The Near-Infrared Broad Emission Line Region of AGN

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Why near-infrared?

excellent instruments at excellent sites (<1 arcsec seeing):
SpeX on IRTF 3 m, GNIRS on Gemini North 8 m, ISAAC on VLT 8 m

unknown broad emission line region physics
(geometry, kinematics, density, state of ionization)

- ➢ near-IR reverberation mapping campaign
- ➢ several near-IR lines for photoionization codes
- ✓ unblended hydrogen profile shapes
- ✓ near-IR continuum properties

Near-infrared spectroscopy

(Landt et al. 2008, ApJS, 174, 282)

SpeX on IRTF 3 m, Mauna Kea, Hawaii

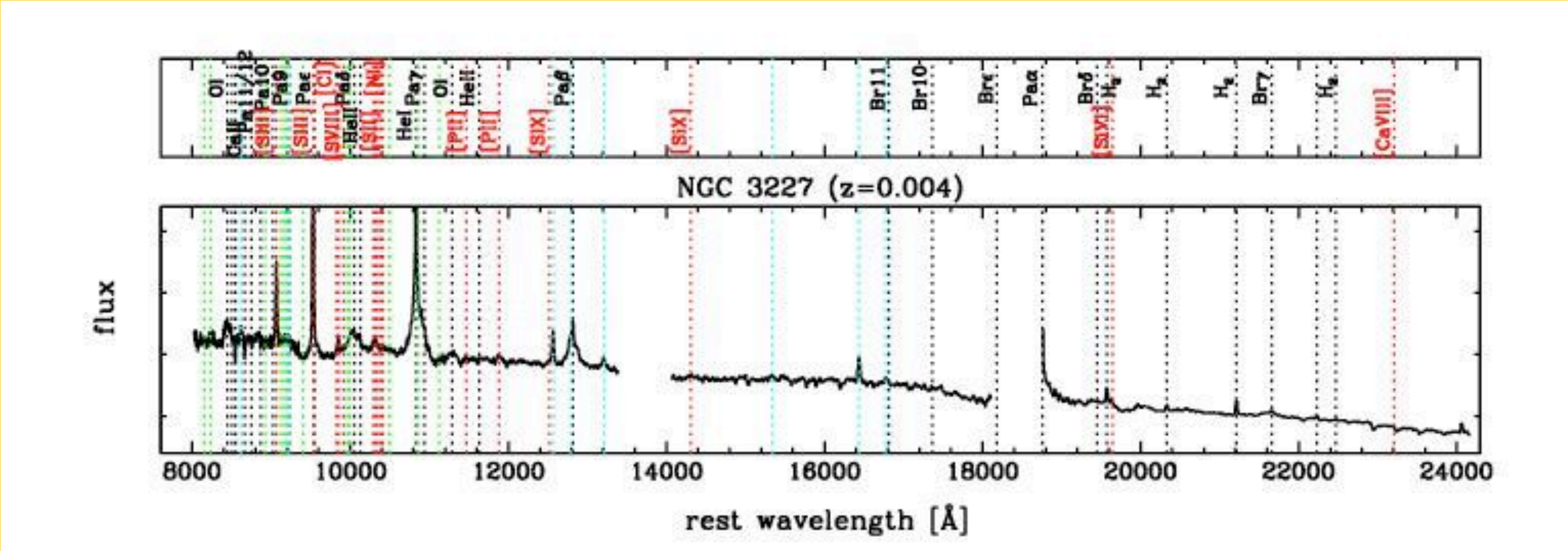
cross-dispersed (0.8 – 2.4 µm)

slit 0.8 x 15 arcsec (R~750)

- 23 well-known broad-line AGN (7/23 NLSy1, $FWHM_{Pa\beta}$<2000 km/s)
- continuum S/N >100
- J<14 mag, on-source ~1 – 1.5 hrs
- 4 observing runs (2004 May – 2007 Jan); ~2 epochs/object
- quasi-simultaneous optical spectra

Near-infrared broad emission lines

(Landt et al. 2008, ApJS, 174, 282)



hydrogen: 11 Paschen lines (Paα to Pa14); 5 Brackett lines (Brγ to Br11)

helium: He I 1.08 μm; He II 1.16 μm and He II 1.01 μm

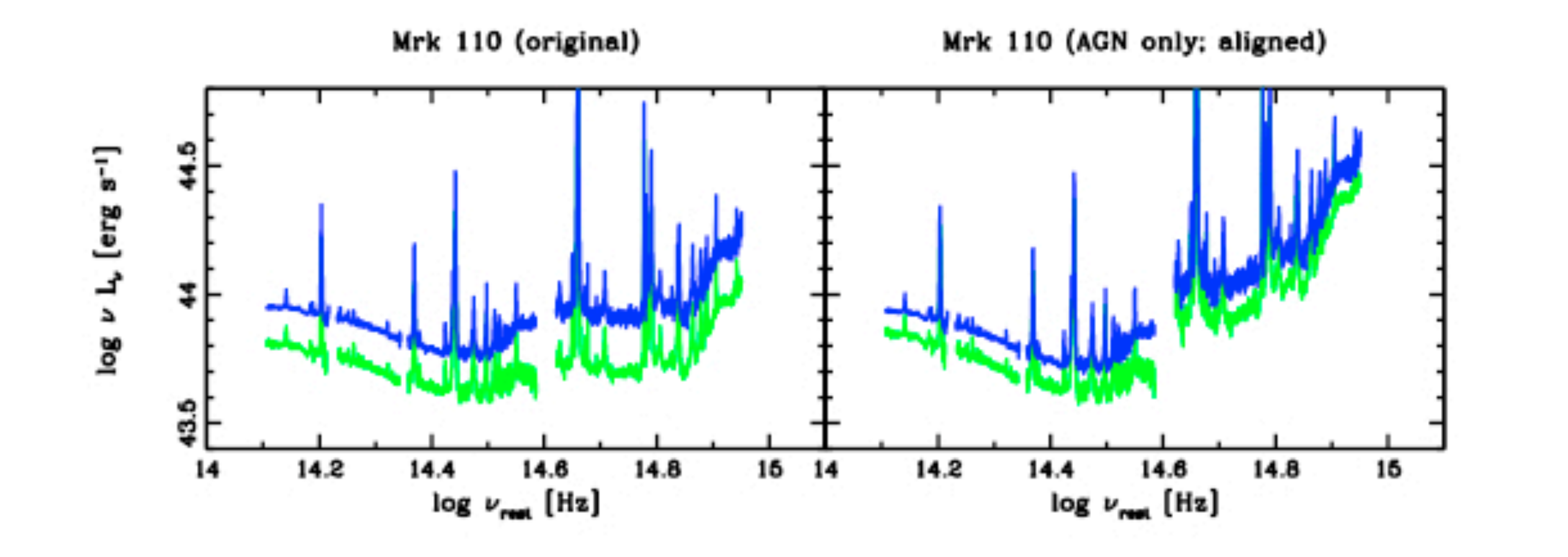
oxygen: O I 1.13 μm, O I λ8446, O I λ7774

iron: several Fe II (Fe II 1.05 μm and Fe II 1.11 μm unblended)

calcium (Ca II triplet) and molecular hydrogen H_2

Near-infrared to optical AGN SEDs

(Landt et al. 2011, MNRAS, accepted; arXiv:1101.3342)

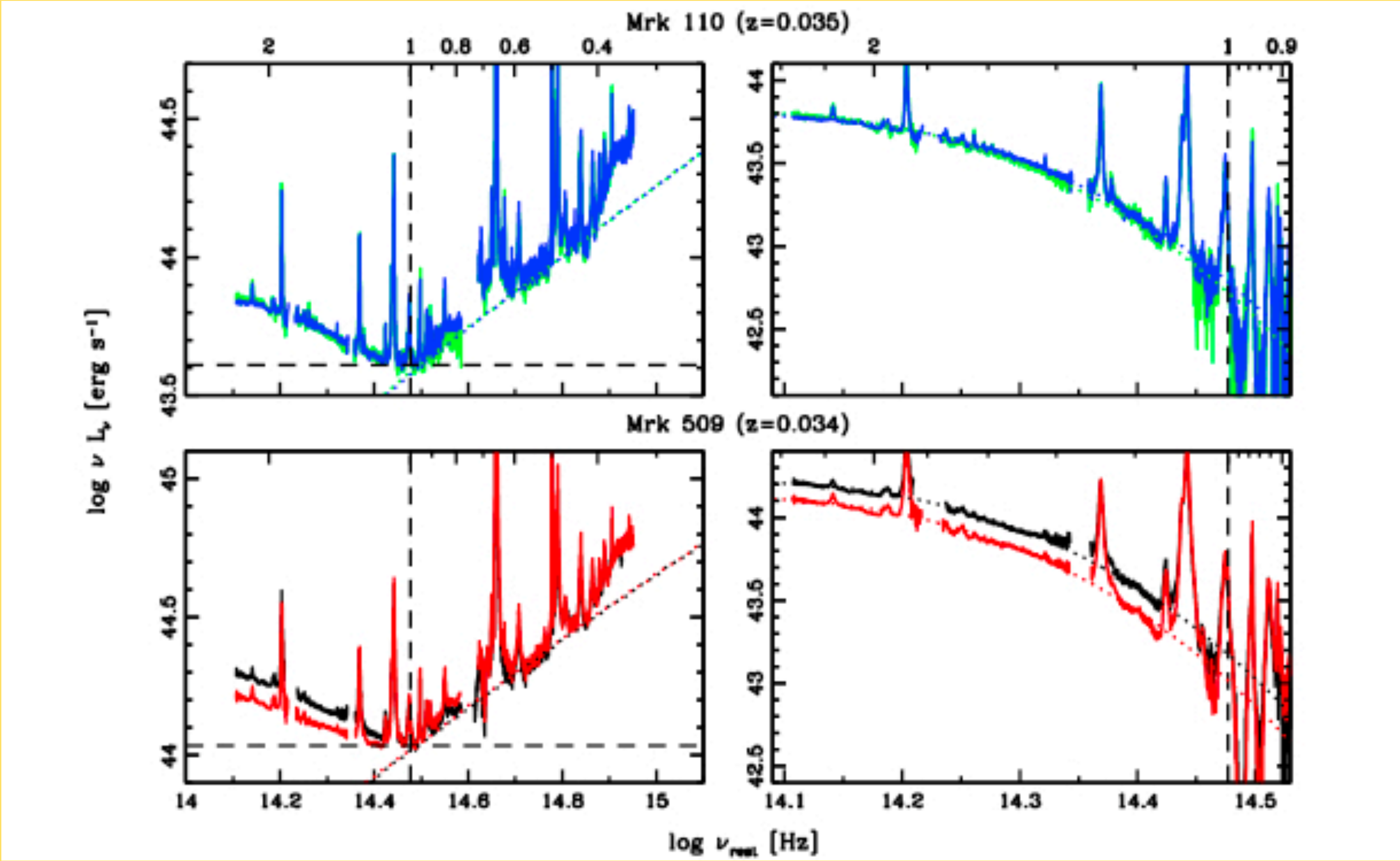


steps for deriving pure AGN SEDs (0.4 – 2.4 μm)

- relative near-IR photometry using [S III] λ9531
- host galaxy flux subtraction (optical/near-IR aperture ~5)
- accretion disc spectrum used for spectral alignment

The one-micron continuum

(Landt et al. 2011, MNRAS, accepted; arXiv:1101.3342)

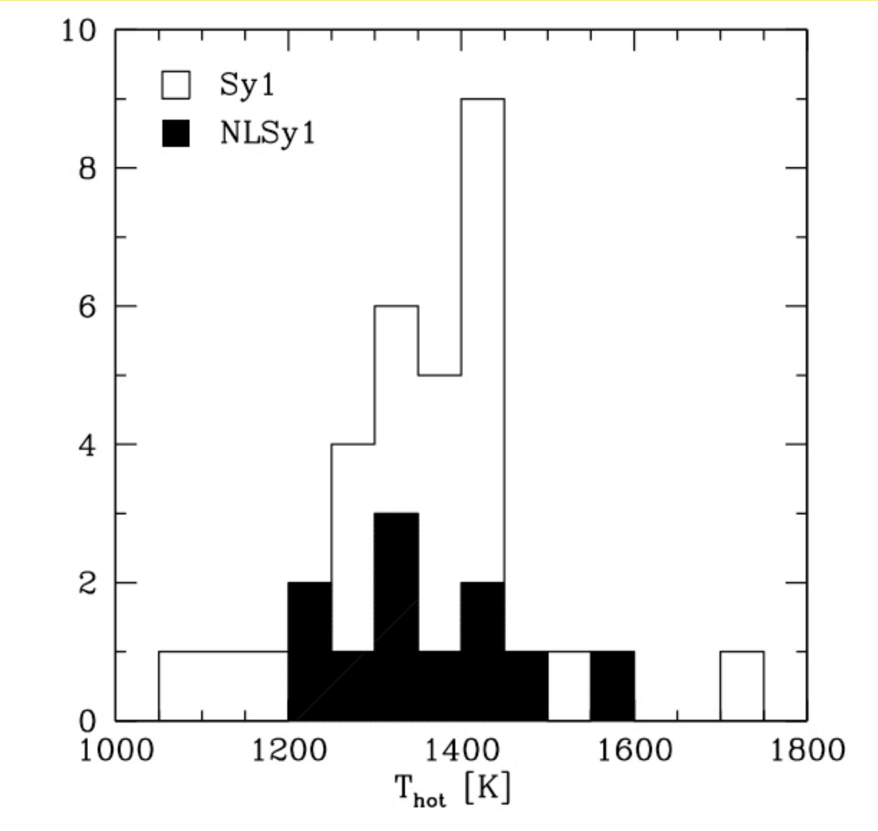


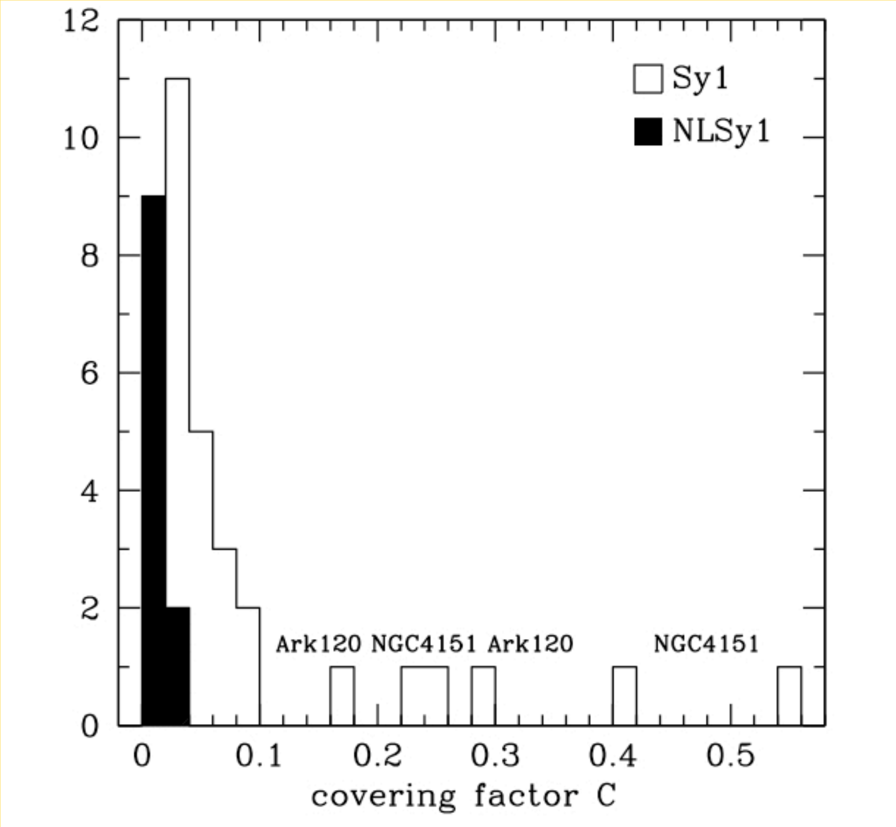
accretion disc spectrum dominates at ~1 μm

BB curvature apparent in near-IR **after** acc. disc subtraction

Hot dust properties

(Landt et al. 2011, MNRAS, accepted; arXiv:1101.3342)





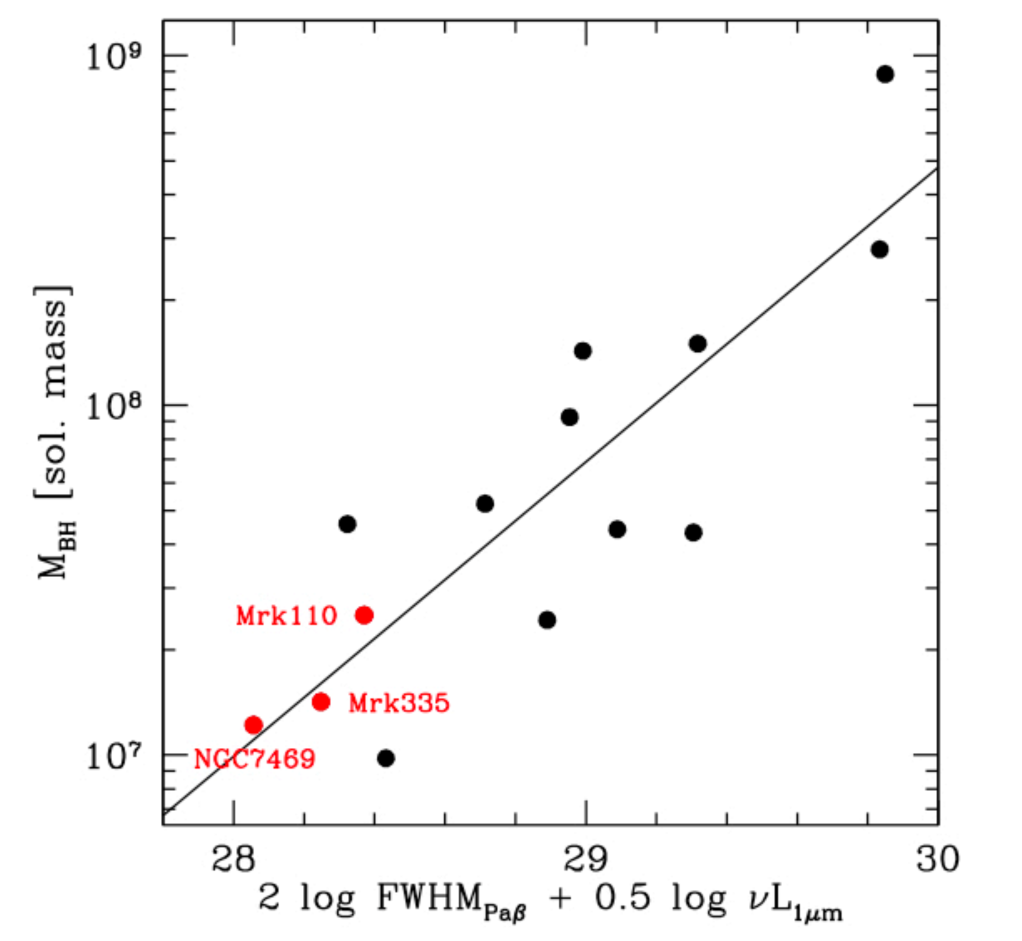
total sample: $\langle T_{hot} \rangle$ = 1365±18 K $\langle C \rangle$=0.07±0.02

NLSy1 (7 obj.): $\langle T_{hot} \rangle$ = 1354±32 K **$\langle C \rangle$=0.013±0.002 (higher λL_{acc})**

Sy1 (14 obj.): $\langle T_{hot} \rangle$ = 1369±22 K $\langle C \rangle$=0.09±0.02

The near-infrared virial product

(Landt et al. 2011, MNRAS, accepted; arXiv:1101.3342)



near-IR virial product:

$M_{BH} \approx v^2 r/G$

surrogates:

v: width of broad Paα or Paβ

r: 1μm continuum luminosity

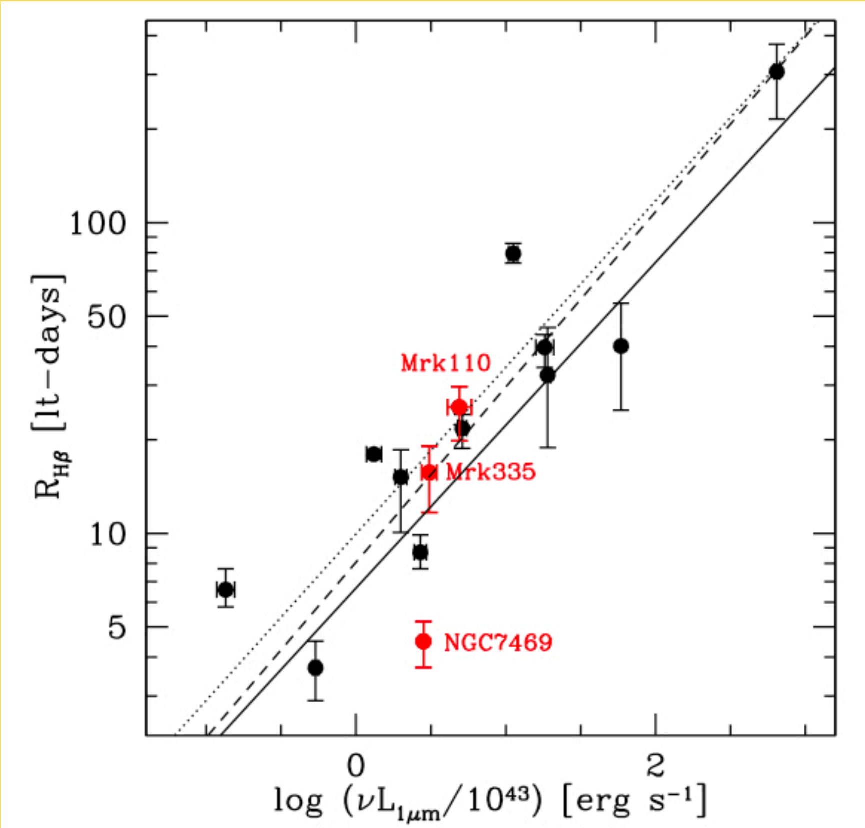
14 obj. with reverberation M_{BH}

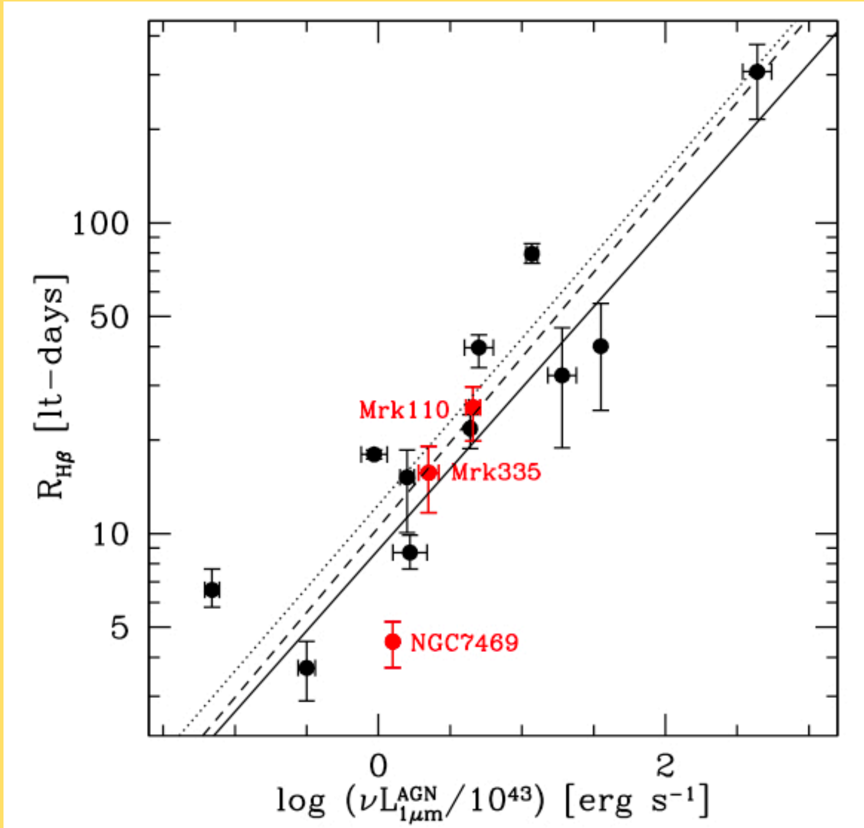
accretion disc dominates at ~1 μm

Paα and Paβ broad-line profiles unblended

The near-infrared R-L relationship

(Landt et al. 2011, MNRAS Letters, accepted; arXiv:1103.2152)

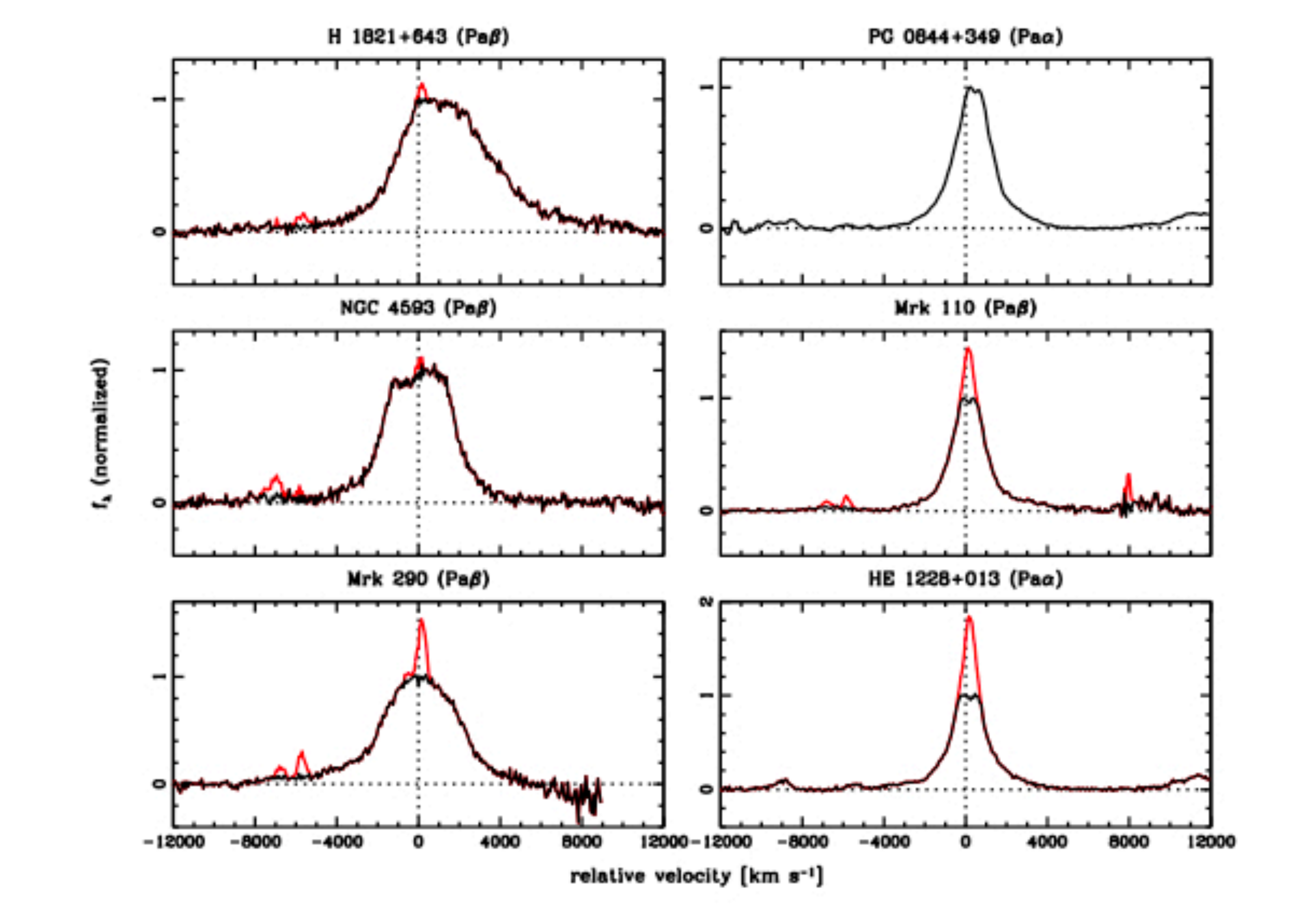




slope of logarithmic near-IR radius-luminosity relationship ~0.5
(independent of host galaxy flux subtraction)

intrinsic scatter ~50% (small sample of 14 obj.)

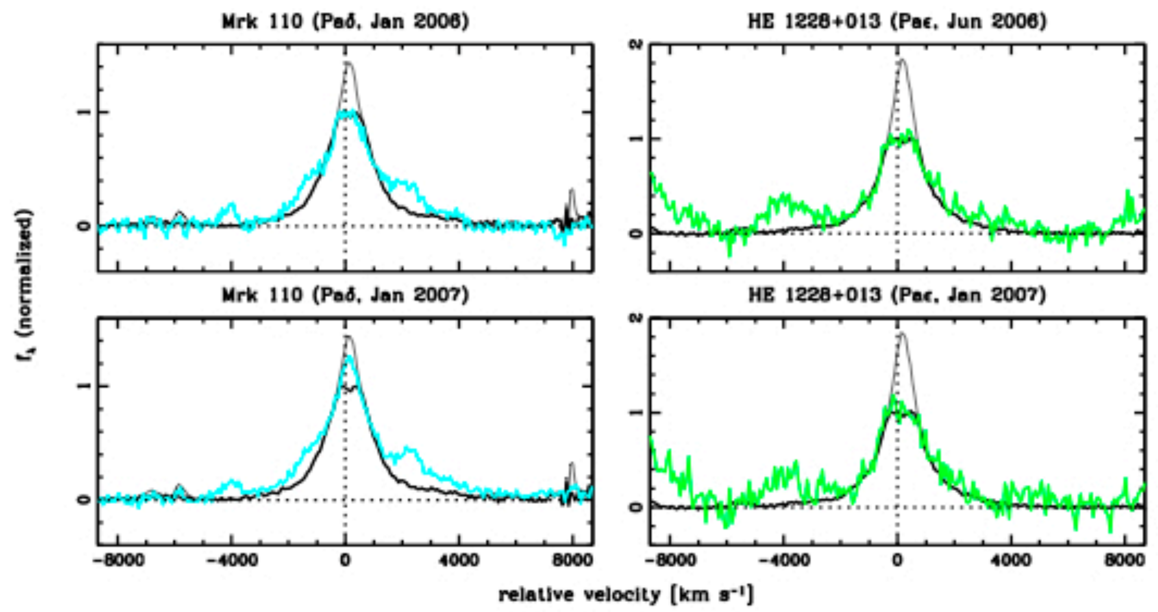
The broad-line region outer radius



Are **all** broad-line profiles intrinsically flat-topped?

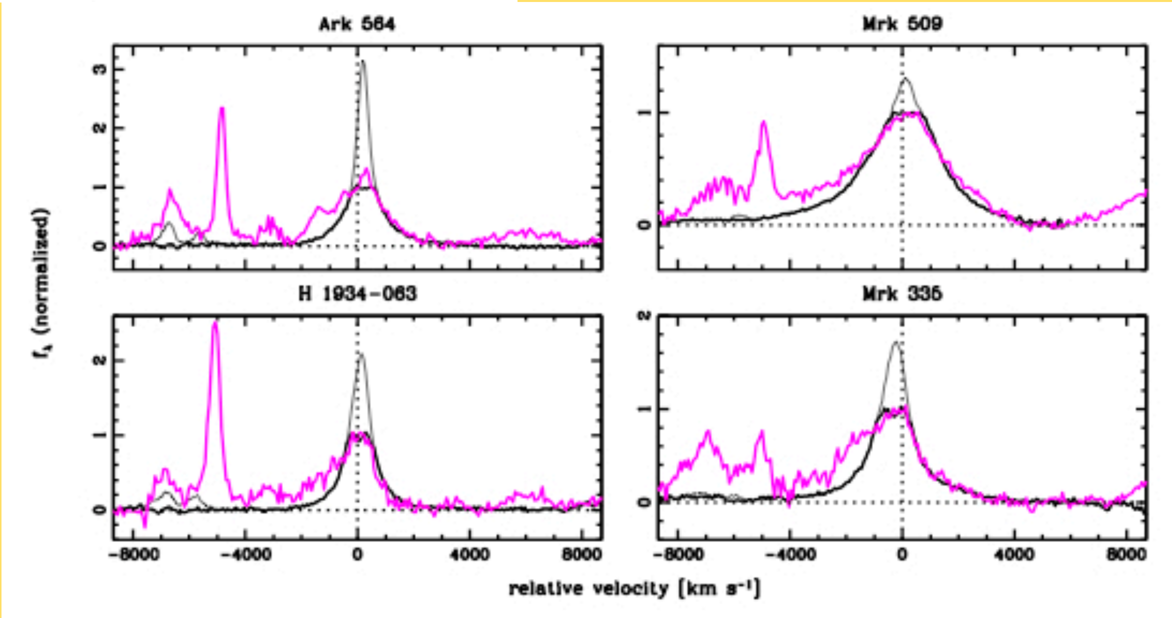
If yes, and gravitation dominates, there is an outer radius!

The “disappearing” narrow-line region



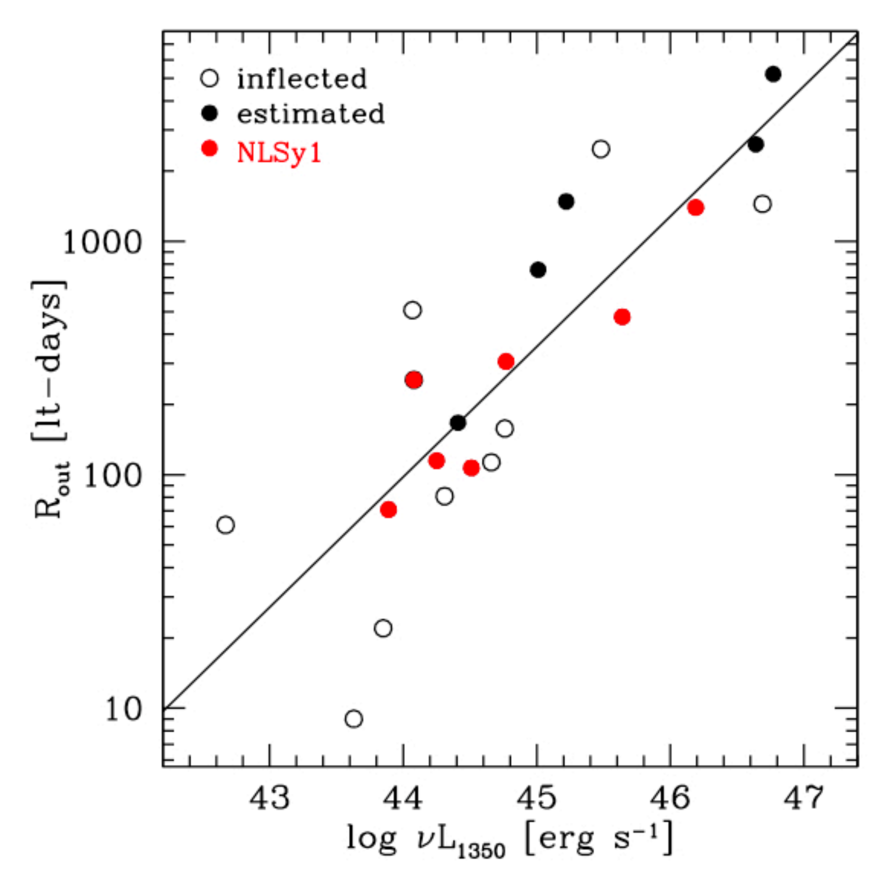
narrow-line can “reappear” in higher AGN state

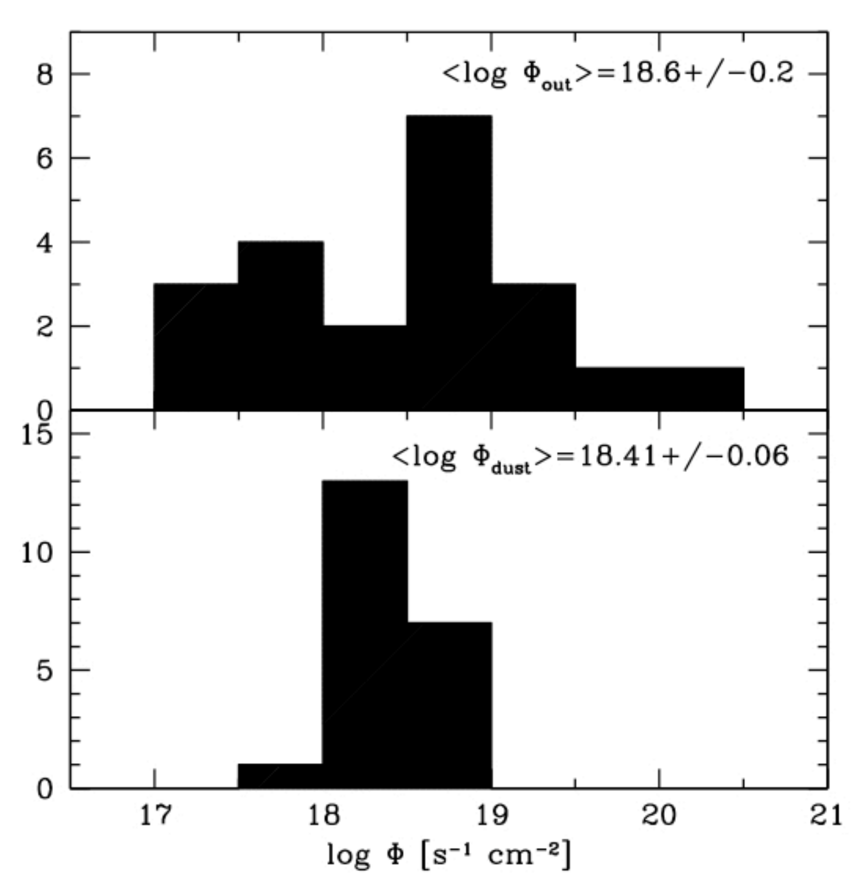
magenta: Pa9 (3-9)



higher-order Paschen lines are intrinsically flat-topped

A broad-line region limited by dust?





logarithmic slope 0.56±0.08

outer radius at same ion. flux Φ

broad-line outer radii similar to average hot dust radii