UNIVERSITÀ DEGLI STUDI FIRENZE

On the [OIII] Equivalent Width distribution and the structure of accretion disk and BLR

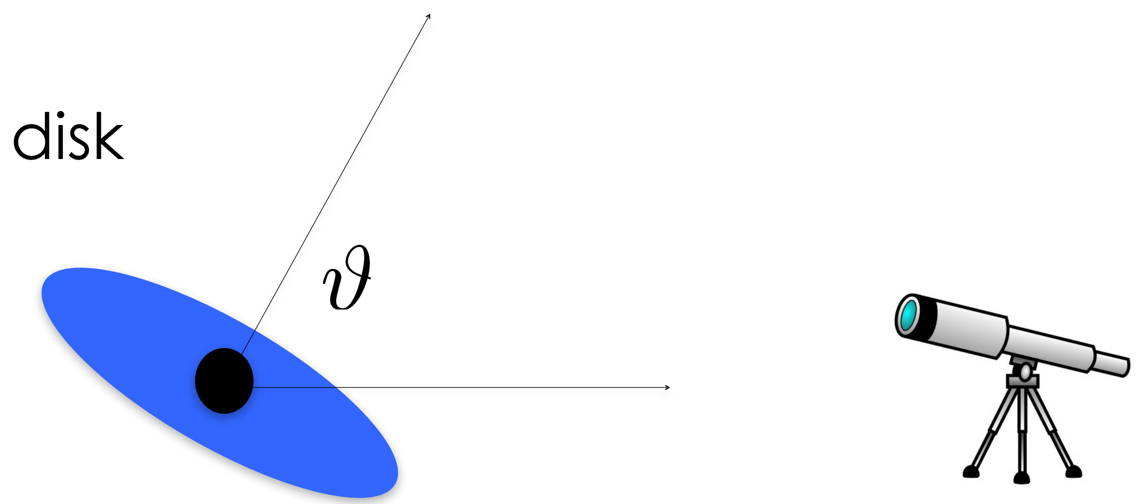
Alessandro Marconi

Department of Physics and Astronomy
University of Florence

INAF-Arcetri Astrophysical Observatory, Florence

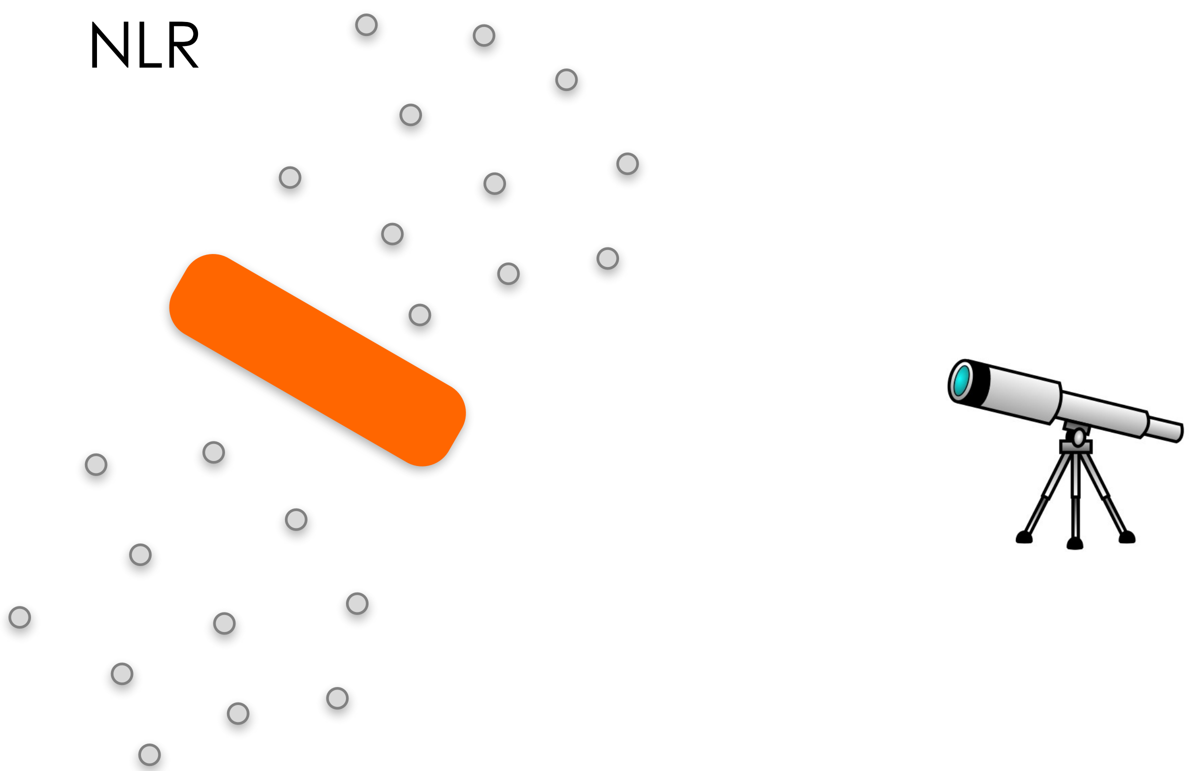
*In collaboration with: **S. Bisogni,** G. Risaliti, M. Salvati*

[OIII] EW as orientation indicator



Continuum emission from geometrically thin, optically thick accretion disk is expected to be ***anisotropic***

$$L_{obs} = L_0 \cos\theta$$



[OIII] Line emission excited from AGN is expected to be ***isotropic*** (Mulchaey+1994; Heckman+2005) or mildly anysotropic (di Serego+97)

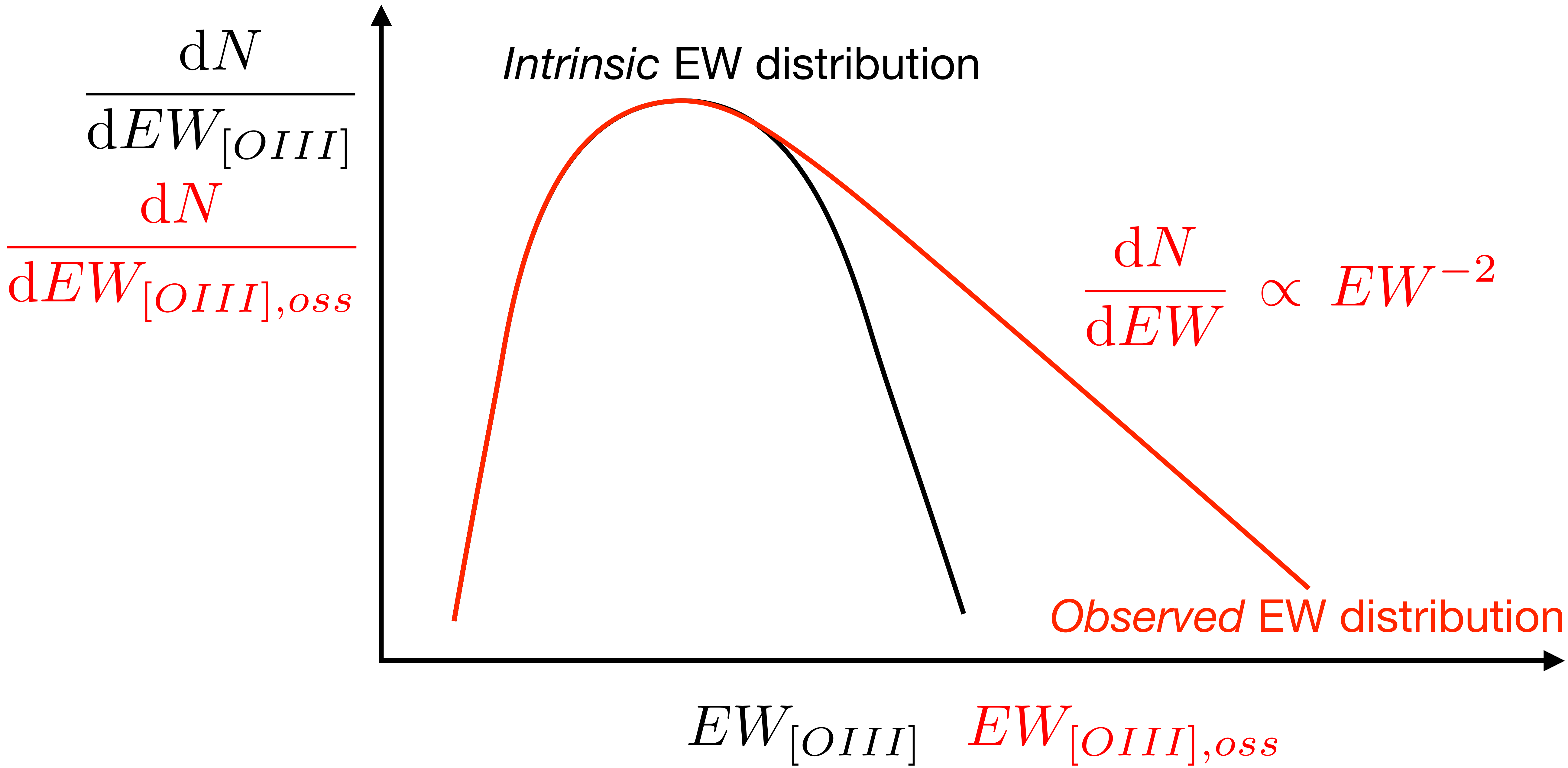
$$L_{[OIII],obs} = L_{[OIII]}$$

$$EW_{[OIII],obs} = EW_{[OIII]} \,/\, \cos\theta$$

Expected distribution of $EW_{[OIII]}$

$$EW_{[OIII],obs} = EW_{[OIII]} \,/\, \cos\theta$$ *with no preferred line of sight*

In the ideal world: can observe the entire population of AGN

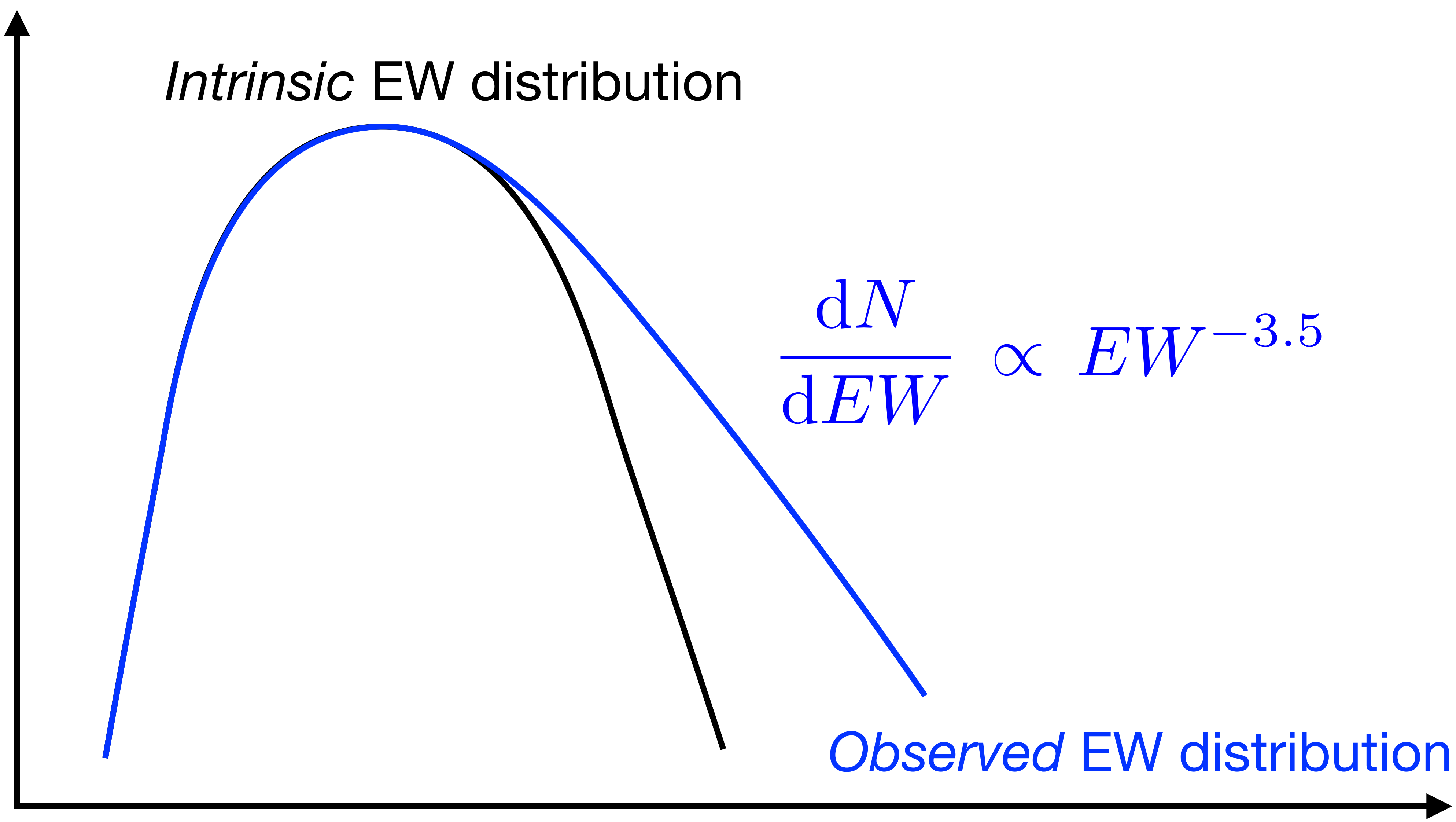


e.g., Netzer 1985, 1990

Expected distribution of $EW_{[OIII]}$

$$EW_{[OIII],obs} = EW_{[OIII]} \,/\, \cos\theta$$ *with no preferred line of sight*

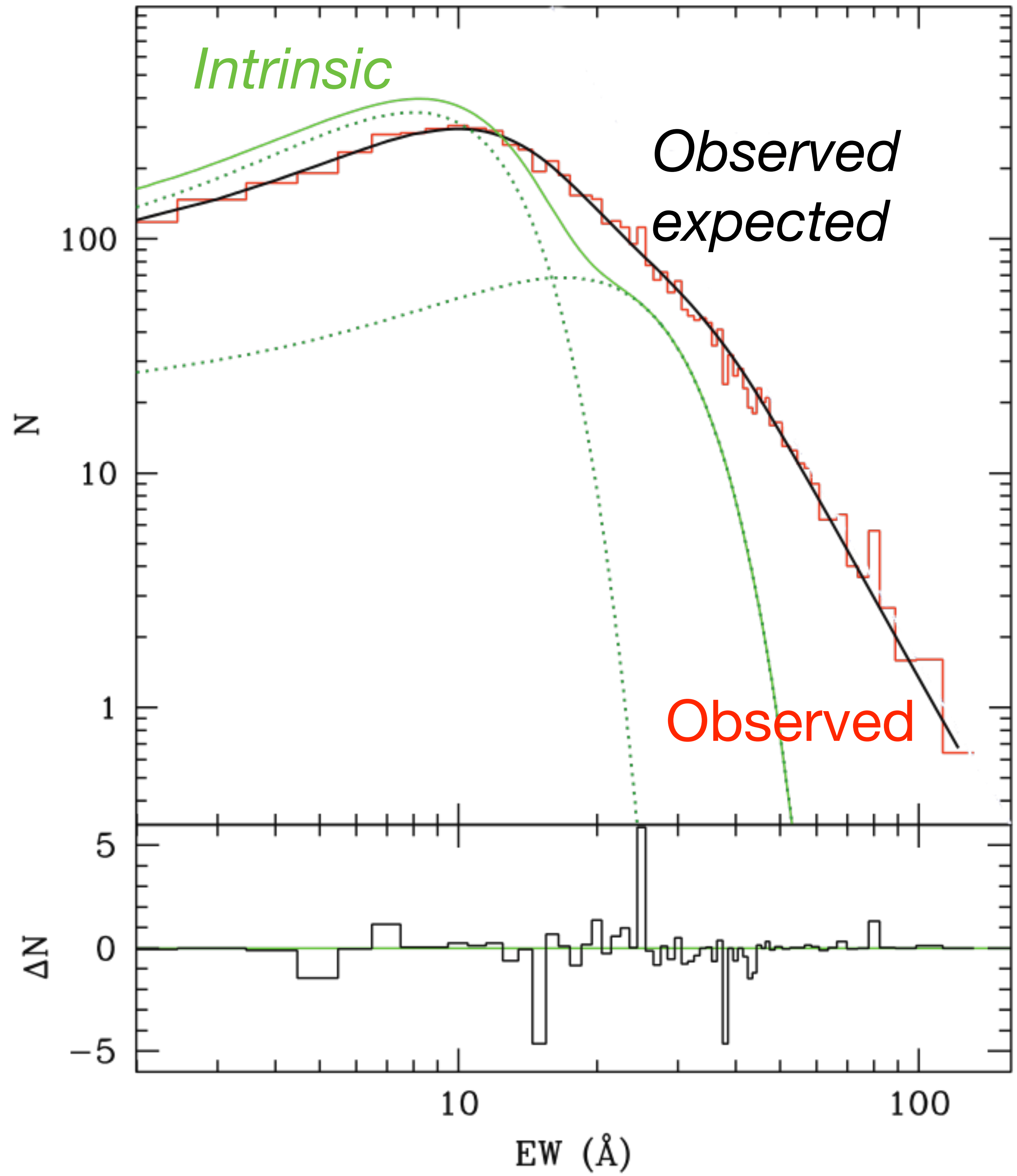
In the real world: can observe a **flux limited sample**



Risaliti, Salvati & Marconi 2011

Quasar sample

- Quasar sample from SDSS DR7, $EW_{[OIII]}$ measurements from Shen+2011
- Selection criteria:
  - "uniform" sample (flux limited sample)
  - $z < 0.8$ (include [OIII] 5007 line profile)
  - average $(S/N)_{pix} > 5$
- Compare observed W[OIII] distribution with expected from $L \cos\theta$ continuum anisotropy



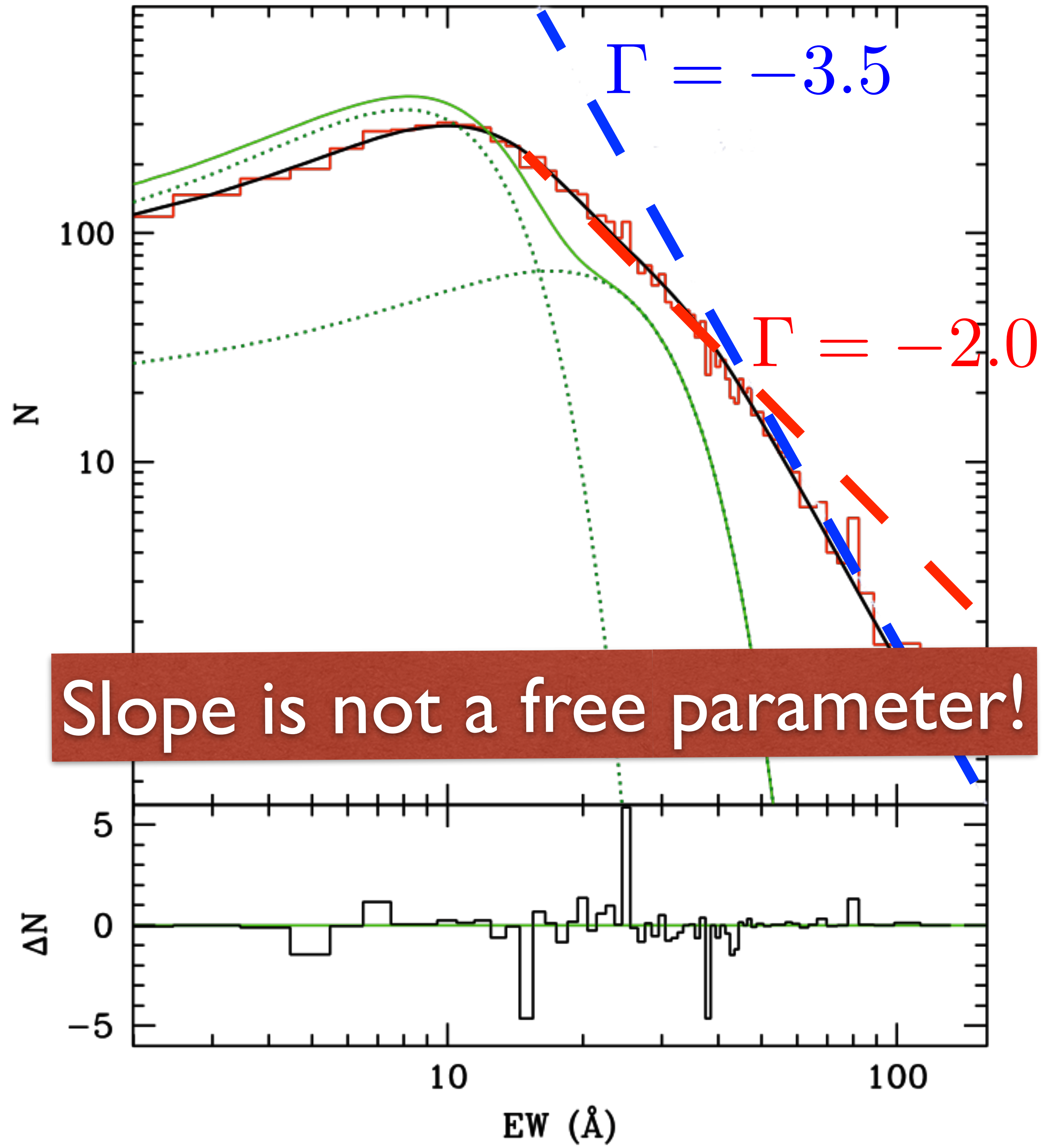
Observed distribution of $EW_{[OIII]}$

Ideal case

$$\frac{\mathrm{d}N}{\mathrm{d}EW} \propto EW^{-2}$$

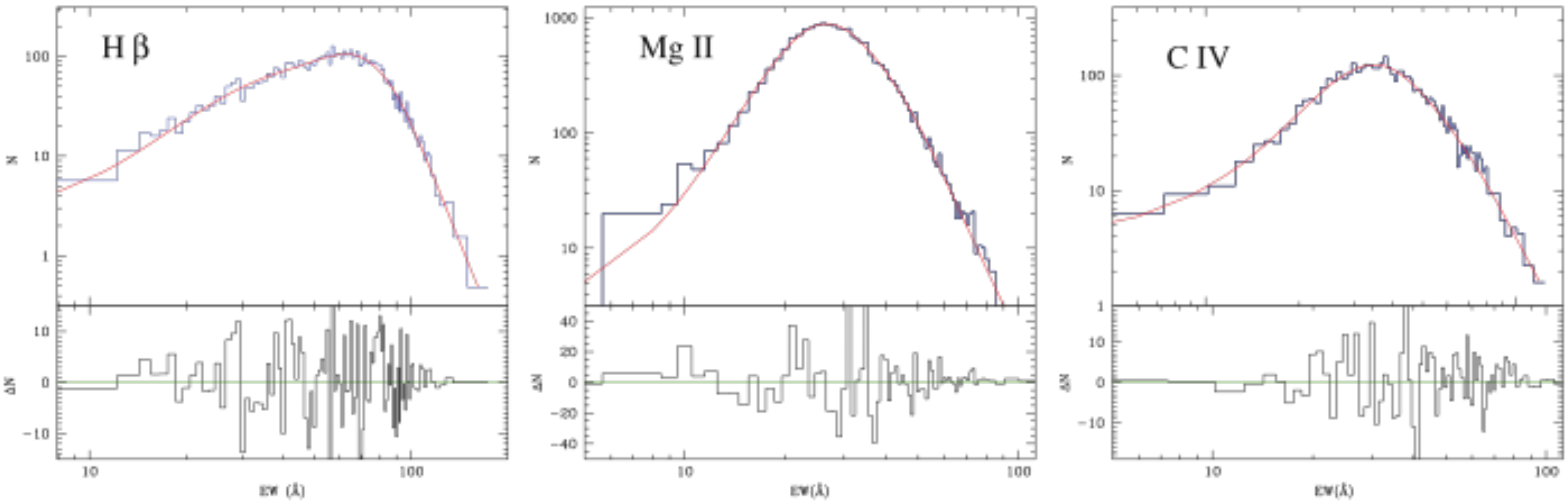
Real case

$$\frac{\mathrm{d}N}{\mathrm{d}EW} \propto EW^{-3.5}$$

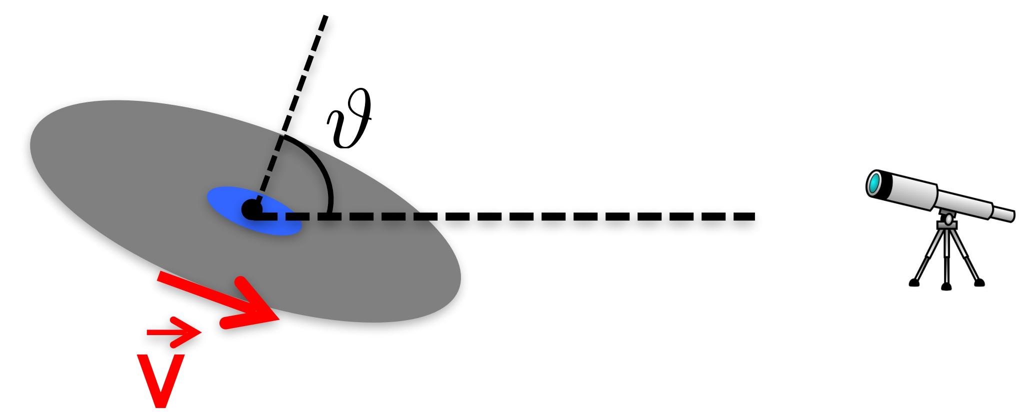


Slope is not a free parameter!

$EW_{[OIII]}$ vs EW of Broad Lines



- EW distributions of Broad Lines do not show -3.5 power law tail
- $L_{[OIII]}/L_{BLR}$ distribution has the same -3.5 power law tail as $EW_{[OIII]}$ distribution
- Broad lines Luminosities behave like continuum luminosities, i.e. $L_{BLR,obs} = L_{BLR} \cos\theta$

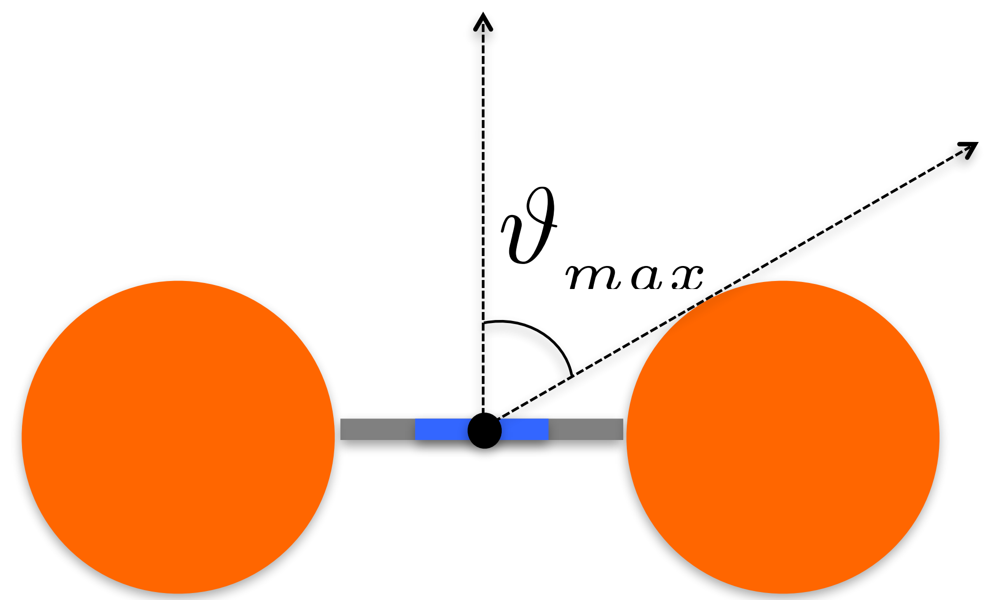


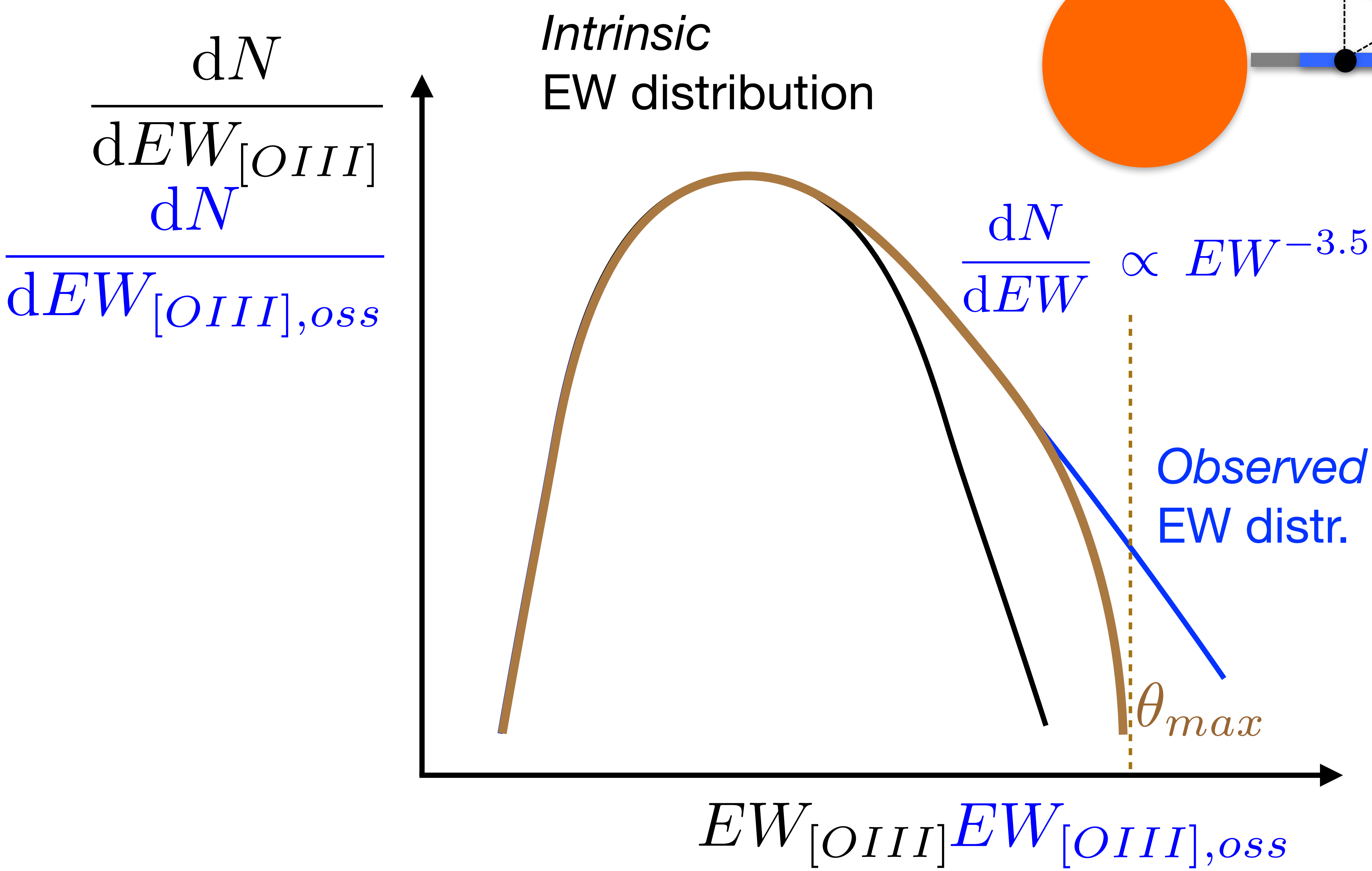
Broad Hβ, MgII, CIV are optically thick lines and BLR has a disk-like structure aligned with the accretion disk. (e.g. Wills & Brown 1986, Netzer 1987, Wills & Brotherton 1995, Goad & Wanders 1996, Smith+2005, Maiolino+2001, Jarvis & McLure 2006, Down+2010)

The presence of the Torus

The torus (or T.O.R.U.S.) prevents observing objects with

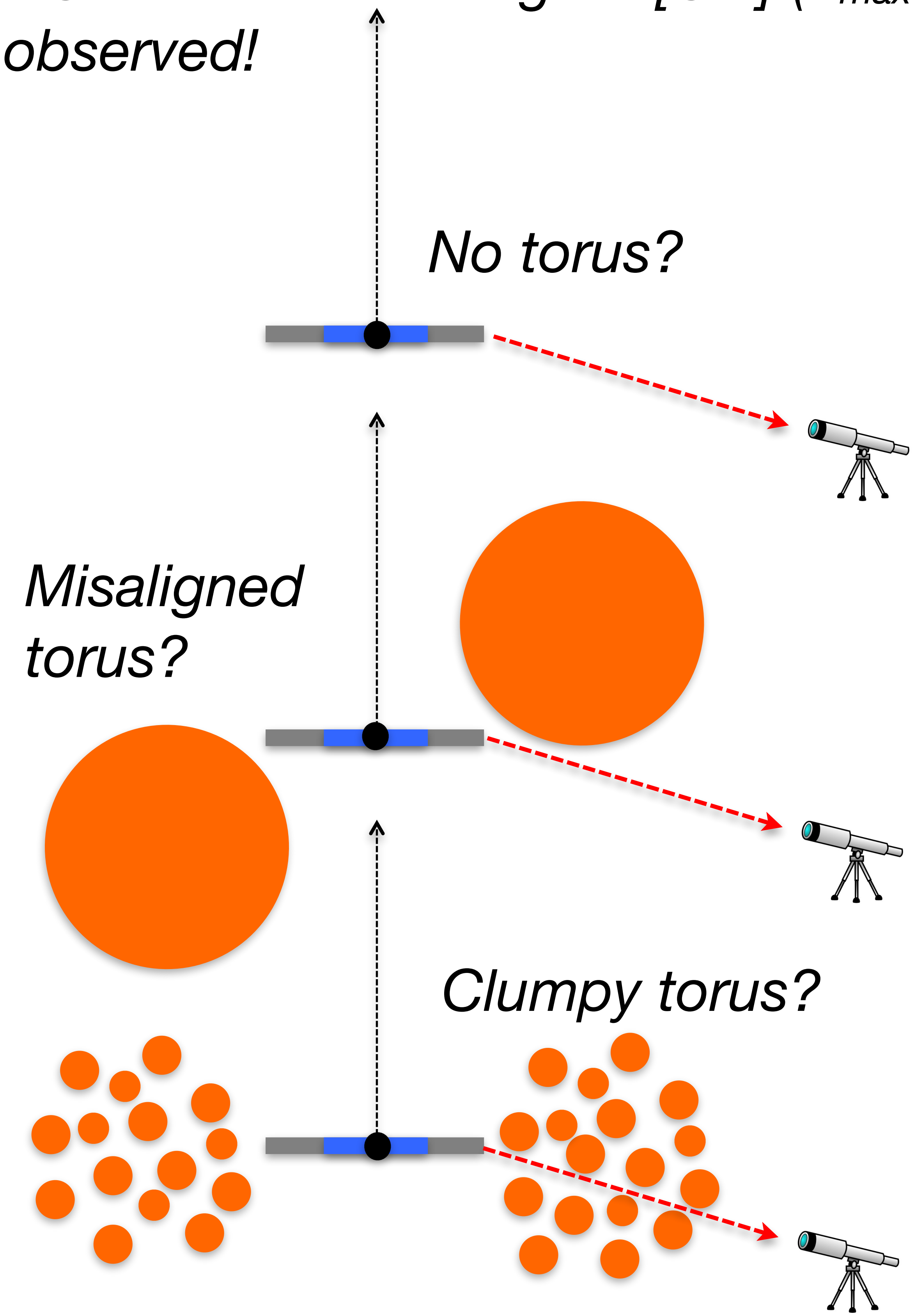
$$\theta > \theta_{max} \quad \text{i.e.} \quad EW \lesssim EW_{max}$$

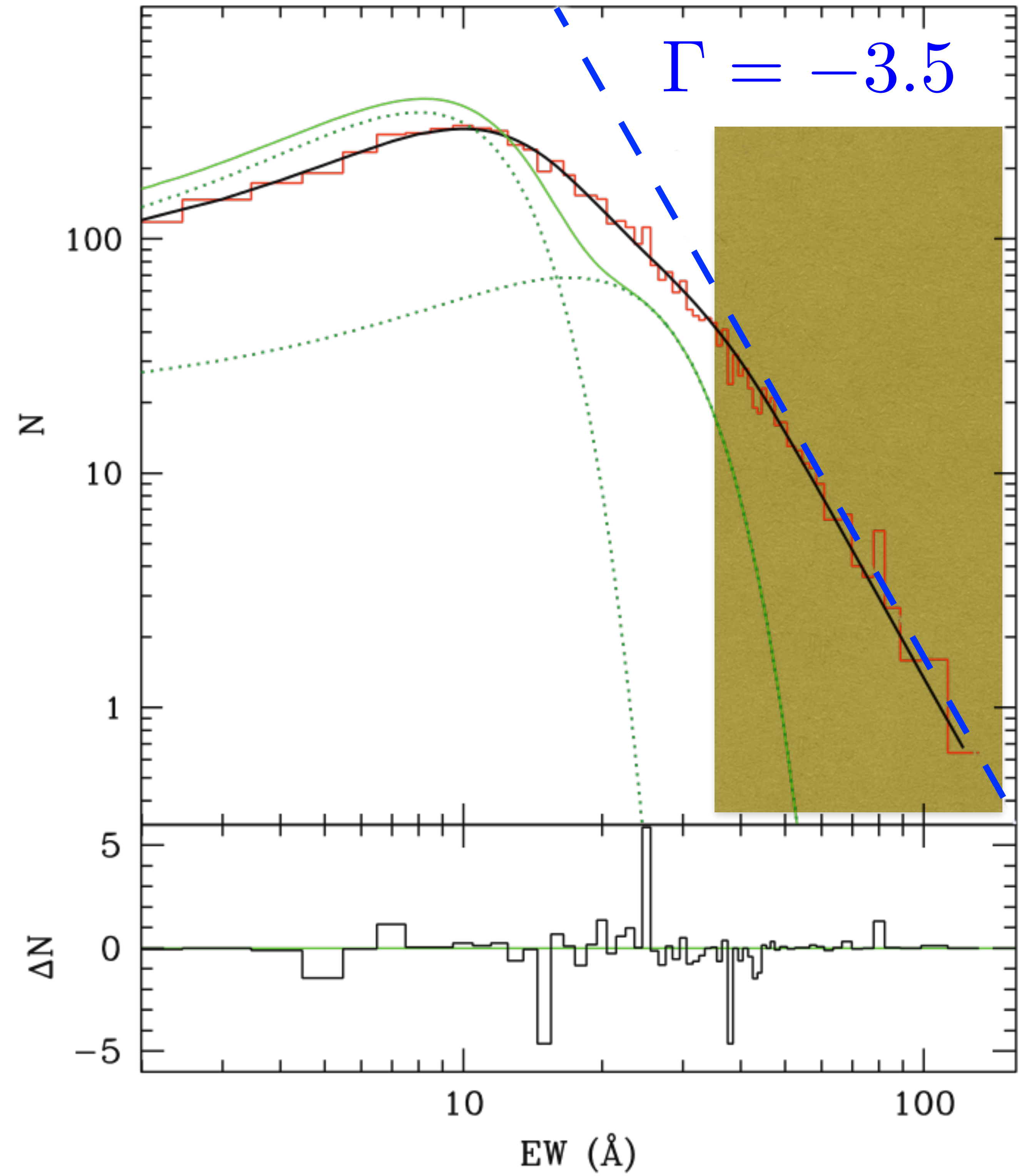




Observed distribution of $EW_{[OIII]}$

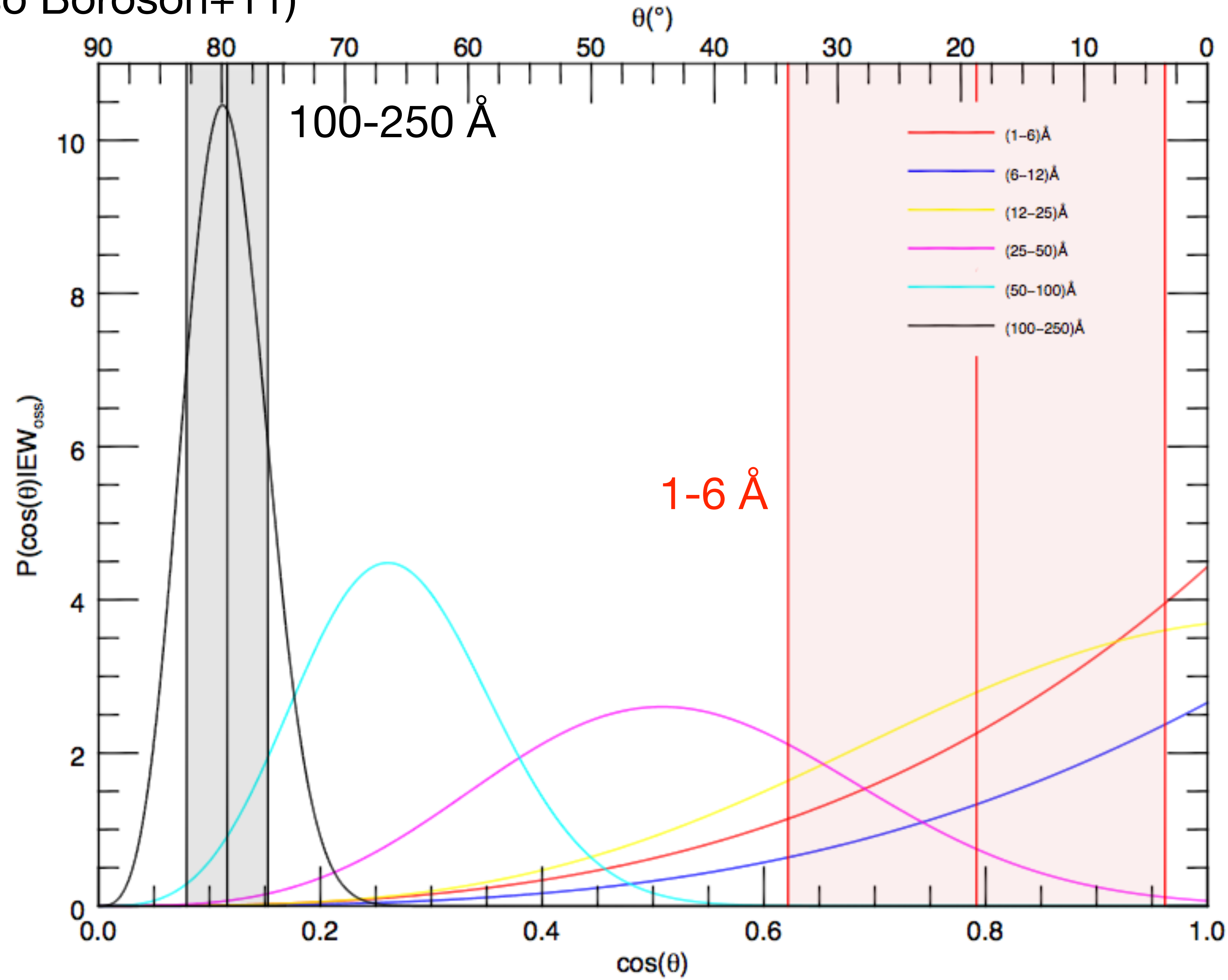
NO "Torus cut" at high W[OIII] (θ_{max} > 85deg). Also sources close to edge on observed!





Inclination from [OIII] EW

- It is possible to invert the distribution and use $EW_{[OIII]}$ as inclination indicator (also Boroson+11)



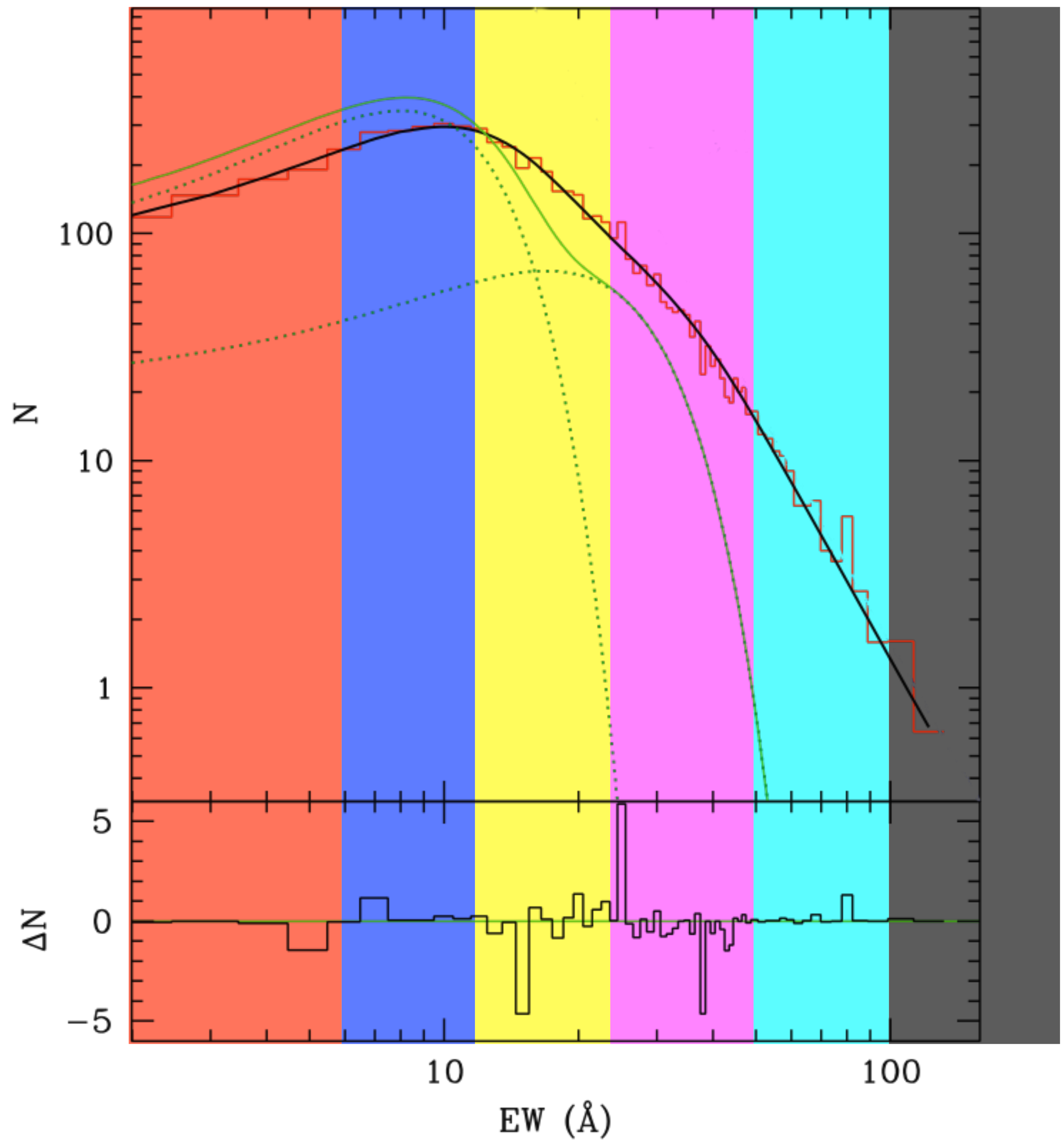
Tests and consequences

- Is the $EW_{[OIII]}$ distribution driven by continuum obscuration (i.e. obscuration toward the AD/BLR)?
- Are there evidences for geometrical projection effects in BLR lines?
- Are there evidences for geometrical projection effects in NLR lines?
- What about the obscuring torus and IR emission?
- Is there a physical interpretation for Eigenvector 1?

Average QSO spectra in EW bins

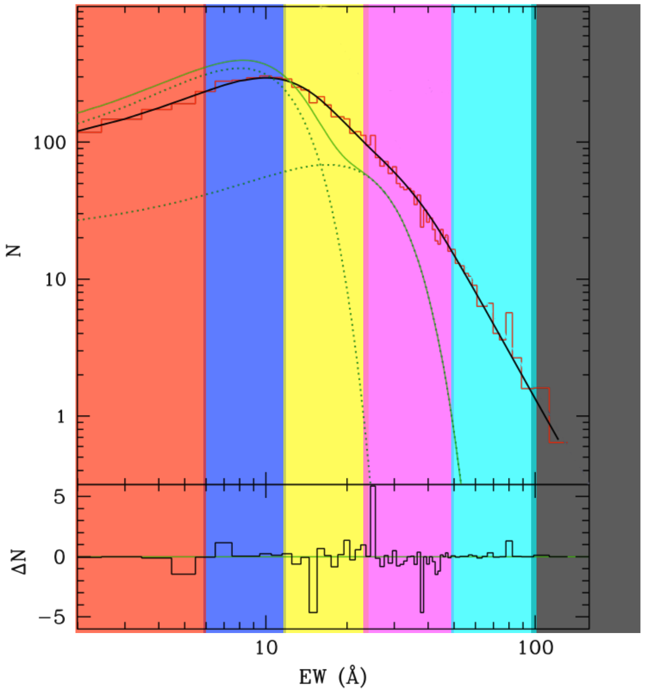
We are interested to average effects on the QSO population, not in intrinsic differences in a given $EW_{[OIII]}$ range …

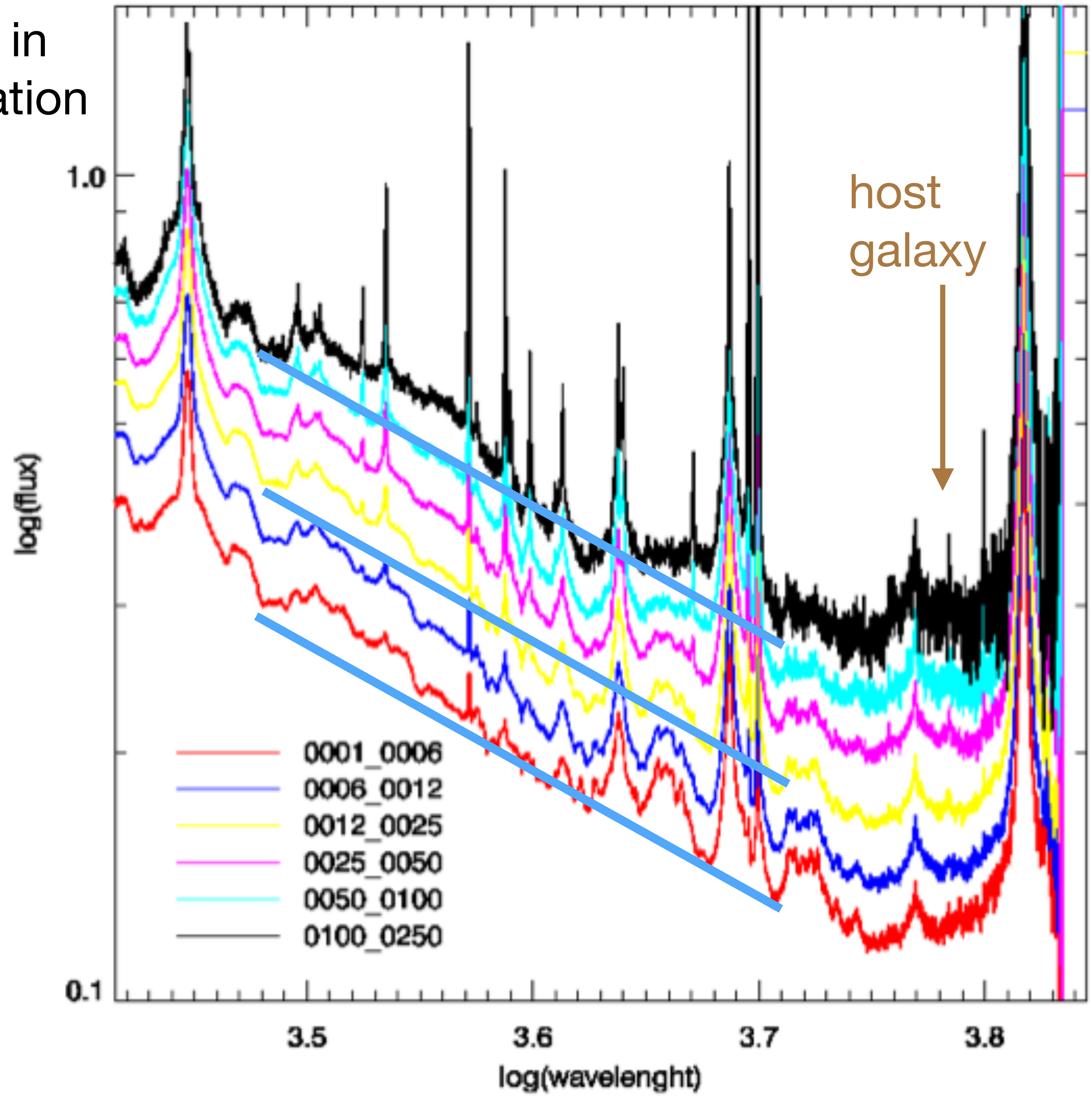
- spectral stacking in EW bins
- entire sample of DR7 quasars to increase statistics (~12000) with $EW_{[OIII]}$ by Shen+11
- no significant differences in stacks by using only targets from uniform sample



EW[OIII] driven by continuum obscuration?

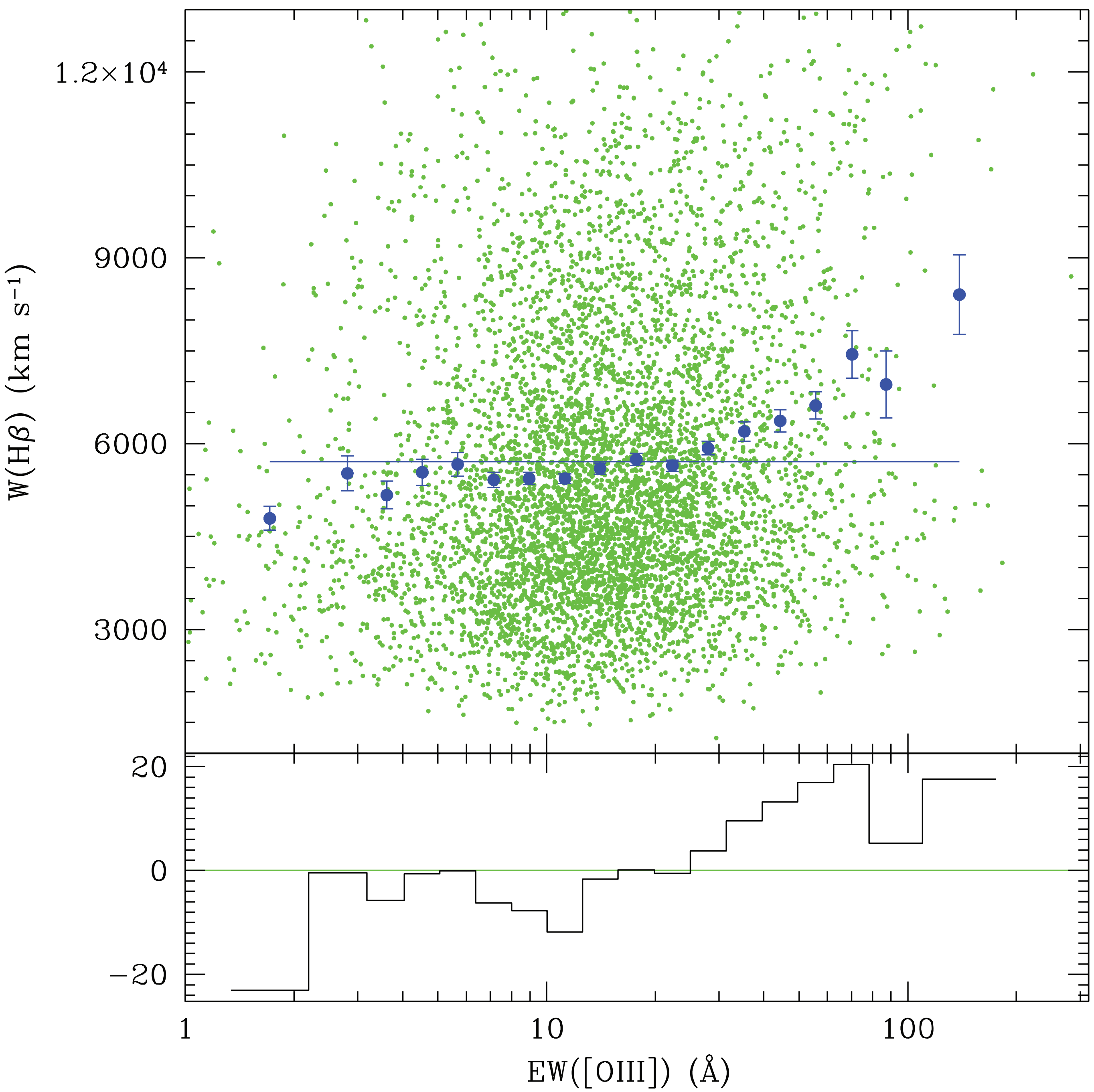
- no significant changes in slope, no dust obscuration
- also no change in AD spectrum …





Geometrical projection effects in BLR lines?

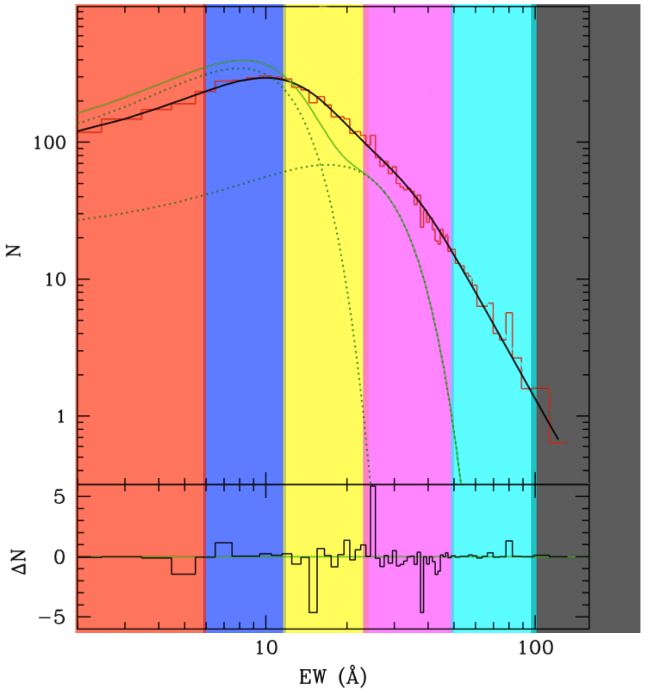
- In high EW sources AD is expected to be seen edge on
- BLR is “disky” like AD
- BLR Line widths are expected to increase on average with $EW_{[OIII]}$

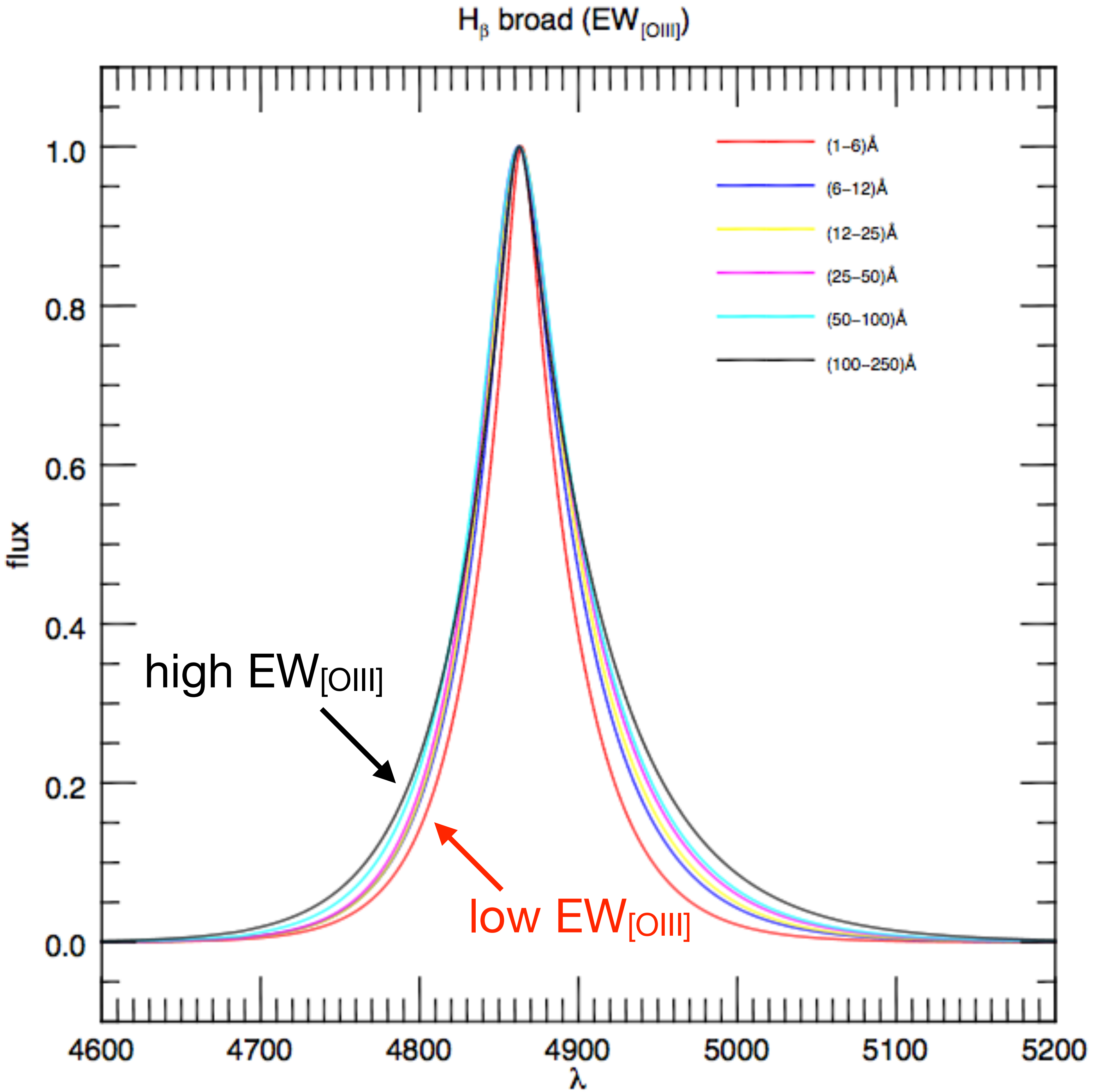


Risaliti+11

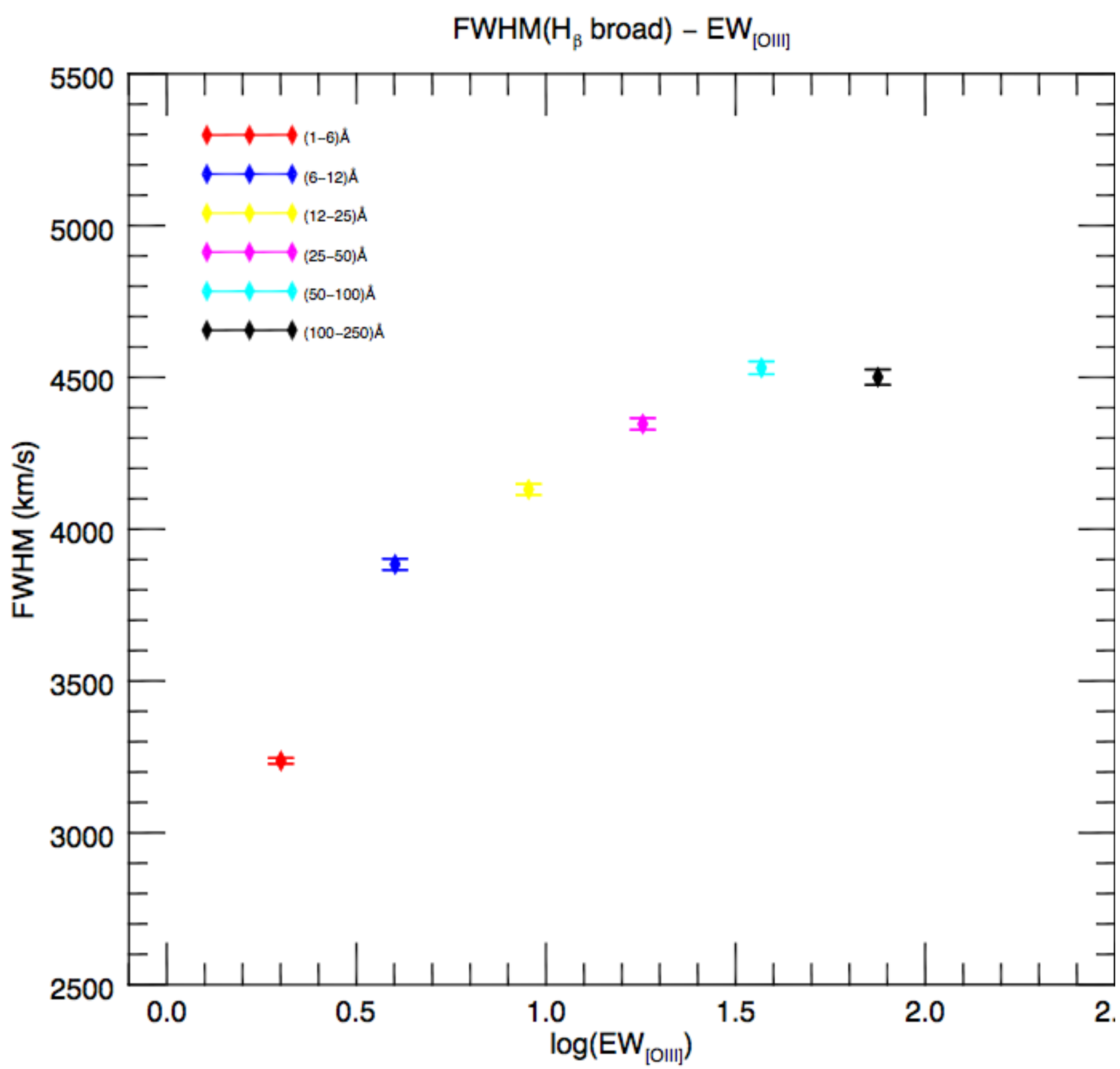
Geometrical projection effects in BLR lines?

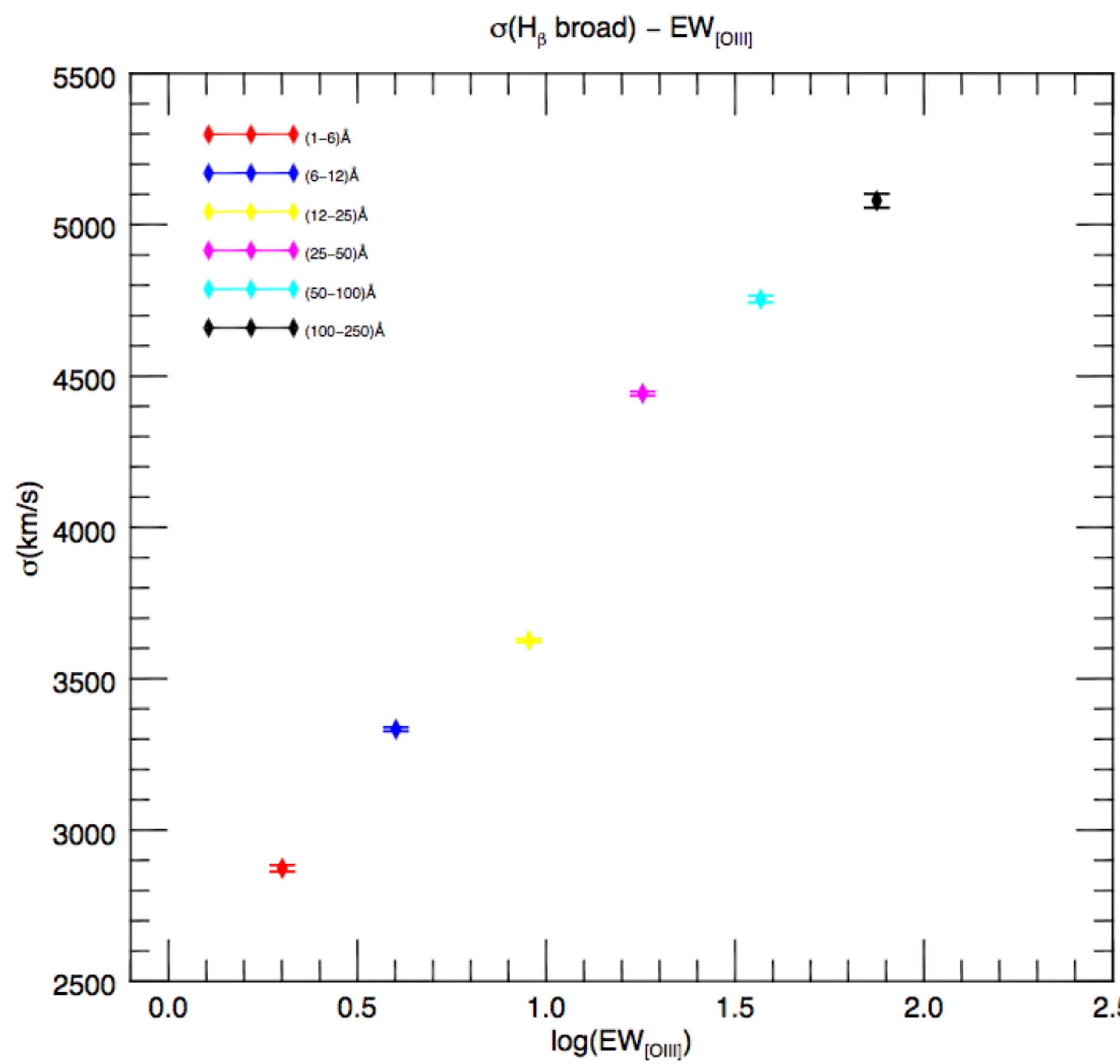
- Same results for Hβ and MgII !





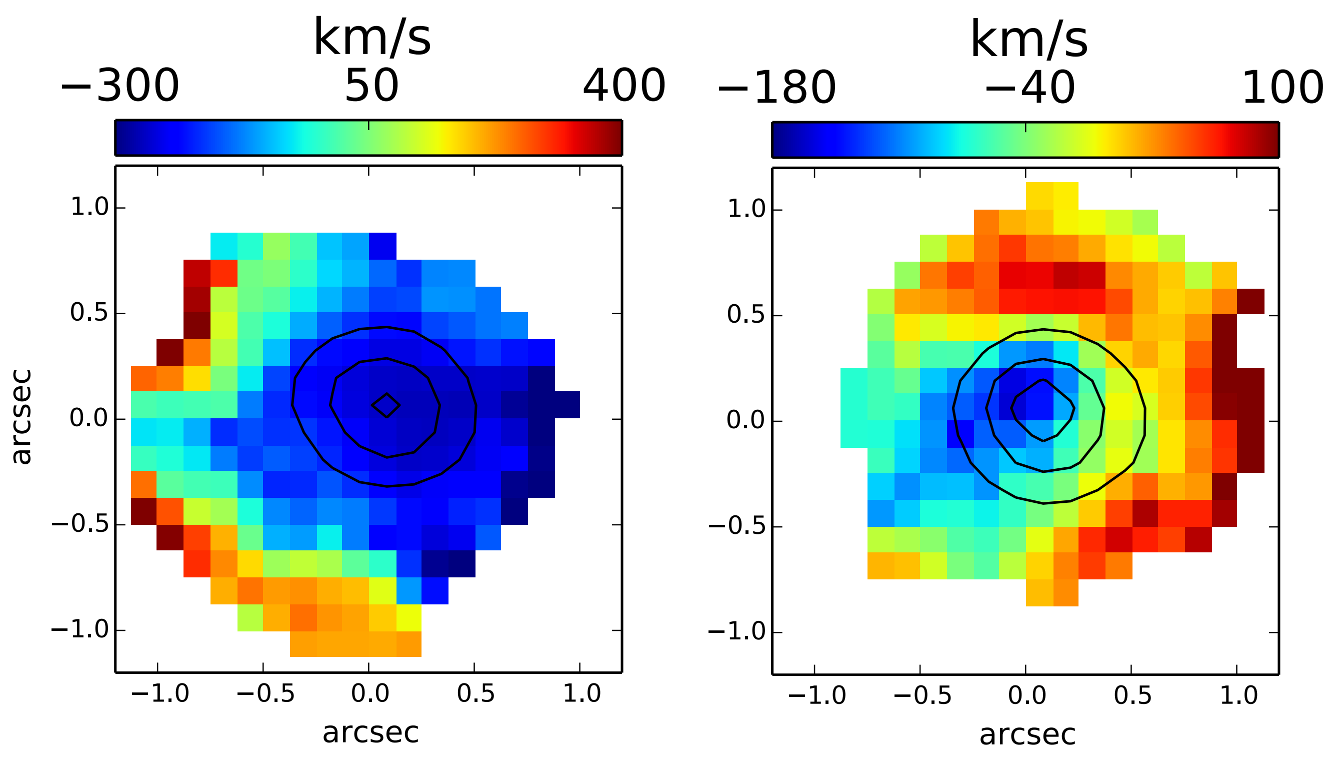
Geometrical projection effects in BLR lines?

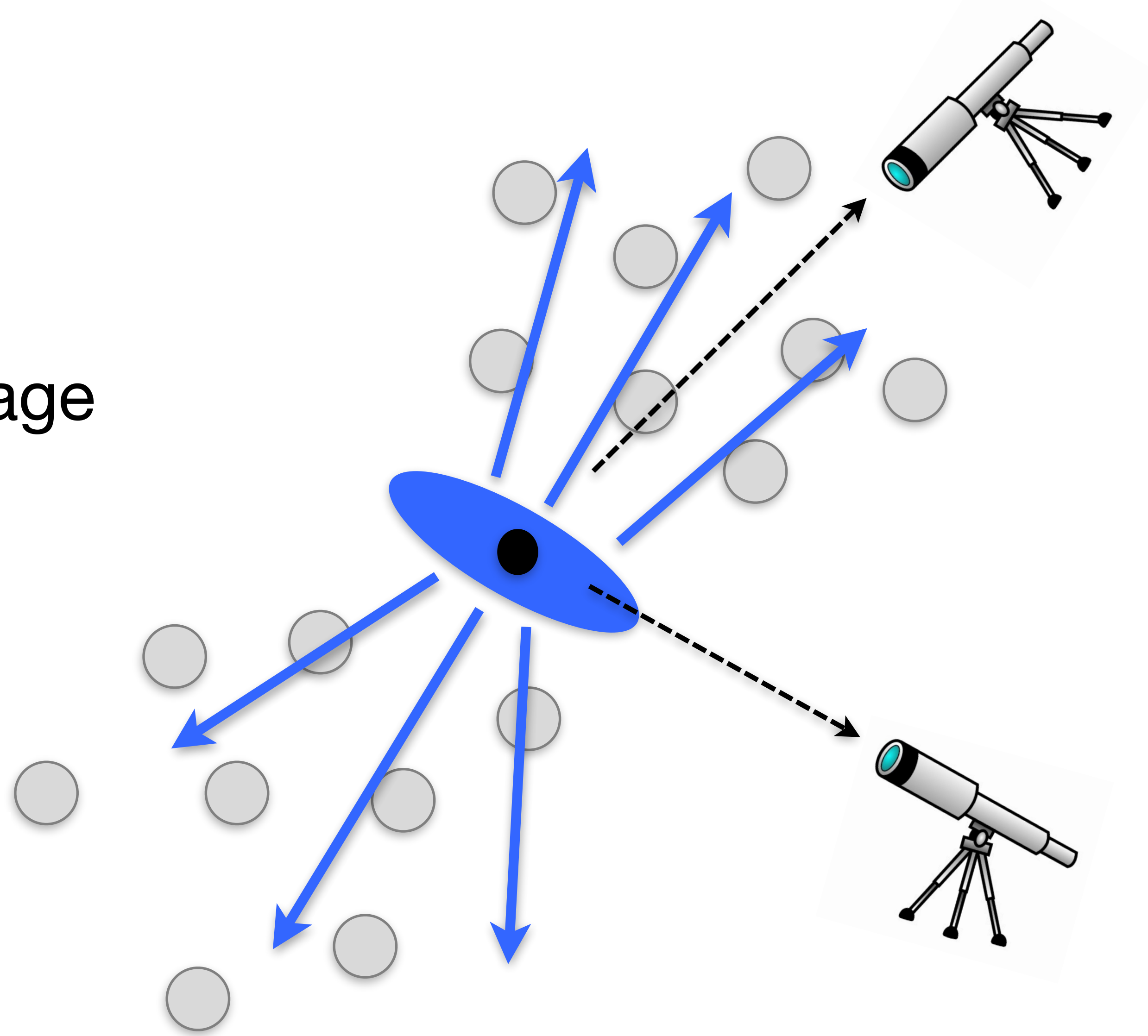




Geometrical projection effects in NLR lines?

- In high EW sources accretion disk is expected to be seen edge-on
- [OIII] is outflowing in ionisation cone (e.g. Fischer+13,14)
- [OIII] outflow velocity should on average decrease with EW (eg. Boroson 2011)

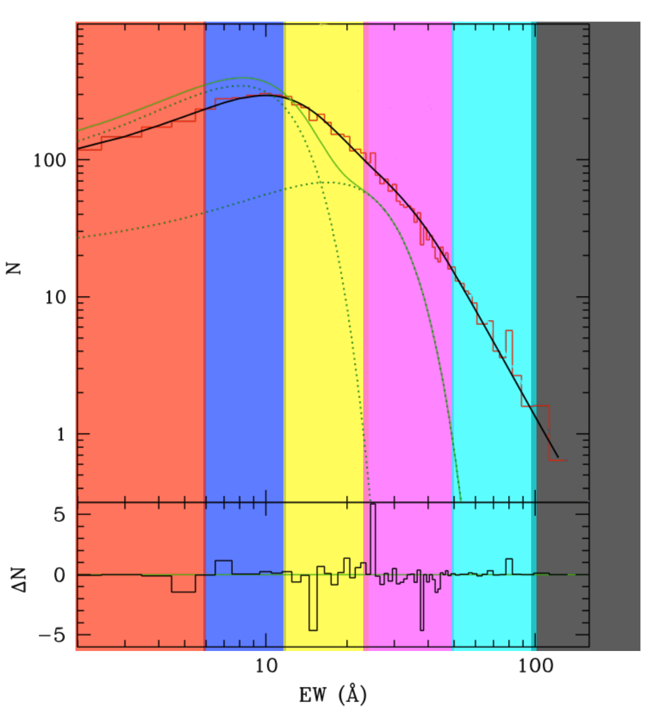


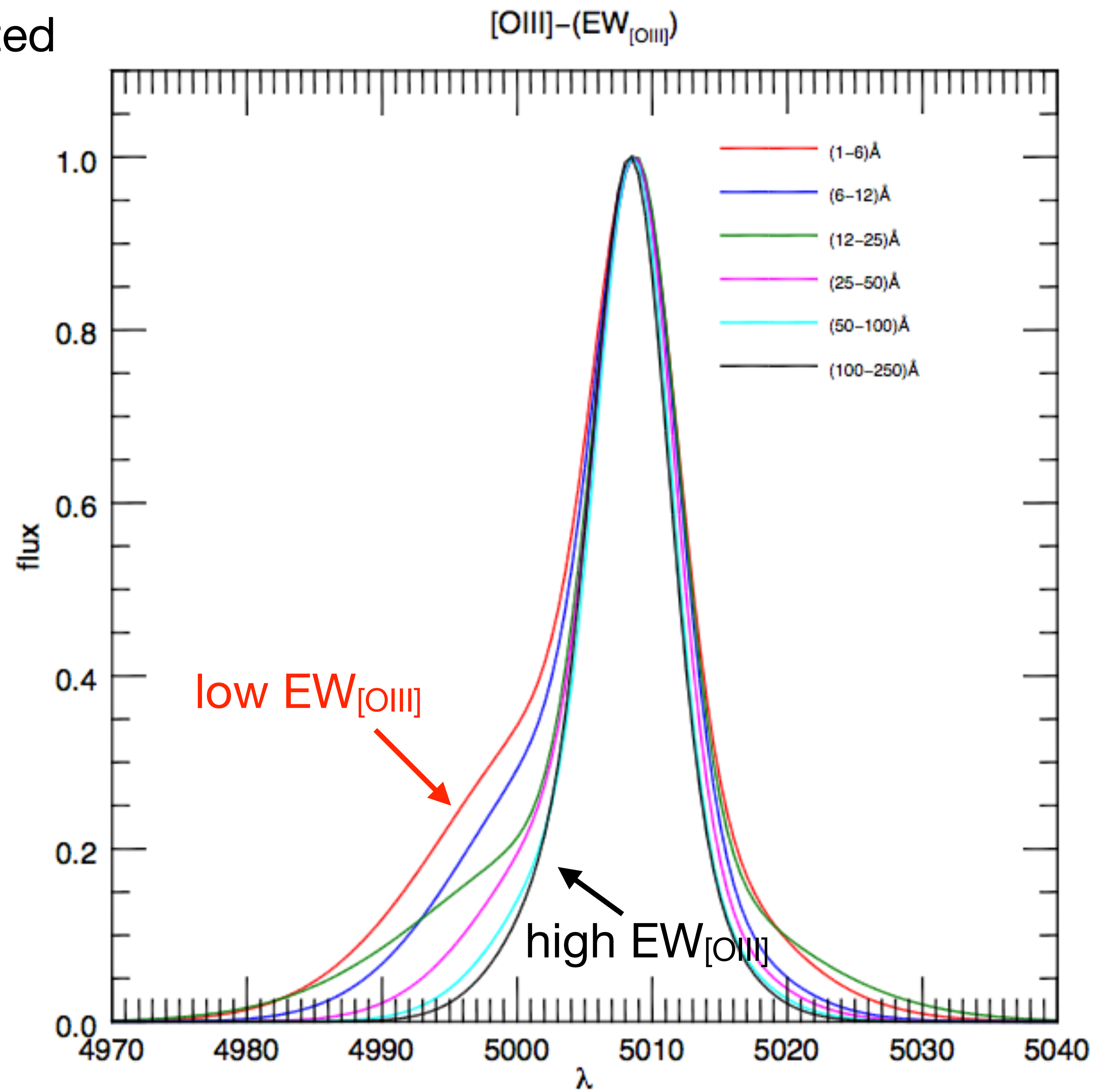


[OIII] velocity maps of z~2.5 QSOs showing conical outflows (Carniani+14)

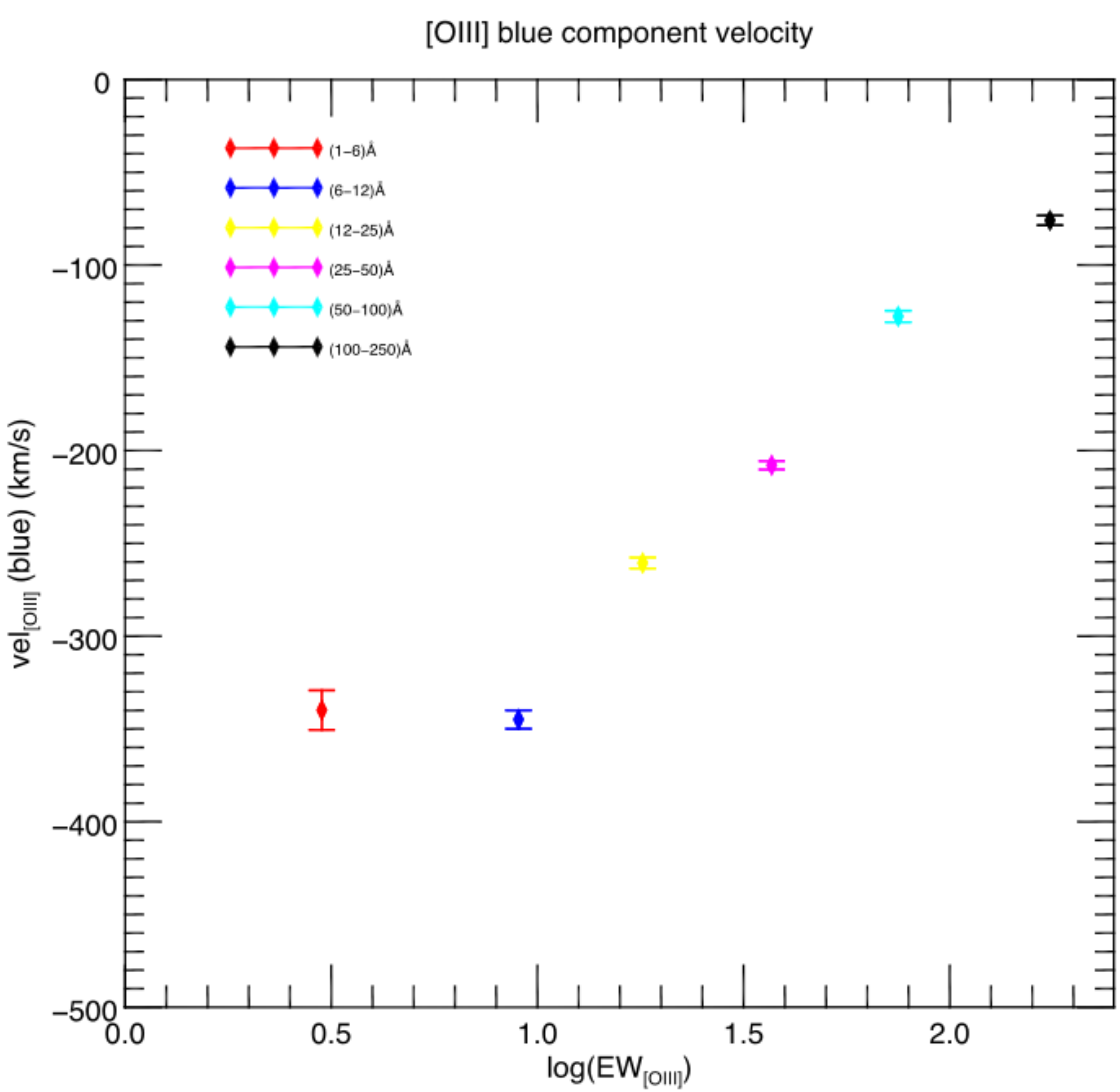
Geometrical projection effects in NLR lines?

- In high EW sources accretion disk is expected to be seen edge-on
- [OIII] is outflowing in ionisation cone (e.g. Fischer+13,14)
- [OIII] outflow velocity should on average decrease with EW (eg. Boroson 2011)



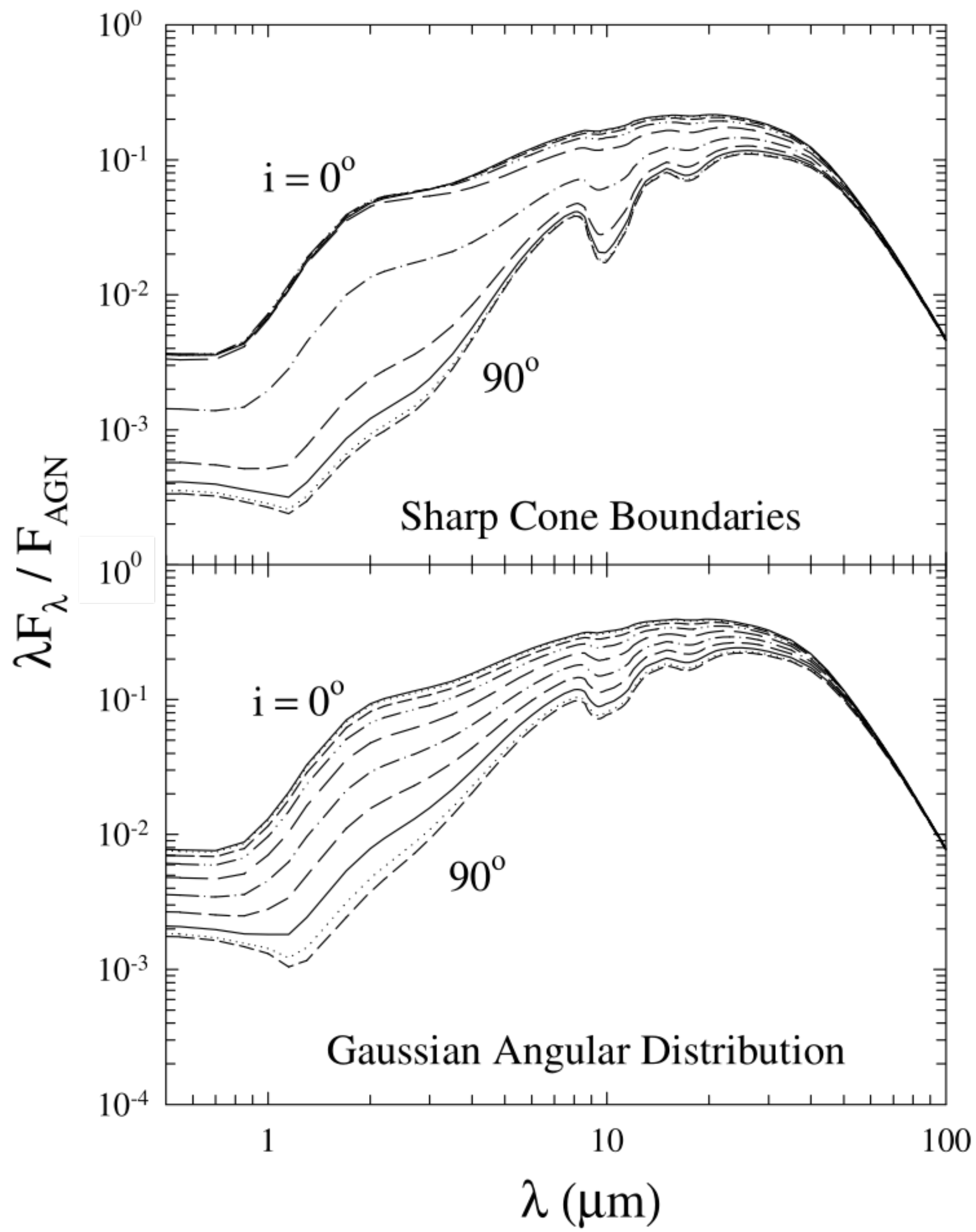


Geometrical projection effects in NLR lines?

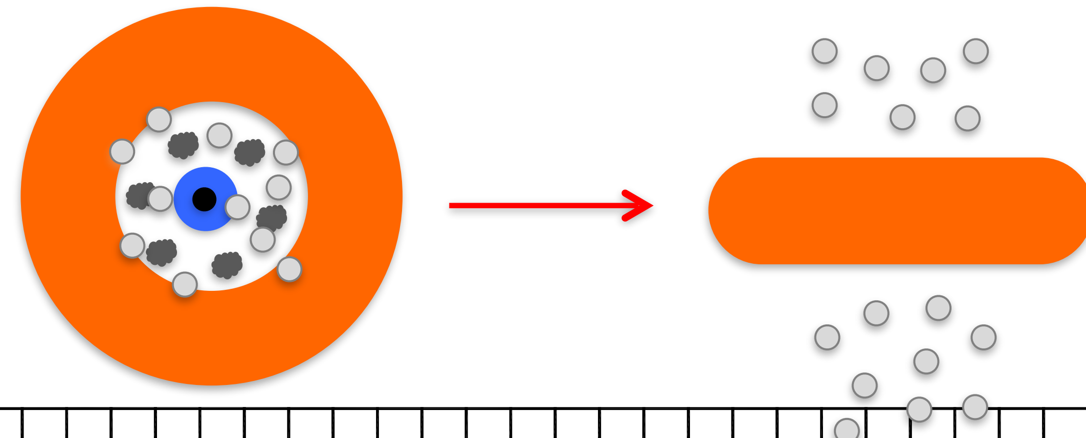


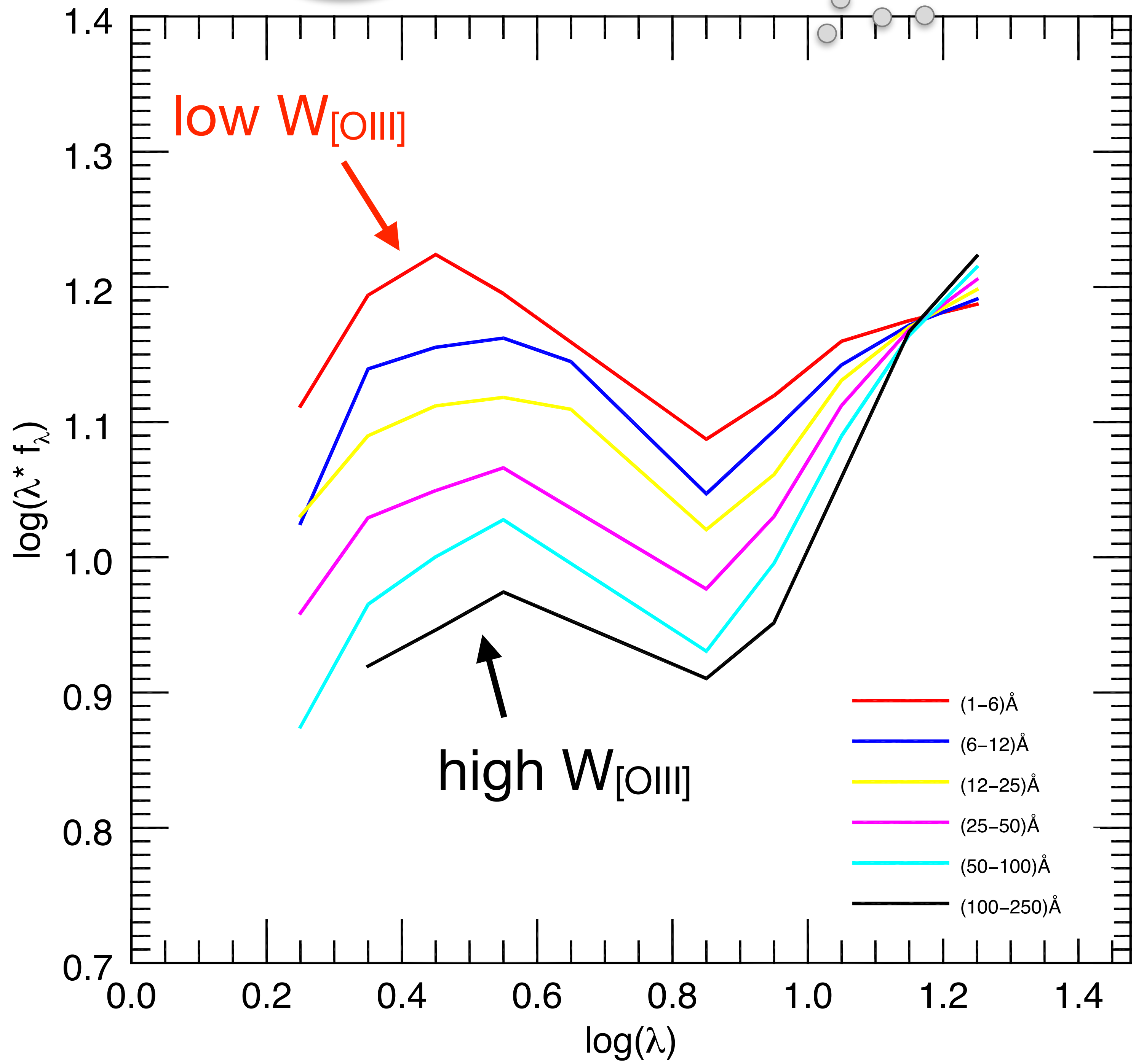
IR emission and the obscuring torus?

- ~All quasars detected by WISE
- Average MIR SED in bins of $EW_{[OIII]}$ (normalized at 20 μm)

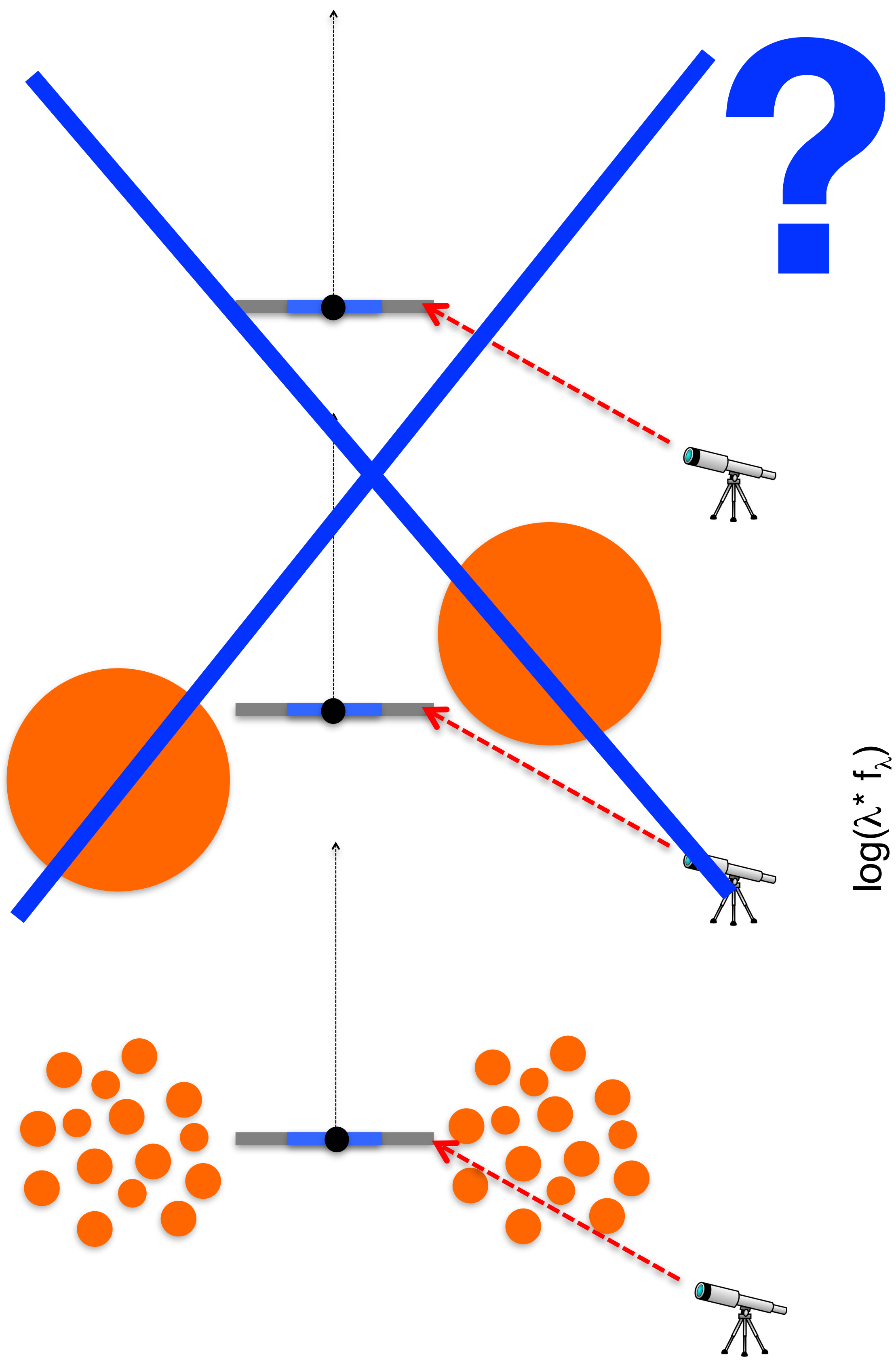


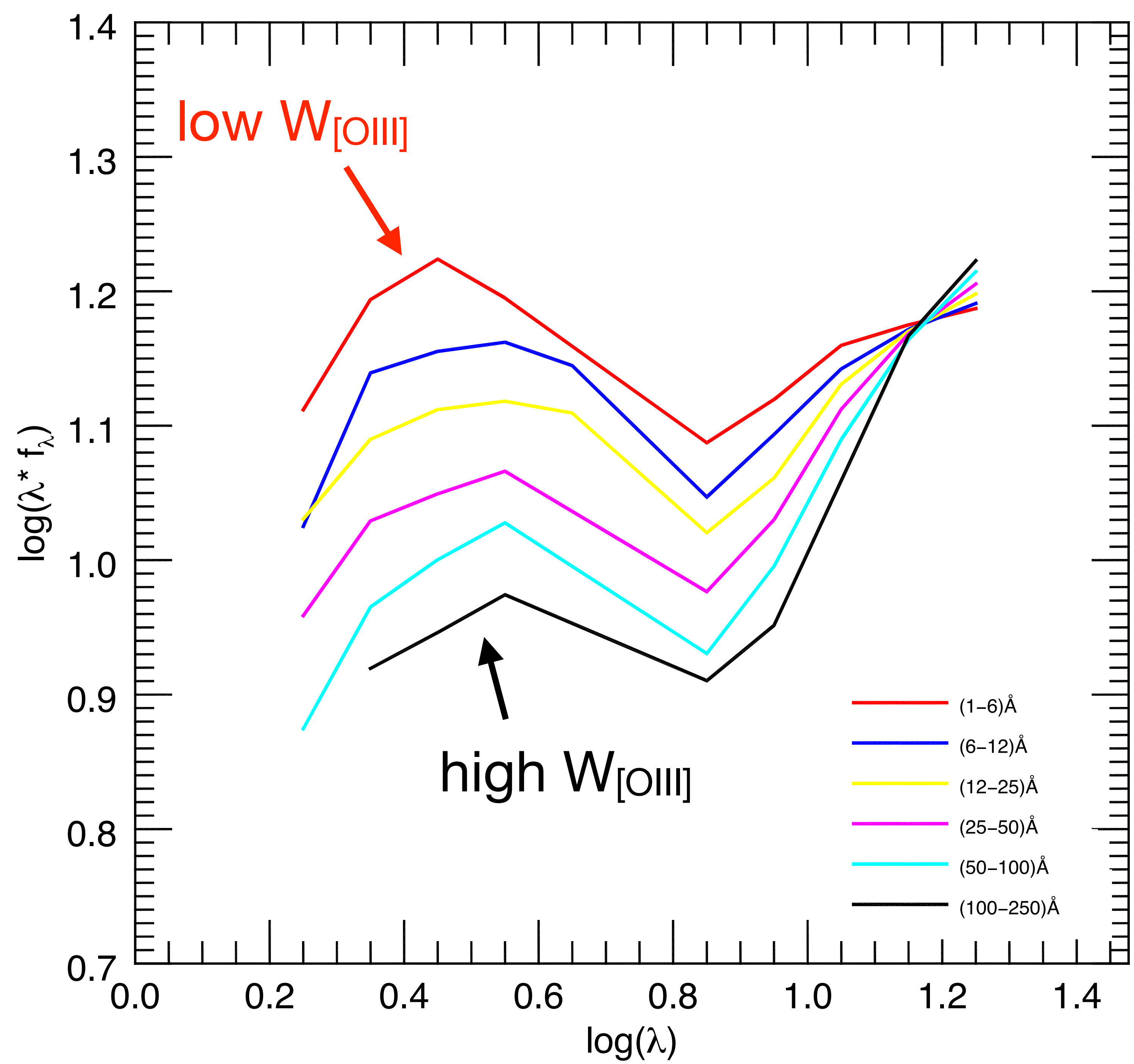
Nenkova+2008, Elitzur 2008





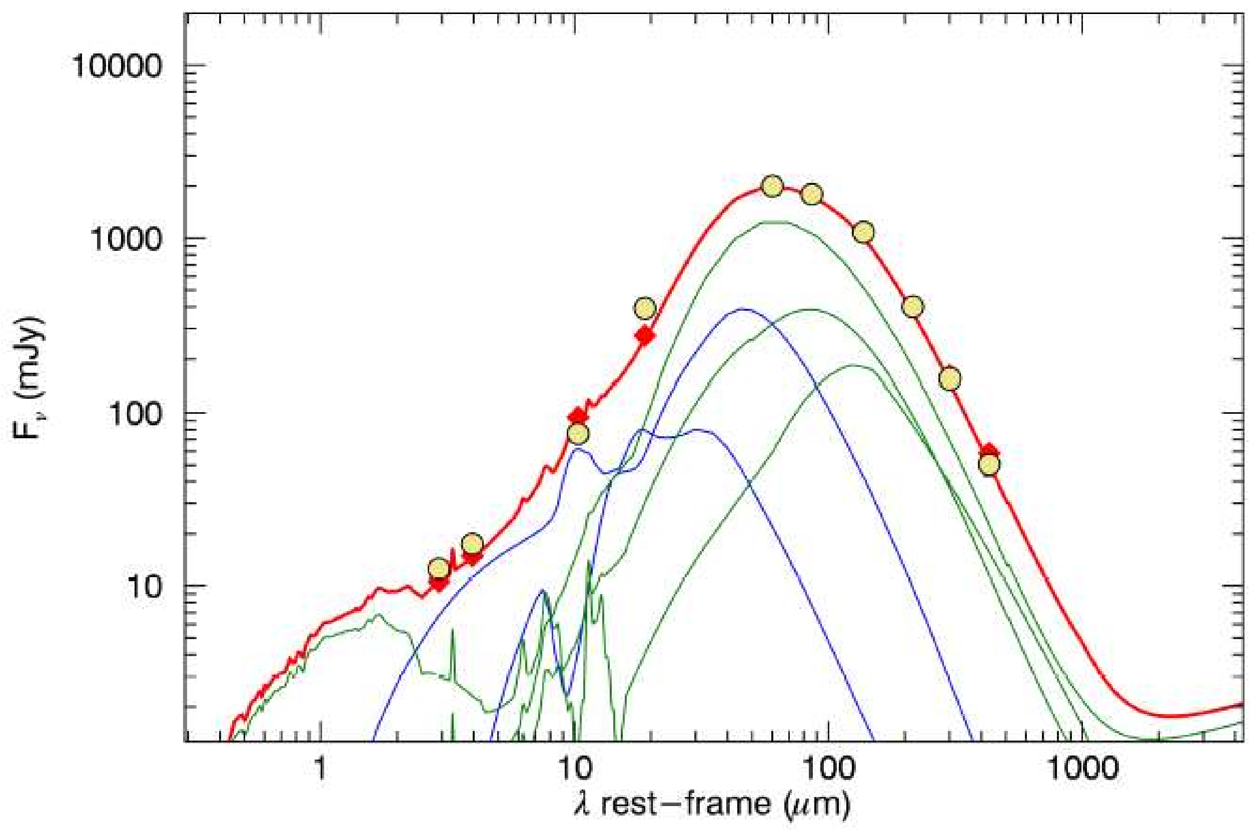
IR emission and the obscuring torus?

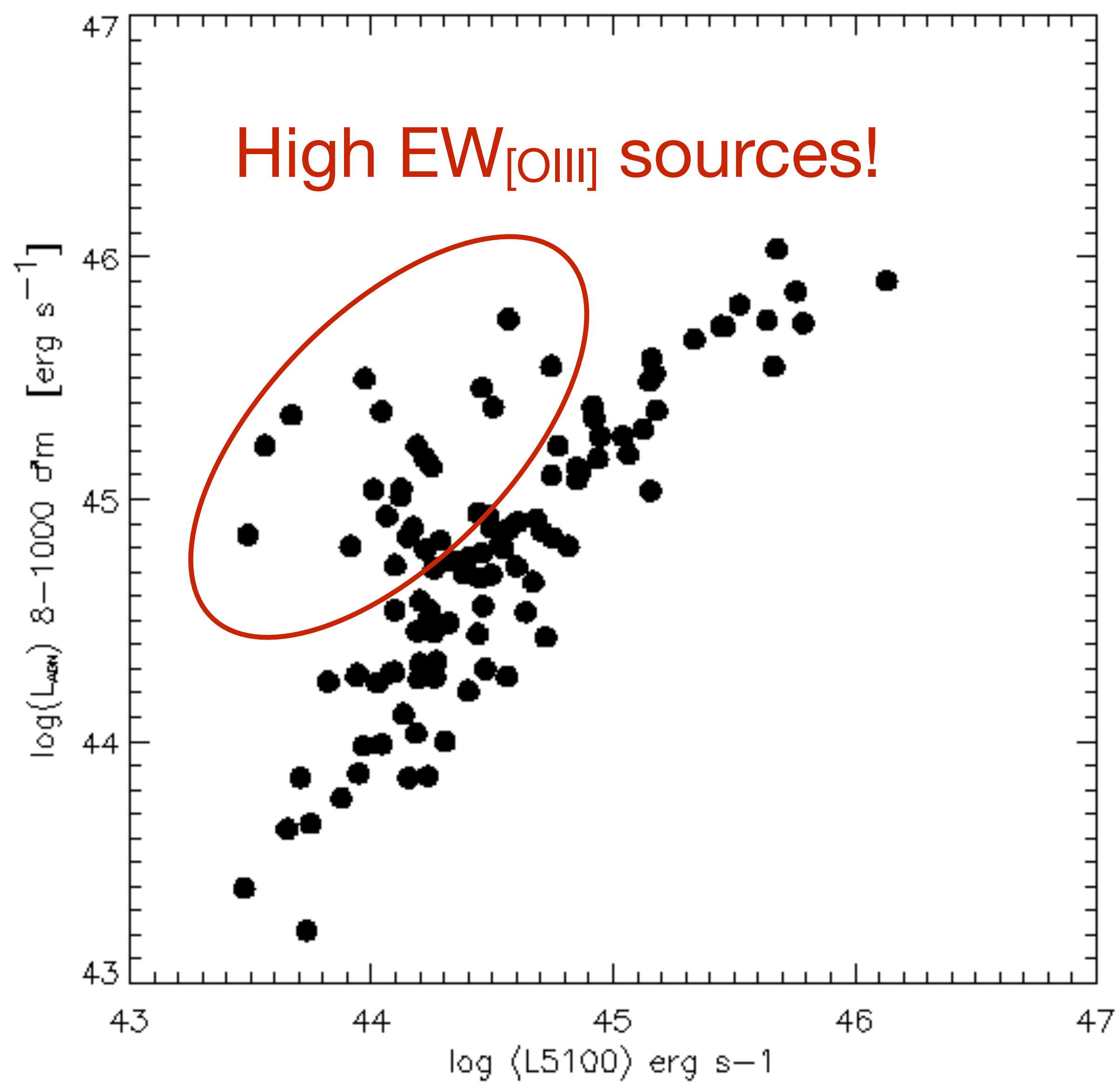




IR emission and the obscuring torus?

- ~100 QSOs with SEDs from near-IR to far-IR
- SED fitting and decomposition of AGN and host galaxy

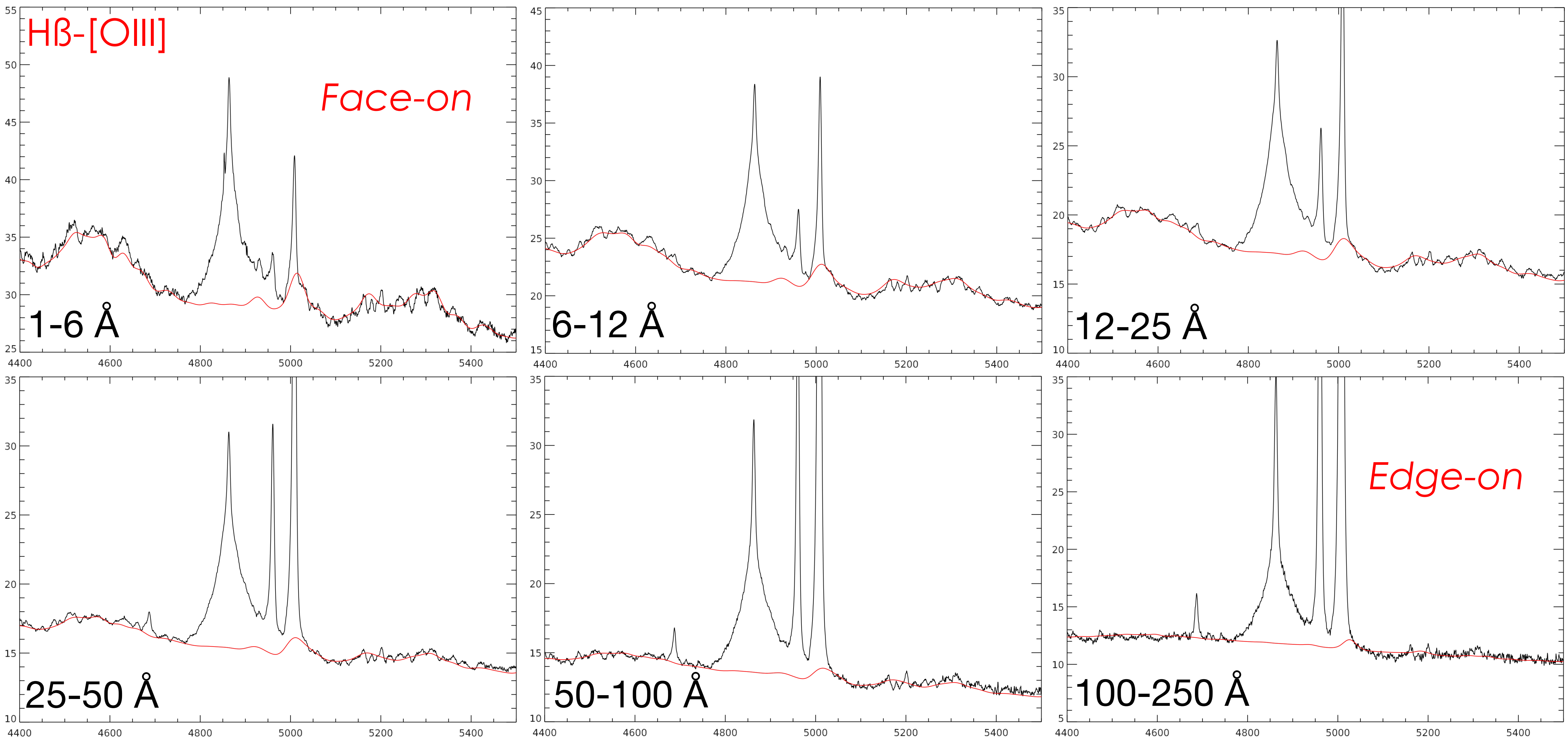




Balmaverde+14

Eigenvector 1

- At least part of the Eigenvector 1 (Boroson & Green 1992) could be ascribed to an inclination effect …



see also Shen & Ho 14

Conclusions

- EW[OIII] distribution indicates that Accretion Disk emission is anysotropic: $L = L_0 \cos\theta$, as expected
  - average spectra in EW[OIII] bins indicate L effect on EW[OIII] is not due to obscuration (i.e. high EW[OIII] sources are not obscured)
- EW[OIII] can be used as an orientation indicator:
  low EW[OIII] face on AD, high EW[OIII] edge on AD,
  - [OIII] outflow velocity anticorrelated with EW[OIII]
- EW_{BLR} distributions (CIV, MgII, Hβ) indicate that BLR is anysotropic like continuum, i.e. BLR is disk-like
  - Confirmed by strict correlation of average BLR line widths and W[OIII]
- Average color of MIR SED is correlated with EW[OIII]
  (i.e. edge on objects are redder, as expected from torus models)
- Possible interpretation of Eigenvector 1 (anticorrelation of FeII and OIII): inclination effect

Risaliti+11, Bisogni+14, stay tuned!