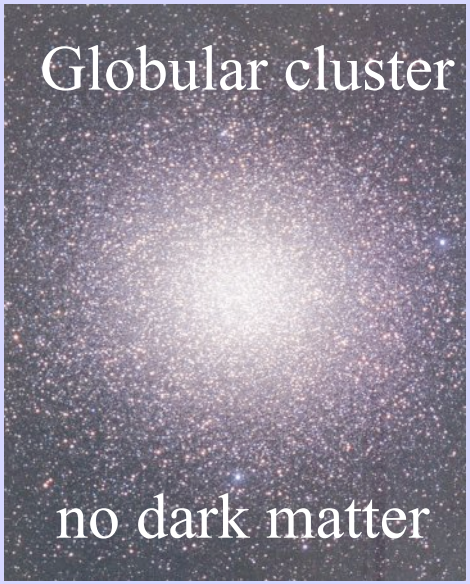
At the interface between star clusters and galaxies



Steffen Mieske

ESO fellowship symposium, 12.-14. November 2007, Vitacura.

Outline:

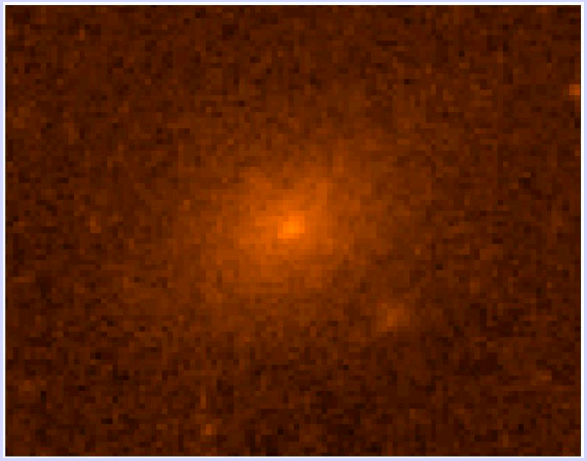
1. **Ultra-compact dwarf galaxies (UCDs):**
   A distinct population of compact stellar systems

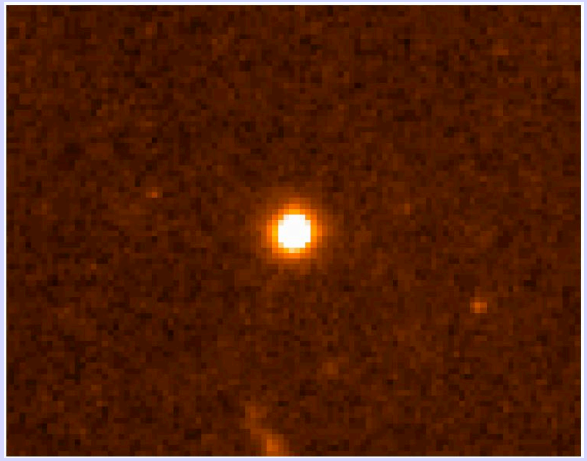
2. **Dark matter in UCDs (?):**
   Constraints on dark matter clustering properties

3. **The colour-magnitude trend of globular clusters:**
   A galaxian property valid for star clusters

1. Ultra-compact dwarf galaxies

Morphology:





Giant **Dwarf** **Ultra-compact dwarf**

1. Ultra-compact dwarf galaxies

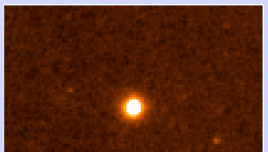
UCDs were discovered about a decade ago
(Hilker et al. 1999, Drinkwater et al. 2000):

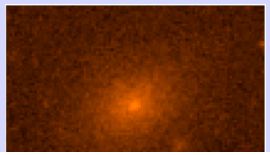
In spectroscopic survey of Fornax cluster, 6 unresolved cluster members were found close to faint survey limit: **$-13.5<M_V<-12$ mag**

- Brighter than ωCen (M_V=-10.5 mag)
- Luminosity comparable to typical dwarf galaxies

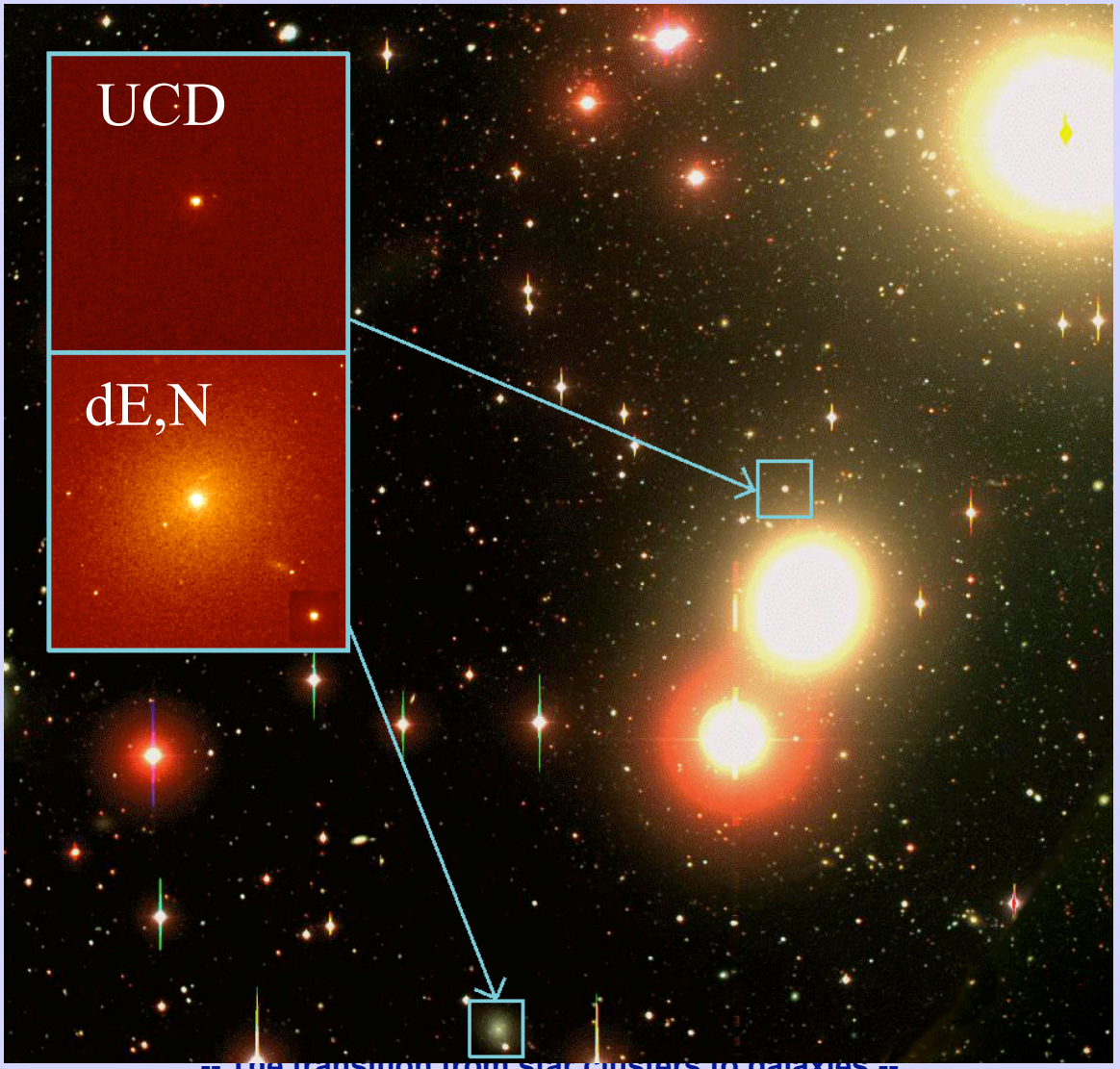
→ Call them „**Ultra-compact dwarf galaxies**“ (Phillipps+ 2001)

Drinkwater et al. 2003, Nature:
„A new class of compact stellar systems
from disruptive processes in galaxy clusters“

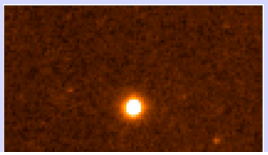


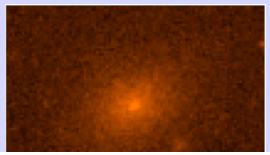


1. Ultra-compact dwarf galaxies



Courtesy of M. Hilker

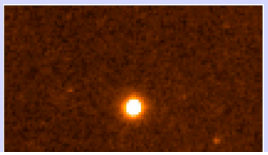


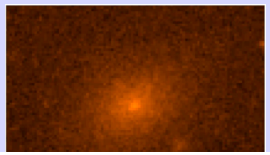


1. Ultra-compact dwarf galaxies

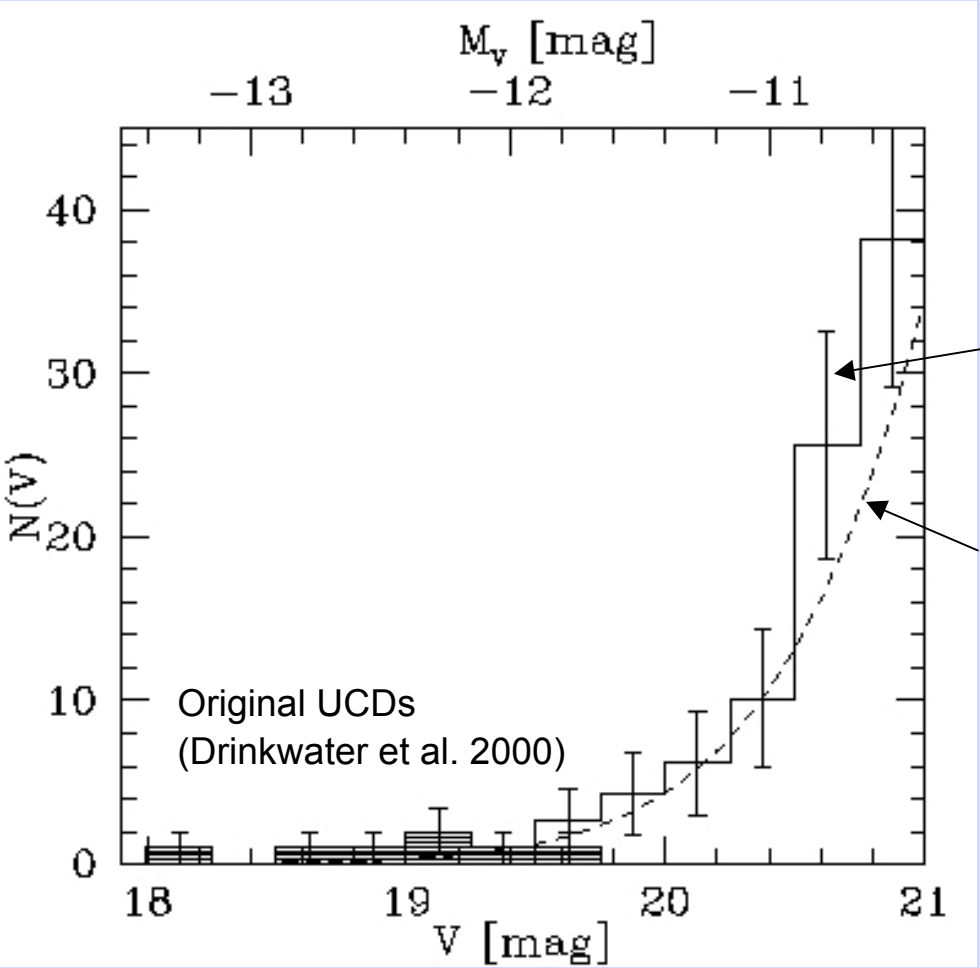
Possible origins of UCDs:

1. **Brightest globular clusters** (Mieske et al. 2004; Dirsch et al. 2003)
   Canonical origin
2. **Stellar super-clusters created in wet mergers** (Fellhauer & Kroupa)
   Advanced origin
3. **Stripped nuclei of dE,Ns** (Bekki et al. 2003)
4. **Genuine compact dwarf galaxies arising from high density peaks of primordial dark matter fluctuations** (Drinkwater et al. 2004)
   Cosmological origin





1. Ultra-compact dwarf galaxies



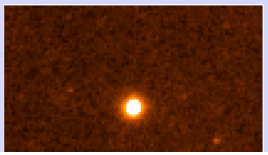
Luminosity distribution of compact objects (Mieske et al. 2004):

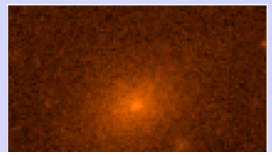
No magnitude gap between UCDs and GCs.

Same population?

What is a UCD???

Extrapolated globular cluster luminosity function (Dirsch et al. 2003)

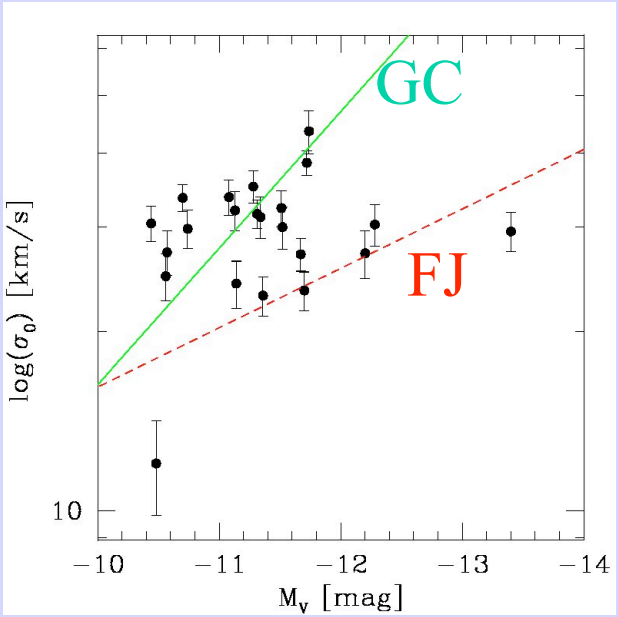


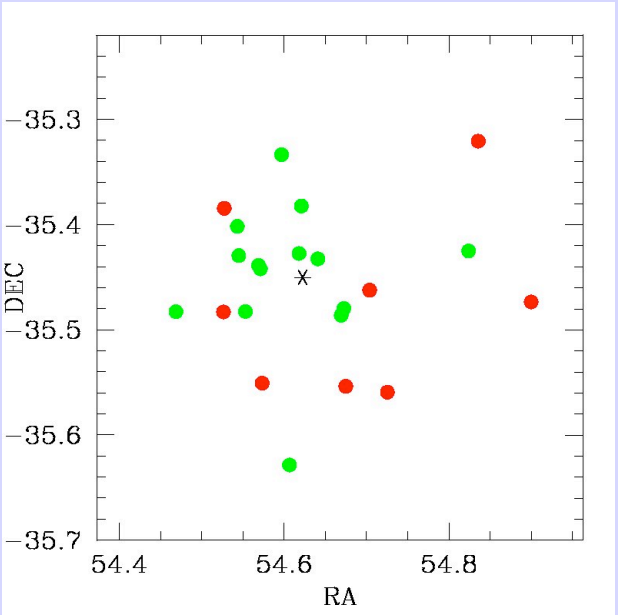


1. Ultra-compact dwarf galaxies

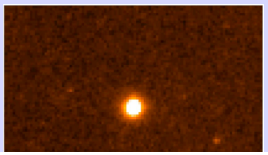
Separation in representations of the Fundamental Plane?

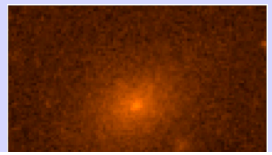
(Mieske et al. 2008 in preparation, using FLAMES spectroscopy + ACS imaging)





Compact objects in range of bright GCs and UCDs appear to fall either along **Faber-Jackson** relation or **globular cluster relation**.
The two groups have slightly different spatial distributions (2.1σ).

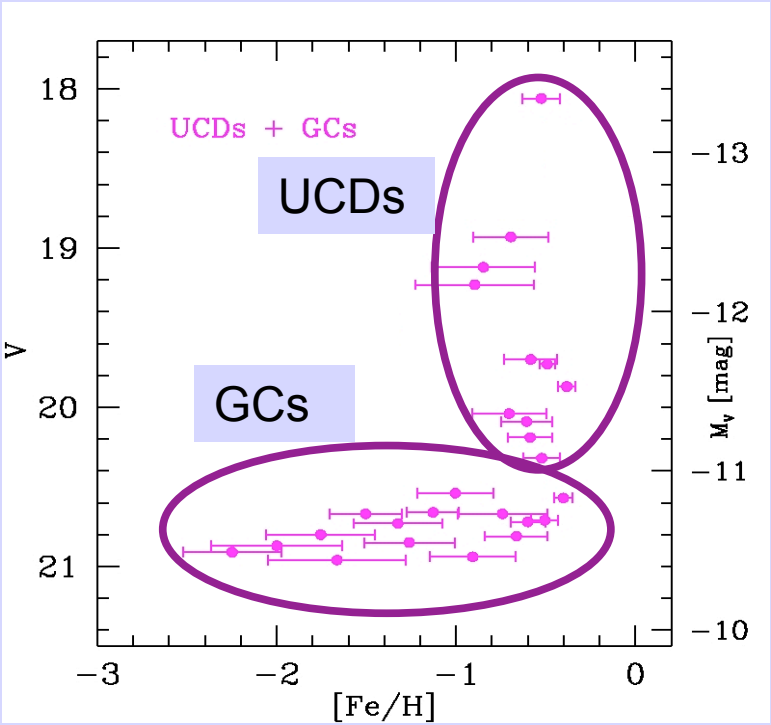


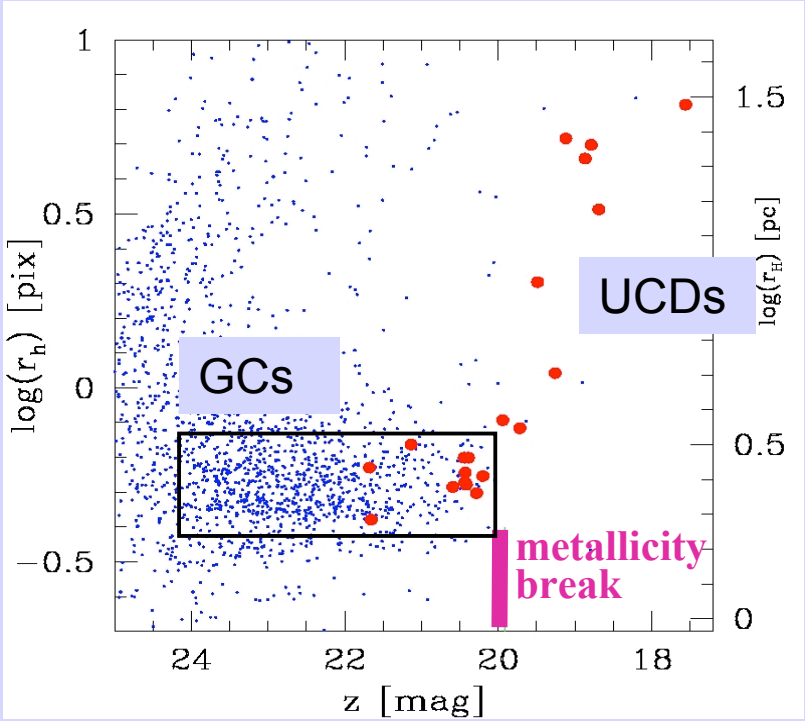


1. Ultra-compact dwarf galaxies

Separation in terms of stellar content and/or size?

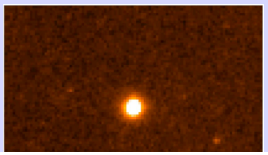
(Mieske et al. 2006, using IMACS spectroscopy + ACS imaging)

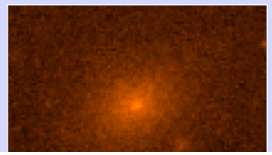




Break in metallicity + size at M_V=-11 mag:

Separation between GCs and UCDs at $3*10^6$ $M_\odot$

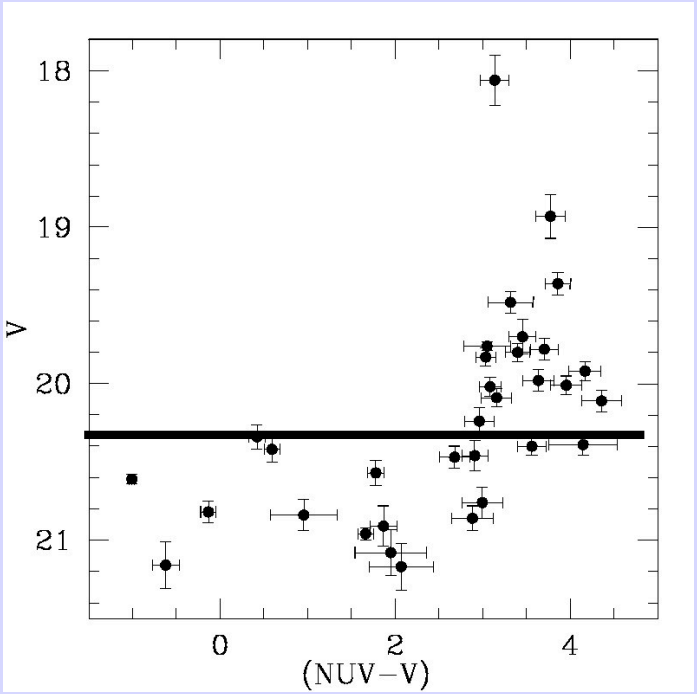




1. Ultra-compact dwarf galaxies

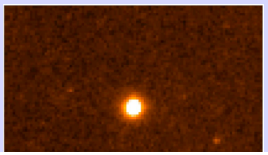
Separation in terms of stellar content and/or size?

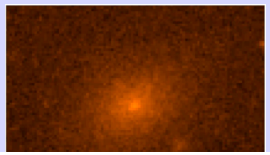
GALEX UV colours of UCDs + GCs:



Break in metallicity + size + UV colours at M_V=-11 mag:

Separation between GCs and UCDs at $3*10^6$ $M_\odot$



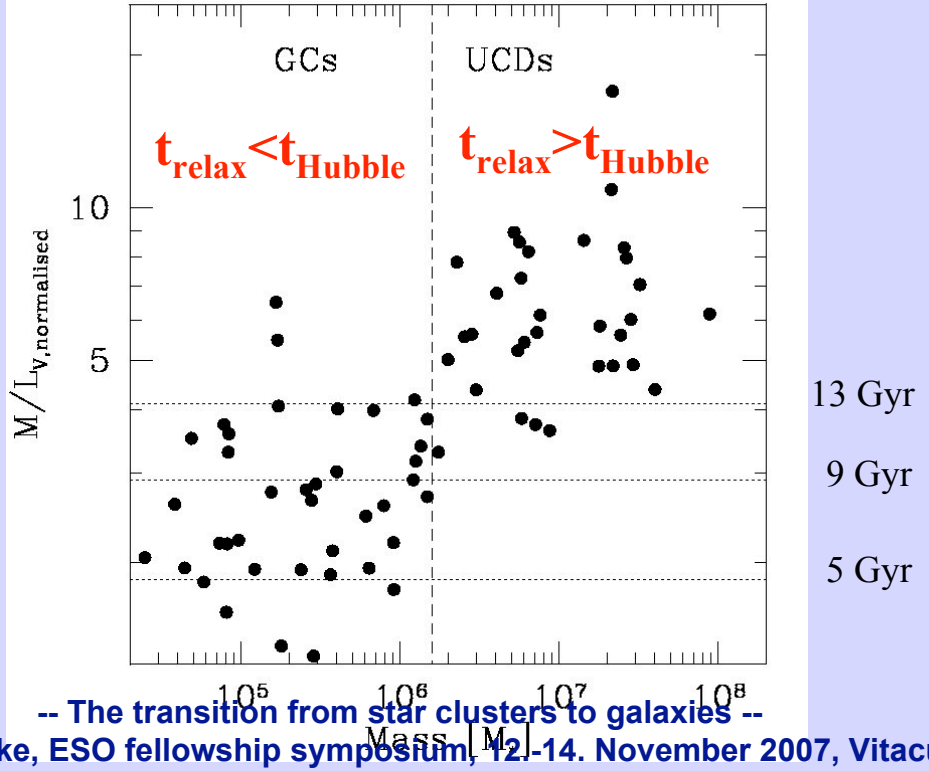


1. Ultra-compact dwarf galaxies

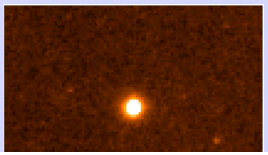
At similar mass: separation in M/L ratios between GCs and UCDs

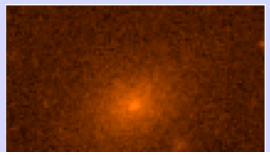
(Mieske & Kroupa 2008, submitted to ApJ, and references therein)

Do UCDs mark the on-set of dark matter domination in small stellar systems?

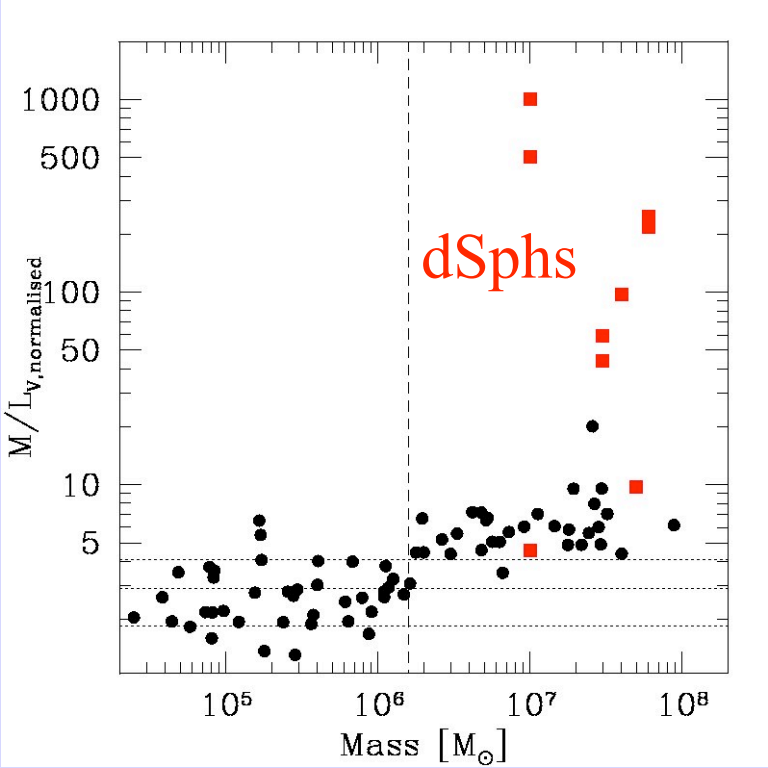


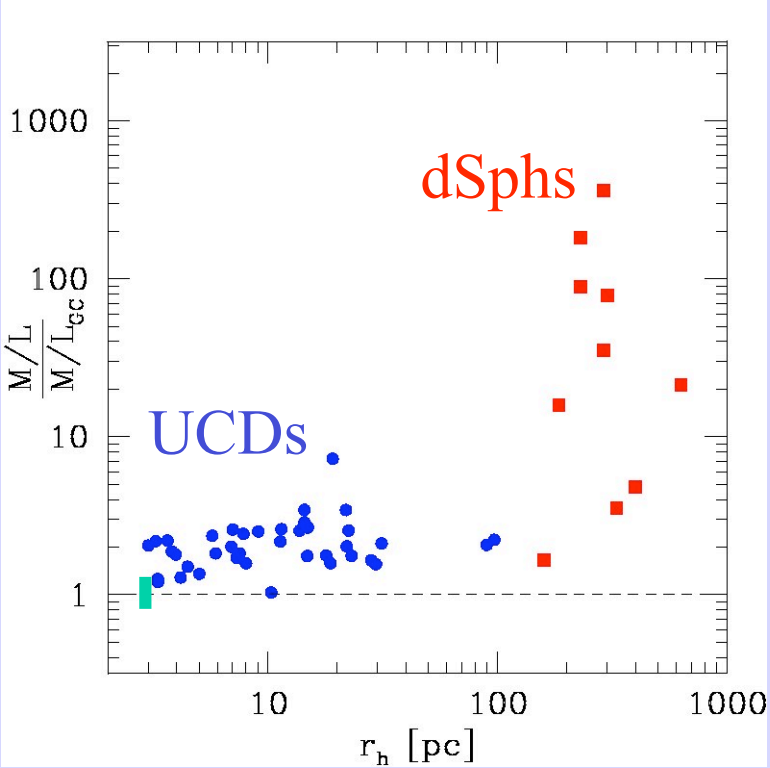
Collection of literature data: Milky Way GCs, Compact objects in CenA and Virgo



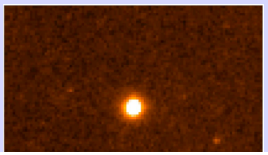


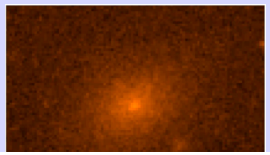
2. Dark matter in UCDs?





UCDs are crucial objects to test whether dark matter clusters at scales < 100pc.



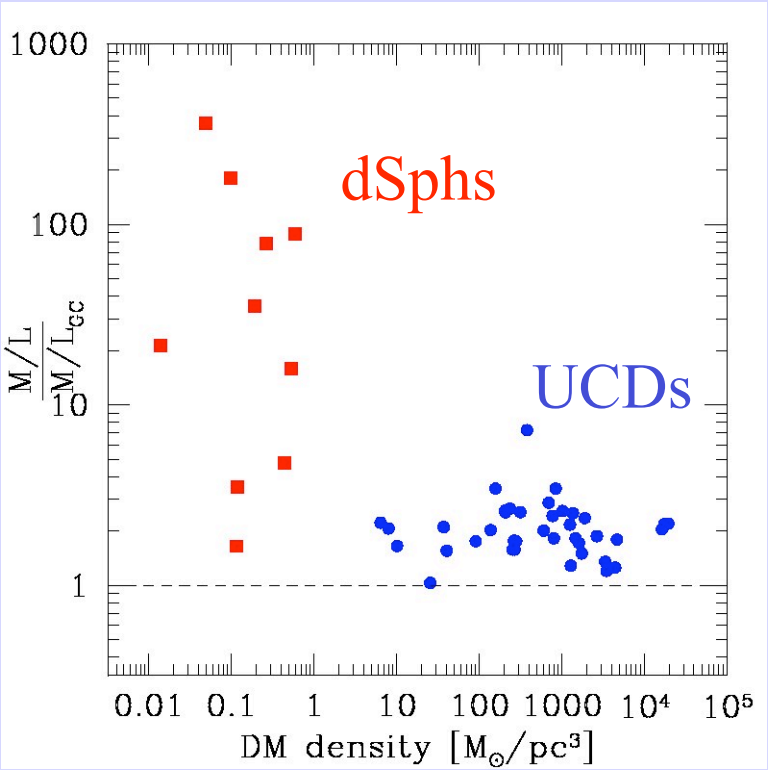


2. Dark matter in UCDs?

If high M/L ratios due to dark matter:
DM densities >10 M_* pc^{-3} within ~20pc.

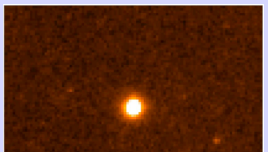
Partially **consistent** with expected central densities of **cuspy** DM halos
(Walker+ `07, Mashchenko & Sills ´05).

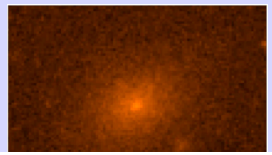
Inconsistent with central **core**
(Gilmore+ `07, Mashchenko & Sills ´05).



UCDs are crucial objects to constrain phase space properties of DM: warm vs. cold

-- The transition from star clusters to galaxies --
Steffen Mieske, ESO fellowship symposium, 12.-14. November 2007, Vitacura.





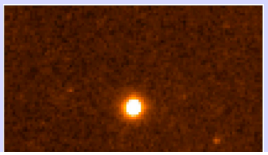
2. Dark matter in UCDs?

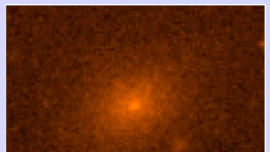
Future steps:

1. **Observational tests of alternatives to DM**

   a) Bottom-heavy IMF: many low-mass stars

   b) Top-heavy IMF: many stellar remnants





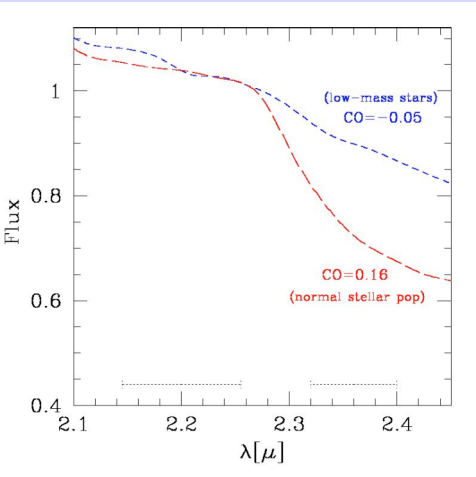
2. Dark matter in UCDs?

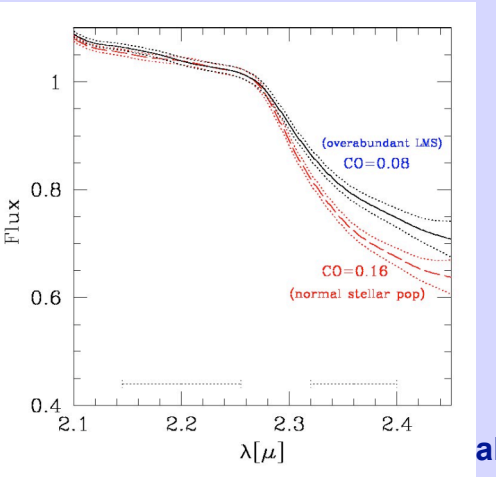
Future steps:

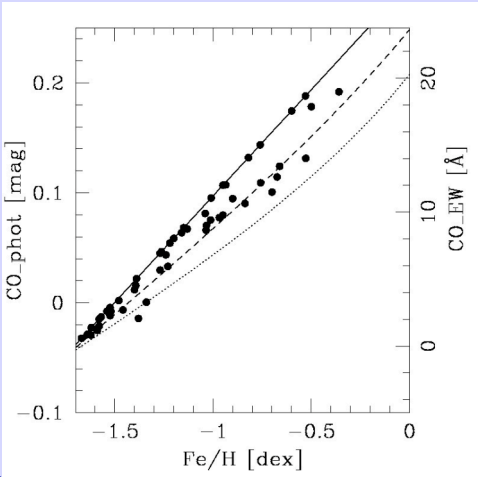
1. Observational tests of alternatives to DM

   a) Bottom-heavy IMF: many low-mass stars

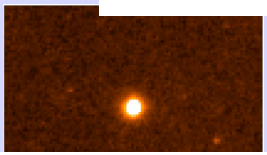
Mieske & Kroupa (2008): use the CO band @ 2.3μ to test for overabundance of low-mass stars

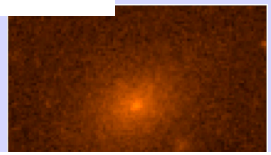






-- The t… alaxies --
Steffen Mieske, ESO fellowship symposium, 12.-14. November 2007, Vitacura.





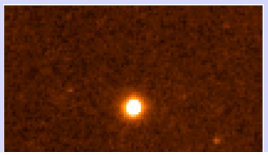
2. Dark matter in UCDs?

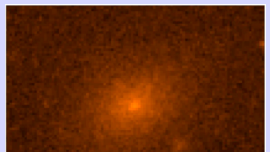
Future steps:

1. **Observational tests of alternatives to DM**

   b) Top-heavy IMF: many stellar remnants

Investigate X-ray emission in UCDs:
- Frequency of LMXBs in UCDs vs. frequency in GCs
- Contrast with frequency expected for top-heavy IMF (Dabringhausen & Kroupa 2008).



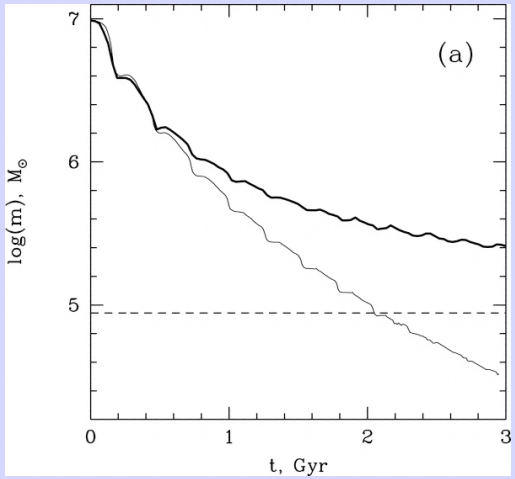


2. Dark matter in UCDs?

Future steps:

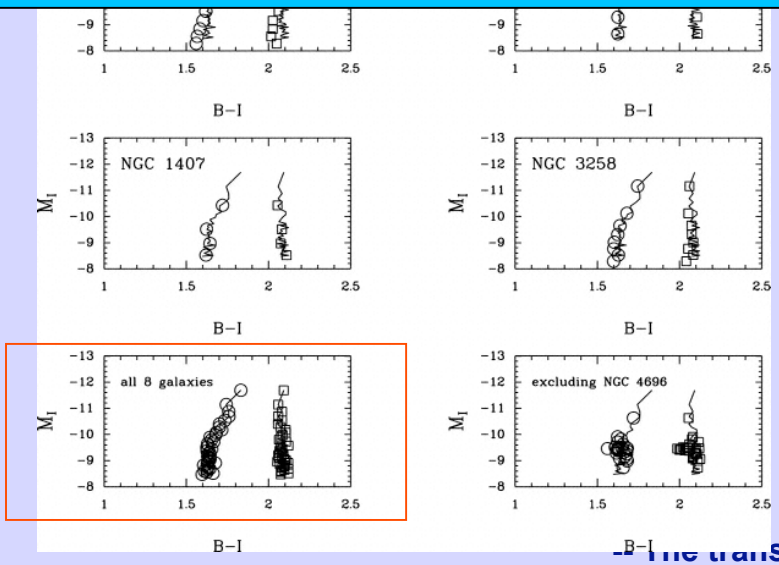
2. **Simulate dynamical evolution of progenitors of UCDs and GCs, forming within individual DM halos.**

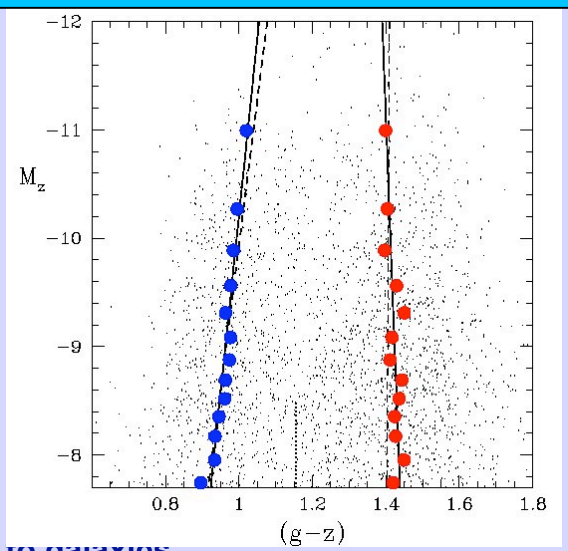
Mashchenko & Sills (2005):
Time evolution of gravitationally bound DM mass in low mass GC halo



3. The colour-magnitude trend of GCs

A colour – magnitude trend had previously been known only for conventional galaxy types, attributed to self-enrichment in deep potential wells.

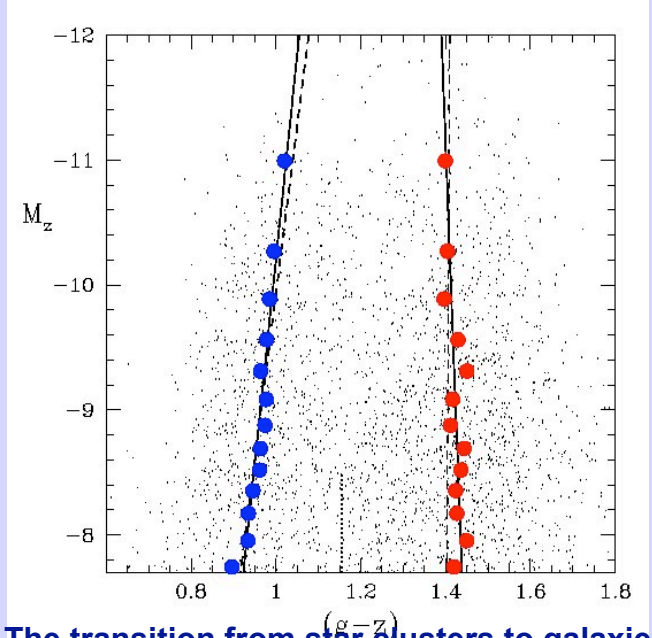




3. The colour-magnitude trend of GCs

What may cause the ‚blue tilt'?

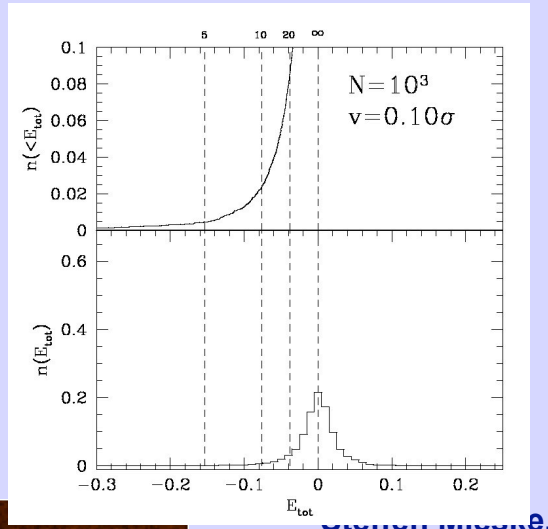
- **Self enrichment** (Strader et al. 2006)
  Possibly enhanced/enabled by deep potential wells in earliest and densest peaks of dark matter fluctuations (Moore et al. 2006)

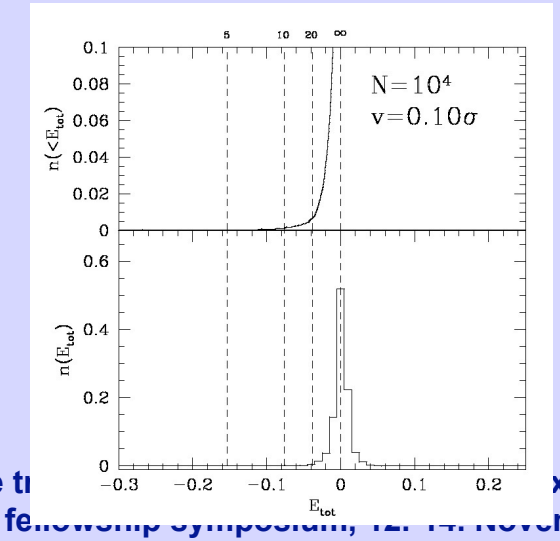


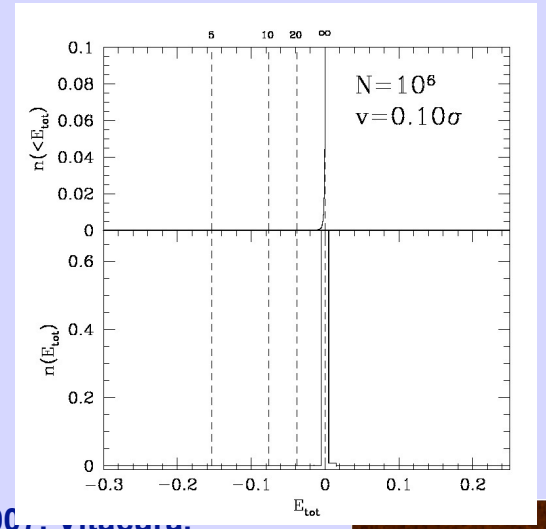
3. The colour-magnitude trend of GCs

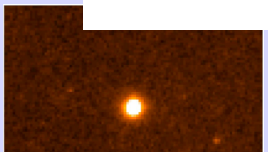
What may cause the ‚blue tilt'?

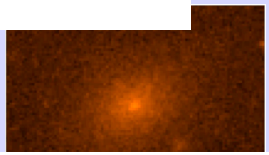
- **Self enrichment** (Strader et al. 2006)
  Possibly enhanced/enabled by deep potential wells in earliest and densest peaks of dark matter fluctuations (Moore et al. 2006)
- **Dynamical effects**
  Field star capture (Mieske & Baumgardt 2007): **NO**







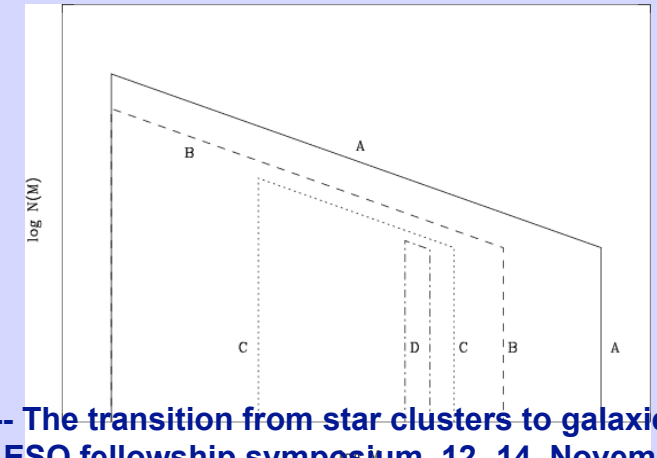


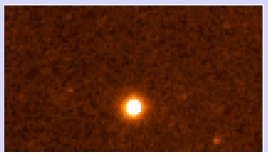


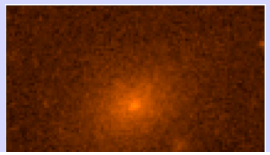
3. The colour-magnitude trend of GCs

What may cause the ‚blue tilt'?

- **Self enrichment** (Strader et al. 2006)
  Possibly enhanced/enabled by deep potential wells in earliest and densest peaks of dark matter fluctuations (Moore et al. 2006)
- **Dynamical effects**
  Field star capture (Mieske & Baumgardt 2007): **NO**
  Cluster star evaporation (Lamers et al. 2006): **unclear, +work tbd**

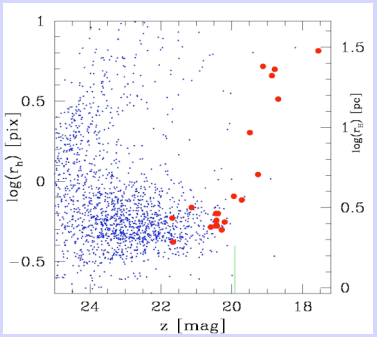


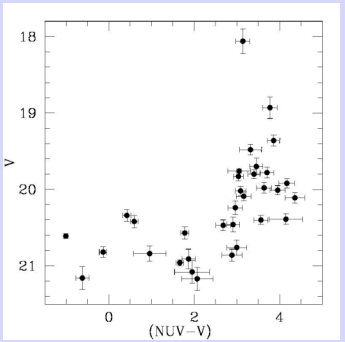




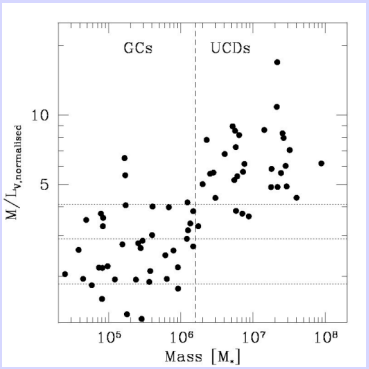
Summary

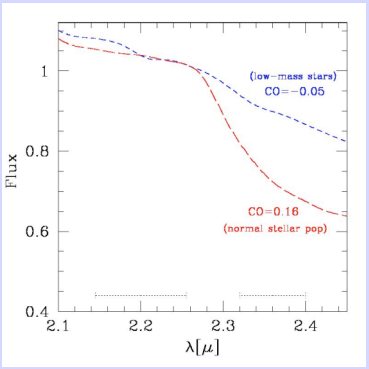
1. UCDs: a distinct class of stellar systems



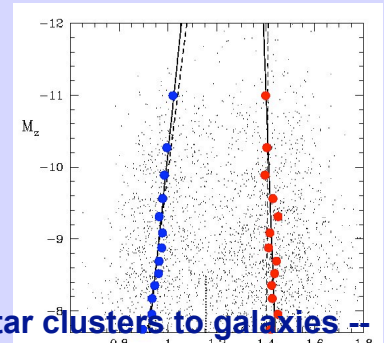


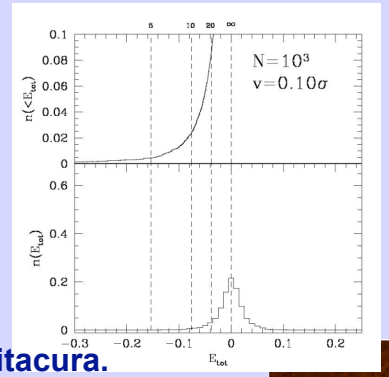
2. Dark matter in UCDs?





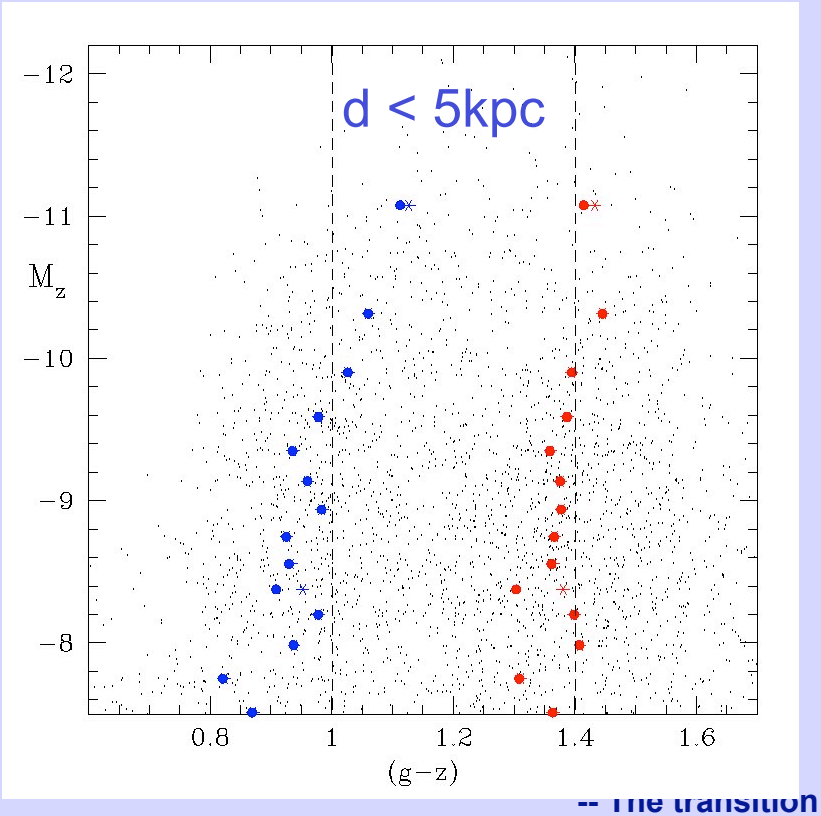
3. The colour-magnitude trend of globular clusters

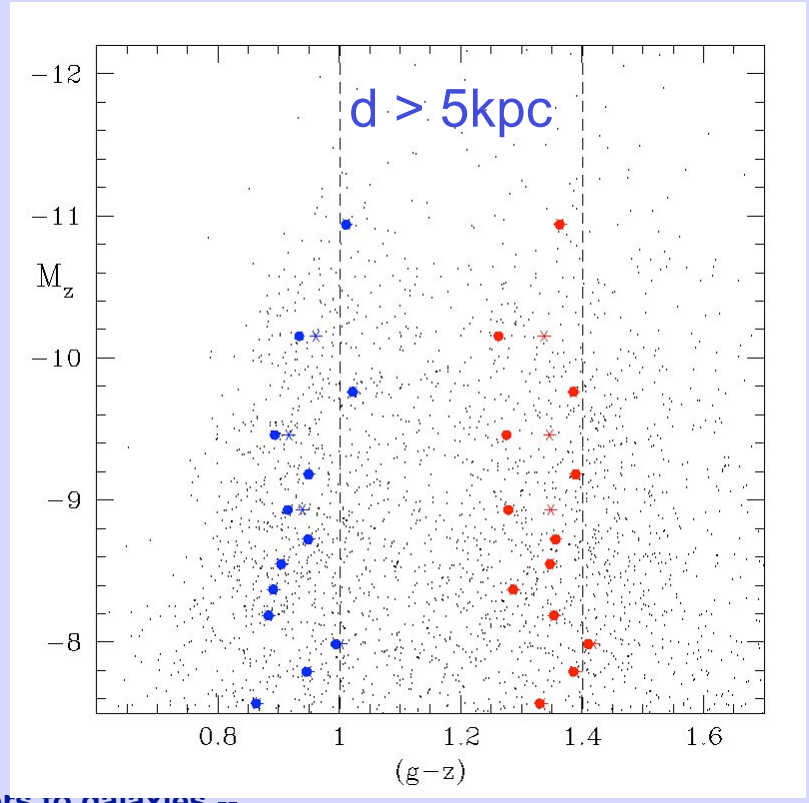


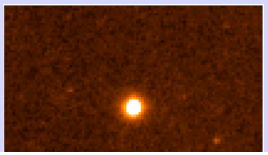


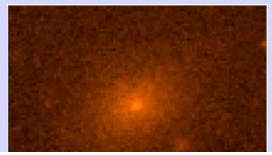
3. The colour-magnitude trend of GCs

Mieske et al. (2006):
Trend is stronger for GCs at smaller galactocentric distance.
Trend is not restricted to brightest cluster galaxies.









2. Dark matter in UCDs?

Future steps:

3. Investigate environmental dependence of ‚need for dark matter‘

Mieske et al. (2008, in prep, using FLAMES data):

UCDs in Fornax have lower M/L ratios than in Virgo.

Younger ages?

Different formation scenario?