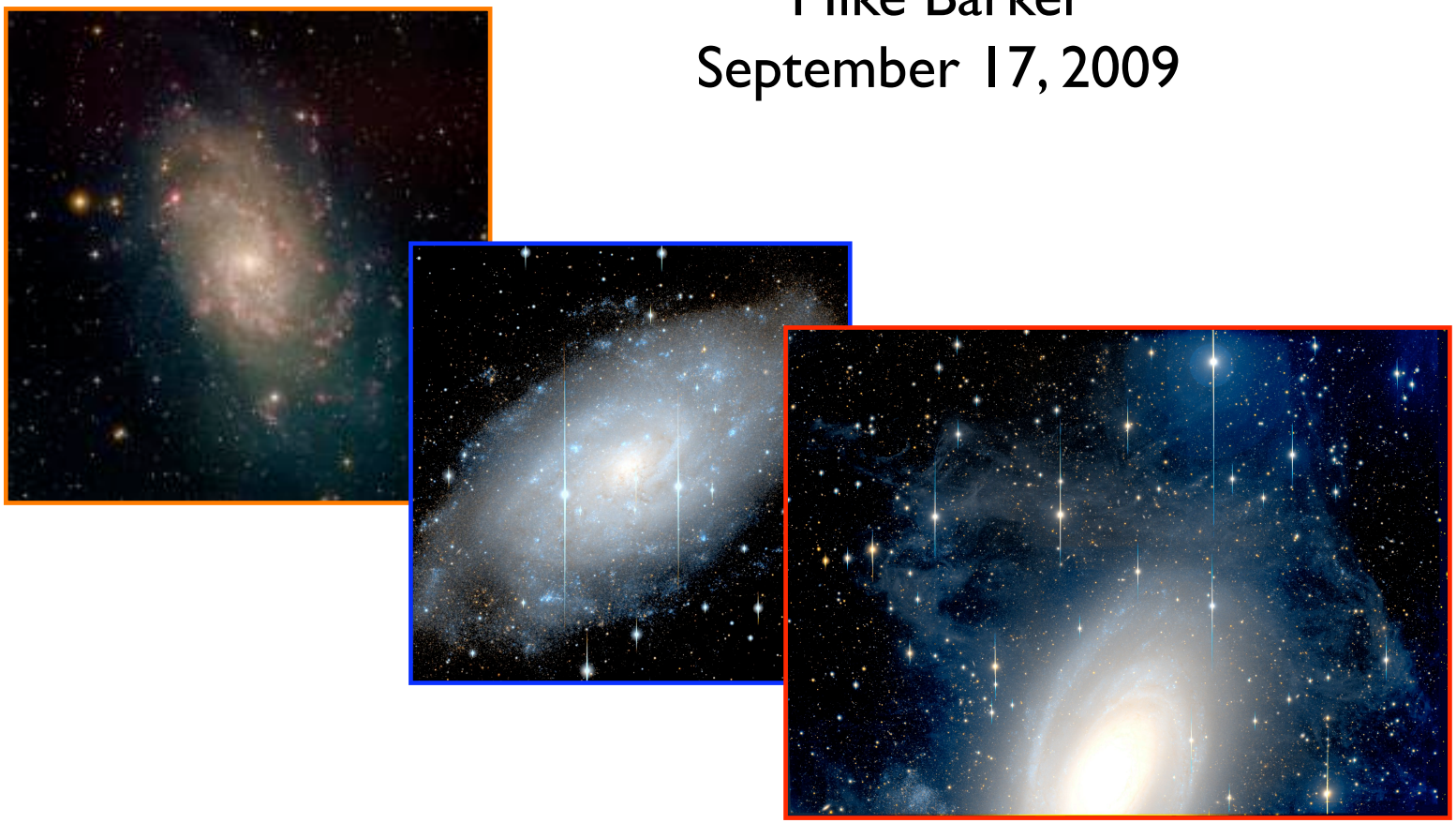
Probing the stellar outskirts of nearby spirals

Mike Barker

September 17, 2009

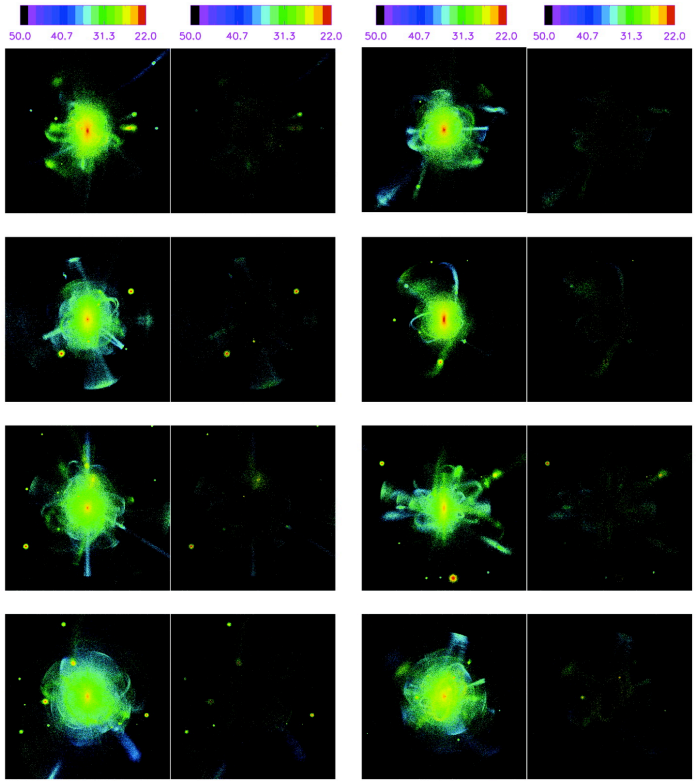


Collaborators

- Annette Ferguson (IfA, Edinburgh)
- Mike Irwin (IoA, Cambridge)
- Nobuo Arimoto (NAOJ, Tokyo)
- Pascale Jablonka (Gen. Obs., Sauverny)
- Ata Sarajedini (UF, Gainesville)
- Doug Geisler (U. Concepcion)
- Paul Harding (CWRU, Cleveland)

Motivation

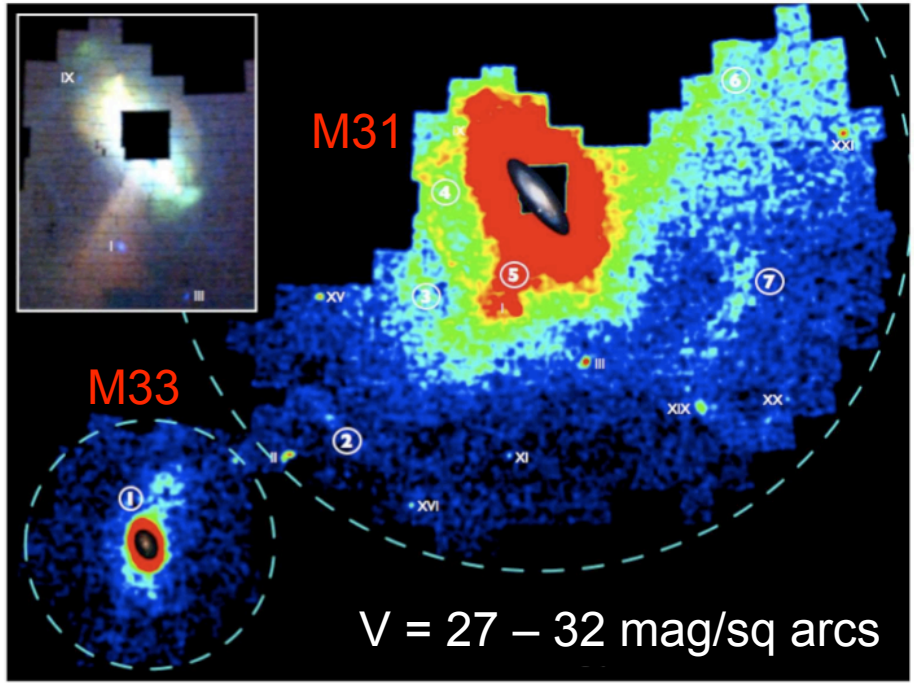
Hierarchical Galaxy Formation



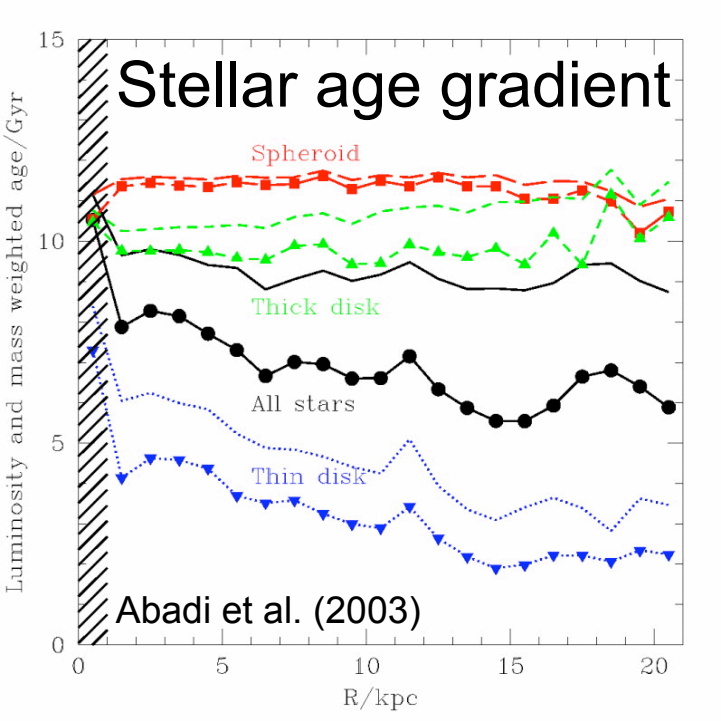
300 kpc

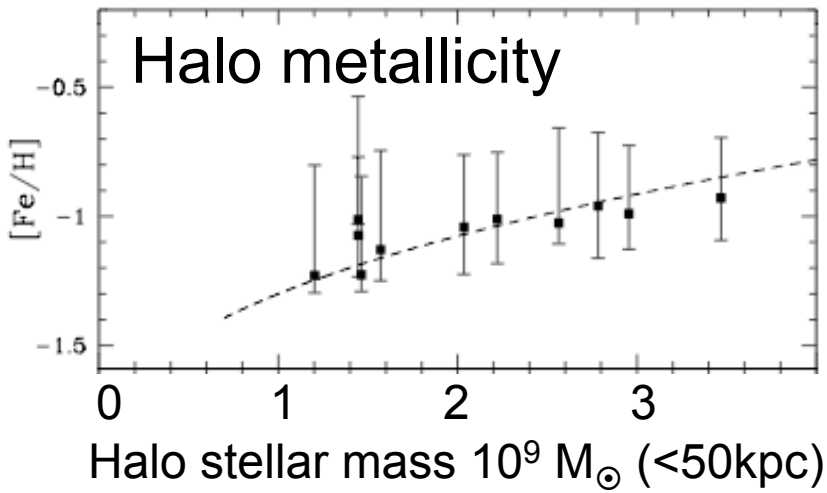
Simulations by
Font et al. (2006)

PAndAS Survey



McConnachie et al. (2009)



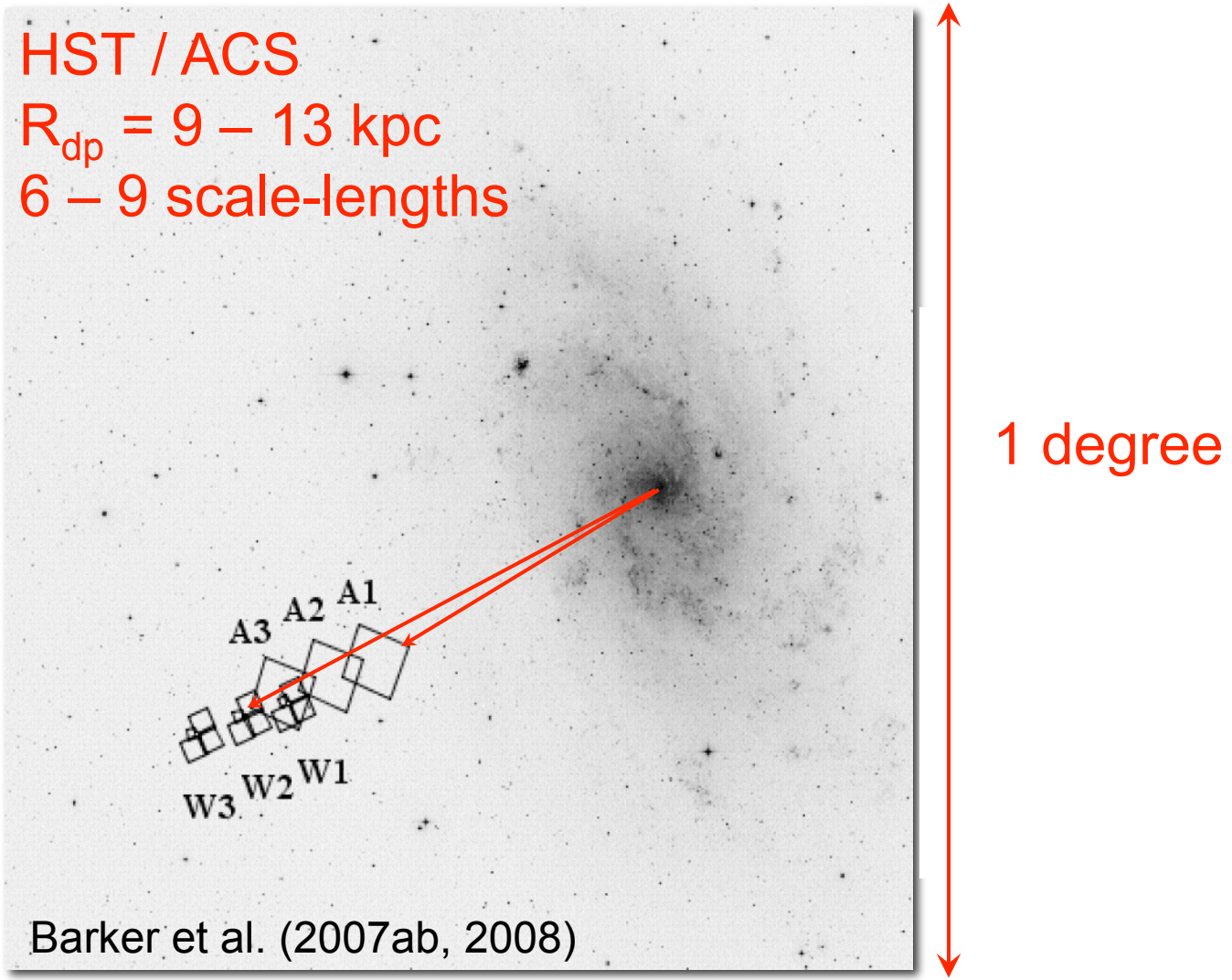


Font et al. (2006)

Basic Questions

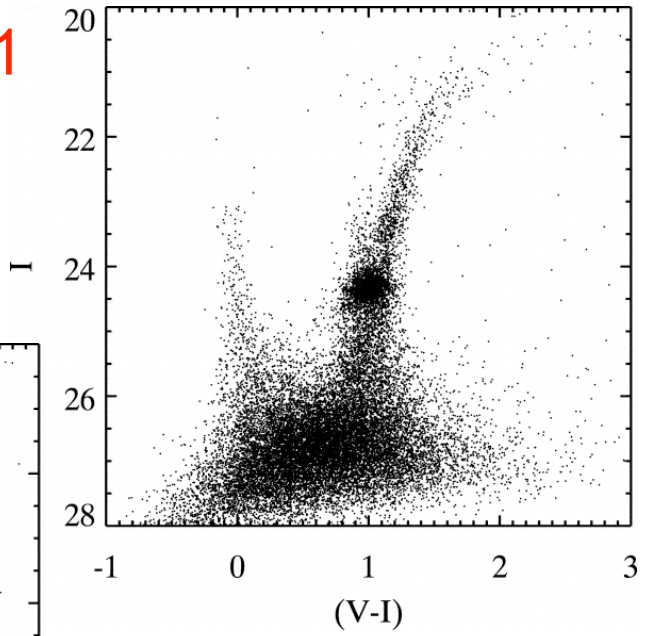
- When and how did disks form their stars?
- Role of gas flows, secular evol?
- Do all spirals have thick disks?
- Does every MW-type galaxy have a metal-poor halo?
- How do the properties of disks and halos vary with mass?

Recent Work on M33



Color-magnitude Diagrams (CMDs)

A1



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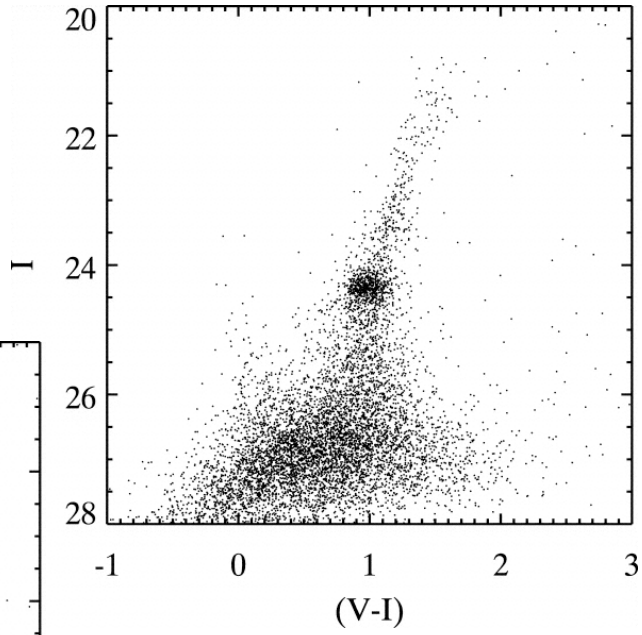

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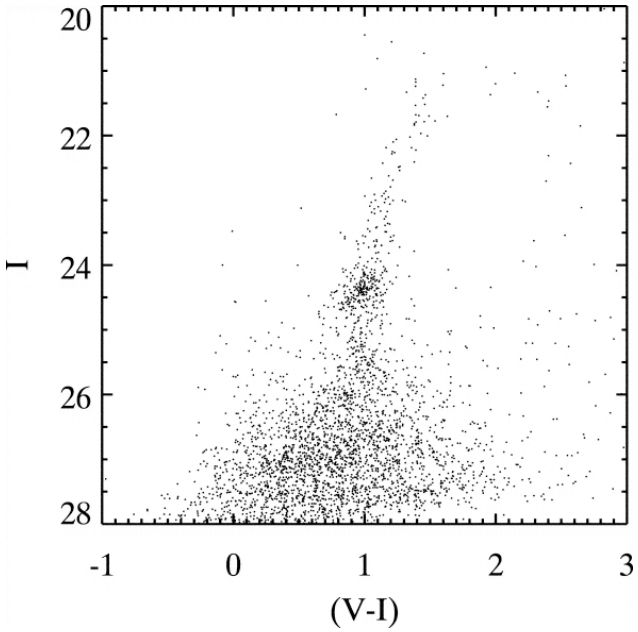
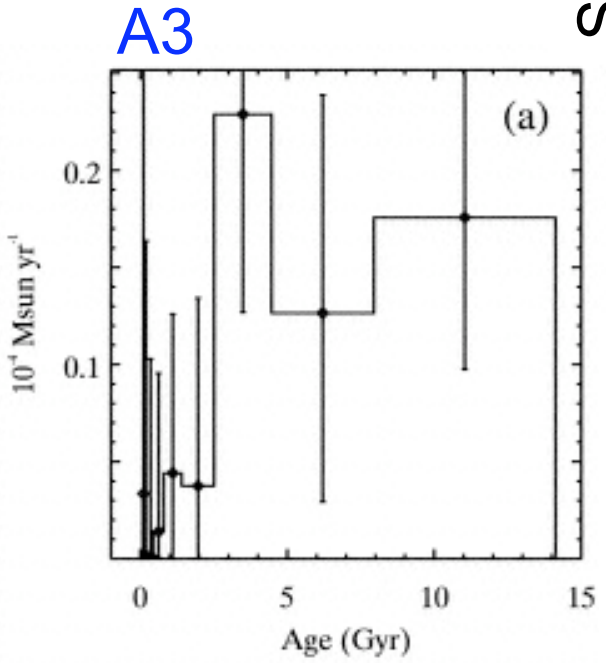
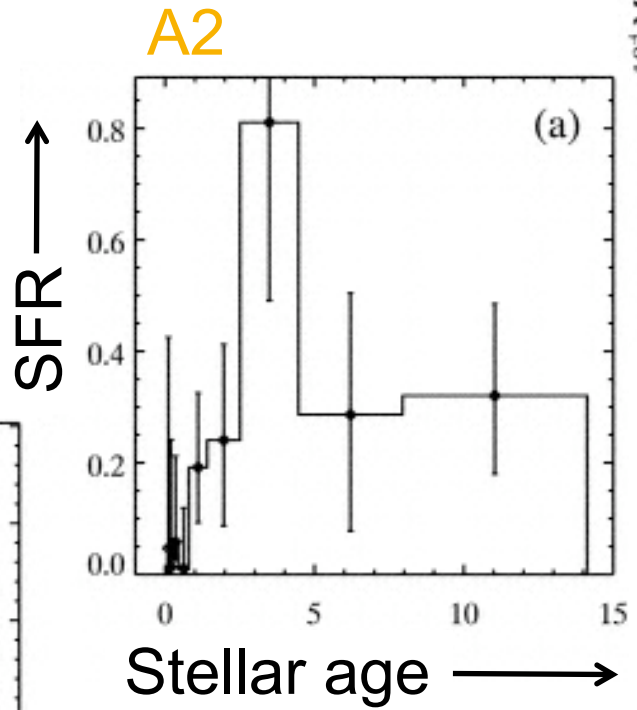


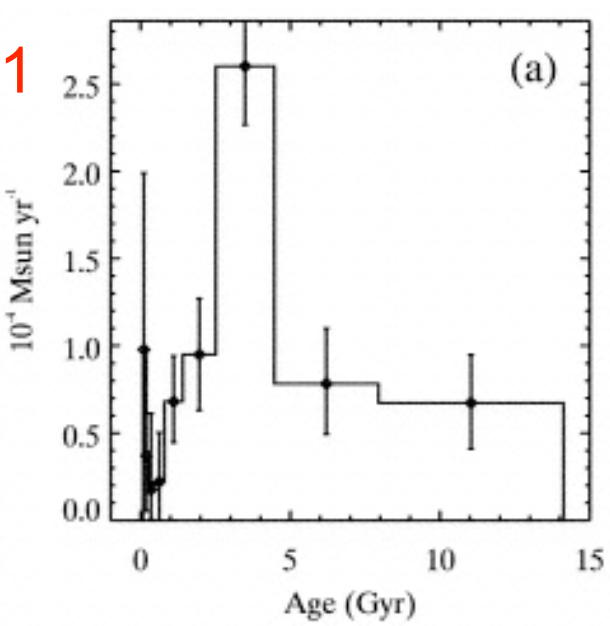
Distribution of stars in a CMD ⟺ Star formation & Chemical enrichment histories

Star Formation Histories

from CMD fitting

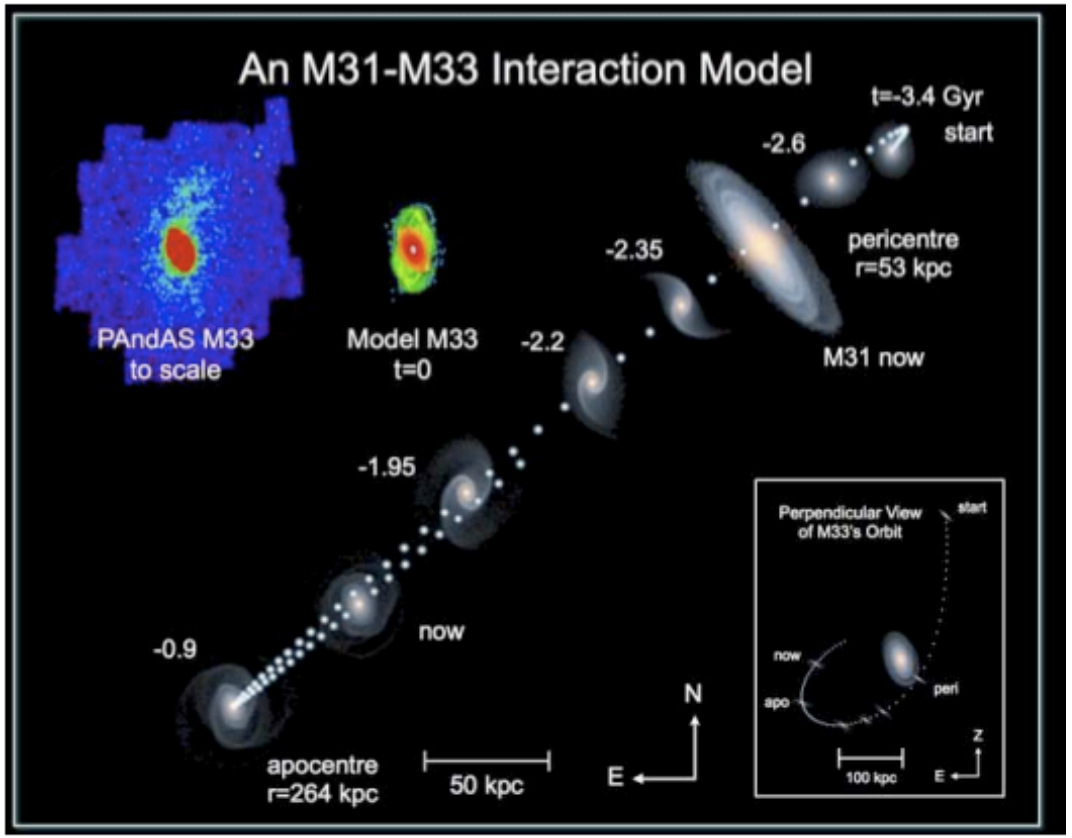






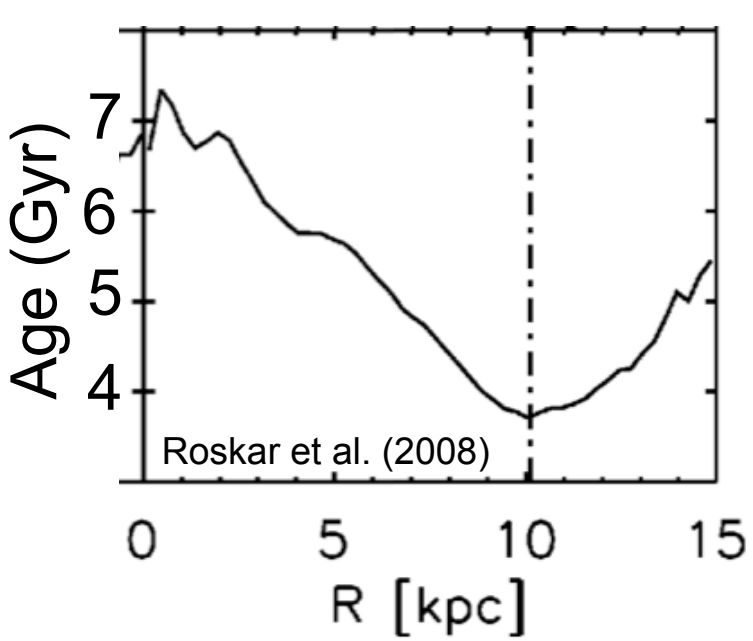
Significant fraction of stars formed at z < 1.
SFR peak 3 – 4 Gyr ago.

PAndAS Survey



McConnachie et al. (2009)

Stellar Radial Mixing



Sellwood & Binney (2002)
Roskar et al. (2008)

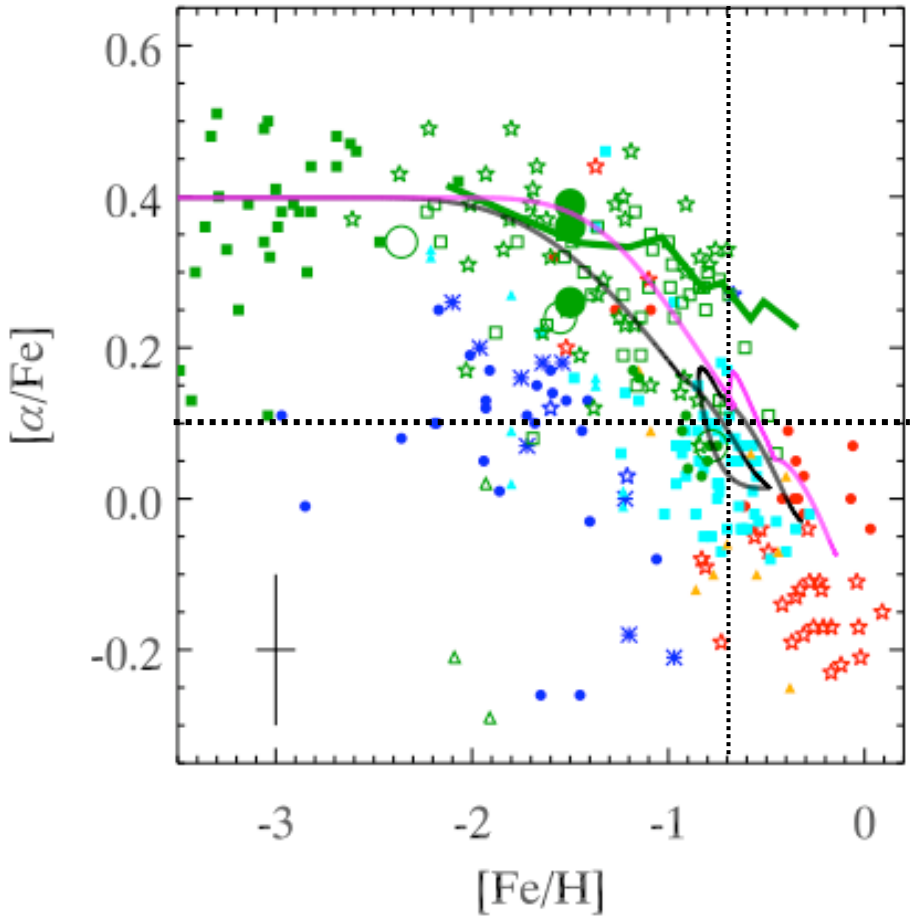
Resonant interactions of stars with transient spiral density waves

→ Scatter stars many kpc

→ Can modify age, [Fe/H] gradients

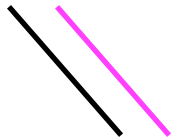
→ Williams et al. (2009): “The detection of inside-out disk growth in M33”

Chemical Fingerprinting



Milky Way halo
dSph satellites
Sagittarius dSph
LMC
Dwarf irregulars

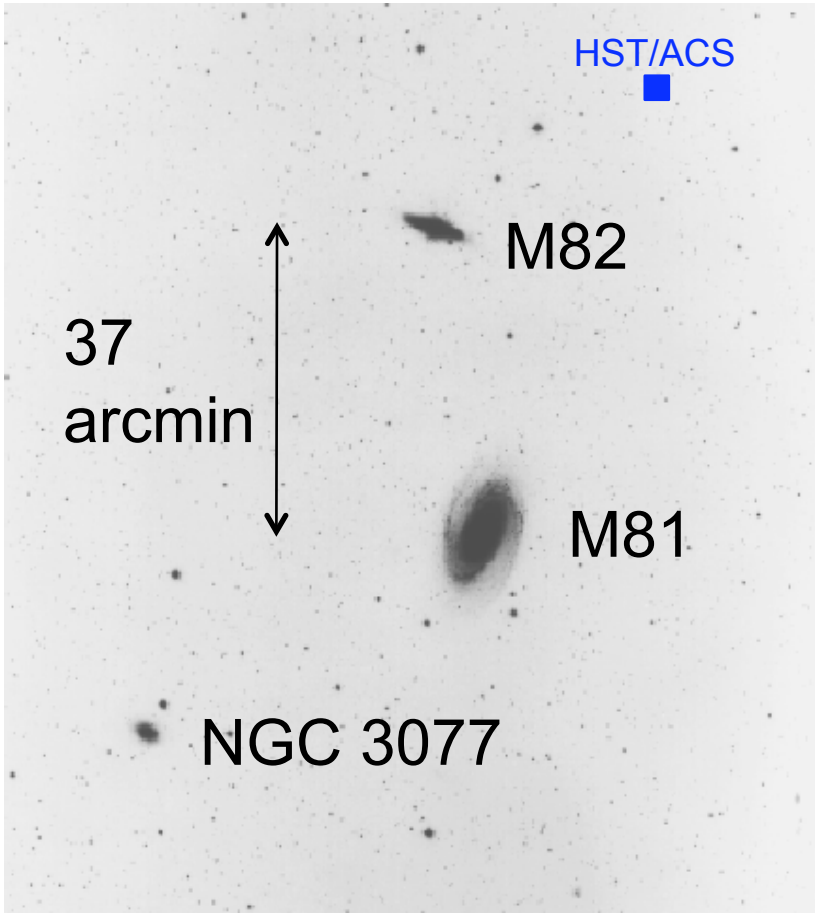
M33 model predictions:



E-ELT can extend chemical fingerprinting to larger distances

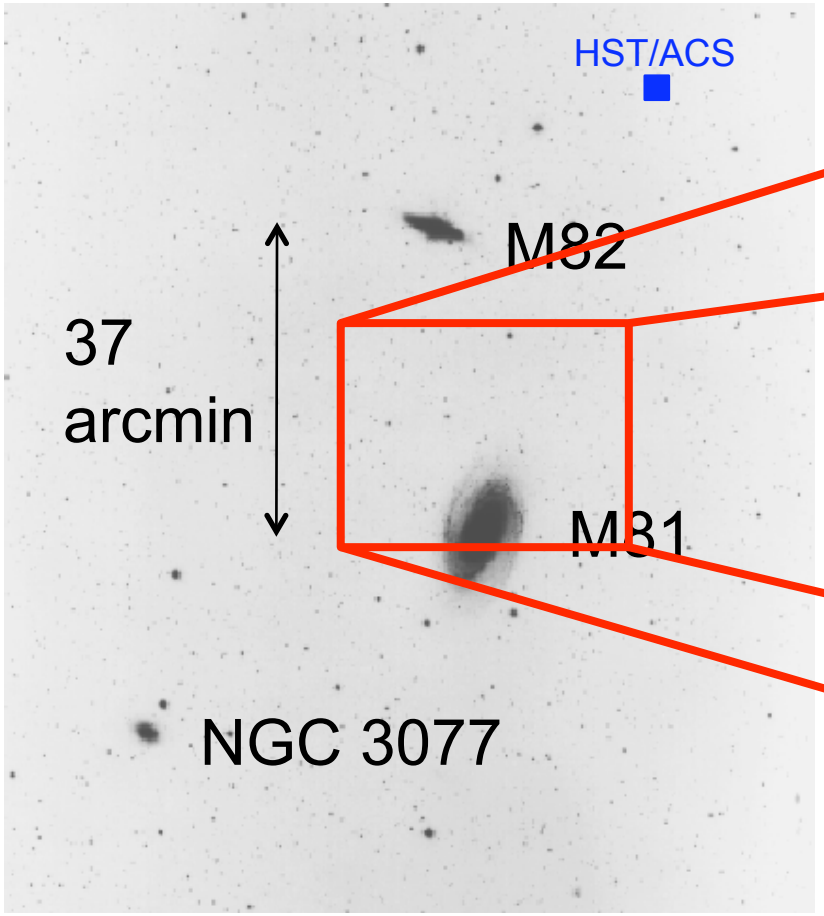
Geisler et al. (2007), Barker et al. (2008)

Beyond the Local Group: M81

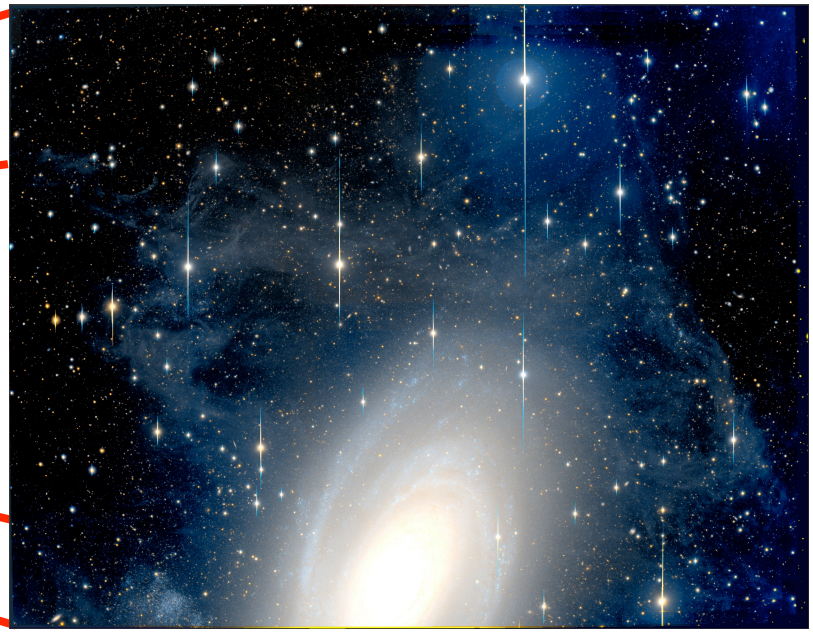


- Need larger sample
- M81 is one of the closest big spiral galaxies like M31
- M81 ~ 4.5x more distant
- Wide-field imaging easier

Wide-field Imaging of M81

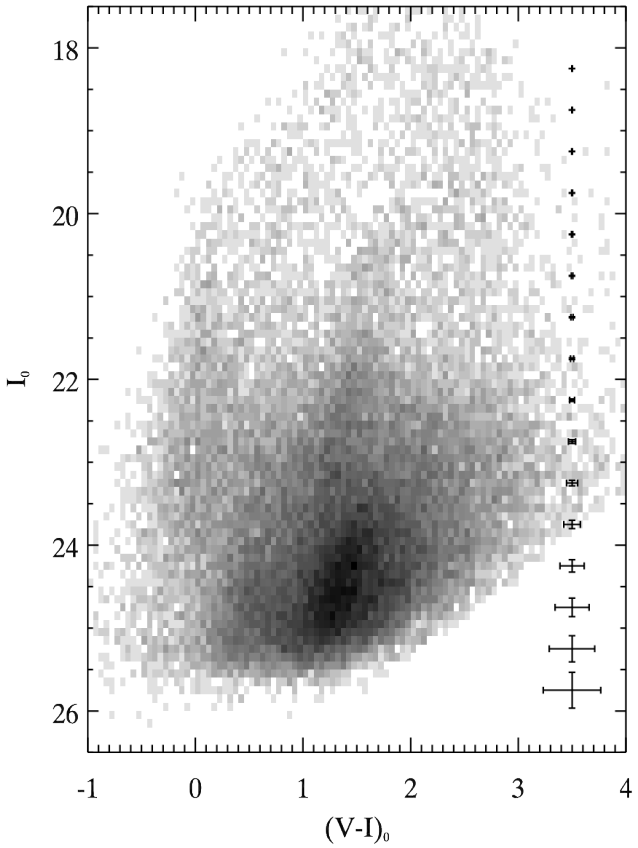


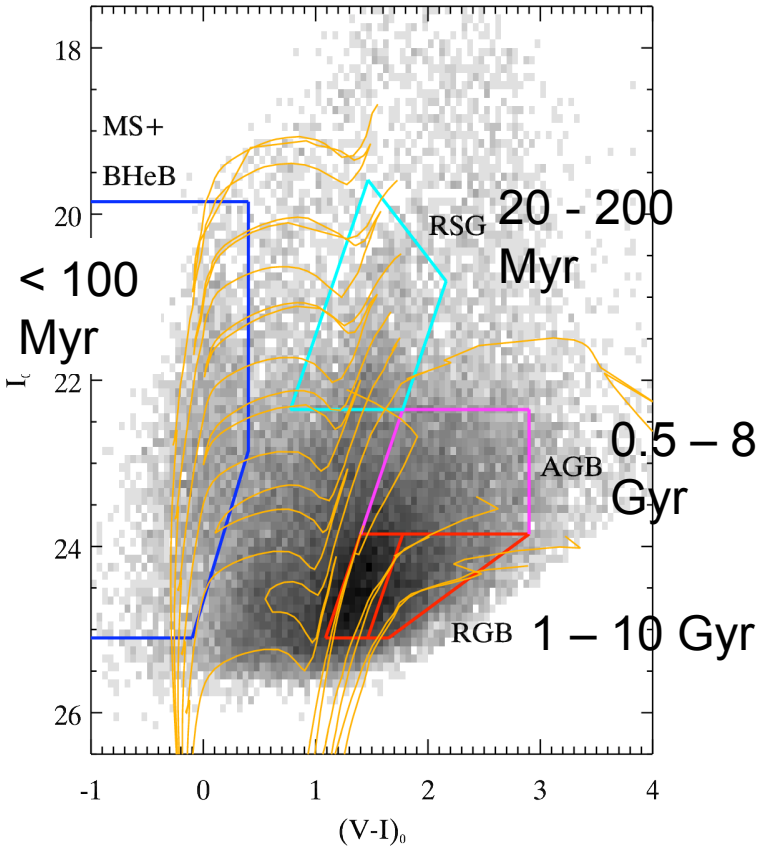
Suprime-Cam on 8-m Subaru



Barker et al. 2009, in press
astro-ph/0909.1430

M81 Color-magnitude Diagram

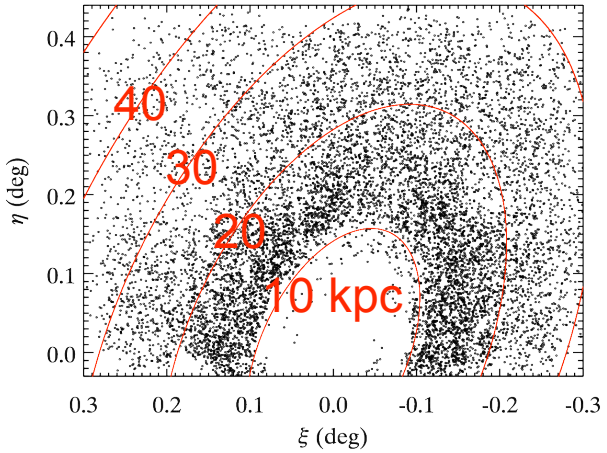


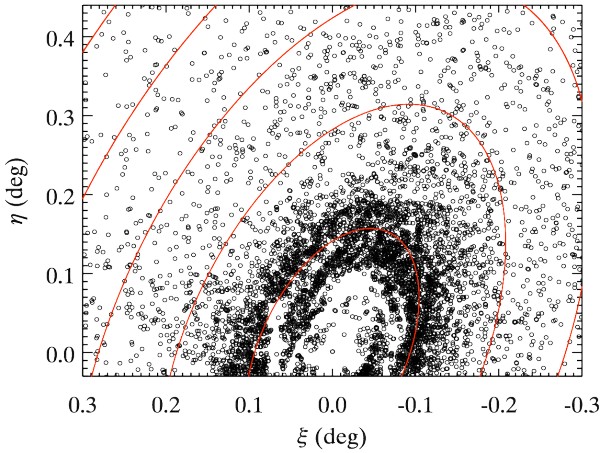


M81 Point Source Maps

RGB

1 – 10 Gyr



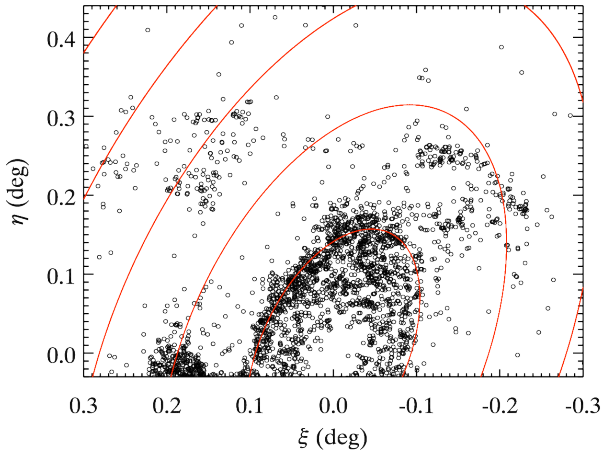


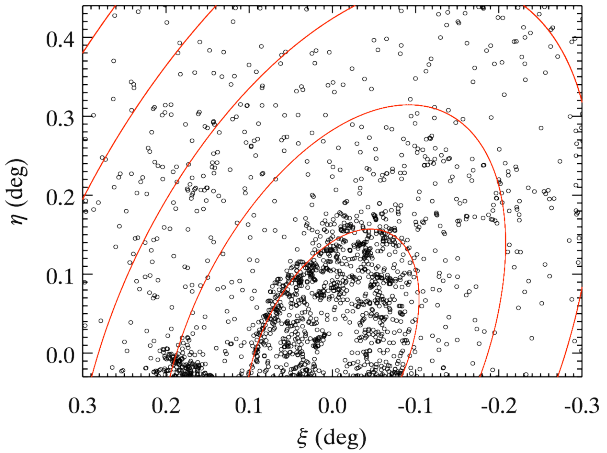
AGB

0.5 – 8 Gyr

MS+ BHeB

< 100 Myr



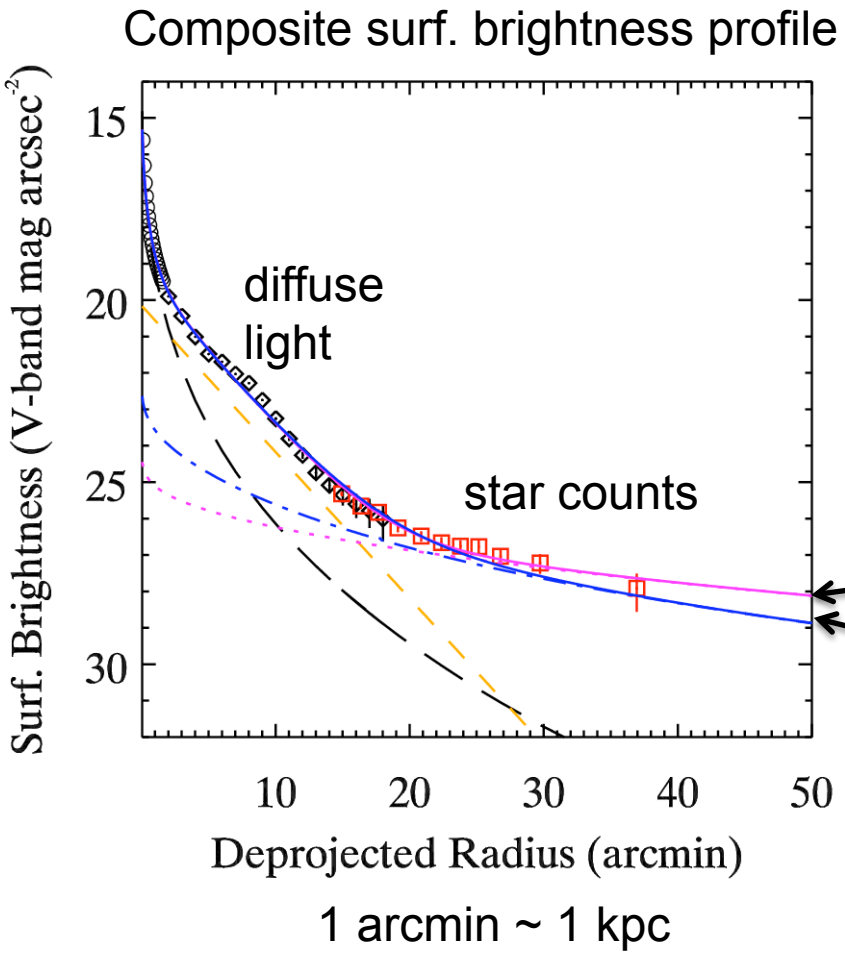


RSG

20 - 200 Myr

The first global view of BOTH young & old resolved stellar structure in M81's outskirts

M81 Extended Component



Spatial distribution

Exp. scale length h ~ 13 kpc

Power law exponent γ ~ -2

Luminosity

L_V ~ a few 10^9 $L_\odot$

Hernquist scale radius:

M31: r_s = 53.1 kpc

MW: r_s = 14 kpc

Metallicity

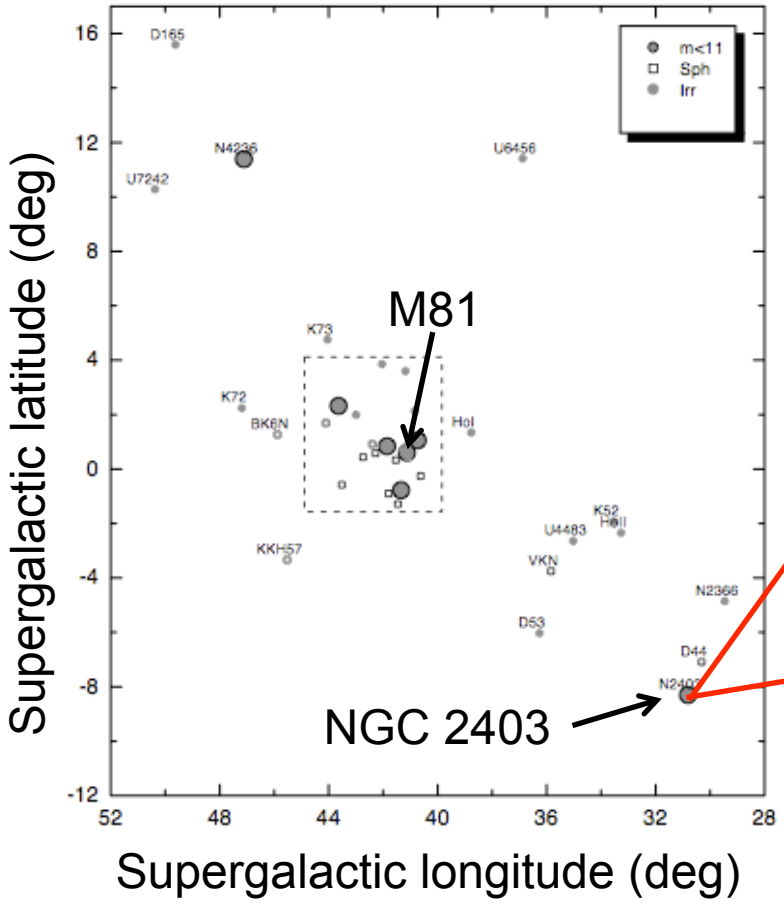
[M/H] = -1.1 +/- 0.3

at R_{dp} = 32 – 44 kpc

for an age of 10 Gyr

Beyond the Local Group: NGC 2403

Karachentsev et al. (2002)



Subaru Suprime-Cam

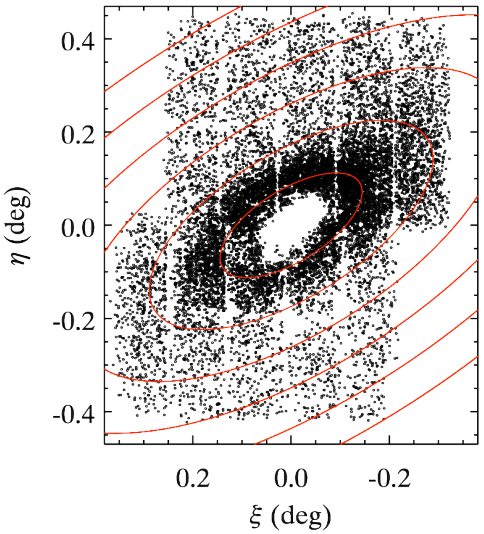
27’ ≈
24 kpc

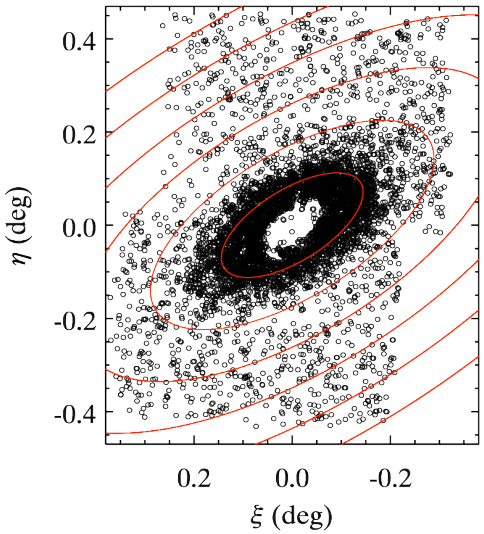
Barker et al. in prep

NGC 2403 Point Source Maps

RGB

1 – 10 Gyr



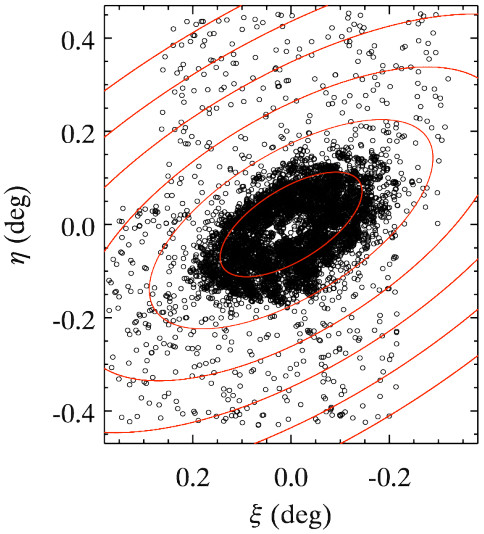


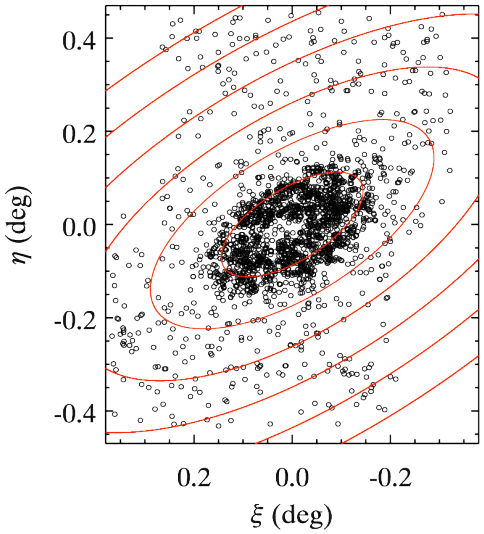
AGB

0.5 – 8 Gyr

MS+ BHeB

< 100 Myr



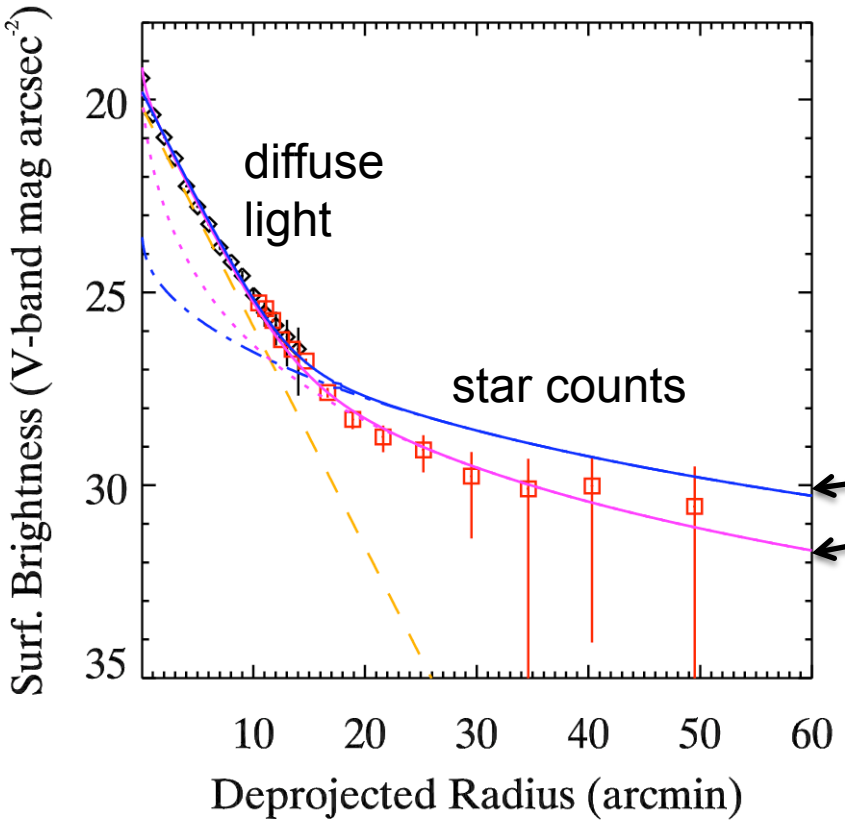


RSG

20 - 200 Myr

NGC 2403 Extended Component

Composite surf. brightness profile



1 arcmin ~ 0.9 kpc

<u>Spatial distribution</u>
Exp. scale length h ~ 3 kpc
Power law exponent γ ~ -2.3

Hernquist scale radius:
MW: r_s = 14 kpc
r_s = 1.8 kpc

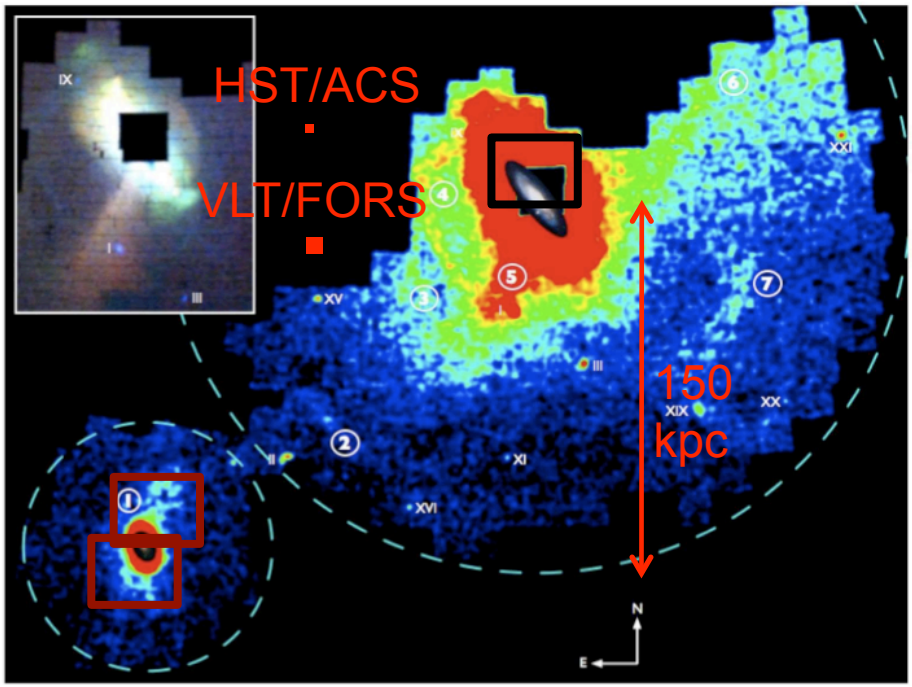
→ More concentrated, less luminous, more metal-poor than in M81

Summary

- Most stars in M33's far outer disk formed at z < 1
- SFR peak a few Gyr ago
- Extended components in M81, NGC 2403
- Halo, thick disk, bulge, perturbed disk?
- Further evidence for faint, complex extended structures in outskirts
- Longer baseline in R and PA
- Spectra → Kinematics, [Fe/H]

Making an Impact with the E-ELT

M31 @ D = 3.6 Mpc



- Chemical fingerprinting:
  [Fe/H], [α/Fe]
- Kinematics of outskirts: thin disks, thick disks & halos
- [Fe/H] gradients
- Targeted deep imaging
- Global vs. local structures
- Wide field important – use in concert with other facilities?

Thank you!