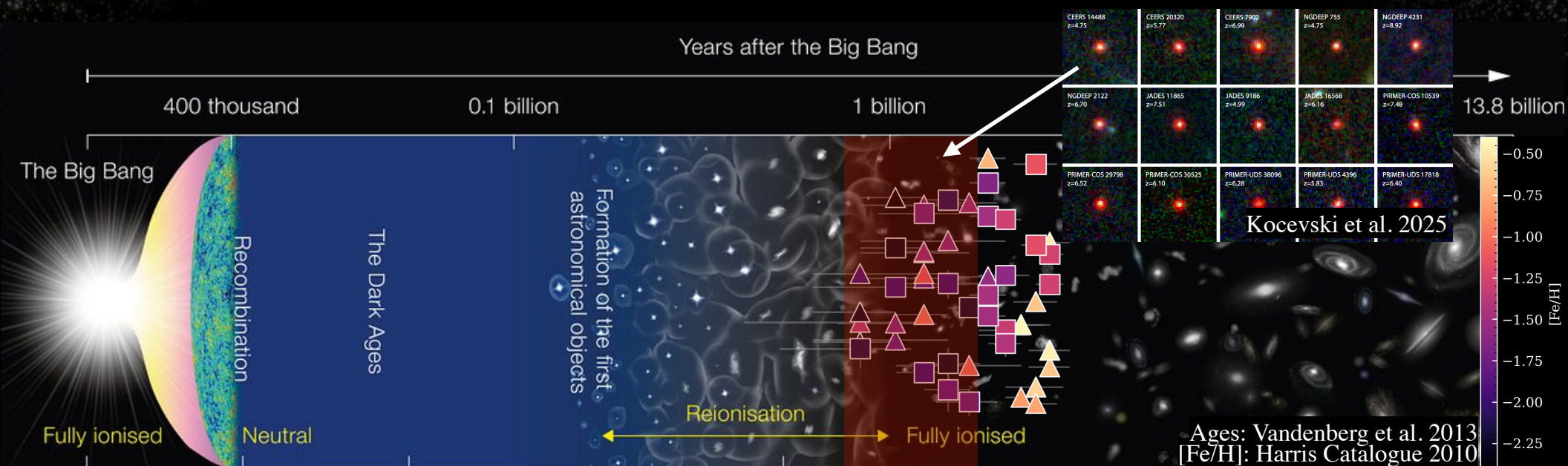


Roman and the Future of Globular Cluster Asteroseismology

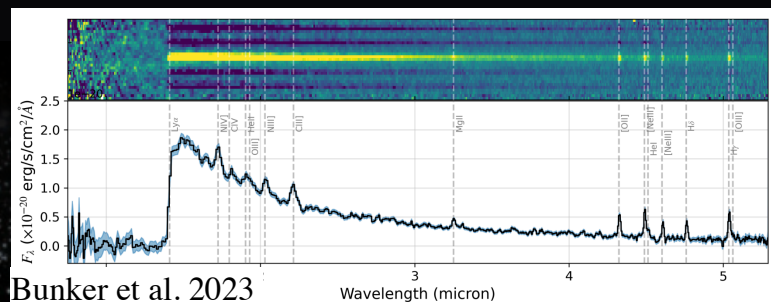
Madeleine McKenzie (Carnegie), Madeline Howell (OSU)
Alison Crisp (OSU), Geoffrey Mo (Carnegie/Caltech)



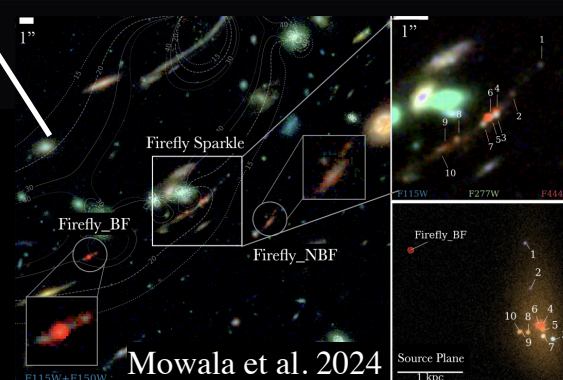
Globular clusters connect the local and high-redshift Universe



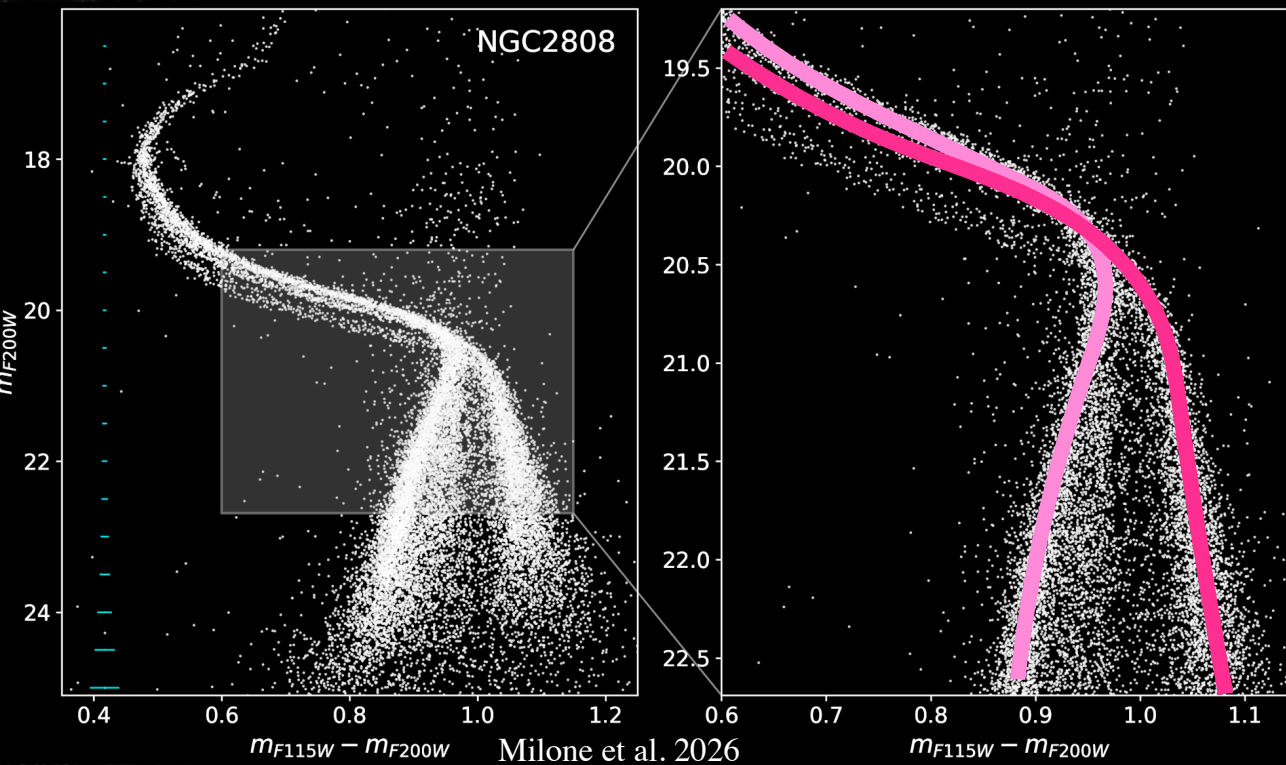
Credit: NAOJ, ESO



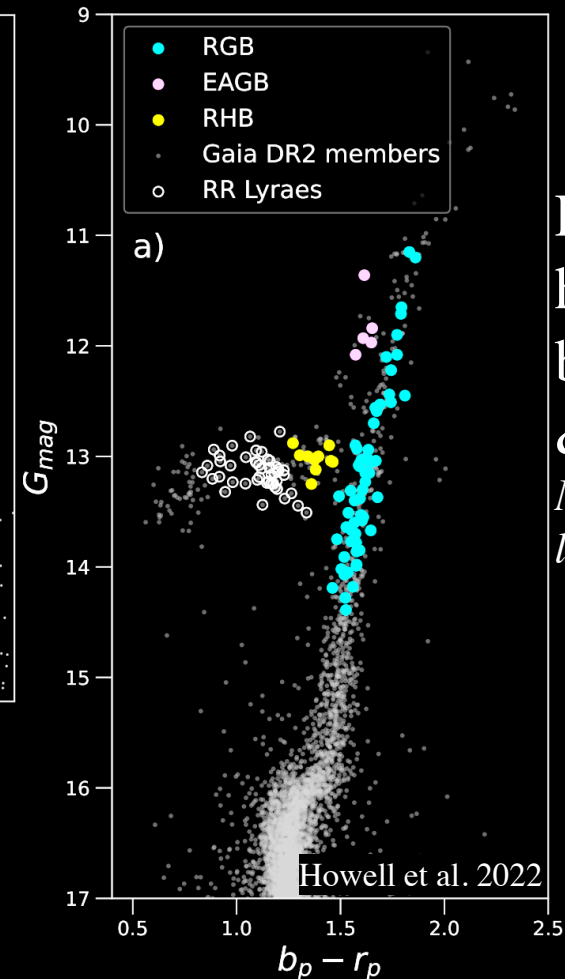
10
Redshift + 1



Globular clusters provide controlled tests of stellar evolution

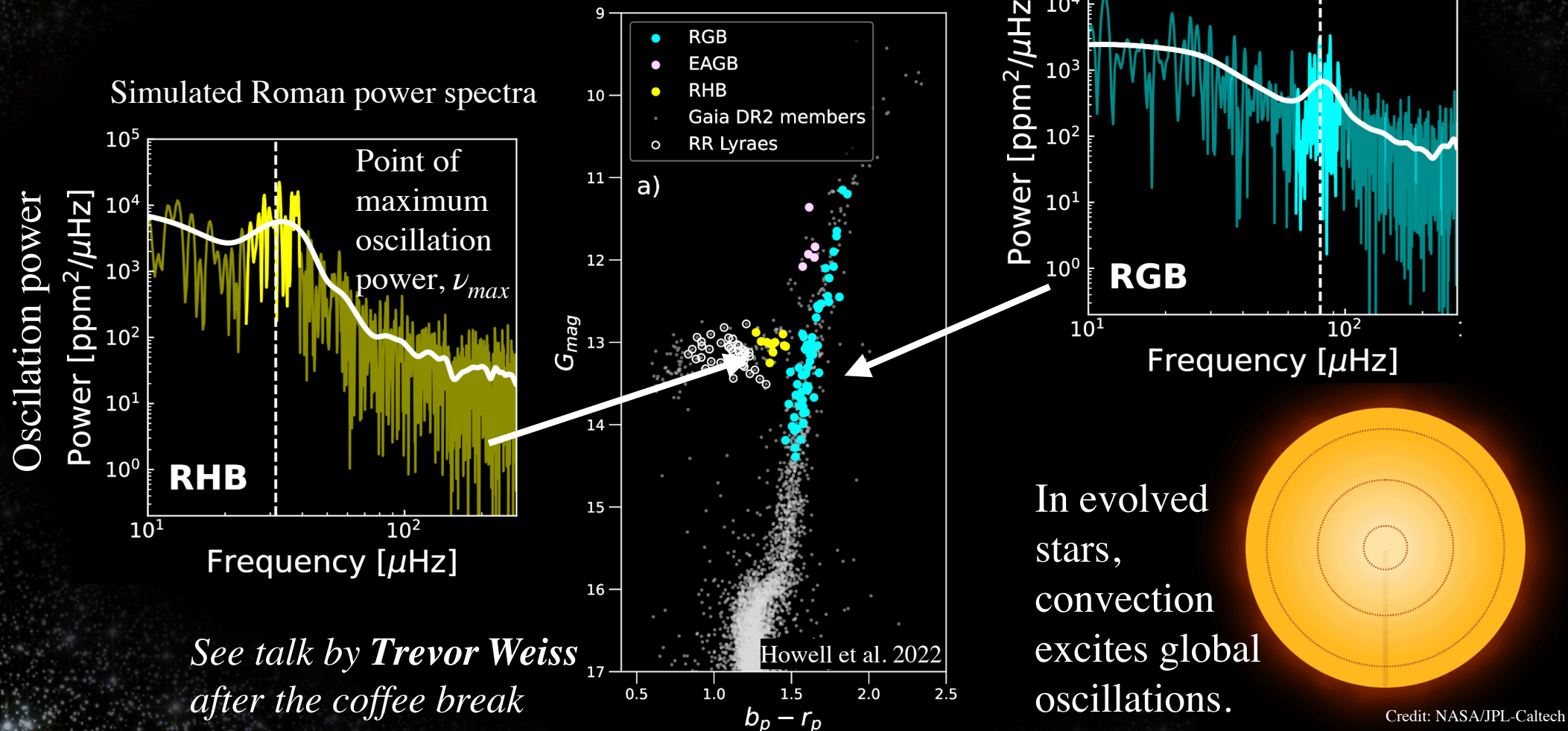


Main sequence and turn-off stars
Initial population differences

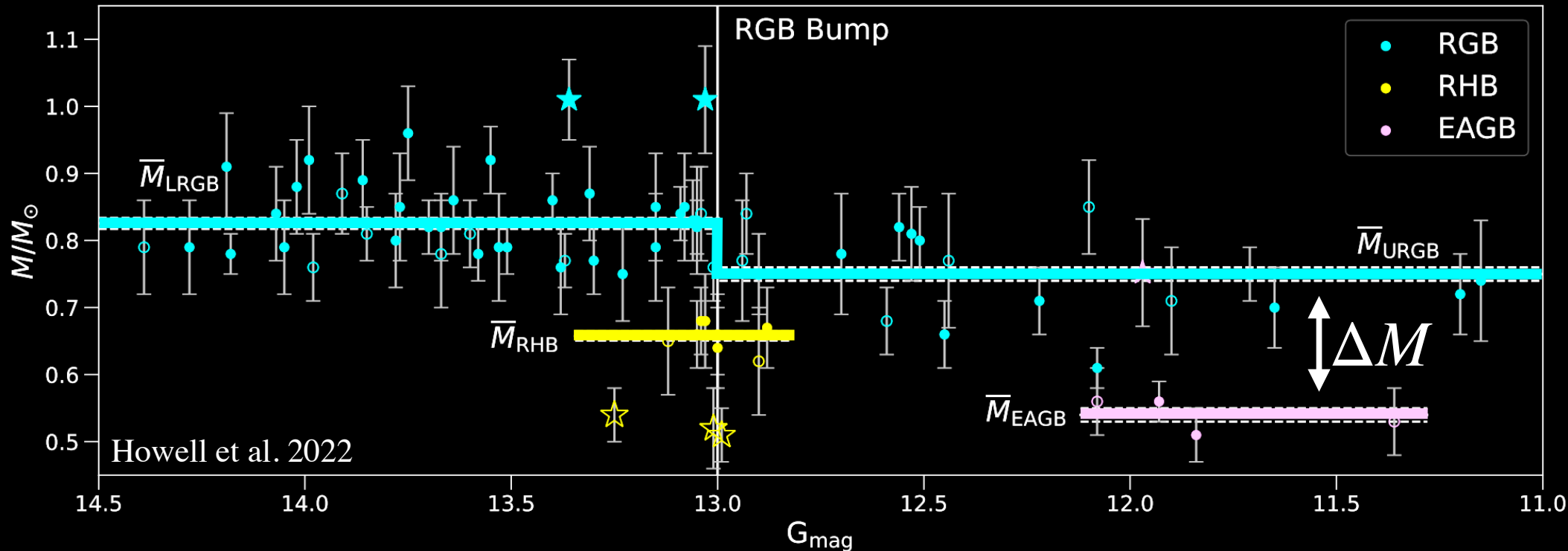


RGB,
horizontal
branch,
& AGB
*Mass loss and
later evolution*

Roman will bring asteroseismology to crowded globular clusters



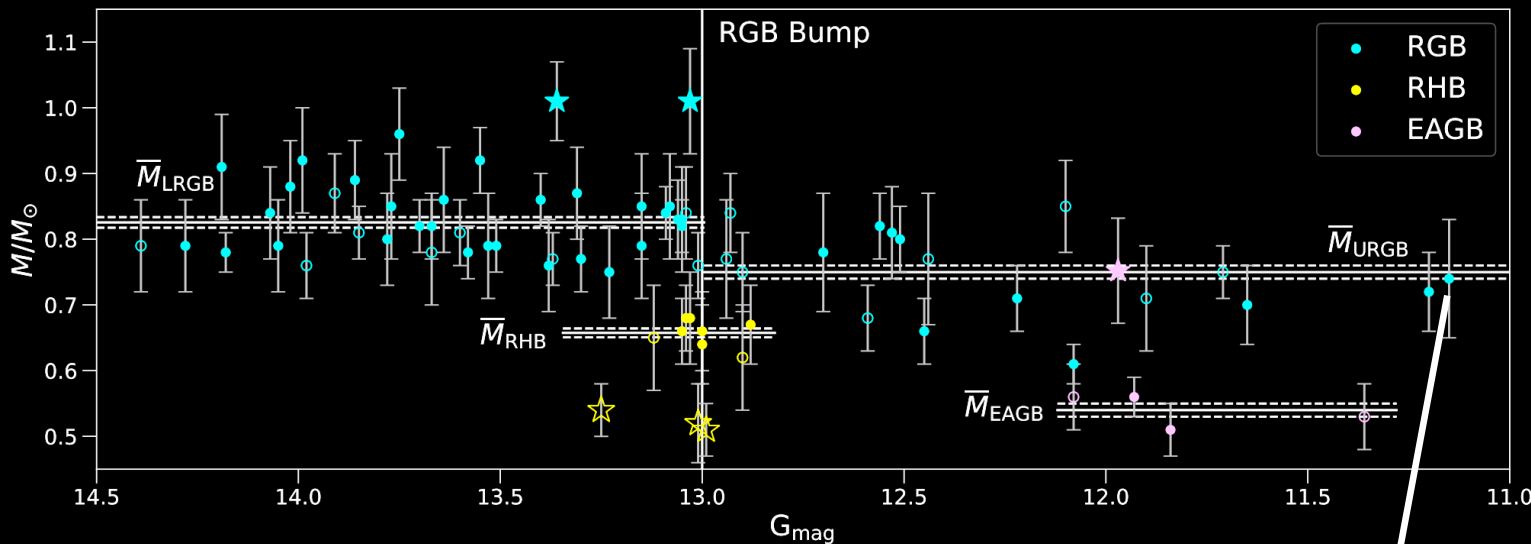
Large asteroseismic samples provide precise ensemble masses



Mean mass decreases from the lower RGB to above the RGB bump, to the horizontal branch, and then again to the early AGB.

Seismic masses directly measure integrated mass loss

Detailed spectroscopy & asteroseismology



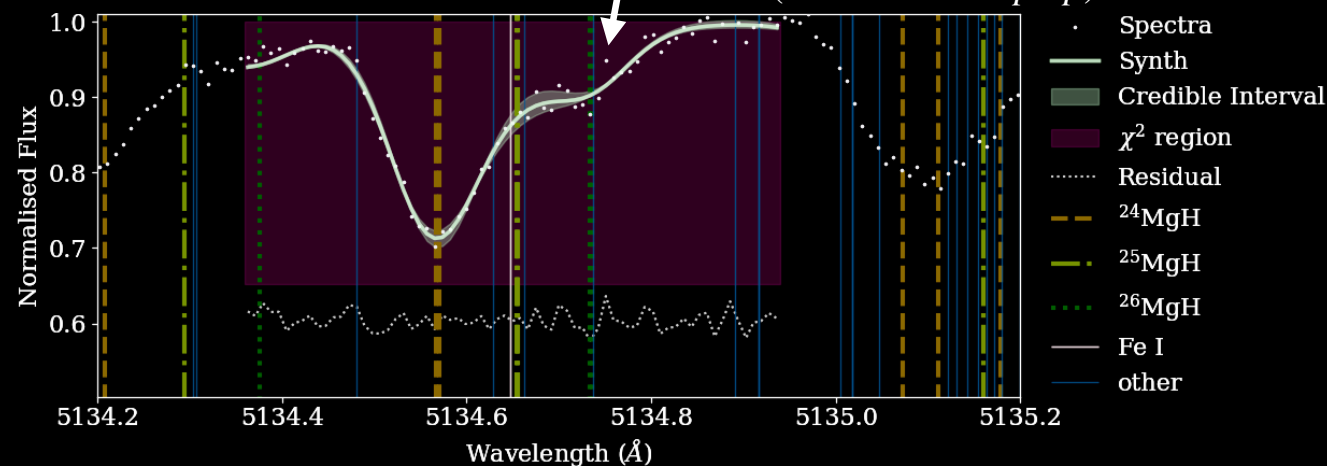
Do chemically distinct populations have different masses, and do they experience different amounts of mass loss?

E.g., High precision abundances & isotopic ratios with the Carnegie Planet Finder Spectrograph (McKenzie+ *in prep*)

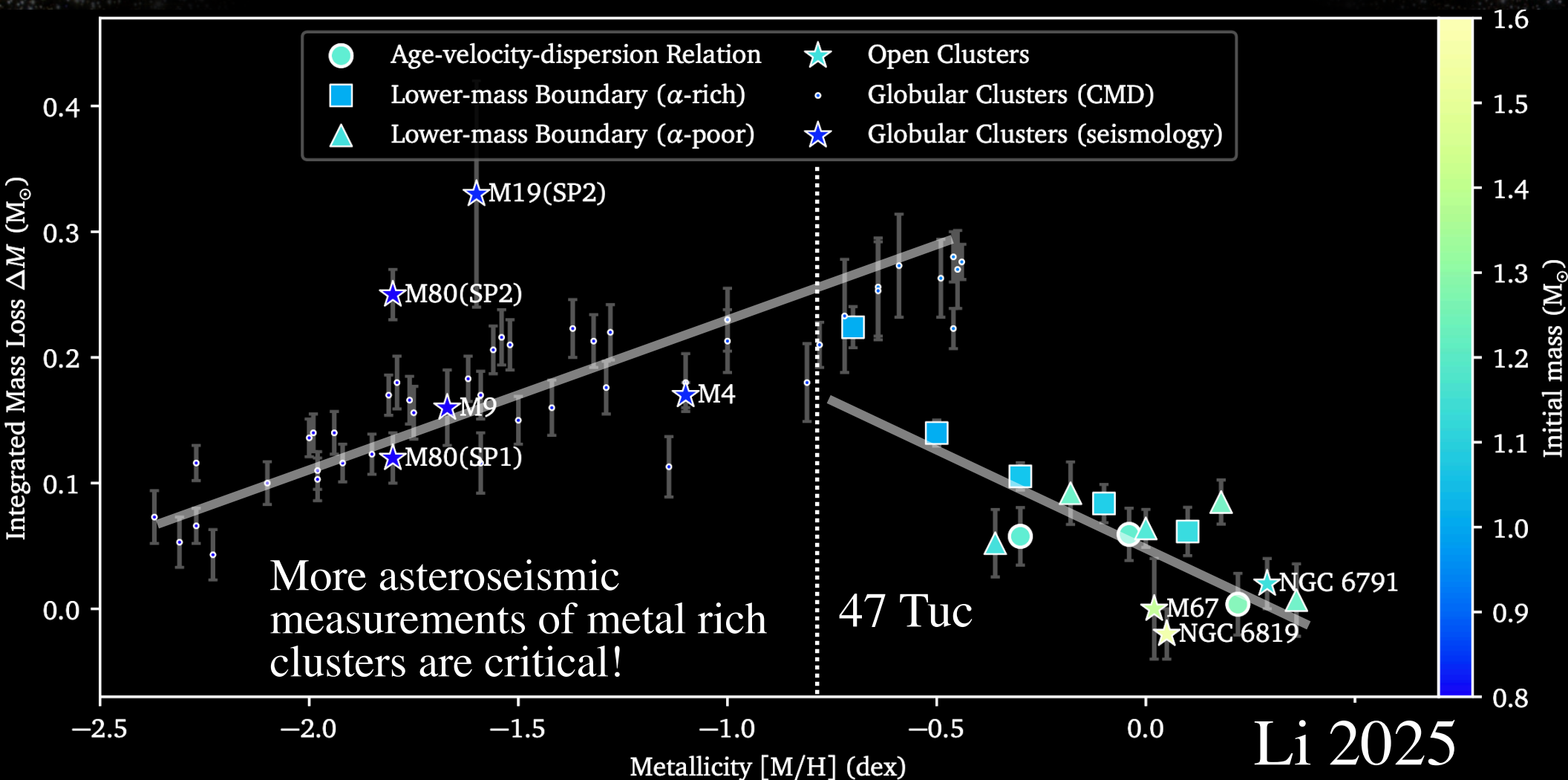
Spectroscopy reveals composition, asteroseismology reveals mass and evolutionary state.

Together, they connect stellar birth chemistry to subsequent evolution.

E.g., see APOKASC, AS-5 Atomic Genesis Explorer



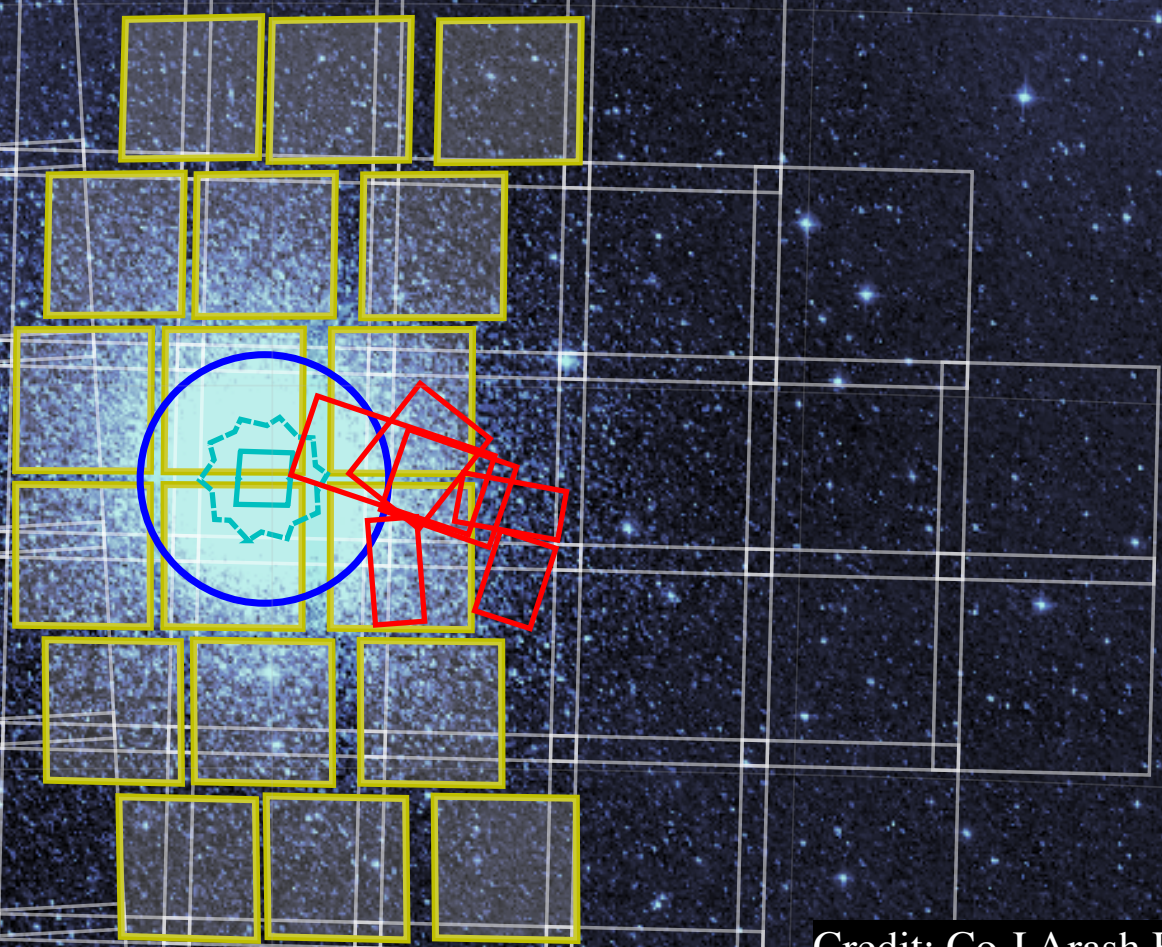
Constraints on mass loss across metallicity



47 Tuc is the ideal first Roman globular-cluster time-domain field

Extensive complementary
optical, infrared, ultraviolet,
X-ray, radio, and
spectroscopic data!

Roman WFI footprint (yellow),
HST WFC3 (green),
LSST DP1 (grey),
ACTA radio coverage (dark blue),
JWST NIRCам (red)



Credit: Co-I Arash Bahramian

47 Tuc *HST* ACS/HRC

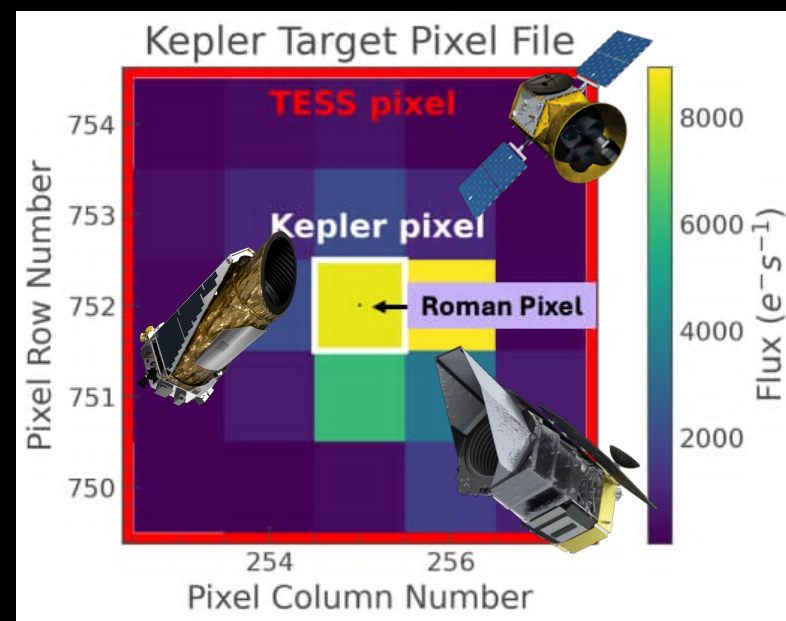


1.5 light-years
0.46 parsec 20"

F814W I
F555W V
F475W B



Roman can separate stars
that other time-domain
surveys blend together



Credit: M. Howell

Credit: NASA, ESA, and G. Meylan

Roman is uniquely suited to Milky Way globular-cluster asteroseismology at scale

★ - ideal
 ✓✓ - strong
 ✓ - possible
 ~ - limited
 X - not well suited

Science case	HST	JWST	Euclid	Rubin	PLATO	Roman
Resolve cluster cores	✓✓	✓✓	~	~	X	✓✓
Reach faint low-mass stars	✓	✓✓	✓	~	~	✓✓
Map wide tidal structure	~	~	✓✓	✓✓	~	✓✓
Work through bulge extinction	~	✓✓	✓	~	X	✓✓
Wide-field space-based imaging	X	X	✓✓	X	✓✓	✓✓
Crowded-field time-domain photometry	✓	✓	~	~	~	★
Bright-star asteroseismology	~	~	X	~	✓✓	✓*
GC red-giant asteroseismology at scale	~	~	X	~	✓	★*

Large-scale red-giant asteroseismology in crowded clusters is a case that uniquely depends on Roman!

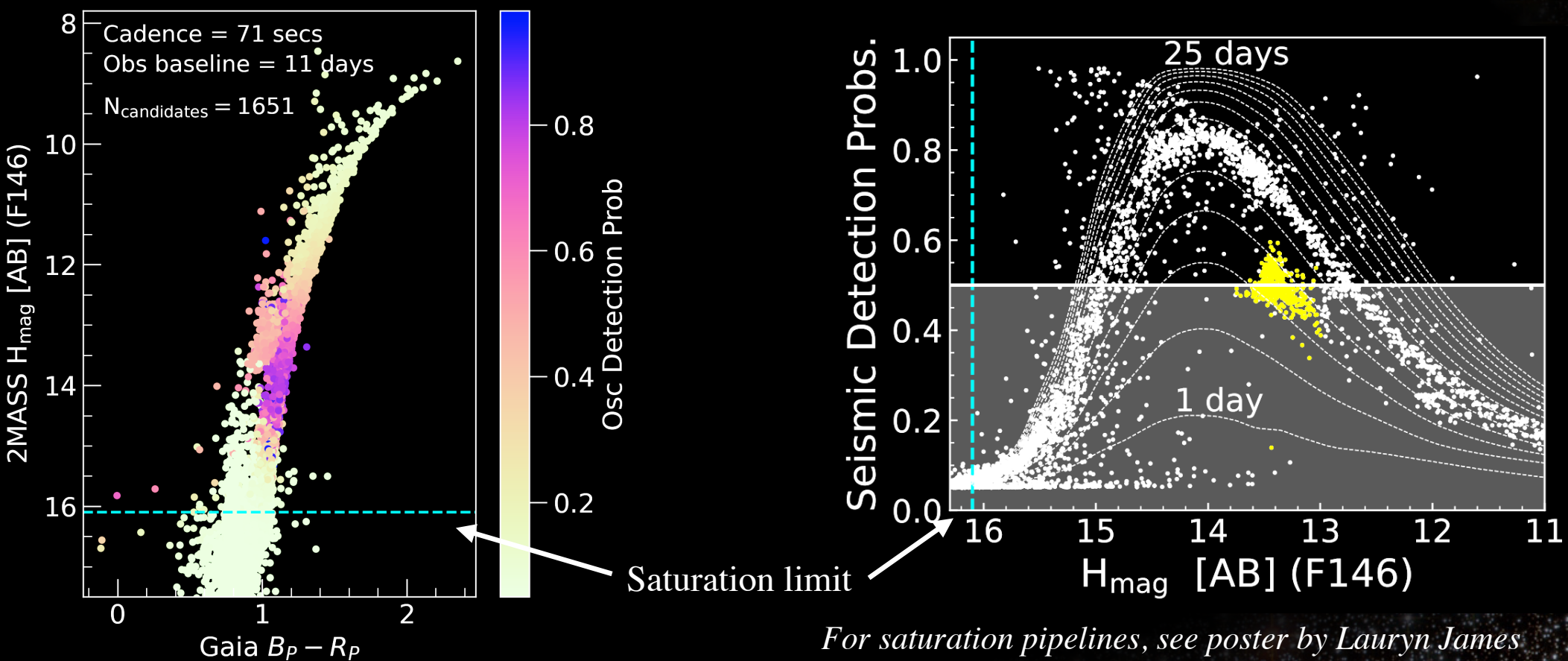
* after correcting for saturation issues

Note: this is undoubtably very biased, take this with a grain of salt.

Recovering saturated giants unlocks the highest-value science

All giants with a high probability of solar like oscillations will be saturated in a 66 s integration.

One solution is to use **halo photometry** to extract non-saturated in the PSF wings, rather than the saturated core.



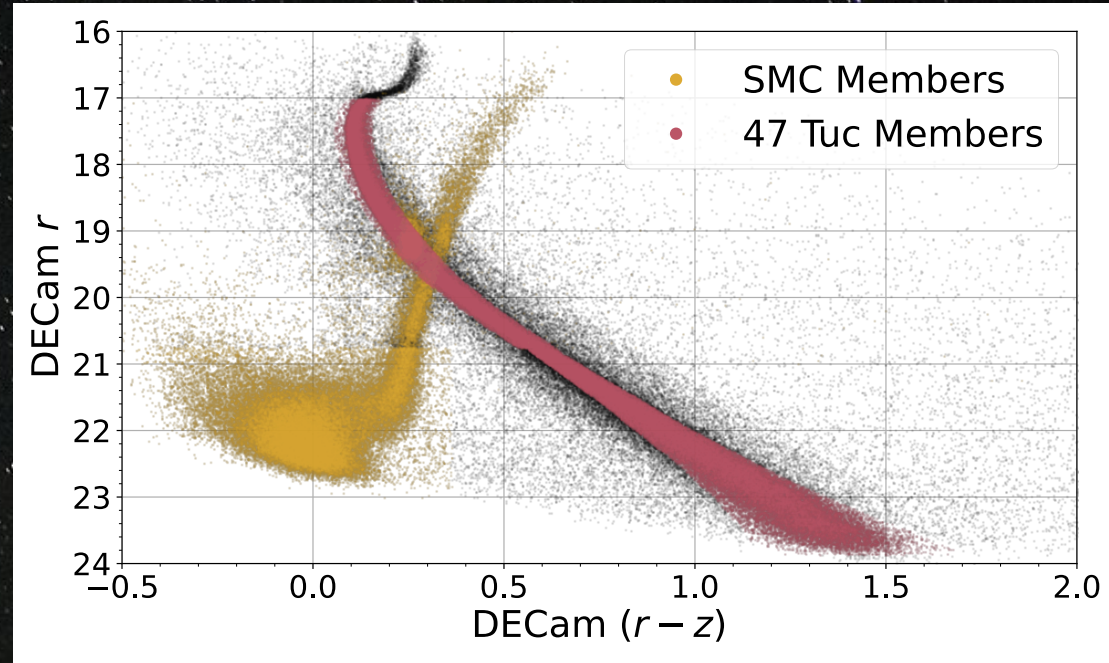
Additional science:

One field also samples the variable-star population of the Small Magellanic Cloud

Cepheids and RR Lyrae: distance-scale and pulsation calibration

Long-period and semi-regular variables: late-stage evolution and mass loss

47 Tuc versus the SMC: compare variability across age and metallicity



e.g., Crisp et al. 2025

Credit: G. Brammer/ESO

Roman could test planet formation in 150,000 metal-poor, alpha-enhanced stars

See also Crisp et al. 2025

Planets in GCs: PSR B1620-26 b discovered in 2003 orbiting a pulsar and white dwarf

Hot Jupiter at the metallicity of 47 Tuc recently discovered by Simon et al. 2026

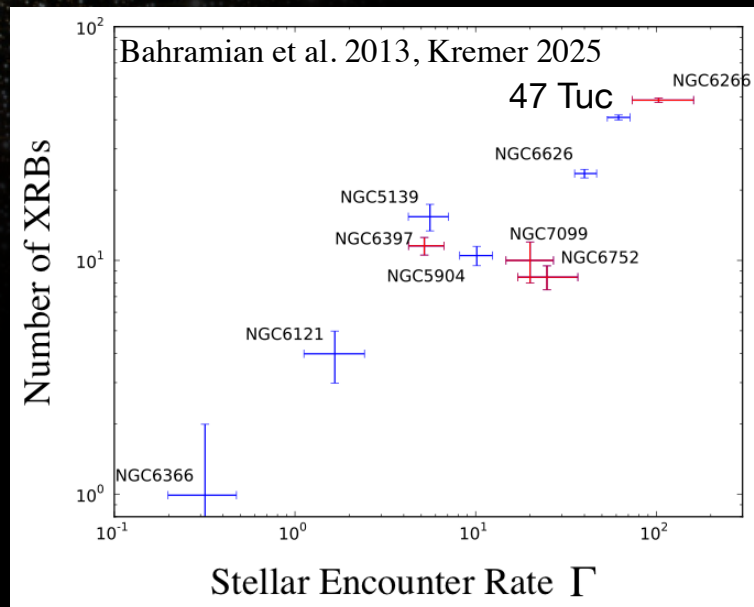
TOI-7169 b: A Hot Jupiter Transiting a Metal-Poor Star

JOSHUA D. SIMON ¹, JOSEPH E. RODRIGUEZ ², JHON YANA GALARZA ³, DAVID W. LATHAM ⁴,
VICTORIA DiTOMASSO ⁴, KAREN A. COLLINS ⁴, JACK SCHULTE ², ANIRUDH CHITI ^{5,6}, SAMUEL N. QUINN ⁴,
MOHAMMAD K. MARDINI ⁷, SHUBHAM KANODIA ⁸, JOHANNA K. TESKE ^{8,1}, PETER S. FERGUSON ⁹,
SAMUEL W. YEE ¹⁰, T. G. TAN ¹¹, KHALID ALSUBAI ¹², KHALID BARKAOU ^{13,14,15}, ZOUHAIR BENKHALDOUN ^{16,17},
KRZYSZTOF BERNACKI ¹⁸, JAIKRIT BHATTACHARYA ¹⁹, JEROME P. DE LEON ²⁰, SARAH J. DEVENY ^{21,22},
MARK E. EVERETT ²³, IZURU FUKUDA ²⁴, AKIHIKO FUKUI ^{20,25}, MICHAËL GILLON ¹⁴, ARVIND F. GUPTA ²³,
STEVE B. HOWELL ²², EMMANUEL JEHIN ²⁶, GAIA LACEDELLI ^{25,27}, ADAM LARK ¹⁹, COLIN LITTLEFIELD ^{21,22},
FELIPE MURGAS ^{25,27}, NORIO NARITA ^{20,25,28}, ENRIC PALLE ^{25,27}, HANNU PARVIAINEN ^{25,27}, ADAM POPOWICZ ¹⁸,
RICHARD P. SCHWARZ ⁴, AVI SHPORER ⁷, ABDERAHMANE SOUBKIOU ¹⁴ AND FRANCIS P. WILKIN ²⁹

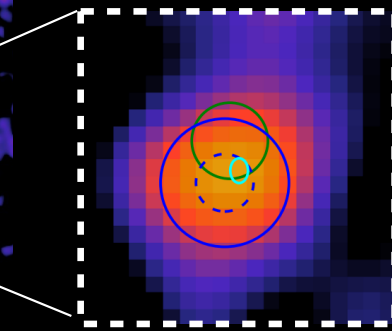
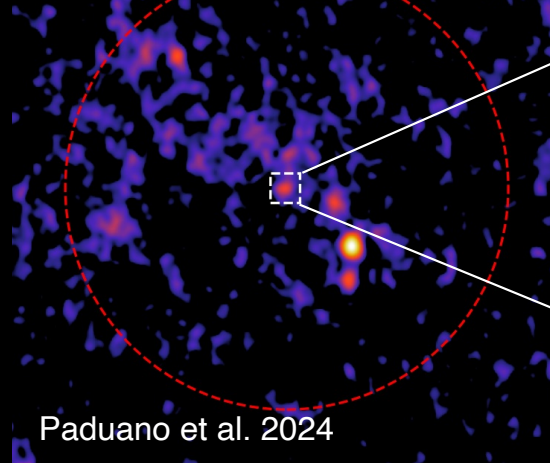
An artists view of a planetary system in the globular cluster M4.

Credit: NASA/ESA and G. Bacon (STScI)

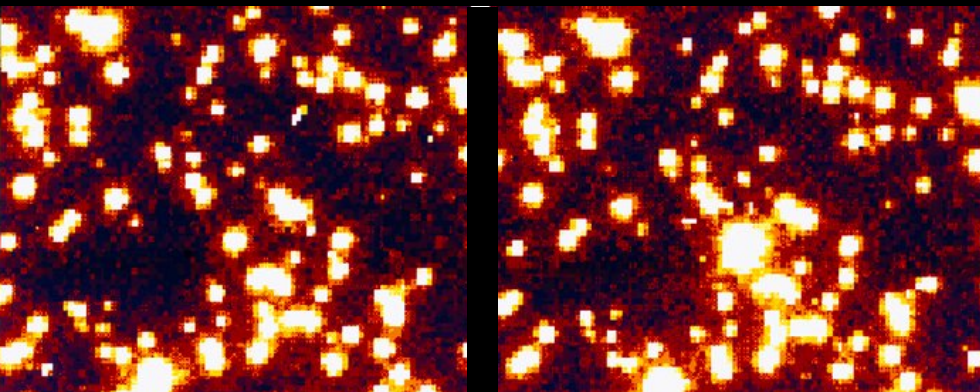
Exotic phenomena in 47 Tuc



A millisecond pulsar or a weakly accreting black hole?

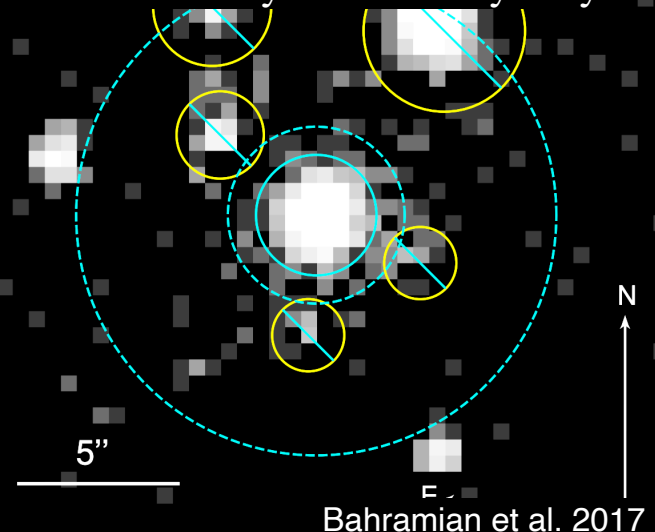


X9: the only known ultracompact BH + WD binary in the Milky Way



The cataclysmic variable AKO 9 in 47 Tuc using HST (Credit: ESO)

+ UV time domain
HST observations
on the core of 47
Tuc (PI: Mo)

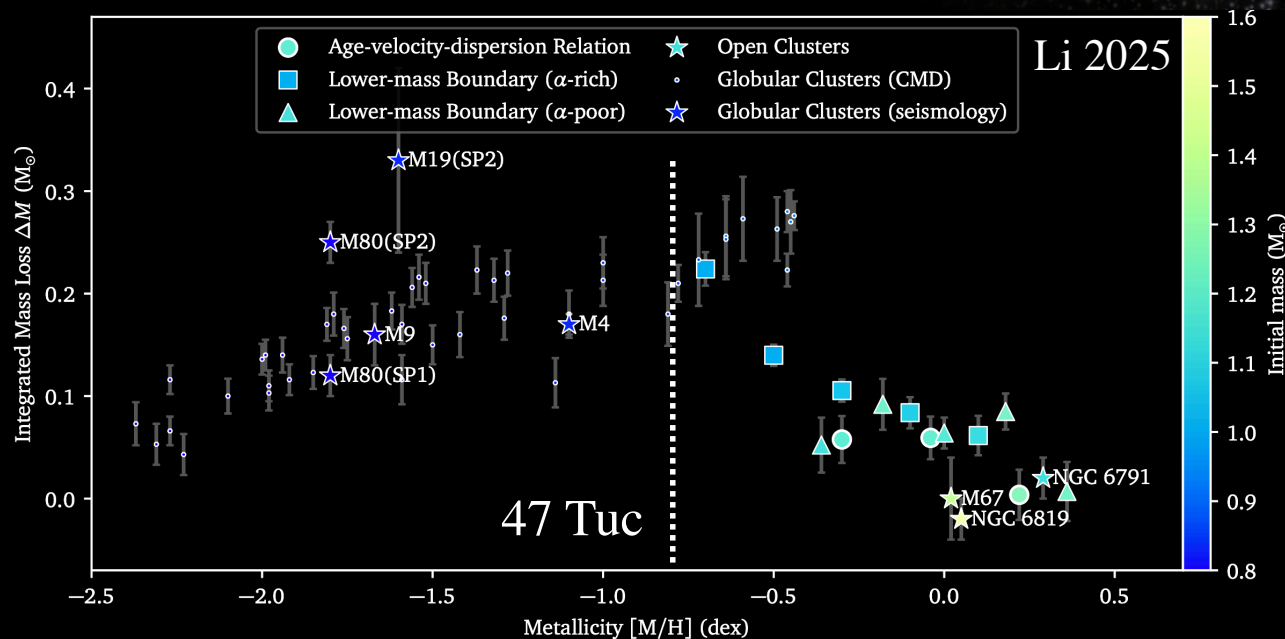


Conclusions

47 Tuc fills a key gap in the metallicity dependence of RGB mass loss.

Seismic masses can test whether the low-metallicity trend continues, flattens, or turns over.

Chemo-seismic analysis connects stellar mass and evolutionary state to chemical composition.



Halo photometry of saturated giants is required to recover the seismic sample and to connect these measurements to the best spectroscopic samples.

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Exotic phenomena: Geoffrey Mo (gmo@carnegiescience.edu)

Spectroscopic connection: Madeleine McKenzie (mmckenzie@carnegiescience.edu)