Structure and Evolution of the AGN Torus and Broad Line Region

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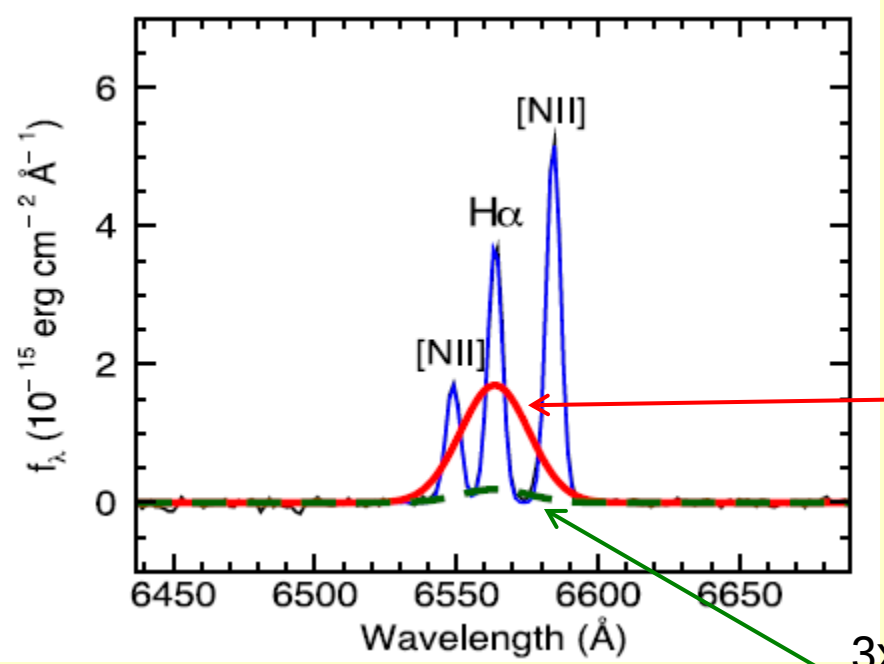
Unification

- All AGN are intrinsically the same
  - differences $\Leftrightarrow$ viewing direction
- Evolution $\Rightarrow$ dM/dt decreases
  - When dM/dt = 0, the AGN is gone
- Evolution $\Rightarrow$ can AGN be intrinsically the same?

Low Luminosities

- Torus disappears
  - Obscuration (Chiaberge+ 99, Maoz+ 05)
  - Thermal dust emission (van der Wolk+ 10, Trump+ 11)
- Broad Lines disappear (true type 2)



GSN 069 (Miniutti+ 13)

$L = 10^{43}$ erg s^{-1}

$M = 1.2 \times 10^6$ M_o

$L/L_{Edd} = 0.53$

expected Hα

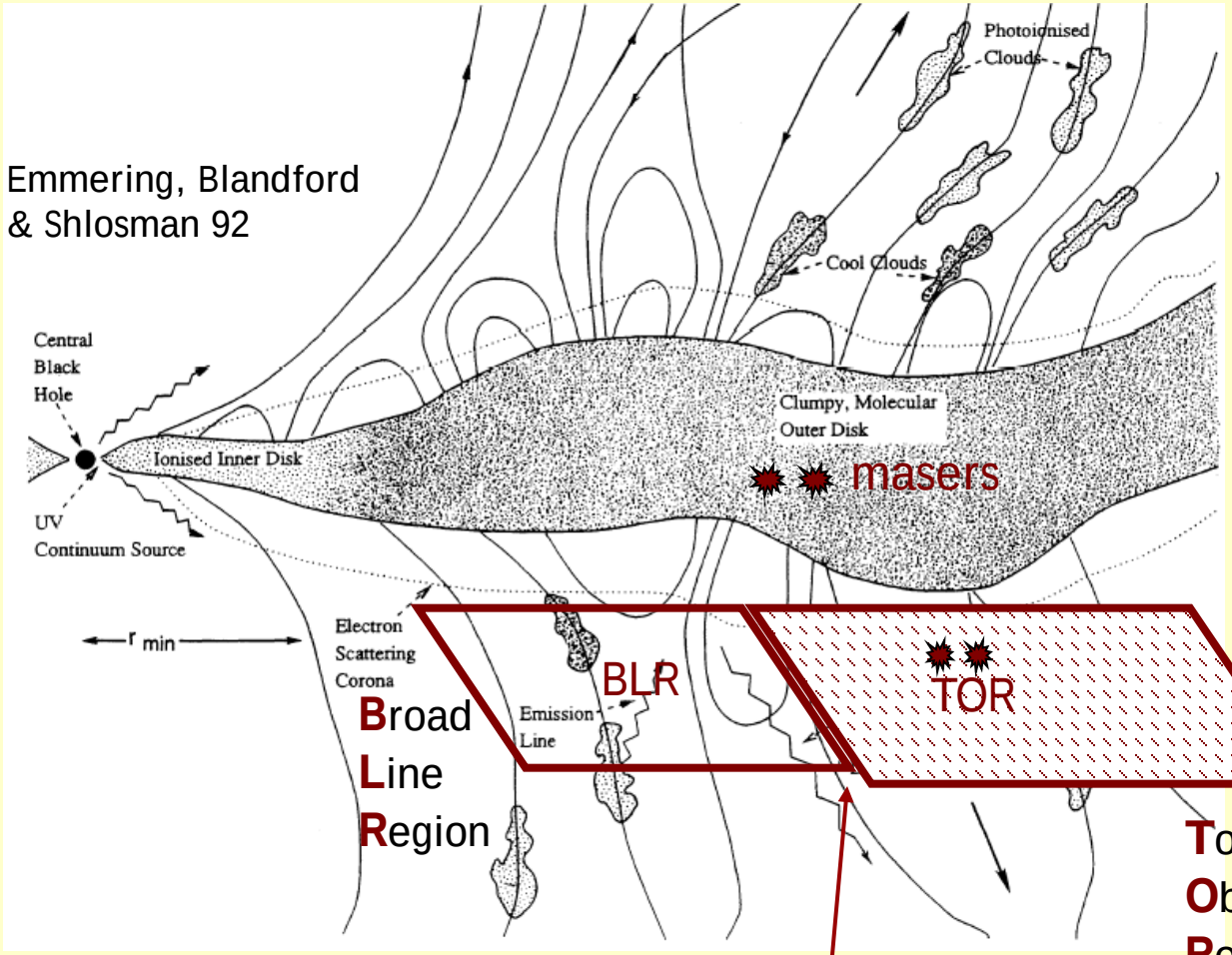
3x residuals (upper limit)
~ 9x less than expected

Fundamental Constraint

- Obscuration, broad line emission require minimal column, N_{min}
- $N_R = \int n(R)\, dR$

$$N_R > N_{min}$$

The Disk-Wind Scenario



Disk-Wind Mass Continuity

BLR or TOR: $N_w \equiv \frac{\dot{M}_w}{4\pi m_p R_d v_{Kd}} = IN_R > IN_{min}$

$L = \varepsilon \dot{M} c^2 = \varepsilon r \dot{M}_w c^2$ $\qquad r = \dot{M}/\dot{M}_w$

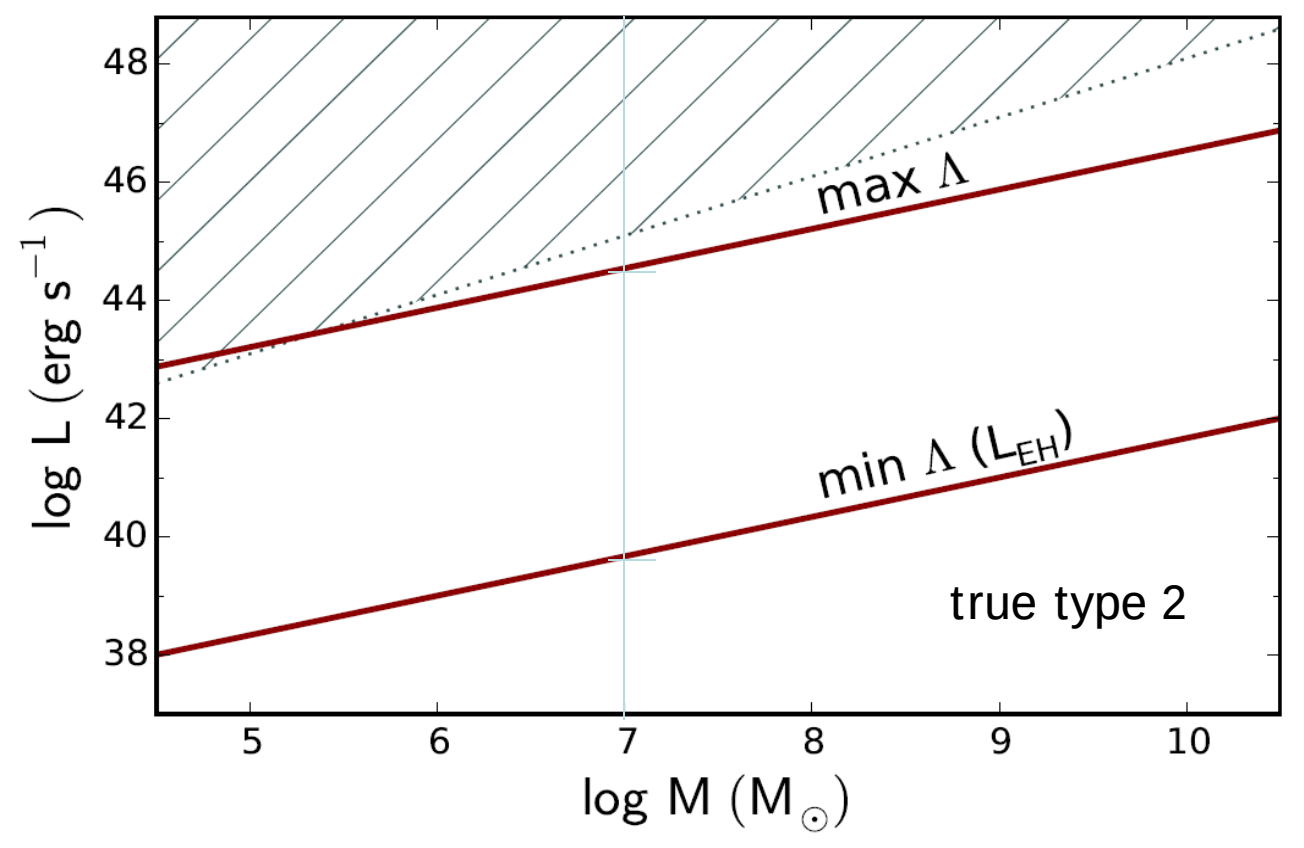
$$\boxed{L > L_{min} = \Lambda M_7^{2/3}}$$

$\Lambda = 3.3 \times 10^{45} (\varepsilon r I)^{4/3}$ erg s^{-1}

BLR/TOR must disappear at small L!

Elitzur & Shlosman '06

Broad Line Emission Constraint

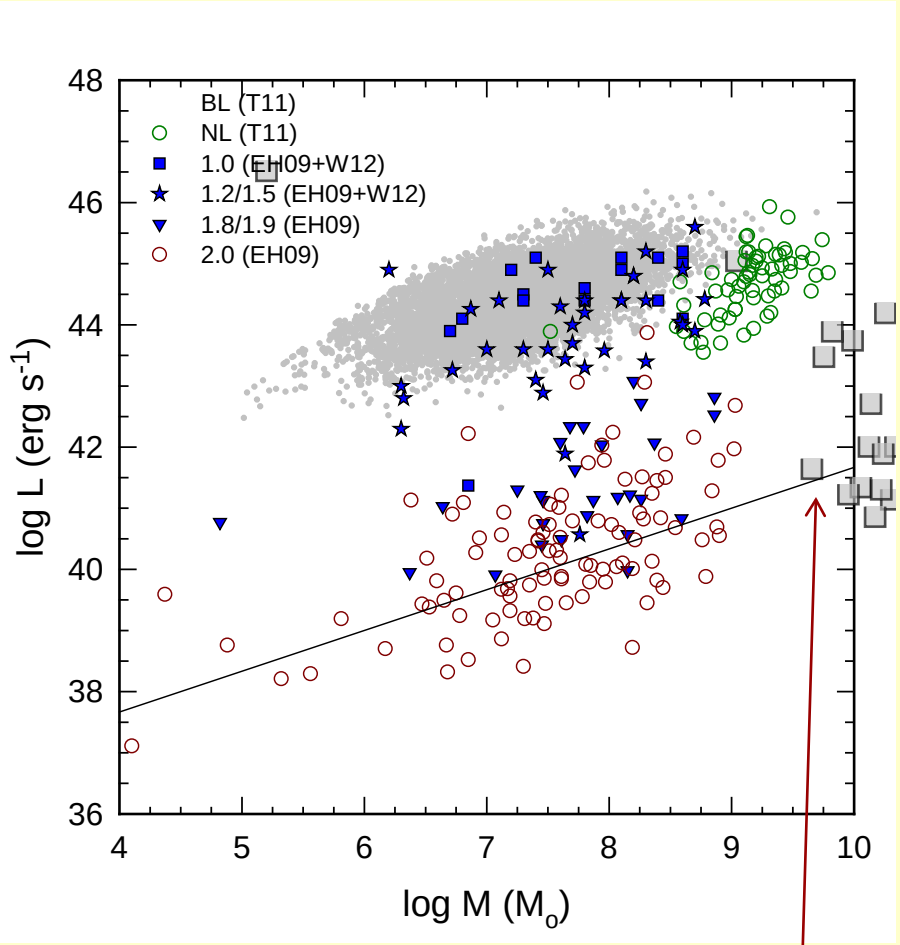


$L > L_{min} = \Lambda M_7^{2/3}$ $\Lambda = 3.3 \times 10^{45} (\varepsilon r l)^{4/3}$ erg s^{-1}

5×10^{39} erg s^{-1} <~ Λ <~ 4×10^{44} erg s^{-1}

Elitzur & Netzer '15

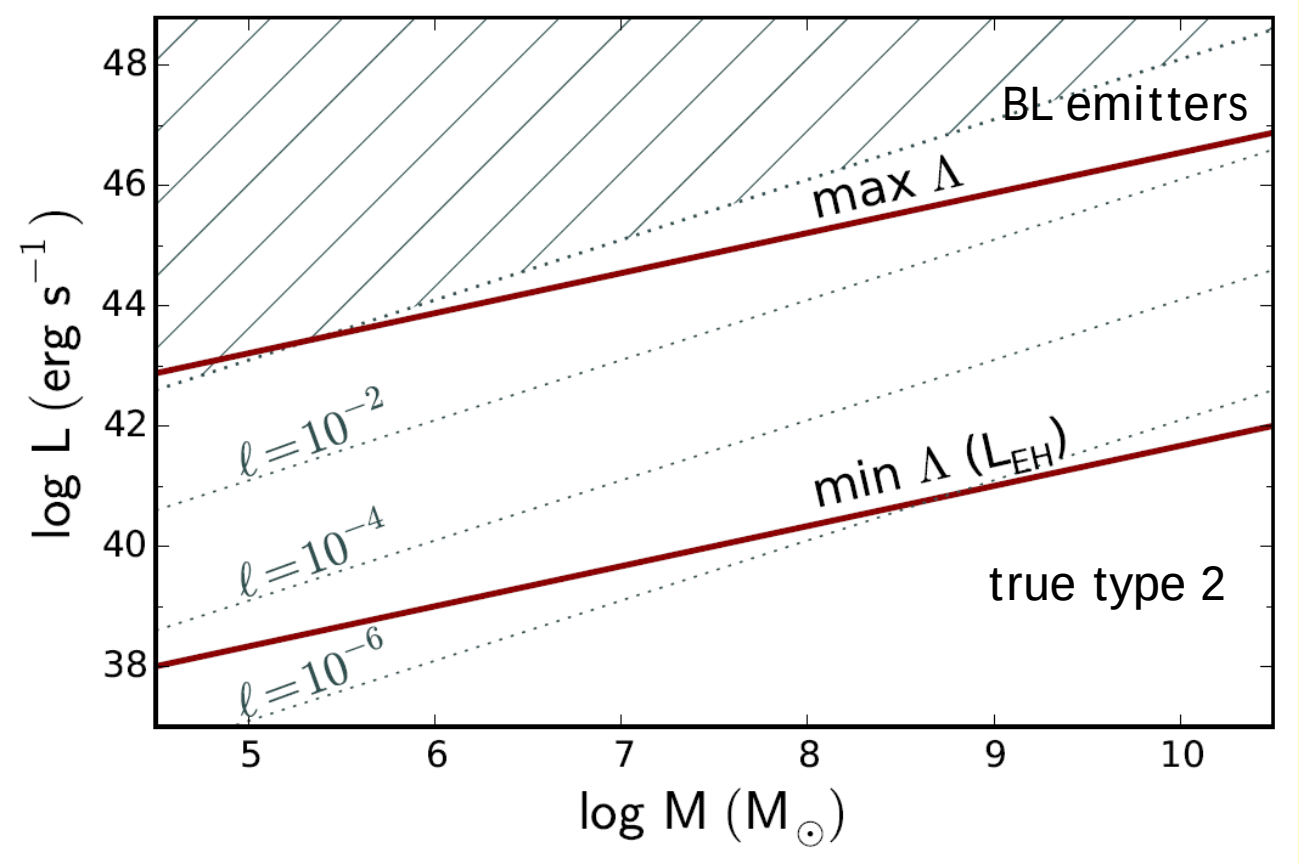
Broad Line Disappearance



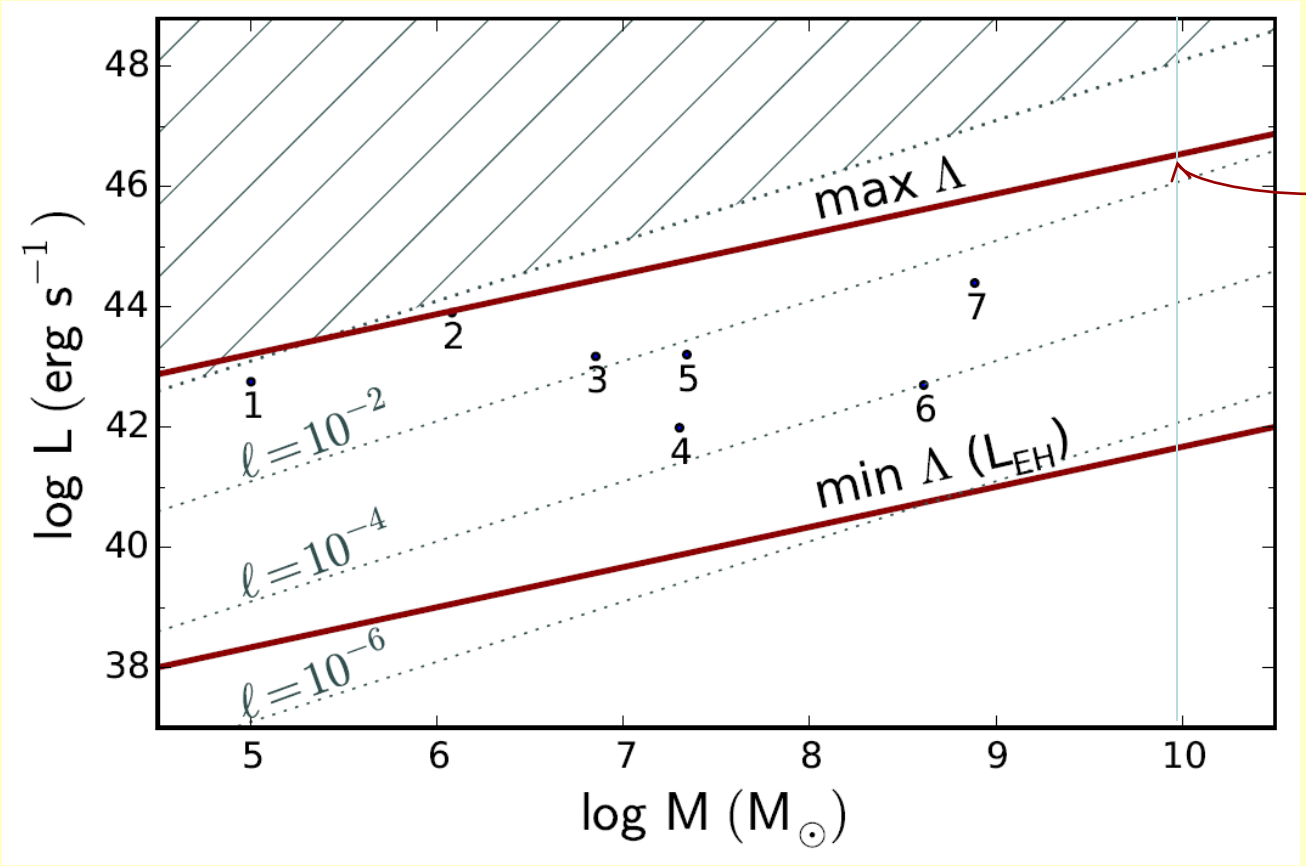
$L = 5 \times 10^{39} M_7^{2/3}$ erg s^{-1}

Elitzur & Ho '09

BL Emission & True Type 2



BL Emission & True Type 2



Confirmed True Type 2:

1 – Ho+12

2 – Miniutti+13

3, 6, 7 – Bianchi+12

4 – Shi+10, SL12

5 – Tran+11, SL12

Potential true type 2!

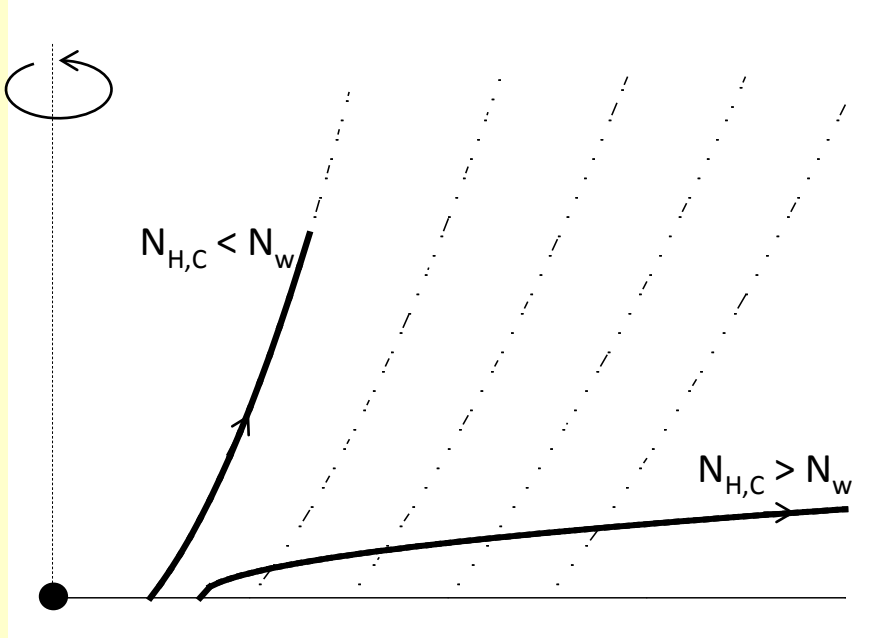
BLR Low-Luminosity Evolution

- Spectral type 1$\rightarrow$ 1.2/1.5 $\rightarrow$ 1.8/1.9 $\rightarrow$ 2 is an evolutionary sequence (Elitzur, Ho & Trump '14):
  - Evolution governed by $L/M^{2/3}$
  - Broad line "covering factor" (L_{BL}/L_{bol}) decreases
  - Double-peaked profiles emerge

Clouds

Force on a cloud = Wind ram pressure – Gravity

$$\frac{F_{grav}}{F_{ram}} \sim \left(\frac{r}{R_d}\right)^{1/2} \frac{N_{H,C}}{N_w}$$



Kartje+ ’99

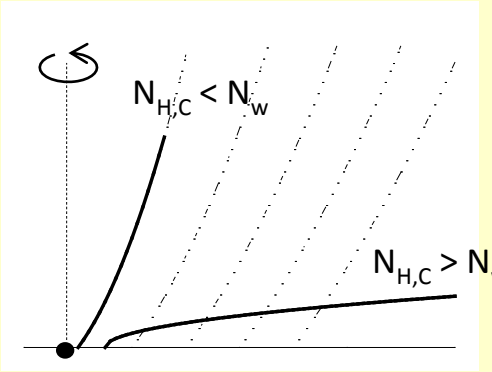
Elitzur+ ’14

A mix of “wind” + “disk” populations

A Two-Component BLR

"wind" : $N_{H,C} < N_w(R_d/R)^{½}$

"disk": $N_w(R_d/R)^{½} < N_{H,C}$



- As L decreases, N_w ($\propto L/M^{2/3}$) decreases
- More clouds become supercritical — "wind" $\rightarrow$ "disk", but not the other way!
- Less central luminosity is intercepted
- Double-peaked profiles emerge

Summary

- BLR (and TOR) disappearance — inherent to disk winds
  - Independent of wind properties (just mass conservation!)
  - All AGN with $L \lesssim 5\times10^{39}\ M_7^{2/3}$ erg s^{-1} are true type 2
  - True type 2 at any Eddington ratio & L as high as ~4×10^{46} erg s^{-1}
- Evolution controlled by L/L_{min} ($\propto L/M^{2/3}$)

- Seeding the wind with clouds explains $1 \rightarrow 1.x \rightarrow 2$
  - Lower BLR "covering factor" together with double peaks
  - Same property, L/L_{min}, controls both mass conservation and cloud motions