The BLR Low Luminosity Evolution

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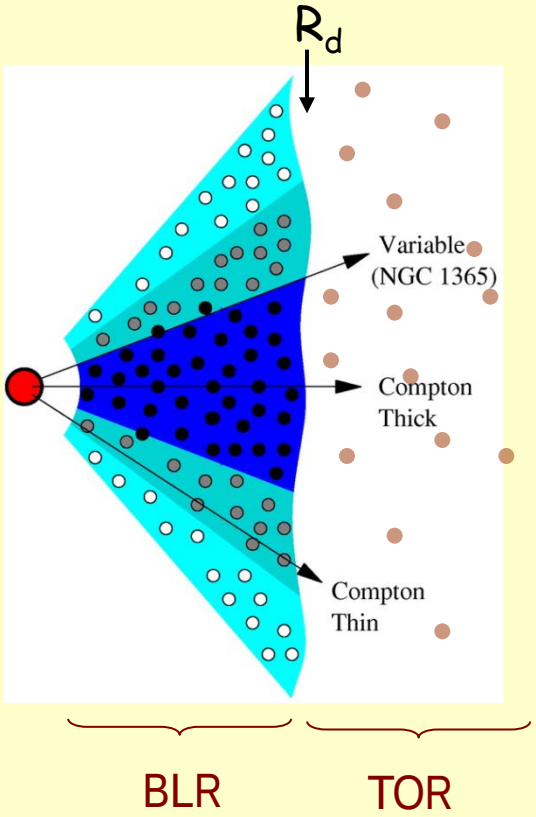
The BLR/TOR Region

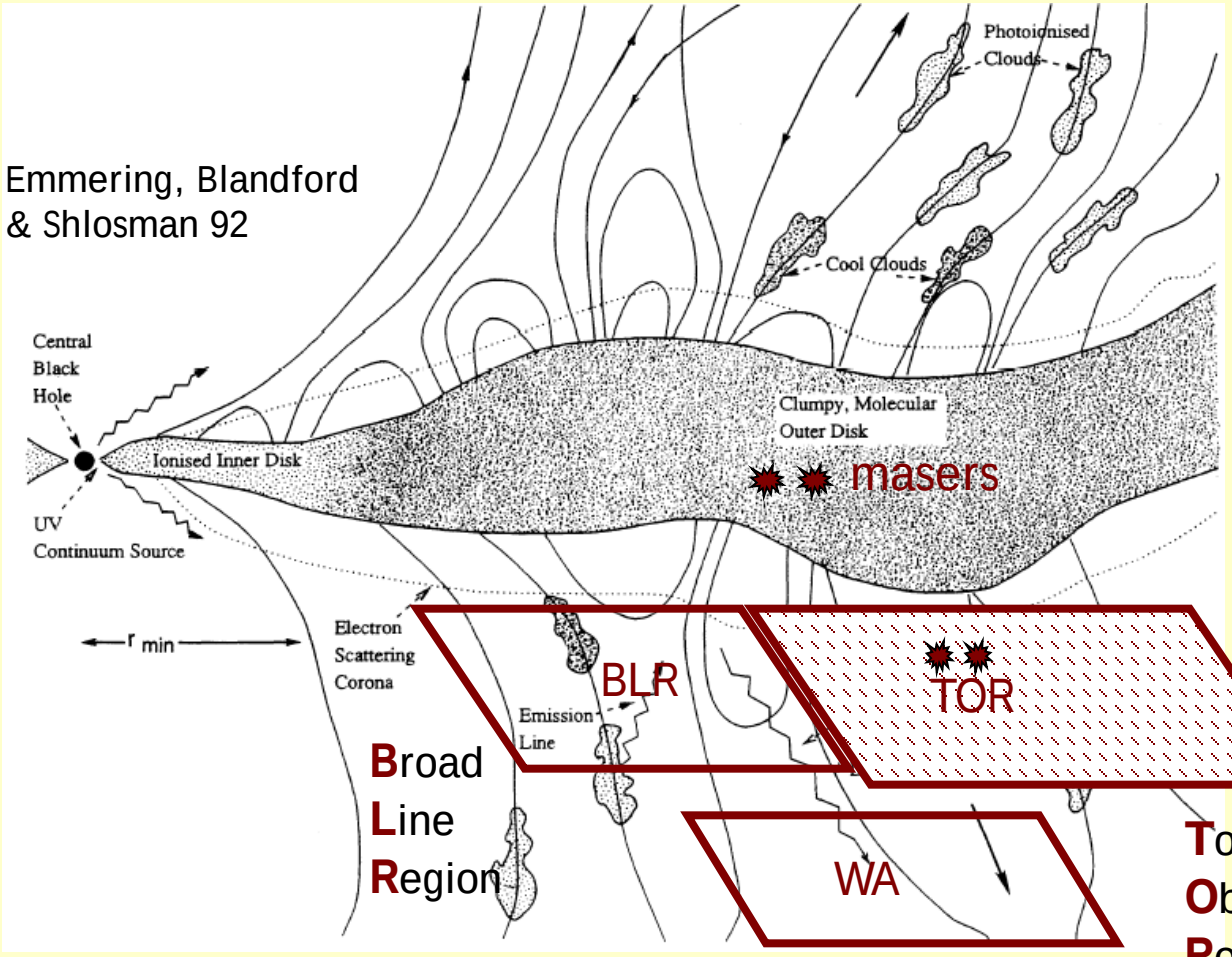


$r < R_d$ — dust free clouds:
Broad **L**ine **R**egion

$r > R_d$ — dusty clouds:
Toroidal **O**bscuration **R**egion

$R_d = 0.4\ L^{½}_{45}$ pc

Grand Unification Theory



Geometry

- Clouds rise and expand $\Rightarrow$
- Column density decreases ($nR \propto M/R^2$) $\Rightarrow$
- *Toroidal structure for both BLR, TOR and X-ray obscuration*

BLR/TOR Mass Outflow Rate

$$\dot{M}_{out} = 2\int nmv_z 2\pi R dR$$

$R_d \propto L^{½}$ $\quad$ $v_K(R_d) \propto (M/R_d)^{½}$ $\quad$ $N_R = \int n dR$

$$L = \eta \dot{M}_{acc}^{BH} c^2 = \eta\alpha \dot{M}_{acc} c^2 \qquad \alpha < 1$$

$$\frac{\dot{M}_{out}}{\dot{M}_{acc}} = \varepsilon \frac{M^{½}}{L^{¾}} \cdot N_R$$

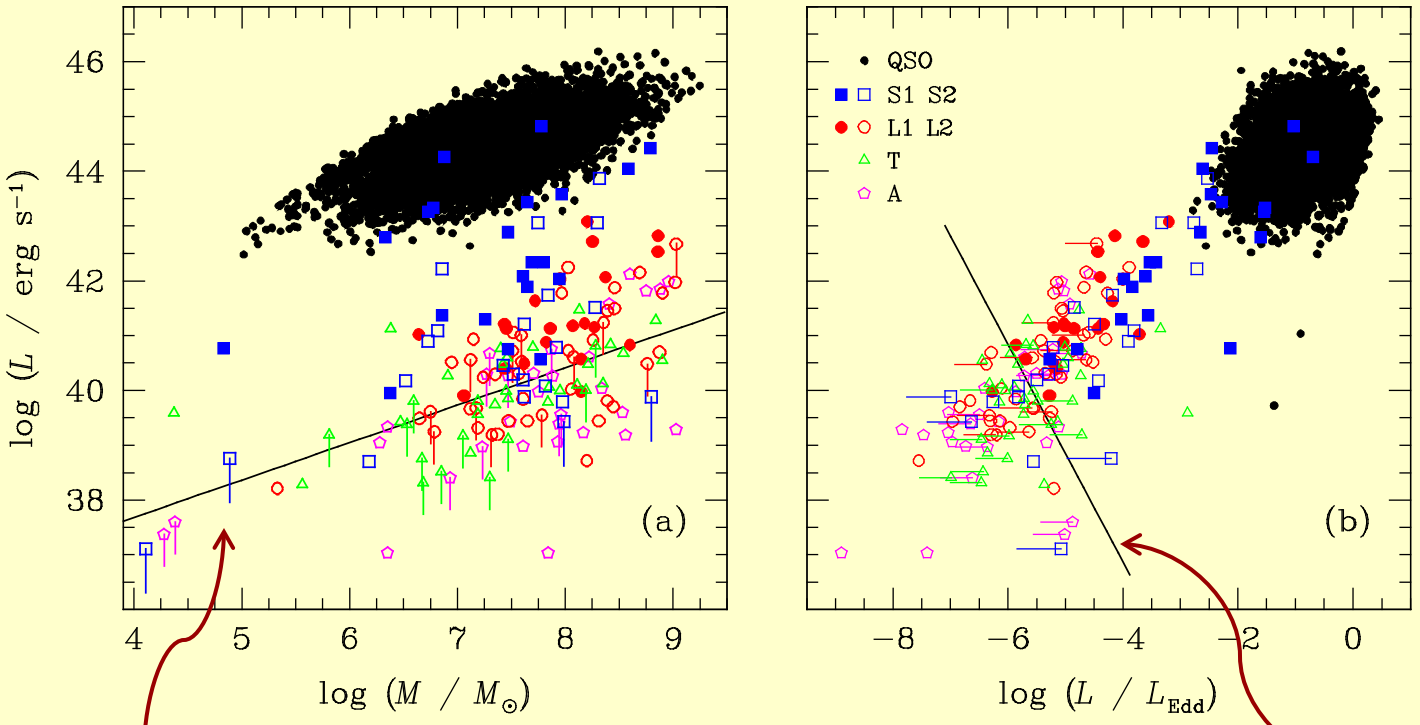
BLR/TOR outflow must disappear at small L!

Elitzur & Shlosman ‘06

BLR Disappearance in LLAGNs

BLR existence: $L > C\, M^{2/3}$

i.e., $L > C\, (L_{Edd}/L)^2$



$\log L = 35 + 2/3 \log M$

$\log L = 28.8 - 2 \log (L/L_{Edd})$

$\eta \approx 4 \cdot 10^{-4} \Rightarrow$ radiatively inefficient accretion!

Elitzur & Ho 2009

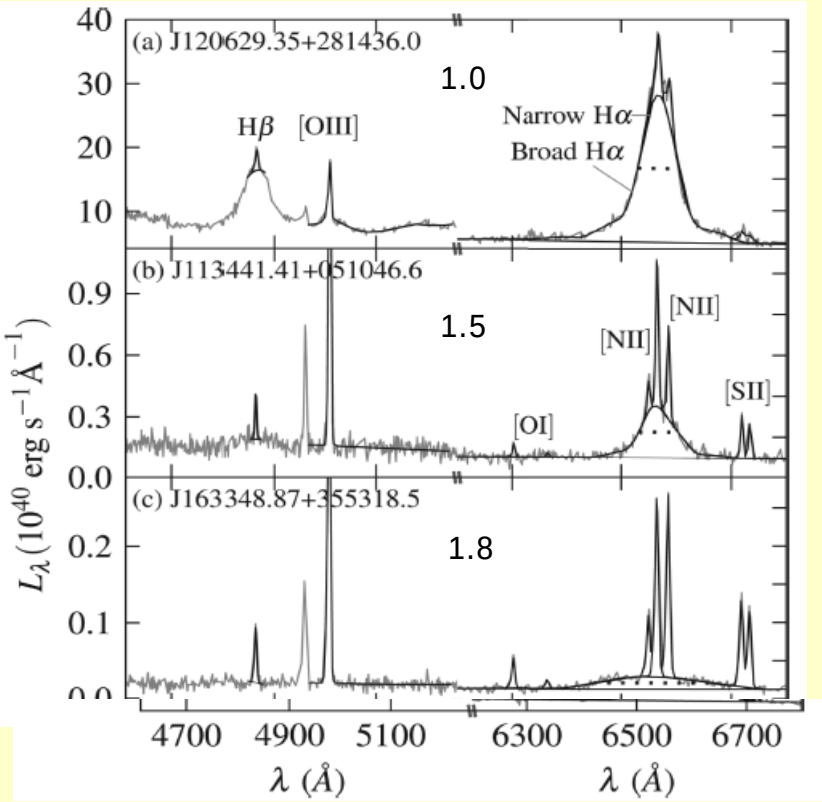
$$L > 3 \cdot 10^{41} \left(\eta_{-2}^2 M_7\right)^{2/3} \text{ erg s}^{-1}$$

Intermediate Seyfert (1.x)

[OIII]/Hβ increases from <0.3 (Sy 1) to > 4 (Sy 1.8)

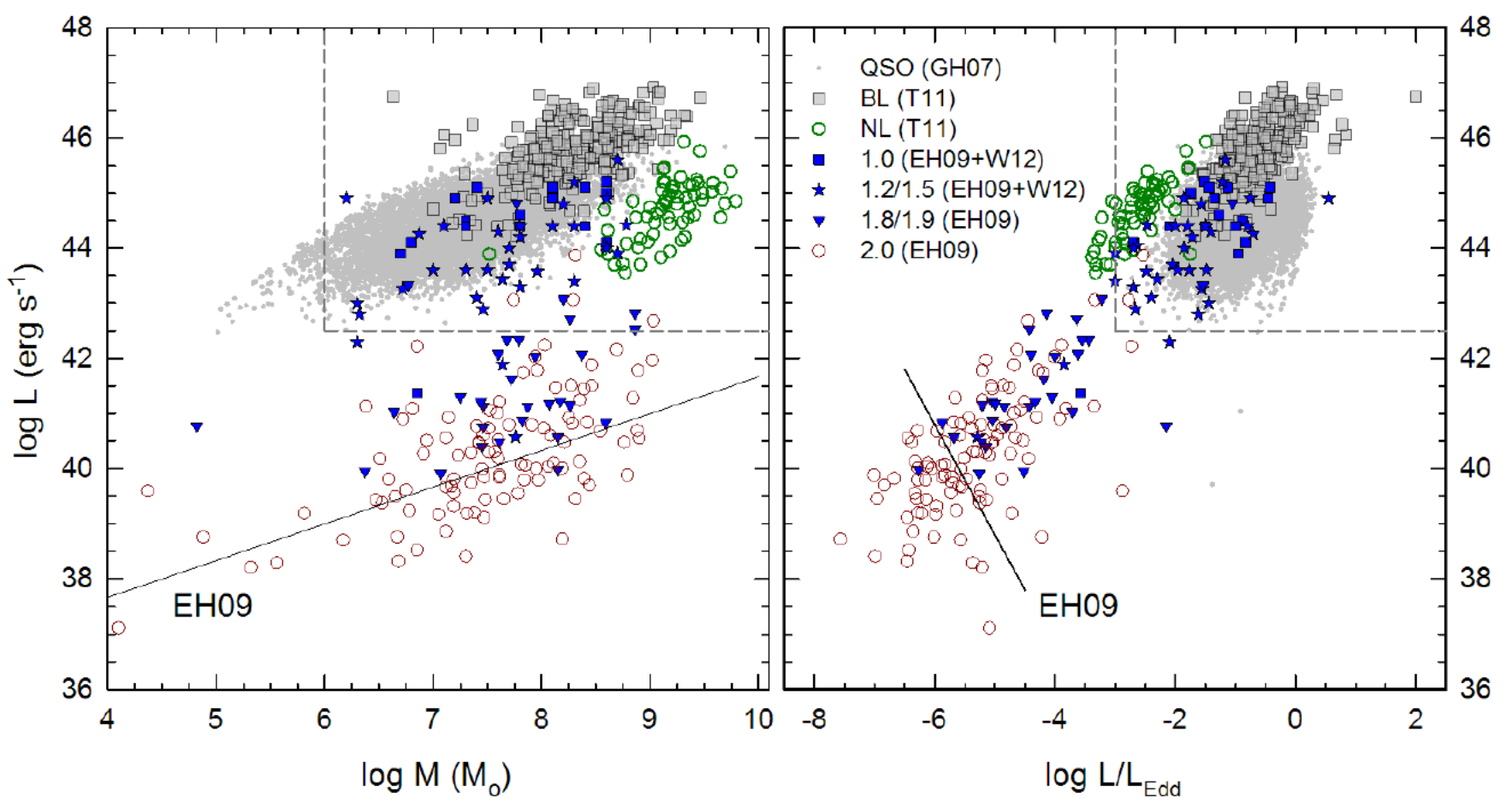
Stern & Laor (2012a,b):

- Spectral class from LnHα/LbHα
- 1.0: LbHα ~ 10^{43} erg s^{-1}
- 1.5: LbHα ~ 10^{42} erg s^{-1}
- 1.8: LbHα <~ 10^{41} erg s^{-1}



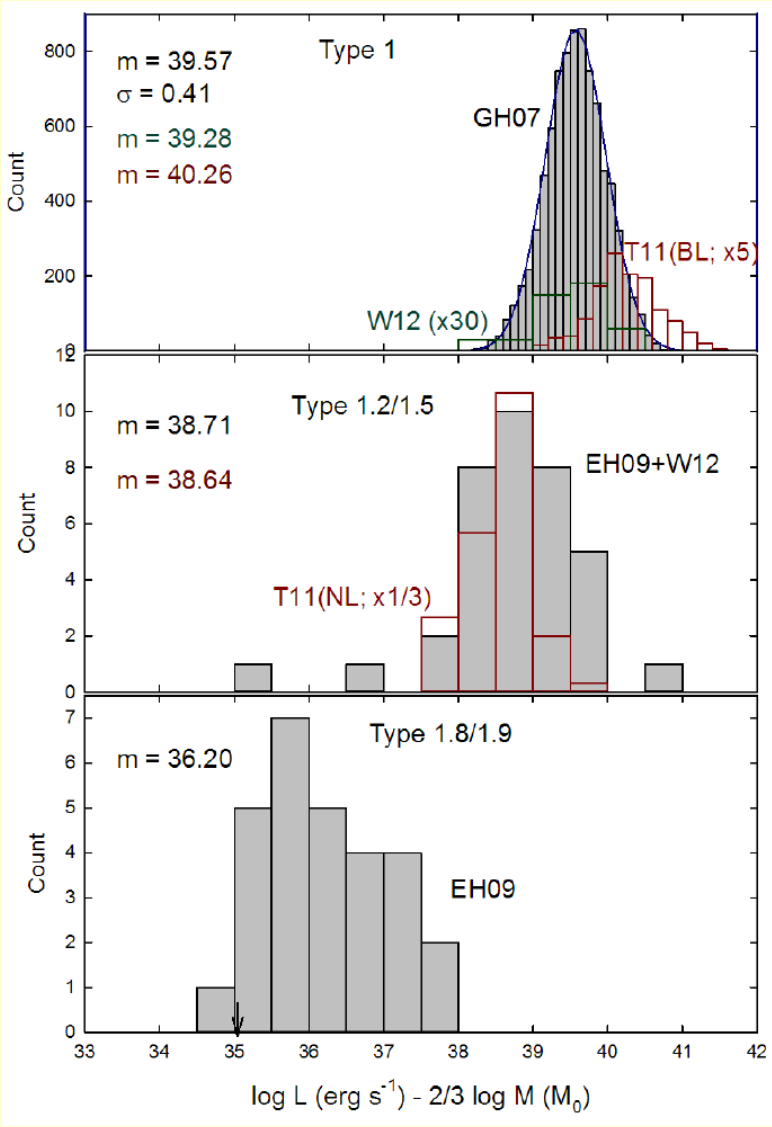
At low luminosity most AGN 1 are intermediate

An Evolutionary Sequence?



Elitzur, Ho & Trump 2014

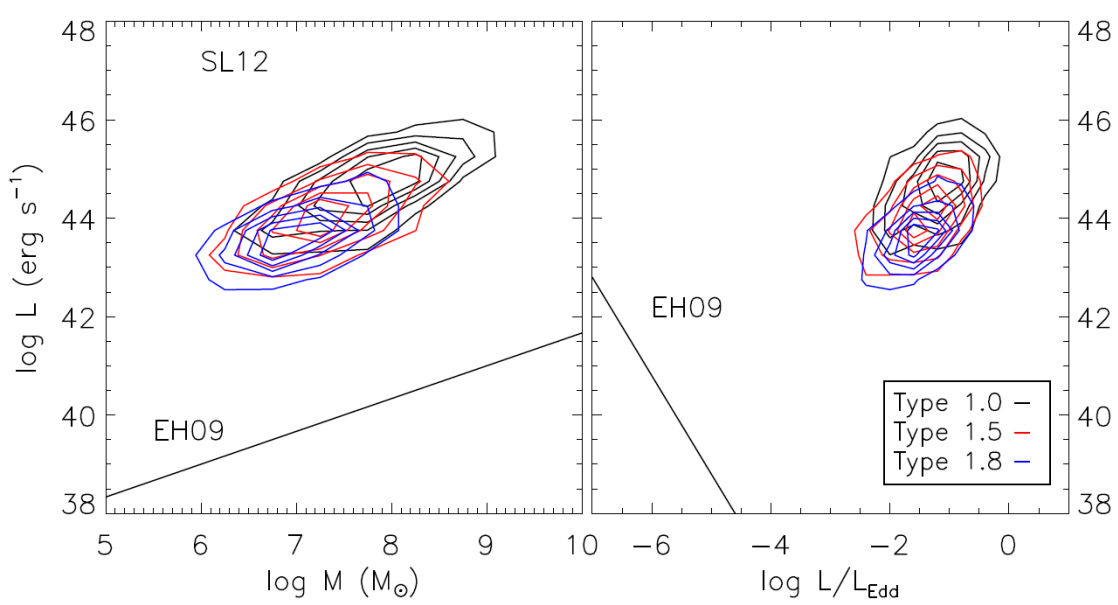
An Evolutionary Sequence!

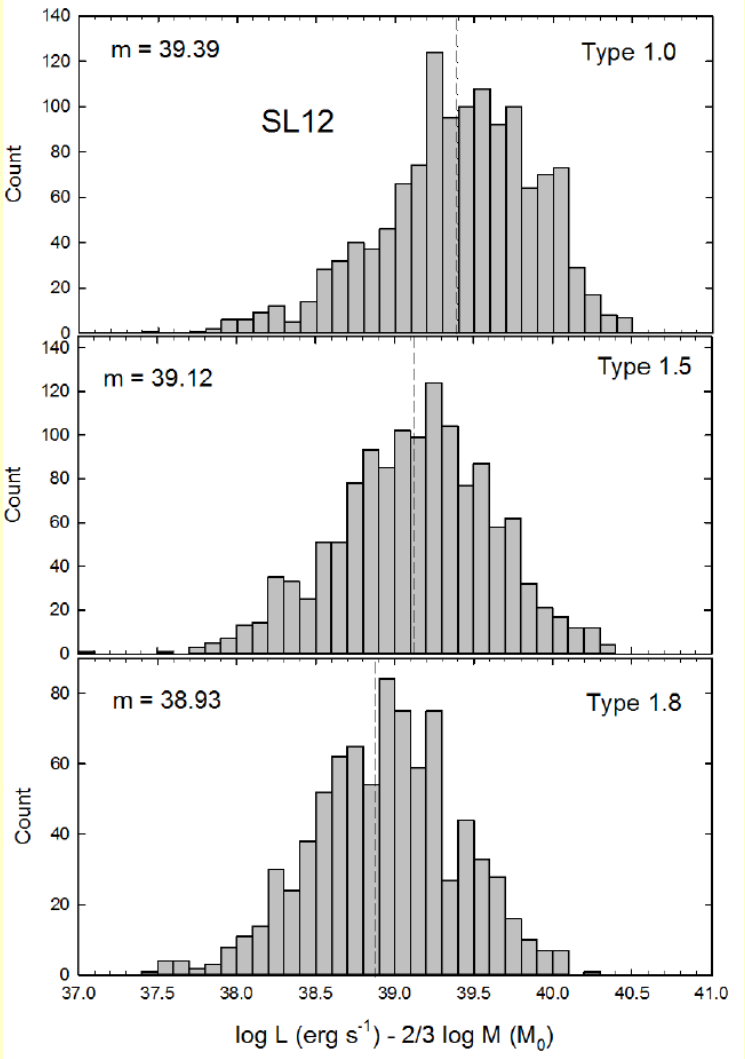


As $L/M^{2/3}$ decreases:

Type 1 → 1.2/1.5 → 1.8/1.9 → "true" Type 2

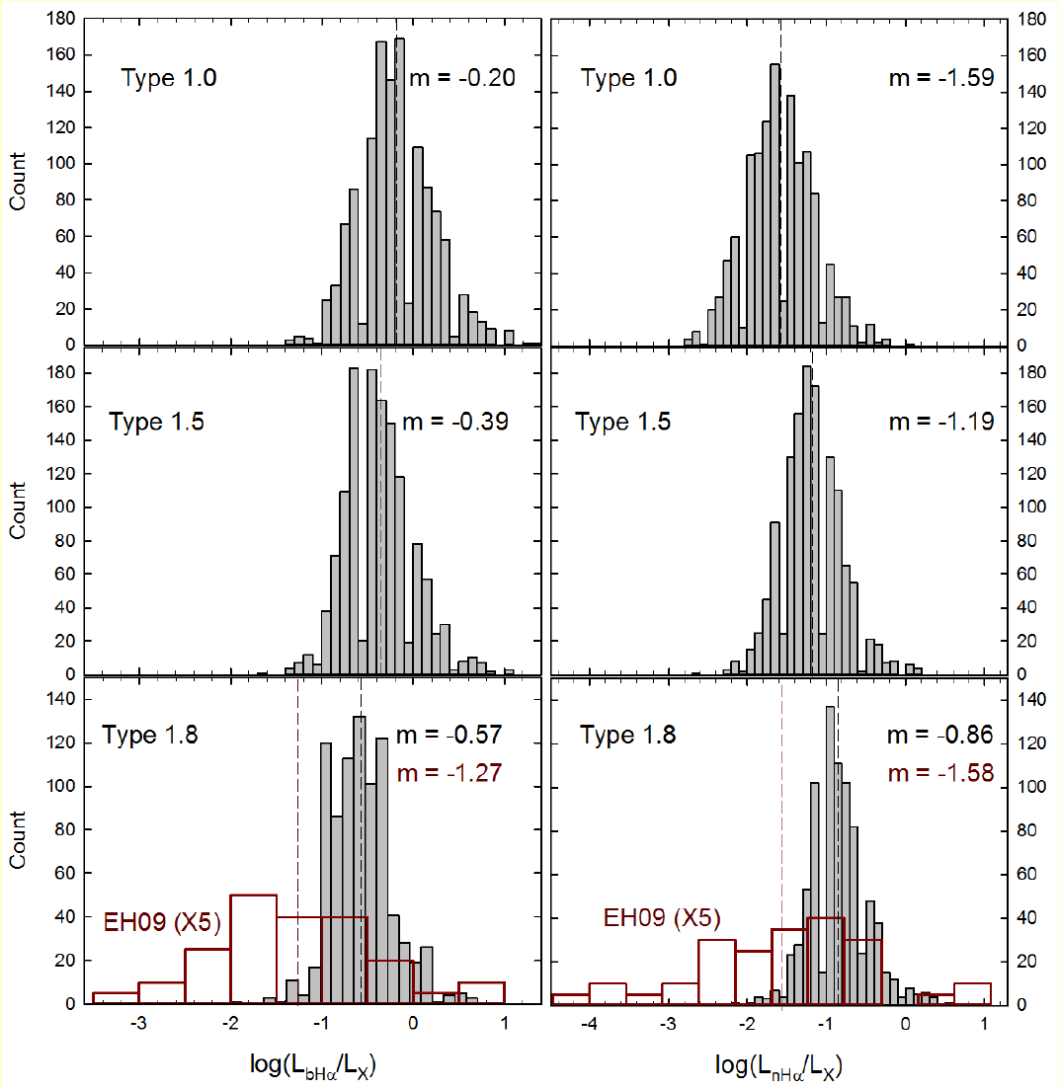
The SL12 Sample





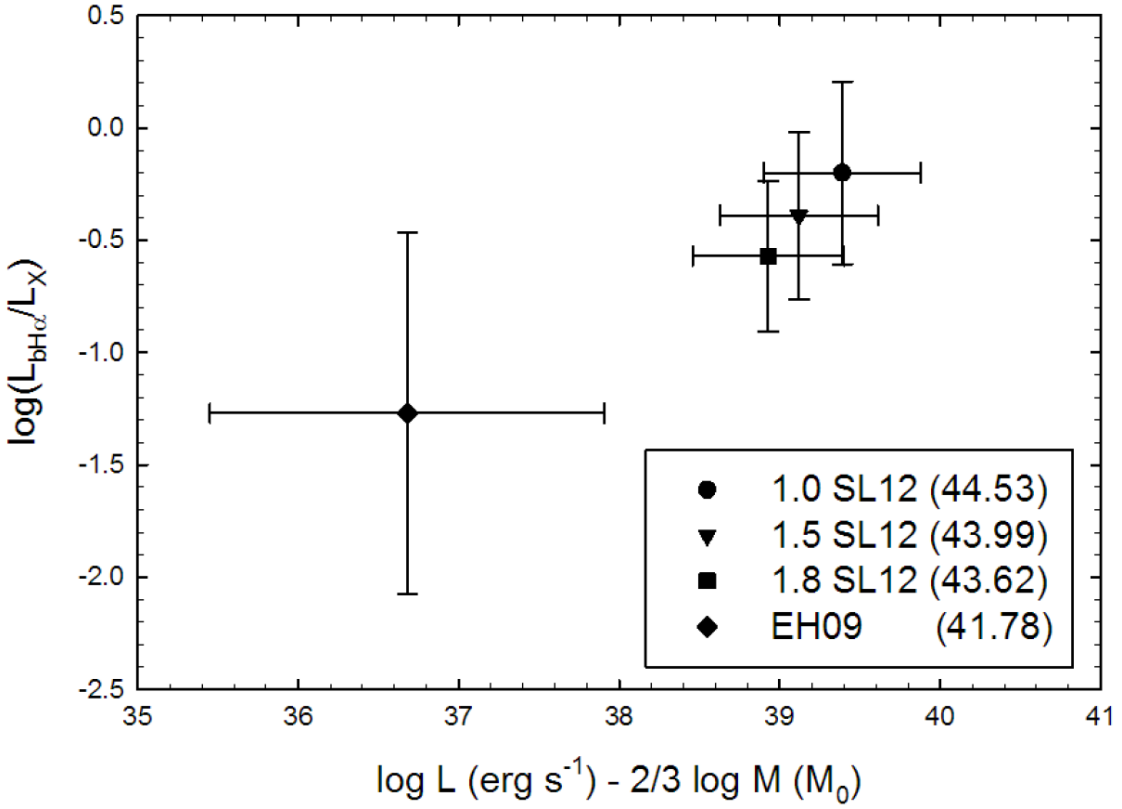
- LbHα/LnHα decreases with $L/M^{2/3}$
- Weaker broad- or stronger narrow lines?

Broad- and Narrow-Line "Covering Factors"



$L_{bH\alpha}/L_X$ *decreases* with $L/M^{2/3}$

Broad Lines “Covering Factor”



- Decrease of more than factor 2 within SL12
- Factor 12 with EH09

Line Profiles

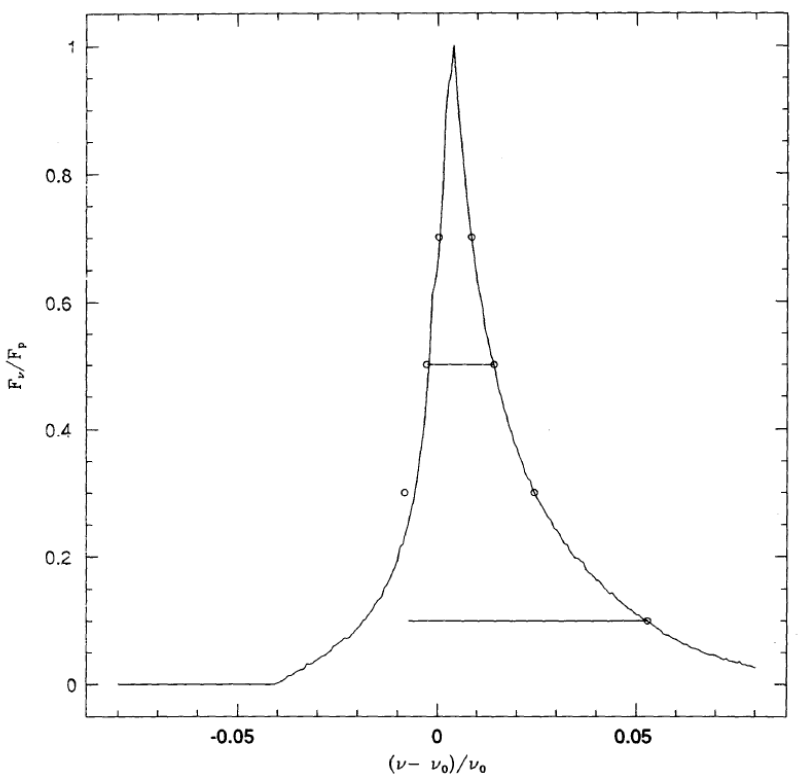
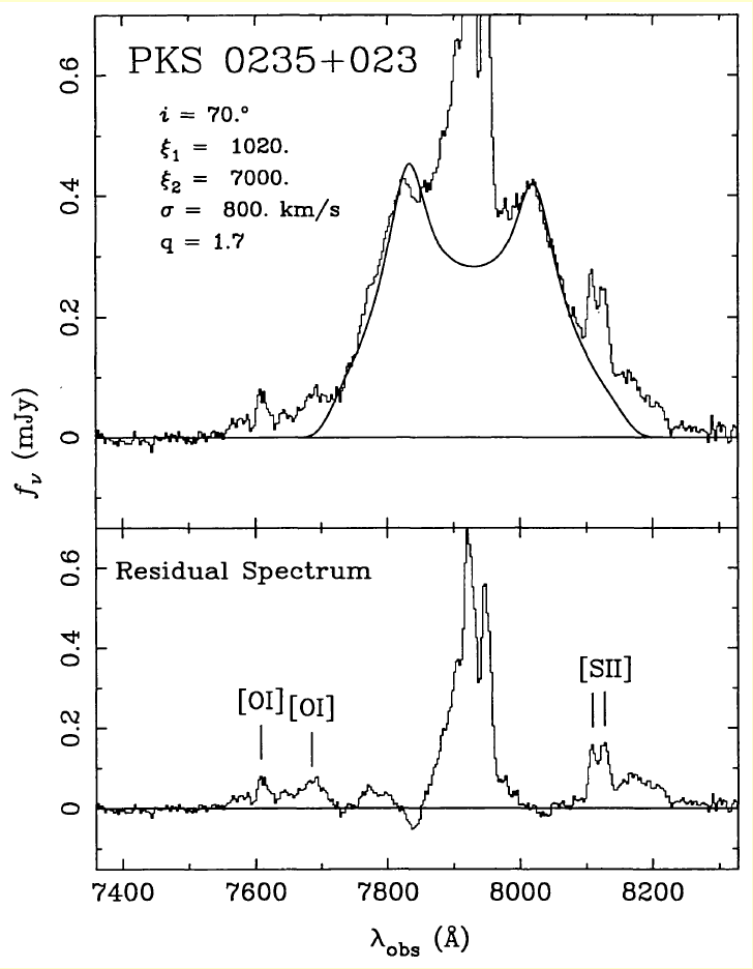


FIG. 5.—The best-fitting model, model 1 (the dashed profile of Fig. 4). The lower and upper solid lines have lengths of 5000 and 18,000 km s^{-1}, representing the FWHM and FWZI, respectively, of a typical C IV profile. The small circles show the asymmetry which would be expected of a typical C IV profile. For this profile, we find the cuspiness measure $C_{0.2} \approx 0.7$ (C_x is defined in eq. [2.5]).



"Typical" profile (Emmering+92)

Double peaks (Eracleous & Halpern 94)

Double Peakers

- Only ~3% of general broad-line population
- Mostly low accretion rates
- Fairly high detection rate at low L/L_{edd}
- Double peaks in many 1.8/1.9 but not 1.2/1.5

BLR Low-Luminosity Evolution

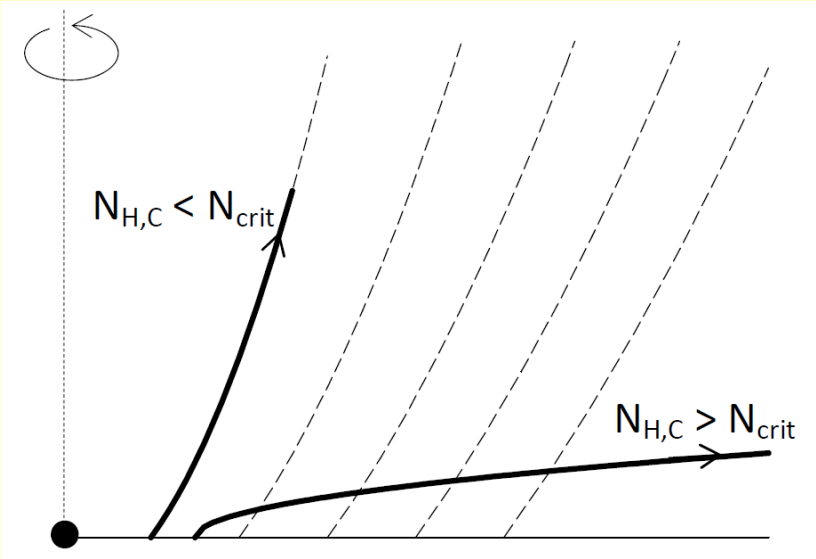
- Spectral type $1 \rightarrow 1.2/1.5 \rightarrow 1.8/1.9 \rightarrow 2$ is an evolutionary sequence:
  - Broad lines “covering factor” decreases
  - Double-peaked profiles emerge
  - Evolution governed by $L/M^{2/3}$

Cloud Trajectories

Force = Wind ram pressure – Gravity

$F_{grav} / F_{ram} \sim N_{H,C} / N_{crit}$

$$N_{crit} = \frac{\dot{M}_w}{4\pi m_H \sqrt{GMr}} = N_{crit}(R_d)\left(\frac{R_d}{r}\right)^{1/2}$$



Kartje+ '99

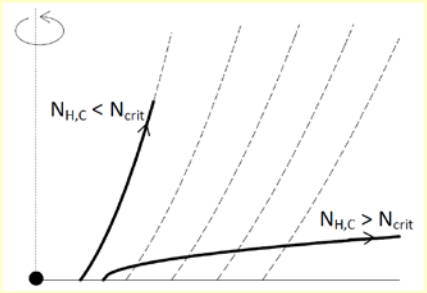
A mix of "wind" + "disk" populations

A Two-Component BLR

BL Emission: $N_{H,C} > N_{H,min} \sim 5 \cdot 10^{21}$ cm^{-2}

"wind" : $N_{H,min} < N_{H,C} < N_{crit}(R_d)(R_d/r)^{½}$

$$N_{crit}(R_d) = 4 \cdot 10^{22} \frac{1}{\eta_{-2}} \left(\frac{L_{45}}{M_7^{2/3}} \right)^{3/4} \quad \text{cm}^{-2}$$



- As L decreases, N_{crit} (~$L/M^{2/3}$) decreases
- More clouds become supercritical ("disk")
- Less central luminosity is intercepted
- Double-peaked profiles emerge
- Effect spreads from outside in

Conclusion

- With the mean $L/M^{2/3}$ for AGN 1.0 and η = 5%,
  N_{crit} ~ $2 \cdot 10^{22}$ — $2 \cdot 10^{23}$ cm^{-2} across the BLR
- $L/M^{2/3}$ spans more than 9 orders of magnitude,
  yet the Sy 1.x onset occurs at the right place
- "wind" + "disk" mix explains naturally the sequence
  Type 1 $\rightarrow$ 1.2/1.5 $\rightarrow$ 1.8/1.9 $\rightarrow$ "true" type 2
- Prediction: Effect spreads from outside in