The Panchromatic Hubble Andromeda Treasury (PHAT)

Image: SWIFT

Dan Weisz
University of Washington

Galactic Scale Star Formation
University of Heidelberg
7.31.12

The Panchromatic Hubble Andromeda Treasury (PHAT)

The Stats

828 HST Orbits

Near-UV to Near-IR
Resolved Star Imaging
for ~ 1/4 of M31's
Star-Forming Disk

Final catalog will contain
~ 100 million stars

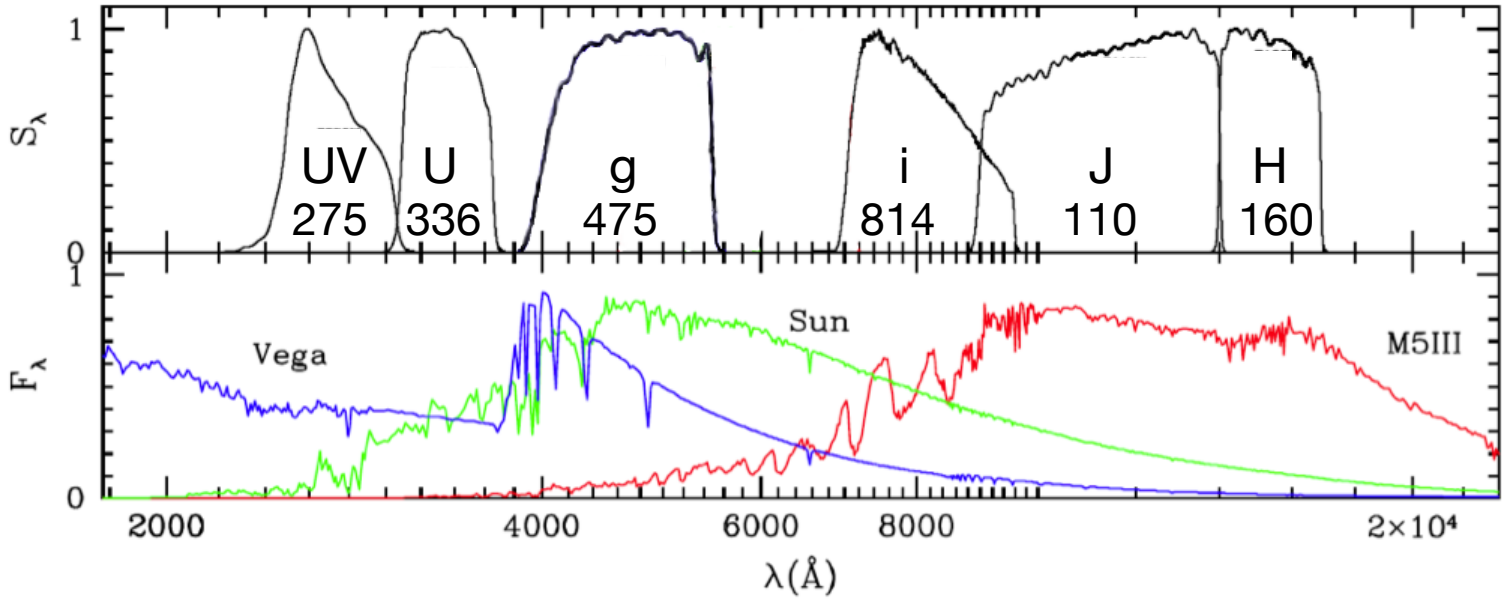
Important anchor for a
detailed understanding
of an $L_{\star}$ environment

The Team

Julianne Dalcanton (PI)
Ben Williams
Dan Weisz
Morgan Fouesneau
Andy Dolphin
Hans-Walter Rix
Dustin Lang
Anil Seth
Leo Girardi
Karl Gordon
Cliff Johnson
Knut Olsen
Paul Hodge
Jon Holtzman
Jake Simones
Lori Beerman

Tod Lauer
Dimitrios Gouliermis
Phil Rosenfield
Luciana Bianchi
Raja Guhathakurta
Claire Dorman
Adam Leroy
Eric Bell
Nelson Caldwell
Karrie Gilbert
Jason Melbourne
Abi Saha
Ata Sarjedini
Evan Skillman
Martha Boyer
Hui Dong

The Panchromatic Hubble Andromeda Treasury (PHAT)



Project Timescales: 3-4 Year Observing Plan
Yr 1-3 Mostly Complete, 70% of data in hand
Yr 4 Underway; Anticipate Completion in 2013

Comprehensive Ancillary
Imaging and Spectroscopy
VLA, CARMA, Herschel, Spitzer,
Swift, GALEX, XMM, Chandra
Keck, Palomar, MMT, LBT Spectroscopy

See Talk by Andreas Schruba

and

Poster by Maria Kapala

Panchromatic Hubble Andromeda Treasury (PHAT)

Dalcanton+ 2012

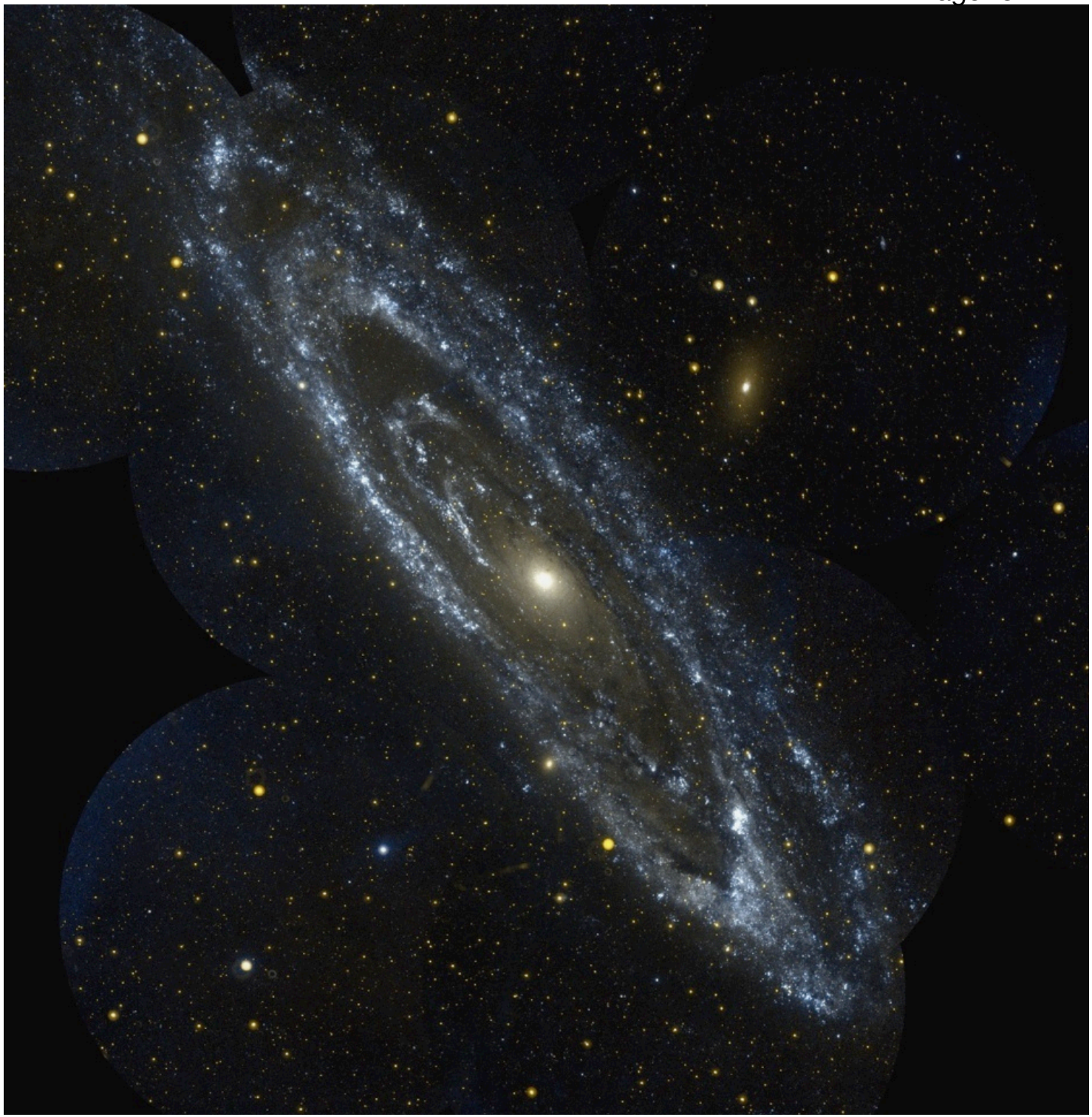
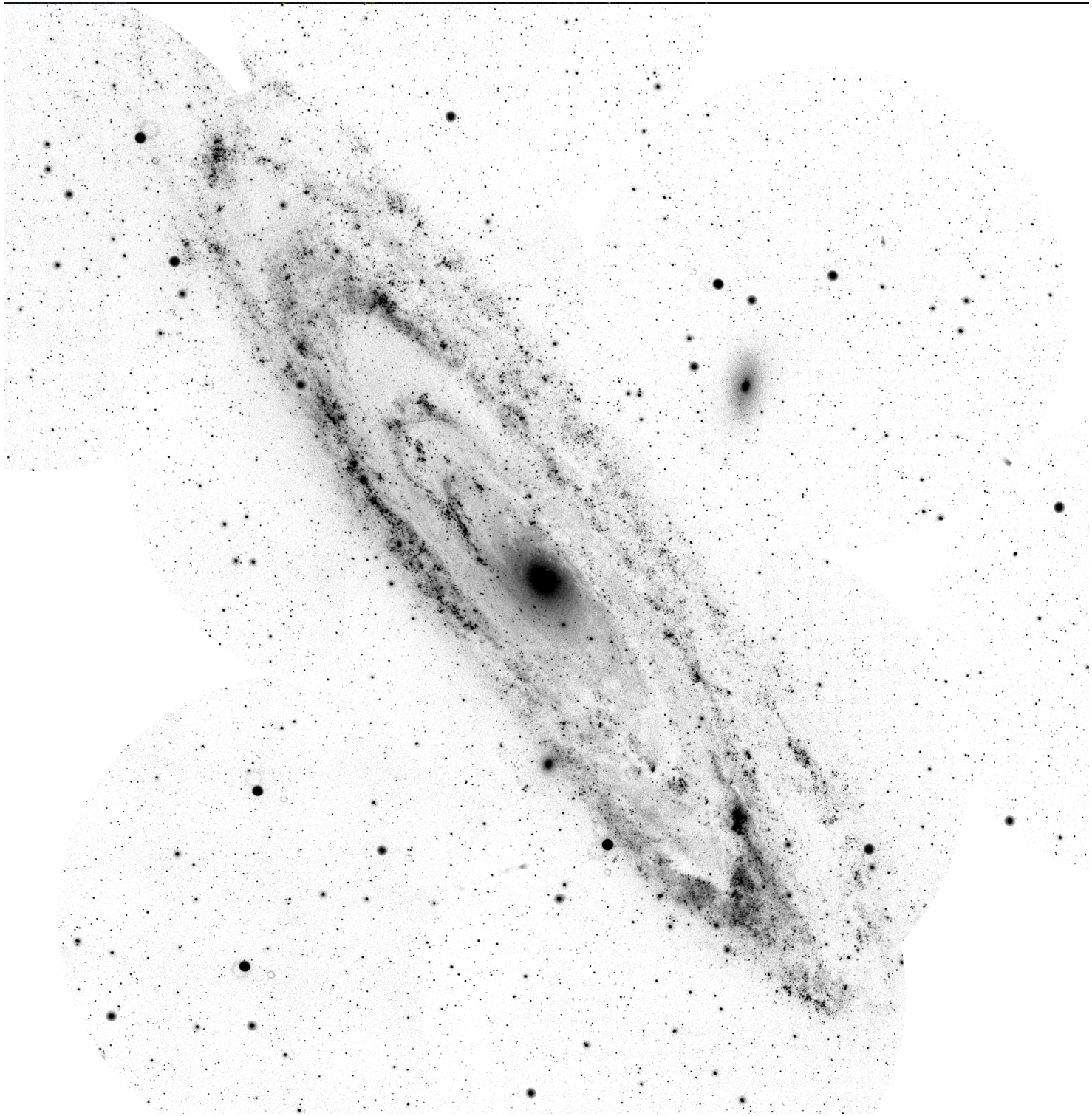


Image: GALEX

PHAT
PANCHROMATIC HUBBLE ANDROMEDA TREASURY

Panchromatic Hubble Andromeda Treasury (PHAT)

Dalcanton+ 2012

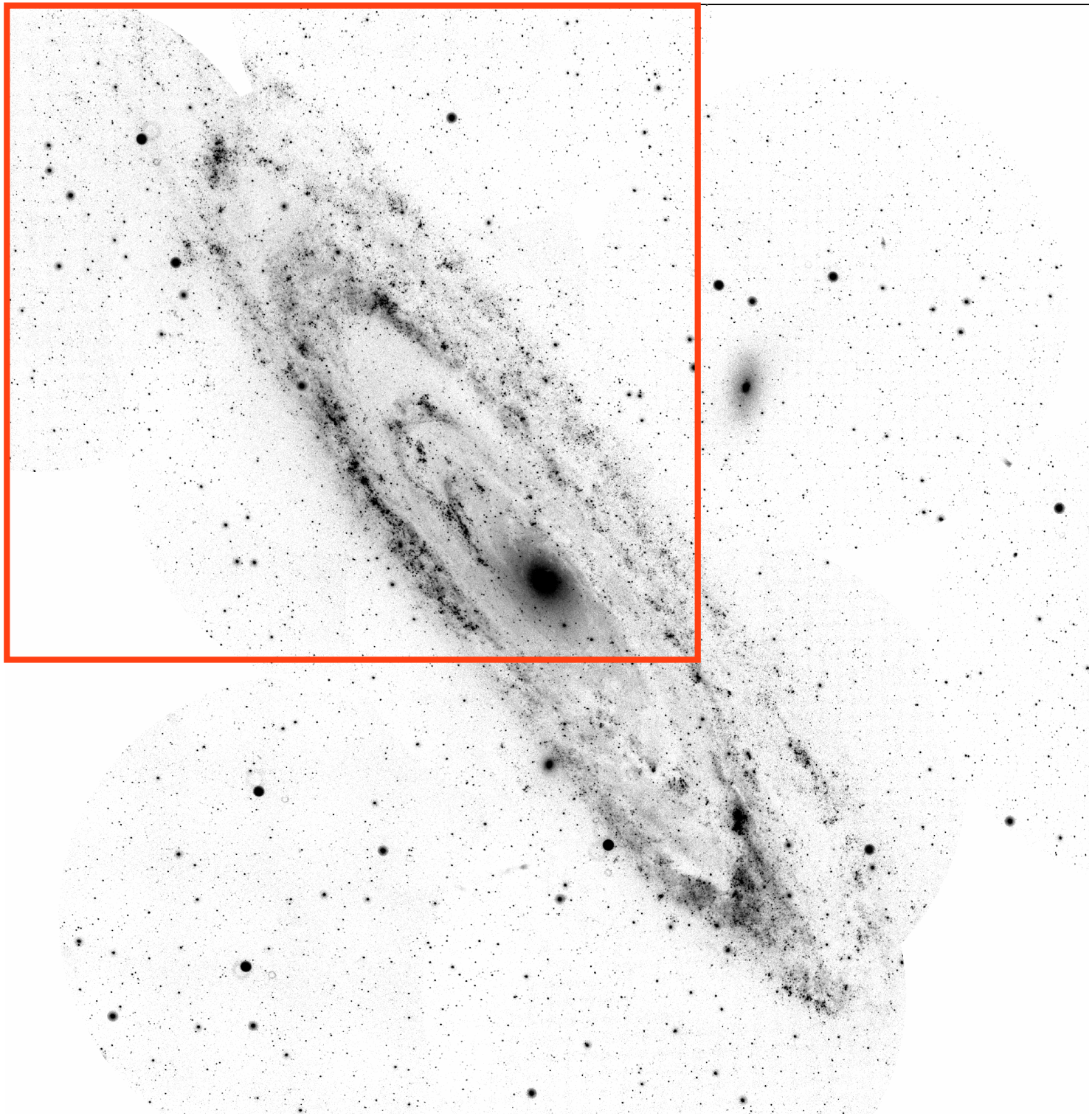


PHAT

PANCHROMATIC HUBBLE ANDROMEDA TREASURY

Panchromatic Hubble Andromeda Treasury (PHAT)

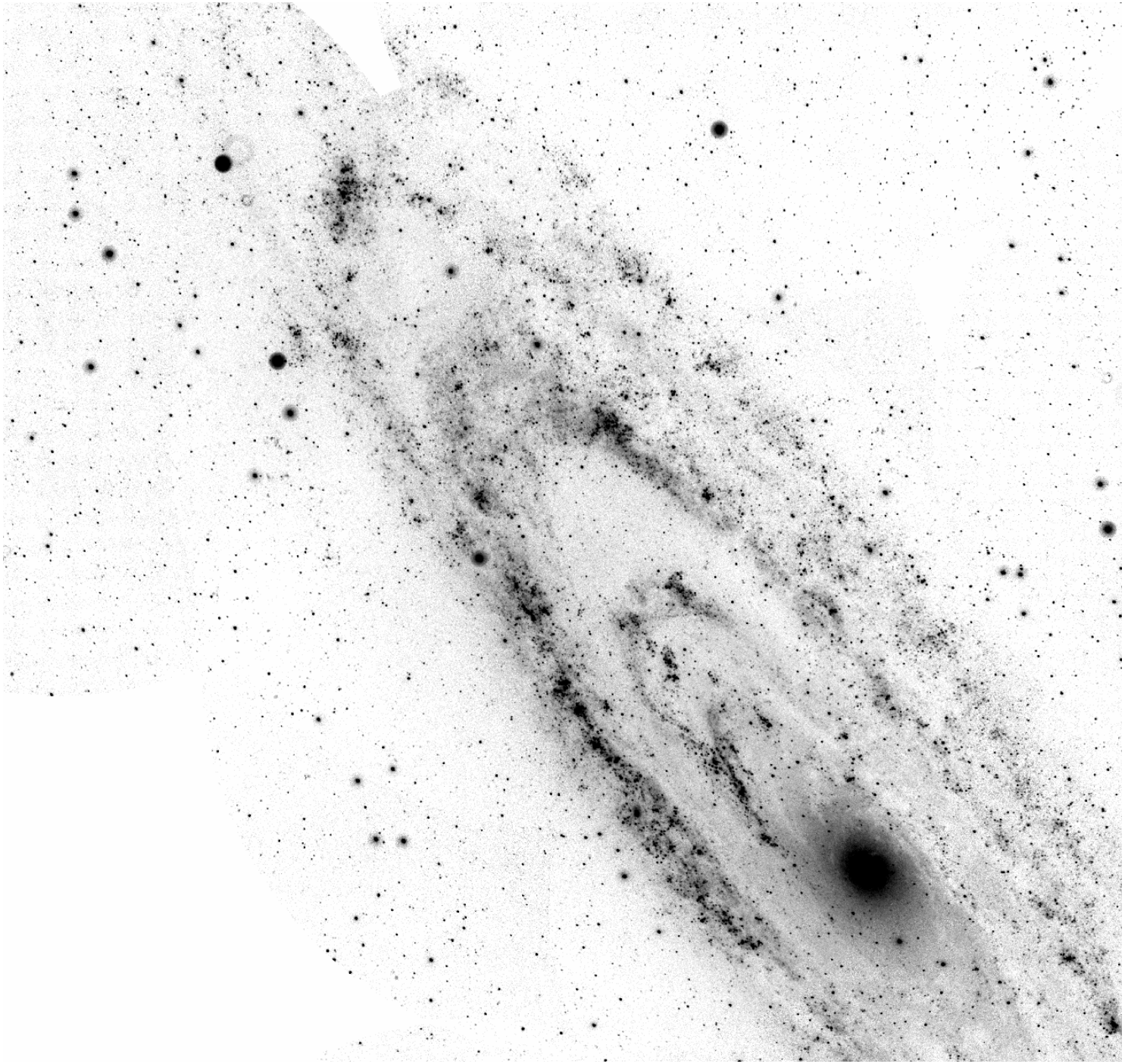
Dalcanton+ 2012



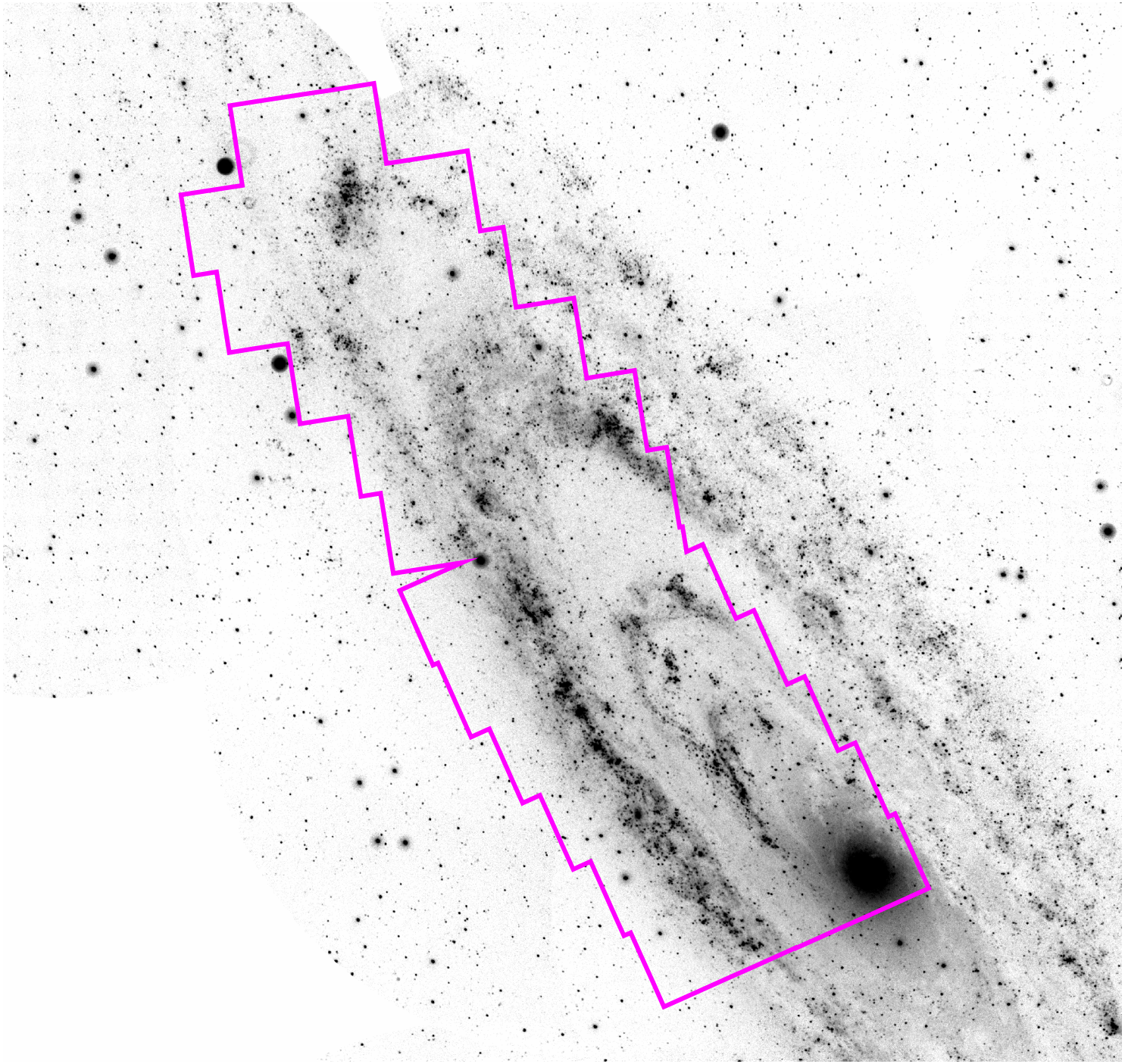
PHAT

PANCHROMATIC HUBBLE ANDROMEDA TREASURY

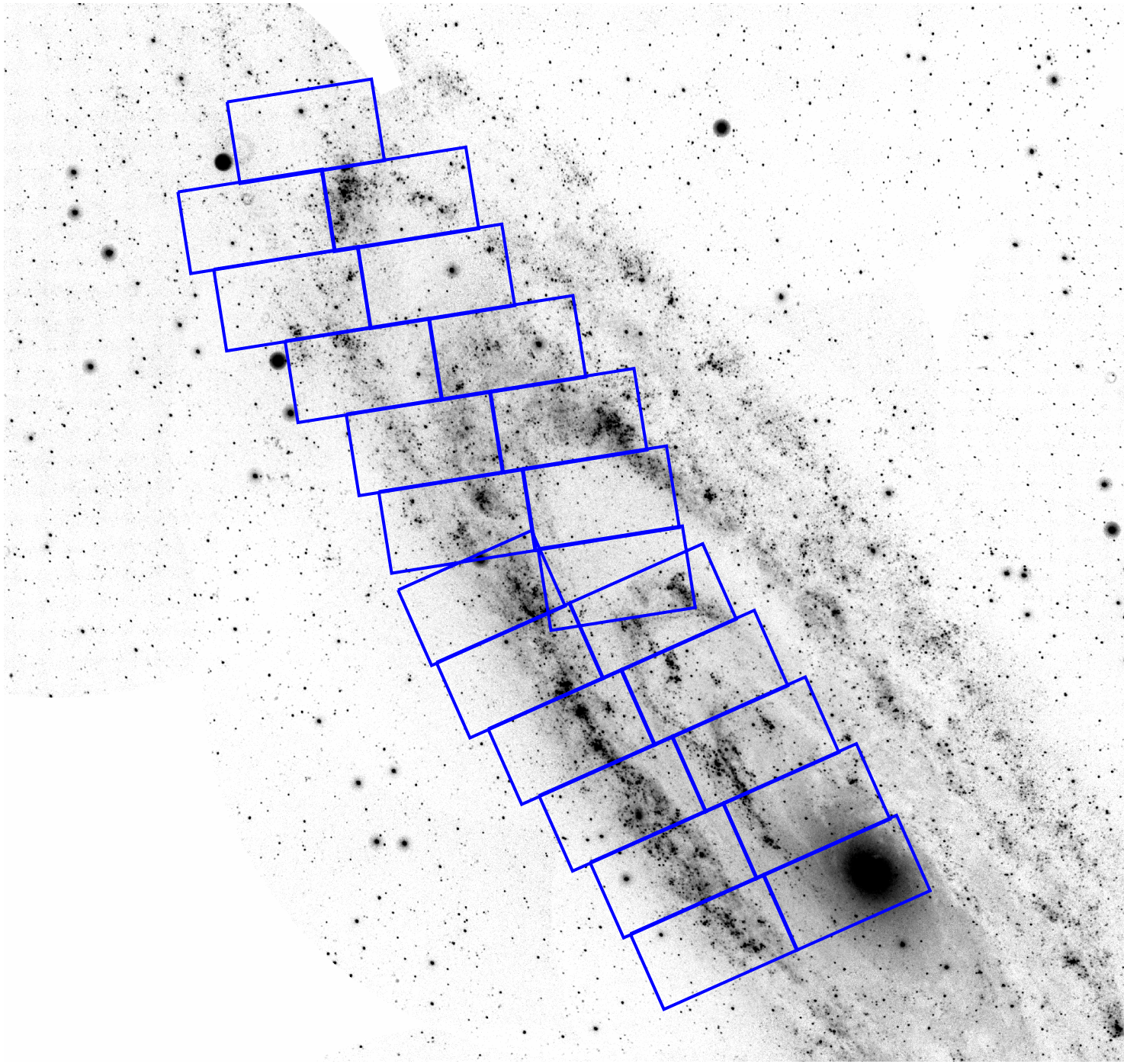
Panchromatic Hubble Andromeda Treasury (PHAT)



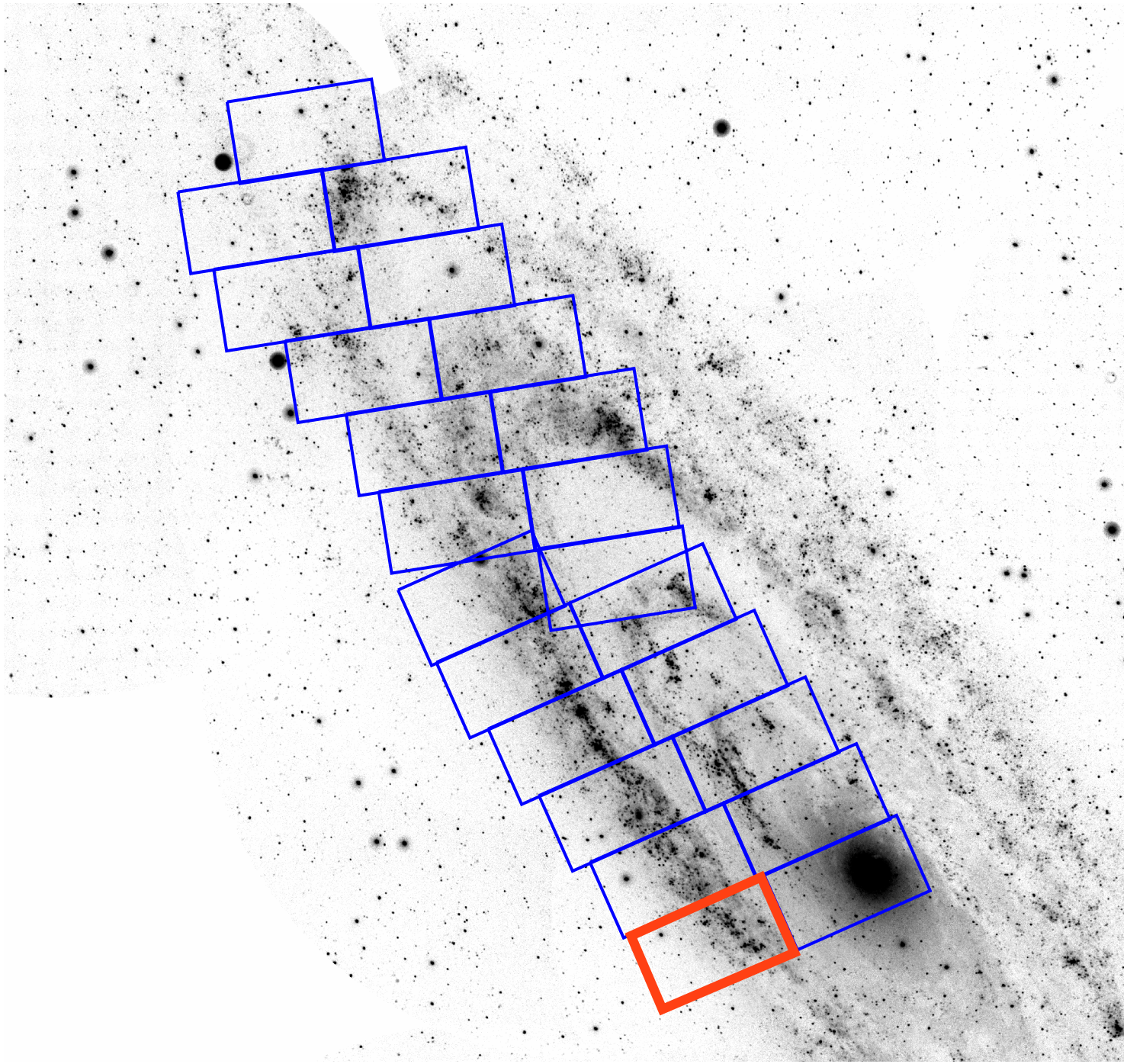
Panchromatic Hubble Andromeda Treasury (PHAT)



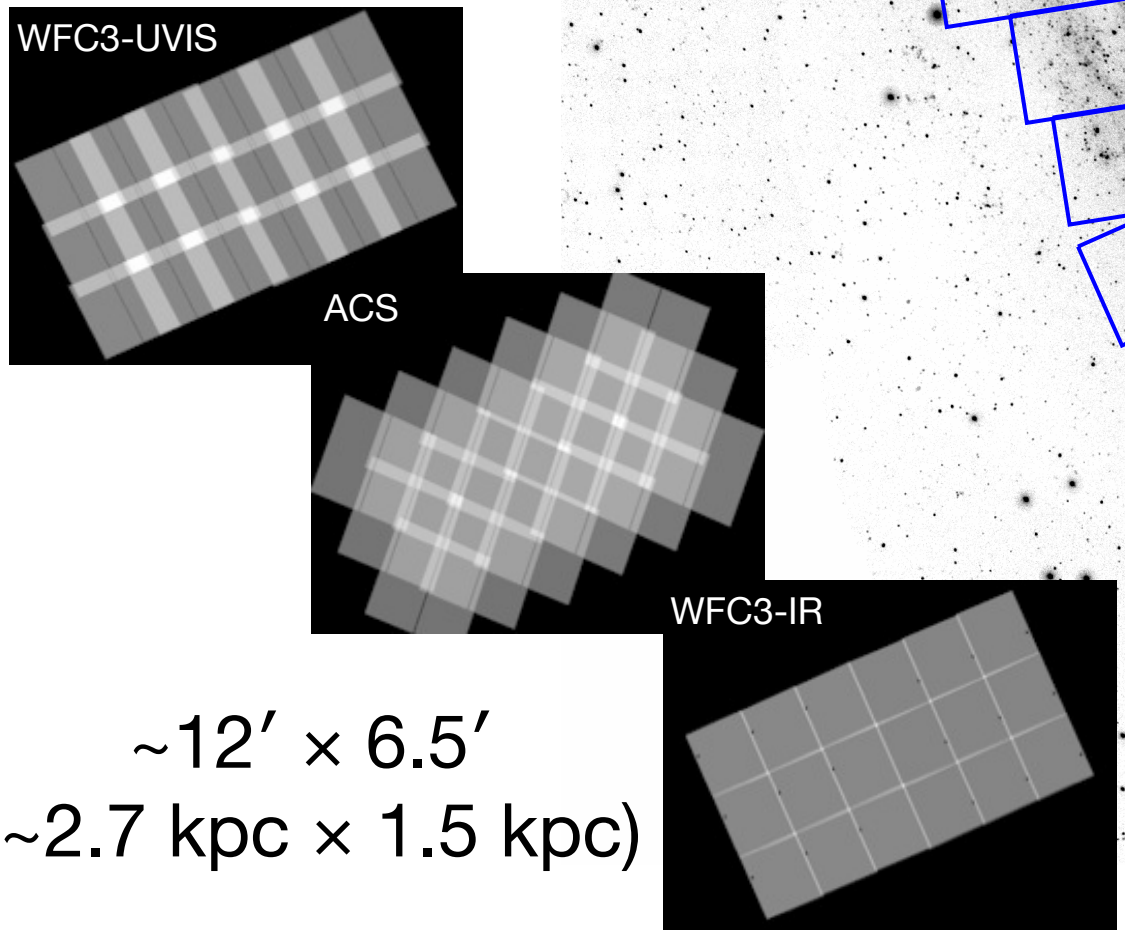
Panchromatic Hubble Andromeda Treasury (PHAT)



Panchromatic Hubble Andromeda Treasury (PHAT)

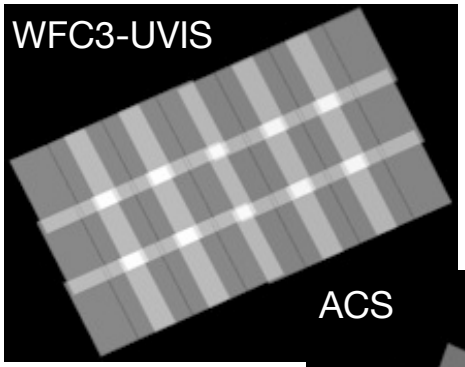


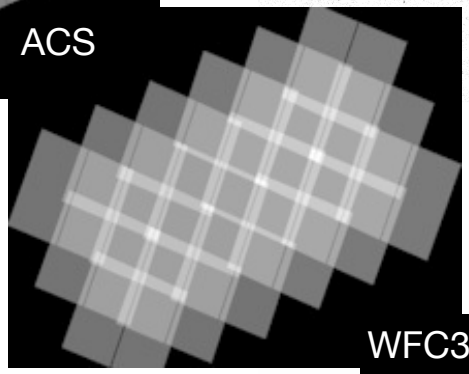
Panchromatic Hubble Andromeda Treasury (PHAT)

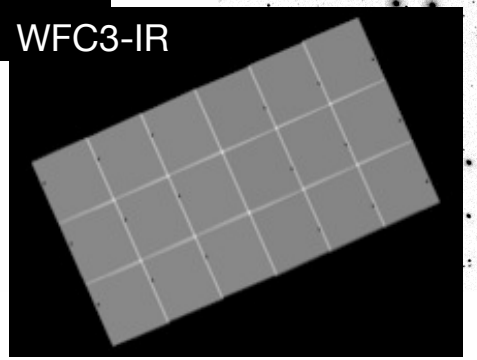


~12′ × 6.5′
(~2.7 kpc × 1.5 kpc)

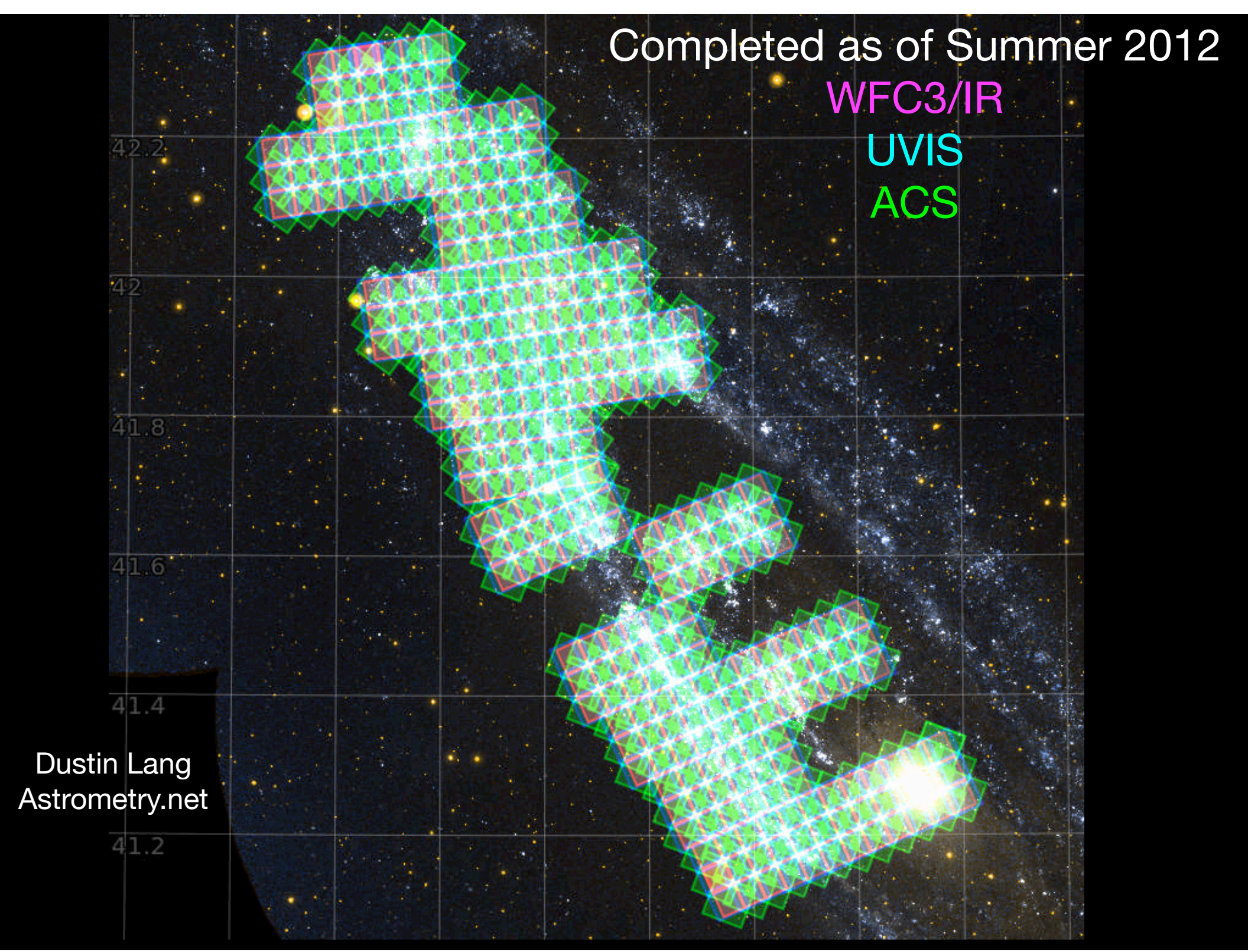
Panchromatic Hubble Andromeda Treasury (PHAT)

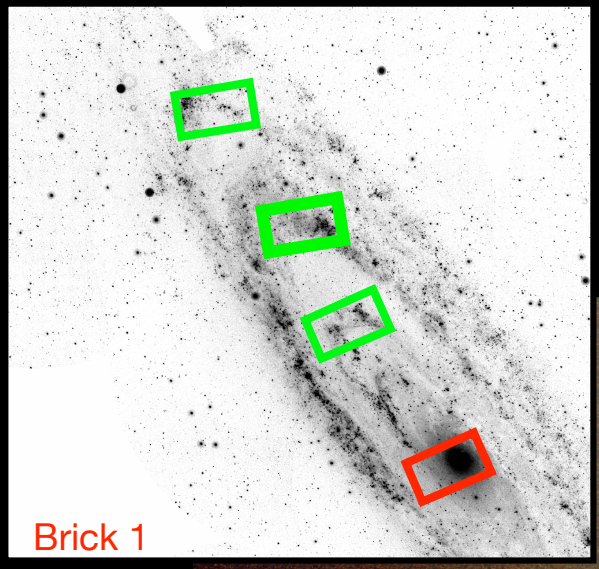




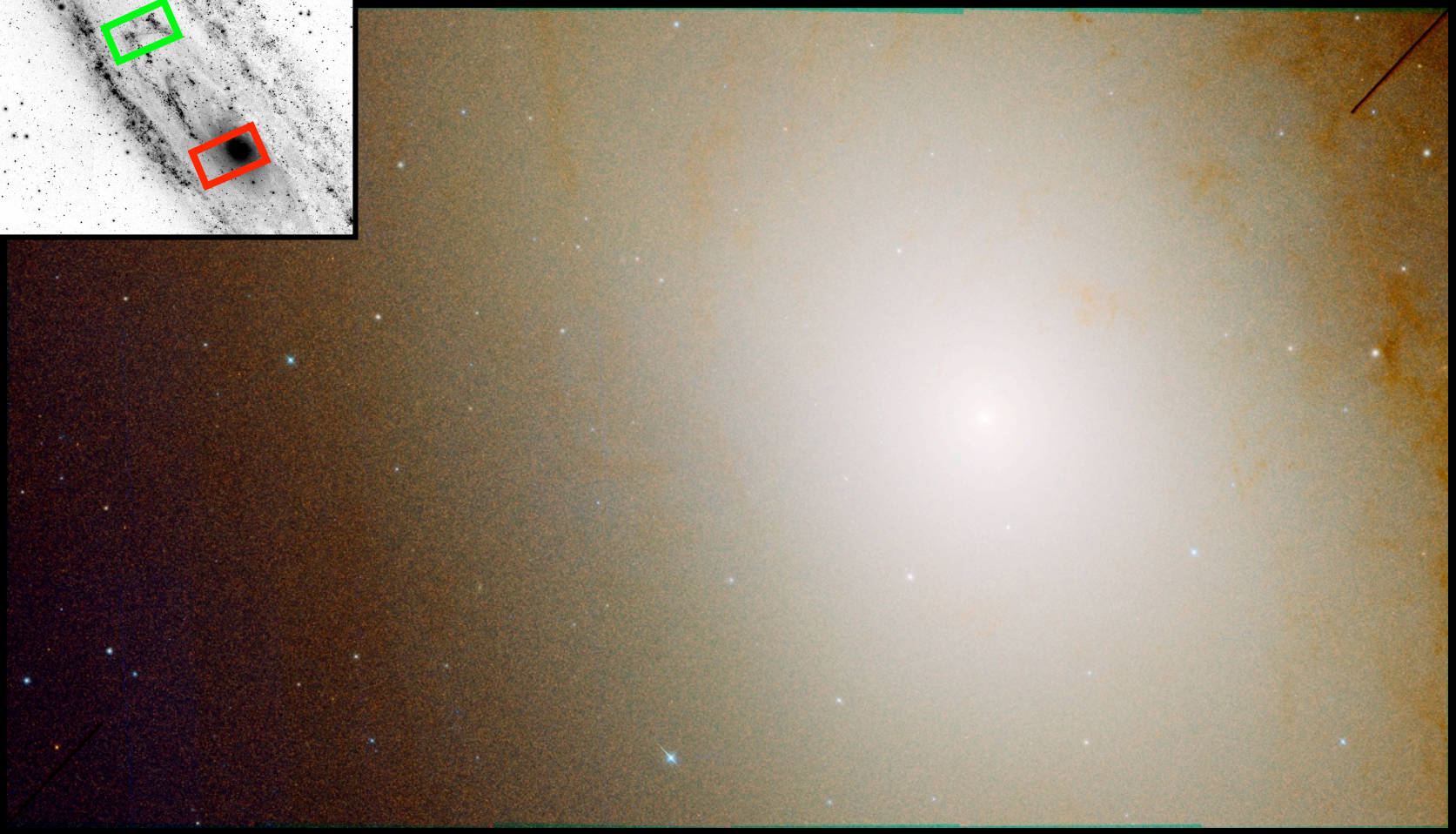


~12′ × 6.5′
(~2.7 kpc × 1.5 kpc)

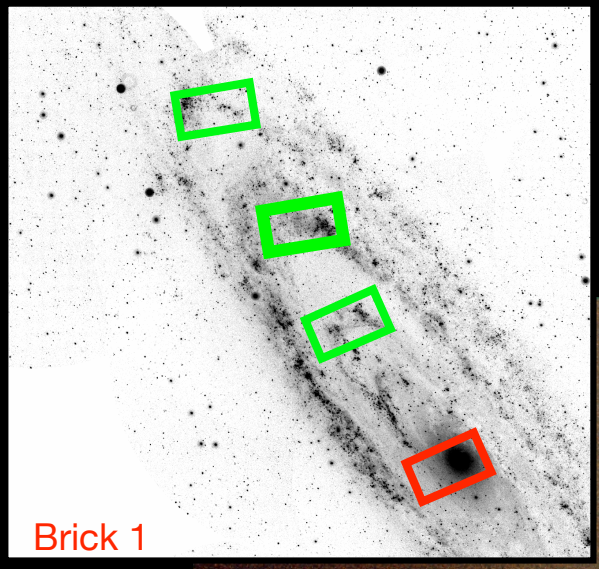

Completed as of Summer 2012
WFC3/IR
UVIS
ACS
42.2
42
41.8
41.6
41.4
41.2
Dustin Lang
Astrometry.net



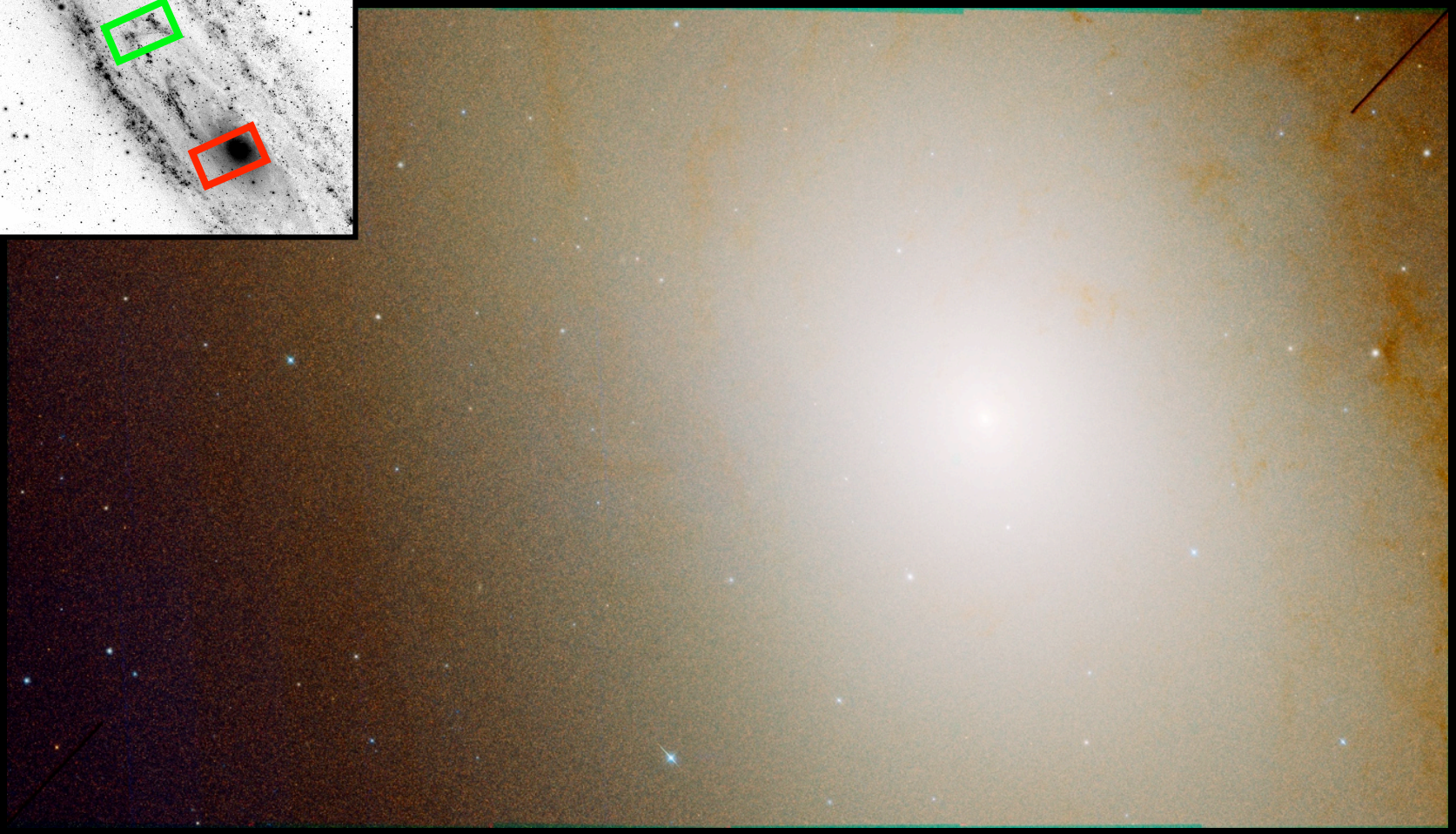
F336W+F475W+F814W+F160W



~1.5 kpc

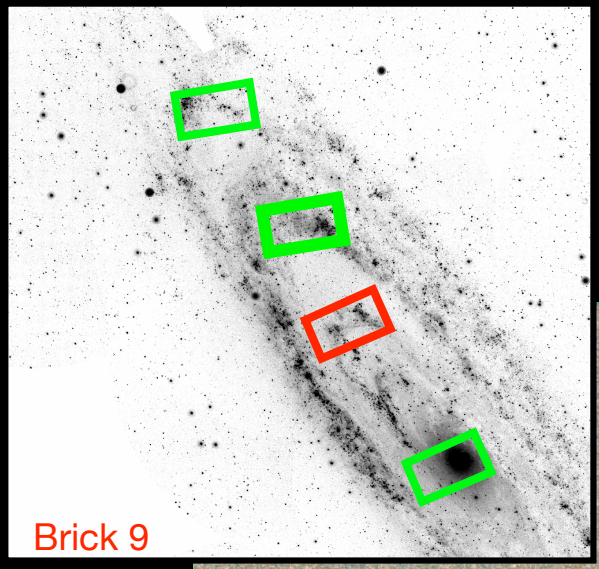


F336W+F475W+F814W+F160W

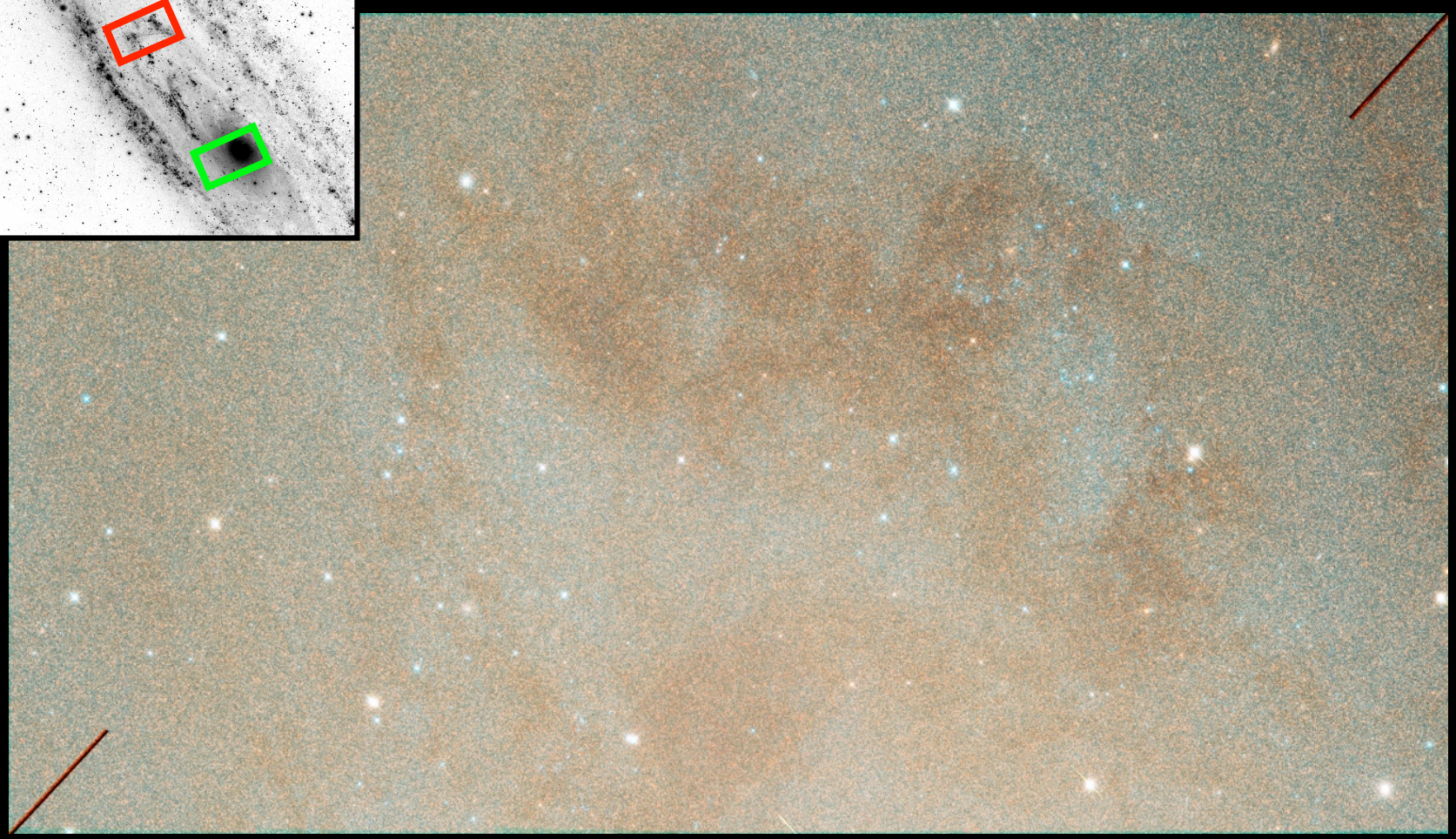


~1.5 kpc

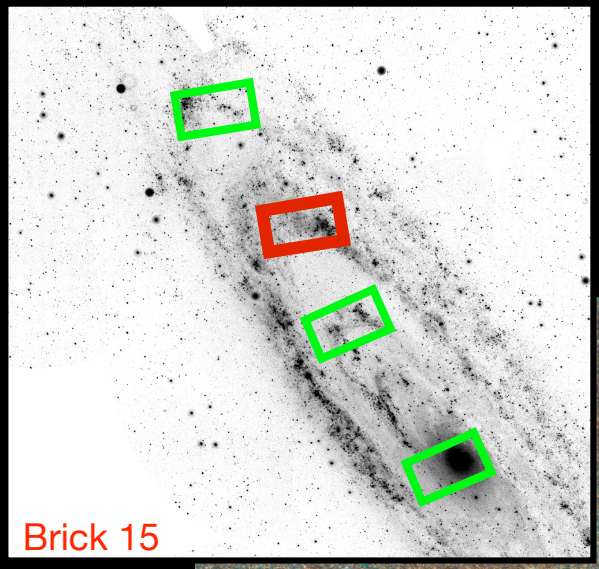
Characterizing UV Bright Populations in the Bulge of M31
Rosenfield+ 2012



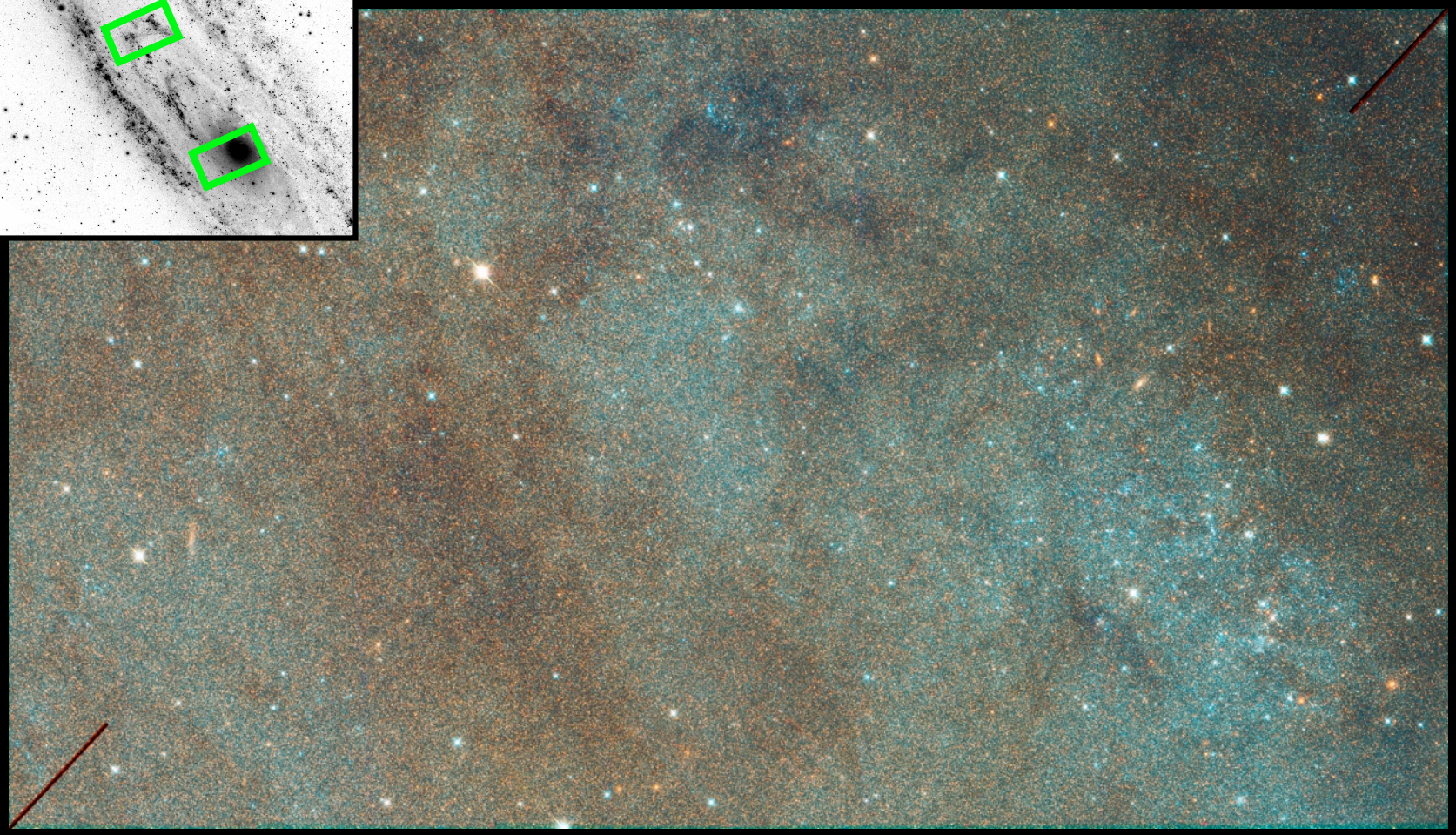
F336W+F475W+F814W+F160W



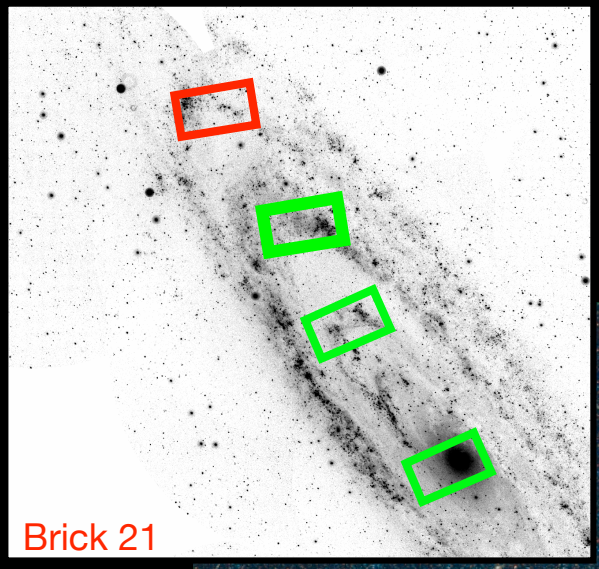
~1.5 kpc



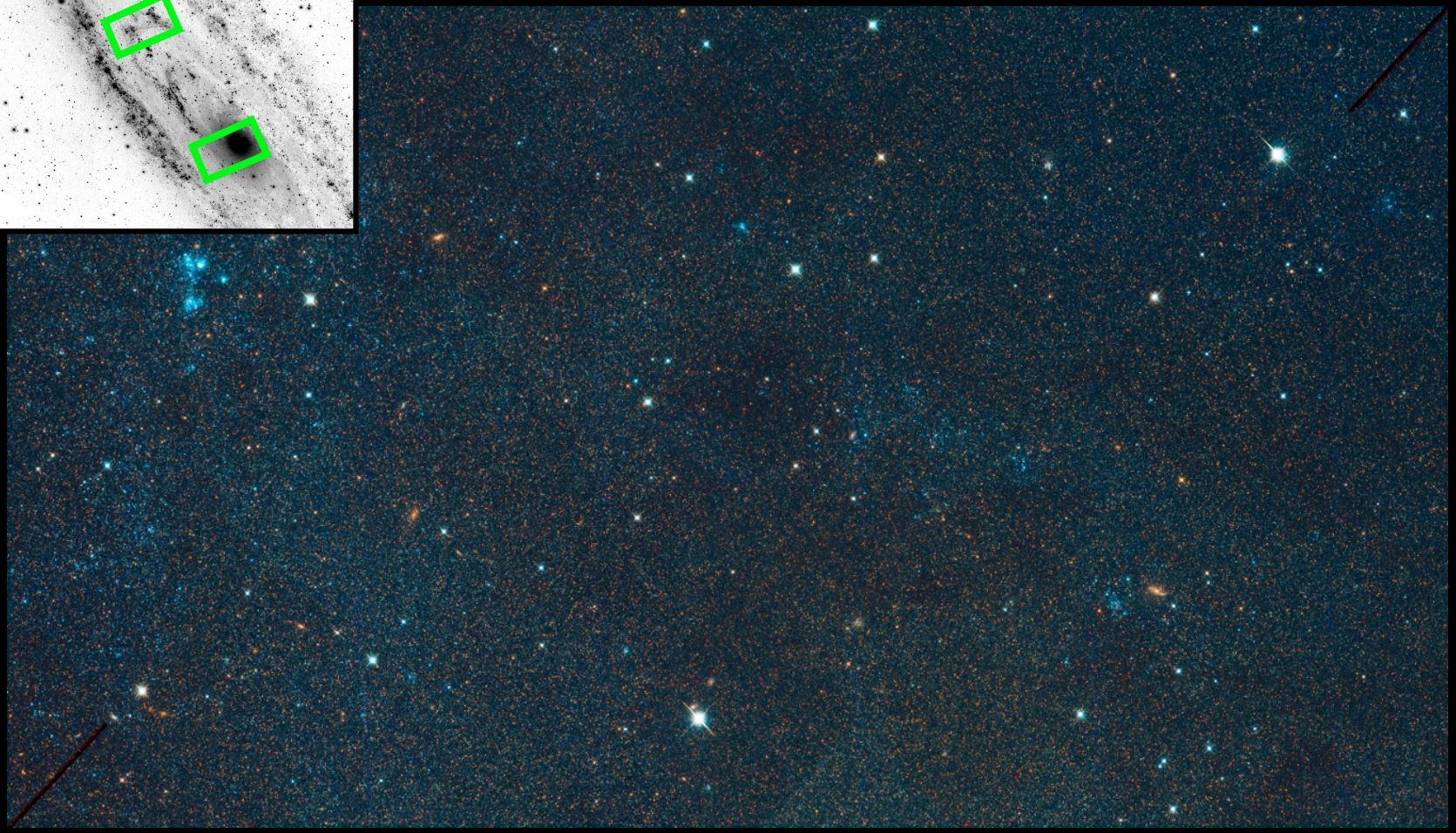
F336W+F475W+F814W+F160W



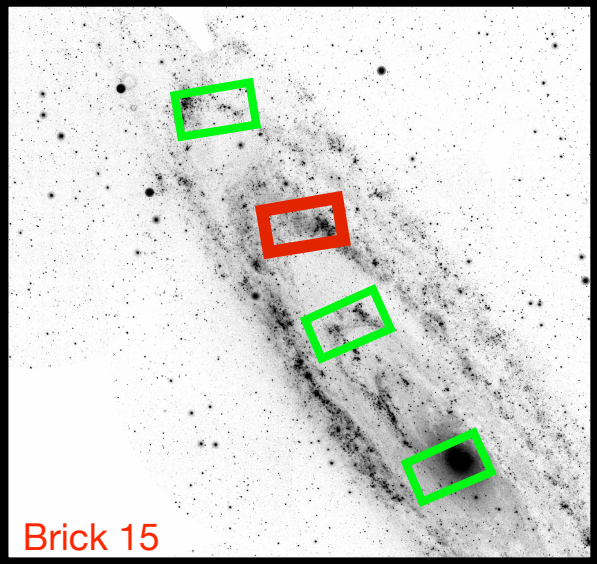
~1.5 kpc

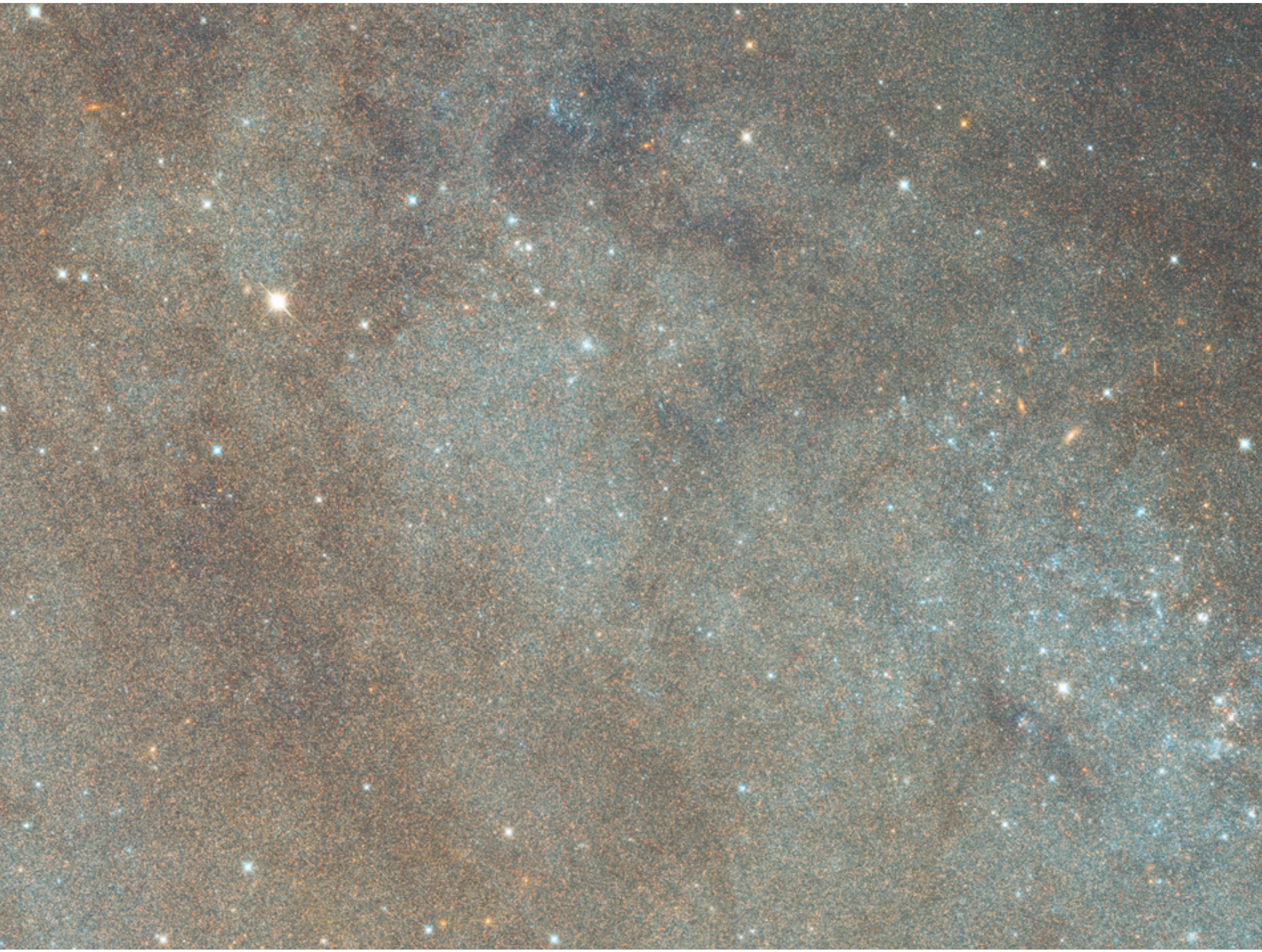


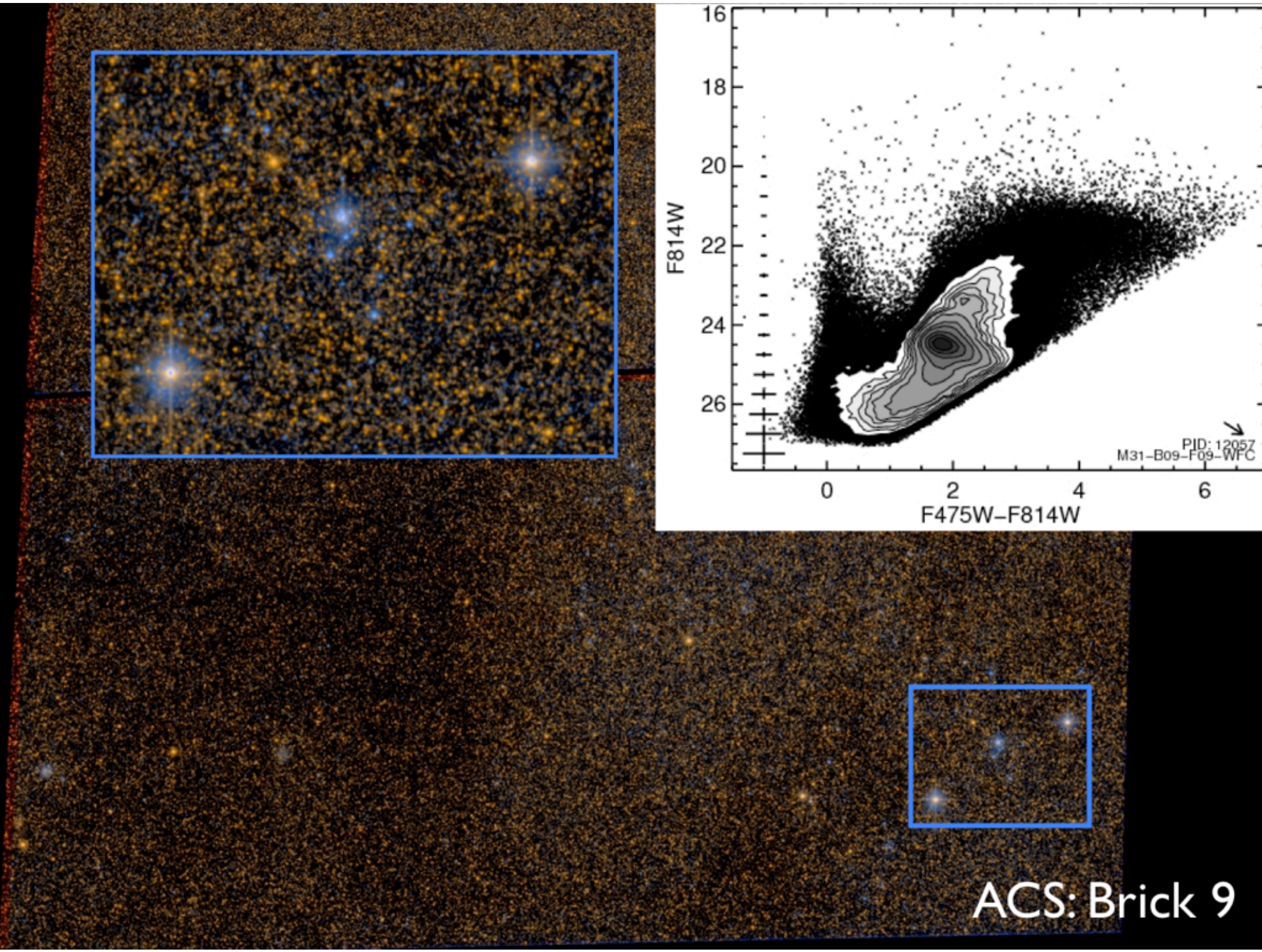
F336W+F475W+F814W+F160W

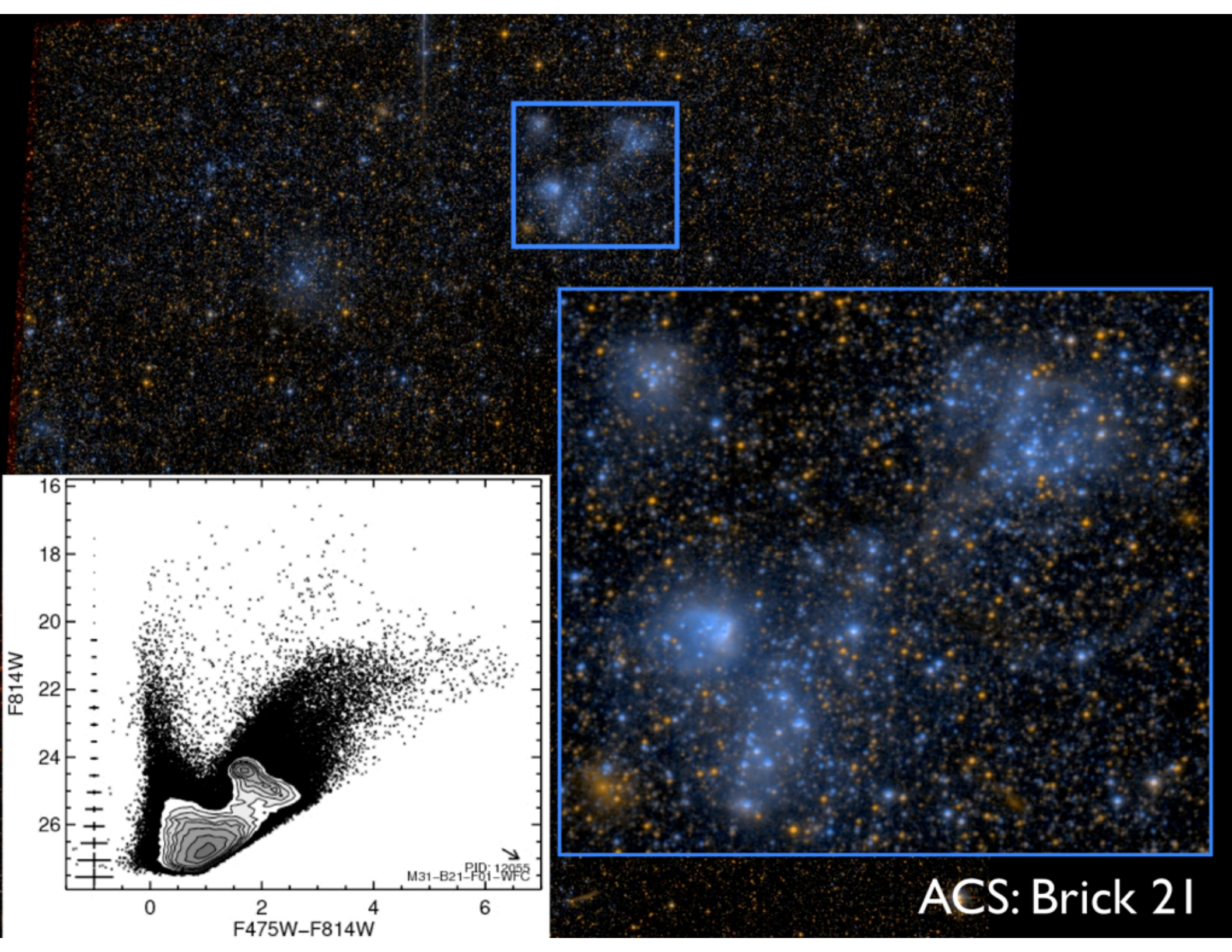


~1.5 kpc


Brick 15




16
18
20
22
24
26
F814W
0
2
4
6
F475W–F814W
PID: 12057
M31-B09-F09-WFC
ACS: Brick 9


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

Early Science

Star Cluster Catalog

Star Cluster Age and Mass Distributions

Dust Heating Mechanisms

Field vs. Clustered Star Formation

Ancient UV Bright Stellar Populations

Dust Mapping

Mapping Structure with the Horizontal Branch

Dust Heating Mechanisms

Inferring the High Mass Stellar IMF

Stellar SED Fitting

Isolated Massive Stars

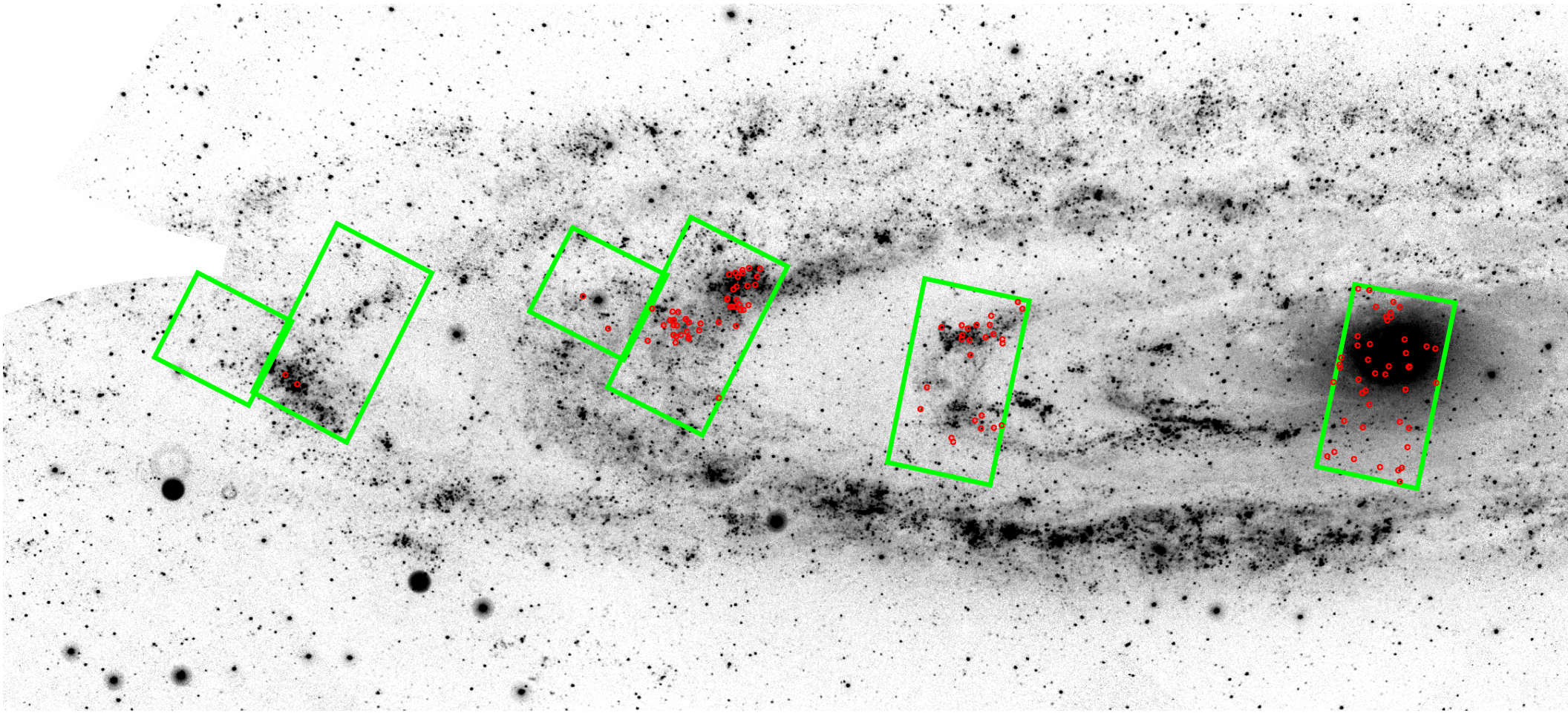
Dust Emissivity Variations

Spatially Resolved Star Formation History

Star Clusters

Cliff Johnson, Morgan Fouesneau, Anil Seth, Nelson Caldwell,
Paul Hodge, Izaskun San Roman, Knut Olsen, Lori Beerman

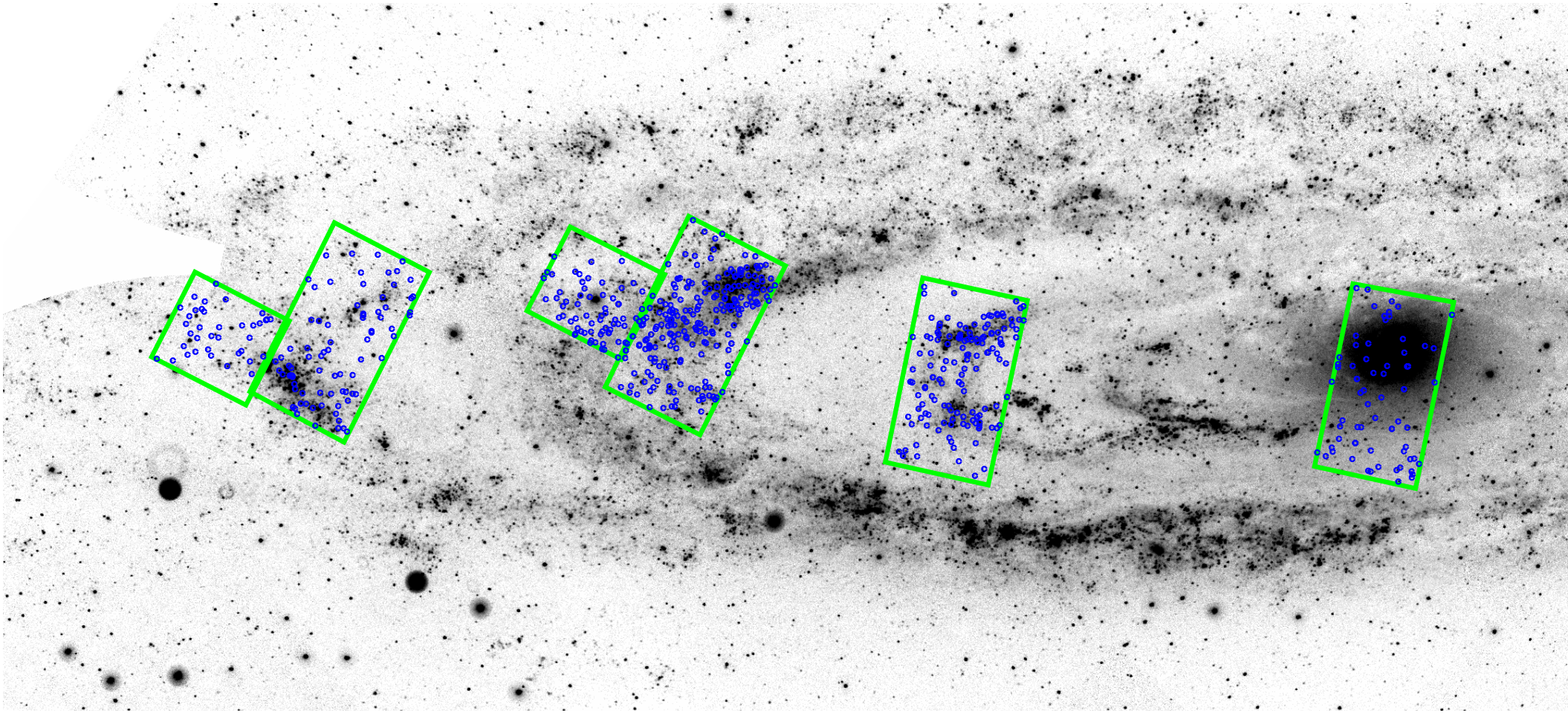
Before PHAT



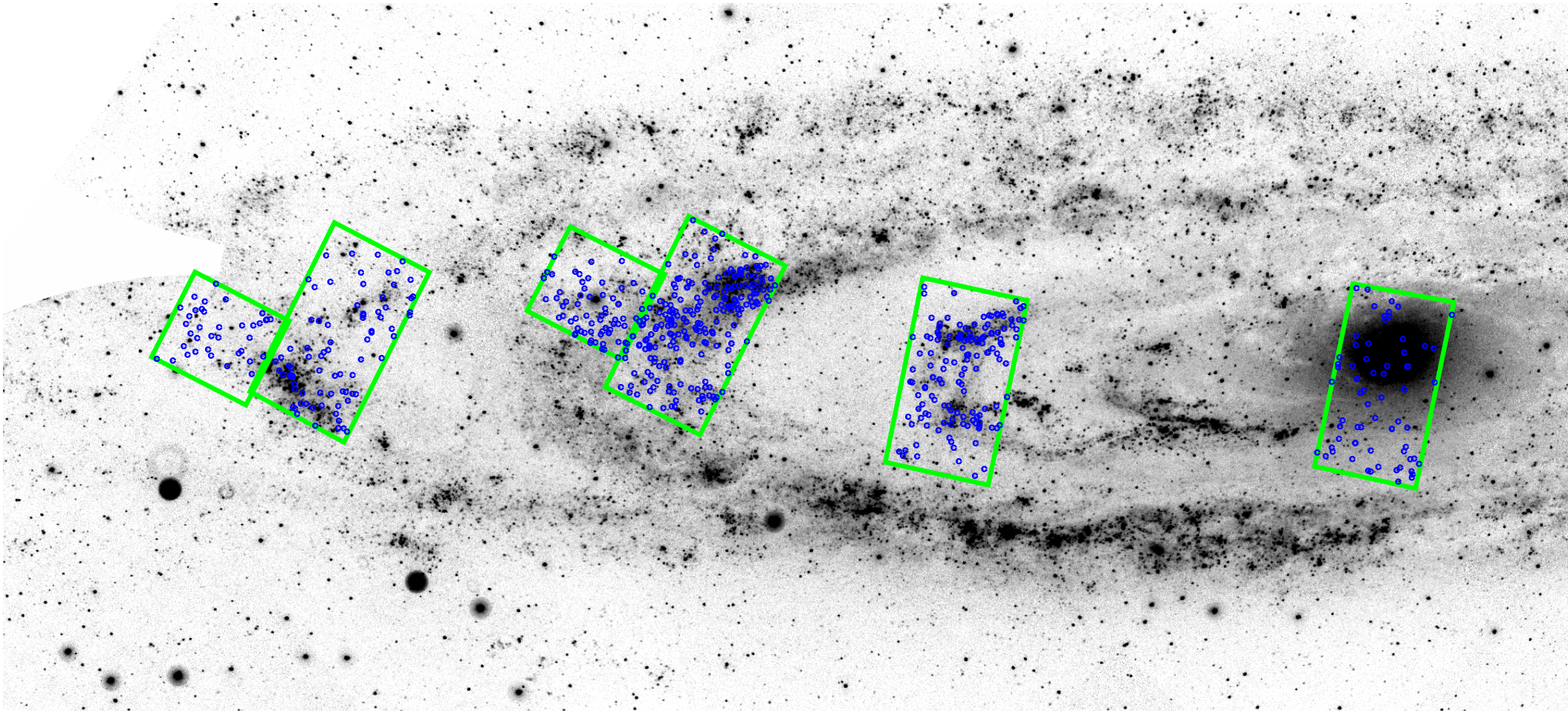
Revised Bologna Catalog
Krienke & Hodge

132 Known Clusters

After PHAT



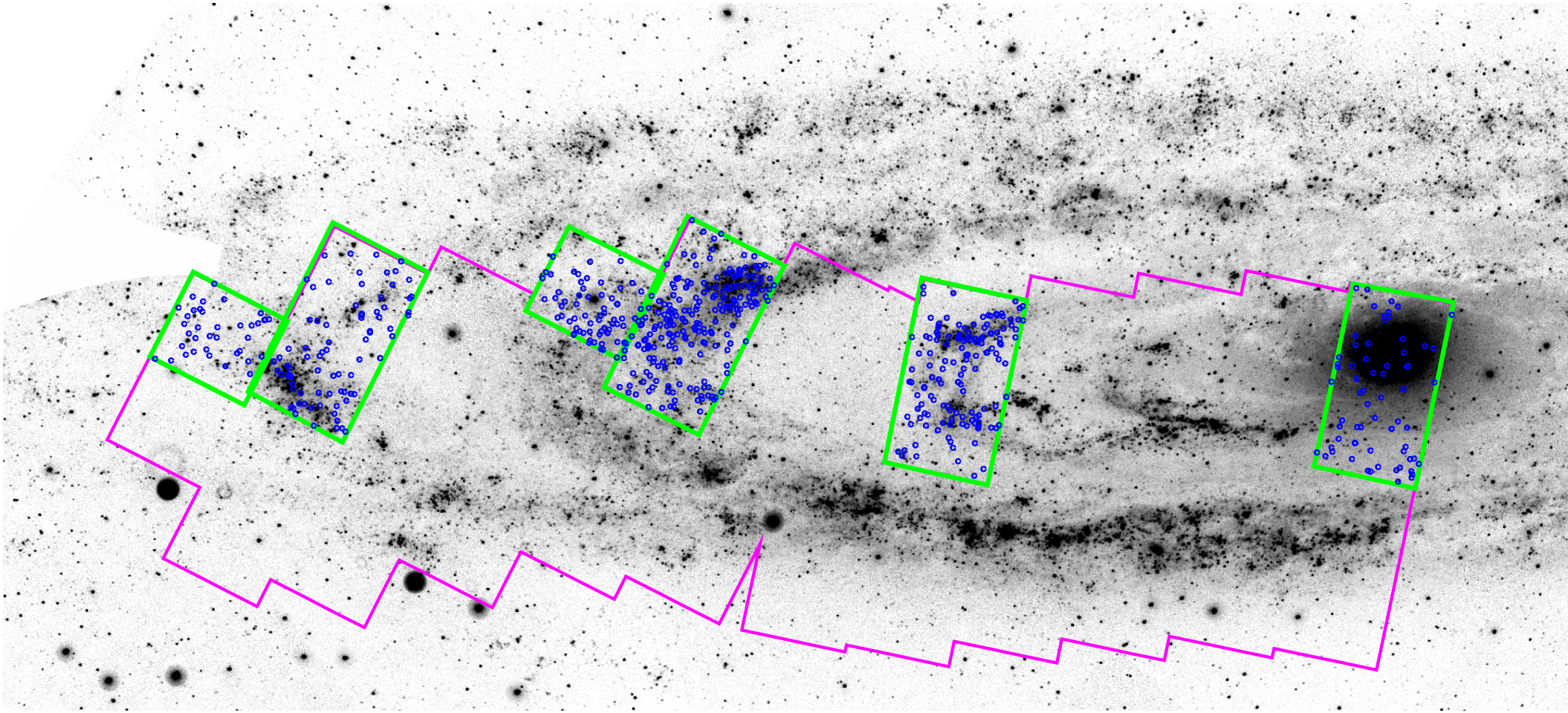
After PHAT



605 Current Cluster Candidates

L. C. Johnson+ 2012

After PHAT

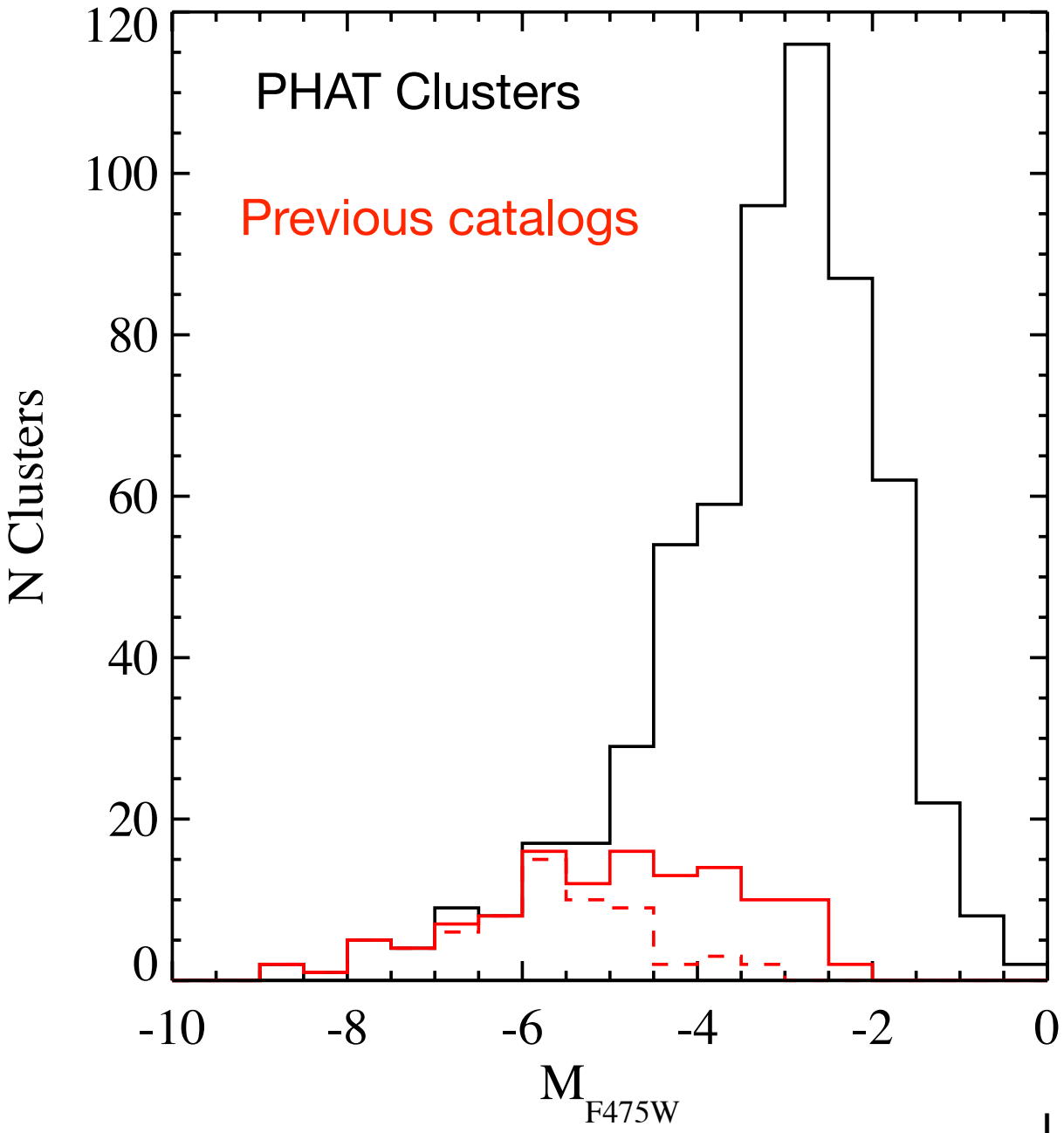


~2500 Total Expected Cluster Candidates

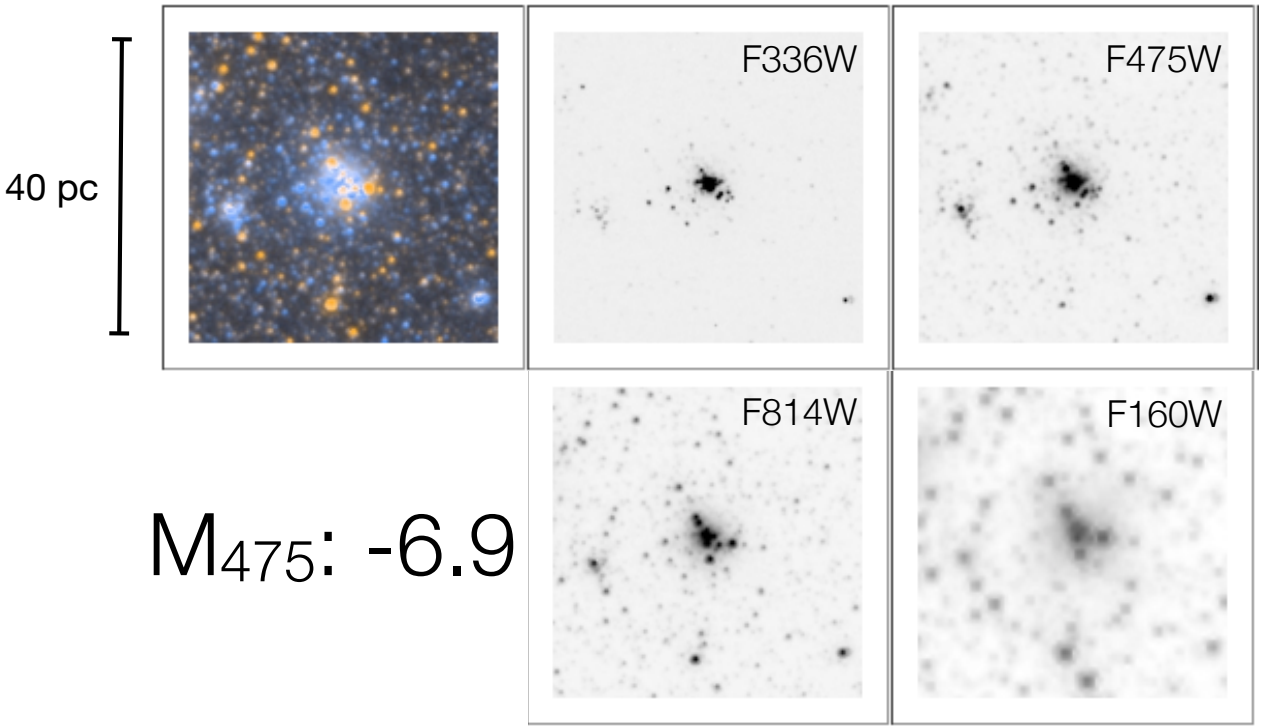
Teaming with Zooniverse
Fall 2012 Launch

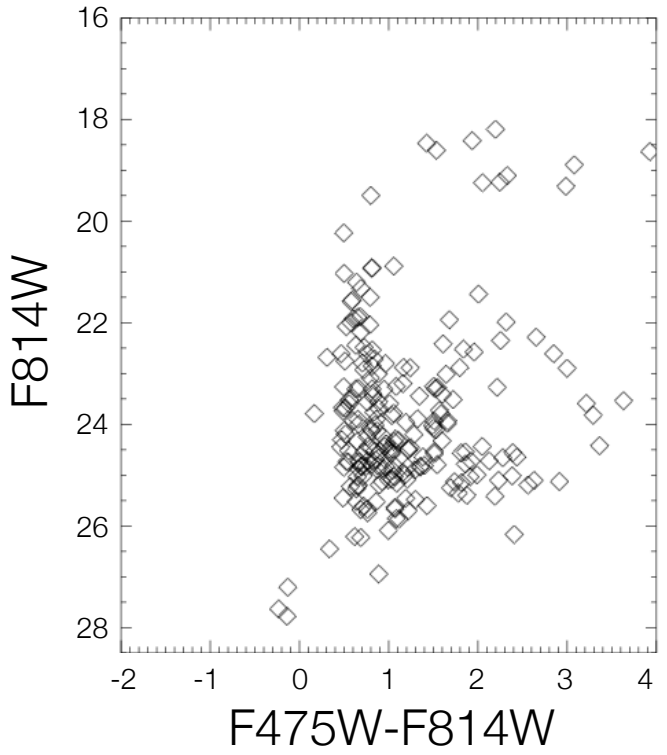
L. C. Johnson+ 2012

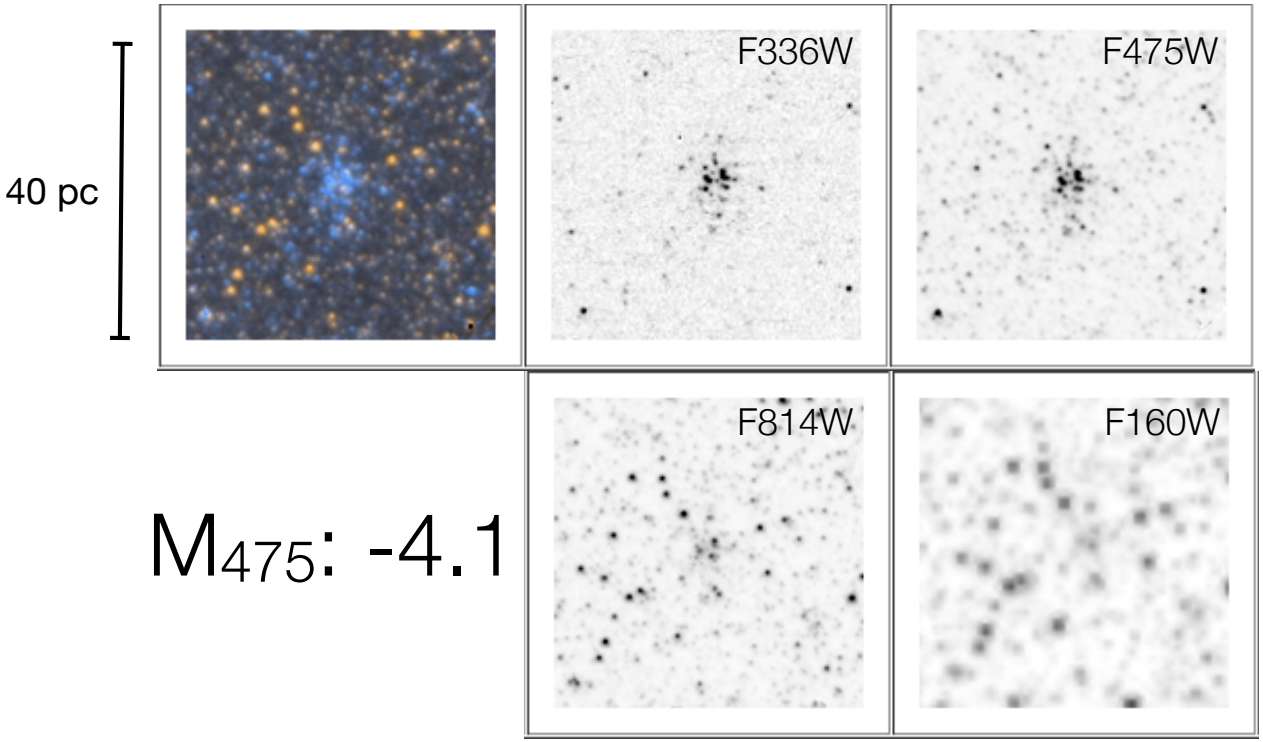
Clusters in PHAT Year 1 Area



L. C. Johnson+ 2012


40 pc
F336W
F475W
F814W
F160W
M475: -6.9


16
18
20
22
24
26
28
F814W
-2
-1
0
1
2
3
4
F475W-F814W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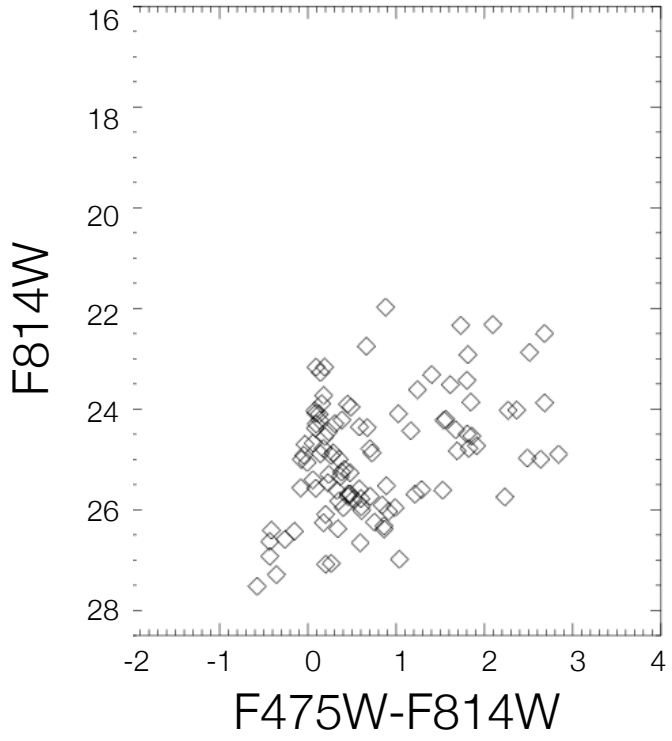
F336W
F475W
F814W
F160W
M475: -4.1


16
18
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22
24
26
28
F814W
-2
-1
0
1
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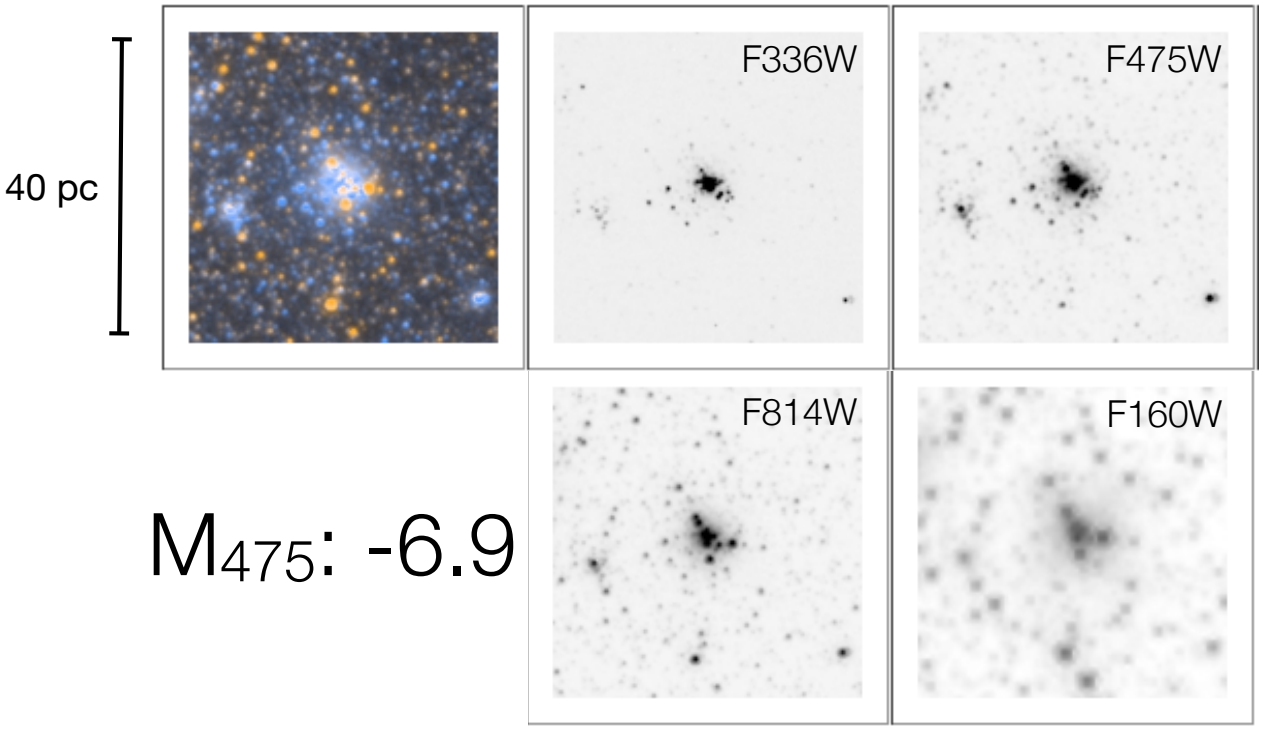
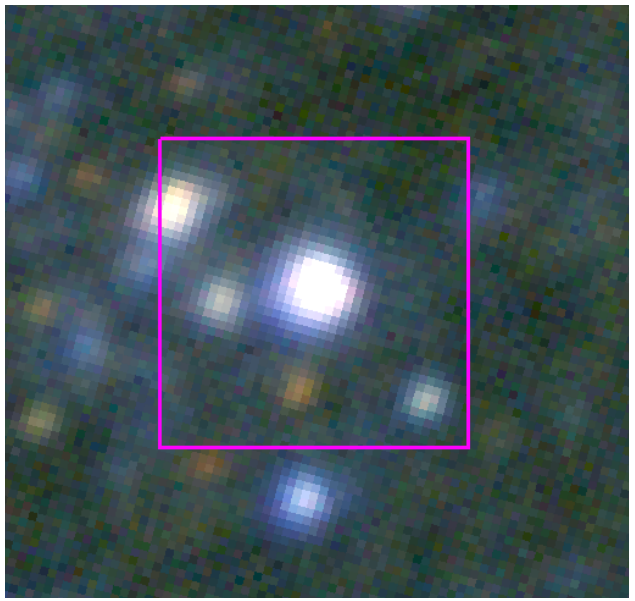
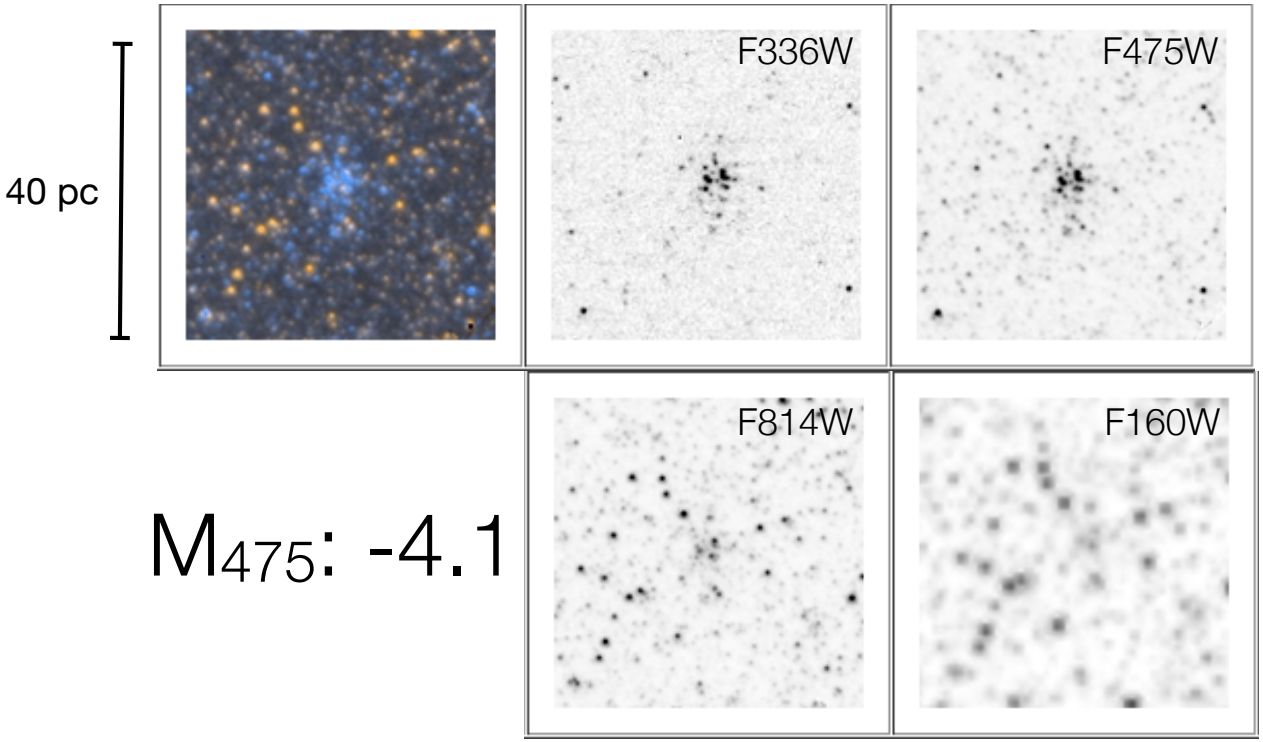
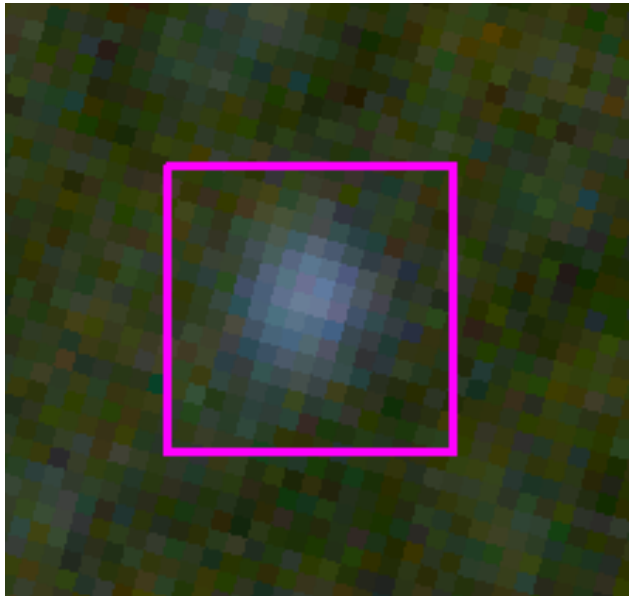
3
4
F475W-F814W


40 pc
F336W
F475W
F814W
F160W
M475: -6.9



Massey LGS

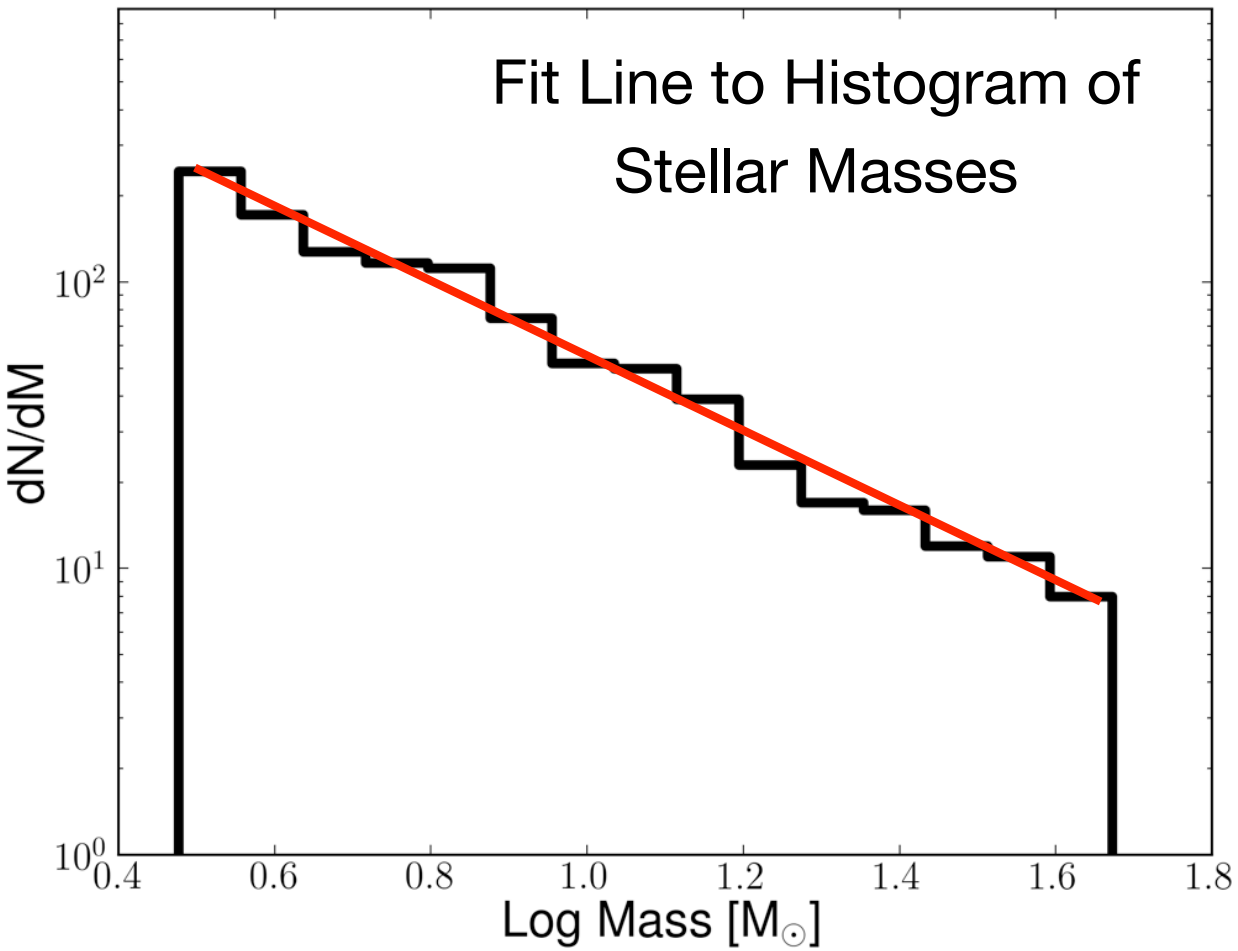

40 pc
F336W
F475W
F814W
F160W
M475: -4.1



High Mass Stellar IMF

Dan Weisz, Morgan Fouesneau, David Hogg, Hans-Walter Rix, Andy Dolphin,
Dustin Lang, Julianne Dalcanton, Eric Bell, Dimitrios Gouliermis, Evan Skillman

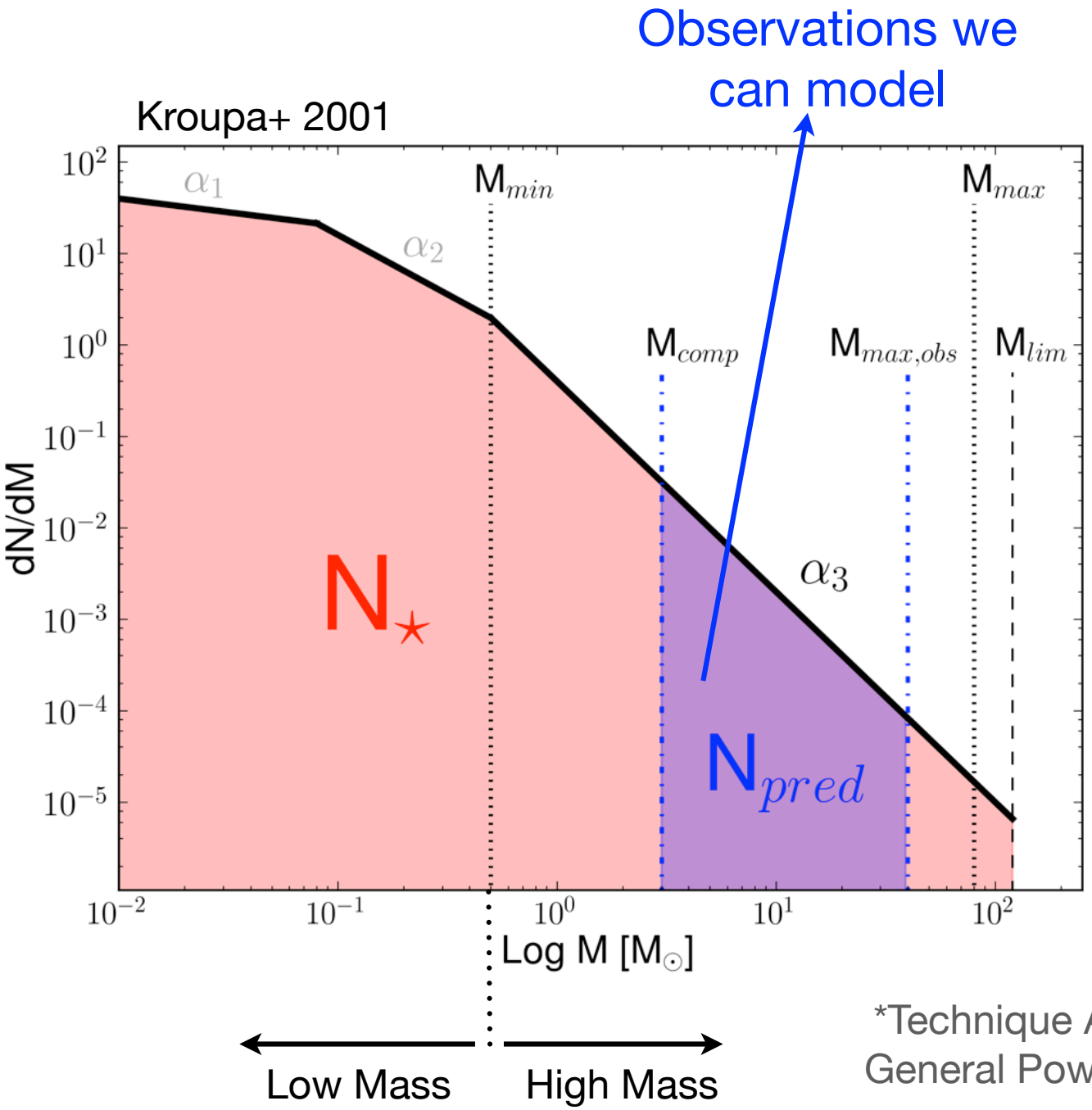
Conventional MF Slope Determination



- Choice in bin sizes?
- Mass Uncertainties?
- Completeness Effects?
- What about upper mass limit?
- Error Bars on Slope?

Inadequate approach for measuring the MF.
Hard to say anything about the IMF.

Probabilistic Approach to MF Measurement*



Simple MF Model

$P(\theta|M) \propto P(M|\theta)\ P(\theta)$

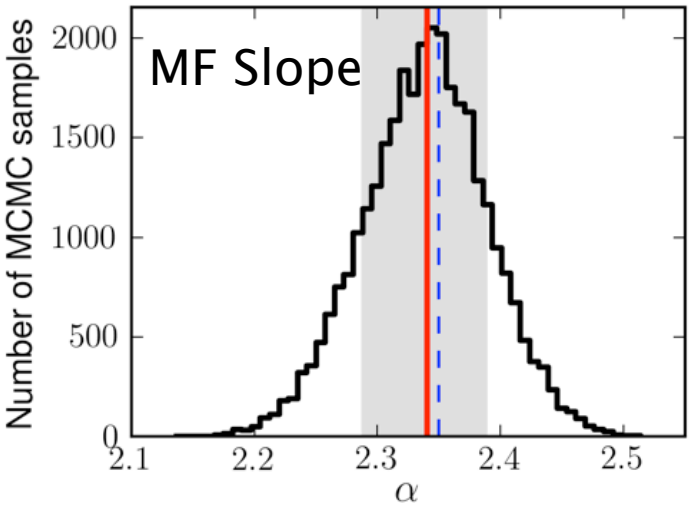
$P(M|\theta) \propto M^{-\alpha}$

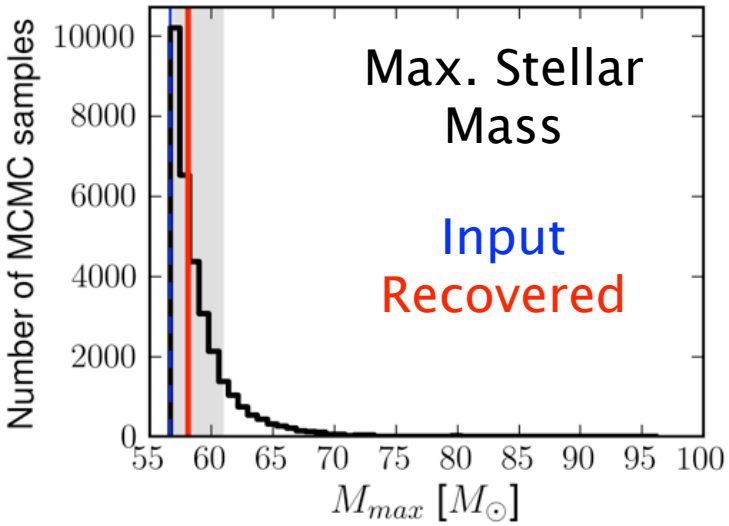
$\theta = \{\alpha, M_{Max}, N_{Pred}\}$

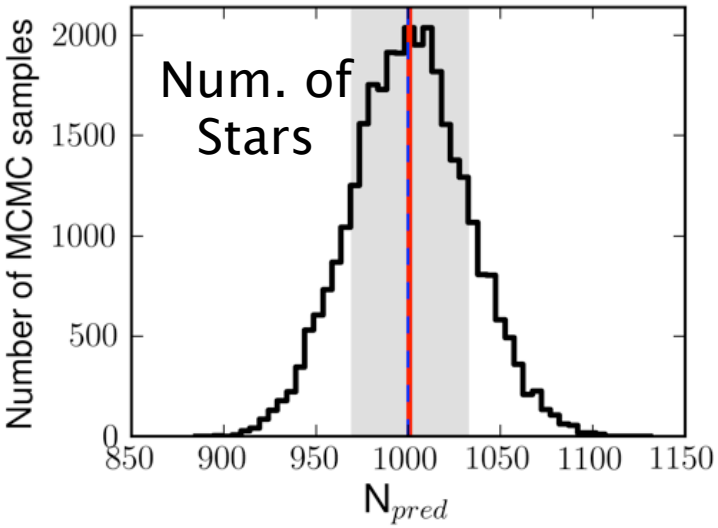
*Technique Applicable to General Power-law Fitting

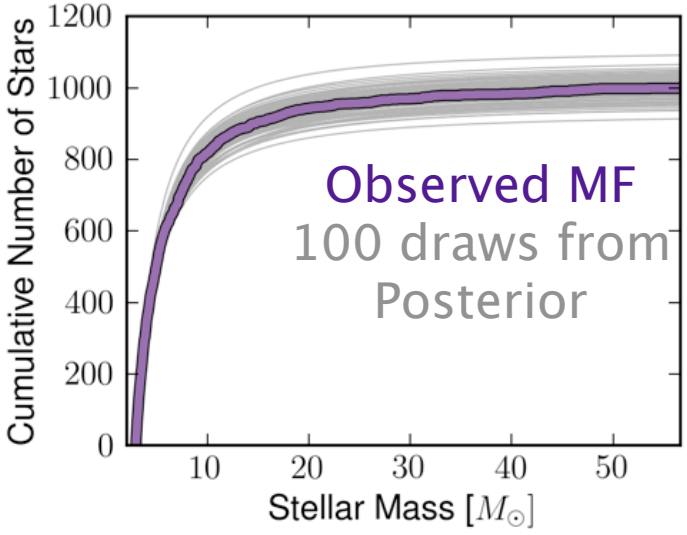
Weisz+ 2012

Marginalized Distributions of Posterior for a Simulated Cluster









- Perfectly known masses
- Perfectly known completeness

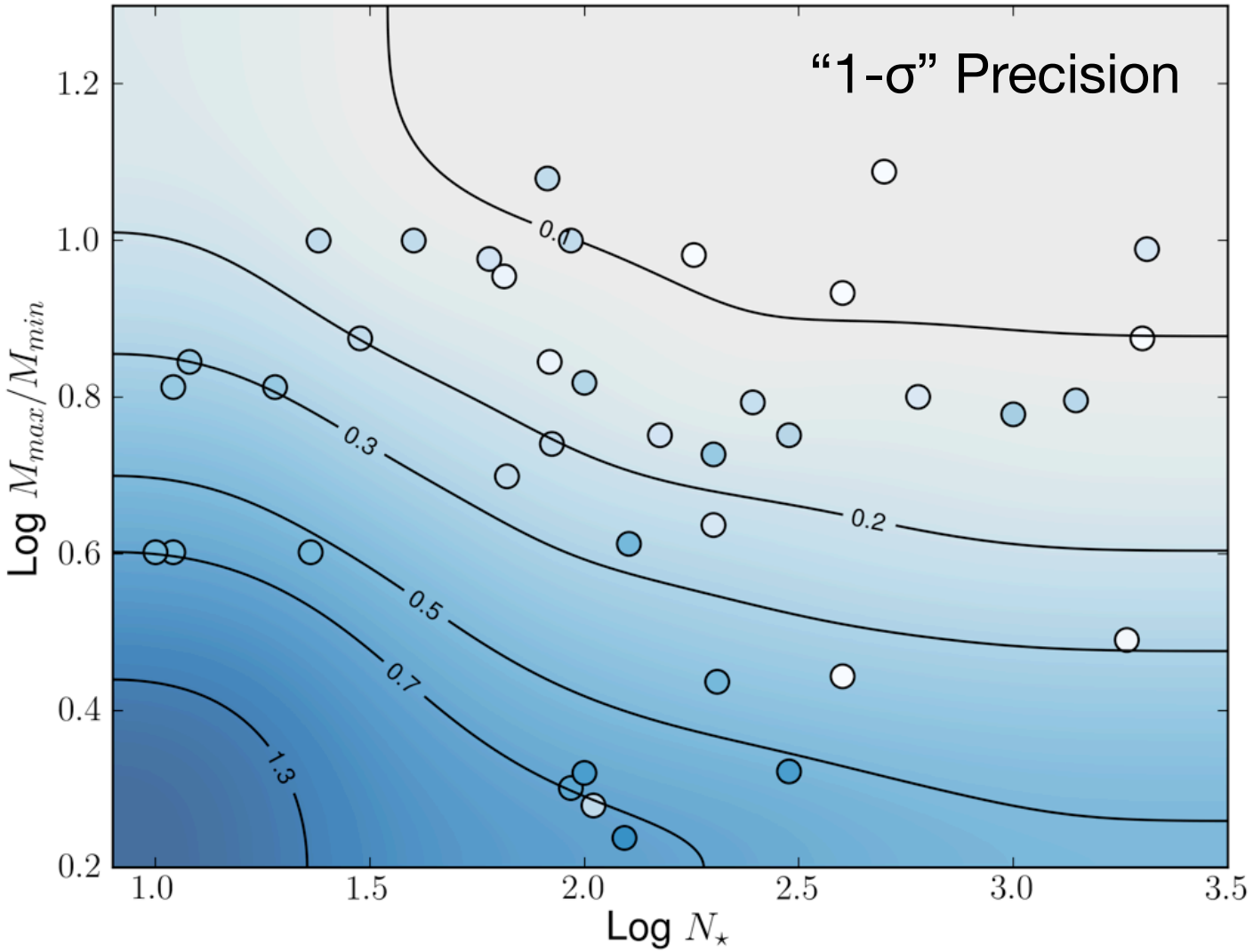
Sampled using
emcee
Foreman-Mackey+ 2012

Recovered MF slope = Input IMF Slope

Measuring cluster MF tells us about IMF slope

Weisz+ 2012

Theoretical Precision Limits vs. Literature Values



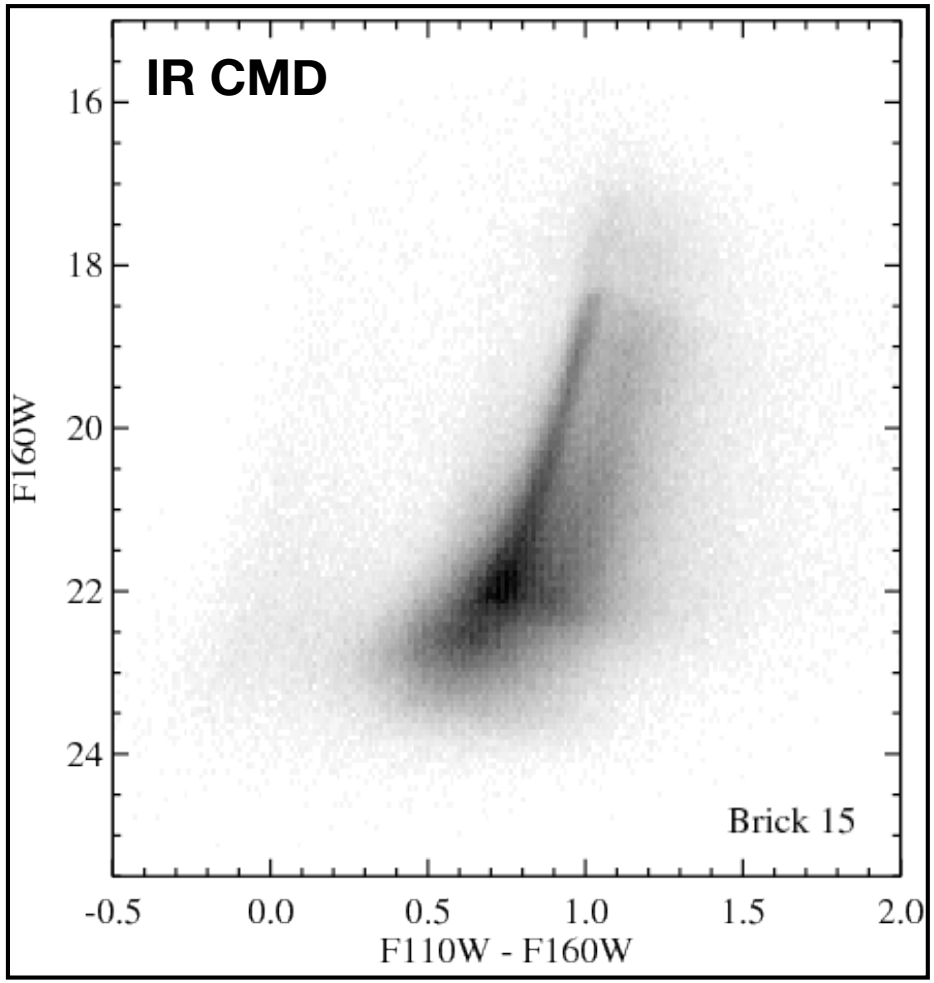
Points too light -> Below Theoretical Precision Limit
Points too dark -> Above Theoretical Precision Limit

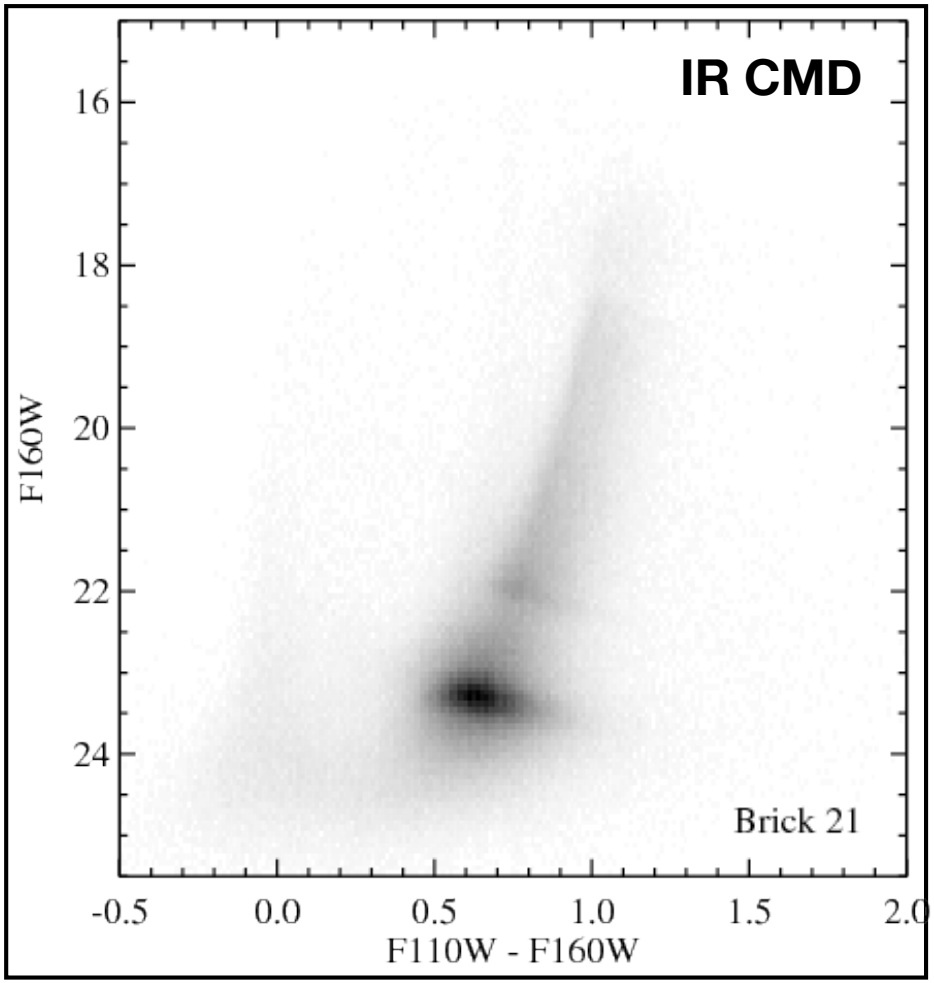
~2/3 of Error bars on MF slopes in the literature are below the theoretical limit

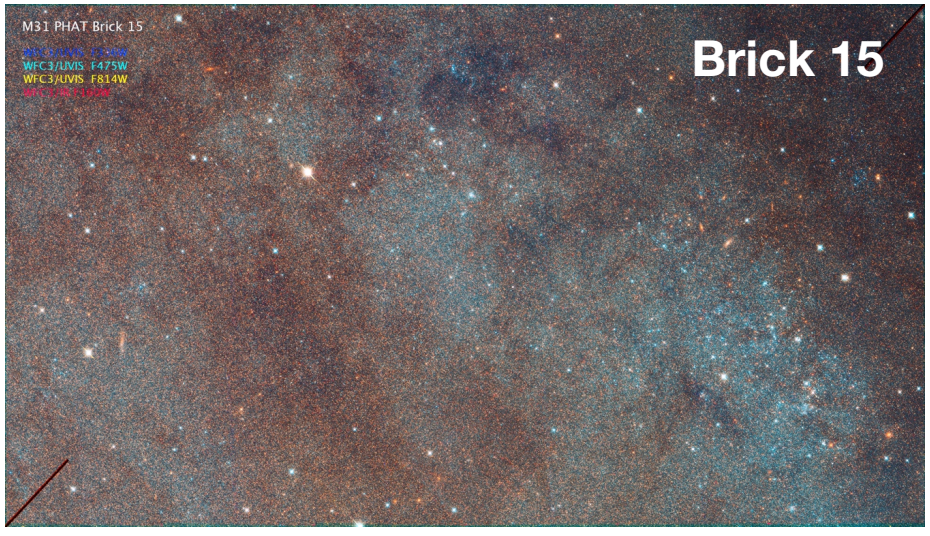
Weisz+ 2012

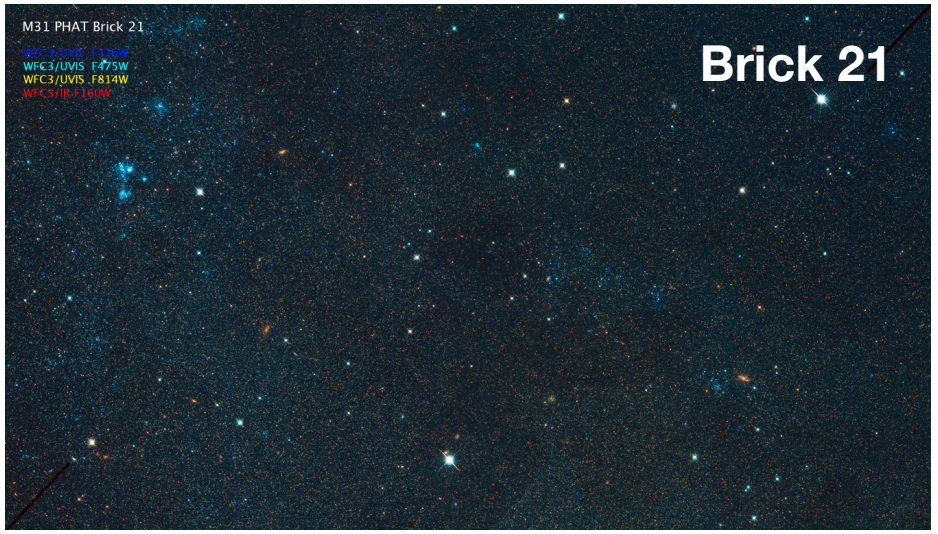
Dust Mapping

Julianne Dalcanton, Karl Gordon, Lucianna Bianchi,
Martha Boyer, Andy Dolphin, David Hogg, ...

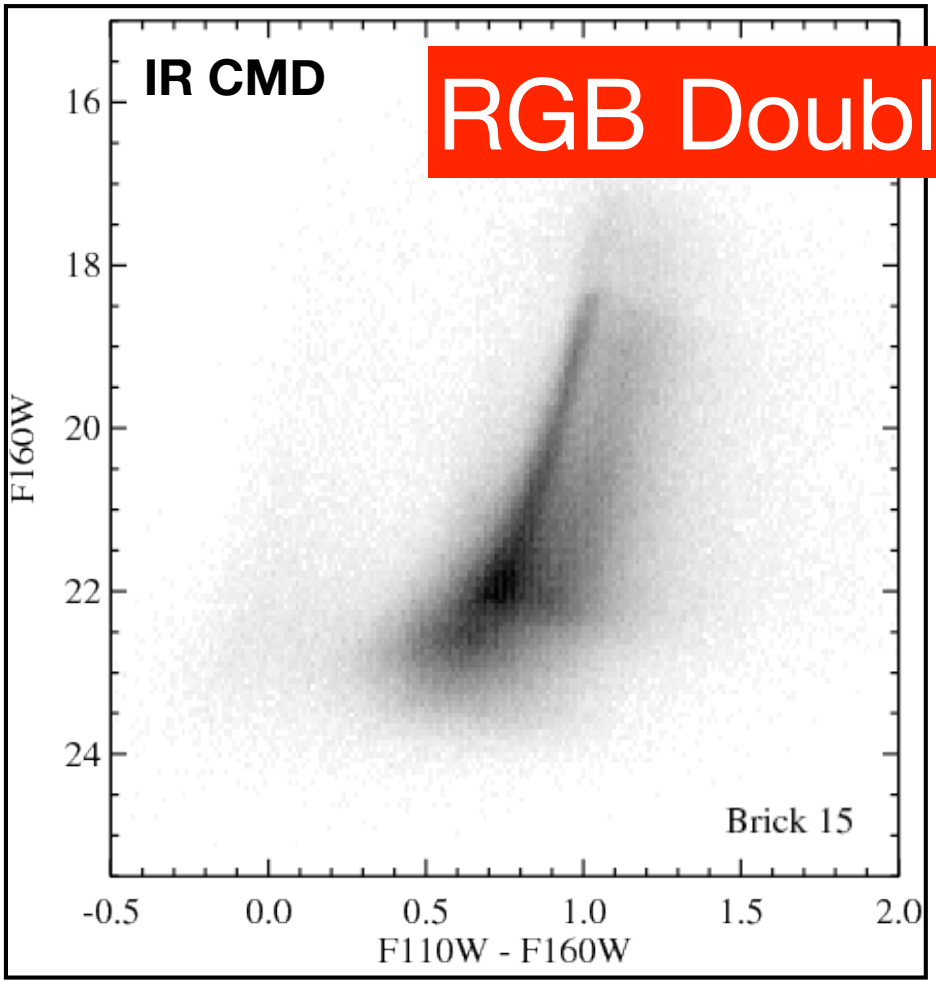

IR CMD
16
18
20
22
24
F160W
Brick 15
-0.5
0.0
0.5
1.0
1.5
2.0
F110W - F160W

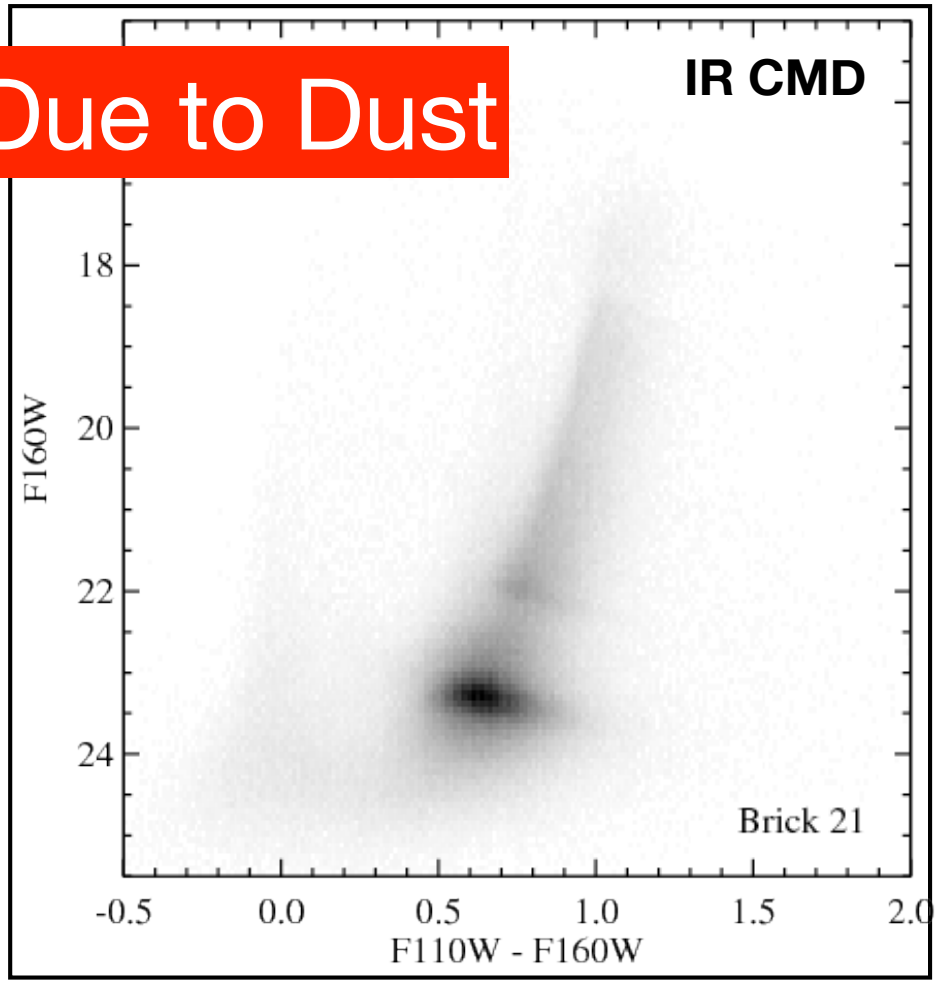

IR CMD
16
18
20
22
24
F160W
Brick 21
-0.5
0.0
0.5
1.0
1.5
2.0
F110W - F160W

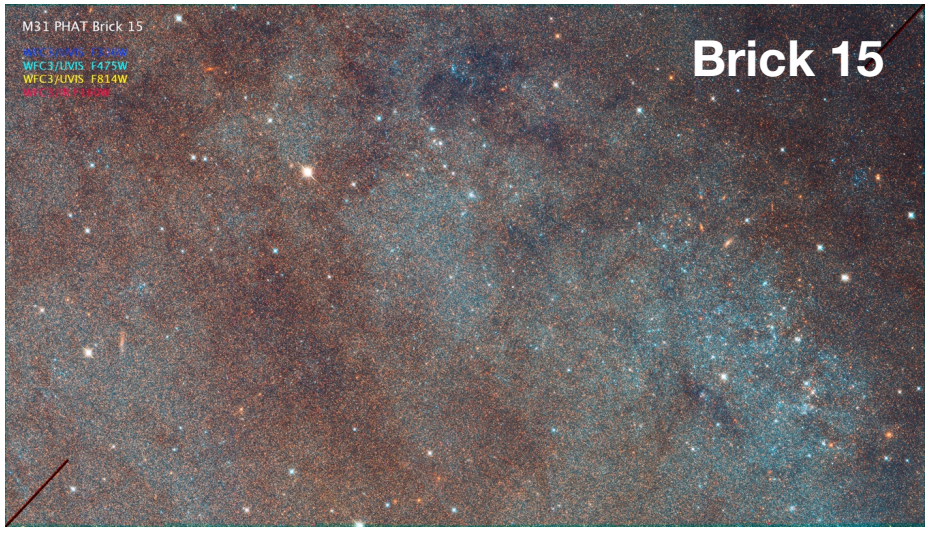

M31 PHAT Brick 15
WFC3/UVIS F475W
WFC3/UVIS F814W
Brick 15

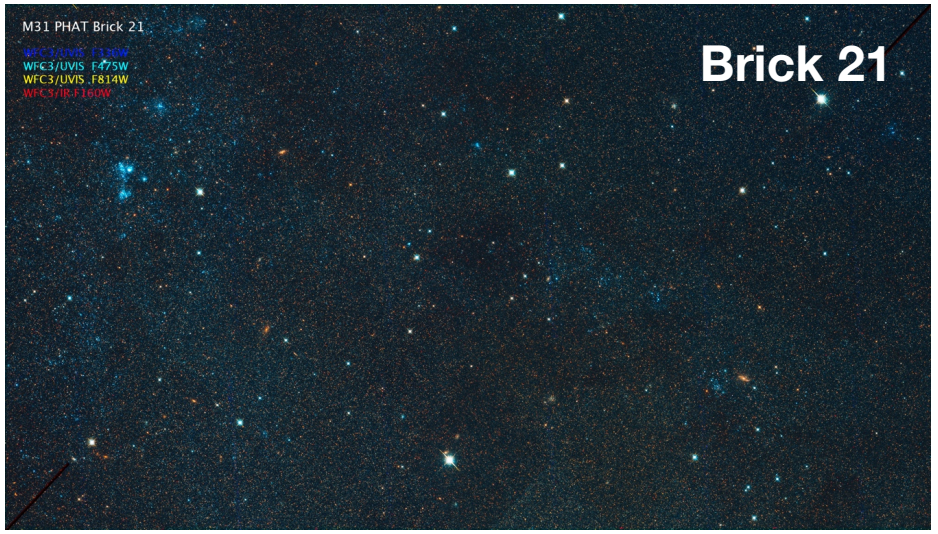

M31 PHAT Brick 21
WFC3/UVIS F475W
WFC3/UVIS F814W
WFC3/IR F160W
Brick 21

RGB Doubling Due to Dust

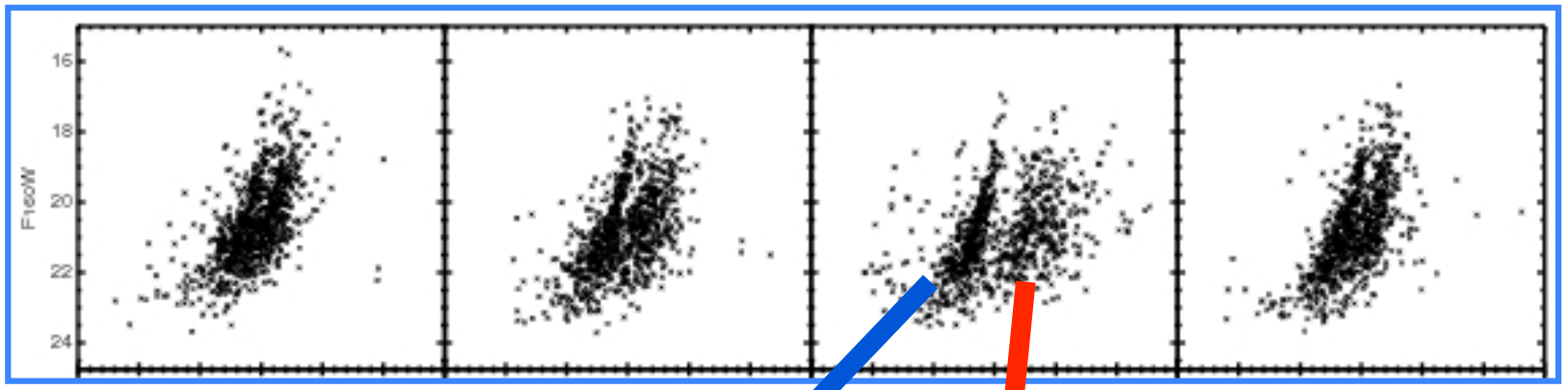








Subregions of single WFC3/IR frame



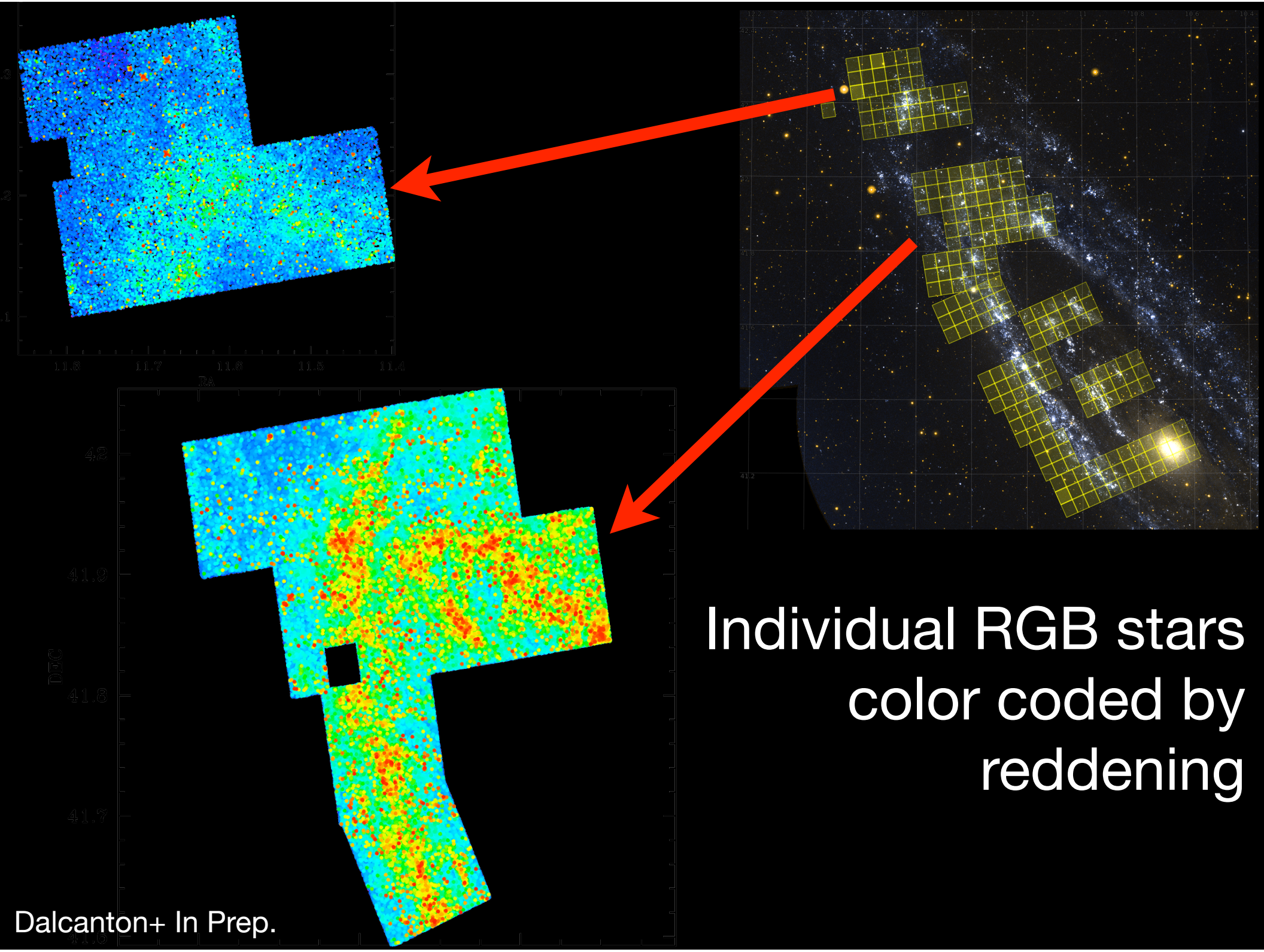
Unreddened RGB

Reddened RGB

Foreground stars

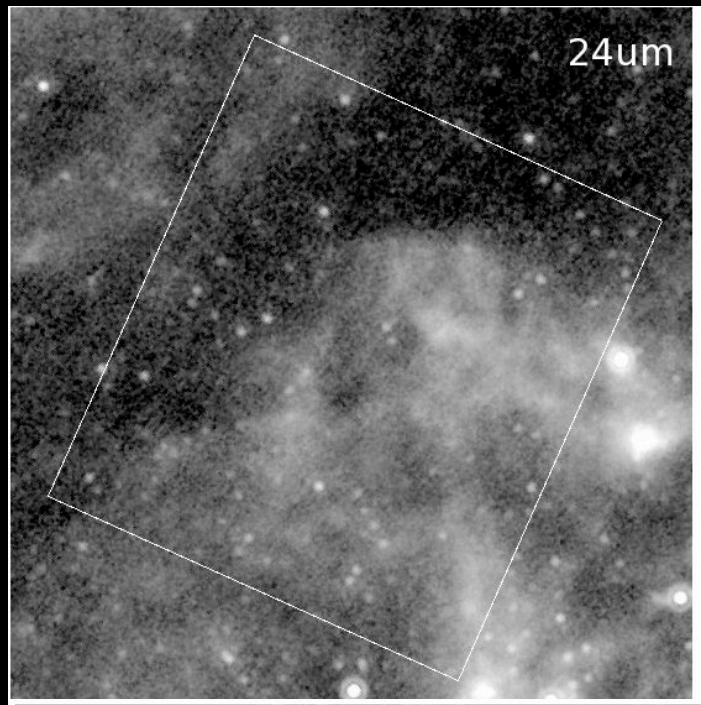
Background stars

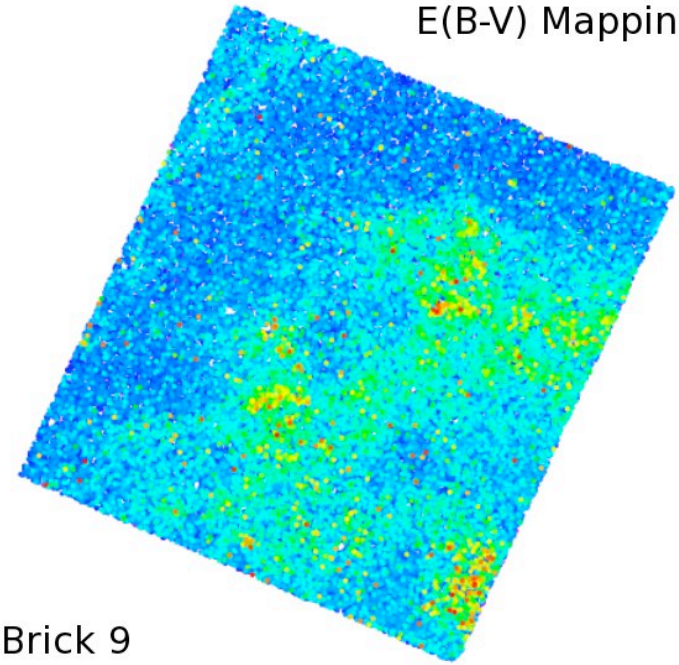
Dalcanton+ In Prep.


11.8
11.7
11.6
11.5
11.4
RA
42
41.9
41.8
41.7
DEC
Individual RGB stars
color coded by
reddening
Dalcanton+ In Prep.

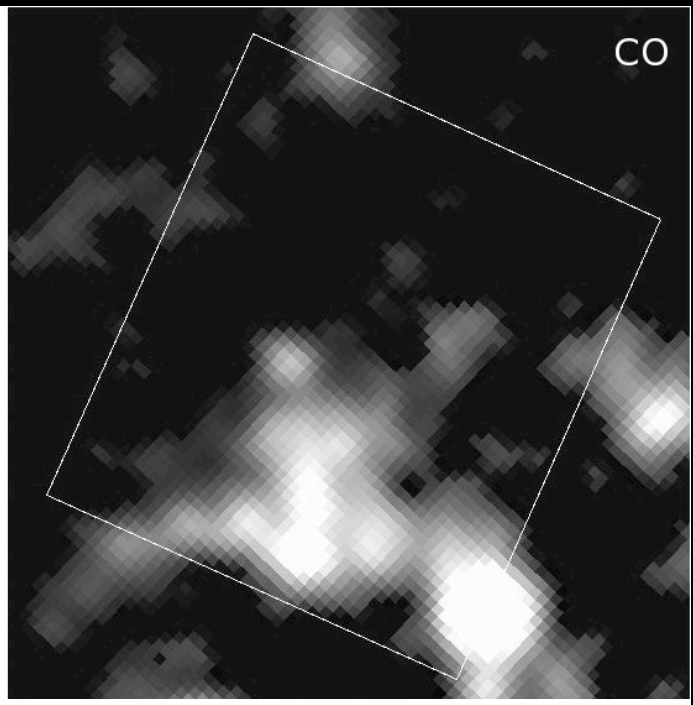
3x3 WFC3/IR

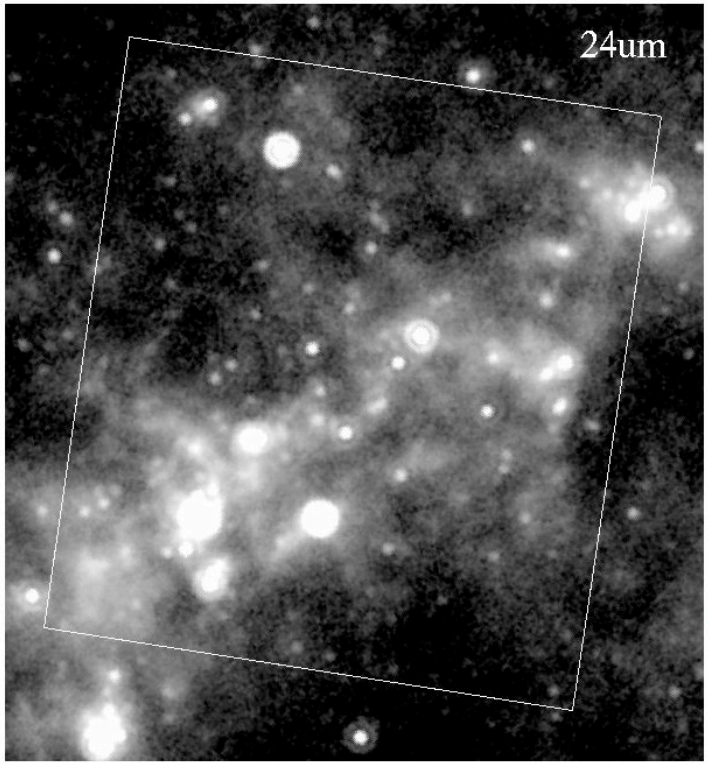
Dalcanton+ In Prep.

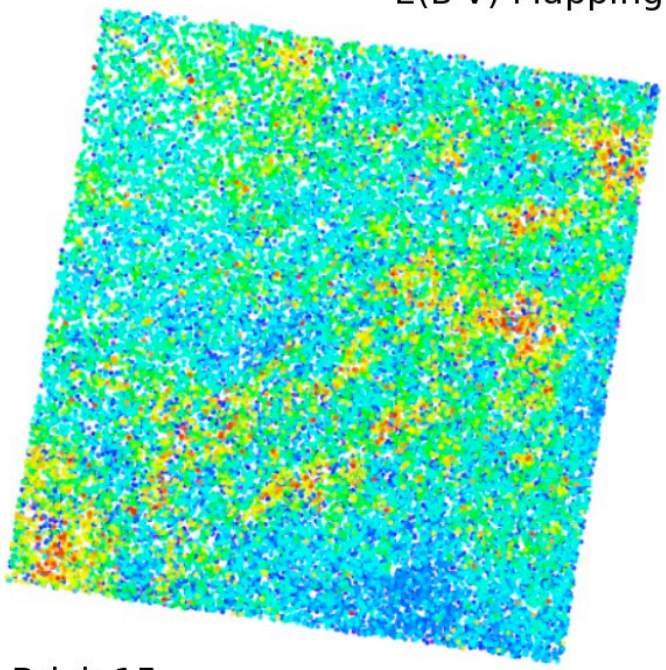




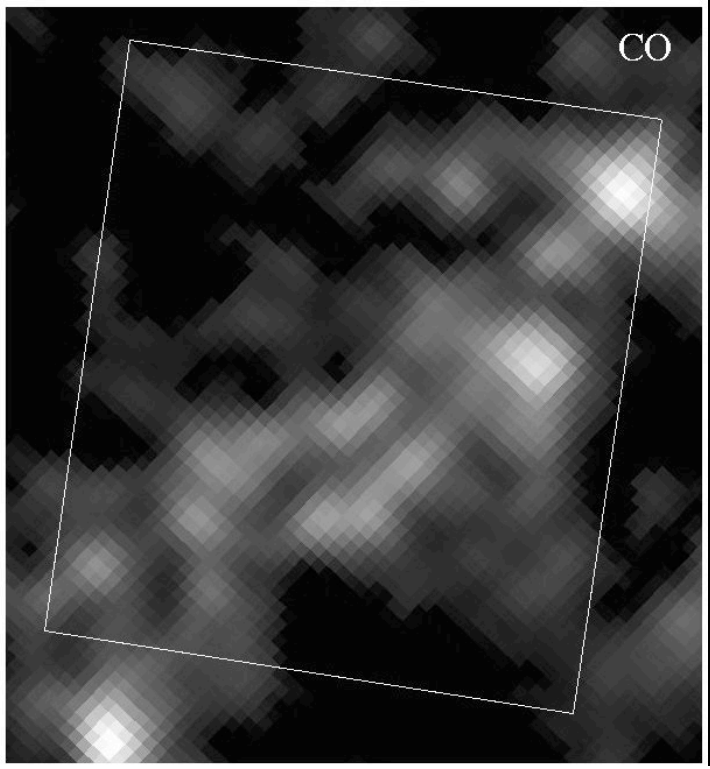
Brick 9







Brick 15



Summary

The Stats

828 HST Orbits

Near-UV to Near-IR
Resolved Star Imaging
for ~ 1/4 of M31's
Star-Forming Disk

Final catalog will contain
~ 100 million stars

Important anchor for a
detailed understanding
of an L★ environment

Early Science

Star Cluster Catalog

Star Cluster Age and Mass Distributions

Dust Heating Mechanisms

Field vs. Clustered Star Formation

Ancient UV Bright Stellar Populations

Dust Mapping

Mapping Structure with the Horizontal Branch

Dust Heating Mechanisms

Inferring the High Mass Stellar IMF

Stellar SED Fitting

Isolated Massive Stars

Dust Emissivity Variations

Spatially Resolved Star Formation History

DR1 http://archive.stsci.edu/prepds/phat/