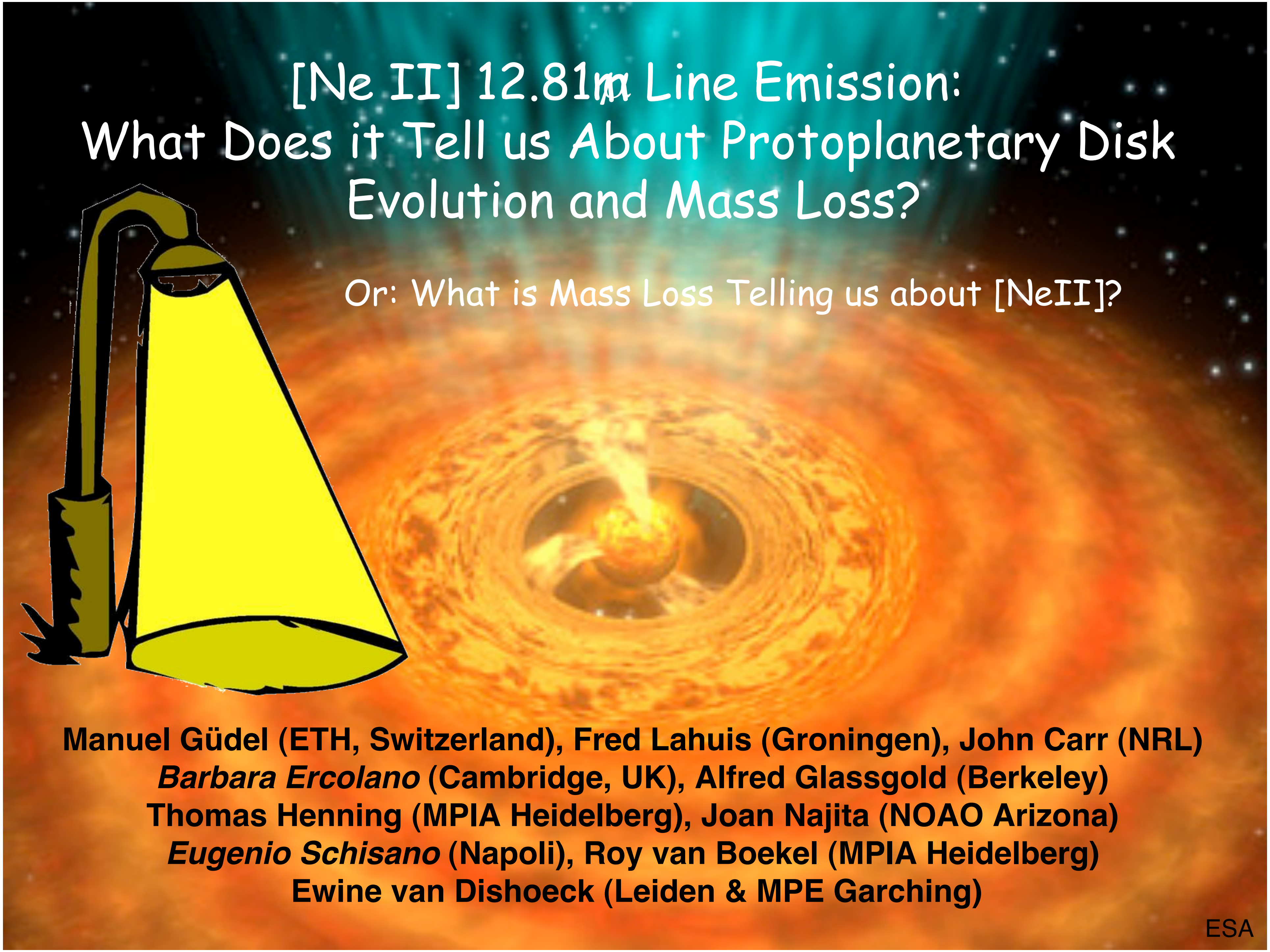
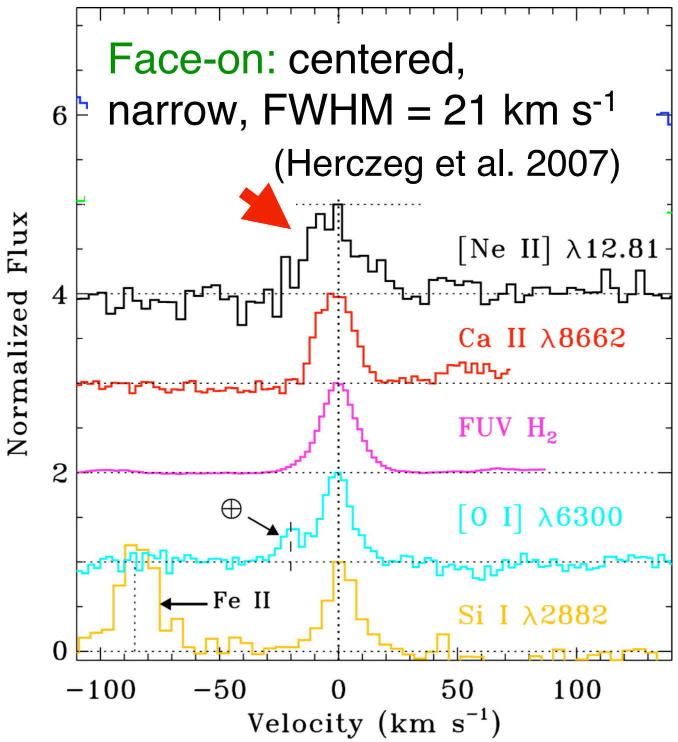
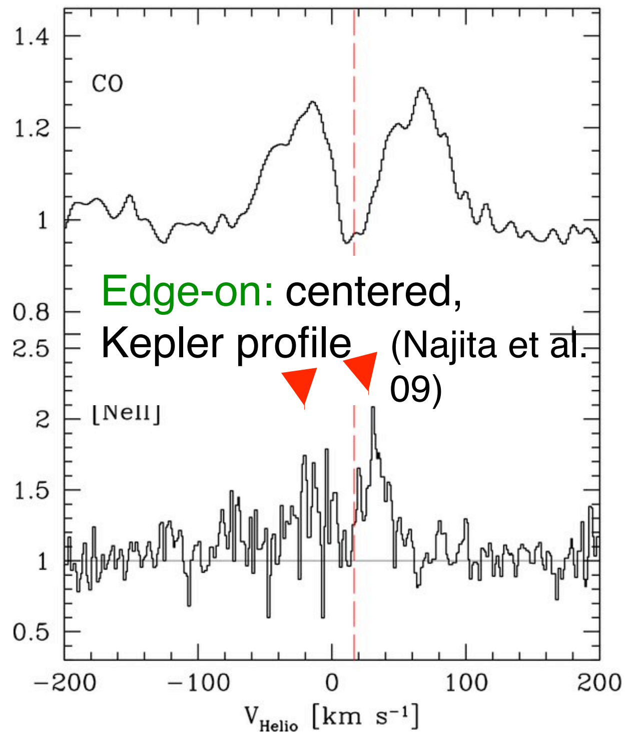

[Ne II] 12.81μm Line Emission:
What Does it Tell us About Protoplanetary Disk
Evolution and Mass Loss?
Or: What is Mass Loss Telling us about [NeII]?
Manuel Güdel (ETH, Switzerland), Fred Lahuis (Groningen), John Carr (NRL)
*Barbara Ercolano* (Cambridge, UK), Alfred Glassgold (Berkeley)
Thomas Henning (MPIA Heidelberg), Joan Najita (NOAO Arizona)
*Eugenio Schisano* (Napoli), Roy van Boekel (MPIA Heidelberg)
Ewine van Dishoeck (Leiden & MPE Garching)
ESA

# [Ne II] 12.81$\mu$m from X-ray Irradiated Disk?

- Tracer for hot, X-ray/EUV ionized gas in the inner disk
- Should scale linearly with $L_X$ for constant disk (Glassgold et al. 2007, Meijerink et al. 2008)




(alternative view: photoevaporative flows, → Ilaria Pascucci's talk, poster by Owen et al. **B21**; Pascucci & Sterzik 2009; calculations: Alexander 2008)

# Statistical Study: Characterization of [Ne II] Sample

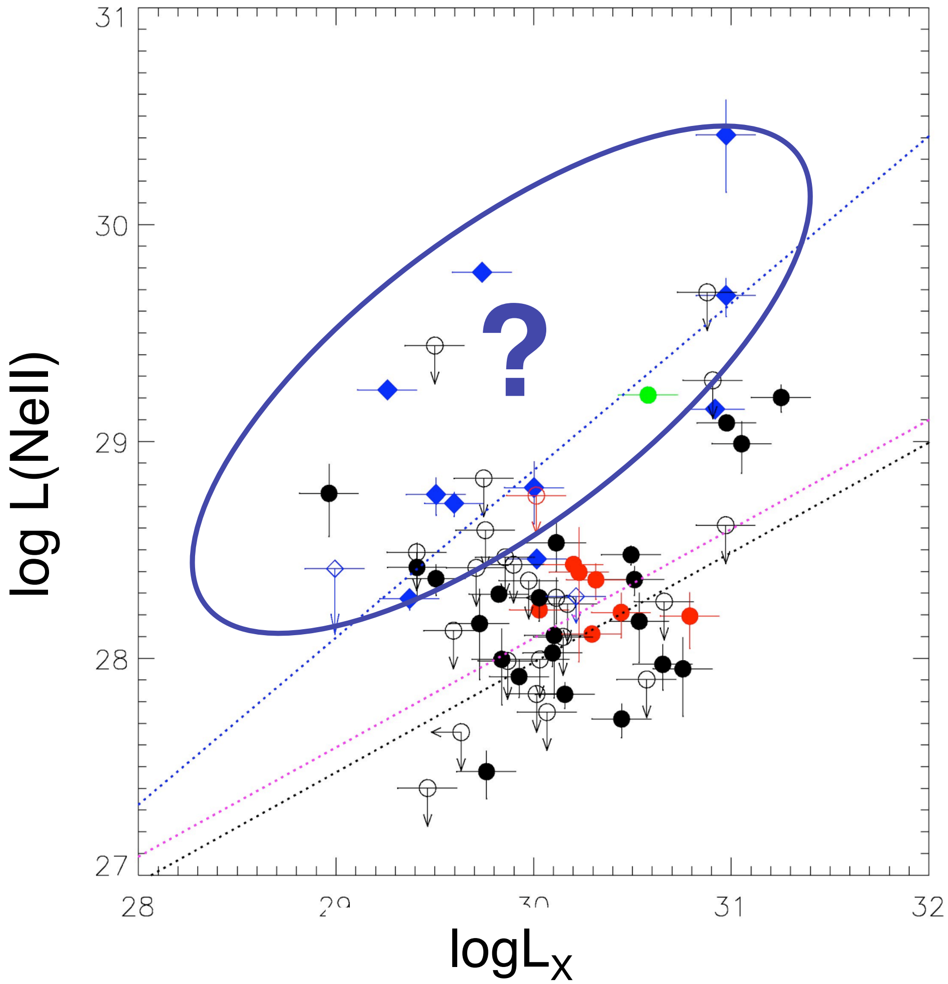
[NeII] emission survey of 92 CTTS (Spitzer c2d, etc):

58 [Ne II] detections, 34 UL
64 X-ray detections, 3 UL (XMM or Chandra)
40 [Ne II] & X-ray detections

*14 jet-driving CTTS*
*13 transition disks*

(See also Flaccomio et al. 2009 for Class I)

# Does [Ne II] Correlate with $L_X$?

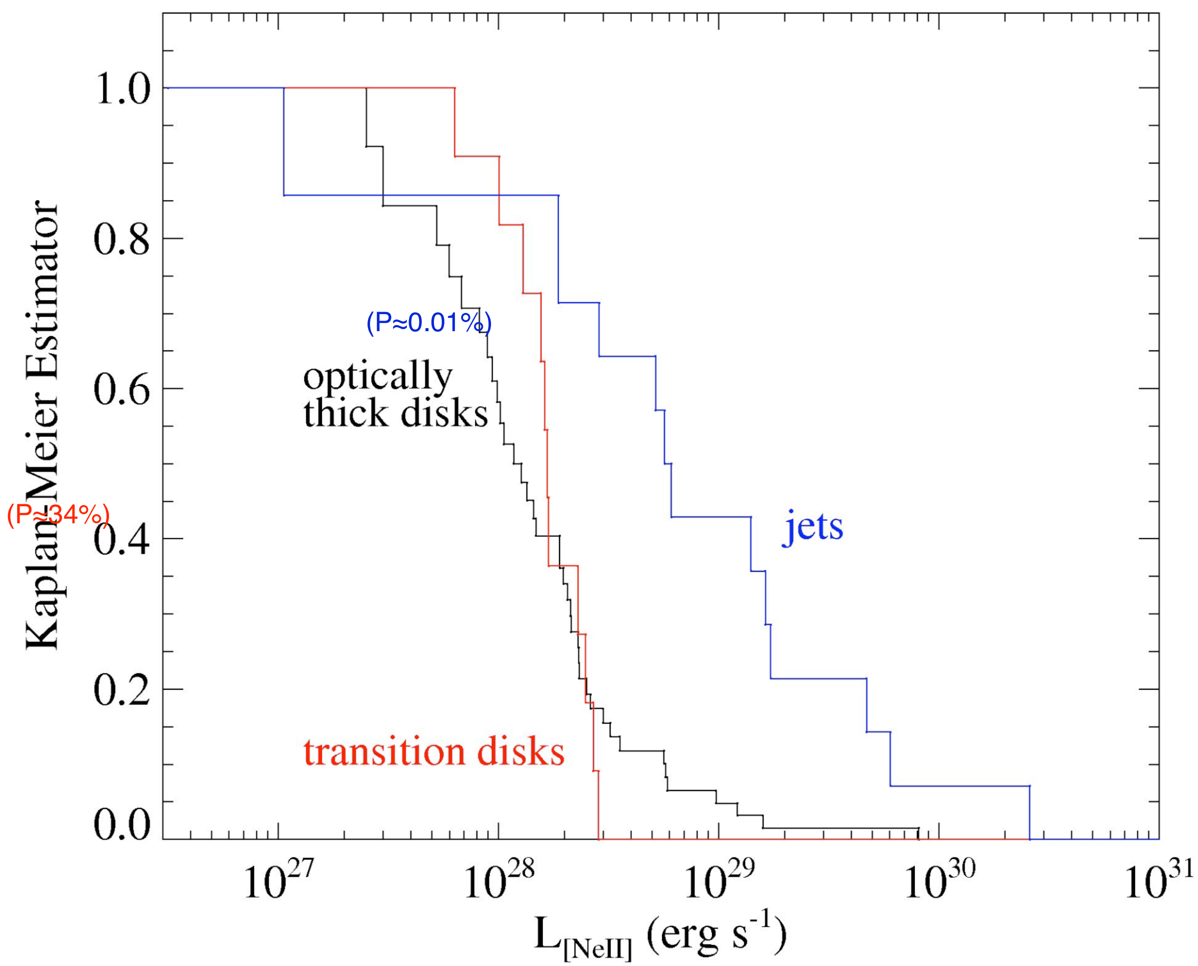



- Optically thick disks
- Transitional disks
- Disks with jets

Trend $L(NeII) \propto L_X^{0.5}$

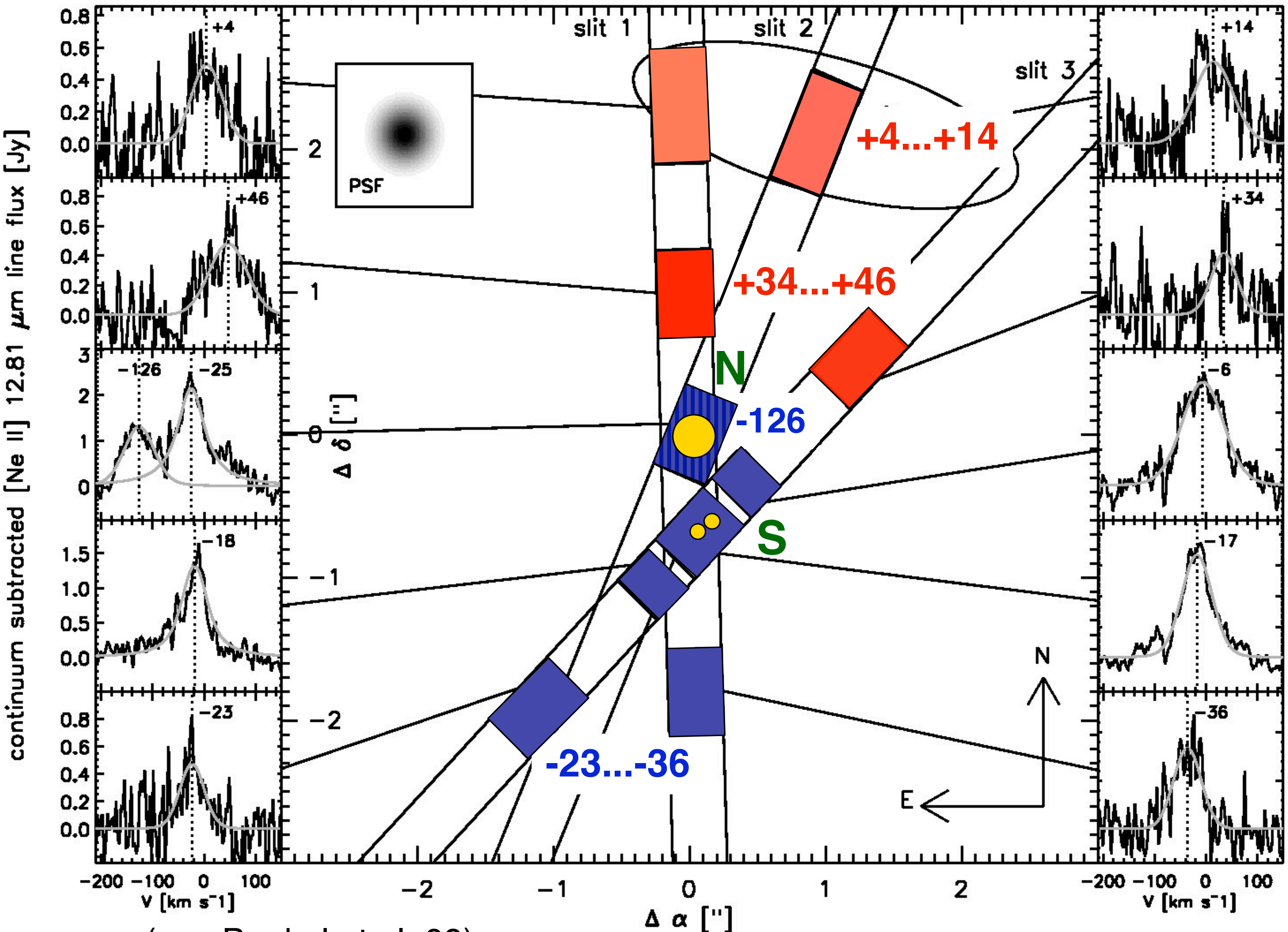
- *but largely dominated by scatter.*

See also poster by Carla Baldovin Saavedra et al., B50




*Presence of jet increases L(NeII) by ≈10x*

(Güdel et al. 2009)

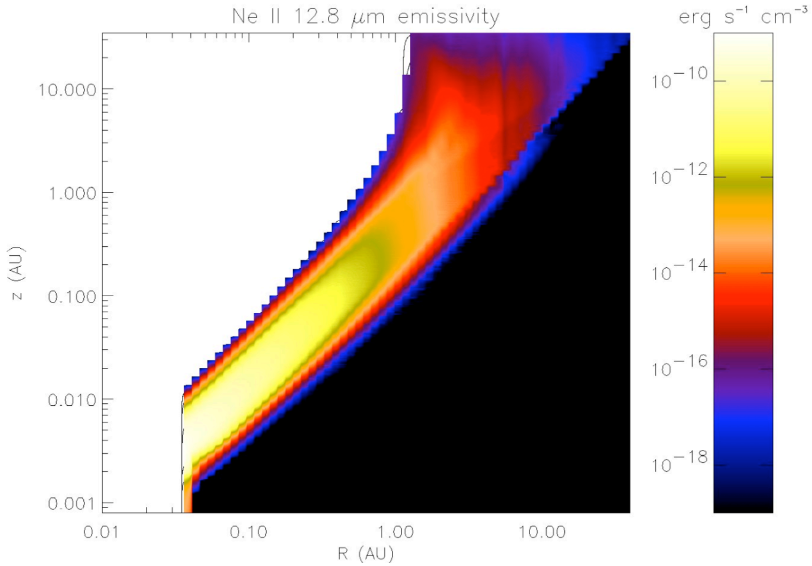



(van Boekel et al. 09)

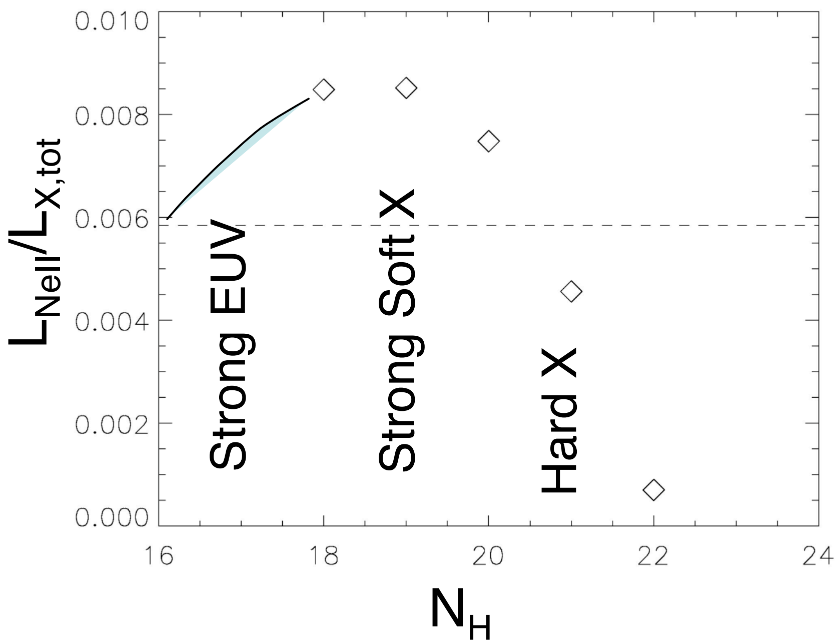
# No Jets: Are Disks Doing the Job? – But Why the Scatter?

- MC rad. transfer MOCASSIN (Ercolano et al. 03)
- self-consistent hydrostatic disk

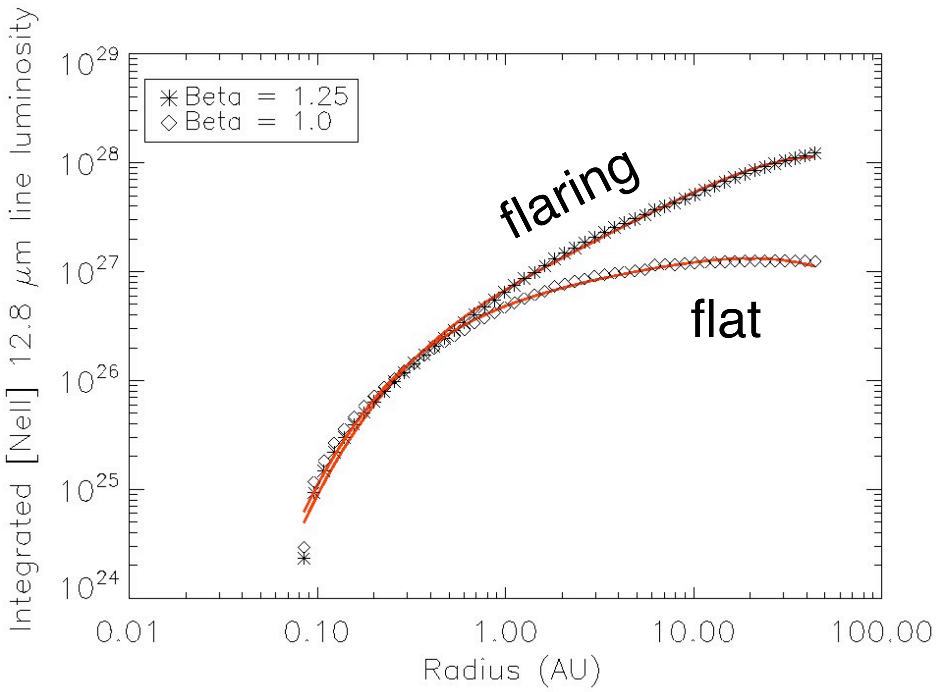
  *or*
- analytical flared-disk model, β = 1 or 1.25
- X-ray + EUV irradiated, + *absorbing screen*
- $2\times10^{30}$ erg $s^{-1}$ (0.1-10 keV) *transmitted*




(Schisano, Ercolano, Güdel 2009)

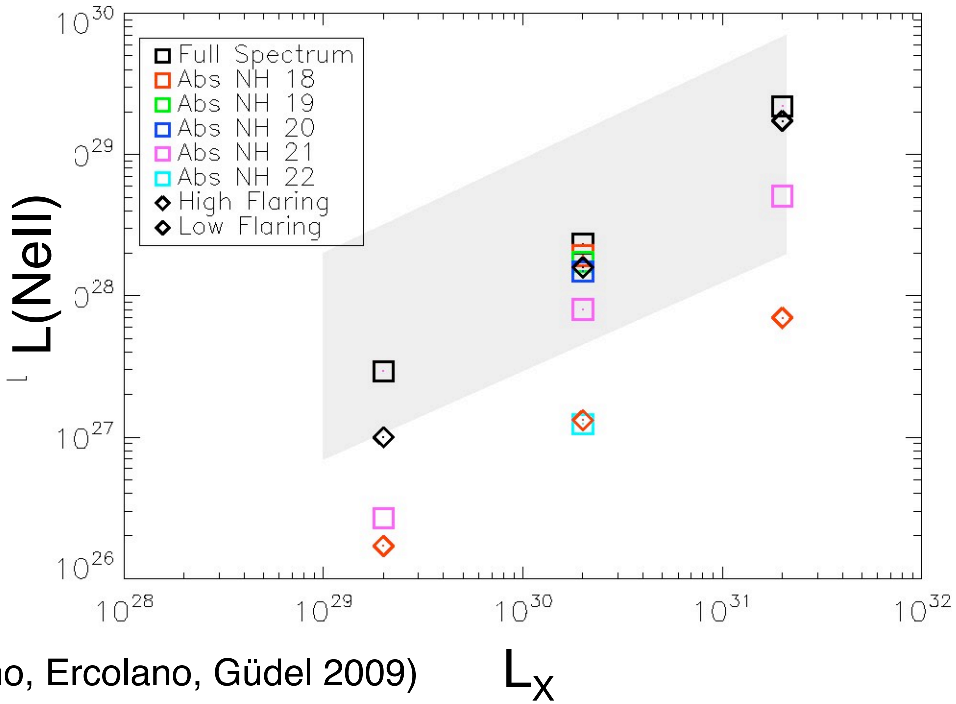


- flaring: larger solid angle of disk
  → more [NeII] emission
  → at larger average distance




- Fainter [NeII] sources match predictions

- <u>Scatter</u> introduced from variation in
  - spectral hardness/$N_H$ (soft X best)
  - disk flaring (strong best)




(Schisano, Ercolano, Güdel 2009)

# Disk Irradiation: What High-Energy Radiation?

- Wind mass loss rate ≈ 0.1 x mass accretion rate (White & Hillenbrand 2004)

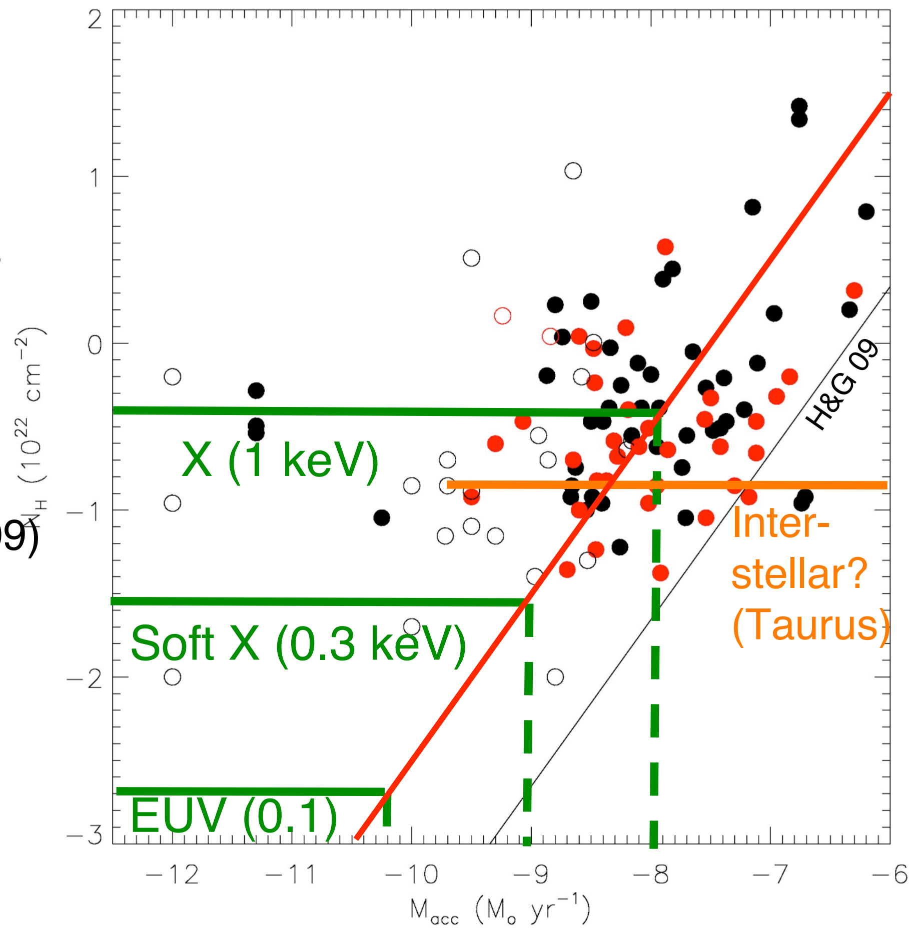
$N_H \propto \dot{M}_{loss} = 0.1\dot{M}_{acc}$ → absorption (Hollenbach & Gorti 2009)

- Only X-rays reach CTTS disks

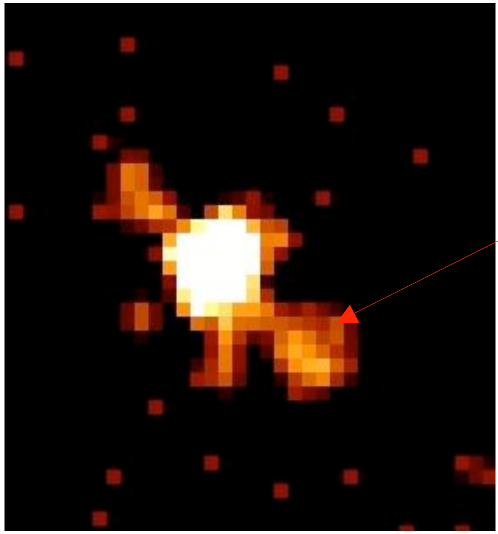
- EUV only relevant for transition disks

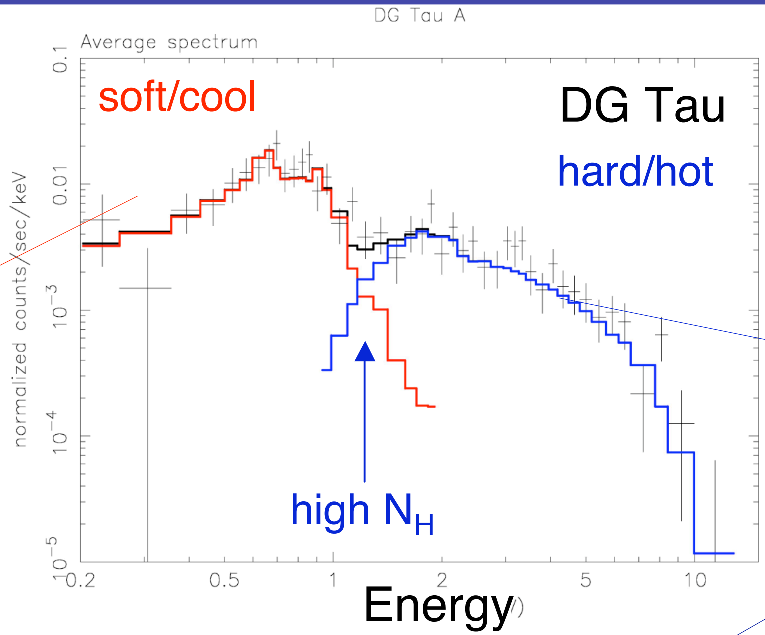
- → some [NeII] closer to star:
  accretion columns?
  photoevap. flows? (→Owen et al. 2009)

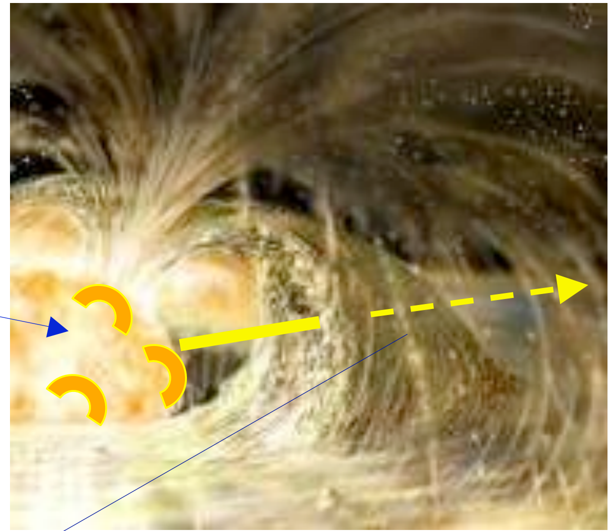
*<u>Caveat</u>: $N_H$ is toward observer, not disk*



# Strong Accretion: Other Sites of [NeII] Emission?





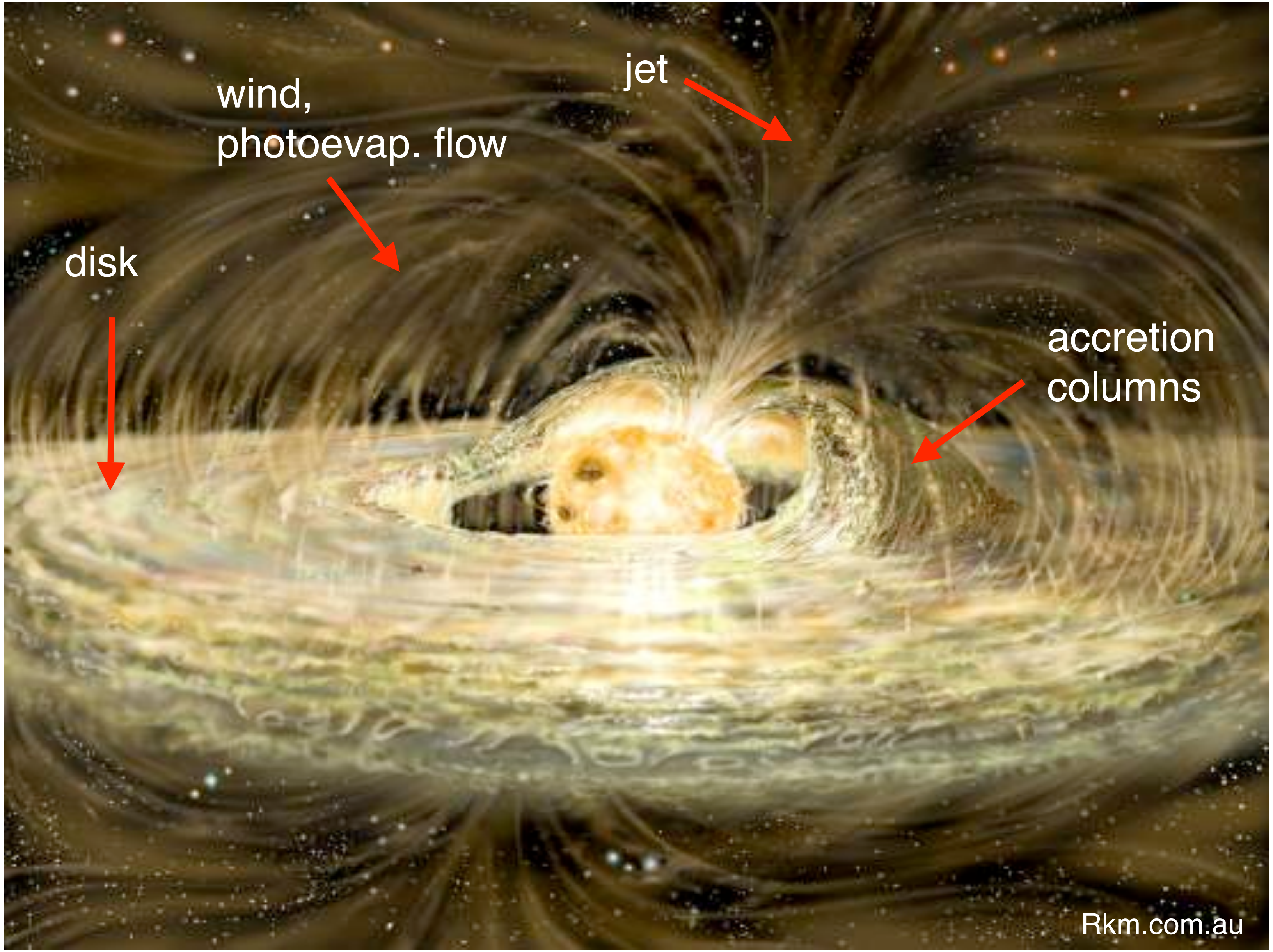
**Coronal (hard) emission** *absorbed by dust-depleted accretion flows with $N_H > 10^{22}$ cm$^{-2}$:*

*all EUV + soft X < 1.2 keV absorbed.*
*But DG Tau is a very strong [NeII] source!*

→Ionisation + [NeII] emission in accretion columns

Ercolano et al. (2009):
dominates for $N_H > 10^{20}$ cm$^{-2}$ in a 4π "screen"

## Conclusion:
## Evolutionary Trends? – [NeII] Diagnoses Different Regions



END