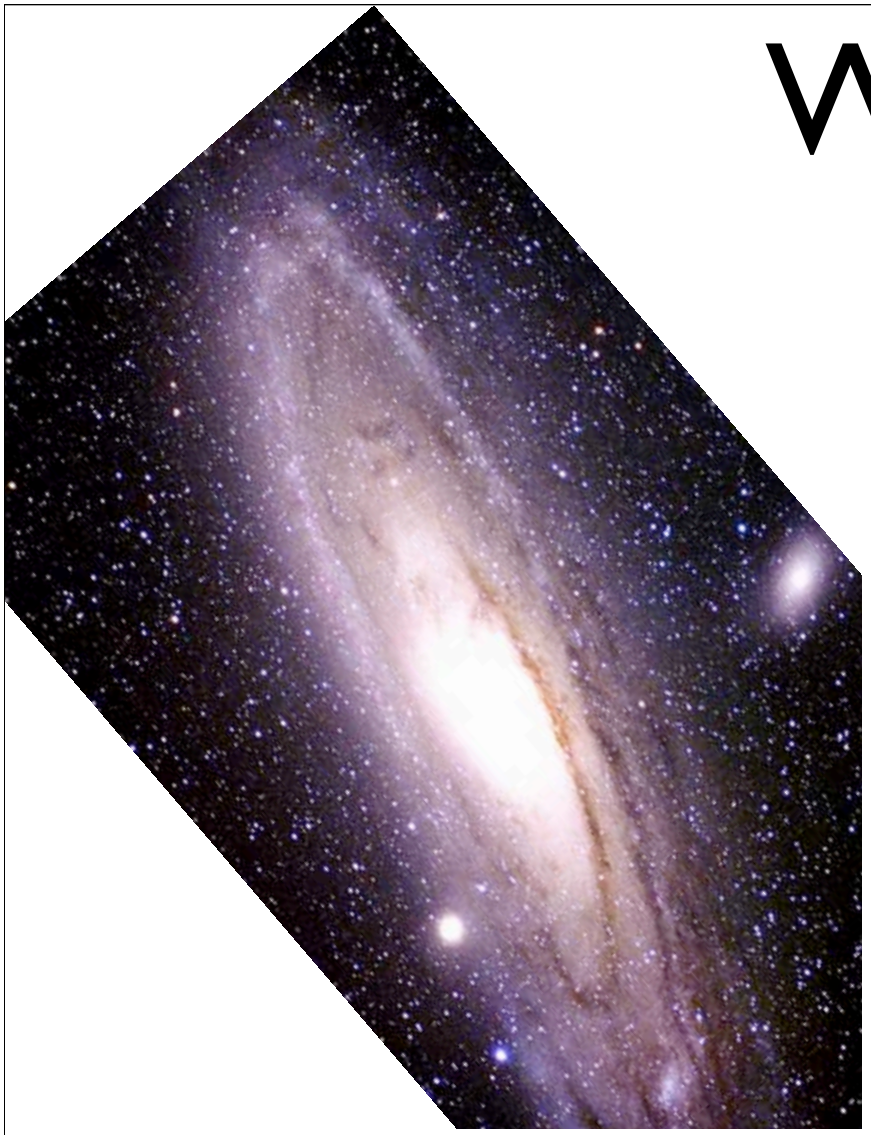
The Panchromatic Hubble Andromeda Treasury

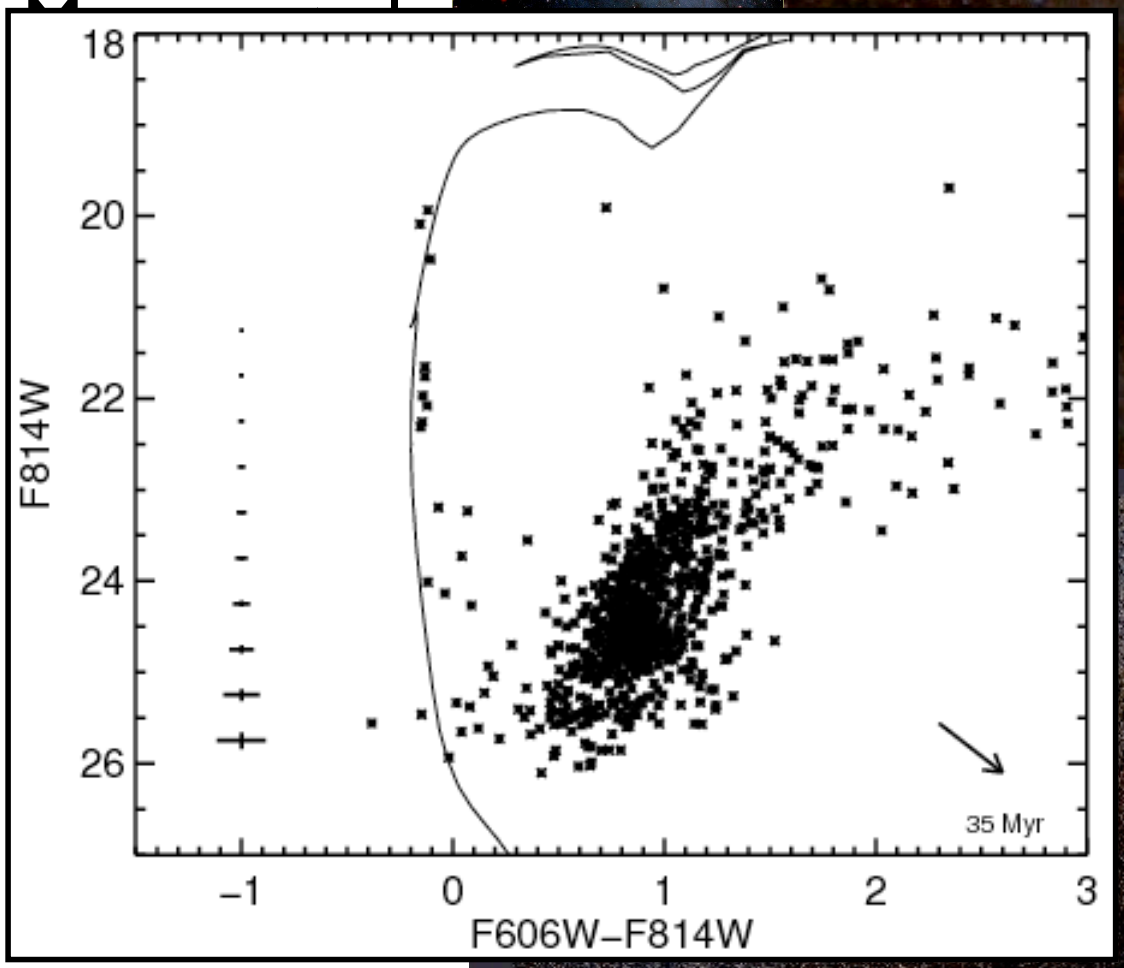


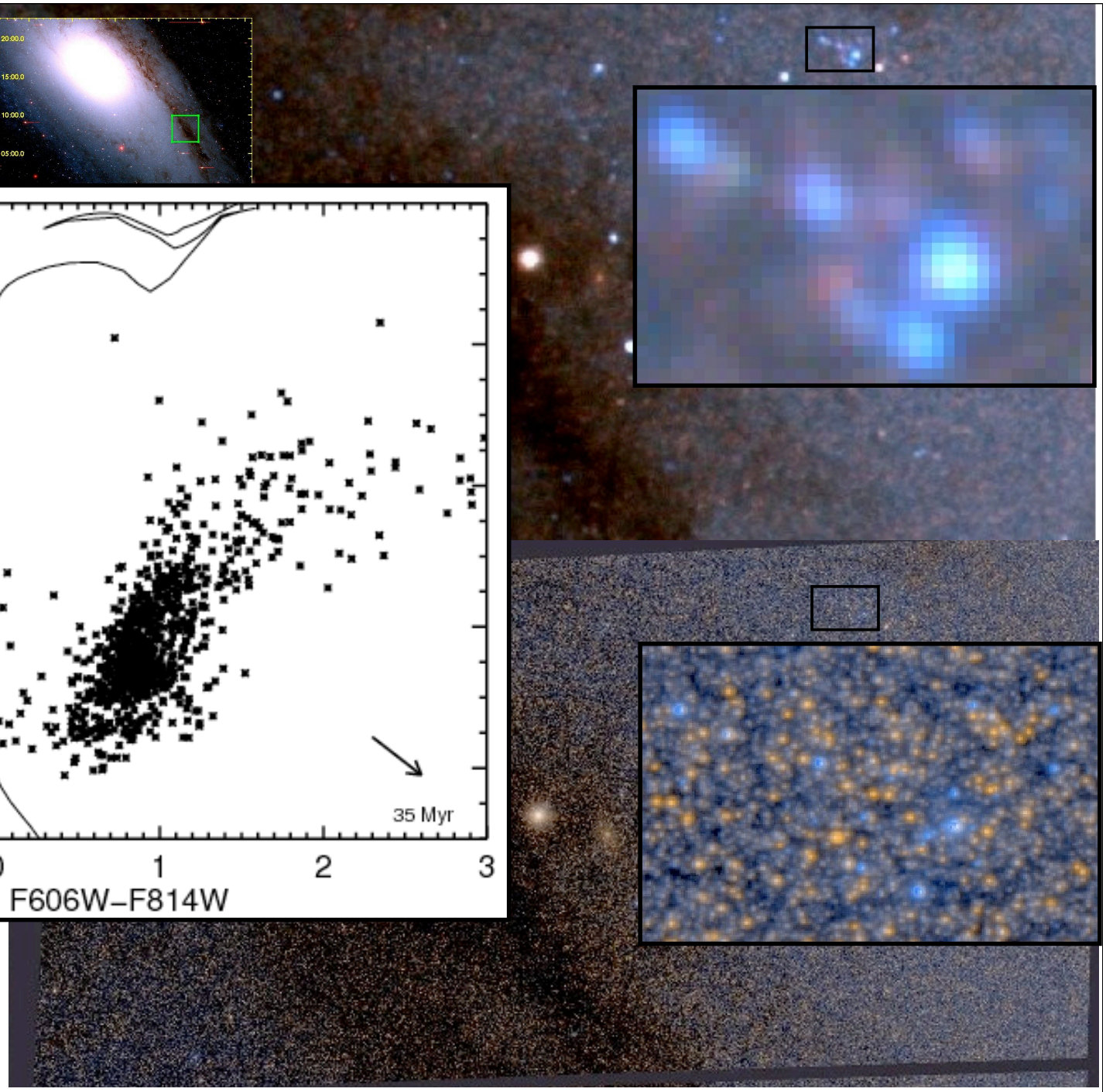
Why HST+M31?

- Millions of stars at a common distance, with *known environments*
- Rich existing catalogs & coverage
- Wide range of [Fe/H], reaching super-solar

Add a high metallicity, massive galaxy anchor to LMC/SMC

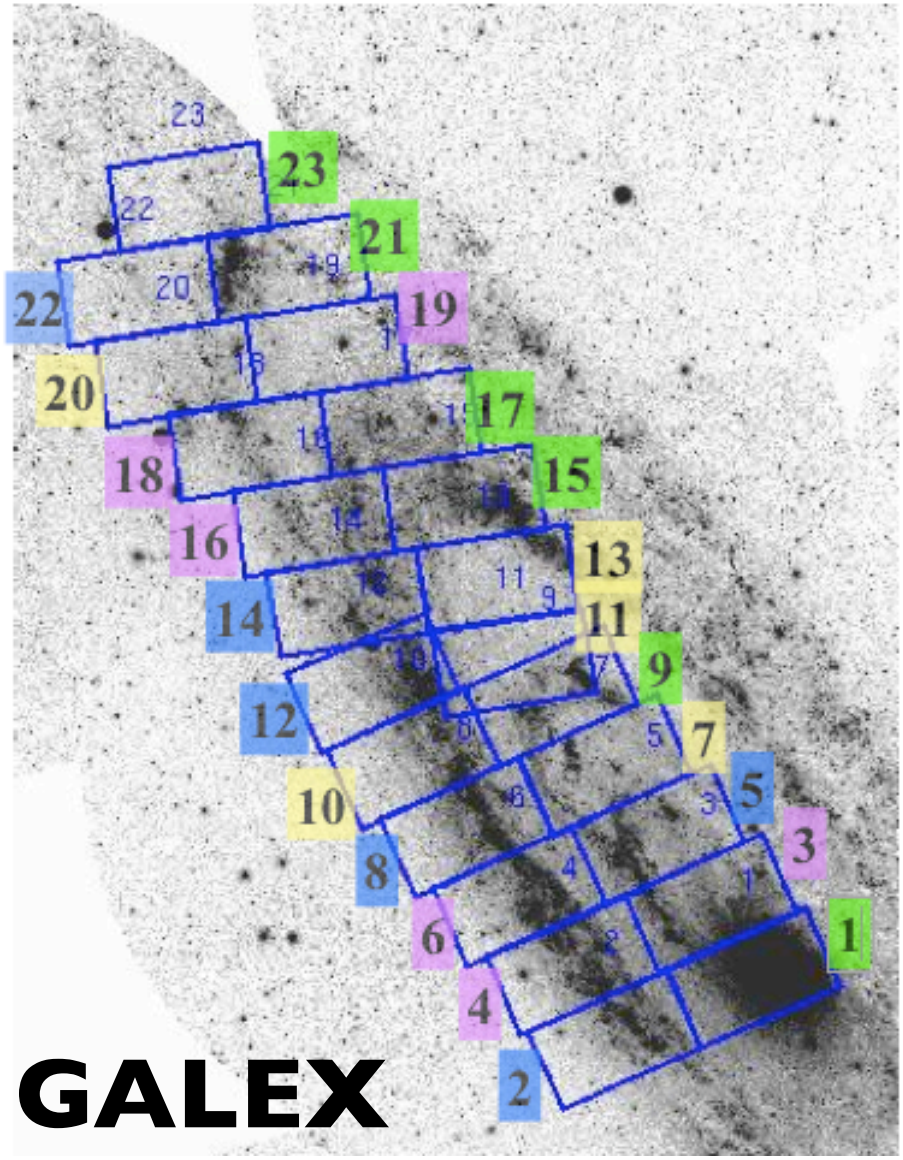
Ground





HST (ACS)

Multi-cycle HST Tiling of M31

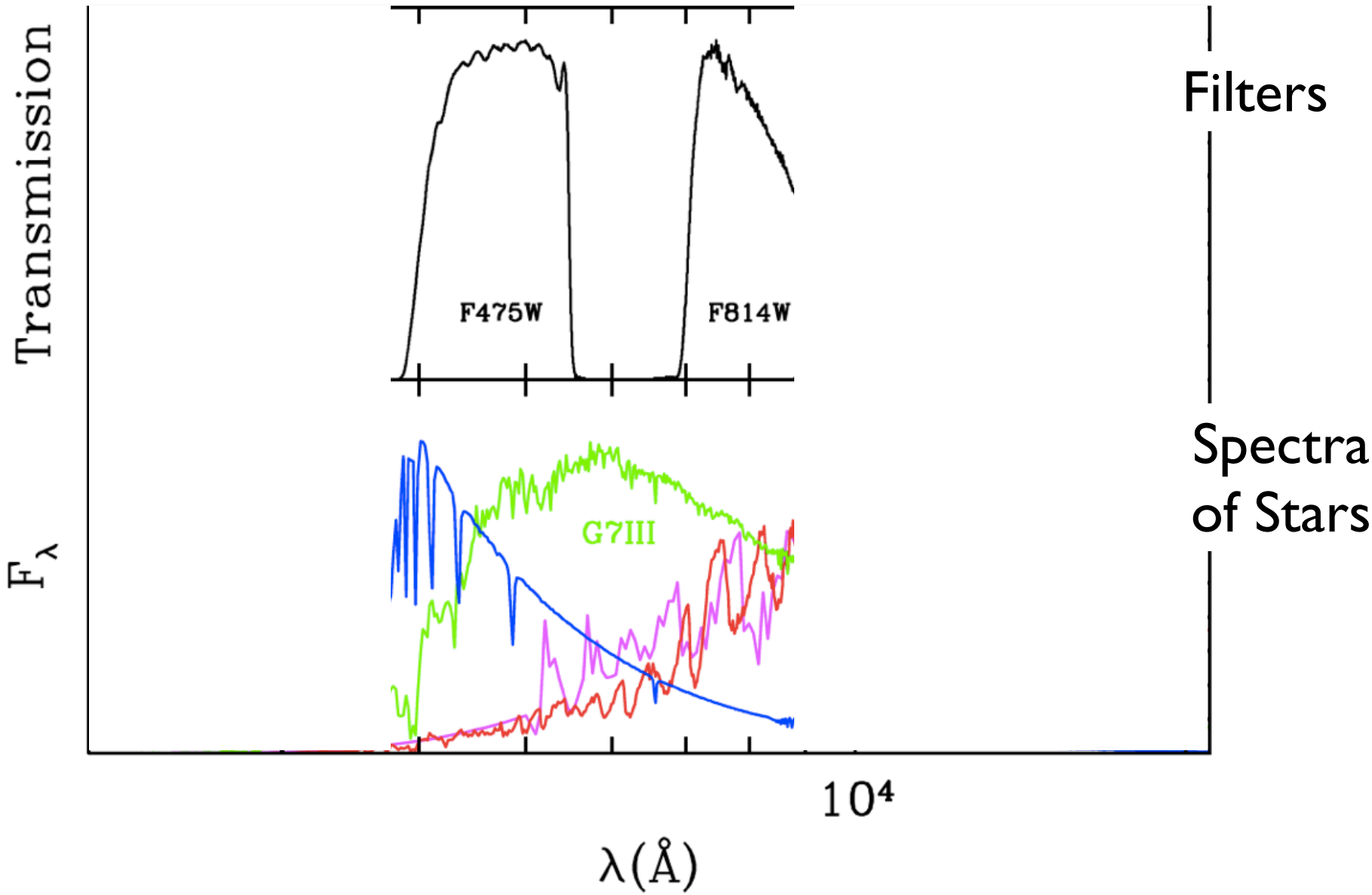


PHAT

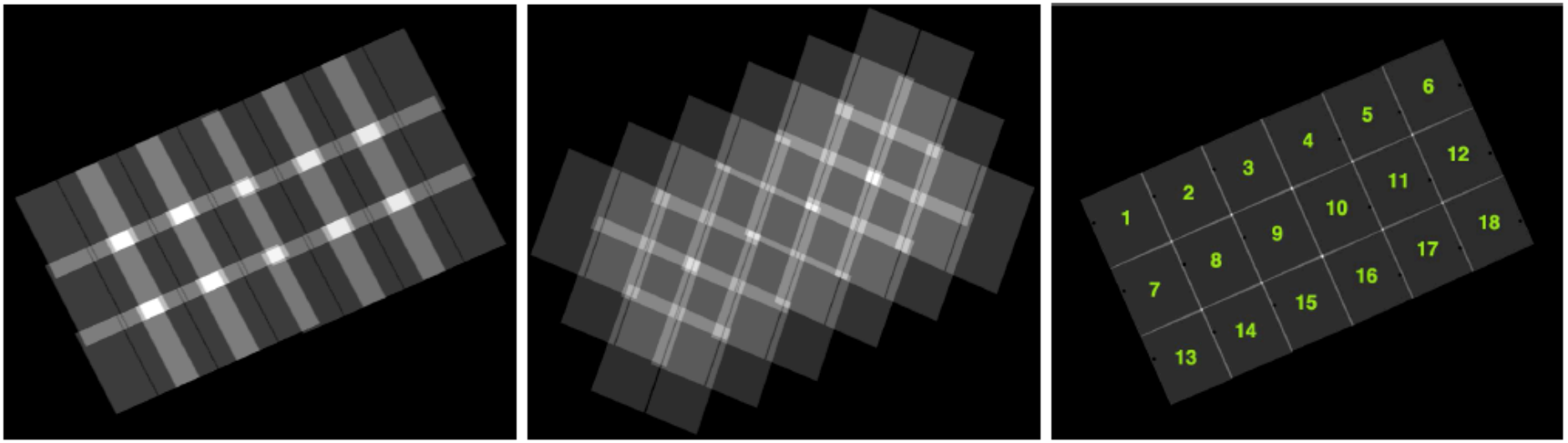
PANCHROMATIC HUBBLE ANDROMEDA TREASURY

- 828 orbits, 4 years
- 6 Filters (UV-NIR)

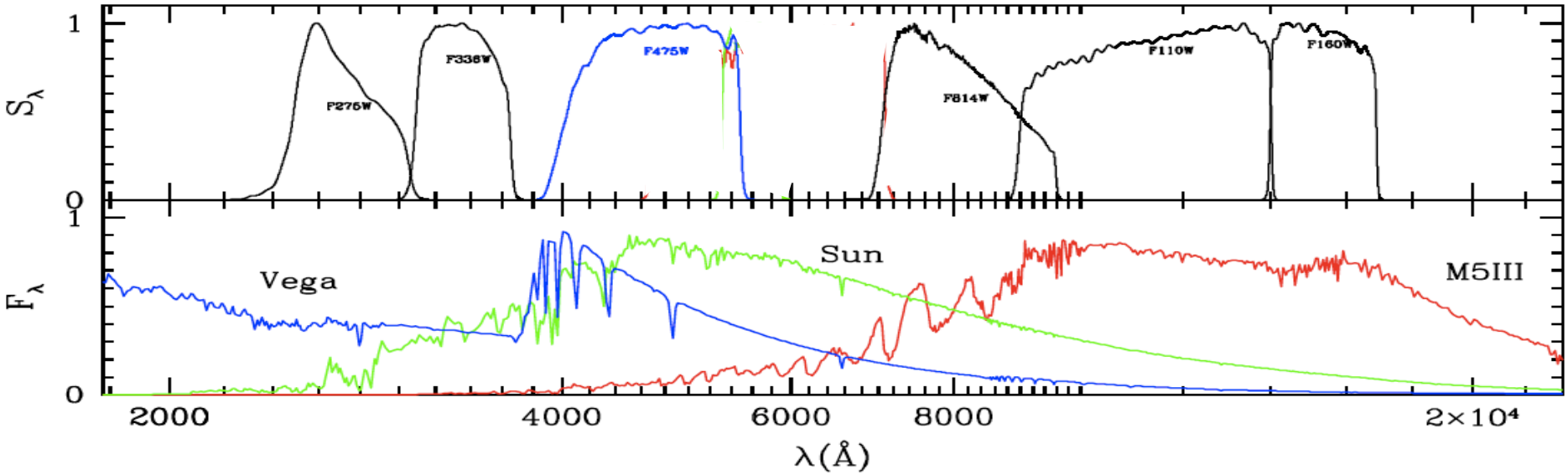
PHAT Filter Set



Observing Strategy (3x6 “Bricks”)

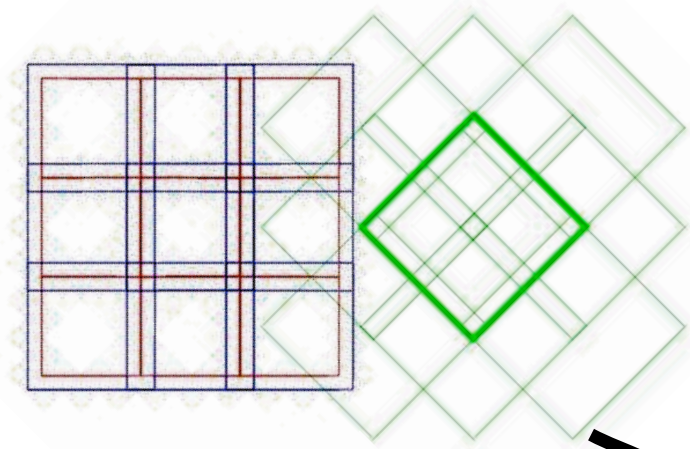


F275W F336W F475W F814W F110W F160W



WFC3/IR +
WFC3/UVIS

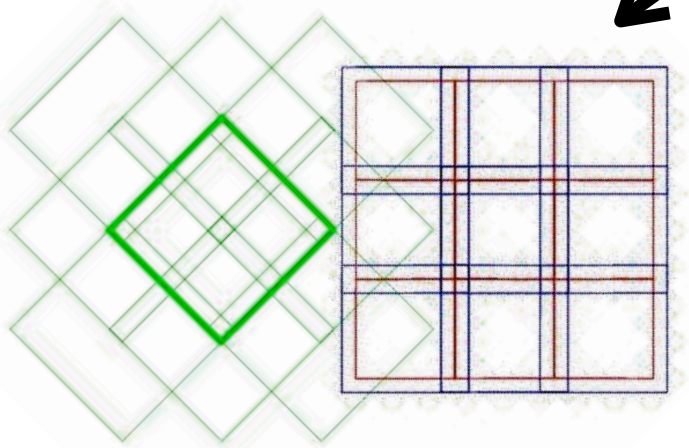
ACS



1.5 kpc x 3.0 kpc
at M31

+

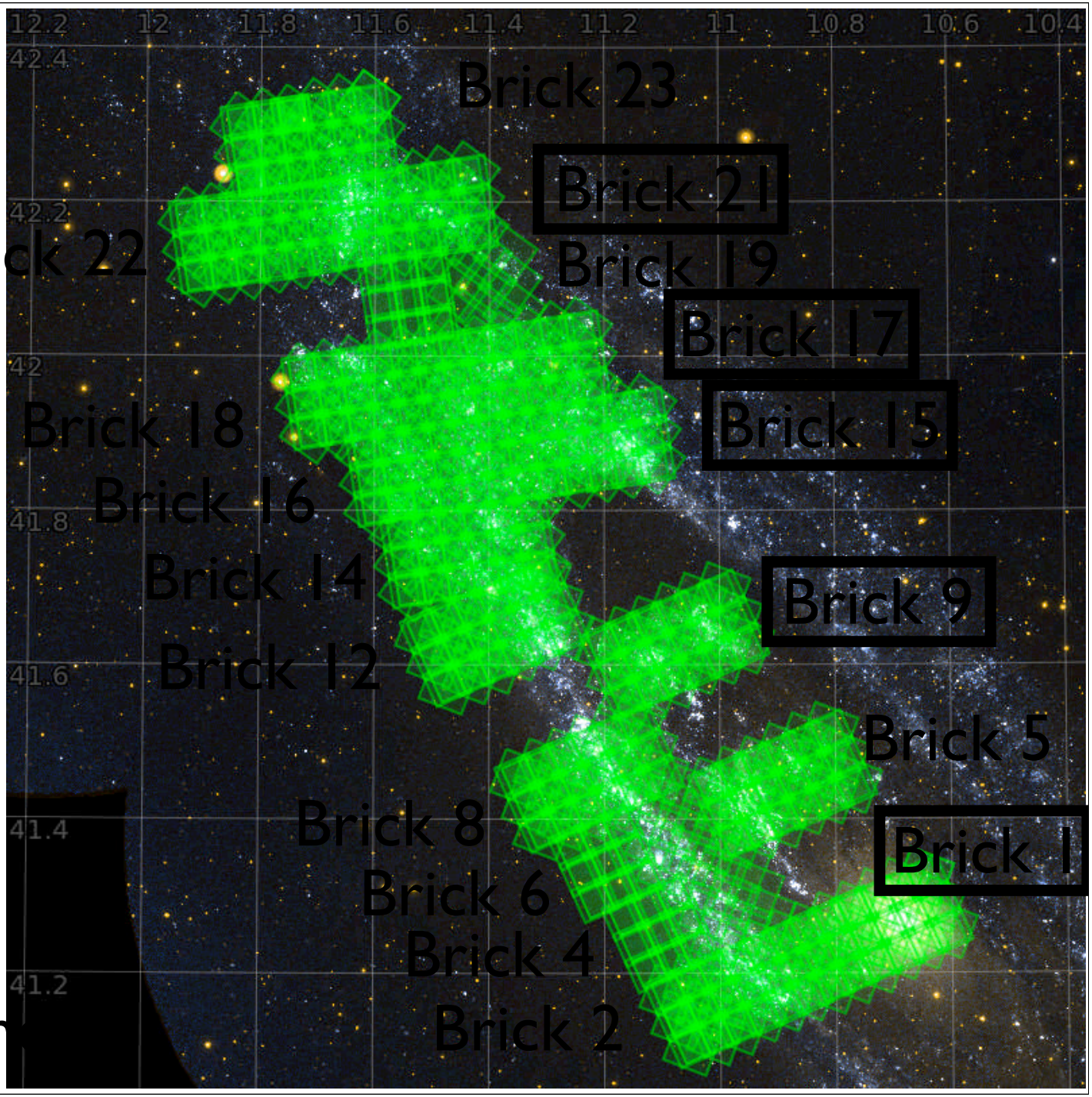
180° flip
(6 Months)



ACS

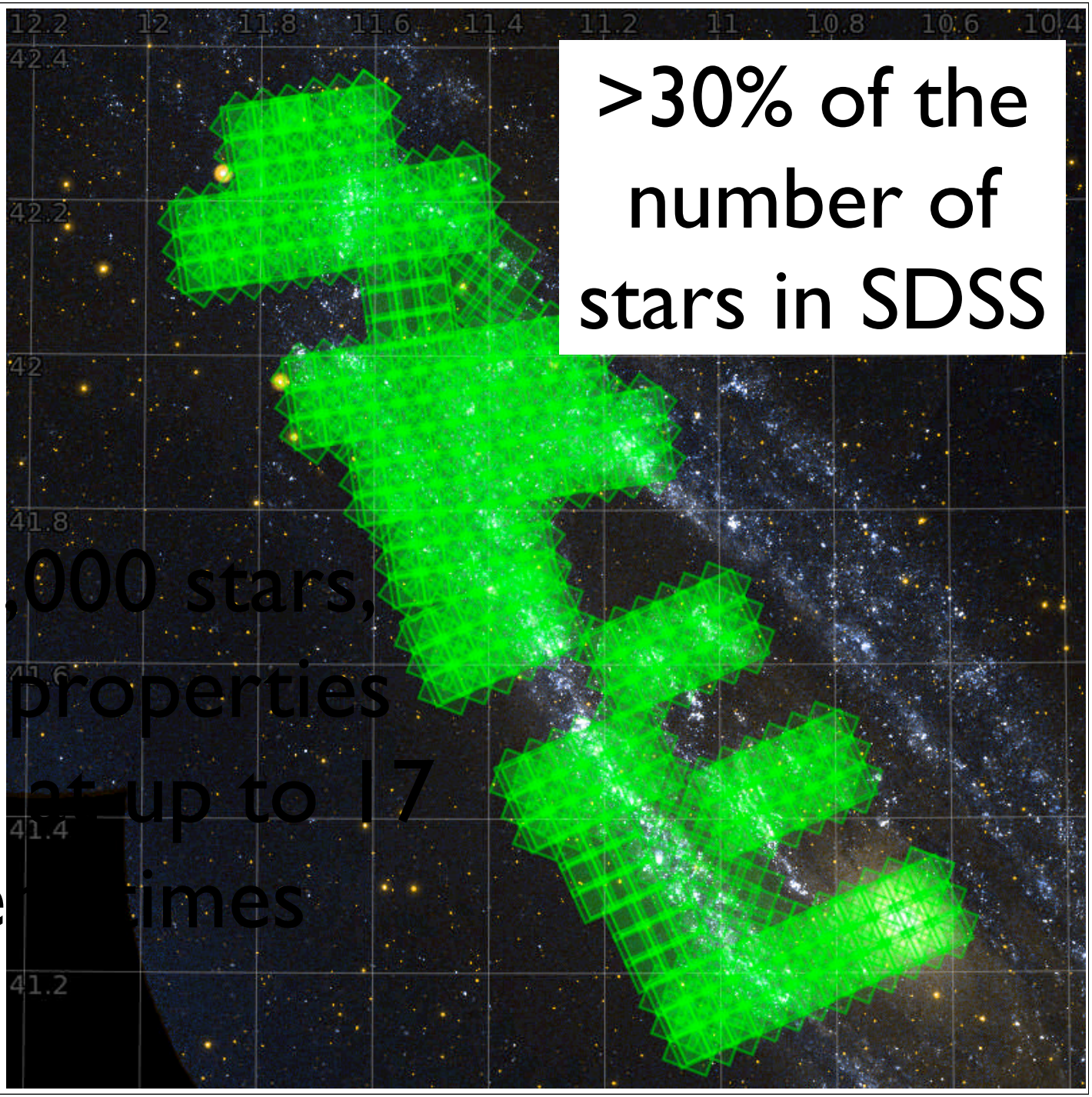
WFC3/IR +
WFC3/UVIS

GALEX
image

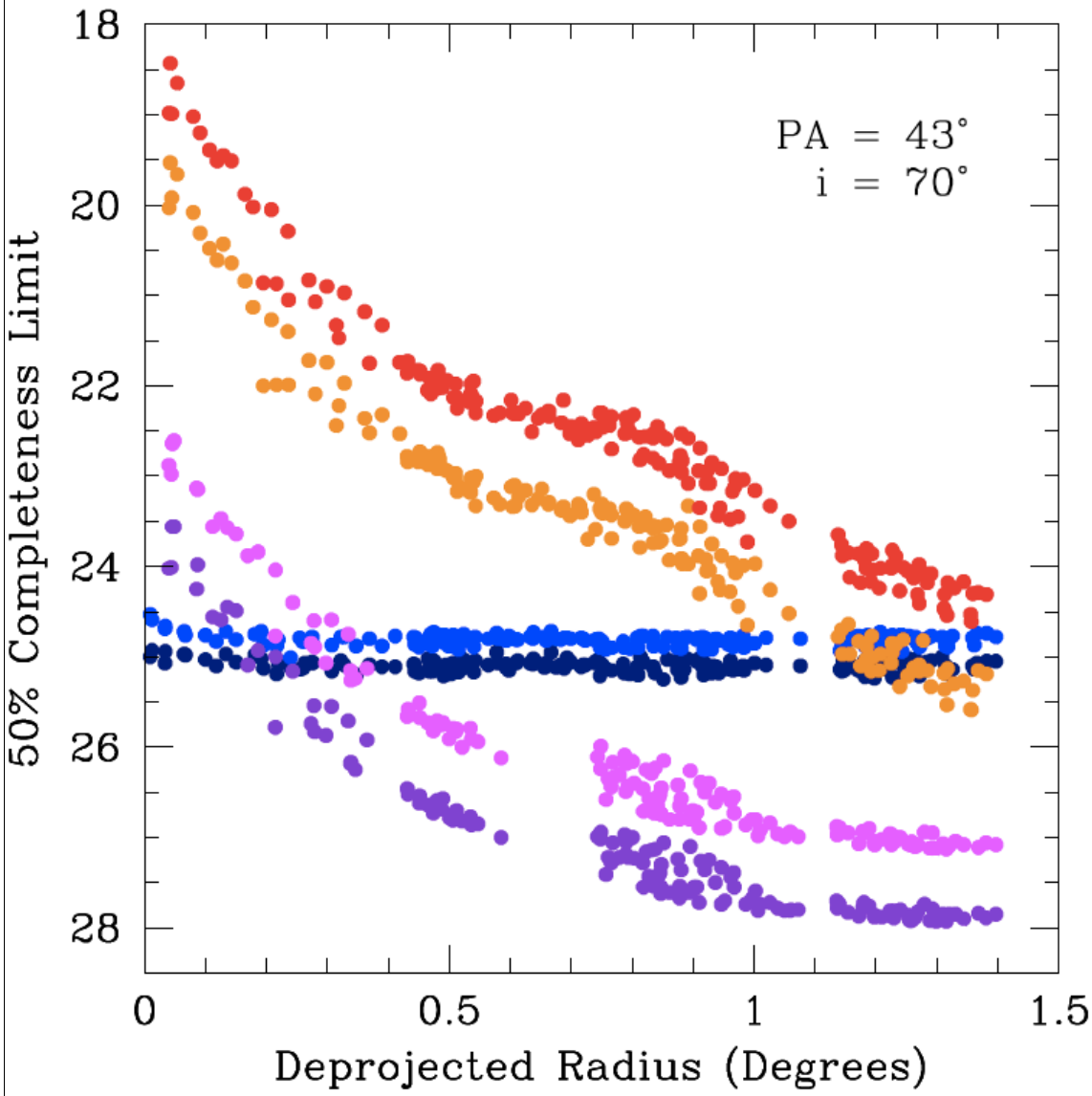


Dustin Lang
Astrometry.n

~90,000,000 stars, multiple properties measured at up to 17 different times



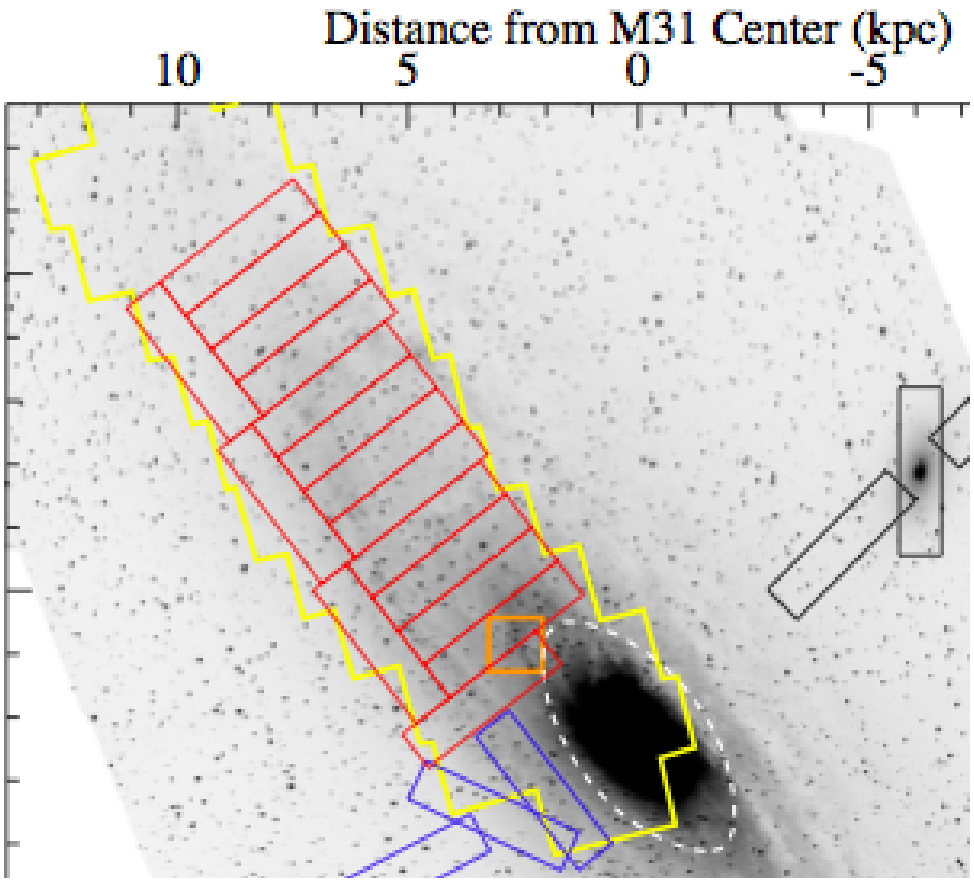
Depth varies with Radius



Crowding limited in NIR & optical

F160W
F110W

F814W
F475W



Extensive DEIMOS Spectroscopy

Claire Dorman
Raja Guhathakurta
Jason Kalirai
Kirsten Howley

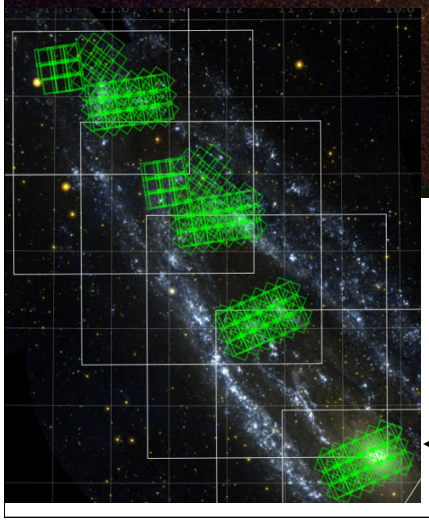
Phase I (complete!):
Primarily AGB/RGB
A few X-Ray Counterparts
A few Candidate PNe

Phase II Targets:
Hot stars (spectral typing)
X-ray, QSO, PNe

See Talks at this meeting

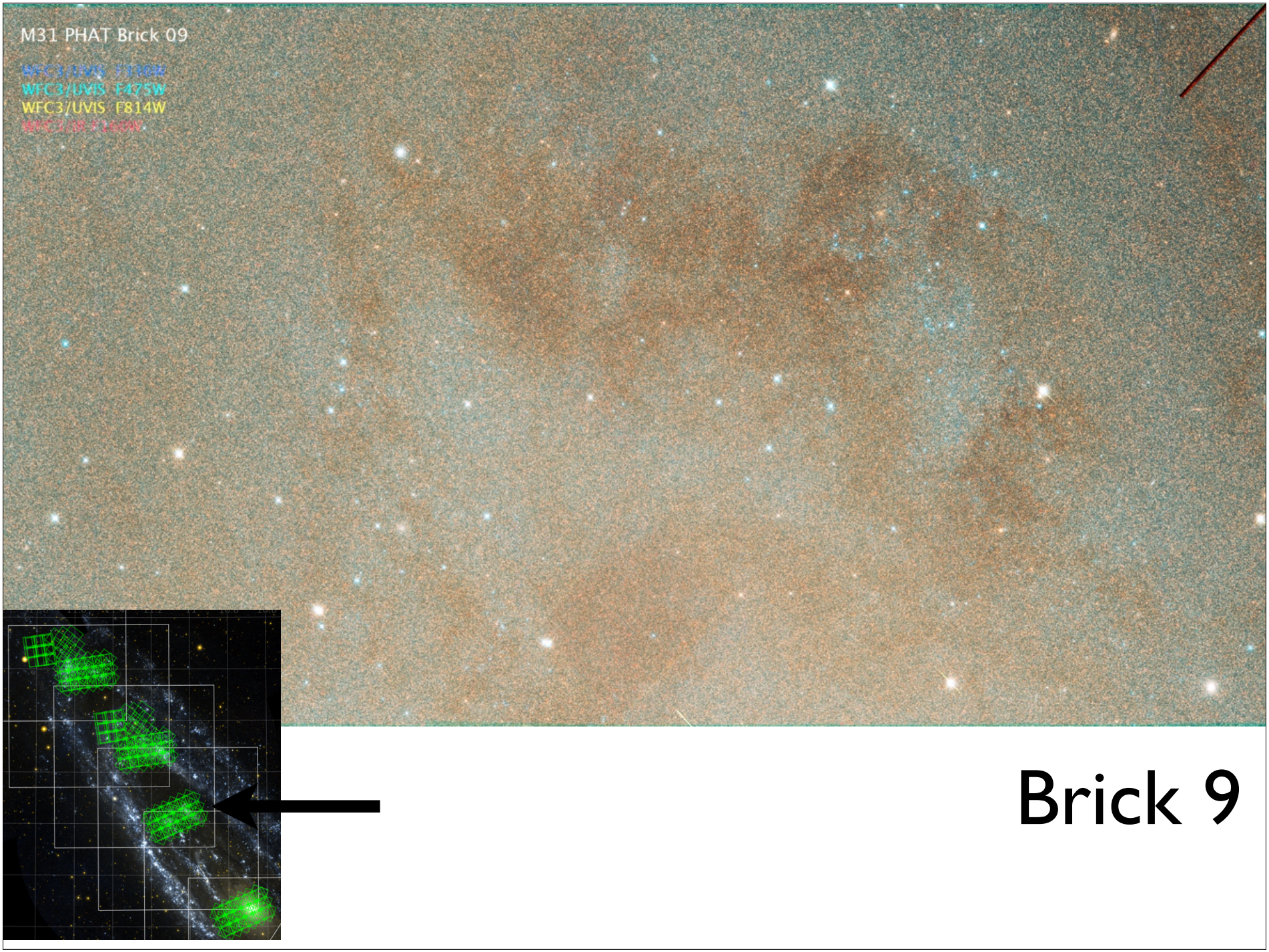
Other supporting spectroscopy:
Skillman, Berg, & Kirby (HII region abundances)
Caldwell (stellar clusters and PNe)

Images by Zolt Levay (STScI)

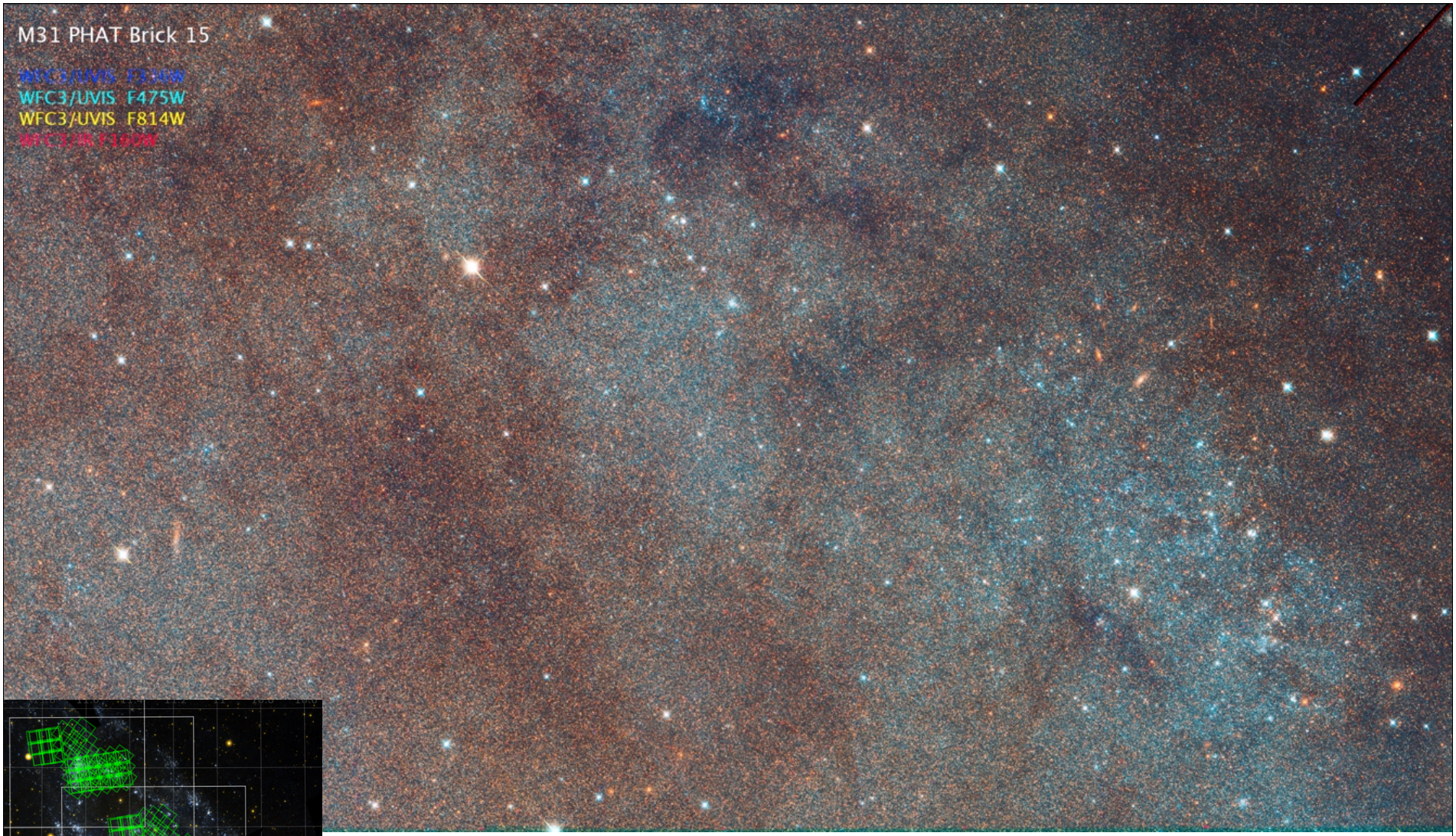


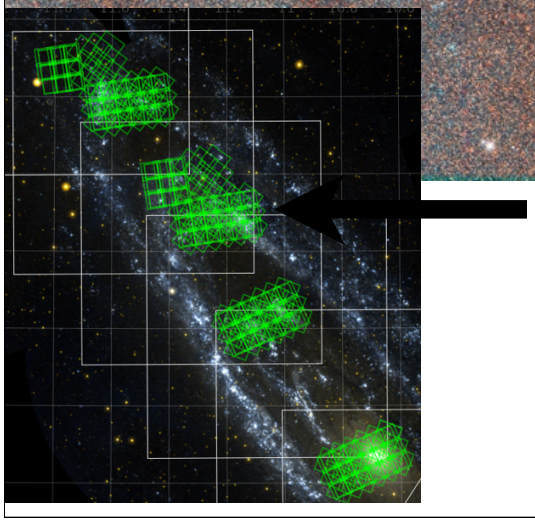
Brick 1

See Poster by Hui Dong on dust

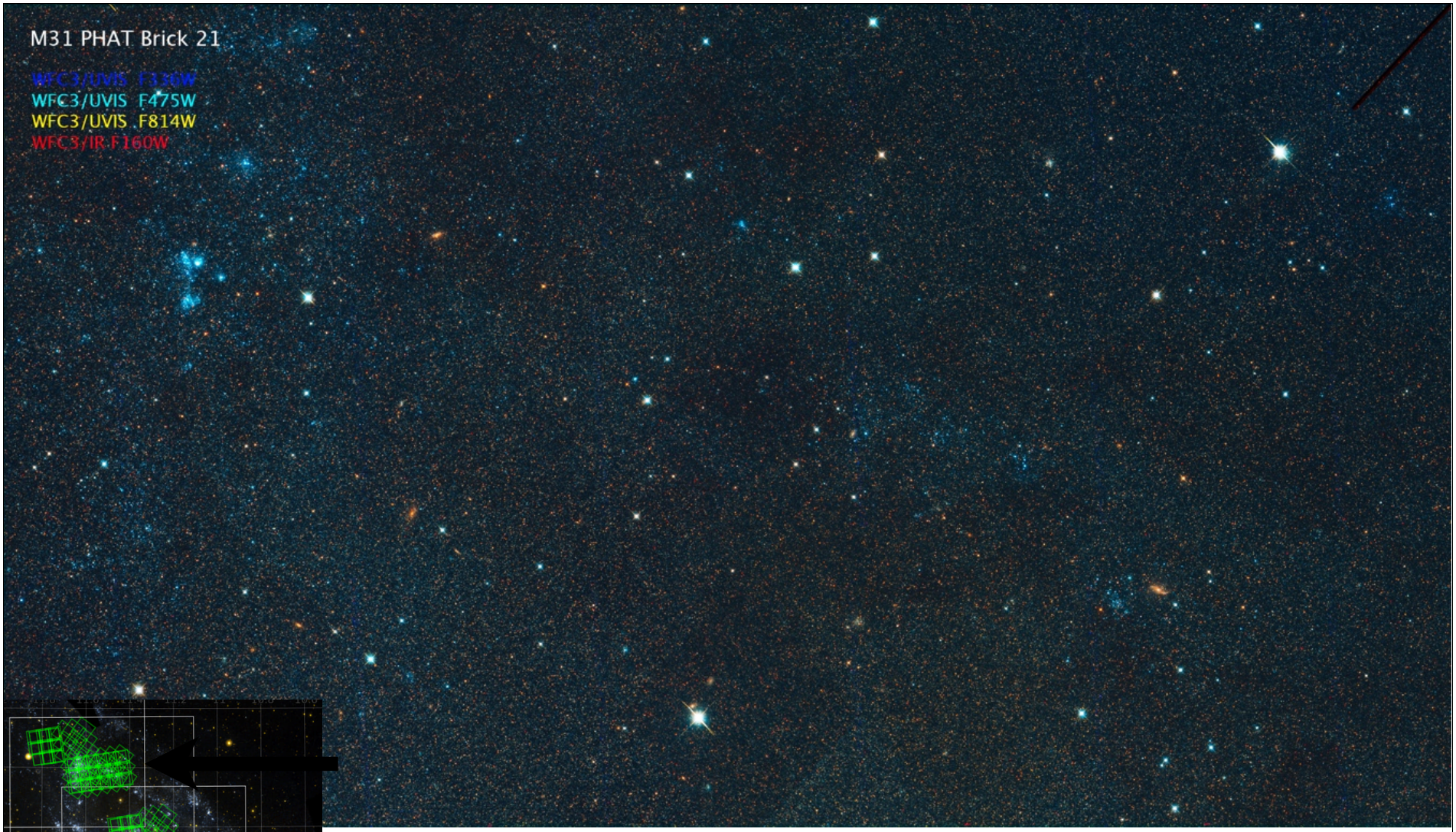


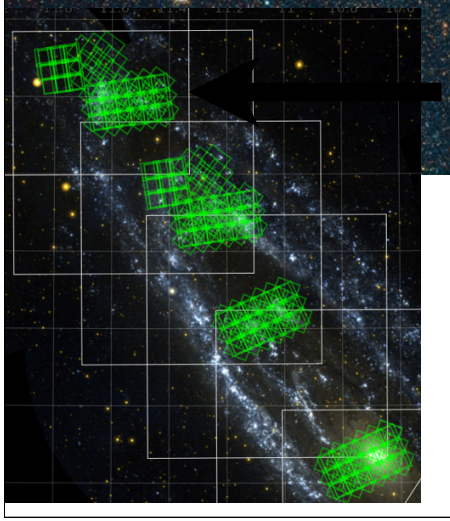
Brick 9



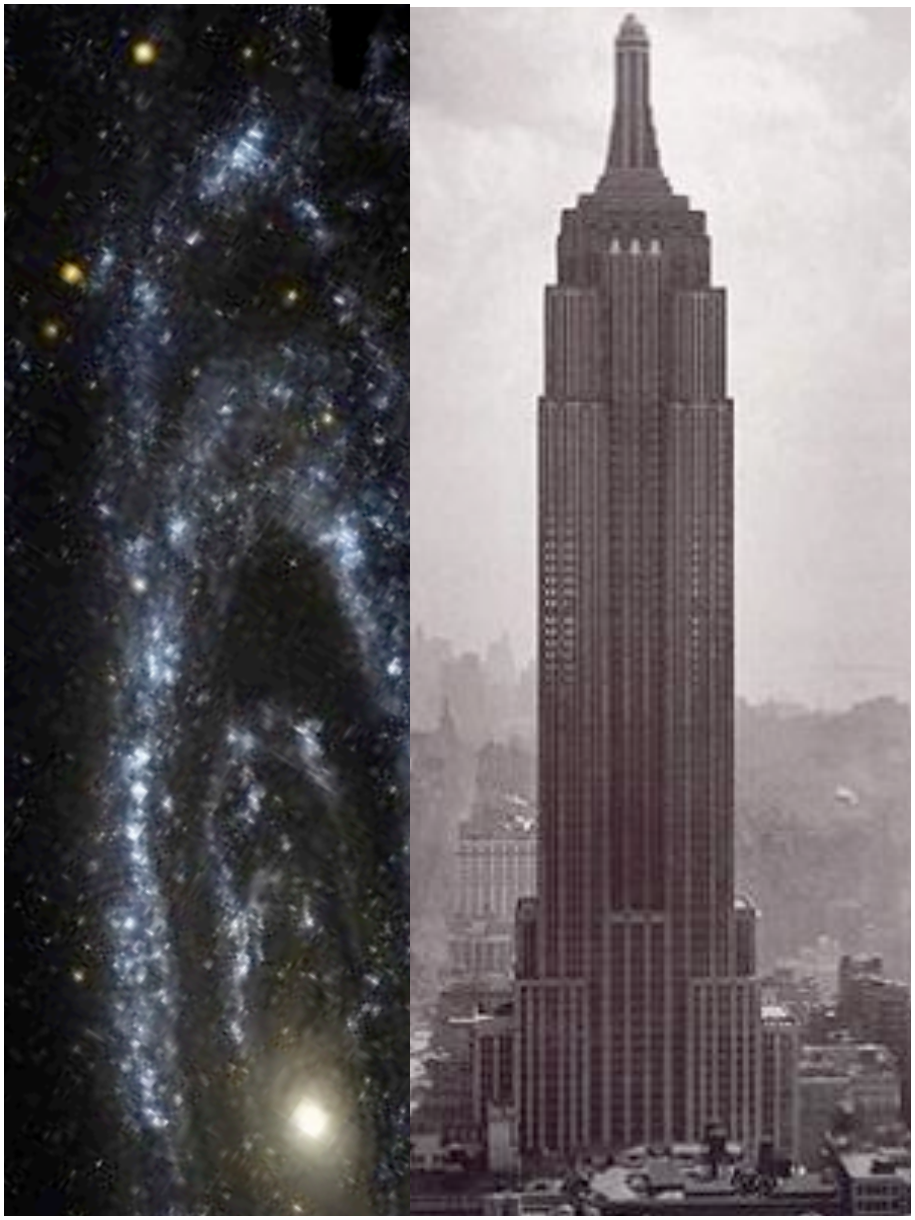


Brick 15

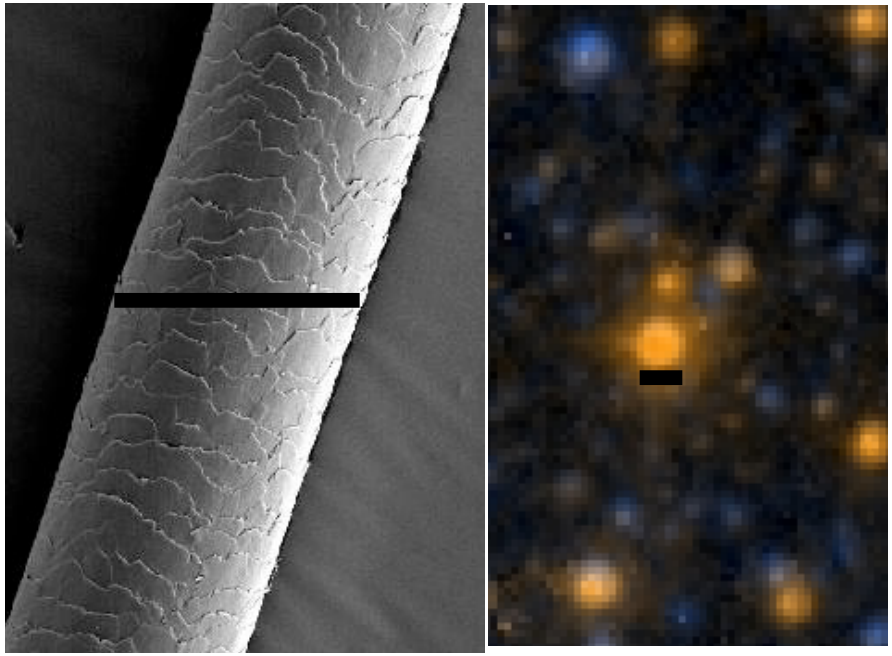

M31 PHAT Brick 21
WFC3/UVIS F336W
WFC3/UVIS F475W
WFC3/UVIS F814W
WFC3/IR F160W

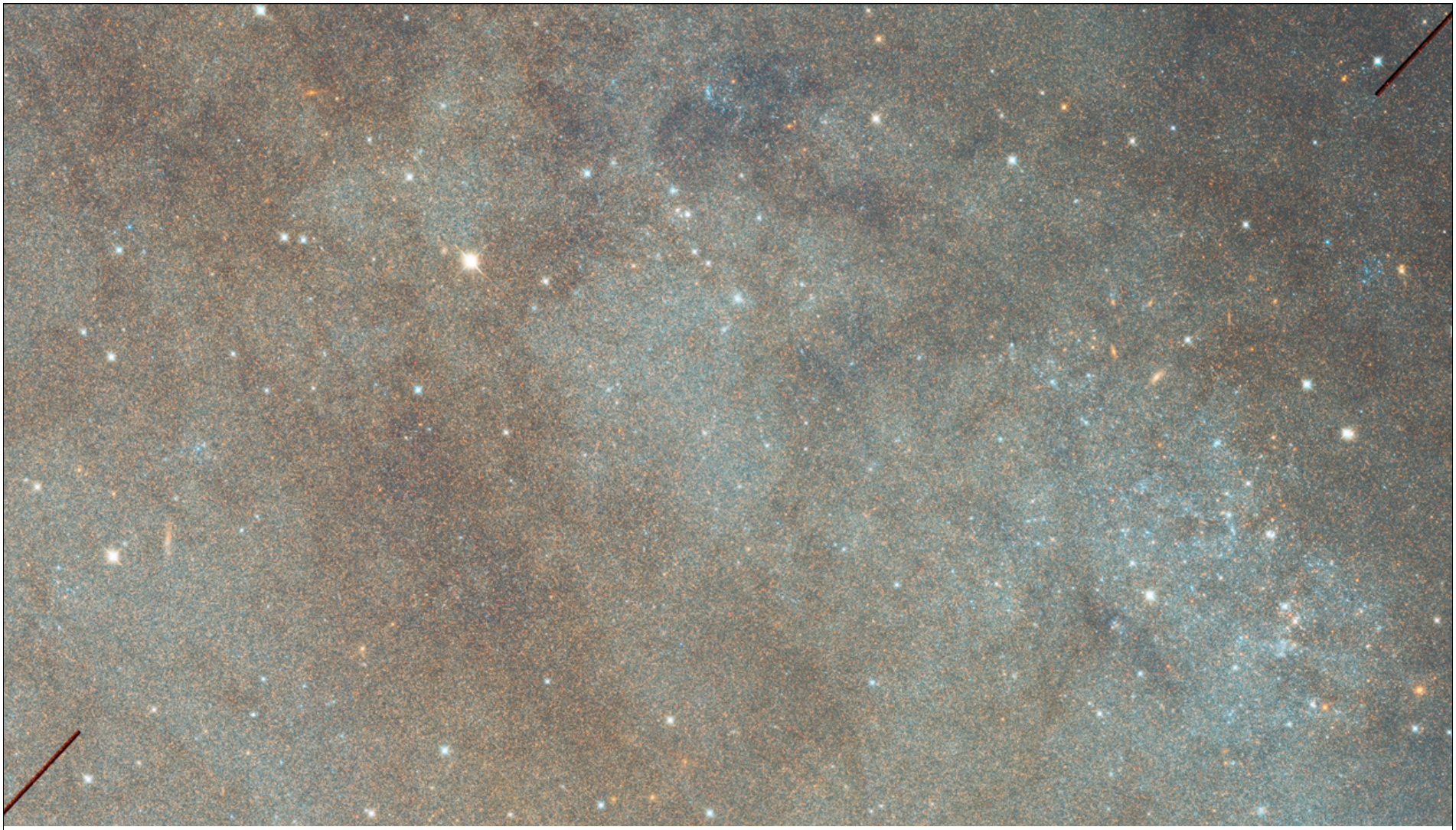


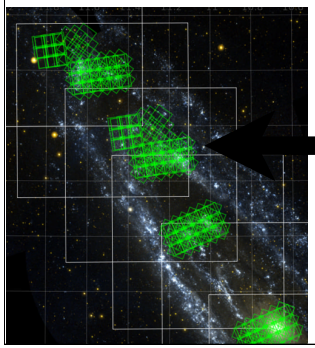
Brick 21



Like looking at the Empire State Building, but being able to resolve a human hair

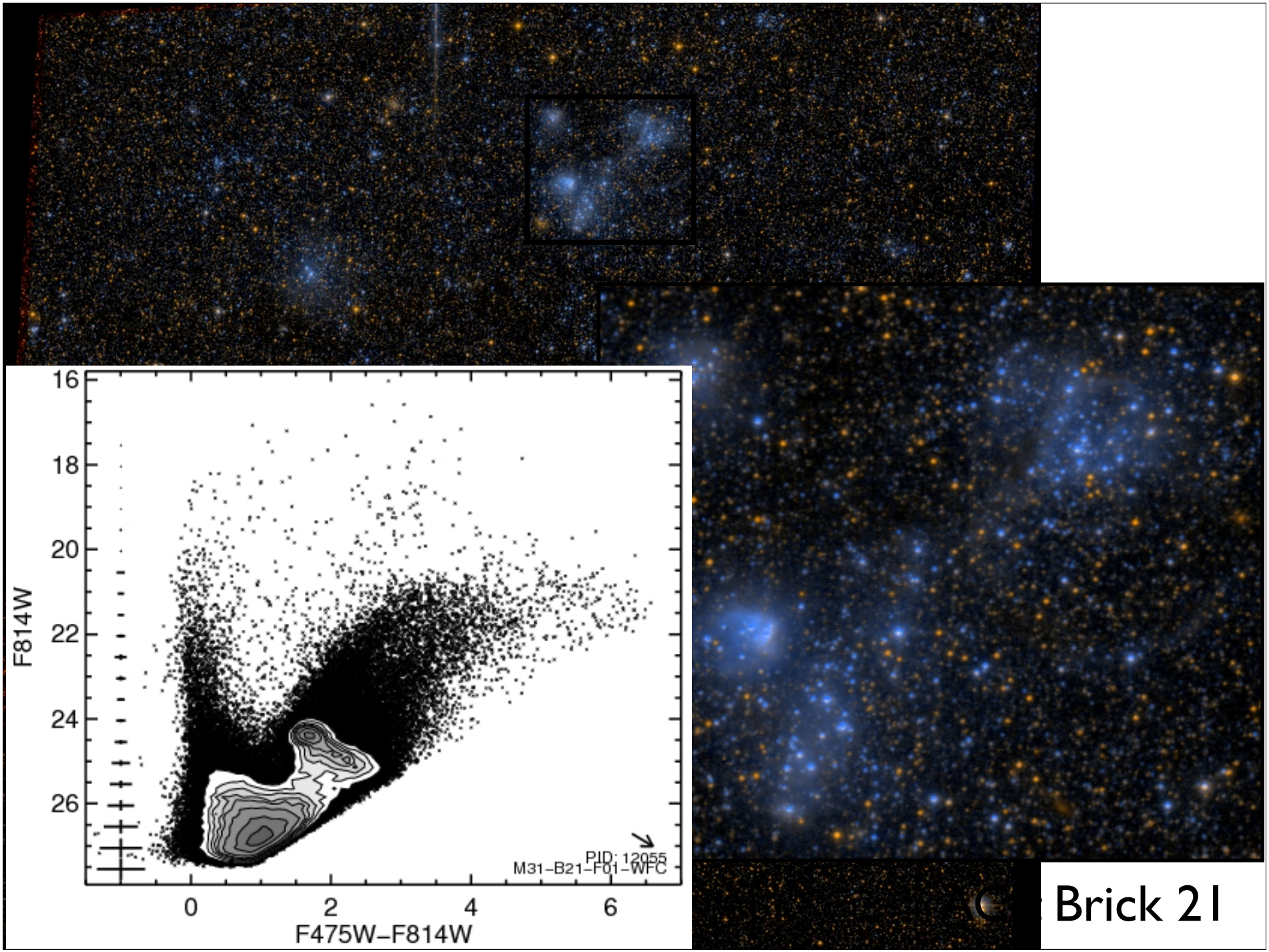




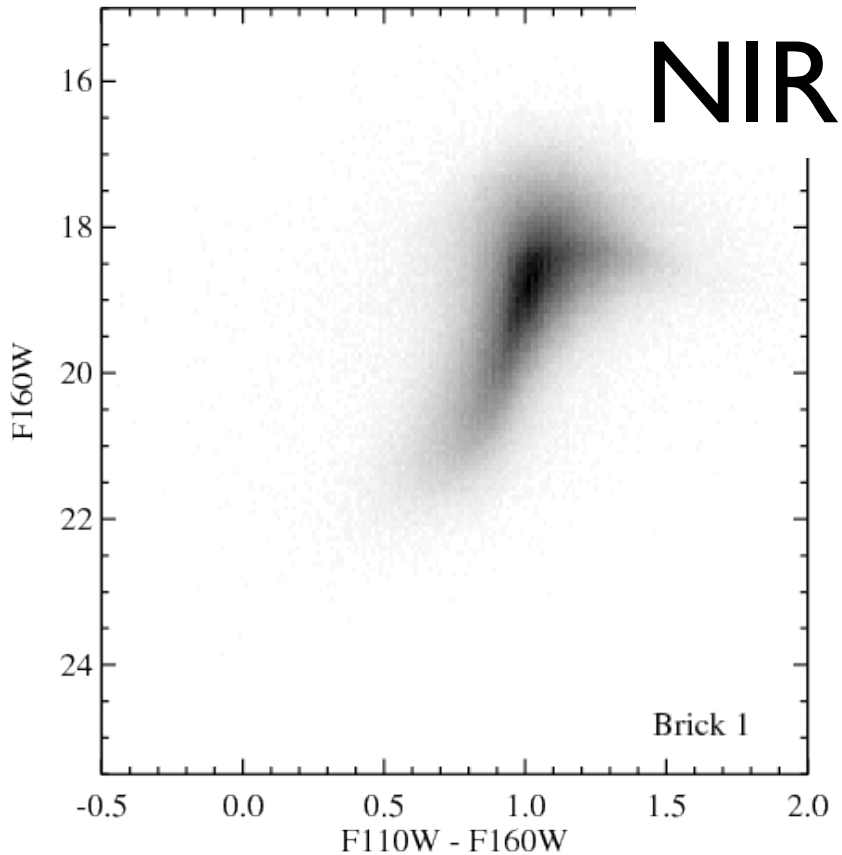


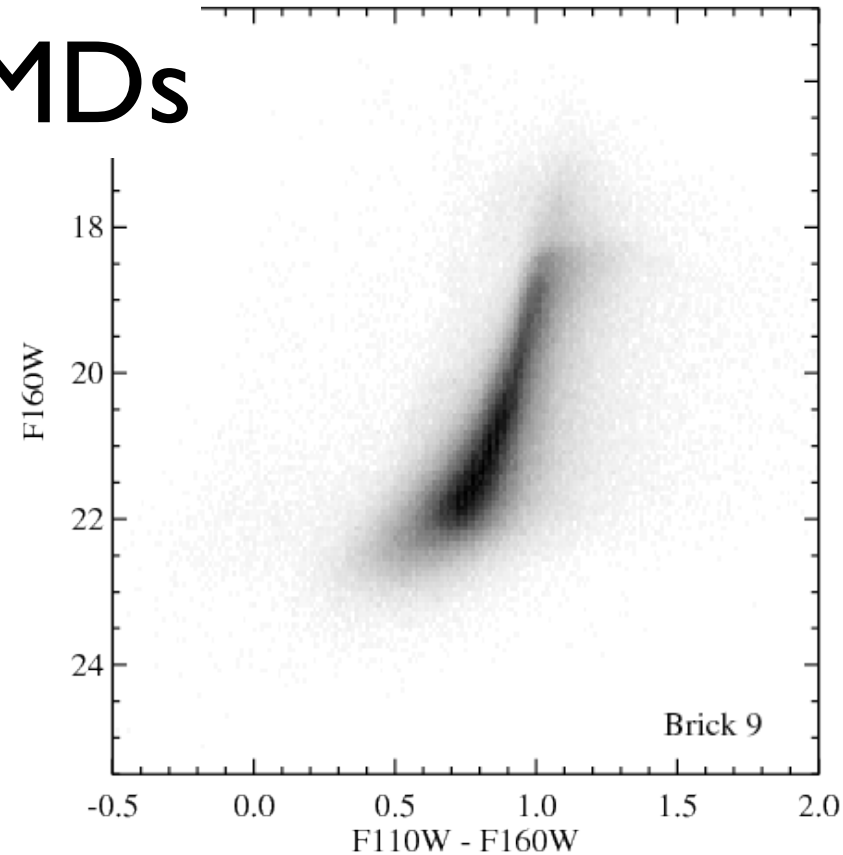
Brick 15

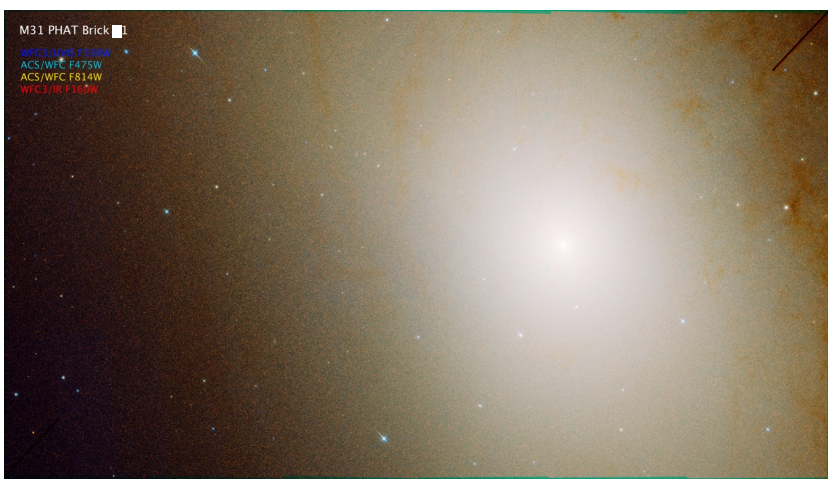
See Talk by Bianchi

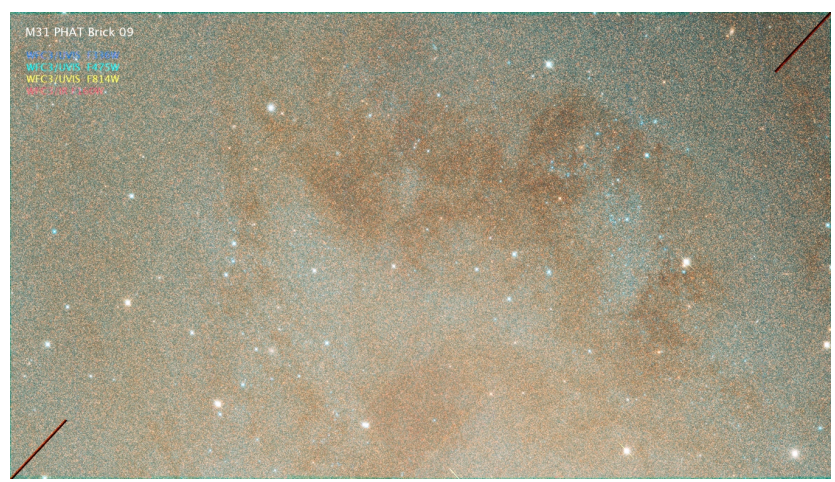

16
18
20
22
24
26
F814W
0
2
4
6
F475W−F814W
PID: 12055
M31−B21−F01−WFC
Brick 21

NIR CMDs

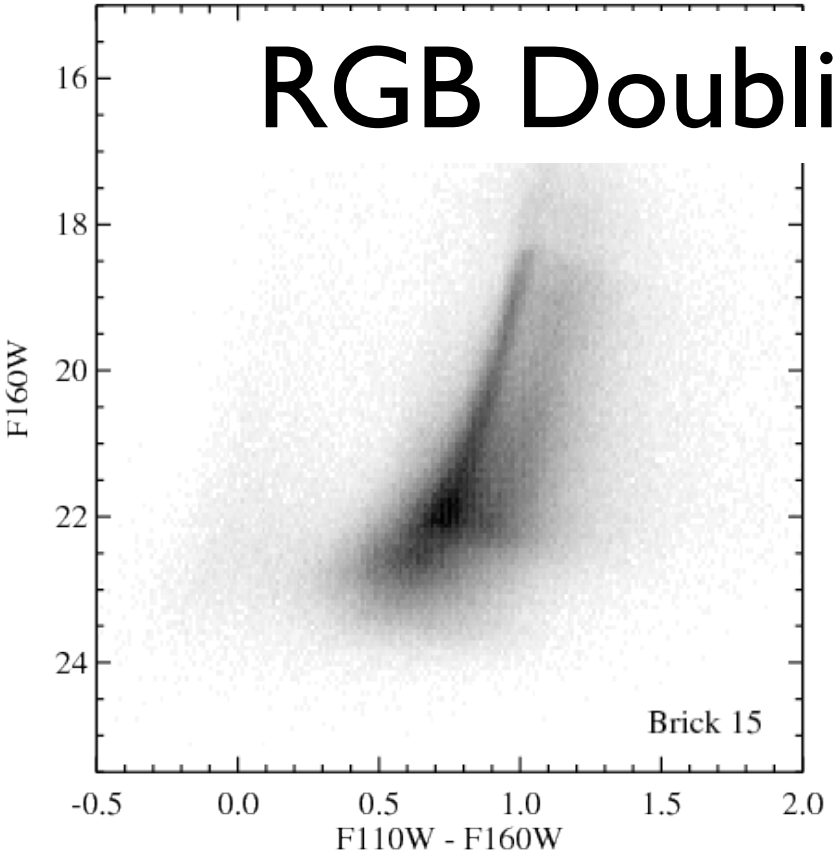

16
18
20
22
24
F160W
Brick 1
-0.5
0.0
0.5
1.0
1.5
2.0
F110W - F160W

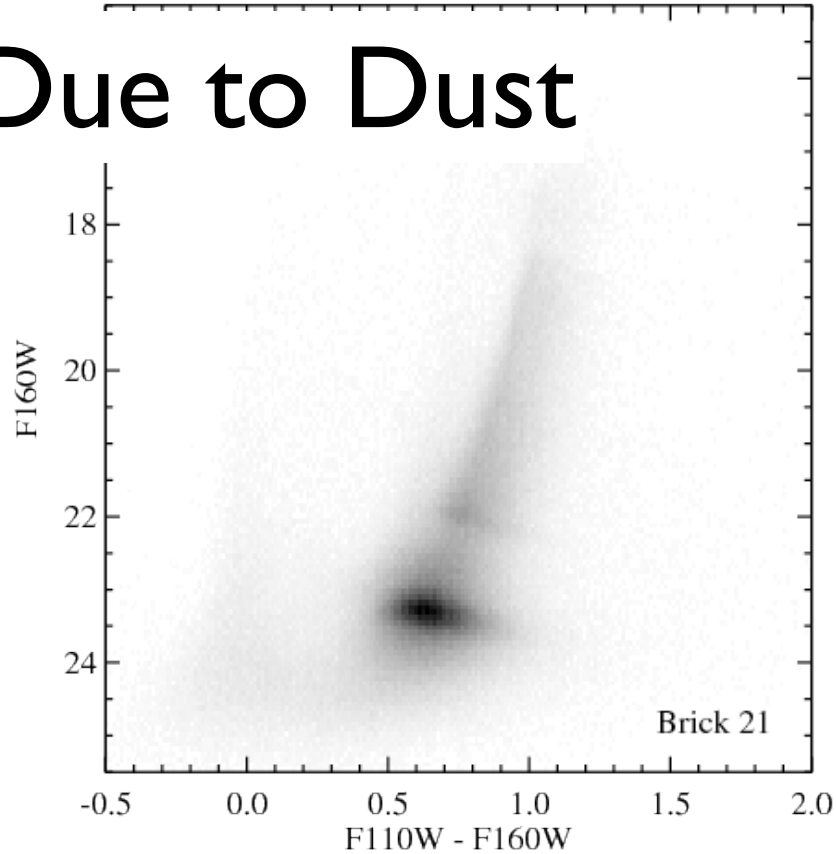

18
20
22
24
F160W
Brick 9
-0.5
0.0
0.5
1.0
1.5
2.0
F110W - F160W

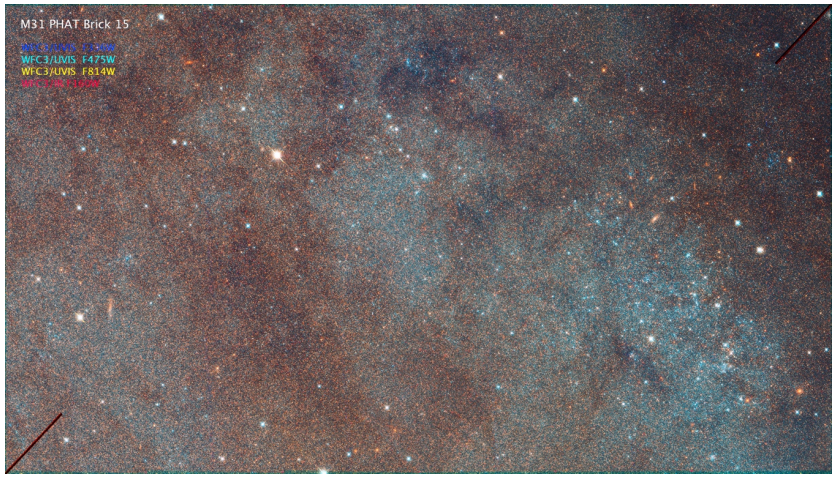

M31 PHAT Brick 1
ACS/WFC F475W
ACS/WFC F814W
WFC3/IR F160W

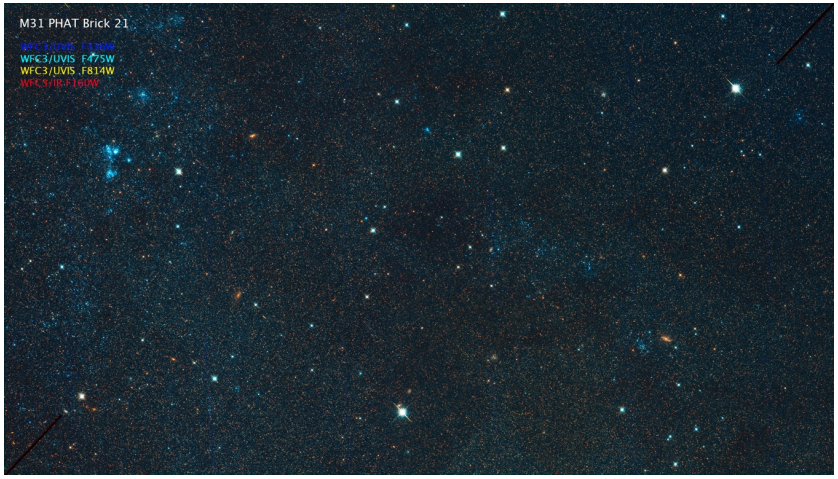

M31 PHAT Brick 09
WFC3/UVIS F475W
WFC3/UVIS F814W

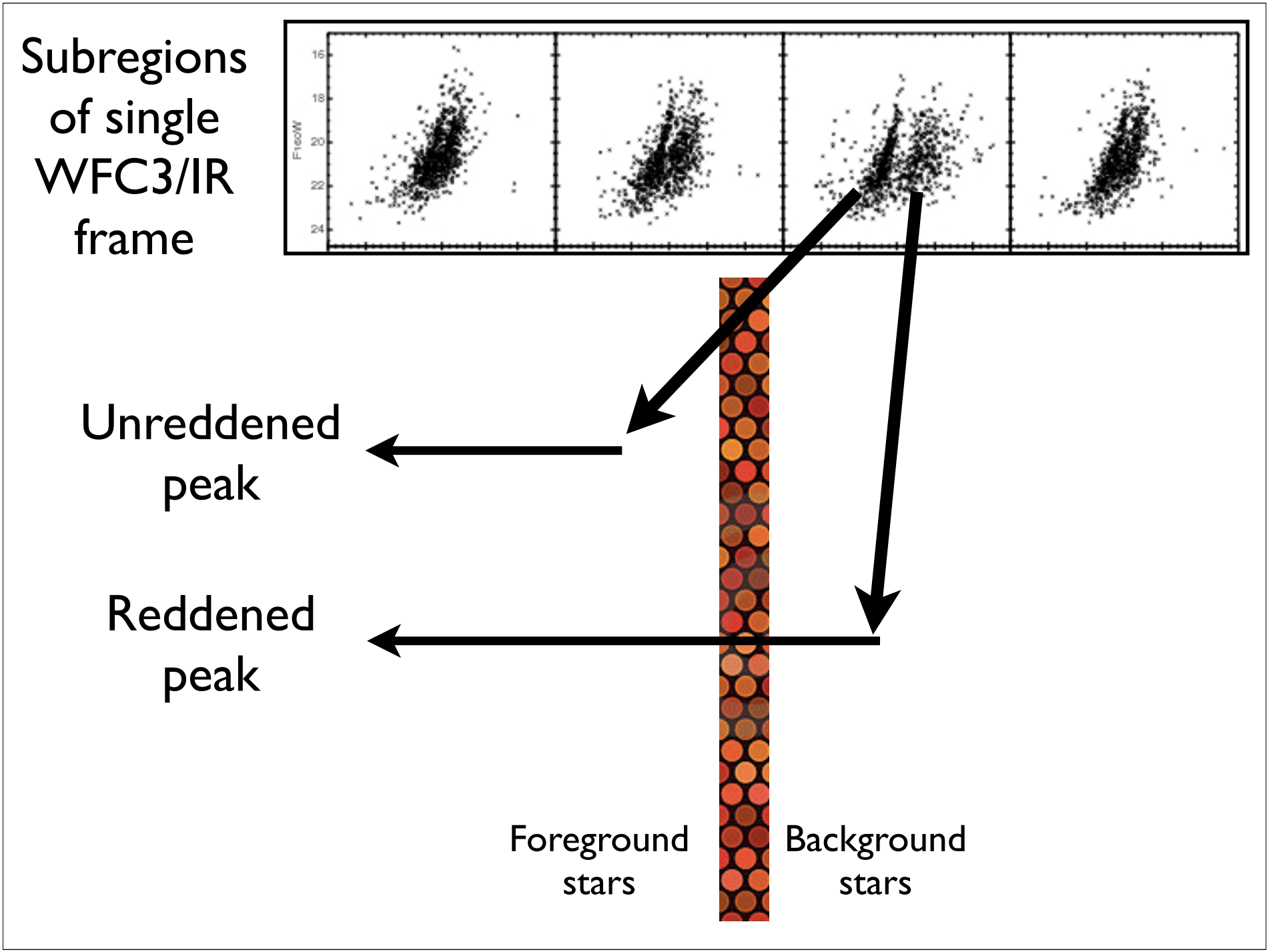
RGB Doubling Due to Dust

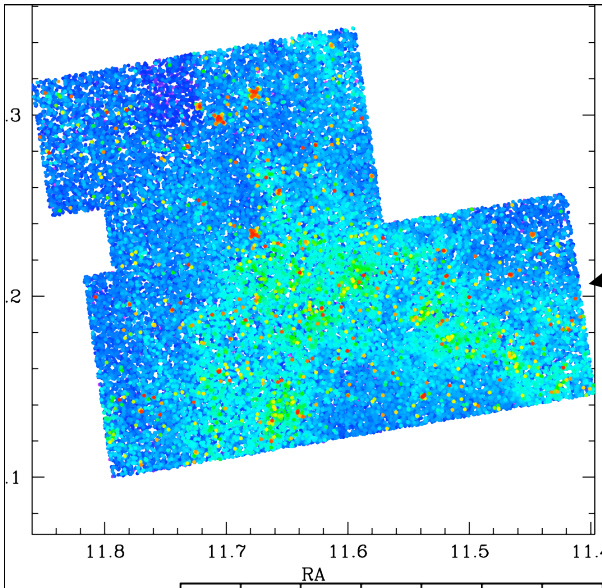


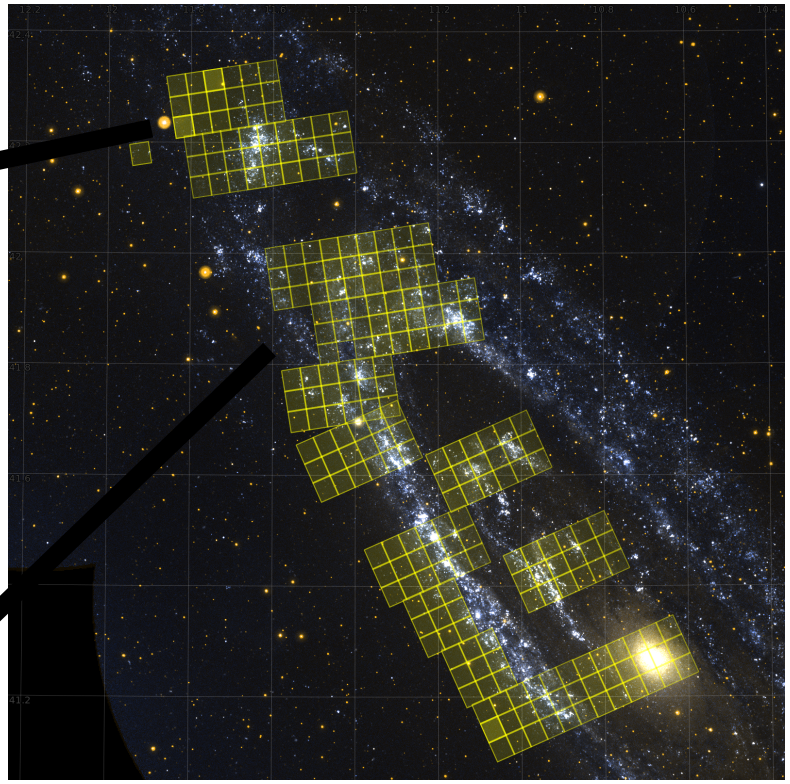


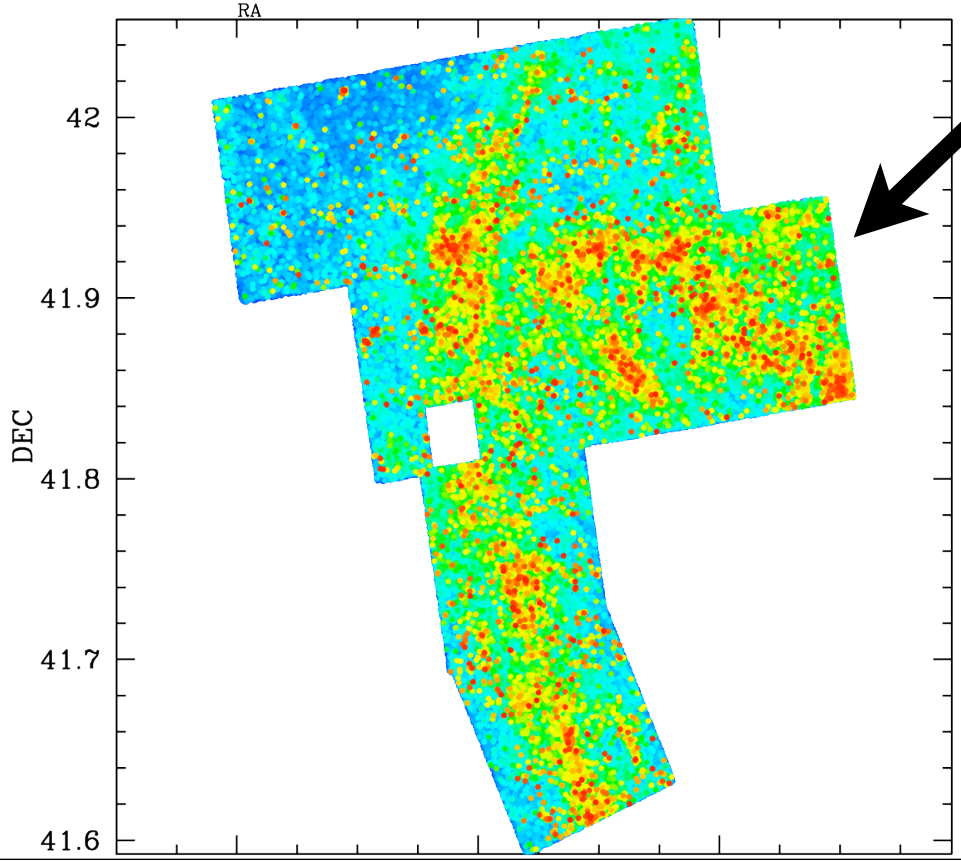





Subregions of single WFC3/IR frame
F160W
16
18
20
22
24
Unreddened peak
Reddened peak
Foreground stars
Background stars

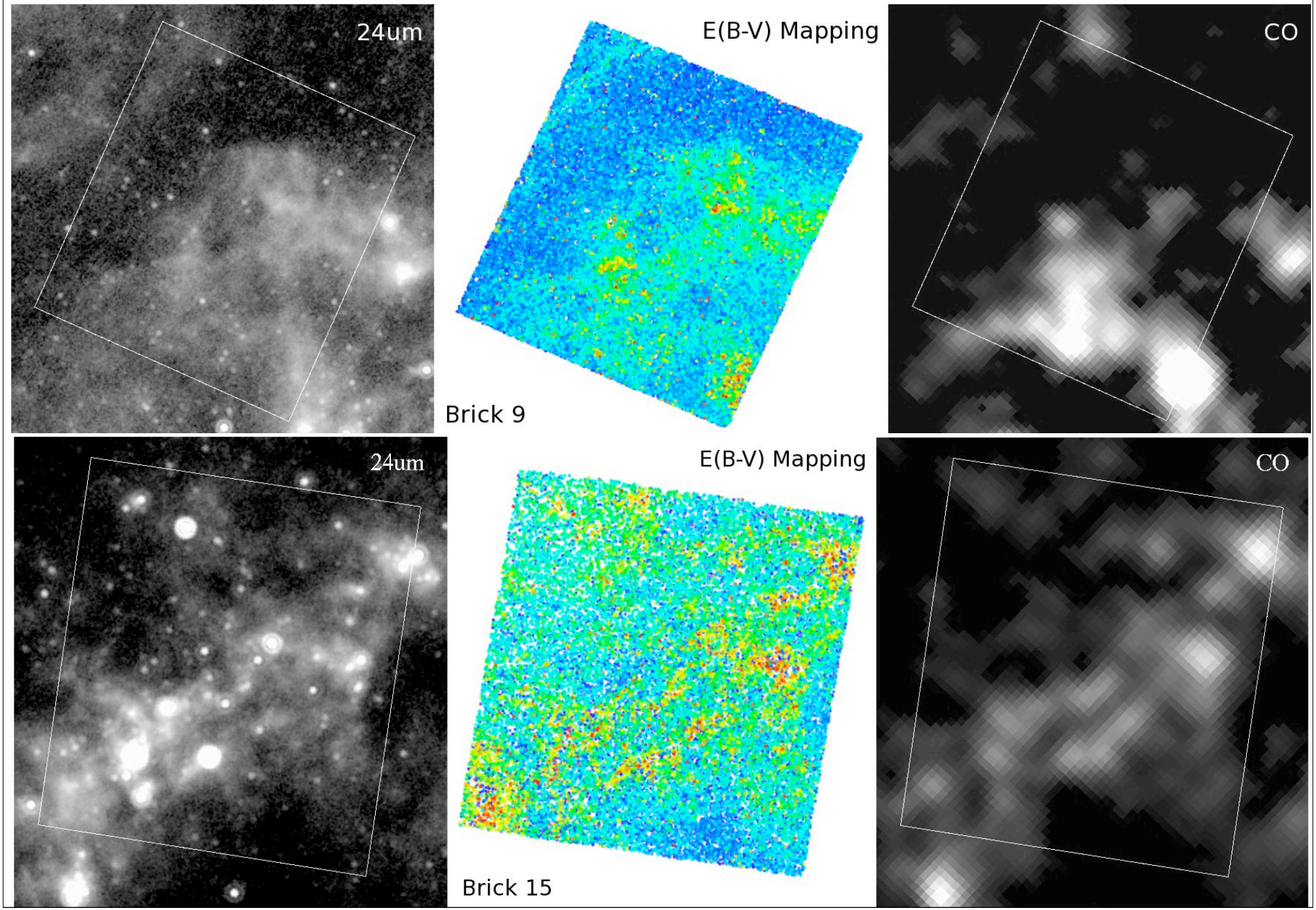






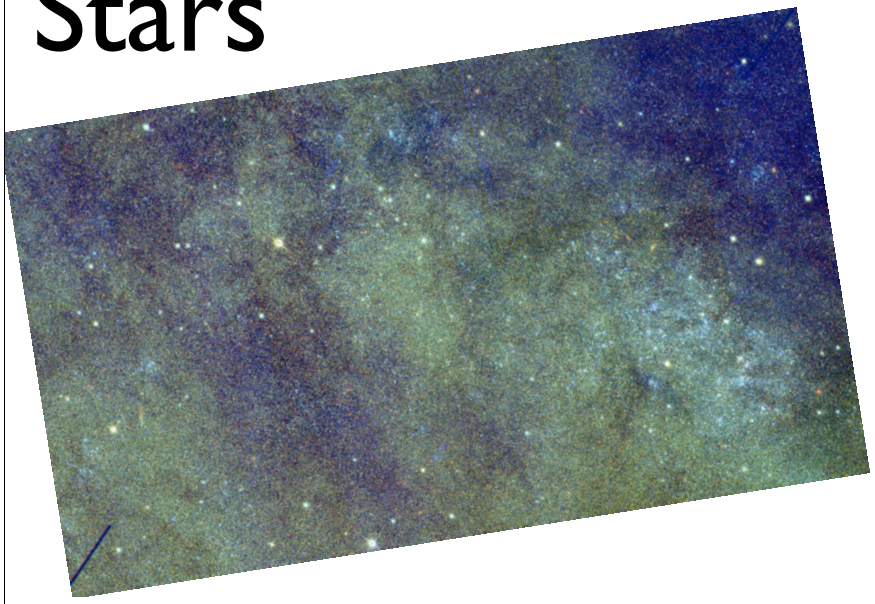
Individual RGB stars color coded by reddening

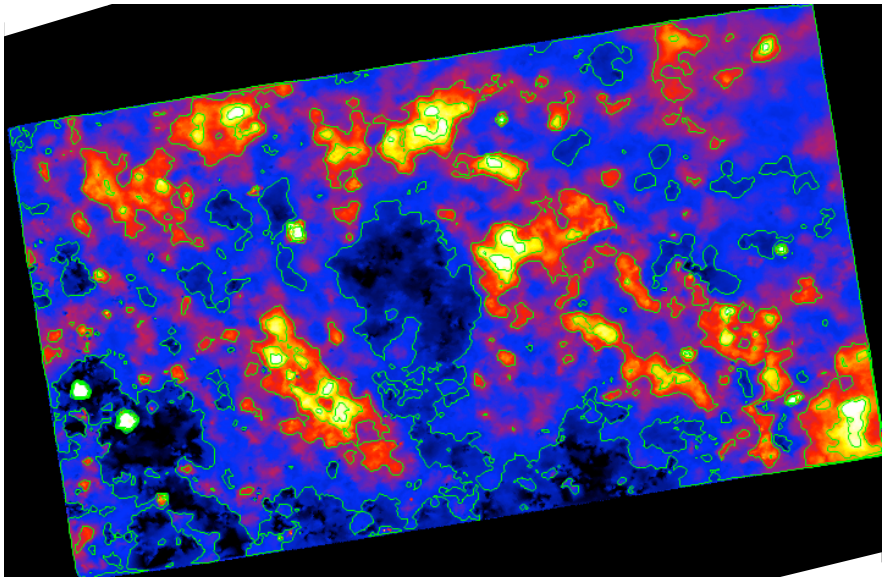
3x3 WFC3/IR



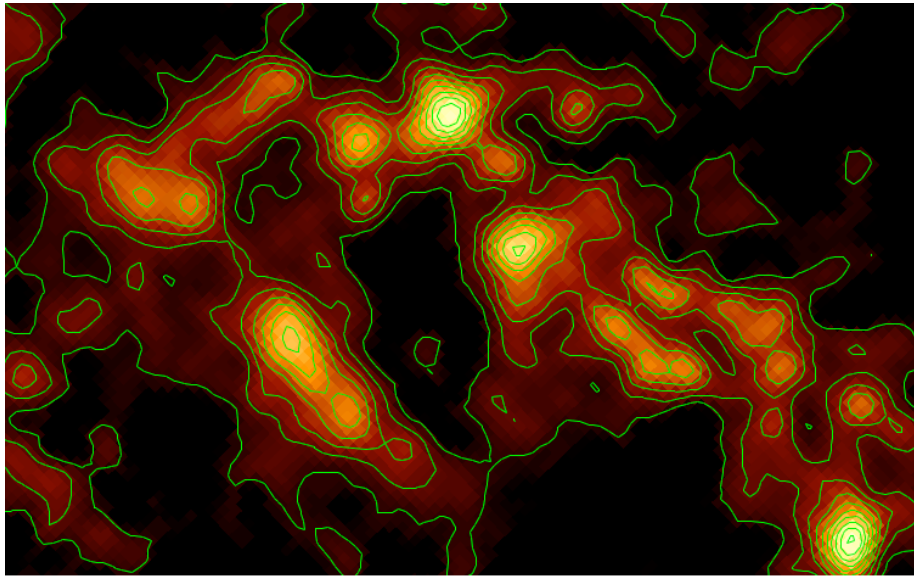
Connecting major baryonic phases: Stars + Dust + Gas

Stars





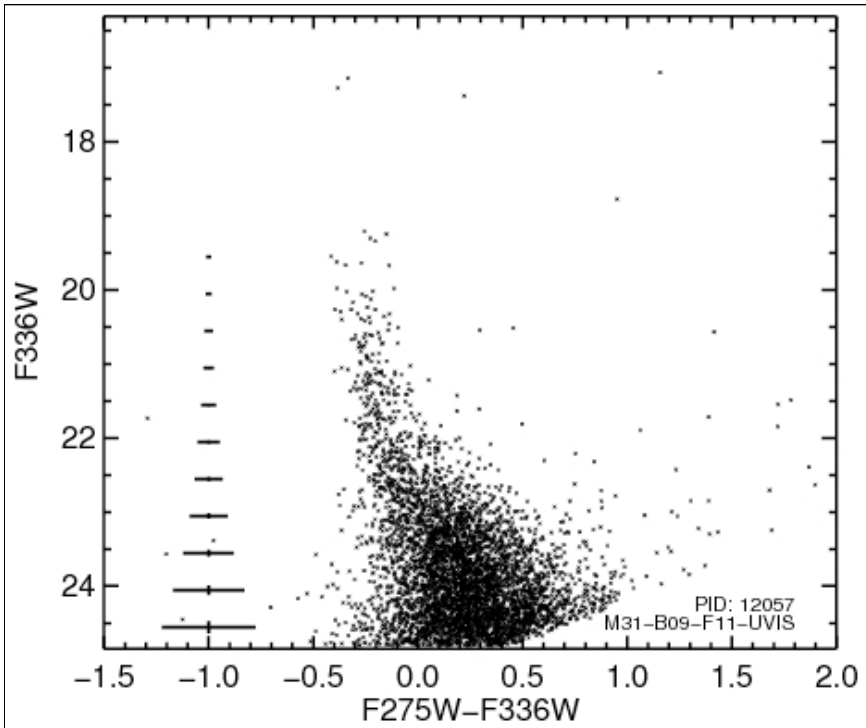
Dust (from HST IR)

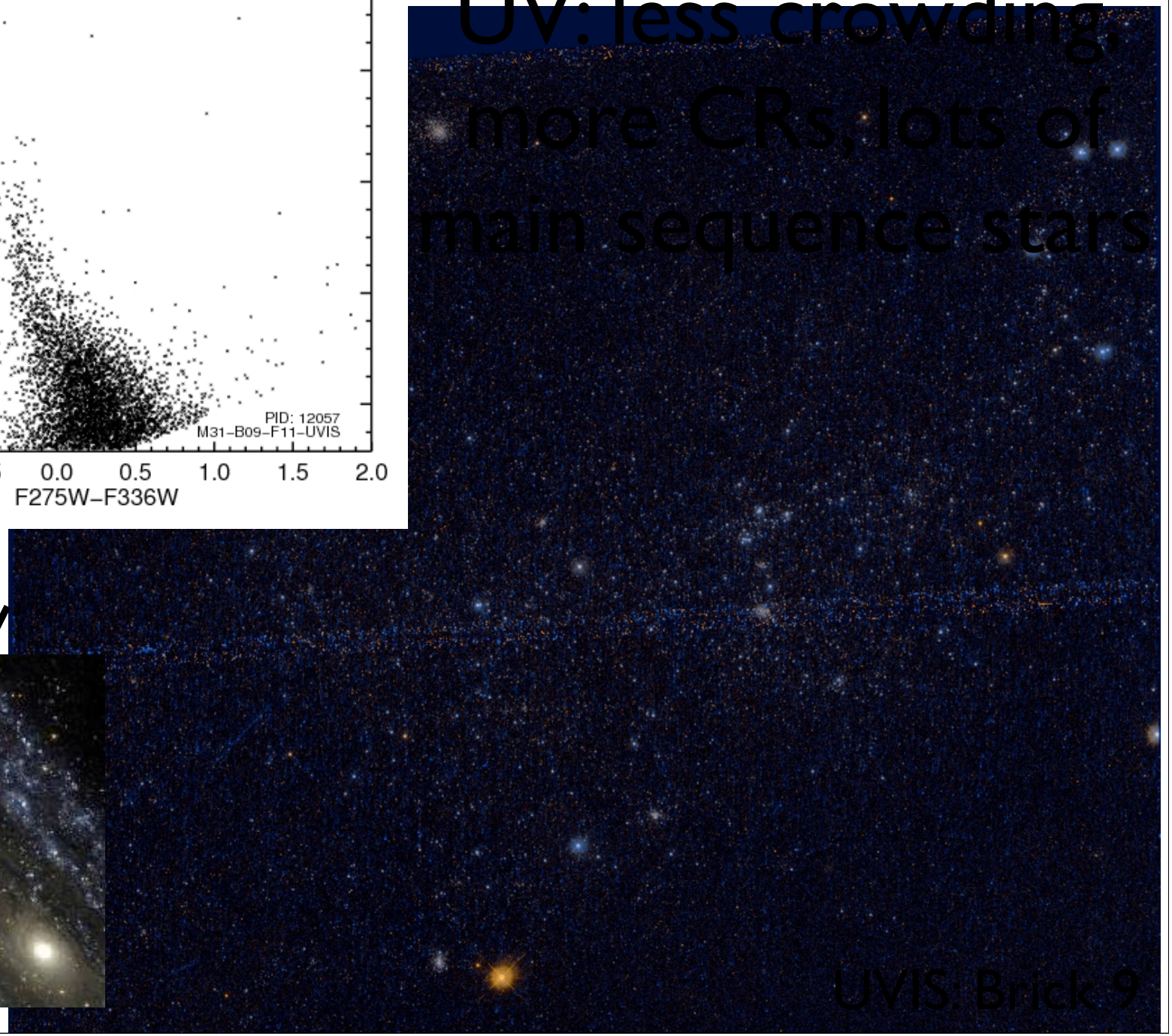


Molecular Gas

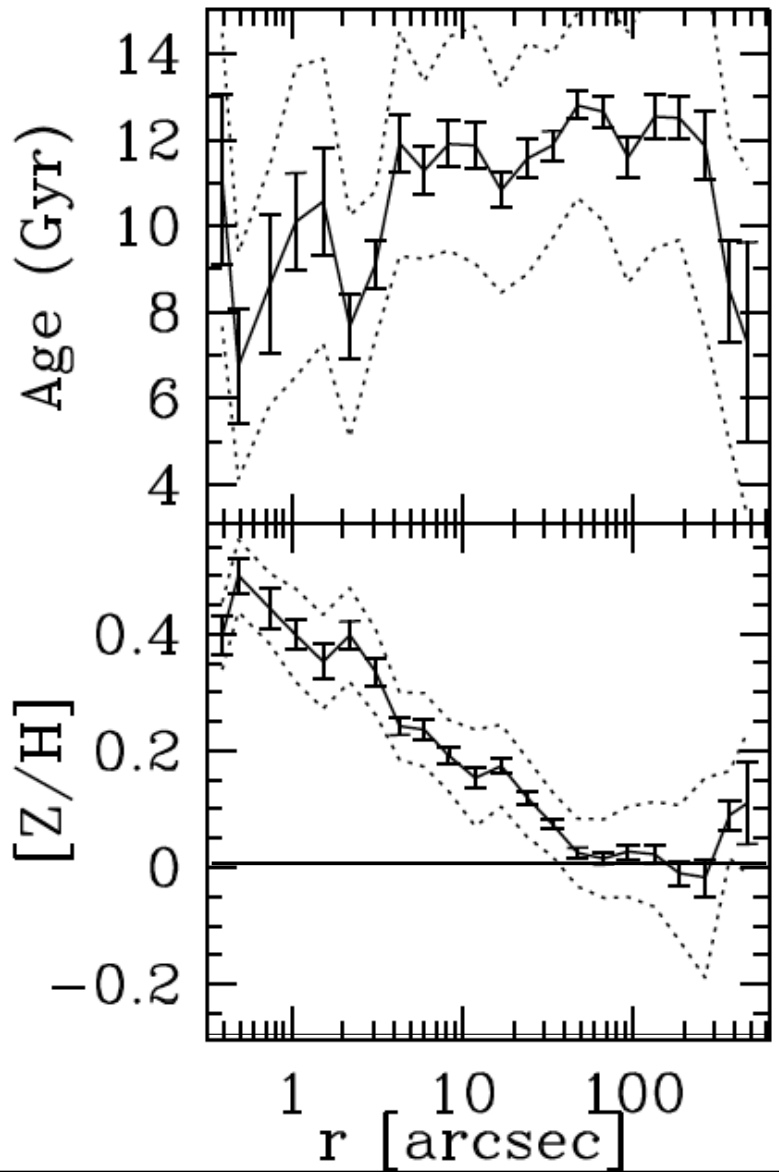
See Talks by Sandstrom and Schruba, Poster by Kapala

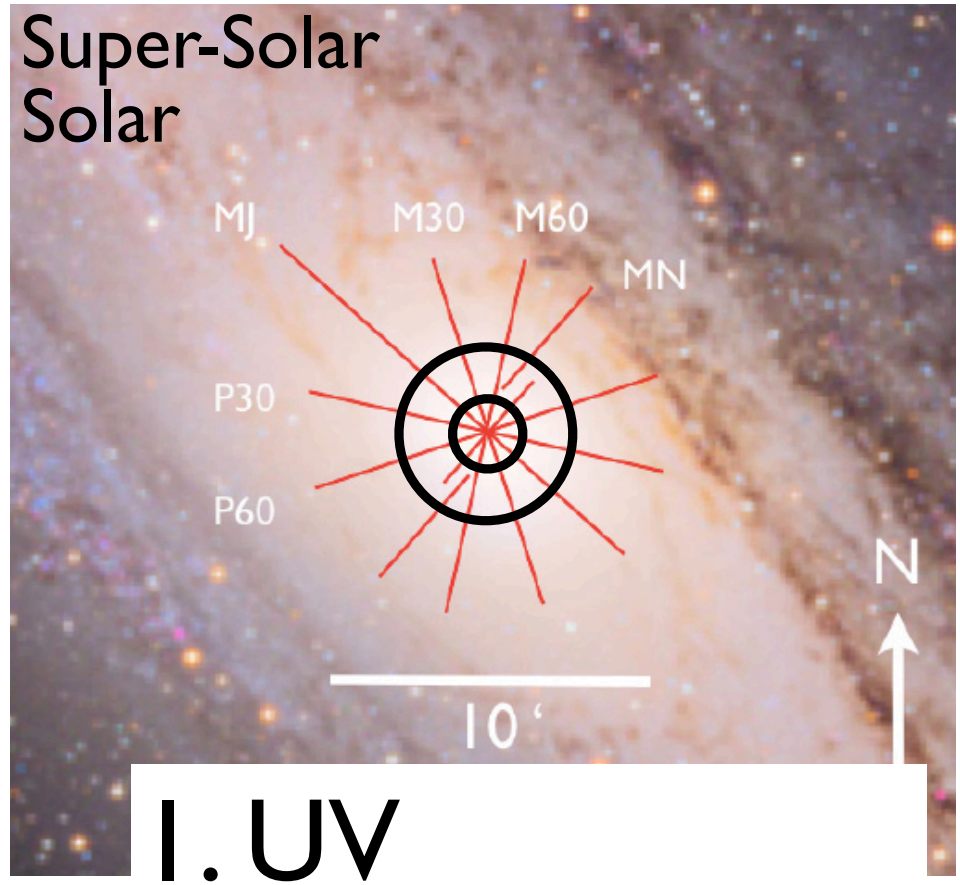
UV: less crowding, more CRs, lots of main sequence stars





Stars in the Bulge are Odd



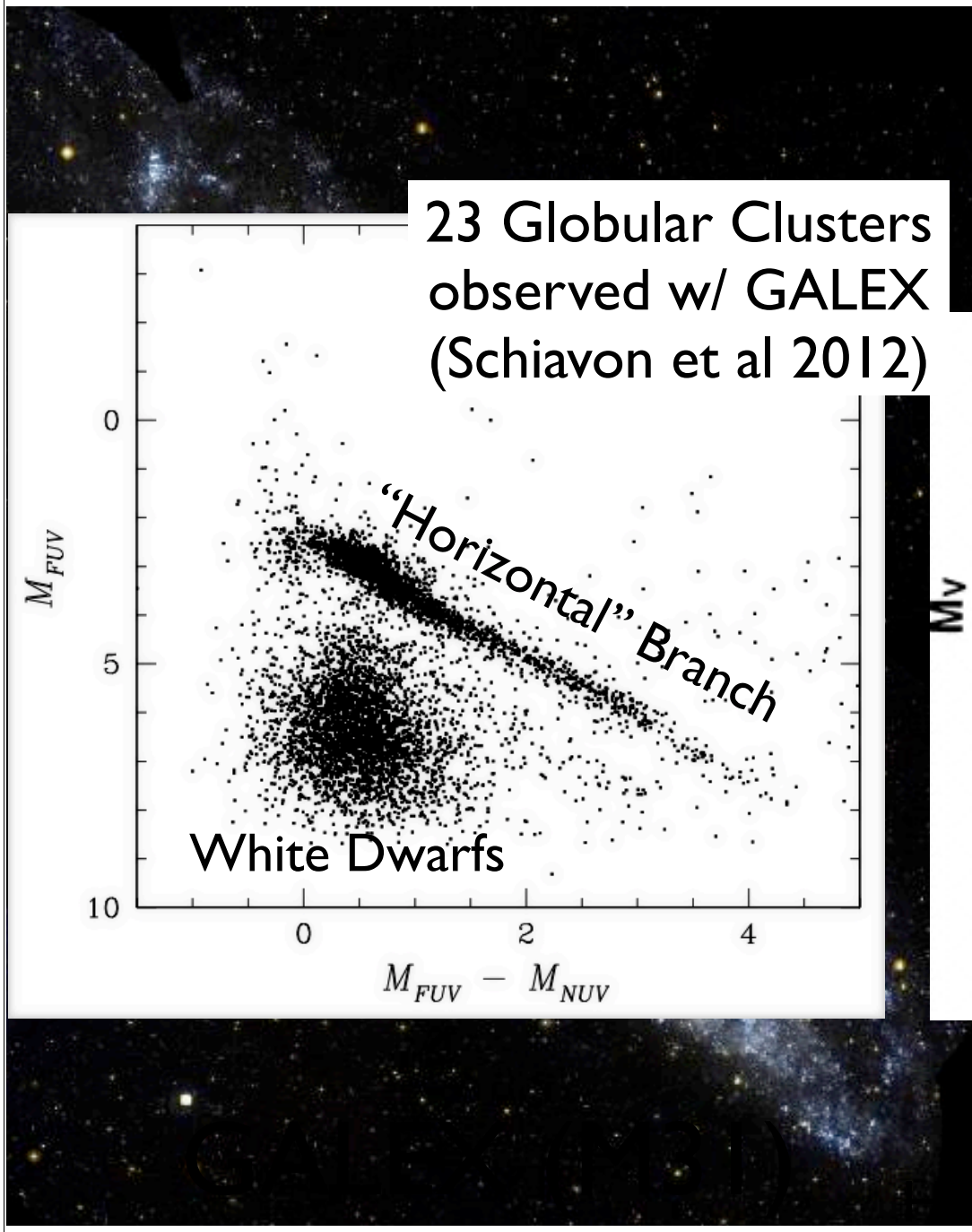


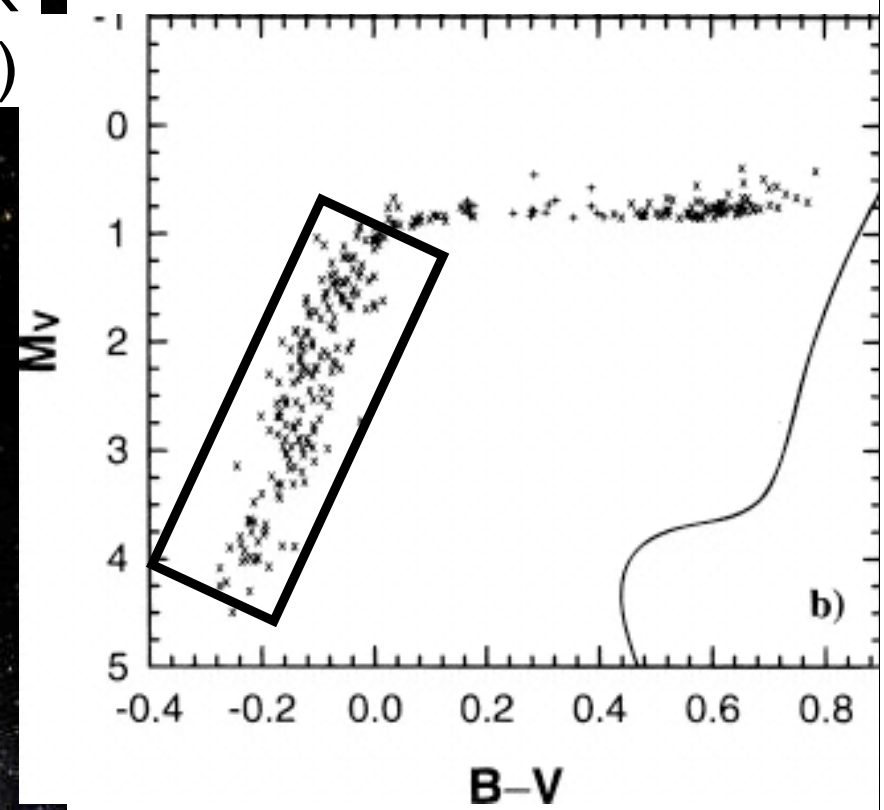
1. UV
2. Optical+NIR

Saglia et al 2010; Lick Indices

Extreme Horizontal Branch (HB) Stars

$T_{eff} > 10^4$K



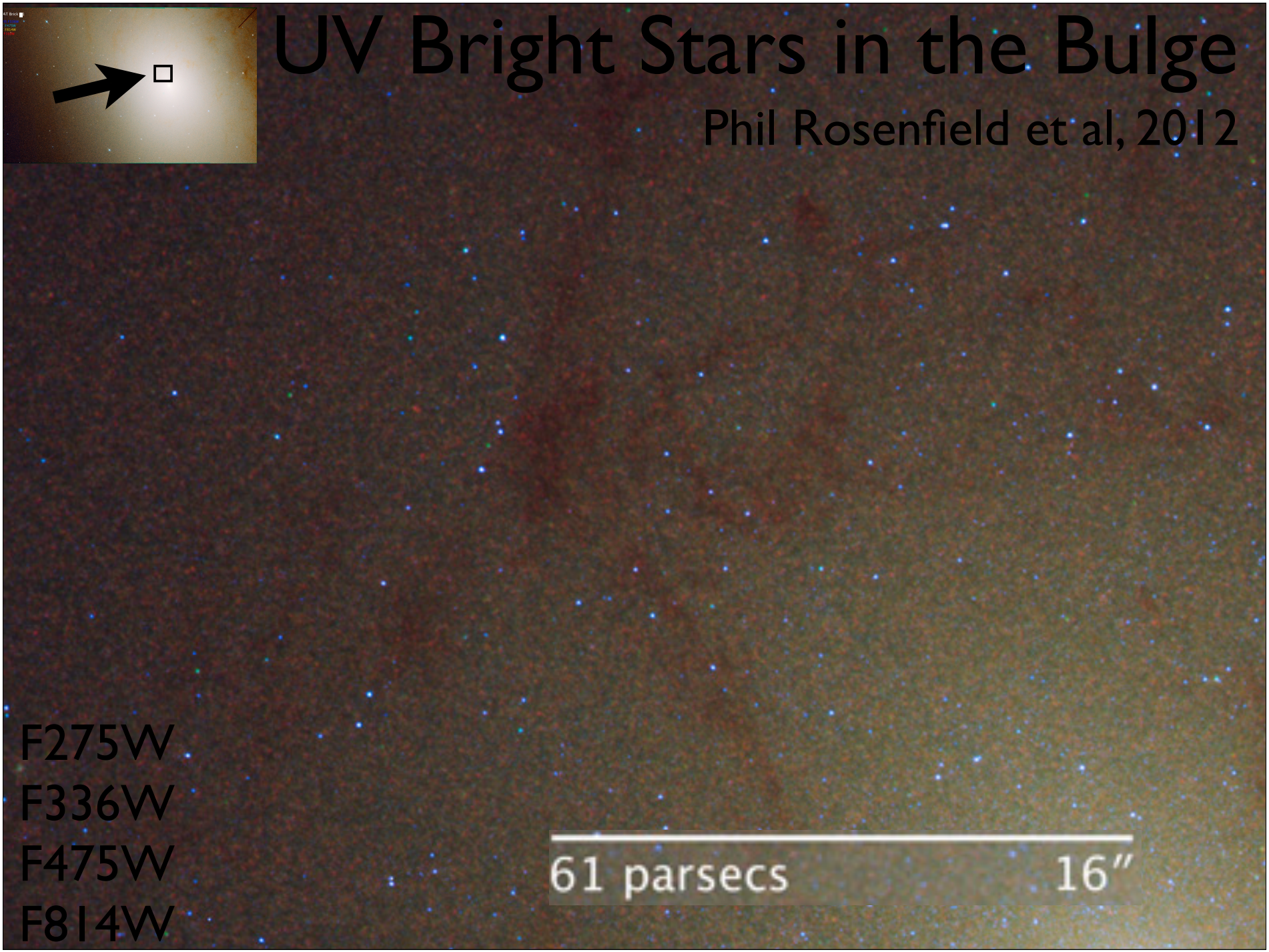


Brown et al 1998, 2000

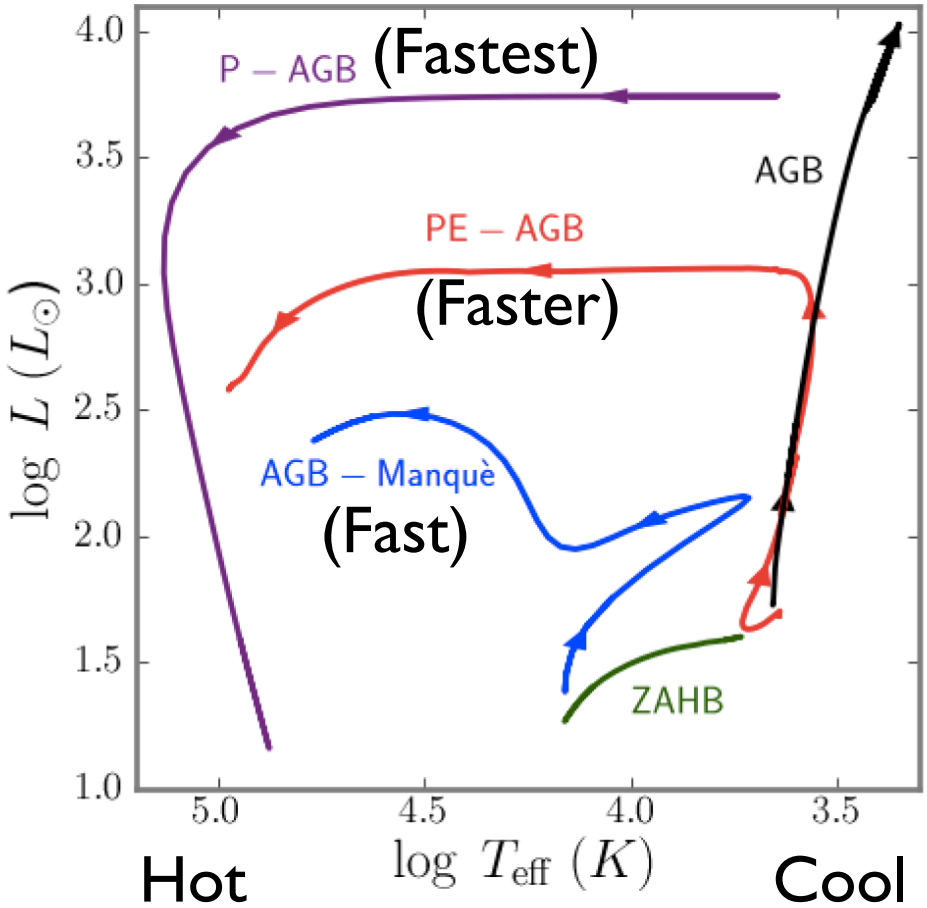
: Core He-burning, after RGB

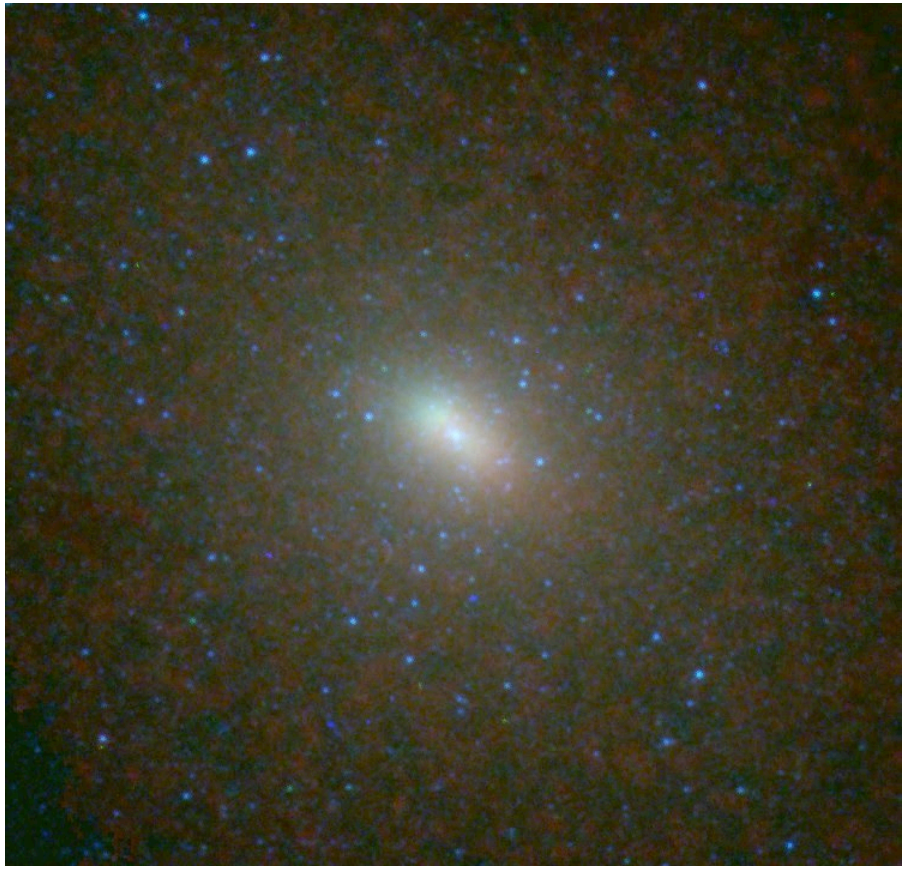
UV Bright Stars in the Bulge

Phil Rosenfield et al, 2012



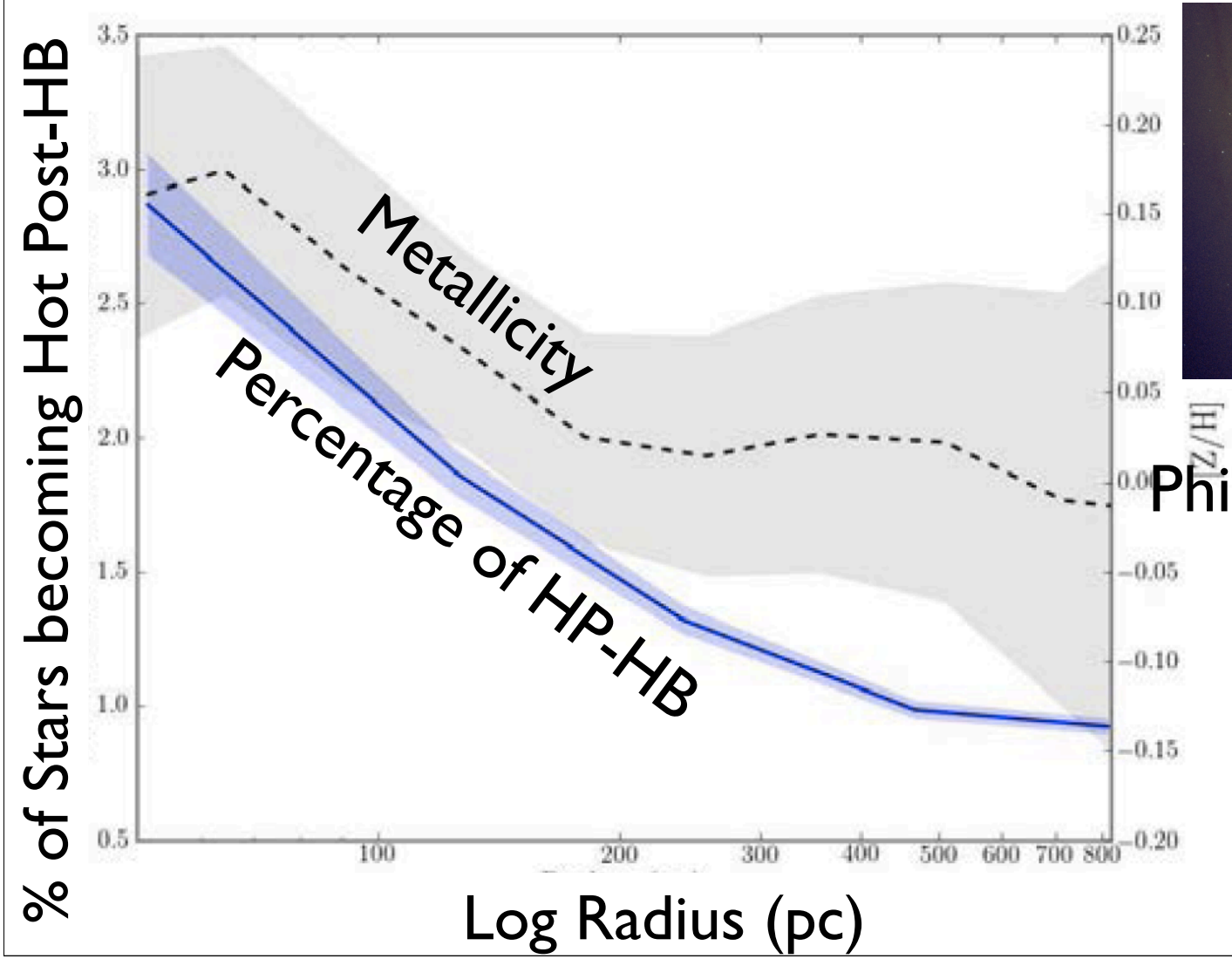
Can Detect Hot HB Descendants

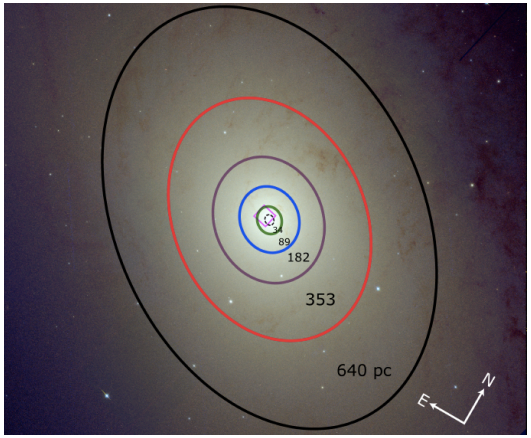




Origin? Lost envelope on RGB

Strong radial variation in fraction of hot stars with high RGB mass loss

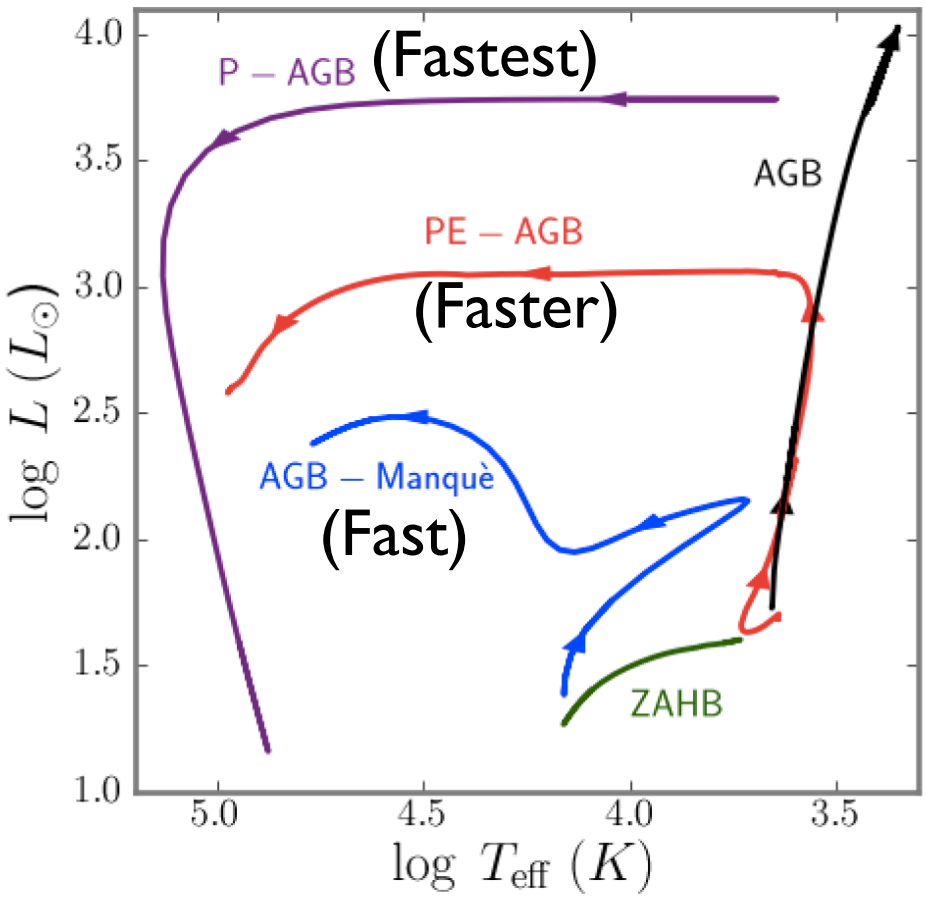




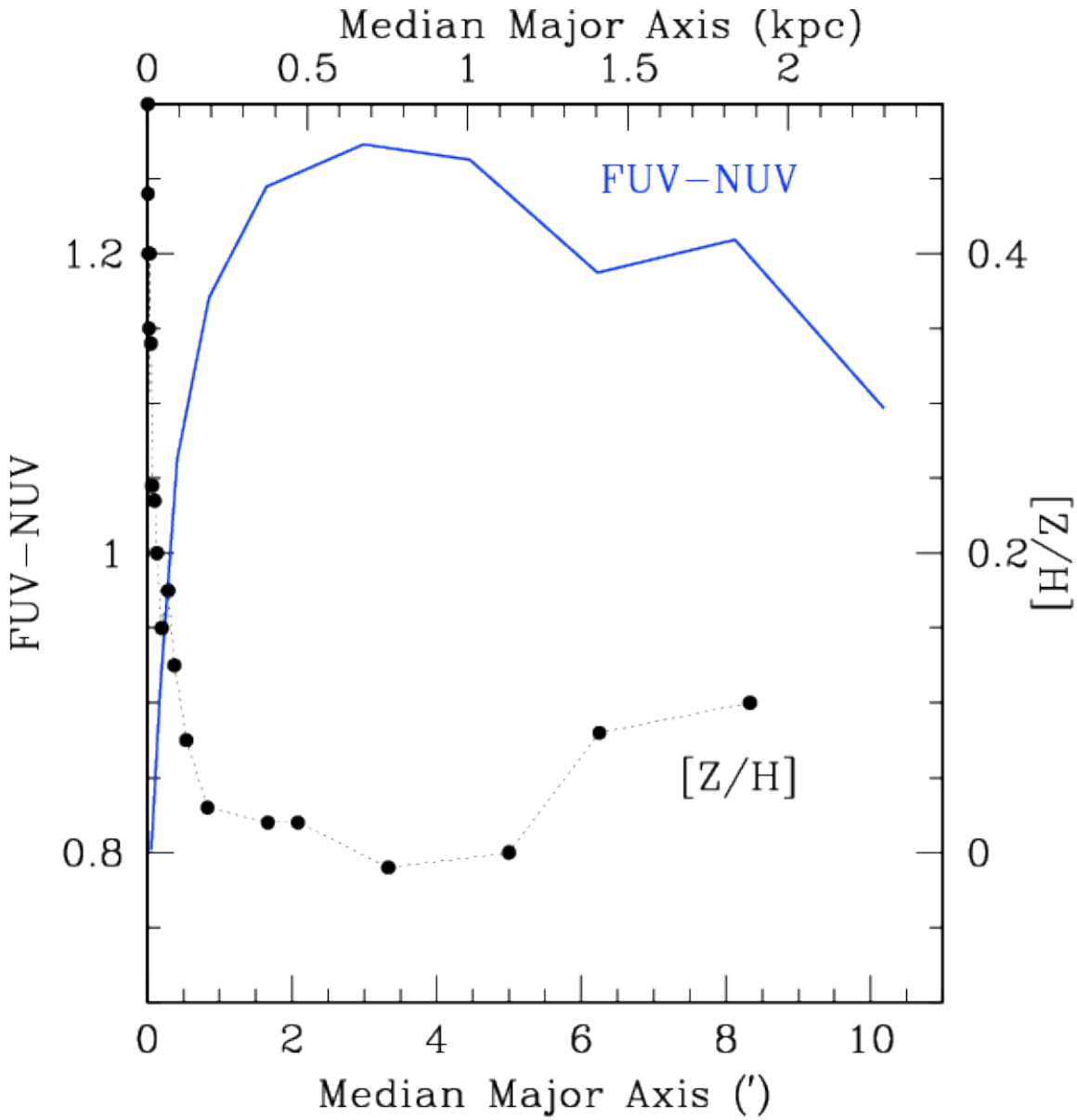
Phil Rosenfield, et al 2012

Metallicity from Saglia et al 2010 Lick Indices

Affects other phases that are important in the optical and IR!



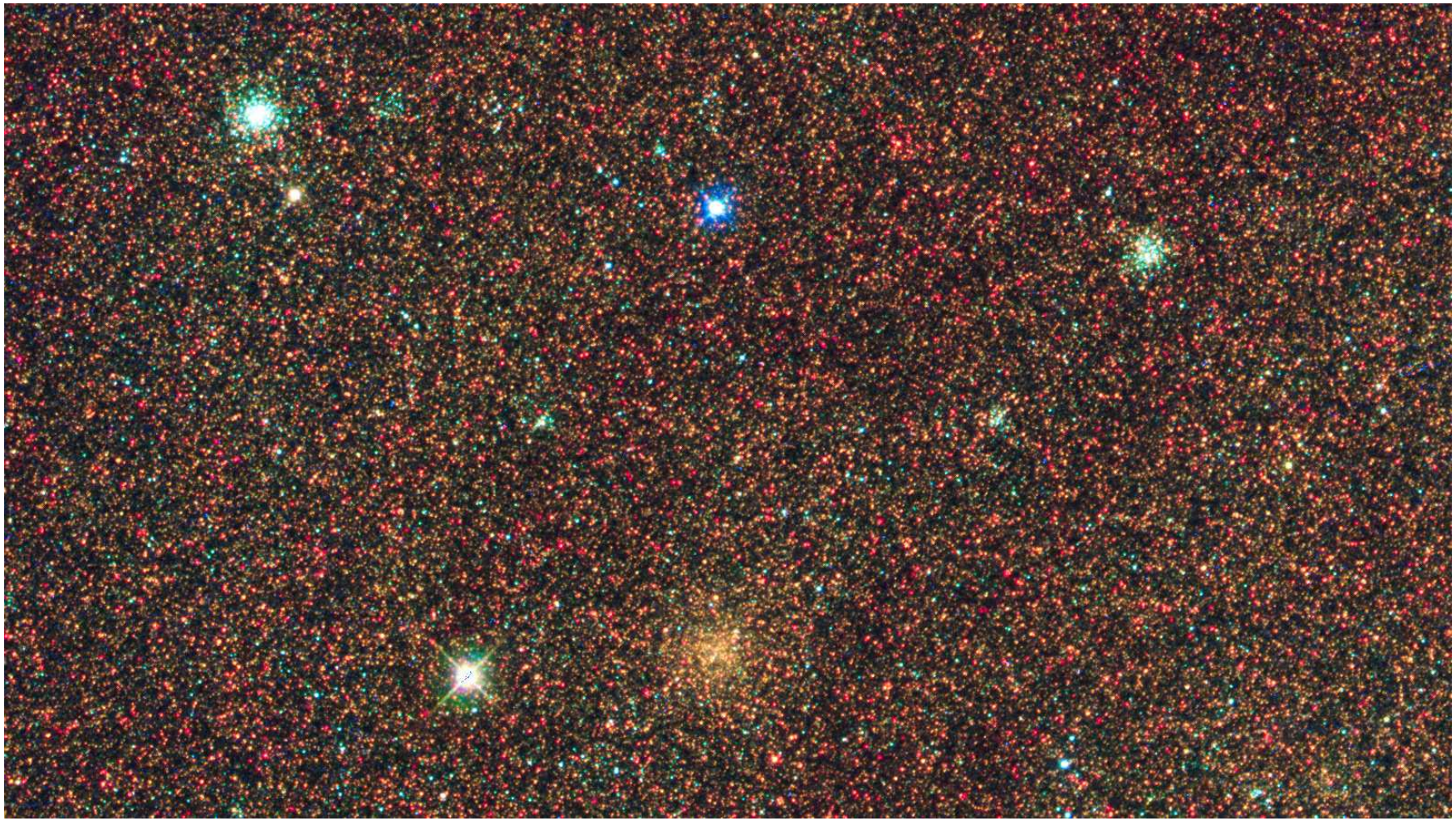
- Numbers & luminosity function of IR-bright AGB
- Gas return through RGB winds



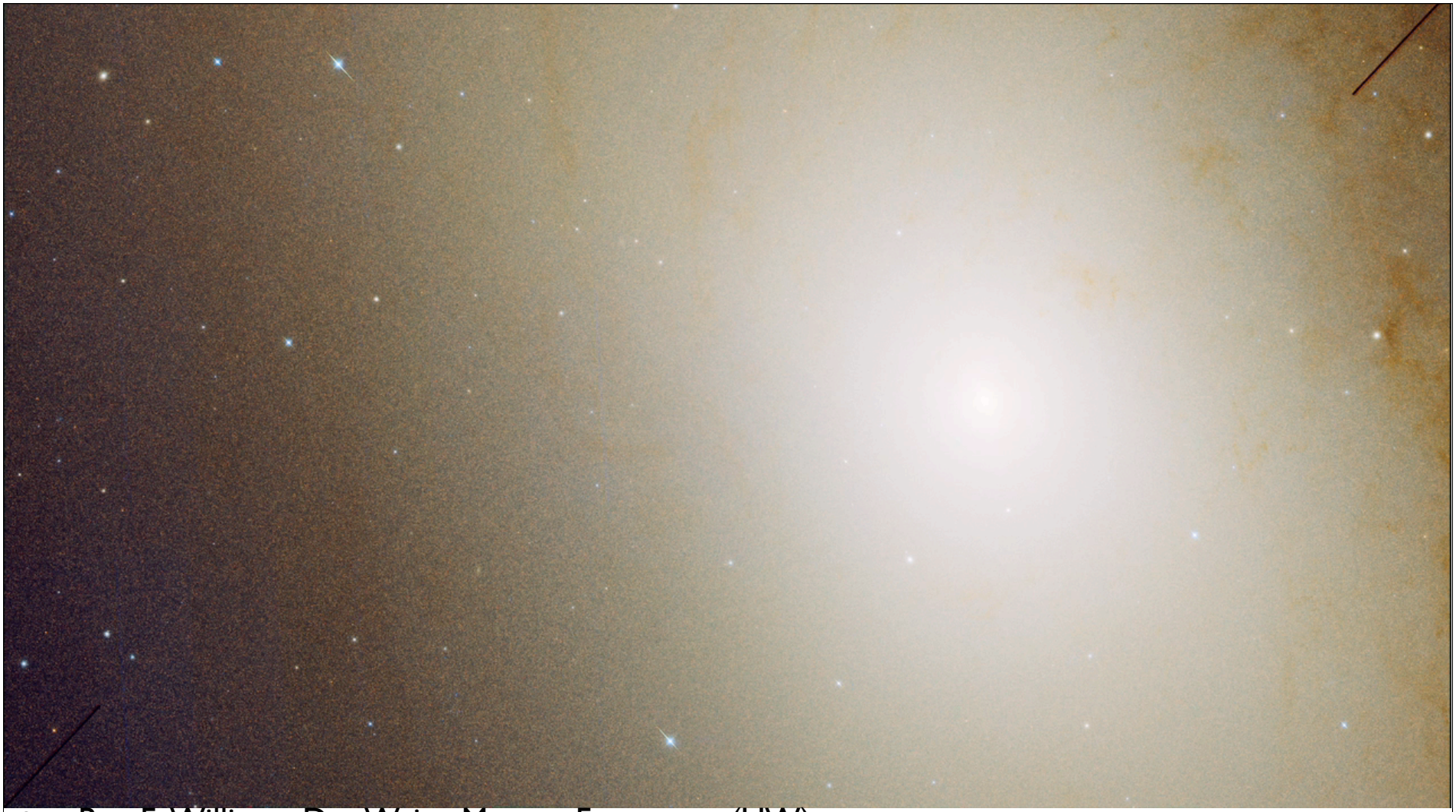
FUV-NUV color tracks metallicity

Production of Extreme Horizontal Branch linked to bulge metallicity

Summary



Tons of Stars = Tons of Science



- Ben F. Williams, Dan Weisz, Morgan Fouesneau (UW)
- Phil Rosenfield, Cliff Johnson, & Lori Beerman (UW grad students)
- Tod Lauer, Knut Olsen, & Hui Dong (NOAO)
- Nelson Caldwell (CfA)
- Dustin Lang (Princeton)
- Luciana Bianchi (JHU)
- Andrew Dolphin (Raytheon)
- Leo Girardi & Paola Marigo (Padova)
- Karl Gordon & Jason Kalirai (STScI)
- Anil Seth (U. Utah)