Narrow Absorption Line Outflows in high-z Environments

Leah Simon

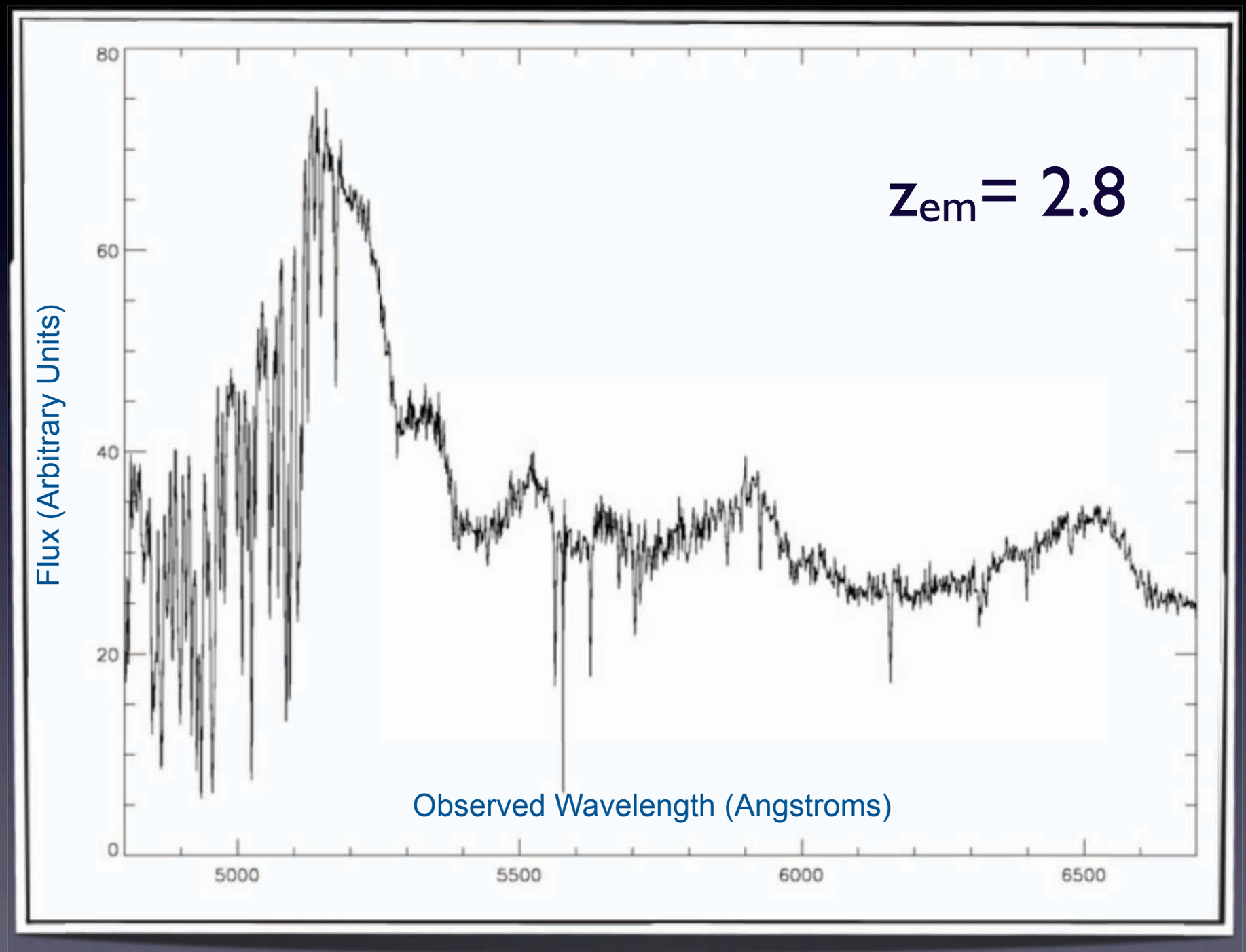
AGN Winds in Charleston

October 15, 2011

Survey Goals

- Identify intrinsic narrow absorption lines (NALs) in quasar spectra
- Study origin of intrinsic NALs to understand quasar environments, specifically find NALs in quasar outflows
- Characterize basic properties of intrinsic NALs, especially quasar outflow NALs
- Characterize NAL outflows in the broader context of all quasar outflows

Typical quasar spectrum



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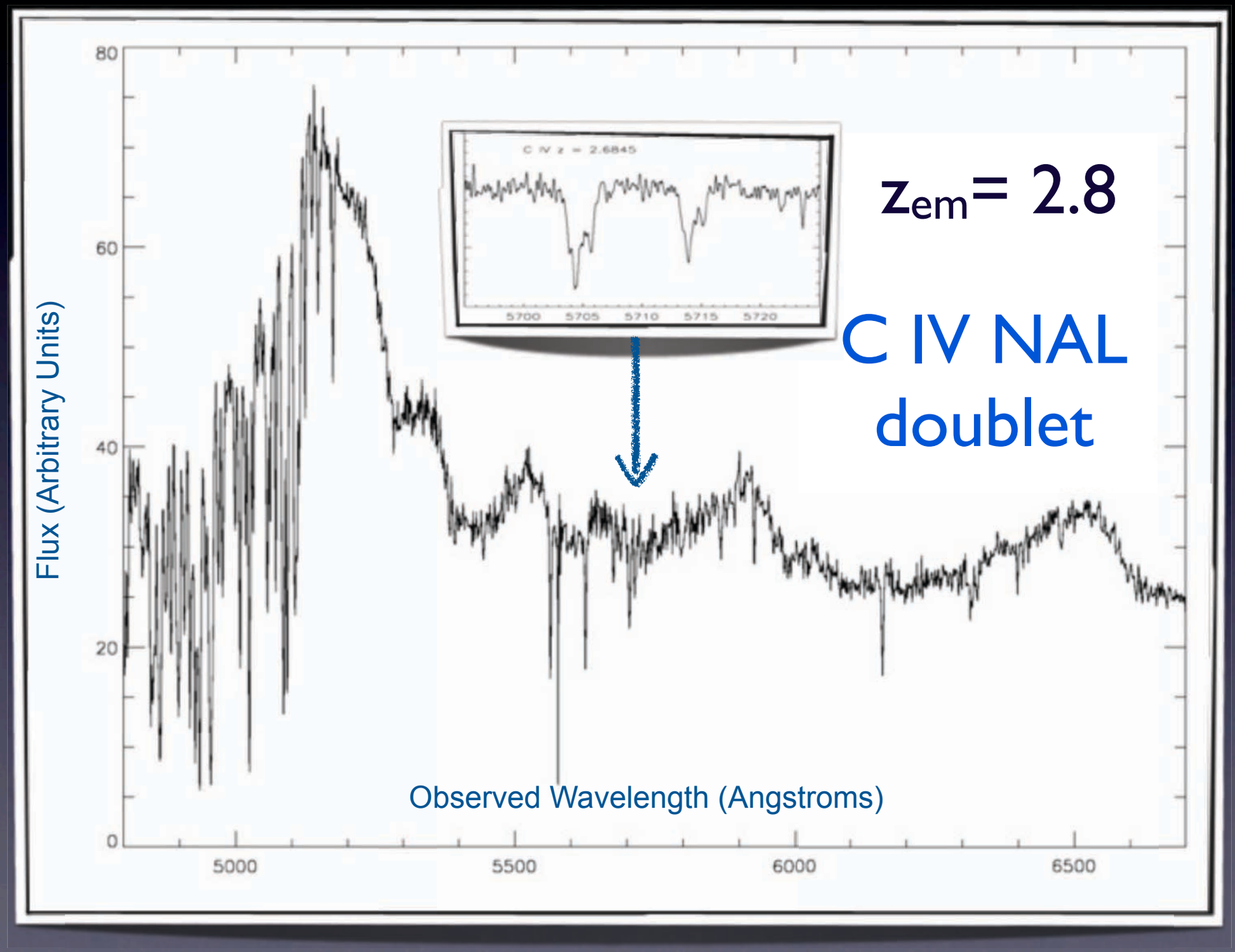
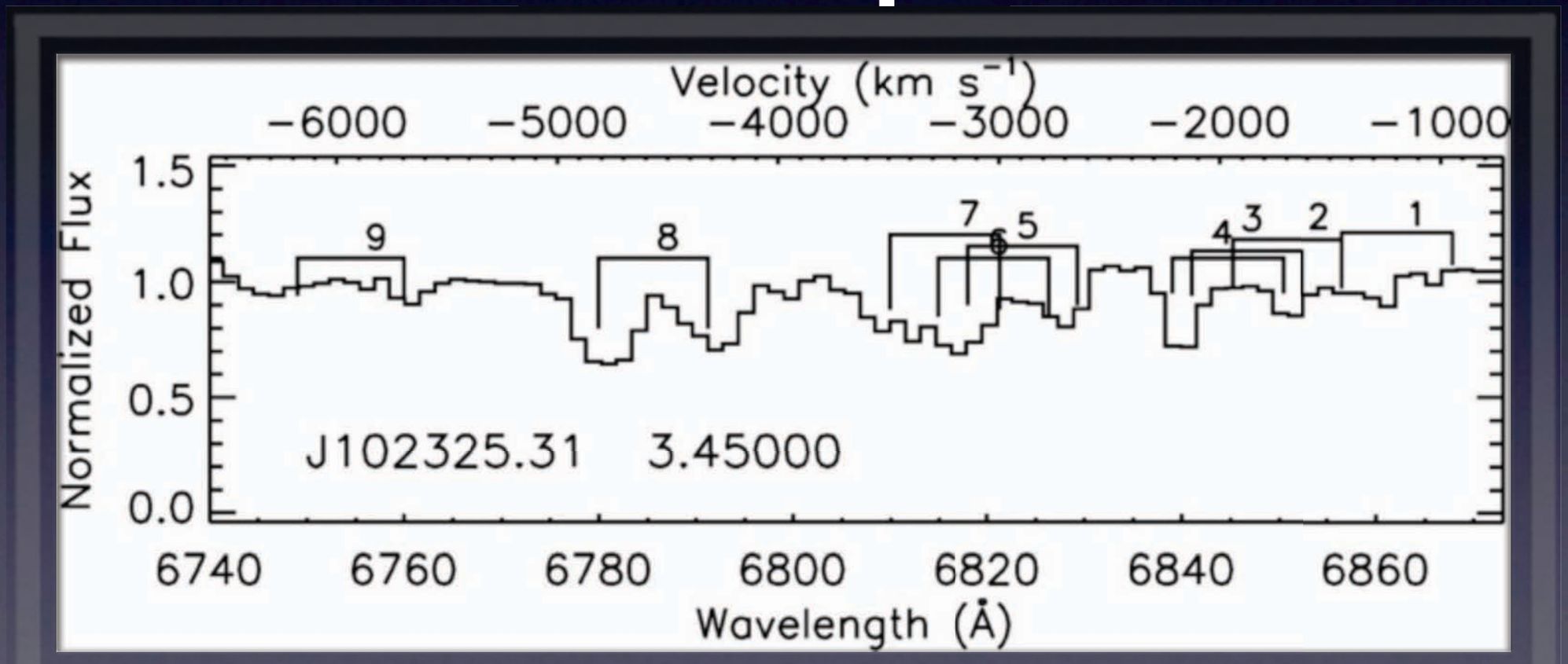


C IV Narrow Absorption Lines: Groups



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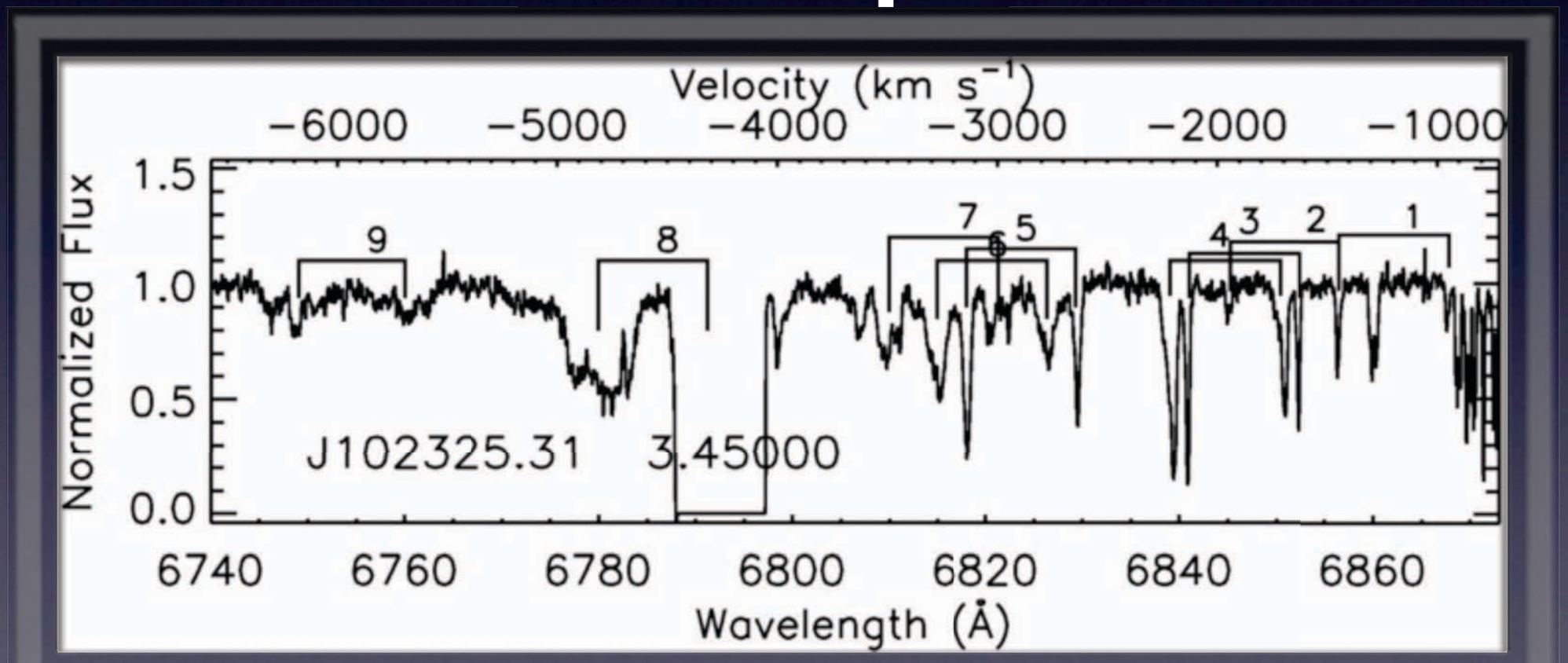

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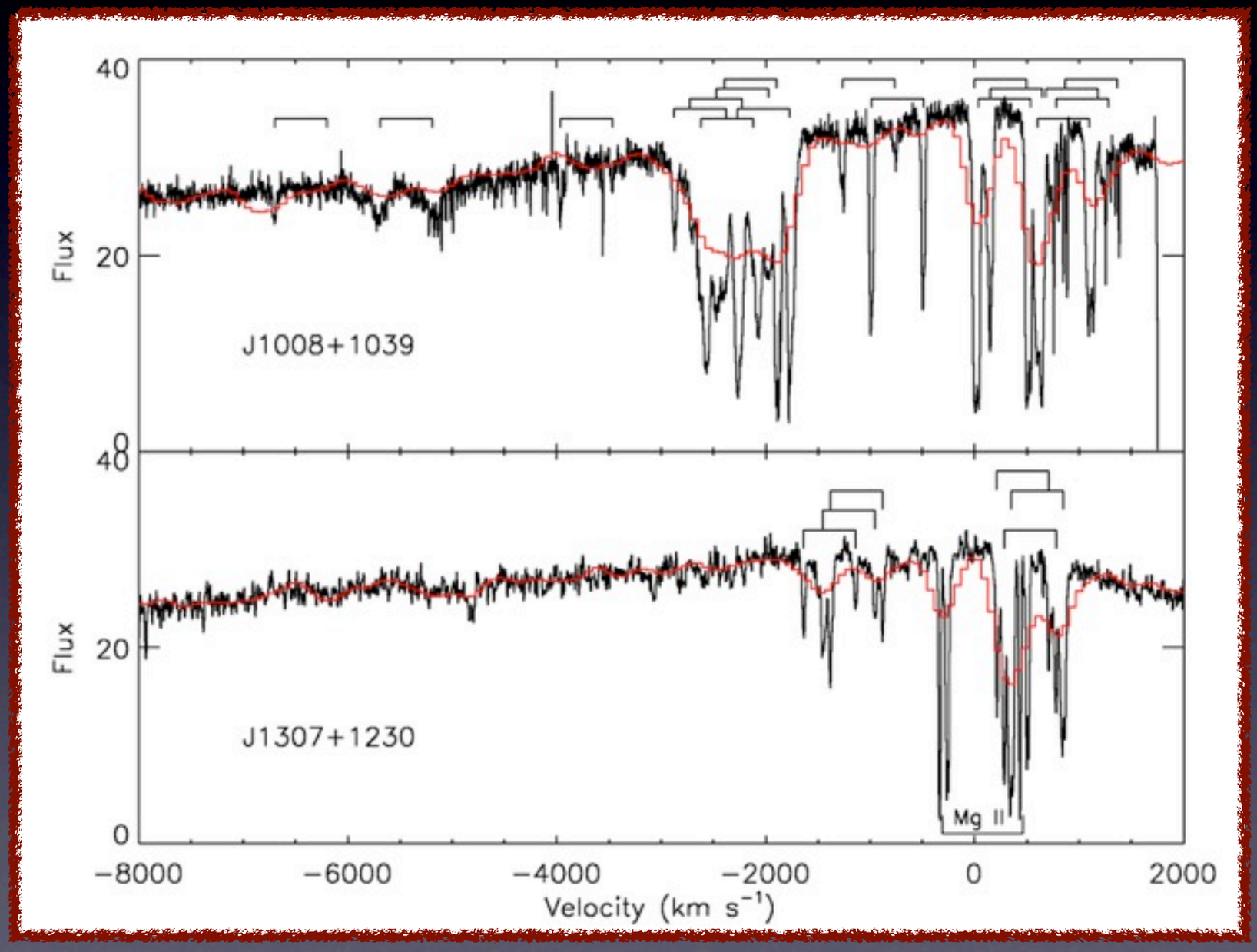
- 271/136 Absorption Line Components/Systems

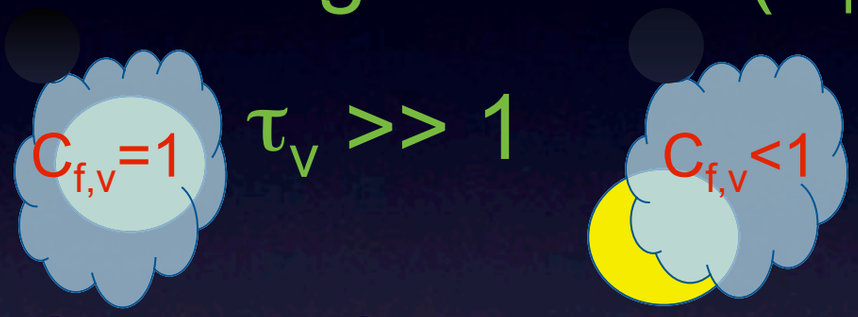
High resolution data

- Black is Magellan/ Keck data
- Red is SDSS



Diagnostics

Covering Fraction ($C_{f,v}$)



$I_v = I_{0,v}e^{-\tau}{}_v = 0$ $I_v = I_{0,v}e^{-\tau}{}_v \neq 0$

If not accounted for, surplus I_v artificially decreases τ_v, N

$C_{f,v}$ < 1 means small clouds, probably very near continuum source!

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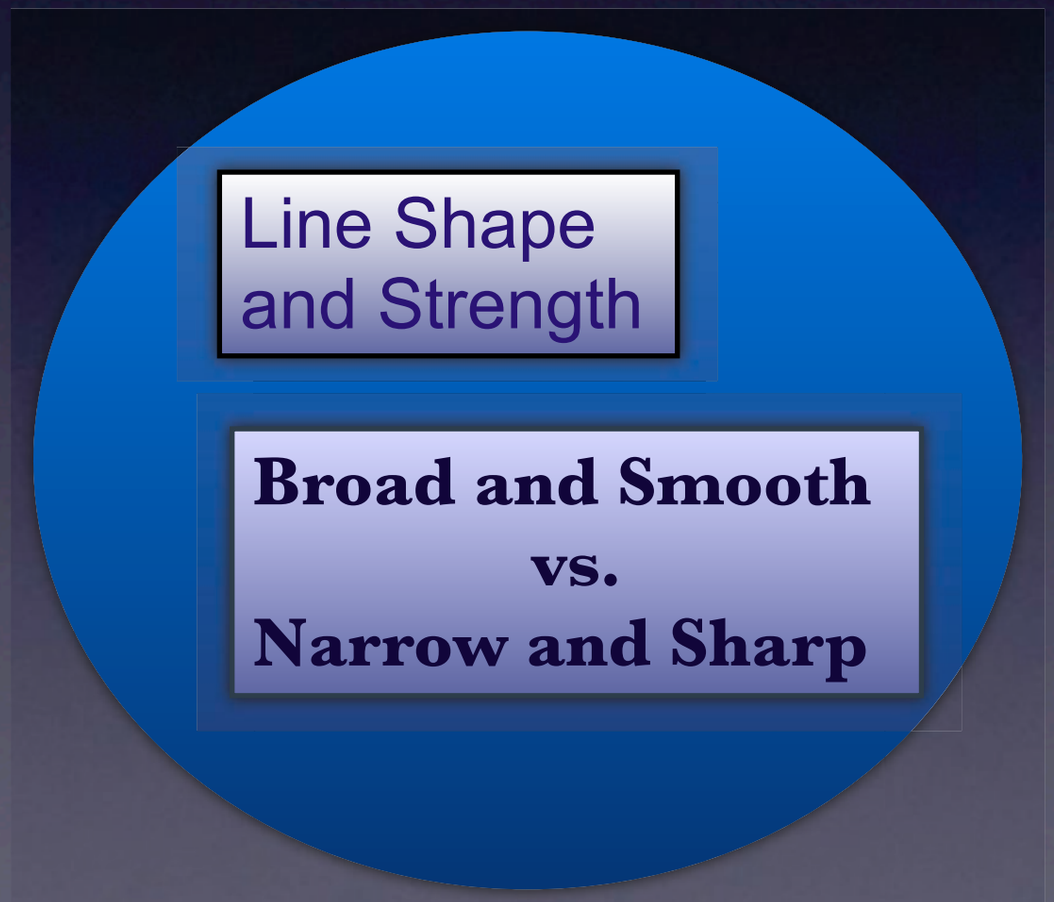

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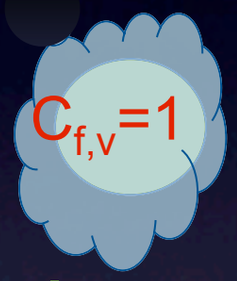

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Diagnostics

Class A: Intrinsic

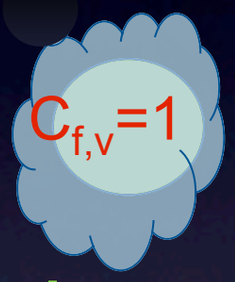
Class B: Probably Intrinsic

Class C: Everything else

Line Shape and Strength

Broad and Smooth vs. Narrow and Sharp

Covering Fraction ($C_{f,v}$)



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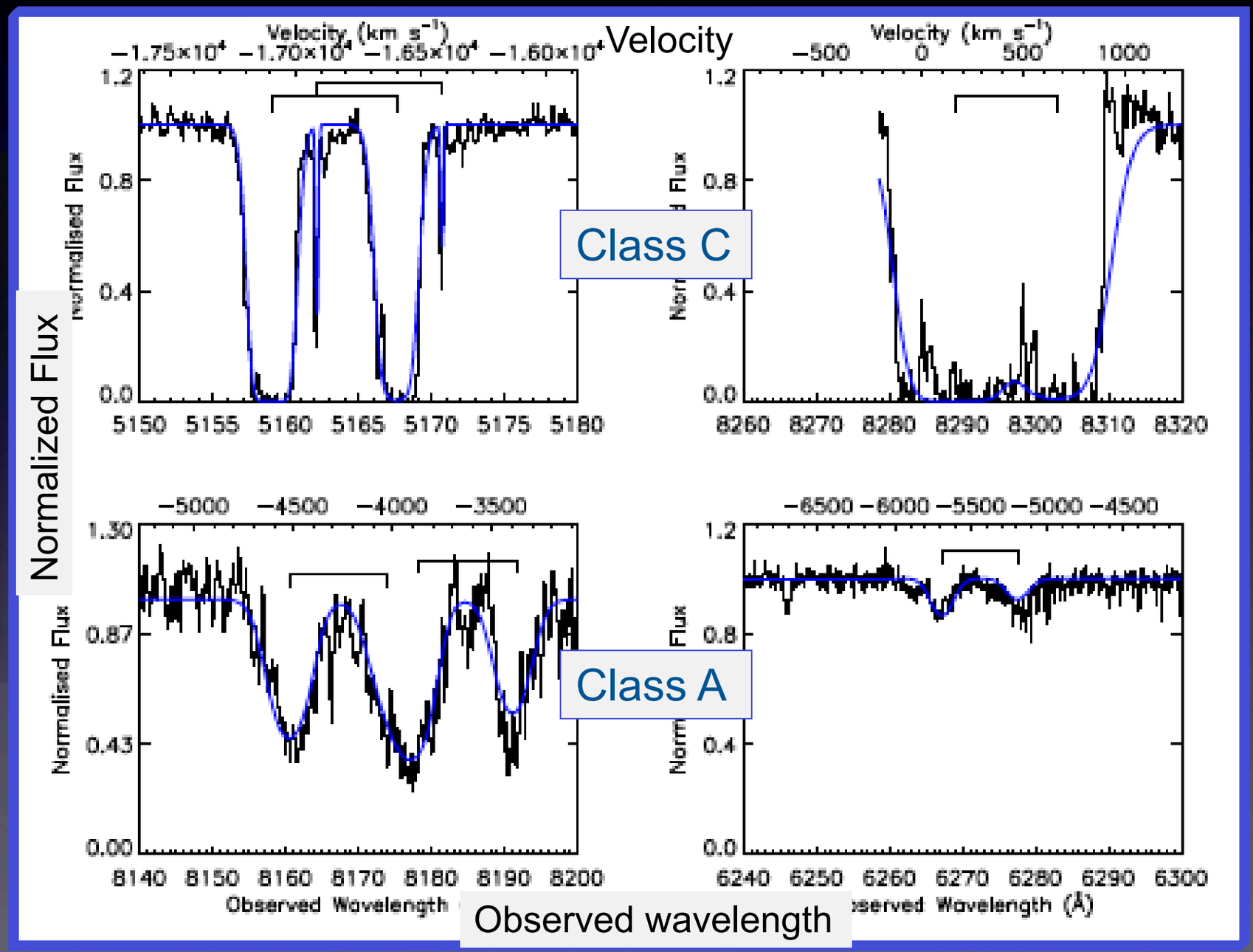
Line Shape and Strength

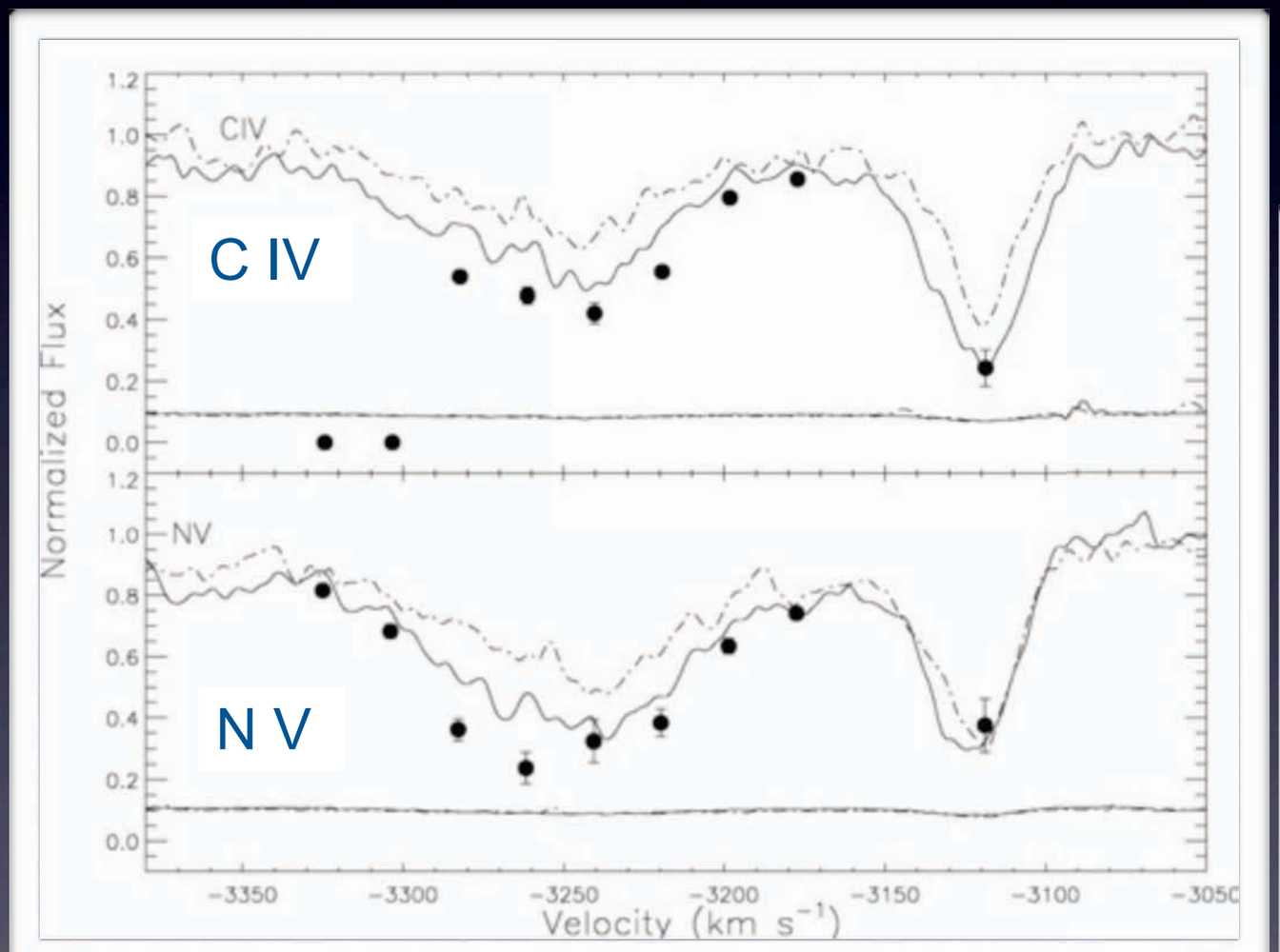
b < 60 km s^{-1}: Class C

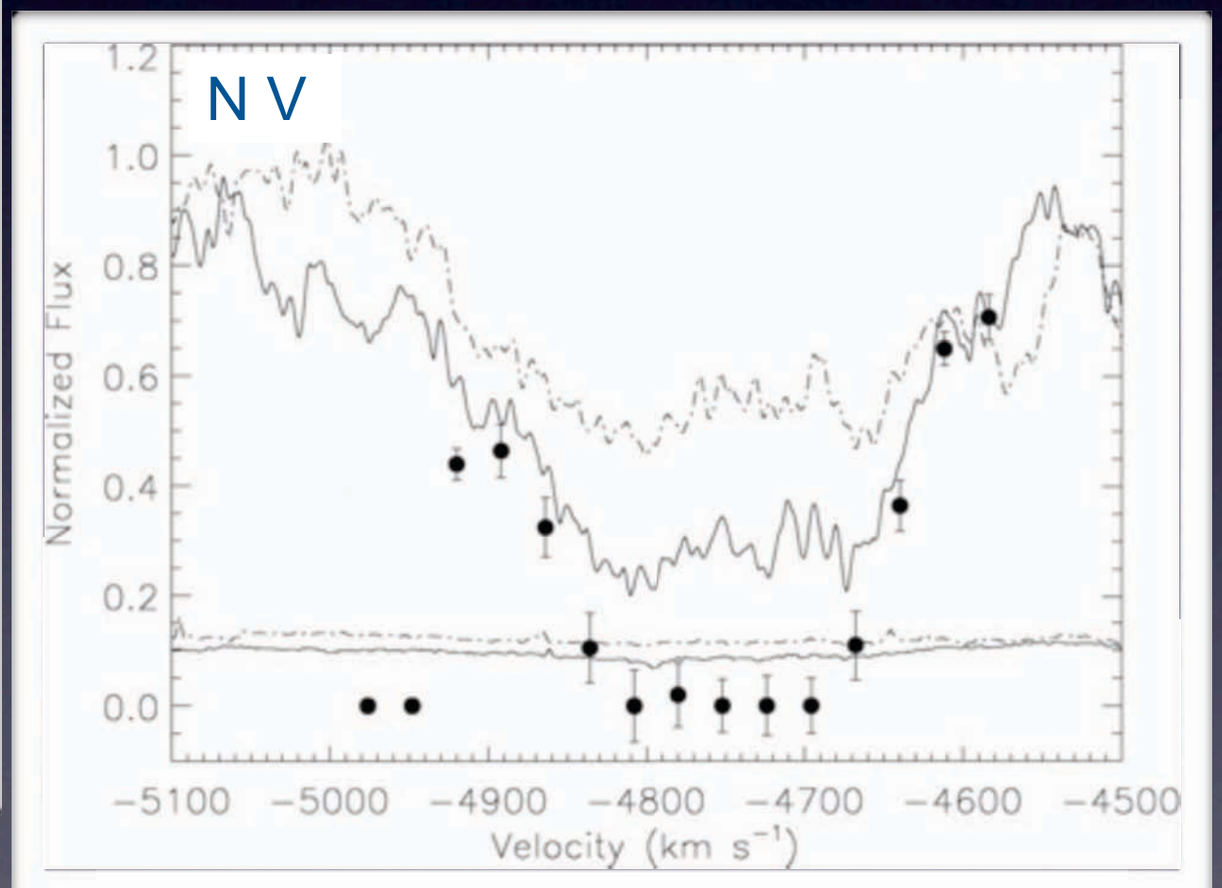
60 < b < 80 km s^{-1}: Class B

b > 80 km s^{-1}: Class A



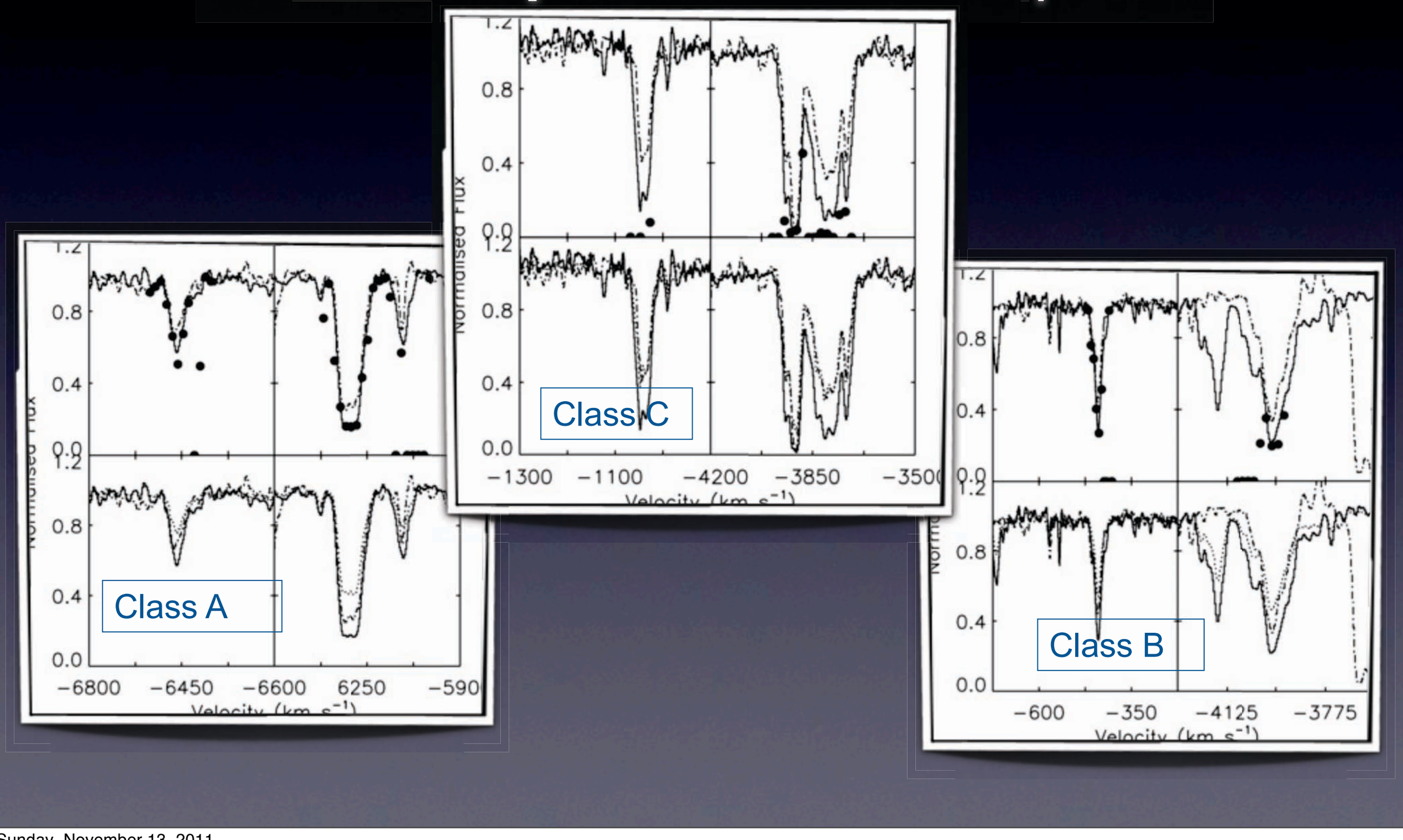
Point by Point Covering Fractions



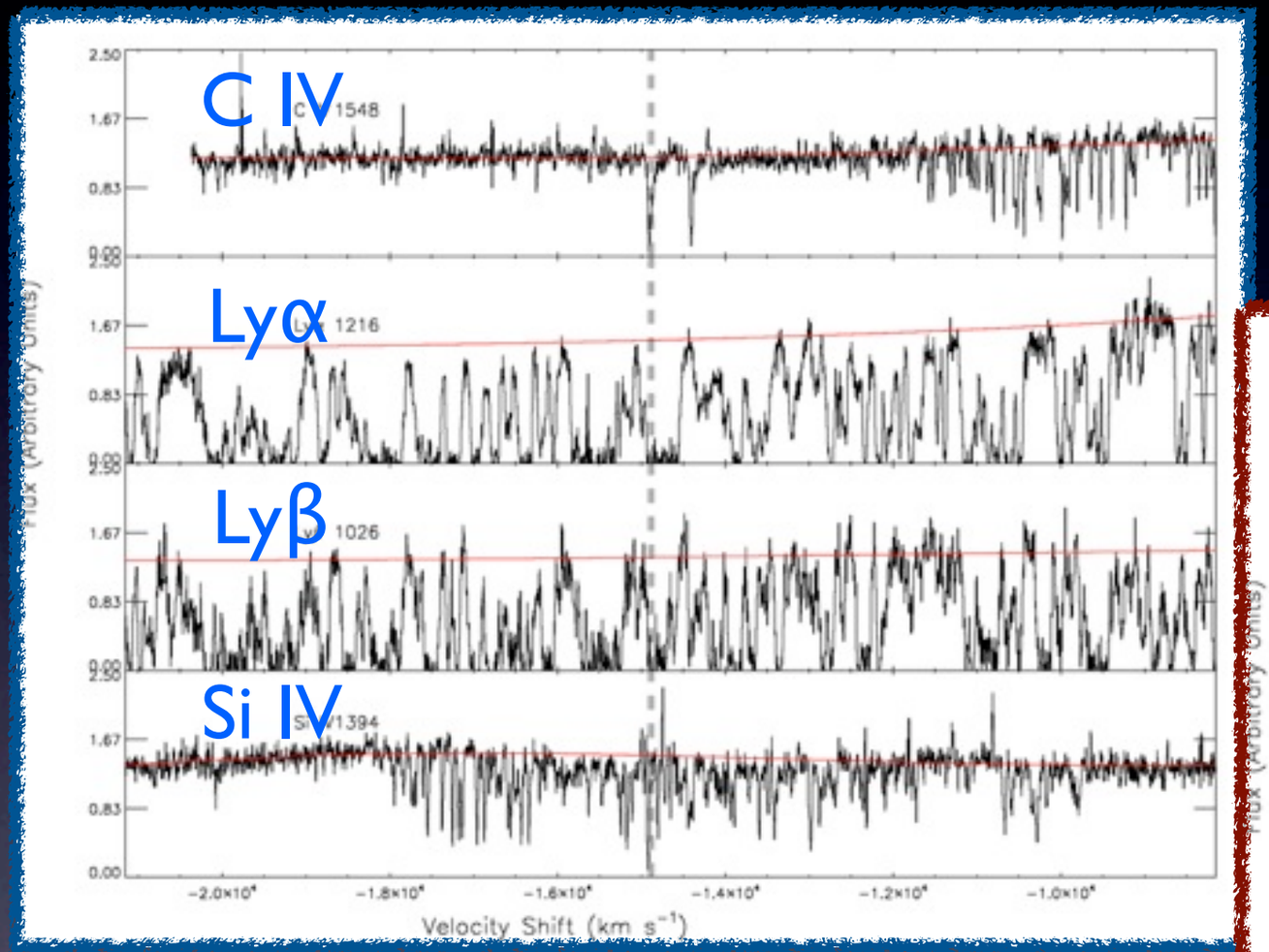


Simon & Hamann 2010, MNRAS 409: 269S

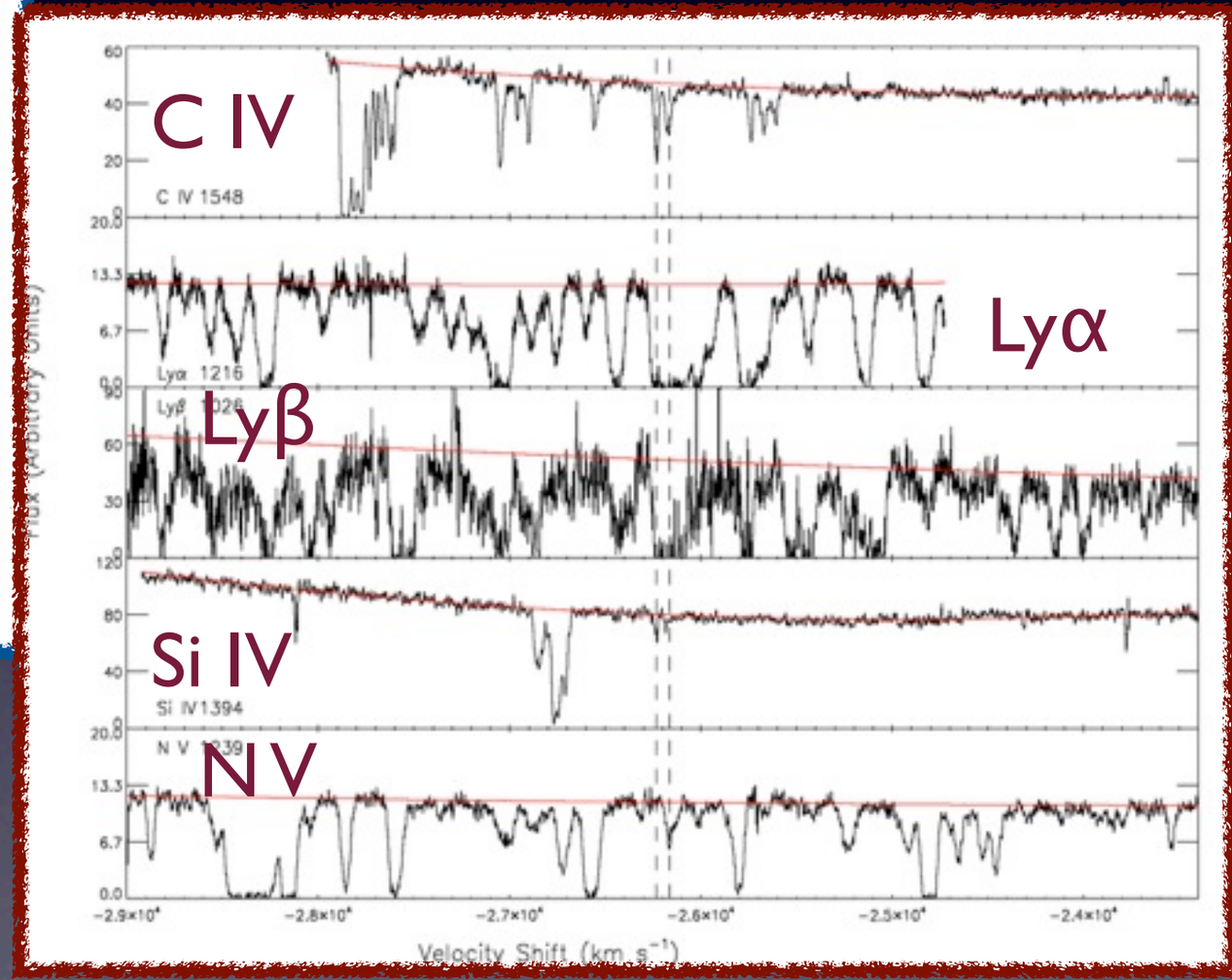
Point by Point and τ-ratio predicted C_f



Continuum Fitting

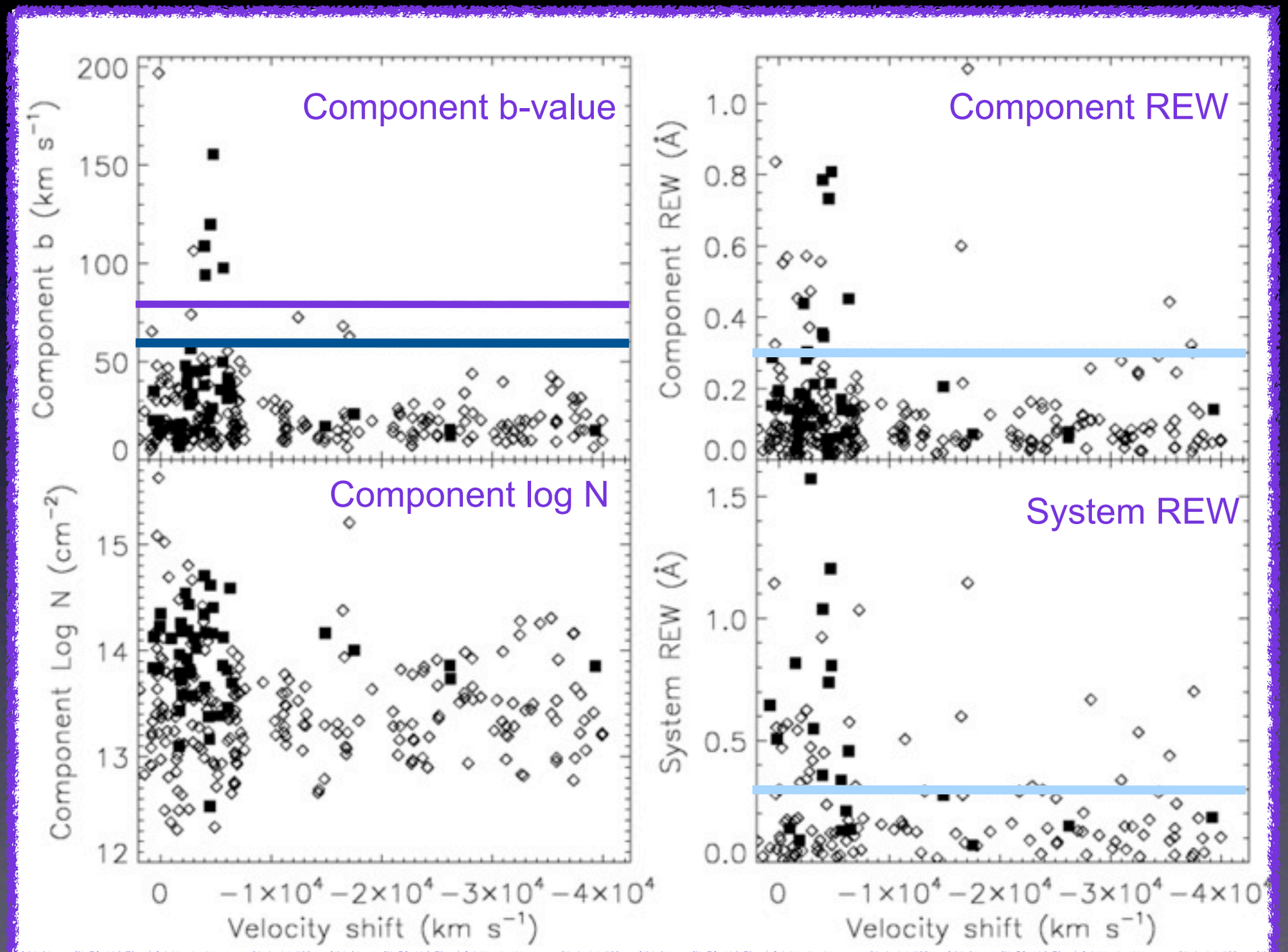


Velocity Shift (km s^{-1})



Velocity Shift (km s^{-1})

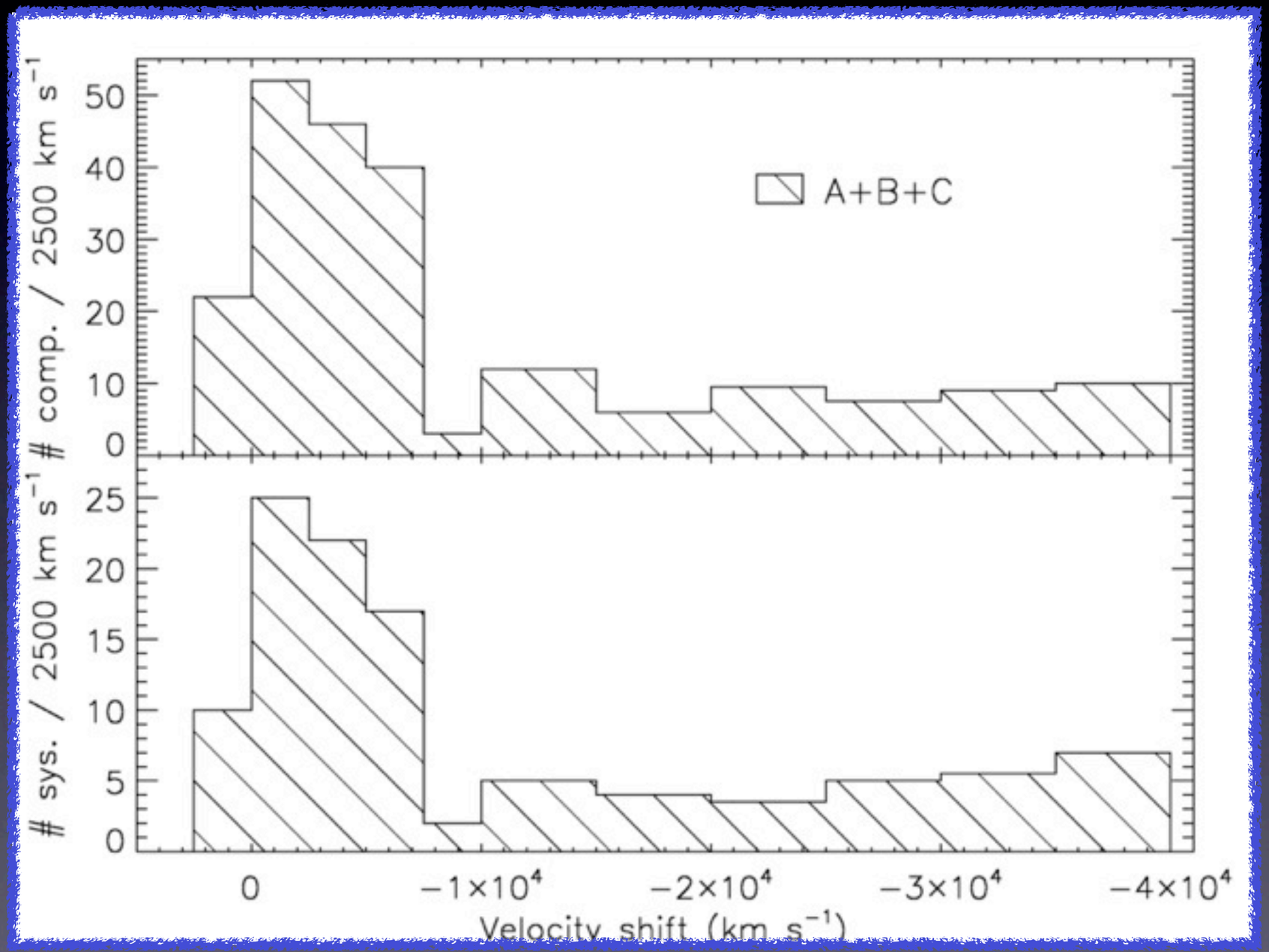
NAL Overview



Solid black symbols are intrinsic NALs

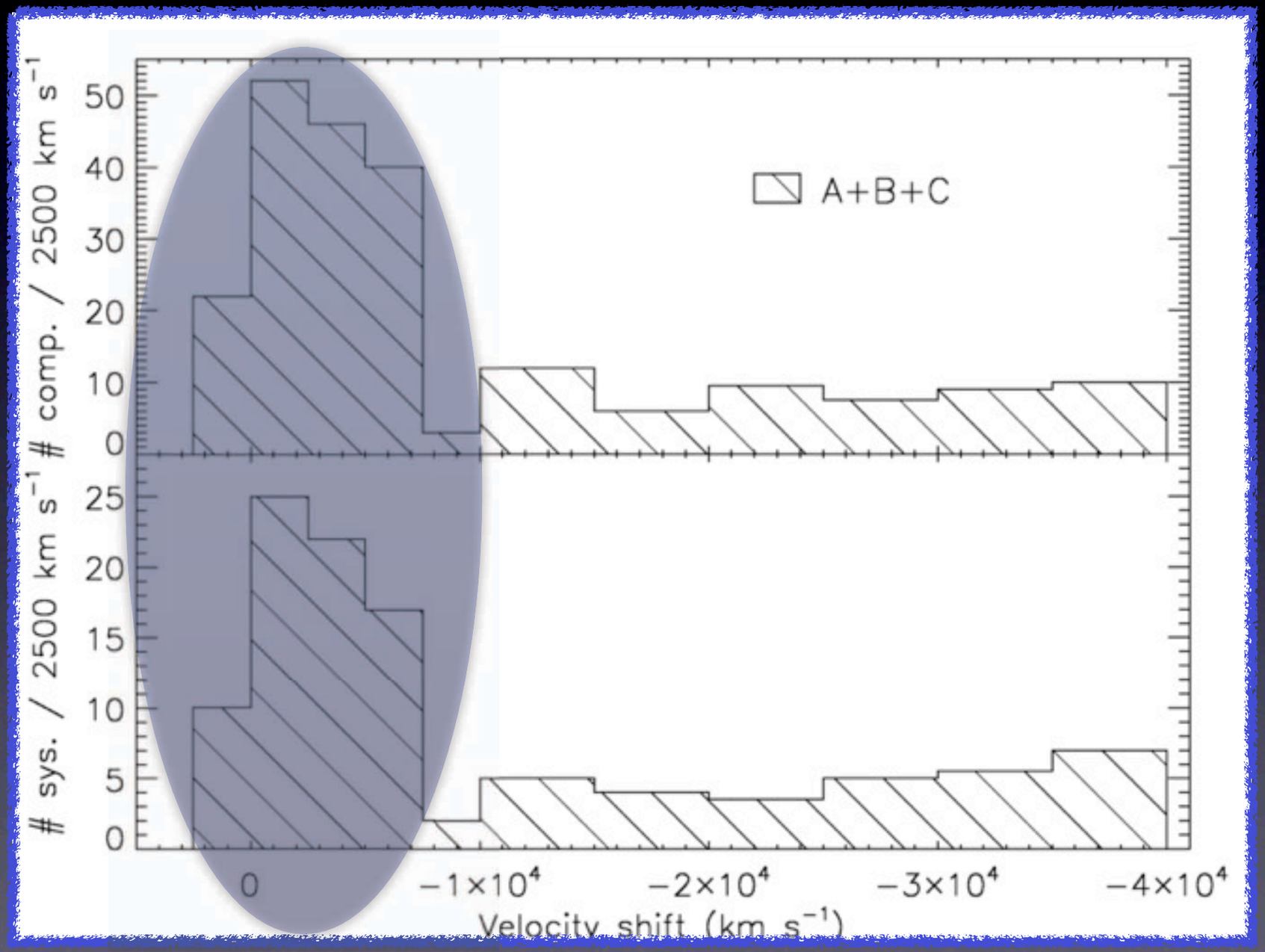
Open diamonds are intervening or ambiguous origin NALs

NALs by velocity shift

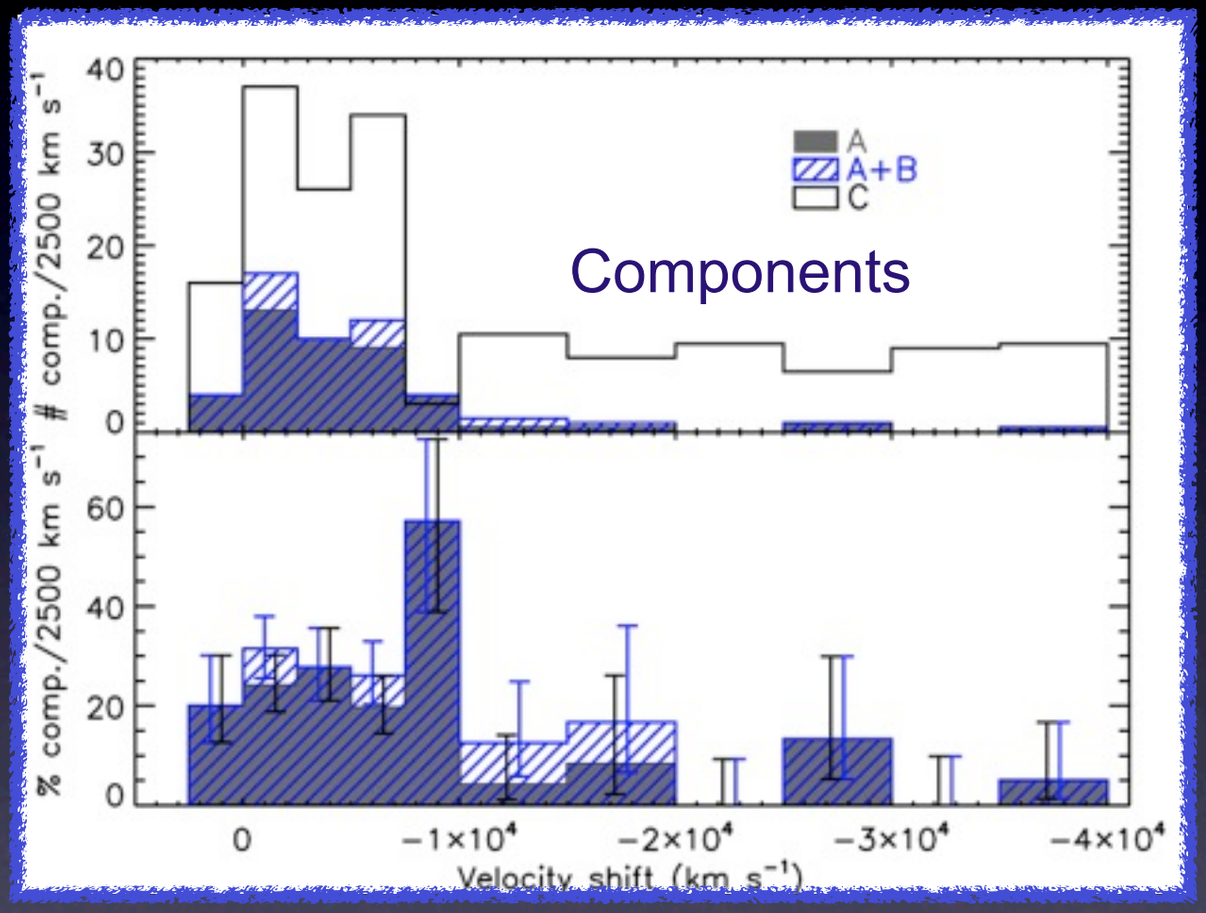


NALs by velocity shift

Excess at $v < 8000$ km s^{-1}



Intrinsic Fractions

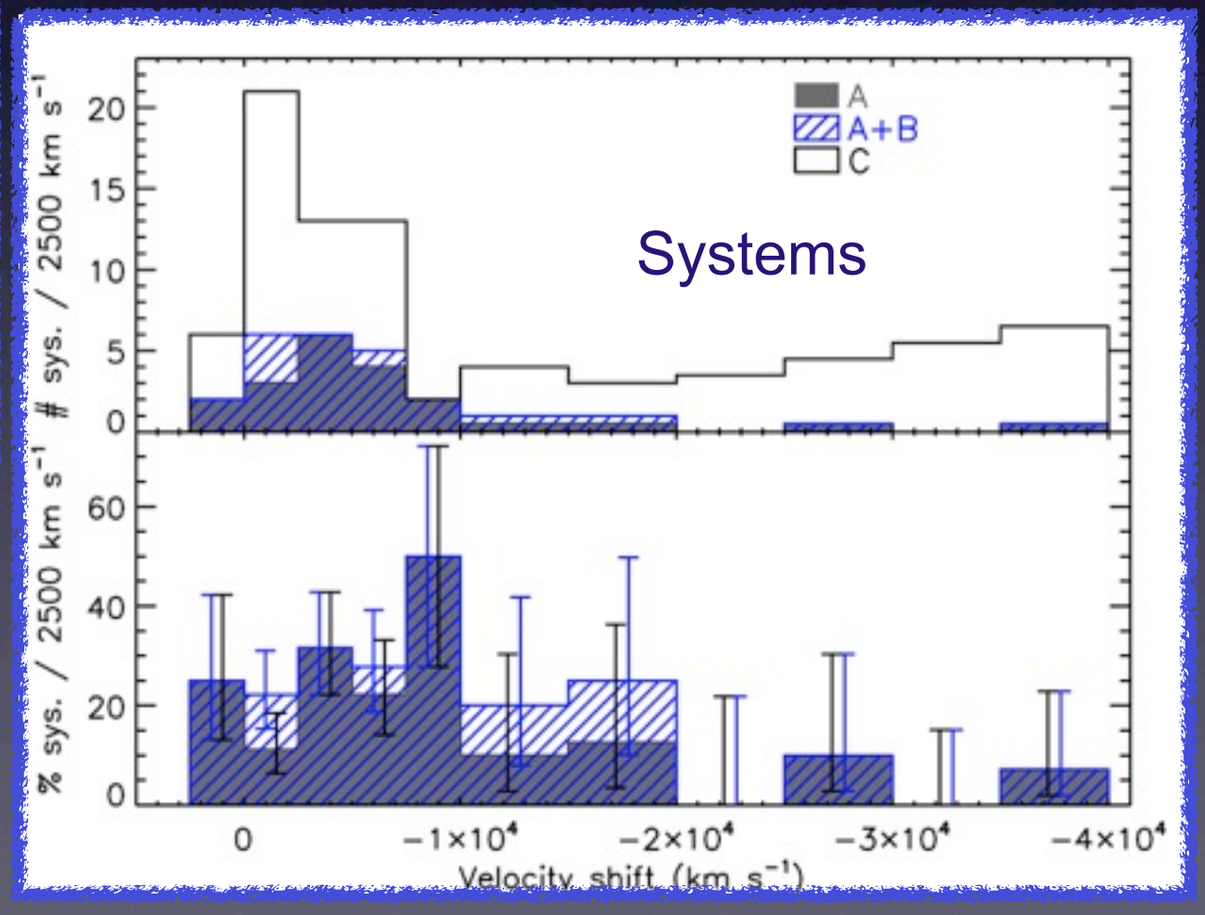


$v < 5000$ km s^{-1}: 30%

$v < 12{,}000$ km s^{-1}: 25%

$v < 40{,}000$ km s^{-1}: 20%

$v > 5000$ km s^{-1}: 10-15%



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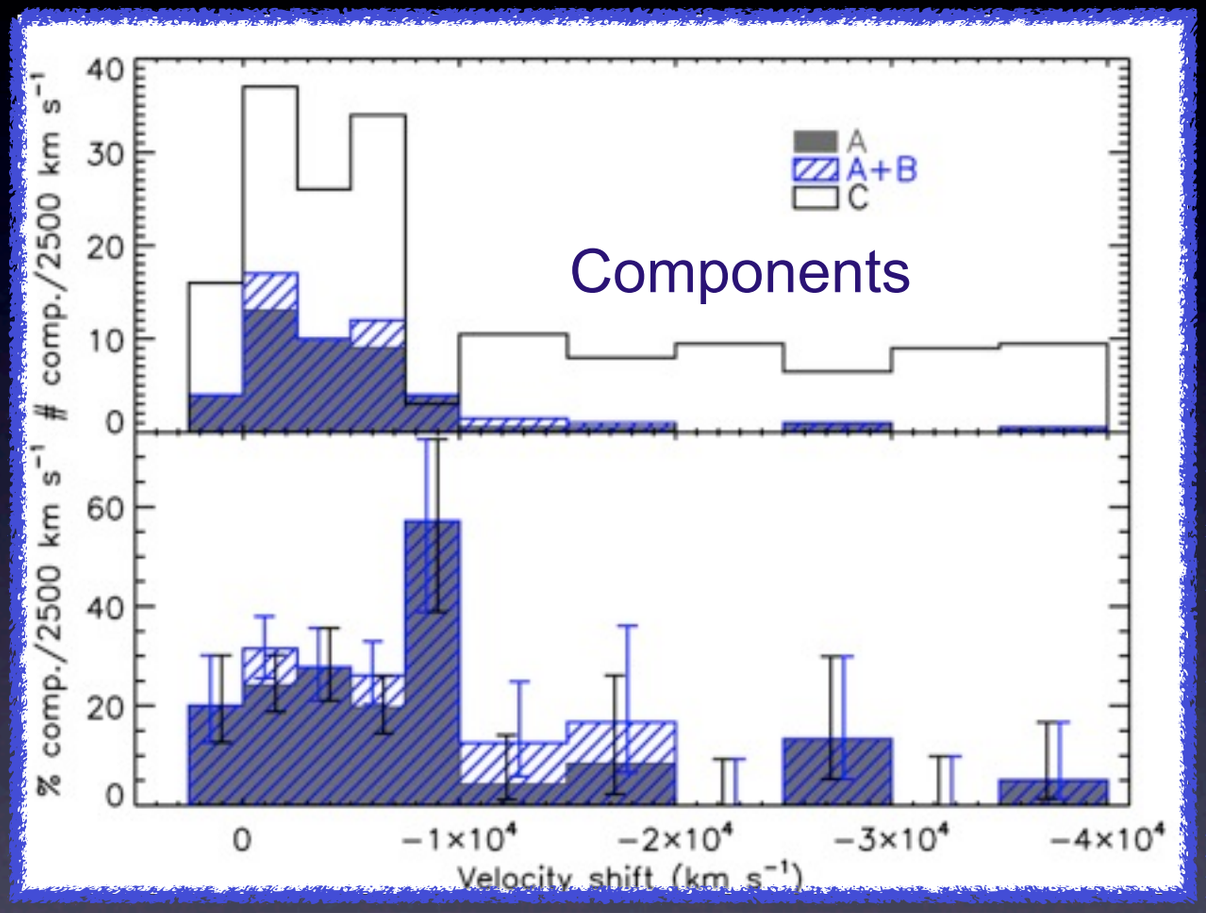

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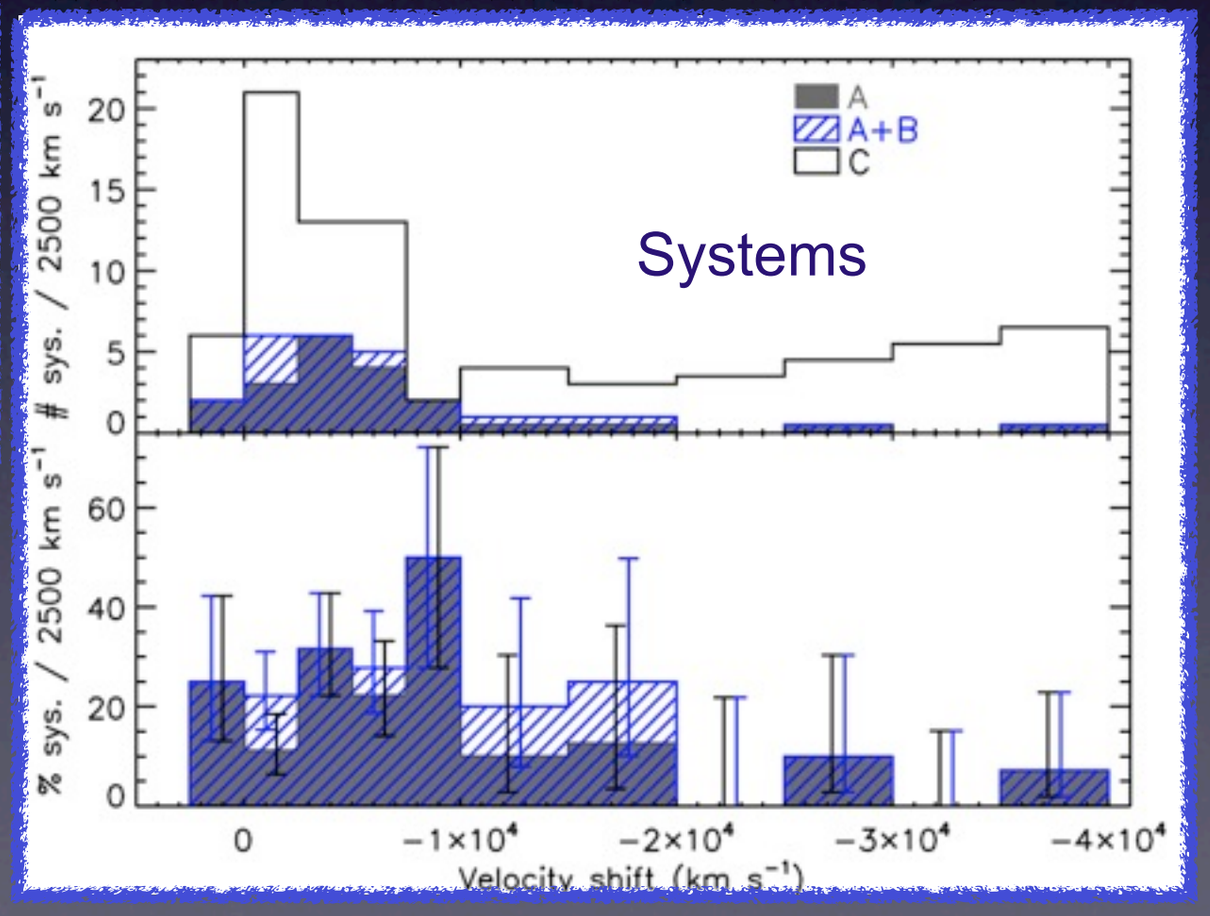
Intrinsic NAL with v > 2500 km s^{-1} must be quasar outflow!



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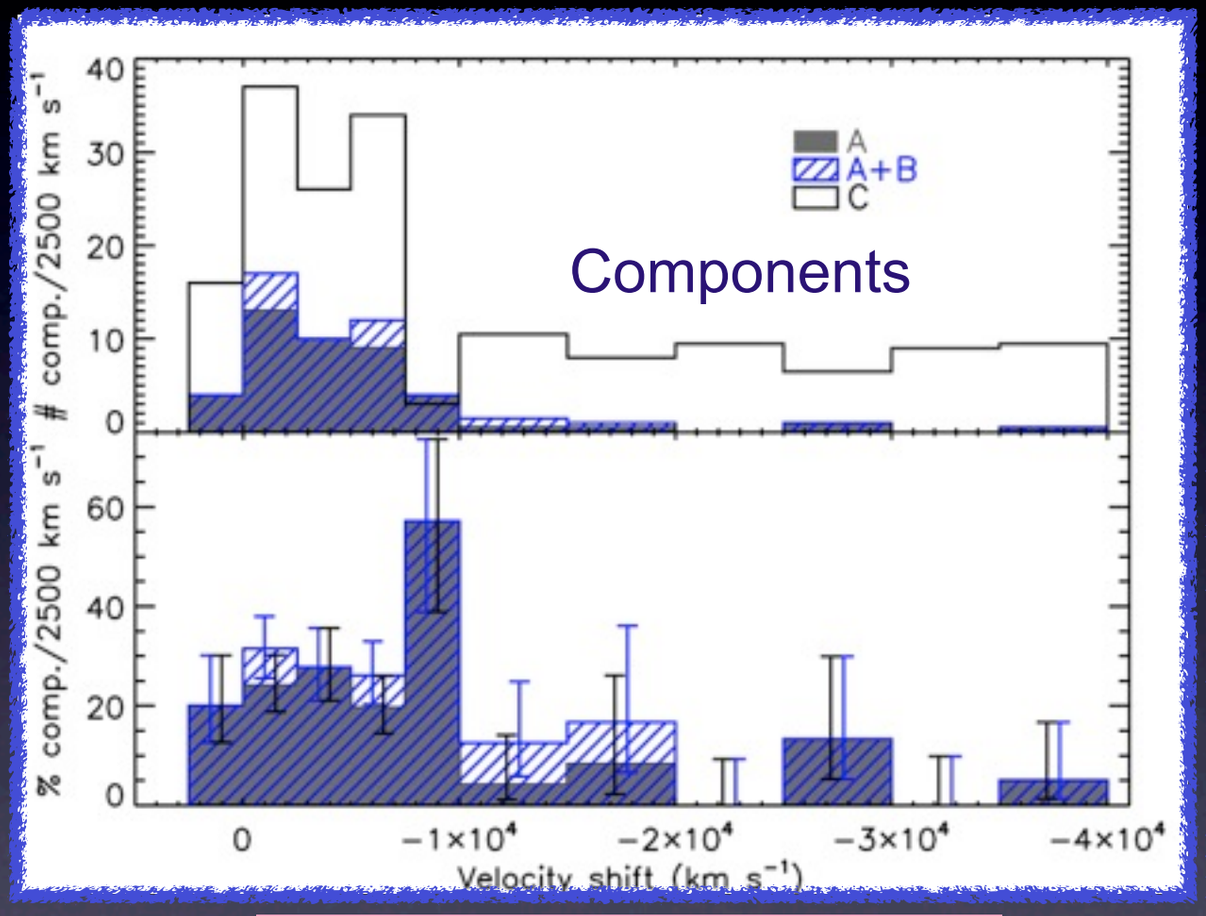

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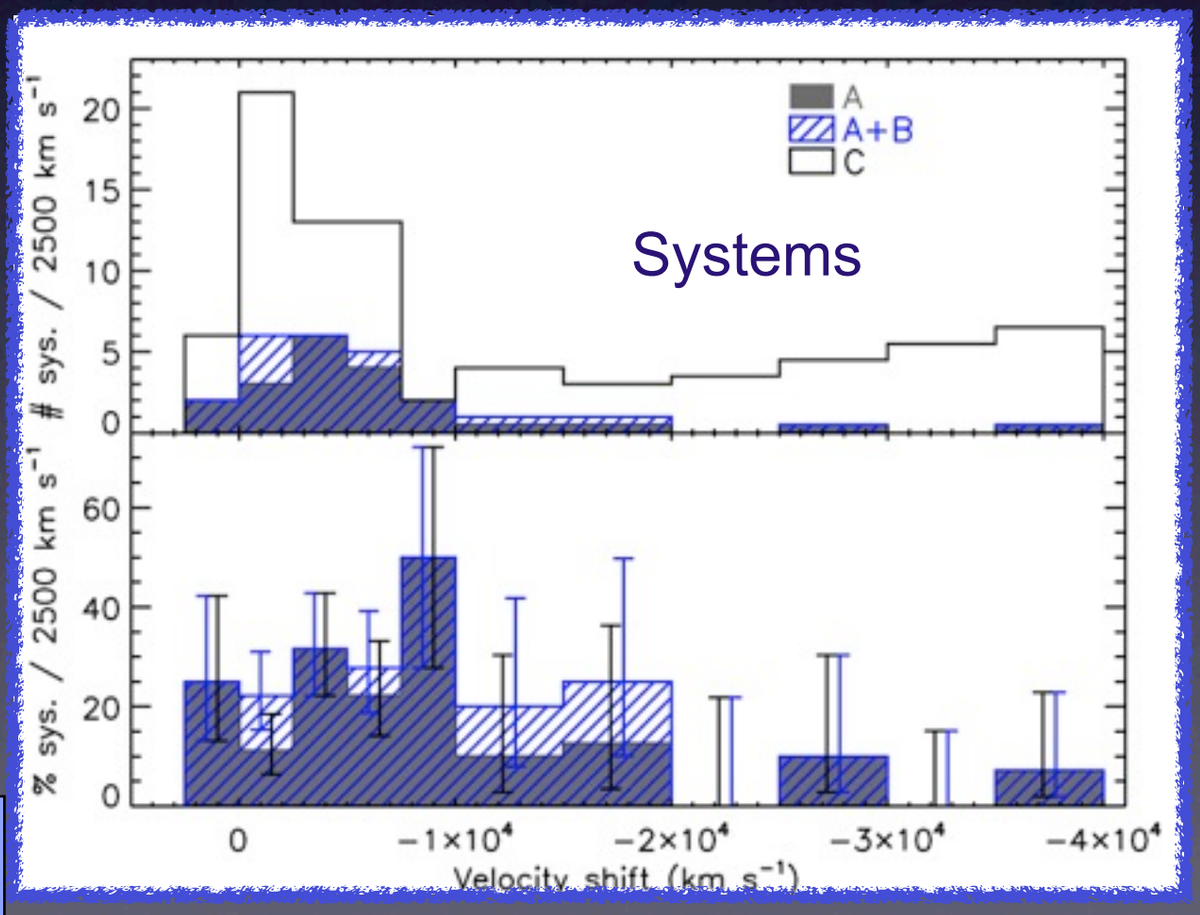
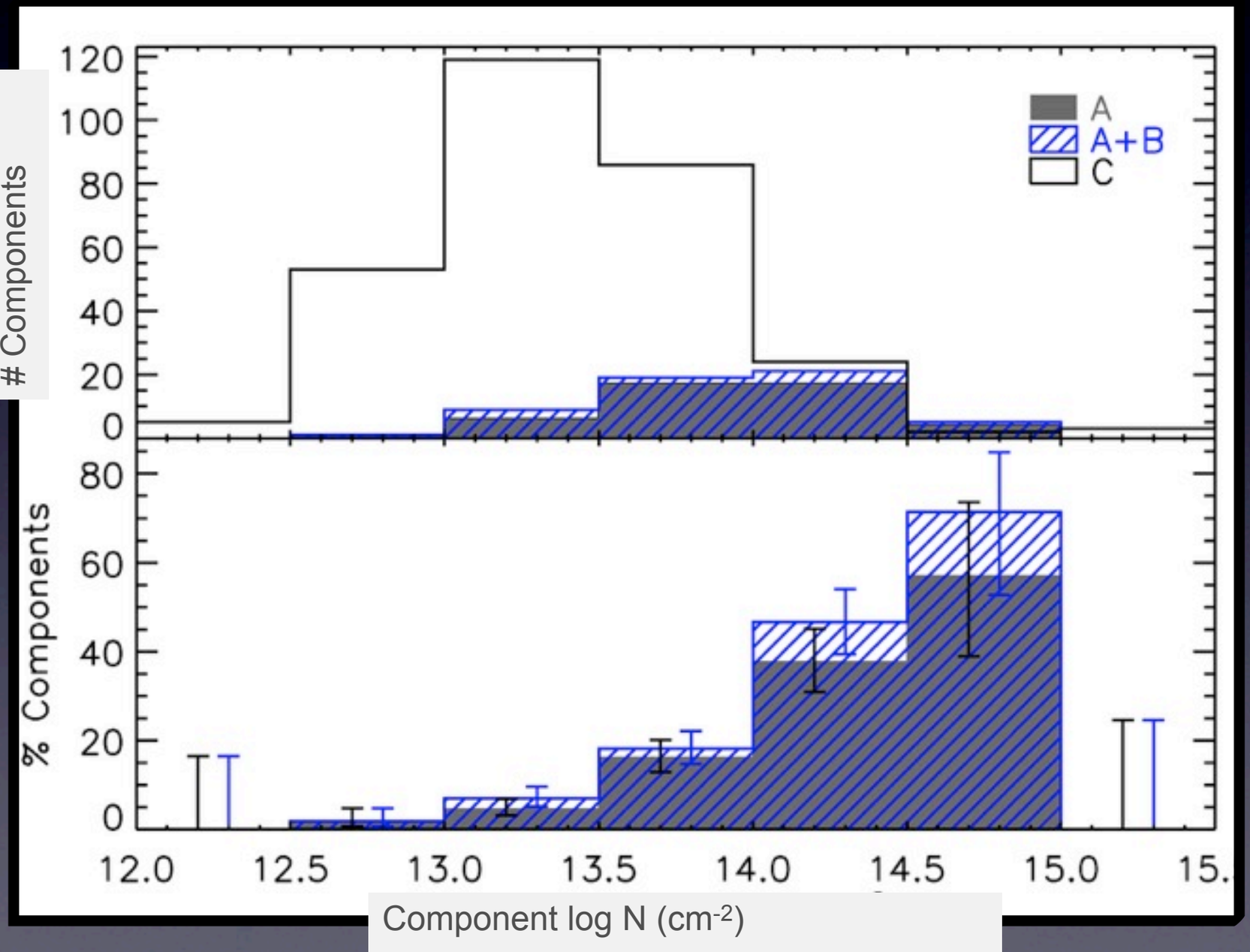


Intrinsic NAL with $v > 2500$ km s^{-1} must be quasar outflow!

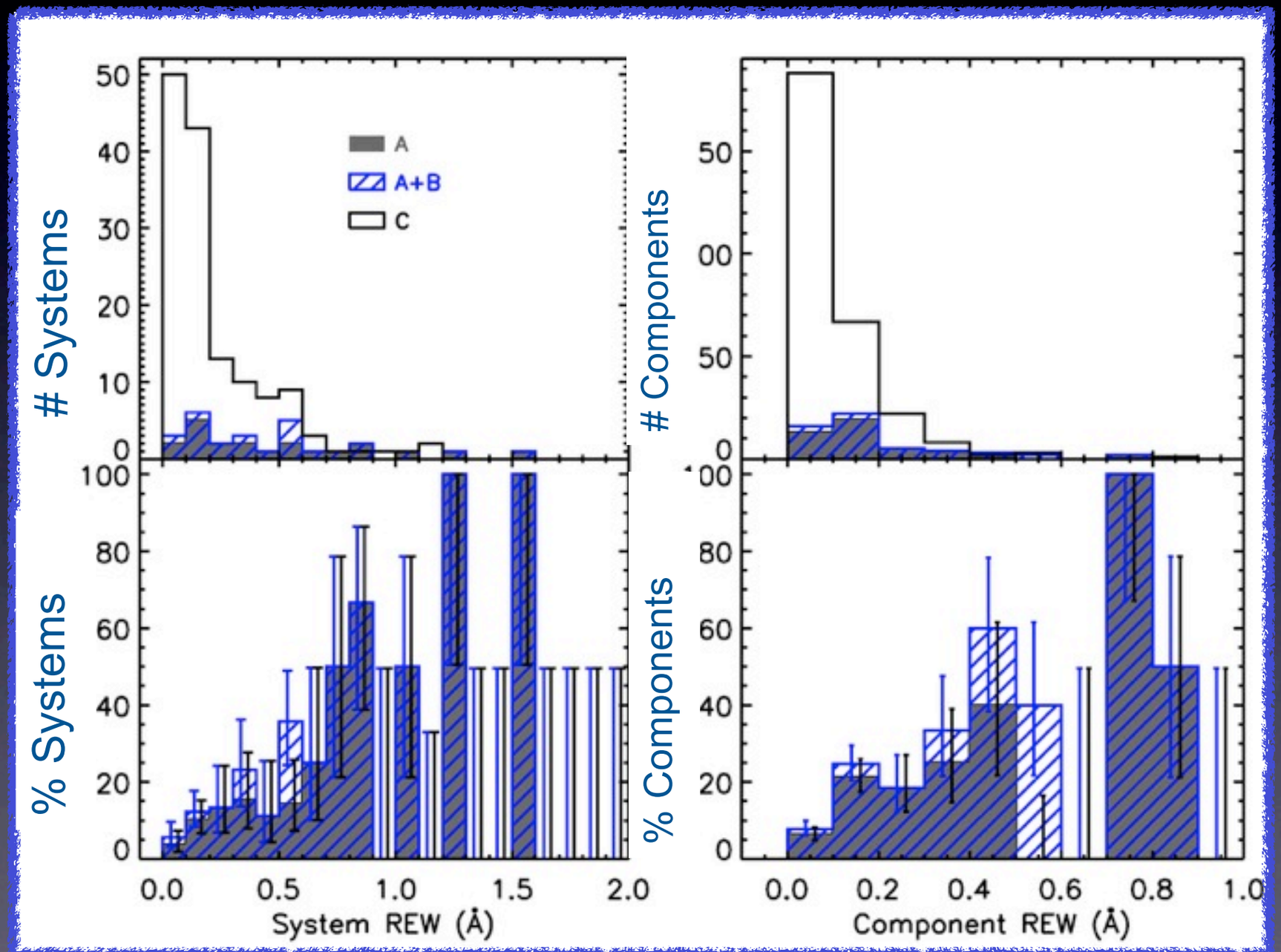
60-77%

Column Density

Percentage of intrinsic NALs rises with increasing logN



Equivalent Width



Class A mean: 0.20 Å (0.50 Å)

Class C: 0.12 Å (0.26 Å)

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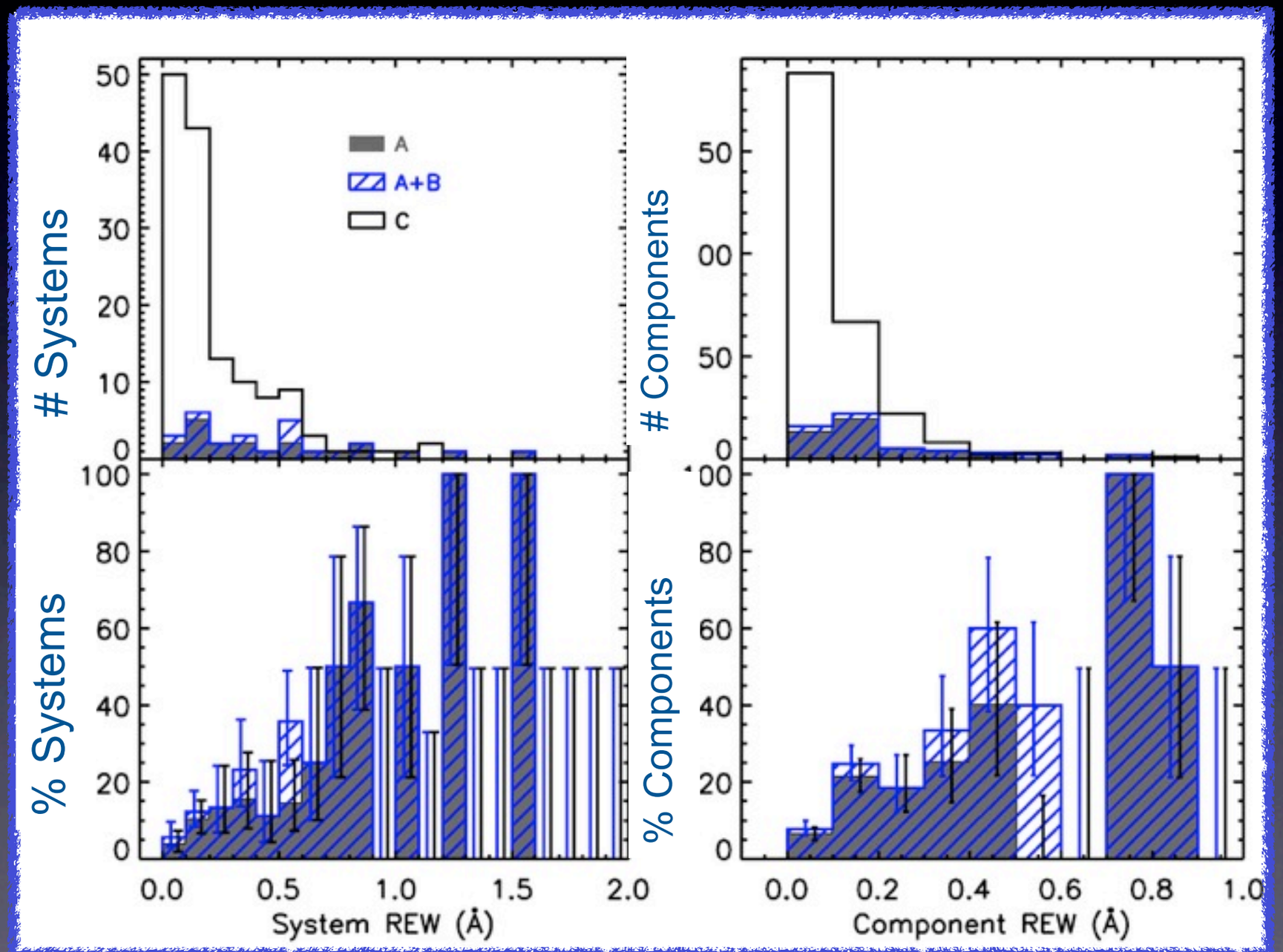


Class A mean: 0.20 Å (0.50 Å)

Class C: 0.12 Å (0.26 Å)

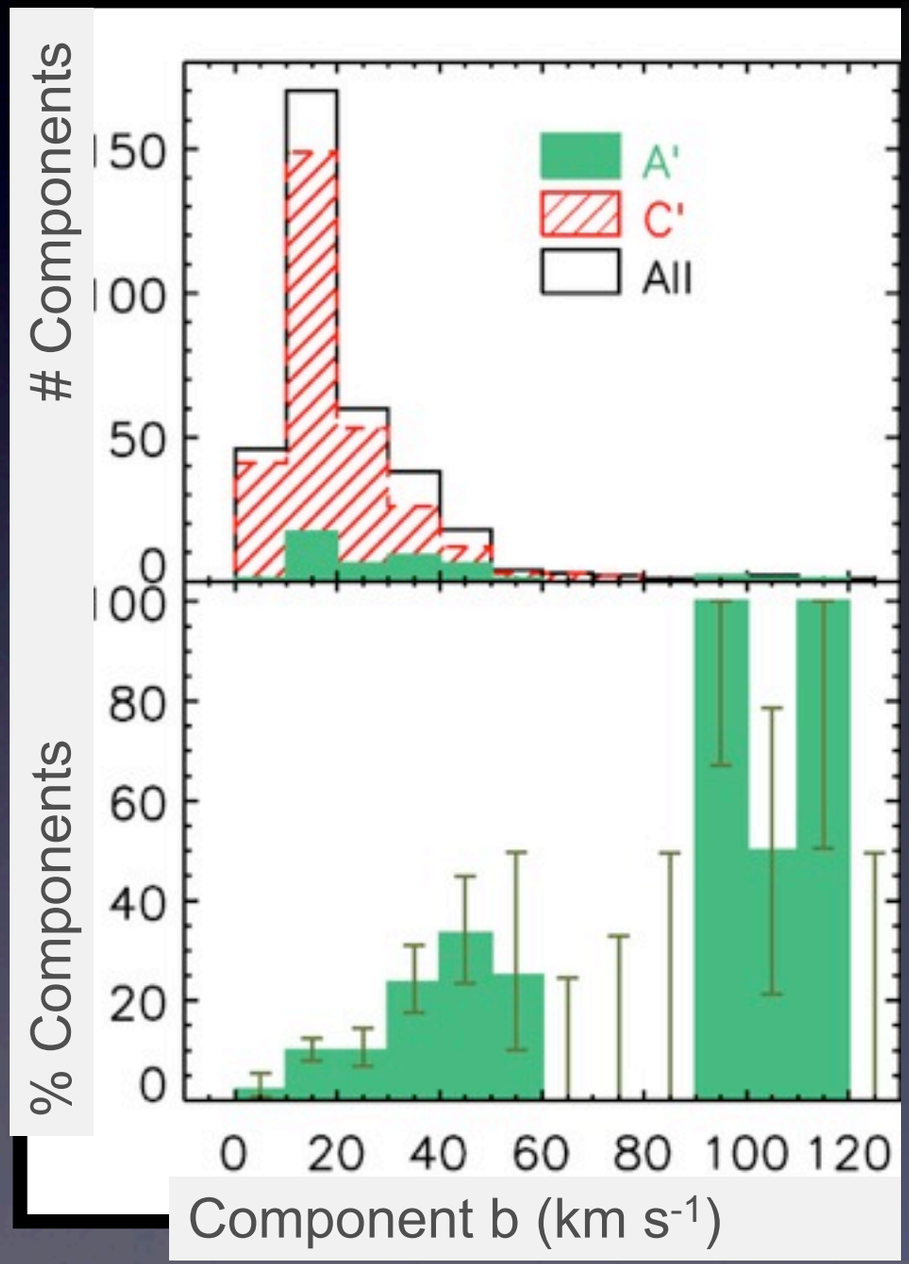
Class A and C NALs look very much alike! Very large REW more likely intrinsic

Doppler Width

Class A mean:
34 km s^{-1}

Class C mean:
21 km s^{-1}

30% in class A for
30 < b < 60 km s^{-1}
only
10% in class A for
b < 30 km s^{-1}



Intrinsic and 'other' NALs look very similar

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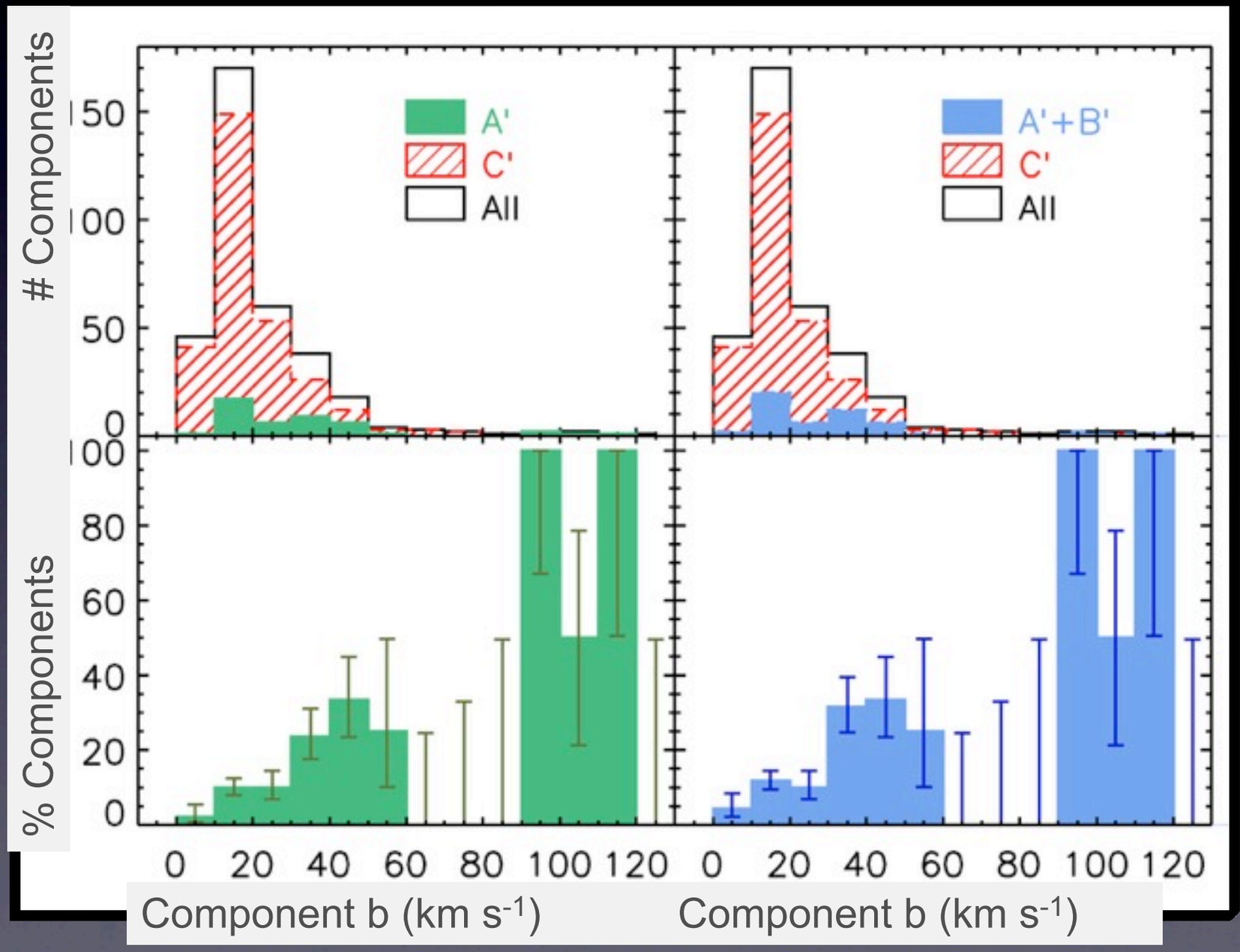

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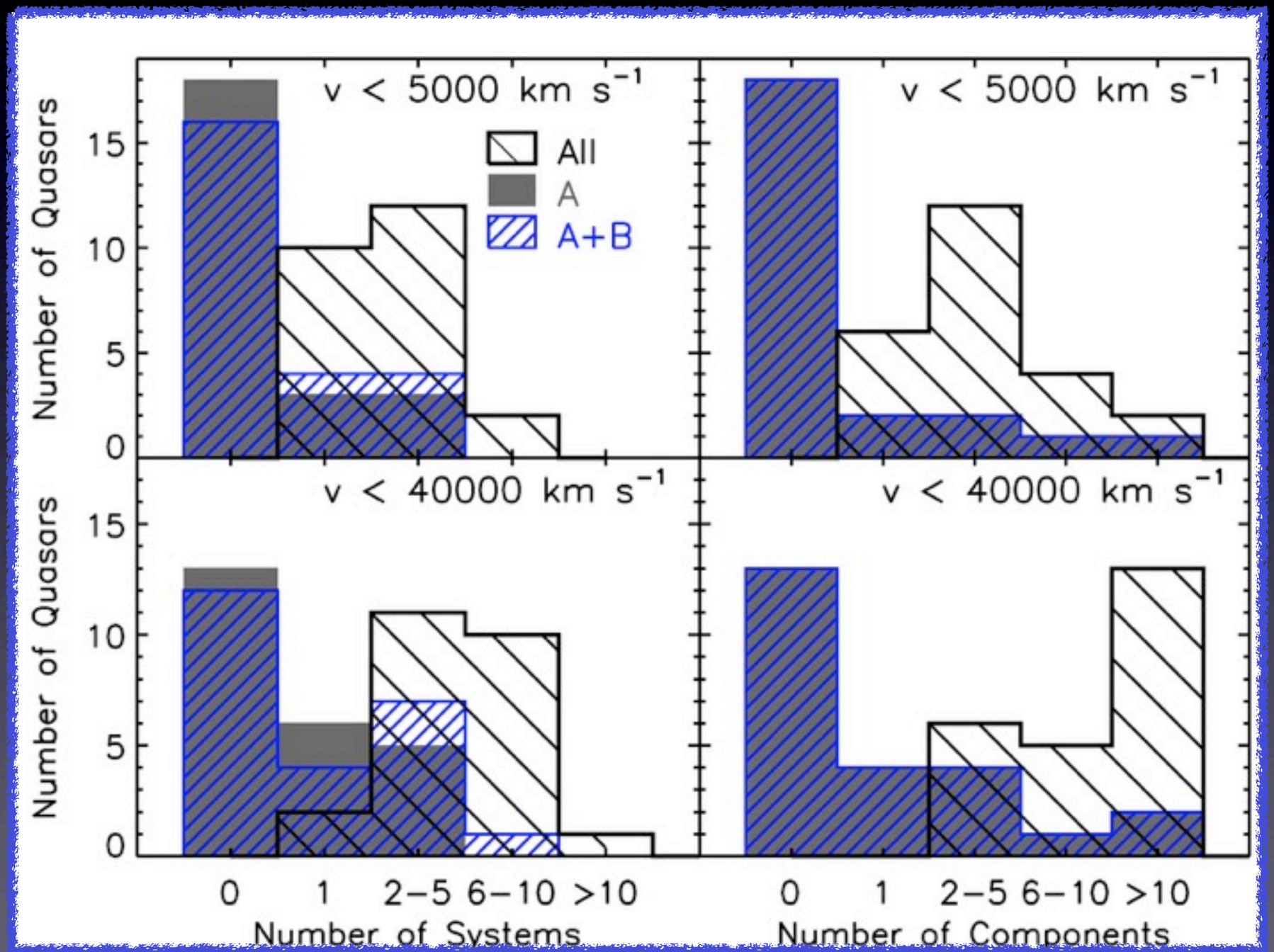
NALs per quasar



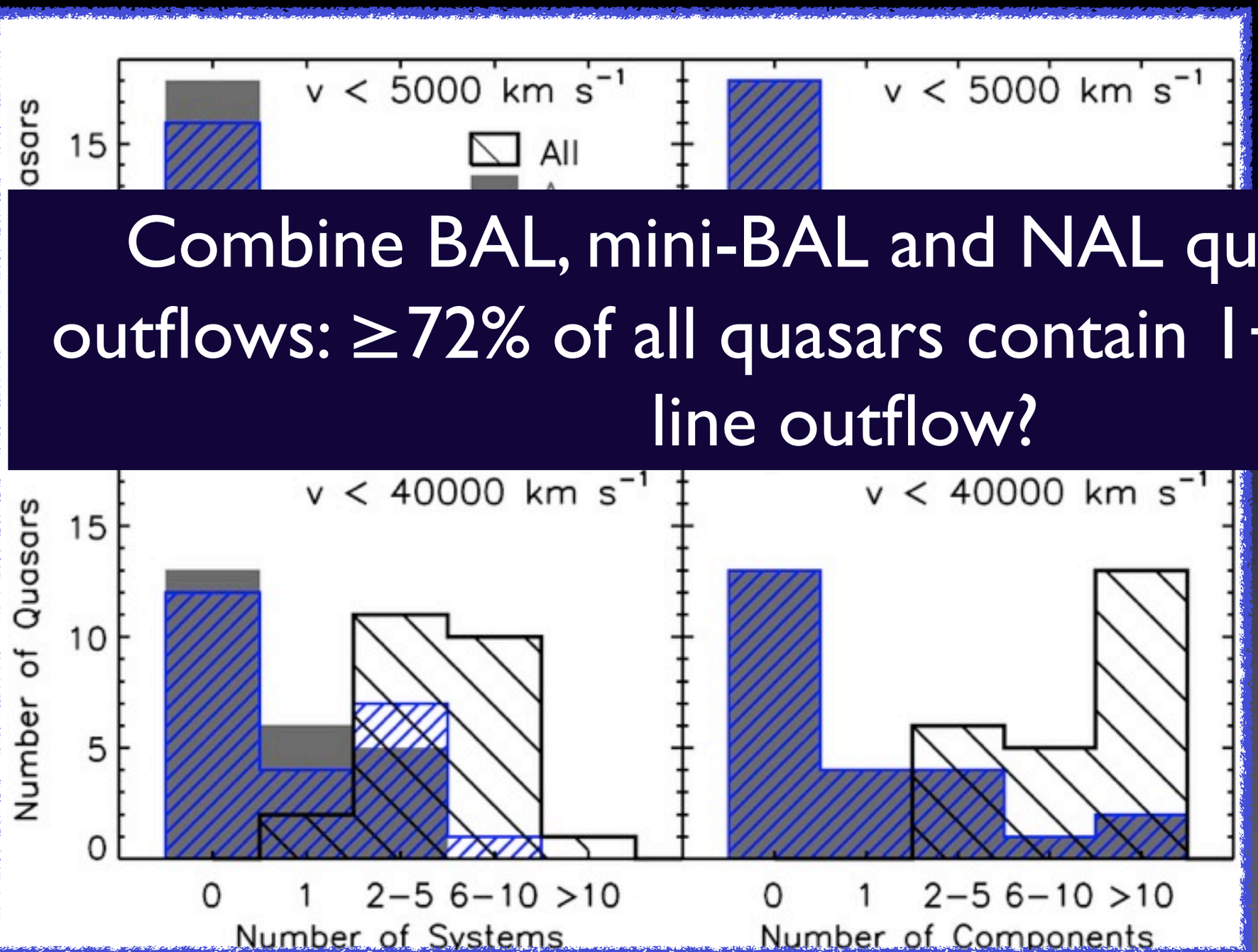
46% of quasars have 1+ NAL below 40,000 km s^{-1}.

29% of quasars have 1+ NAL above 5000 km s^{-1}.

⬆

These are outflows!

NALs per quasar



Combine BAL, mini-BAL and NAL quasars with outflows: ≥72% of all quasars contain 1+ absorption line outflow?

46% of quasars have 1+ NAL

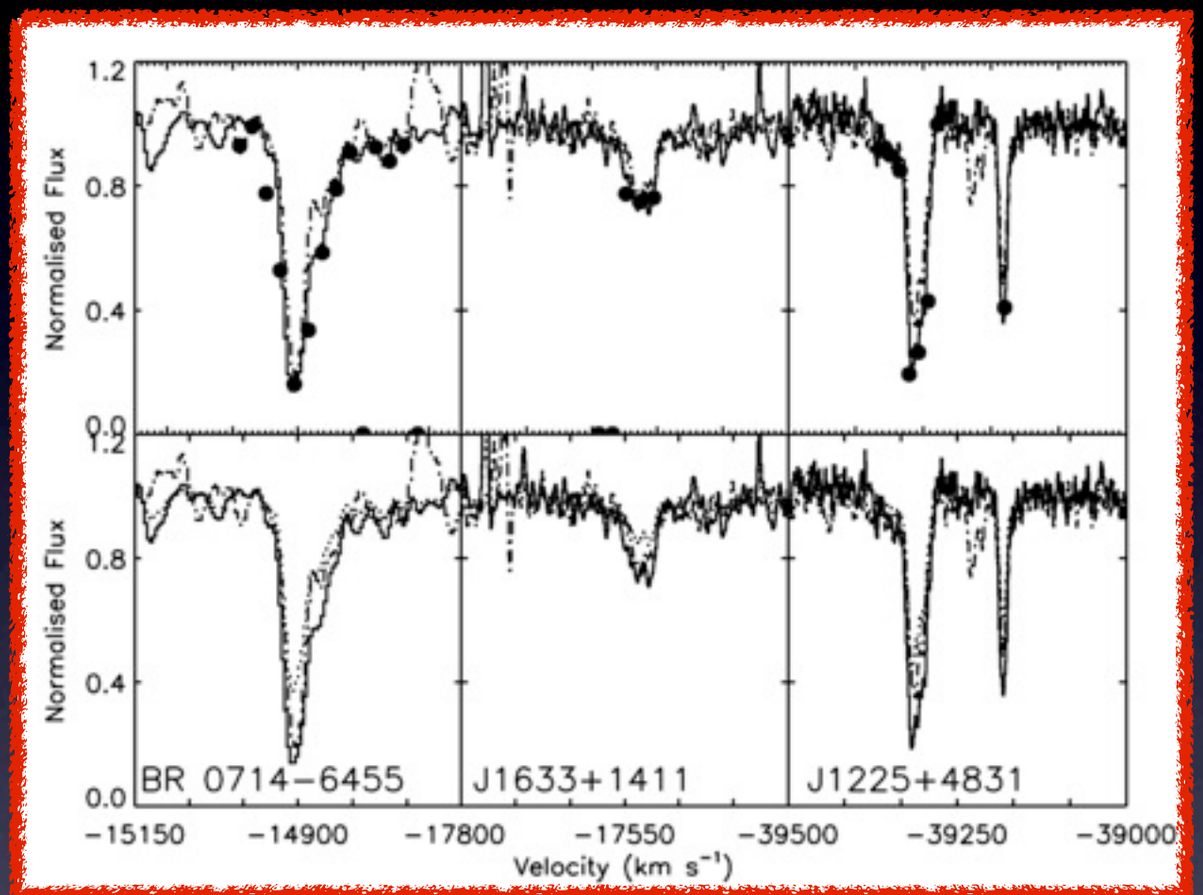
…m

…s have 1+ NAL above 5000 km s^{-1}.

⬆

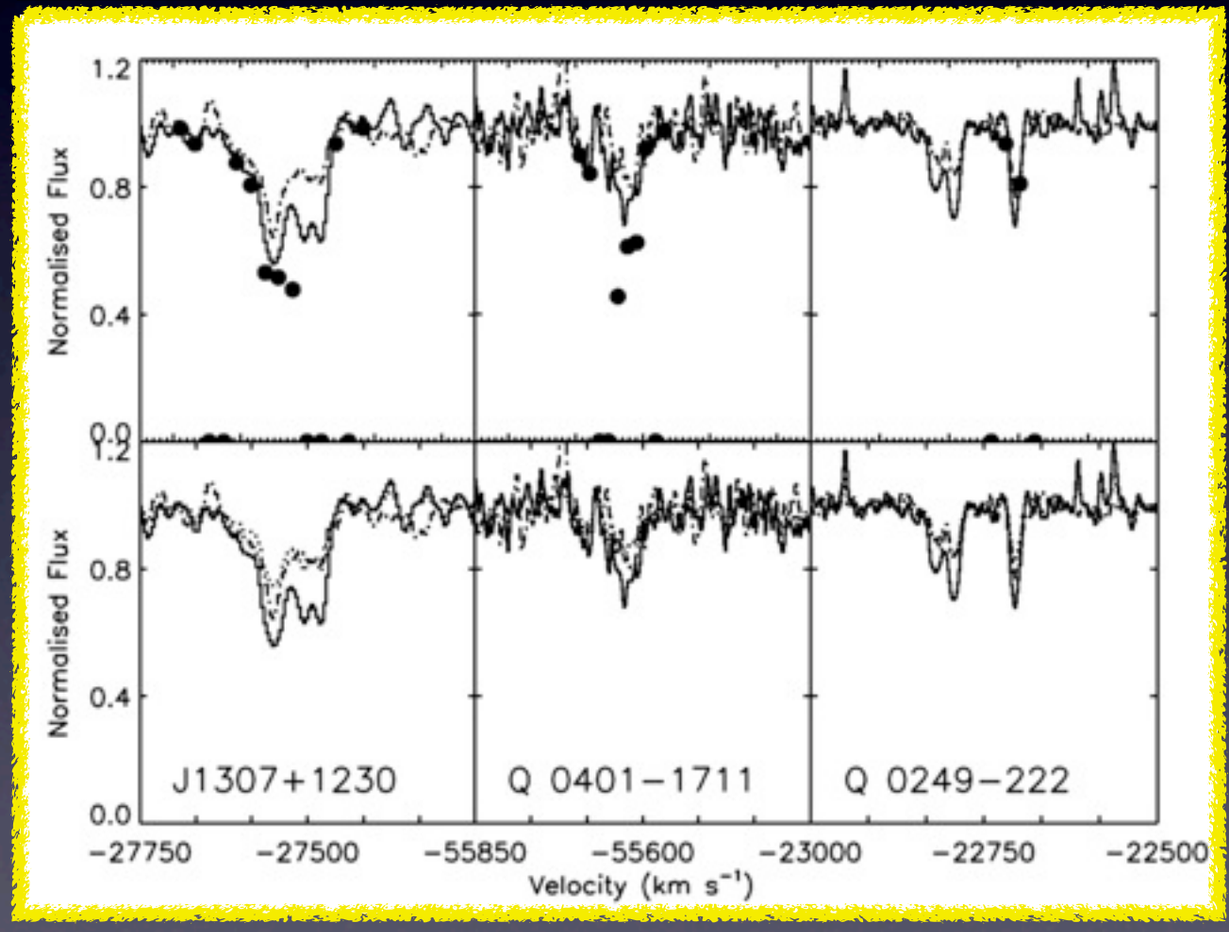
These are outflows!

High Velocity Outflows

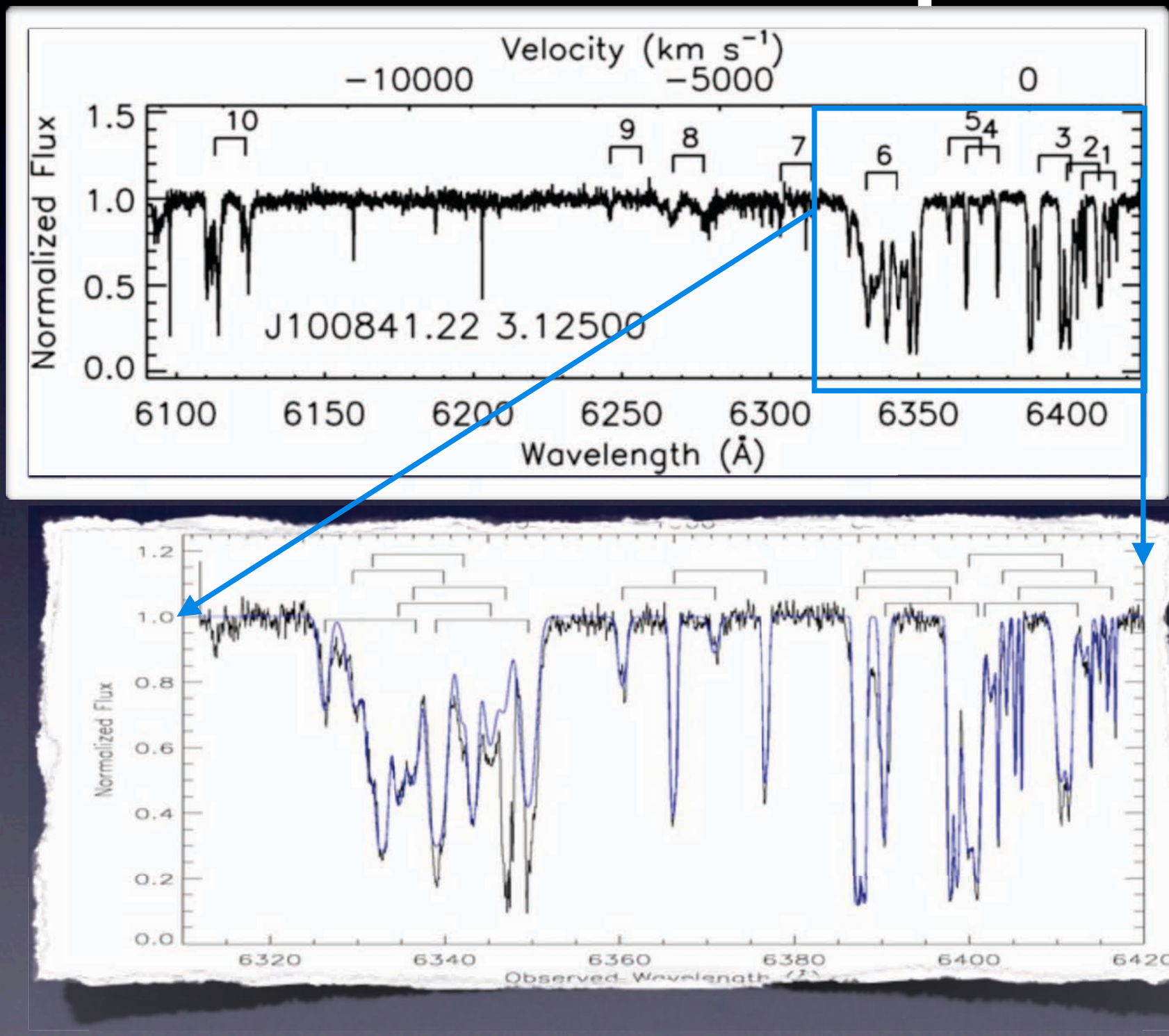


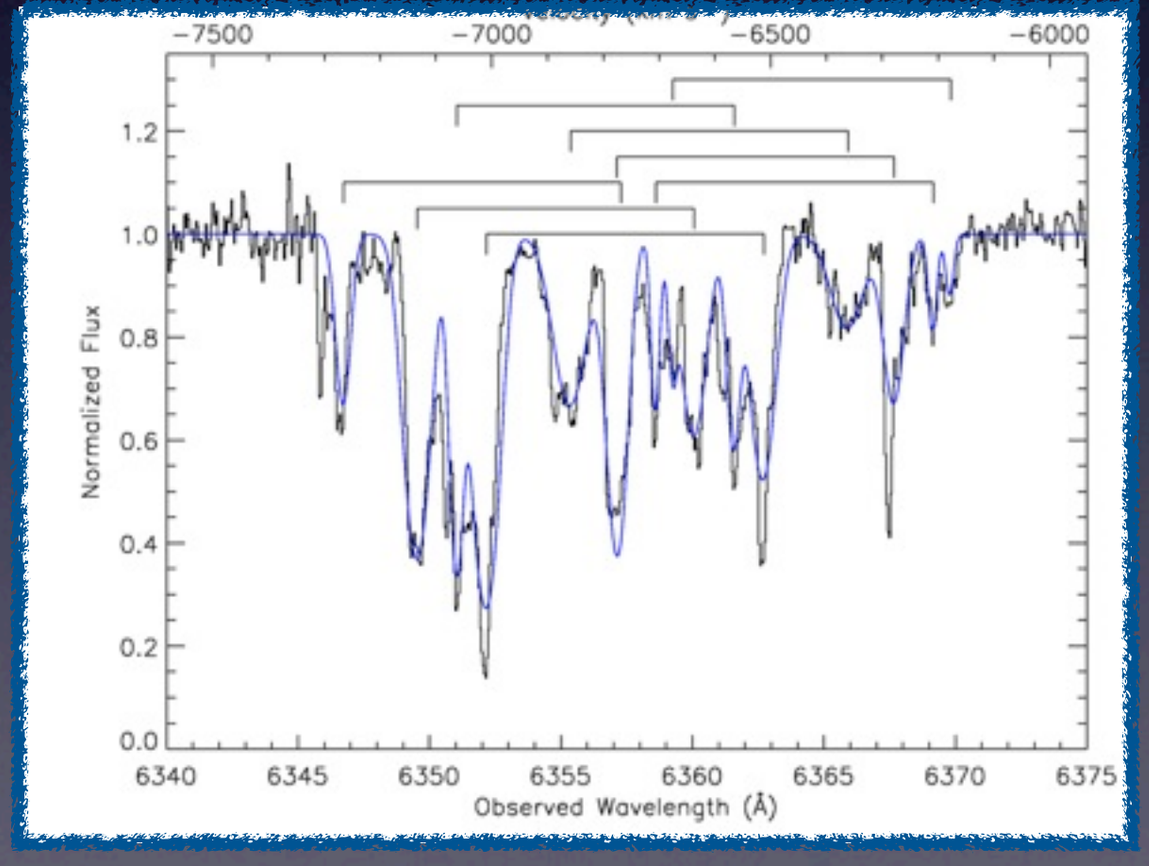
Solid Evidence (Class A)

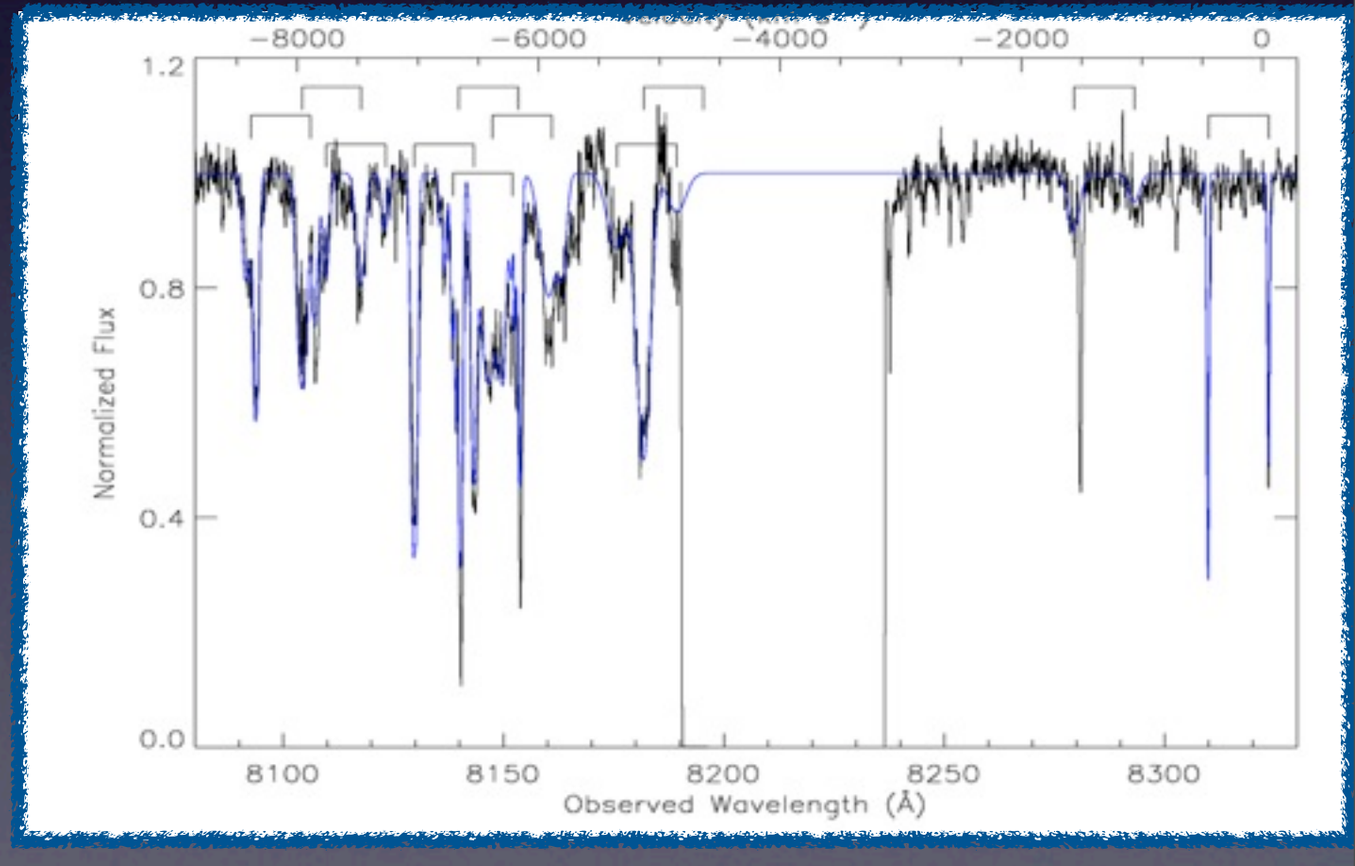
Inconclusive Evidence (Class C)

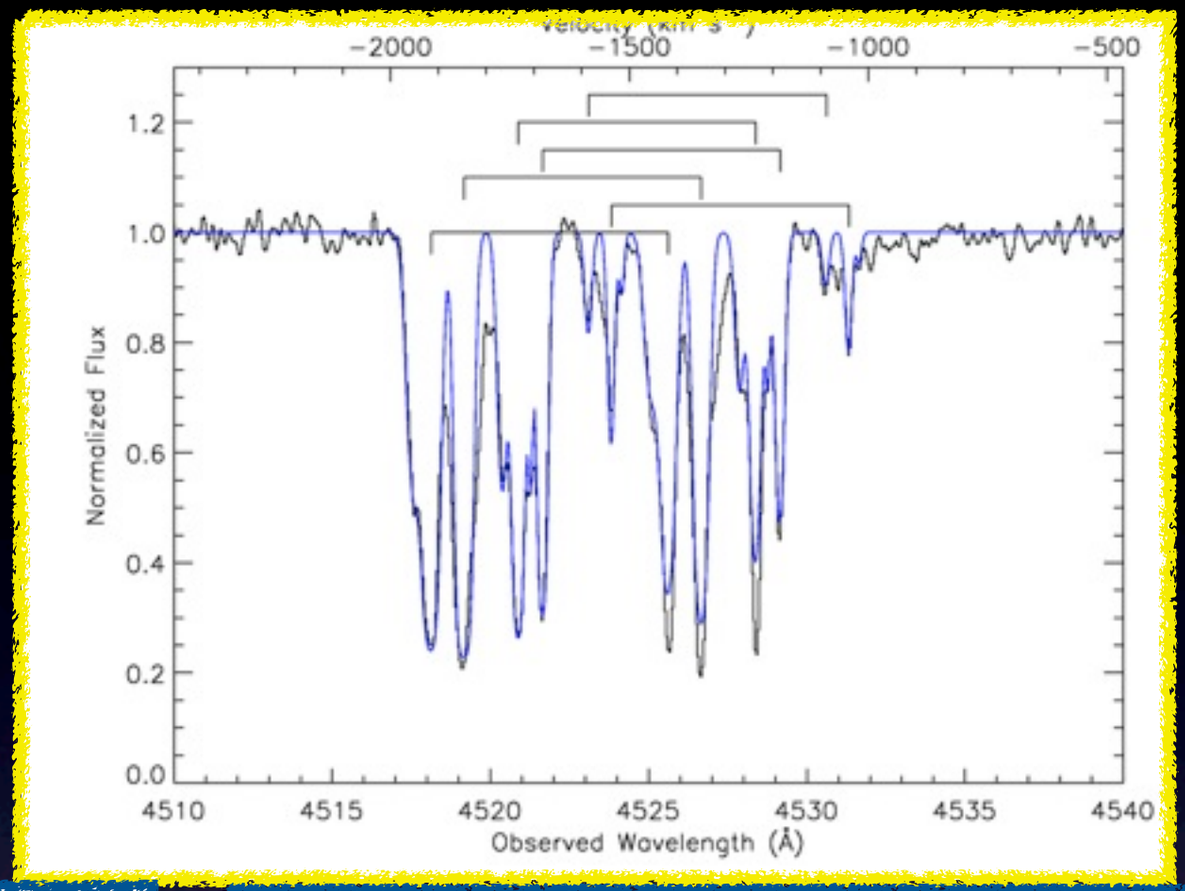


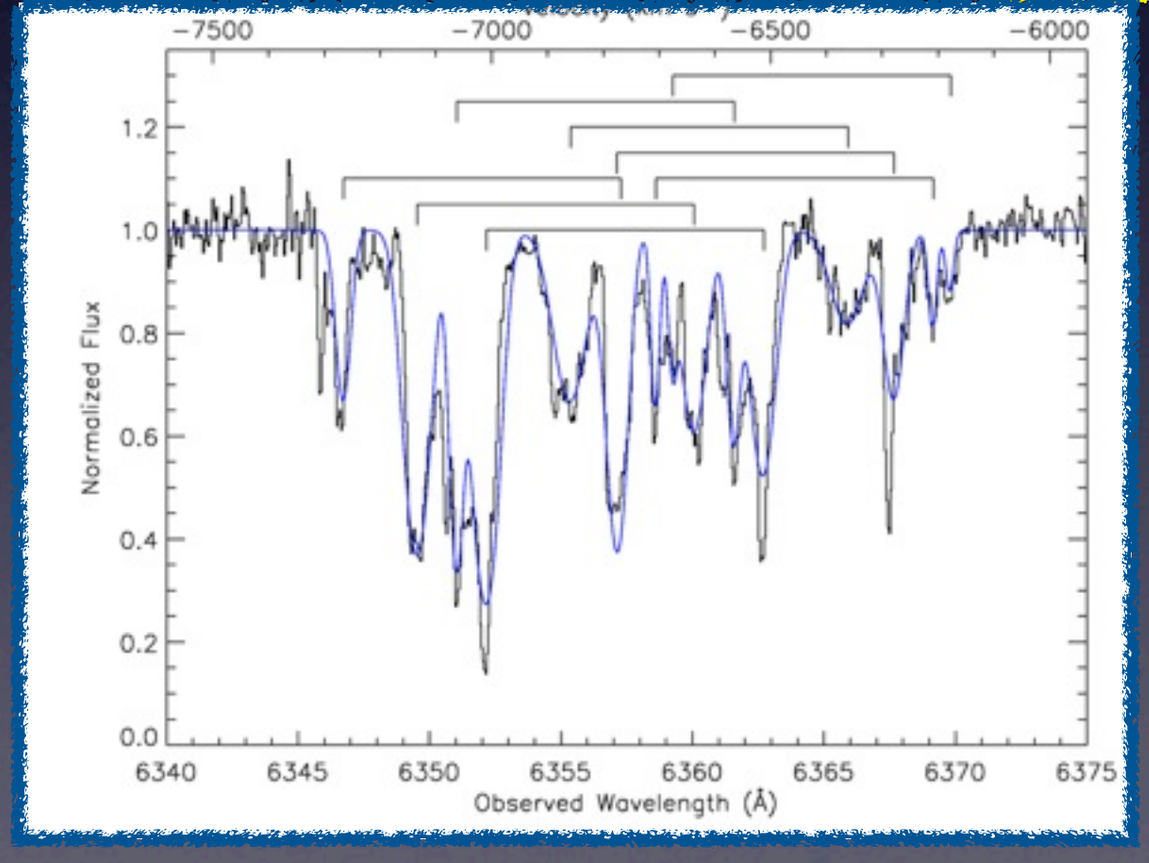
“Rich” NAL Complexes




−7500
−7000
−6500
−6000
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Normalized Flux
6340
6345
6350
6355
6360
6365
6370
6375
Observed Wavelength (Å)


−8000
−6000
−4000
−2000
0
1.2
0.8
0.4
0.0
Normalized Flux
8100
8150
8200
8250
8300
Observed Wavelength (Å)


−2000
−1500
−1000
−500
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Normalized Flux
4510
4515
4520
4525
4530
4535
4540
Observed Wavelength (Å)


−7500
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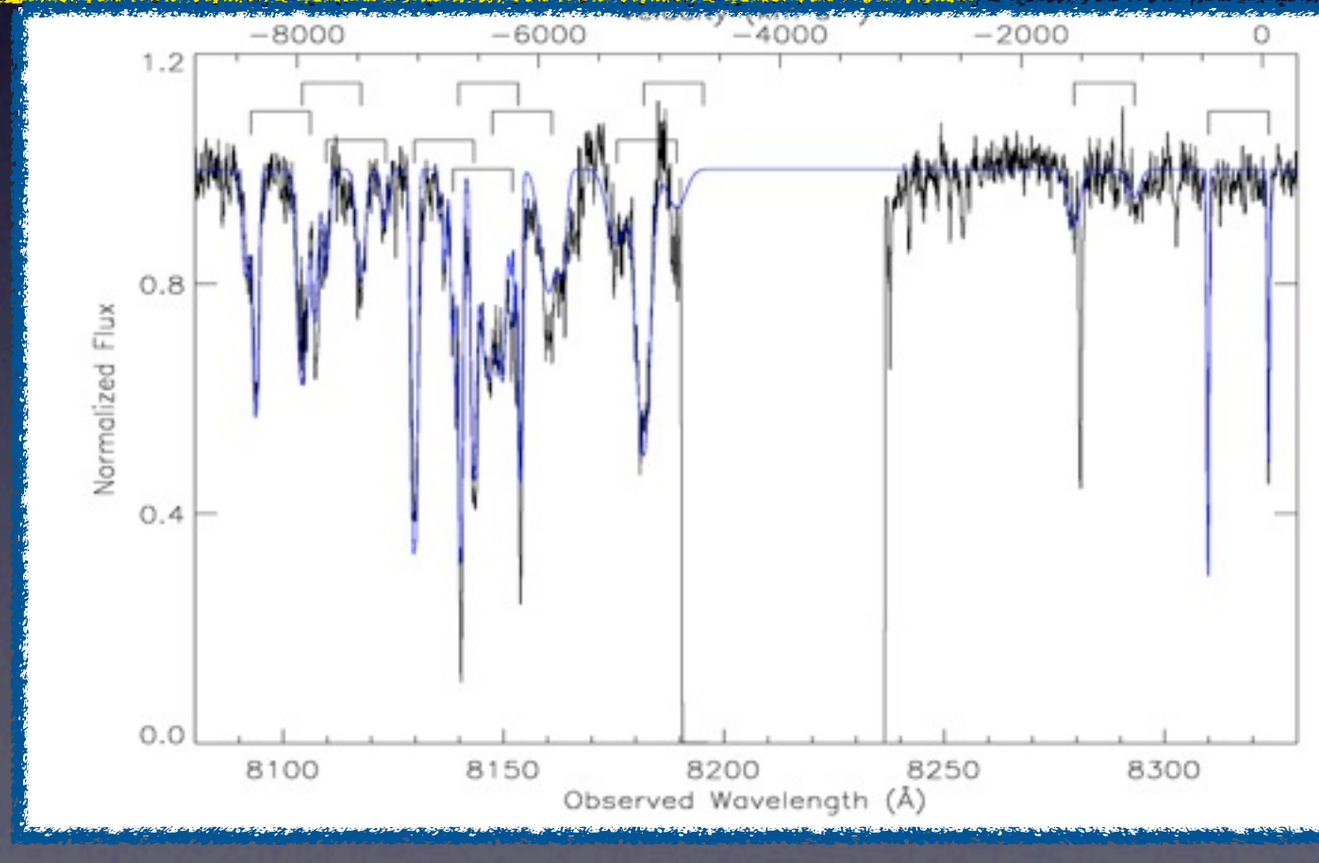
−8000
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0.4
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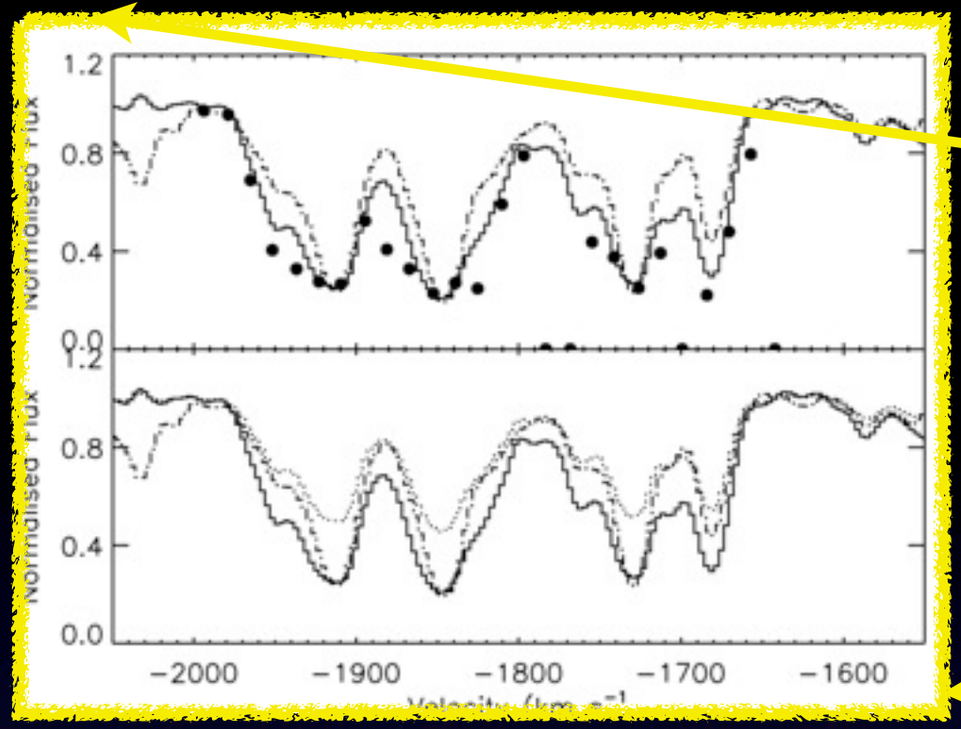
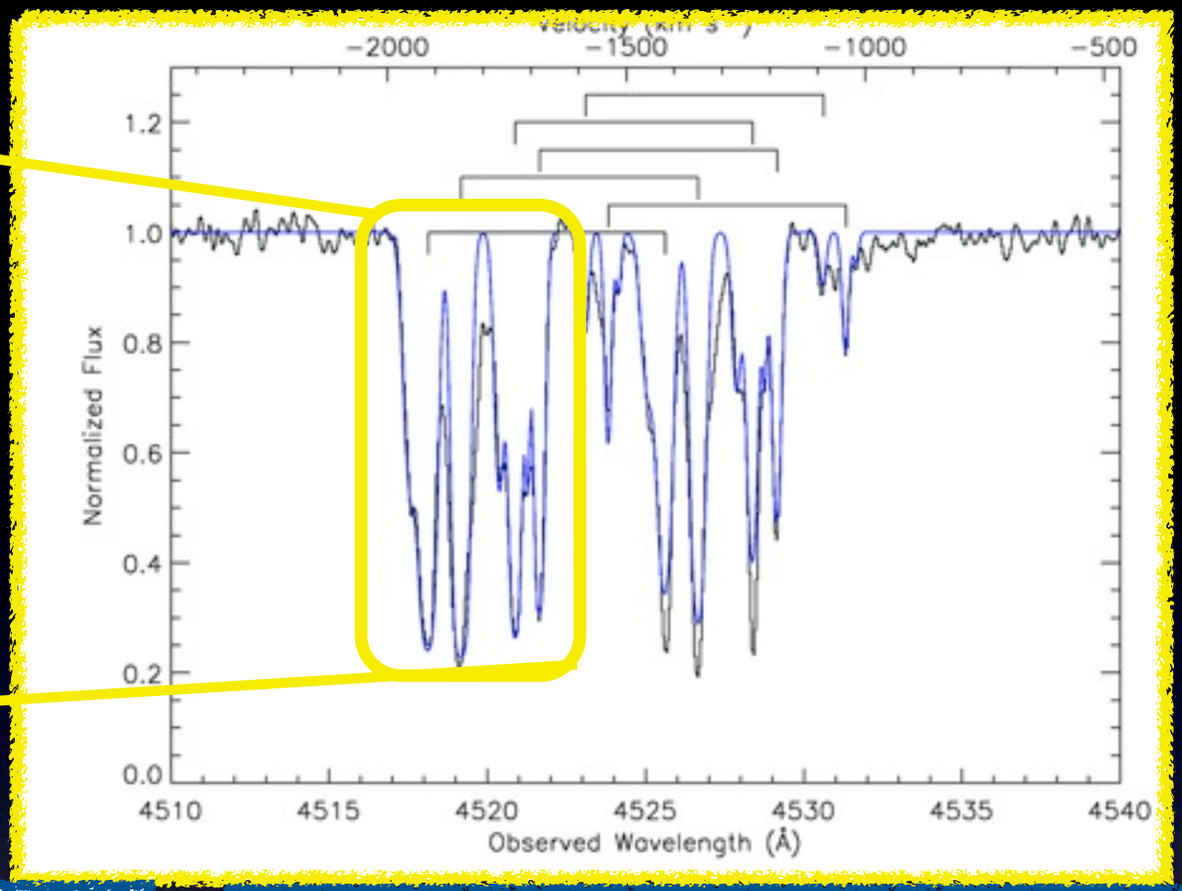

Normalised Flux
1.2
0.8
0.4
0.0
−2000
−1900
−1800
−1700
−1600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4510
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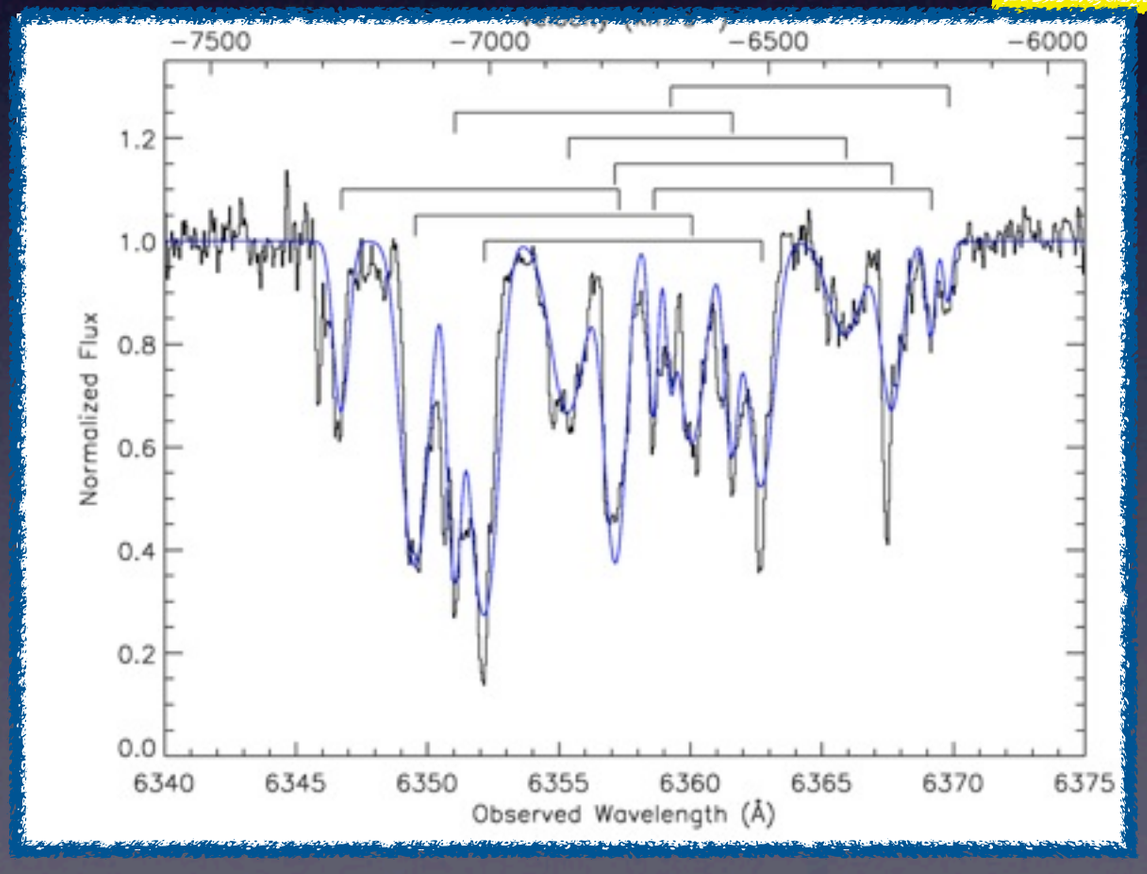
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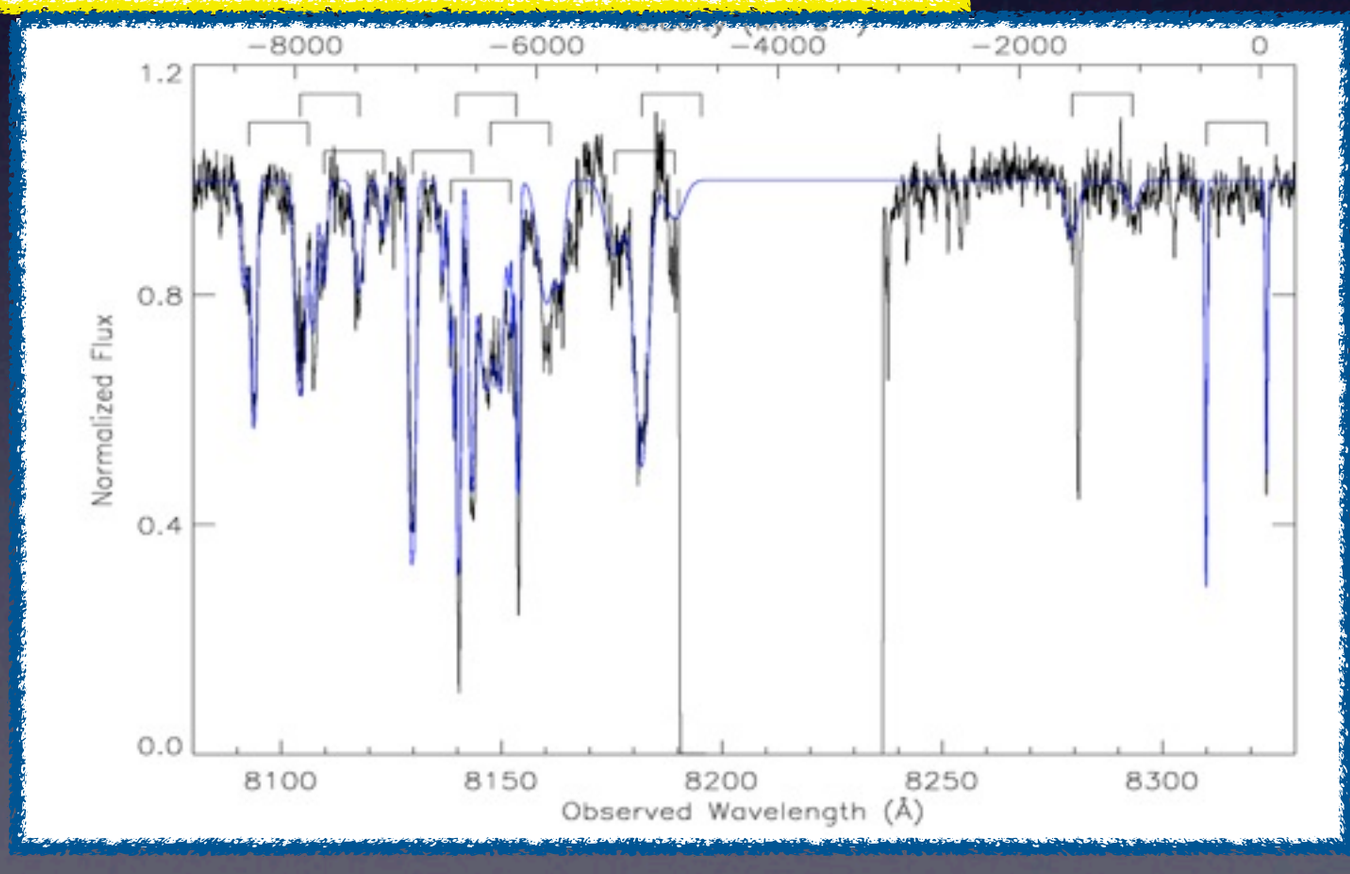
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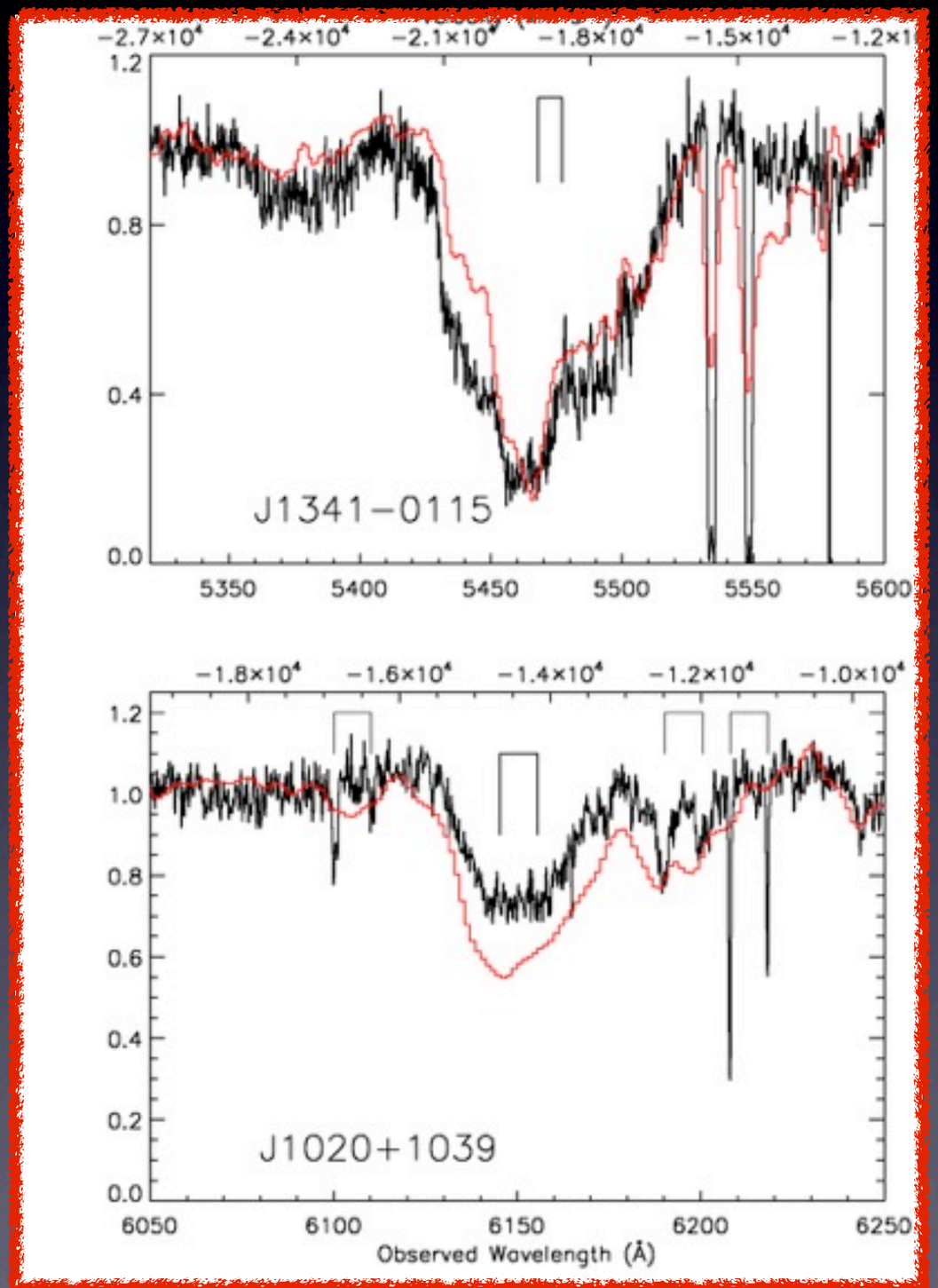
Observed Wavelength (Å)

Broad(ish) absorption



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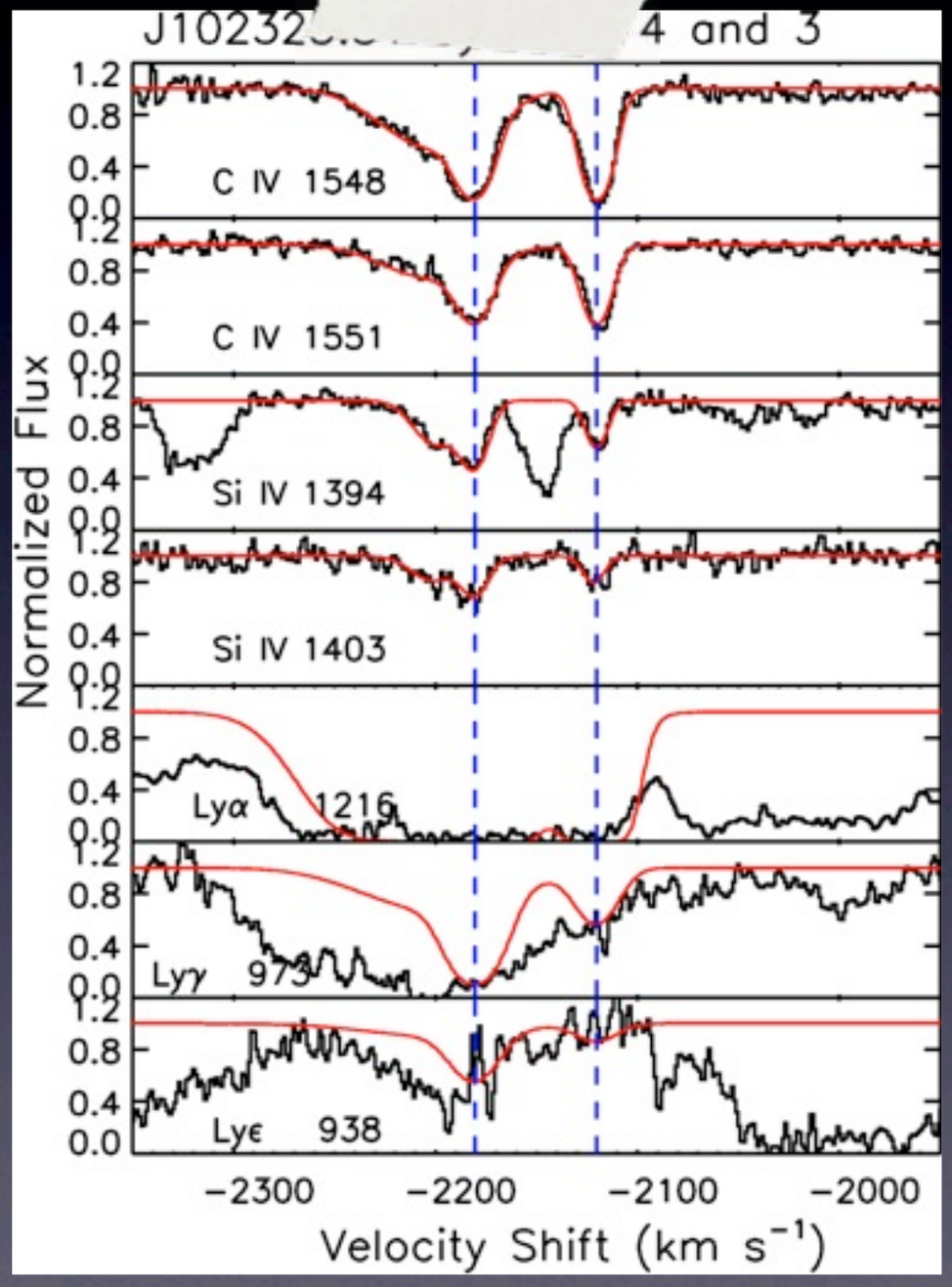
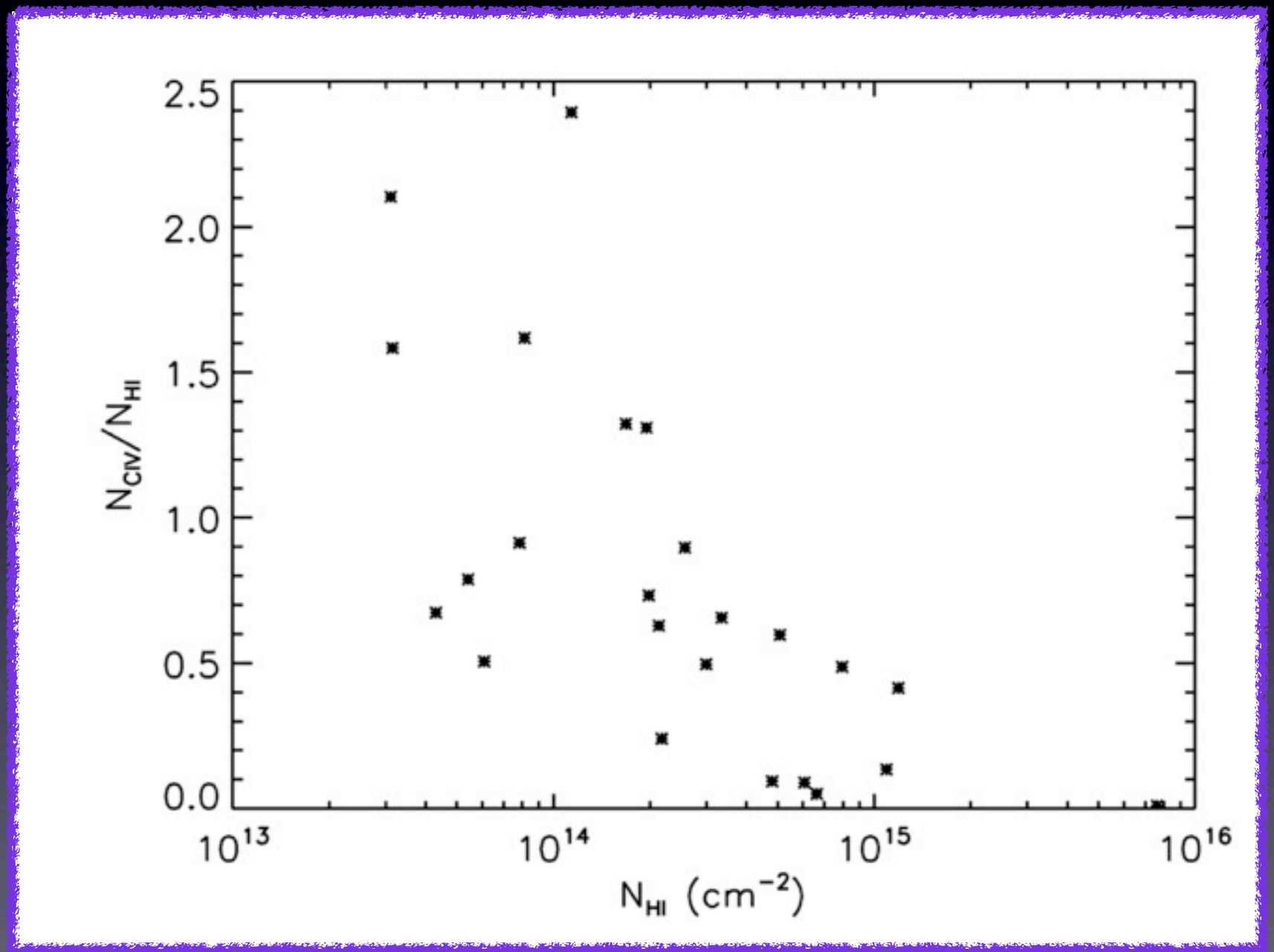
- Rich NAL complexes --where do these highly structured, multicomponent outflows come from?

Sample Data


4 and 3
C IV 1548
C IV 1551
Si IV 1394
Si IV 1403
Lyα 1216
Lyγ 973
Lyε 938
Normalized Flux
1.2
0.8
0.4
0.0
−2300
−2200
−2100
−2000
Velocity Shift (km s^{-1})

Intrinsic Ionization



Intrinsic Column Density