Spectral Dramatic change of FeLoBAL SDSS J1632+4504

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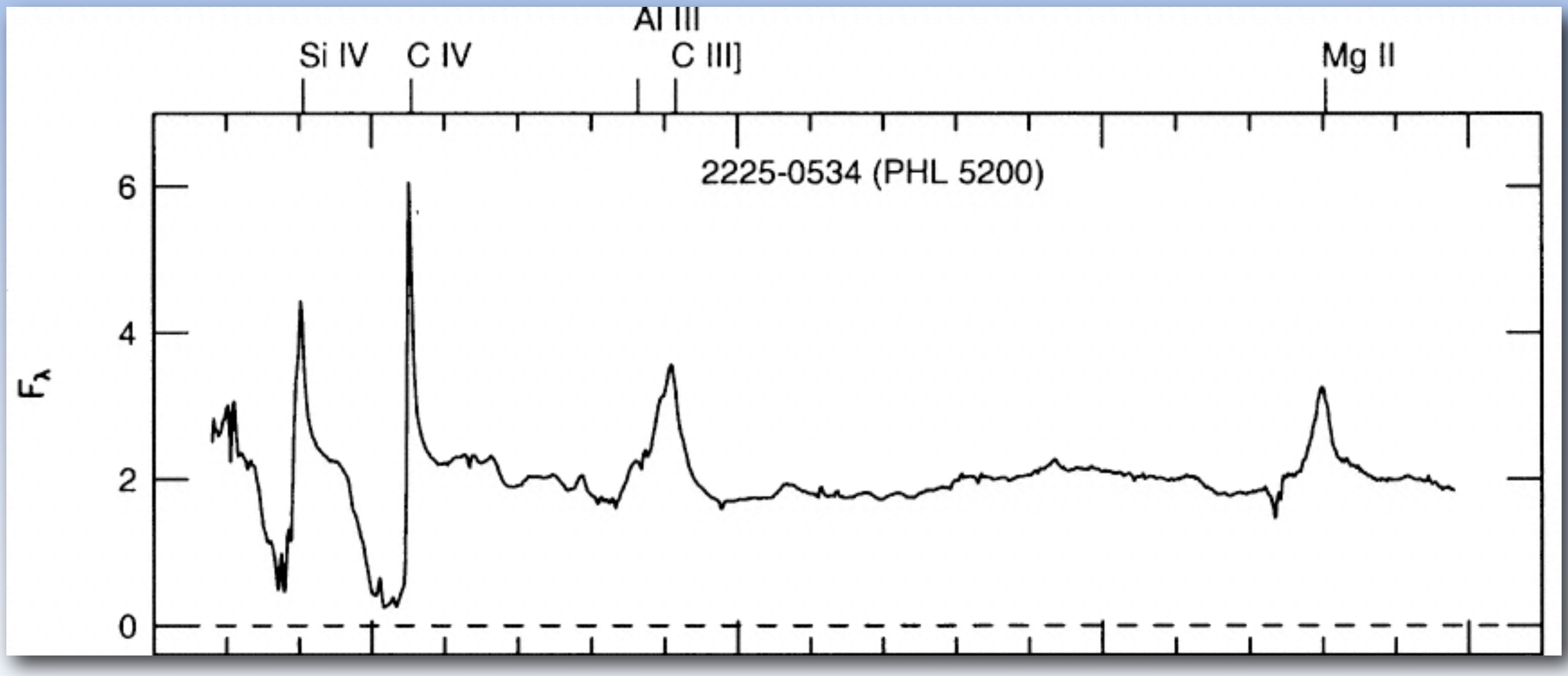
B4 variability of NAL & mini-BAL

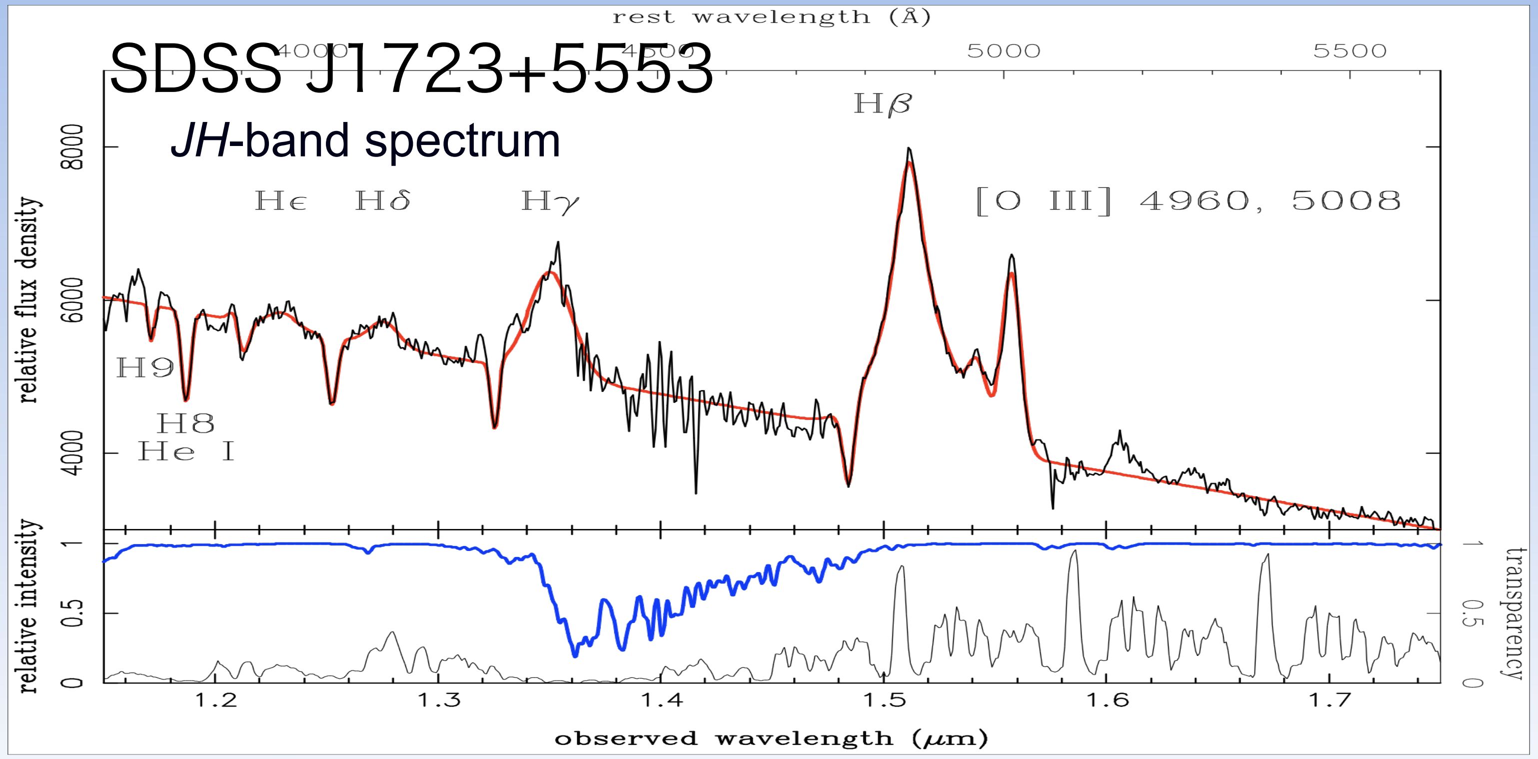
What are BAL quasars ?

- Broad absorption line (BAL) quasars

  show broad (1000 - 10000 km/s) **blueshifted** absorption from ions.

- 10 - 20 % of all quasars are BAL quasars.

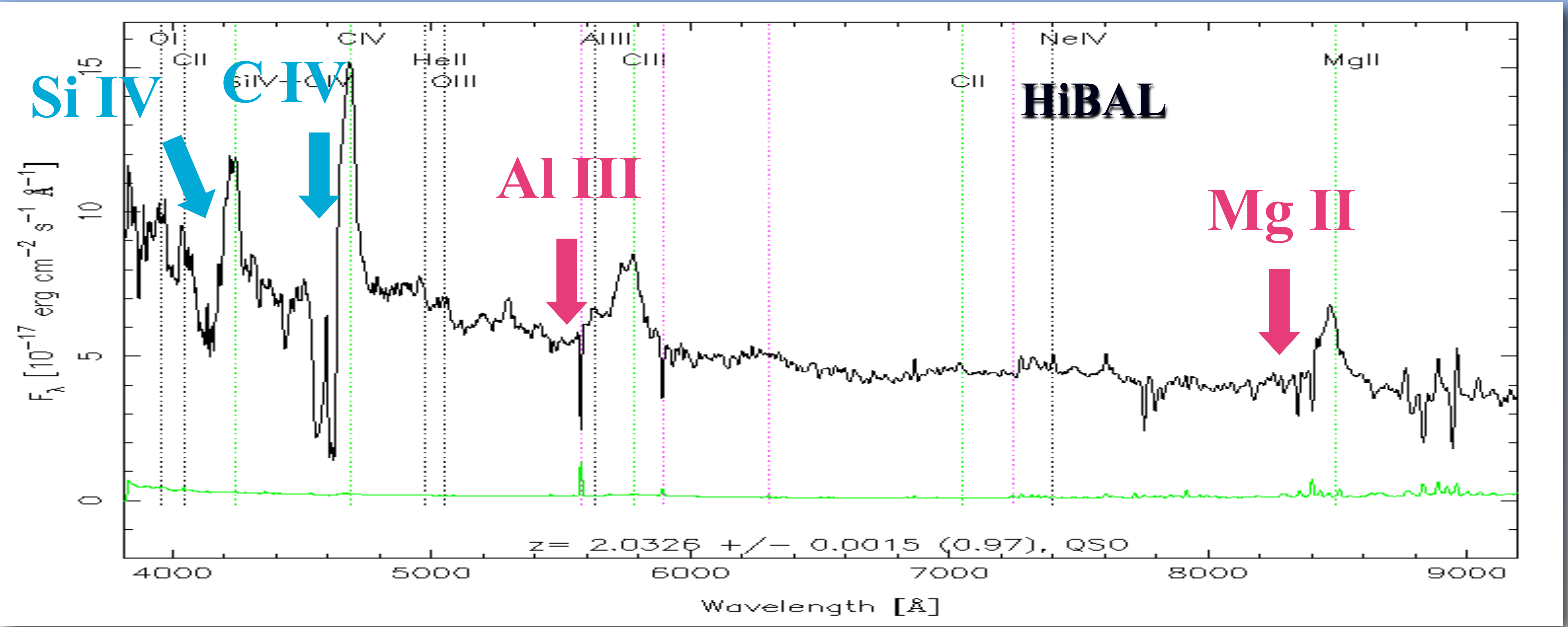




- divided into three observation subtypes

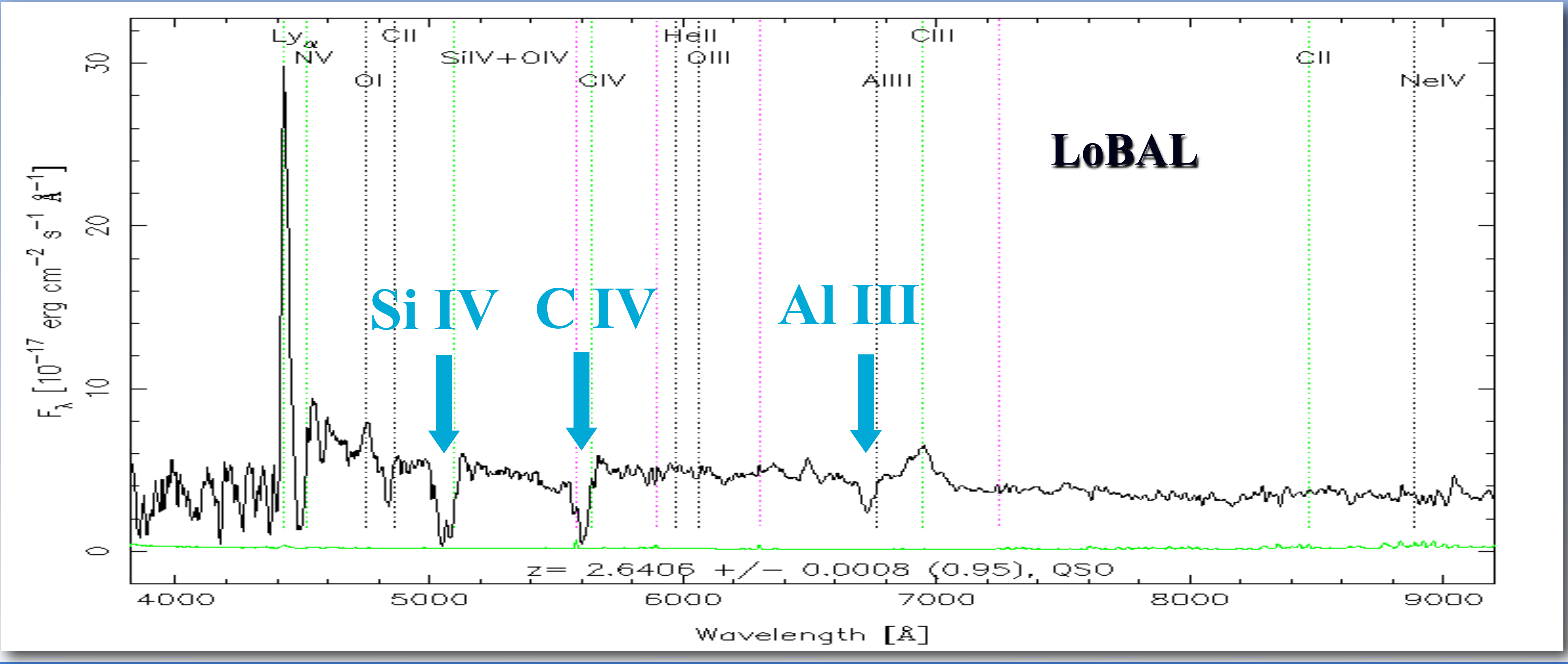
✓ High-ionization BAL quasars (HiBAL)

- Lyα, N V, Si IV and C IV, but no Al III nor Mg II



✓ Low-ionization BAL quasars (LoBAL)

- high ionization lines + Al III, Mg II
- ~1% of all quasars

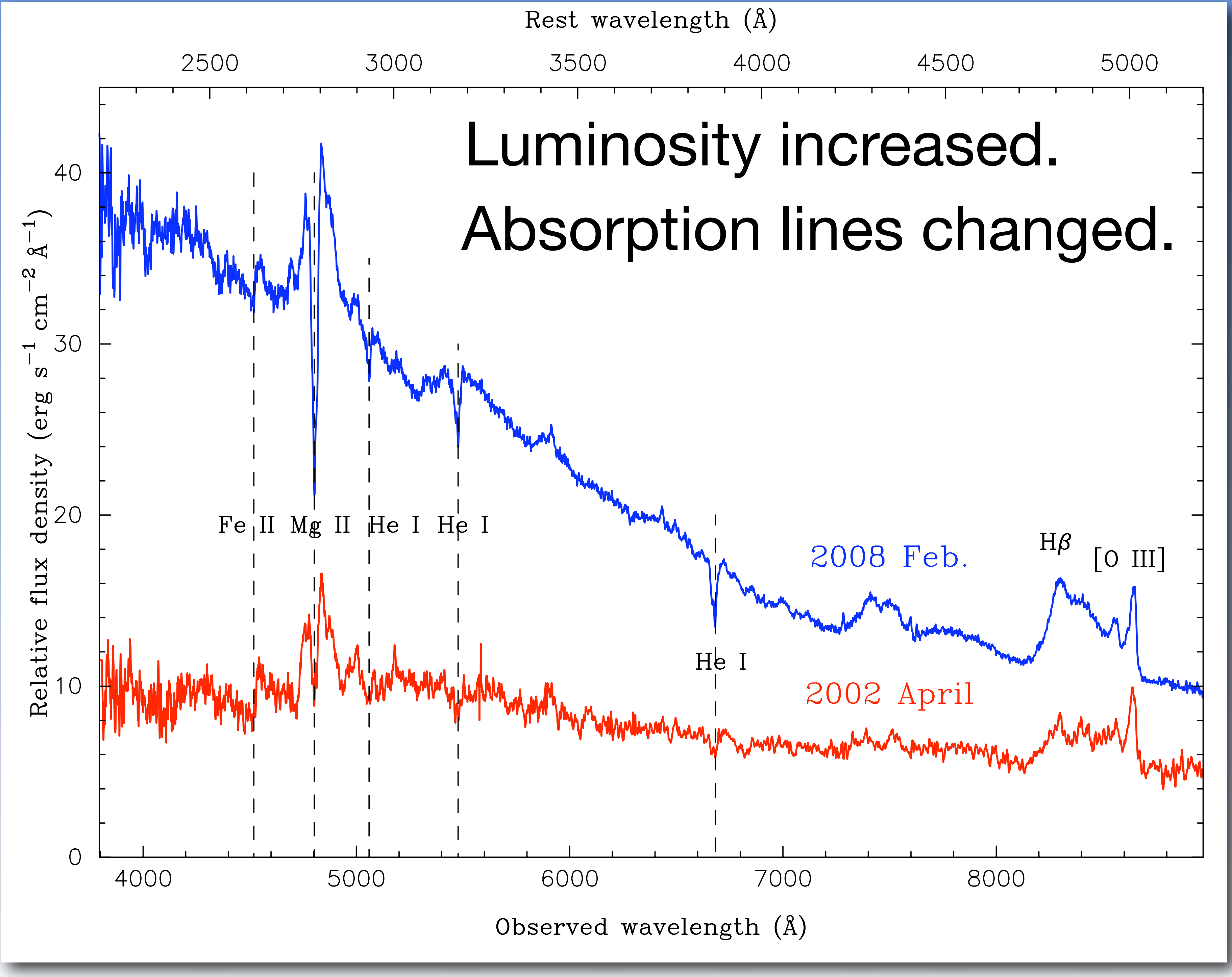


✓ Iron Low-ionization BAL quasars (FeLoBAL)

- high ionization lines + Al III, Mg II + Fe II
- 0.3% of all quasars.
- Some of them have Balmer absorption lines (Aoki et al. 2006, 2007; Hall 2007).

SDSS J163255.46+420407.7

Search for Balmer absorption



2002 April (SDSS)

2008 February (Subaru/FOCAS)

$\Delta\lambda$=7Å

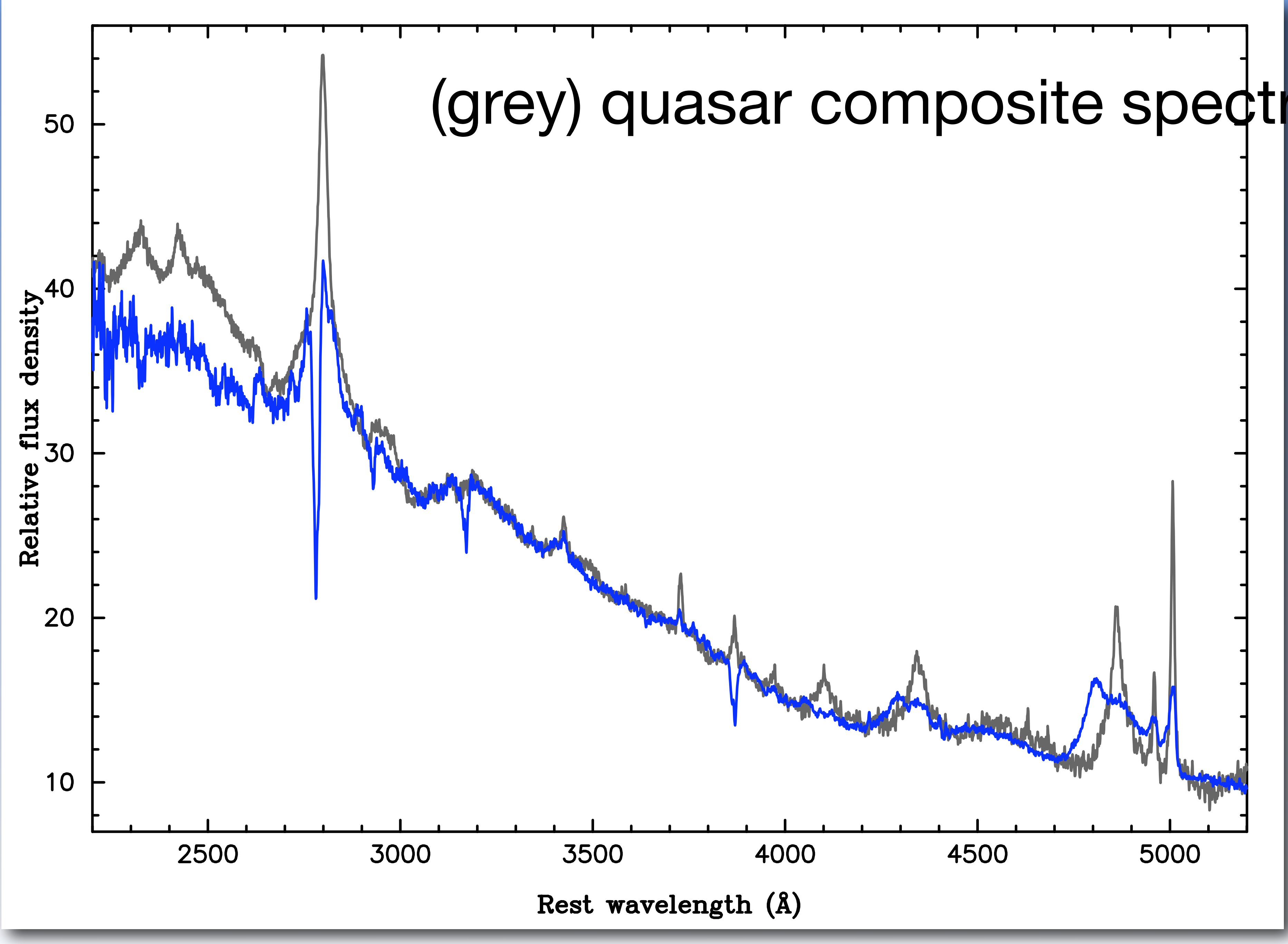
3.4 yrs in quasar's frame.

z=0.725

M_i=-24.35

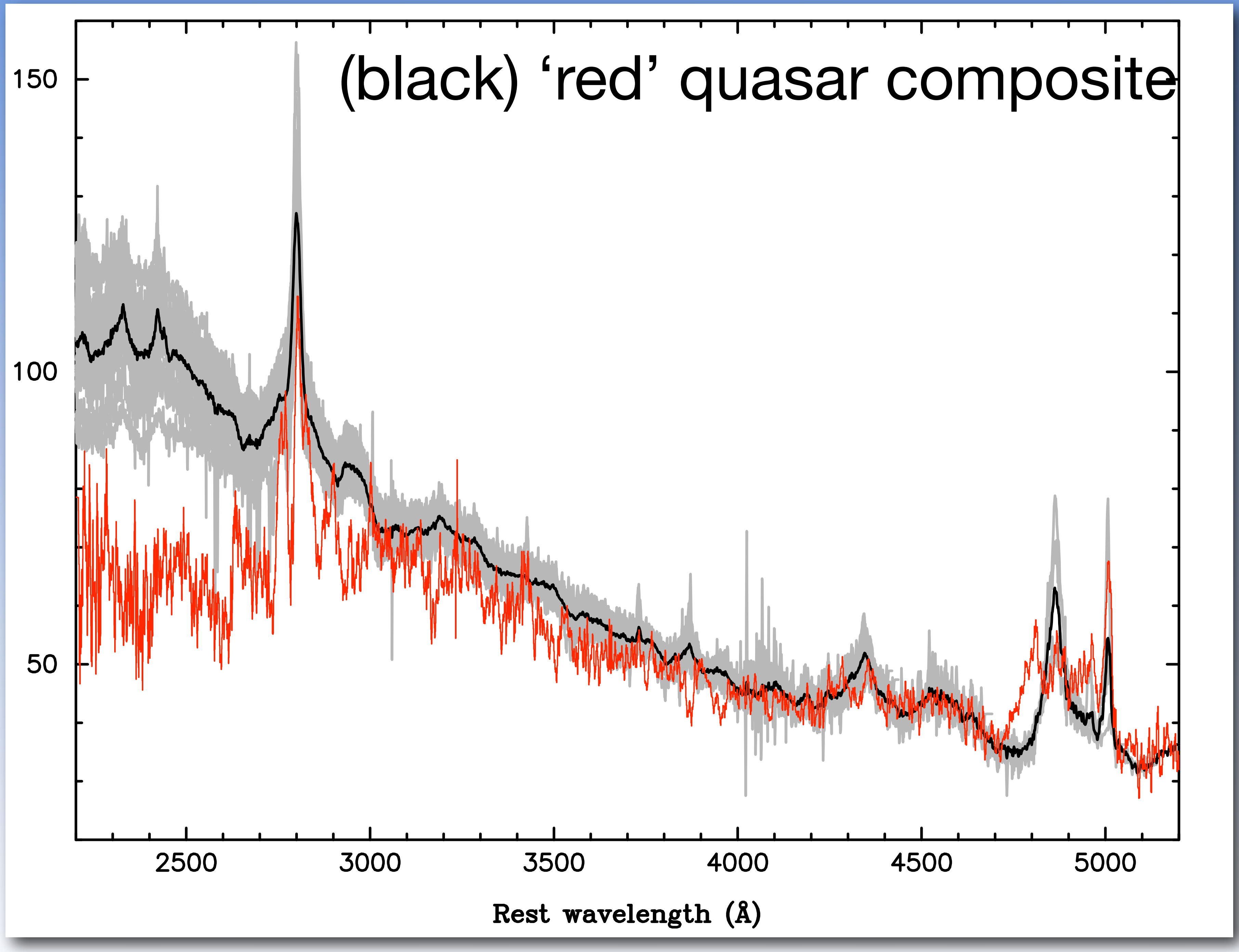
2008 February

- remarkably similar to the composite (> 3000Å).
- “blue” as quasar composite.



2002 April

- λ < 4000 Å: many absorption lines



Normalized spectra

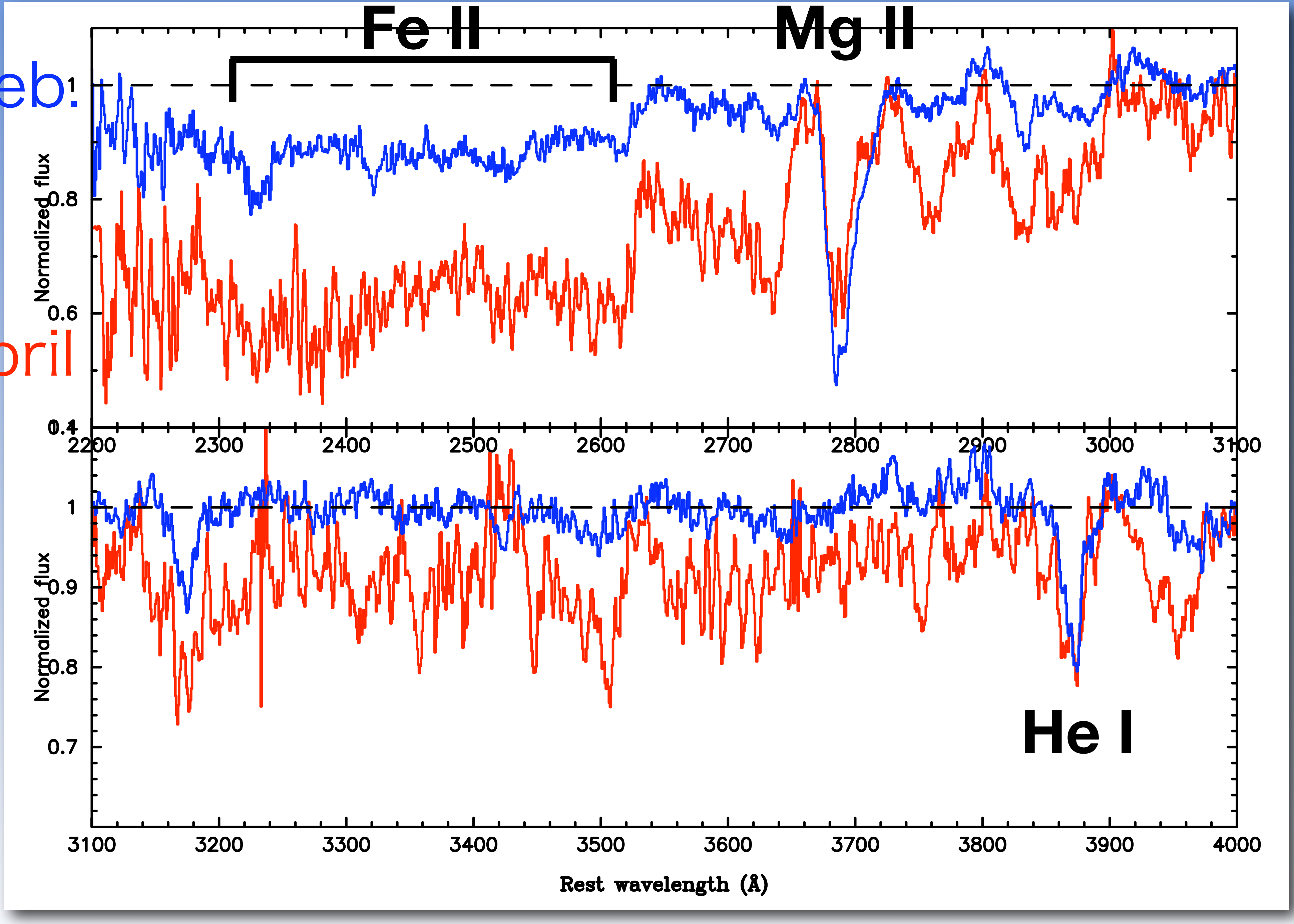
- Mg II, He I:

  Not changed much

  (< 30%).

- Fe II:

  80% weak.



What caused absorption variation ?

- covering factor change
- ionization/excitation change
- both

✓ difficult to measure covering factors by low-resolution spectra.

✓ ionization change is possible because luminosity increased.

Density constrain

- recombination time is necessary to change ionization.
- recombination time is inversely proportional to electron density.

$t_{recombination} = (n_e\ \alpha)^{-1}$, α: recombination coefficient

$\alpha_{H^+} = 5.4 \times 10^{-13}\ cm^3\ s^{-1}$ (7000 K) (Verner & Ferland 1996)

- $t_{recombination} < 3.4$ yrs ($=1.1 \times 10^8$ s) in quasar's rest frame.
- $n_e > 1.7 \times 10^4\ cm^{-3}$

Size constrain

- size < 3.4 light-year (=1 pc).
- Density and size constrains suggest absorption caused by like broad-line region gas.

BAL type

- SDSS J1632+4204 switched to LoBAL from FeLoBAL.

★"Bright" SDSS J1632 resembles to "average" quasar.

★Bright phase may be usual.

- Quasars sometimes may become FeLoBALs. FeLoBALs may be quiescent phase.
- NGC 4151: Fe II appear/disappear depend on the luminosity (Crenshaw et al. 2000).
- Fraction of BAL type may be determined "life" time of absorbing gas.

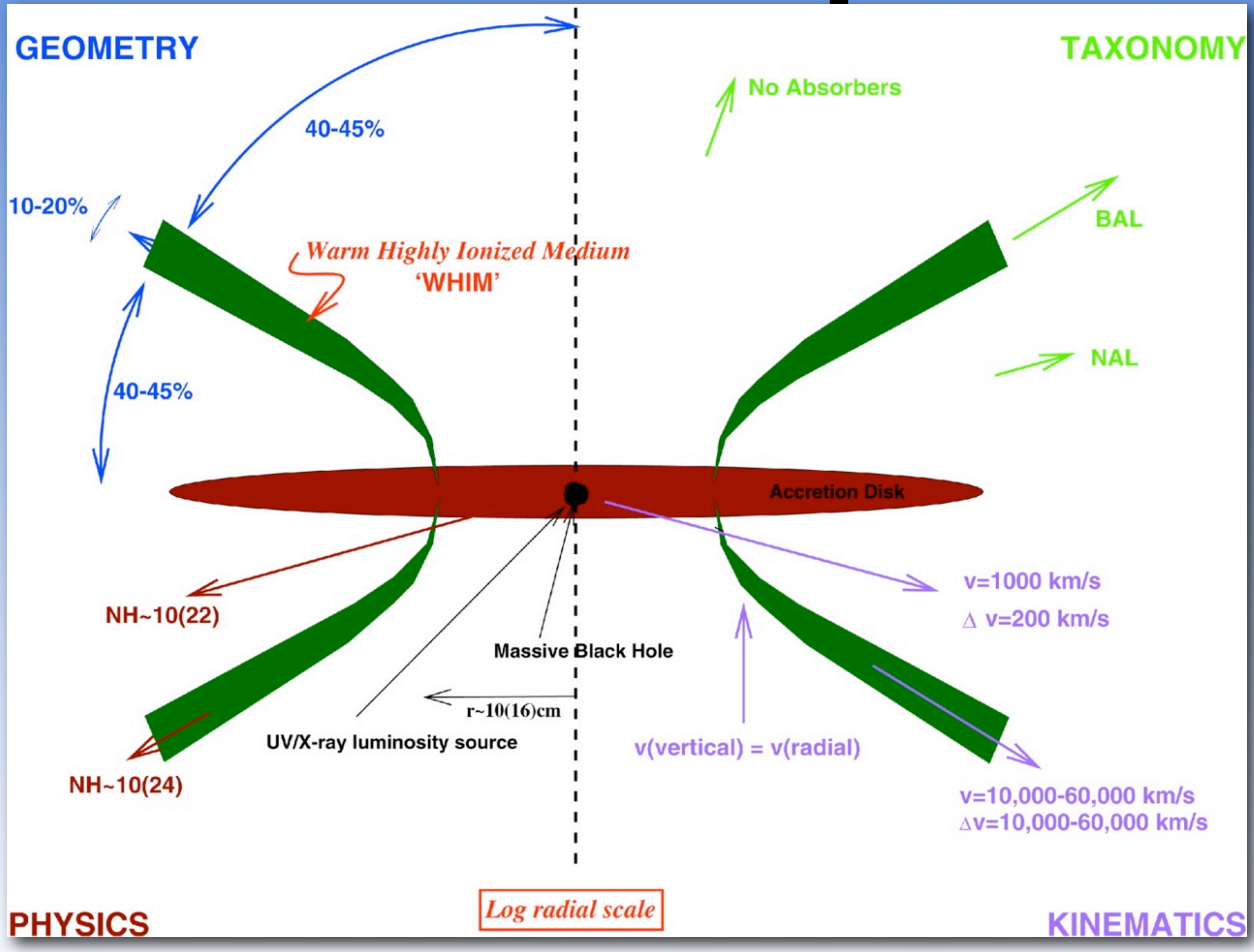
Time variation of BAL

- High ionization absorption line (C IV) change only by 30% in 3-6 yrs (Gibson et al. 2008).
- SDSS J1632+4204: Fe II absorption decreased by 80%.
- Fe II absorption lines in NGC 4151 also anti-correlated with luminosity (Crenshaw et al. 2002).

BAL quasar & non-BAL quasar

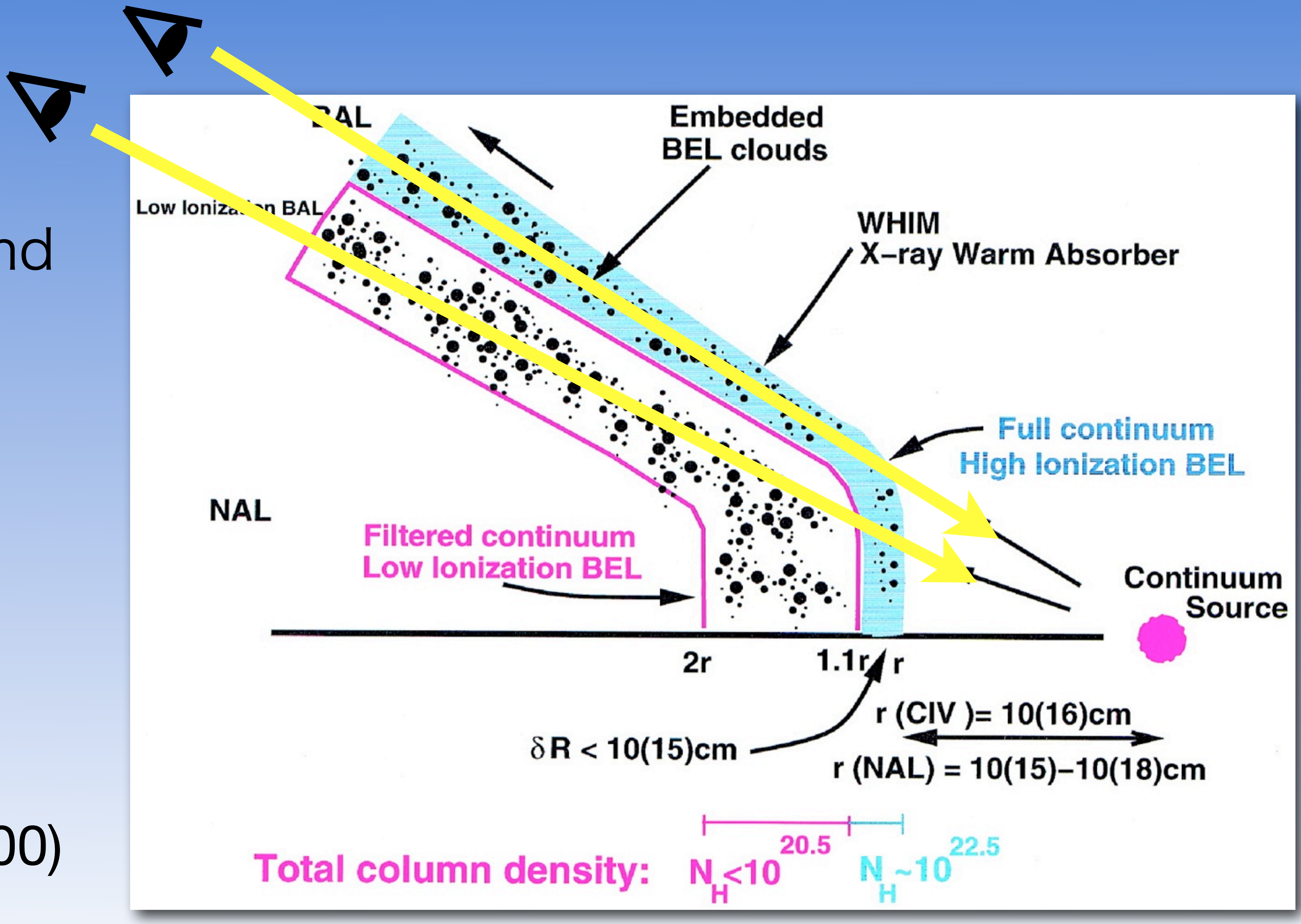
- disk wind model
- orientation-dependent "unified" scheme

fraction = covering factor



Elvis (2000)

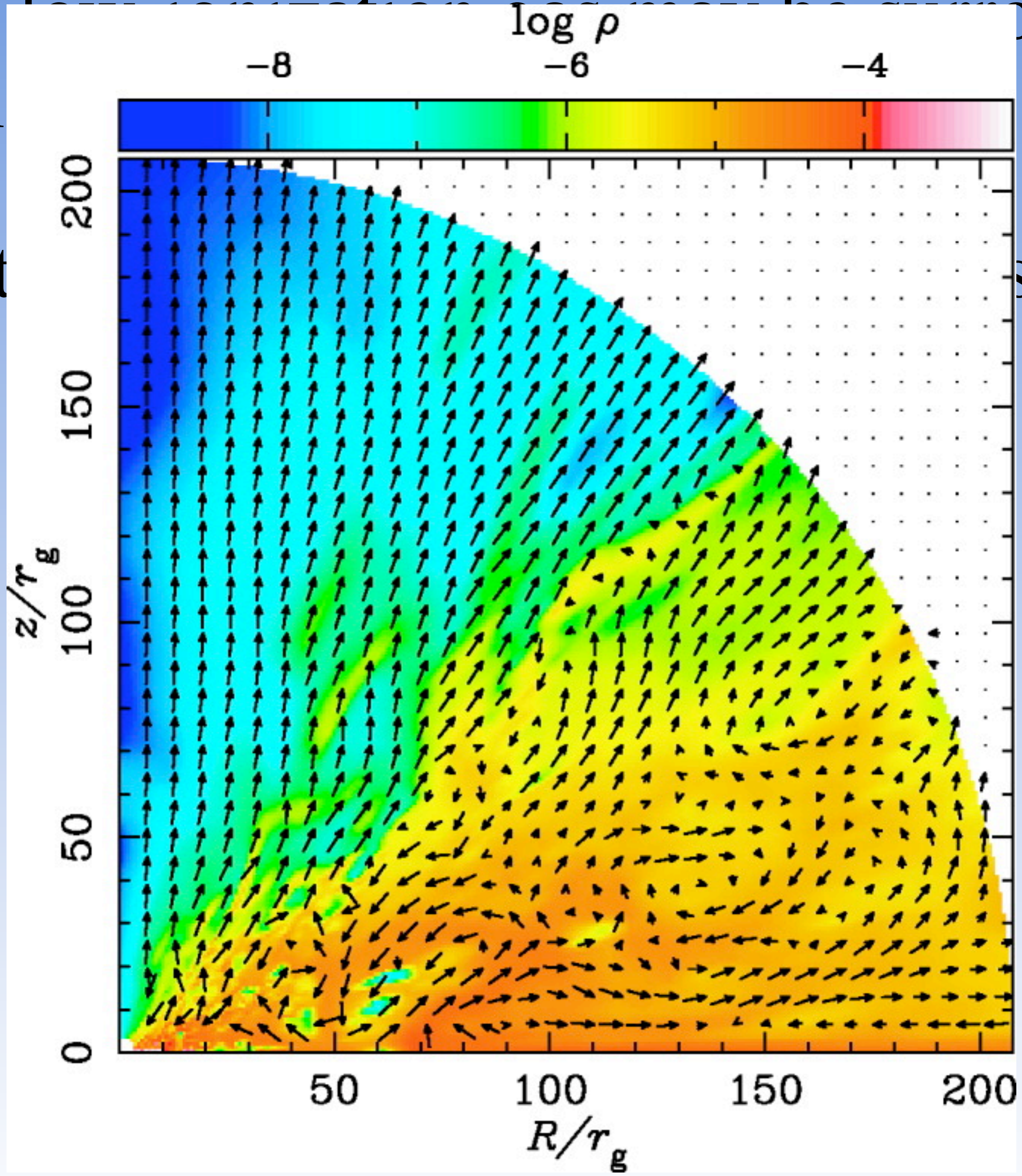
Stratified wind



Elvis (2000)

Outflow structure

- high-density & … unded by low-density & high-ionization
- Recent simulat … stability (Ohsuga et al. 2005).



Conclusions

- SDSS J1632+4404 showed changes over 3.4 yrs in quasar's frame
  - ✓ 80% decrease of Fe II absorption line.
  - ✓ < 30% increase of Mg II absorption line.
  - ✓ 40% decrease of He I absorption line.
  - ✓ factor 3 increase of luminosity at 2600 Å.
- These changes are possible due to increase of ionization.

Conclusions (2)

- $n_e > 1.7 \times 10^4$ cm^{-3}, size < 3.4 pc. Related with BLR.
- FeLoBALs may be quiescent phase of quasar activity.
- Fe II absorption may occur by denser gas than gas produce C IV absorption.
- Monitoring observations are interesting and important.

"Deep" into time domain (span & frequency)

Do you have any questions ?