

Reverberation mapping of the
UV Fe III $\lambda\lambda 2039-2113$
feature in quasars

Point source monitoring with IFS

Outline

- SMBH mass measurements – virial theorem / gravitational (and transverse Doppler) redshift
- UV Fe III $\lambda\lambda 2039-2113$ – prone to microlensing and systematically redshifted in quasars
- Quasar monitoring – infer the size of the region emitting the UV Fe III $\lambda\lambda 2039-2113$ blend
- Long-slit vs. IFS based monitoring of a point source – acquisition, DAR, spectral resolution, calibration

Virial vs. gravitational redshift mass estimates

Virial factor. Largely unknown.
Depends on geometry and
presence of non-gravitational
Forces.

Spectroscopy. Ambiguity
In the definition. Contaminating
Features.

$$M_{BH} = f \frac{(FWHM)^2 R}{G}$$

$$M_{BH} = \frac{2c^2}{3G} \frac{\Delta\lambda}{\lambda} R$$

Reverberation Mapping.
R-L scaling-

Gravitational Redshift
Microlensing

Less than 30% of uncertainties
Arising from transverse Doppler

Spectroscopy

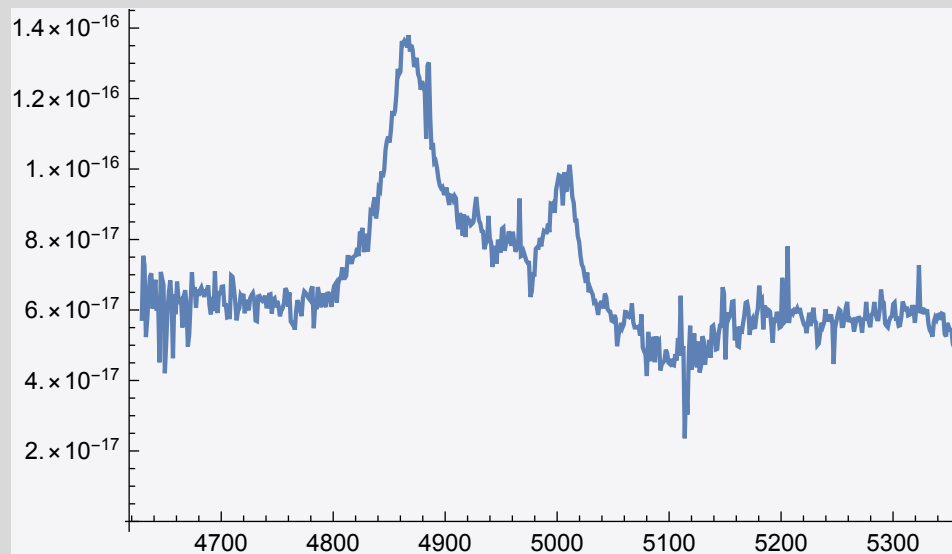
Gravitational redshift in strong BELs?

$$\frac{\Delta\lambda}{\lambda} = \frac{3}{2} f [FWHM/c]^2.$$

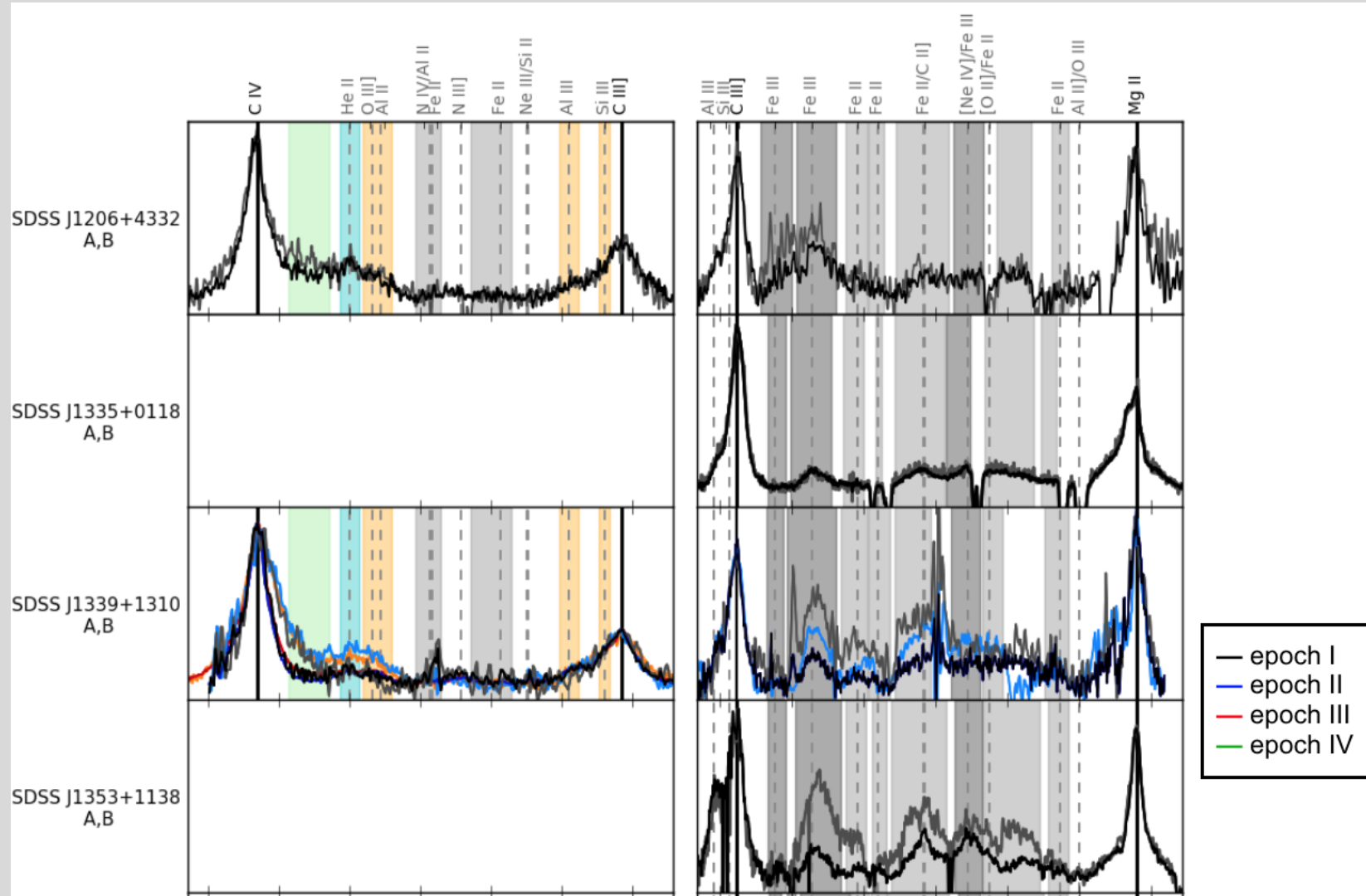
$$\Delta\lambda \approx 1\text{\AA}$$

1

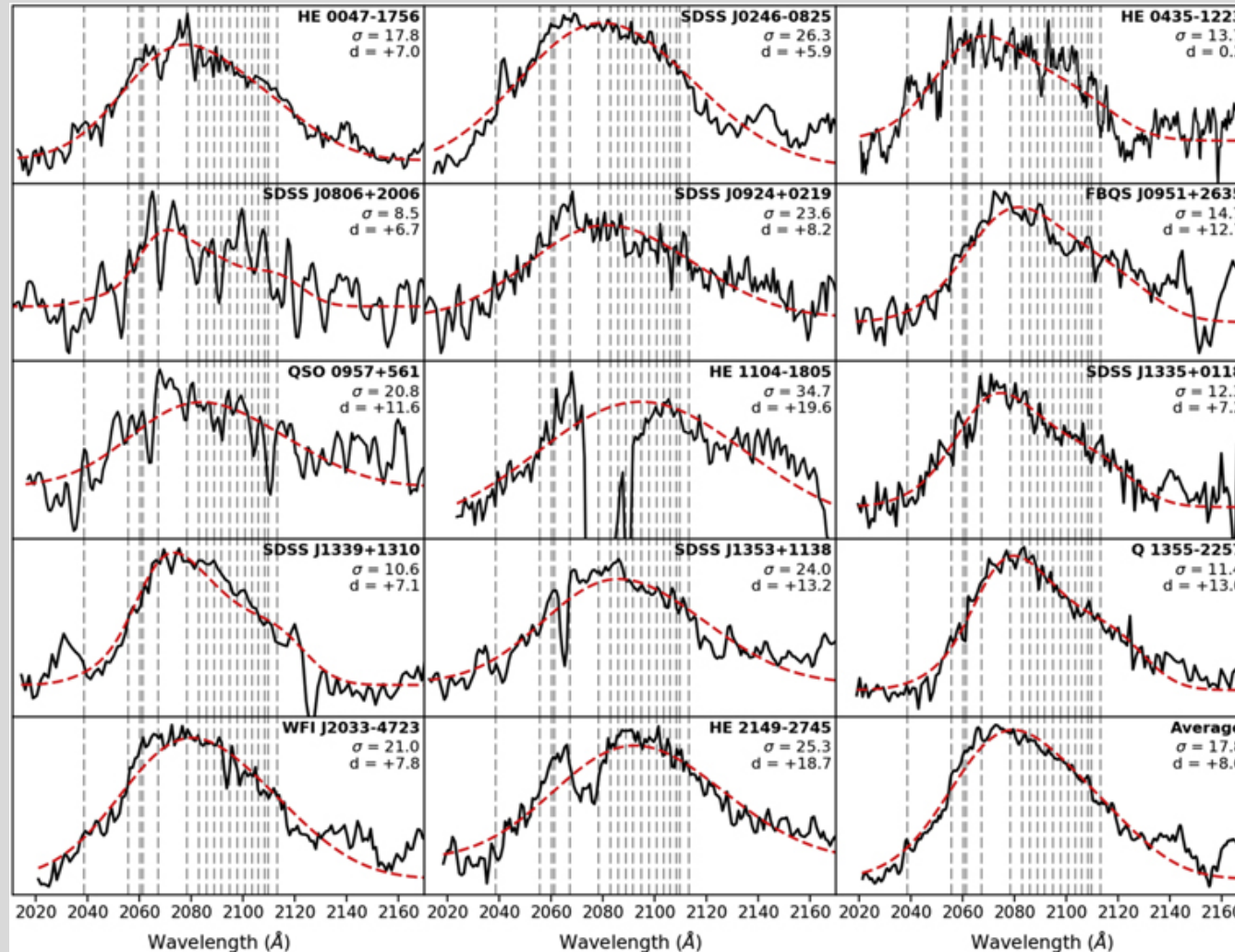
≈ 5000 km/s



Microlensing of BELs – UV Fe III



UV Fe III λ 2039-2113 – Systematic redshifts



Average estimate for lens galaxies

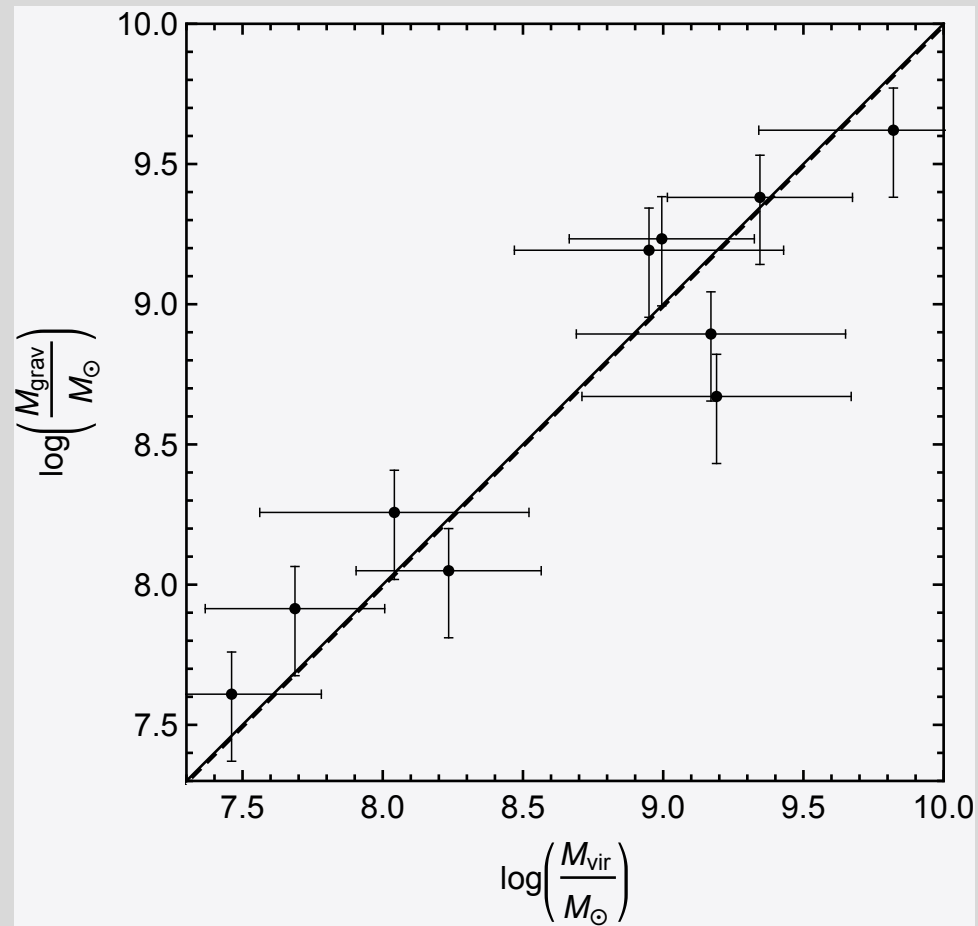
$$M_{BH} \simeq \frac{2c^2}{3G} \frac{\Delta\lambda}{\lambda} R = \left(\frac{z_{grav}}{0.005} \right) \left(\frac{R}{10 \text{ light days}} \right) (0.58 \times 10^9 M_{\odot}).$$

- HE 0047-1756, SDSS 0246-0285, SDSS 0924+0219, FBQ 0951+2635, Q 0957+561, HE 1104-1805, SDSS 1335+0118 and HE 2149-2745 (Peng et al. 2006 and Assef et al. 2011)
- $R_{\text{micro}} \approx 13$ light days

$$\langle M_{BH}^{micro} \rangle \simeq (0.9 \pm 0.5) \times 10^9 M_{\odot}$$

$$\langle M_{BH}^{virial} \rangle \simeq 0.93 \times 10^9 M_{\odot}$$

Mass_{grav} vs Mass_{virial}

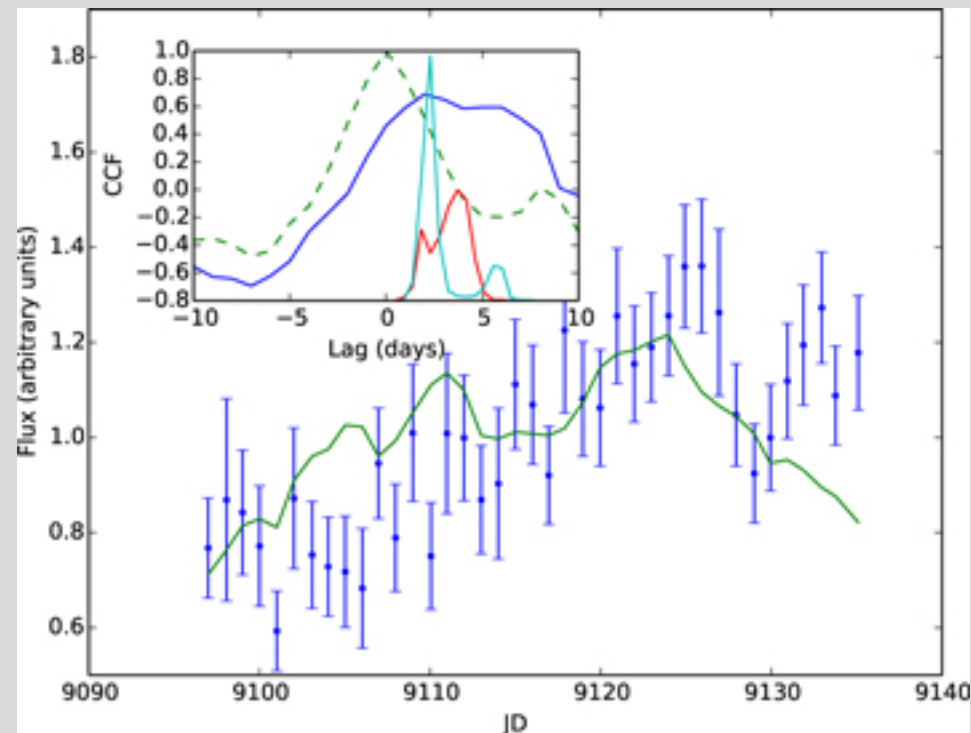


Science Case - Summary

- Systematic redshifts of Fe III $\lambda\lambda$ 2039-2113
- match the expected gravitational redshifts if the size of the UV Fe III emitting region is of 13 lt-days, as estimated by microlensing
- correlate with the squared widths of several BELs used as virial indicators
- predict mass estimates consistent with the virial masses

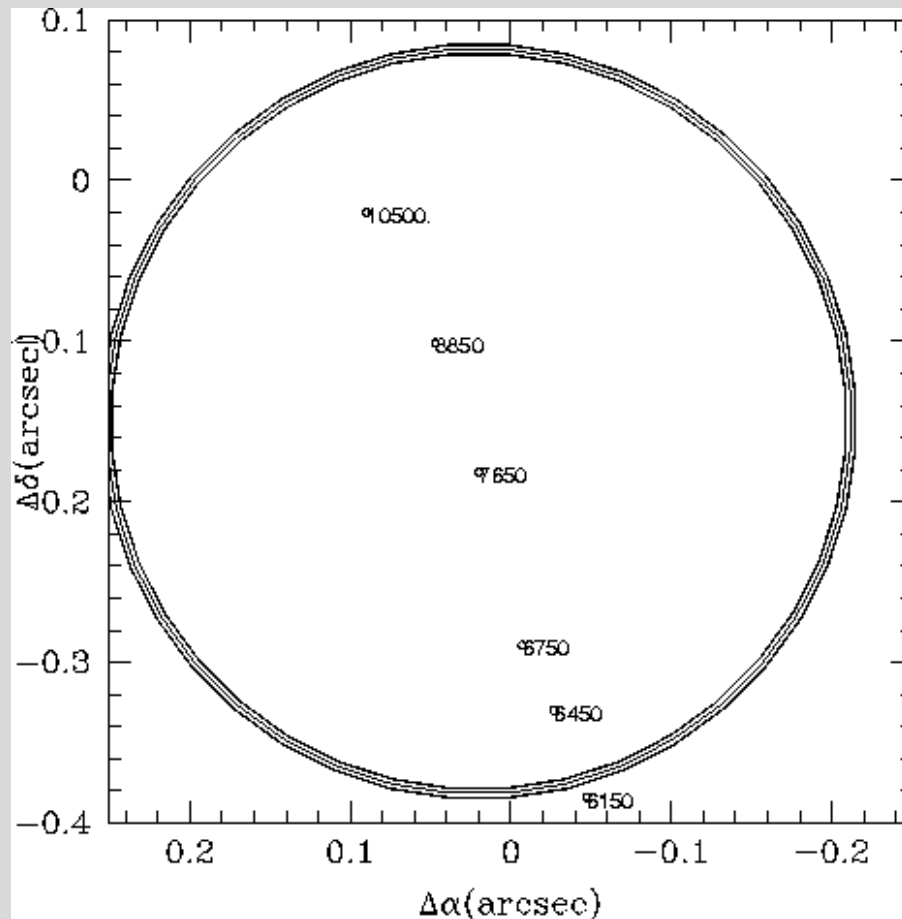
Quasar Monitoring

- Reverberation mapping observations of Fe III $\lambda\lambda 2039-2113$ are needed to confirm the small size of the emitting region.



NGC 5548

Chromatic Atmospheric Refraction



- Acquisition, Centering, Paralactic Angle
- Spectral resolution

Conclusion

- IFS can be the first choice technique to do spectroscopic monitoring of point sources

IFS based monitoring - Improvements

- Calibration star in the FoV of the IFU
- Flux and PSF calibration in auxiliar IFU

Systematic redshift of the UV Fe III lines in quasars:
measuring SMBH masses
under the gravitational redshift hypothesis

Mediavilla et al., 2018, ApJ, 862, 104

Measuring SMBH masses: correlation between
the redshifts of the the UV Fe III lines and
the widths of the BEL

Mediavilla et al., 2019, ApJ, 880, 96