WFIRST-AFTA: Local Group Science

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Image Credit: Robert Gendler

Overview

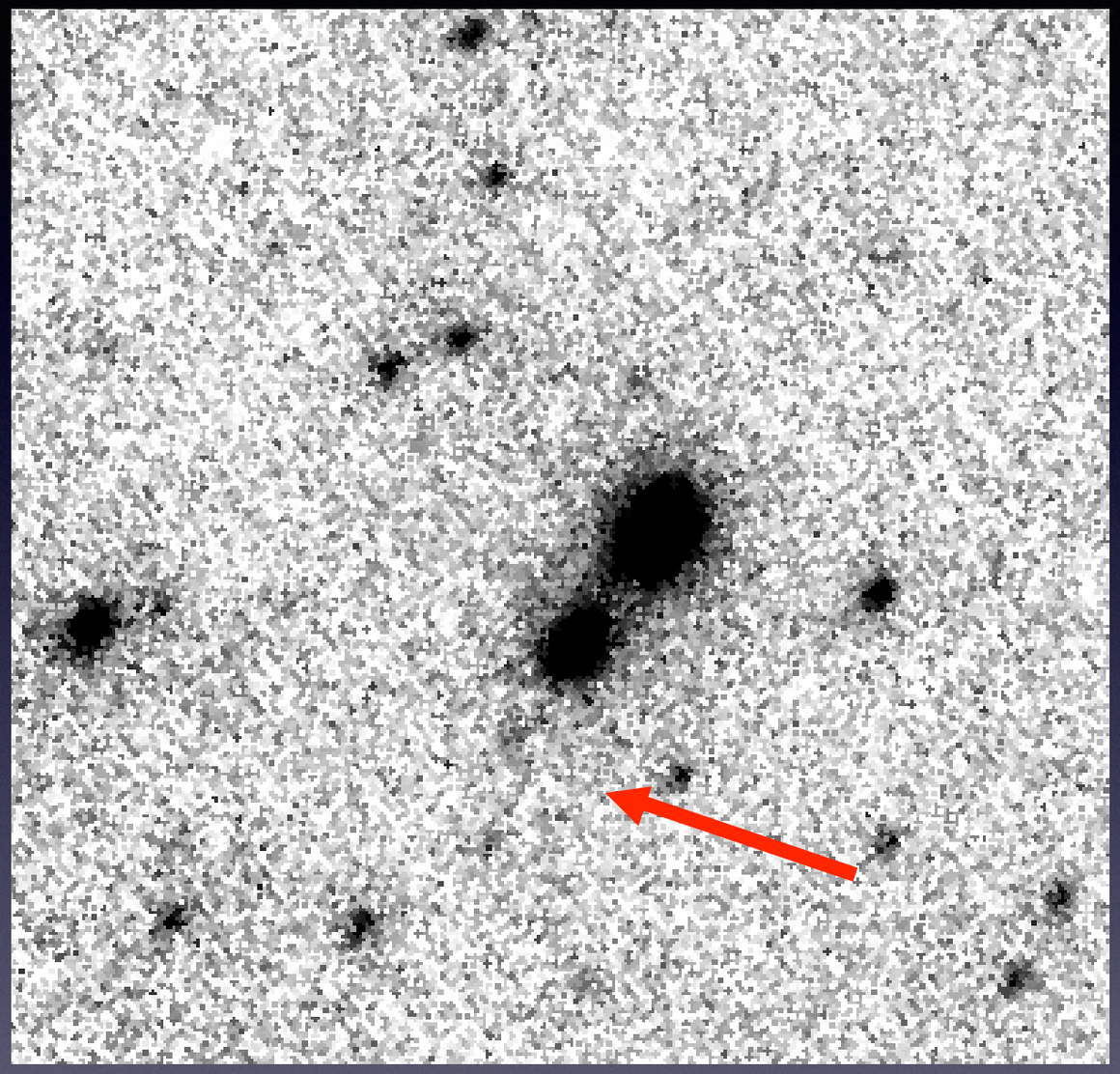
- Basic terminology
- Importance of Stellar Pops
- Possible scientific applications of WFIRST in the Local Group

Why HST?

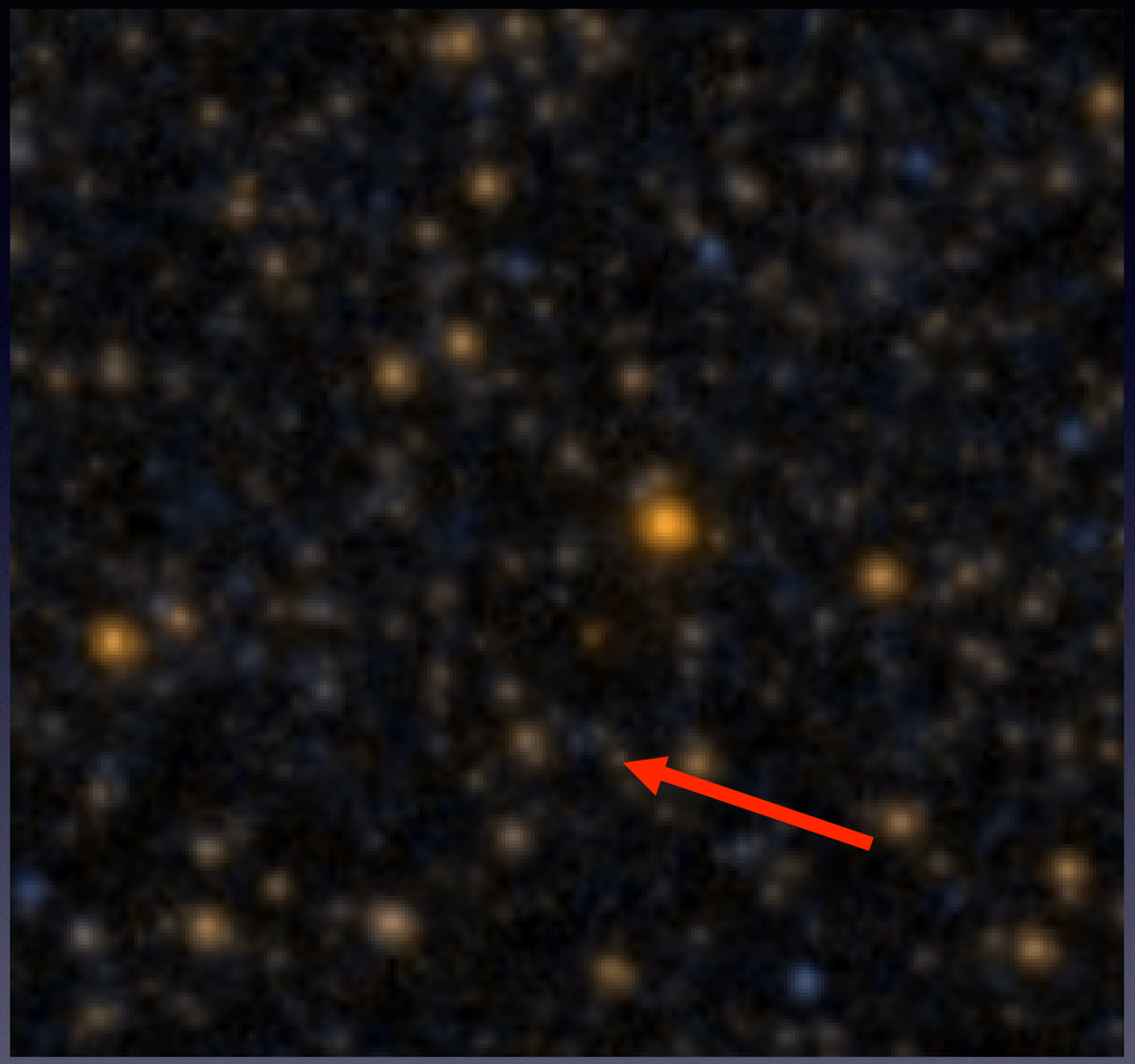
Ground

HST

PSF Stability: Precision + deblending



K-band
(Keck AO)

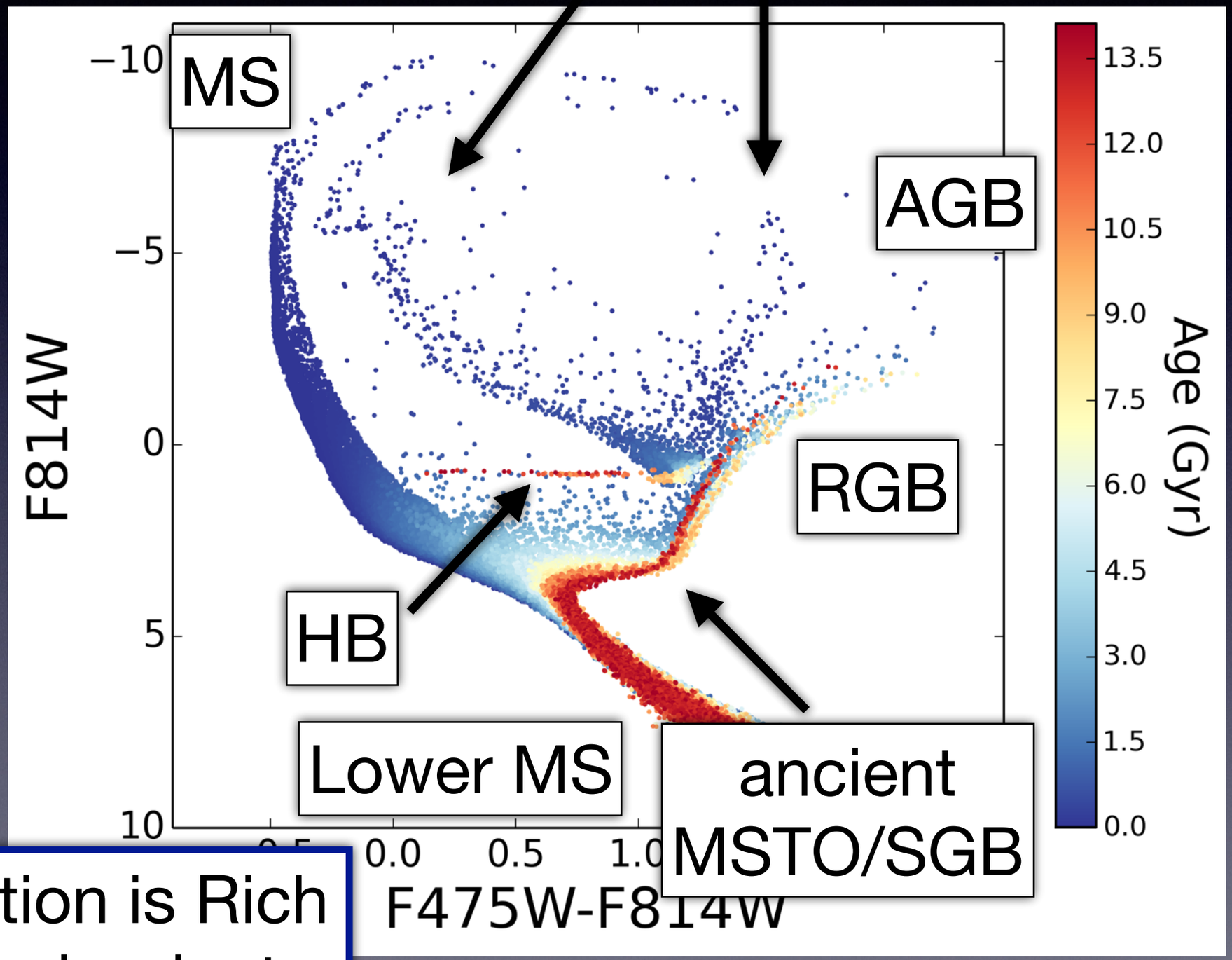


F475W+F814W
(ACS)

KKH 98, Keck AO: J. Melbourne+ 2008

Brief Intro to Stellar Populations in the Local Group

BHeBs & RHeBs
(25-500 Myr)



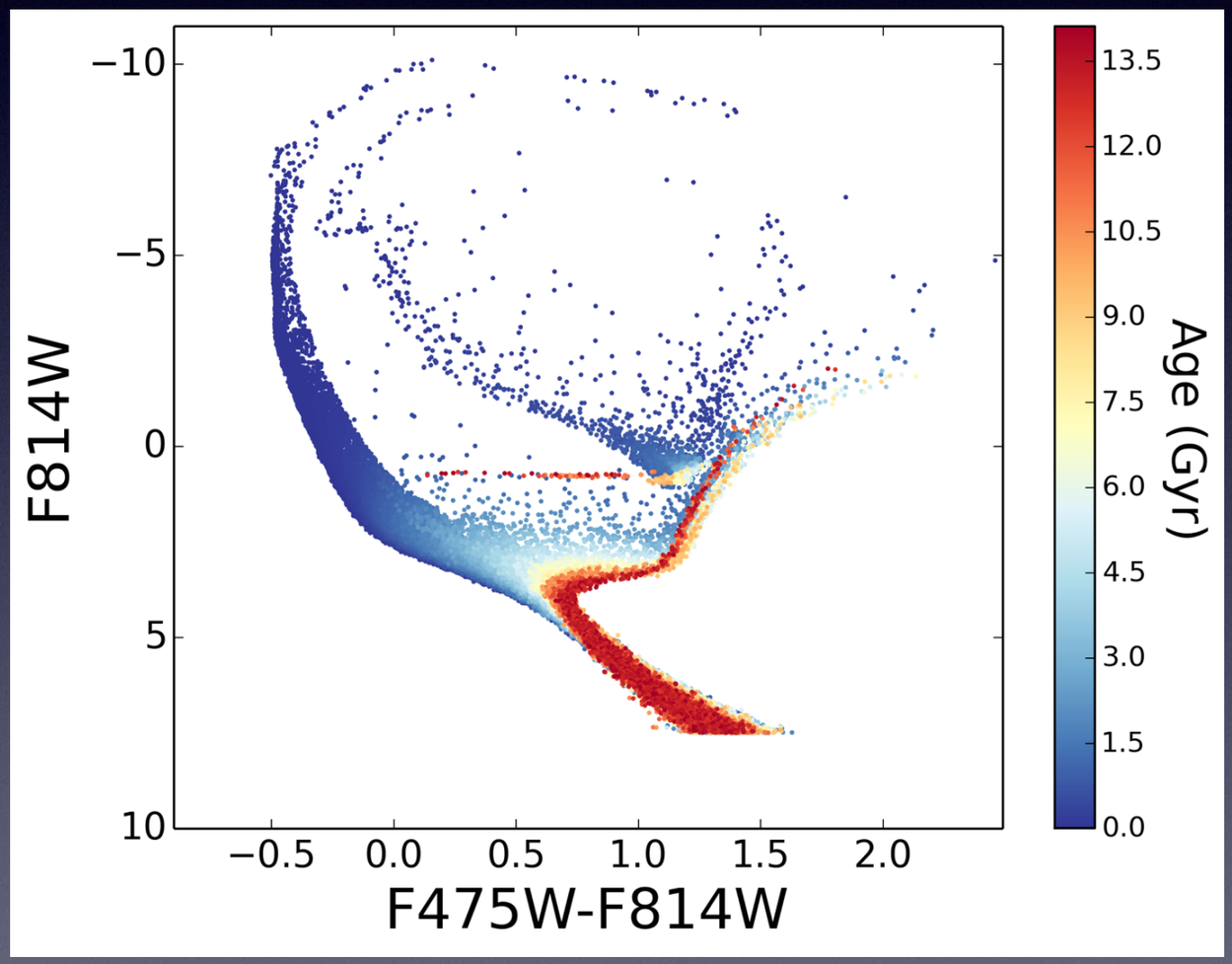
Brighter

Hotter

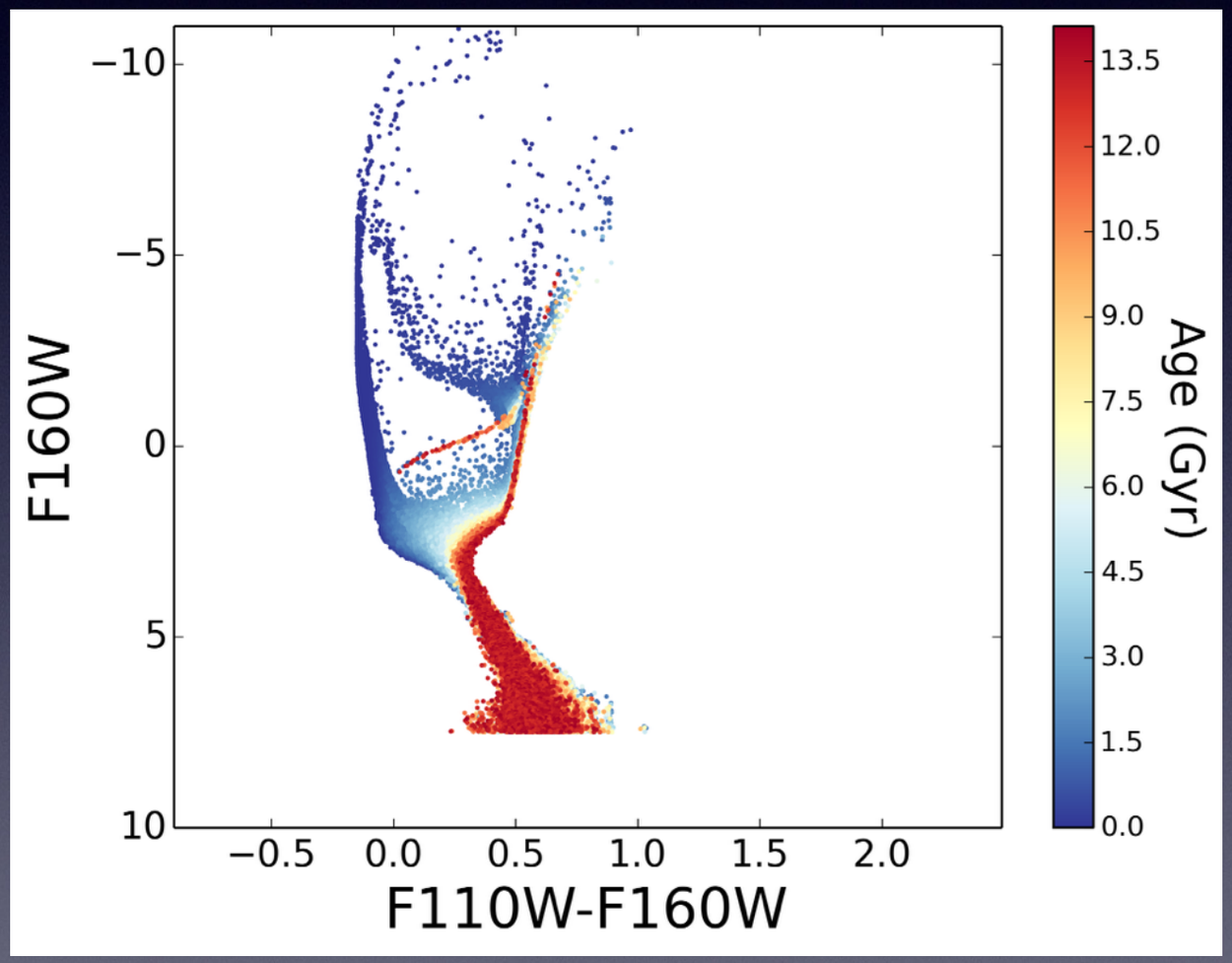
Information is Rich and Redundant

Brief Intro to Stellar Populations in the Local Group

Optical CMD



Near-IR CMD

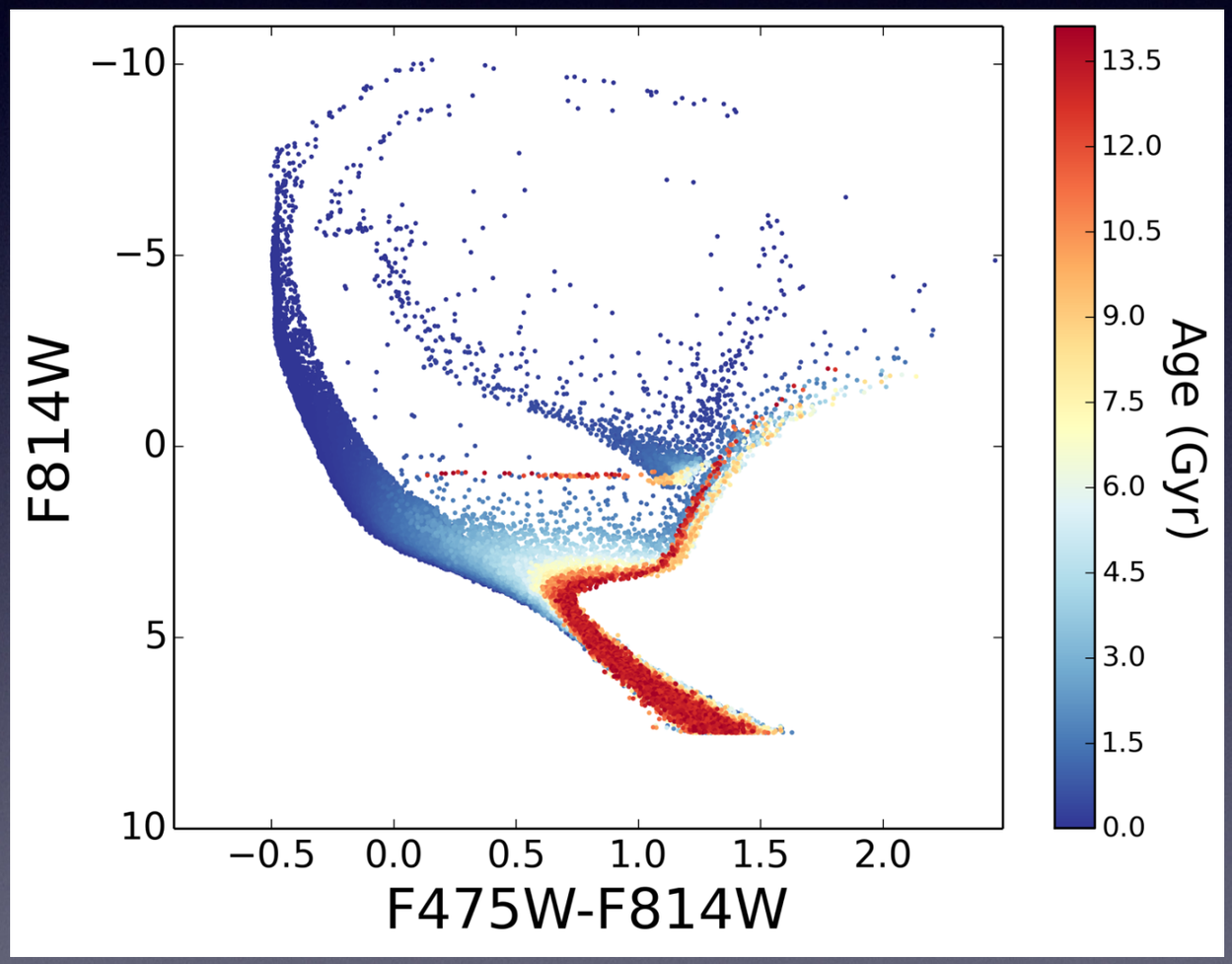


Broad Color Range

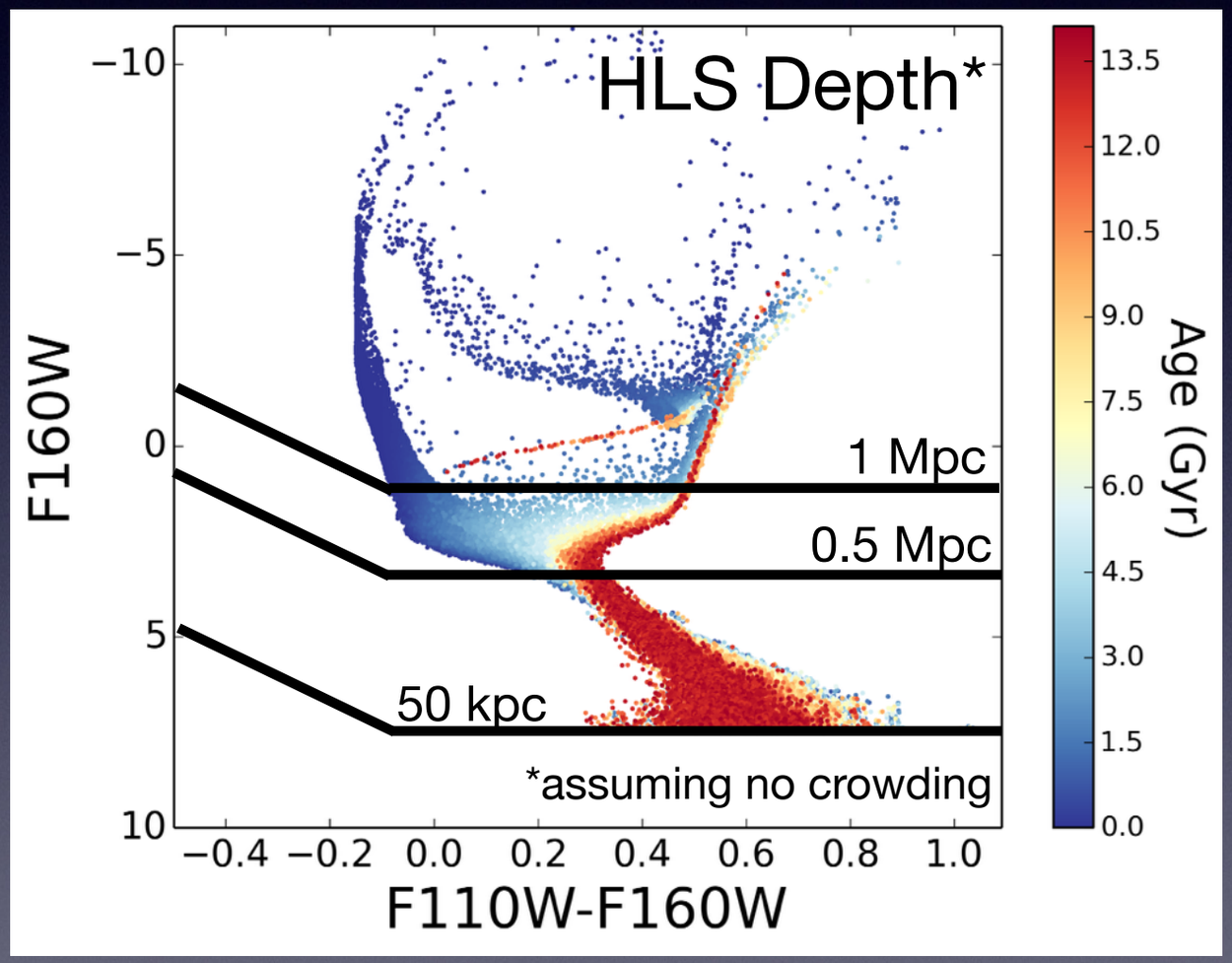
Narrow Color Range

Brief Intro to Stellar Populations in the Local Group

Optical CMD



Near-IR CMD



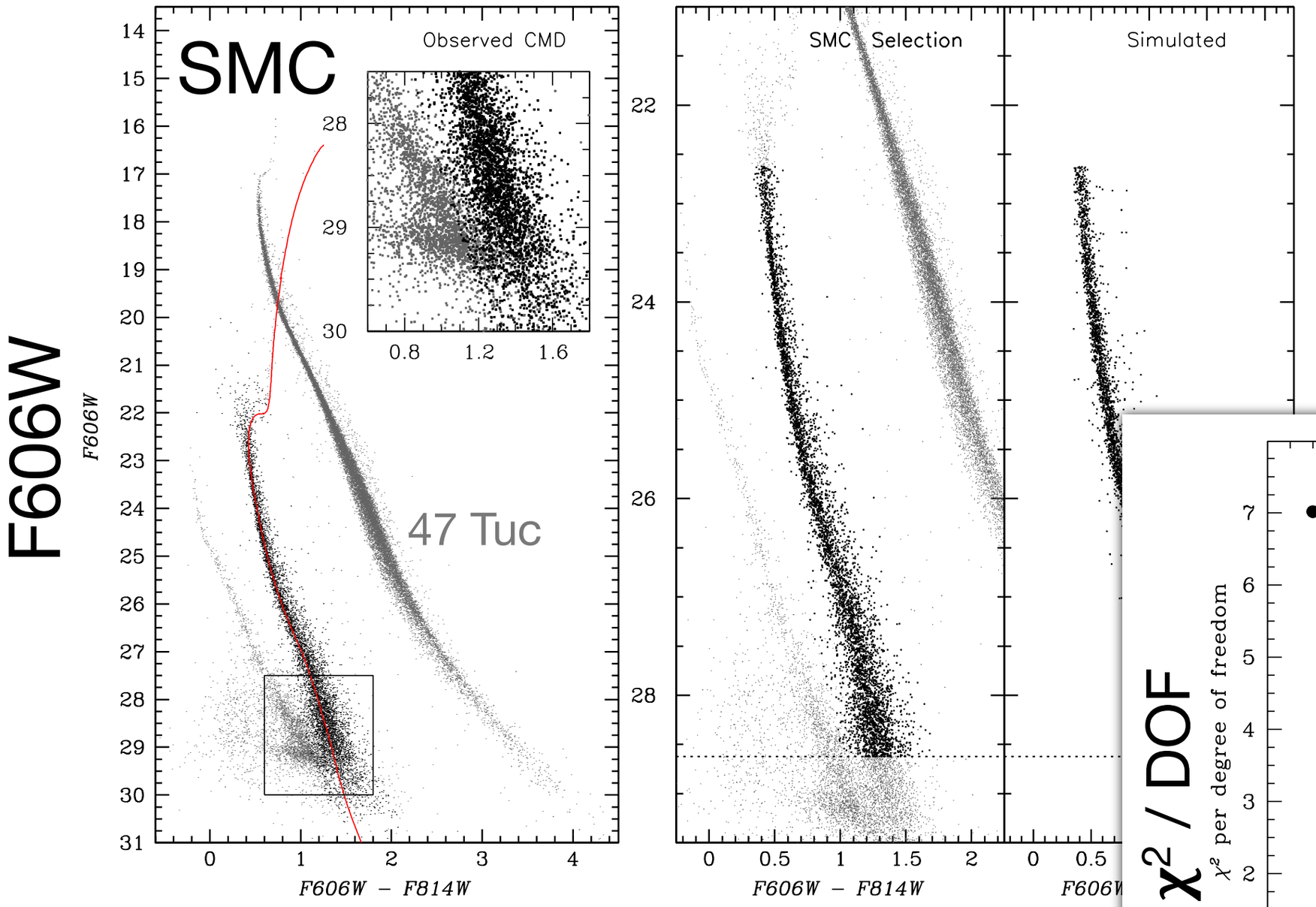
Broad Color Range

Narrow Color Range

Importance of Stellar Pops

- Ground truth for “subgrid physics”
  - age, energy input, ISM, metallicity, SFR, dust, integrated luminosity, SN remnant masses, IMF
- Non-dissipative tracer of large-scale interactions
- Necessary to test connections between baryonic and dark matter in small galaxies

The Stellar IMF in LG Dwarfs

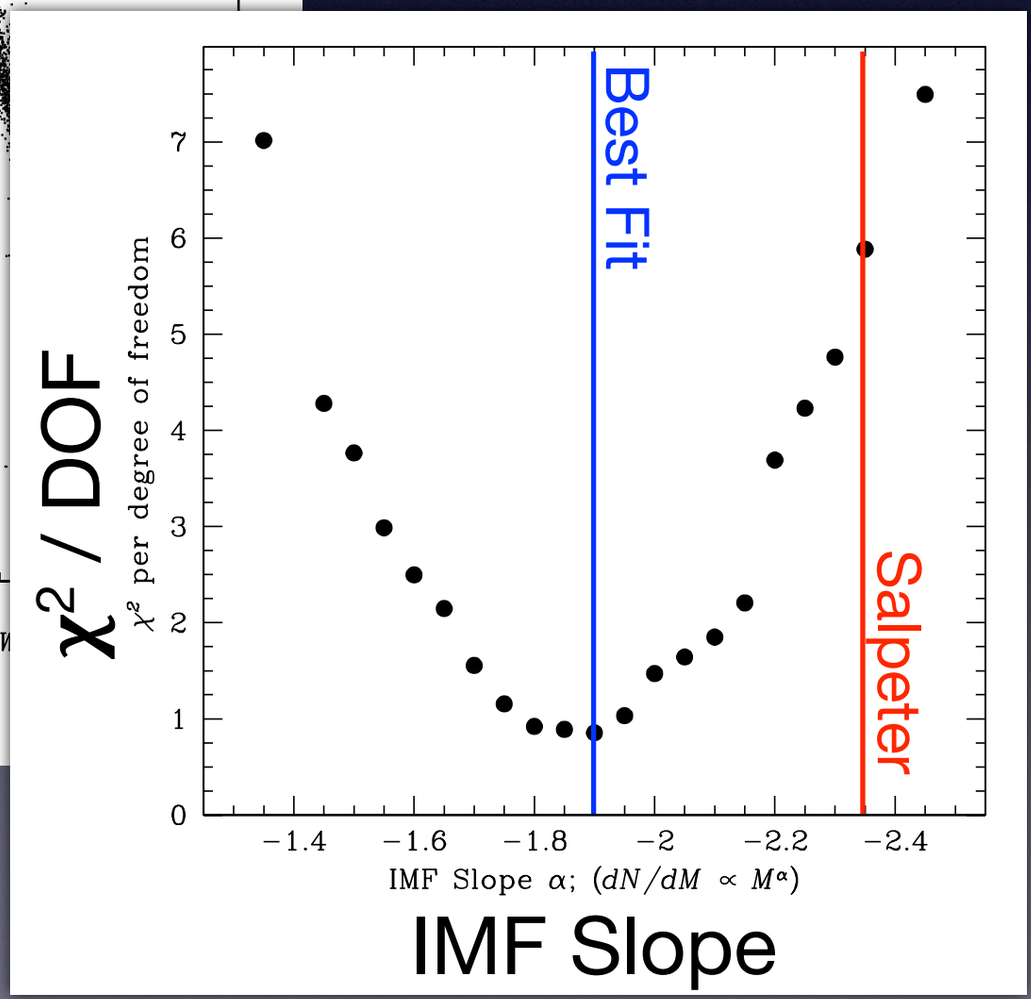


Kalirai+ 2013

F606W-F814W

121 ACS orbits

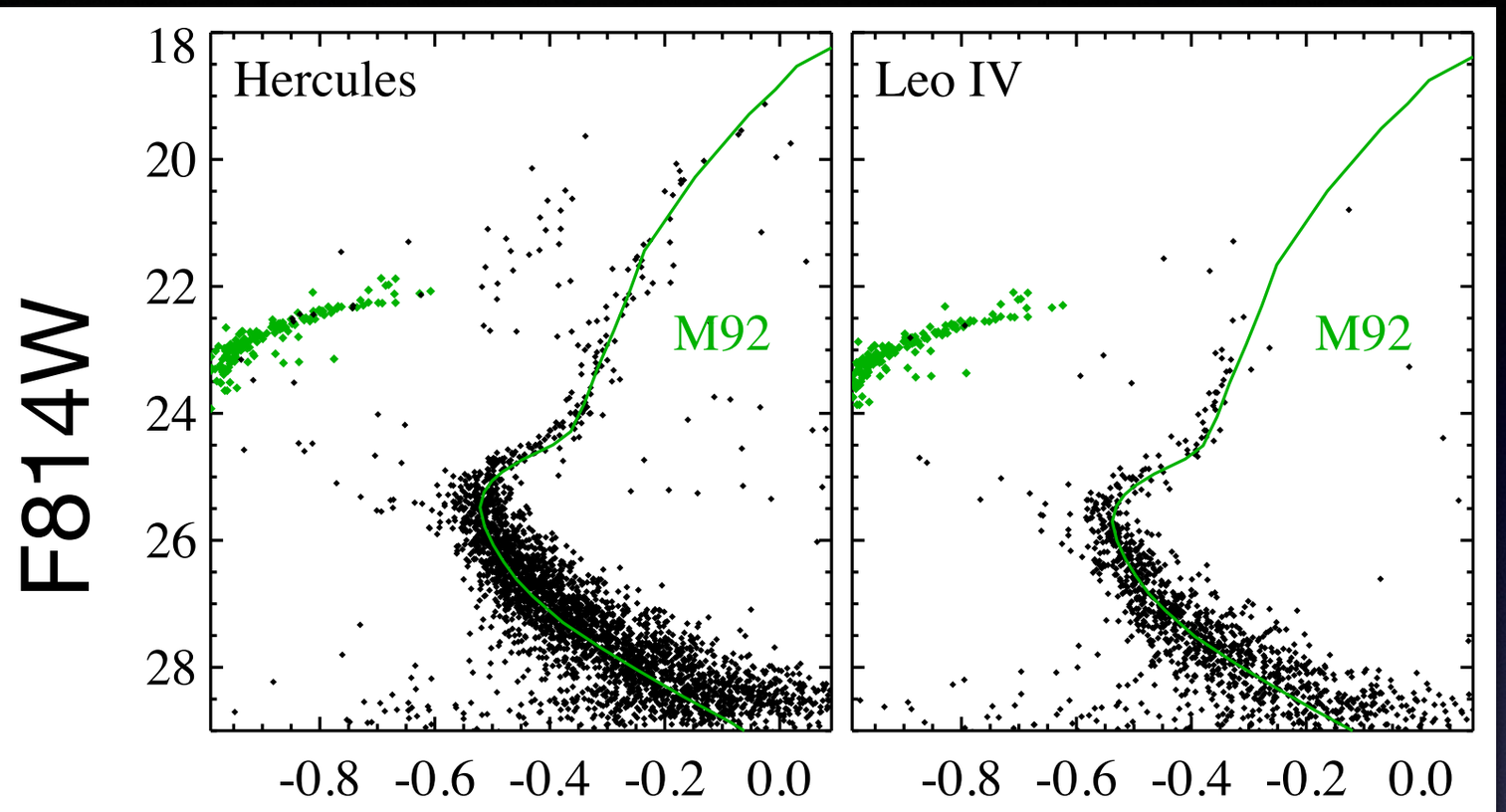
(GO-11677; PI: H. Richer)



IMF Slope

Same science in
the Near-IR : ~12 orbits

The Stellar IMF in LG Dwarfs

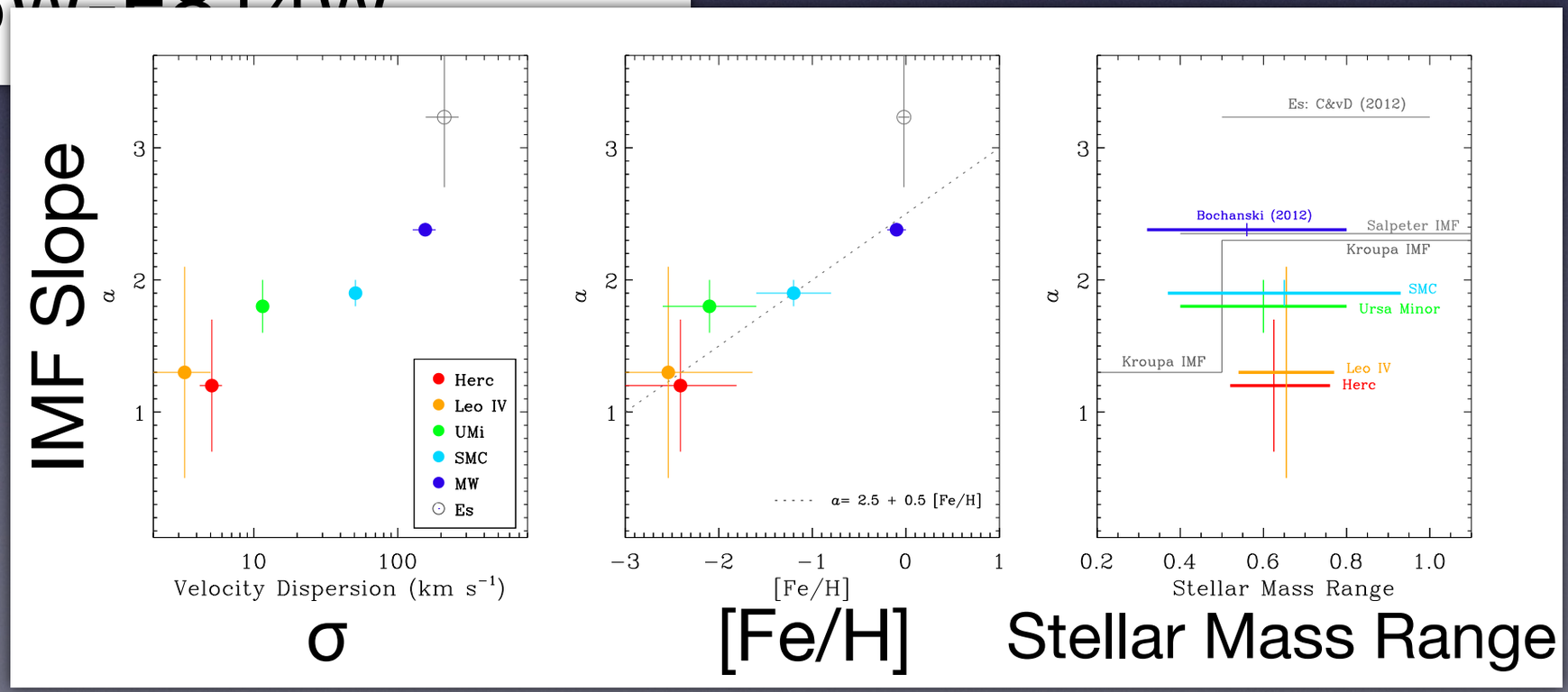


Geha+ 2013

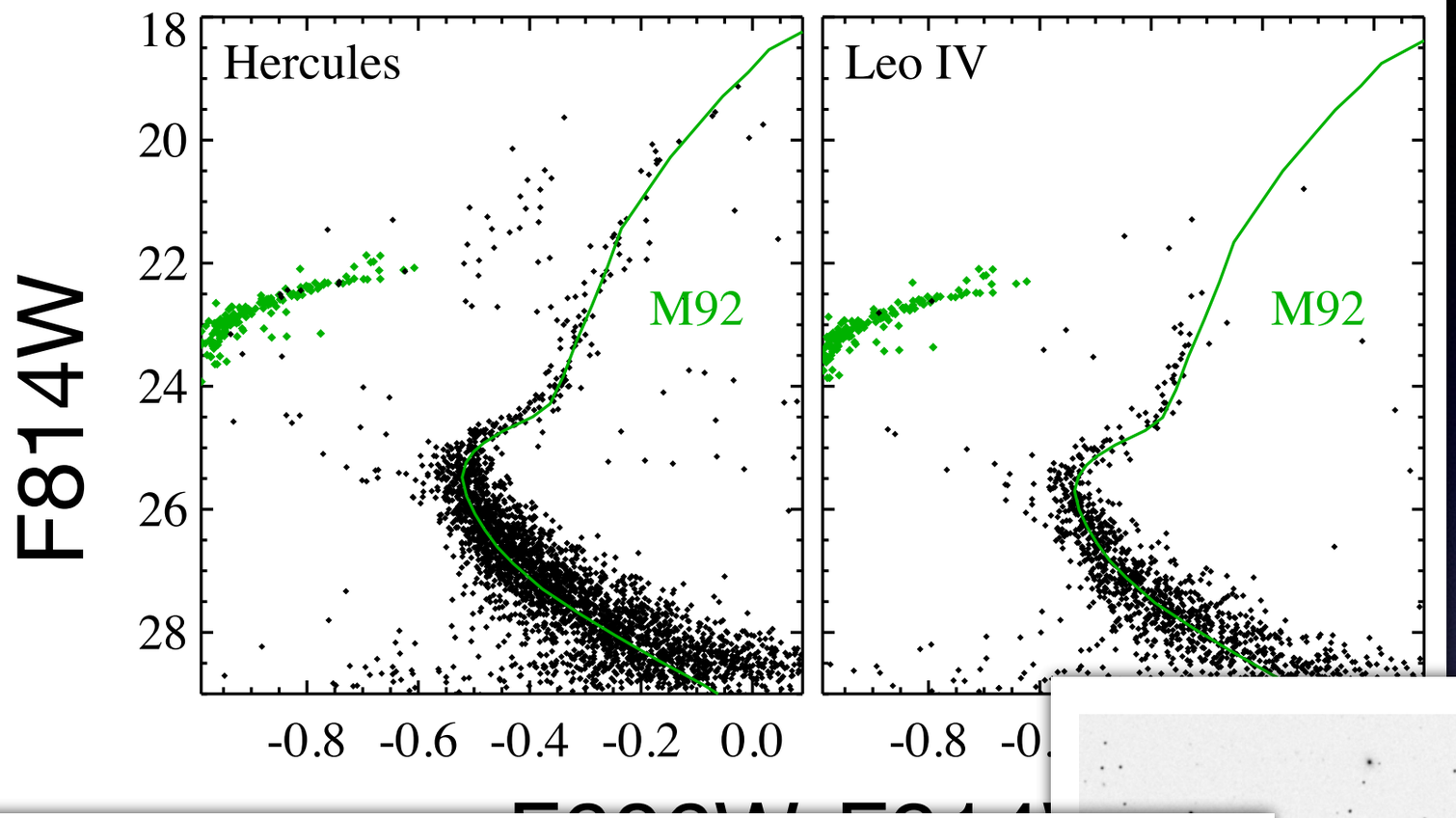
Brown+ 2012,2014

Low-Mass IMF
Slope varies
with sigma, [Fe/H]

Current data not
deep enough to
rule out
MW Chabrier IMF to
high confidence

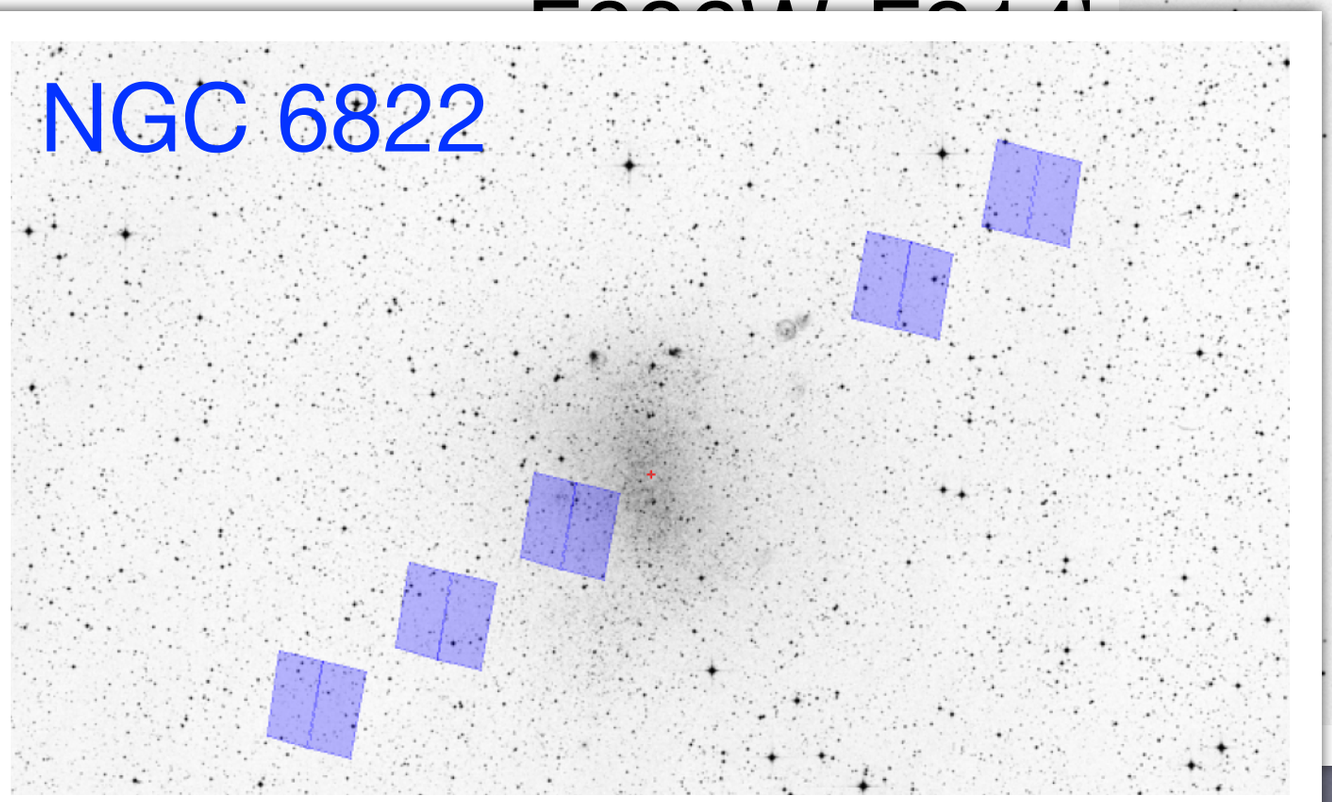


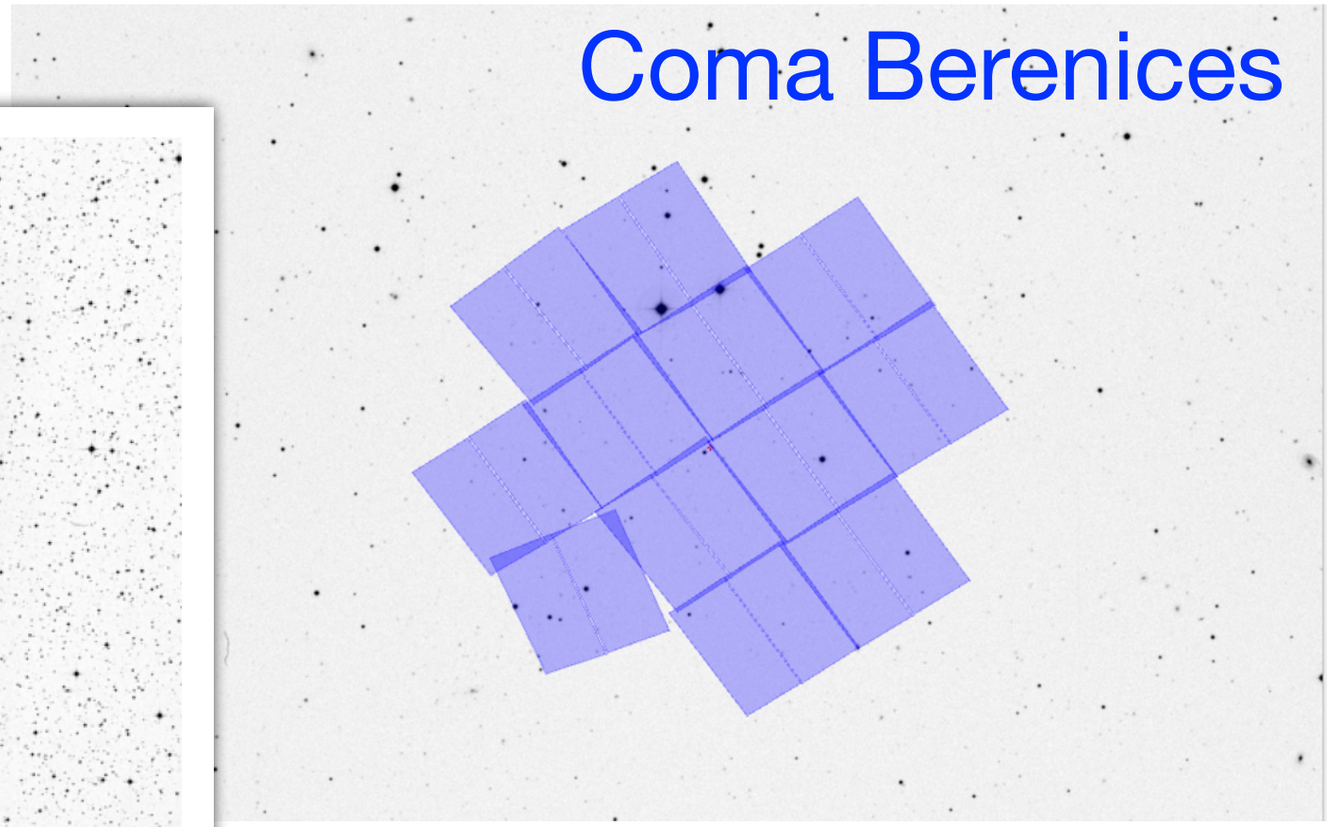
WFIRST: Local Group Dwarfs



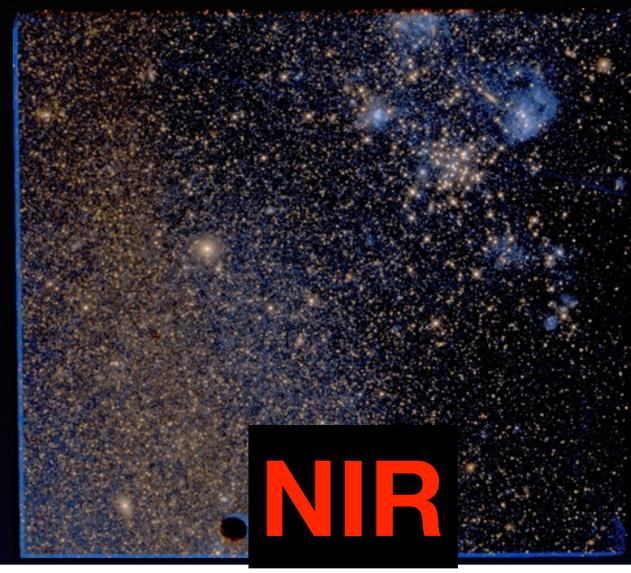
Wider field
Get more stars faint stars for IMF

Detect and characterize entire dwarf galaxies

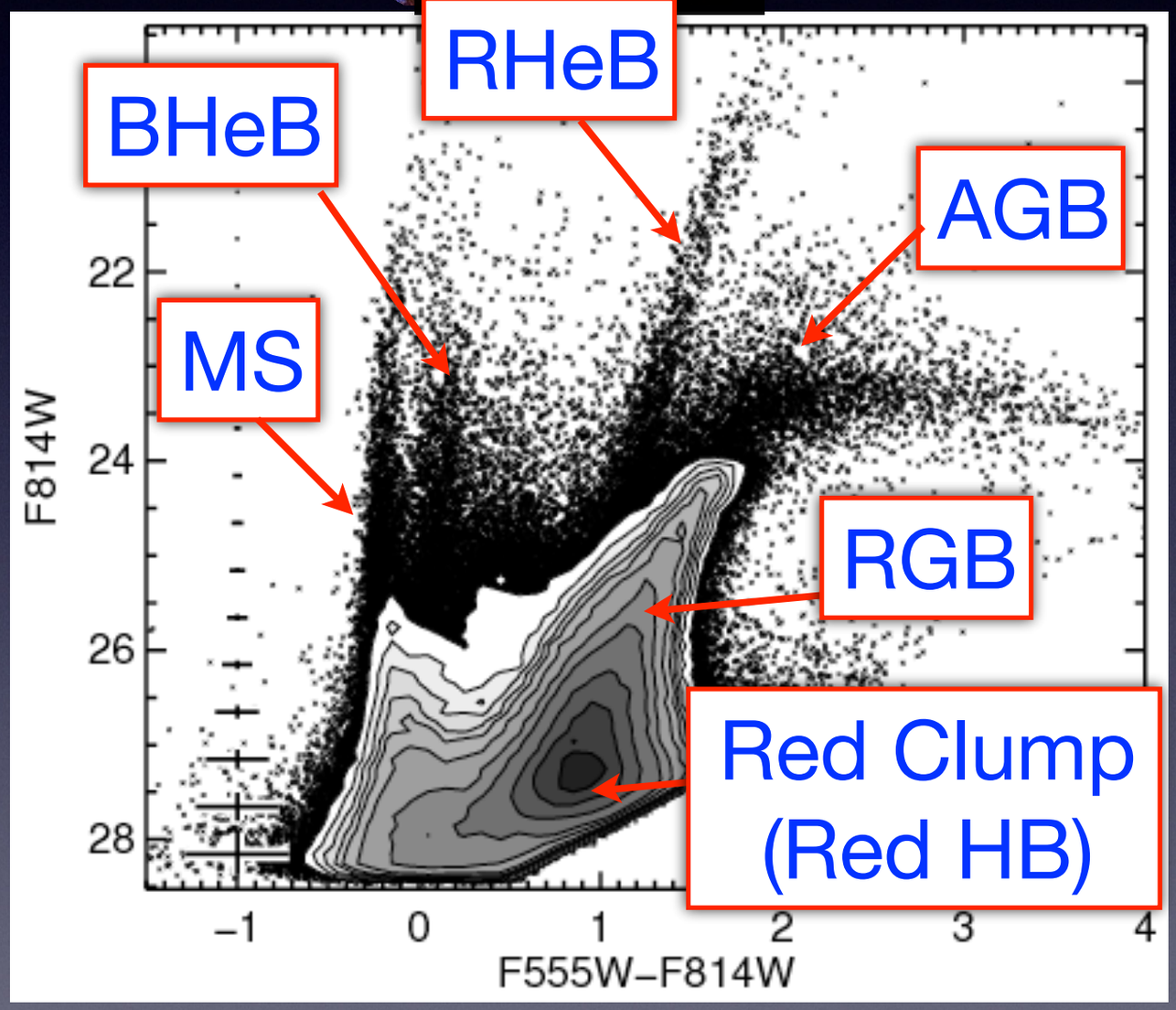


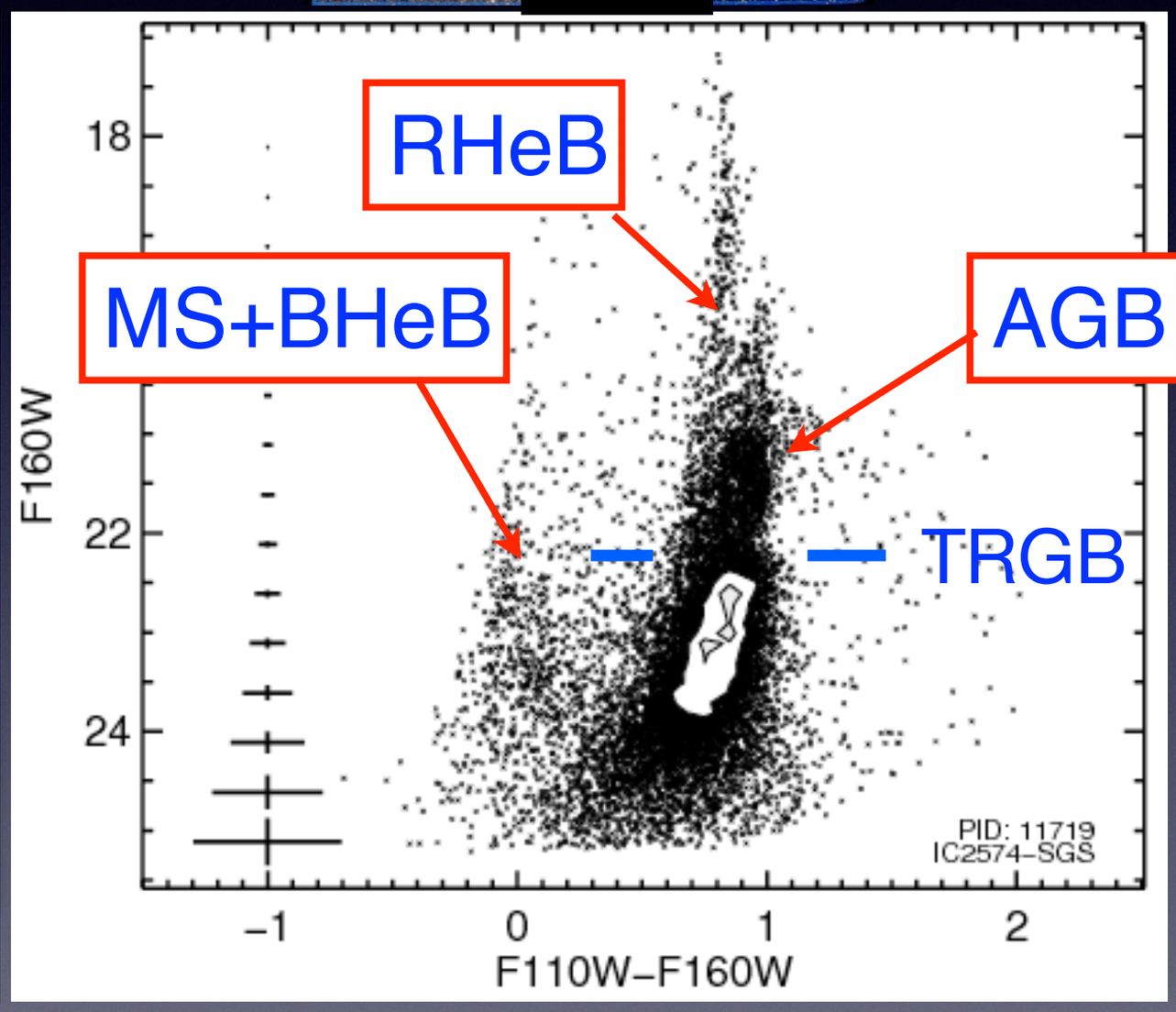


Optical



NIR

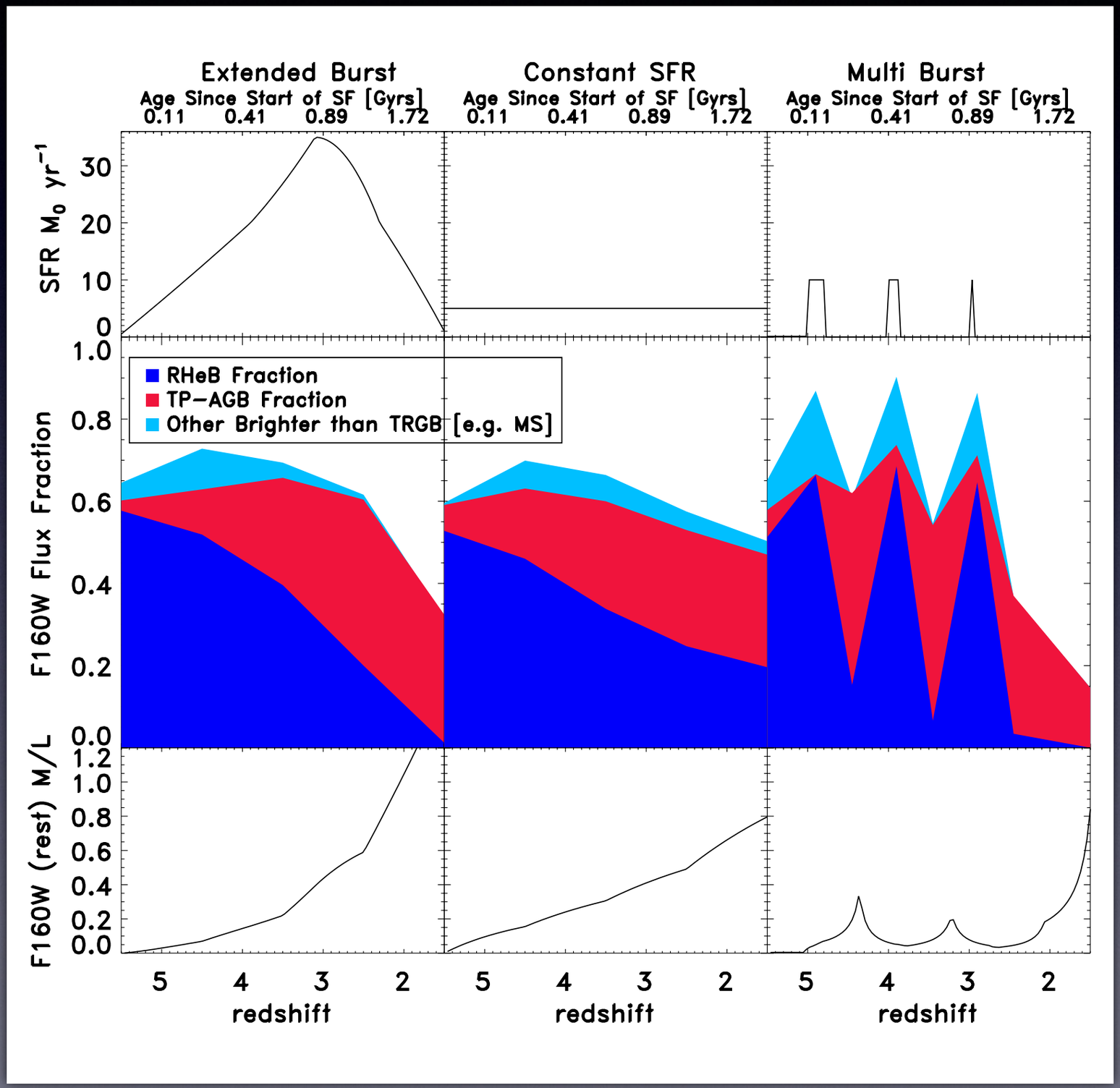




V-I vs I

J-H vs H

Cool Stars can dominate rest-frame near-IR flux at early times

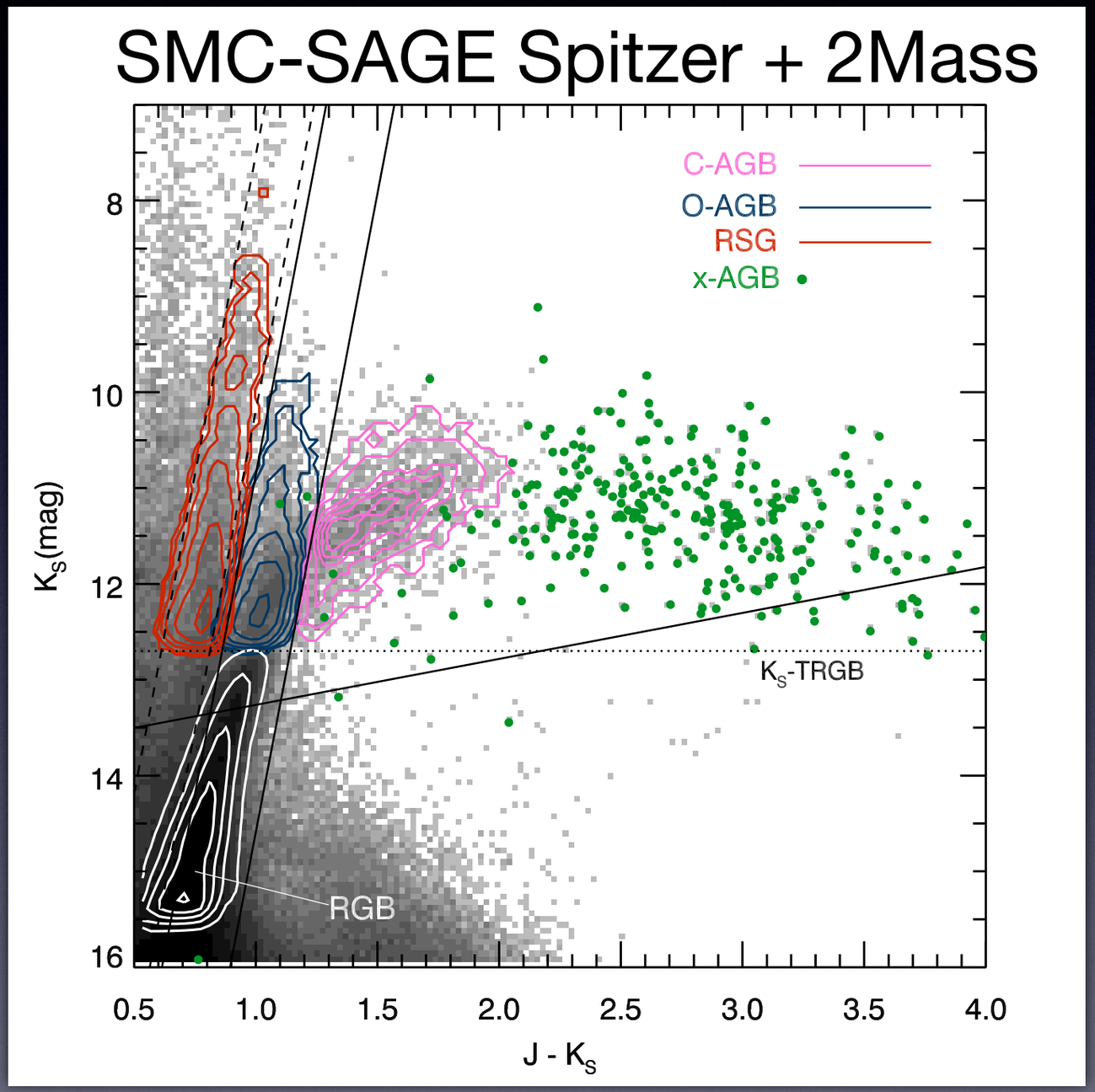


Few RGB stars at high-z

AGB & RHeBs account for ~70% of rest-frame near-IR flux at high redshifts

Melbourne+ 2012

Rare Phases of Evolution: AGB & RHeB Stars



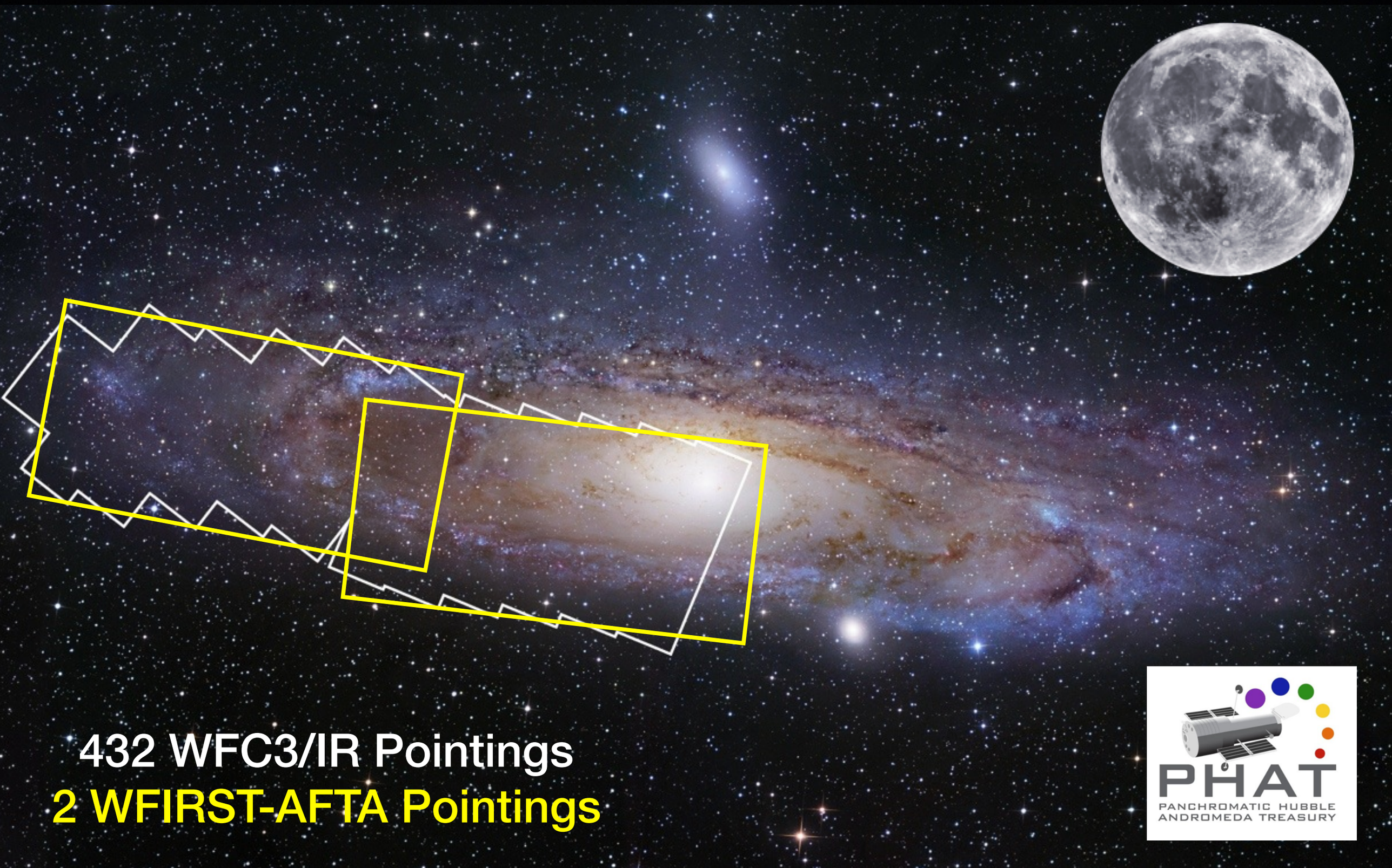
Boyer+ 2011

Short lifetimes: challenging to find

Rapid Evolution: challenging to model

LG survey for rare, IR-bright stars = great WFIRST science case

HST's Wide Area UV-Opt-IR Map of M31



mage: Dustin Lang
astrometry.net

~50% of the number of stars in SDSS

>117,000,000 stars, multiple properties measured at up to 17 different times

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

Filters

Transmission

F275W F336W F475W F814W F110W F160W

F_λ

Vega G7III M5III C_{3200K}

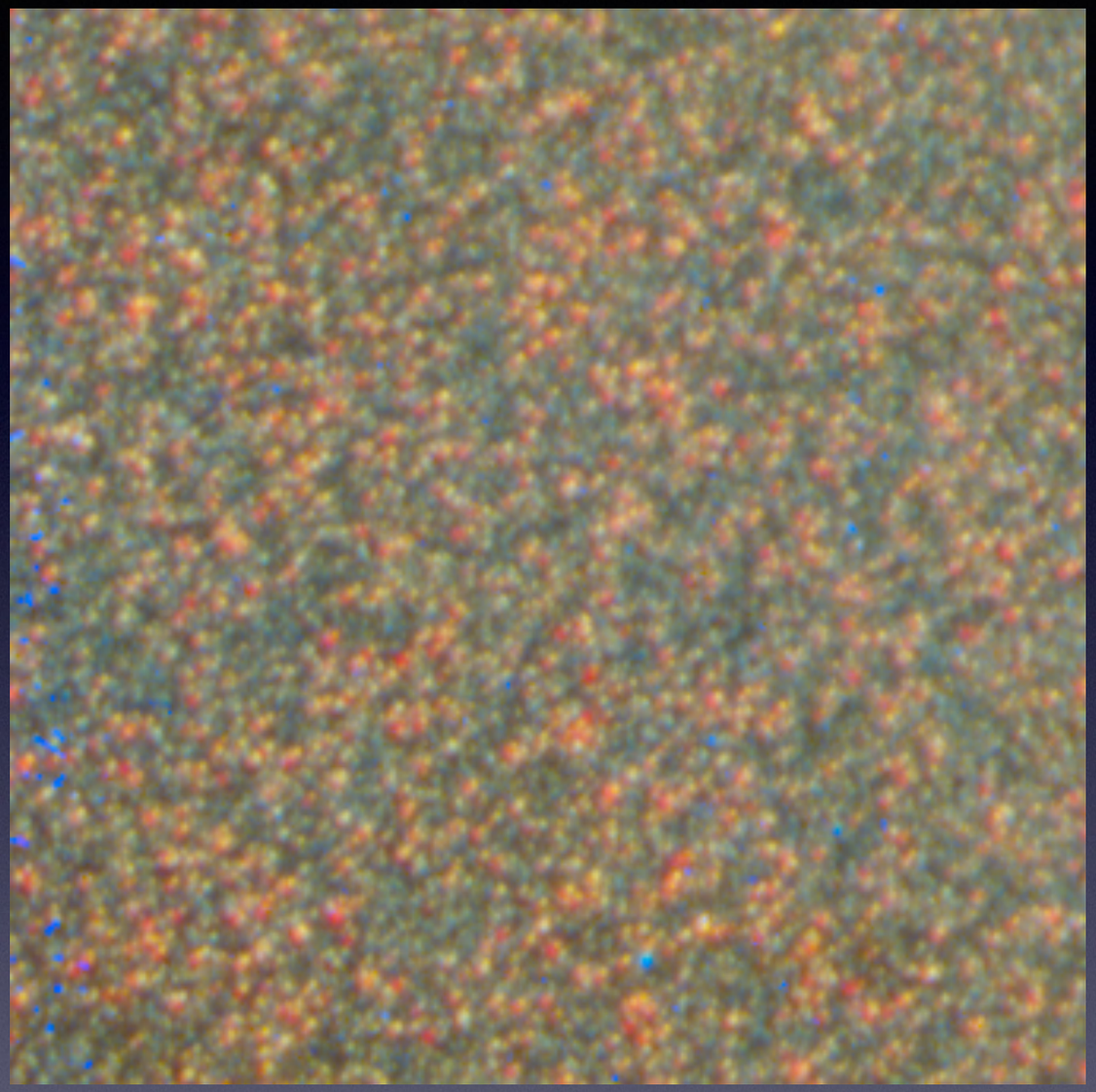
Spectra of Stars

10^4

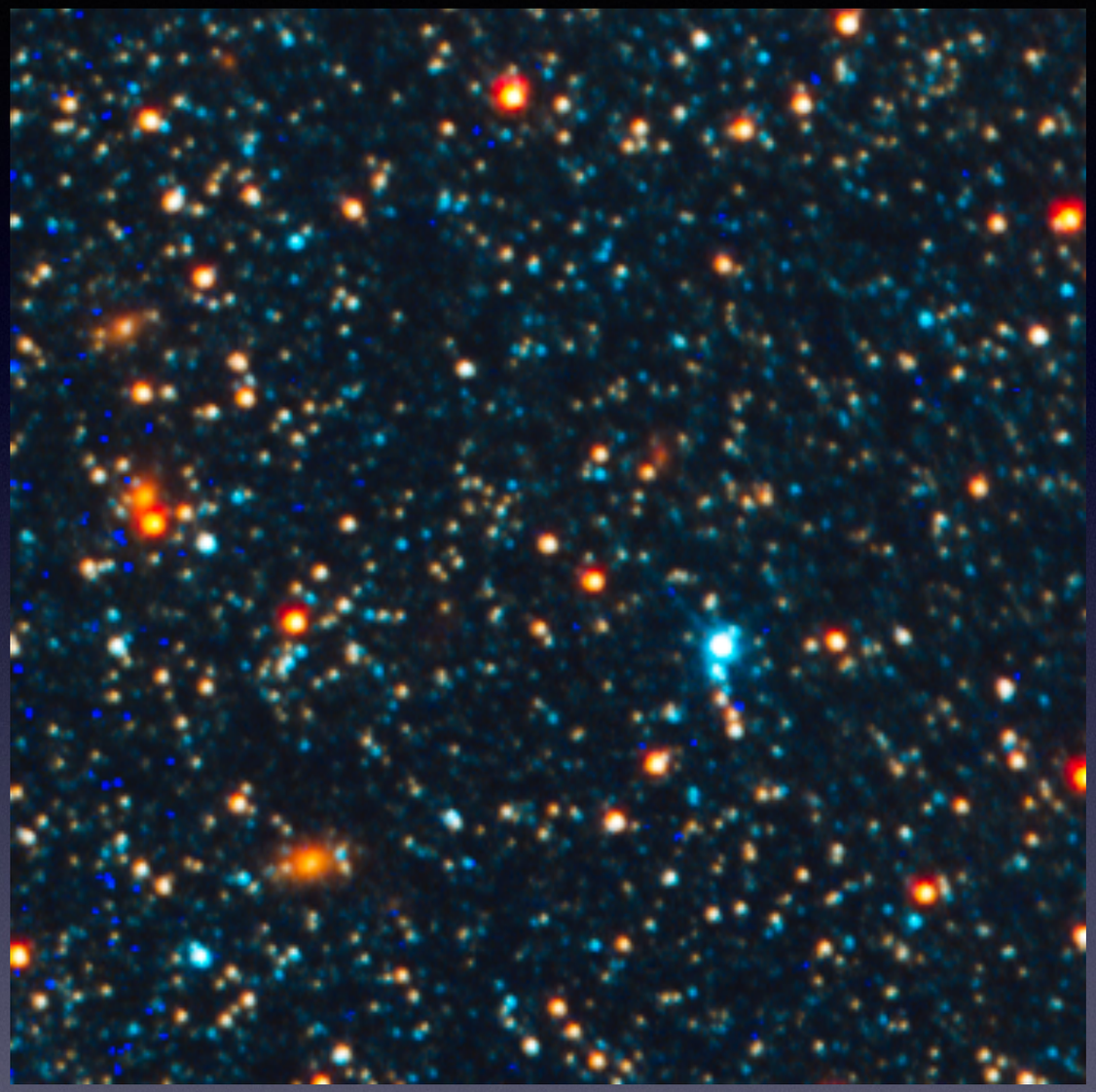
$\lambda(\text{Å})$

JWST

“Crowding” varies with Radius

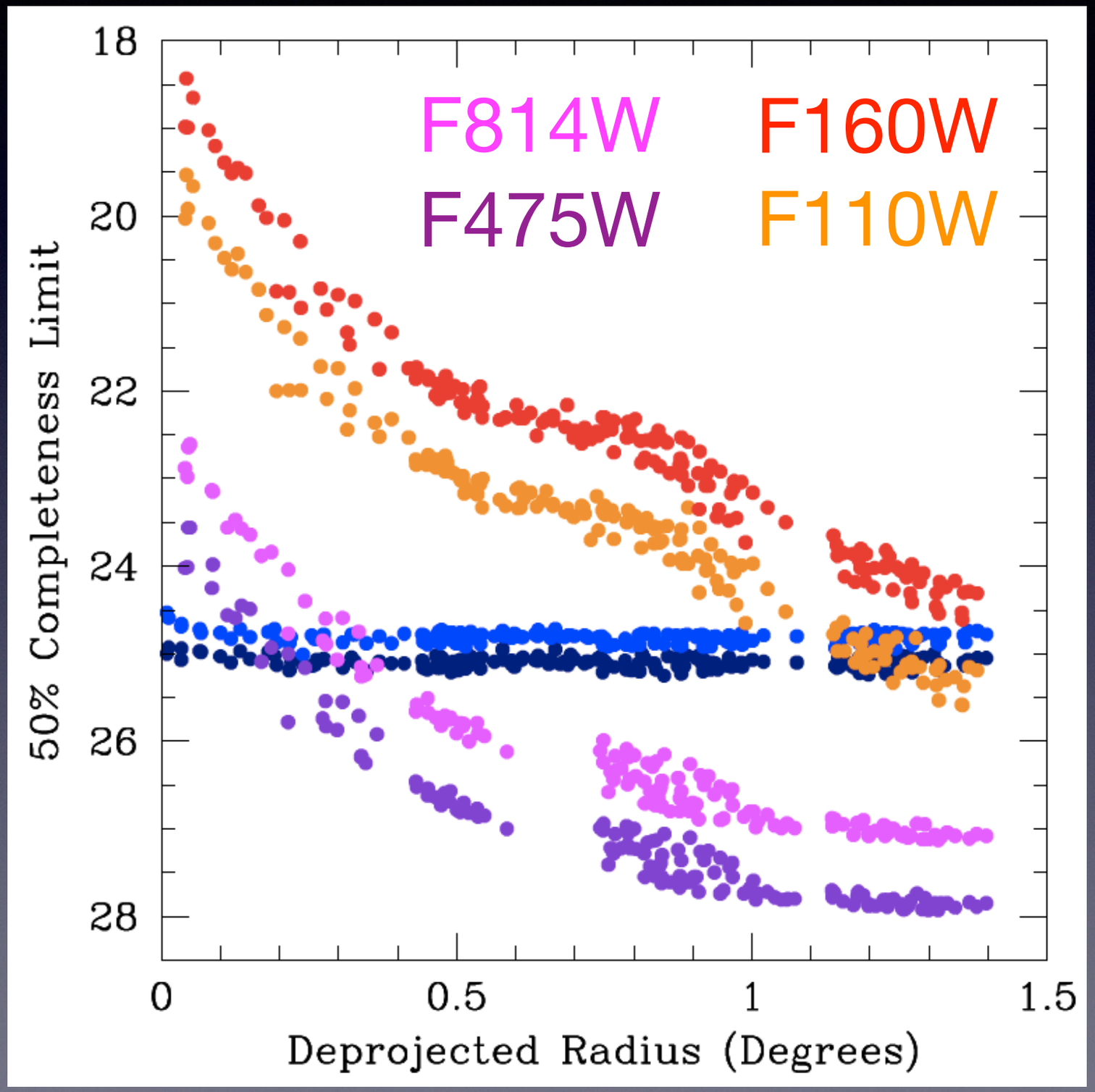


Outer Bulge of M31



Outer Disk of M31

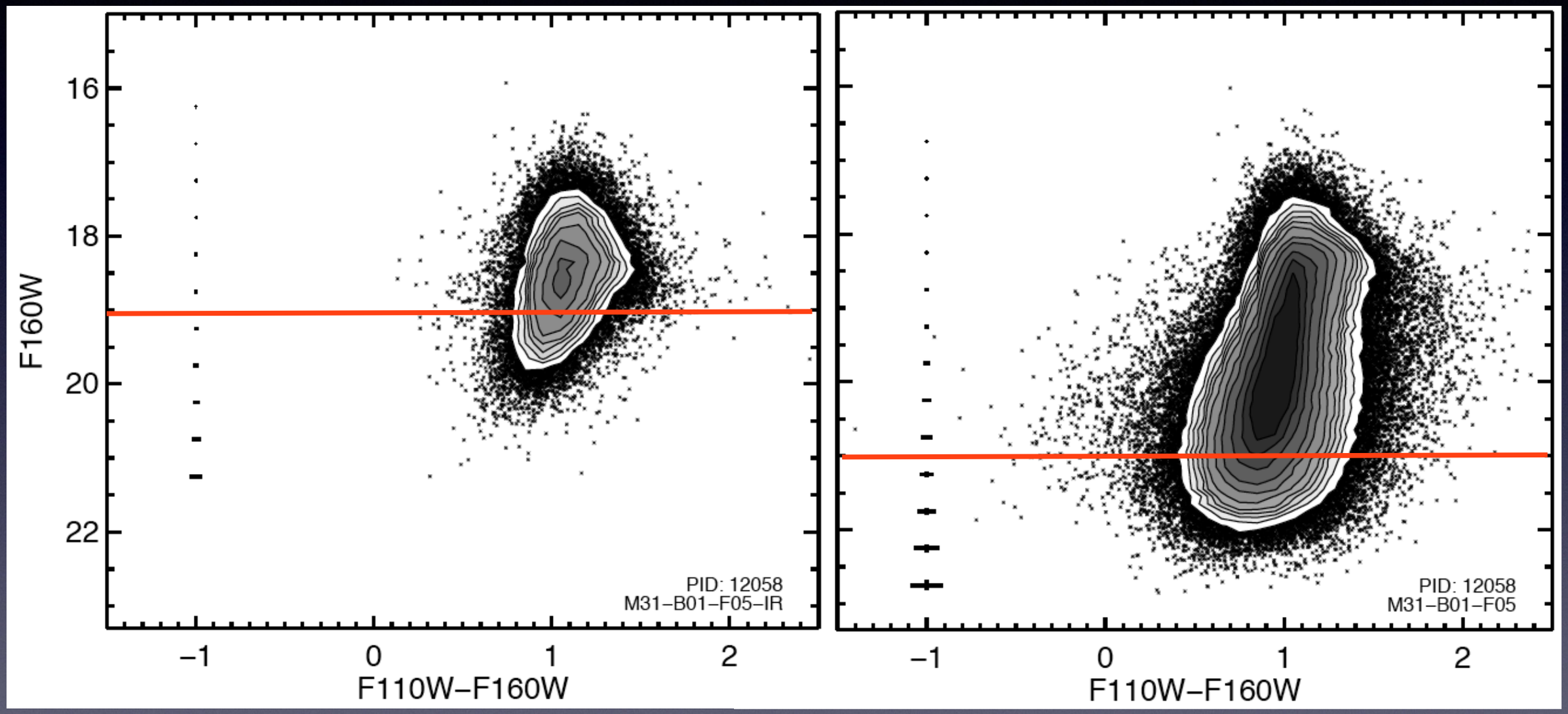
Depth varies with Radius



Crowding limited* in NIR & optical

*Maximum possible # of stars per arcsec^2 = 0.5 million per ACS image

Leverage full multi-camera data



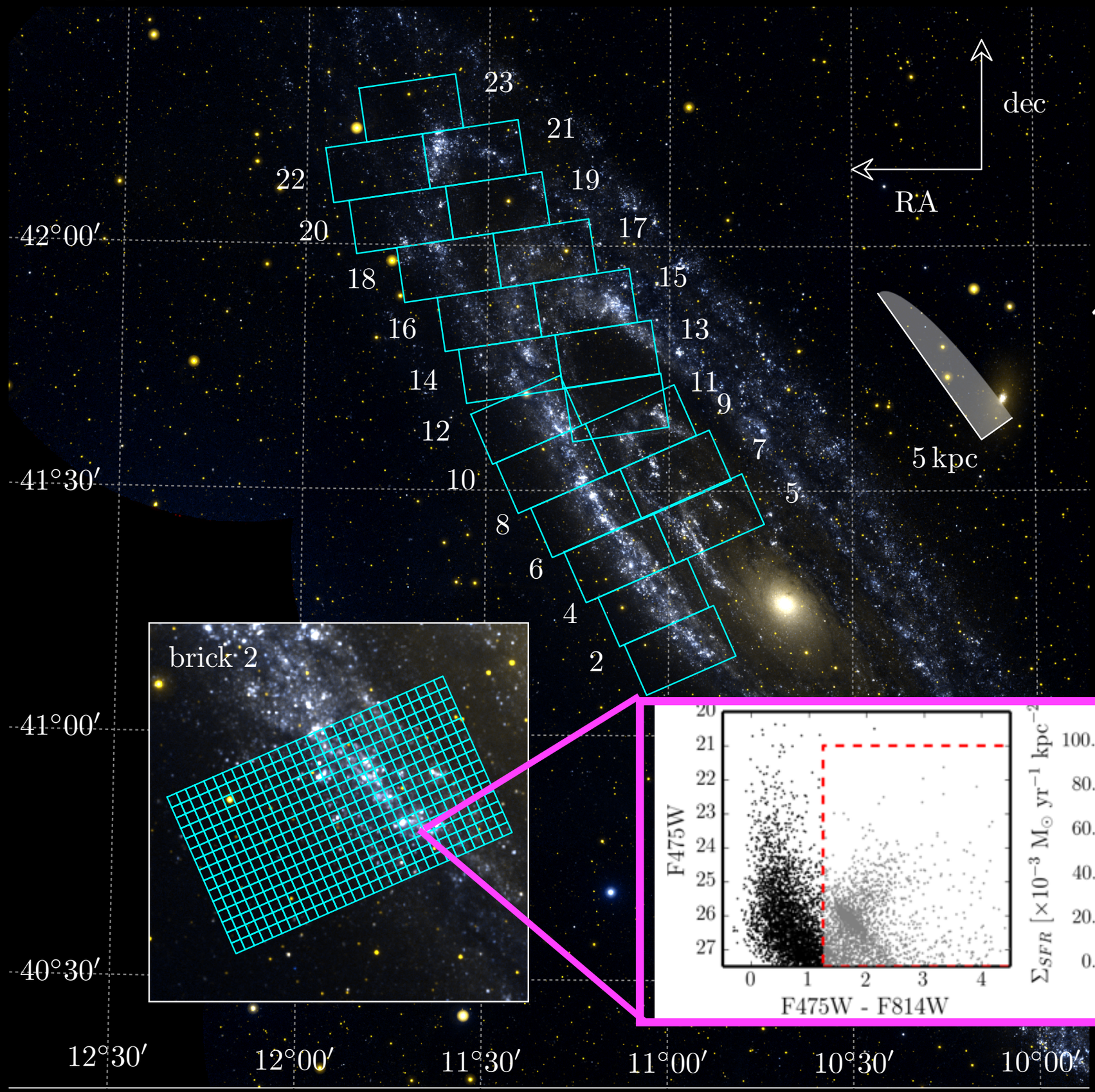
IR data only

Same IR data, but including higher res optical data in PSF fitting

Williams+ 2014

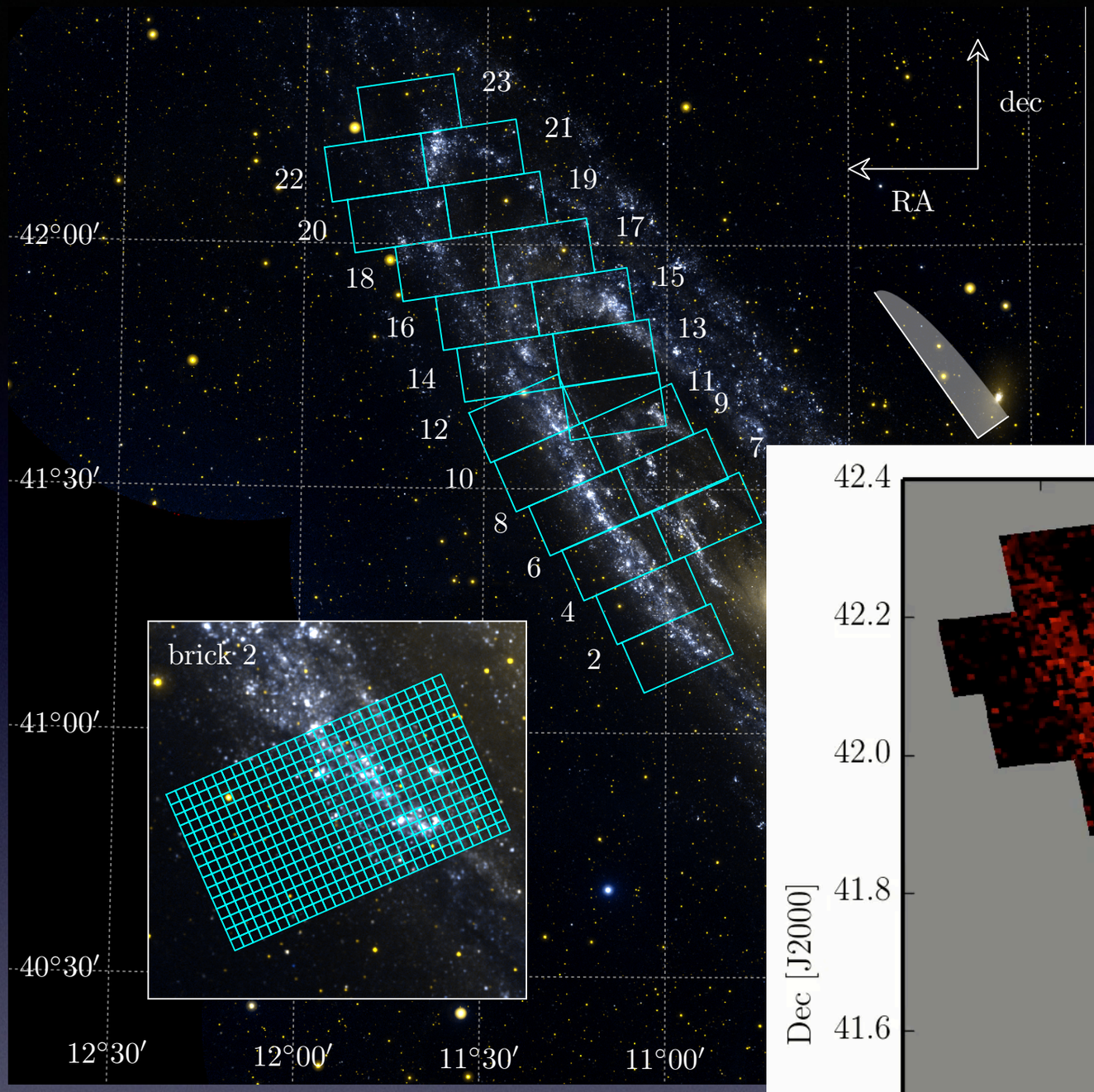
Spatially Resolved SFH of M31

Alexia Lewis (UW)

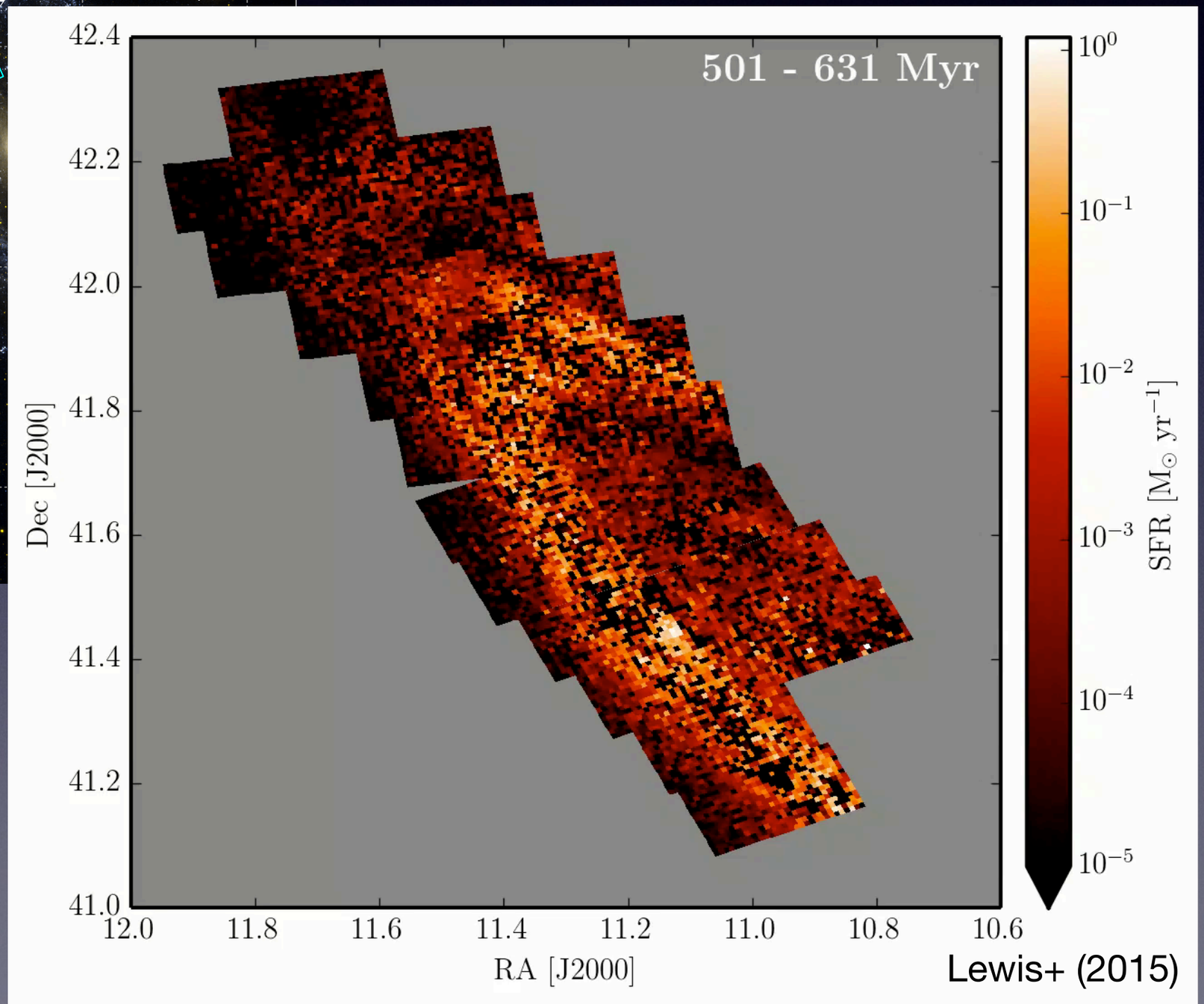


Measure SFHs of ~9000 independent 100x100pc regions from optical-only CMDs

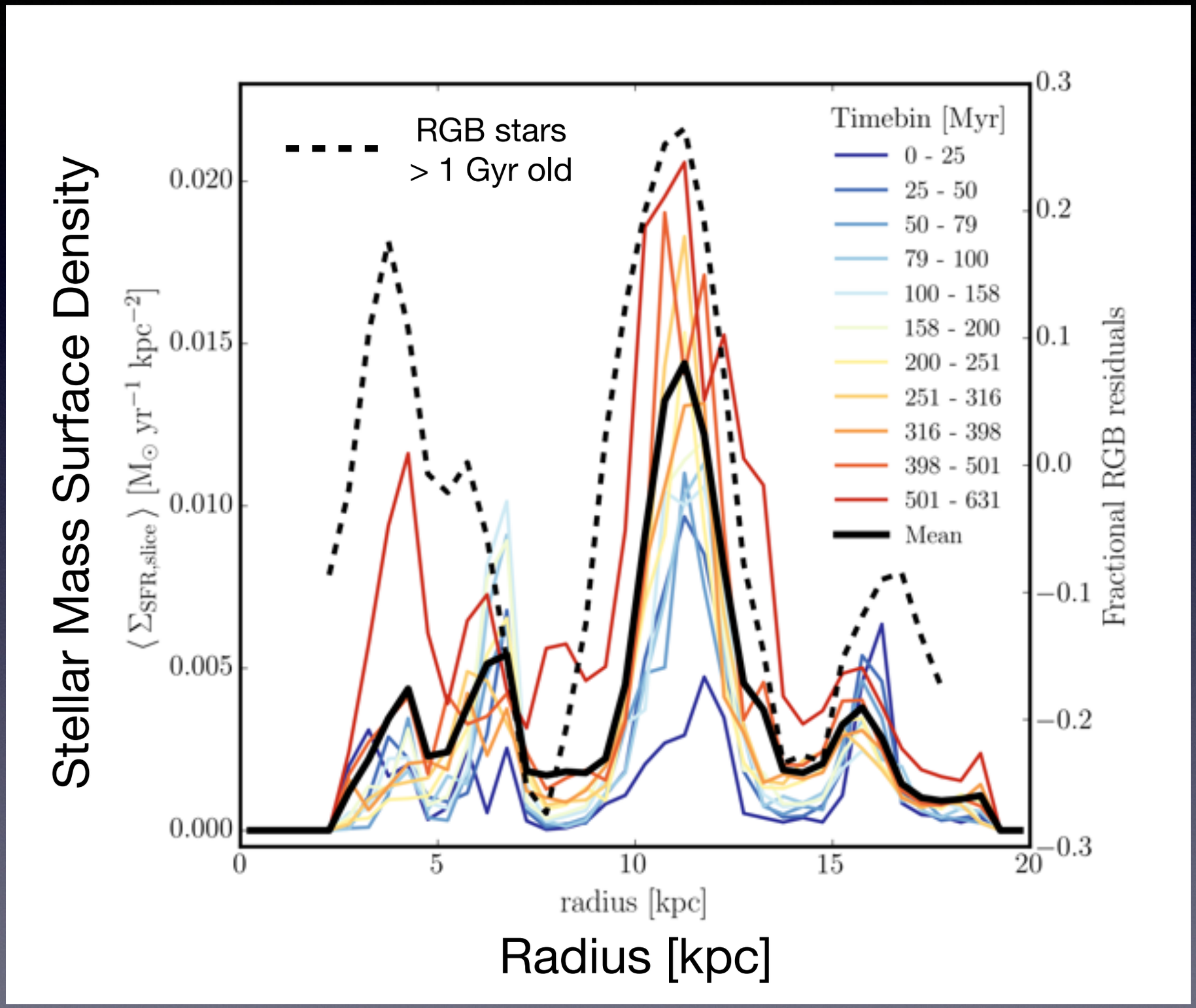
Spatially Resolved SFH of M31



SFHs of Local Group galaxies would benefit from wide, bluer filter

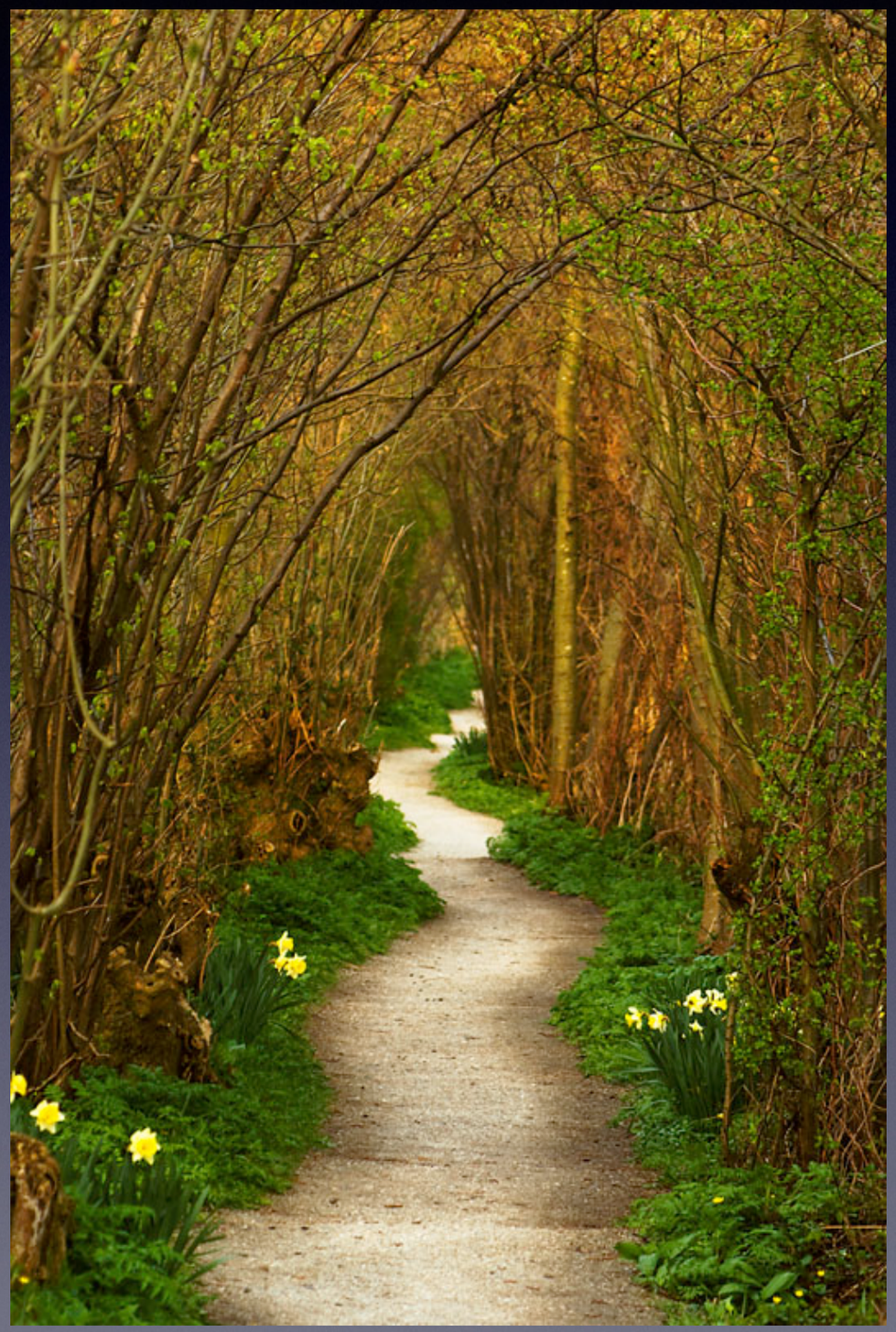


Long Live the Rings



Lewis+ (2015)

Mapping the Dusty ISM

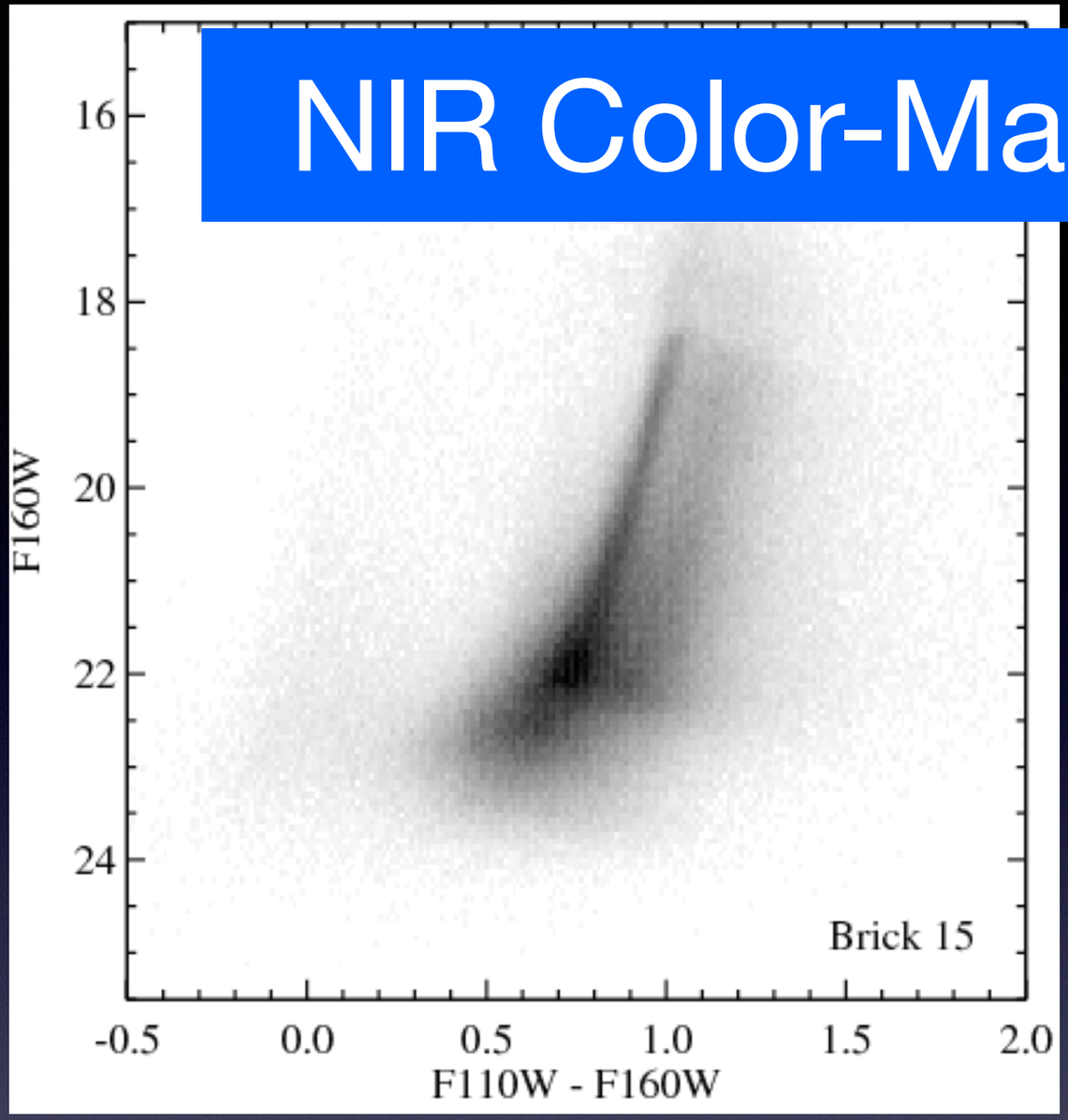


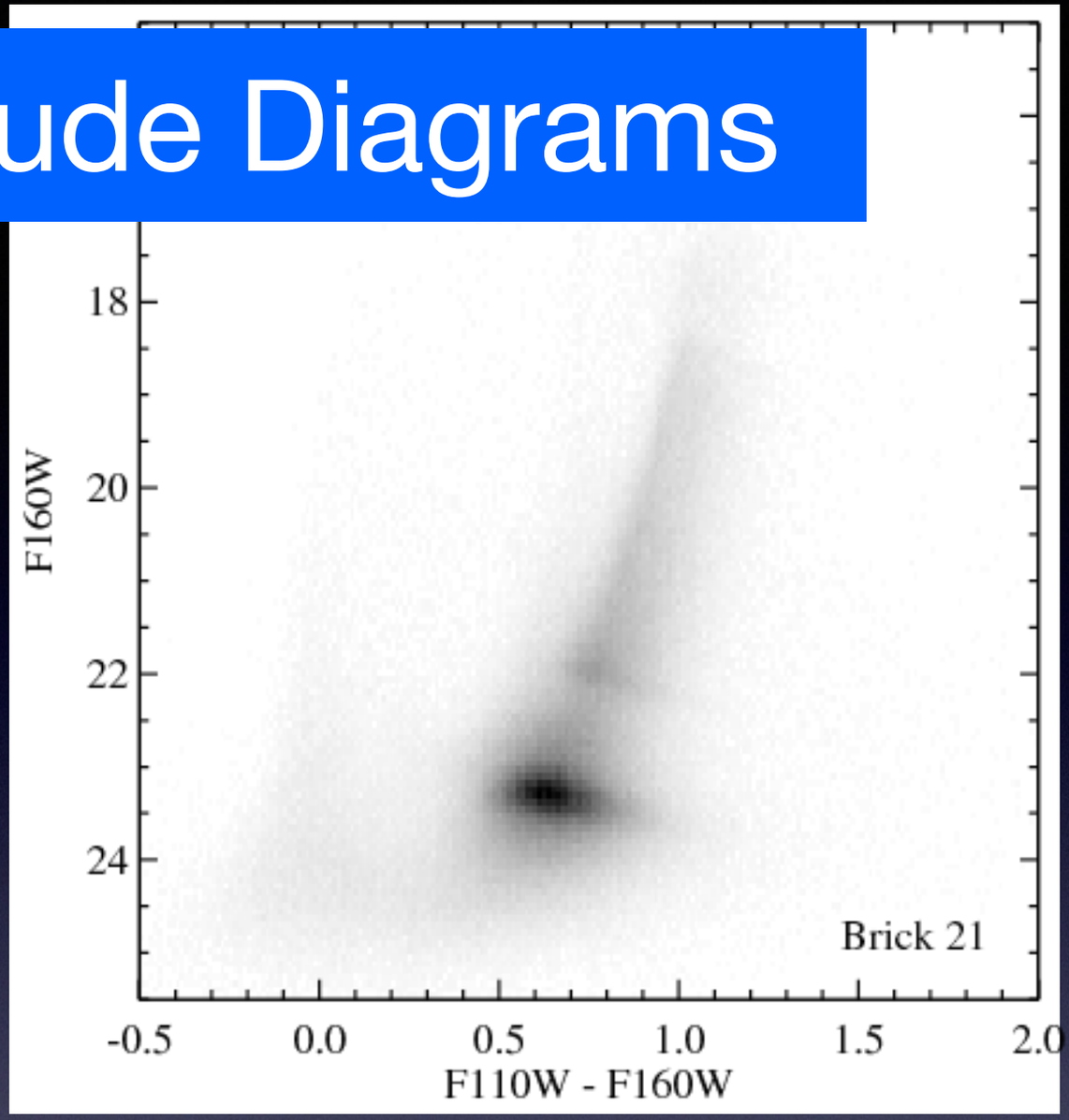
"How I took a winding path to somewhere I didn't expect to go"

~ Julianne Dalcanton

w/ Morgan Fouesneau

NIR Color-Magnitude Diagrams

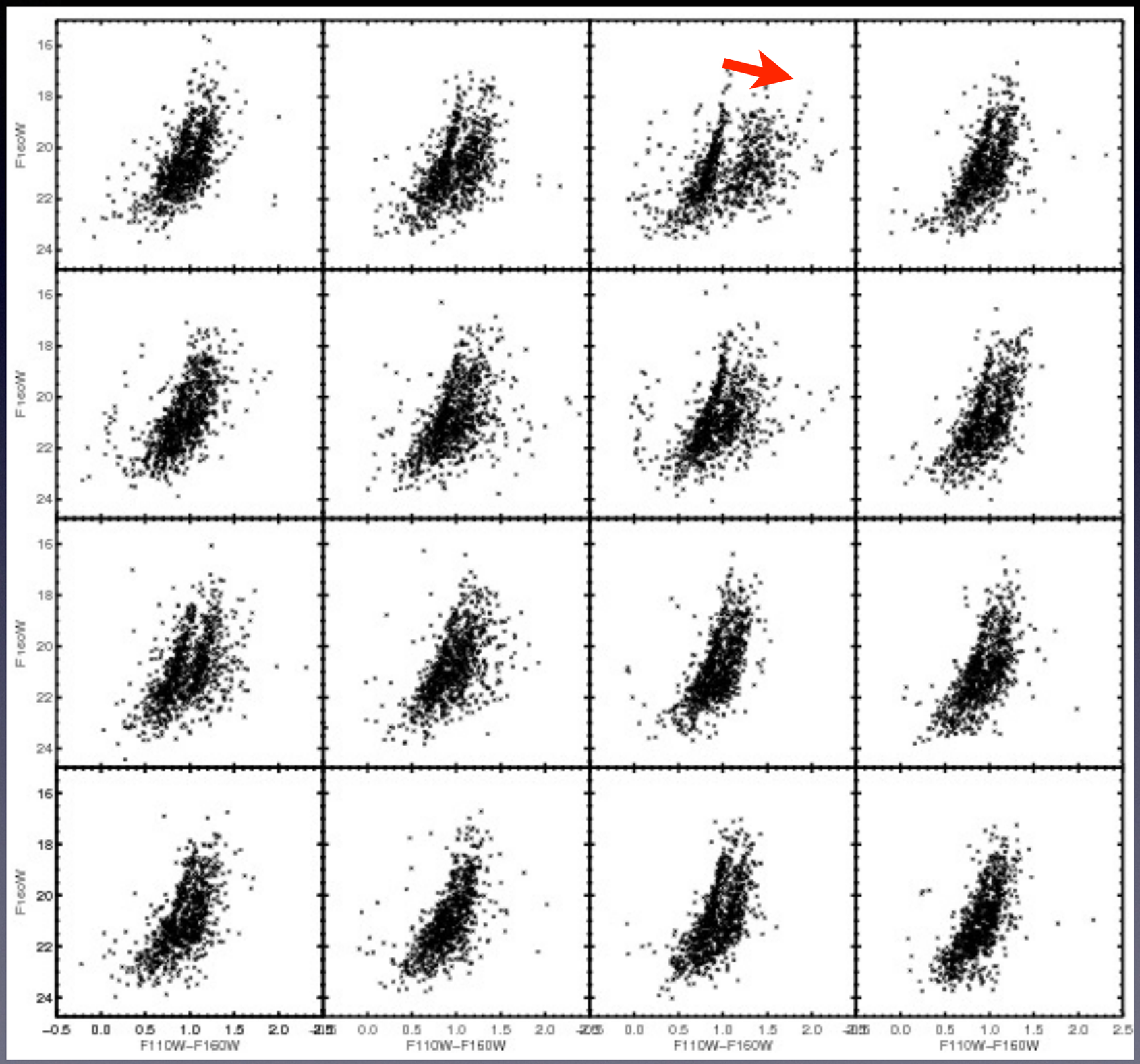




RGB Extended to the Red

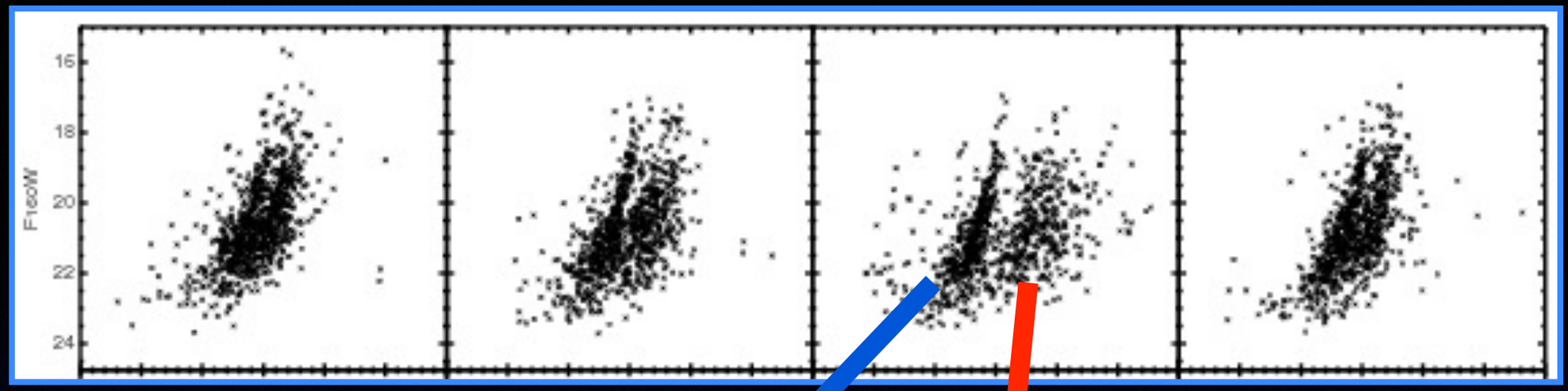
Dalcanton+ 2015

Red Giant Branch is Doubled



F110W-F160W CMD of Single WFC3/IR frame, subdivided in 4x4 grid

Subregions of single WFC3/IR frame



Unreddened peak

Reddened peak

Complicates CMD interpretation, but great for quantifying dust

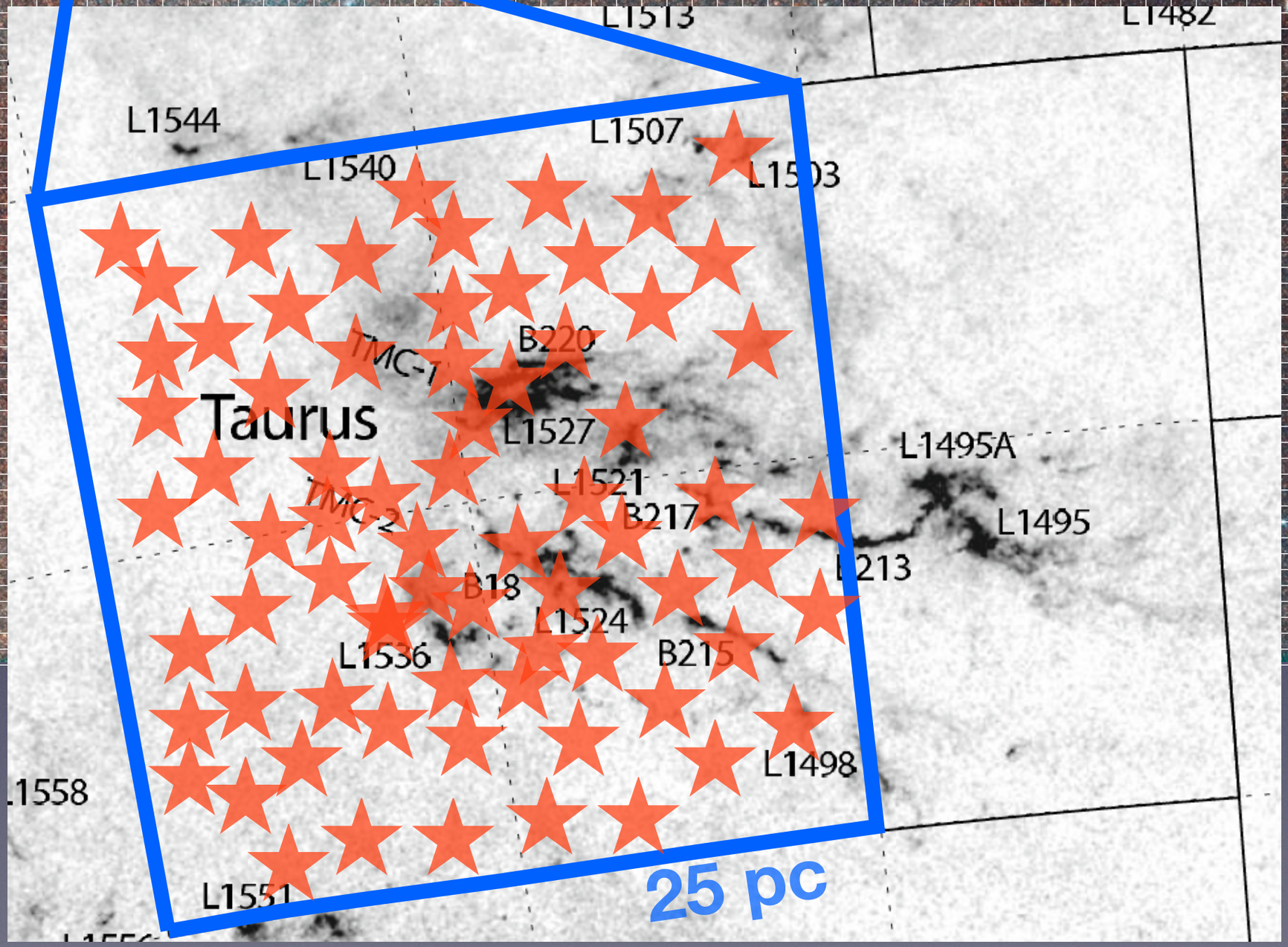
Foreground stars

Background stars

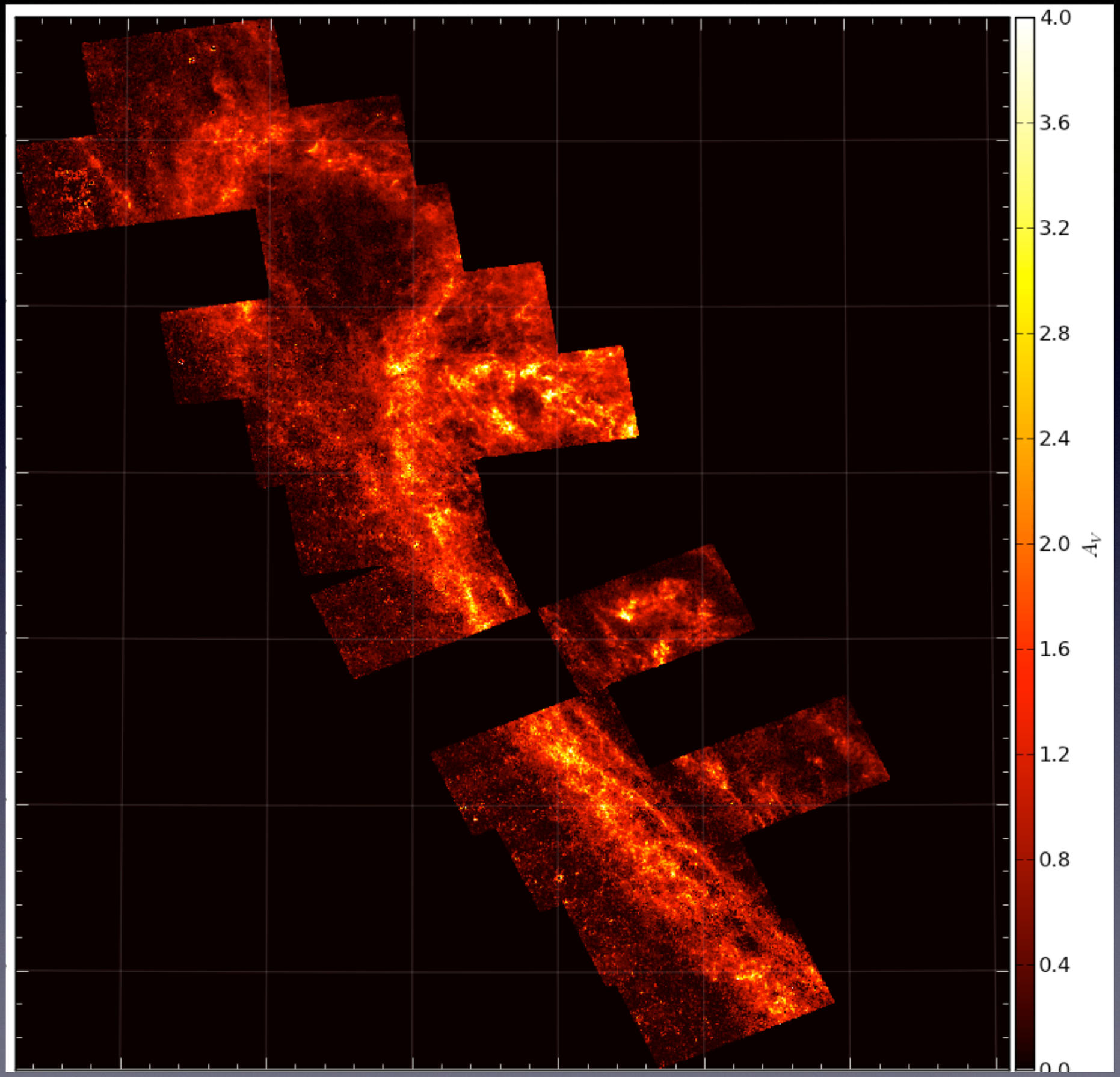
M31 PHAT Brick 15

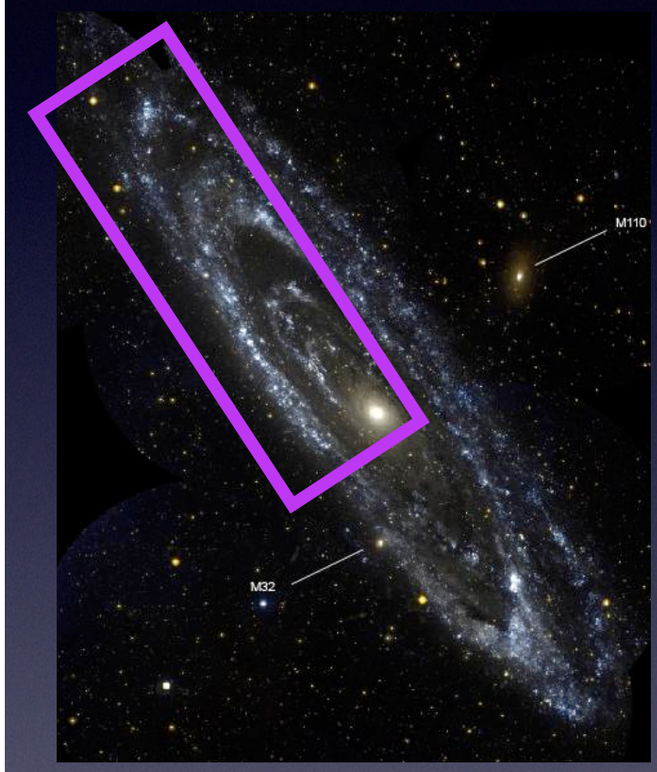
WFC3/UVIS F275W
WFC3/UVIS F475W
WFC3/UVIS F814W
WFC3/IR F160W

6.6” = 25 pc
pixels

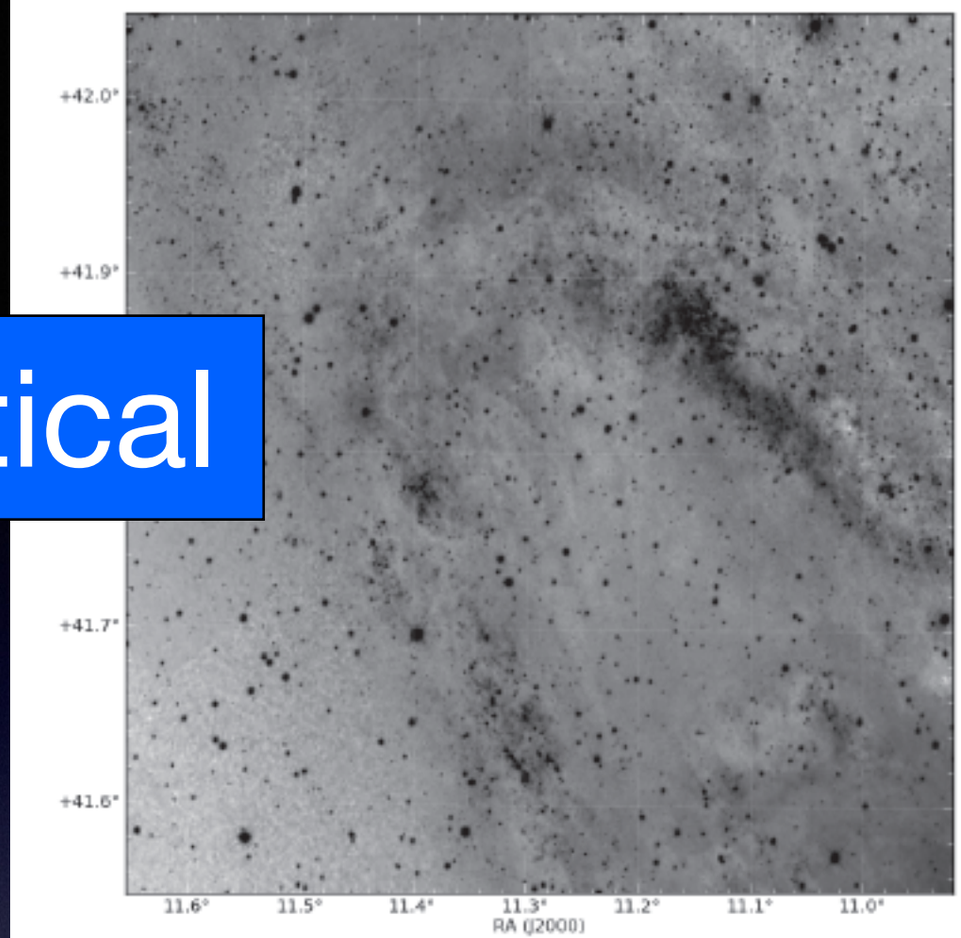


2MASS Extinction map: Lombardi et al 2010

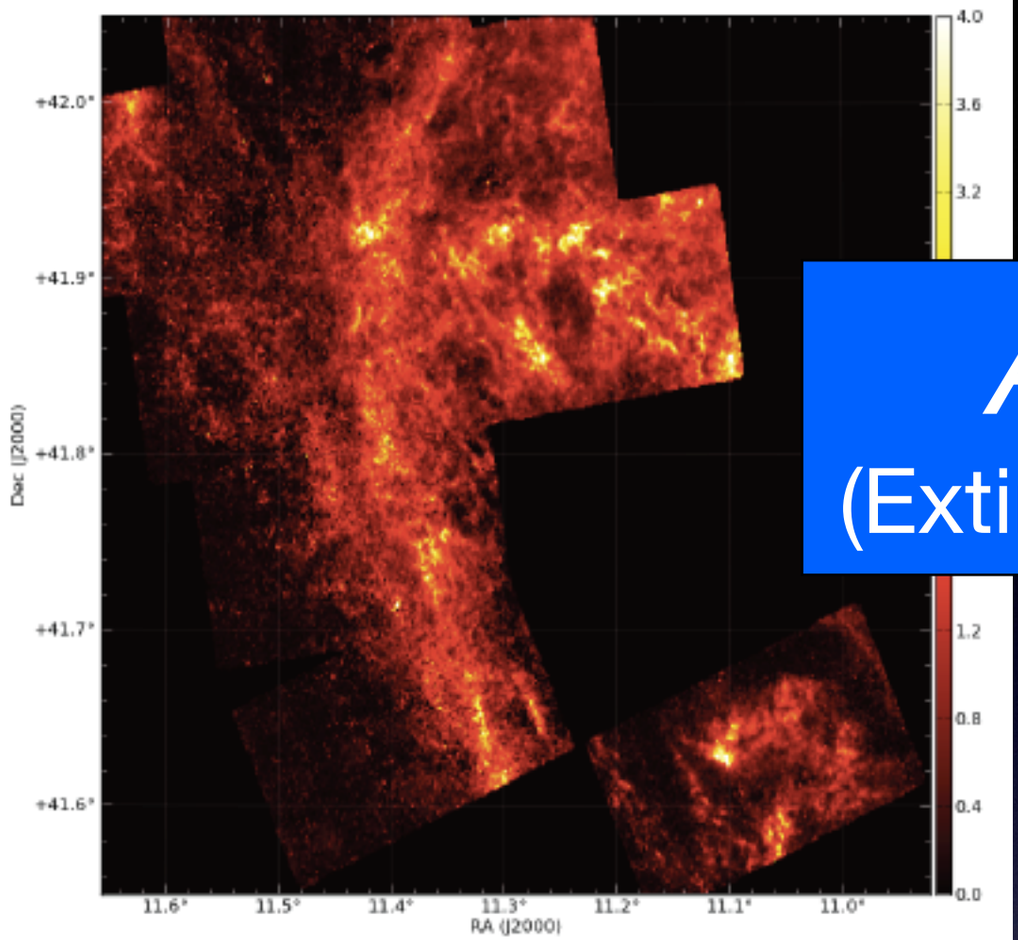




Residual structure: 1.5% flat fielding errors in WFC3/IR!

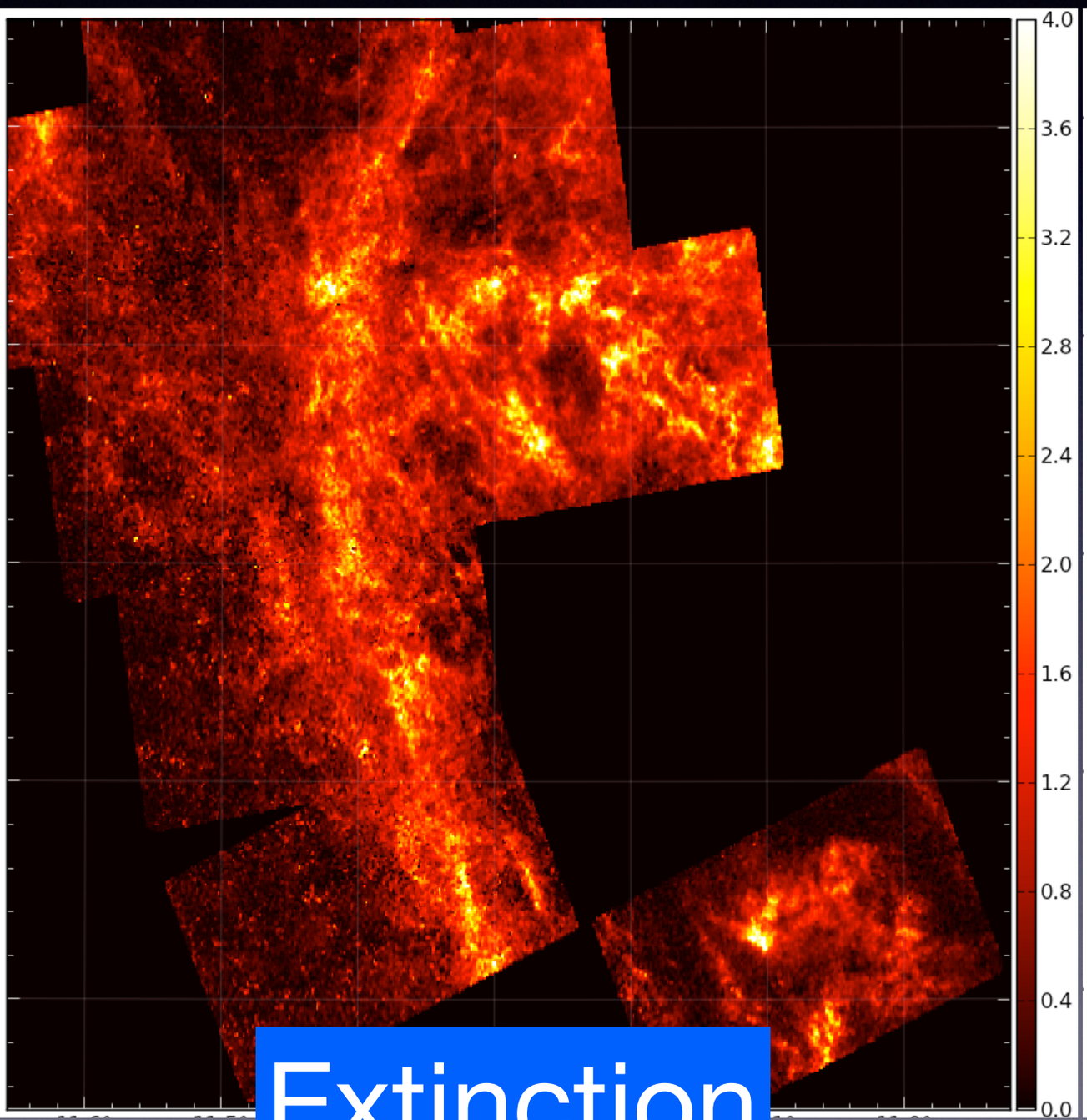


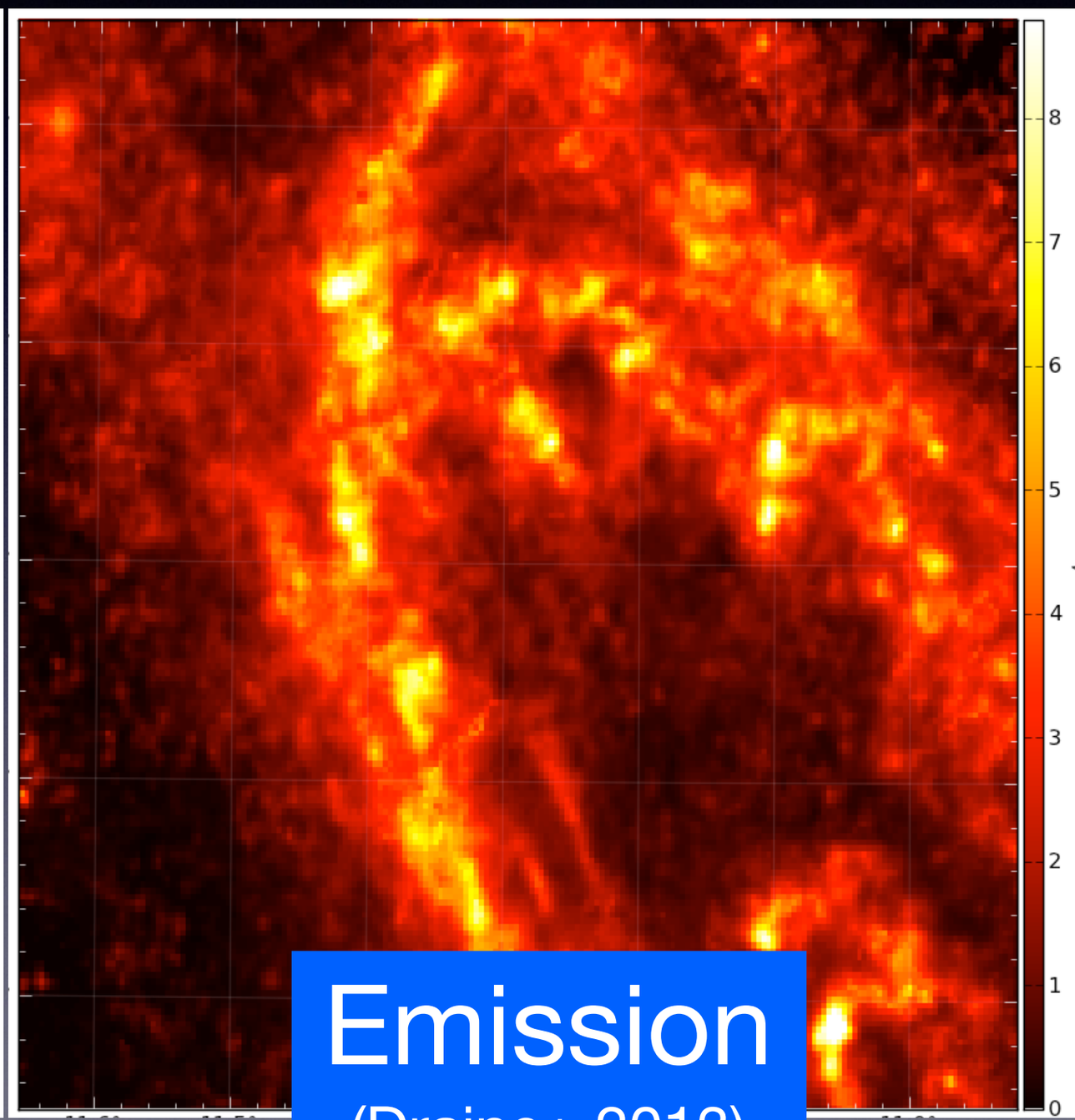
Optical



A_V (Extinction)

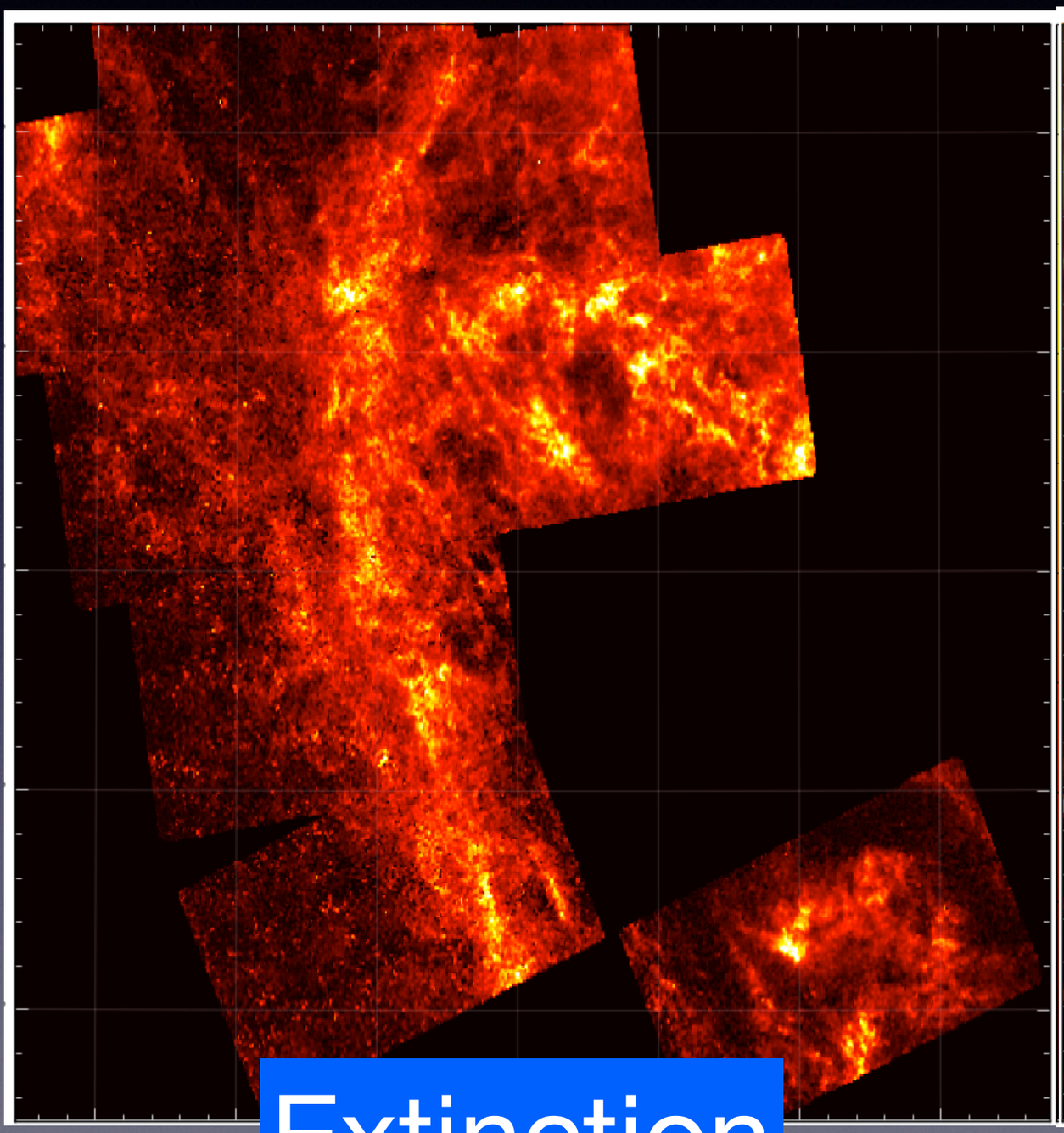
Superb Agreement w/ Dust Morphology from Emission



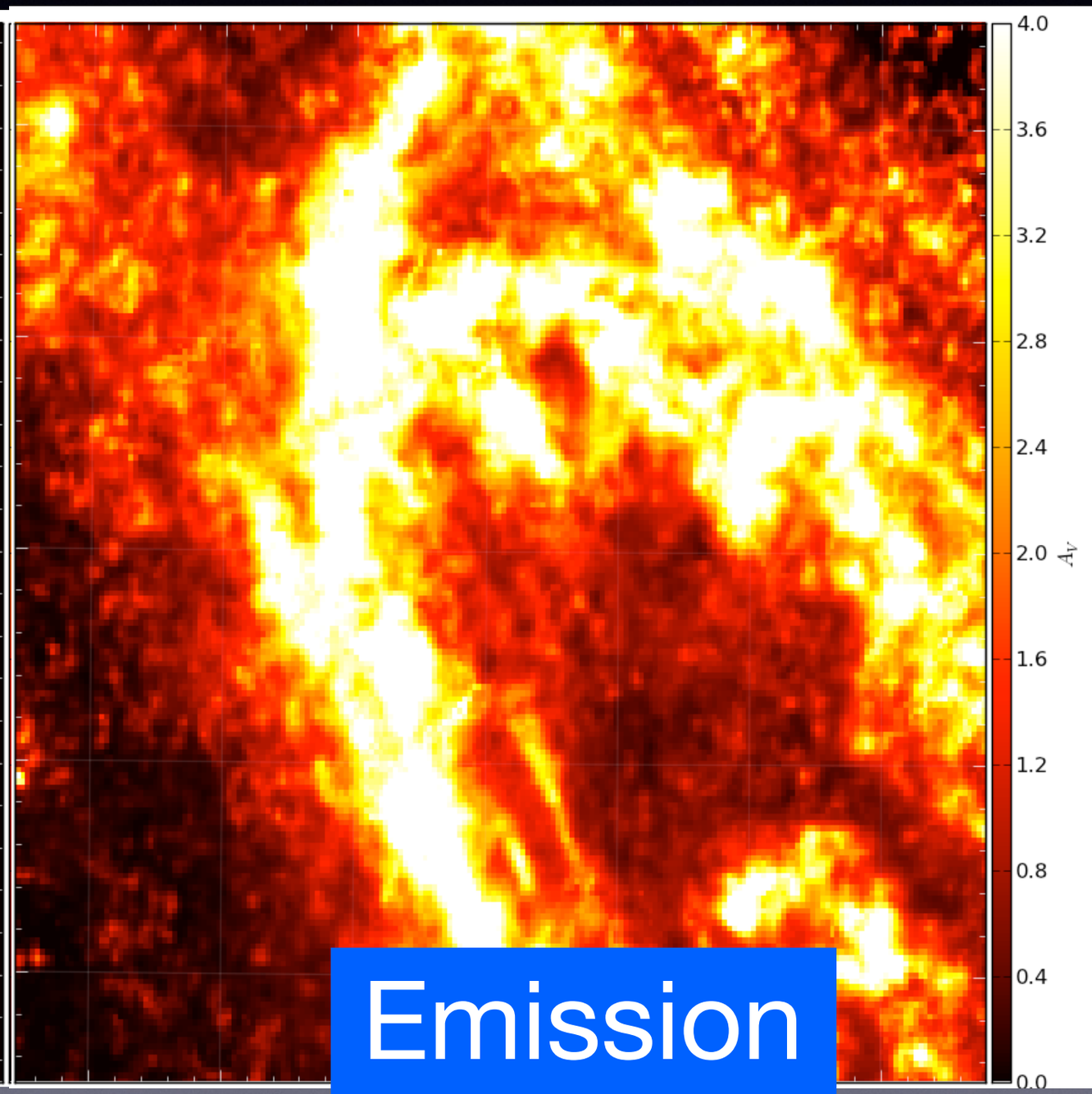


But, normalizations don’t agree.

Emission-based dust masses high by factor of ~2

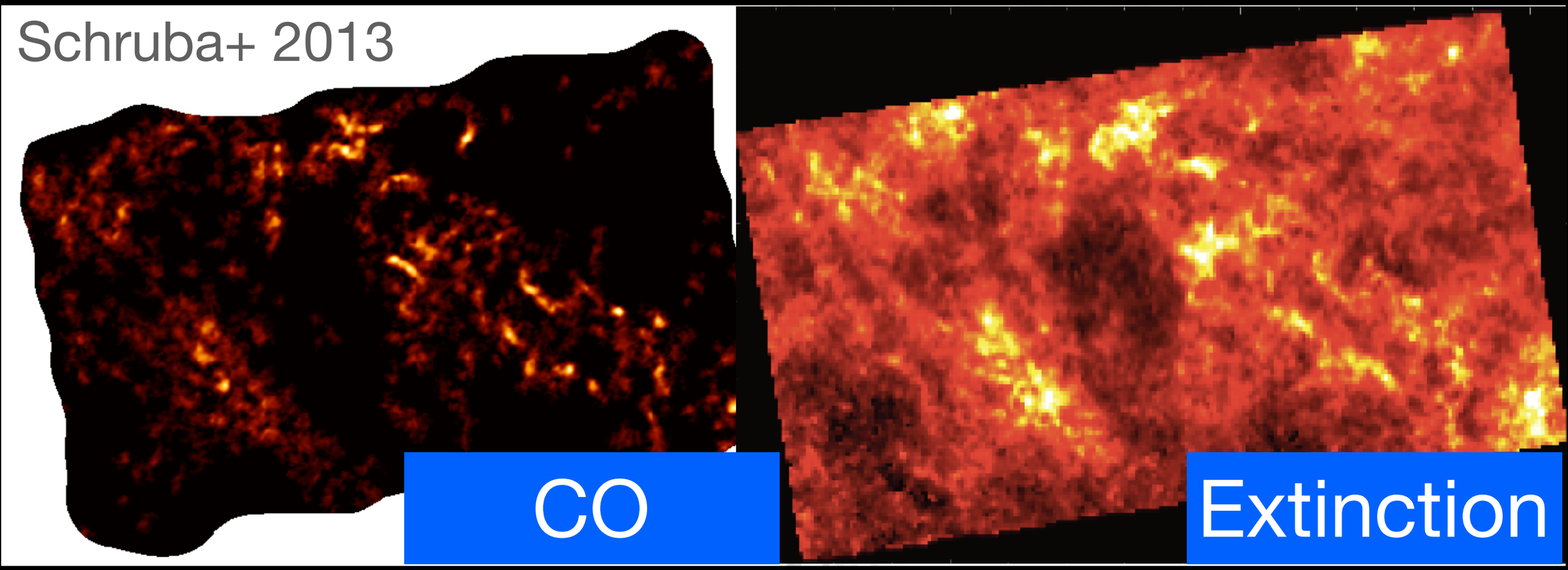


Extinction

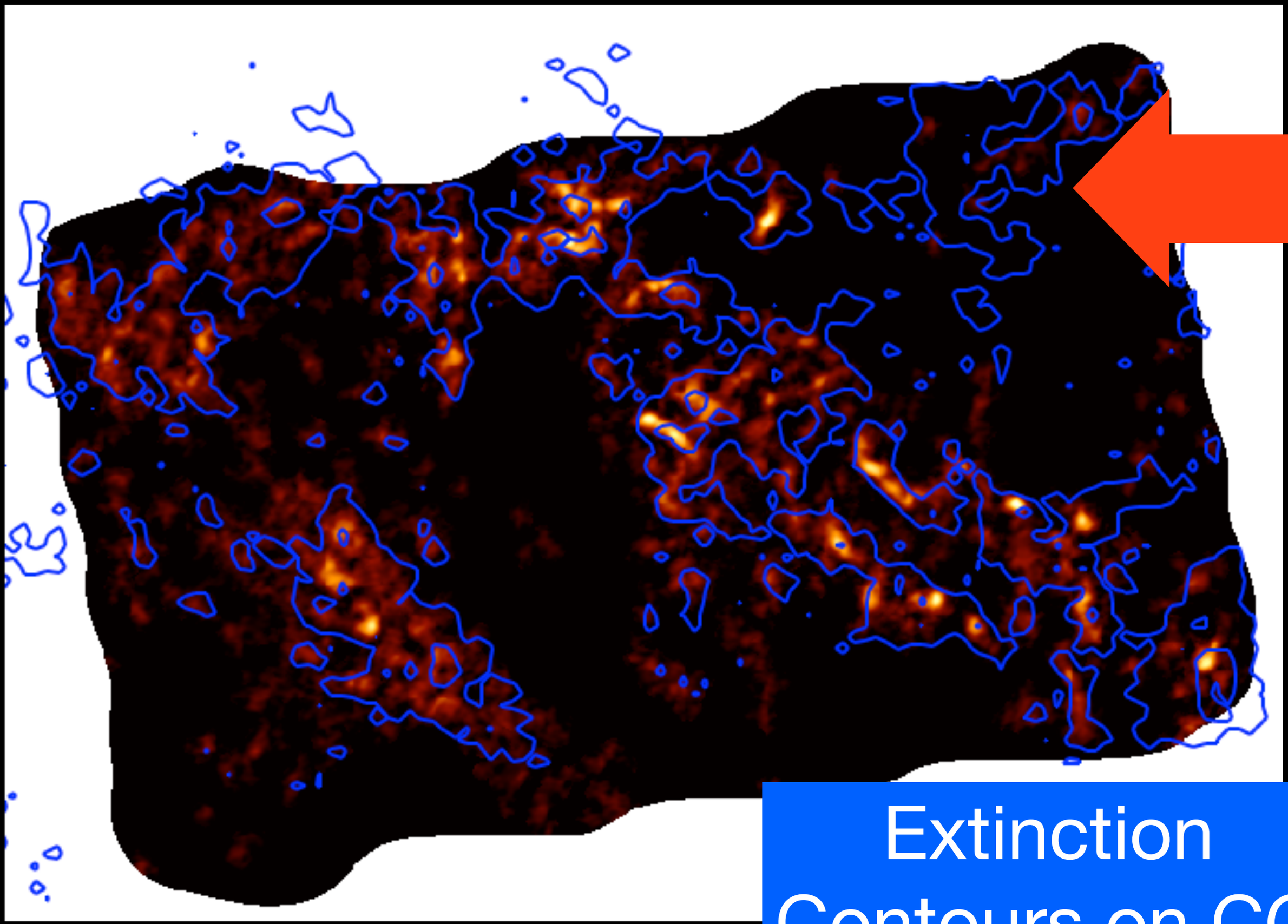


Emission
(Draine+ 2013)

Comparison w/ CO

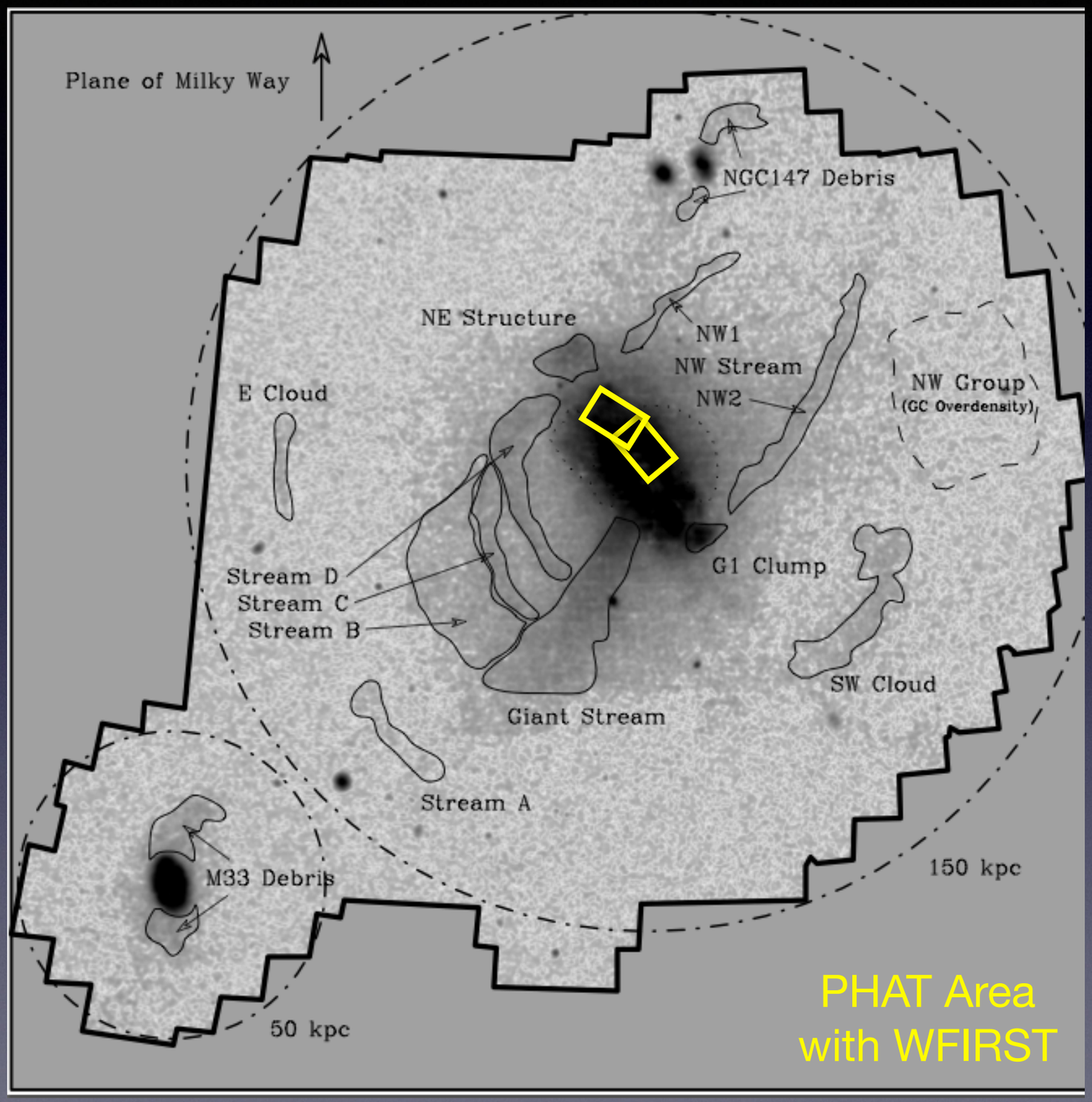


- General morphological agreement
- But not perfect....

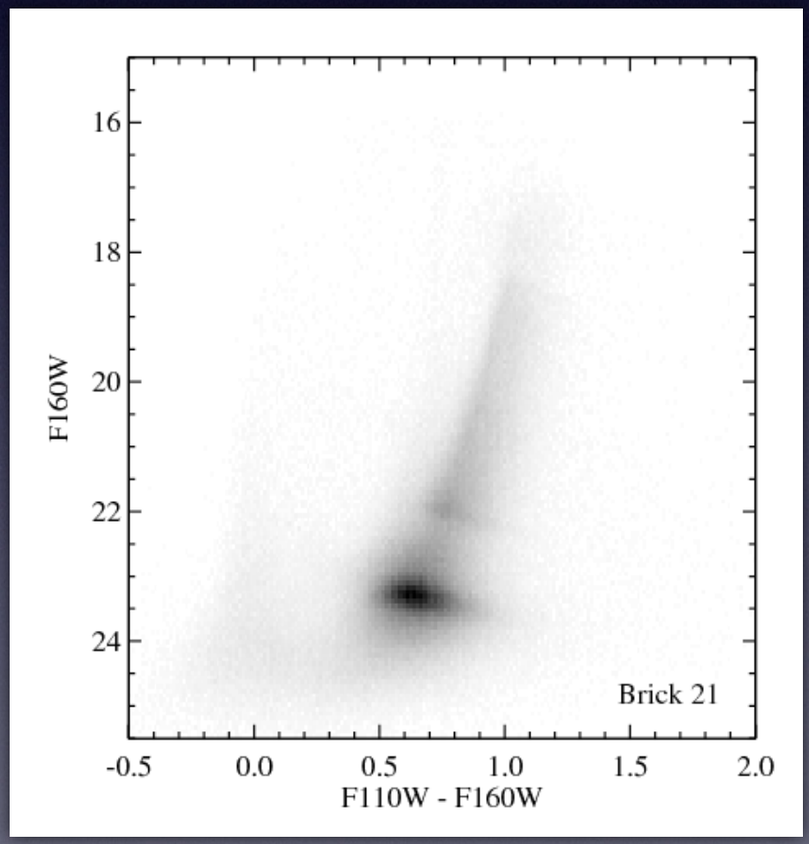


Extinction
Contours on CO

Mapping M31 with WFIRST



PHAT Depth CMDs
in ~5000s



PANDAs Survey: McConnachie+

Summary

- Near-IR: efficient for (luminous) cool stars
- Potentially Transformative Science in LG:
  - IMF and low-mass stars outside the MW
  - complete census of luminous cool stars
  - ISM, dust mapping, dust tomography
  - large scale mapping of accretion in M31
  - Inner MW, deeper into the disk and halo
  - find and characterize dwarf galaxies and halos
  - proper motions and internal stellar kinematics
- Good potential synergy with future high resolution imaging