The UCD/cE Divide: Aiming to Bridge the Gap

Mark A. Norris
MPIA

Sheila Kannappan (UNC), Duncan Forbes (Swinburne), Aaron Romanowsky (SJSU), Jay Strader (MSU), Jean Brodie (UCSC), Favio Faifer (CONICET), Avon Huxor (ARI), Matthias Frank (LSW)

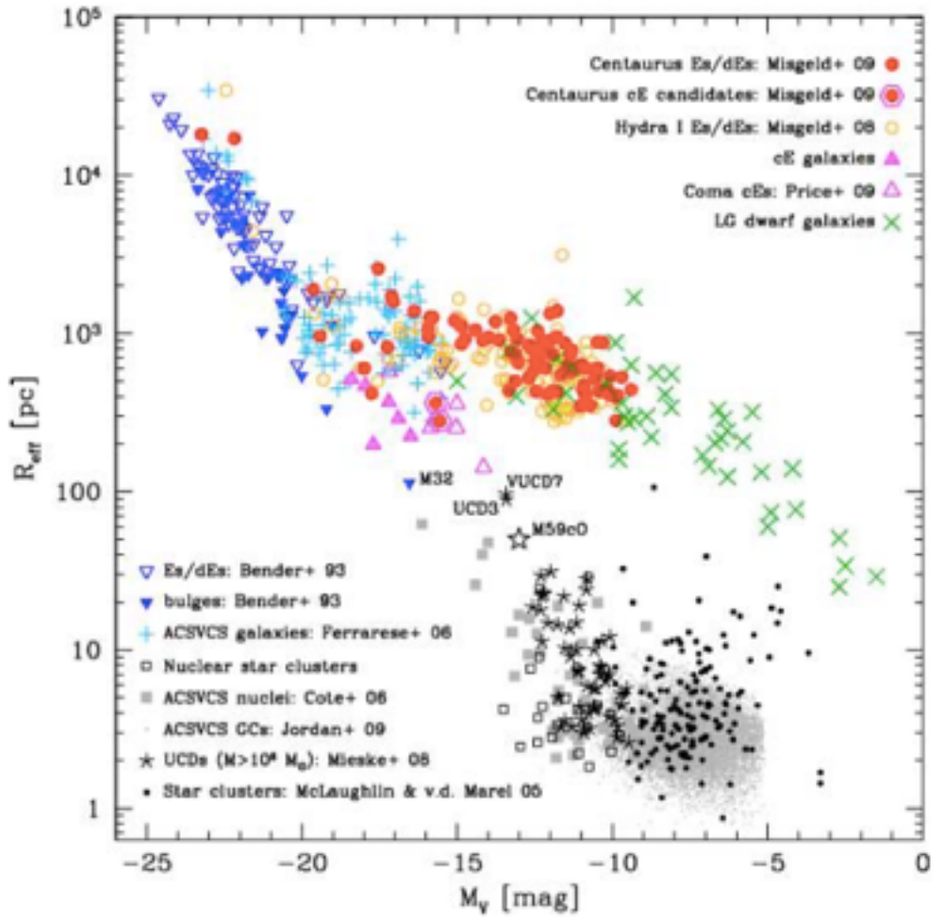
Motivation

cEs are interesting.

Motivation

cEs are interesting.

1) They are intermediate between star clusters and galaxies in most properties.

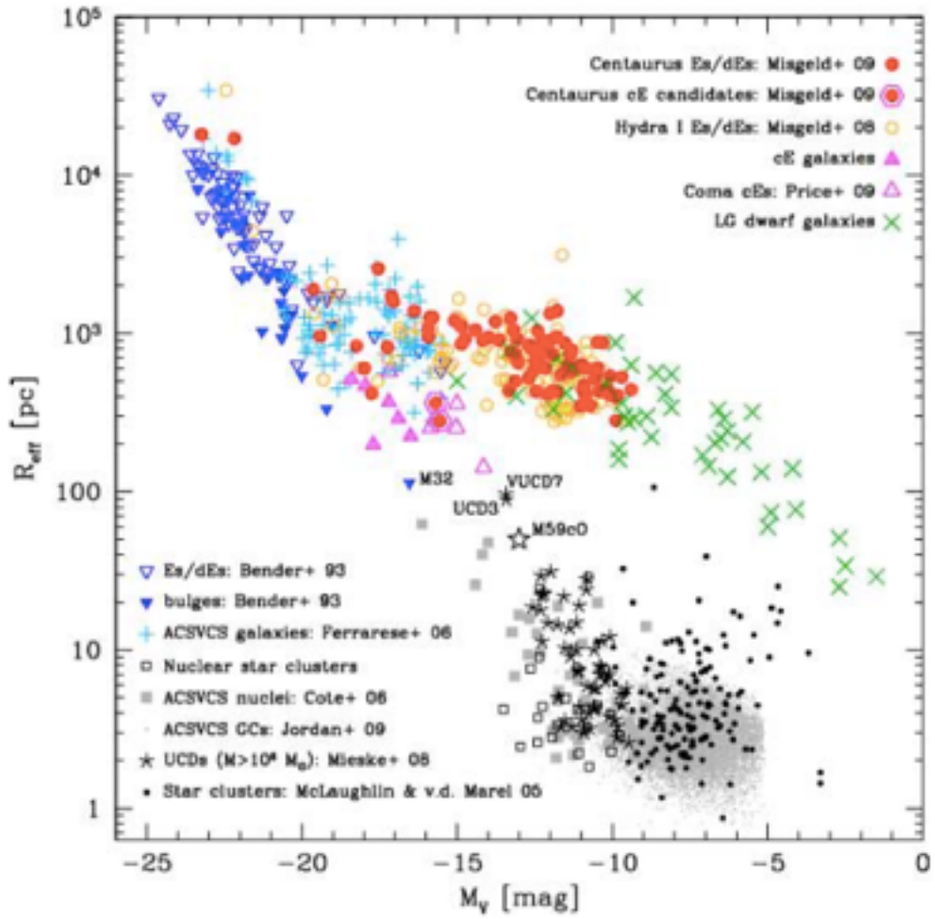


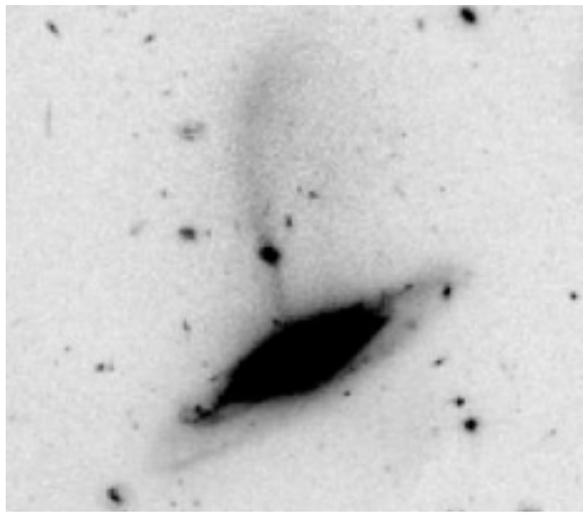
Motivation

cEs are interesting.

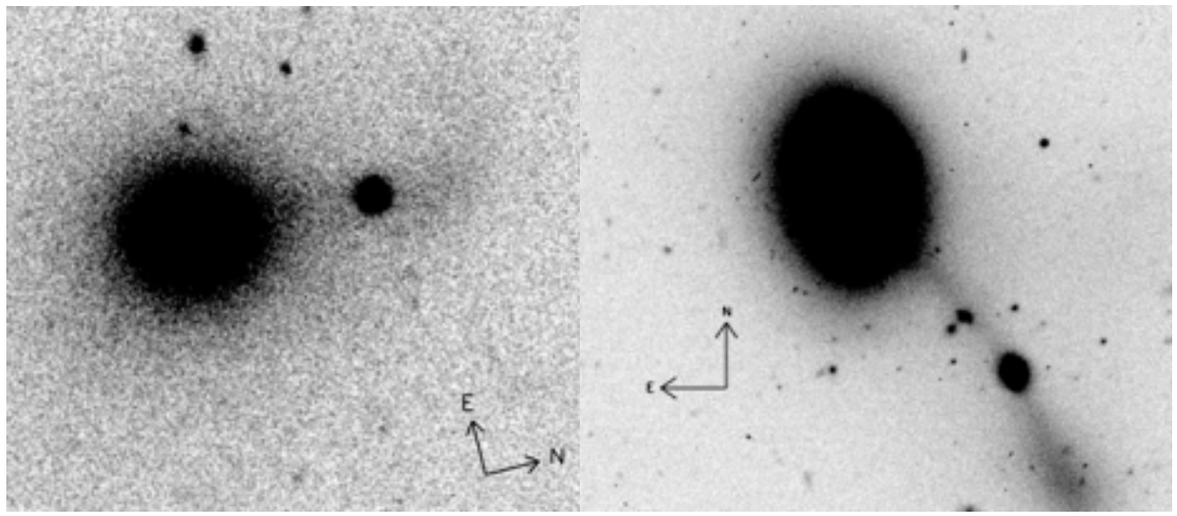
1) They are intermediate between star clusters and galaxies in most properties.

2) They are thought to form through the stripping of larger galaxies - potentially long lived signs of merger histories.





Forbes et al. 2003



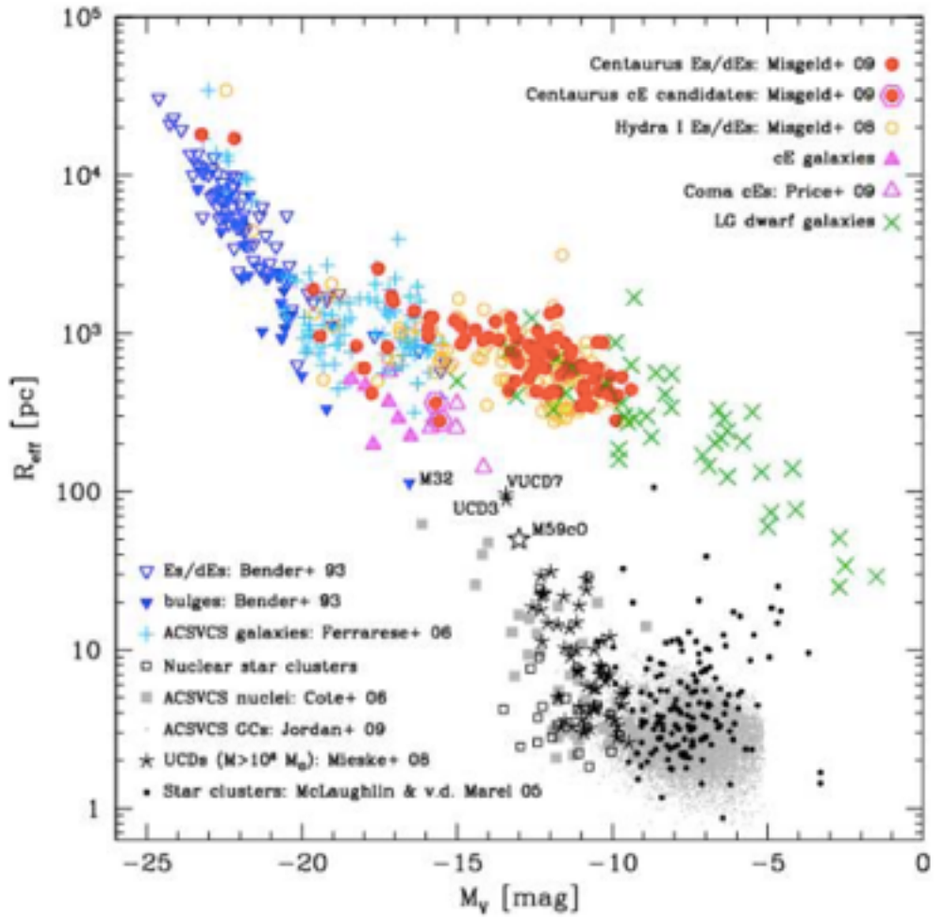
Huxor, Phillips, Price & Harniman 2011

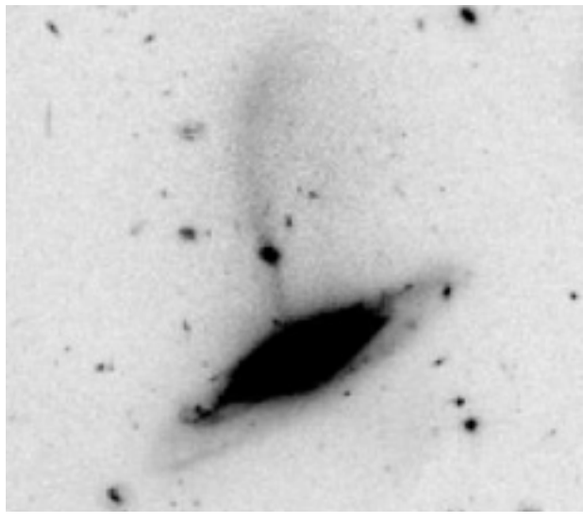
Motivation

cEs are interesting.

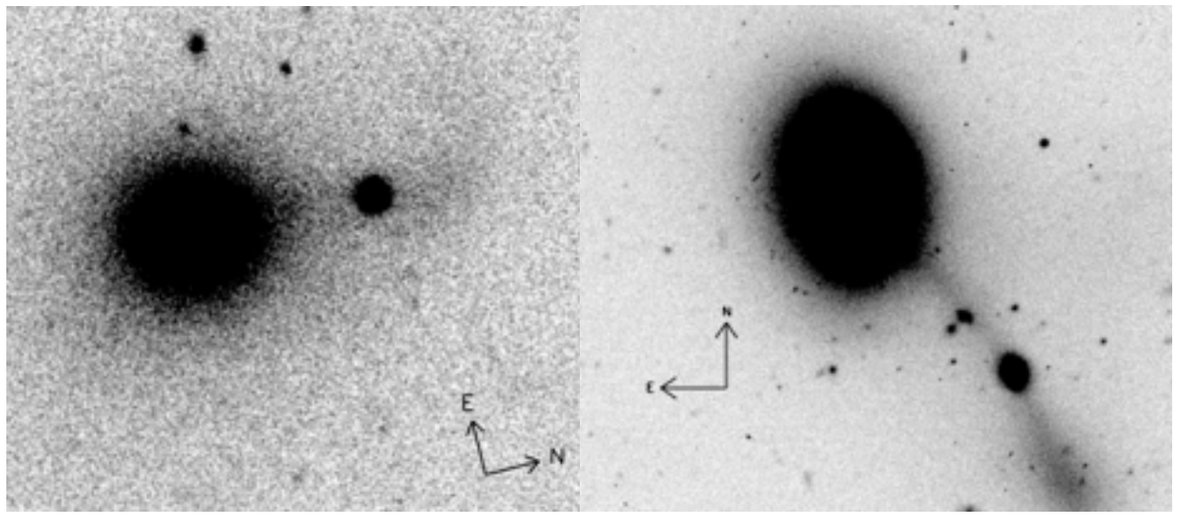
1) They are intermediate between star clusters and galaxies in most properties.

2) They are thought to form through the stripping of larger galaxies - potentially long lived signs of merger histories. - though see talk by Analia Smith-Castelli and Huxor et al. 2013 for other possibilities.





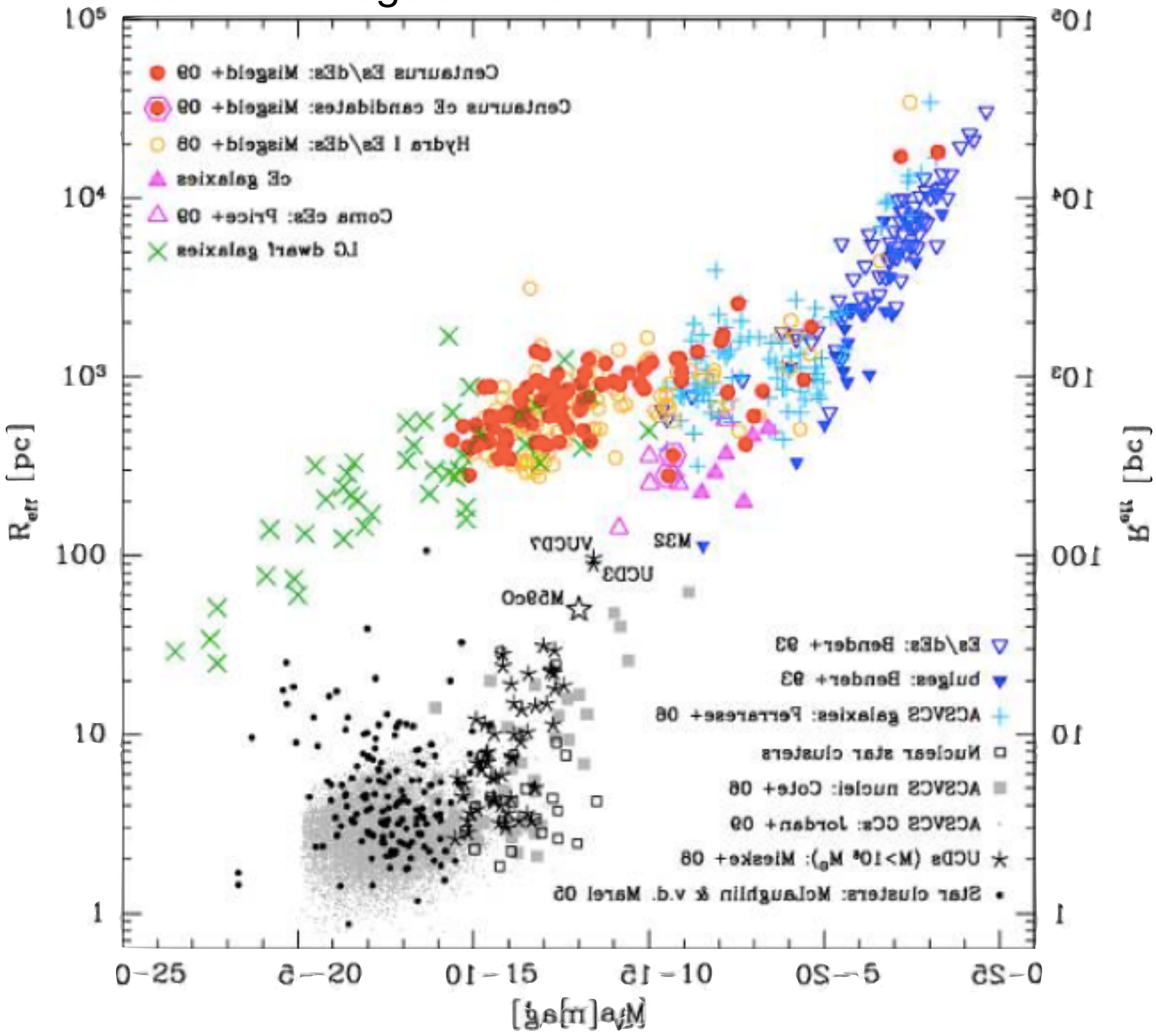
Forbes et al. 2003



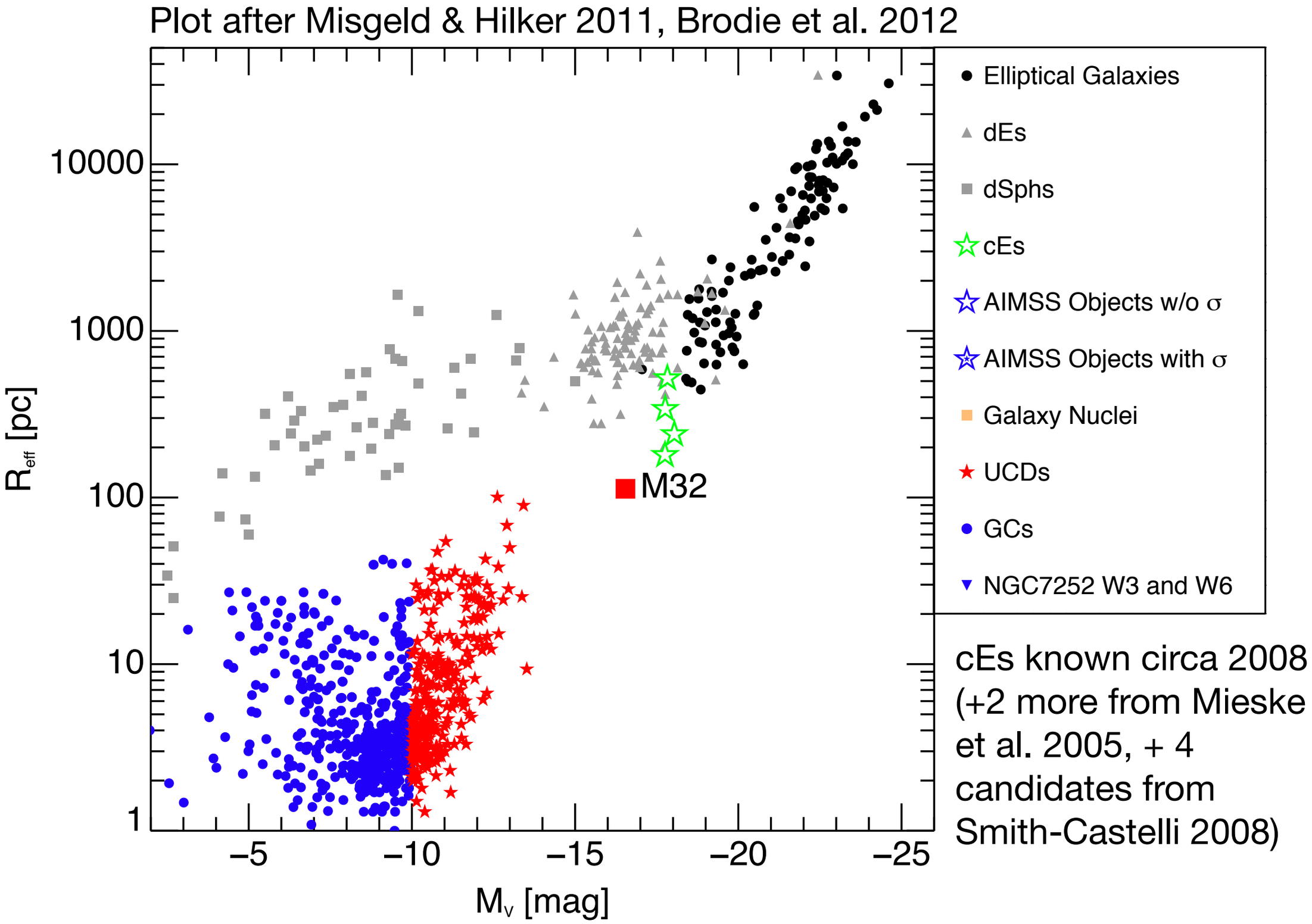
Huxor, Phillips, Price & Harniman 2011

cE Recent History

Plot from Misgeld & Hilker 2011

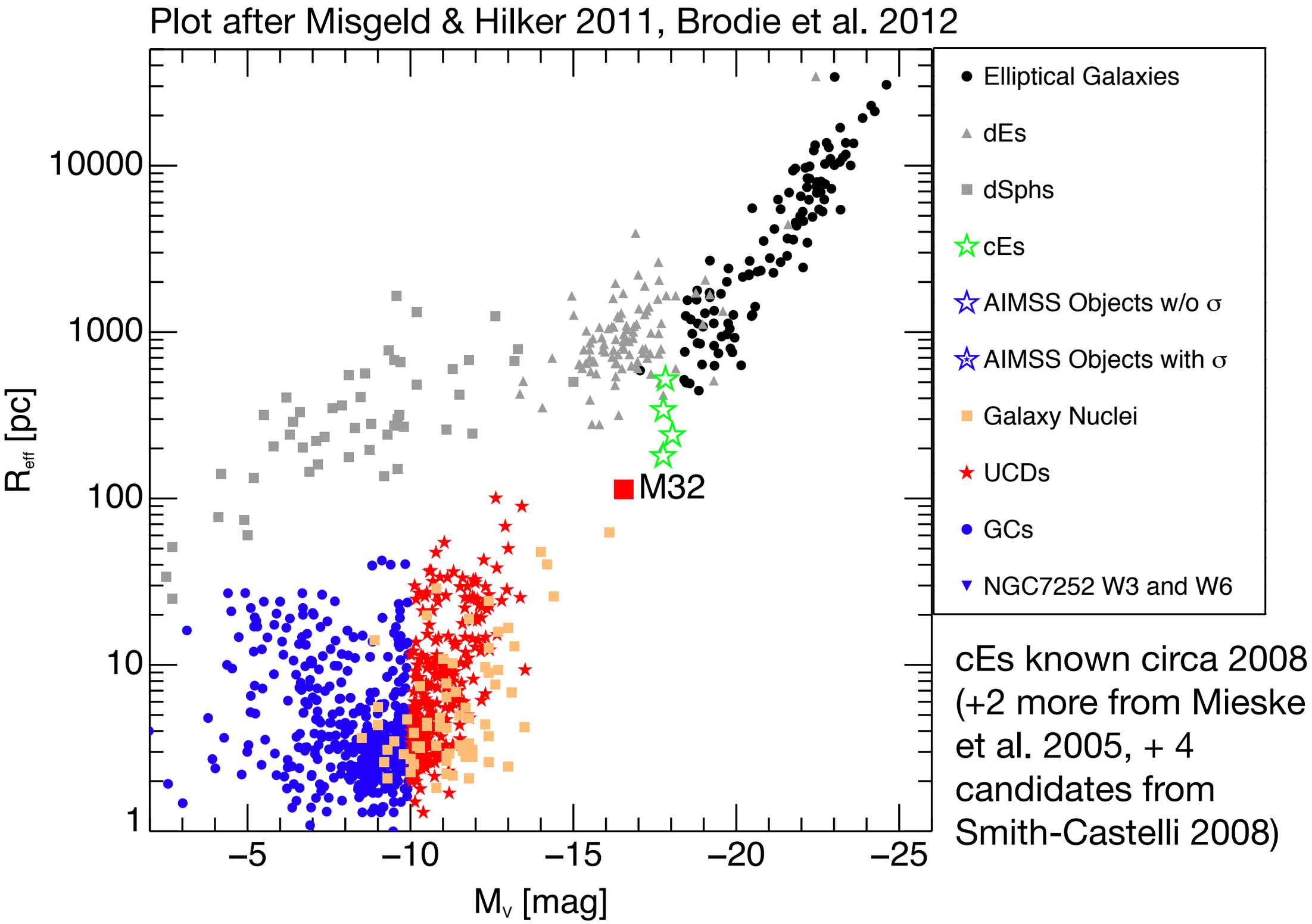


cE Recent History



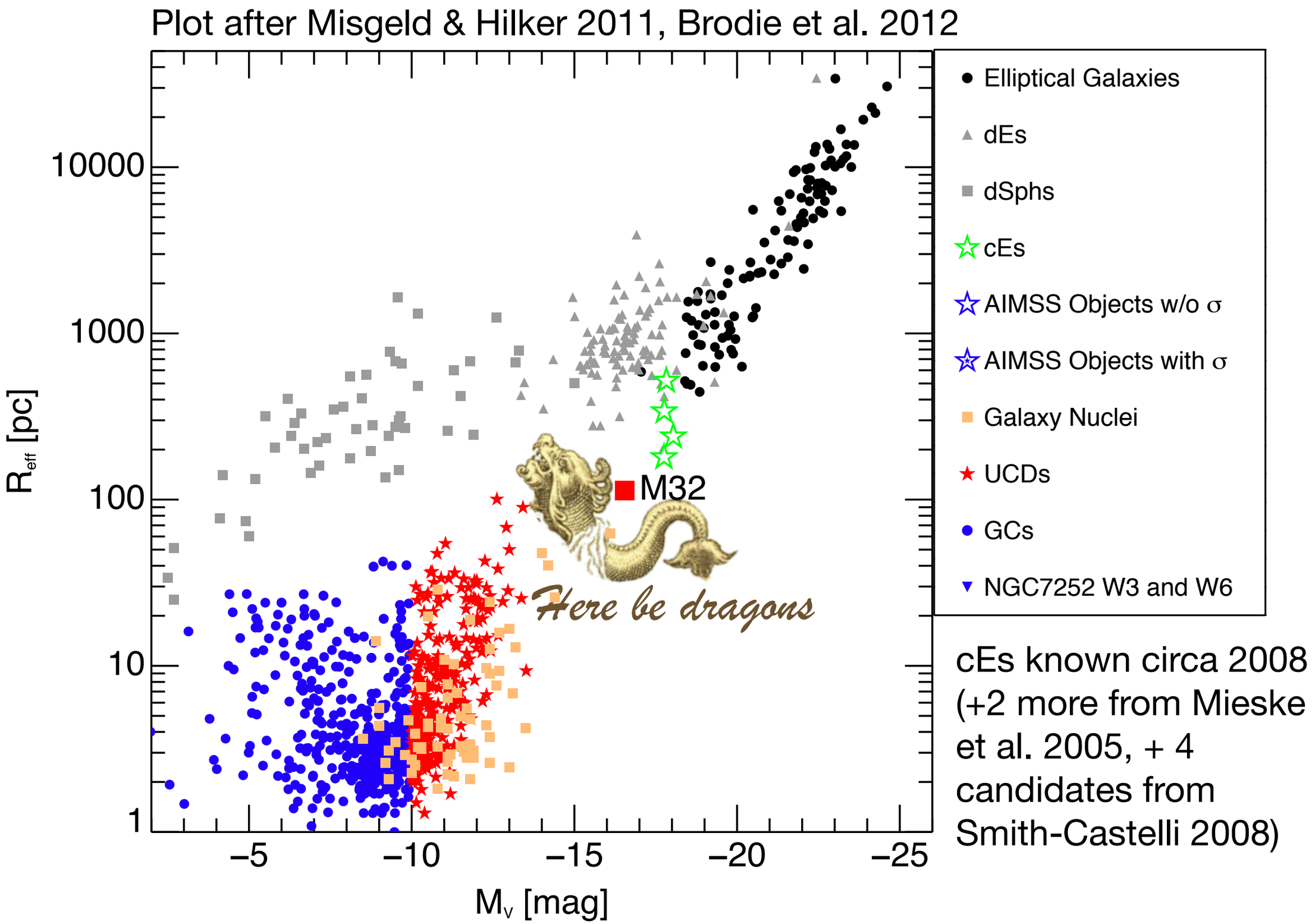
cEs known circa 2008 (+2 more from Mieske et al. 2005, + 4 candidates from Smith-Castelli 2008)

cE Recent History



cEs known circa 2008 (+2 more from Mieske et al. 2005, + 4 candidates from Smith-Castelli 2008)

cE Recent History



cEs known circa 2008 (+2 more from Mieske et al. 2005, + 4 candidates from Smith-Castelli 2008)

The AIMSS Survey

The Archive of Intermediate Mass Stellar Systems - a two part project:

1.) The AIMSS Survey - Archival HST survey for compact stellar systems: massive GCs, UCDs, and cEs.

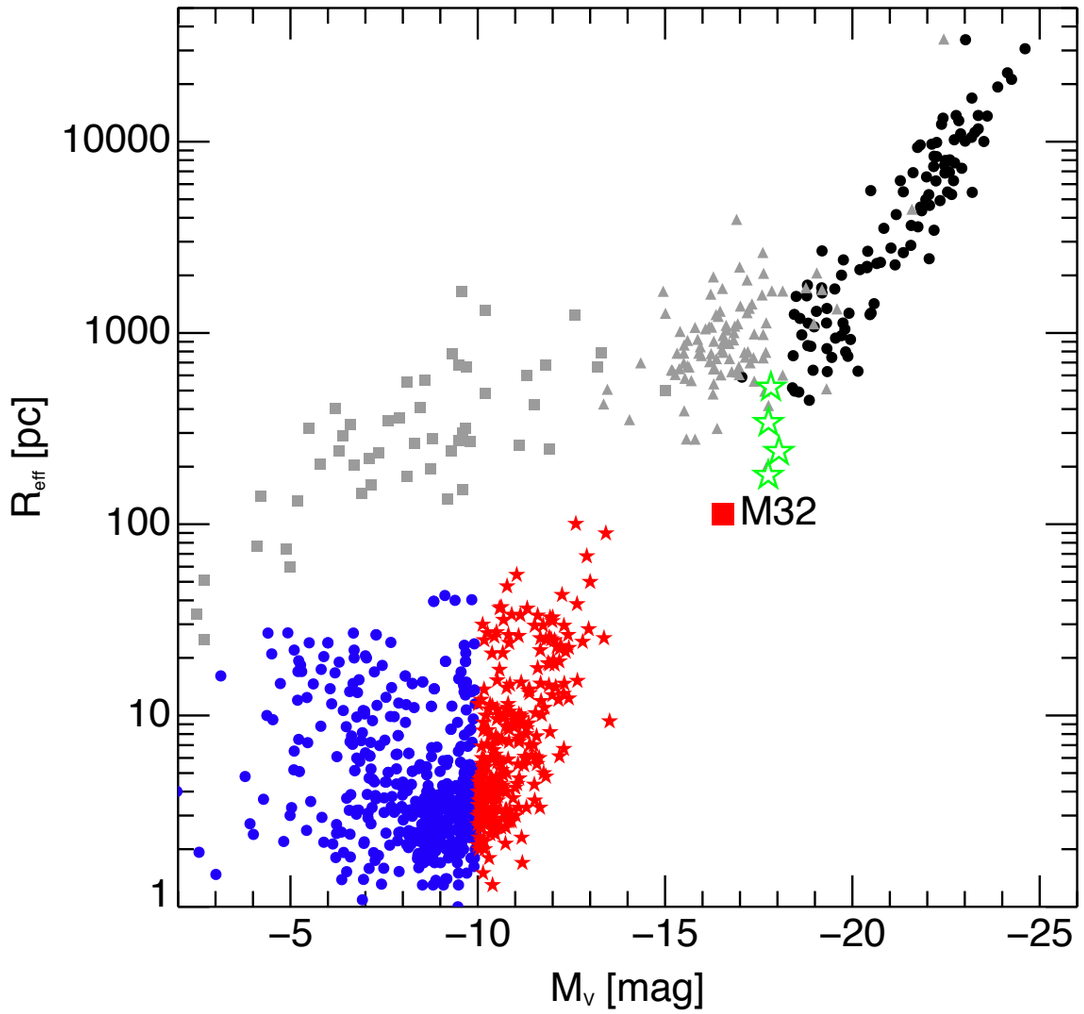
Select candidates based on position in luminosity-size relation assuming they were at the distance of the host galaxy:

The AIMSS Survey

The Archive of Intermediate Mass Stellar Systems - a two part project:

1.) The AIMSS Survey - Archival HST survey for compact stellar systems: massive GCs, UCDs, and cEs.

Select candidates based on position in luminosity-size relation assuming they were at the distance of the host galaxy:

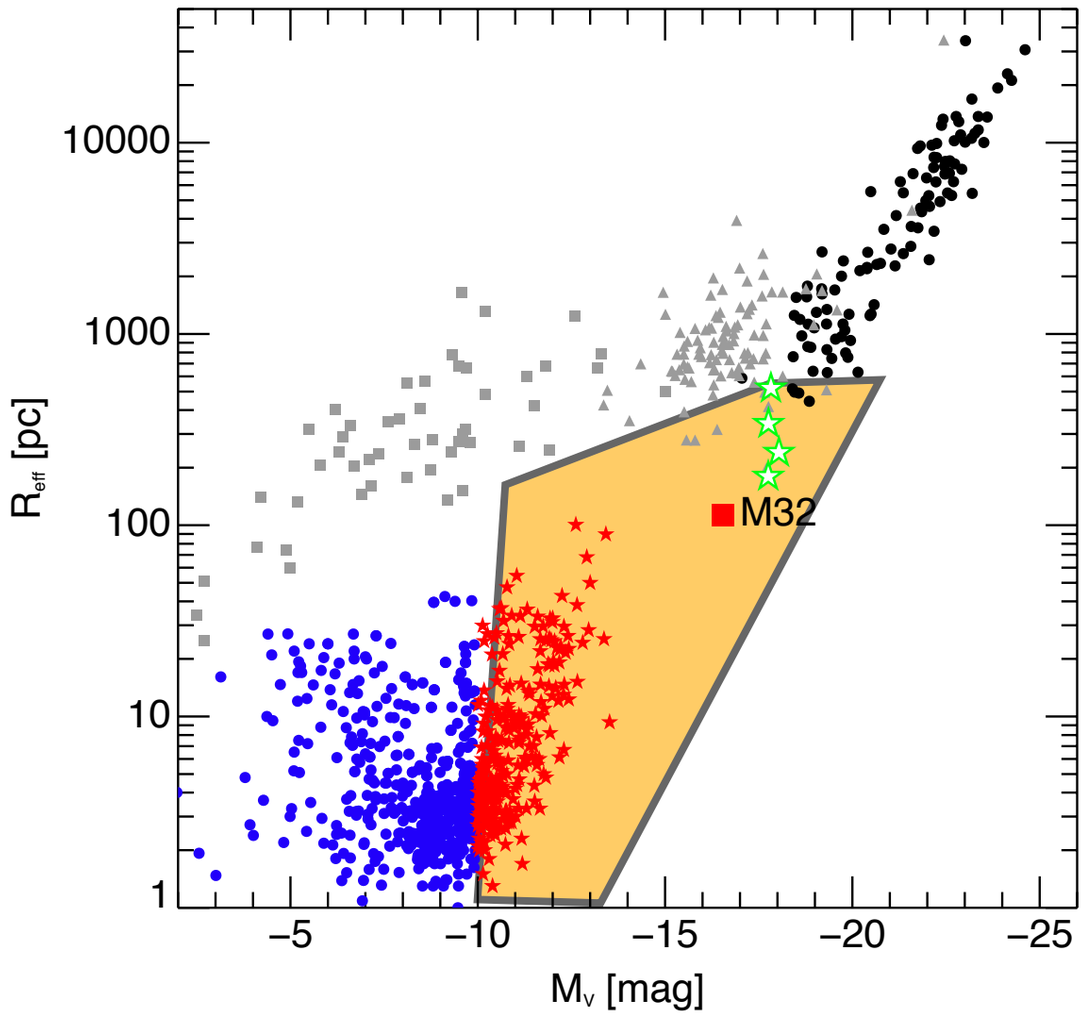


The AIMSS Survey

The Archive of Intermediate Mass Stellar Systems - a two part project:

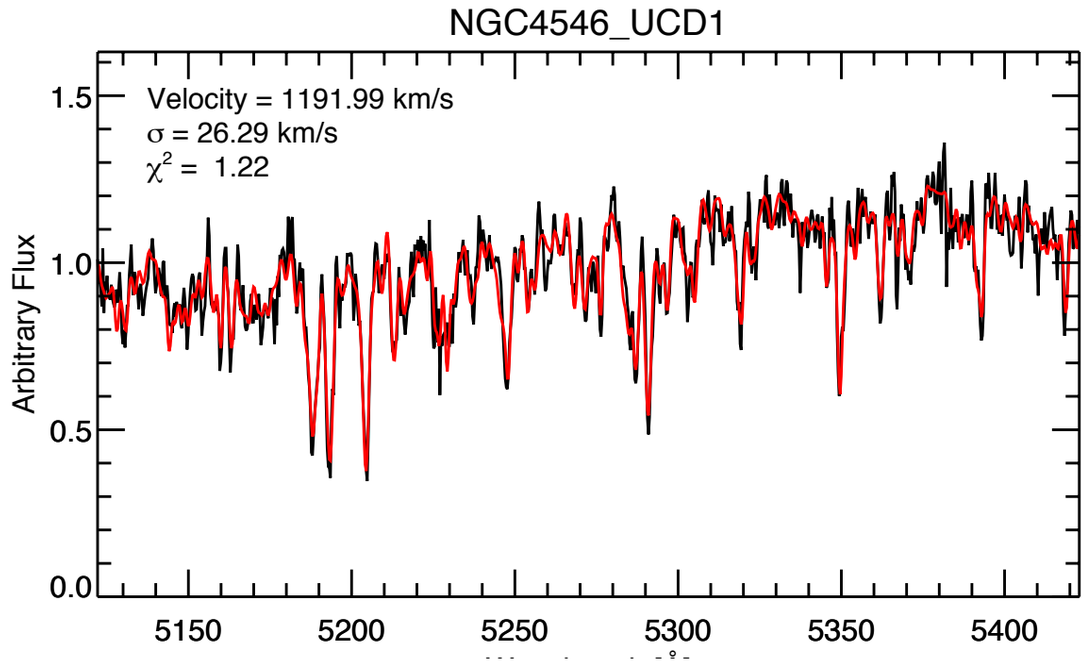
1.) The AIMSS Survey - Archival HST survey for compact stellar systems: massive GCs, UCDs, and cEs.

Select candidates based on position in luminosity-size relation assuming they were at the distance of the host galaxy:



The AIMSS Survey

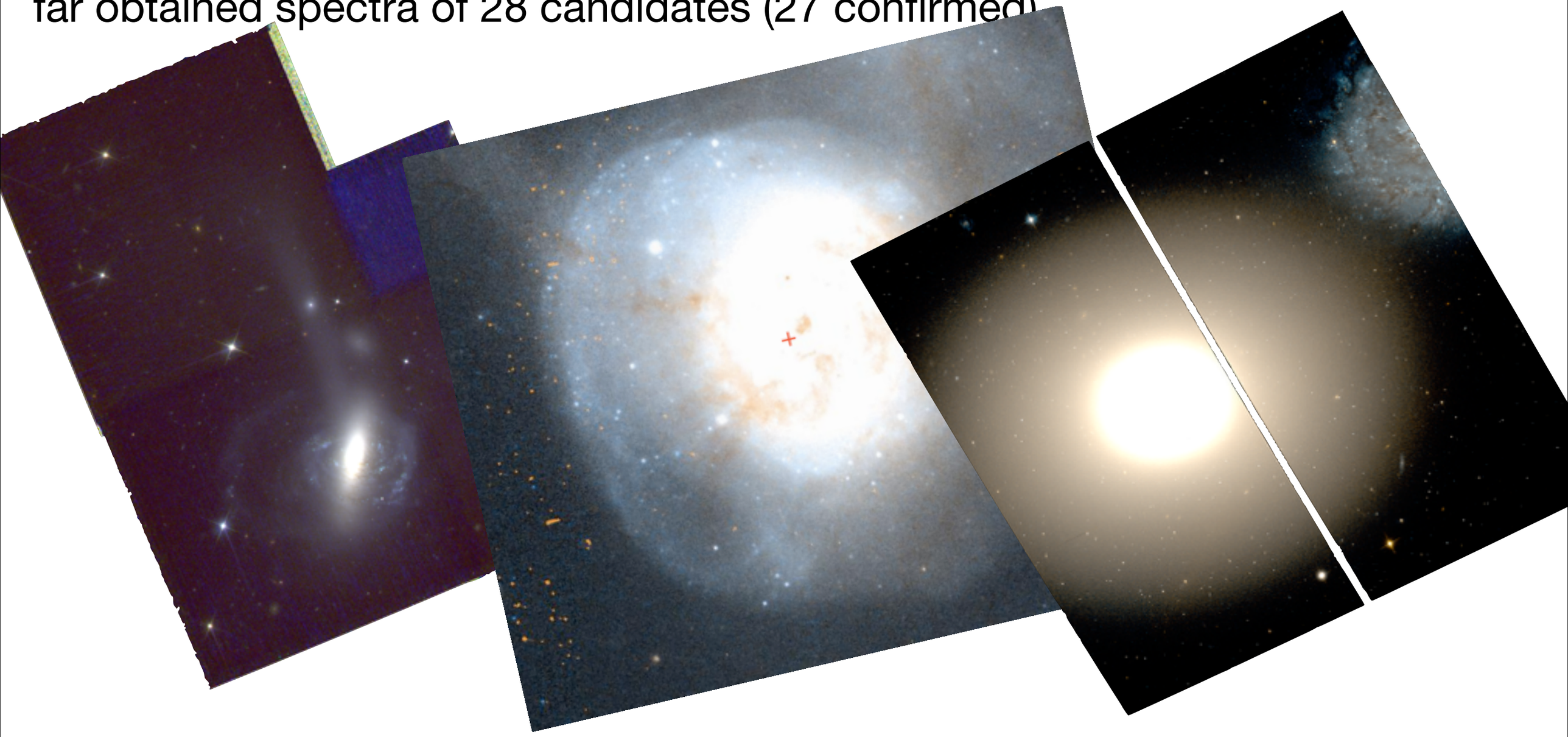
Confirming redshifts from Keck, SOAR, and Gemini + internal velocity dispersions for most



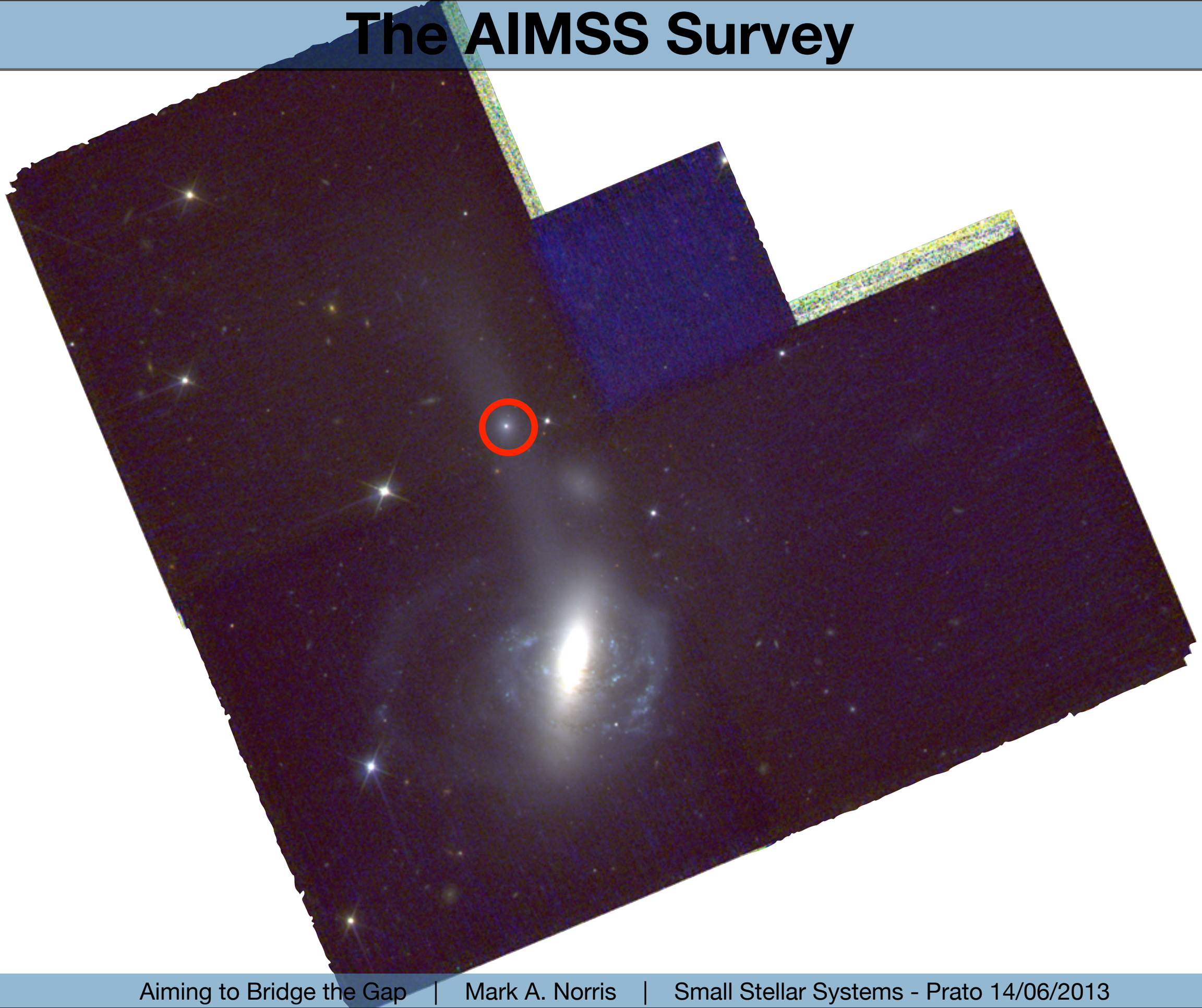
The AIMSS Survey

Initially searched HST imaging of 76 nearby galaxies - found 9 UCD candidates - obtained spectra of 4 (all 4 confirmed). Published in Norris & Kannappan 2011.

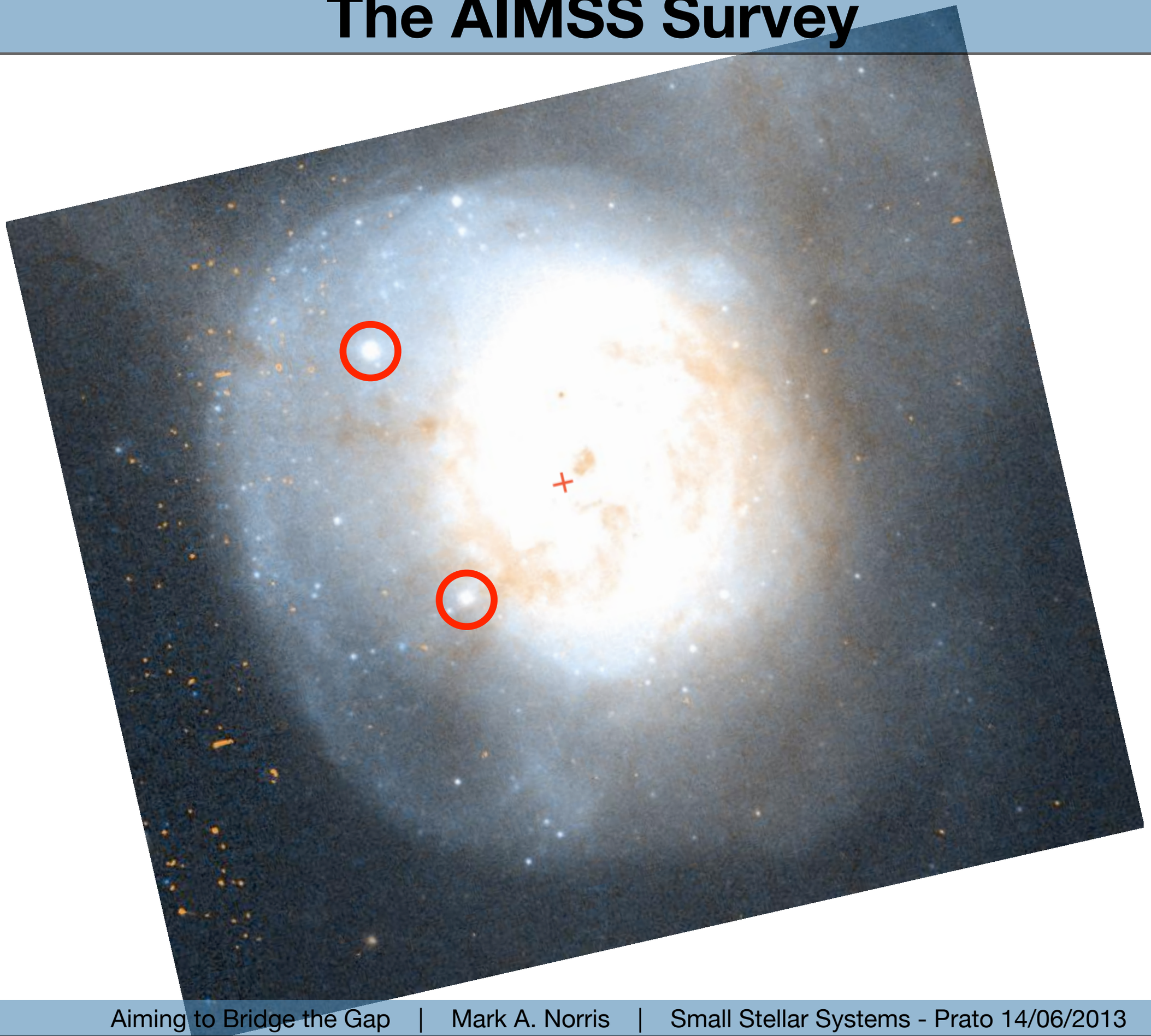
Then expanded to HST imaging of >500 galaxies - hundreds of candidates, so far obtained spectra of 28 candidates (27 confirmed)



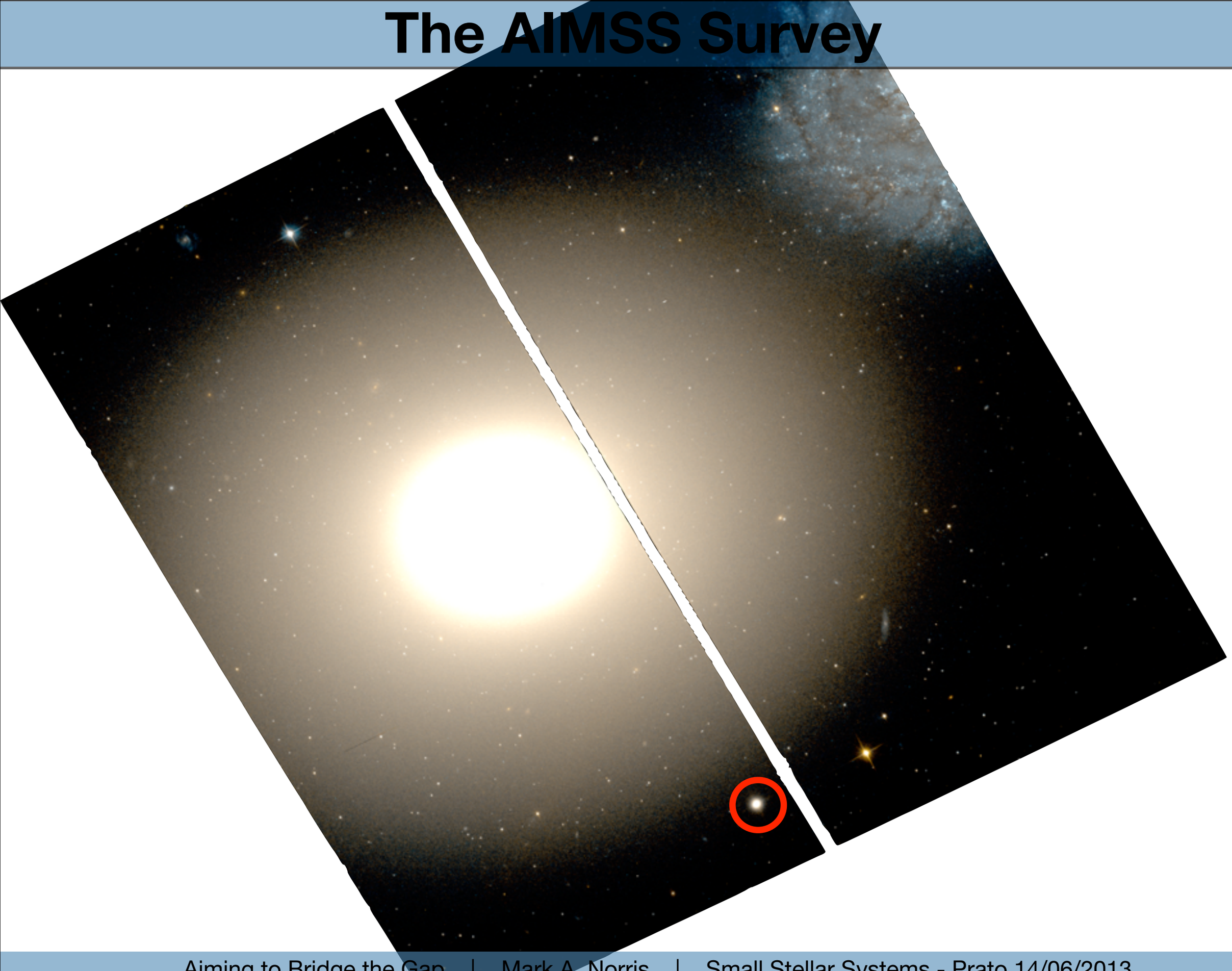
The AIMSS Survey



The AIMSS Survey



The AIMSS Survey



The AIMSS Survey

The Archive of Intermediate Mass Stellar Systems - a two part project:

1.) The AIMSS Survey - Archival HST survey for compact stellar systems: massive GCs, UCDs, and cEs.

Select candidates based on position in luminosity-size relation assuming they were at the distance of the host galaxy:

Strengths: Sensitive to all objects - GCs, YMCs, UCDs, cEs
Structural information, colour gradients

The AIMSS Survey

The Archive of Intermediate Mass Stellar Systems - a two part project:

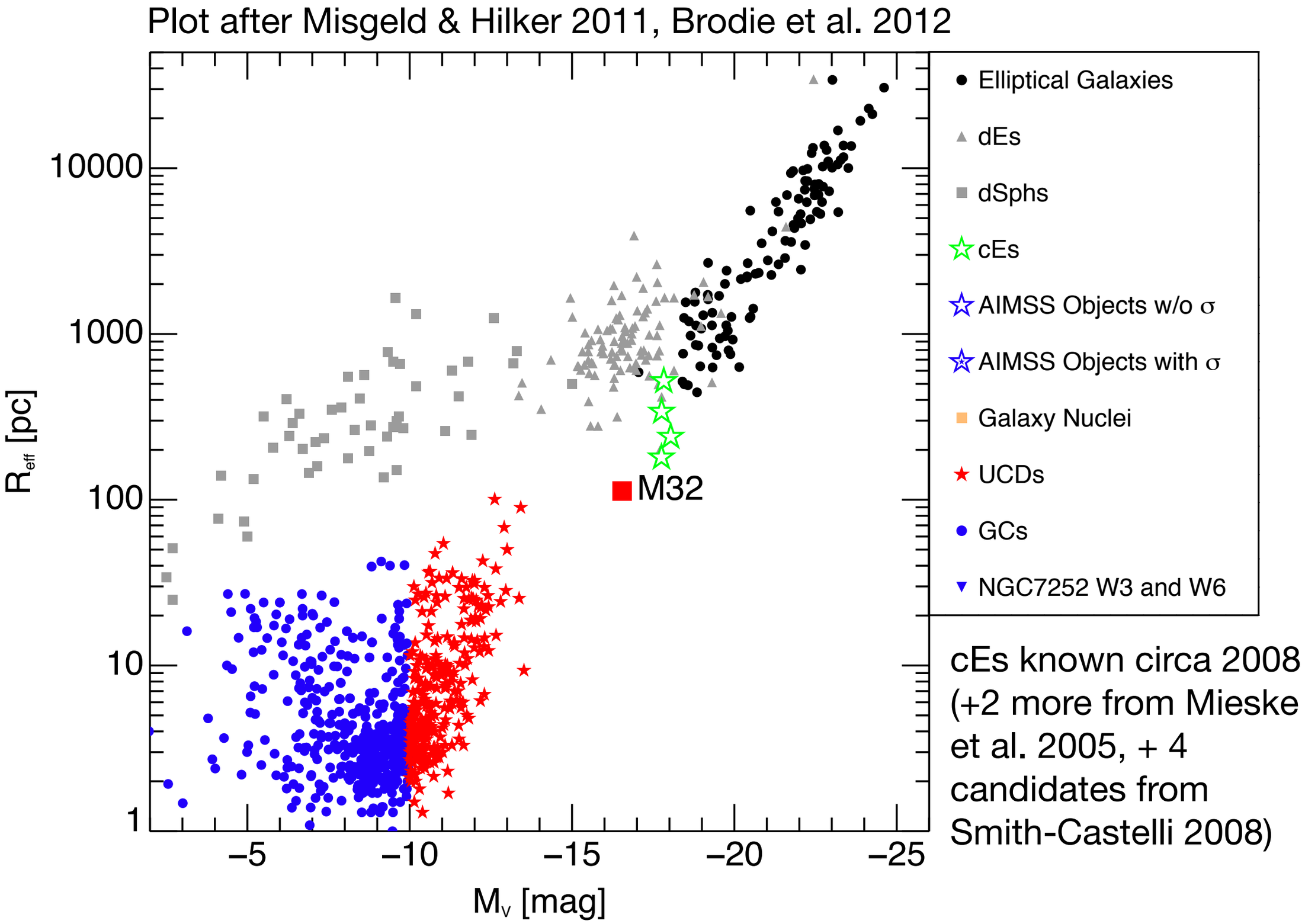
1.) The AIMSS Survey - Archival HST survey for compact stellar systems: massive GCs, UCDs, and cEs.

Select candidates based on position in luminosity-size relation assuming they were at the distance of the host galaxy:

Strengths: Sensitive to all objects - GCs, YMCs, UCDs, cEs
Structural information, colour gradients

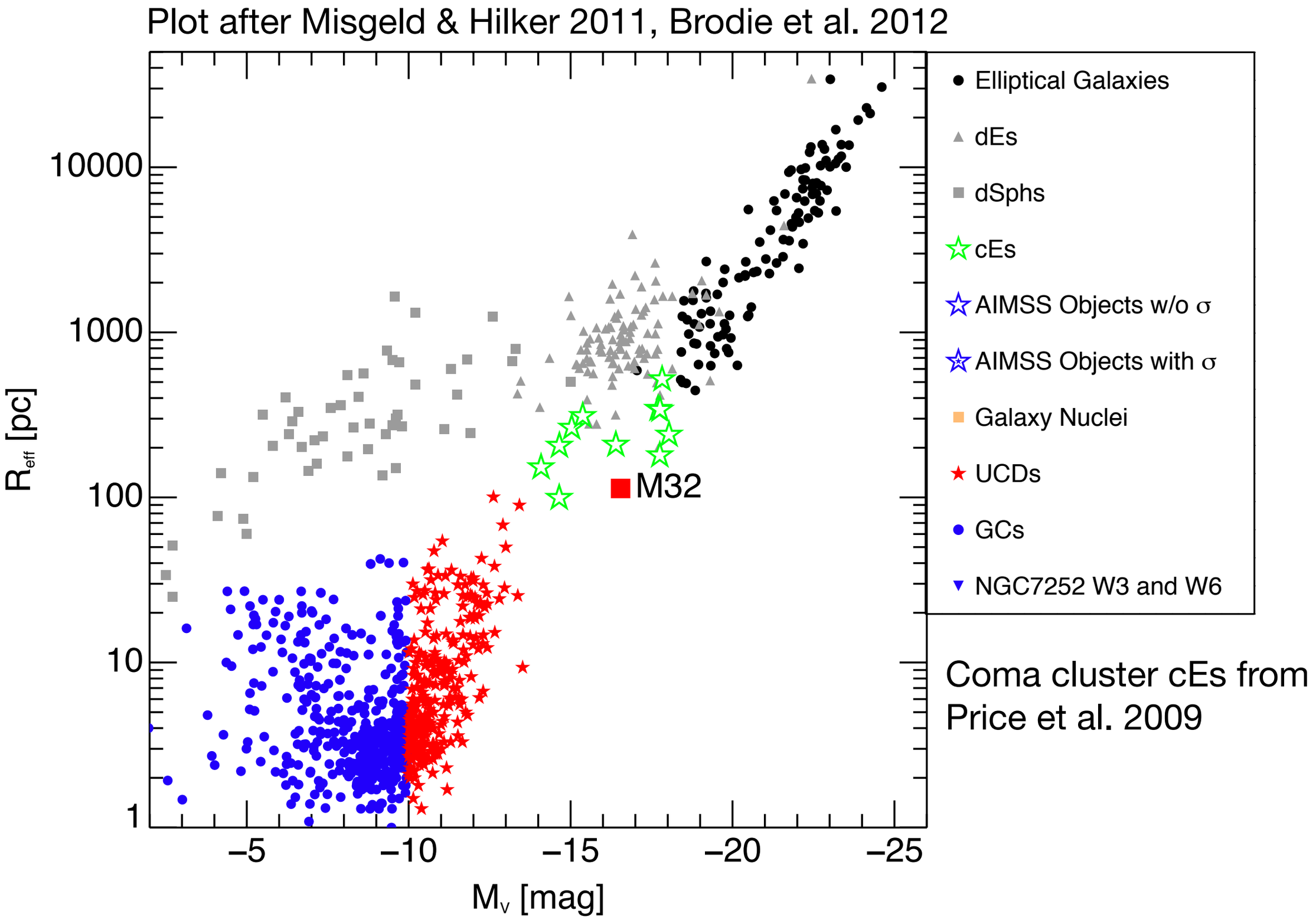
Weaknesses: Totally inhomogeneous - get whatever HST observed
Environmental analyses ~impossible - need volume/magnitude limited spectroscopic samples see talk by Igor Chilingarian next

cE Recent History



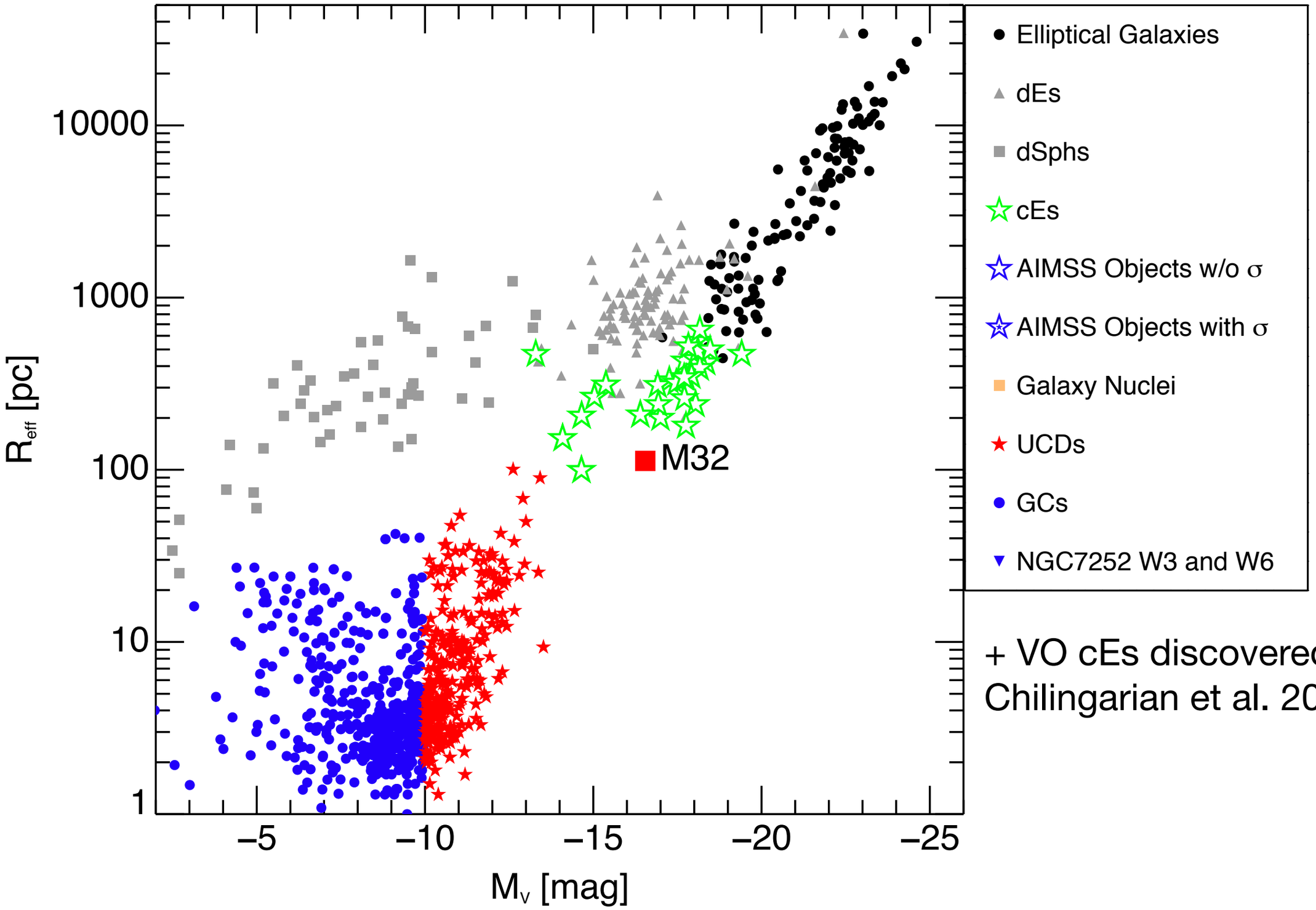
cEs known circa 2008 (+2 more from Mieske et al. 2005, + 4 candidates from Smith-Castelli 2008)

cE Recent History



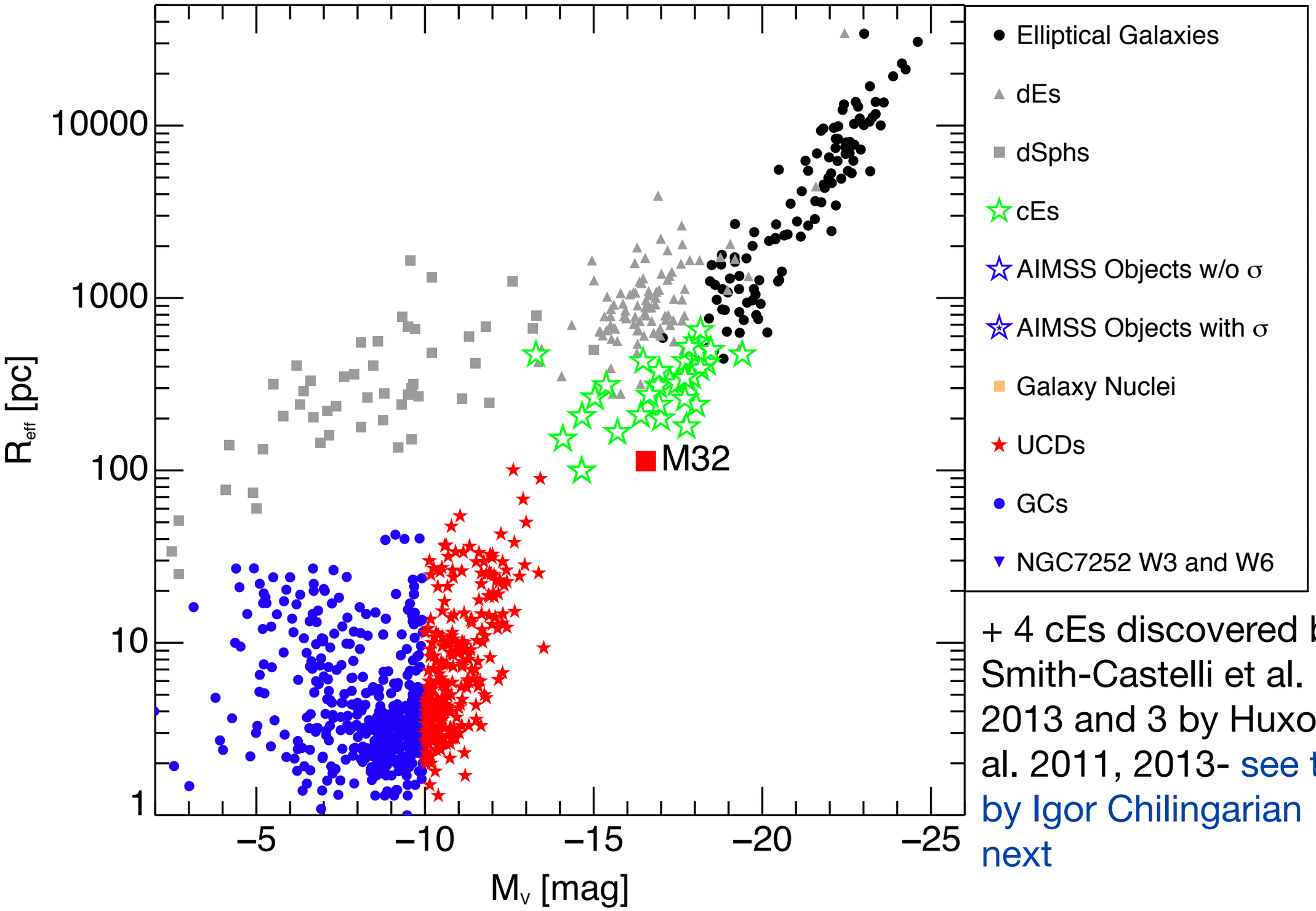
Coma cluster cEs from Price et al. 2009

cE Recent History



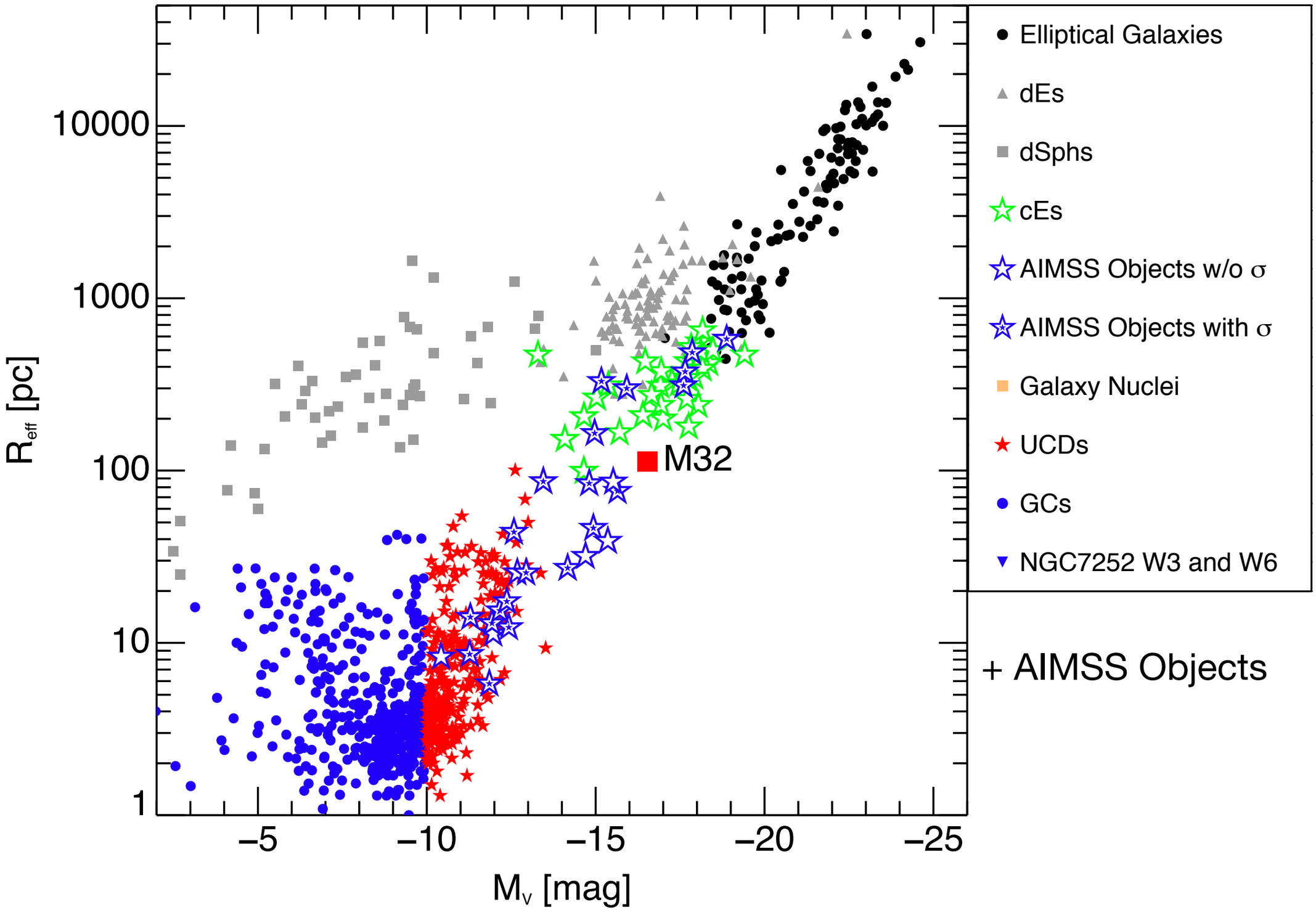
+ VO cEs discovered by Chilingarian et al. 2009

cEs BCT (Before Chilingarians Talk)

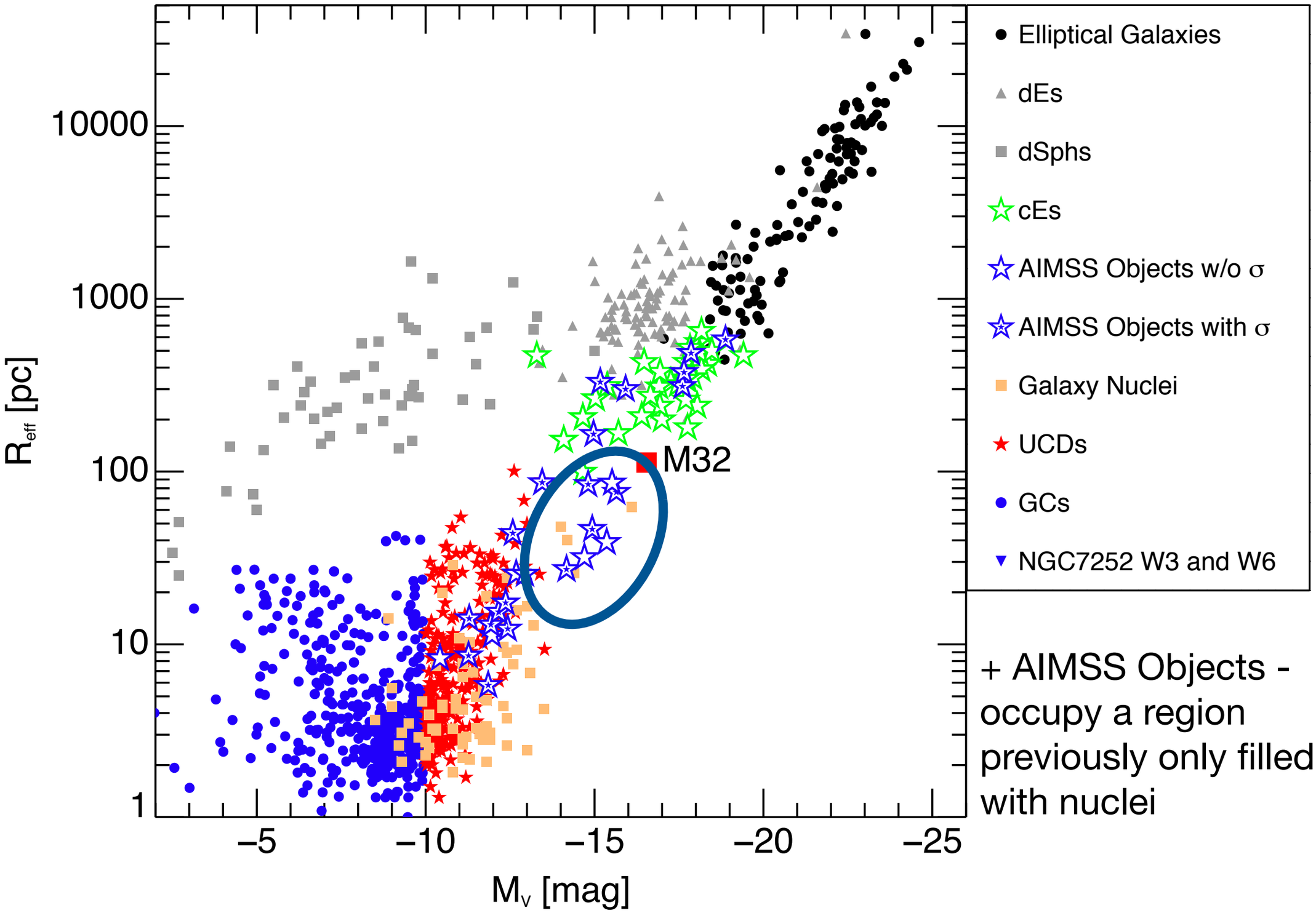


+ 4 cEs discovered by Smith-Castelli et al. 2013 and 3 by Huxor et al. 2011, 2013- see talk by Igor Chilingarian next

The AIMSS Survey

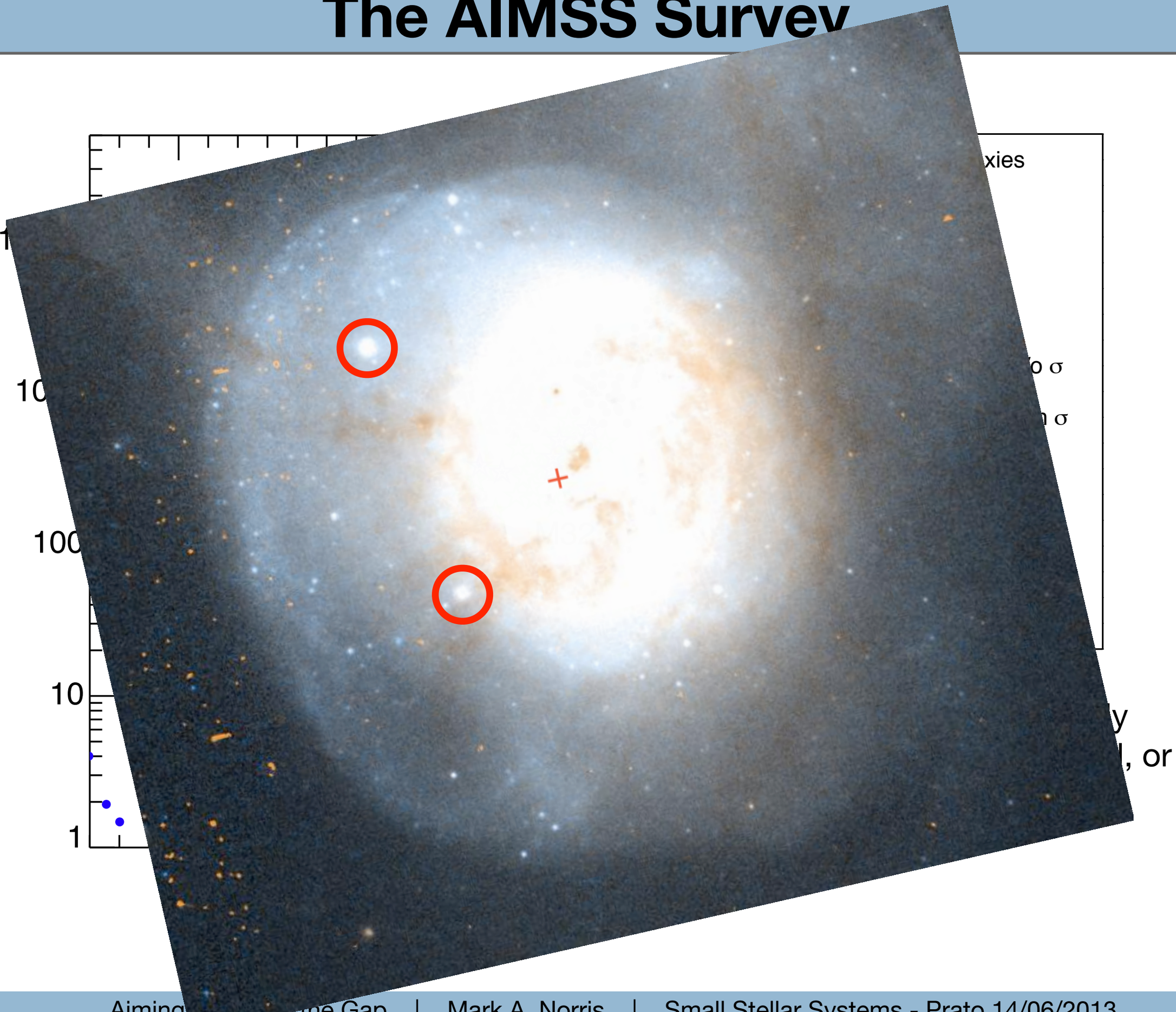


The AIMSS Survey

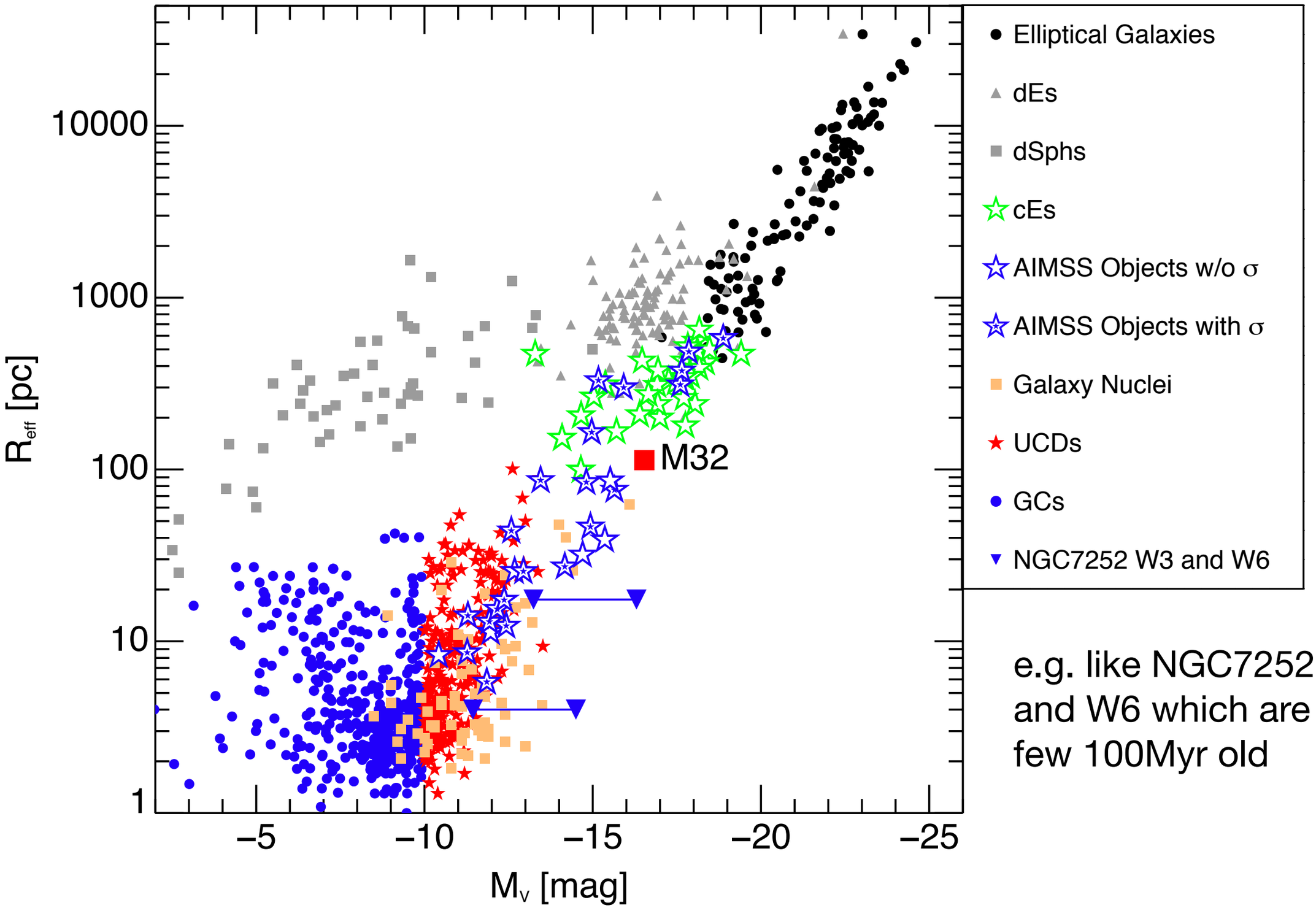


+ AIMSS Objects - occupy a region previously only filled with nuclei

The AIMSS Survey

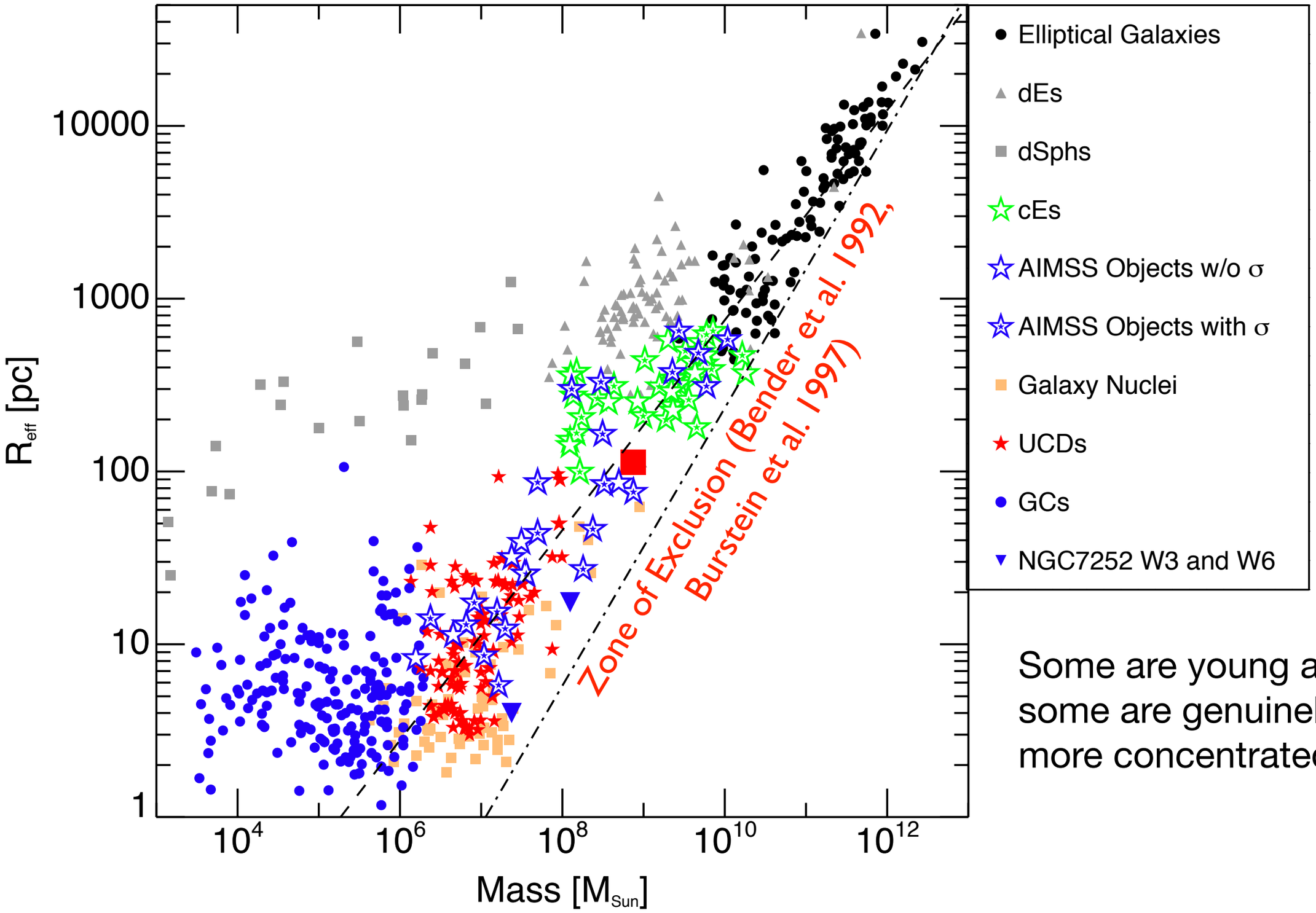


The AIMSS Survey



e.g. like NGC7252 W3 and W6 which are ~ a few 100Myr old

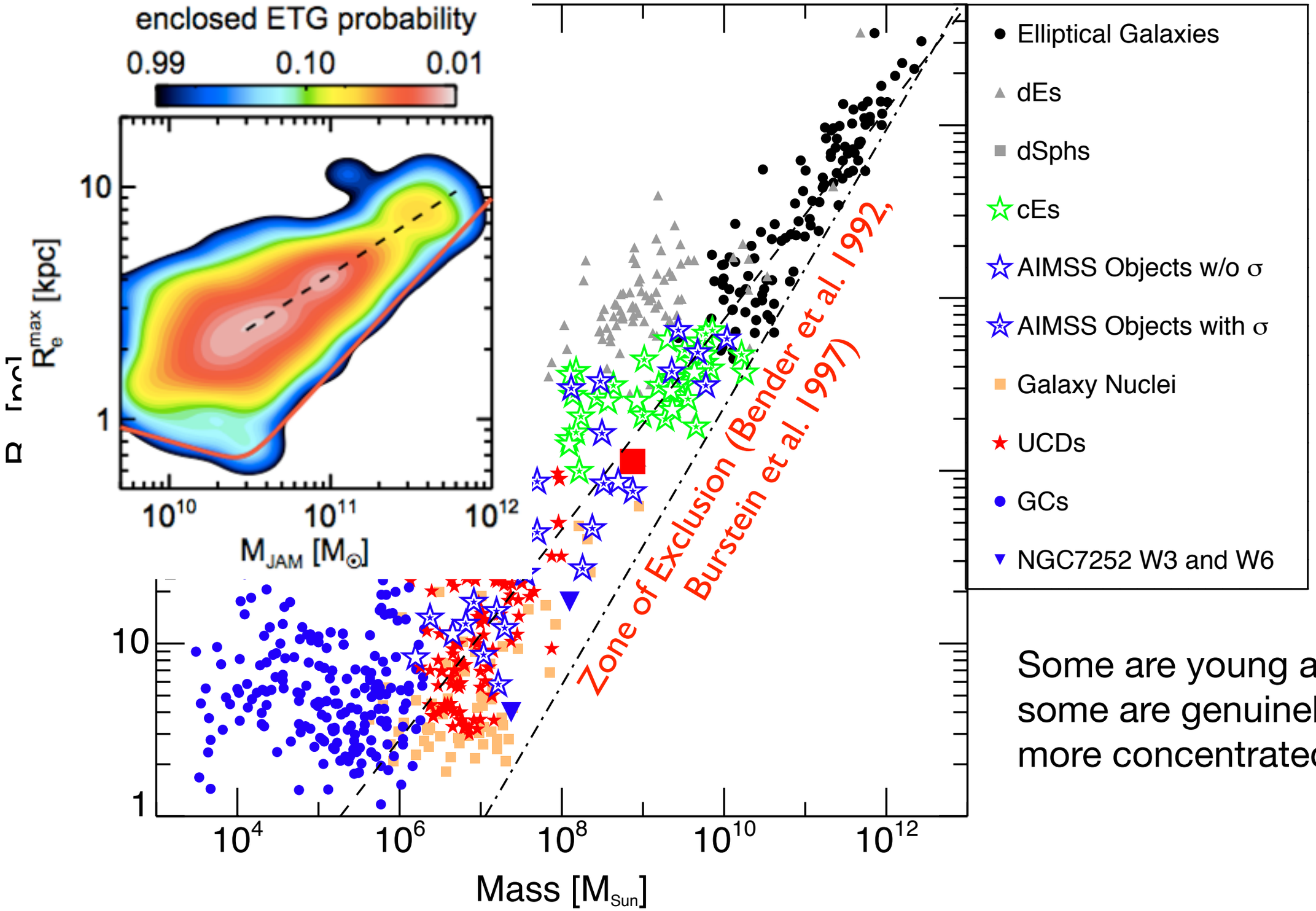
Stellar Mass - Size



Some are young and some are genuinely more concentrated.

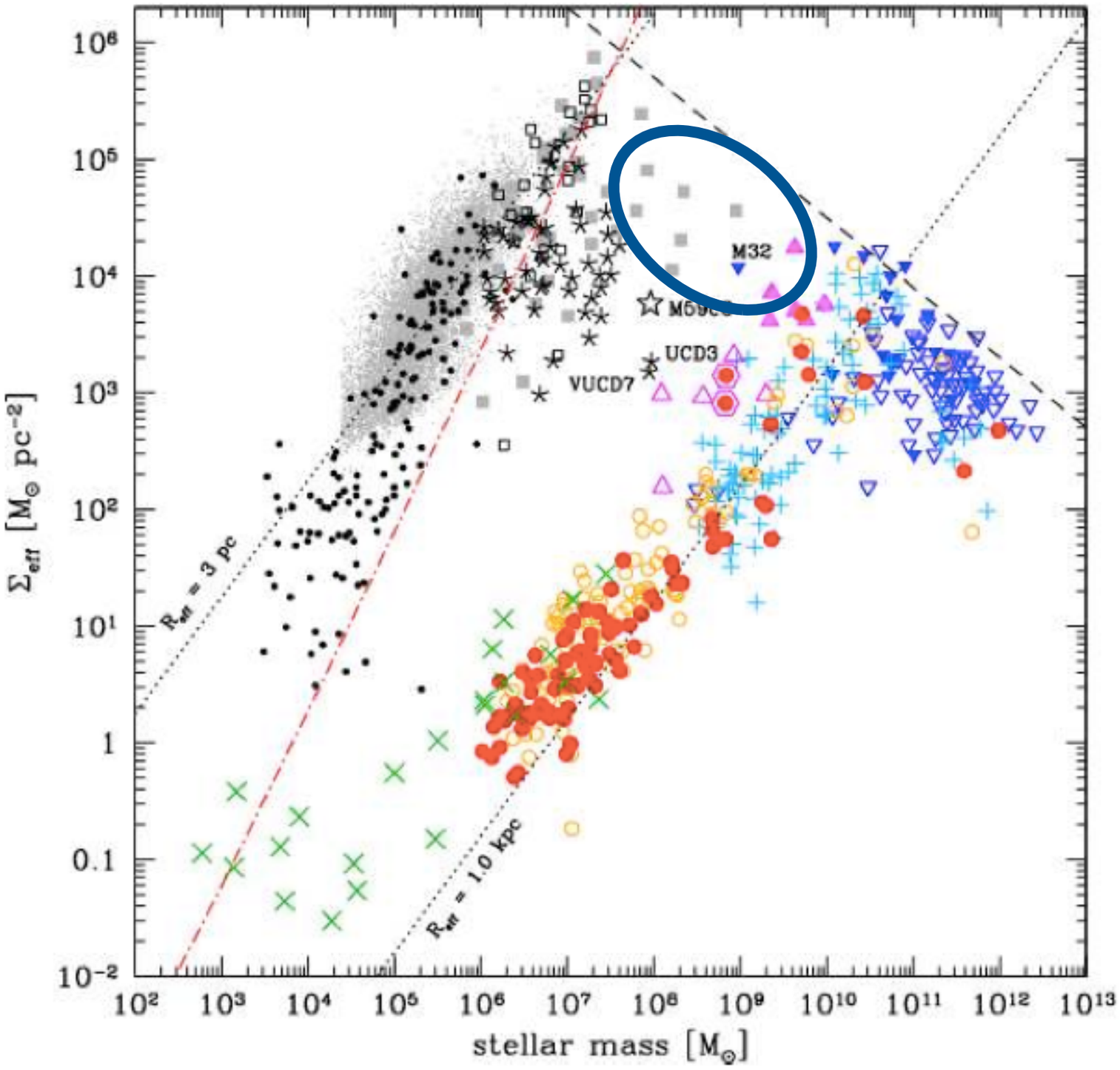
Stellar Mass - Size

Cappellari et al. 2012 (ATLAS^{3D} XX)



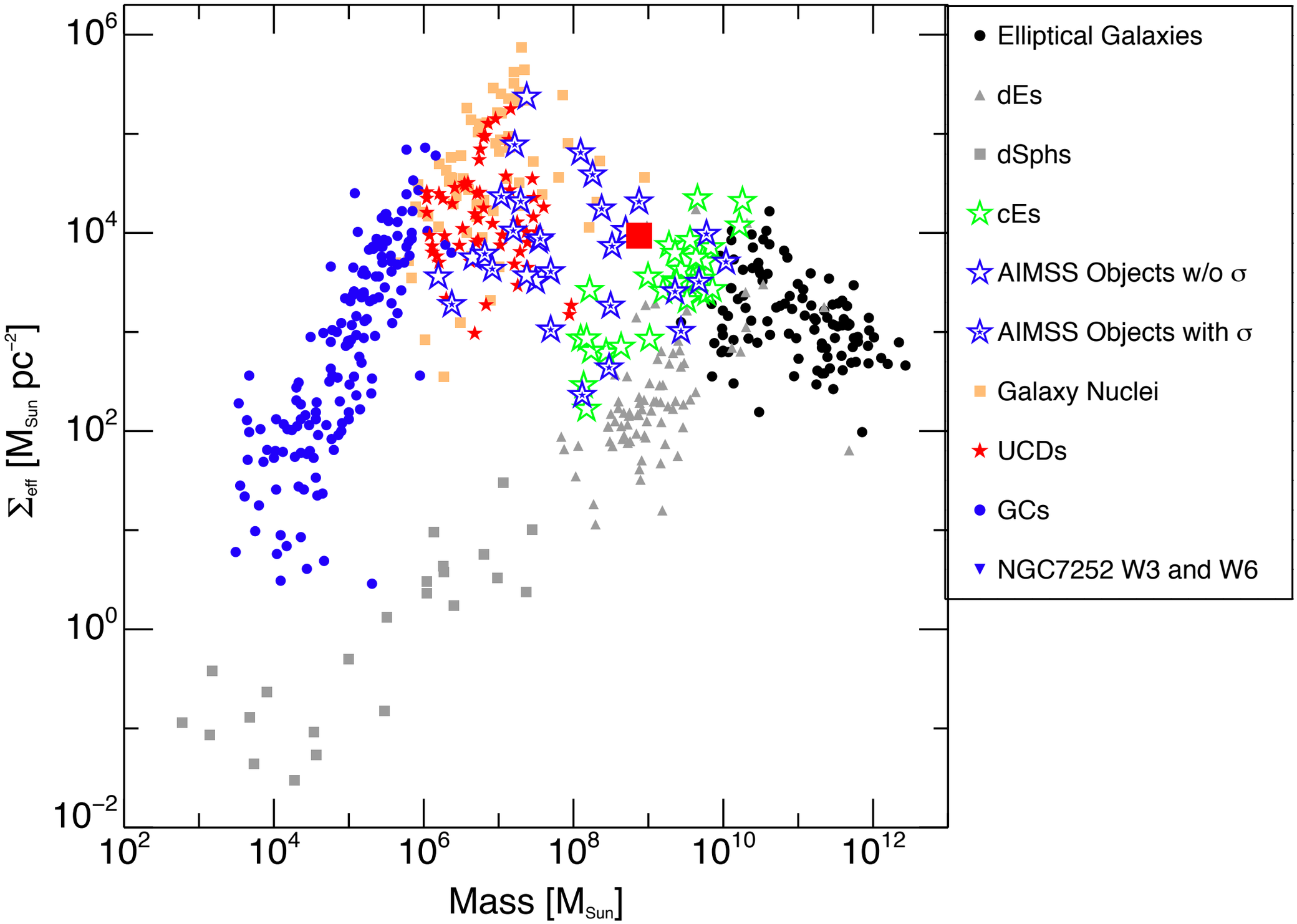
Some are young and some are genuinely more concentrated.

Stellar Mass - Mass Surface Density

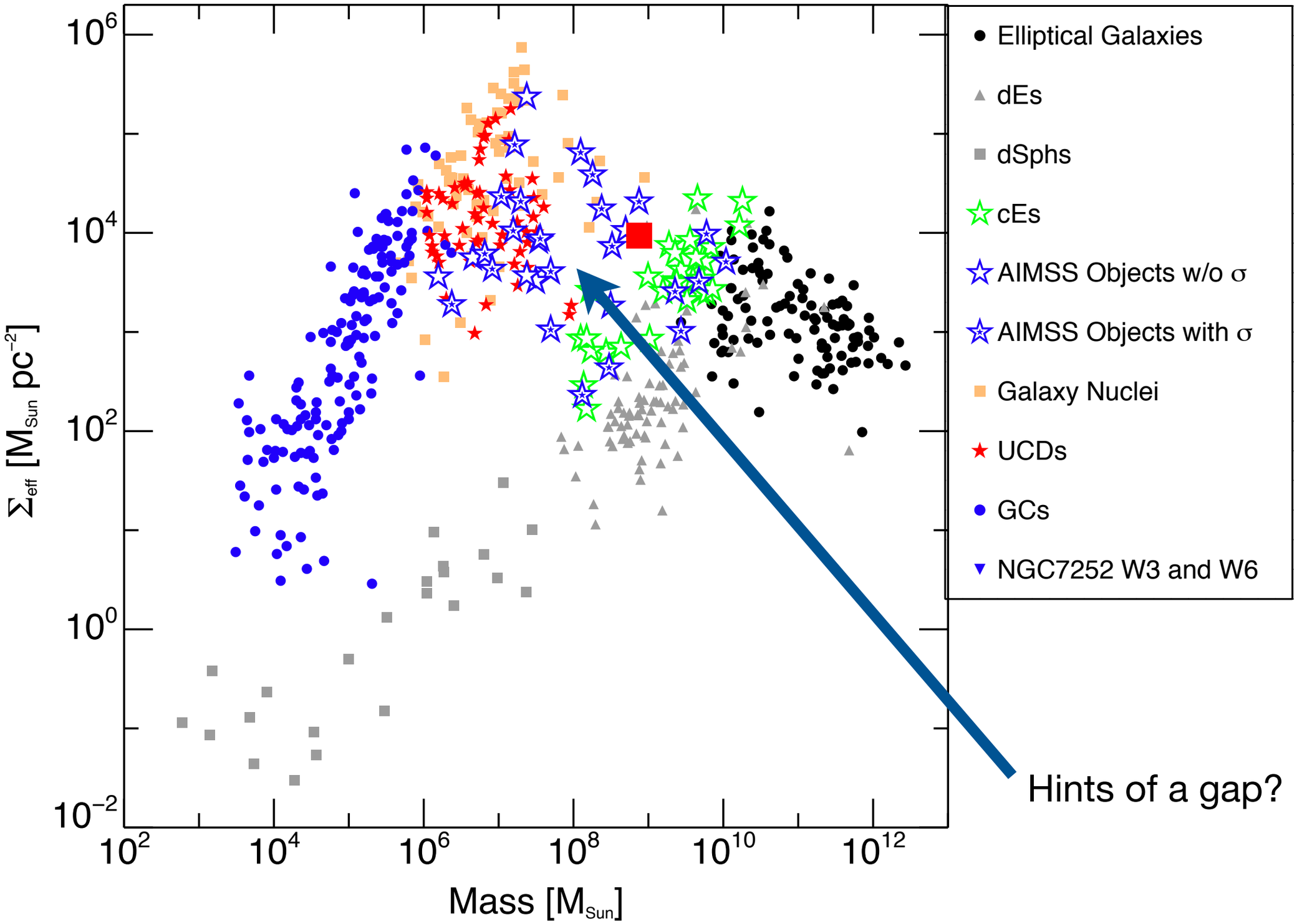


The situation as of Misgeld & Hilker 2011

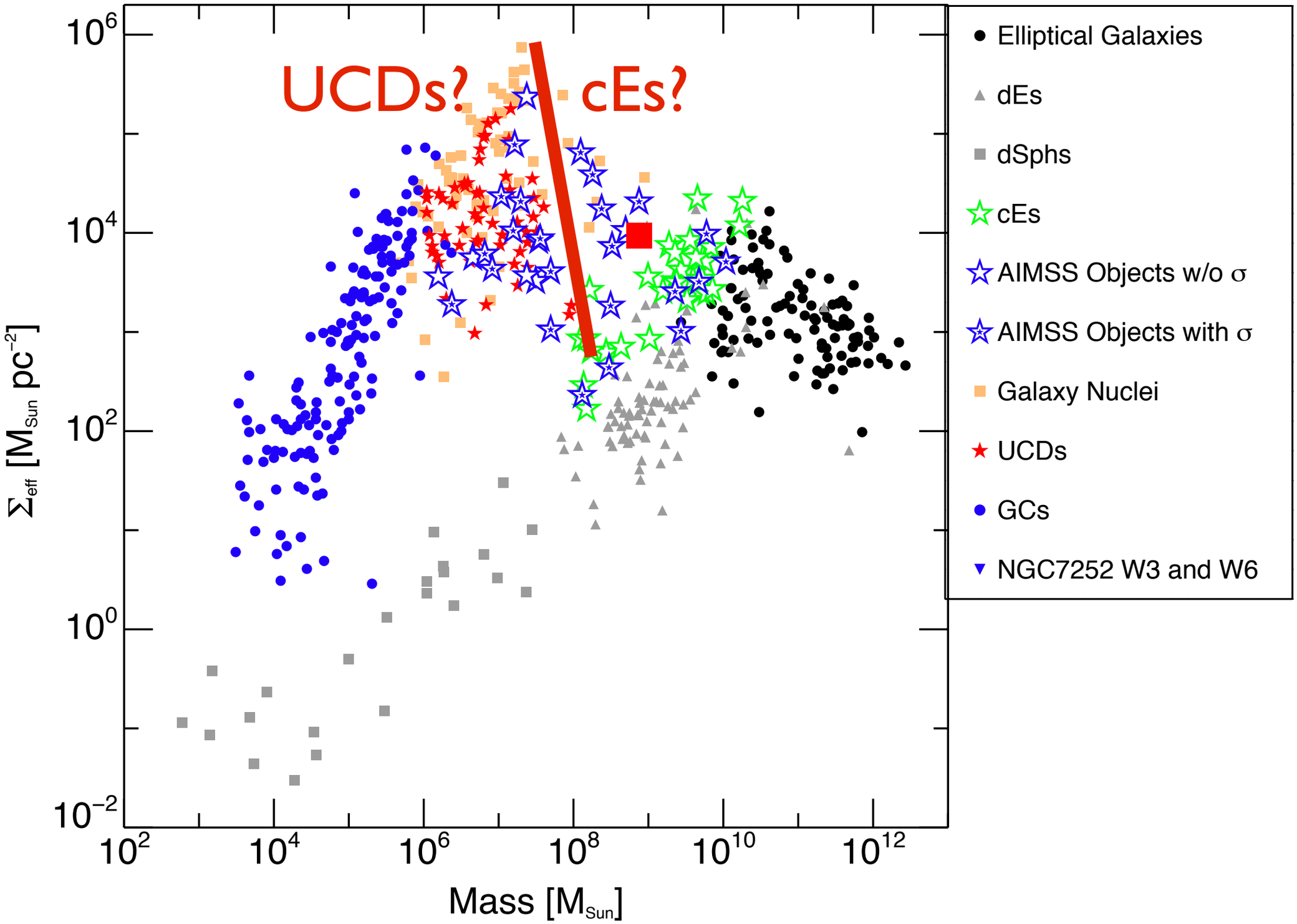
Stellar Mass - Mass Surface Density



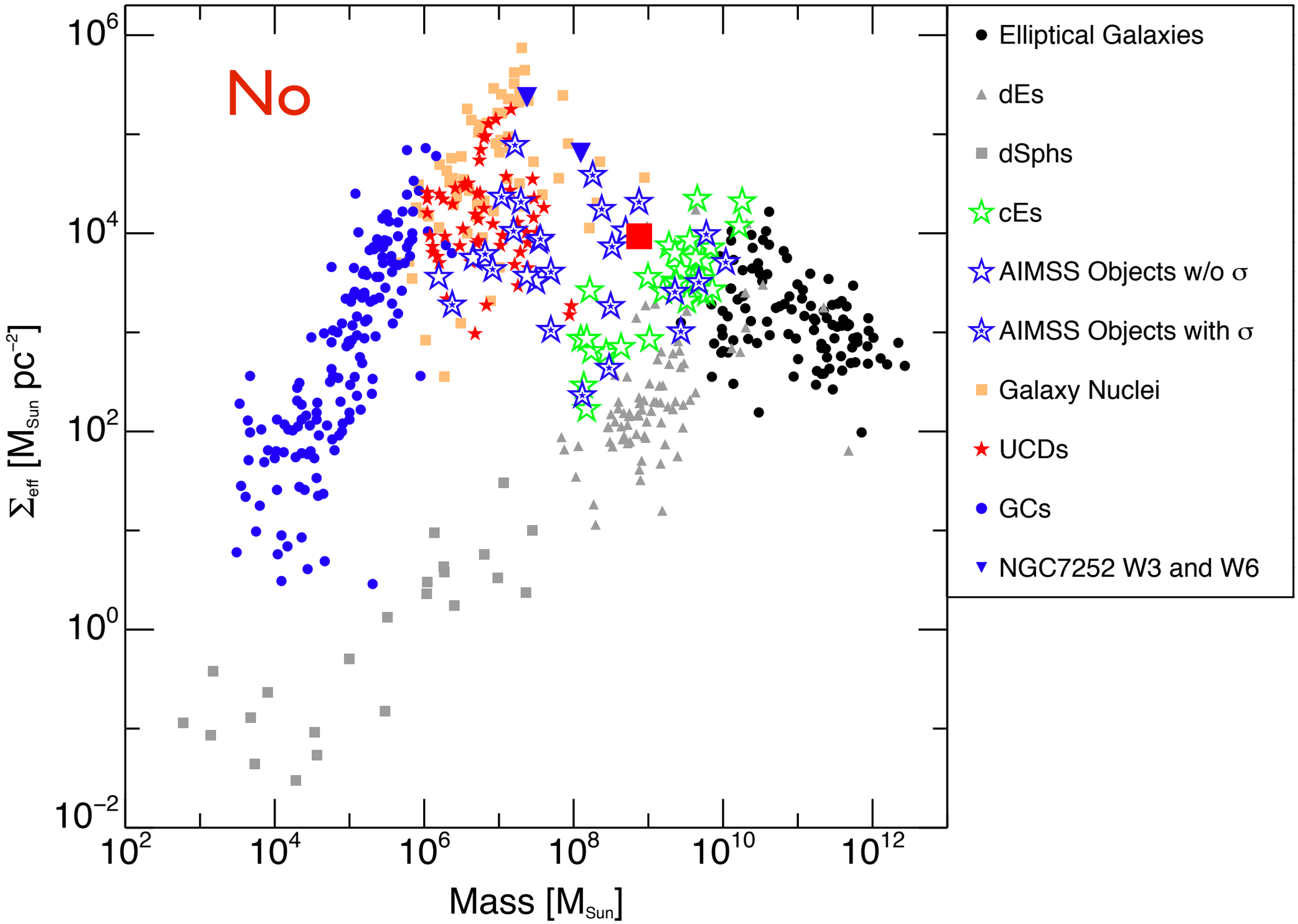
Stellar Mass - Mass Surface Density



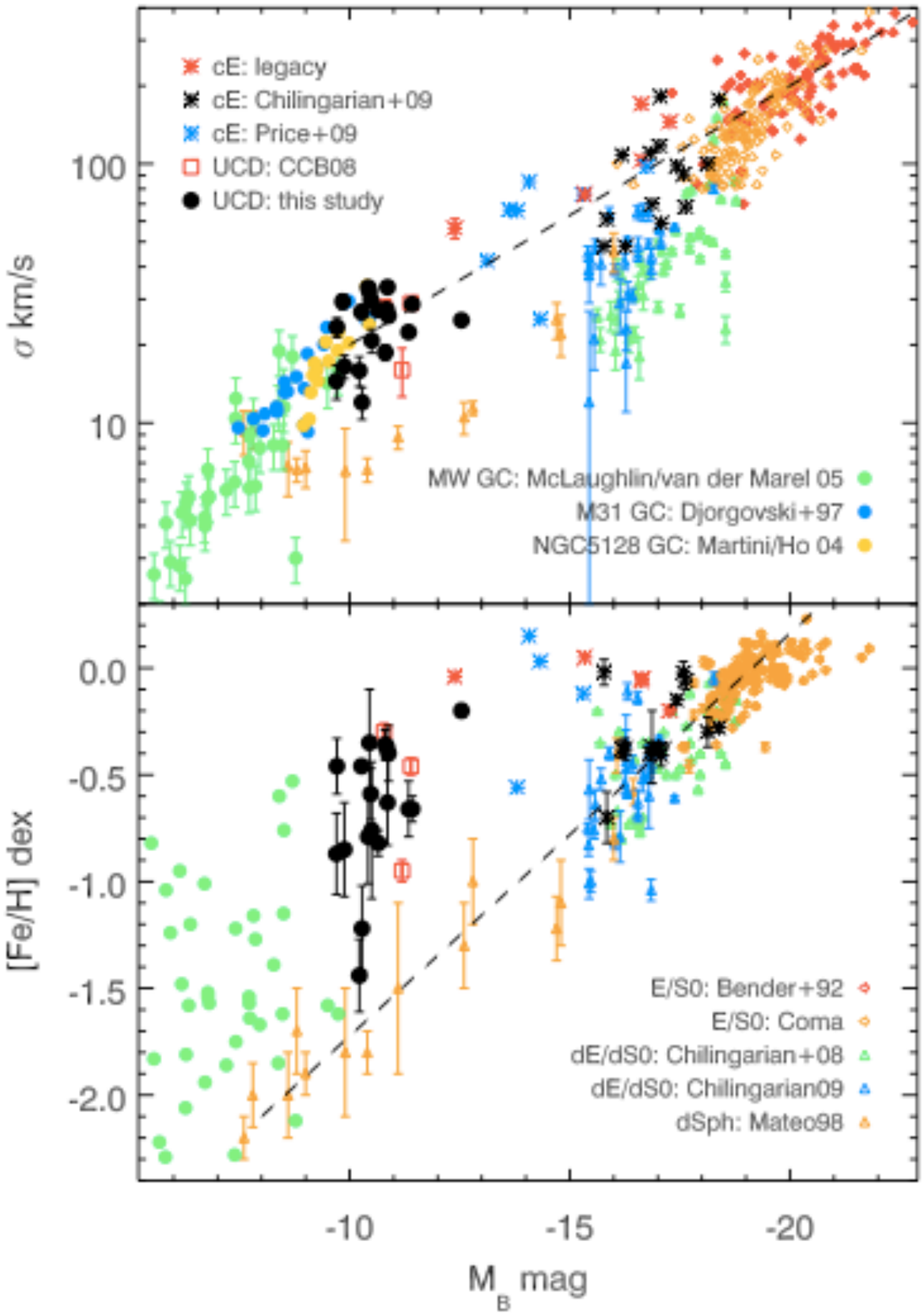
Stellar Mass - Mass Surface Density



Stellar Mass - Mass Surface Density



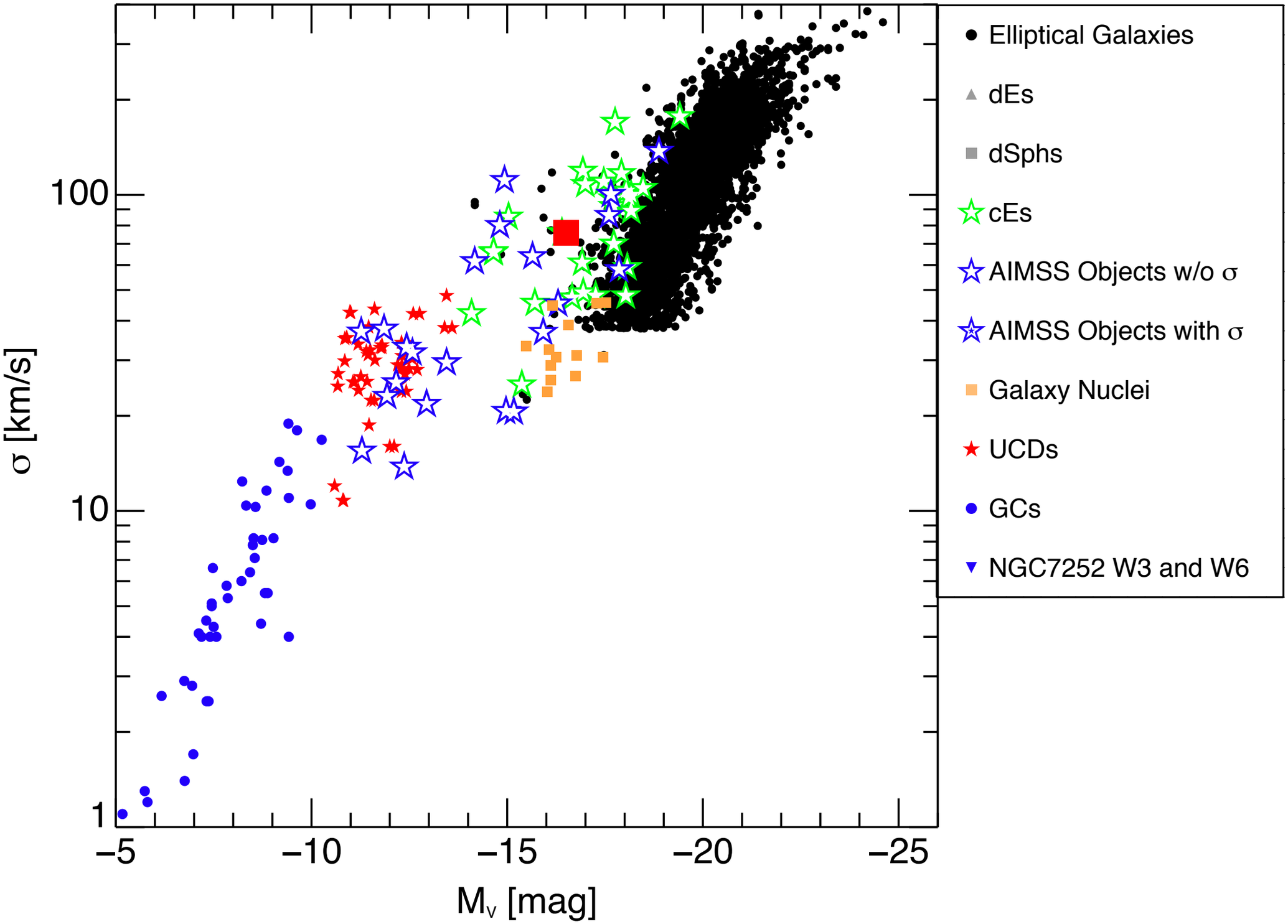
Velocity Dispersion



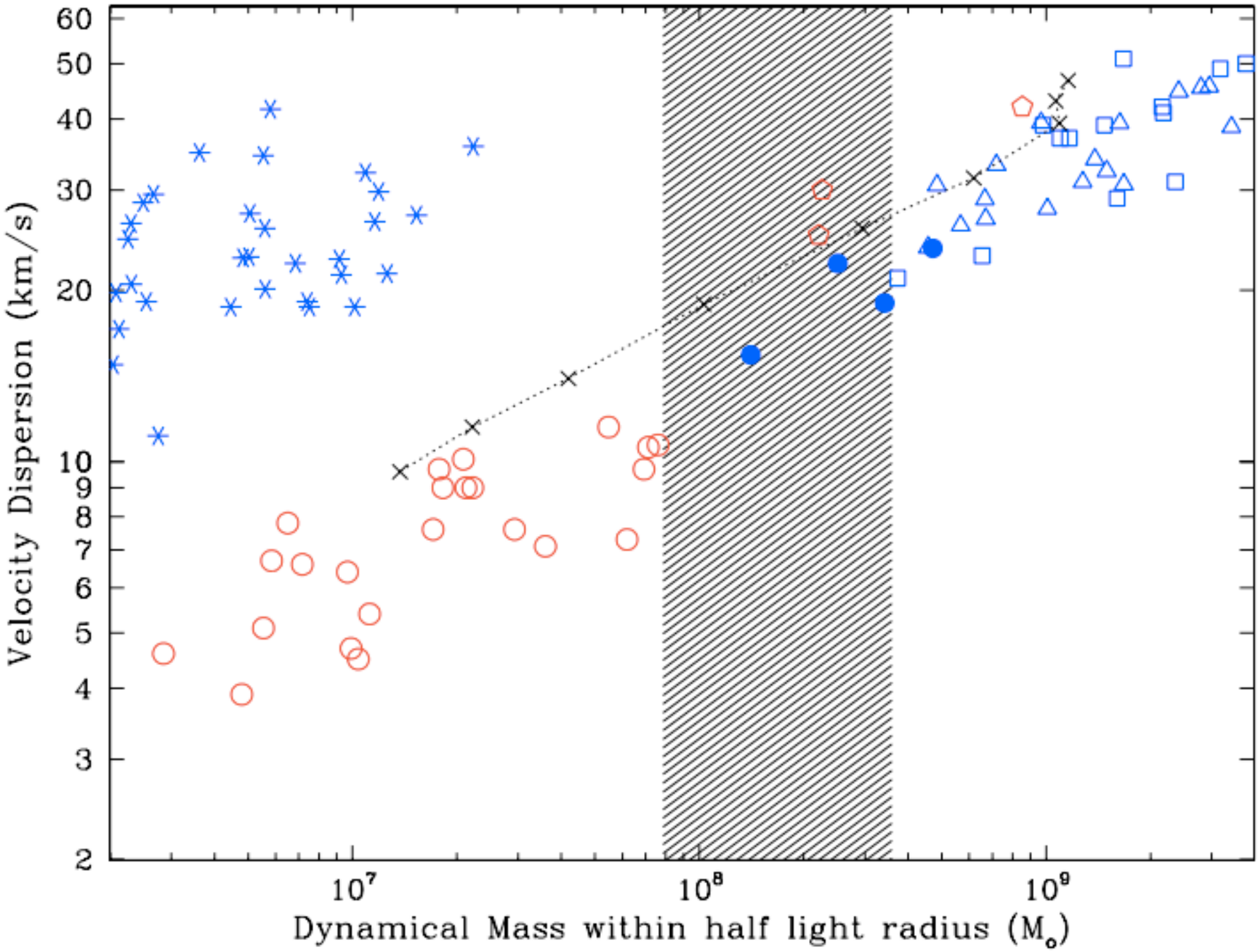
Sigma vs M_B from Chilingarian, Mieske, Hilker, & Infante 2010

Hints of a separation between UCDs/cEs and dEs/dS0s.

Velocity Dispersion



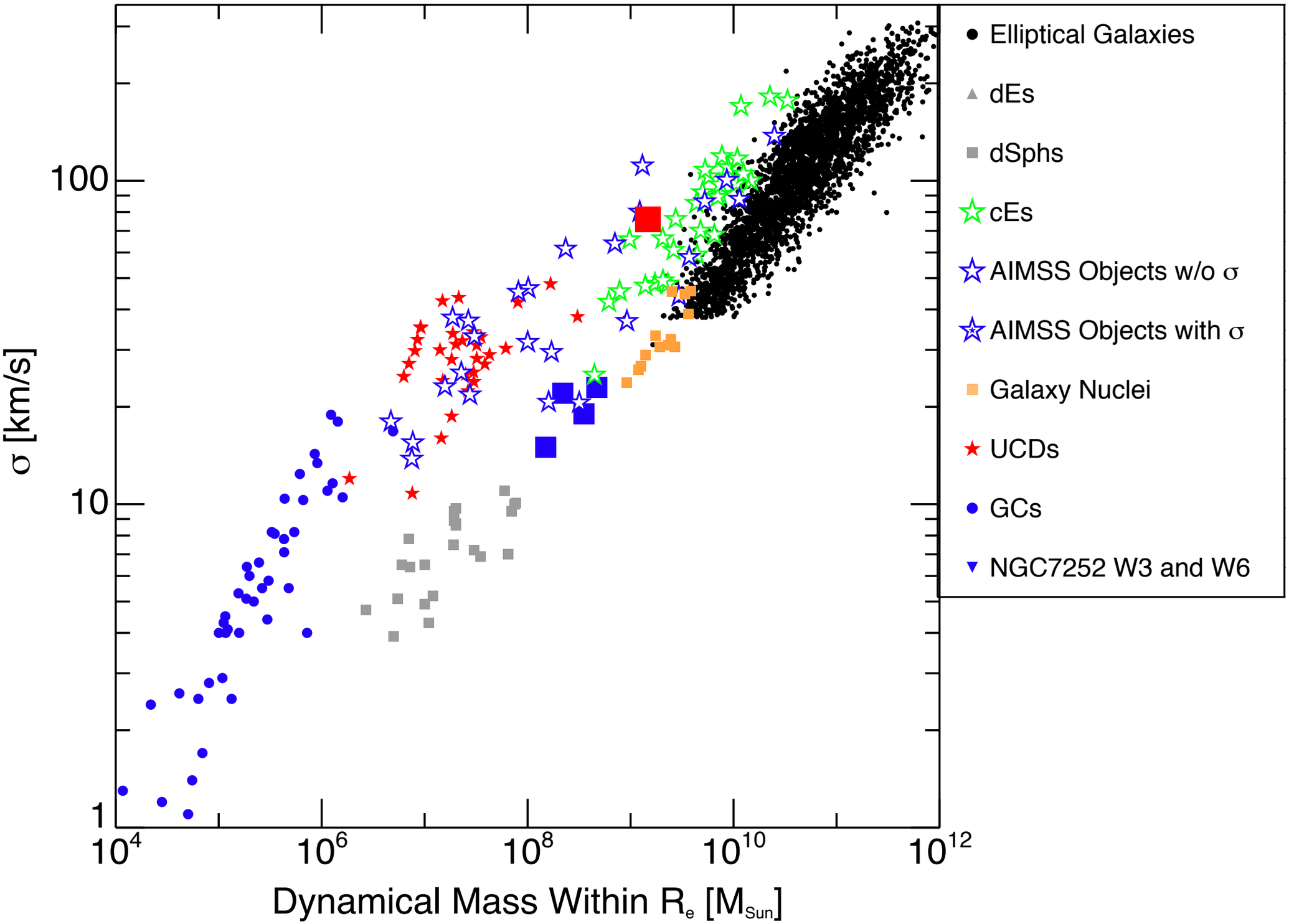
Velocity Dispersion



From Forbes, Spitler, Graham, Foster, Hau & Benson. 2010

Velocity Dispersion

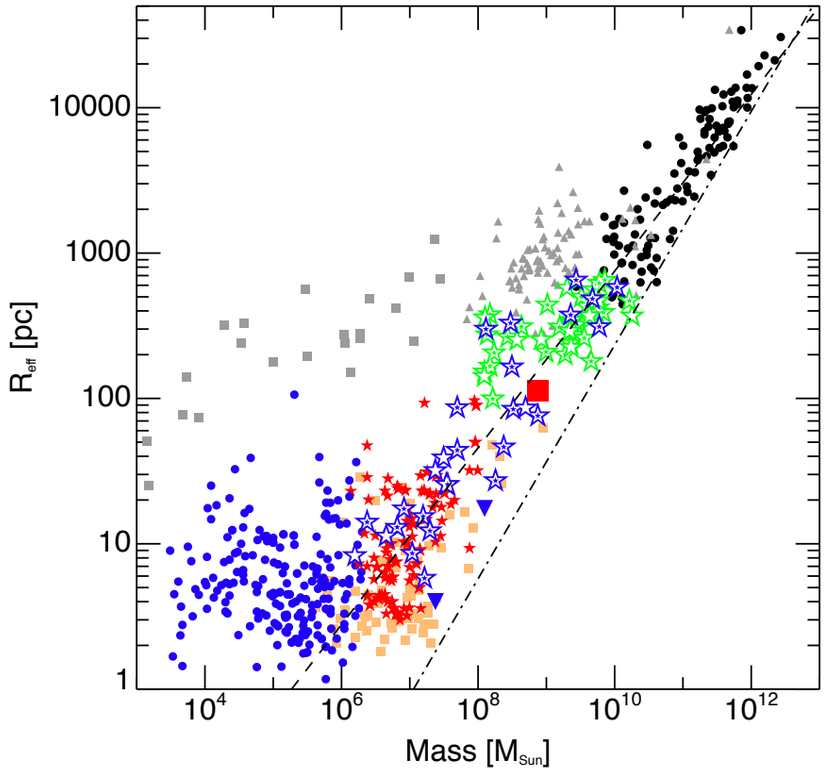
Two sequences in σ - dynamical mass - GCs/UCDs/cEs different from galaxies and nuclei.

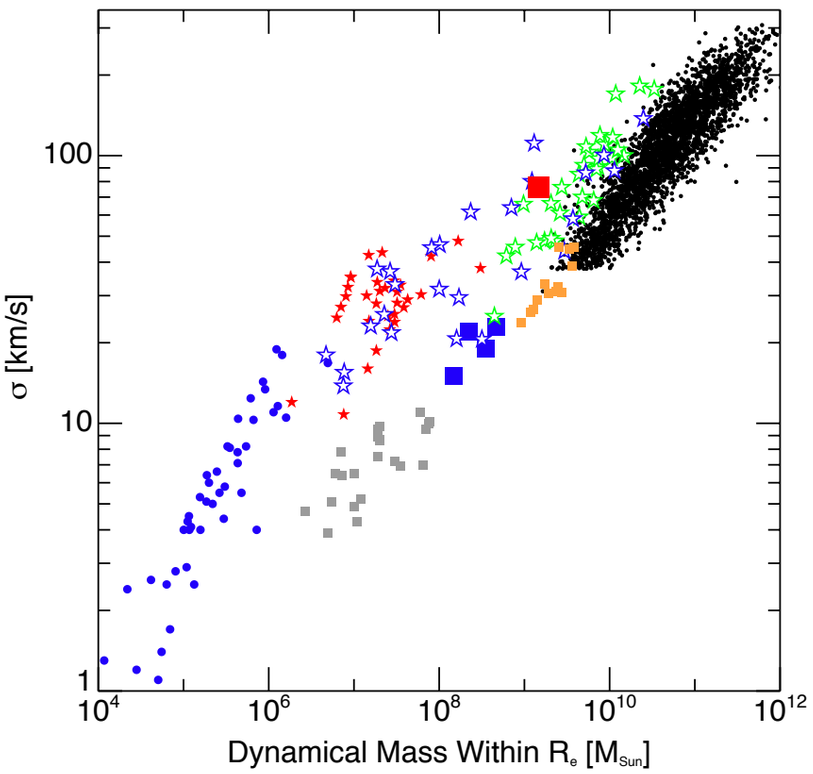


Conclusions

1) We have successfully “bridged the gap” -
we now have a continuous sequence of objects
from GCs with R_e = 1pc to gEs with R_e = 30kpc.

2) Our objects are some of the densest free-floating objects known.
Still nothing in the “zone of exclusion”.





3) So far, our cEs seem consistent with a stripping scenario. They display central σ more consistent with objects 10-100 times their dynamical mass.

Ongoing spectroscopy for stellar population information will be able to confirm this conclusion.

Open Questions

1) How common are compact ellipticals? **- See next talk by Igor Chilingarian.**

2) Can cE's form in more than one way? **- See paper by Huxor, Phillips and Price 2013, for an example of a very isolated cE.**

3) Are some cE's related to the massive compact galaxies at intermediate z?

The AIMSS Catalogue

2) The AIMSS Catalogue - A fully comprehensive catalogue of CSS properties:

- All available photometry, UV to IR
- m-M/distance
- Structural parameters; R_e, Sersic n, King n etc
- Stellar Population parameters, Age, [Z/H], [α/Fe]
- V, σ, $M_\star$, M_{dyn}

WE WANT YOU!R DATA

The AIMSS Catalogue

The AIMSS Catalogue

To help with the legacy value of your data please consider:

1) Providing uncertainties! Especially on photometry.

2) Obtaining multi-band photometry in common systems. Ideally SDSS or Johnson-Cousins + 2MASS

3) Once published, providing it to me to add to the catalogue, I will be setting up a web form to do this

Thank You