



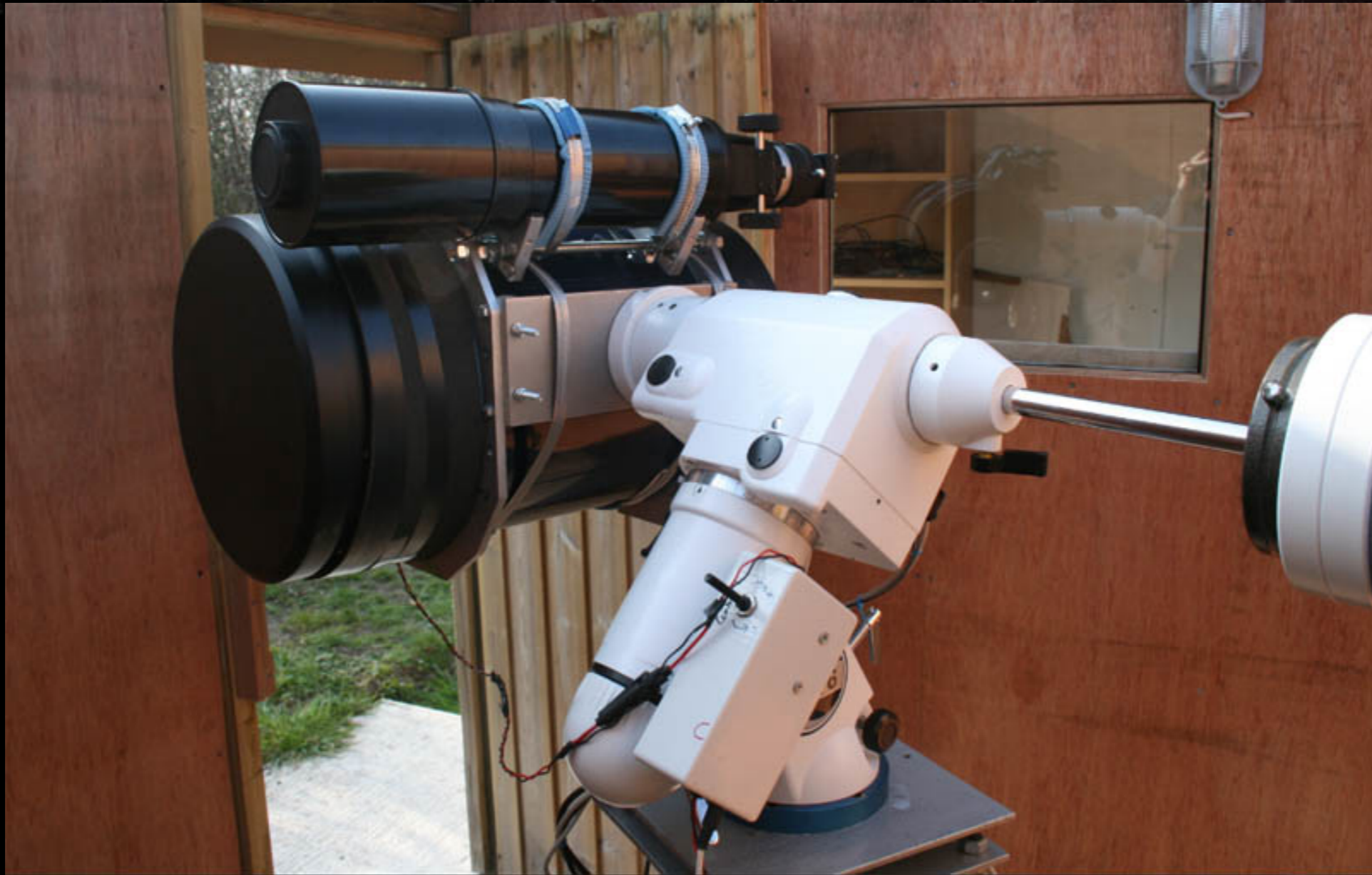
Badly behaved infants:  
**The first 10 Myr**  
Darryl Sergison

Illustration: ESO/L. Calçada

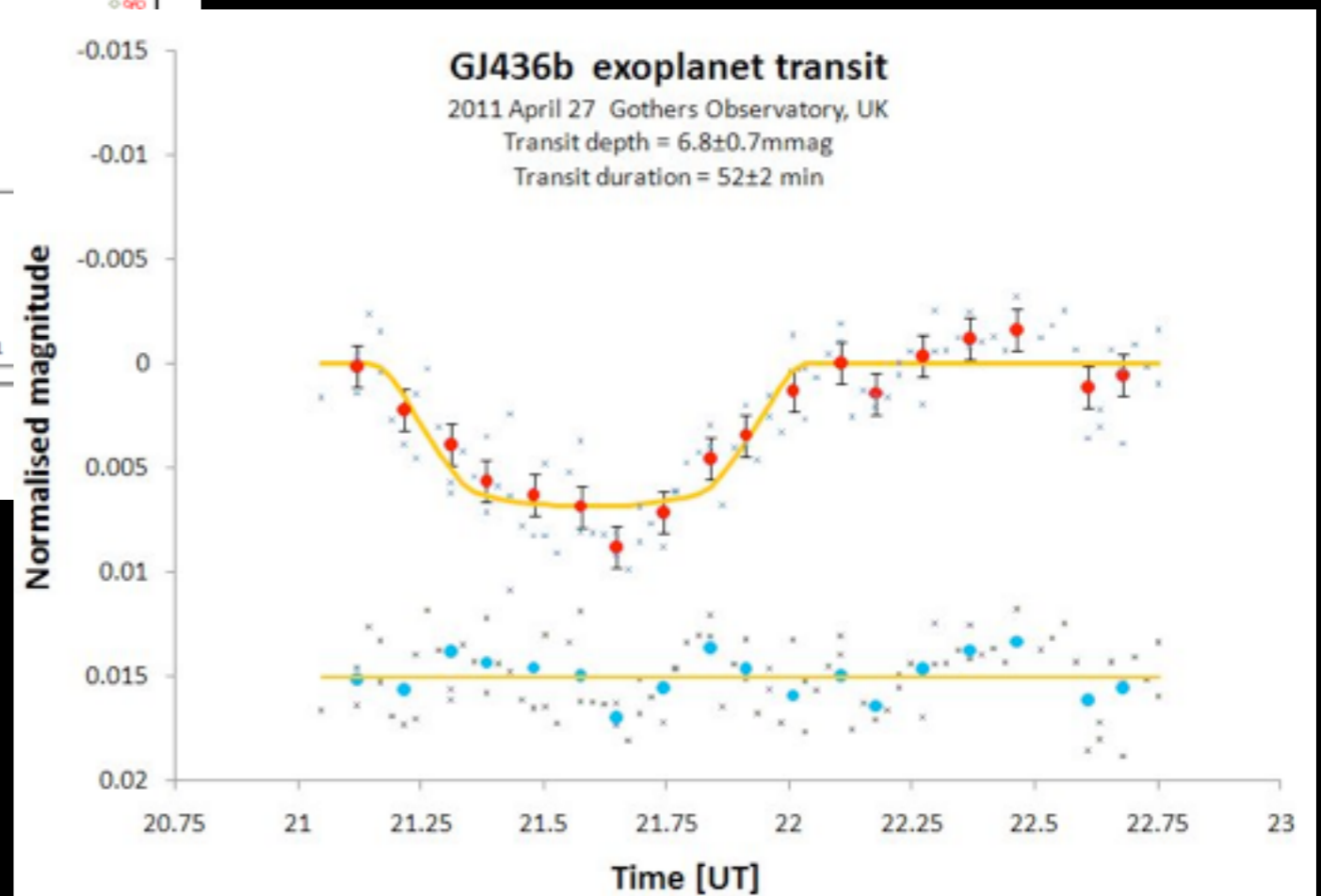
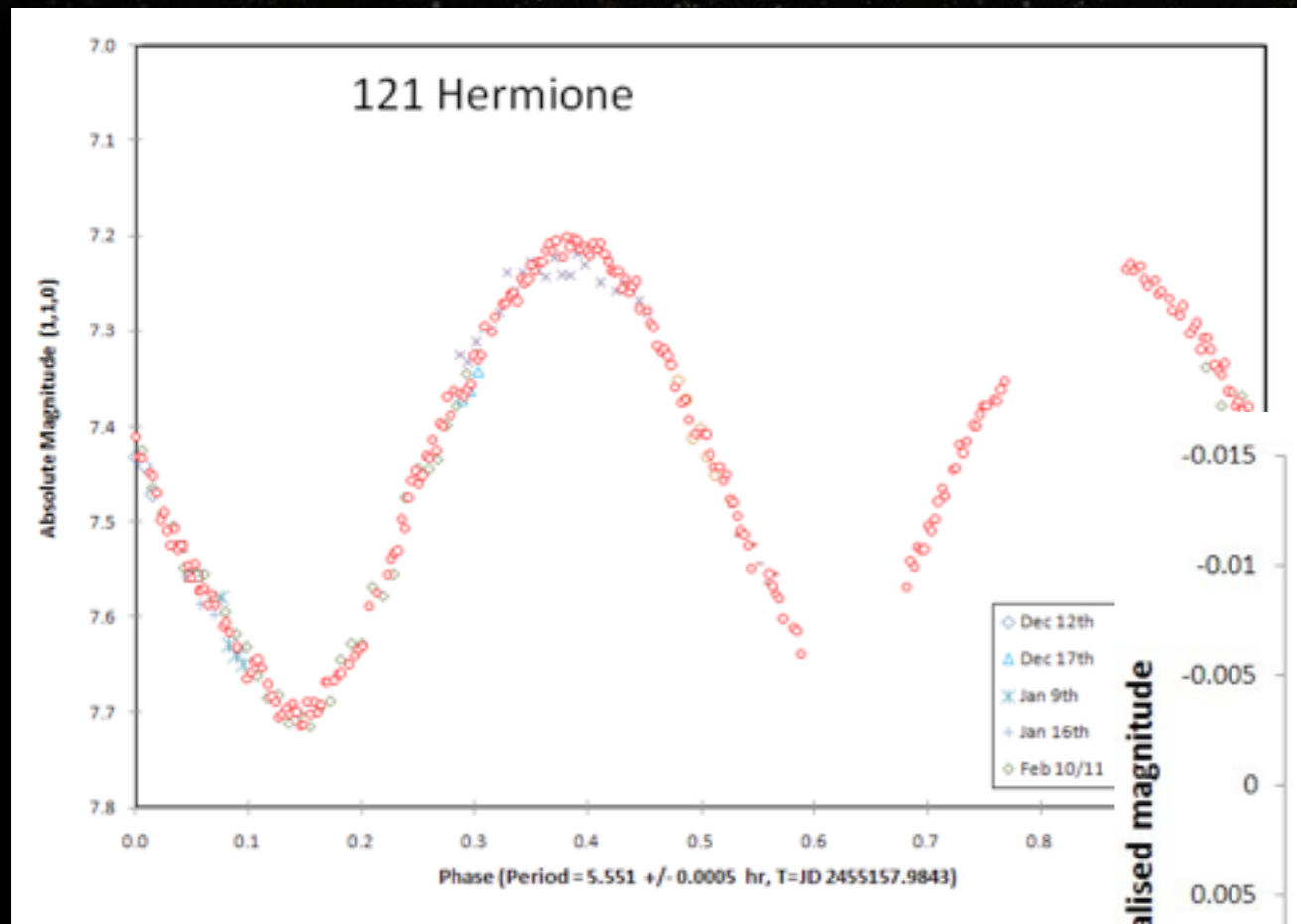
# Introduction

- ★ Brief outline of star-formation
- ★ Introduction to young stars/YSOs
- ★ Why are young stars so interesting observationally?

# My beginnings in Astronomy



# Some lightcurves



# Giant molecular clouds - stars and shocks

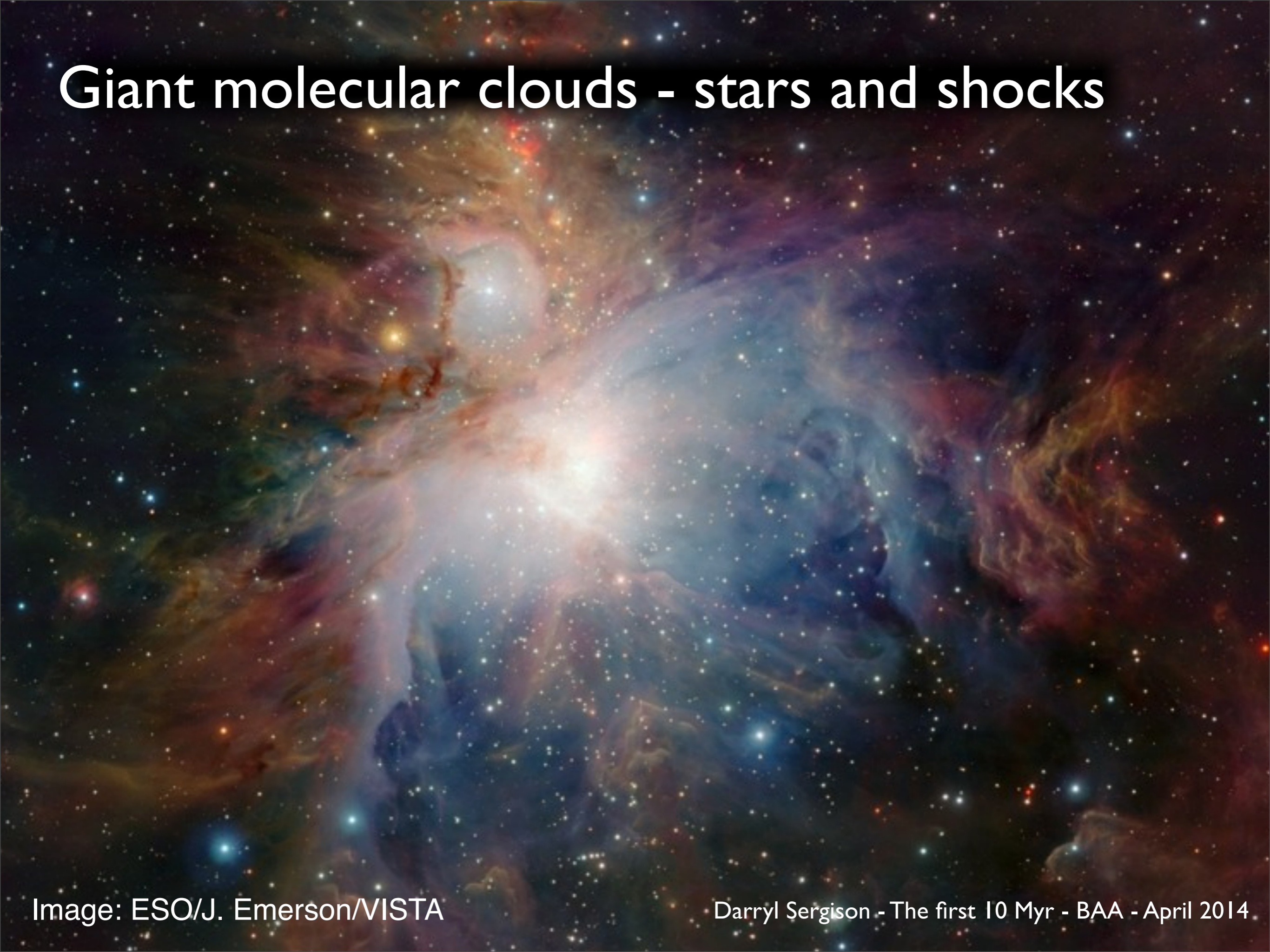


Image: ESO/J. Emerson/VISTA

Darryl Sergison - The first 10 Myr - BAA - April 2014

# Giant molecular clouds - cold dust

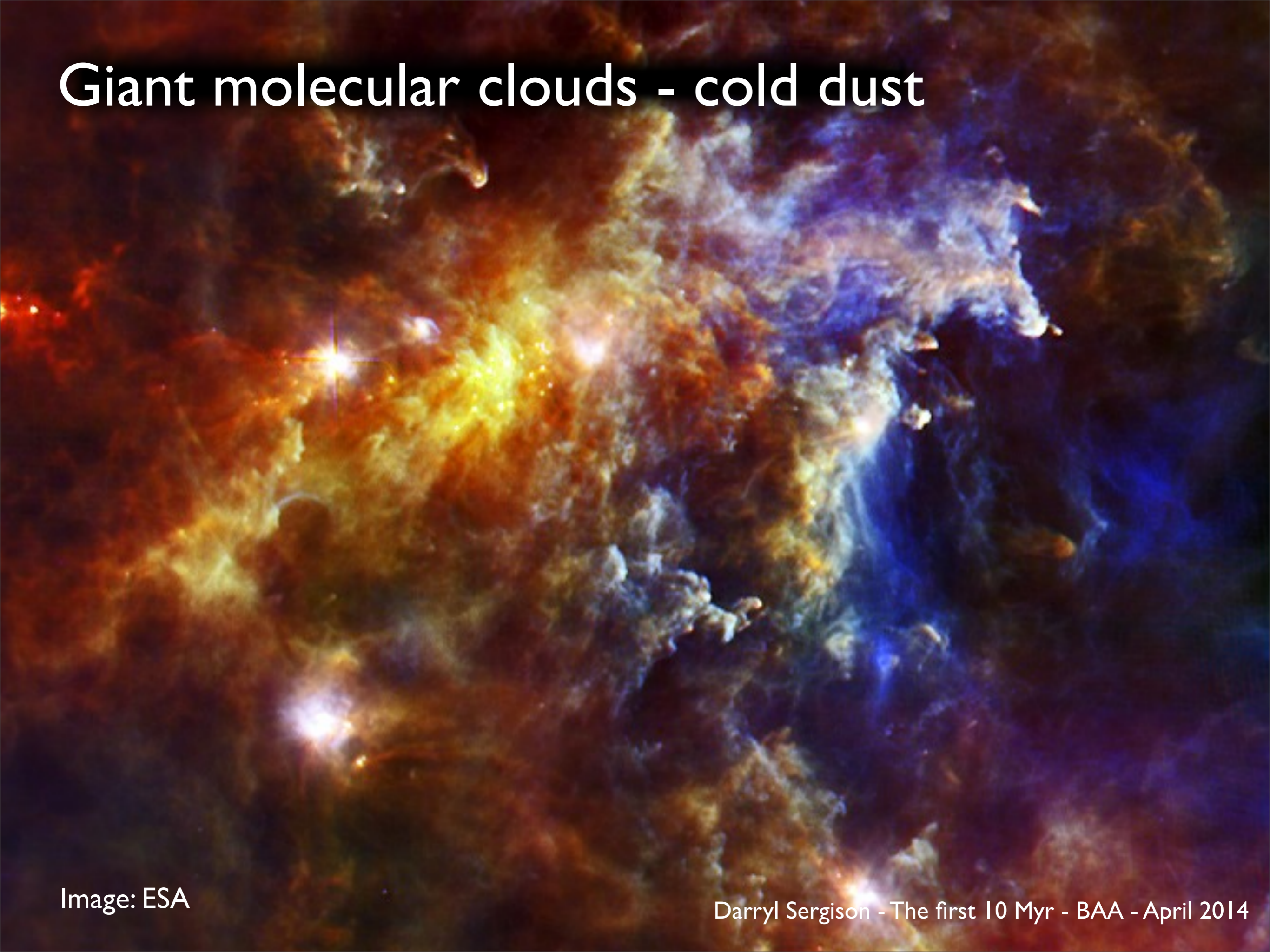


Image: ESA

Darryl Sergison - The first 10 Myr - BAA - April 2014

# The collapse..

Dimensions: 82496. AU Without Radiative Feedback Time: 196935. yr



-1.5 -1.0 -0.5 0.0 0.5 1.0

Log Column Density [ $\text{g}/\text{cm}^2$ ]

Dimensions: 82496. AU With Radiative Feedback Time: 196935. yr



-1.5 -1.0 -0.5 0.0 0.5 1.0

Log Column Density [ $\text{g}/\text{cm}^2$ ]

Matthew Bate

# Young Stellar Objects

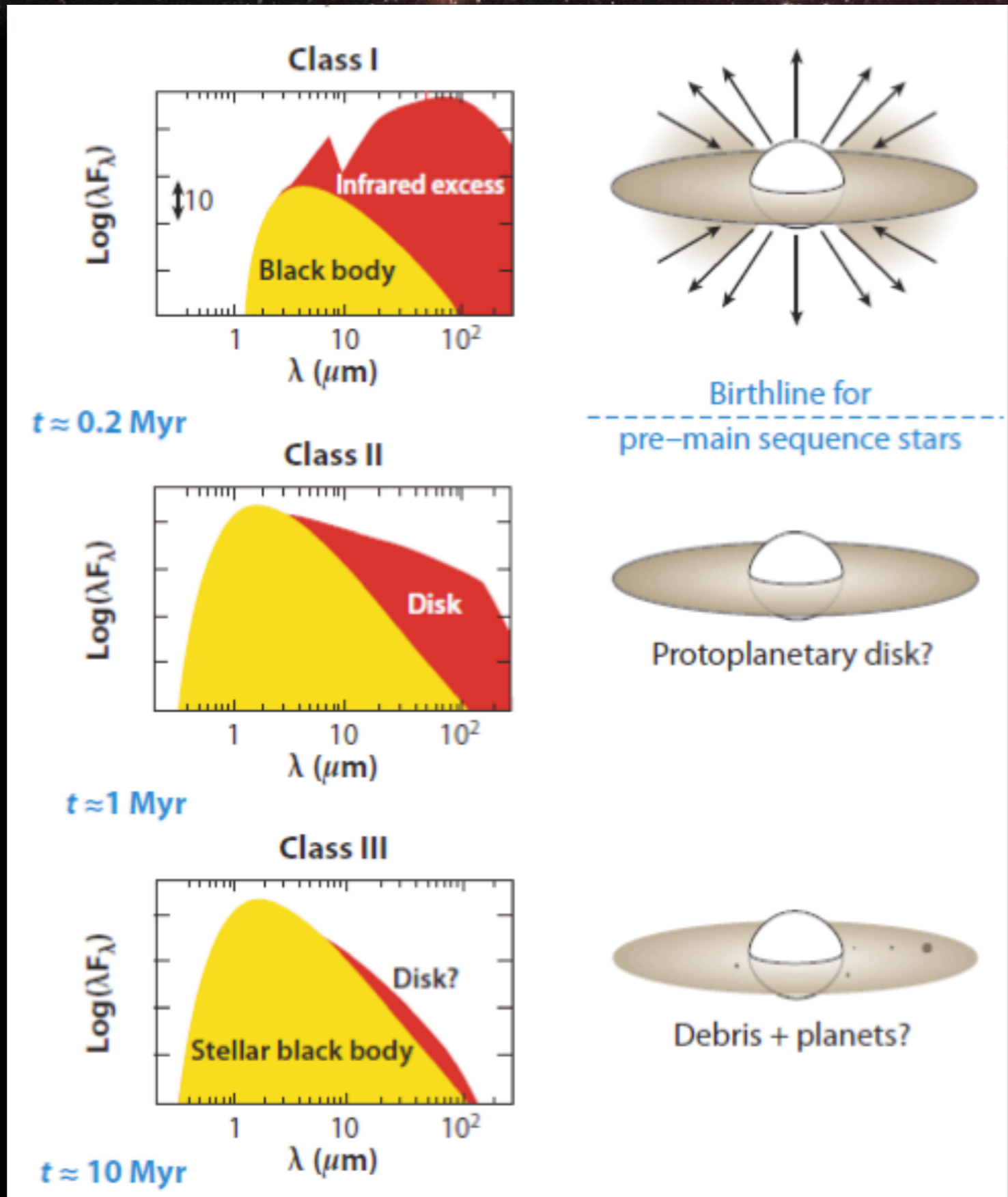


Image: Adam Block/Mount Lemmon  
SkyCenter/University of Arizona

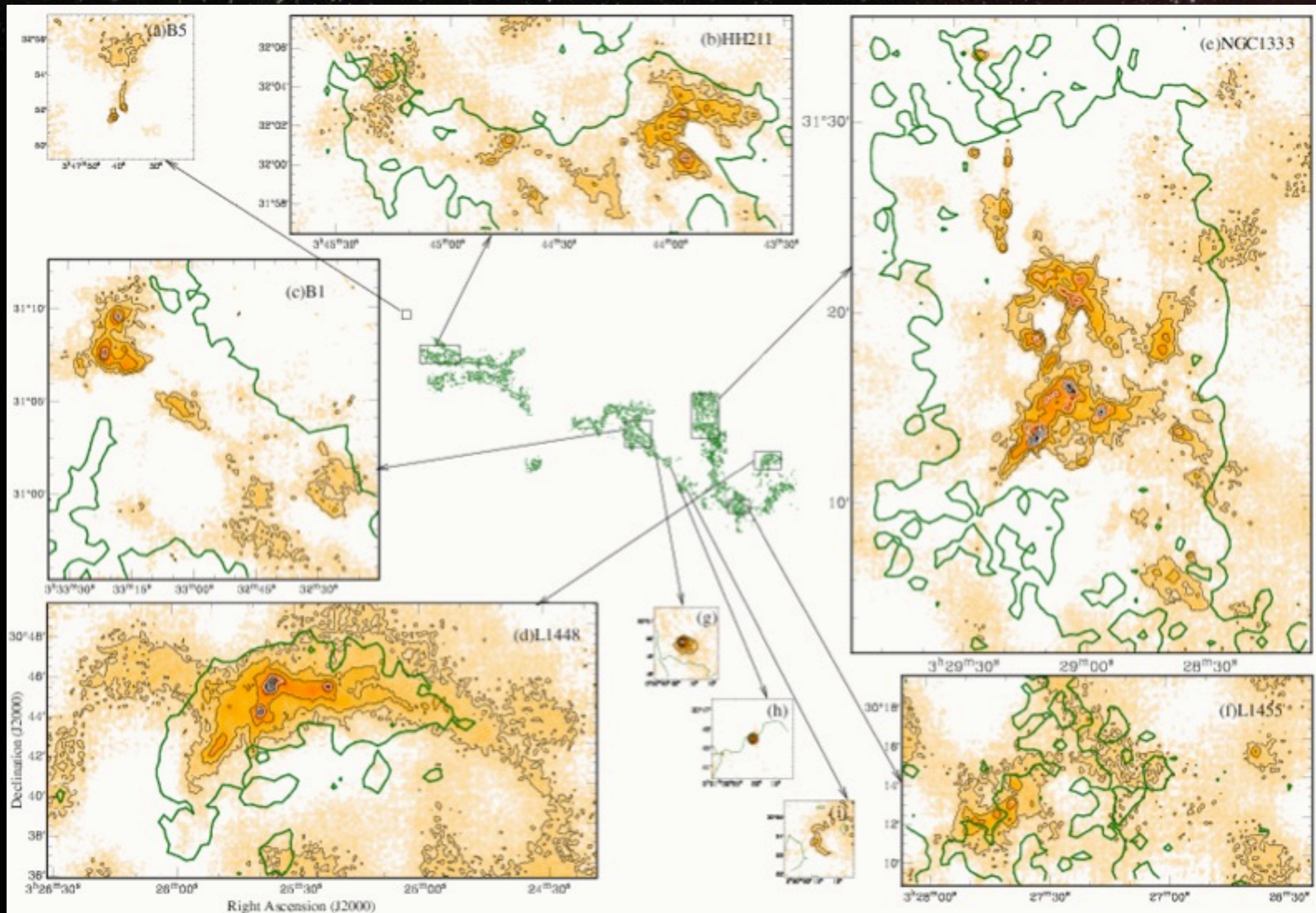
Darryl Sergison - The first 10 Myr - BAA - April 2014



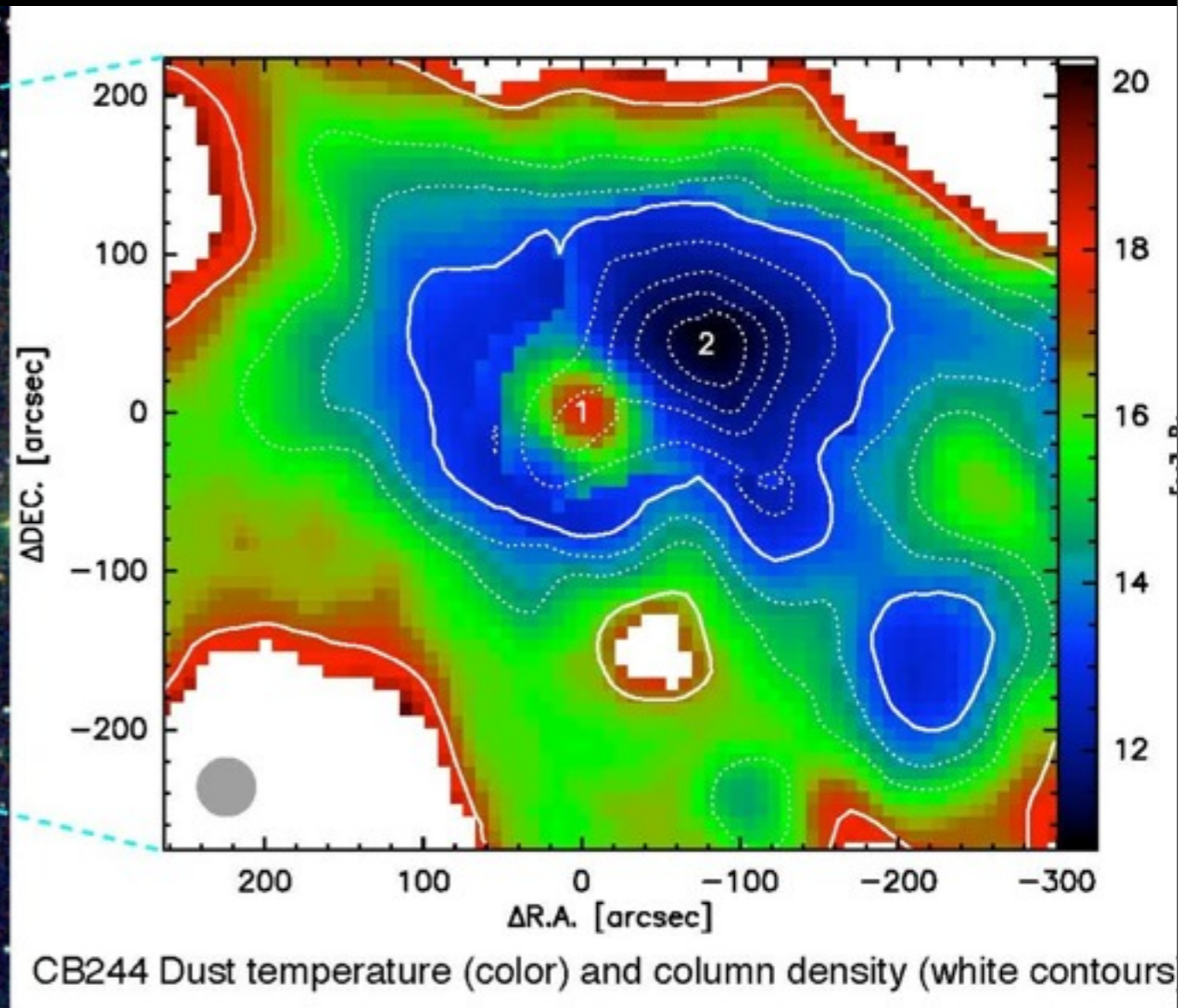
# YSOs: classification



# Class I: Embedded objects



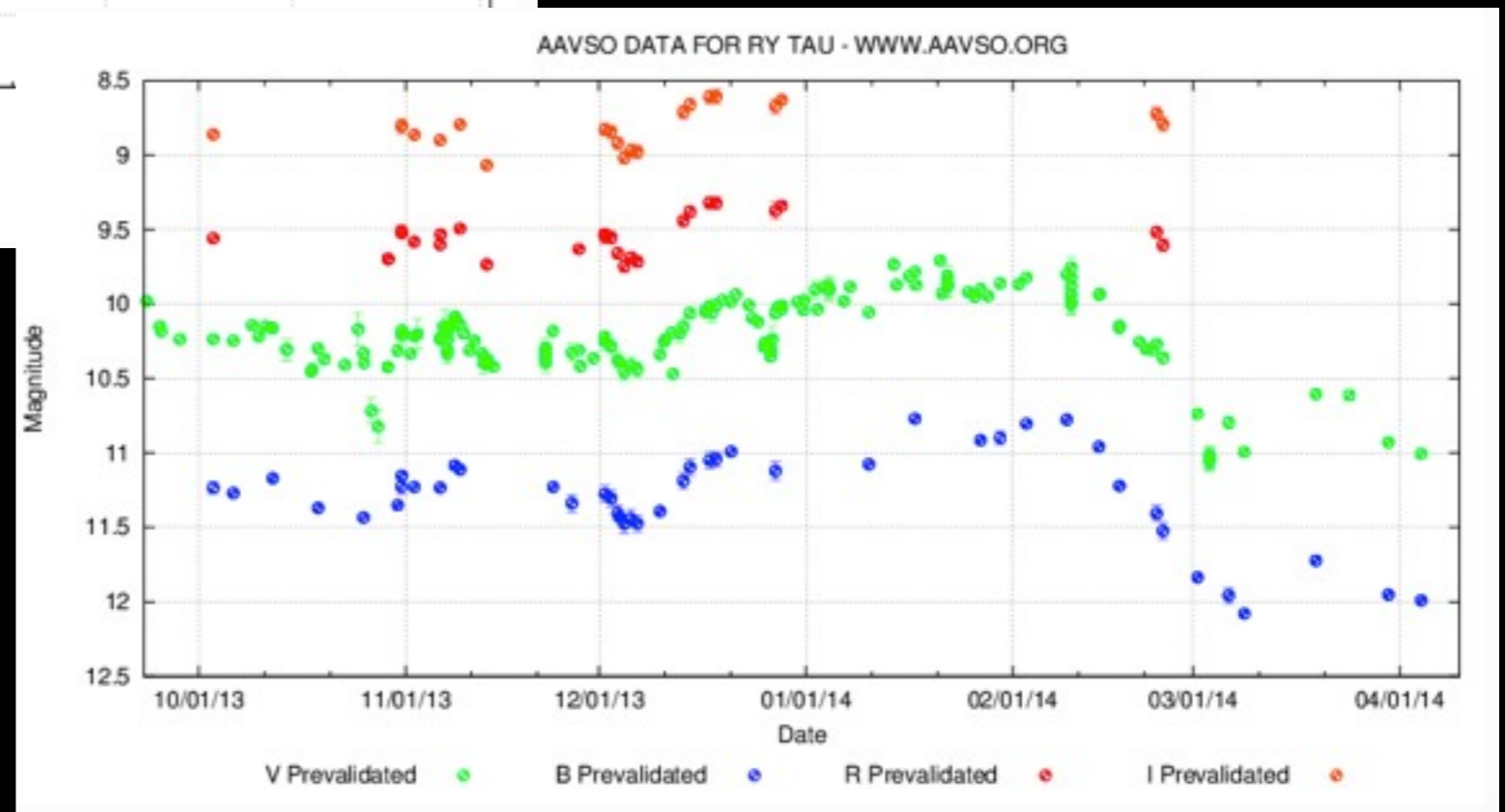
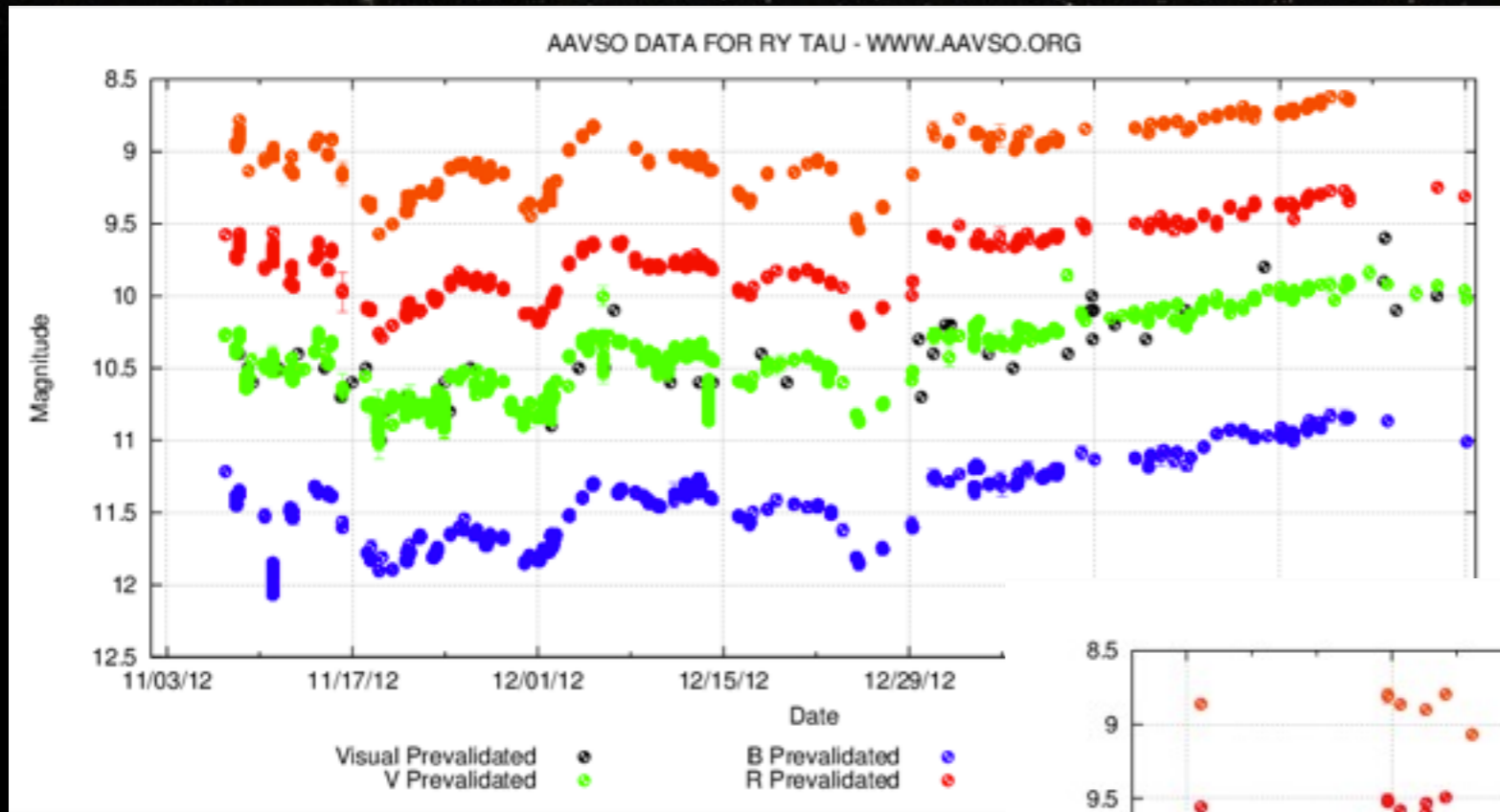
# Class I observations: a star forming core



# Class II: Classical T-Tauri stars

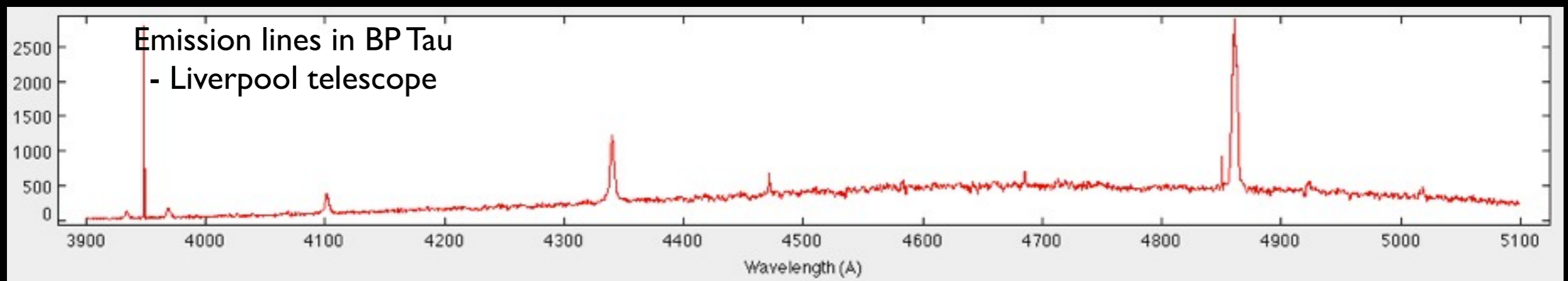
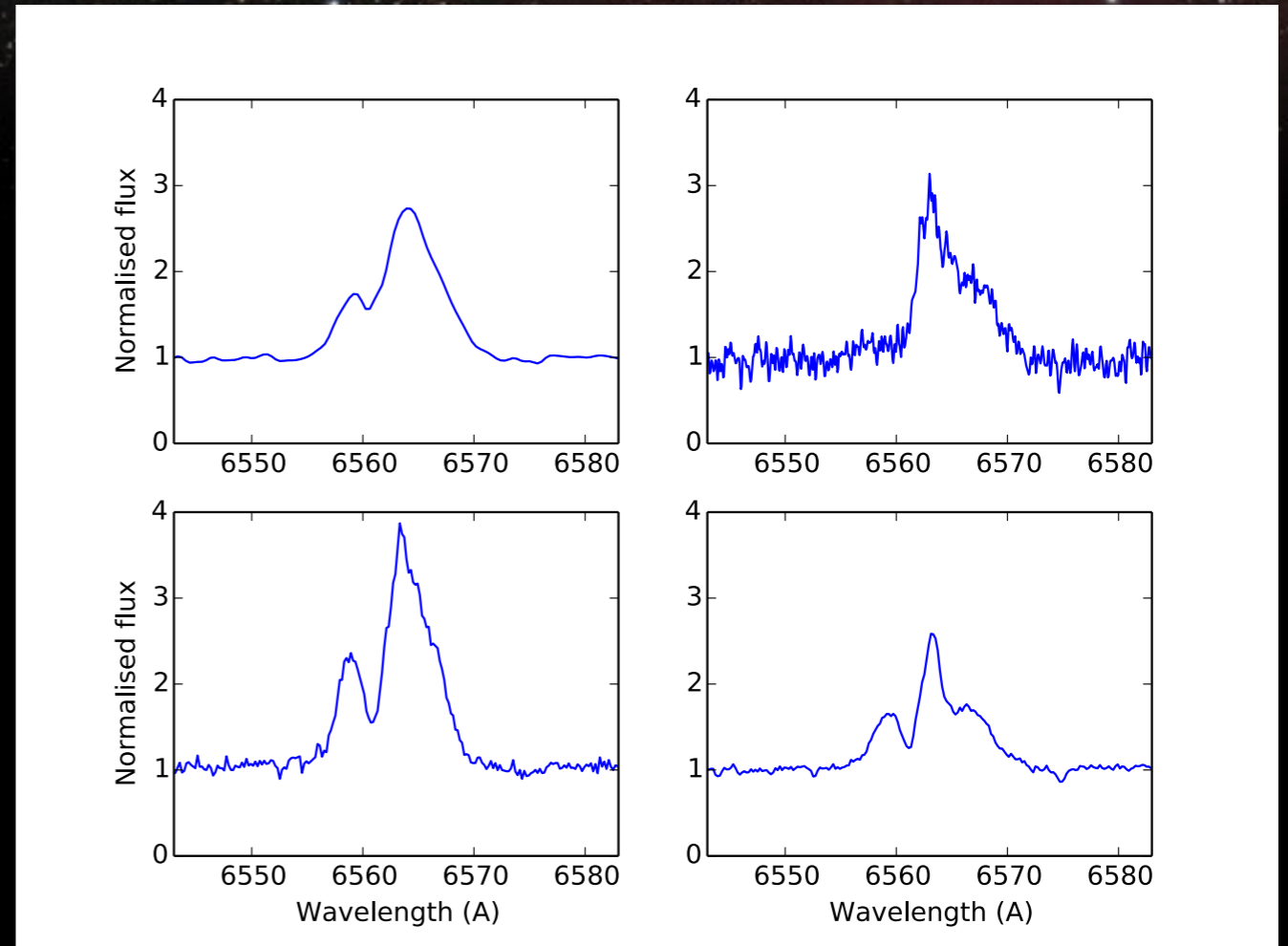
The image shows a young star, a Classical T-Tauri star, surrounded by a large, dark, dusty protoplanetary disk. The star is located at the center of the disk, emitting a bright blue-white light. Two prominent, narrow jets of gas and dust, known as bipolar outflows, extend from the poles of the star, one pointing towards the top and one towards the bottom of the frame. The outflows are illuminated by the star's light, showing a mix of blue and red colors. The background is a dark field of stars, with a few brighter stars visible.

# Optical Variability

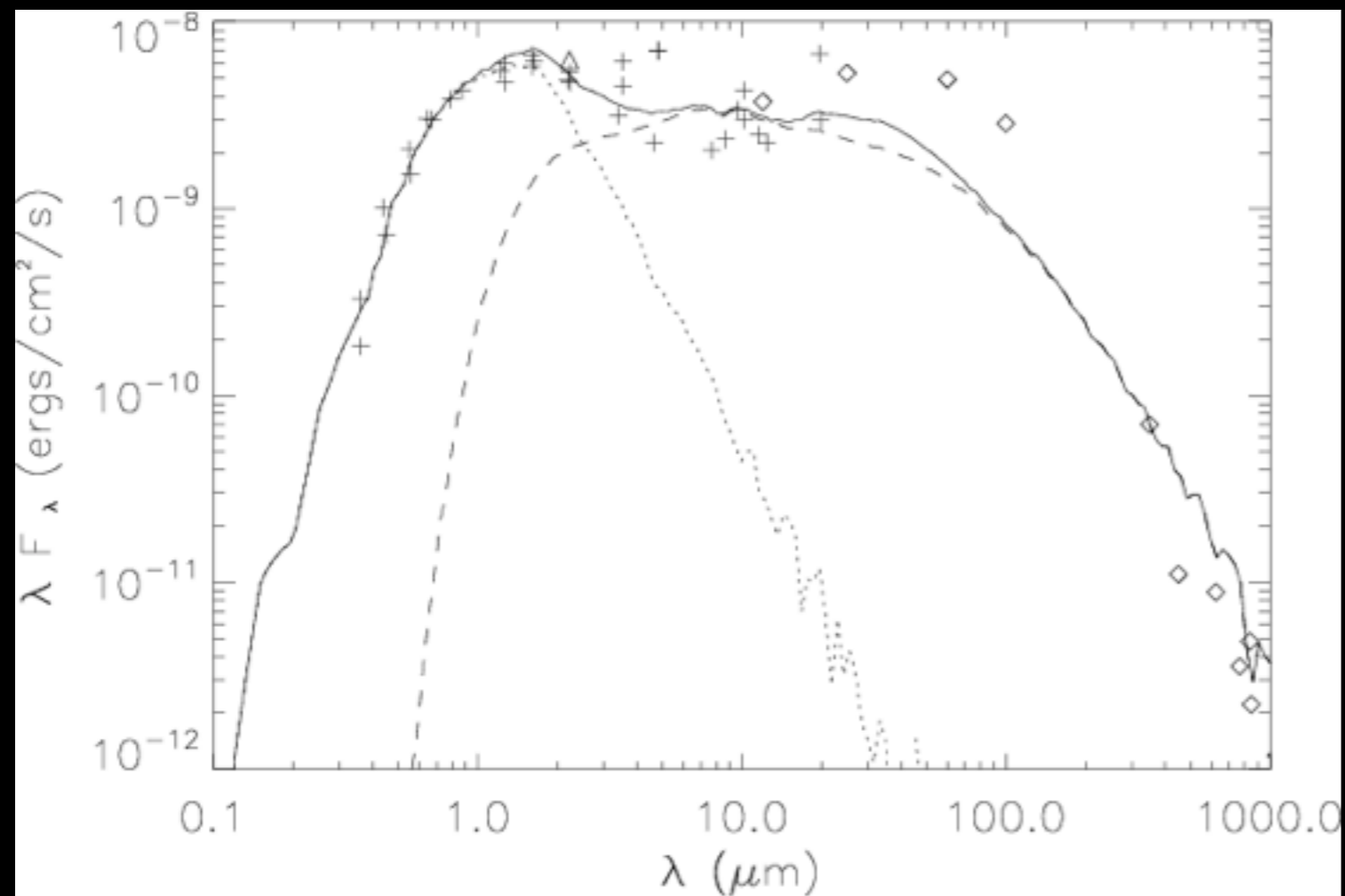


# Strong and variable emission lines

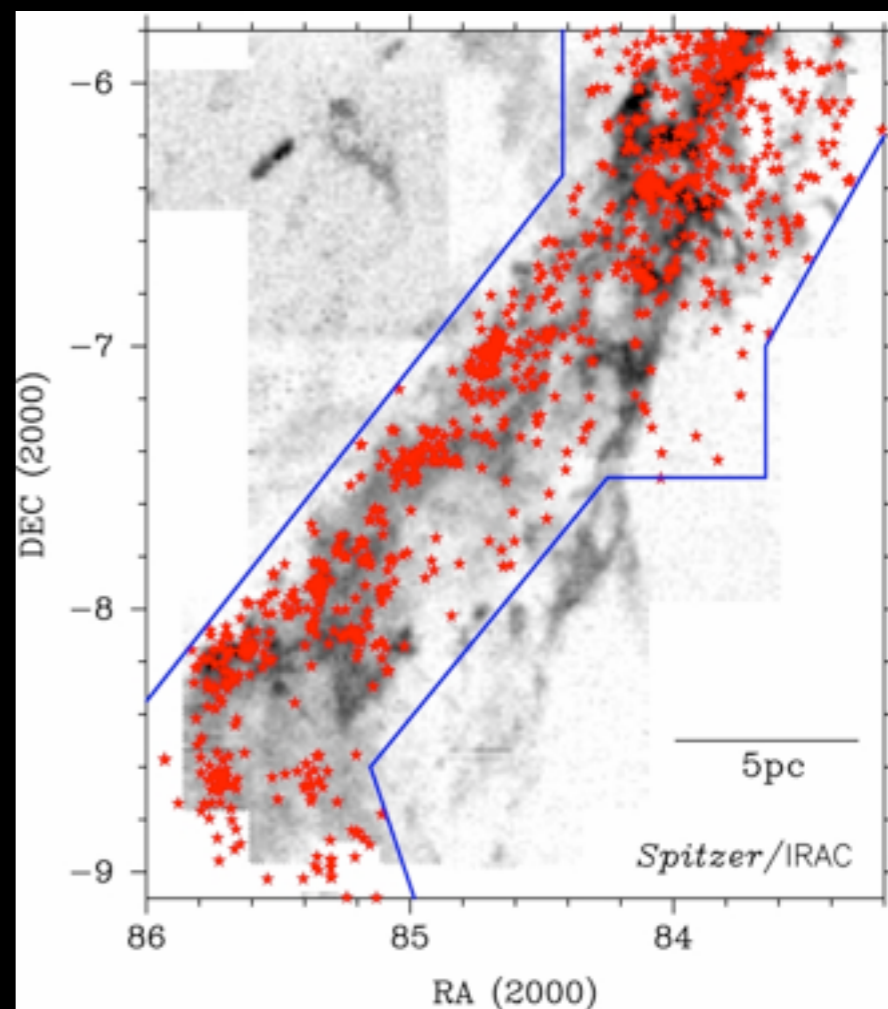
Amateur H $\alpha$  spectra of RY  
Tau by C.Buil and  
S.Charbonnel



# Mid-IR excess

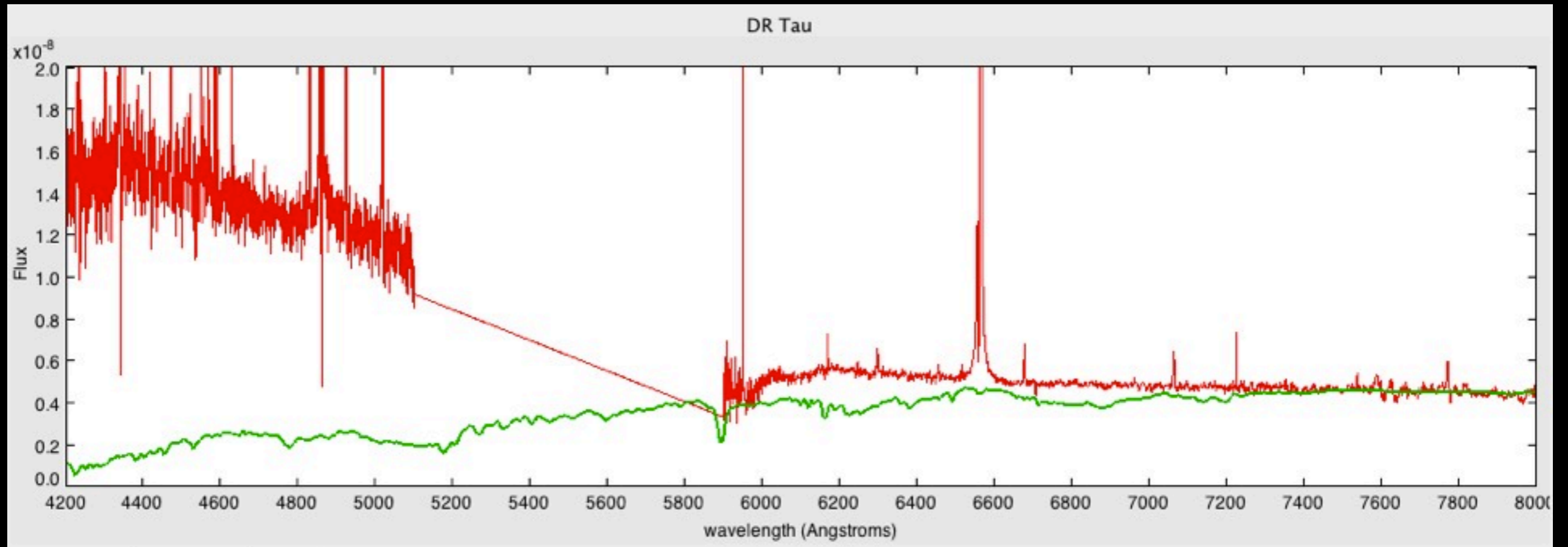


Gustafsson et al. 2008



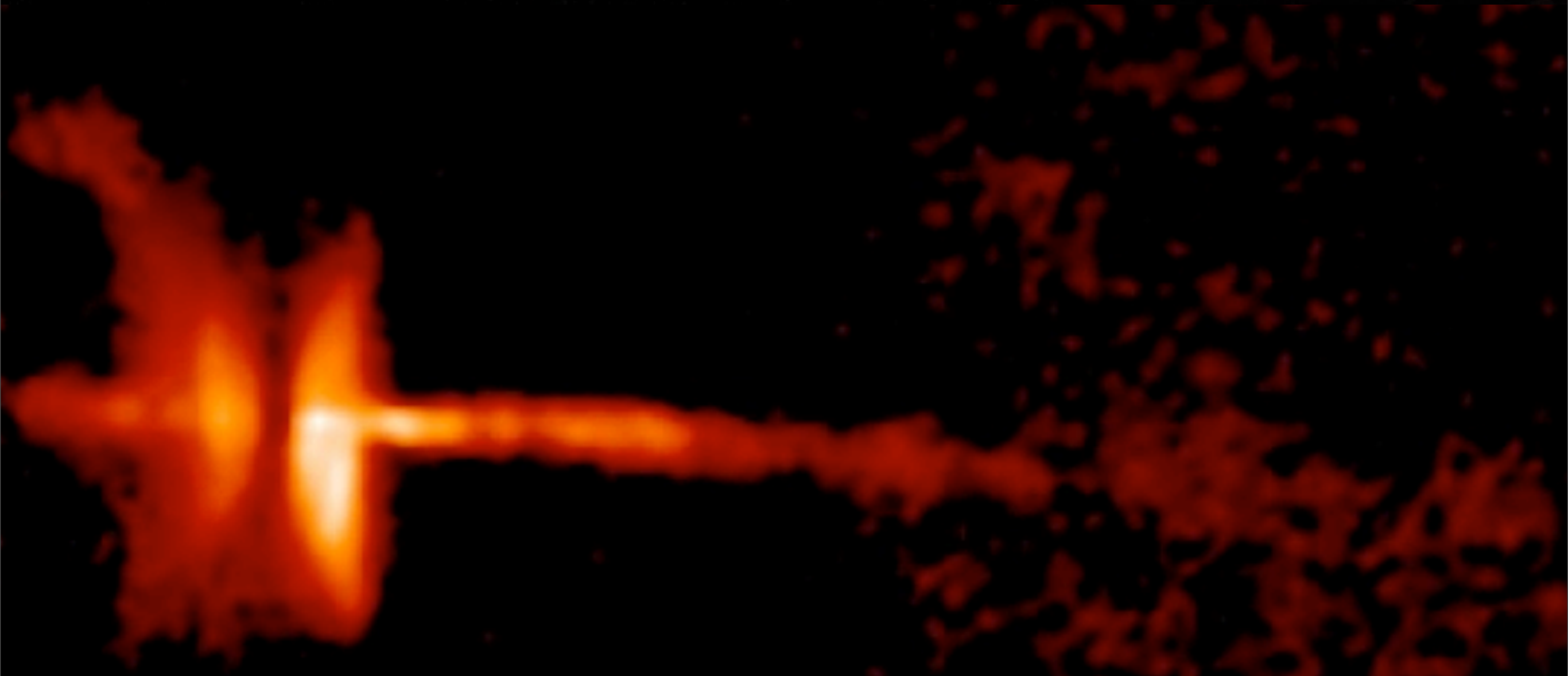
Megeath et al. 2012

# Ultraviolet excess



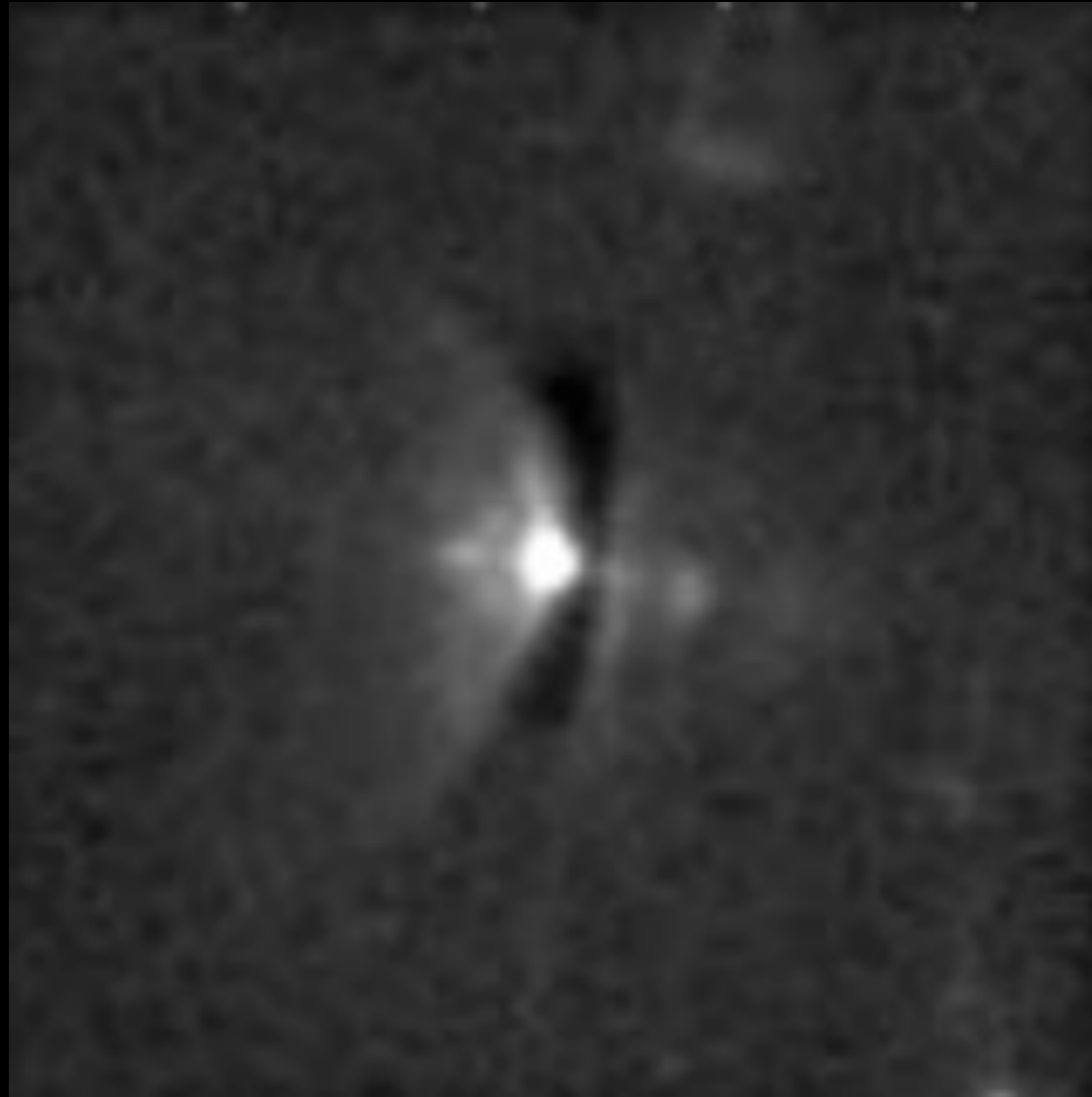


# Dynamic jets

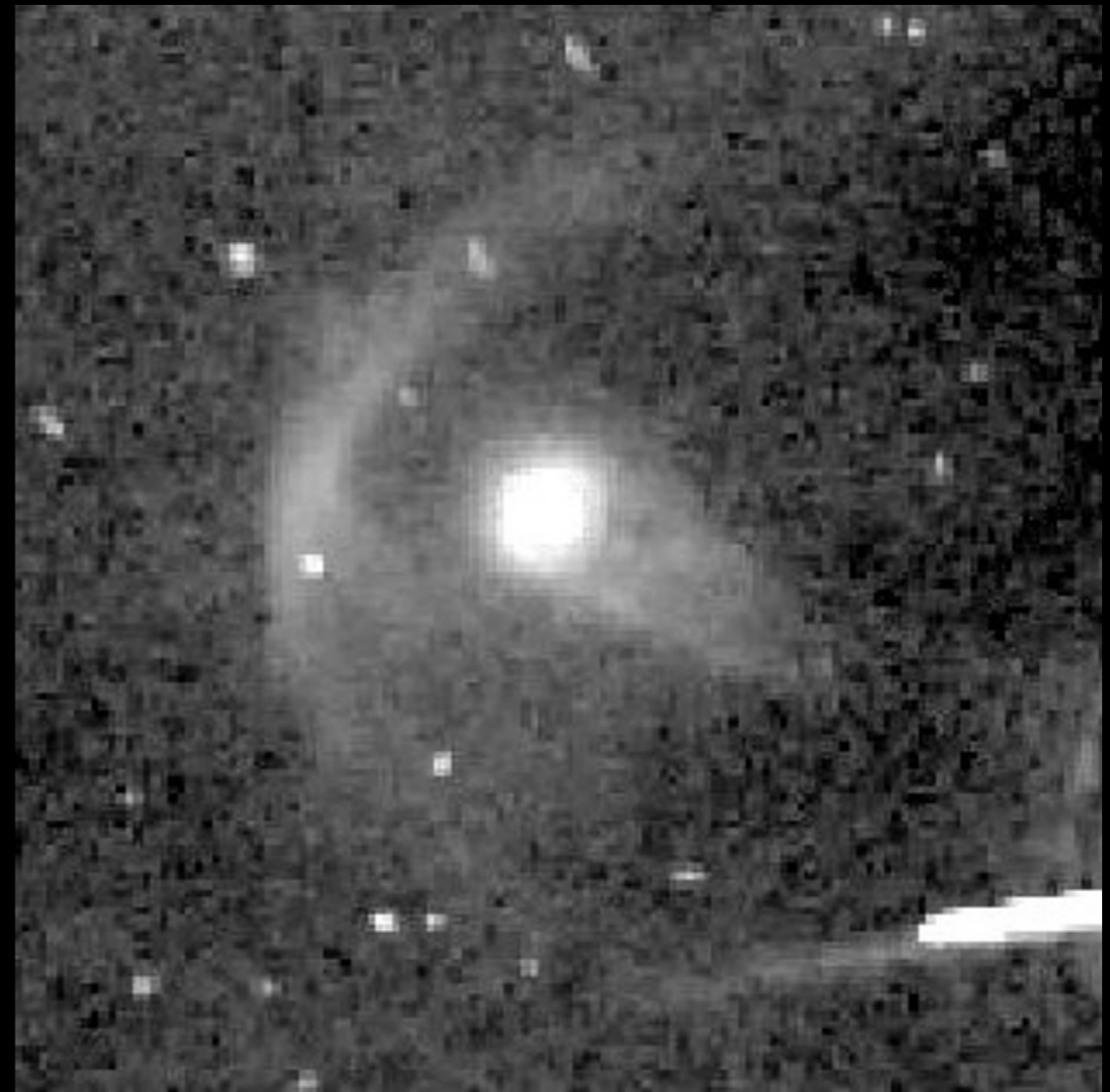


**The Dynamic HH 30 Disk and Jet**  
Hubble Space Telescope • WFPC2

# ONC proplyds



Smith et al. (2005)

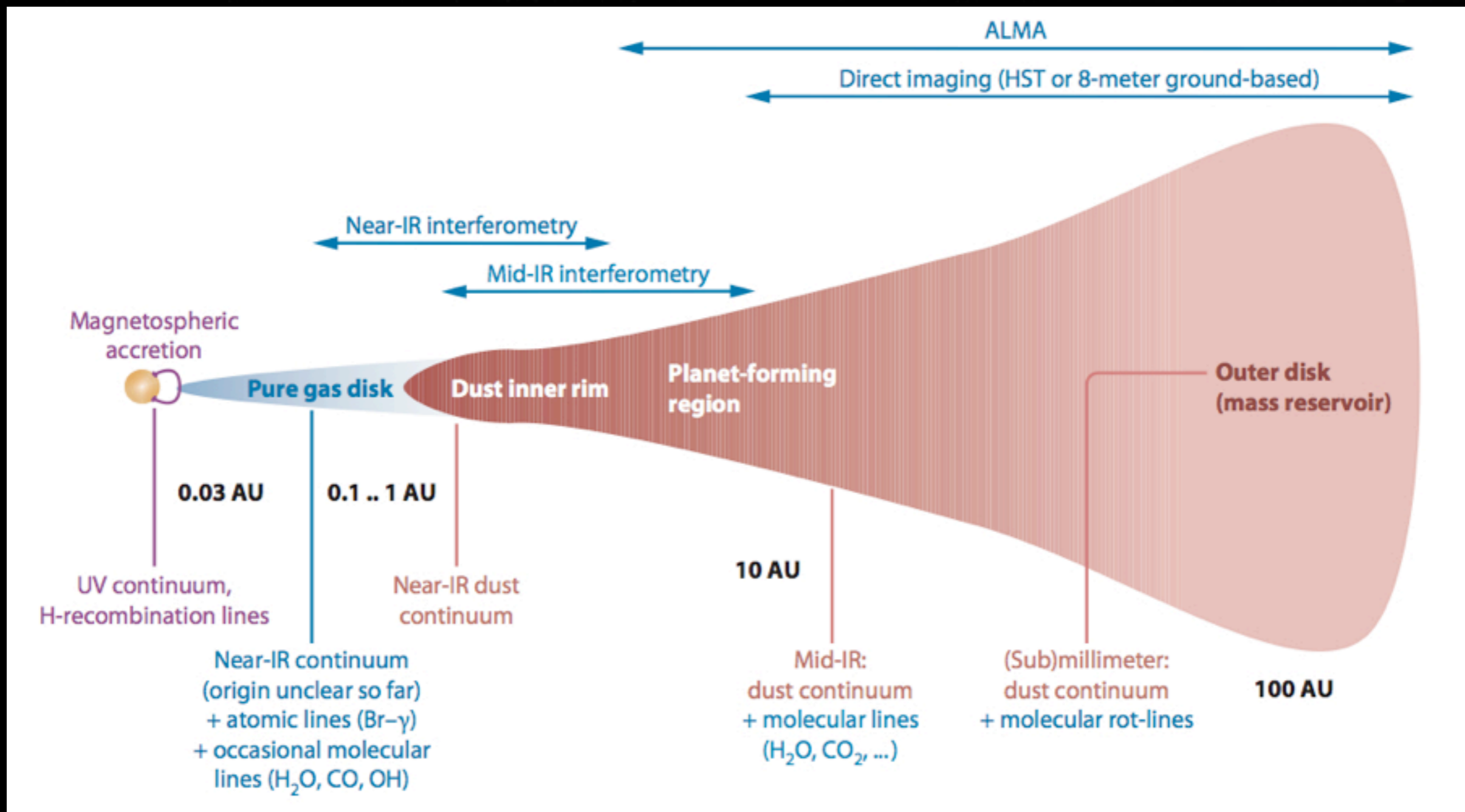


Ricci et al. (2008)



How do we explain these  
unusual observed properties?

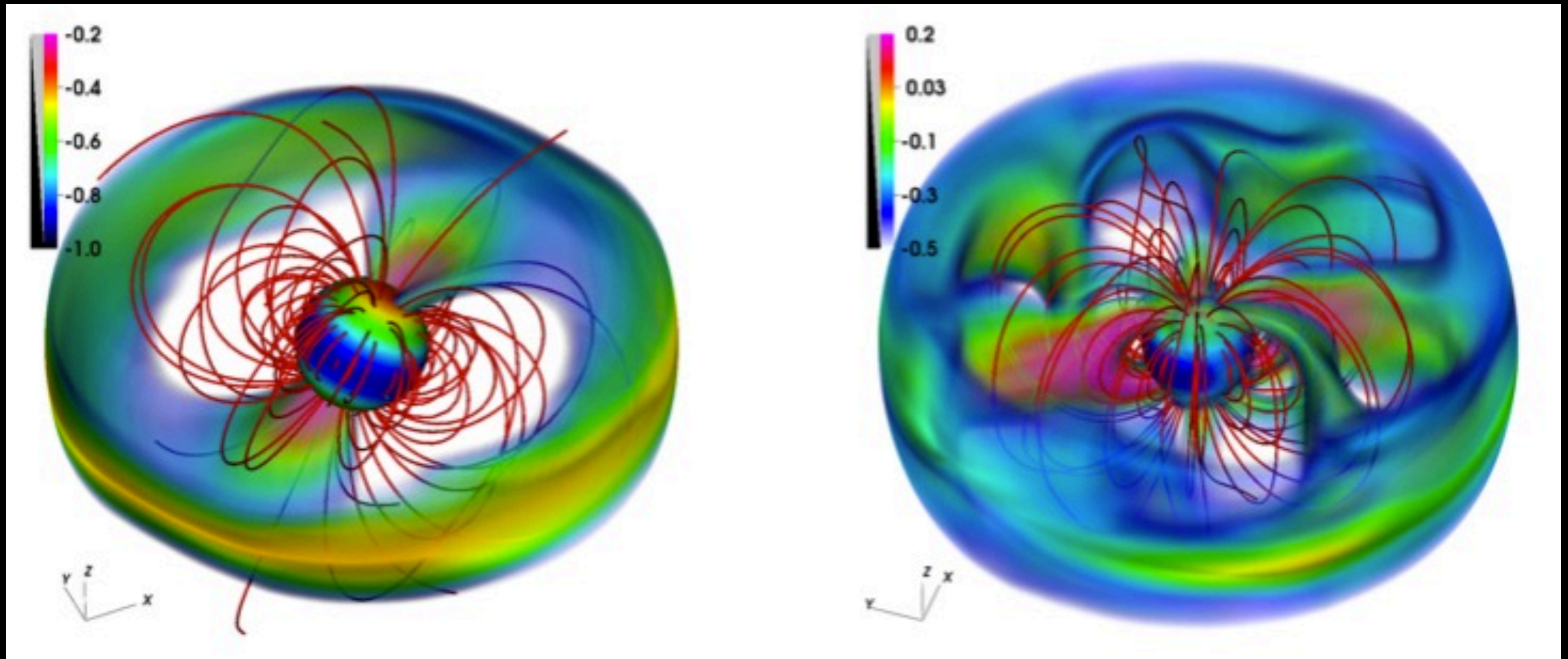
# Anatomy of a Classical T-Tau Star ( $< 2 M_{\odot}$ )



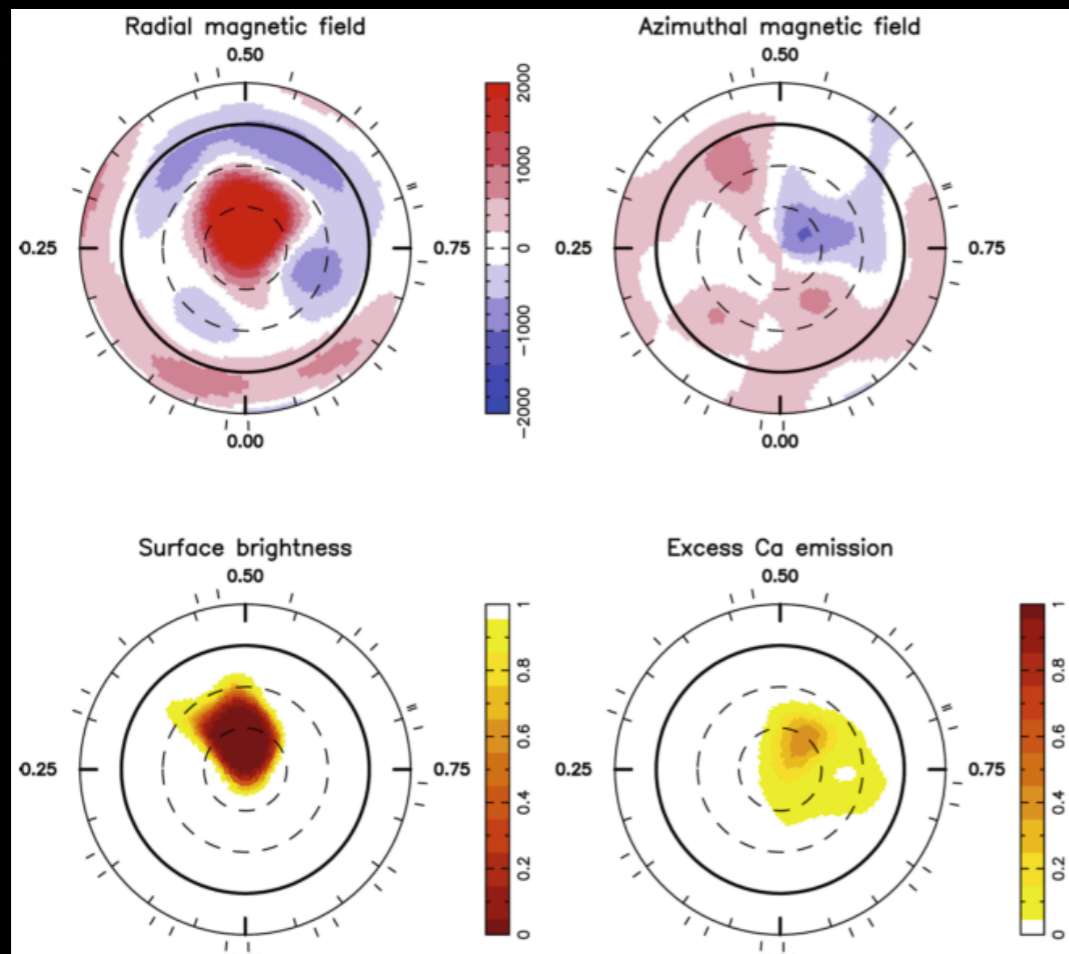
# Anatomy of a Classical T-Tau Star ( $< 2 M_{\odot}$ )



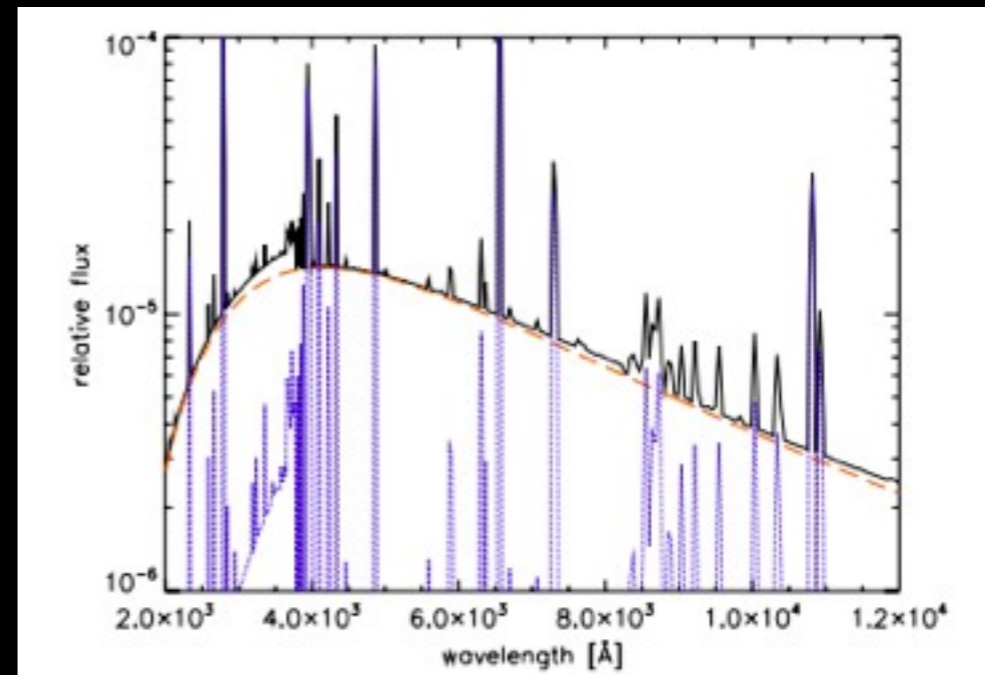
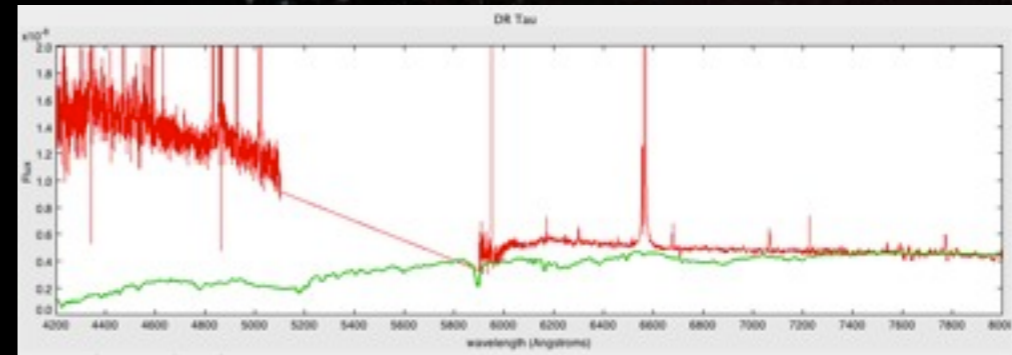
# Sources of variability: Accretion flows



# Accretion hotspots:



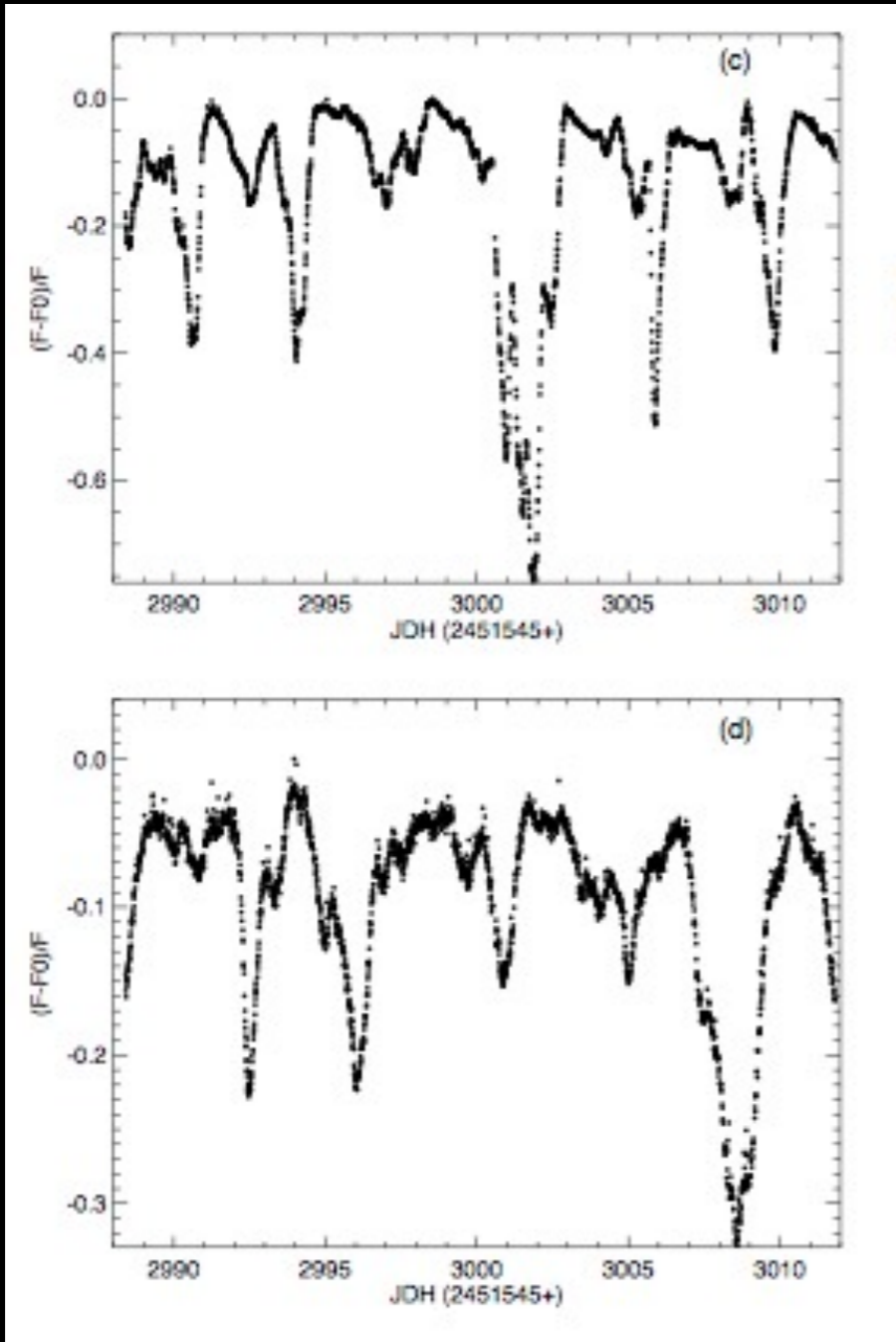
Donati et al. 2011



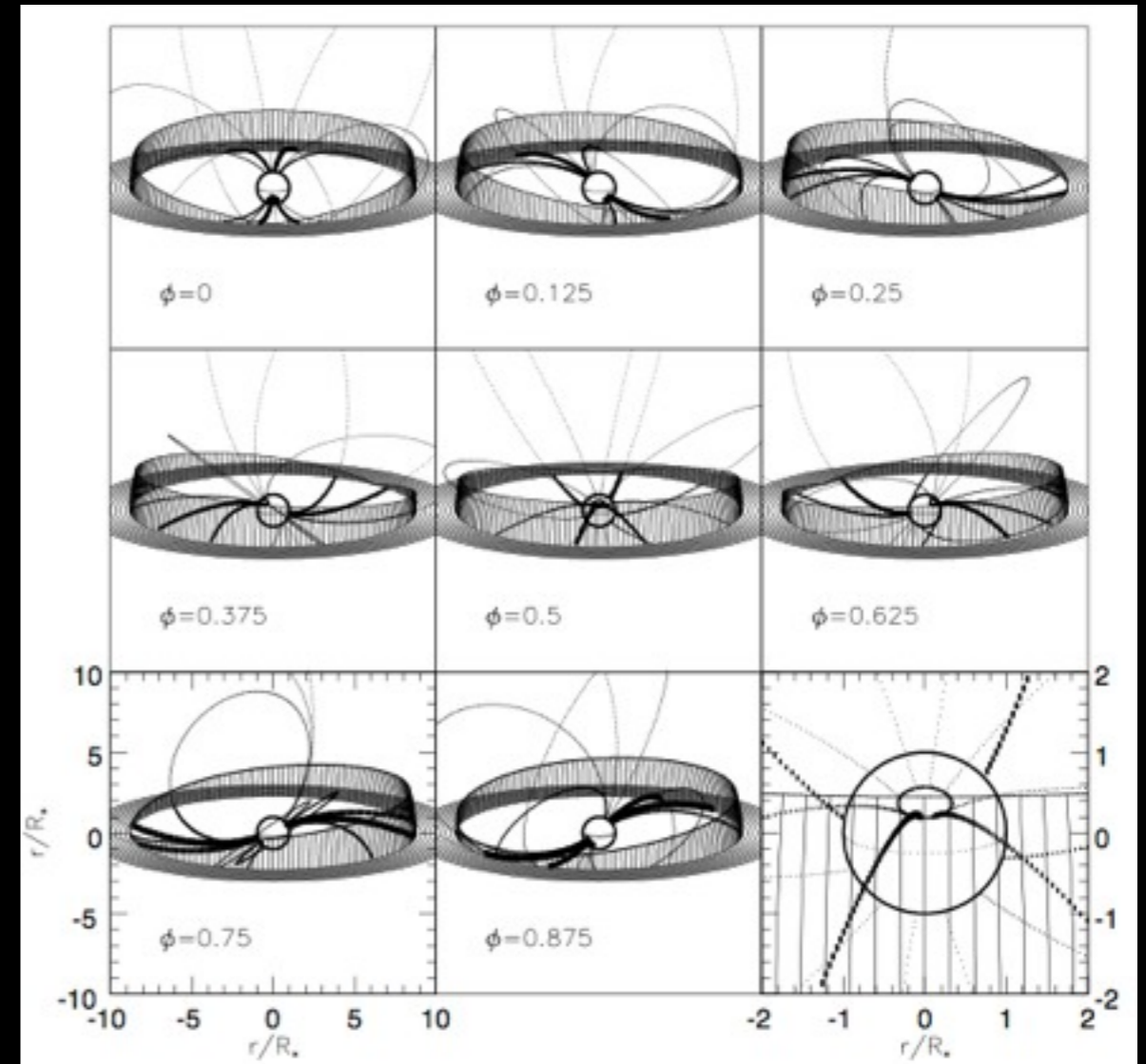
Da Rio et al. 2009

~8,000K black body plus  
optically thin Balmer  
continuum

# Variability from obscuration by circumstellar material



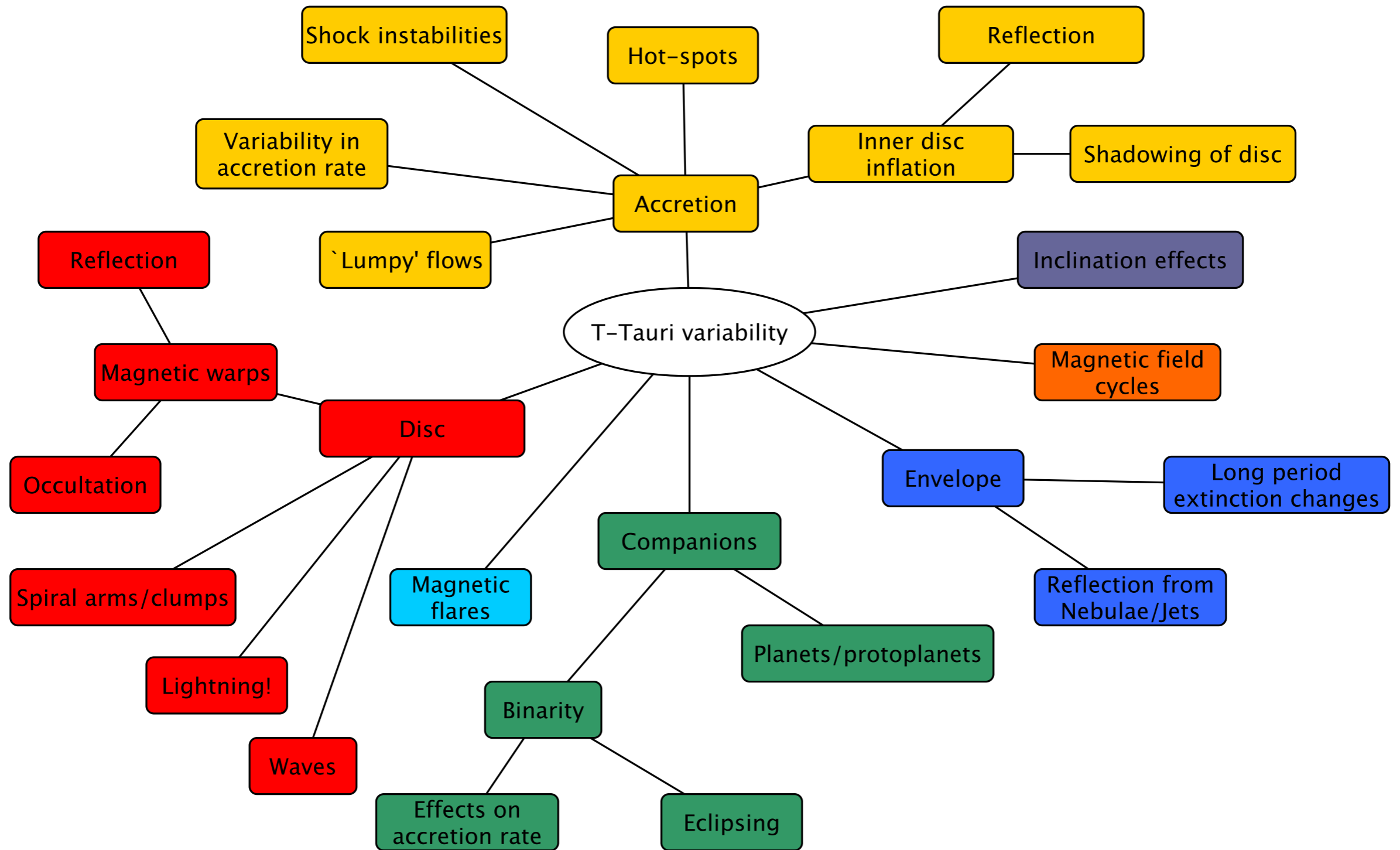
Alencar et al. 2010



Bouvier et al. 1999



# Many mechanisms at play...



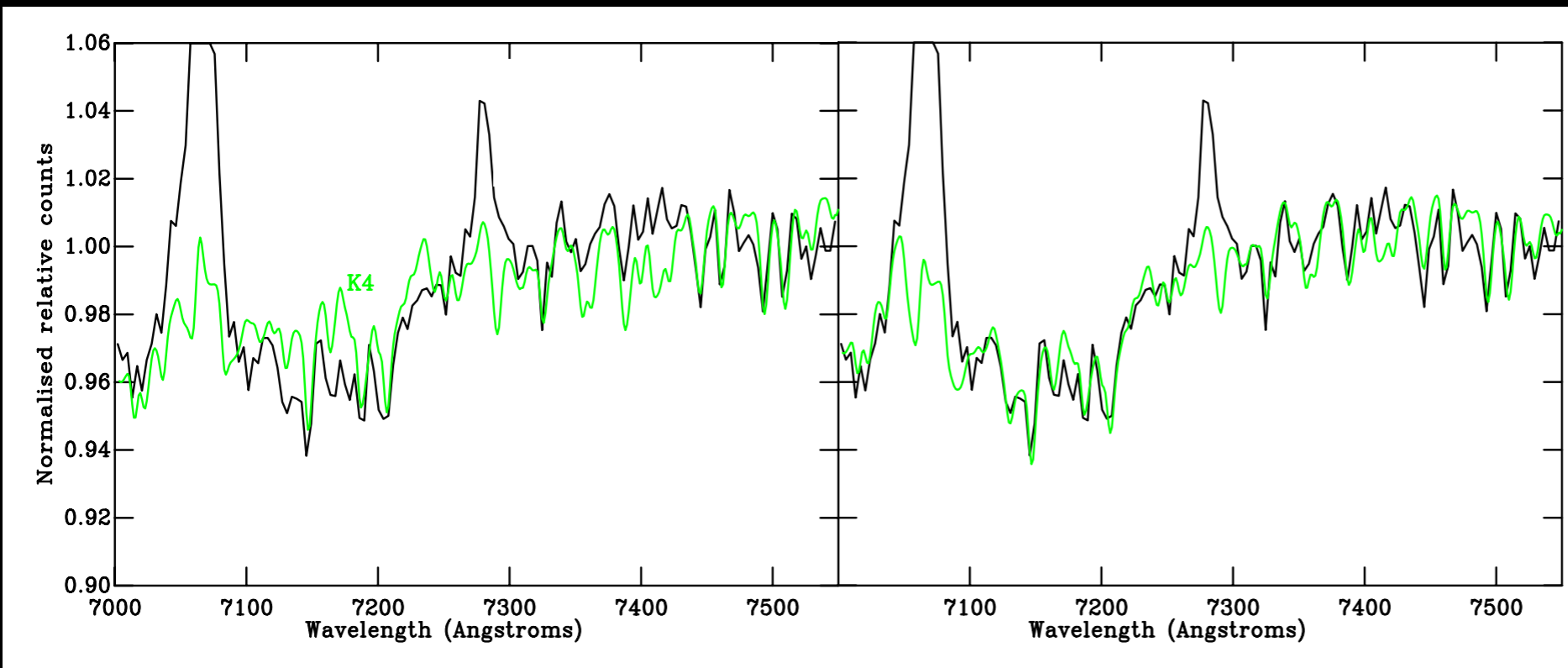
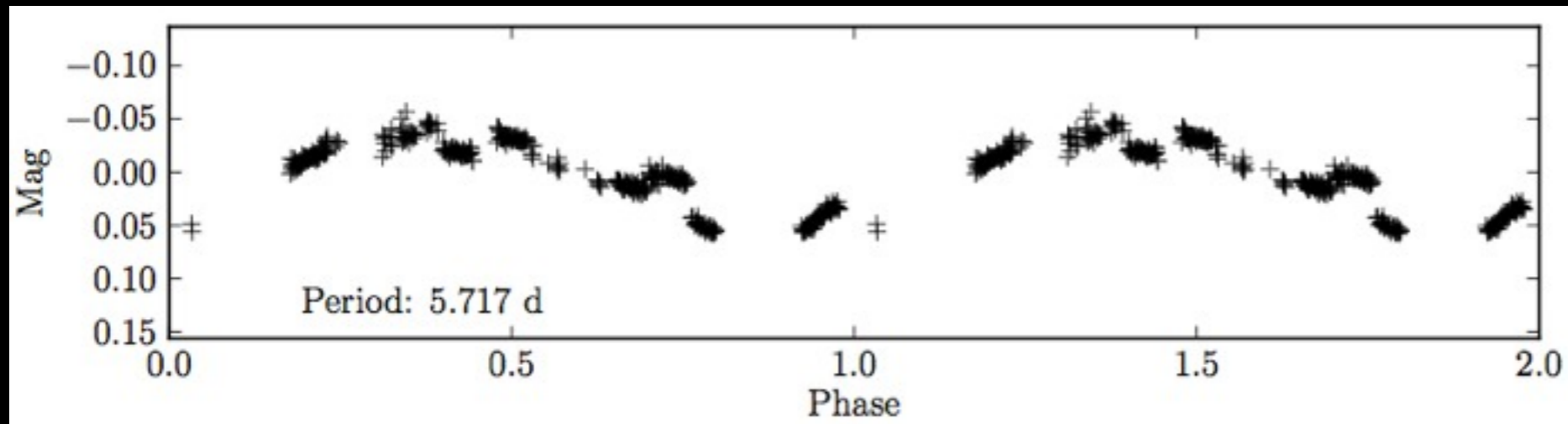
# Class III: Weak T-Tauri stars



Image: Roth Ritter

Darryl Sergison - The first 10 Myr - BAA - April 2014

# T-Tauri spots



# Spots, debris and planets

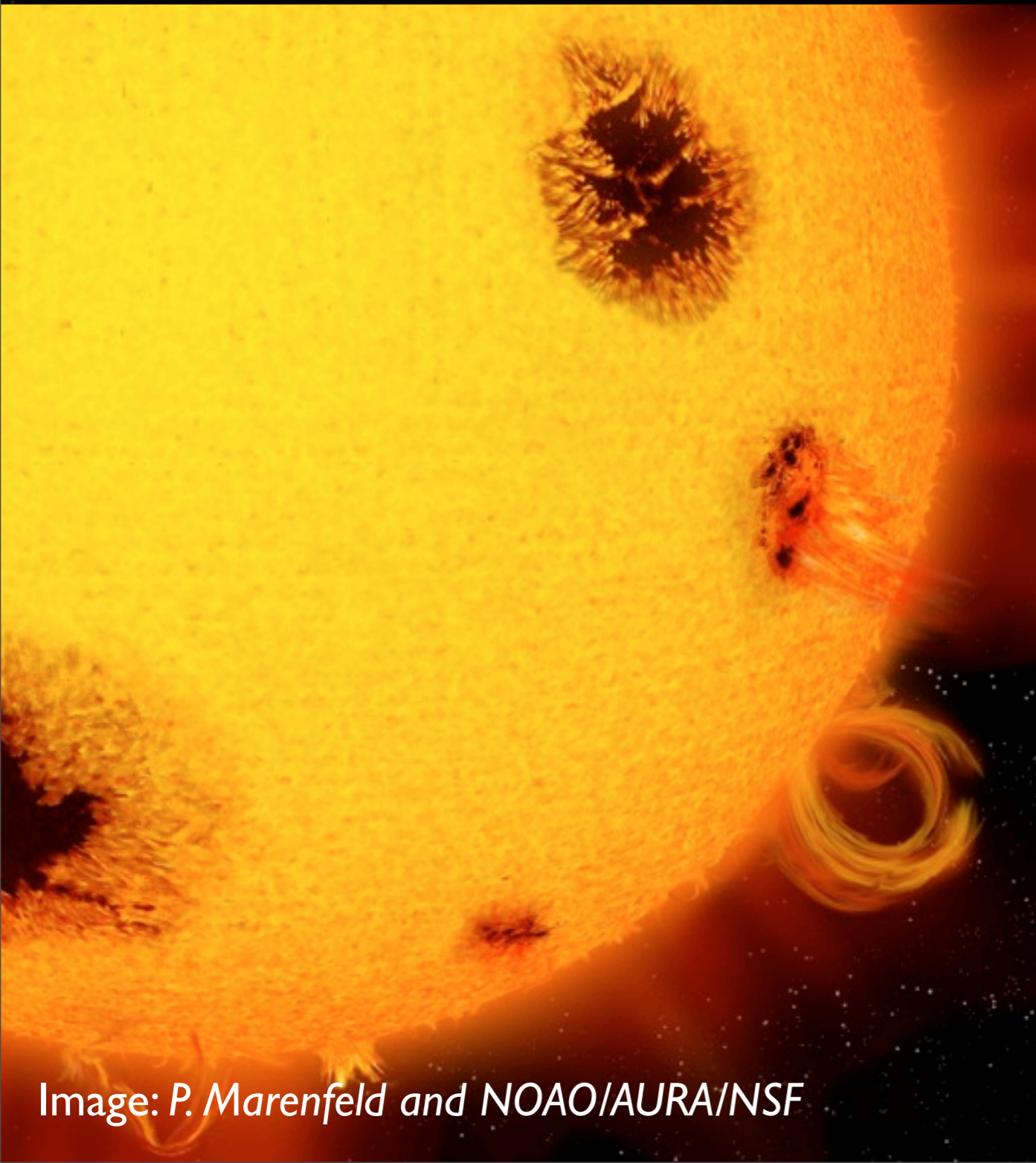
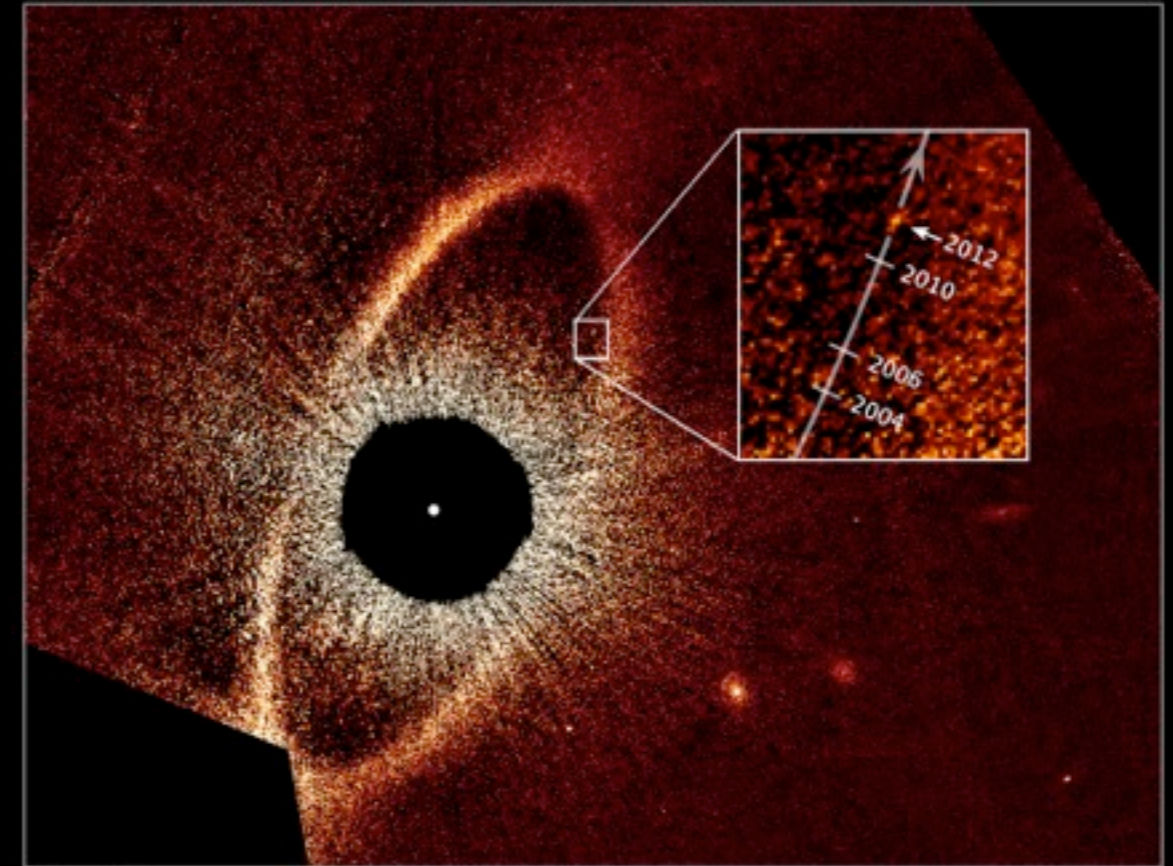


Image: P. Marenfeld and NOAO/AURA/NSF

Fomalhaut System

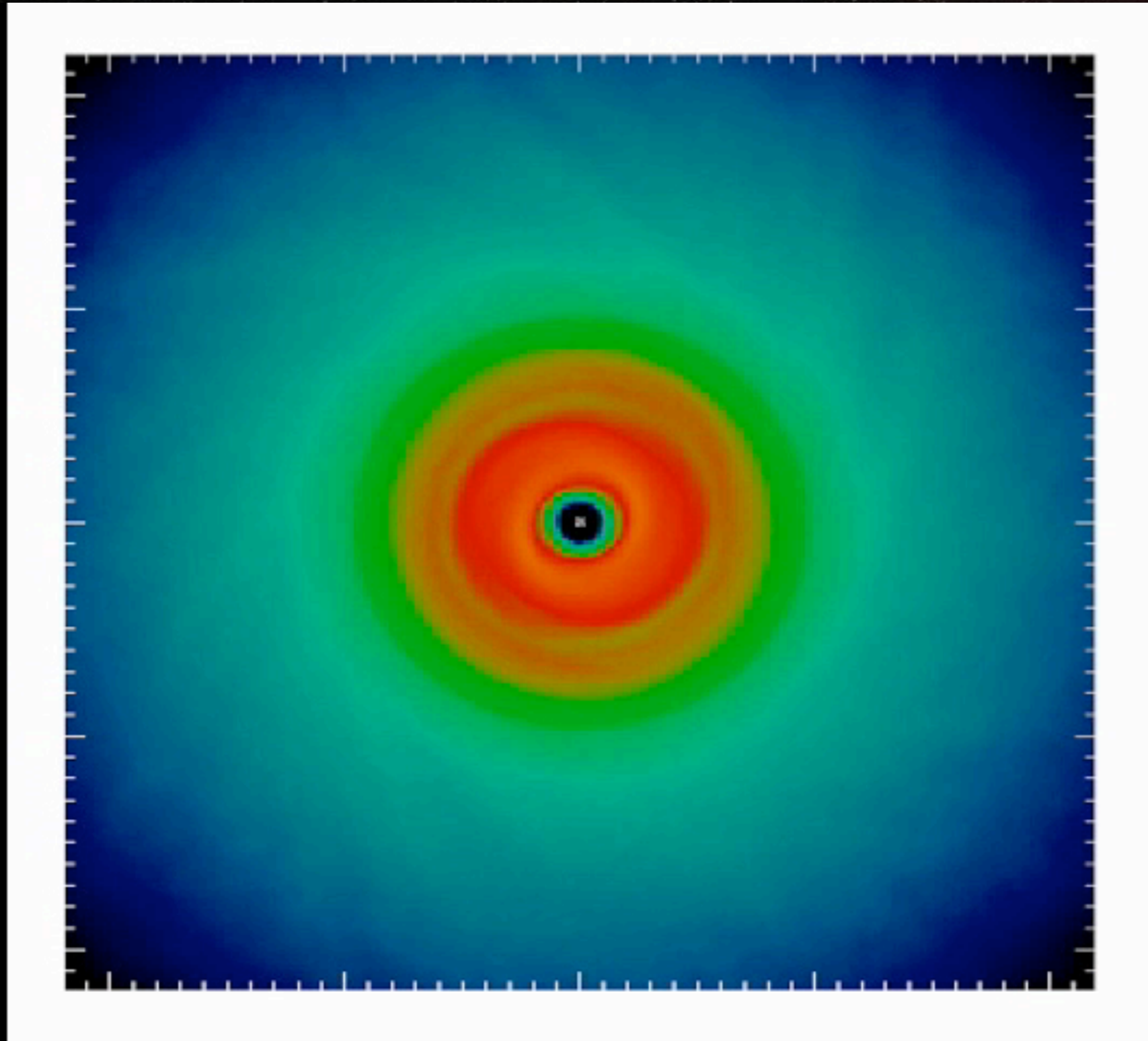
Hubble Space Telescope • STIS



NASA and ESA

STScI-PRC13-01a

# Dissipation of the disc



You might think we've got  
YSOs all figured out.  
But...



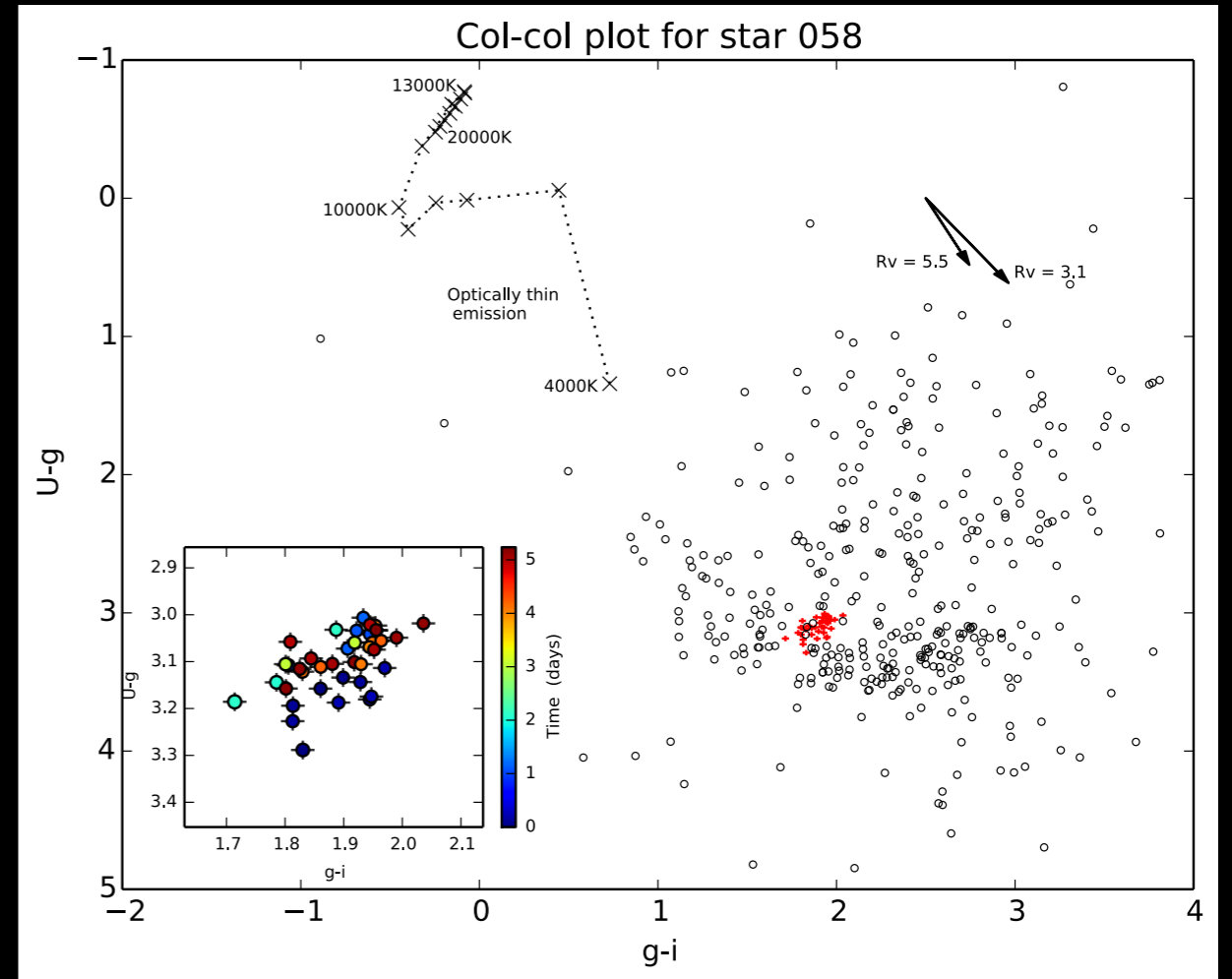
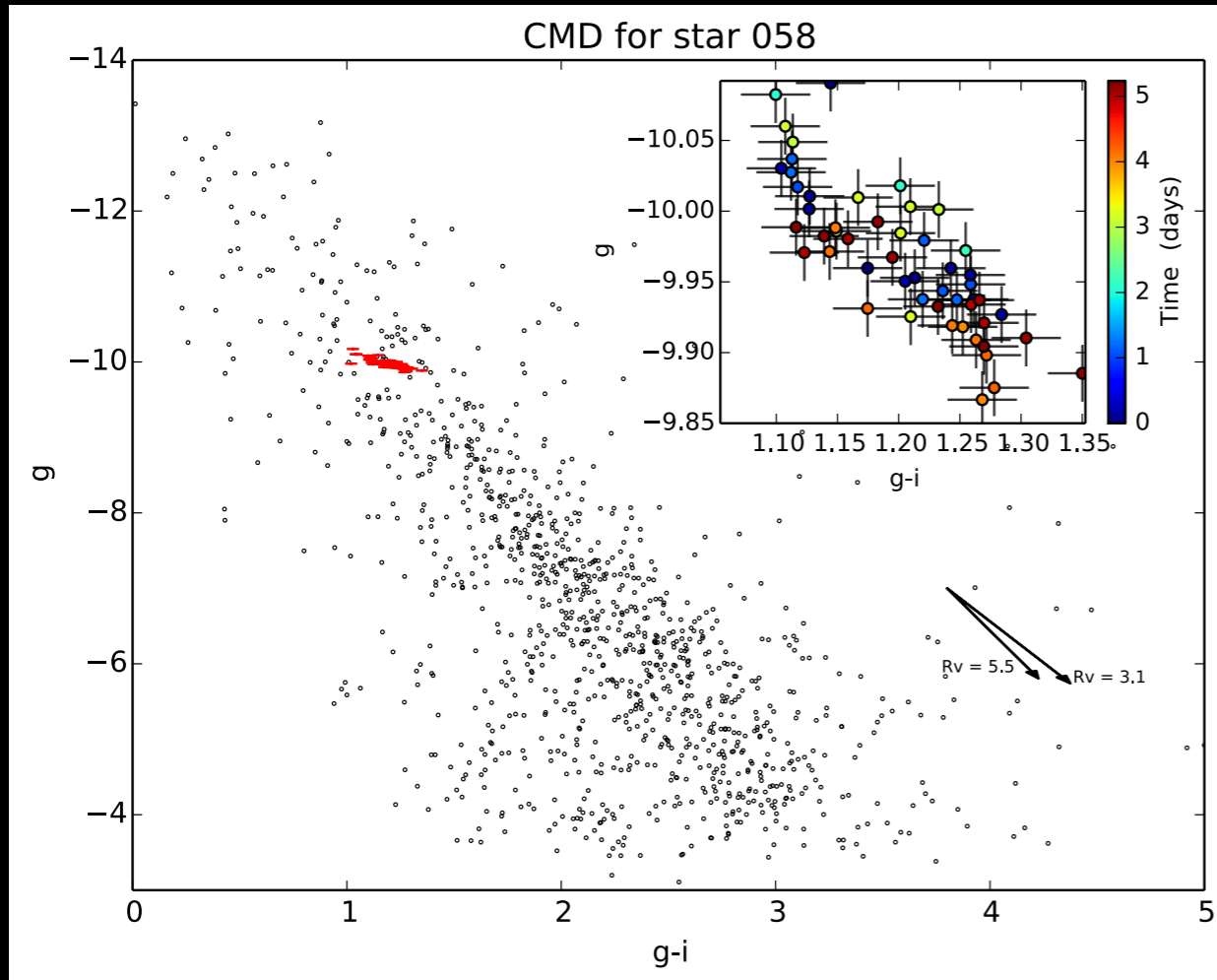
# Observing Orion



Image: K.L. Luhman, G. Schneider, E. Young, G.  
Rieke, A. Coiera, H. Chen, M. Rieke, R. Thompson.

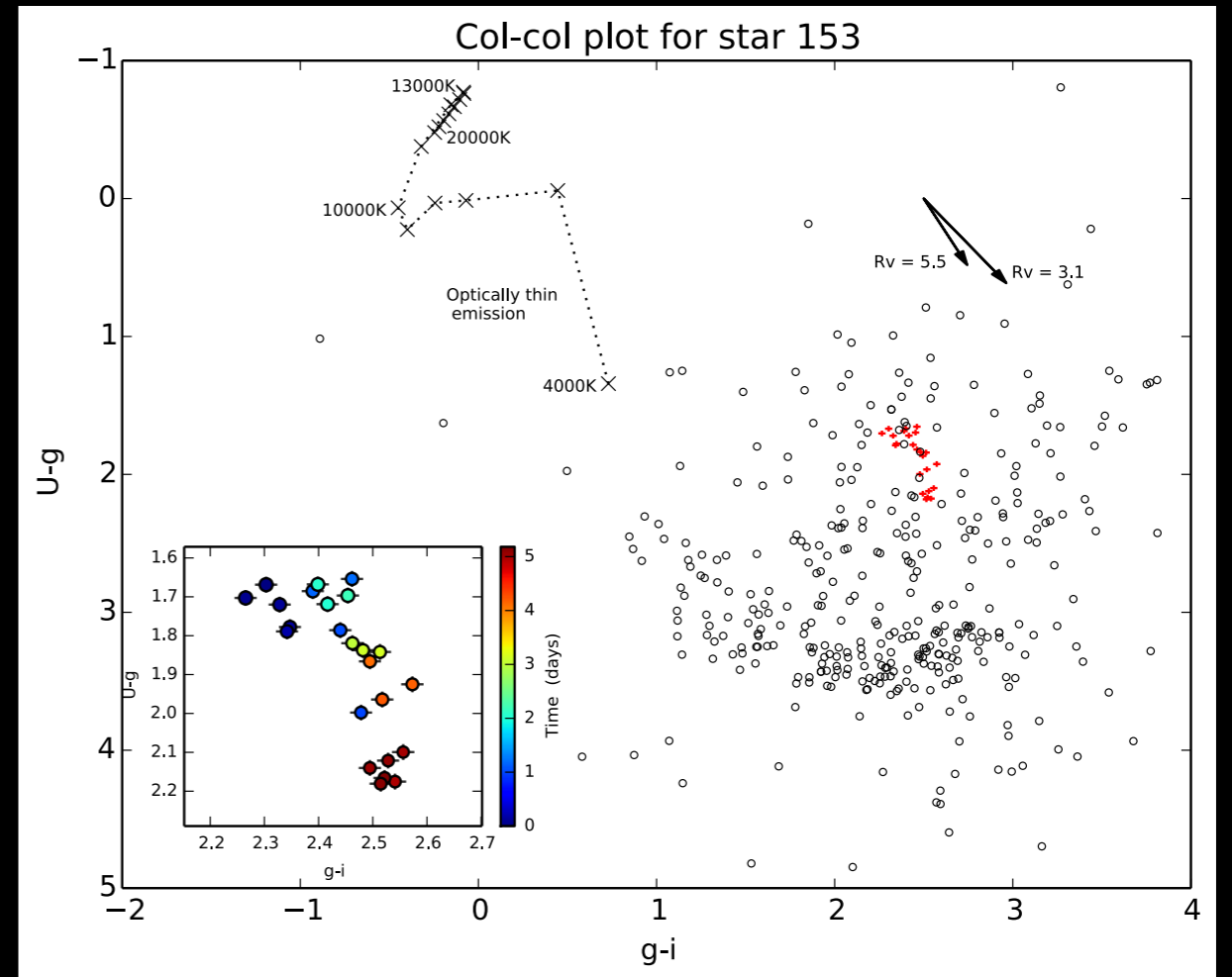
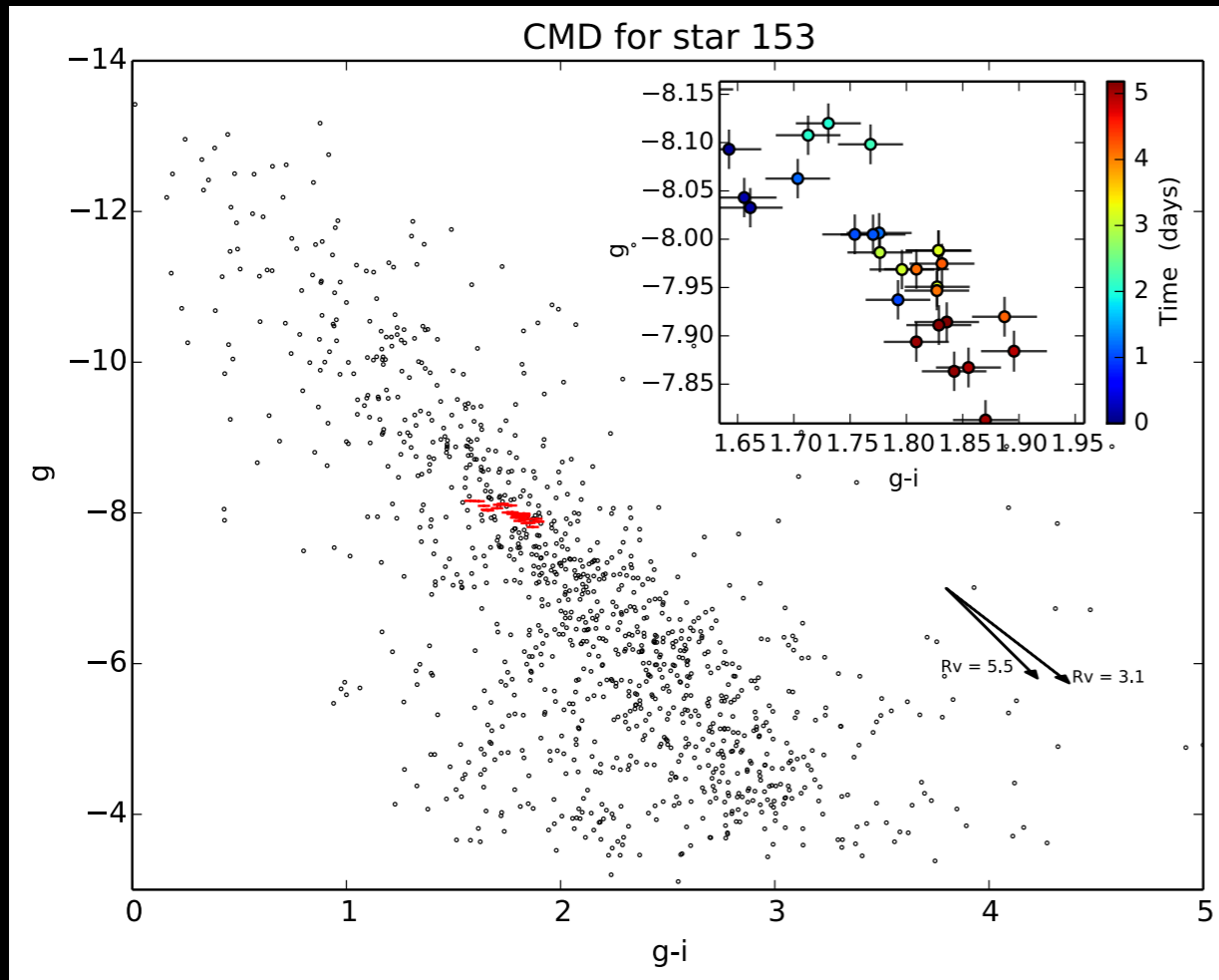
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# Variability: spots?

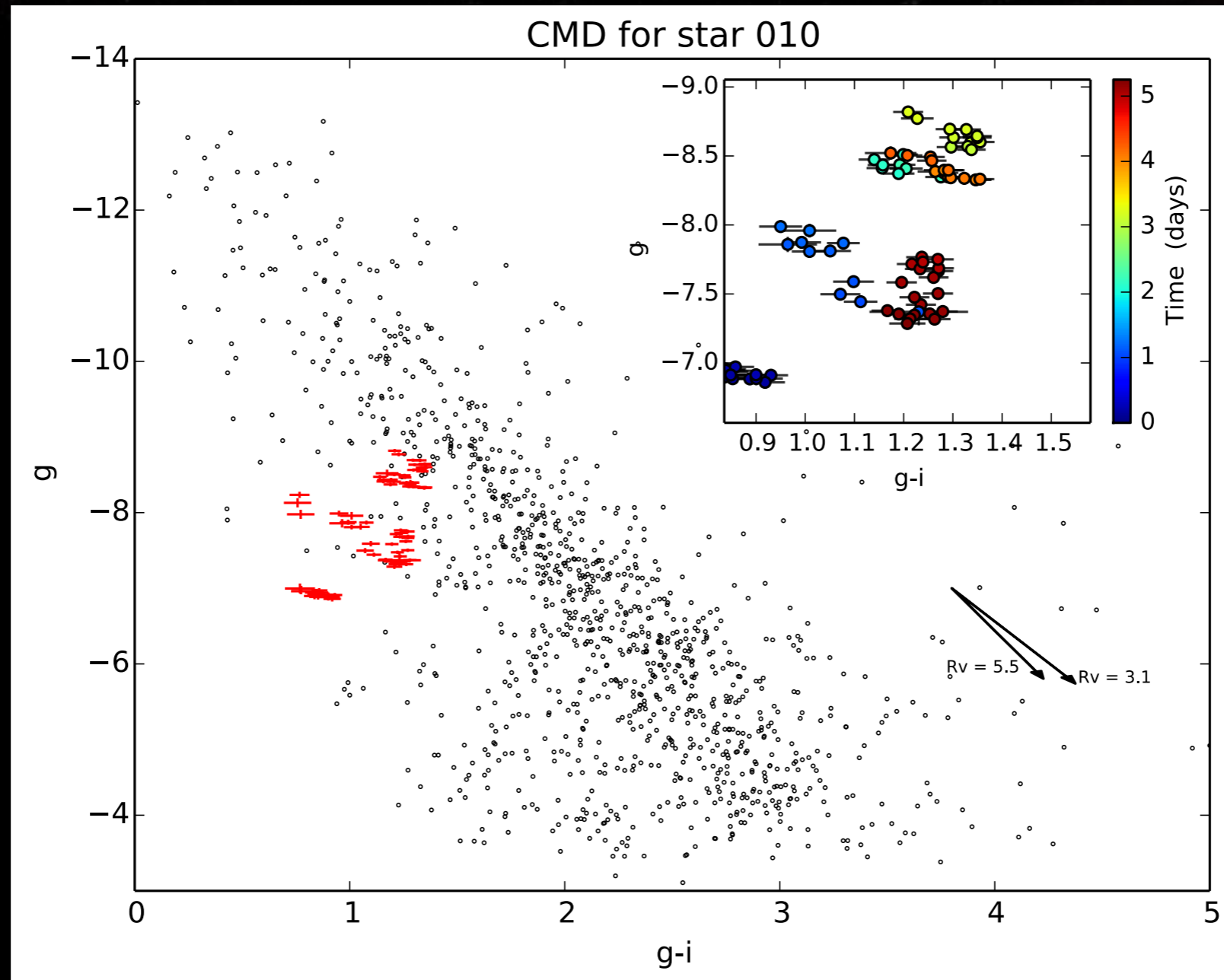




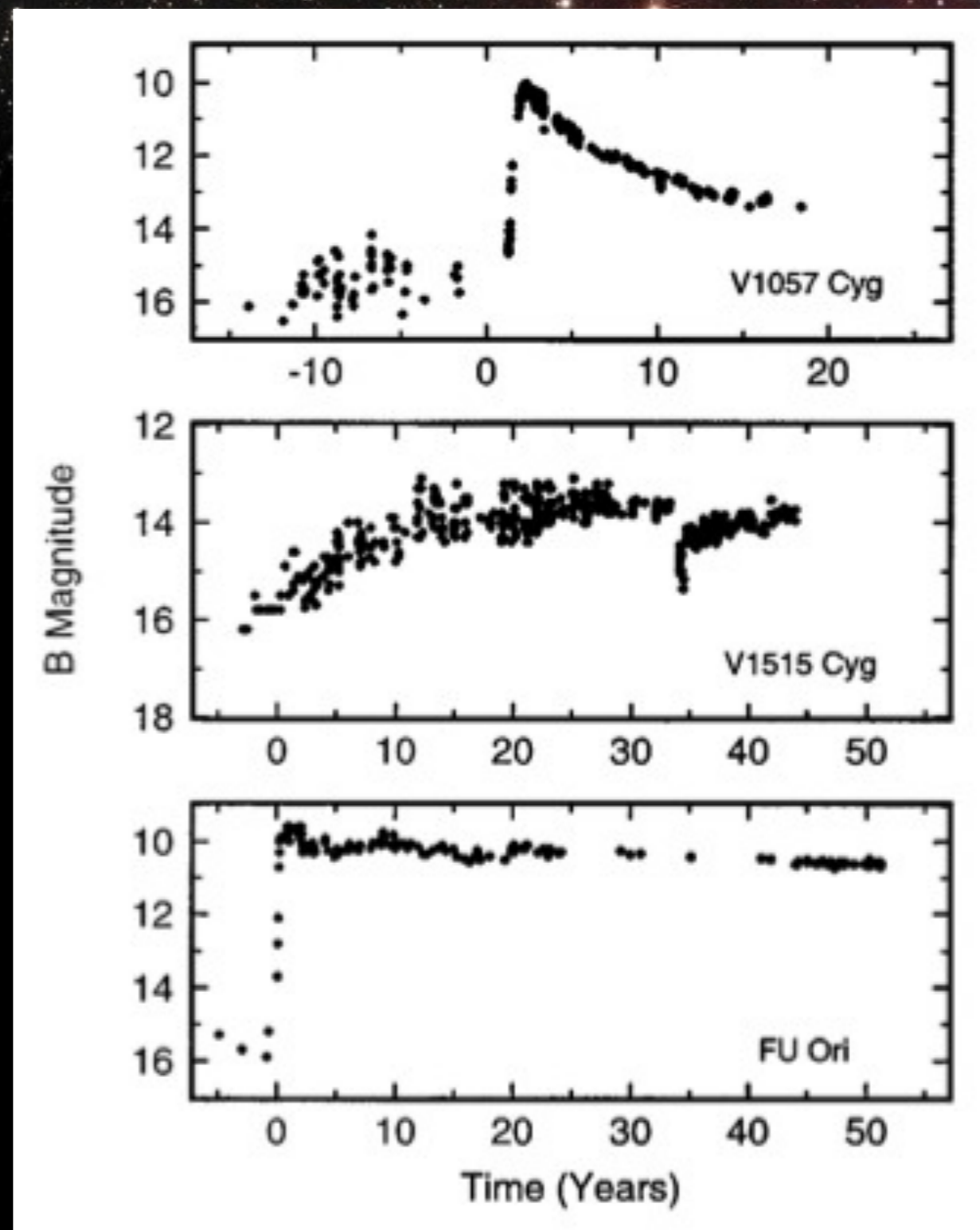
# Variability: accretion?



# Variability: answers on a postcard..



# FU Ori stars: YSOs in outburst



Hartmann and Kenyon. 1996

# Why observe YSOs as an amateur?

- ★ T-Tauri stars are variable on timescales from minutes to thousands(probably!) of years
- ★ They are bright, rich and variable in broadband photometry and spectral features from UV to mid-IR
- ★ There is always something interesting happening to observe!

# If you want to do science

- ★ Long term photometric monitoring (in as many different bands as possible) contributed to AAVSO archives are really VERY useful.
- ★ Individuals/small groups monitoring spectral behaviour of stars is useful to catch 'unusual events'.

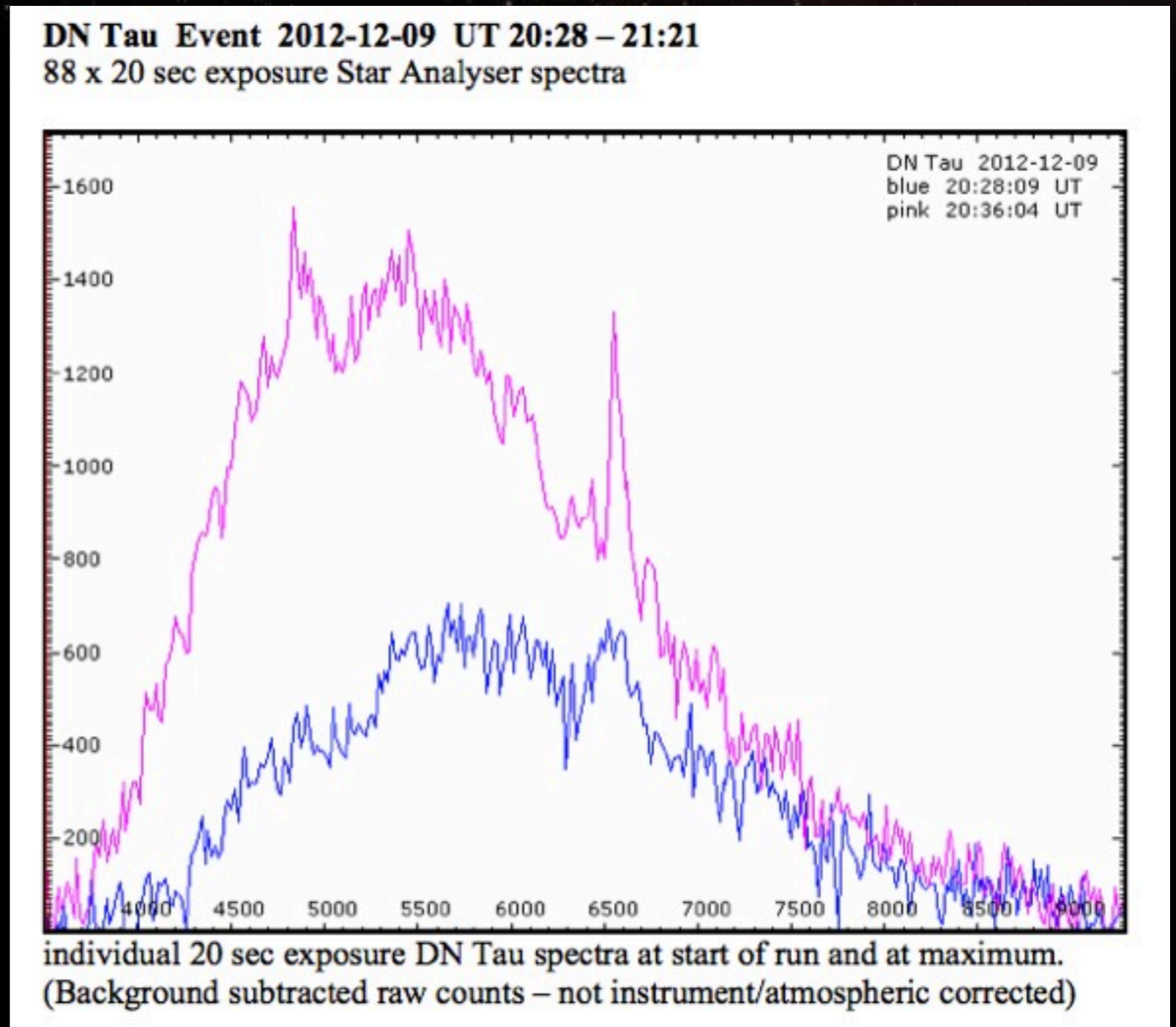
# One example..

Robin Leadbeater

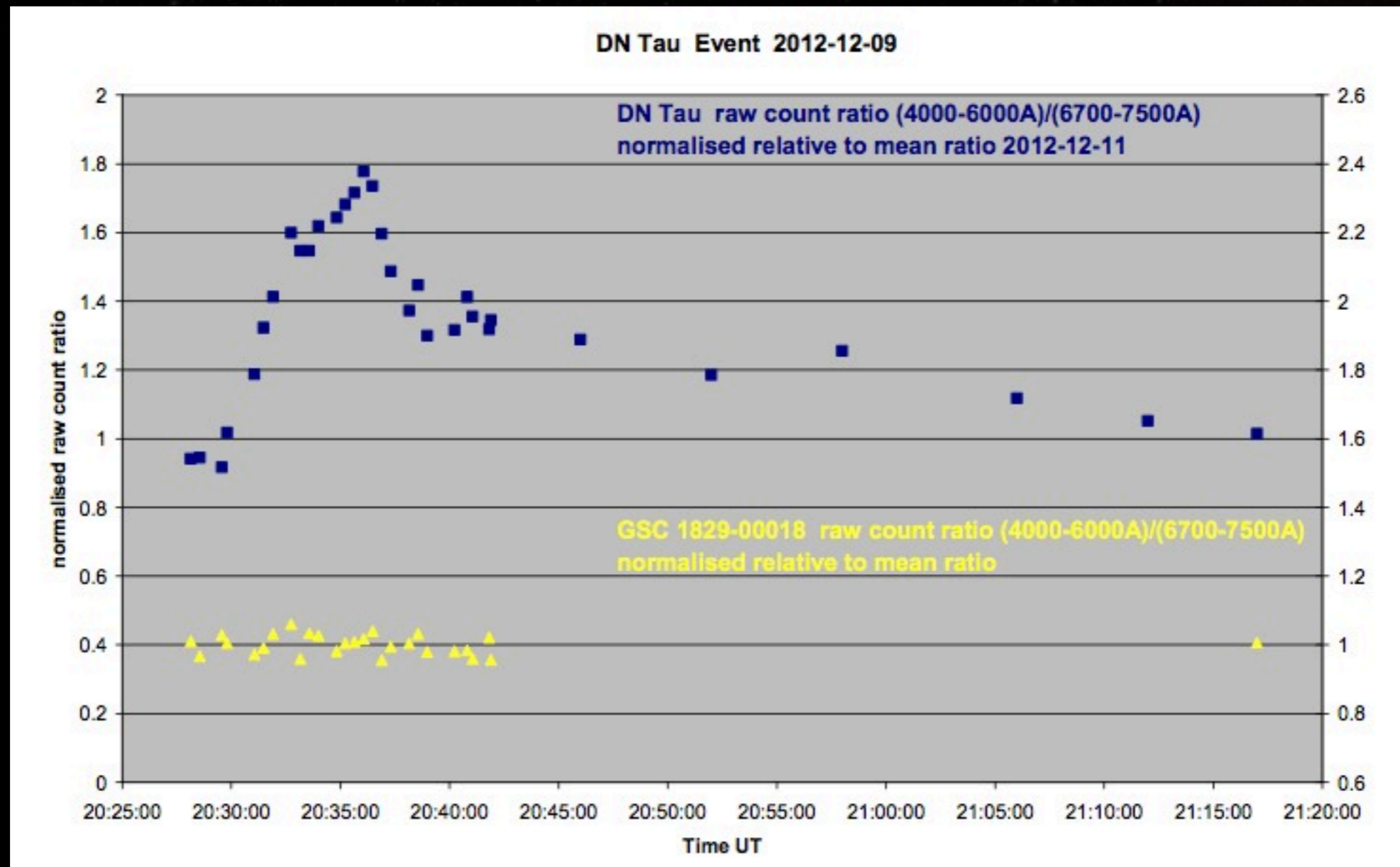
Time series of low resolution star analyzer spectra

Accretion/flaring outburst

I have not found anything like this in professional literature



# One example..



# In conclusion

- ★ Young stars are interesting and dynamic objects which seem to love to surprise and confound theory!
- ★ Offer lots of interesting observing for amateurs