



The Stellar Populations of
IC 10 and NGC 1569
observed with Keck LGSAO and HST

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Properties of IC 10

- Small irregular starburst (BCD) galaxy on outskirts of Local Group
 - $R \sim 1$ kpc
 - $M \sim 1-2 \times 10^9 M_{\odot}$
- Low metallicity ($Z \sim 0.2-0.3 Z_{\odot} \sim Z_{\text{SMC}}$)
- Brief, galaxy-wide burst of SF occurred within last 10 Myr
 - Numerous HII regions
 - Large H α and FIR luminosity
 - Highest SFR of any LG dwarf ($> 0.7 M_{\odot} \text{ yr}^{-1}$)
 - Large population of W-R stars ($N_{\text{WR}} > 24$; SMC has ~ 8)
 - Highest surface density of W-Rs in LG ($\sim 8 \text{ kpc}^{-2}$; MW $\sim 2.5 \text{ kpc}^{-2}$)
 - Anomalously high WC/WN ratio ($\sim 1-2$) for its Z (10x too large!)
 - Have WN stars been missed in surveys?
- $b = -3.3^{\circ}$
 - Uncertain reddening: $A_V = 1.2 - 6.0$ mag
 - Uncertain distance: $D = 0.5 - 3.0$ Mpc
- Ideal extragalactic target for NIR observations with LGSAO
 - Nearby, relatively large A_V (foreground and internal), high ρ_{\star}
 - Bright tip-tilt guide stars available

IC 10

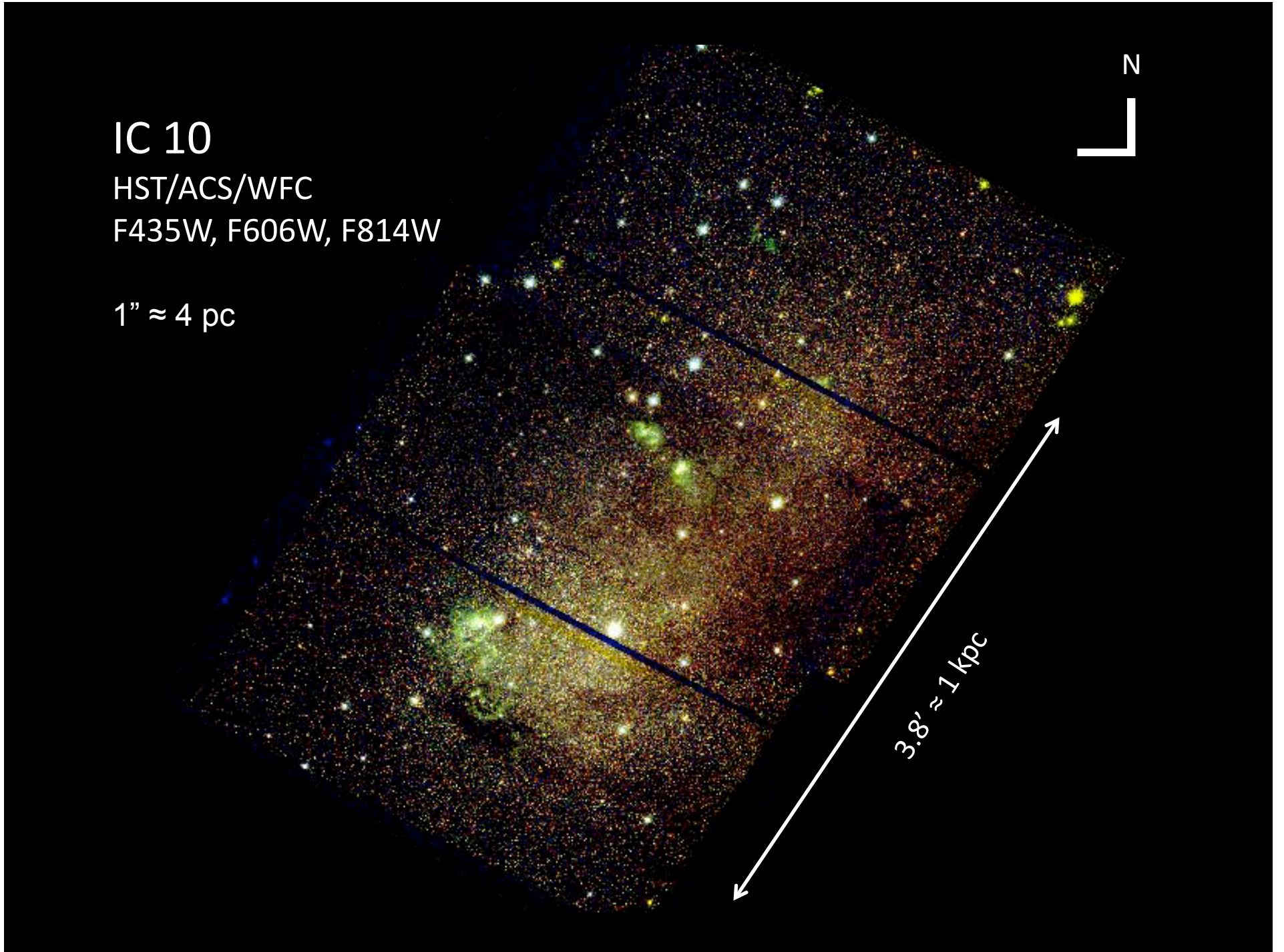
HST/ACS/WFC

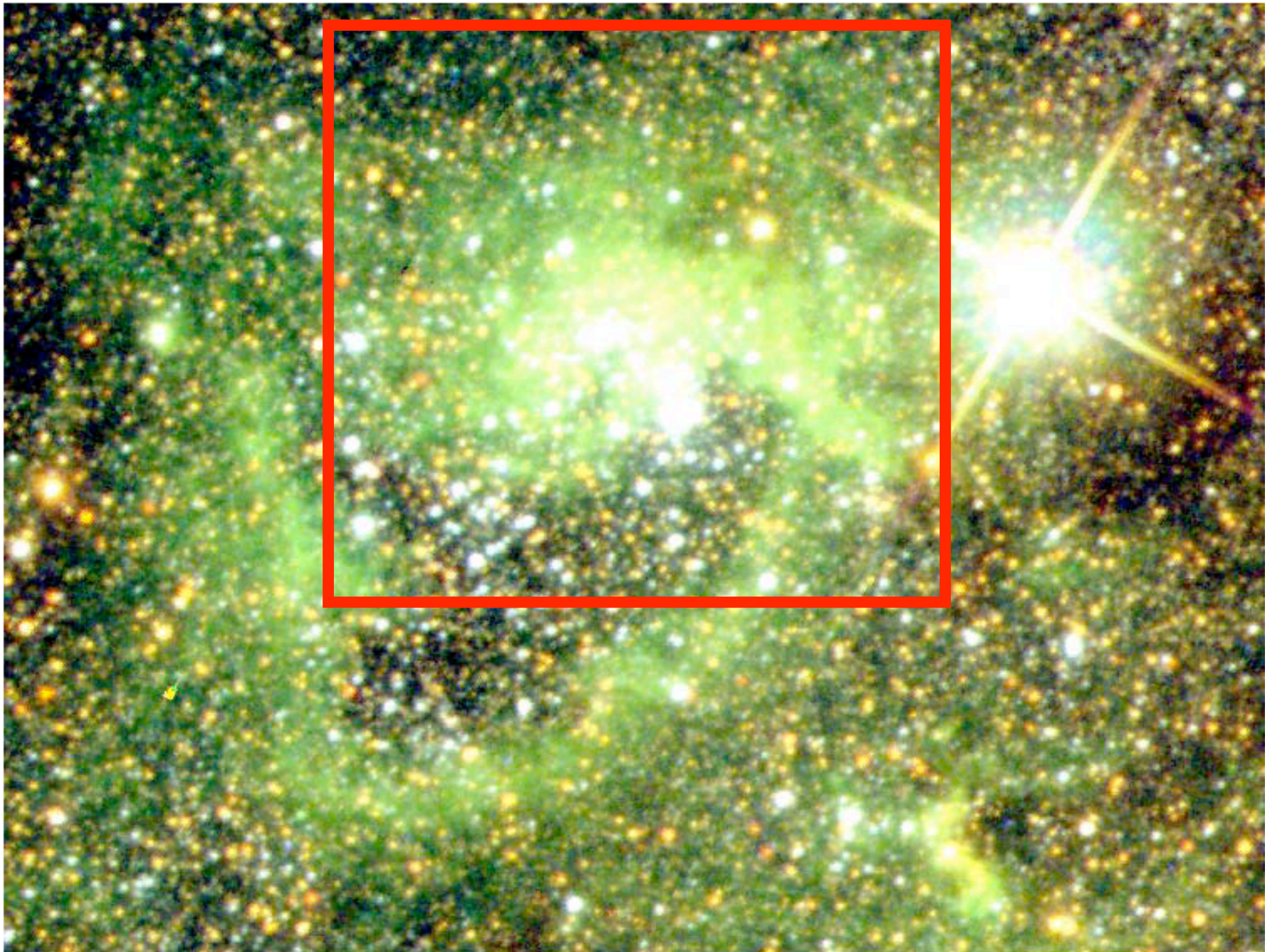
F435W, F606W, F814W

1" \approx 4 pc



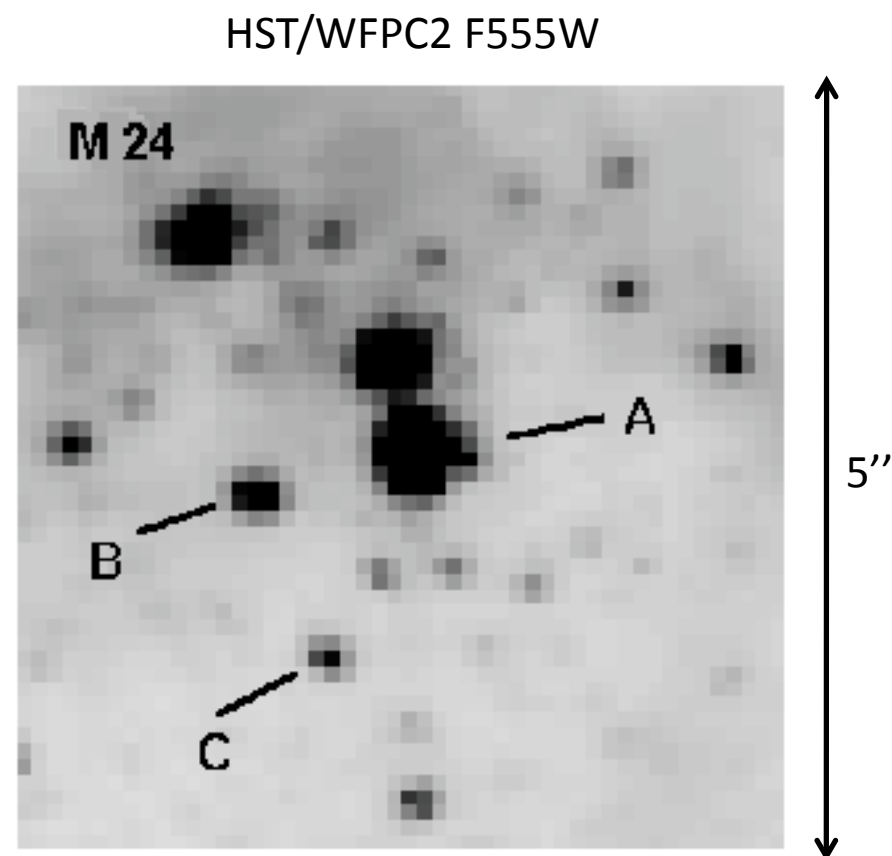
3.8' \approx 1 kpc





WR Object: [MAC92] 24

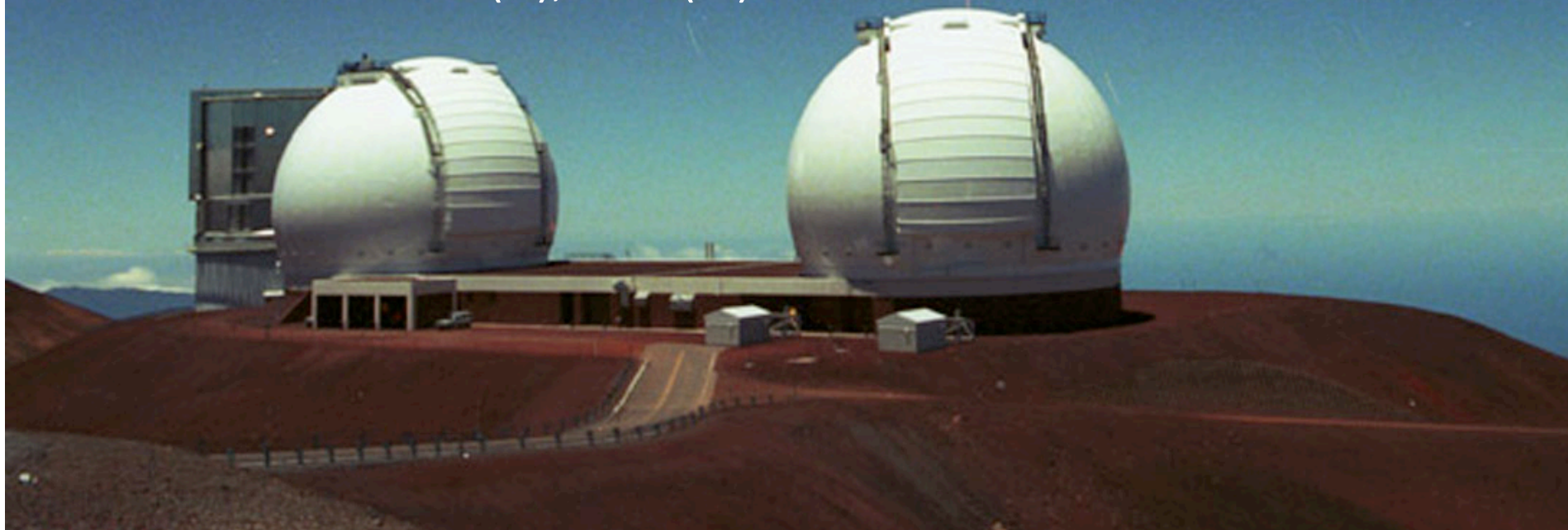
- Brightest W-R candidate in IC10
- Lies within prominent H II region HL 111c
- Lies at center of a young stellar cluster (Hunter 2001)
- Uncertain spectral type
 - Weak, broad He II 4686 emission (Massey & Holmes 2002)
 - WN+OB?
- Three components (A, B, C)
- Cluster itself?



Crowther et al. (2003)

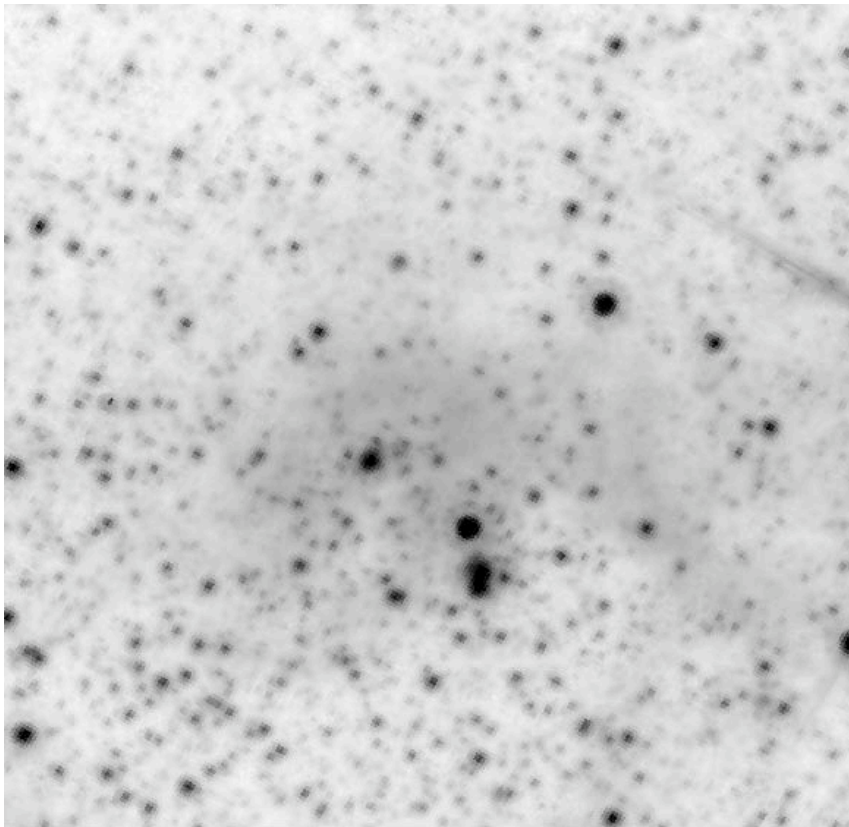
Observations

- NIR Data:
 - NIRC2/Keck II/LGSAO H and K'
 - $0.01''\text{pixel}^{-1}$
 - Final FOV = $12.2'' \times 12.2''$
 - $t_{\text{exp}} = 1200 \text{ s (H)}; 1500 \text{ s (K')}$
 - FWHM = $0.048'' \text{ (H)}; 0.051'' \text{ (K')}$
 - Strehl $\sim 18\% \text{ (H)}; 32\% \text{ (K')}$
- Optical Data:
 - HST/ACS/WFC F814W
 - $0.05''\text{pixel}^{-1}$
 - $t_{\text{exp}} = 1080 \text{ s}$
 - FWHM = $0.08''$

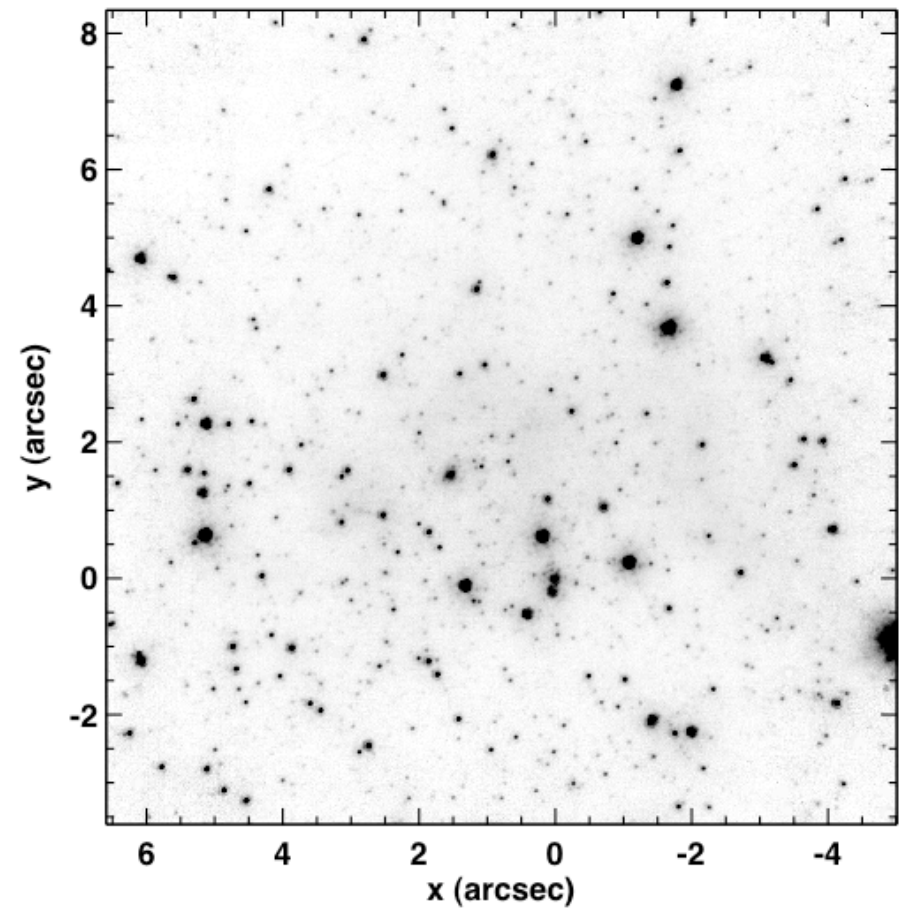


ACS WFC / NIRC2 Comparison

HST/ACS/WFC F814W

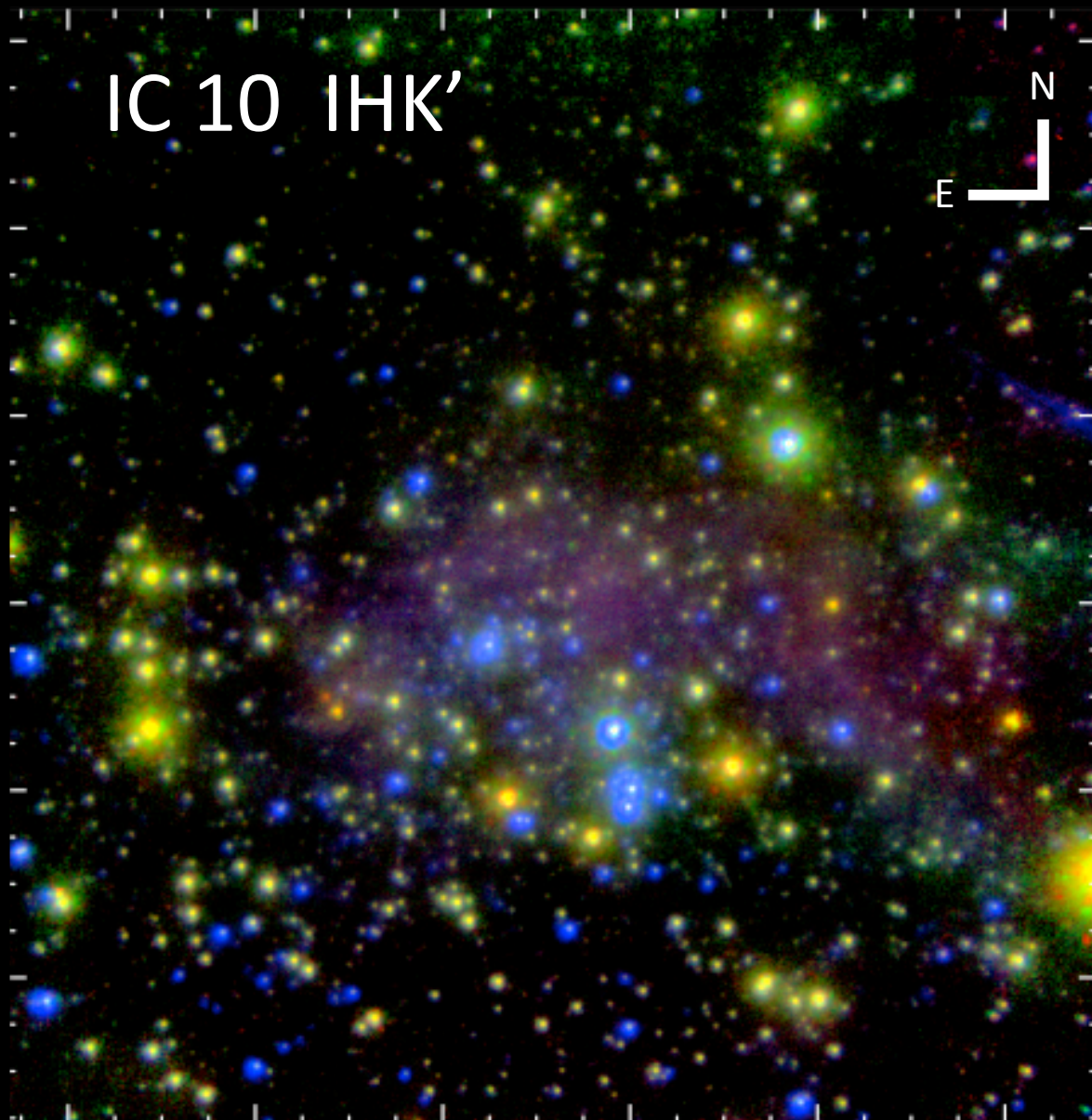


Keck II/NIRC2/LGSAO K'



IC 10 IHK'

12.2" x 12.2"
47 pc x 47 pc



Vacca, Sheehy, & Graham (2007)

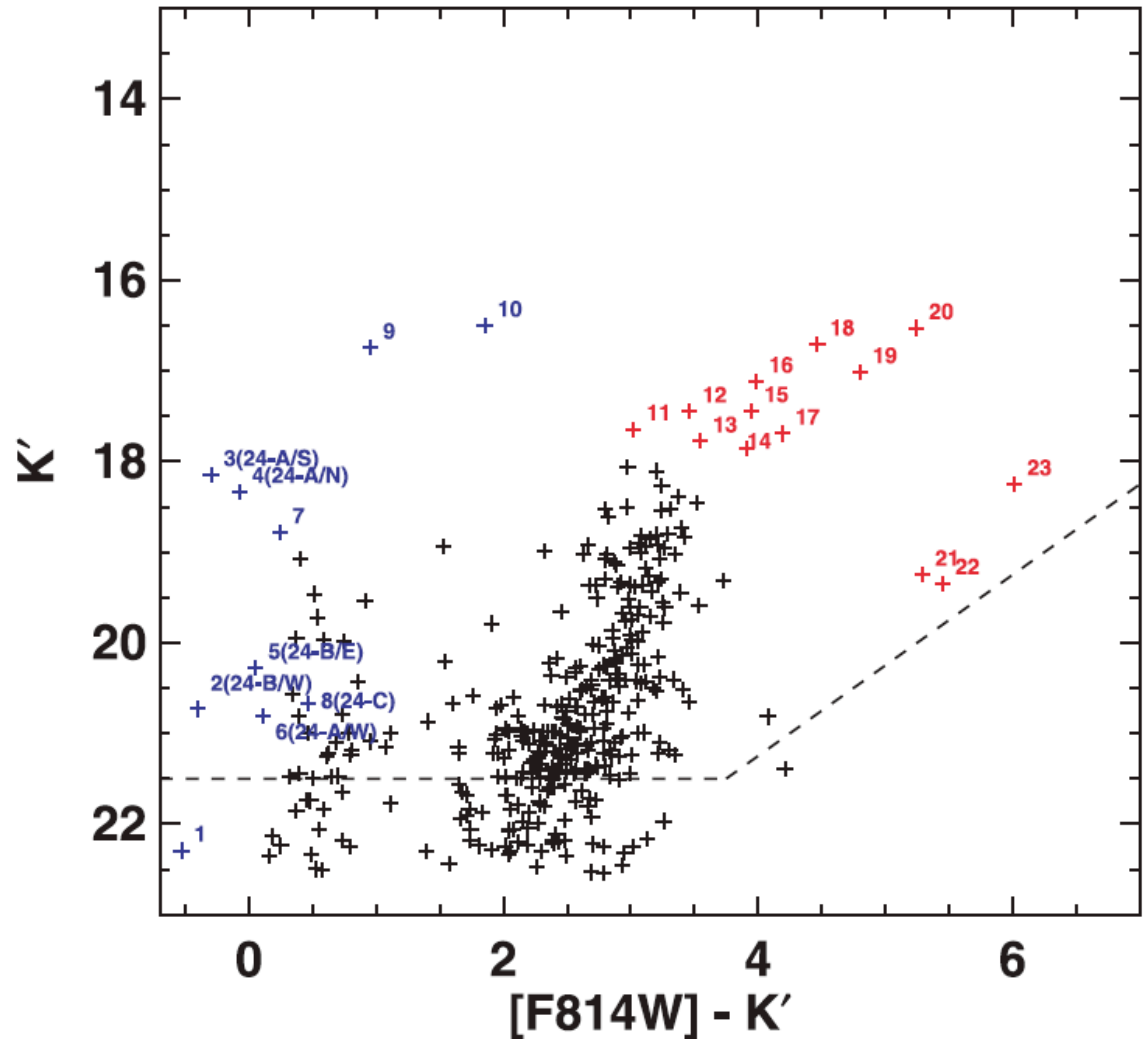
CMD of IC 10 [MAC92] 24 Region

Optical Data:

- PSF fitting (Anderson & King 2006)
- 690 stars found in F814W
- $[F814W]_{\text{Lim}} \sim 25.25$
- $\sigma < 0.04$ mag for $[F814W] < 23.0$

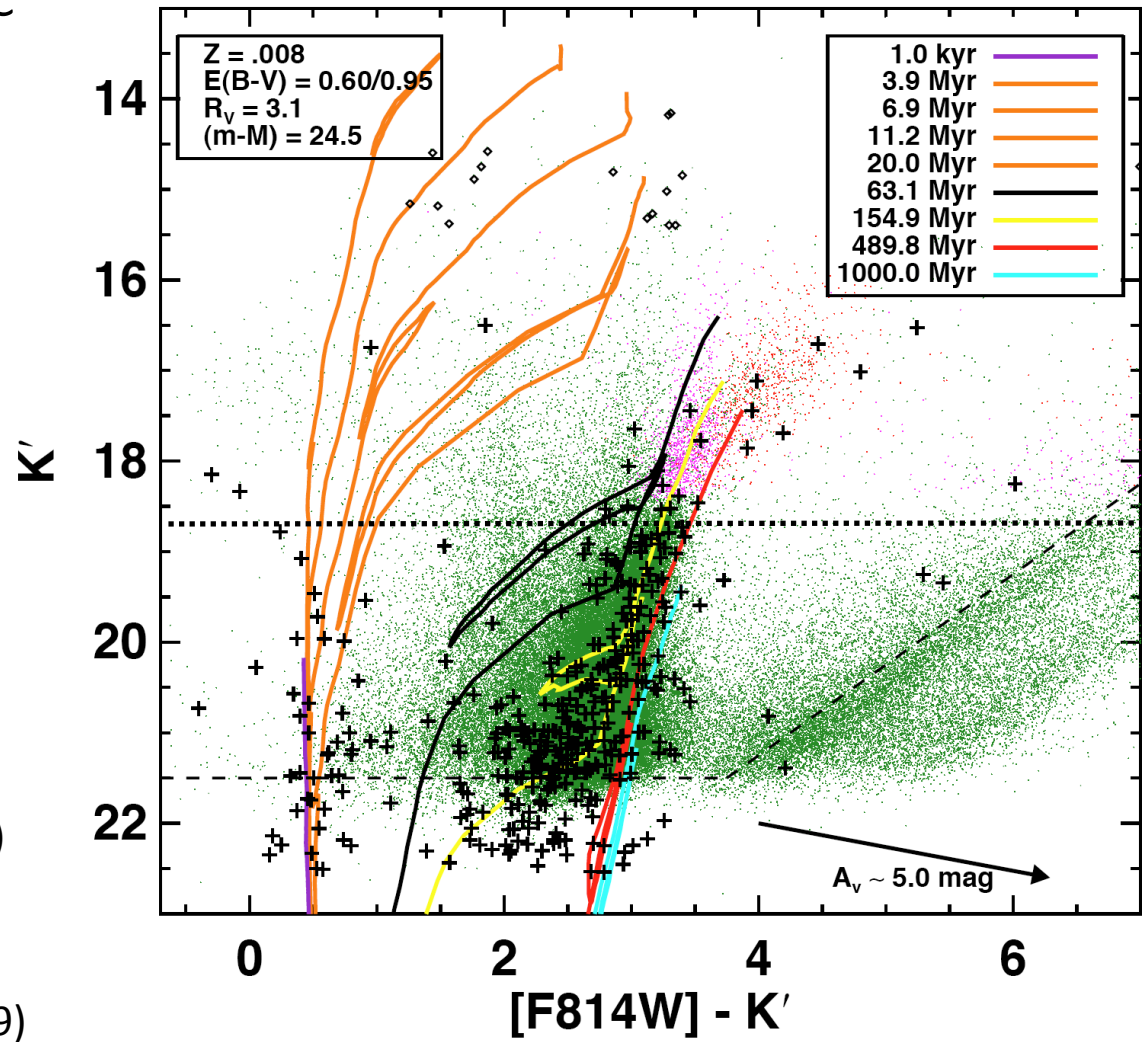
NIR Data:

- MTF-fitting method (Sheehy et al. 2006)
- 661 stars found in H
- $H_{\text{Lim}} \sim 22.3$ (50% complete)
- $\sigma_H < 0.05$ mag for $H < 21.5$
- 585 stars found in K'
- $K'_{\text{Lim}} \sim 21.5$ (50% complete)
- $\sigma_K < 0.05$ mag for $K' < 21.5$
- $[F814W]-K'$ for 380 stars



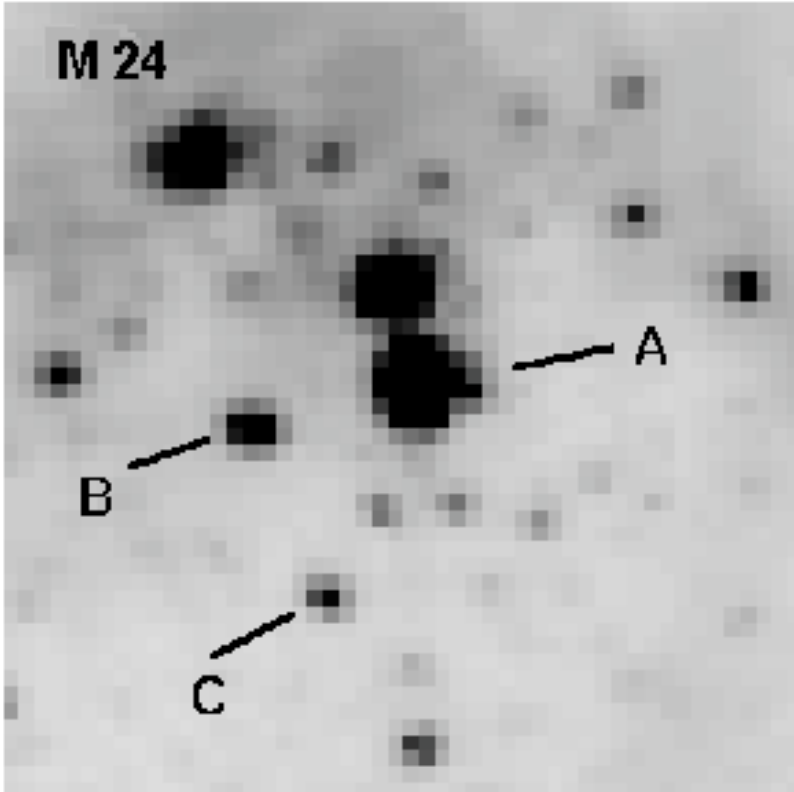
CMD of IC 10 [MAC92]WR 24 Region

- DENIS/2MASS catalogue of SMC (Zaritsky et al. 2002)
 - $Z \sim 0.2 Z_{\odot}$
 - $E(B-V)$ (blue ★) = 0.65
 - $E(B-V)$ (red ★) = 0.95
 - $DM \sim 24.5$ ($D \sim 790$ kpc)
- Lejeune & Schaerer (2001) isochrones
 - $Z \sim 0.4 Z_{\odot}$
 - $E(B-V)$ (blue ★) = 0.60
 - $E(B-V)$ (red ★) = 0.95
 - $DM \sim 24.5$ ($D \sim 790$ kpc)
- Two stellar populations:
 - MS and BSGs ($\tau < 20$ Myr)
 - RGs and AGBs ($\tau \sim 150-500$ Myr)
 - Differential reddening
- TRGB: $DM_0 = 24.48 \pm 0.16$ mag
 - Confirmed by Sanna et al. (2009) using entire ACS/WFC field

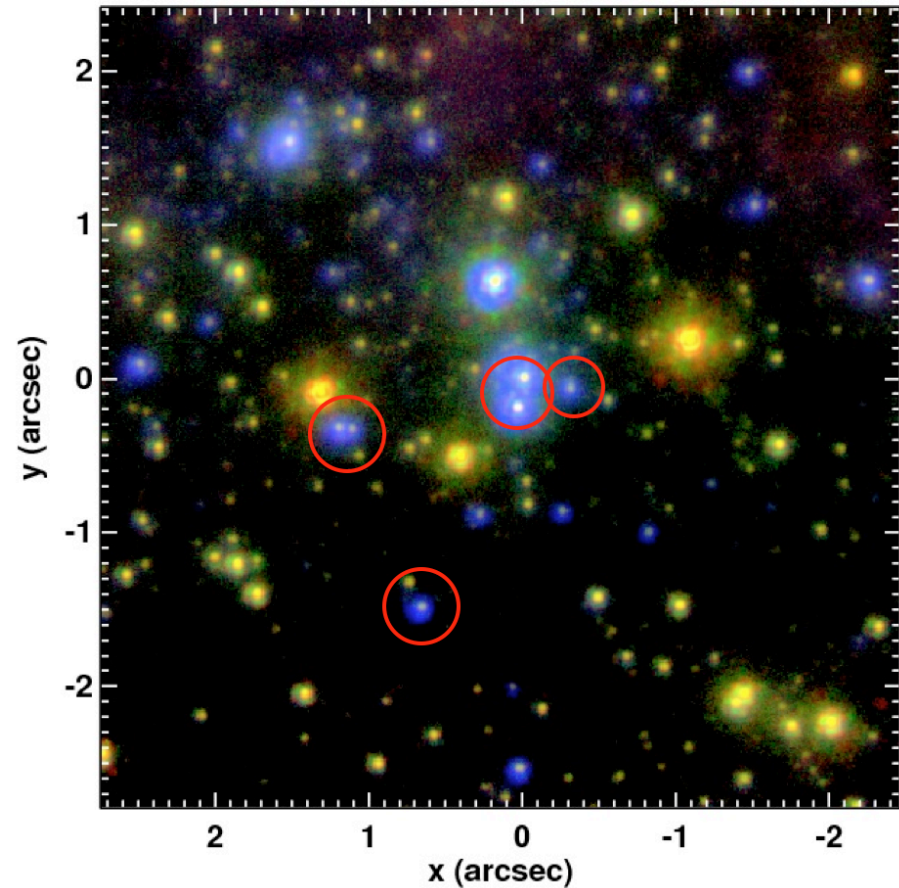


Advantages of High Resolution

HST/WFPC2 F555W



HST/ACS/WFC F814W + Keck II/NIRC2 H,K'



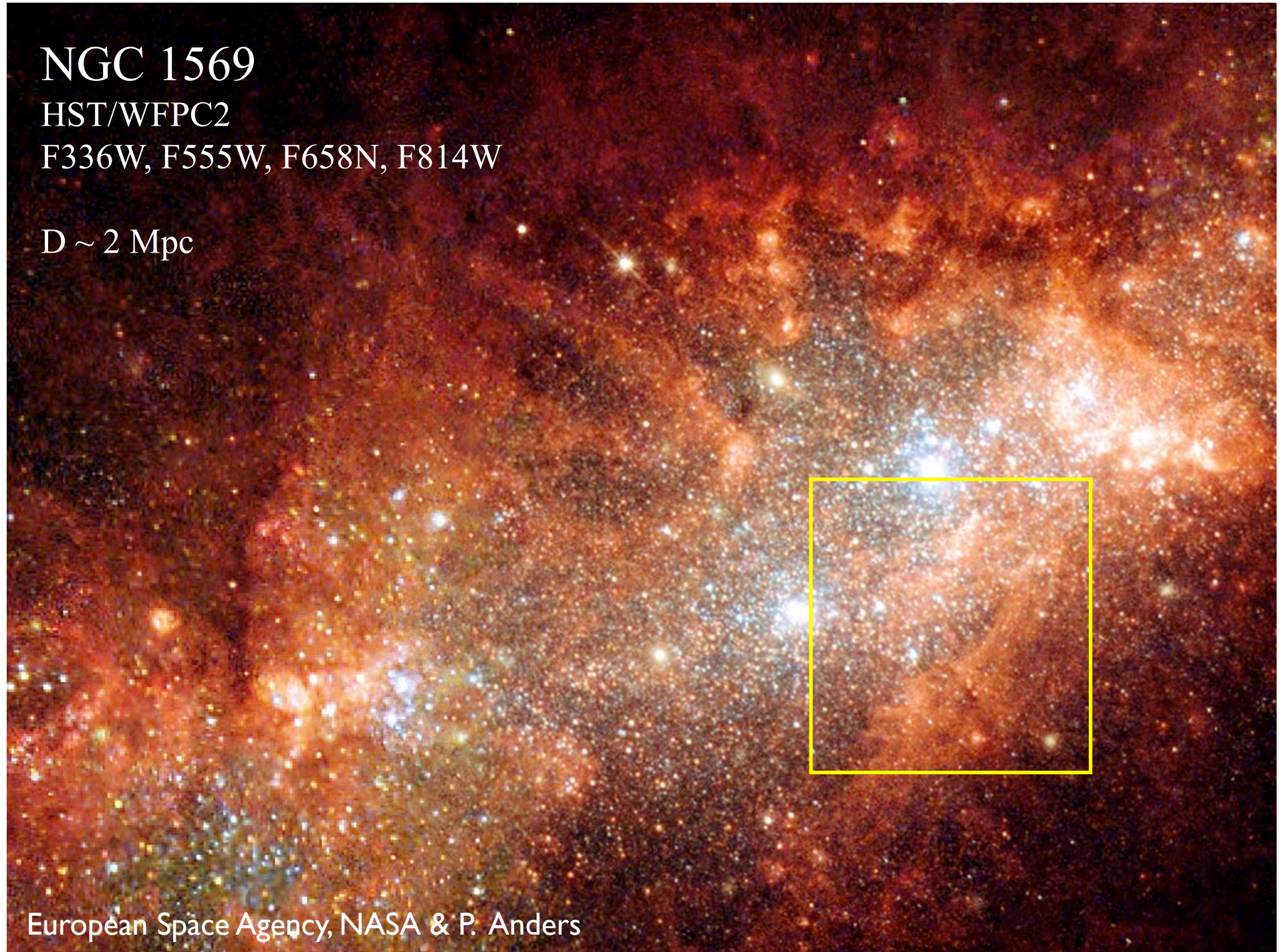
- Resolved the (blue) central components of a young stellar cluster ($r_h \sim 3.2$ pc)
- WR 24 A and B resolved into multiple bright, blue components
 - 4 WN candidates with $([F814W]-K')_0 \sim -0.6$; $-4 > M_K > -6$
- WN/O ratio ~ 0.14 : $\tau_{SB} < 5$ Myr

NGC 1569

HST/WFPC2

F336W, F555W, F658N, F814W

$D \sim 2 \text{ Mpc}$



European Space Agency, NASA & P. Anders

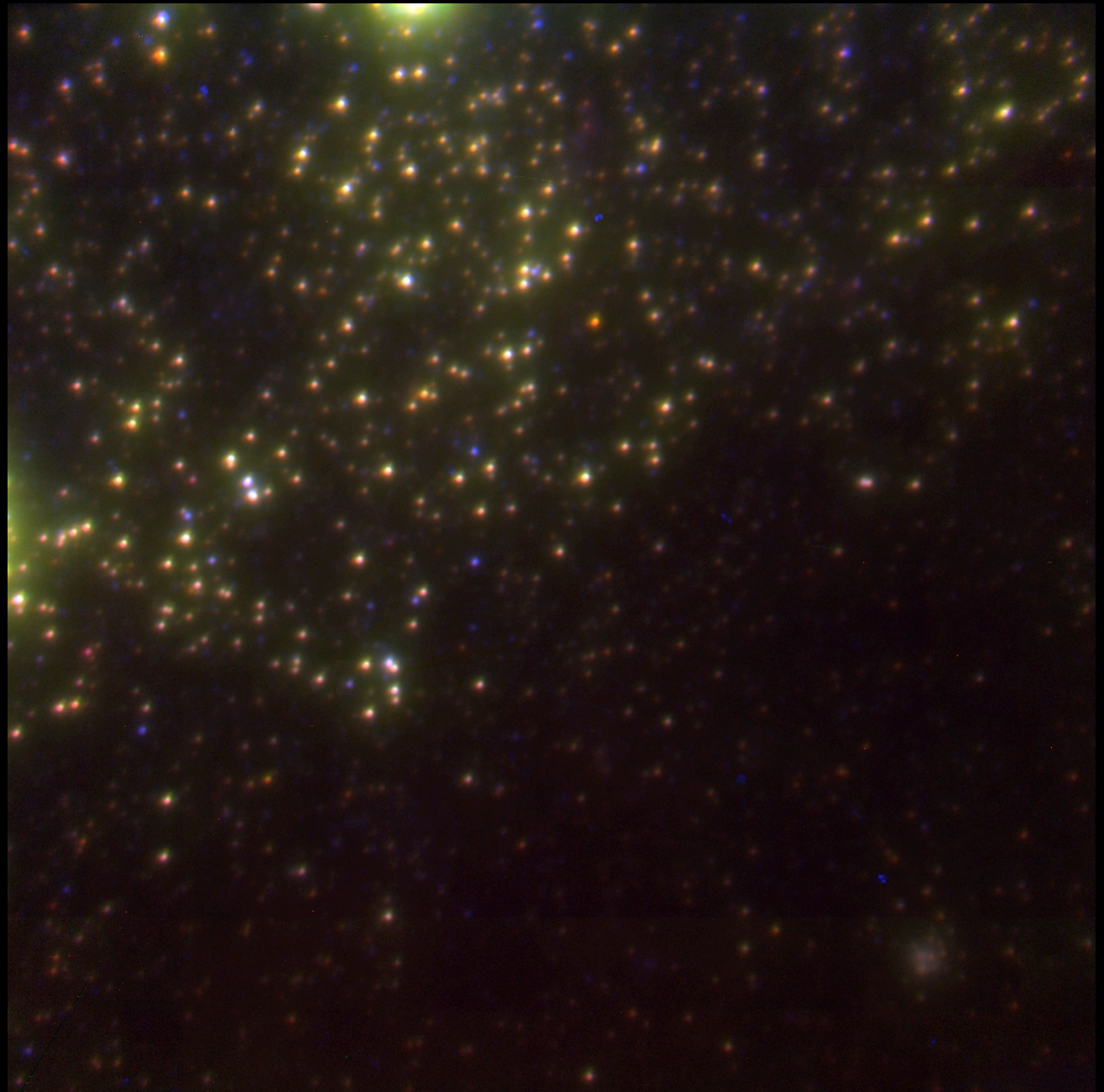
NGC 1569

'Deep Field'
ACS/HRC F814W
+ NIRC2 HK'

$t_{\text{exp}} = 390 \text{ s (F814W)}$

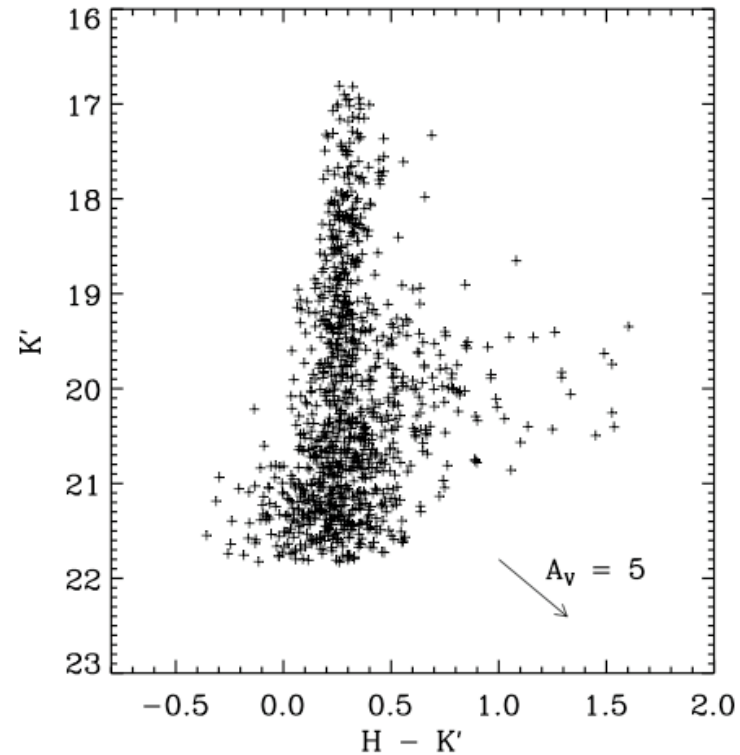
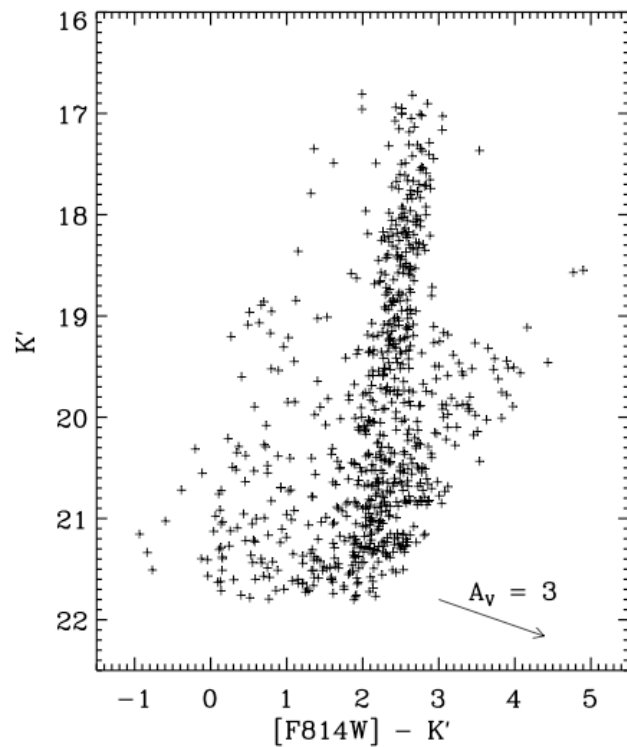
$t_{\text{exp}} = 2400 \text{ s (H)}$

$t_{\text{exp}} = 1500 \text{ s (K')}$



McCrary, Vacca & Graham, in prep.

NGC 1569: Preliminary CMDs



- 2520 stars in F814W, 1146 stars in H, 1233 stars in K'
 - ~1000 stars with H-K', ~700 with [F814W]-K colors
- Analyzing CMDs to determine:
 - A_V , D_{TRGB} , SF age, SF history

Conclusions

- NIR LGSAO + HST/ACS is a powerful combination for high spatial resolution studies of extragalactic stellar populations, particularly for starburst regions with large A_v and ρ_{\star}
- Photometry with high precision and accuracy is achievable with LGSAO even on extragalactic objects