CARMENES target characterisation
Mining public archives for high-resolution spectra of M dwarfs with exoplanets

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Introduction

- **CARMENES target characterisation: mining public archives for high-resolution spectra of M dwarfs with exoplanets**

- 2093 M dwarfs in CARMENCITA database (February 2014). Spectral types from M0 to M9

- 128 UVES spectra of 61 stars in the range 3250-10500 Å

- Aims: the spectral characterisation of the maximum possible number of stars will be essential for CARMENES to discover M dwarfs that are candidates to host exoplanets

Introduction: HARPS & UVES

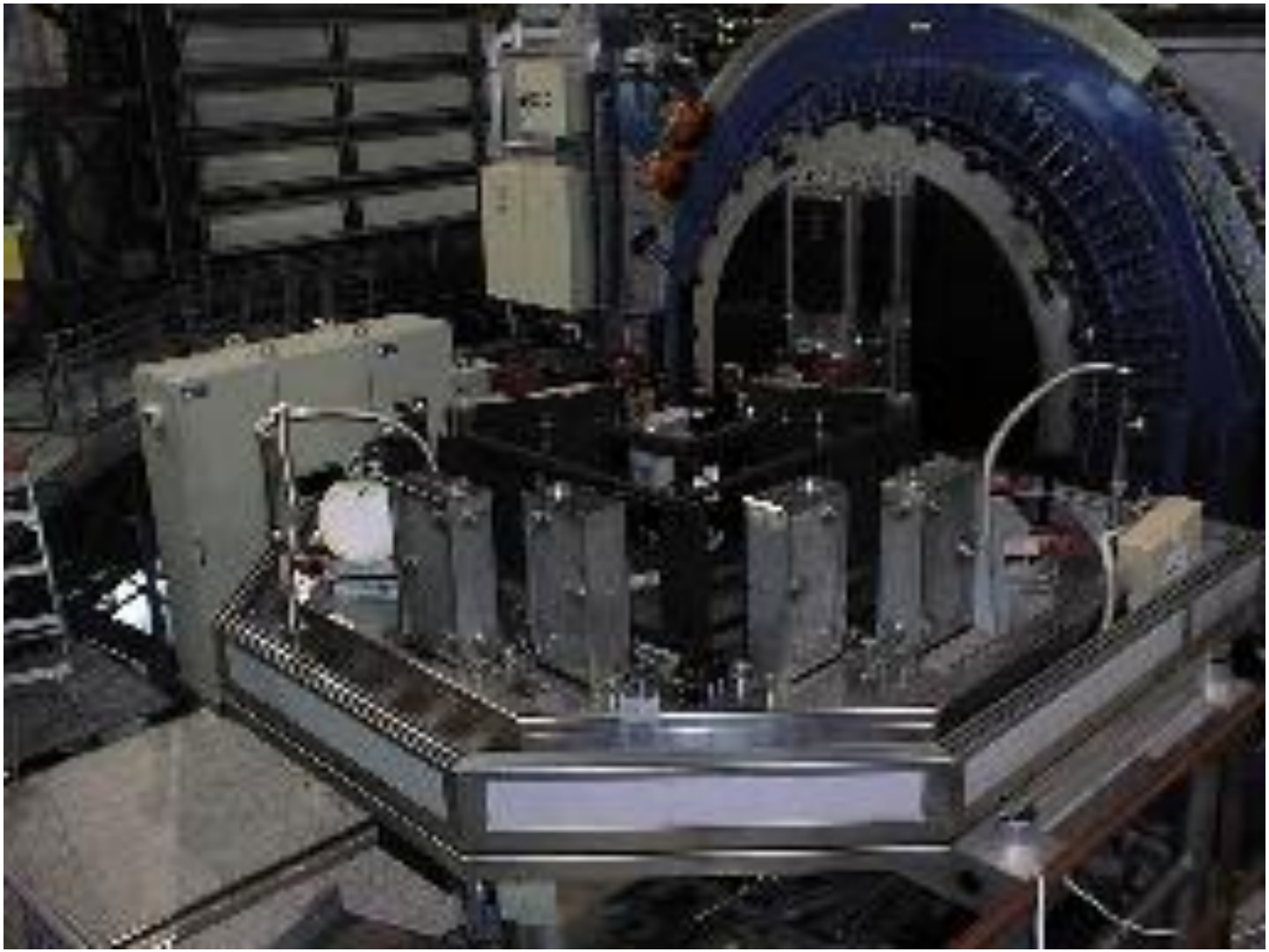
- High-resolution spectrographs

- HARPS (R = 115,000): measurement of radial velocities. Long term radial velocity accuracy. Cassegrain focus of the 3.6 m telescope in La Silla

- UVES (R = 40,000–110,000): optical spectrograph. Two arms: UV to Blue, and Visual to Red. Nasmyth B focus of UT2 telescope in Cerro Paranal

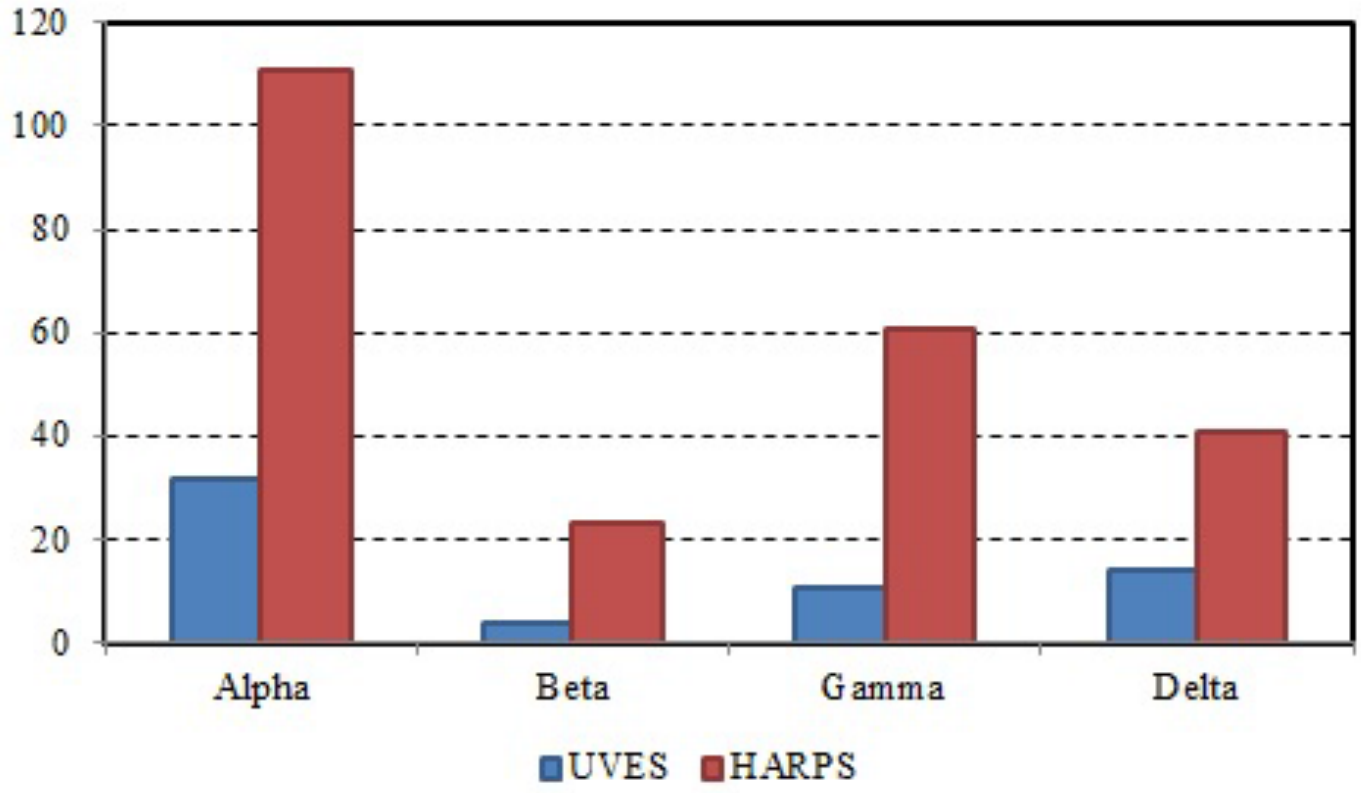
Introduction: HARPS & UVES

Introduction: HARPS & UVES

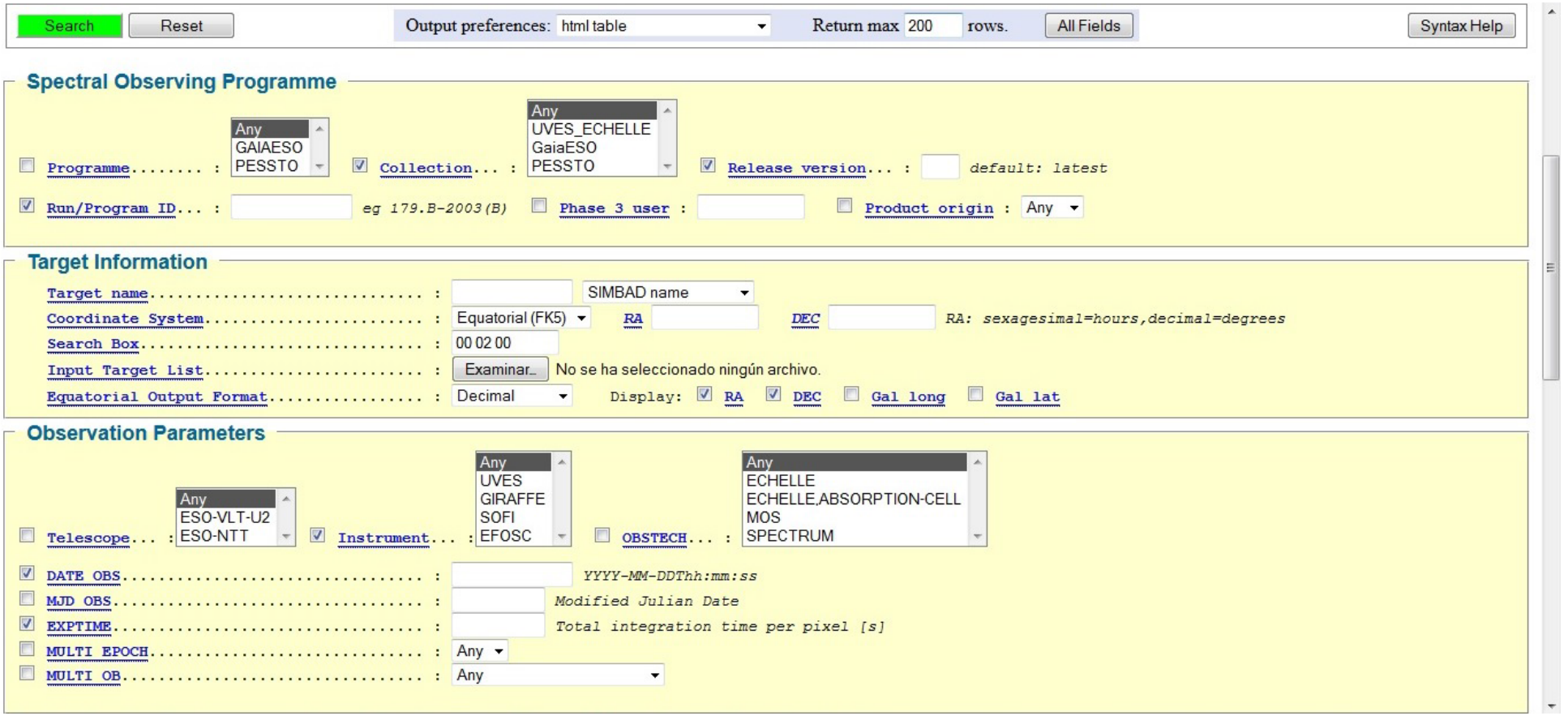


Analysis

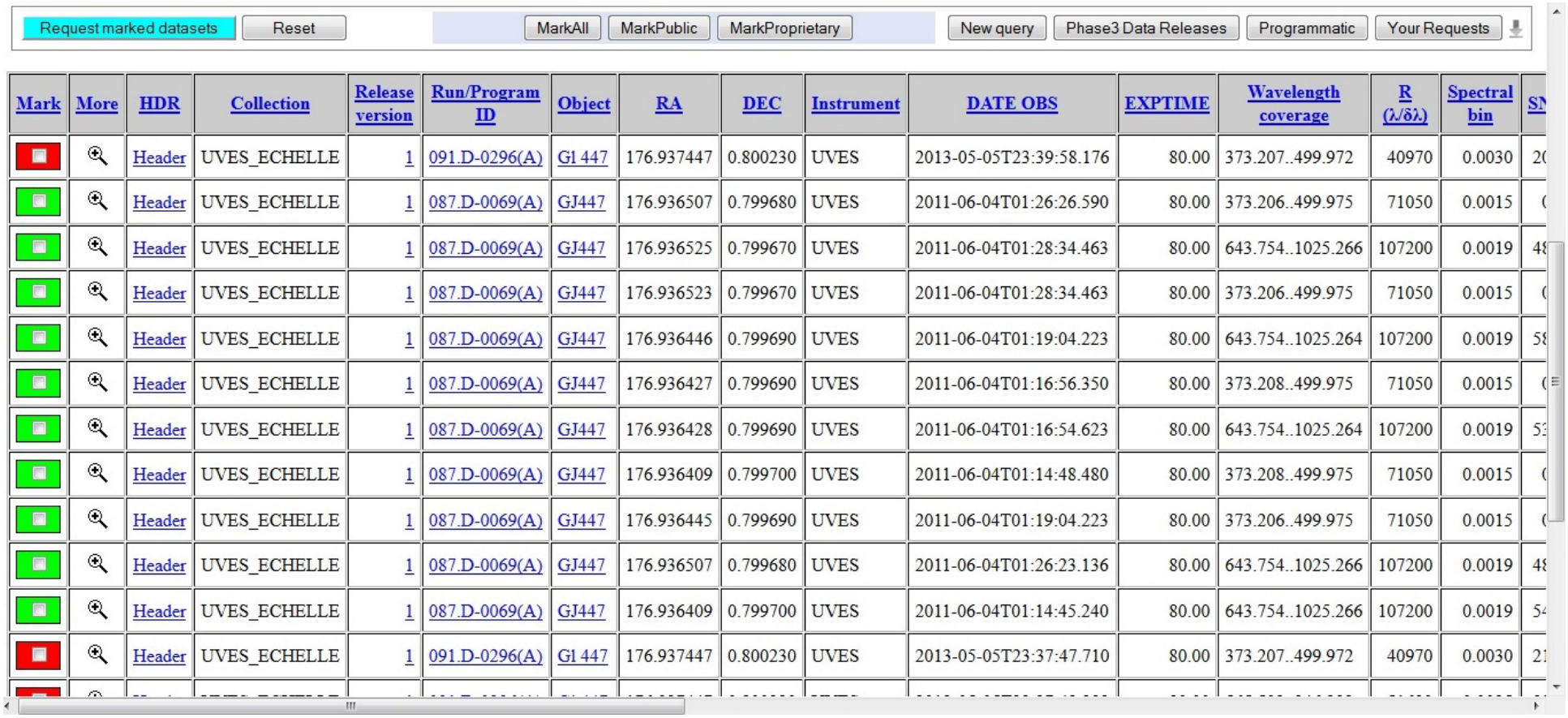
- We have correlated CARMENCITA database stars with HARPS and UVES catalogues. Classification based on priorities (Alpha, Beta, Gamma, Delta)



Analysis: UVES query form



Analysis: UVES query



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Mark	More	HDR	Collection	Release version	Run/Program ID	Object	RA	DEC	Instrument	DATE OBS	EXPTIME	Wavelength coverage	R (λ/δλ)	Spectral bin	SN
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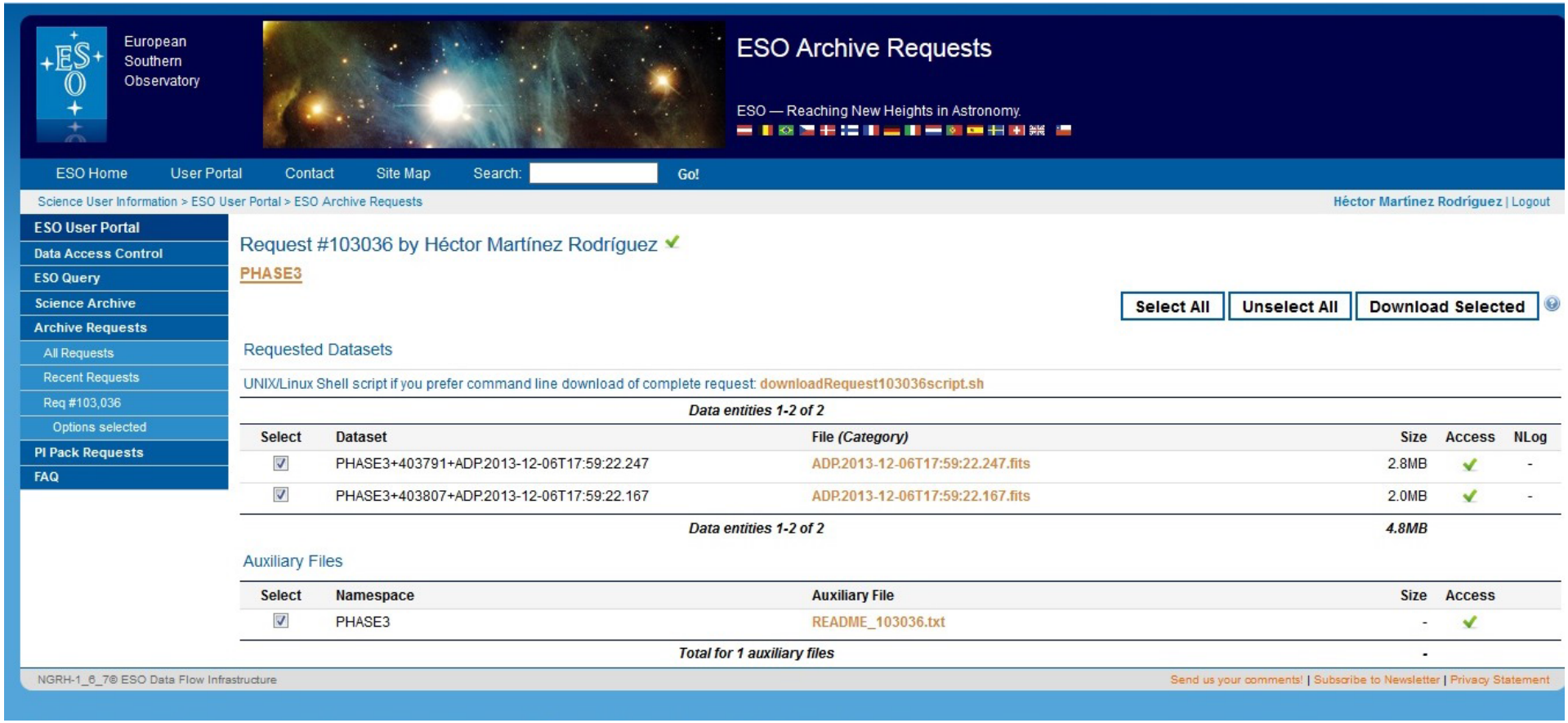
Analysis: UVES data request



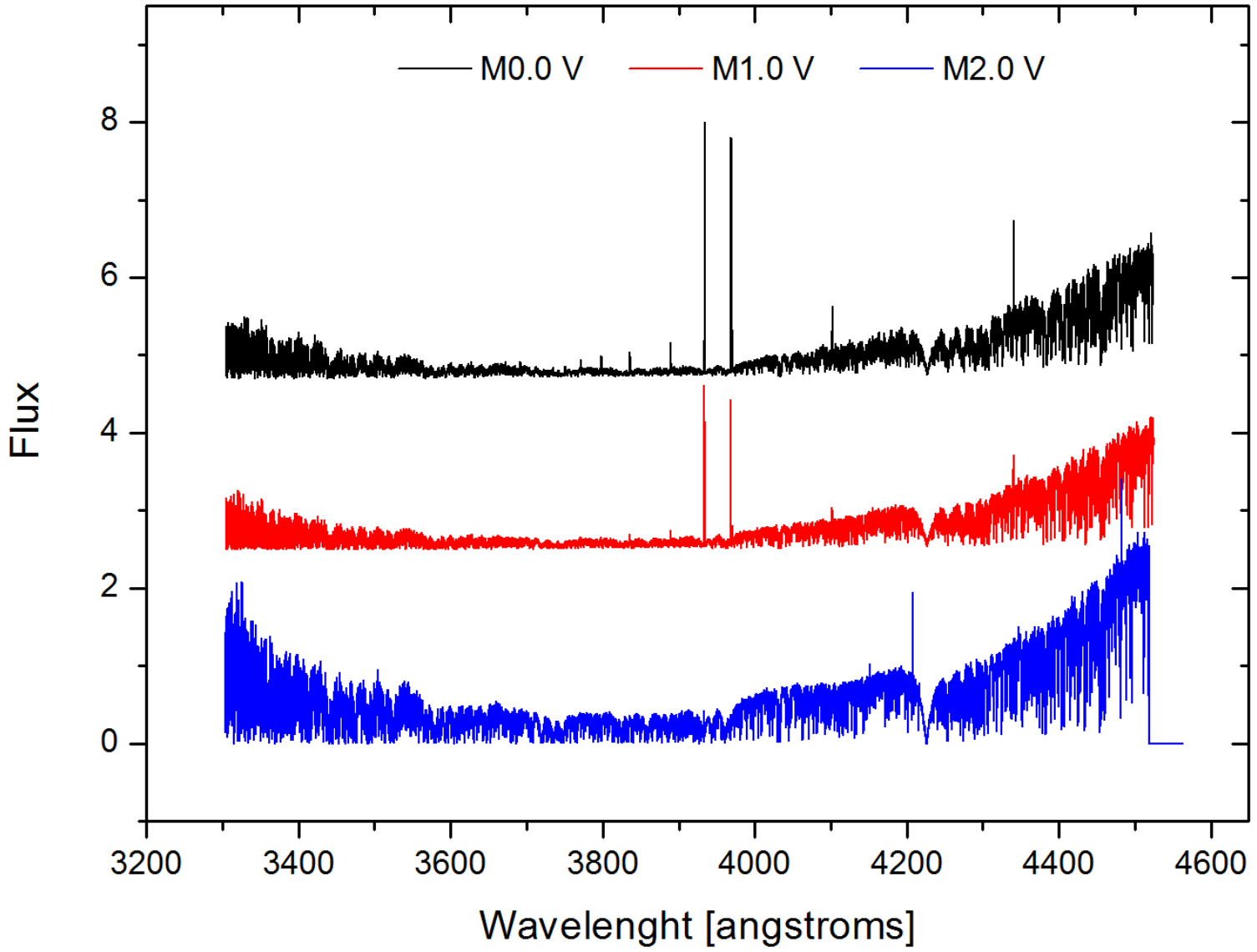
Analysis: UVES spectra

- 12 different channels. 128 spectra (72+7+14+35) of 61 stars (32+4+11+4). 37 spectra should be thrown away (low S/N ratio, cosmic rays, bad quality, primary companions)

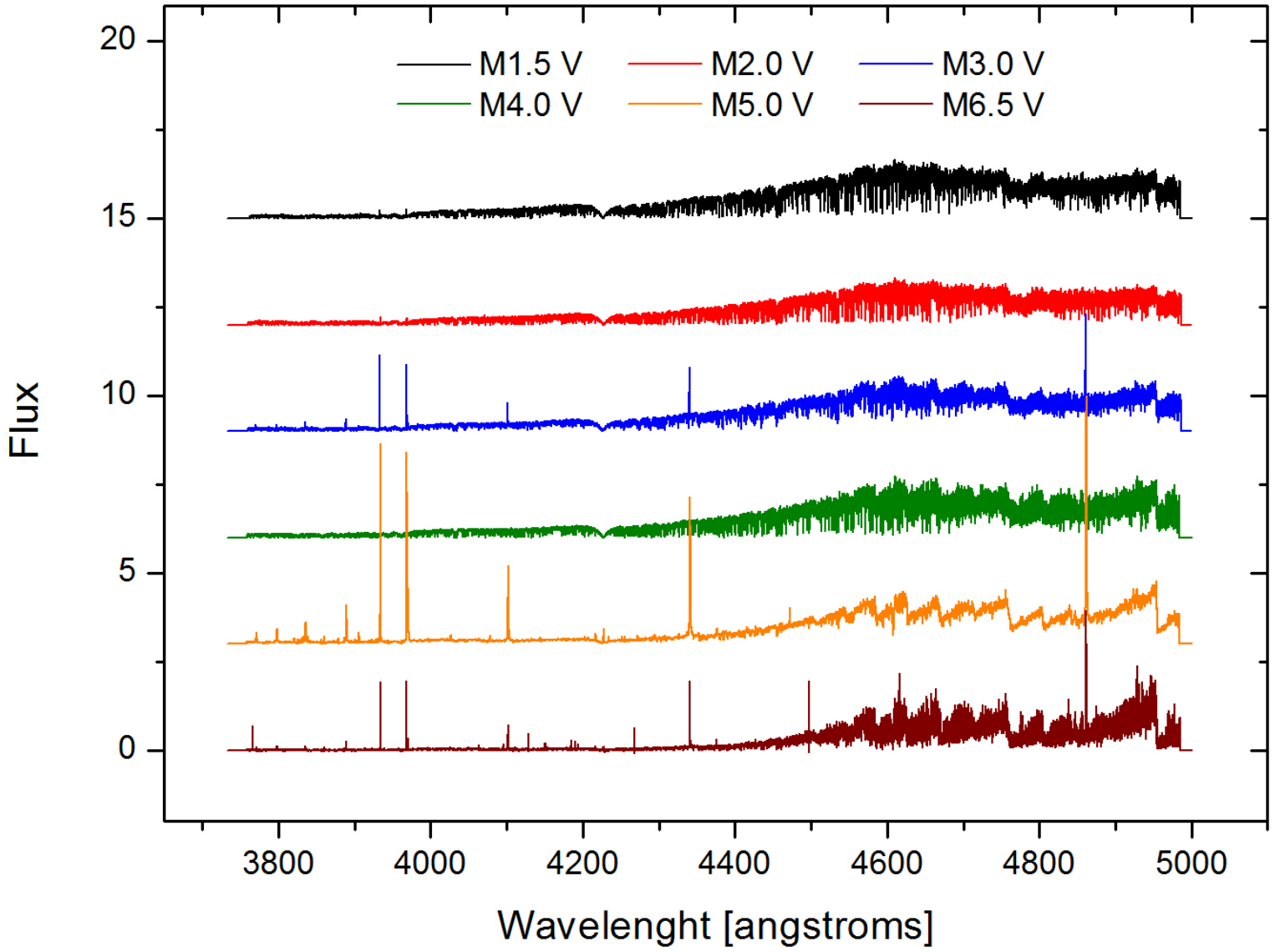
- One-dimension spectra read thanks to IRAF

- We have measured pseudo-equivalent widths (*pEW*s) of lines in absorption and emission and rotational velocities thanks to these spectra

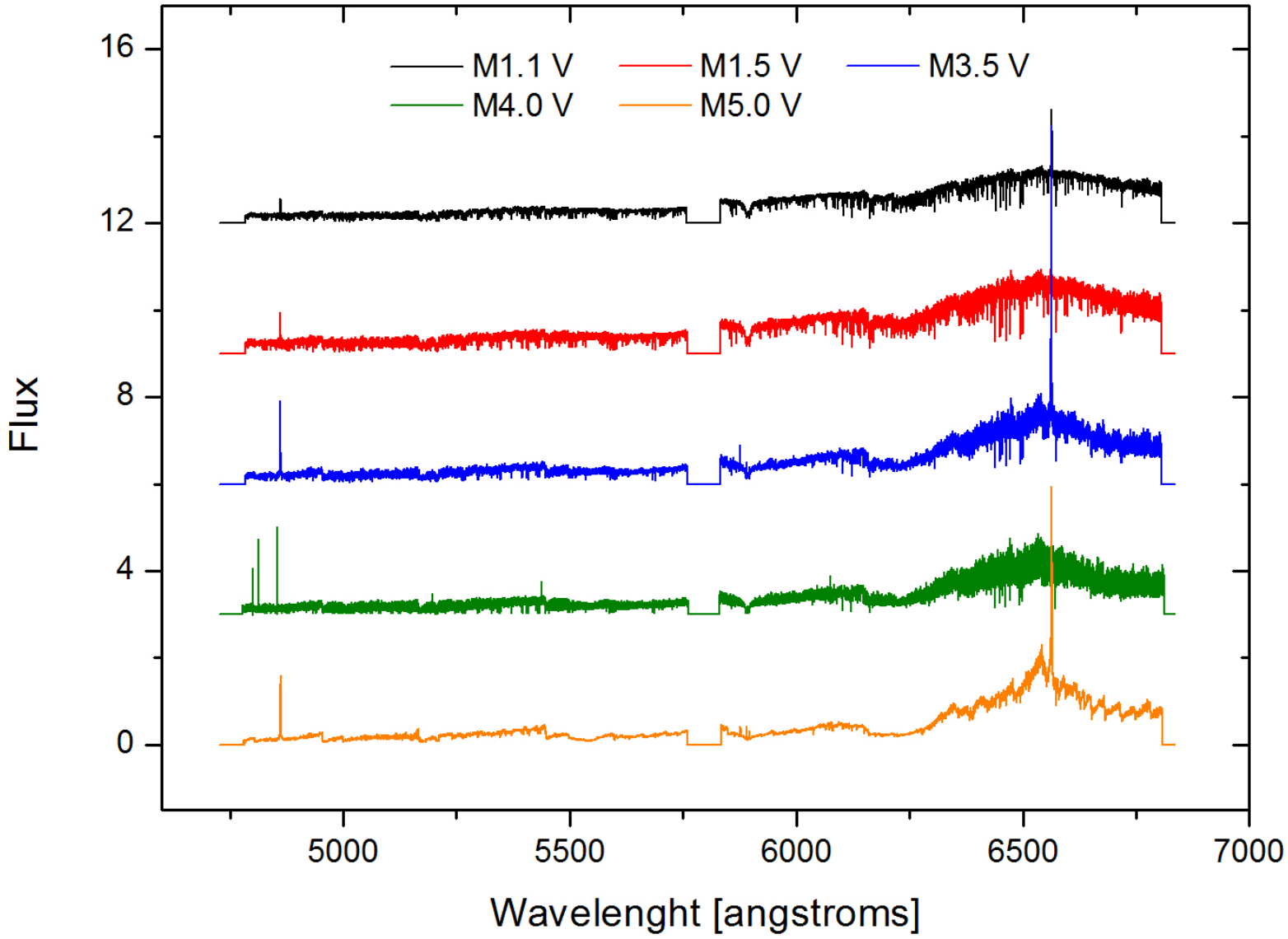
Analysis: UVES spectra BLU390



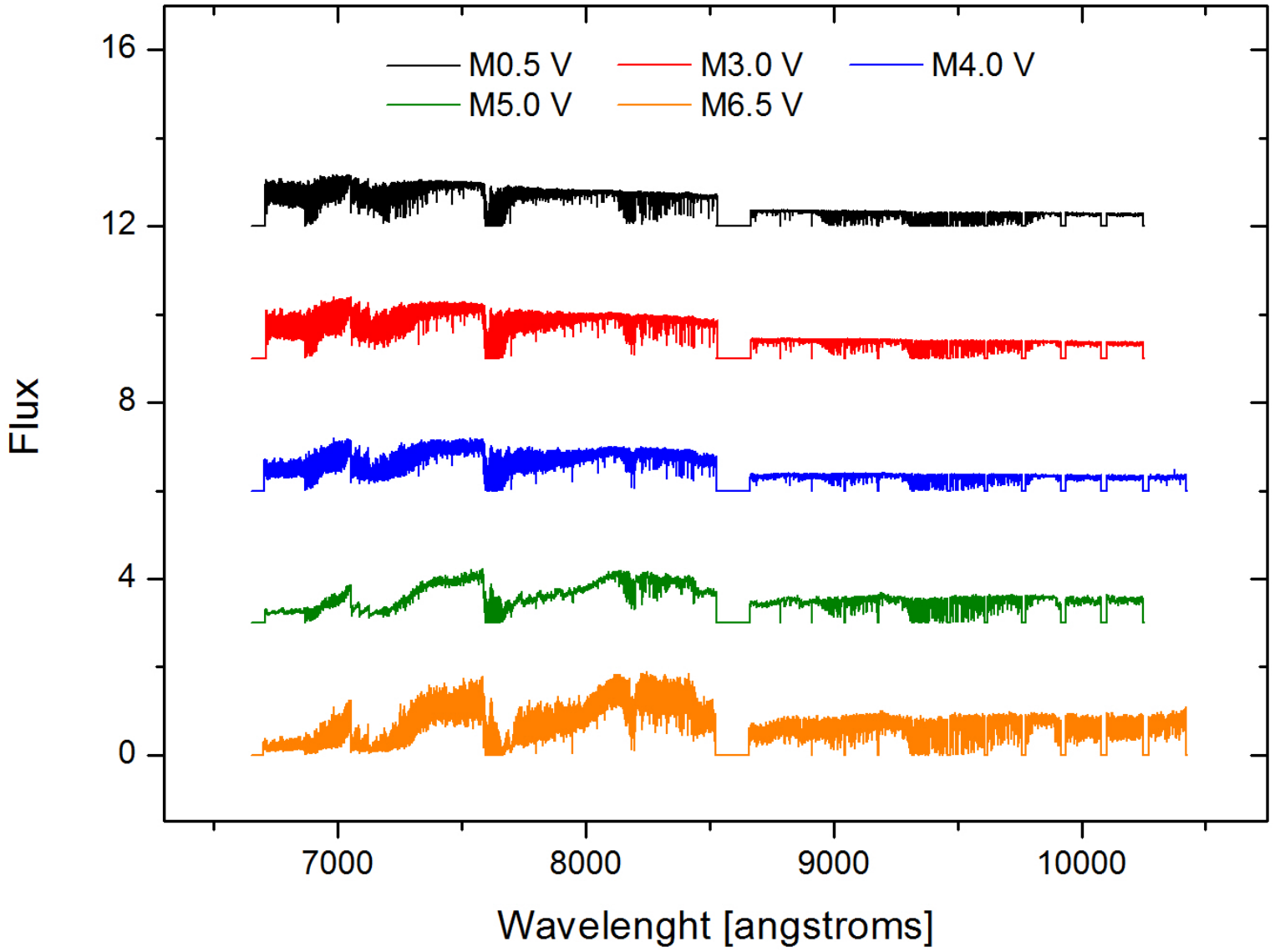
Analysis: UVES spectra BLU437



Analysis: UVES spectra RED580



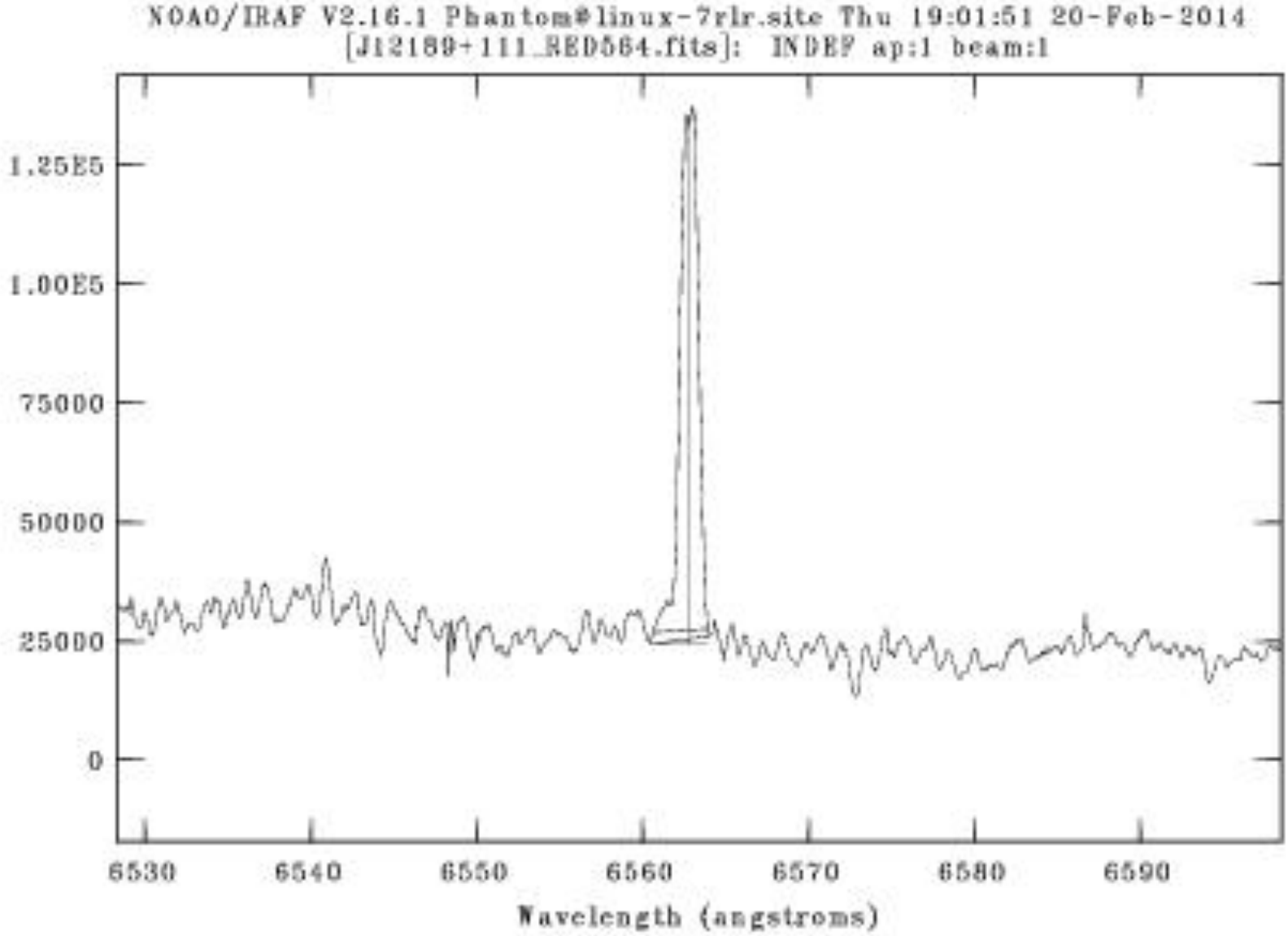
Analysis: UVES spectra RED860



Analysis: *pEWs*

- Balmer series: Hα, Hβ, Hγ, Hδ, Hε, Hζ, Hη
- He $_{I}$ D_3 , Na $_{I}$ D_1&D_2 , Ca $_{II}$ H&K lines
- Positive values for absorption lines and negative values for emission lines
- **`splot`** task, integration with **`e`** (small vertical movements along the lines centres)
- Final *pEW* values: arithmetic mean of three measurements and standard deviation as the statistical error

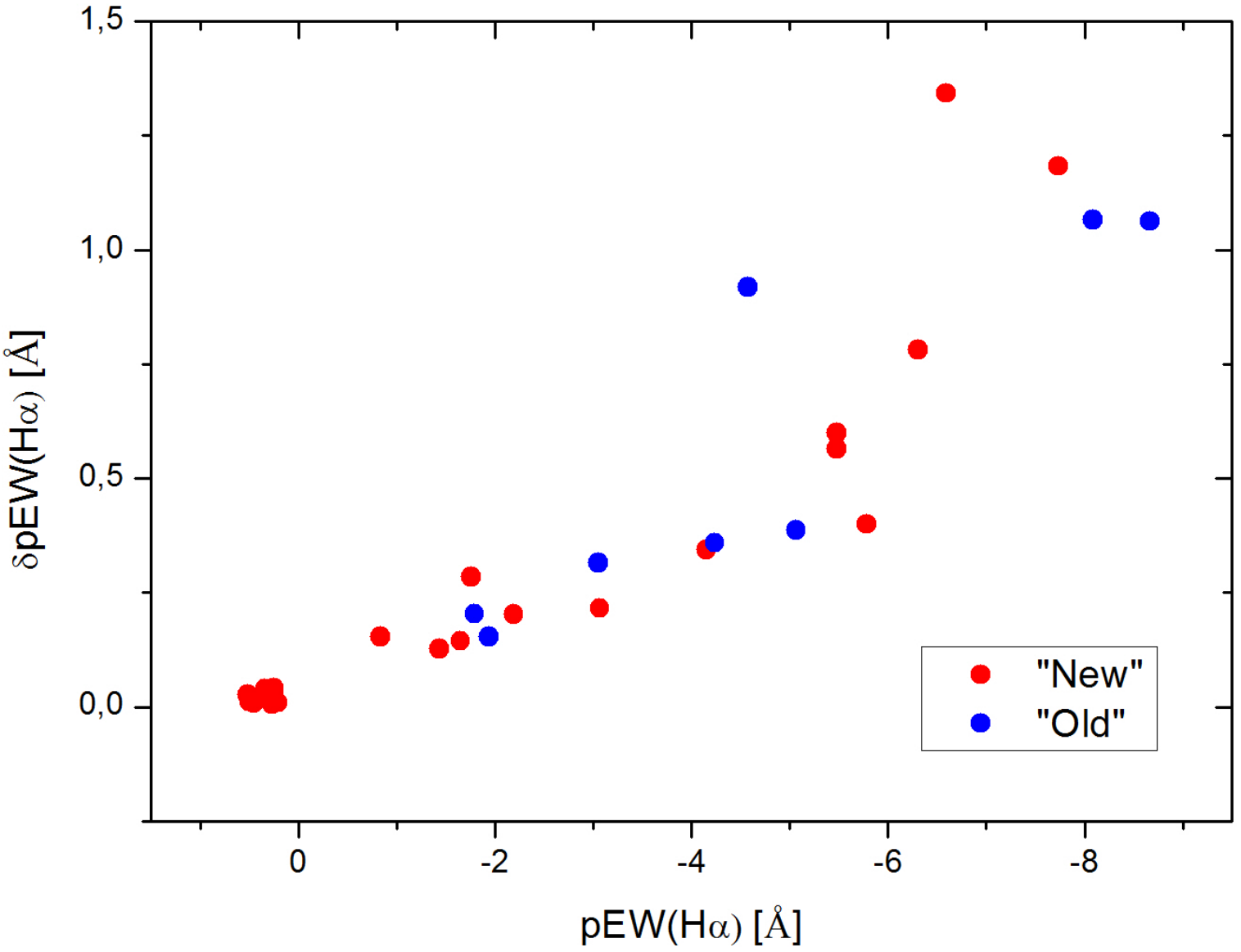
Analysis: *pEWs*



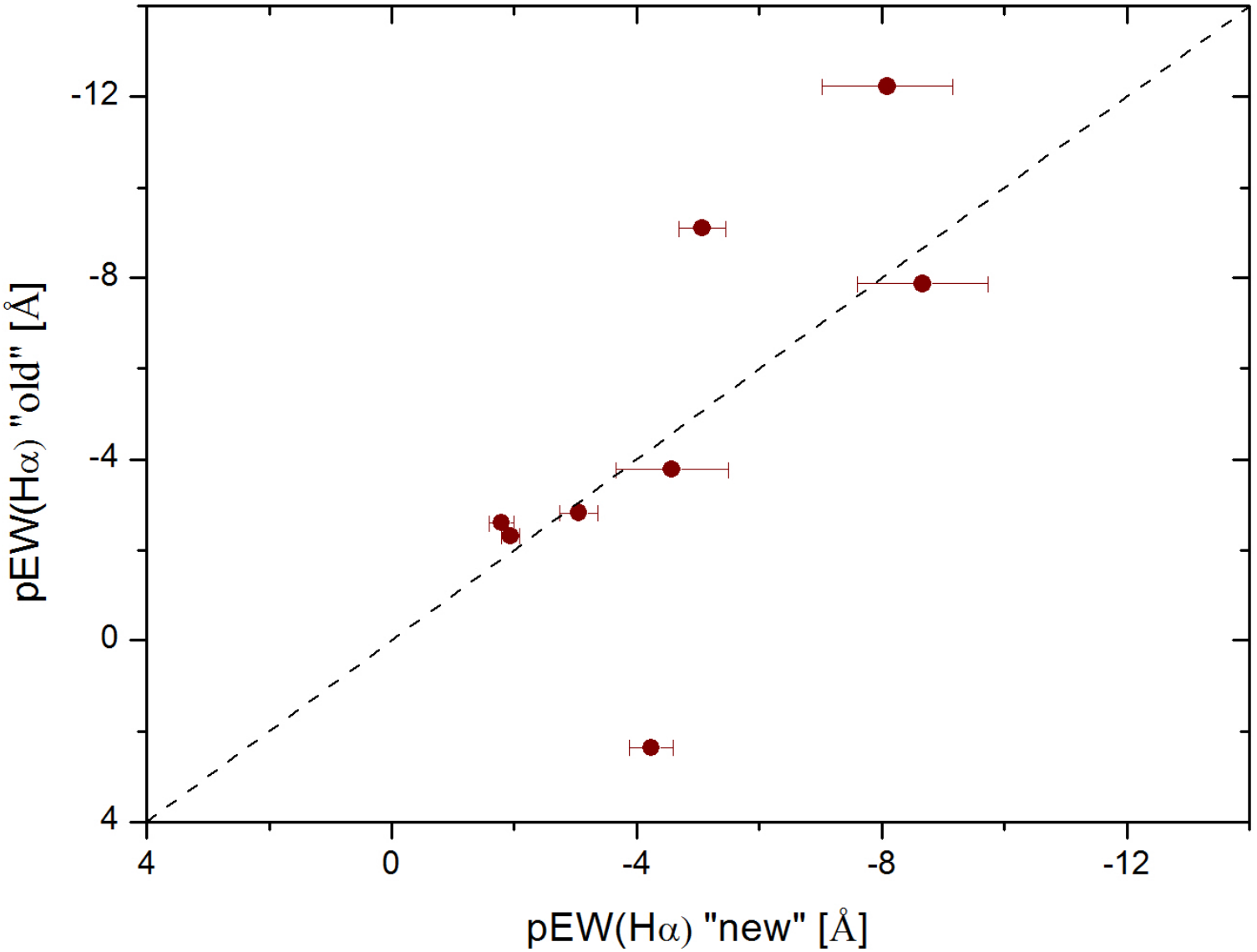
Analysis: Hα line

- *pEW*(Hα) values will help us to find both low- and high-activity stars
- 37 values for 35 stars
- 8 values already present in CARMENCITA ("old")

Analysis: Hα line



Analysis: Hα line



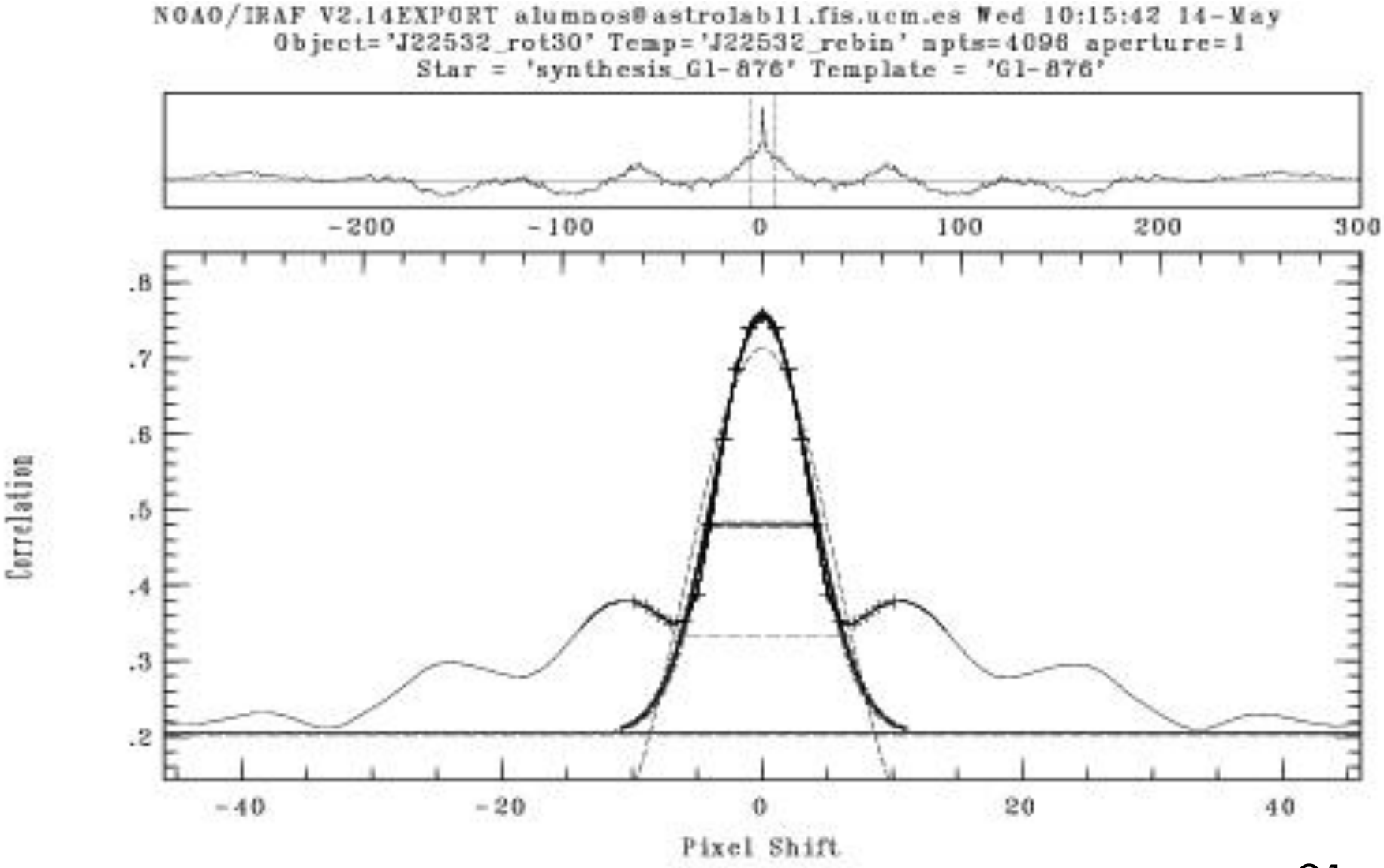
Analysis: rotational velocities

- The rotation of an M dwarf is closely related to its chromospheric activity: the faster the star rotates, the more active it is

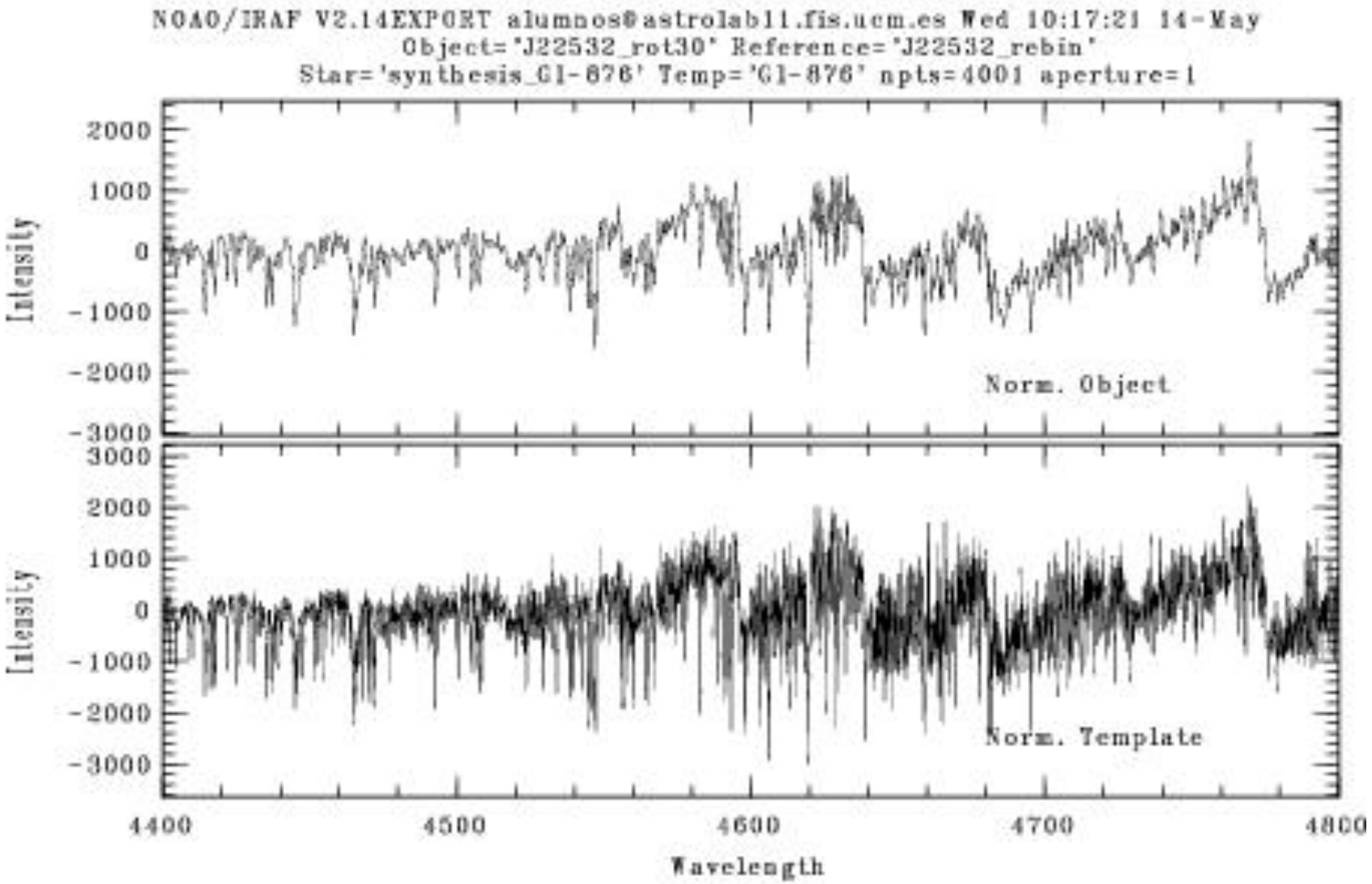
- Typically, M dwarfs rotational velocities are located in the range 2-30 km/s

- Cross-correlation profiles with IRAF (**`fxcor`**) to calculate $v \sin i$

Analysis: rotational velocities



Analysis: rotational velocities



Analysis: rotational velocities

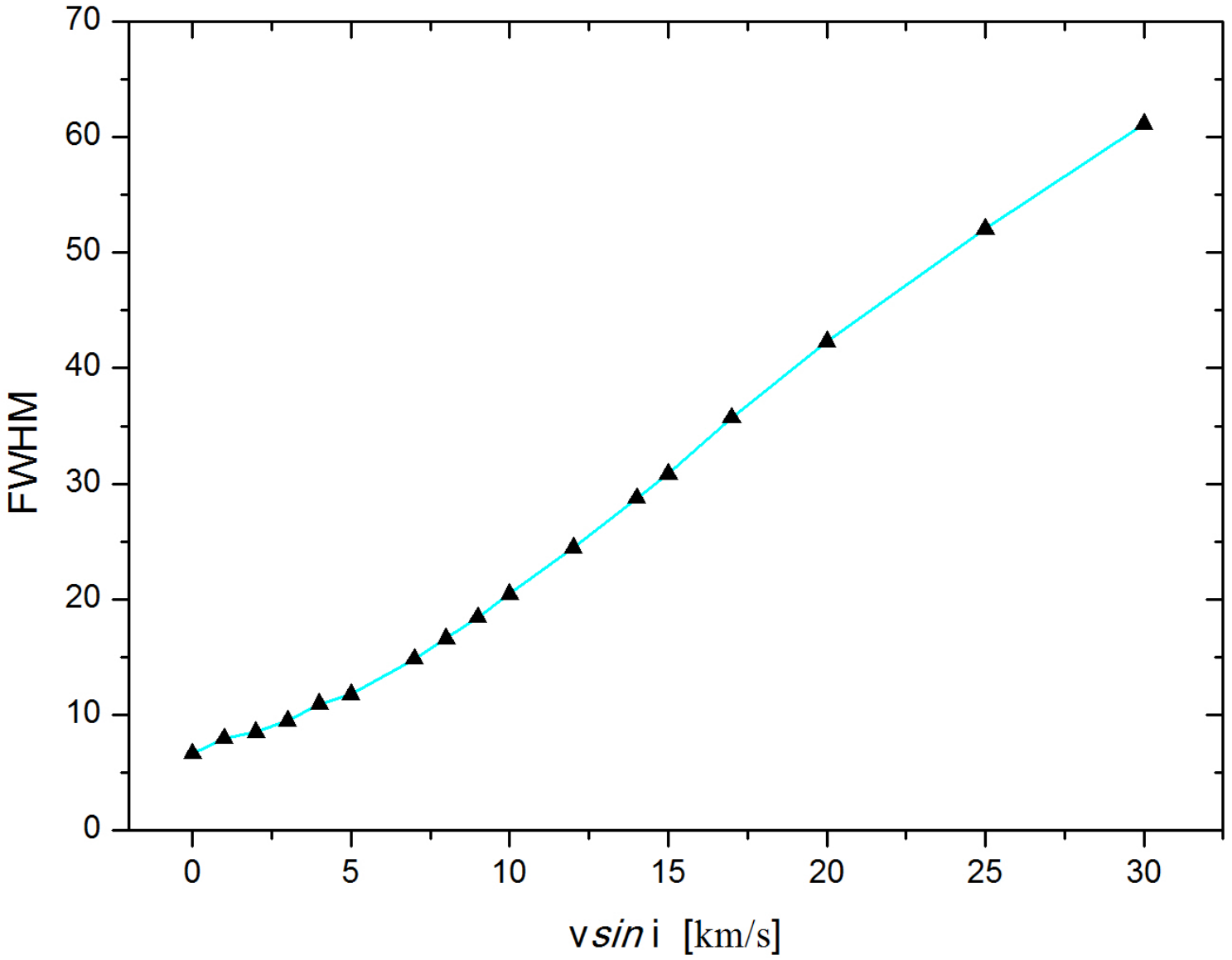
- We need "template" stars with low rotation with which to compare the problem stars

- We have found low-rotation stars in our sample taking the ones with Hα absorptions: 7 template stars

- Wavelength range: BLU437, RED564 and RED580 channels

- Spectra broadened using the program **`starmod`** to build calibration curves (FWHM vs $v \sin i$)

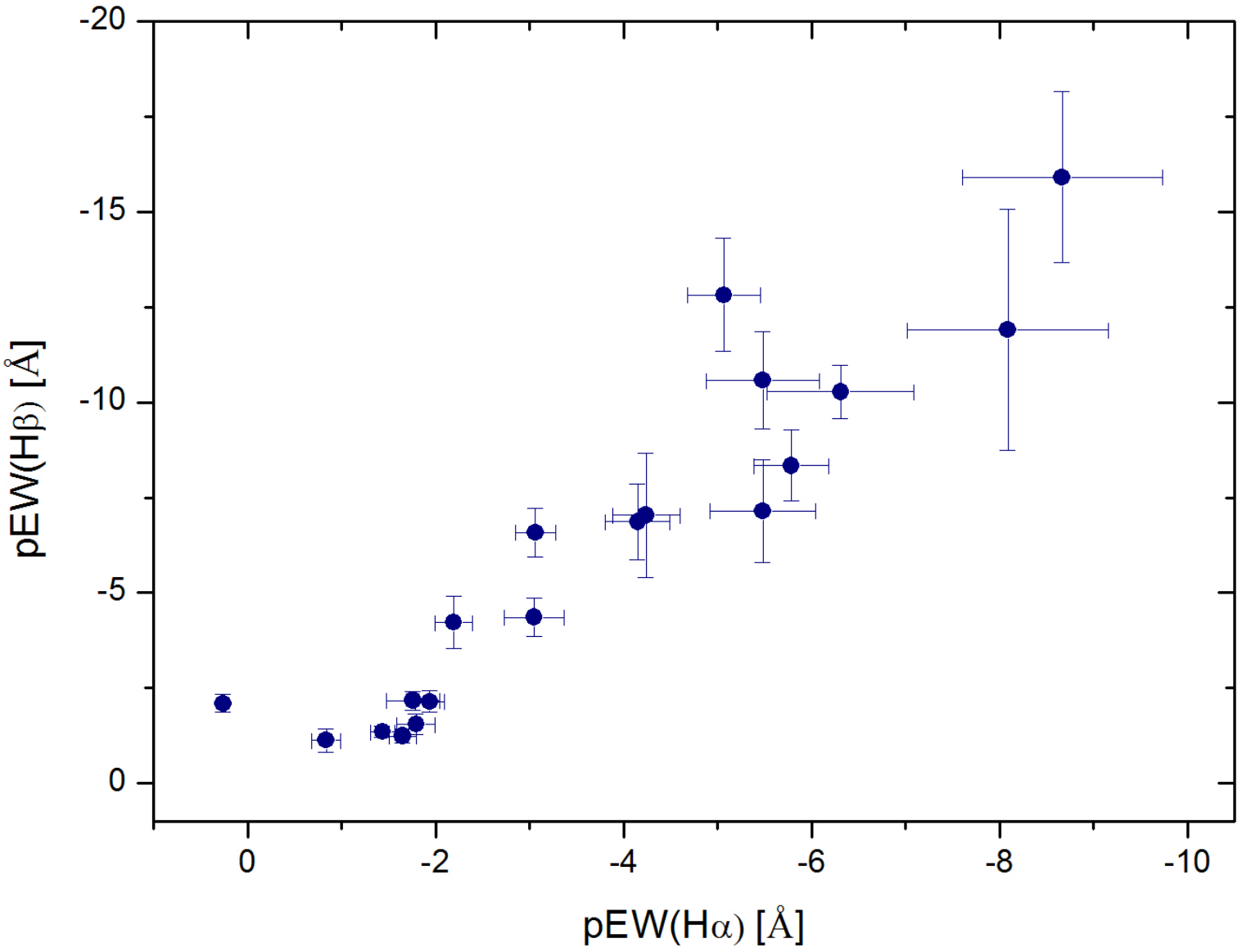
Analysis: rotational velocities



Results: *pEWs* vs *pEW*(Hα)

- Linear fits for all the *pEW* values
- The only fit that approaches to a straight line corresponds to Hζ line ($R^2 = 0.8741$)
- Pearson coefficients for He, Na and Ca fits are very low, although there exists a tendency
- In most of the cases there are few stars that get out of the linear fits (probably caused by flares)

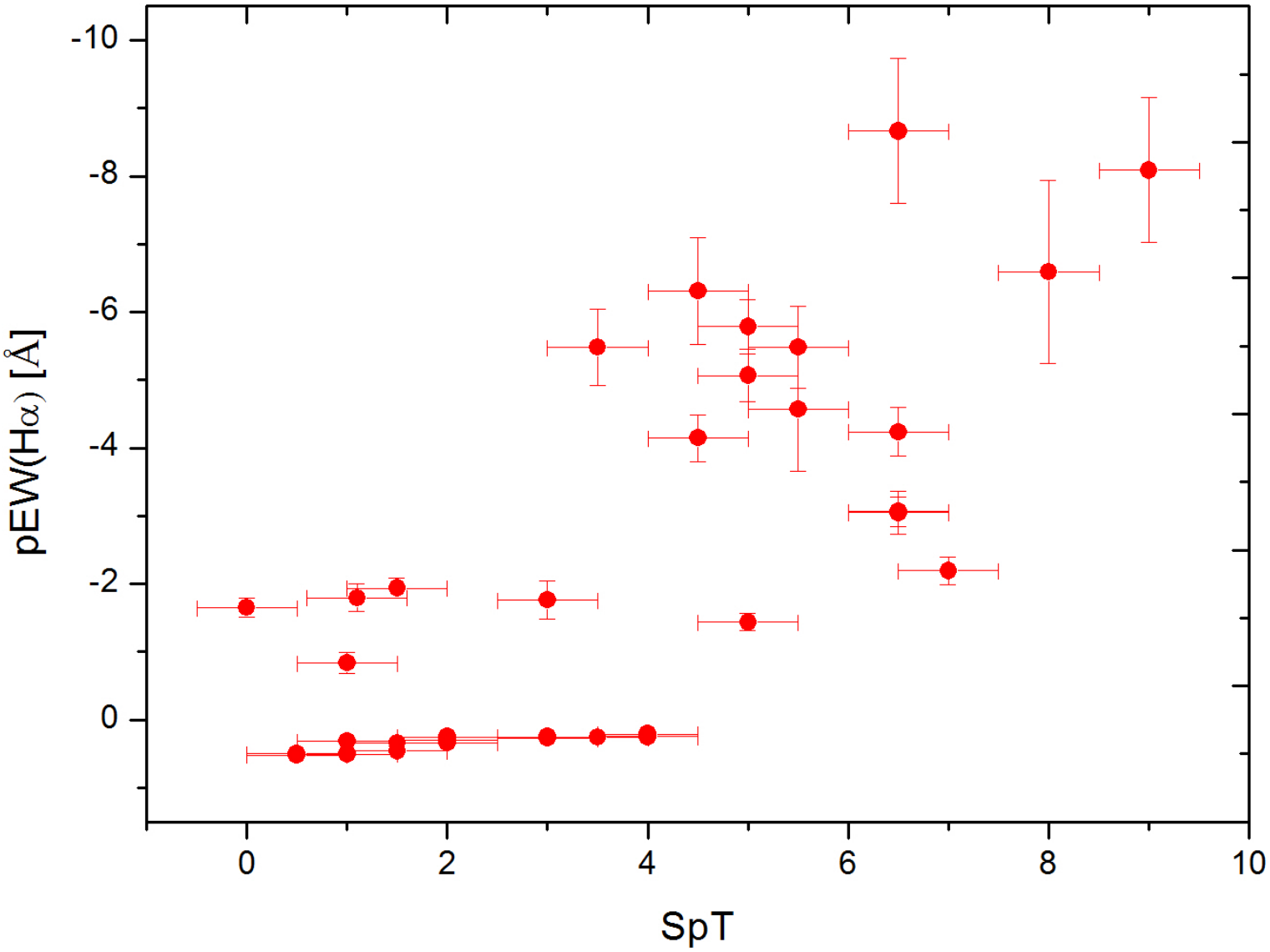
Results: *pEWs* vs *pEW*(Hα)



Results: *pEWs* vs spectral types

- Low-activity stars are usually the early-type ones
- High-activity stars are usually the late-type ones
- Again, we have found some stars that probably present flares

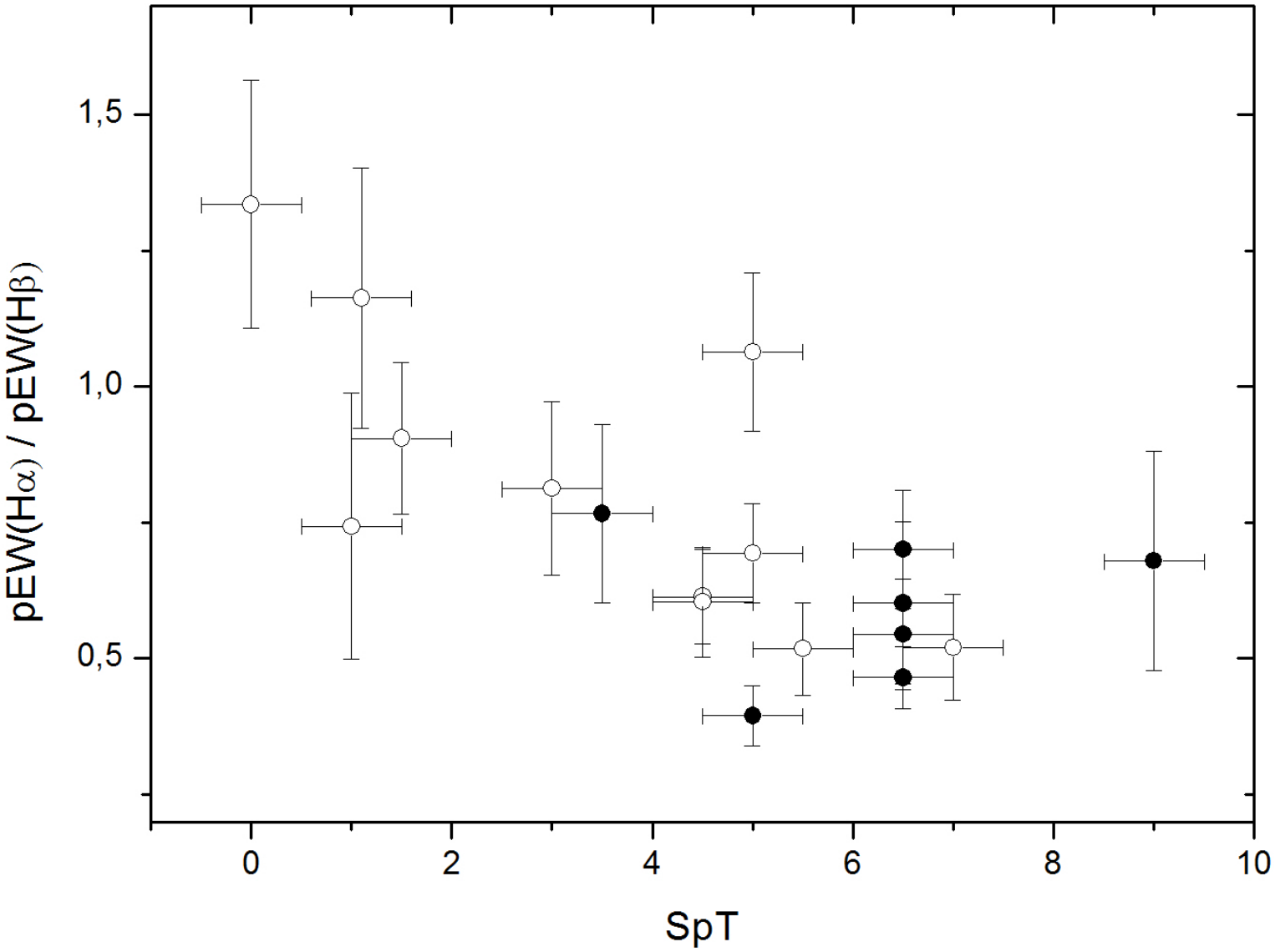
Results: *pEWs* vs spectral types



Results: flares

- 8 stars that likely present flares
- Balmer decrement *pEW*(Hα)/*pEW*(Hβ)
- Relatively low in the case of flares

Results: flares



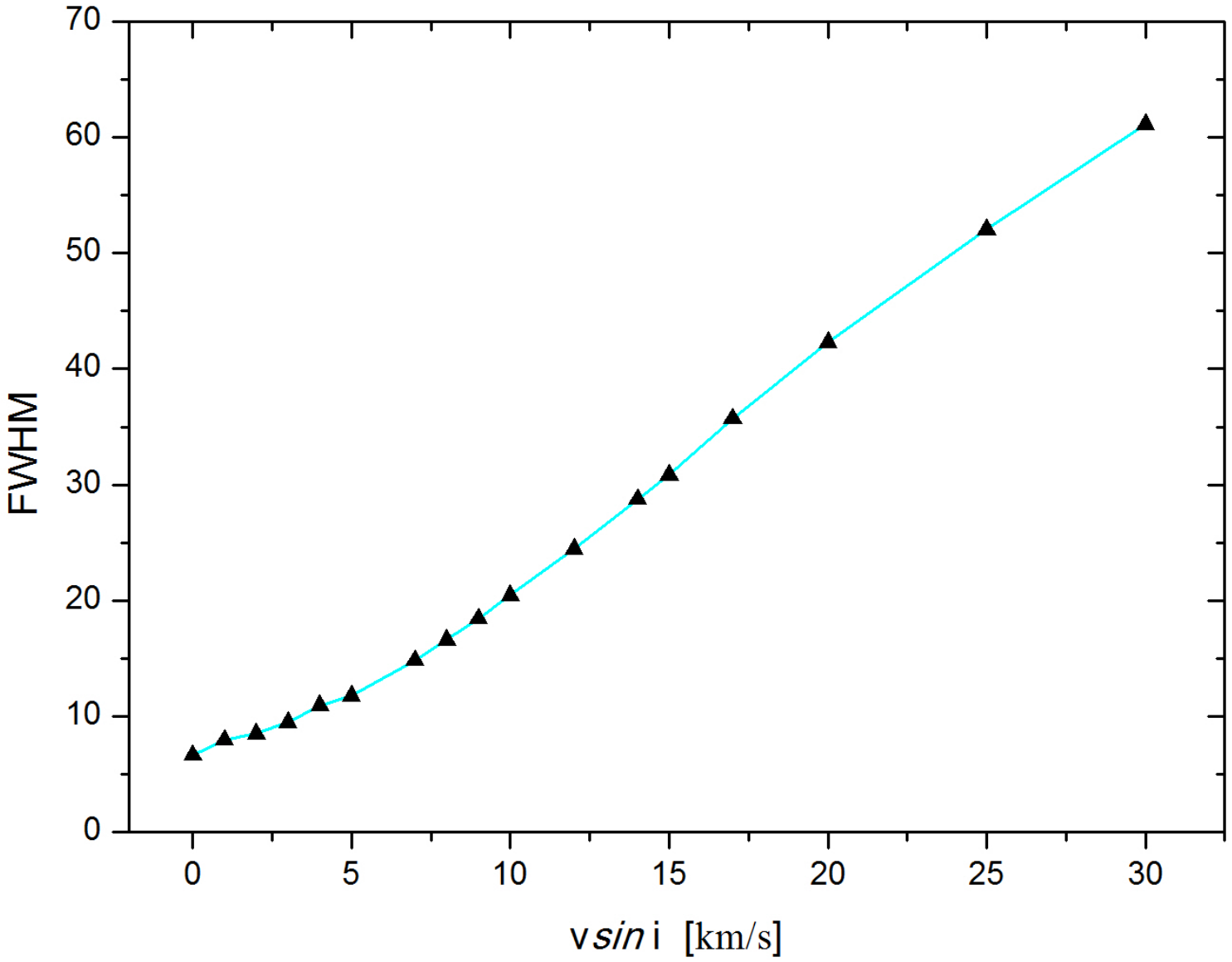
Results: values of $v \sin i$

- $v \sin i$ values for 24 stars. 17 stars have a registered value in CARMENCITA database

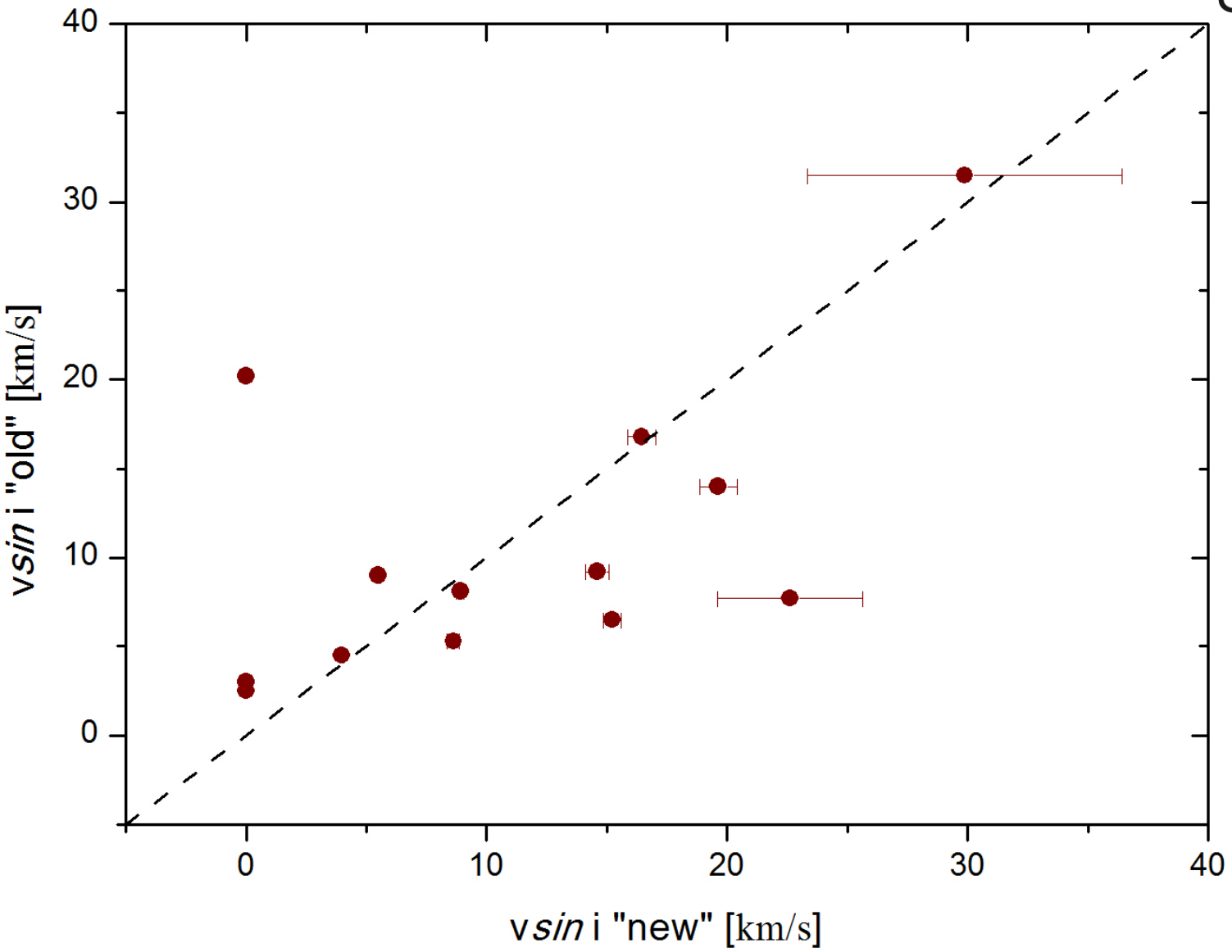
- Narrow profiles: for 8 stars, including our templates, we have obtained $v \sin i = 0^*$. Lower limit close to 2-3 km/s

- In general, our results differ very little from the ones of CARMENCITA. There is a remarkable discrepancy for one star (one of our templates)

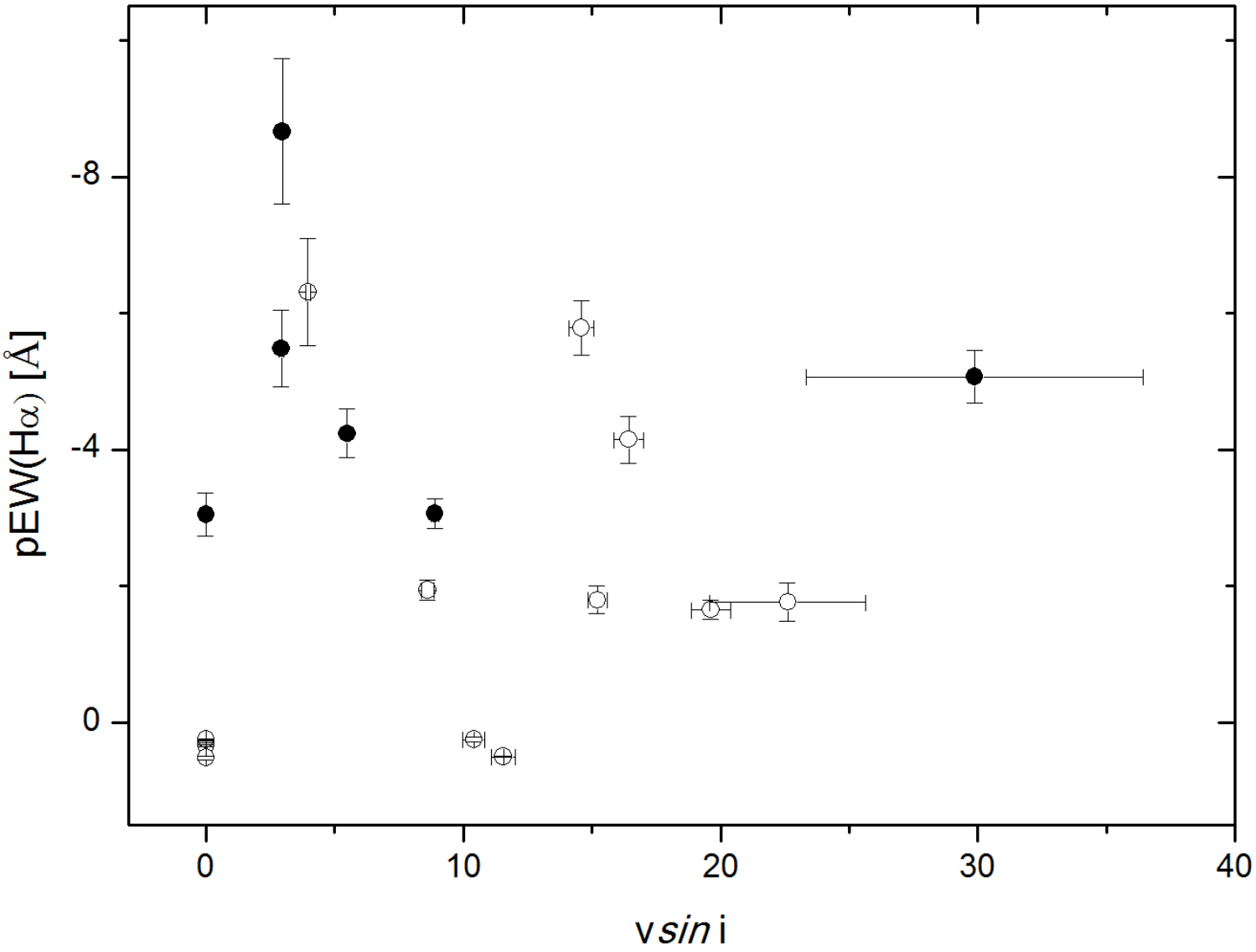
Results: values of $v \sin i$



Results: values of $v \sin i$



Results: *pEW*(Hα) vs $v \sin i$



Conclusions

- 128 UVES spectra for 61 stars
- *pEW*(Hα) for 35 stars with 27 new values
- $v \sin i$ for 24 stars with 7 new values
- We have found both low- and high-activity stars. The first ones are interesting for CARMENES (radial velocity profiles)

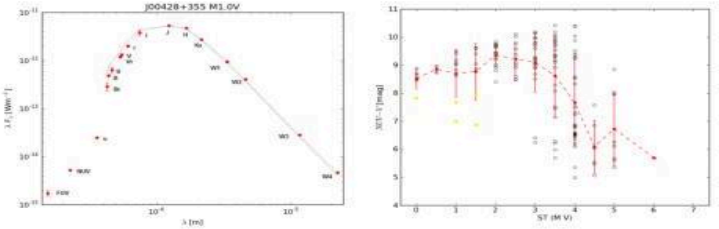
Preparation of the carmenes Input Catalogue

Mining public archives for stellar parameters and spectra of M dwarfs with master thesis students

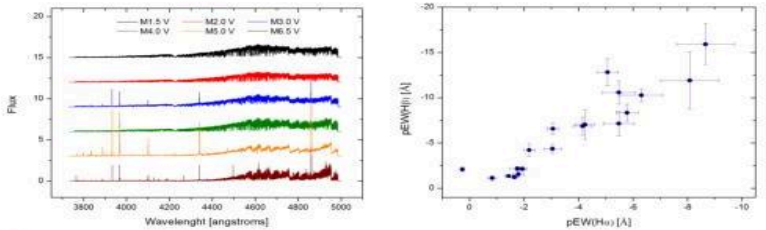
D. Montes[8], J. A. Caballero[10], F. J. Alonso-Floriano[8], M. Cortés-Contreras[8], E. González-Álvarez[8], D. Hidalgo[8], G. Holgado[8], H. Martínez-Rodríguez[8], J. Sanz-Forcada[10] and the CARMENES Consortium[1,2,3,4,5,6,7,8,9,10,11] (http://carmenes.caha.es/)

[1]Max-Planck-Institut für Astronomie • [2]Instituto de Astrofísica de Andalucía • [3]Landessternwarte Königstuhl • [4]Institut de Ciències de l'Espai • [5]Institut für Astrophysik Göttingen • [6]Instituto de Astrofísica de Canarias • [7]Thüringer Landessternwarte Tautenburg • [8]**Universidad Complutense de Madrid** • [9]Hamburger Sternwarte • [10]Centro de Astrobiología • [11]Centro Astronómico Hispano-Alemán – Calar Alto Observatory

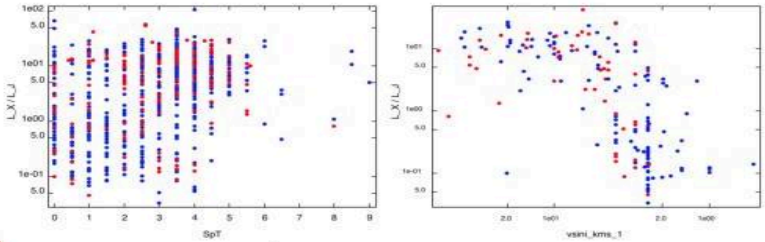
We are compiling the most comprehensive database of M dwarfs ever built, CARMENCITA, the **CARMENES Cool dwarf Information and daTa Archive**, which will be the CARMENES 'input catalogue'. In addition to the science preparation with low- and high-resolution spectrographs and lucky imagers (see the other posters at Cool Stars 18), we compile a huge pile of public data on over 2100 M dwarfs, and analyze them, mostly using virtual-observatory tools. Here we describe four specific actions carried out by *master students*. They mine public archives for additional high-resolution spectroscopy (UVES, FEROS and HARPS), multi-band photometry (*FUV-NUV-u-B-g-V-r-R-i-J-H-Ks-W1-W2-W3-W4*), X-ray data (*ROSAT*, *XMM-Newton* and *Chandra*), and periods, rotational velocities and Hα pseudo-equivalent widths. As described, there are many interdependences between all these data.



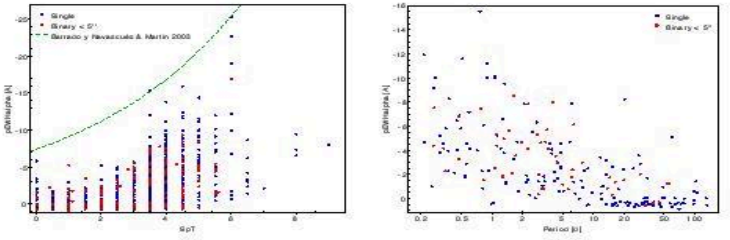
Photometry. *Holgado* compiled photometric data from *GALEX*, SDSS, Tycho-2, UCAC4, CMC14, 2MASS and *WISE* archives for constructing cleansed spectral energy distributions of 158 CARMENCITA stars (*left panel*: SED of FF And) and studying colour-colour relations of 361 bright, late-type, single M dwarfs that surpasses previous works. He also quantified the ultraviolet-excess emission and identified active early M dwarfs (*right panel*: *NUV-FUV* vs. spectral type).



High-resolution spectroscopy. *Martínez-Rodríguez* downloaded 128 UVES spectra of 61 CARMENCITA stars in eight channels (*left panel:* BLU437) and measured pseudo-equivalent widths of Hα−η, Ca II H&K, Na I D1&2 and He I D3. He measured *pEW*(Hα) of 27 M dwarfs for the first time and studied its relation to other lines in emission (right panel: *pEW*(Hβ) vs. *pEW*(Hα)). He also measured *vsini* of 24 stars (7 new) and identified wrong values published in the literature.



X-ray emission. *González-Álvarez* added new X-ray count-rate and hardness-ratio data of 188 M dwarfs to CARMENCITA. She calculated X-ray fluxes and luminosity ratios L_X/L_J for 770 stars in total and investigated its variation with spectral type (*left panel*) and rotational velocity (*right panel*). She corroborated with a large sample that close binaries (red dots) are more active than single stars and that X-ray saturation starts at *vsini* ≈ 5 km/s.



Rotation and activity. *Hidalgo* ransacked dozens of publications and compiled photometric periods for 217 CARMENCITA stars, rotational velocities for 420, pEW(Hα)s for 1766, and membership in young moving groups for 44. He studied the relation between spectral type, Hα activity (*left panel*), close multiplicity, periods (*right panel*) and *vsini*, from where he identified three stars with inclination angles *i* =79.3 to 81.6 deg: DT Vir AB, BD-21 1074 A and FF And.

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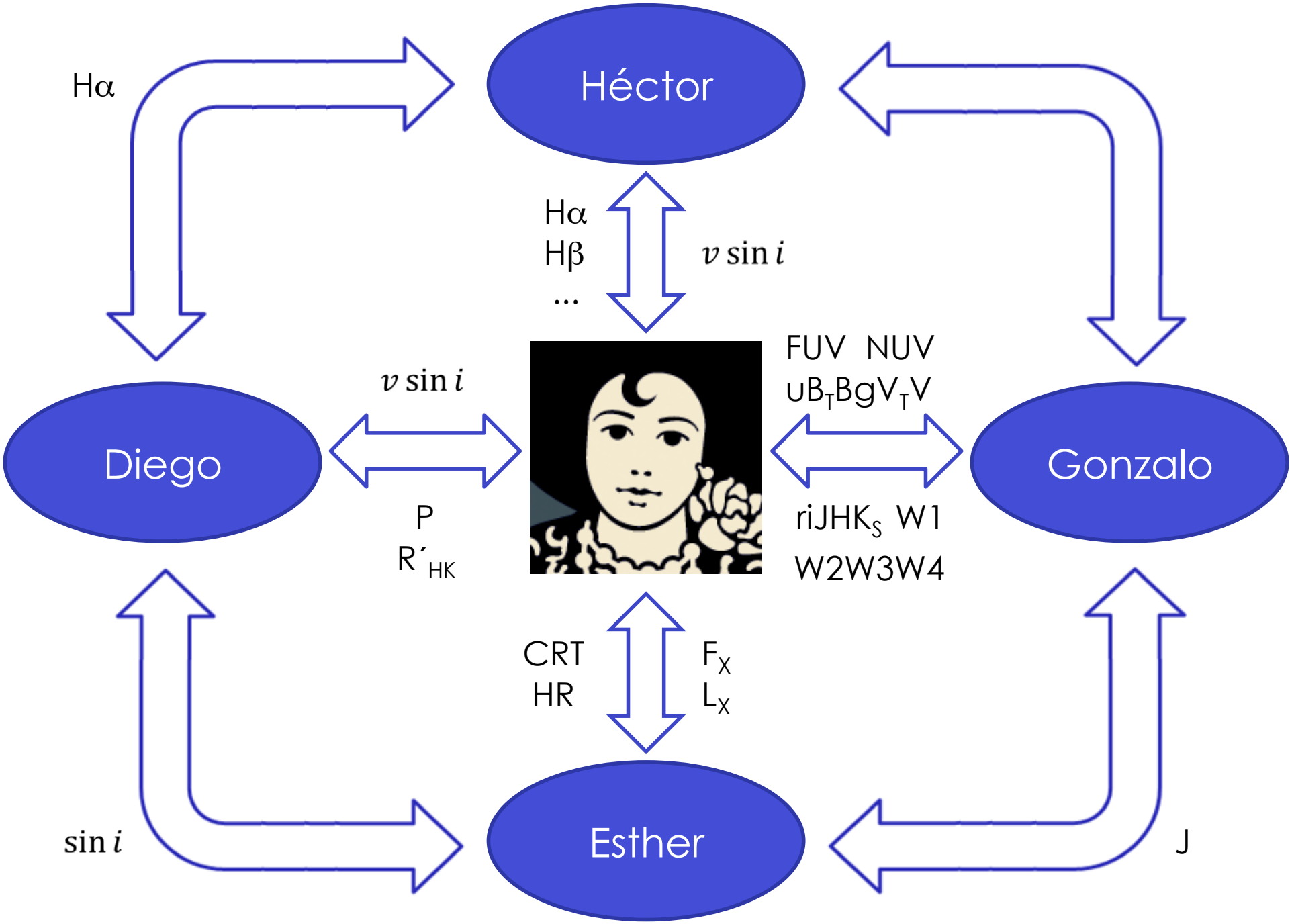

http://carmenes.caha.es/ext/armada/

Carmencita

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Last db version
2014-04-24

CARMENCITA

Database

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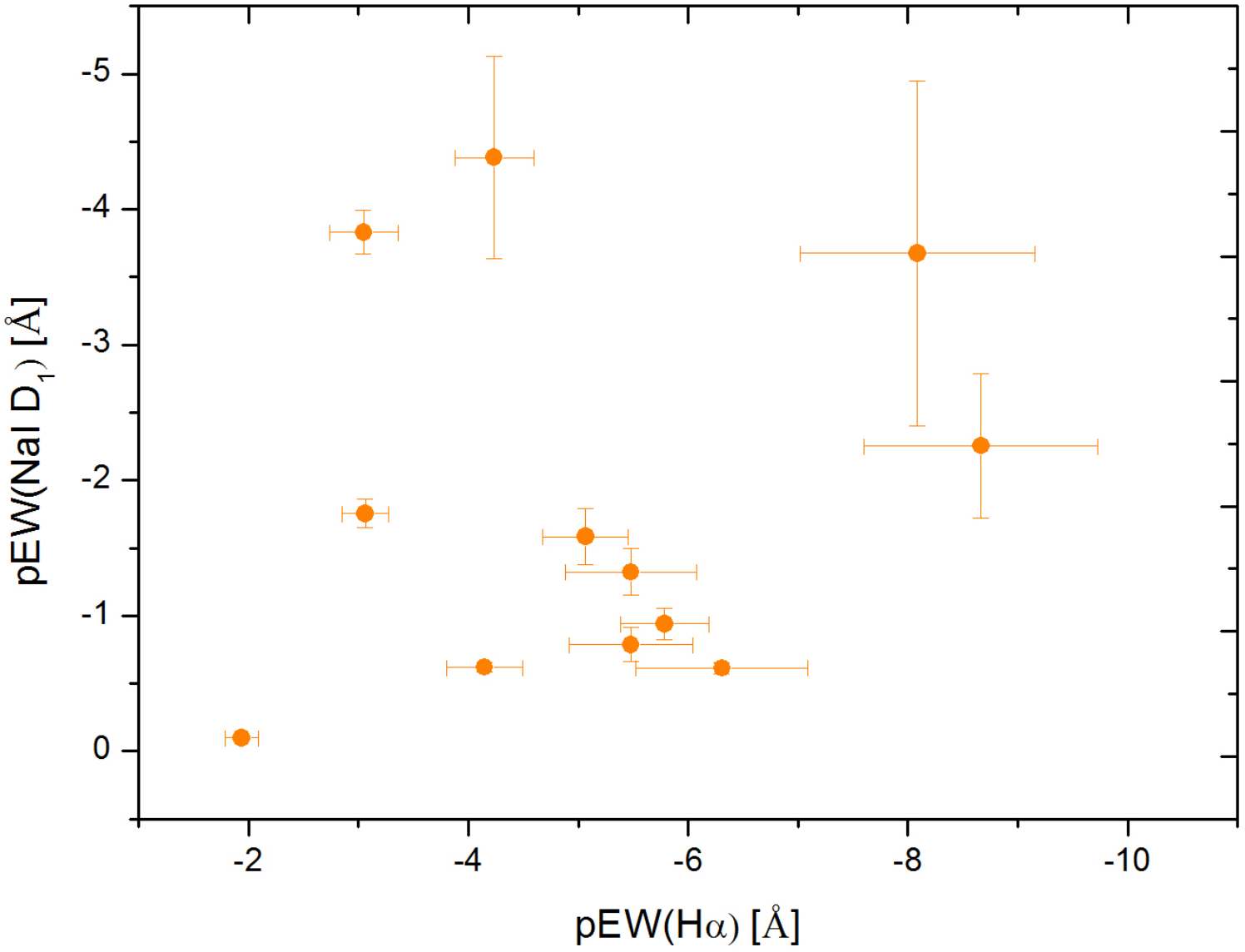
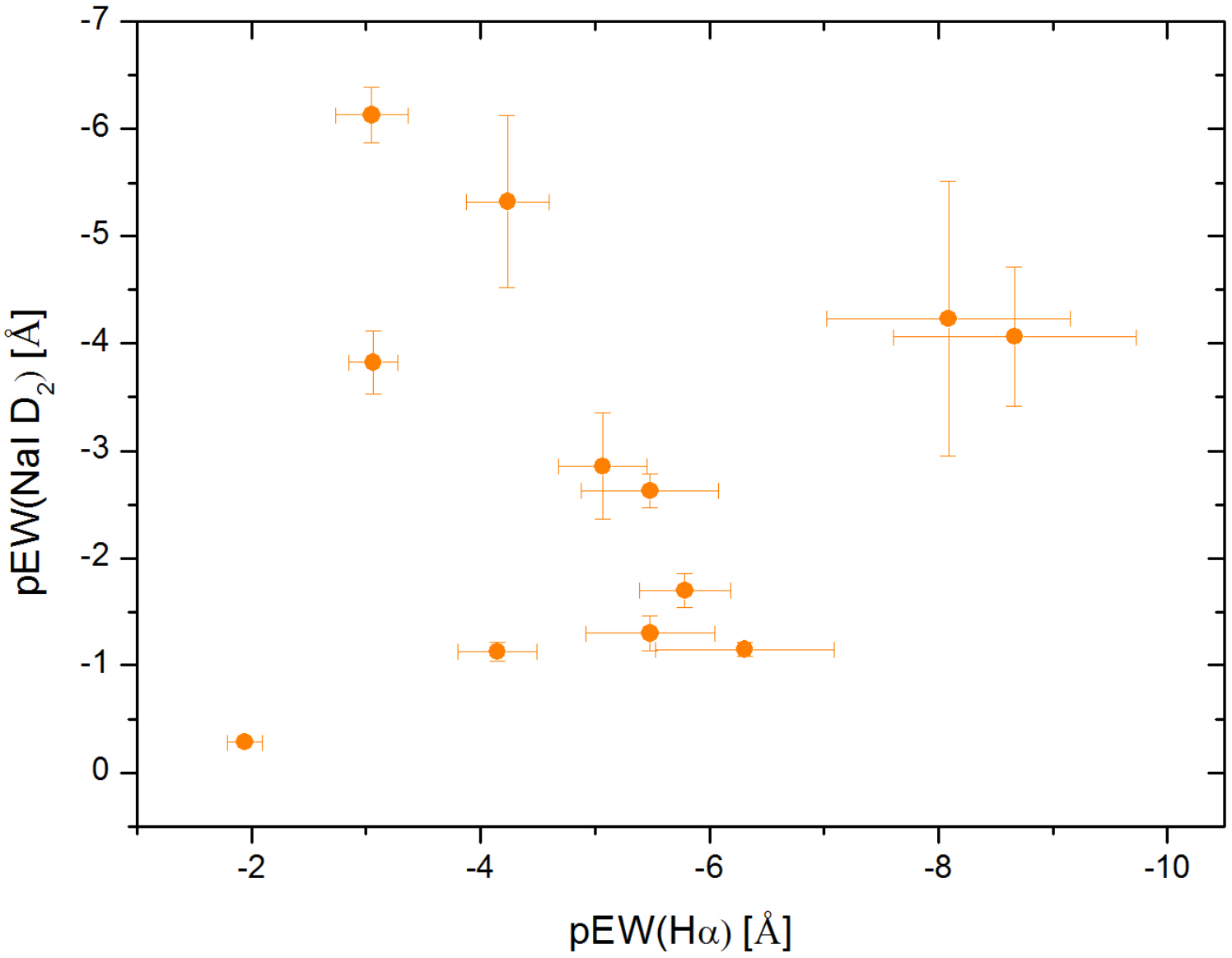
recno	Karmn	SS	Name	SpT	RA_J2000	DE_J2000	J_mag	vsini_kms_1
5	J00051+457	S3	GJ 2	M1.0 V	00:05:10.78	+45:47:11.6	6.704	2.76
6	J00056+458	S3	HD 38B	M0.0 V	00:05:40.90	+45:48:37.5	6.142	5.3
7	J00067-075	S1	GJ 1002	M5.5 V	00:06:43.26	-07:32:14.7	8.323	3>=
19	J00131+703	S3	TYC 4298-613-1	M2.0 V	00:13:11.55	+70:23:25.8	8.259	...
22	J00136+806	S3	G 242-048	M1.5 V	00:13:38.81	+80:39:56.9	7.756	4.0
26	J00158+135	S2	GJ 12	M3.0 V	00:15:49.20	+13:33:21.9	8.619	...
28	J00162+198W	S1	EZ Psc	M4.0 V	00:16:14.63	+19:51:37.6	7.875	...

carmenes

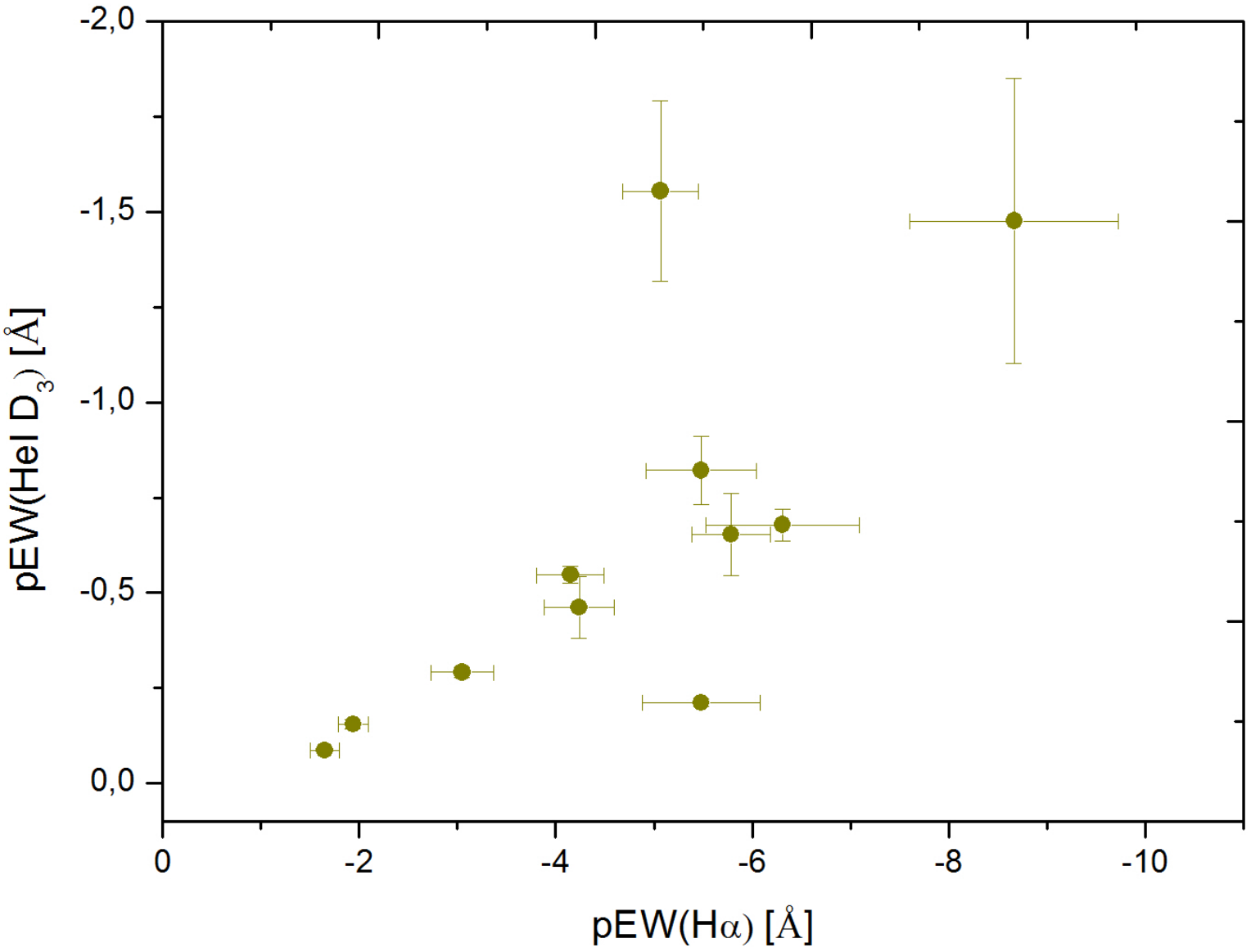
Results: *pEWs* vs *pEW*(Hα)



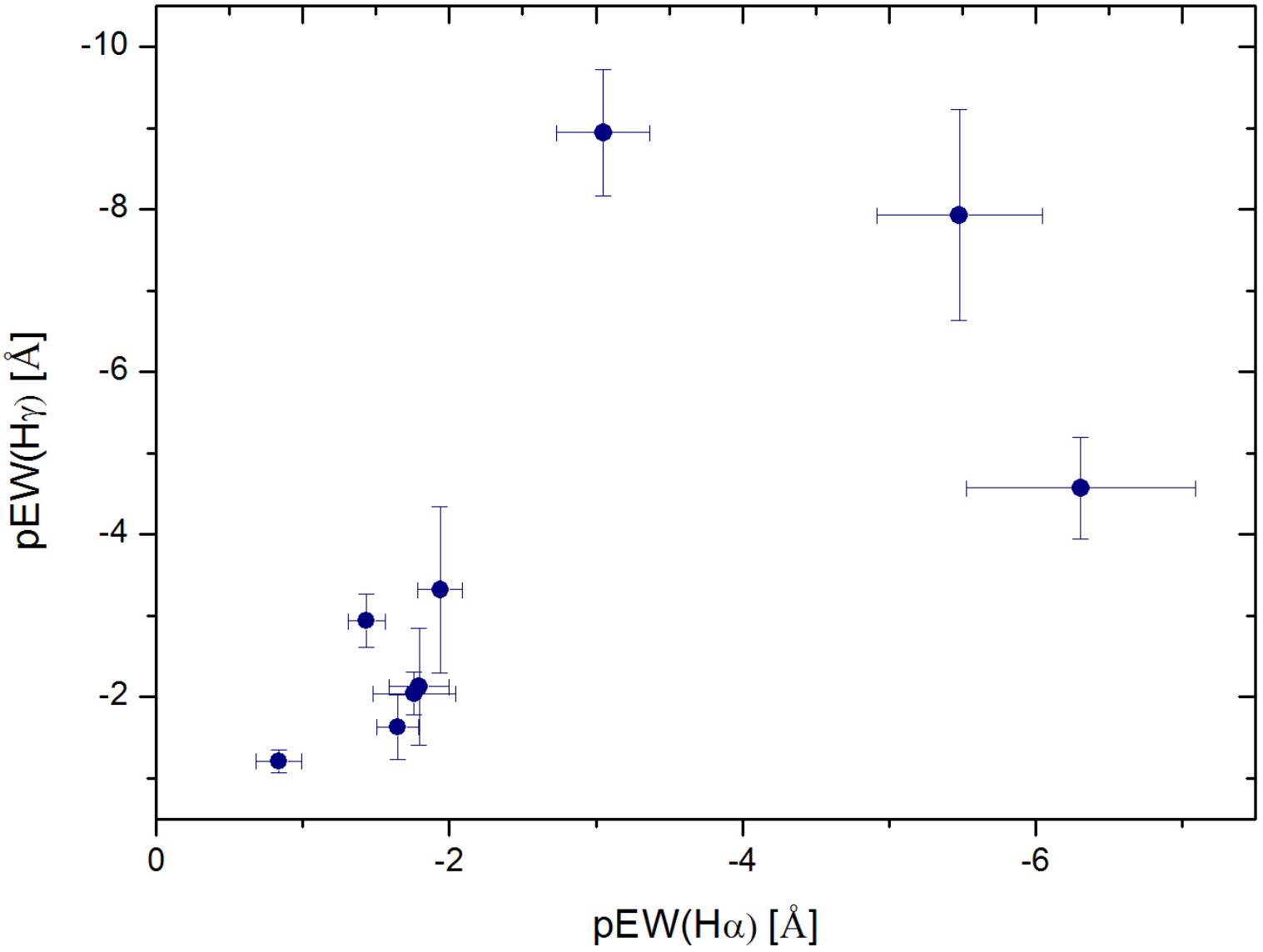
Results: *pEWs* vs *pEW*(Hα)



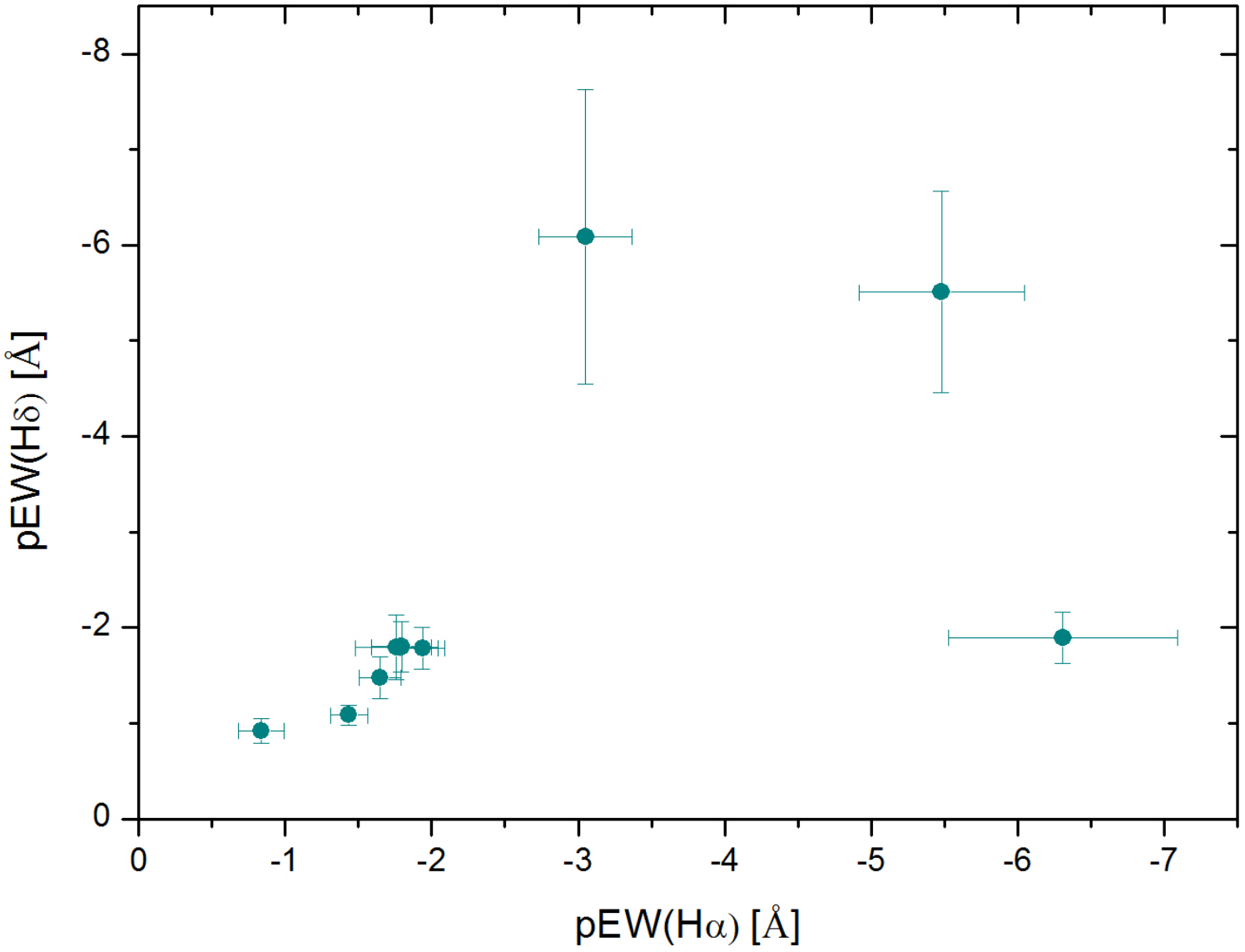
Results: *pEWs* vs *pEW*(Hα)



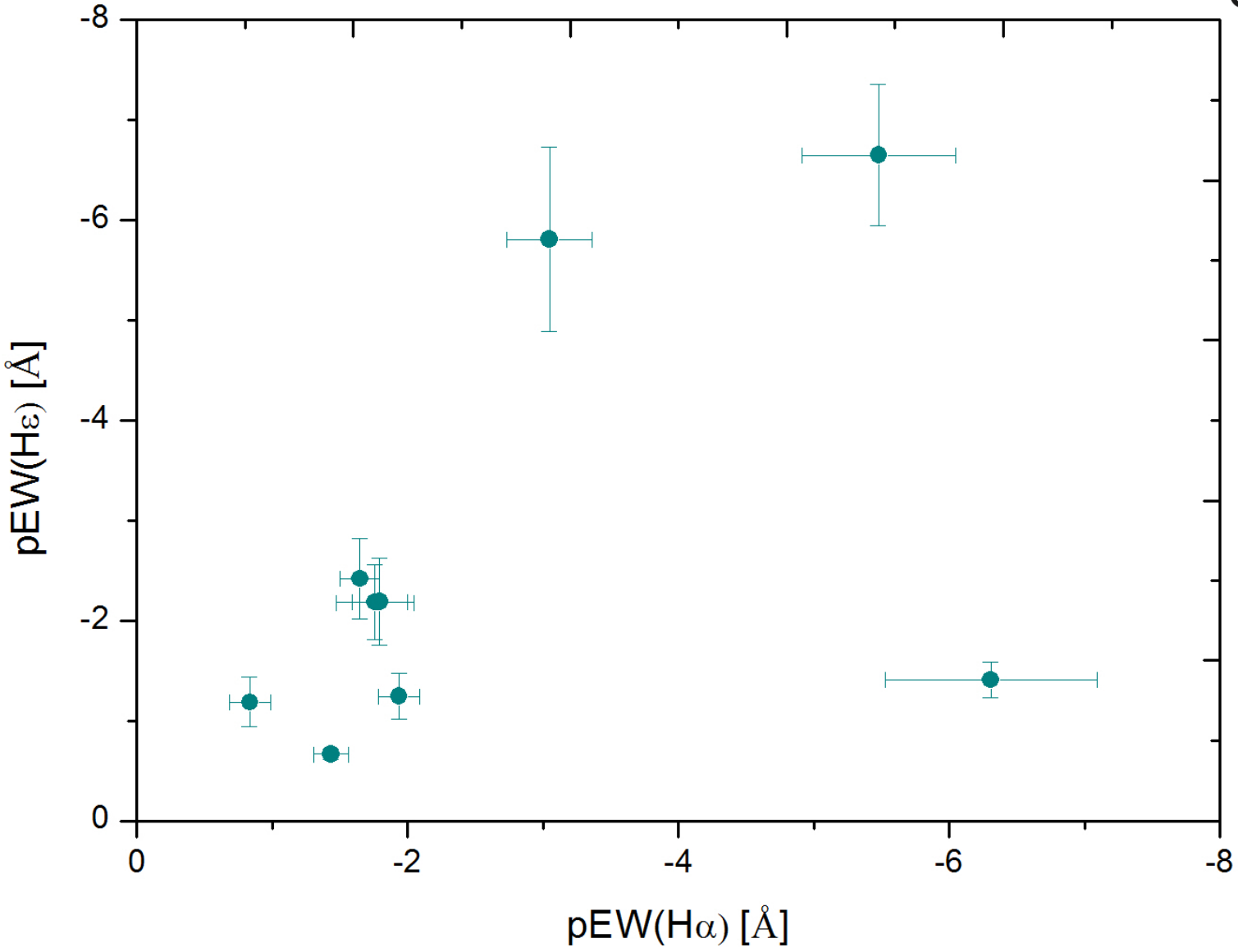
Results: *pEWs* vs *pEW*(Hα)



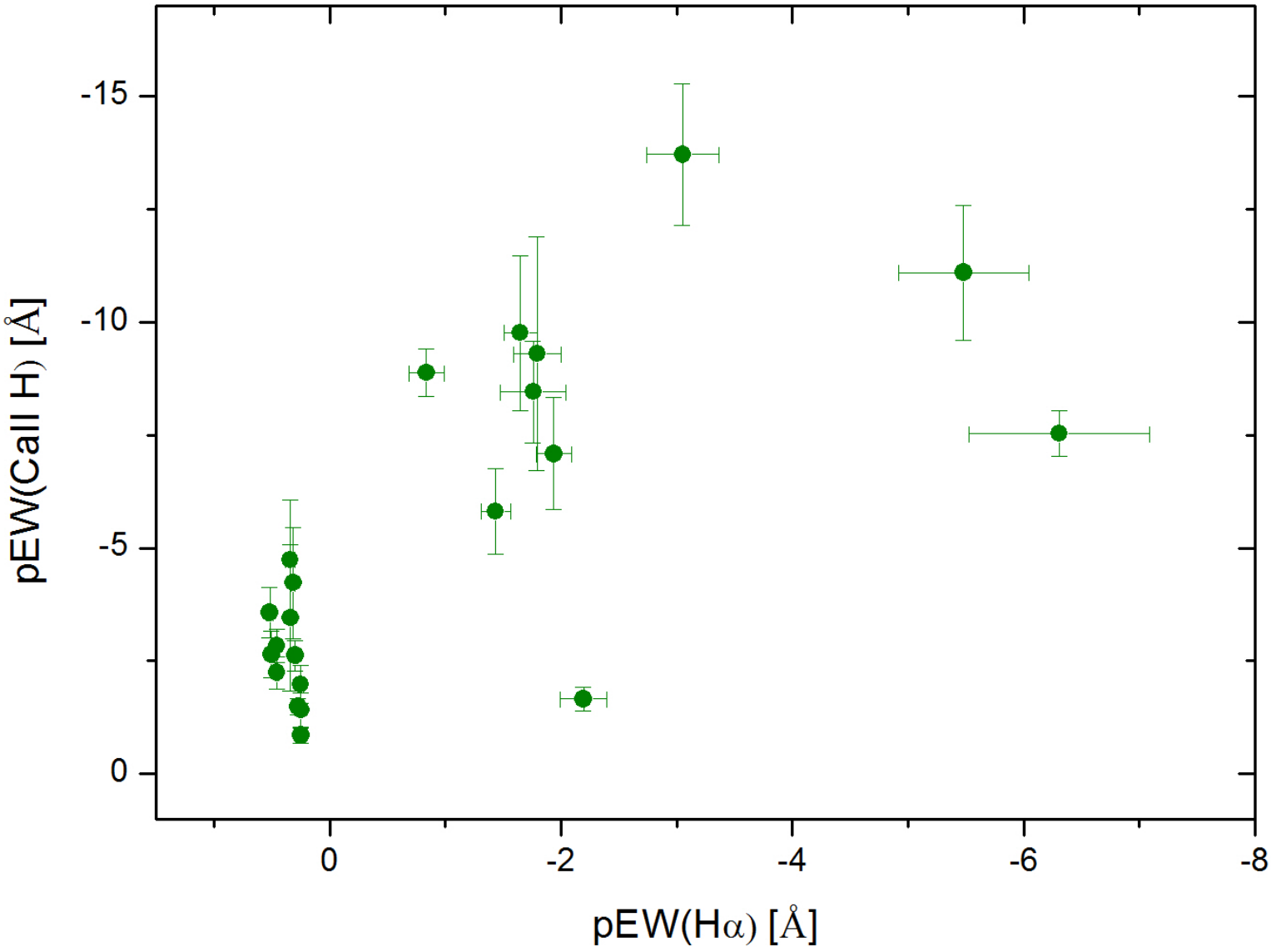
Results: *pEWs* vs *pEW*(Hα)



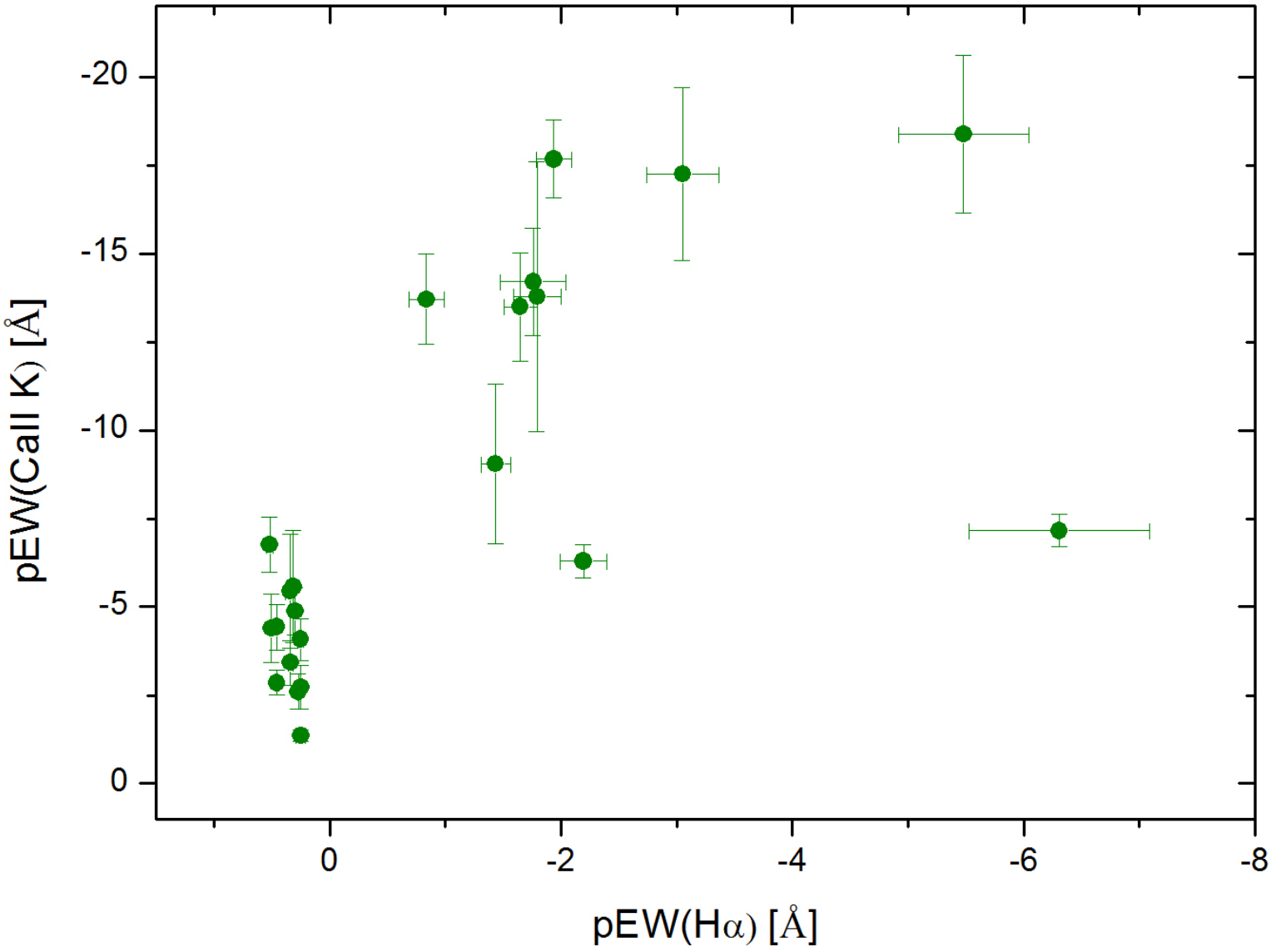
Results: *pEWs* vs *pEW*(Hα)



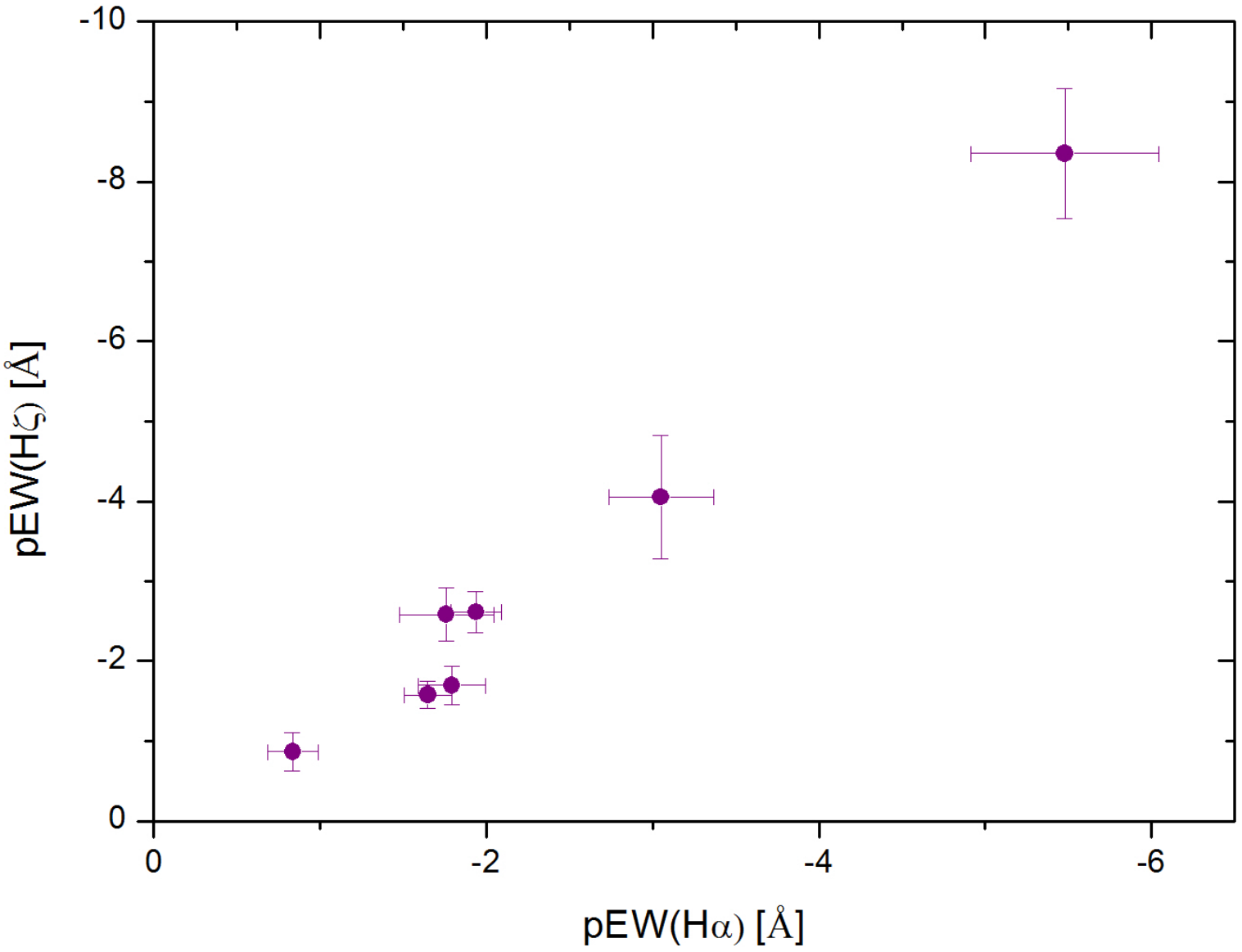
Results: *pEWs* vs *pEW*(Hα)



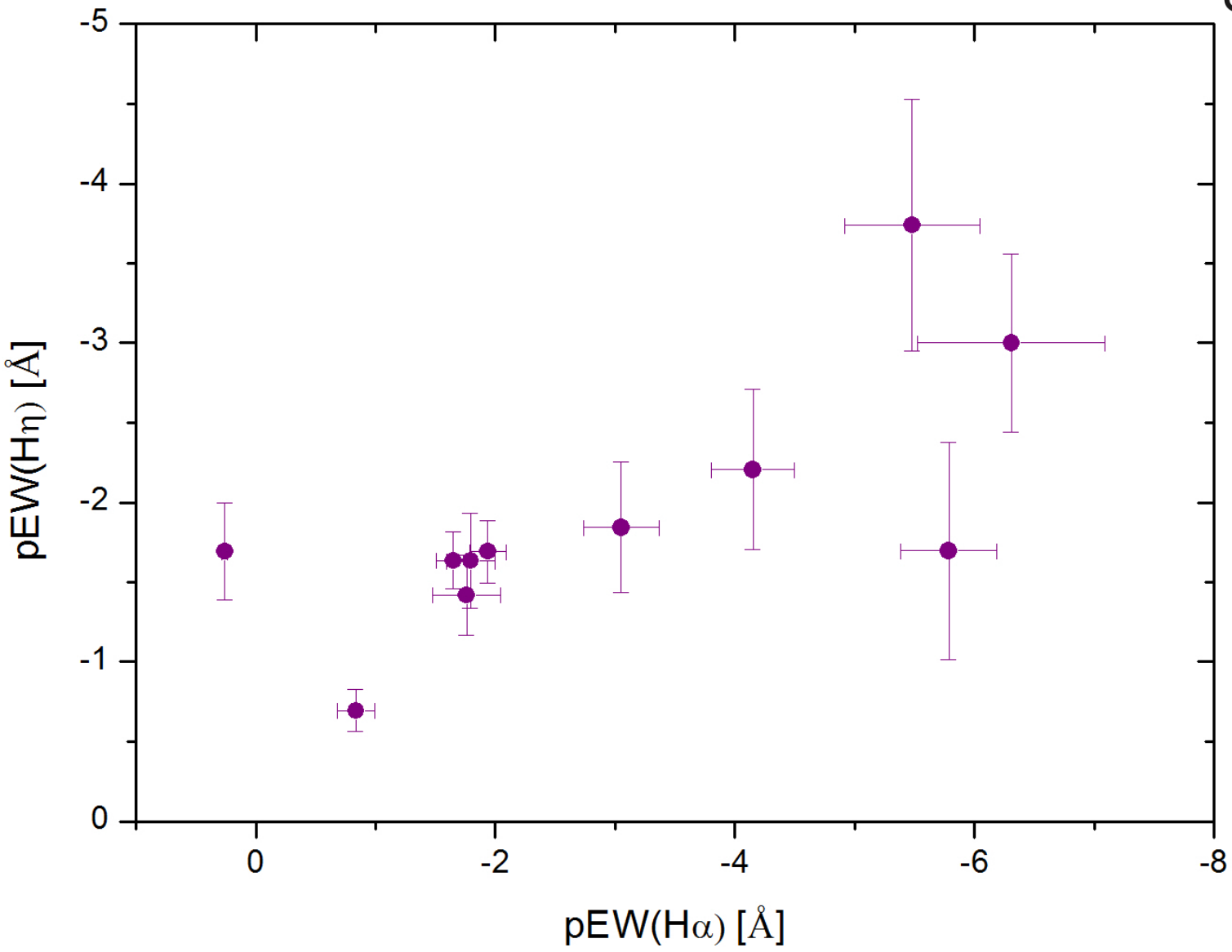
Results: *pEWs* vs *pEW*(Hα)



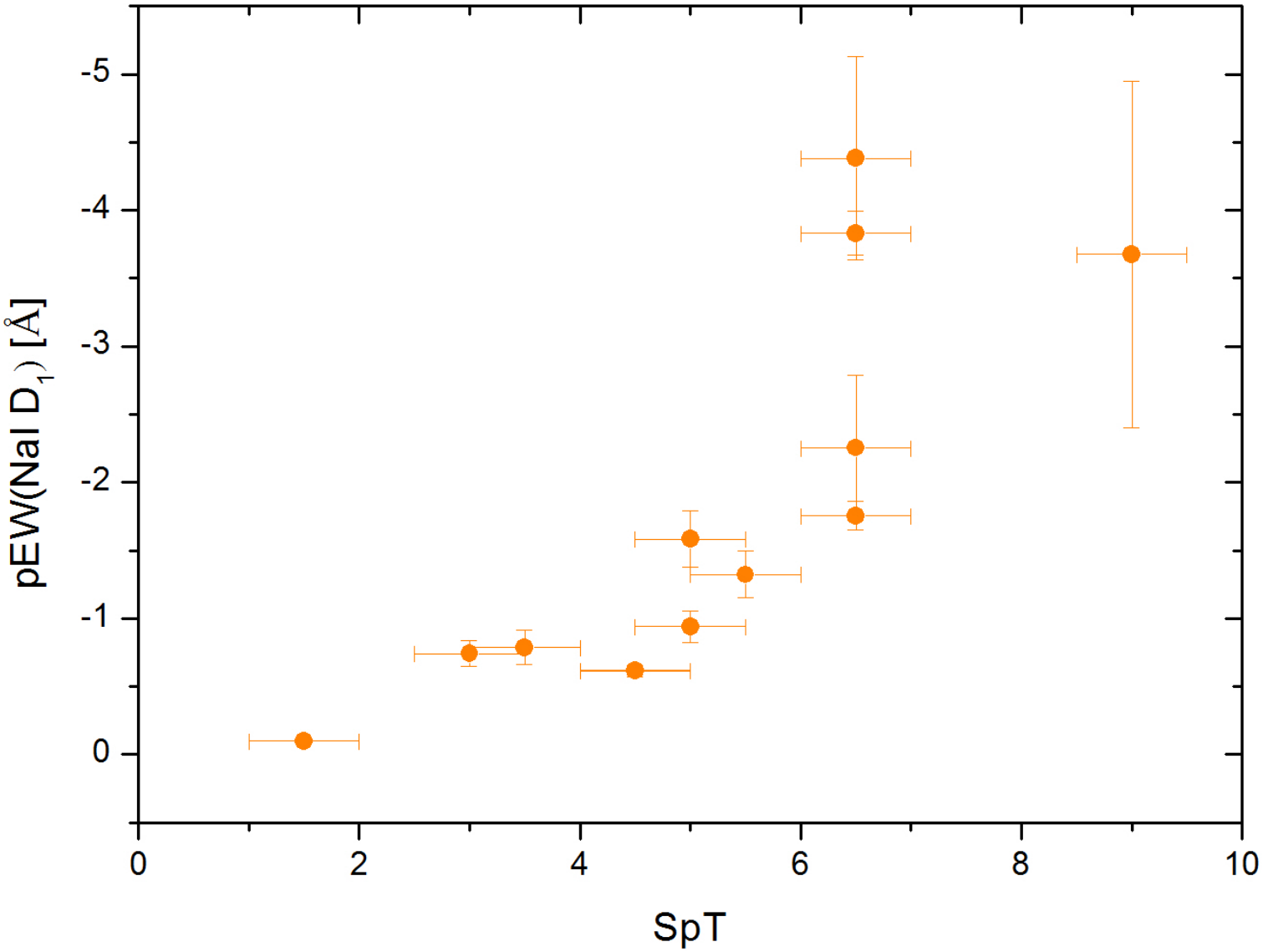
Results: *pEWs* vs *pEW*(Hα)



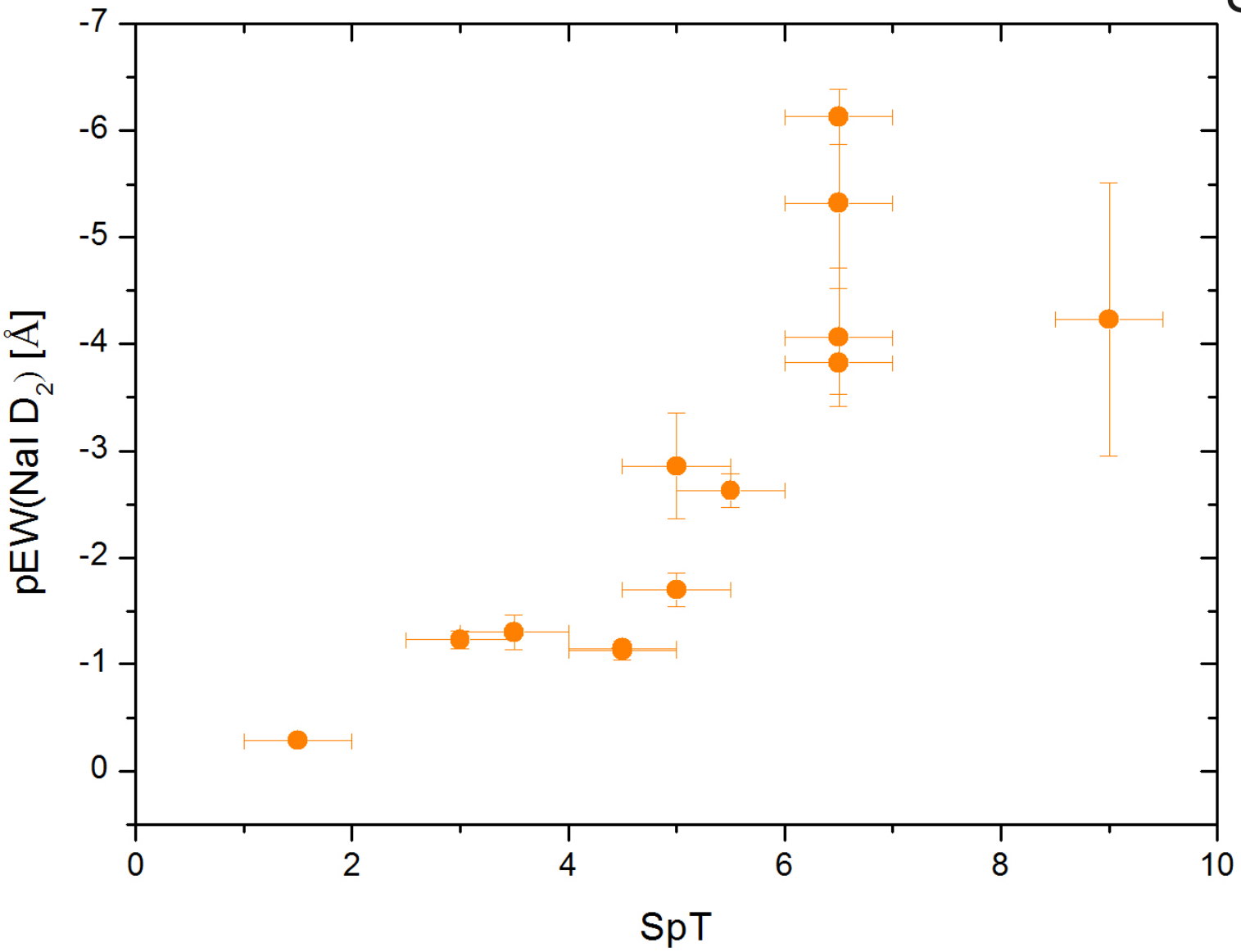
Results: *pEWs* vs *pEW*(Hα)



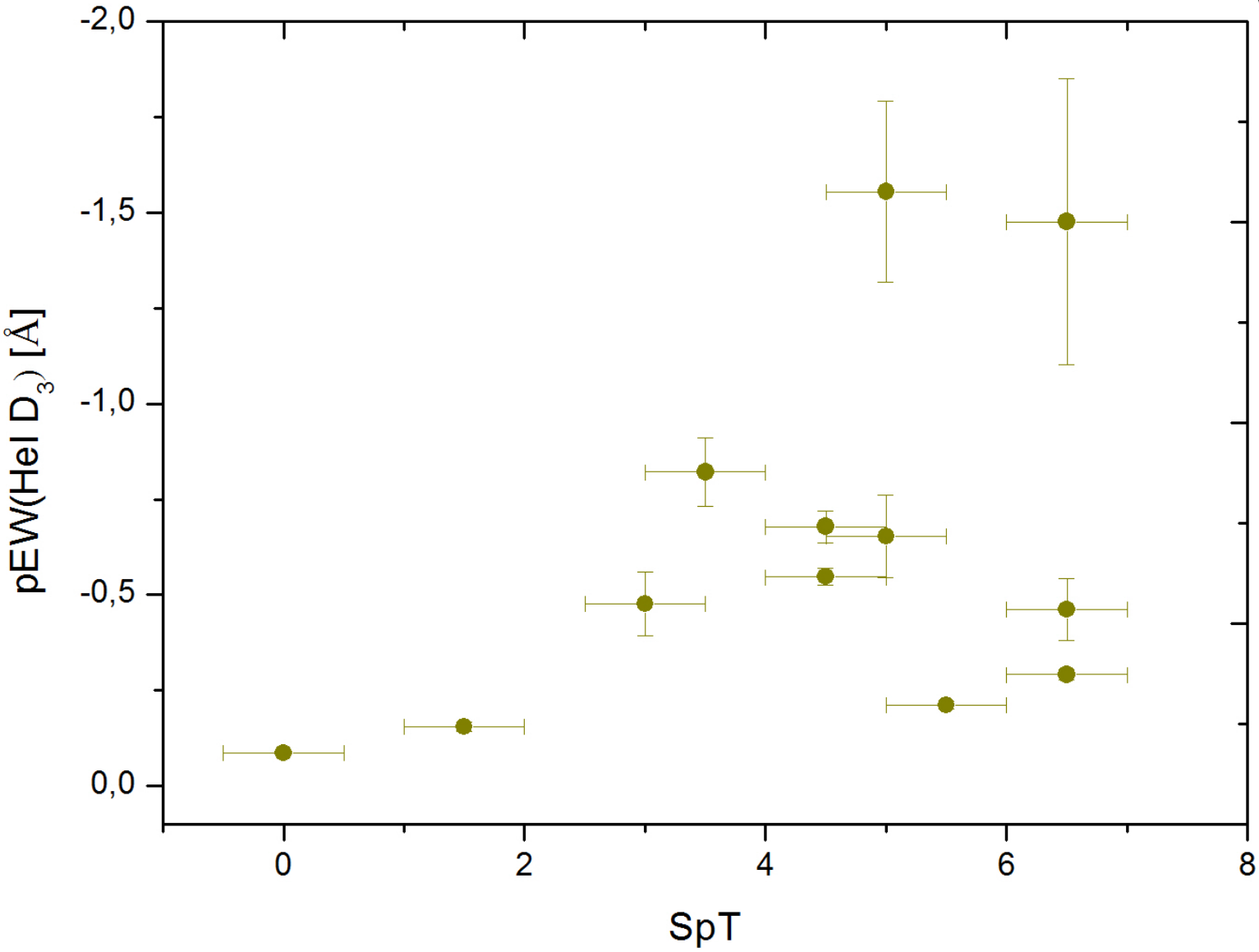
Results: *pEWs* vs spectral types



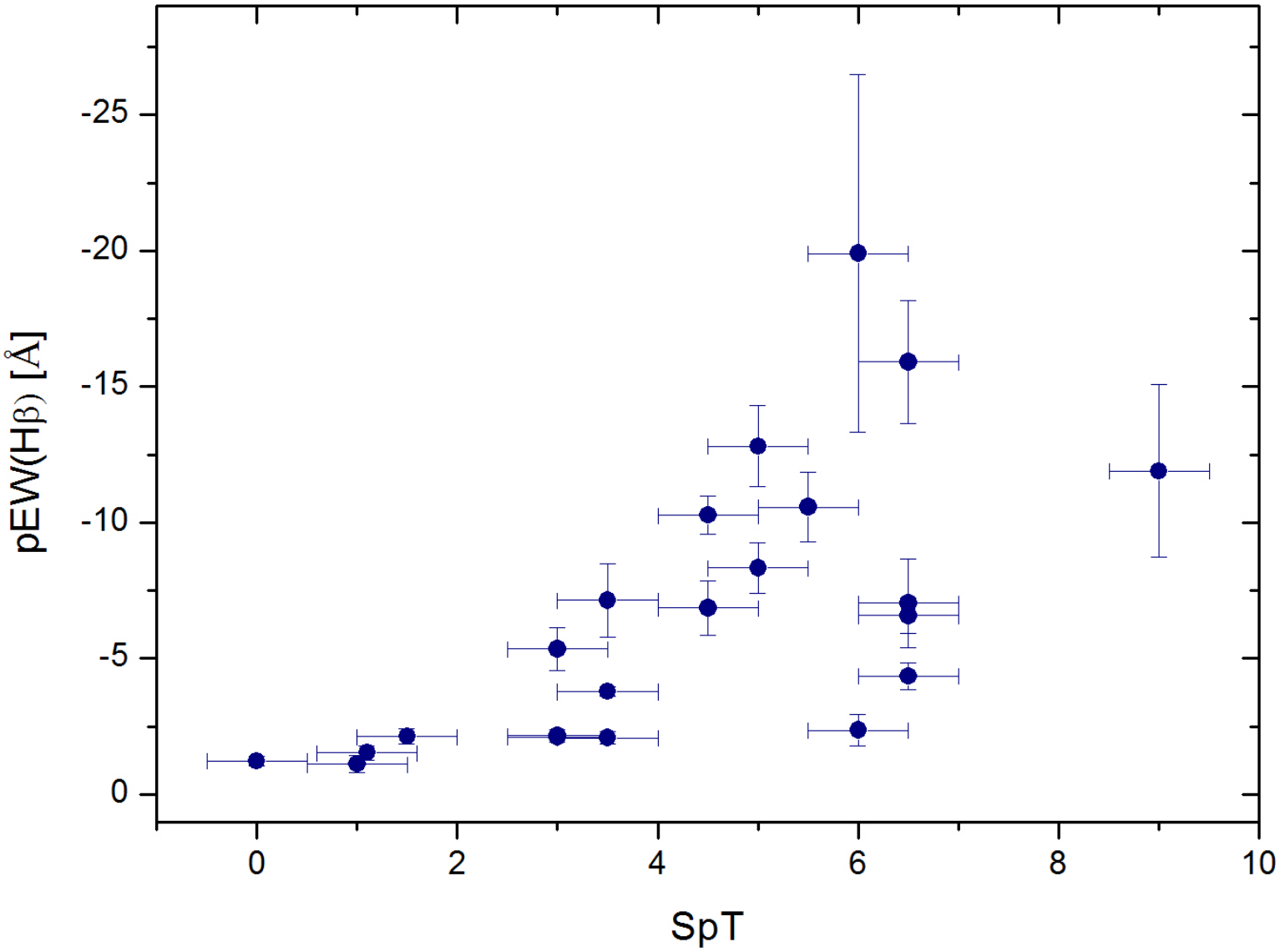
Results: *pEWs* vs spectral types



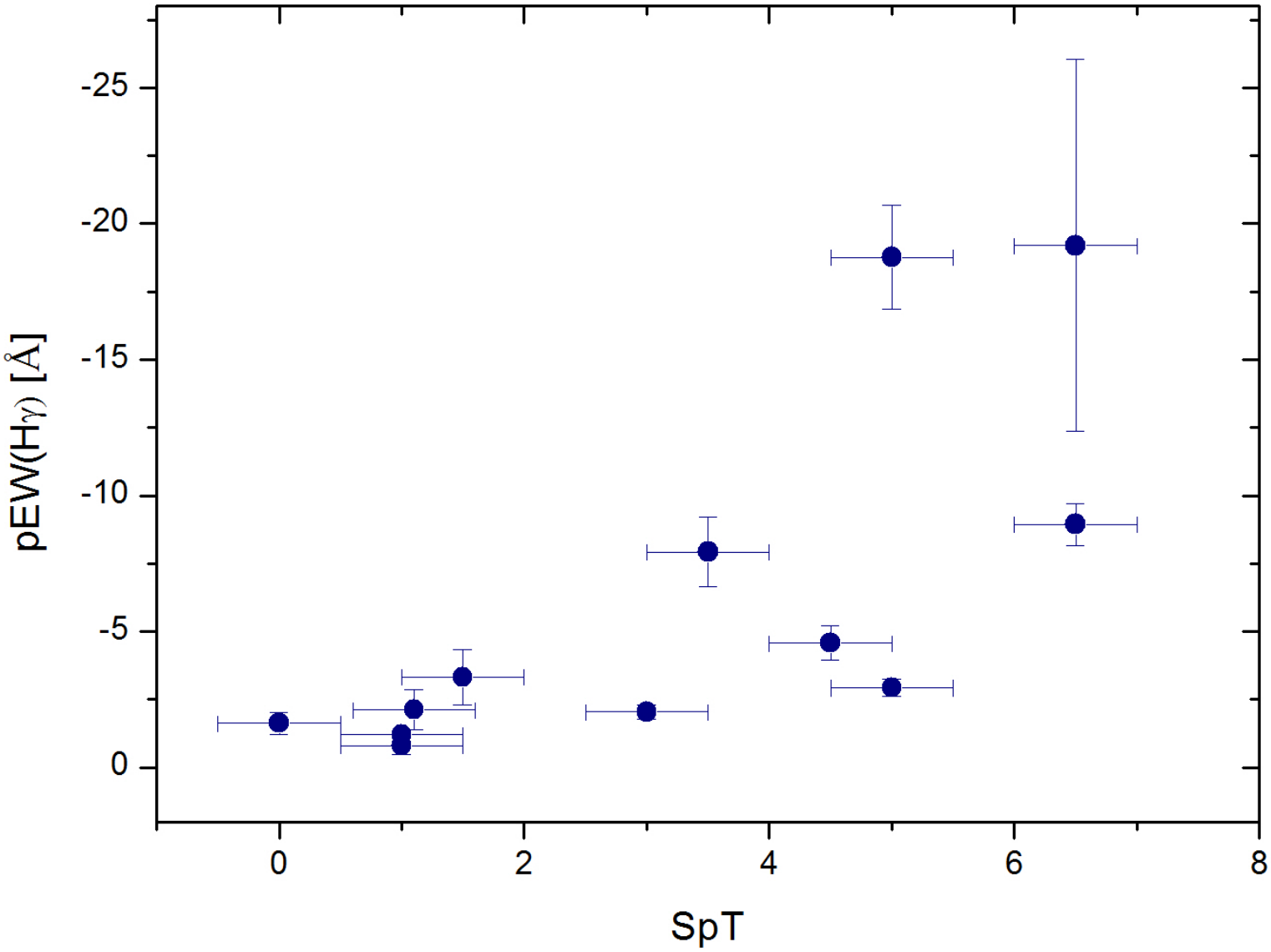
Results: *pEWs* vs spectral types



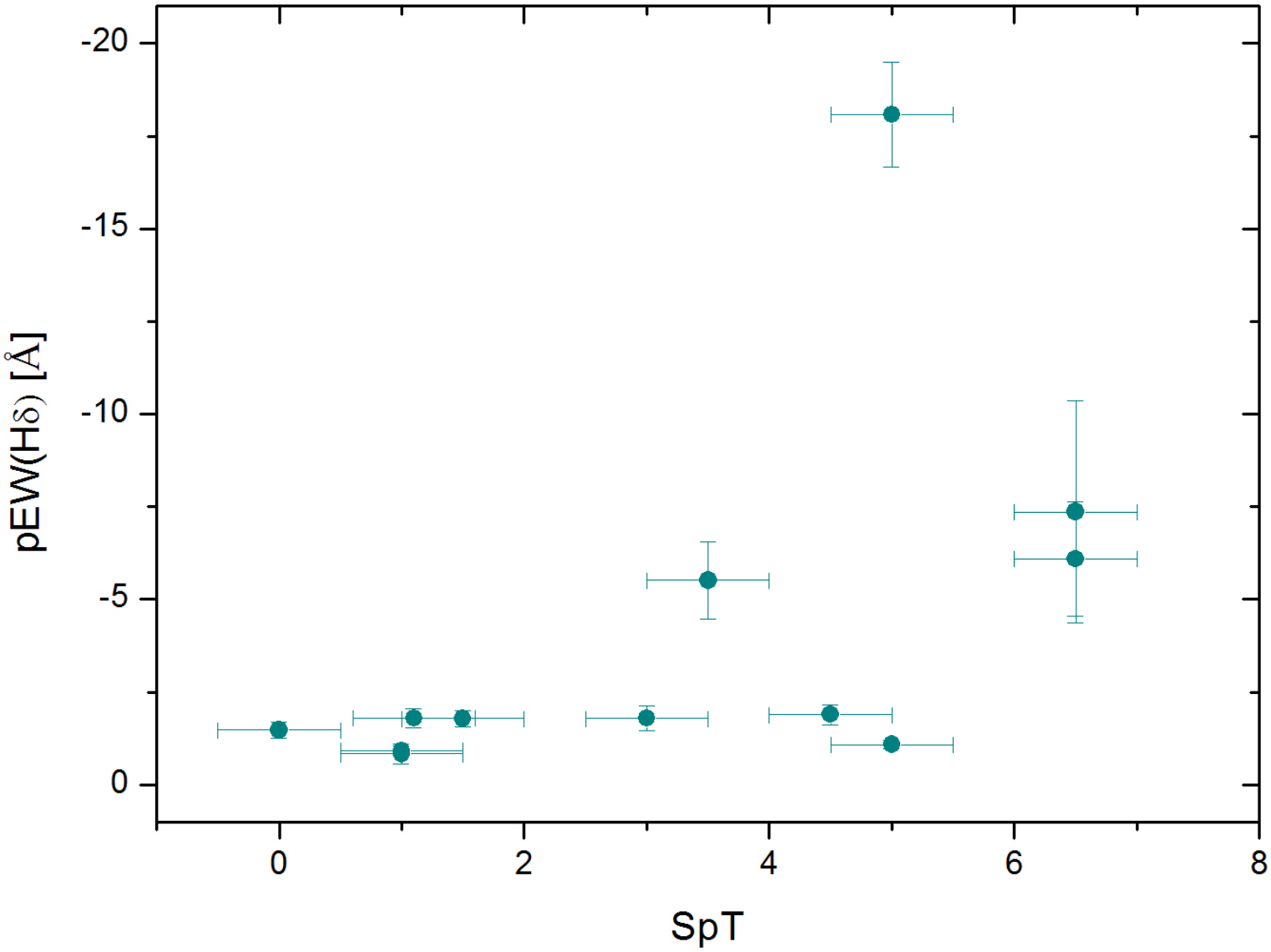
Results: *pEWs* vs spectral types



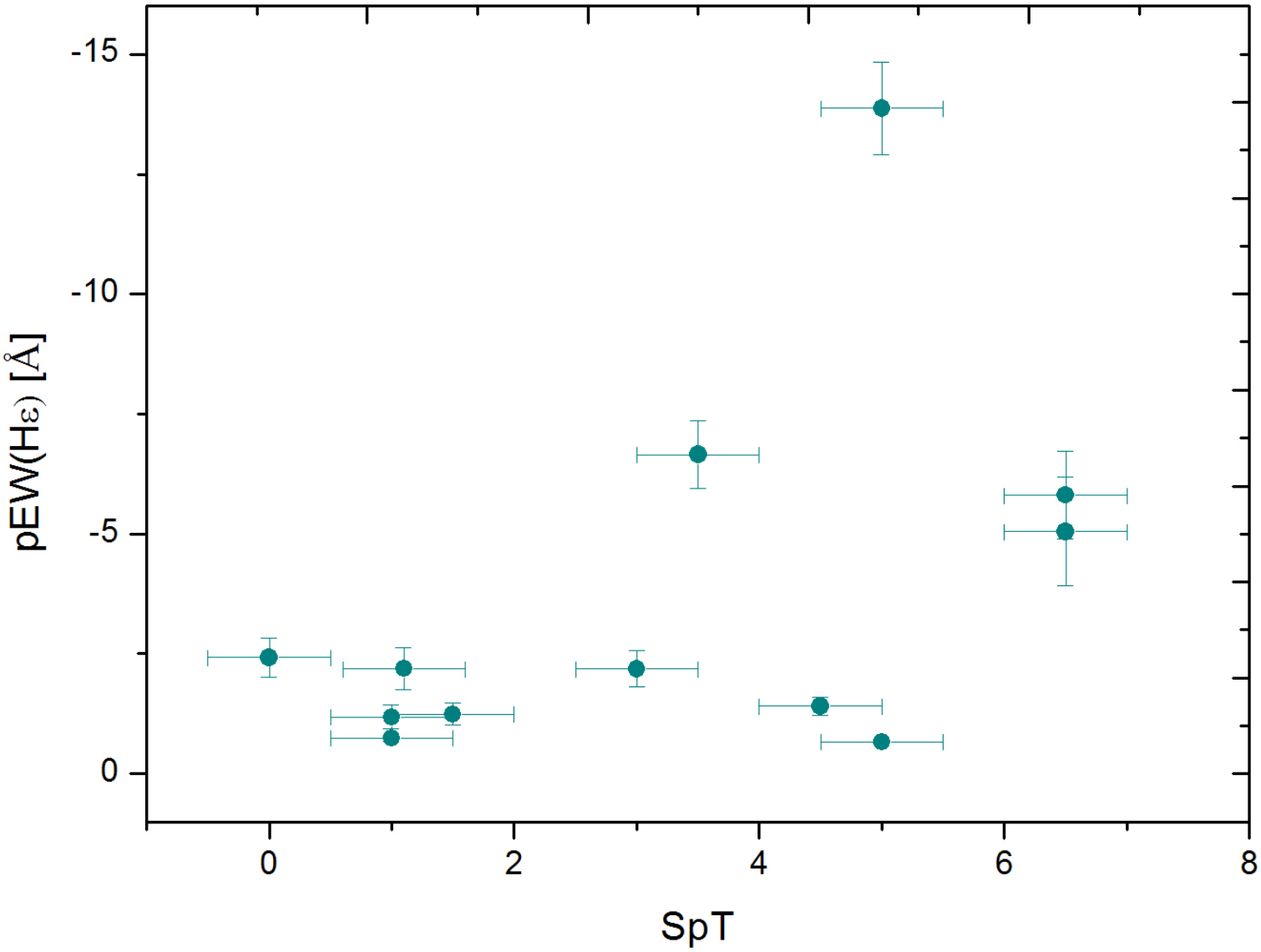
Results: *pEWs* vs spectral types



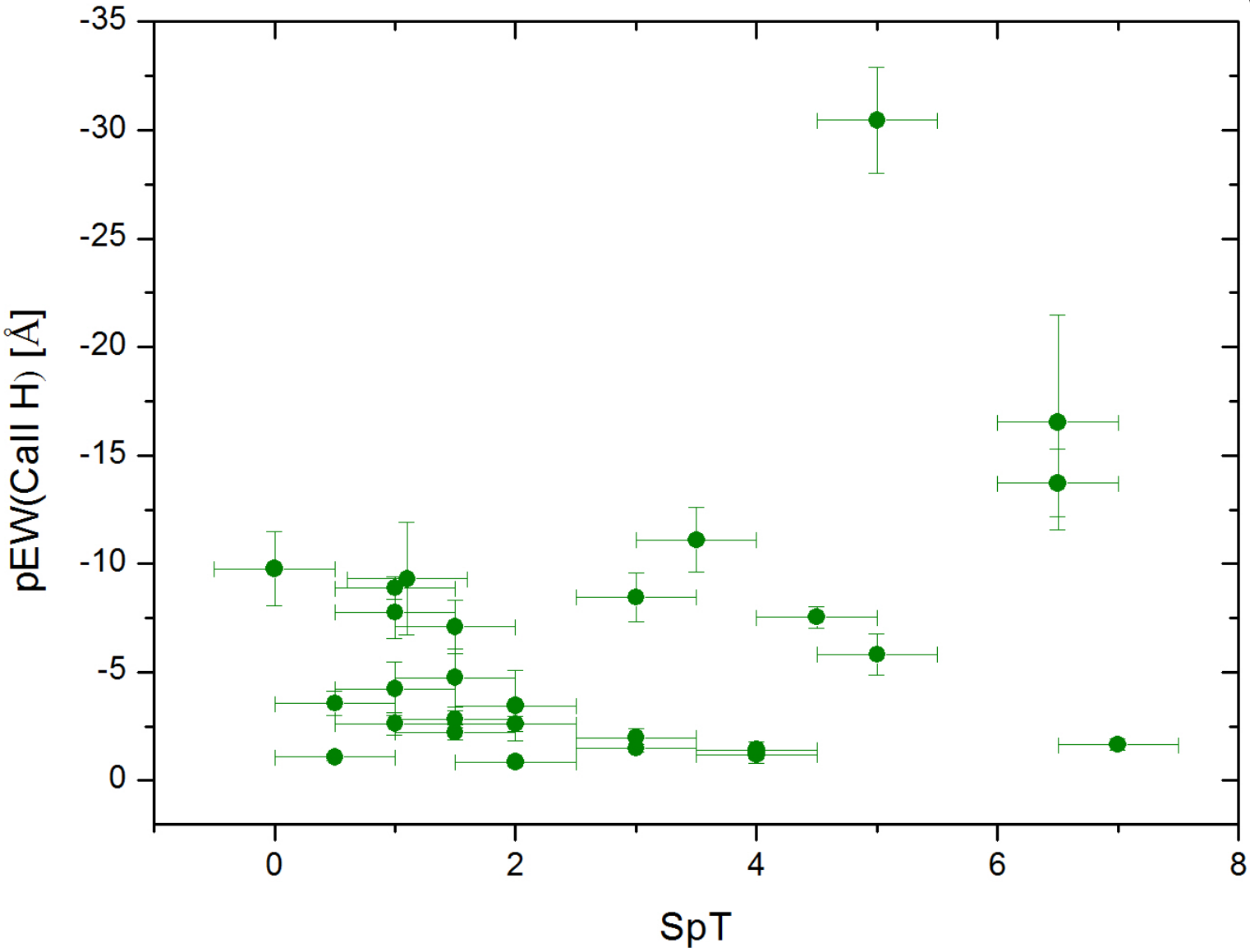
Results: *pEWs* vs spectral types



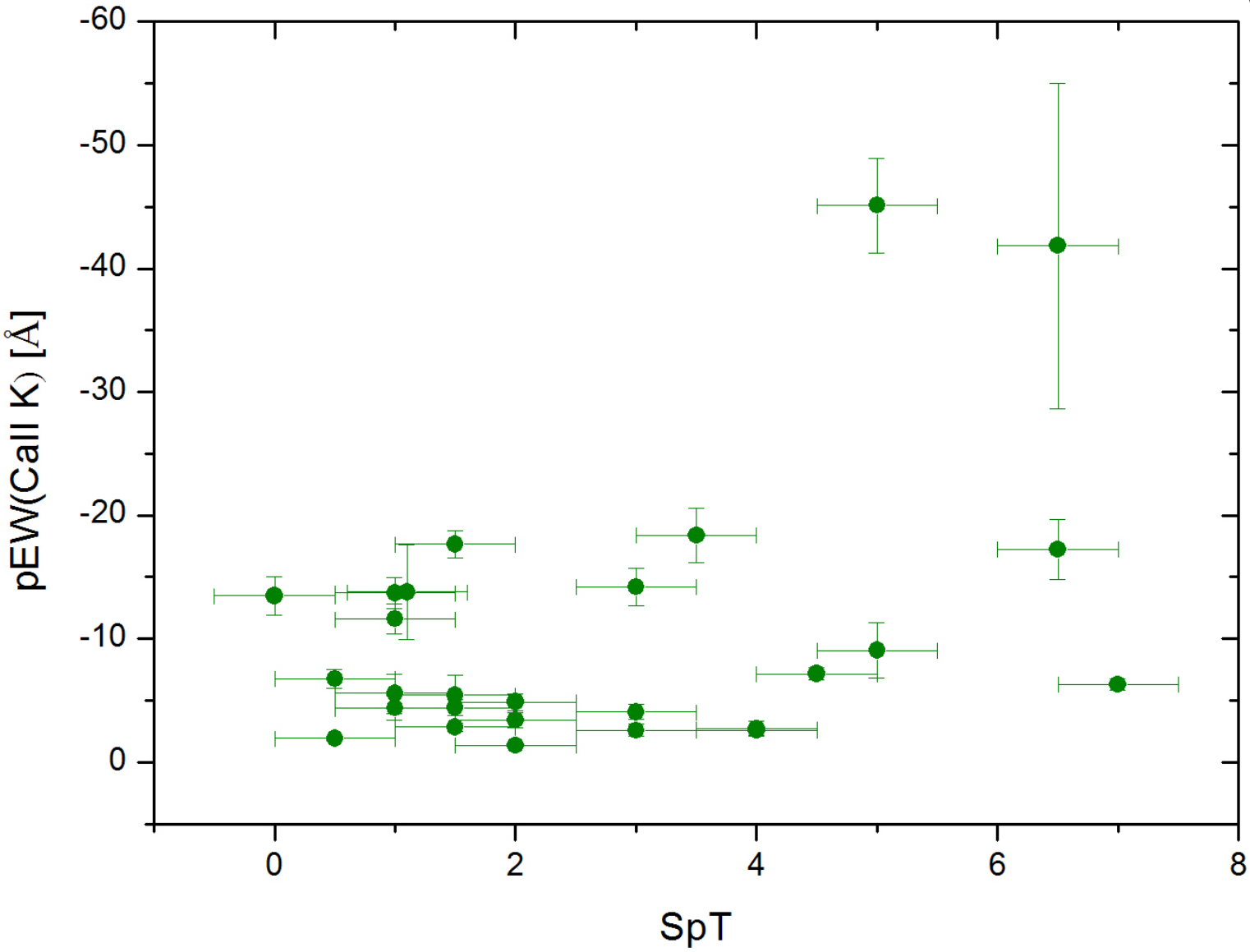
Results: *pEWs* vs spectral types



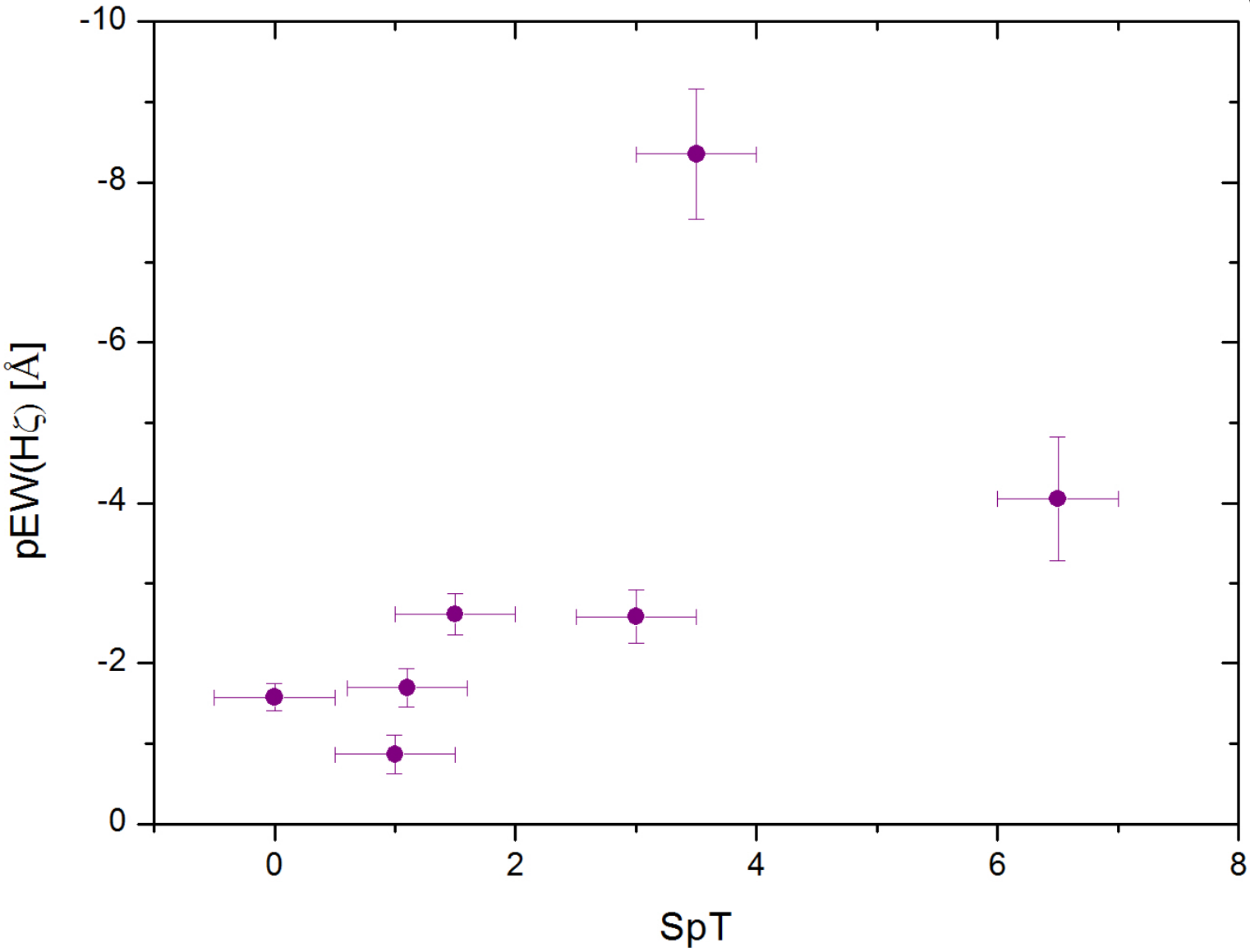
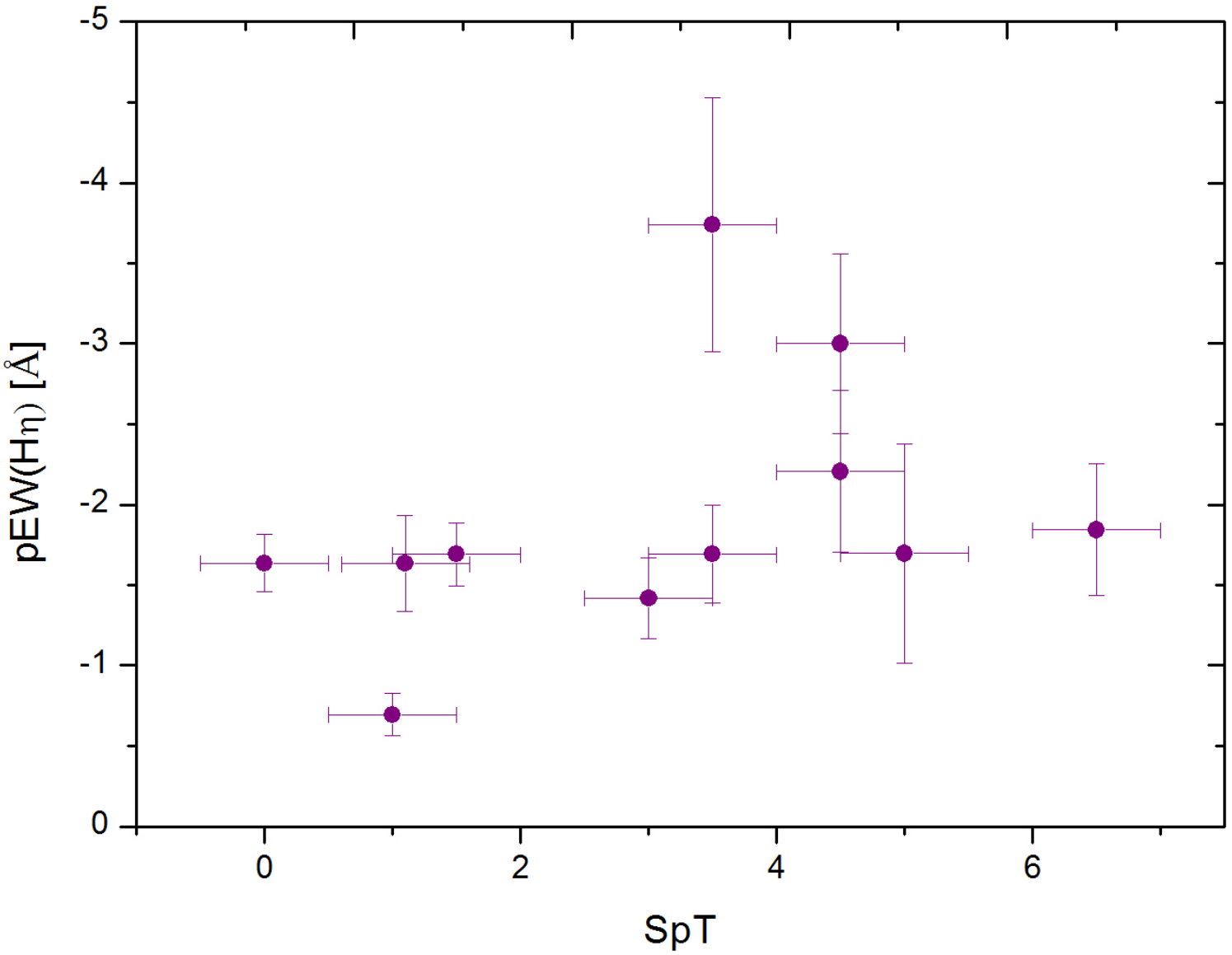
Results: *pEWs* vs spectral types



Results: *pEWs* vs spectral types



Results: *pEWs* vs spectral types



Results: *pEWs* vs spectral types