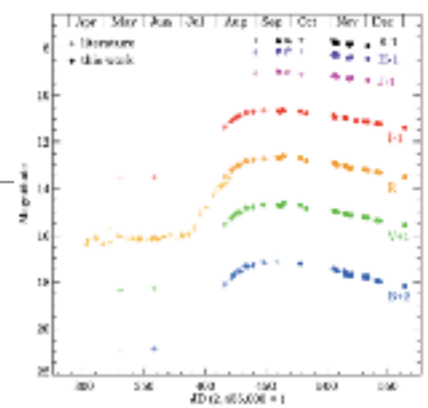
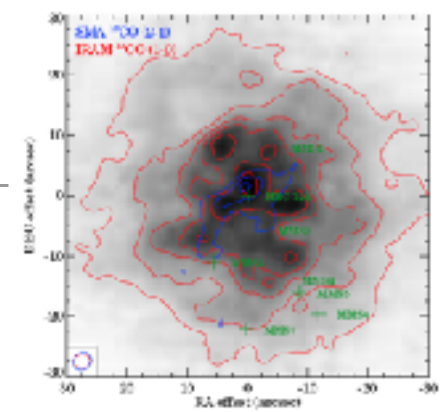
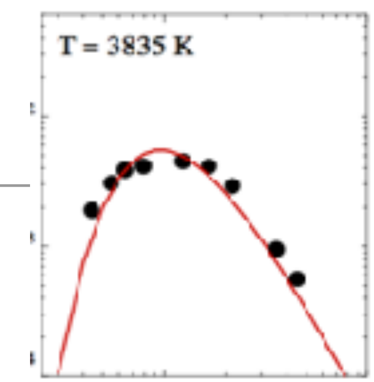
Latest observations of the FU Orionis-type young eruptive star HBC 722







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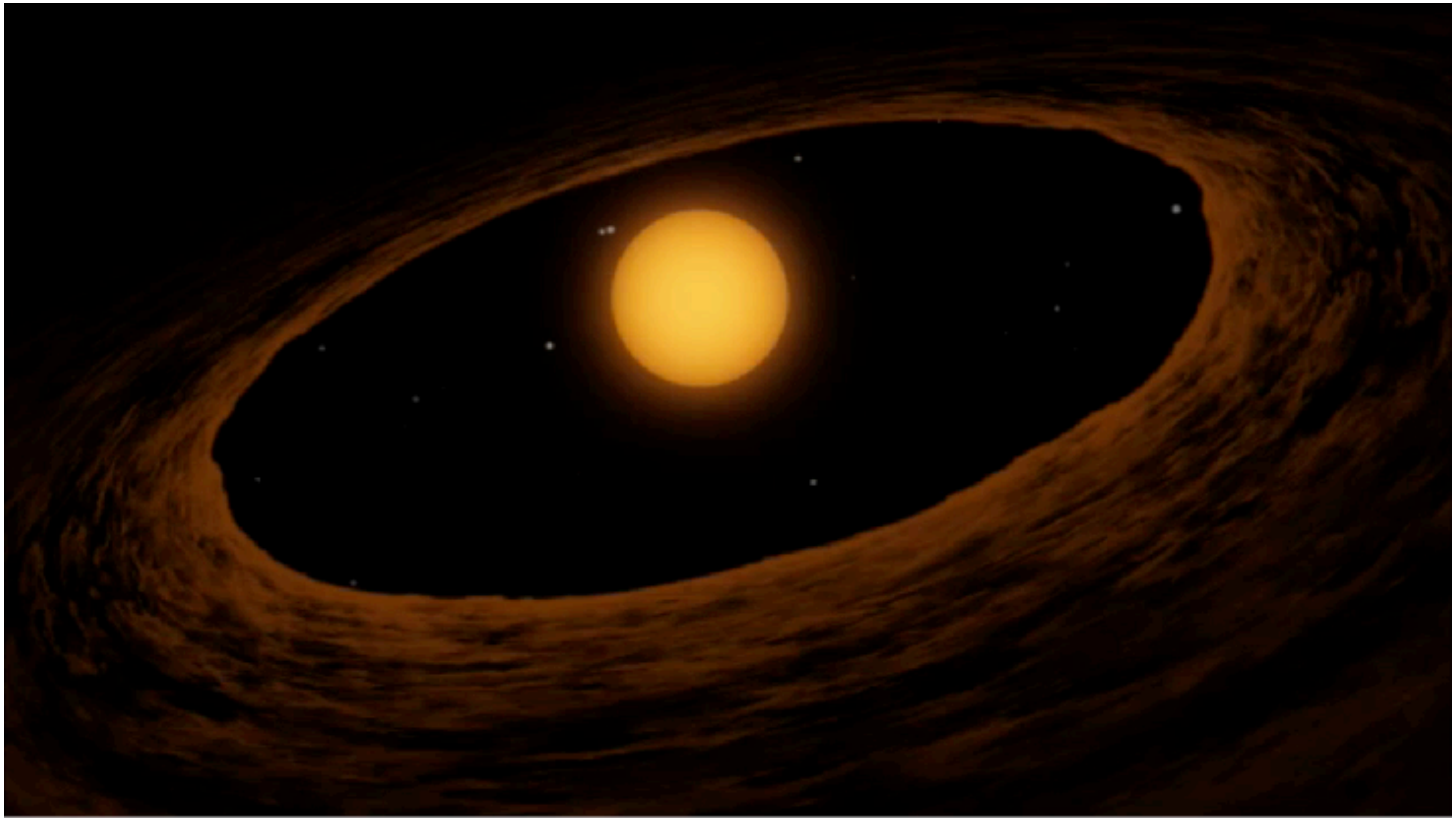
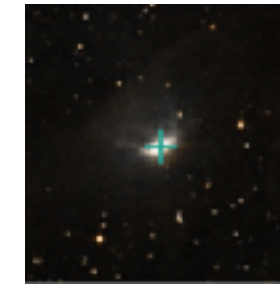
Star formation in time

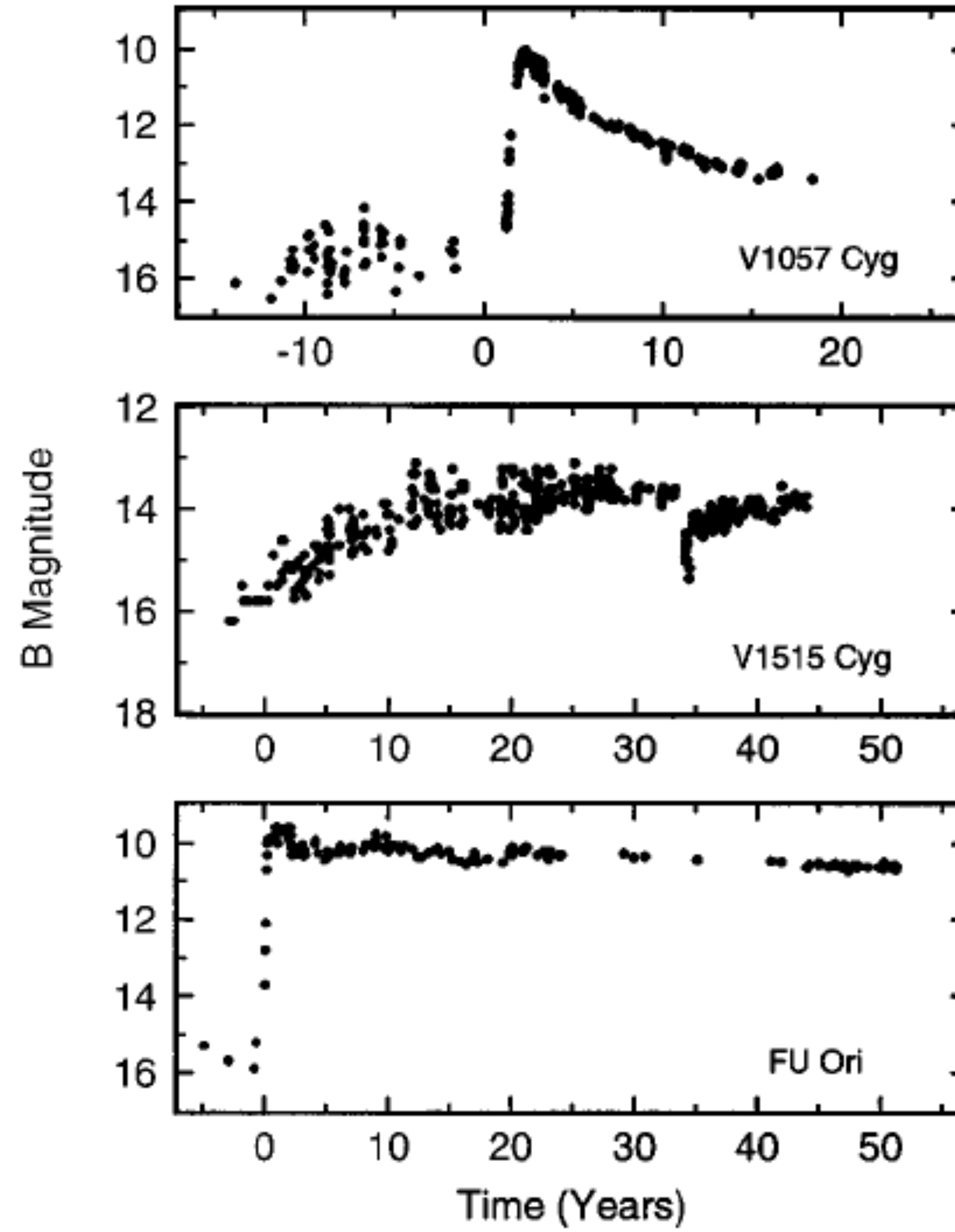
- Star formation is an intrinsically time dependent process
- Typical timescale: 10^4-10^6 yrs
- Rapid process: 0.1% of Sun's lifetime
- There exist even more rapid variations: fluctuating accretion rate up to 10^{-4} M_{Sun}/yr
- Possible solution to the luminosity problem



FU Orionis-type stars (FUors)



- Young stars with large outburst (4–5^m) in optical light (Herbig 1977)
- Outburst light curves are heterogeneous
- Reflection nebula, IR excess
- Spectral type: F-G supergiant (optical) K-M giant or supergiant (NIR)
- Increased accretion up to 10^{-4} M_{Sun}/yr
- Special spectroscopic features: blueshifted absorption in Balmer lines, CO bandhead in absorption,...
- Temperature highest in the mid-plane
- Progenitor: low-mass star (V1057 Cyg)??



Hartmann & Kenyon (1996)

Physical mechanisms

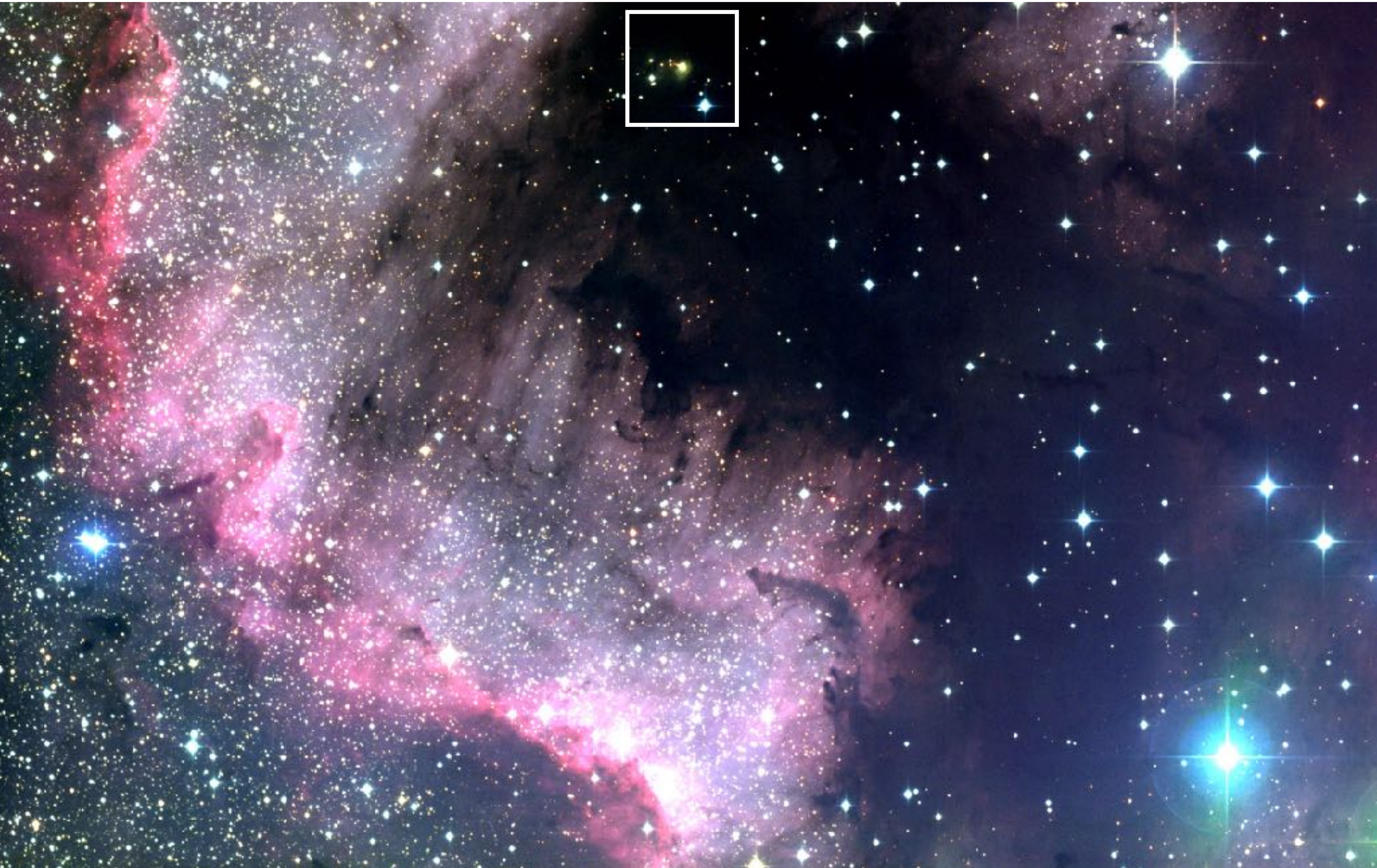
Matter (1) accumulates then (2) falls onto the star

- Interactions of binary or multiple systems where tidal forces disturb the circumstellar disk (Bonnell & Bastien 1992)
- Thermal instabilities in the disk alone (Bell et al. 1995) (“S-curve”)
- Planet-disk interactions, where thermal instabilities in the disk are caused by the presence of a massive planet (Lodato & Clarke 2004)
- Gravitational instabilities in the disk due to the mass infall from the rotating envelope onto the disk (Vorobyov & Basu 2006)
- Slow accumulation of matter due to gravitational instability, triggering the magnetorotational instability, which leads to rapid accretion. Thermal instability is triggered in the inner disk (Zhu et al. 2009)
- Matter piling up at the corotation radius (D’Angelo & Spruit 2010)
- Conical wind model / Propeller regime (Marina Romanova)

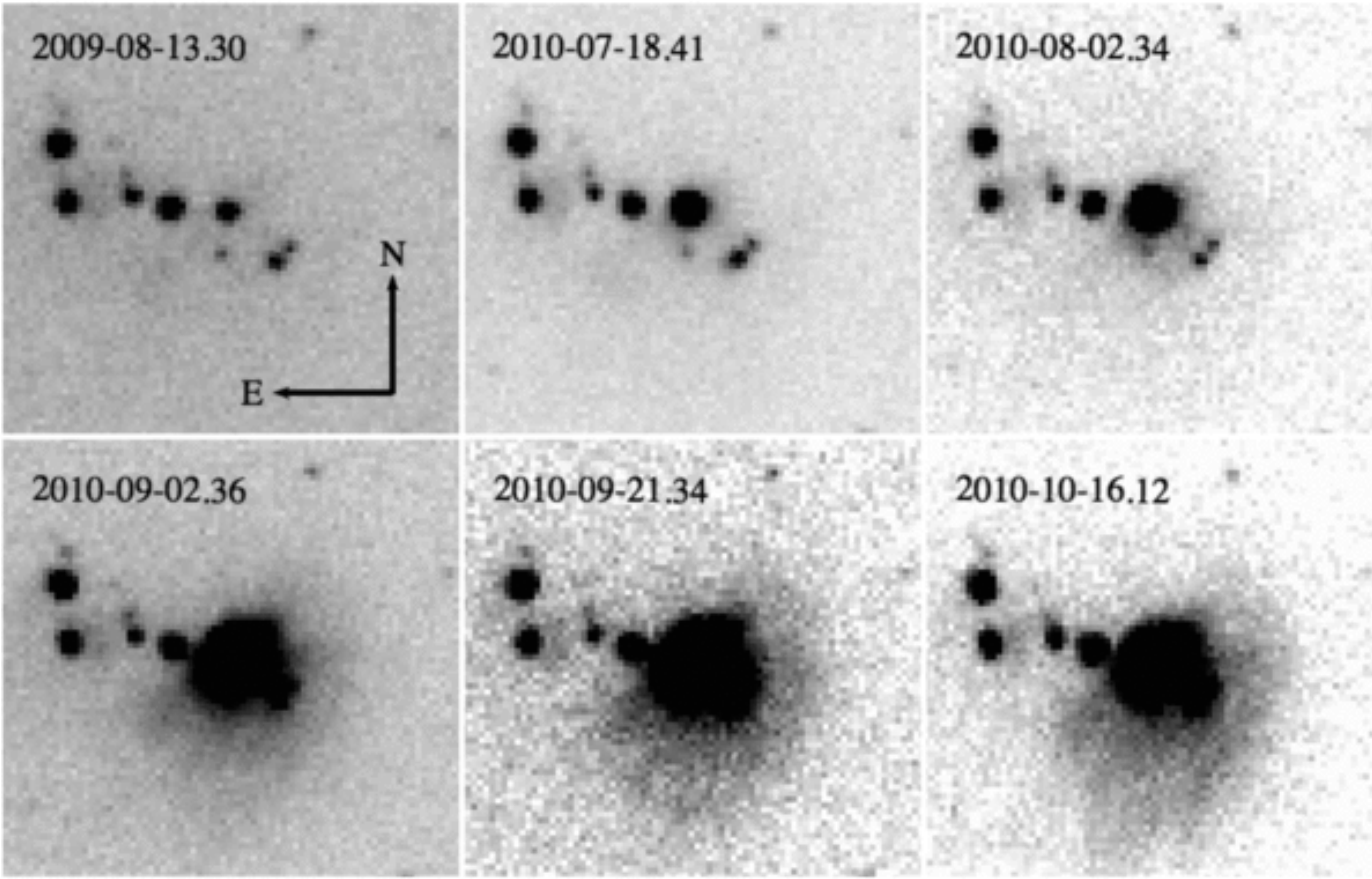
Badly missing pre-outburst observations.

The outburst of HBC 722

The outburst of HBC 722



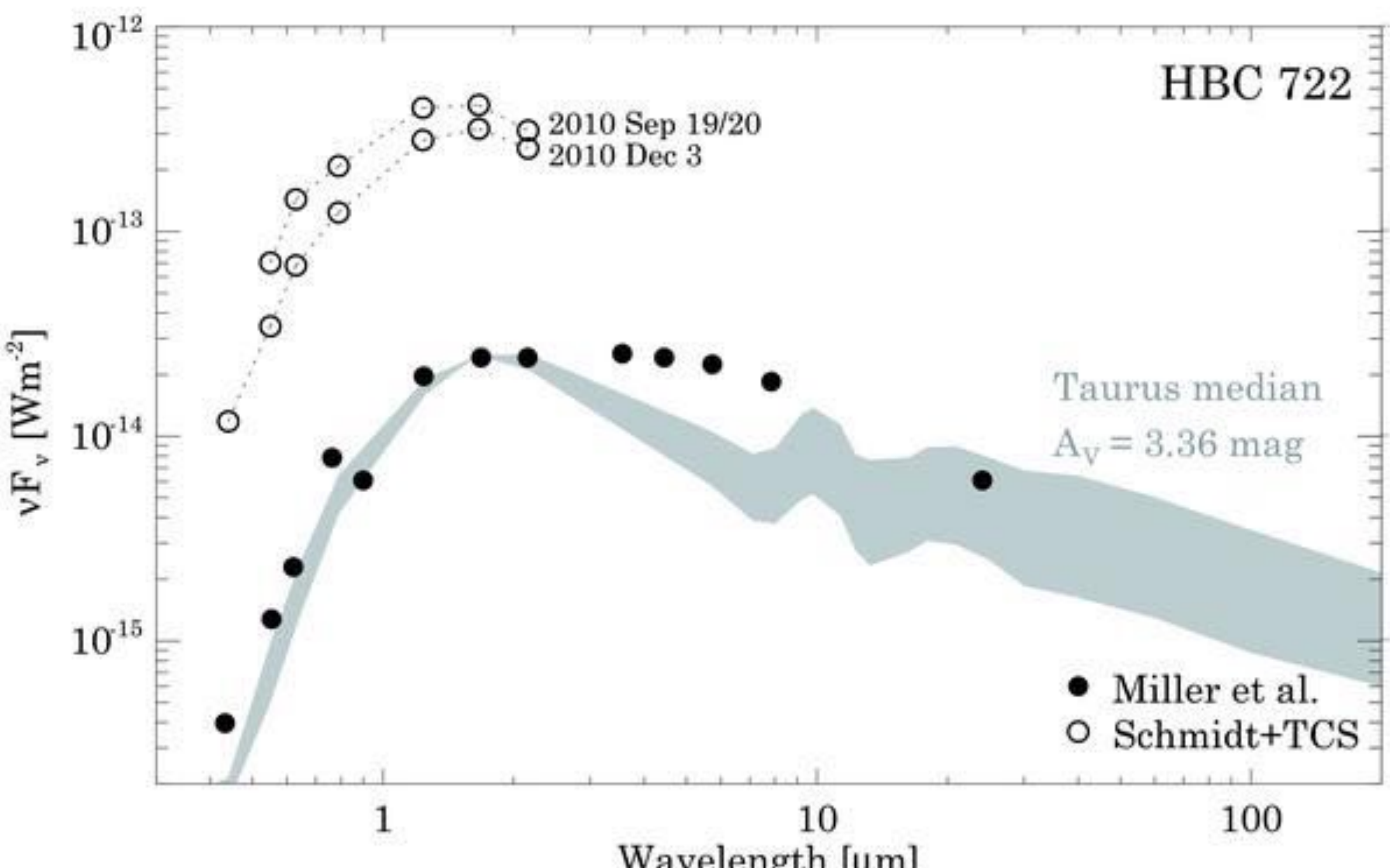
The outburst of HBC 722



Miller et al. (2011)

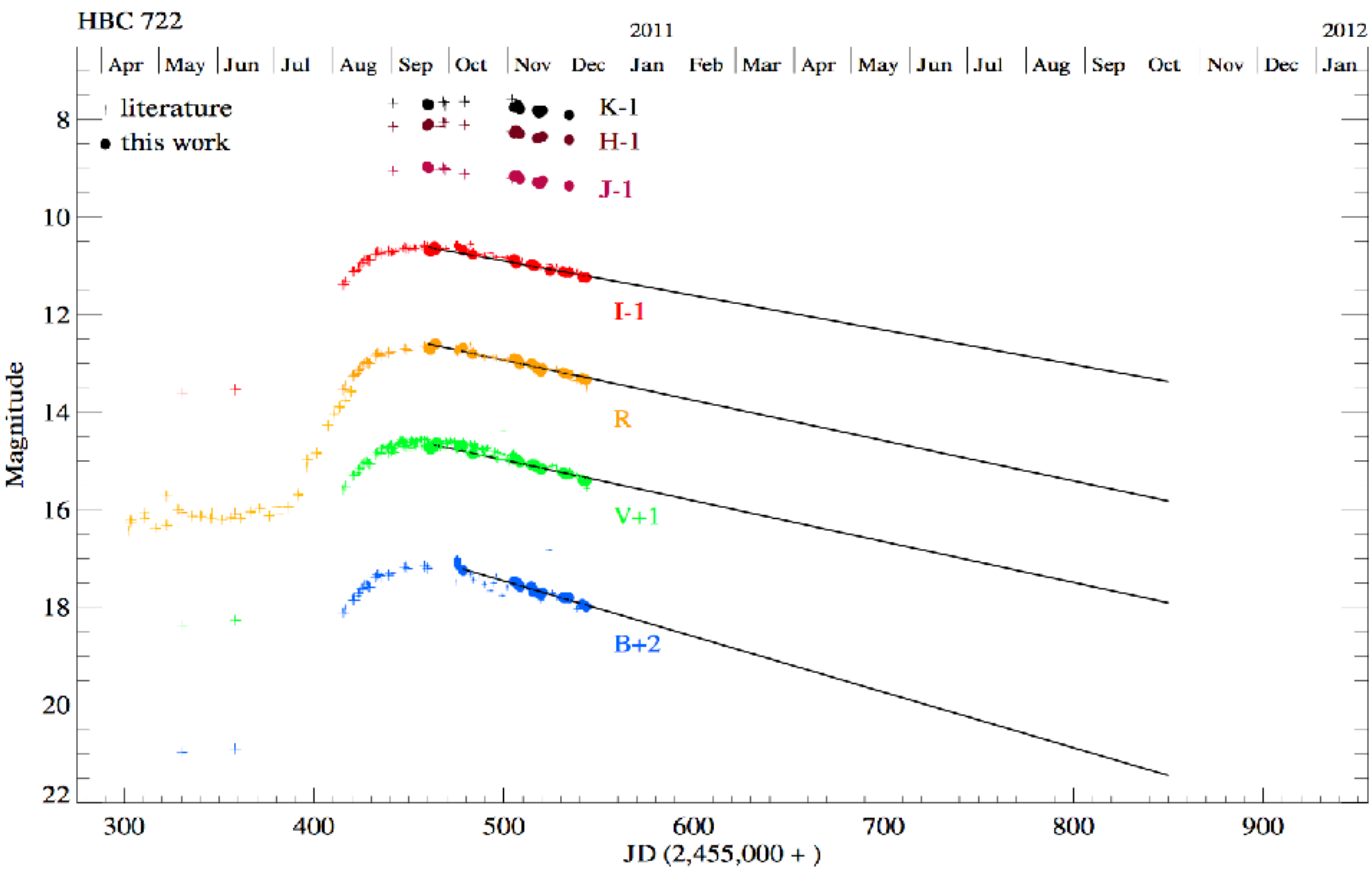
The progenitor

- SED from archive data, 0.85 L_{Sun}
- SED shape is similar to Taurus median
- Slightly reddened (A_V = 3.36 mag), K7-type, usual T Tauri star
- Excess in the mid-infrared, similar to DR Tau, highly accreting object, prominent Hα profile



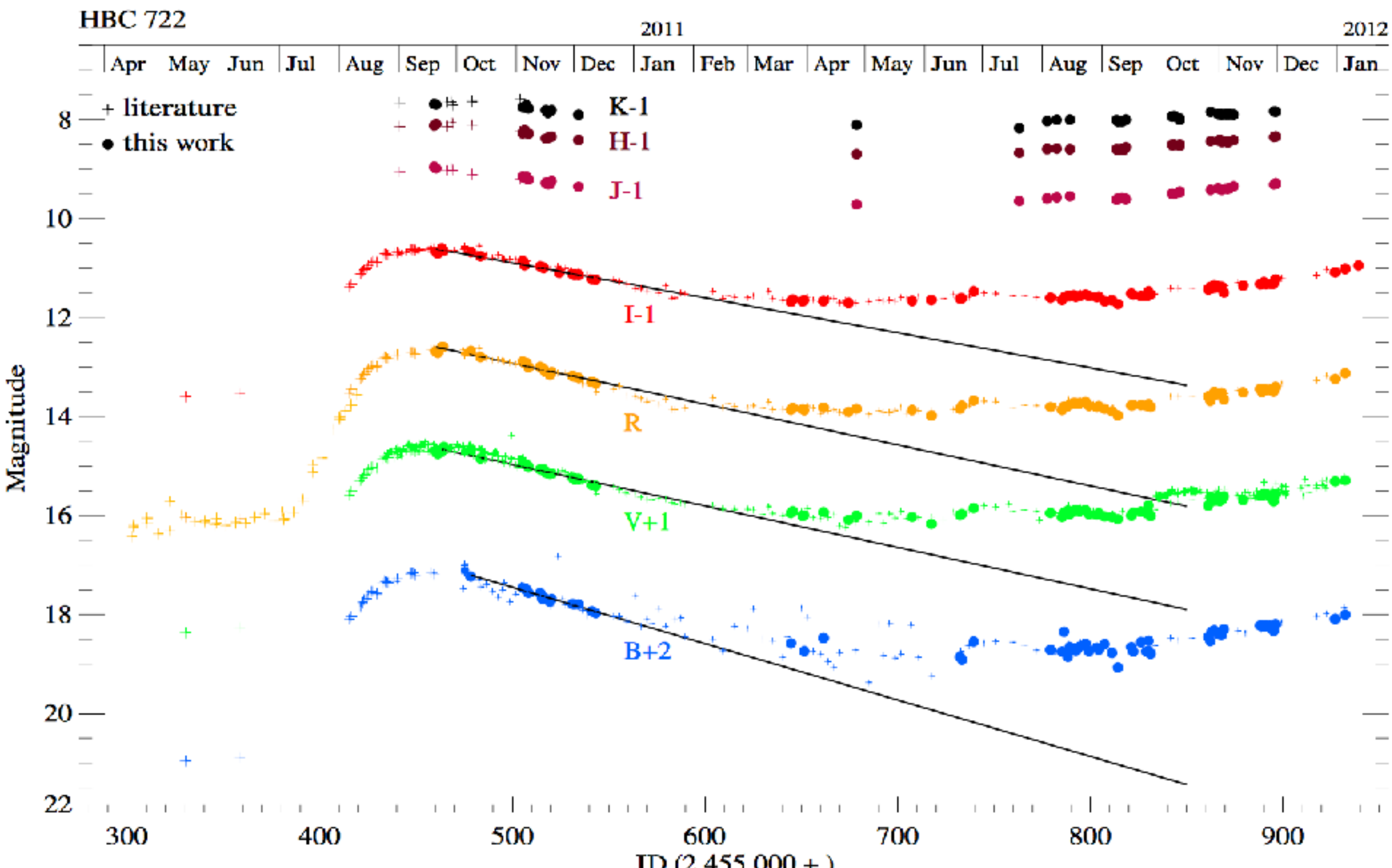
Kóspál et al. (2011)

Fading rate

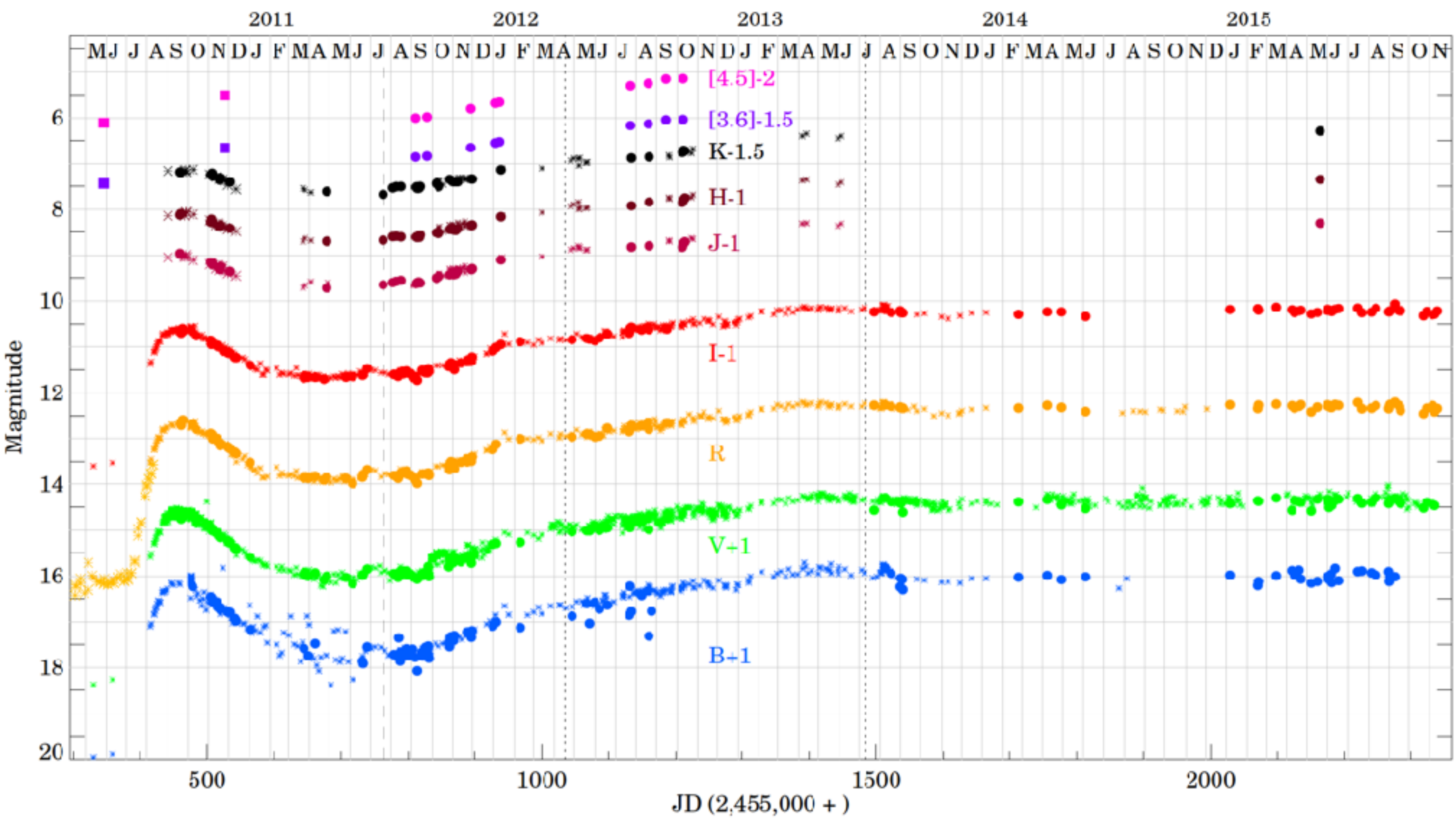


HBC 722
2011
2012
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
literature
this work
K-1
H-1
J-1
I-1
R
V+1
B+2
Magnitude
8
10
12
14
16
18
20
22
300
400
500
600
700
800
900
JD (2,455,000 +)

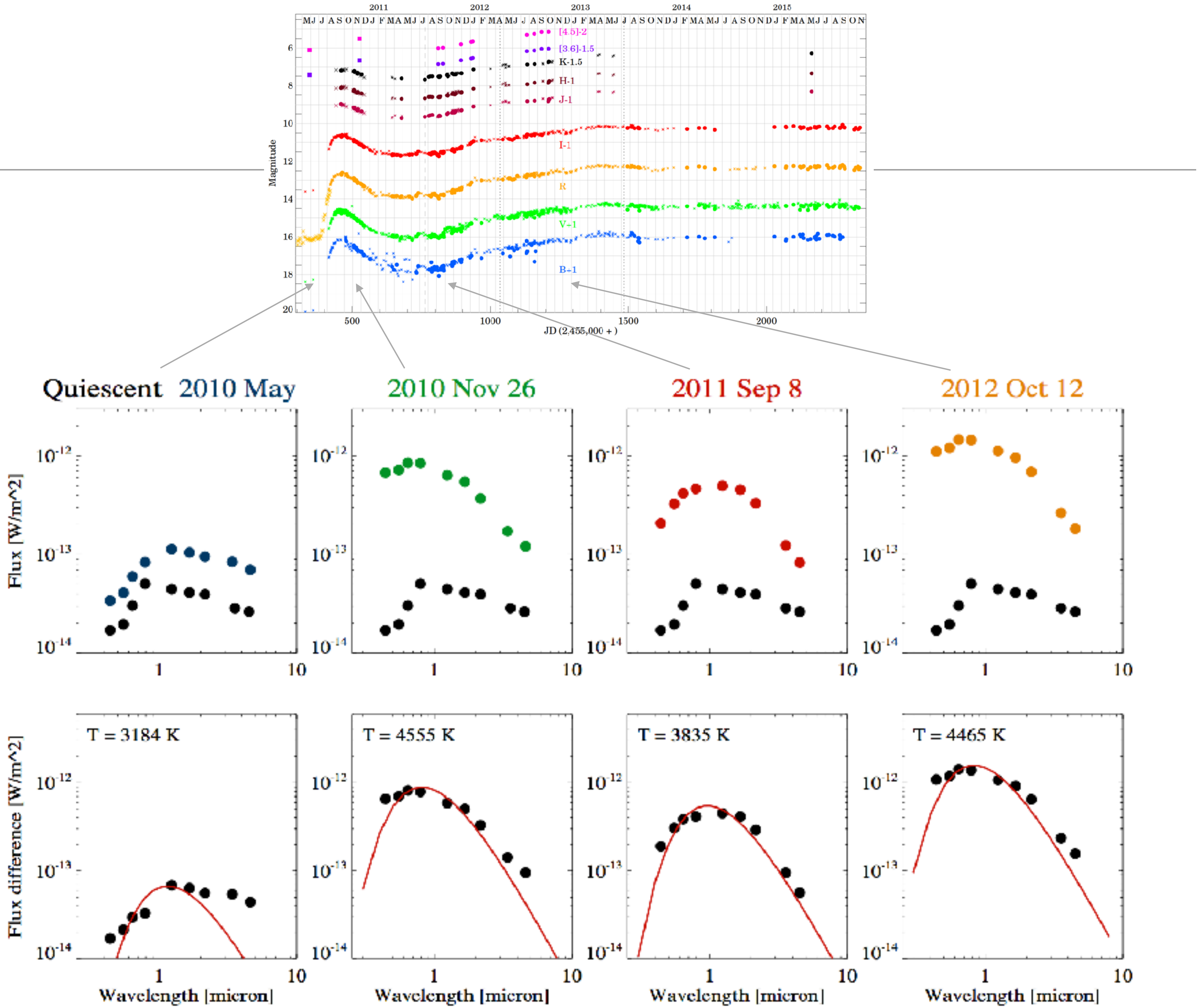
Long-term evolution



Latest light curves

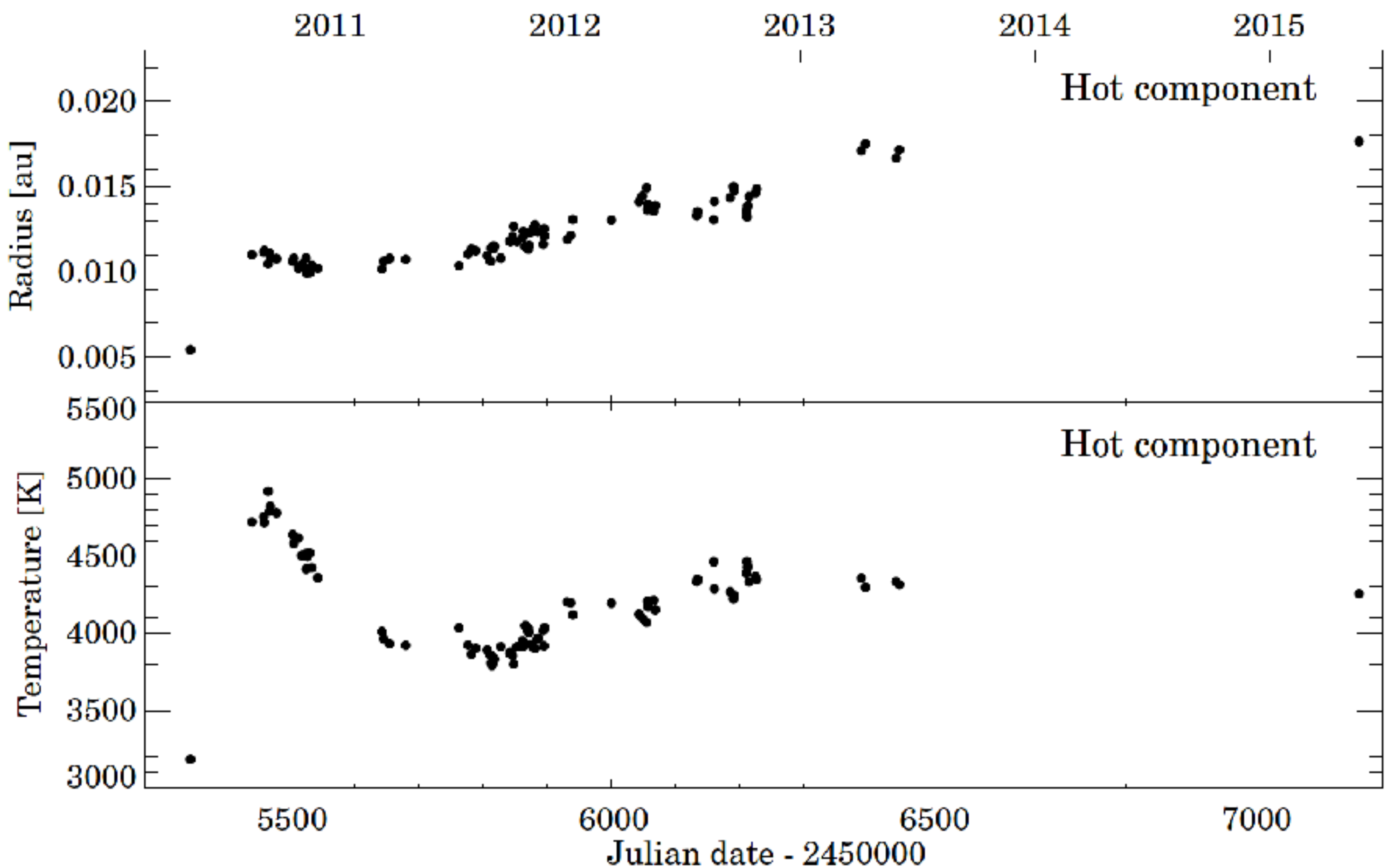


Kóspál et al. (in prep.)



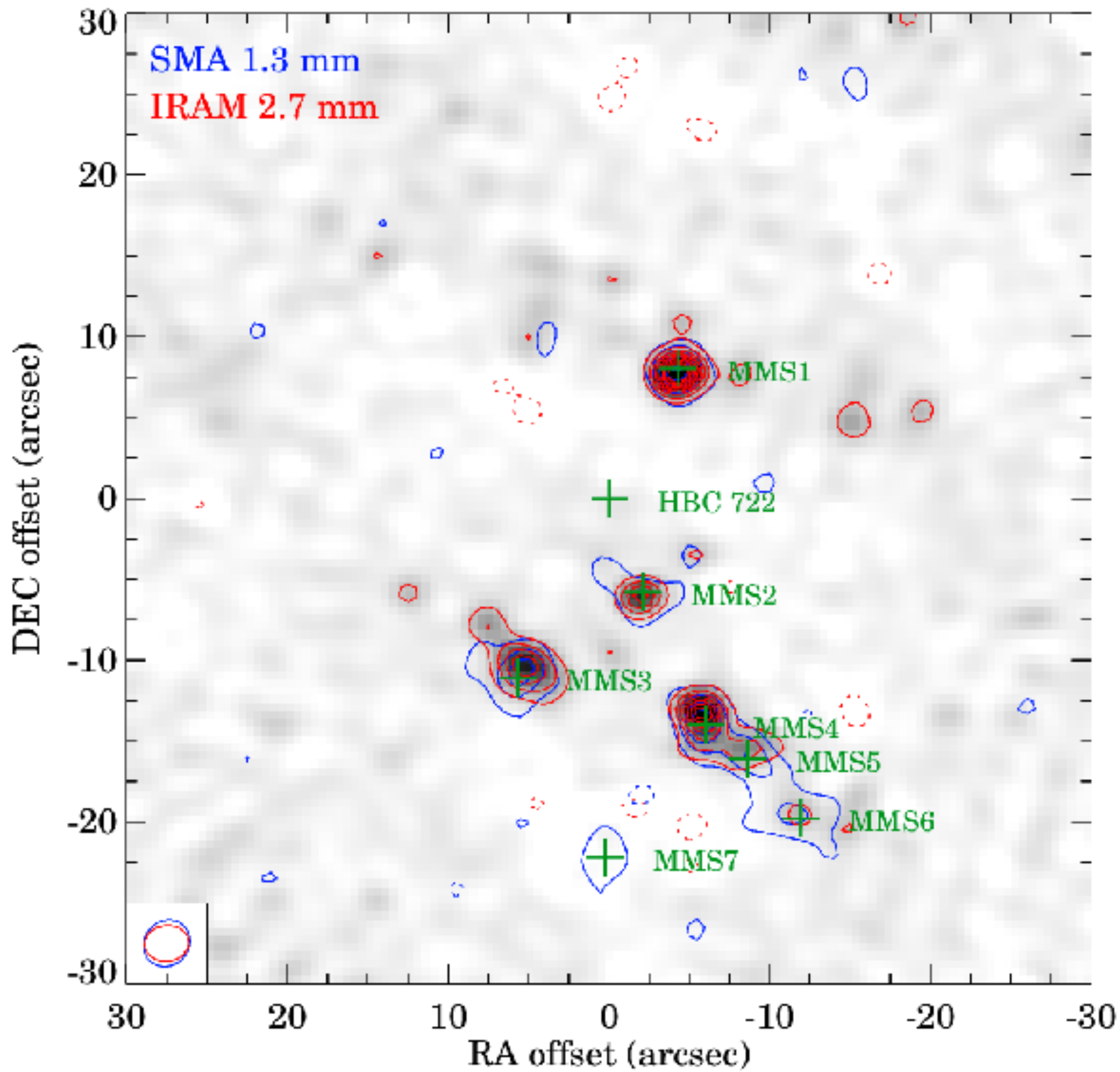
Kóspál et al. (in prep.)

Hot, optically thick material in the system



Kóspál et al. (in prep.)

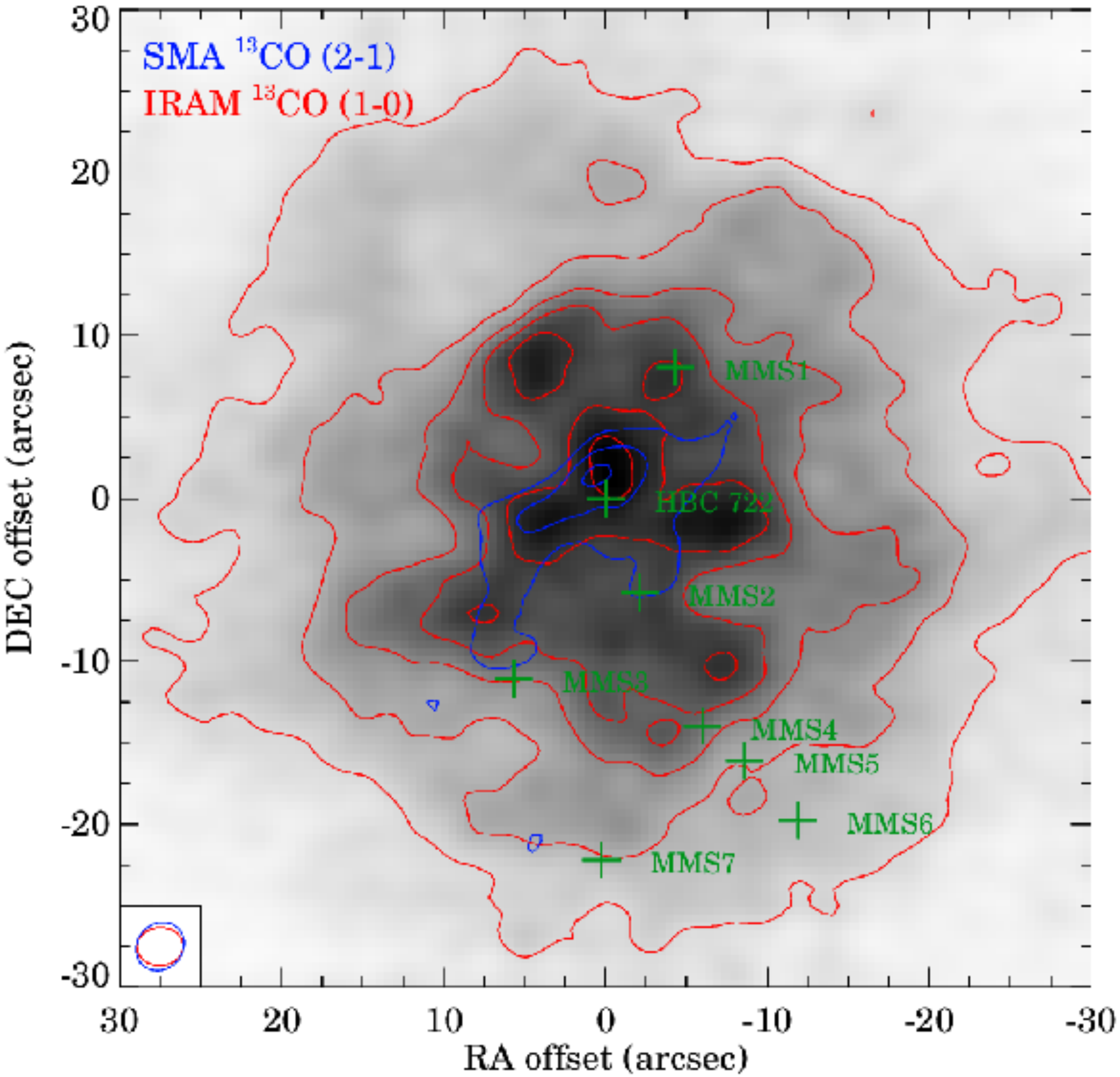
Environment: dust continuum



Kóspál et al. (in prep.)

- Interferometric data of the millimeter continuum
- HBC 722 non-detection
- 3 sigma upper limits:
  - IRAM 2.7 mm: < 0.24 mJy/beam
  - SMA 1.3 mm: < 5 mJy/beam
- Circumstellar mass is less than about 0.01 – 0.02 M_{Sun}
- Waiting for the delivery of our ALMA data

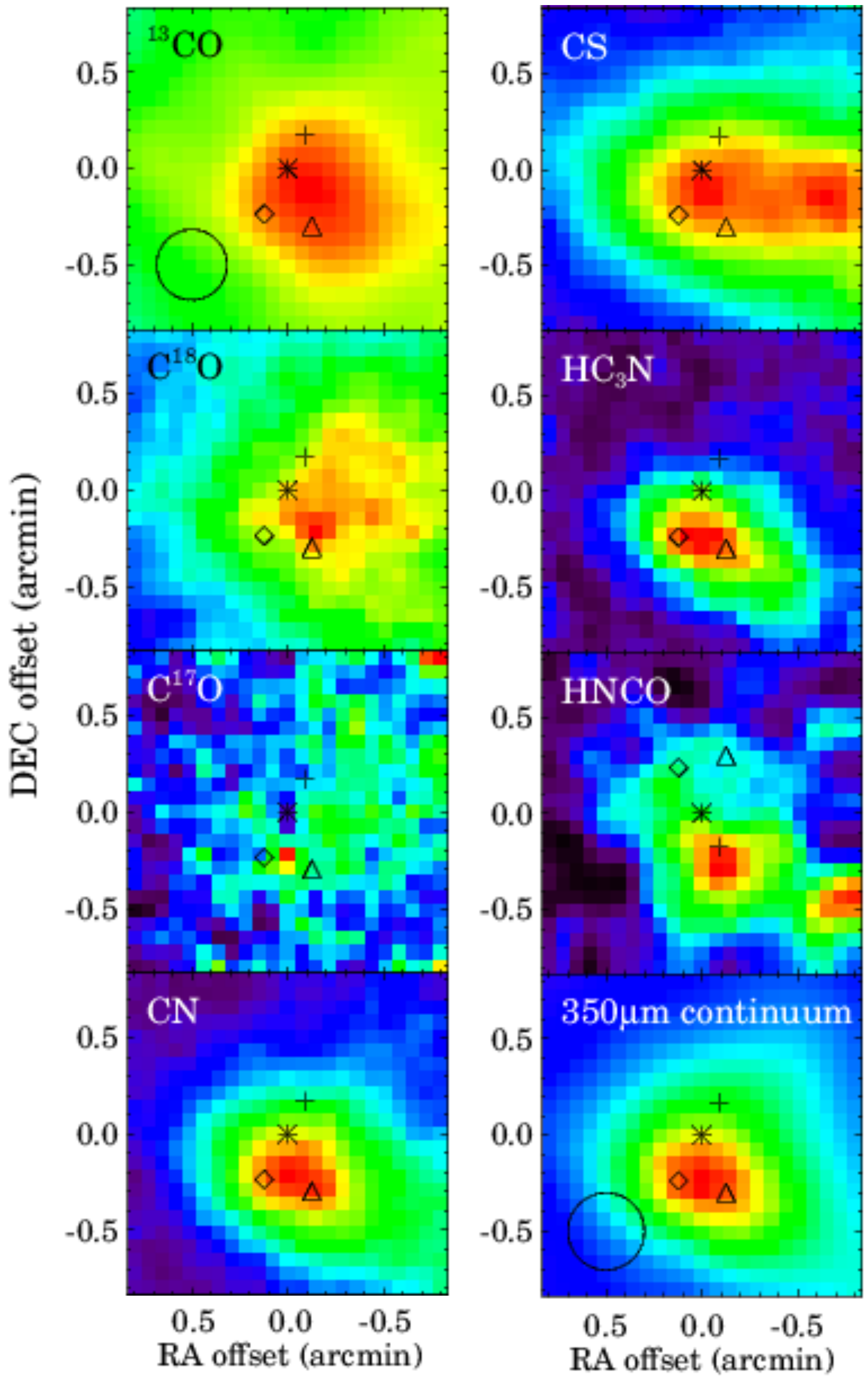
Environment: molecular spectroscopy



Kóspál et al. (in prep.)

- Total intensity of ^{13}CO emission measured with IRAM PdBI + IRAM 30 m
- HBC 722 is directly undetected
- Several CO clumps, most of them not coinciding with mm continuum sources
- Temperature between 20 K and 32 K
- $C^{18}O/^{13}CO$ ratio suggests optically thin emission
- Total mass is 7 – 10 M_{Sun}

Environment: molecular spectroscopy



Kóspál et al. (in prep.)

- Single-dish molecular line survey
- Lines with low excitation potential (5.3 – 34 K)
- Lines with high critical density (up to 2×10^6 cm^{-3})
- Cold, dense gas
- HBC 722 did not form in isolation

What have we learnt?

- Normal-looking T Tauri stars can produce outburst
- FUor outbursts can occur in low mass disks without massive envelope
- During outburst the gas disk becomes optically thick (increasing column density)
- There is an initial peak, material falling from the inner disk.
- Increasing T and R -> classical ionization front expansion

Thanks for your attention!

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