MHD modeling of accretion impacts in CTTS: Observability and diagnostics in UV and X-ray bands

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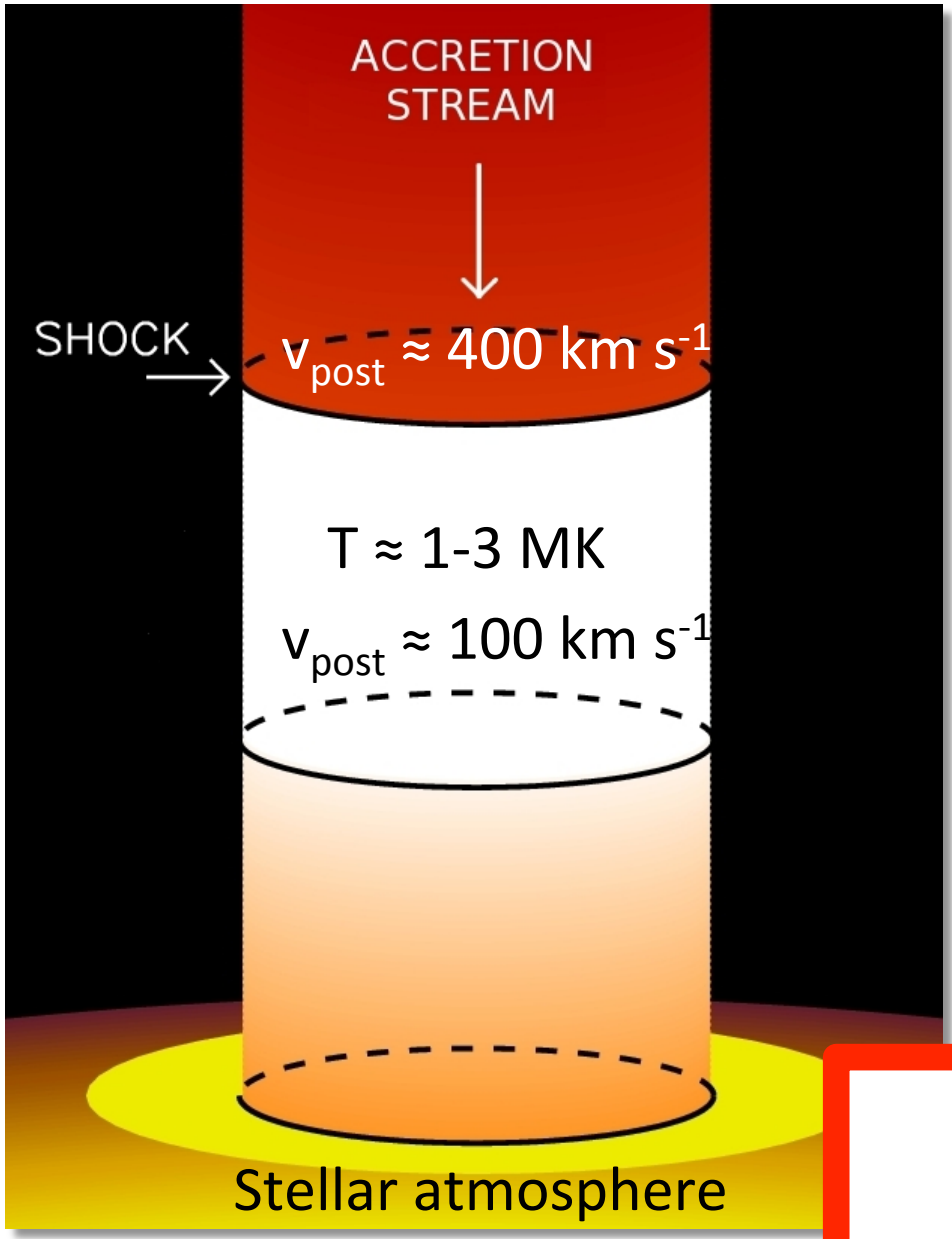
ACCRETION SCHOCK IN CTTS



STUDYING SHOCK REGION ALLOWS TO:

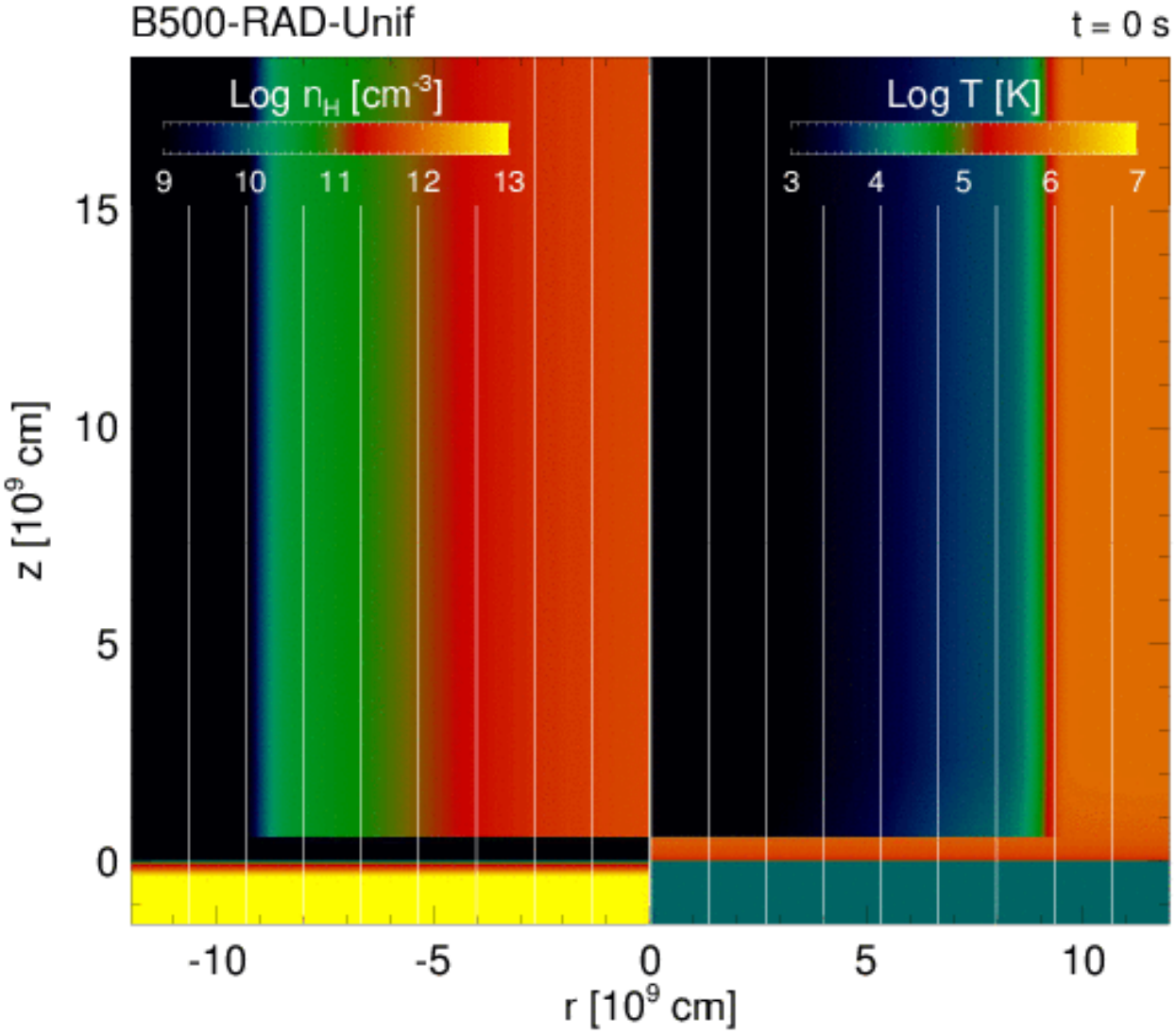
- Test the physical condition of the accretion stream (velocity, density, chemical composition)
- Test the geometry of the system.

OPEN ISSUES:

- Local absorption.
- UV and X-ray line luminosities.
- UV and X-ray line profiles.
- Contributions to UV lines from pre- and post-shock.

MHD SIMULATIONS +
SPECTRAL SYNTHESIS

MODELING



(Bonito et al. 2014)

2D MHD numerical simulation of the impact of an accretion stream onto the chromosphere of a CTTS.

We used:

- PLUTO code (Mignone et al. 2007).

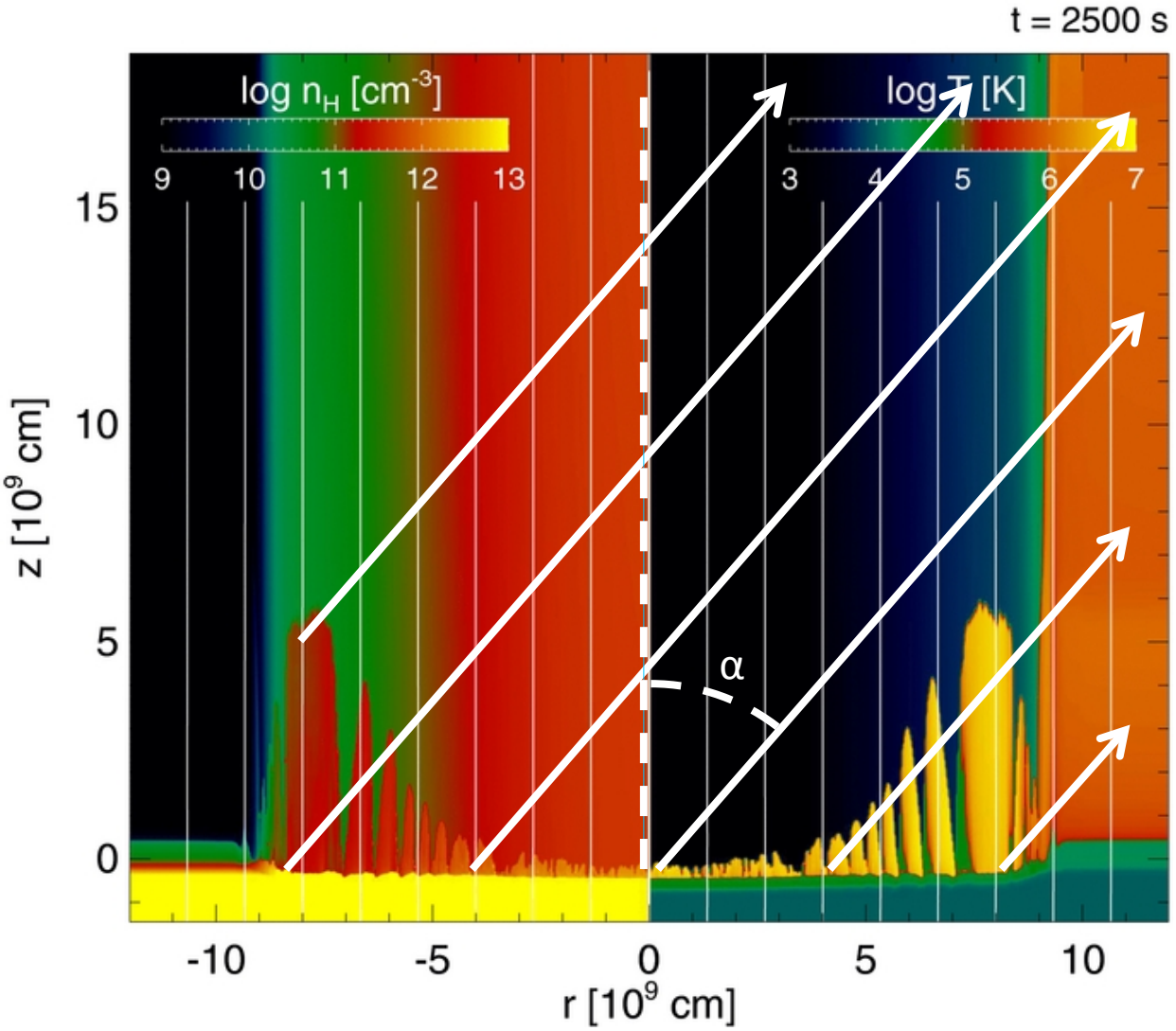
We took into account:

- radiative cooling
- thermal conduction
- gravity
- stellar atmosphere

Stream properties:

- radial distribution of density: 5×10^{10}–5×10^{11} cm^{-3}
- v_0 = 500 km s^{-1},
- T_{pre} = 10^3–10^4 K
- B = 500 G
- Stream radius = 10^{10} cm

SPECTRAL SYNTHESIS



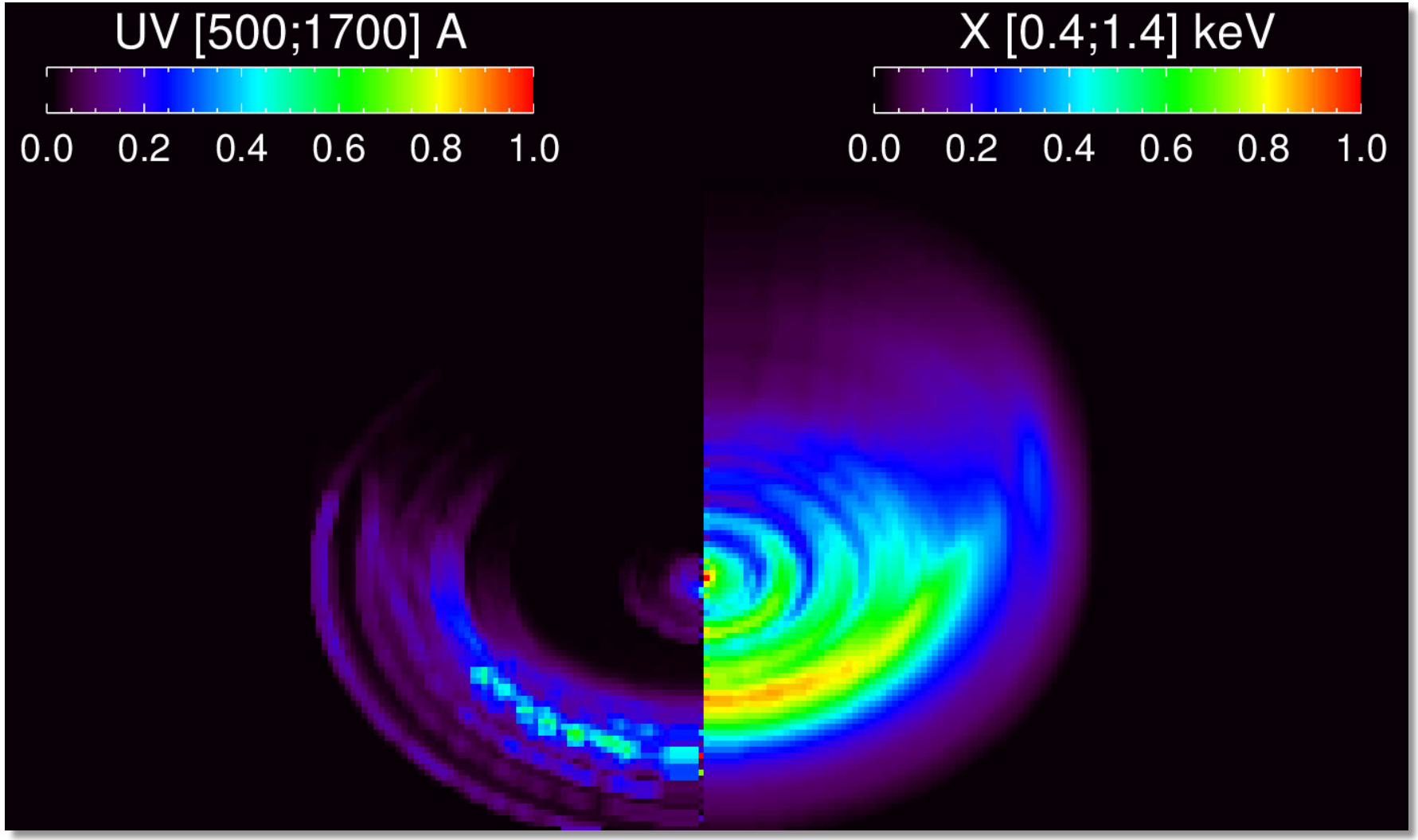
We computed UV and X-ray spectra considering:

- Local absorption
- Doppler shift
- Different viewing angle α

We compared them with observations, focusing on:

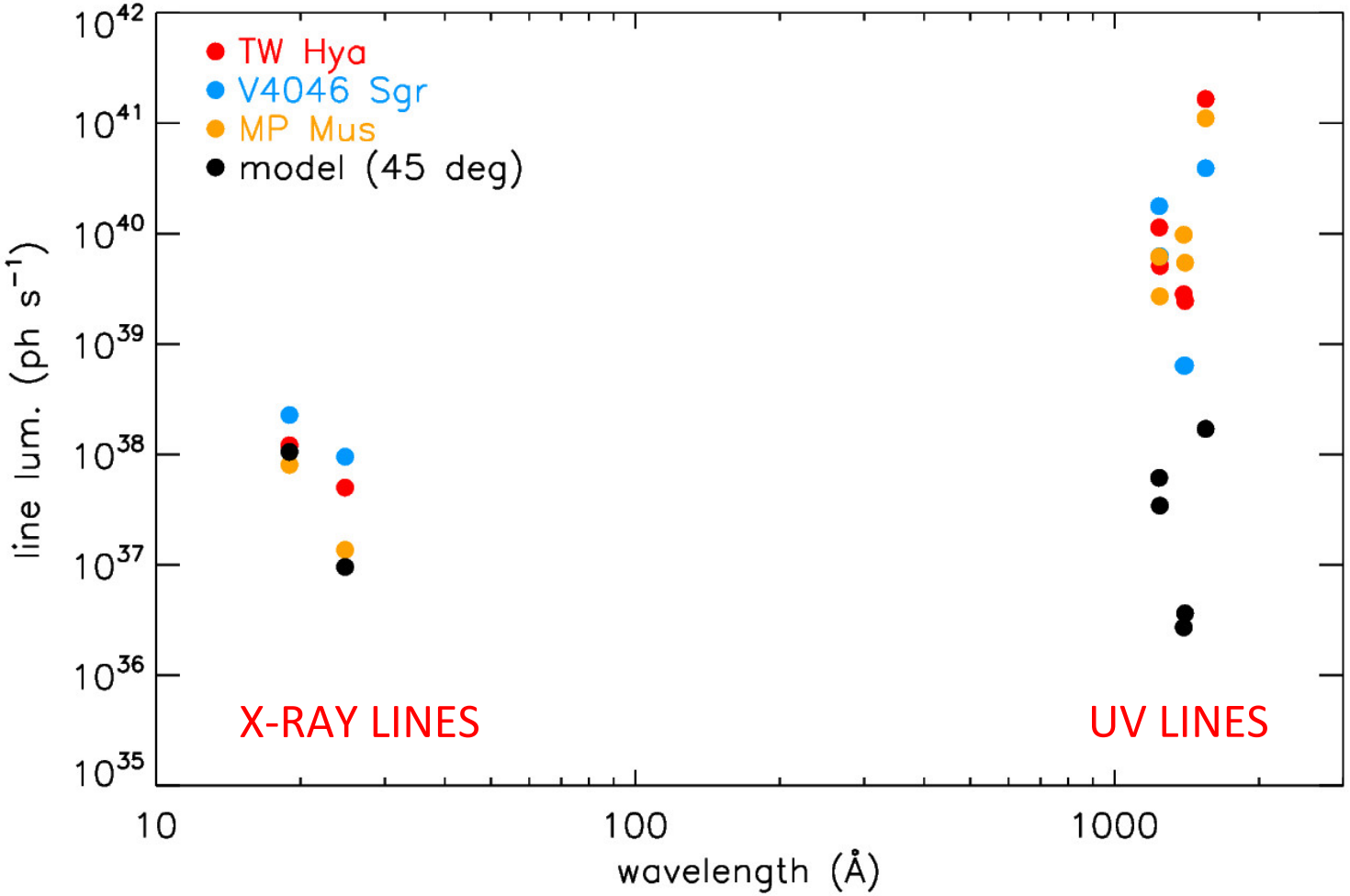
- Line/band luminosity
- Line profile

X-RAY vs UV LUMINOSITY: THE ROLE OF LOCAL ABSORPTION



- Different wavelengths monitor different portions of the stream.
- A significant fracion of UV and X-ray emission is absorbed locally →possible pre-shock heating (Costa et al. in preparation).

LINE LUMINOSITY: OBSERVED AND PREDICTED

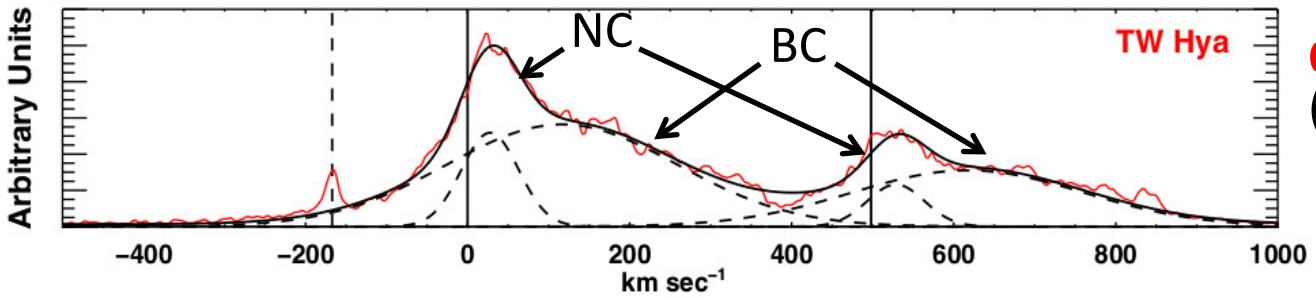


1. UV and X-ray lines are emitted by post-shocks of different streams at different velocities.

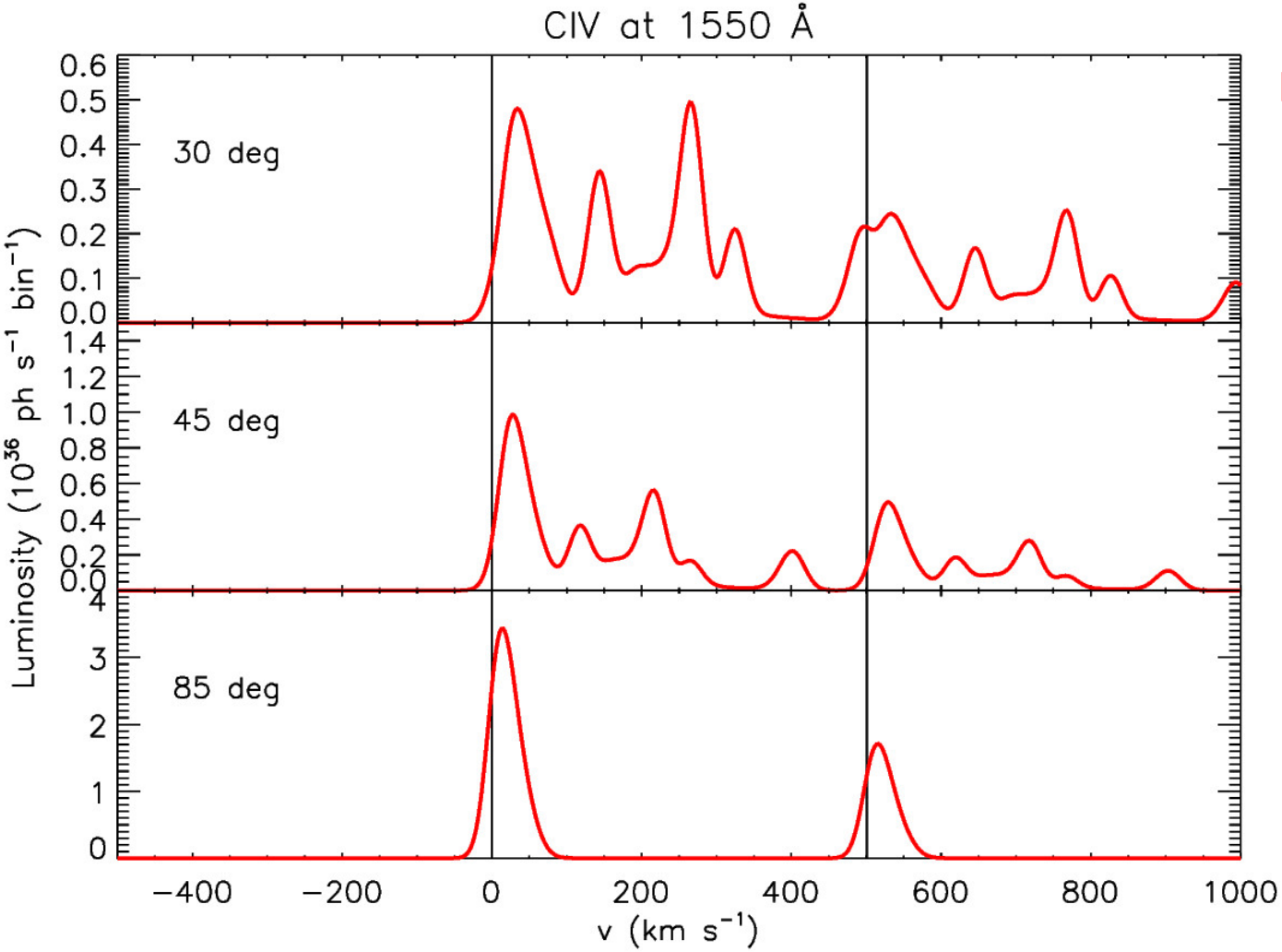
2. The accretion stream is different from that considered (a time-variable density could increse the UV to X relative emission, Colombo et al. in preparation);

3. the pre-shock significantly contributes to the UV lines.

LINE PROFILE OF THE CIV DOUBLET AT 1550 Å



OBSERVED
(Ardila et al. 2013)



PREDICTED

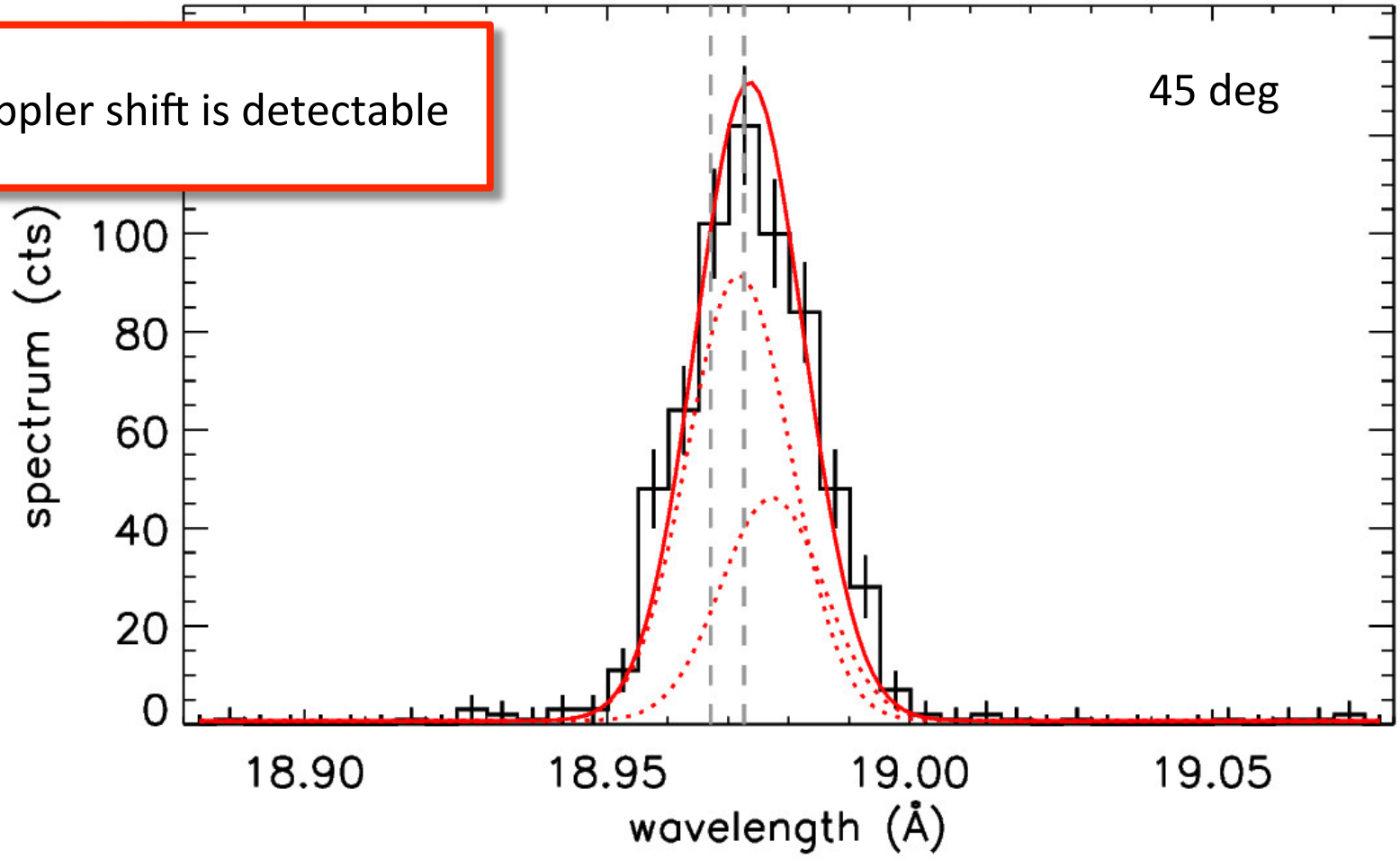
- CIV post-shock emission: vast range of velocity.
- CIV profile strongly depends on viewing angle.

SIMULATED PROFILE OF THE OVIII DOUBLET AT 18.97 Å

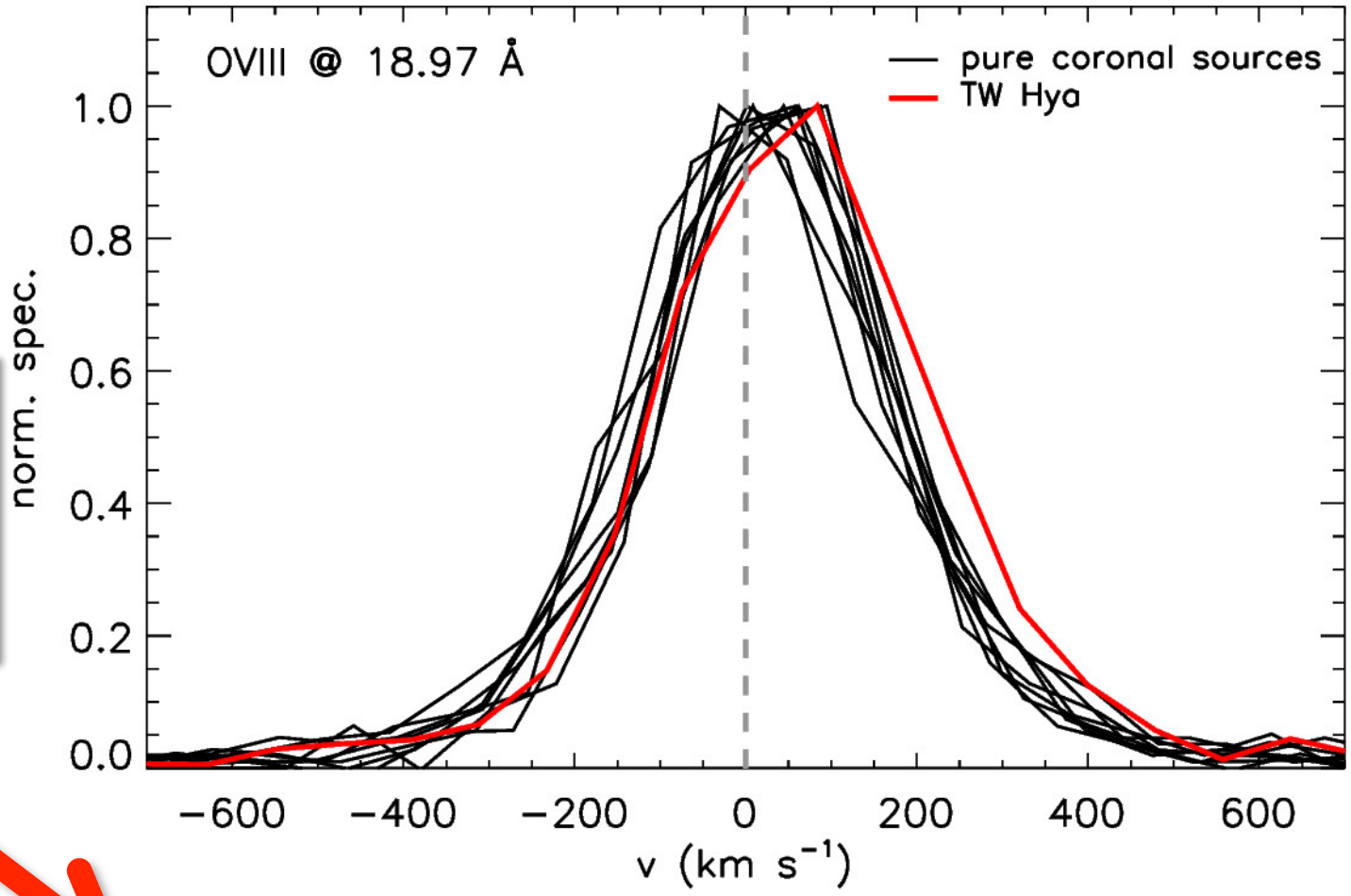
Spectral resolution: X-rays ≈ 85 km s^{-1},UV ≈ 15 km s^{-1}.

- We simulated a Chandra/HETG X-ray spectrum, with a S/N ratio similar to the TW Hya one.
- We fitted line position to check whether the Doppler shift is detectable.

Even at 45 deg a Doppler shift is detectable



OBSERVED PROFILE OF THE OVIII DOUBLET AT 18.97 Å



TW Hya X-ray spectrum is Doppler shifted of 35 ± 5 km s^{-1}

See the poster Argiroffi et al. for more details

Same velocity of CIV NC (Ardila et al. 2013), likely the UV and X-ray lines originate in the same post shock region.

Accretion footpoints are at low latitude.

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CONCLUSIONS

ABSORPTION:

- Importance of local absorption → heating of the pre-shock.

LINE LUMINOSITIES:

- Reconcile UV and X-ray line luminosity (UV emission from both pre- and post-shock, several streams, density variations).

LINE PROFILES:

- Predicted CIV line profile from the post-shock shows a vast range of velocity.
- X-ray: OVIII line Doppler shift → detectable, and detected! → position of the base of the accretion stream.
- OVIII and CIV NC: same velocity → both lines likely originate in the same post-shock region.