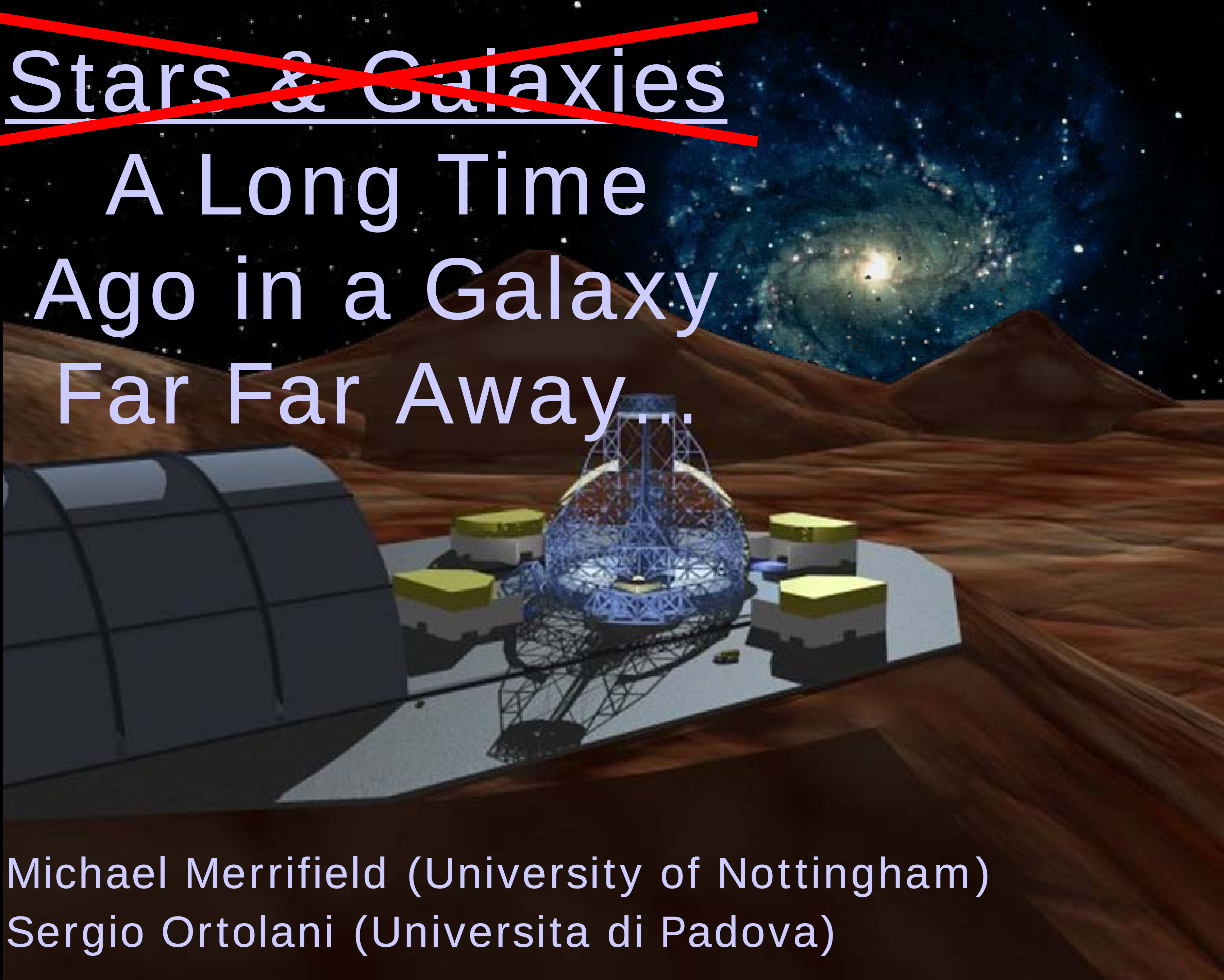
~~Stars & Galaxies~~

A Long Time Ago in a Galaxy Far Far Away…



Michael Merrifield (University of Nottingham)
Sergio Ortolani (Universita di Padova)

Summary: Ultra-High Resolution Studies of the ISM

Adamson et al.

With an ELT, we can escape “photon starvation” to:

- Work at very high dispersion
  — exploit atmospheric gaps to explore mid-infrared
  — explore important species that do not emit in sub-mm

- Obtain very high signal-to-noise ratio spectra
  — explore fine-scale structure of the ISM
  — monitor its variability

- Measure low levels of polarization
  — study individual ISM clouds in other galaxies
  — measure interstellar polarization curve at high resolution to determine relationship between dust and molecules

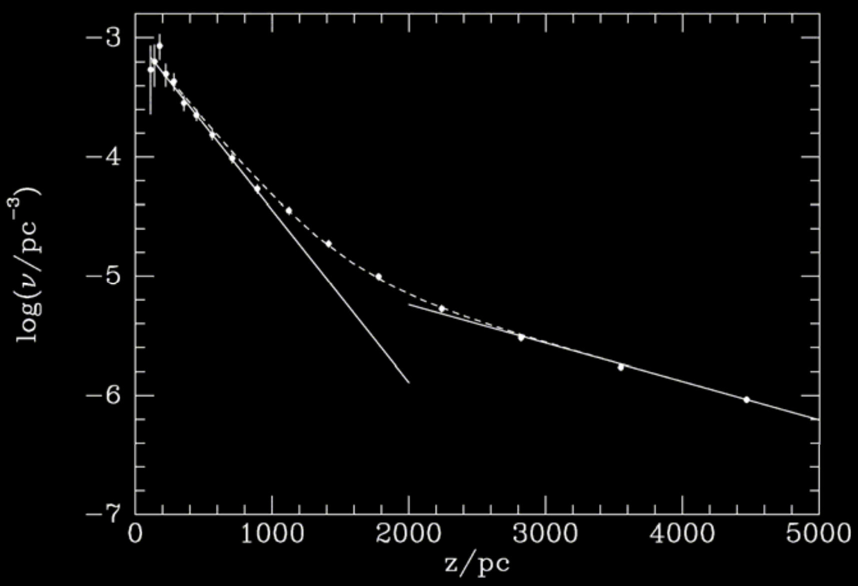
Summary: Ultra-High Resolution Studies of the ISM

Adamson et al.

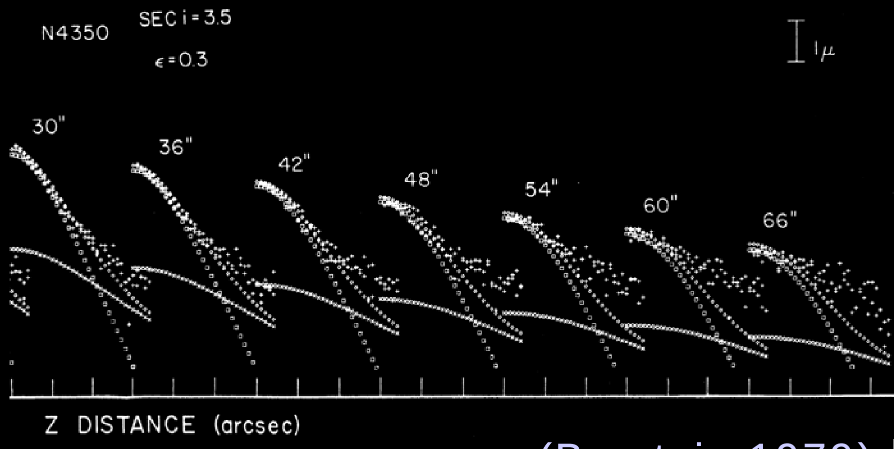
- Study the ISM at high redshift
  - — map out ISM metallicity as a function of redshift
  - — map out ISM dust content as a function of redshift
- Make optical studies of heavily obscured regions
  - — use well-calibrated optical diagnostics
  - — study atomic as well as molecular physics in these regions

Summary: Resolved Populations

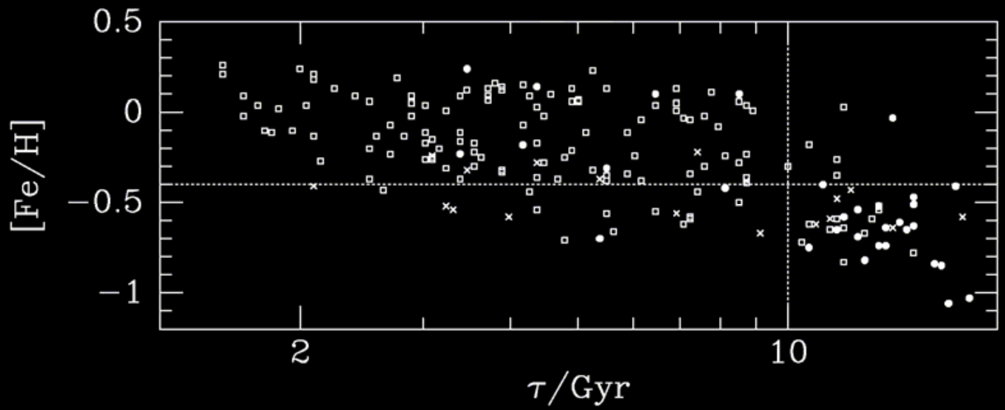
Merrifield et al.



(Gilmore & Reid 1983)



(Burstein 1979)

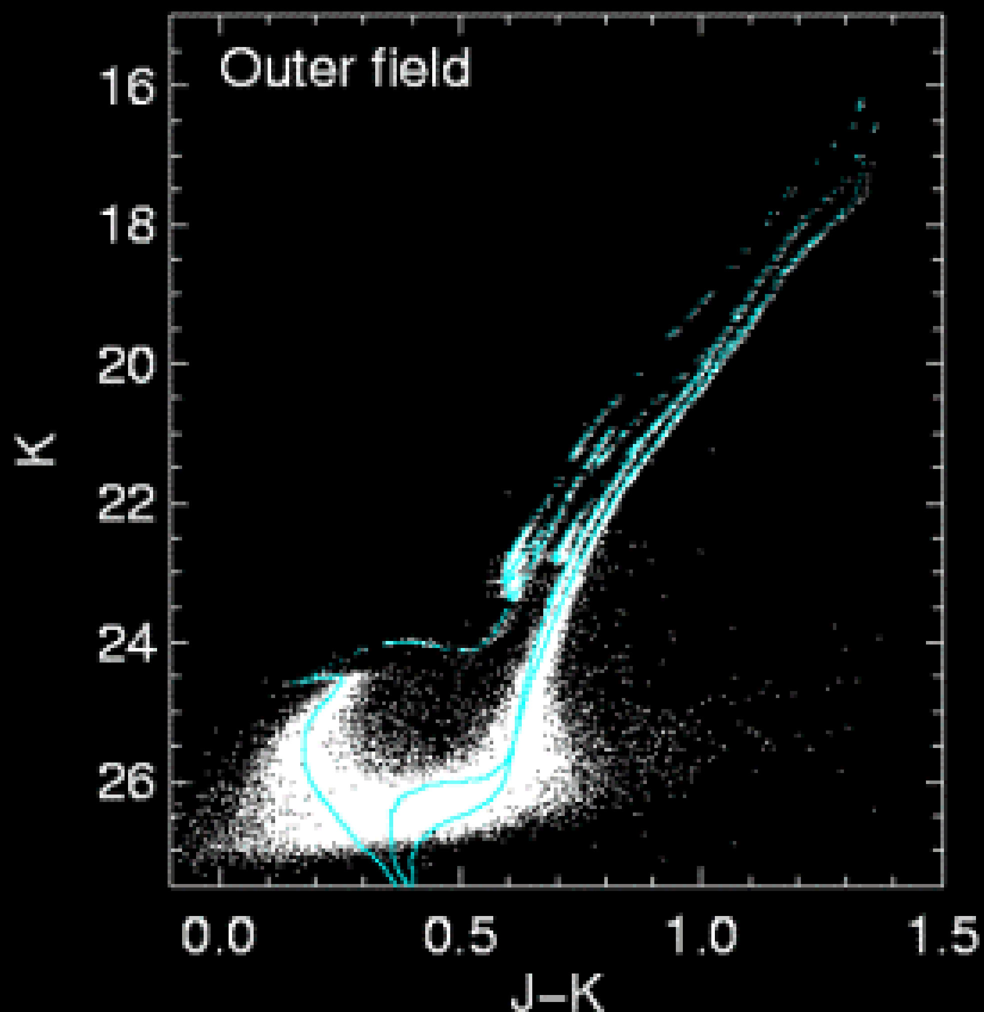


(Edvardsson *et al*. 1993)

(Robert Gendler)

Summary: Resolved Populations

Merrifield et al.

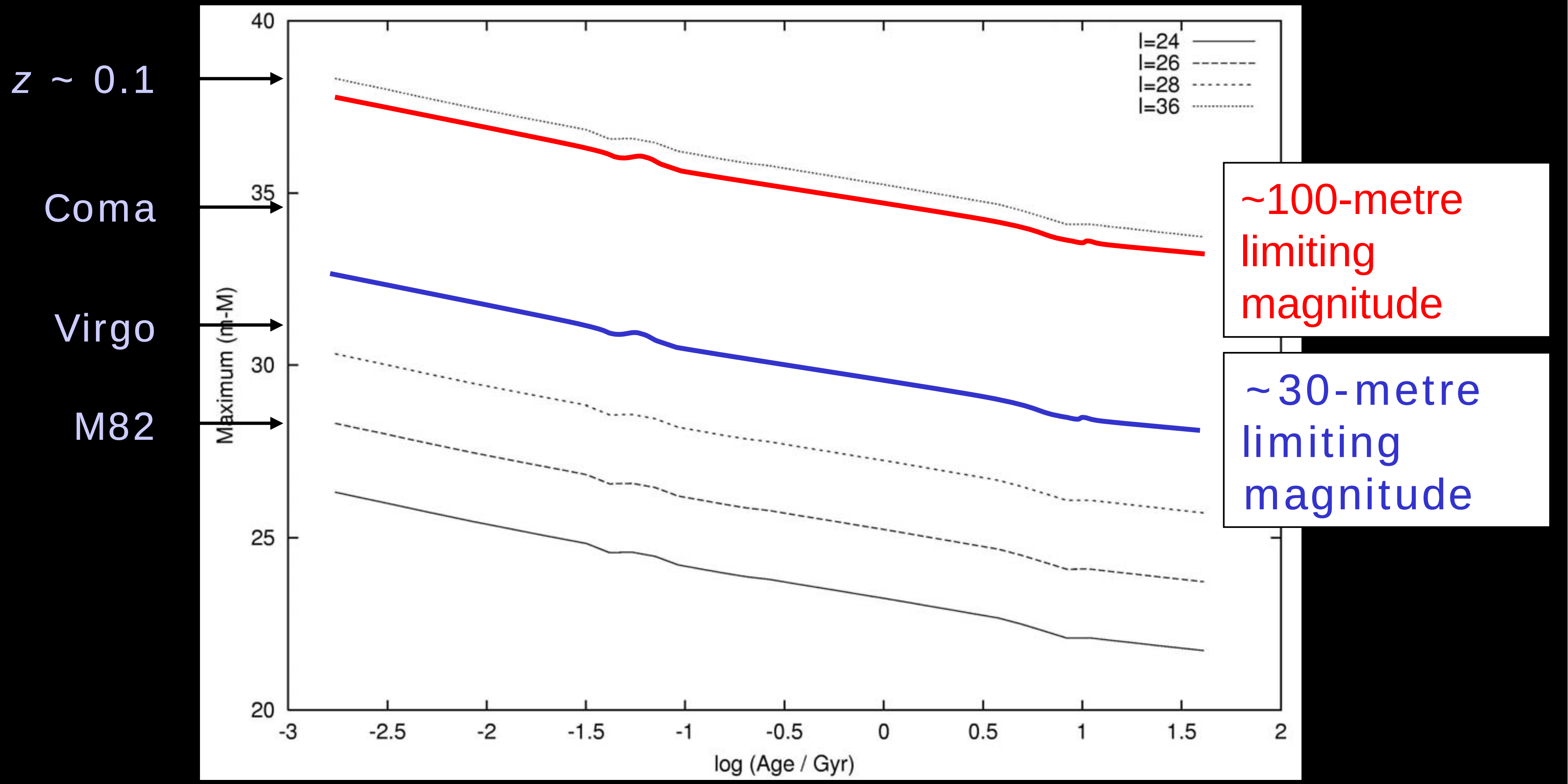


(from GSMT study)

- We can learn a lot about the formation and evolution of our nearby neighbours with a 30-m telescope
- What about a more representative slice of the Universe?
- Need to reach main sequence turn-off.

Summary: Resolved Populations

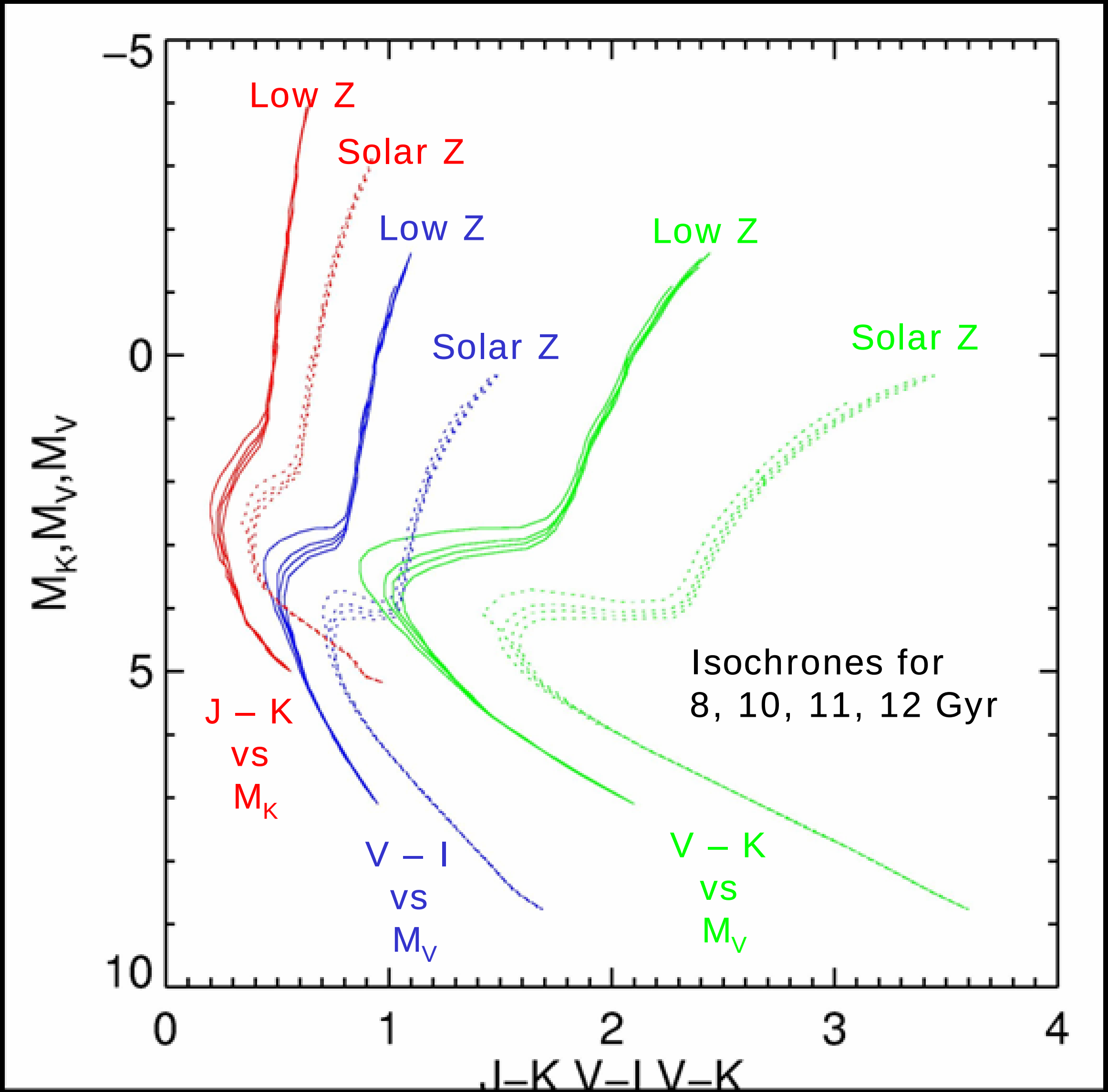
Merrifield et al.



(from Frayn 2003)

Summary: Resolved Populations

Merrifield et al.

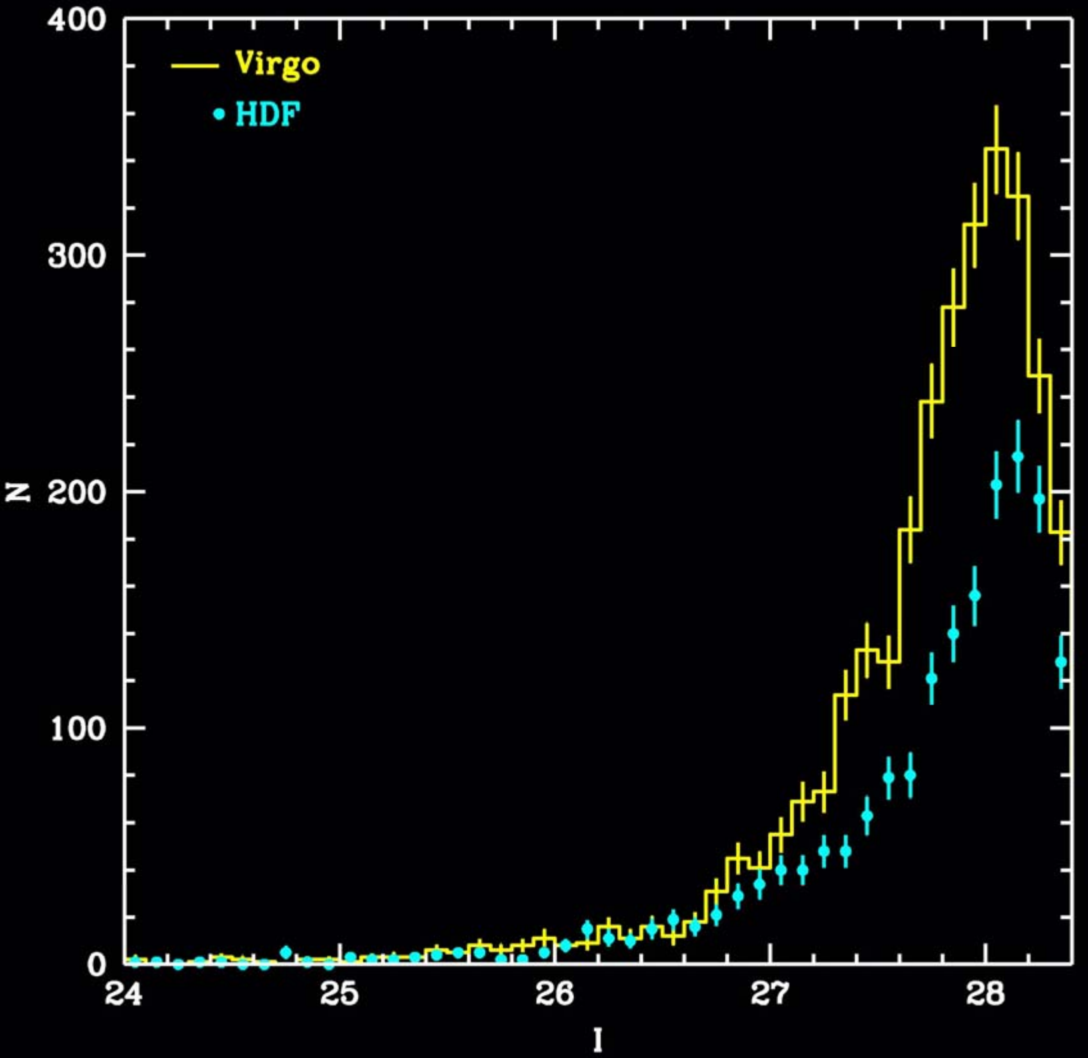


(from Rosie Wyse)

Summary: Intergalactic Stars

Gratton et al.

Hibbard & van Gorkom (1996)

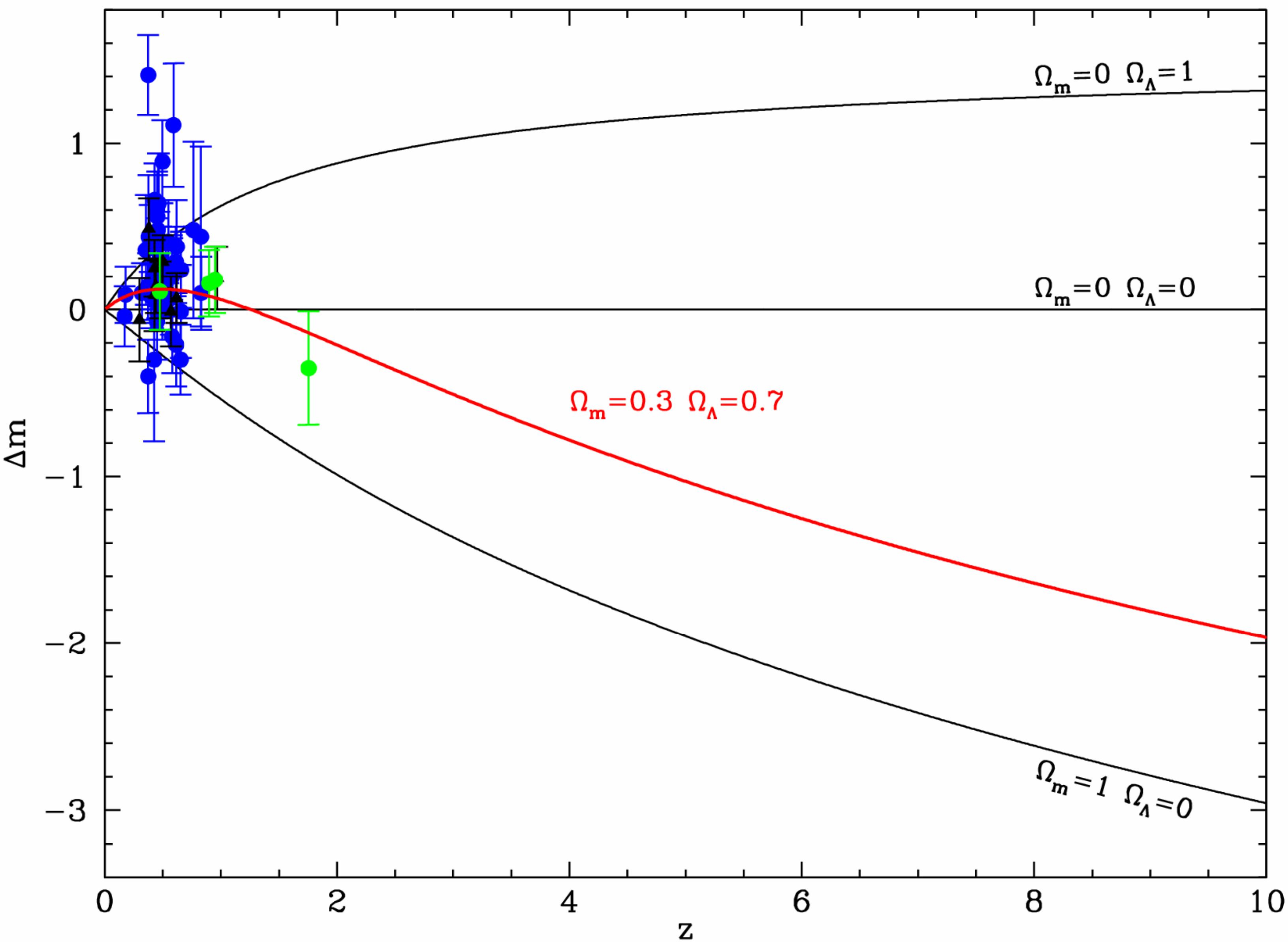


Ferguson, Tanvir & von Hippel (1998)

Summary: Star Formation History from Supernovae

Della Valle et al.

- Significant ionizing flux only produced by most massive stars with $M > 40M_a$
  - — UV and Hα fluxes not robust indicators of star formation
- All stars more massive than $8M_a$ contribute to supernova rate
  - — SNe good indicators of star formation
  - — visible at all redshifts
- Proposed search using 4 months of ELT time will yield ~350 SNe out to z ~10
  - — could be done in parallel with other studies



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$\Omega_m=0\ \ \Omega_\Lambda=0$
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Δm
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6
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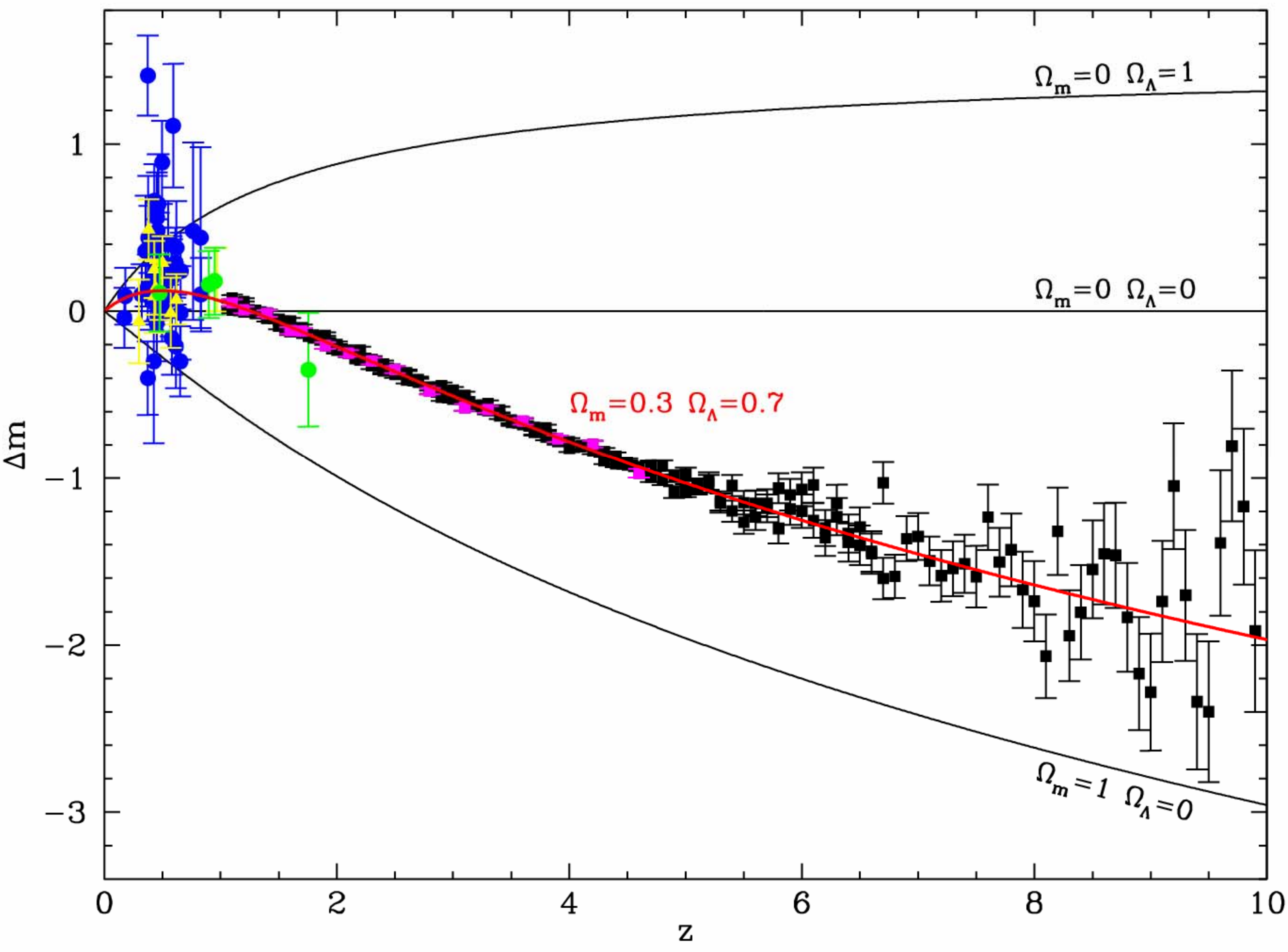

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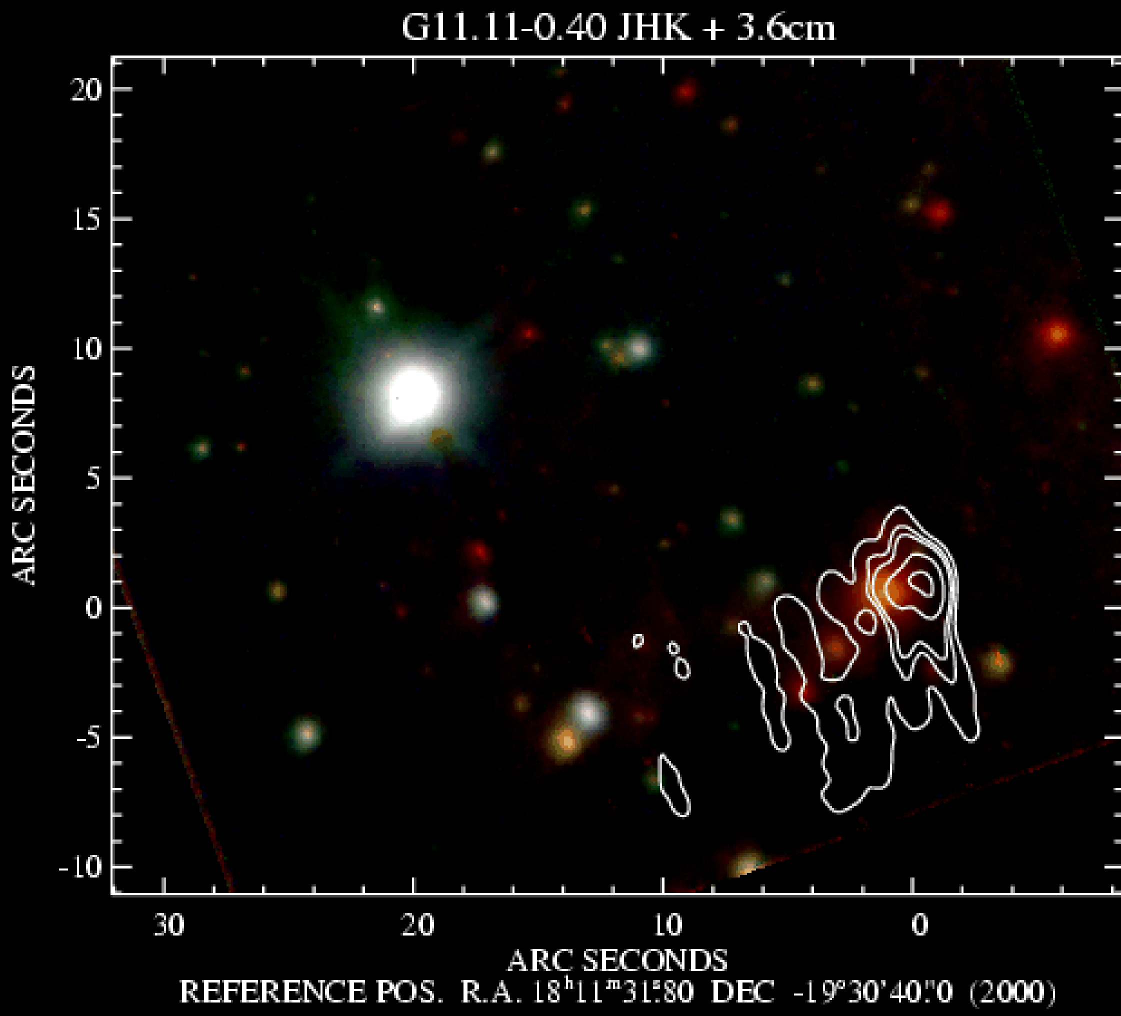
Summary: Star Formation in the Context of Galaxies

De Grijs et al.



(Henning *et al.* 2001)

- With a 100m telescope, can resolve the stars in even compact HII regions throughout Local Group.

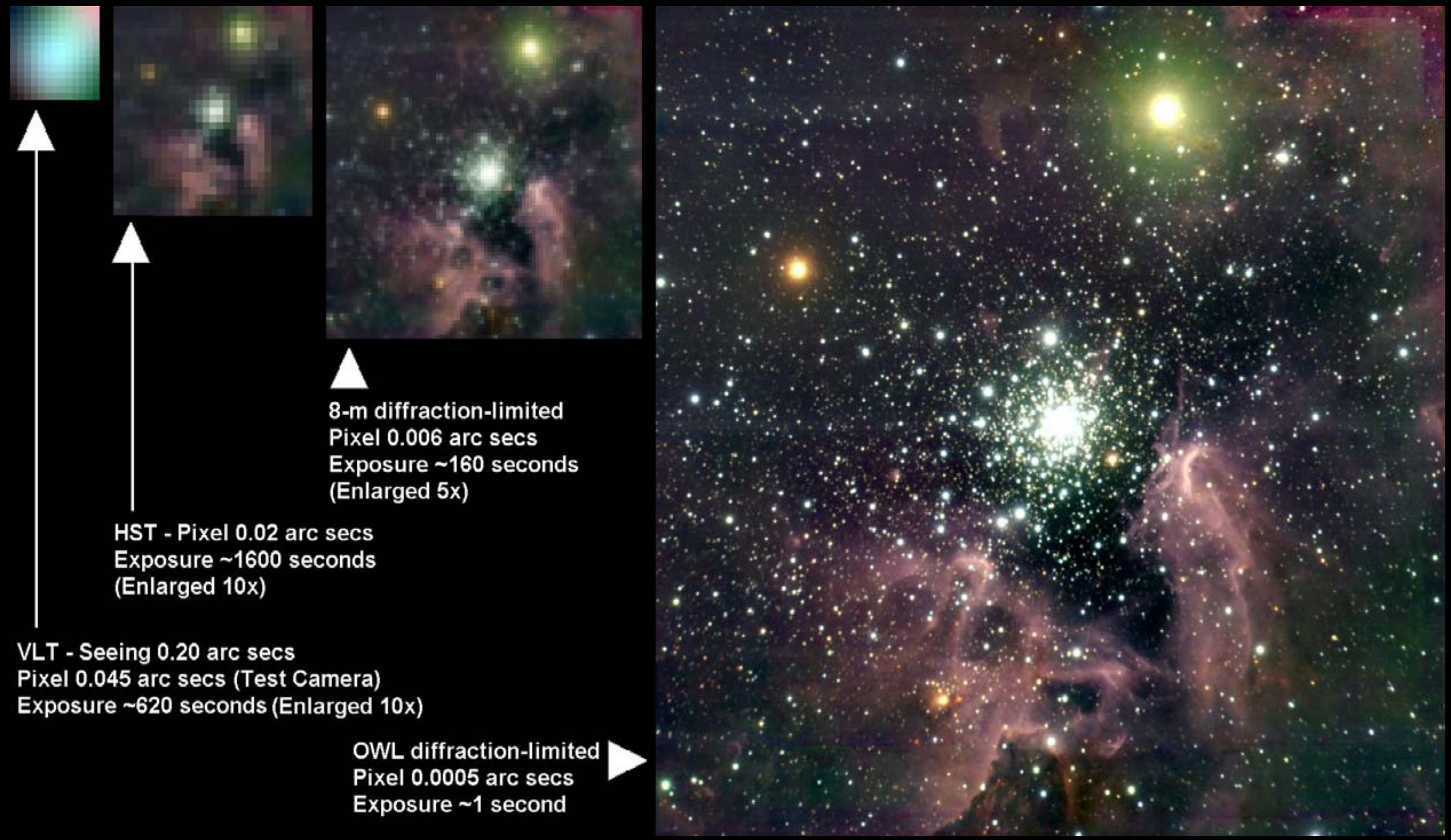
  — test universality of IMF

  — calibrate SFR measures

  — investigate feedback, chemical enrichment, etc.

Summary: Star Formation in the Context of Galaxies

De Grijs et al.

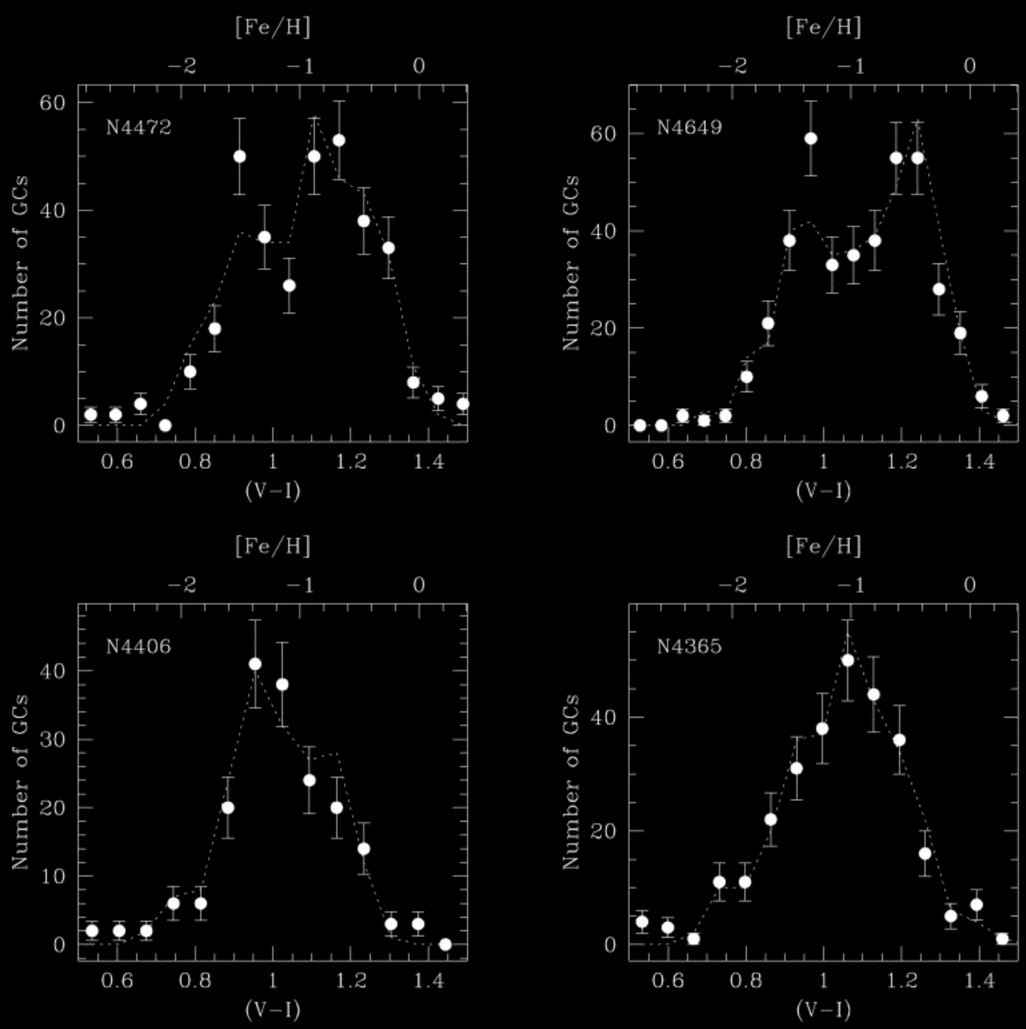


With a 100m telescope:

- — Can spatially and spectrally resolve rich star clusters in all environments (normal galaxies of all types, starburst and post-starburst systems)
- — Can explore extremes of feedback microphysics in starburst systems
- — Can compare IMF, etc, to “field” star formation

Summary: Star Formation in the Context of Galaxies

De Grijs et al.

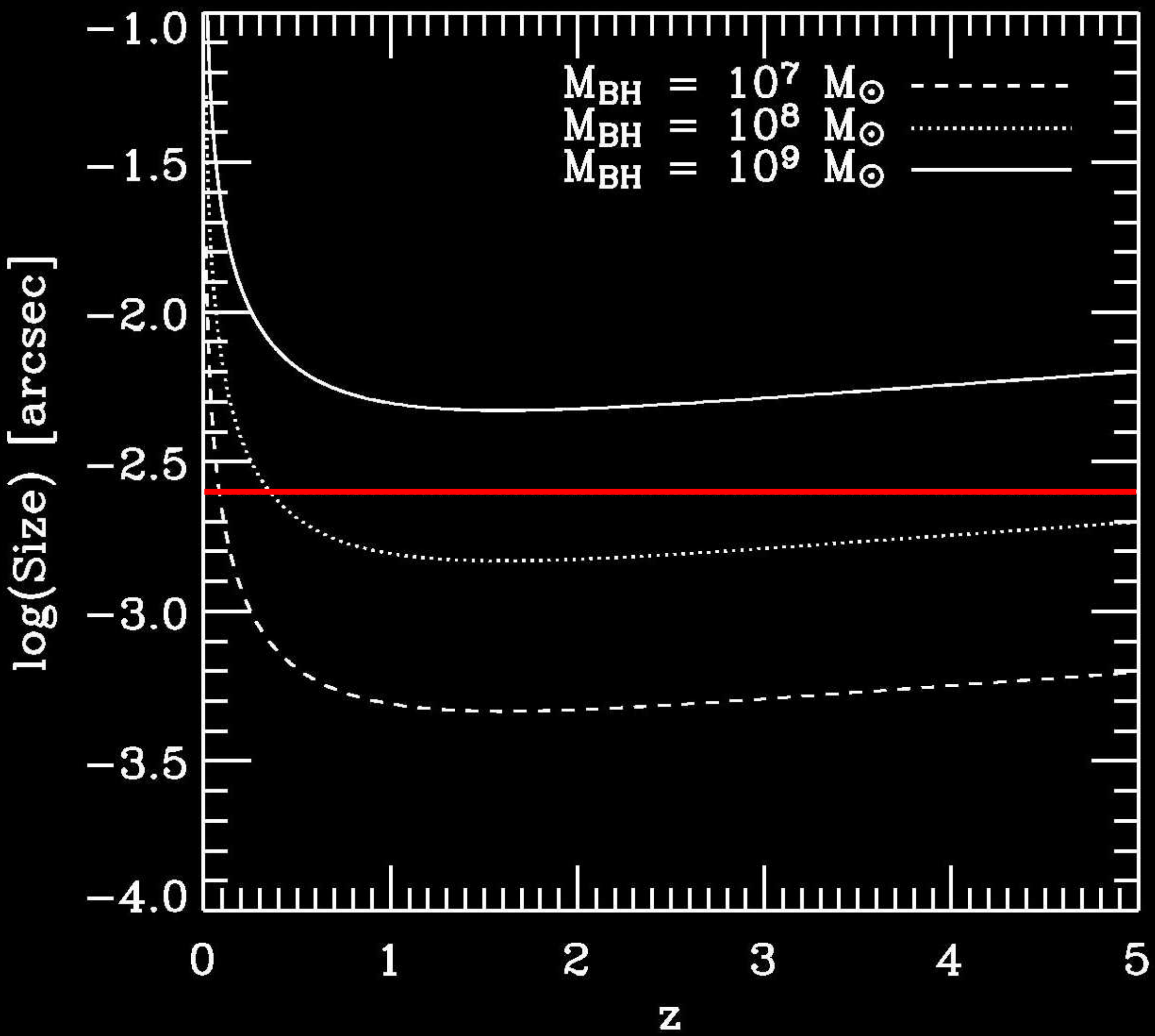


With a 100m telescope, these studies could be made out to cosmological distances.

Cote *et al.* (2002)

Summary: Massive Black Hole Demographics

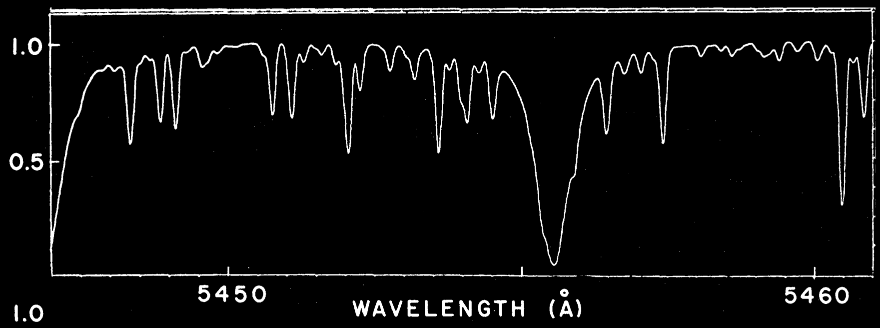
Hughes et al.



- With a 100m telescope, can resolve sphere of influence of black holes:
  - — at all redshifts for most massive black holes
  - — out to "evolutionary" distances over a useful range of masses
  - — at all credible masses out to Virgo Cluster

Summary: Massive Black Hole Demographics

Hughes et al.



Typical K giants have iron lines with widths of only ~ 3 km/s

(Bonnell & Branch 1979)

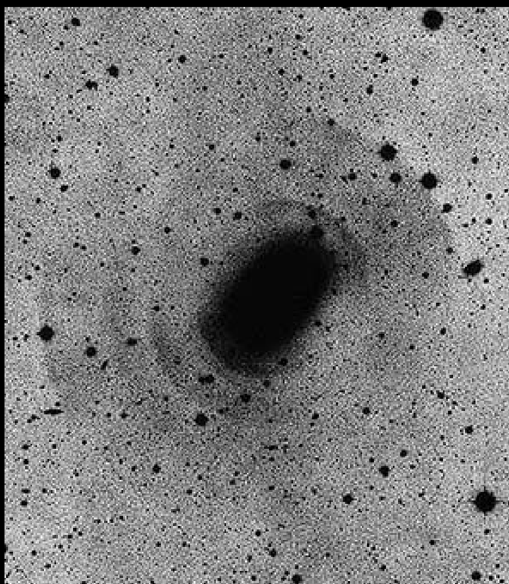
If there are not too many stars in a single spectrum, then we will still be able to measure their individual kinematics by resolving these lines.

- For example, with a 100-m telescope, the centre of an elliptical in the Virgo Cluster will contain ~10 RGB stars per resolution element

- These will be resolved out by a spectral resolution of ~20 km/s (*c.f.* ~300km/s velocity dispersion of galaxy).

- The requisite signal-to-noise ratio can be obtained in ~1 night with a 100-m telescope

Other Issues: Stellar Kinematics & Dynamics



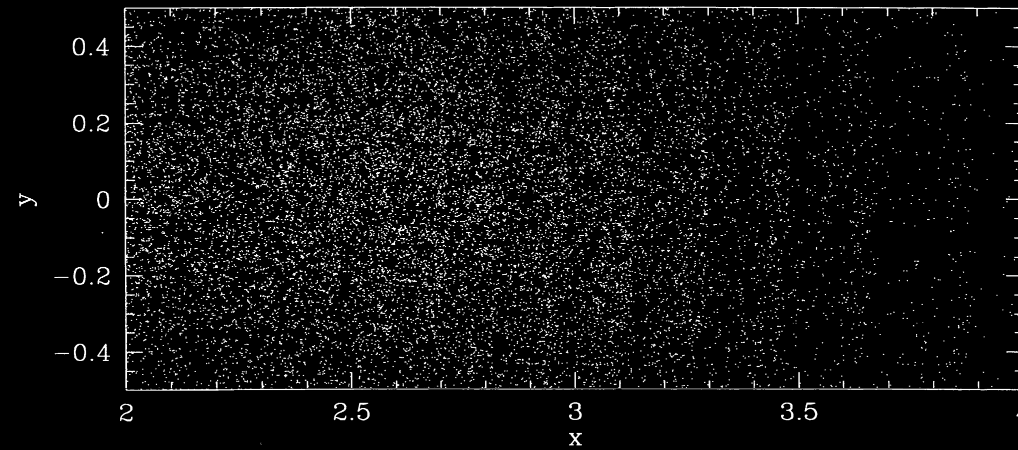


Figure 1. Projected density of part of the shell system generated by a small unbound satellite falling into a spherical isochrone potential.

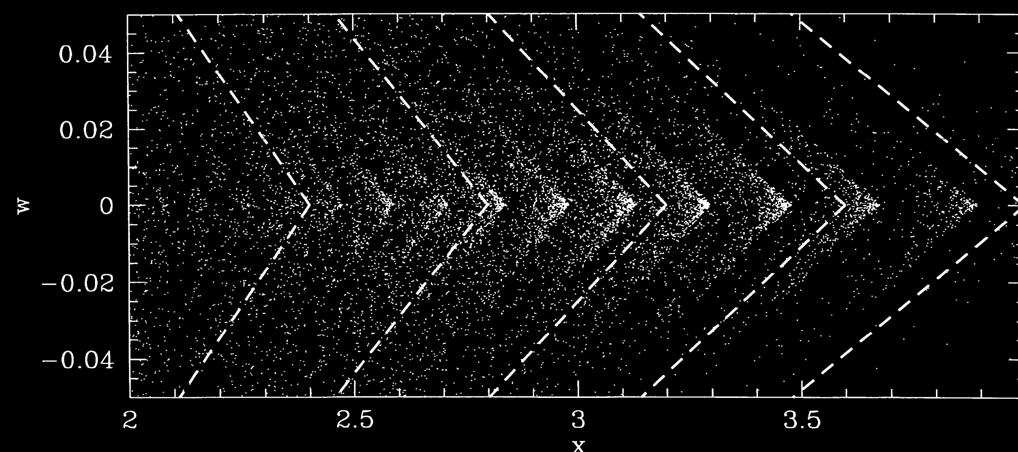
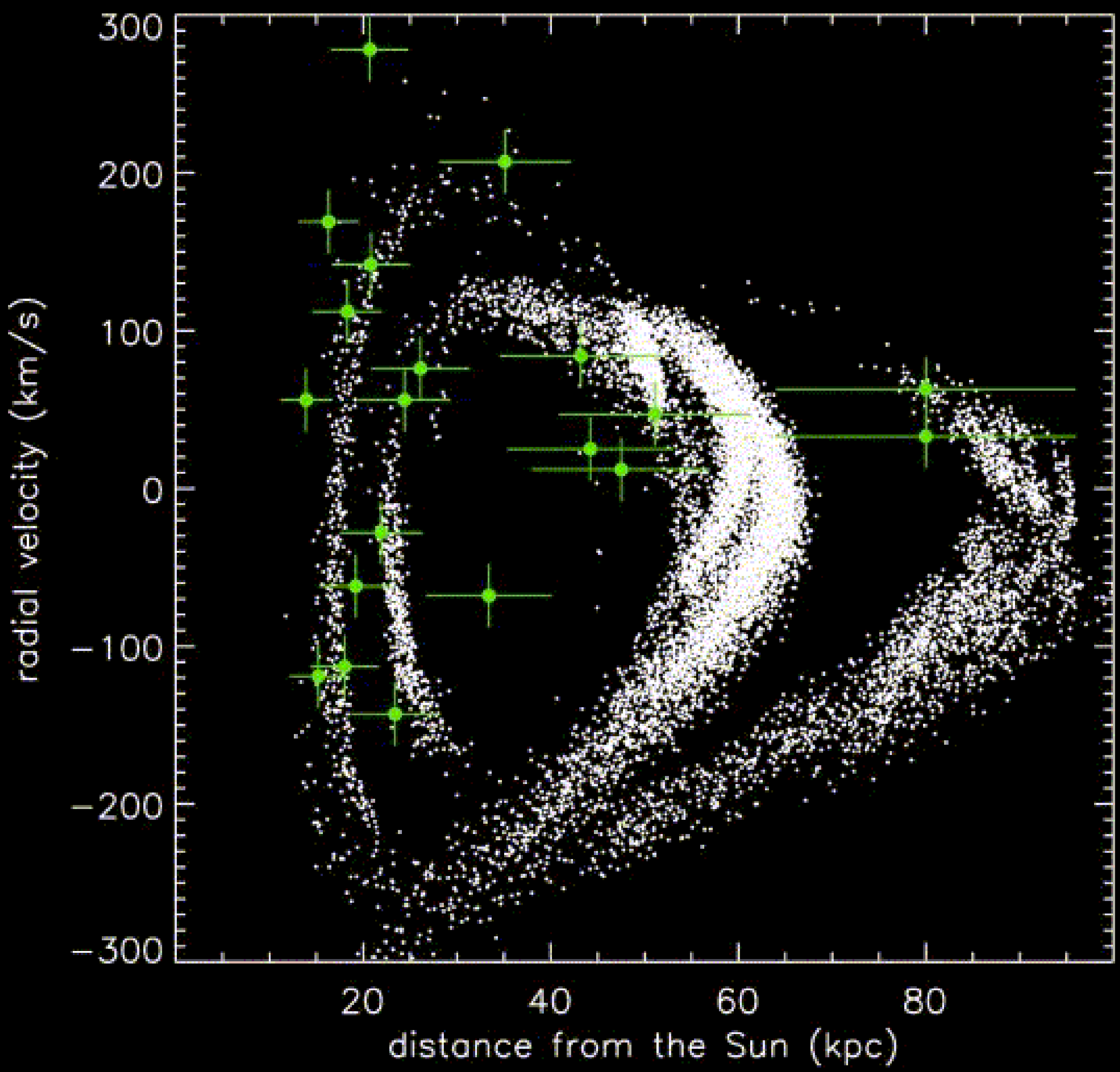


Figure 2. The velocity structure of the shells shown in Fig. 1. The slopes of the V-shaped line profiles agree well with the predictions of the approximate formula of equation (7) (shown as dashed lines).

(Merrifield & Kuijken (1998))

Other Issues: Stellar Kinematics & Dynamics



(Spaghetti Survey; Helmi 2002)

The Bottom Line

Recall that in terms of efficiency, surveys $\propto D^0$, resolved sources $\propto D^1$ and unresolved sources $\propto D^2$, so an ELT is an ideal instrument for studying stars

A suitably-designed ELT will provide definitive answers to *the most fundamental questions* about the relationship between stars and galaxies:

How do stars form in galaxies?

How are galaxies formed from stars?

These answers dovetail with ELT work on galaxy formation in its cosmological context (see "Galaxies and Cosmology"), and the localized physics of star formation (see "Planets and Stars").

However, these science drivers impose some strong design constraints:

— Aperture must be ~100m to reach a representative slice of the Universe

— Telescope must work at optical wavelengths to address many of the scientific issues (discrimination of CM diagram, source confusion, etc)

— But optical AO-corrected field does not have to be very large