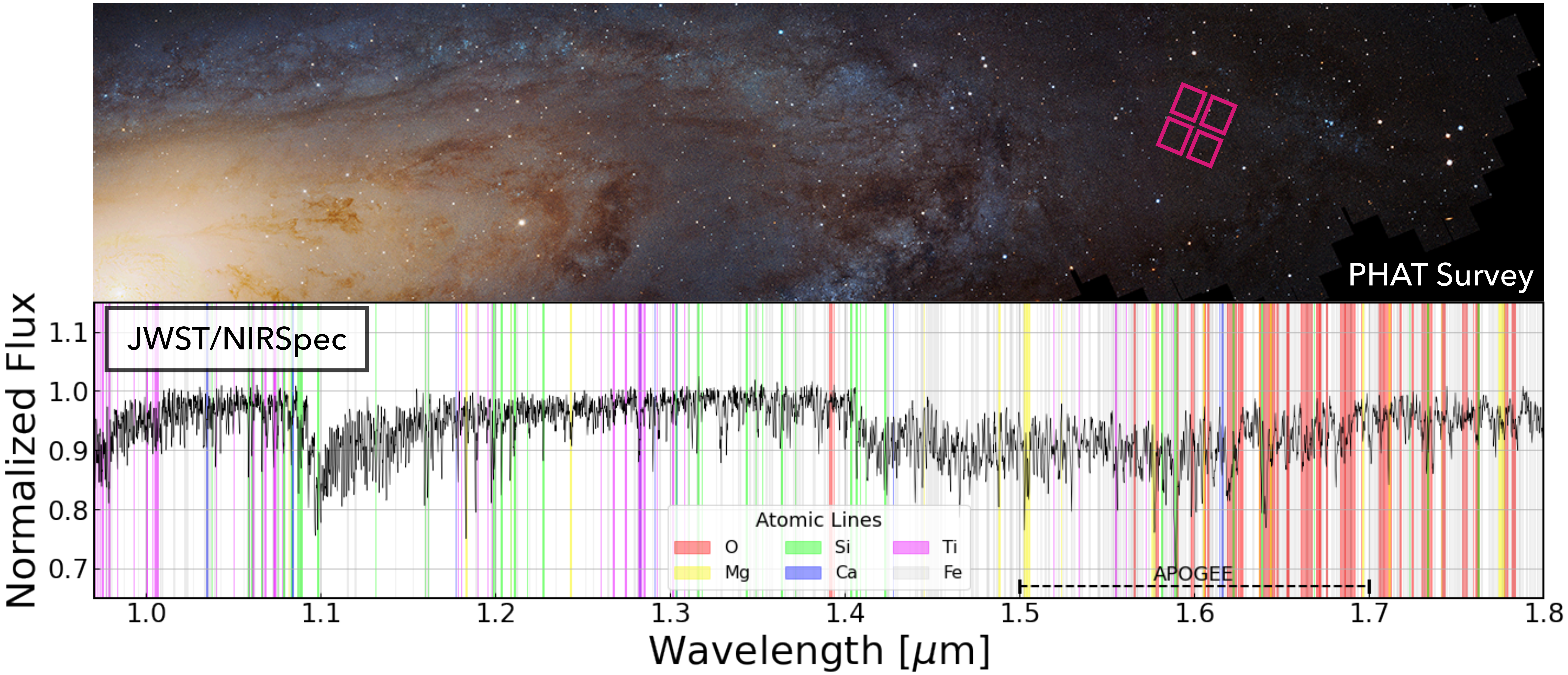
Stellar Chemistry from Resolved Stars Beyond 1 Mpc w/ Space-Based MOS

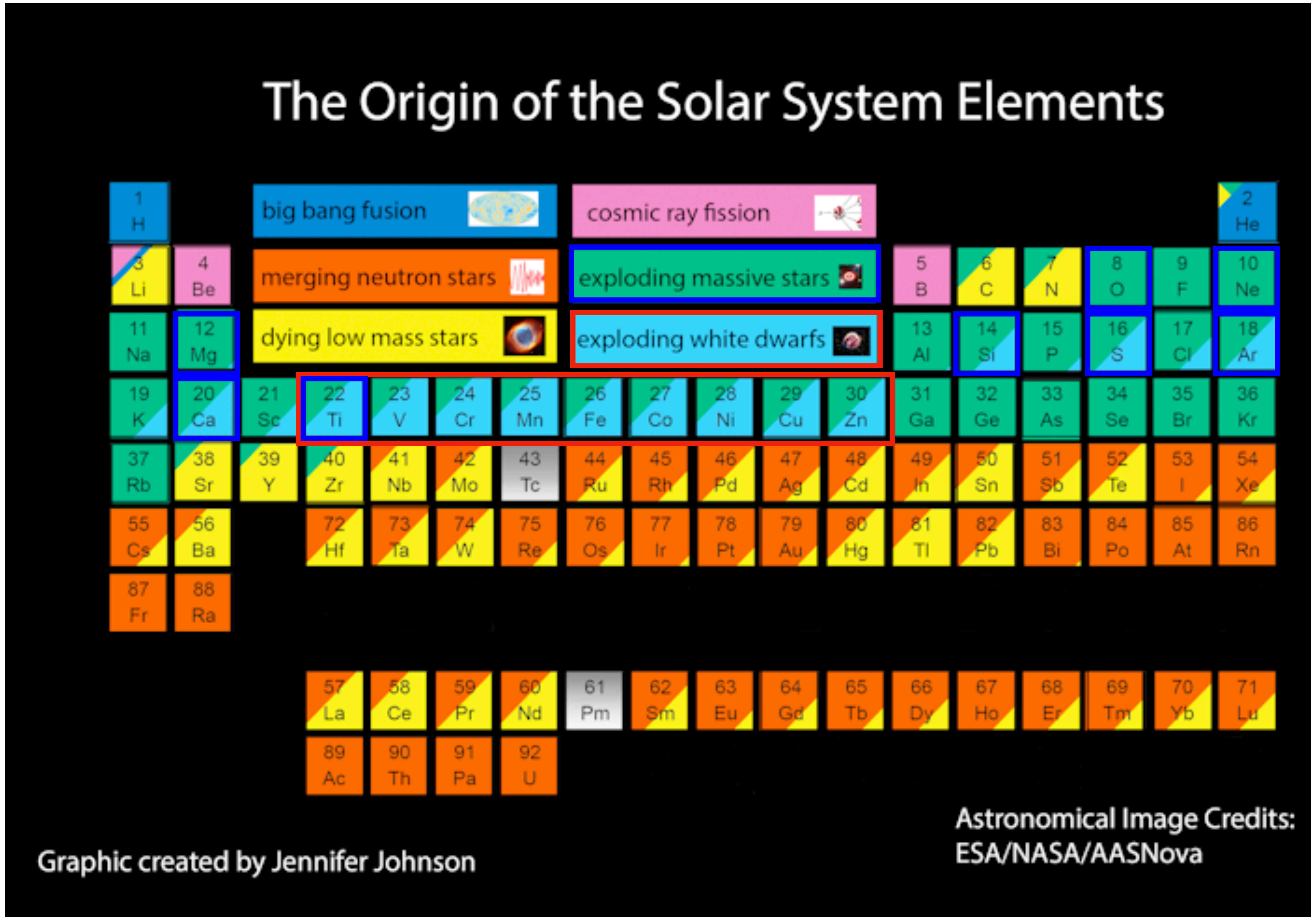
Nathan Sandford
UC Berkeley

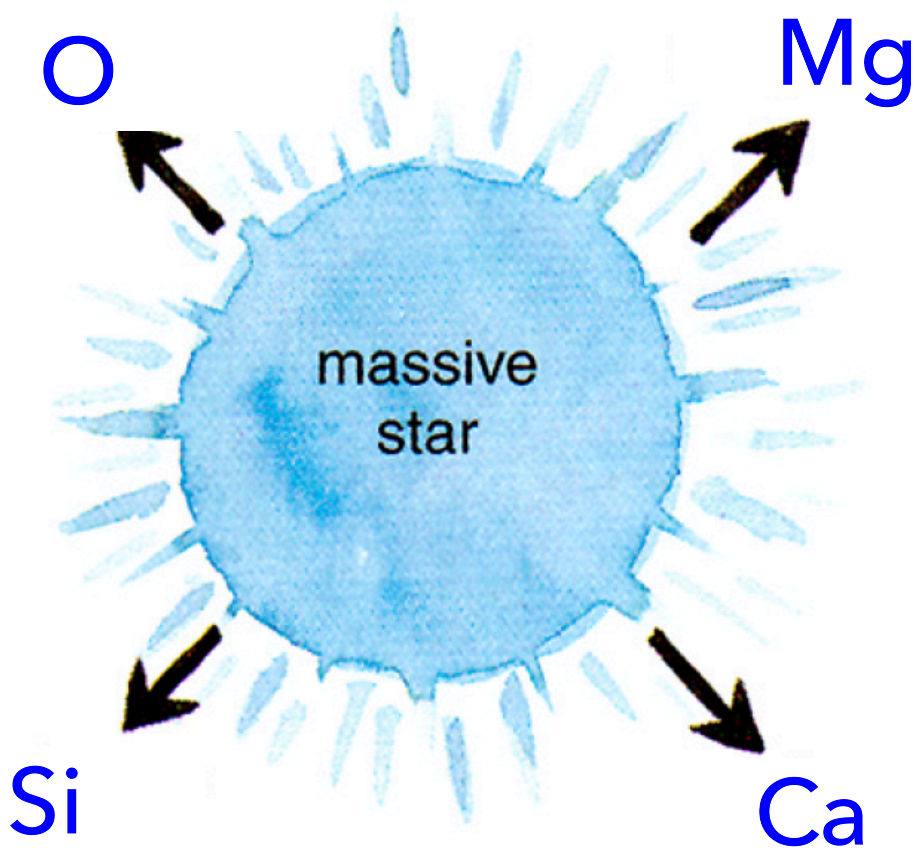
In Collaboration w/
Dan Weisz (UCB)
Yuan-Sen Ting (ANU)



NUCLEOSYNTHESIS:

α-elements & Iron-peak elements





Core-Collapse SNe

- Short enrichment timescale (~10–100 Myr)
- Produces higher fraction of α elements

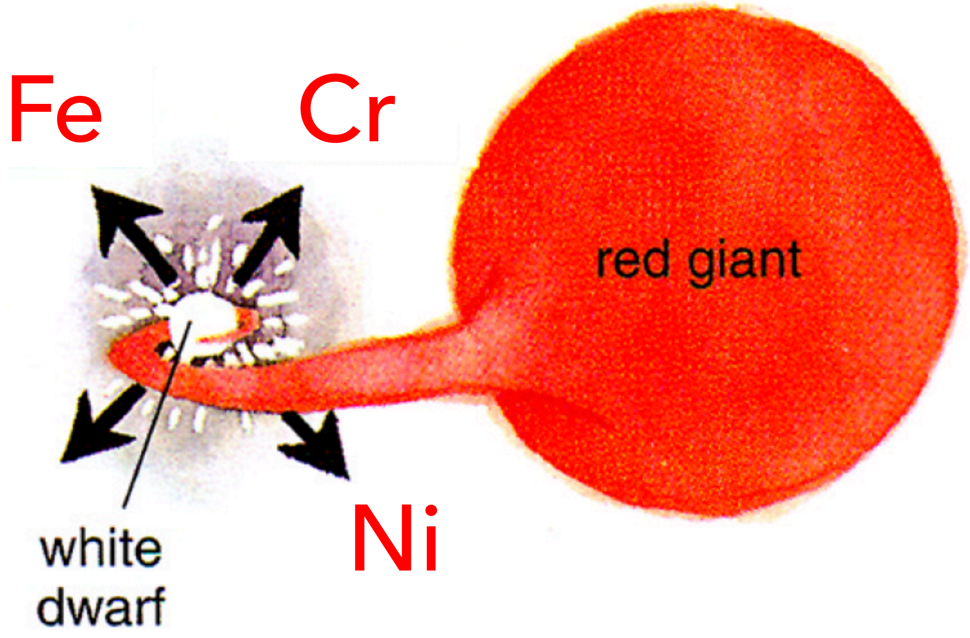


Image Credit: Cristina Chiappini

Type Ia SNe

- Longer enrichment timescale (>100 Myr)
- Produces higher fraction of Iron-Peak elements

NUCLEOSYNTHESIS:

[α/Fe] vs. [Fe/H] Evolution

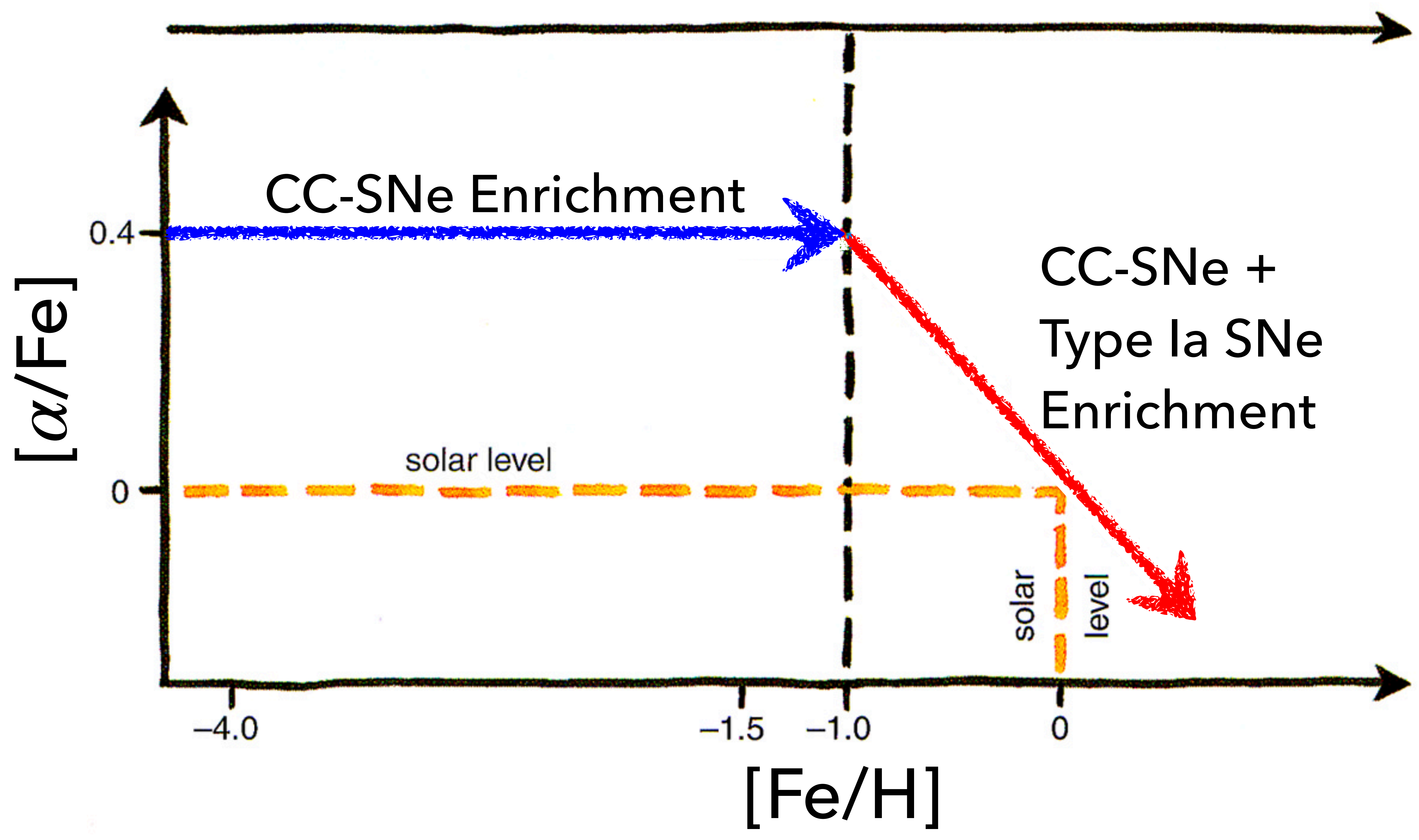


Image Credit: Cristina Chiappini

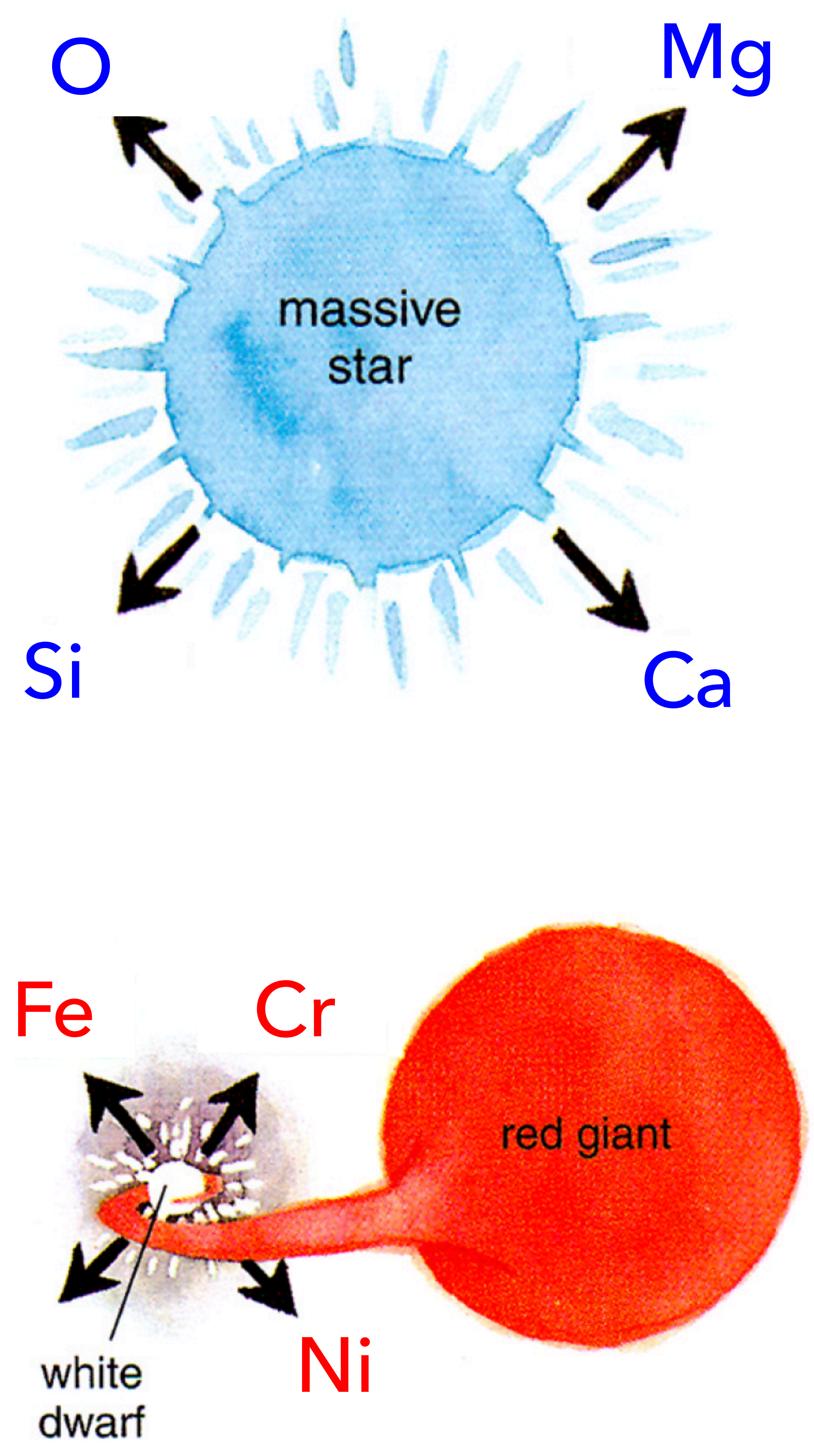


Image Credit: Cristina Chiappini

Core-Collapse SNe

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Type Ia SNe

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[α/Fe] IN THE MILKY WAY

DISTANCE ~ 25 KPC

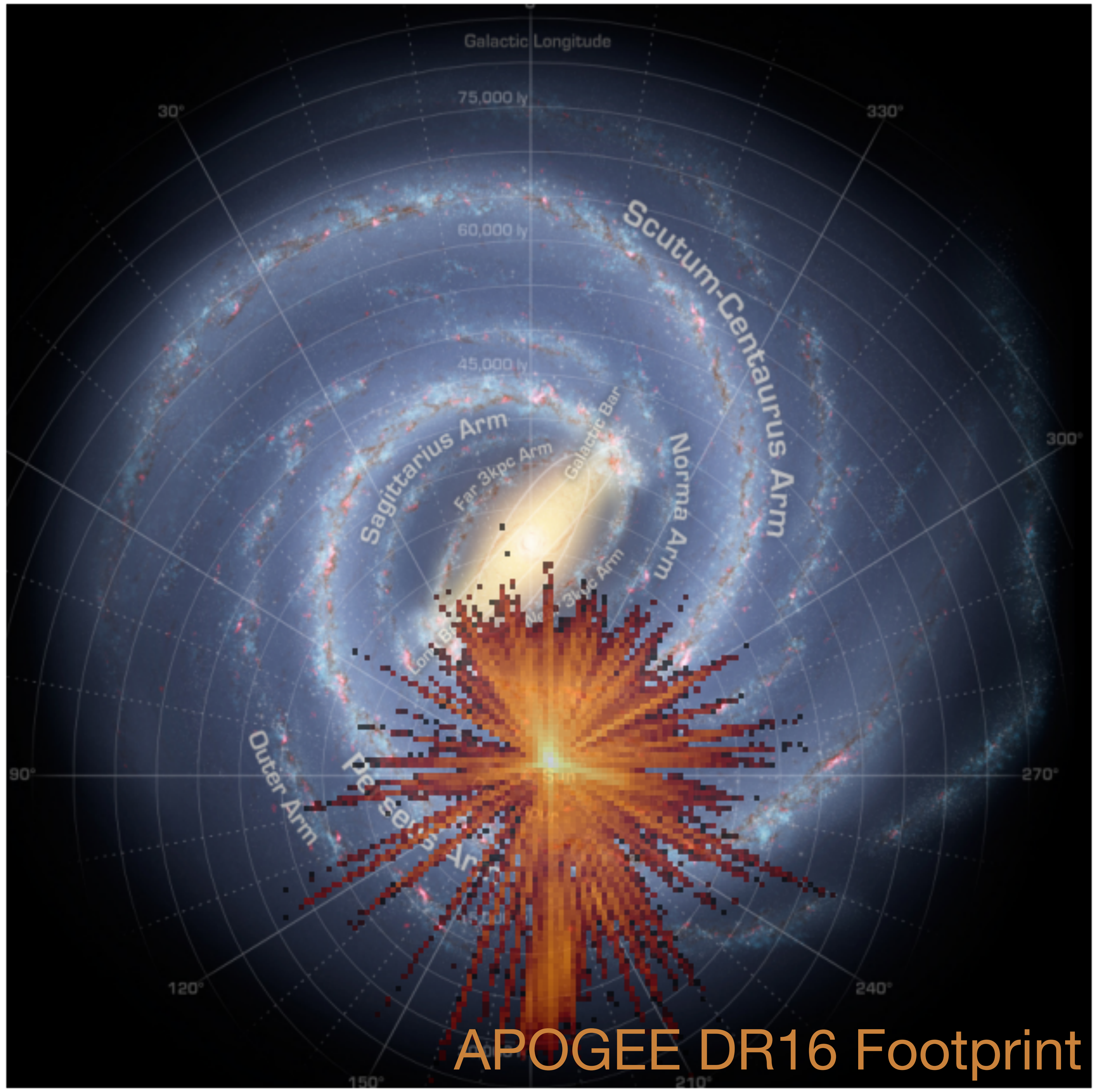
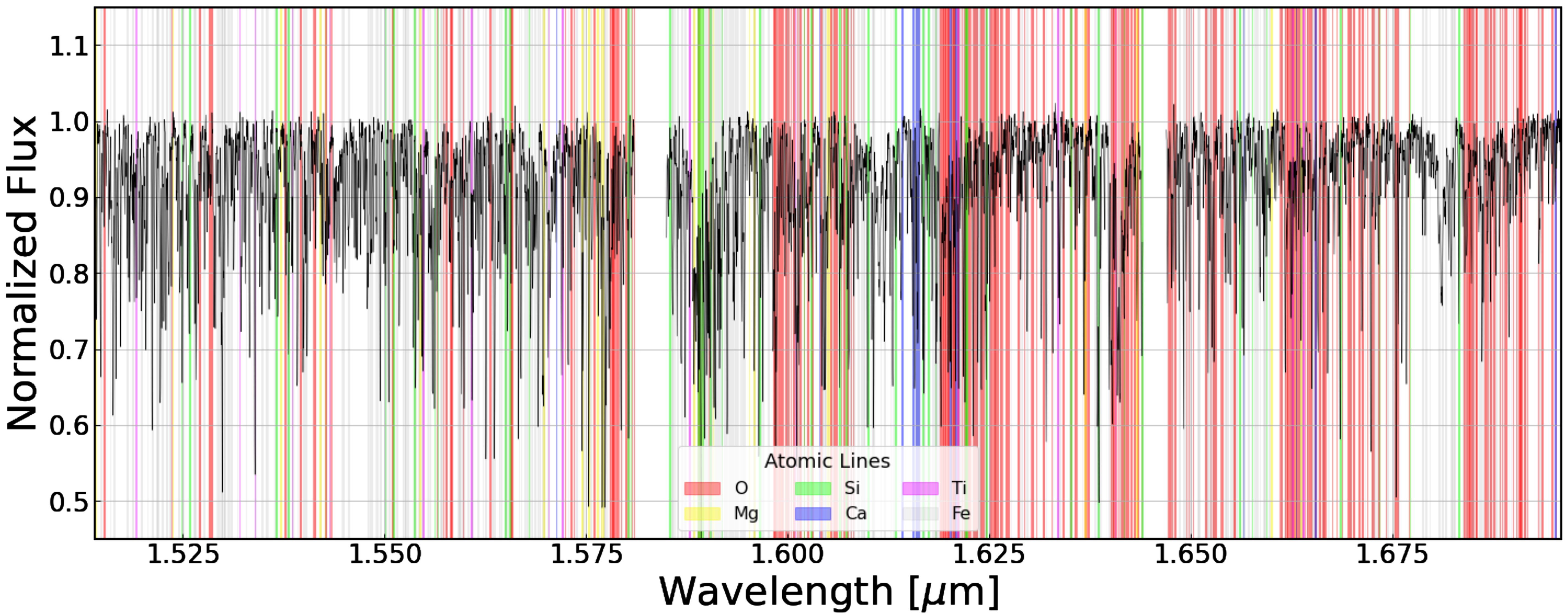


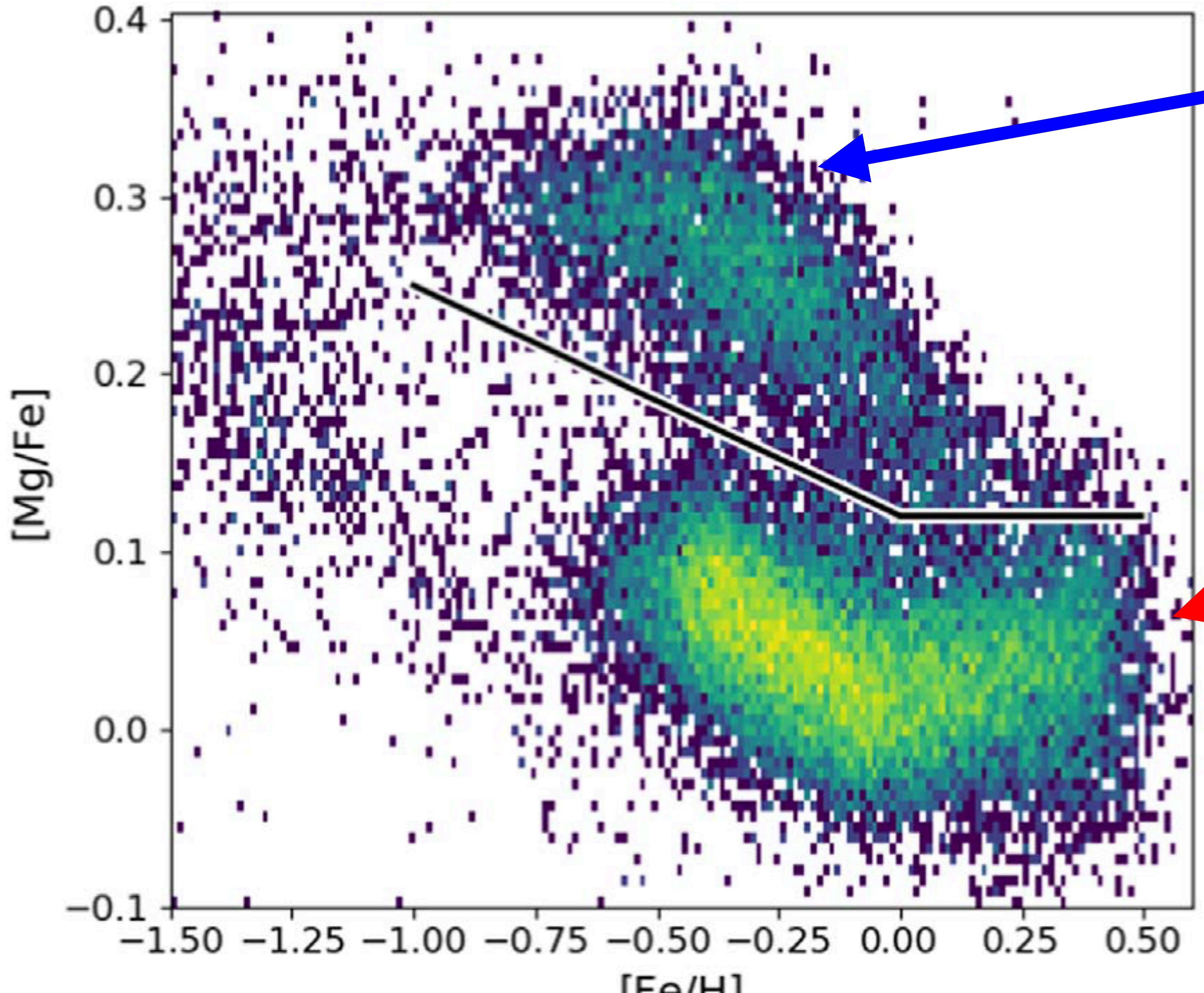
Image Credit: NASA/JPL-Caltech/R. Hurt (SSC/Caltech)

- **APOGEE Survey** (2.5-meters)
  - 10^5 MW stars
  - High-Resolution, Near-IR Spectra
    - $R \sim 22500$, 1.5–1.7 μm, S/N > 100



$[\alpha/\text{Fe}]$ IN THE MILKY WAY

DISTANCE ~ 25 KPC



Weinberg+ 2019

High α

- Thick Disk & Halo Stars
- Older, Metal-poor population
- Shorter formation timescale
- Ex-situ & In-situ star formation

Low α

- Thin Disk
- Younger, Metal-rich population
- Longer formation timescale
- In-Situ star formation

$[\alpha/\mathrm{Fe}]$ IN MILKY WAY SATELLITES

DISTANCE ~ 100 KPC

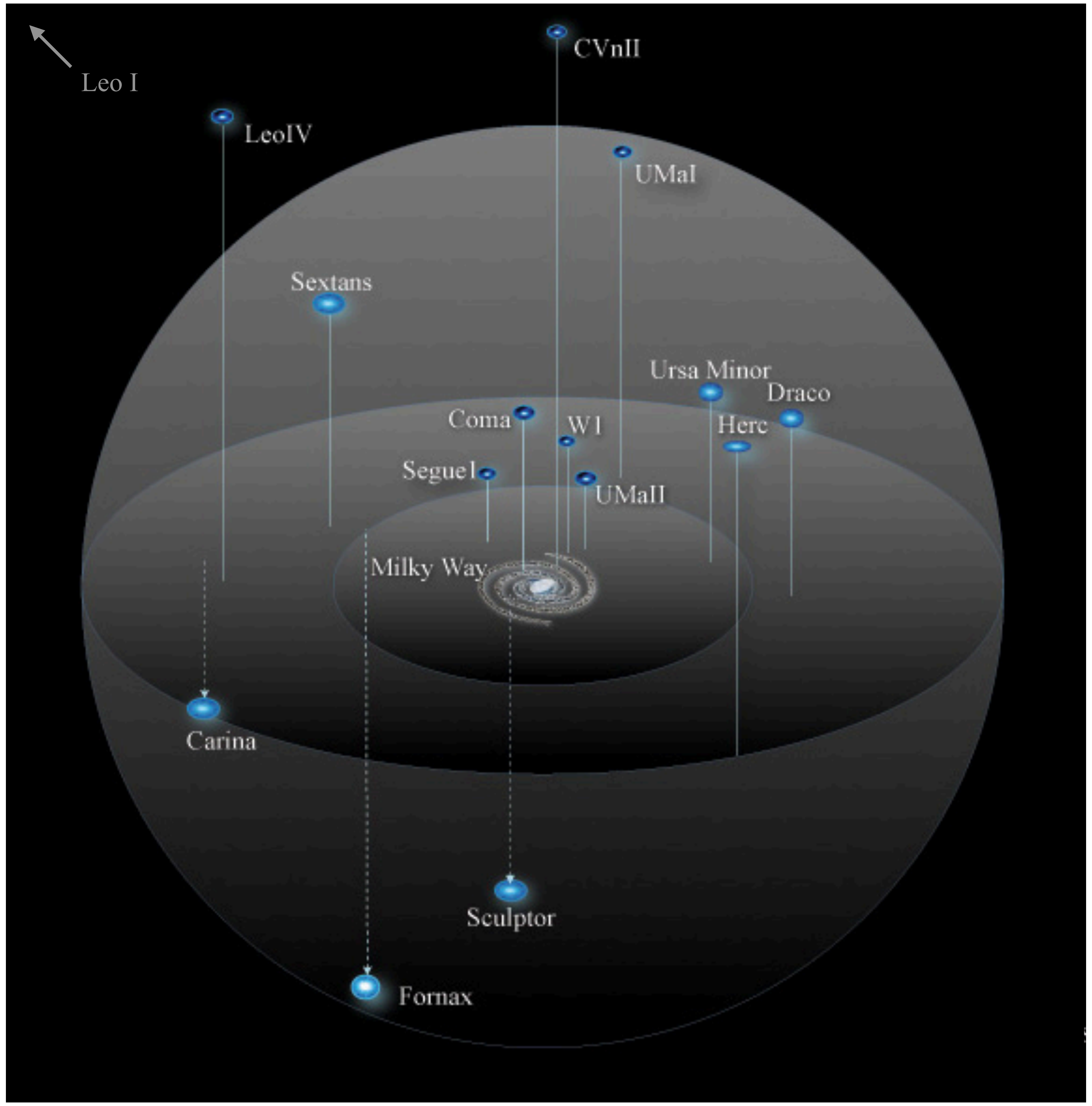
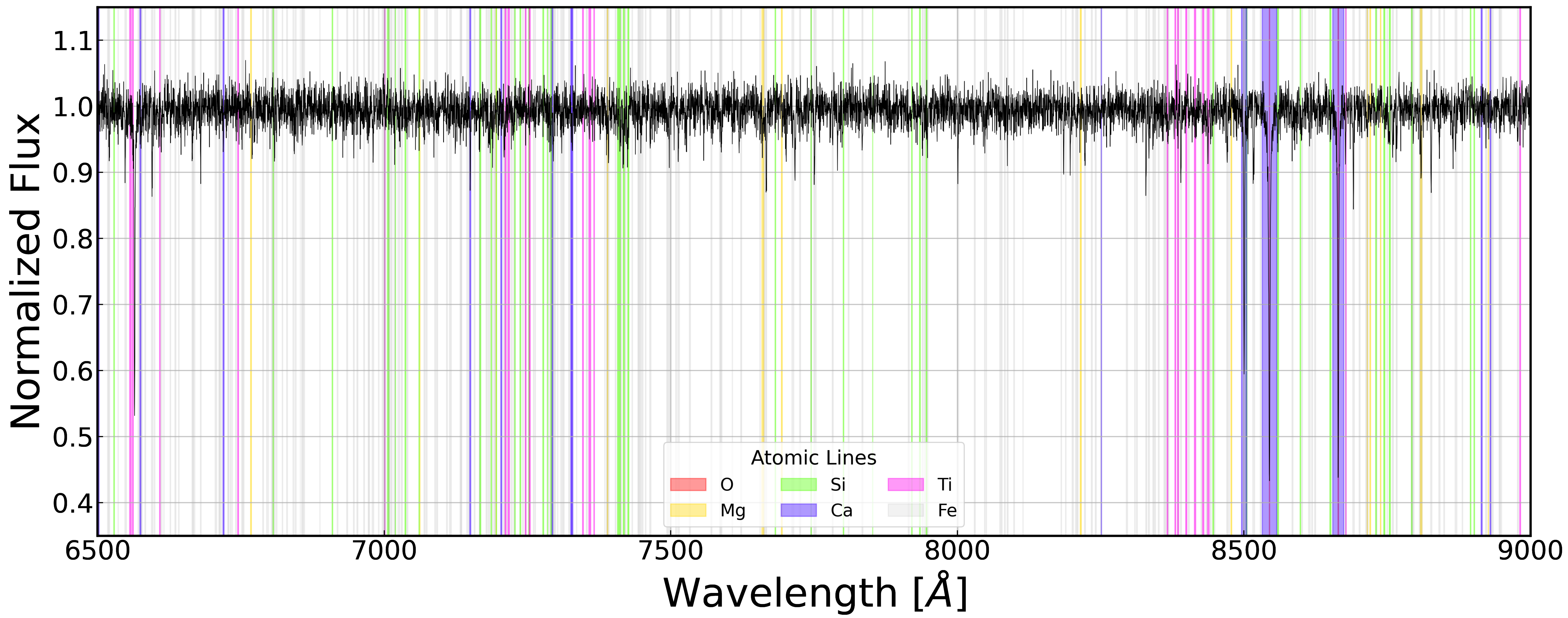


Image Credit: J. Bullock/M. Geha/R. Powell

- **Keck/DEIMOS** (10-meters)
  - 10^4 MW dSph stars
  - Medium-Resolution, Red-Optical Spectra
    - $R \sim 6500,\ 6500\text{–}9000$ Å, S/N ~ 50



$[\alpha/\mathrm{Fe}]$ in Milky Way Satellites

Distance ~ 100 kpc

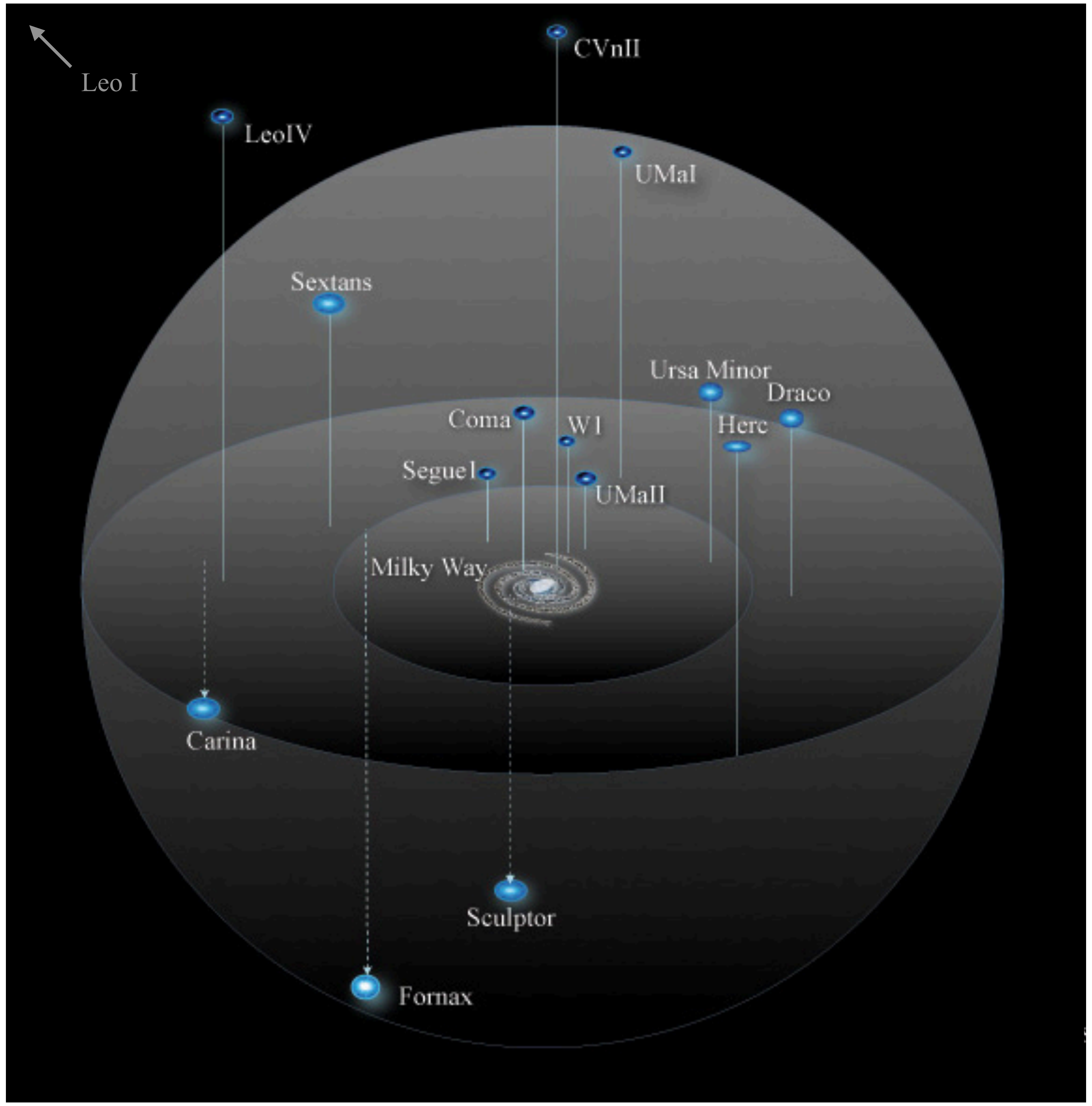
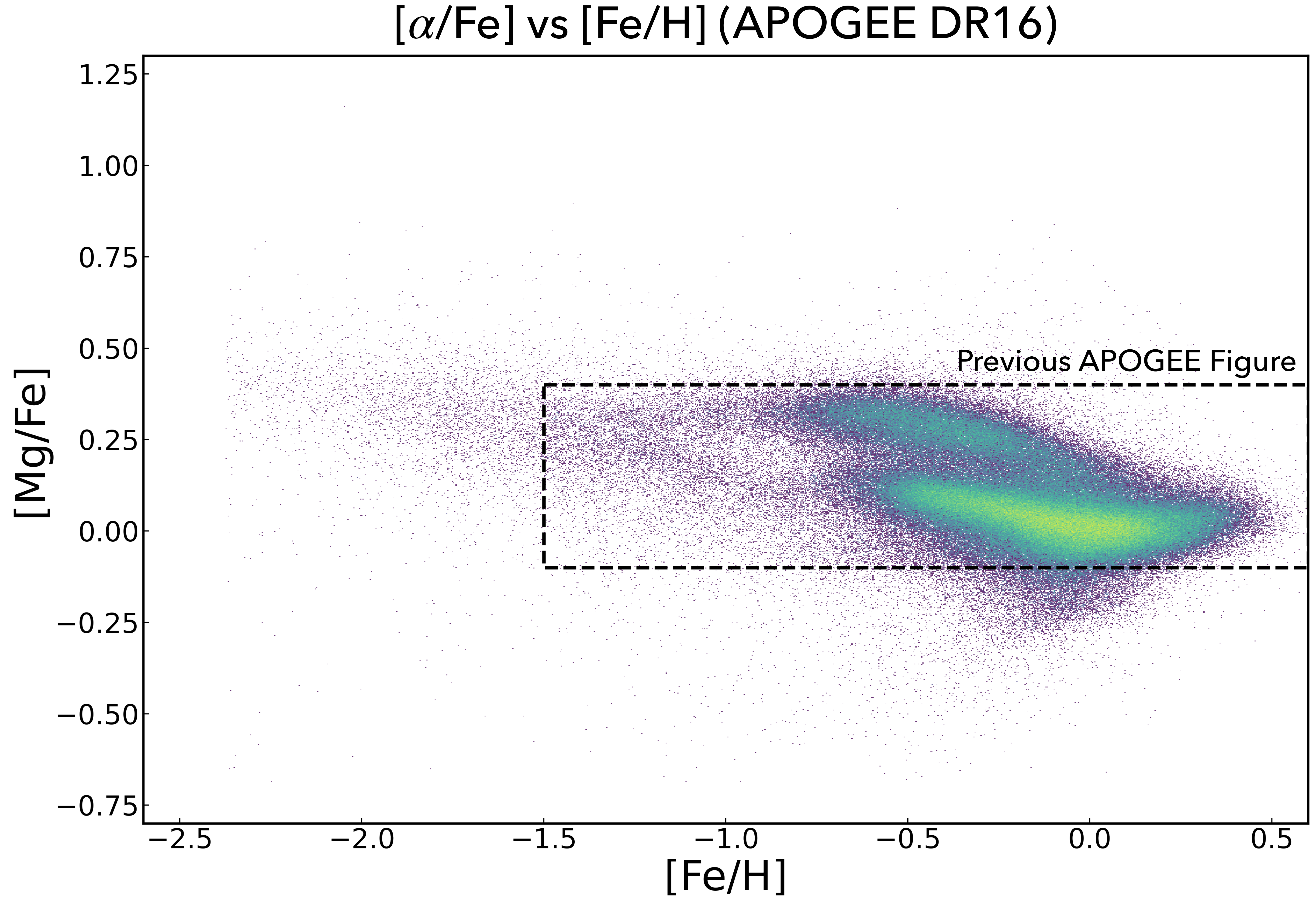
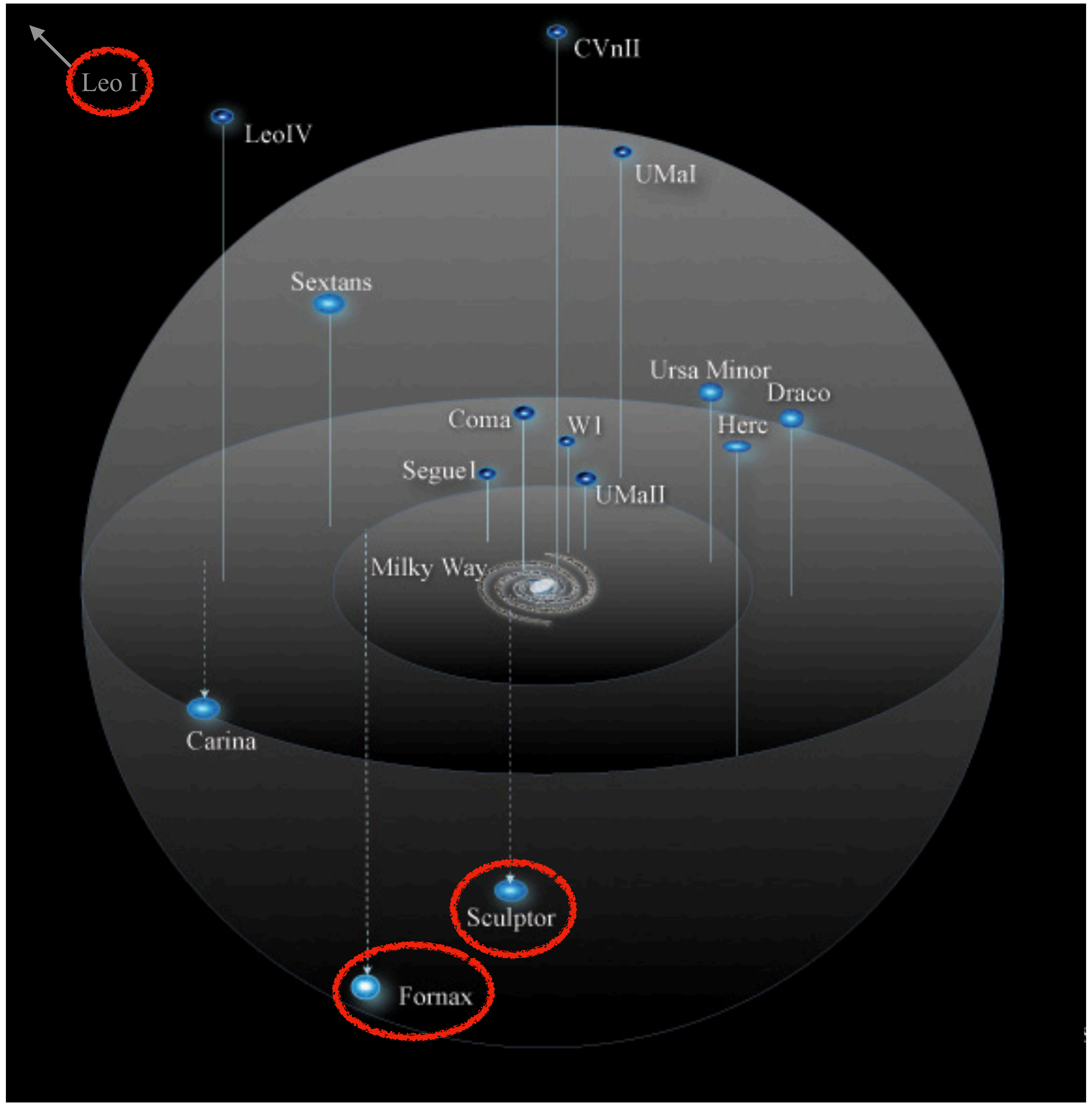


Image Credit: J. Bullock/M. Geha/R. Powell



[α/Fe] IN MILKY WAY SATELLITES

DISTANCE ~ 100 KPC



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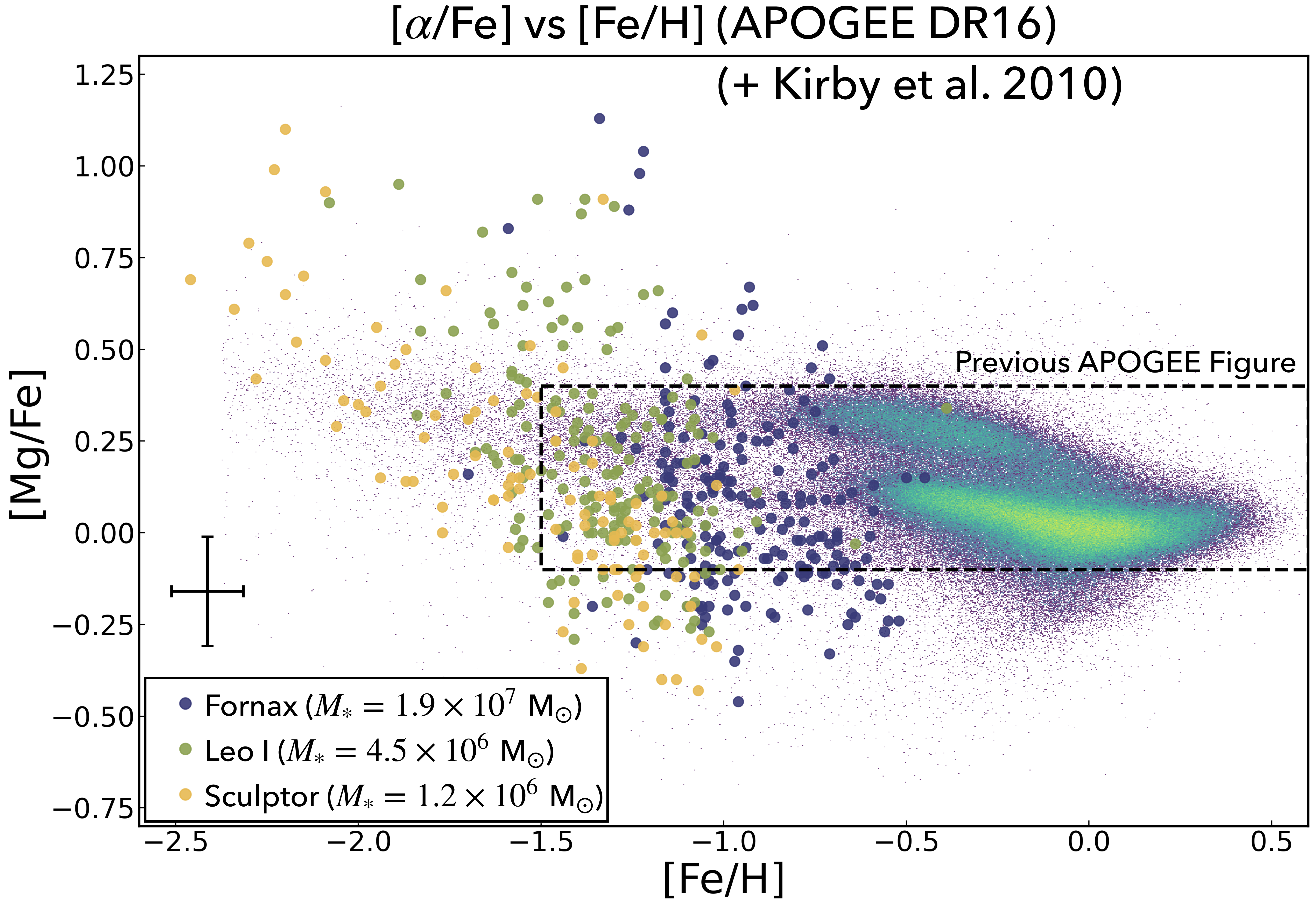
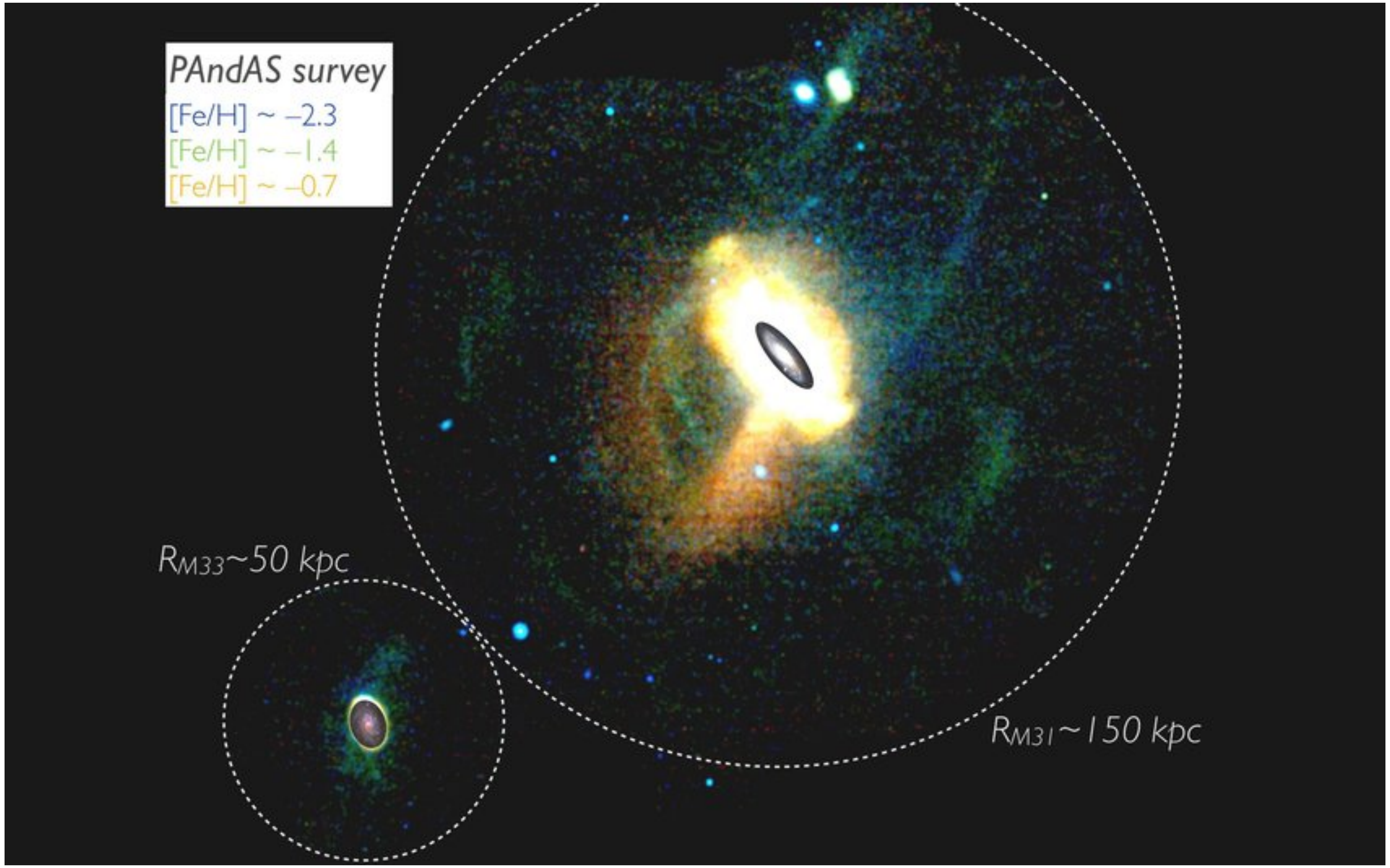


$[\alpha/\text{Fe}]$ IN THE M31 SYSTEM

DISTANCE ~ 0.8 MPC



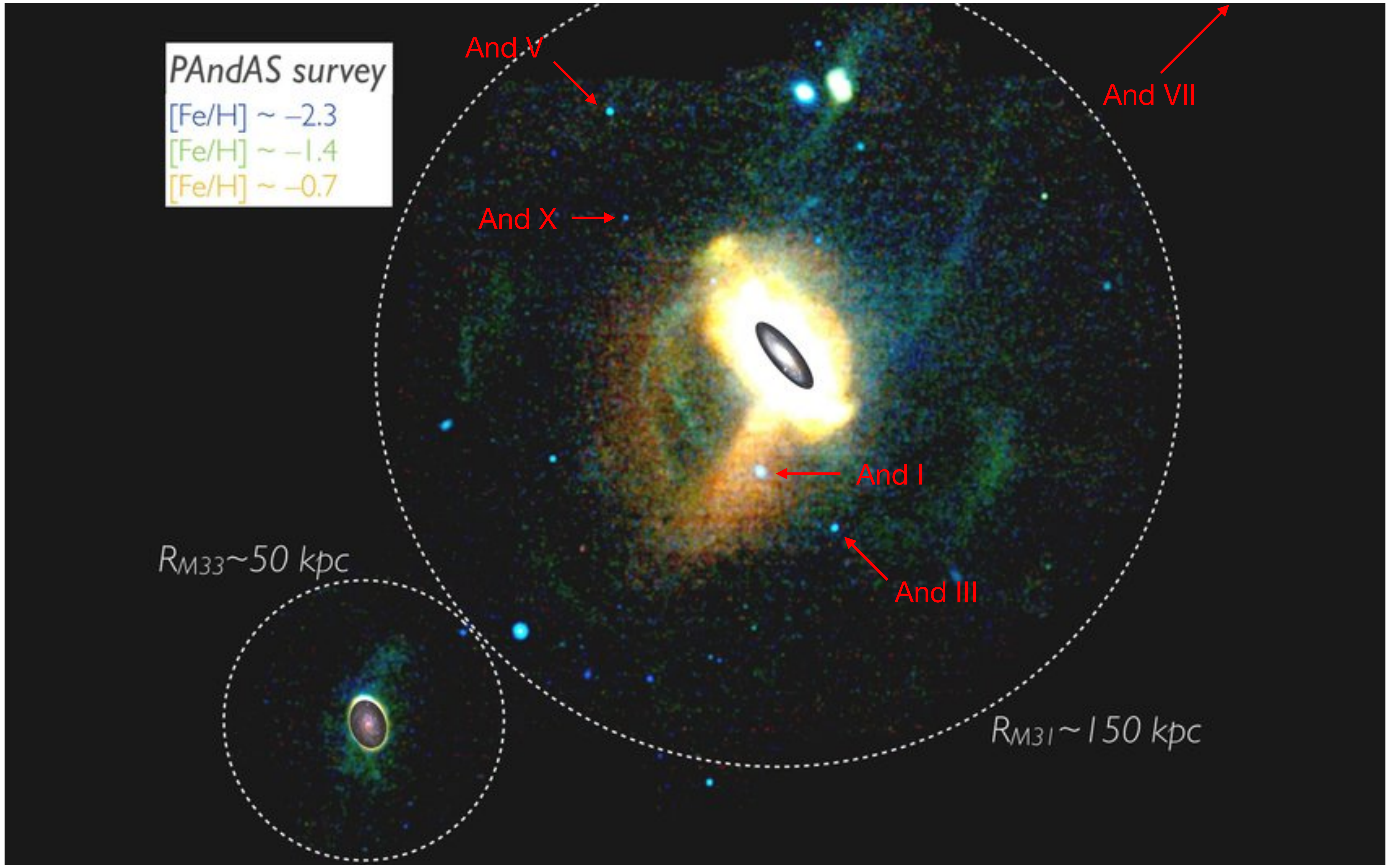
Martin+ 2013; McConnachie+ 2018

PAndAS Survey of M31 & M33

- Lots of substructure
- Very different accretion history than the MW
- How does this manifest in $[\alpha/\text{Fe}]$ vs. [Fe/H]?

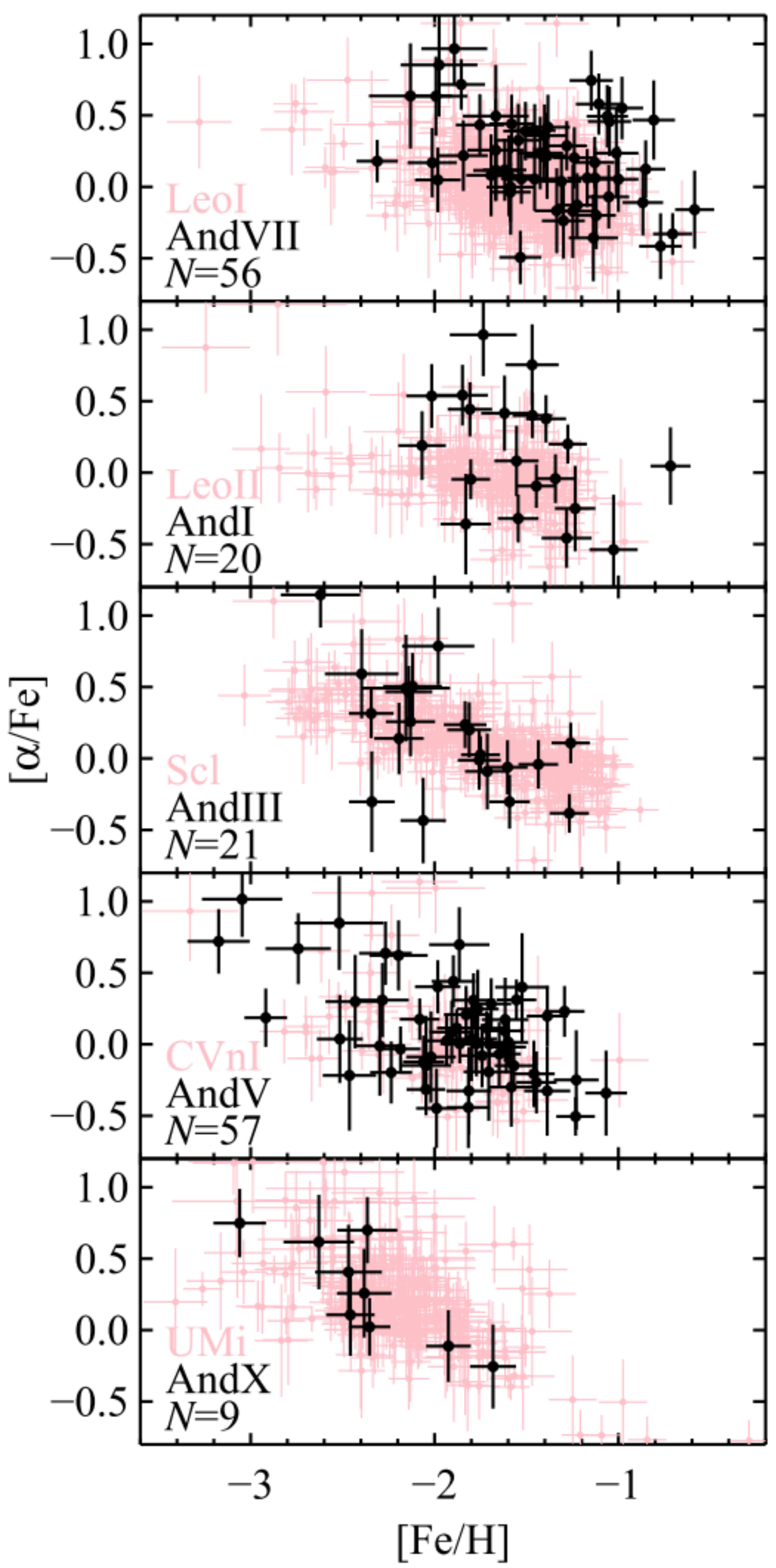
$[\alpha/\mathrm{Fe}]$ IN M31 SATELLITES

DISTANCE ~ 0.8 MPC



Martin+ 2013; McConnachie+ 2018

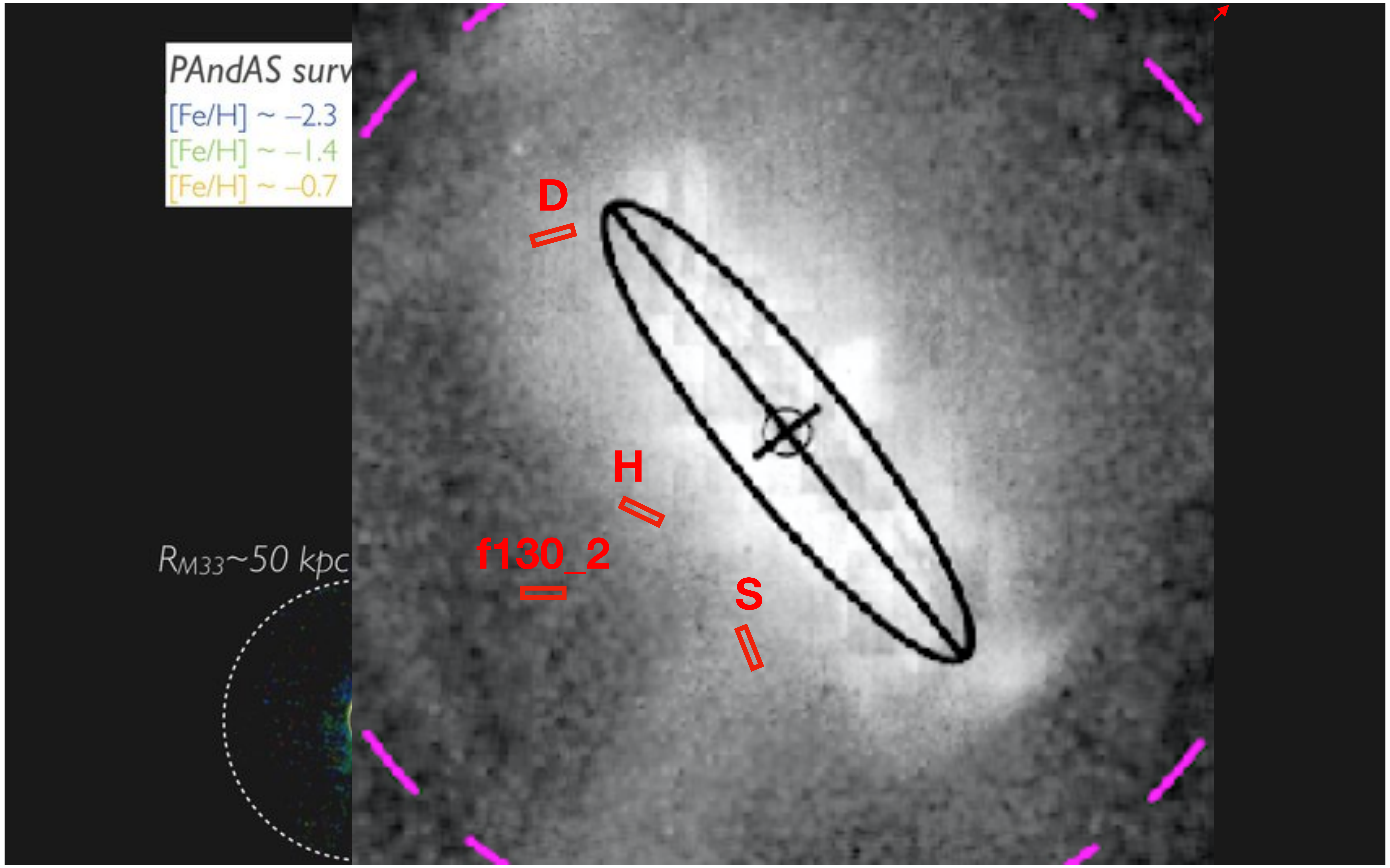
M31 Satellites



Kirby+ 2020

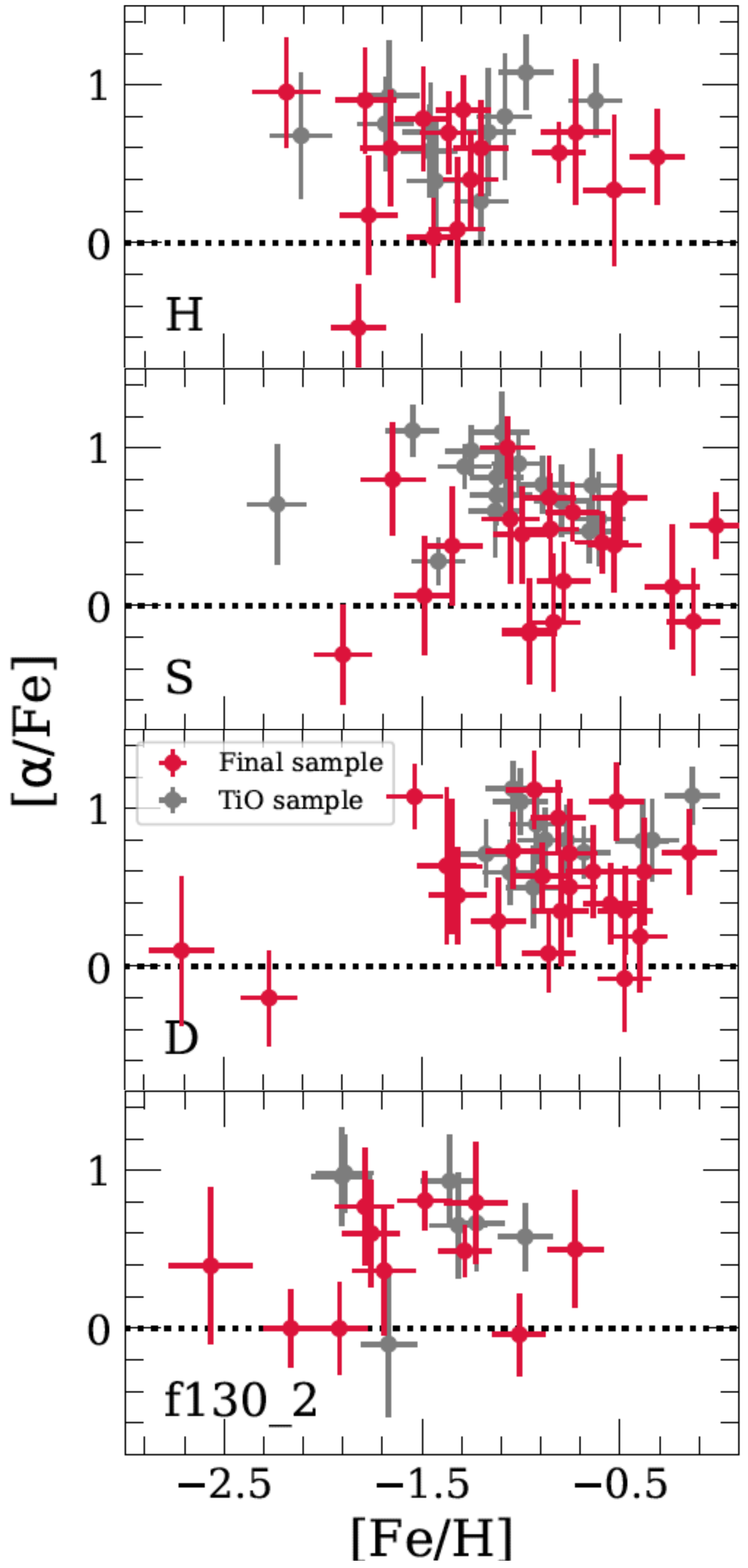
$[\alpha/\text{Fe}]$ IN M31'S OUTSKIRTS

DISTANCE ~ 0.8 MPC



Martin+ 2013; McConnachie+ 2018

M31 Outskirts

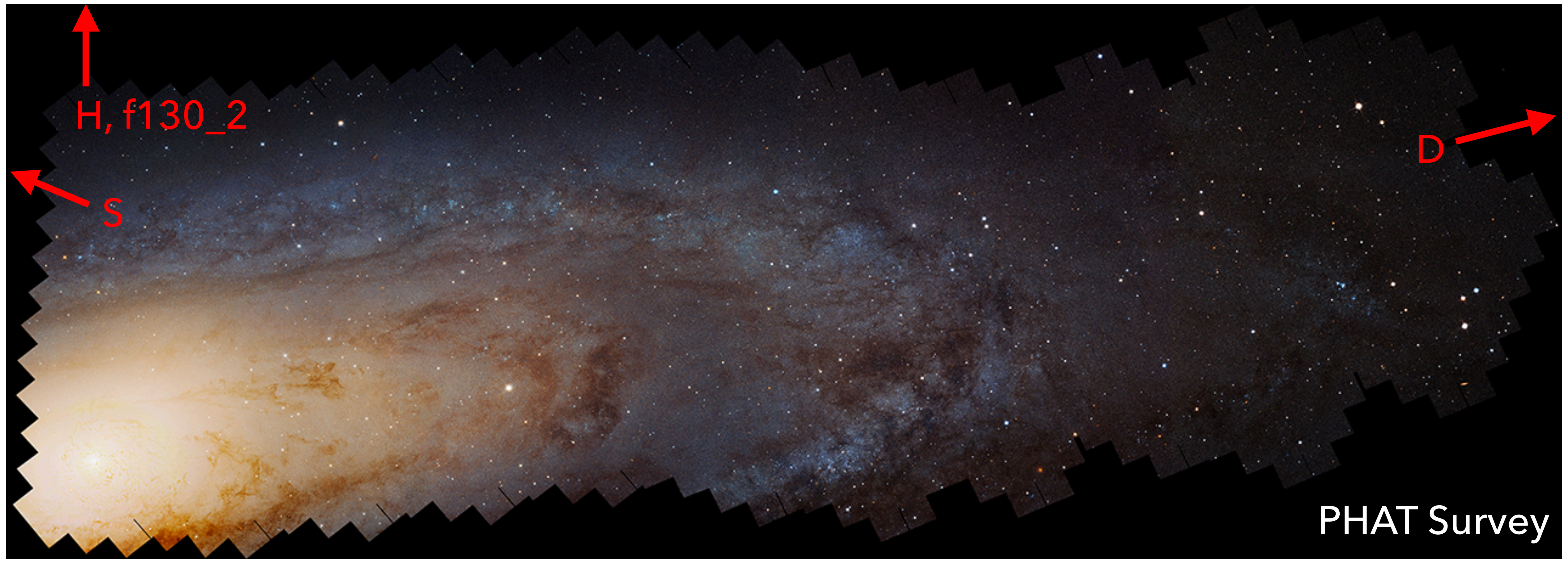


Gilbert+ 2019; Escala+ 2020

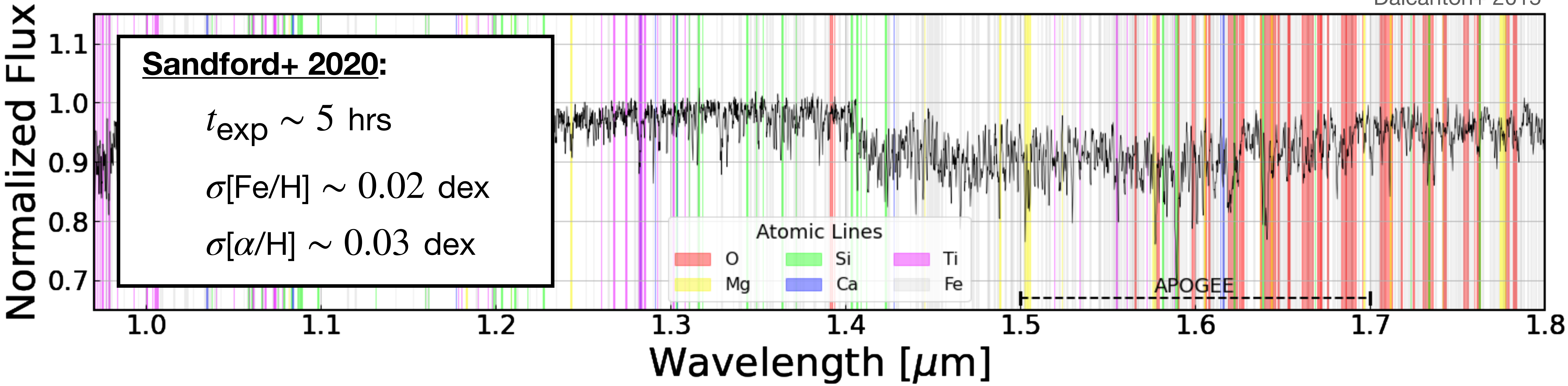
$[\alpha/\mathrm{Fe}]$ IN M31'S DISK

DISTANCE ~ 0.8 MPC

- **JWST/NIRSpec** (6.5-meters)
  - 0".2 Spatial Resolution
  - Low-Resolution, Near-IR Spectra
    - $R \sim 2700,\ 0.97\text{-}1.82\ \mu$m



Dalcanton+ 2015



[α/Fe] IN M31'S DISK

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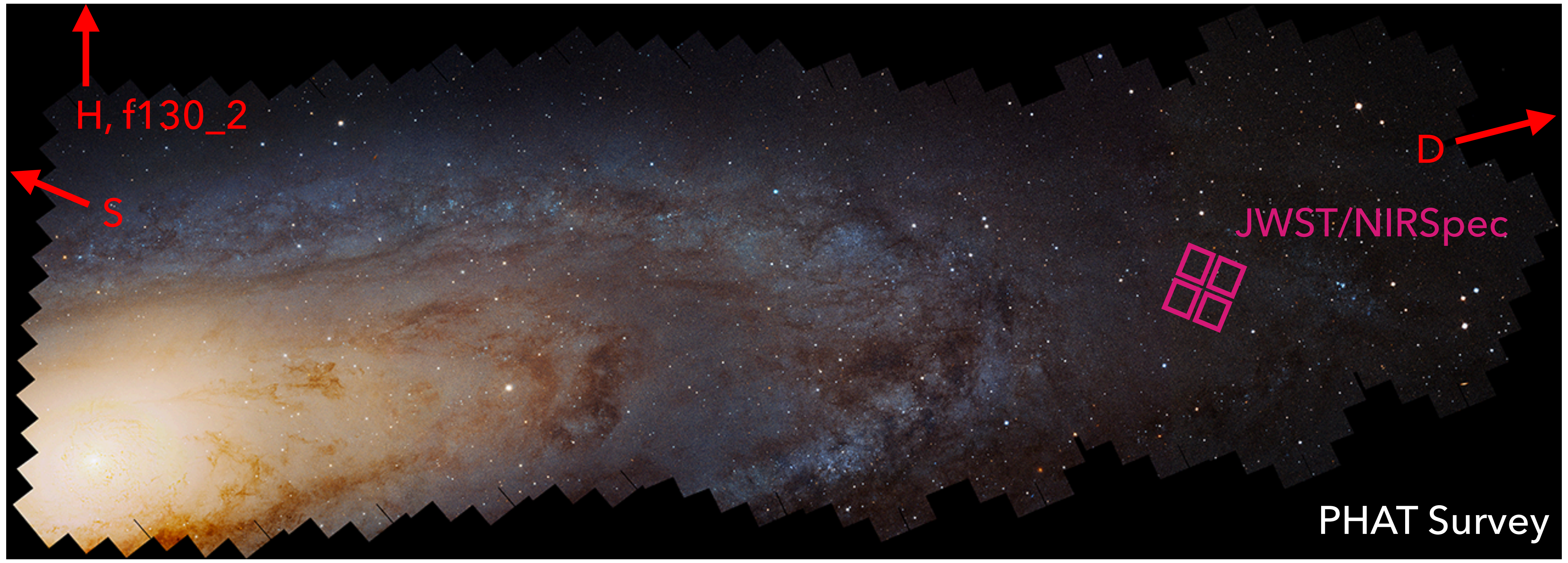


Dalcanton+ 2015

Sandford+ 2020:

$t_{\mathrm{exp}} \sim 5$ hrs

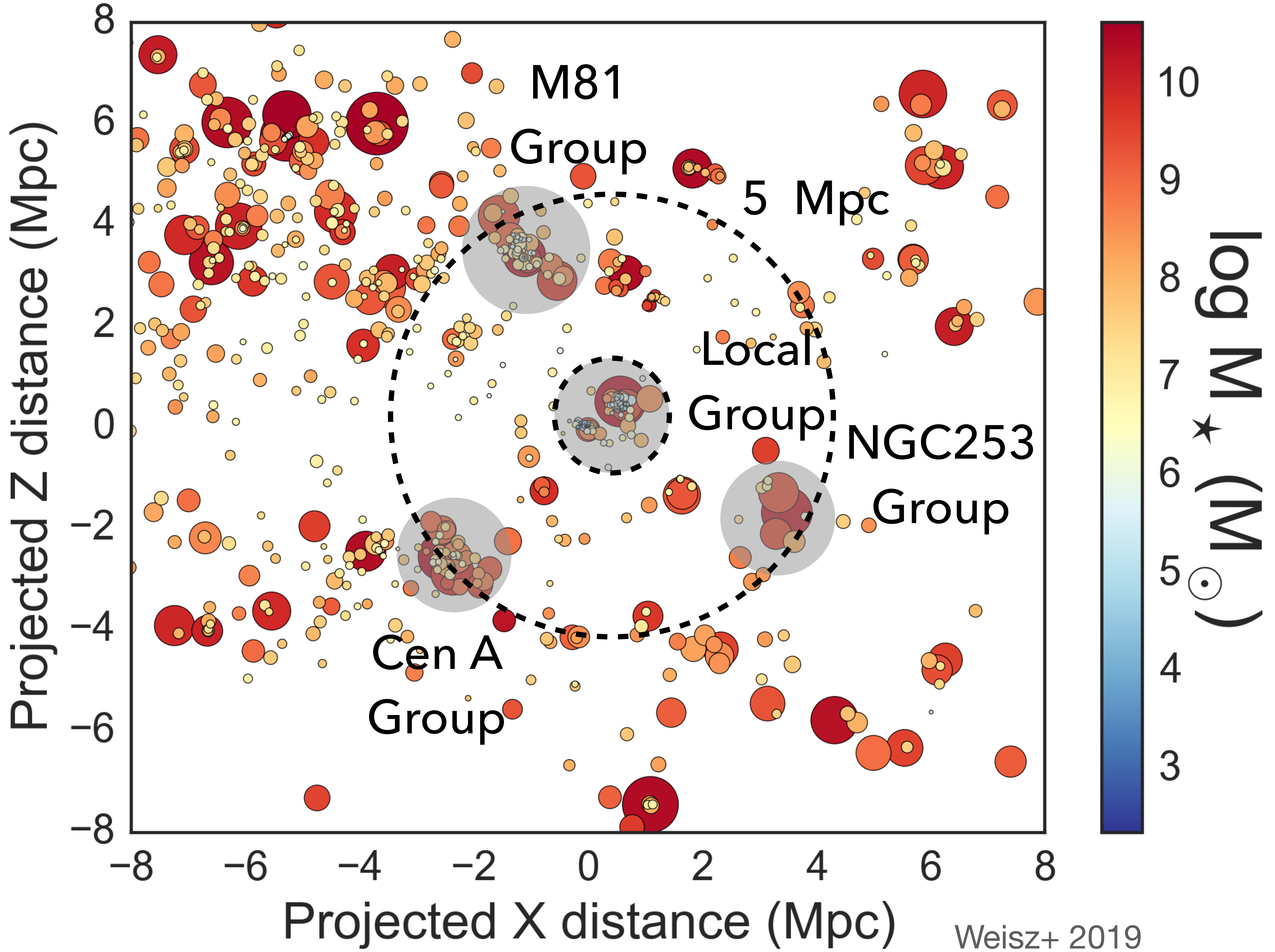
σ[Fe/H] ~ 0.02 dex

$\sigma[\alpha$/H] ~ 0.03 dex

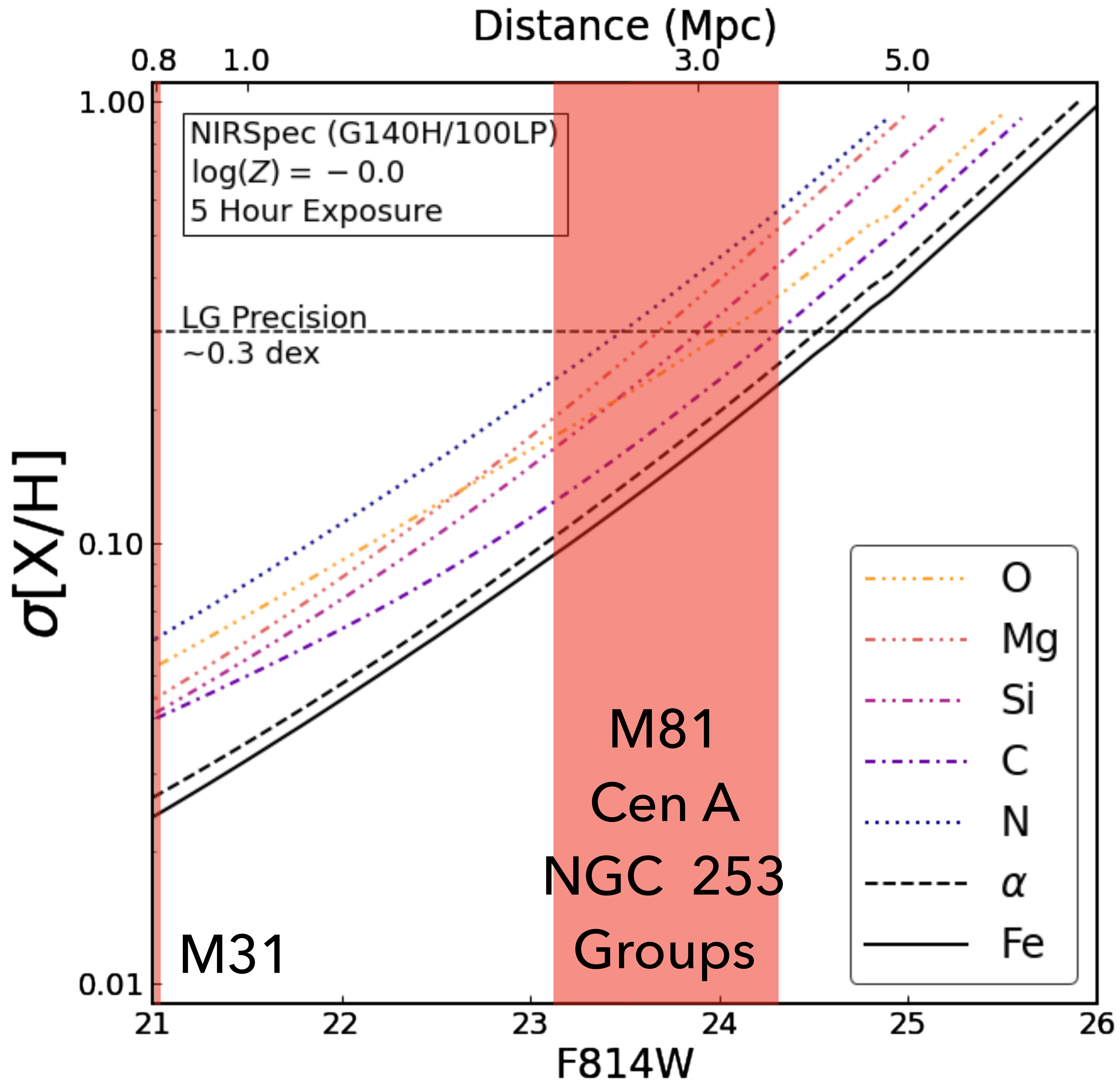
- **GO Cycle 1**
  - "Searching for α-Abundance Bimodality in the M31 Disk"
  - PI's: Nidever, Gilbert & Tollerud
  - $n_{\mathrm{stars}} \sim 130$ @ $R \sim 15$ kpc

$[\alpha/\mathrm{Fe}]$ Beyond the Local Group

Distance > 1 Mpc



Weisz+ 2019



Sandford+ 2020

CONCLUSION

- Space-Based MOS will
  - Transform the field of faint, crowded field stellar spectroscopy
  - Enable MW spectroscopic science in M31
  - Enable Local Group spectroscopic science out to several Mpc

- **Sandford+ 2020**
  - Forecasts for 20+ spectrographs, including: Keck/DEIMOS, VLT/GIRAFFE, Keck/FOBOS, Subaru/PFS, MSE, JWST/NIRSpec, E-ELT/MOSAIC

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Forecasting Chemical Abundance Precision for Extragalactic Stellar Archaeology

Nathan R. Sandford[1], Daniel R. Weisz[1], and Yuan-Sen Ting[2,3,4,5]
[1] Department of Astronomy, University of California Berkeley, Berkeley, CA 94720, USA; nathan_sandford@berkeley.edu
[2] Institute for Advanced Study, Princeton, NJ 08540, USA
[3] Department of Astrophysical Sciences, Princeton University, Princeton, NJ 08544, USA
[4] Observatories of the Carnegie Institution of Washington, 813 Santa Barbara Street, Pasadena, CA 91101, USA
[5] Research School of Astronomy and Astrophysics, Australia National University, Cotter Road, ACT 2611, Canberra, Australia
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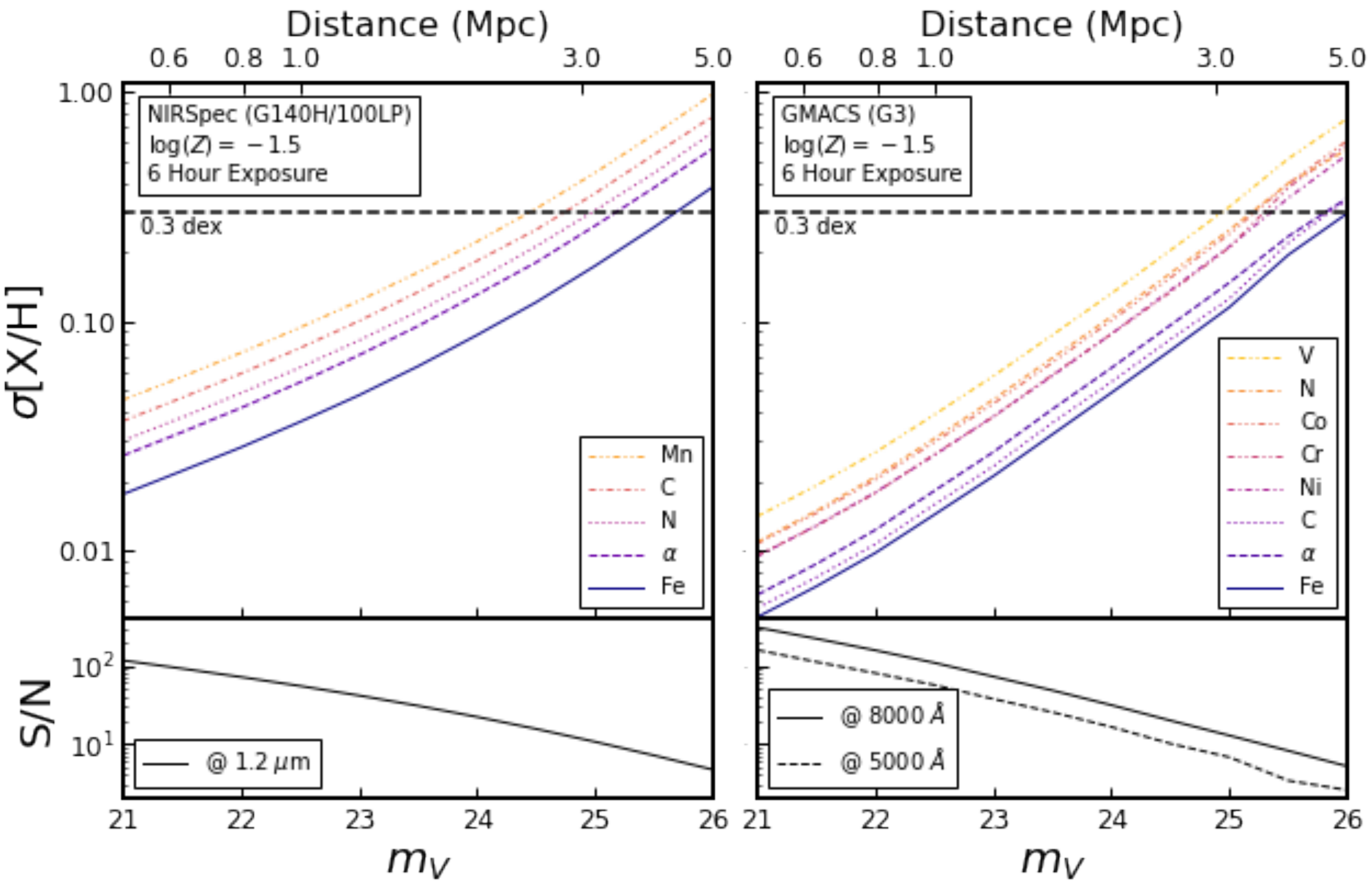
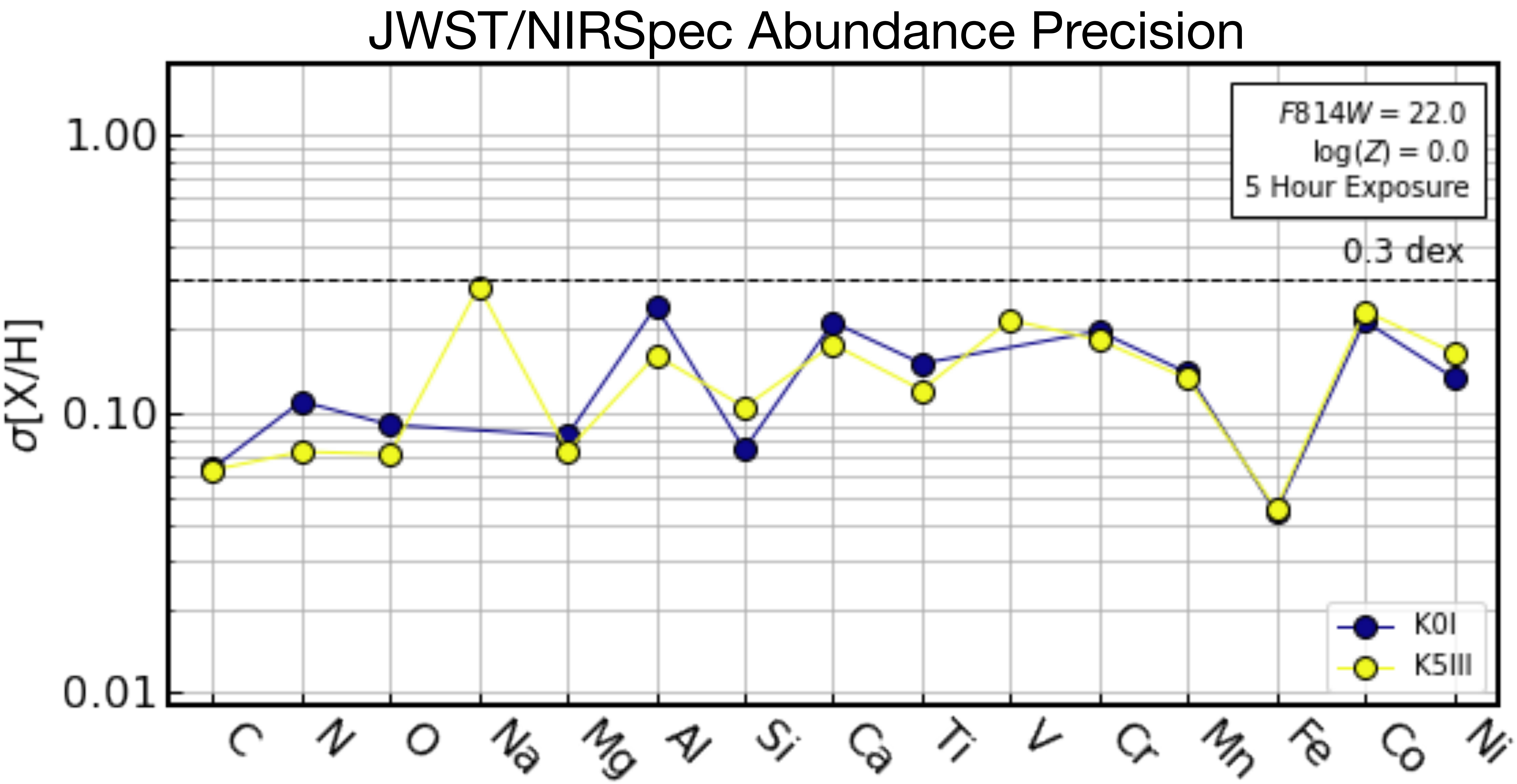
JWST vs. ELTs



Sandford+ 2020

RECOVERY OF INDIVIDUAL ELEMENTAL ABUNDANCES



Sandford+ 2020