Report of the delta Sco periastron passage campaign 2011

(November 2011)

One of the most interesting astronomical events of this year, at least from view of the astrospectroscopy, was certainly the periastron passage of the Be-binary δ Scorpii. δ Sco is a bright, interferometrically discovered binary system with a primary of the spectral type B0, an angle of inclination of its orbital rotation axis regarding the line of sight of the observer of 38° and a companion star, whose spectral type is at present assumed as type B, and which moves on an elliptical orbit with the eccentricity e = 0,94 and a period of approx. 10.6 years. Fig. 1 shows the change of radial velocity during the periastron passage of August - September in 2000, whereby the observation density was not sufficient for a precise determination of the periastron time. Red points = measurements of Miroshnichenko [1, 2]; the green line represent calculations of Tango et al. [3] and the orange line the "best-fit model" of Mailland et al. [4].

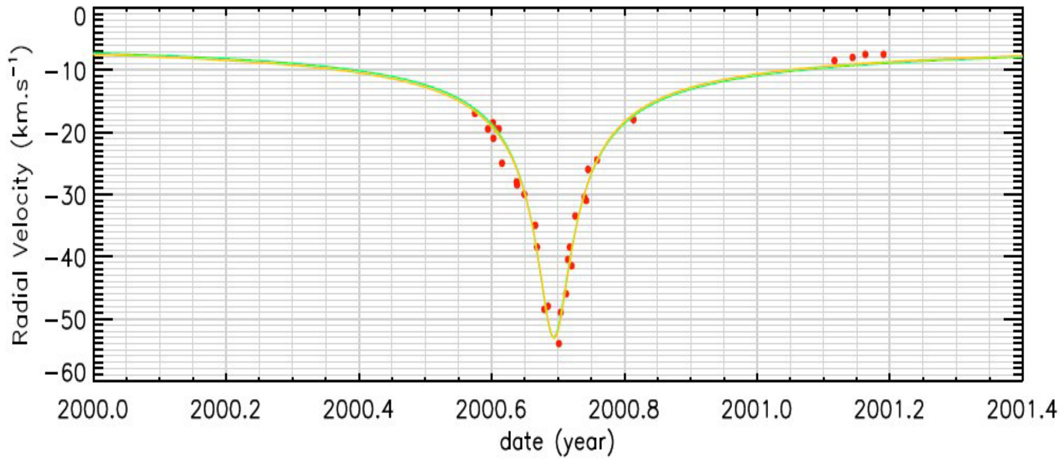


Fig. 1: Radial velocity during the periastron passage July to September 2000

In the context of the 2011 campaign the pleasing high participation of international observers since January has led to an observation density higher than previously obtained for δ Sco. Most of the spectra were measured using the program SpecRave, developed specially for radial velocity measurements (a co-operation between my colleague Roland Buecke and the VdS group „Computer Astronomy". Fig. 2 shows the result of our radial velocity measurements since January this year until today.

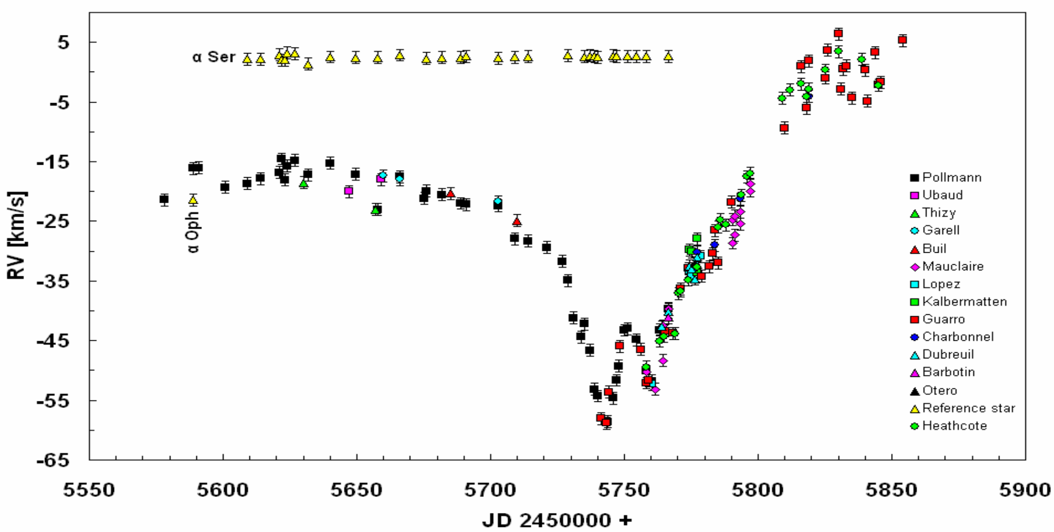


Fig. 2: Radial velocity measurements of the campaign since January 2011 until today

The primary goal of the campaign was to determine the time of the periastron passage as precisely as possible. The high observation density allowed this time to be determined using a method commonly used in the in the observation of variable stars. This method is based on calculating the linear regression for the descending and rising parts of the curve. The time of the periastron passage then lies at the intersection of the two regression lines. Our observations showed this to be 2011-07-01, 02:30 UT. The deviation from the predicted date 2011-07-05 amounts about 4 days.

Additionally a feature was seen in the radial velocity curve which was not expected in this form neither by the professional nor amateur astronomers. This was the „double dip“ between 11th and 23th July (JD 2455754 – 2455766). Initial speculations from the professional astronomical community suggest that there may be a third body in δ Sco binary system in the proximity of the companion. Based on this hypothesis, the possible existence of a third component is derived on basis of an analysis of the radial velocities from 1902 to 1975 with a period from 302.6 days ± 0.26 on an eccentric orbit [5].
A further unexpected result of the campaign is the development of a „bump “on the red flank of the Hα peak in high resolution spectra from the swiss amateur Patricia Otero between 31th July to 6th August (fig. 3, left), and particularly clear from the australian amateur Bernard Heathcote on 12th August (fig. 3 right).

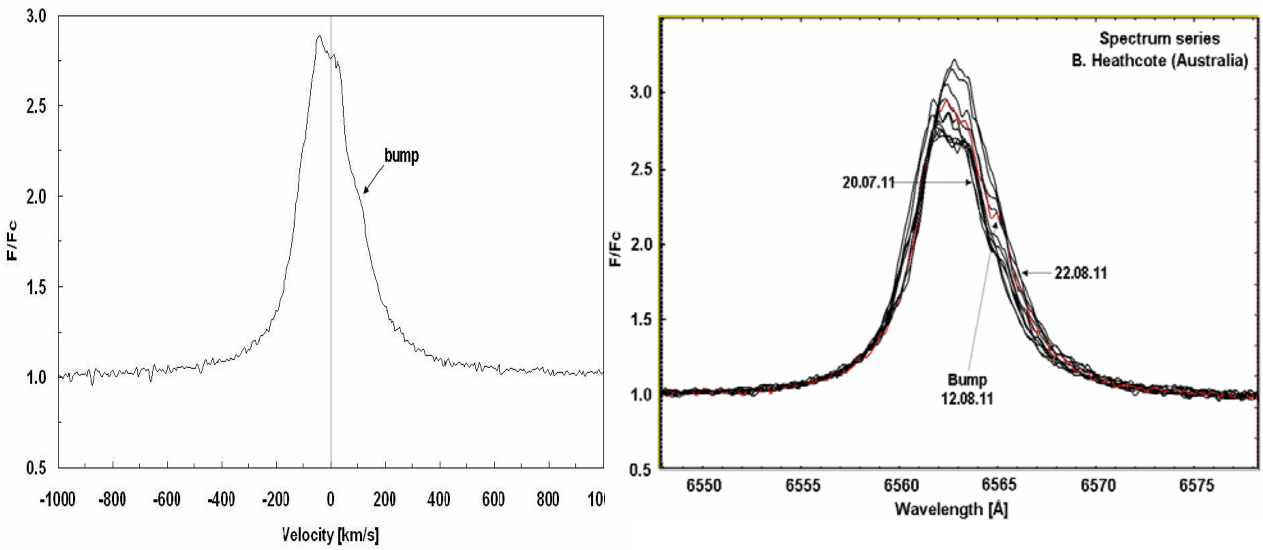


Fig. 3: The red flank emission bump in independent spectra of P. Otero and B. Heathcote

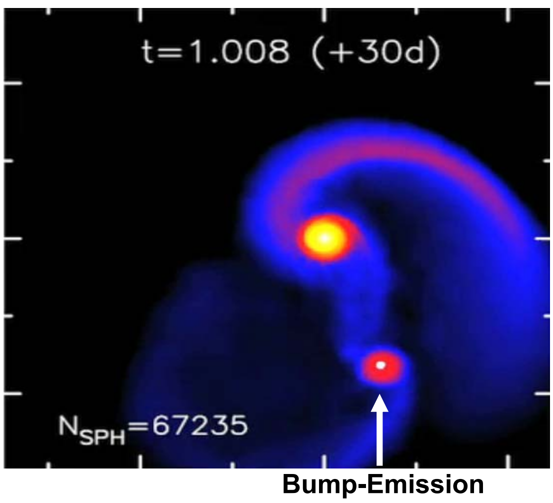


Fig. 4: The emission bump and its possible explanation in Okazaki´s model

In the model simulation (fig.4) of the Be star researcher A. Okazaki [6], which is based on results from the periastron passage in 2000, the formation of the circumstellar disk around the secondary seems to be a robust feature due to the tidal interaction with the secondary.

If approx. 20-30 days after the periastron, the terrestrial observer was looking in downward direction (in the i, j, k coordinate system of unit vectors) of the animation frame, the secondary's circumstellar disk would show up as an enhancement a "bump" in the red wing of the Hα-emission (priv. communication A. Okazaki, Nov. 2011).

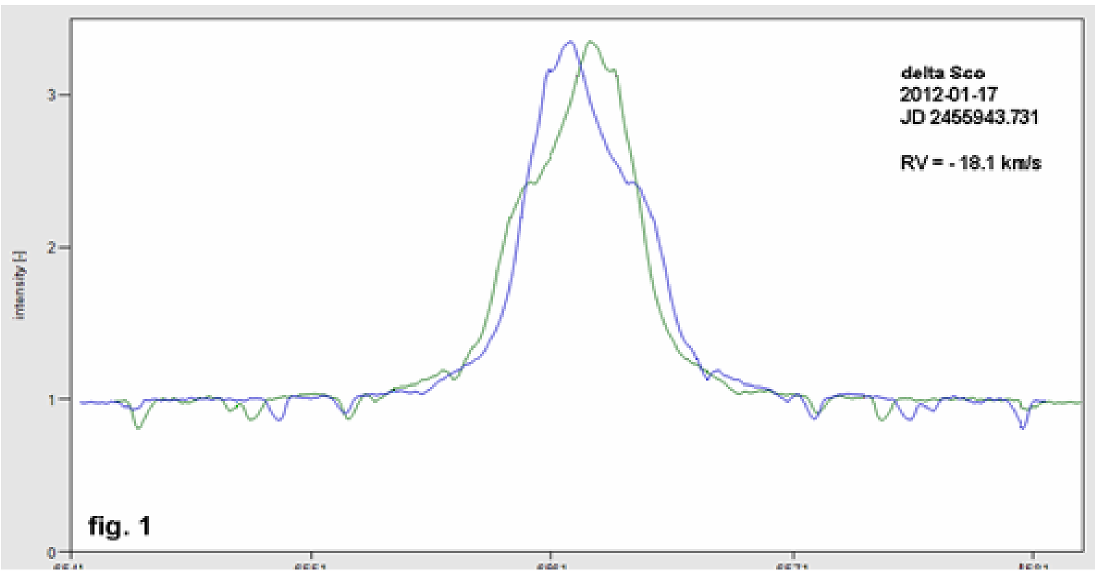
Reference:

[1] Miroshnichenko, A.S., Fabregat, J., Bjorkman, K.S., et al. 2001, A&A, 377, 485
[2] Miroshnichenko, A.S., Bjorkman, K.S., Morrison, N.D., et al. 2003, A&A, 408, 305
[3] Tango, W. J. et al., Mon. Not. R. Astron. Soc., 18 (2008)
[4] Meilland et al., A&A, June 10, 2011
[5] Gandet, T. L., priv. communication, July 2011
[6] Okazaki, A., http://www.elsa.hokkai-s-u.ac.jp/~okazaki/index-e.html

Ernst Pollmann

Report continuation
January 2012

In a first spectrum of January 17th of the new visibility period 2012, the Hα radial velocity has been evaluated with the mirroring method (fig.1). This method is useful in case of asymmetrical line profiles, as it is to see in this new spectrum. The RV value fits well to the RV monitoring campaign of 2011. Although there are several open questions regarding the RV "double dip" and the RV increase after the periastron passage until approx. 5 km/s (fig. 2), we will continue our effort.
The Hα EW did increase too, corresponding the behavior after the last periastron passage 2000 (fig.3)



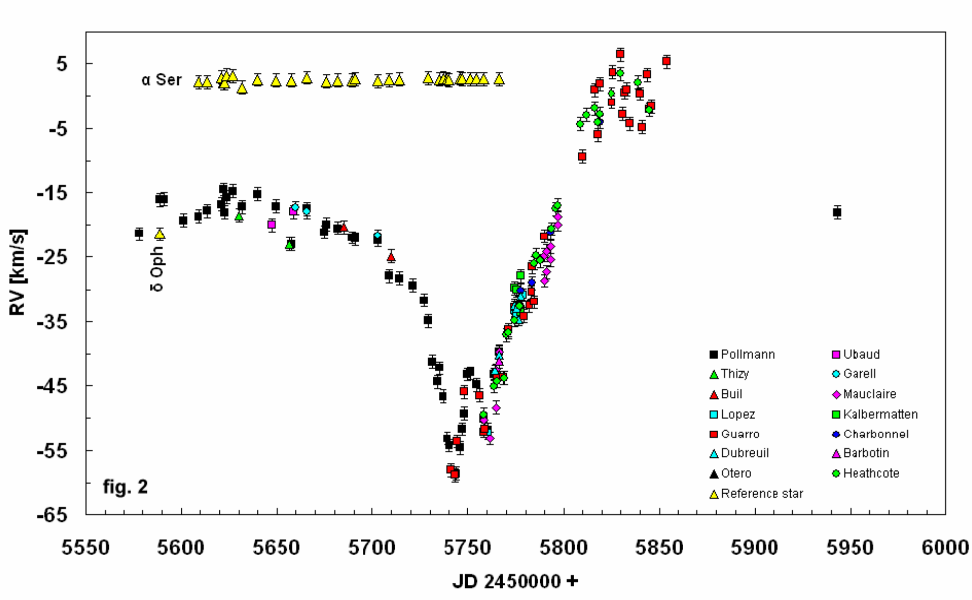


fig. 2

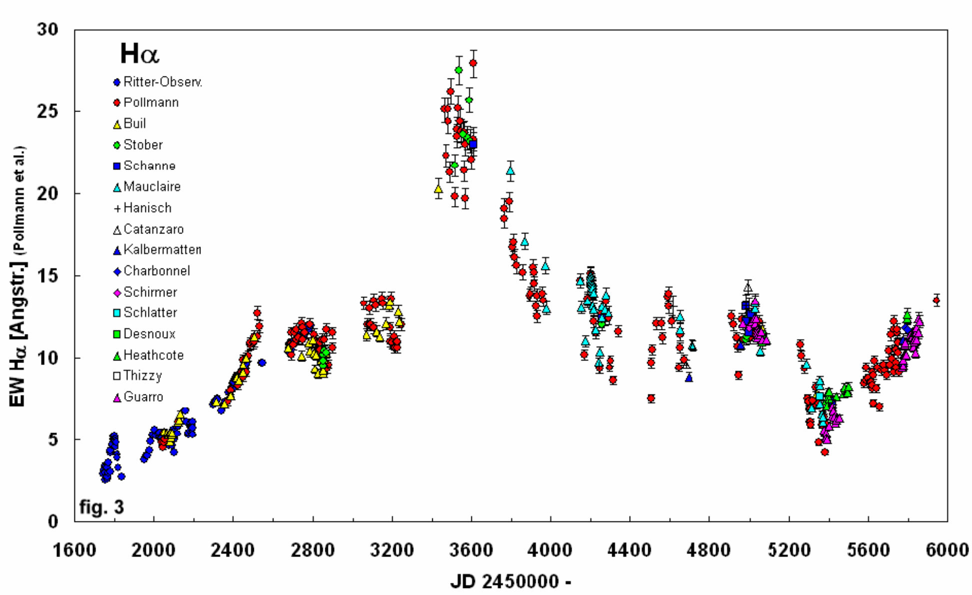


fig. 3

February 2012

Hα-RV-evaluation with the mirror method. Program HRV-MM 1.2 developed by Roland Bücke, http://www.astro.buecke.de

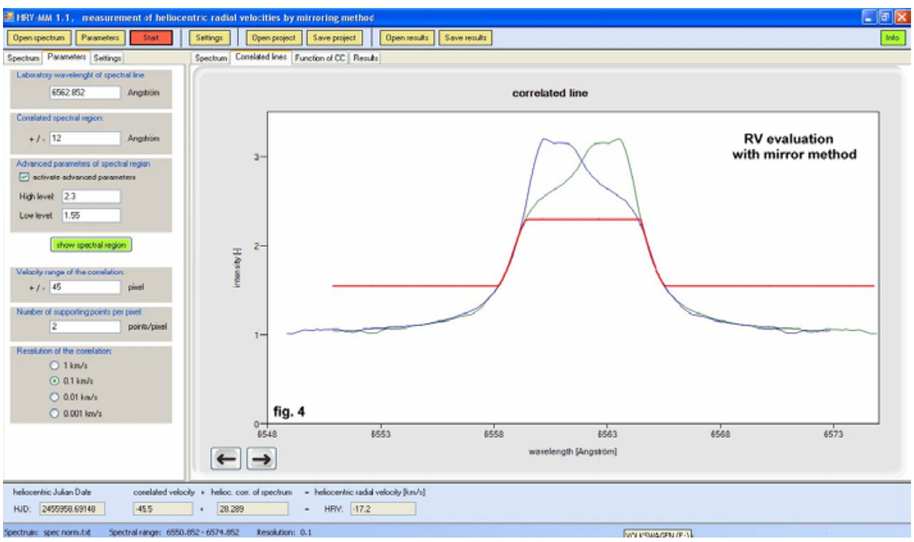
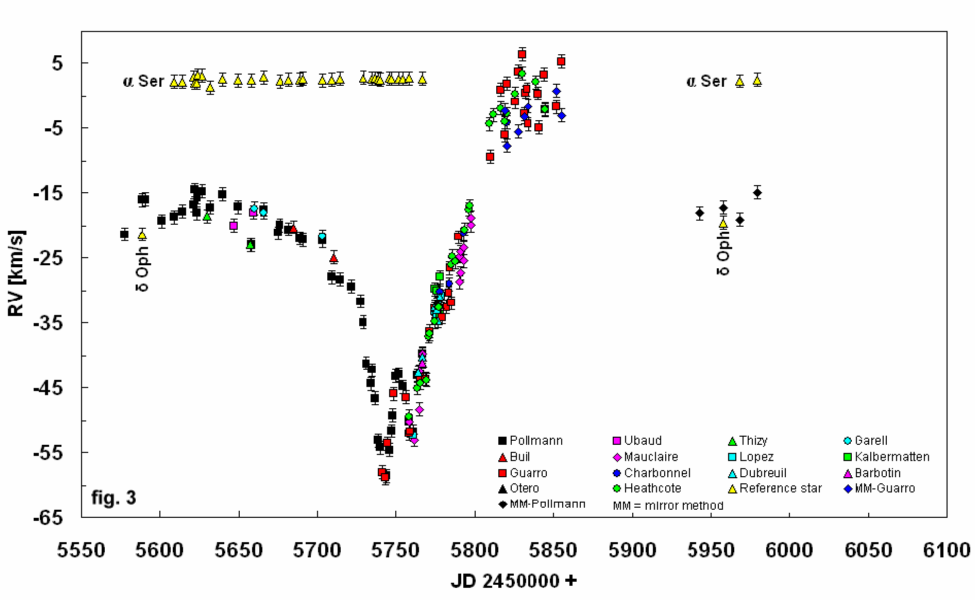


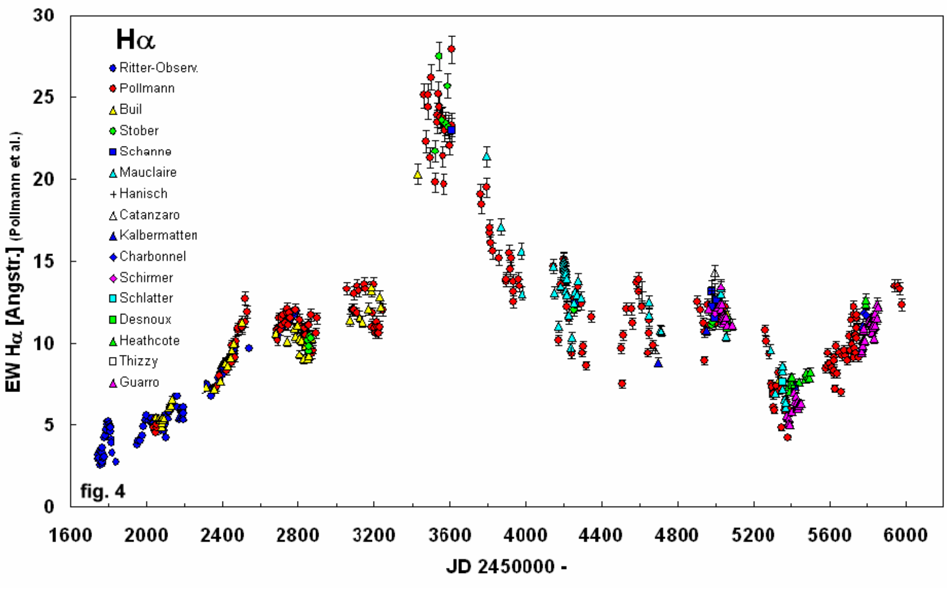
fig. 4



RV double check of several spectra (taken in autumn 2011 of J.Guarro and B. Heathcote) and 2012-monitoring with the MM method (fig. 3). It seems, that this technic leads to more consistency in RV, particularly when the observation height of the star is low.

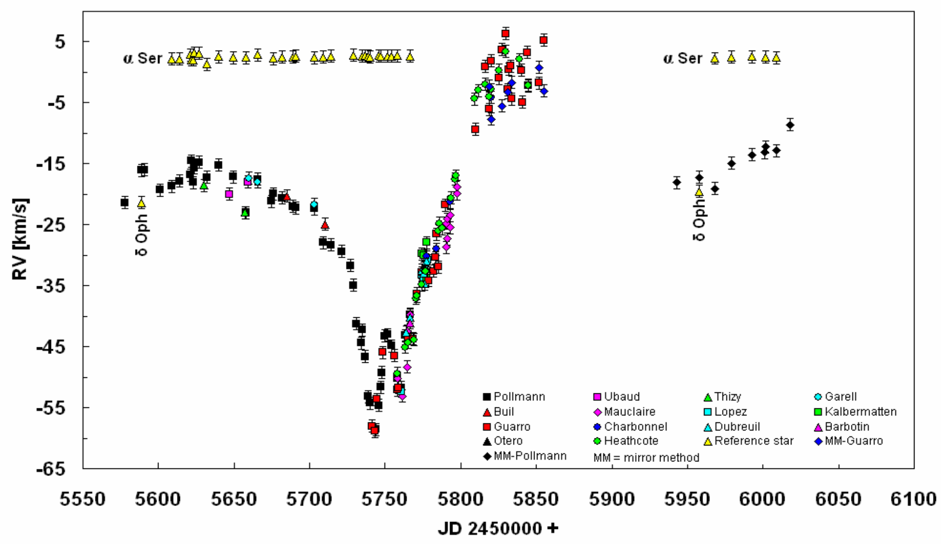
Anatoly Miroshnichenko´s comment to the RV behaviour:

I think what we observe is effects of the tidal interaction between the stellar components. The secondary has taken part of the disk as it was expected and shown in Okazaki's movie. The additional minimum of the radial velocity on your plot right after the periastron (near JD 5760) can be explained as a blue shift of theline profile as the secondary moved away from the Earth after passing near the primary. What you see in 2012 may be due to the same effect as the secondary continues to move away. However, I'm not sure how large the radialvelocity change is between November 2011 and January-February 2012.

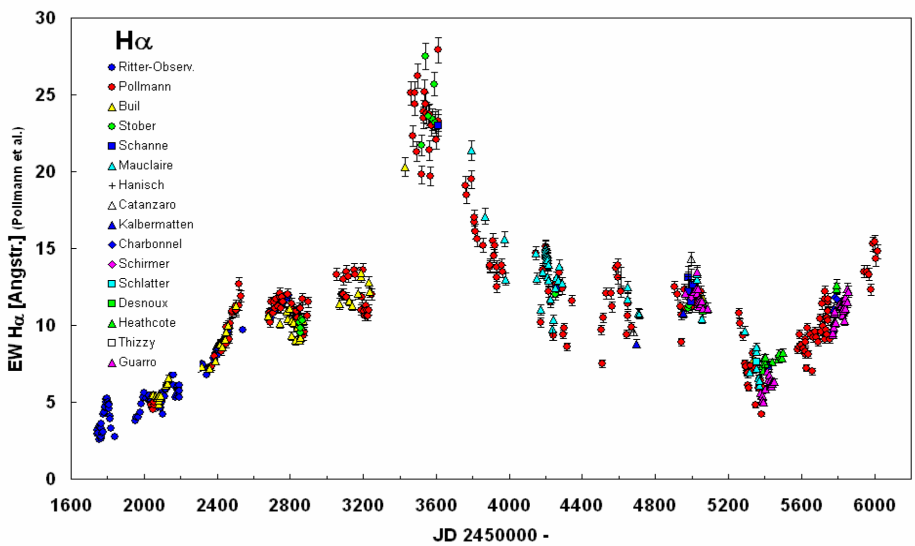


Corresponding the behavior after the previous periastron passage, the Hα-EW is increasing evenly.

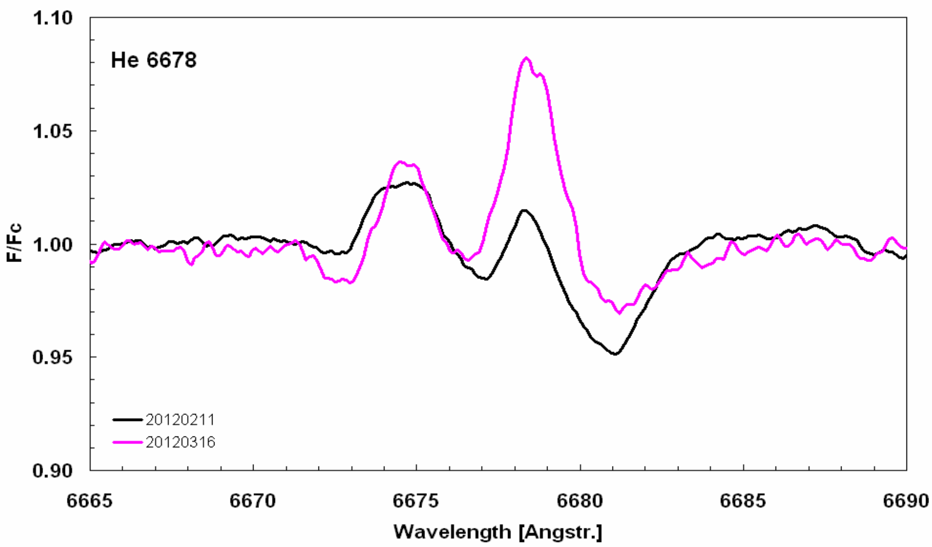
March 2012



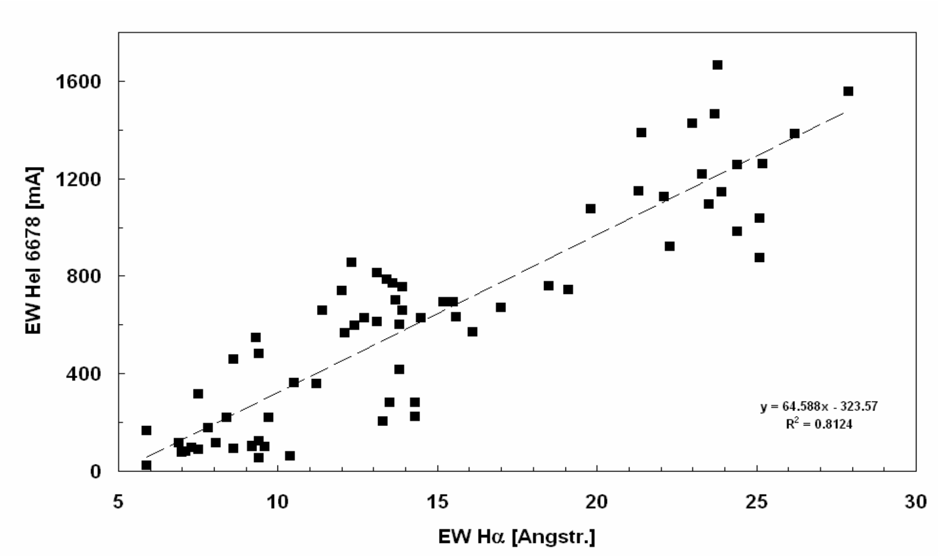
Continuation of the Hα-radial velocity monitoring
All new measurements have been performed with the MM-method



Continuation of the Hα-EW monitoring

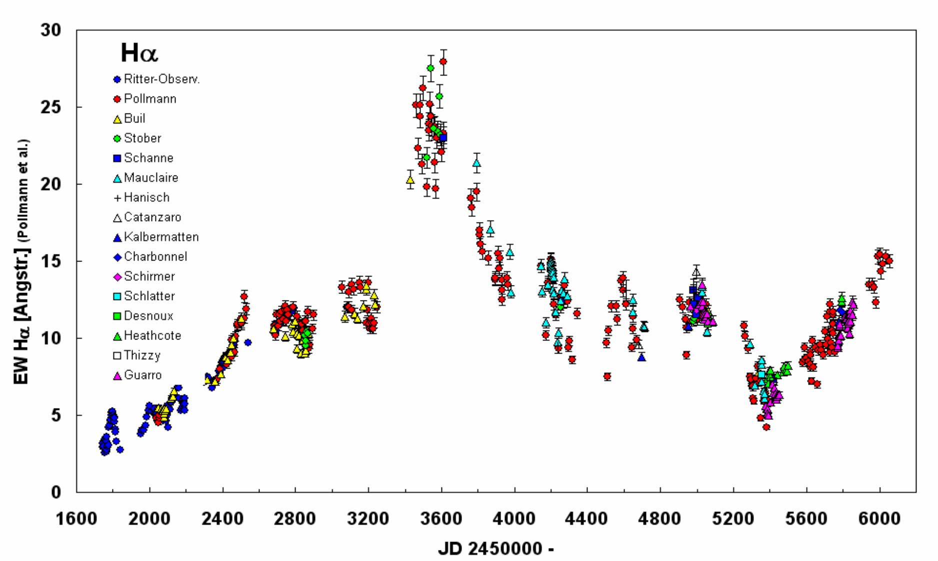


The emission features of HeI6678 become more and more stronger

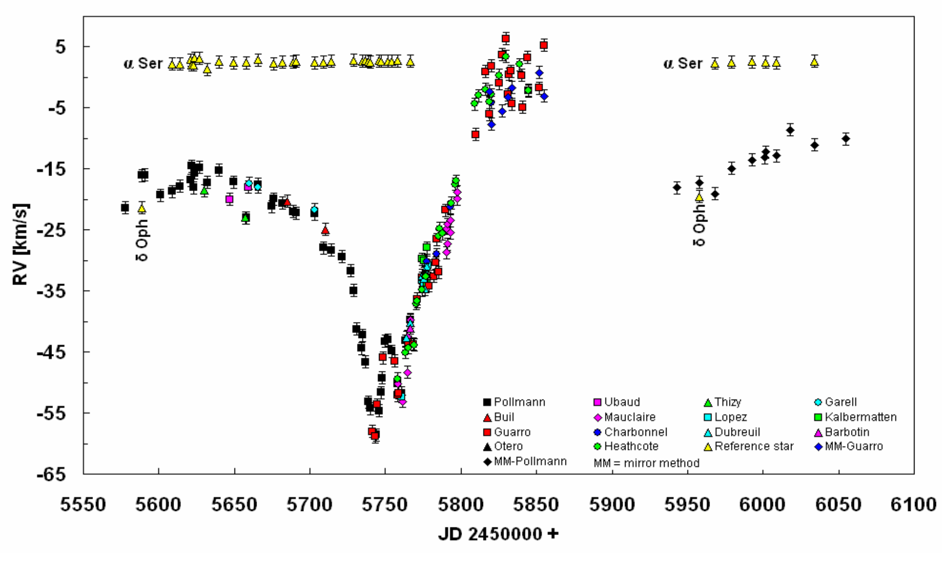


In this context the monitoring of the He6678-emission intensity (EW) versus Hα-EW will be continued

April 2012

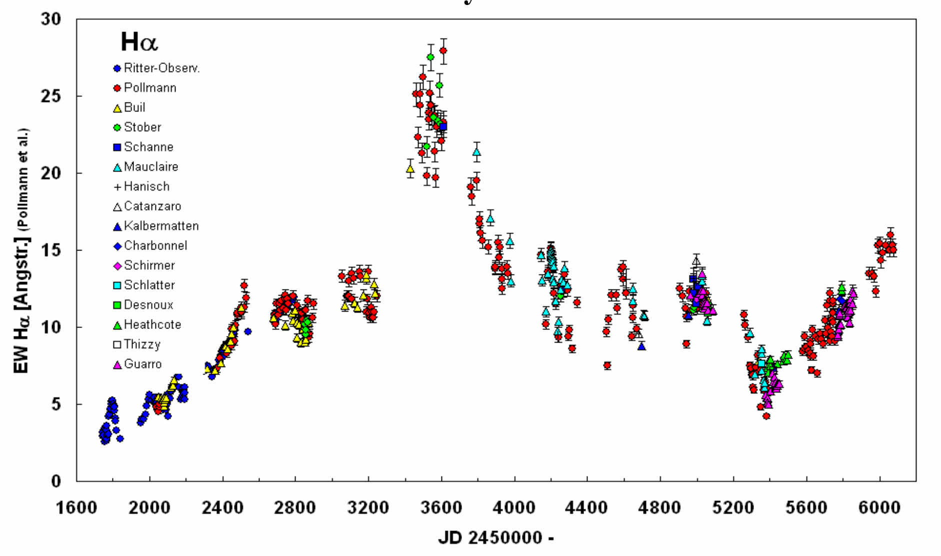


Continuation of the Hα-EW monitoring

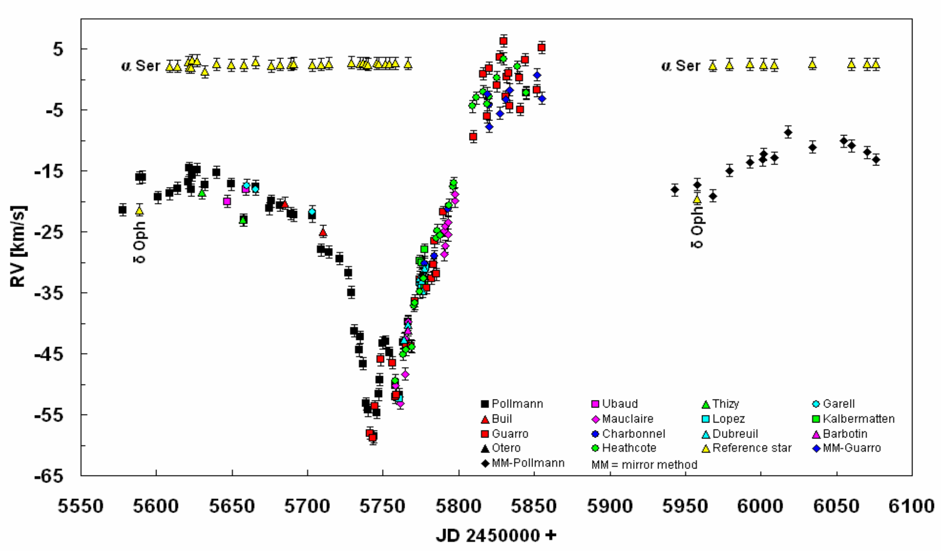


Continuation of the Hα-radial velocity monitoring

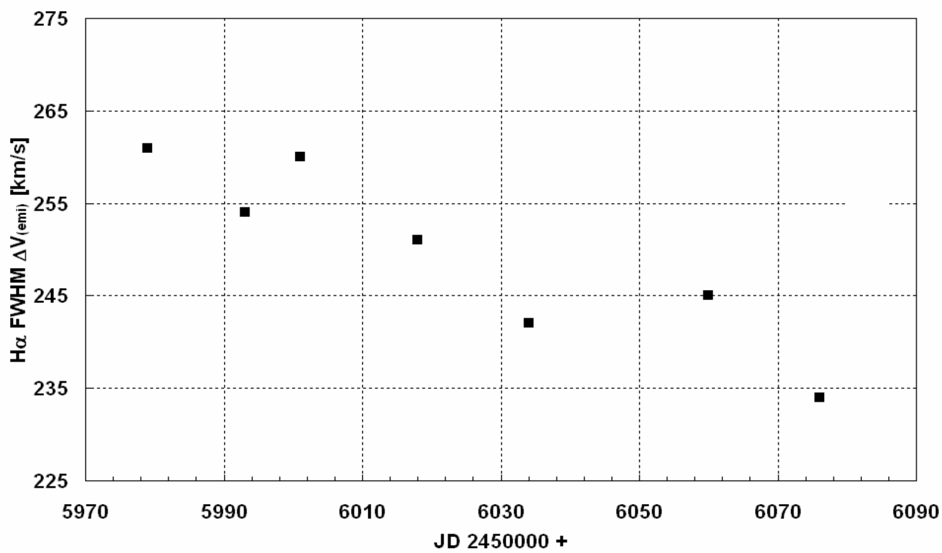
May 2012



Continuation of the Hα-EW monitoring

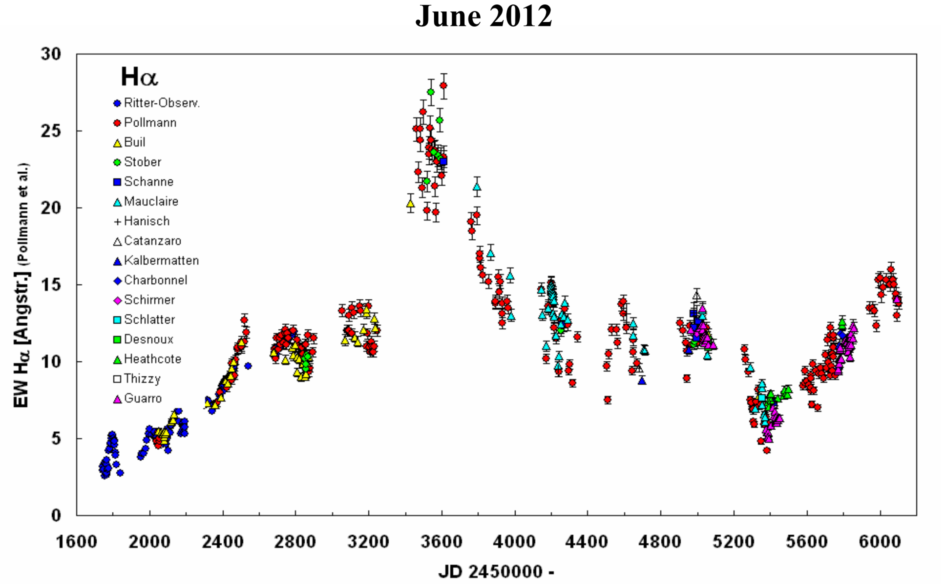


Continuation of the Hα-radial velocity monitoring

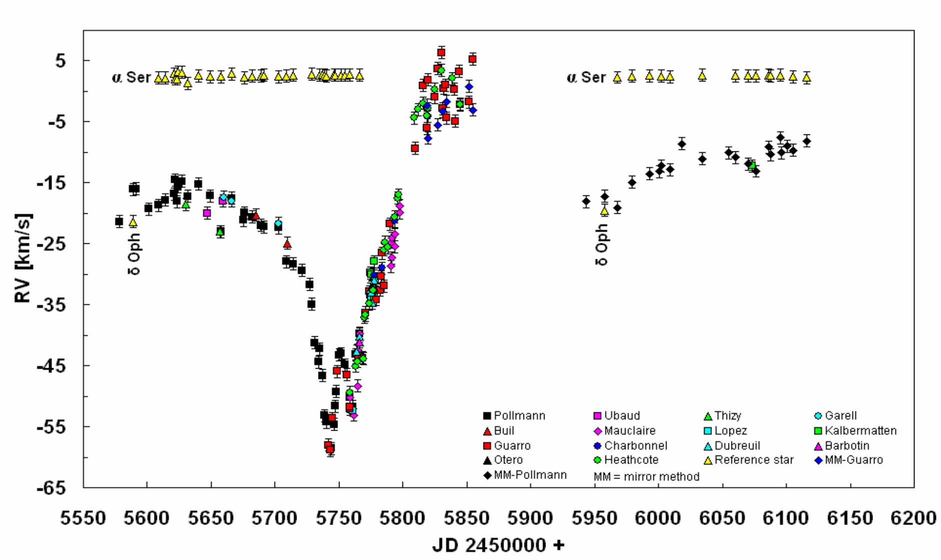


Disk growth leads to decrease of the FWHM velocity

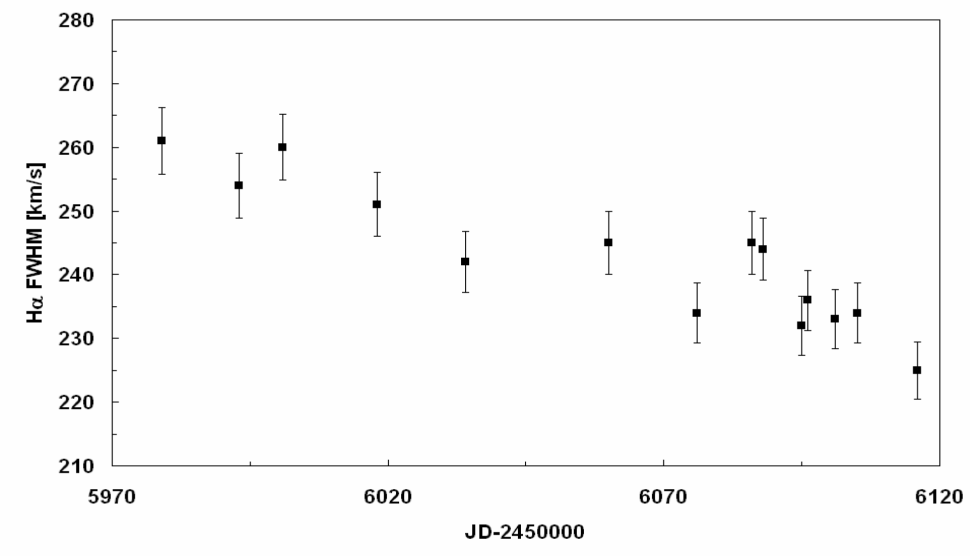
June 2012



Continuation of the Hα-EW monitoring

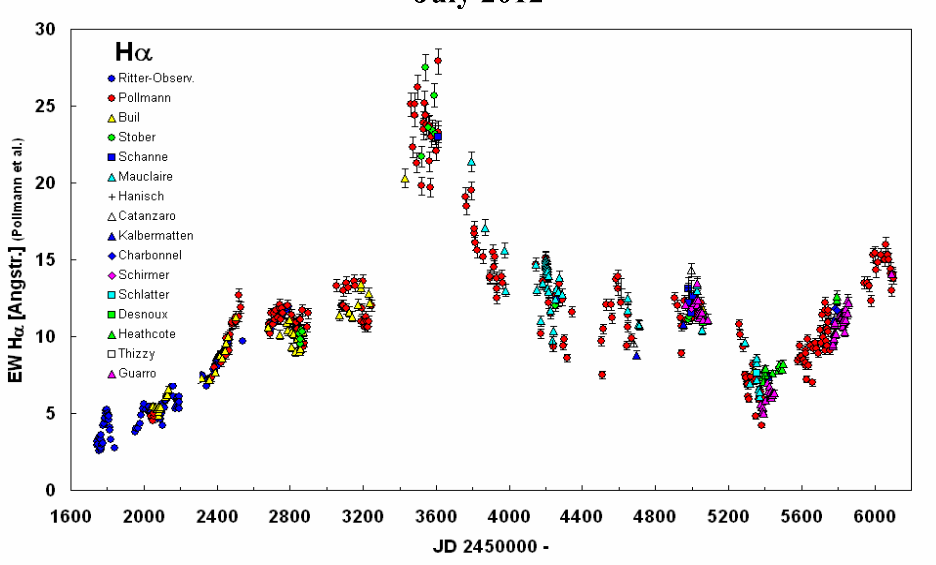


Continuation of the Hα-radial velocity monitoring

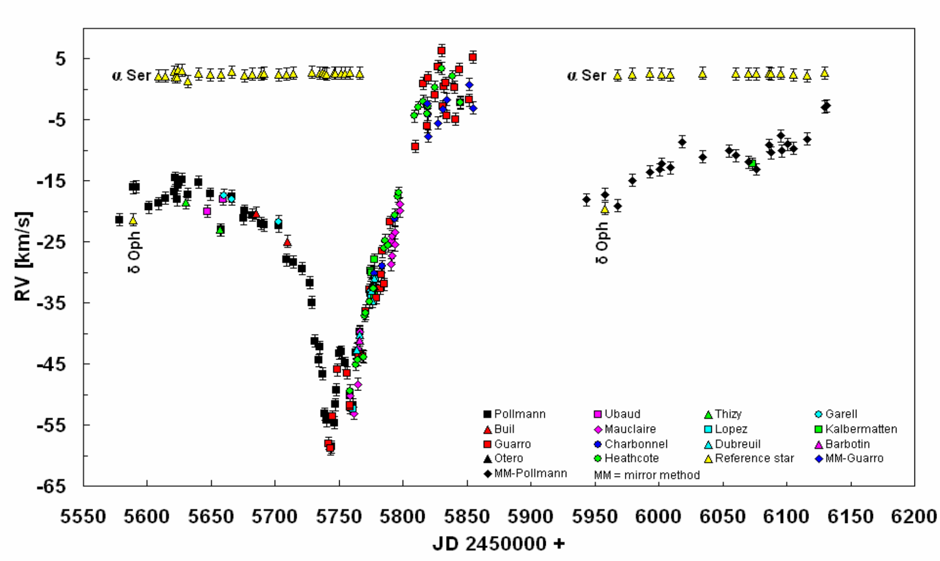


Disk growth leads to decrease of the FWHM velocity

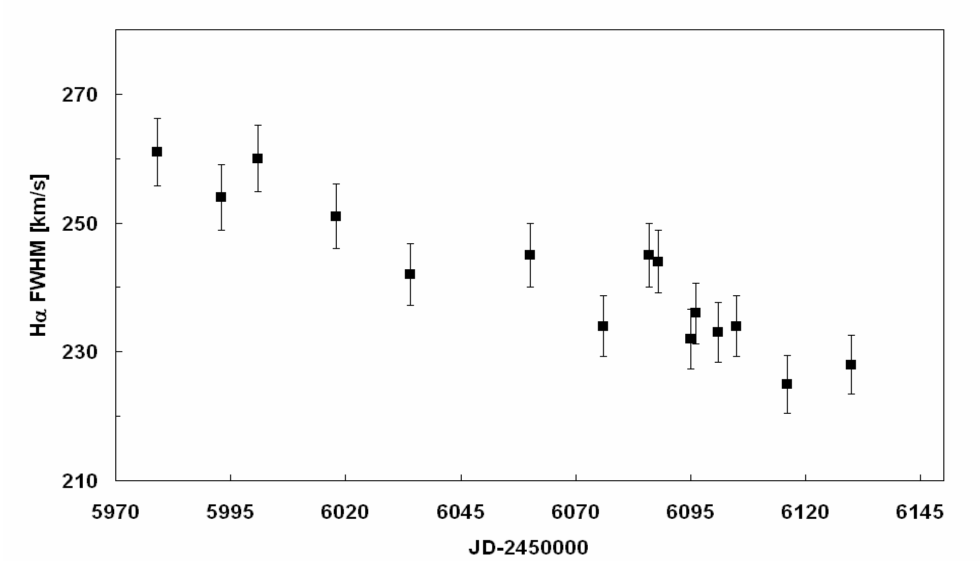
July 2012



Continuation of the Hα-EW monitoring

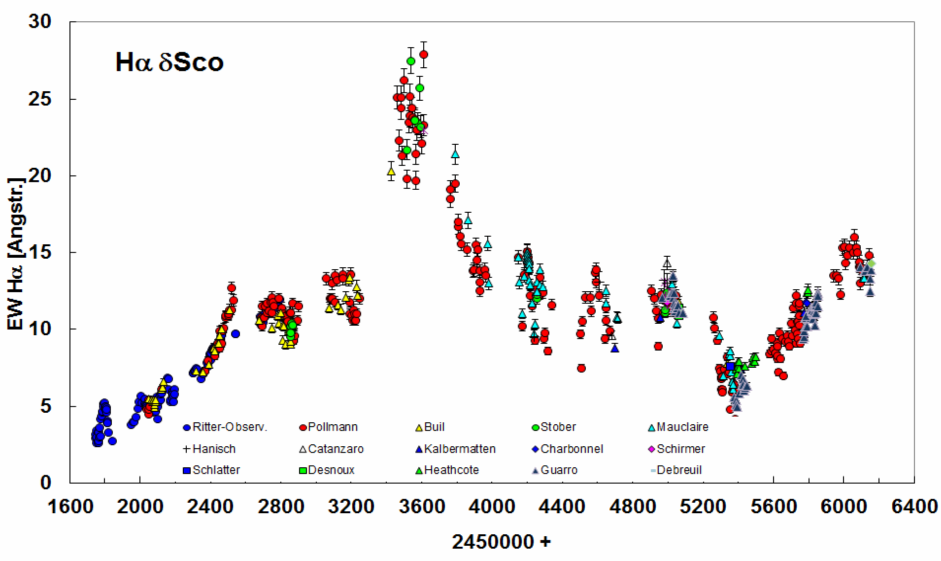


Continuation of the Hα-radial velocity monitoring

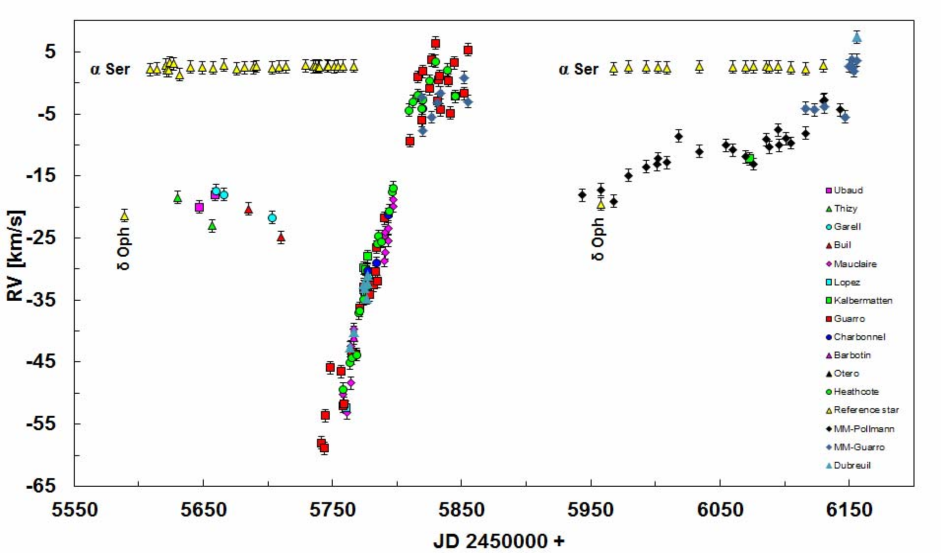


Disk growth leads to decrease of the FWHM velocity

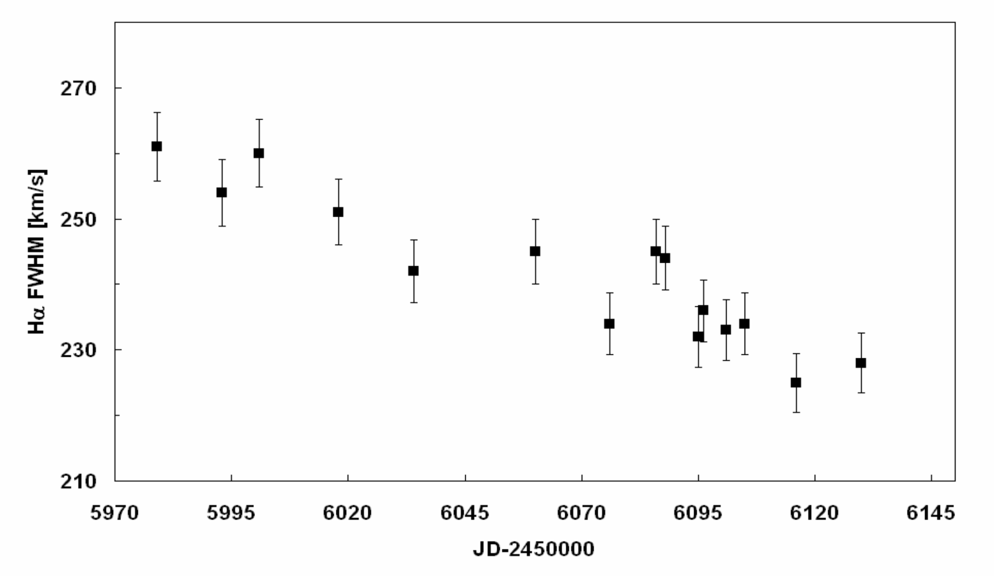
August 2012



Continuation of the Hα-EW monitoring



Continuation of the Hα-radial velocity monitoring



Disk growth leads to decrease of the FWHM velocity