

# The Be Binary Delta Scorpii and Its 2011 Periastron Passage

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**In collaboration with:**

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# Parameters of $\delta$ Sco

Optical brightness without disk,  $V=2.32$  mag

Spectral type B0.3 IV

Distance,  $D = 123 \pm 15$  pc

Luminosity,  $\log L/L_{\odot} = 4.4 \pm 0.1$

Surface temperature,  $T_{\text{eff}} = 27500 \pm 500$  K

Surface gravity,  $\log g = 4.0$  (typical of a dwarf)

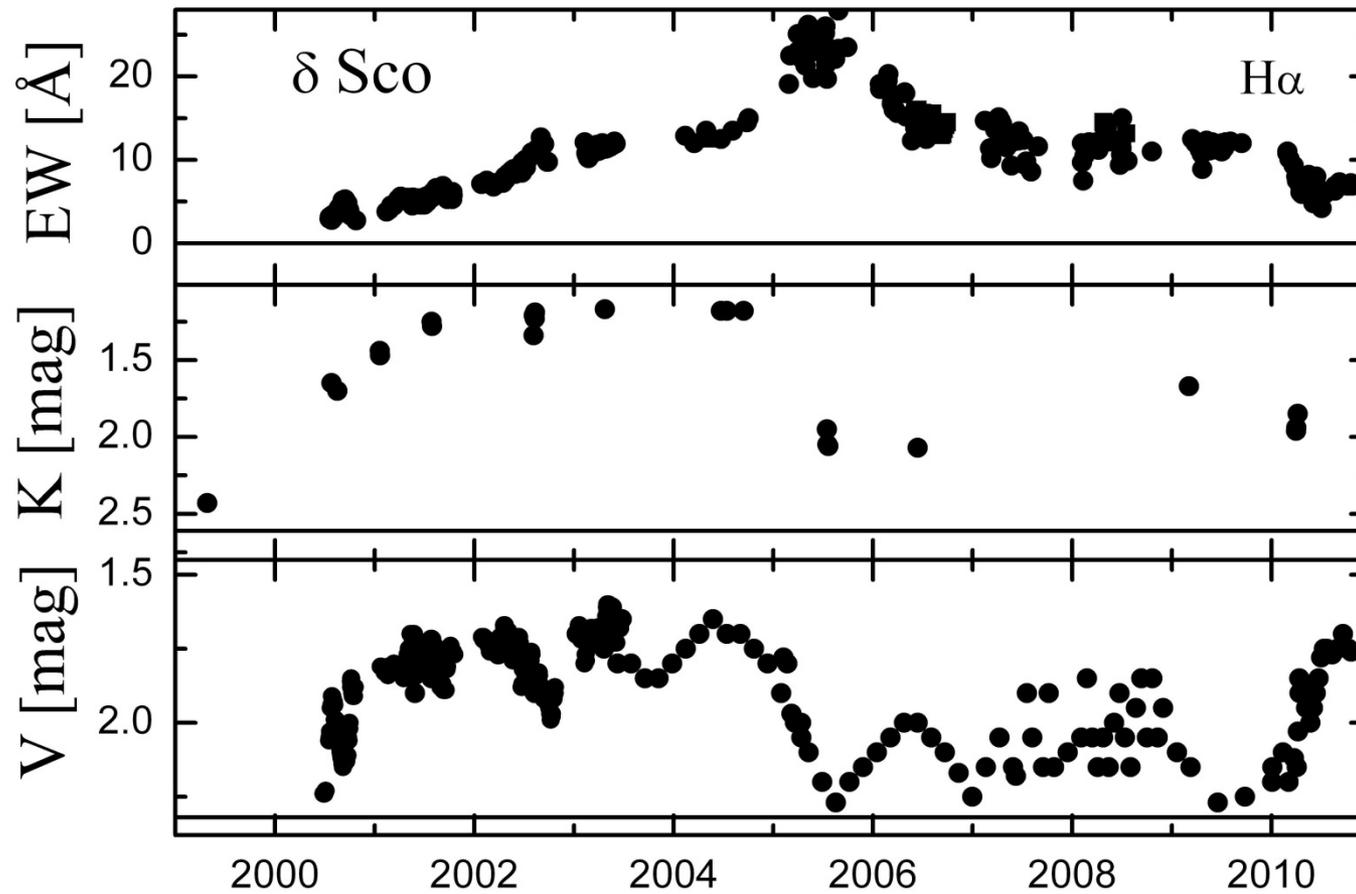
Binary system with an angular separation  
from 0."2 (apastron) to 0." 006 (periastron)

Orbital period,  $P = 10.8$  years

Eccentricity,  $e = 0.94 \pm 0.01$

Secondary,  $\Delta V \sim 1.7$  mag, Sp.T.  $\sim$  B3 (uncertain)

# Brightness – Spectrum



# Goals of the 2011 Campaign

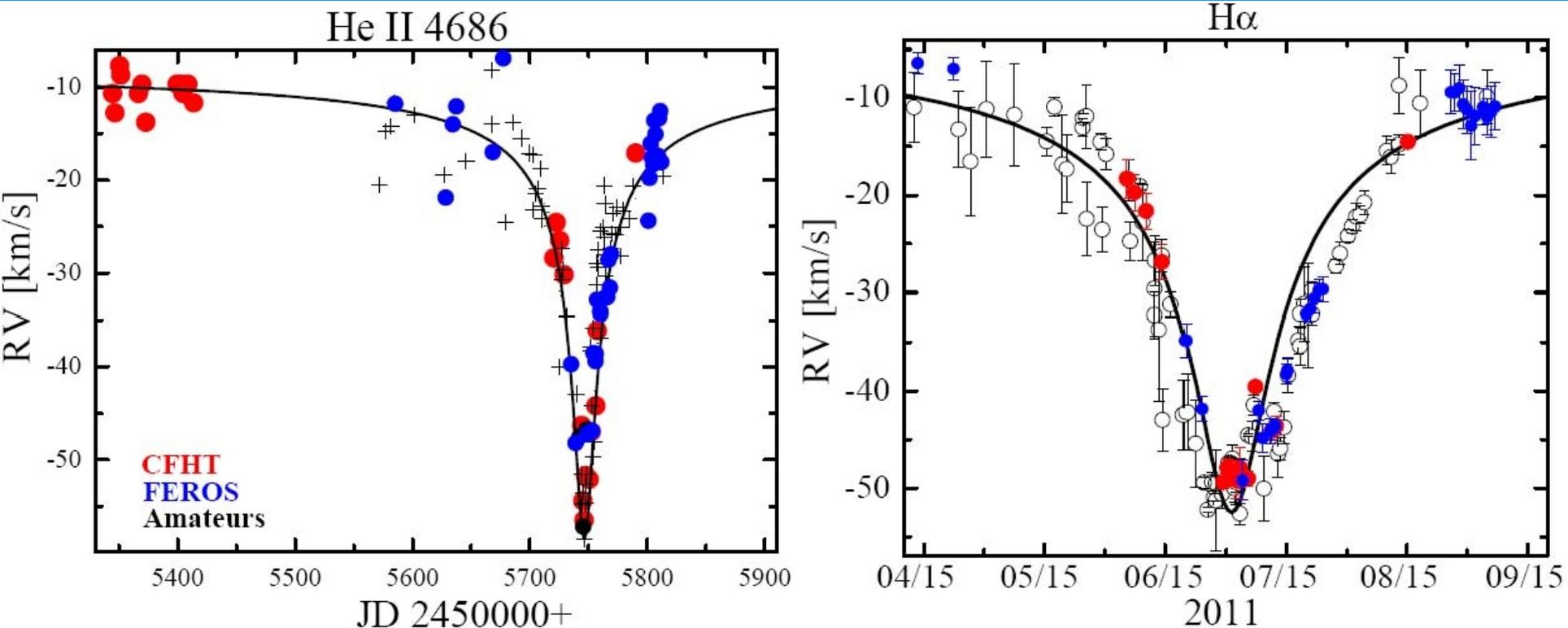
## Take spectra as frequently as possible to:

- obtain a well-defined radial velocity curve to independently constrain the orbital period
- study line profile variations to search for effects of the tidal interaction on the disk and possibly get some information about the secondary component

## Numbers of spectra obtained:

Year	Professionals		Amateurs	
	spectra	nights	spectra	nights
2000	30	30	2	2
2010	~200	30	~200	83
2011	~300	40	~300	149

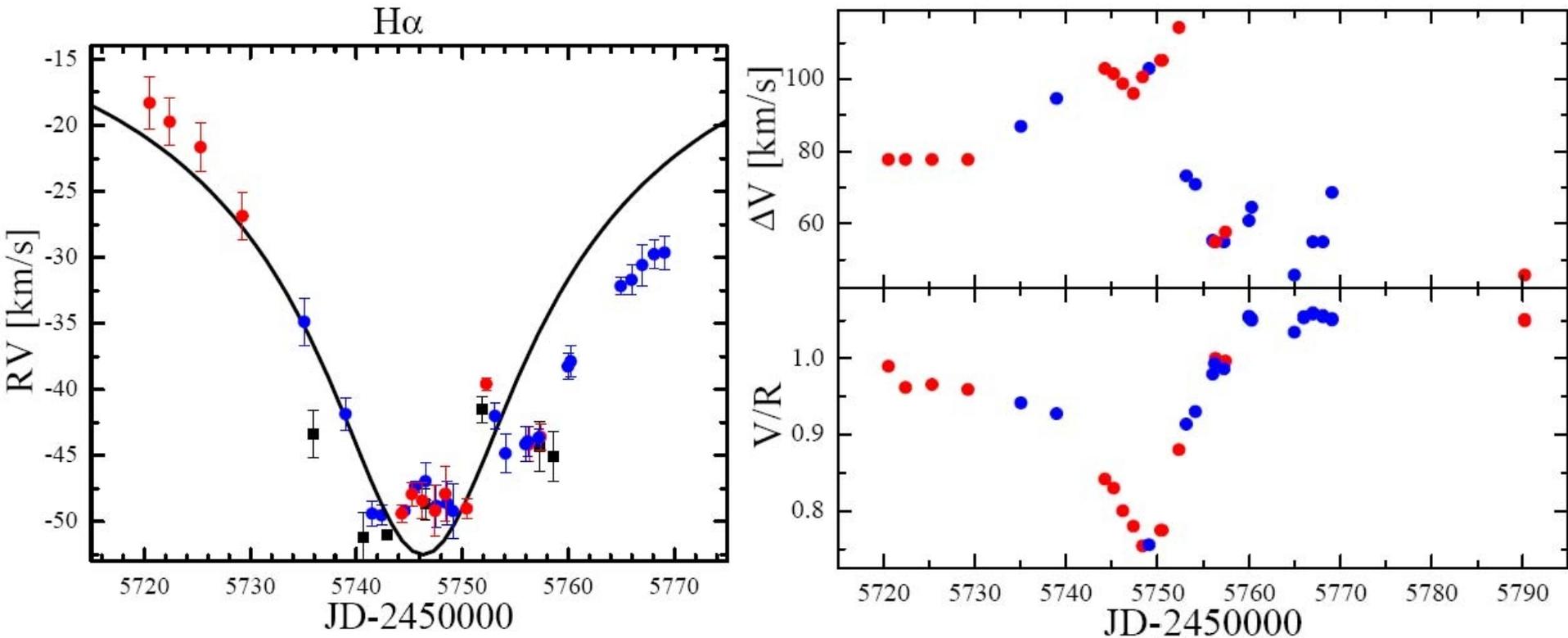
# RV Curves at Periastron 2011



Amateurs data are shown by pluses for the HeII line and by open circles for H $\alpha$ .

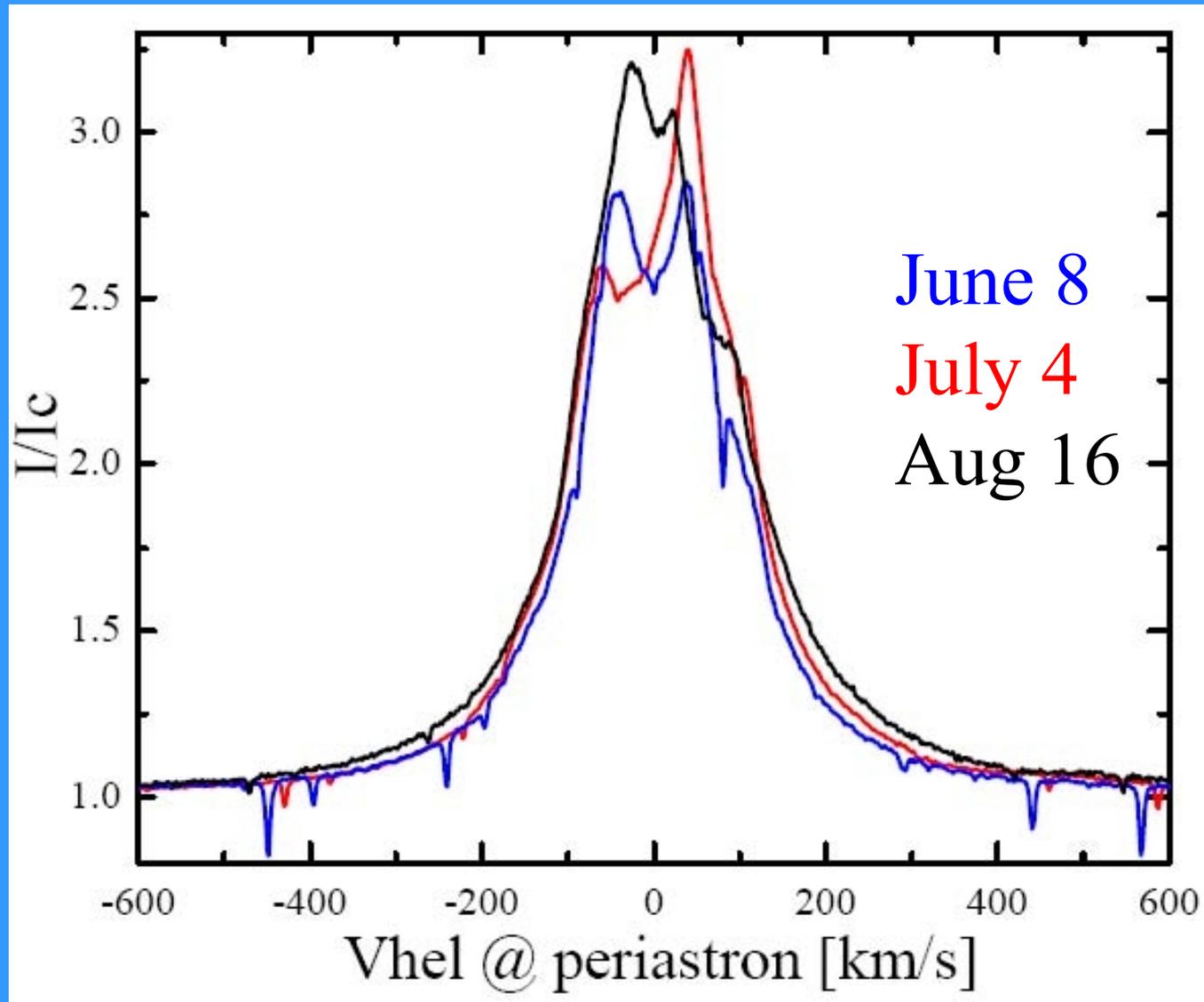
The solid line shows the RV behaviour in 2000.

# Periastron in $H\alpha$



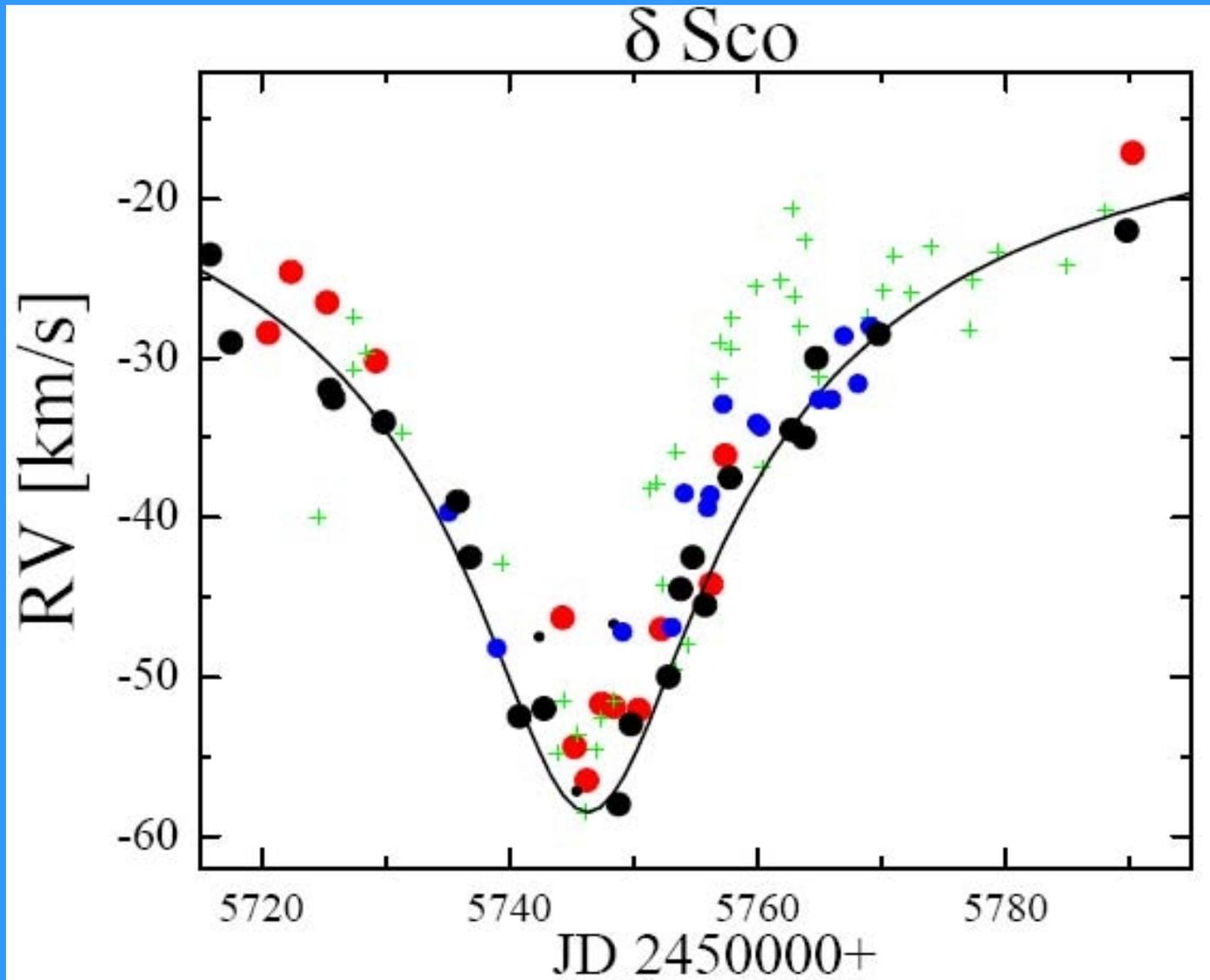
The left panel shows deviations from the expected RV curve due to interaction between the primary's disk and the secondary component.

# H $\alpha$ Profile at Periastron



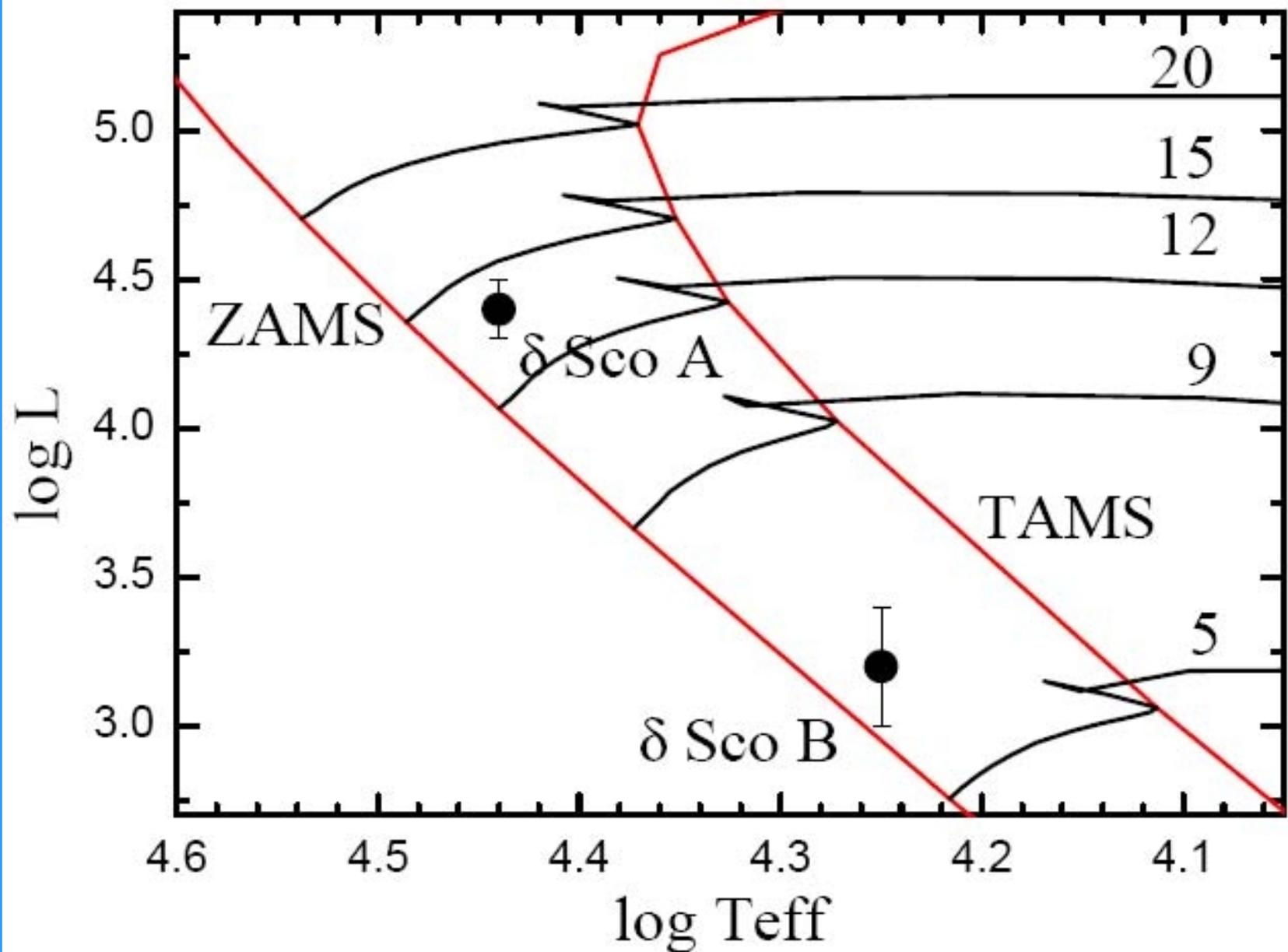
The line equivalent width was stable  $\sim 11-12 \text{ \AA}$

# Periastron in He II 4686 Å



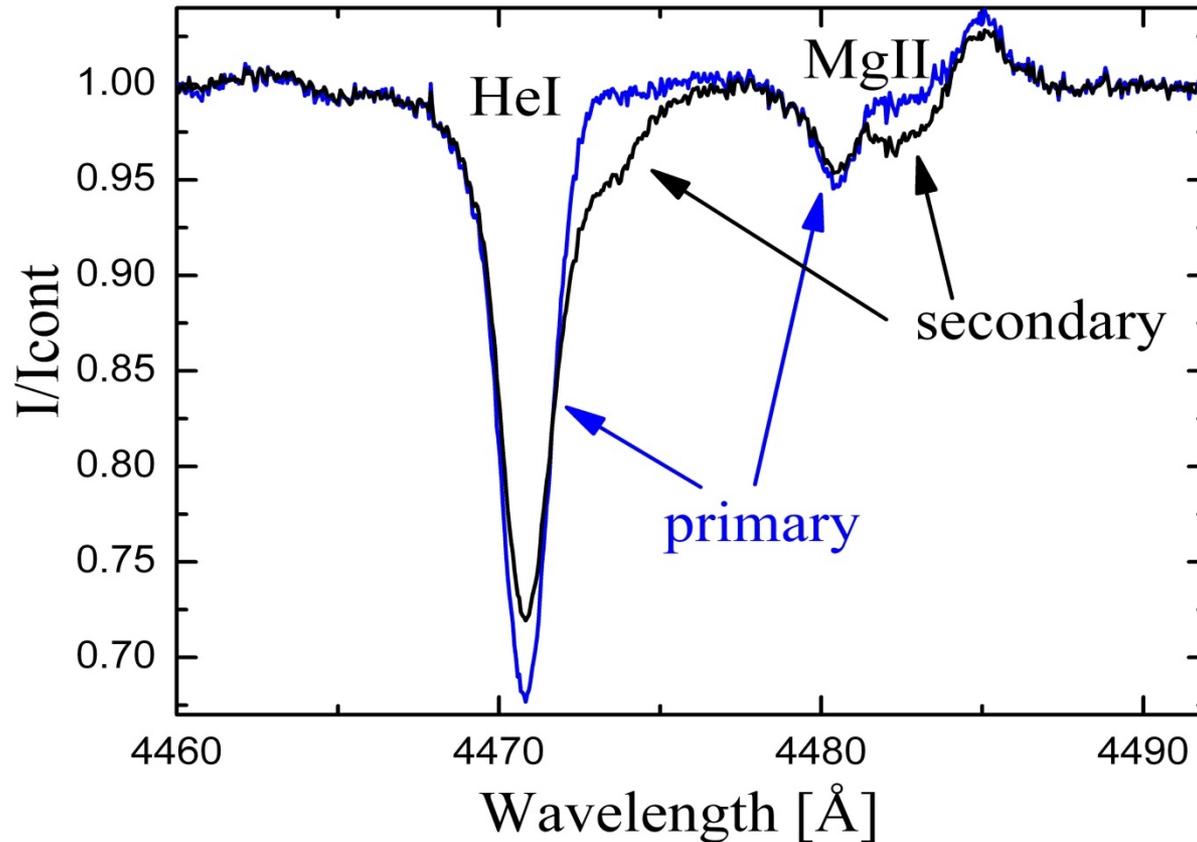
Black dots are data from 2000

# $\delta$ Sco in the HRD (prediction)



# Secondary's Trace at Periastron

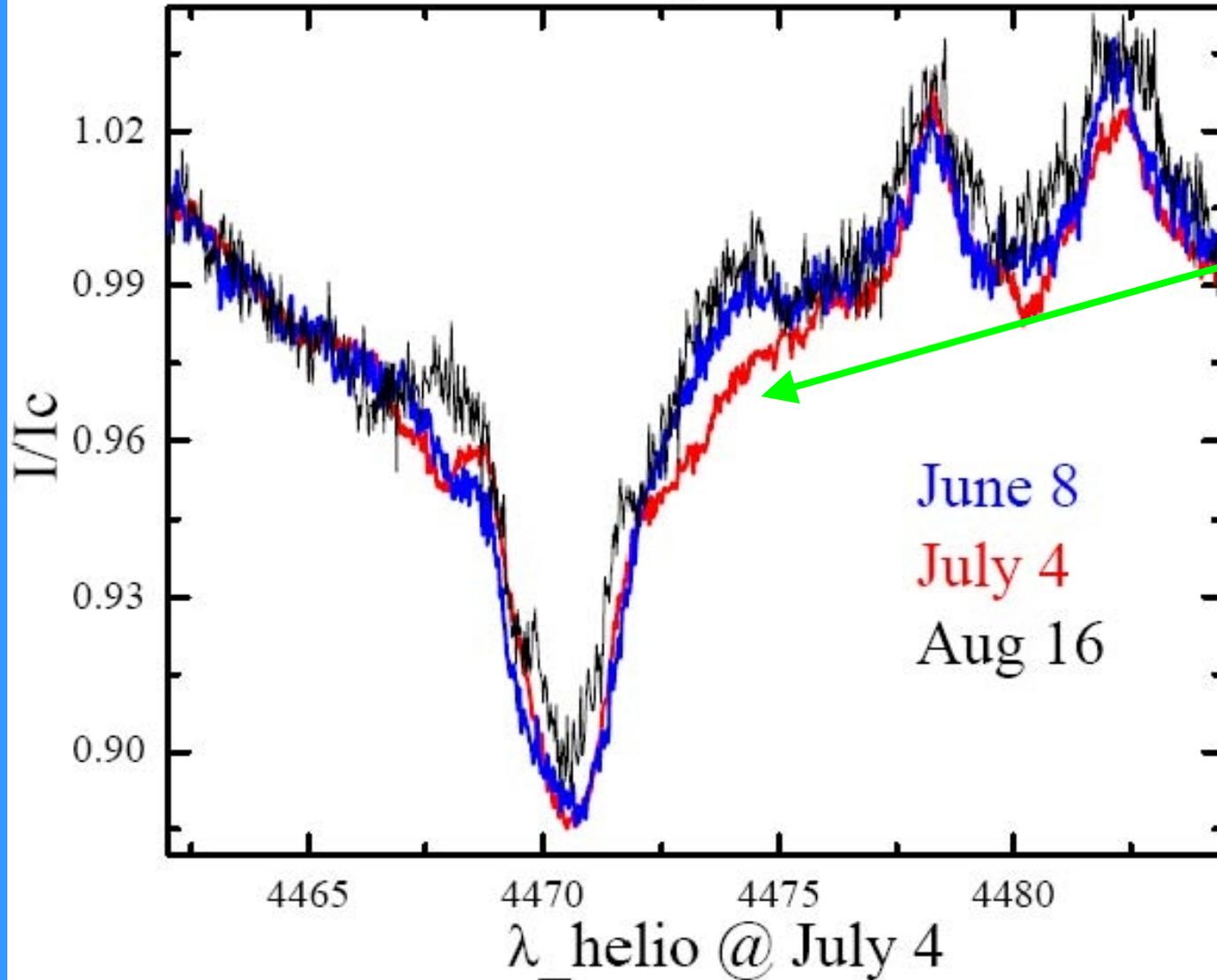
Radial velocity difference is  $\sim 120$  km/s



Prediction for B0 + B3, both  $v \sin i = 150$  km/s, brightness ratio  $\Delta V = 1.7$  mag (ignore the feature at 4485  $\text{\AA}$ ).

# Observed He I 4471

HeI 4471 at periastron 2011



Possible  
trace of the  
secondary  
component

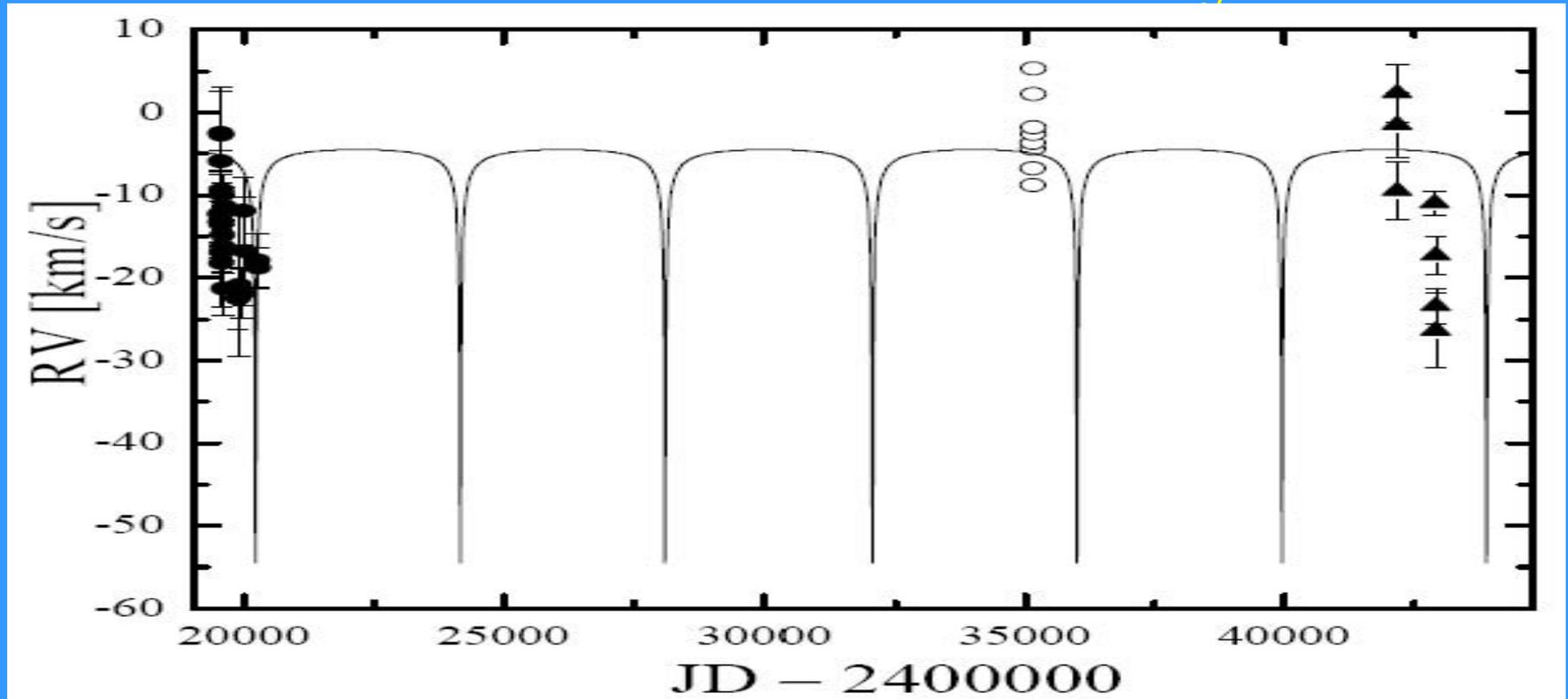
# What Is $\delta$ Sco?

- The Bright Star Catalog mentions a component with a 20-day orbital period
- Most Be binaries with non-degenerate secondary components have circular orbits.
- Radial velocities in the XX century show variations additional to those expected at periastra.
- Be/X-ray binaries have eccentric orbits.
- The system is surrounded by a dusty envelope seen that could have resulted from an explosion.

## Hypotheses:

- ✓ There is a third, degenerate(?) star in the system
- ✓ The binary is a runaway from a cluster

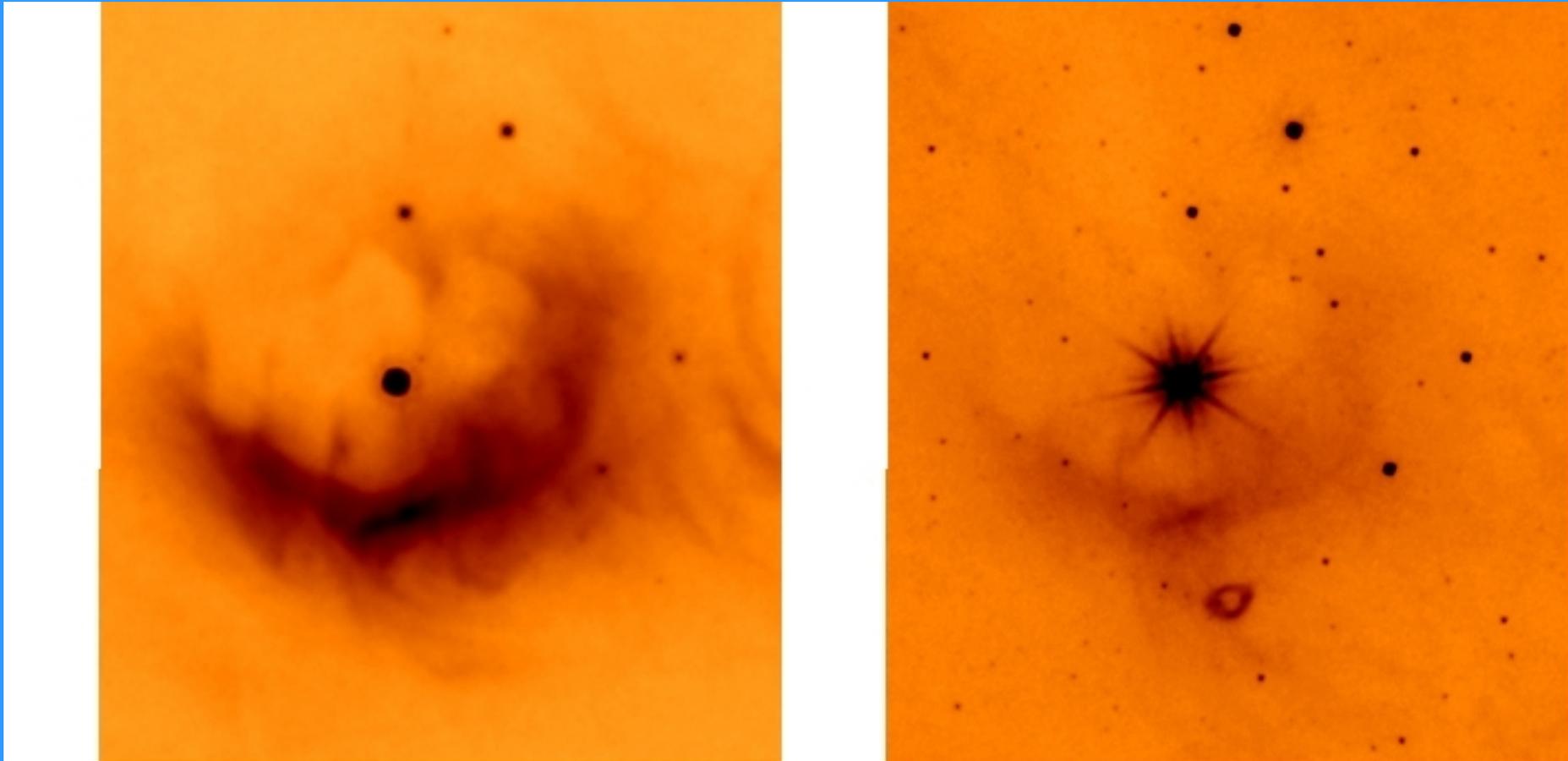
# Historical Radial Velocity Data



## Periodogram and stability analysis by A. Pasetchnik:

- Periods shorter than  $\sim 10.5$  years are insignificant
- Any internal component is unstable after few orbits
- Orbital period may change due to an external component

# The Shell of $\delta$ Sco



WISE images at 22 (left) and 12 (right) microns  
(found by Vasilij Gvaramadze, Sternberg Inst., Moscow, Russia)

# Conclusions

- Orbital period is  $10.8147 \pm 0.0013$  yr =  $3950 \pm 5$  d
- Spectroscopy near periastron did not clearly reveal properties of the secondary that is consistent with an early- to mid-B spectral type
  - The IR shell near the system suggests that it is a runaway from a young cluster
  - The radial velocity in 2011 curve slightly deviates from that in 2000 (possible 3<sup>rd</sup> component)
  - The 2011 campaign reveal that amateur spectroscopy becomes an important factor in astronomy of emission-line stars