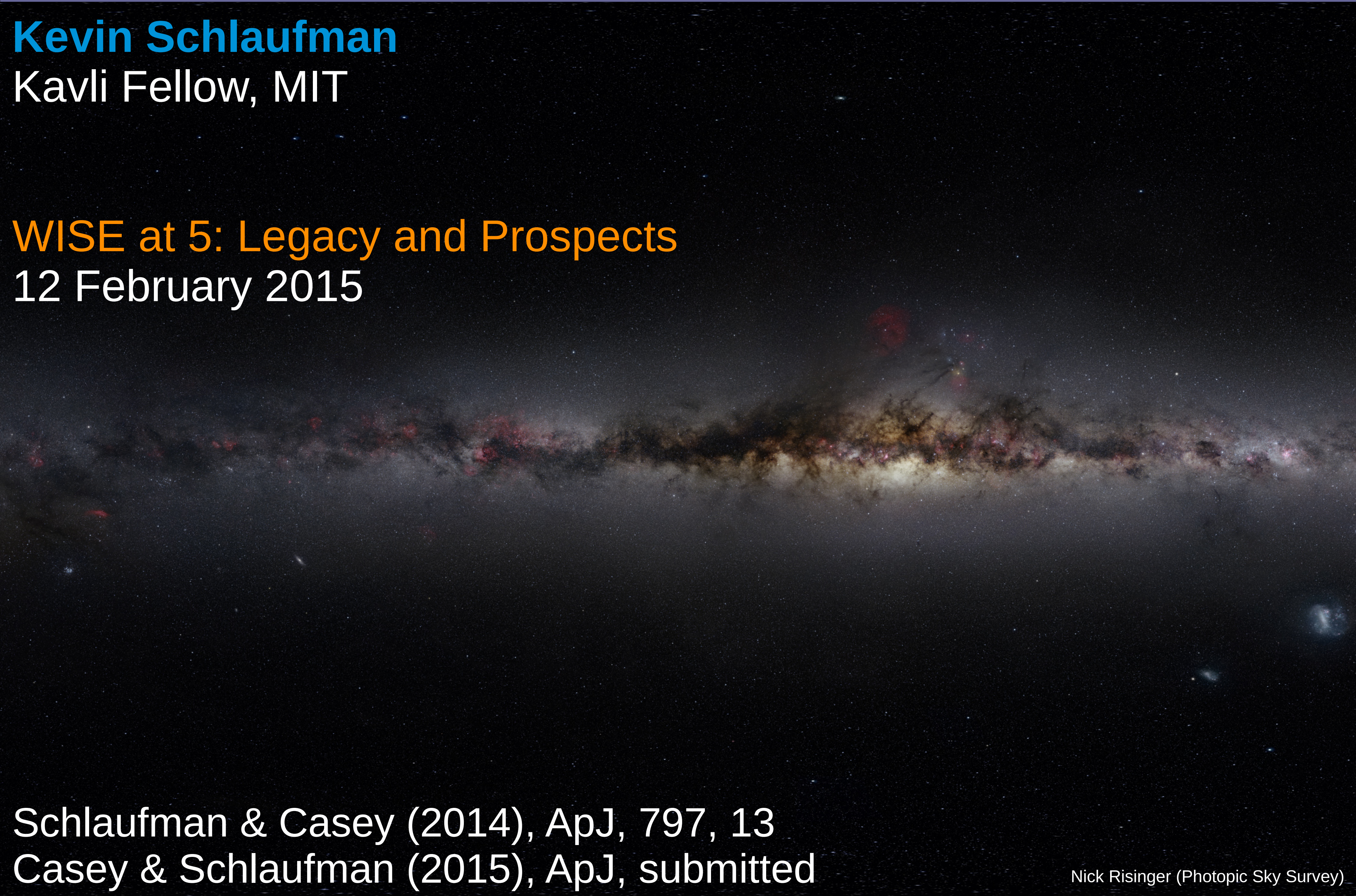
The Best and Brightest Metal-poor Stars

Kevin Schlaufman
Kavli Fellow, MIT

WISE at 5: Legacy and Prospects
12 February 2015



Schlaufman & Casey (2014), ApJ, 797, 13
Casey & Schlaufman (2015), ApJ, submitted

Nick Risinger (Photopic Sky Survey)

The Best and Brightest Metal-poor Stars

Kevin Schlaufman and Andy Casey
Kavli Fellow, MIT IoA Cambridge

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The First Stars: Population III

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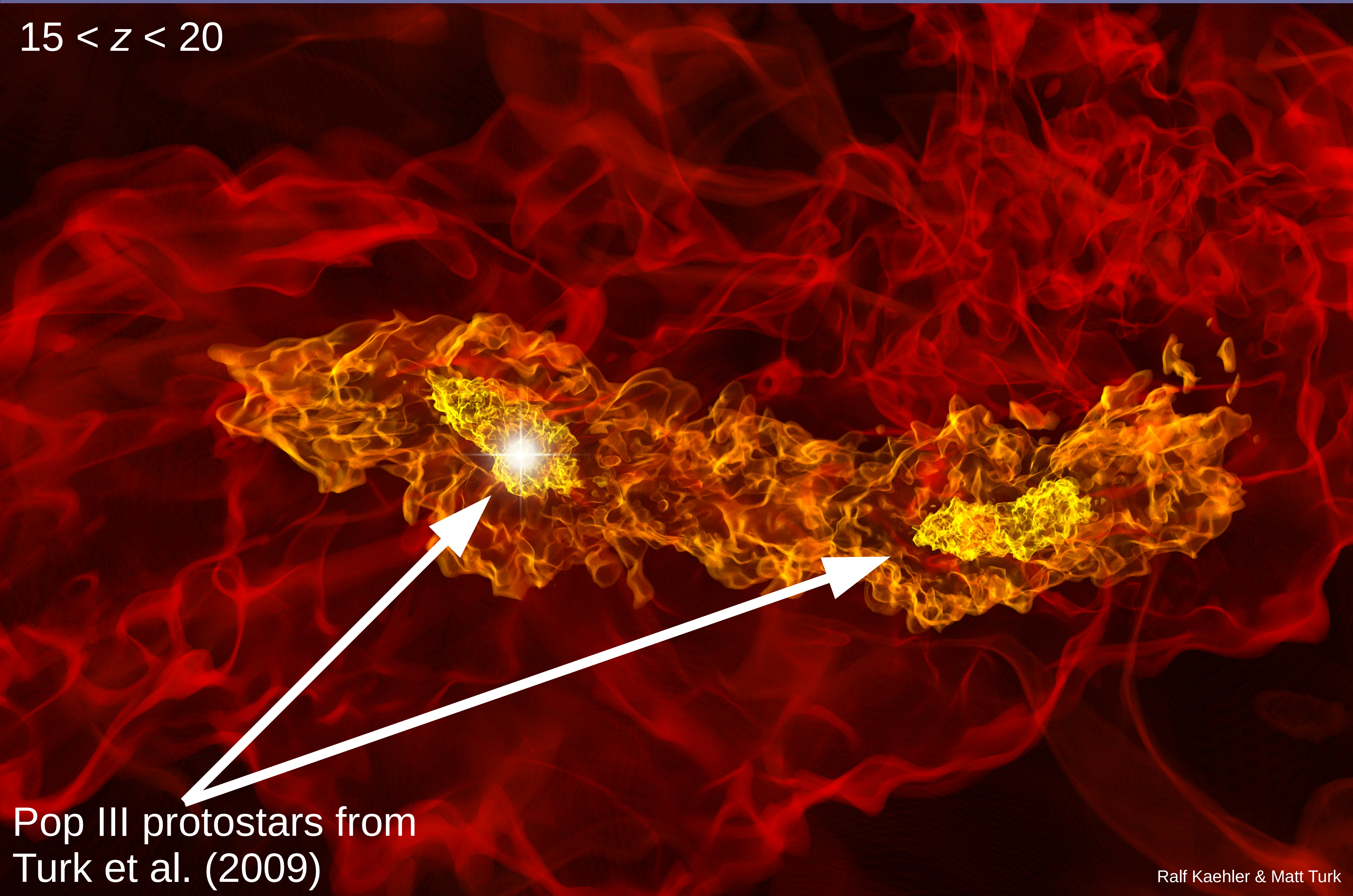

Metal-poor Star Candidates

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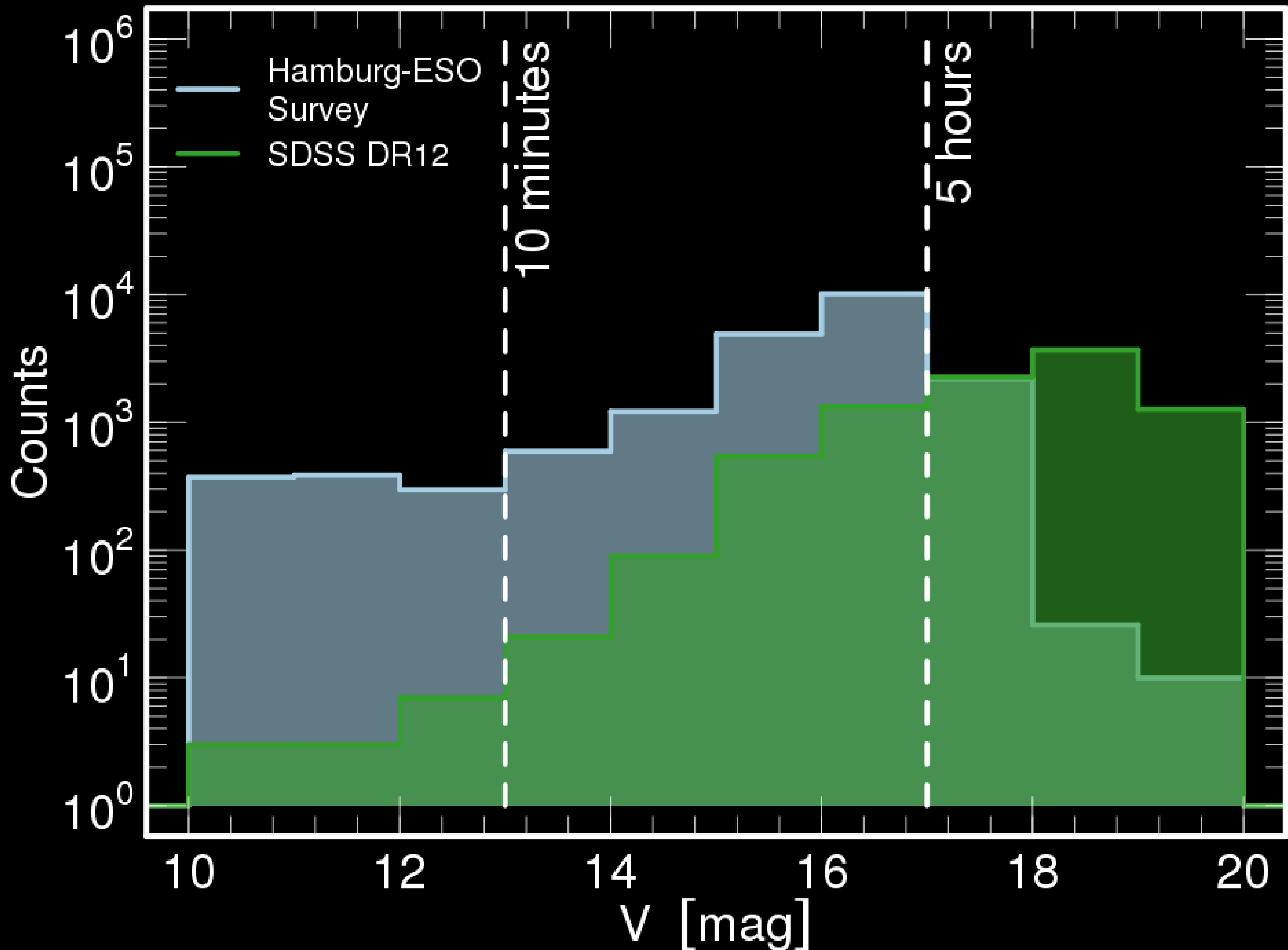

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Spectroscopy First

While classical searches for metal-poor stars have achieved many successes, they are not perfect:

(1) They are resource intensive.
(2) They fail in regions of high extinction and/or reddening.
(3) They fail in crowded regions.
(4) They only identify candidates with faint apparent magnitudes.

Theory of Infrared EMP Selection

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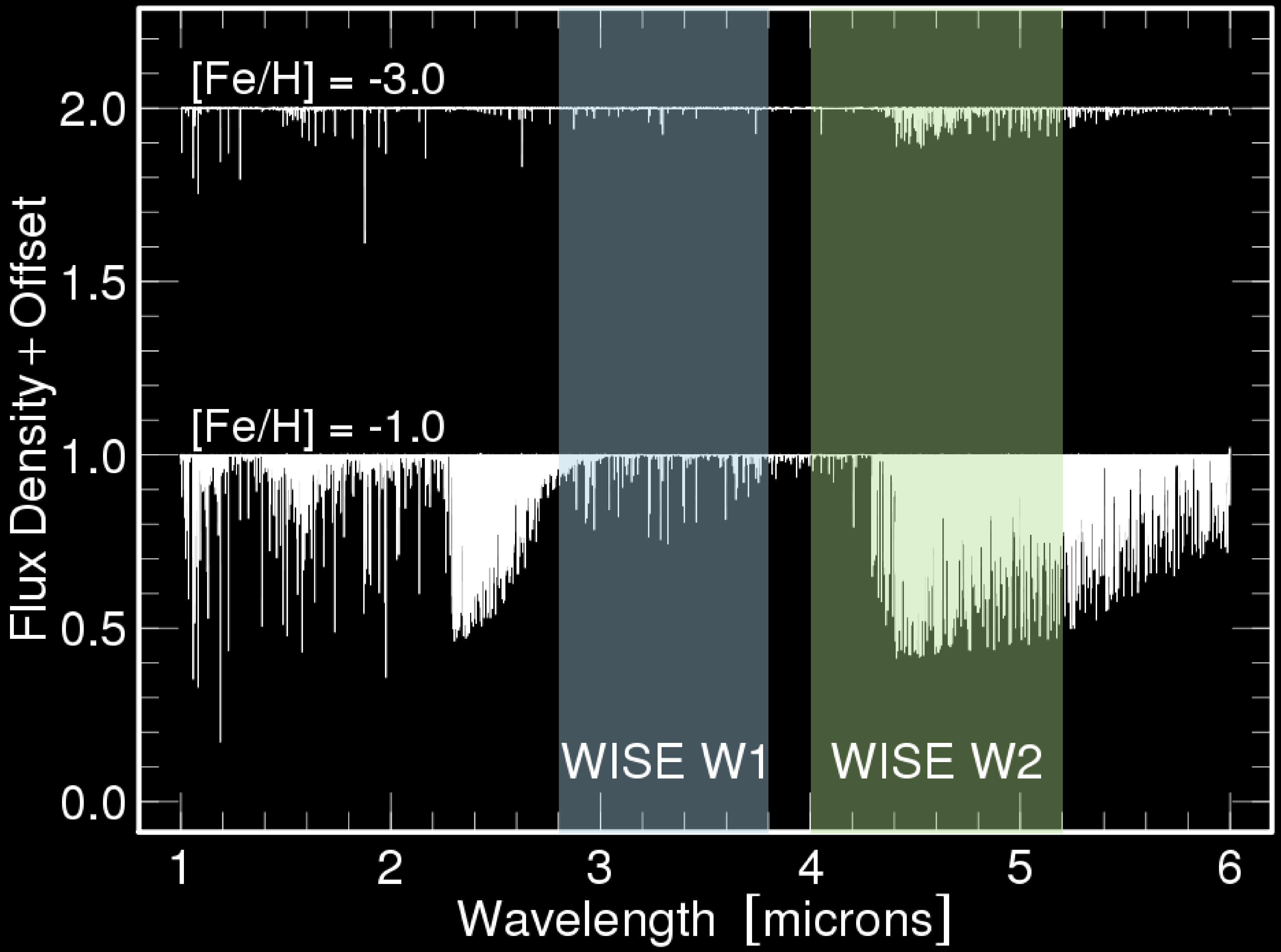
12 February 2015
Schlaufman & Casey (2014)



Practice of Infrared EMP Selection

Schlaufman & Casey (2014)

(1) Select cool stars
=> $0.45 < J - H < 0.60$

Practice of Infrared EMP Selection

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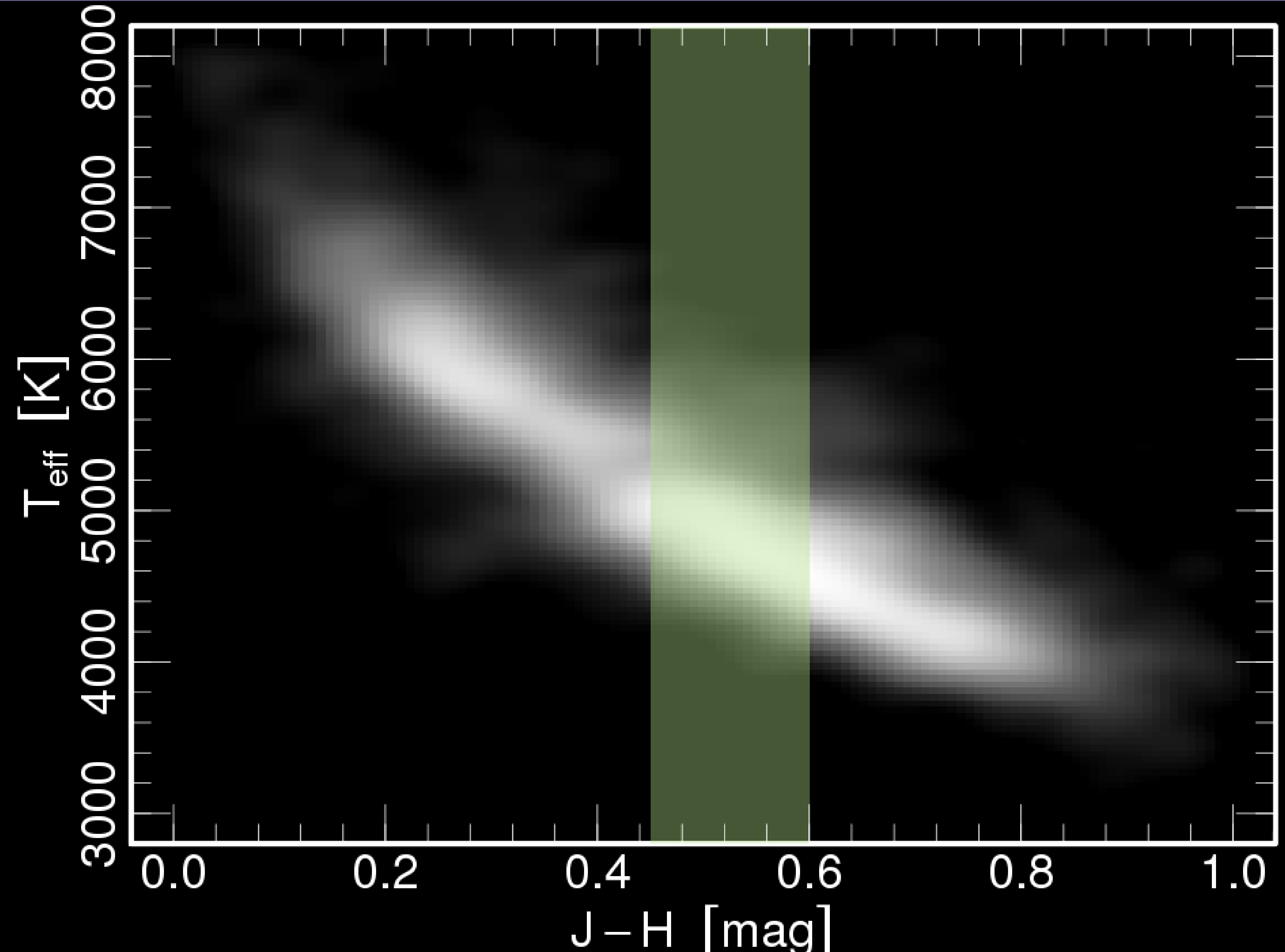
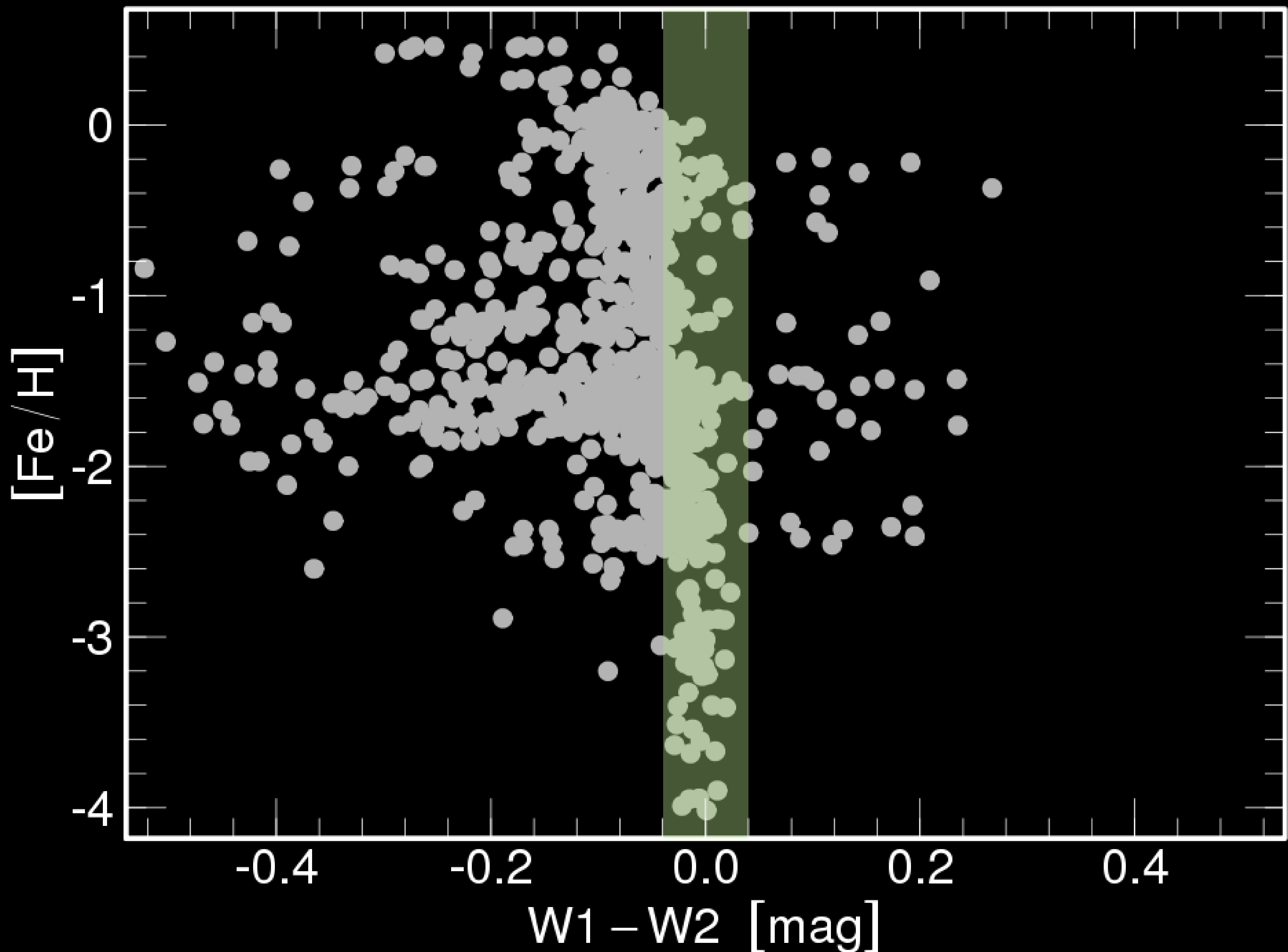


Proof of Concept

Schlaufman & Casey (2014)



Practice of Infrared EMP Selection

Schlaufman & Casey (2014)

(1) Select cool stars
=> $0.45 < J - H < 0.60$

(2) Select metal-poor stars
=> $-0.04 < W1 - W2 < 0.04$

(3) Refine focus on metal-poor stars
=> $J - W2 > 0.5$ and
$J - W2 > 0.5[(B - V) - 0.8] + 0.6$

(4) Use logistic regression to enhance focus

Practice of Infrared EMP Selection

Kevin Schlaufman

Schlaufman & Casey (2014)

(1) Select cool stars
=> 0.45 < *J* – *H* < 0.60

(2) Select metal-poor stars

	Our Selection	Chance
-3.0 < [Fe/H] < -2.0	32.5%	0.1%
-4.0 < [Fe/H] < -3.0	3.8%	0.01%

(4) Use logistic regression to enhance focus

Apparent Magnitude Distribution

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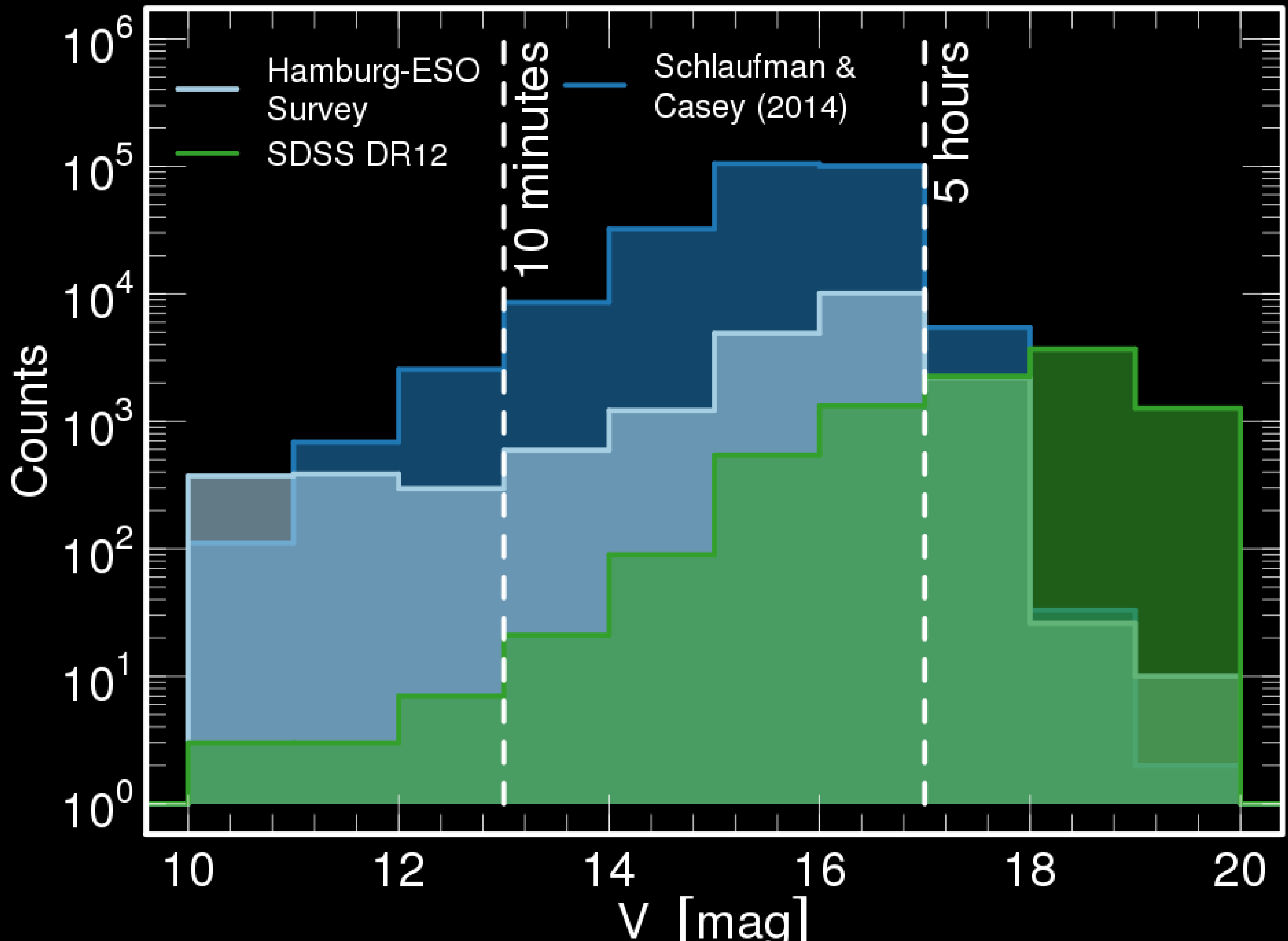
Schlaufman & Casey (2014)



Distance Distribution

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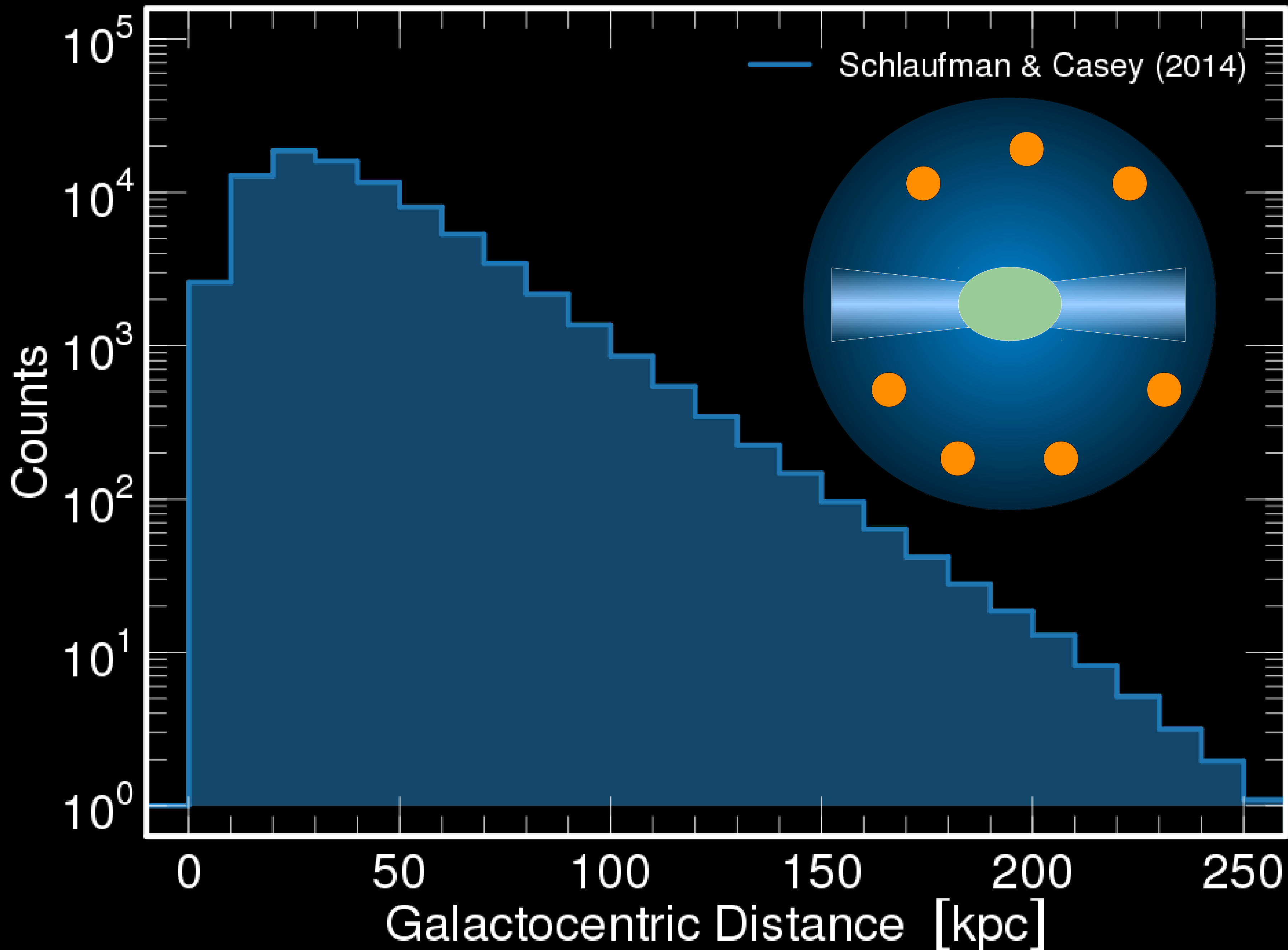
Schlaufman & Casey (2014)



The Old and the New

Spectroscopy First

While classical searches for metal-poor stars have achieved many successes, they are not perfect:

(1) They are resource intensive.
(2) They fail in regions of high extinction and/or reddening.
(3) They fail in crowded regions.
(4) They only identify candidates with faint apparent magnitudes.

WISE Photometry

The infrared selection of Schlaufman & Casey (2014) addresses many of those issues:

(1) It uses only public APASS optical, 2MASS infrared, and WISE mid-infrared photometry.
(2) A infrared-only variant is well suited to the identification of metal-poor stars in highly extincted and reddened fields.
(3) It works well in crowded fields.
(4) It identifies many bright candidates

Follow-up Program

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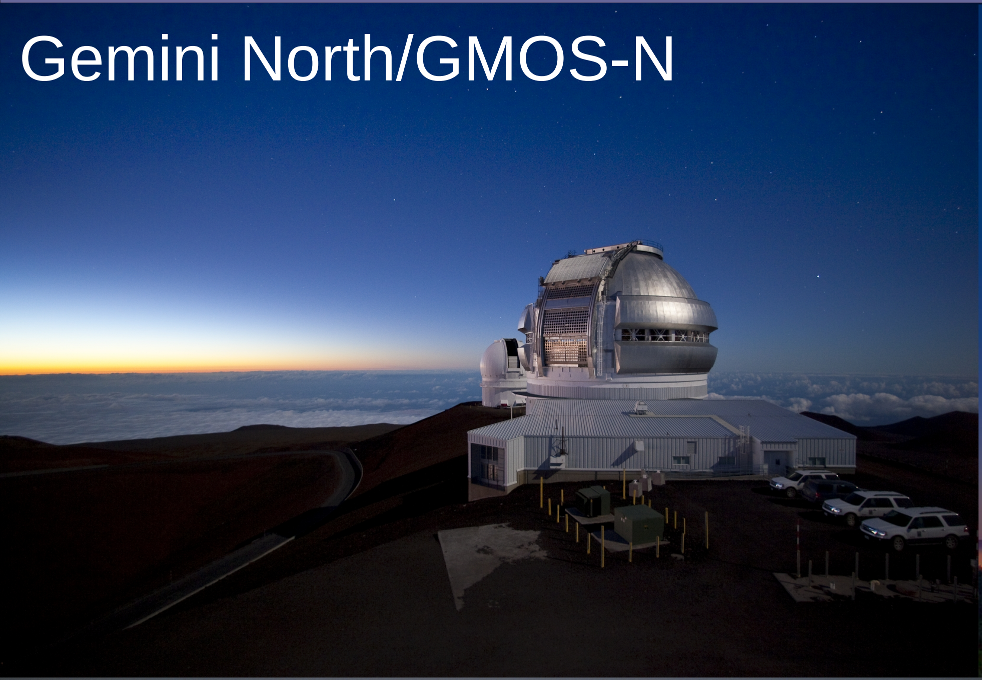

Metal-poor Stars != First Stars

Stars at a given metallicity form over a wide range in redshift, so metallicity alone is an imperfect measure of absolute age.

Oldest Stars are in the Bulge!

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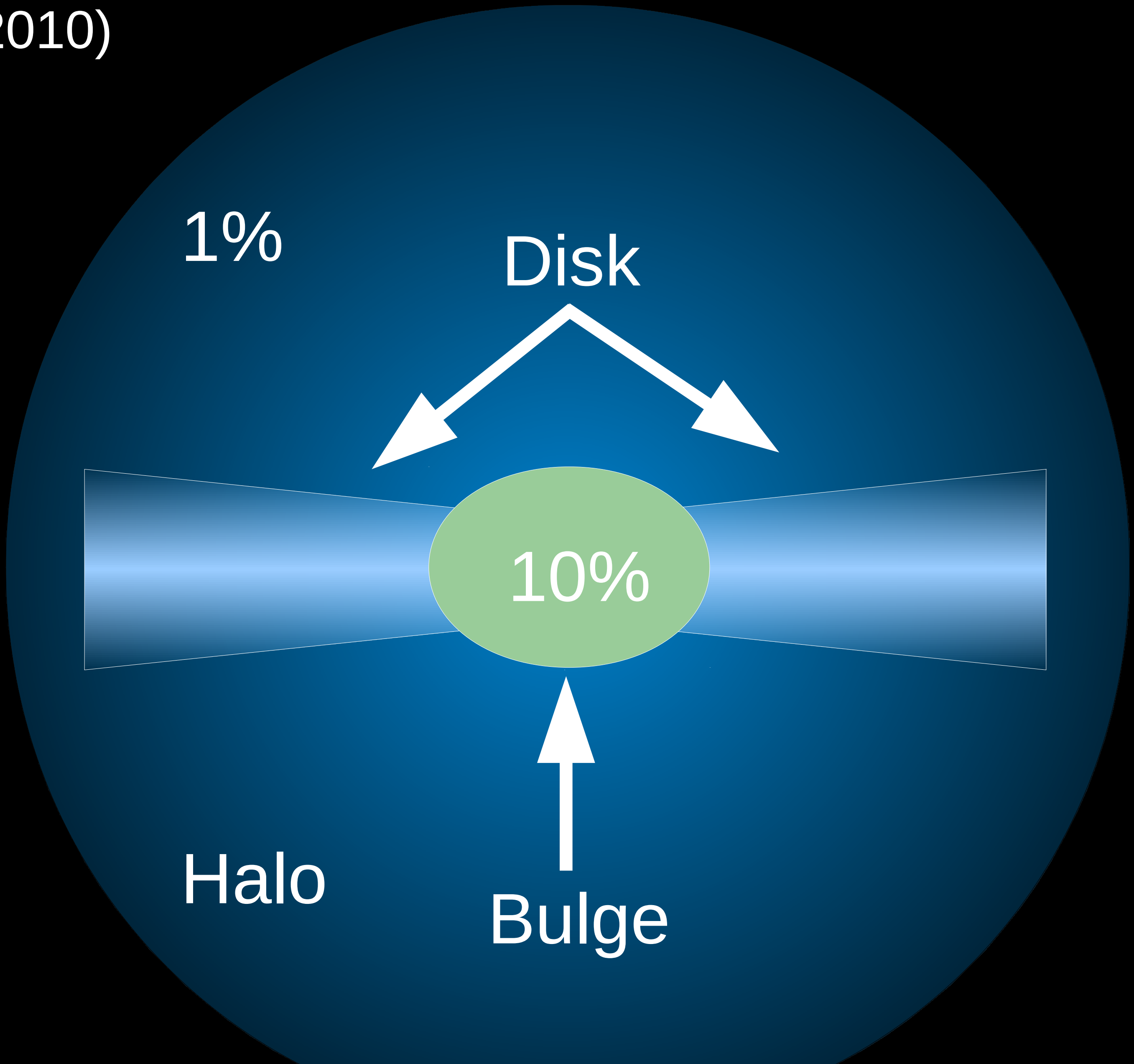
Tumlinson (2010)



Extremely Metal-Poor (EMP) <=> -4.0 < [Fe/H] < -3.0

Most Metal-poor Stars in the Bulge

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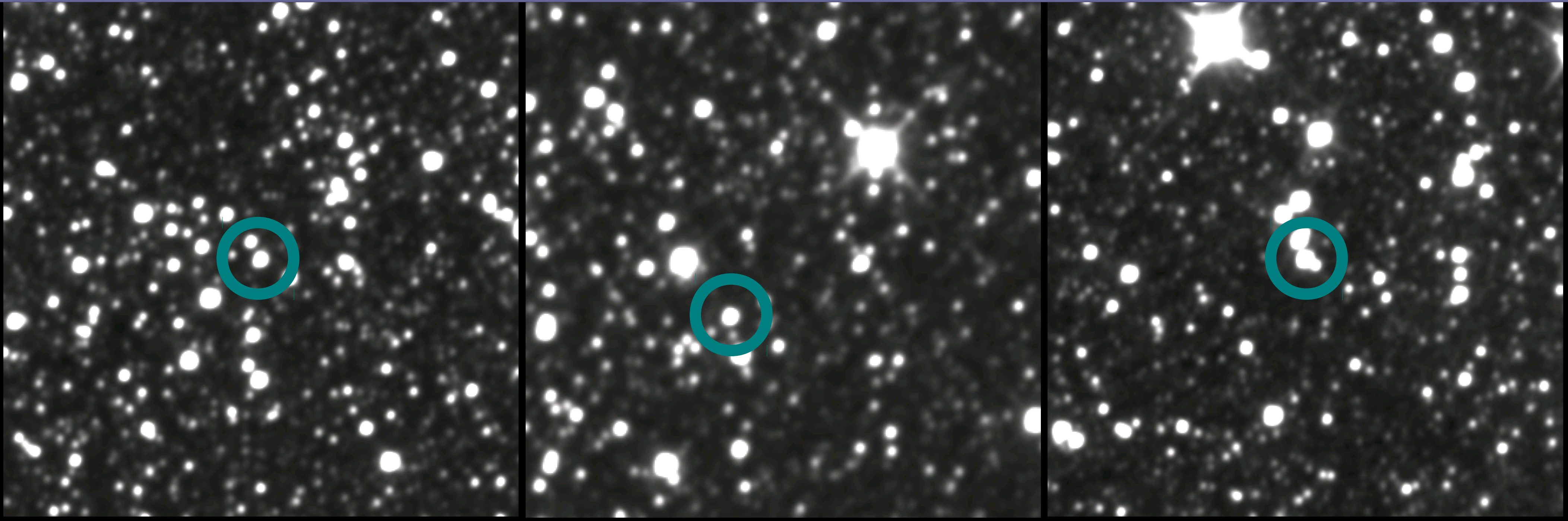
12 February 2015
Schlaufman & Casey (2014)



Star (2MASS)	T_{eff}	log *g*	[Fe/H]
J183713-314109	4797	0.99	-2.70
J181503-375120	4728	1.09	-2.84
J155730-293922	4720	1.12	-3.02

Most Metal-poor Stars in the Bulge

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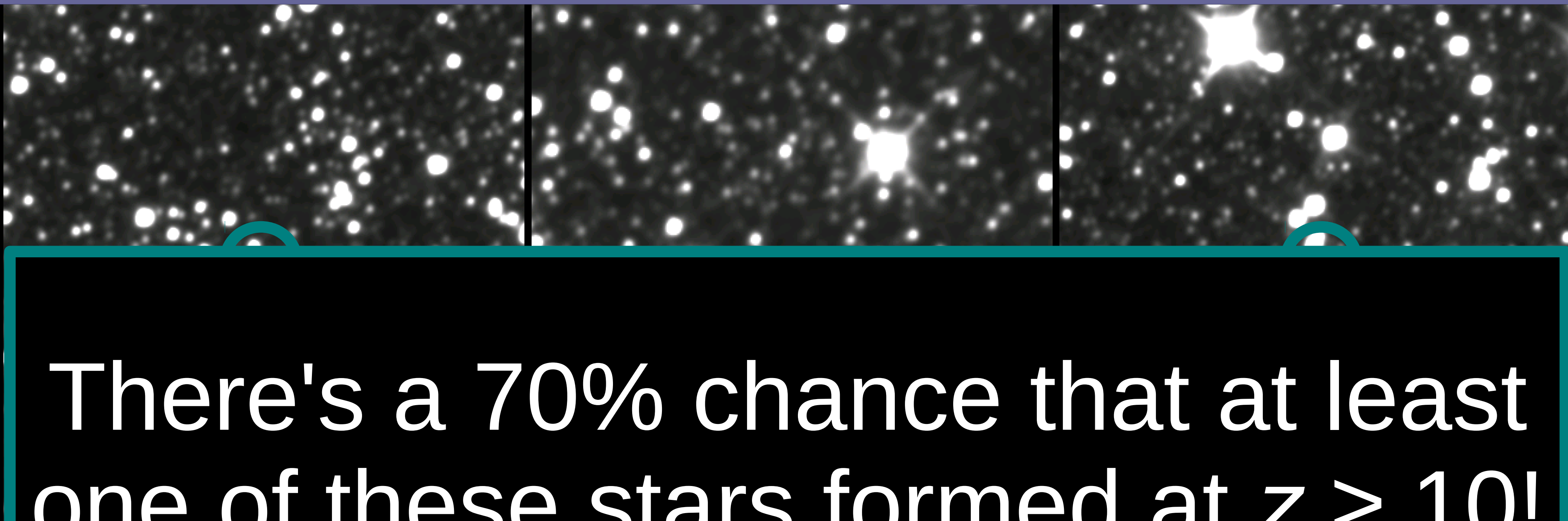
12 February 2015
Casey & Schlaufman (2015)



There's a 70% chance that at least one of these stars formed at $z \geq 10$!

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Detailed Abundances

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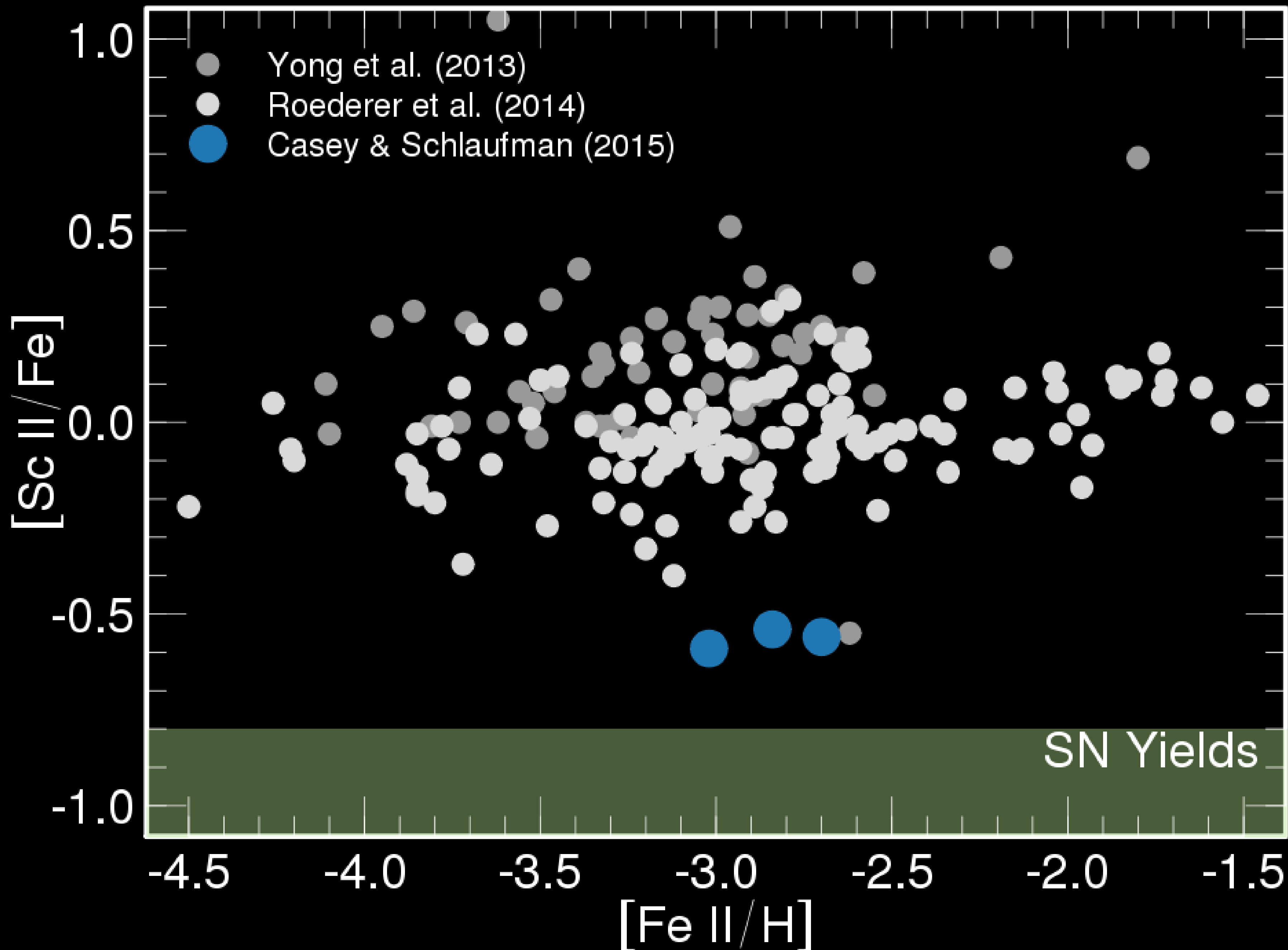
Casey & Schlaufman (2015)



Detailed Abundances

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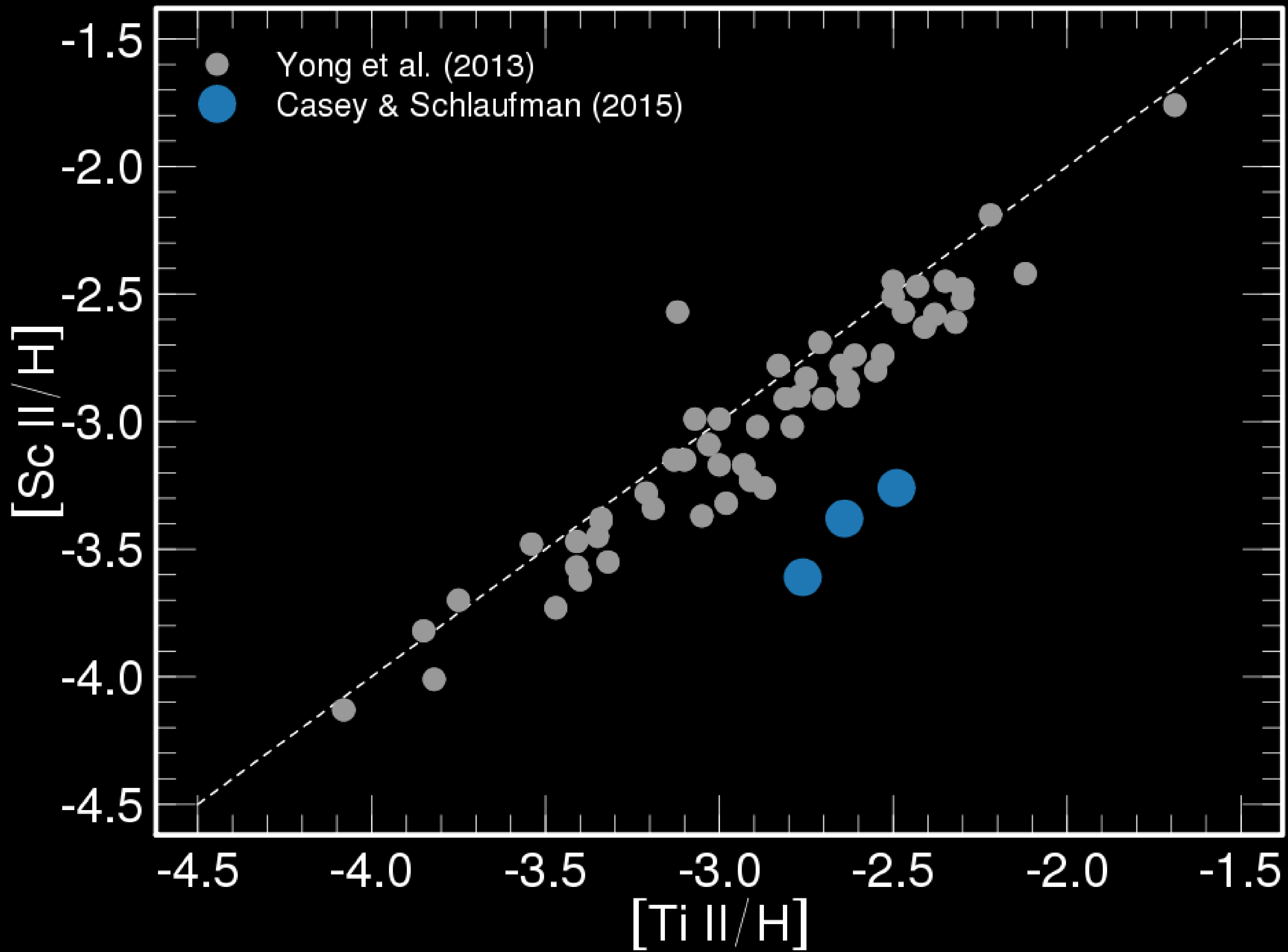

AAT/AAOmega Follow-up Program

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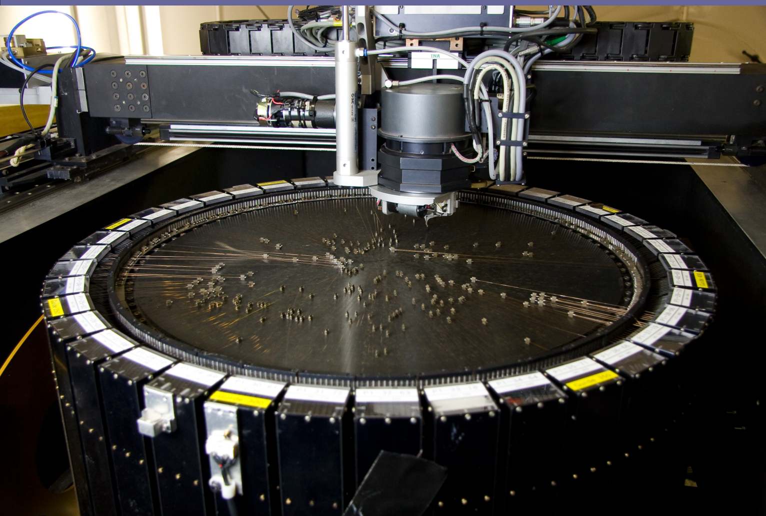

Future Work

The Brightest Metal-poor Stars: a field survey based on Schlaufman & Casey (2014) will double the number of known EMP stars with $V < 12$. Only stars this bright can efficienty be observed with *HST*/COS+STIS UV spectroscopy.

The Most Ancient Stars: a bulge survey based on the infrared-only selection of Schlaufman & Casey (2014) will identify >100 EMP stars in the bulge, >10 of which should have formed at $z > 15$. It provides the best chance to identify any existing Pop III stars.

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A few possibilities...

(1) Metal-poor K giants as tracers of the distance halo
- Dark Energy Spectroscopic Instrument (DESI), Subaru Prime Focus Spectrograph,...

(2) Asteroseismology of extremely metal-poor stars
- *K2*, Transiting Exoplanet Survey Satellite (TESS),...

(3) Extremely metal-poor stars in dwarf galaxies, including the Magellenic Clouds

(4) Extremely metal-poor stars in the halos of nearby galaxies with *JWST*/NIRCam grism spectroscopy

(5) Gaia parallaxes and proper motions for orbital analyses