The First Alpha Abundances In Isolated Dwarf Galaxies from JWST

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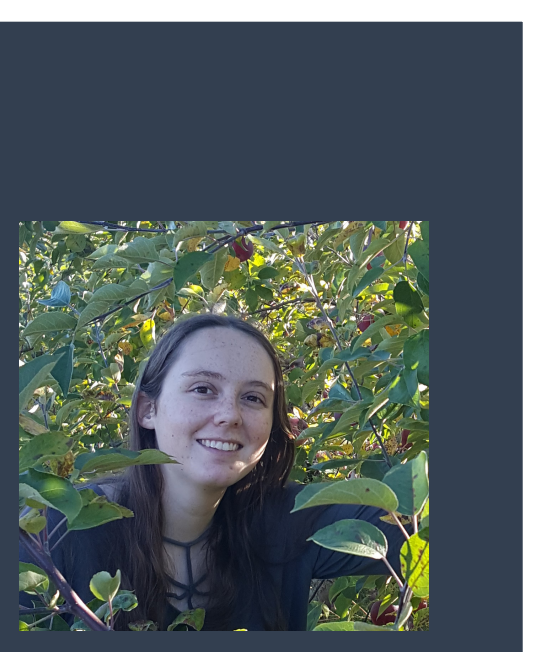

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Introduction

Isolated Dwarf Galaxies: As opposed to the dwarf satellite galaxies of the Milky Way (MW), isolated dwarf galaxies exist in the field, far from a more massive host.

- Evolution is driven only by internal properties (e.g., feedback, outflows) and external factors intrinsic to the universe as a whole (e.g., gas accretion, cosmic reionization) – **free from effects from a host galaxy** like in satellites (e.g., ram pressure, tides)
  - Environmental effects have been proposed to induce more efficient star formation and may explain why the (isolated until ~5Gyr ago; Besla et al. 2012) LMC and SMC, as well as the isolated dwarf Leo A, have low α abundances for their masses

Why α Abundances?:

- **α abundance traces star formation efficiency**
- **[α/Fe] vs [Fe/H] diagram helps us trace star formation history (SFH)**
  - e.g., height of α-plateau (set by the number of Type II SNe and IMF) and location of knee (set by onset of Type Ib SNe).

Why Use JWST?: JWST offers an unprecedented combination of resolution, sensitivity, and multiplexing, meaning even a modest observing program can access **hundreds of new stellar spectra outside of the Milky Way's satellites.**

- Addresses main challenges: crowding and distance modulus

Selection of Isolated Dwarf Galaxies: We target three isolated dwarfs **spanning the range of inferred SFHs**.

- Leo A (recent SFH), IC1613 (intermediate/constant SFH), and Tucana (ancient SFH)
- Leo A has ~20 red **giant branch** (RGB) stars' abundances already measured (Kirby et al. 2017), while IC 1613 and Tucana have none

Methods

Data taken as part of GO-3788; PI Weisz

Observation strategy: We use JWST NIRSpec's Micro-Shutter Array (MSA) to take R~2700 spectroscopy of **~200 RGB stars** in the wavelength range **~0.9-1.8 microns**.

- 3-configuration, 2-dither strategy, with a dispersion direction dither (0.5-shutter width) to better sample wavelength space
  - We use as few as a single-shutter slit per source
- Prioritize centering in slit and maximizing number of targets
  - Further select more central/rightward targets to achieve fullest/redder wavelength coverage (improving precision)
- Take target acquisition imaging for each configuration to precisely determine the positions of sources in their slits

Data reduction and analysis: We use the python package **spyderwebb** (Nidever et al. 2023) to **simultaneously fit** the spectra from all six exposures, using a trained set of Payne (Ting et al 2019) models of RGB stars.

- Use nearby background slits (empty of stars with F814W<25) to construct a master background for each source

Challenges

NIRSpec Undersampling:

- Particularly apparent for point sources
- Extracted **1D exposure spectra show sawtoothing** corresponding to pixel aliasing effects from the curved trace
  - Sawtooth width is similar to broad absorption line width at redder wavelengths

Multiplexing and Background Subtraction:

- Large dispersion-dither can push targets into different slits
- Observe the most targets into the MSA by using only a single slitlet (as opposed to the standard 3-slitlet slit)
  - If a target is not well-centered in this single slitlet, some of the flux is lost due to **light leaking**
  - Since each slitlet is only ~4 pixels tall, it is near-impossible to do local background subtraction

***Looking Forward*: Projecting the model spectra into 2D space** and fitting directly to the 2D observed spectra would make working around the sawtooth artifacts unnecessary and simplify uncertainty calculations (e.g. de Graaff et al 2024).

- Requires knowing source's in-slit position to high precision

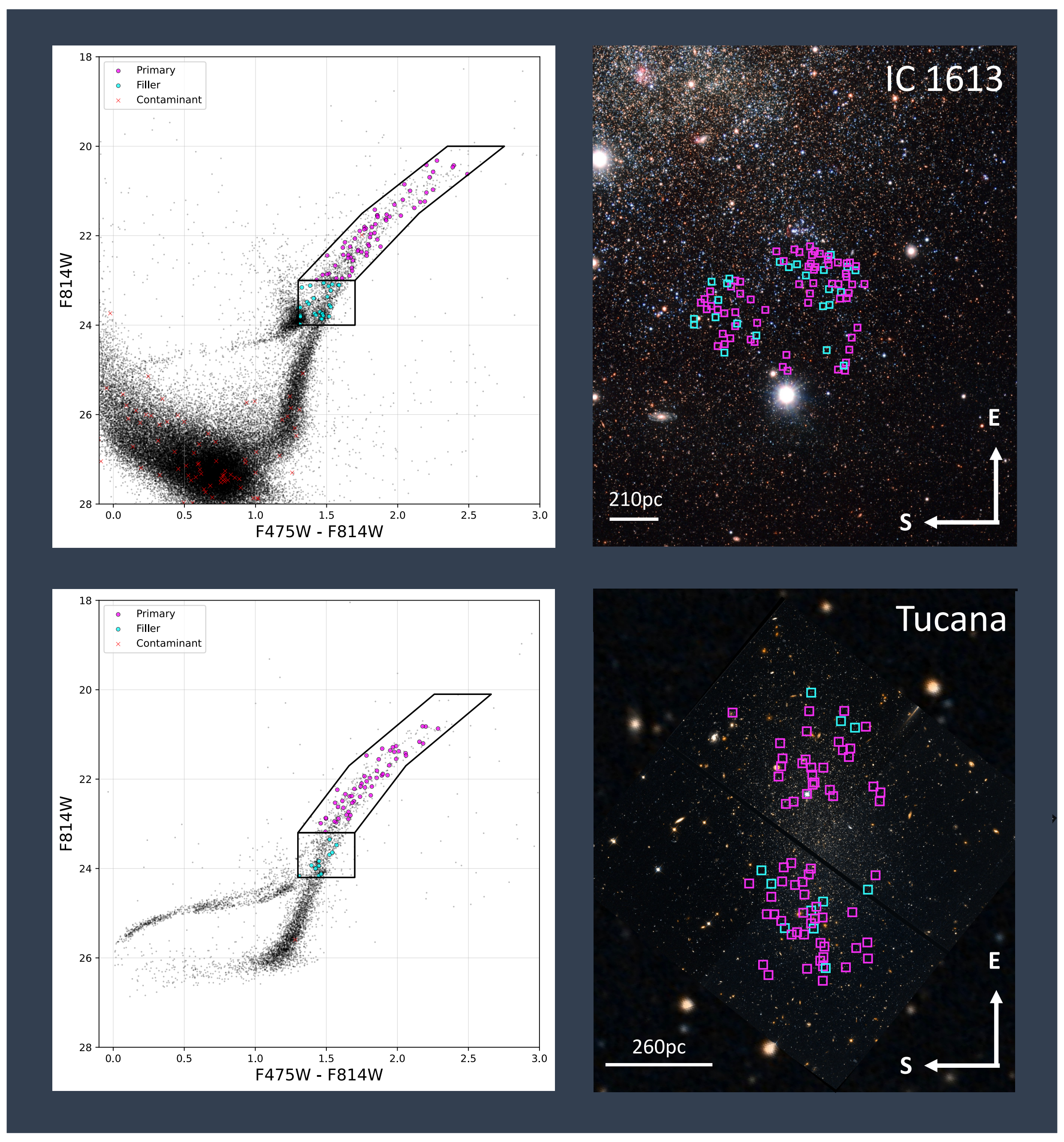
IC 1613 and Tucana

***IC 1613:* 63 Primary Targets**, 29 RV Only Targets (Filler)

- Scheduled for Jan 2023, but failed due to binary guide star
  - Rescheduled to be observed at the end of 2024

***Tucana:* 65 Primaries**, 12 RV Only Targets (Filler)

- Scheduled to be observed between **July 9 - July 20, 2024.**



Acknowledgements & References

Acknowledgements: We are grateful to our points of contact at STScI, Dan Coe and Shelley Meyett. We are also thankful for the efforts of GO-2609; PI Nidever, for their suggestions in Nidever et al. 2023 and for their *spyderwebb* package. We extend special thanks to Gabe Brammer and Martje Slob for their expertise and helpful discussions.

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Leo A: Preliminary Results

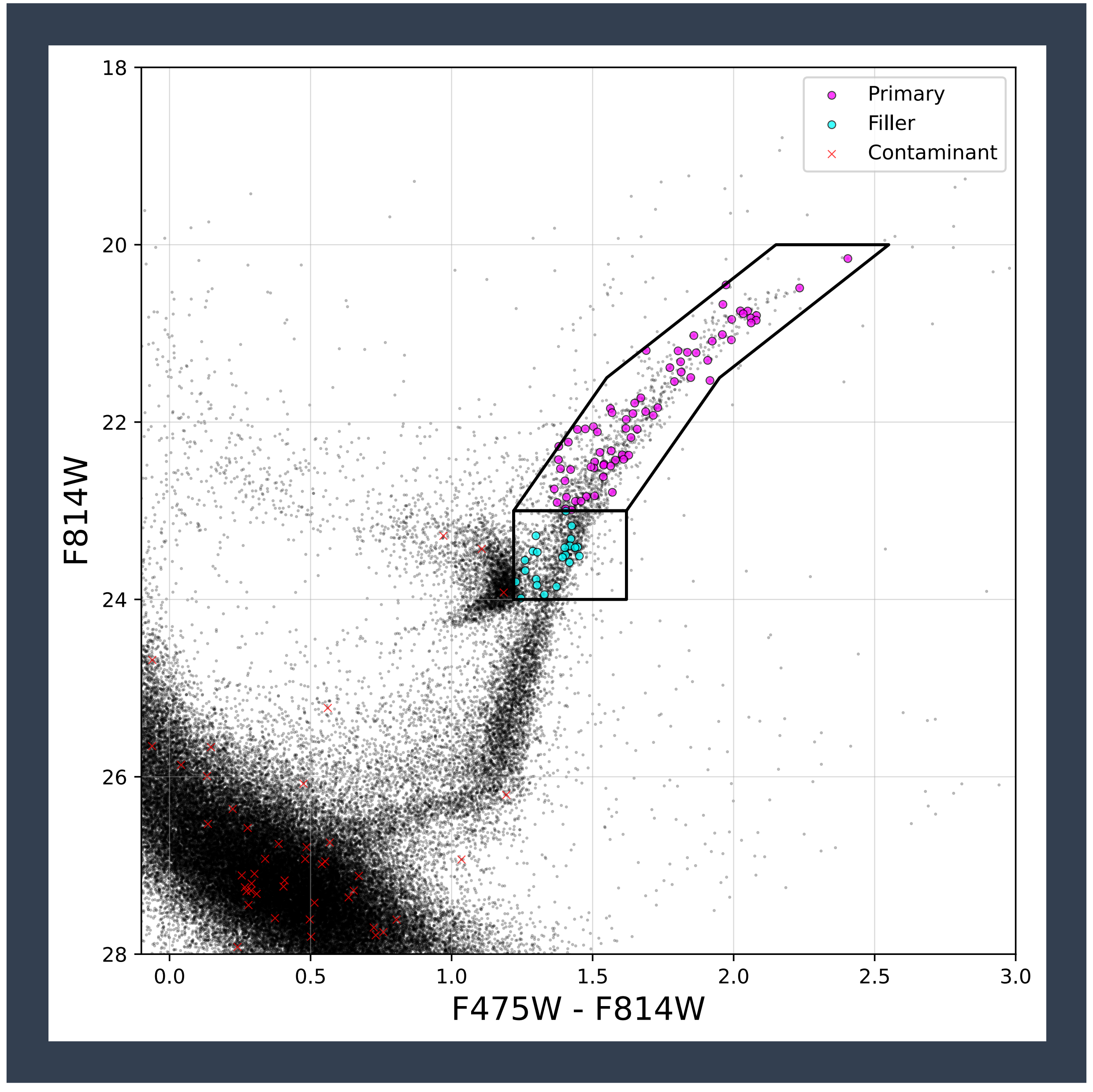
***Leo A:* 72 Primary Targets**, 23 RV Only Targets (Filler)

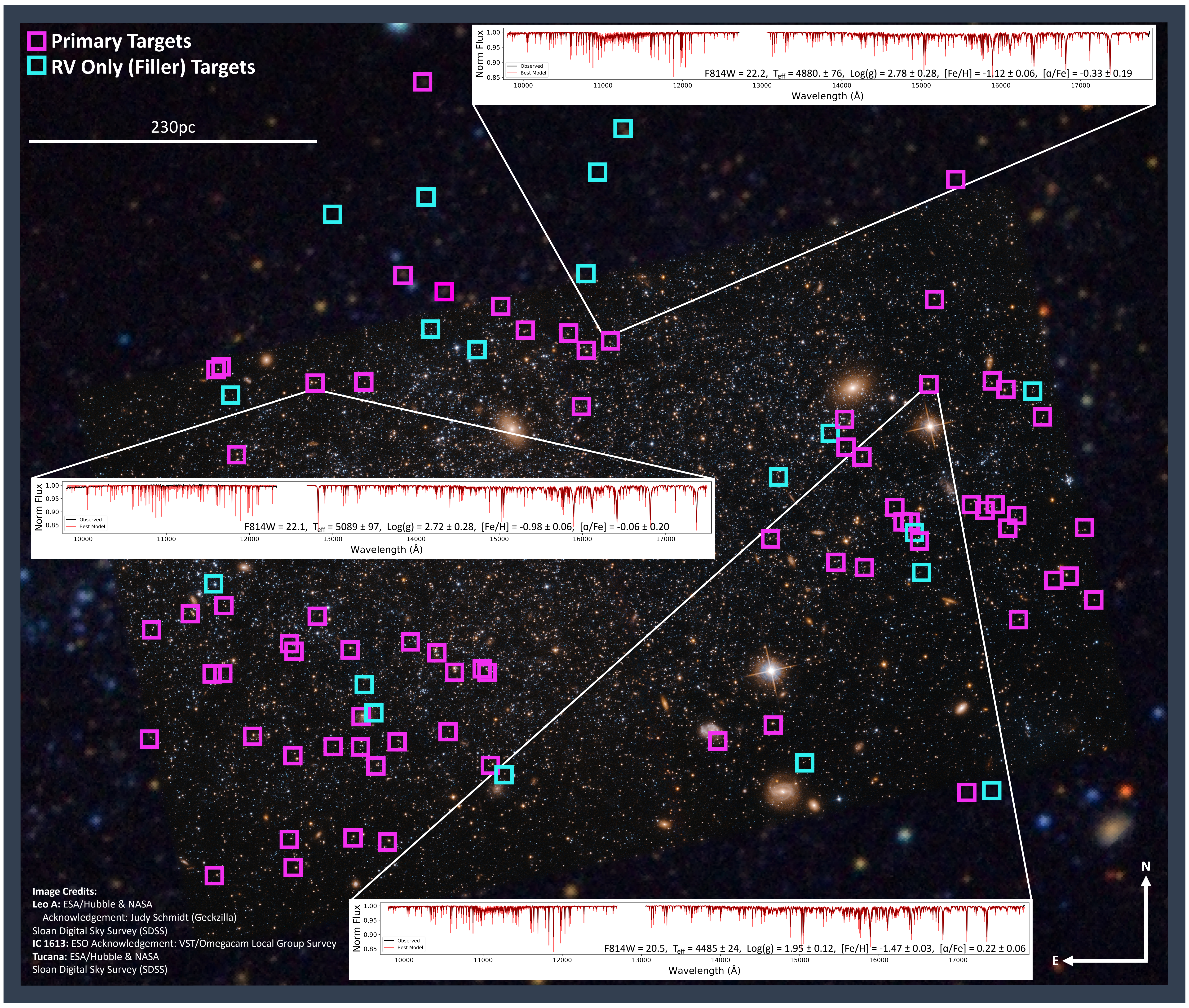
- Right: spatial distribution of target RGB stars
  - Overlay: three sample spectra of primary targets, observed and best-fitting model (w/parameters)
- Below: target RGB stars' color-magnitude diagram

Key Takeaways:

- Payne RGB models **appear to fit well** by eye to the data!
  - Model lines deeper, likely due to their higher resolution
- Initial **[Fe/H]s are consistent** with, but at the **higher end** of, literature values (cf. Kirby et al. 2017, Fig. 9)
- Initial **[α/Fe]s seem reasonable** with literature values, though uncertainties are a bit high (cf. Kirby et al. 2017, Fig. 13)

Next Steps: [α/Fe] vs [Fe/H] diagram and radial velocities





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Acknowledgement: Judy Schmidt (Geckzilla)
Sloan Digital Sky Survey (SDSS)
IC 1613: ESO Acknowledgement: VST/Omegacam Local Group Survey
Tucana: ESA/Hubble & NASA
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