Resolving the Milky Way with WFIRST

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A View of ~~Galaxies in the Universe~~ Stellar Populations

Timescale of Stellar Evolution

The Color-Magnitude Relation

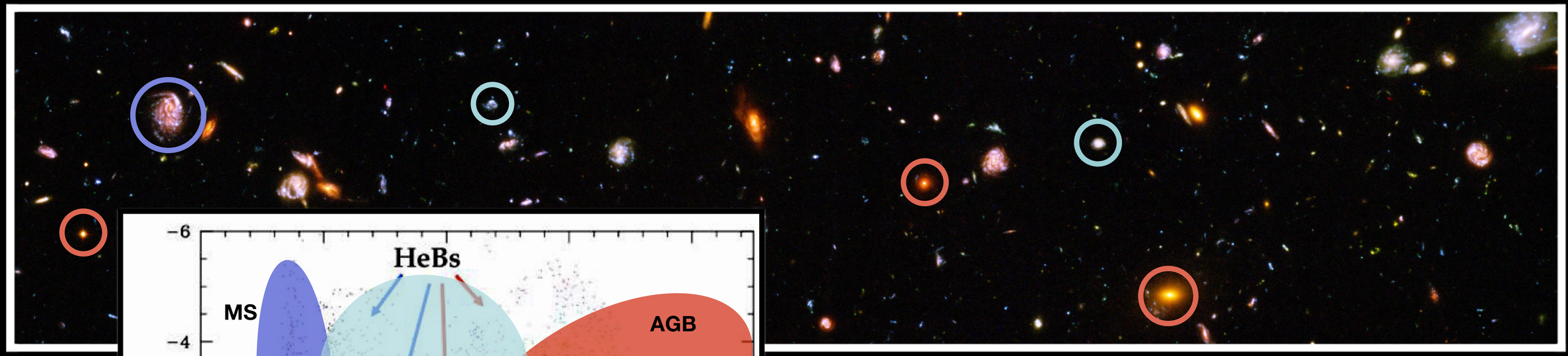
The Initial Mass Function of Stars

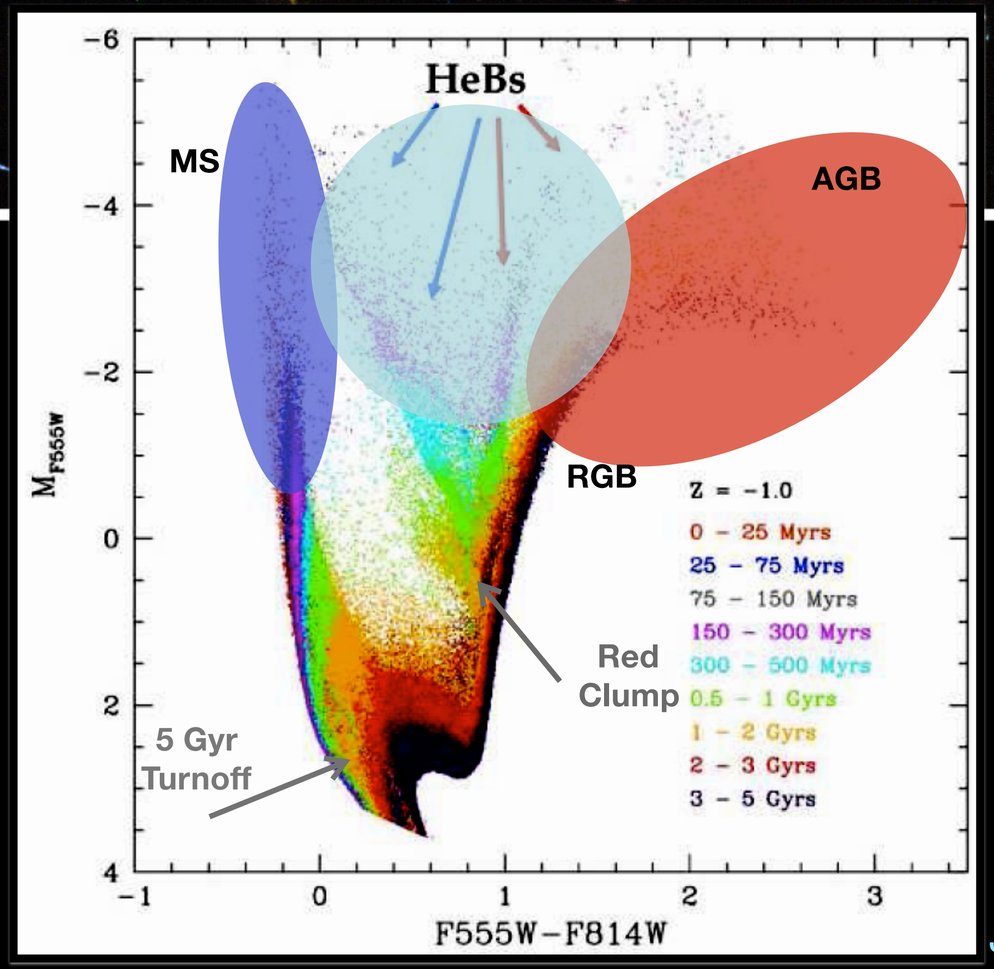
Archaeology of Galaxies

Timing of Mass Loss and Feedback

Star Formation

A View of Stellar Populations

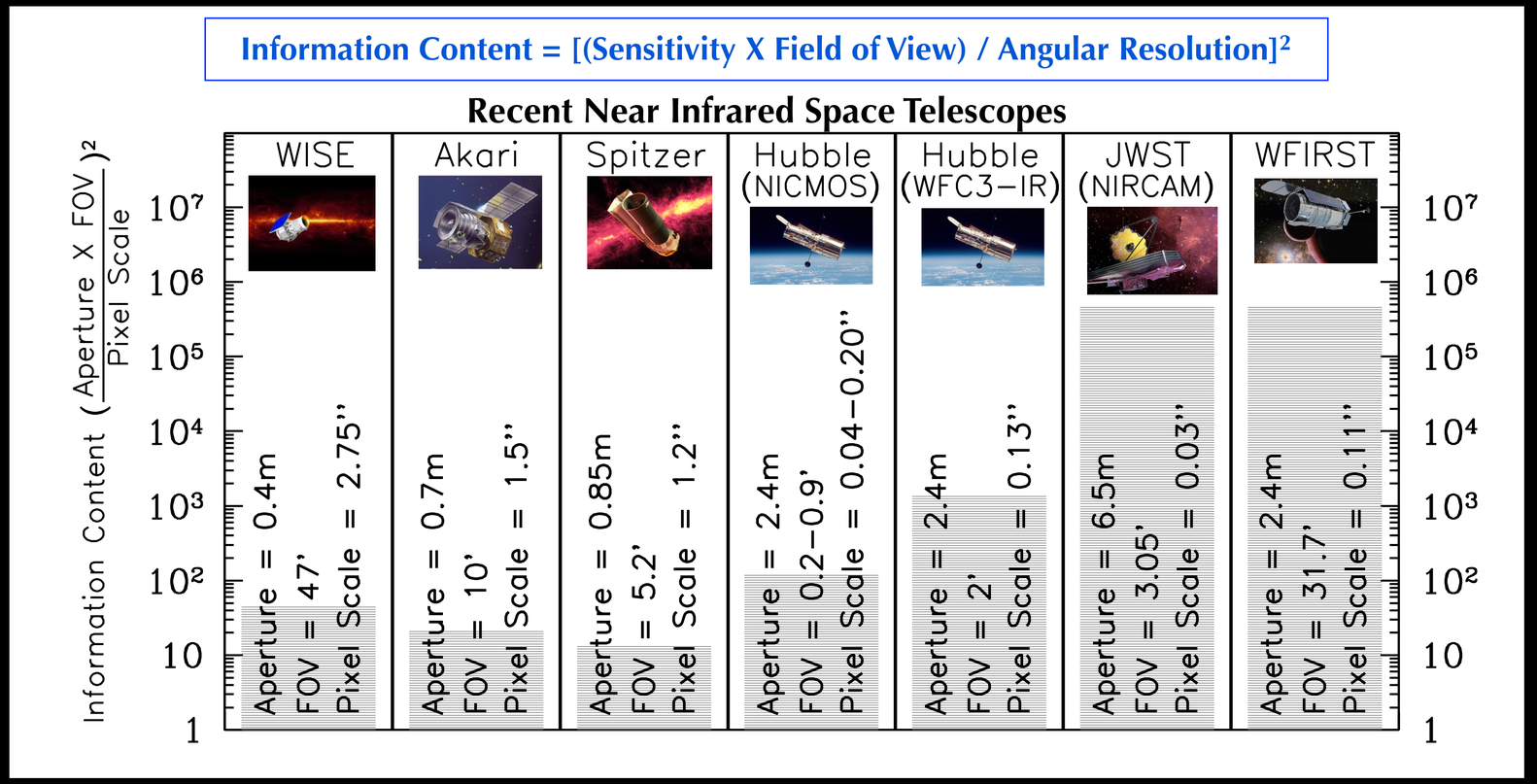




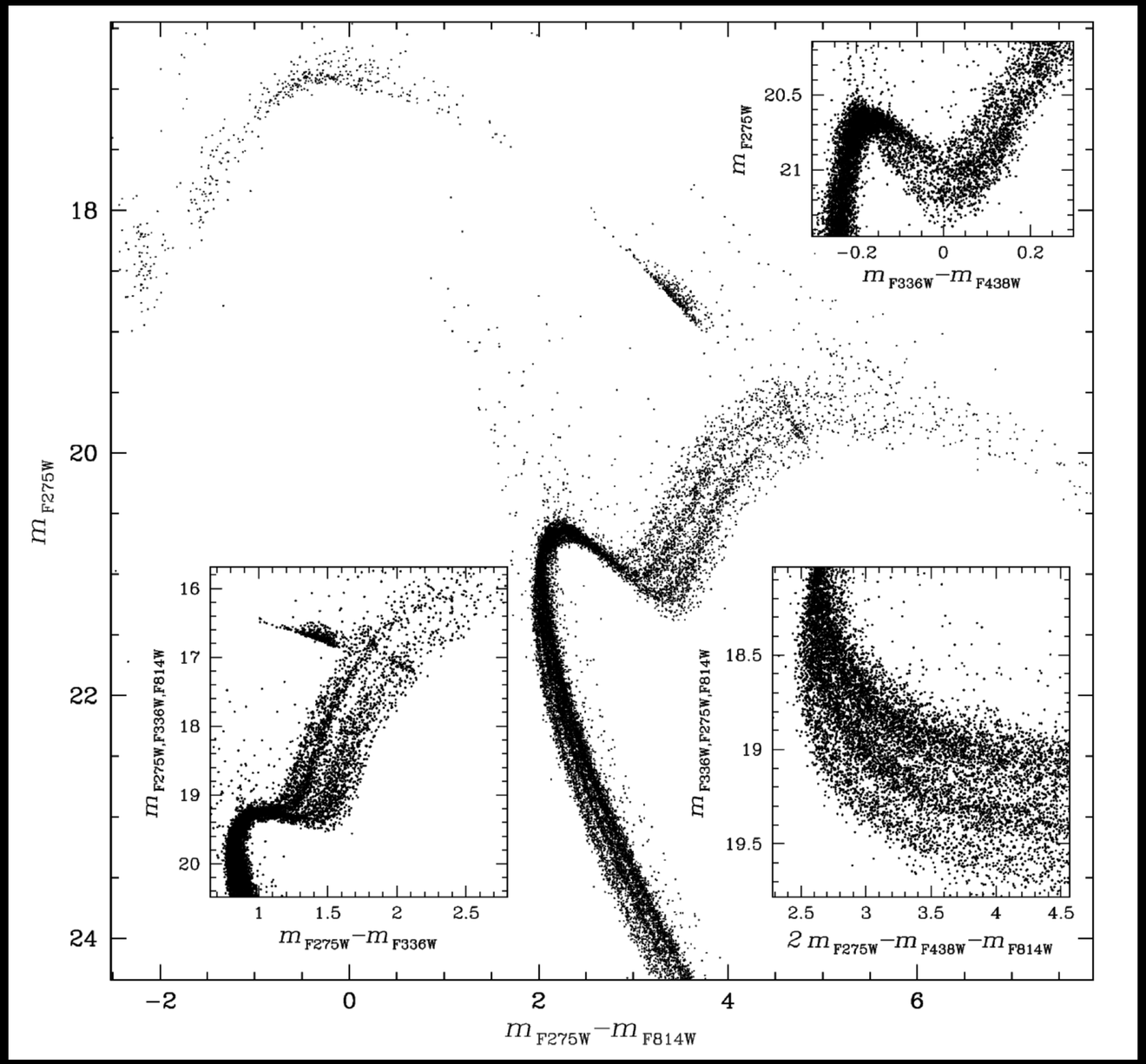
J. Dalcanton (2010, priv comm.)

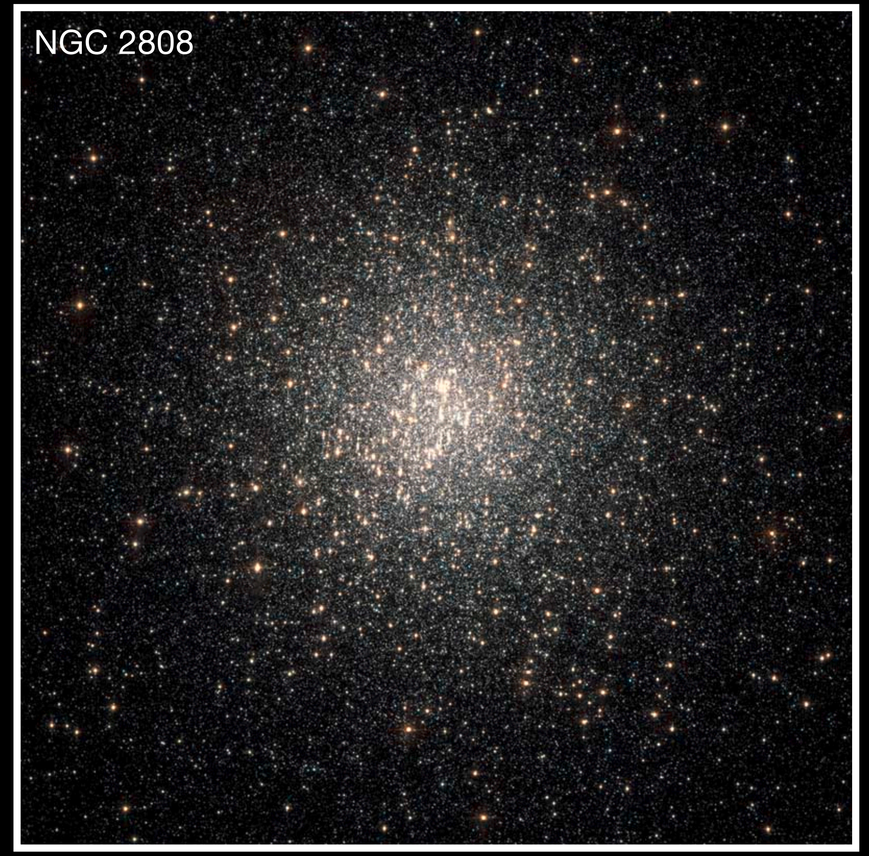
Three Components to Our Milky Way Program

Information Content = [(Sensitivity X Field of View) / Angular Resolution]^2



The Importance of High-Precision Photometry





Milone et al. (2015)
Piotto et al. (2015)

Milky Way Populations: From Visible to the Infrared

Science Opportunities

1.) S T R E T C H the CMD to measure more accurate fundamental properties
2.) Measure and calibrate the IR color-magnitude and mass-luminosity relations
3.) Establish (cosmologically interesting) sub-Gyr ages for Milky Way populations
4.) Leverage GAIA to map general Milky Way sight lines into co-spatial populations

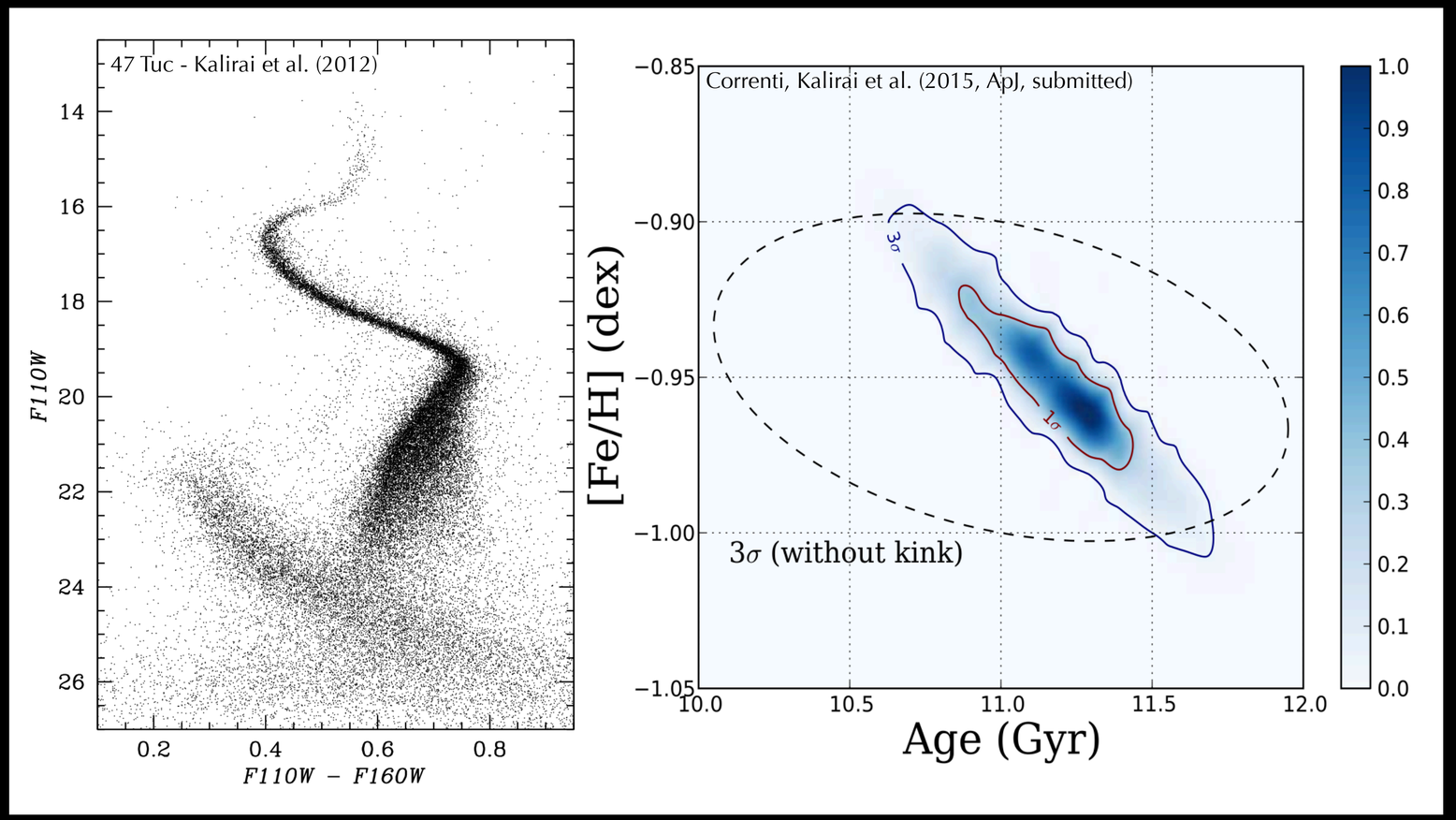
What WFIRST Brings to the Table

1.) Superb sensitivity at near-IR wavelengths
2.) High resolution imaging
3.) Wide field of view

Measuring and Applying the IR Color Magnitude Relation

Cospatial Populations in the Milky Way

- ★ 10,000s integrations with WFIRST will measure M dwarfs out to the edge of the Milky Way
- ★ Modeling stellar populations on this IR plane will yield sub-Gyr ages
- ★ Best constraints to date on when baryonic structure formation began in the Universe
- ★ The IMF down to below the H burning limit, and its variation with environment
- ★ Broad applications from the first calibration of the color-magnitude relation in the IR
- ★ Add new insights on early cluster formation and bring new IR diagnostics to multiple population scenarios



WFIRST Stellar Models

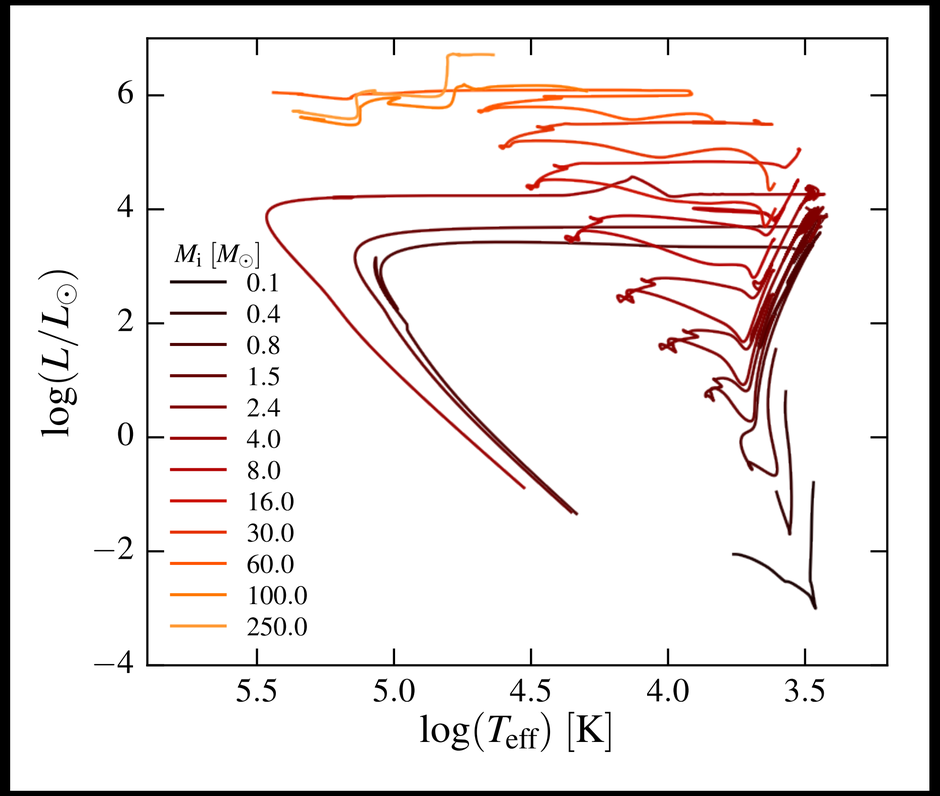
MIST
MESA

MIST - MESA Isochrones and Stellar Tracks (Choi et al. 2016)

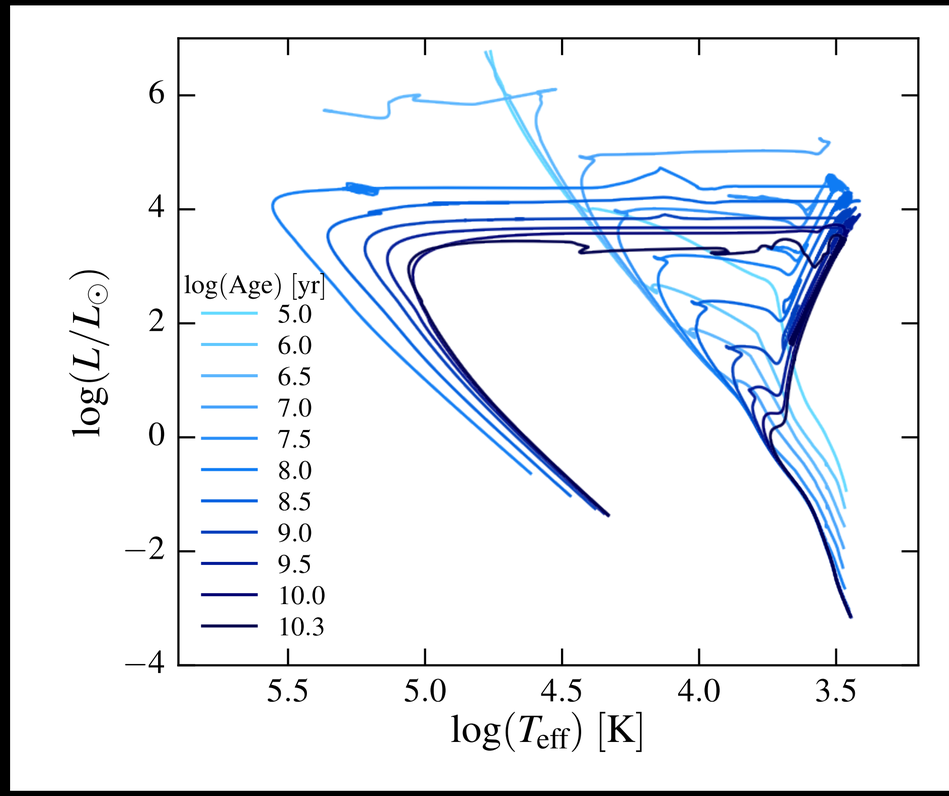
- ★ Stellar evolution models computed using MESA (Paxton et al. 2011; 2013; 2015)
- ★ Open source software
- ★ Continuous evolution through challenging phases (e.g., He core flash)
- ★ Parallelization = possible to produce large grids of models
- ★ Self consistent modeling of the stellar main sequence, post main sequence, and white dwarf cooling sequence
- ★ Will run specific models (e.g., non solar abundances or specific abundance patterns) in house for the FSWG

MIST Model Grid

-4.0 < [Fe/H] < 0.5
5.0 < log(Age) < 10.3
0.1 < M [$M_\odot$] < 300
Pre-MS to advanced phases
(e.g., WD & end of C-burn)
Stellar rotation



Evolutionary Tracks



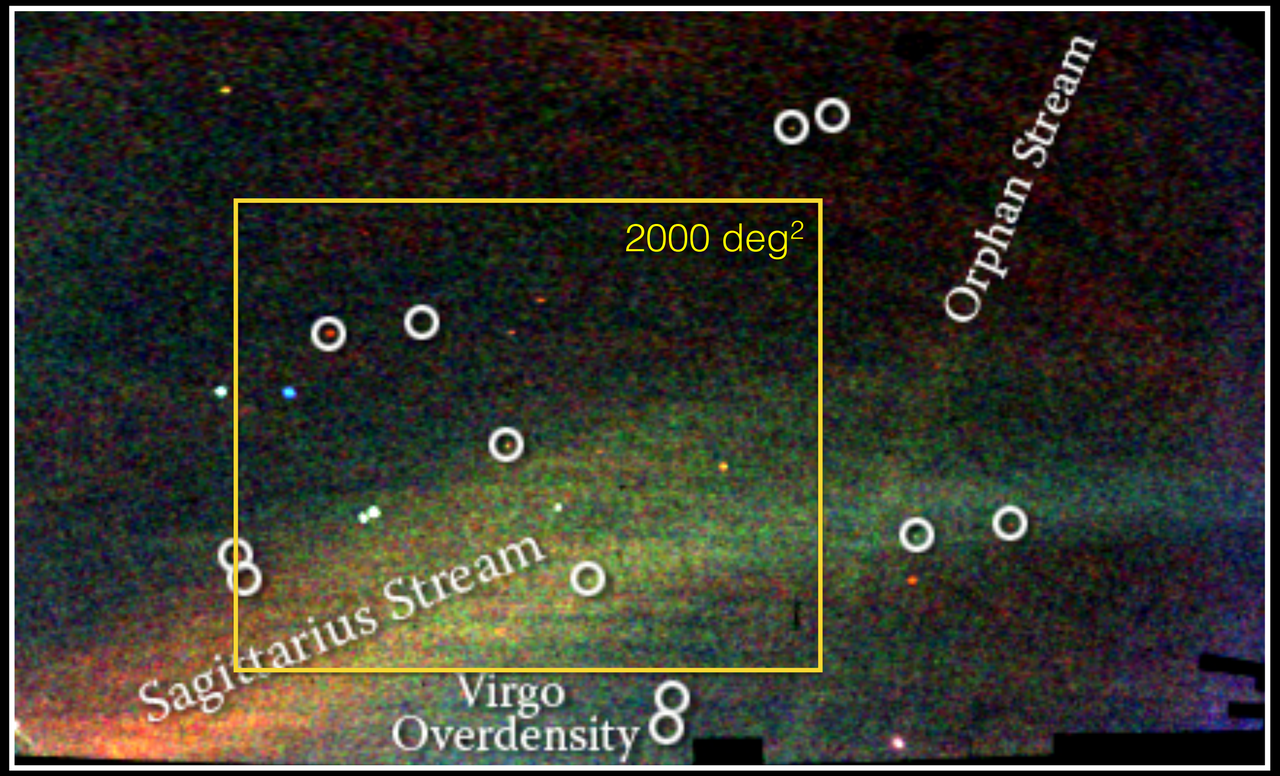
Isochrones

Wide Field Maps of the Milky Way Halo

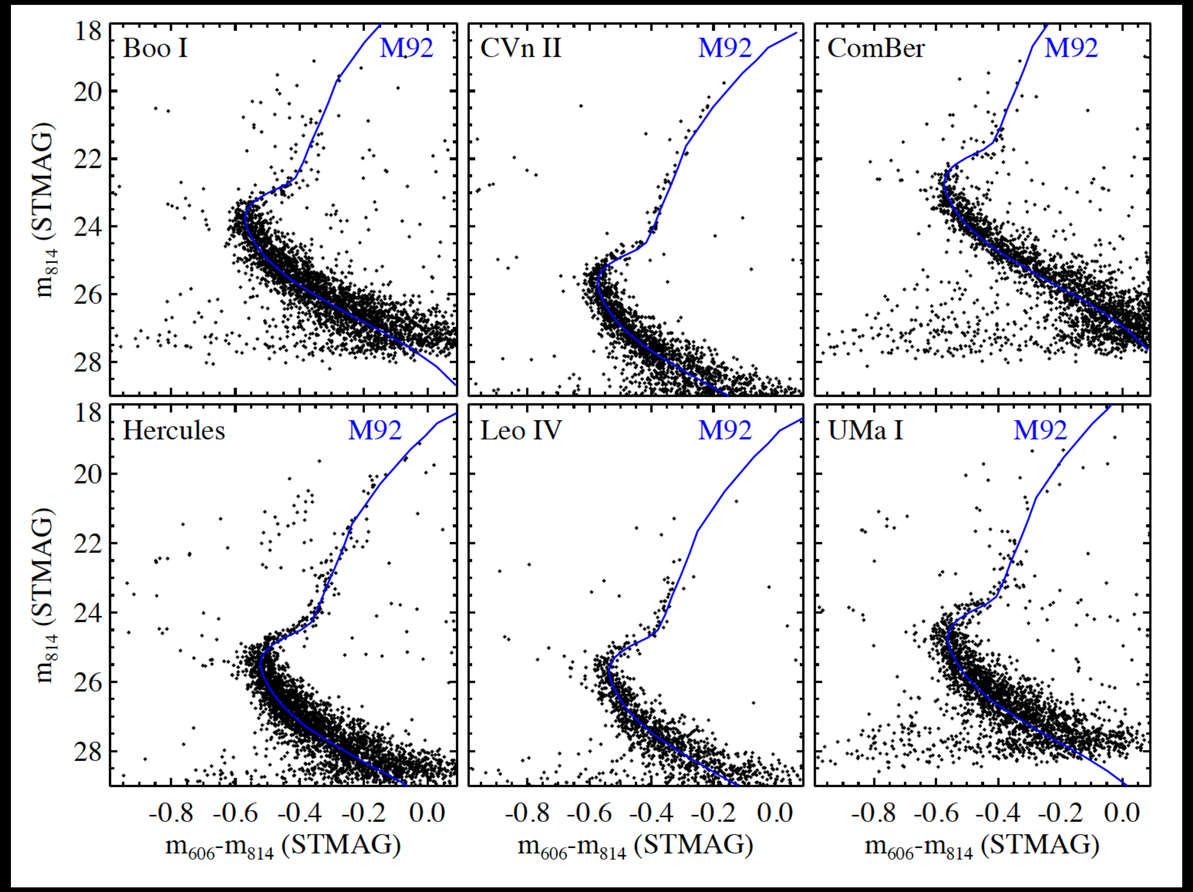
Substructure and Dwarf Galaxies

★ Dramatically increase the contrast of Milky Way streams and UFDs enabling detection through the halo
- SDSS Field of Streams detects the faintest substructure to merely 1% of the MW Volume
- WFIRST HLS will enable structure detection throughout the full volume of the 2000 sq deg

★ WFIRST is also the ideal tool to characterize the star formation histories of this pristine material



SDSS Field of Streams - Belokurov et al. (2006)

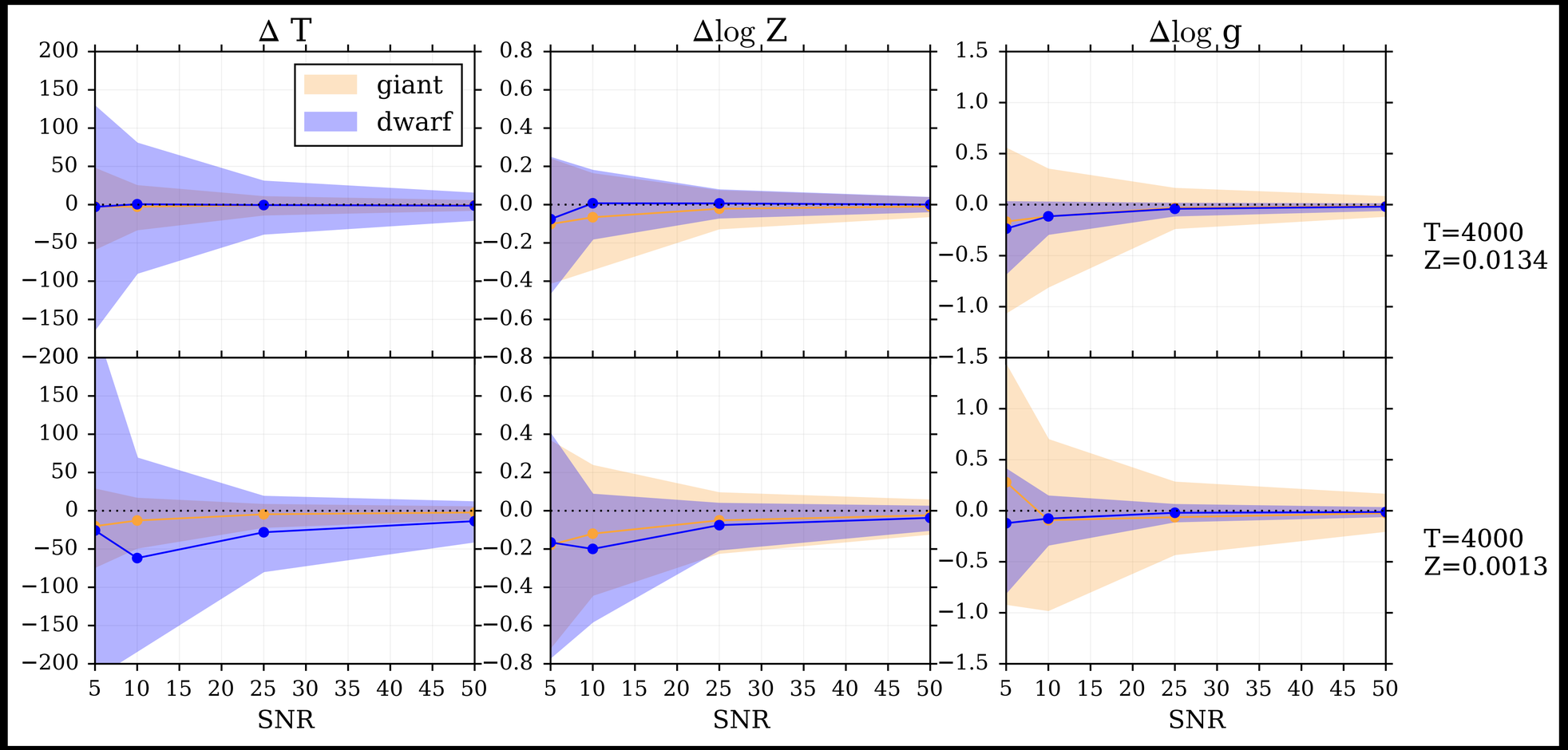


Brown et al. (2014)

Optimal Detection and Characterization of Substructure

Substructure and Dwarf Galaxies

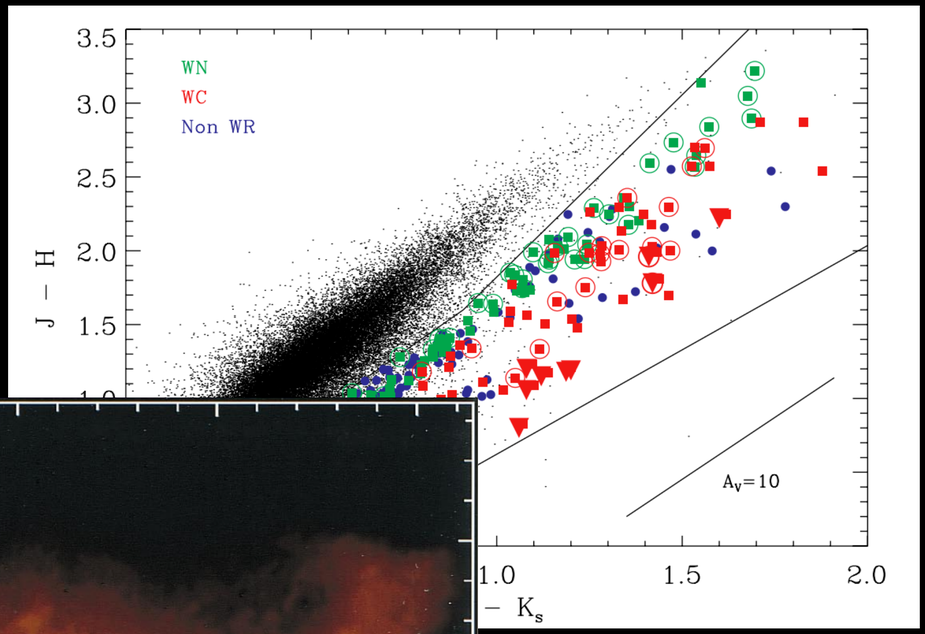
- ★ Will build, test, and optimize algorithms for finding tidal debris and new faint dwarf galaxies in the HLS (to date, all known stellar streams have been discovered via by-eye searches of stellar density maps)
- ★ Will develop new algorithms using a new suite of hydrodynamical simulations of stellar halos
- ★ Will explore the use of the IR ‘kink” as a new standard candle to detect substructure and measure metallicities
- ★ Will explore combined use of deep photometry and the grism to constrain age, metallicity, and IMF of substructure



Star Formation and Massive Stars

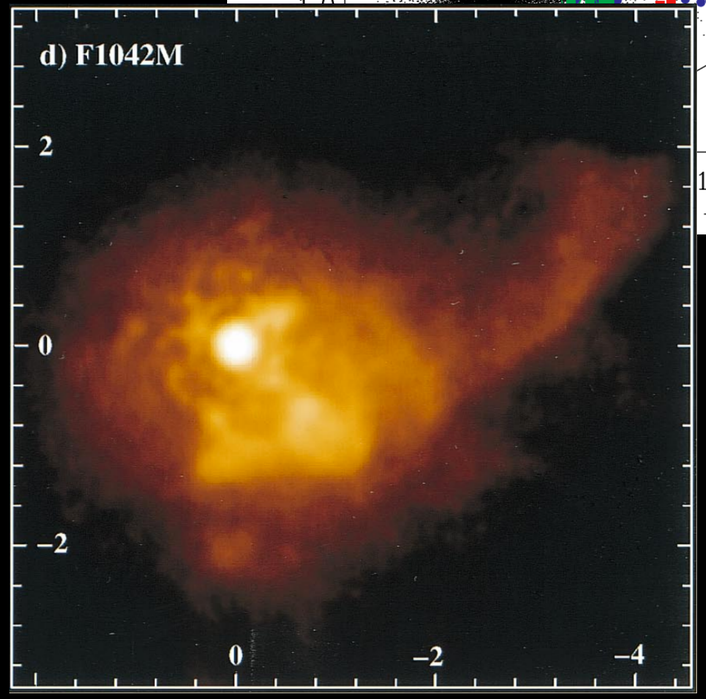
WFIRST WFI Milky Way Opportunities

- ★ High resolution, wide field surveys of interesting sight lines in the Galactic plane are non existent
- ★ WFIRST can enable a complete census of the evolved massive star population in the Galactic disk
  - constrain models of post main-sequence evolution and feedback
  - measure star formation rates and early evolution of star clusters
  - explore binarity in massive stars
- ★ Will develop multi-band IR diagnostics for all classes of massive stars

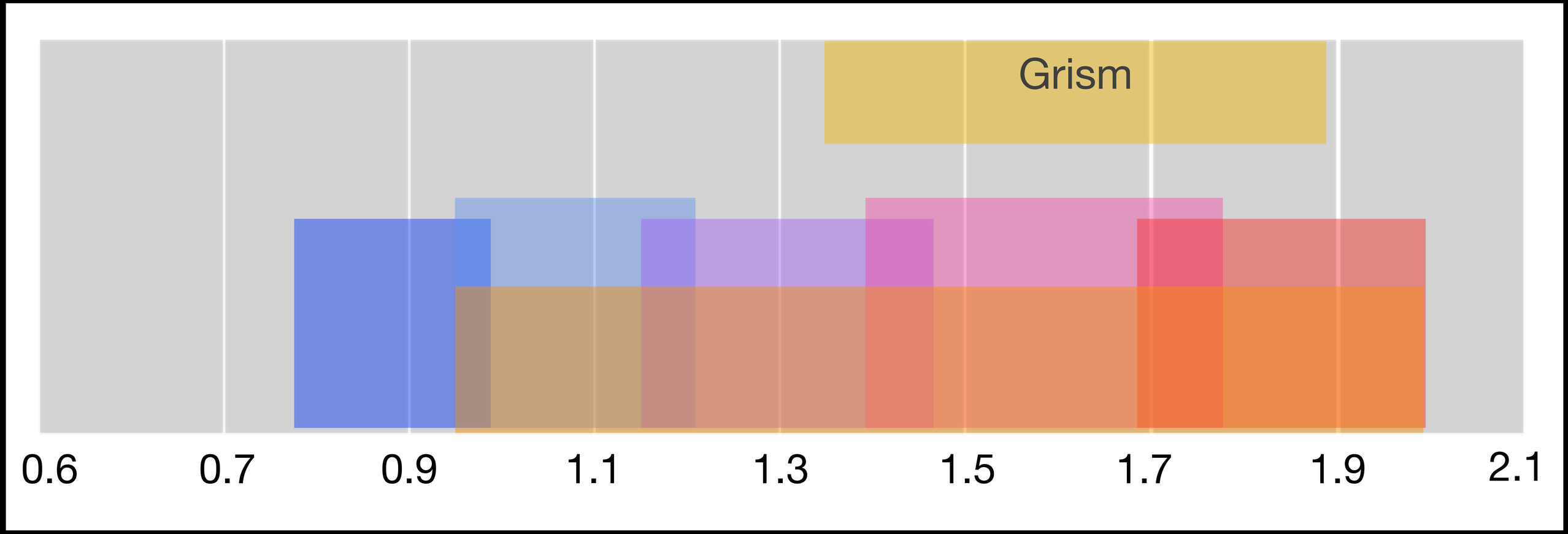


WFIRST CGI Milky Way Opportunities

- ★ CGI can directly image the environments of massive stars
- ★ Mass loss mechanisms and rates
- ★ Feedback and stellar evolution timescales
- ★ Compare circumstellar morphologies and supernovae remnants to probe eruption and supernova kinematics
- ★ Models of circumstellar environment morphologies for different evolutionary stages and mass loss prescriptions

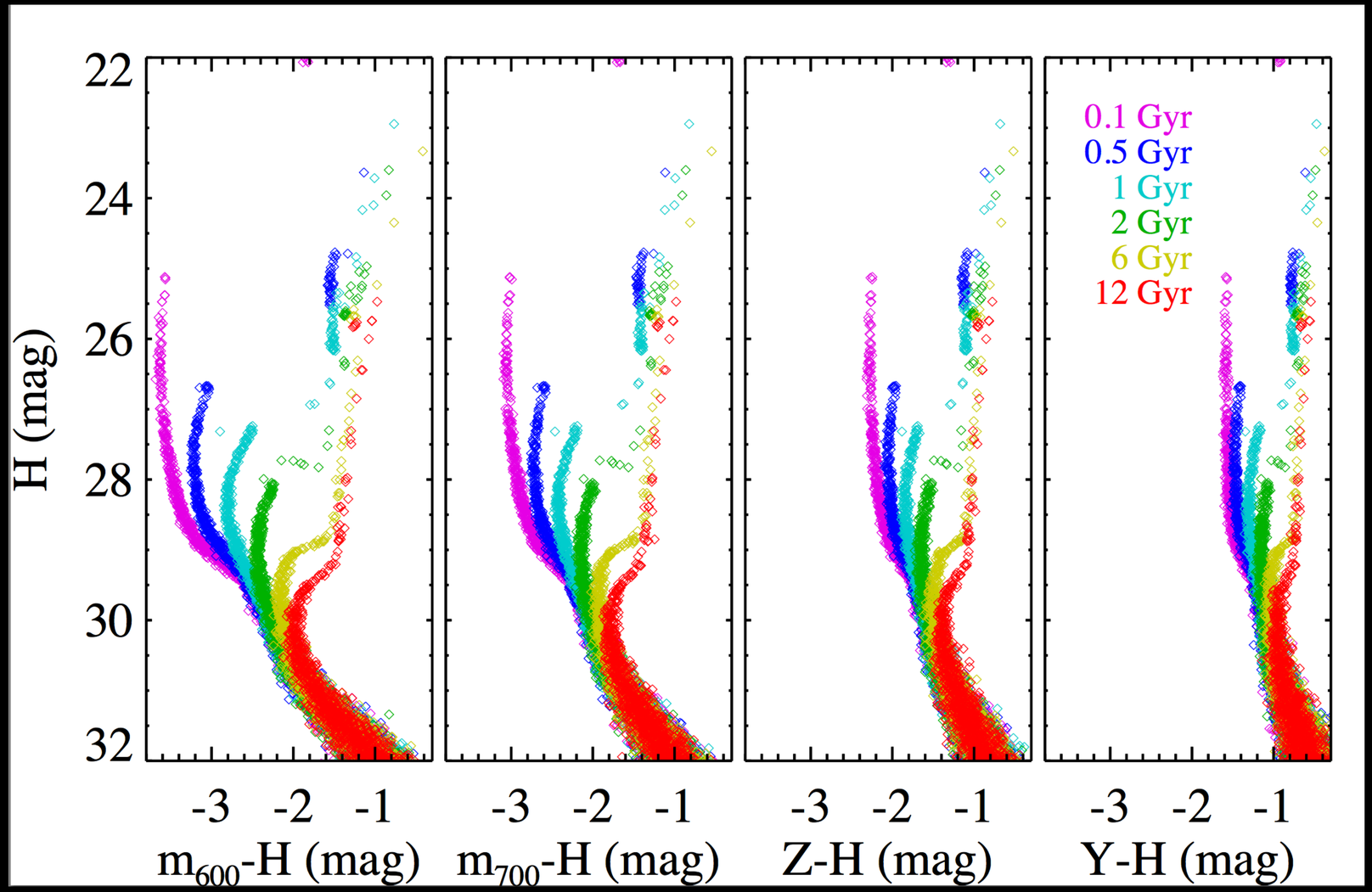


The Current WFIRST Filters



J. Dalcanton

Advantages of Pushing WFIRST Bluer



T. Brown

Broadly Speaking

- ★ m_{600} increases age resolution by 100%
- ★ m_{700} increases age resolution by 50%

Synergistic Studies with Other SITs

WFIRST WFI Milky Way Opportunities

- ★ Interfacing with other UVOIR missions in the 2020s
  (our team has strong representation on JWST, TMT, GMT, Keck, LSST, NASA APS)
- ★ Simulating wide field astrometric capabilities for Galactic dynamics & structure
  - Masses of faintest MW satellites, mass of the MW halo, testing cold vs warm DM
  (working w/ D. Spergel)
- ★ Going from stellar isochrones to WFIRST pop synthesis models for galaxy studies
  (working w/ GO extragalactic teams)
- ★ Applying IR phot and spec diagnostics to stellar populations in the bulge (GI program)
  (working w/ S. Gaudi and the microlensing team)
- ★ Coronagraphy applications for non exoplanet and debris disk sources
  (working w/ M. Turnbull, B. Macintosh and the coronagraphy teams)
- ★ Algorithms to detect and interpret Milky Way halo substructure
  (strong synergies with the WINGS program)

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