UNIVERSITY OF CALIFORNIA
SANTA CRUZ

THE HIGH REDSHIFT ULTRA-FAINT GALAXIES

The Near-Field Deep-Field Connection
14th Feb 2014

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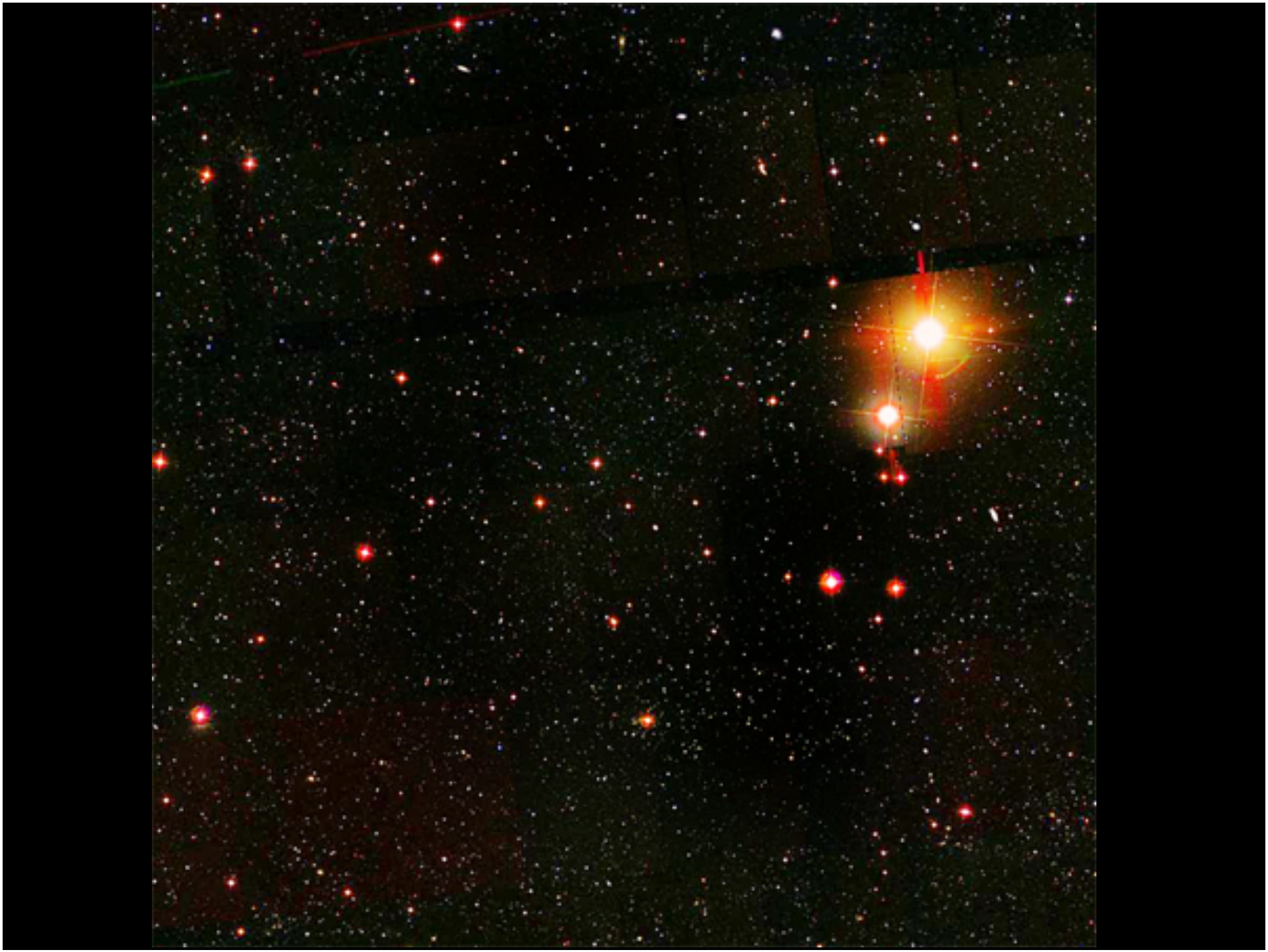
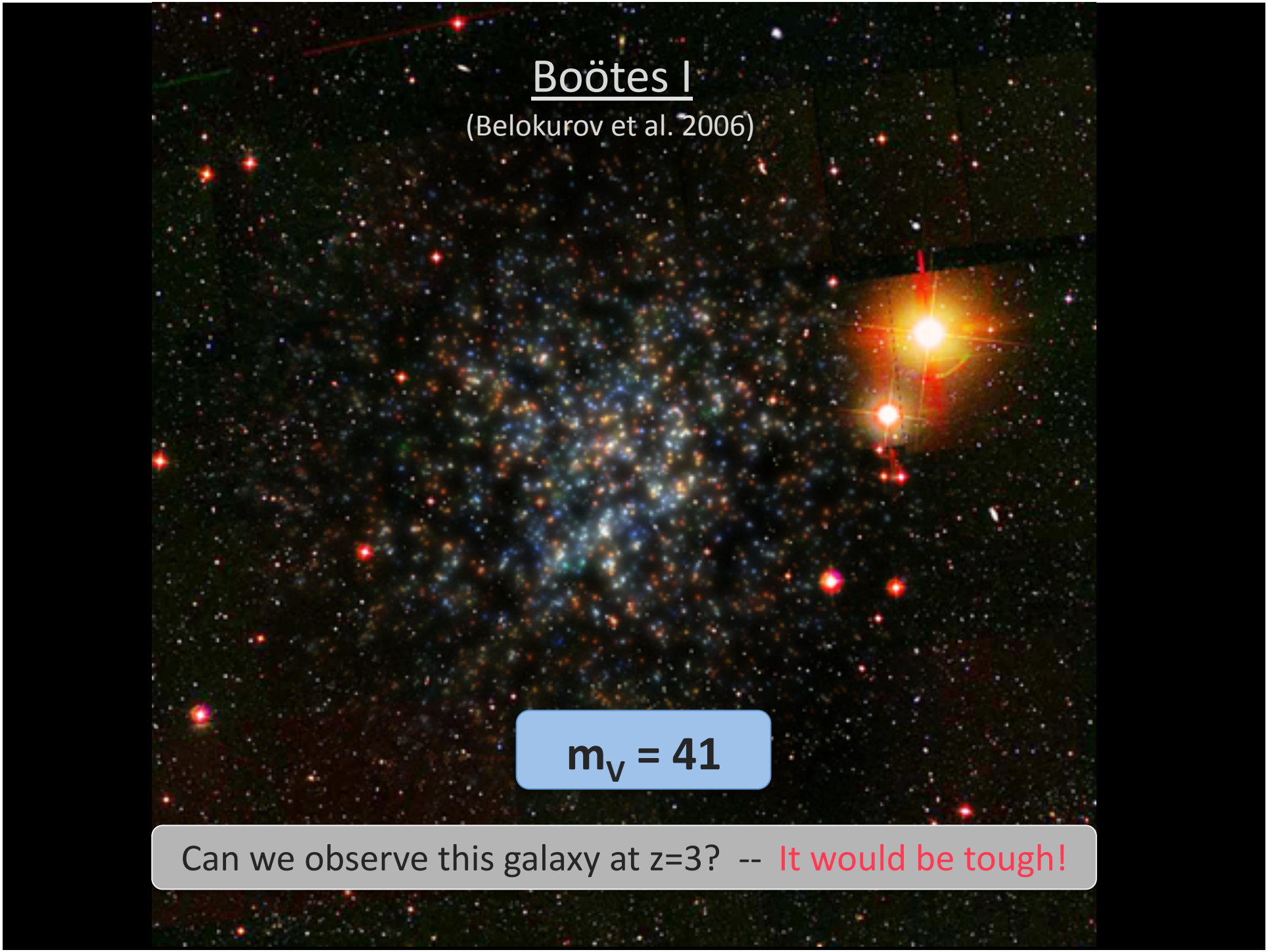
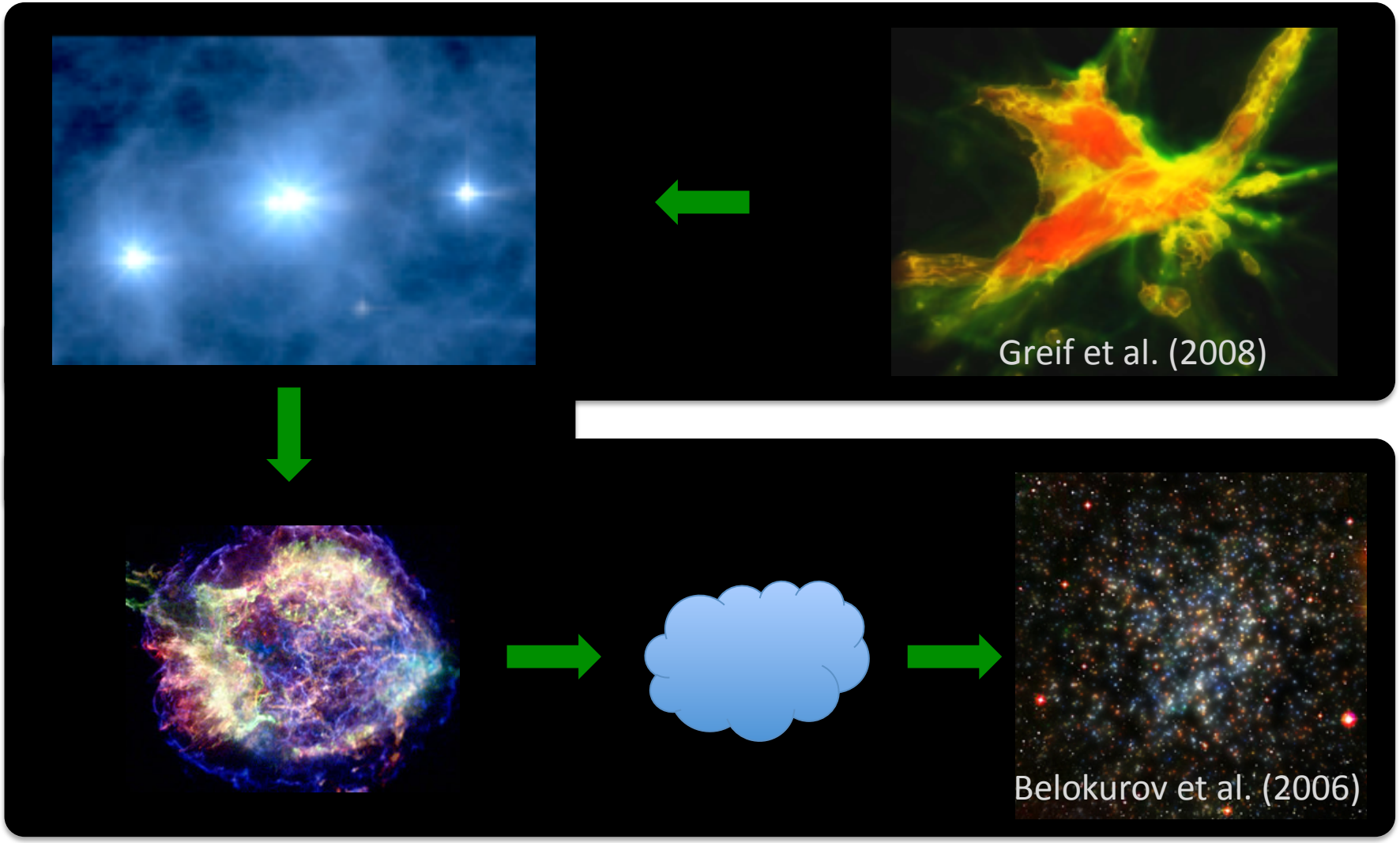
Collaborators: Max Pettini (IoA, Cambridge), Regina Jorgenson (IfA, Hawaii), Michael Murphy (Swinburne), Chuck Steidel (Caltech), Gwen Rudie (Caltech), Poul Nissen (University of Aarhus)

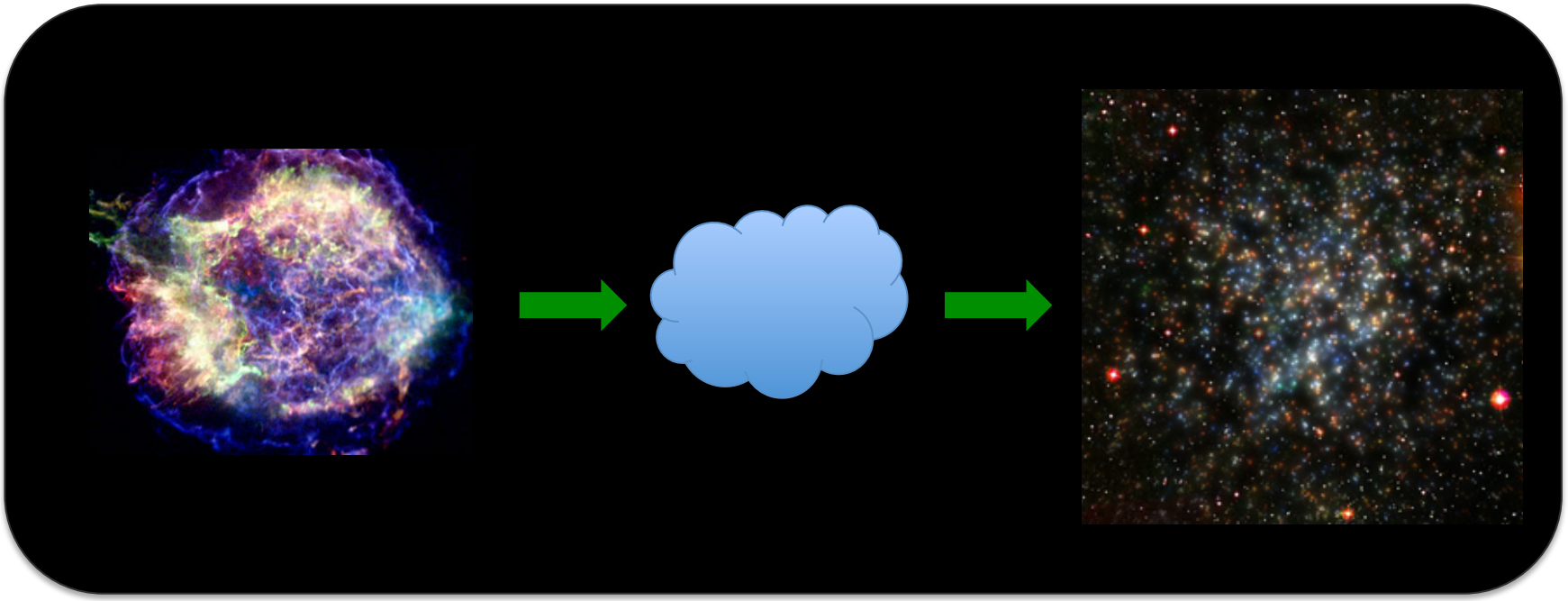



Boötes I
(Belokurov et al. 2006)
$m_V = 41$
Can we observe this galaxy at z=3? -- It would be tough!

Formation of the UFDs



Progenitors of the UFDs



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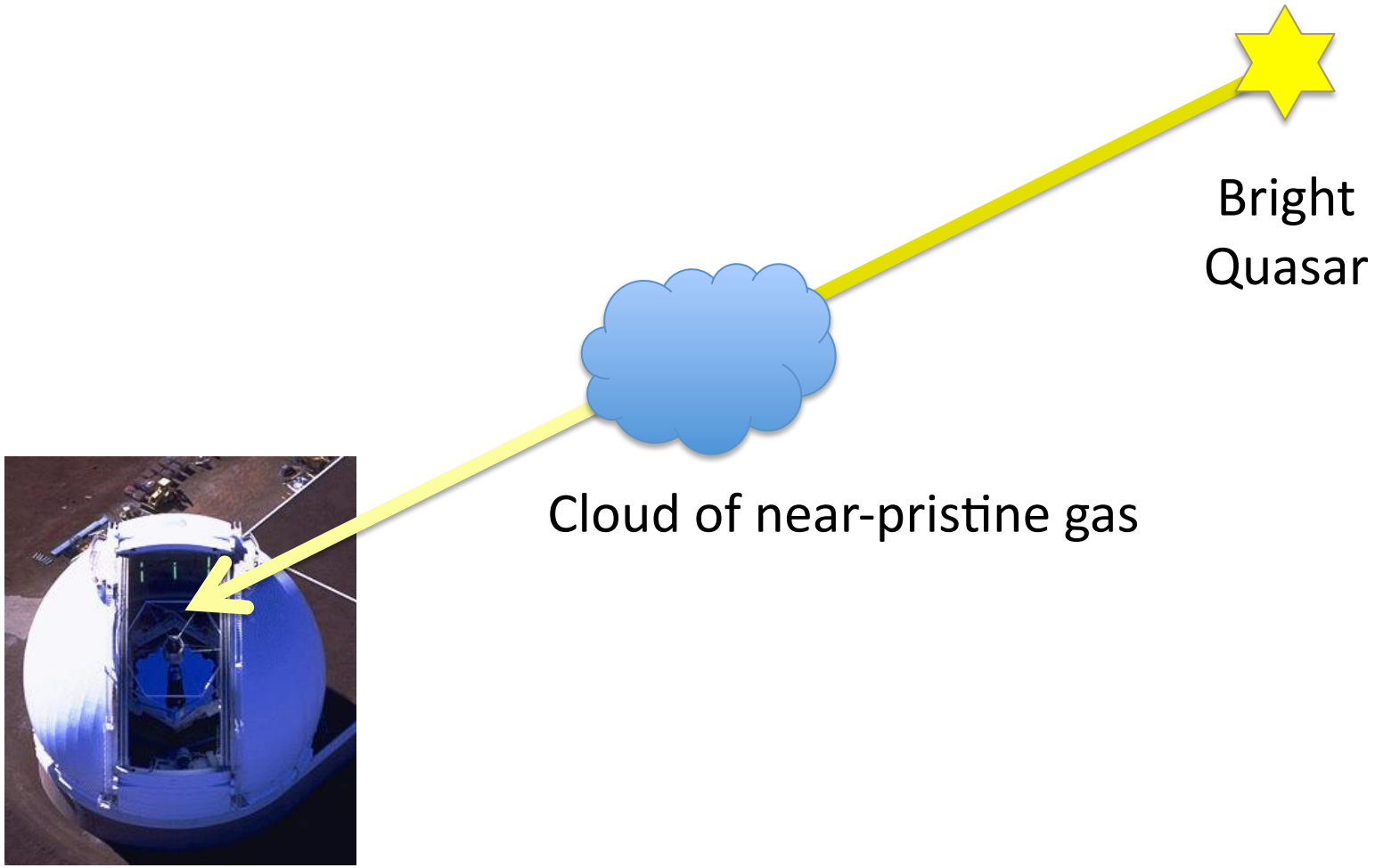
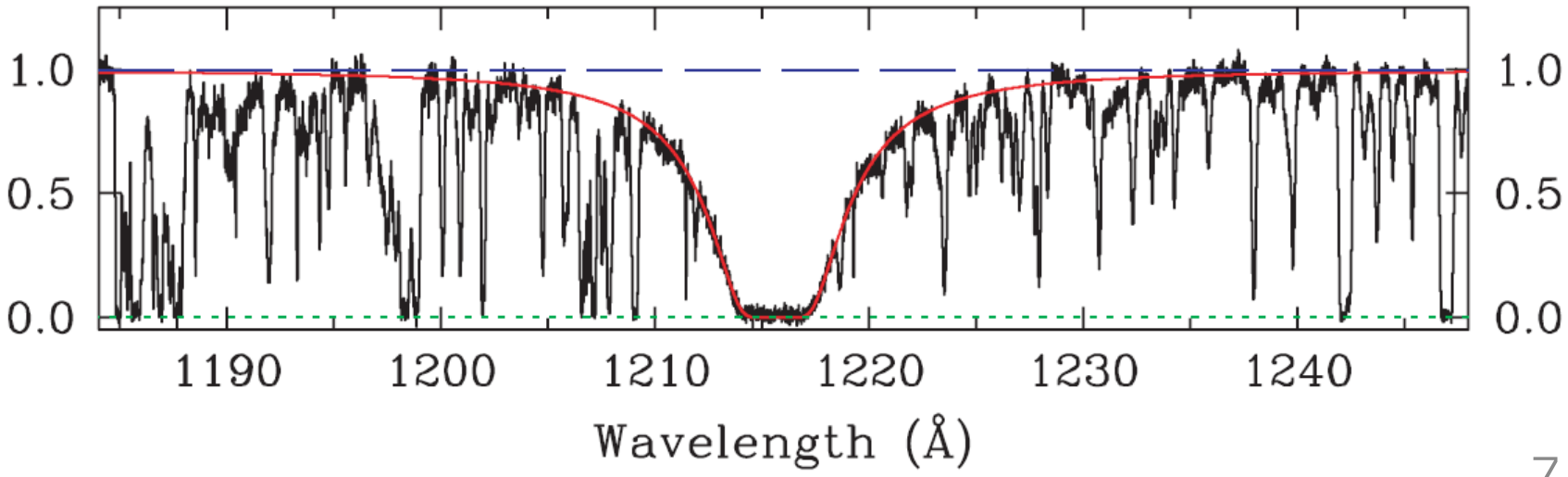


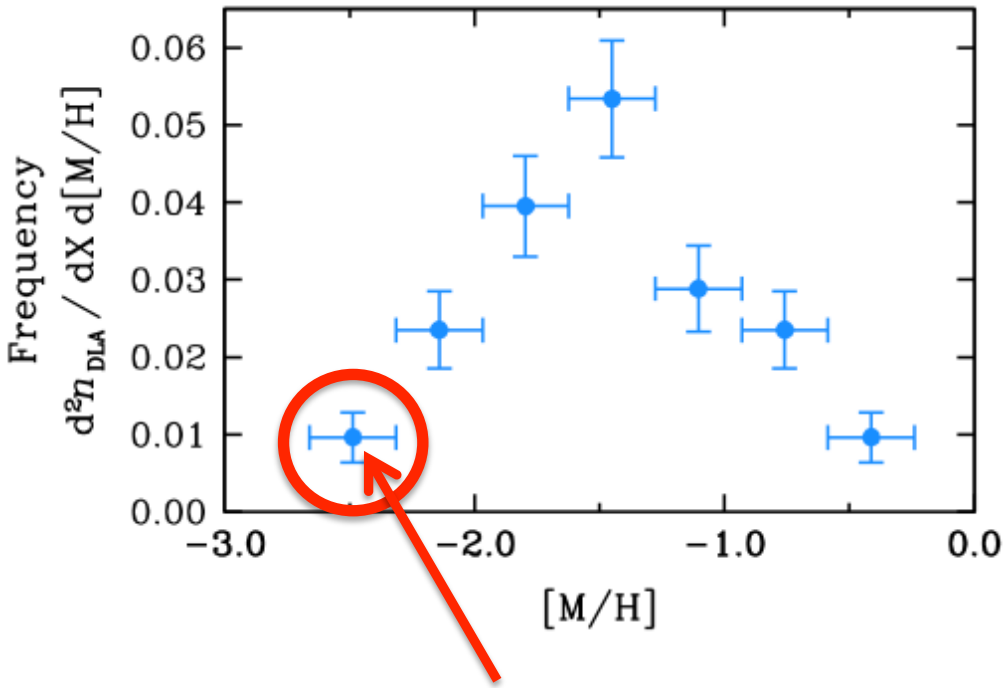
Damped Lyman alpha systems

- log $N(\mathrm{H\,I})$ / cm^{-2} ≥ 20.3
- Characteristic damping wings
- Neutral gas reservoirs at high redshift
- Self-shielded

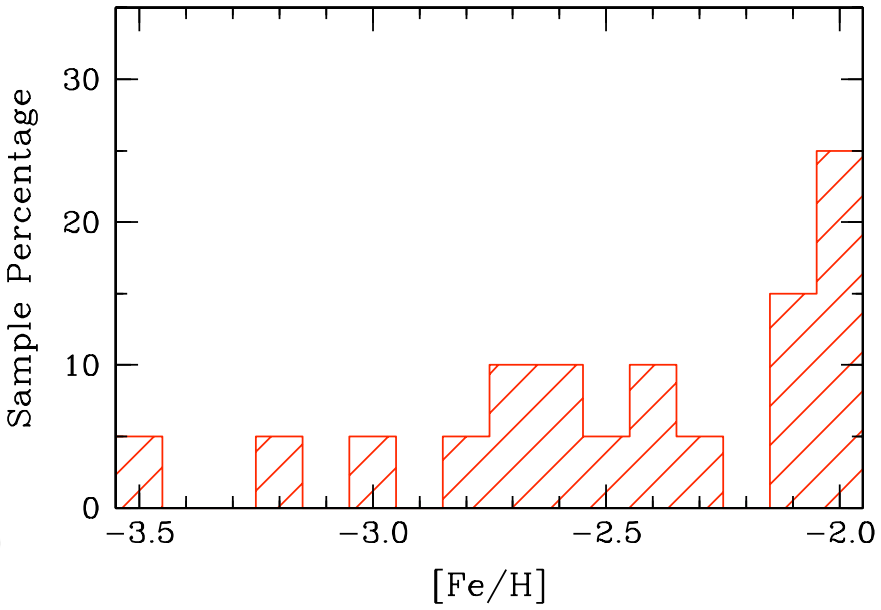


The Metal-poor DLAs Survey

Data from:
Rafelski et al. (2012), ApJ, 755, 89



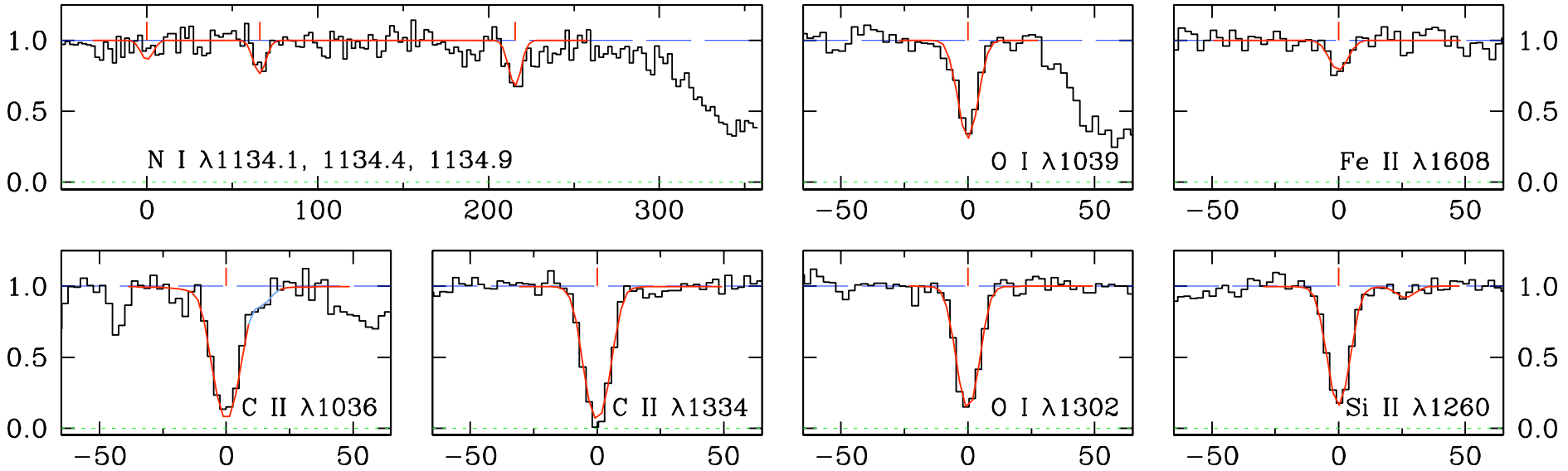
Cooke et al. (2011b) MNRAS, 417, 1534



We want to find these DLAs!

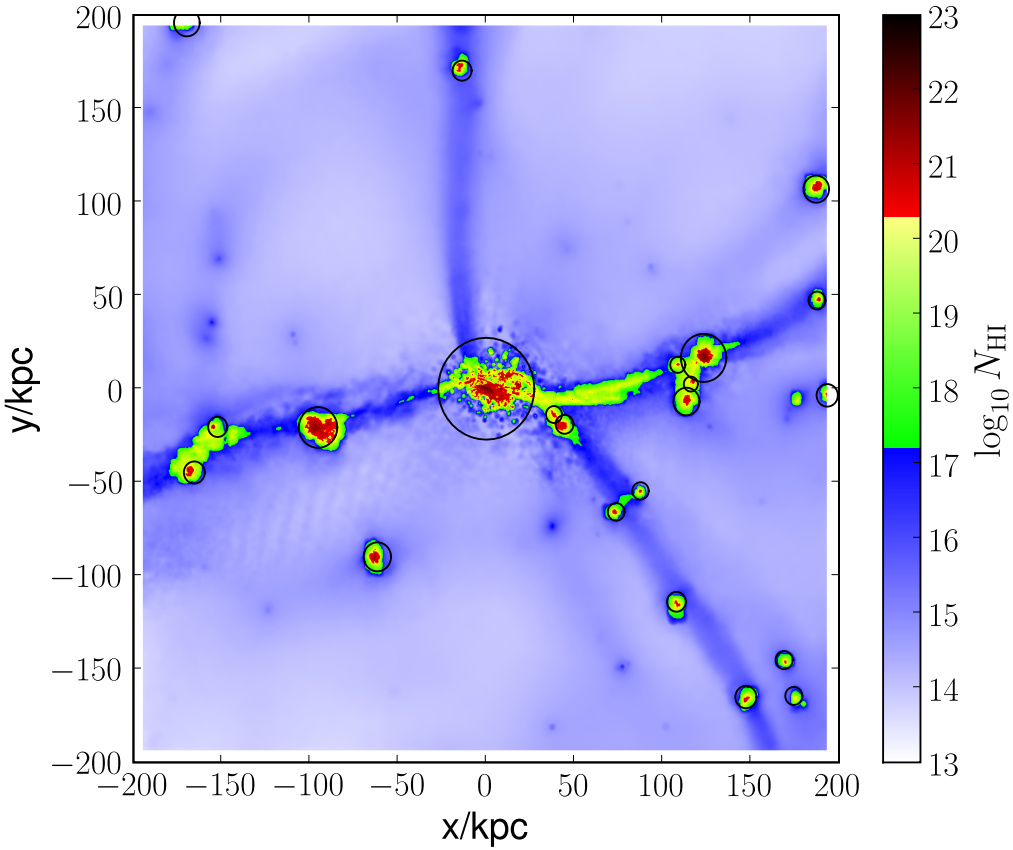
The sample

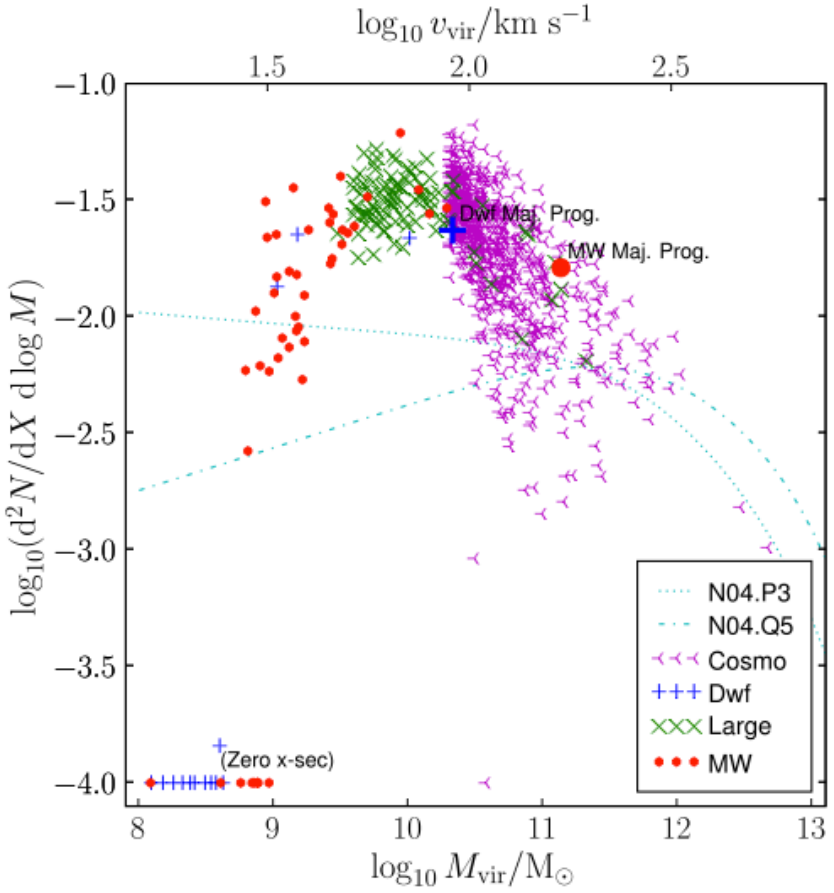
- 22 DLAs total (10 from the literature) --- z_{abs} = 2.3 – 3.7
- [Fe/H] < -2.0 --- "Very Metal-Poor"
- Observed with VLT+UVES & Keck+HIRES (R > 30,000)
- Exposure time ≈ 10 hrs → S/N ≈ 30



Connecting the Near-Field to the Deep-Field: Simulated DLAs

Pontzen et al. (2008)





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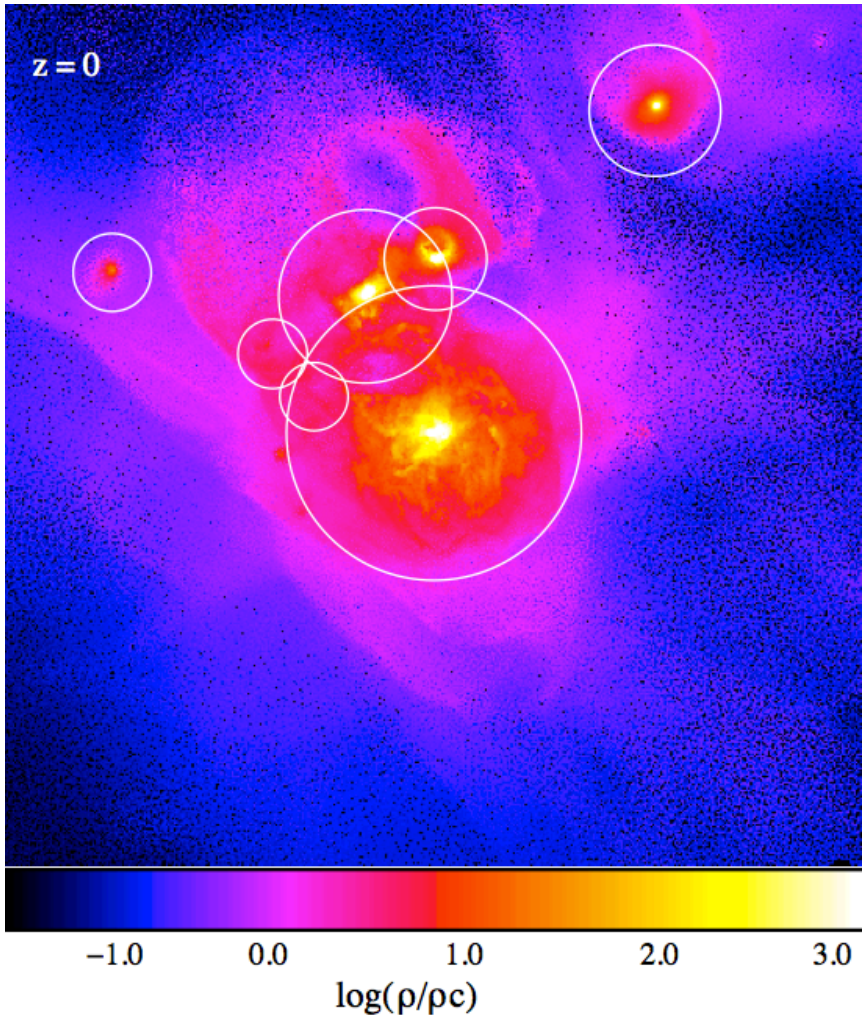
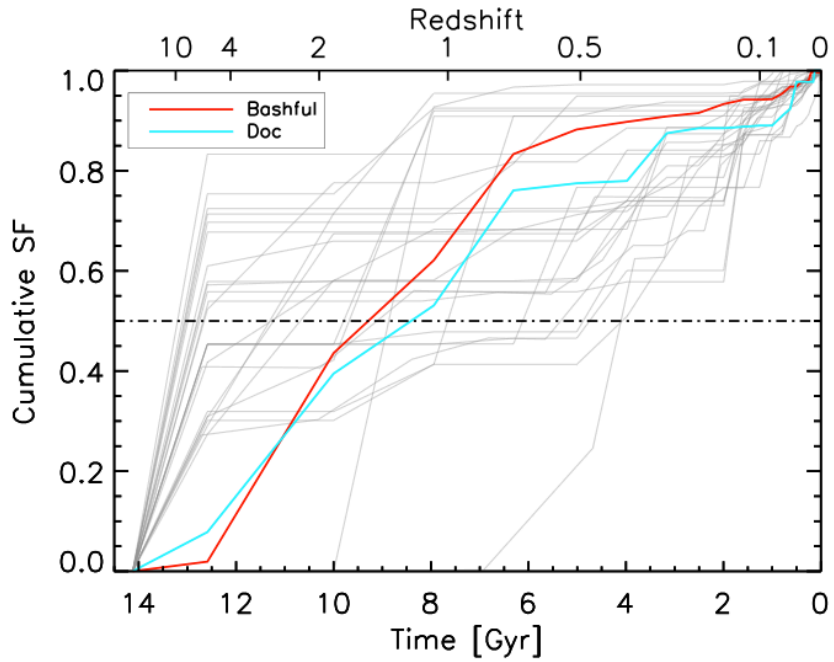
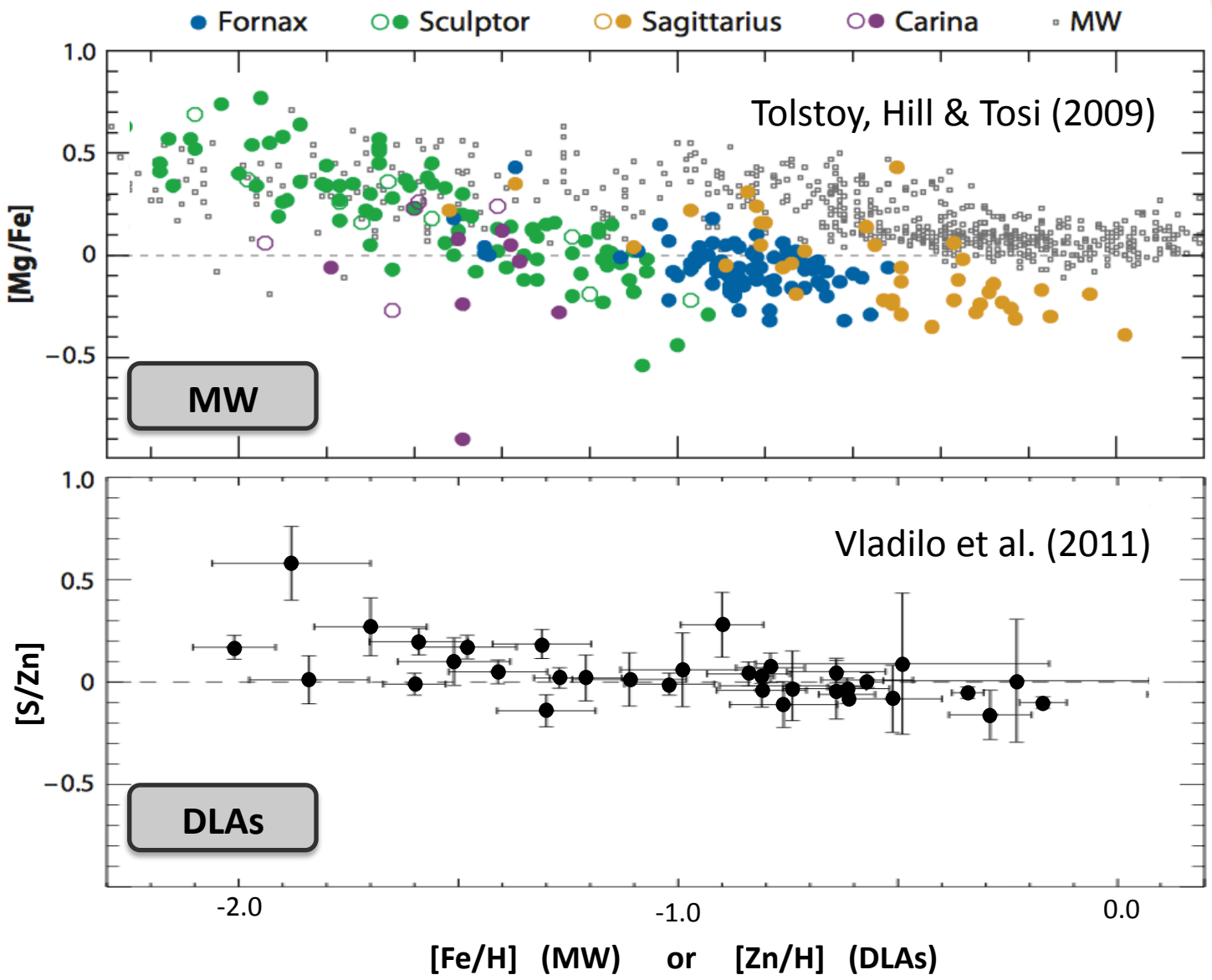
Shen et al. (2013)



(see also Weisz et al. 2011)



Connecting the Near-Field to the Deep-Field: Chemistry



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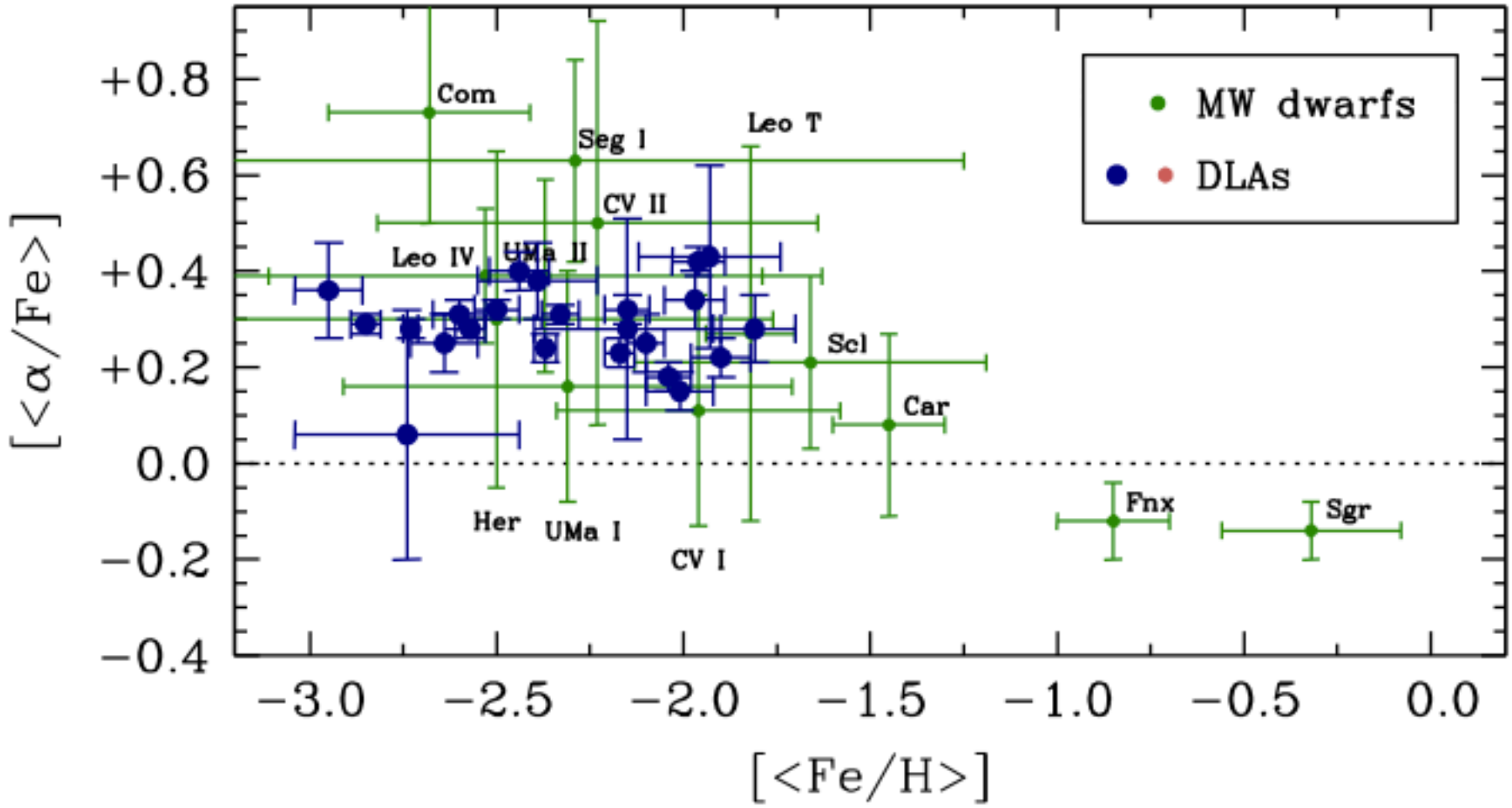

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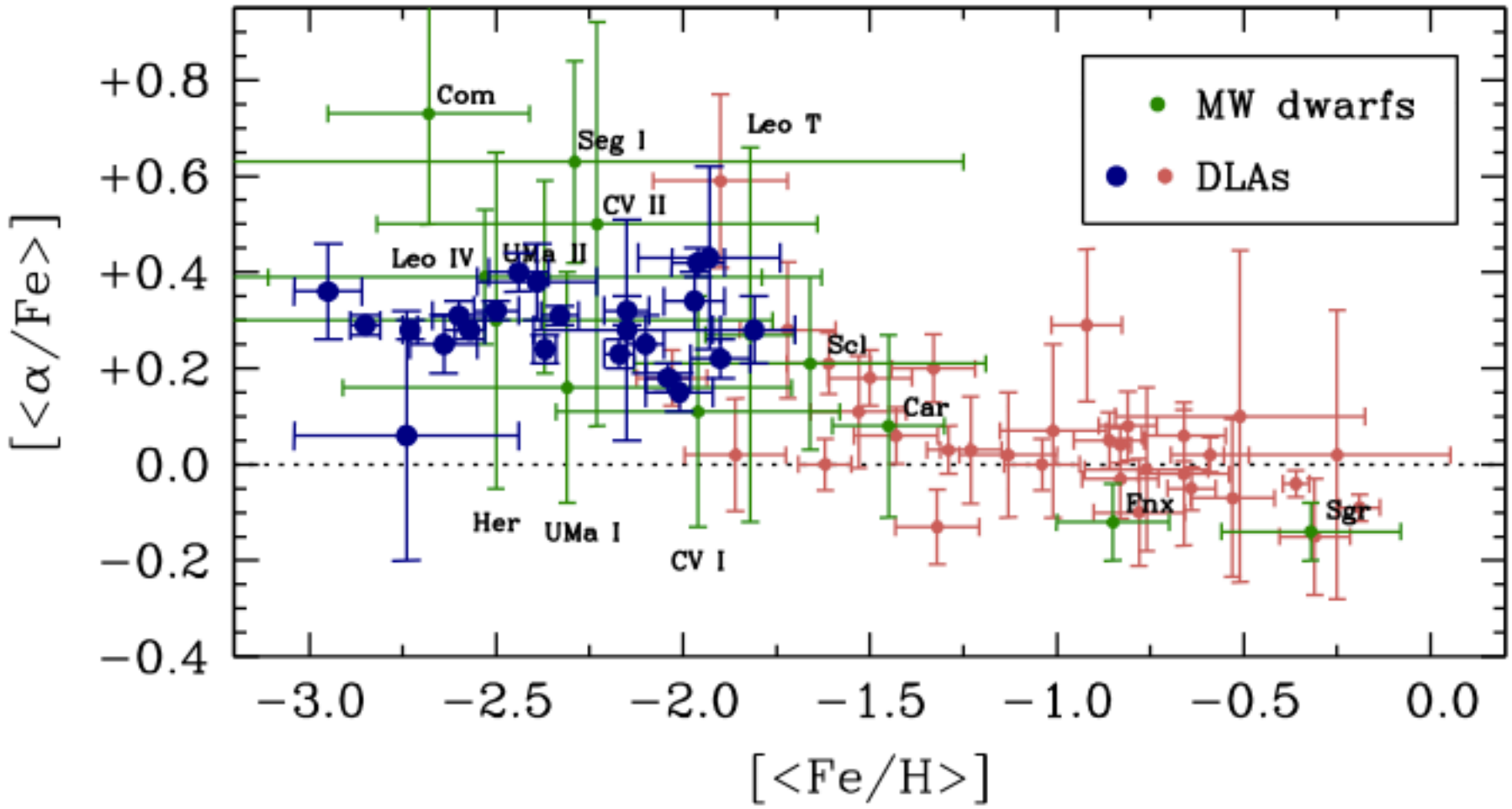
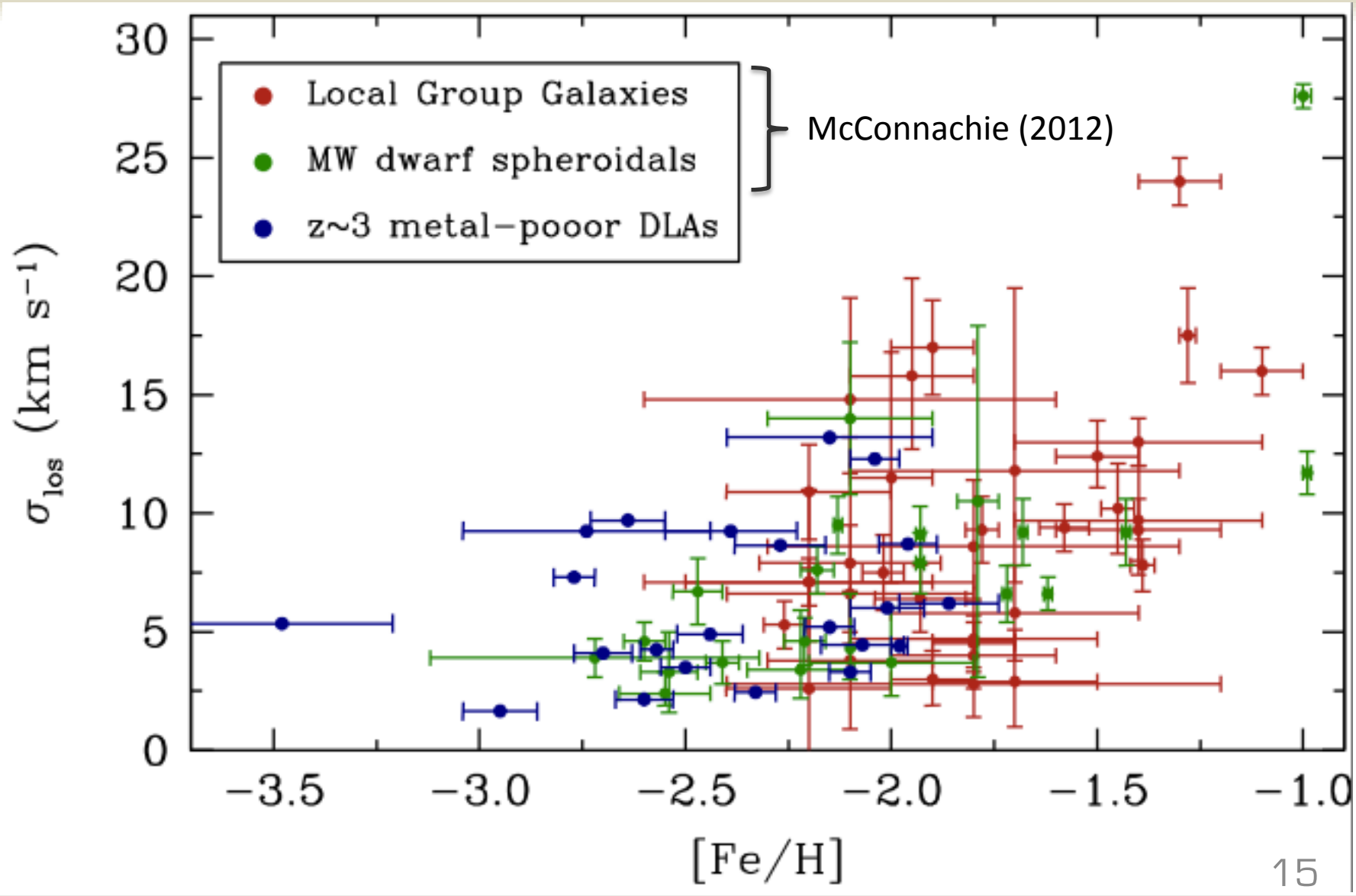


Connecting the Near-Field to the Deep-Field: Kinematics



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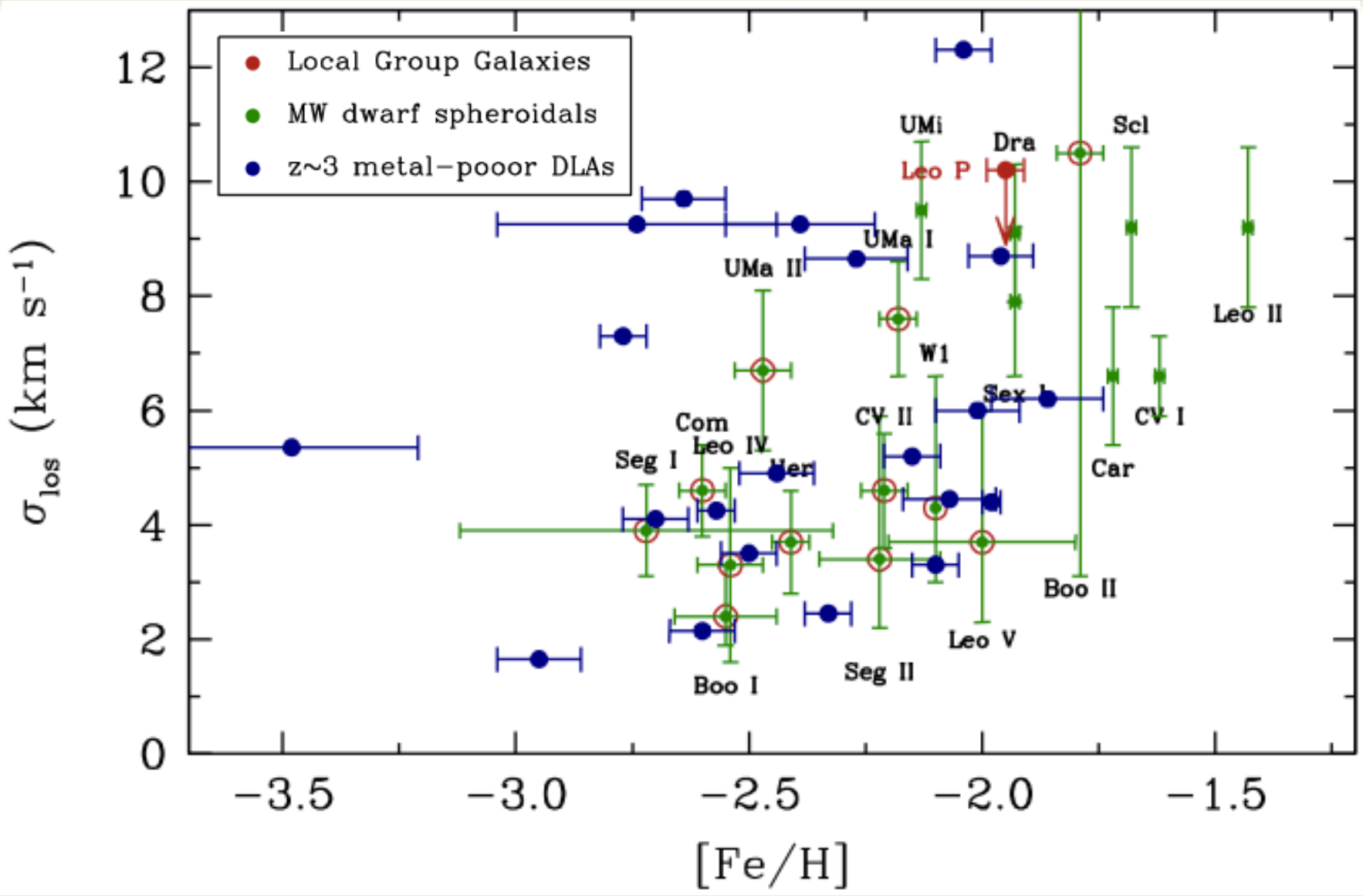
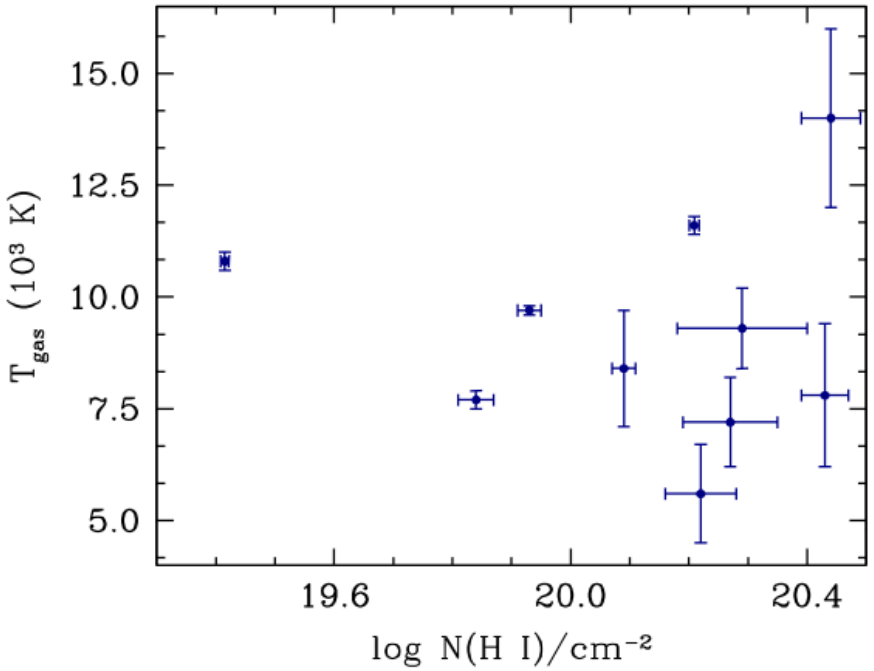
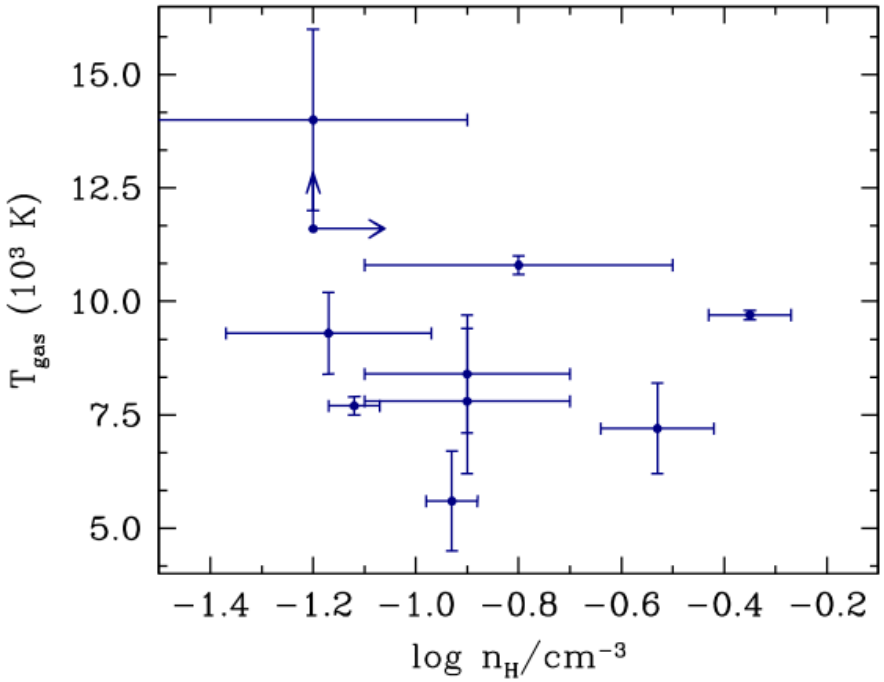


Birth clouds of the second stars



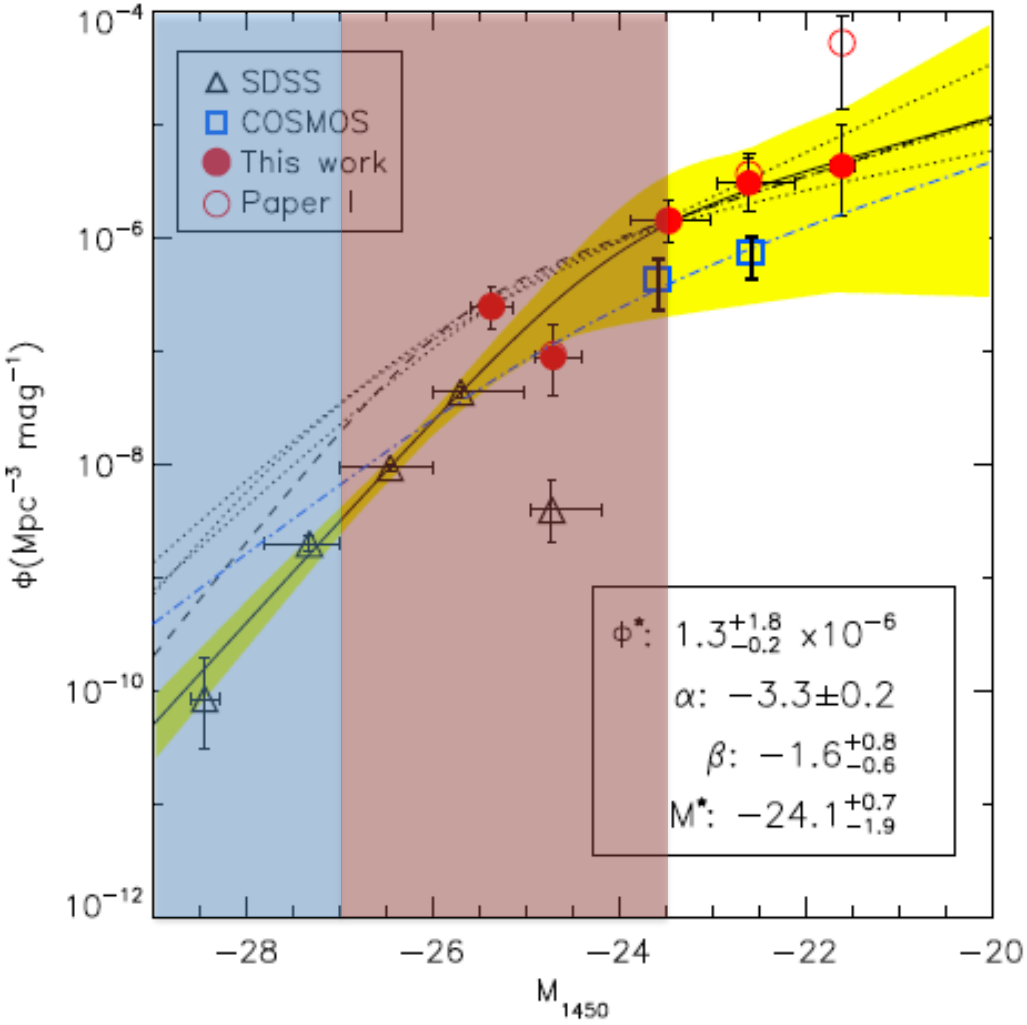


Temperature	≈ 7000 K
Density	≈ 0.1 cm^{-3}
Neutral gas mass	< 10^7 $M_\odot$

For [Fe/H] ≈ -3.0, typical neutral gas mass is ≈ 10^5 $M_\odot$

New Horizons

QSO Luminosity Function



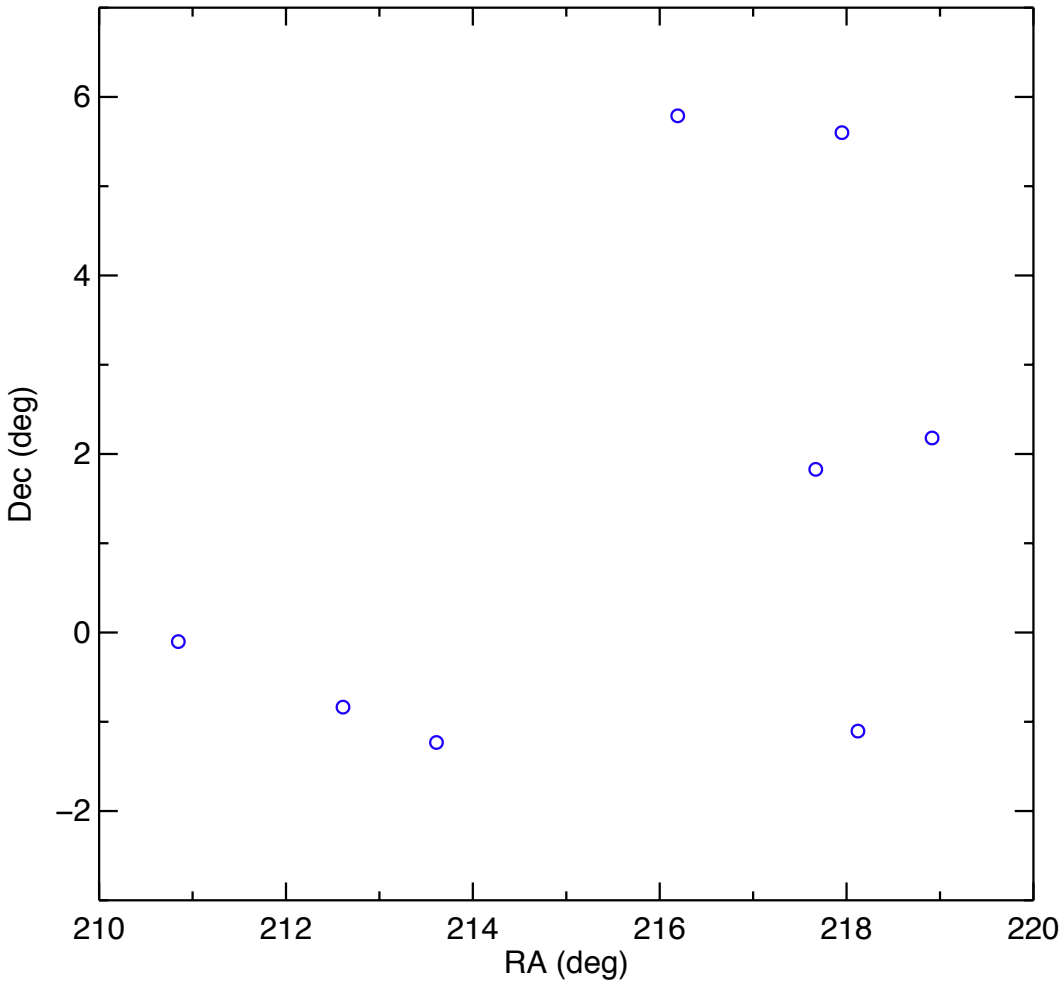
8-10m class telescopes

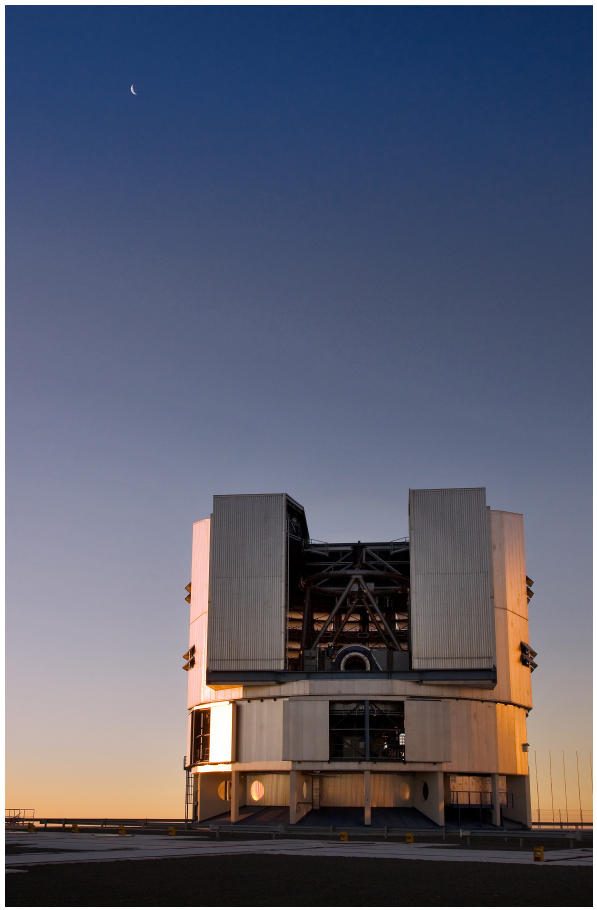
The 30+m telescopes

Glikman et al. 2011

QSOs that can feasibly be observed with 8-10m class telescopes.

8 QSOs at z>2 with $m_r < 18$

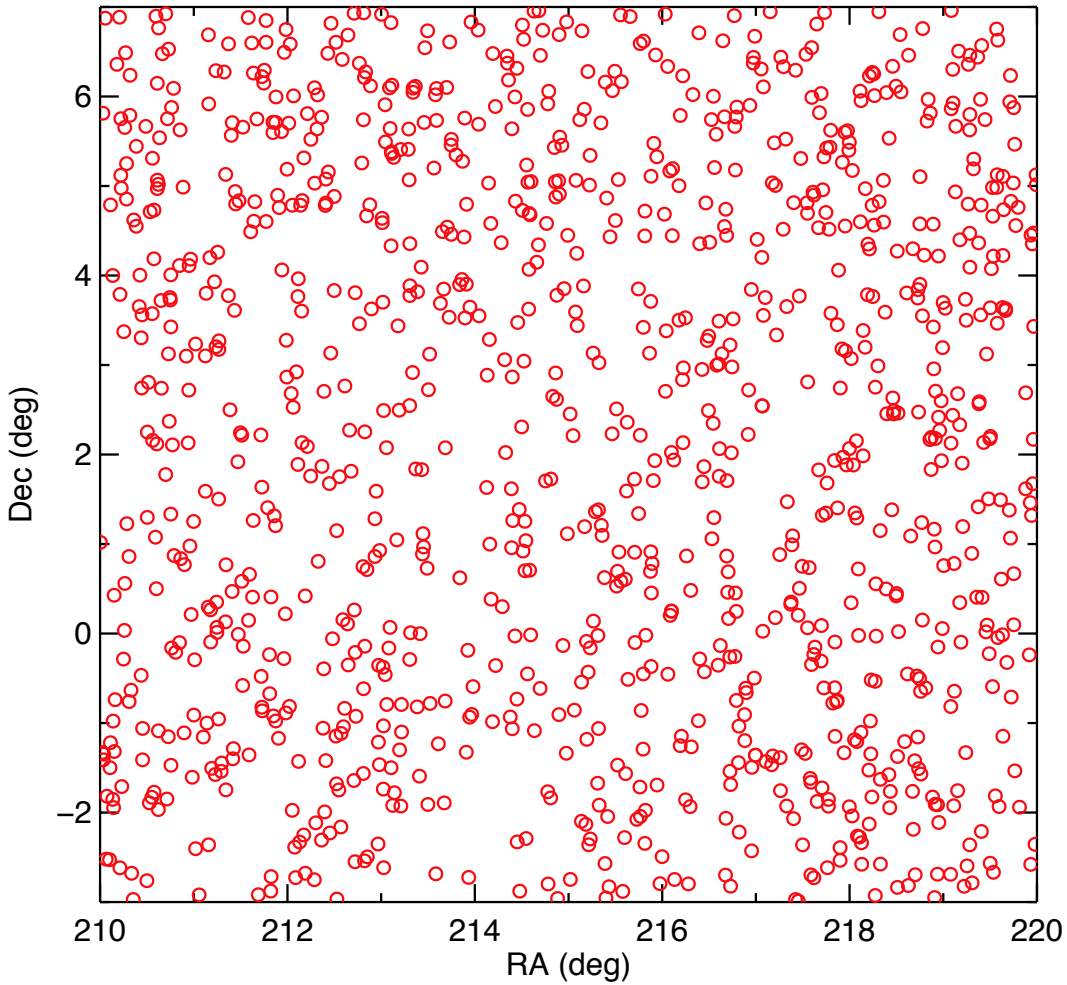


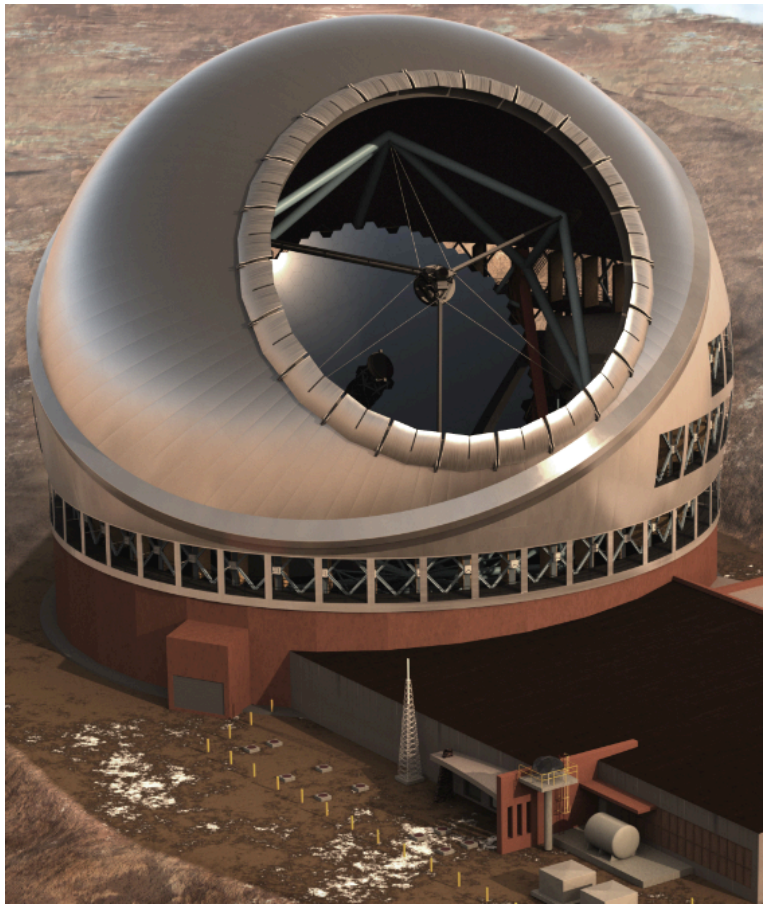


Courtesy: G. D. Becker

QSOs that can feasibly be observed with 30+m telescopes.

~1000 QSOs at z>2 with $m_r < 21$





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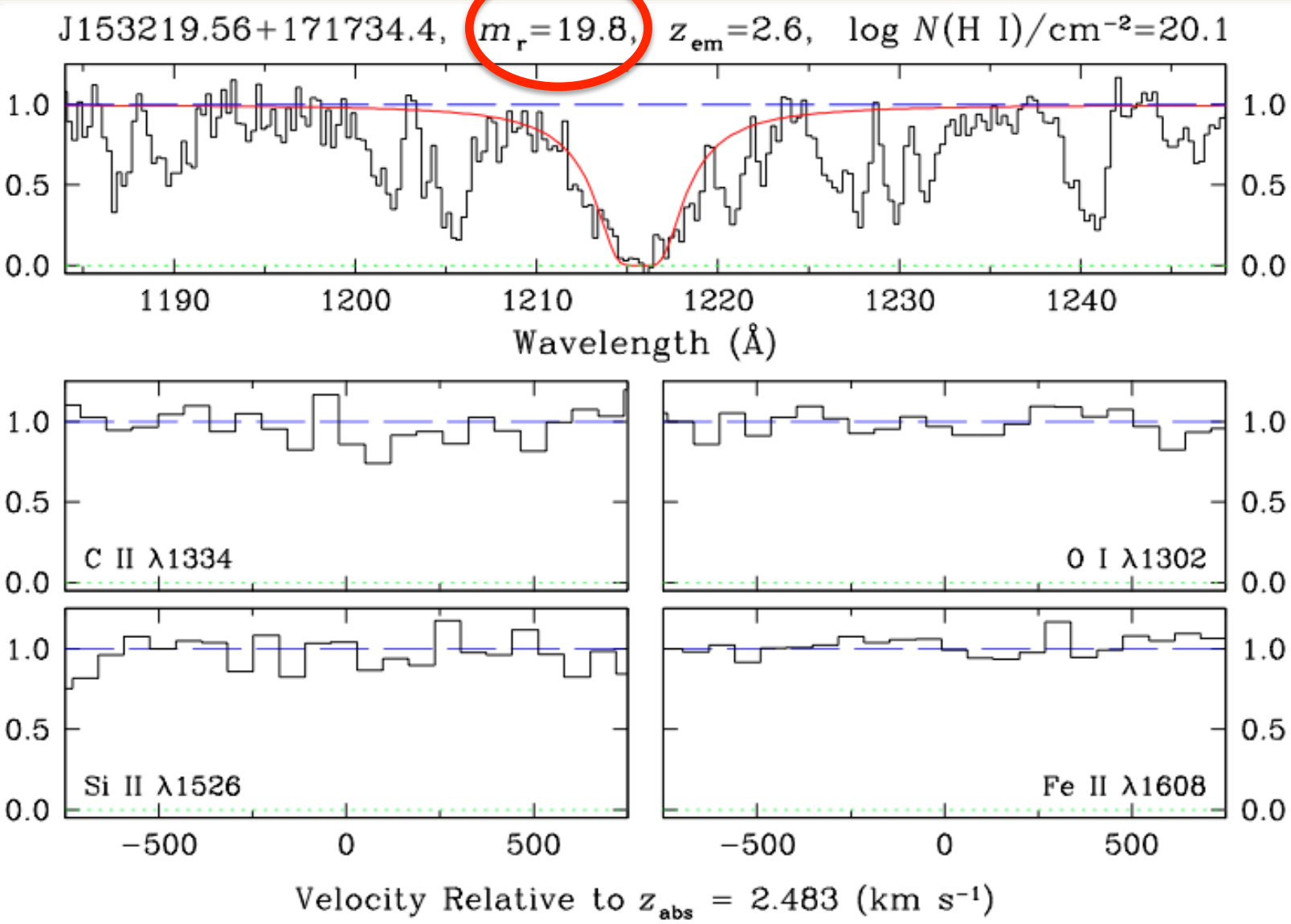
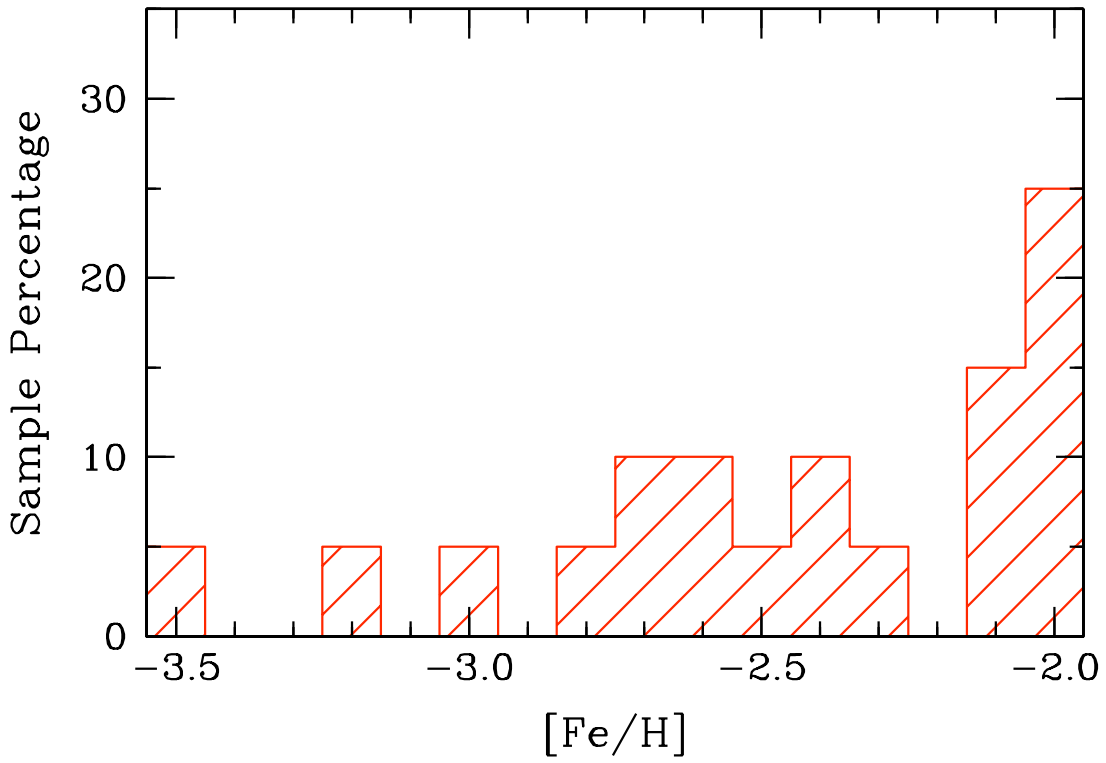
Here is one example



Summary and Conclusions

Conducted a survey to study the most metal-poor DLAs as probes of early stellar nucleosynthesis



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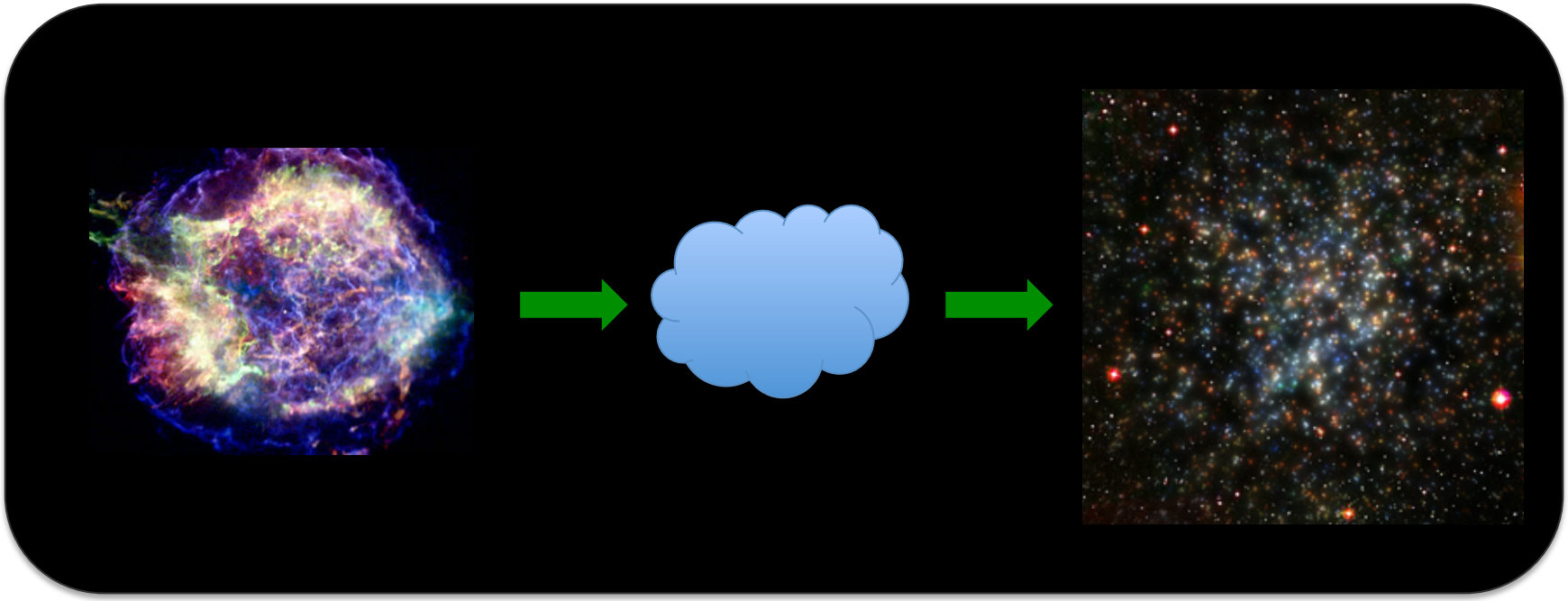
These appear to be the progenitors of the UFD galaxies – seen 10 billion years ago



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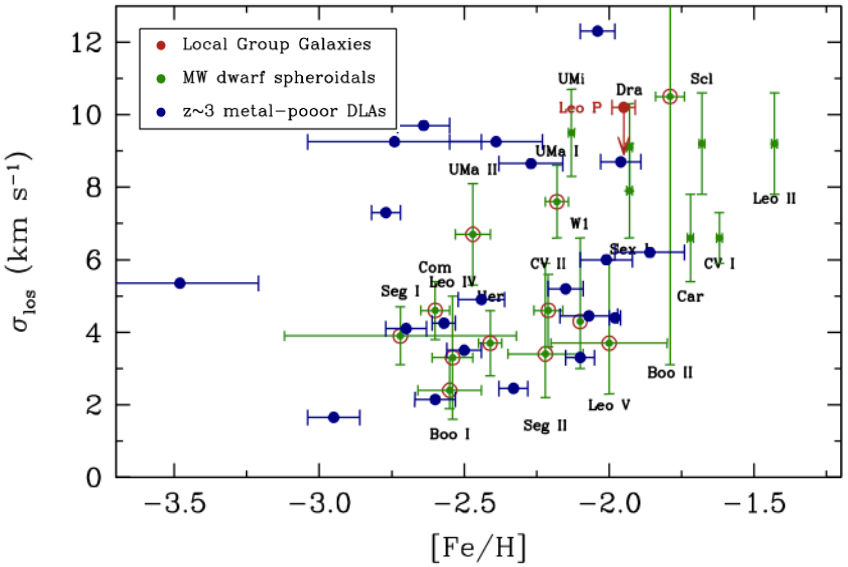

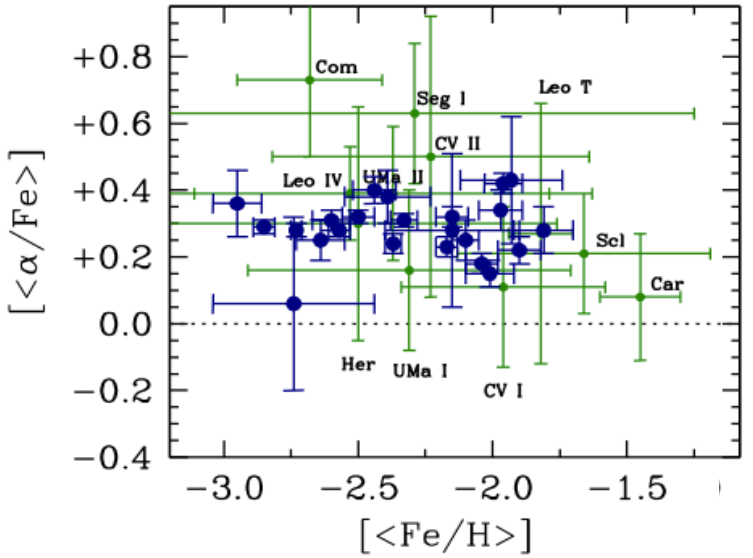

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These appear to be the progenitors of the UFD galaxies – seen 10 billion years ago
Good agreement with kinematics and chemistry from local group galaxies
Derived a few key physical properties of the gas that seeds the second stars

Temperature	≈ 7000 K
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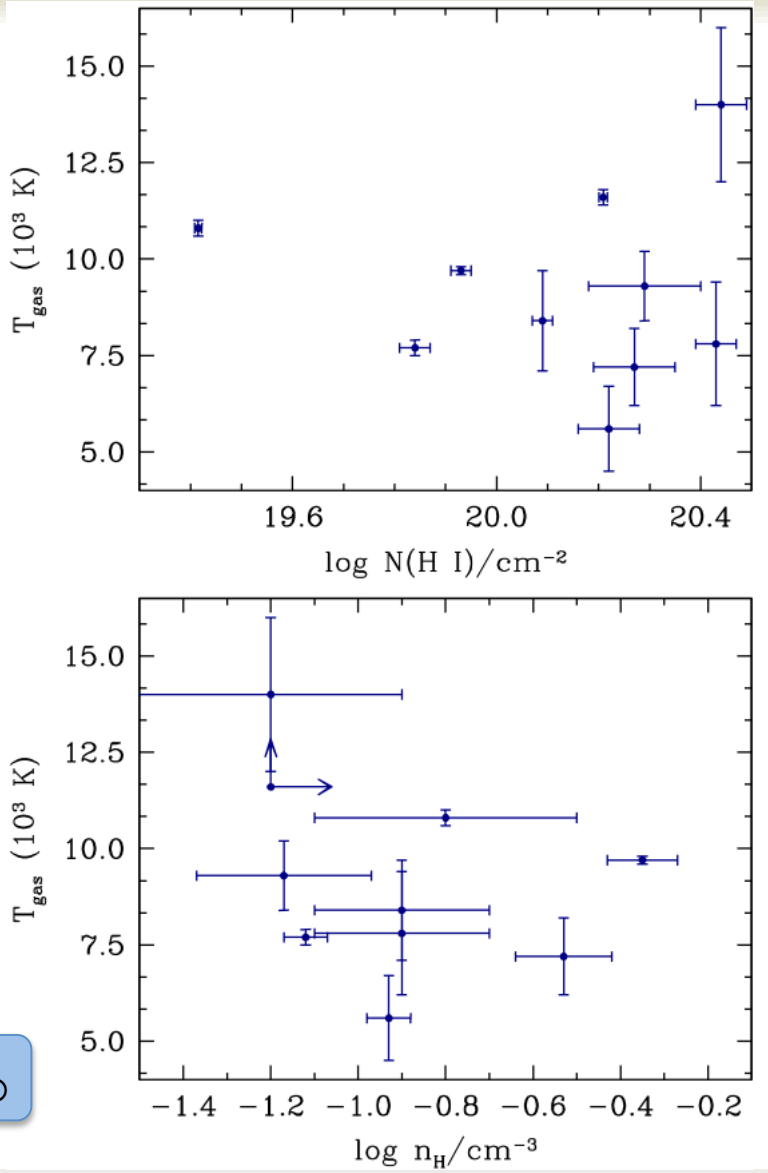

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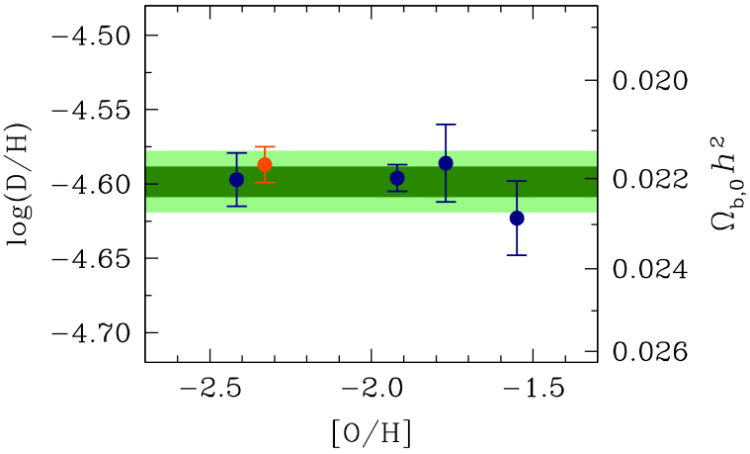
Such systems afford precise measures of the primordial element abundances

Cooke et al. (2014) ApJ, 781, 31



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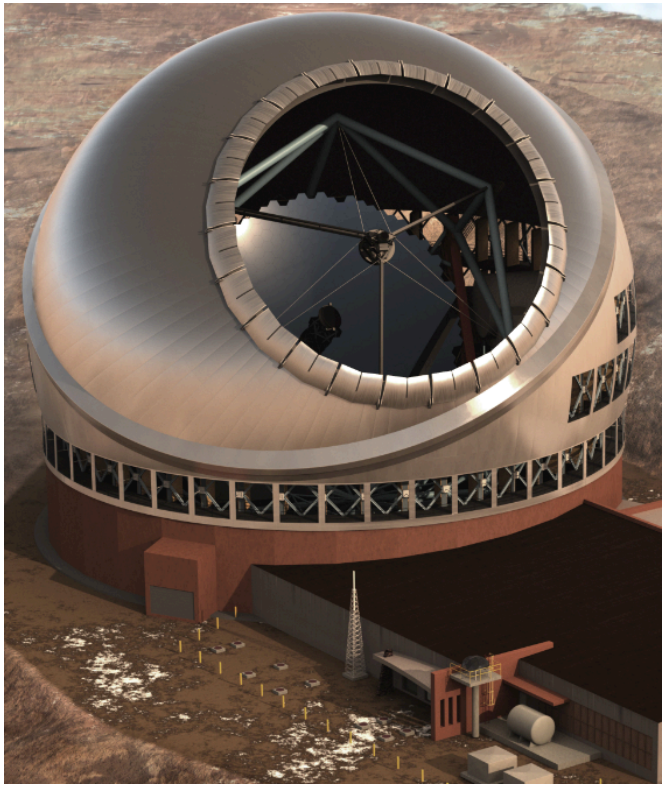

- The most metal-poor DLAs are ideal environments to probe early nucleosynthesis and the properties of dwarfs/UFDs