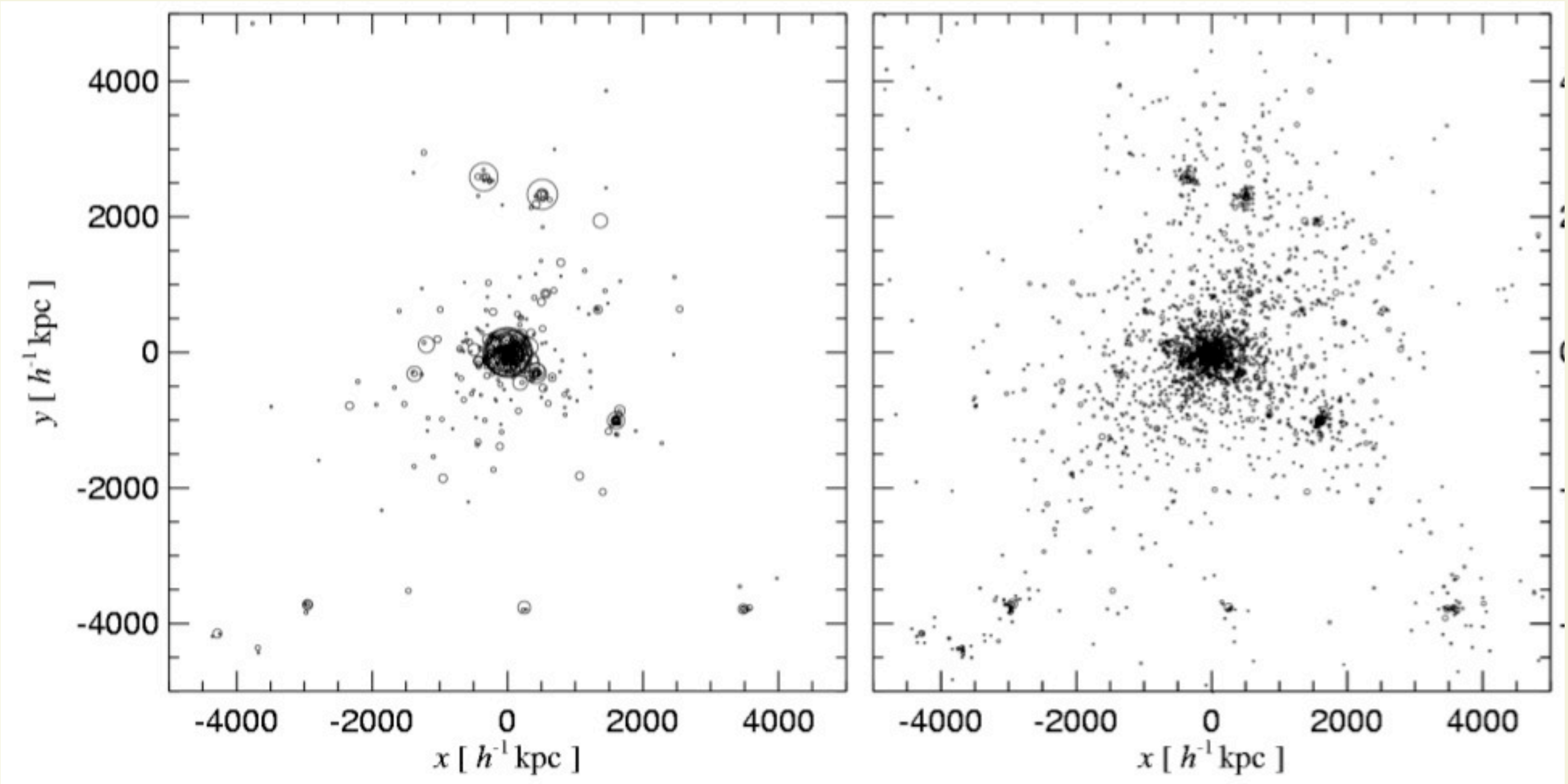
MOAO in the Galactic Centre

Kim Venn (UVic)

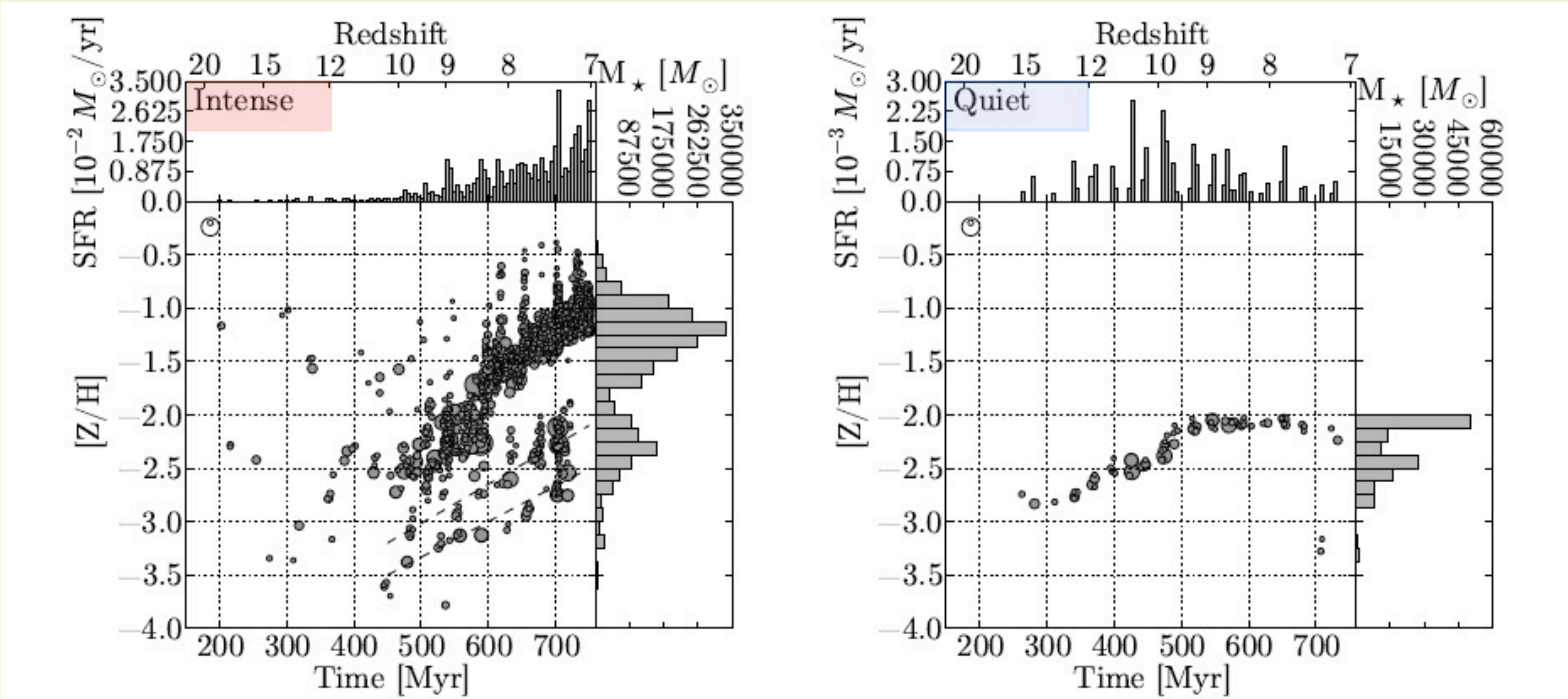
Thinkshop : potsdam
August 2014

1% EARLIEST STARS

1% MOST METAL POOR



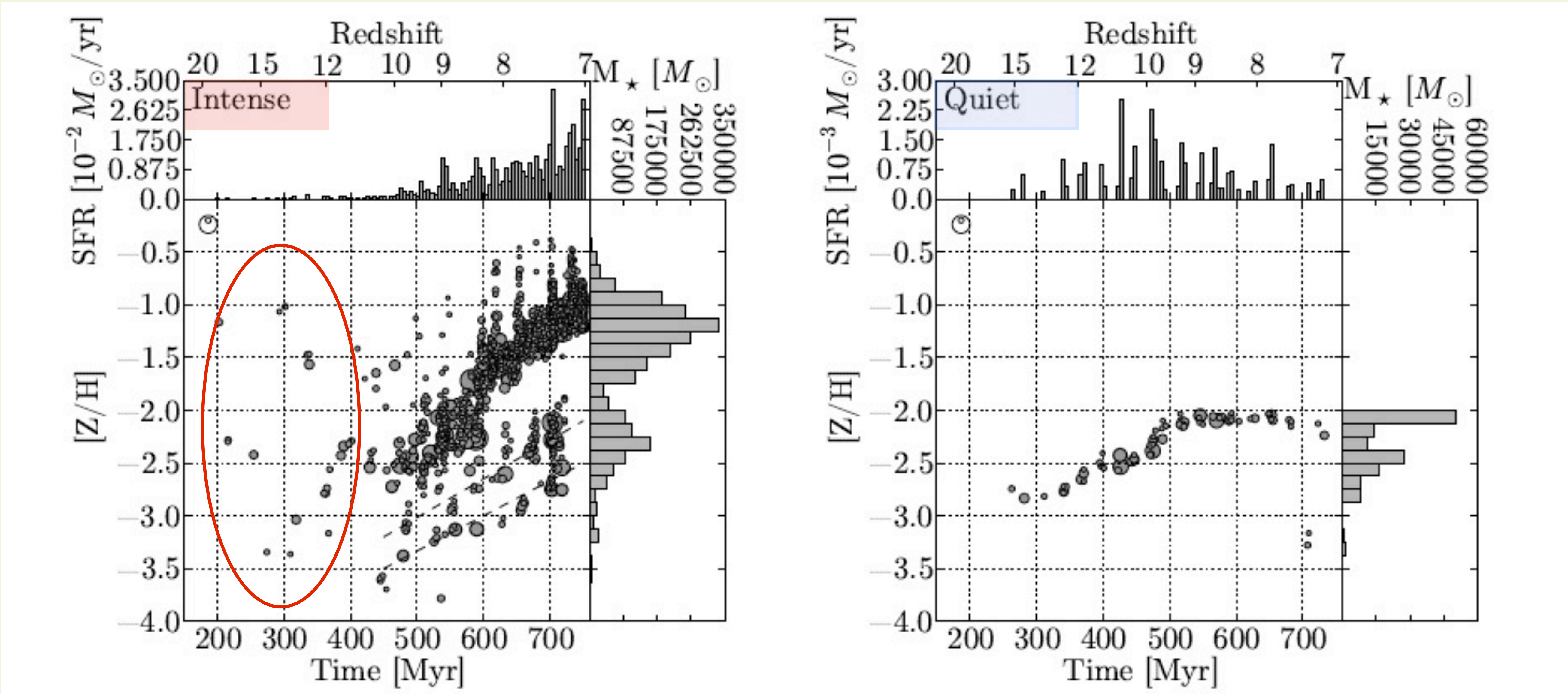
Z=0



The OLDEST stars are not necessarily the most metal poor,

e.g., the Intense Model's oldest stars can have [Z/H] > -1.0 to -3.5.

e.g., the Quiet Model's most metal poor stars form later.



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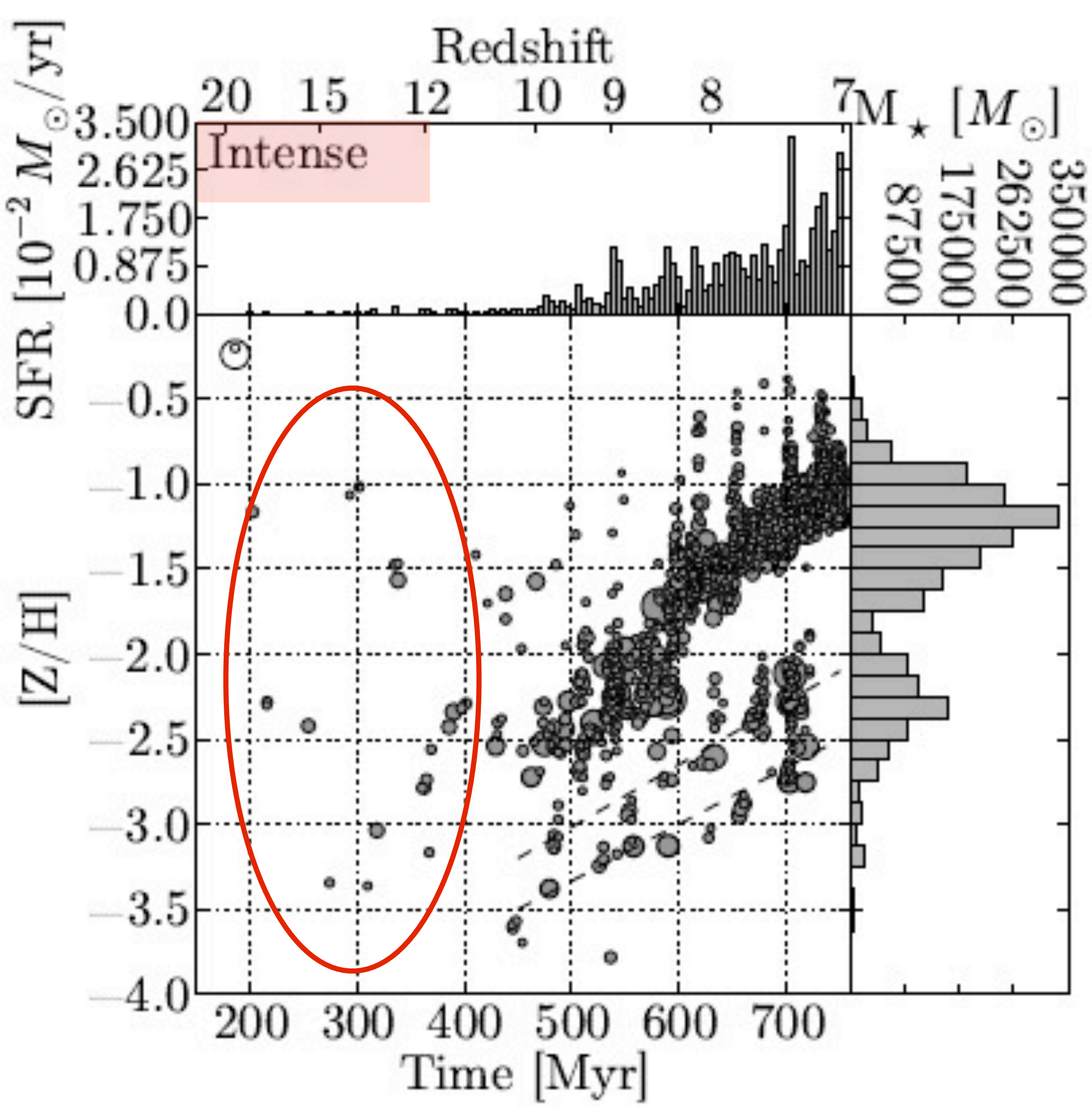

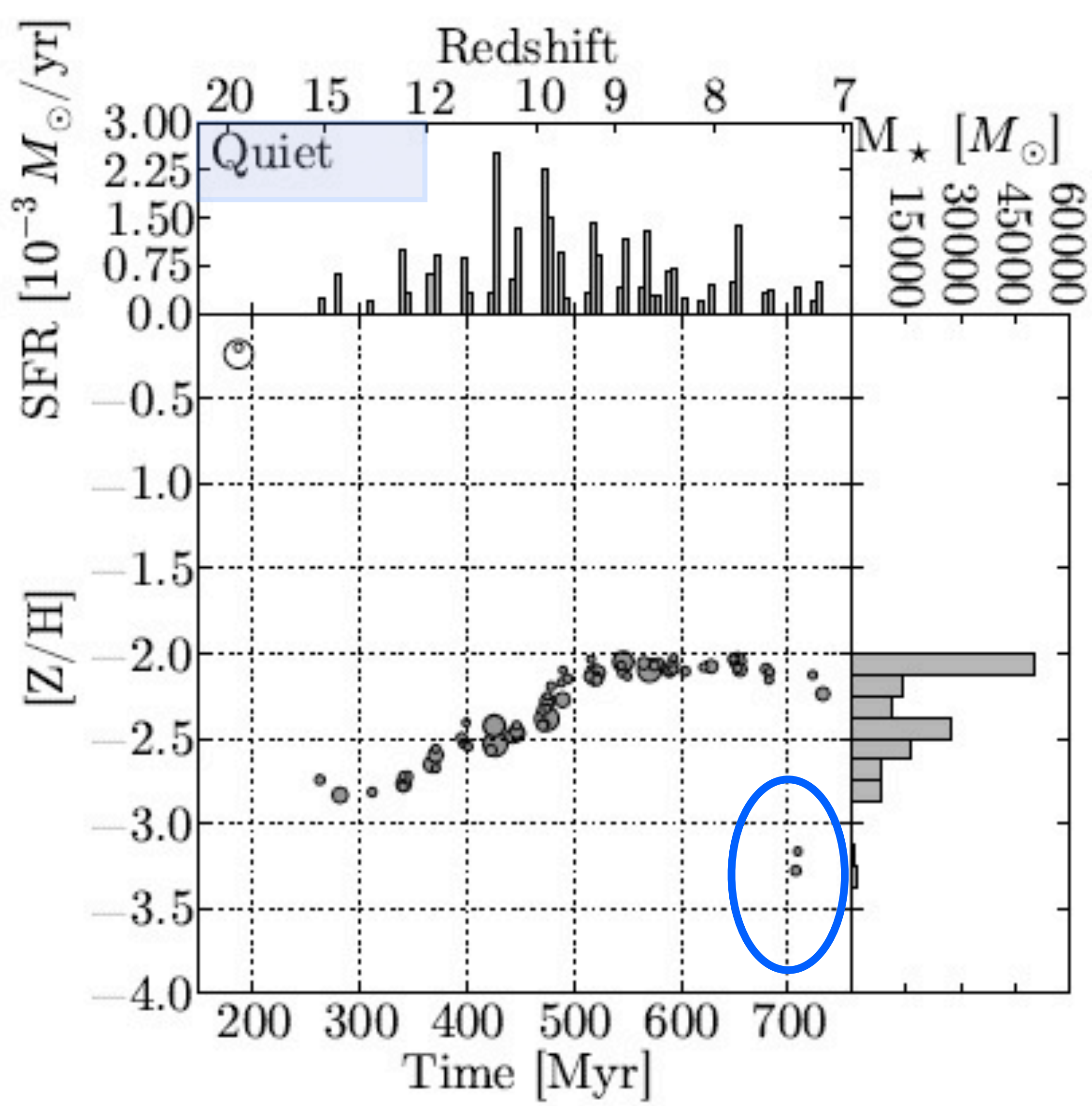

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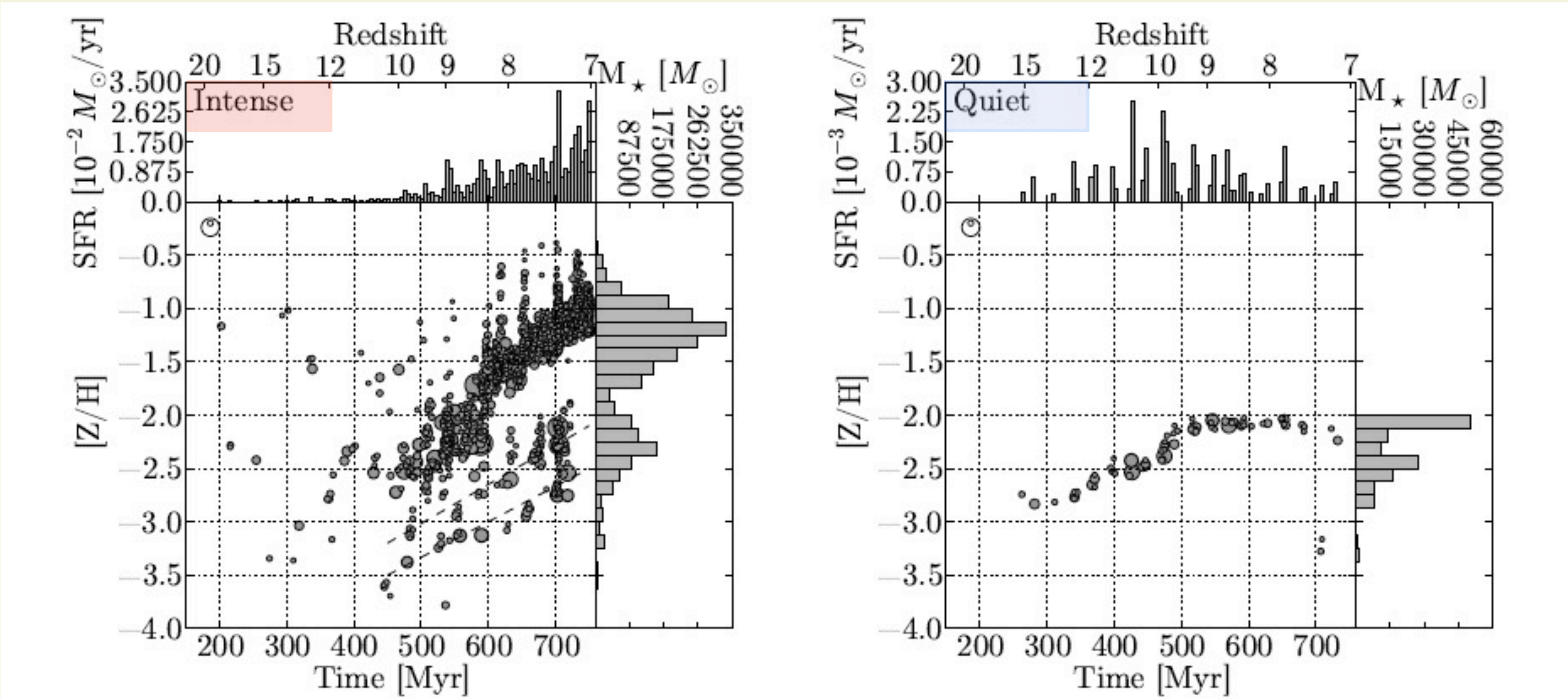
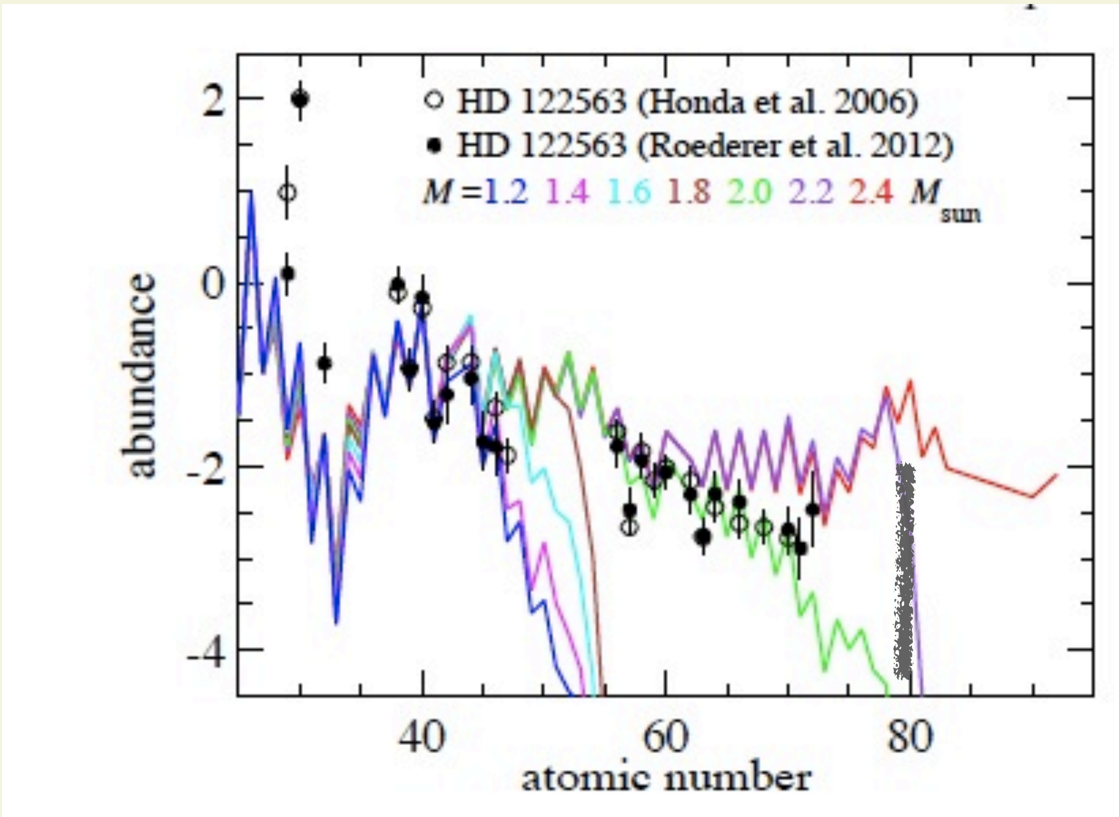
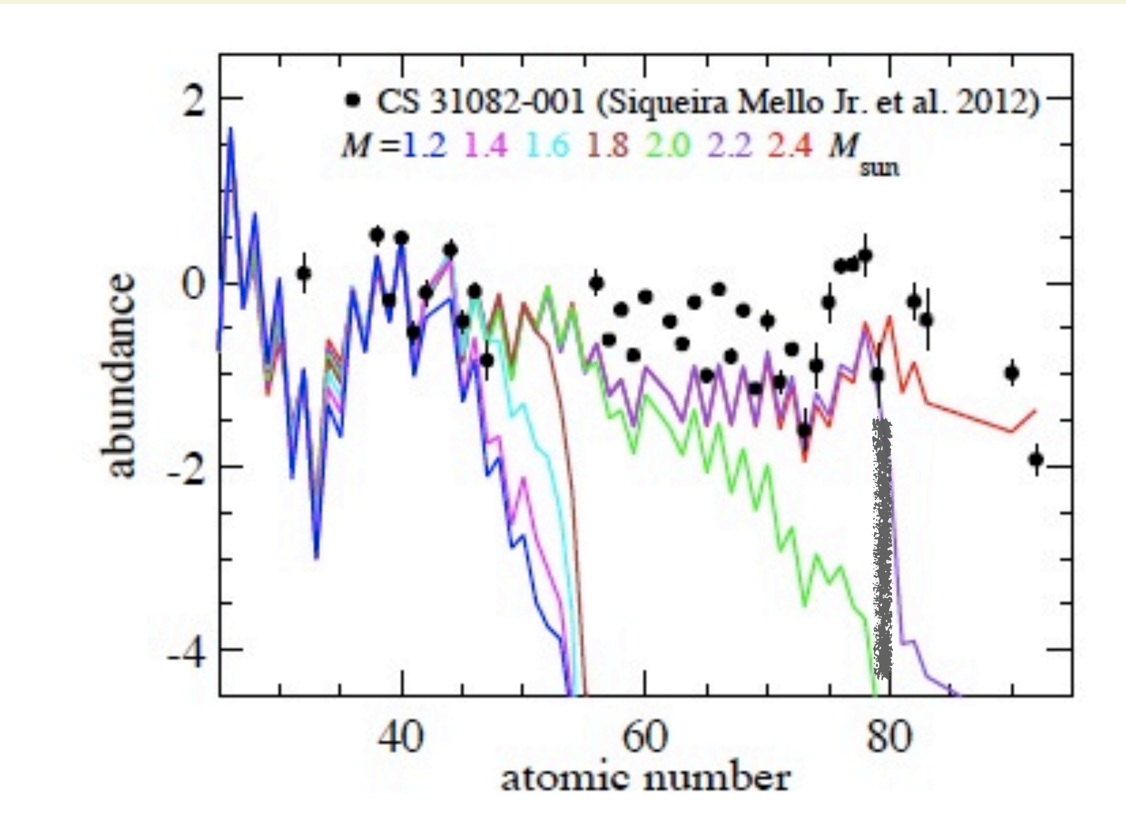
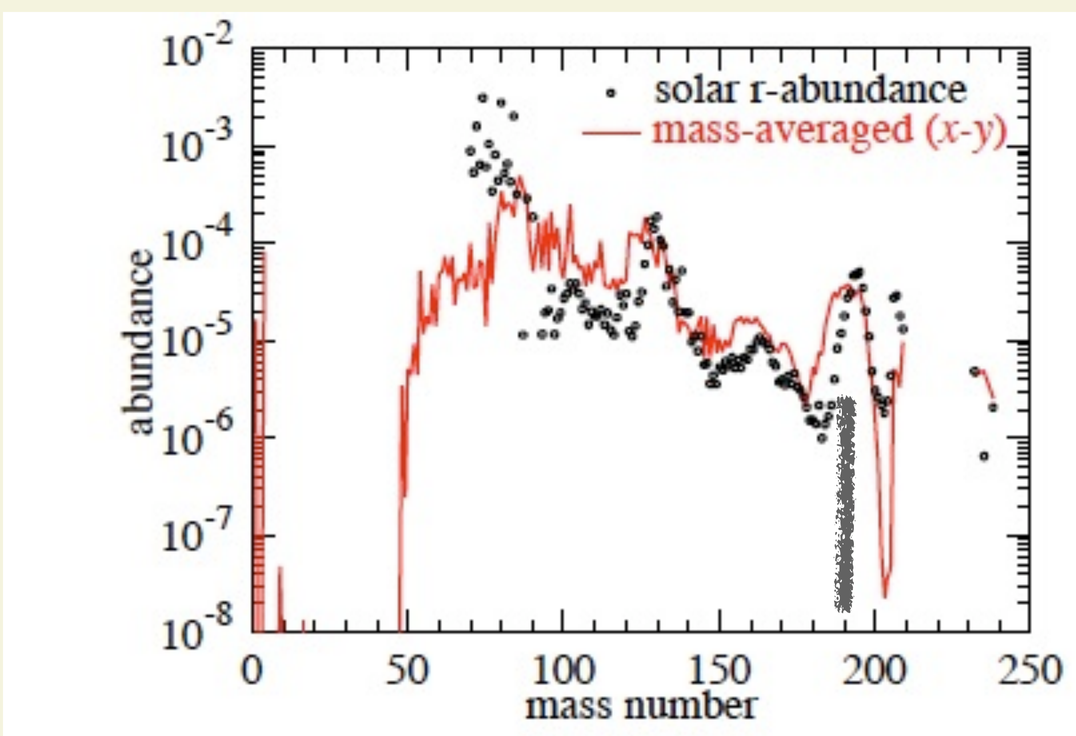


Thus, rather than focusing on most MP stars ([Fe/H] < -3) curious what MP stars in the Galactic Bulge may look like.

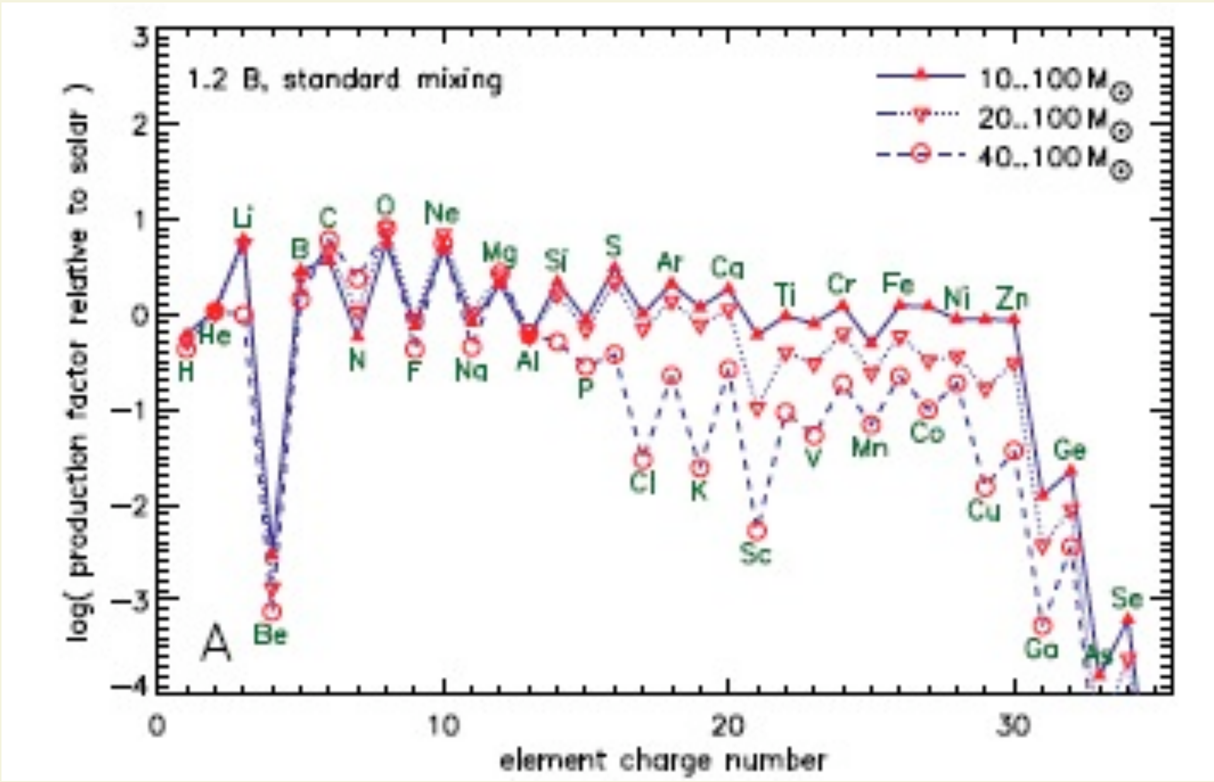






Wanajo 2013:
PNS winds in core collapse SN
Even highest masses cannot reproduce heaviest r-process elements.

Wanajo et al. 2014:
Neutron star mergers rare, but excellent source for heavy r-process elements.

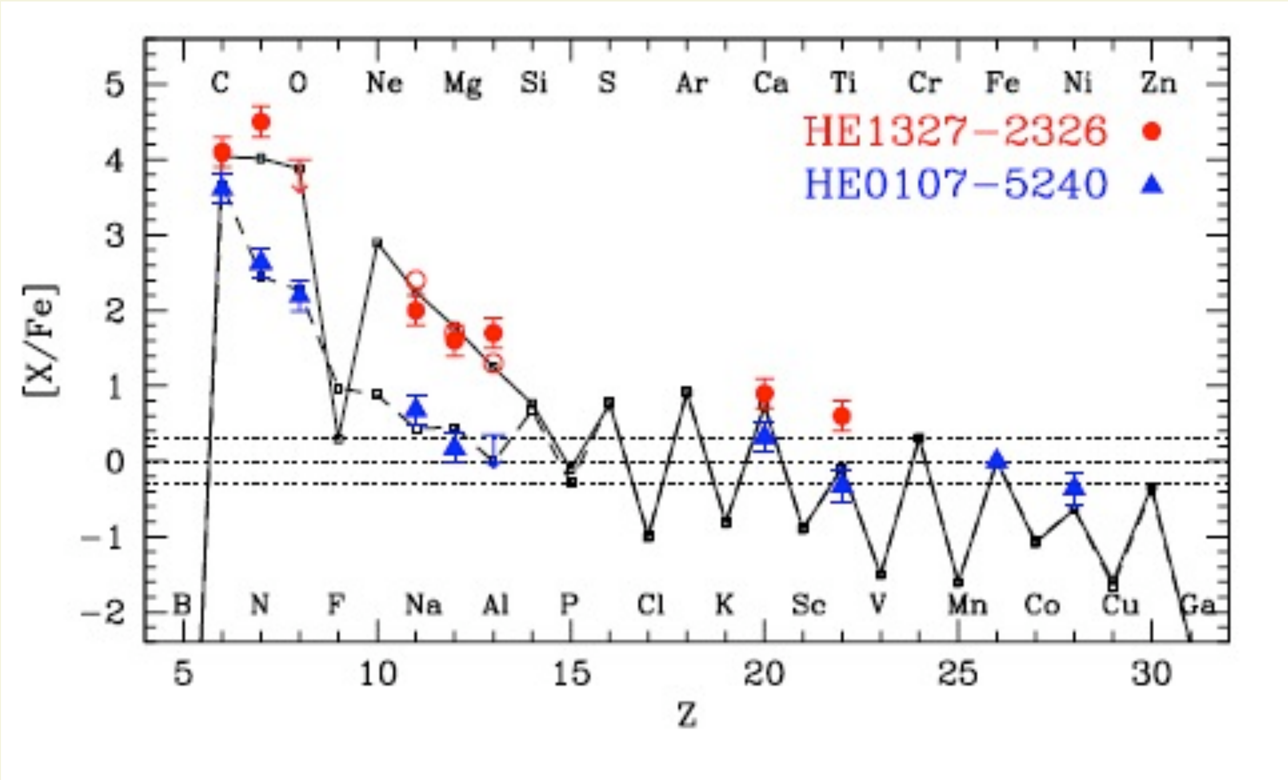


Heger & Woosley 2008

sample of models

little/no yields beyond Fe

similarly PISN (Heger & Woosley 2002)



Iwamoto et al 2005

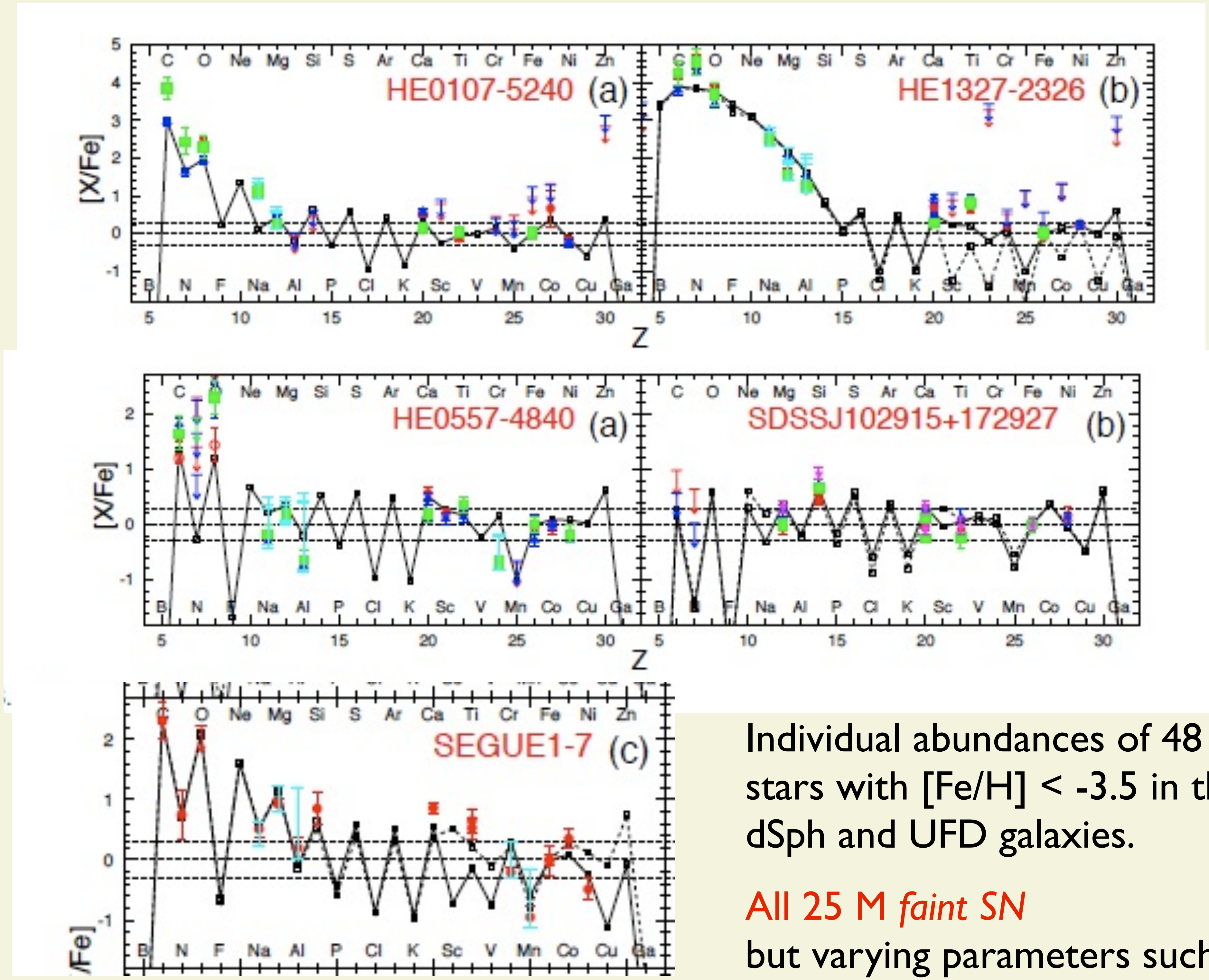
25 M Pop III "faint supernova"

(extensive mixing & fallback during the explosion)

"Faint SN"

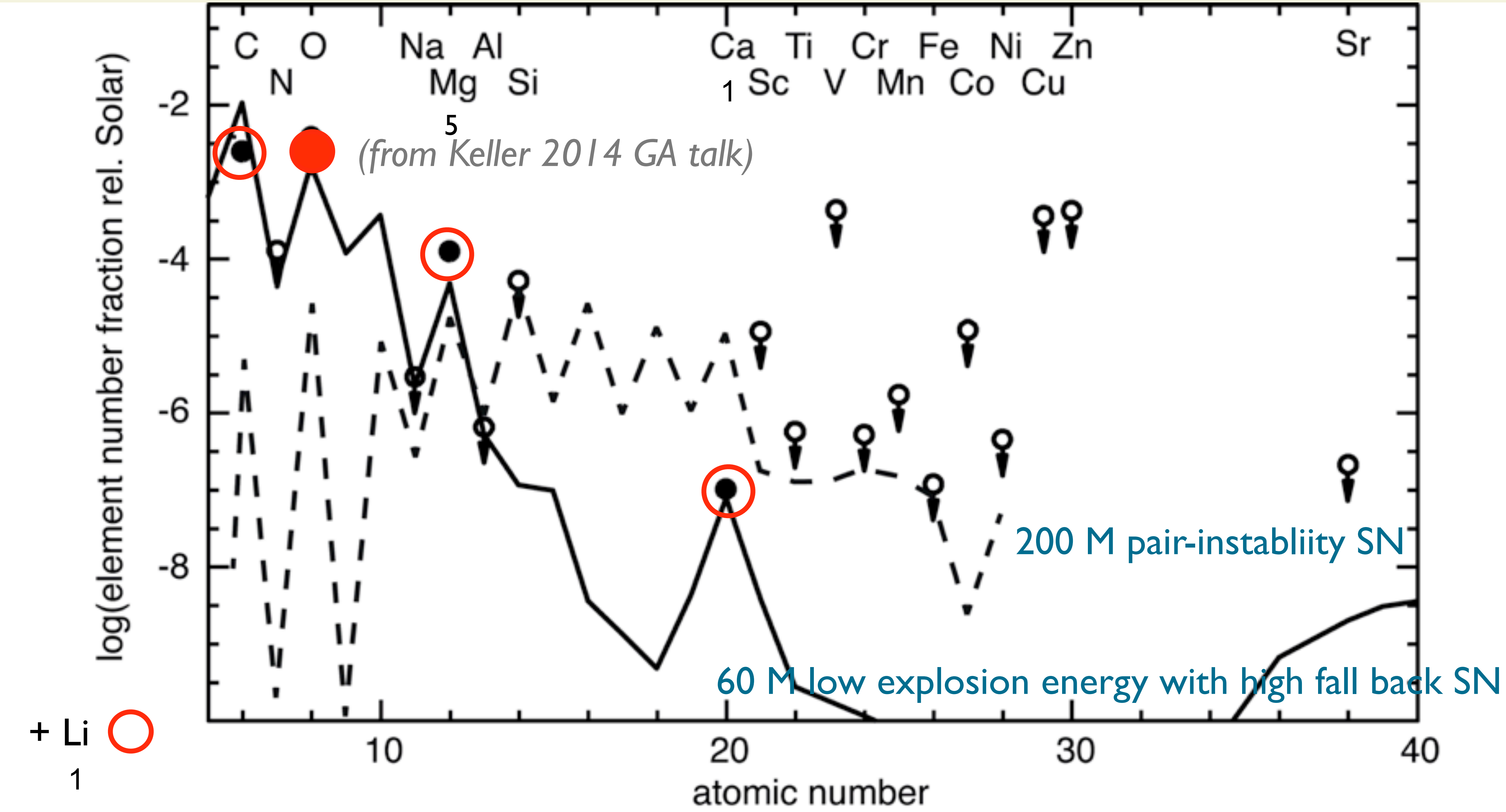
- is faint because Fe is synthesized from the 56Ni that powers the light curve.
- observed (e.g., SN1999br, SN 2008ha)
- satisfies many observational constraints (see list by Tominaga et al. 2014)

Tominaga et al. 2014: 25 M Faint SNe



Individual abundances of 48 metal poor stars with [Fe/H] < -3.5 in the MW halo, dSph and UFD galaxies.

All 25 M *faint SN*
but varying parameters such as explosion energy, mass cuts, mixing efficiencies, etc.



The solid line shows the abundances predicted for a 60 M Population III star of relatively low explosion energy (1.8×10^{51} erg) and low levels of internal mixing (Joggerst, Woosley & Heger 2009). The dashed line shows the expected yield from a 200 M supernova (pair-instability mechanism).

Thus, are the metal poor stars in the MW halo and dwarfs actually representative of the First Stars?

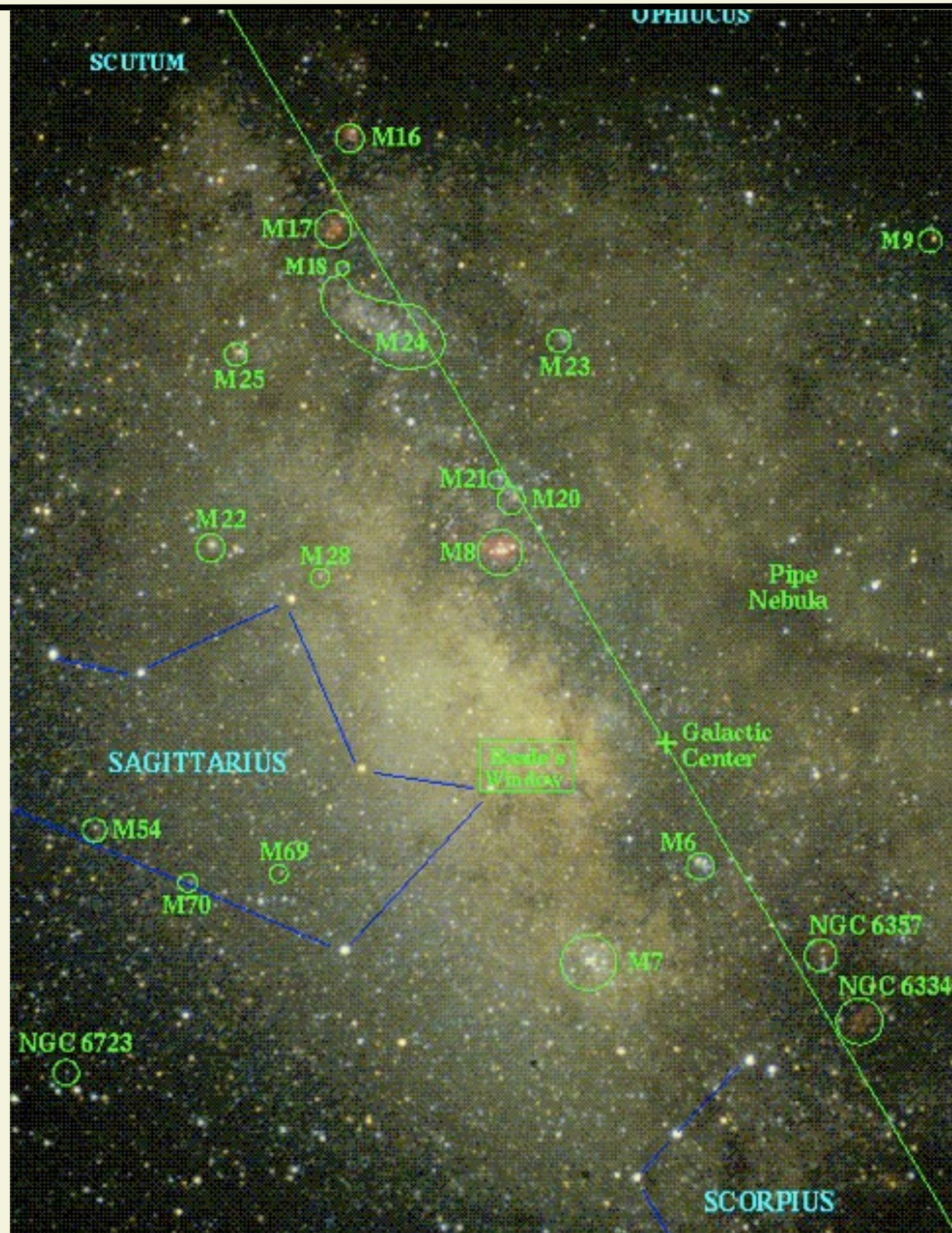
Did 25 M faint SN contribute to

the ionizing photons at reionization?

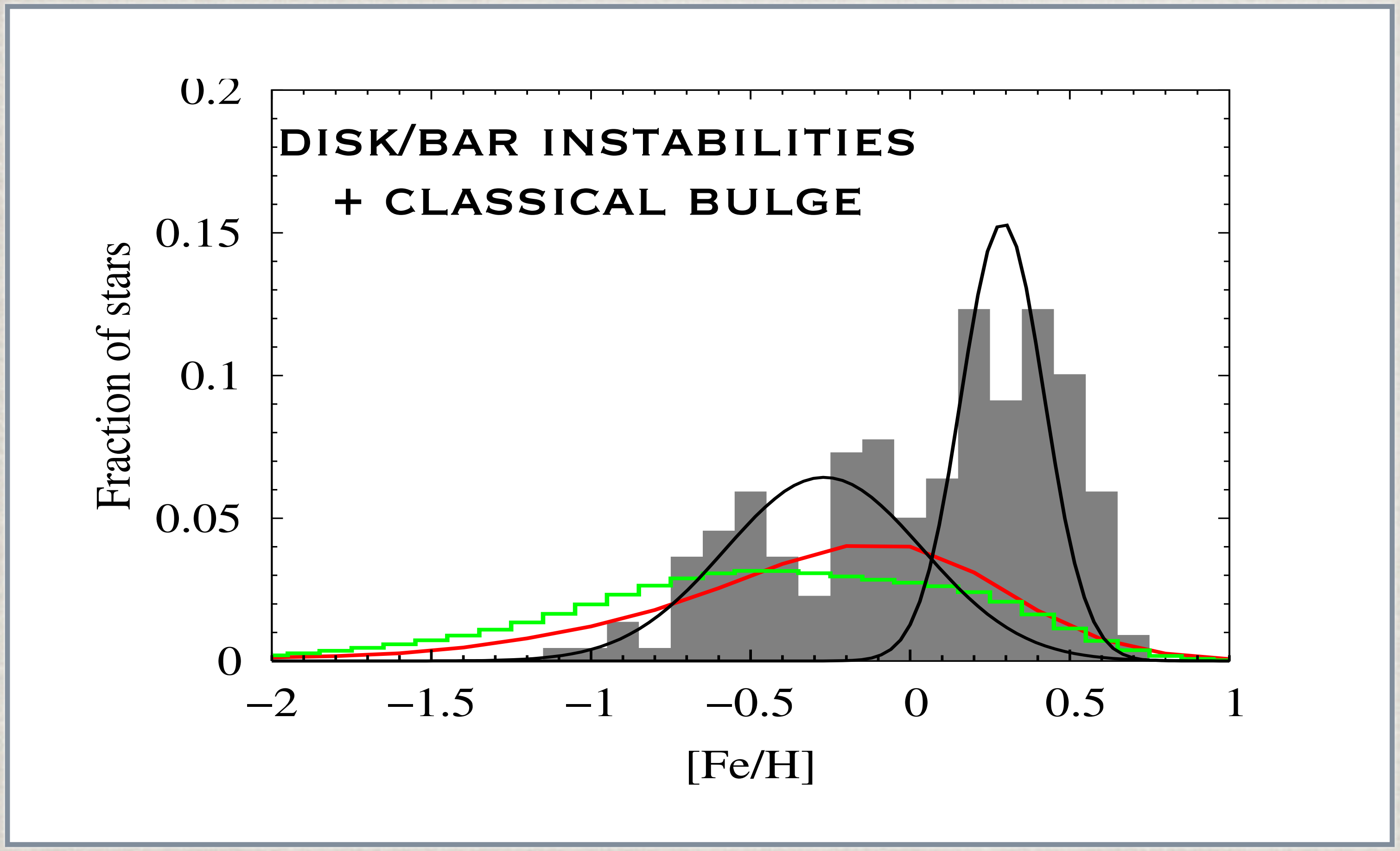
the earliest stages of feedback?

significant stages of chemical evolution?

If this were easy, it would have been done



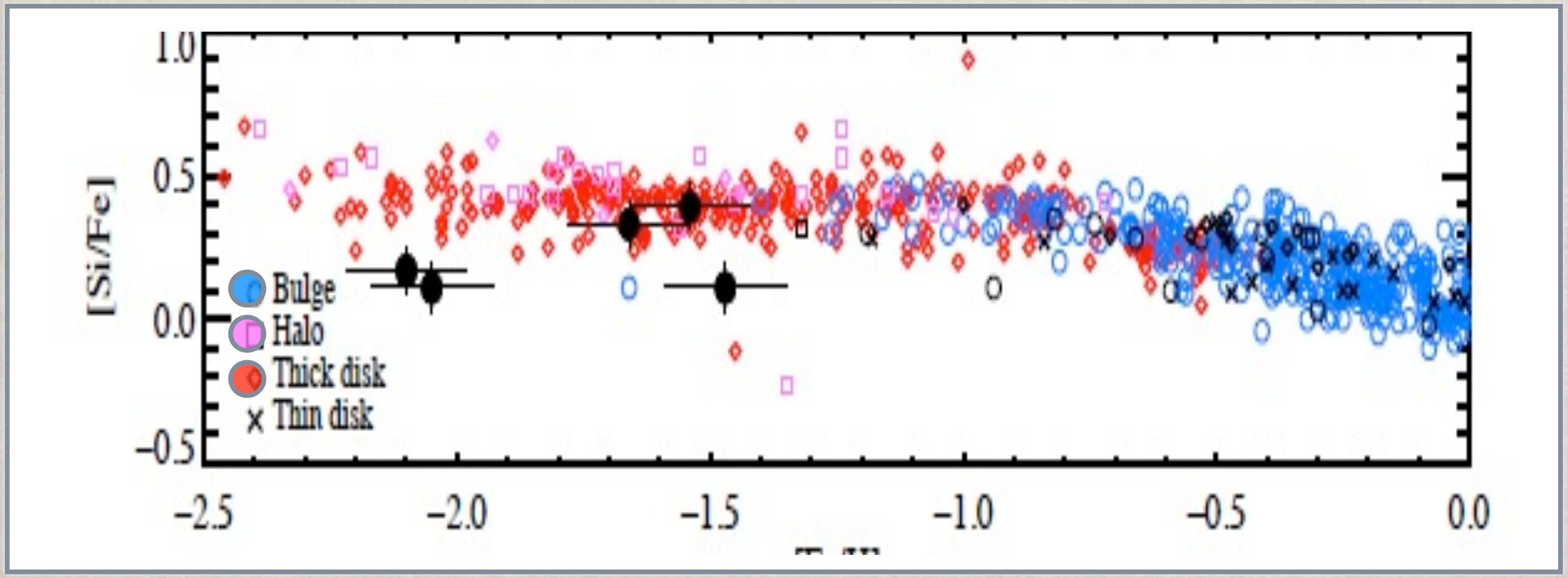
Bulge Metallicity Distribution Function - past



Hill et al. 2011

~200 RGBs

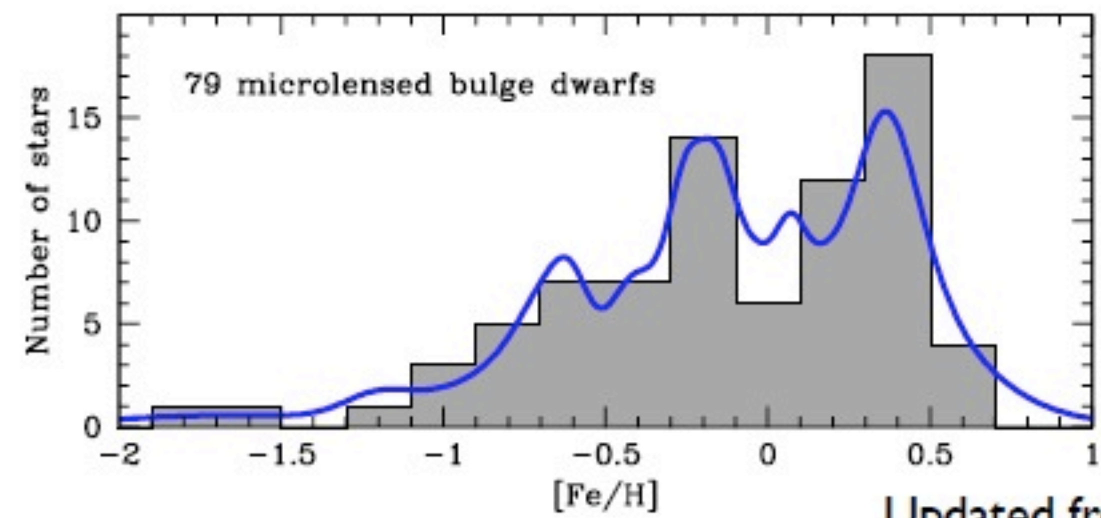
in Baade's Window



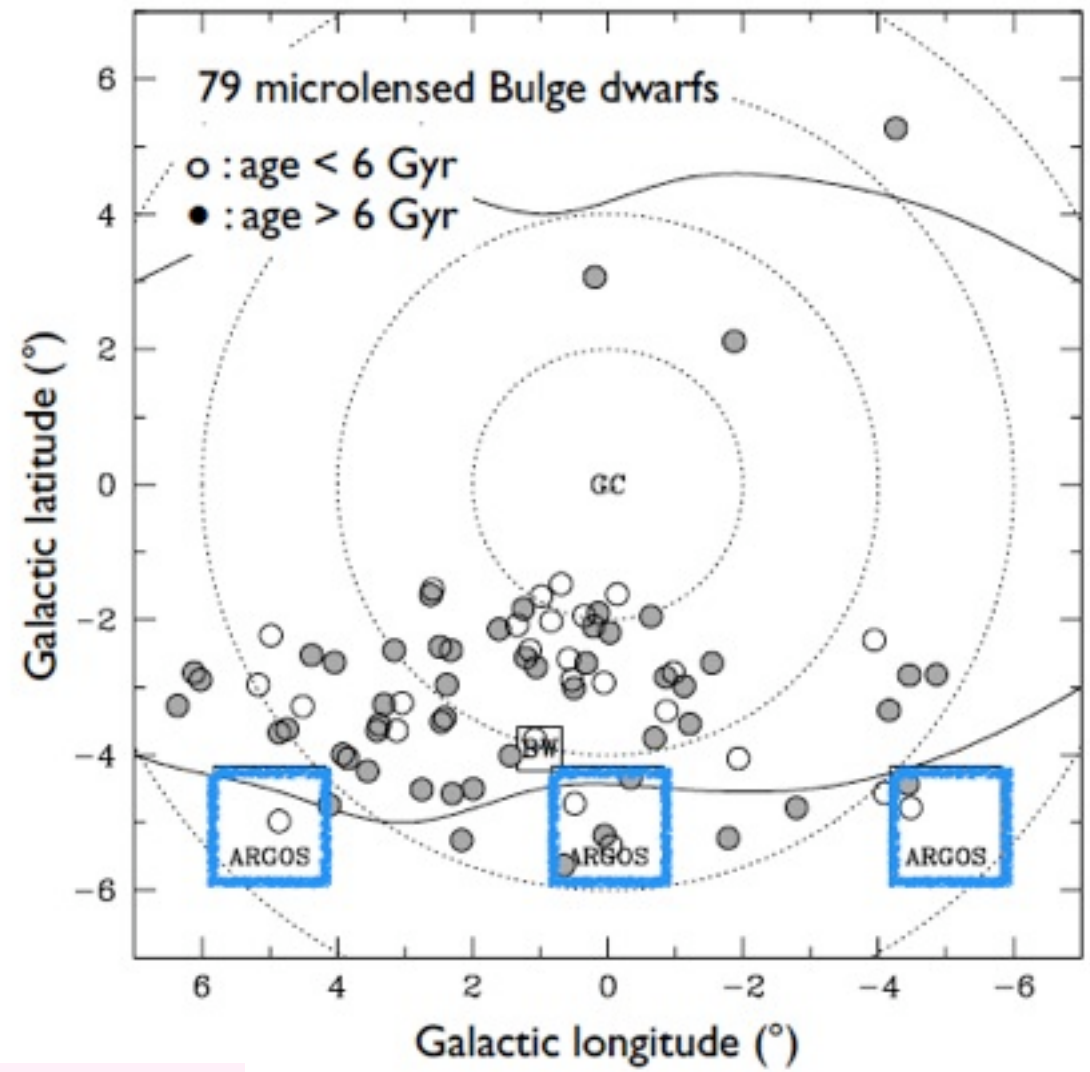
Garcia-Perez et al. 2013

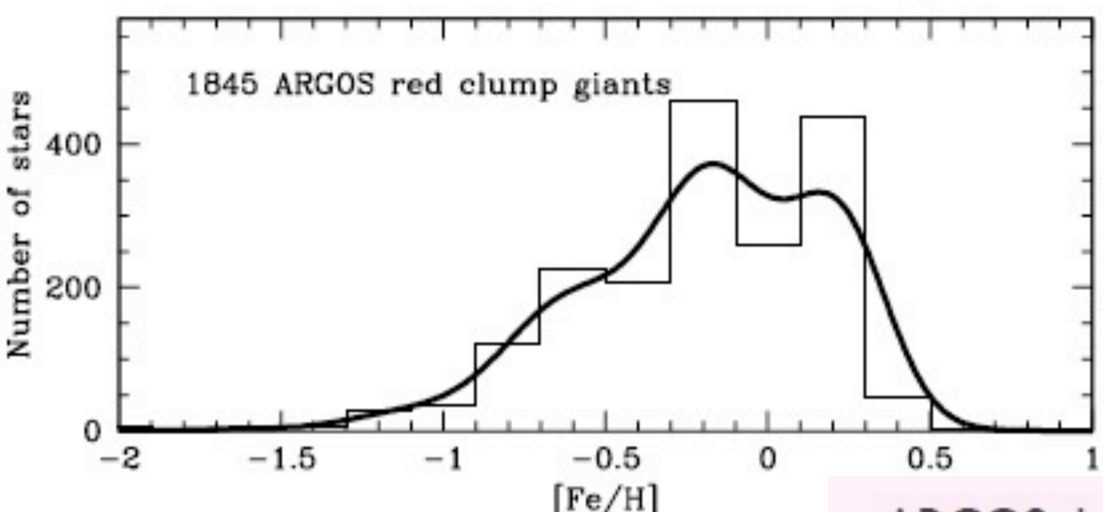
2403 bulge RGBs from APOGEE

Bulge Metallicity Distribution Function - Today



Updated from Bensby et al. (2013)





ARGOS data from Melissa Ness' (2013)
AAOmega R~11,000 CaT survey 28,000 stars

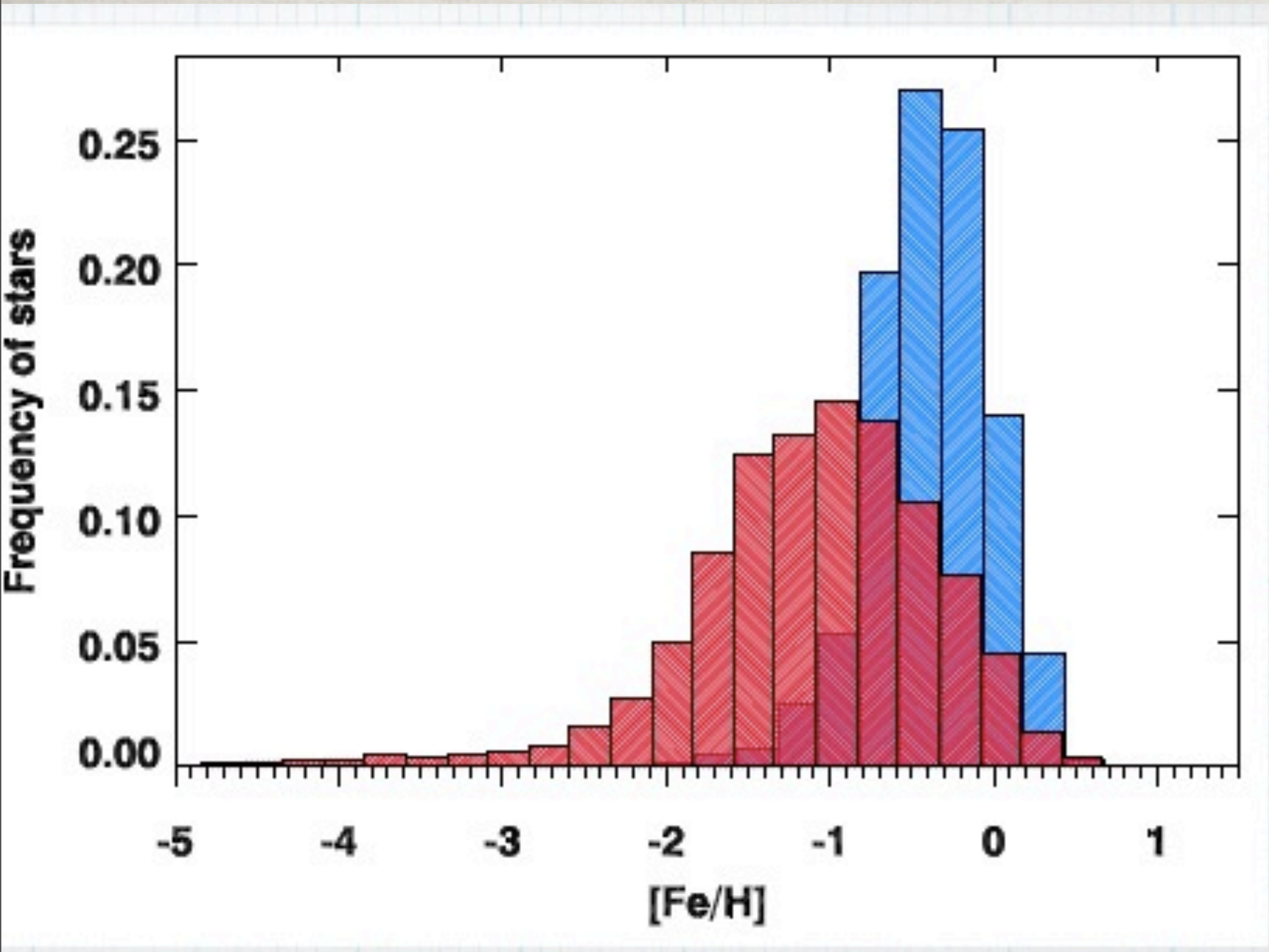
The ARGOS data includes positions & velocities as well.
They attribute the bulge components to instability-driven bar/bulge formation but do not exclude a weak underlying classical merger-generated bulge component.
And still all stars with [Fe/H] > -2

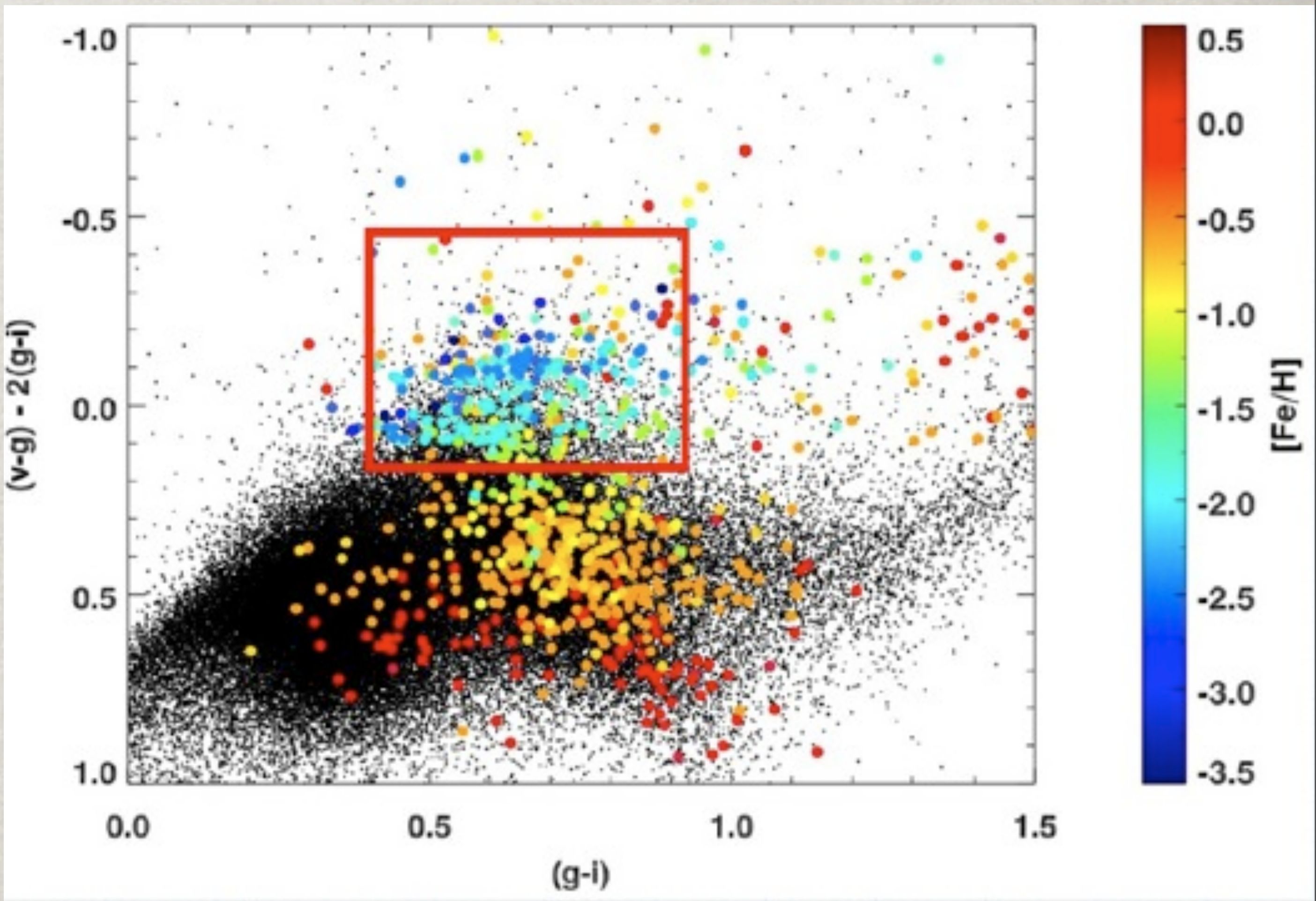
Search for metal poor stars in the Bulge

(Howes, Asplund, Freeman et al 2014 in prep)

AAOmega EMBLA (Howes et al. 2014 in prep)
AAOmega ARGOS (Ness et al. 2013)

60 stars with [Fe/H] < -3 !
classical bulge?
related to First Stars?
note biased MDF

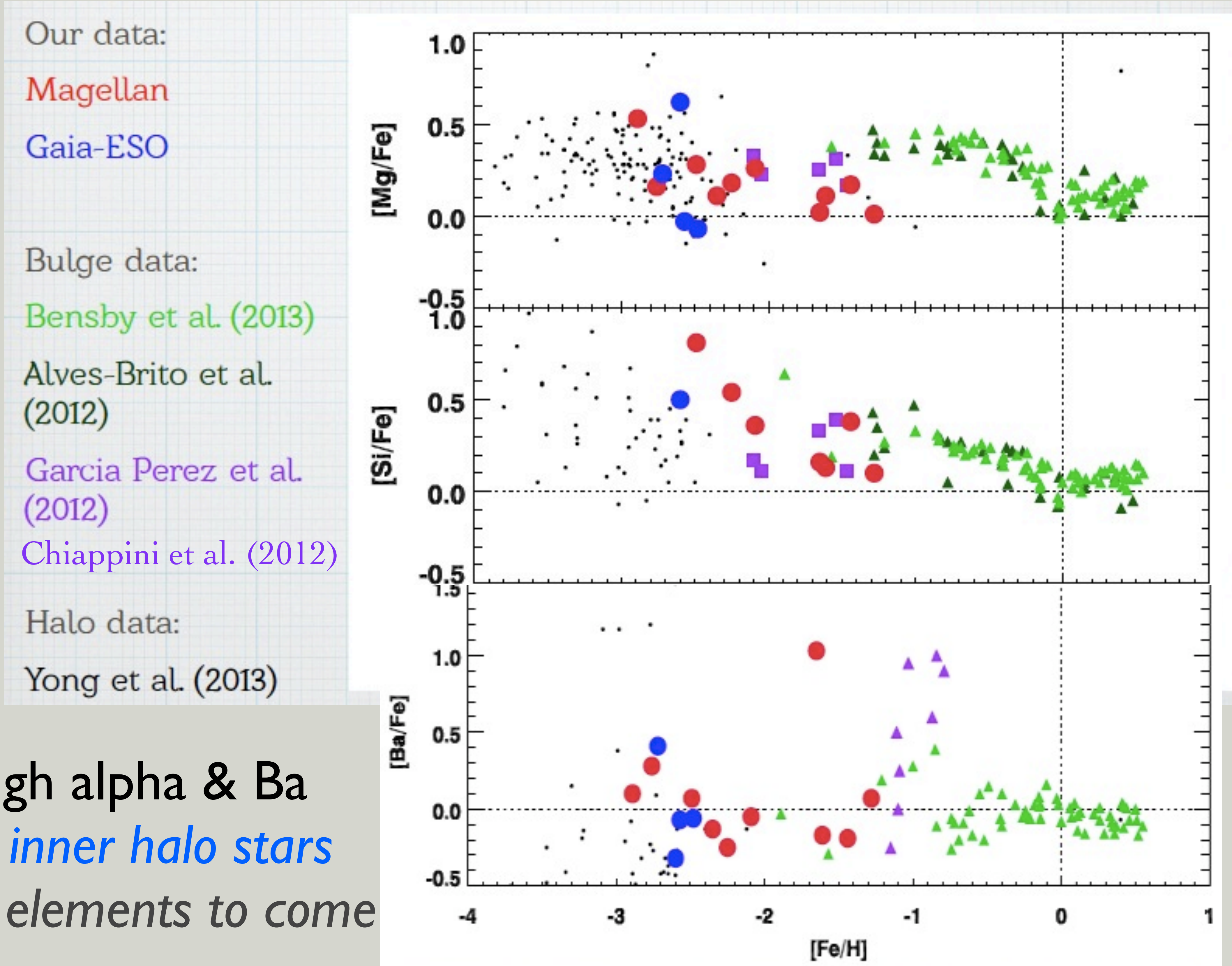




AAOmega (350 stars per 2h)
selected from SkyMapper, also with
Gaia-ESO and Magellan follow-up (July 2014)

Chemical Tagging in the Bulge

Howes et al. 2014 in prep.



High alpha & Ba

like inner halo stars

more elements to come

IN THE BULGE / OF THE BULGE? *Howes et al. 2014 in prep.*

* Two of the Gaia-ESO stars are on very eccentric orbits, passing through from the halo.
* Other two have orbits more like bulge or disc stars?

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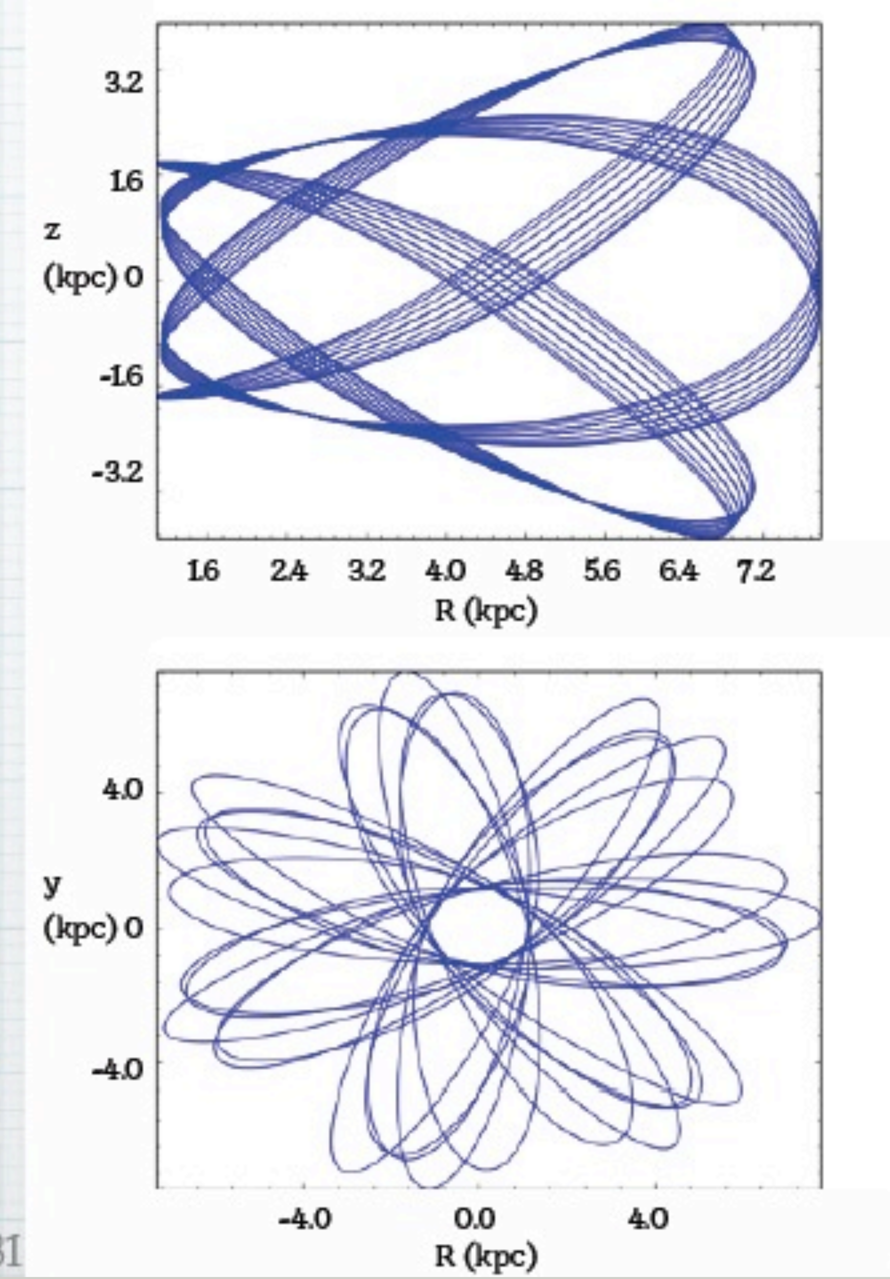


Gaia proper motions will be very useful here!

RAVEN
MOAO
+IRCS
Subaru

HST WFC3 Galactic Bulge Treasury

Brown et al. 2009, 2010

H ~ 16, reddening free indices
where RGBs with [Fe/H] < -2

RAVEN is a Canadian-Japanese collaboration

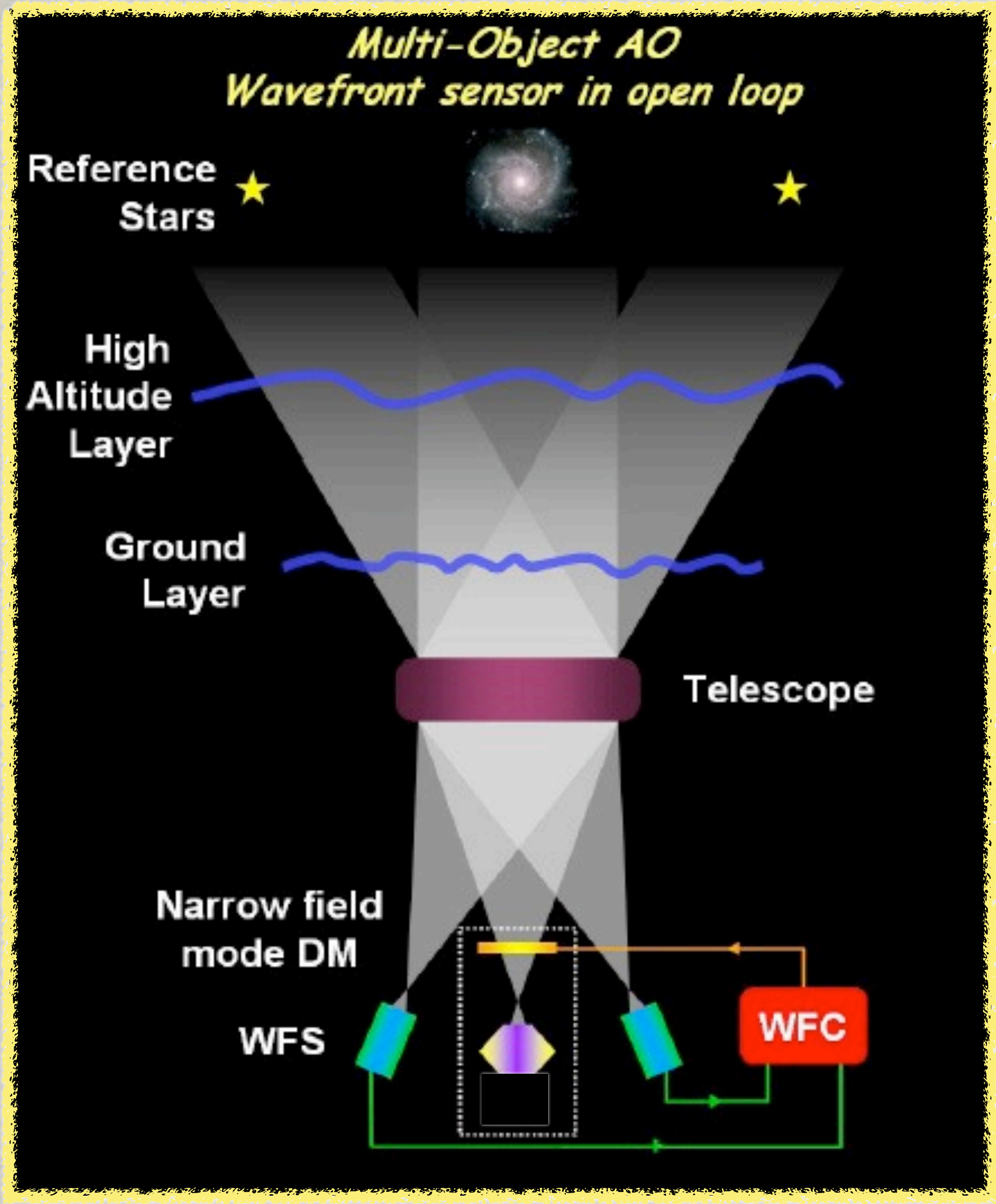
Collaboration : UVic, NRC-HIA, NAOJ, & U.Tohoku

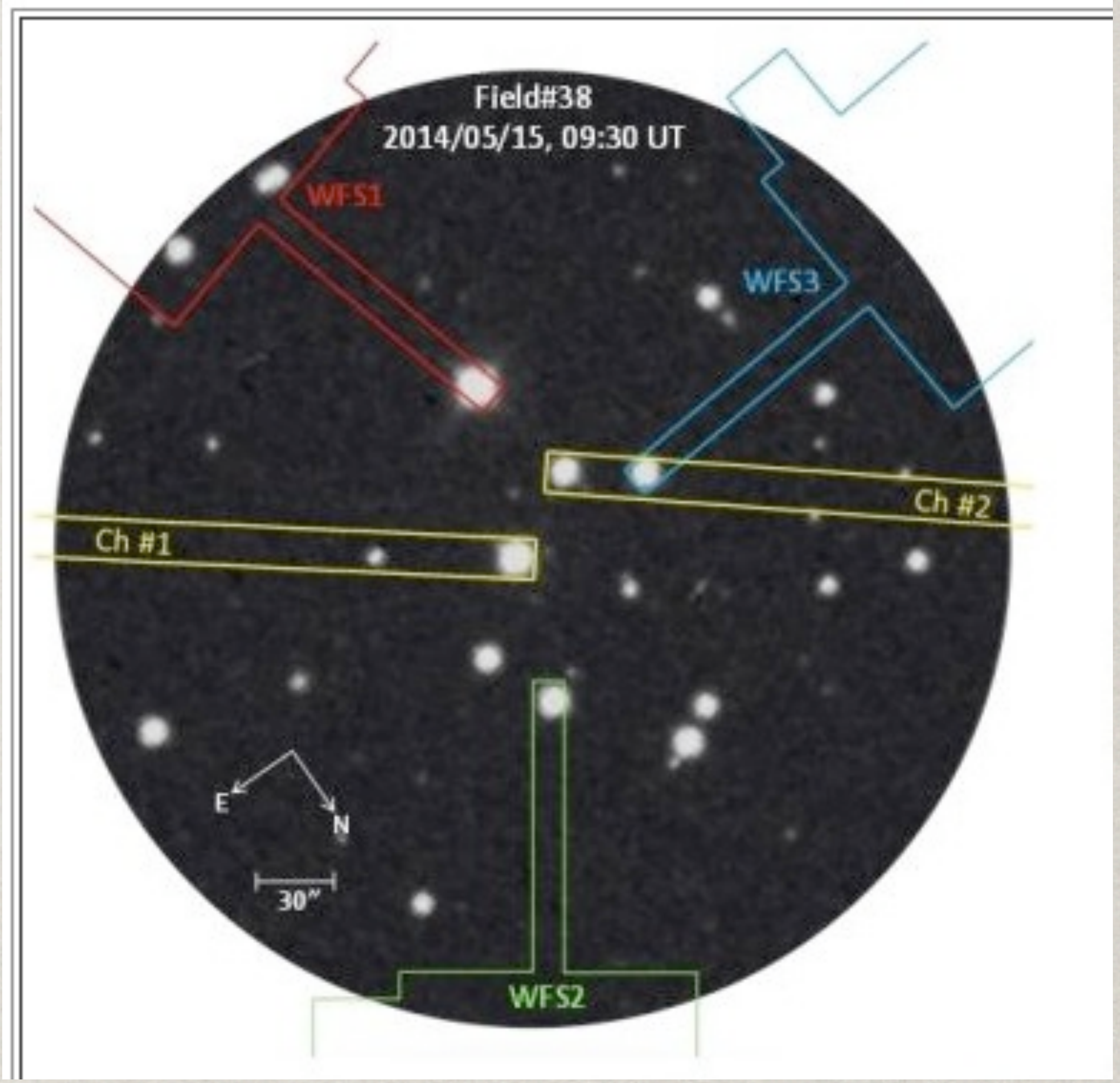
Timeline: CoDR March 2011

Shipped to Subaru Telescope, Dec 2013

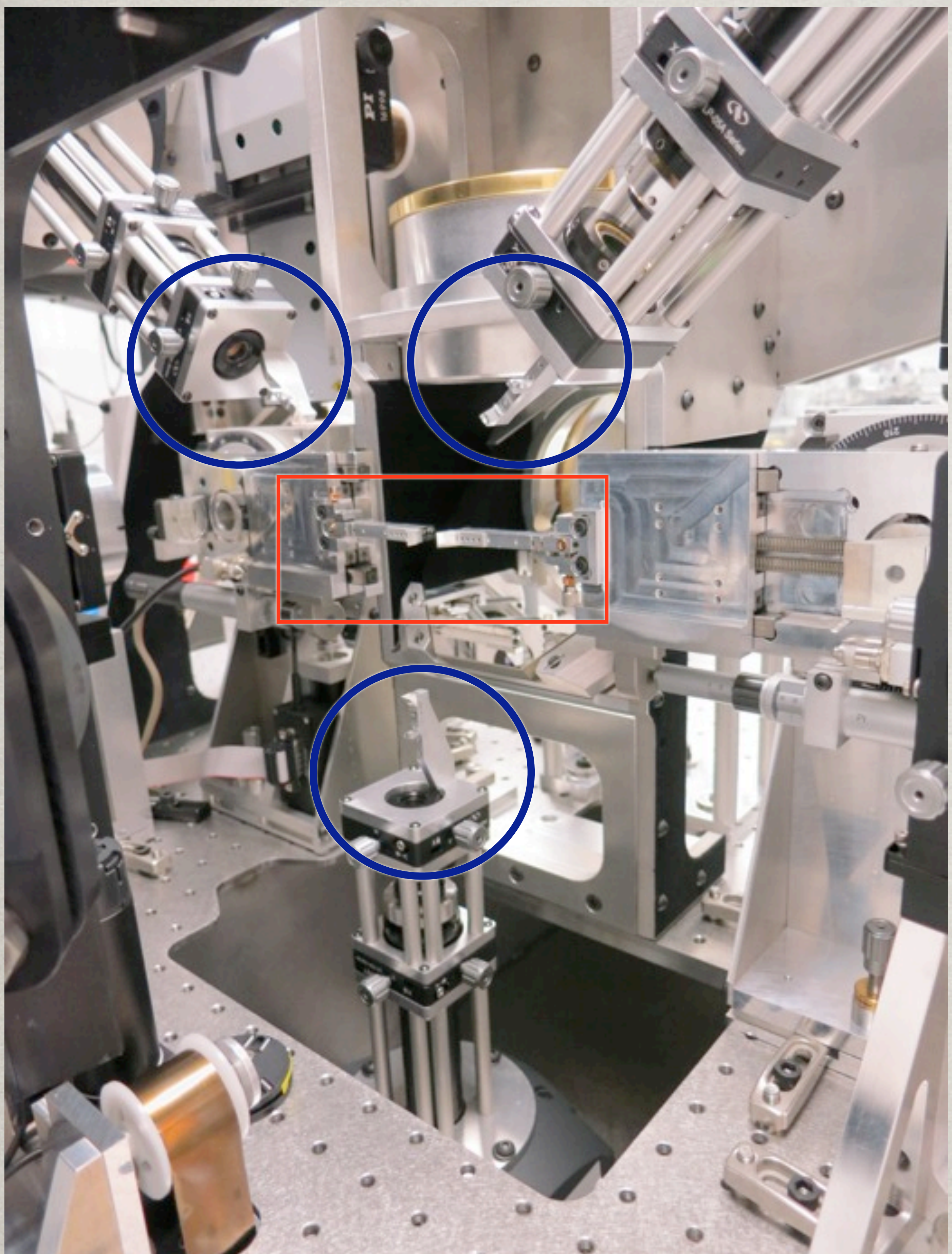
First light May 2014

Engineering run Aug 2014



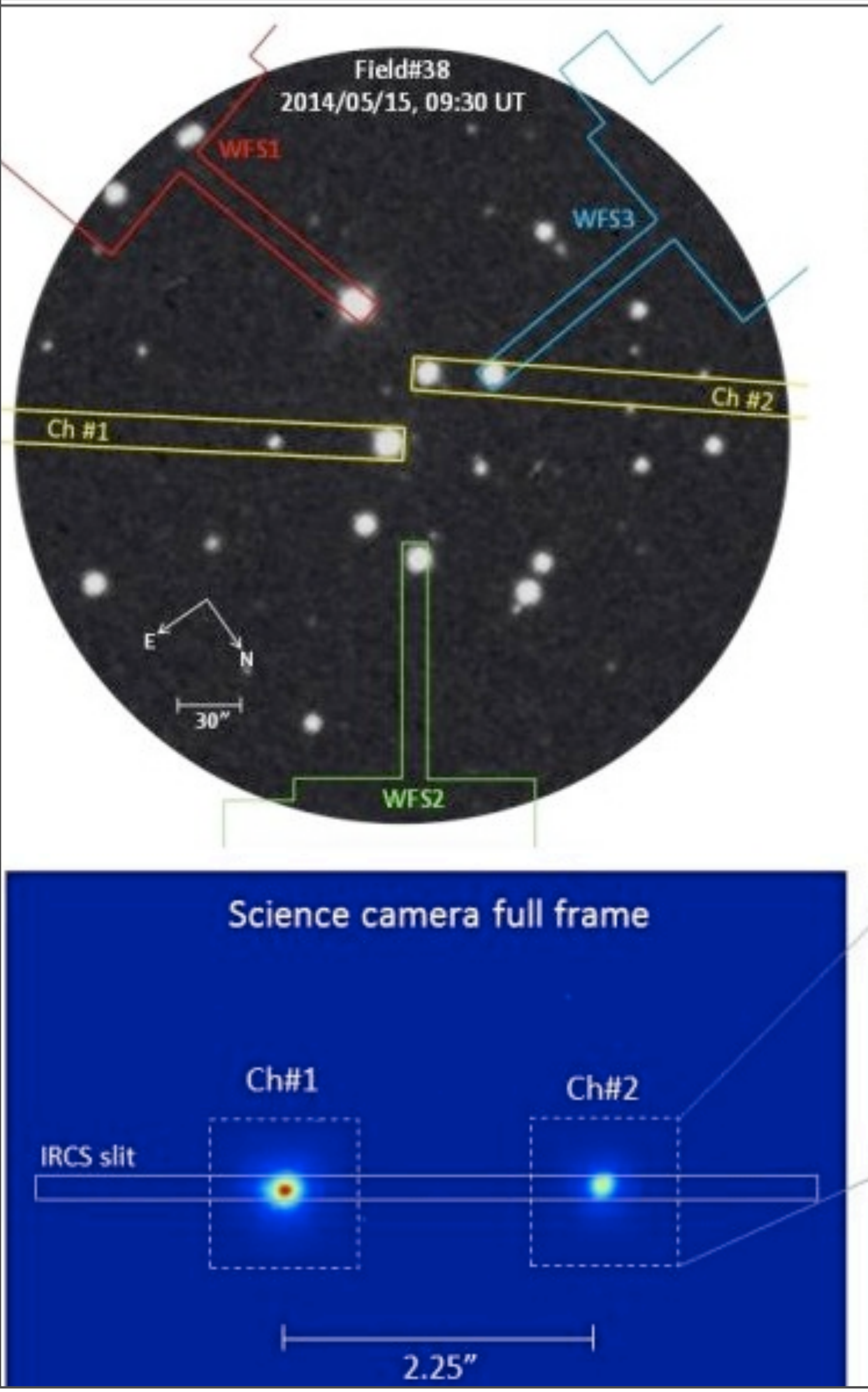


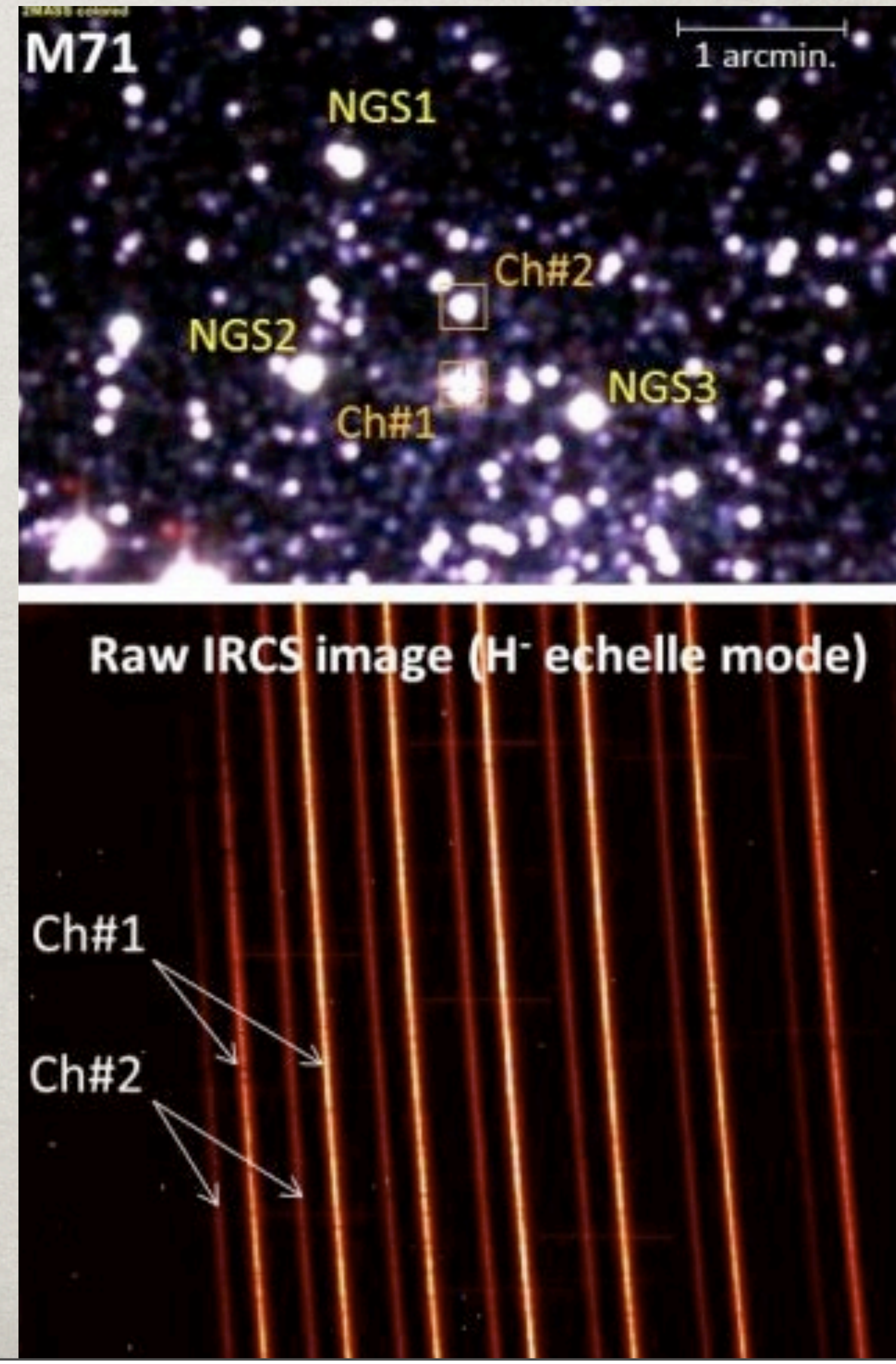
Multiple WFS calculate the turbulence over the FOV, but only one DM only corrects a small portion of sky.
Here shown on-axis.



First light of RAVEN, a MOAO instrument at Subaru Telescope

May 29, 2014 http://web.uvic.ca/~lardiere/raven/releaseMay14/ravenFirstLight.html

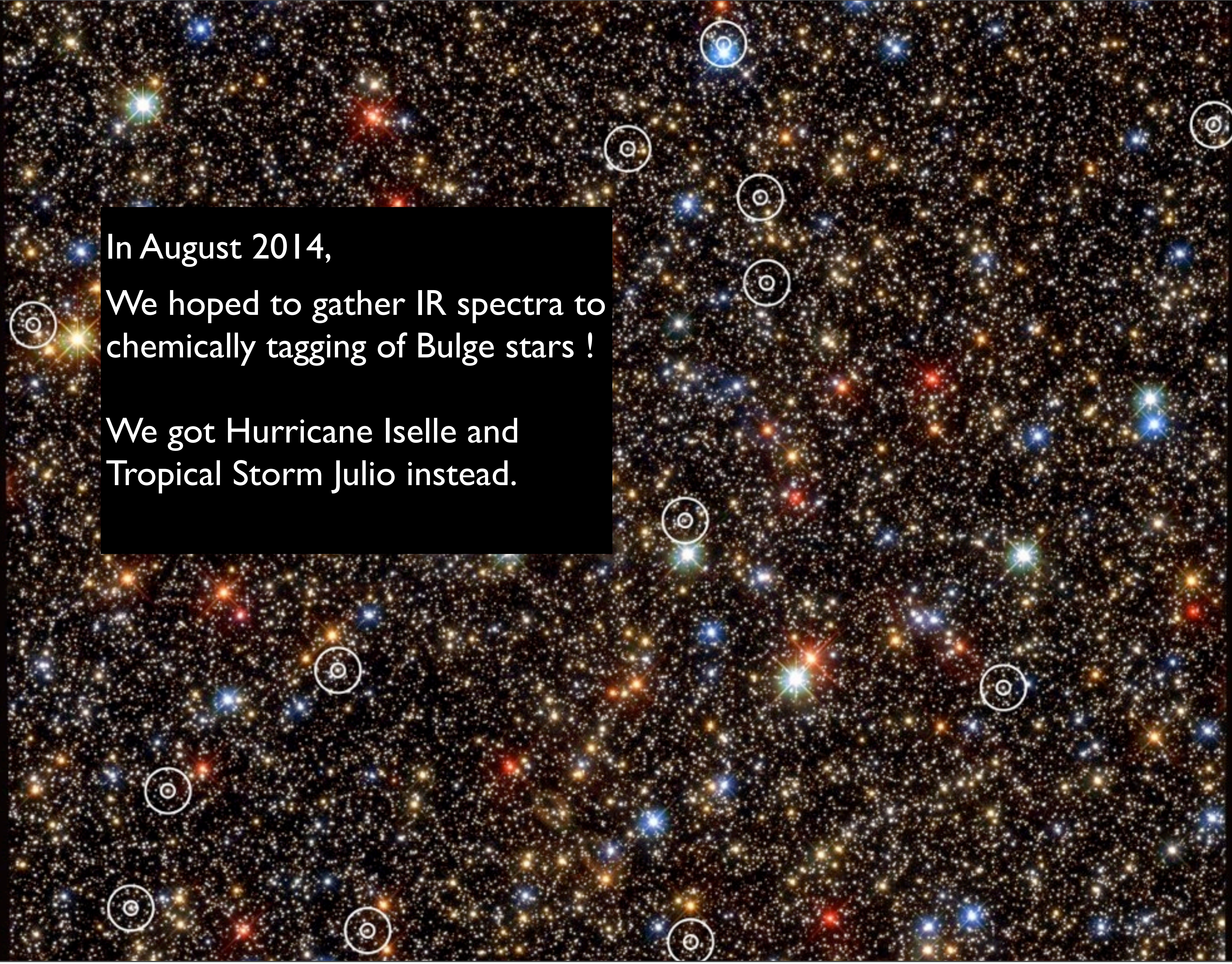




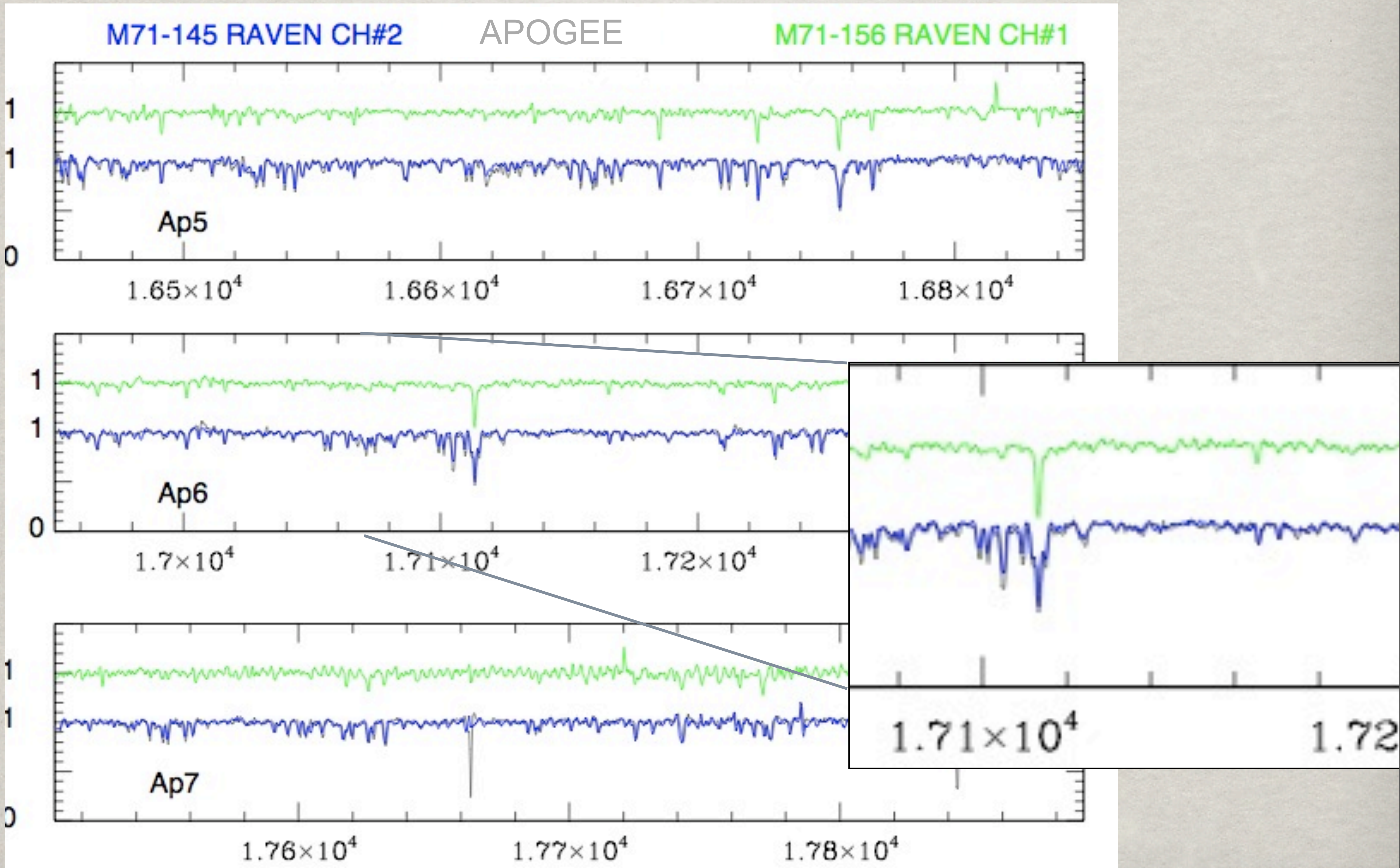
In August 2014,

We hoped to gather IR spectra to chemically tagging of Bulge stars !

We got Hurricane Iselle and Tropical Storm Julio instead.



First RAVEN spectra : *M71*

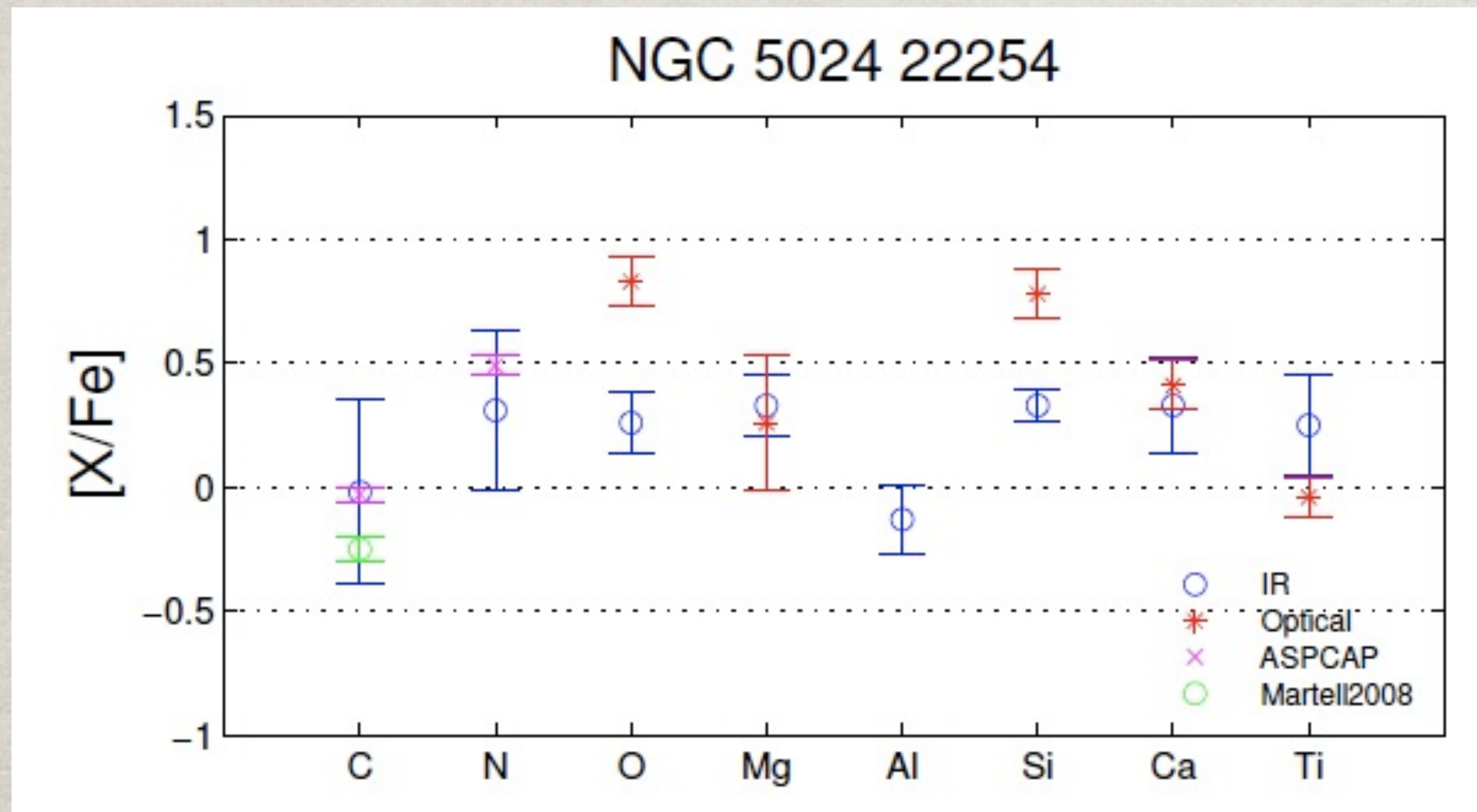


IR & Optical Analysis of [Fe/H] < -2

Lamb, Venn et al. 2014 in prep

Optical: from HET spectrum, SNR~50
IR: from APOGEE spectrum, SNR~100

[Fe/H] = -2.1

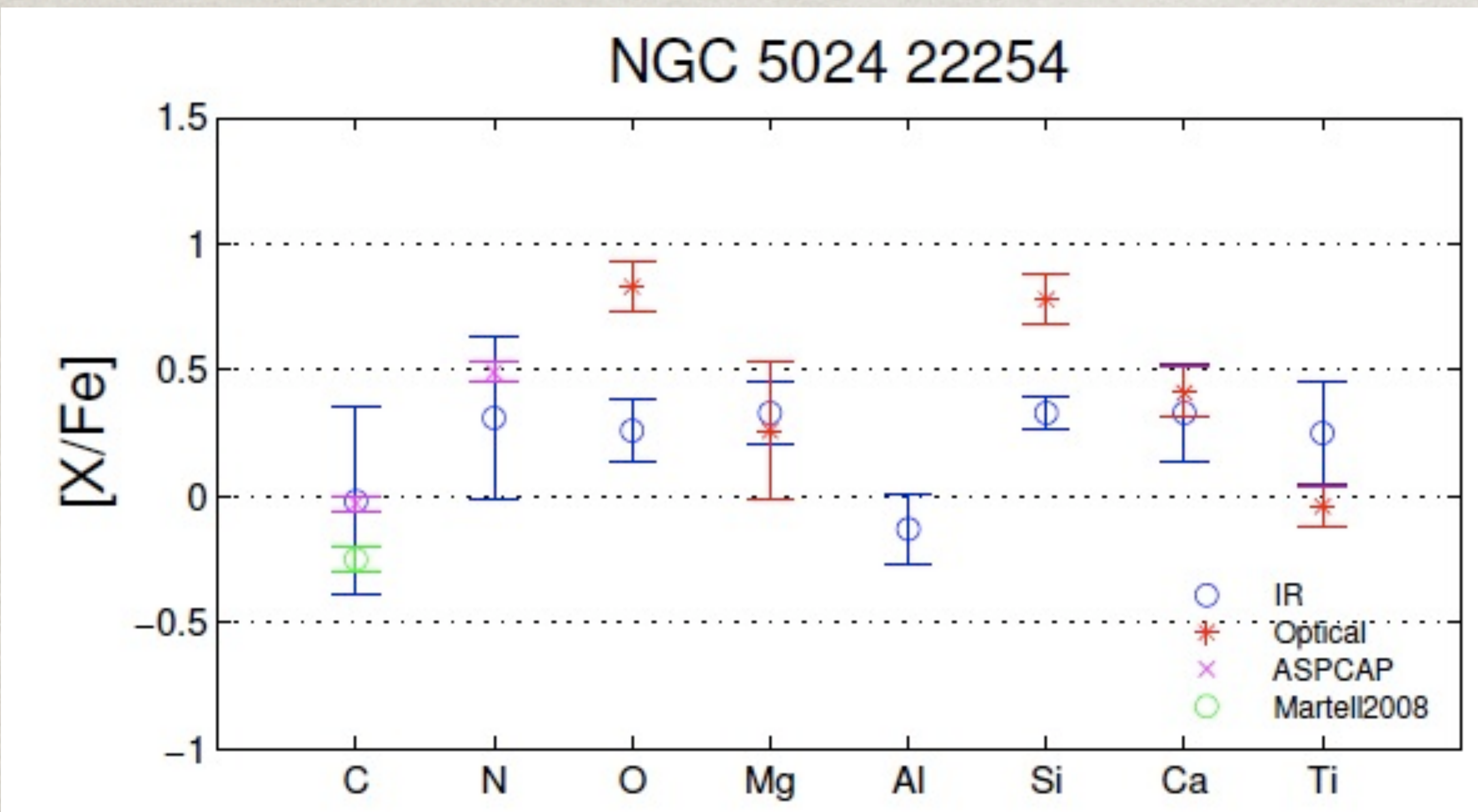


ADVANTAGES / DISADVANTAGES OF IR SPECTRA

Lamb, Venn et al. 2014 in prep

Advantages:
- reddening negligible
- works with AO
- CN**O**, **Si**, Al
- independent **Mg**, Ti, **Fe**
- isochrone fits

Disadvantages:
- stellar parameters trickier
- [Fe/H] < -2.5 ?
- heavy elements ?



Conclusions

1. Earliest stars in the Galactic Centre may have had different masses, properties, etc. and left different remnants from the MW halo & dwarf galaxy metal poor stars.

2. These remnants will be *really* hard to find (metal poor? crowded? high reddening? very rare.)

3. IR spectroscopy may be needed or complement optical spectra of metal poor objects in the Galactic Centre.

4. AO helps with spatial resolution, MOAO multiplex advantages and is now a real option.