GHOSTS

Probing the Outskirts of Disk Galaxies

Roelof de Jong (AIP)

GHOSTS Survey team:

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Chris Purcell (Pittsburgh)
Anil Seth (CfA/Utah)
Jonathan Sick (Rice)
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Marija Vlajic (AIP)
Dan Zucker (Macquarie/AAO)

Galaxy
Halos
Outer Disks
Substructure
Thick Disks
Star Clusters

GHOSTS

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GHOSTS The Survey

- GHOSTS samples the resolved stellar populations in the outskirts of 16+ nearby disk galaxies with a large HST ACS/WFPC2/WFC3 survey
- HST allows us to go to larger distances (more galaxies), denser regions (disk outskirts) and larger radii (less contamination)
- Science goals of GHOSTS:
  - Structure, substructure and metallicities of stellar halos
  - Stellar age/metallicity distributions in disk outskirts (scaleheigth/length, disk heating, truncations, warps)
  - Globular cluster systems

GHOSTS ACS Observations

NGC 0247
NGC 0253
NGC 0891
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NGC 4945
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IC 5052
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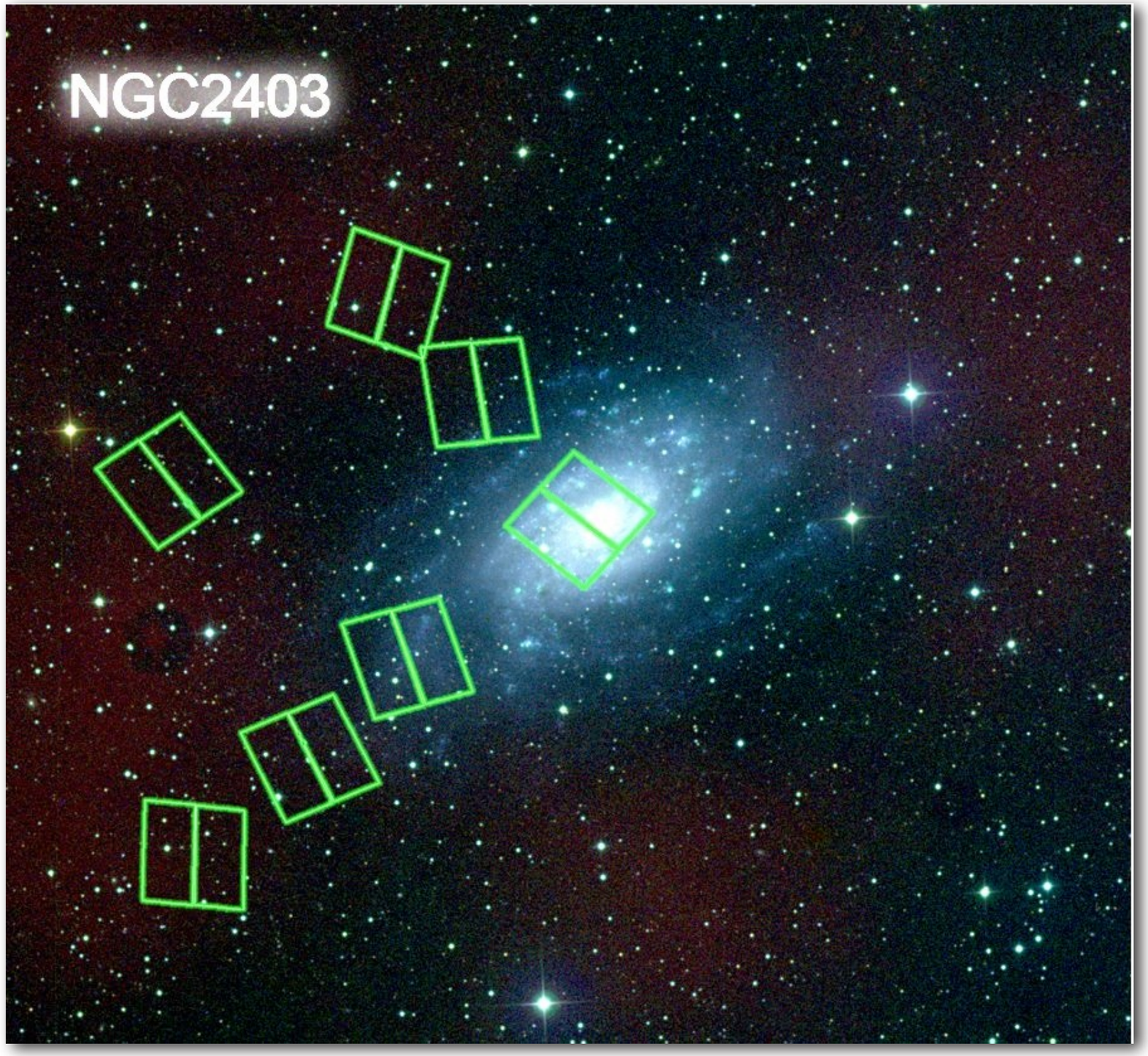

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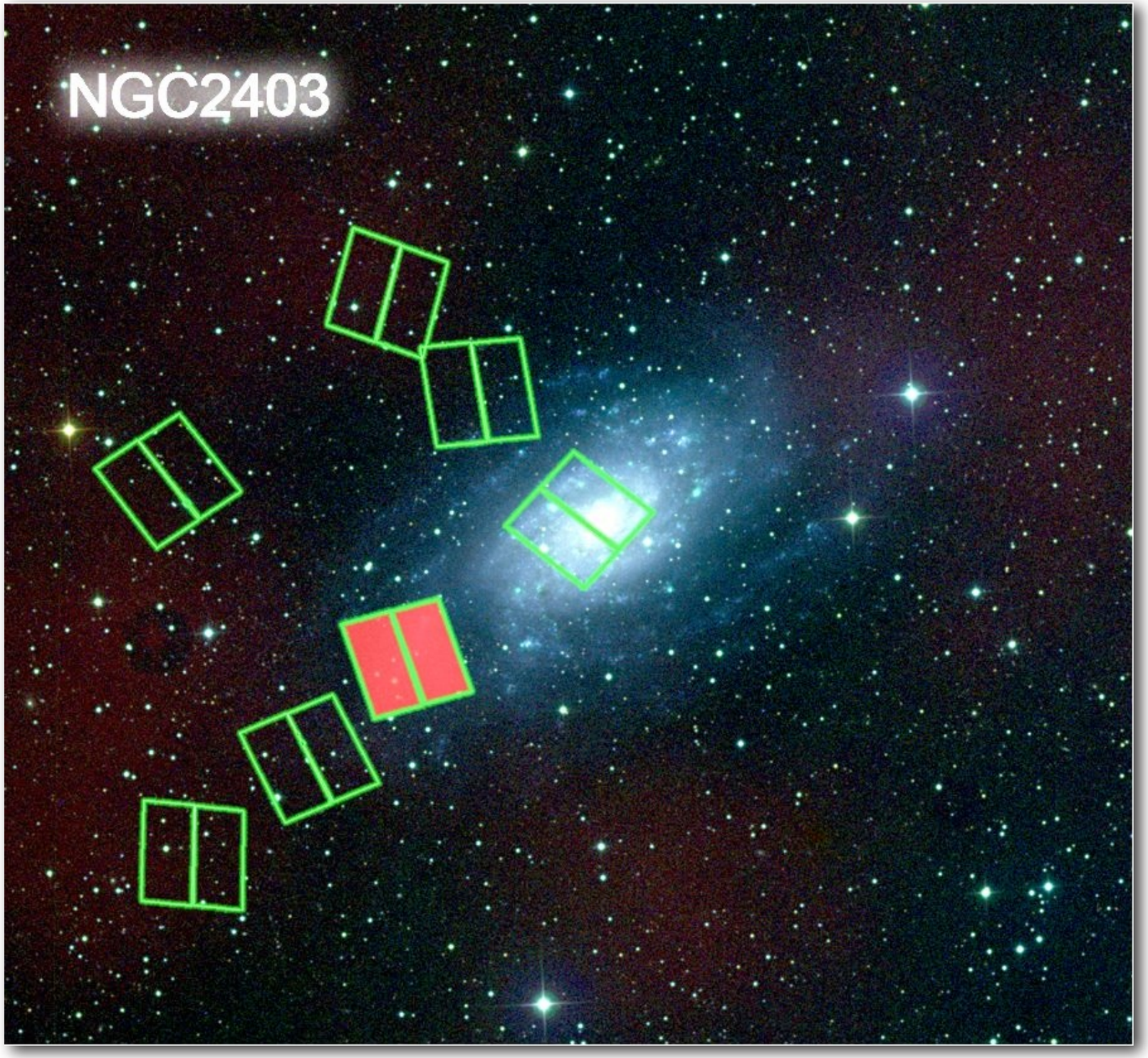

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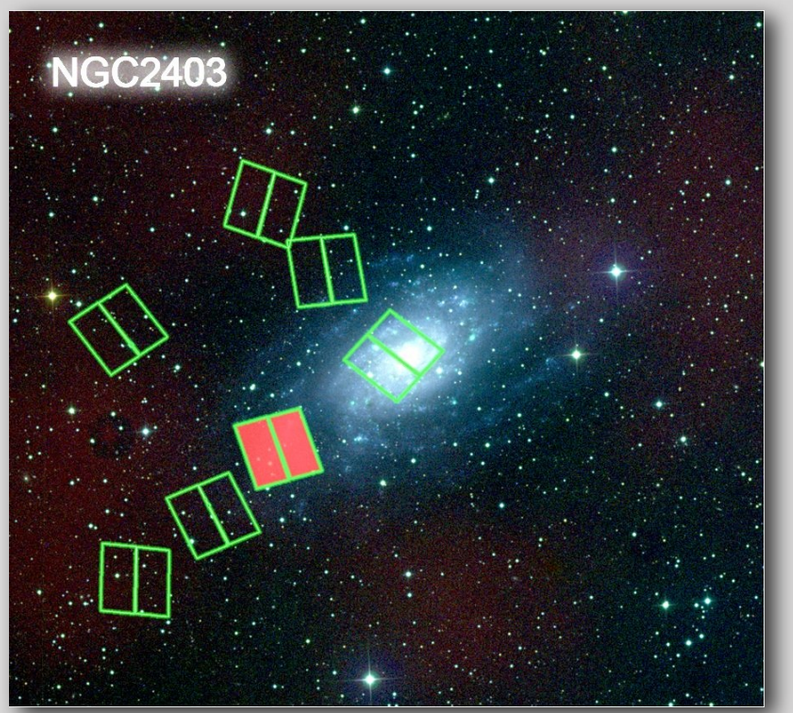

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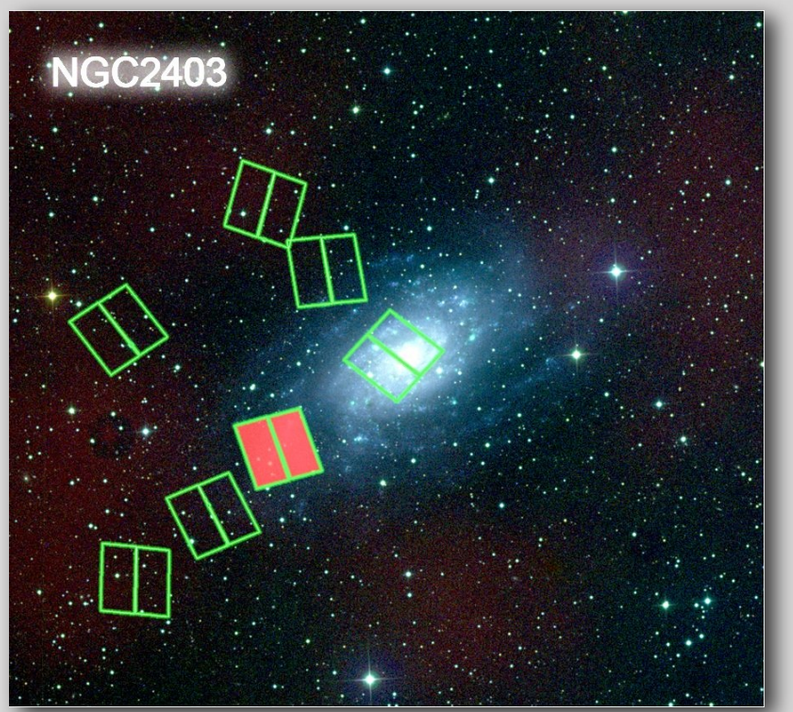

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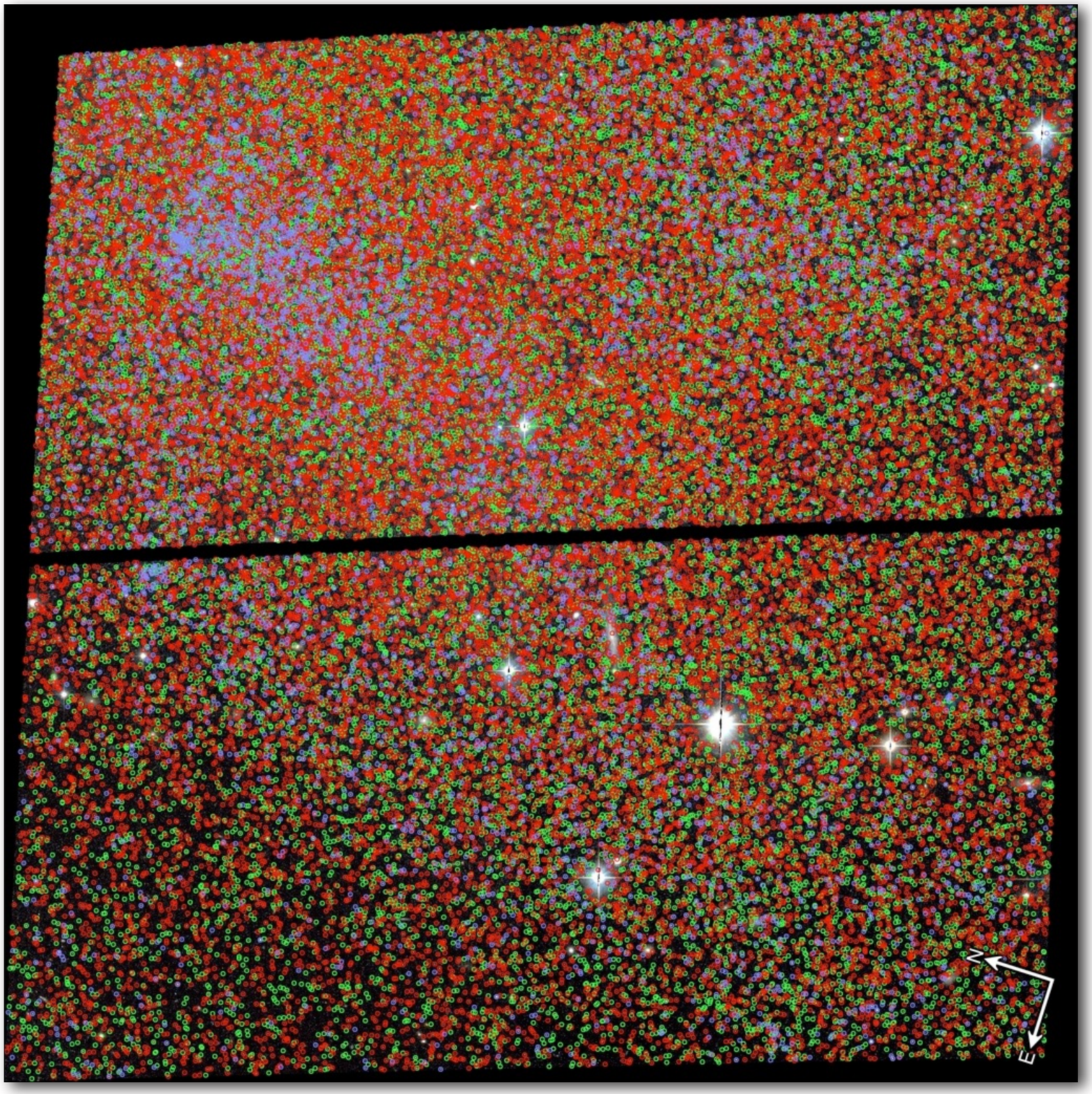

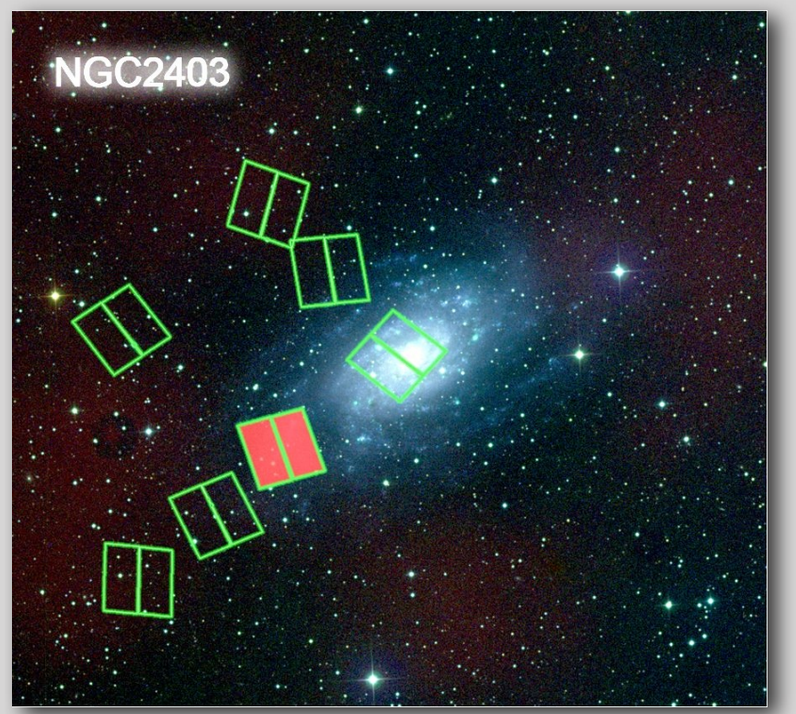

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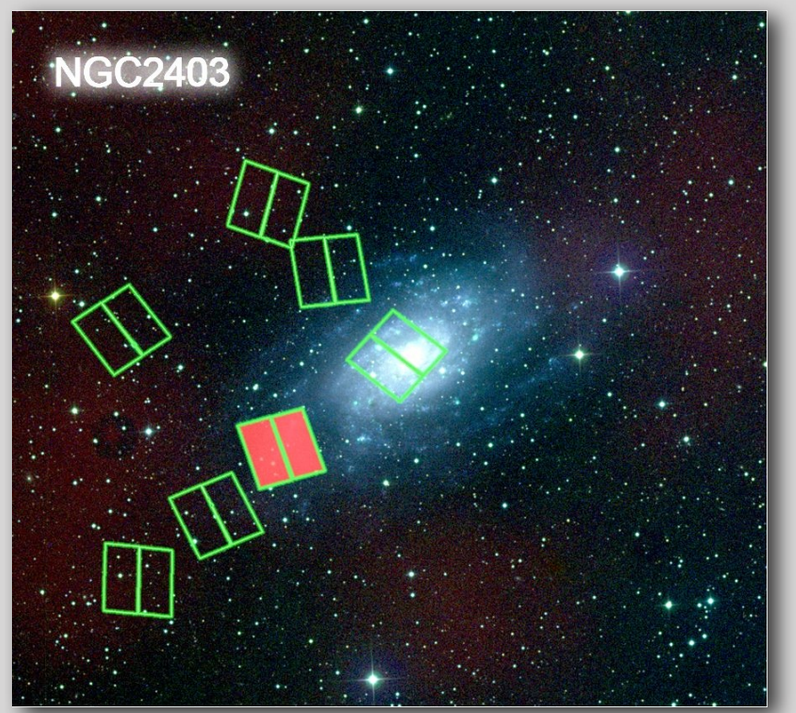

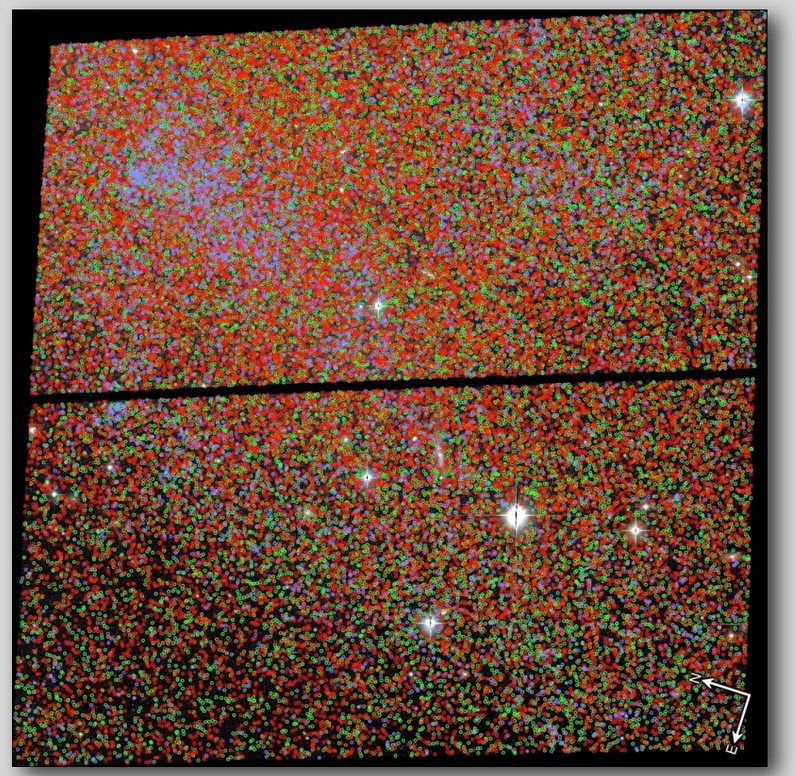

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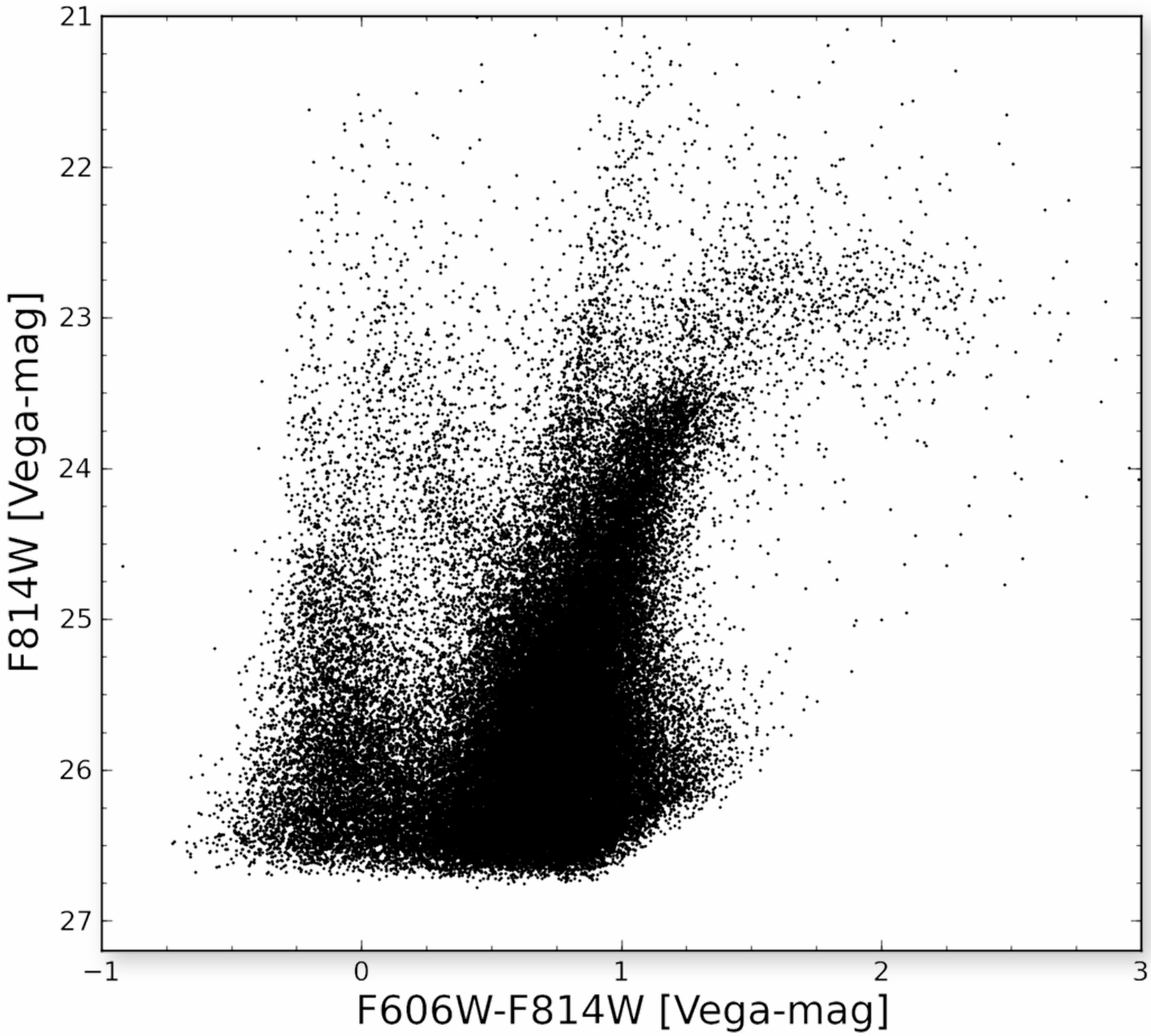

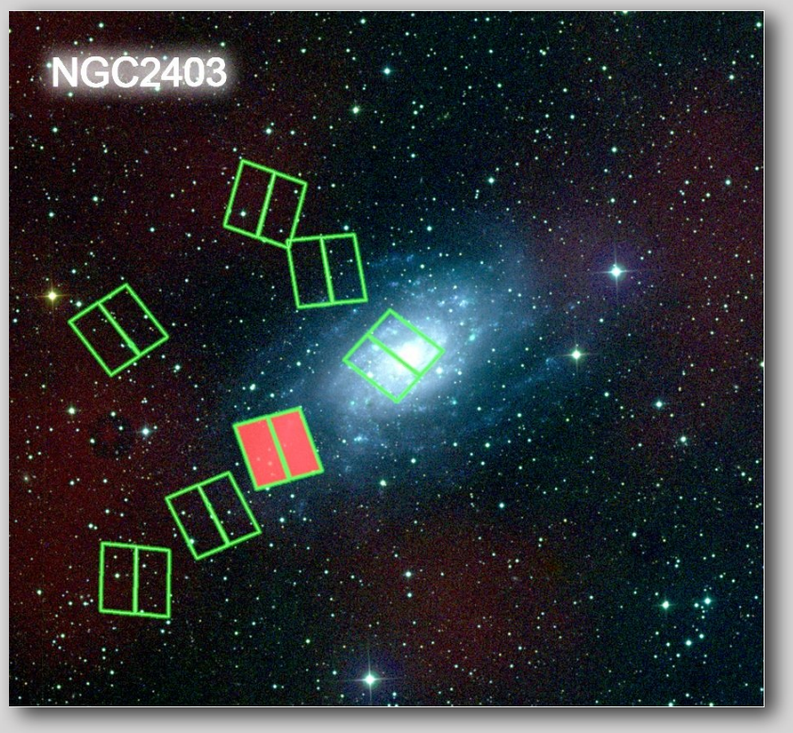

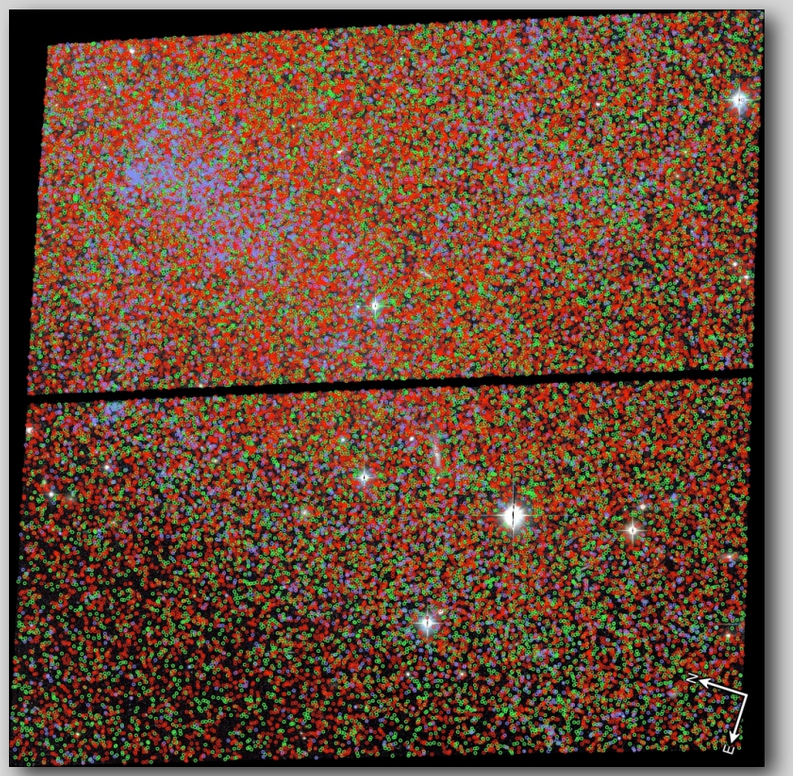

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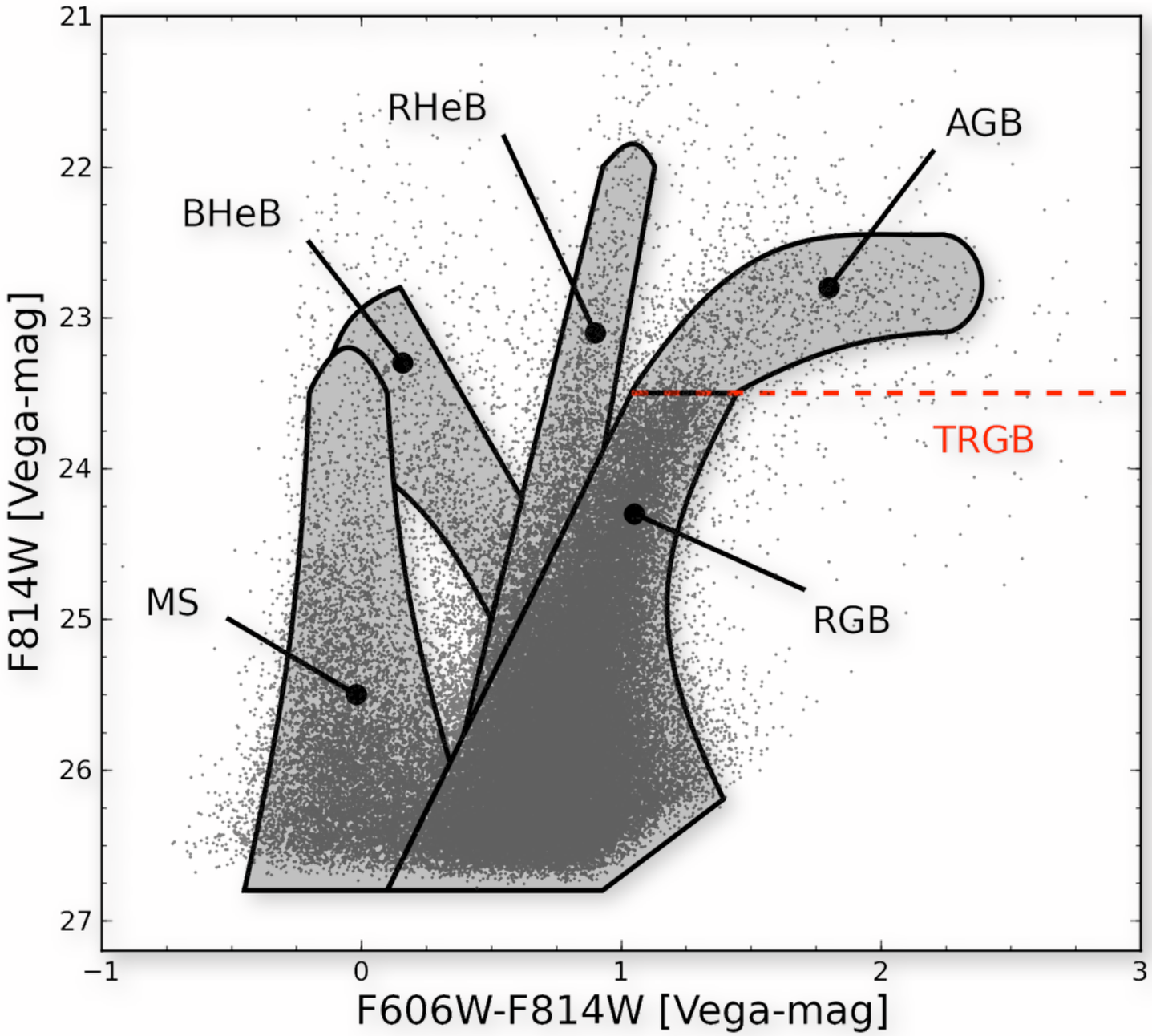

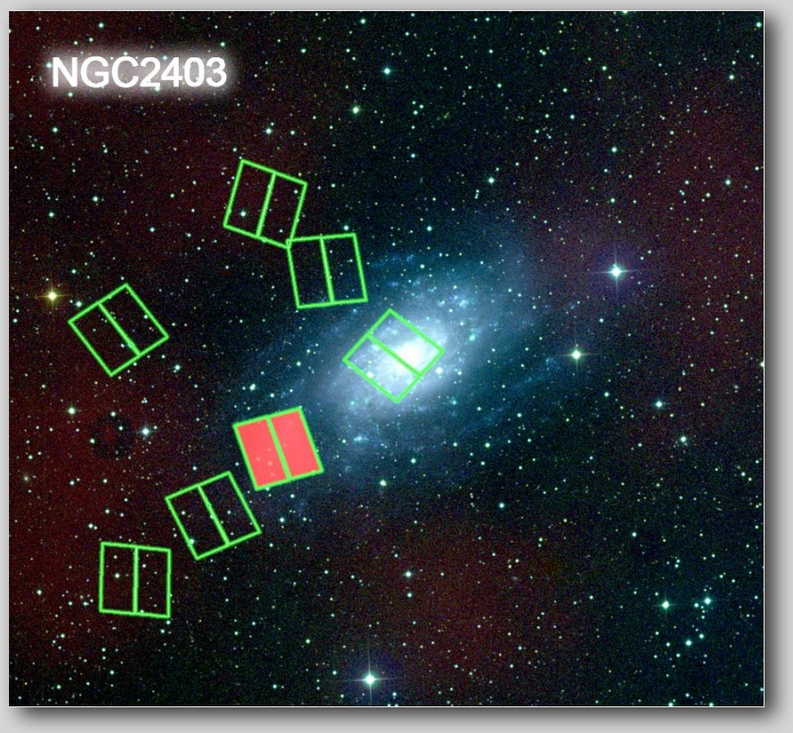

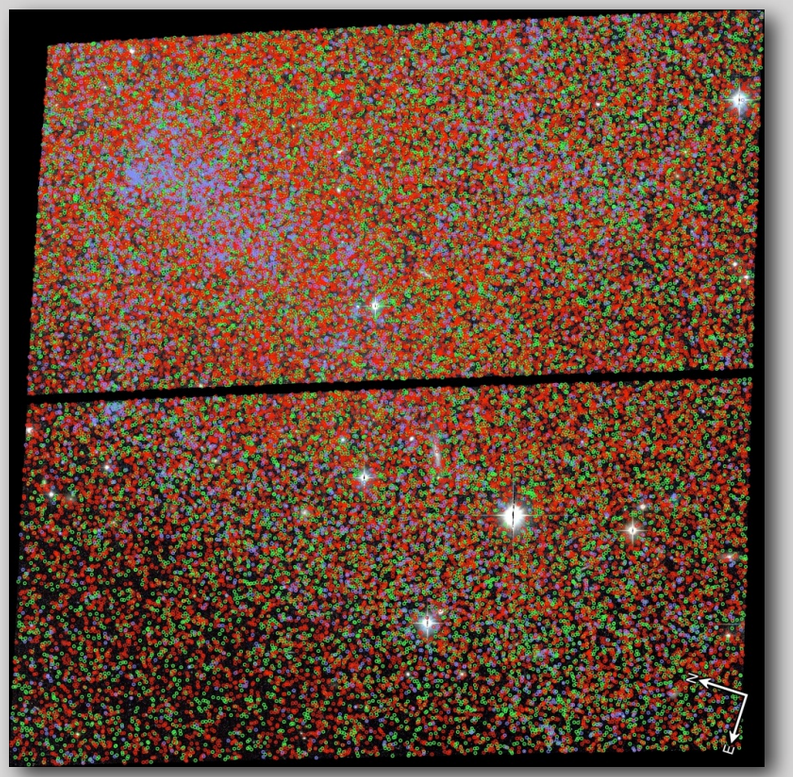

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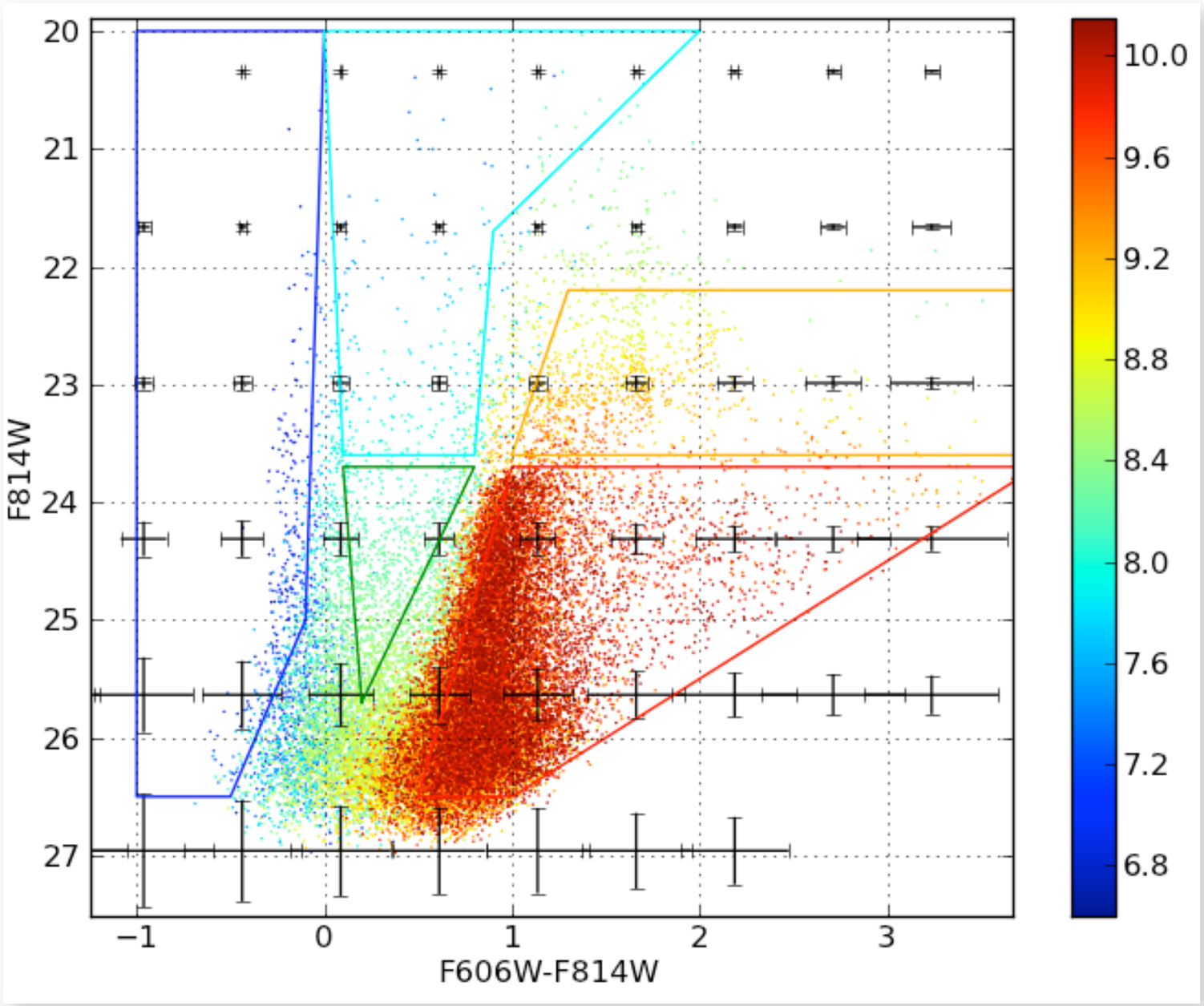

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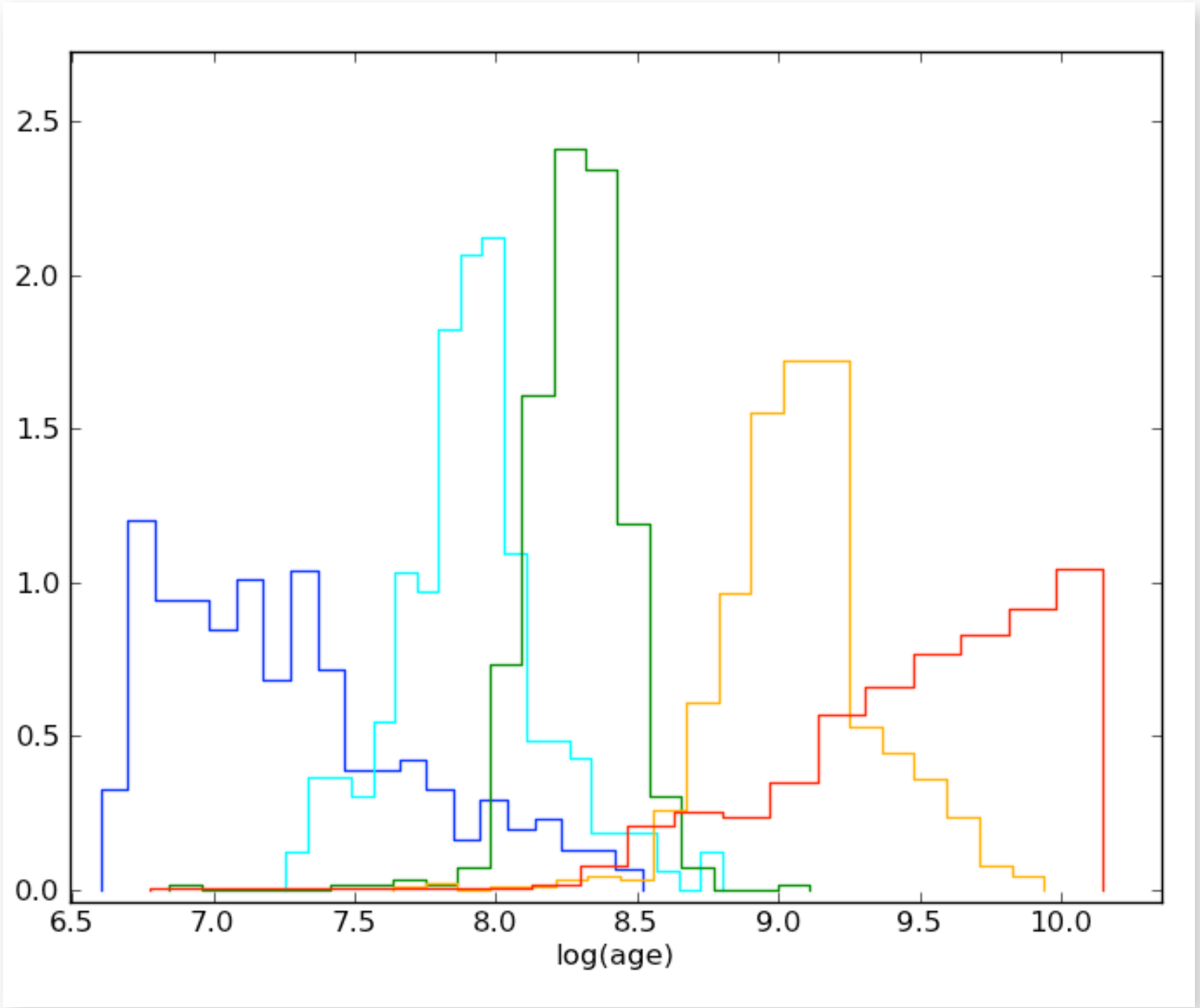

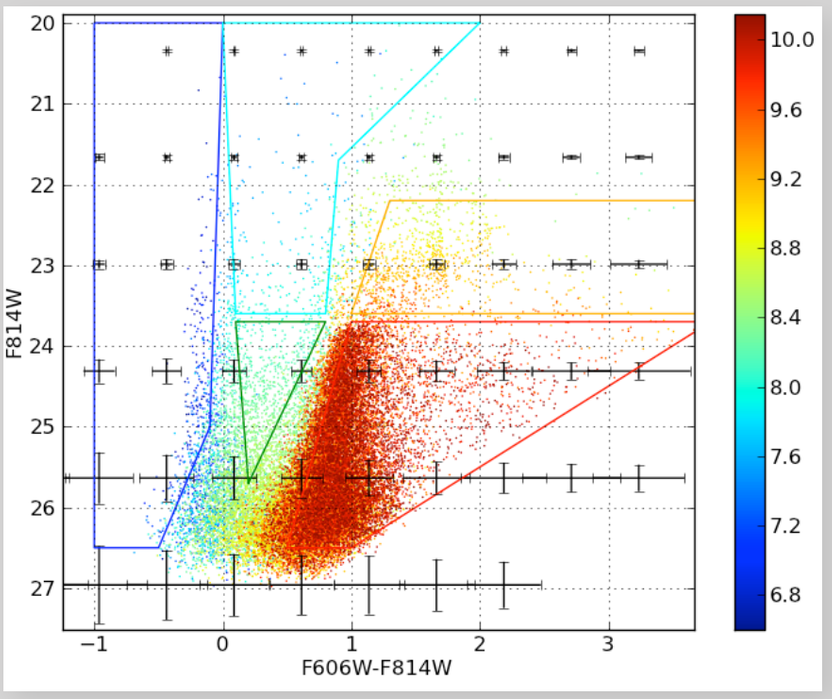

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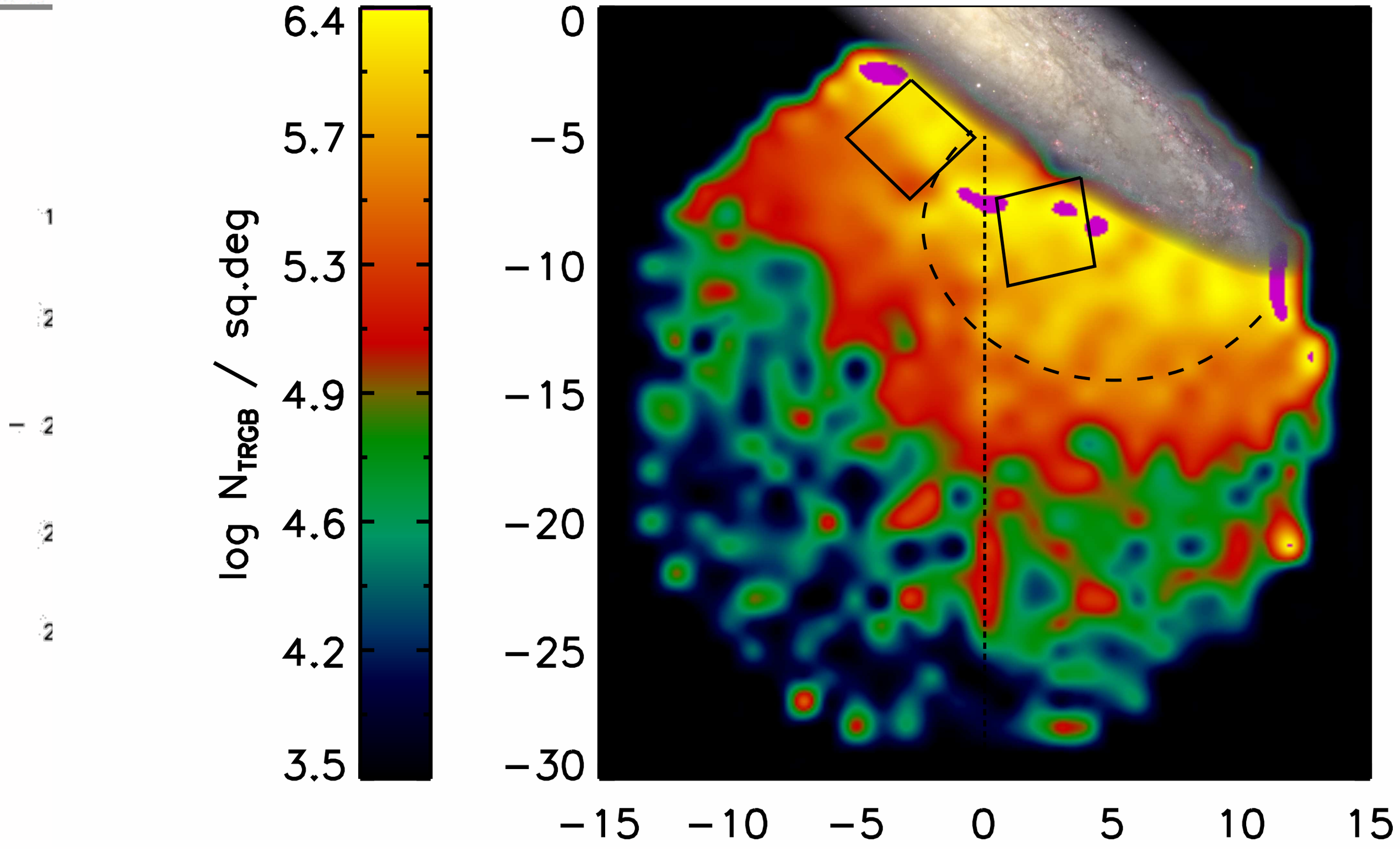
GHOSTS Resolved Stars - NGC 253



Bailin et al. (2011)

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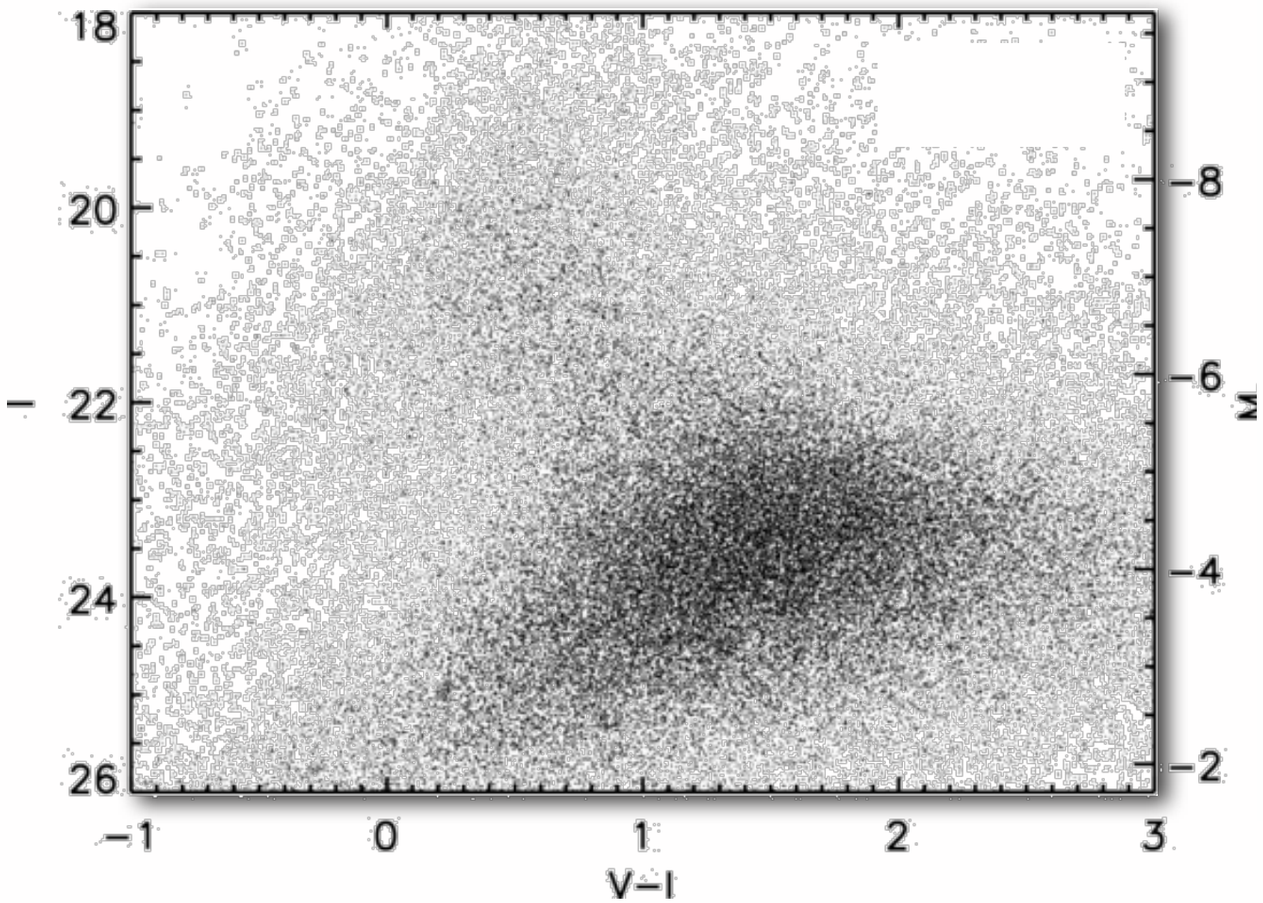
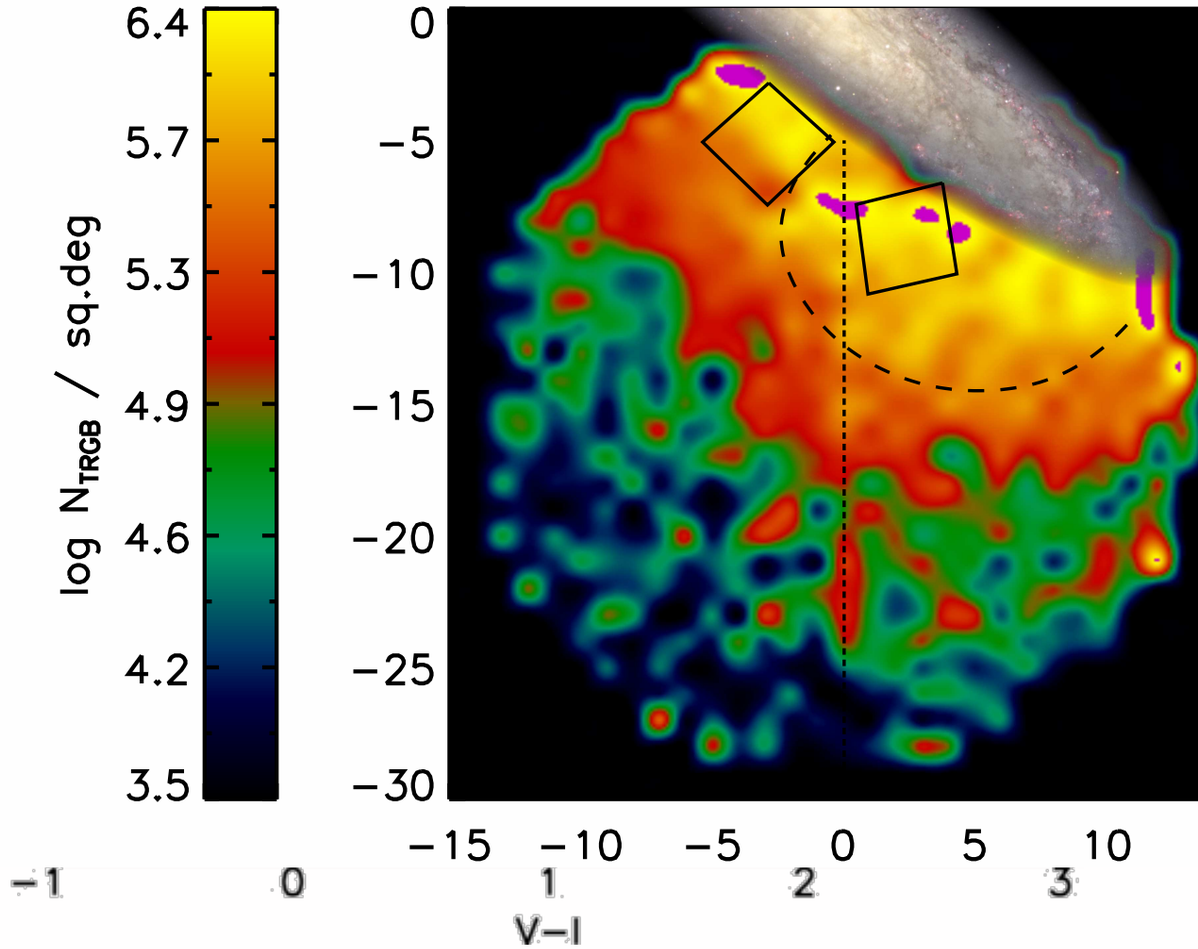
GHOSTS Resolved Stars - NGC 253

IMACS (Magellan)





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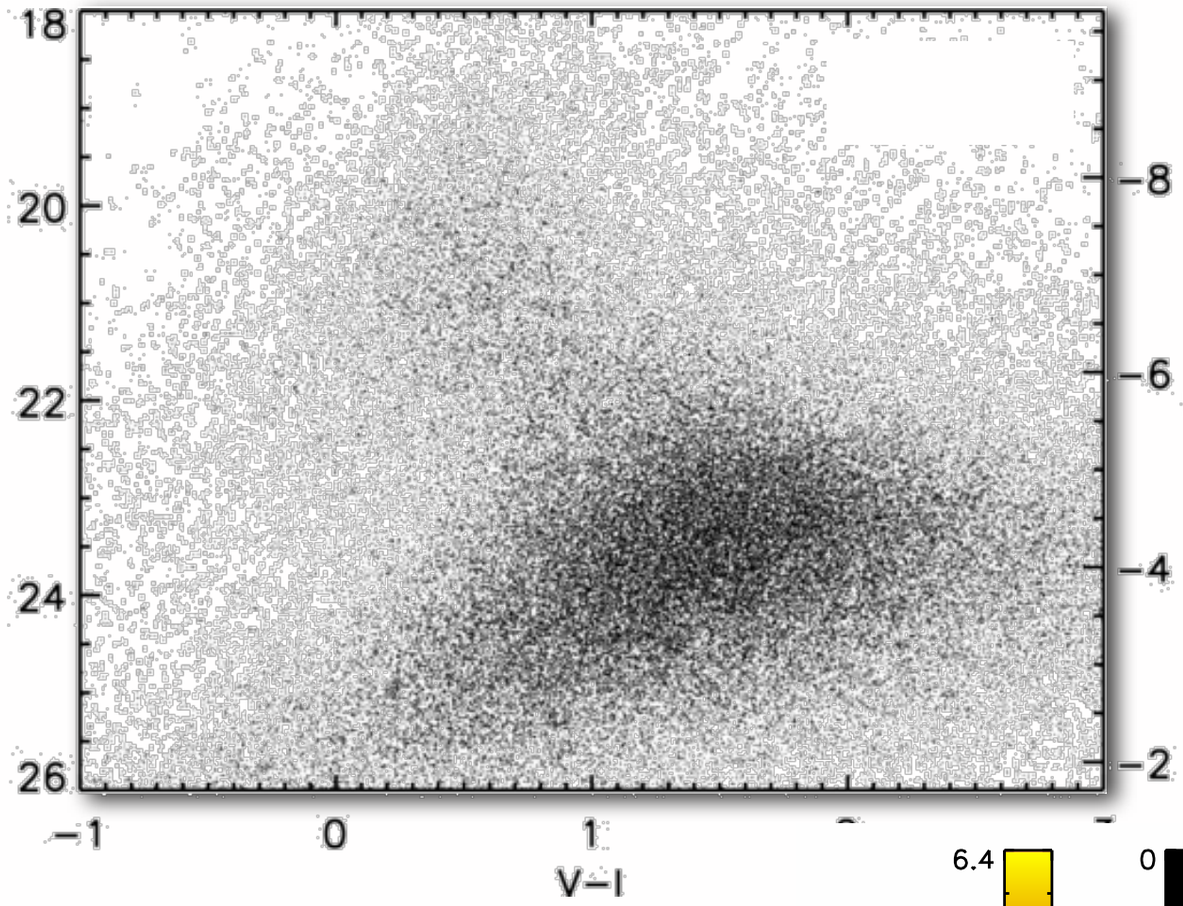
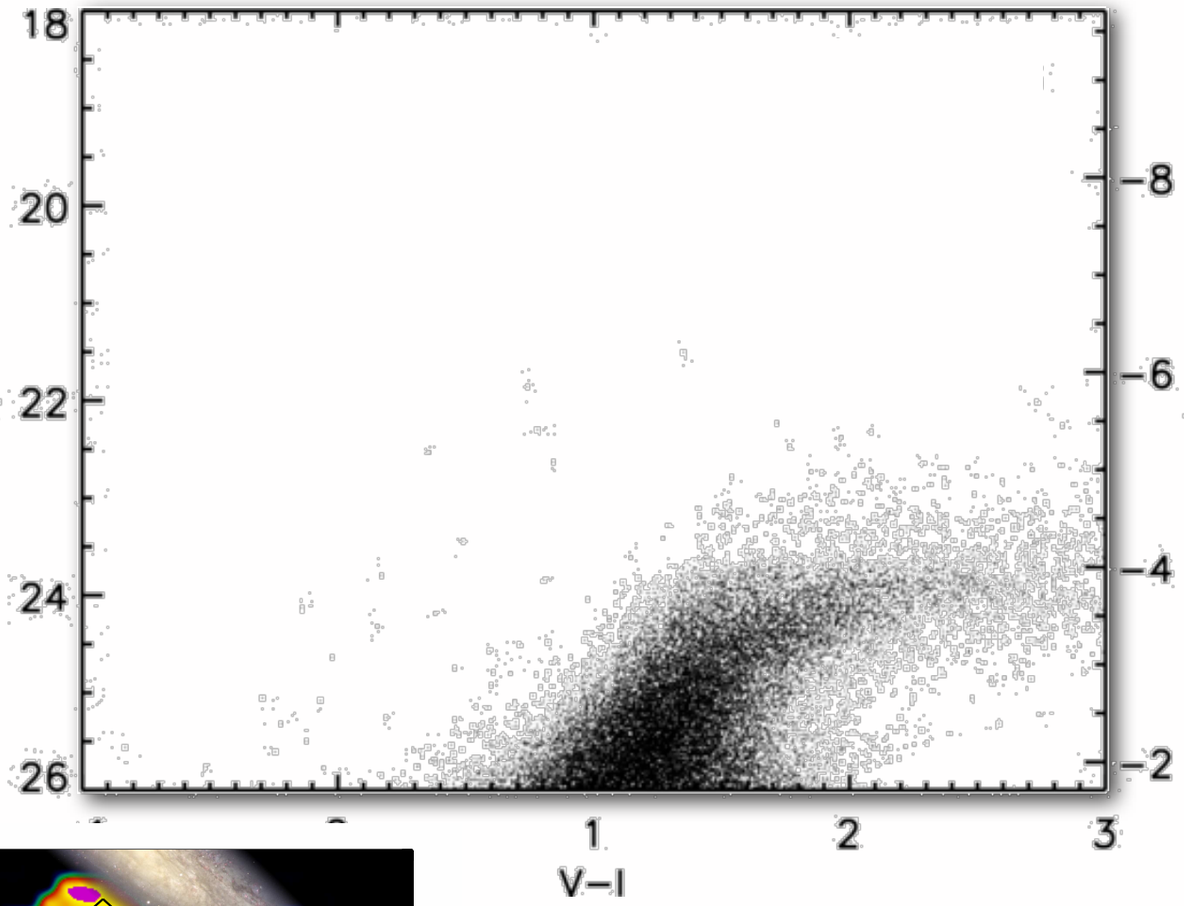
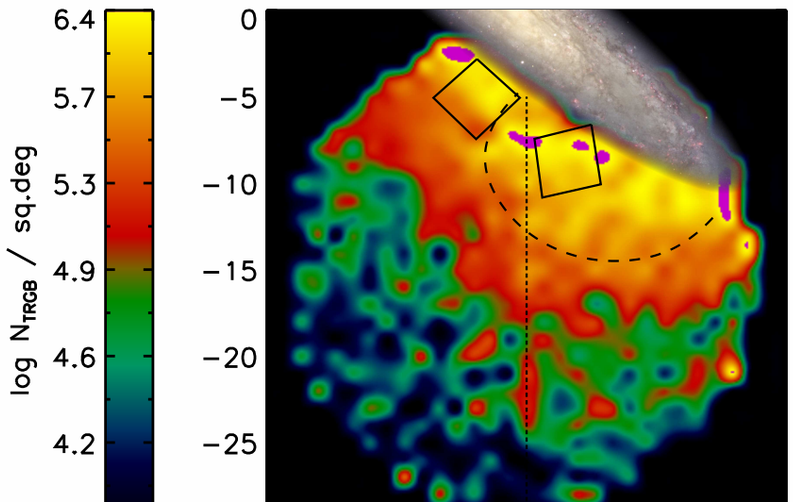


GHOSTS (HST)



Bailin et al. (2011)



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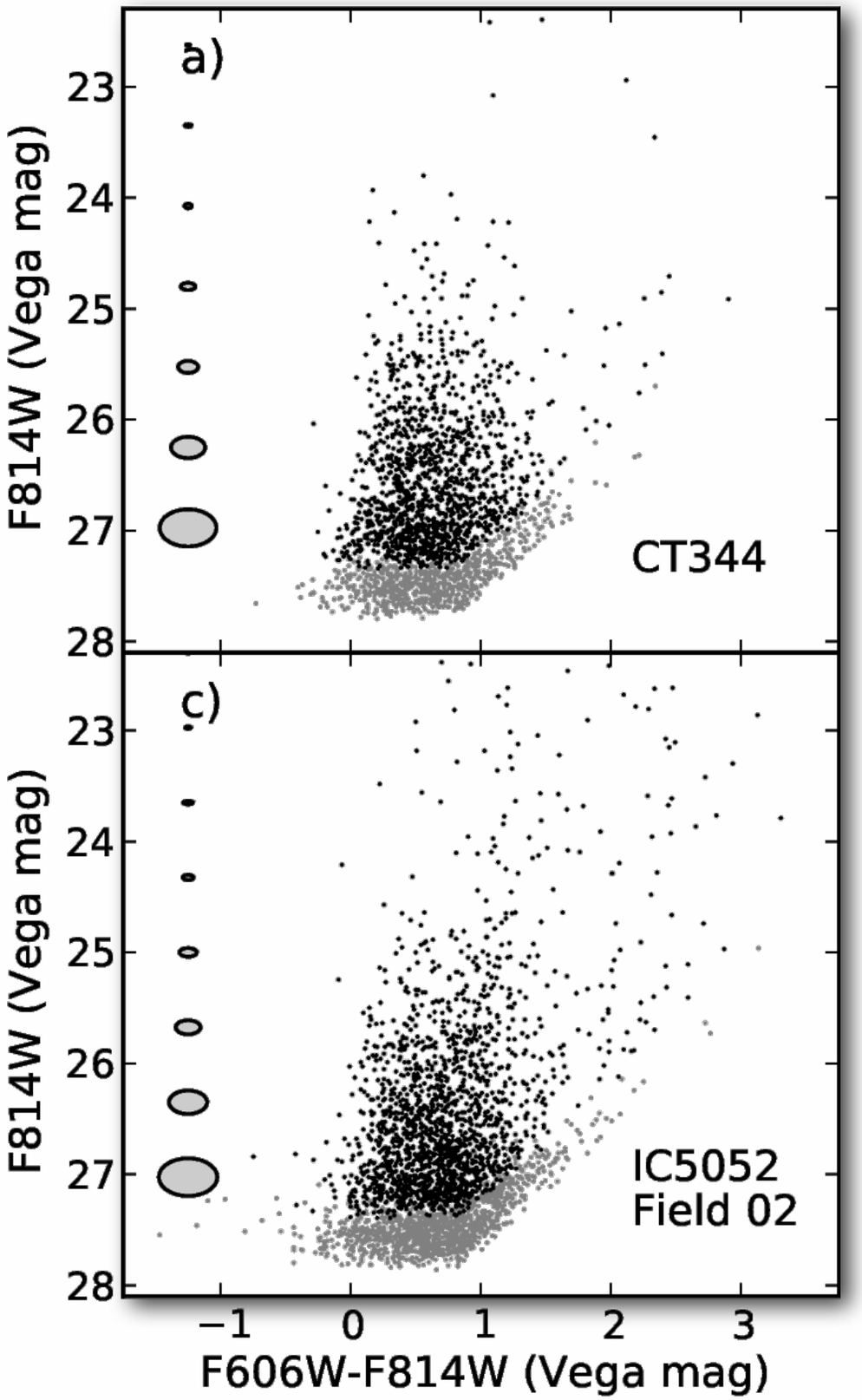

Blank (high-z) field from archive

GHOSTS Stellar Halo Field

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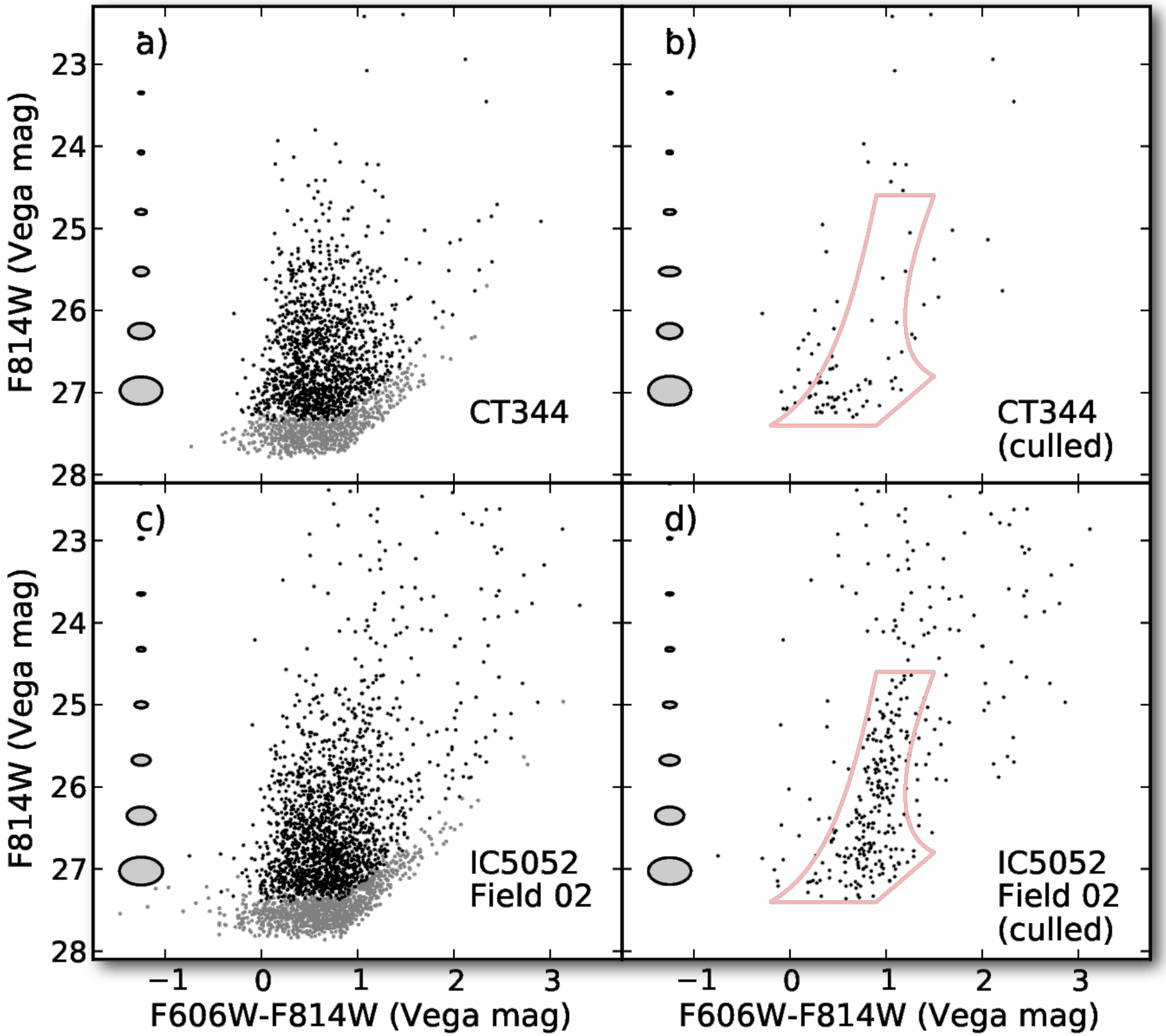
GHOSTS ACS Observations



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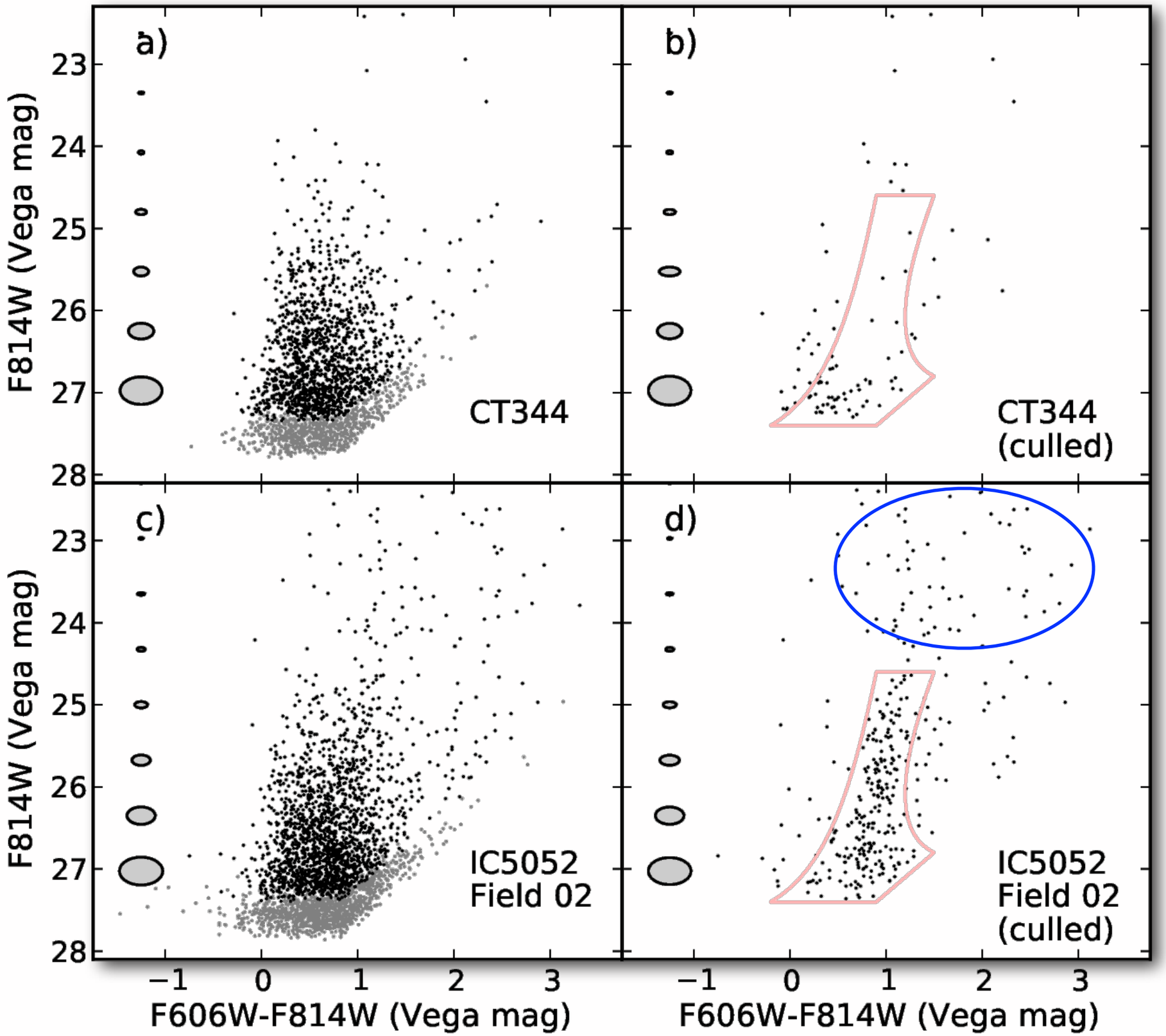

MW halo foreground
Radburn-Smith in prep.

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GHOSTS Sample Overview

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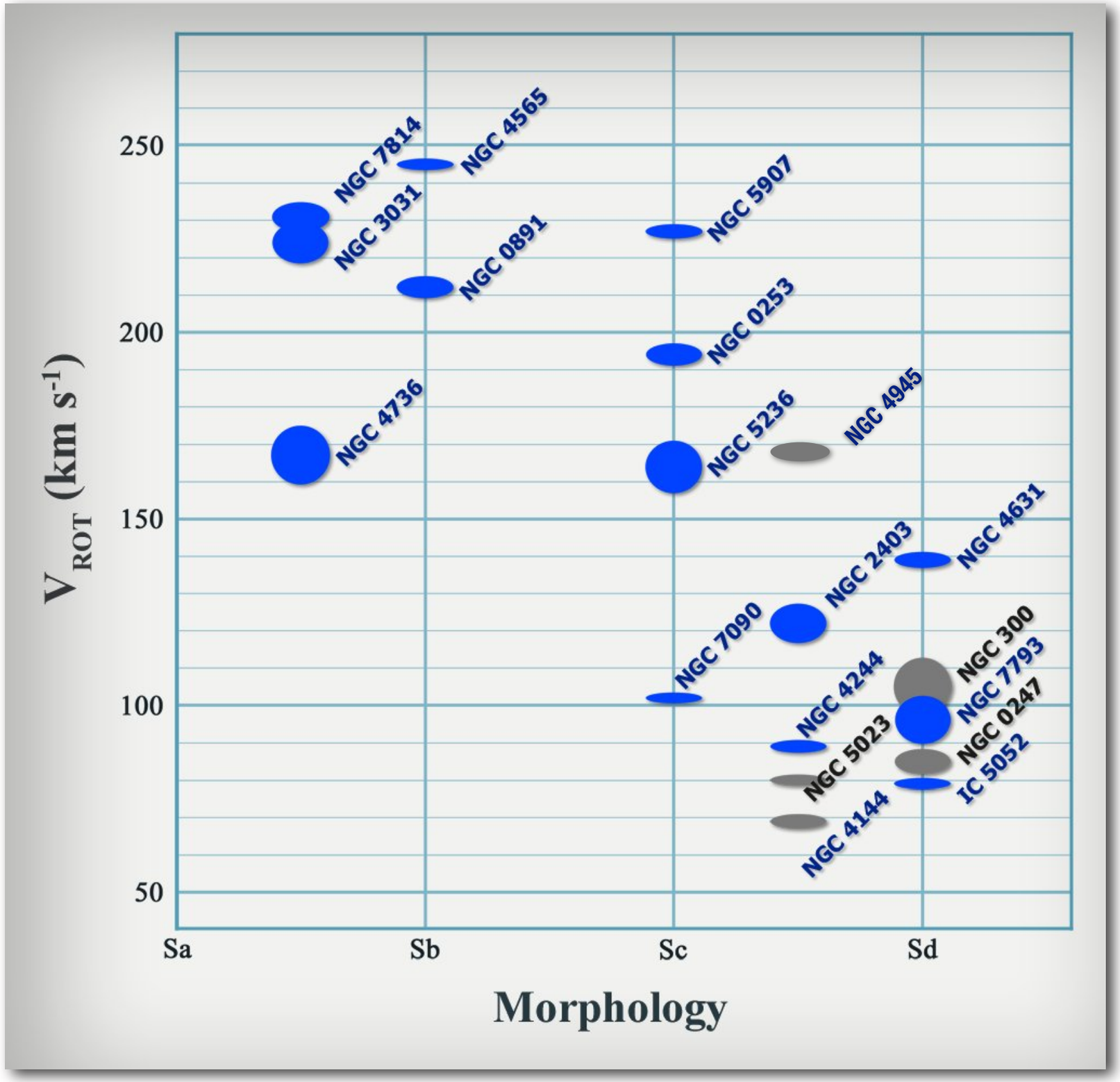

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GHOSTS Stellar Halo Profiles

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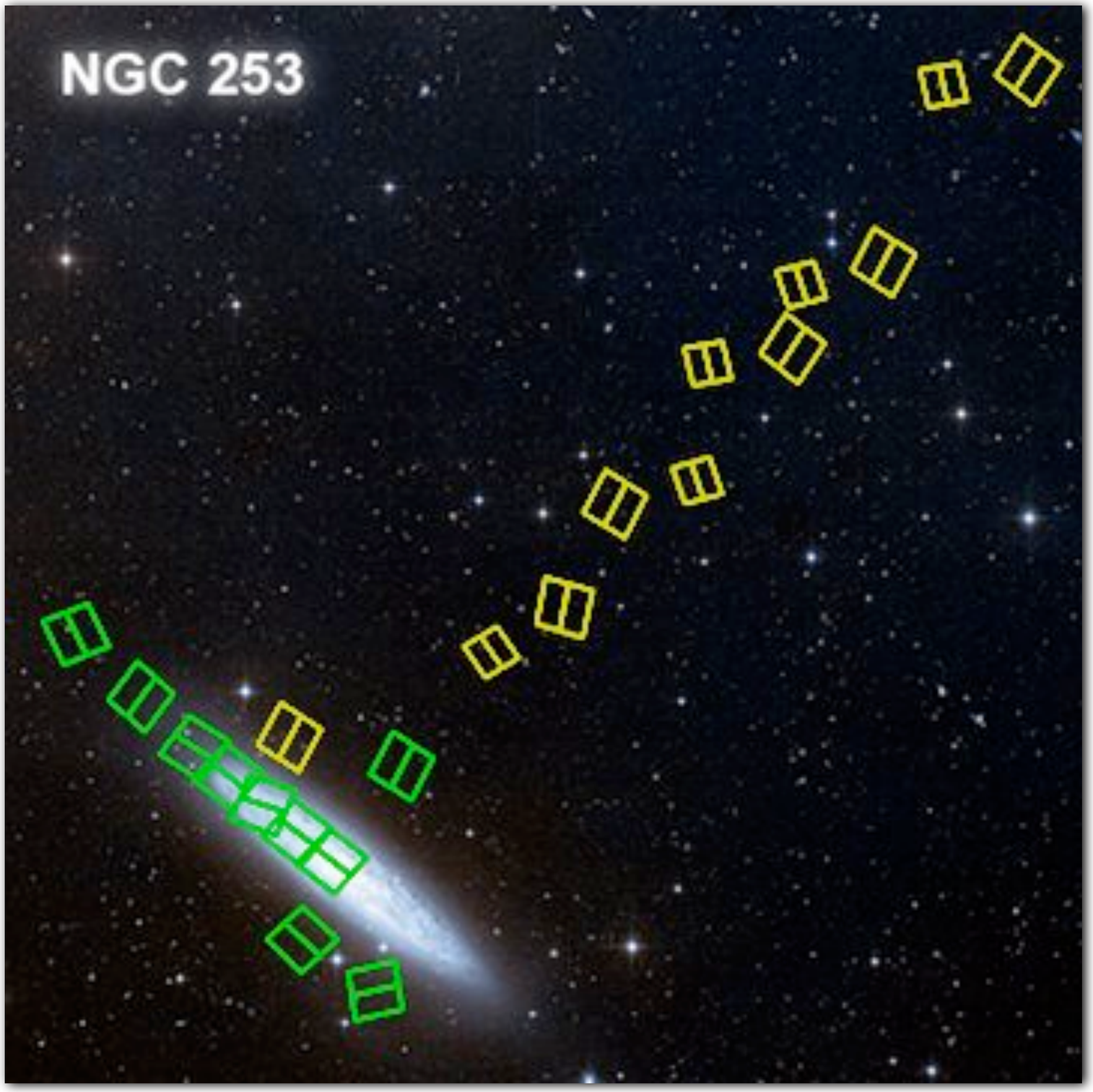

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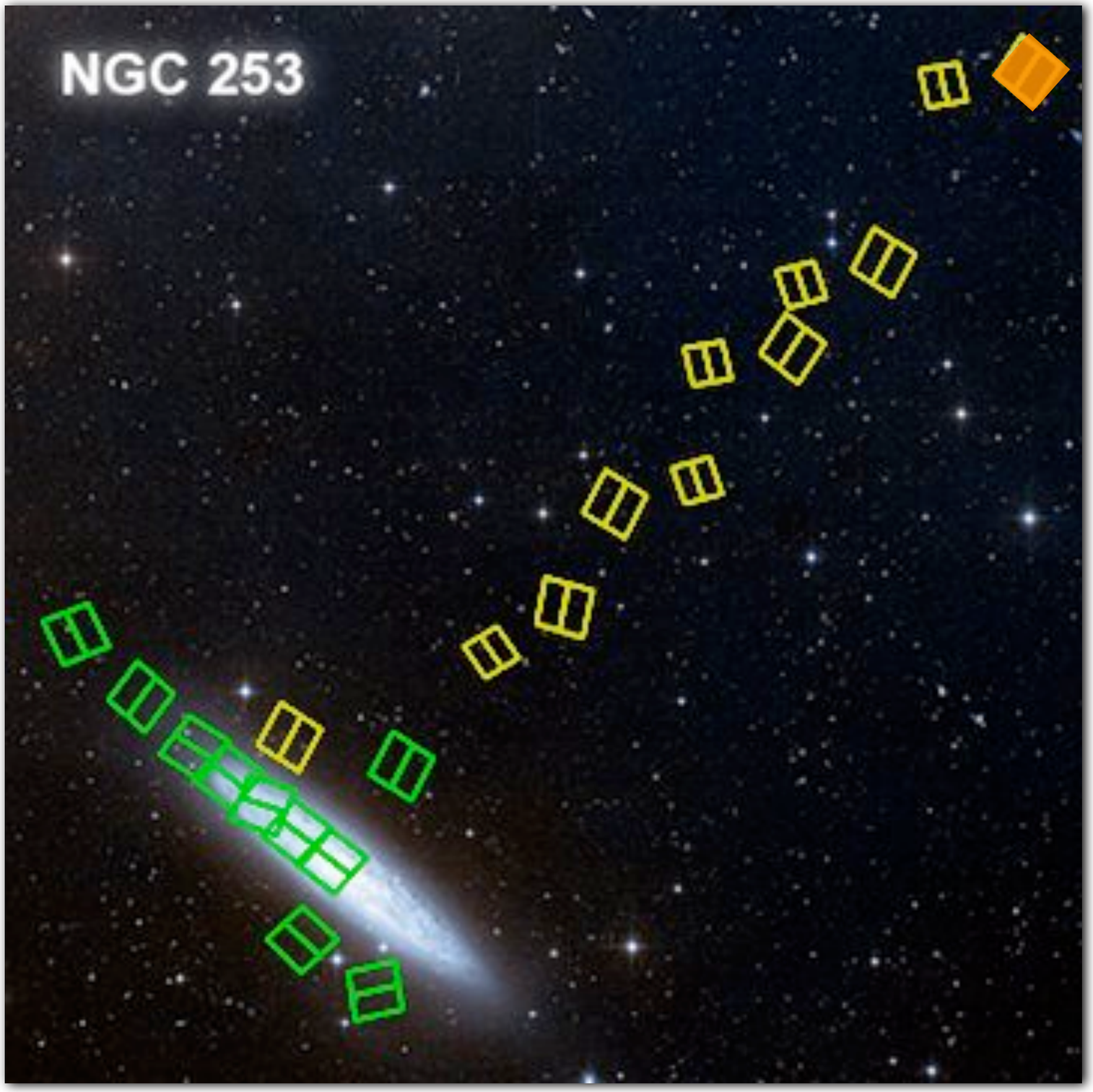

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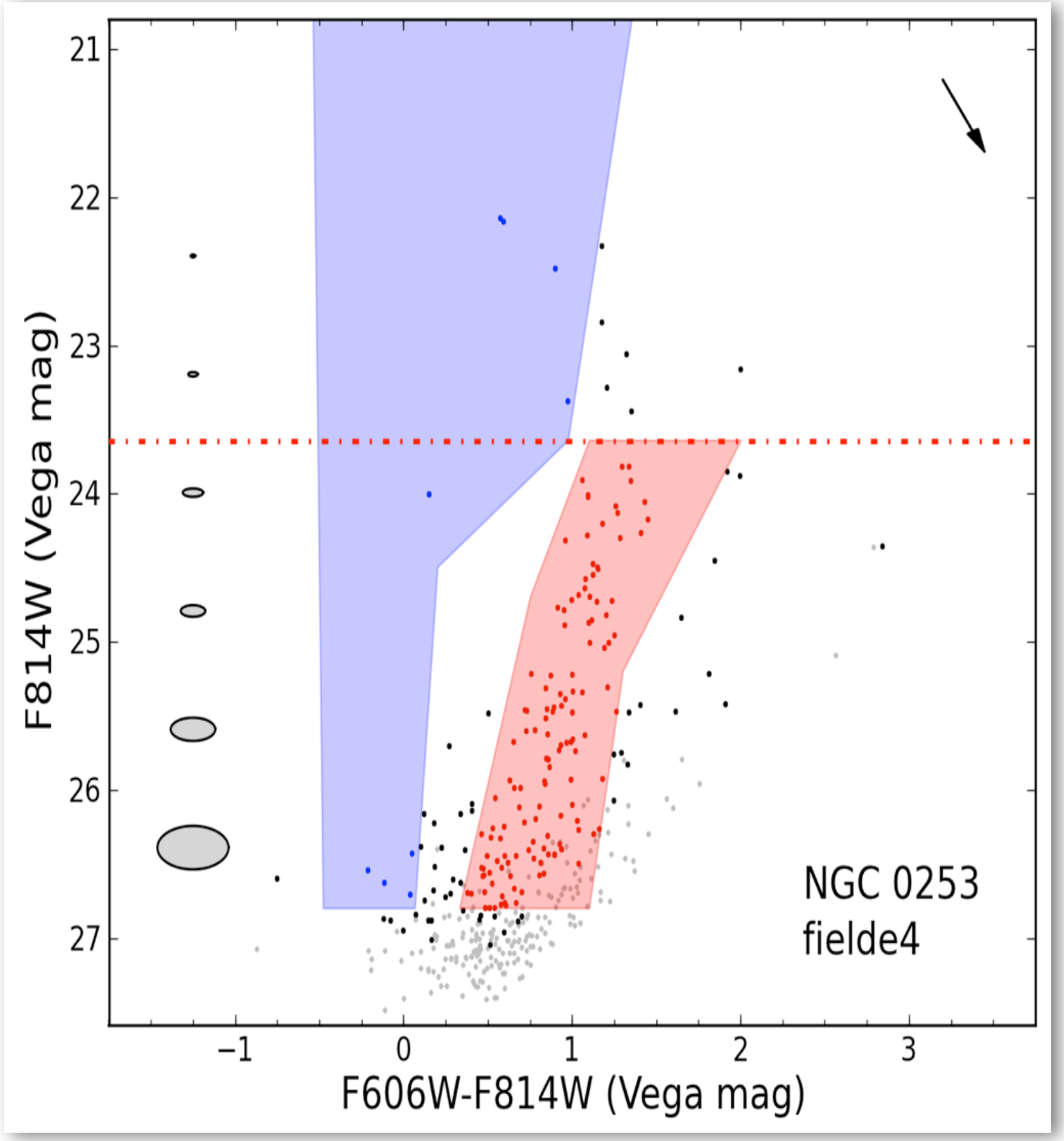

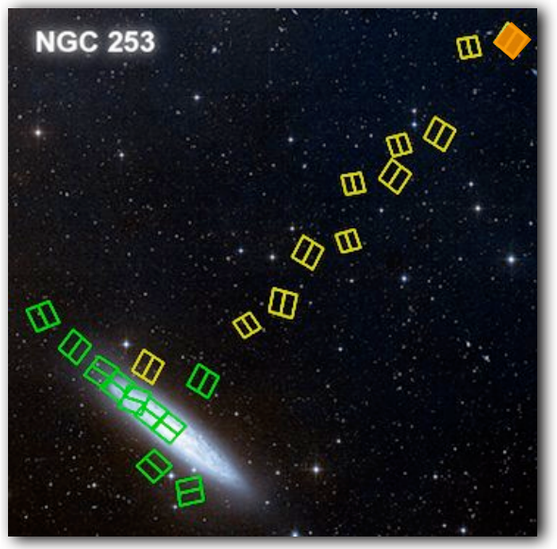

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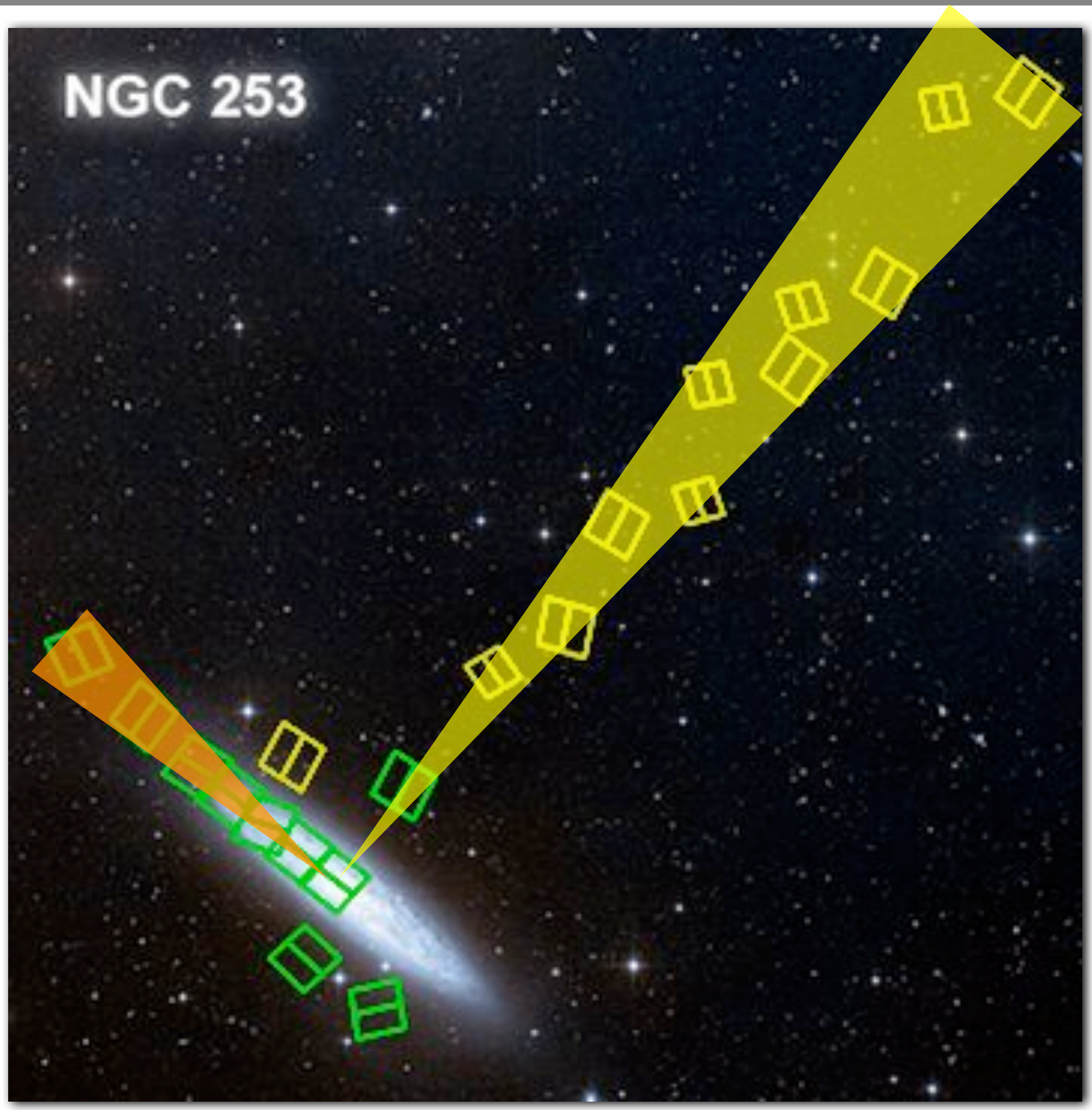

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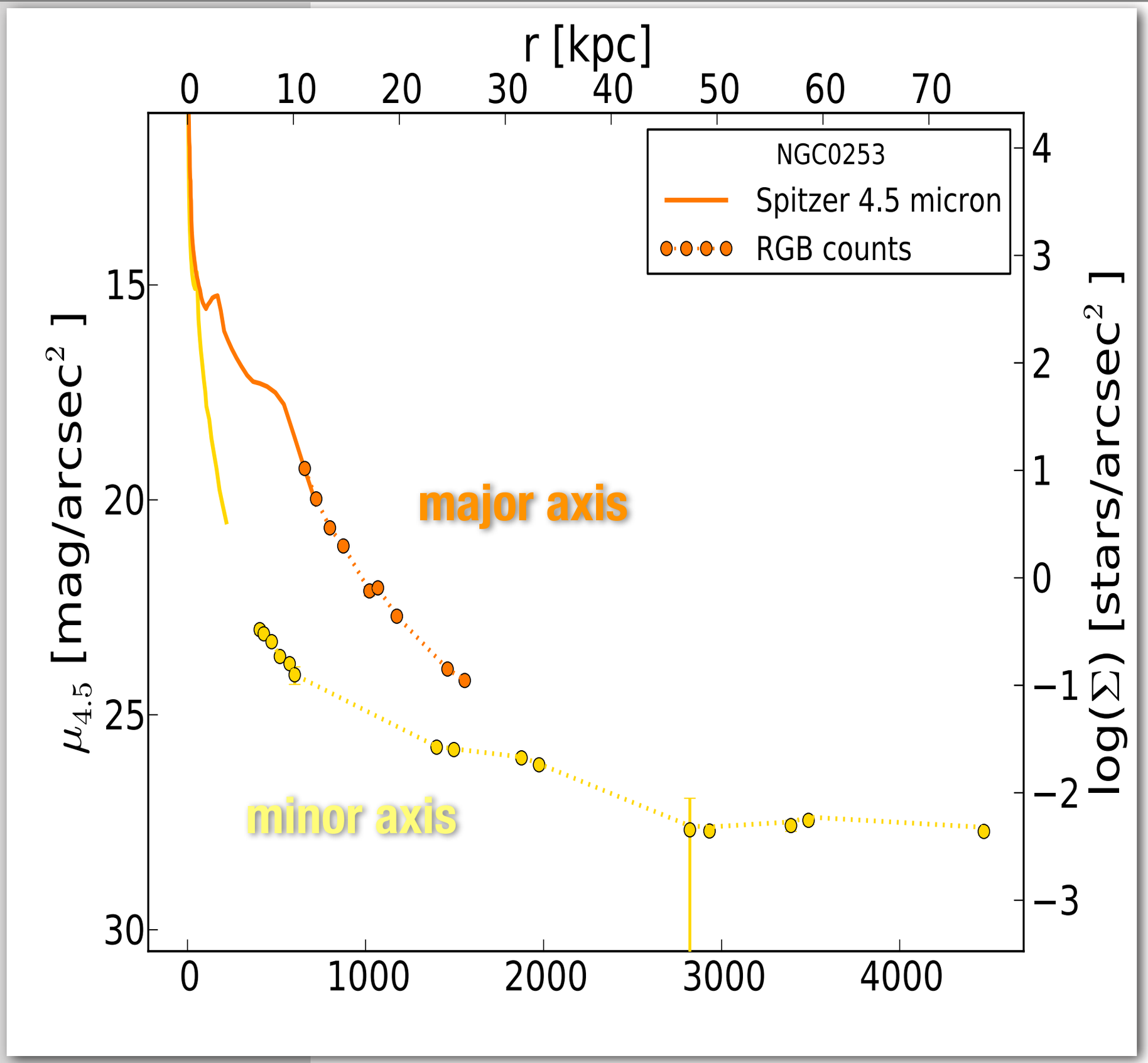

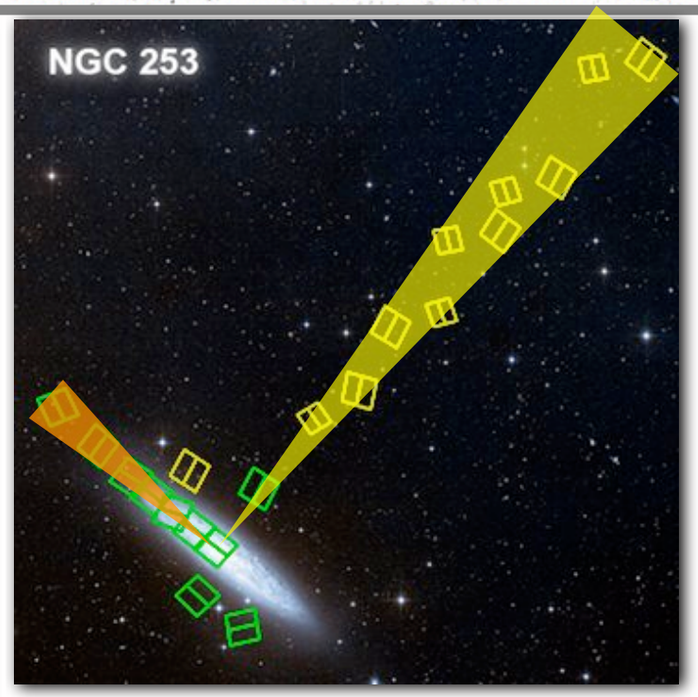

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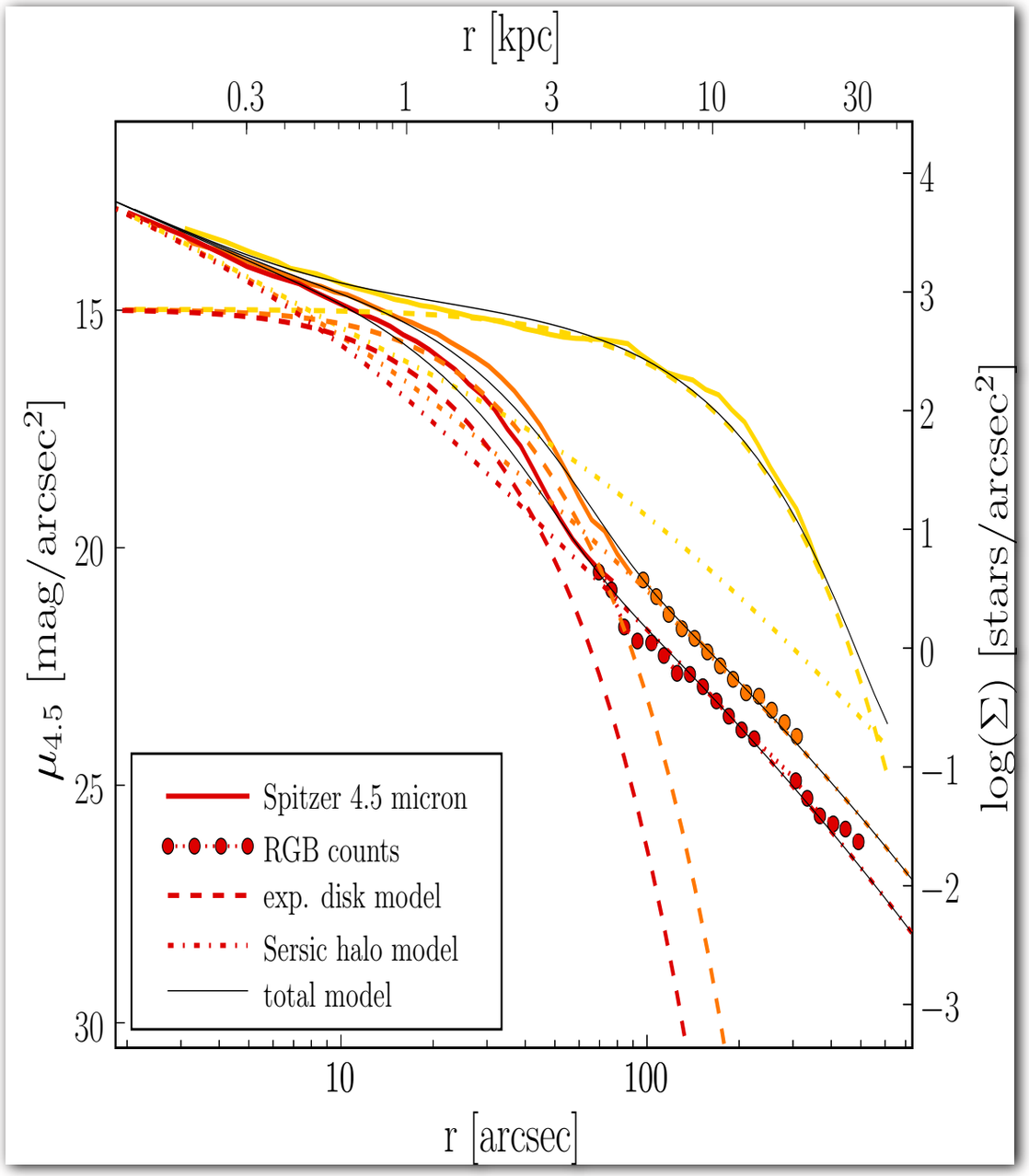

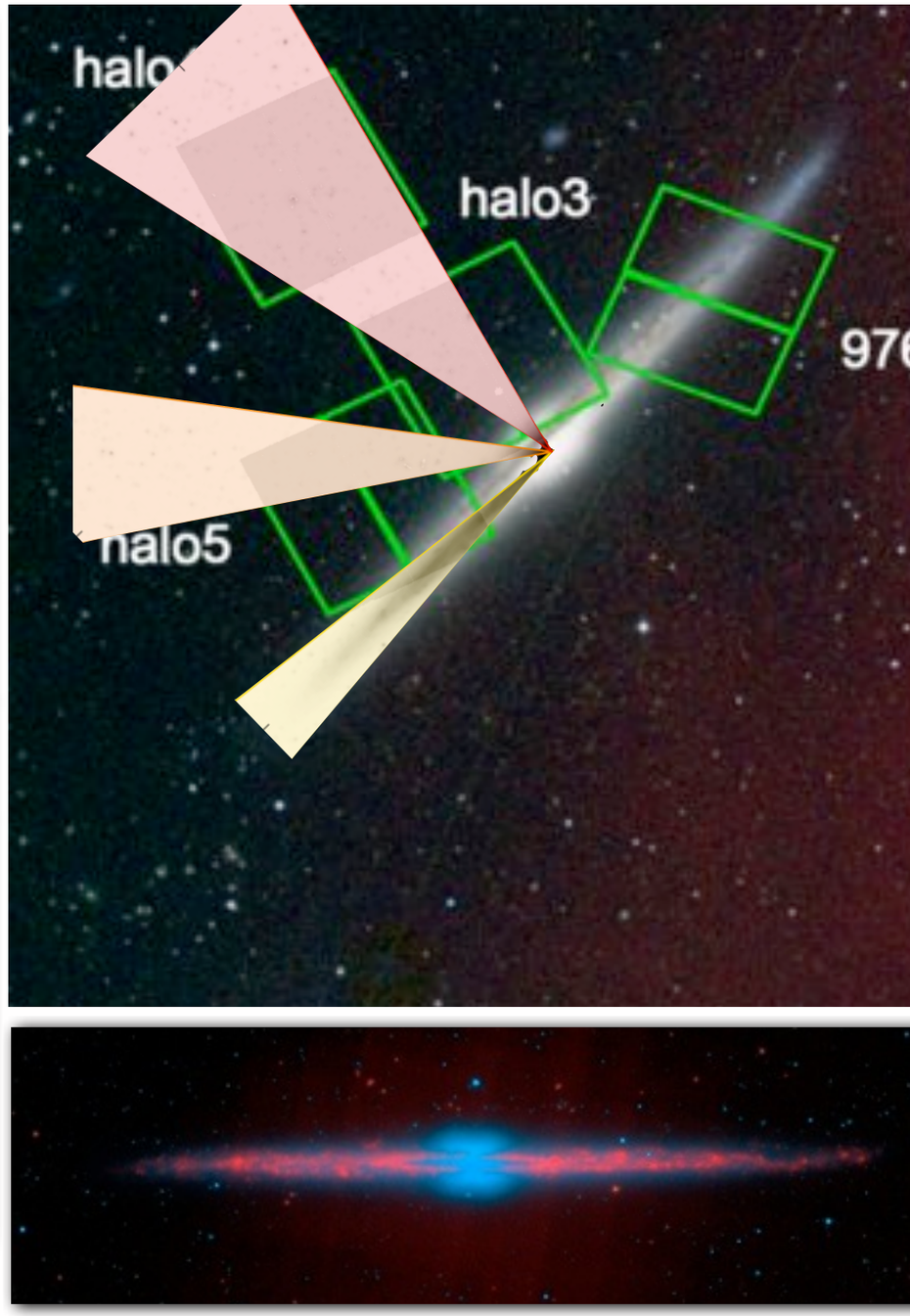

- **Most galaxies fitted with single Sersic spheroid and exponential disk**

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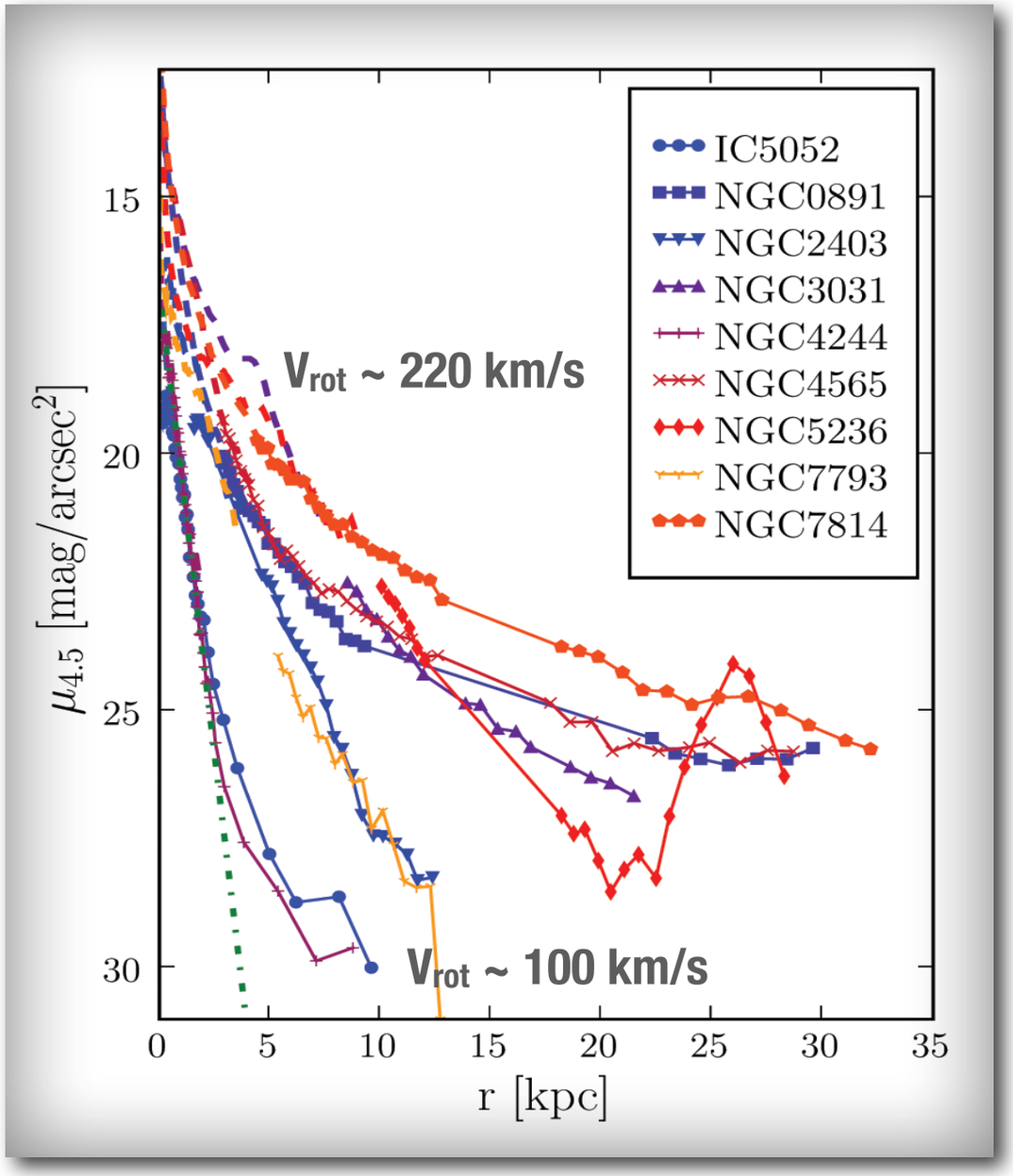
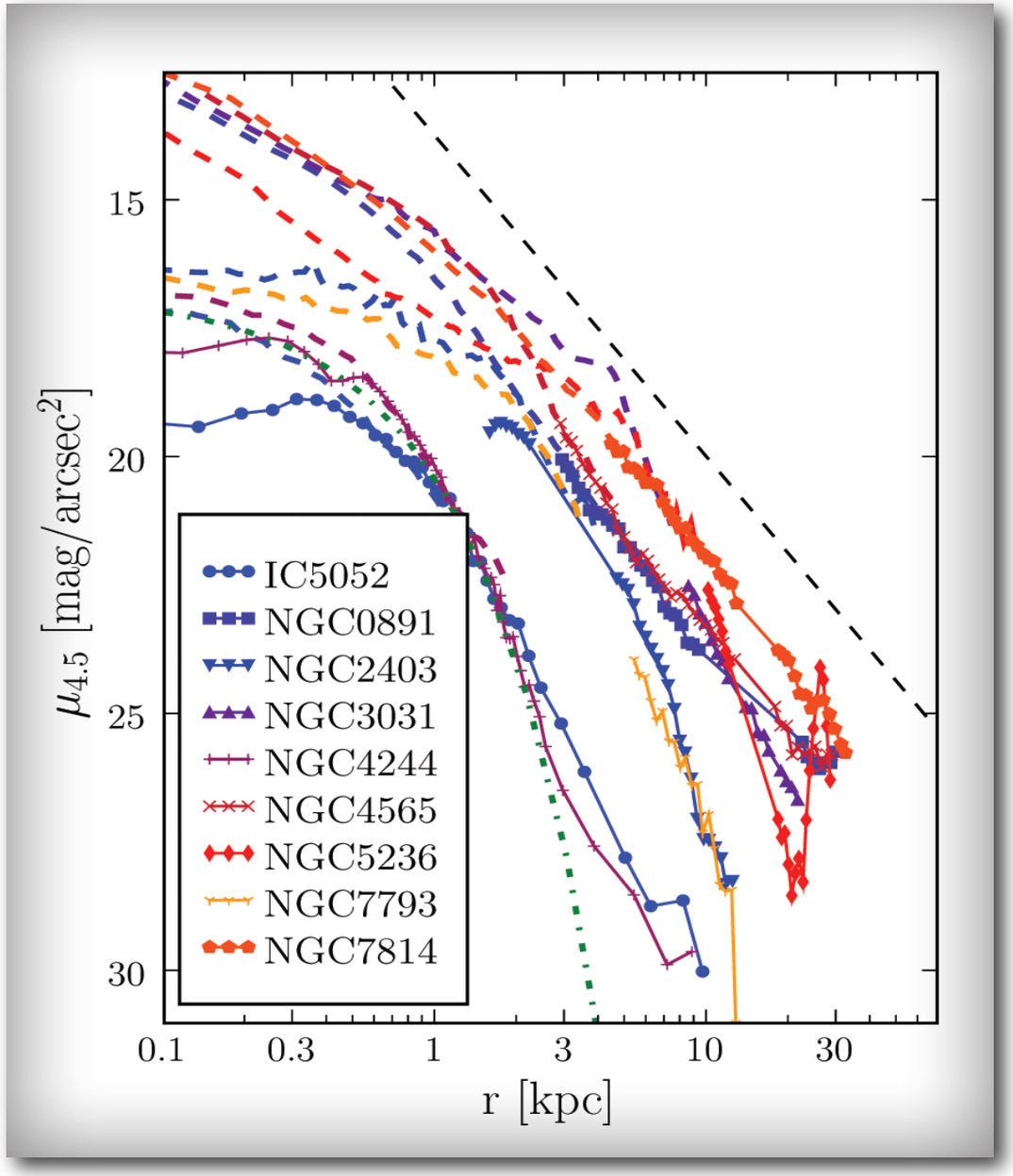
GHOSTS Stellar Minor Axis Profiles





- **Larger galaxies have fractionally larger envelopes** (Purcell et al 2009)
- **Profiles correlate more with bulge-to-disk ratio than V_{rot}**
- **Inner halos are compact (Sersic n~5) and flat (c/a~0.3)**

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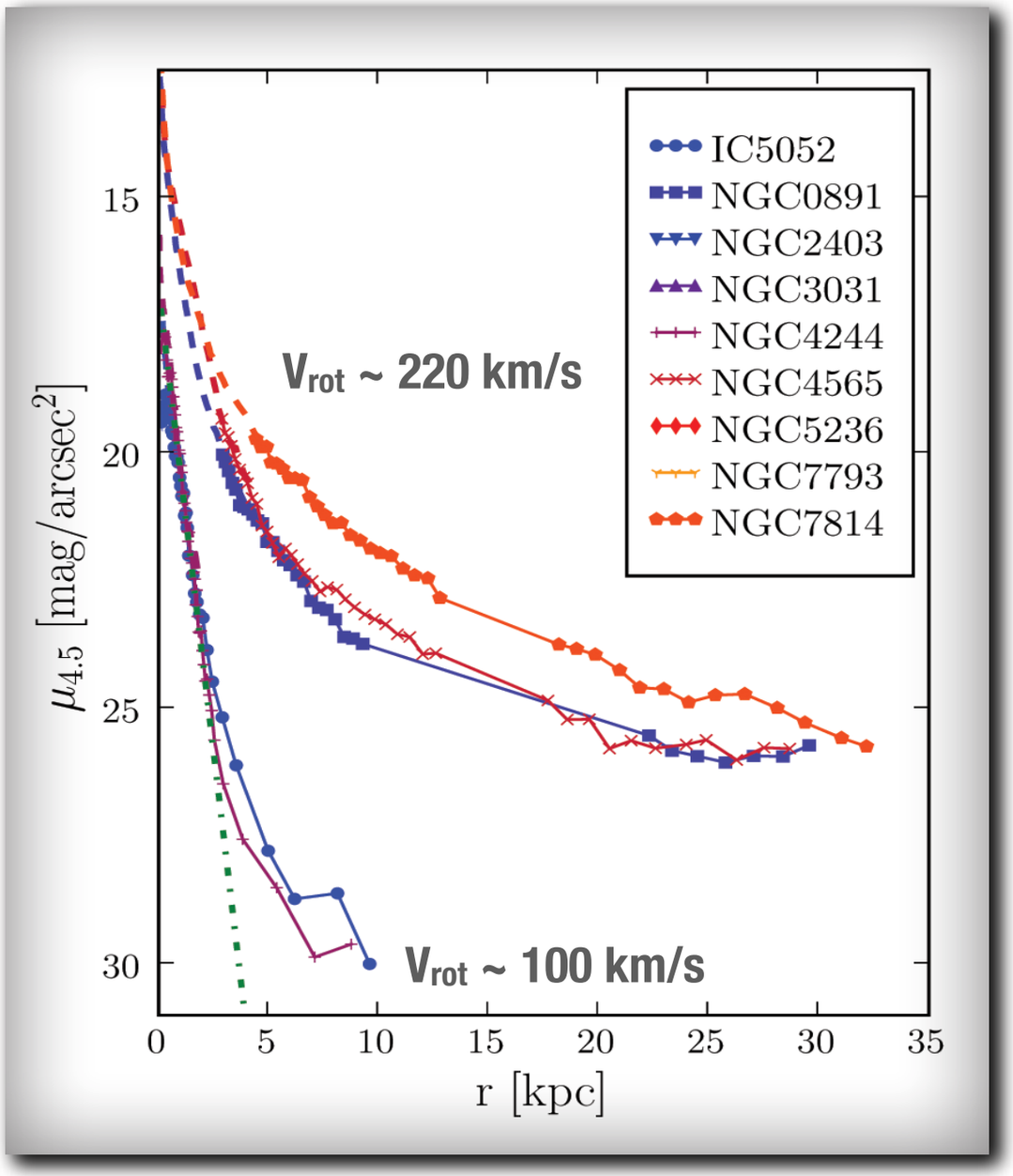

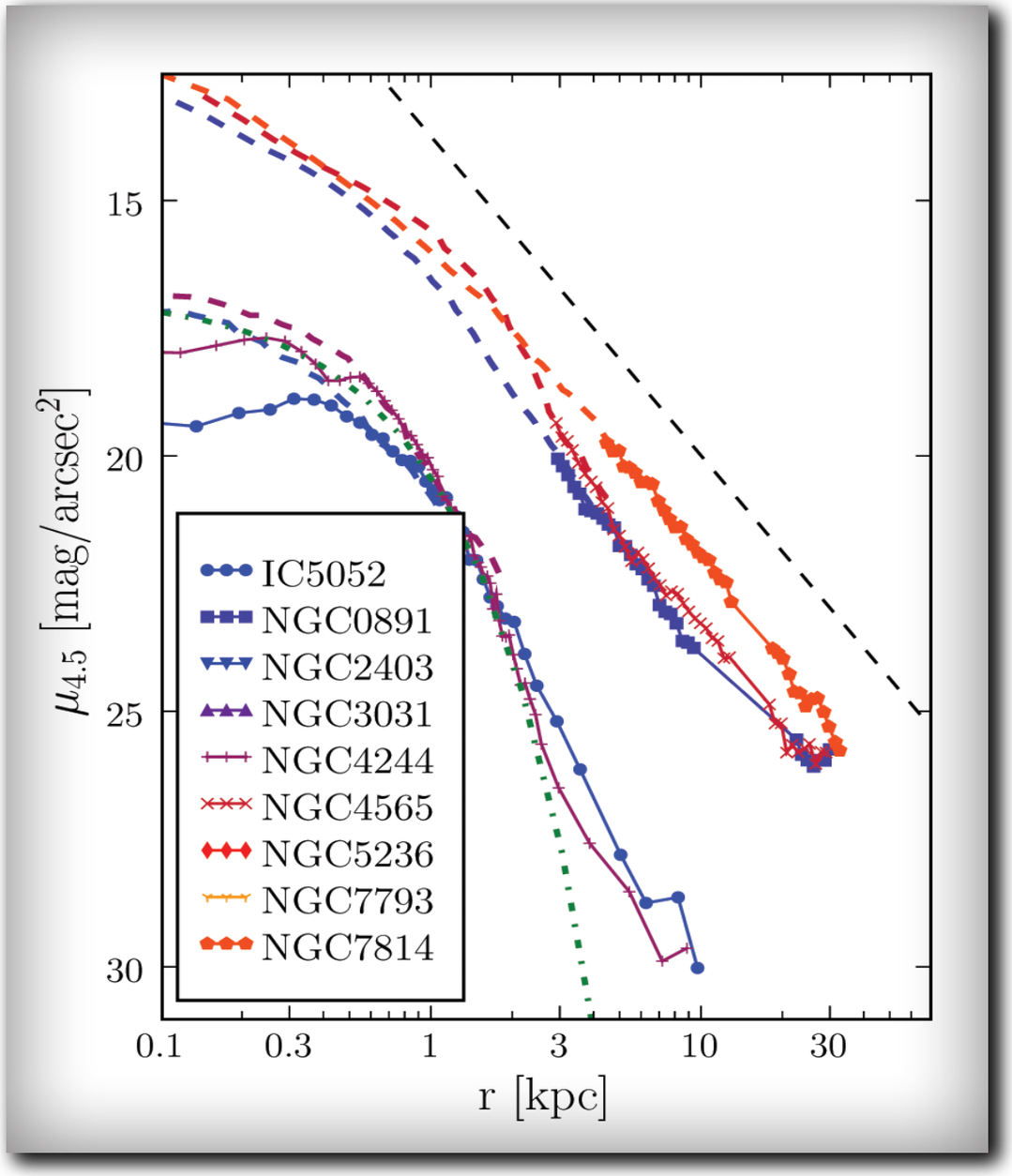

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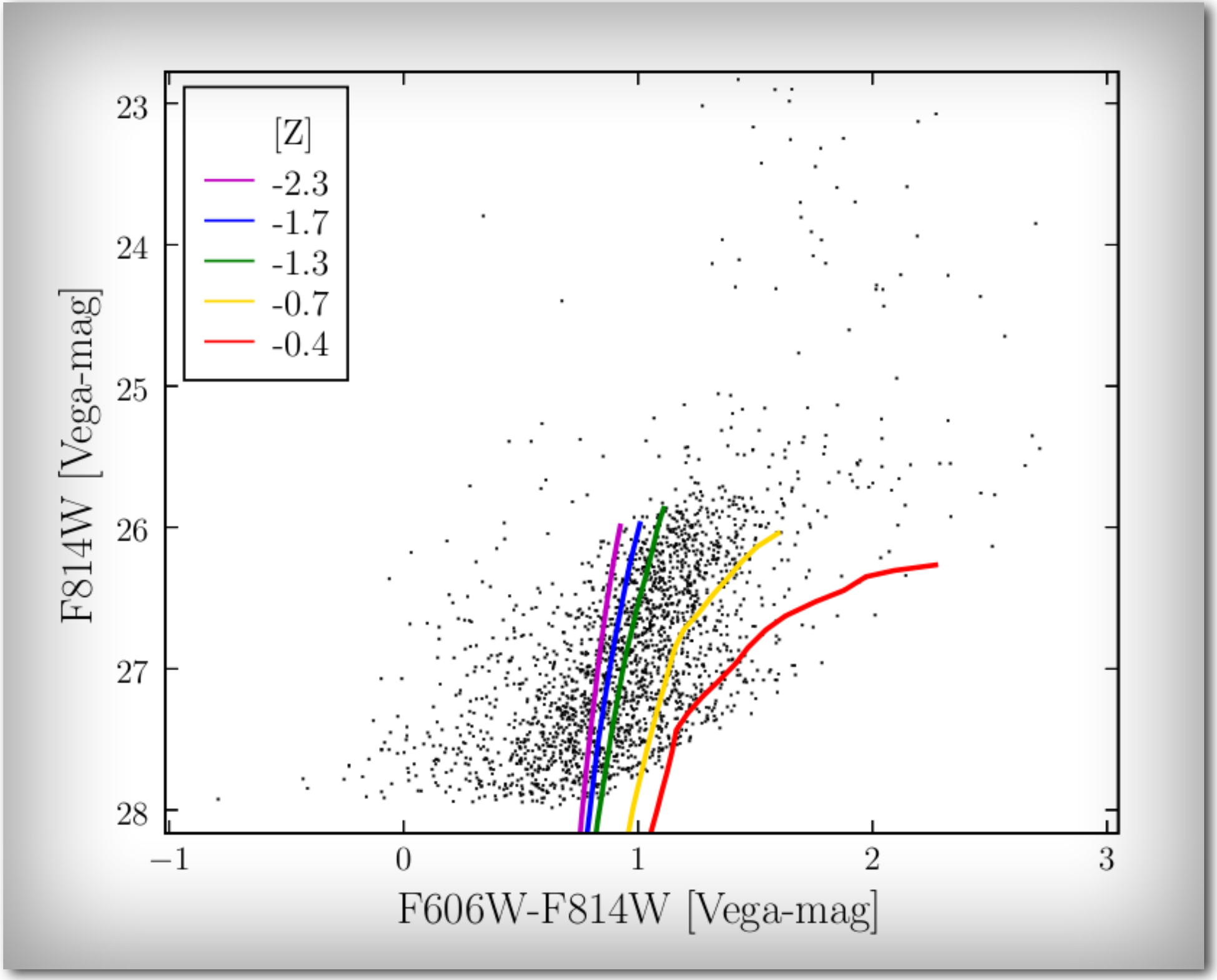
GHOSTS Stellar Halo Metallicities



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GHOSTS Stellar Halo Color Profiles

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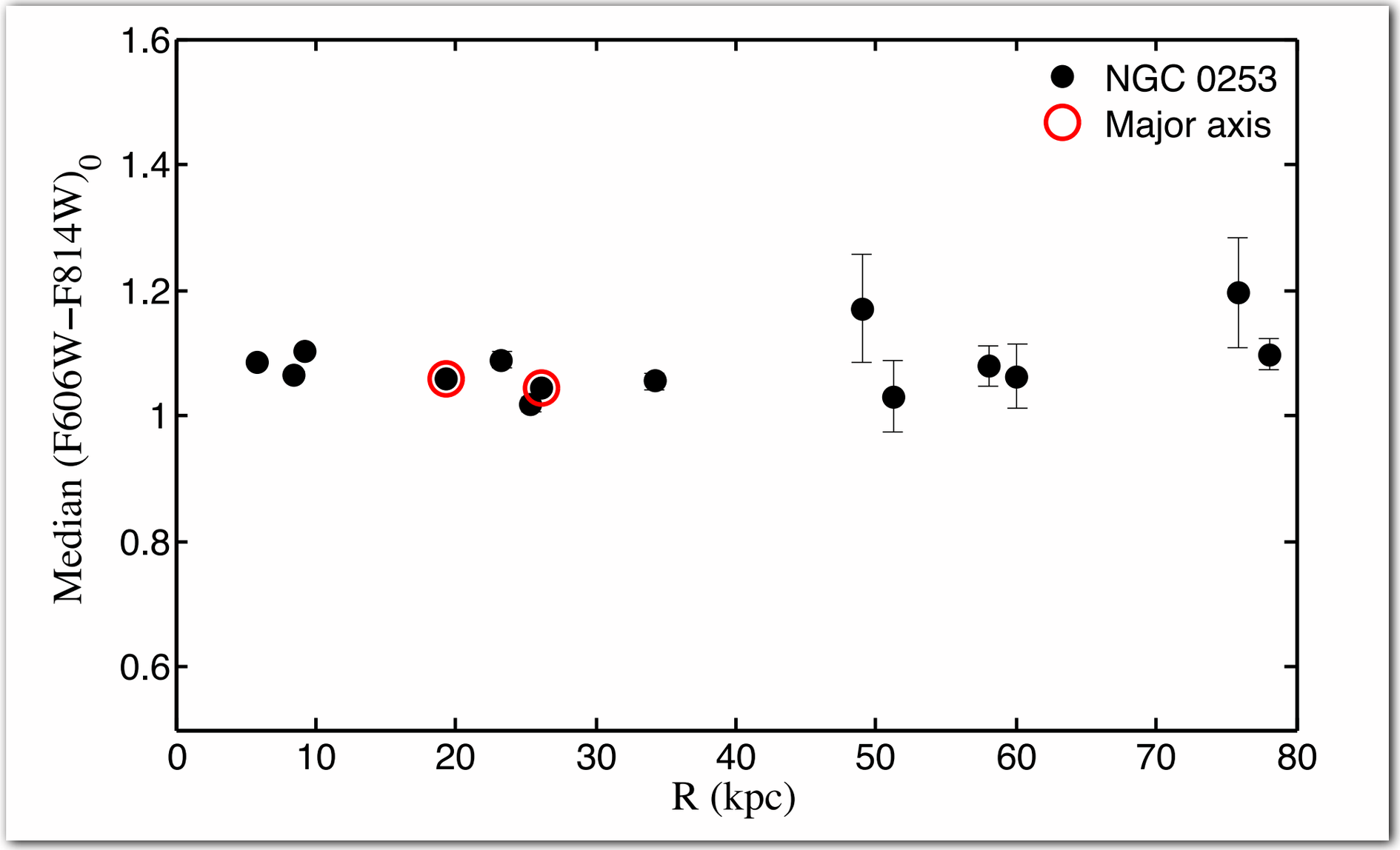

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GHOSTS Stellar Halo Color Profiles

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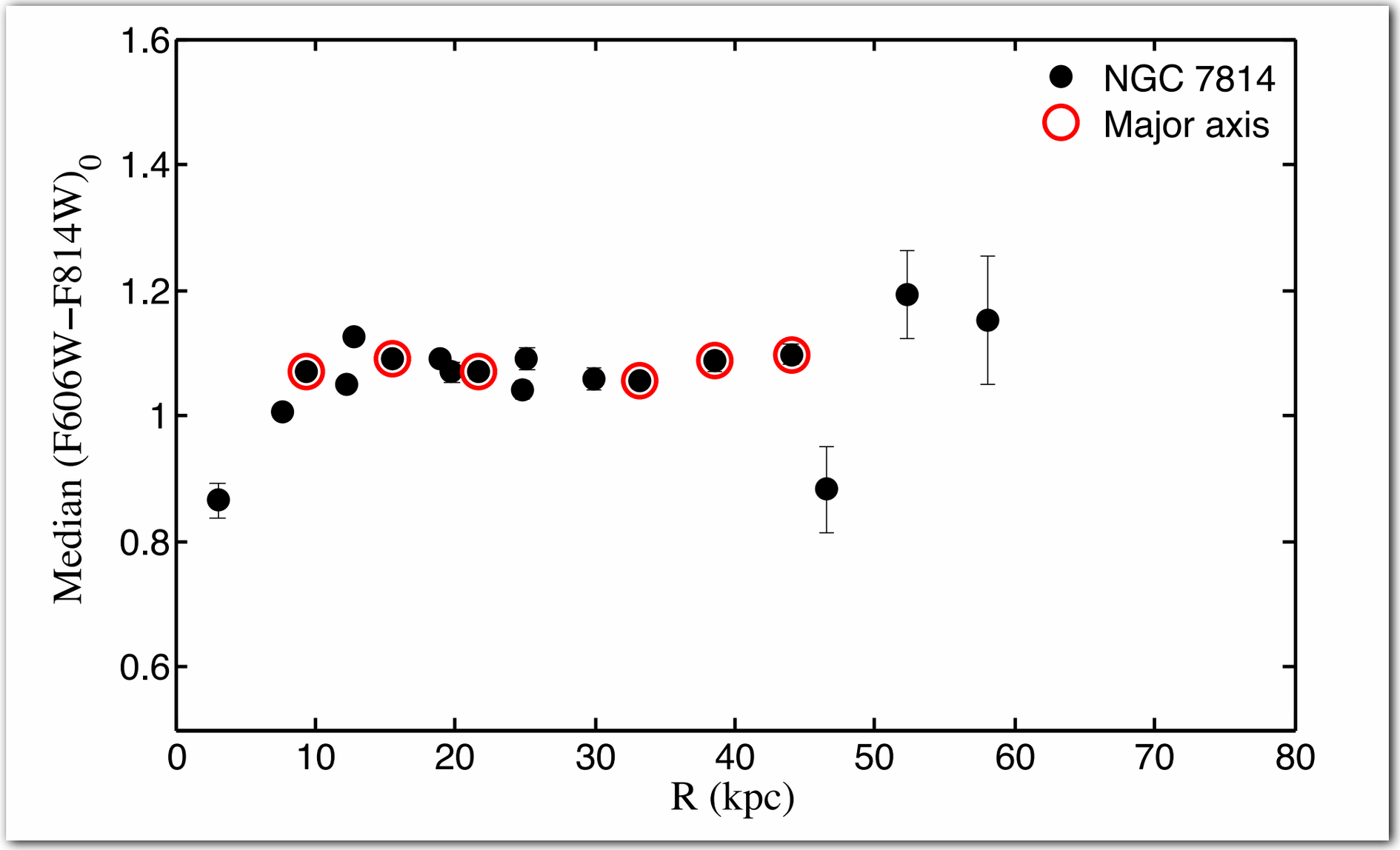

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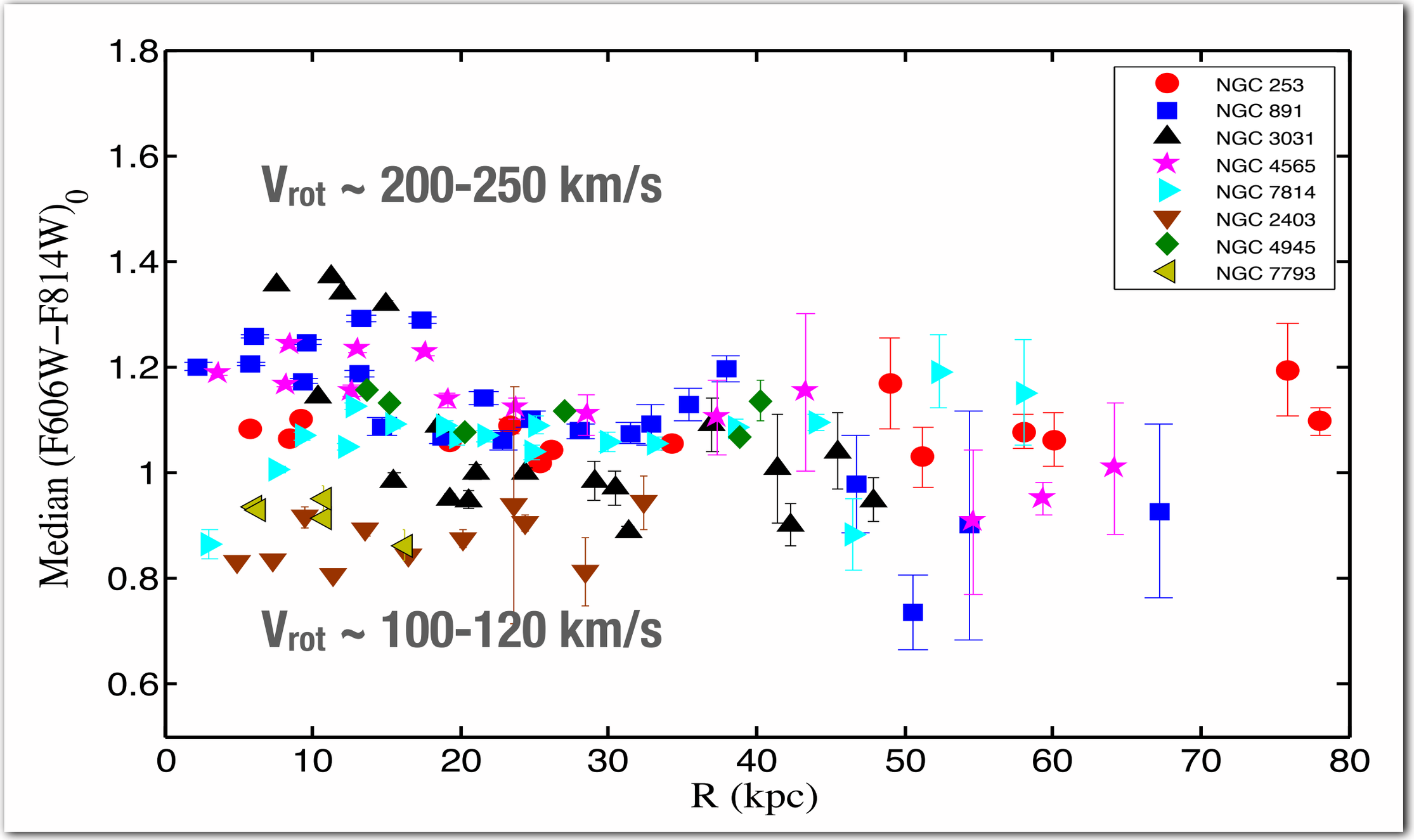
GHOSTS Stellar Halo Color Profiles



Monachesi et al., in prep.

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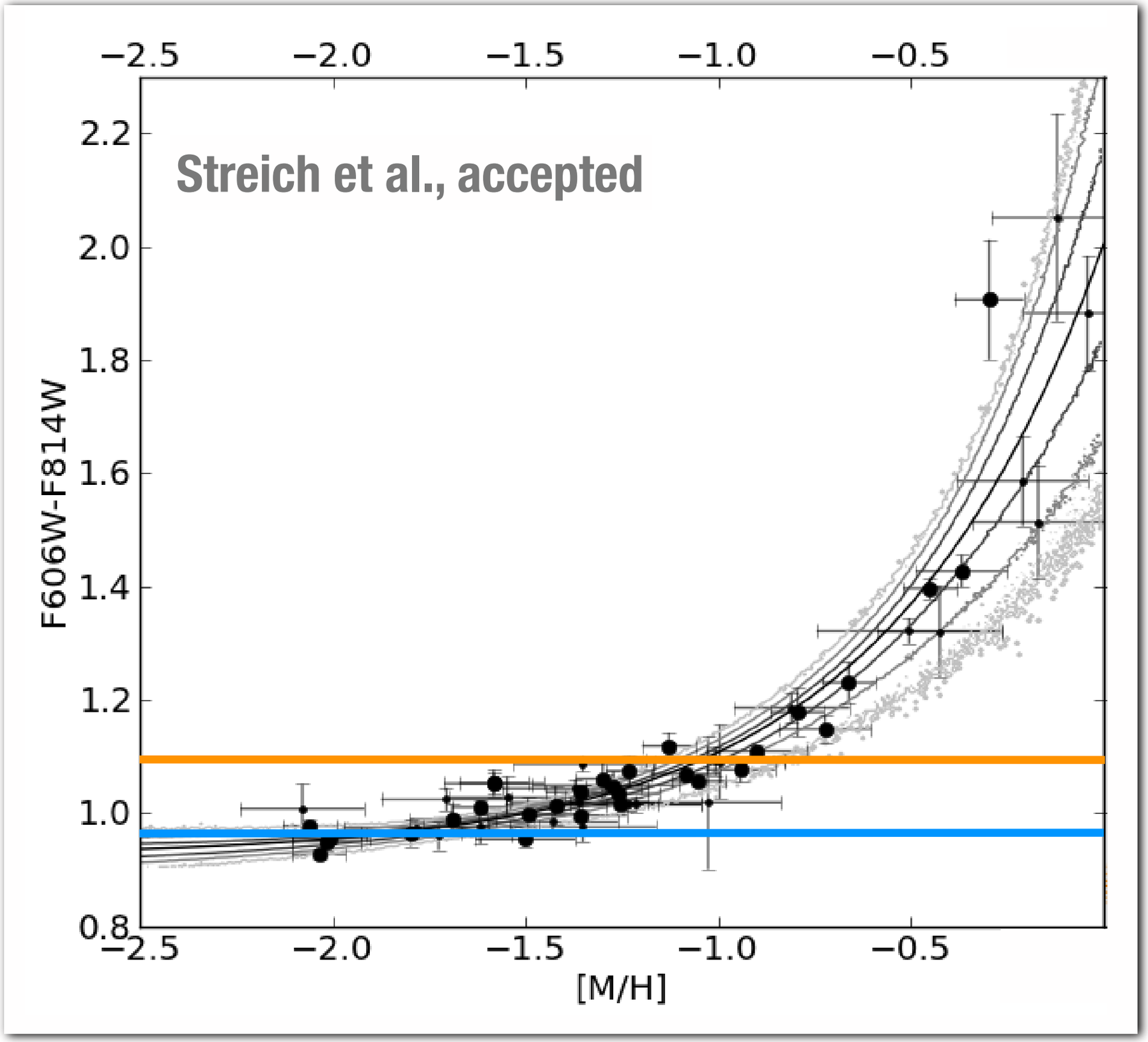
GHOSTS MW Globular Clusters



[Fe/H] ~ -1.0

[Fe/H] ~ -1.5-4.0

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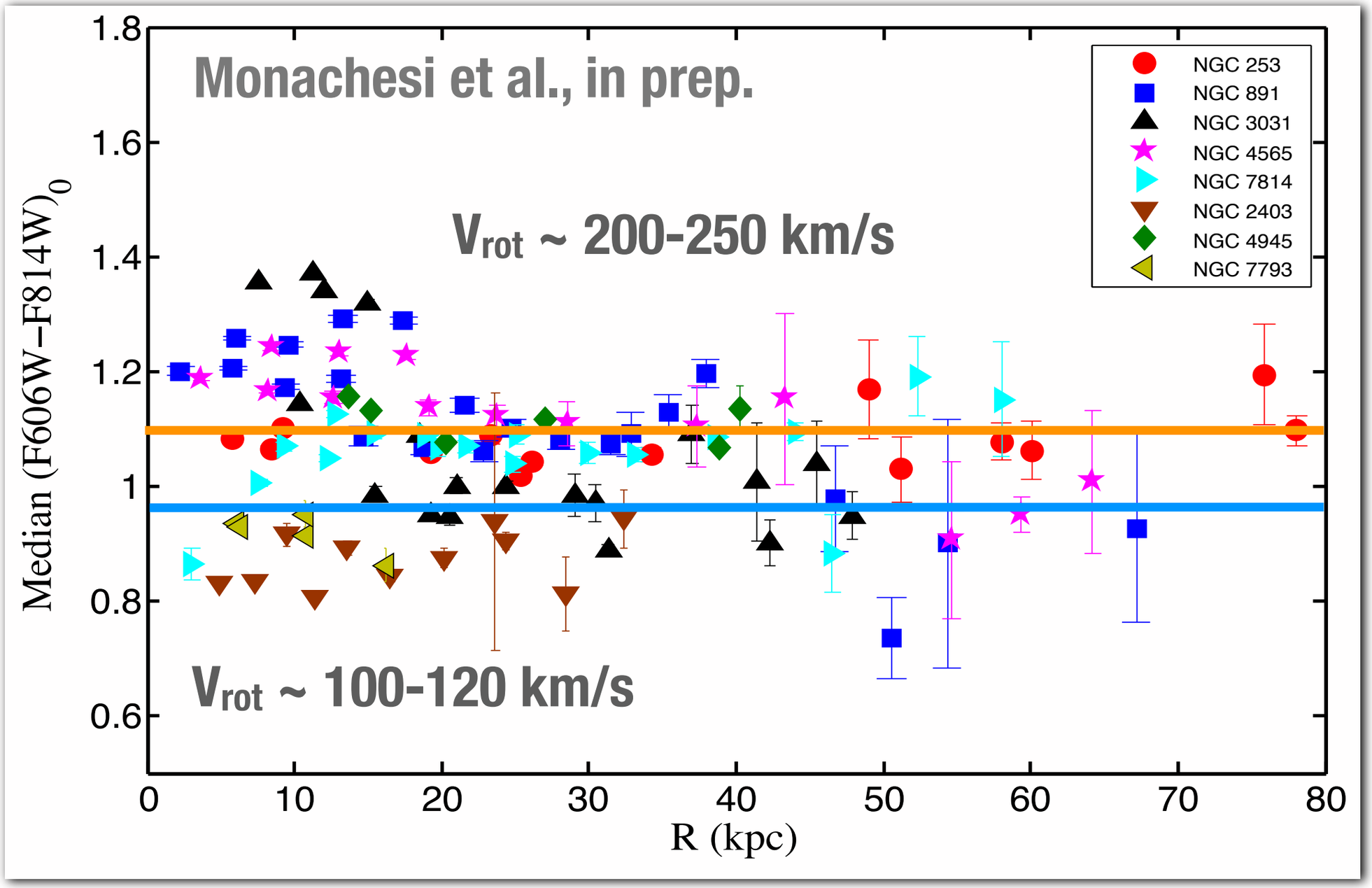

[Fe/H] ~ -1.0

[Fe/H] ~ -1.5-4.0

- Most galaxies no significant color gradients between 20-80 kpc
- RGB halos of small galaxies bluer than most metal-poor MW globulars, probably younger population

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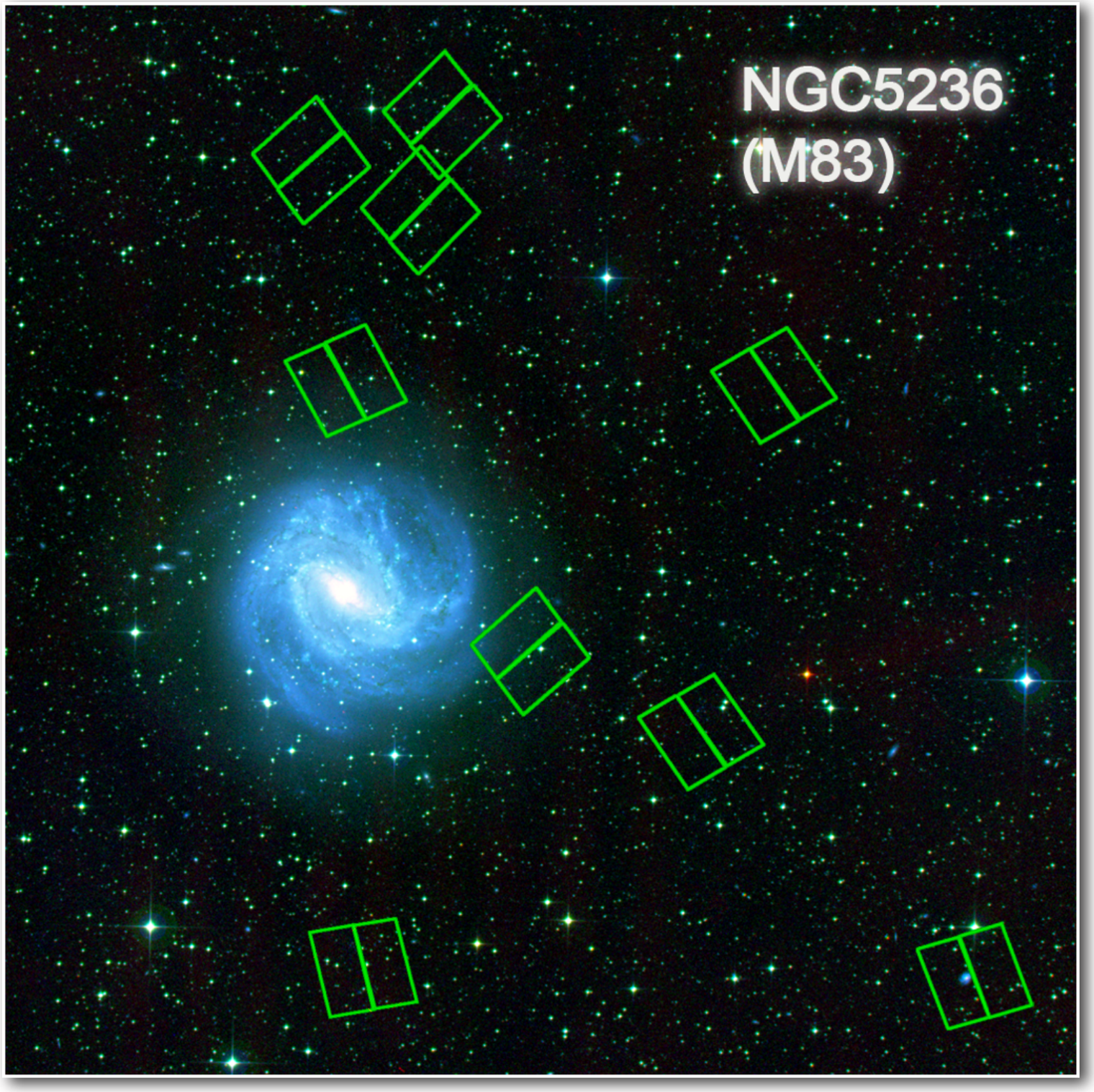
GHOSTS Stellar Streams & Substructure

NGC 0247
NGC 0253
NGC 0891
NGC 2403
NGC 3031
NGC 4244
NGC 4565
NGC 4631
NGC 4736
NGC 5023
NGC 4945
IC 5052
NGC 5236
NGC 5907
NGC 7793
NGC 7814



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GHOSTS Stellar Streams

NGC 0247
NGC 0253
NGC 0891
NGC 2403
NGC 3031
NGC 4244
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NGC 4631
NGC 4736
NGC 5023
NGC 4945
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NGC 5236
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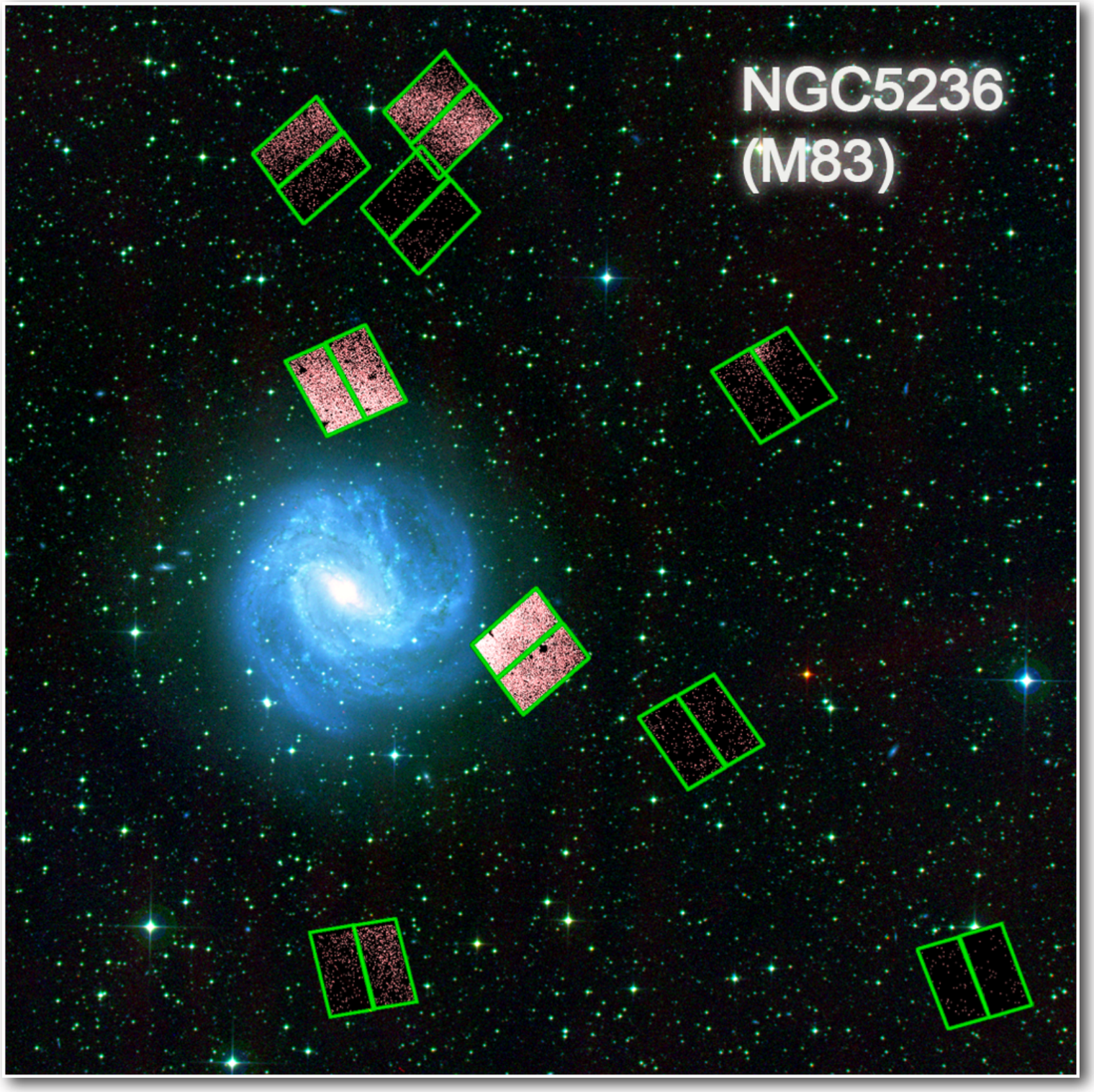

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GHOSTS Stellar Streams

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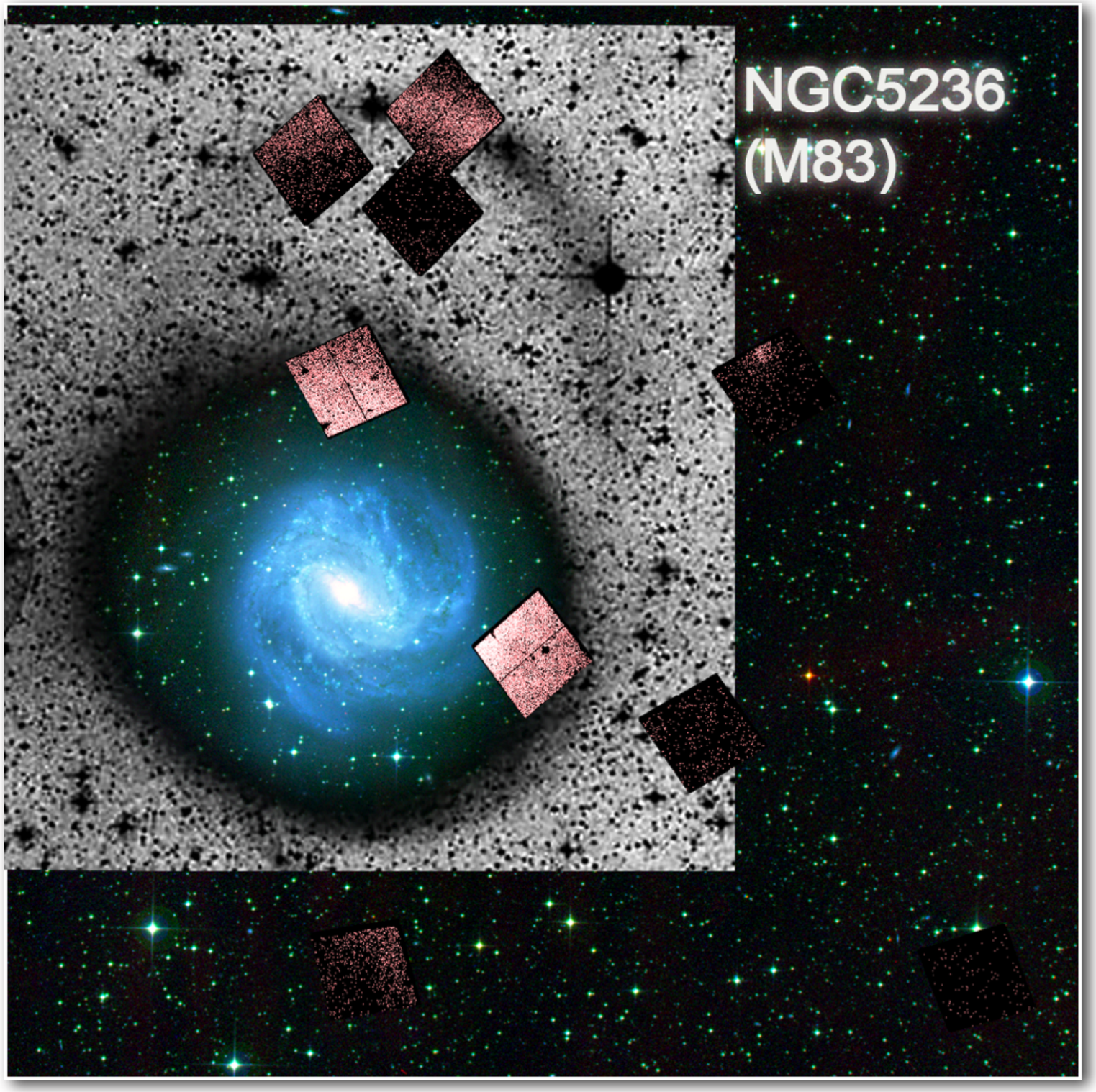

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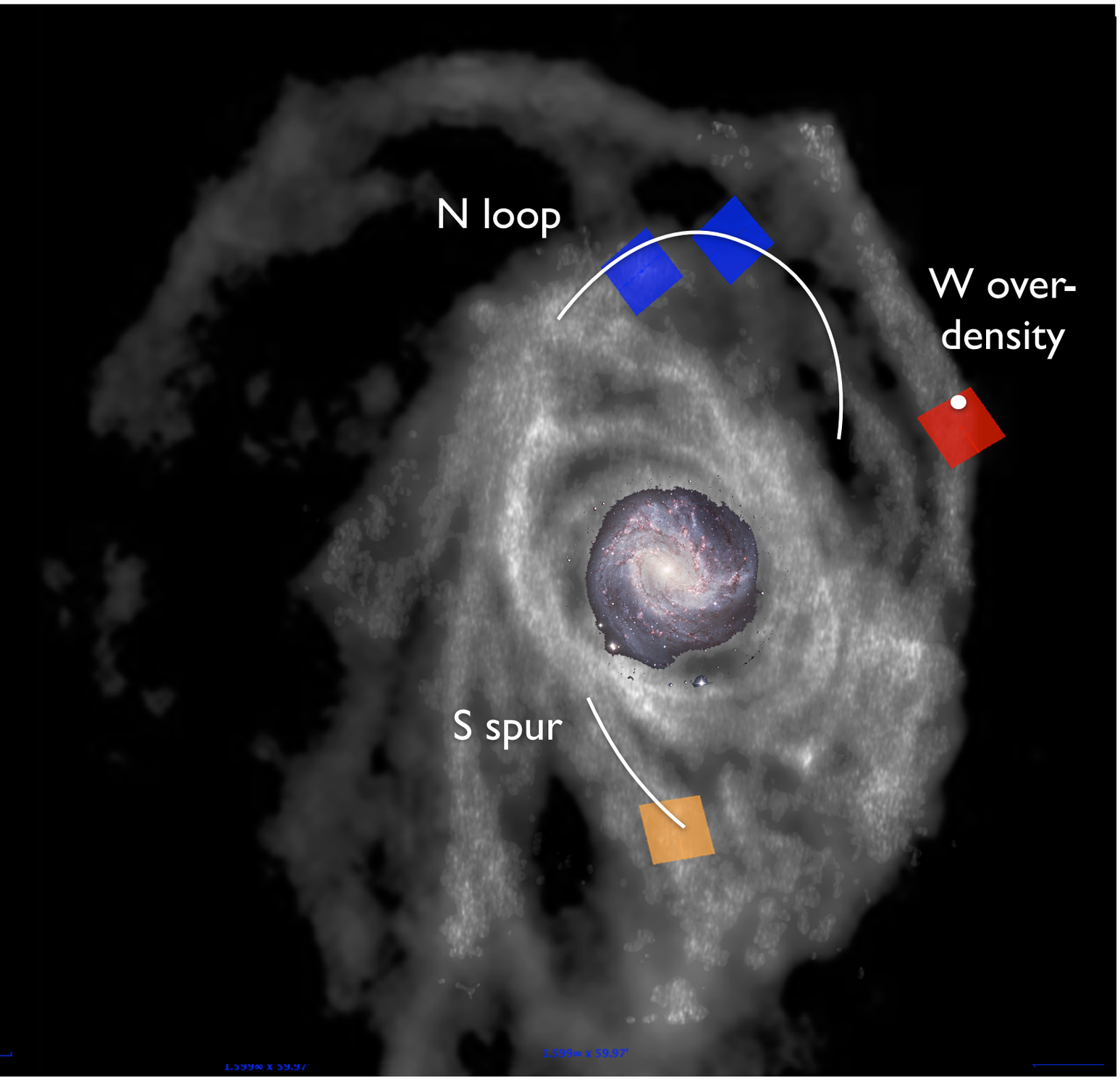
GHOSTS M83: A new dwarf companion?



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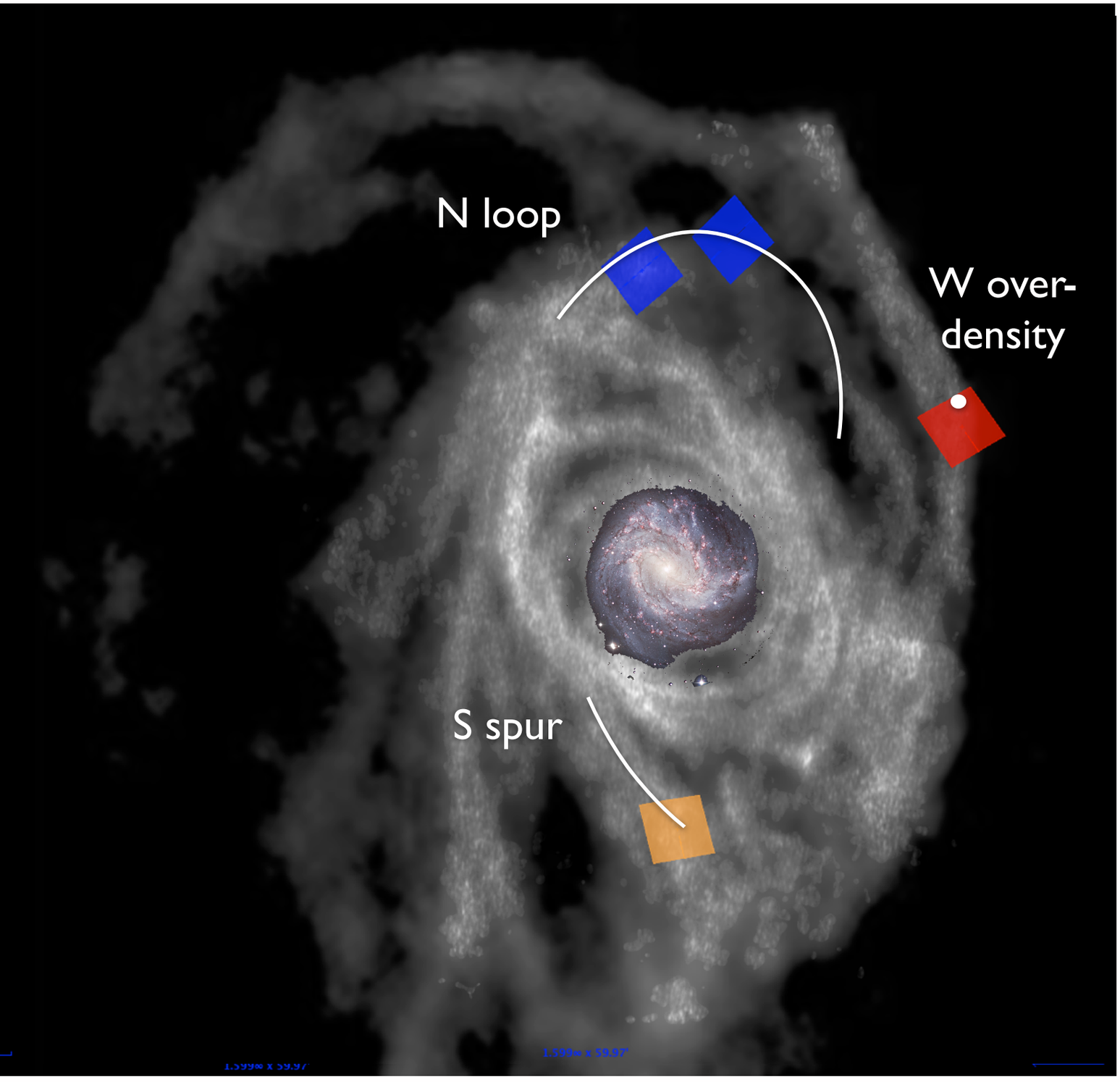
GHOSTS M83: A new dwarf companion?



- M83 surrounded by large HI streams

- Possible origin:
  - primordial accretion
  - gas rich satellite
  - tidal stripping

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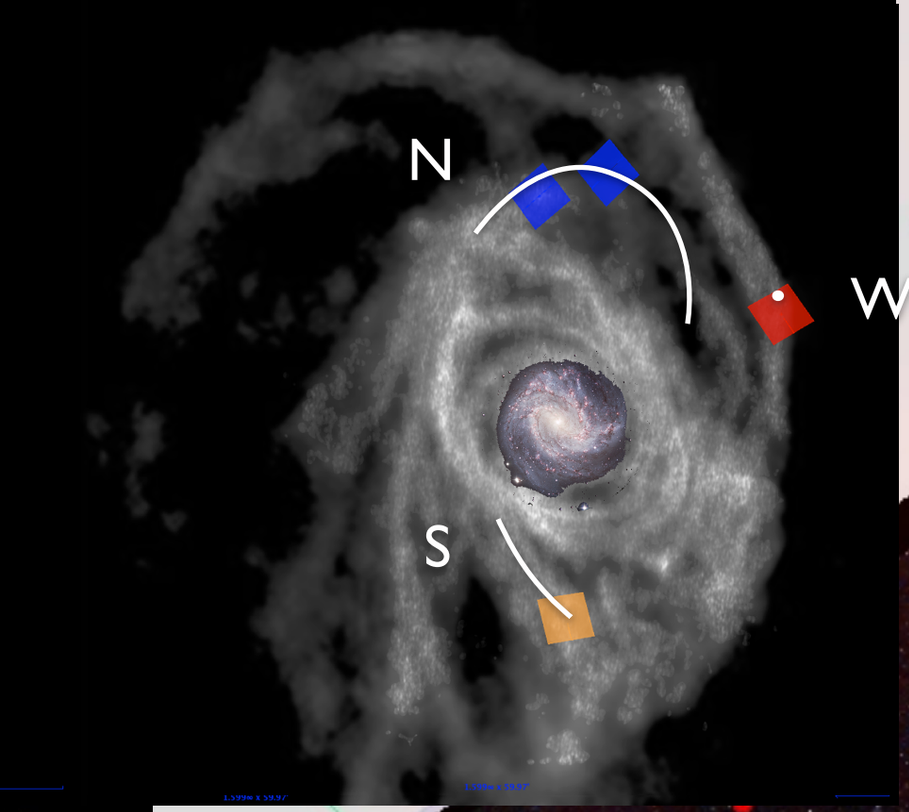

N
W
S

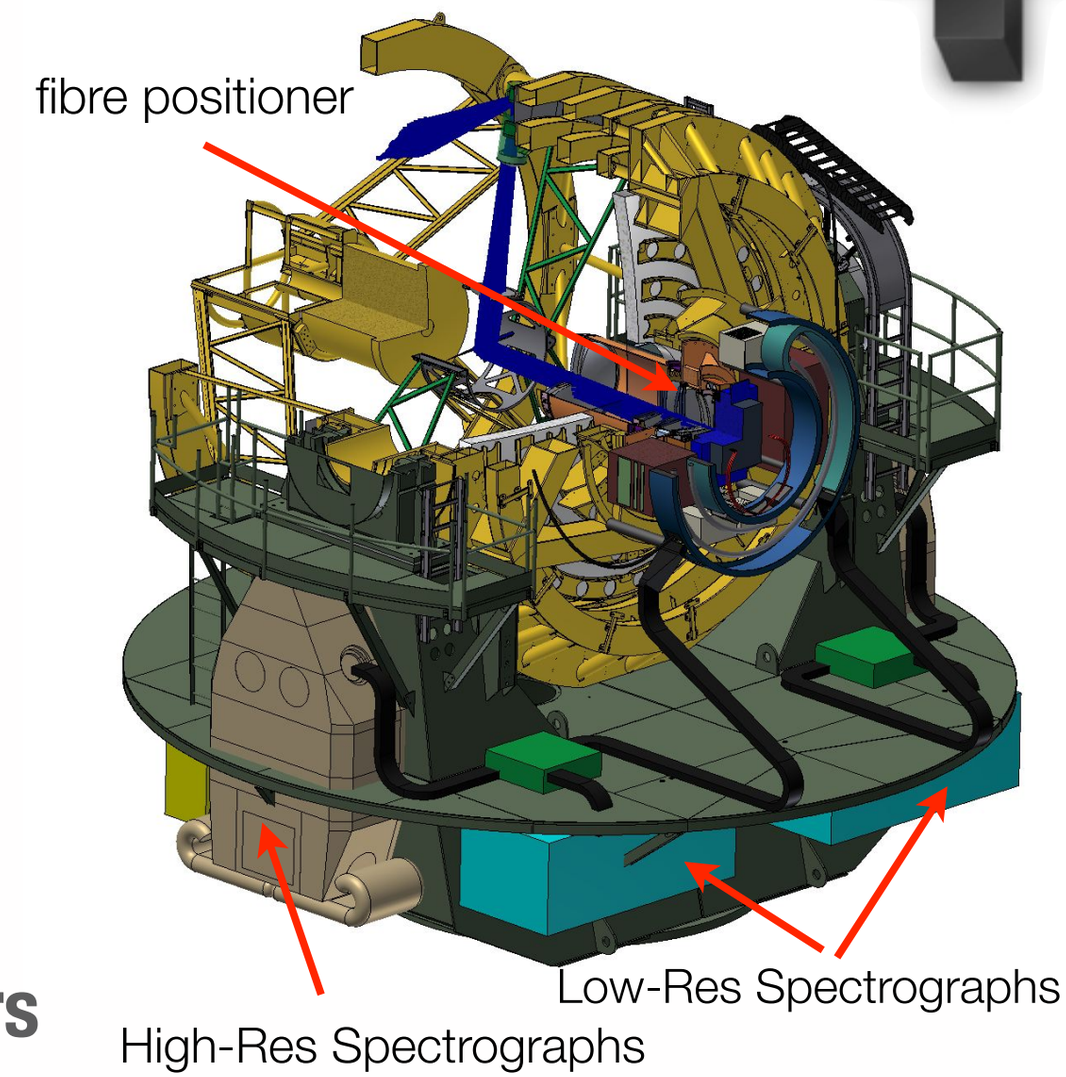
4MOST – 4m Multi-Object Spectroscopic Telescope

- Next generation spectroscopic survey facility selected for the VISTA telescope of ESO

- Specs:
  - 2.5 degree diameter Field-of-View
  - 2400 fibres
  - Resolution R~5000 and R~20,000
  - Wavelength 390-930 nm

- Permanent survey mode for 5 years with many surveys in parallel starting in 2019
- Will observe >20 million objects in 5 years

- Ideal for complement Gaia mission for MW halo studies, eROSITA galaxy cluster dark halos, lensing imaging surveys, etc.



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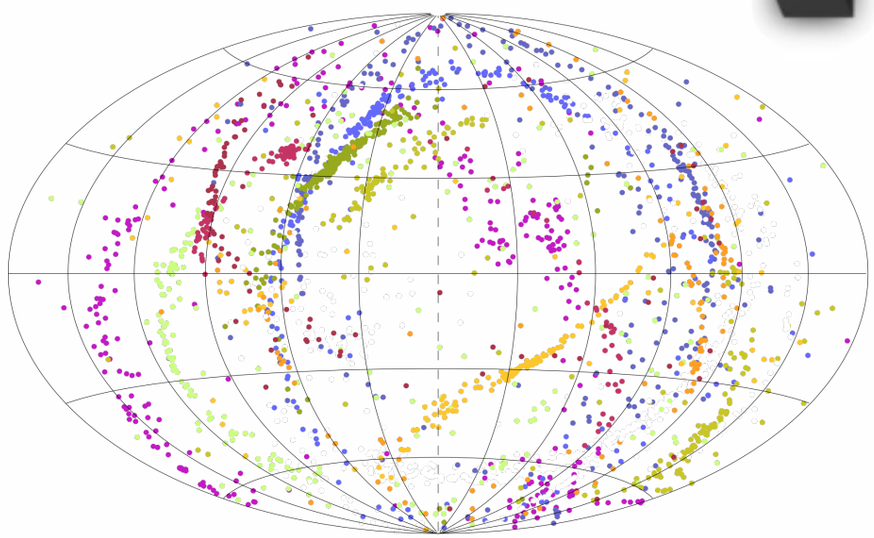
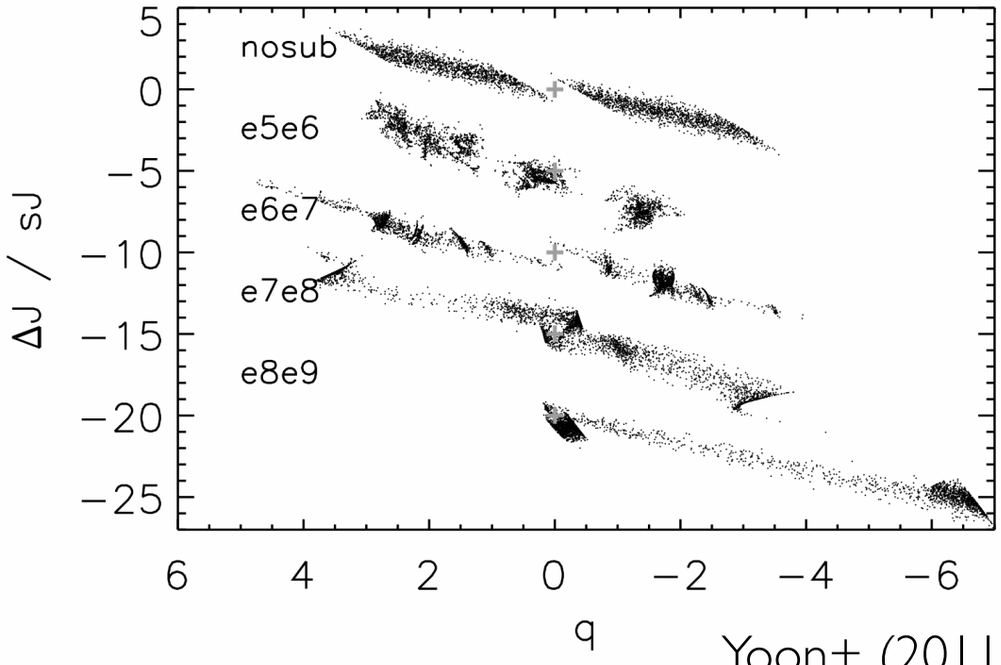
4MOST MW halo survey

- Obtaining spectra of >10^6 halo stars allows:
  - Determining the Milky Way 3D potential from streams to ~100 kpc
  - Measuring the effect of baryons:
    - has there been significant adiabatic contraction?
    - is there a disk-like DM component?
    - does the DM respond to the bar?
- Determine the mass spectrum of Dark Matter halo substructure by the kinematic effects on cold streams of 10^3–10^5 $M_\odot$



Cooper+ (2010)



Yoon+ (2011)

GHOSTS Summary

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GHOSTS Summary

- Stellar halos are very compact (Sersic index 4-6)
- Inner halos (<25 kpc) are very flattened (c/a ~ 0.3–0.4)
- Substructure in stellar halos is diverse
  - streams, young & old dwarfs
- RGB stars show no significant color gradient (i.e. metallicity gradient) between 20 and 80 kpc
- RGB halo stars of small galaxies are bluer than the most metal-poor MW globular clusters (hence younger)

http://archive.stsci.edu/prepds/ghosts

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