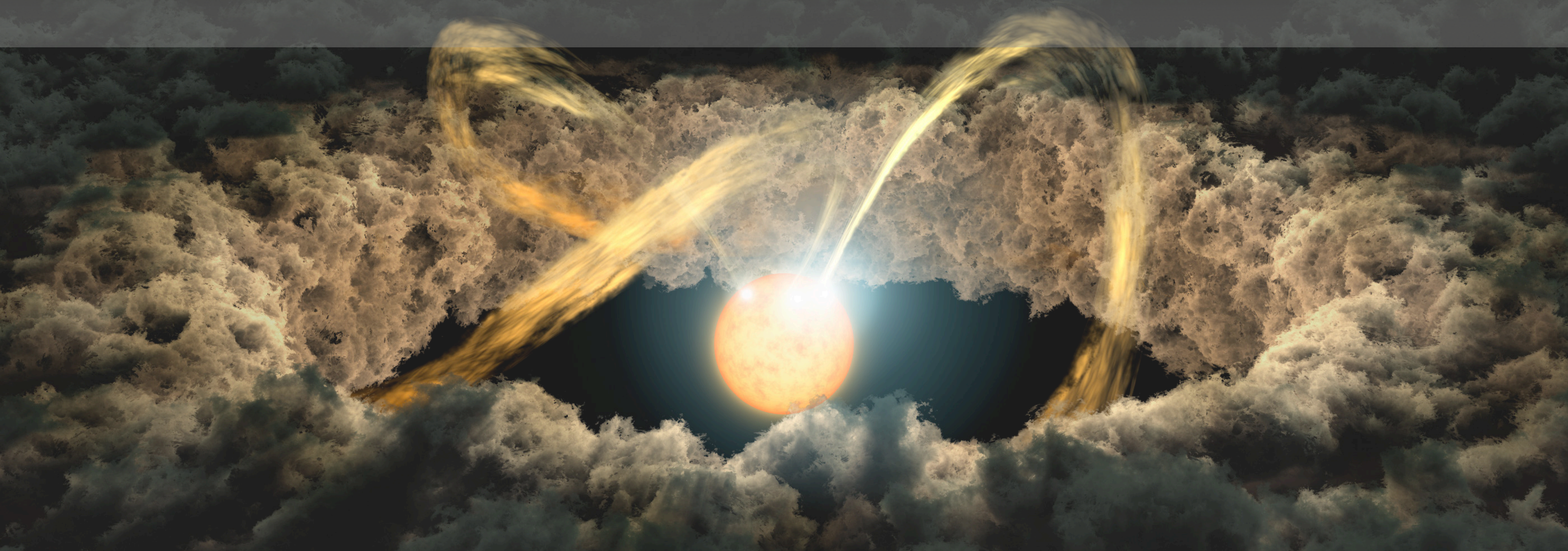
ACCRETION VARIABILITY IN YOUNG LOW MASS STARS



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Accretion in Stellar Systems

August 9th, 2018

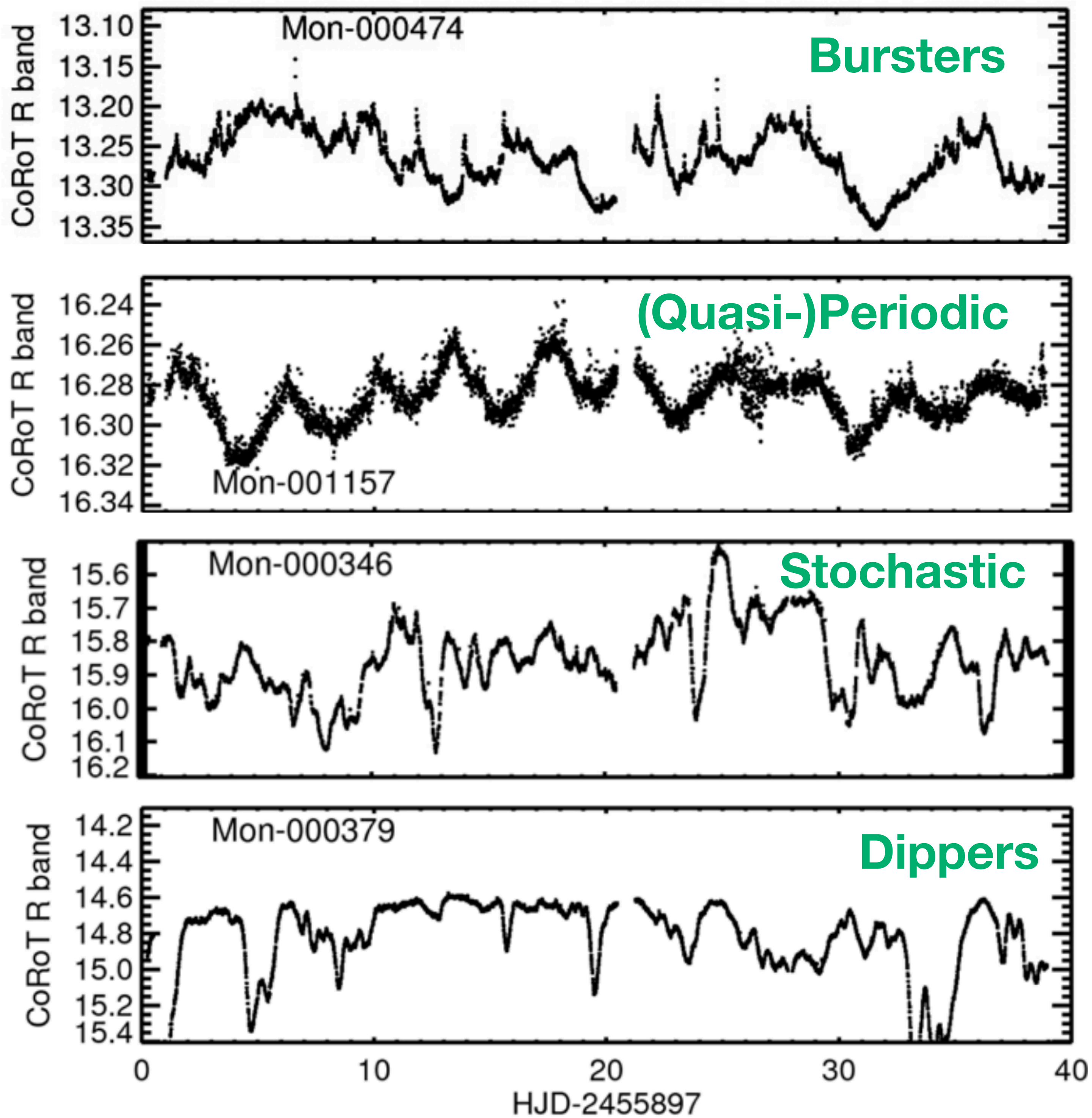
BOSTON UNIVERSITY

Accretion variability in young low mass stars

- How variable are young low mass stars in the UV?
- What is driving burst dominated lightcurves of young low mass stars?
- Do current accretion diagnostics consistently recover accretion rates?

Observed variability in young stars

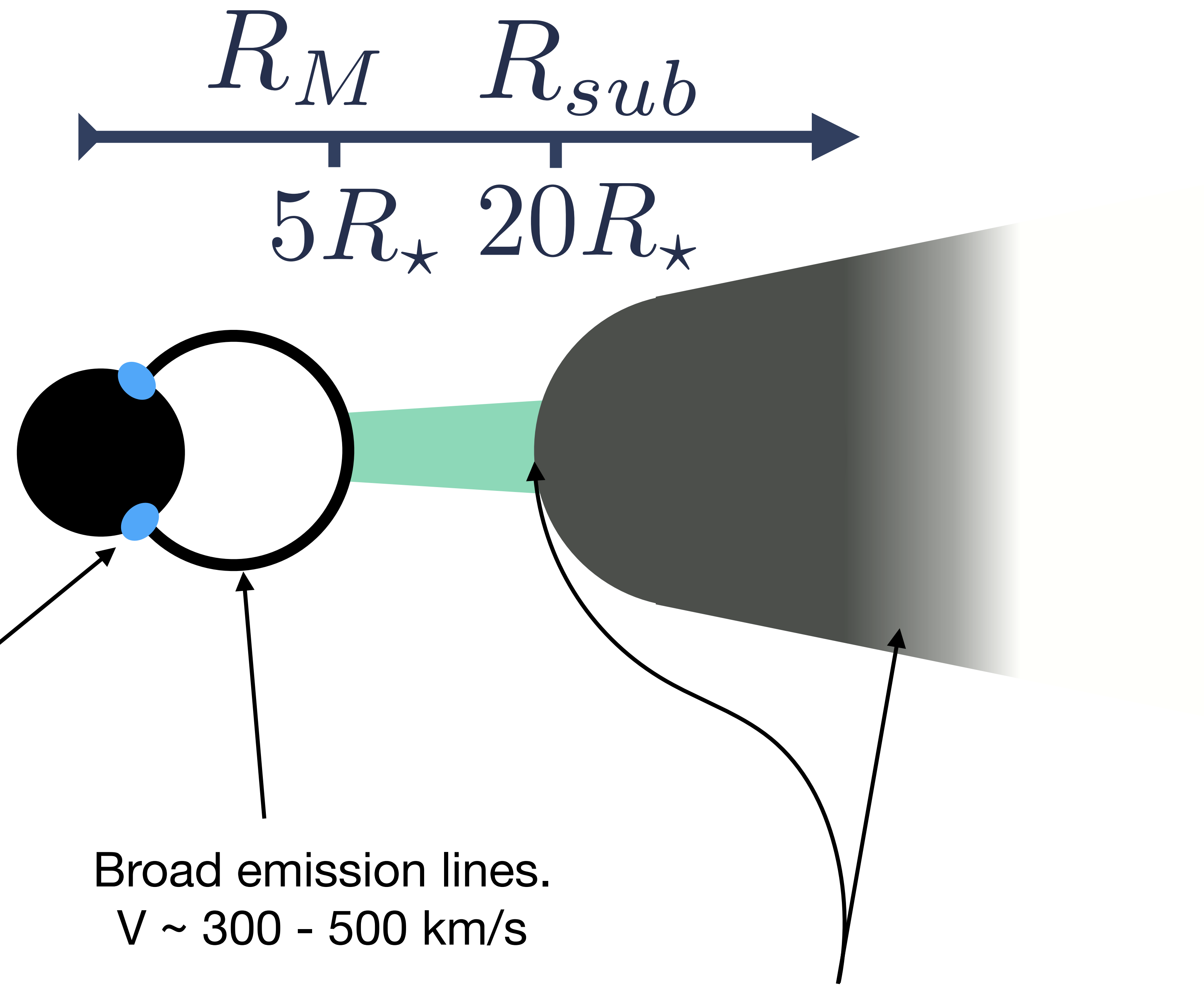
Young stars can be categorized using optical light curves based on the periodicity and symmetry of their short timescale variability



Cody et al. (2014)

An idealized view of magnetospheric accretion

Magnetic fields on T Tauri stars are quite strong (~1-2kG at the surface e.g., Johns-Krull et al. 2004)



UV continuum excess + UV lines

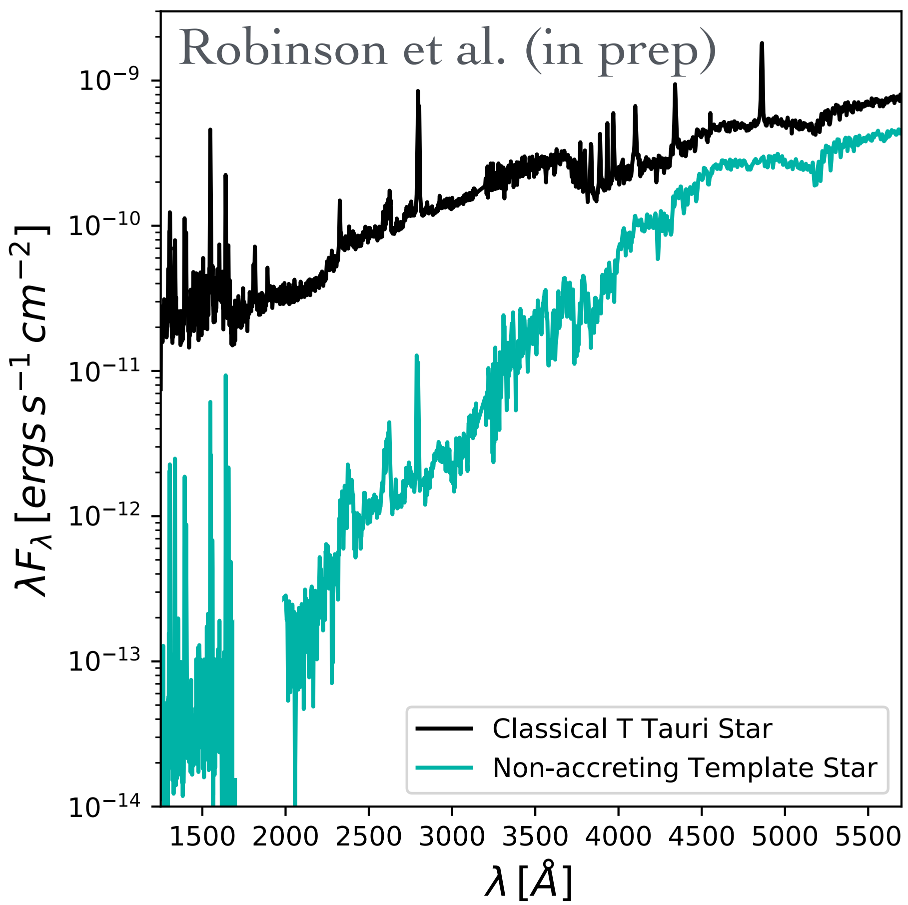
Broad emission lines.
V ~ 300 - 500 km/s

IR + mm excess from dusty disk and illuminated wall

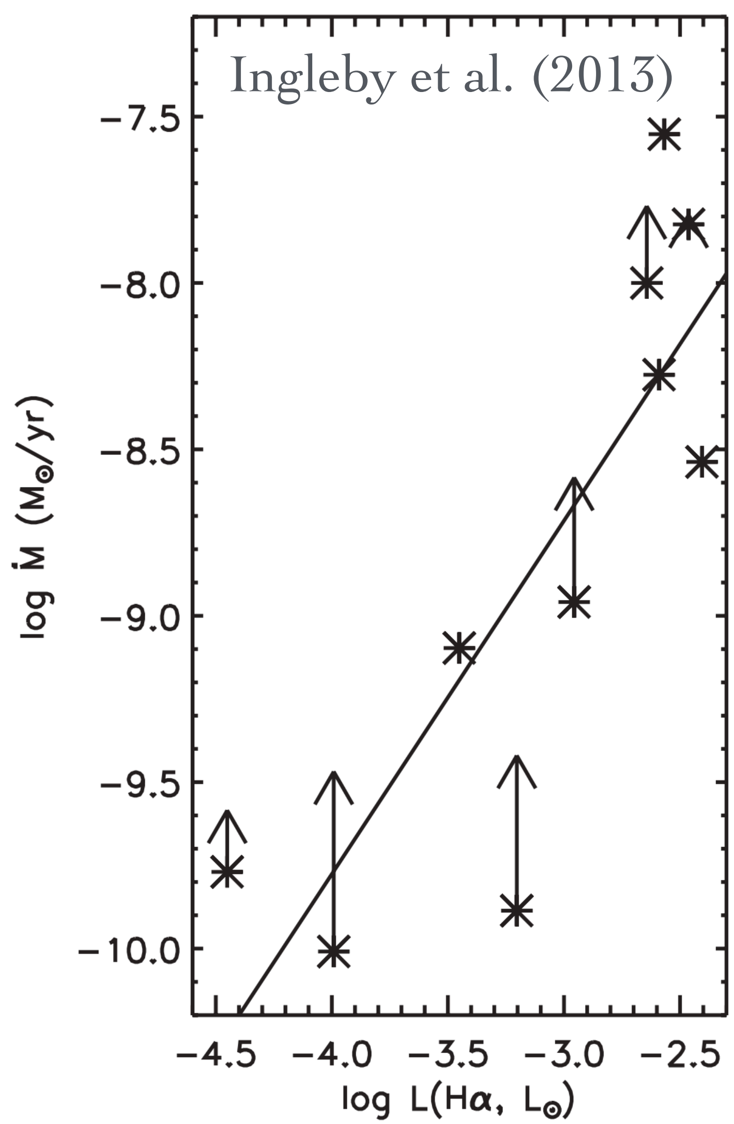
(For a review, see Hartmann et al. 2016)

Common methods of measuring accretion rate

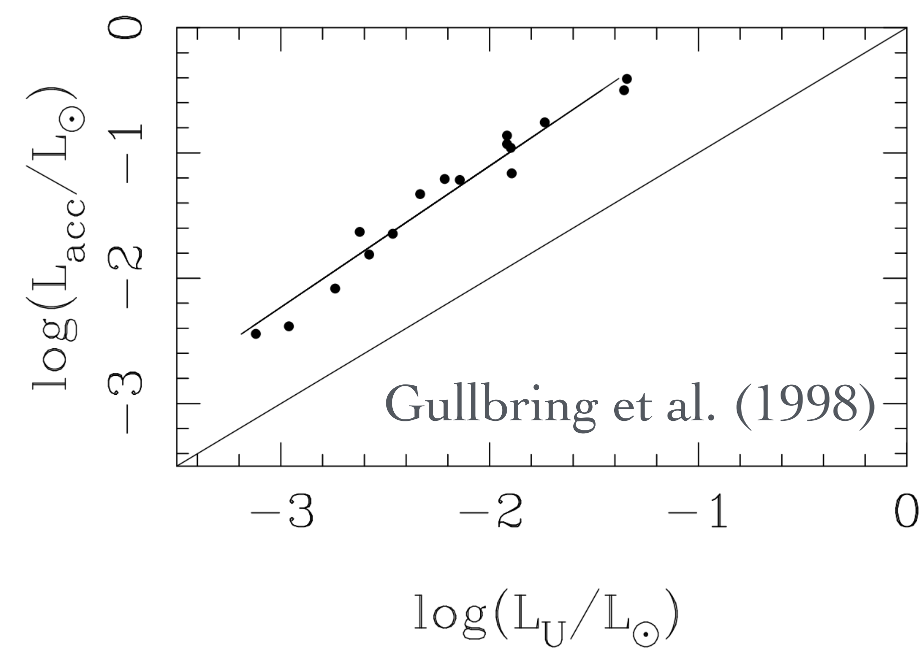
NUV spectra



Spectral lines



Photometry



Typical accretion rate for T Tauri stars:

$$\sim 1 \times 10^{-8} M_\odot\, \mathrm{yr}^{-1}$$

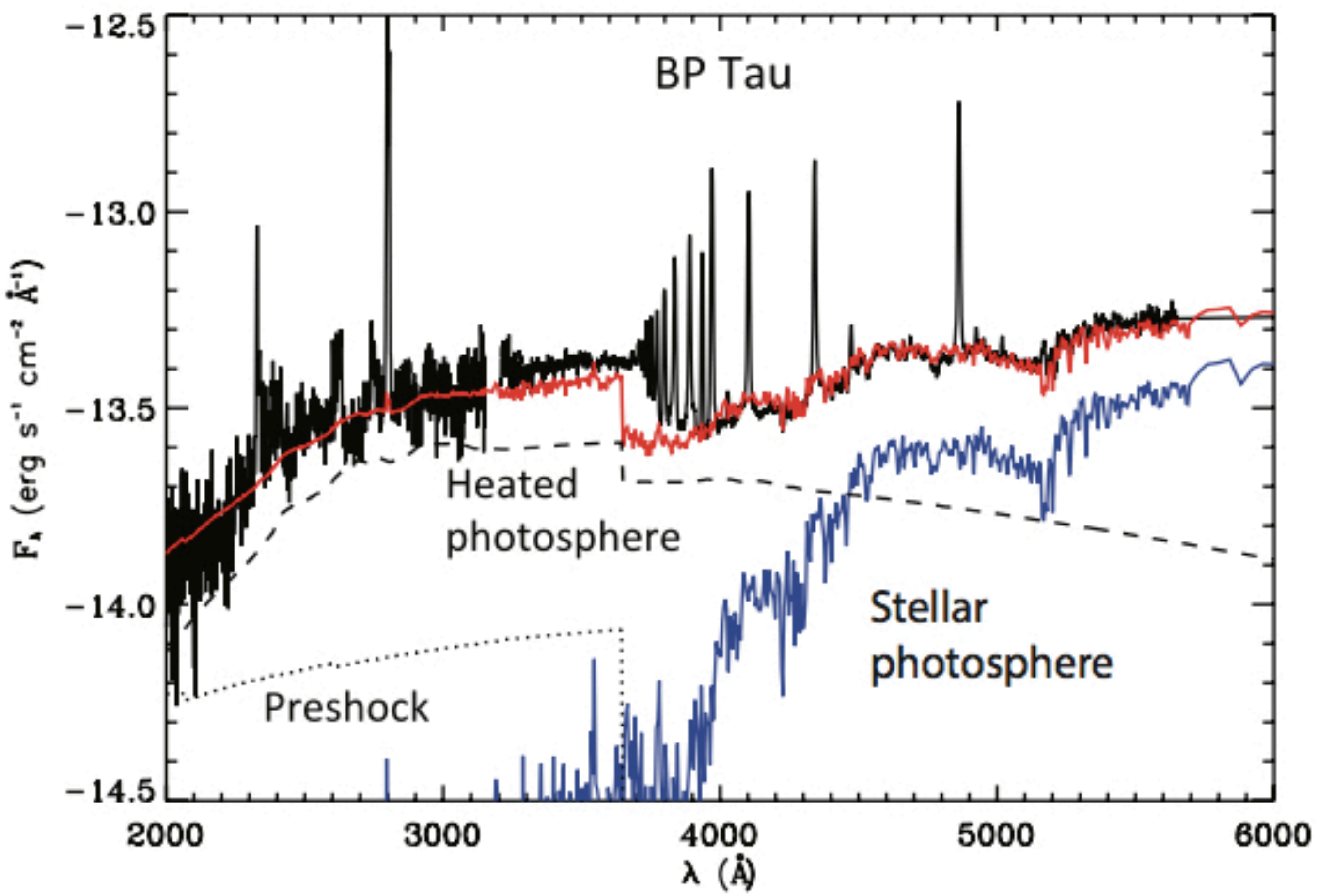
Hartmann et al. (1998)

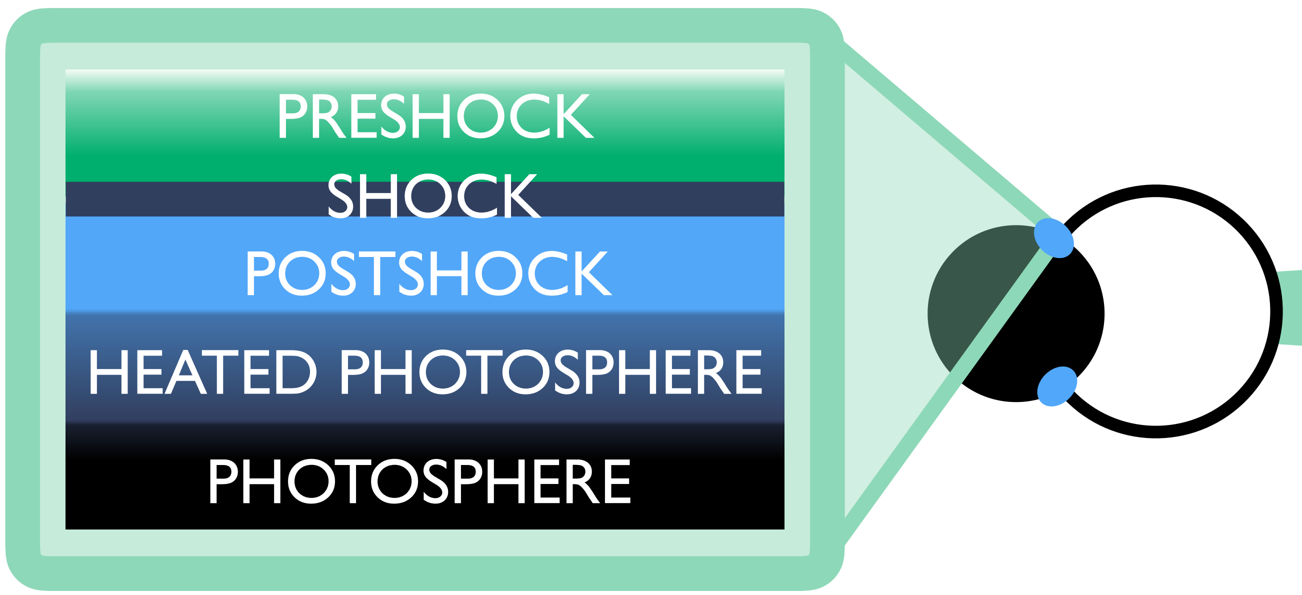
Most direct method of measuring accretion rate: NUV spectra

Our model: Newly updated version of the Calvet et al (1998) models

1D nLTE slab model (uses c17.00 release of Cloudy)

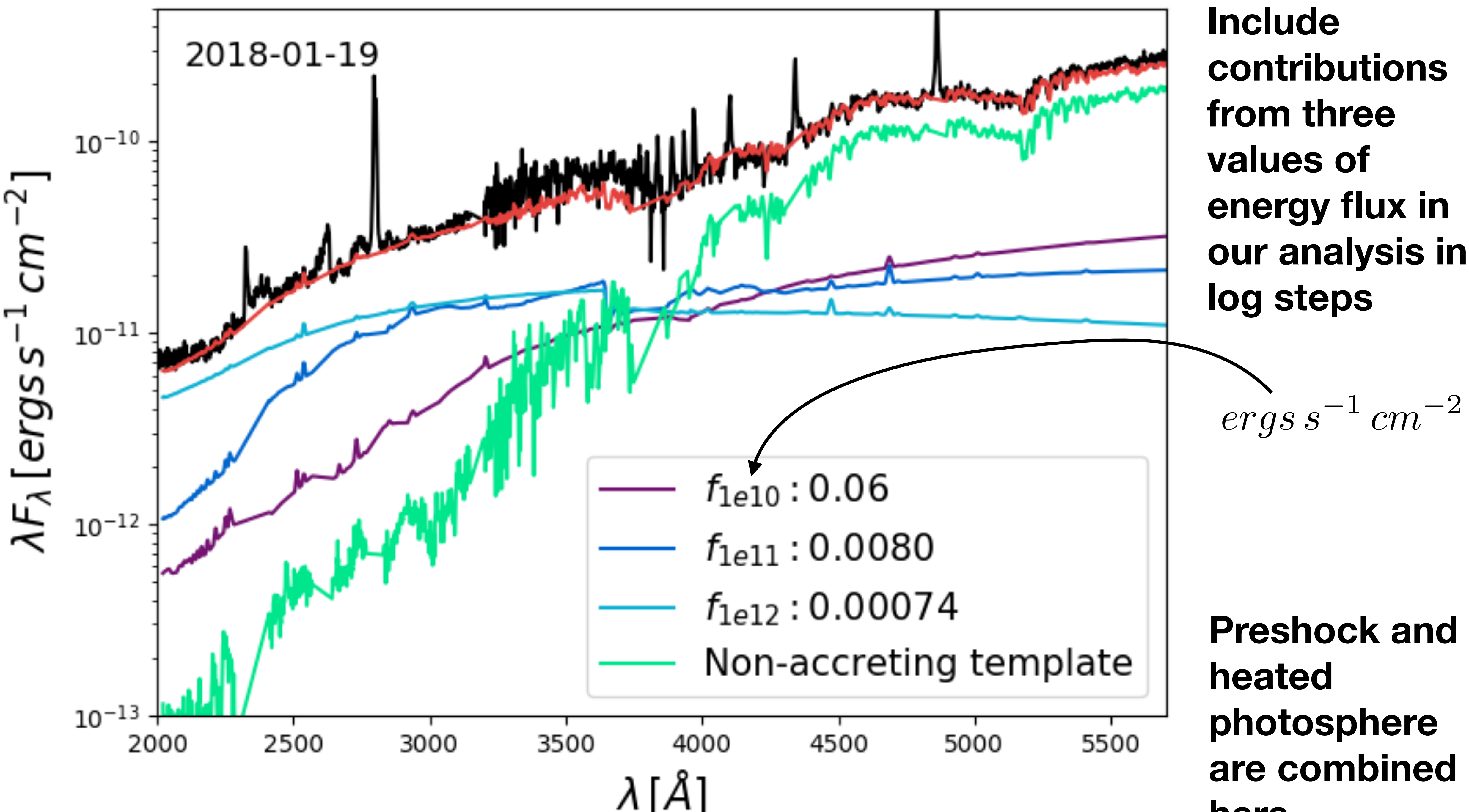
Fraction of star covered by shocks: f





Hartmann, Herczeg & Calvet (2016)

Different column energy fluxes have different shapes in the NUV

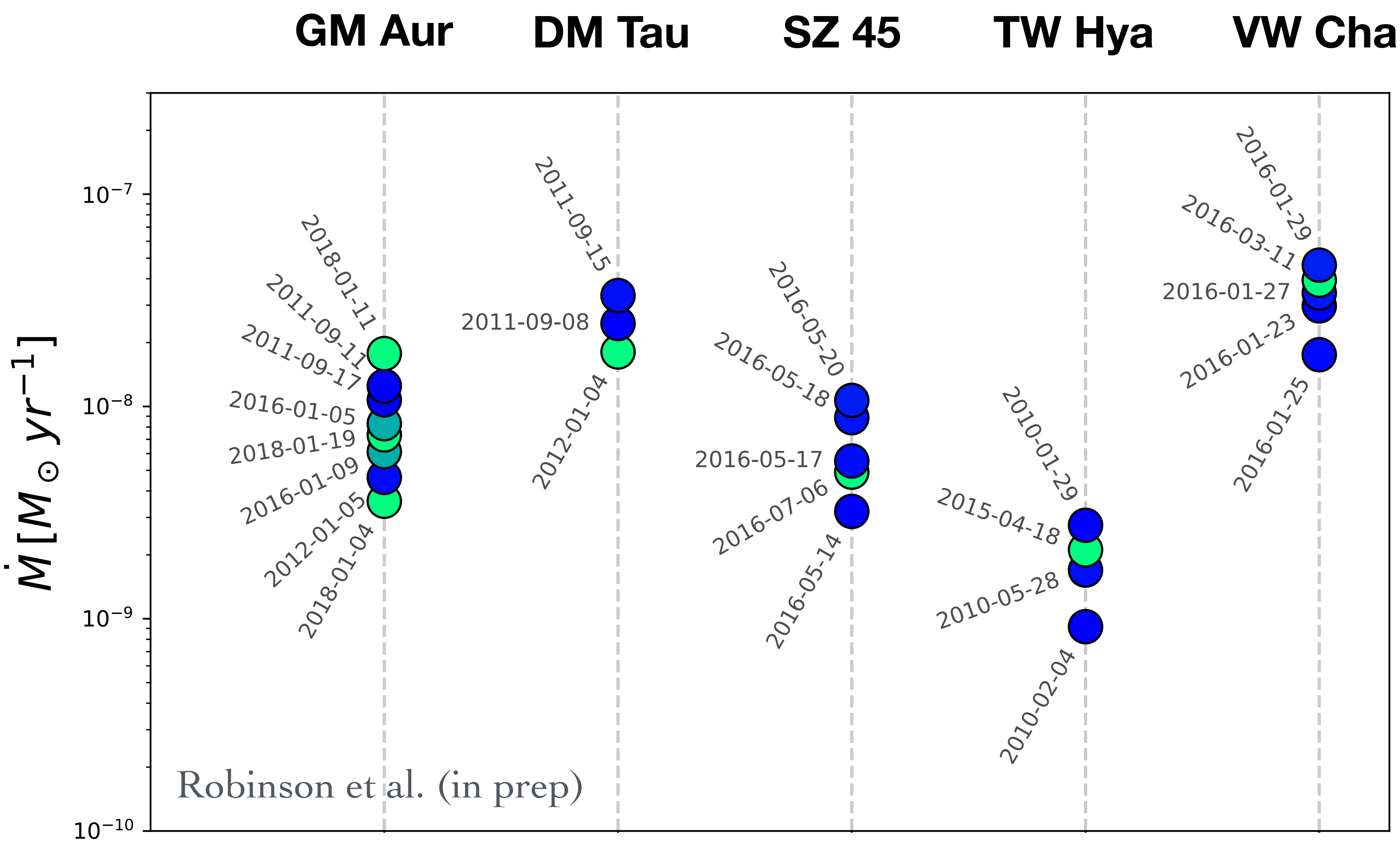


Include contributions from three values of energy flux in our analysis in log steps

Preshock and heated photosphere are combined here

Robinson et al. (in prep)

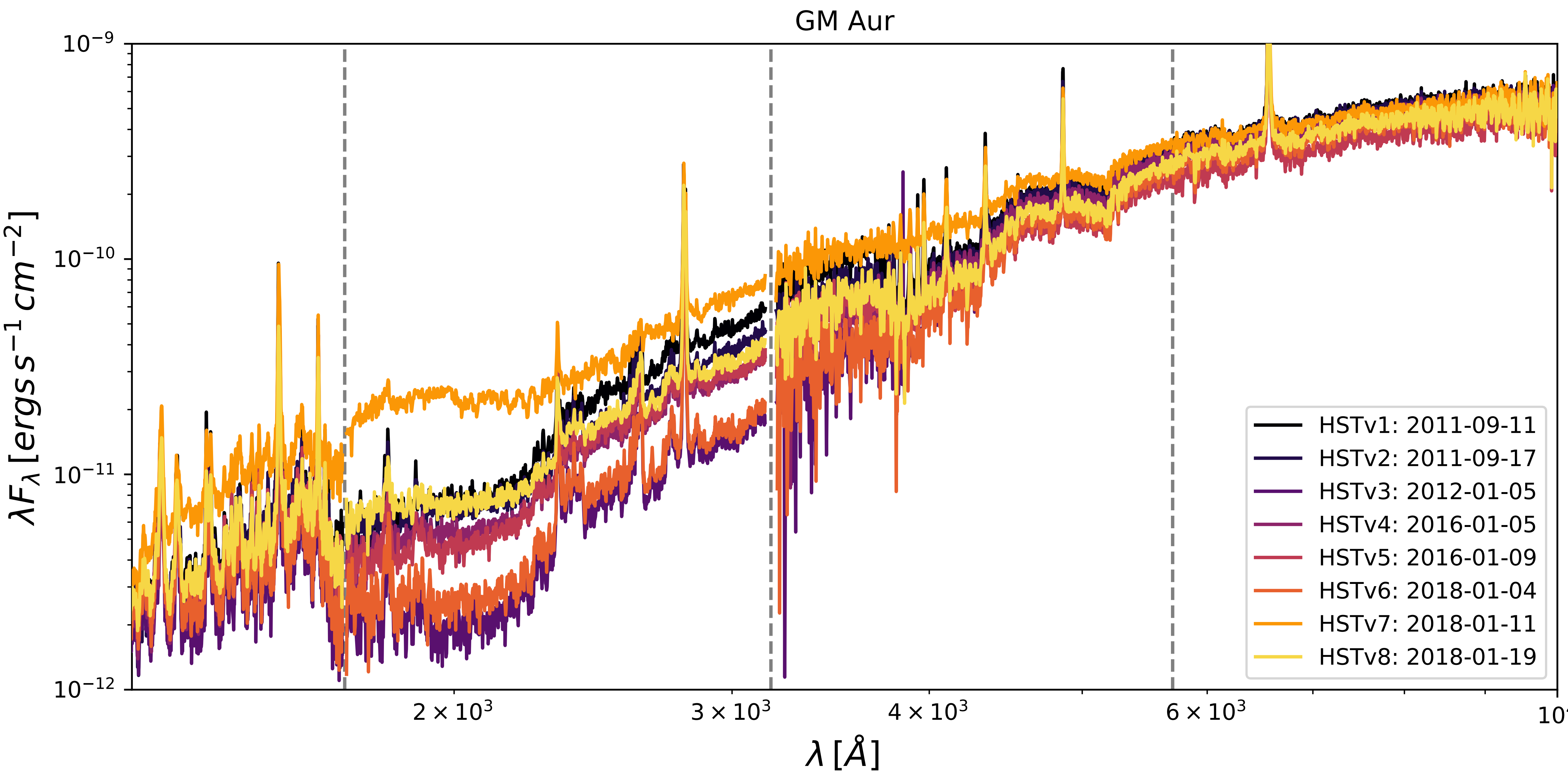
Our sample: 25 FUV-NIR HST STIS spectra



Points with similar colors were taken closer to each other time time.

Δt **between epochs ranges between years, months, and weeks.**
Wavelength coverage: 1200 - 10000 angstroms (FUV - NIR)

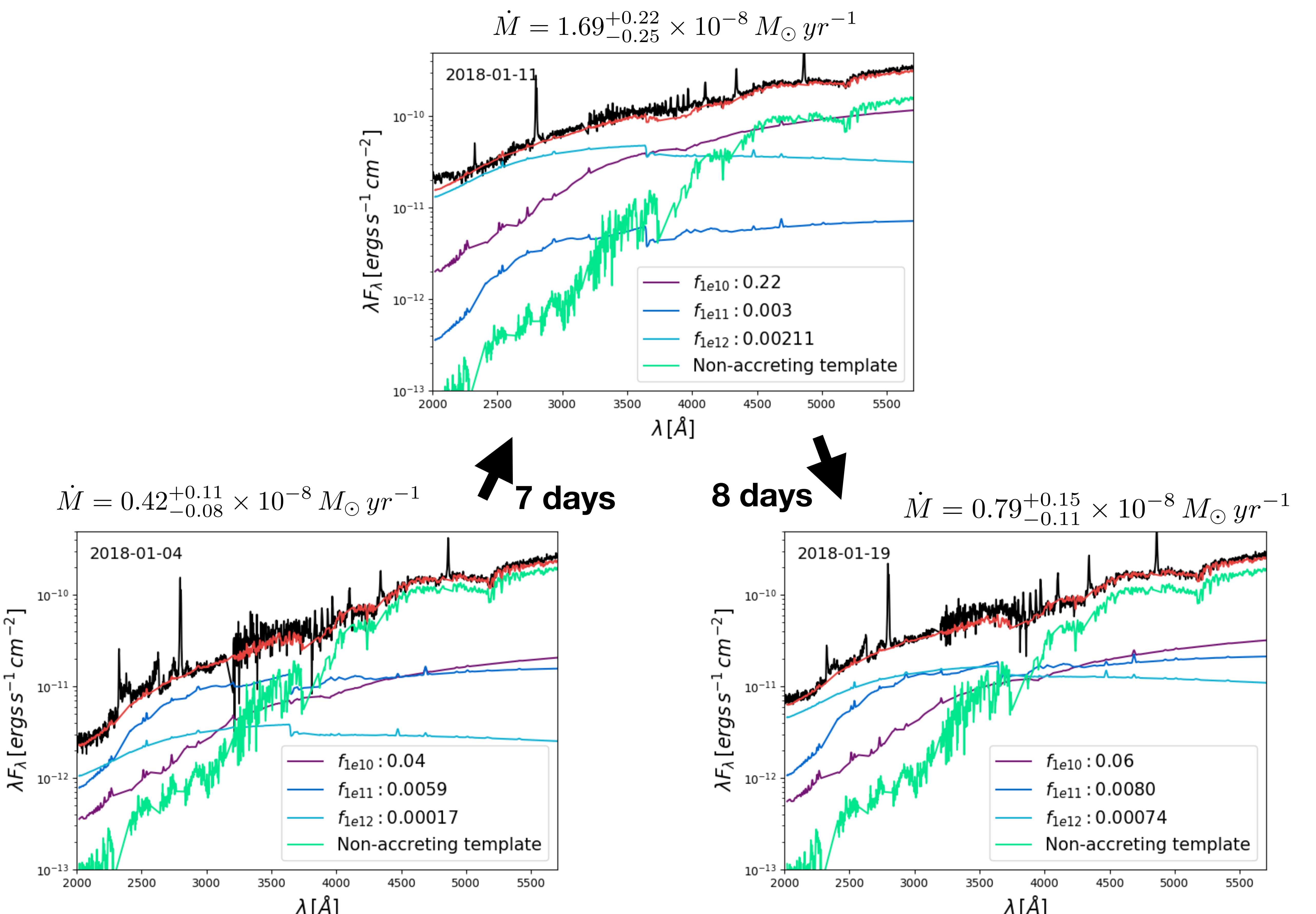
Example of variability: GM Aur



Epoch 7: Possibly an example of an accretion burst as seen in the UV?

Robinson et al. (in prep)

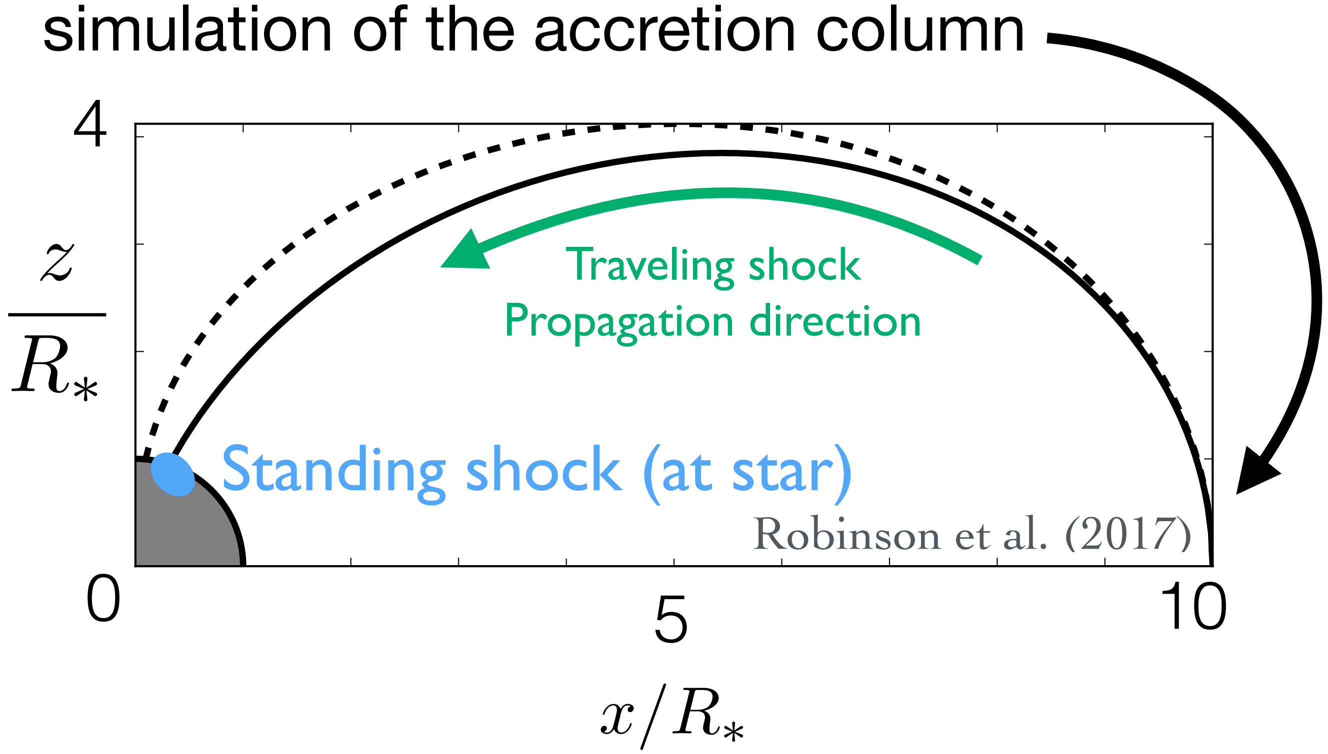
GM Aur spectra during the rapid spike in accretion



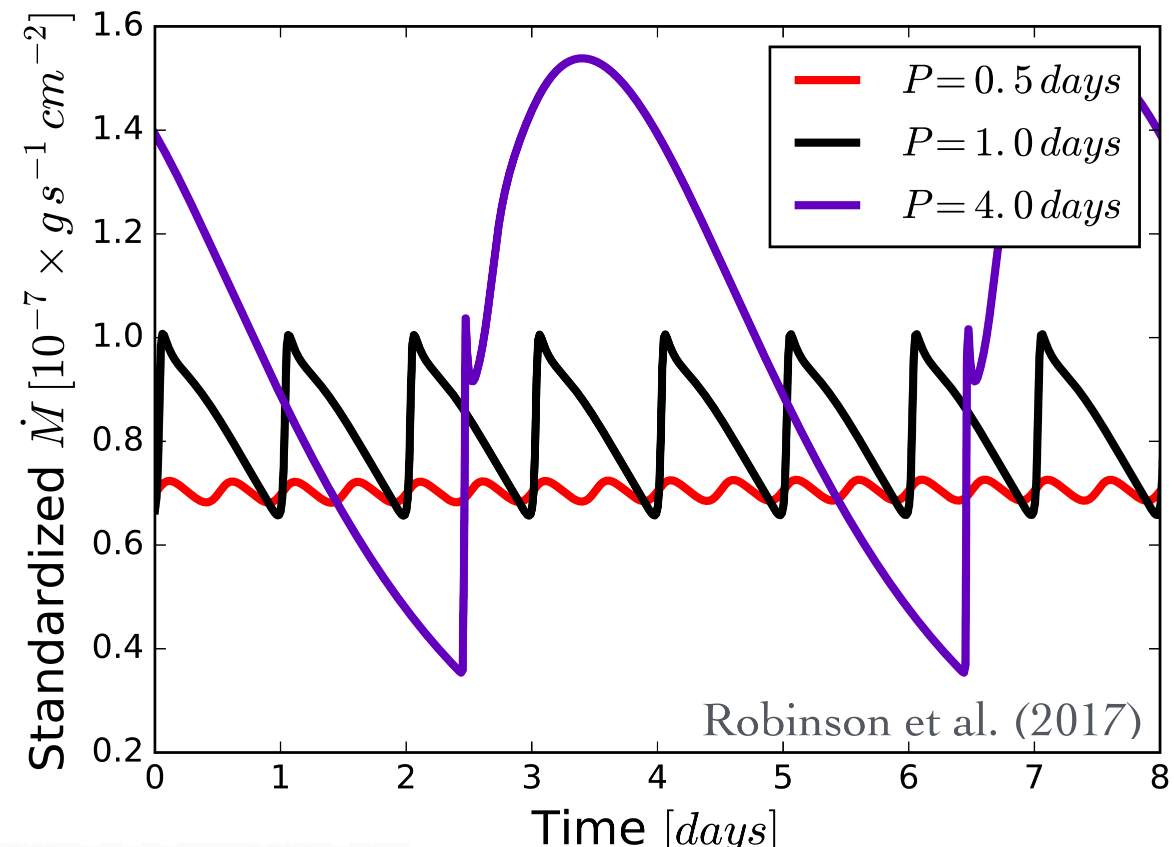
Robinson et al. (in prep)

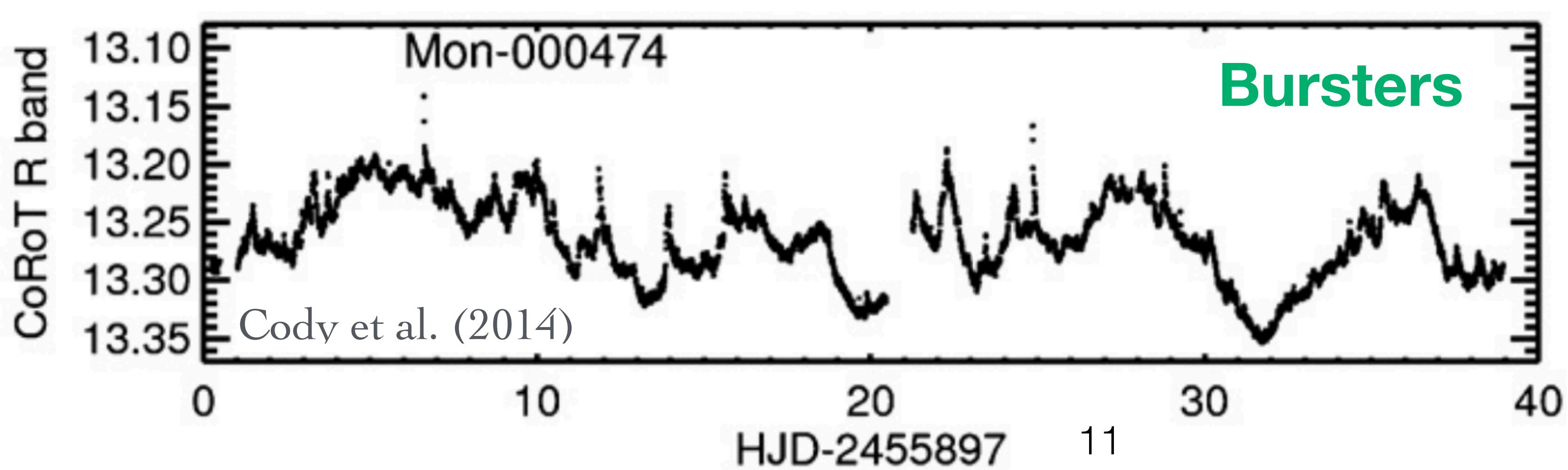
Accretion bursts may be produced by inhomogeneities in the inner disk

We introduced density perturbations at the inner edge of the disk in a 1D HD simulation of the accretion column

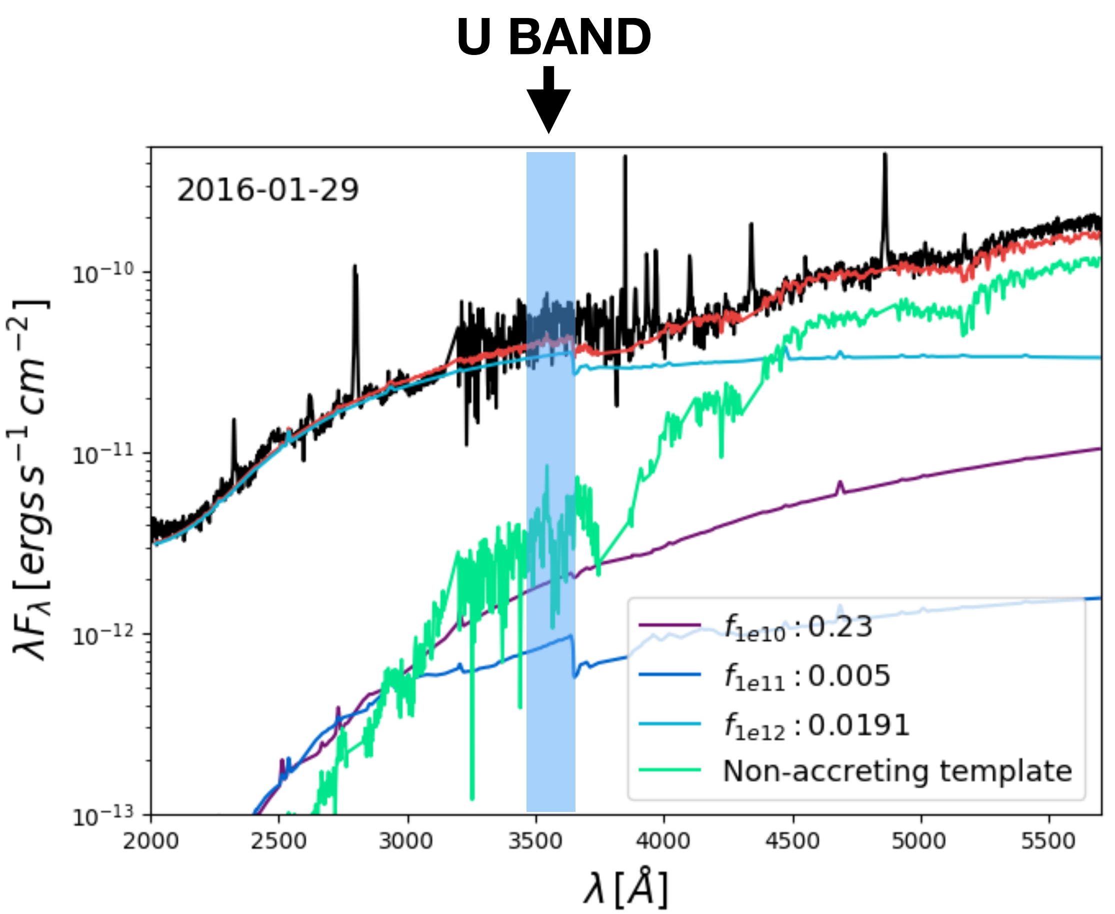


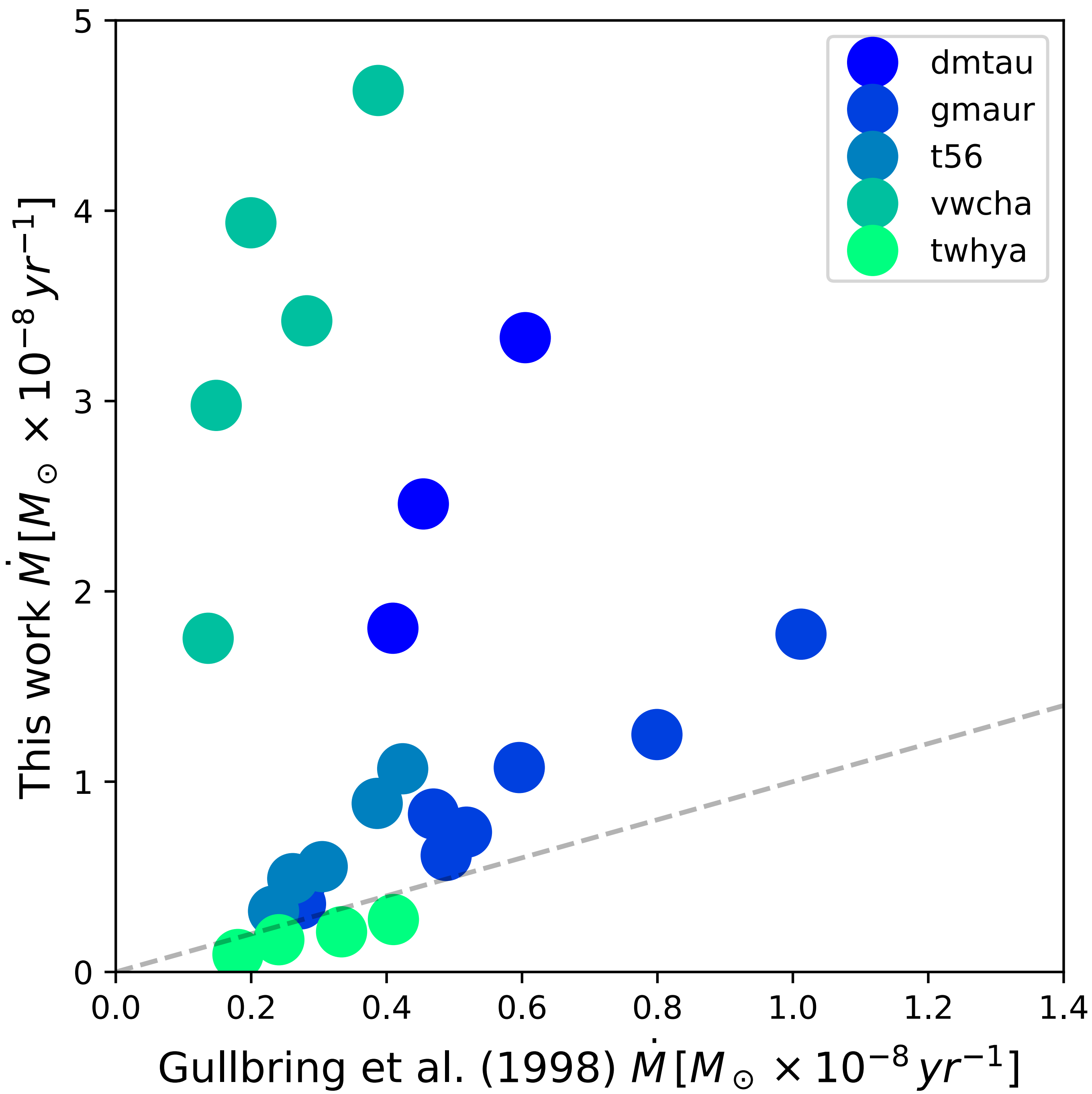
Driving period of perturbations sets accretion behavior at the star



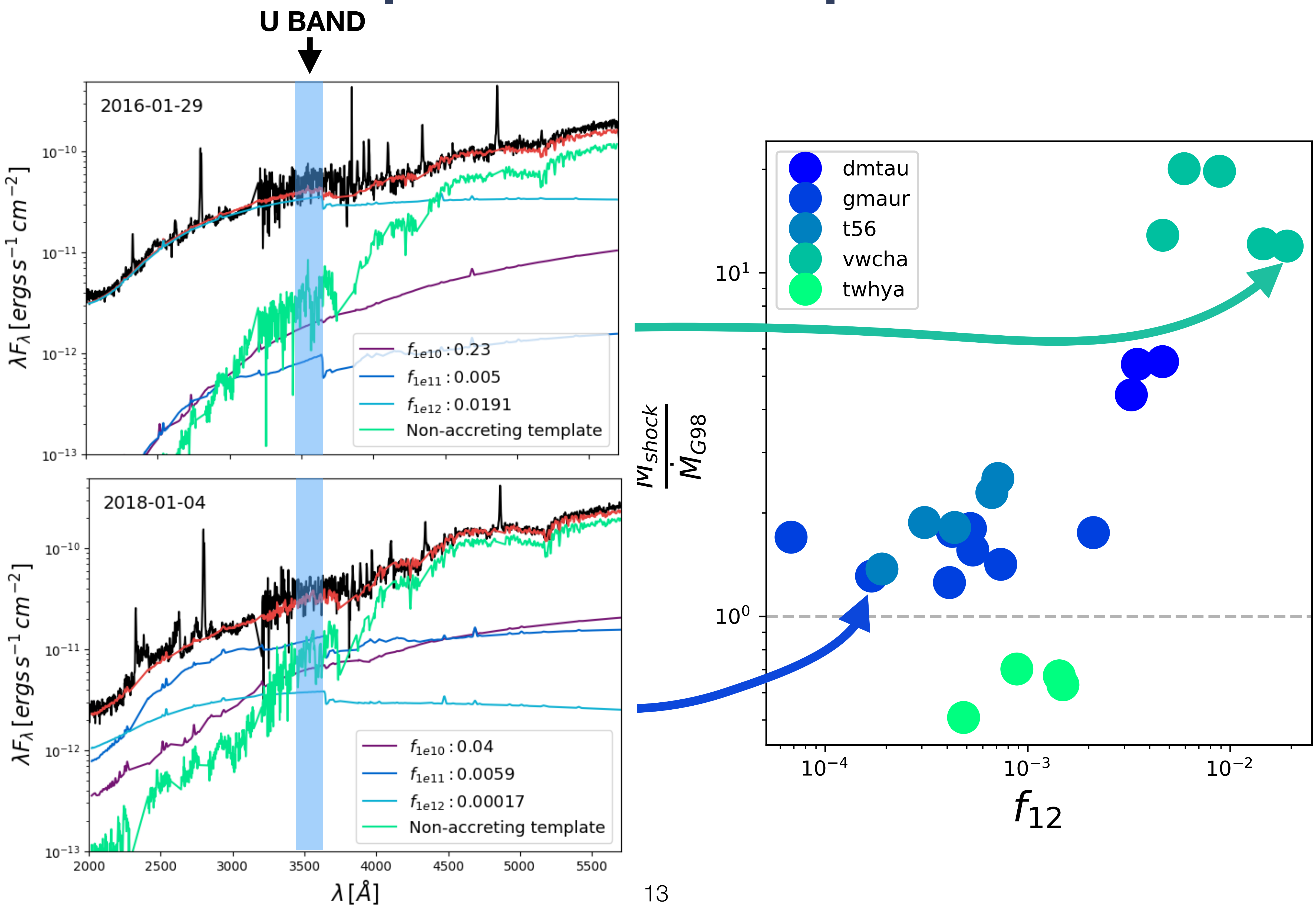


Mass accretion rates from U band photometry can be very different

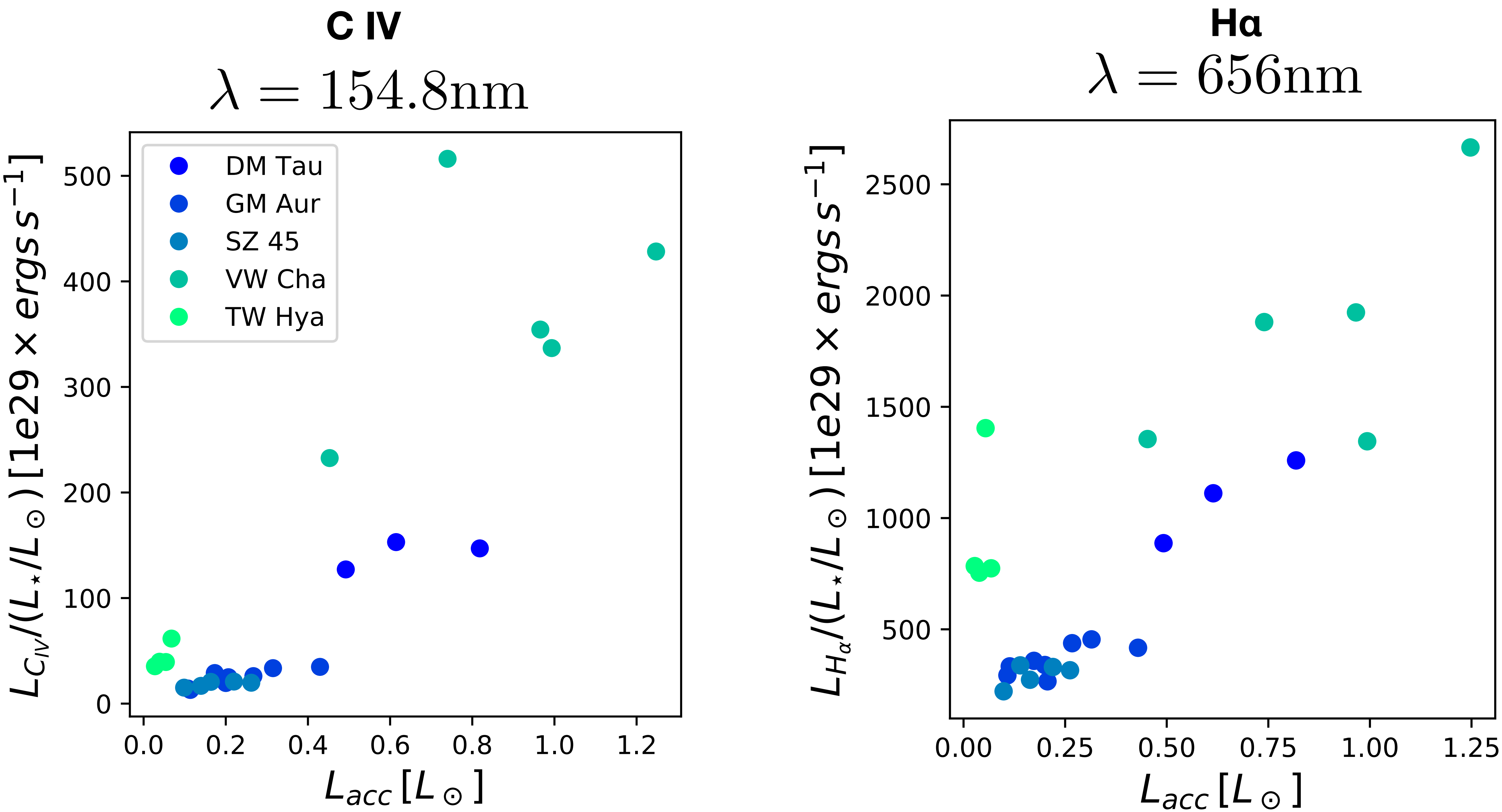




Contributions from high density columns explains discrepancies



Spectral lines can be used as accretion diagnostics, but some scatter



Accretion variability in young low mass stars

1) How variable are young low mass stars in the UV?

We see changes in mass accretion rates as large as one order of magnitude over our fastest cadence of 1 week.

2) What is driving burst dominated lightcurves of young low mass stars?

Qualitative evidence suggests inhomogeneities in the inner disk that vary on roughly day timescales.

3) Do current accretion diagnostics consistently recover accretion rates?

The commonly used U Band diagnostic gives inconsistent results when high density columns are present.

Correlations exist with emission lines, but there is some scatter in relationships.

NUV spectra are necessary to extract accurate mass accretion rates.

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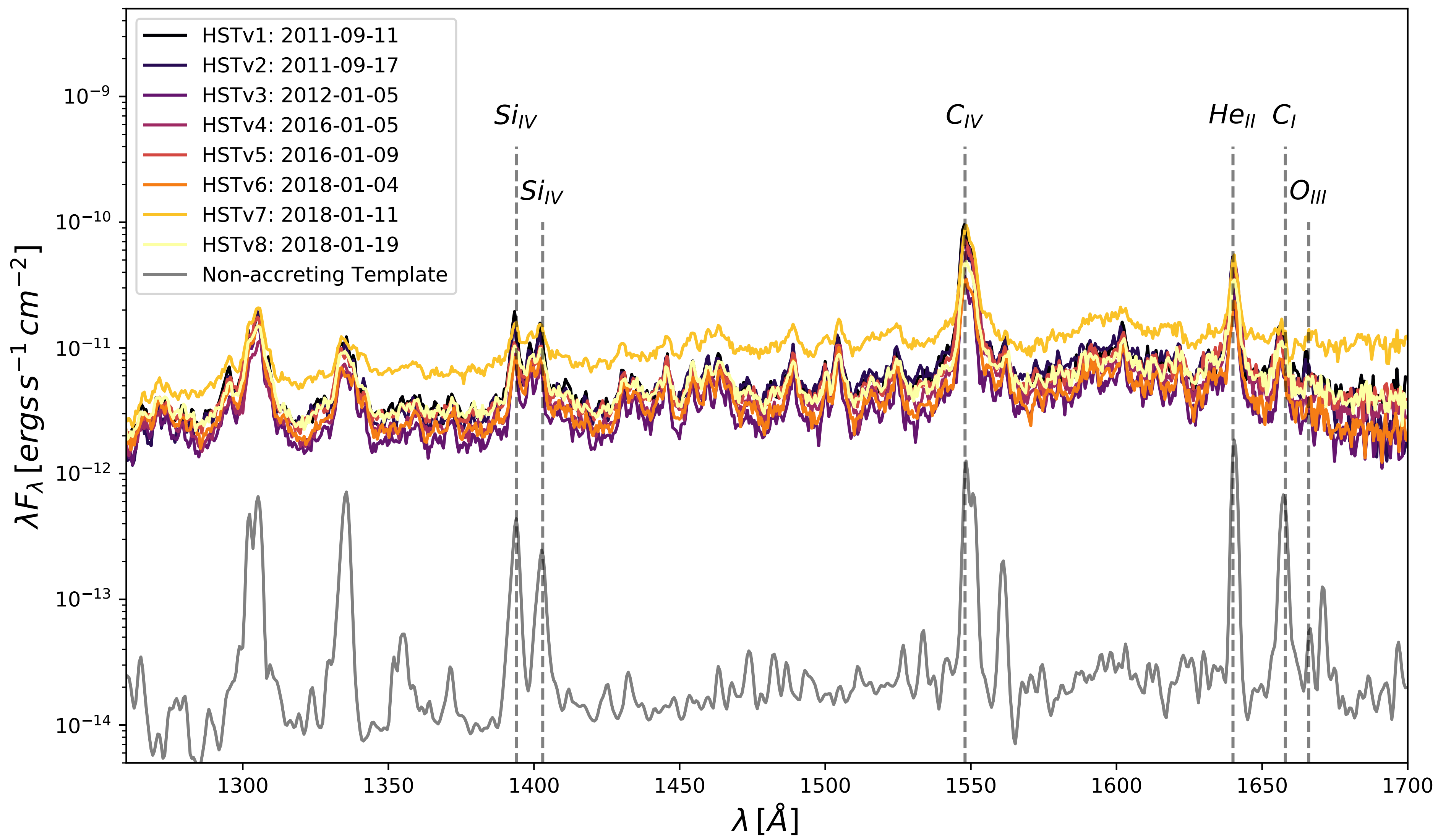
Secret slides!

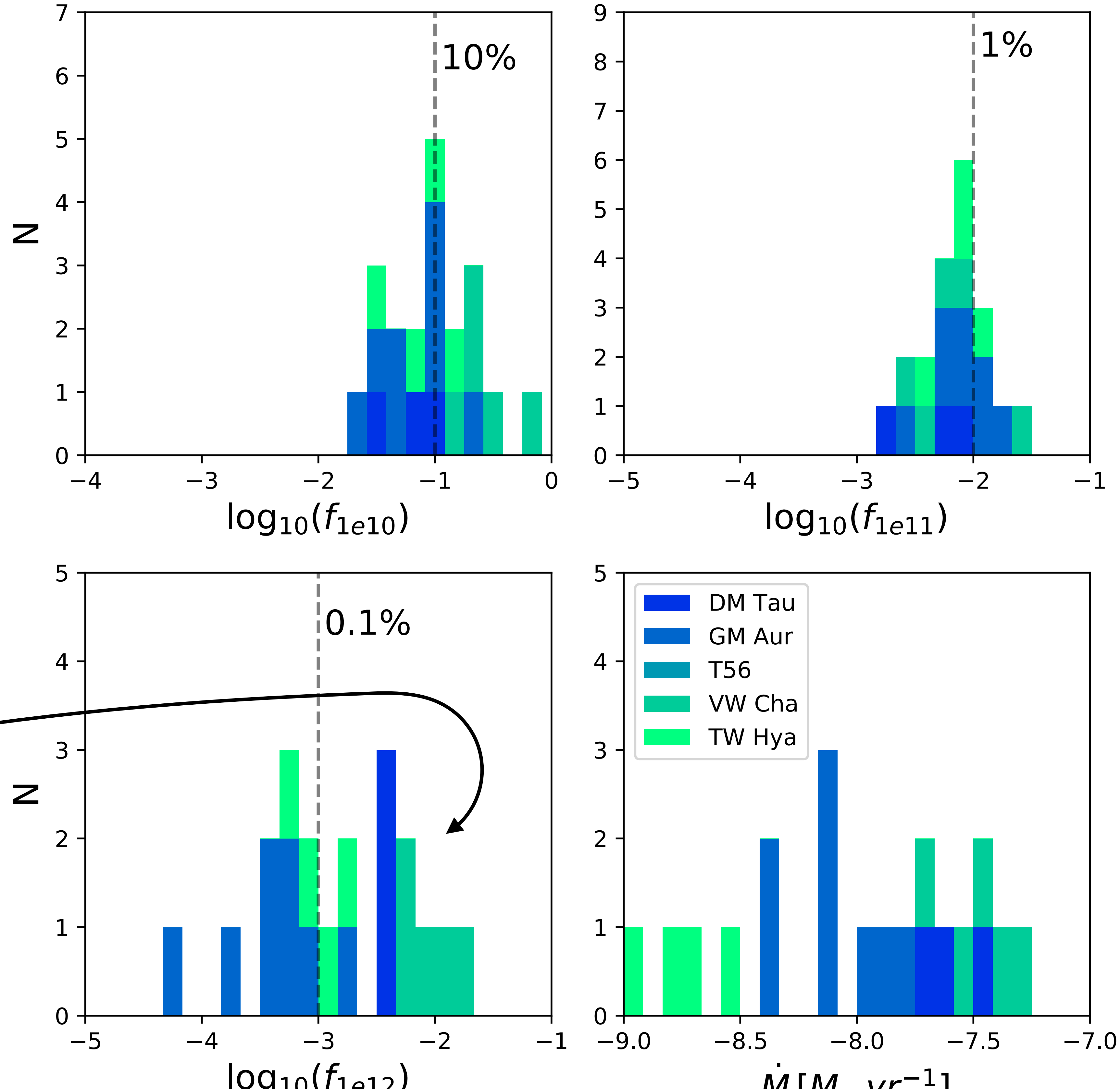
Flux in the FUV



Stellar parameters

OBJECT	SpT	T [K]	MASS [Msun]	EPOCHS
GM Aur	K5	4350	1.36	8
DM Tau	M2	3560	0.56	3
SZ 45	M0.5	3780	0.85	5
VW Cha	K7	4060	1.24	5
TW Hya	K7	4060	0.79	4

Surface coverage of columns varies between object and observation



VW Cha + DM Tau have significant contributions from high density columns

Robinson et al. (in prep)