Risaliti and Elvis 2010A&A...516A..89R

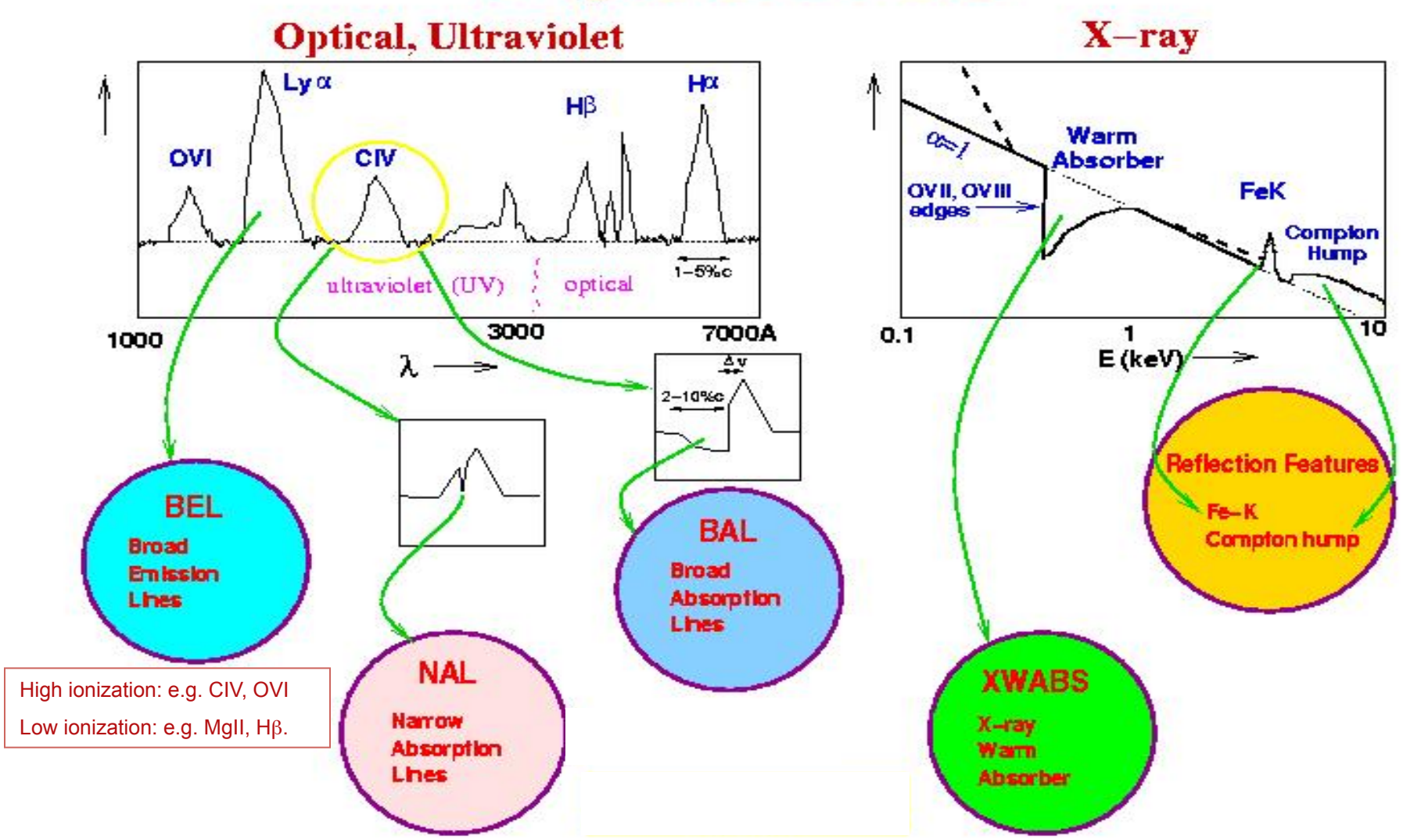
# AGN Structure from the Three Forms of Radiation Pressure

Martin Elvis

*Harvard-Smithsonian Center for Astrophysics*

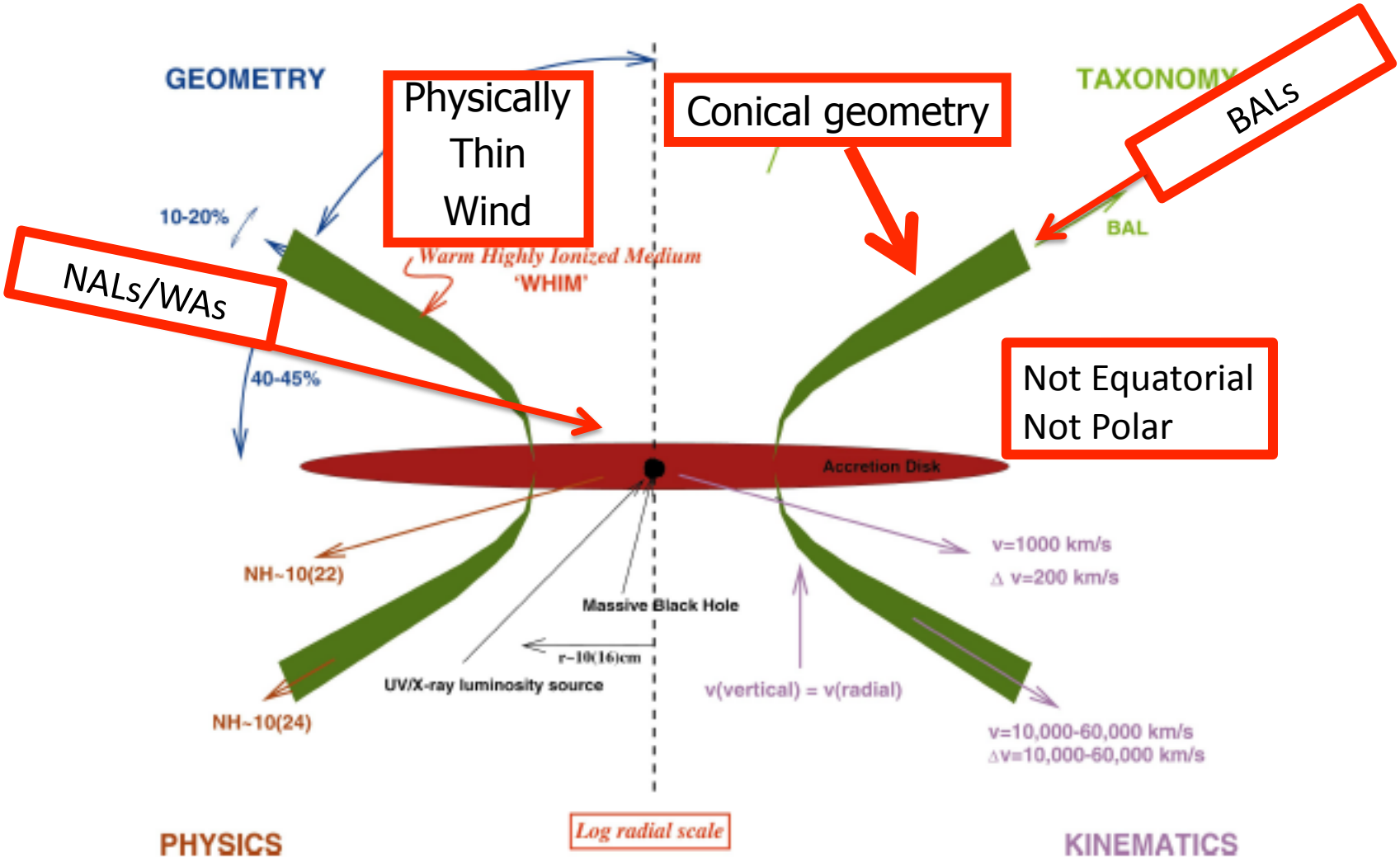
# Atomic Features in Quasar Spectra

Should have a Unified, Simple Theory



# Major Features of Elvis 'Funnel Wind'

Elvis 2000 ApJ 545, 63; 2003 astro-ph/0311436



# The 3 Forms of Radiation Pressure

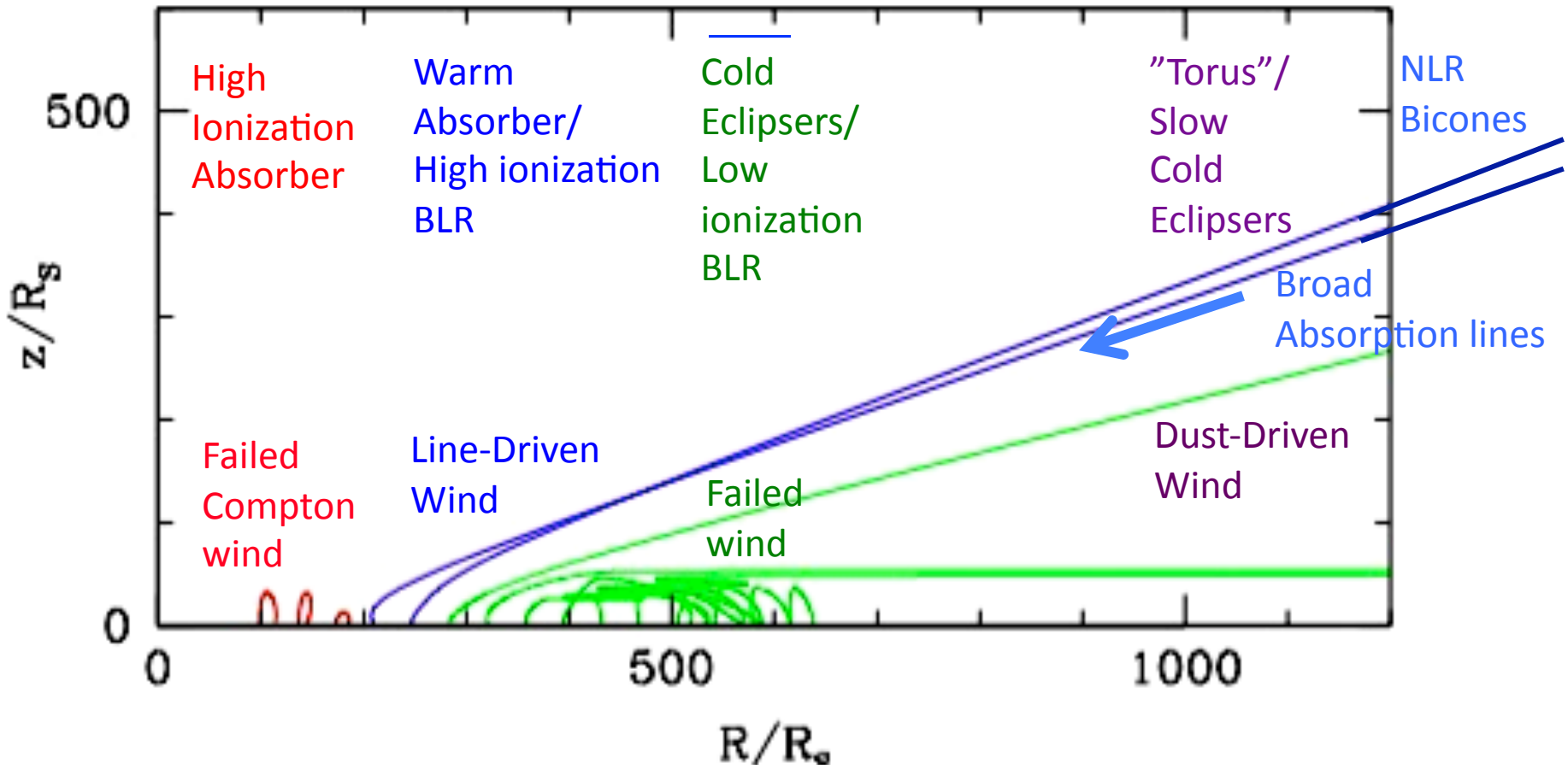
Structure of this talk:

1. Compton scattering – *short*
2. **Line driving - *long***
3. Dust driving - *short*
4. Implication - *short*

# *Claim:* Radiation Driving Determines Quasar Structure

Elvis 2000ApJ...545...63E

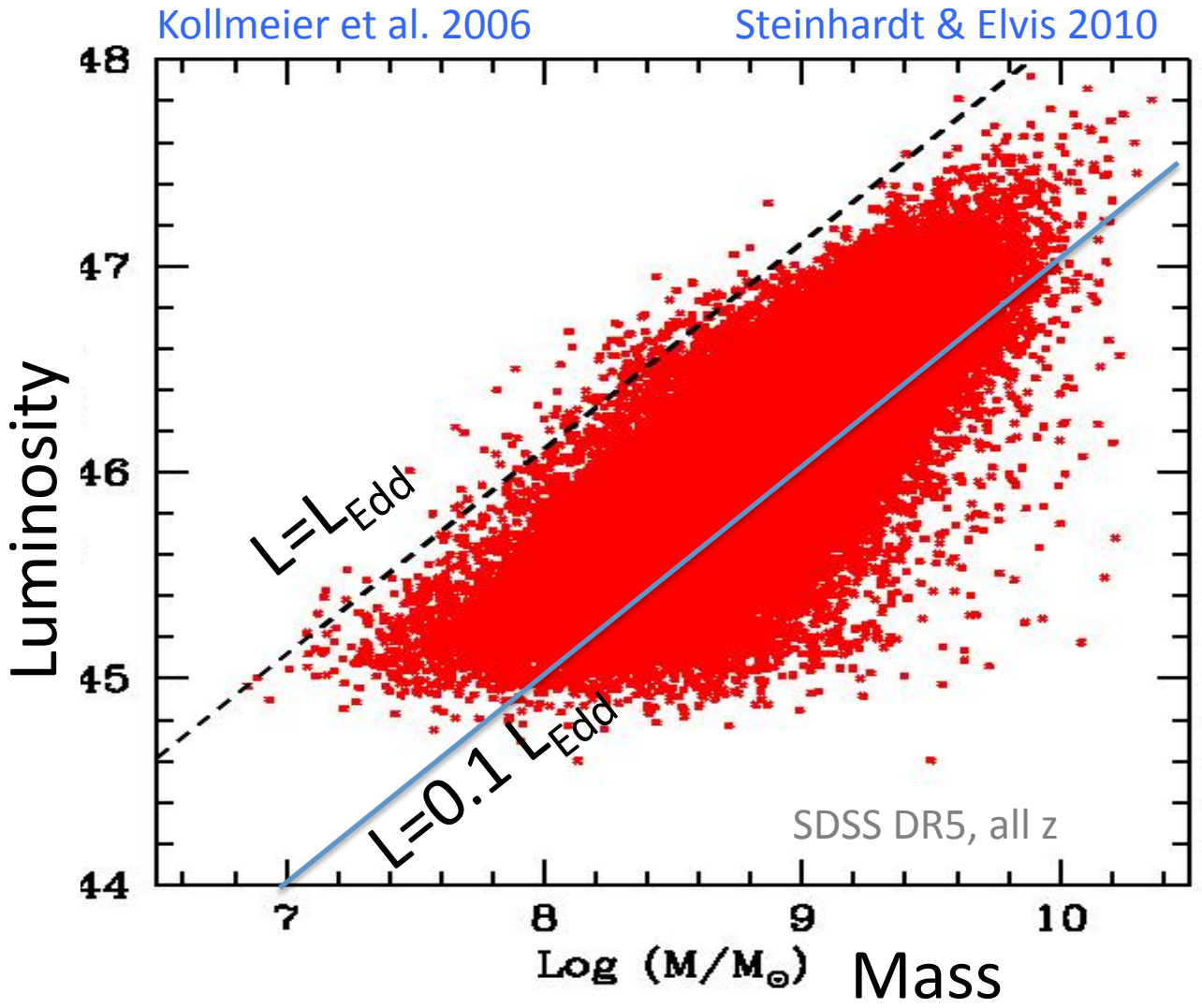
Risaliti and Elvis 2010A&A...516A..89R



# Compton Driving

# Only works at or above Eddington

Failed Compton wind in most AGN?



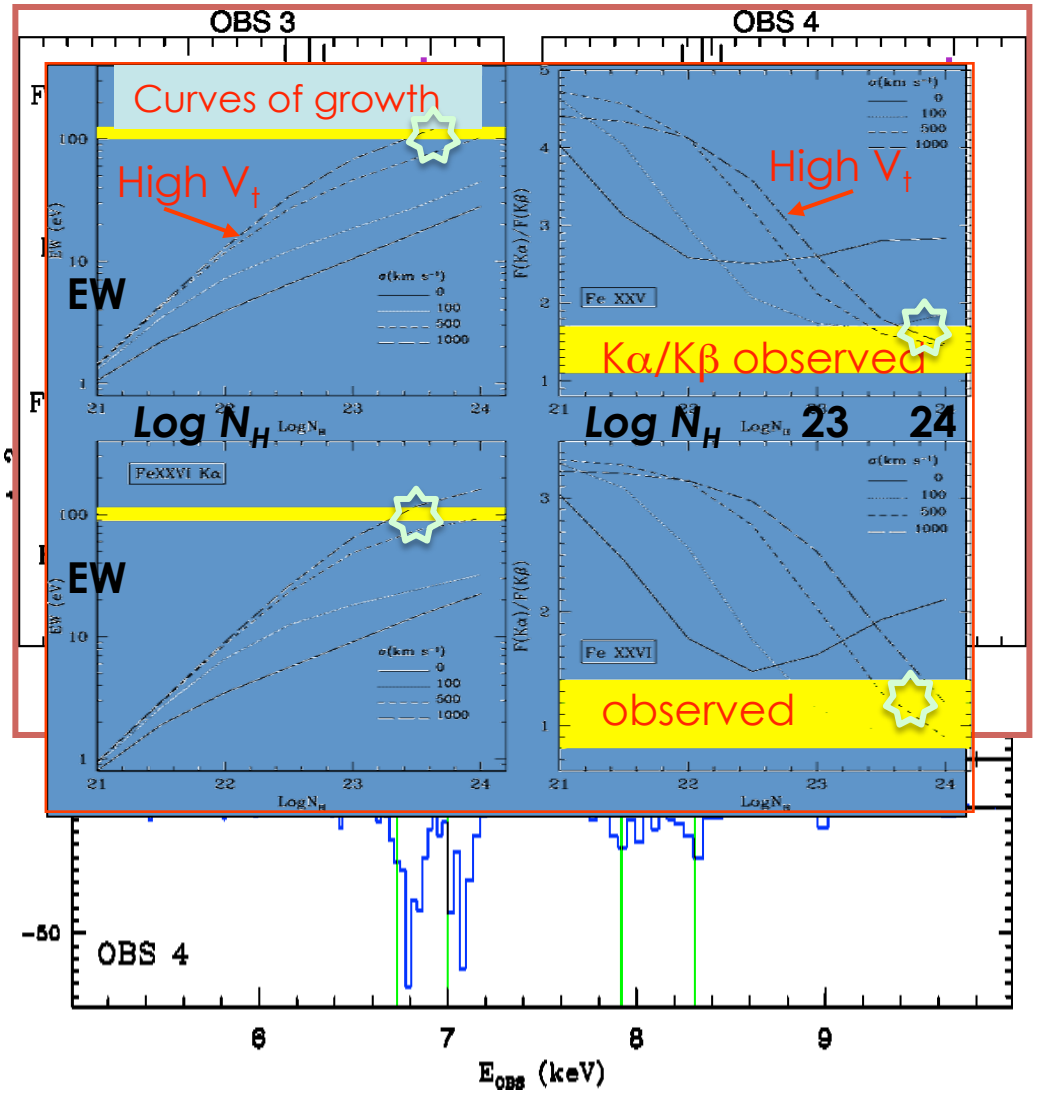
# Failed Compton Winds in Sub-Edd AGNs

- High Ionization WA:
  - *FeXXV, FeXXVI K-$\alpha$, K-$\beta$*
  - *log*$U_X$~0
- Variable velocity outflow
  - 2500 → 5000 km/s in 1.5 years
- Broadened
  - $v_{turb}$~500-1000km/s

  → Unstable, turbulent
- Compton ~thick
  - $N_H > 10^{23.5}$ cm$^{-2}$
  - Compton scattering
  - **R ~ 50**$(M/M_8)^{-1}$ **$R_s$**
- Not Eddington limited

→ "Failed wind"

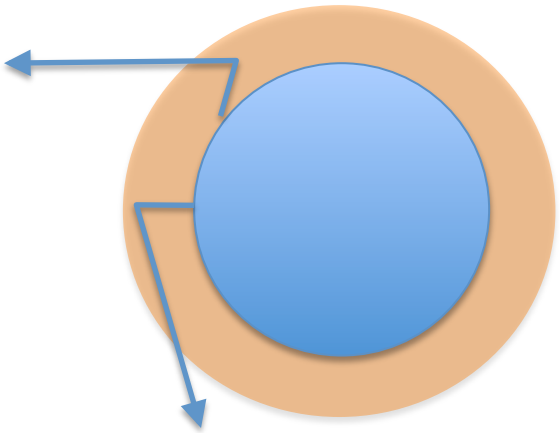
NGC1365: Risaliti et al., 2005, ApJL, 630, L129



# Disk Geometry Creates Shielding Gas

Risaliti and Elvis 2010A&A...516A..89R

Spherical: no net effect



*$\tau$ >~1 = "hitchiking gas" of Murray & Chiang 1997*

# Line Driving

# Warm Absorbers and Associated Absorbers

- Line Driving: Multiplier >100 x Compton scattering in O-stars– works far below $L_{Edd}$
  - Castor, Abbott & Klein 1975 (CAK)
  - Murray et al, Murray & Chiang, Proga, …
- Widely accepted for WA and UV NALs
- 2-3 phase medium fits all cases
  - Krongold et al., Netzer et al., Andrade-Velazquez et al. 2010ApJ...711..888A
- *Equatorial?*
- *Wide range of radii?*
- Non-analytical, hard to span parameter space with hydro simulations

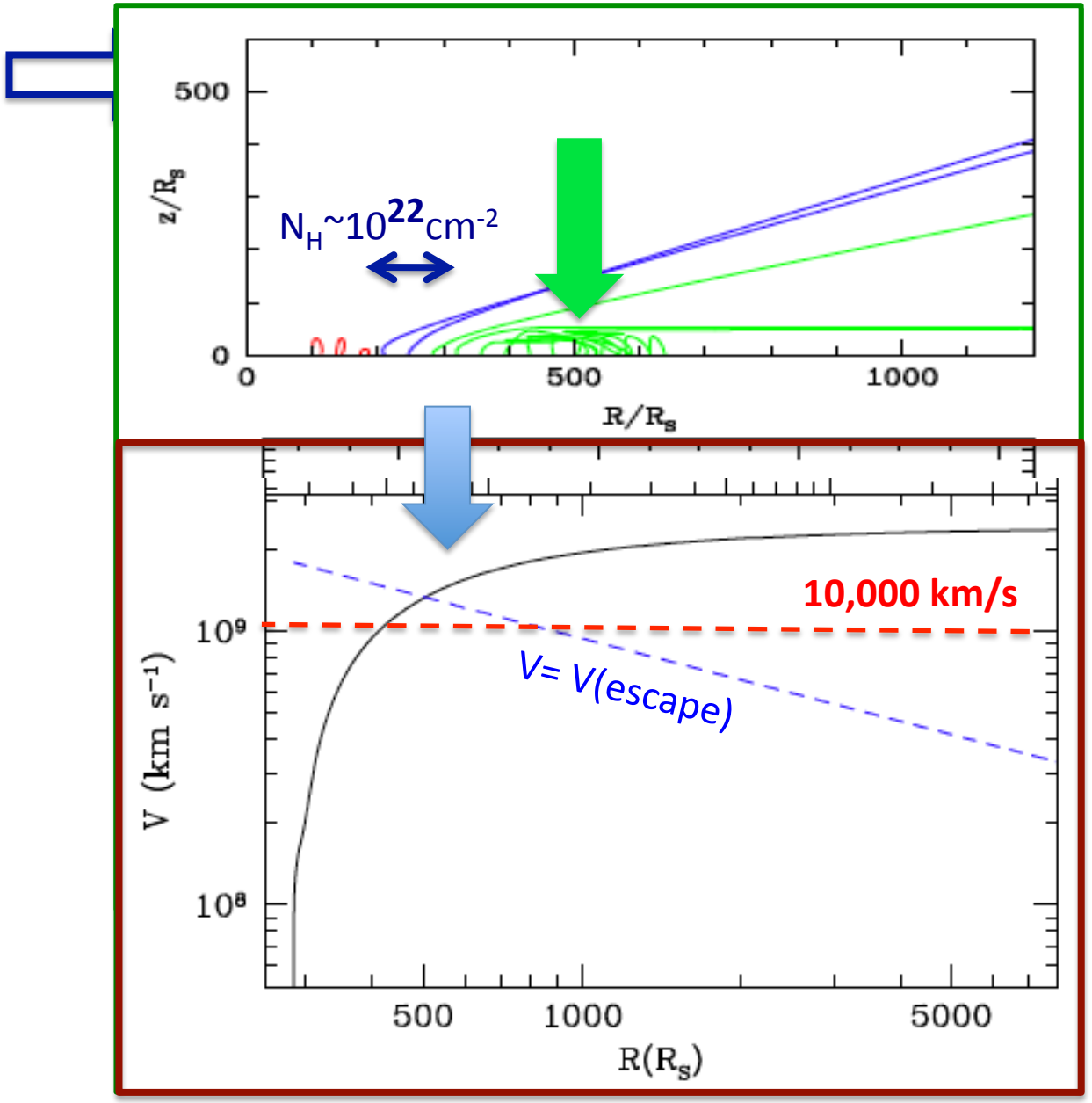
# A Non-Hydrodynamical Model for Acceleration of Line-Driven Winds in AGNs

Risaliti and Elvis 2010A&A...516A..89R

- Supersonic wind from early on
- Separate acceleration from launching
  - Initial vertical velocity
- Treat as gas elements
  - BH gravity
  - Line driven radiation pressure
  - Point X-ray source
  - Disk UV source
  - Radiative transfer
  - CLOUDY + CAK = QWIND

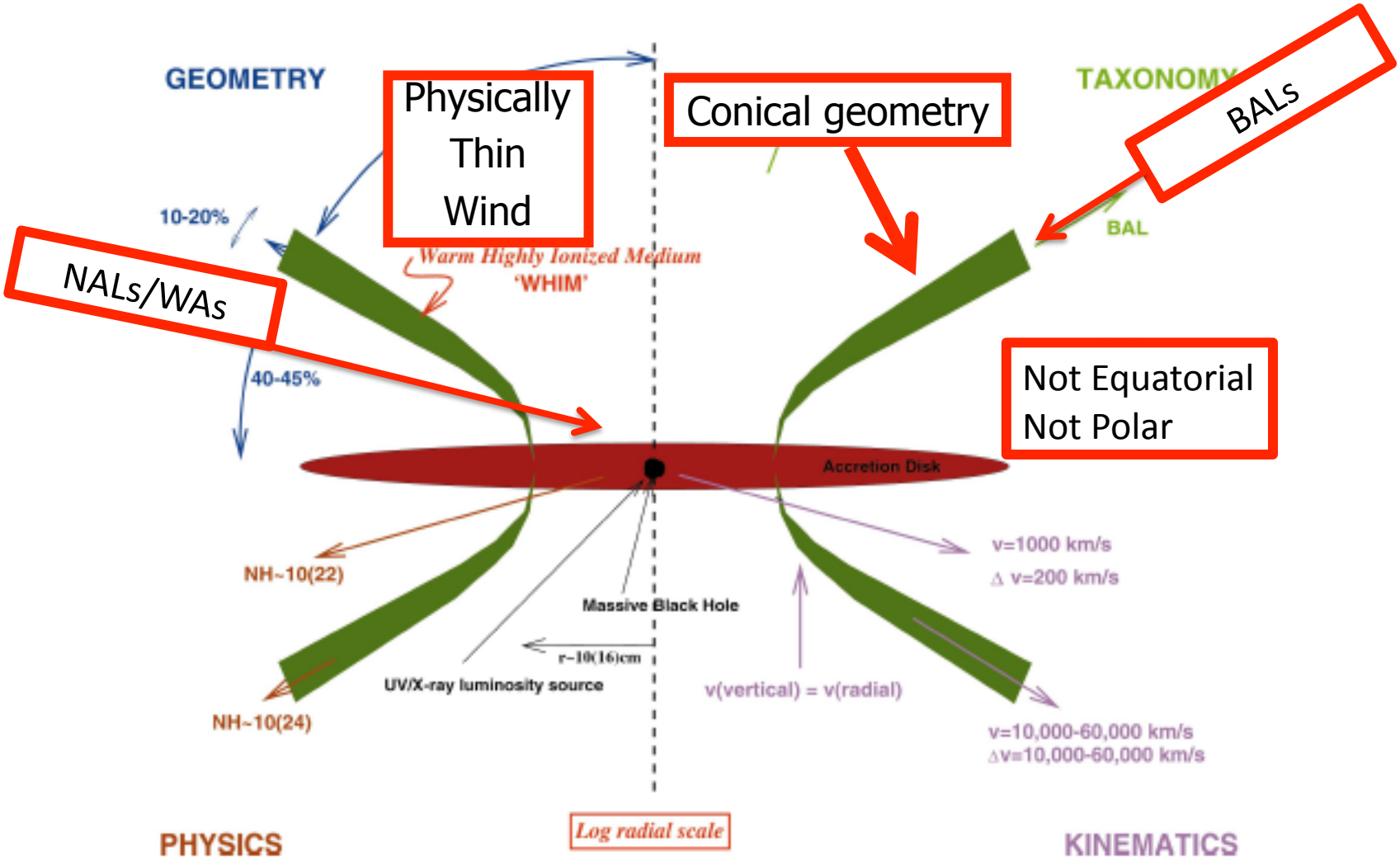
Same approach as: Icke et al. 1980; Tajima & Fukue 1996; Watarai & Fukue 1999

# Results

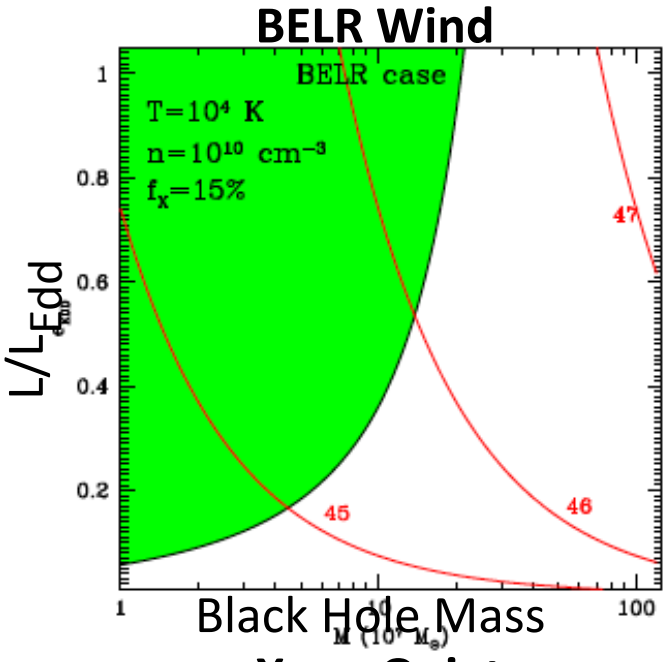

500
0
z/R_s
N_H~10^22cm^-2
0
500
1000
R/R_s
10,000 km/s
V= V(escape)
10^9
10^8
V (km s^-1)
500
1000
5000
R(R_s)

# Reproduces Major Features of Elvis 'Funnel Wind'

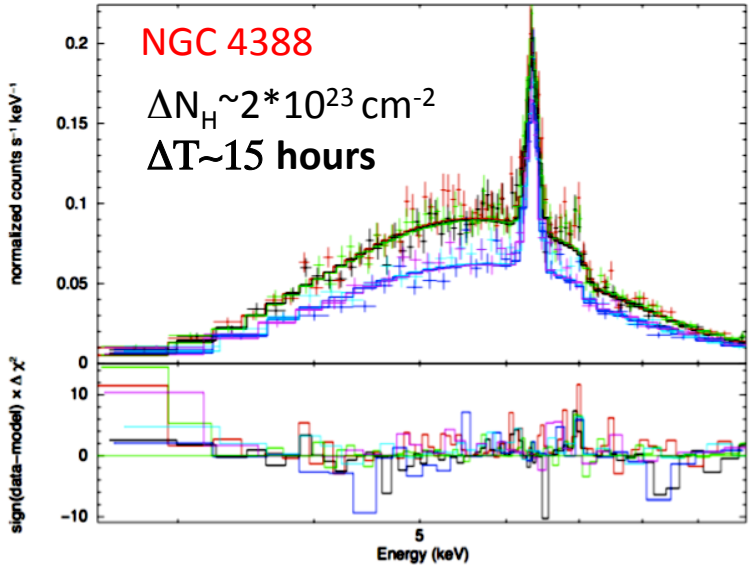
Elvis 2000 ApJ 545, 63; 2003 astro-ph/0311436



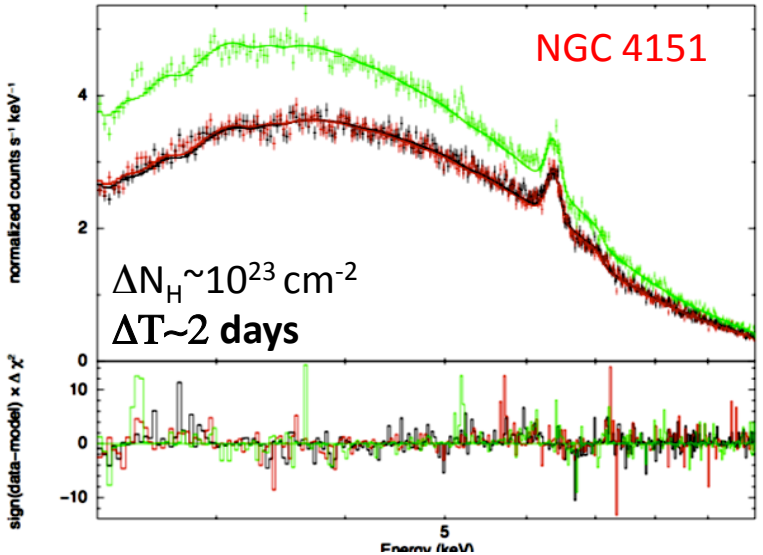
# Exploring Parameter Space



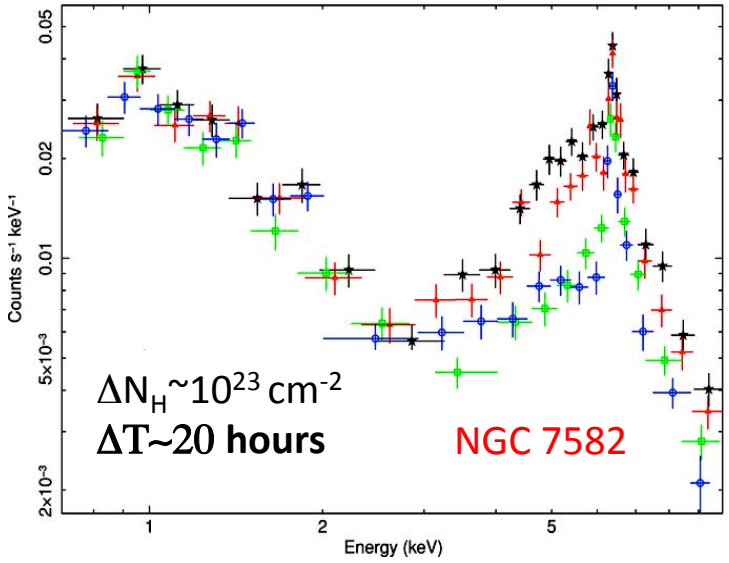
# Rapid X-ray Eclipses – days to hours



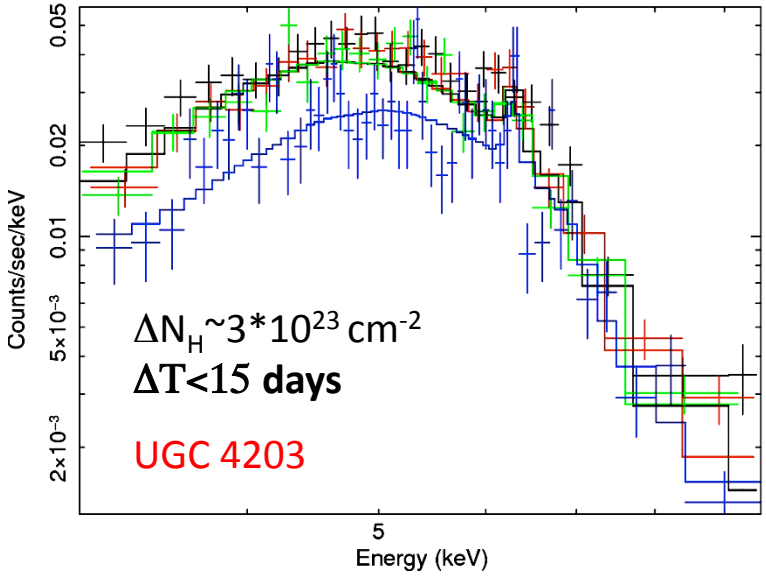

Elvis et al., 2004




Puccetti et al., 2007

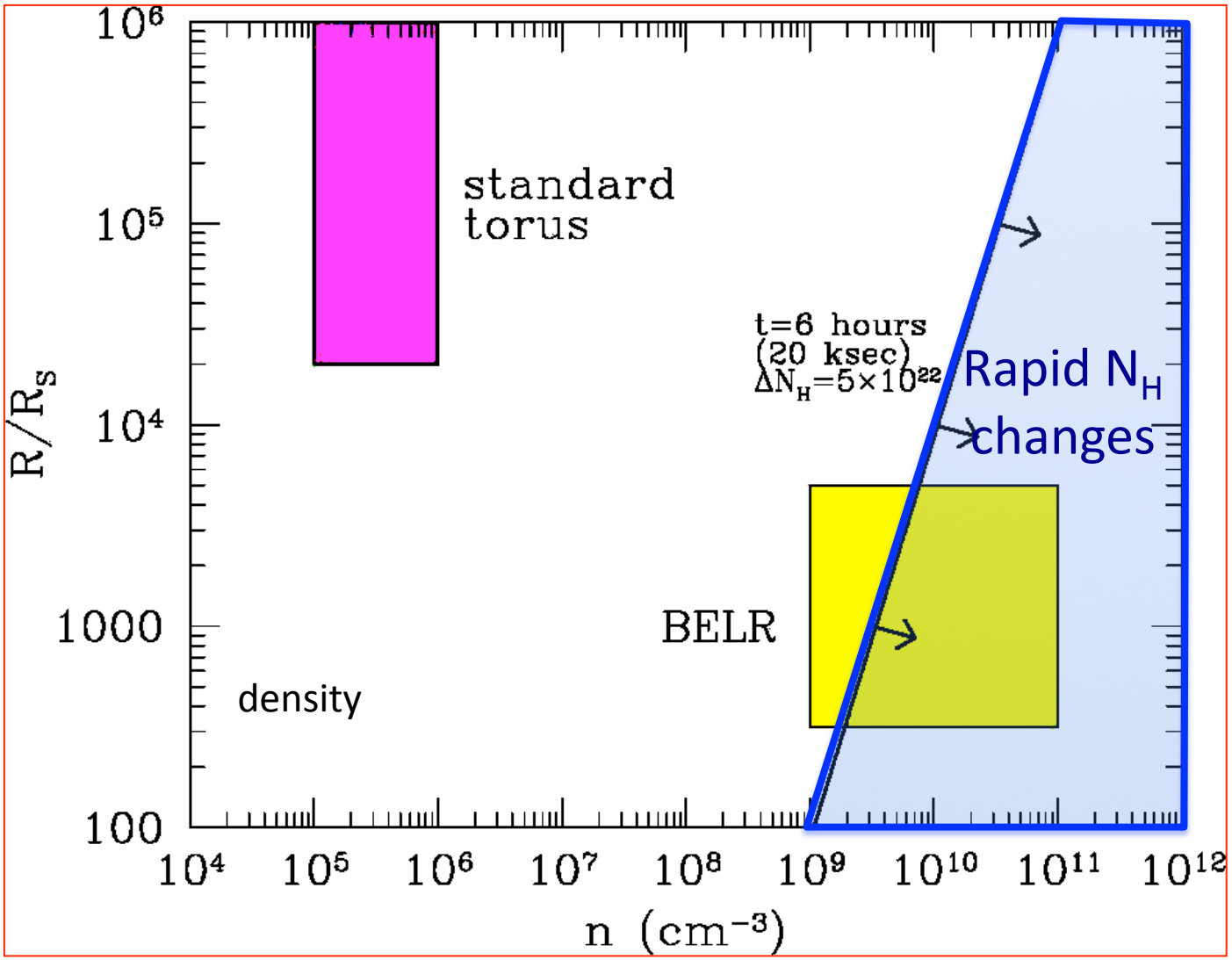



Bianchi et al. 2009




Risaliti et al., 2010

# Transiting, Transient BLR clouds

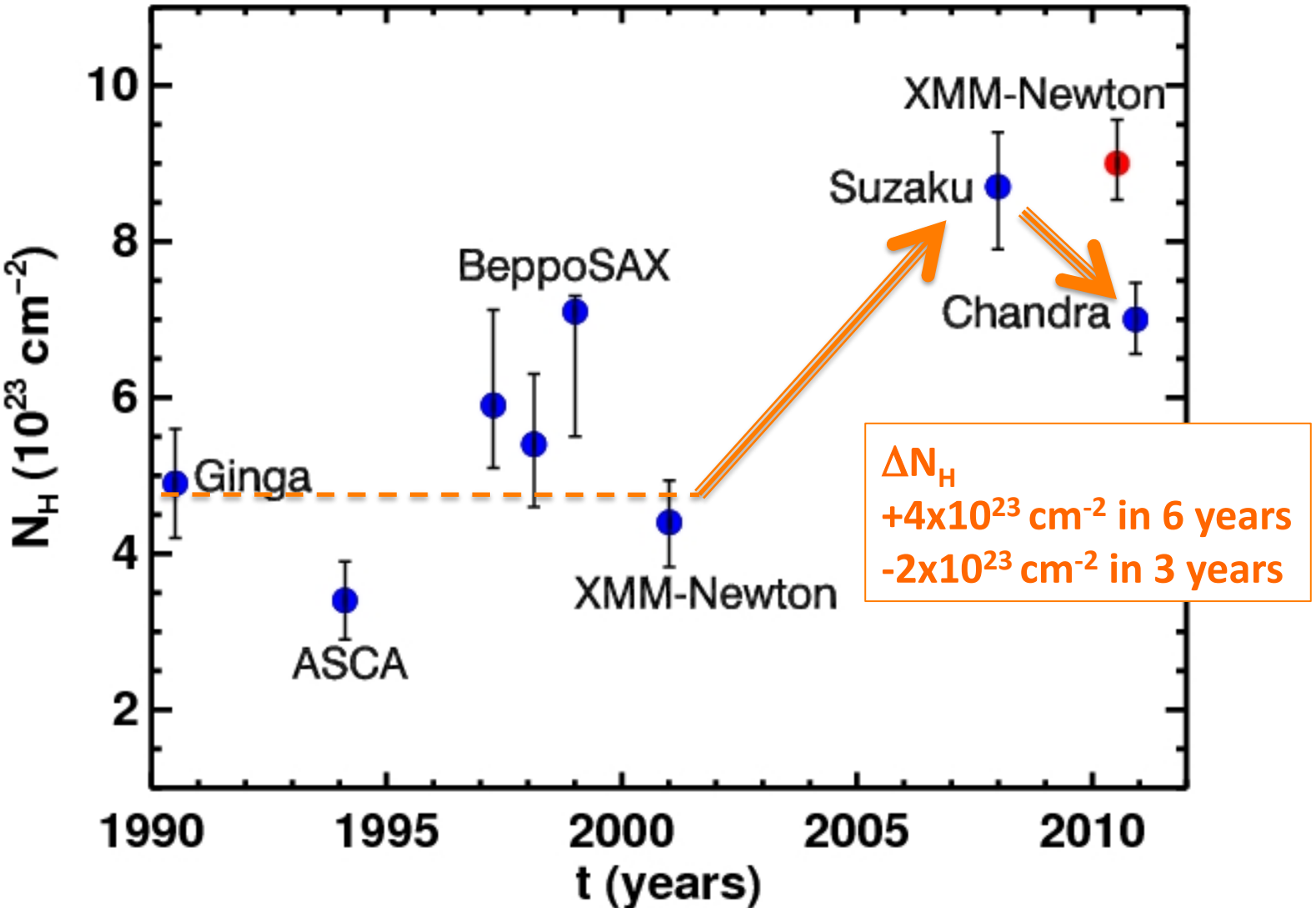



Sizes D ~ $10^{13}$ cm. Blobs or sheets?

# Dust Driving

# Slow $N_H$ Variations in NGC 4507

Marinucci, Risaliti & Elvis 2011, in prep.

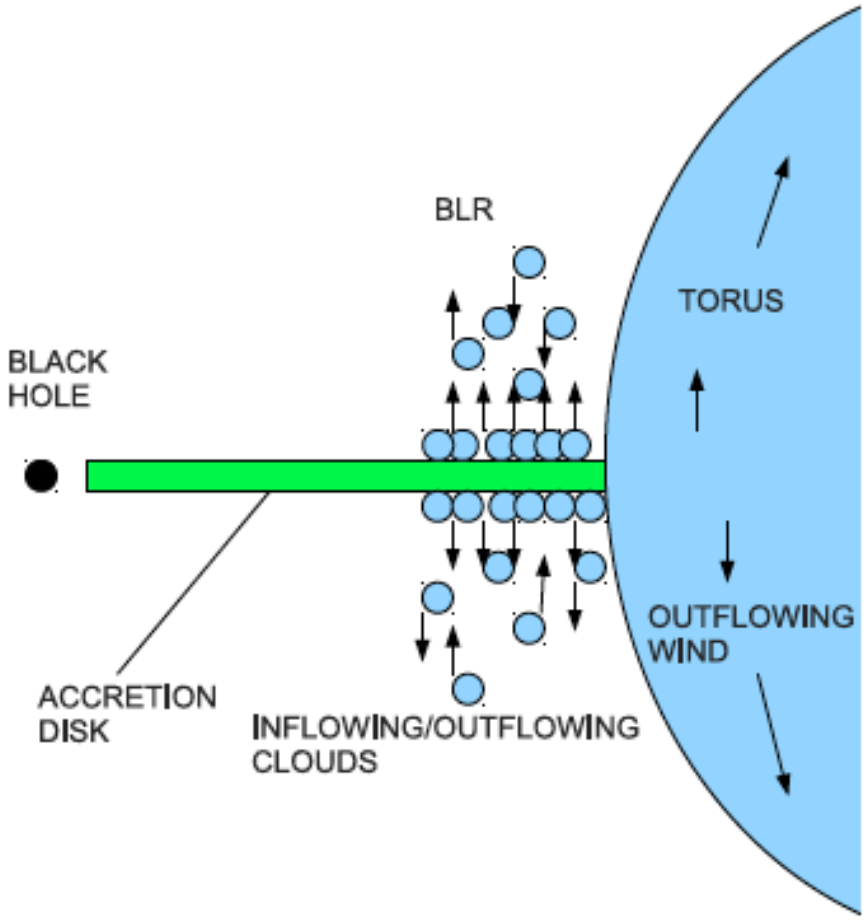



Other “type changing” AGNs

# BLR Clouds Launched by Dust Driving

Czerny & Hrniewicz 2011 A&A 525 L8

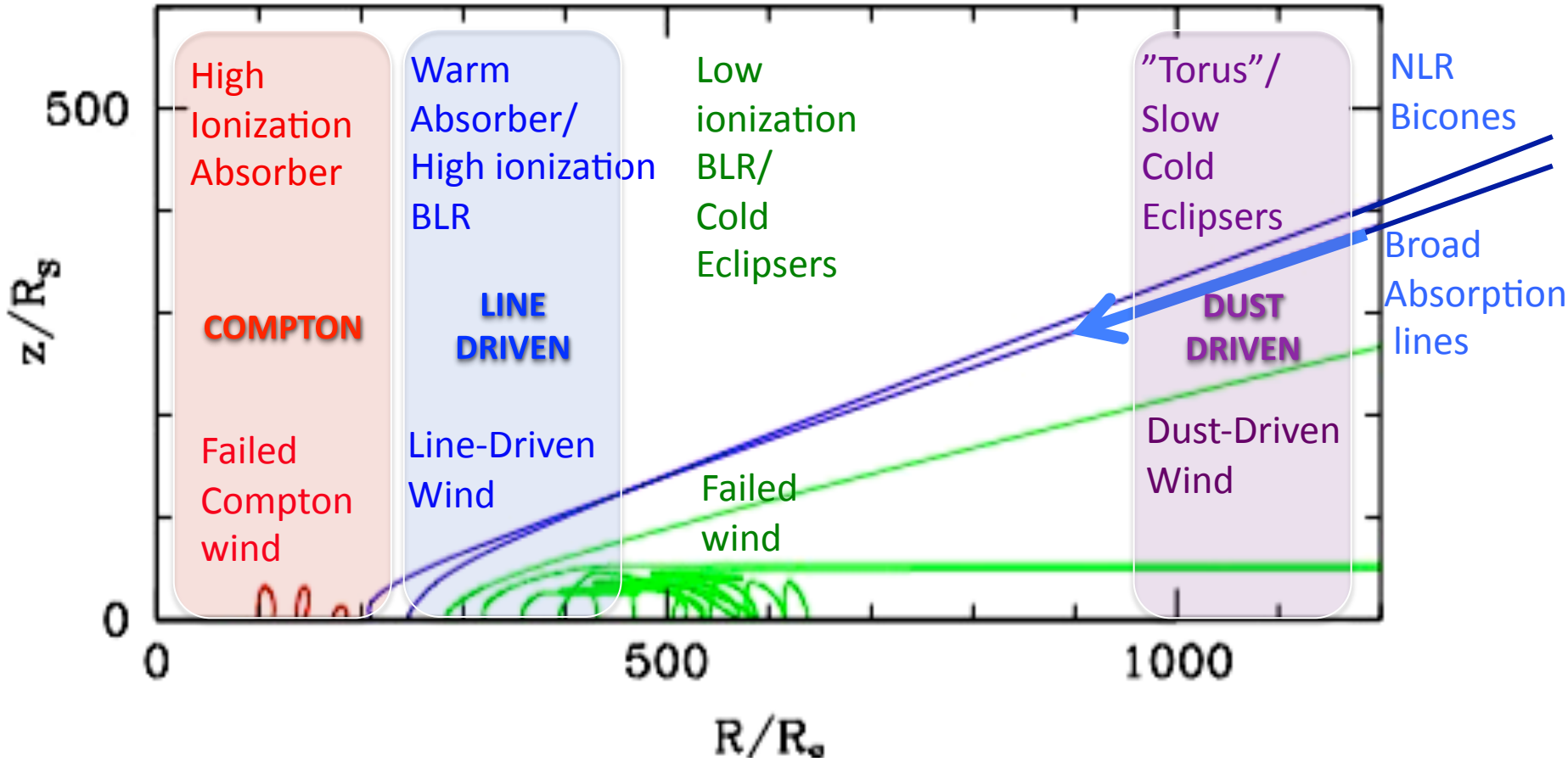
- Most efficient absorber
- Dust formed when outer disk atmosphere <1000K
- Happens from Hβ radius outward
- Slow $N_H$ eclipses ~years



# The 3 Forms of Radiation Driving Determine Quasar Structure

Elvis 2000ApJ...545...63E

Risaliti and Elvis 2010A&A...516A..89R




Good MBH From MgII

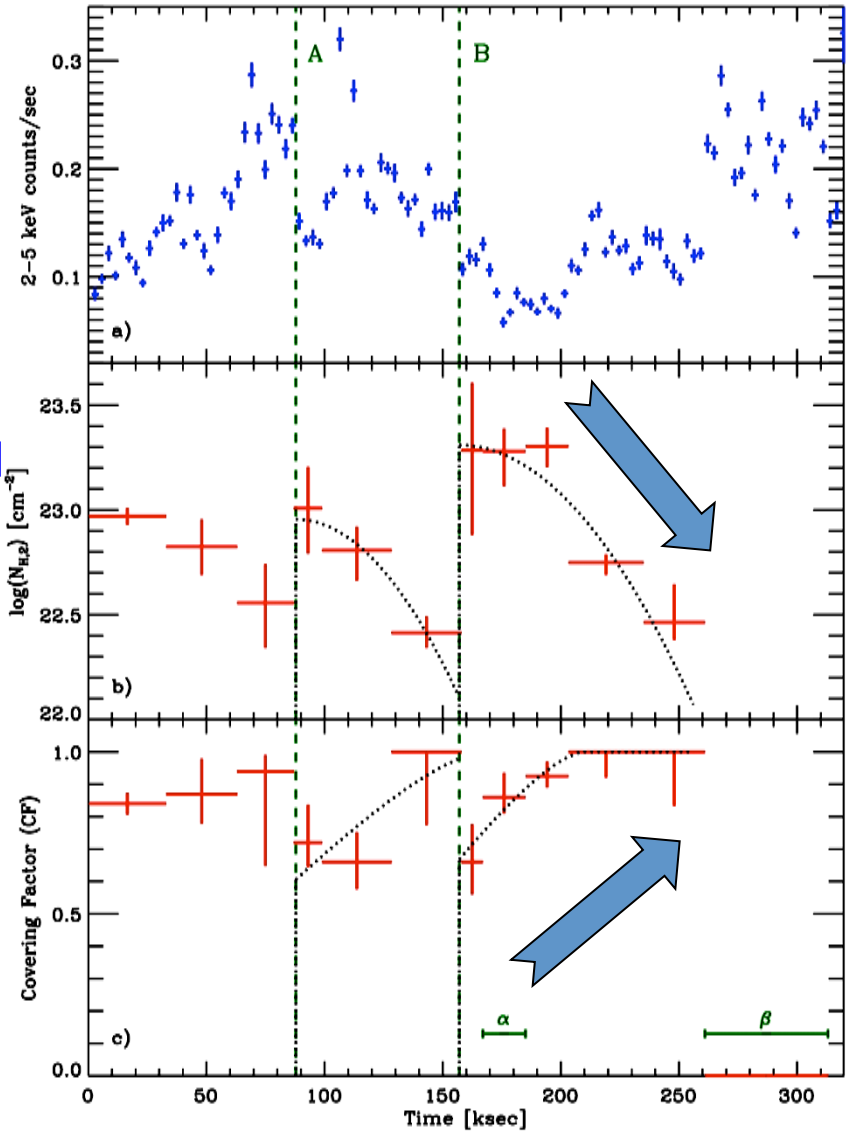
# Implication:
# Matter Launched at all Disk Radii

# Evidence: Short-lived BLR clouds, constantly renewed

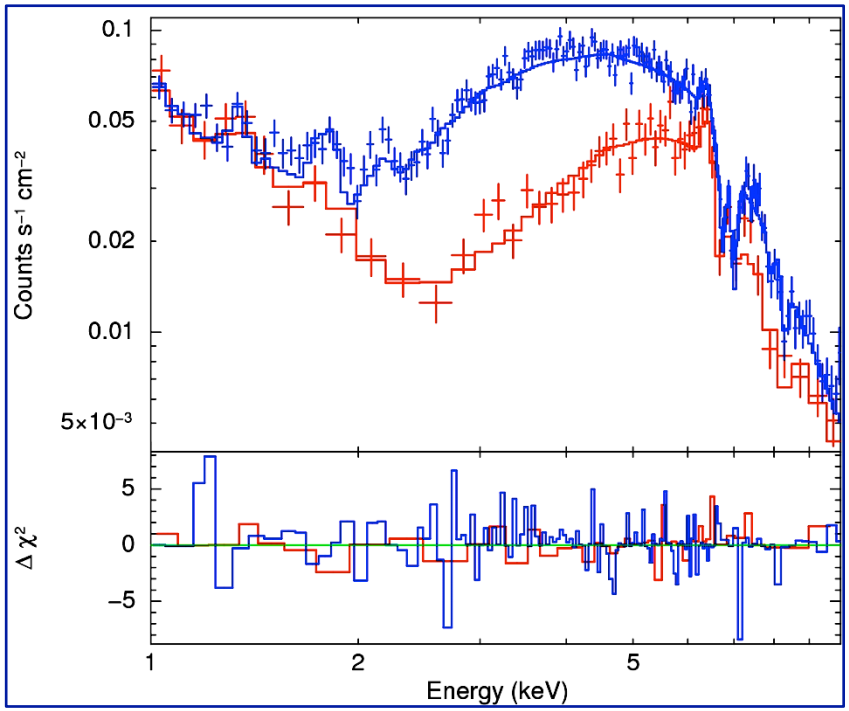
HR

$N_H$

CF



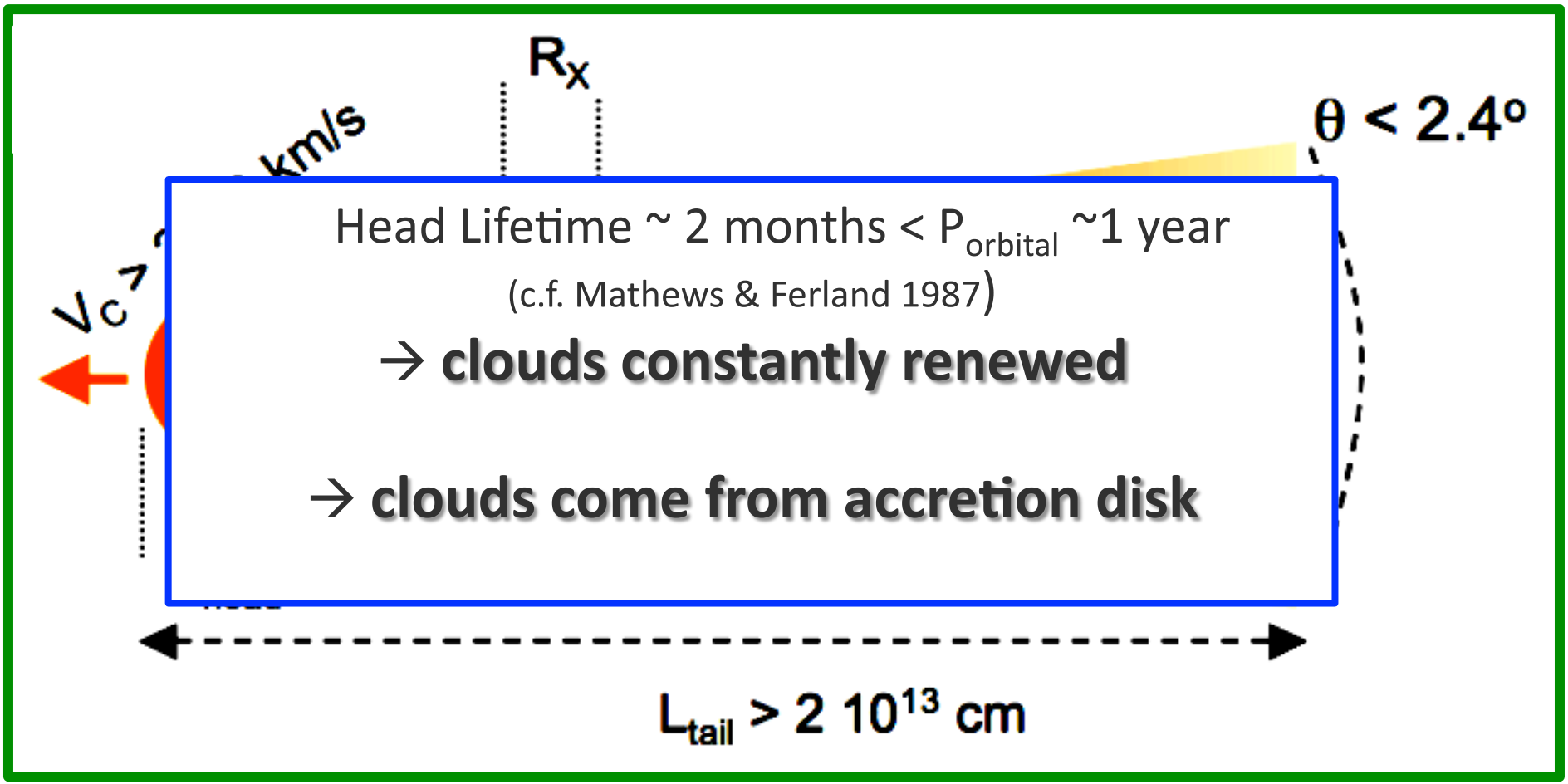

Maiolino et al. 2010



# Evidence: “Cometary” Eclipsers

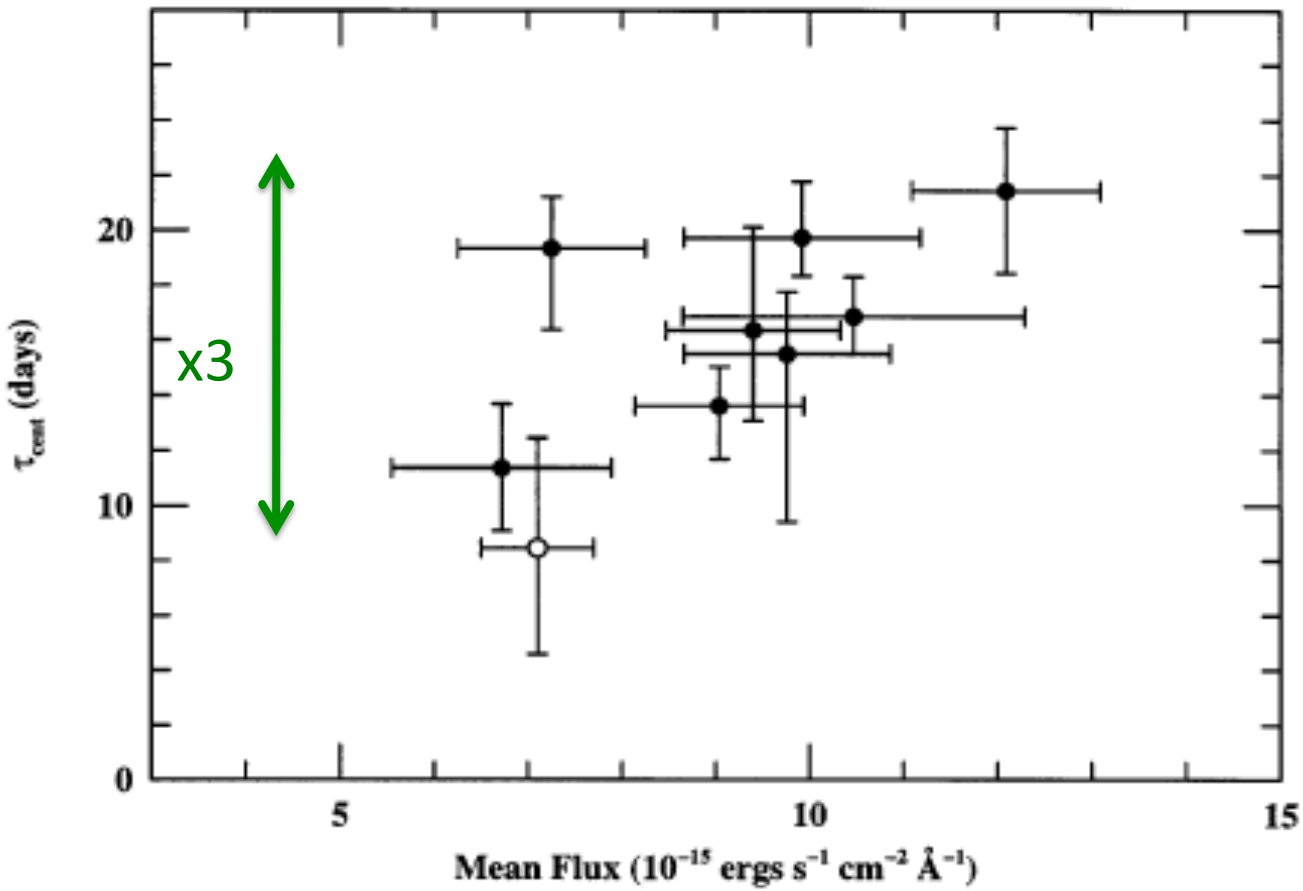
NGC 1365 Suzaku

Maiolino et al. 2010



# BLR ‘Breathing’

Peterson et al. 1999 ApJ, 510, 659



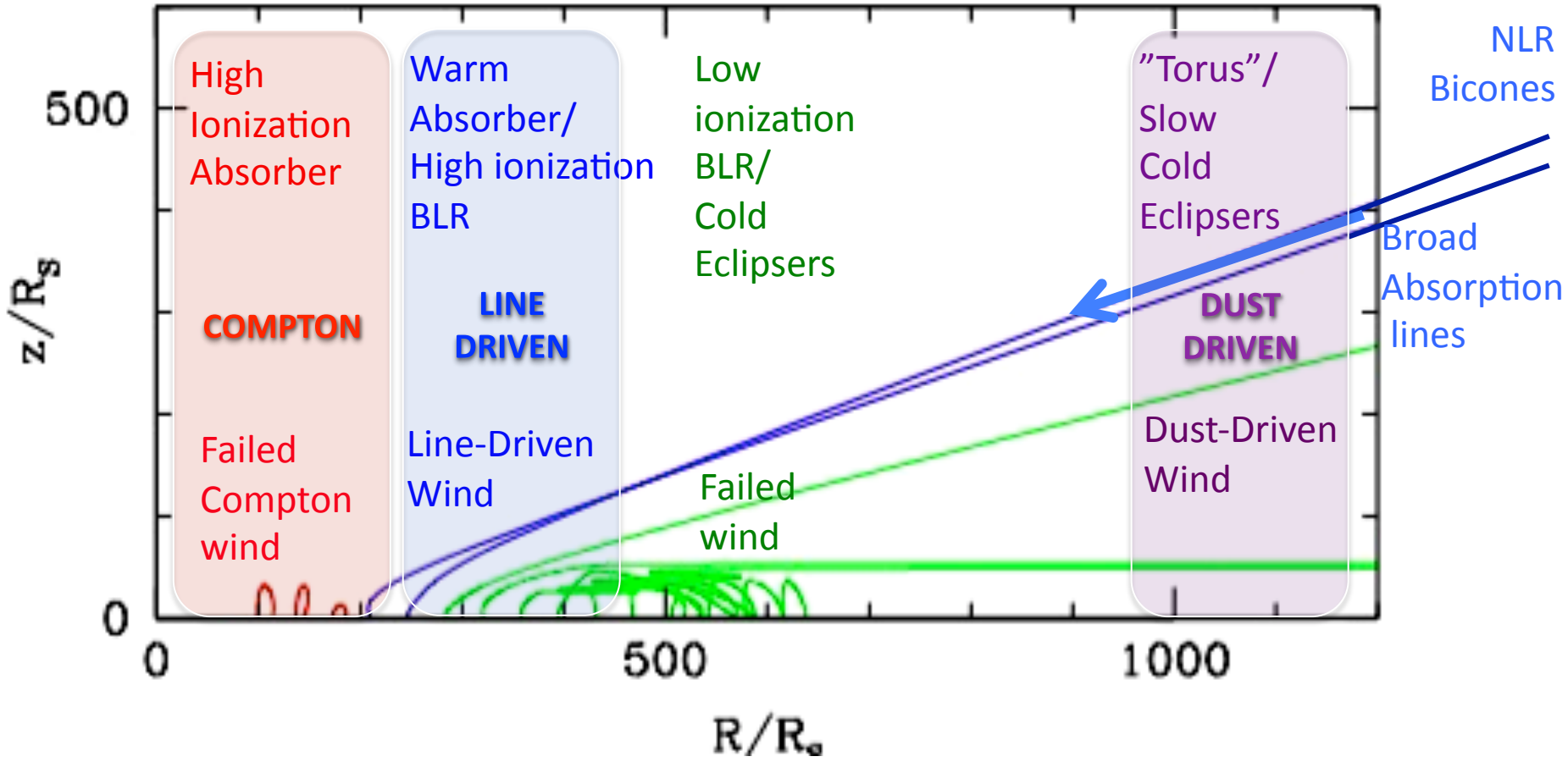

➜ *gas ejected over whole range of radii*

# Question becomes: What is the Launching Mechanism?

- Distinct from Acceleration
- One mechanism, or multiple?
- Multiple:
  - Dust Driving: $T_{disk} < 1000$ K
  - Line Driving: $T_{disk} >\sim 30{,}000$ K
  - *What about $1000 < T_{disk} < 30{,}000$?*
- Single: Magnetic recombination
  - Solar Coronal Mass Ejections reach 1000 km/s
  - Driven by MRI?
  - *Is disk ionized enough at all radii?*
- *MHD winds?*

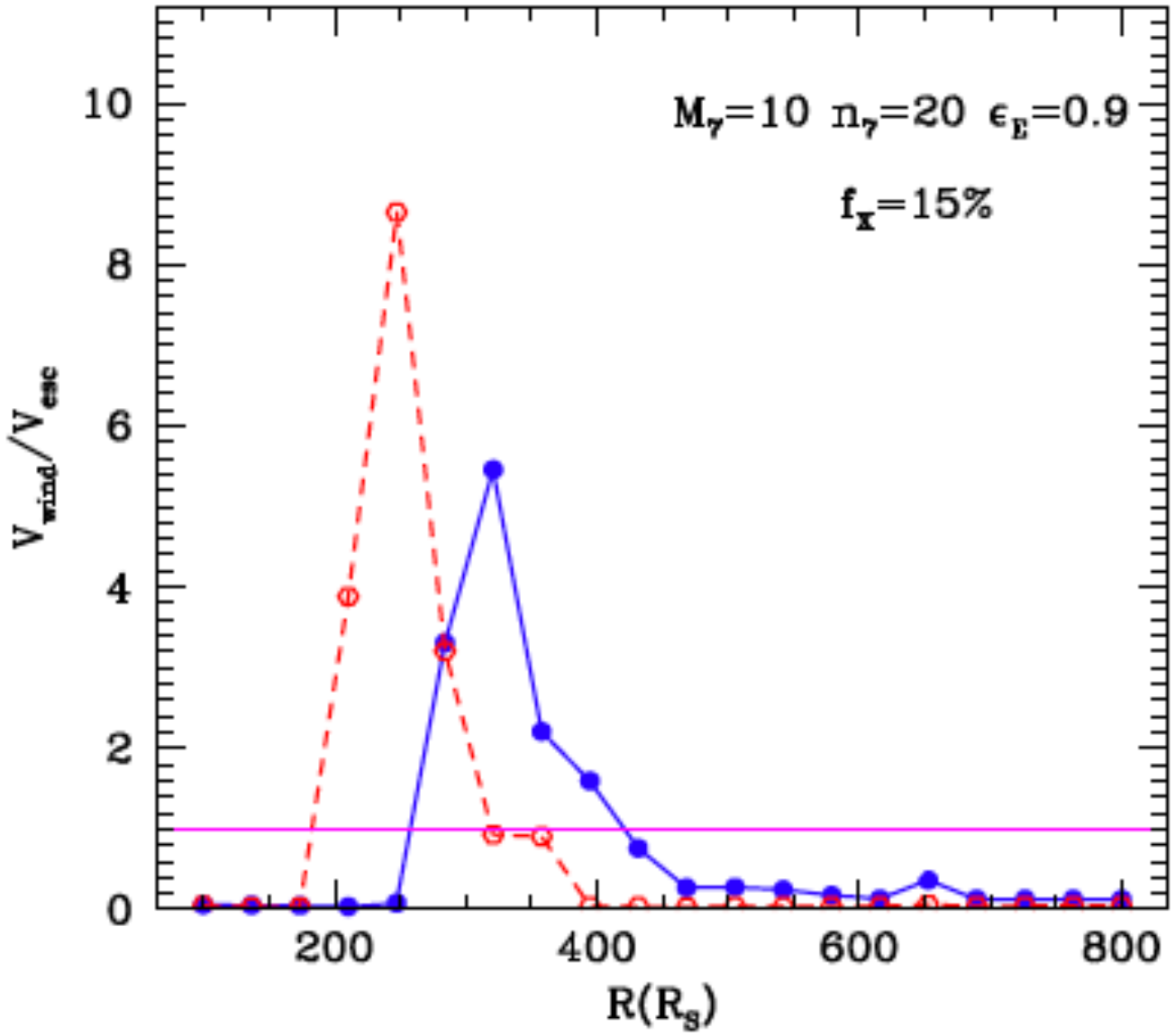
# The 3 Forms of Radiation Driving Determine Quasar Structure

Elvis 2000ApJ...545...63E
Risaliti and Elvis 2010A&A...516A..89R



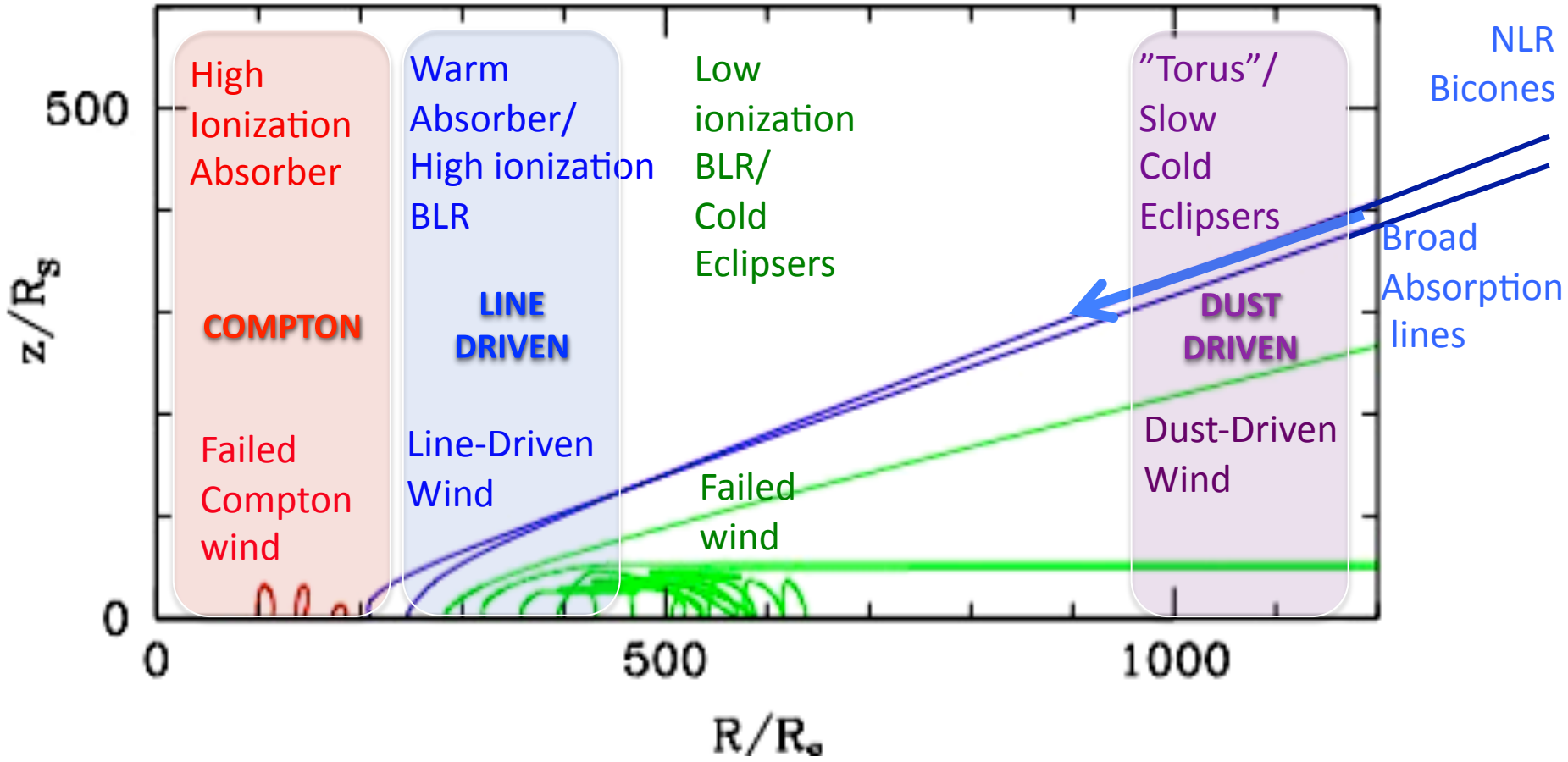

Now explore broad parameter space, launching

# High $L/L_{Edd}$ does not automatically imply a faster wind



# The 3 Forms of Radiation Driving Determine Quasar Structure

Elvis 2000ApJ...545...63E
Risaliti and Elvis 2010A&A...516A..89R




Now explore broad parameter space, launching