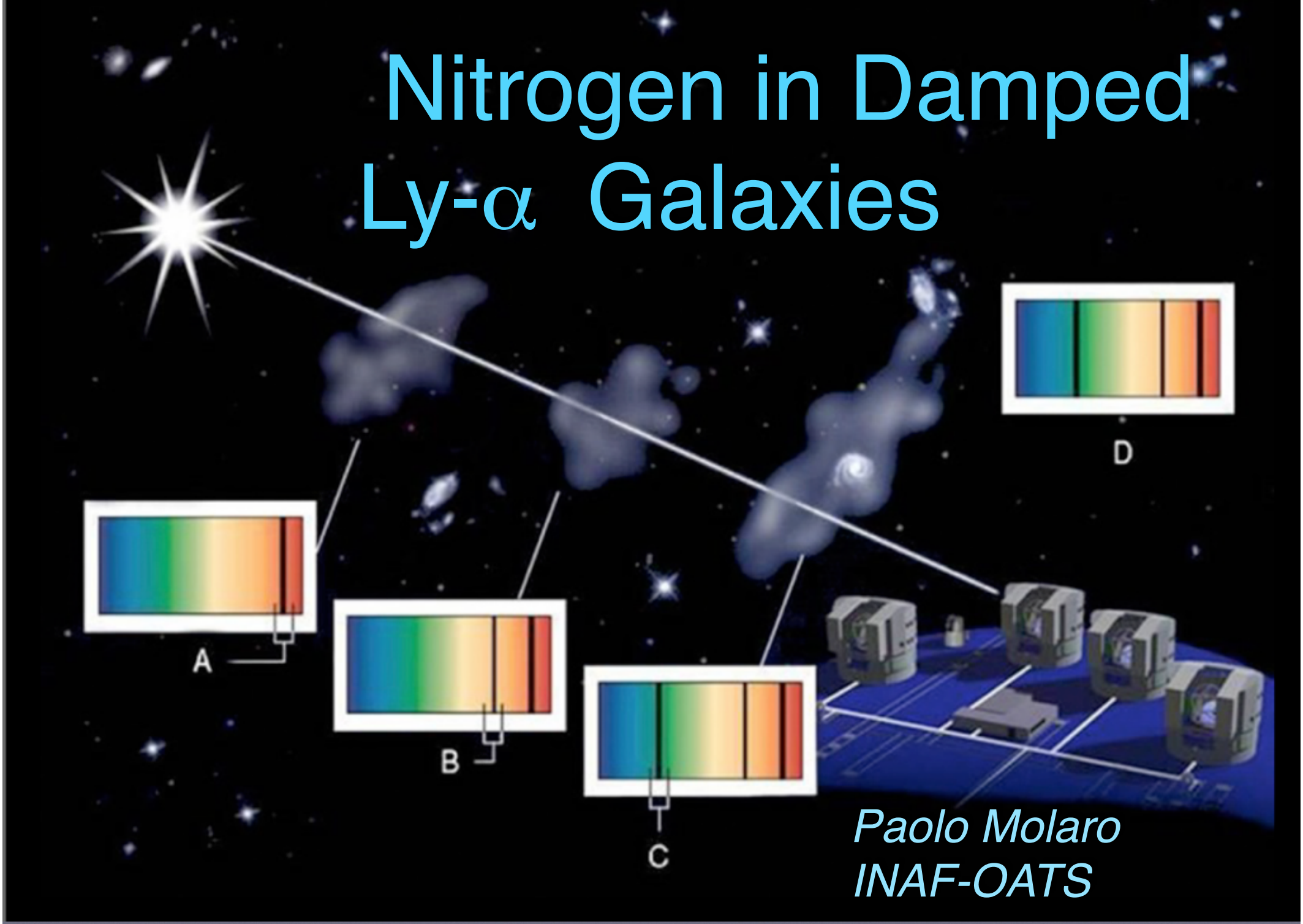
Nitrogen in Damped Ly-α Galaxies



Paolo Molaro
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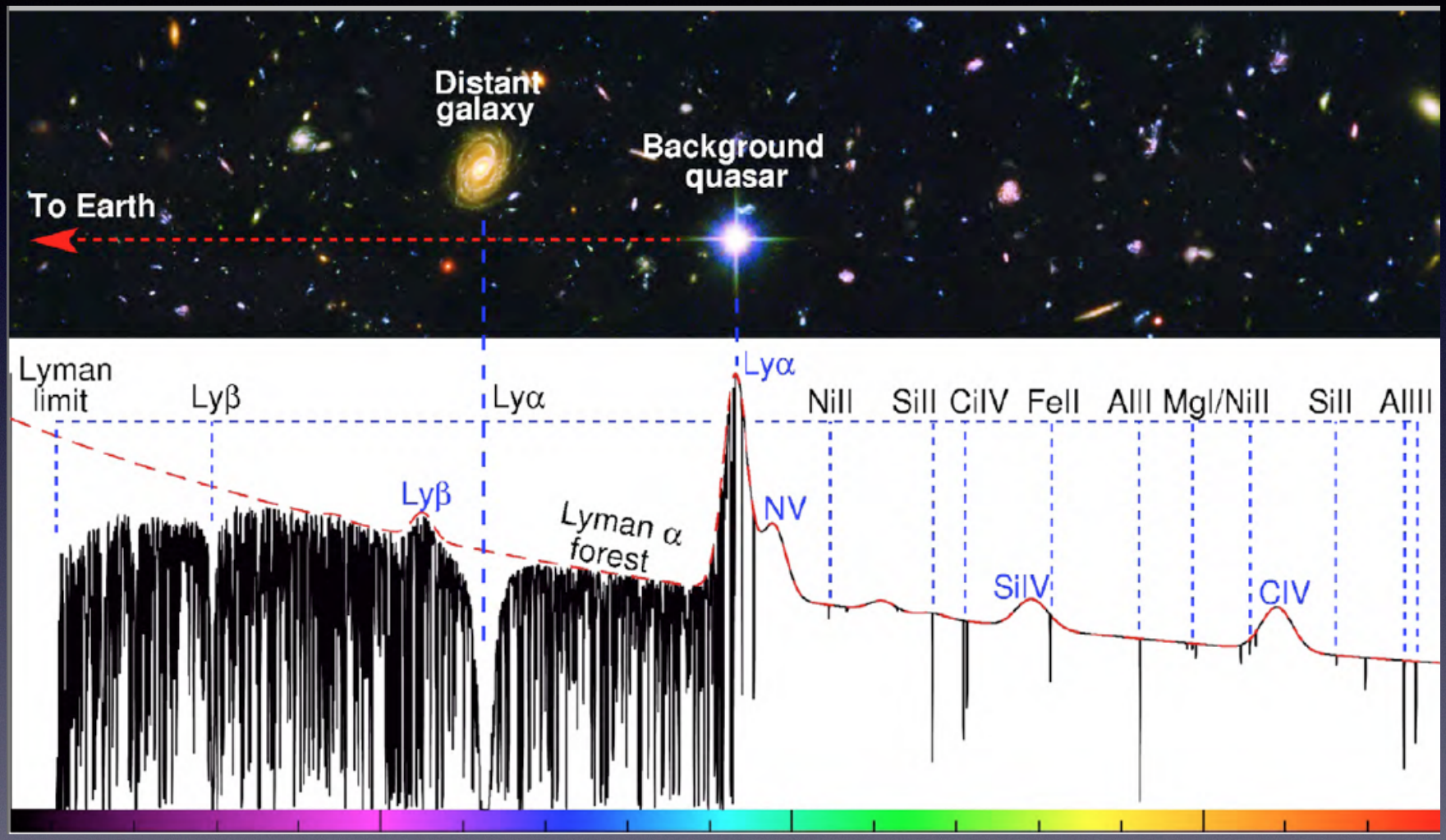
DLA in a nutshell

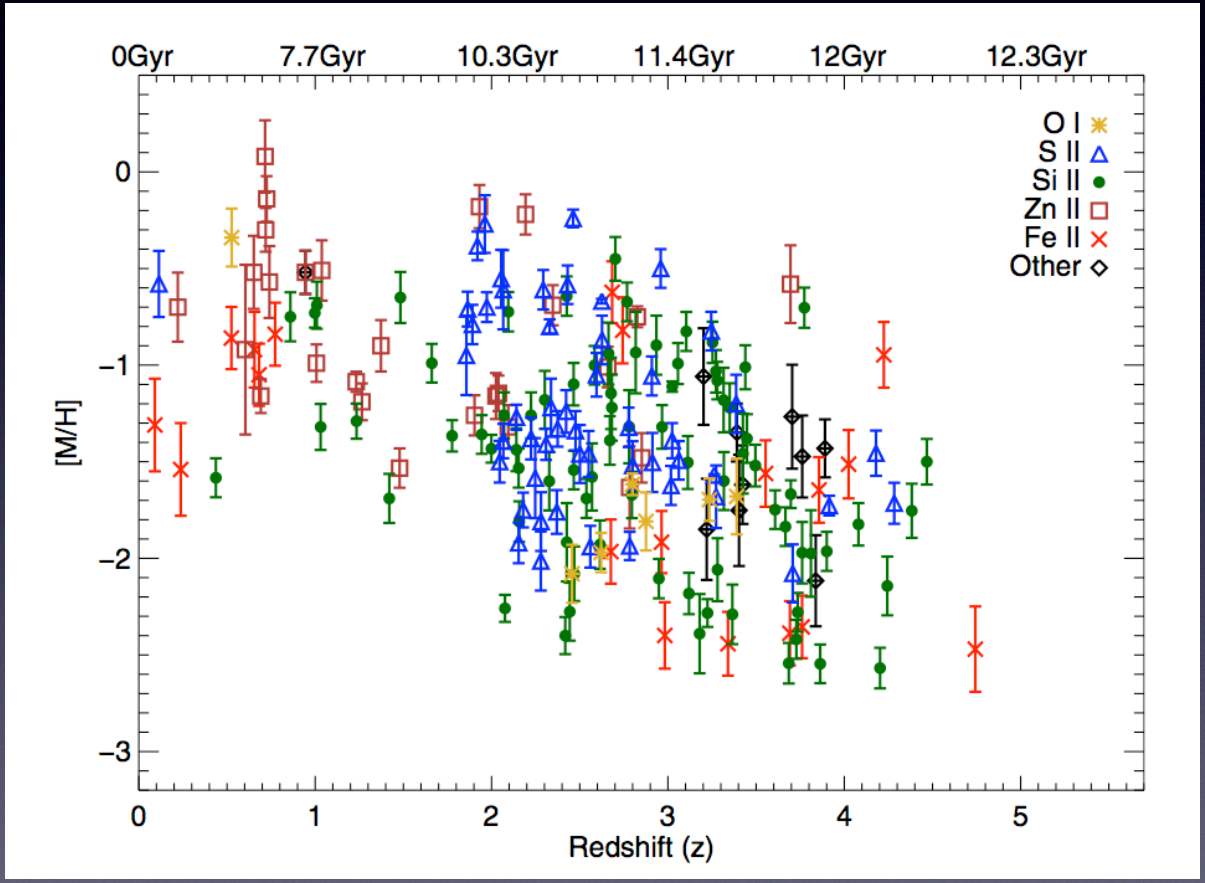
$N(HI) > 10^{20.3}$ atoms cm^{-2}



Ly α absorption profile with damping wings

Optically thick to ionizing radiation

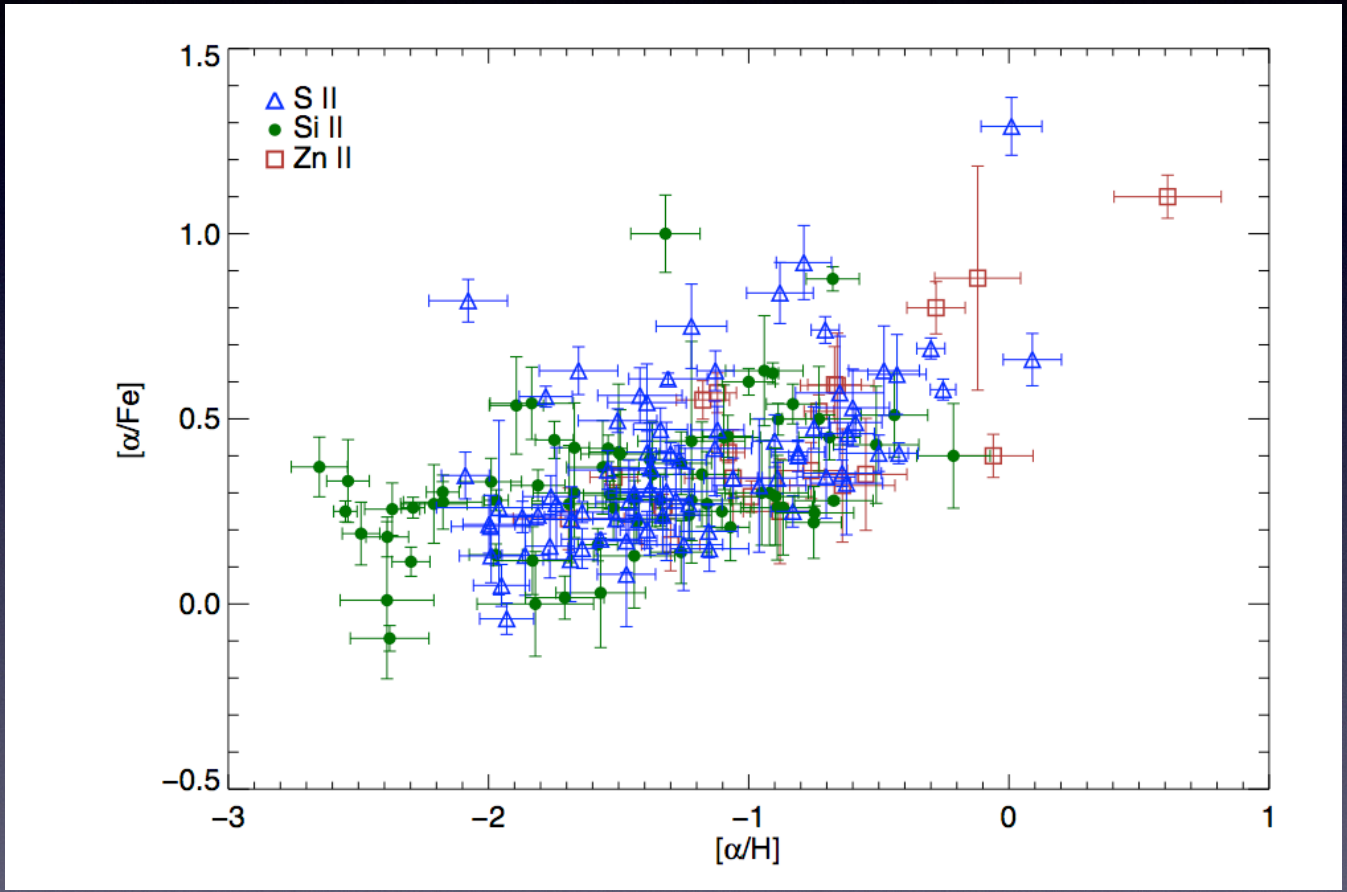
Accurate abundances throughout the whole universe (unbiased with respect to Luminosity or Mass)



Rafelski et al 2012

DLAs probes early stellar nucleosynthesis

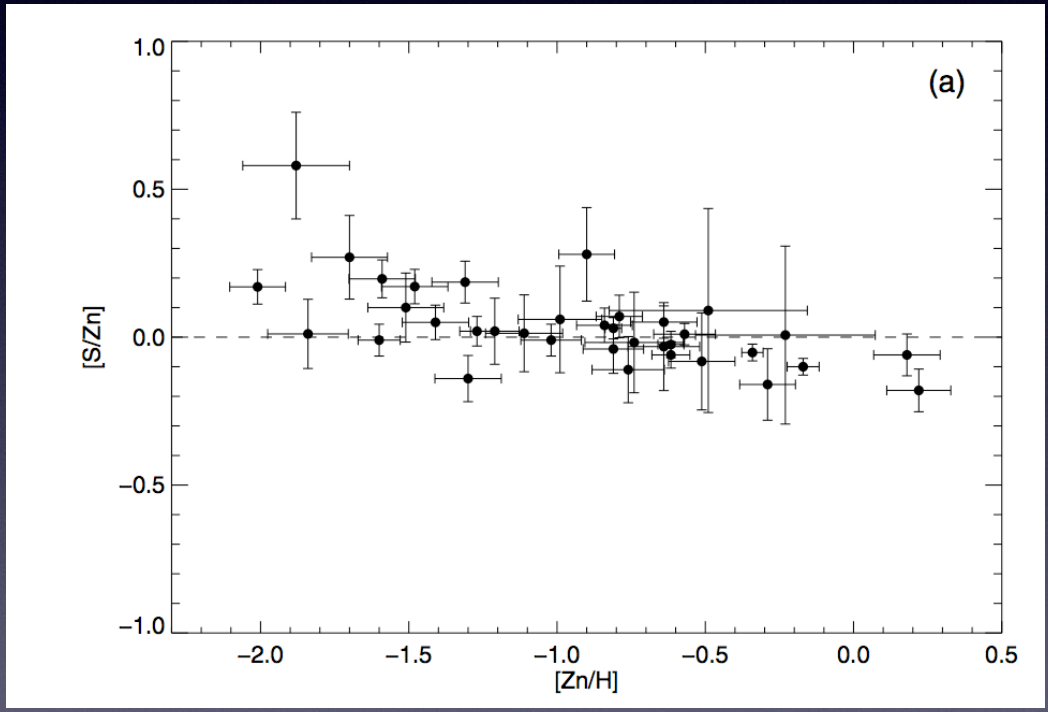
[α/Fe] ?



"false" behaviour

Sulphur & Zinc

S, Zn both non-refractory
S α-element
Zn iron-peak element

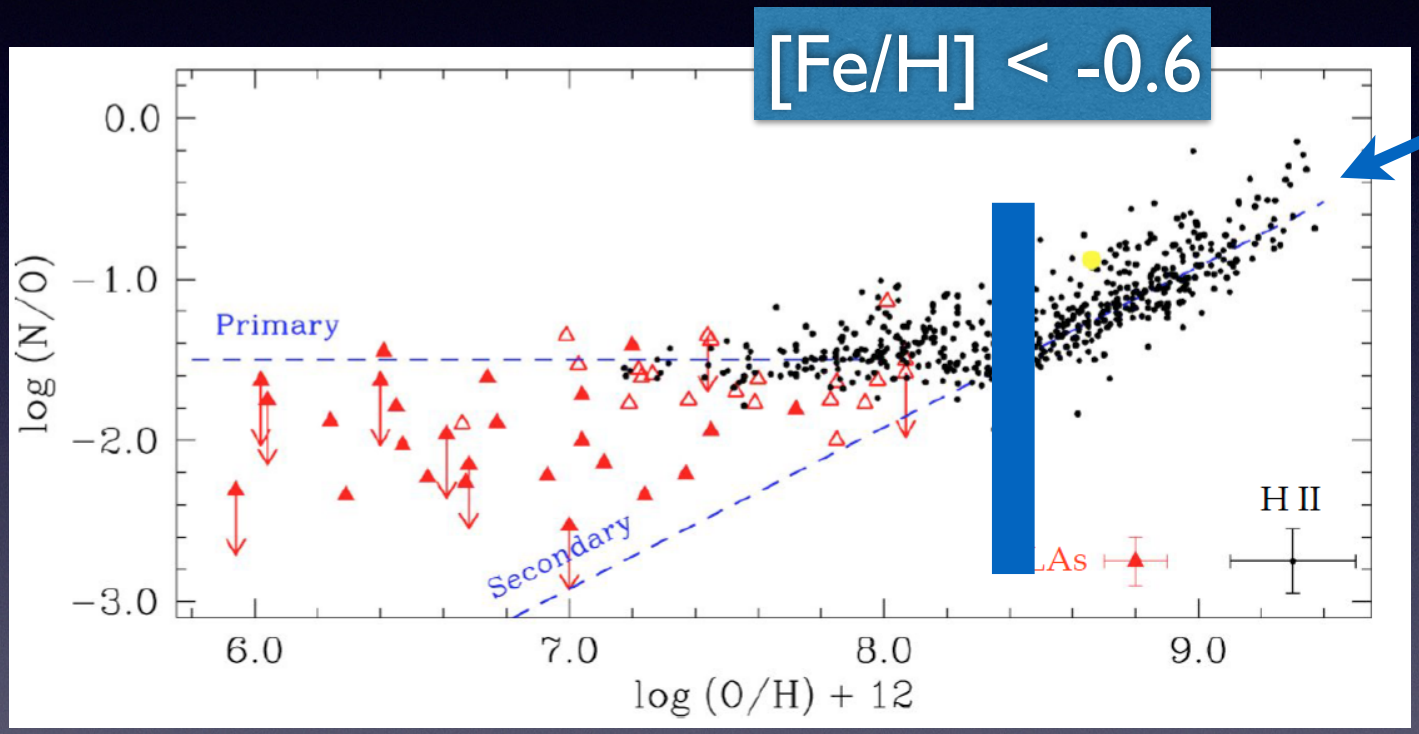


Centurion et al 2003,
Rafelski et al 2012

[α/Fe] ~ 0, 0.3

Nitrogen

- Special Nucleosynthesis:
- N is produced in the CNO cycle (CN branch) from C and O
  - ➡ Secondary Element



Pettini et al 2008

- [Fe/H]> -0.6 N secondary behaviour

- [Fe/H] < -0.6 N primary: nucleosynthesis in IMS (4-8 M), which undergo HBB, C is produced in situ

Zafar et al MNRAS 2014

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Miriam Centurión, INAF-OATS
Popping Attila, ICRAR, Australia

Digging inside the Ly α forest

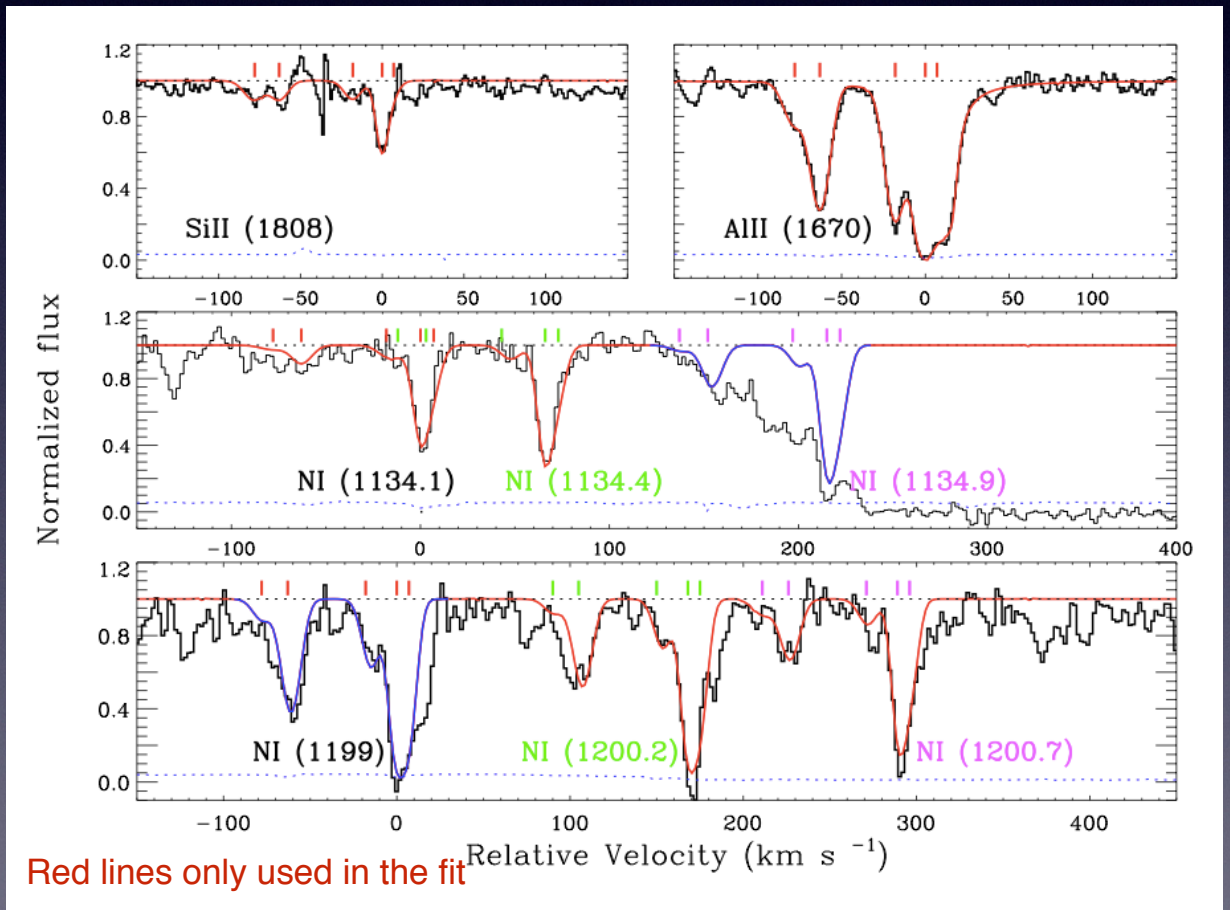
6 NI transitions in the forest:
NI 1134.1 1134.4 1134.9
NI 1199.0 1200.2 1200.7

B 2348-0180

z = 2.6147

✓No need for dust correction

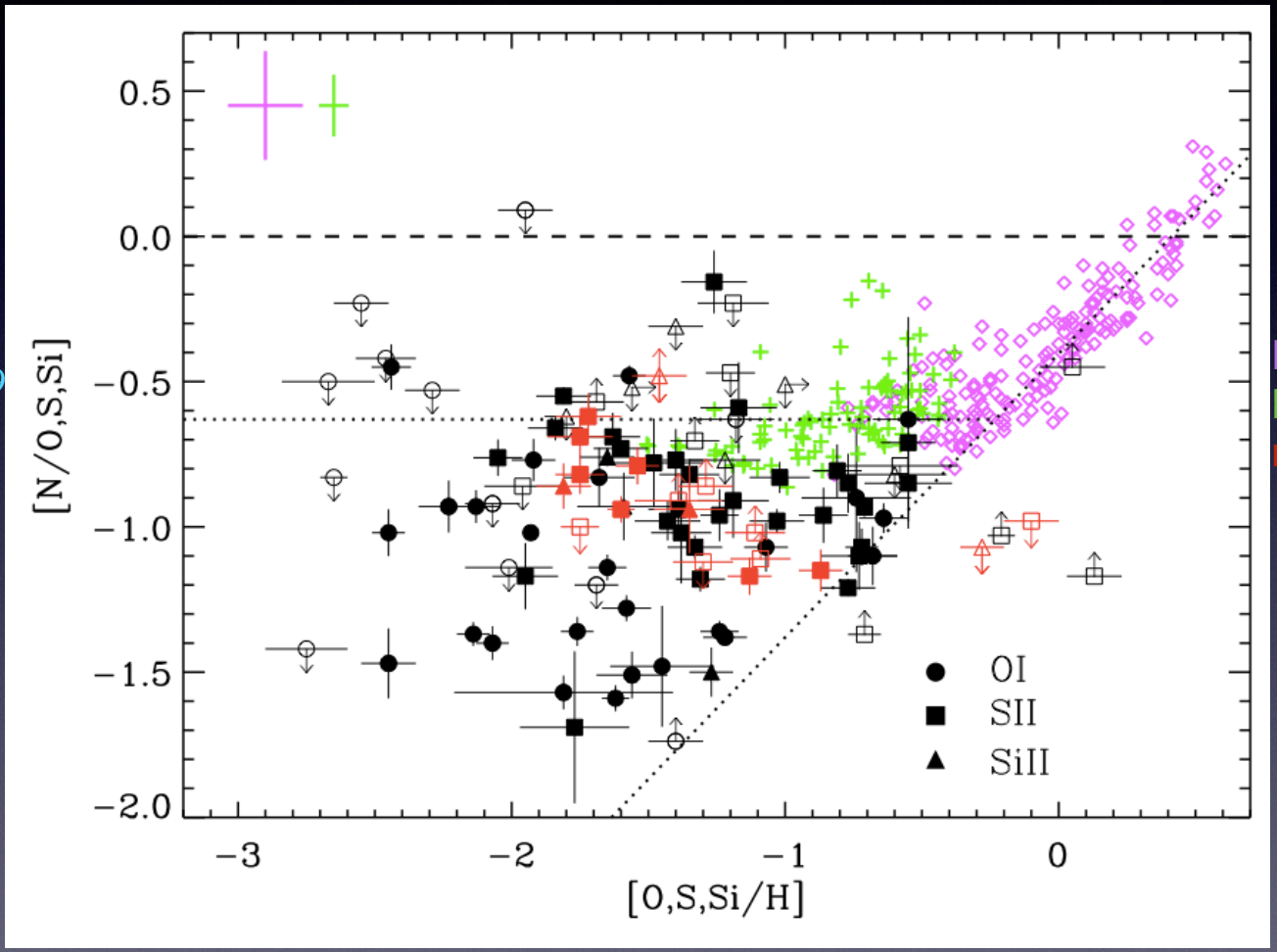
	b(km/s)	logN(NI) cm(-2)
1	5.4(6)	13.63(3)
2	5.1(4)	14.25(4)



Red lines only used in the fit

70 measurements

solar values
Asplund etal 2009

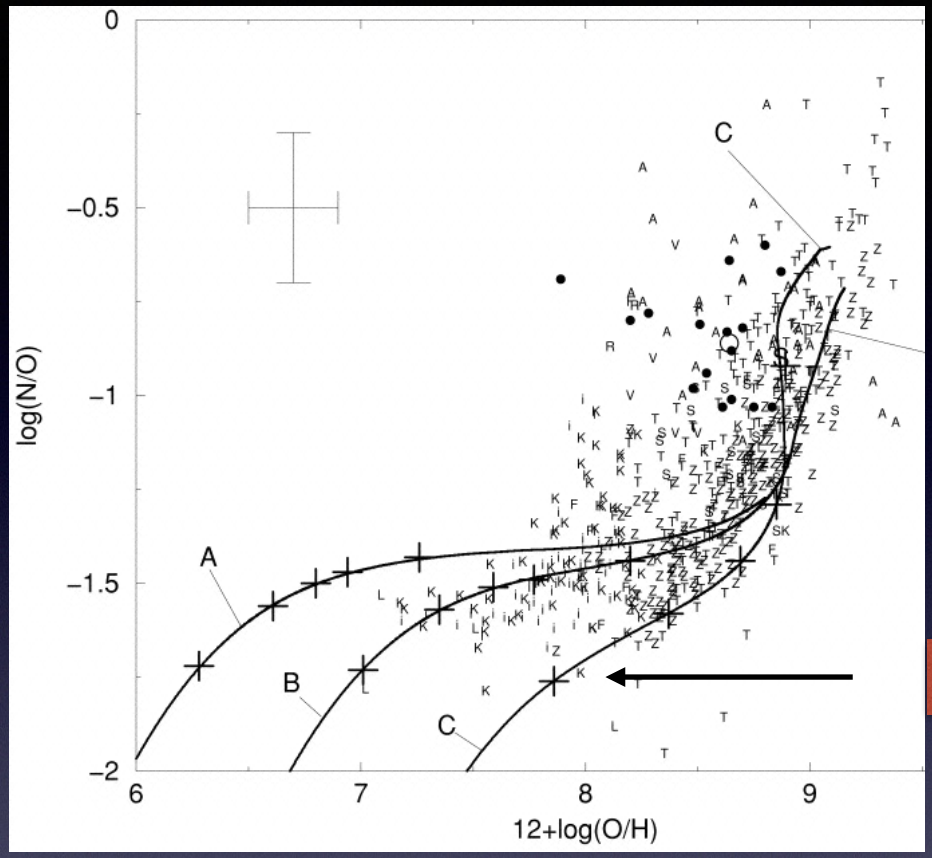


HII regions Van Zee et al '98
BCG Izotov Thuan 2004
new measurements

- Total sample 70 measurements and 38 limits

- Large spread in [N/α]: > one order of magnitude (real)
- The highest [N/α] are at the level of the HII plateau

Henry et al (2000)

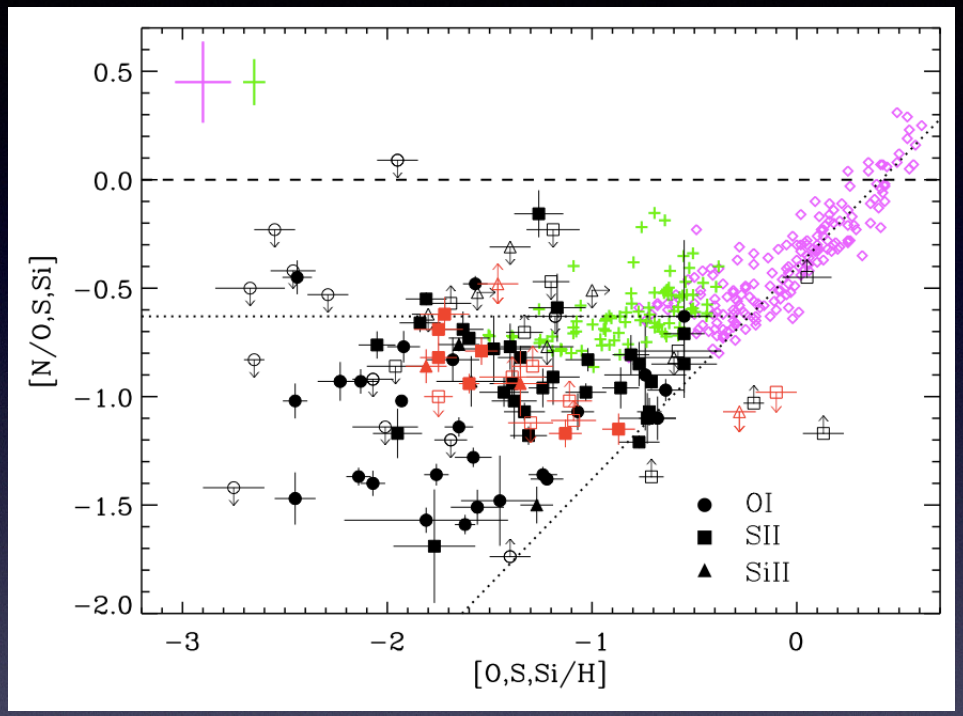


250 Myr

SFR

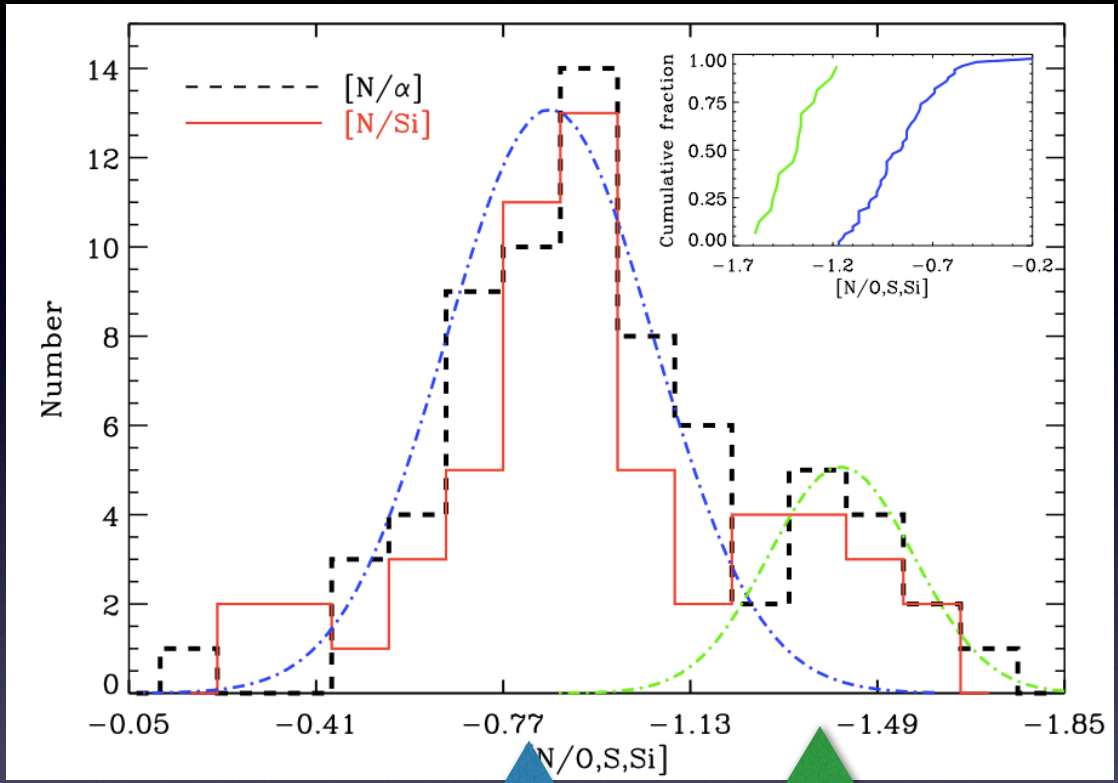
The primary component of N becomes evident when the SFR is slow

➡ DLA are characterized by a low SFR



Why few [N/O] -1.5 ?
Why no [N/O] < -1.7 ? not "observational" limit

BIMODAL DISTRIBUTION



ONLY MEASUREMENTS

Ryan- Joiner Normality
Wilcoxon Rank Sum (RS)
F-stat 98% prob bimodal

77%

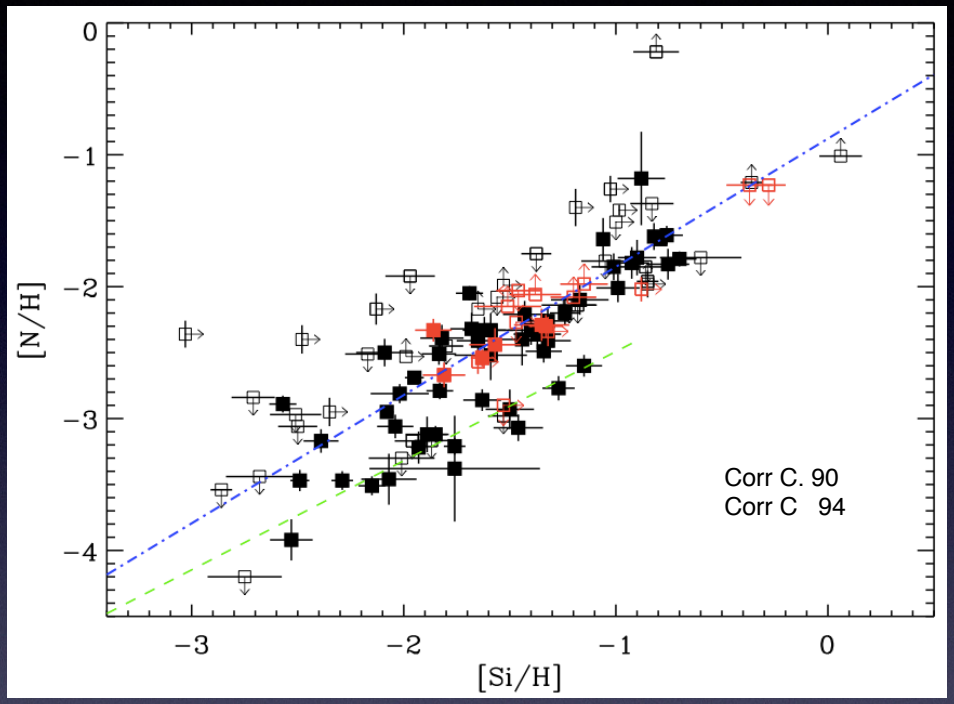
23%

[N/Si]= -0.83±0.21

[N/Si]=-1.40±0.13

already suggested by Prochaska et al 2002, Centurion et al 2003

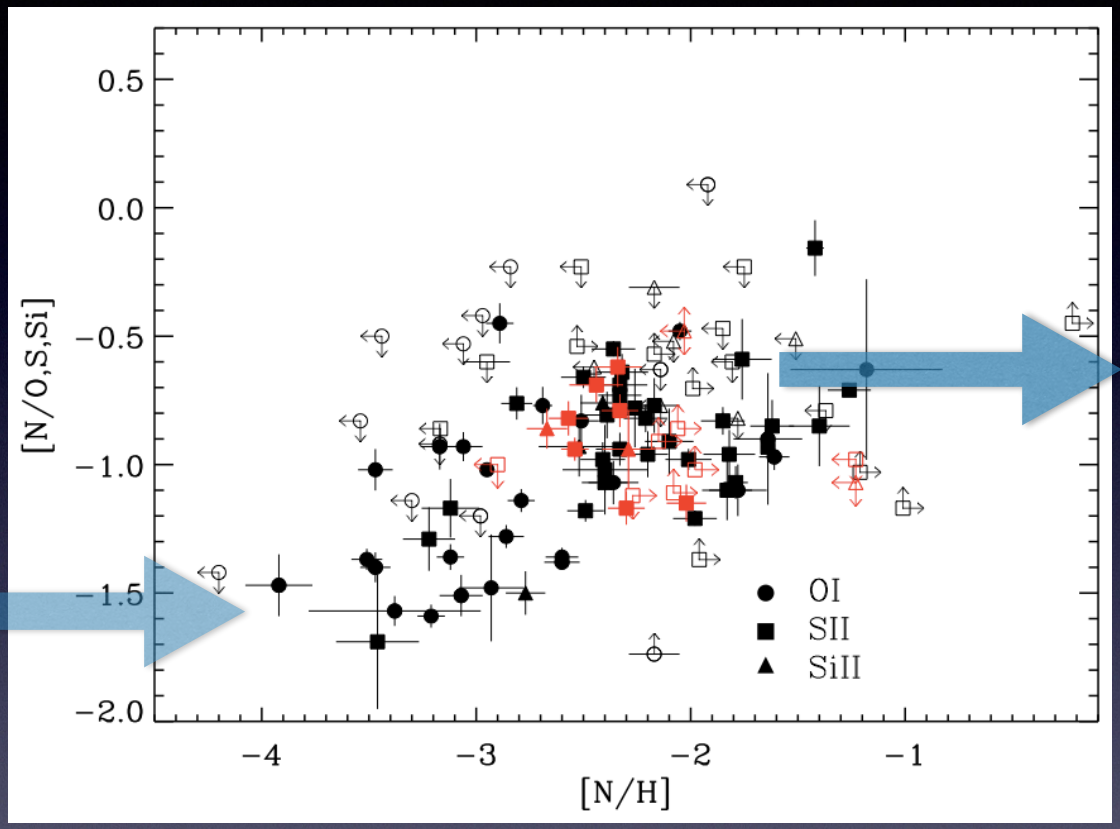
N goes in lockstep with Si



2 "primary" nucleosynthesis processes for N

A) High N/O by IMS

B) Low N/O primary N production by a new process
rotating massive stars: diffusion of C into the H burning shell
(Meynet and Maeder 2002, Limongi's talk)



TEMPORAL EVOLUTION?

Summary

- DLAs are low-alpha galaxies as the Local Dwarf Galaxies
- Unique probes of N nucleosynthesis The N/O distribution has no astronomical counterparts: requires a low SFR .
- There is evidence for a bimodal distribution:
  - ➡ 77%, [N/O] = -0.84 (~ HII, BCG, same producers).
  - ➡ 23%, [N/O] = -1.4.
- Both show a strictly primary behaviour and N tracks the alpha elements
- Low N/O are young systems and the primary N production could be the rotating massive stars of Meynet and Maeder (2002).
- Future: N is foreseen to be made in first stars (zero metals) (Heger Woosley 2010, Limongi Chieffi 2012) this is not yet observed in the lowest DLA.

Thanks!