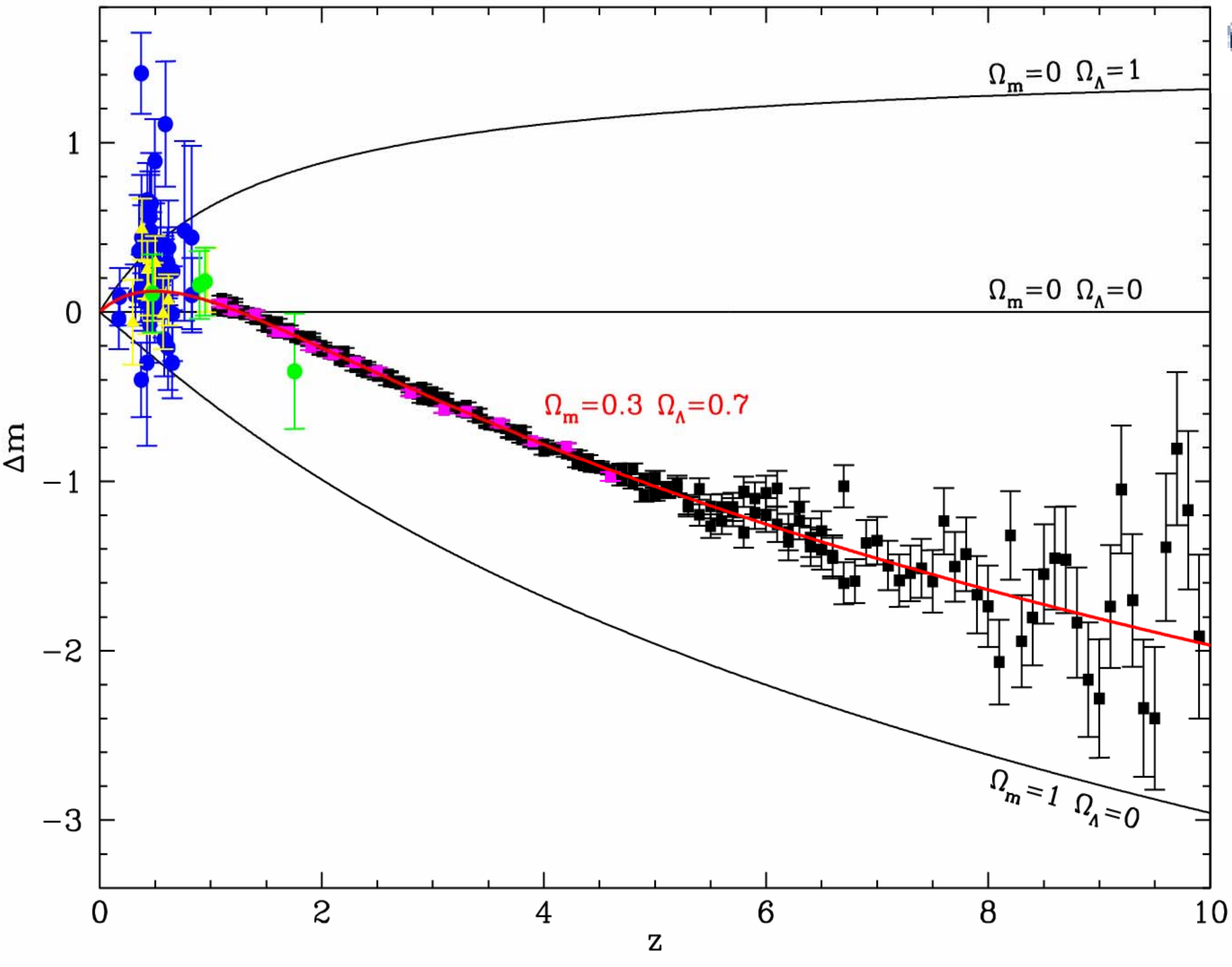
Grand Total = 600h (search) + 150h (K follow-up) + 200h (spectroscopy) = 950h + 10%

1050h or 130 nights to study 400 SNe up to $z = 10$



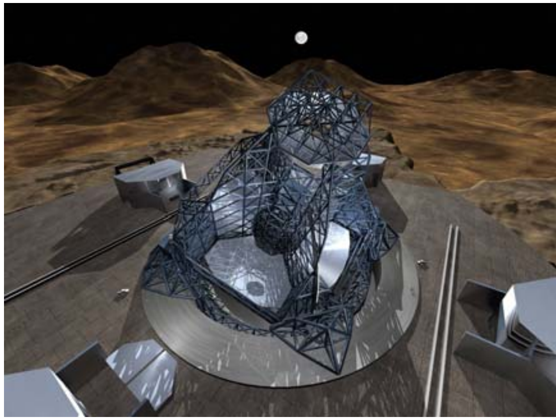


Current SN data



$\Omega_m=0$ $\Omega_\Lambda=1$
$\Omega_m=0$ $\Omega_\Lambda=0$
$\Omega_m=0.3$ $\Omega_\Lambda=0.7$
$\Omega_m=1$ $\Omega_\Lambda=0$
Δm
z
1
0
−1
−2
−3
0
2
4
6
8
10

Telescope specifications



To carry out this programme, we require:

- *A site from which Virgo or Fornax is visible*

-*Telescope diameter > 50 metres*

- *Operates at optical and near-infrared wavelengths*

- *Diffraction-limited down to optical wavelengths (R band?)*

  - *over a relatively small field of view (1 arcminute?)*

- *A big CCD camera*