

Accretion as the Driving Mechanism for the Observed X-ray Emission in TW Hya

Mark Reynolds

(University of Michigan)

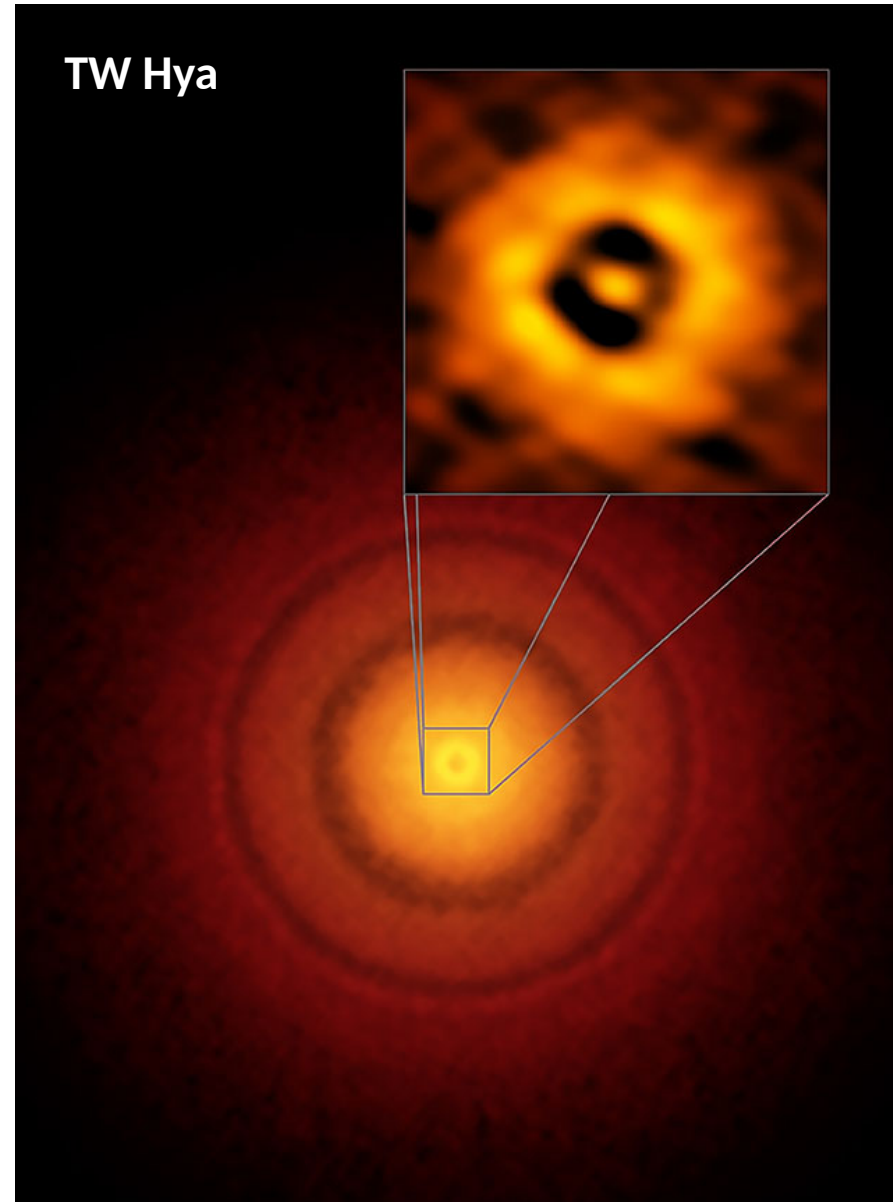
Thanawuth Thanathibodee (University of Michigan), Nuria Calvet
(University of Michigan)

Why Should You Care?

- Star & Planet formation

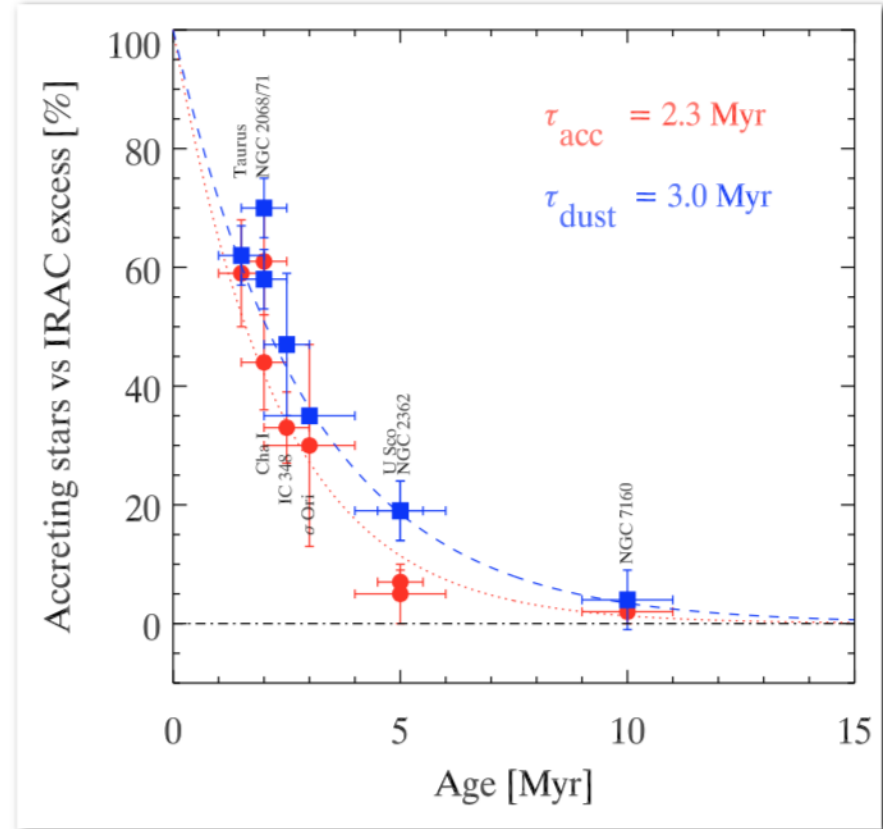
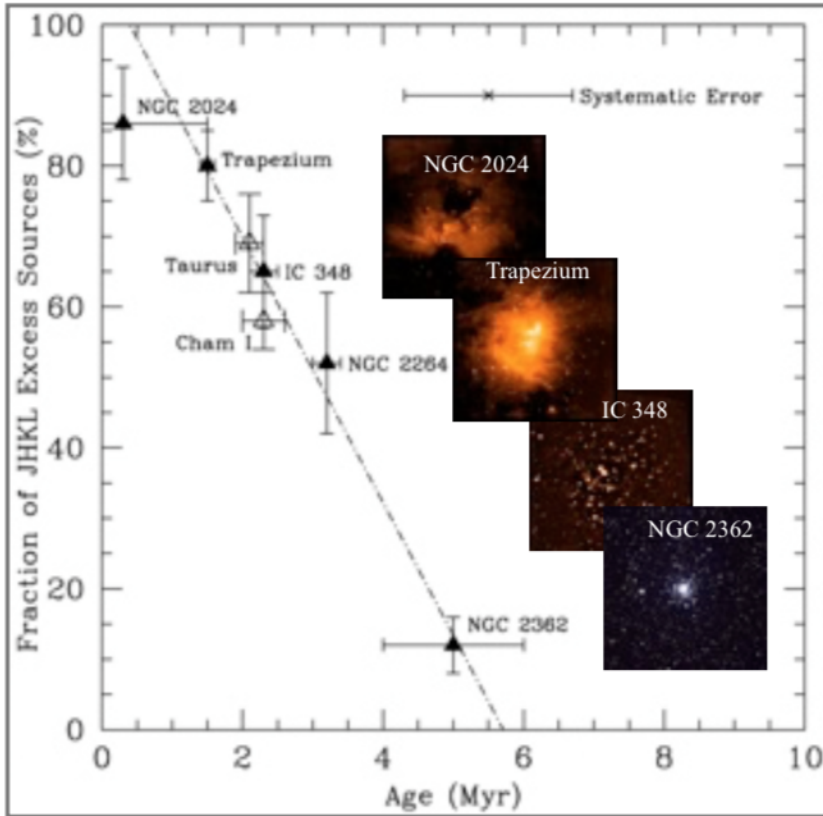
This observation of the TW Hydrae T-Tauri system is on a similar spatial scale as the Earth/Sun system.

- * Hints of ongoing planet formation.
- * Methanol is present in this disk.



Why Should You Care?

- Star & Planet formation



Mean Disk Lifetime \approx 3 Myr

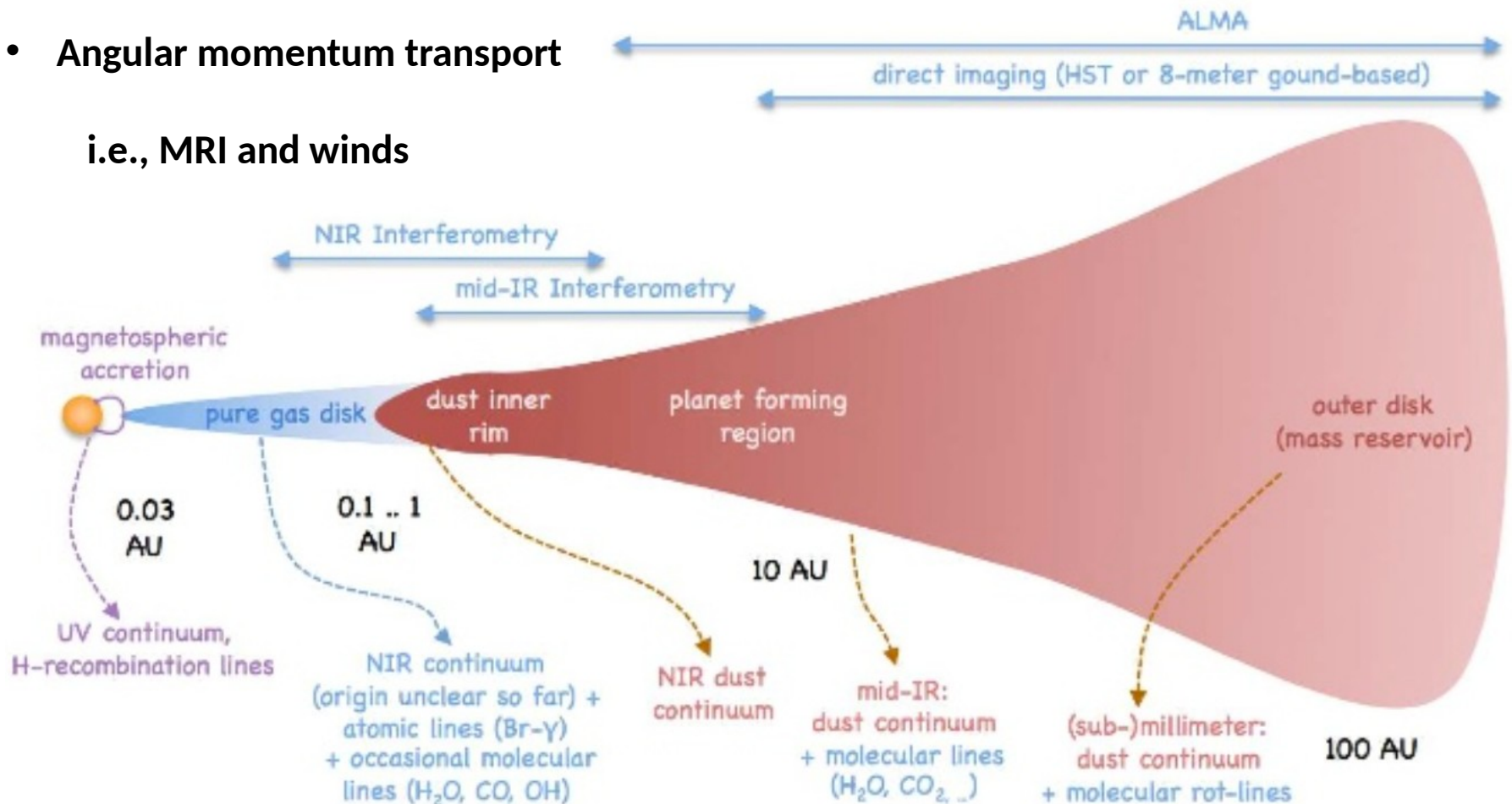
**** dM/dt ****

Why Should You Care?

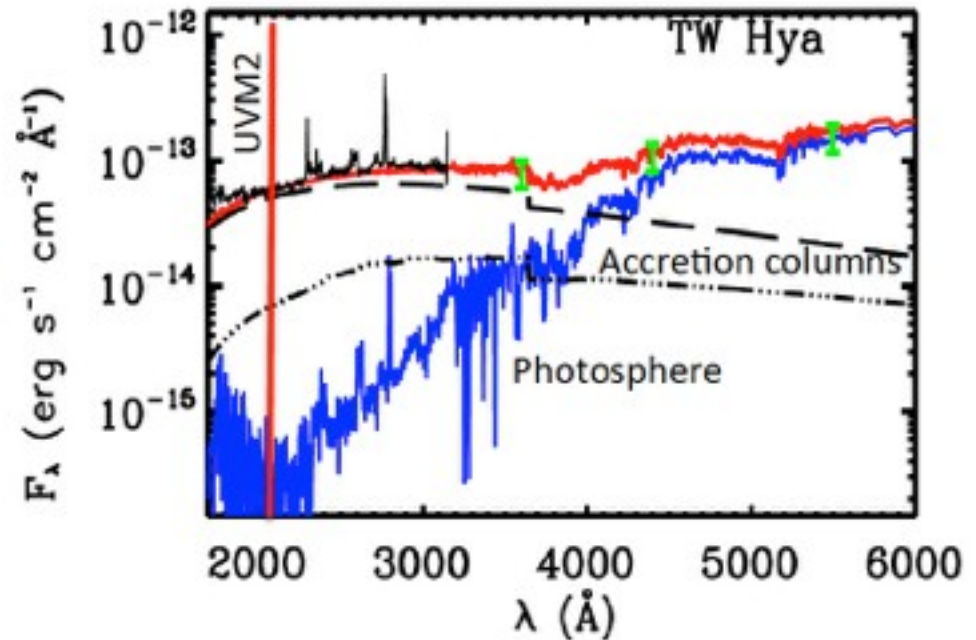
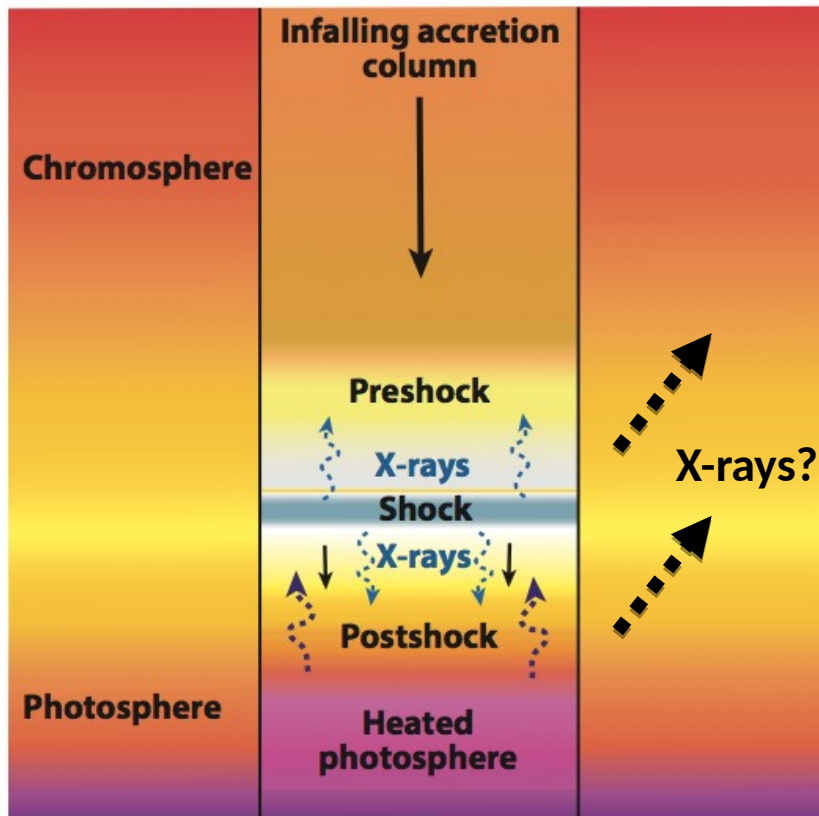
- Proto-planetary Accretion Disk Structure

- Angular momentum transport

i.e., MRI and winds

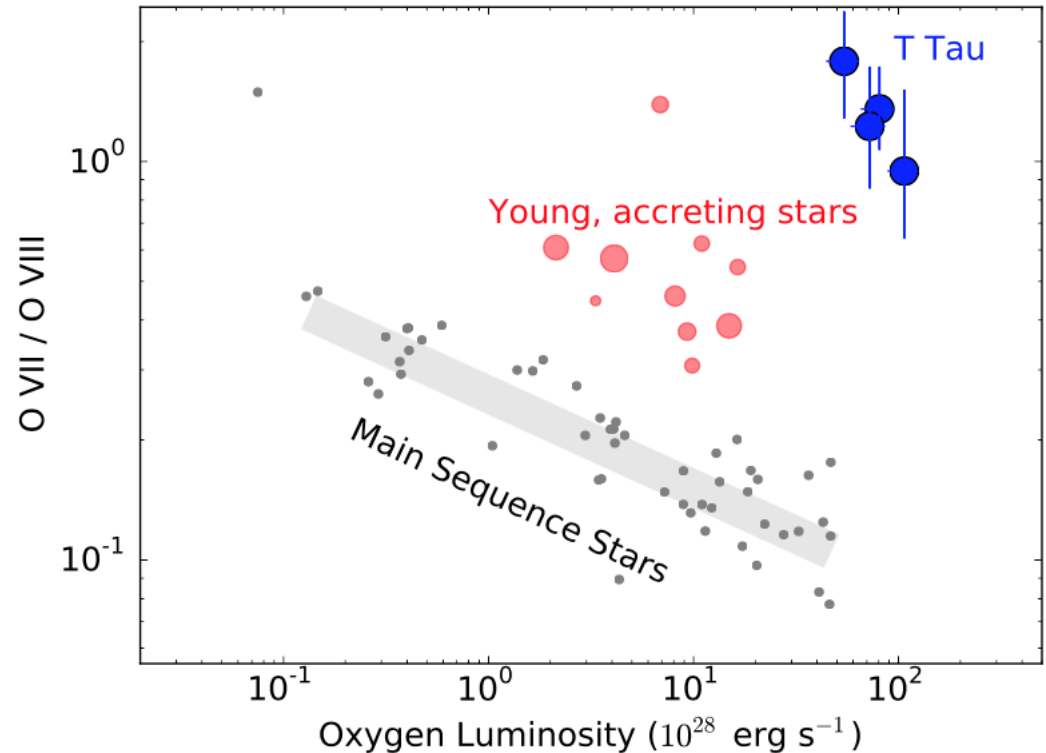
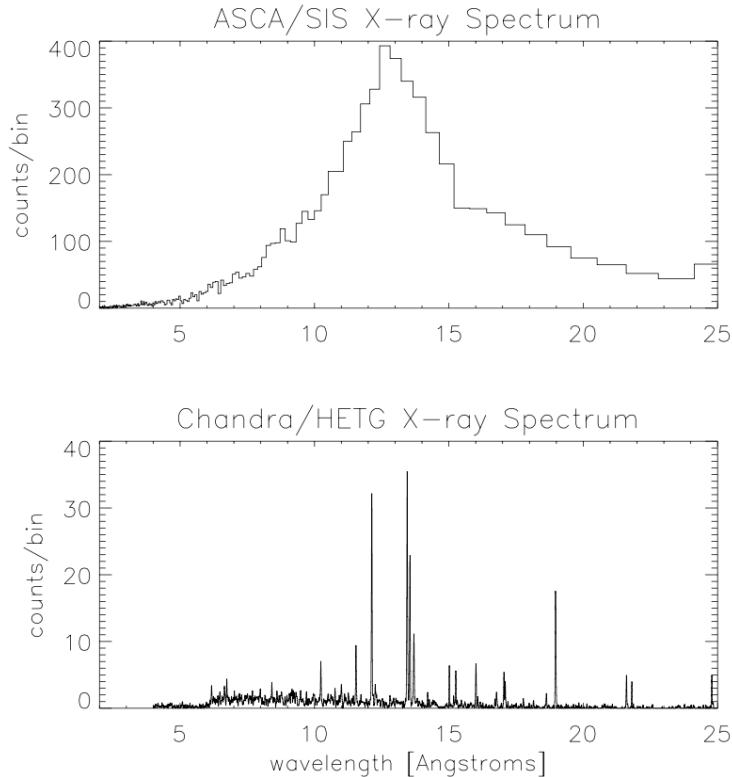


The Stellar Accretion Model



The Inner accretion flow as observed from TW Hya

Previous X-ray Observations

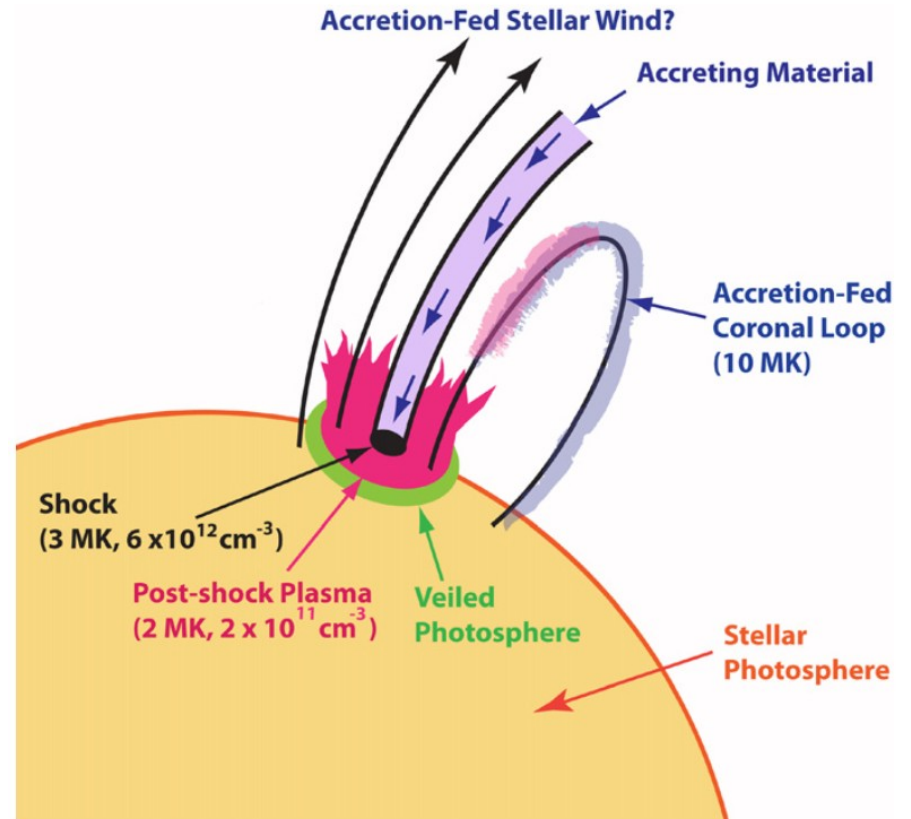
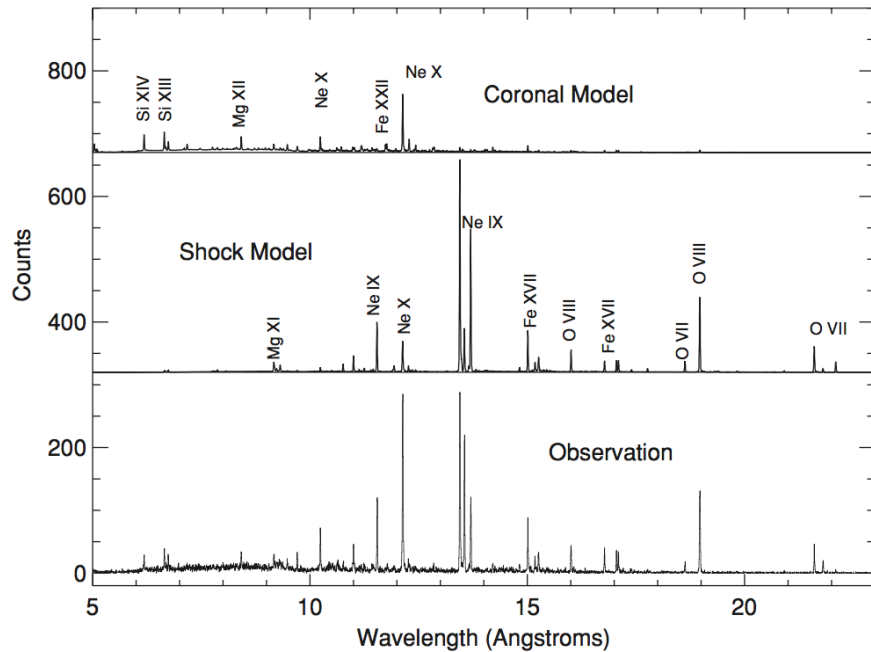


**But, an excess of soft X-rays is clearly present in accreting young stars.
Is this generated in the shock?**

Kastner+ (1999, 2002); Gunther+ (2007); Argiroffi+ (2007); Schneider+ (2018)

Previous X-ray Observations

Densities of O VIII and Ne IX found to disagree with standard accretion shock models.



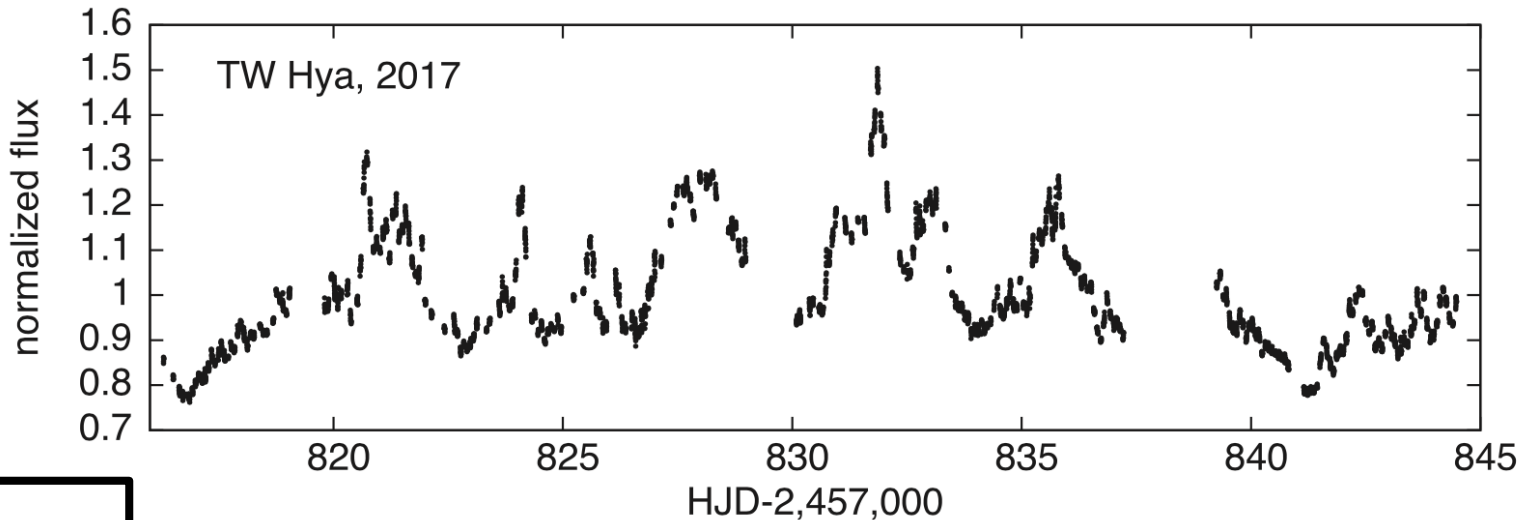
Long *Chandra*/HETGS stare at TW Hya

Multi-component plasma detected

Brickhouse+ (2010)

TW Hya

- Optical Properties



Face-on ($i \sim 7^\circ$)

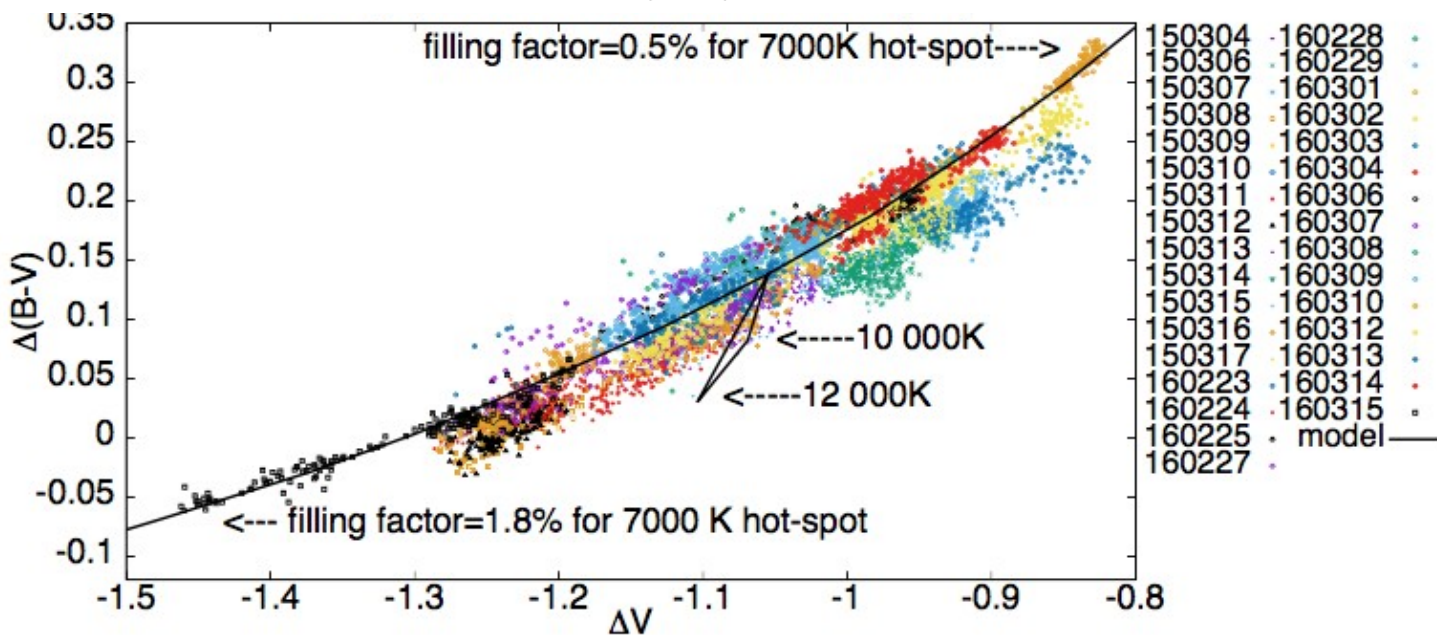
$D \sim 57$ pc

$M \sim 0.8 M_{\text{sun}}$

$\tau \sim 8$ Myr

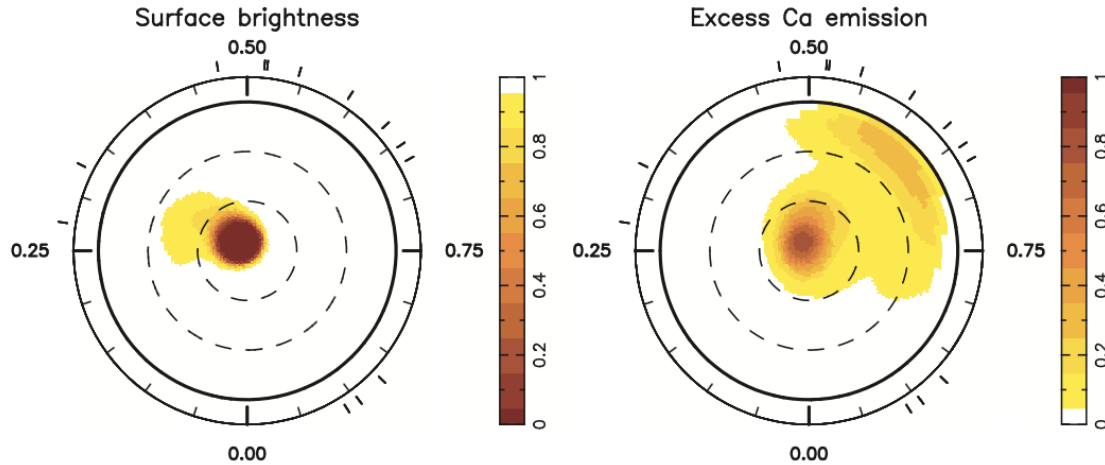
$B \sim 2.8$ kG

Siwak+ (2018)



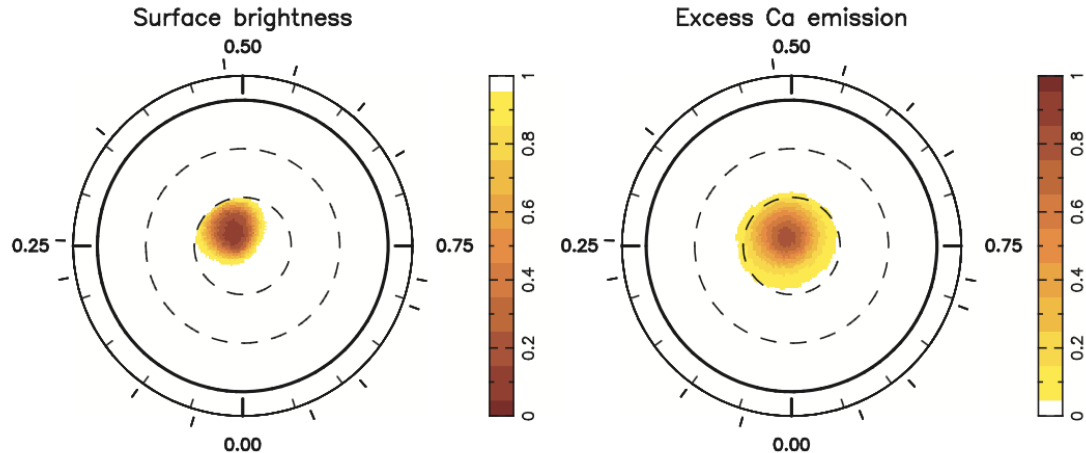
TW Hya

- Magnetic field properties



Dipole B-field geometry.

Face-on ($i \sim 7^\circ$)
 $D \sim 57$ pc
 $M \sim 0.8 M_{\text{sun}}$
 $\tau \sim 8$ Myr
 $B \sim 2.8$ kG



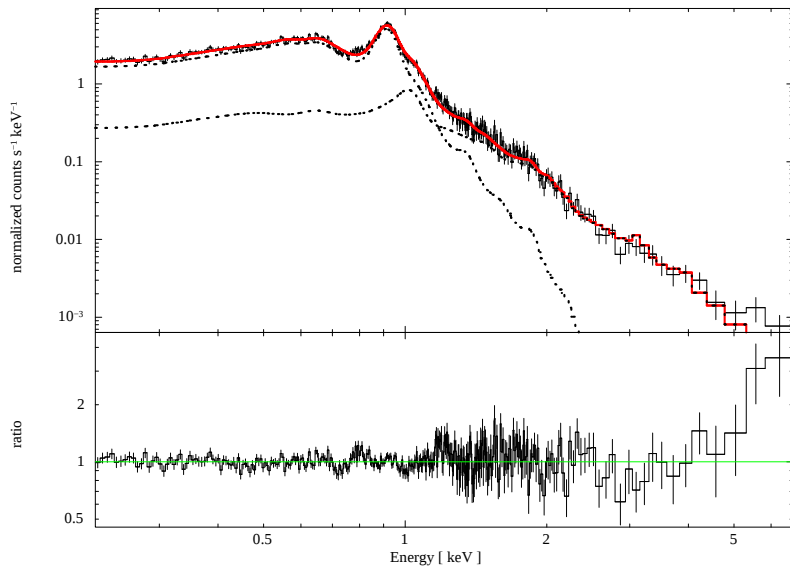
Variable!

Donati+ (2011)

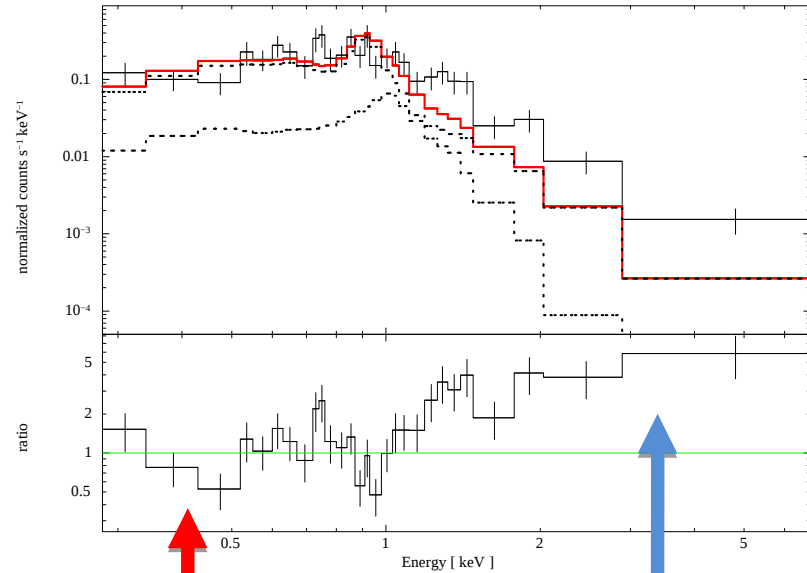
TW Hya

- Our proposed experiment with *Swift*

XMM-Newton EPIC-pn



Swift XRT



Classic 2 temperature T-Tauri spectrum

□ Soft excess & corona

Clear coronal variability!

What about the soft X-rays?

Kastner+ (1999, 2002); Stelzer & Schmitt (2004)

TW Hya

- X-ray spectra as observed by *Swift*/XRT

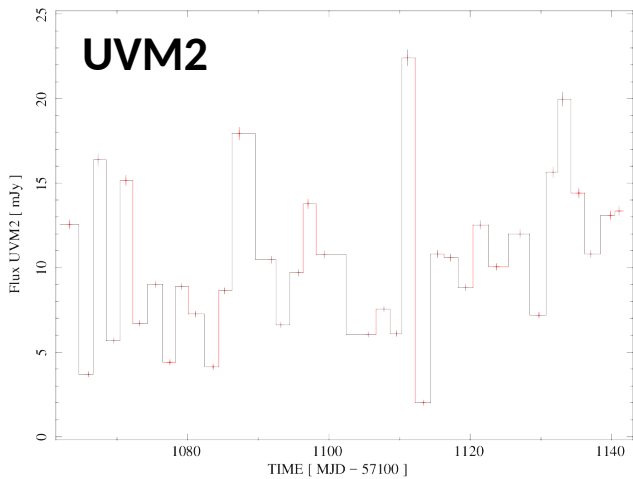
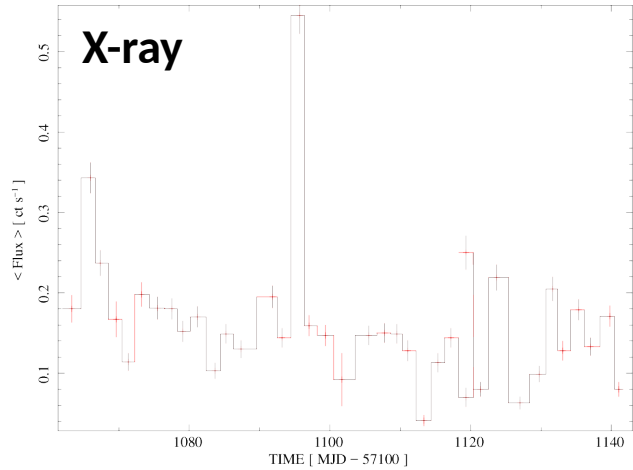


Observations every 3-5 days for approx. 10 weeks.

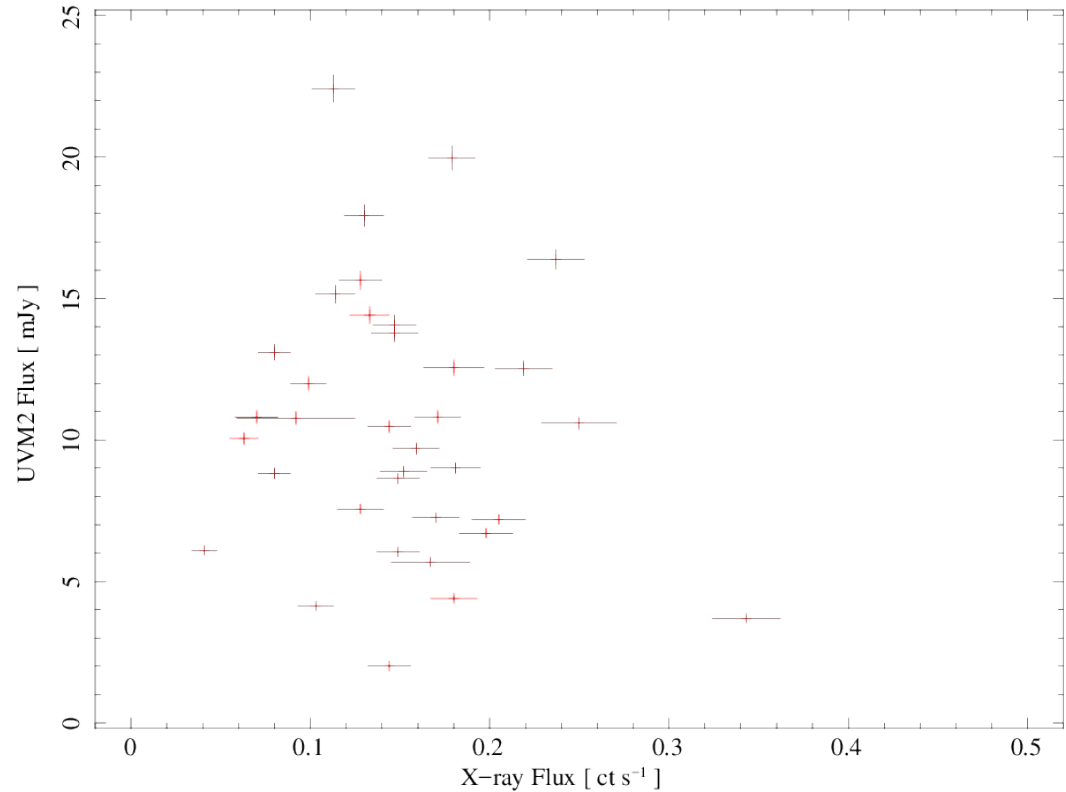
Simultaneous X-ray and UV measurements.

TW Hya

- **Swift X-ray and UV lightcurves**



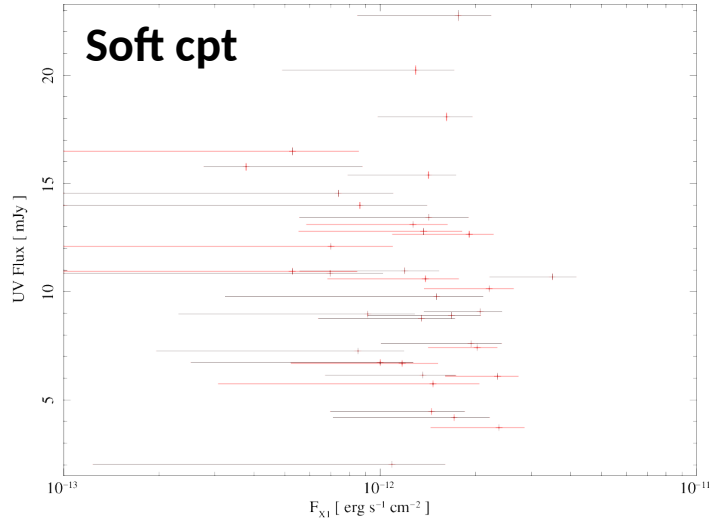
UV vs X-ray



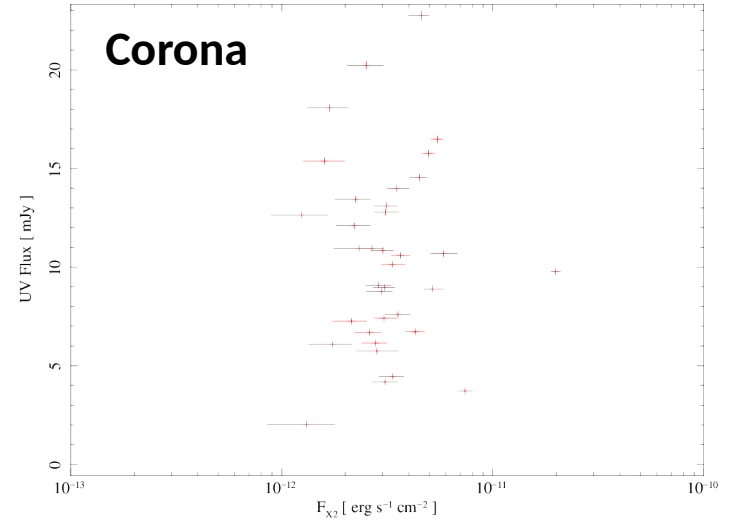
No correlation between the X-ray and UV flux!

TW Hya

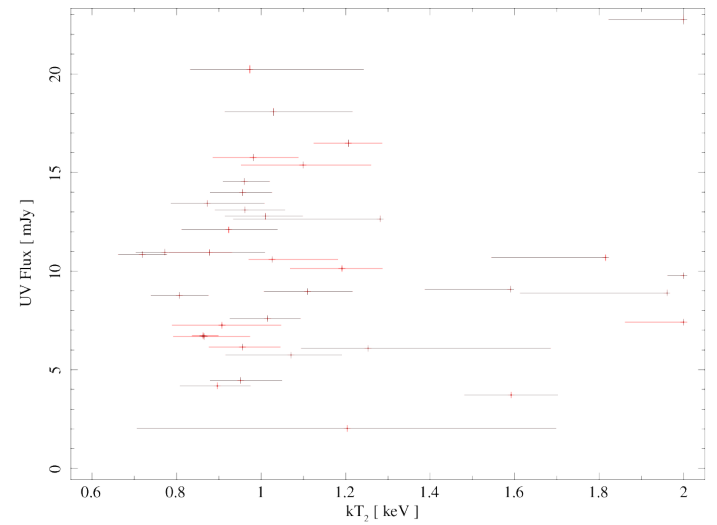
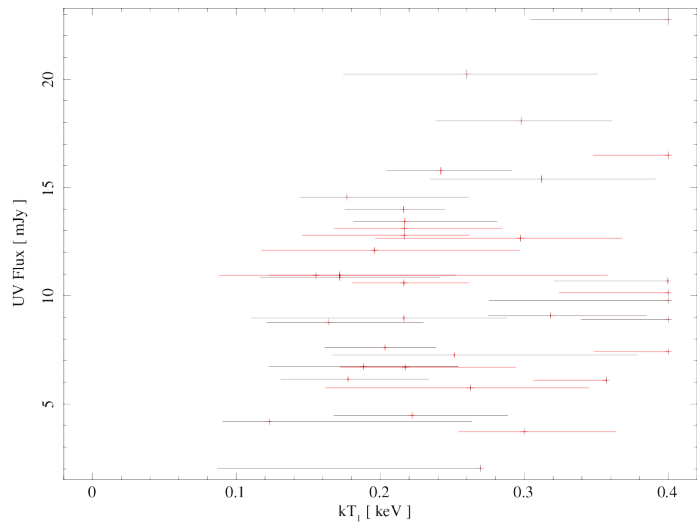
- X-ray spectral properties vs UV flux



□ Flux □

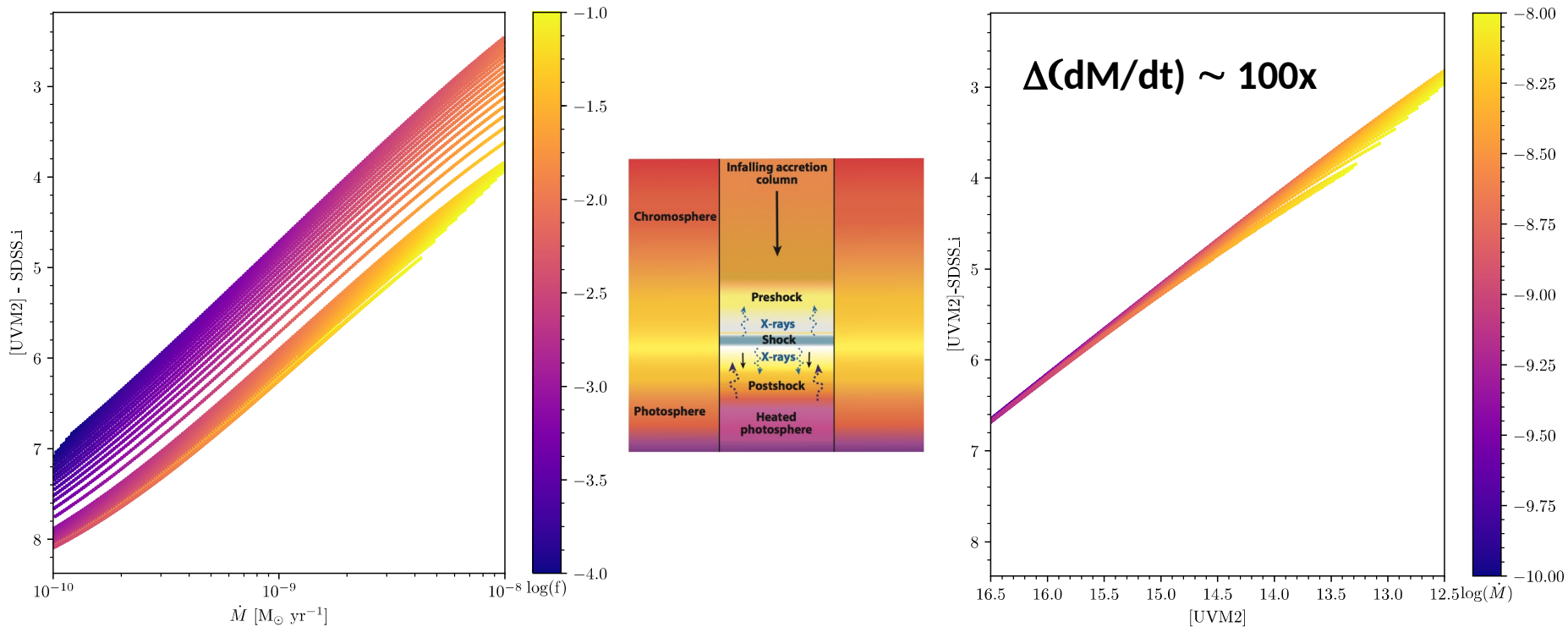


□ Temp □



TW Hya

- Accretion shock model (Calvet++; Ingleby+ 2011)

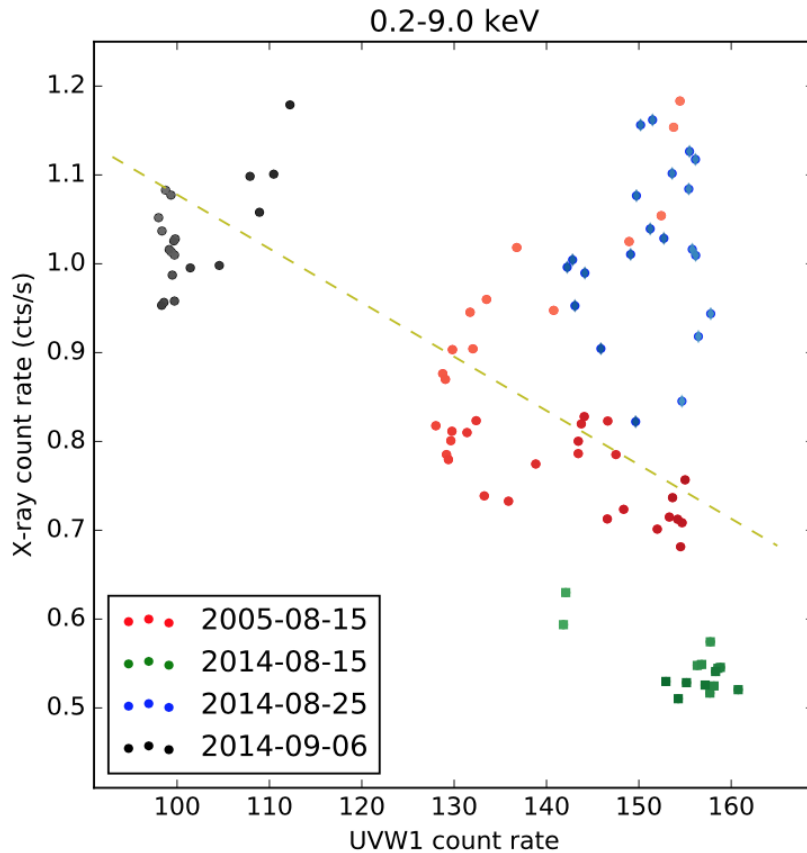


The observed UV lightcurve implies a highly variable accretion column.

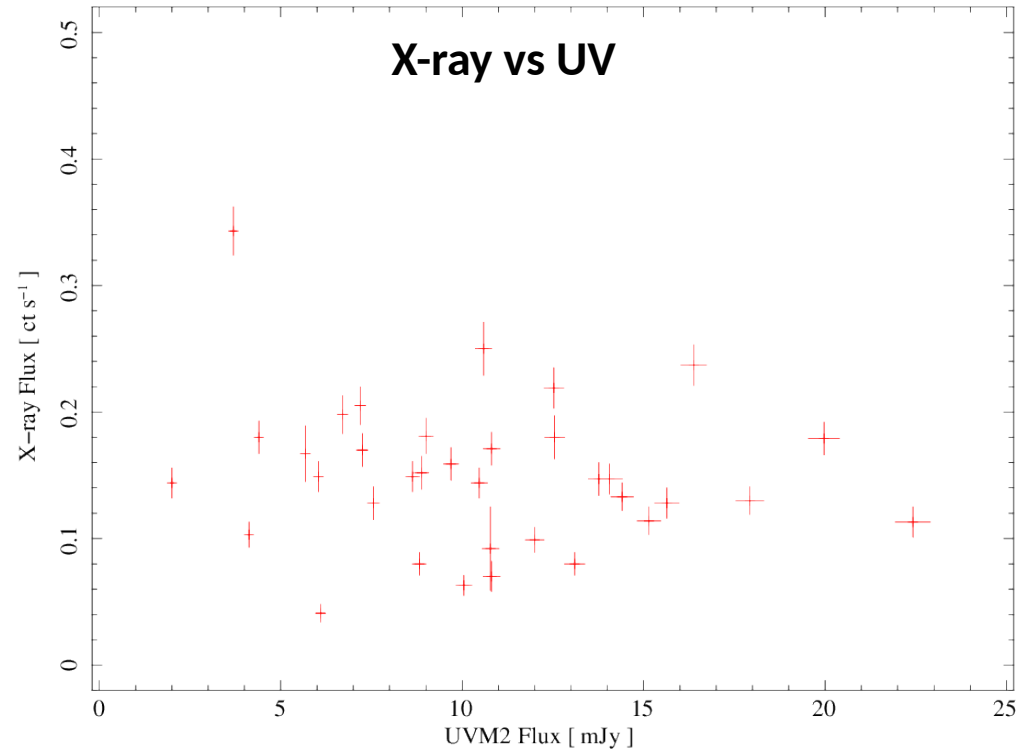
Modeling by Thanawuth Thanathibodee (also see his poster!).

T Tau vs TW Hya

- How universal is the X-ray/UV behavior in Tw Hya?



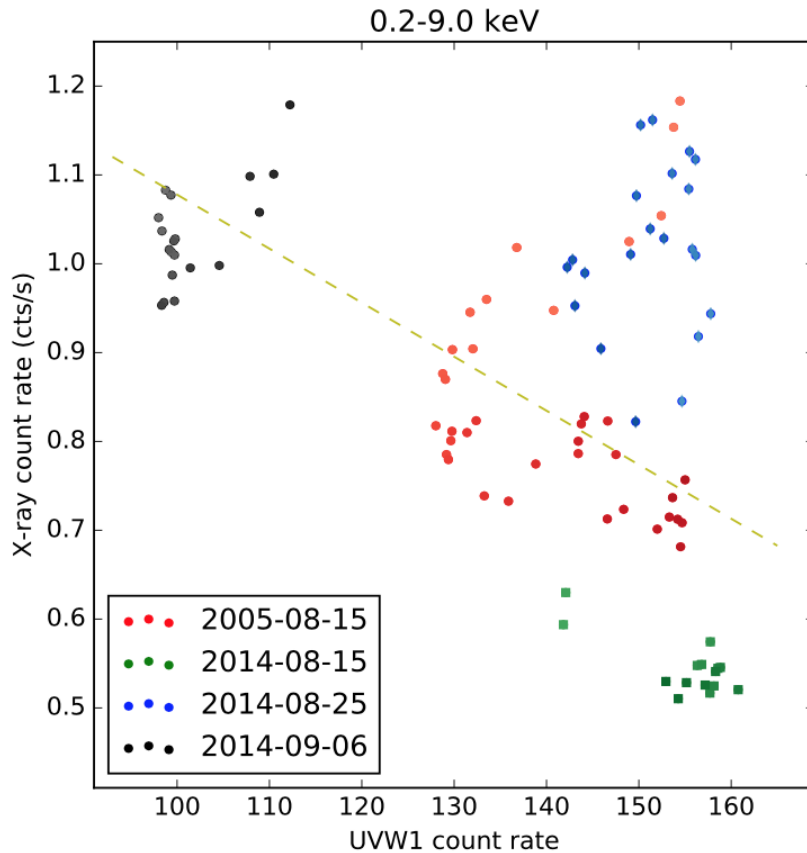
OM - UVW1



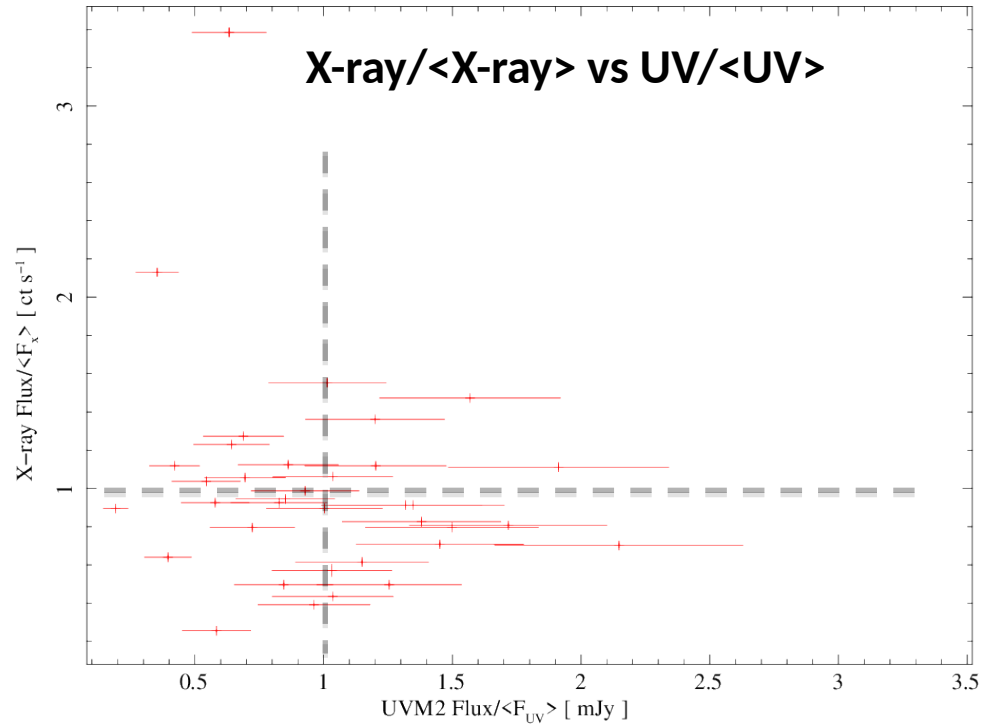
UVOT - UVM2

T Tau vs TW Hya

- How universal is the X-ray/UV behavior in Tw Hya?



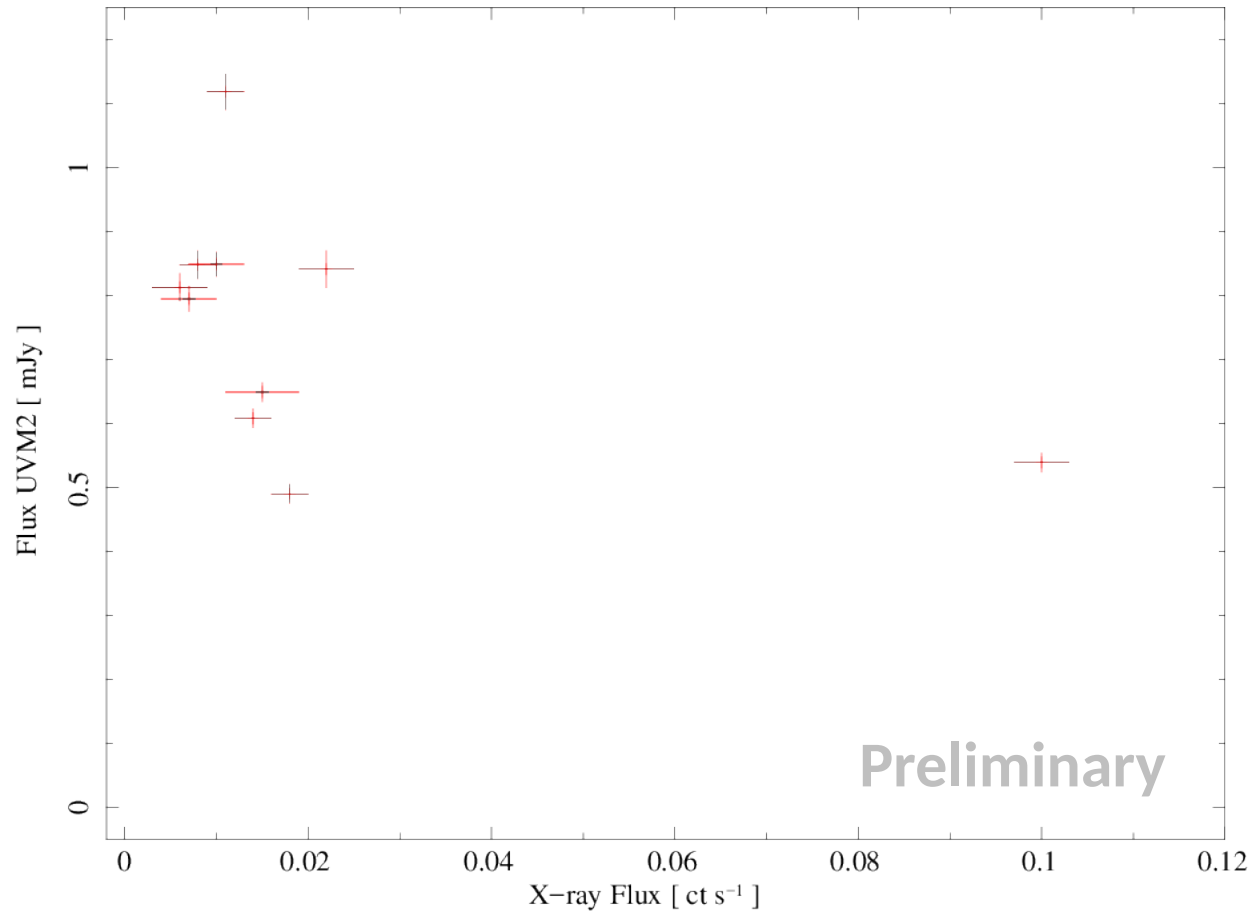
OM - UVW1



UVOT - UVM2

GM Aur

- Ongoing *Swift* program to obtain X-ray and UV for GM Aur.



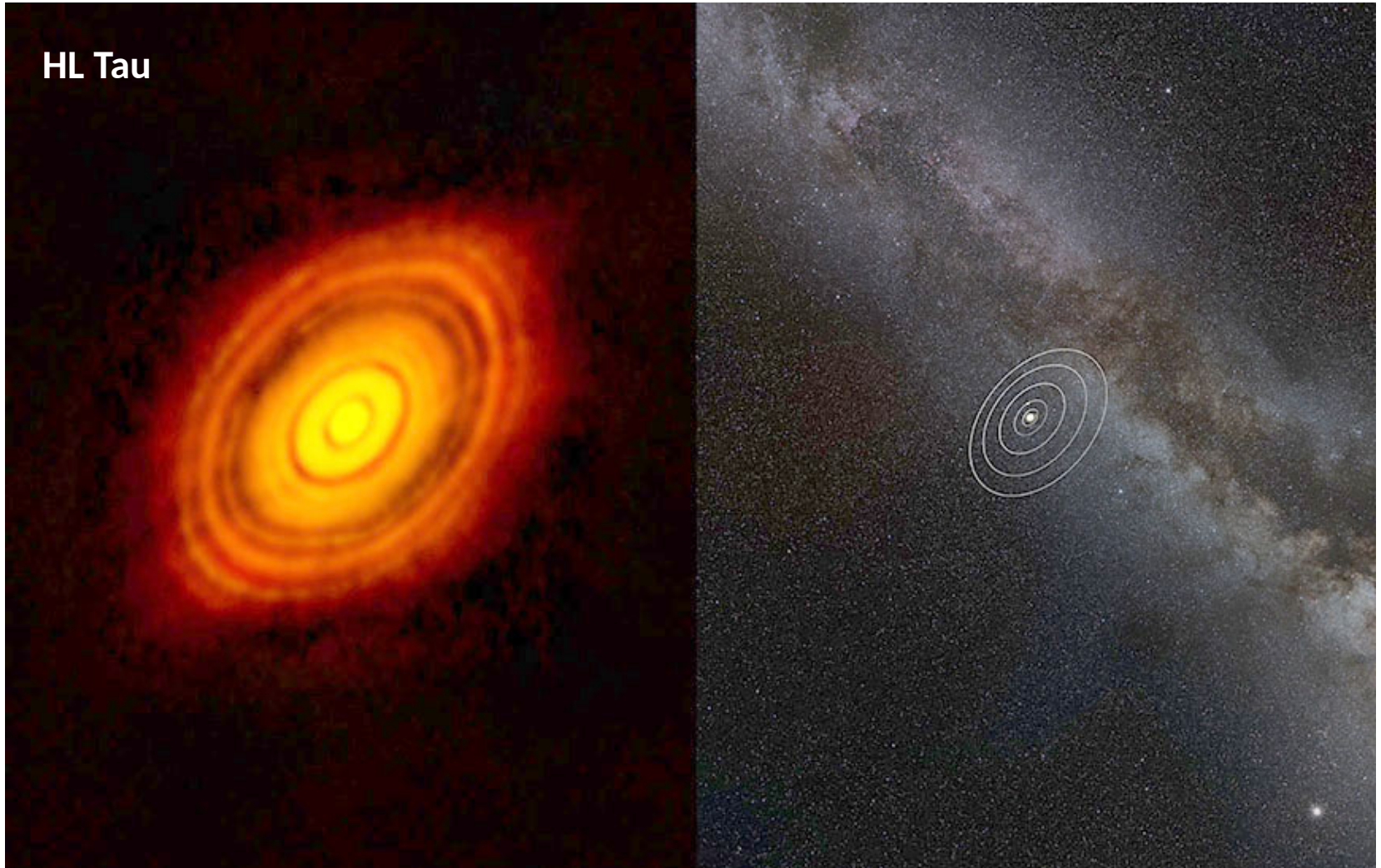
No correlation again? ... tbc

Stay tuned, further observations underway...

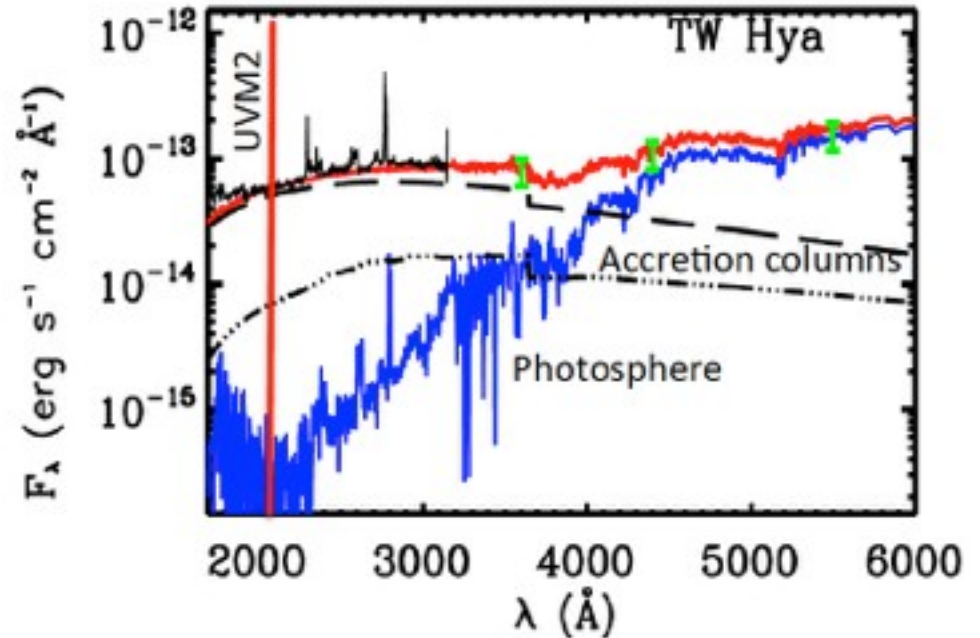
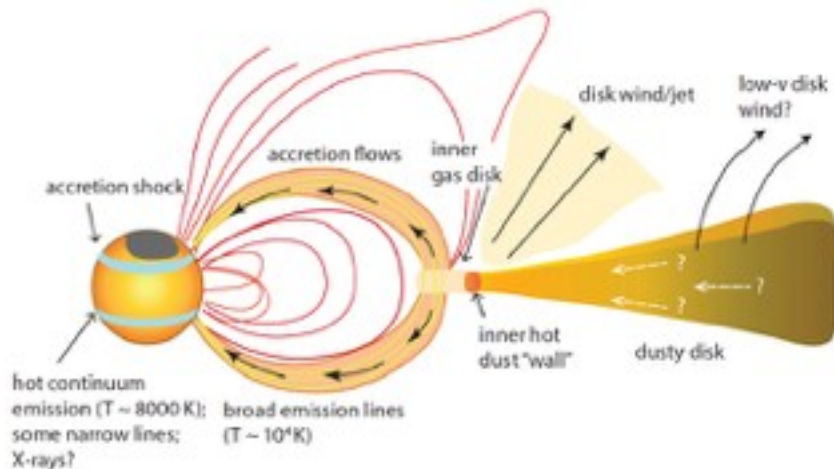
Summary

- *We have carried out a simultaneous study of the X-ray and UV emission from TW Hya over the space of 10 weeks.*
- *The properties of the accretion flow as measured in the UV and X-ray are consistent with previous studies.*
- *We find no correlation between the UV emission and the X-ray emission (total or soft/hard alone).*
- *This suggests that the relationship between the accretion shock and soft X-ray excess is complicated.*

Why Should You Care?



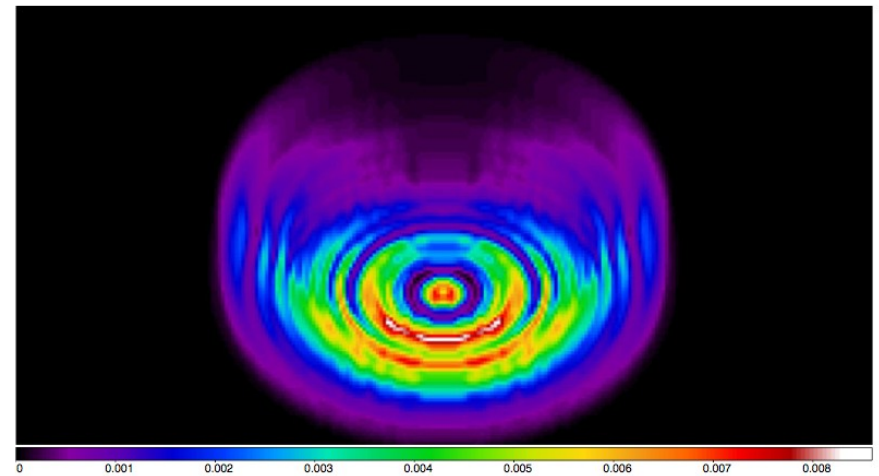
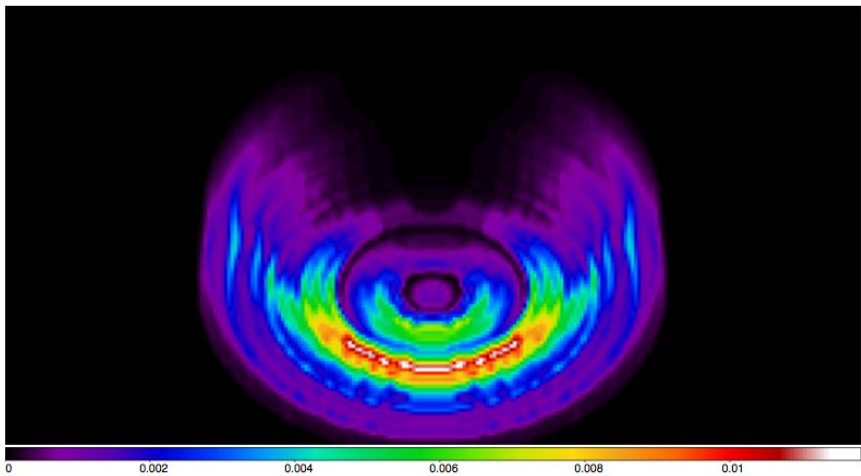
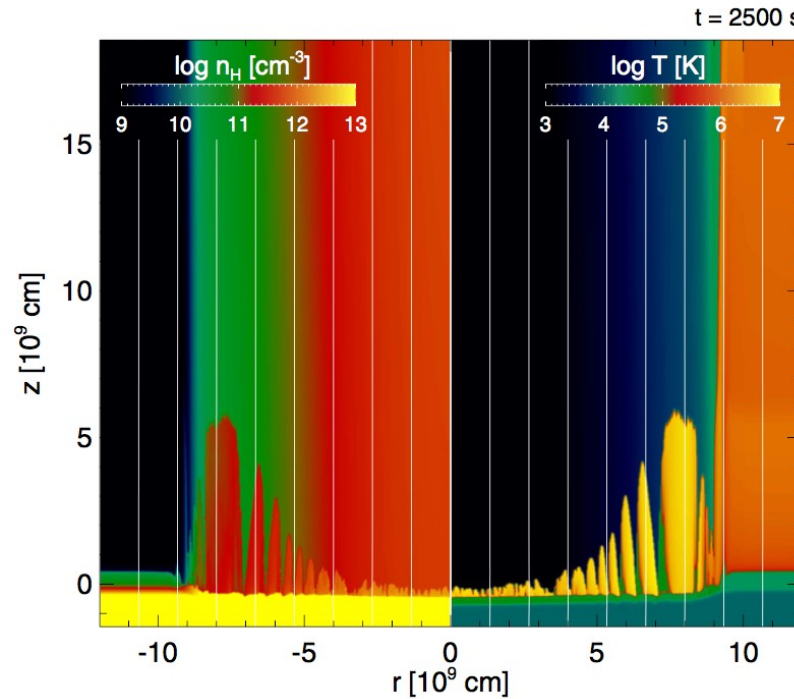
The Stellar Accretion Model



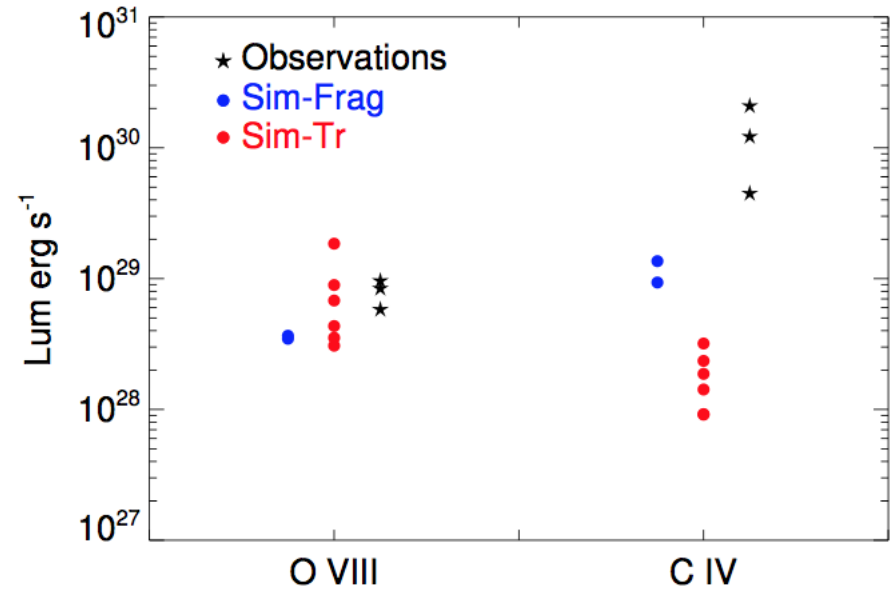
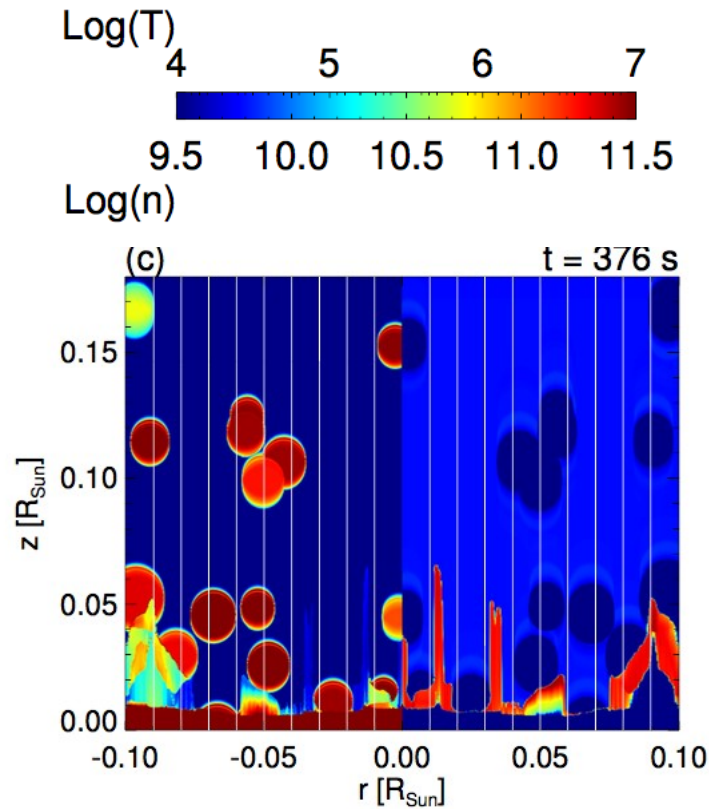
X-rays? !!!

The Inner accretion flow as observed from TW Hya

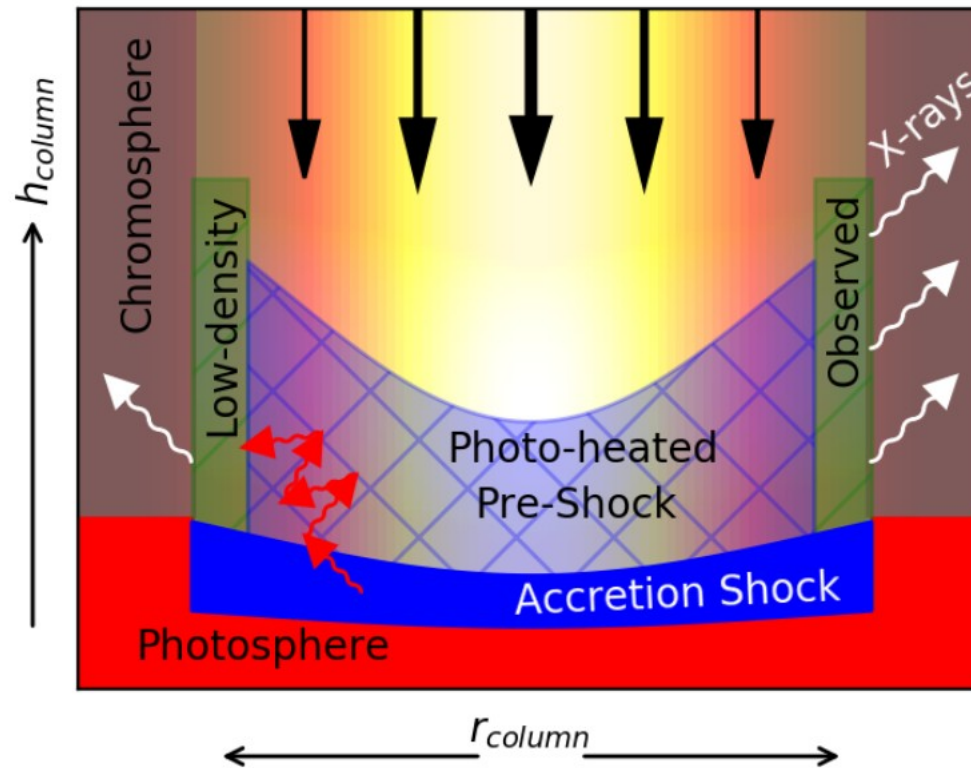
Accretion Shock - MHD Simulation



Accretion Shock - MHD Simulation

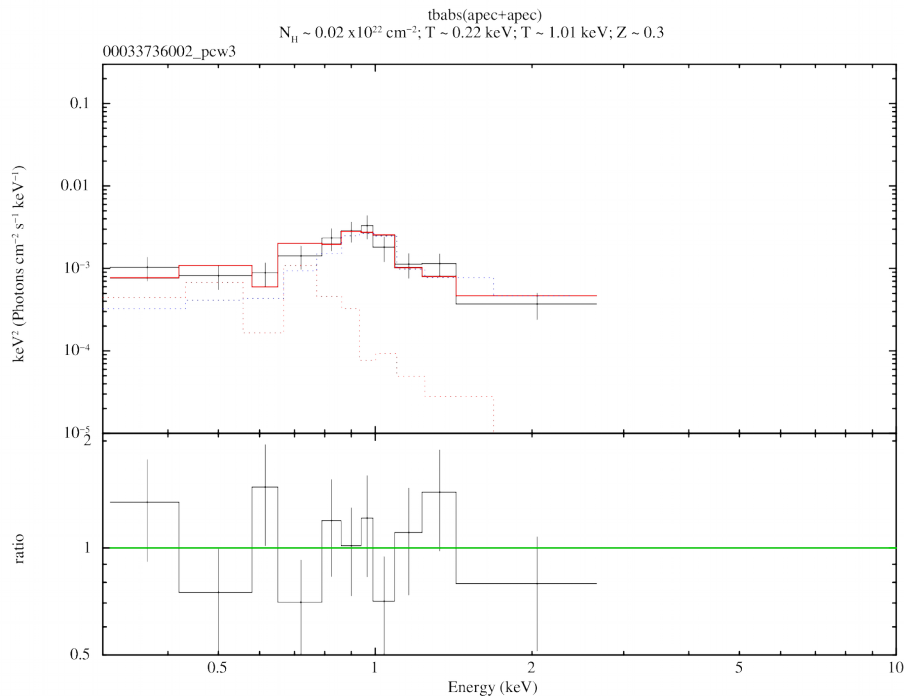


A Stellar Accretion Model

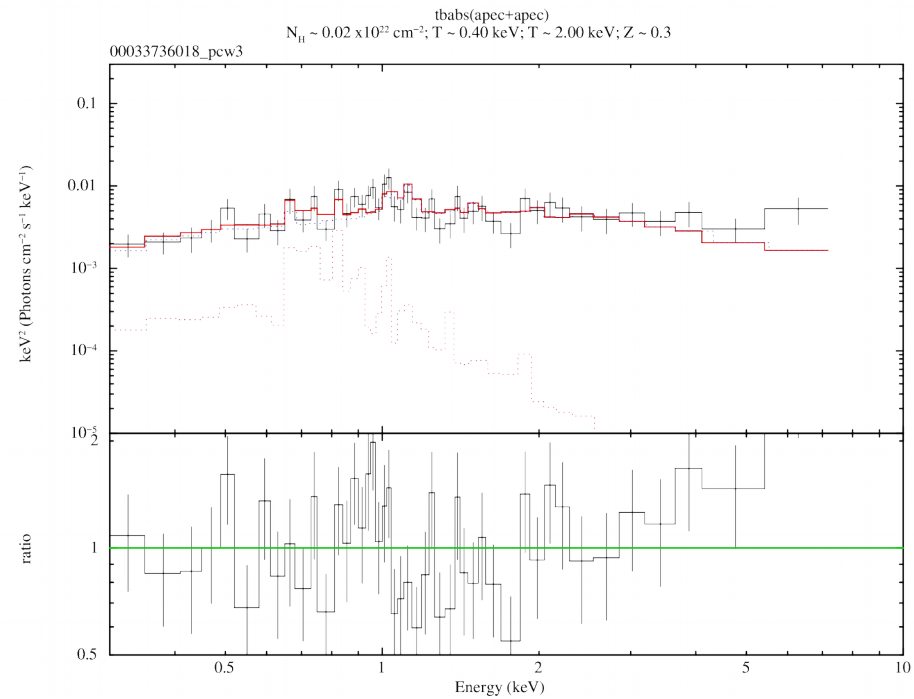


TW Hya

- X-ray spectra as observed by *Swift*/XRT



□ Soft excess & corona contribute

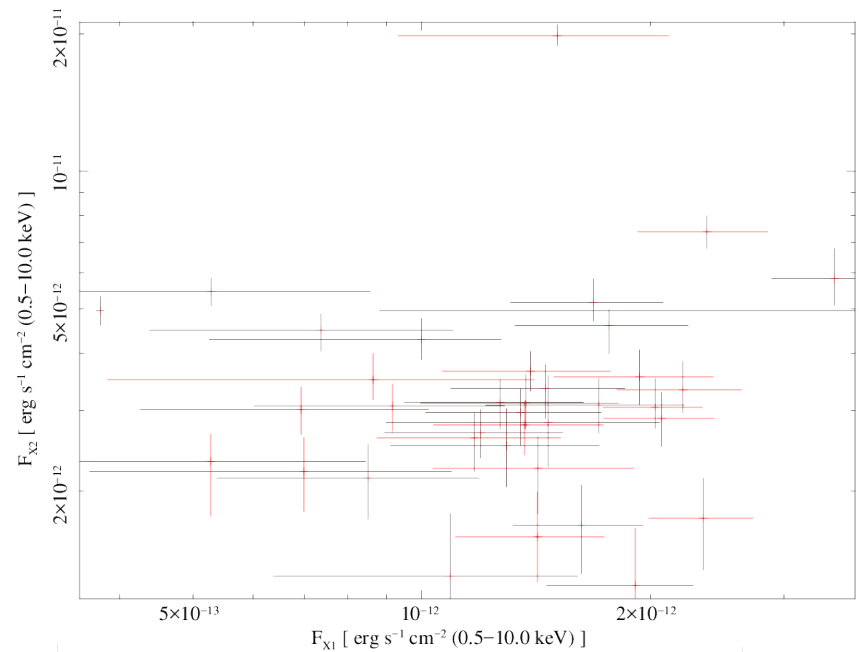
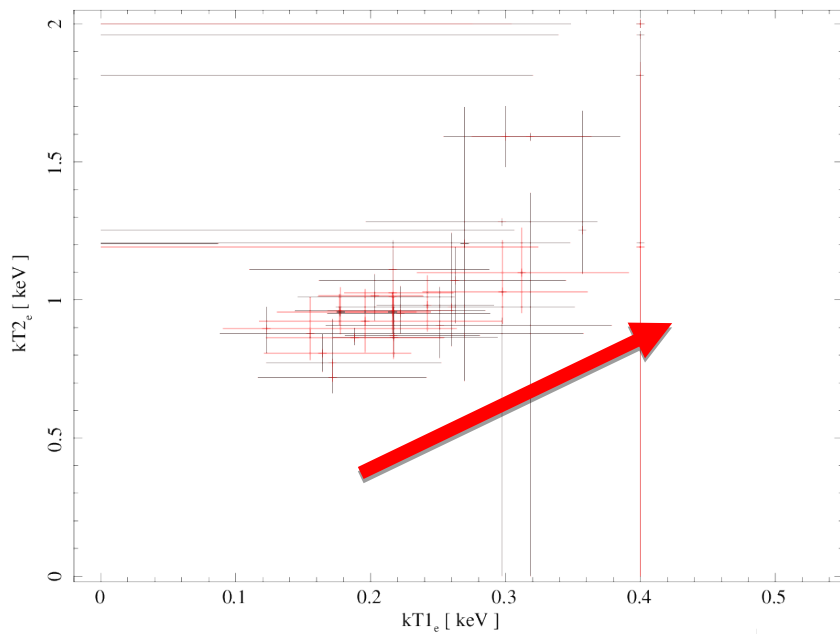


□ Coronal component dominates!

X-ray variability is predominantly due to the corona

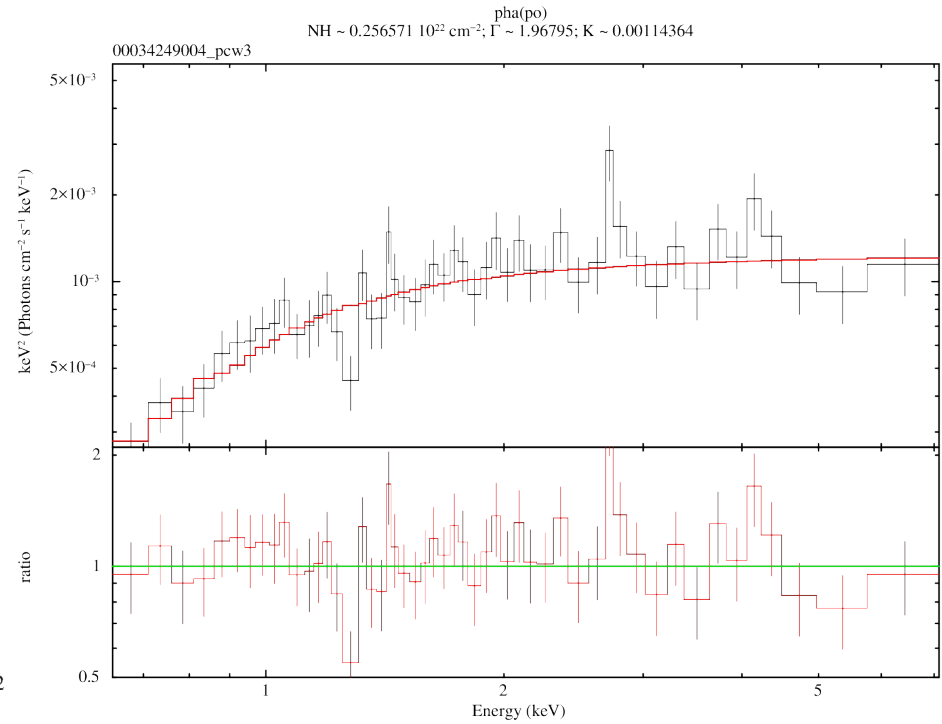
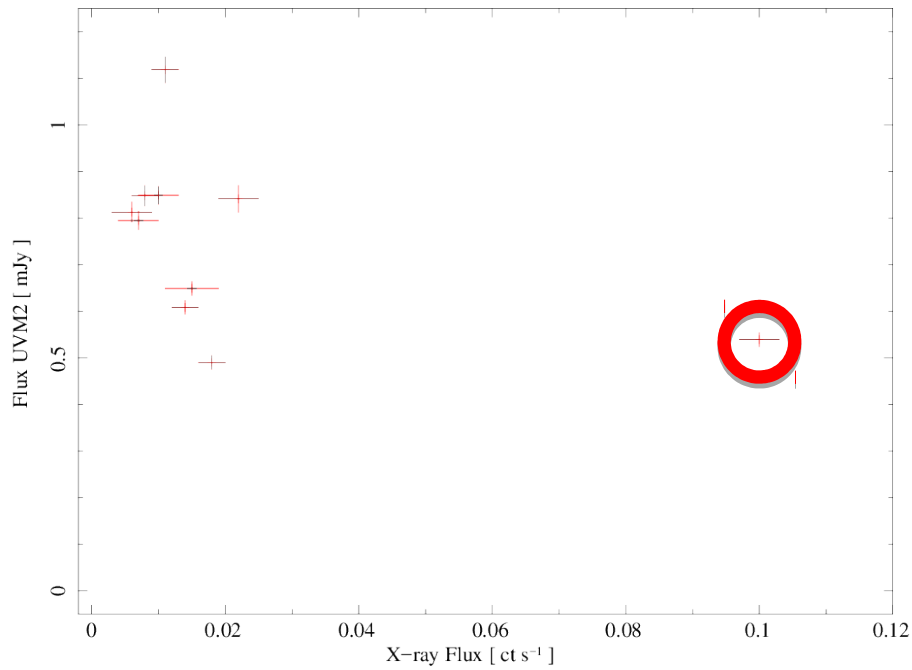
TW Hya

- X-ray spectral properties



Soft temp Hard temp

GM Aur



No correlation again? ... tbc

Stay tuned...