Using Andromeda XIX to probe galaxy evolution at the lowest surface brightnesses

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University of Surrey

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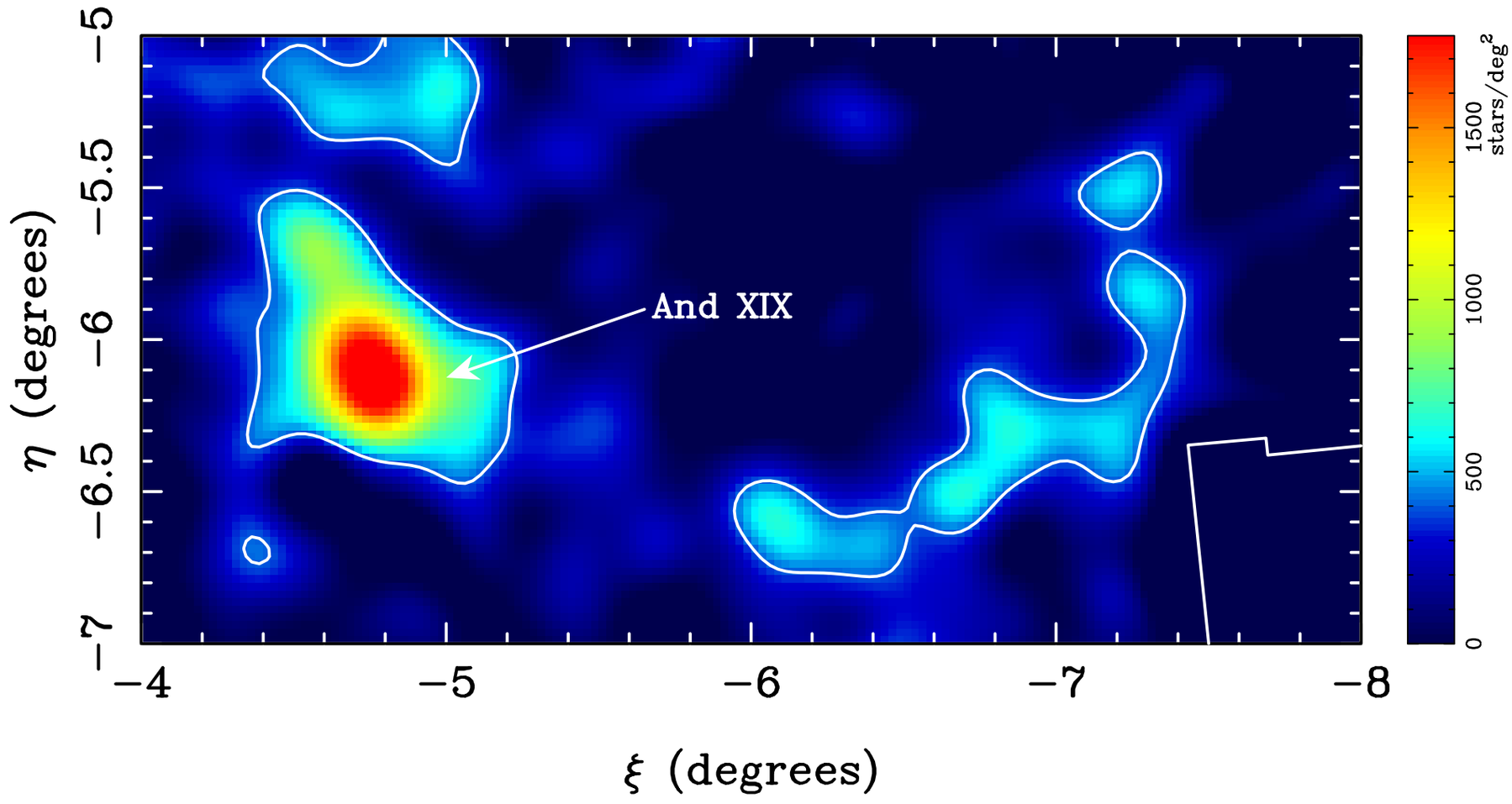
Andromeda XIX - a Hipster galaxy

Diffuse before it was cool



McConnachie et al. 2008

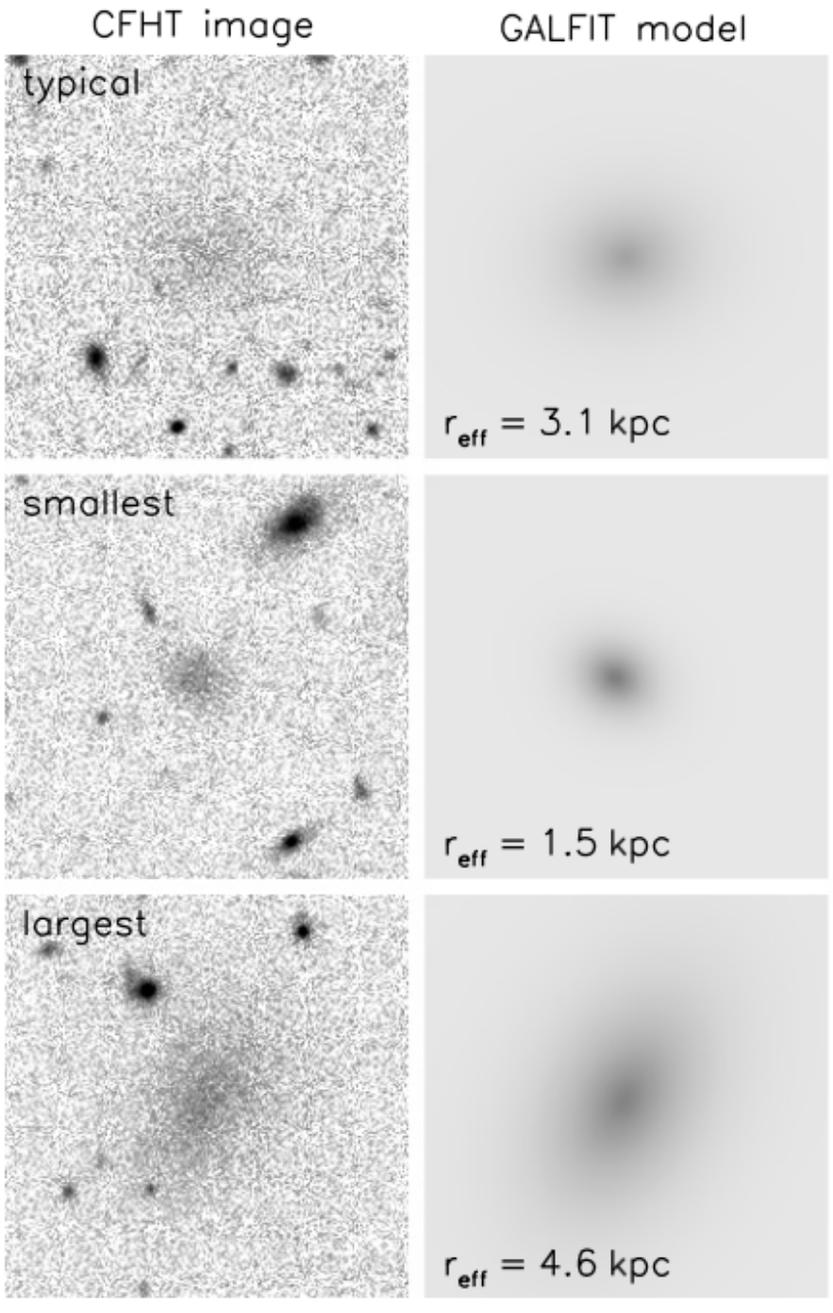
CFHT imaging

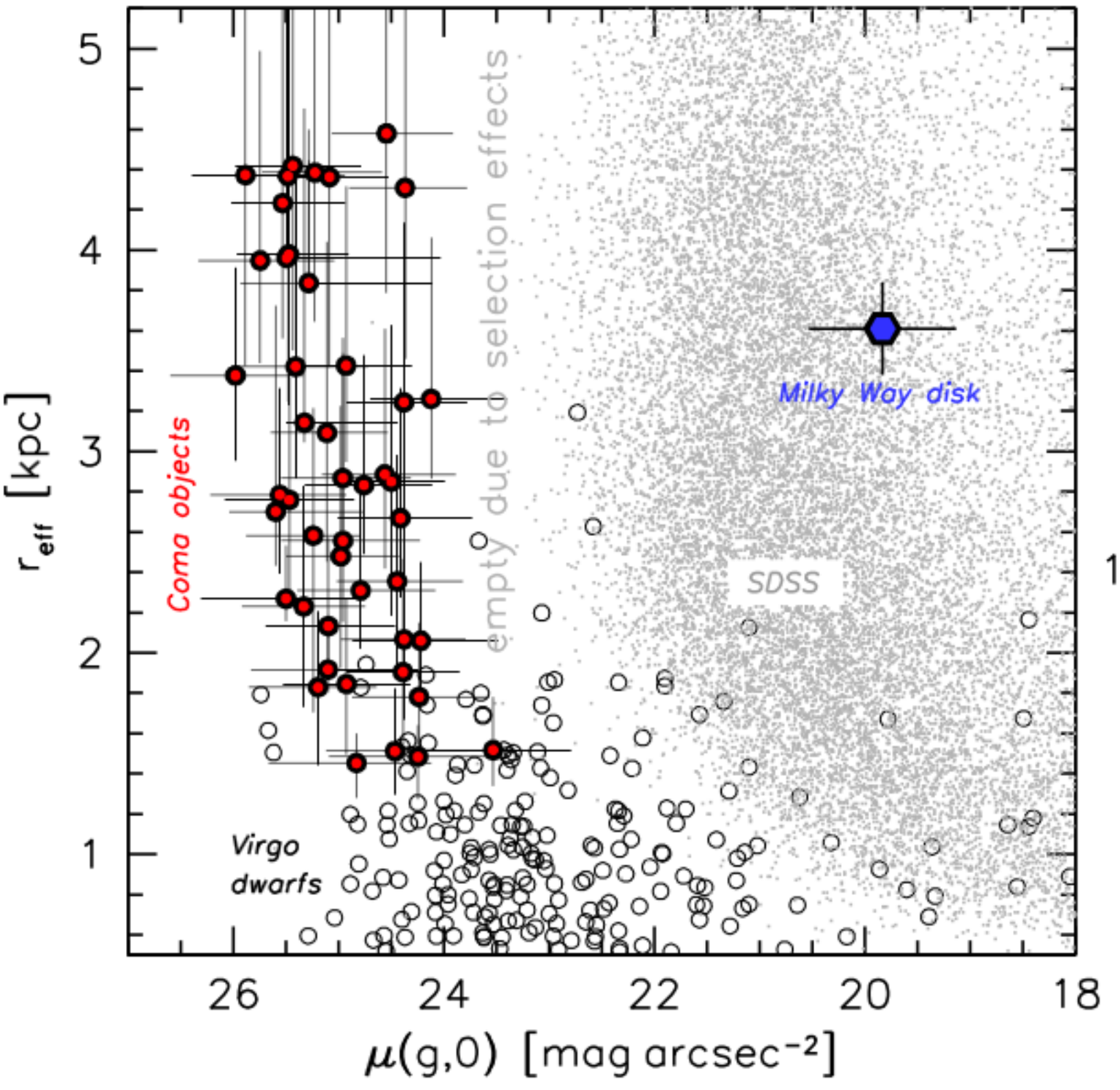
Bate et al. 2013

Surprisingly low velocity dispersion…

Collins et al. 2013,
McGaugh & Milgrom (2013)

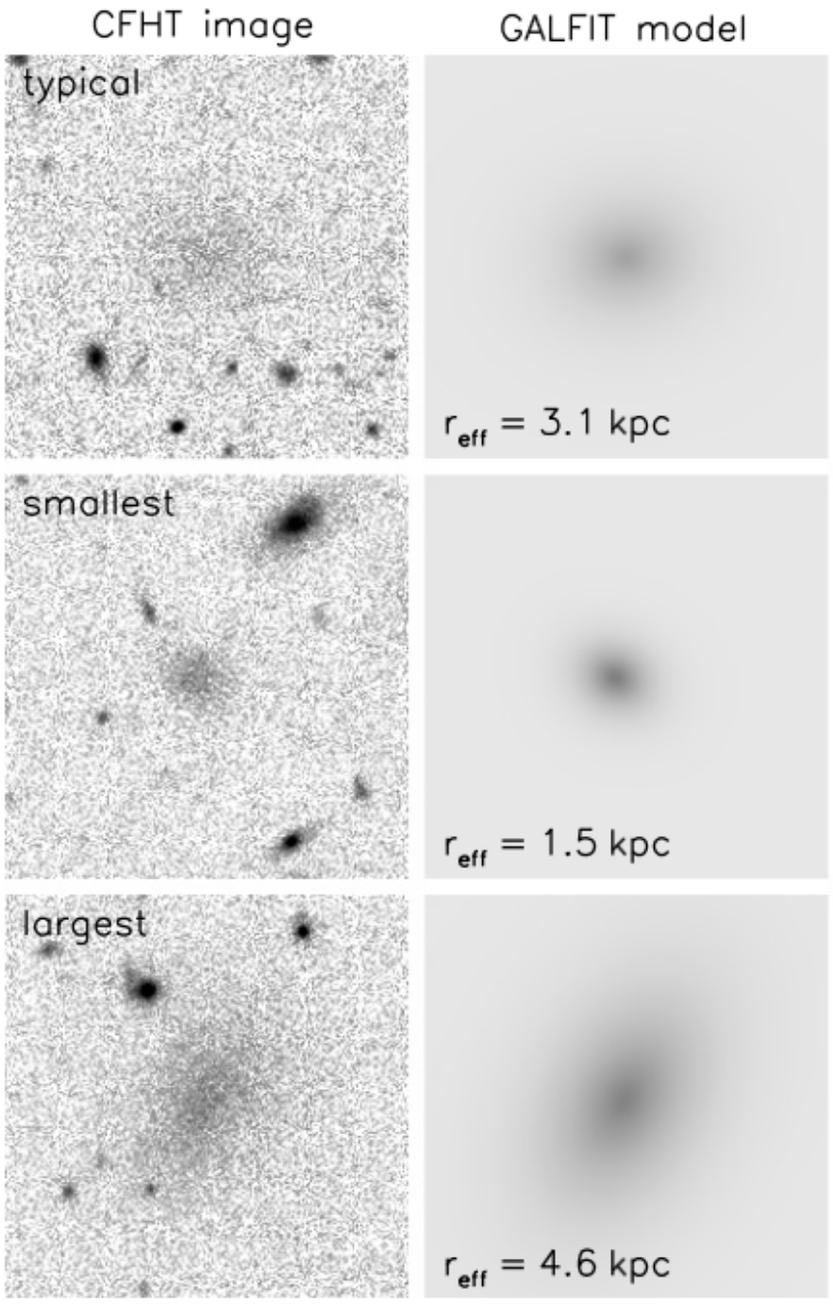
Recently, diffuse galaxies have become cool



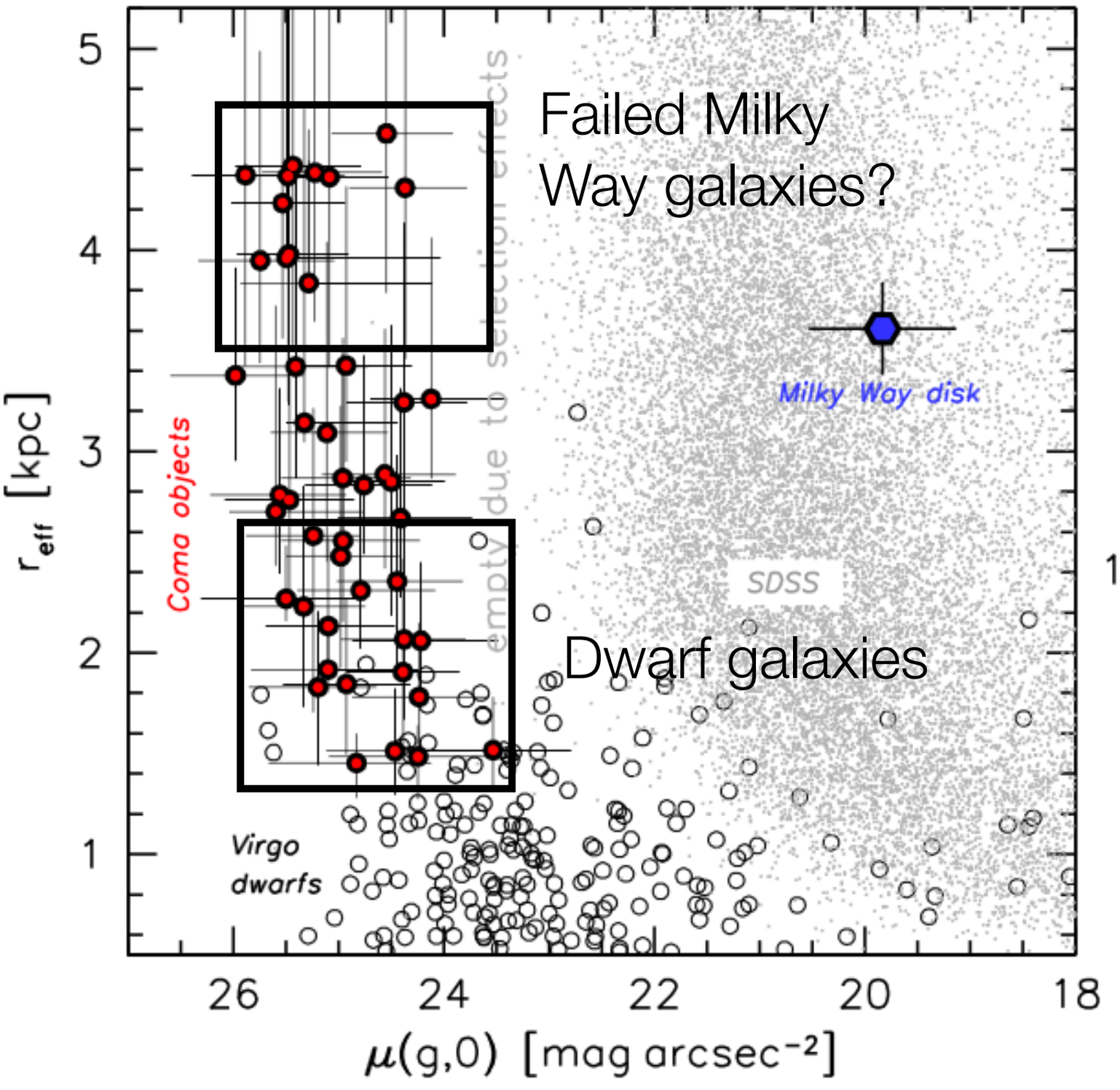


van Dokkum et al. 2015

But how do they form?

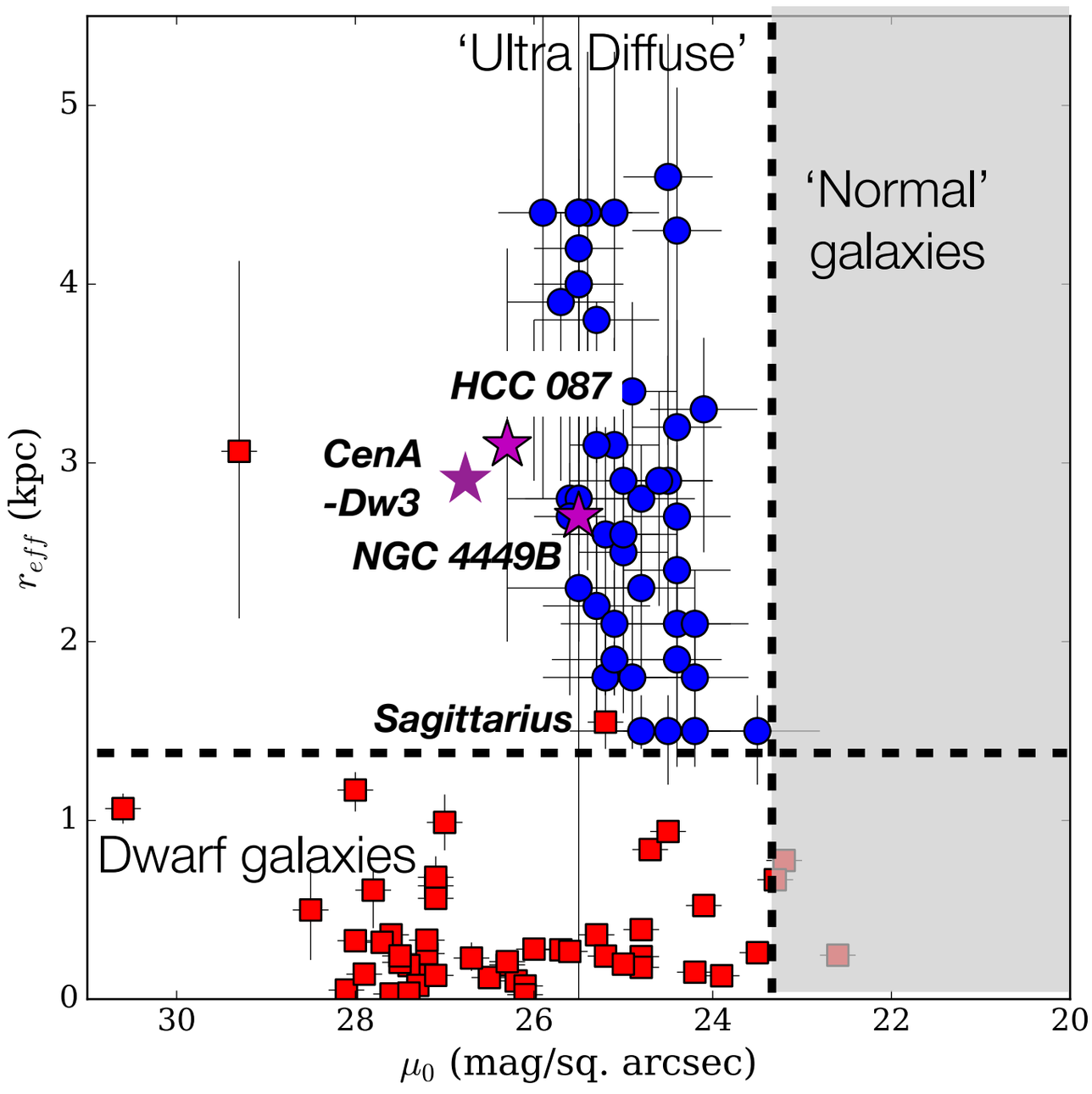


Di



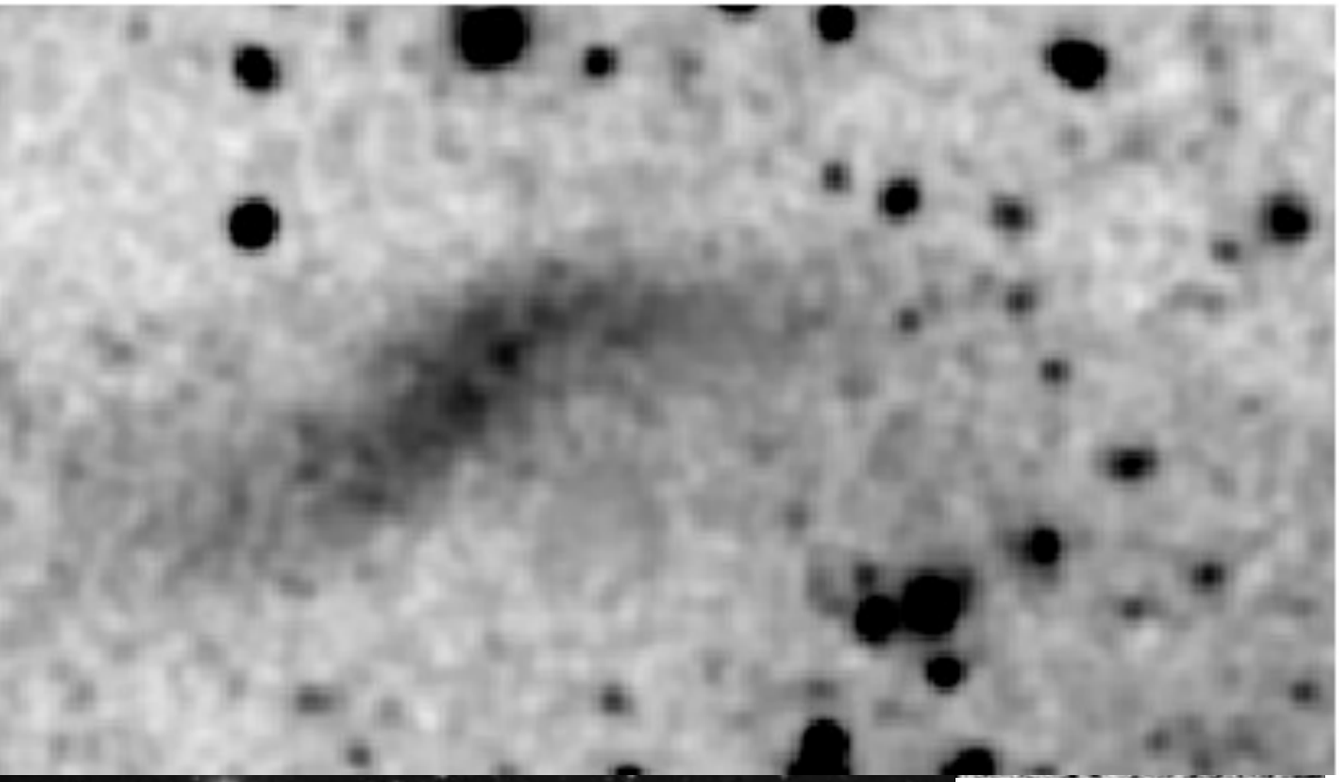
van Dokkum et al. 2015

We can learn from ‘local’ analogues

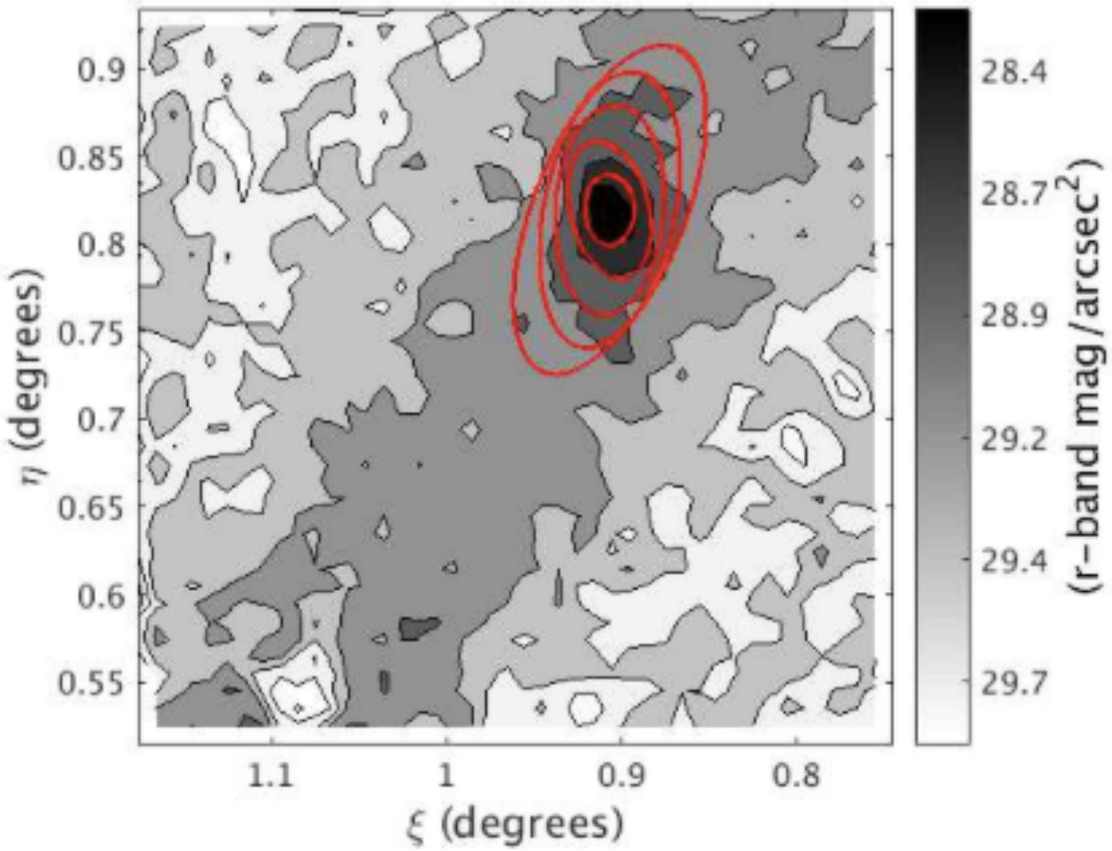


van dokkum+15, Crnojevic+15, McConnachie+12, Martin+16

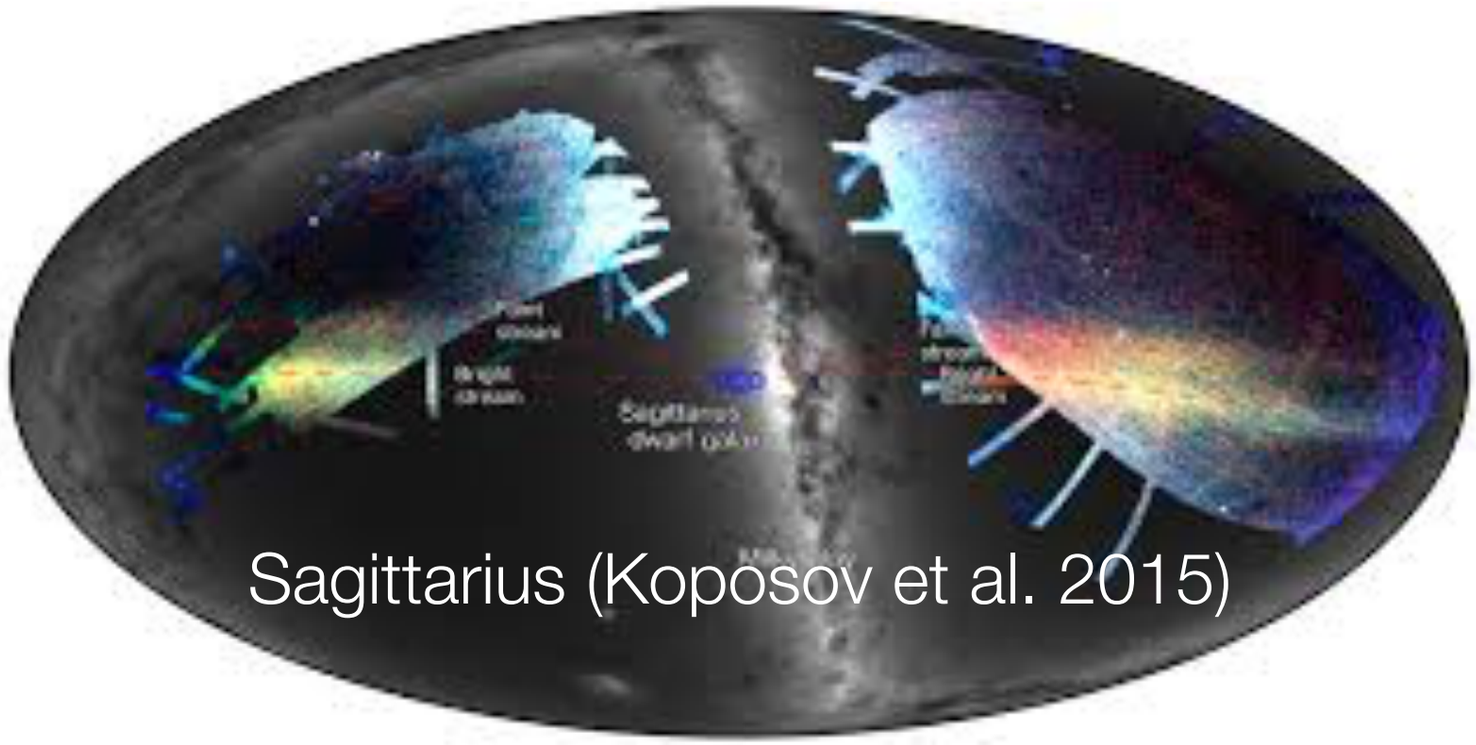
HCC-087 (Koch et al, 2012)



CenA-MM-Dw3, Crnojevic+15



NGC 4449B, (Rich et al. 2012, Martinez-Delgado et al. 2012)



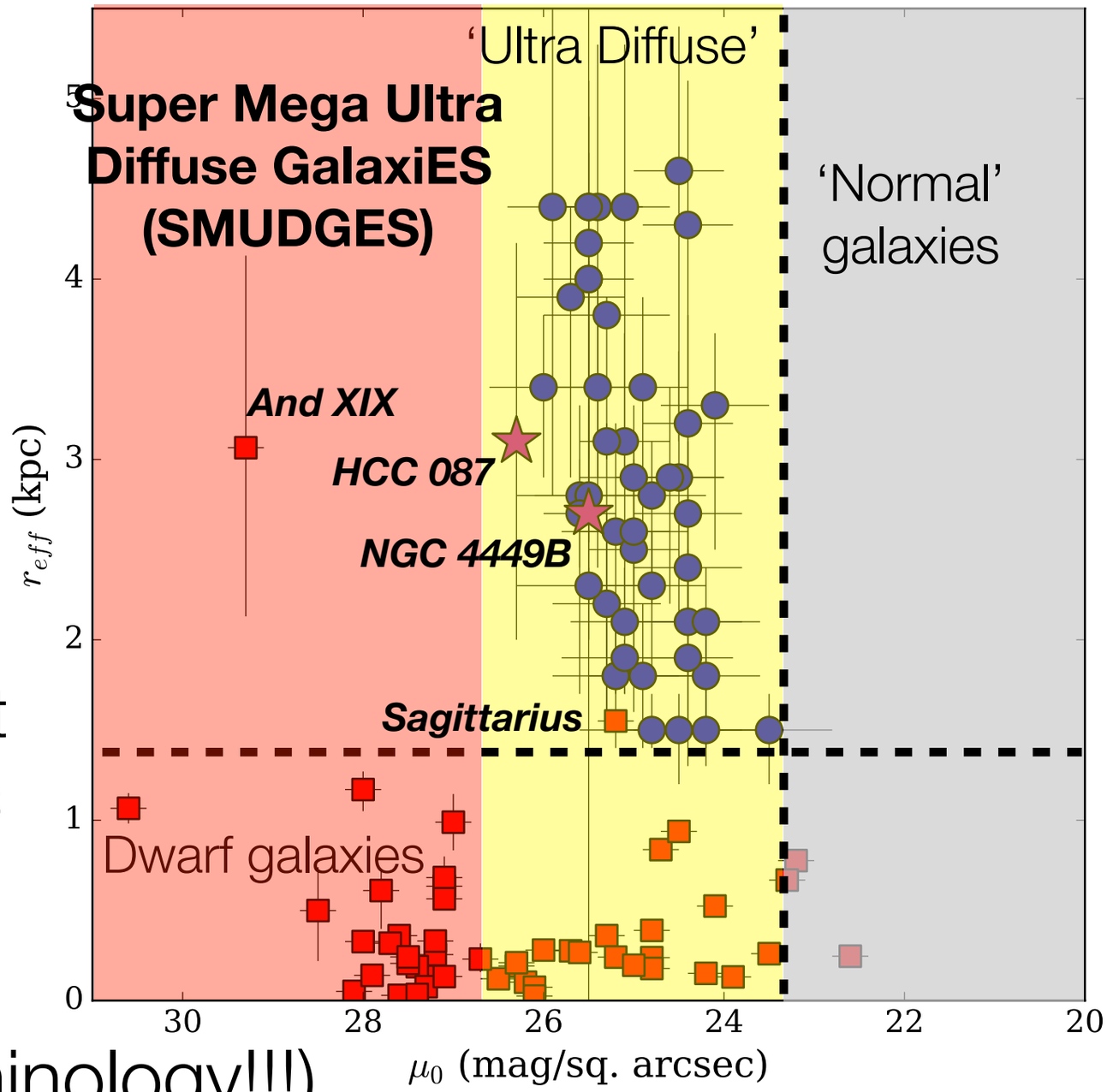
Sagittarius (Koposov et al. 2015)

We can learn from ‘local’ analogues

Most local analogues are stripped. What about And XIX?

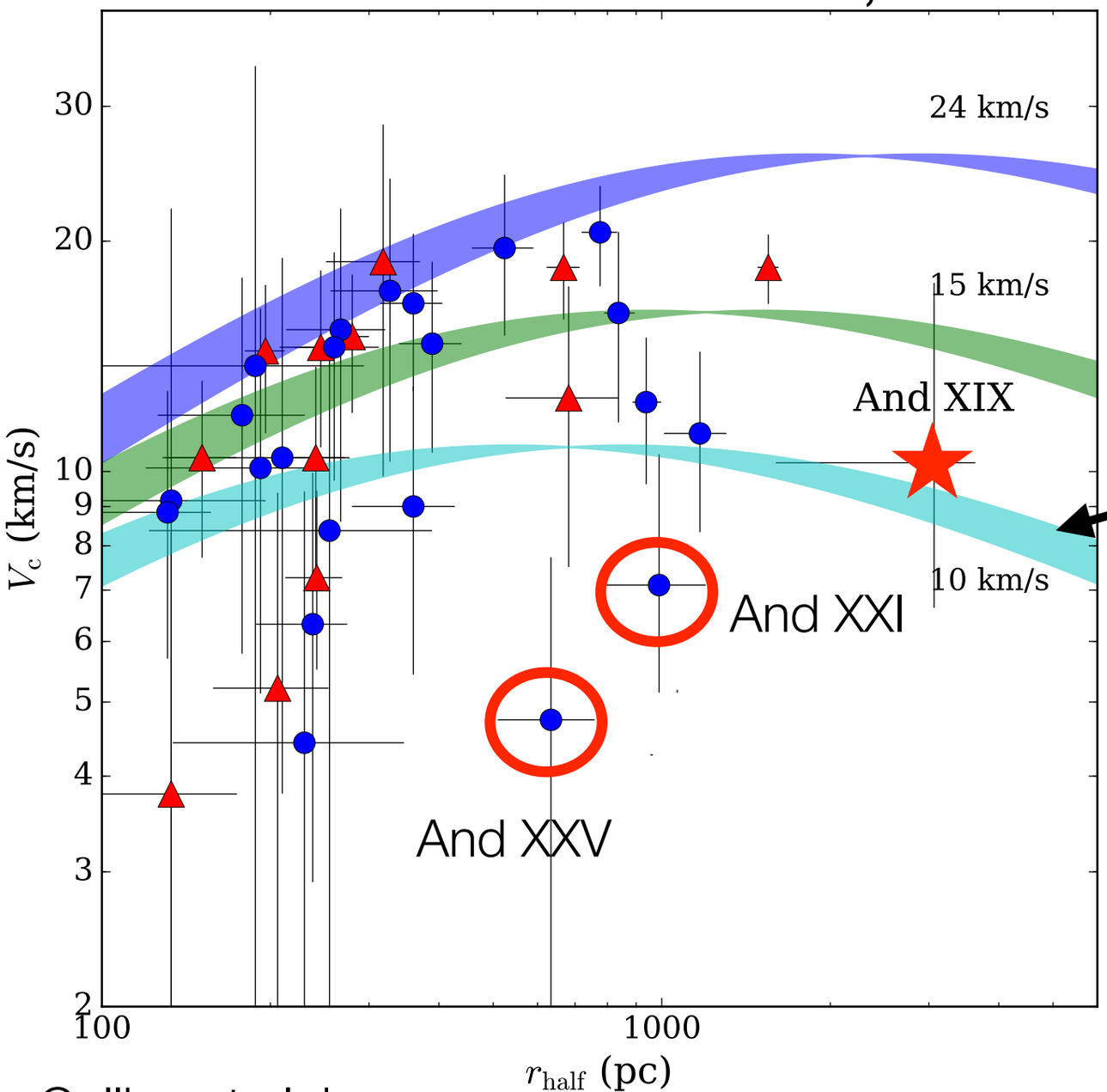
Although… I’ve been informed that it doesn’t count as a UDG…

(NOT official terminology!!!)



Andromeda XIX - a low mass halo?

Dark matter dominated, but…



Collins et al. in prep

Cooling limit for forming a galaxy
(e.g. Haiman+97)

Data from Walker+09, Tollerud+12,14, Collins+13,15, Caldwell+17

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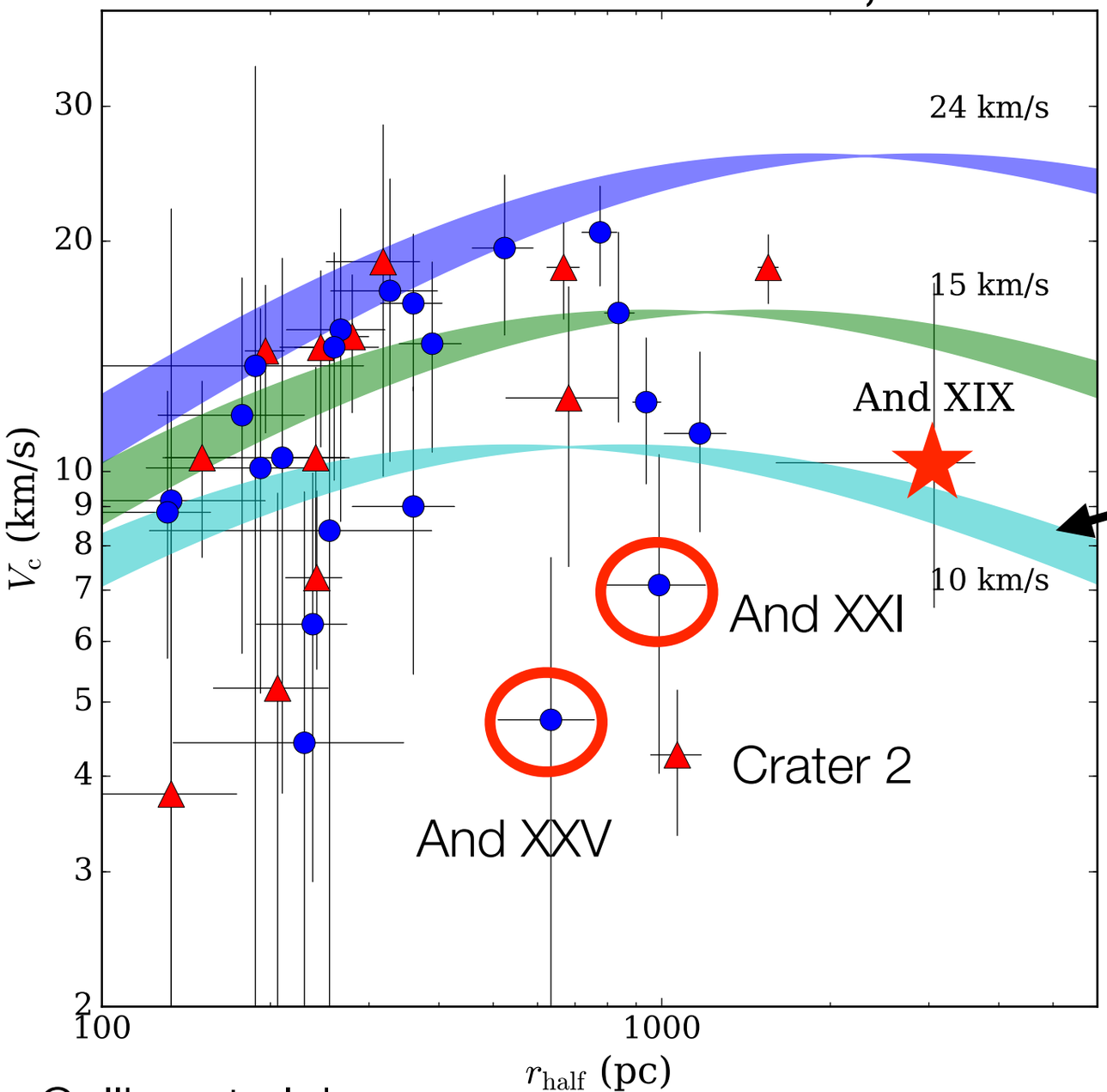


Collins et al. in prep

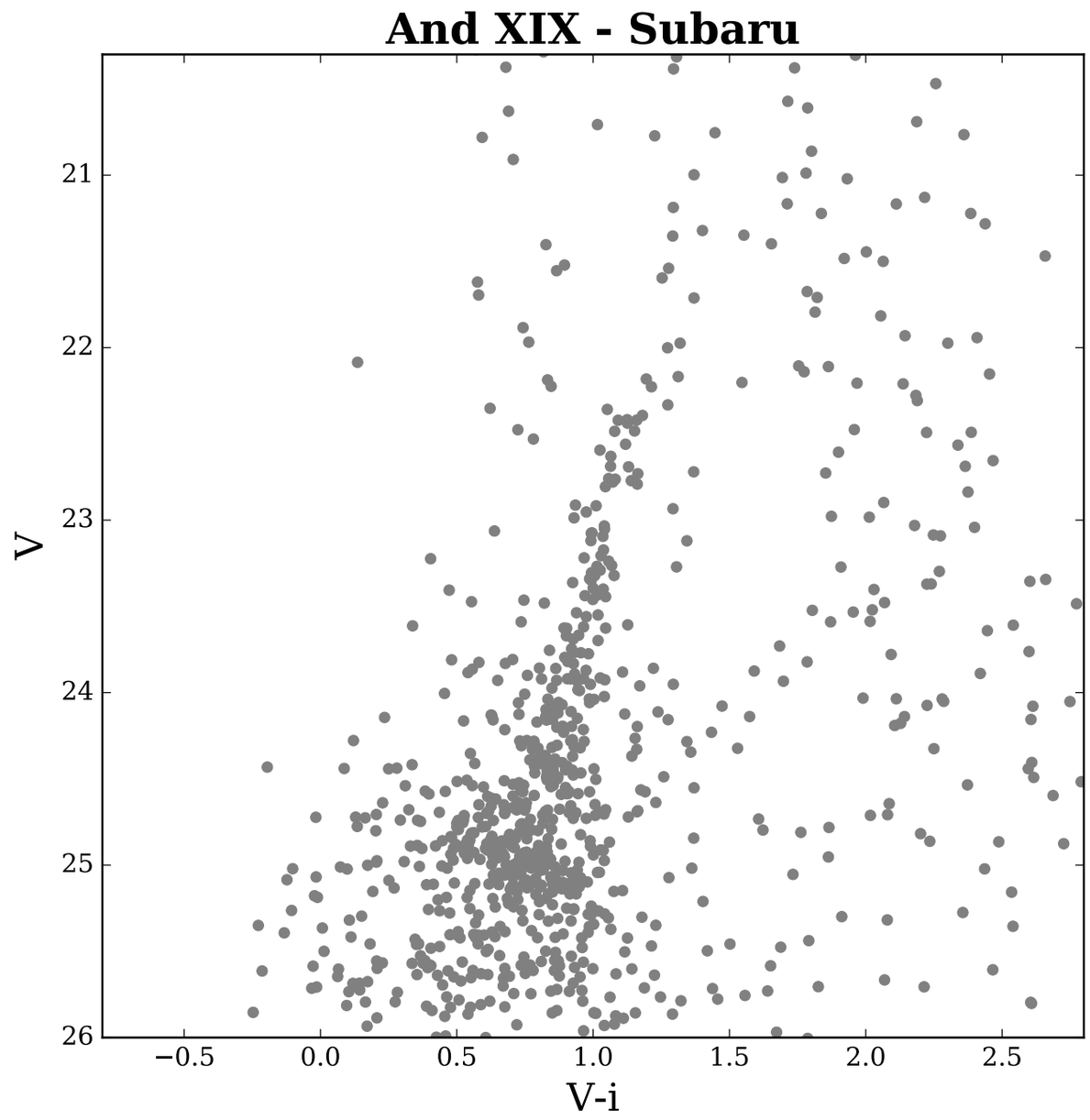
Cooling limit for forming a galaxy
(e.g. Haiman+97)

Same mass-to-light ratio as Dragonfly 44 (van Dokkum+2016, M/L~45 M_{sun}/L_{sun}), but clearly *not* a failed Milky Way

Data from Walker+09, Tollerud+12,14, Collins+13,15, Caldwell+17

So, what's going on?

Deeper imaging and more spectra



Collins+ in prep

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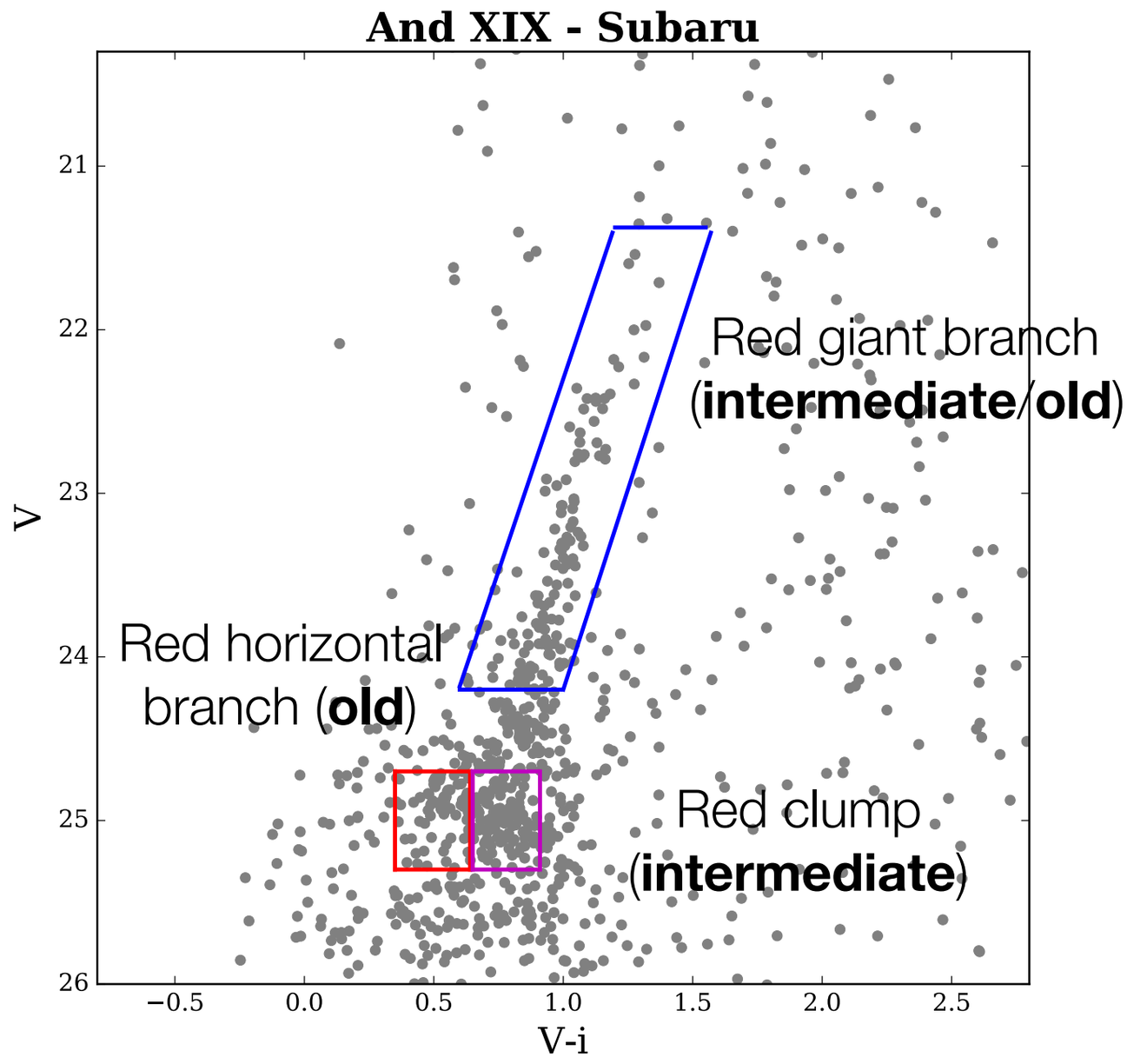
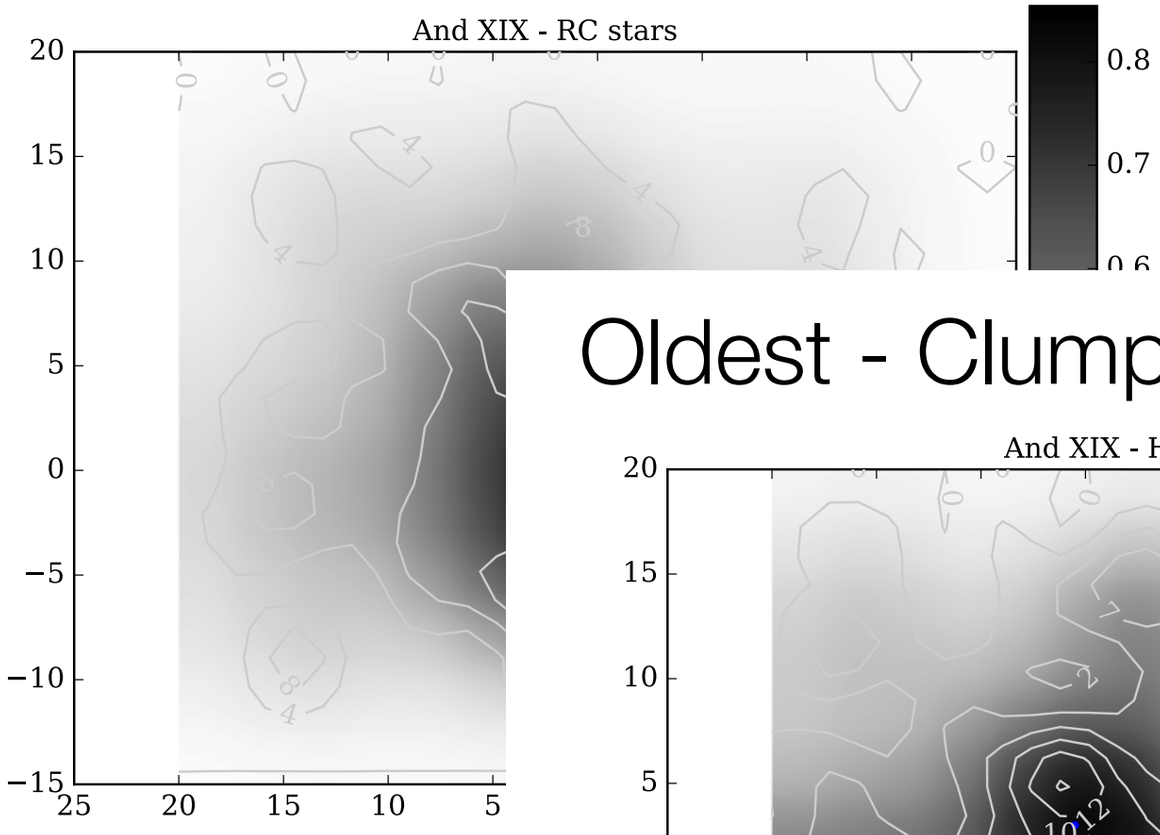


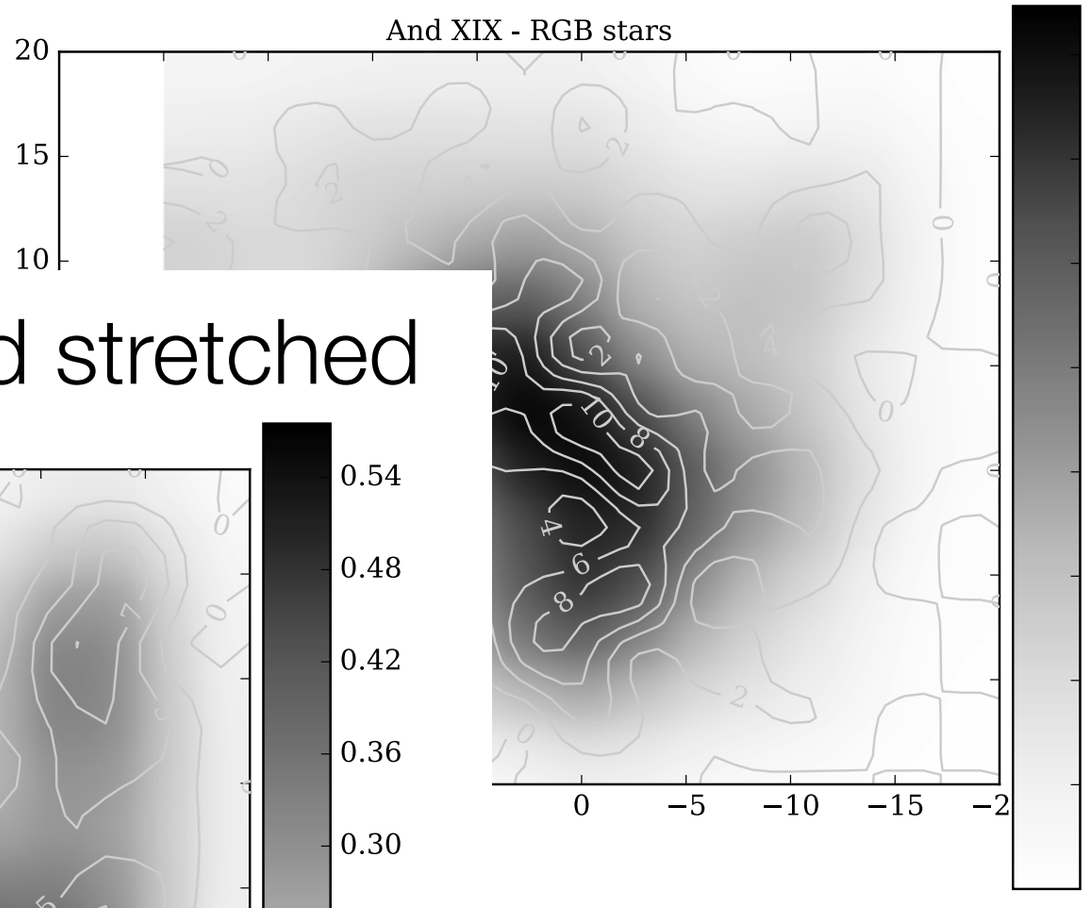
Collins+ in prep

Different spatial positions

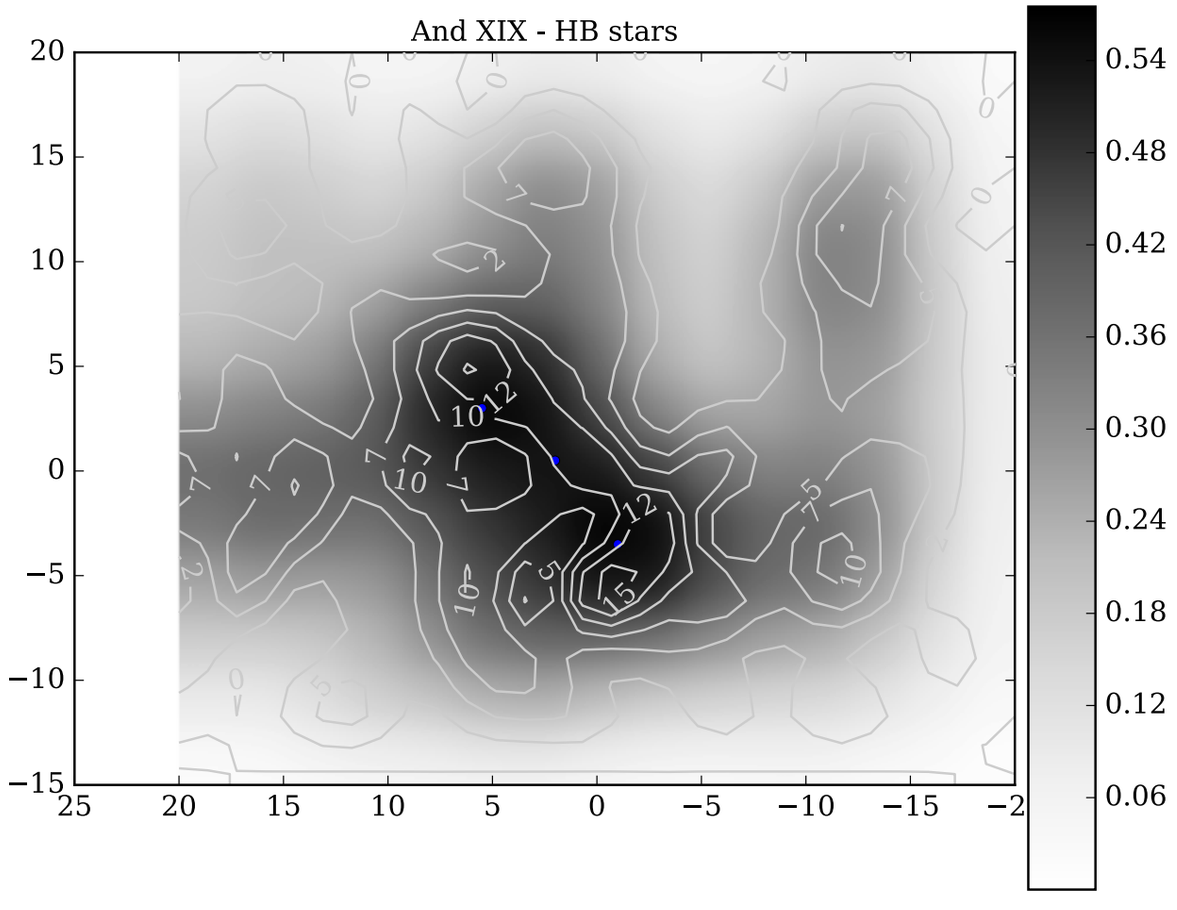
Youngest - smooth



Middle-est - less smooth



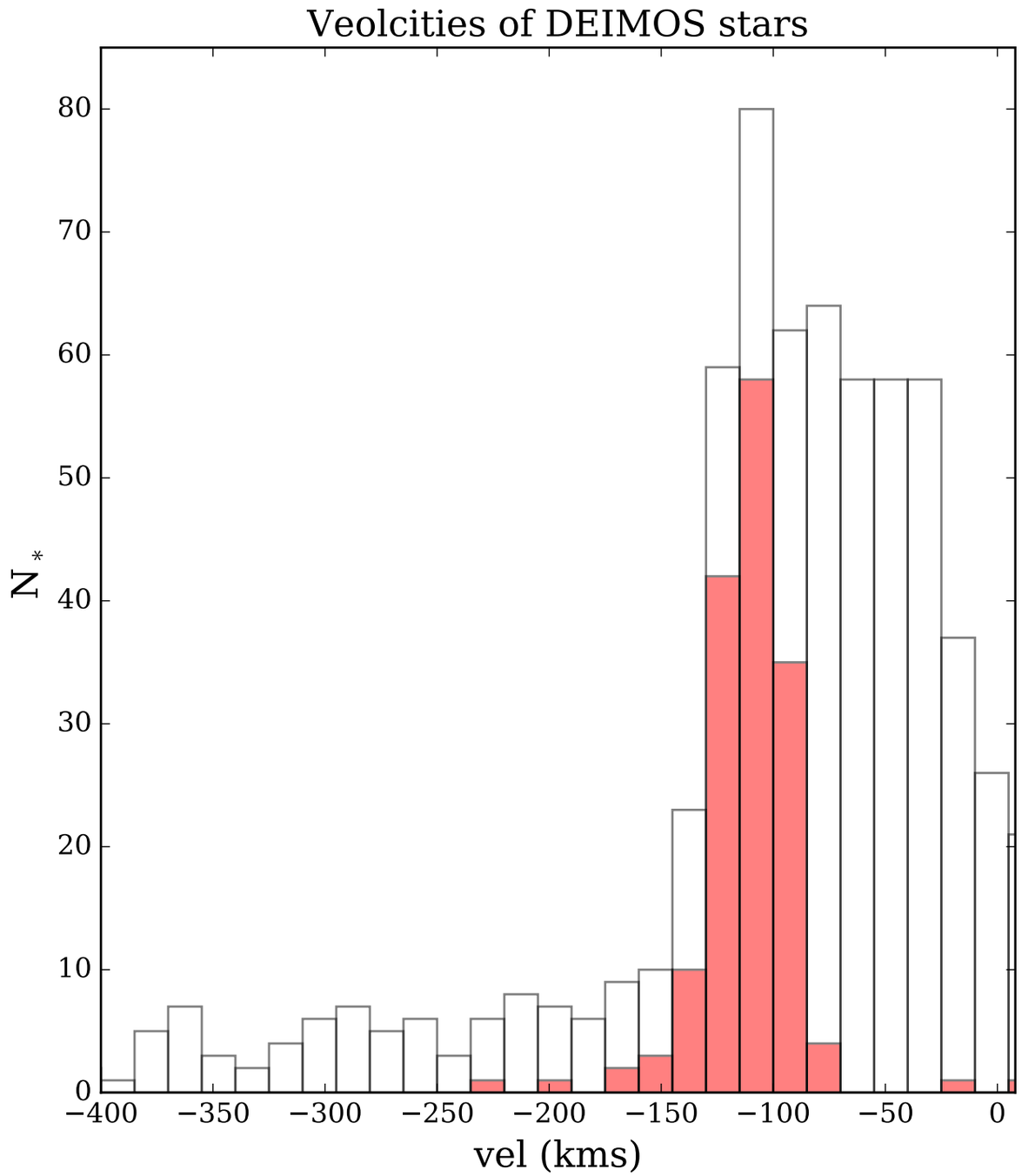
Oldest - Clumpy and stretched



Collins+ in prep

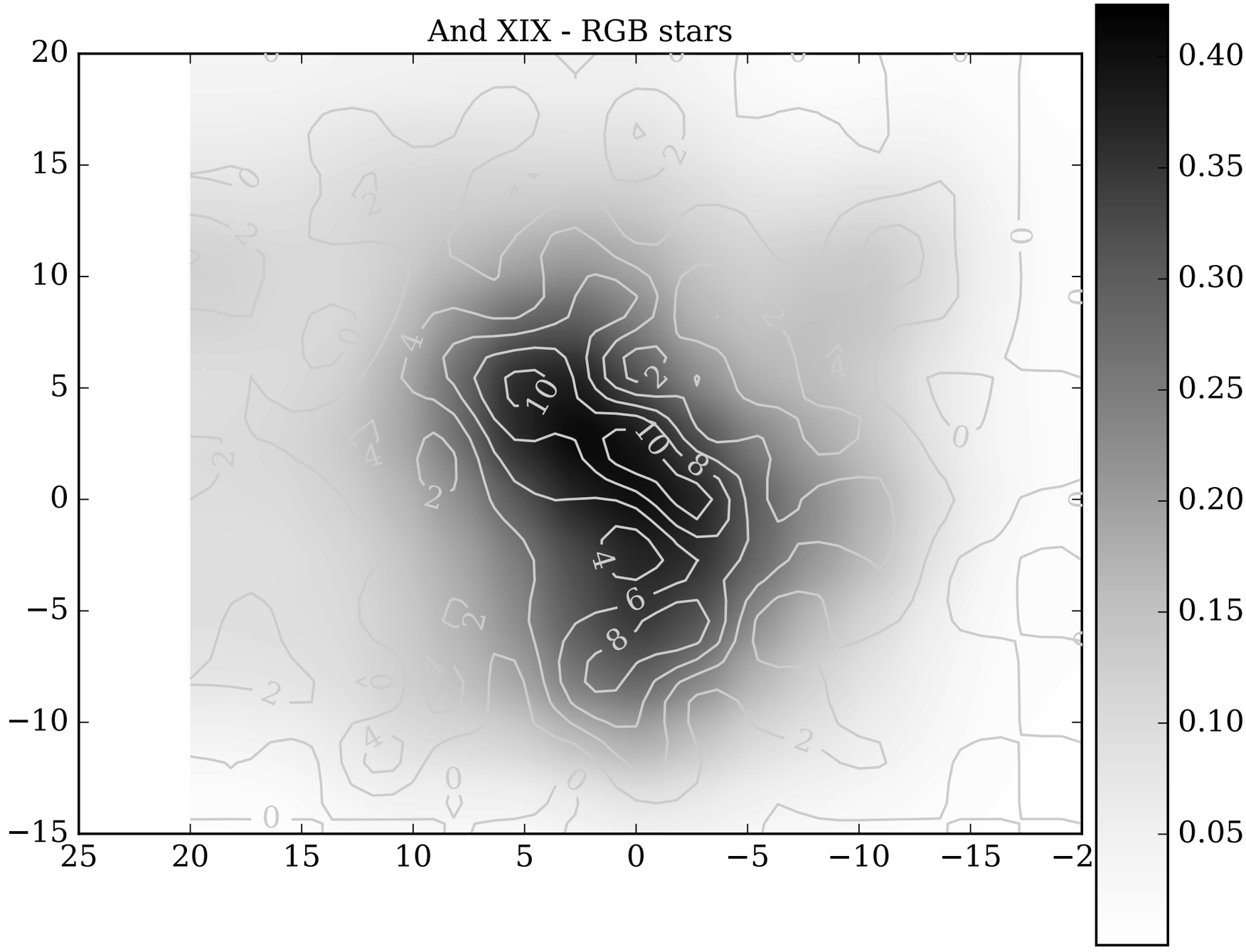
Dynamics of And XIX from Keck II DEIMOS spectra

It's a tricky beast…



With secure members, can run simple analysis to measure systemic velocity, dispersion, and look for signs of rotation/gradient

(My strong prior prediction)



Collins+ in prep

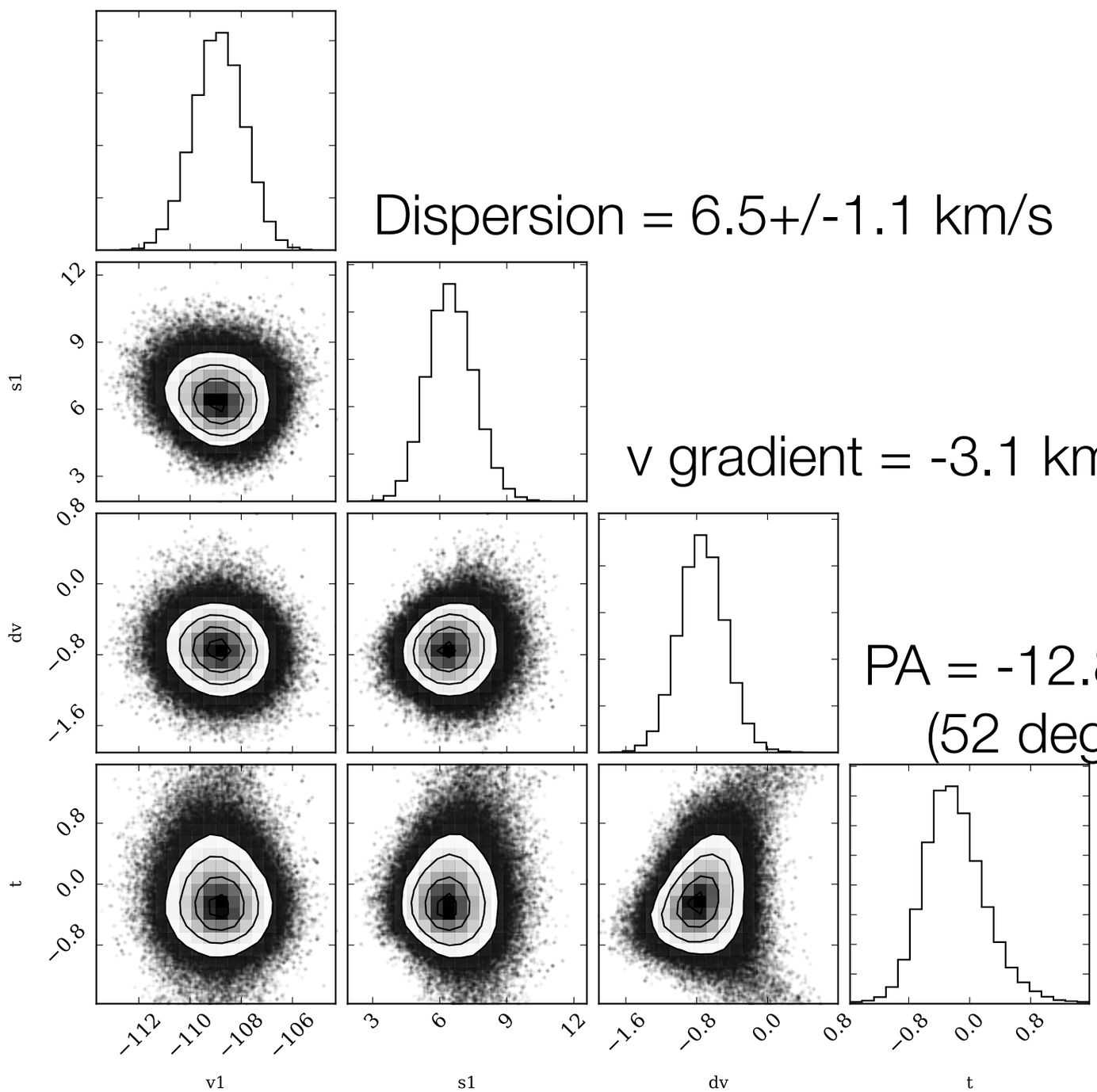
A velocity gradient offset from the major axis?

v_r = -108.9 +/-1.0 km/s

Dispersion = 6.5+/-1.1 km/s

v gradient = -3.1 km/s/kpc

PA = -12.8 degrees
(52 deg offset)



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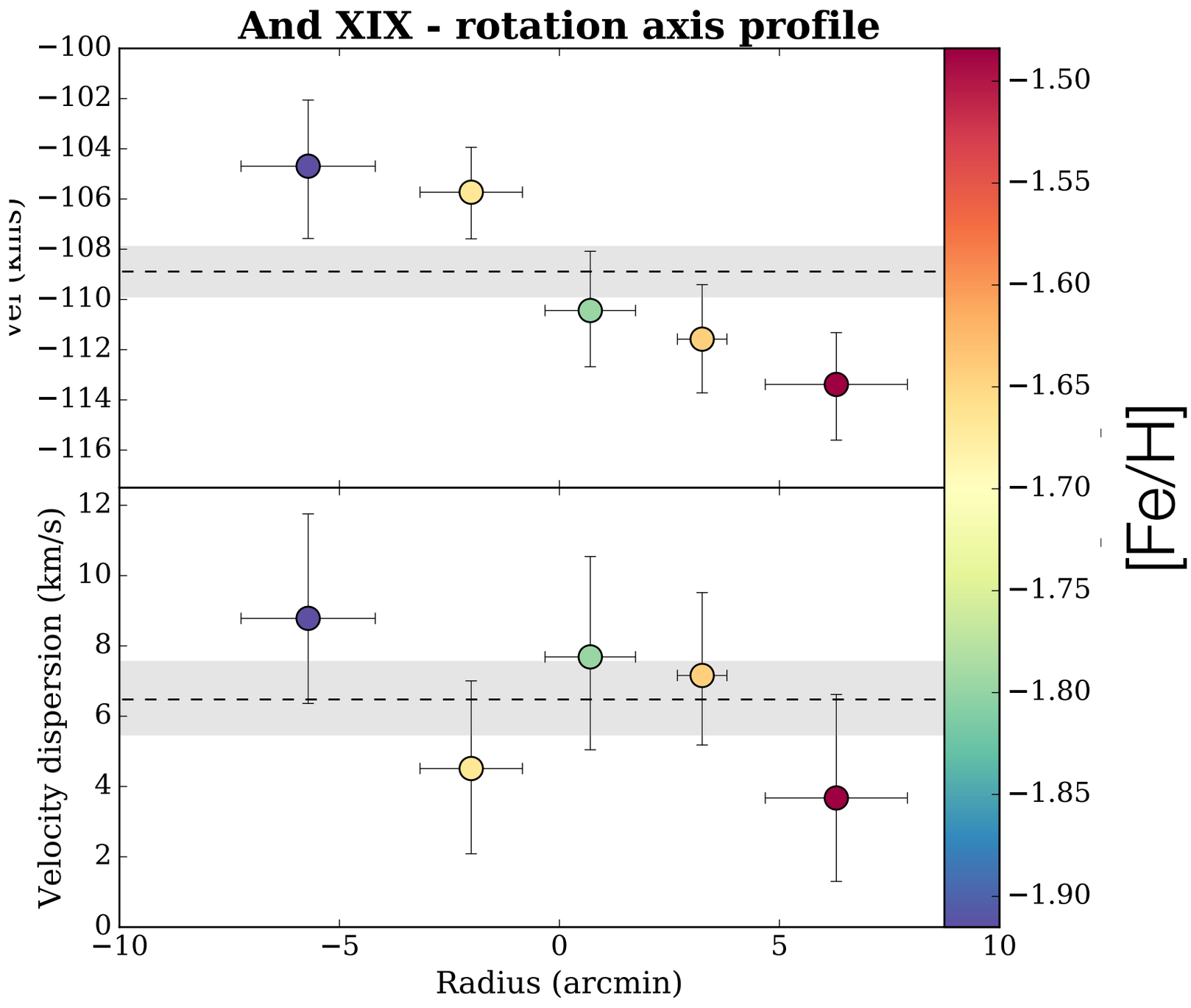
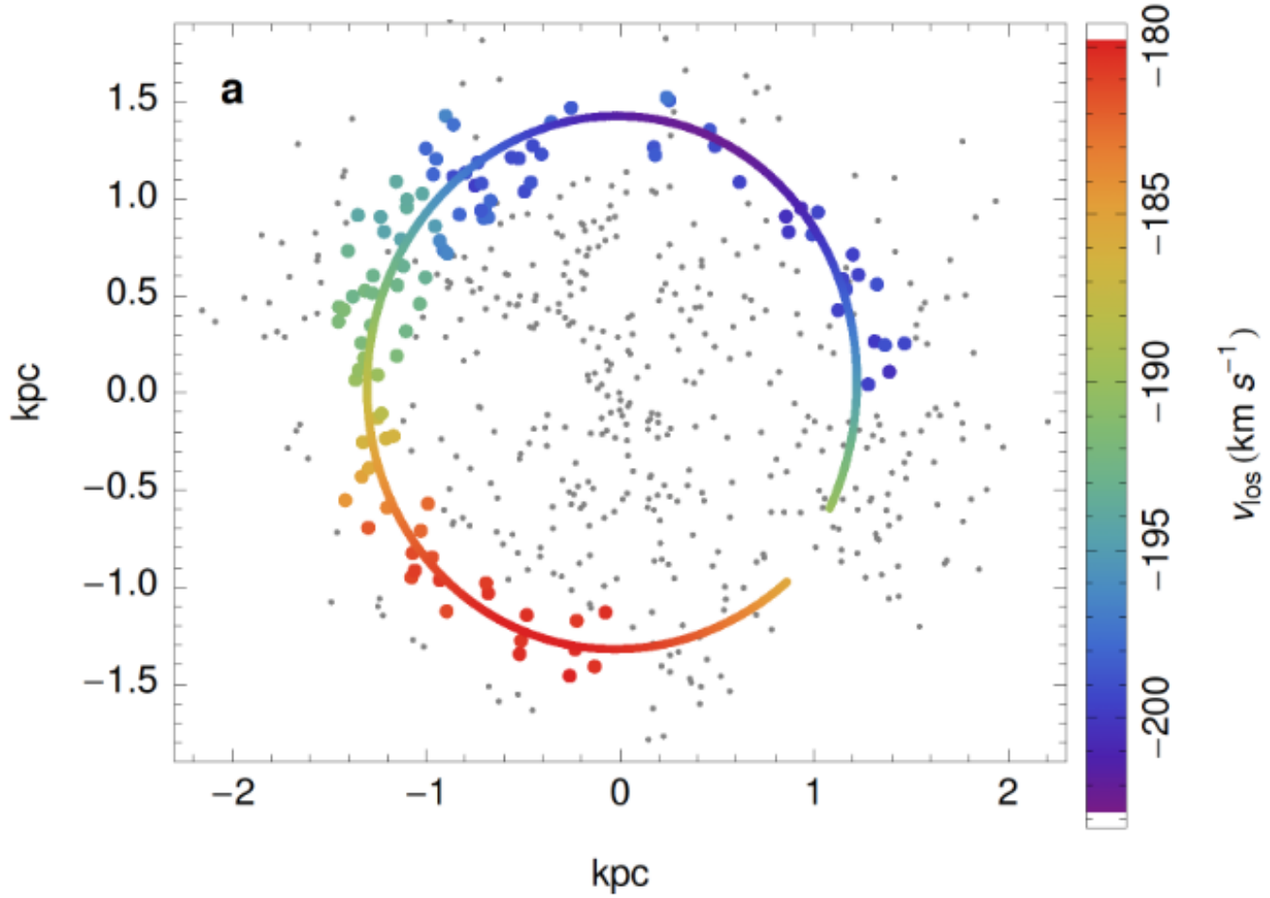


Other dSph galaxies with off-axis rotation

Andromeda II

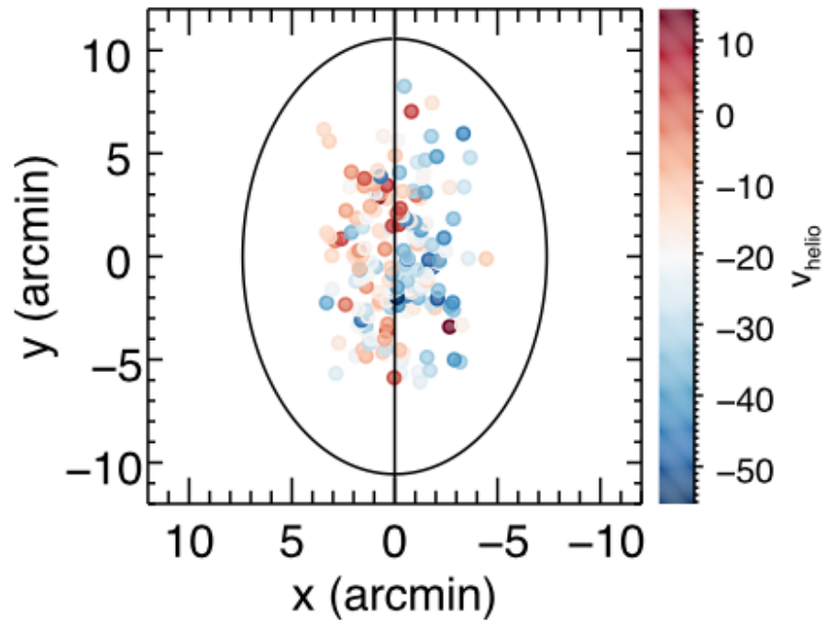
Ho et al., 2012; Amorisco et al. 2014

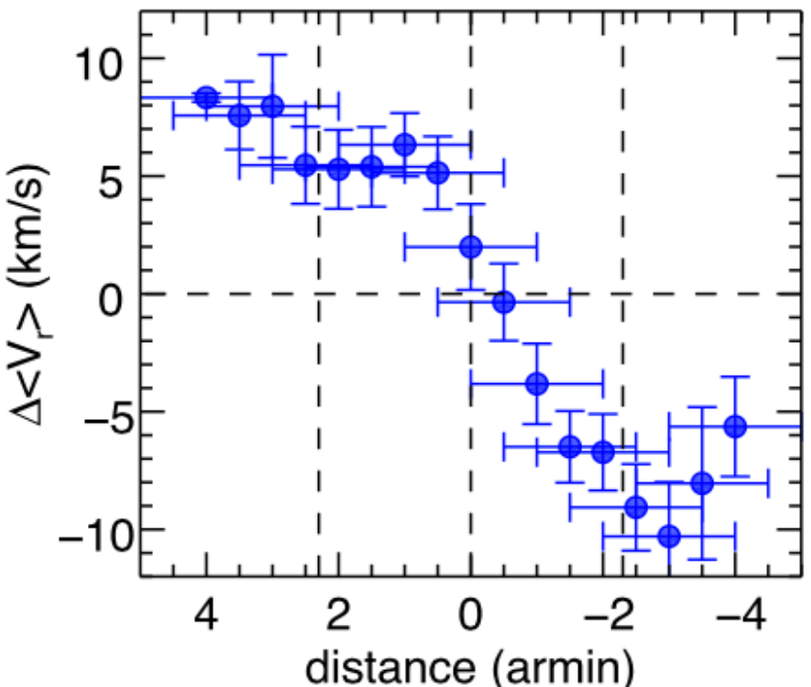


Merger remnants?

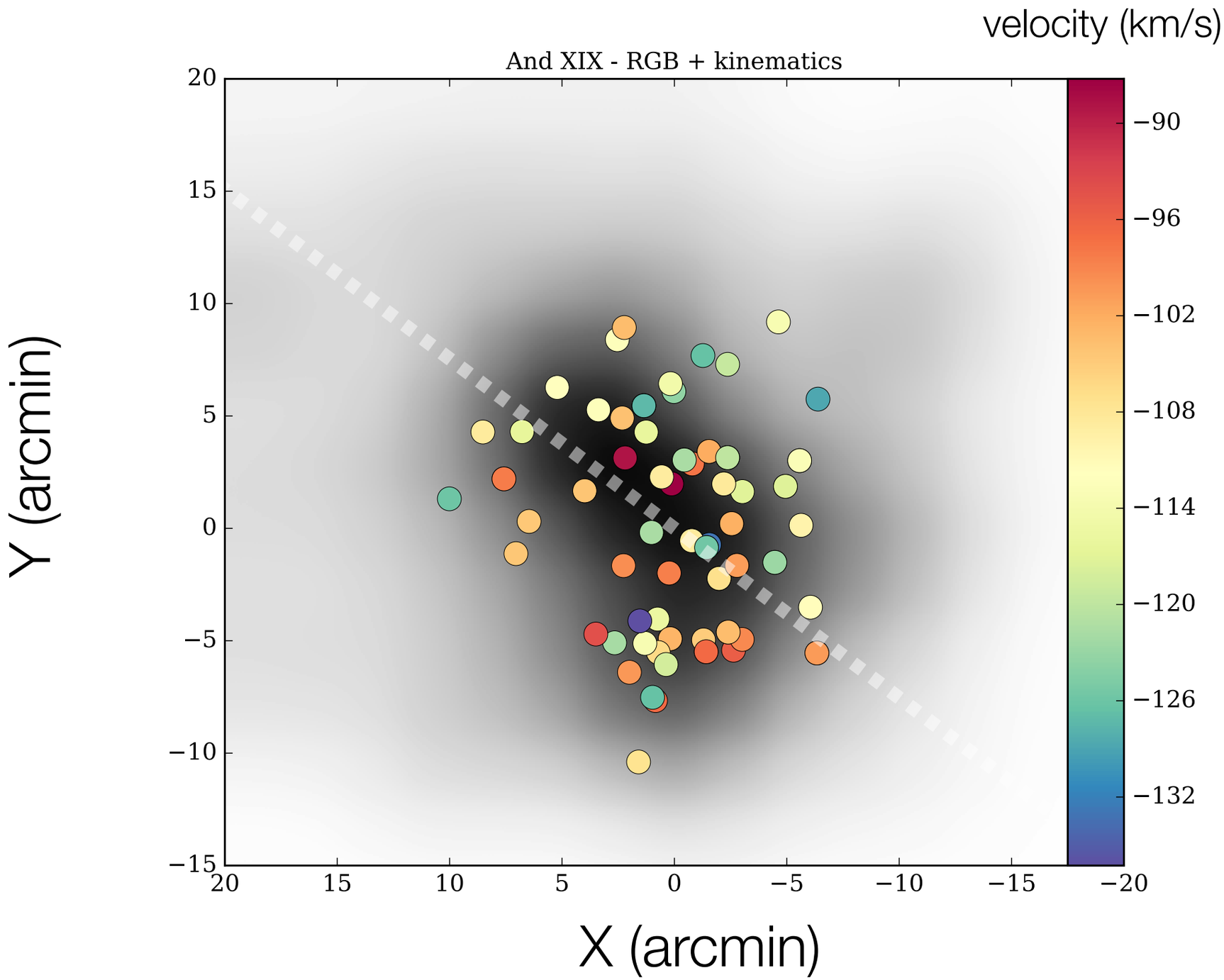
Phoenix

Kacharov et al. 2017

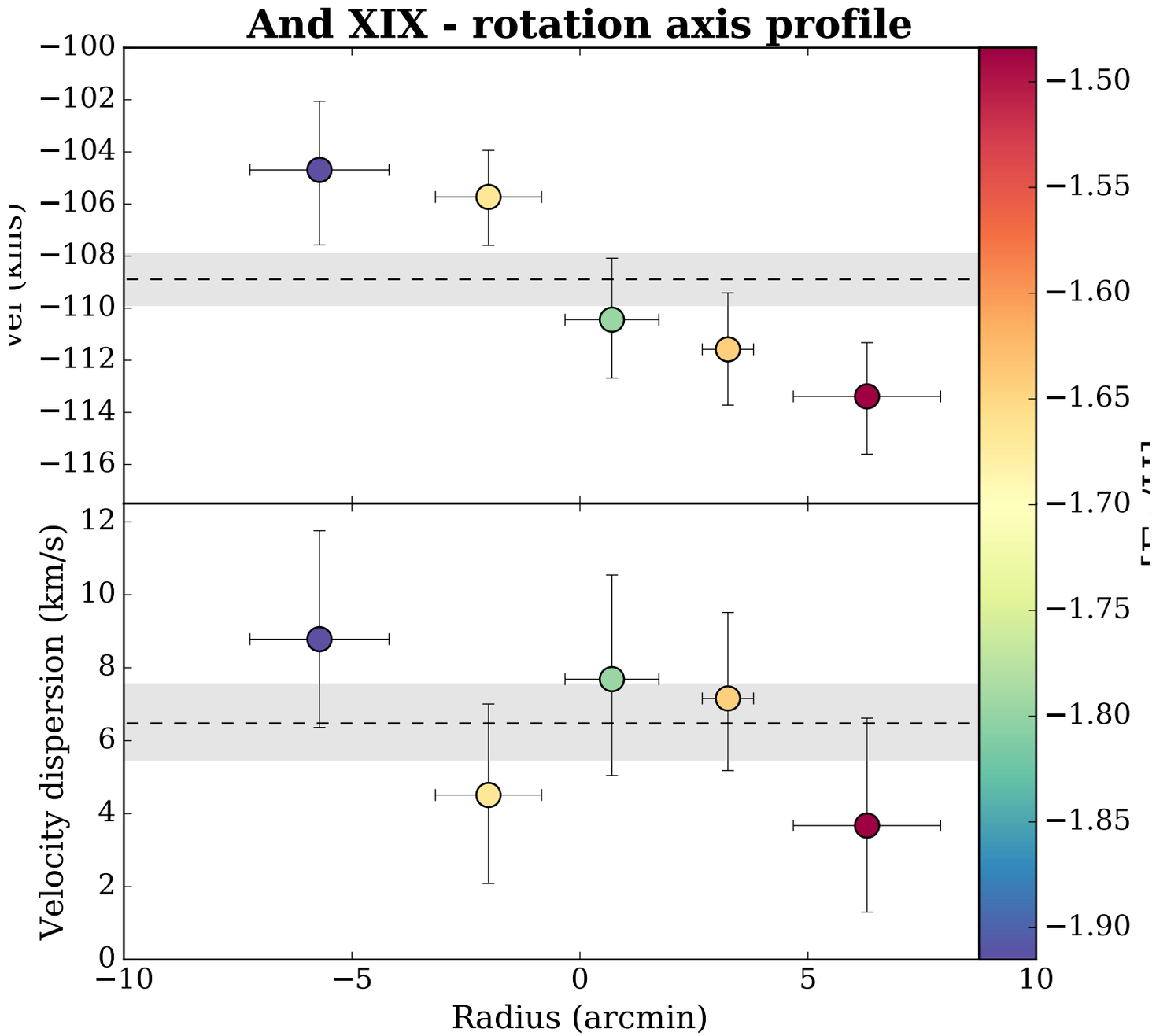




And XIX: Rotation? Or substructure..?



What about the metallicities of the stars?



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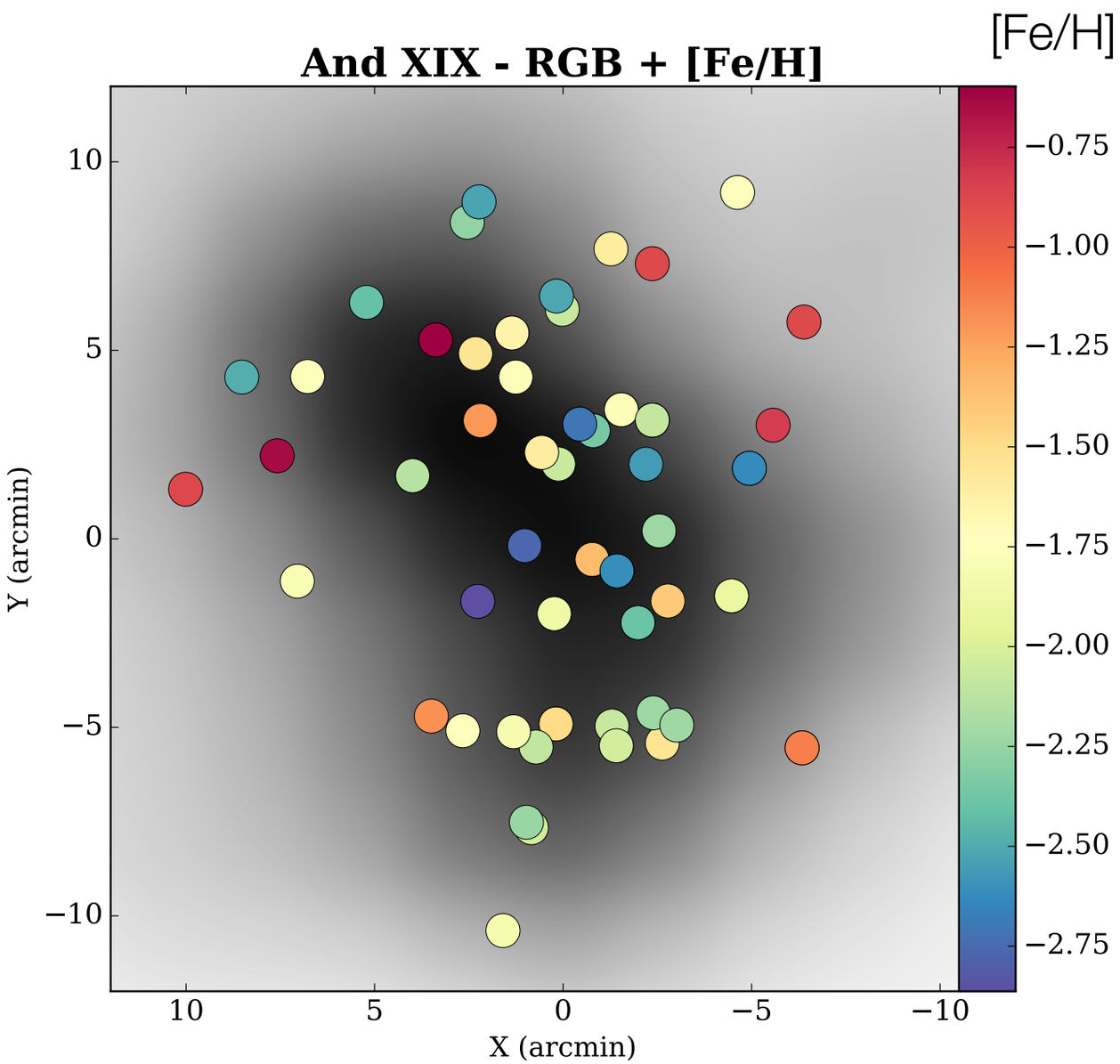

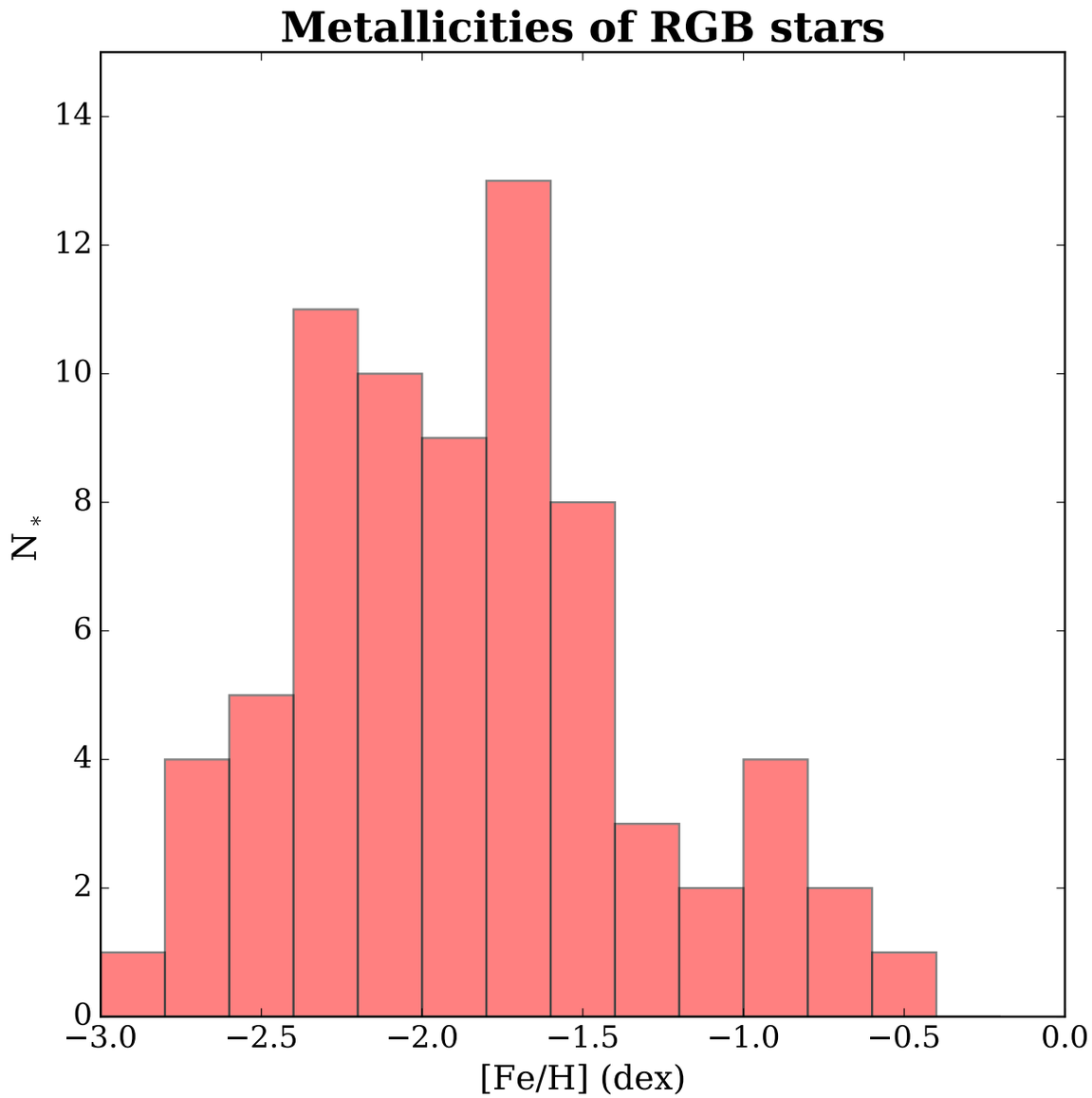

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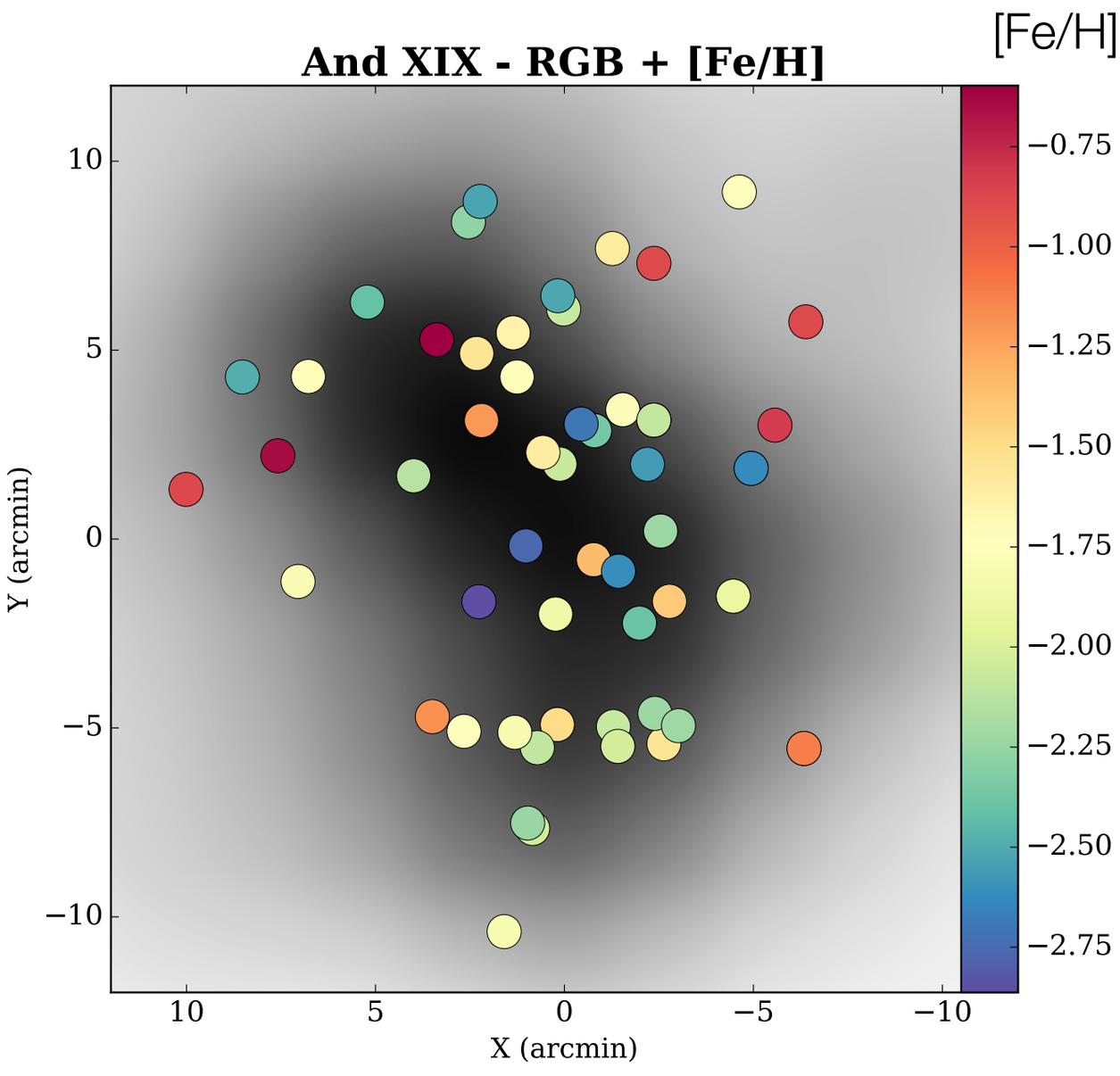

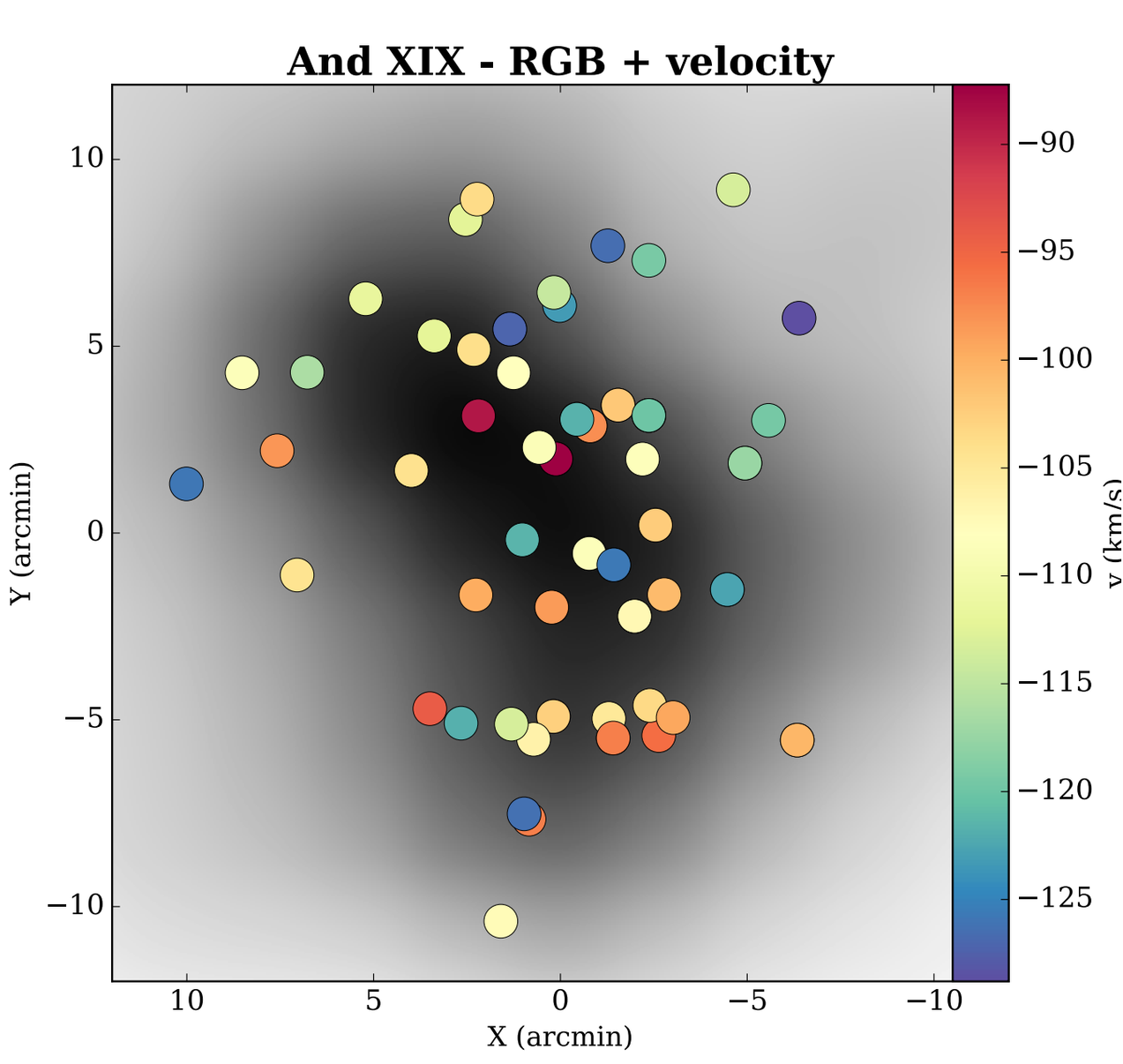

Summary

- The low surface brightness Universe is an interesting place

- Many local ultra-diffuse galaxies are tidally disrupting

- And XIX is an extreme object, that seems be rotating

- Shows some evidence of different stellar populations in clumps/streams?

- Merger? Substructure? Other..?

Questions I have…

- What is happening at the lowest surface brightnesses?
- Are ultra diffuse galaxies the tip of the iceberg? And XIX and Crater 2 suggest so…
- Can these extreme systems inform us about:
  (i) galaxy formation physics?
  (ii) cosmology?