Simultaneous Chandra and HST spectroscopy of an accreting young star

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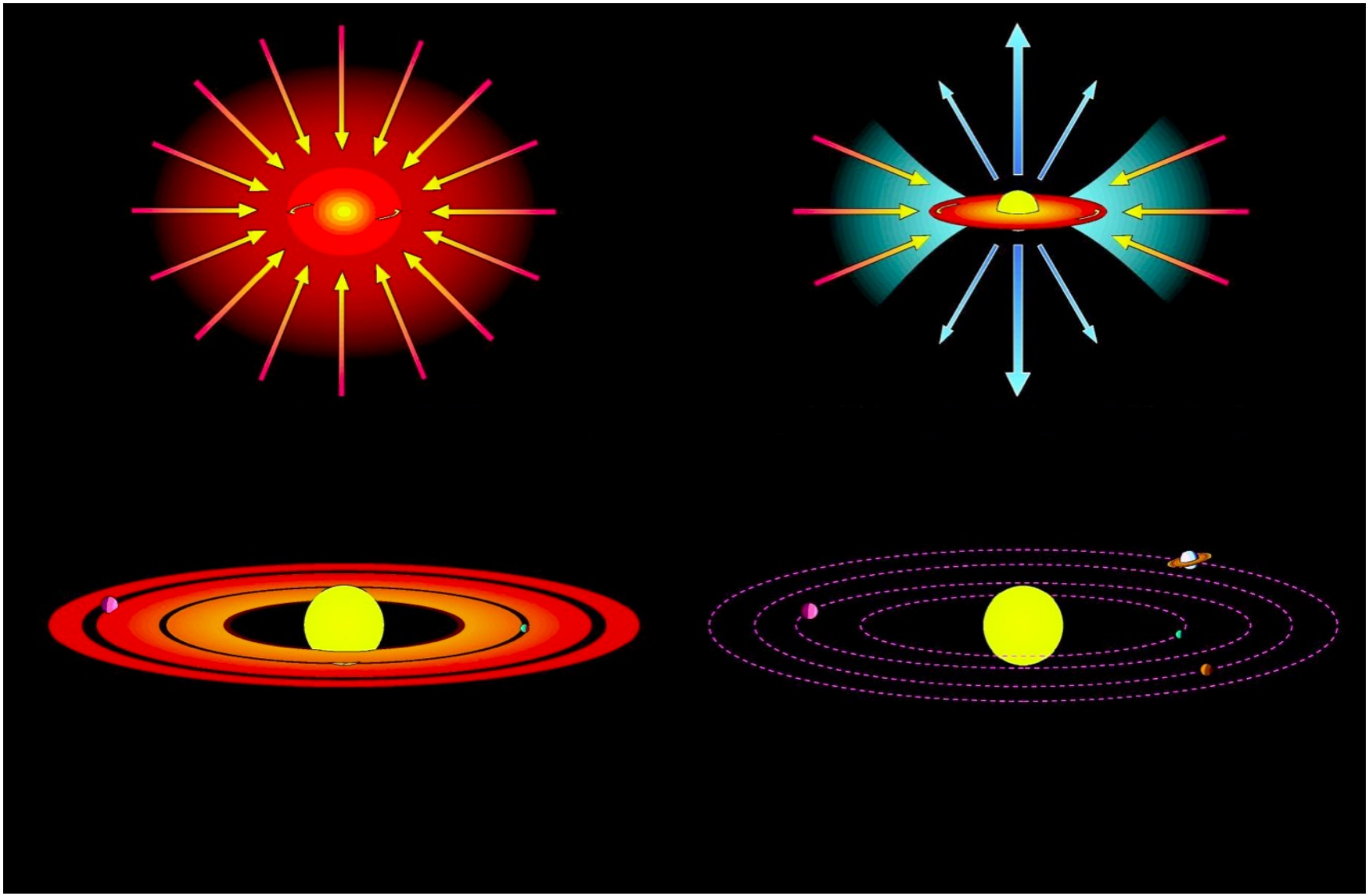
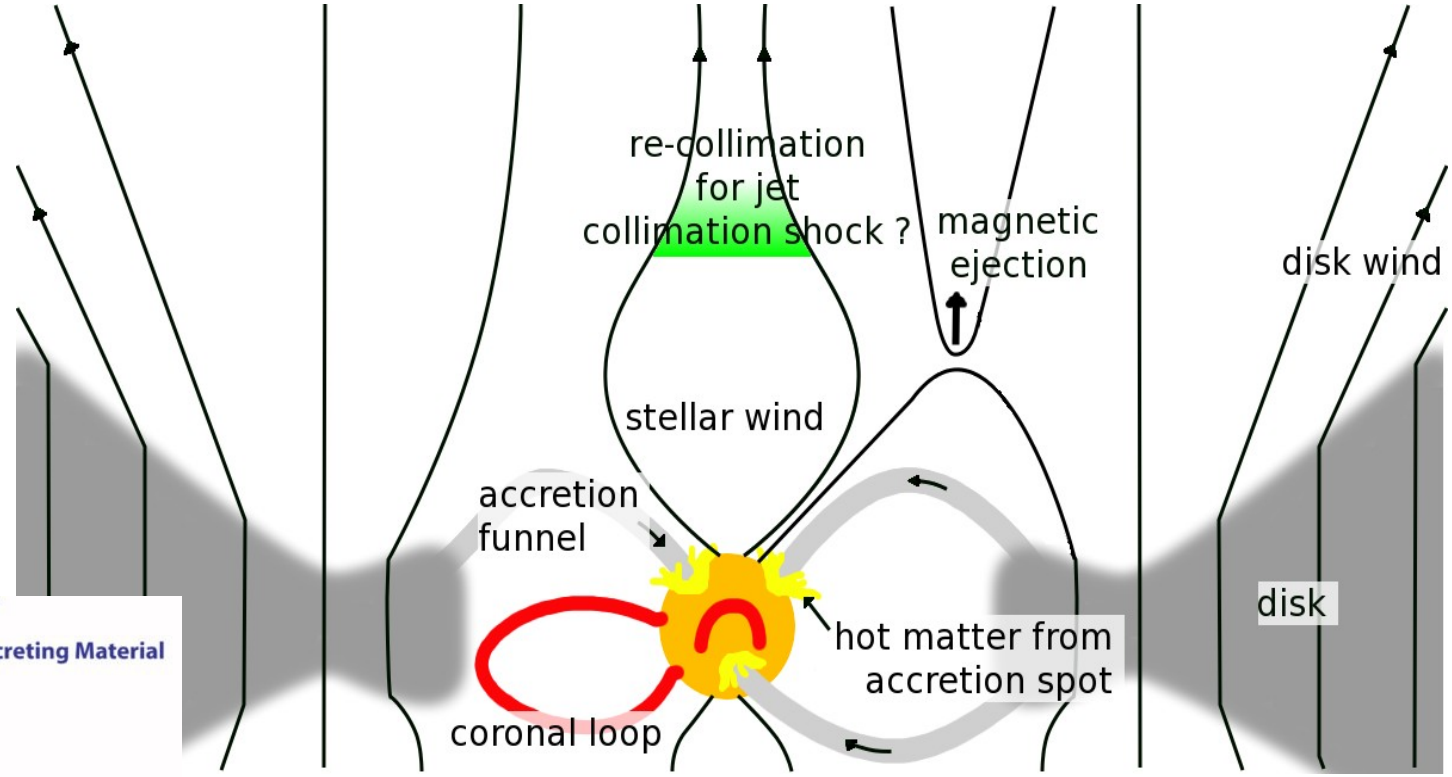
Phases of star formation



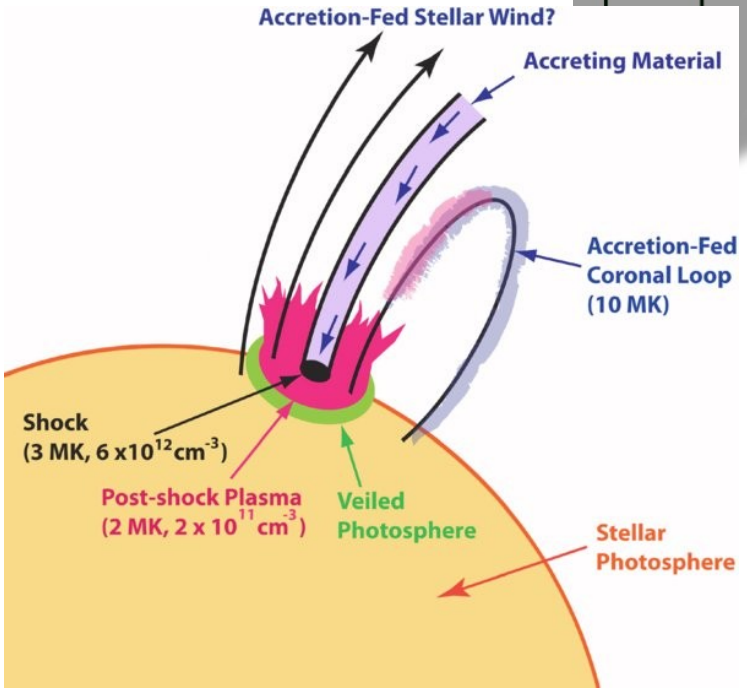
Artist: McCaughrean

Hot gas around T Tauri stars

Günther (2013)



Brickhouse et al. (2010, 2012)

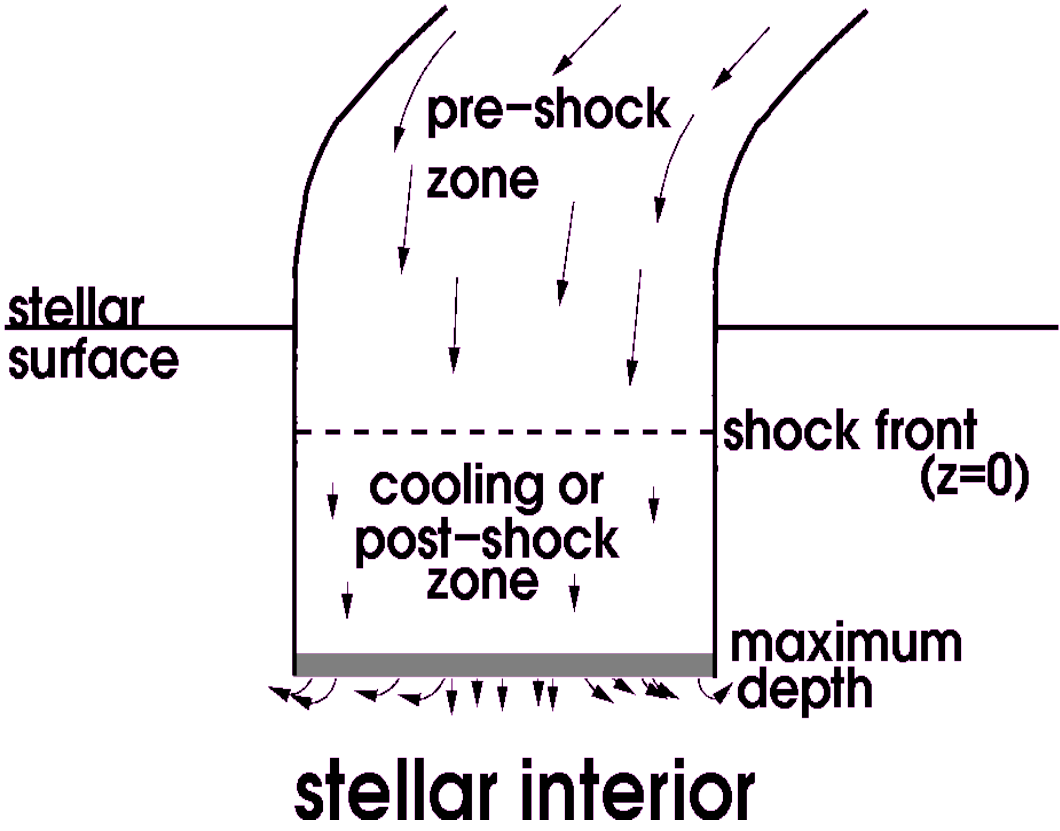


Hot wind?

Dupree et al (2005) vs Johns-Krull & Herczeg (2007)

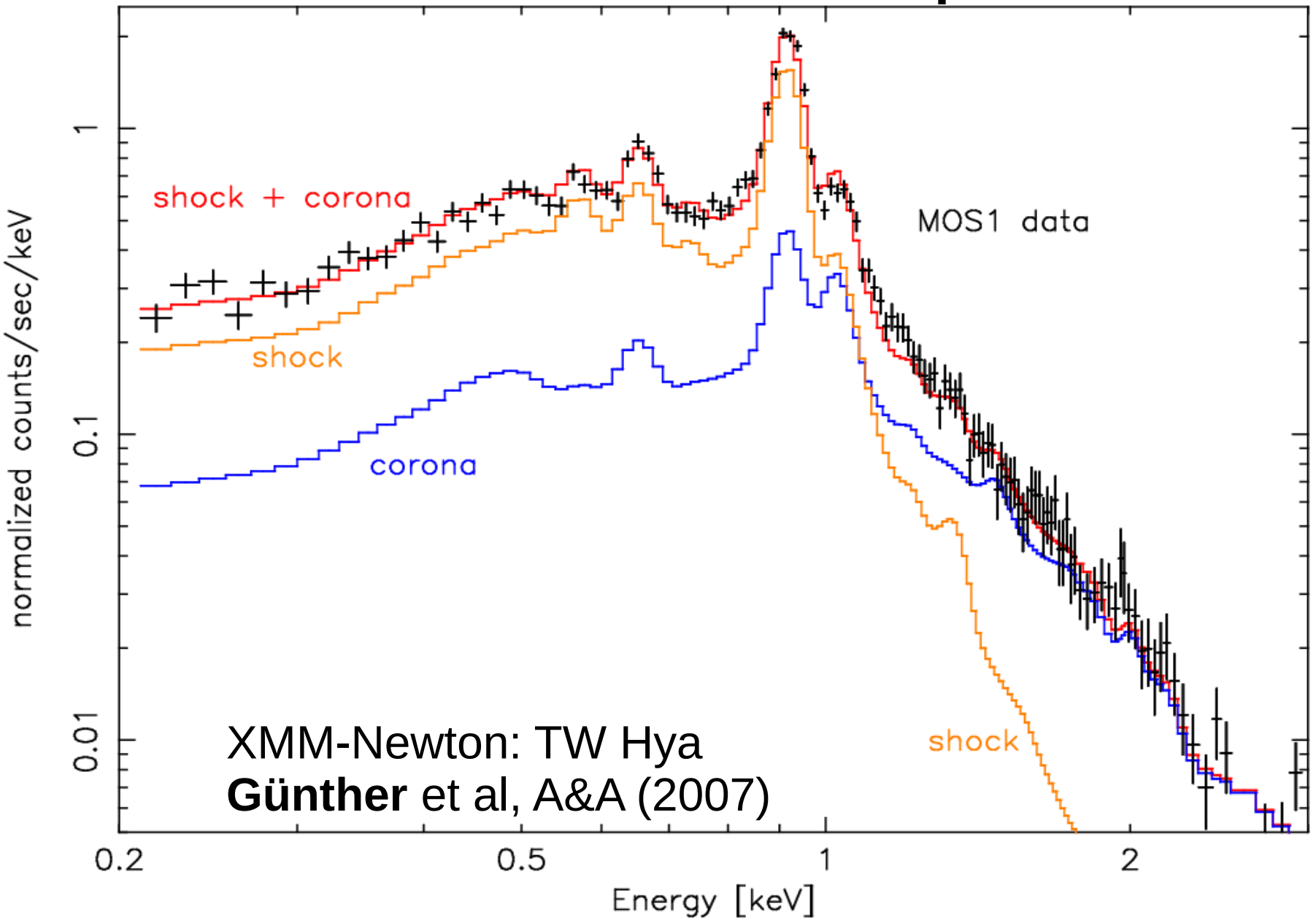
The accretion model

- 1D stationary
- optically thin
- no heat conduction
- Maxwell velocity distribution (different temperature for electrons / ions)
- magnetic field does not change dynamics
- non-equilibrium ionisation calculation



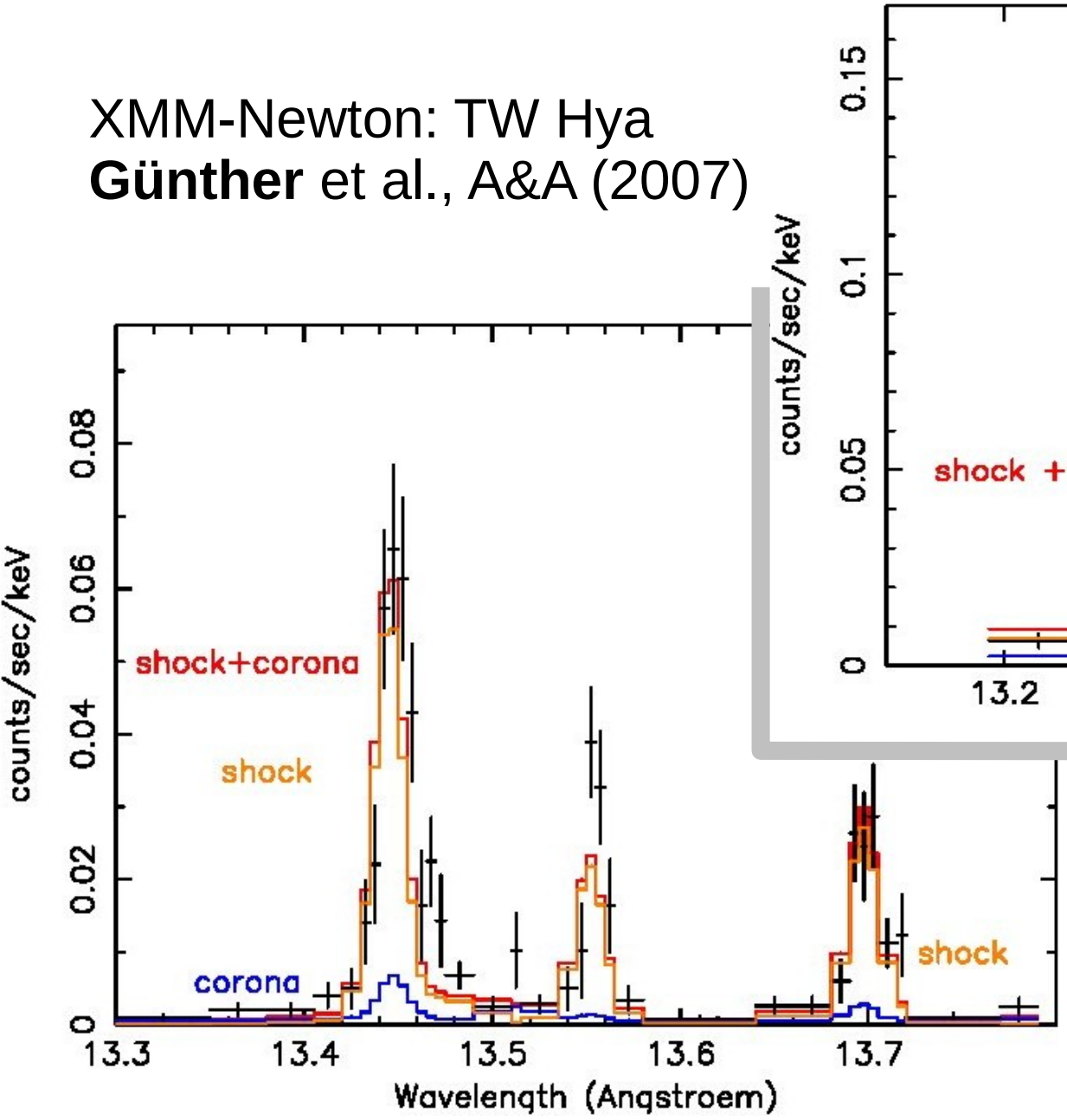
Günther et al., A&A (2008)
Günther, AN (2011)

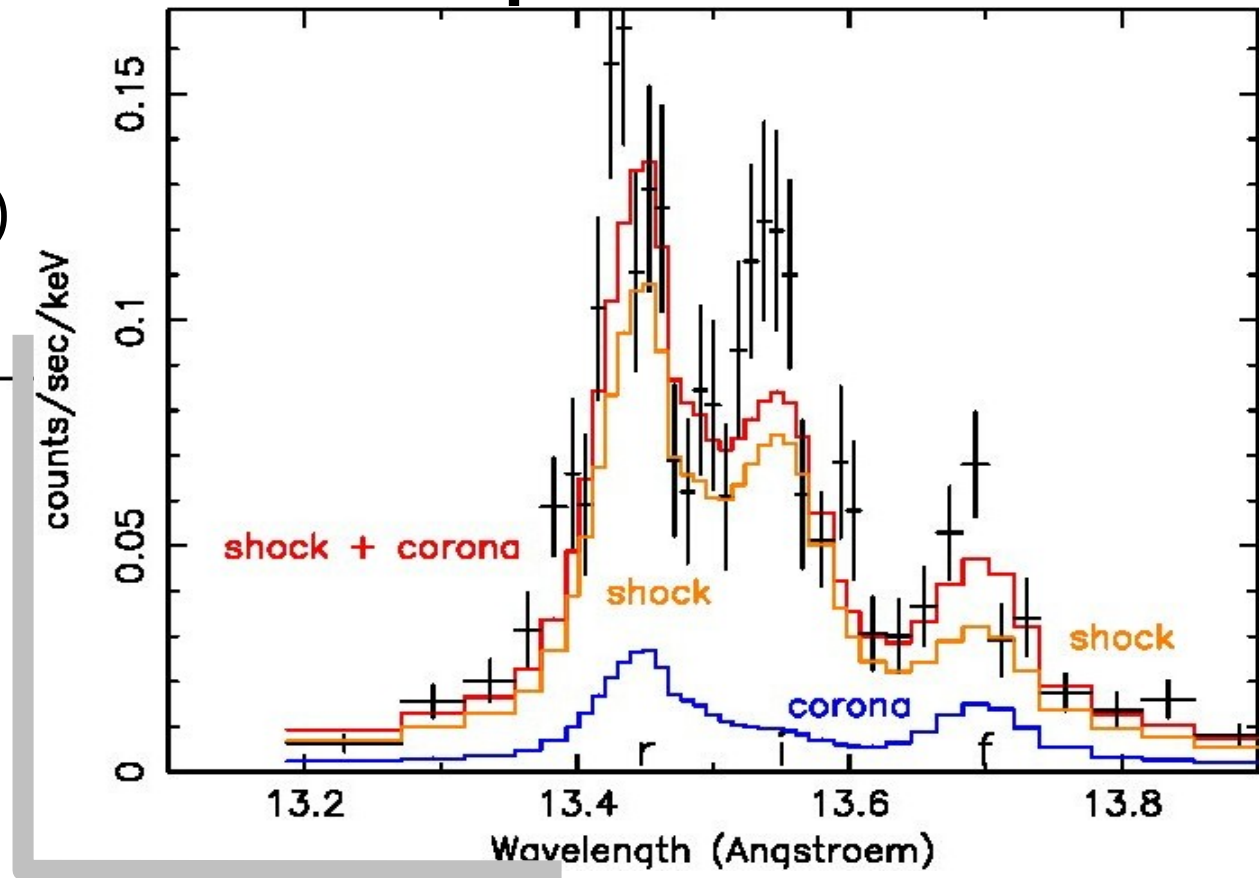
Fits to broad band spectra



Fits to He-like triplets

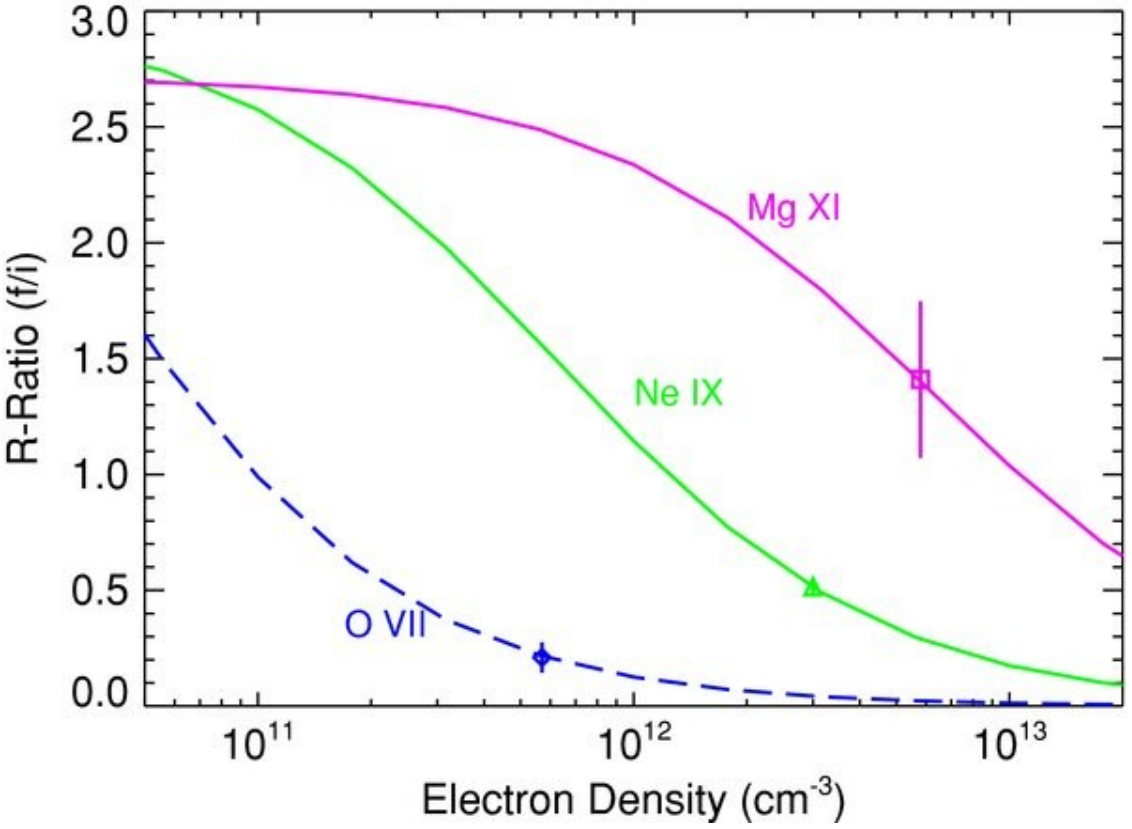
XMM-Newton: TW Hya
Günther et al., A&A (2007)

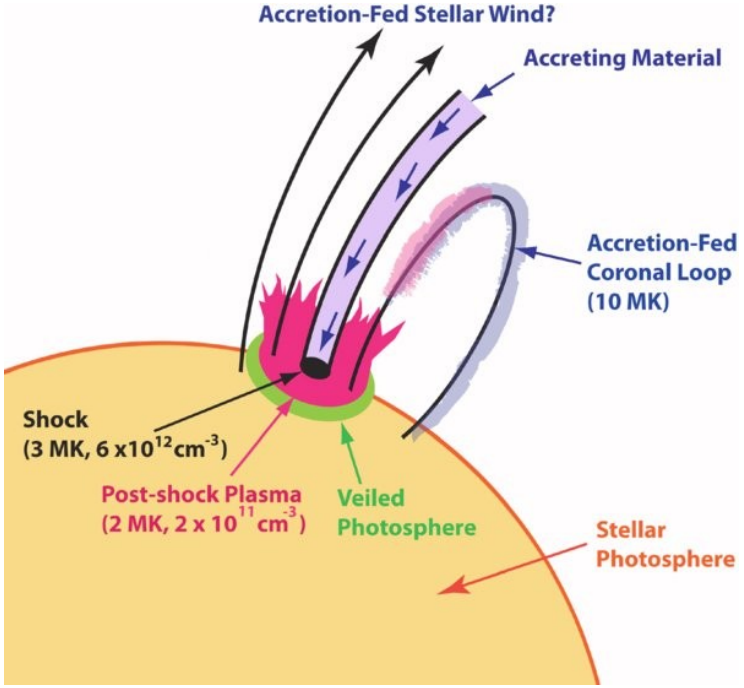




Chandra: V4046 Sgr
Günther et al., MmSAI (2007)

Problems with current models: Accretion interacts with the star

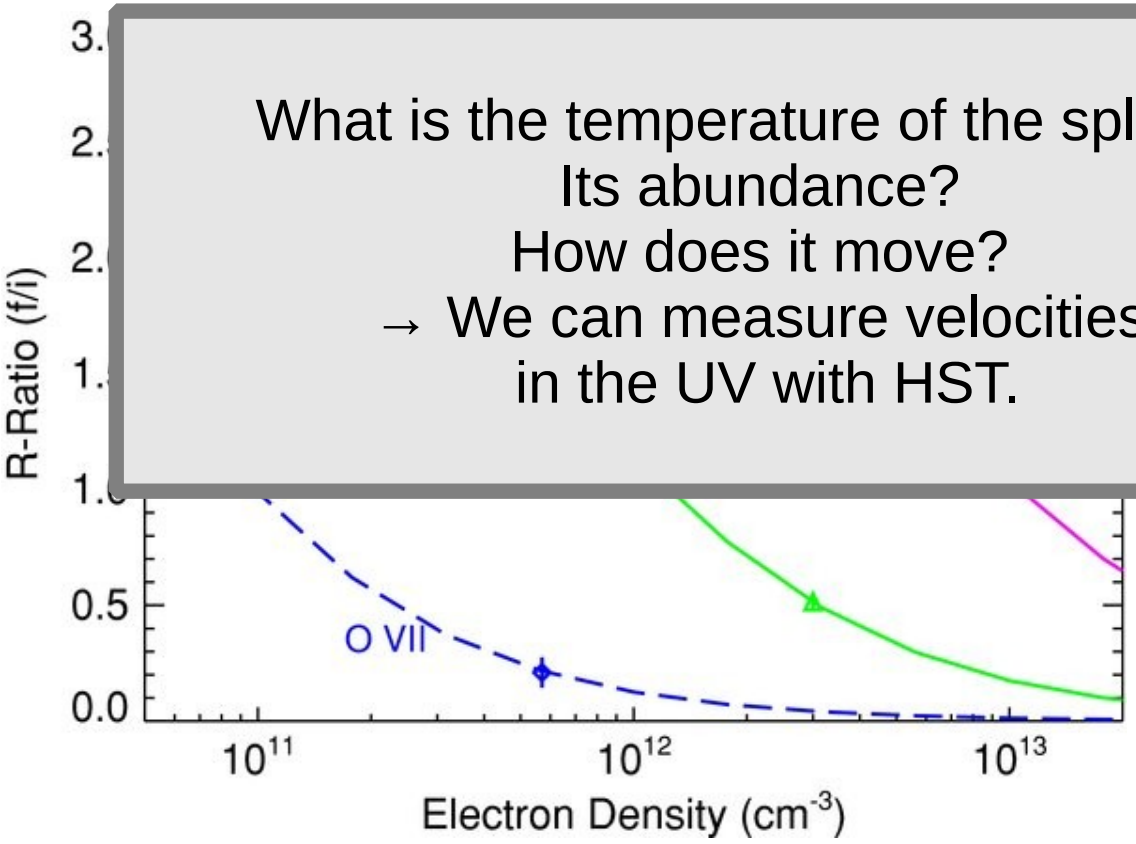


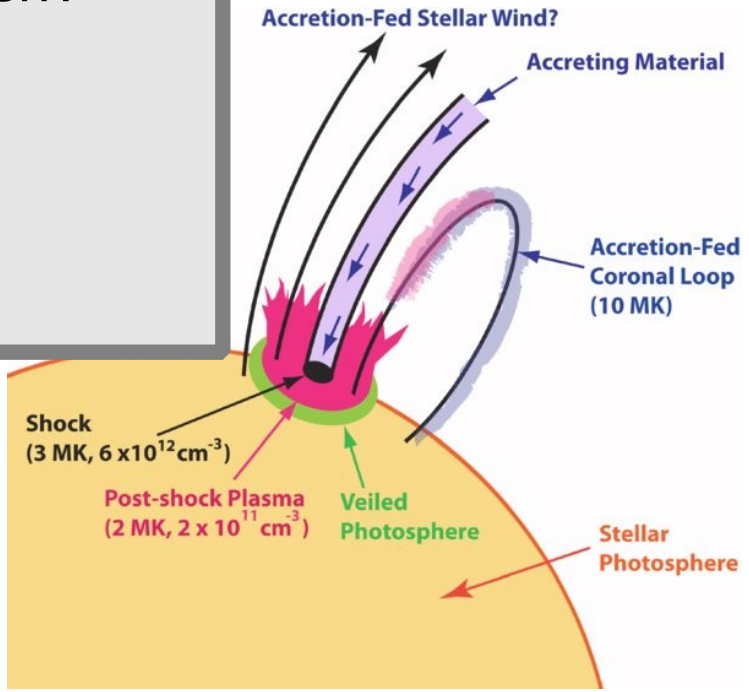


TW Hya: 500 ks Chandra observation
Brickhouse et al. ApJ (2010)
Brickhouse, Cranmer, Luna, **Günther** et al. ApJ (2012)

Problems with current models: Accretion interacts with the star

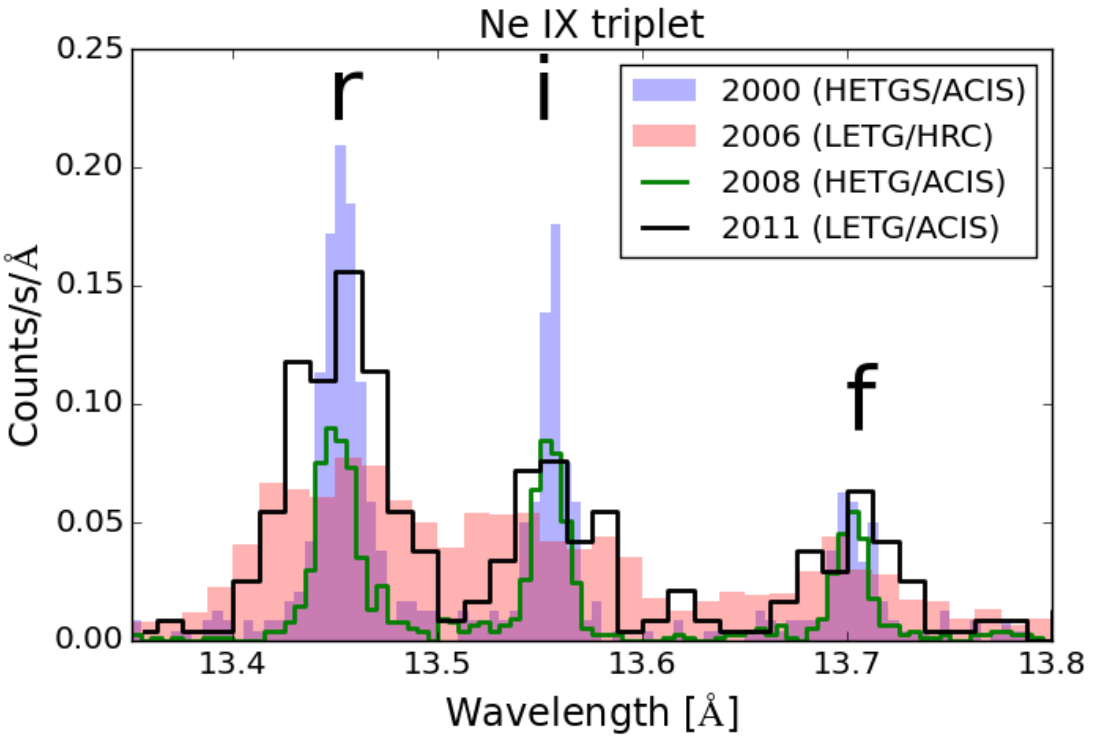
What is the temperature of the splash?
Its abundance?
How does it move?
→ We can measure velocities in the UV with HST.

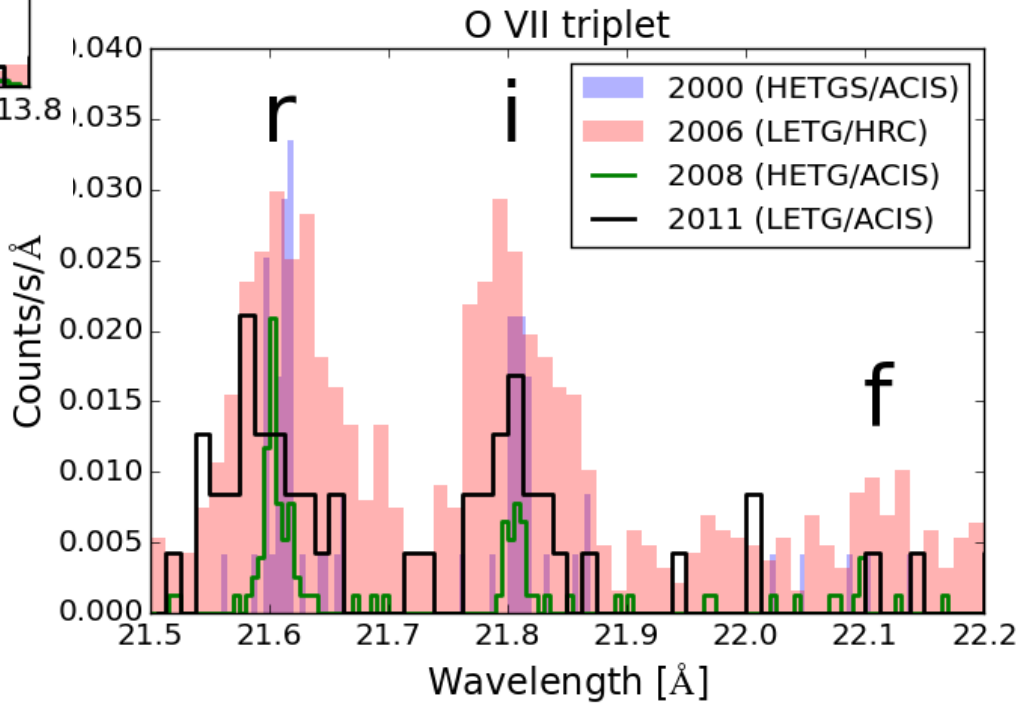




TW Hya: 500 ks Chandra observation
Brickhouse et al. ApJ (2010)
Brickhouse, Cranmer, Luna, **Günther** et al. ApJ (2012)

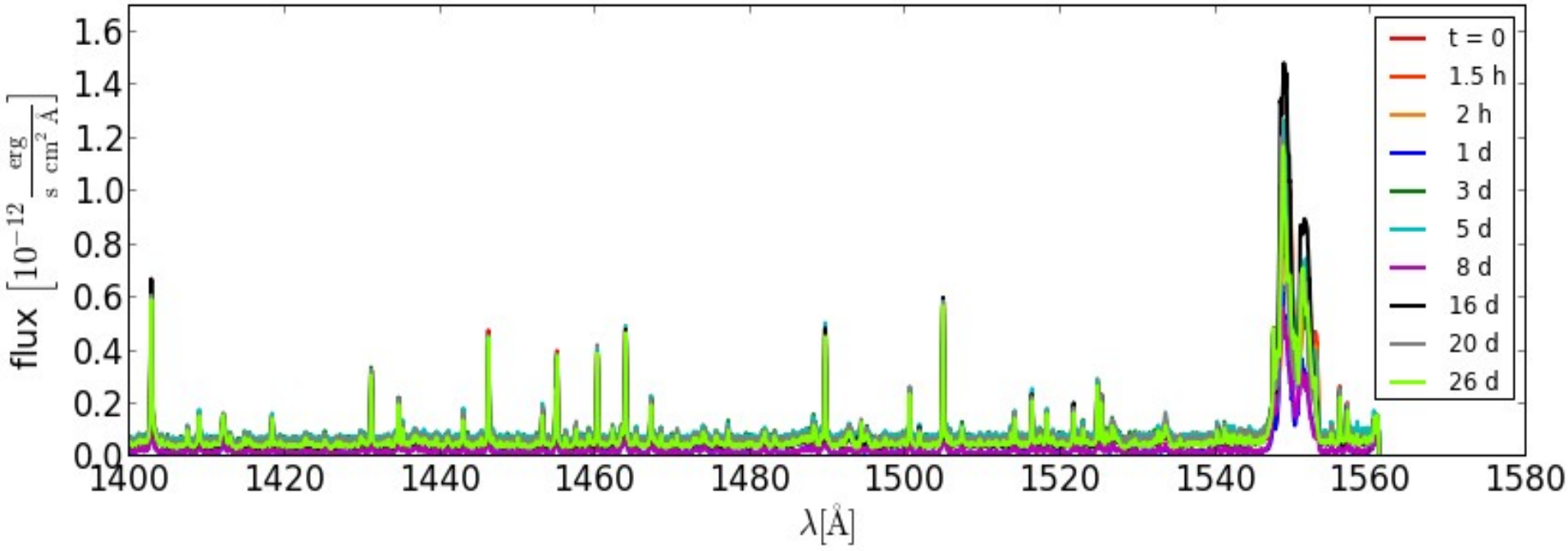
Need for simultaneous data!



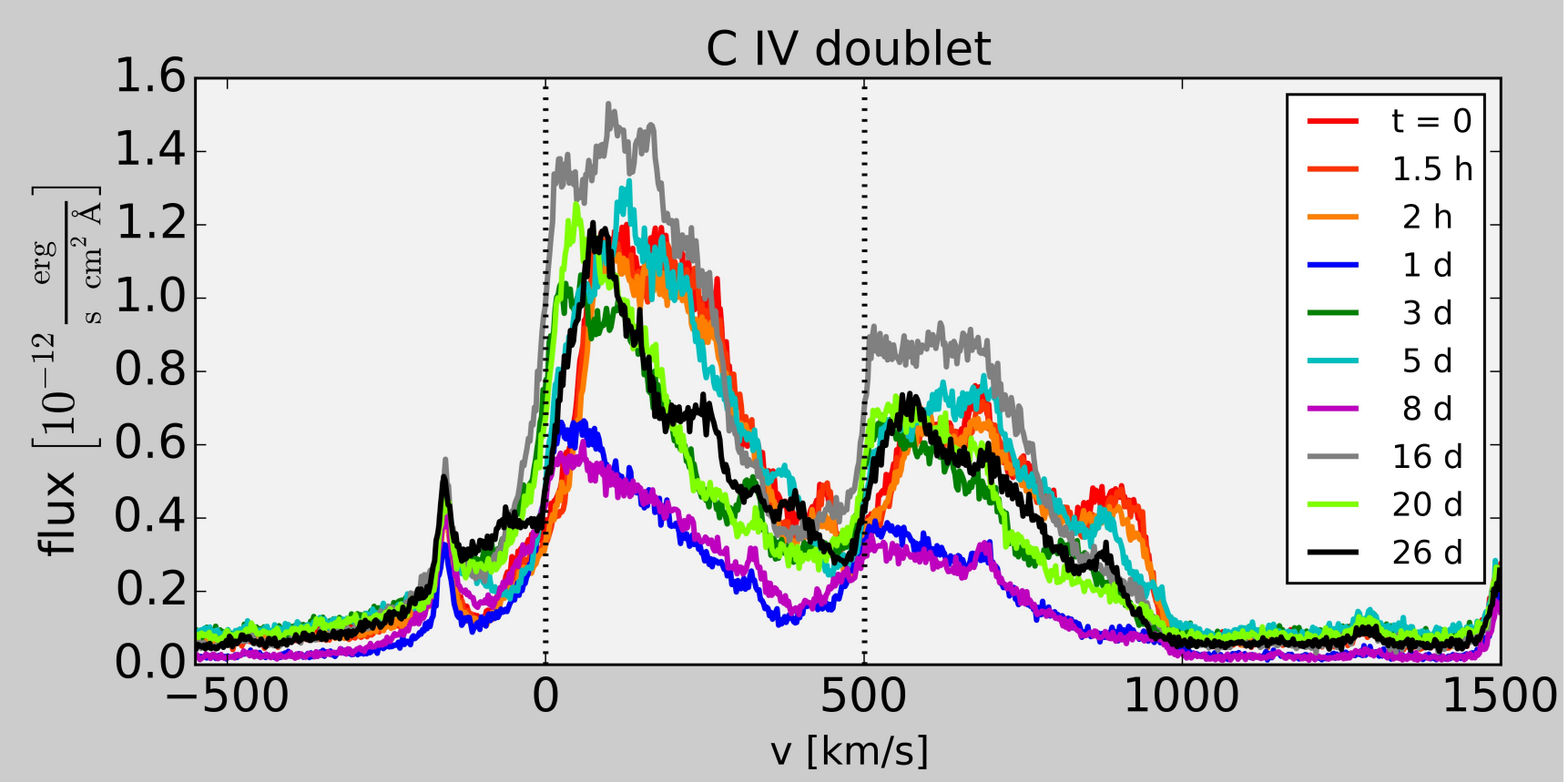


HST/COS data

- 10 orbits HST/COS, spread over one month
- Major components:
  - C IV: accretion shock
  - Continuum: shock-heated photosphere
  - H_2: excited disk (Herczeg et al. 2002, 2004)



C IV emission lines



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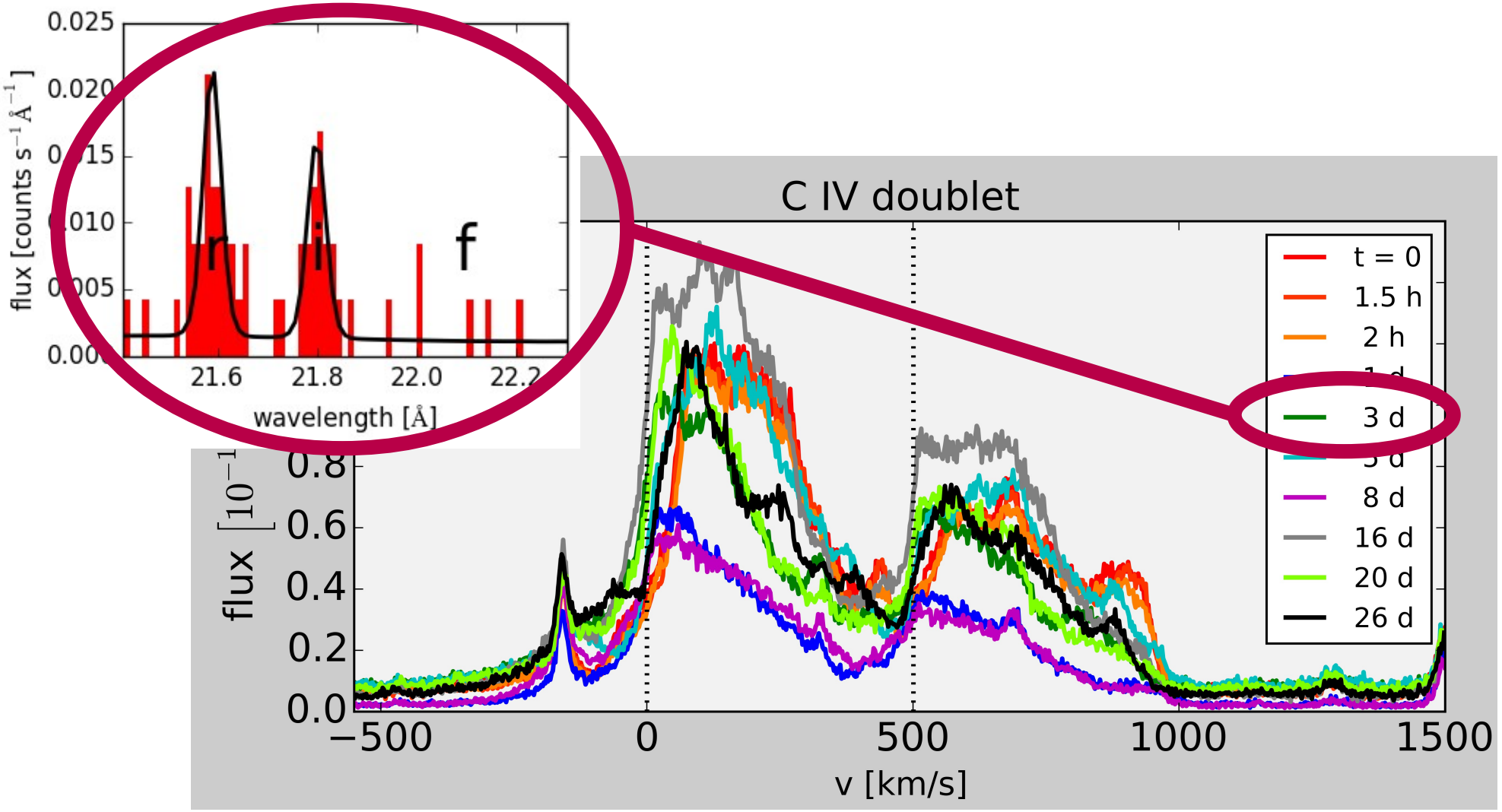
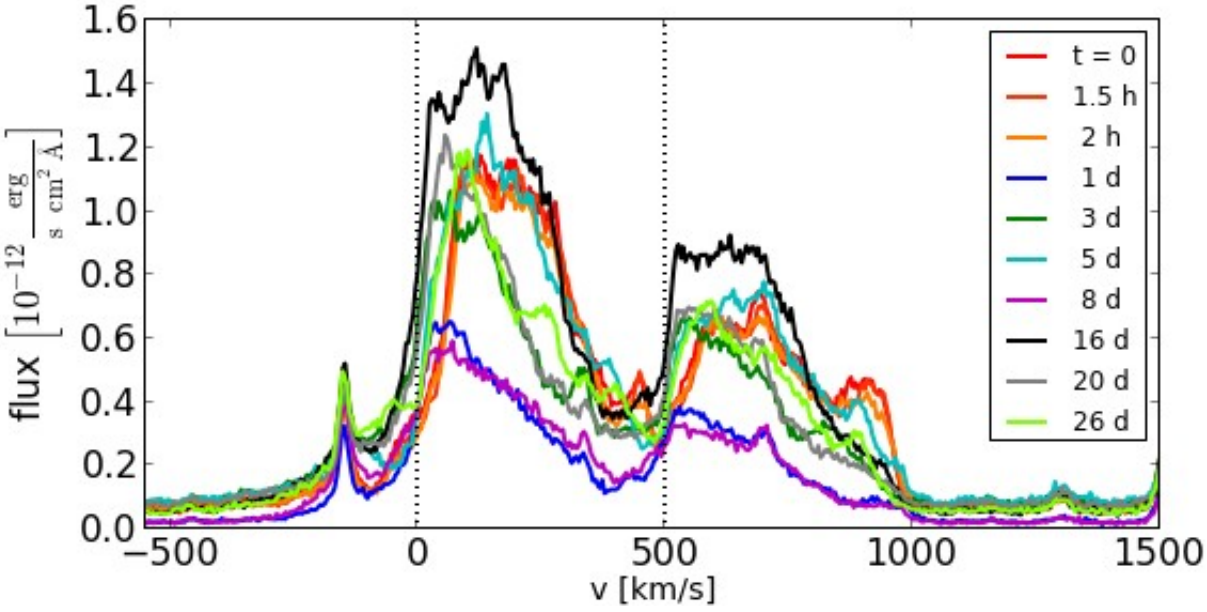
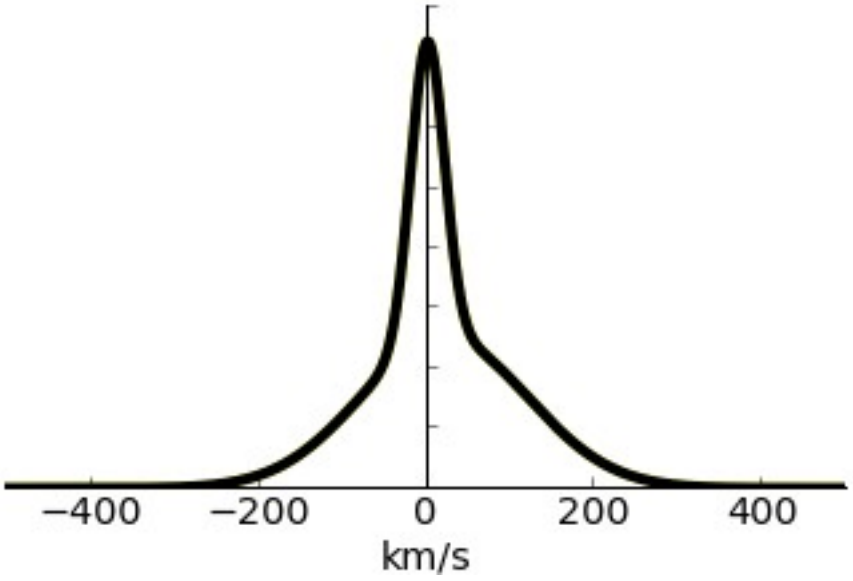


How can we explain the C IV (and other hot ion line) shapes?

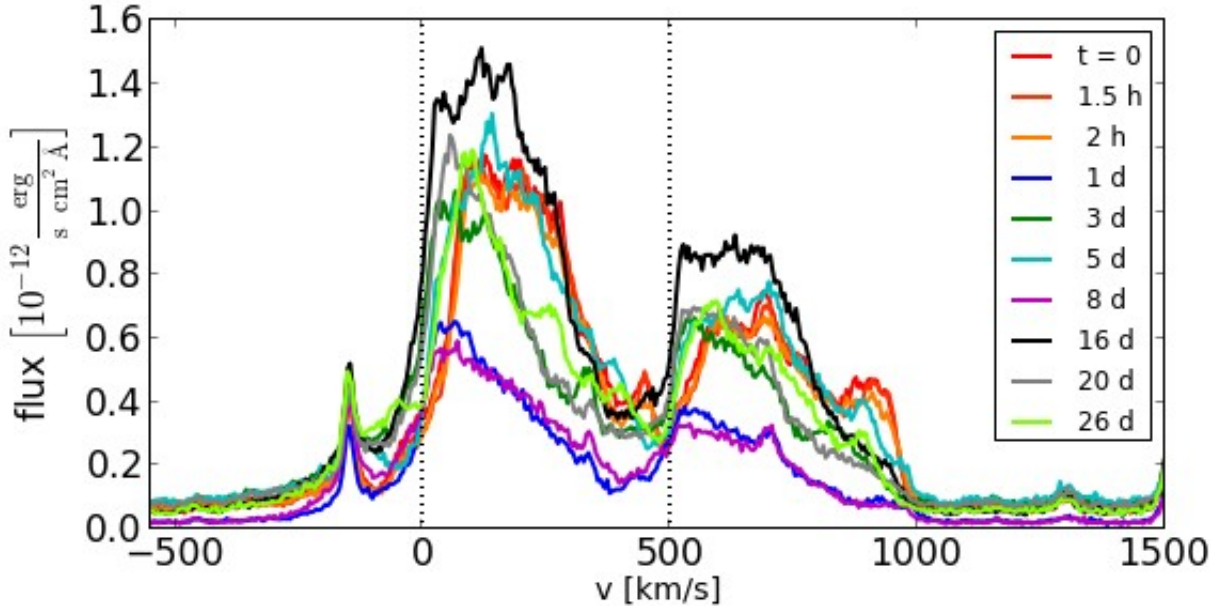
- Non-accreting TTS have two component C IV lines (Ardila et al. 2013)

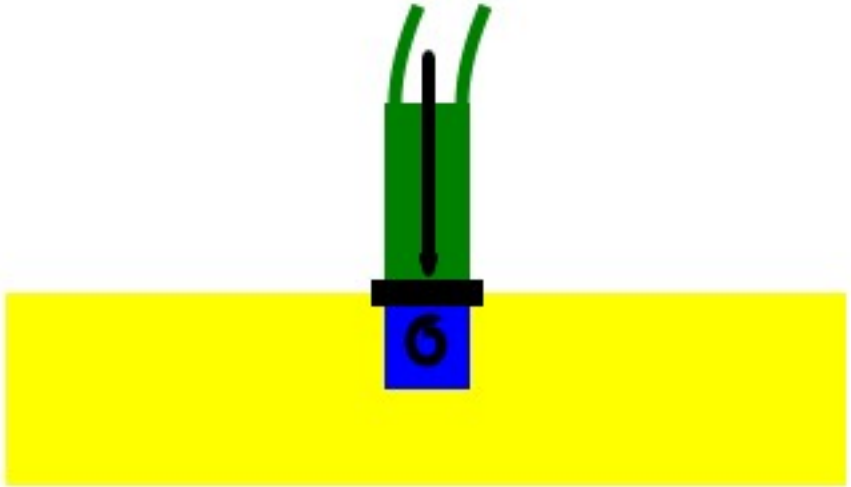


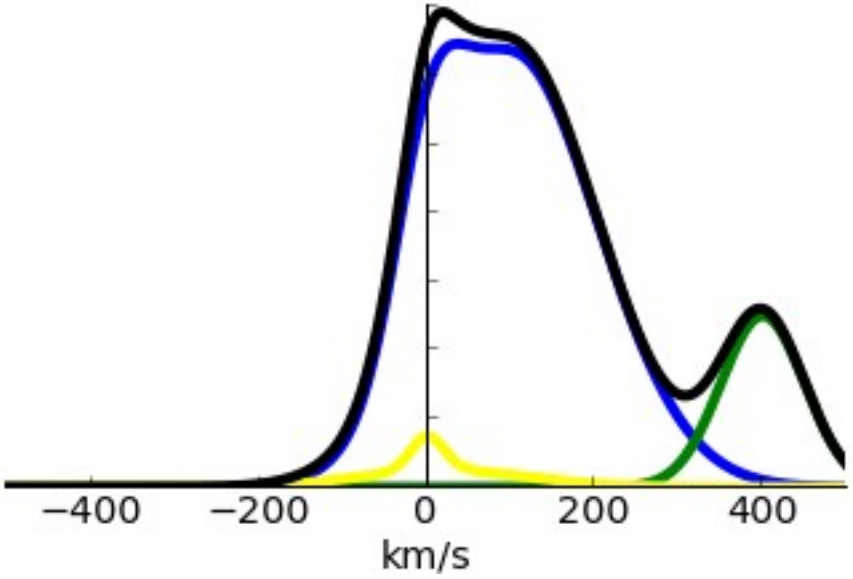


How can we explain the C IV (and other hot ion line) shapes?

- Pre-shock: freefall velocity
- Post-shock: tubulence, <¼ freefall velocity

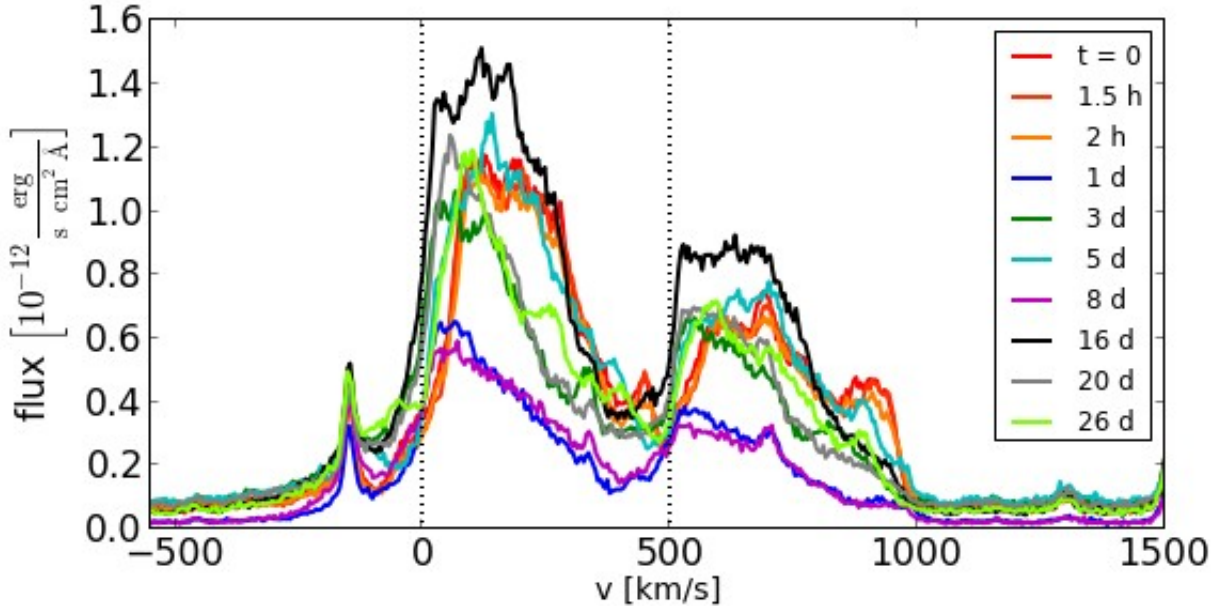


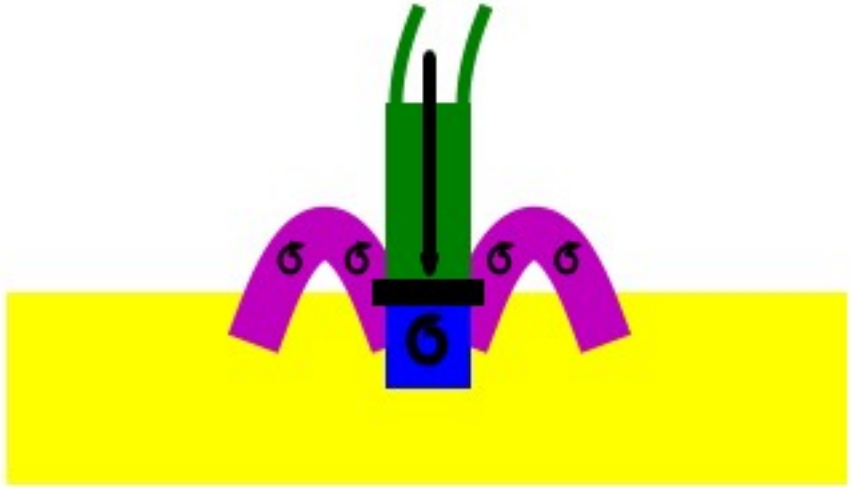


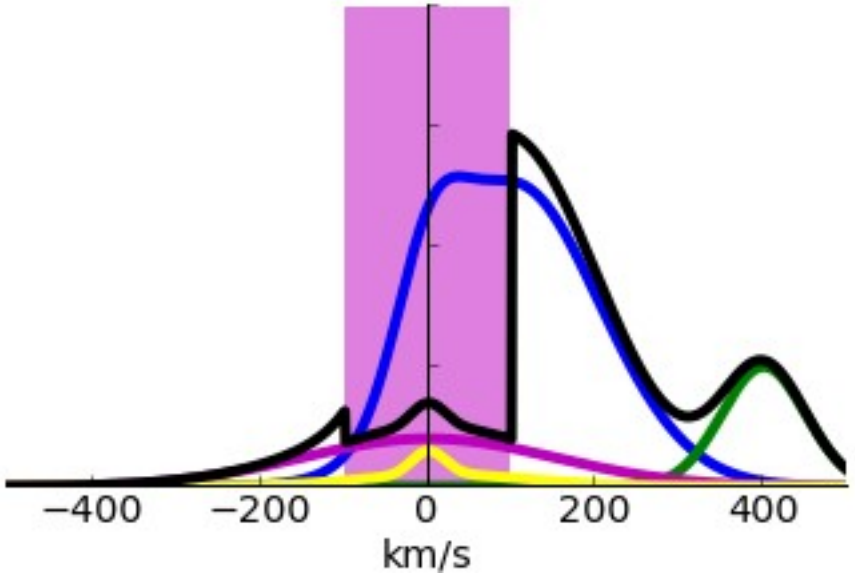


How can we explain the C IV (and other hot ion line) shapes?

- Splatter:
  turbulent,
  variable
  bulk < 100 km/s
  absorbtion







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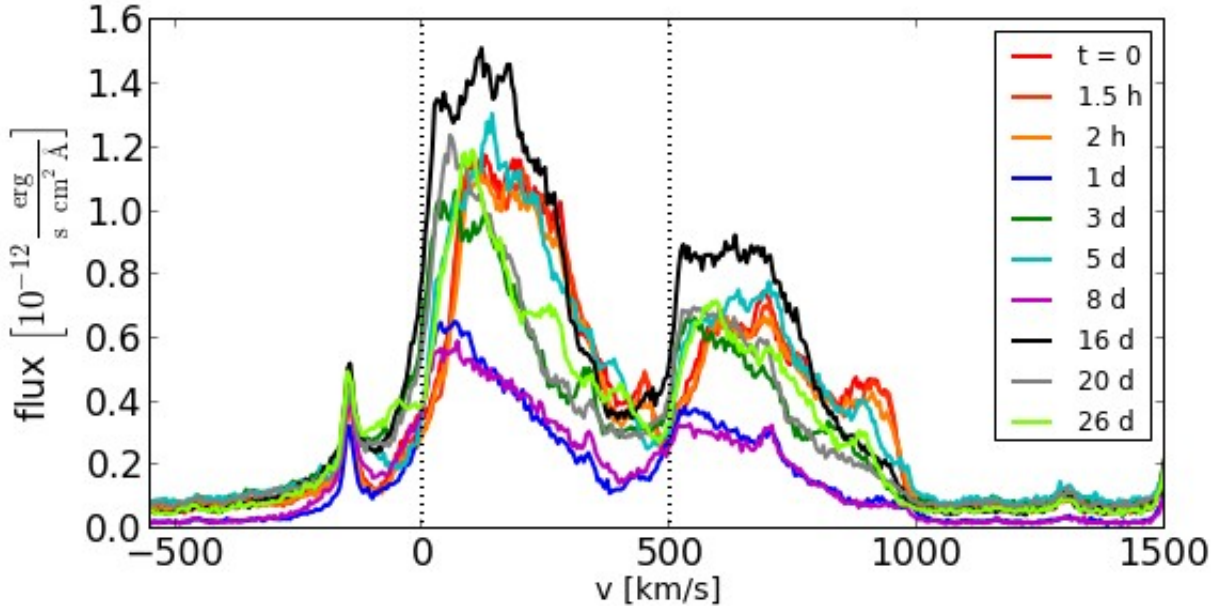
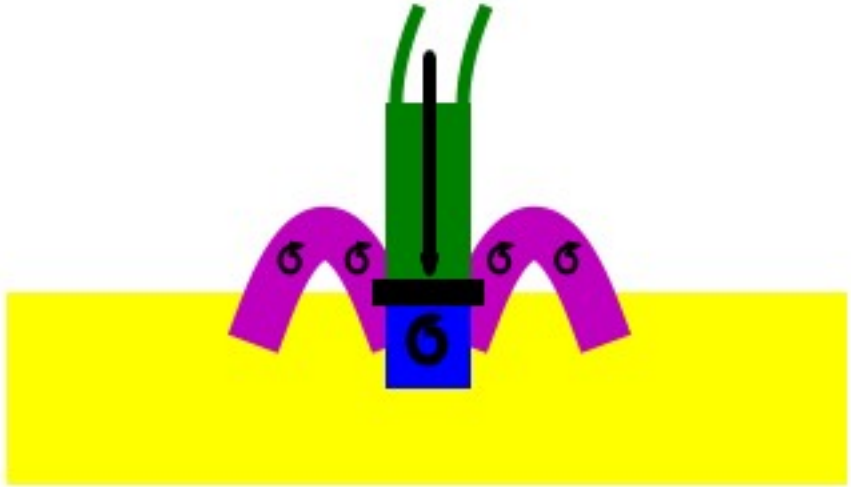
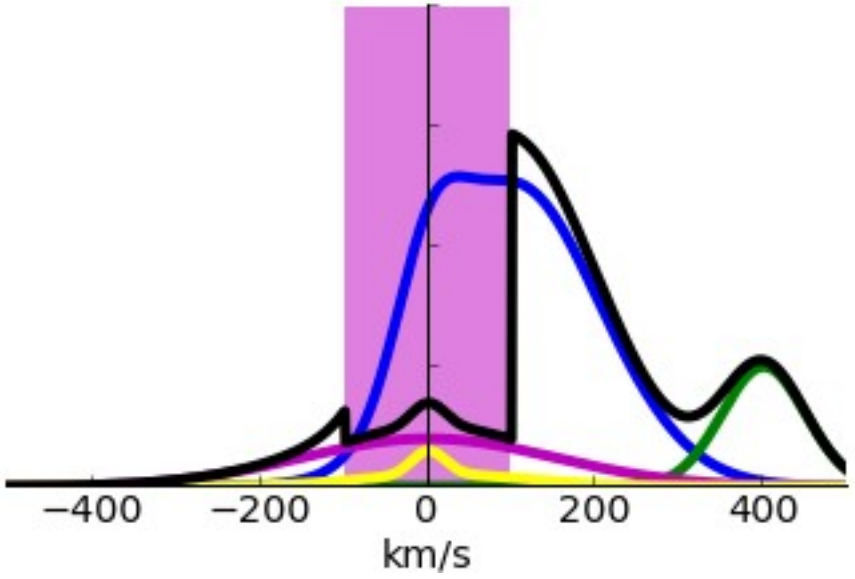
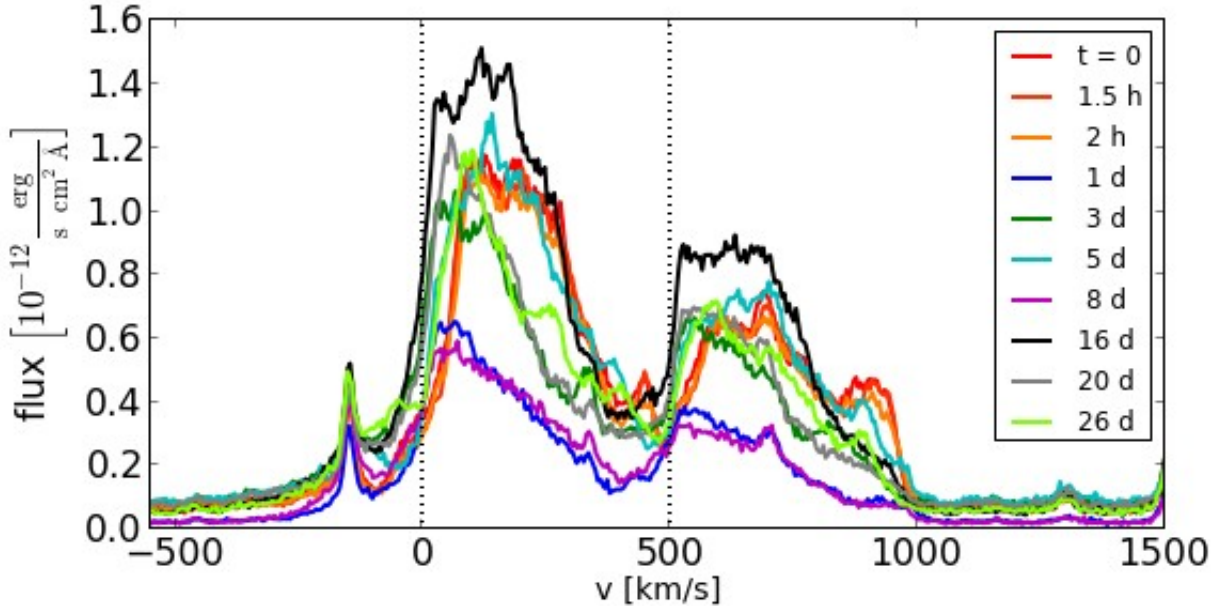


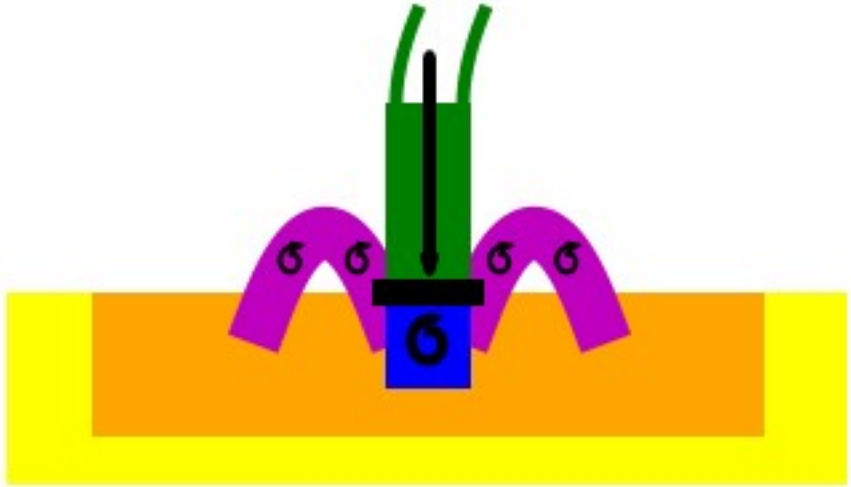


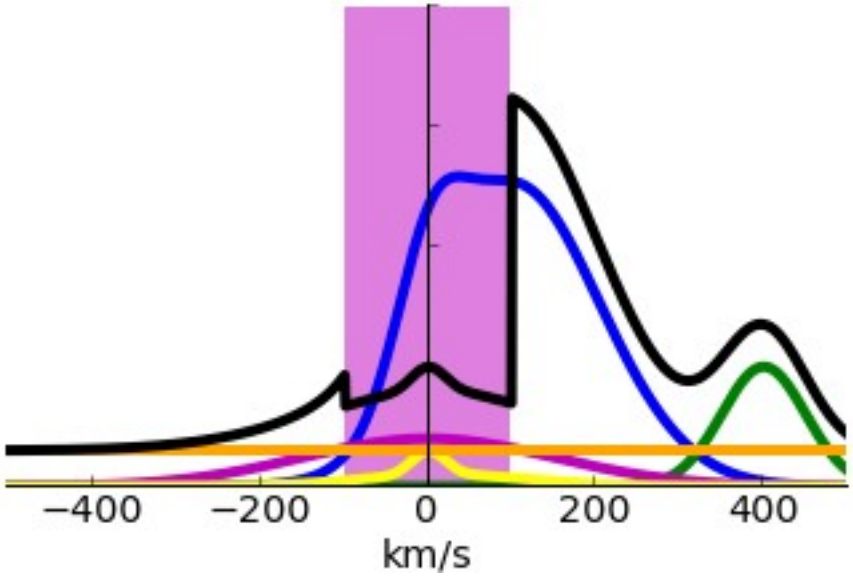


How can we explain the C IV (and other hot ion line) shapes?

- Heated photosphere: 20,000 K varies with accretion







Summary

- Chandra spectra show high-densities in TW Hya due to the accretion shock.
- We observe exceptionally low f/i ratios.
- This model is tuned using kinematic information from HST/COS.
- No hot wind, but a hot splatter (a failed wind)

Optical depth

- C IV is a doublet, with an intrinsic line ratio 2:1
- If the 1448 Ang line is lower, this indicates optical depth in the emission region.