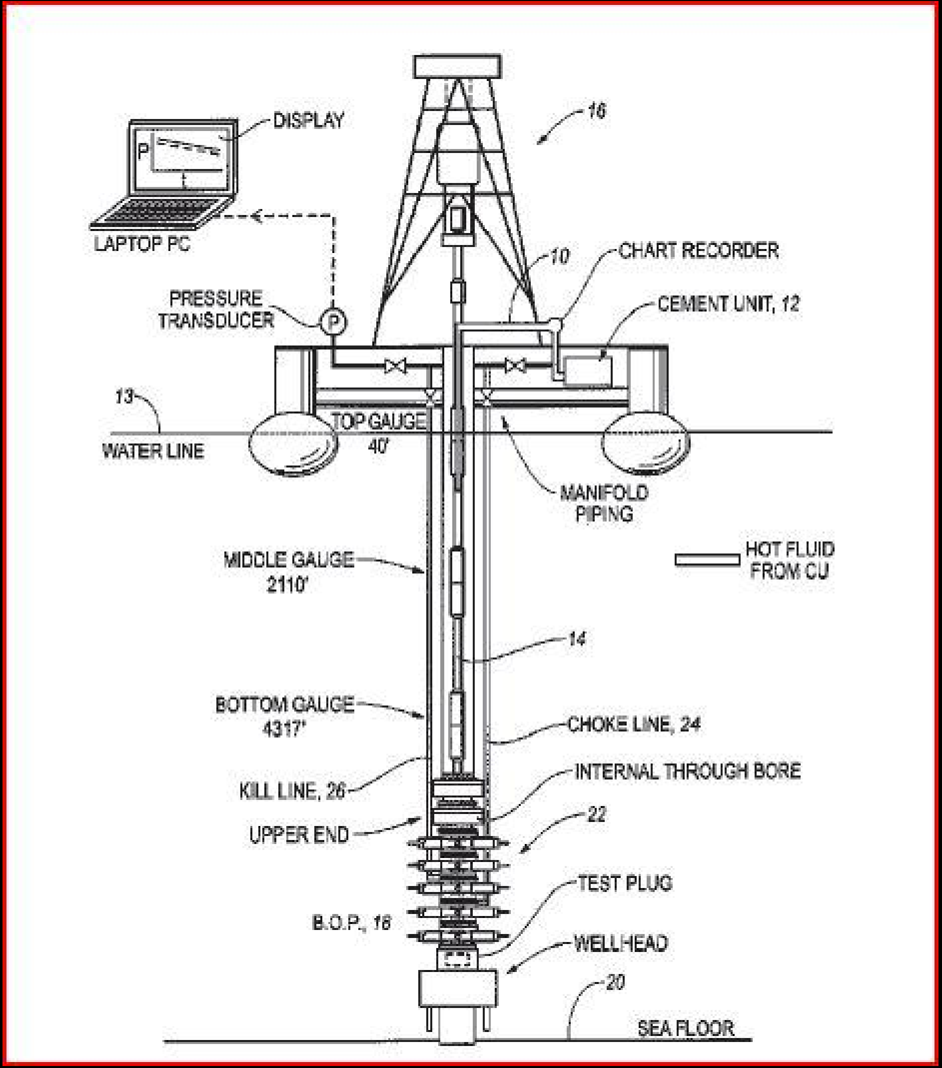
Metal Loss from Dwarf Galaxies

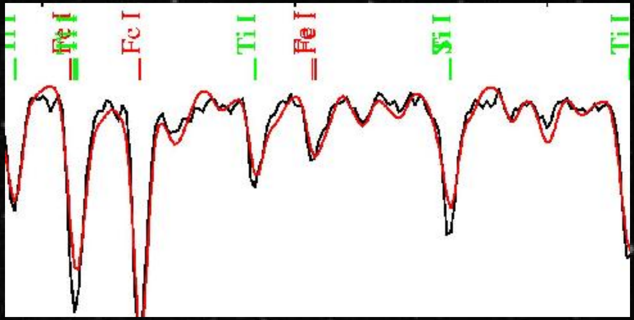


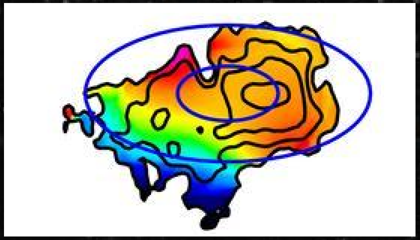
USA Provisional Patent Application filed on Feb. 1, 2007 under Ser. No. 60/887,739 and entitled "Improved Blowout Preventer System."

Evan Kirby
Caltech

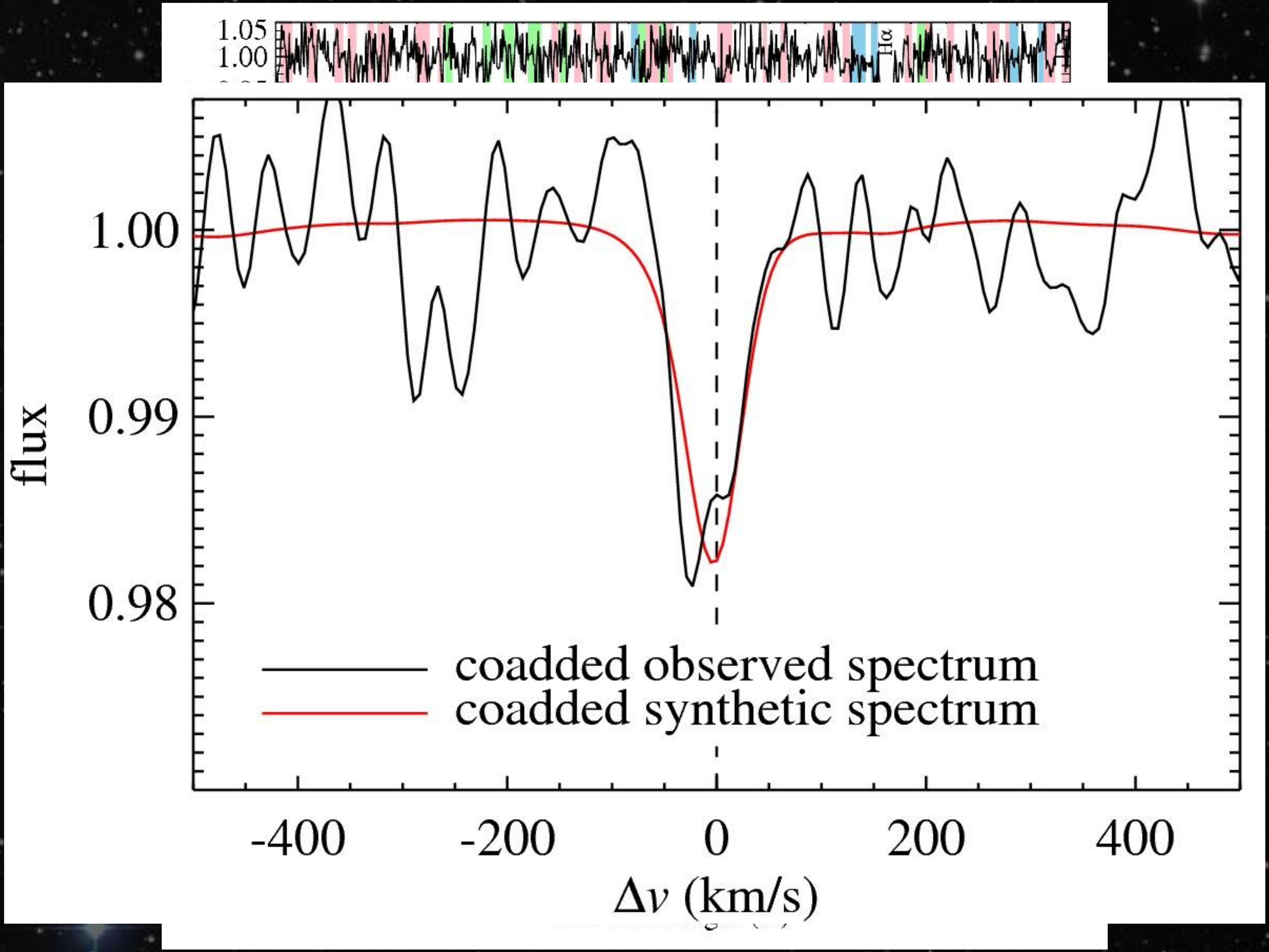
Medium-Resolution, Multi-Object Stellar Spectroscopy and Dwarf Galaxy Metallicity Distributions

- Why medium-resolution spectroscopy?
- Metal removal from dwarf galaxies
- The dIrr → dSph transformation





Detailed abundances may be measured from med-res spectra.



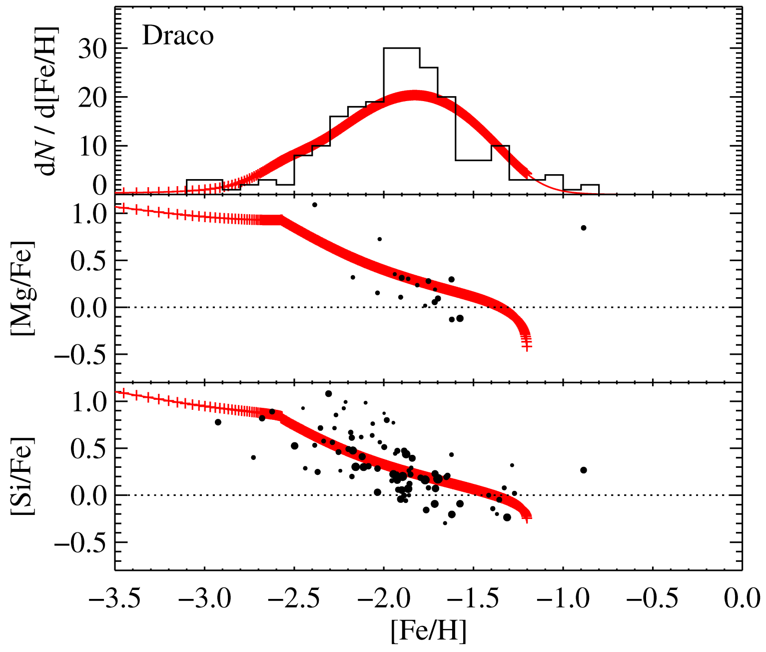
EK et al. 2009, ApJ, 705, 328
Frebel, EK, & Simon 2010, Nature, 464, 72

A catalog of multi-element abundances in MW dSphs

dSph	N	t_{exp} (hours)
Fornax	675	4.1
Leo I	827	15.5
Sculptor	376	3.3
Leo II	258	5.3
Sextans	141	5.8
Draco	298	6.0
Canes Venatici I	174	6.2
Ursa Minor	212	5.1
Ultra-faint dwarfs	297	26.2
Total	3258	77.4

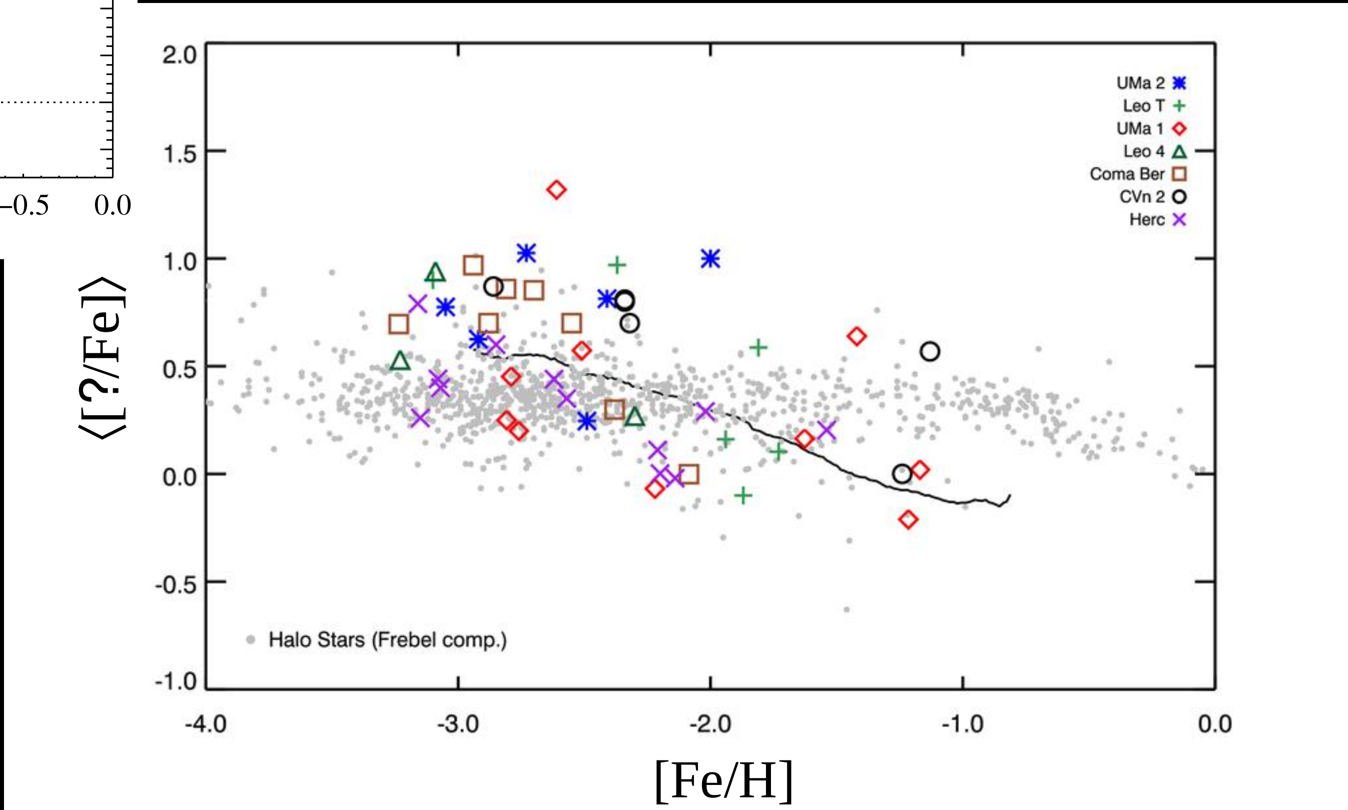
EK et al. 2010, ApJS, 191, 352
Simon & Geha 2007, ApJ, 670, 313

I'm going to talk about Fe, but there are more things in heaven and earth ...

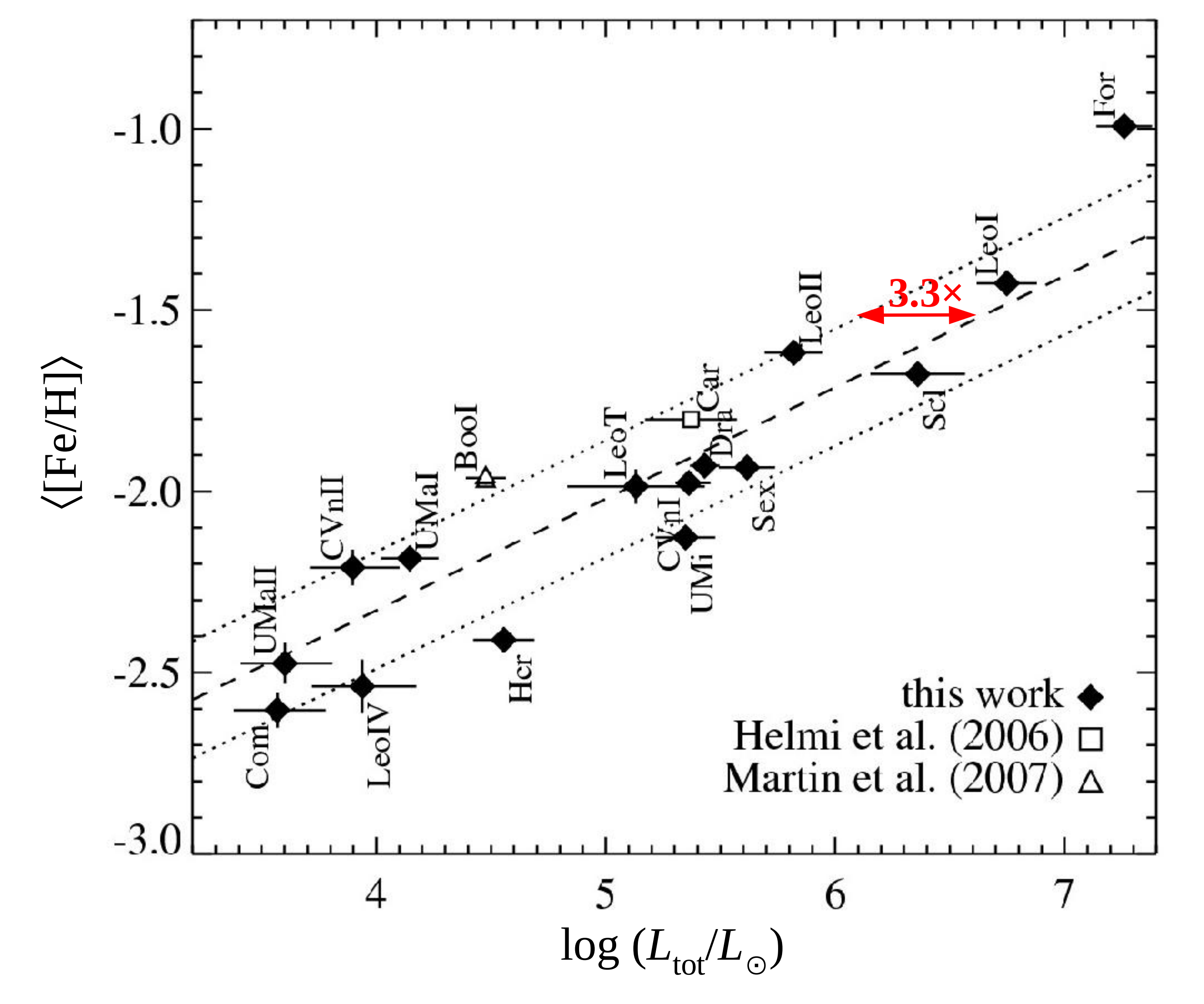


EK et al. 2011b, ApJ, 727, 79

Luis Vargas's poster:

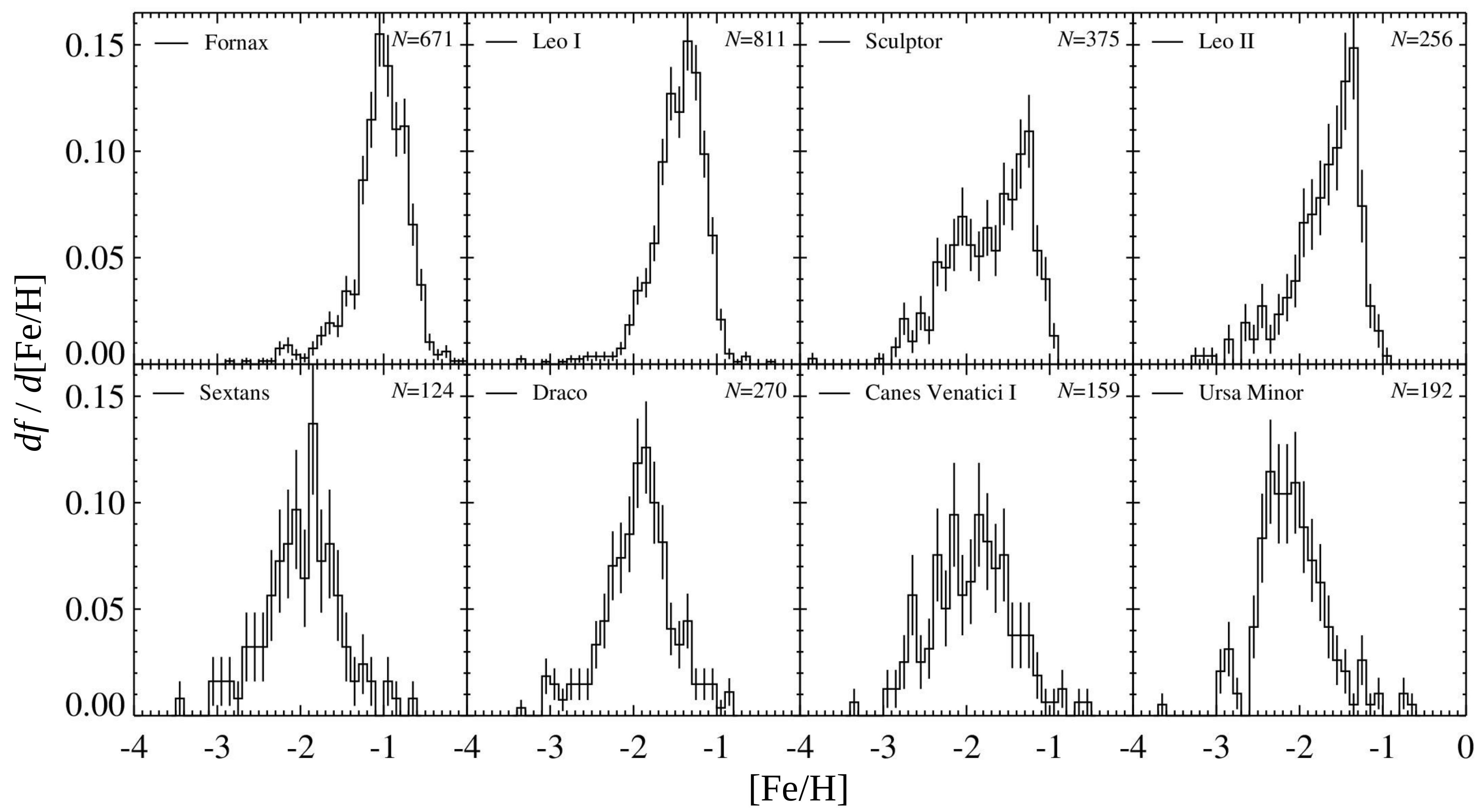


The dependence of metallicity on luminosity places limits on tidal stripping.



EK et al. 2008, ApJL, 685, L43
EK et al. 2011a, ApJ, 727, 78

The metallicity distributions of dwarf galaxies evolve with luminosity.



EK et al. 2011a, ApJ, 727, 78

The metallicity distributions of dwarf galaxies evolve with luminosity.

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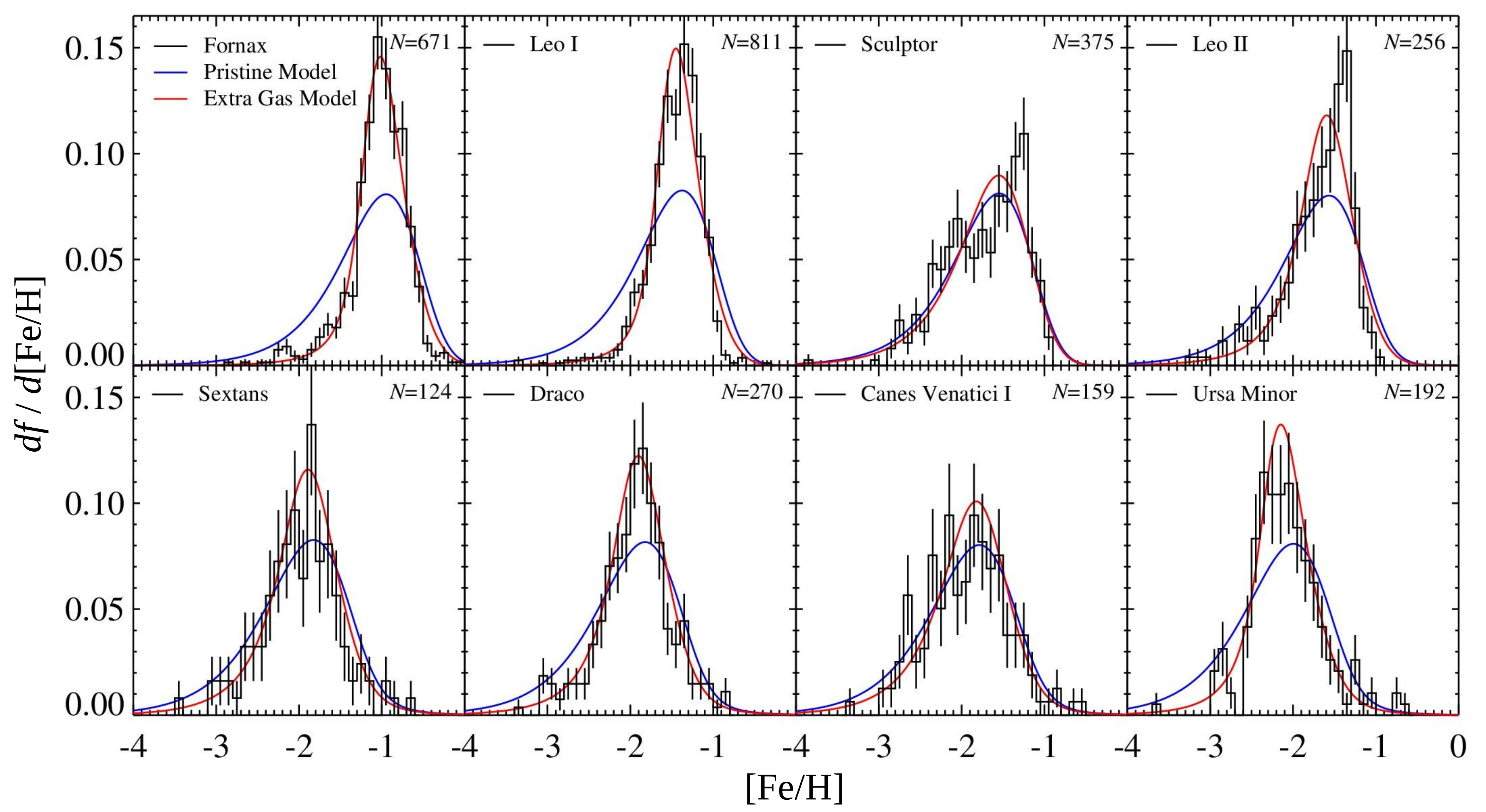
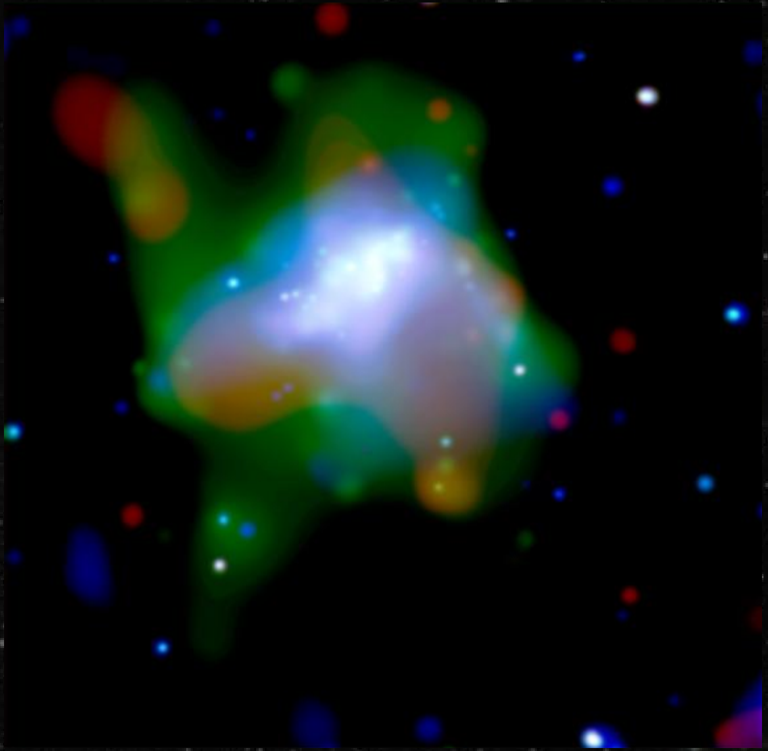


EK et al. 2011a, ApJ, 727, 78

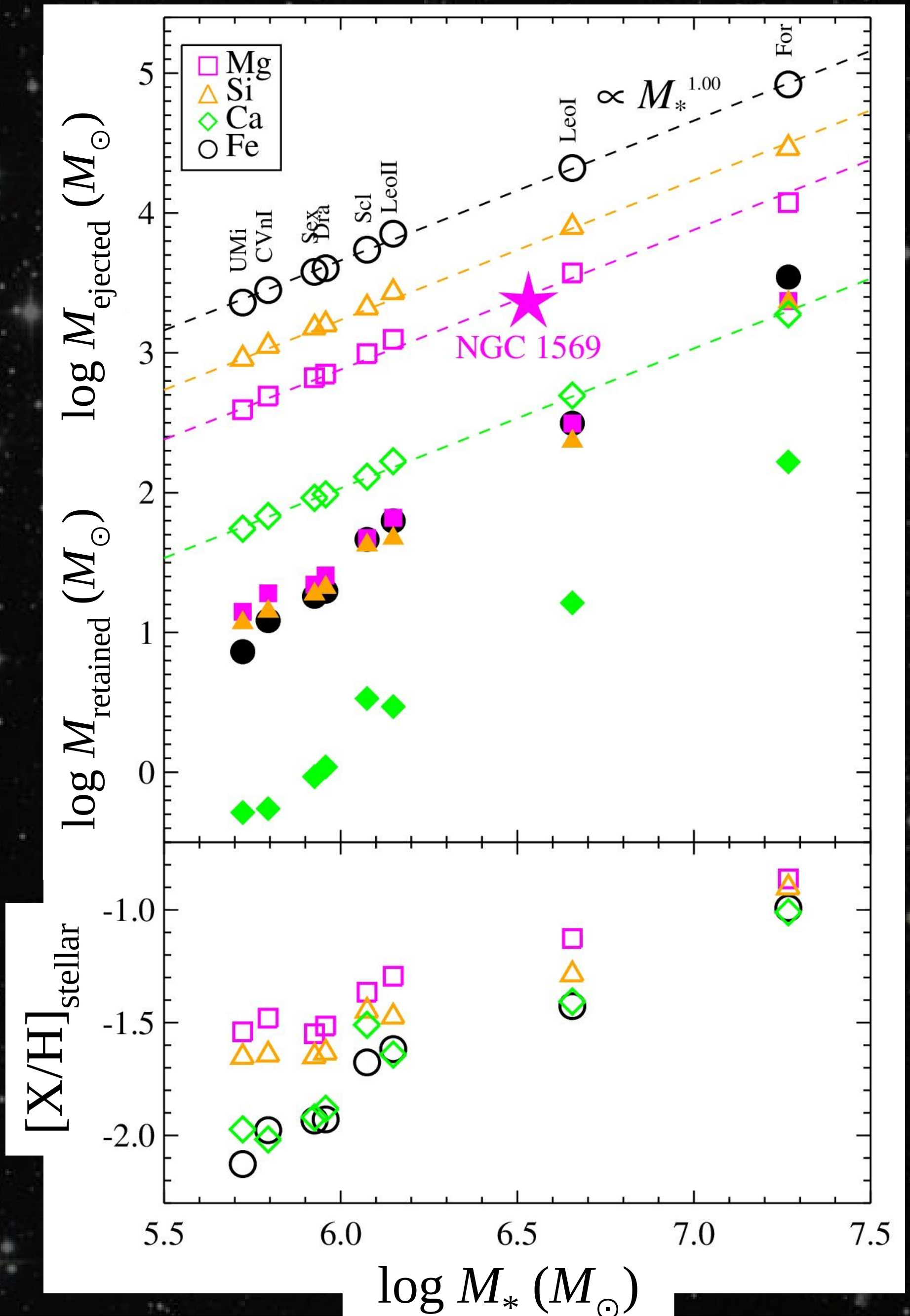
Dwarf galaxies lose almost all of their metals in outflows.

HST+WIYN: M. Westmoquette



Chandra: C. Martin, H. Kobulnicky, T. Heckman

The amount of metals lost is a strong function of stellar mass.



EK, Martin, & Finlator 2011, ApJL, 742, L25

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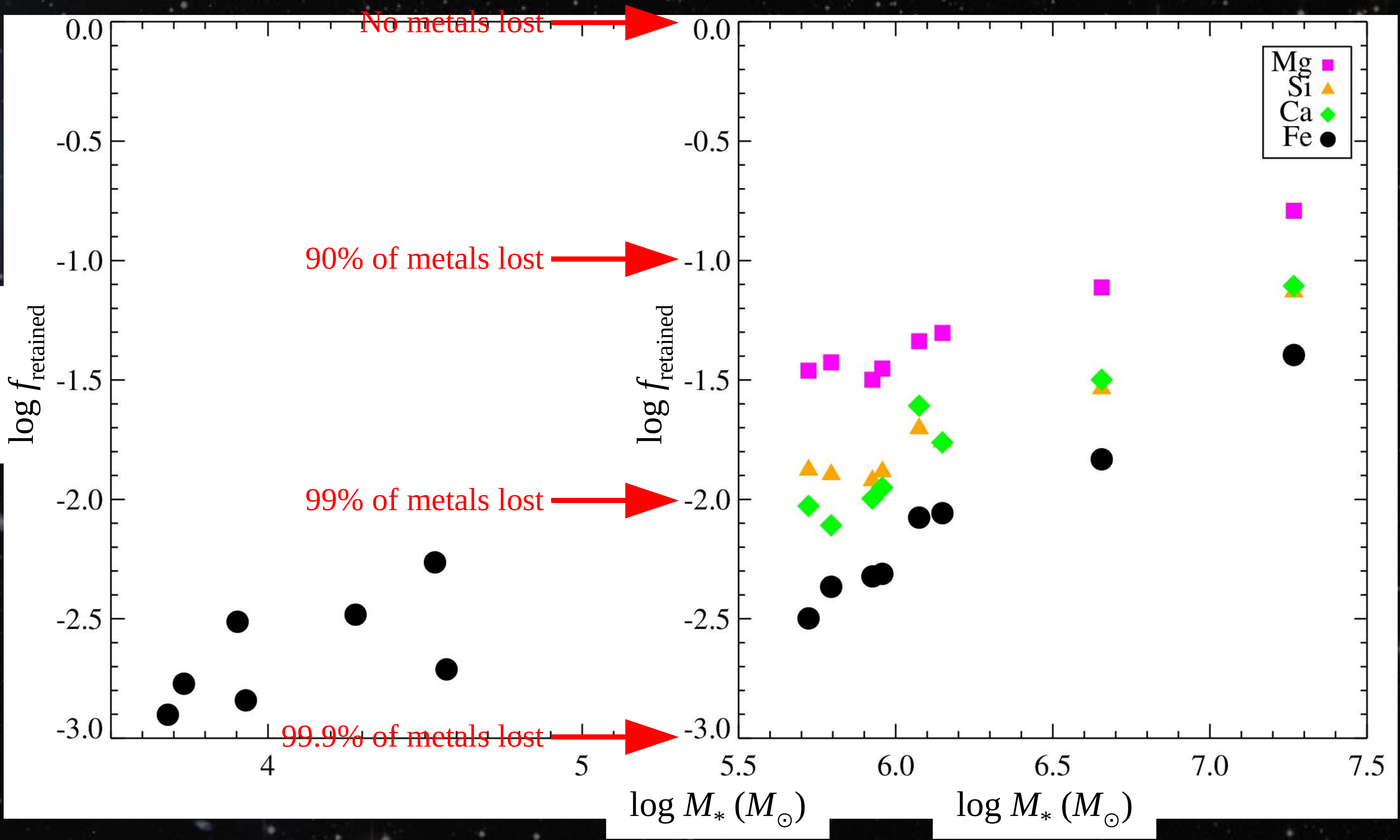
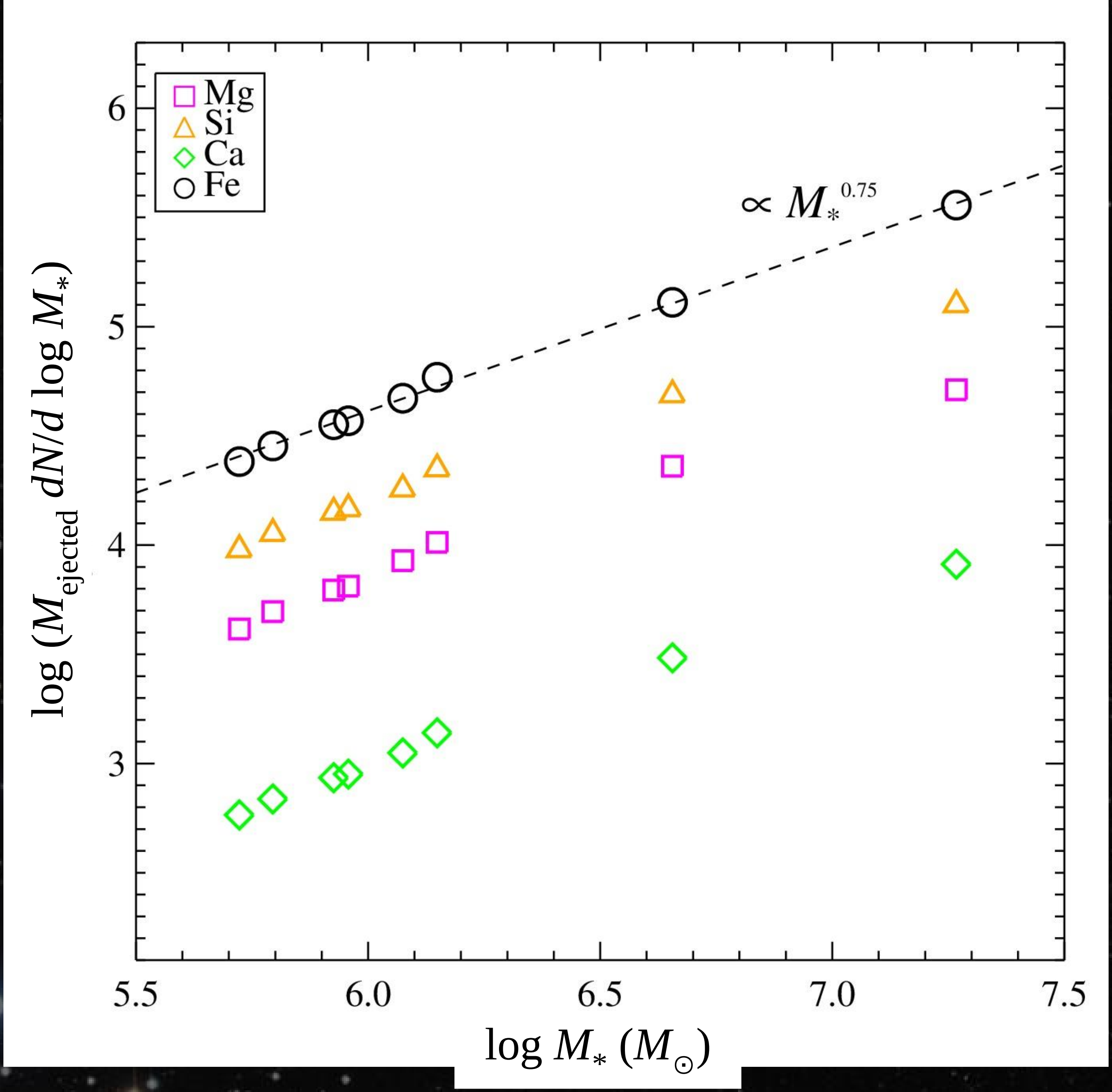


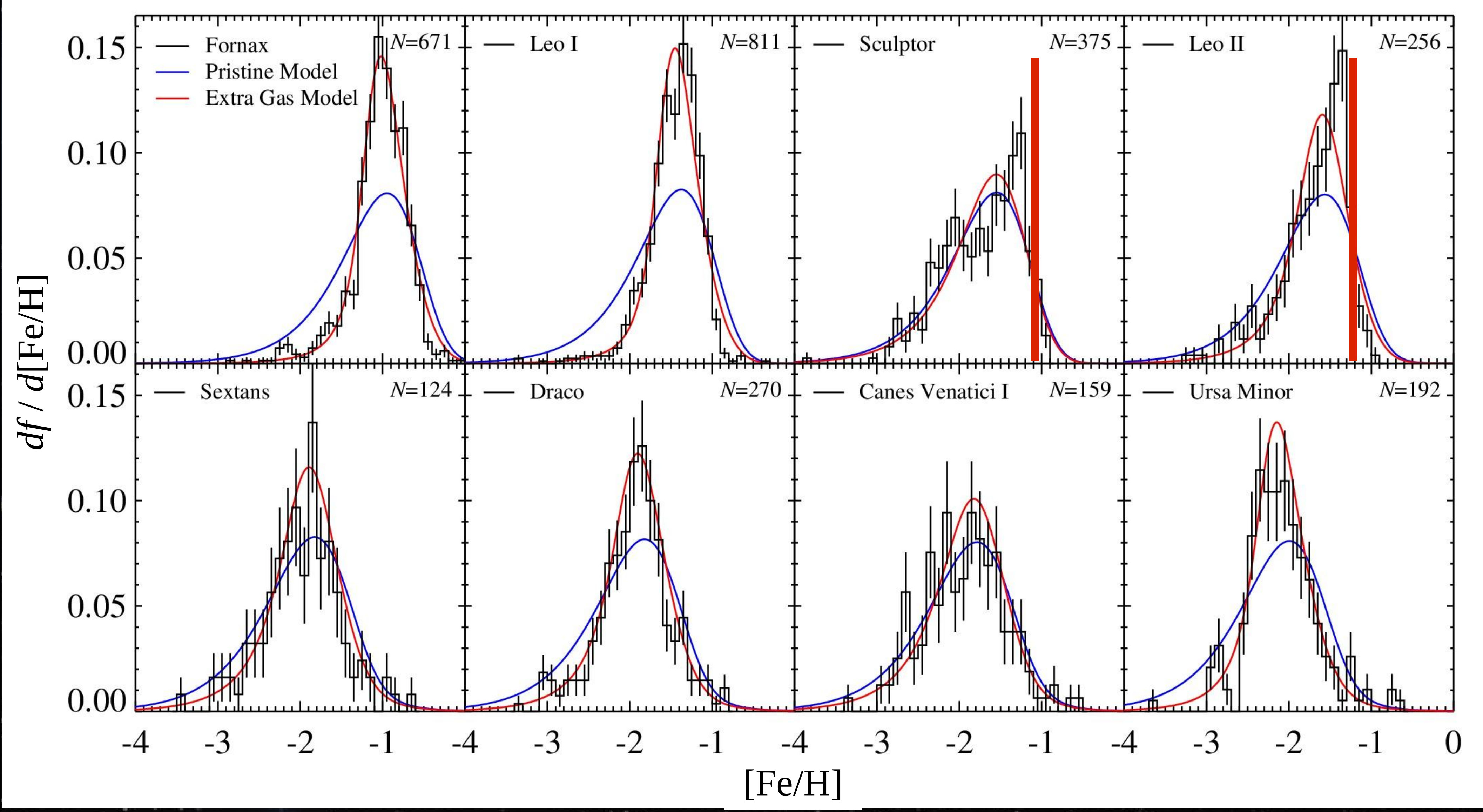
EK, Martin, & Finlator 2011, ApJL, 742, L25

Smaller dSphs contribute negligibly to the IGM.



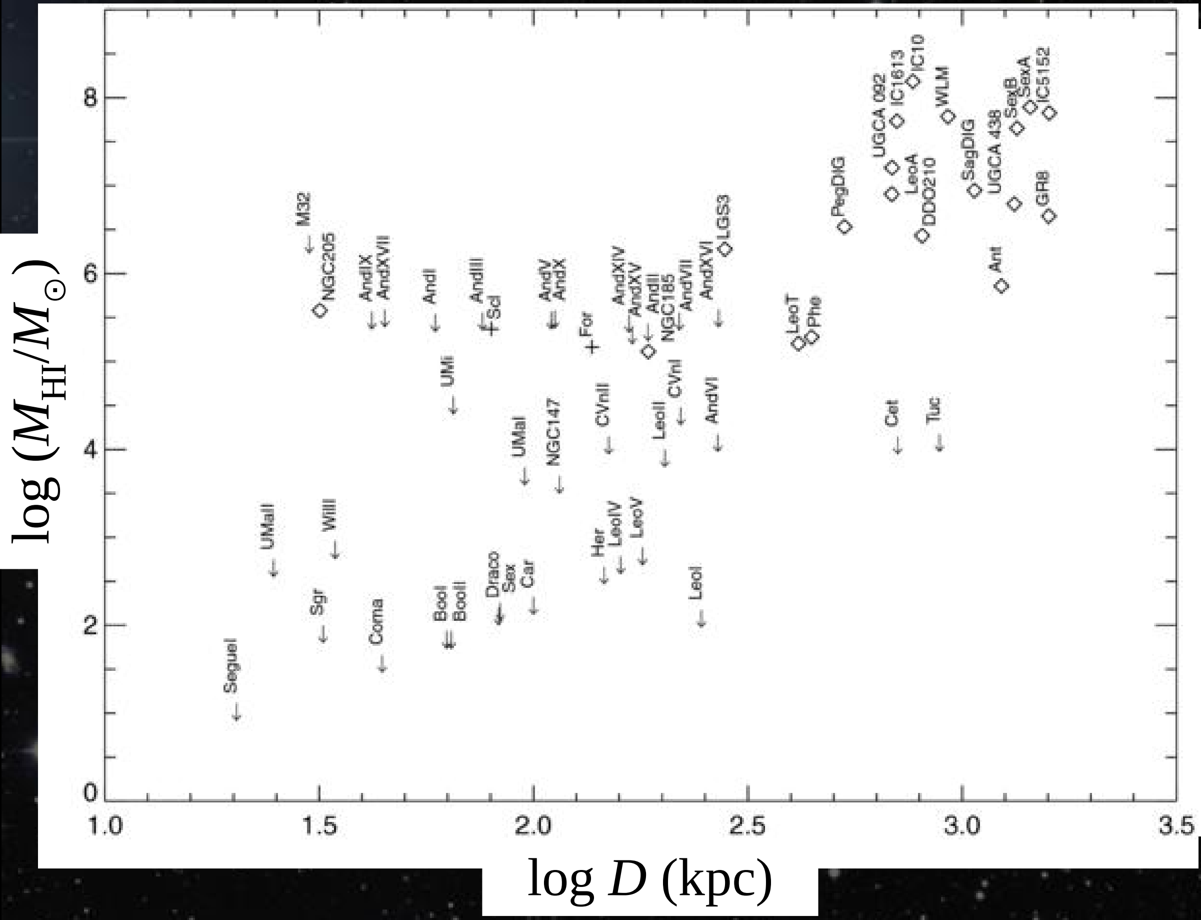
EK, Martin, & Finlator 2011, ApJL, 742, L25

The shapes of some metallicity distributions suggest catastrophic gas removal.

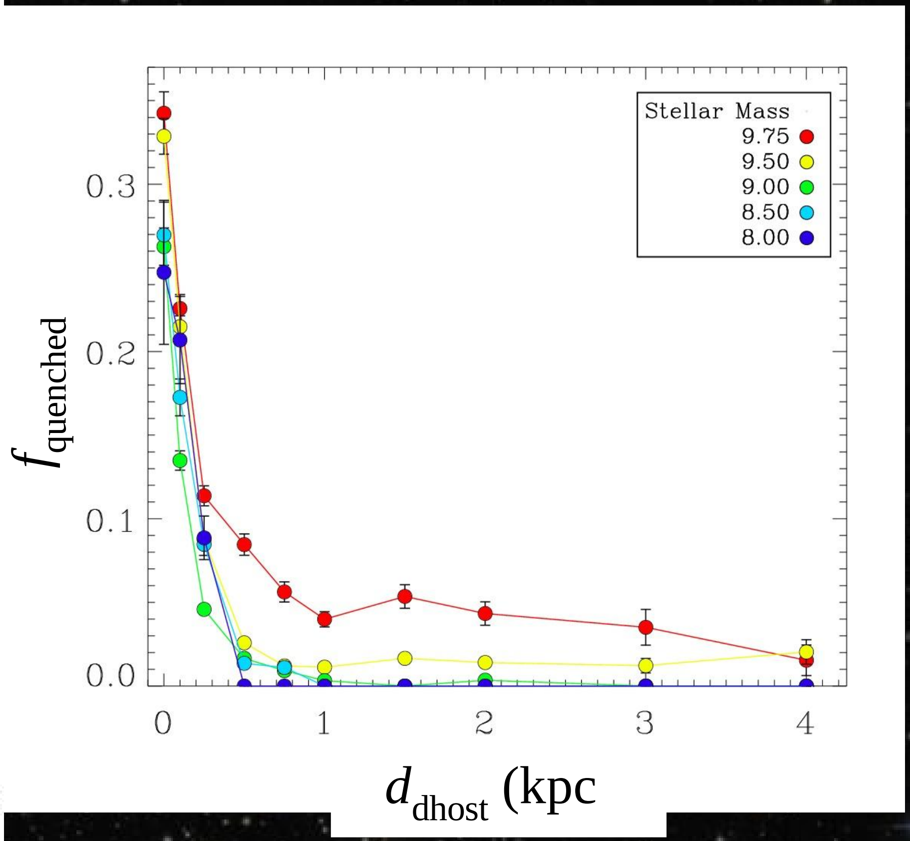


EK et al. 2011a, ApJ, 727, 78

Environment affects stellar populations.

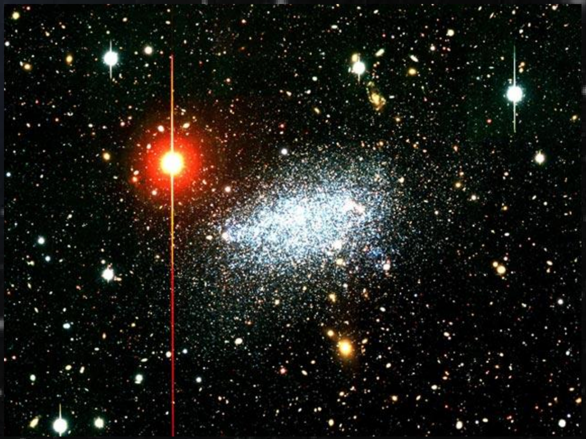


Grcevich & Putman 2009, ApJ, 696, 385



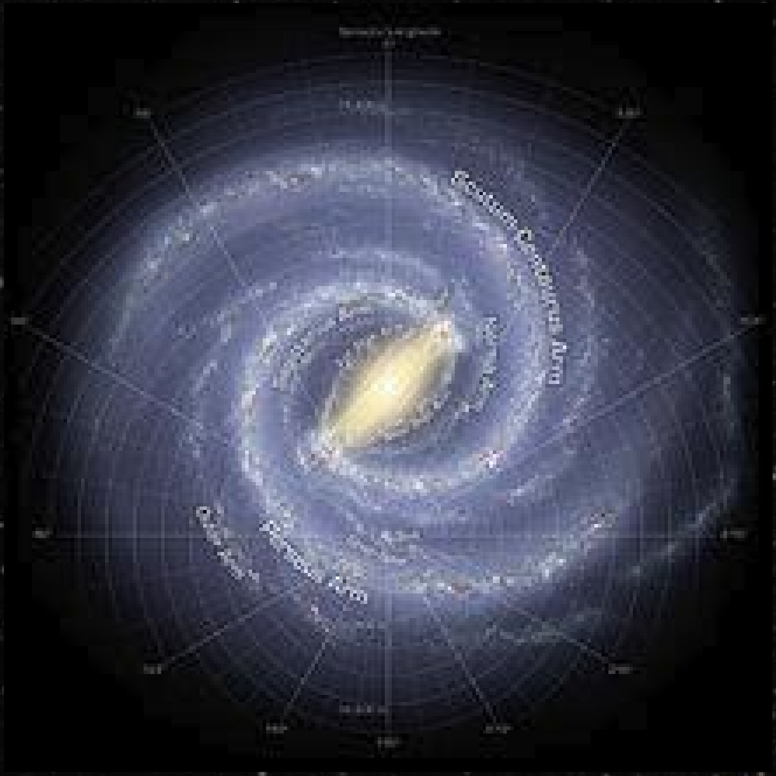
Geha et al., in prep.

DIrrs may turn into dSphs in a dense environment.



Leo A dIrr

+

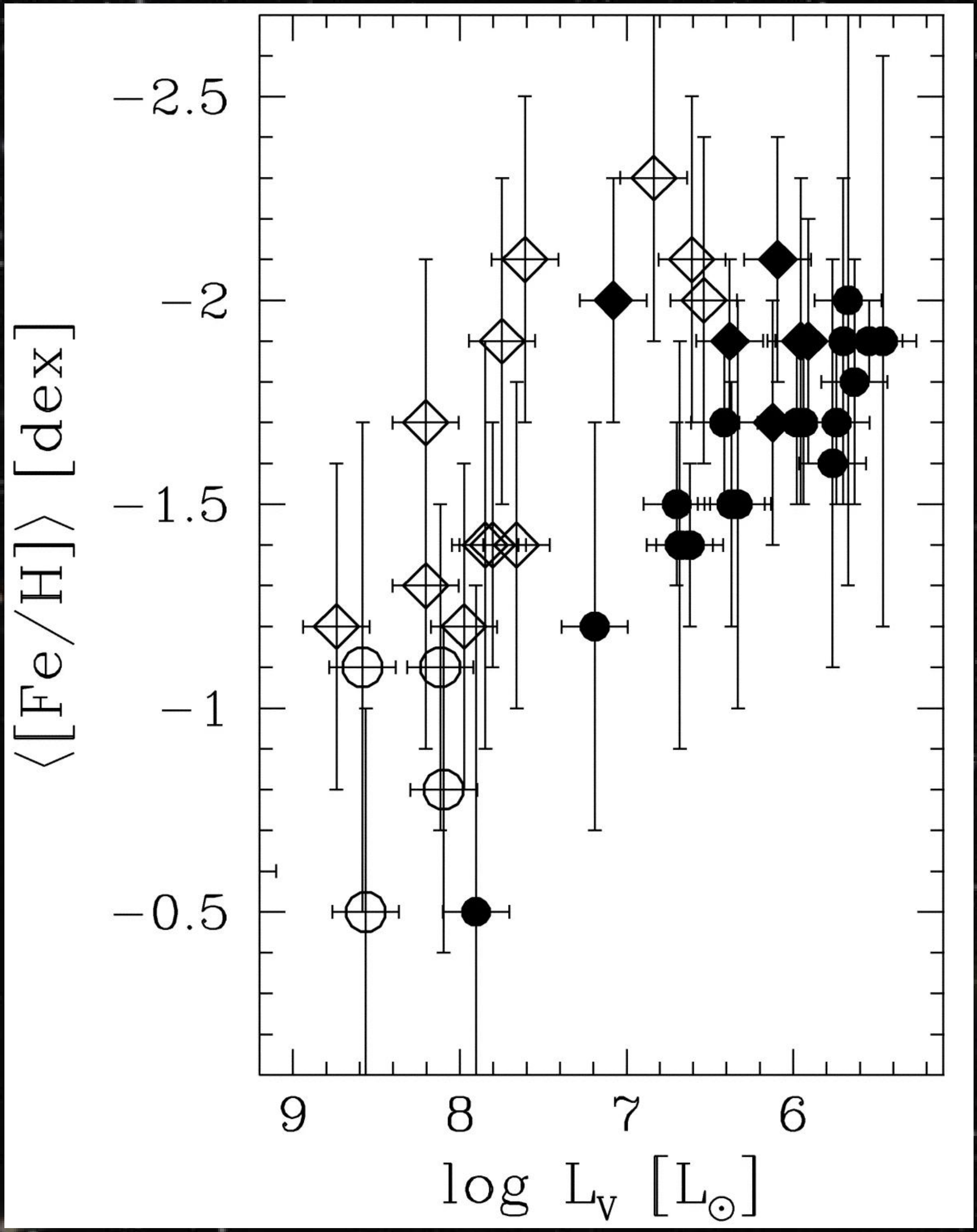


Milky Way

=

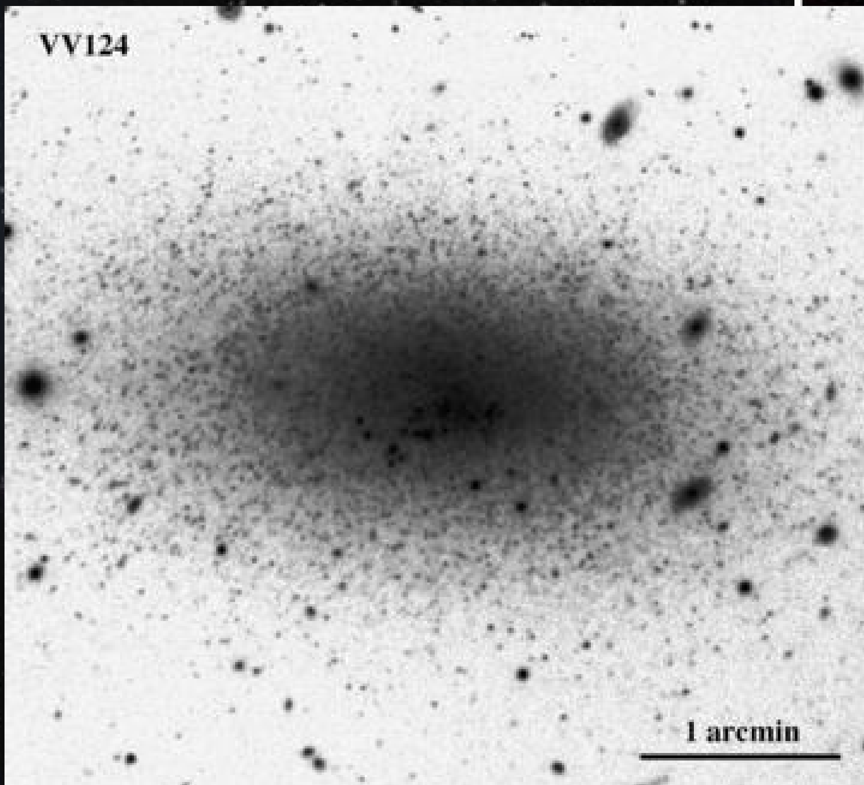
Leo I dSph

The metallicity-luminosity relation challenges the dIrr → dSph transformation model.

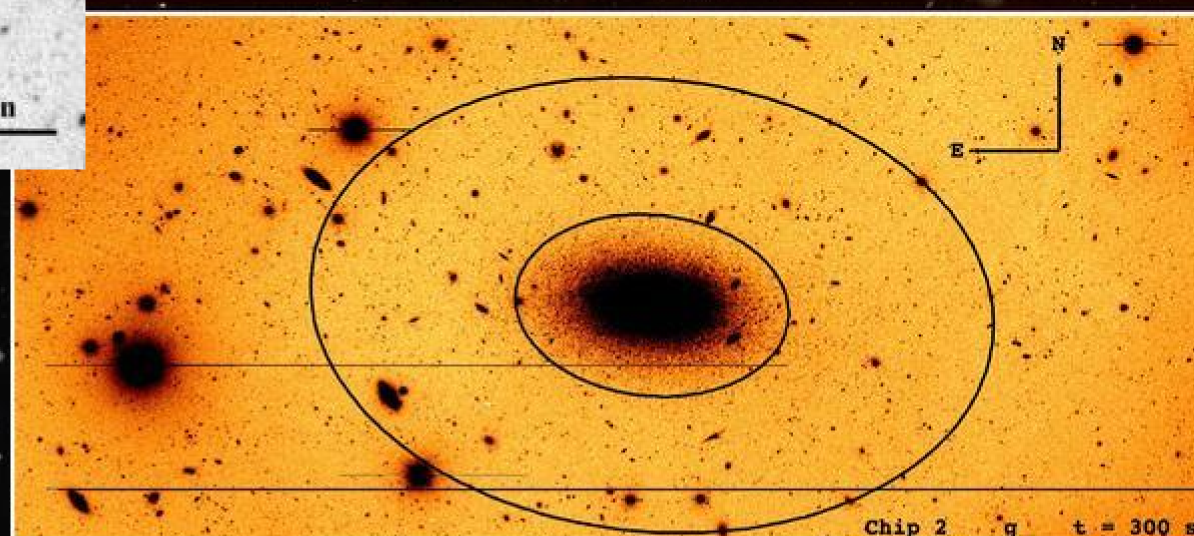


Grebel, Gallagher, & Harbeck 2003, AJ, 125, 1926

VV124 is the “newest” neighbor of the Local Group.

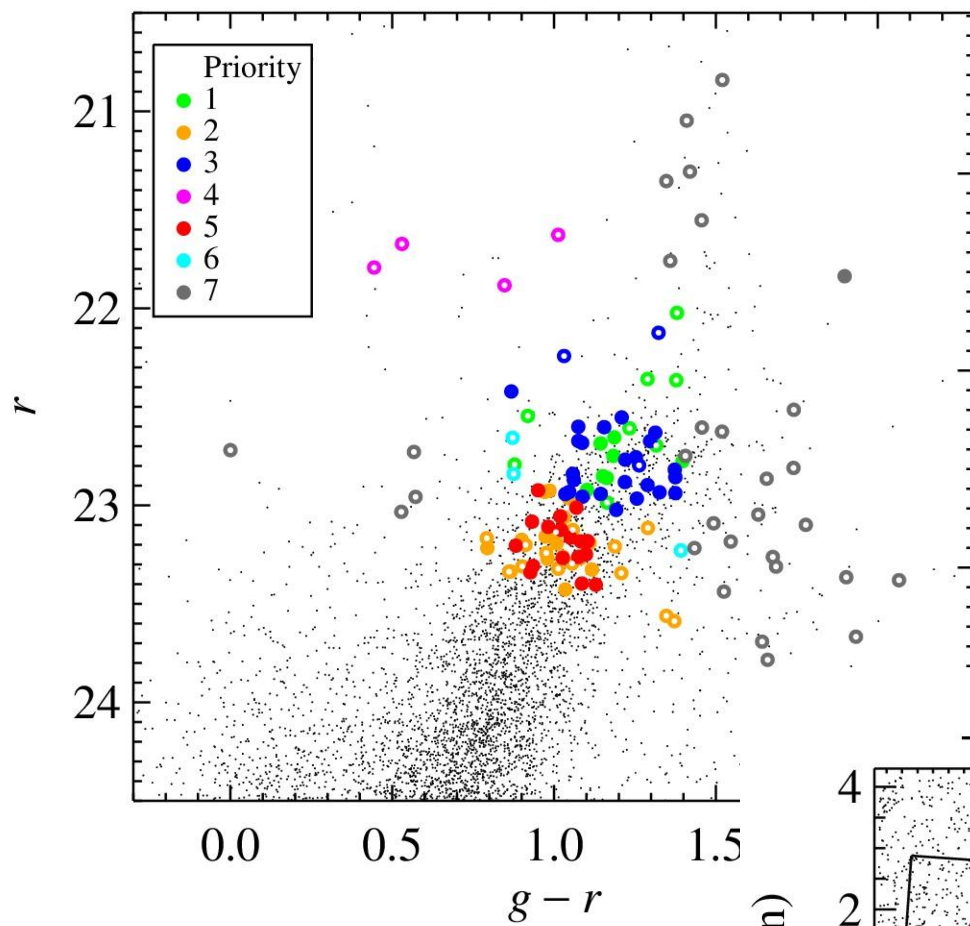


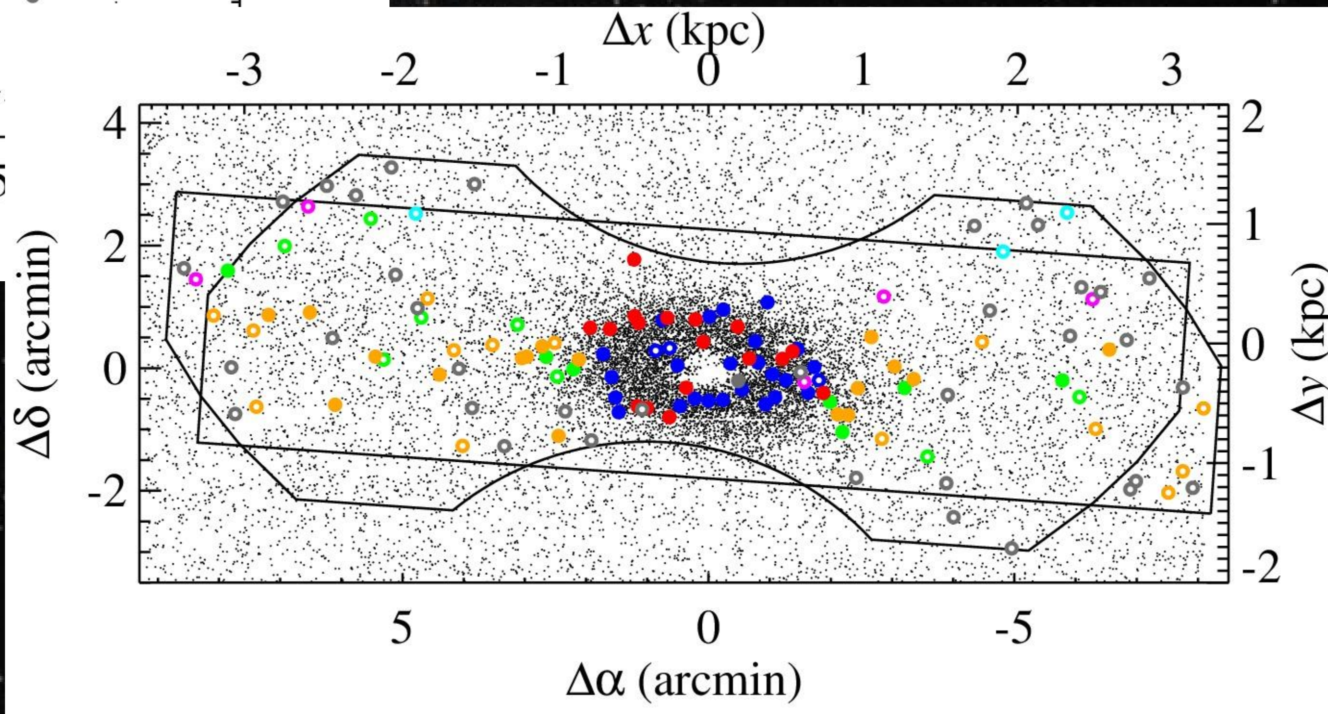
Kopylov et al. 2008, MNRAS, 387, L45



Bellazzini et al. 2011, A&A, 527, A58

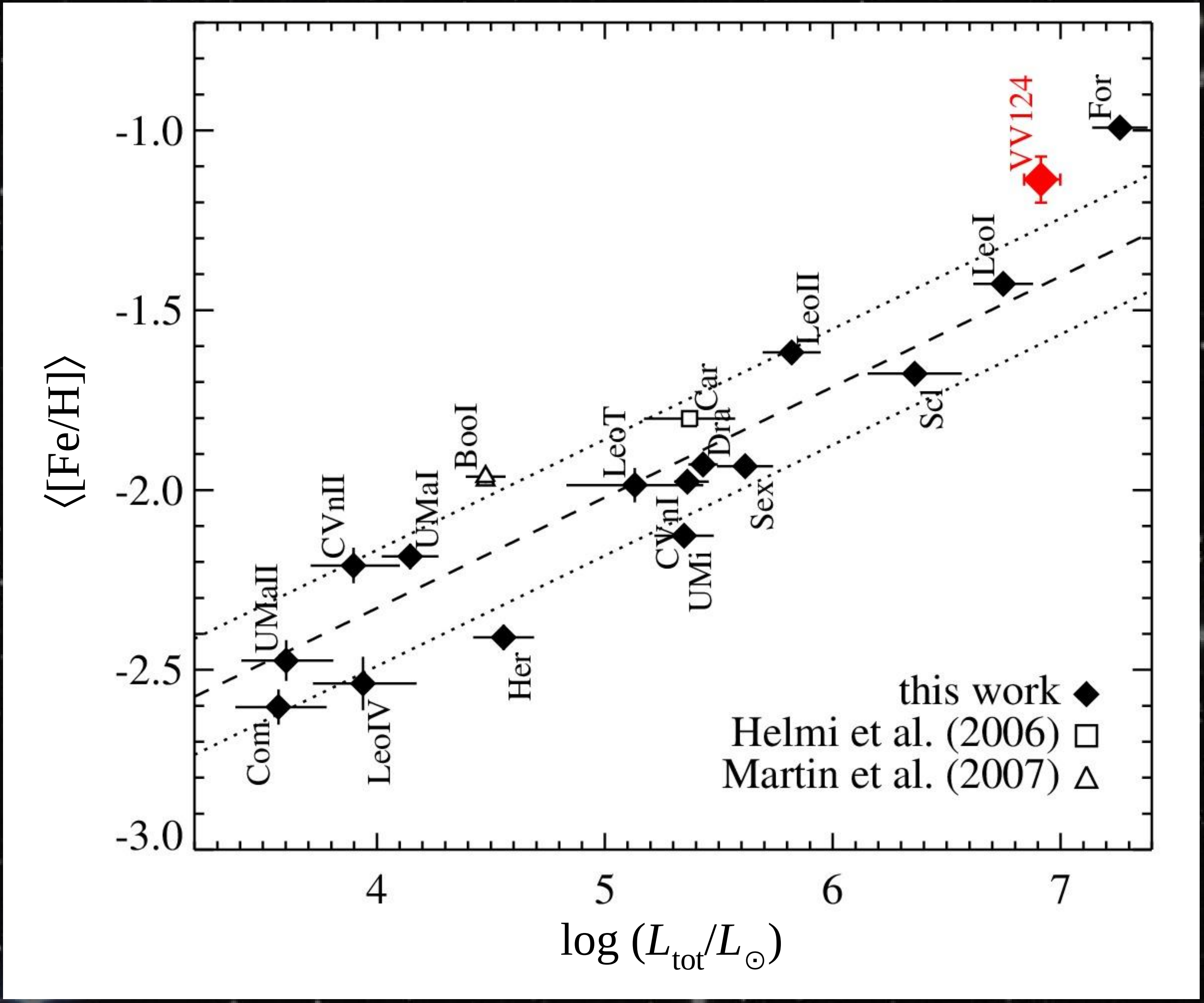
I pointed DEIMOS at VV124, 1.3 Mpc away.





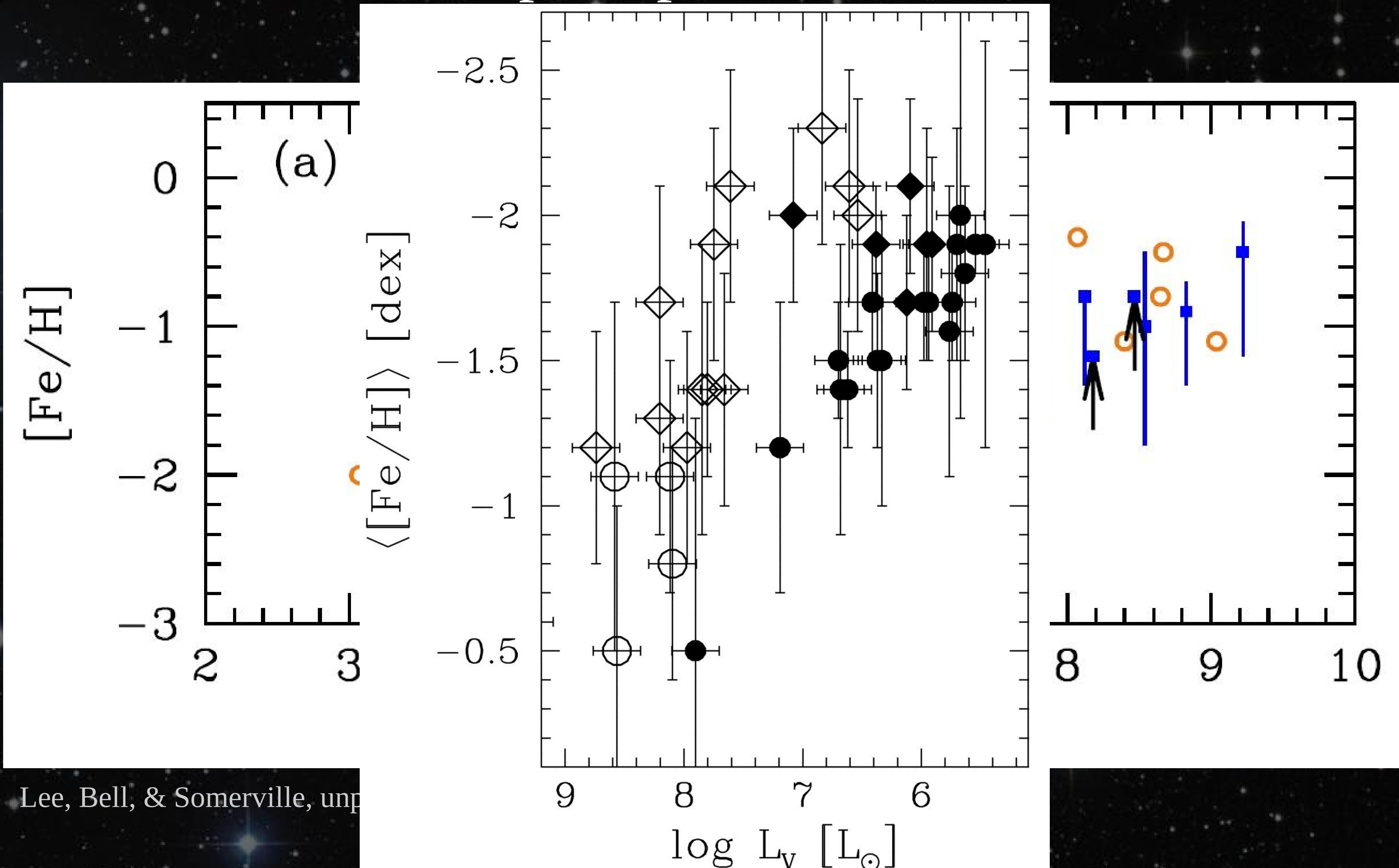
EK, Cohen, & Bellazzini, ApJ, submitted

VV124 and dSphs obey the same metallicity-luminosity relation.



EK, Cohen, & Bellazzini, ApJ, submitted

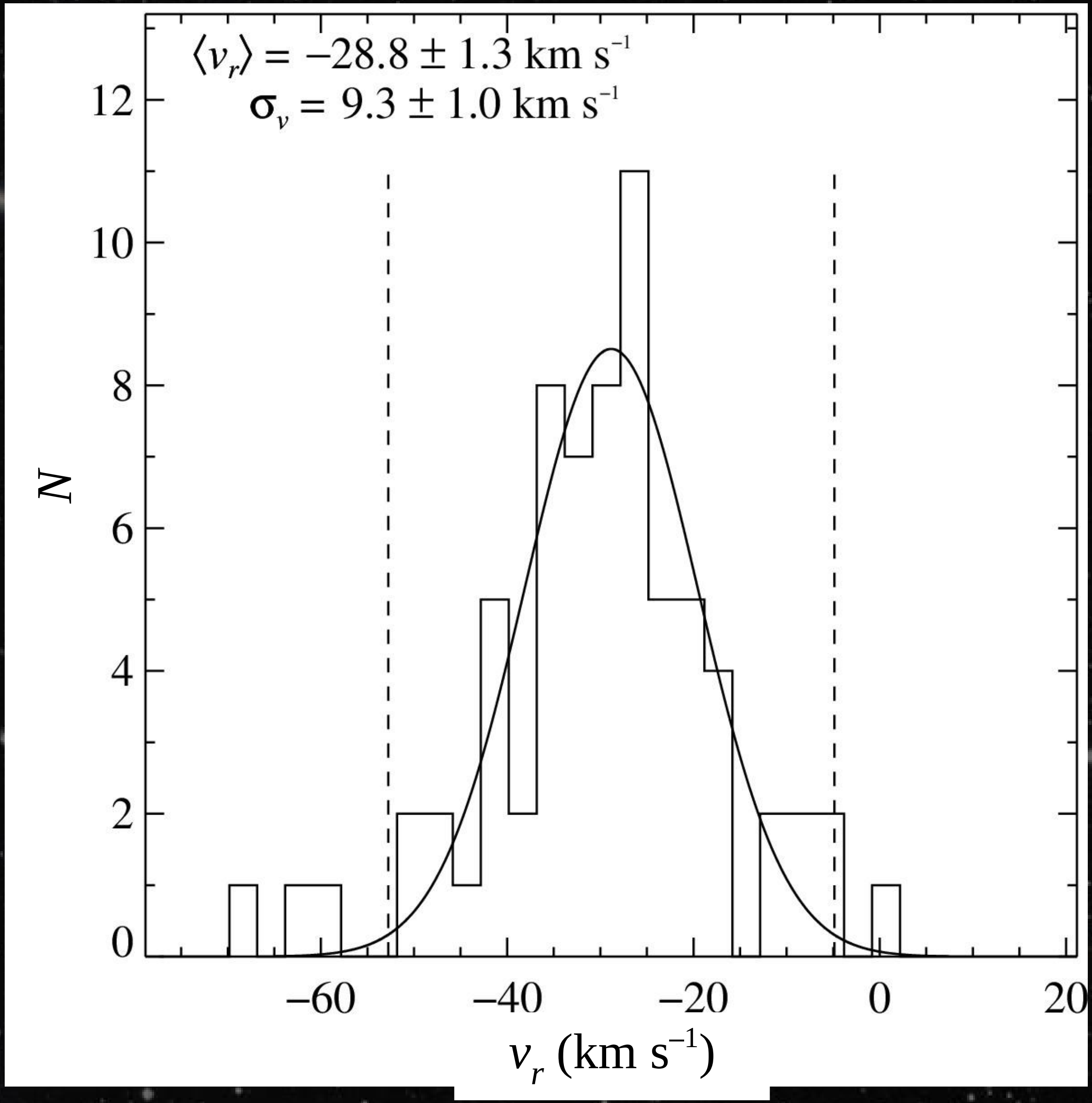
The dIrr-dSph metallicity dichotomy is perhaps fictional.



Lee, Bell, & Somerville, unp

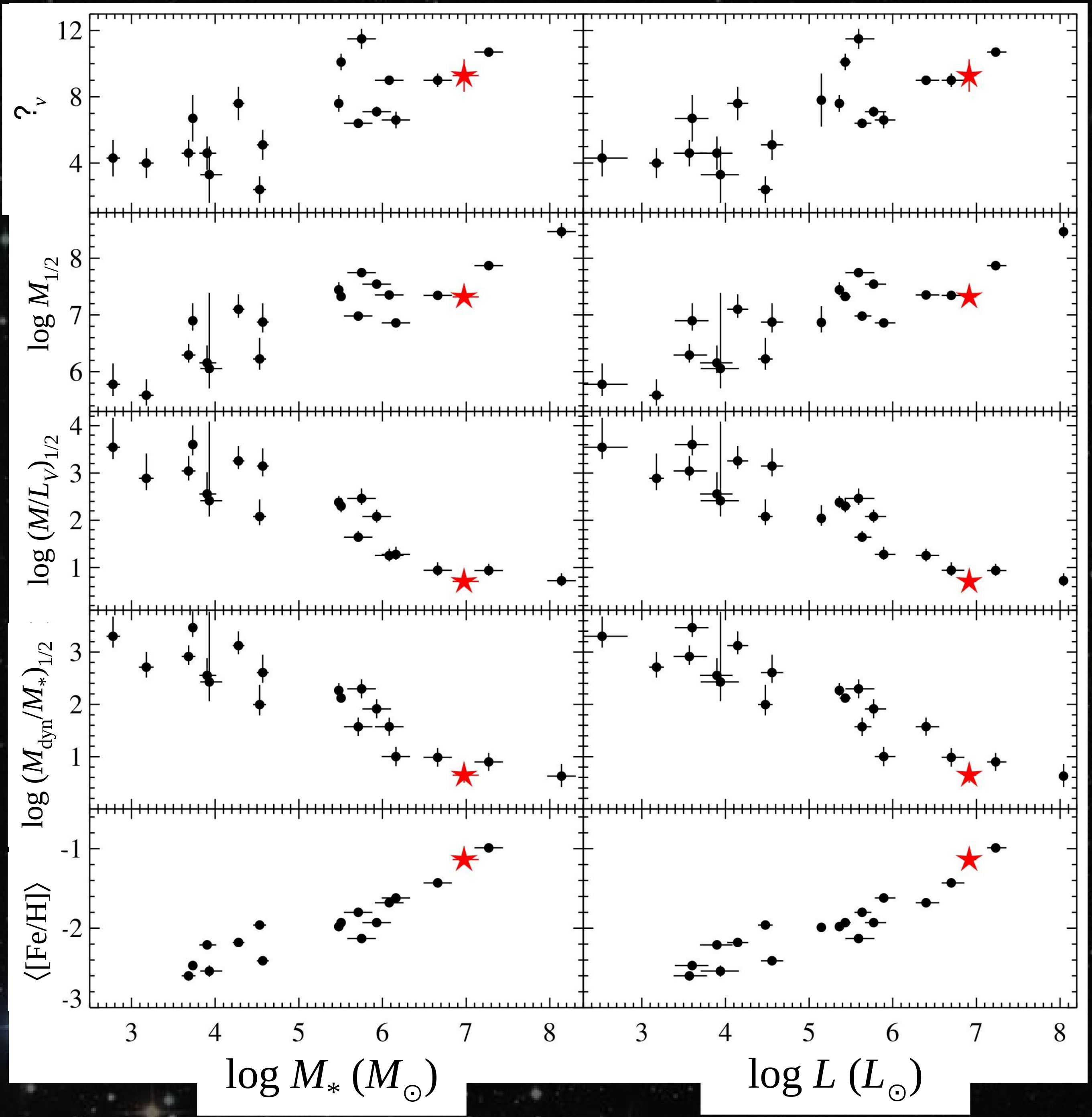
Grebel, Gallagher, & Harbeck 2003, AJ, 125, 1926

VV124 is dark matter-dominated like a dSph.



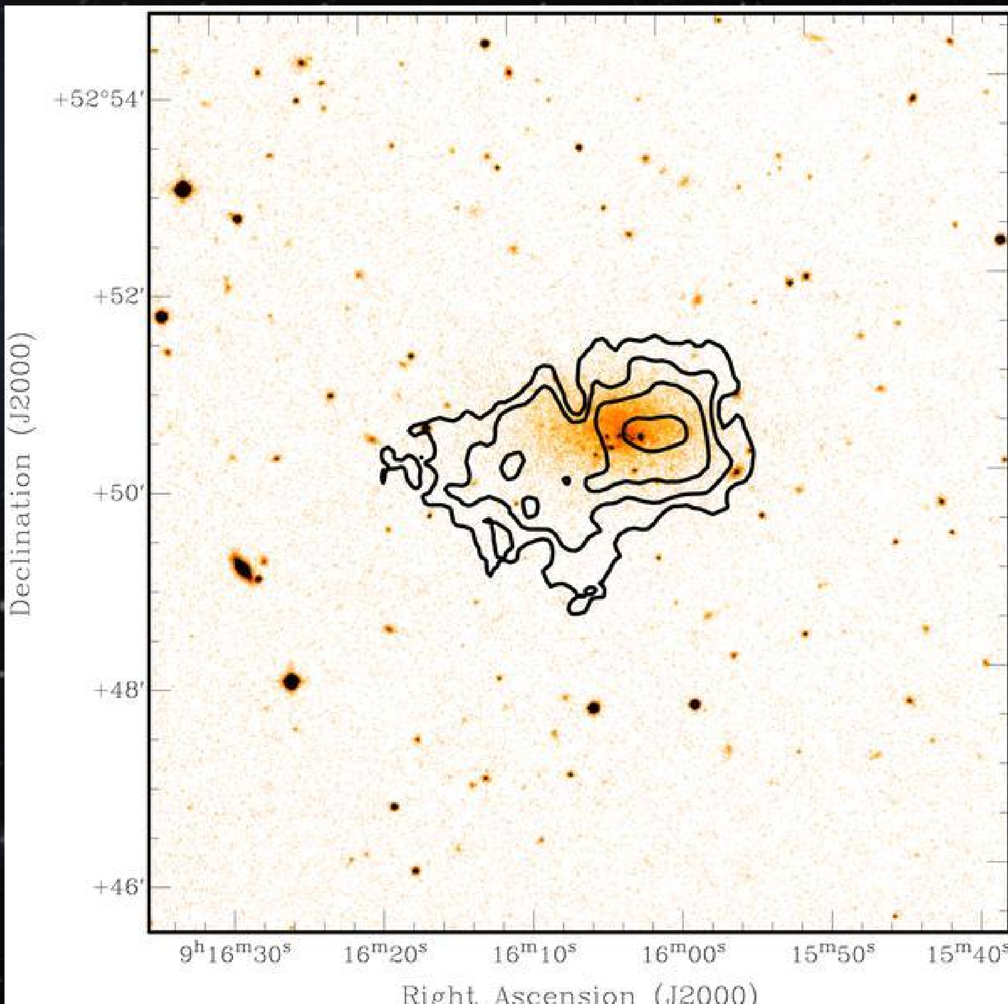
EK, Cohen, & Bellazzini, ApJ, submitted

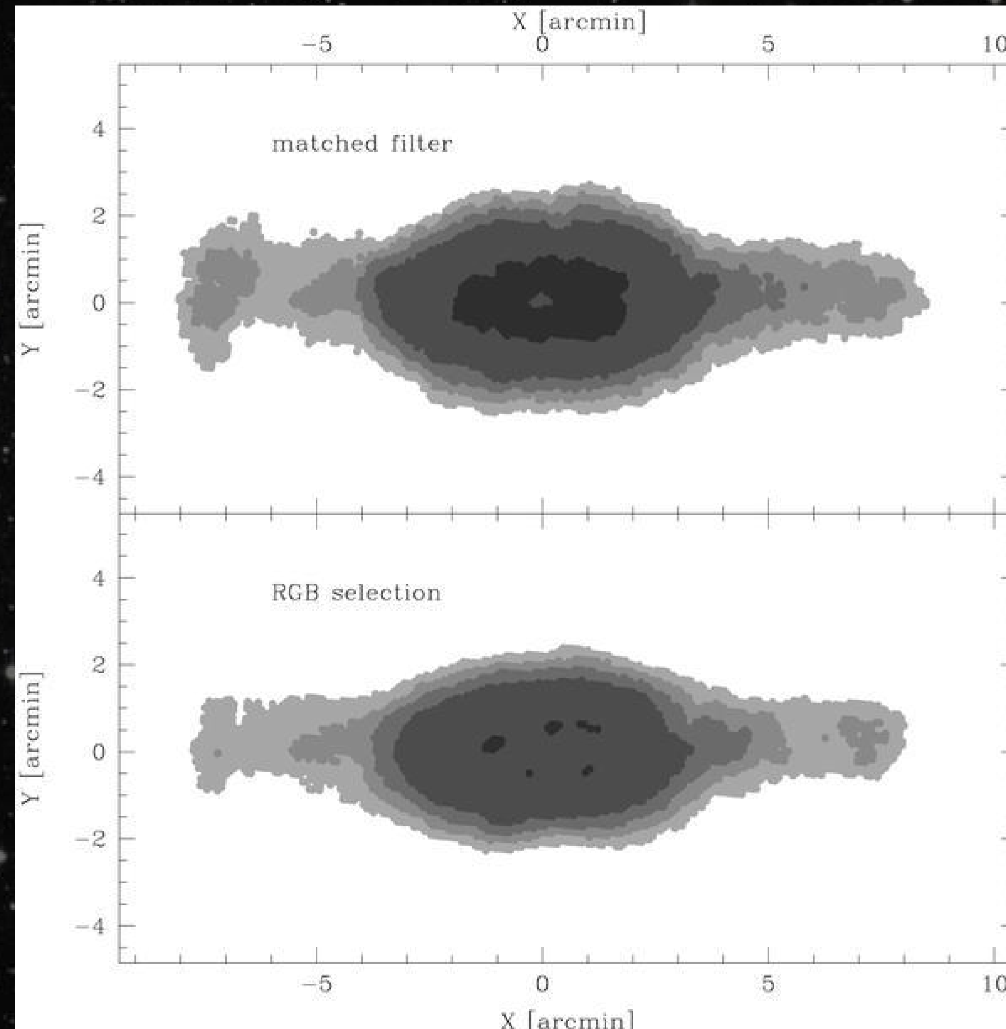
In fact, VV124 looks like a dSph all around ...



EK, Cohen, & Bellazzini, ApJ, submitted

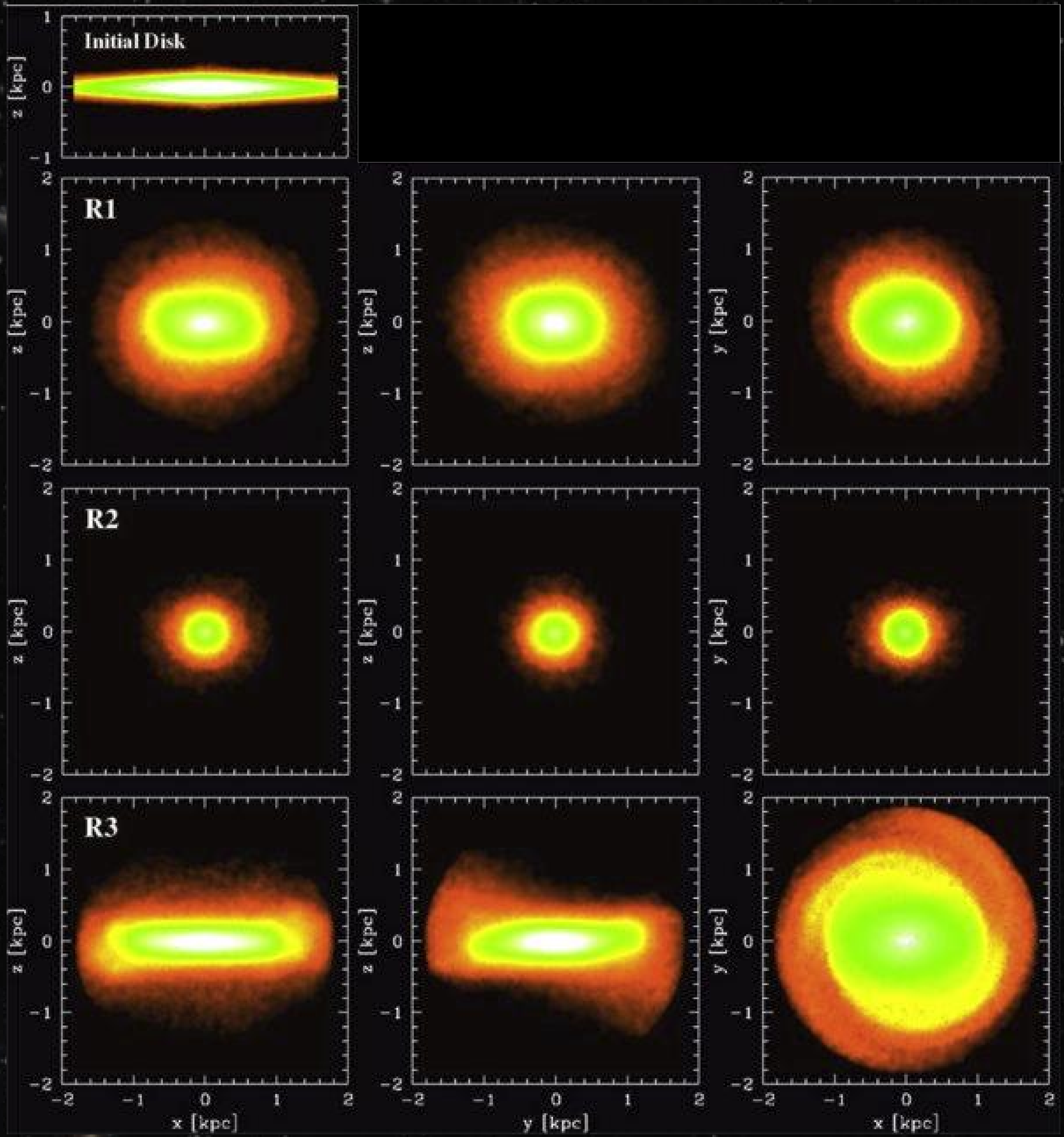
… except that it has gas … and an apparent disk.





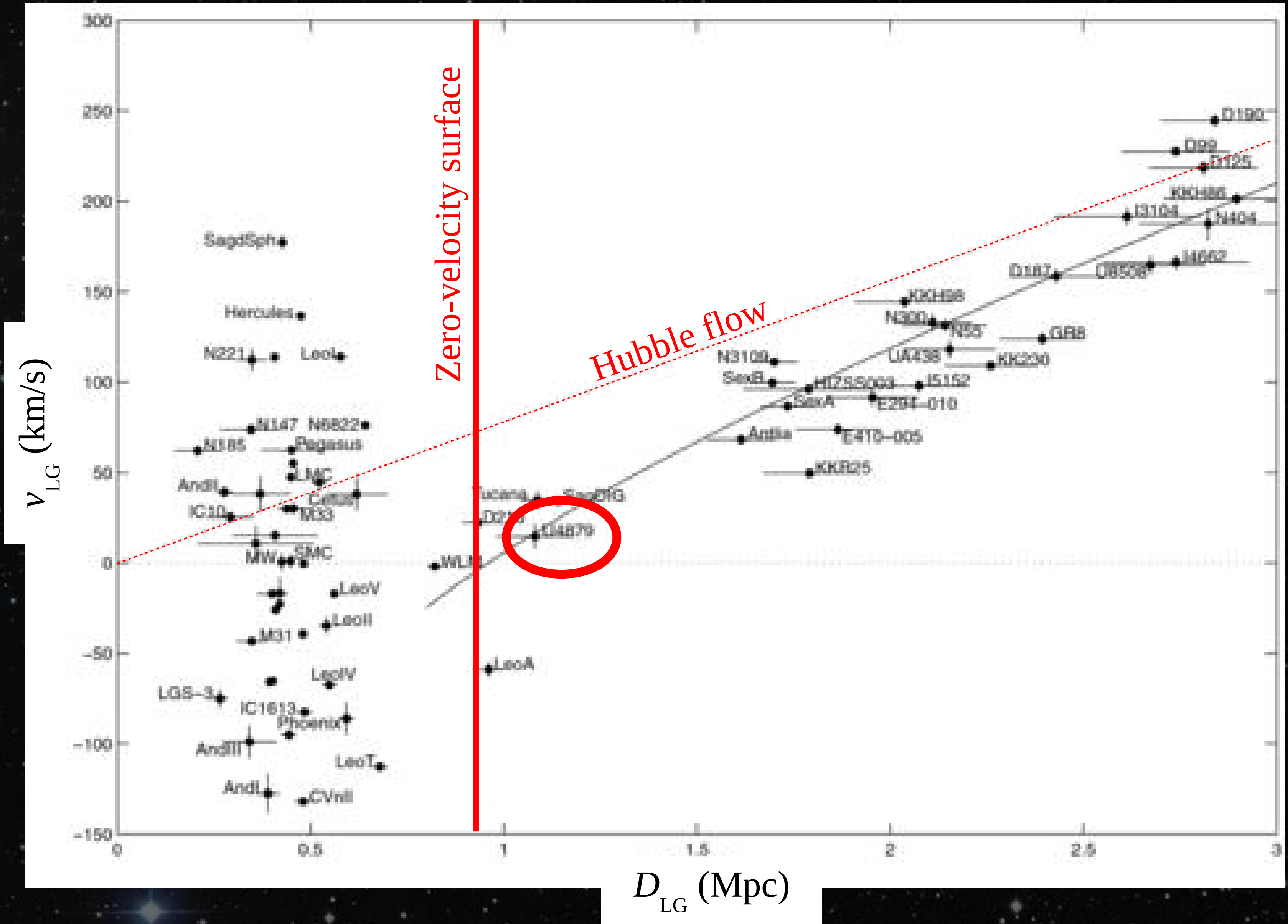
Bellazzini et al. 2011, A&A, 527, A58

VV124 is an excellent candidate for tidal stirring, whereby a dIrr becomes a dSph.



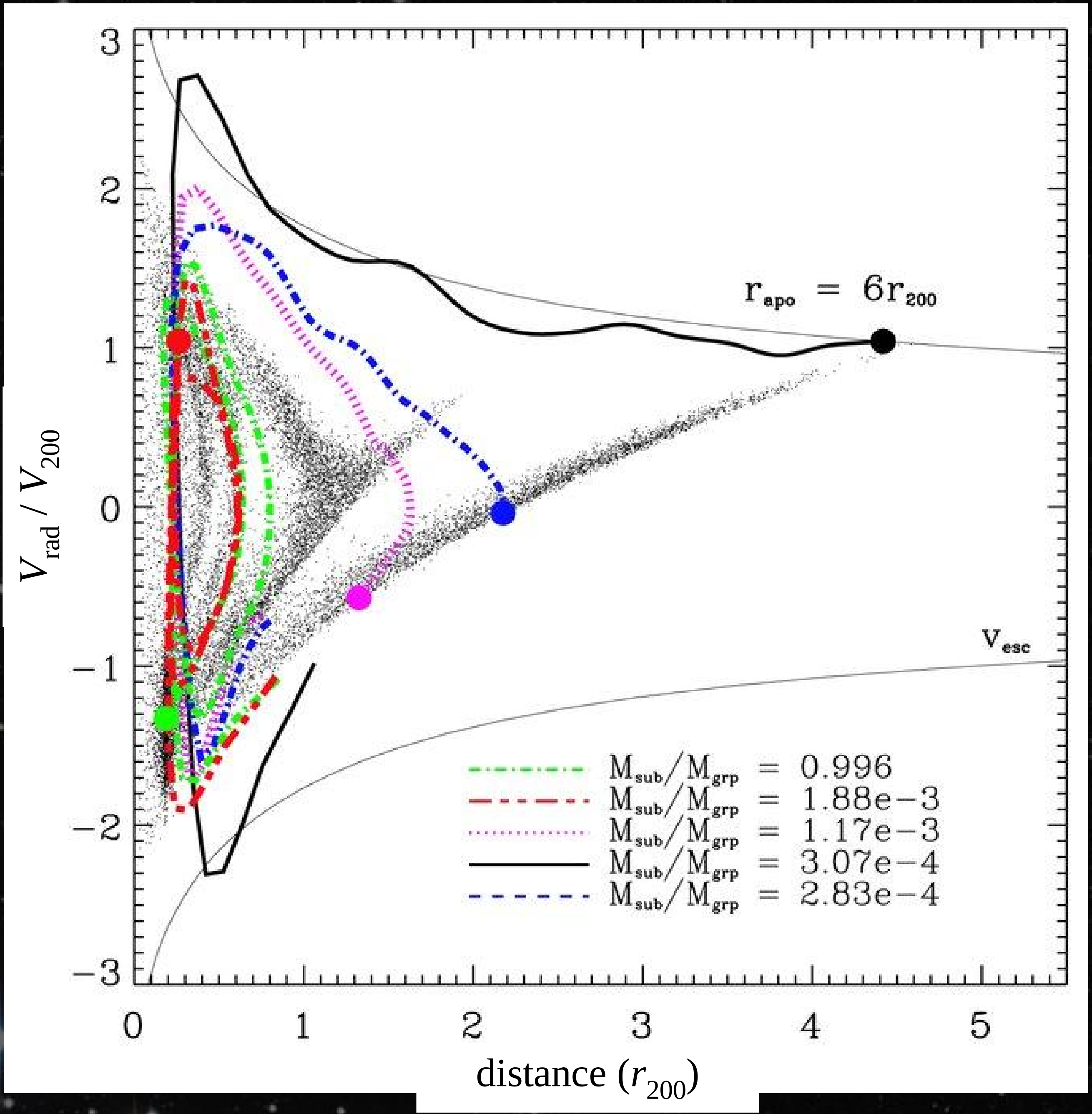
Kazantzidis et al. 2011, ApJ, 726, 98

VV124 may not have interacted with the Milky Way or M31 ...



Karachentsev et al. 2009, MNRAS, 393, 1265

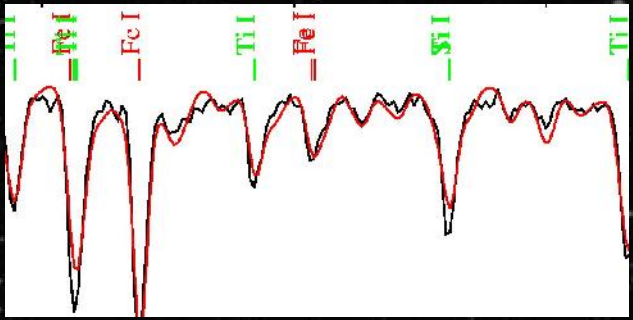
… or maybe it did.



Ludlow et al. 2009, ApJ, 692, 931

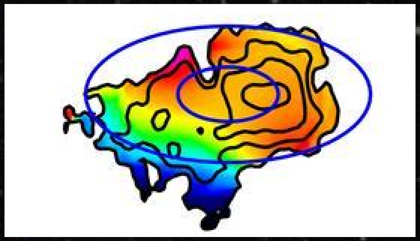
Conclusions

- **Medium-resolution spectroscopy** is an efficient way to measure elemental abundances.



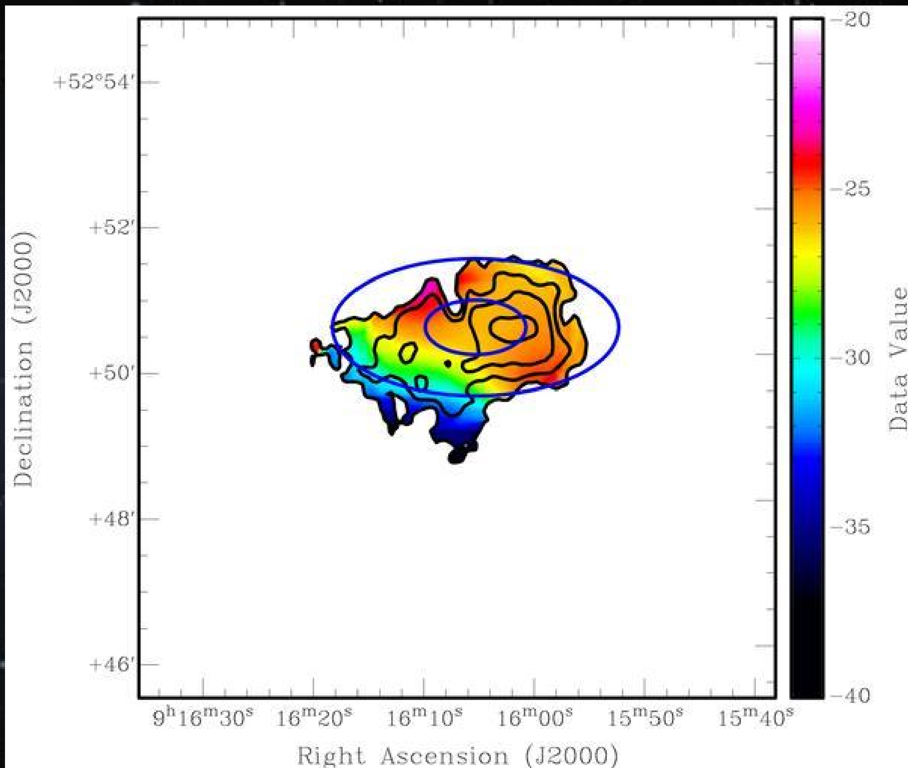
- Dwarf galaxies **lost >96% of their metals** to galactic outflows and gas stripping.

- DIrrs and dSphs might obey the same mass-metallicity relation, which supports the **dIrr→dSph** theory.

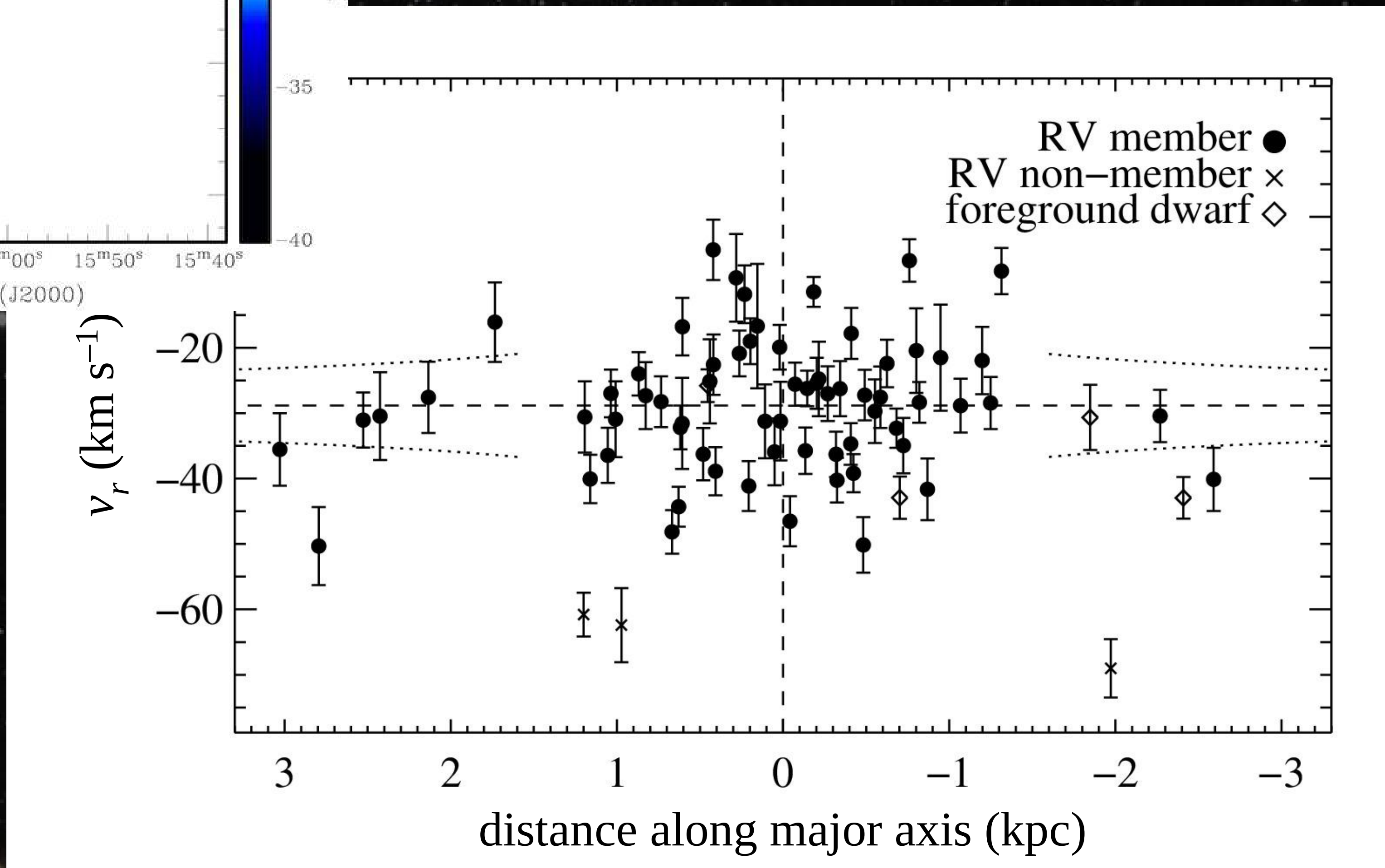


- But ultra-faint dwarfs did not become ultra-faint through tidal stripping.

But VV124 does not rotate!



Bellazzini et al. 2011, A&A, 527, A58



EK, Cohen, & Bellazzini, ApJ, submitted