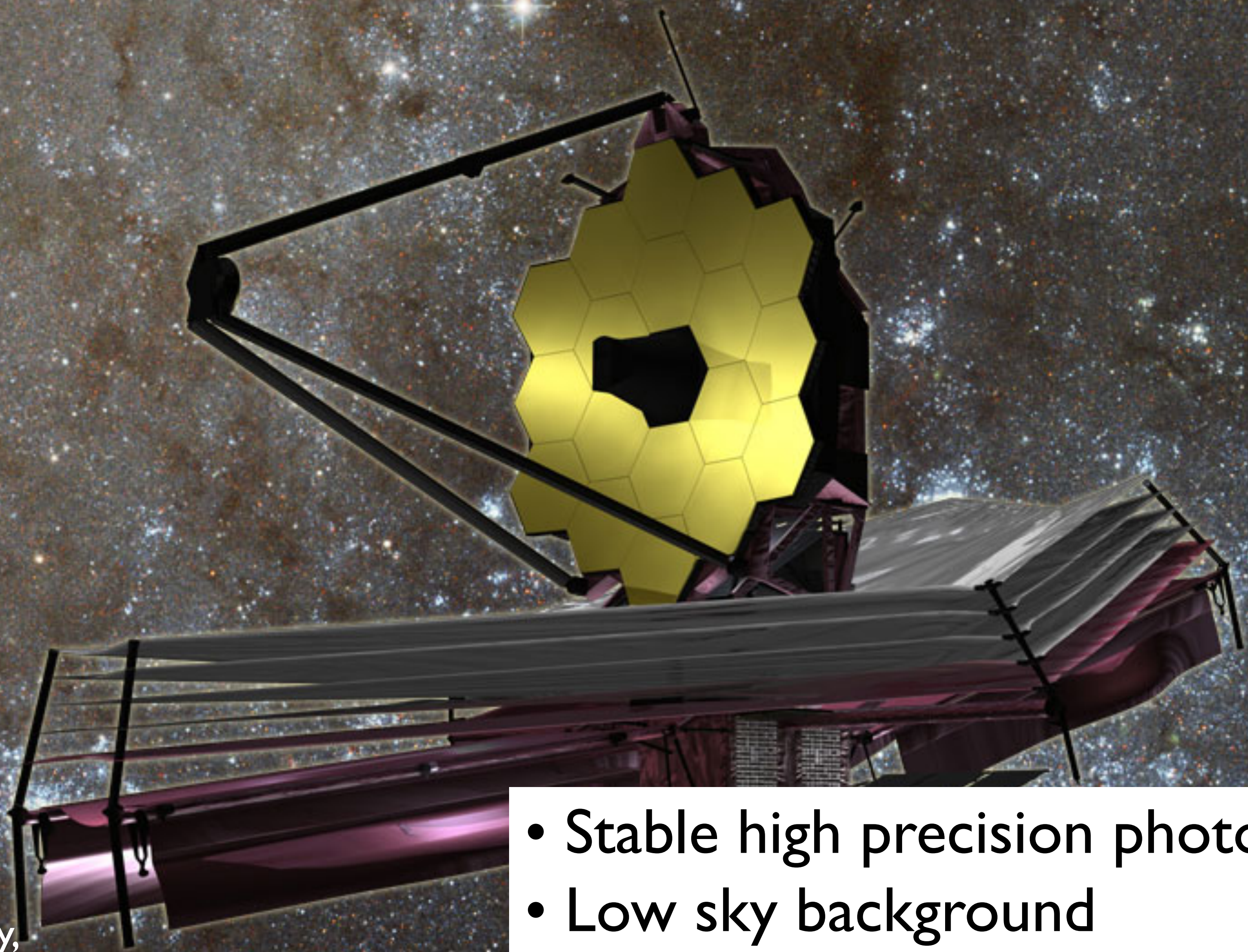
JWST for Resolved Stellar Populations

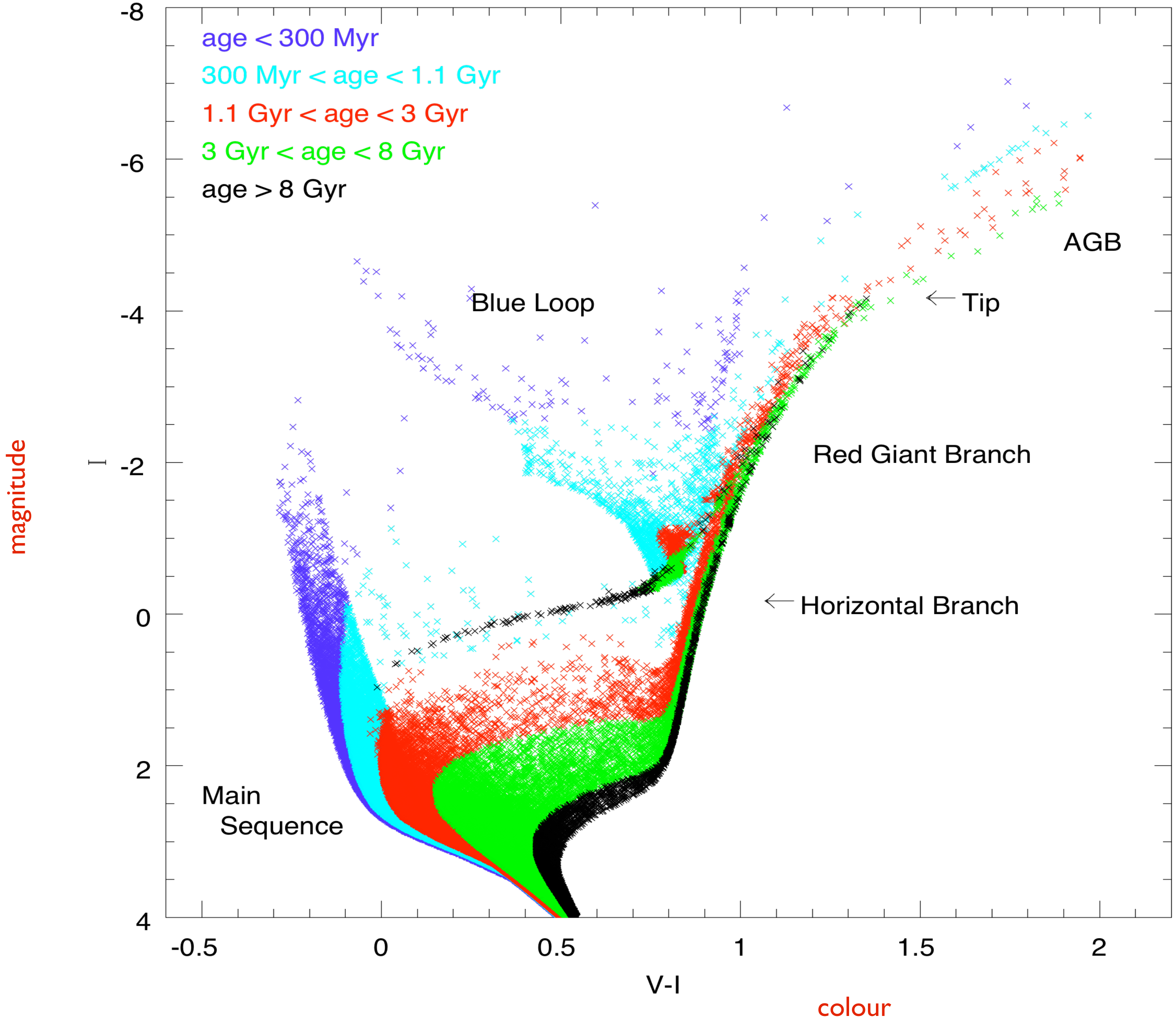
Resolved Stellar Populations in the near-infrared



- Stable high precision photometry
- Low sky background
- Exquisite and stable spatial resolution

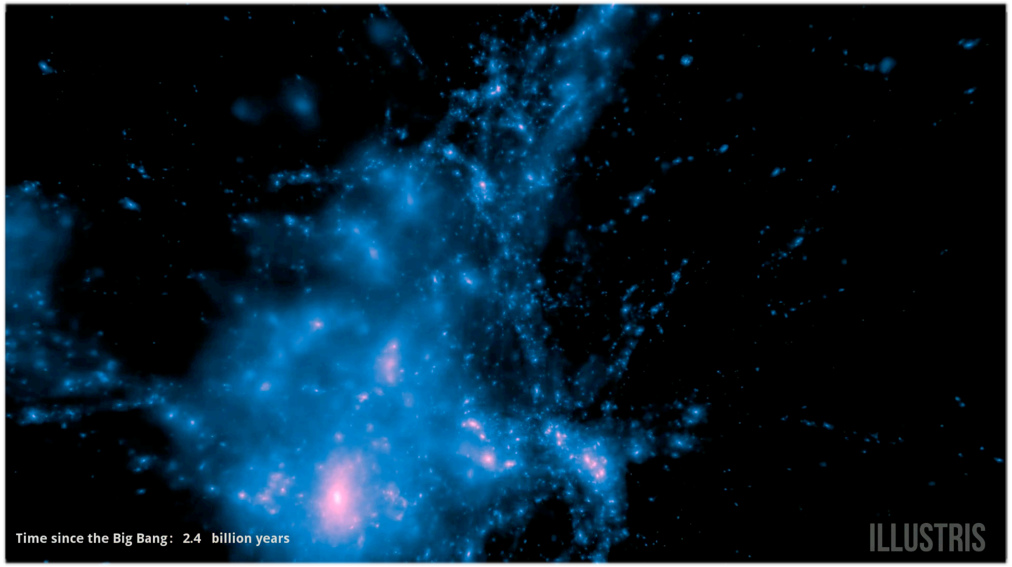
Eline Tolstoy,
Kapteyn Astronomical Institute,
University of Groningen

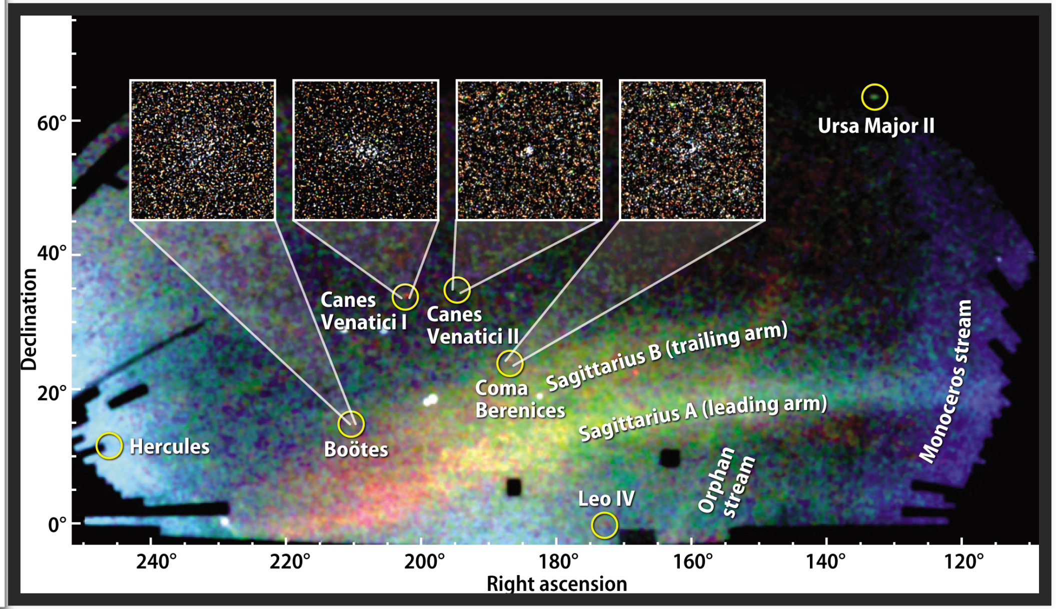
Colour-Magnitude Diagram Analysis



Tosi et al. 1991; Aparicio et al. 1996; Tolstoy & Saha 1996; Dolphin 1997, 2002; Hernandez et al. 2000; Ikuta & Arimoto 2002; Gallart et al. 2005; Cignoni & Tosi 2010; de Boer et al. 2012

High-Resolution Tests of Galaxy Formation Theories





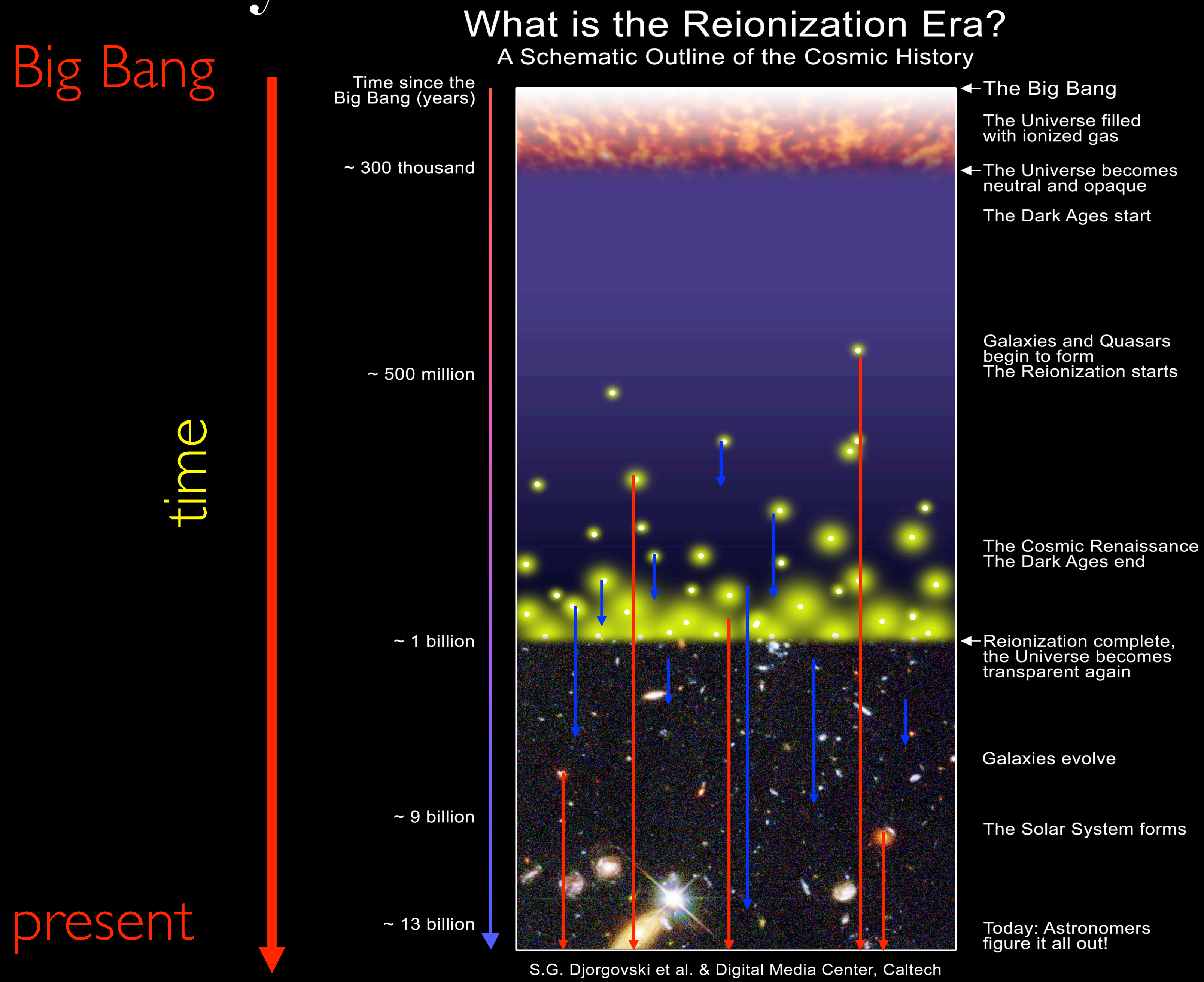
Belokurov et al. 2007

Outstanding Problems

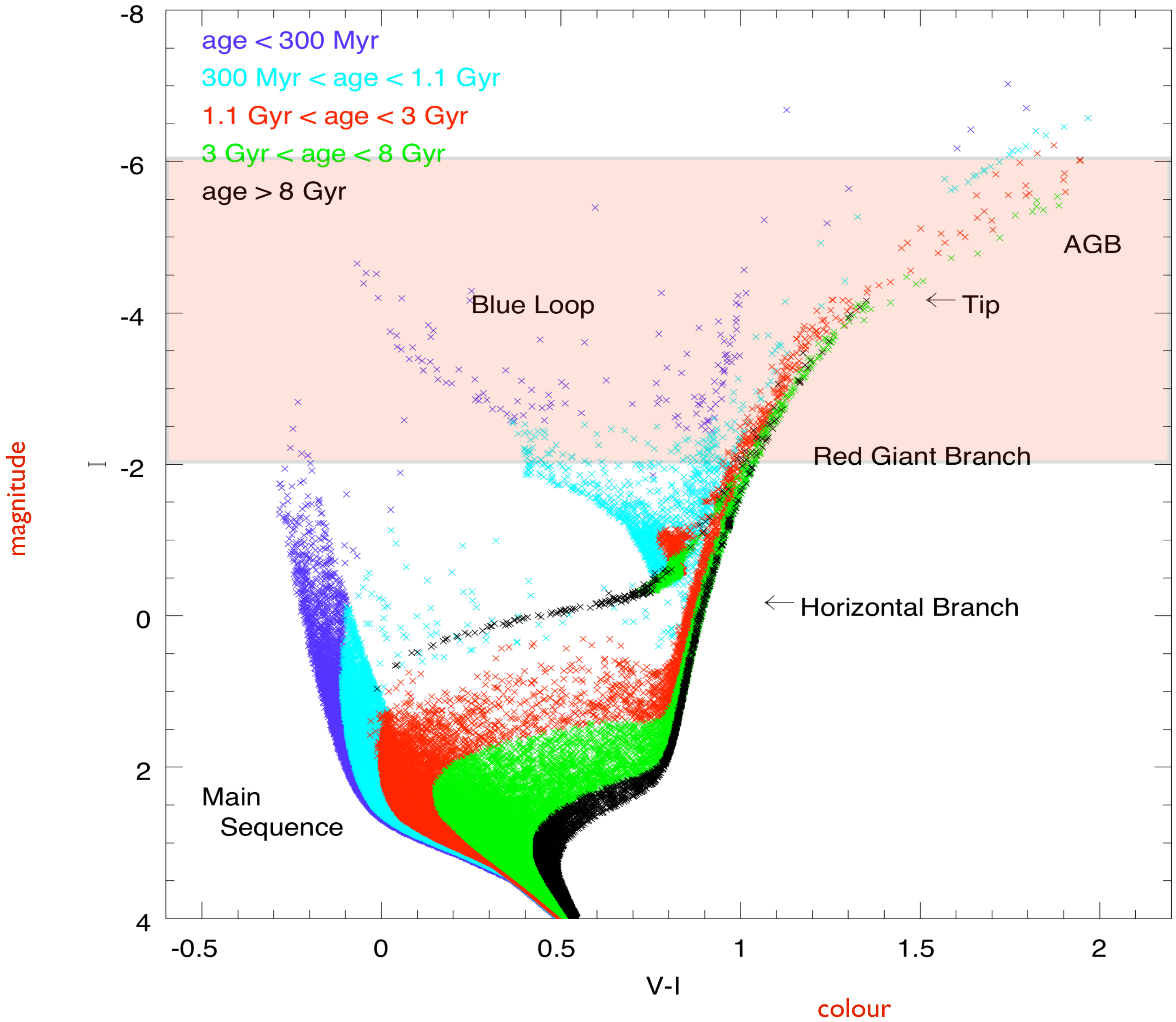
1.) Is the census of small satellites consistent with CDM predictions on galactic scales?
2.) Is there a low luminosity threshold for galaxy formation?
3.) Is the spatial distribution of dSphs (planar vs spherical) consistent with CDM?
4.) Can we test different DM models with 3D resolved velocities?
5.) Do sub-Gyr age measurements reveal any cosmologically-driven synchronization in the SFHs?

slide from Jason Kalirai (Project Scientist - James Webb Space Telescope)

Cosmic History



Colour-Magnitude Diagram Analysis



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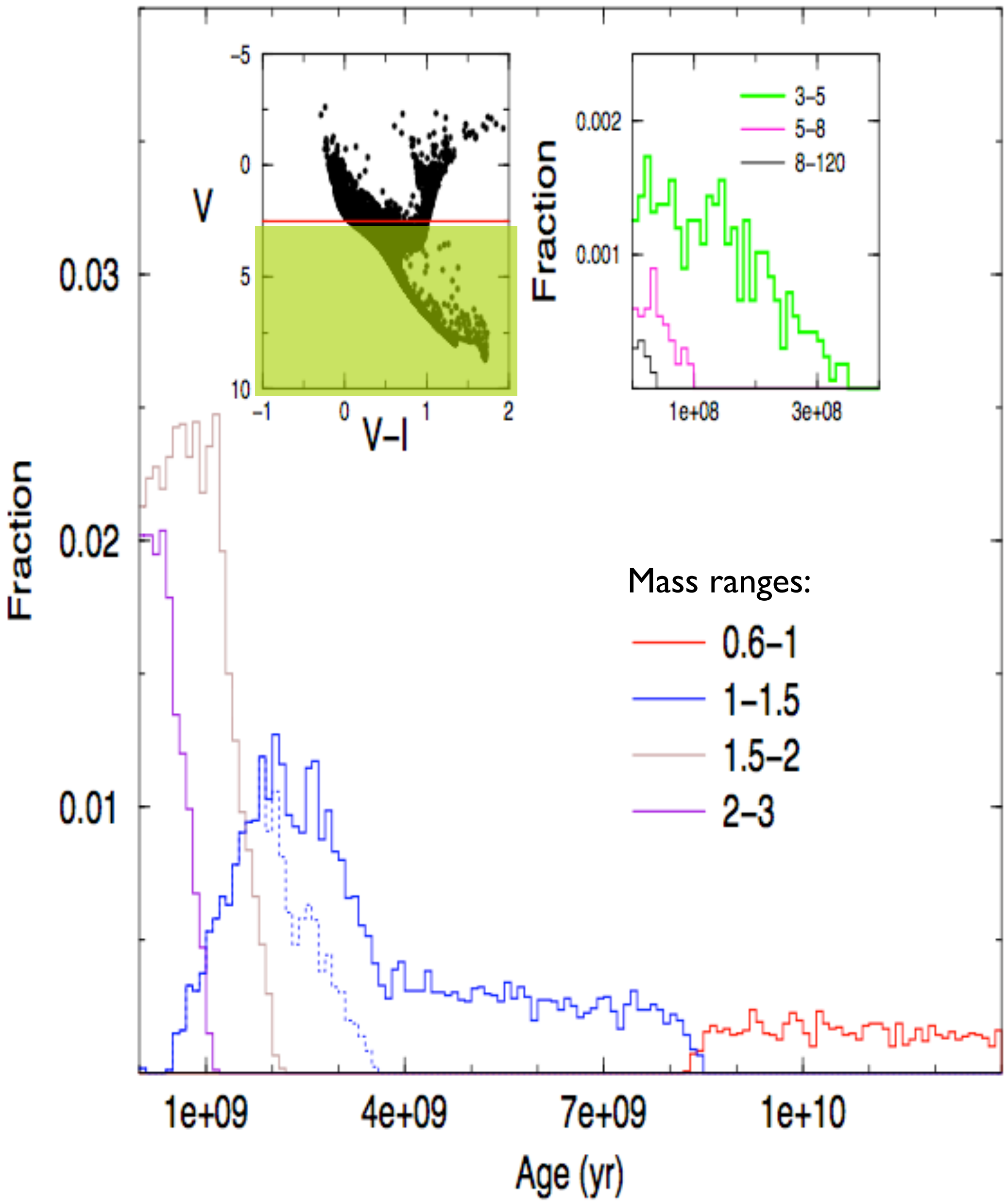
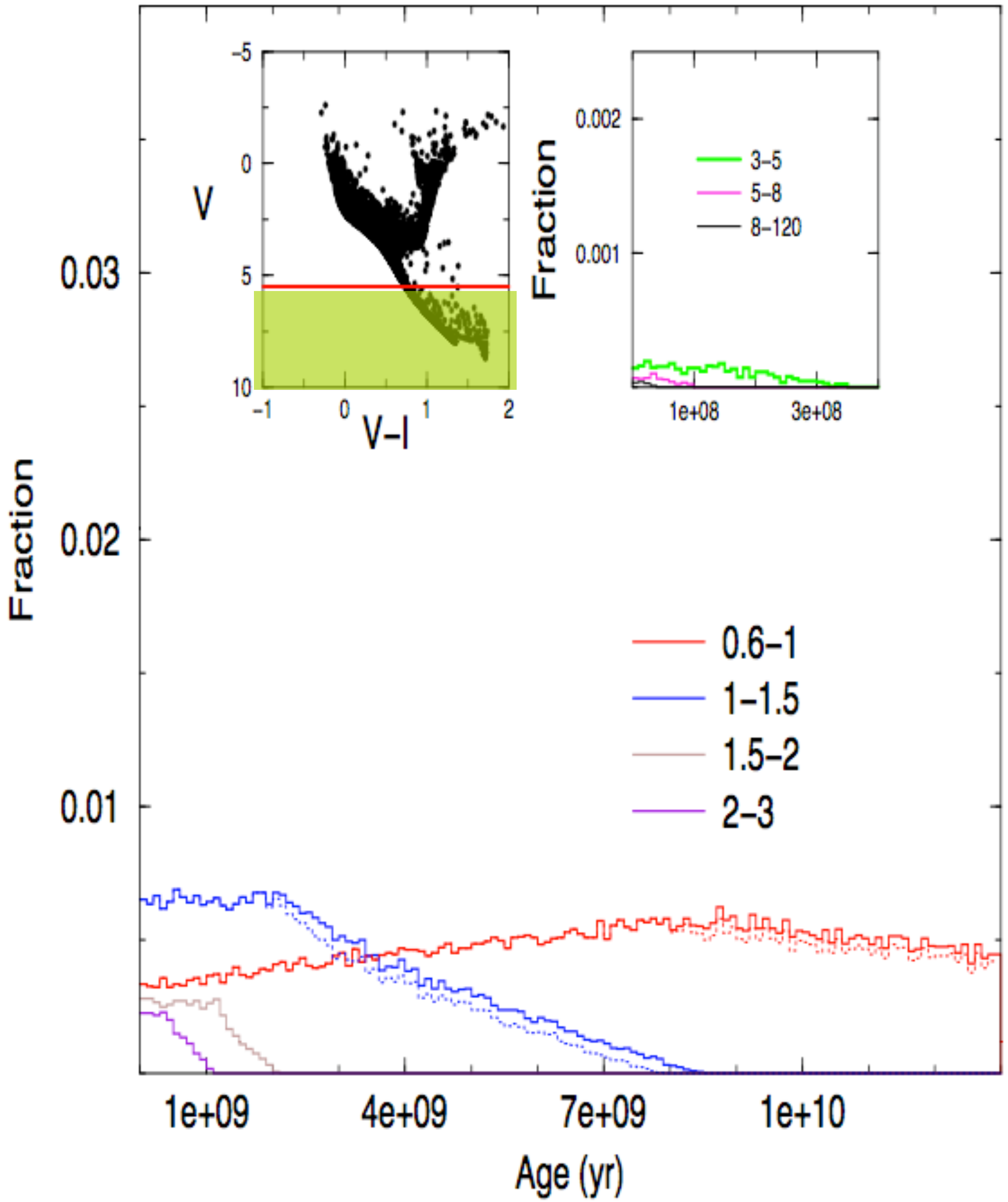
Age Sensitivity

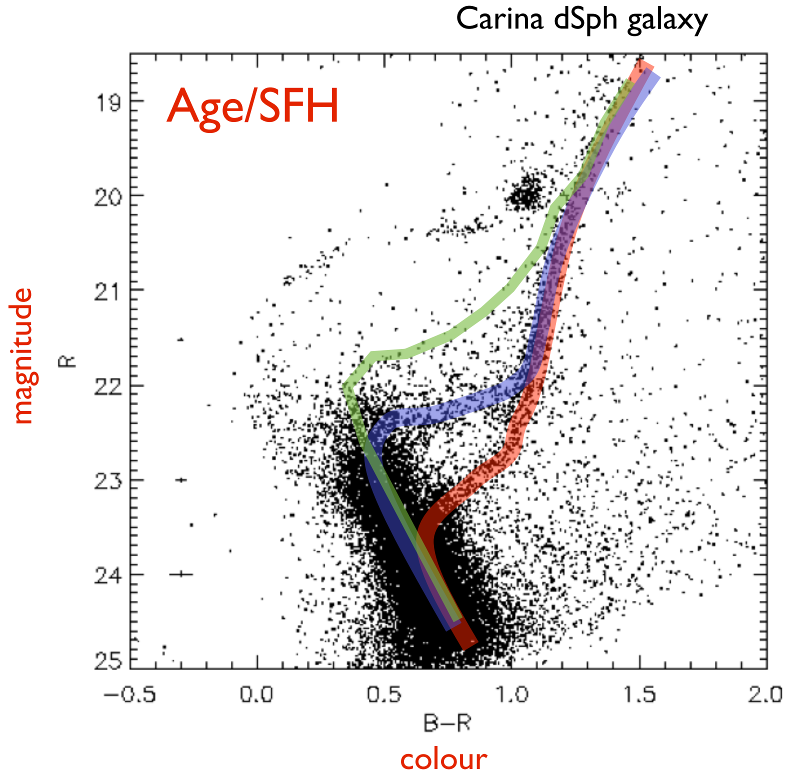


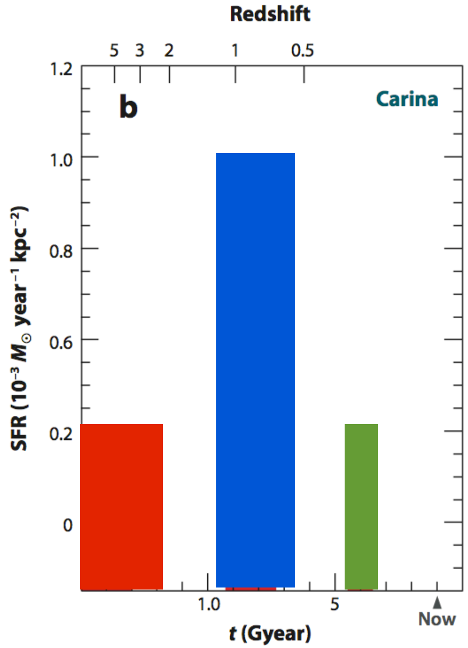
Assuming constant SFR over 13Gyr



Cignoni & Tosi 2010, *Advances in Astronomy, pp.1-26*

Complex (Old) Stellar Populations





Different filter combinations

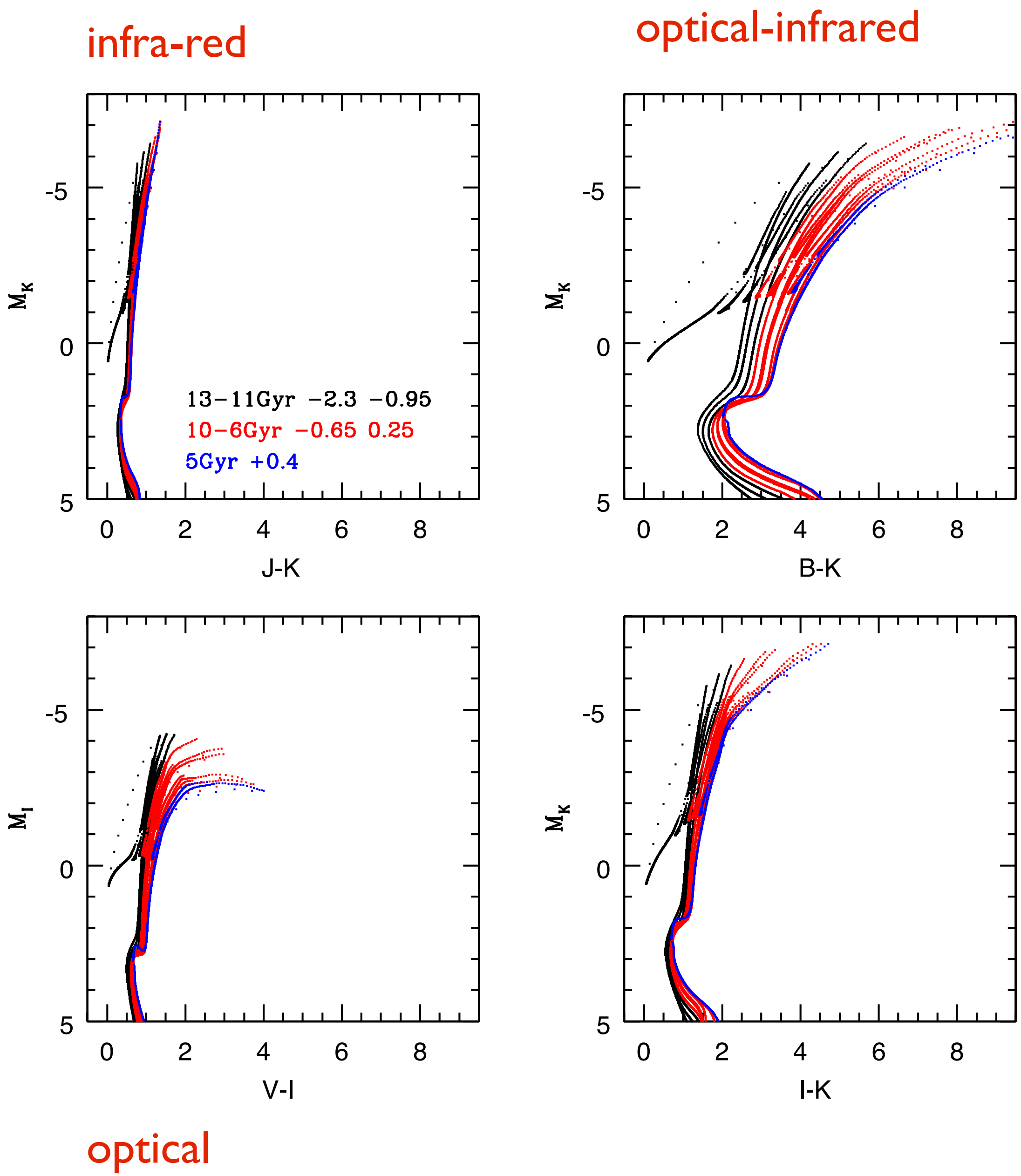
Teramo isochrones

NGC3379 m-M= 30.   (10Mpc)

M81/Scl m-M= 27.7   (3.5Mpc)

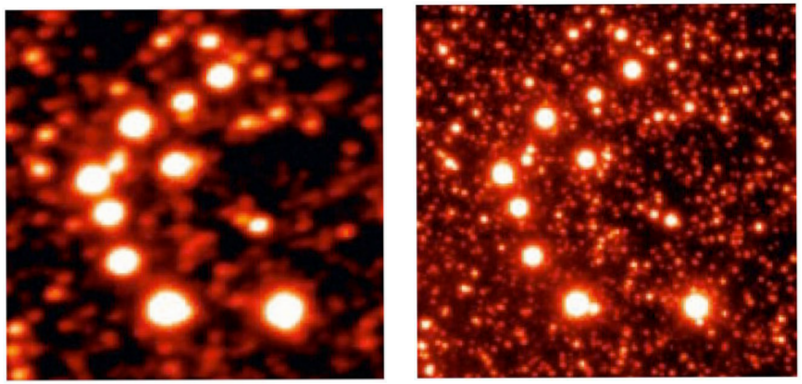
ngc55 m-M= 26.3   (1.8Mpc)

M31   m-M= 25.   (1Mpc)



Resolution AND Sensitivity

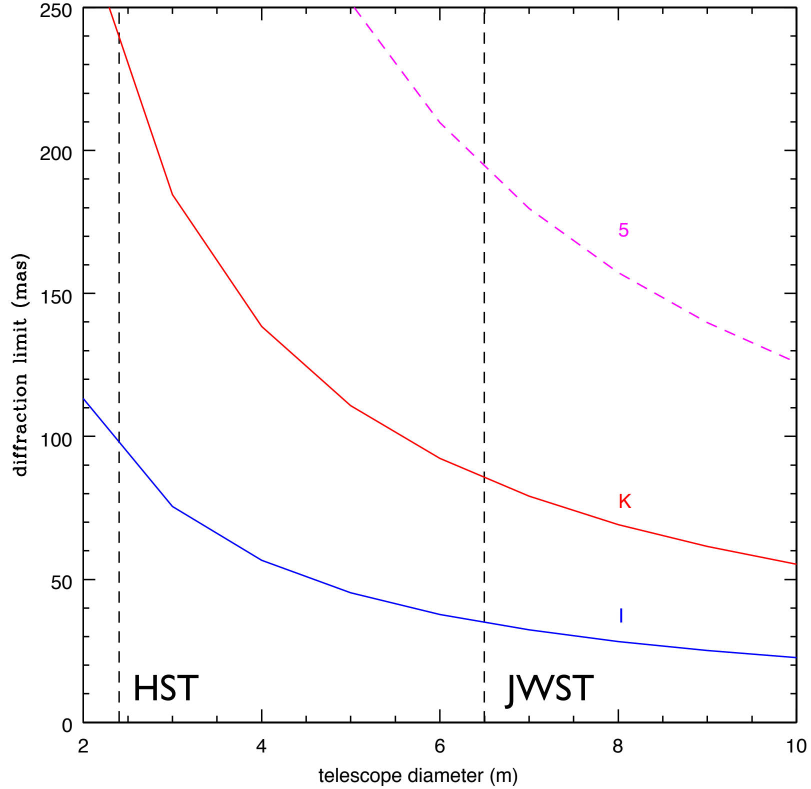
VLT/ISAAC (K) VLT/MAD (K) 20x20arcsec



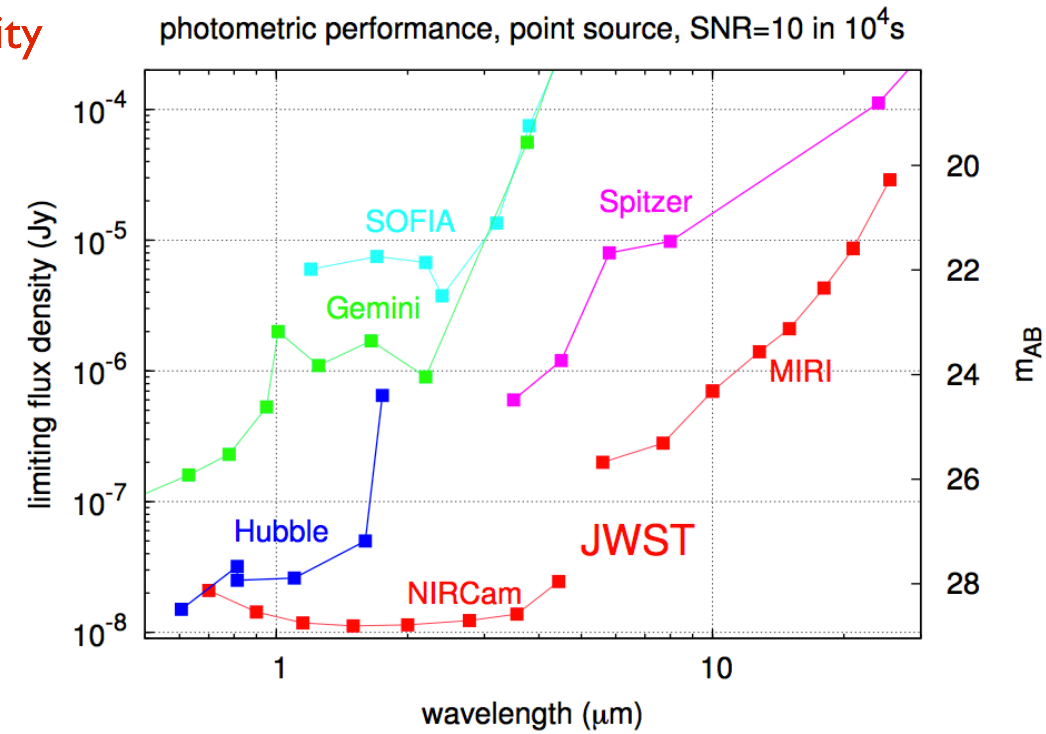
0.6arcsec <0.1arcsec

Omega-Cen (Marchetti et al. 07 ESO Messenger)

Diffraction Limit



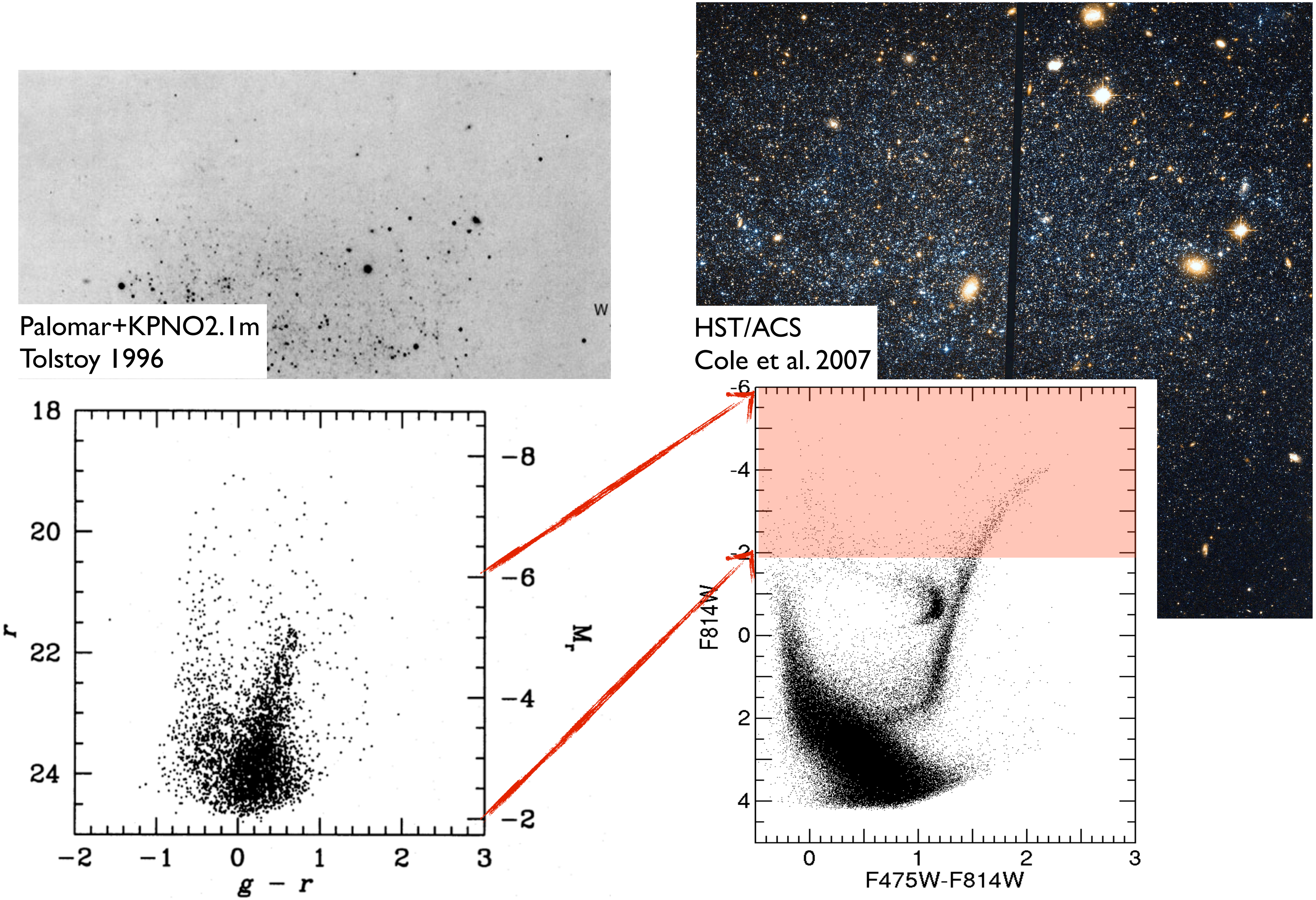
Sensitivity



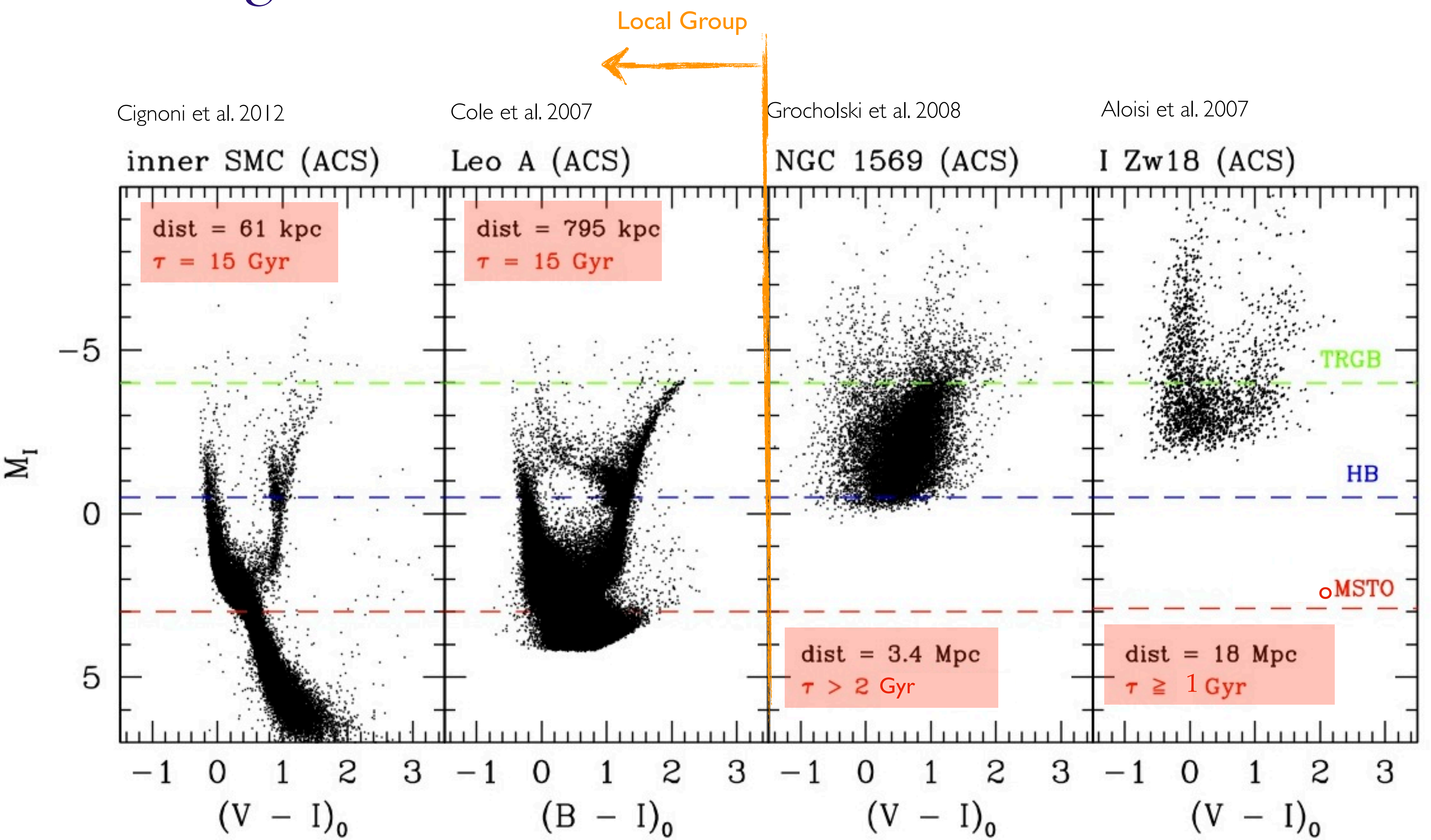
I=AB-0.45
J=AB-0.9
H=AB-1.4
K=AB-1.9

Resolution AND Sensitivity

Need high spatial resolution, accurate photometry and flux sensitivity to accurately measure the colours and magnitudes of faint resolved stellar populations

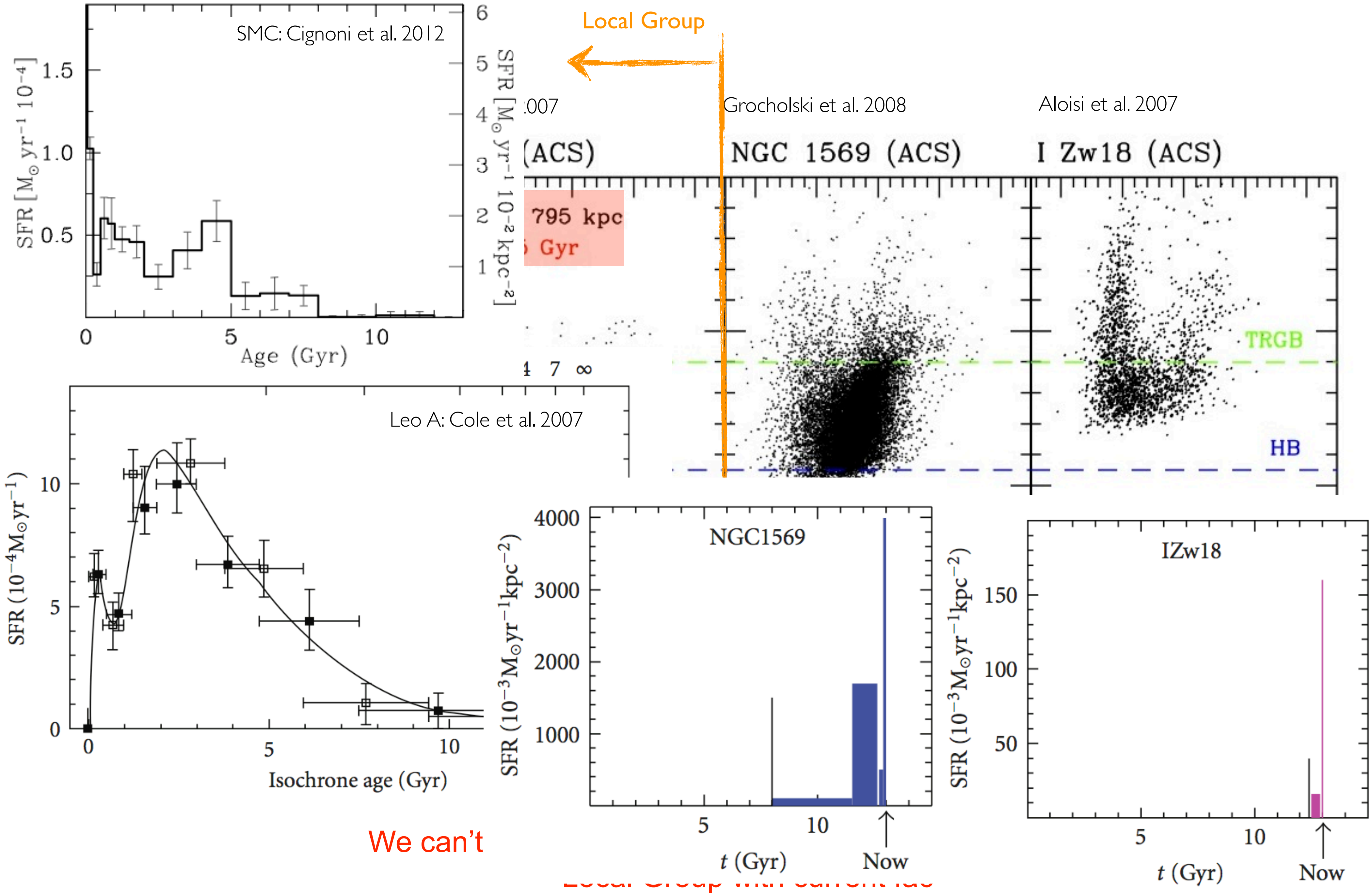


Probing Different Environments



We can't study all galaxies with the same detail and beyond the Local Group with current facilities.

Probing Different Environments

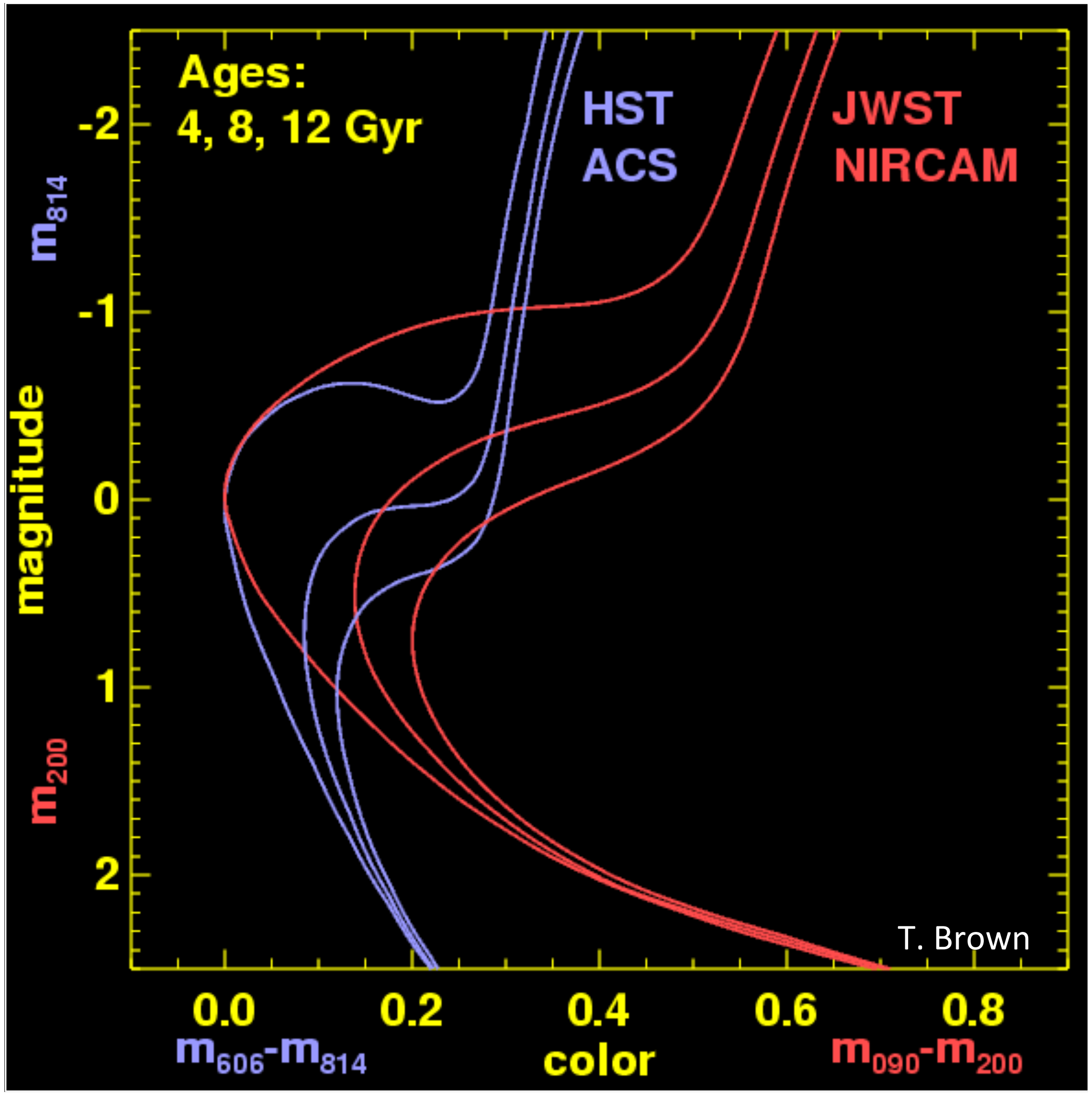


We can't

Resolved Stellar Populations in the Near IR

Main-Sequence Turnoff Fitting

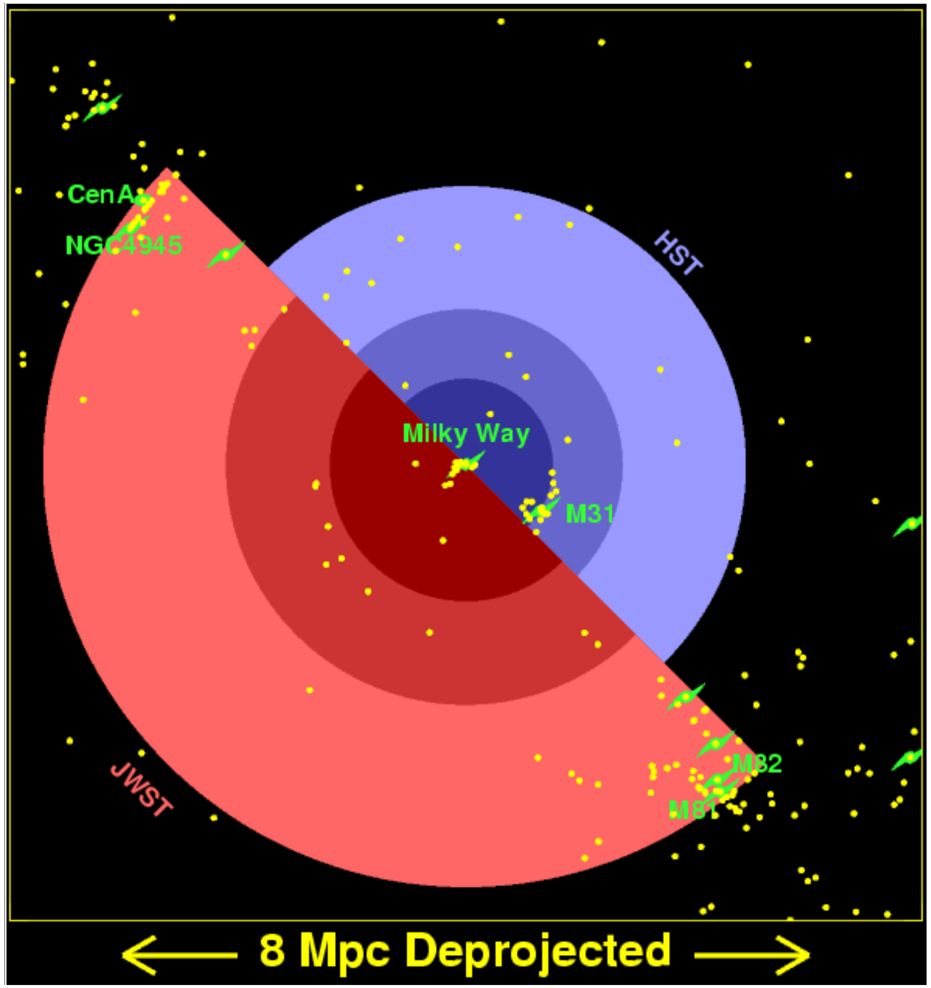
JWST Offers:
- Well separated filters in λ.
- Superb sensitivity.
- Larger field of view.
- Diffraction limited.



→ Transform current optical survey to panchromatic study.
→ Calibration and tests of stellar evolution models into the IR.
→ More sensitive mapping of star formation spreads.

slide from Jason Kalirai (Project Scientist - James Webb Space Telescope)

Increasing Survey Area with JWST



from Brown et al. 2008 White Paper on Studying Resolved Stellar Populations with JWST

The volume of space that can be surveyed in10, 100, and 1000 hrs reaching 0.5 mag below the Main Sequence turnoff in a 12 Gyr old population.

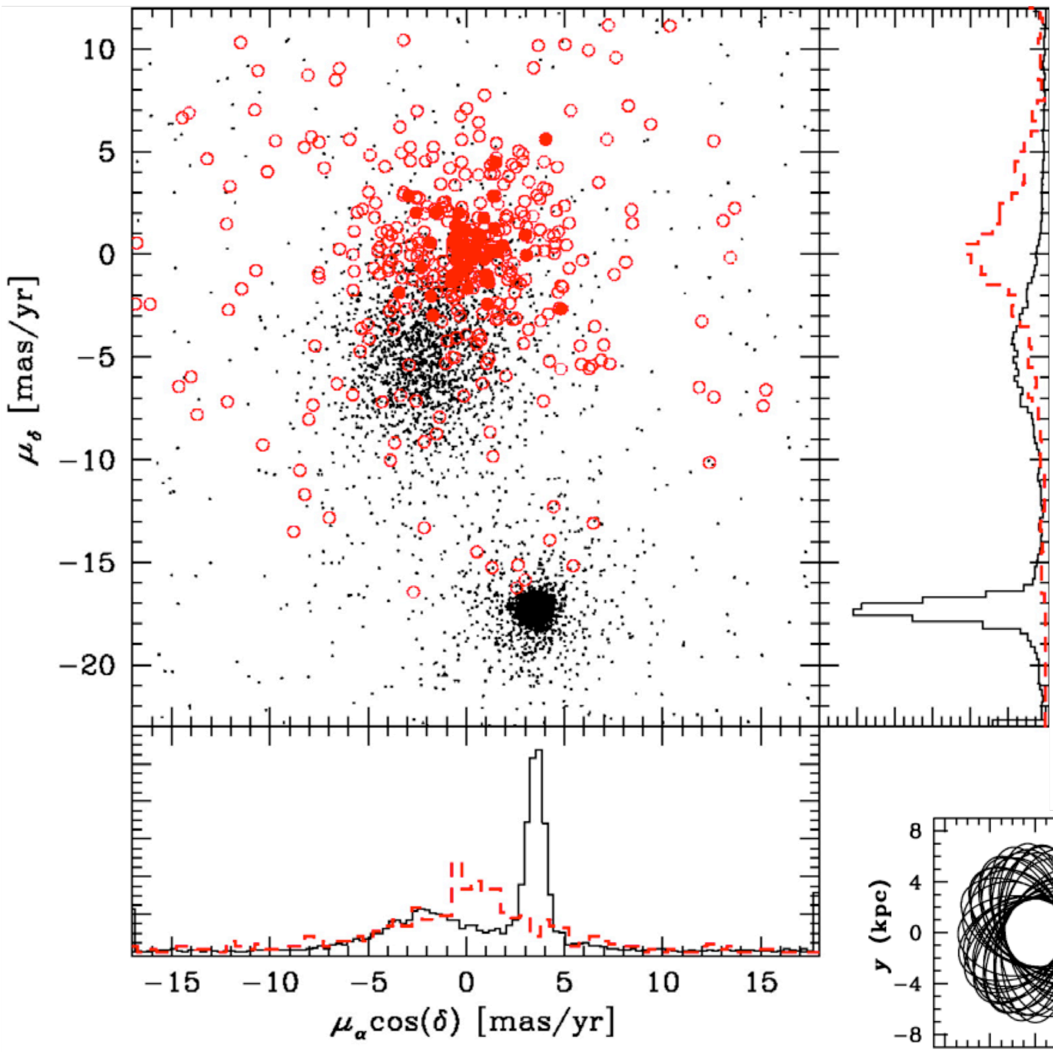
1 Mpc, m-M=25 oMSTO~29; HB~24.7

1.7 Mpc, m-M=26.1 oMSTO~30.1; HB~25.8

4 Mpc, m-M=28 oMSTO~32; HB~27.7

Object	$(m-M)_0$	θ(1 pc)
LMC	18.5	4"
M31	24.3	0.3"
Sculptor Group	26.5	0.1"
M81/82	27.8	0.06"
Cen A	28.5	0.04"
Leo Group	30.0	0.02"
Virgo Cluster	31.2	12 mas
Fornax cluster	32.0	11 mas
50Mpc	33.5	4 mas
Arp220	34.5	2 mas
Perseus Cluster	34.5	2 mas
Stephan's Quintet	35.0	2 mas
Coma Cluster	35.0	2 mas
Redshift z~0.1	38.5	0.5mas
Redshift z~0.3	41	0.2mas

Proper Motions of Stellar Systems



NGC6397

red: galaxies

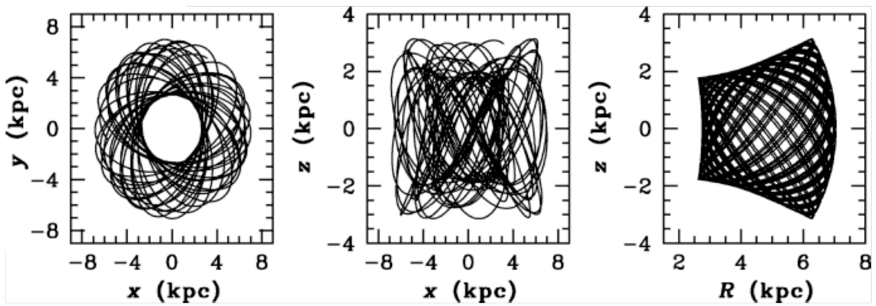
black: field stars & cluster members

10 years of HST data:

$\mu_\alpha \cos\delta = 3.56 \pm 0.04$ mas yr^{-1}

$\mu_\delta = -17.34 \pm 0.04$ mas yr^{-1}

- provides orbit around Milky Way
- frequent passages through the disk



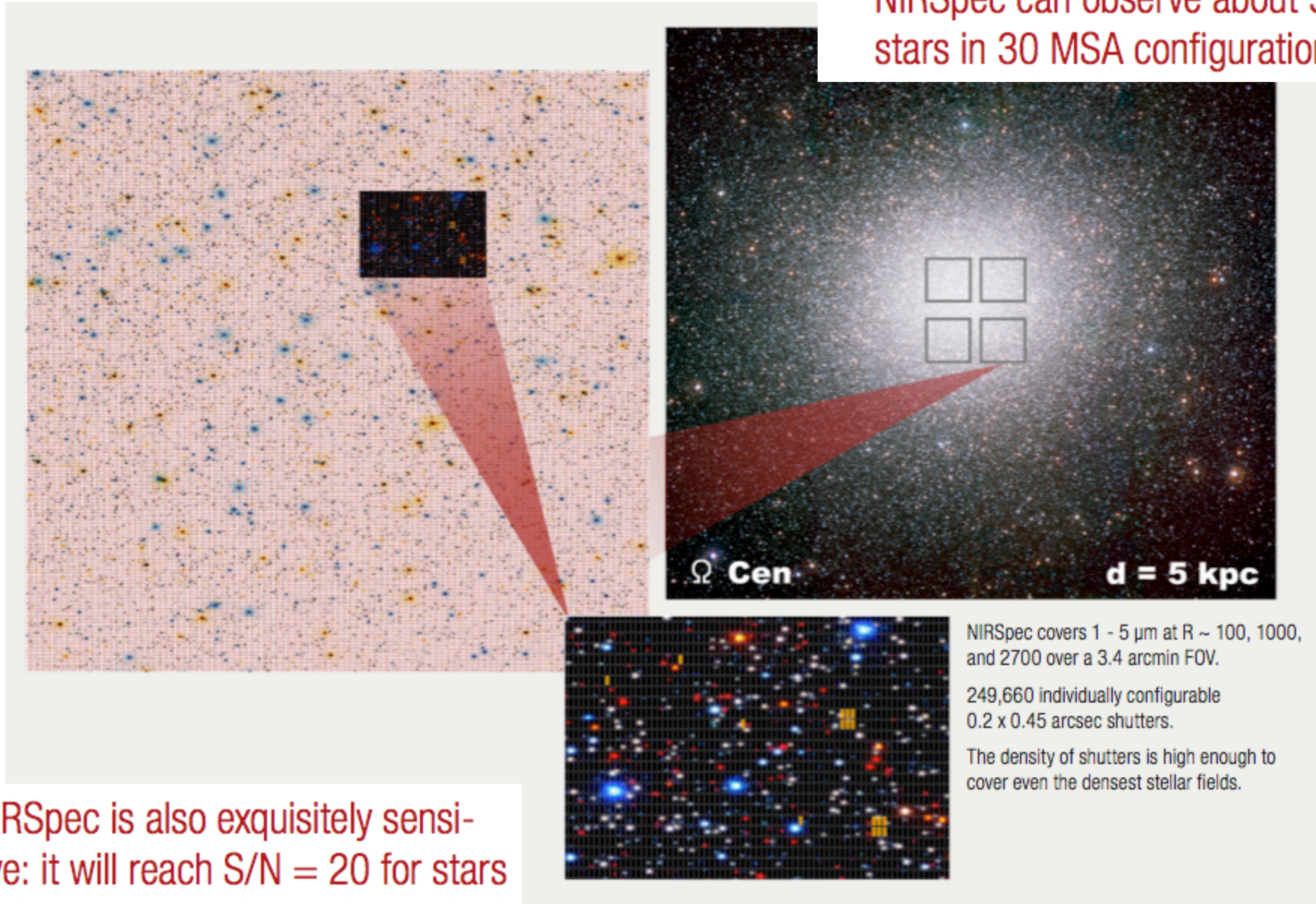
Kalirai et al. 2007 ApJL, 657, L93

Resolved Stellar Systems

Simulation of Omega Centauri
credit: NASA, ESA & J. Anderson (STScI)

Spectroscopy with JWST

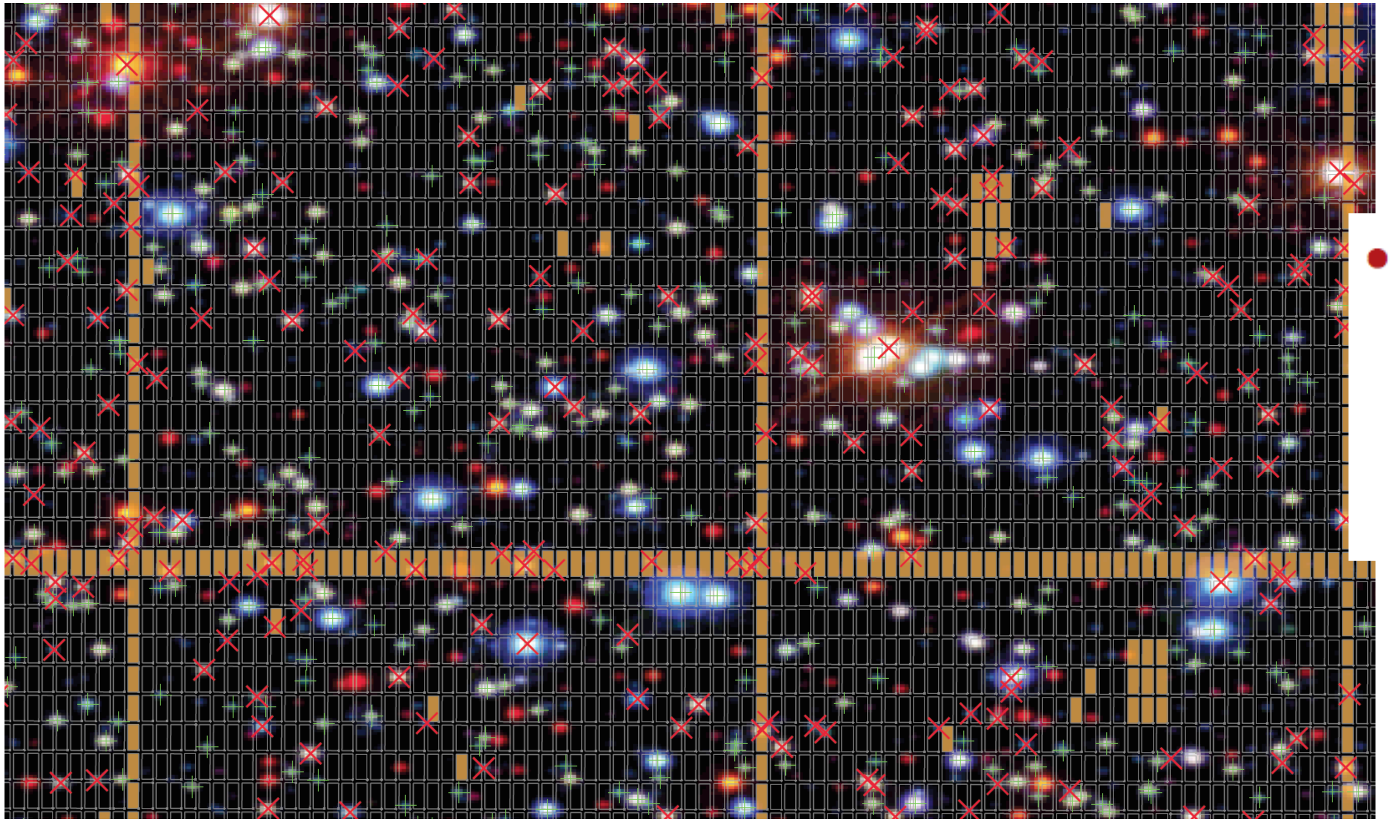
- In this particular Ω Cen pointing, NIRSpec can observe about 5000 stars in 30 MSA configurations.



- NIRSpec is also exquisitely sensitive: it will reach S/N = 20 for stars at J = 20 in 15 minutes for each of the three bands covering 1 - 5 μm.

NASA's James Webb Space Telescope Highlight

Spectroscopy with JWST



NIRSpec MSA in Dense Stellar Fields
Jason Tumlinson & Jay Anderson

- NIRSpec can work effectively in fields where there are up to 1 star for every 3-5 shutters, such as globular clusters or the Galactic bulge.

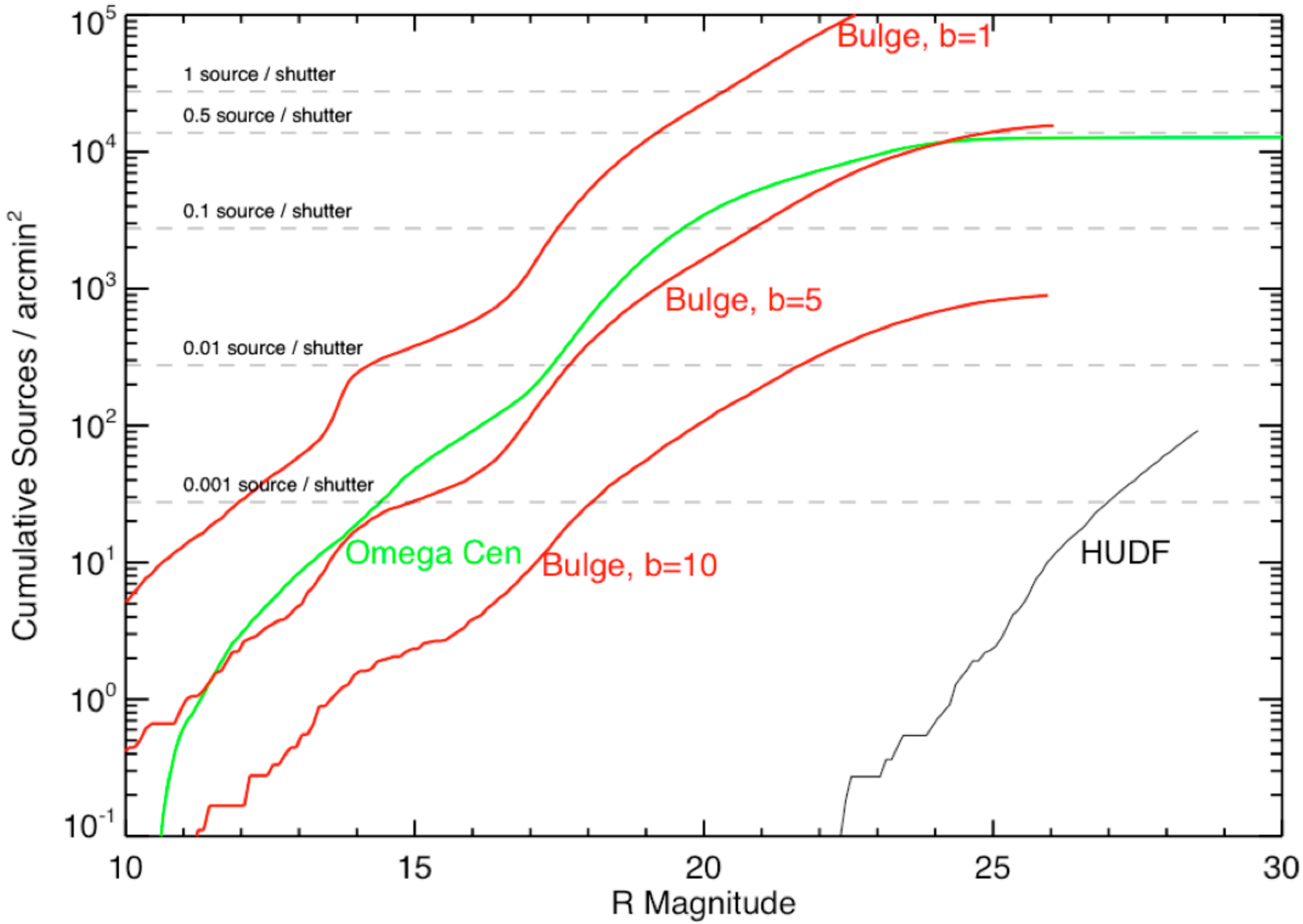
+ Targets in operable shutter
x Targets outside shutters

- NIRSpec will be extremely effective at obtaining large statistical samples of stellar spectra in dense fields (~200 objects at one go is possible).
- Very efficient because it can be done by reconfiguring the MSA only, without dithering. Sky background is obtained "for free". Observer decides which shutters to open and close.
- This technique could be employed in globular clusters, star forming regions, the Galactic disk, and the bulge.

slide from Jason Kalirai (Project Scientist - James Webb Space Telescope)

Spectroscopy with JWST

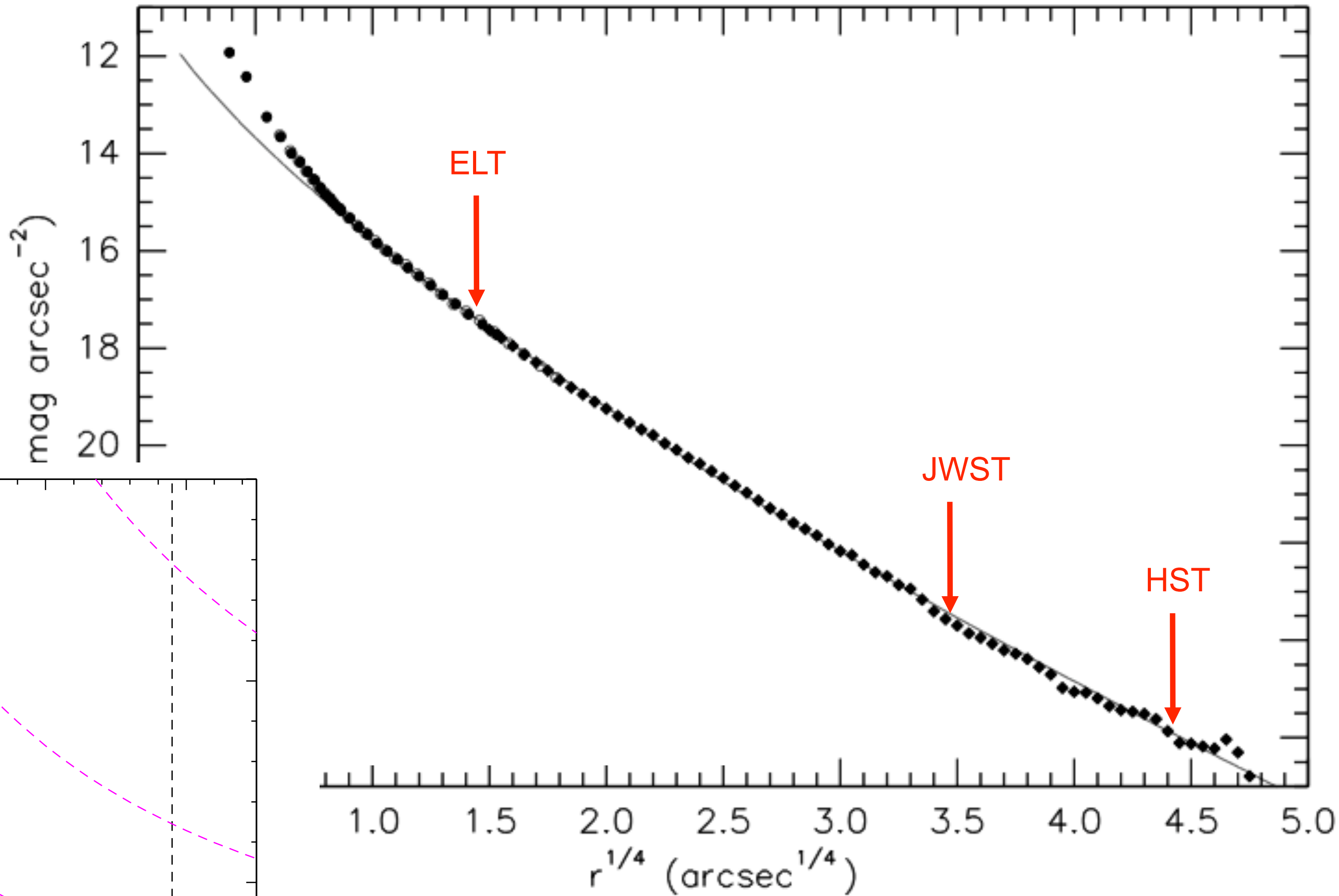
Tumlinson, JWST Technical Report, 2010

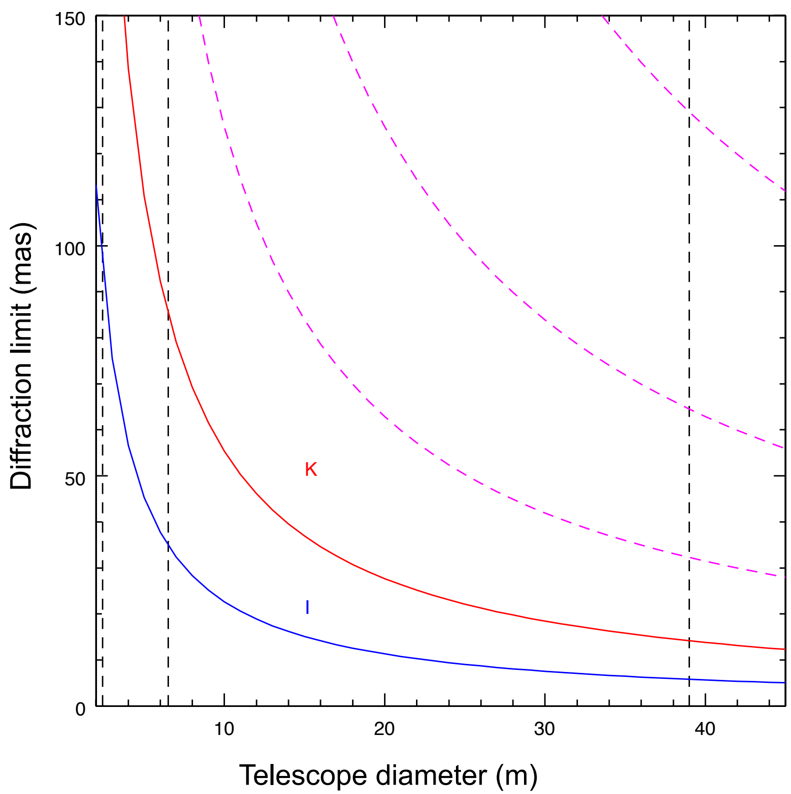


Cumulative density of sources versus R magnitude for Omega Cen and J magnitude for the Milky Way bulge at three Galactic latitudes. The MSTO for Omega Cen lies at R~18, for the bulge at J~19. NIRSpec will easily reach below the turnoff in both cases.

Resolving the RGB

An Elliptical Galaxy in Virgo...





Resolved stellar populations anchor our knowledge of the Universe

JWST Characteristics

1.) Superb sensitivity at near-infrared wavelengths.
2.) Multiple imaging and spectroscopic modes with fine sampling.
3.) High spatial resolution.
4.) Relatively large fields of view.

Synergy with other facilities

1.) Extremely large telescopes (E-ELT, TMT, GMT)
2.) Upcoming large surveys (EUCLID, LSST)
3.) HST will hopefully still be around.

adapted slide from Jason Kalirai (Project Scientist - James Webb Space Telescope)