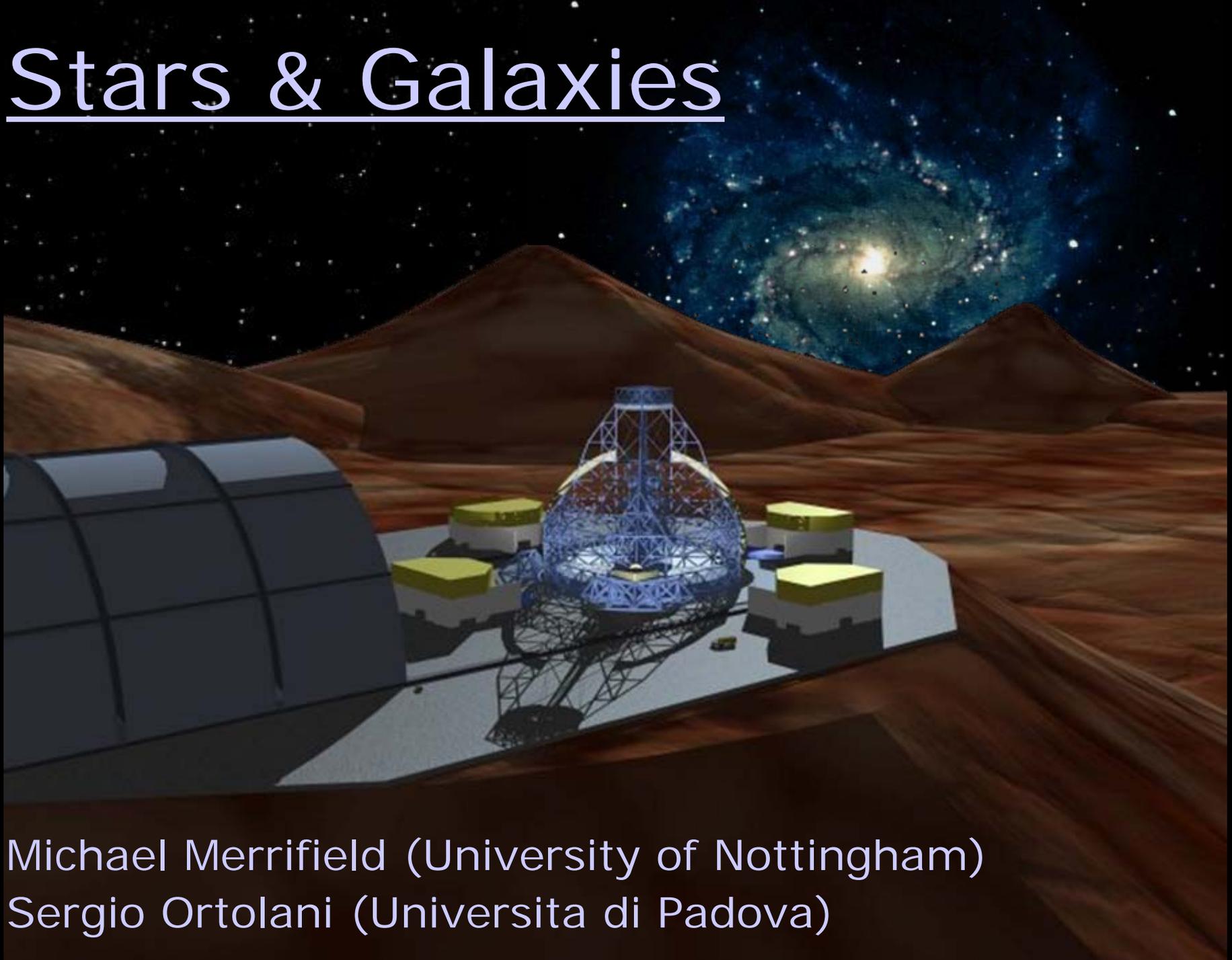


# Stars & Galaxies



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

# Interested People

Andy Adamson

University of Hawaii

Jane Buckle

University of Hawaii

Massimo Della Valle

Osservatorio Astofisco di Arcetri

Raffaele Gratton  
Richard de Grijs

Osservatorio Astronomico di Padova  
University of Sheffield

Mark Hughes

University of Hertfordshire

Michael Merrifield

University of Nottingham

Sergio Ortolani  
Steve Phillipps

Osservatorio Astronomico di Padova  
University of Bristol

Rosie Wyse

Johns Hopkins University

# Project Ideas

## Outcome for Marseille

Ultra-High-Resolution Studies  
of the ISM

Andy Adamson  
Ewine van Dishoeck  
Jane Buckle

Summary submitted

Intergalactic Stellar Populations

Raffaele Gratton  
Steve Phillipps  
Sergio Ortolani

Talk scheduled

Resolved Stellar Populations in  
Representative Environments

Michael Merrifield  
Carme Gallart  
Raffaele Gratton  
Knut Olsen  
Rosie Wyse  
Mohamed Mouhcine

Summary submitted

Star Formation History of the  
Universe from Supernovae

Massimo Della Valle  
Roberto Gilmozzi

Summary submitted  
Talk scheduled?

Measuring Cosmological Parameters  
Using Primary Indicators

Massimo Della Valle  
Roberto Gilmozzi

Moved to G&C session

Star Formation in the Context of  
Galaxies

Richard de Grijs

Summary submitted  
Talk scheduled

Stellar Kinematics and Populations  
around Massive Black Holes

Mark Hughes  
Michael Merrifield  
Alessandro Marconi  
Dave Axon

Summary submitted  
Talk scheduled

# Summary: Ultra-High Resolution Studies of the ISM

*Adamson et al.*

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

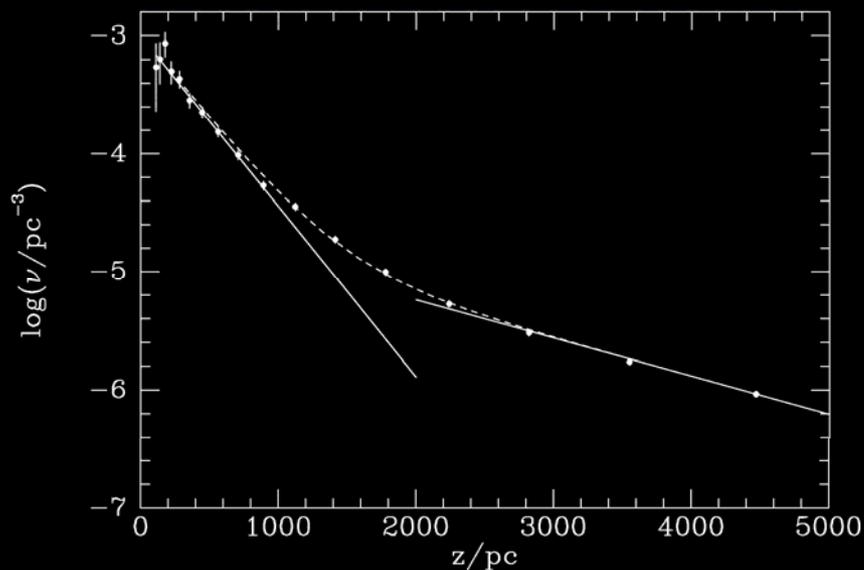
- Work at very high dispersion
  - exploit atmospheric gaps to explore mid-infrared
  - explore important species that do not emit in sub-mm
- Obtain very high signal-to-noise ratio spectra
  - explore fine-scale structure of the ISM
  - monitor its variability
- Measure low levels of polarization
  - 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.*

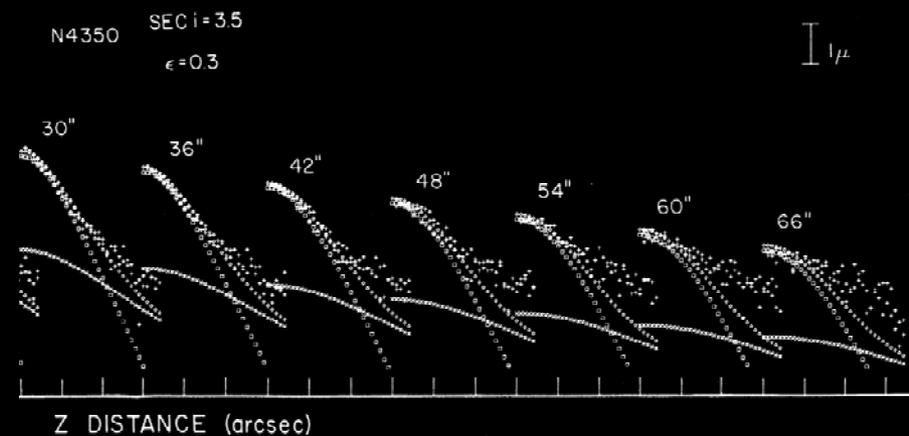
- Study the ISM at high redshift
  - map out ISM metallicity as a function of redshift
  - map out ISM dust content as a function of redshift
- Make optical studies of heavily obscured regions
  - use well-calibrated optical diagnostics
  - study atomic as well as molecular physics in these regions

# Summary: Resolved Populations

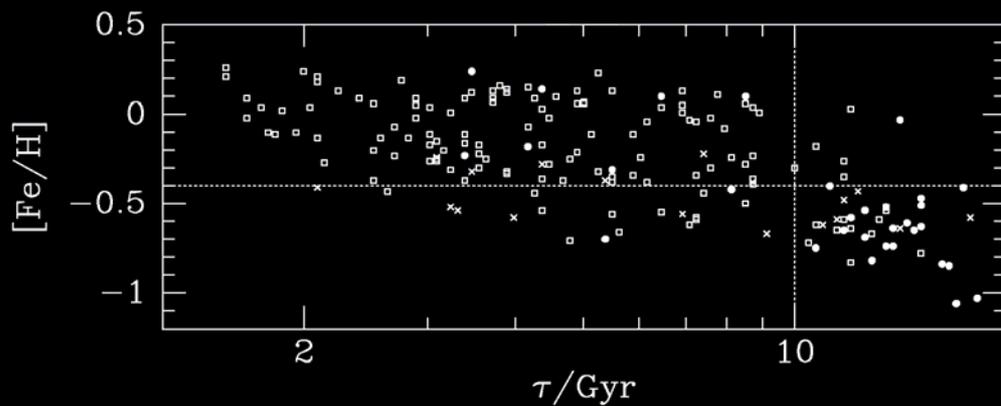


(Gilmore & Reid 1983)

*Merrifield et al.*



(Burstein 1979)



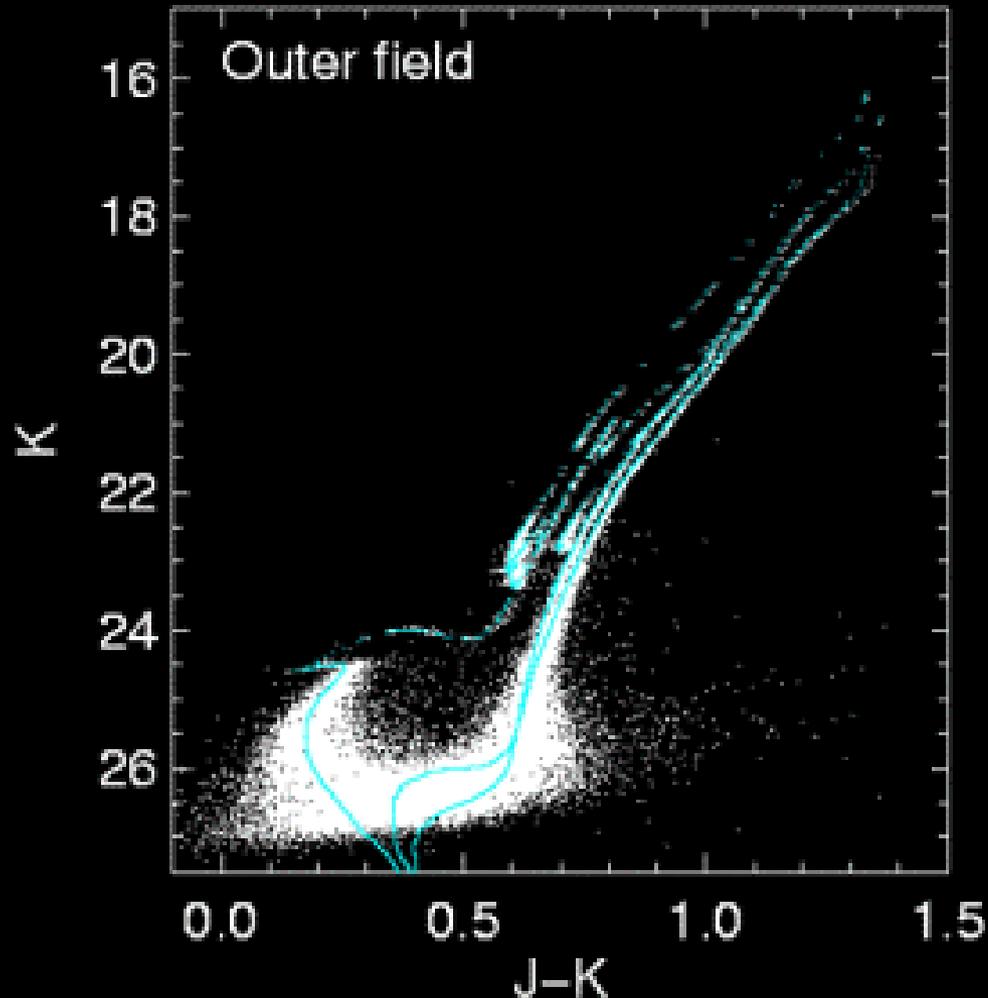
(Edvardsson *et al.* 1993)



(Robert Gendler)

# Summary: Resolved Populations

*Merrifield et al.*

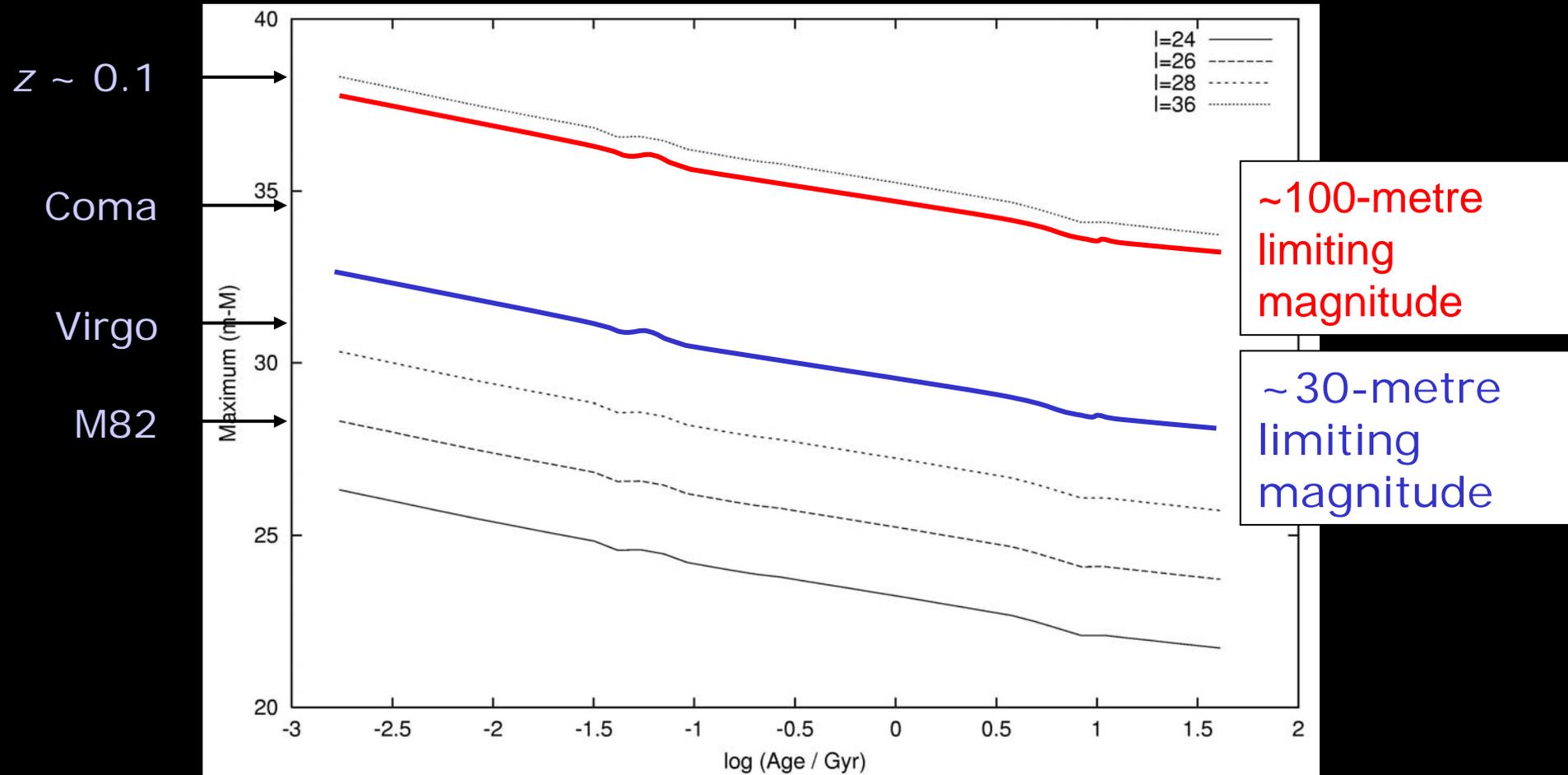


(from GSMT study)

- 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

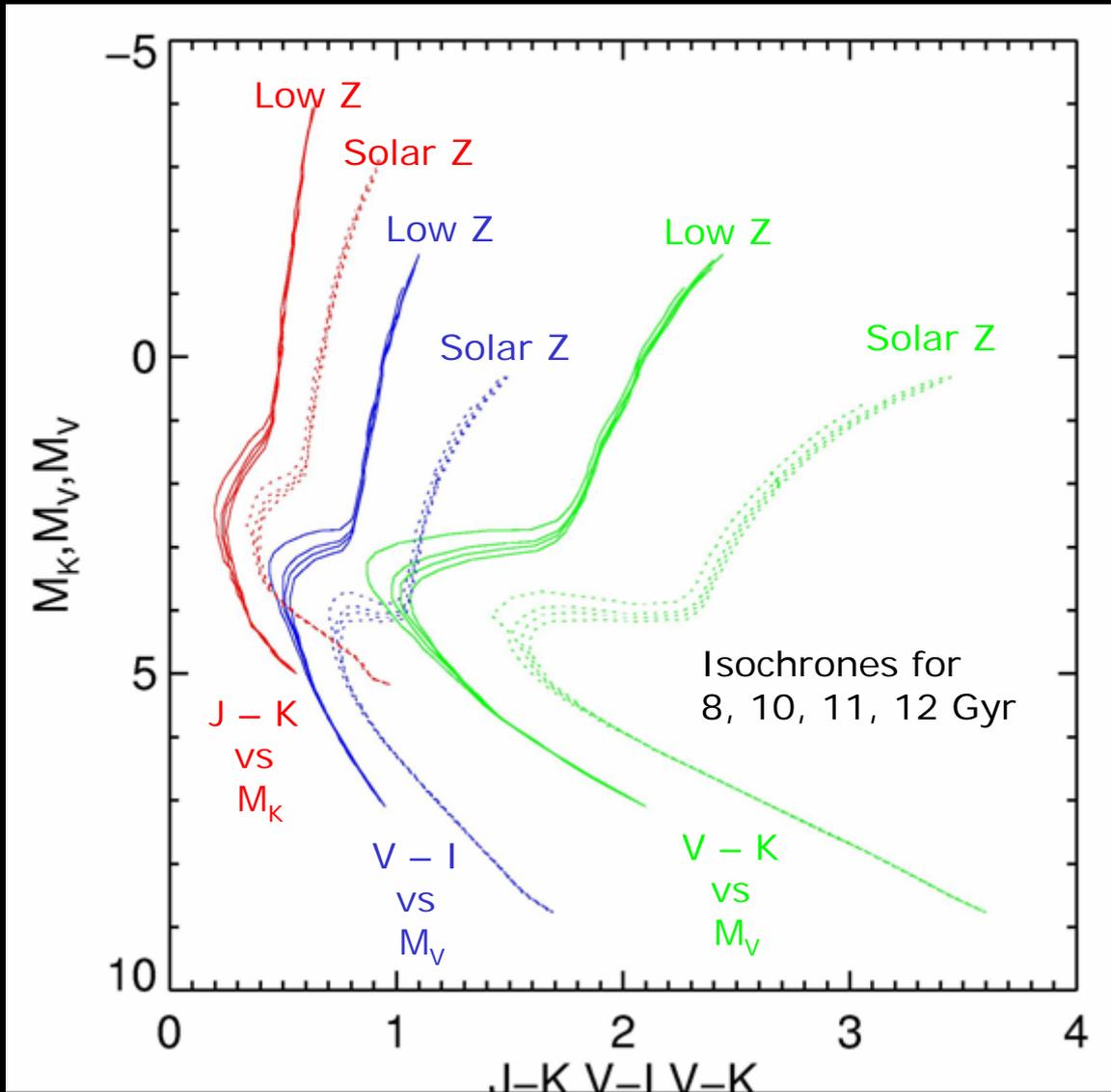
*Merrifield et al.*



(from Frayn 2003)

# Summary: Resolved Populations

*Merrifield et al.*



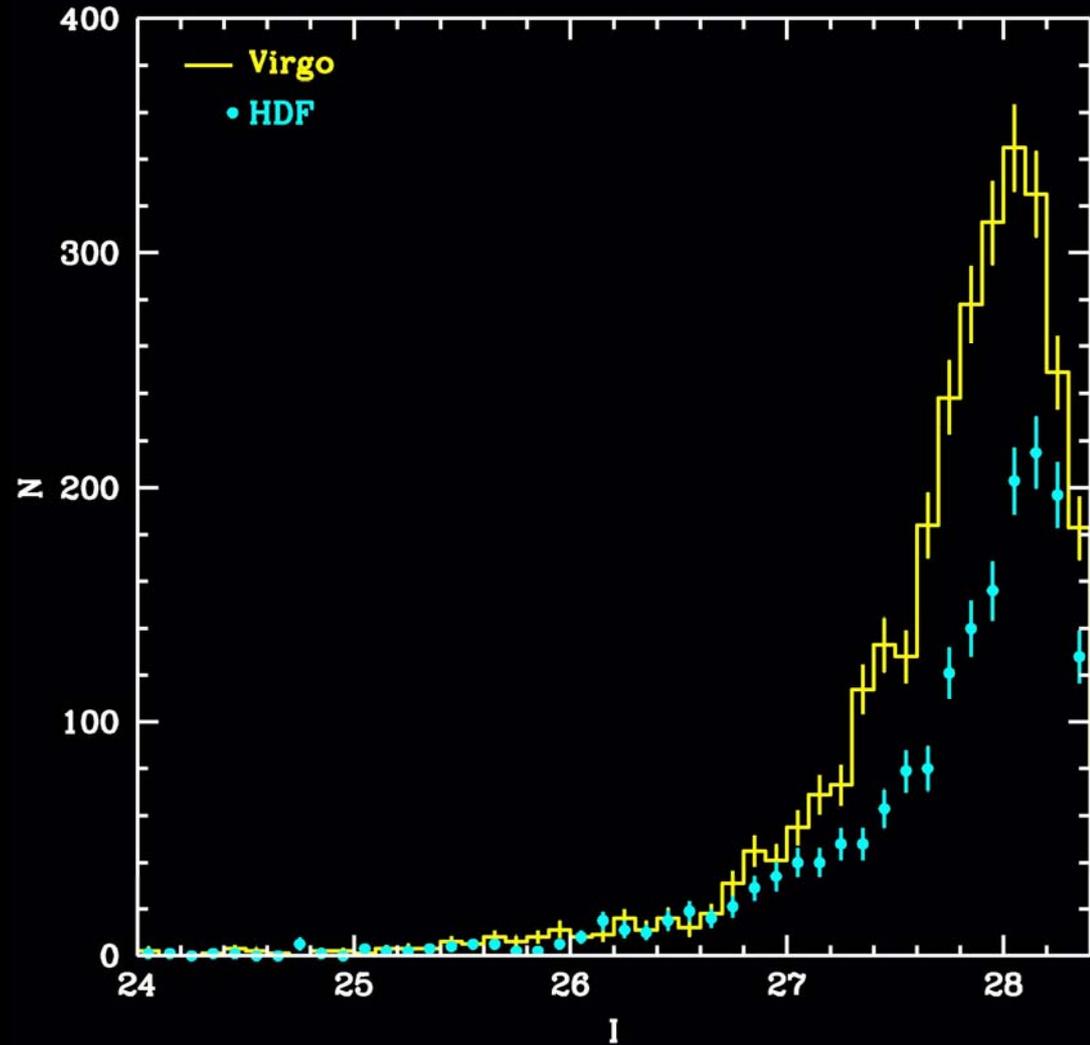
(from Rosie Wyse)

# Summary: Intergalactic Stars

*Gratton et al.*



Hibbard & van Gorkom (1996)



Ferguson, Tanvir & von Hippel (1998)

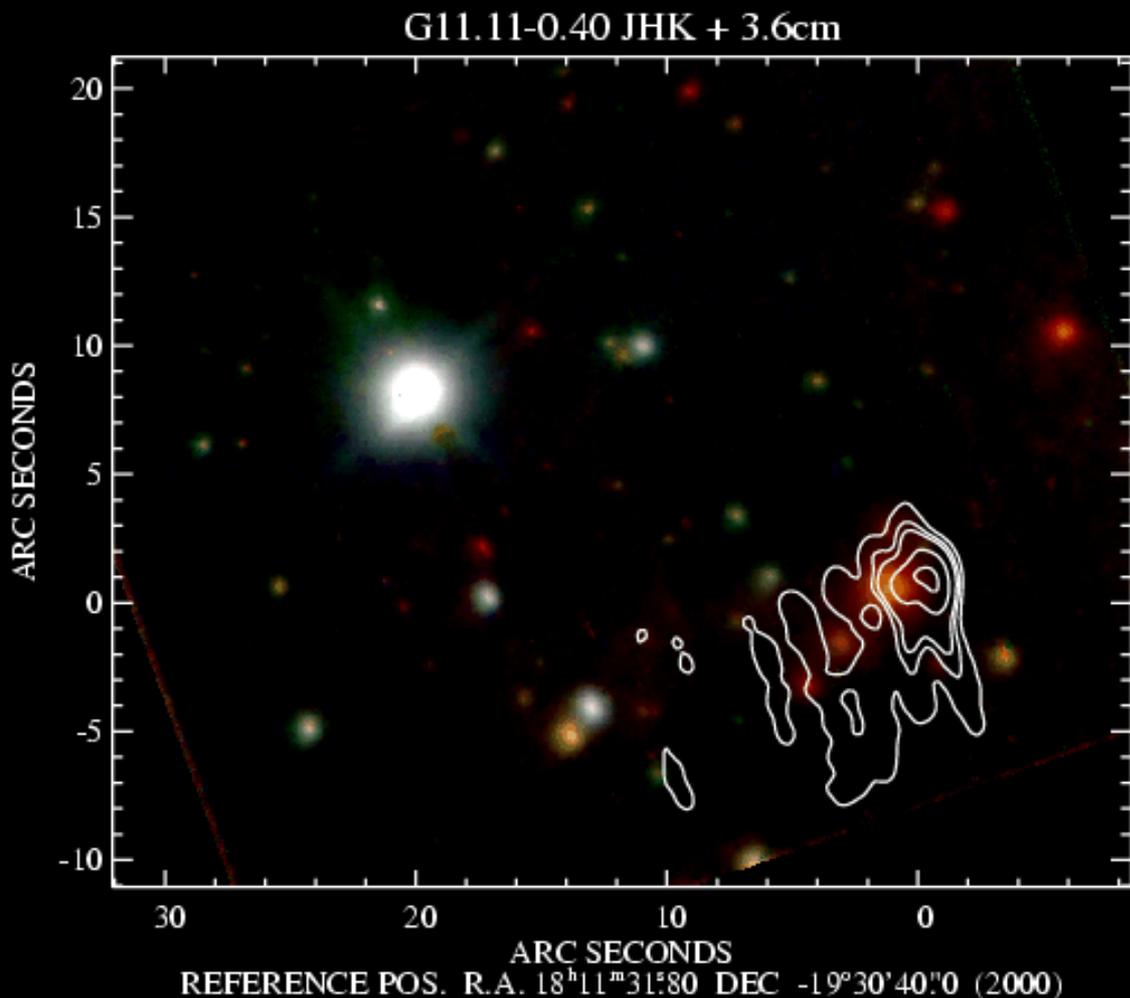
# Summary: Star Formation History from Supernovae

*Della Valle et al.*

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

# Summary: Star Formation in the Context of Galaxies

*De Grijs et al.*

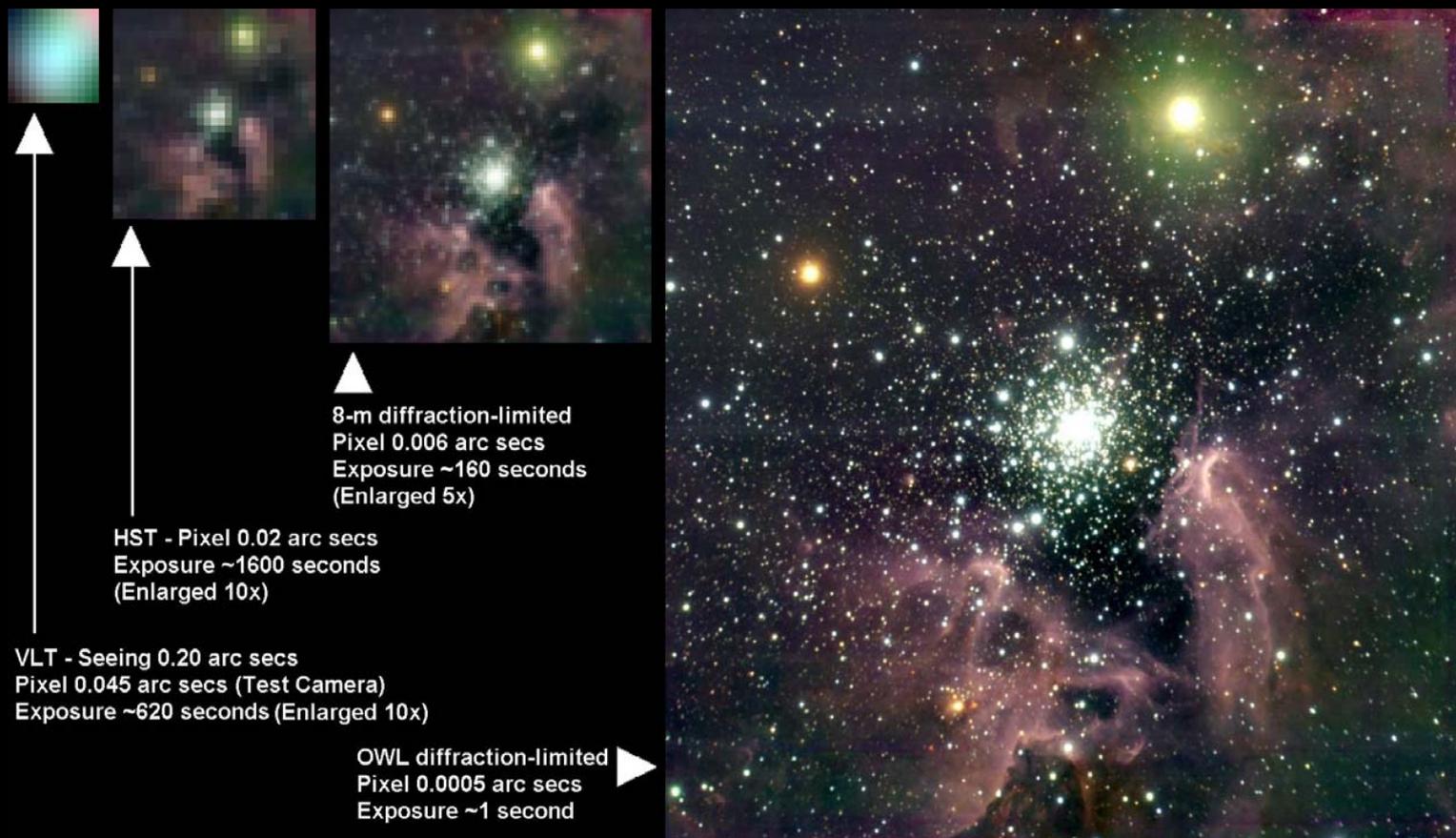


- With a 100m telescope, can resolve the stars in even compact HII regions throughout Local Group.
  - test universality of IMF
  - calibrate SFR measures
  - investigate feedback, chemical enrichment, etc.

(Henning *et al.* 2001)

# Summary: Star Formation in the Context of Galaxies

*De Grijs et al.*

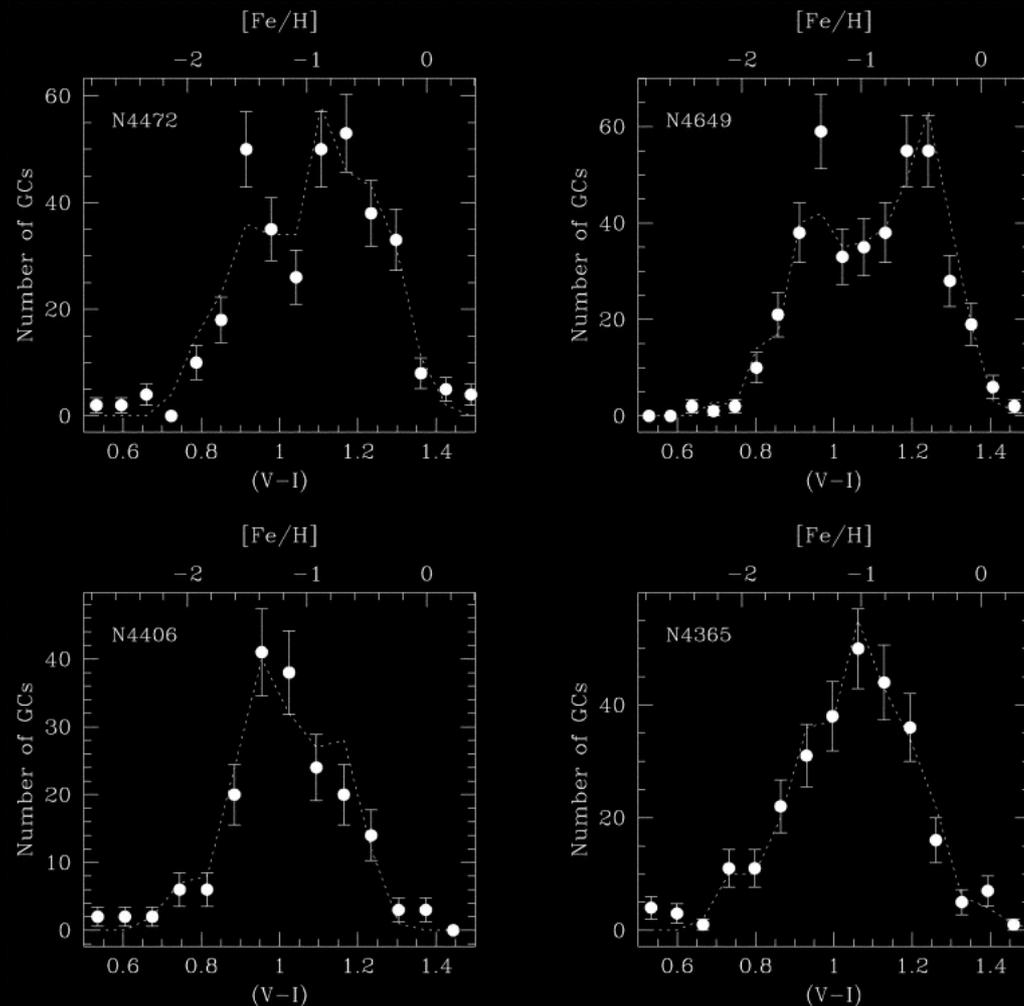


With a 100m telescope:

- 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

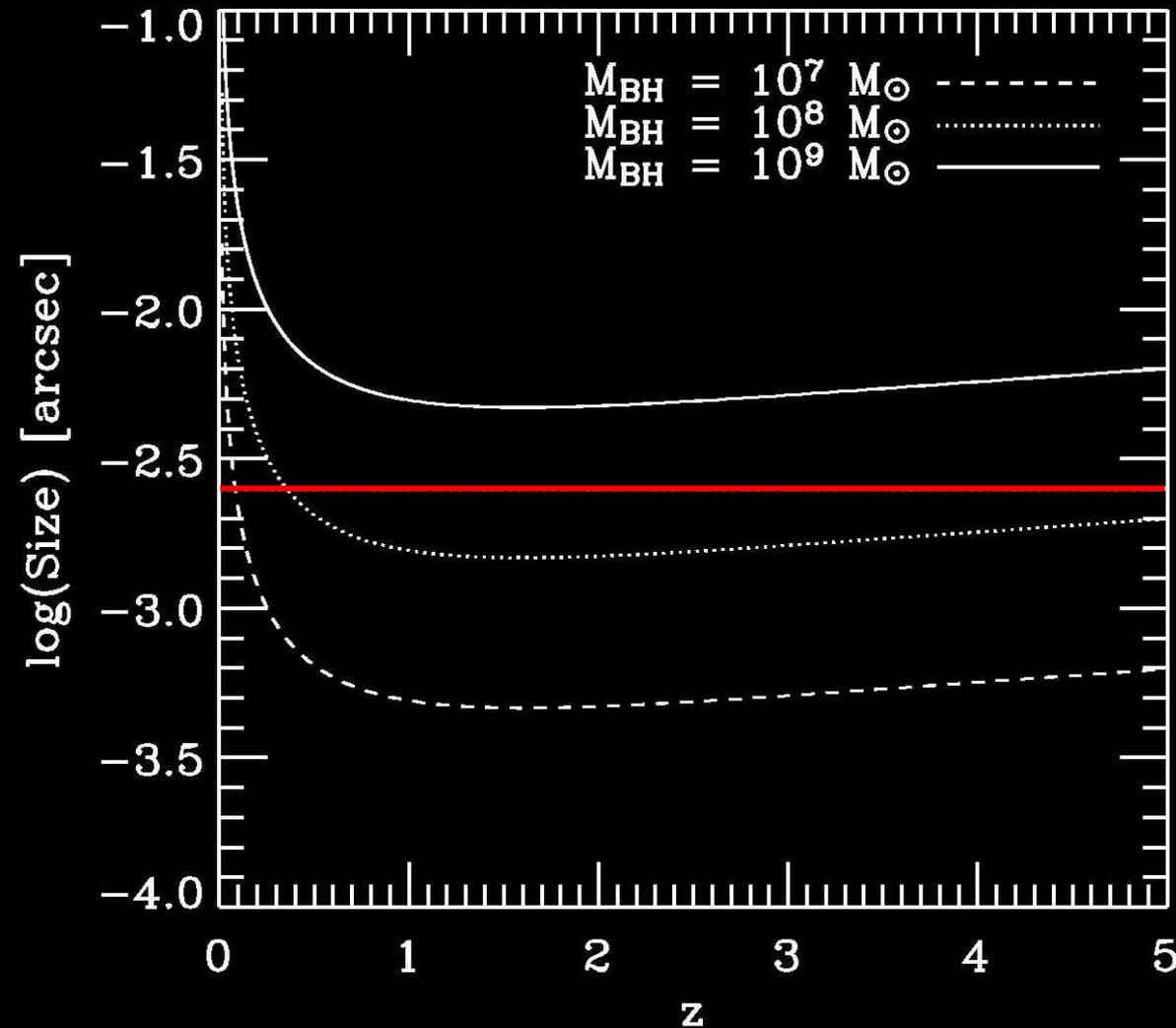
*De Grijs et al.*



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

# Summary: Massive Black Hole Demographics

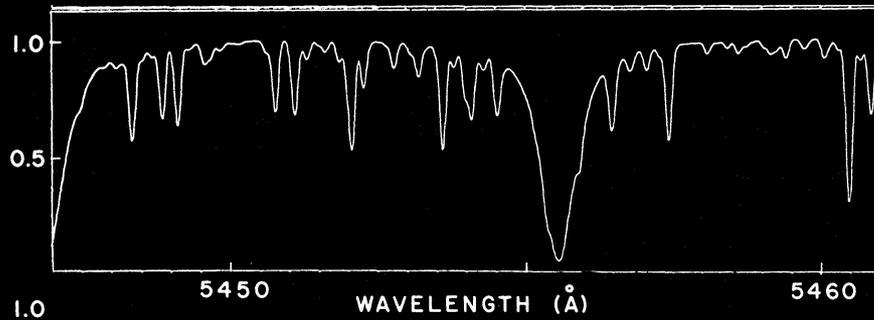
*Hughes et al.*



- 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  $\sim 3$  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  $\sim 10$  RGB stars per resolution element
- These will be resolved out by a spectral resolution of  $\sim 20$  km/s (*c.f.*  $\sim 300$  km/s velocity dispersion of galaxy).
- The requisite signal-to-noise ratio can be obtained in  $\sim 1$  night with a 100-m telescope

# Other Issues: Stellar Kinematics & Dynamics

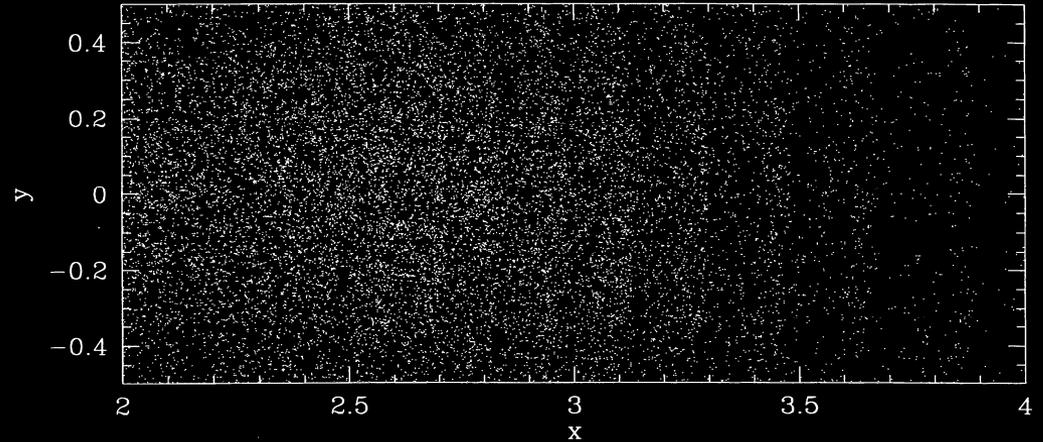
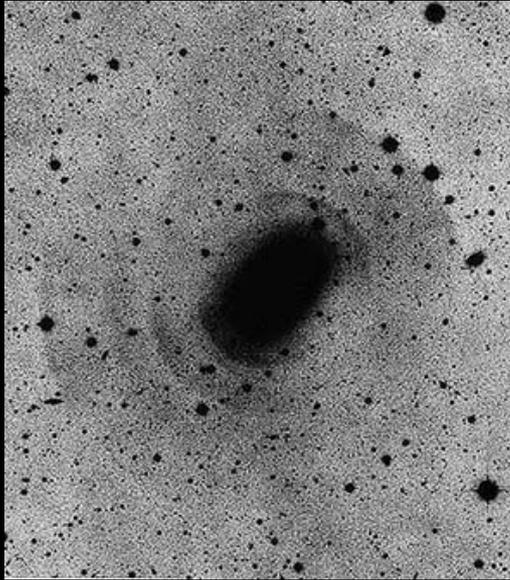


Figure 1. Projected density of part of the shell system generated by a small unbound satellite falling into a spherical isochrone potential.

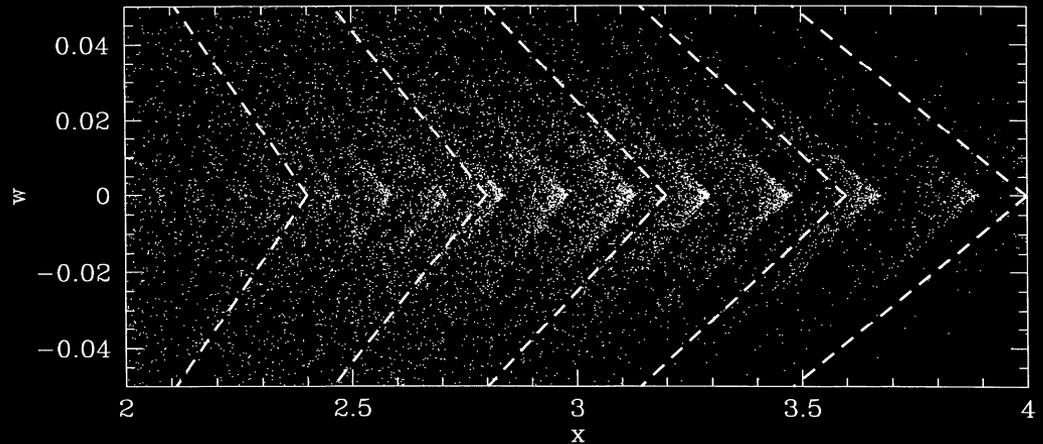
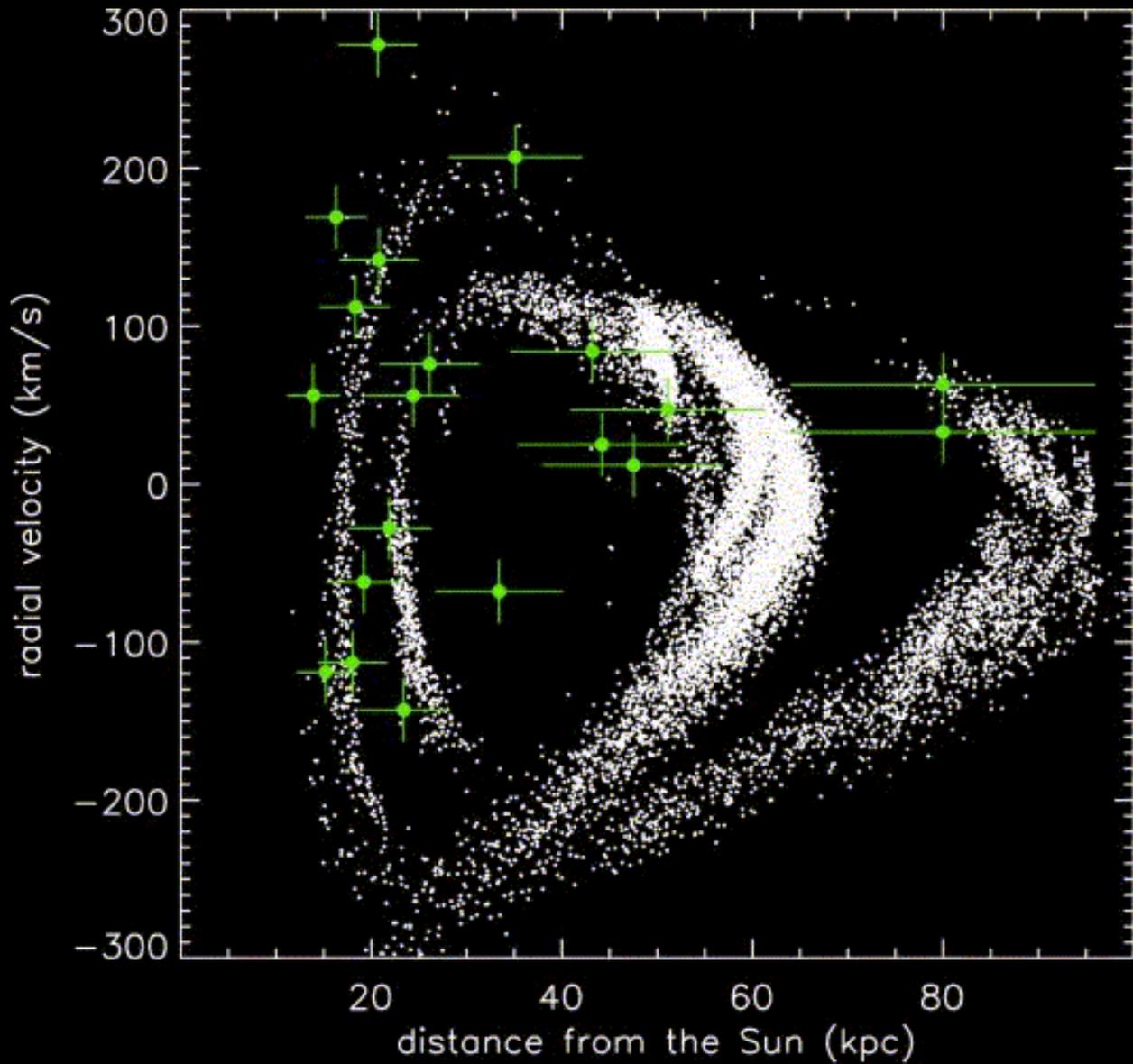


Figure 2. The velocity structure of the shells shown in Fig. 1. The slopes of the V-shaped line profiles agree well with the predictions of the approximate formula of equation (7) (shown as dashed lines).

(Merrifield & Kuijken (1998))

# Other Issues: Stellar Kinematics & Dynamics



(Spaghetti Survey; Helmi 2002)

# The Bottom Line

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  $\sim 100\text{m}$  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)

## The Next Steps

At this meeting, and in the coming weeks, we need to:

- Decide how to combine the existing work into a single high profile project
- Figure out what calculations, simulations, etc, need to be made to make the case.
- Carry out the calculations, simulations, etc.
- Figure out what our bottom line is for the lowest specification telescope that is worth building (optical? aperture?)
- Write the case.