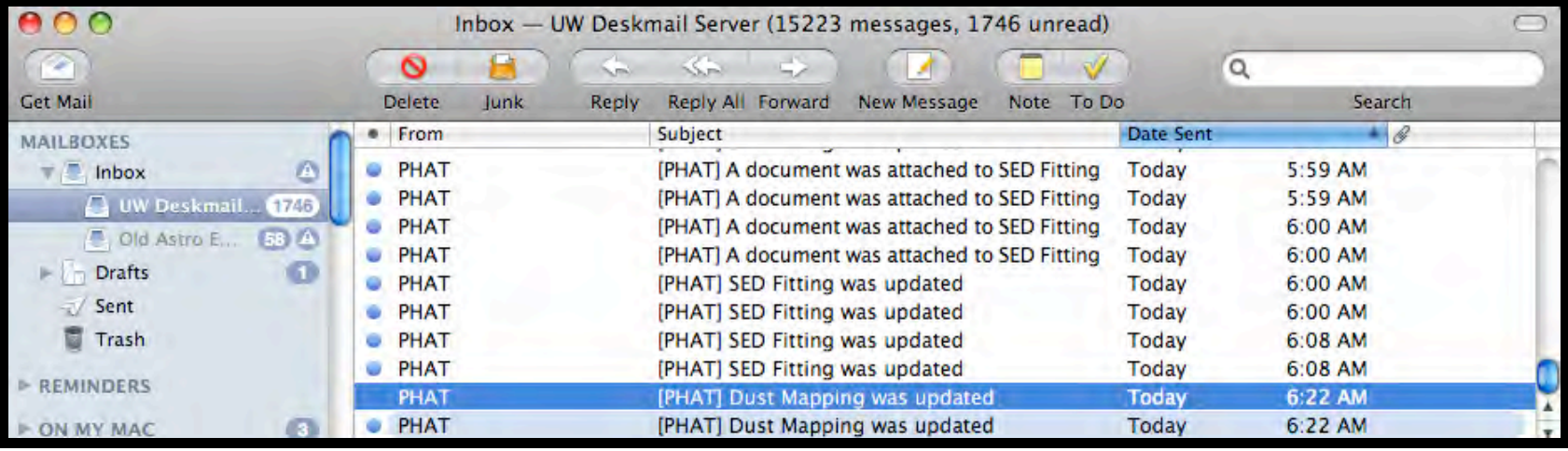
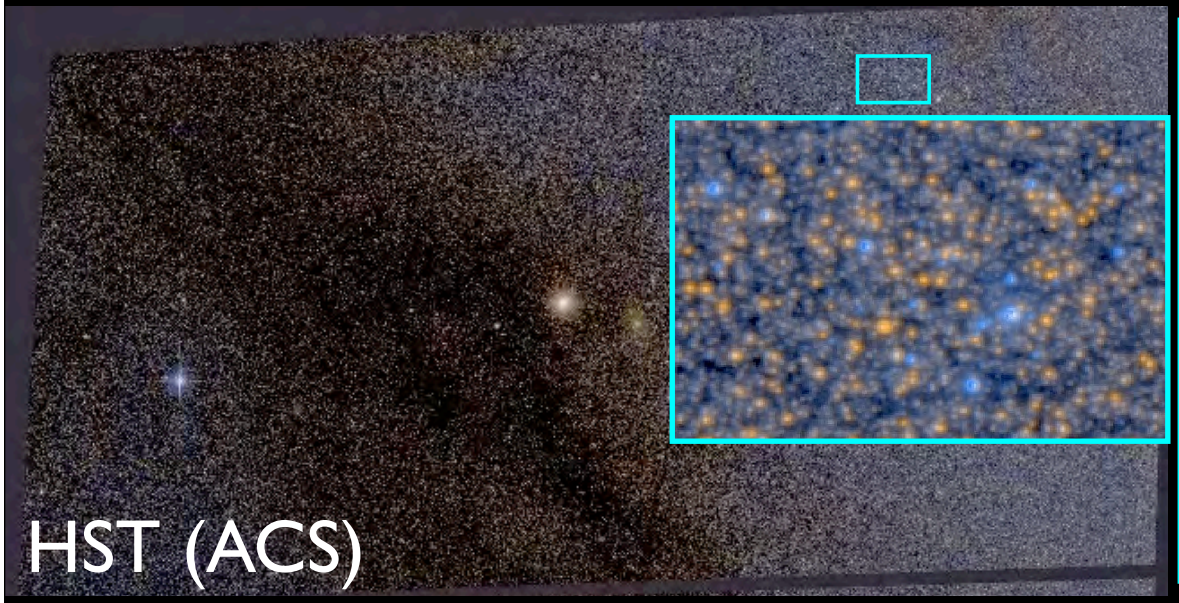
The Panchromatic Hubble Andromeda Treasury

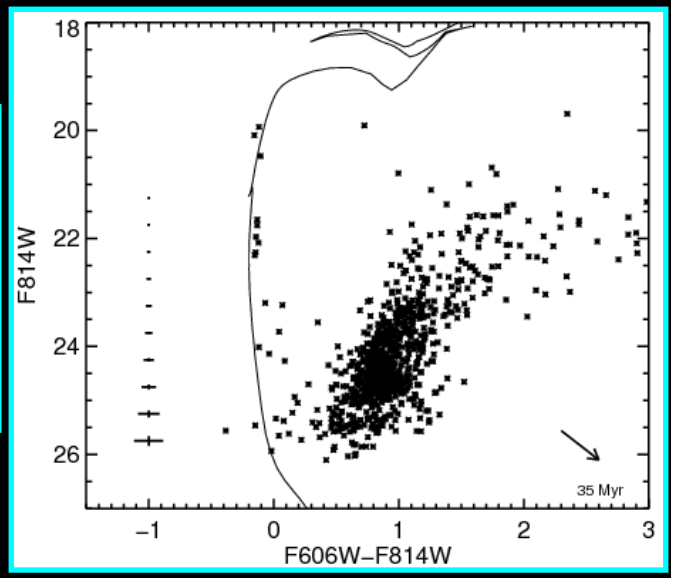
Organization

- ~30 people, including grad students
- Most have worked together in previous large programs
- First team meeting next week in Seattle
- Extensive use of collaborative websites

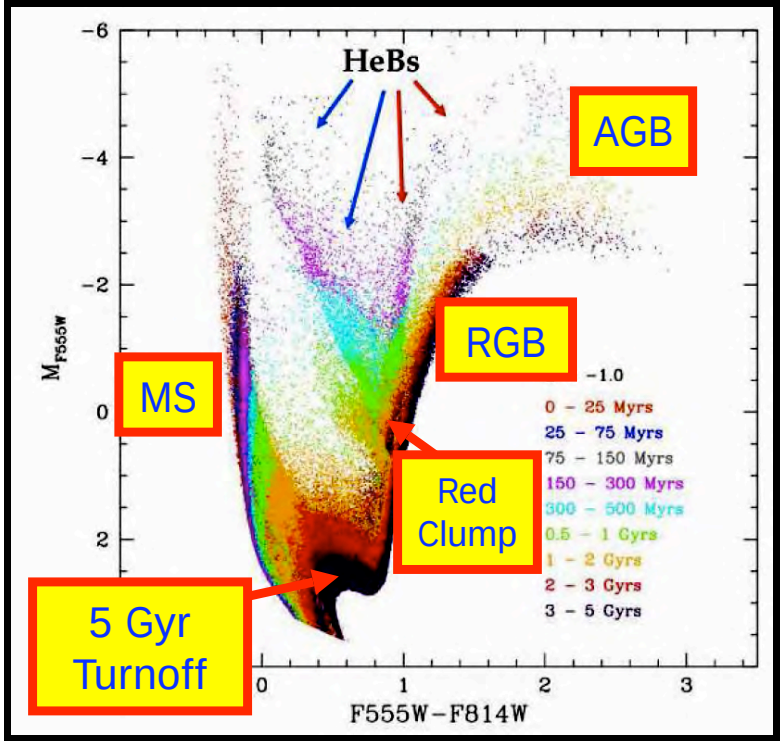


HST is unparalleled for measuring colors and luminosities of stars





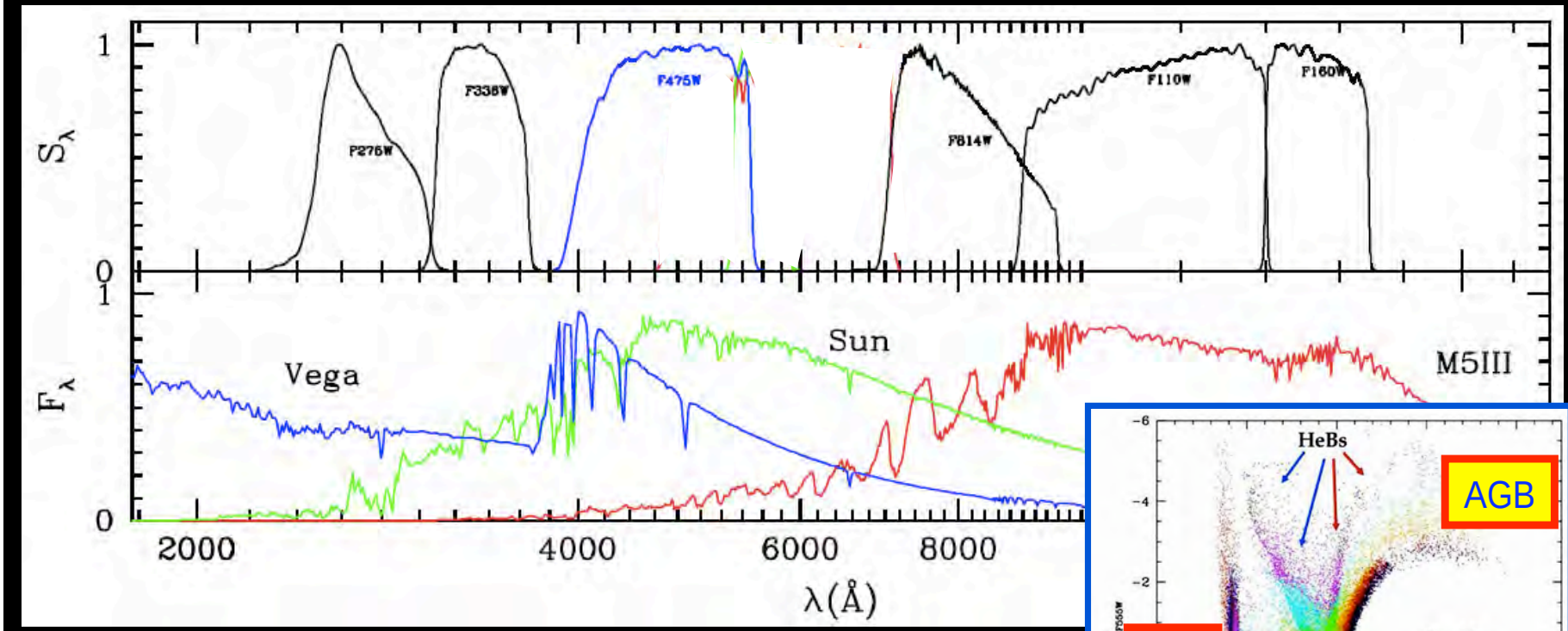
Resolved Stars Allow Measurements of:

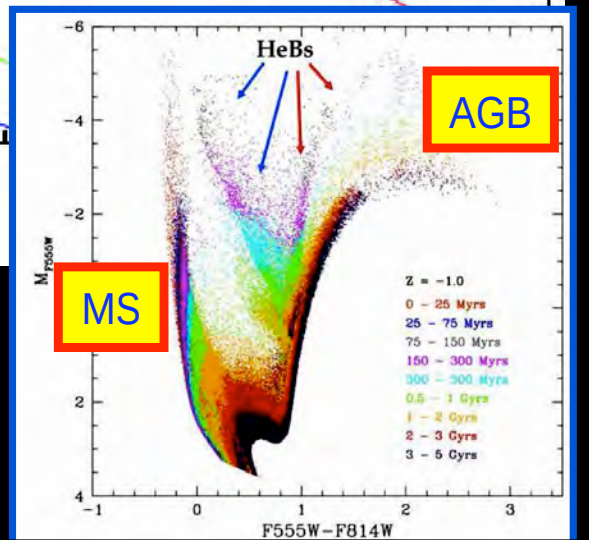


Color coded by age

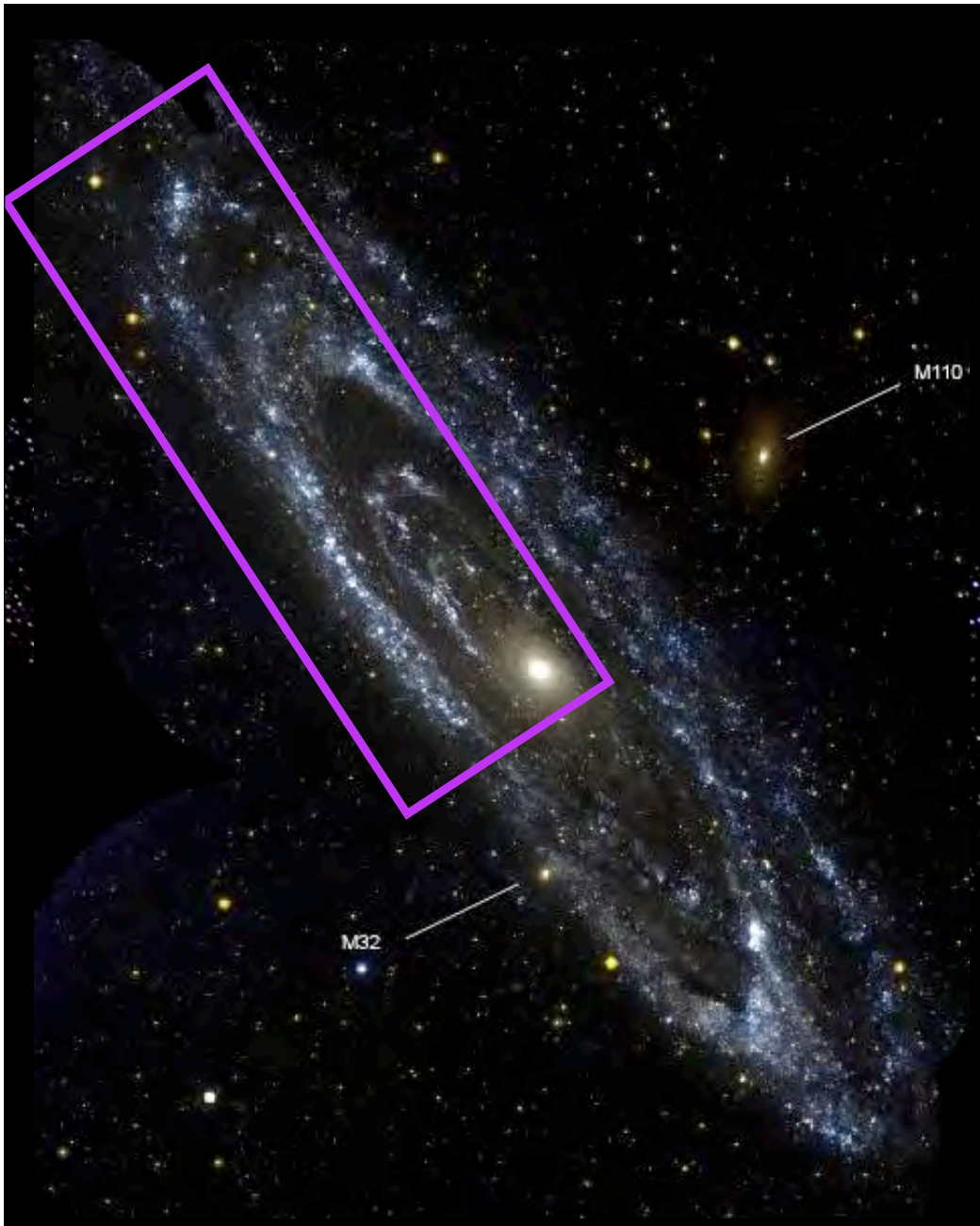
- Star formation histories
- Stellar evolution models
- Extinction maps
- Stellar mass functions
- Cluster mass functions
- Calibration of SF indicators
- SNe progenitors
- Age dating of SN remnants
- Coupling between SF & ISM
- Variable star luminosities

Requirement: Coverage from UV to NIR





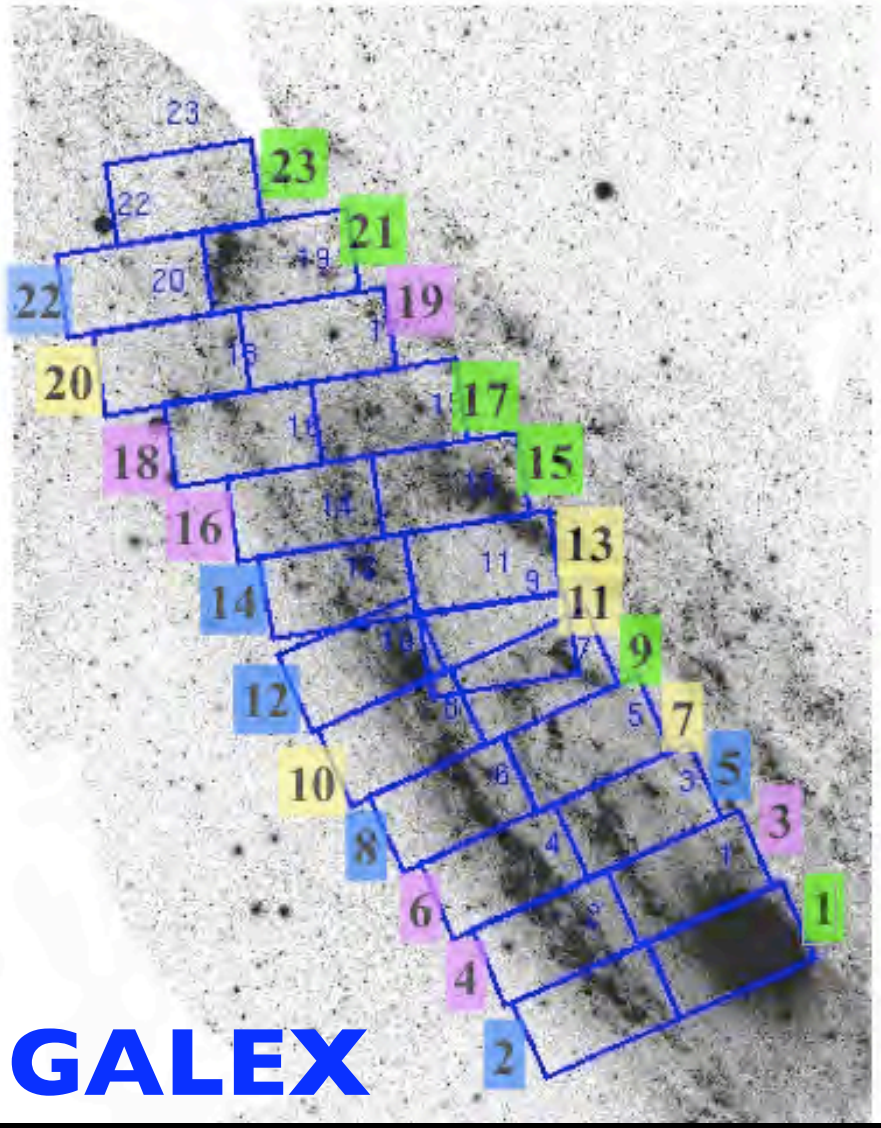
+ Large Areas



M31

- Wide range of metallicities
- Millions of stars at a common distance
- Wide range of SF intensities
- Close enough to maximize depth
- Rich existing catalogs & coverage

Plan: 6-Filter HST Tiling of M31



Year 1
- 21
- 15
- 9
- 1
- 17
- 23

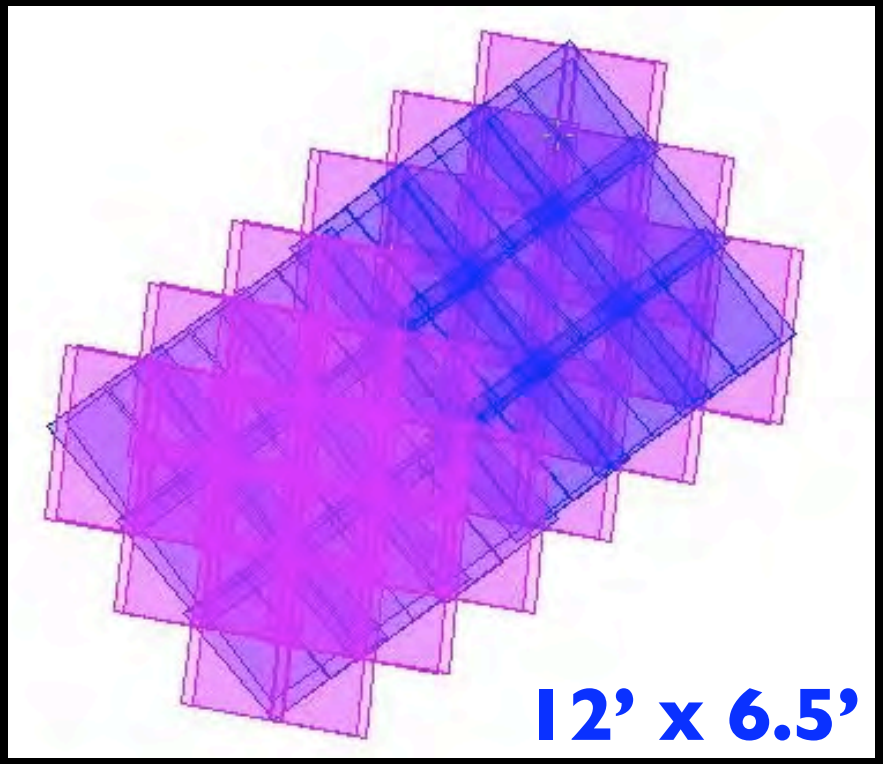
Year 2
- 12
- 14
- 2
- 5
- 8
- 22

Year 3
- 6
- 16
- 4
- 18
- 3
- 19

Year 4
- 10
- 20
- 7
- 13
- 11

828 Orbits

18 pointing tiling "brick"

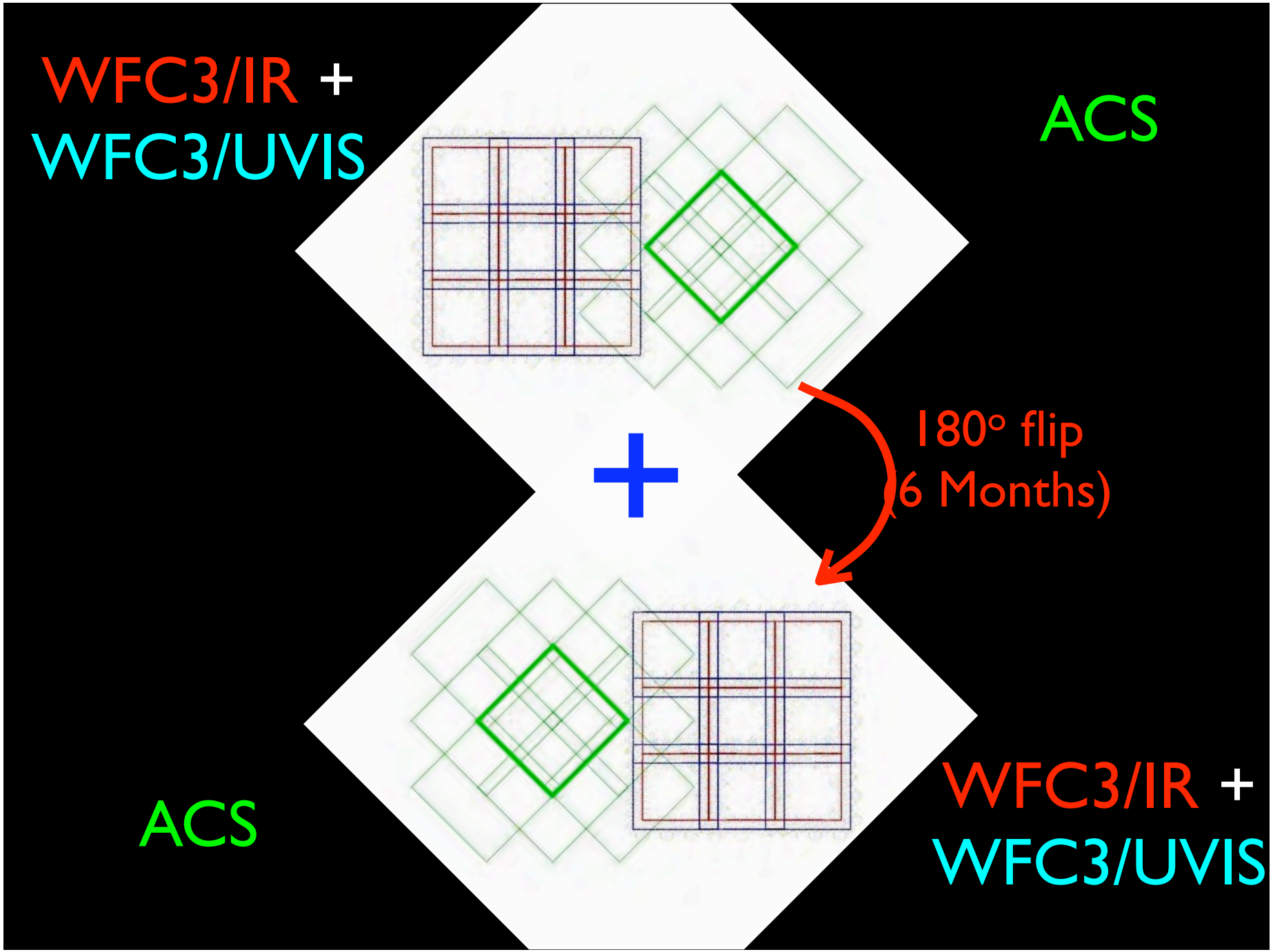


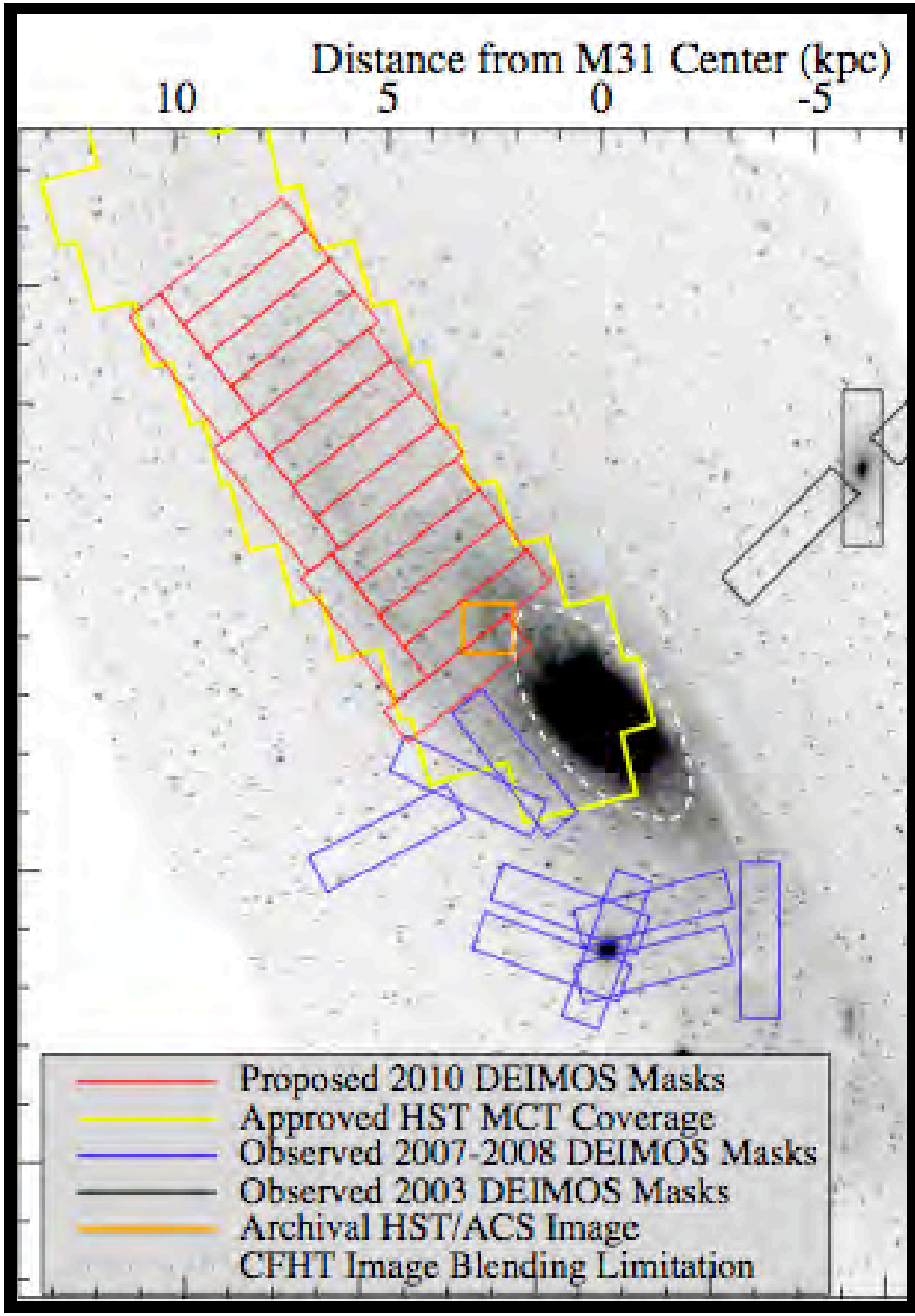
Ben Williams

2 Orbits per pointing

18 orbits at 180° orientation flip from the other 18 orbits

Orbit 1: WFC3/IR (primary) + ACS (parallel)
Orbit 2: WFC3/UVIS (primary) + ACS (parallel)


WFC3/IR +
WFC3/UVIS
ACS
180° flip
(6 Months)
ACS
WFC3/IR +
WFC3/UVIS



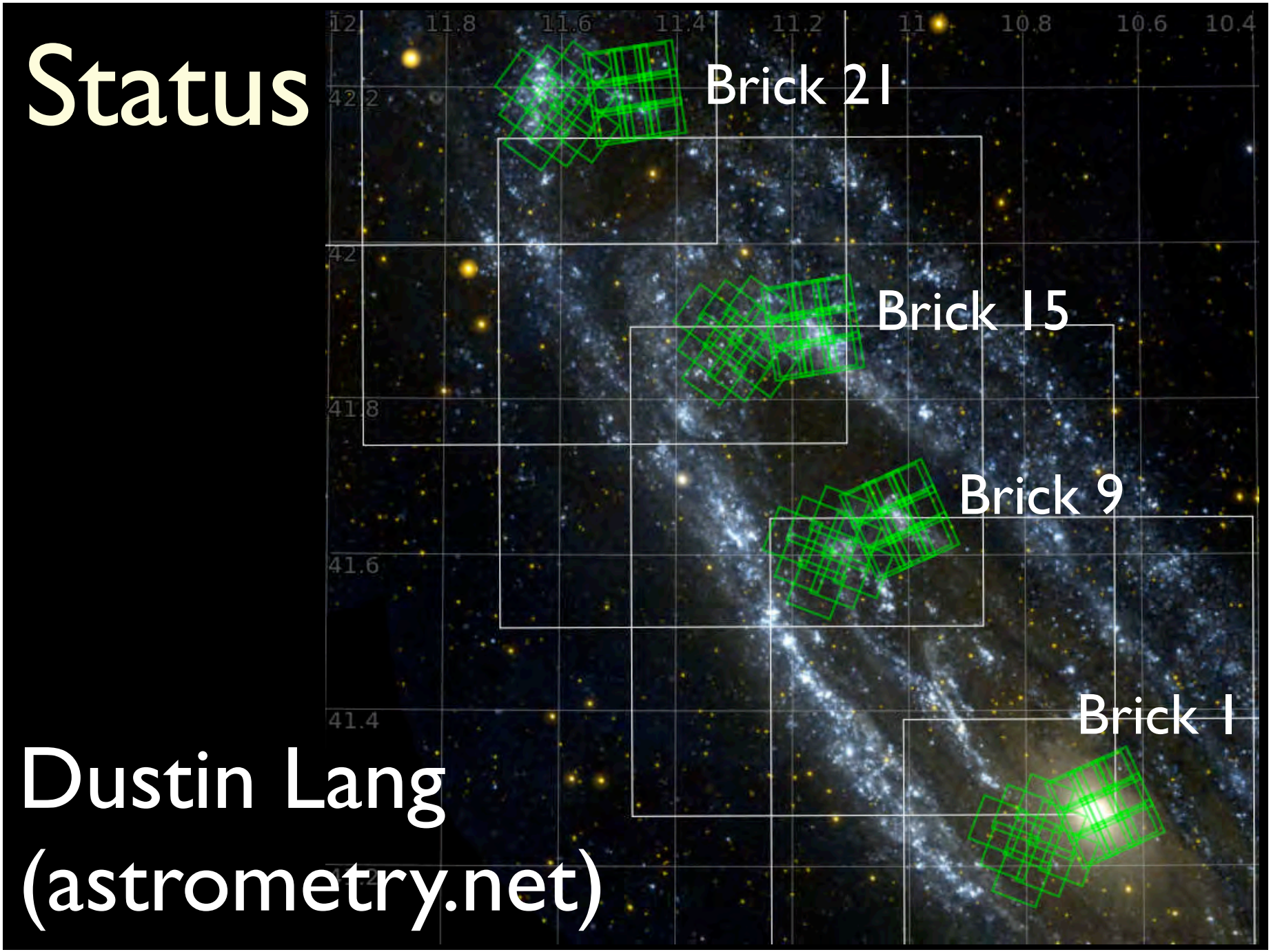
Extensive DEIMOS Spectroscopy

Claire Haliday
Jason Kalirai
Kirsten Howley
Raja Guhathakurta

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

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

Status



Dustin Lang
(astrometry.net)

Status

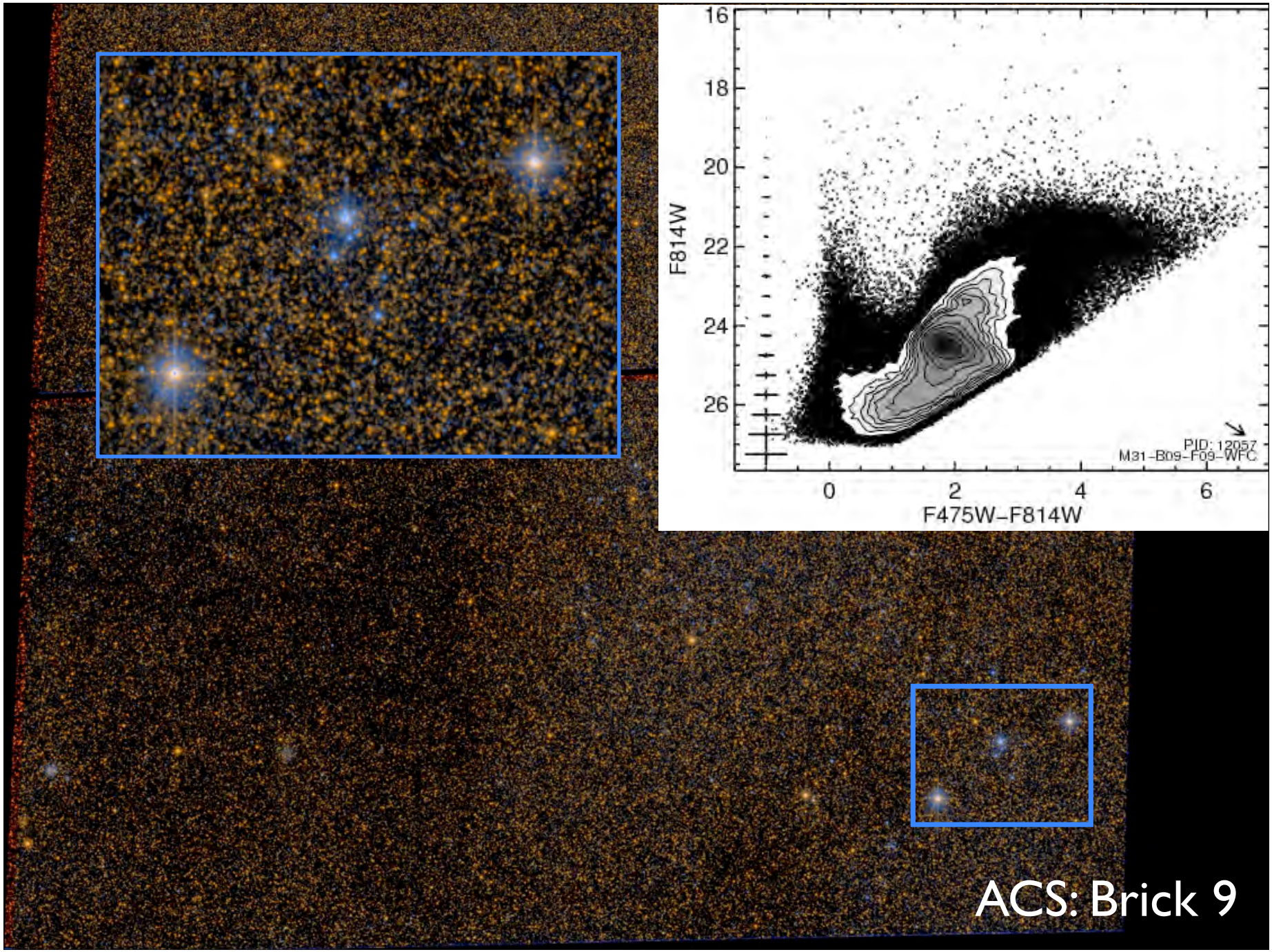
- Completed Orbits: 72 (<9%) -- Thanks!
- Photometric measurements so far: 37 million
- Total CPU time: ~250 CPU days
- Typical depths:

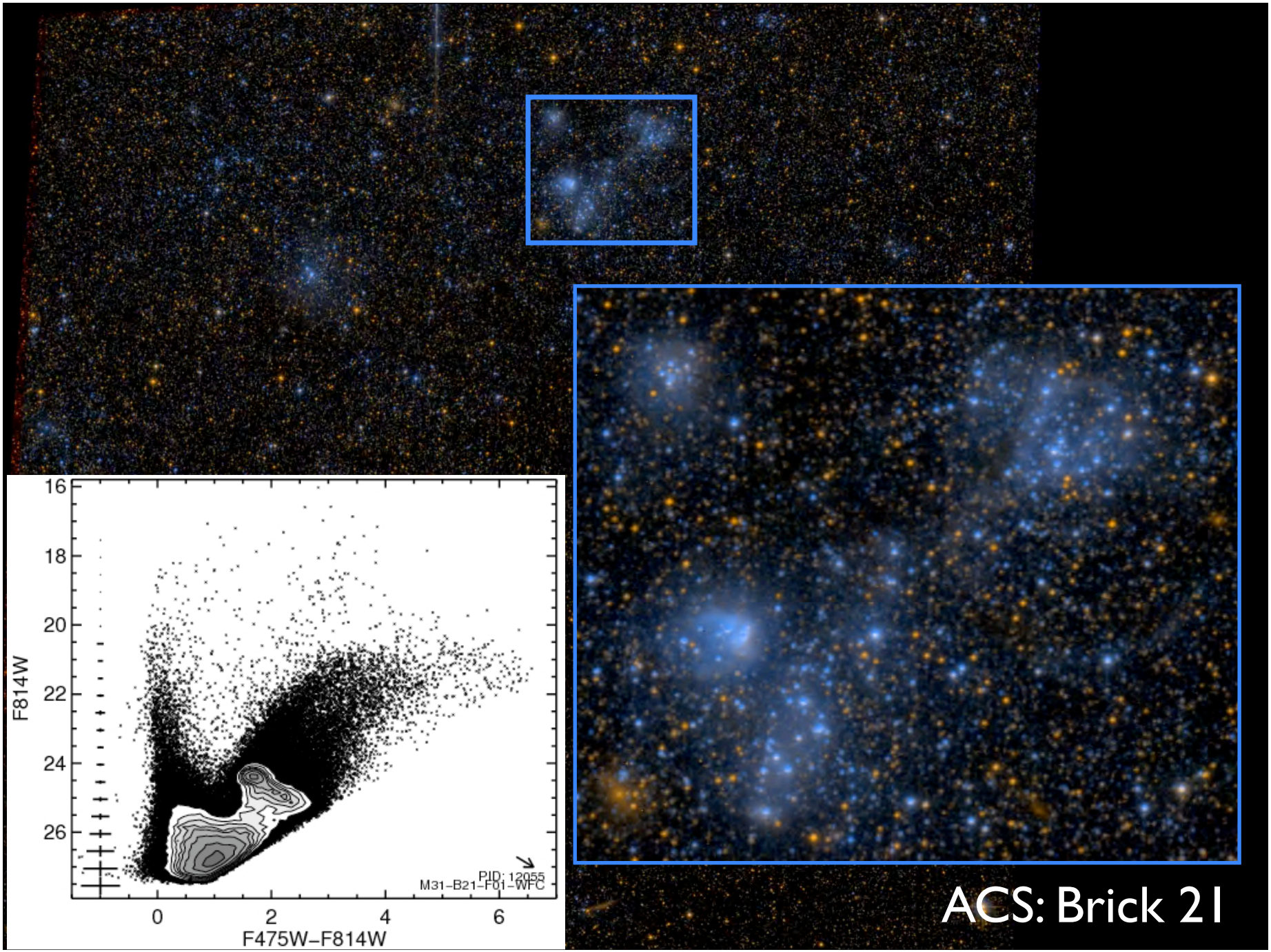
  UVIS: F275W ~ 25, F336W ~ 25

  ACS: F475W ~ 27, F814W ~ 25

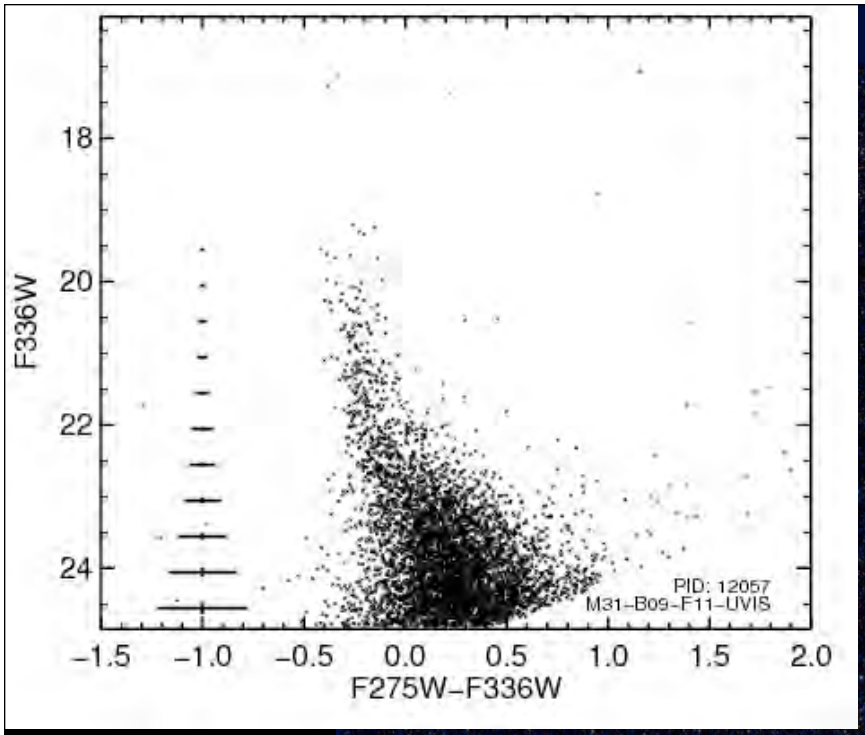
  IR: F110W ~ 24, F160W ~ 23

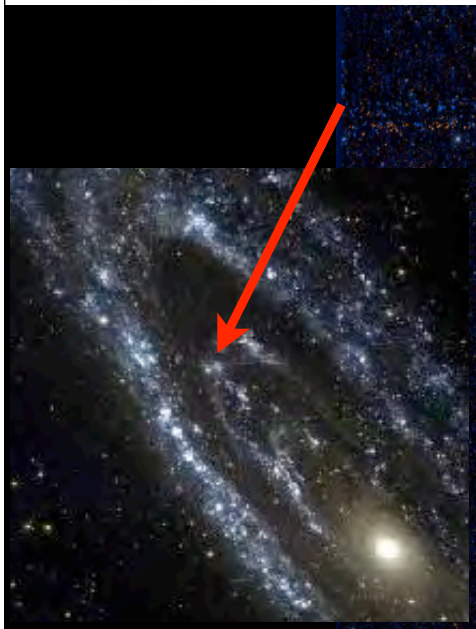
- ~3200 DEIMOS Spectra (Kinematics, mostly)


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

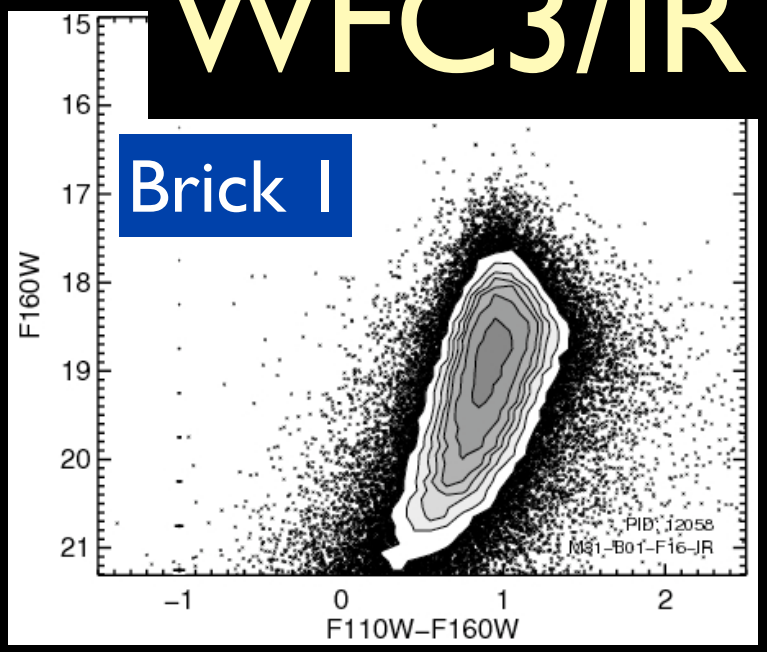
UVIS: less crowding, more CRs

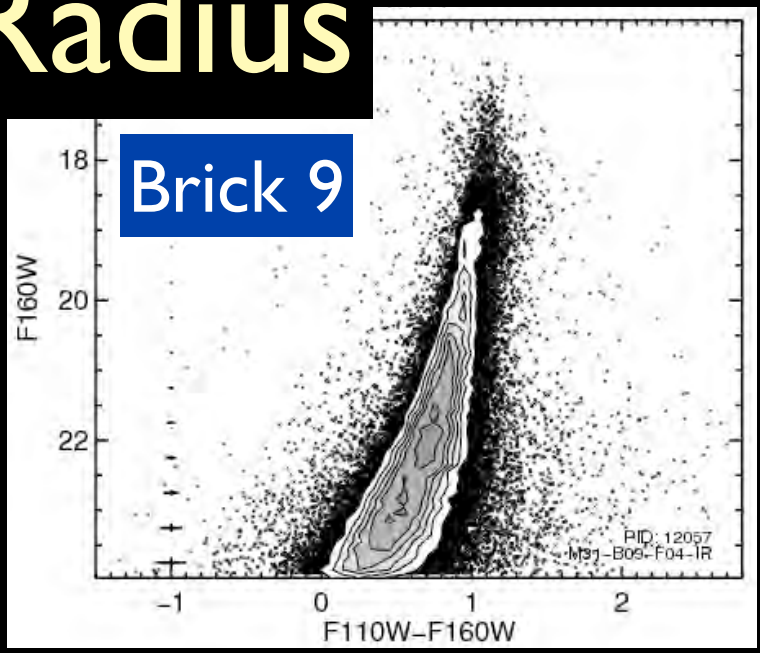


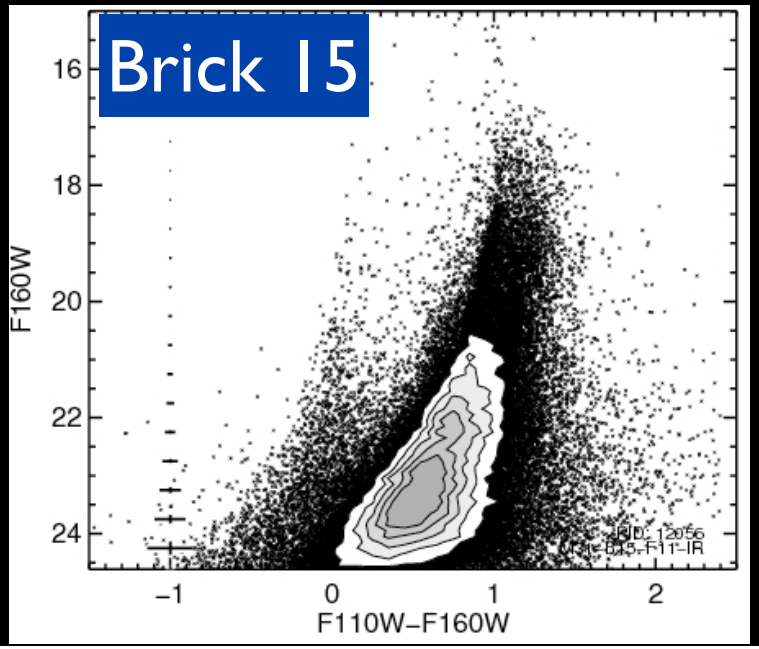


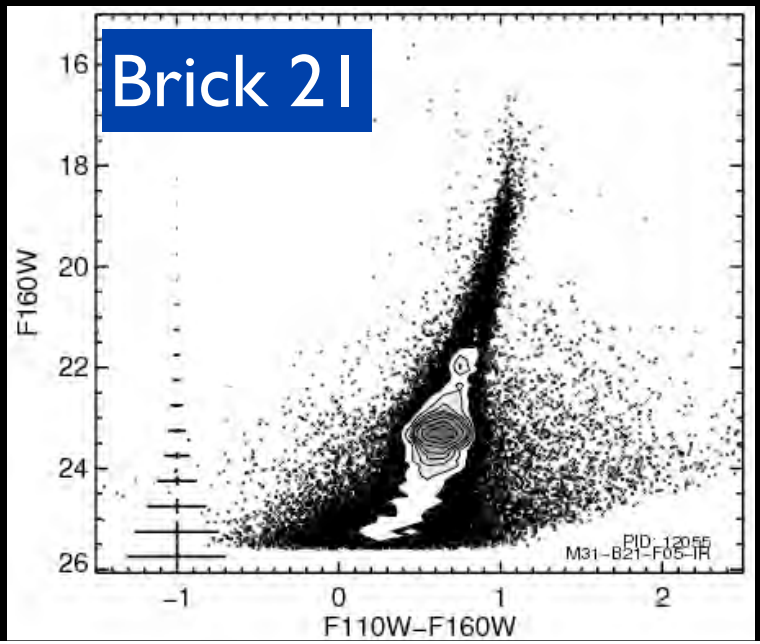
UVIS: Brick 9

WFC3/IR vs Radius



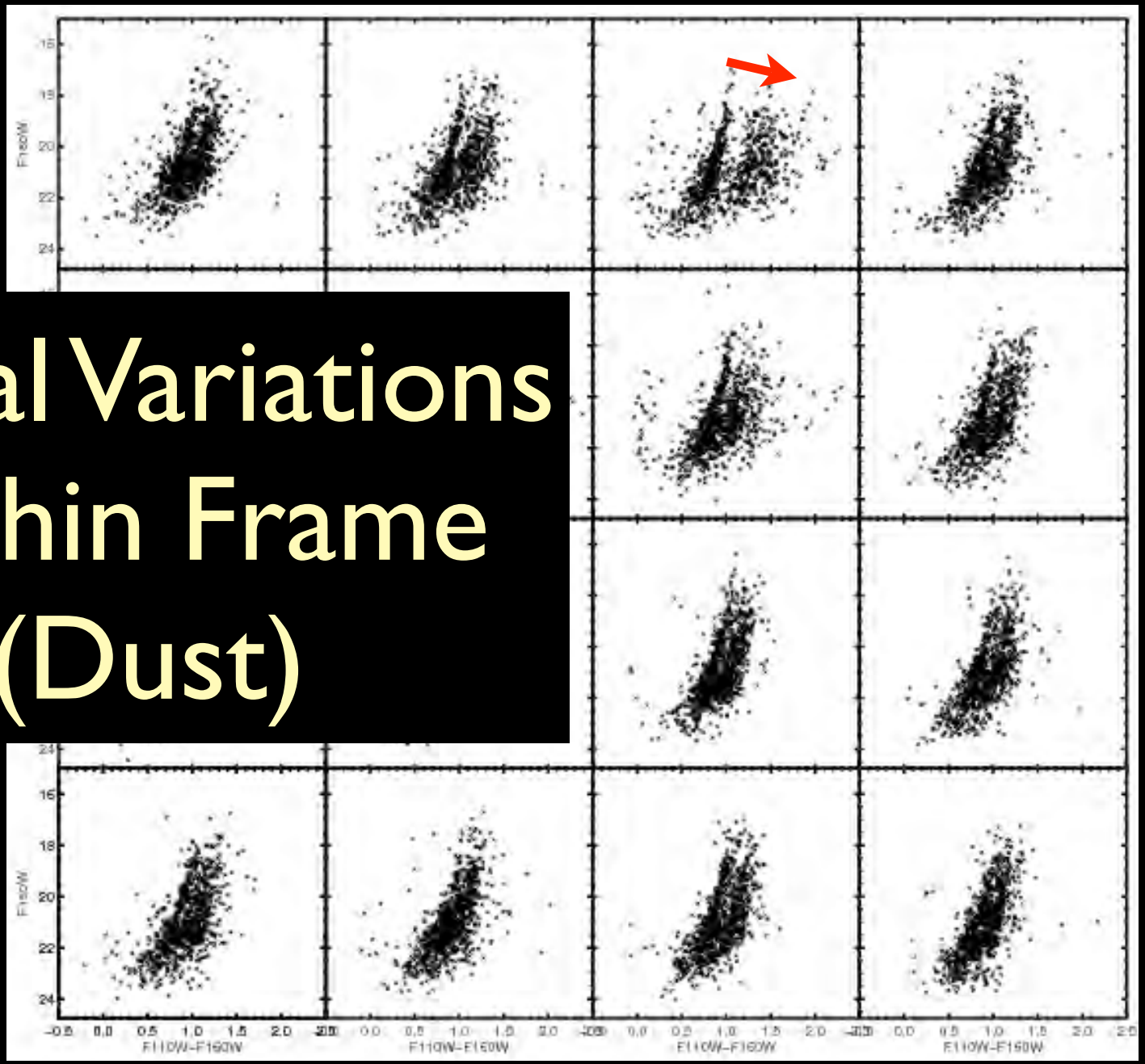




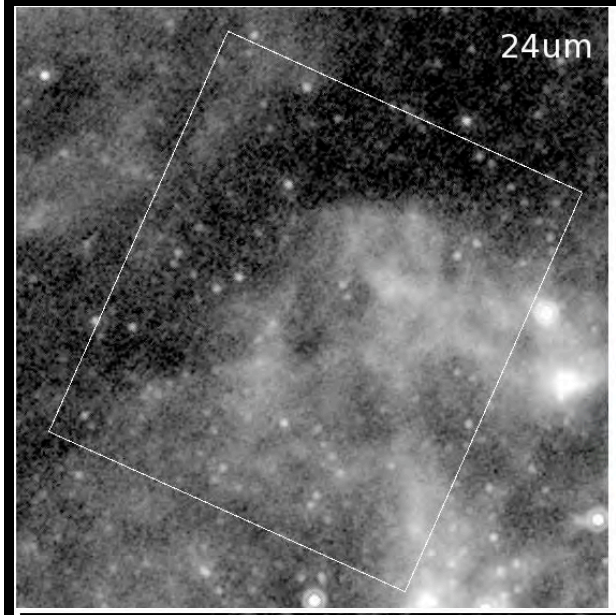


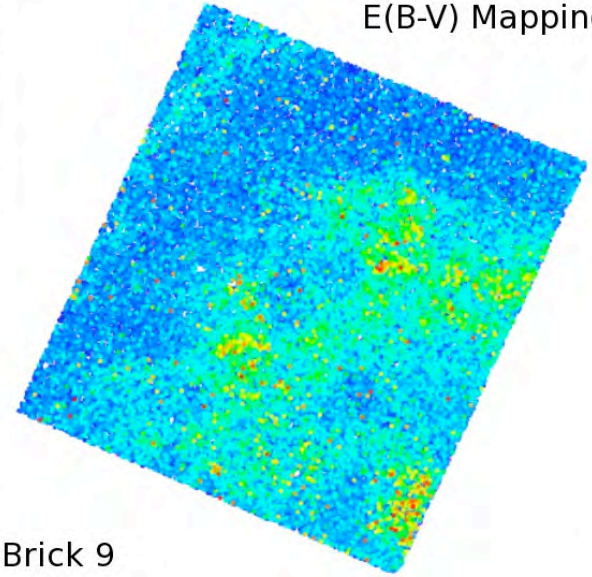
Spatial Variations Within Frame (Dust)

Higher Quality Photometry Only

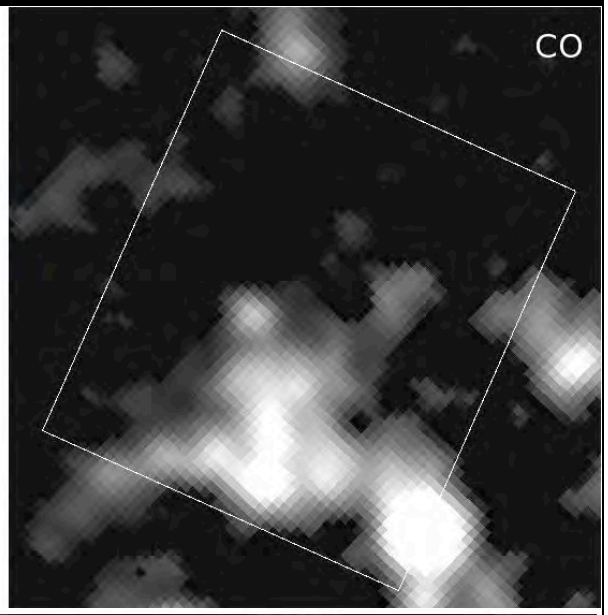


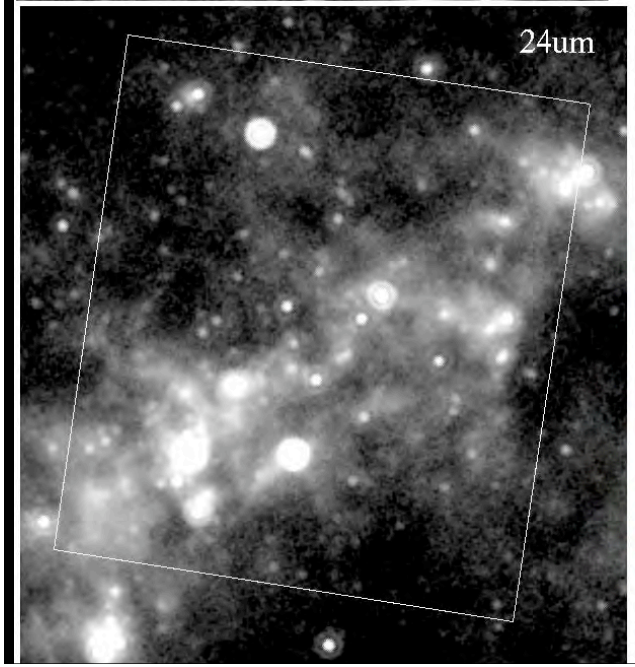
3x3 WFC3/IR

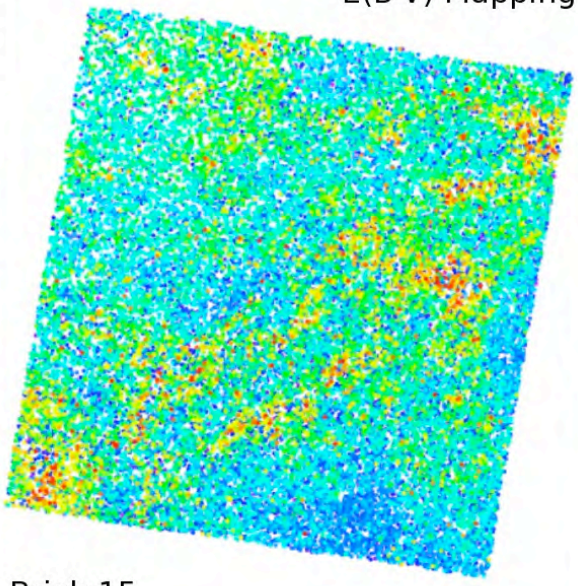




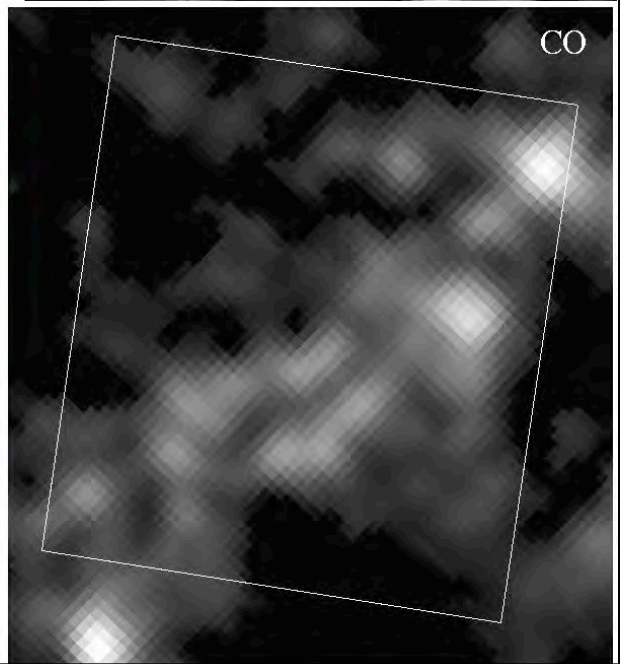
Brick 9



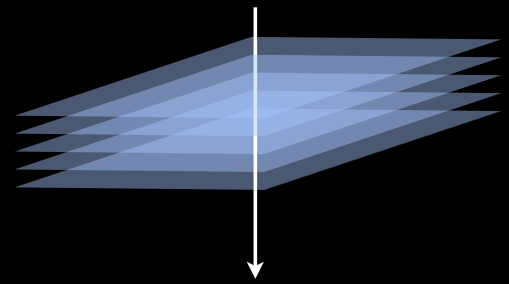




Brick 15

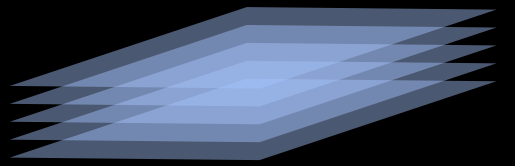


PHAT Photometry Workflow



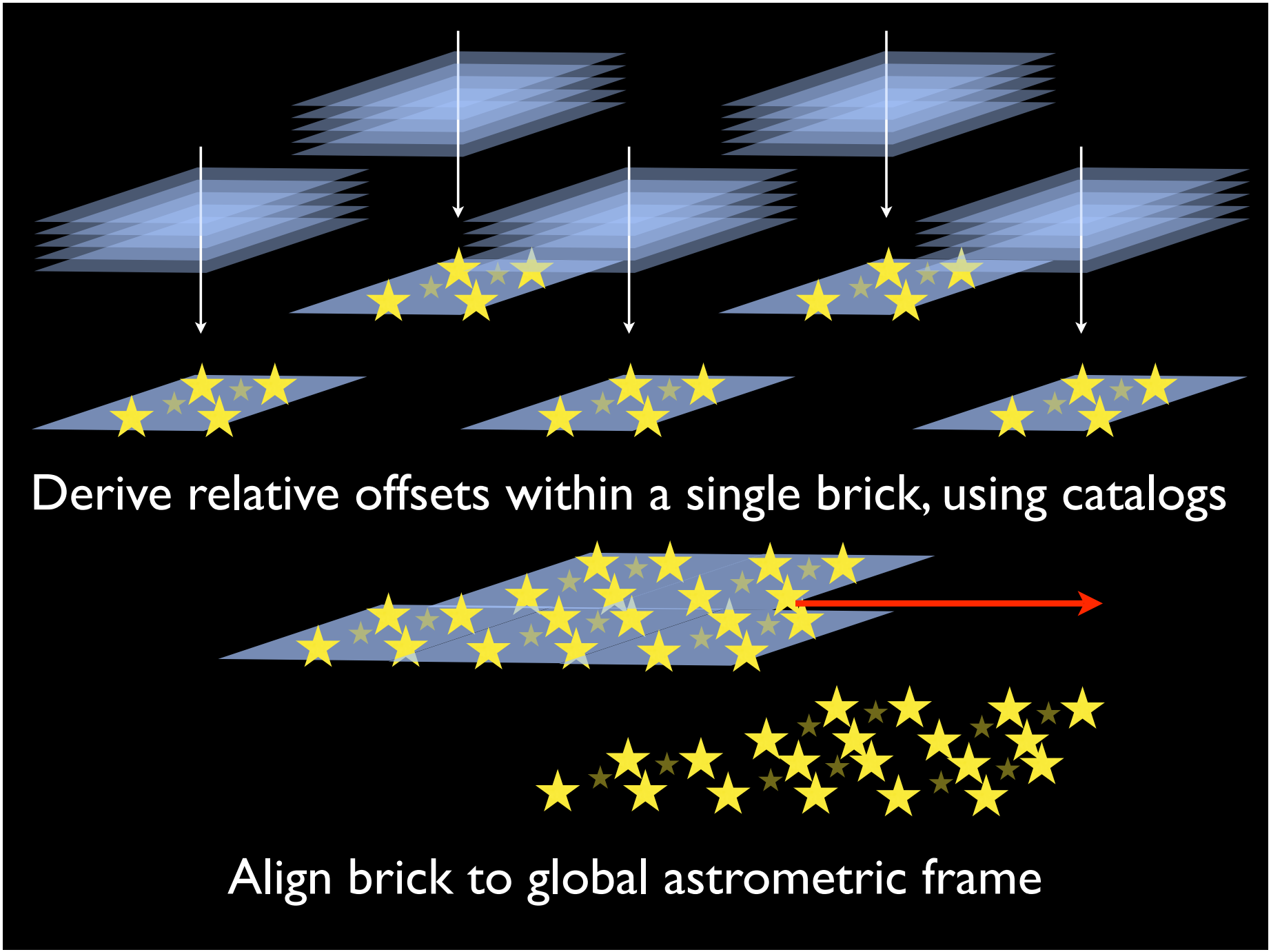
Align Images (one camera+visit)
then Combine

Find All Stars

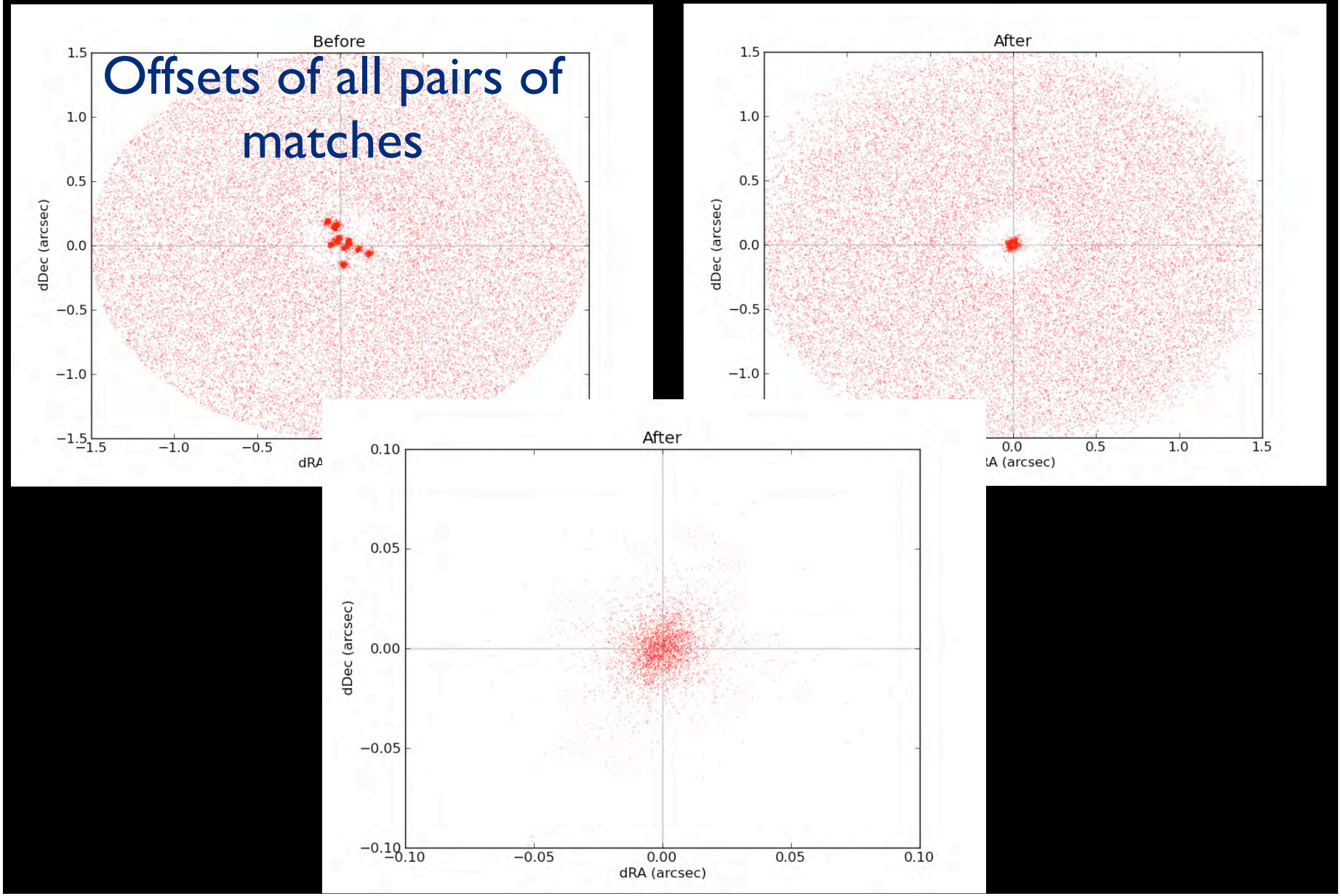


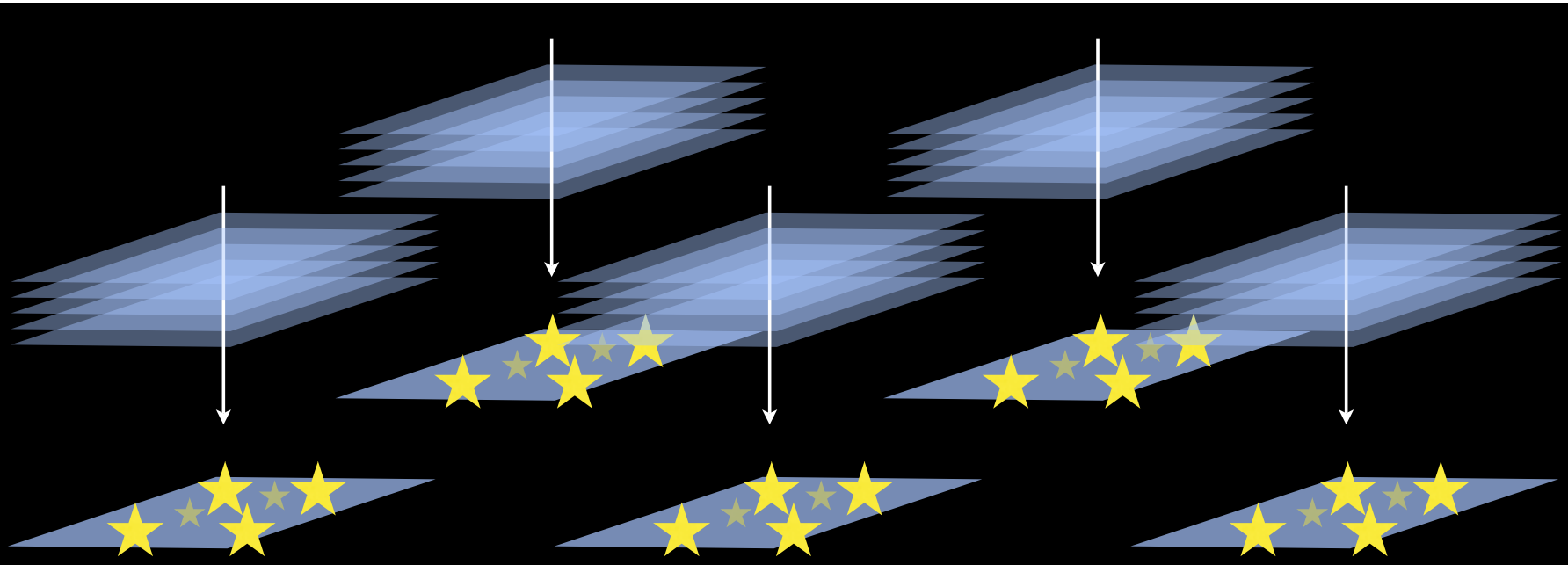
Fit PSF Amplitude in Individual Images

Subtract Stars & Repeat


Derive relative offsets within a single brick, using catalogs
Align brick to global astrometric frame

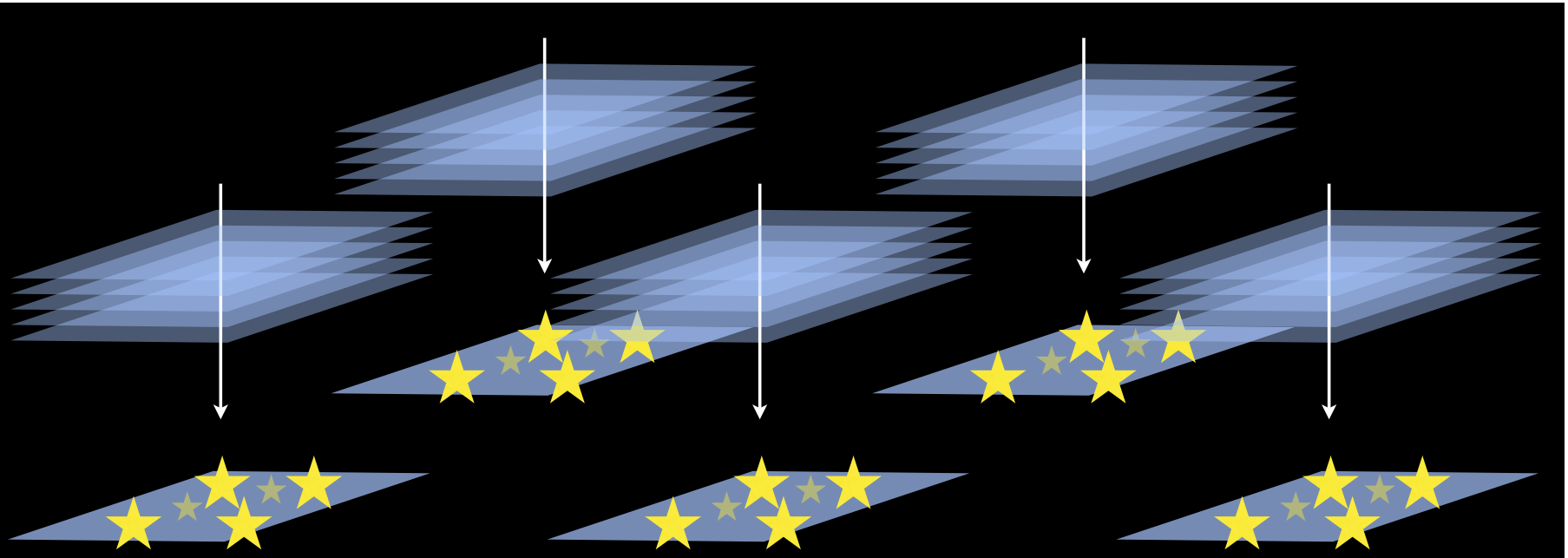
WFC3/IR


Before
Offsets of all pairs of matches
dDec (arcsec)
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−1.5
−1.0
−0.5
After
dDec (arcsec)
1.5
1.0
0.5
0.0
−0.5
−1.0
0.0
0.5
1.0
1.5
After
dDec (arcsec)
0.10
0.05
0.00
−0.05
−0.10
−0.10
−0.05
0.00
0.05
0.10
dRA (arcsec)



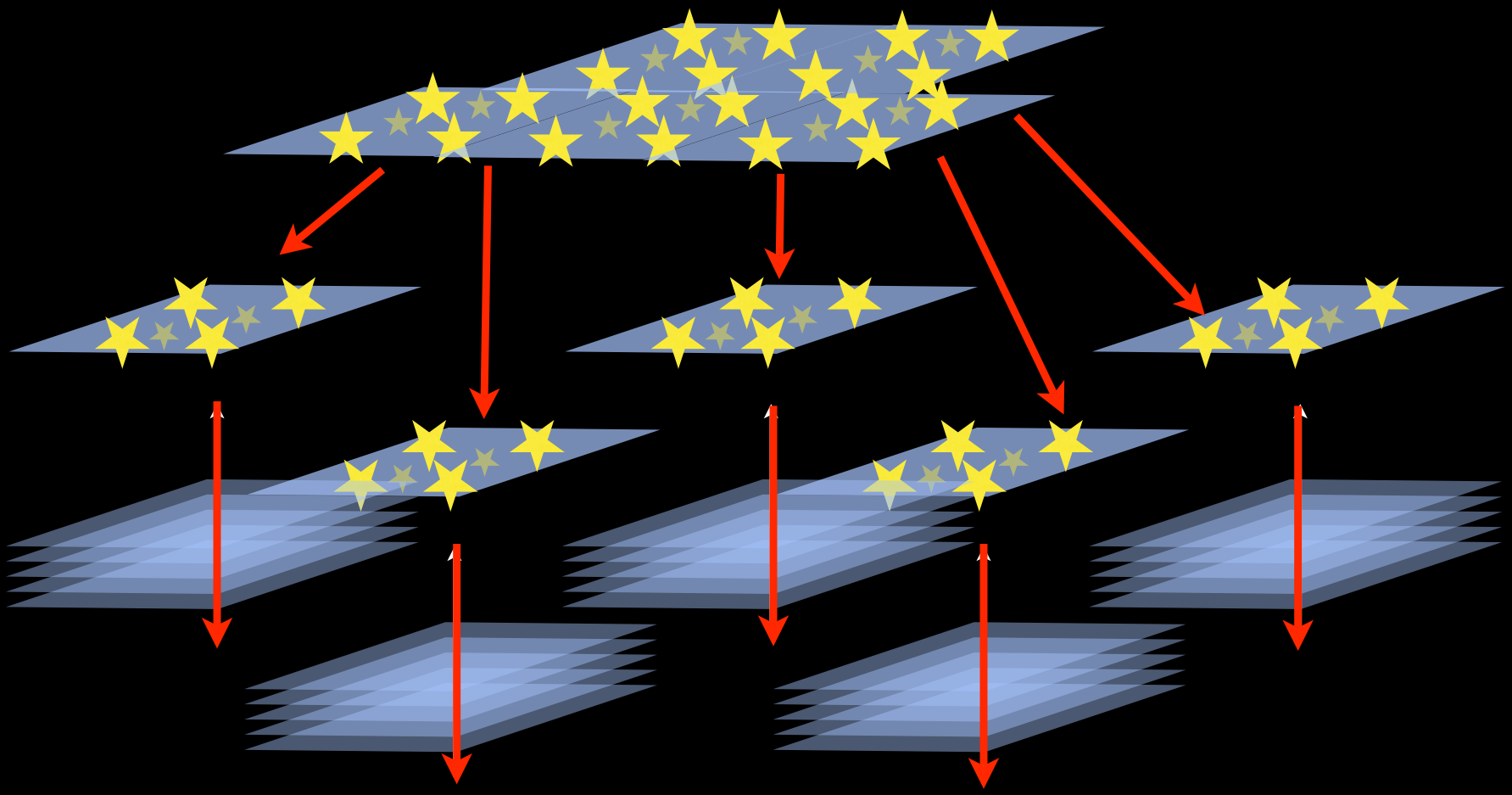
Phase II: Derive relative offsets **& geometric distortions** within a single brick, using catalogs

Improved geometric distortions will be released back to STScI

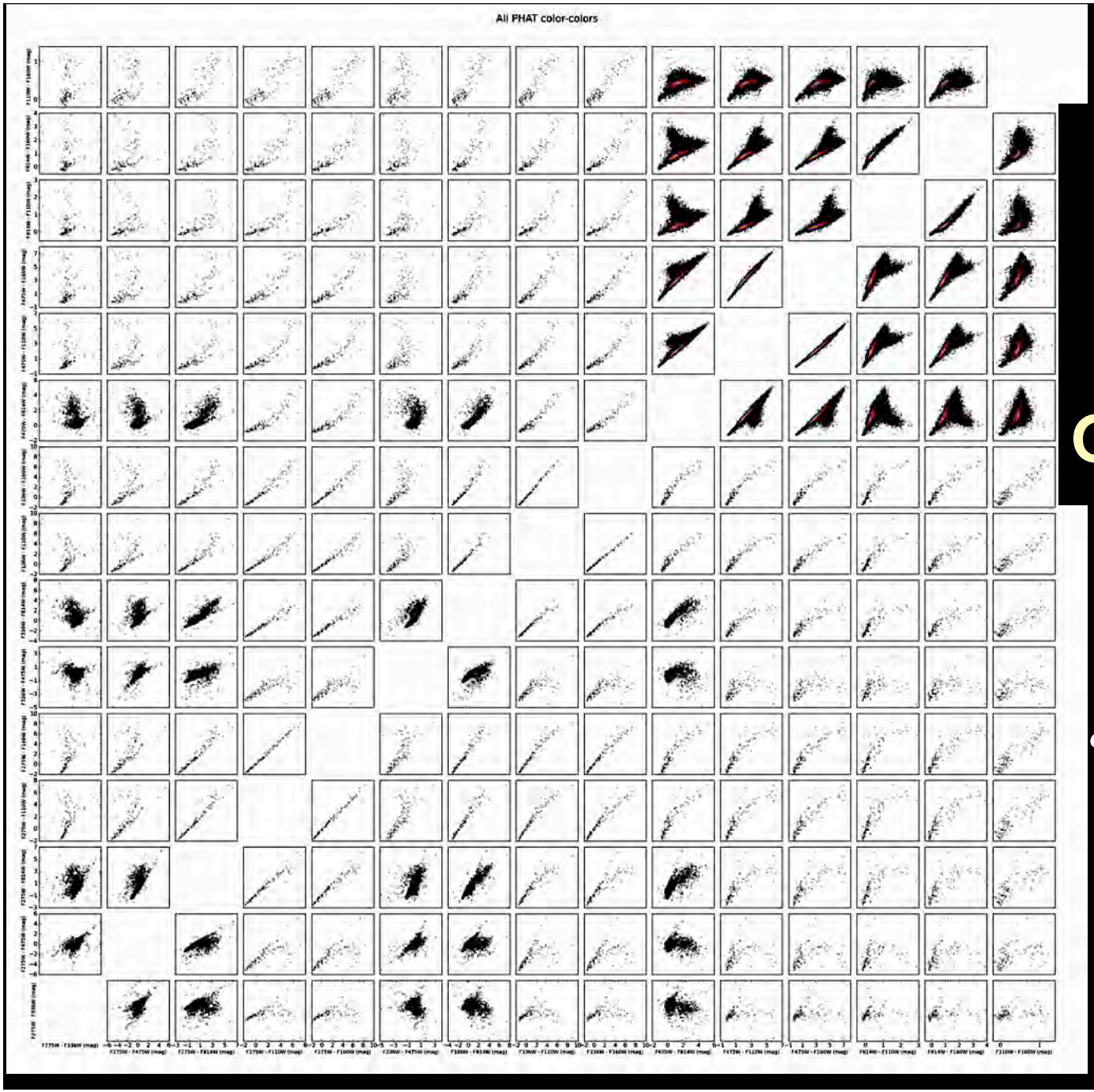


Phase III: Derive relative offsets & geometric distortions within a single brick, using **images directly**

Propagate astrometry back to catalogs & images



Phase I: Merge photometry at the catalog level

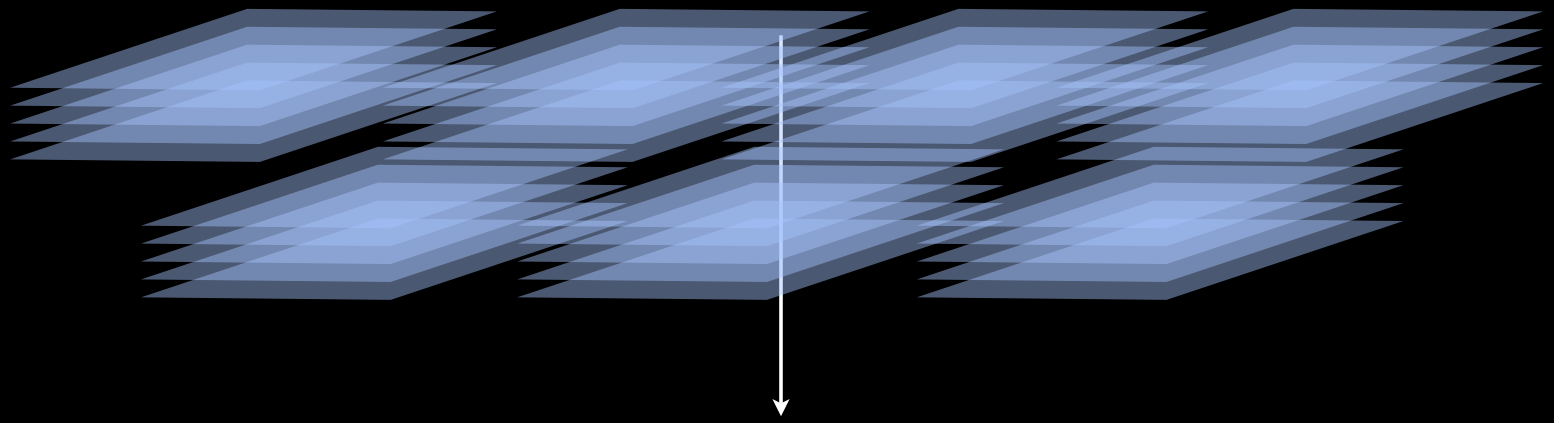


Color-color diagrams

From overlapping "teeth" with 6-filter coverage

Dustin Lang

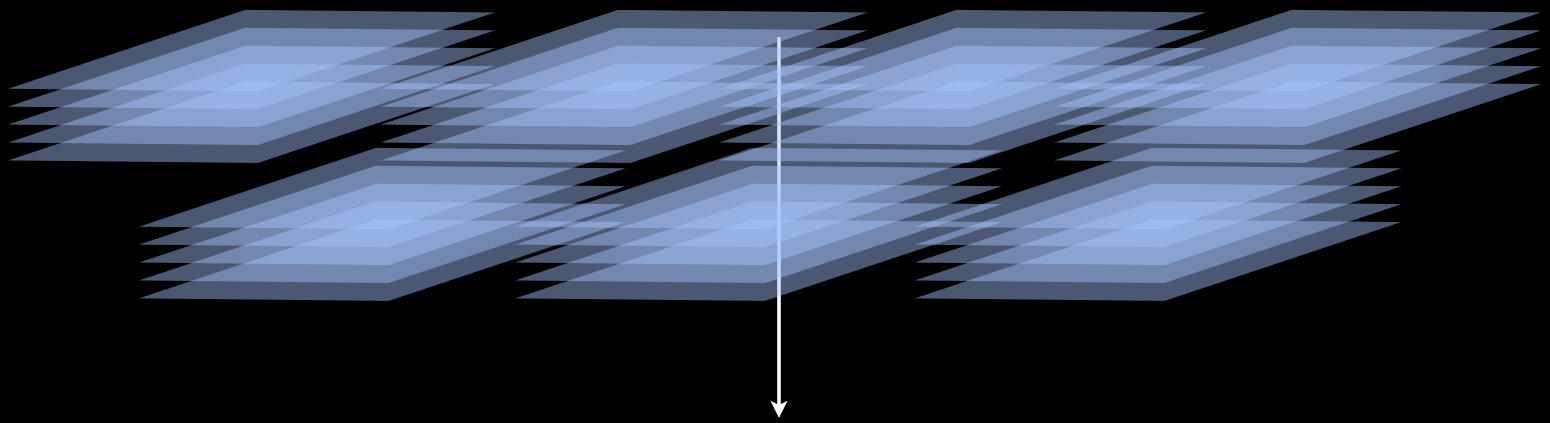
Phase II Photometry



Carry out alignment + photometry for **all images (in all visits)** in a single brick, for a single camera

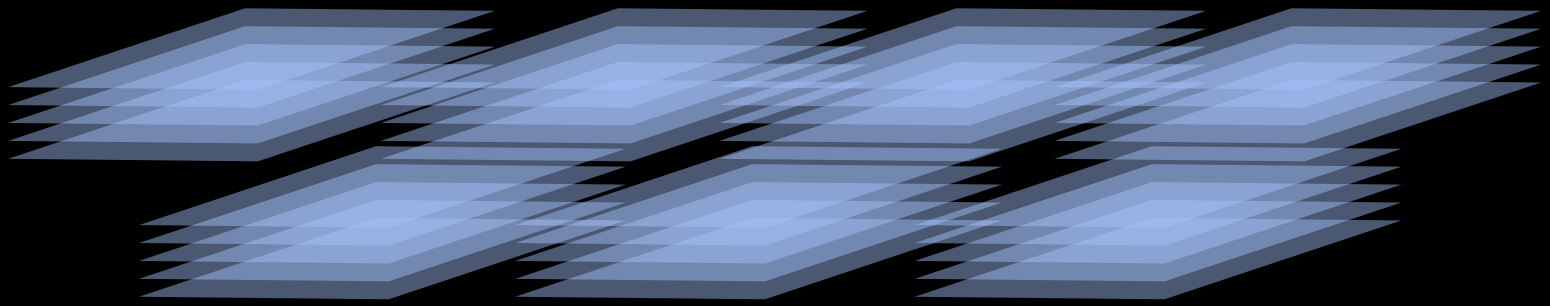
Most accurate way of producing photometry in overlap regions

Phase III Photometry



Carry out alignment + photometry for all images in a single brick, **for all cameras**

Phase IIIa: Nyquist Sampled Photometry

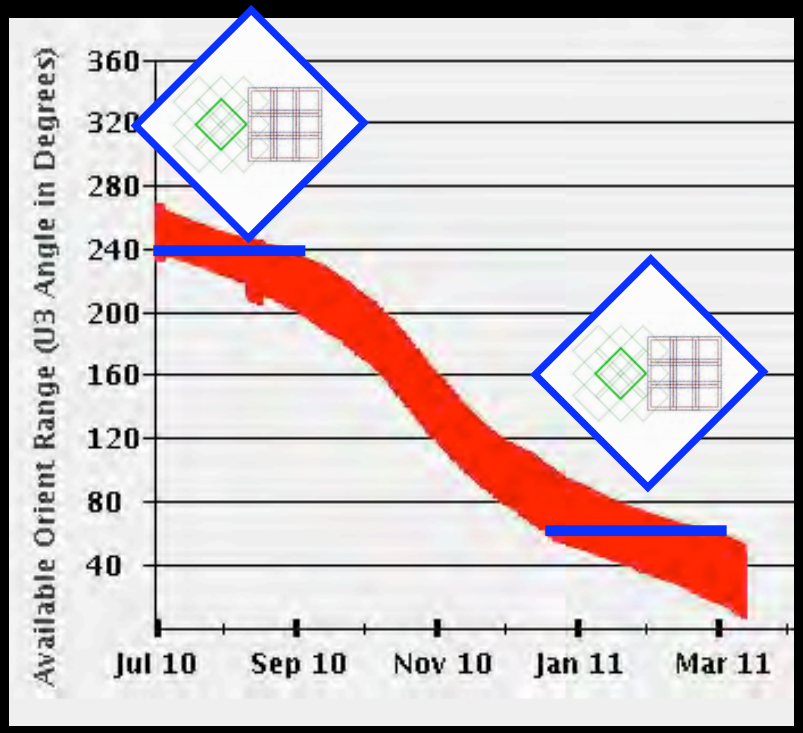


Completely independent photometric technique, with potential to reach fainter limiting magnitudes in crowded regions

See recent paper on M32

Timescales for Delivering Photometry

~6 months after completion of a brick, with increasing complexity



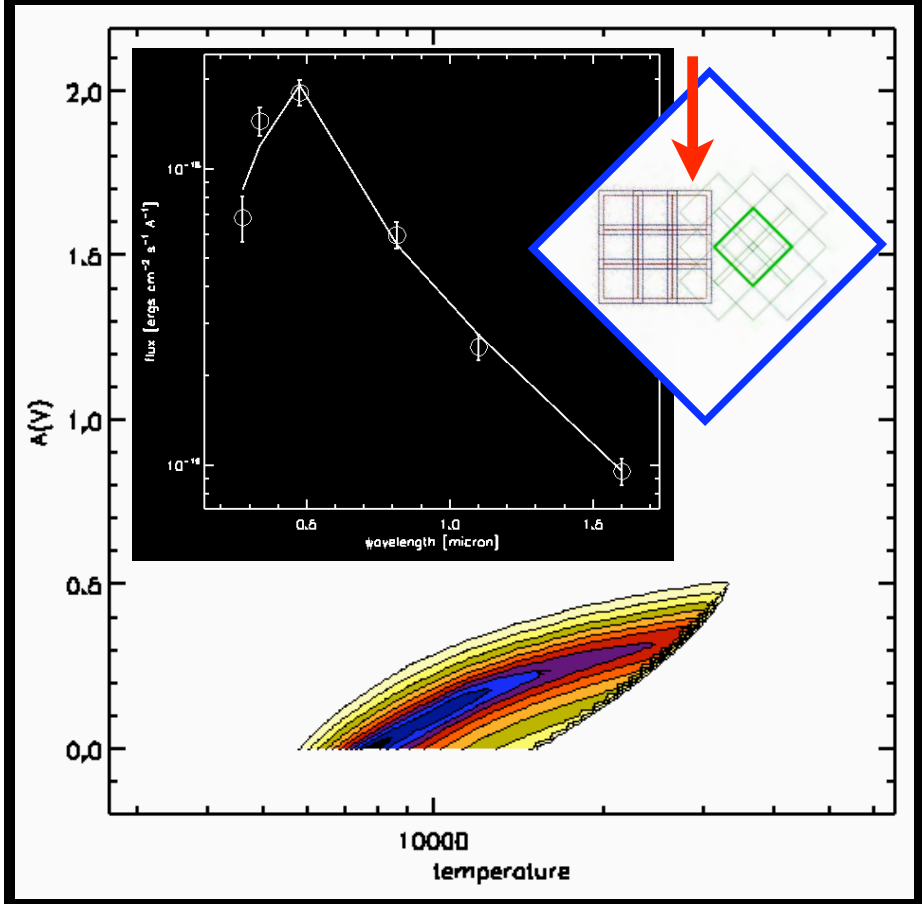
Bricks completed in 6 month intervals

- Visit level photometry + alignment + merged catalogs
- Brick level merged photometric catalogs
- Brick level photometry + merged camera catalogs
- Full Brick photometry across all cameras

Photometric Data Products

- Binary FITS tables of all photometric parameters, at both field and brick catalog levels (fast release schedule)
- SQL database hosted at MAST, including region functionality (slower release schedule)
- Standard multidrizzled images (fast release schedule)
- Nyquist-sampled optimally reconstructed images (slower release schedule)

PHAT HLSP: Stellar Parameters [L_{bol}, T_{eff}, E(B-V)]

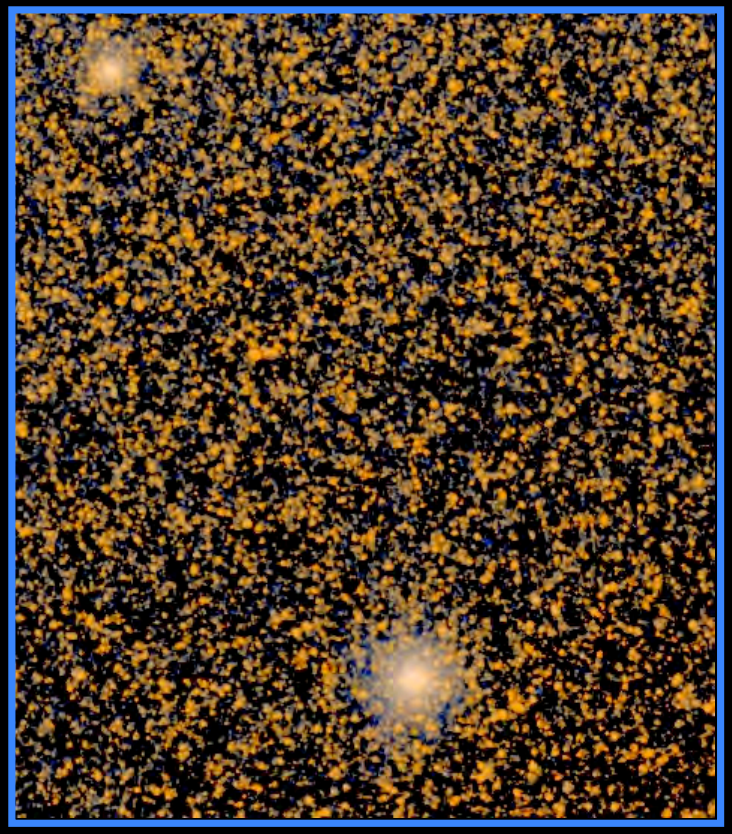


- Requires fully vetted 6-filter photometry
- Extending to include Bayesian priors on CMD & reddening distributions
- Will iterate in response to spectral typing

Initially ~12 months after completion of a brick, but faster in later years

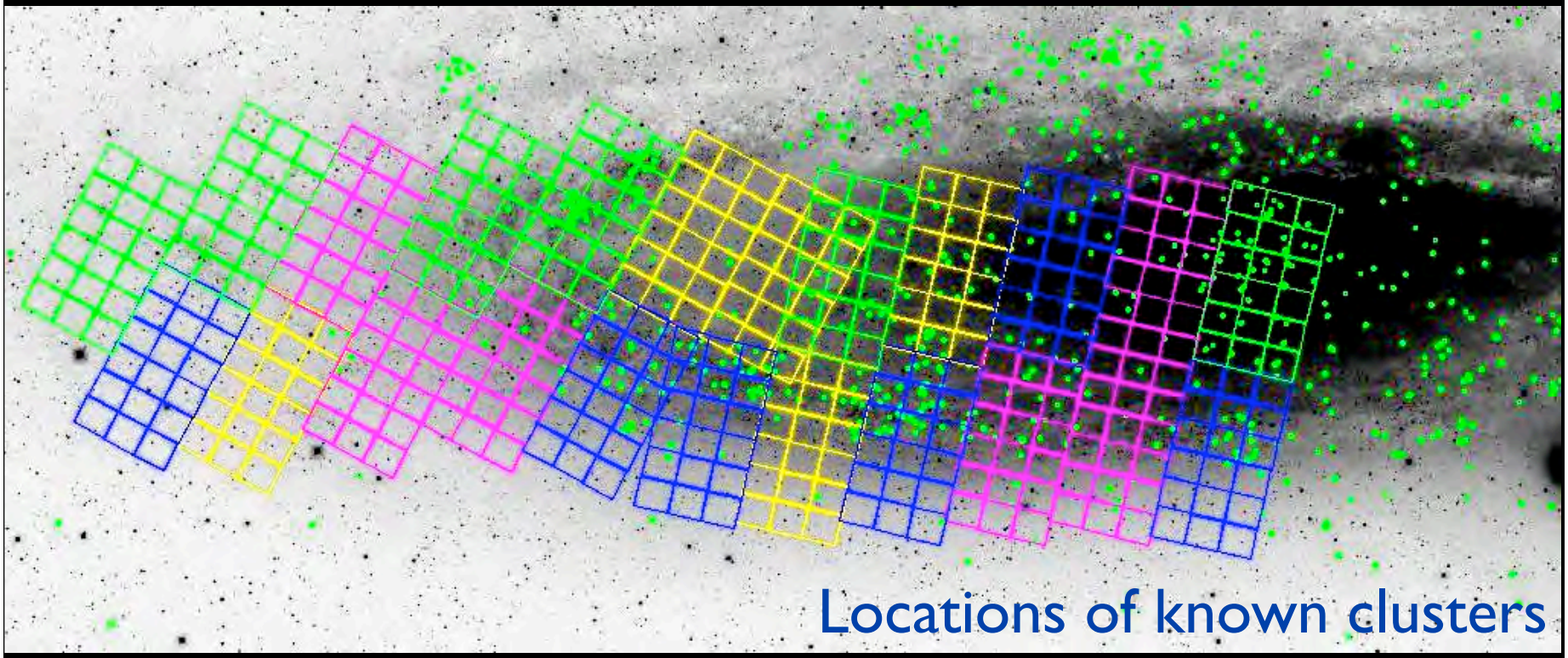
PHAT HLSP: Stellar Clusters

Resolved



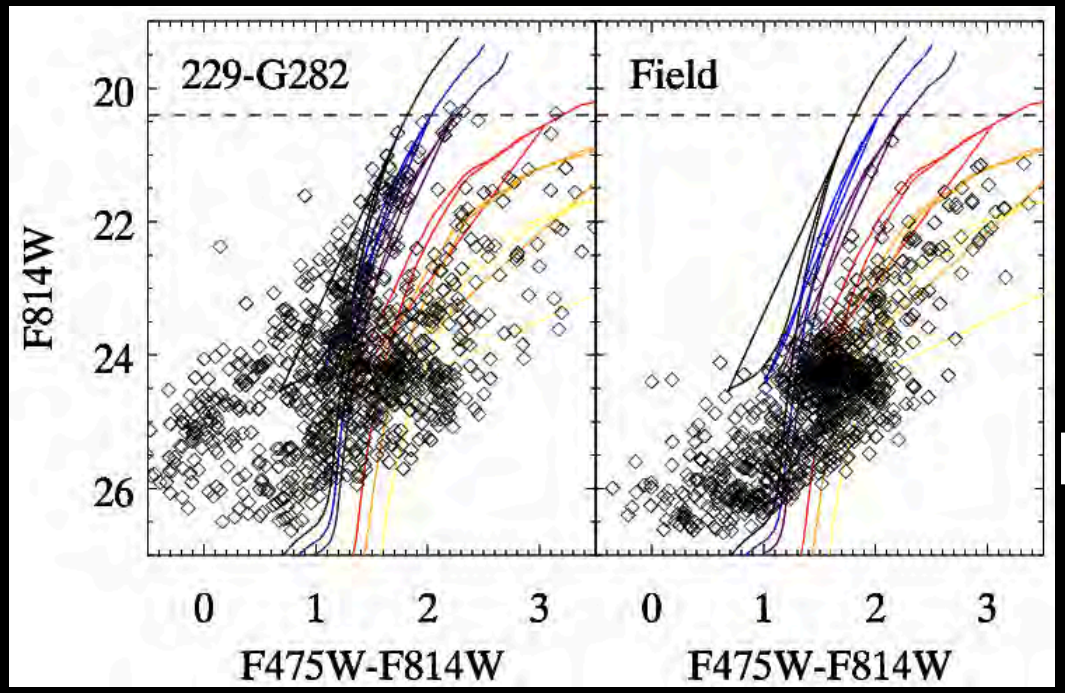
UnResolved

Phase I: Identification of Stellar Clusters



- Some machine algorithms possible for initial identification of candidates
- Requires extensive human verification

Phase II: Characterization of Stellar Clusters



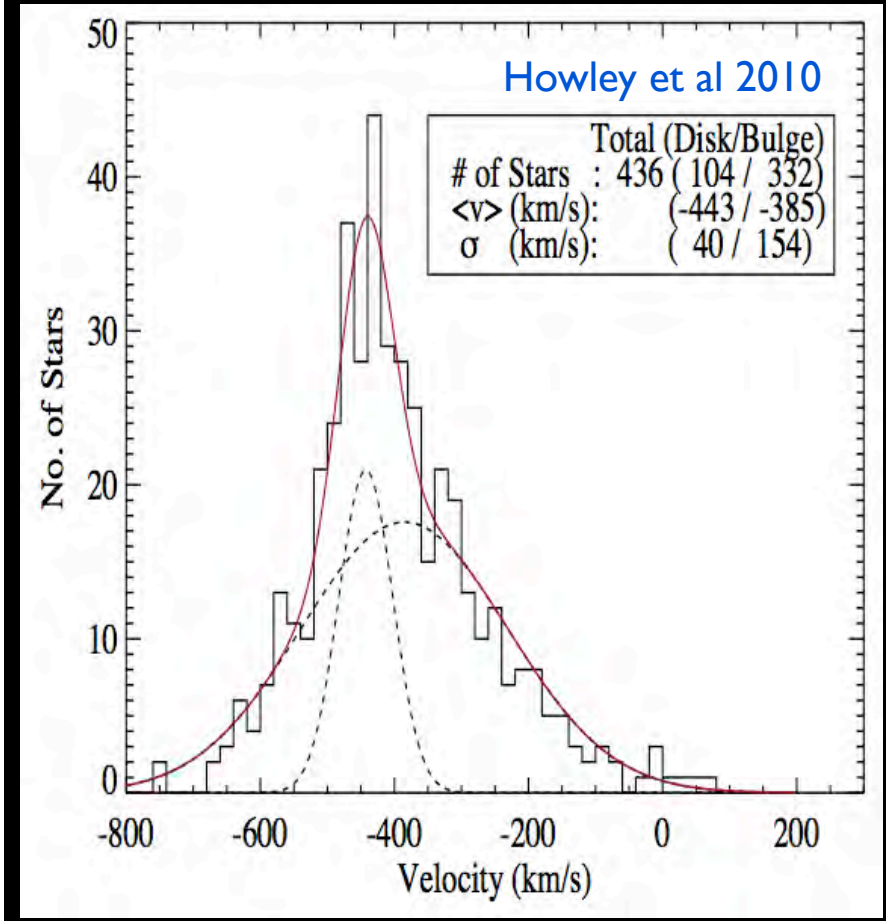
Spectroscopic
[Fe/H]=-2.1

10 Gyr Isochrones
[Fe/H]=-2.3, -1.7, -1.3, -0.7, -0.4

- Analysis of resolved CMDs
- Analysis of integrated flux
- Simultaneous analysis of both resolved & unresolved flux

~18 months of completion of a brick? (Uncertain: verification much more complex)

PHAT HLSP: Spectroscopy



- Rectified 2D spectra (1 per slit) and extracted 1-d spectra for target stars
- Extracted radial velocity
- Spectral type (Phase II spectroscopy)

~12 months after completion of a brick

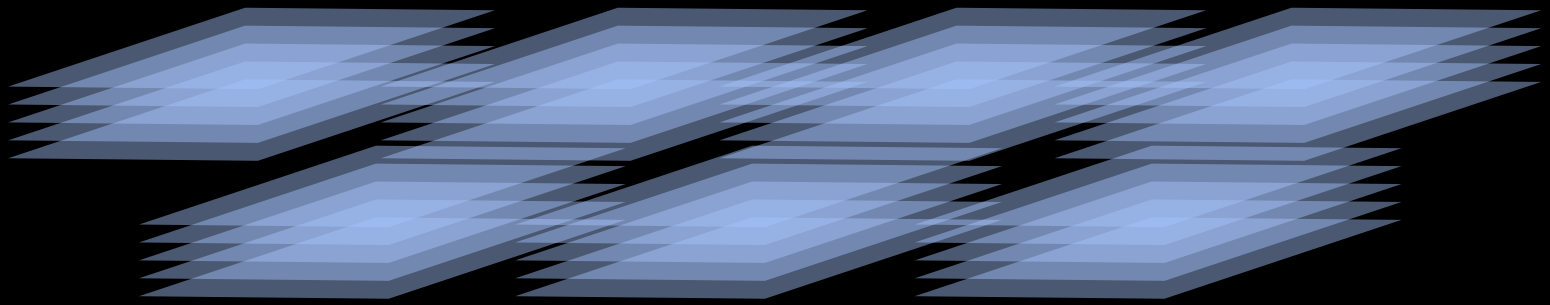
Note: Phase I spectroscopy targeted sources from CFHT images. Interpretation of spectra requires uncrowded HST images

Other expected community data products

- Revised Padova isochrones
- Updated functionality in DOLPHOT
- Catalogs of variables (selected off overlapping images, and cross correlated with ground-based catalogs)
- Extinction maps
- Catalogs of x-ray source identifications
- Catalogs of QSOs and PNe

Released digitally, usually along with publication of relevant papers

Note: Huge Computing Requirements



~400,000 sources per pointing in stacks of >20 images, with 18 pointings per brick

~1 million artificial star tests per camera, per pointing

Stellar parameter fitting for each source requires full Markov chain Monte Carlo

Only feasible solution is cloud computing

Immediate Schedule

- First 4 brick complete: February 2010
- First photometry release: Late summer 2010
- First stellar parameter release: Spring 2011
- First spectroscopy release: Spring 2011

Thanks!