Investigating the QSO environment with the spectra of the XQ-100 Legacy Survey

Valentina D'Odorico

INAF – Osservatorio Astronomico di Trieste

Prologue

- All the work has been carried out by Serena Perrotta (SISSA – Trieste)
- The aim of the work is to use the narrow absorption lines in the XQ-100 spectra to characterize the QSO outflows and the QSO environment
- The main difficulty is to identify the intrinsic absorption lines (due to gas which is part of the AGN/host galaxy environment)
- This is still a work in progress!

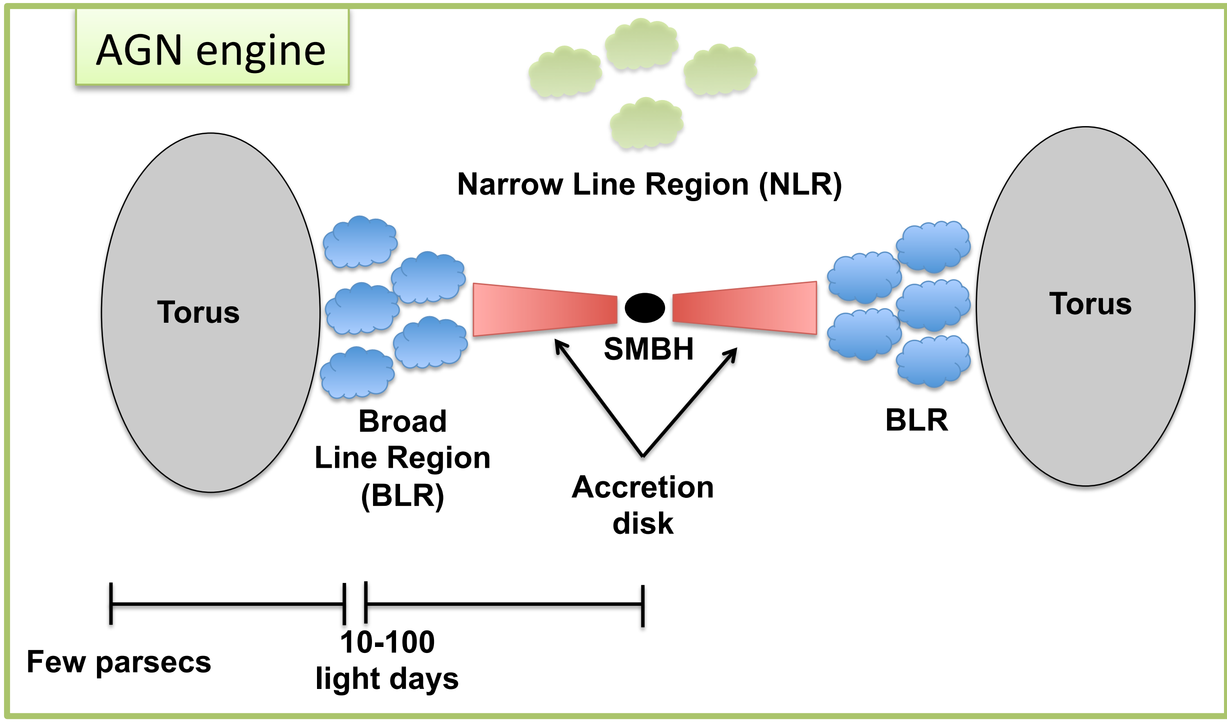
QSO outflows

AGN unification model

✧ Massive outflows from the accretion disk region are necessary to decrease angular momentum and allow mass accretion to the SMBH;

✧ The same outflows could transfer thermal and mechanical energy to the ISM of the host galaxy (AGN feedback) and blow out material to the IGM.

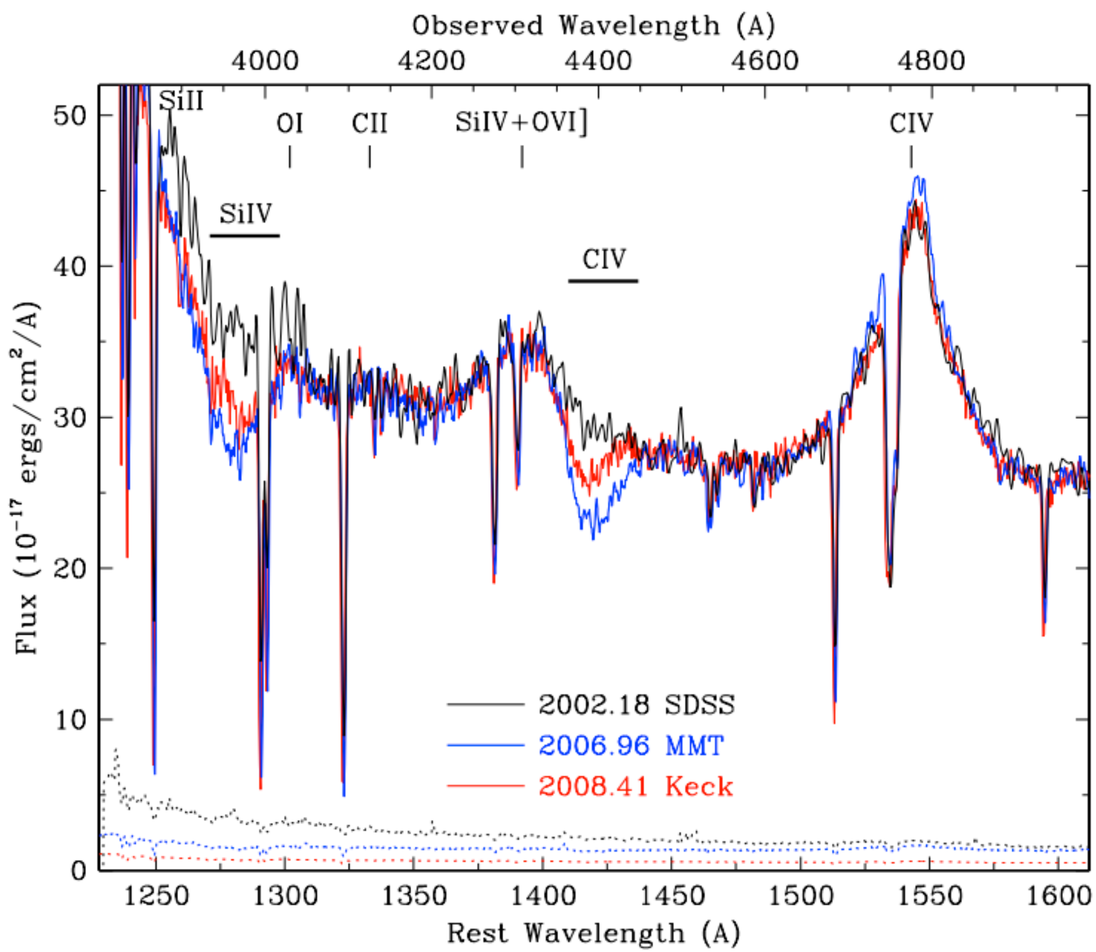
Understanding the physics of outflows is crucial!



QSO absorption spectra

Broad absorption lines (BAL): width > 2000 km/s

- Intrinsic nature;
- Originating in the accretion region;
- Expelled at very high velocity (up to ~0.1c, in this case 26,300 km/s);
- Detection rate ~23 % (Hewett & Foltz 2003)



Hamann et al. 2008

QSO absorption spectra

Broad absorption lines (BAL): width > 2000 km/s

Narrow absorption lines (NAL): width < 500 km/s (often <50 km/s)

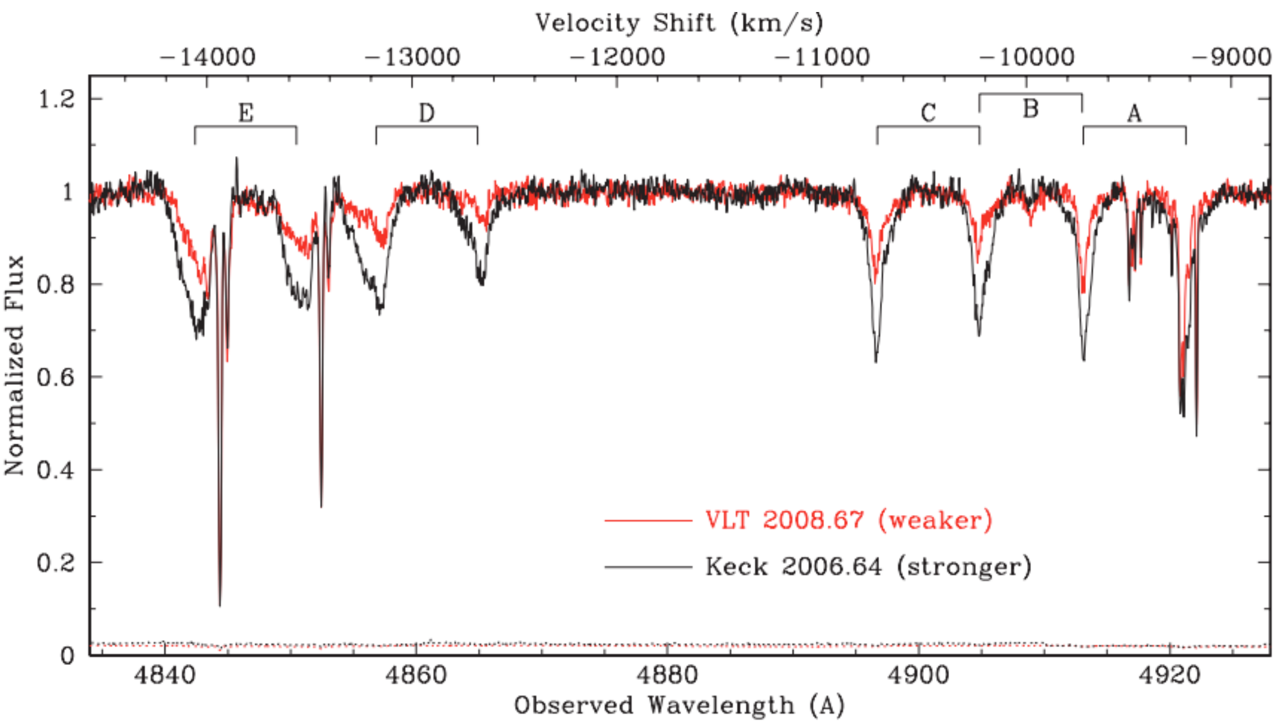
Intrinsic and intervening

Intrinsic nature:

- Partial coverage;
- Time variability;
- High photoionization parameter;
- High metallicity

Associated absorbers:

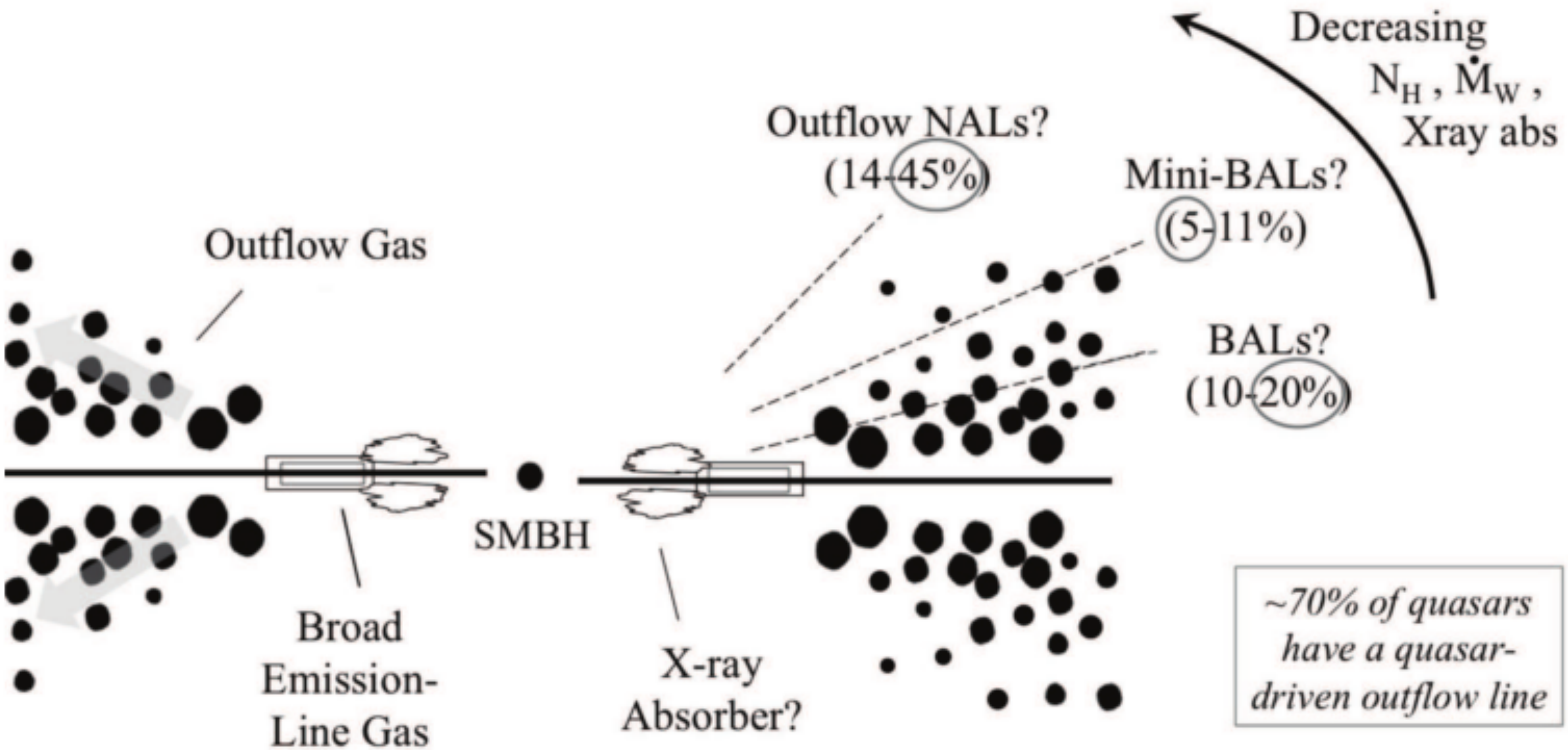
v_{shift} < 5000 km/s



Hamann et al. 2011

QSO absorption spectra

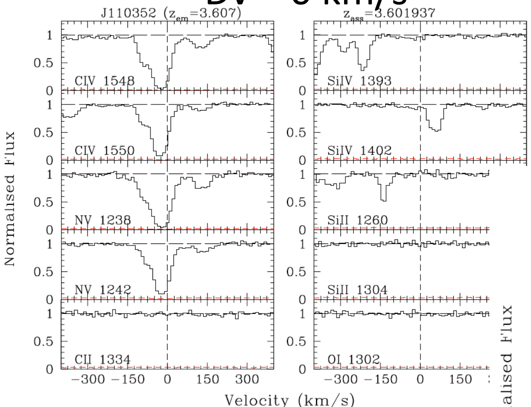
Broad absorption lines (BAL): width > 2000 km/s
Narrow absorption lines (NAL): width < 500 km/s (often <50 km/s)
Mini BALs: intermediate class (intrinsic)



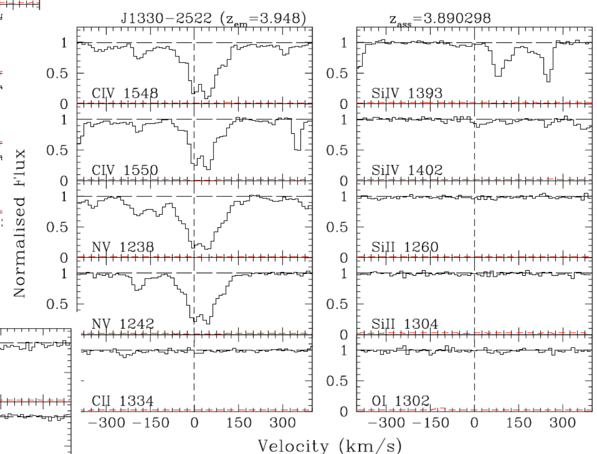
Hamann et al. 2012

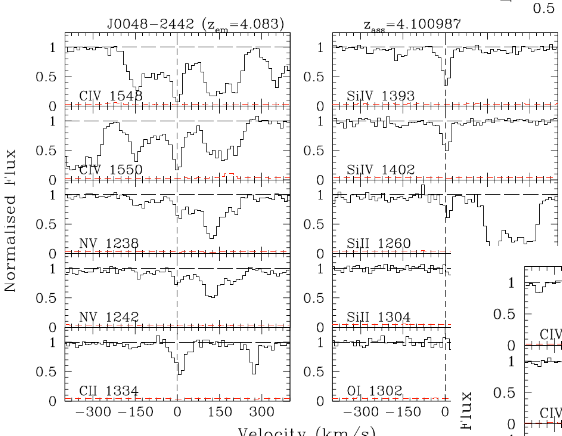
NALs in XQ-100: C IV sample

Dv ~ 0 km/s



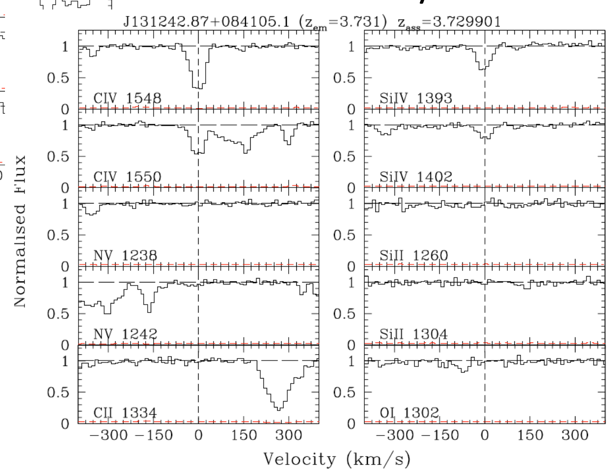
Dv ~ 3500 km/s





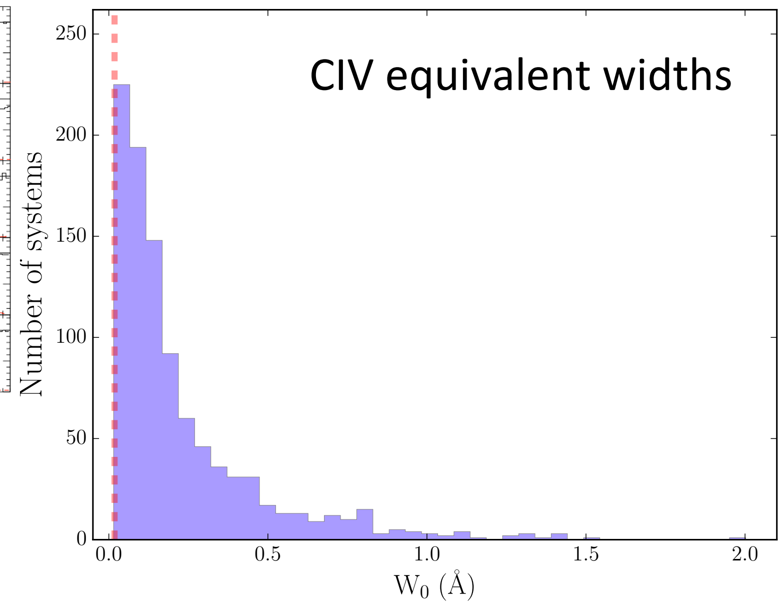
Dv ~ 3000 km/s

Dv ~ 70 km/s



986 C IV systems with

$-73000 < v_{shift} < +1000$ km/s



Associated ionic transitions:

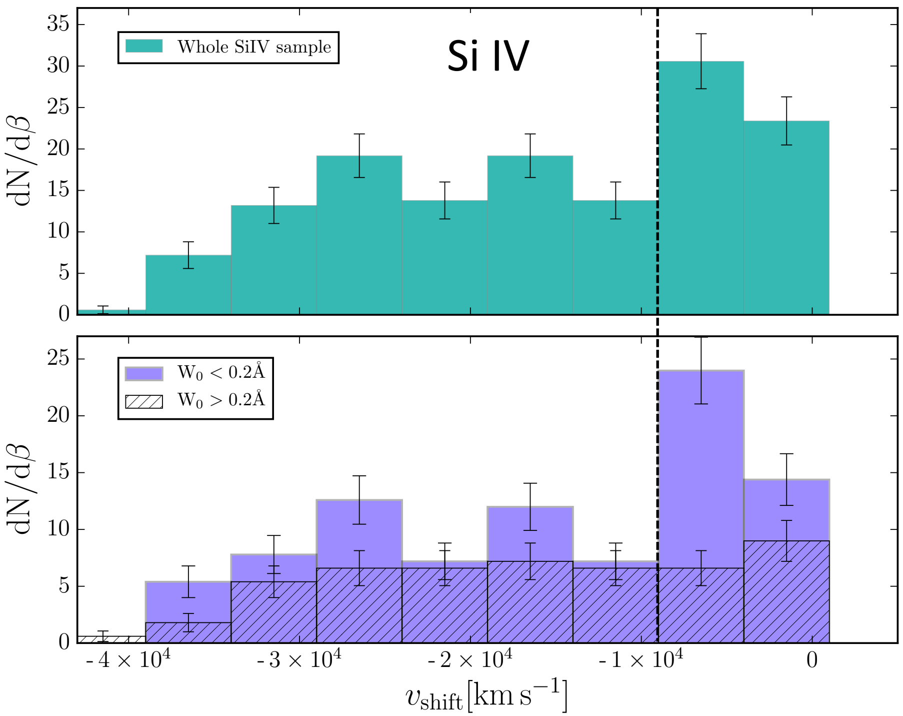
236 Si IV with $-45000 < v_{shift} < +1000$ km/s

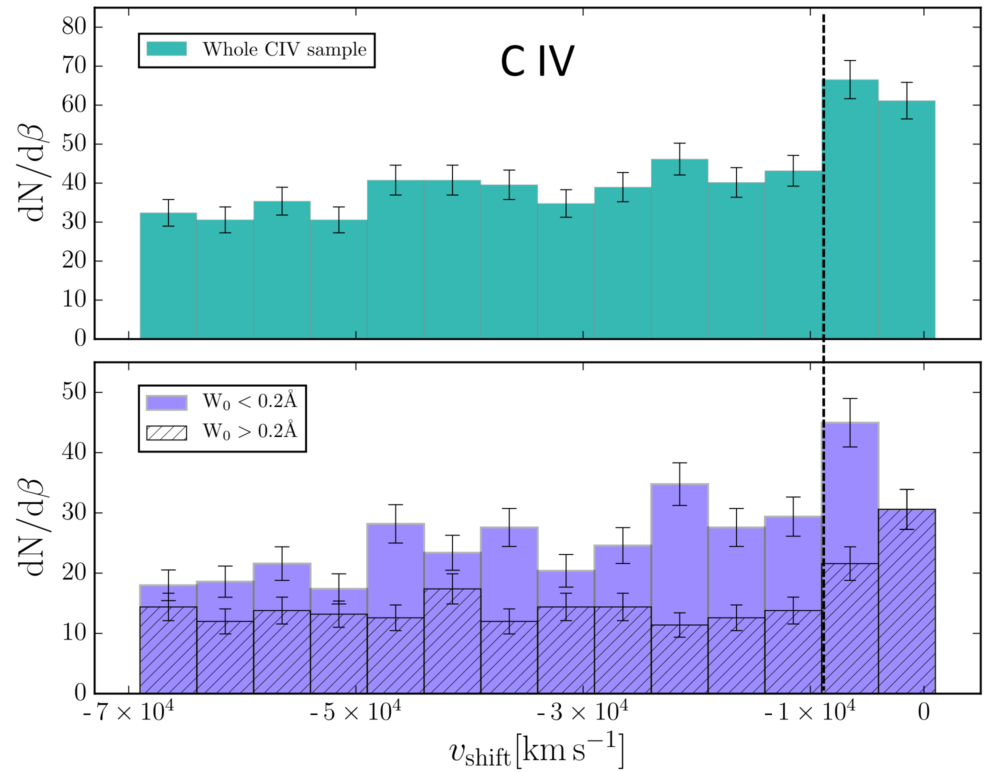
46 N V with $-5000 < v_{shift} < +1000$ km/s

26 C II with $-10,000 < v_{shift} < +1000$ km/s

NALs in XQ-100: C IV and Si IV

Velocity Offset Distributions



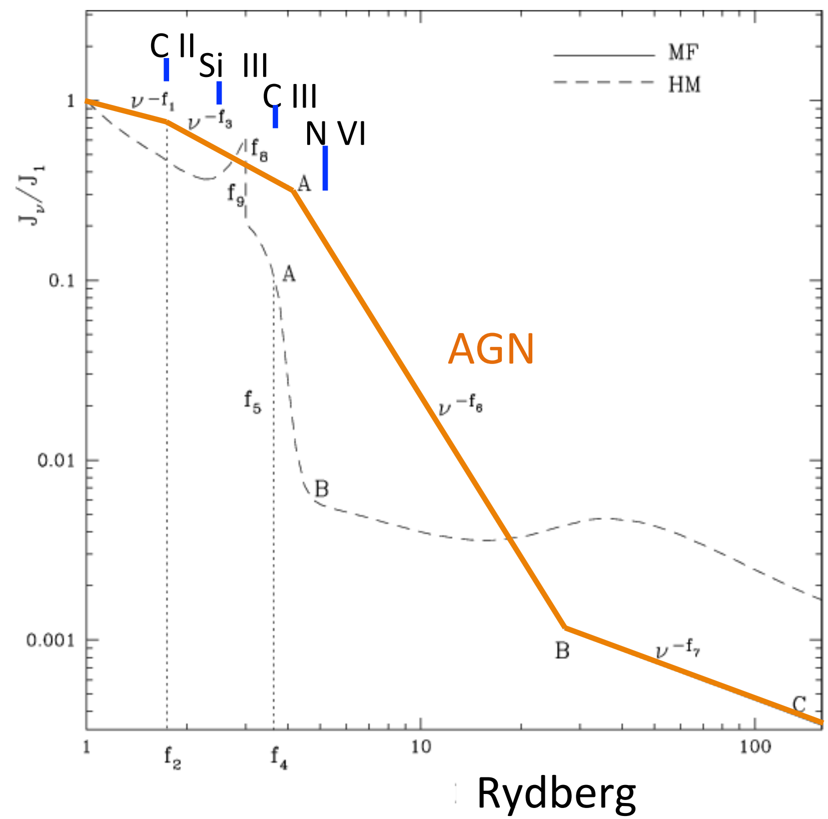


- The excess in the number of absorptions extends to ~10,000 km/s
- The detection rate of C IV in the range -5000 < v_{shift} < +1000 km/s is **72 %**
- The detection rate of C IV in the range -10,000 < v_{shift} < -5000 km/s is **64 %**
- But for -10,000 < v_{shift} < +1000 km/s is again **72 %**

NALs in XQ-100: intrinsic systems

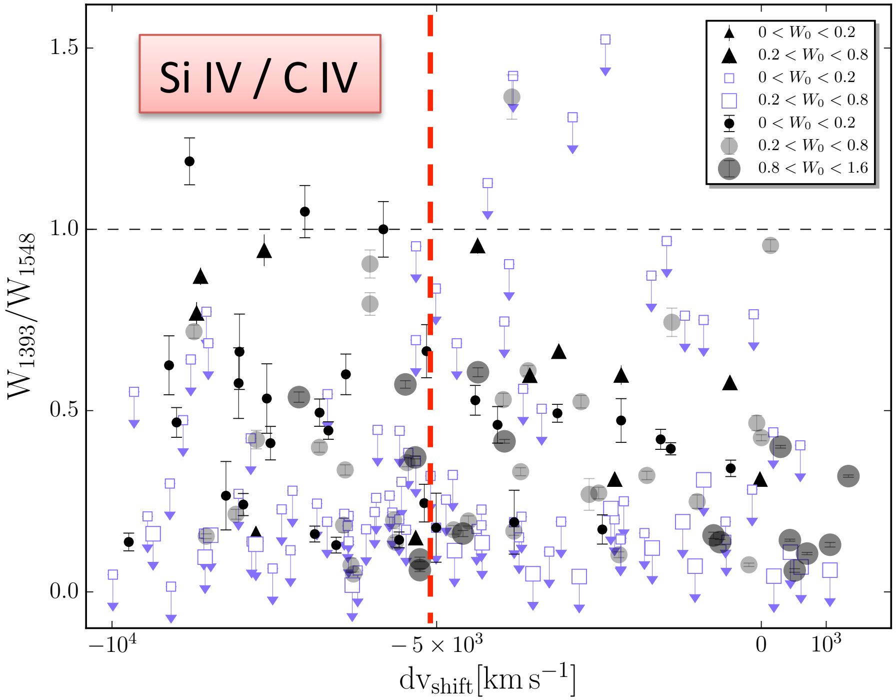
First Evaluation: ionization status ➔ presence of N V

- ✧ 45 % of C IV absorbers show associated N V
- ✧ The detection rate of N V in the range $-5000 < v_{shift} < +1000$ km/s is **26 %**
- ✧ Simon et al (2012) found **28 %** with partial coverage in the same v range
- ✧ Misawa et al. (2007) found **33 %** with partial coverage in the same v range



(Agafonova et al. 2005)

NALs in XQ-100: line ratios

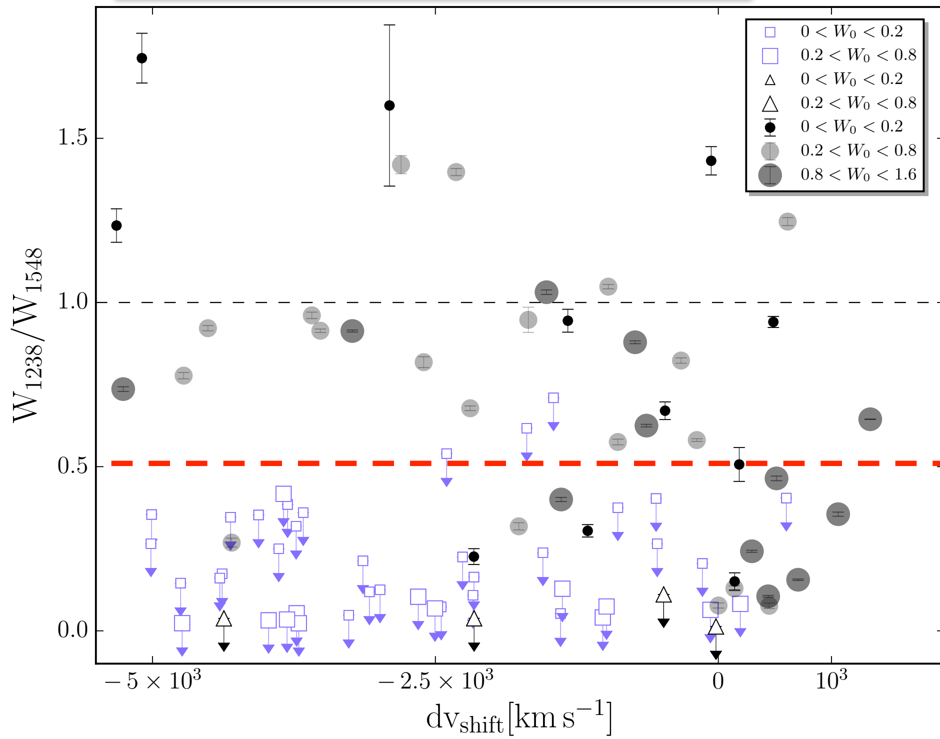


Size of the bullet ➔ C IV equivalent width

Triangles ➔ Damped Lya Systems

Squares ➔ Upper limits

N V / C IV: 45 % detection rate

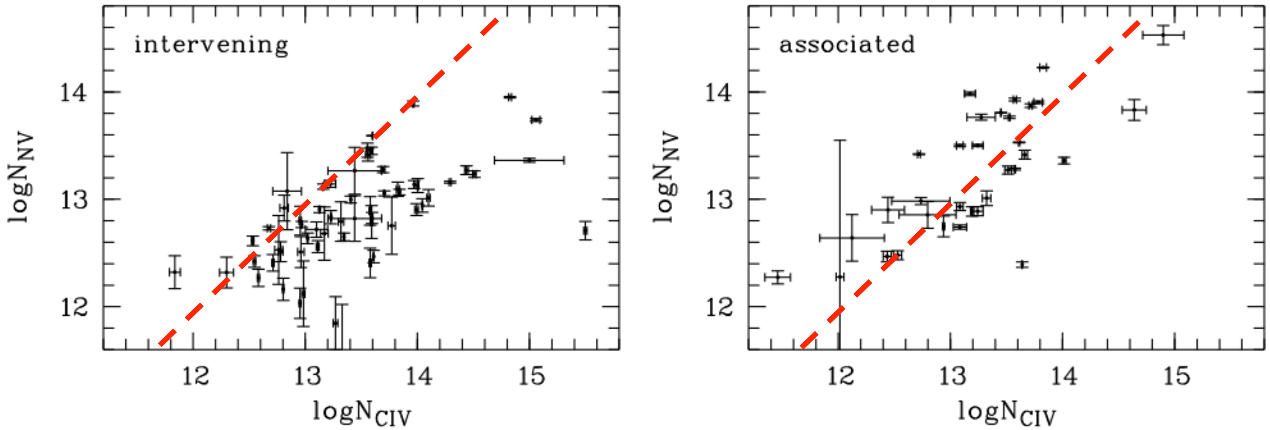


Note that for non-saturated lines:

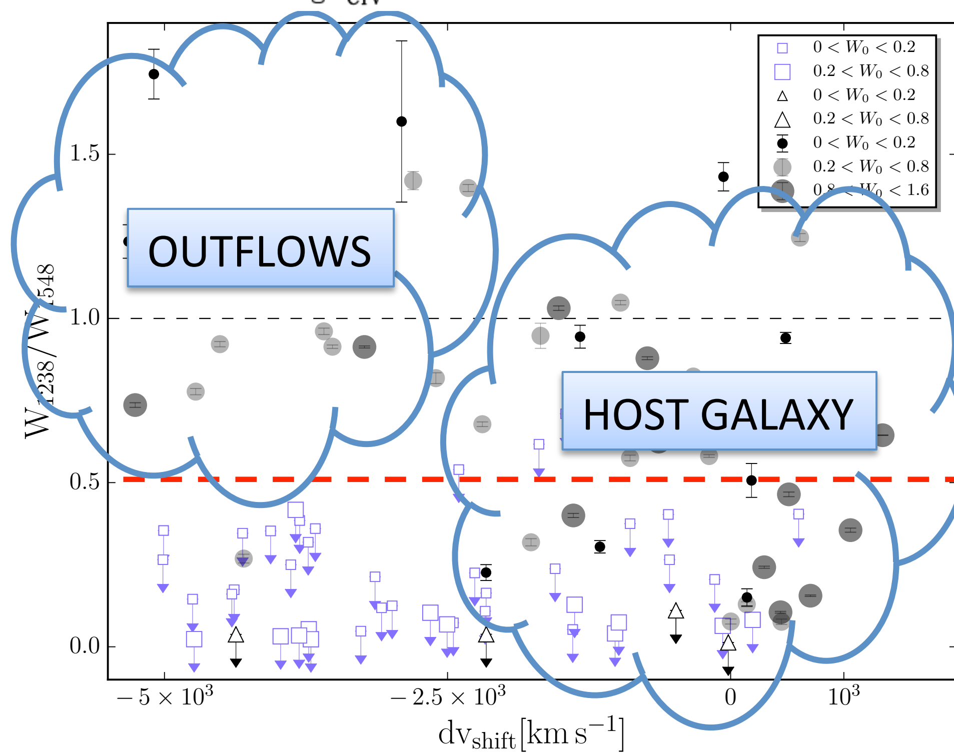
$W_{1238}/W_{1548} \sim 0.52\ N_{1238}/N_{1548}$

$W_{1393}/W_{1548} \sim 2.19\ N_{1393}/N_{1548}$

NALs in XQ-100: line ratios



Significative difference in the ratio log N_{NV} vs log N_{CIV} for intervening and associated systems (Fechner & Richter 2009).

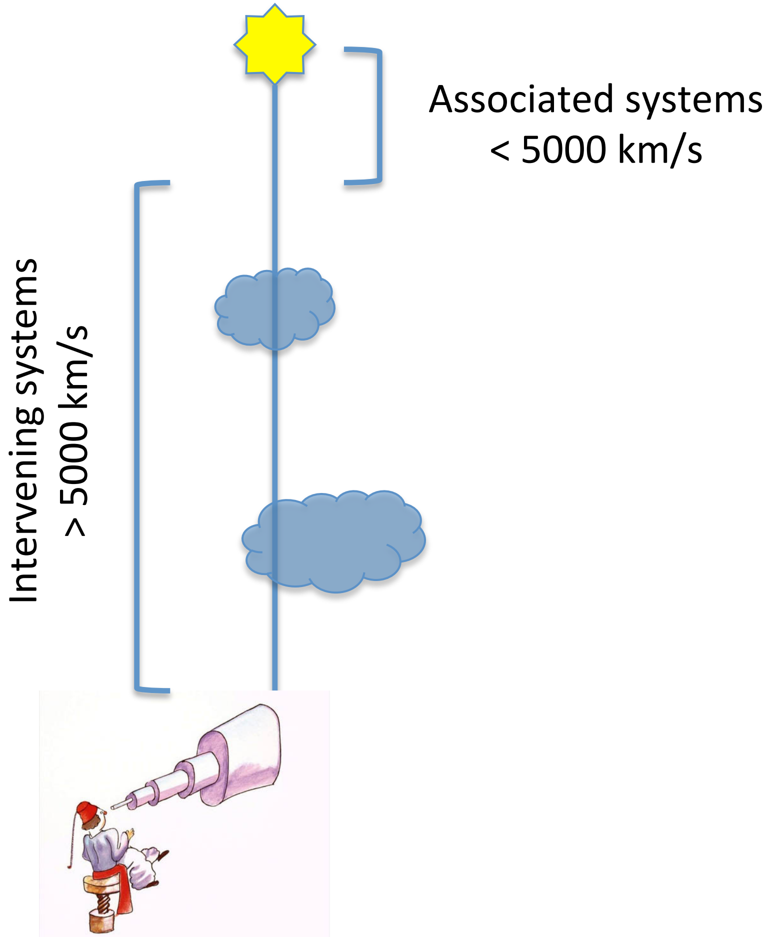


QSO environment along and across los

XQ-100

(Perrotta et al., in prep.)

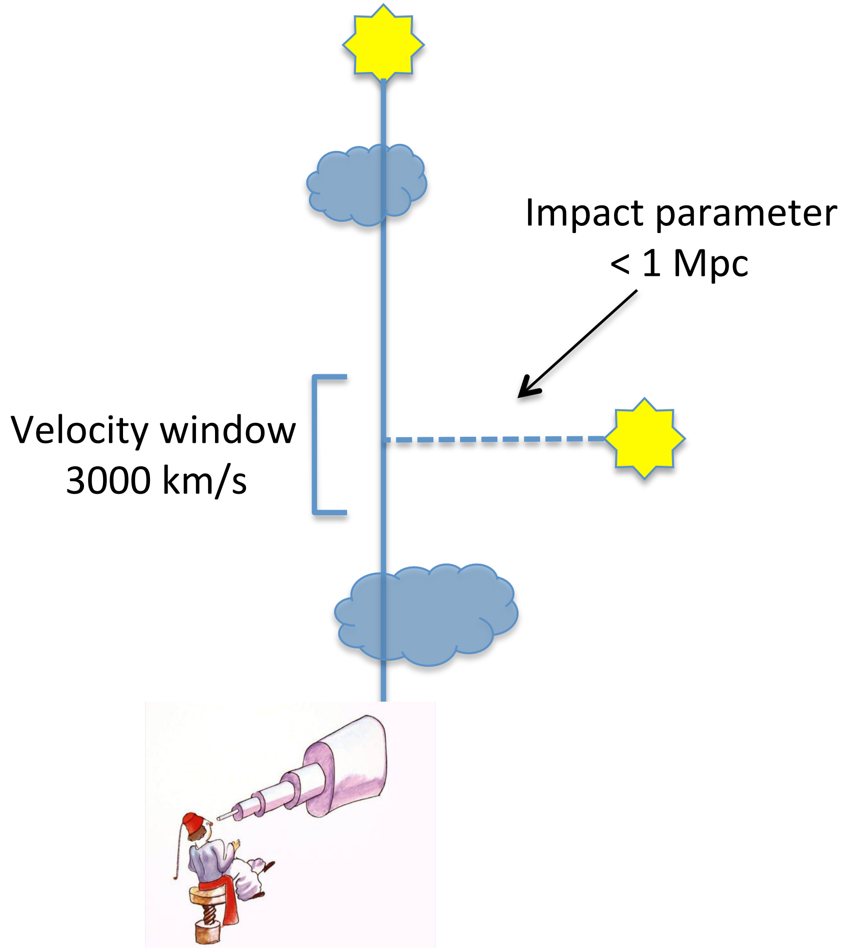
100 single quasar z~[3.5-4.7]



QPQ project

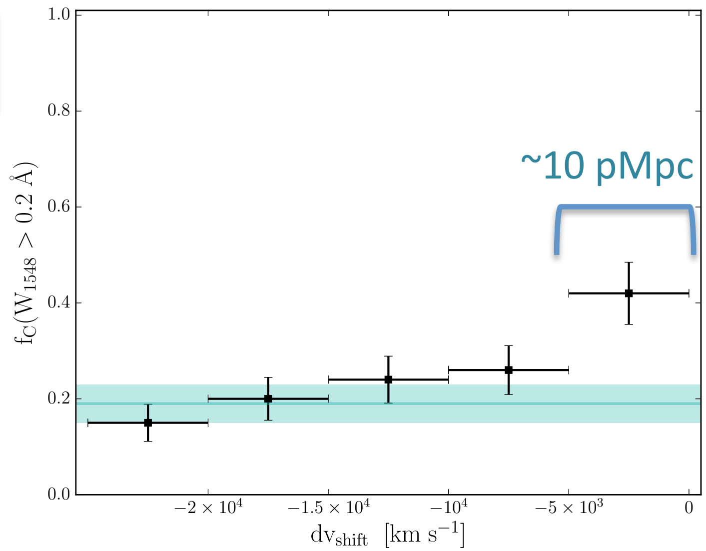
(Prochaska, Hennawi et al.)

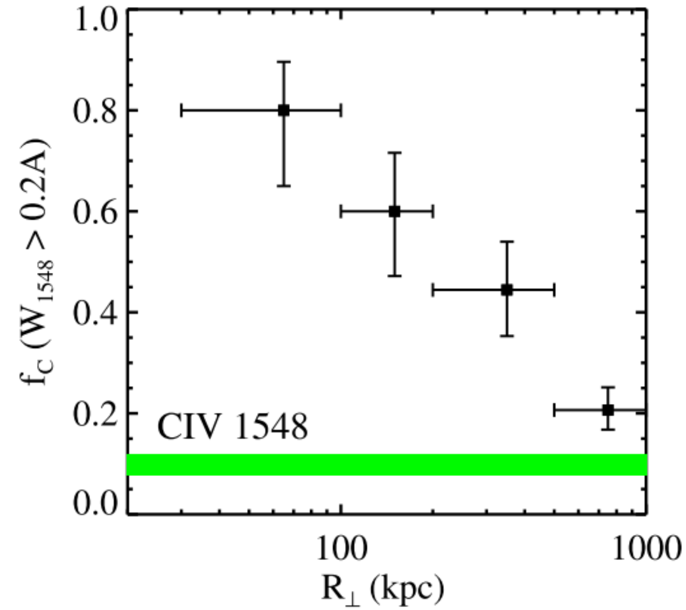
~400 quasar projected pairs z_{med}~2.35



NALs in XQ-100: covering fractions

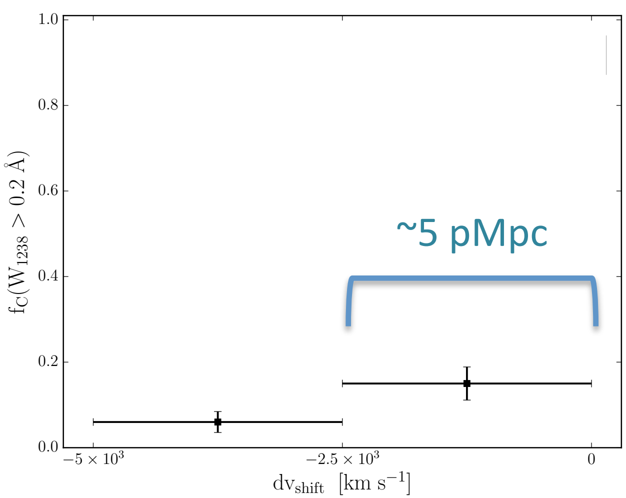
C IV





Prochaska+ 2015

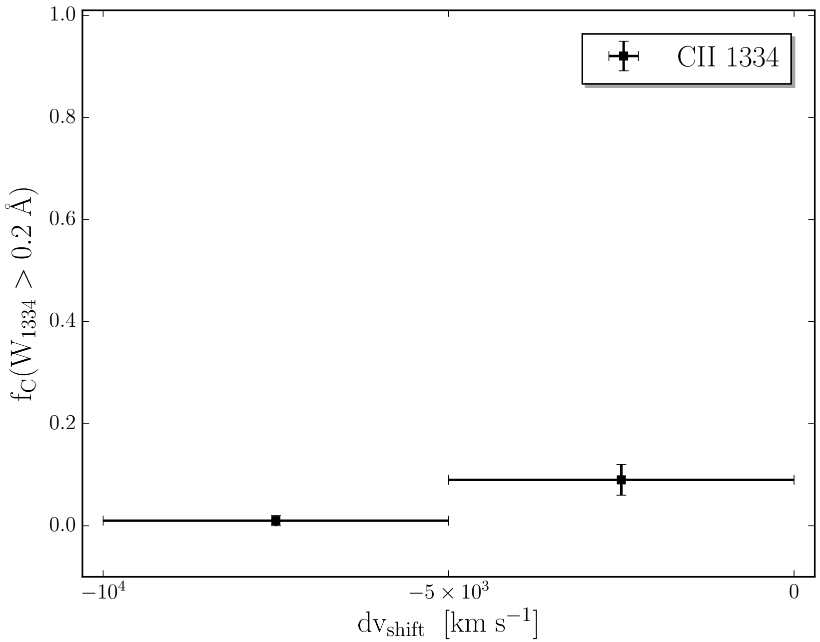
N V

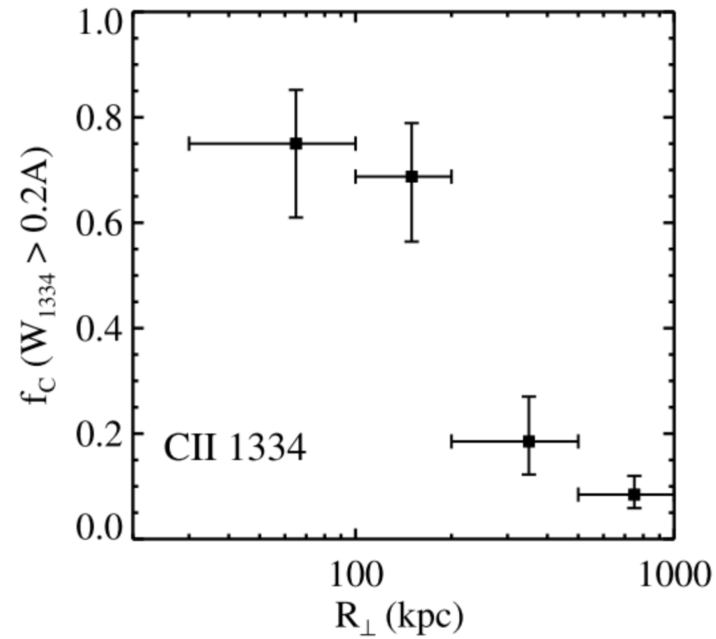


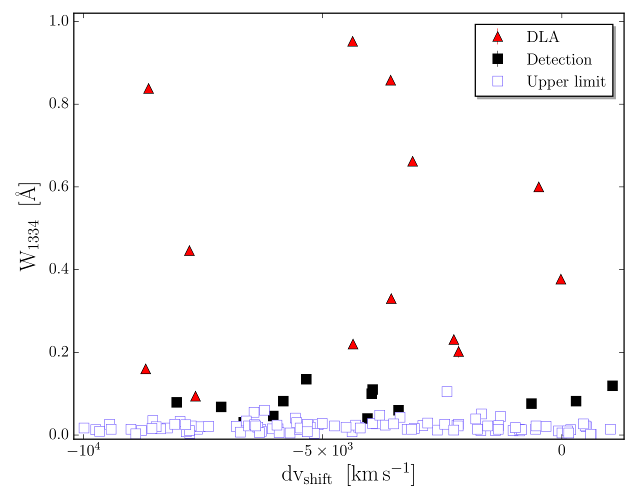
Only 1 N V detected in the QPQ sample ➔ ~0.25 % detection rate; 15 % in the XQ-100 sample with v_{shift} < 2500 km/s and W_{1238} > 0.2 A

NALs in XQ-100: covering fractions

C II







C II detection rate in the XQ-100 sample **8 %** with $v_{shift} < 5000$ km/s and $W_{1334} > 0.2$ A.
All our detections with $W_{1334} > 0.2$ A are Damped Lyman-α systems

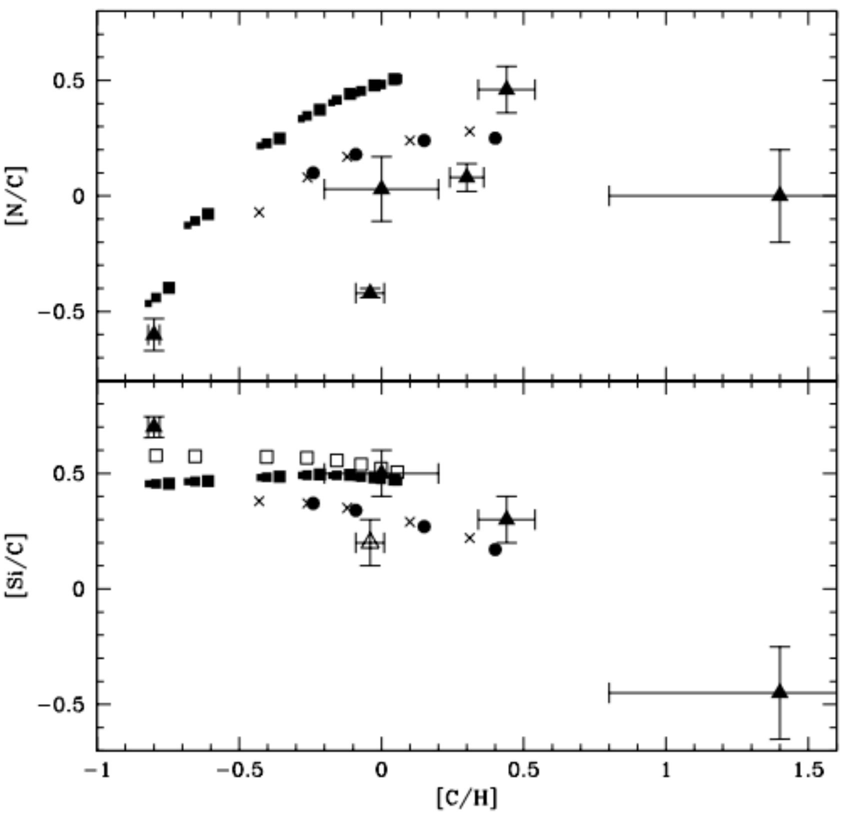
Summary

- Outflows in AGN can be related to the accretion process onto the central SMBH but also to the mechanism necessary to quench star formation in the host galaxy;
- Outflows are observed in absorption, absorbers are classified based on their velocity width (BALs, mini-BALs and NALs);
- We have studied NALs in the XQ-100 legacy survey with a sample of ~1000 C IV absorbers. We find:
  - an excess of absorbers in C IV and Si IV up to ~10,000 km/s velocity shift from the QSO emission;
  - C IV detection rate of **72 %** at v_{shift} < 5000 km/s;
  - N V detection rate of **26 %** at v_{shift} < 5000 km/s, proxy of intrinsic NAL rate;
  - Strong evidence of a different ionization state close to the QSO along and across the LOS

Work in progress

- ✧ Measurement of the column densities with the apparent optical depth method, detection of partial coverage and analysis of ion ratios;

- ✧ Analysis of some interesting systems in high resolution spectra (1 UVES proposal approved, 2 targets observed out of 4) using photoionization modelling



(D'Odorico et al. 2004)

NALs in XQ-100: QSO luminosity

Brighter objects show more C IV observations