The SPLASH Survey
M31's Unusual "Bulge"

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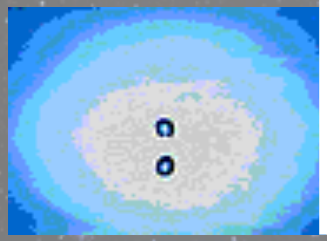
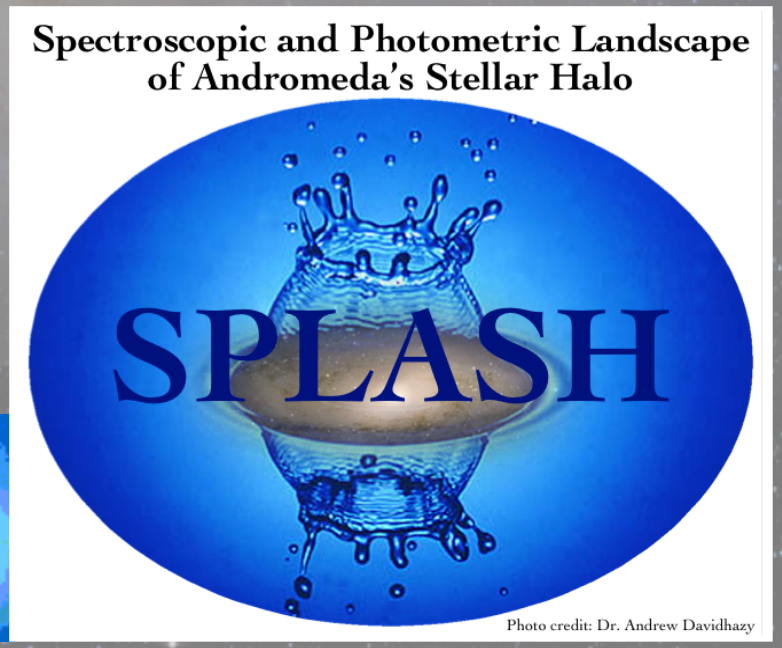
Outline

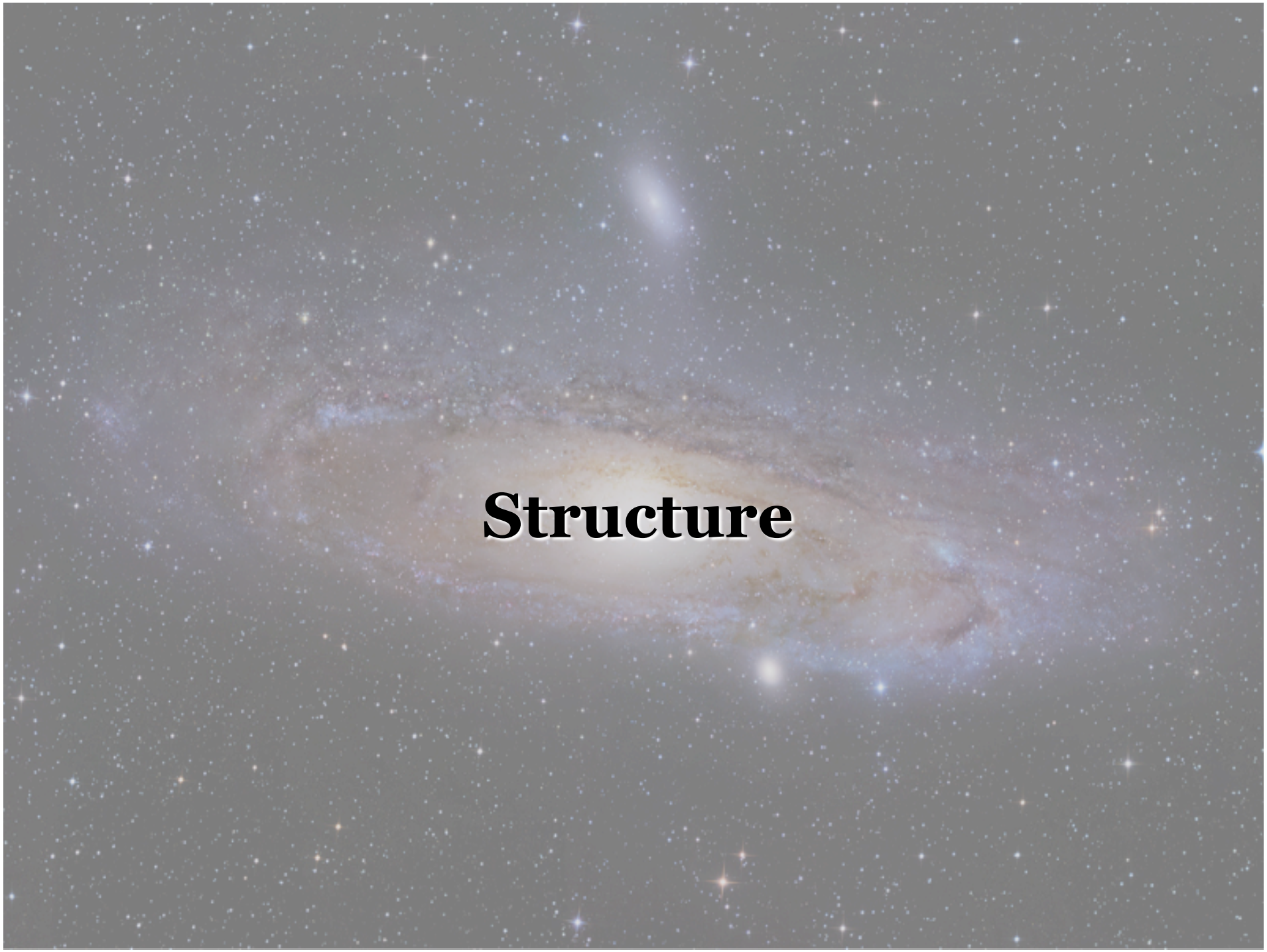
M31's unusual extended "bulge"/inner spheroid:

- Main difference between M31 and MW
- Structure: surface brightness profile, bar/boxiness, substructure (tidal debris)
- Resolved stellar kinematics
- Metallicity
- Star-formation history

Summary

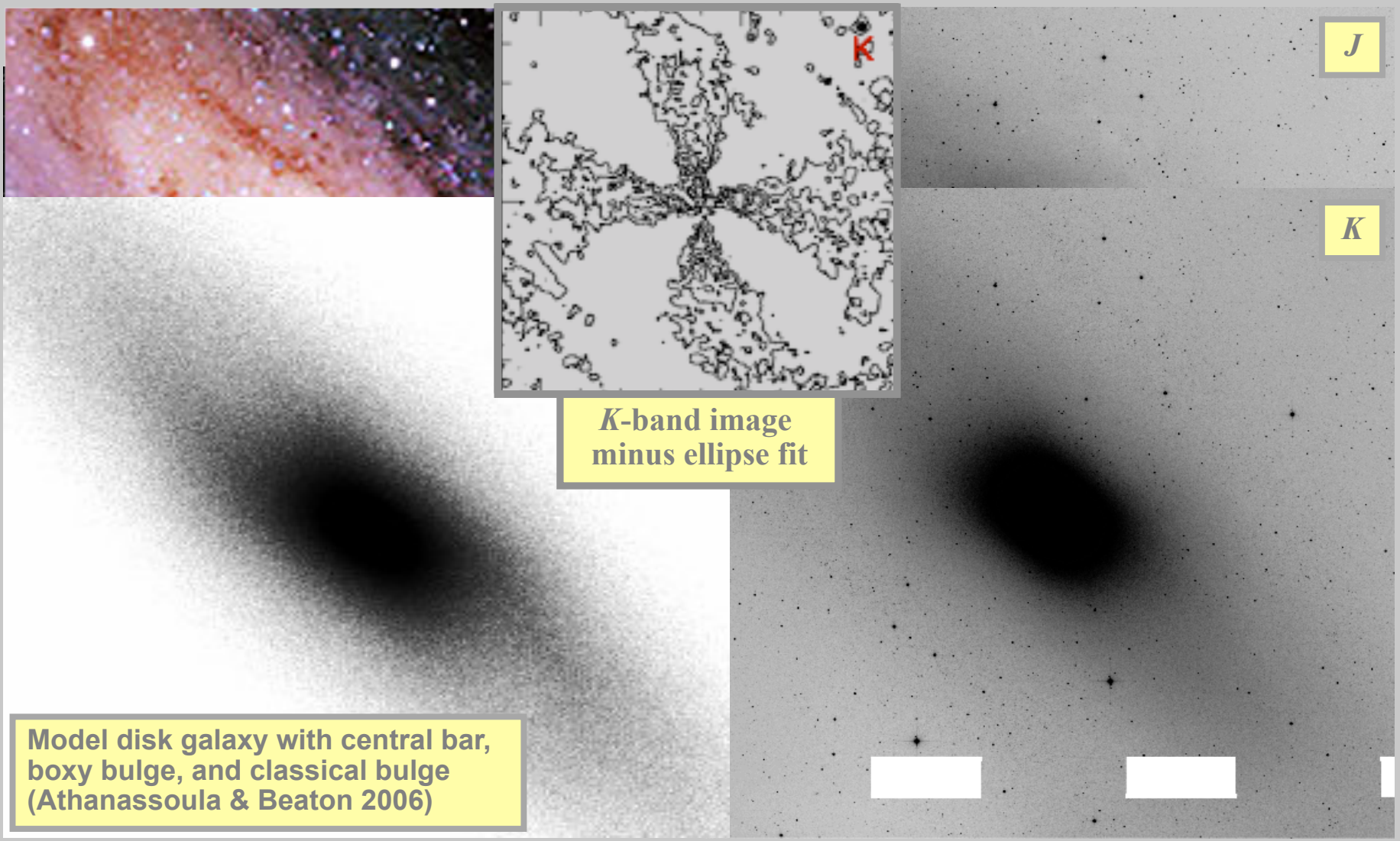





Structure

M31's Boxy Bulge and Central Bar

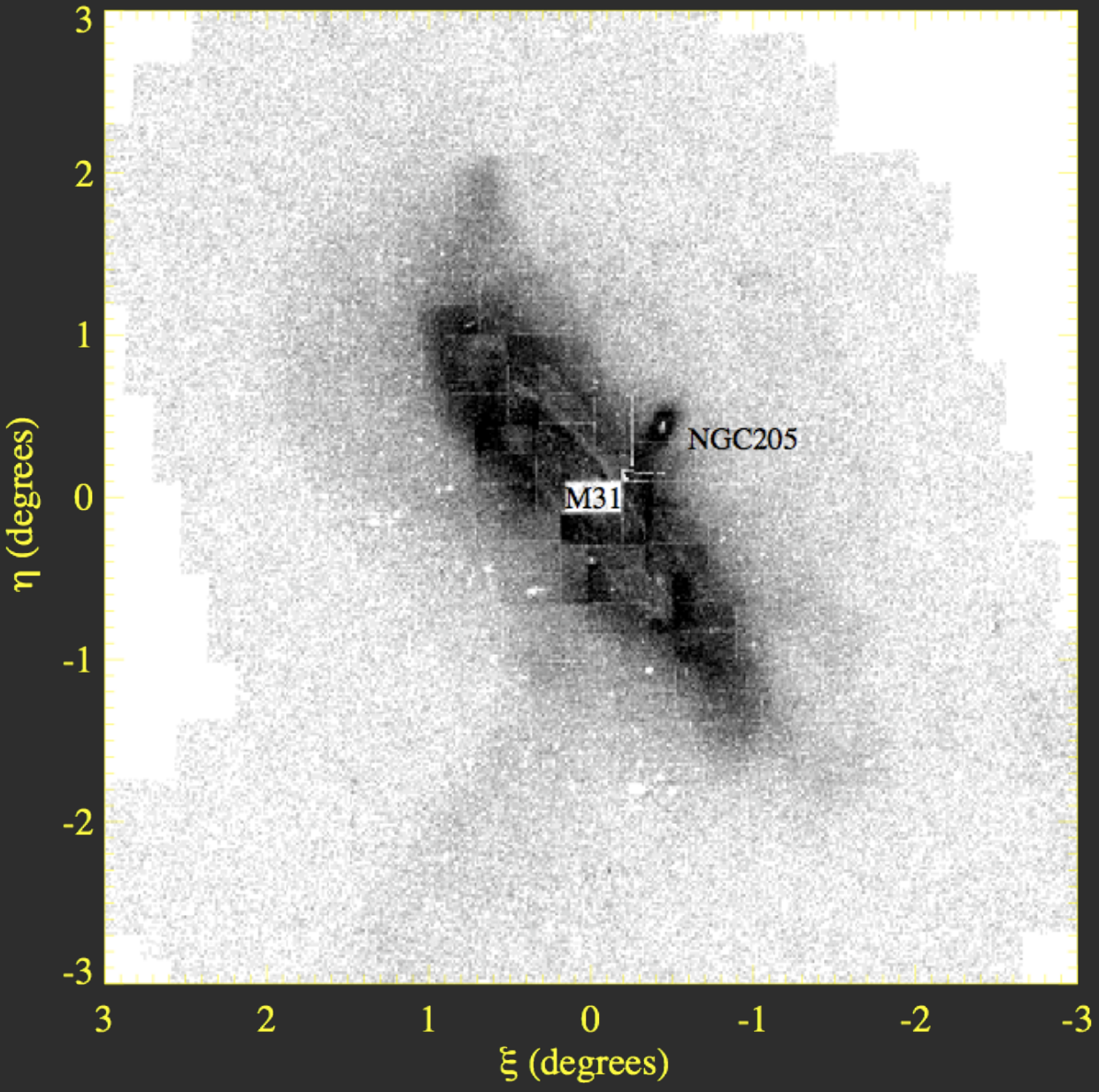
An Unobstructed Wide-field View in the Near Infrared



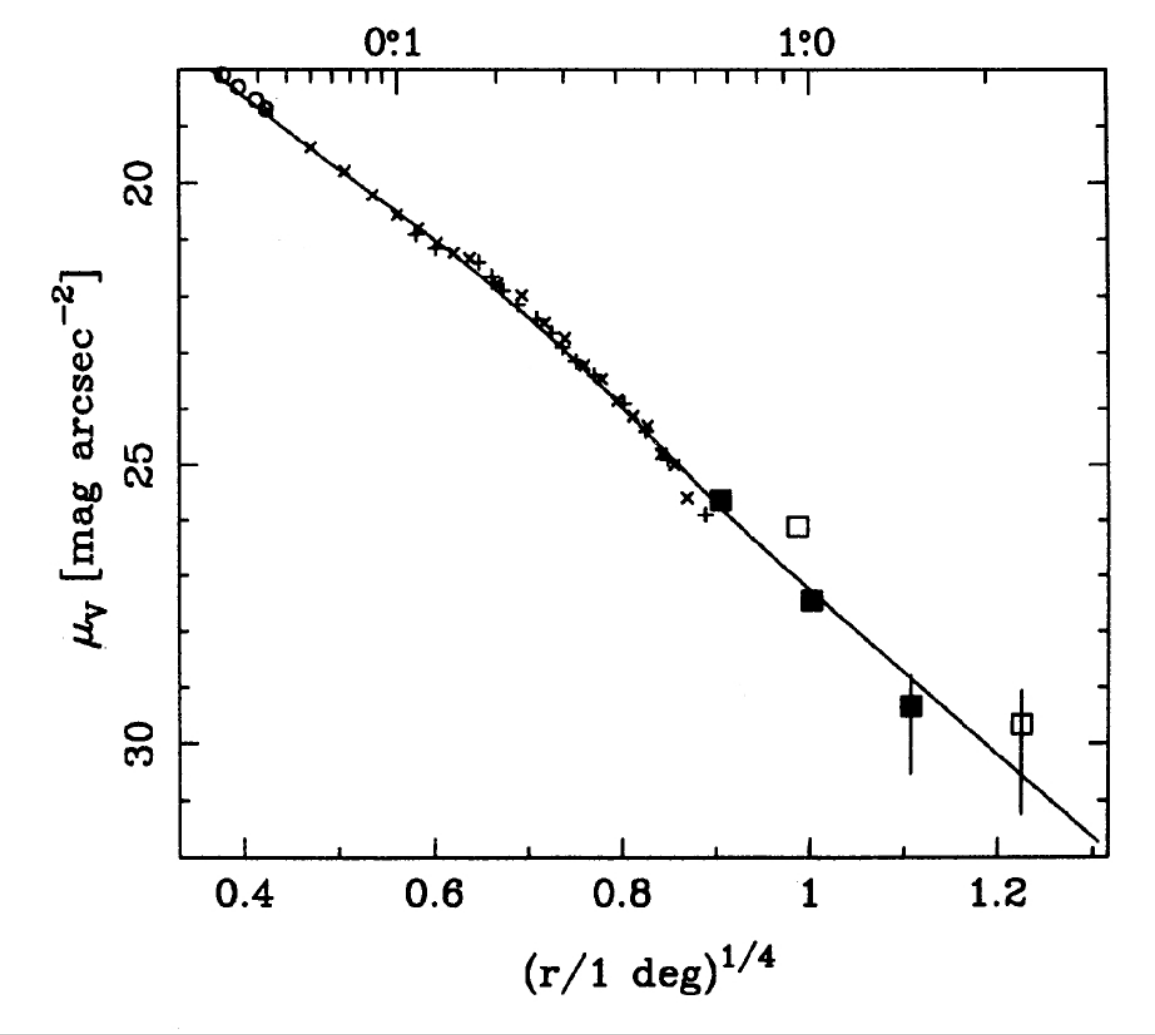
Beaton et al. (2007, ApJL)
Athanassoula & Beaton (2006, MNRAS)

M31 substructure supports violent merger history

- Ibata et al. (2001) discovered a giant stellar debris stream
- Ferguson et al. (2002) found several other significant structures (NE shelf, NGC205 loop, etc.)
- Ibata et al. (2005) found evidence for an "extended disk-like structure" comprising ~10% of the luminous disk mass, extending to ~40 kpc, possibly the result of recent mergers



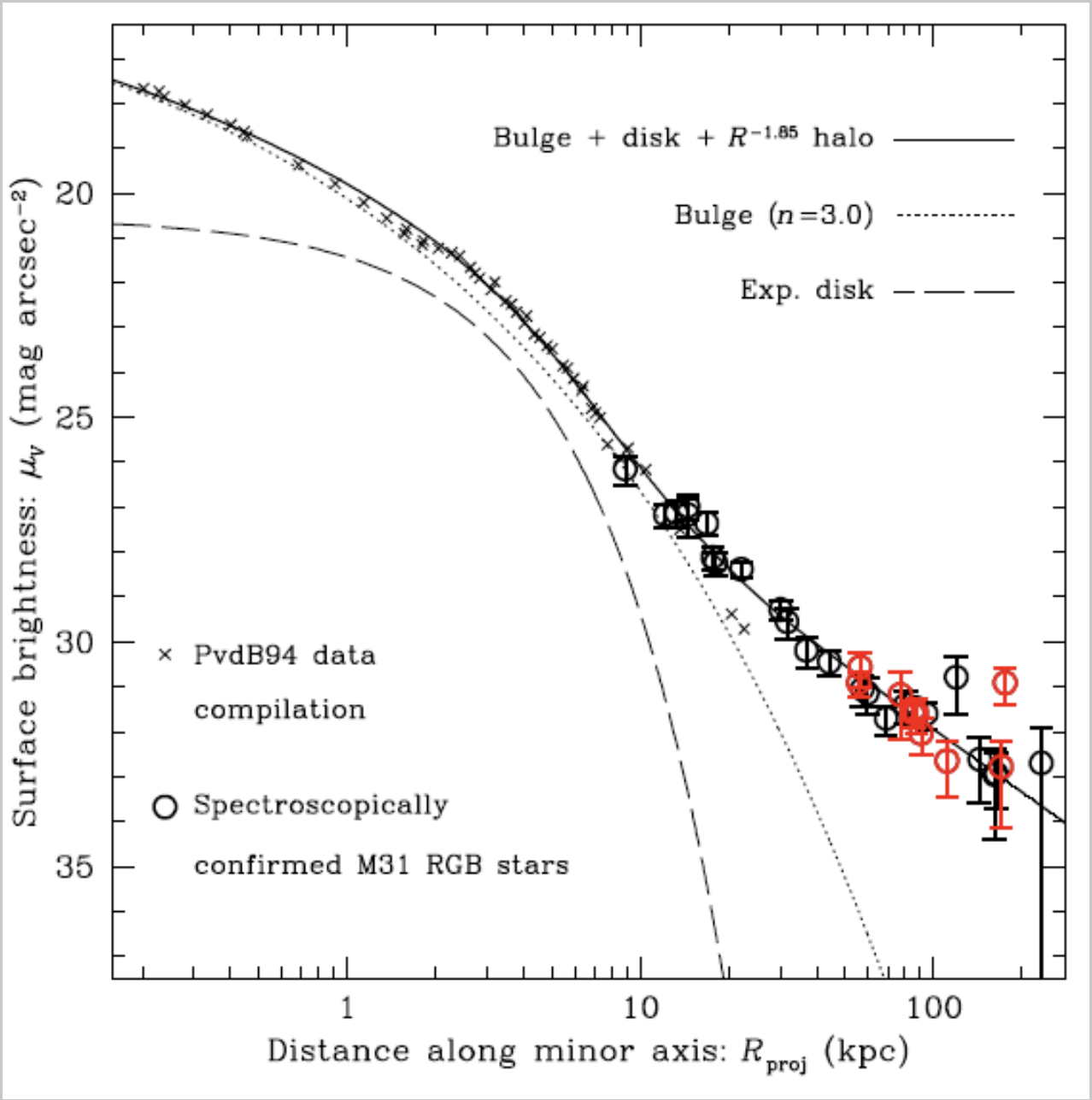
Inner “halo” of M31 looks like a bulge



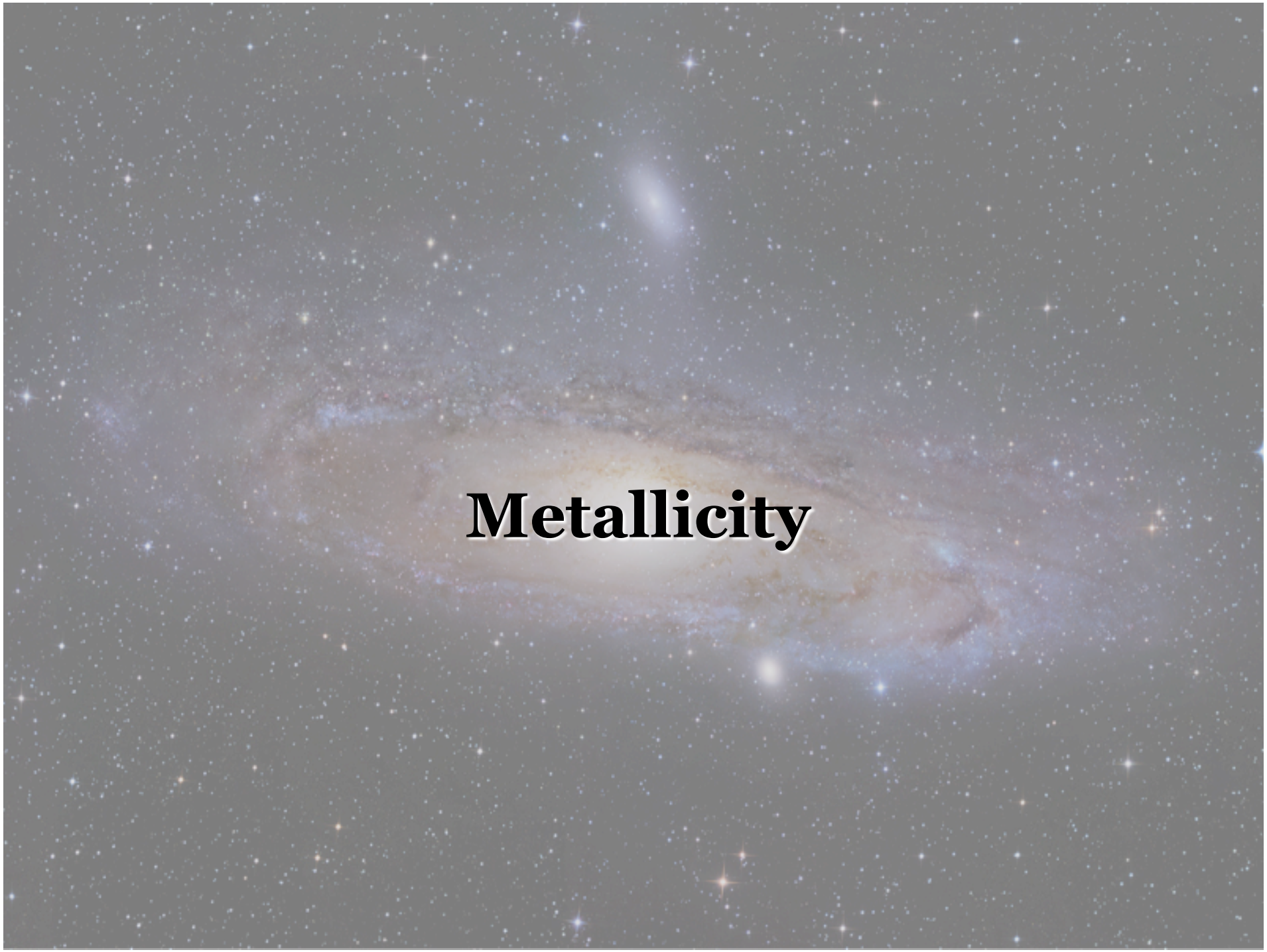
Pritchet & van den Bergh (1994)

Profile looks like a de Vaucoulers $r^{1/4}$ law instead of the canonical power-law r^{-2} halo

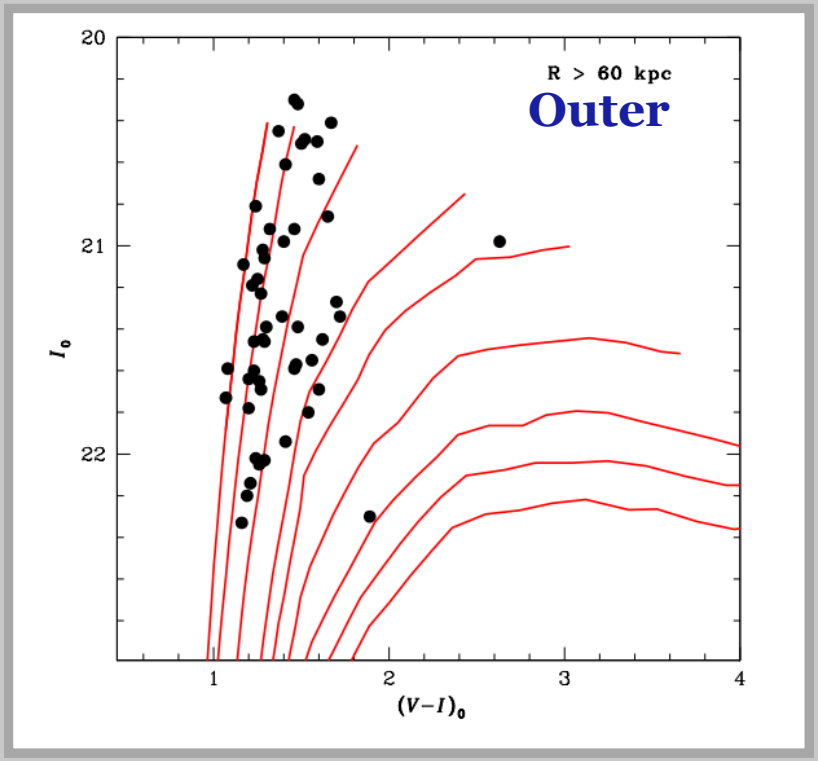
M31's Surface Brightness Profile

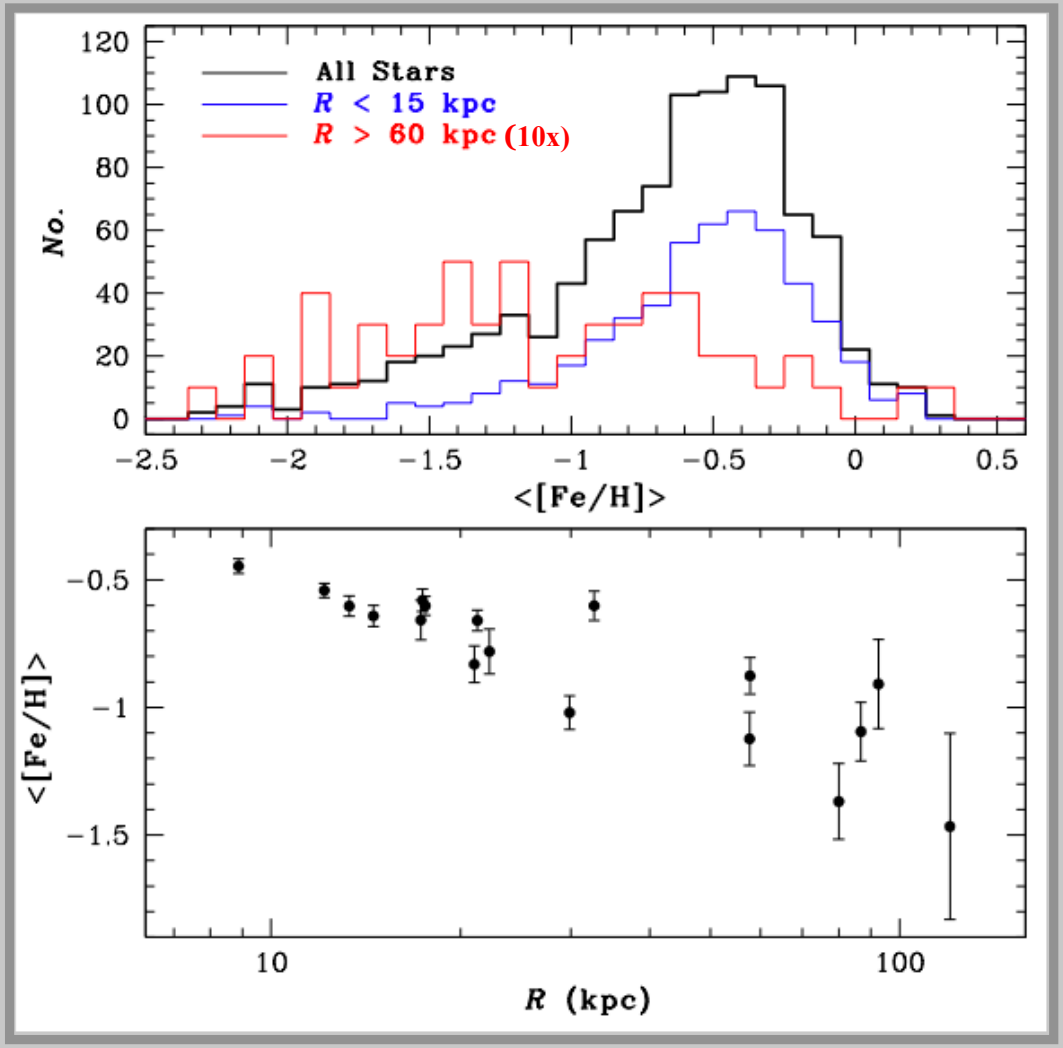


– PG, et al. (2005)
– Gilbert, PG, et al. (2011, in prep)


Metallicity

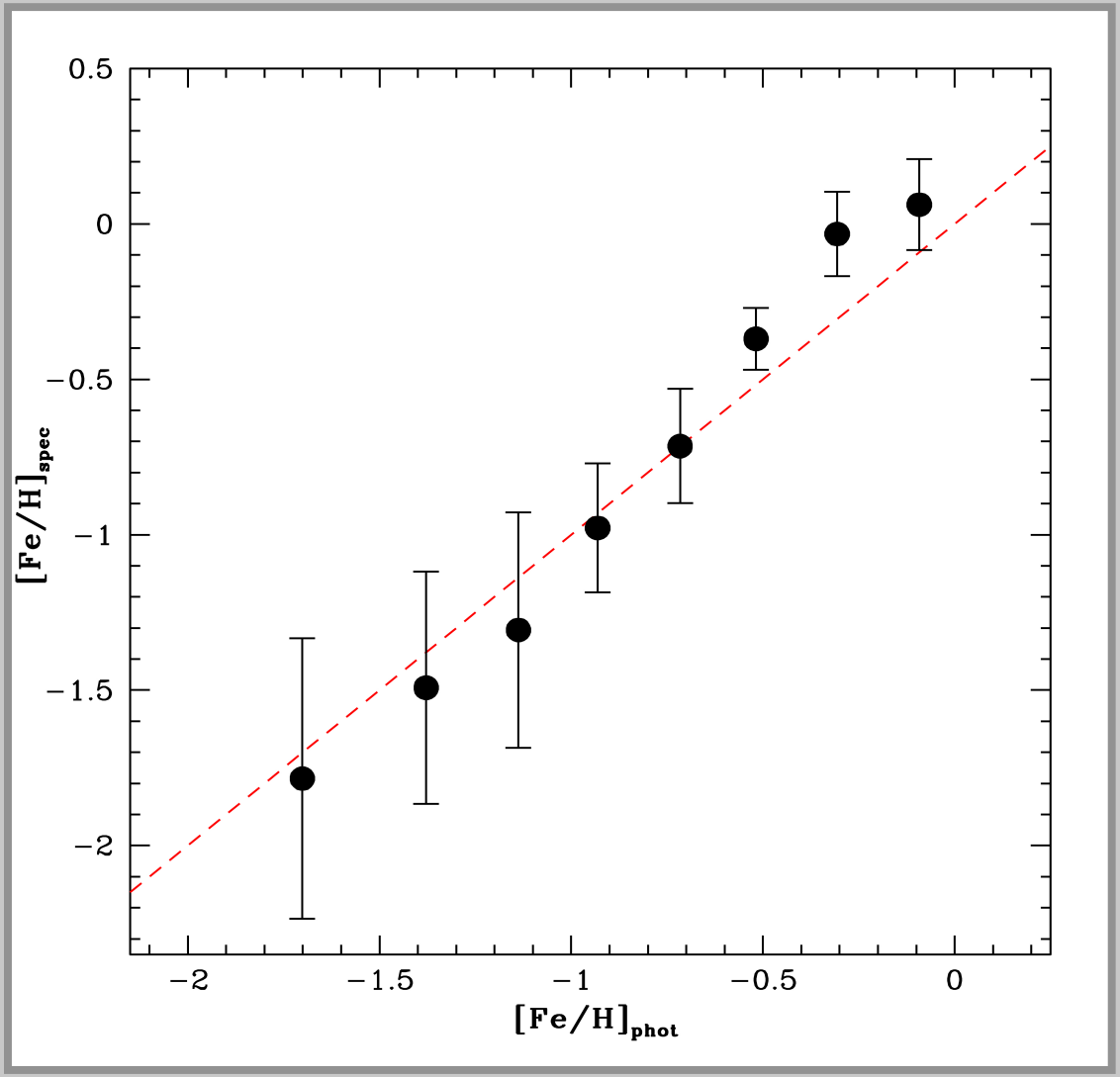
Radial Gradient in Metallicity





Kalirai, Gilbert, PG, et al. (2006b, ApJ); Kalirai, Gilbert et al. (in prep)

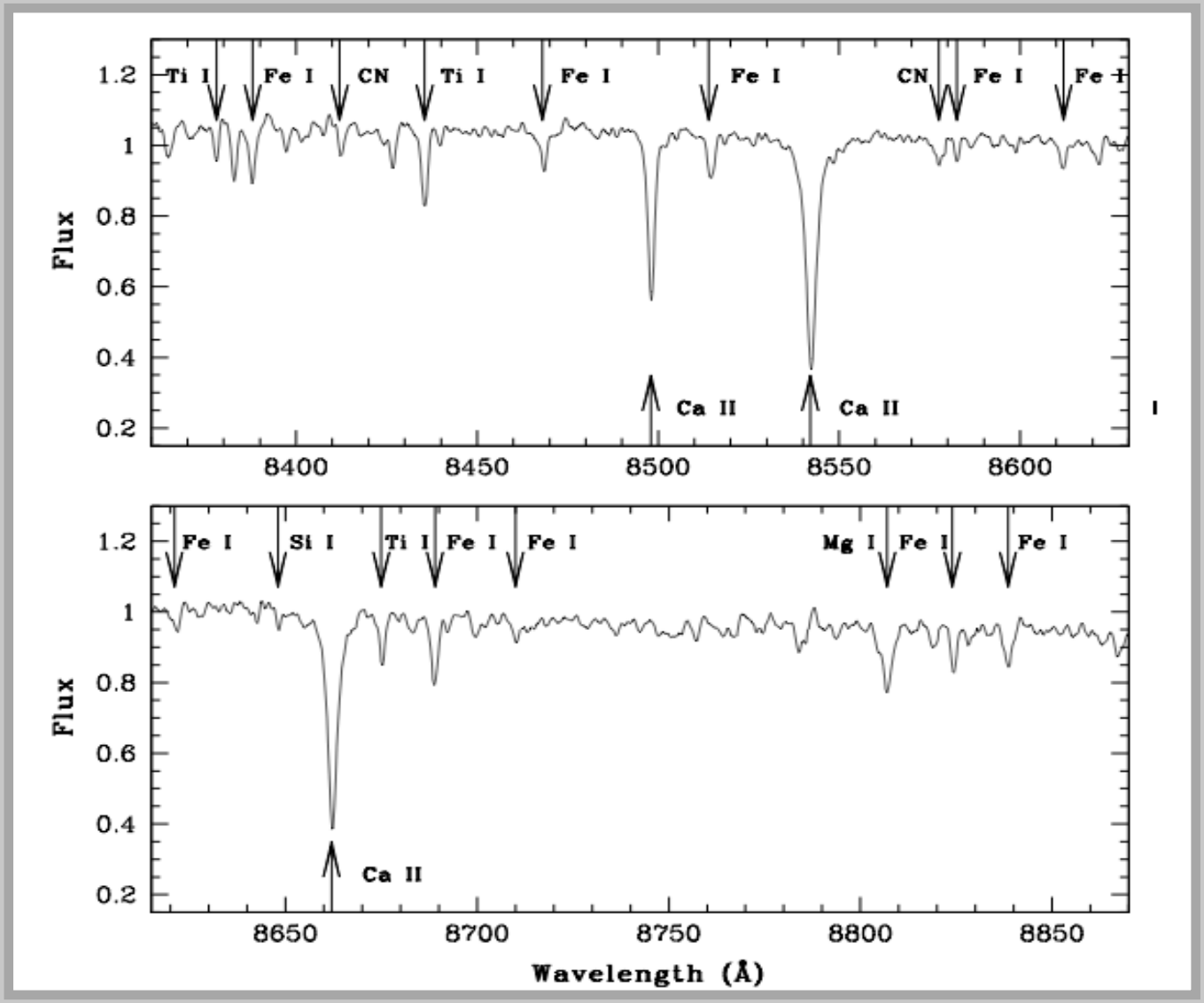
Photometric vs. Spectroscopic [Fe/H] Estimates



Kalirai, Gilbert, PG, et al. 2006b, ApJ

It is reassuring to see that there is a reasonably good correlation between the photometric and spectroscopic [Fe/H] estimates

Detailed Chemical Abundance Analysis based on Co-added Spectra



Evan Kirby, PhD thesis, UCSC

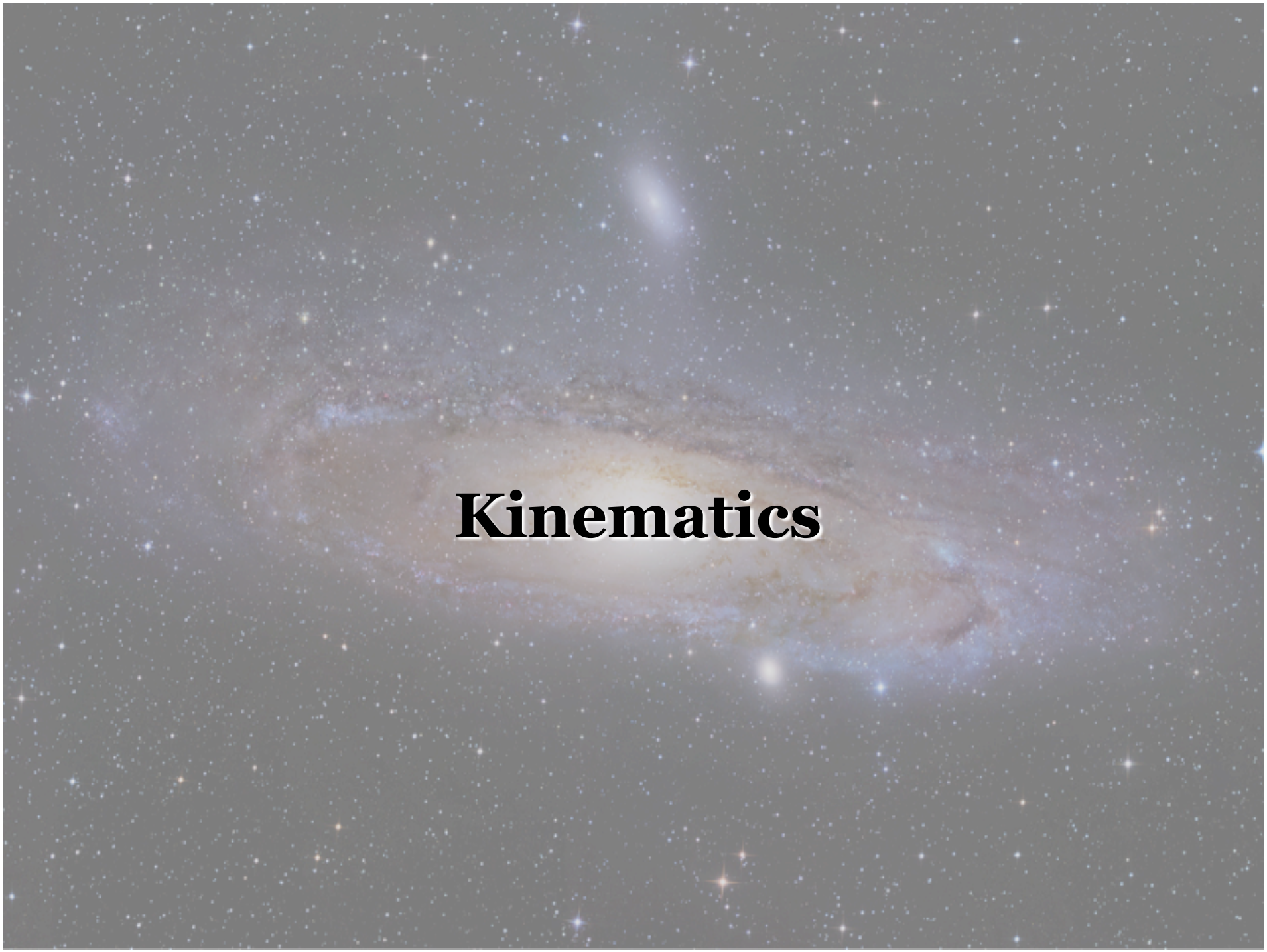
Detailed chemical abundances from Keck/DEIMOS spectra of individual red giant stars in MW GCs and dSph satellite galaxies:

– Kirby, PG & Sneden (2008, ApJ)

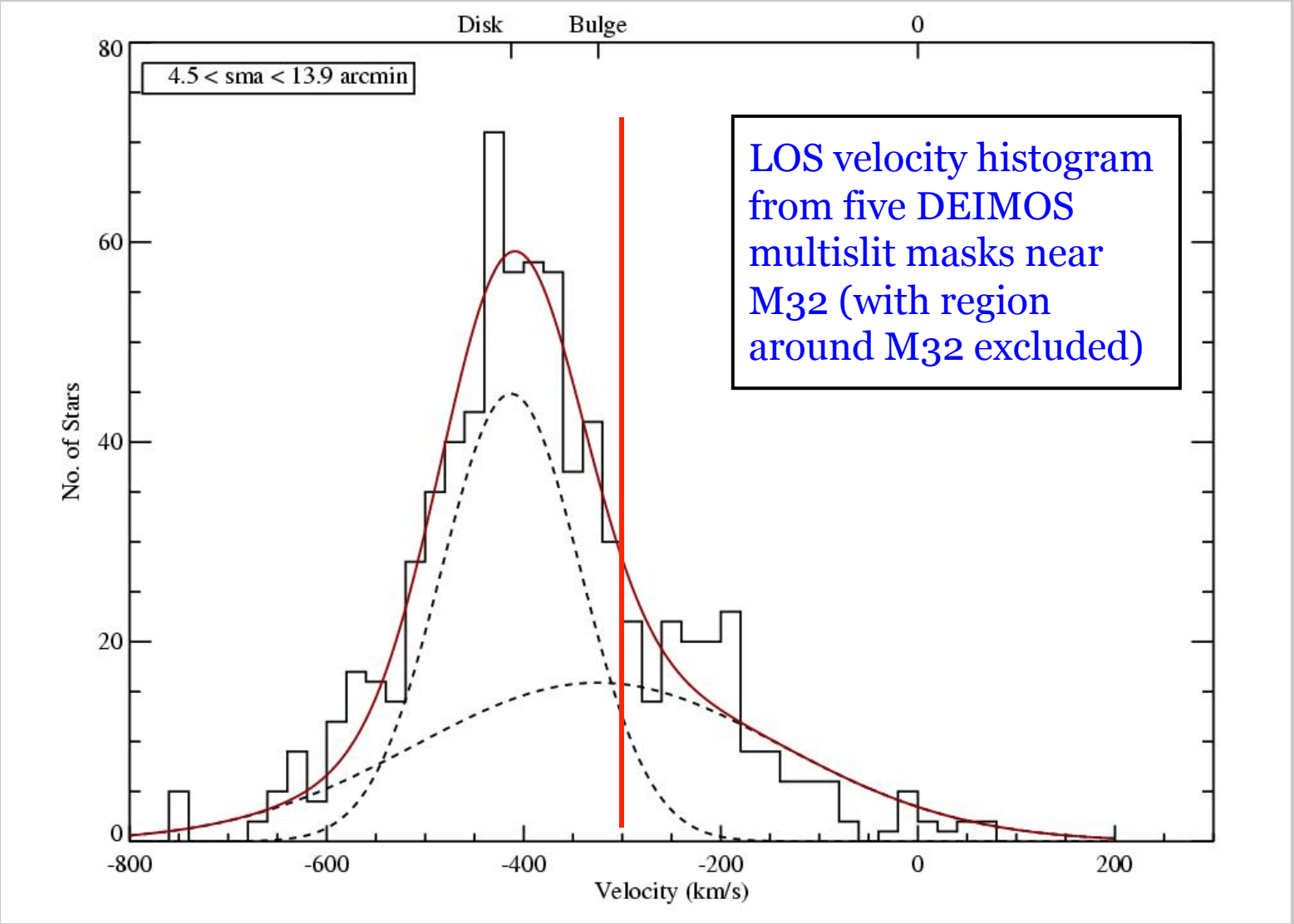
– Kirby et al. (2009–2011, ApJL, and ApJ/ApJS Papers I–IV)

Lei Yang, MS thesis, KIAA/PKU (+ UCSC + Caltech)

Detailed chemical abundances from coadded spectra of RGB stars in M31 dSph/dE galaxies (paper in prep)


Kinematics

Stellar Kinematics of M31's Disk & Spheroid

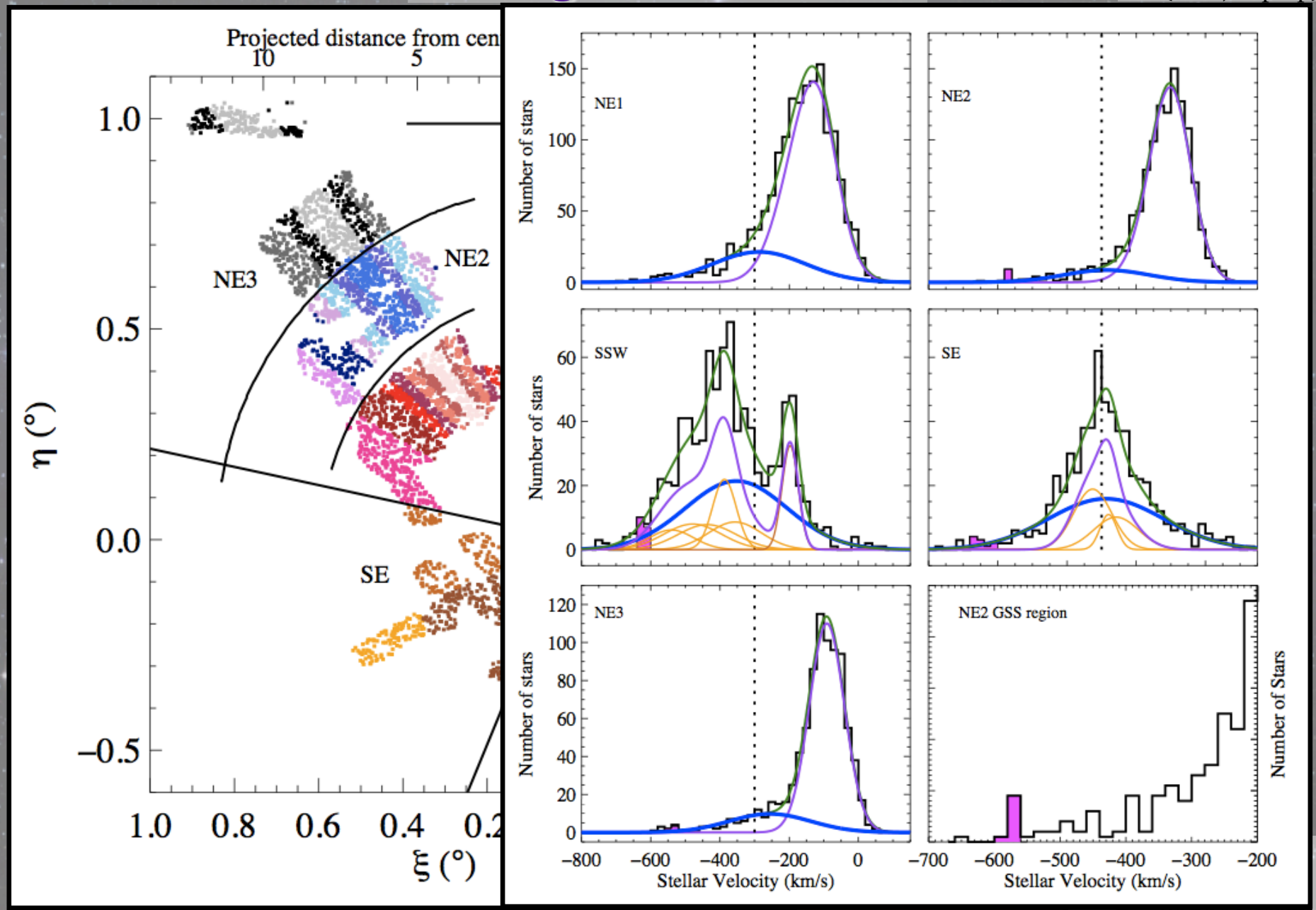


— Well approximated by a cold, rotating disk with a flat rotation curve (v_{rot} = 250 km/s) superposed on a hot spheroidal component with low rotation

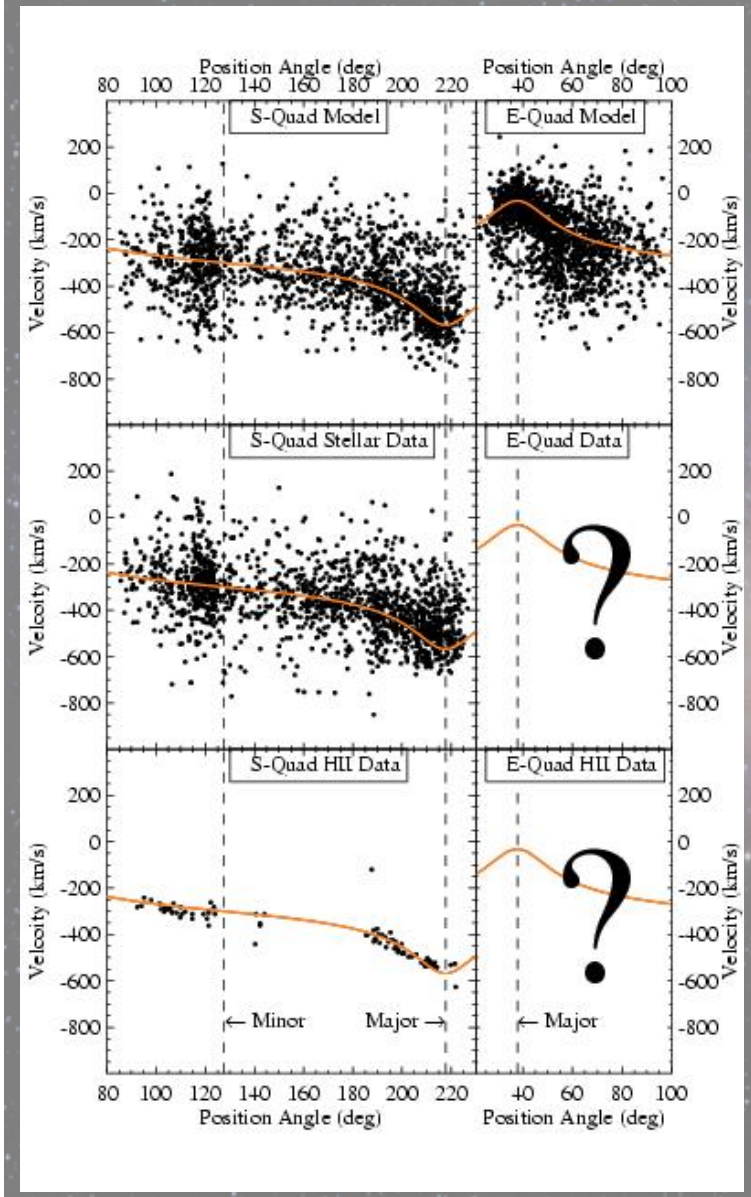
Howley, PG, Kalirai, et al. (2011b, in prep)

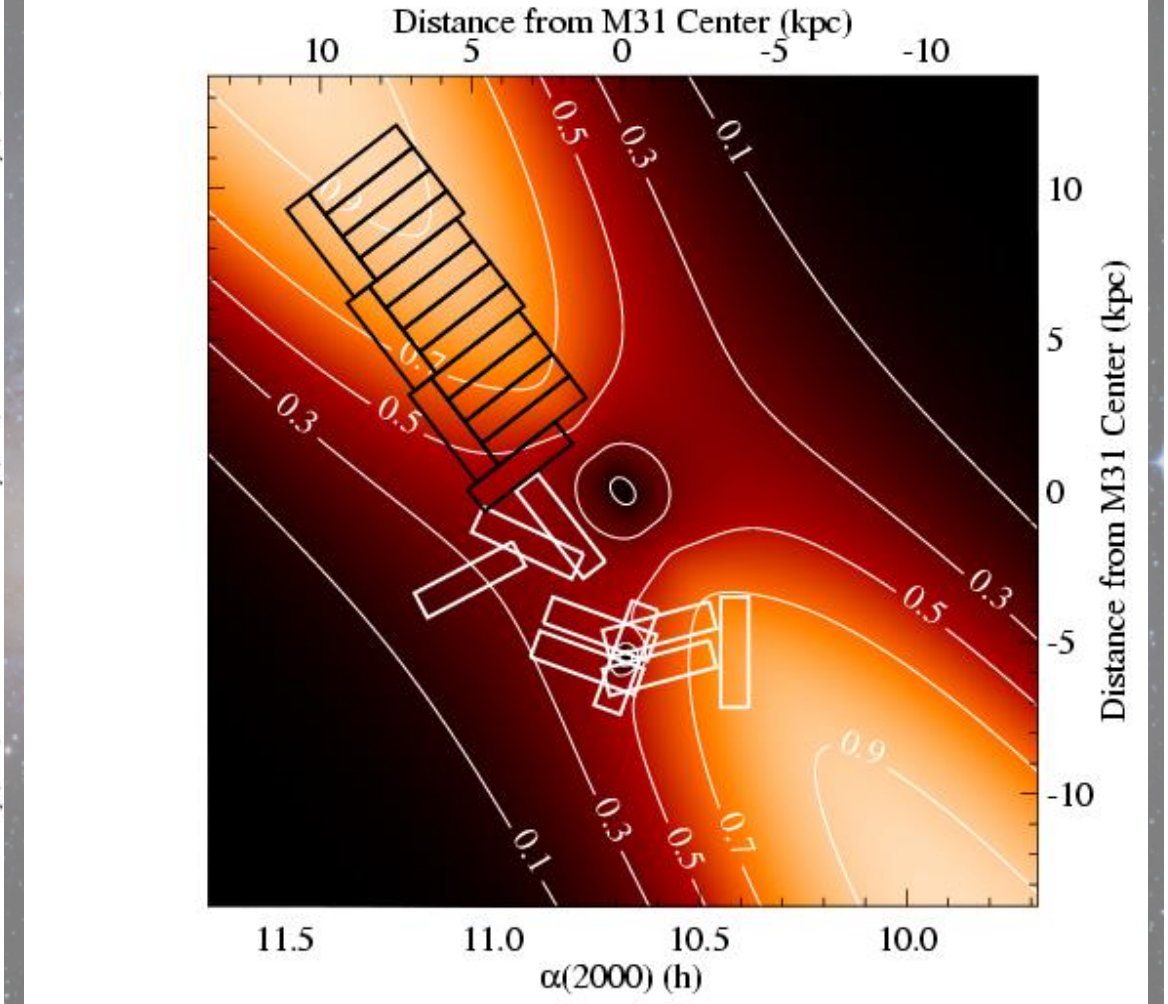
Bulge kinematics

Dorman, PG, et al (2011, in prep)

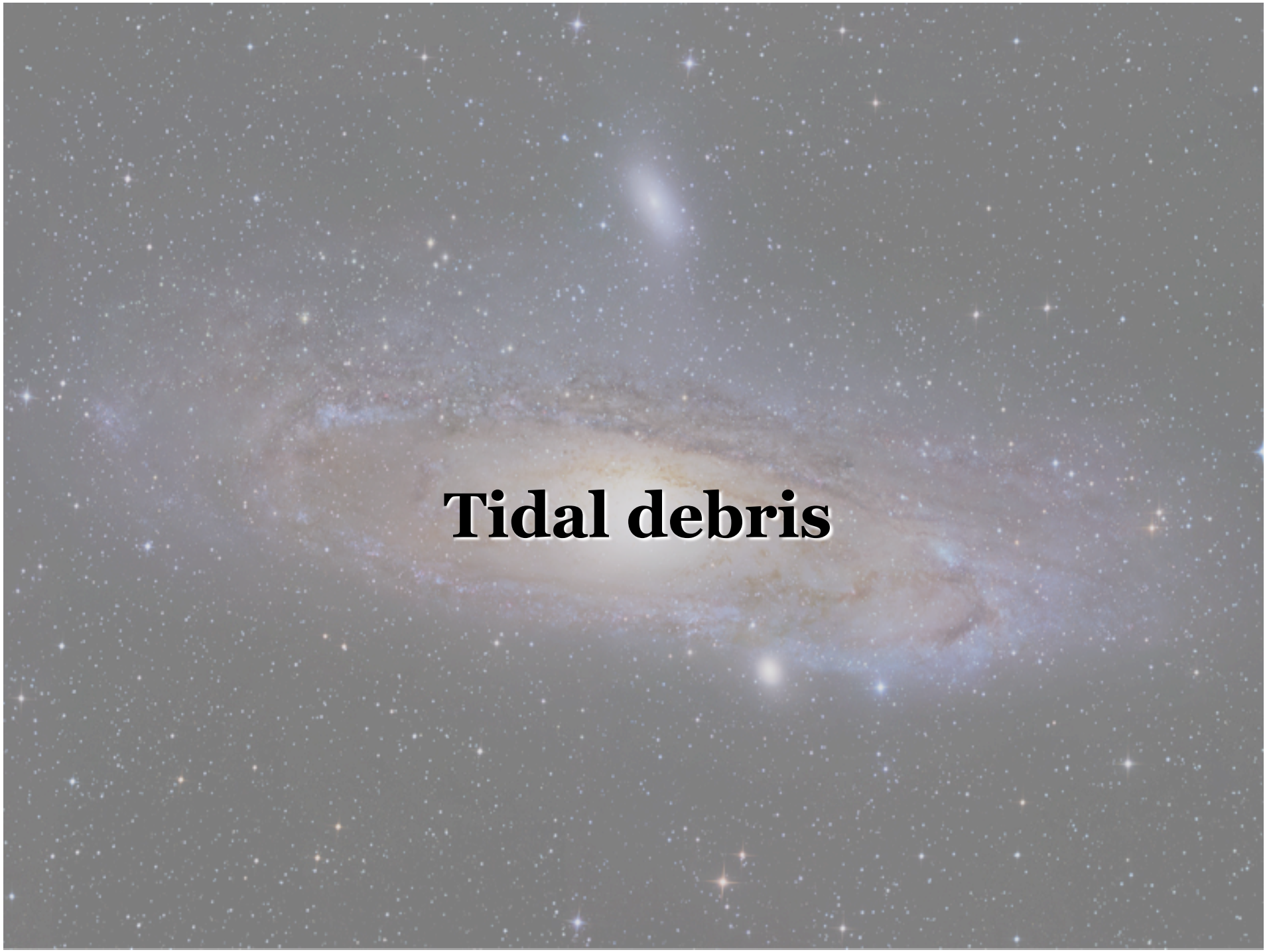


Stellar and ionized gas kinematics

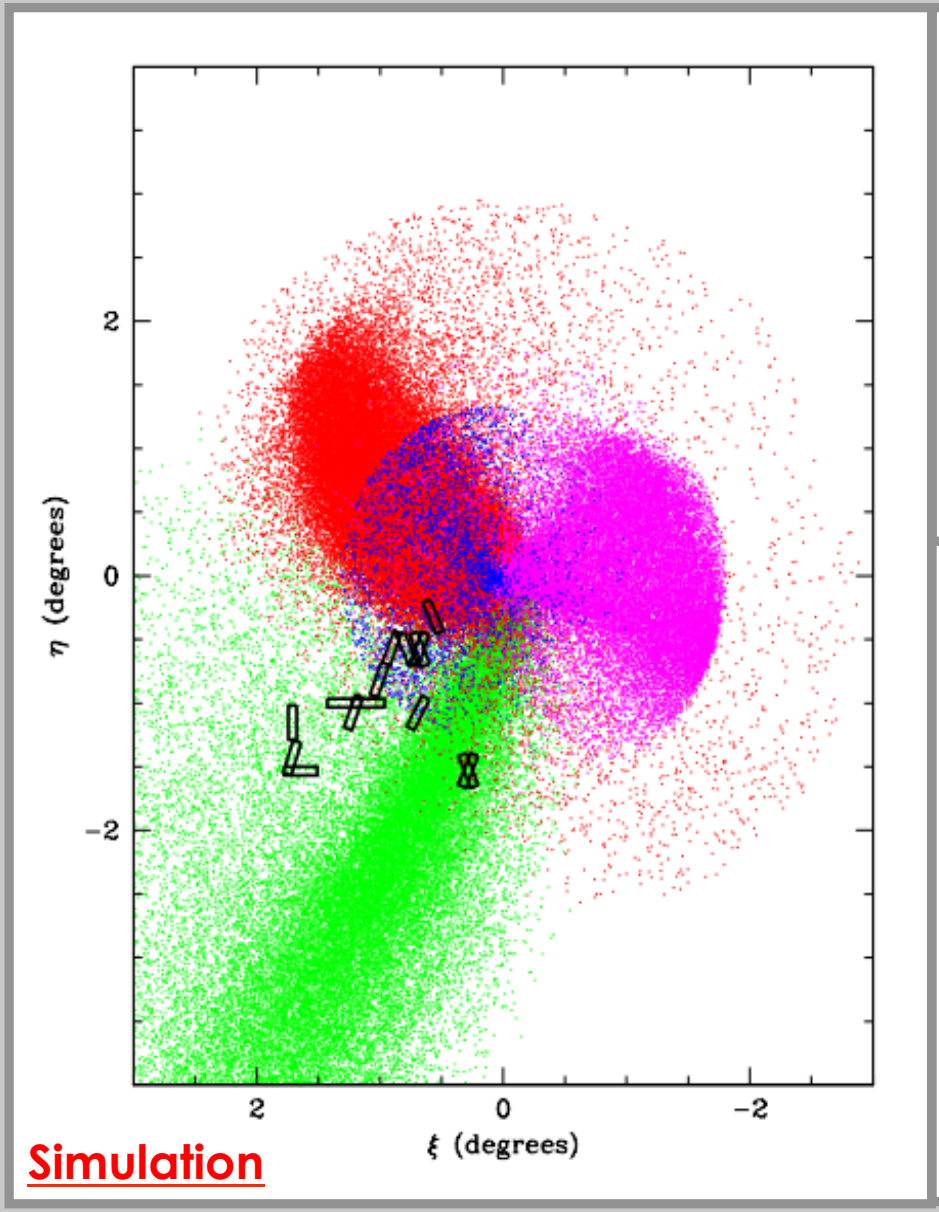


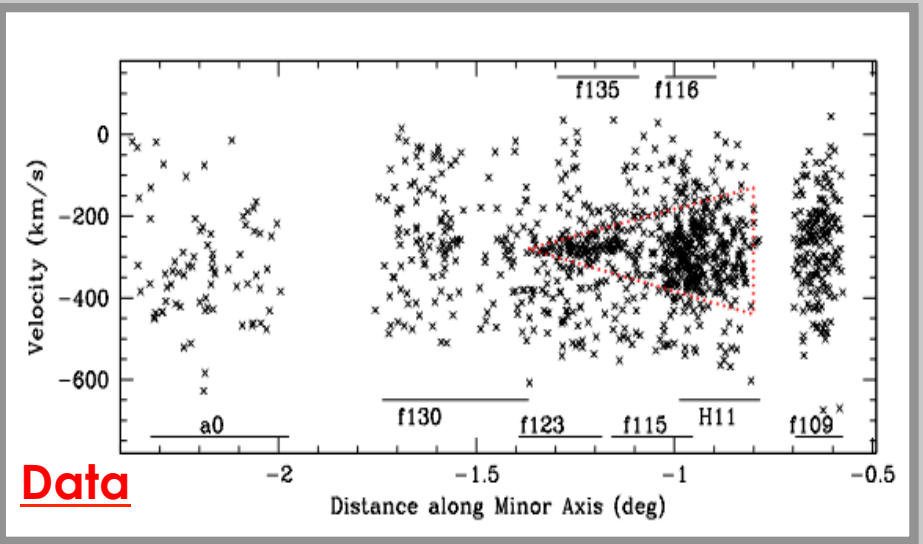


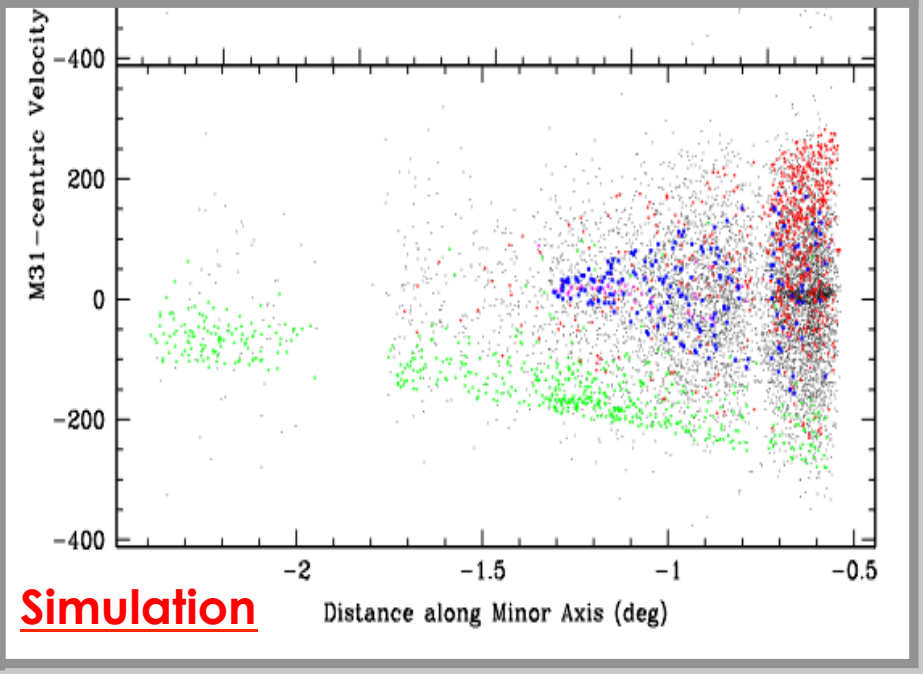
Dorman, PG, et al (2011, in prep)
Howley, PG, Kalirai, et al. (2011b, in prep)


Tidal debris

Giant Southern Stream and Young Shell System in M31



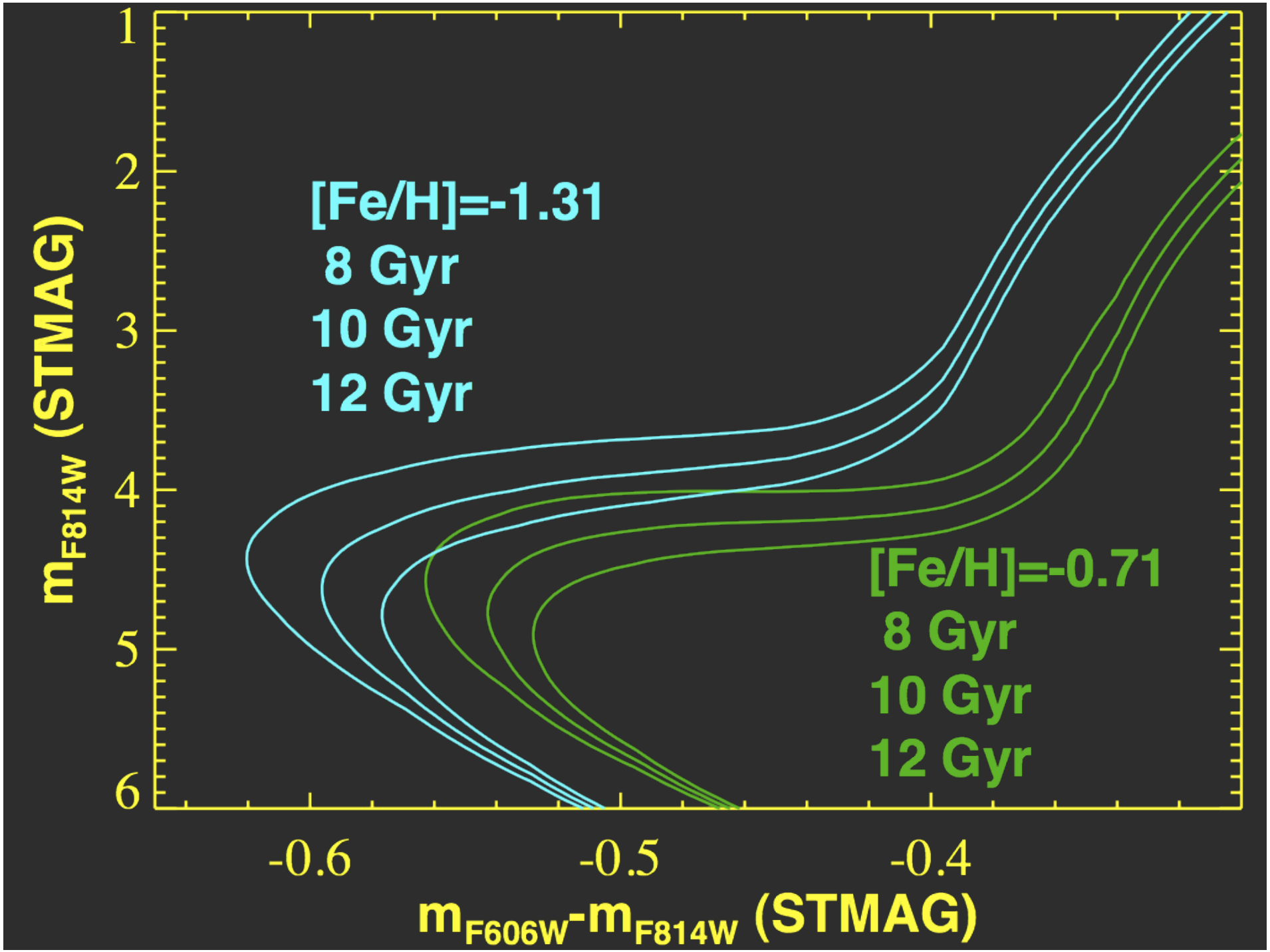


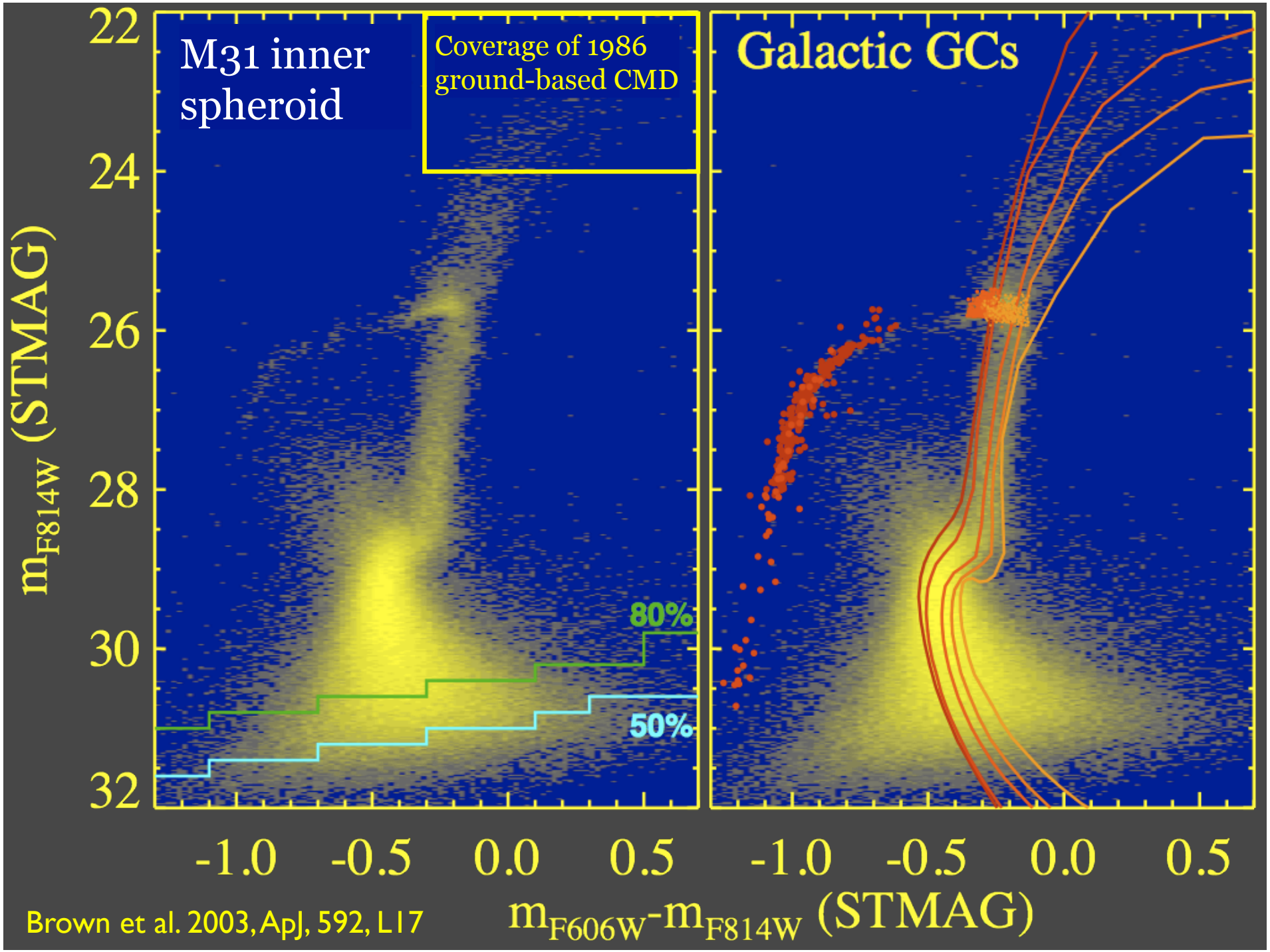


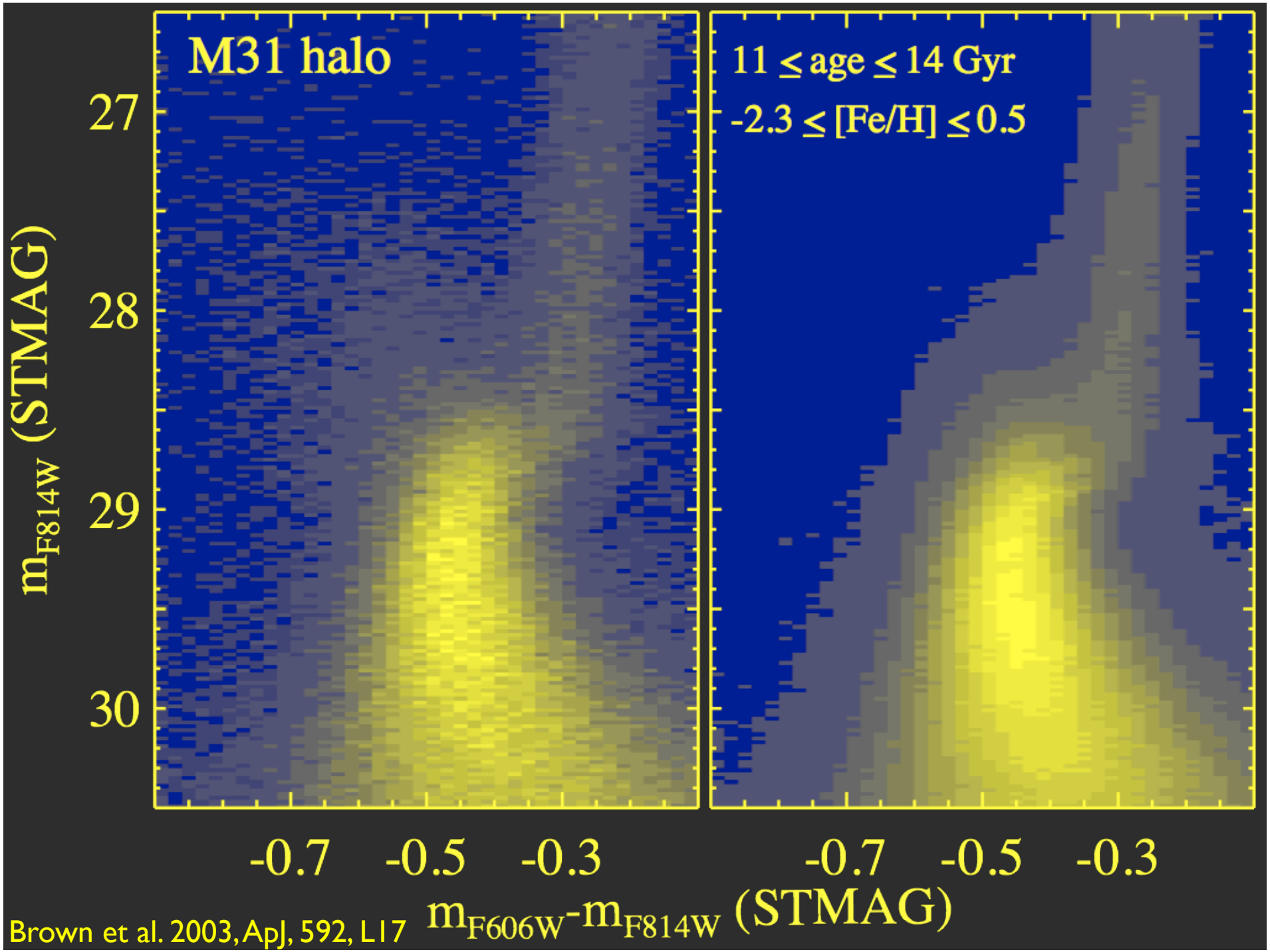
Fardal et al. (2007, MNRAS)

Gilbert et al. (2007, ApJ)

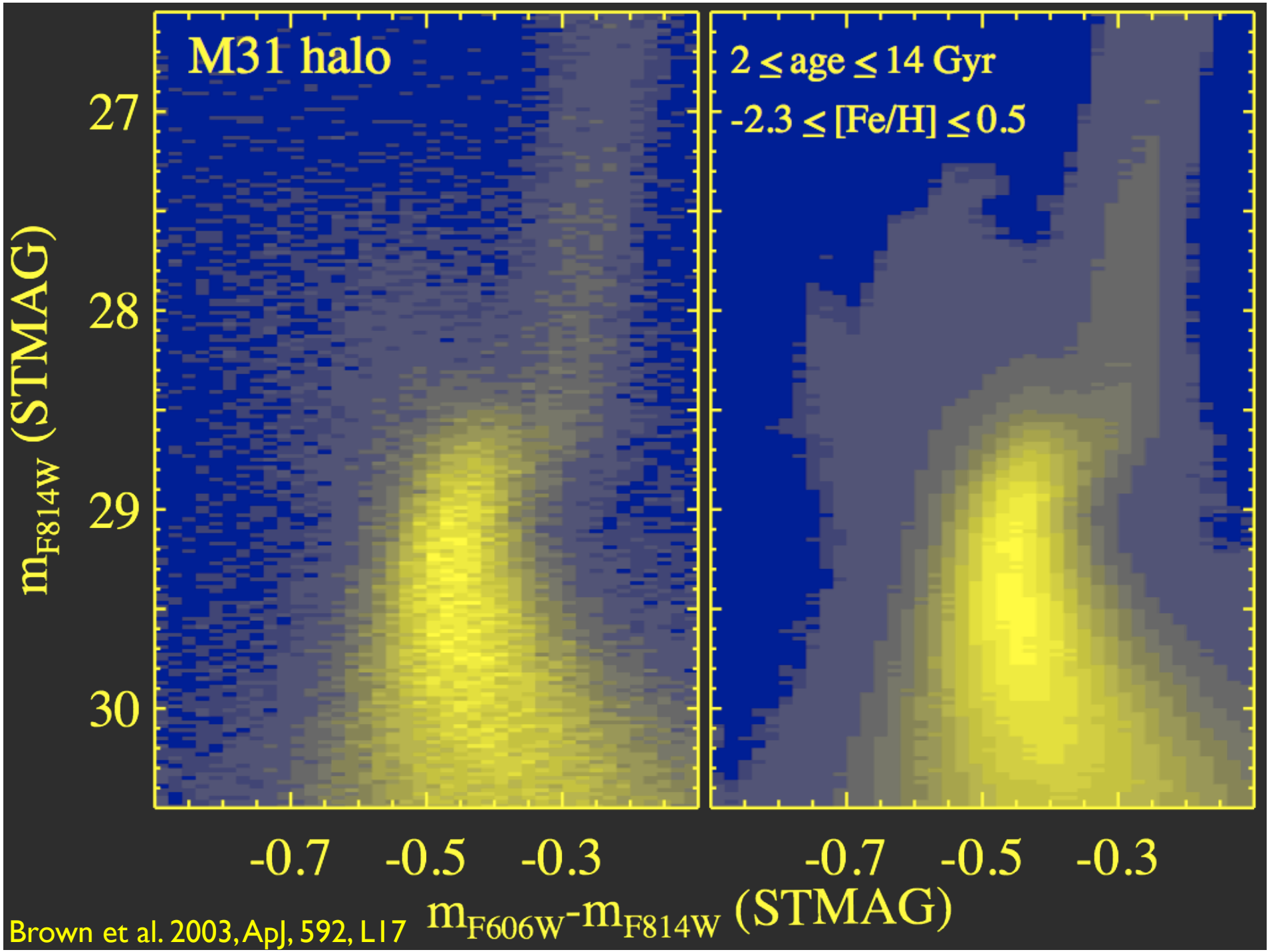

Star-formation history


[Fe/H]=-1.31
8 Gyr
10 Gyr
12 Gyr
[Fe/H]=-0.71
8 Gyr
10 Gyr
12 Gyr
1
2
3
4
5
6
-0.6
-0.5
-0.4
m_F814W (STMAG)
m_F606W-m_F814W (STMAG)


M31 inner spheroid
Coverage of 1986 ground-based CMD
Galactic GCs
80%
50%
22
24
26
28
30
32
m_{F814W} (STMAG)
-1.0
-0.5
0.0
0.5
-1.0
-0.5
0.0
0.5
m_{F606W}-m_{F814W} (STMAG)
Brown et al. 2003, ApJ, 592, L17

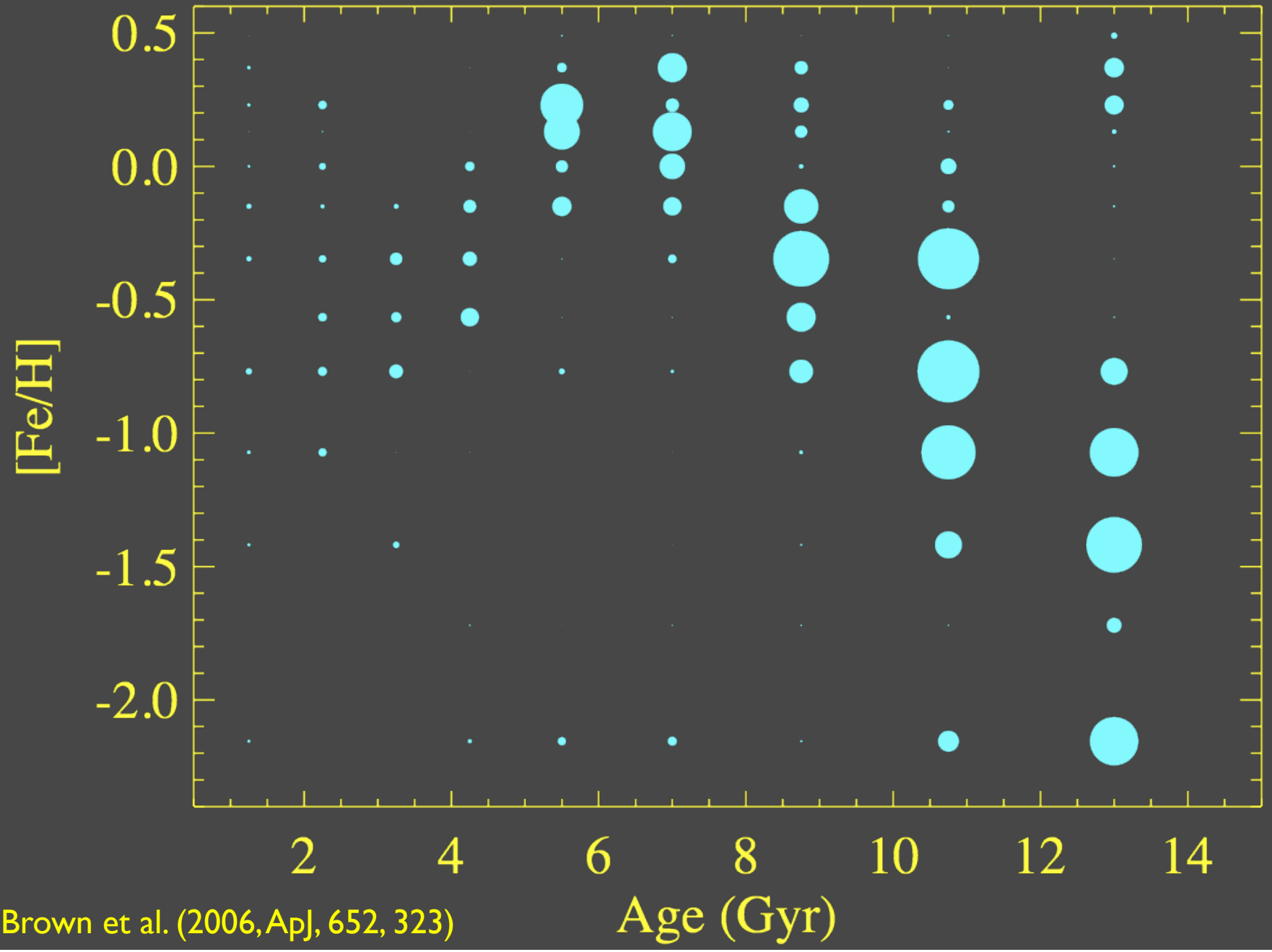


Brown et al. 2003, ApJ, 592, L17



Brown et al. 2003, ApJ, 592, L17

Inner Spheroid Distribution in Age and Metallicity



Brown et al. (2006, ApJ, 652, 323)

Summary

Andromeda's unusual bulge:

- Stars formed *in situ* versus accreted stellar systems
- No structural subcomponent like it in the Milky Way
- Boxy bulge and bar: pseudo-bulge + classical bulge
- Sersic profile with $n = 3$ dominates out to $R \sim 20–30$ kpc on the minor axis
- Metal-rich: $\langle[Fe/H]\rangle \sim -0.7$ with a large spread
- Dynamically hot ($\sigma_{los} \sim 130$ km/s) with a hint of rotation
- Kinematical detection of tidal debris associated with a recent merger event
- Most stars are old but about 20% are of intermediate age