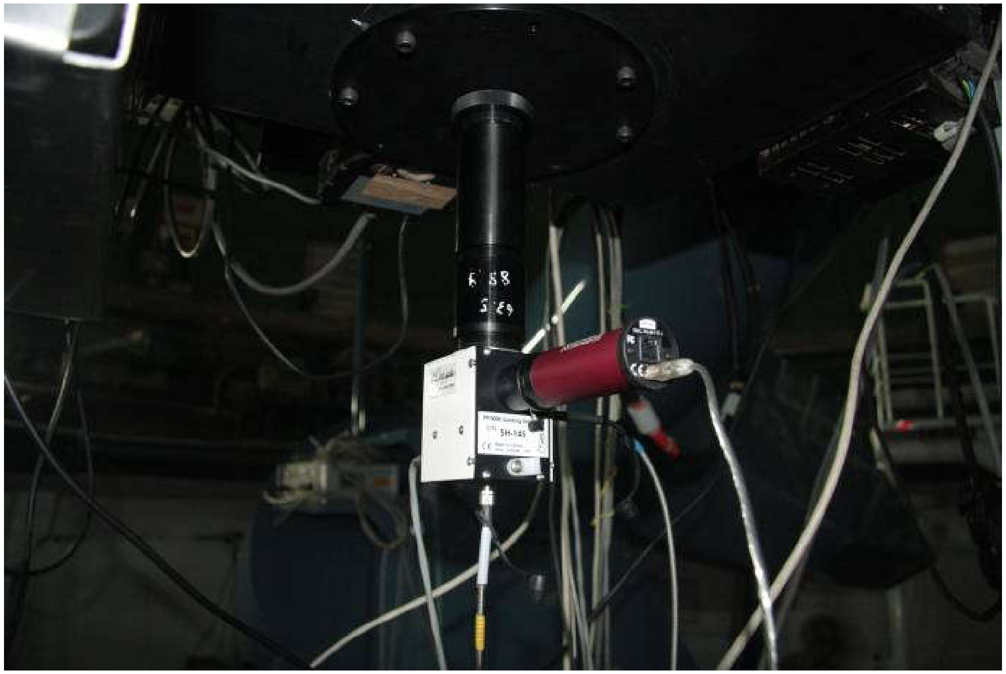
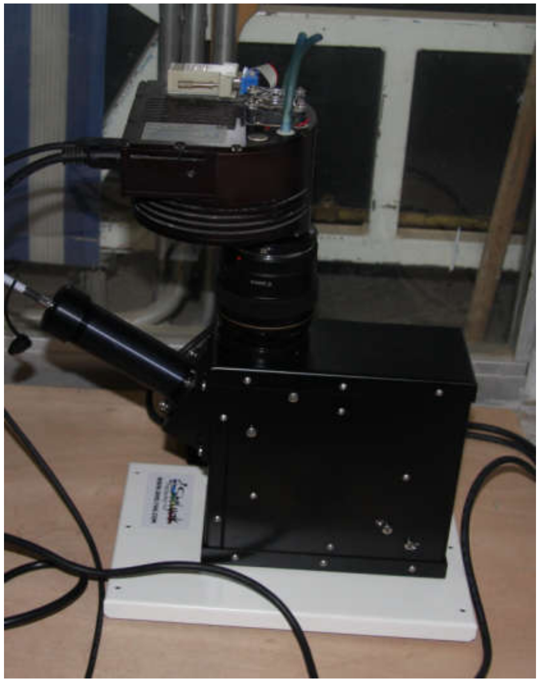
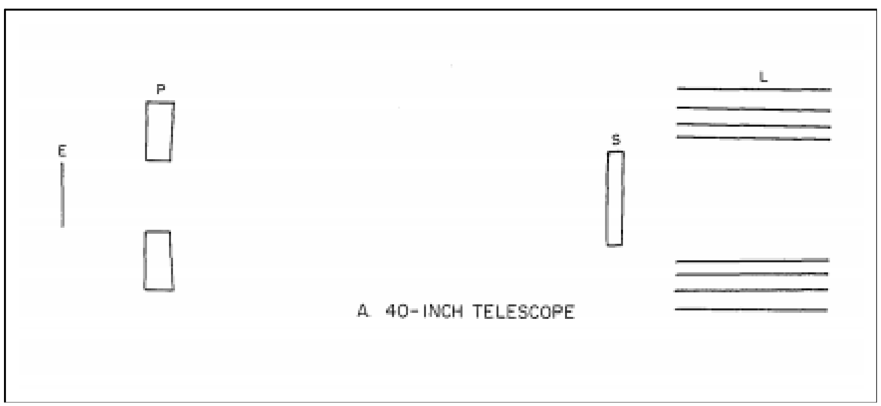


The eShel Spectrograph at Wise Observatory

October 2014

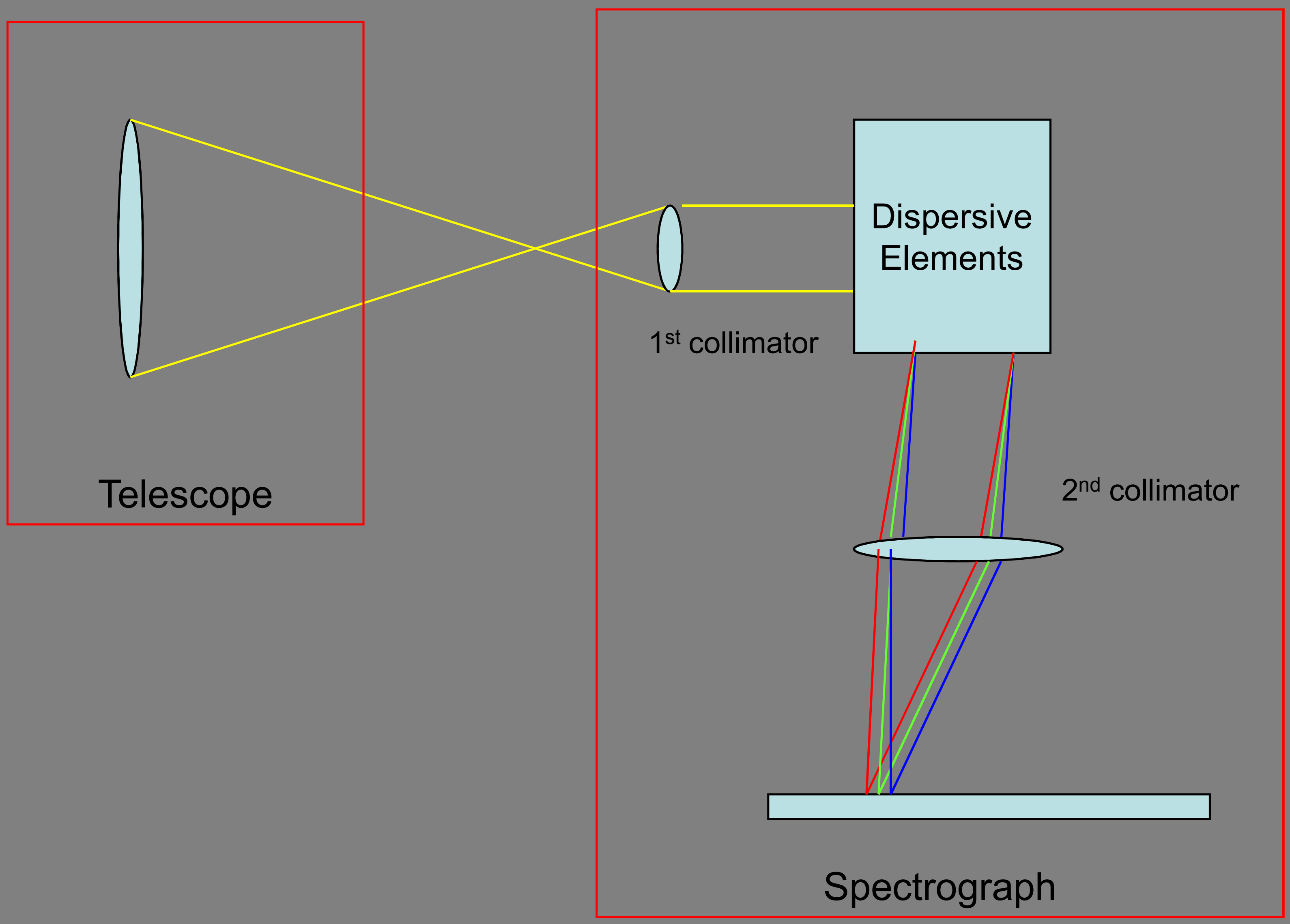


The 1m Telescope

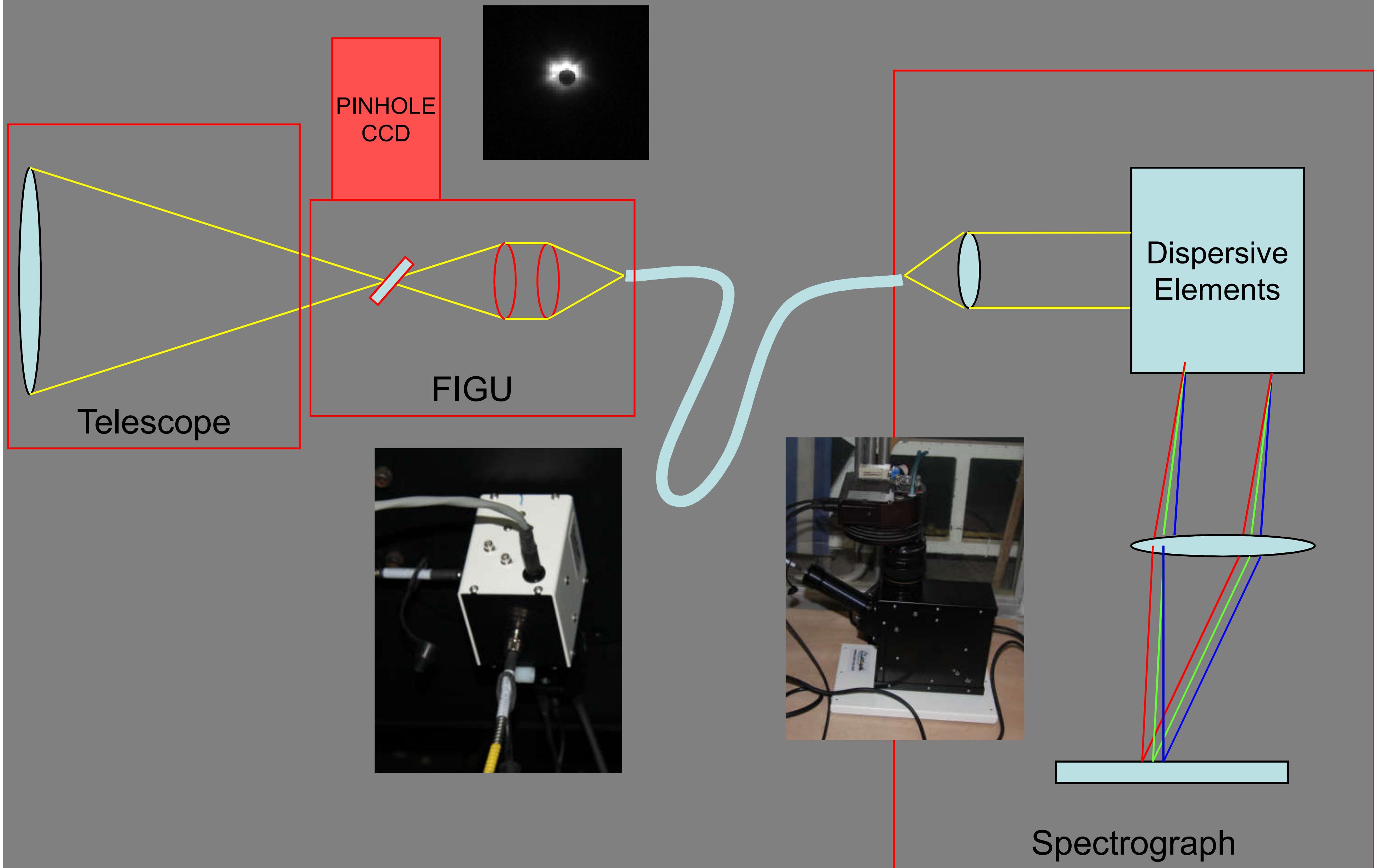


• **40 inch diameter clear aperture f/4 primary mirror,**
• **20.1 inch diameter f/7 Cassegrain secondary mirror**
•**a corrector quartz lens located 4 inches above the surface of the primary mirror.**

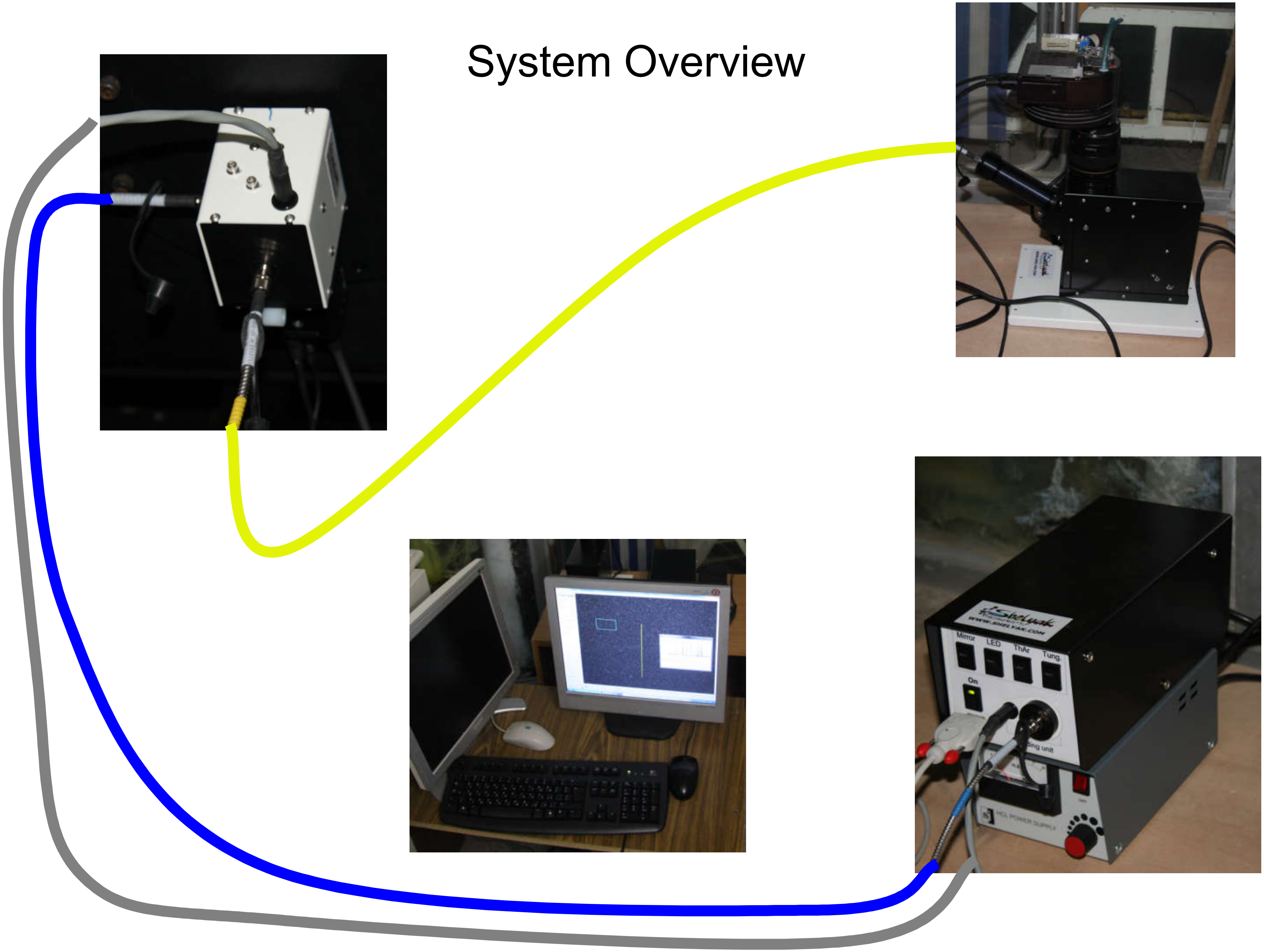
Basic Setup


Dispersive Elements
1st collimator
2nd collimator
Telescope
Spectrograph

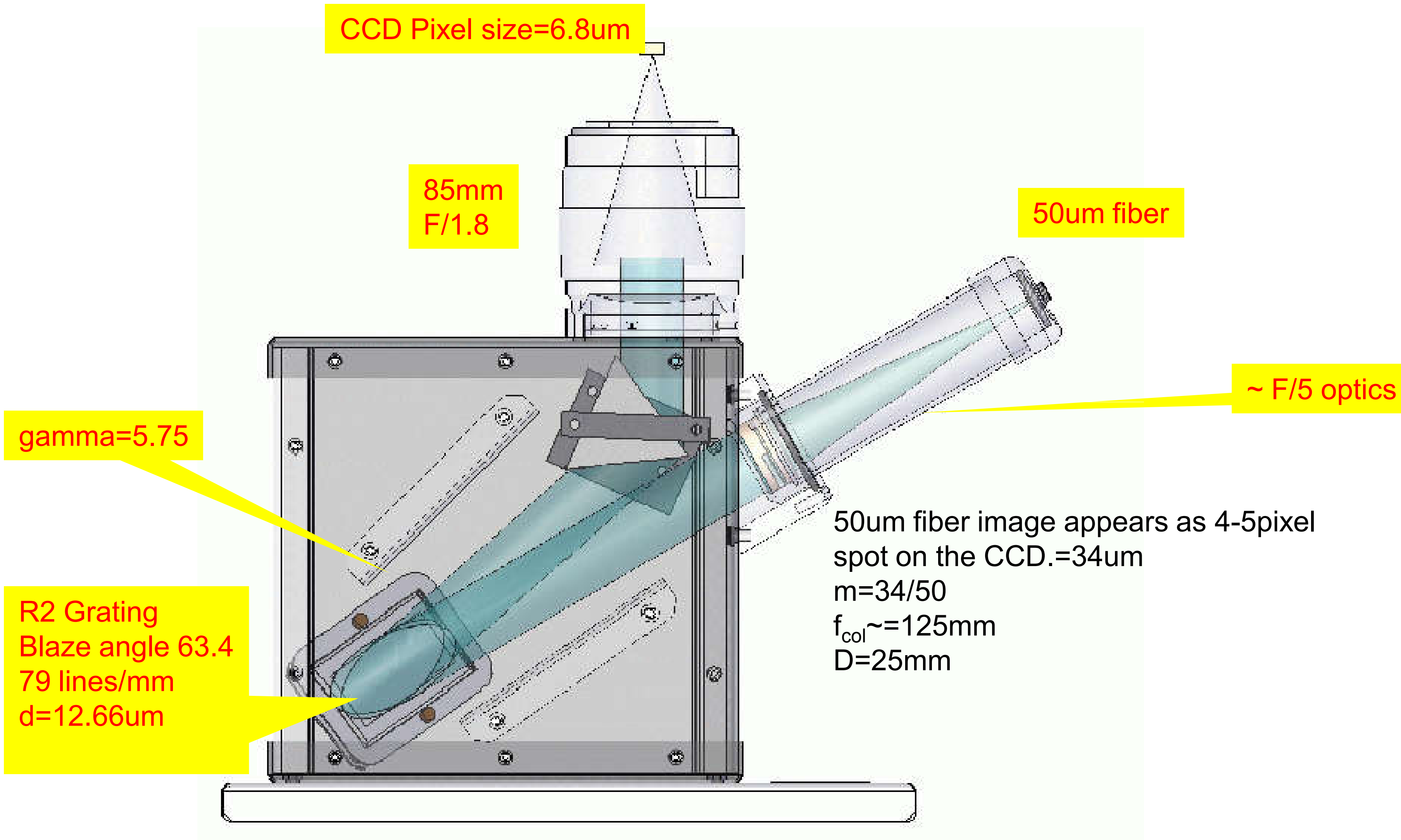
Practical Setup



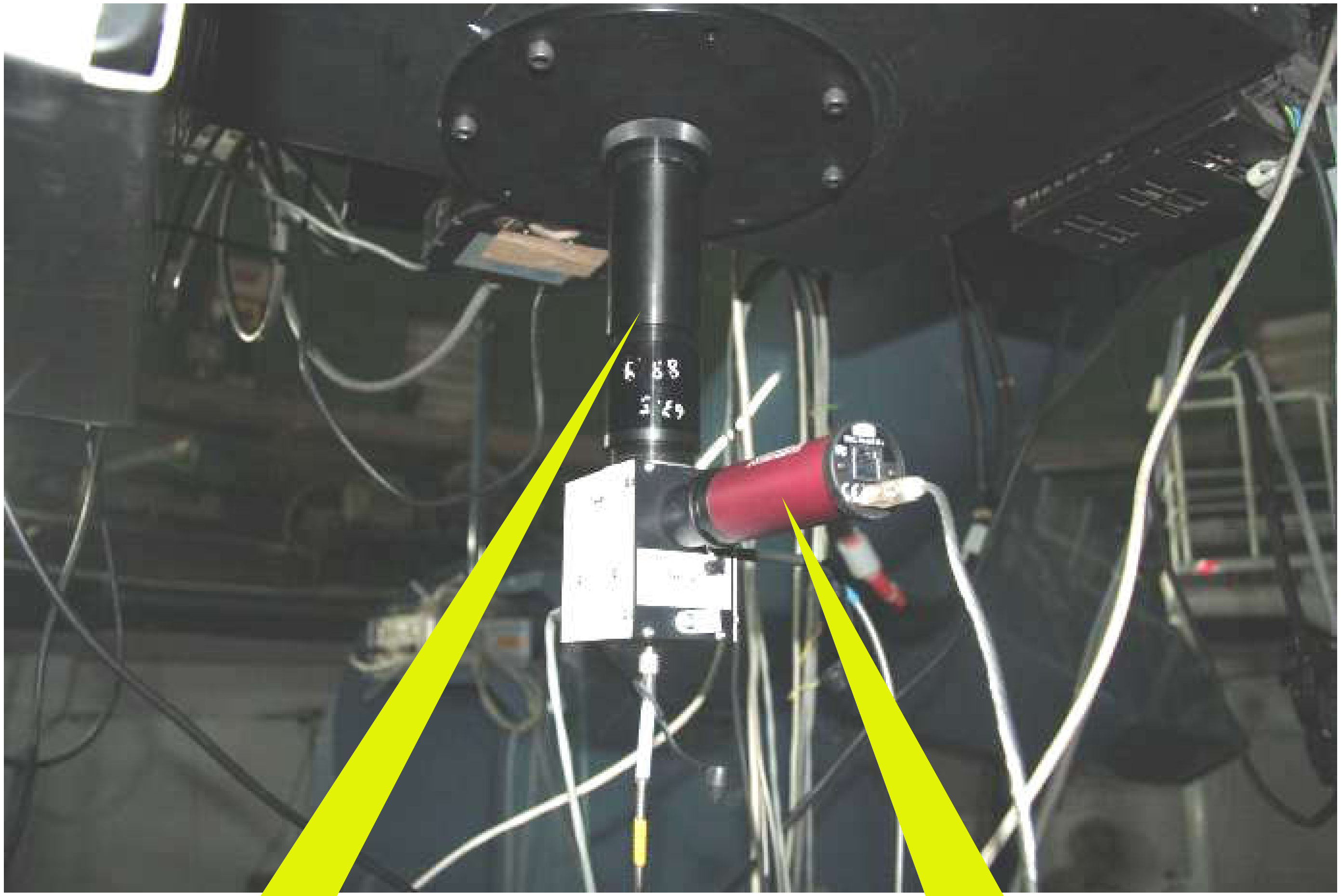
System Overview



Spectrograph unit -Optical Layout



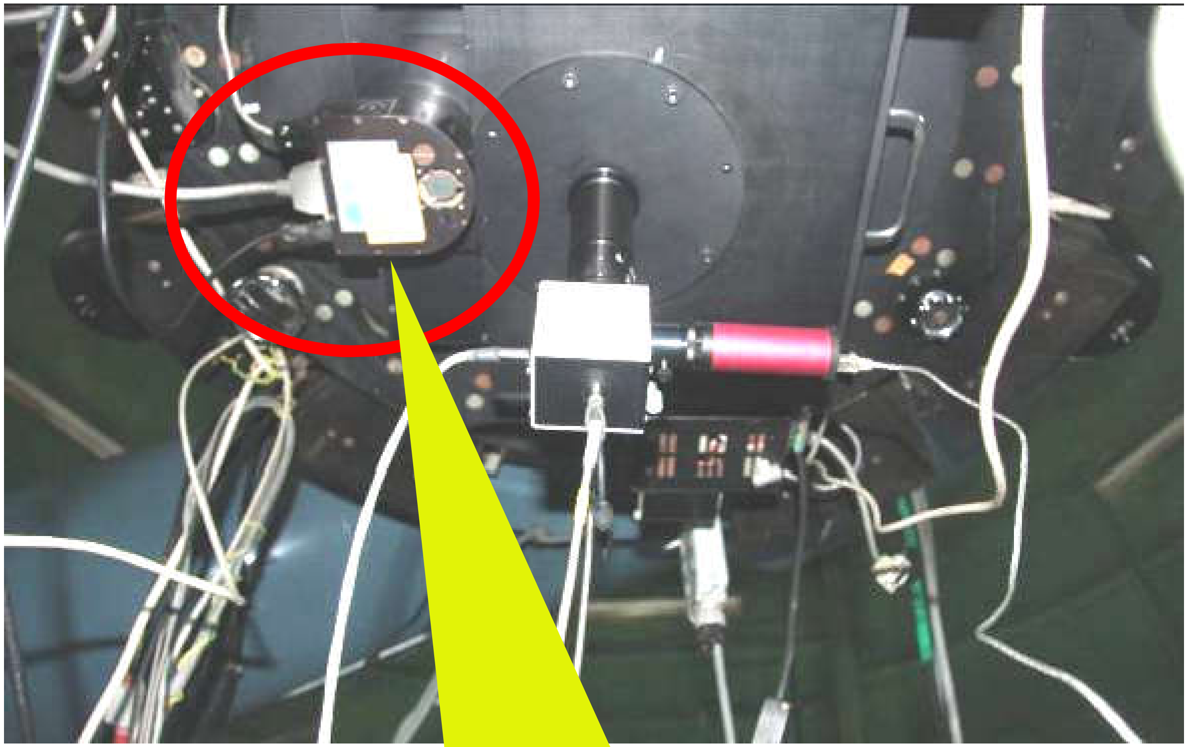
The eShel Setup at Wise



Focal Reducer x1.3

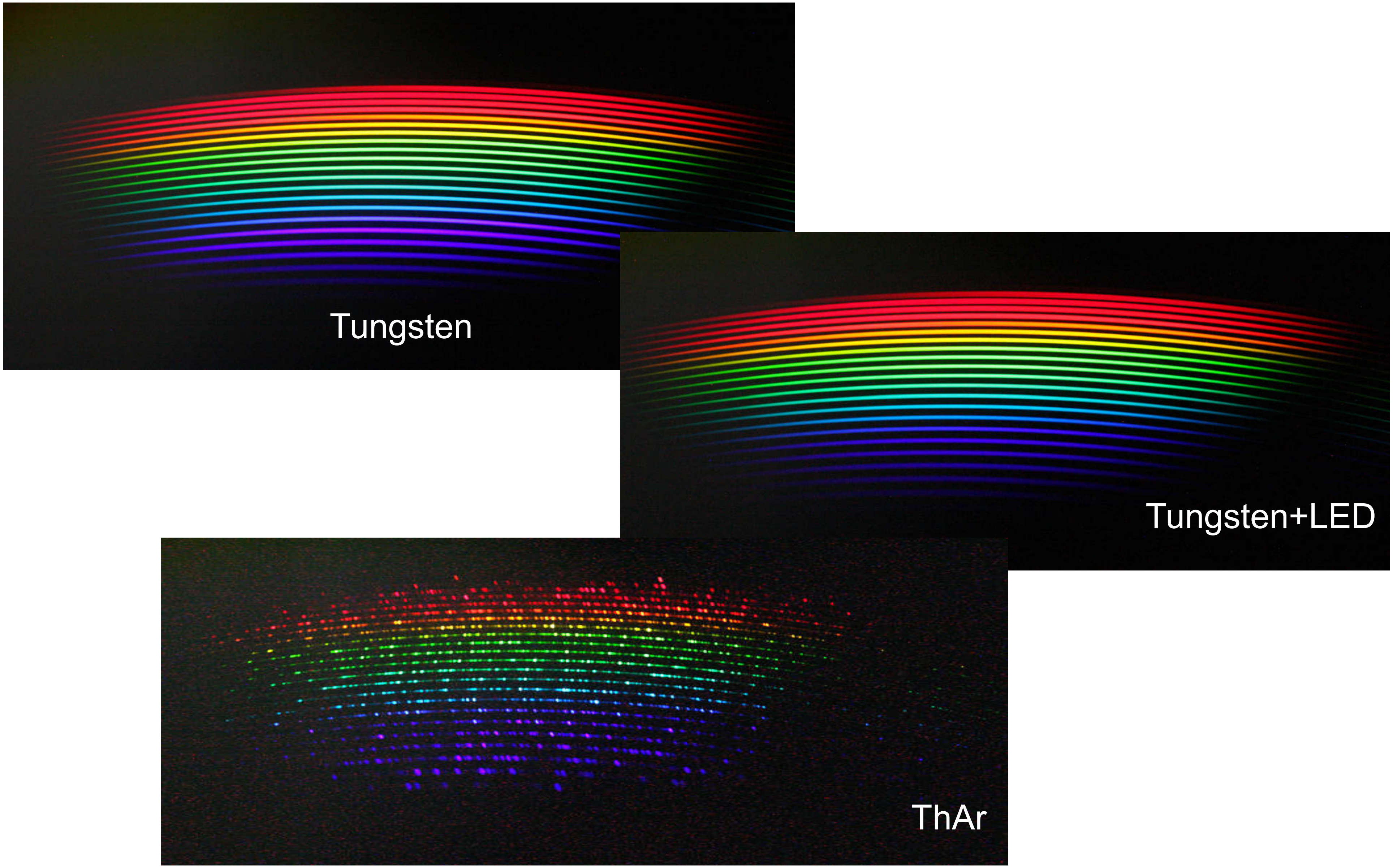
SBIG STi CCD
Scale is ~ 0.2"/pixel

The Guider

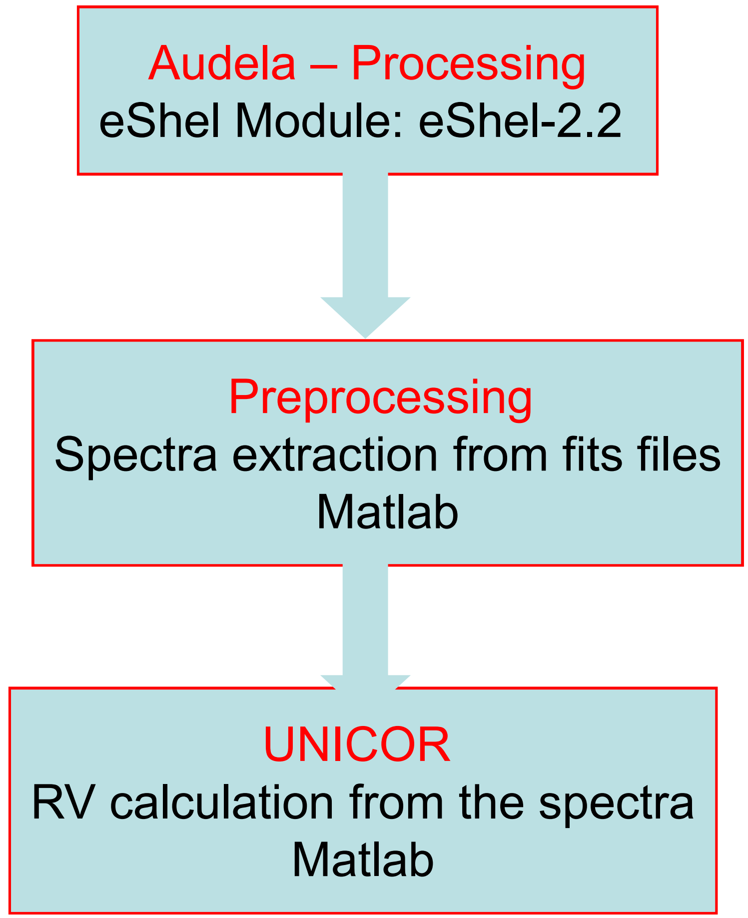


SBIG ST-7 with field expander
Scale is ~ 1"/pixel ~ x5 the scale at the FIGU

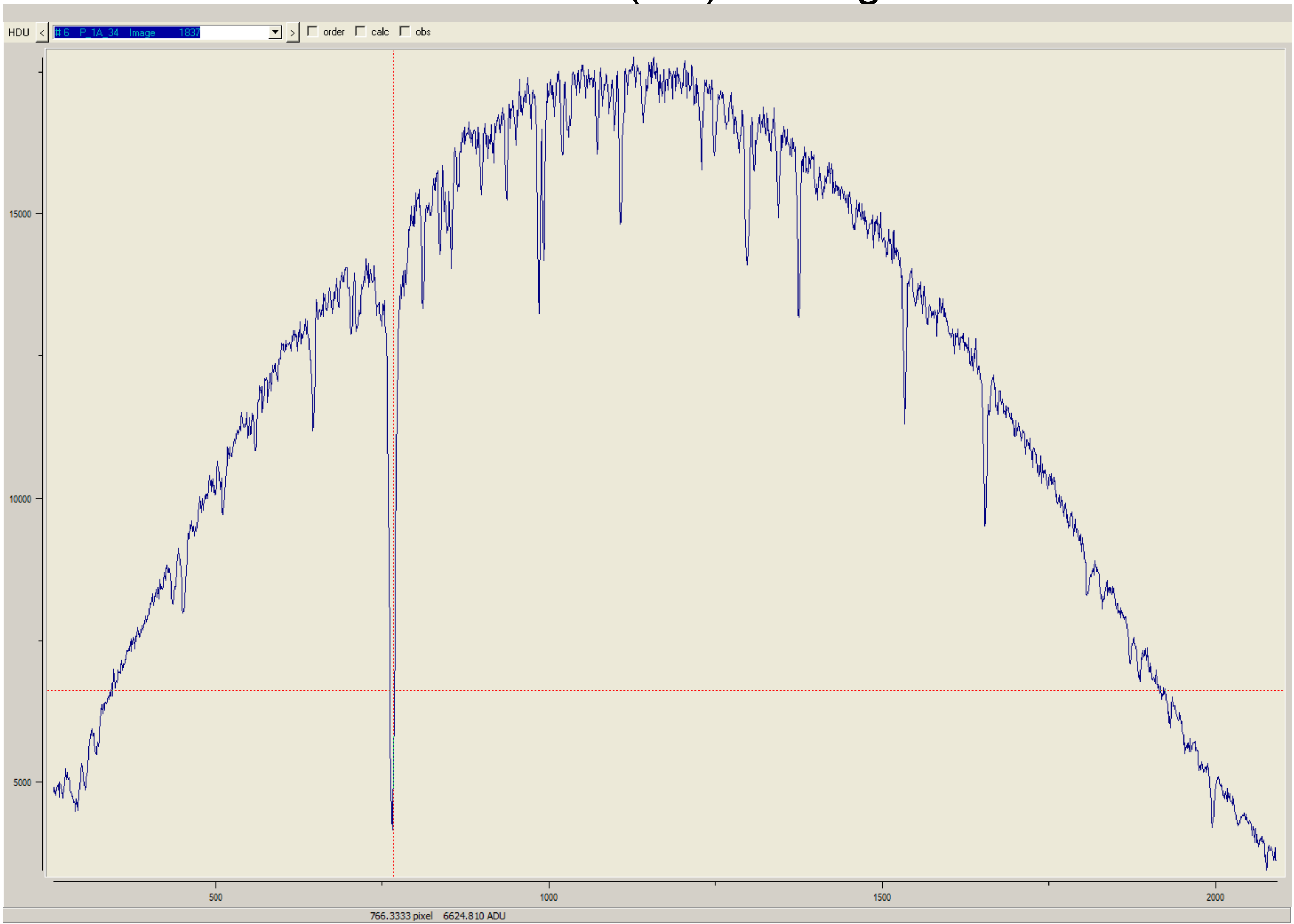
eShel Images -Color



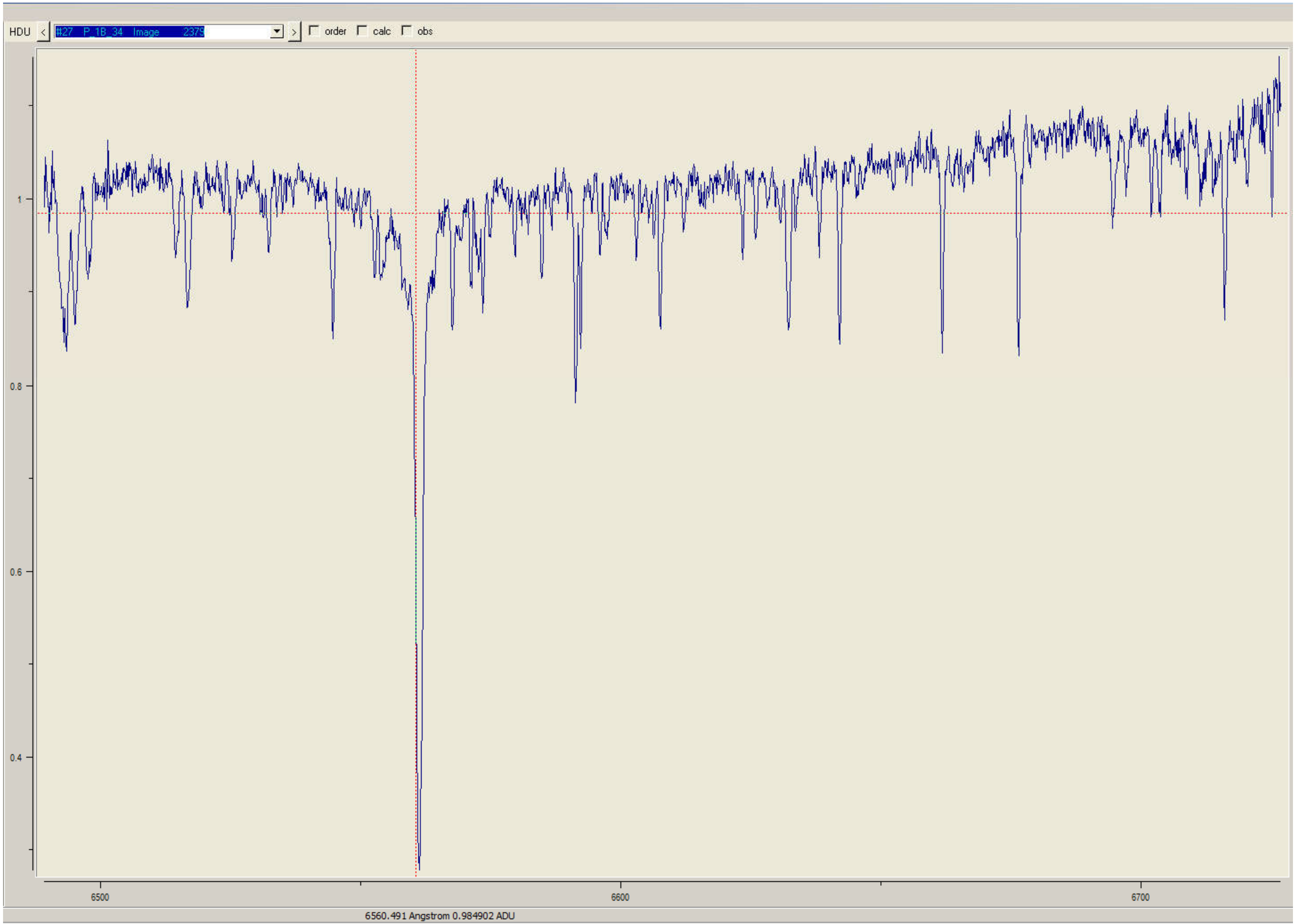
eShel Pipeline at Wise



Order 34 (Hα) 1st stage

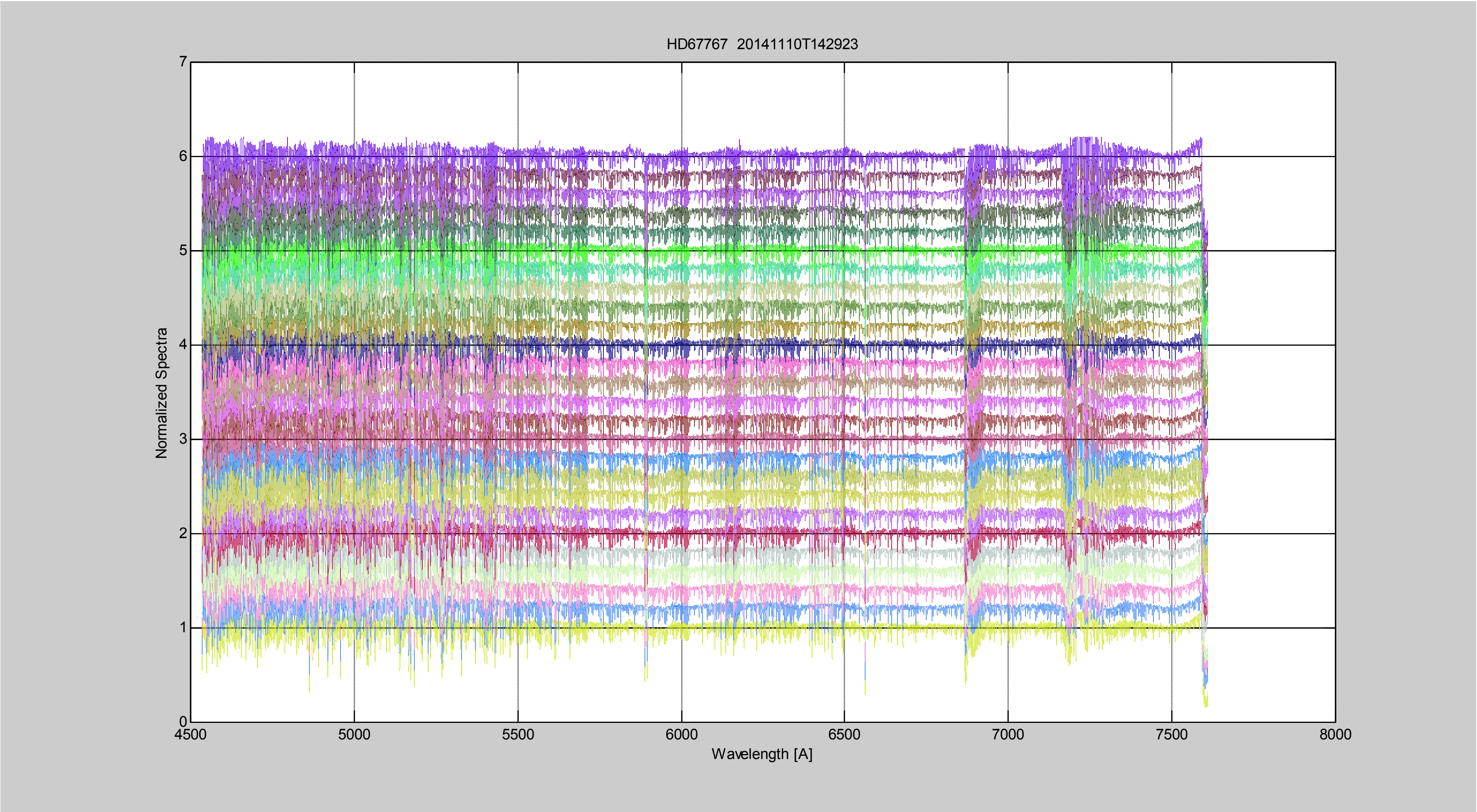


Order 34 (Ha) 2nd stage after wavelength calib

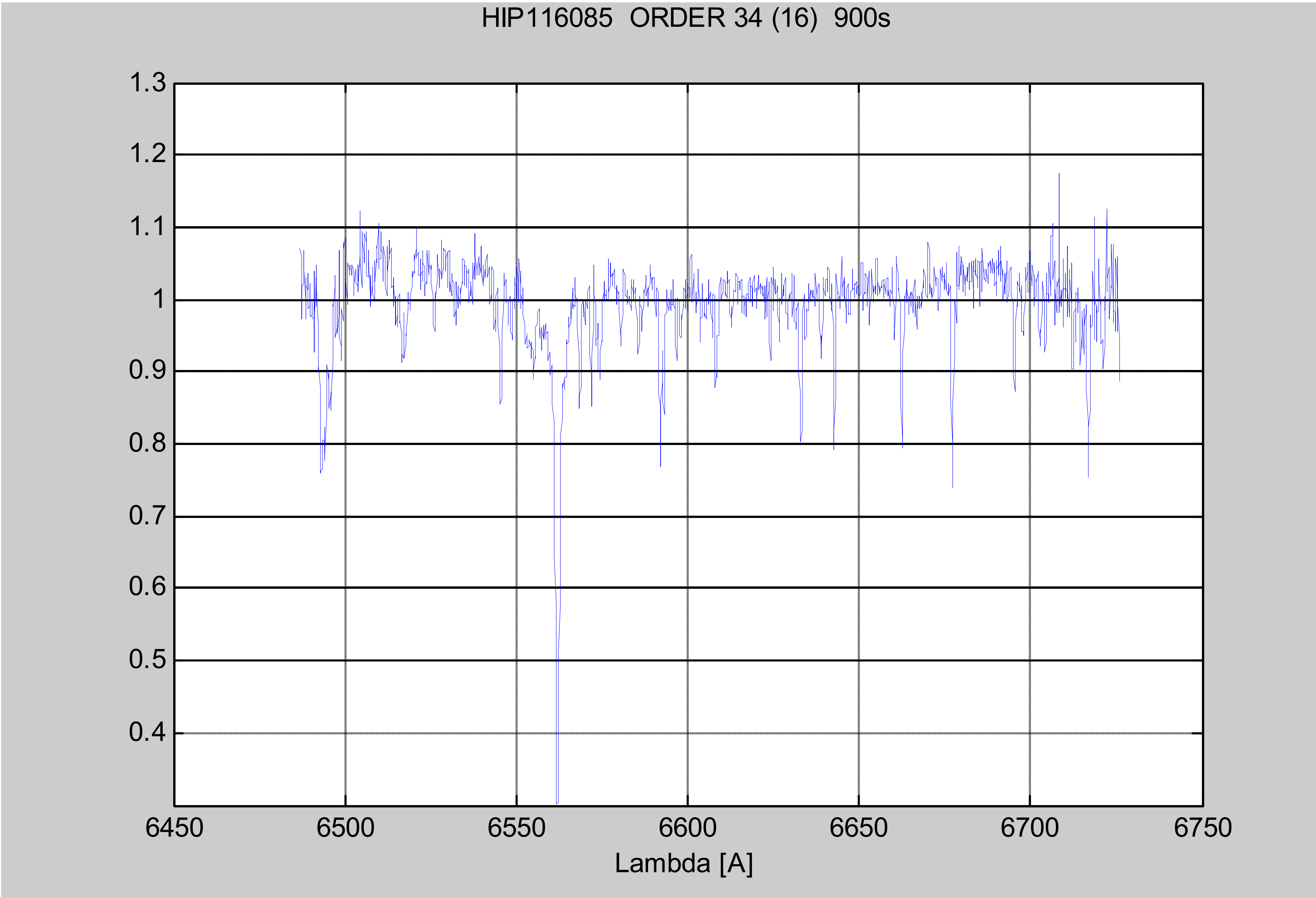


The final Product – Flattened Spectra

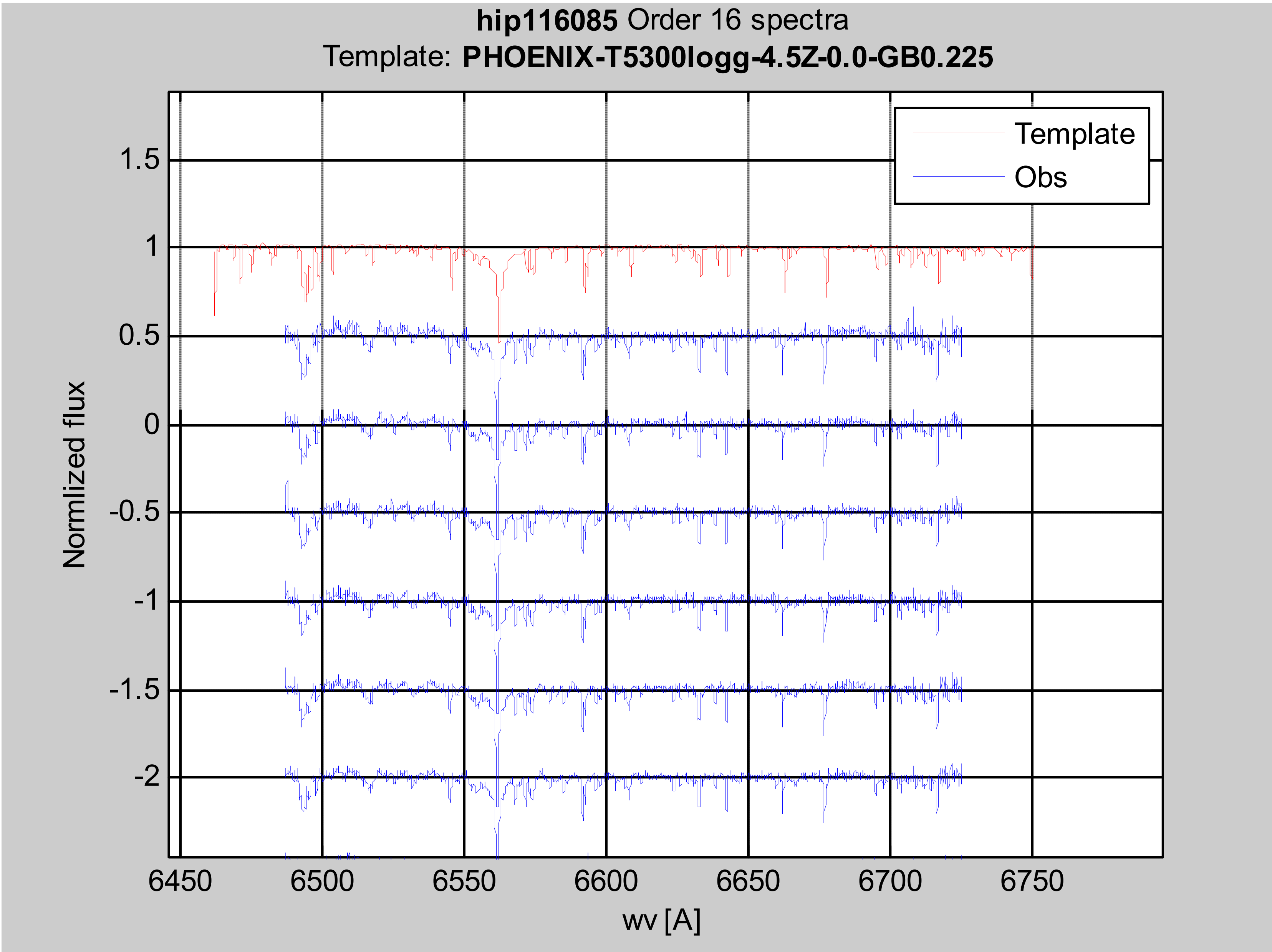
20 orders x No of observations



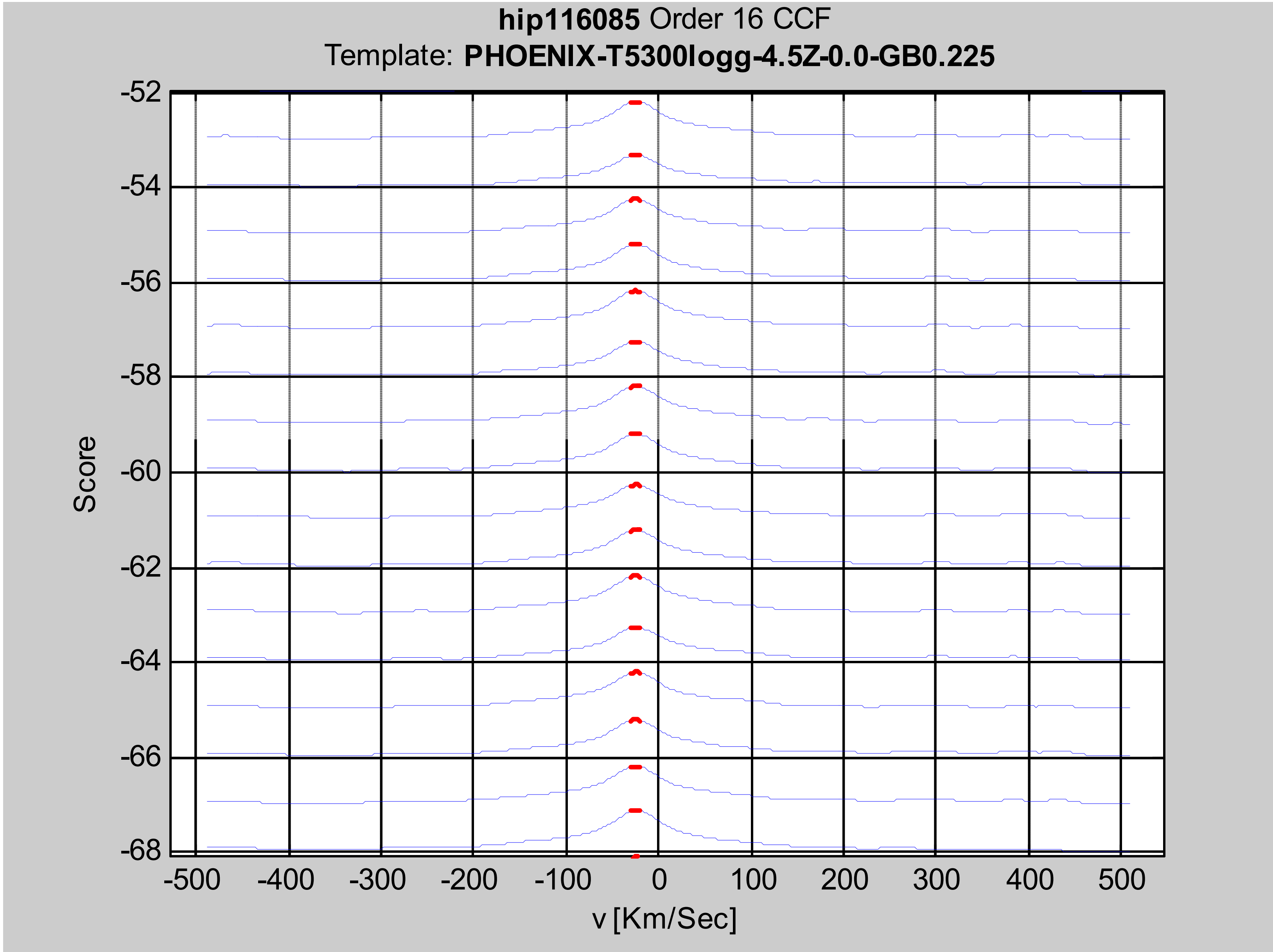
Single Order Spectrum



Unicor: Order 16 Template and Spectrum

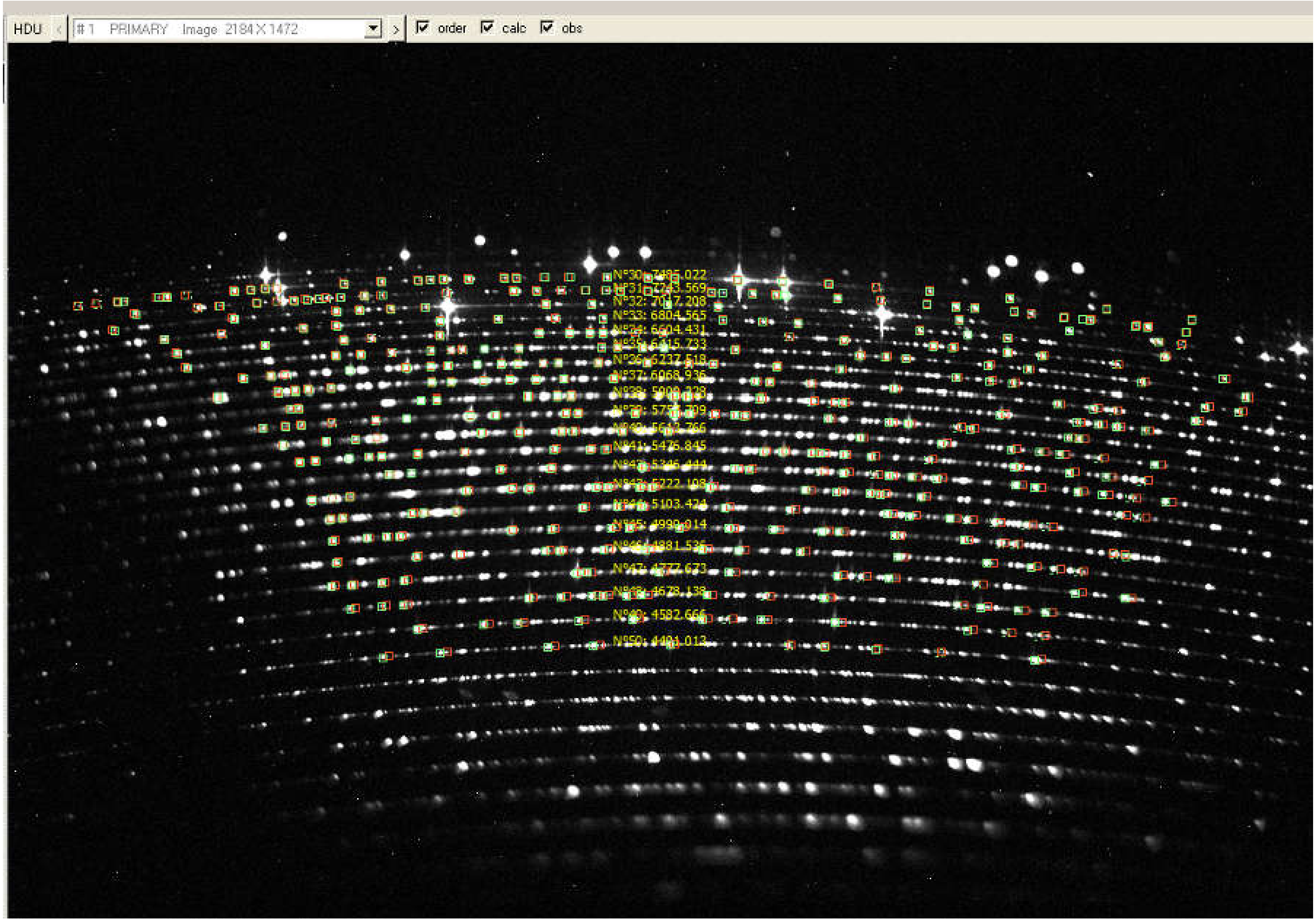


Unicor: CCF of Order 16



Calibration Fit Quality and Stability

ThAr Calibration



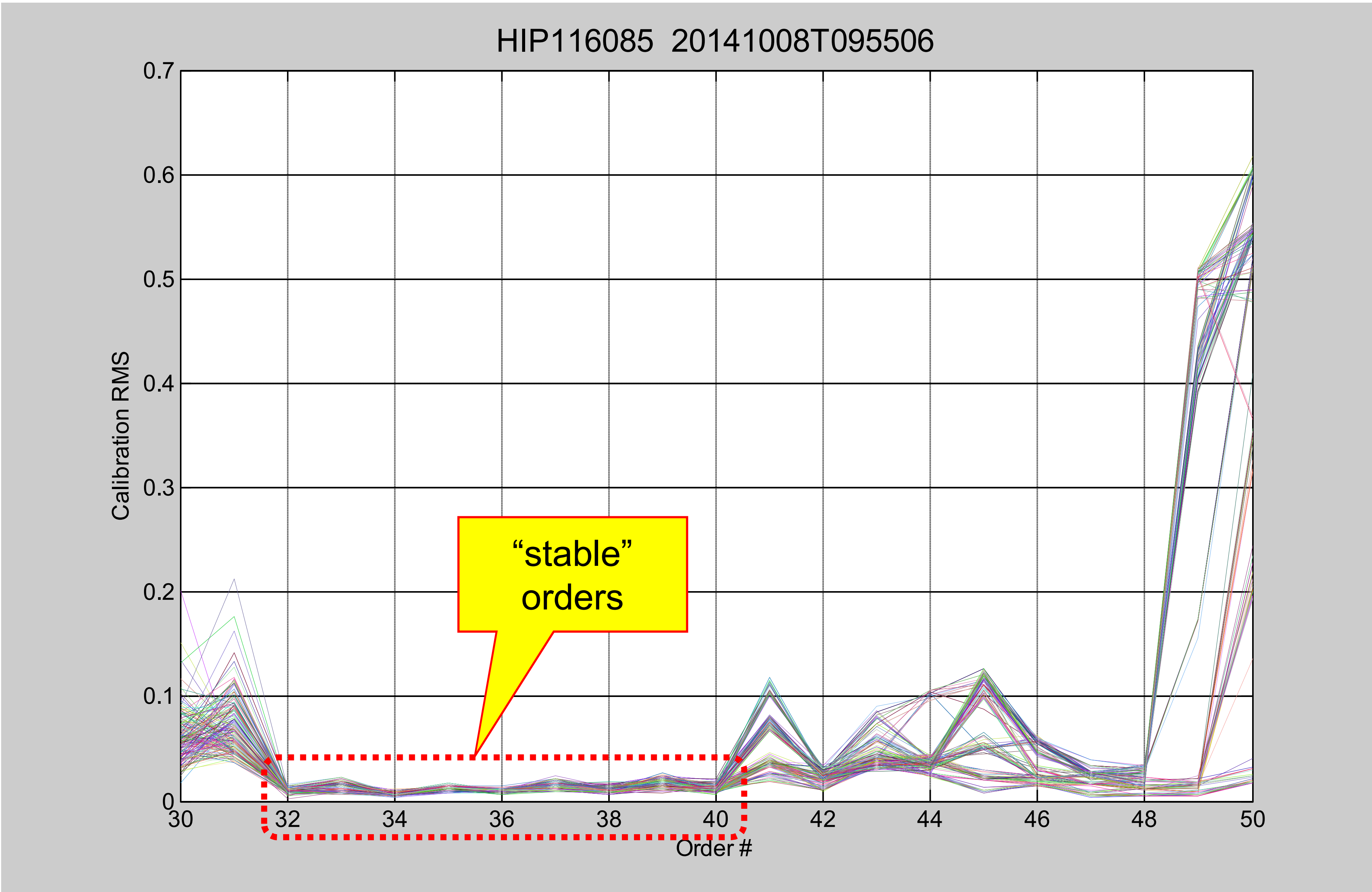
Order Table

HDU < #65 ORDERS Binary 25 X 21 > ☑ order ☑ calc ☑ obs

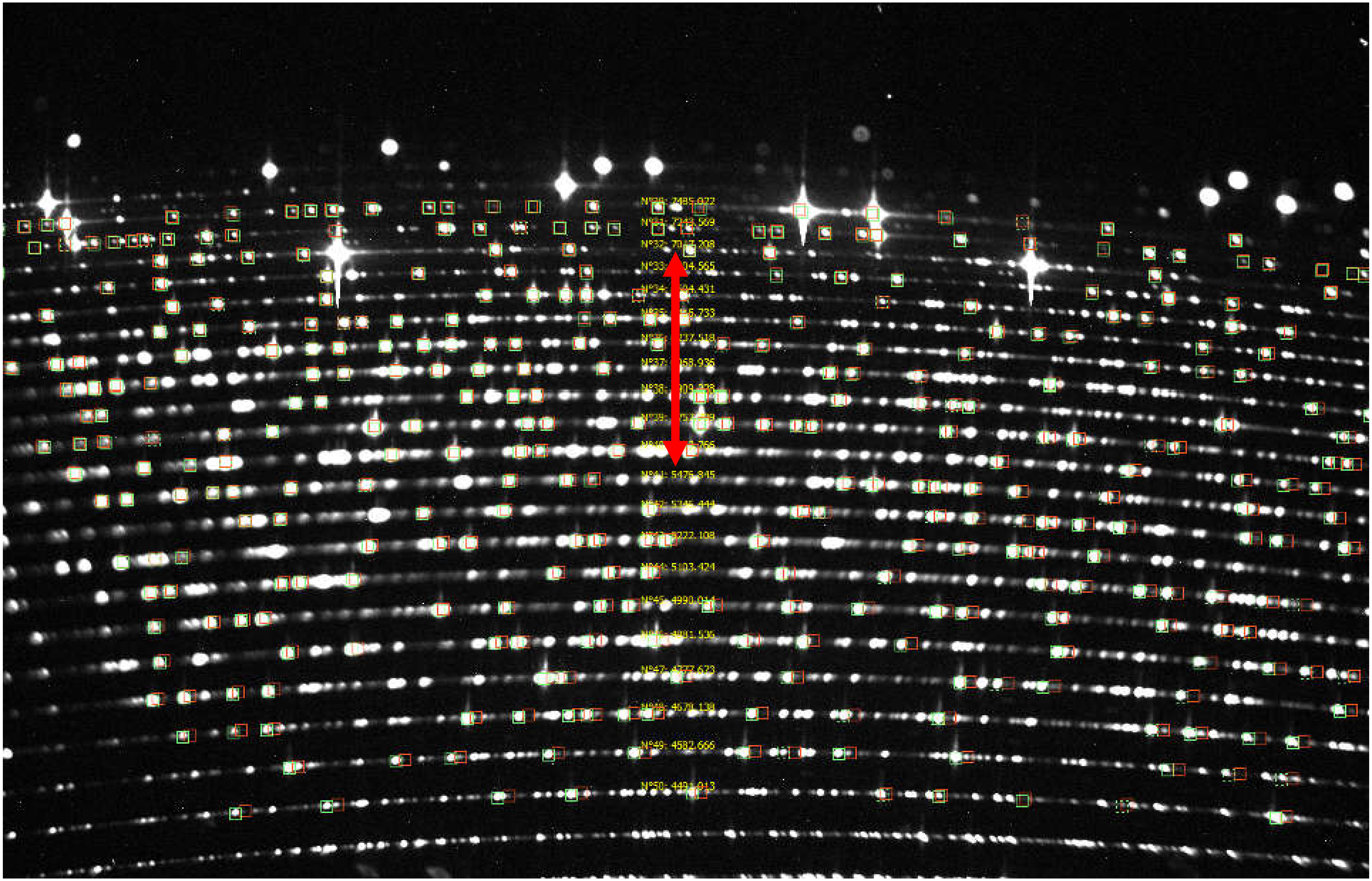
order	flag	min_x	max_x	P0	P1	P2	P3	P4	P5	yc	wide_y	wide_x	slant	rms_order	central	A0	A1	A2	A3	rms_cal	fwhm	disp	resolution	nb_lines
30	1	100	2000	1.009519E+003	1.316368E-001	-6.879312E-005	-1.184652E-009	1.183942E-012	-3.075341E-016	1071.00	12	12	0.00	0.0748	7485.022	1.380609E+000	-3.200825E-004	5.737206E-008	6.552841E-011	0.0381	4.81	0.151	10293.7	26
31	1	100	2000	9.862860E+002	1.322466E-001	-6.649684E-005	-4.194967E-009	2.563257E-012	-5.258613E-016	1049.00	12	12	0.00	0.0468	7243.569	1.282720E+000	-1.844324E-004	1.428591E-007	6.160369E-013	0.0298	4.29	0.144	11739.7	33
32	1	150	2000	9.623610E+002	1.335423E-001	-6.627645E-005	-4.724666E-009	2.744072E-012	-5.425714E-016	1026.00	12	12	0.00	0.0356	7017.208	1.176798E+000	9.038924E-006	1.172155E-007	-4.890391E-012	0.0106	4.32	0.140	11553.8	13
33	1	200	2000	9.377270E+002	1.351216E-001	-6.668332E-005	-4.582927E-009	2.613132E-012	-5.063491E-016	1003.00	12	12	0.00	0.0365	6804.565	1.118005E+000	1.628806E-004	8.876865E-008	-1.021414E-011	0.0080	4.42	0.136	11300.3	12
34	1	250	2100	9.121792E+002	1.380790E-001	-7.037854E-005	-9.132454E-010	7.604787E-013	-1.573130E-016	979.00	12	12	0.00	0.0429	6604.431	1.043621E+000	4.280520E-004	-4.985328E-008	1.532060E-011	0.0037	4.70	0.131	10713.8	14
35	1	270	2100	8.859897E+002	1.399410E-001	-7.103071E-005	-7.116485E-010	6.727605E-013	-1.390314E-016	954.00	12	12	0.00	0.0515	6415.733	1.008922E+000	6.105325E-004	-1.485475E-007	3.167824E-011	0.0121	4.79	0.126	10594.0	18
36	1	300	2100	8.586842E+002	1.434690E-001	-7.496973E-005	2.532160E-009	-7.179839E-013	8.840334E-017	928.00	12	12	0.00	0.0609	6237.518	9.905599E-001	6.445743E-004	-7.350707E-009	-4.328930E-011	0.0138	5.04	0.122	10106.3	20
37	1	330	2100	8.297314E+002	1.512656E-001	-8.728699E-005	1.336501E-008	-5.301171E-012	8.218021E-016	902.00	12	12	0.00	0.0768	6068.936	9.476344E-001	8.373939E-004	-9.901739E-009	-1.198183E-010	0.0185	5.01	0.121	9984.8	16
38	1	360	2100	8.007551E+002	1.535939E-001	-8.784370E-005	1.311877E-008	-5.120115E-012	7.896821E-016	874.00	12	12	0.00	0.0842	5909.228	1.124013E+000	-6.384170E-004	3.665680E-006	-2.499321E-009	0.1102	5.65	0.116	9013.2	15
39	1	390	2000	7.696018E+002	1.617721E-001	-9.925107E-005	2.249857E-008	-8.988120E-012	1.407165E-015	846.00	12	12	0.00	0.0977	5757.709	1.002229E+000	1.304327E-003	-9.005462E-007	3.720986E-010	0.0200	5.40	0.118	9069.4	18
40	1	400	2000	7.350039E+002	1.835339E-001	-1.389385E-004	5.884216E-008	-2.472783E-011	3.984567E-015	817.00	12	12	0.00	0.1303	5613.766	6.646602E-001	5.308859E-003	-9.056949E-006	3.539508E-009	0.1450	5.68	0.109	9065.7	14
41	1	450	2000	7.017365E+002	1.898908E-001	-1.446637E-004	6.229249E-008	-2.594207E-011	4.166599E-015	787.00	12	12	0.00	0.1276	5476.845	1.169663E+000	-1.562613E-004	2.722506E-006	-1.898007E-009	0.0808	5.43	0.109	9236.2	17
42	1	460	2000	6.702276E+002	1.818035E-001	-1.236471E-004	4.256890E-008	-1.760852E-011	2.840459E-015	755.00	12	12	0.00	0.1208	5346.444	-1.899493E+000	1.290288E-002	-1.293074E-005	3.487217E-009	0.2519	5.19	0.102	10090.7	15
43	1	480	2000	6.284005E+002	2.200617E-001	-1.907750E-004	1.010374E-007	-4.189428E-011	6.688686E-015	723.00	12	12	0.00	0.1487	5222.108	9.382631E-001	5.043601E-003	-8.906474E-006	3.805569E-009	0.2706	6.64	0.102	7713.5	14
44	1	500	1900	5.970868E+002	1.977247E-001	-1.431625E-004	5.932935E-008	-2.523850E-011	4.193170E-015	689.00	12	12	0.00	0.1172	5103.424	1.341568E+000	4.437757E-004	1.374882E-006	-1.538750E-009	0.1281	5.16	0.101	9790.2	14
45	1	500	1900	5.607028E+002	1.940160E-001	-1.294903E-004	4.553534E-008	-1.900052E-011	3.120127E-015	654.00	12	12	0.00	0.1114	4990.014	1.202885E+000	3.212187E-003	-4.935189E-006	1.353662E-009	0.1294	5.41	0.096	9571.4	15
46	1	520	1900	5.253325E+002	1.783896E-001	-9.455011E-005	1.434249E-008	-6.073303E-012	1.068945E-015	618.00	12	12	0.00	0.0897	4881.536	1.633100E+000	-1.249534E-003	4.495772E-006	-3.416828E-009	0.2031	5.41	0.096	9392.0	12
47	1	530	1900	4.816655E+002	1.963169E-001	-1.217649E-004	3.747674E-008	-1.566575E-011	2.590253E-015	581.00	12	12	0.00	0.0713	4777.673	1.264806E+000	6.089959E-003	-1.411029E-005	7.192038E-009	0.2515	4.65	0.093	11079.6	10
48	1	560	1900	4.402567E+002	1.945943E-001	-1.112939E-004	2.702234E-008	-1.110372E-011	1.832003E-015	542.00	12	12	0.00	0.0444	4678.138	1.918403E+000	-8.255483E-003	1.312697E-005	-6.182801E-009	0.3615	4.74	0.091	10815.3	14
49	1	560	1800	8.036635E+002	-1.403833E+000	2.750566E-003	-2.661819E-006	1.261076E-009	-2.327801E-013	517.00	12	12	0.00	2.0854	4582.666	-3.450868E-001	1.009451E-002	-1.434822E-005	5.147585E-009	0.3190	3.42	0.088	15175.9	12
50	1	600	1800	3.981613E+002	1.893779E-001	-9.618336E-005	1.416873E-008	-6.204392E-012	1.123553E-015	502.00	12	12	0.00	0.0451	4491.013	6.268248E-001	2.649722E-003	-4.685312E-006	2.489918E-009	0.3387	4.63	0.089	10924.1	10

order	flag	min_x	max_x	rms_order	central	A0	A1	A2	A3	rms_cal	fwhm	disp	resolution	nb_lines
30	1	100	2000	0.0748	7485.022	1.380609E+000	-3.200825E-004	5.737206E-008	6.552841E-011	0.0381	4.81	0.151	10293.7	26
31	1	100	2000	0.0468	7243.569	1.282720E+000	-1.844324E-004	1.428591E-007	6.160369E-013	0.0298	4.29	0.144	11739.7	33
32	1	150	2000	0.0356	7017.208	1.176798E+000	9.038924E-006	1.172155E-007	-4.890391E-012	0.0106	4.32	0.140	11553.8	13
33	1	200	2000	0.0365	6804.565	1.118005E+000	1.628806E-004	8.876865E-008	-1.021414E-011	0.0080	4.42	0.136	11300.3	12
34	1	250	2100	0.0429	6604.431	1.043621E+000	4.280520E-004	-4.985328E-008	1.532060E-011	0.0037	4.70	0.131	10713.8	14
35	1	270	2100	0.0515	6415.733	1.008922E+000	6.105325E-004	-1.485475E-007	3.167824E-011	0.0121	4.79	0.126	10594.0	18
36	1	300	2100	0.0609	6237.518	9.905599E-001	6.445743E-004	-7.350707E-009	-4.328930E-011	0.0138	5.04	0.122	10106.3	20
37	1	330	2100	0.0768	6068.936	9.476344E-001	8.373939E-004	-9.901739E-009	-1.198183E-010	0.0185	5.01	0.121	9984.8	16
38	1	360	2100	0.0842	5909.228	1.124013E+000	-6.384170E-004	3.665680E-006	-2.499321E-009	0.1102	5.65	0.116	9013.2	15
39	1	390	2000	0.0977	5757.709	1.002229E+000	1.304327E-003	-9.005462E-007	3.720986E-010	0.0200	5.40	0.118	9069.4	18
40	1	400	2000	0.1303	5613.766	6.646602E-001	5.308859E-003	-9.056949E-006	3.539508E-009	0.1450	5.68	0.109	9065.7	14
41	1	450	2000	0.1276	5476.845	1.169663E+000	-1.562613E-004	2.722506E-006	-1.898007E-009	0.0808	5.43	0.109	9236.2	17
42	1	460	2000	0.1208	5346.444	-1.899493E+000	1.290288E-002	-1.293074E-005	3.487217E-009	0.2519	5.19	0.102	10090.7	15
43	1	480	2000	0.1487	5222.108	9.382631E-001	5.043601E-003	-8.906474E-006	3.805569E-009	0.2706	6.64	0.102	7713.5	14
44	1	500	1900	0.1172	5103.424	1.341568E+000	4.437757E-004	1.374882E-006	-1.538750E-009	0.1281	5.16	0.101	9790.2	14
45	1	500	1900	0.1114	4990.014	1.202885E+000	3.212187E-003	-4.935189E-006	1.353662E-009	0.1294	5.41	0.096	9571.4	15
46	1	520	1900	0.0897	4881.536	1.633100E+000	-1.249534E-003	4.495772E-006	-3.416828E-009	0.2031	5.41	0.096	9392.0	12
47	1	530	1900	0.0713	4777.673	1.264806E+000	6.089959E-003	-1.411029E-005	7.192038E-009	0.2515	4.65	0.093	11079.6	10
48	1	560	1900	0.0444	4678.138	1.918403E+000	-8.255483E-003	1.312697E-005	-6.182801E-009	0.3615	4.74	0.091	10815.3	14
49	1	560	1800	2.0854	4582.666	-3.450868E-001	1.009451E-002	-1.434822E-005	5.147585E-009	0.3190	3.42	0.088	15175.9	12
50	1	600	1800	0.0451	4491.013	6.268248E-001	2.649722E-003	-4.685312E-006	2.489918E-009	0.3387	4.63	0.089	10924.1	10

ThAr Calibration RMS-Cal



ThAr Calibration



The scatter δv_{RMS}

$$\delta V_{RMS} = \frac{c}{Q \cdot \sqrt{N_{e^-}}}$$

Q Factor- the amount of information in the measured spectrum (no noise)

SNR on total count for photon noise limited system

Q depends on:

- the spectral type of the star
- the resolution of the spectrograph
- the spectral range of the spectrograph

•Ne depends on:

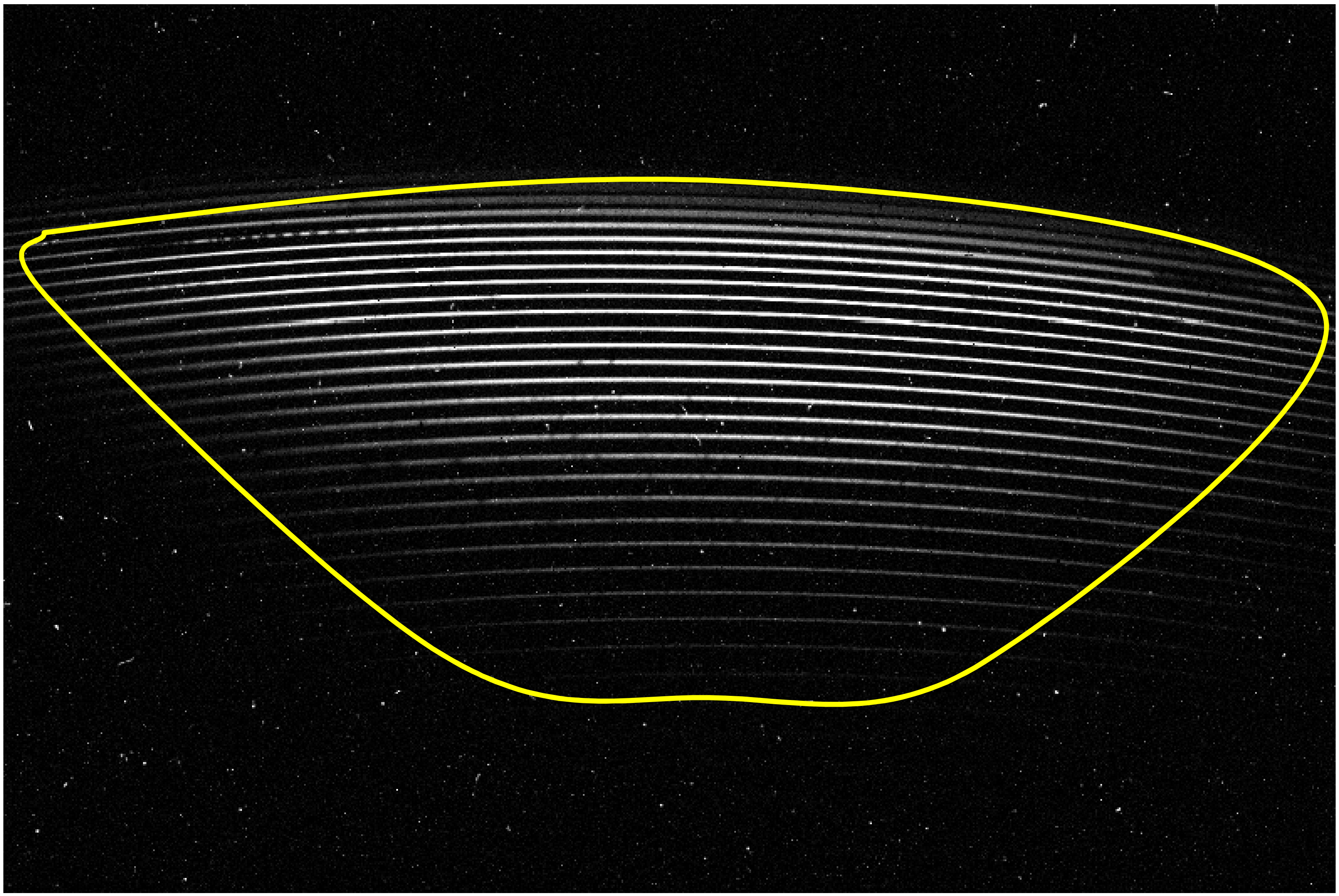
- the number of photons collected from the star
- the efficiency of the spectrograph in converting the photons to usable counts in the spectrum

Evaluating δV

$$\delta V_{RMS} = \frac{c}{Q \cdot \sqrt{N_{e^-}}}$$

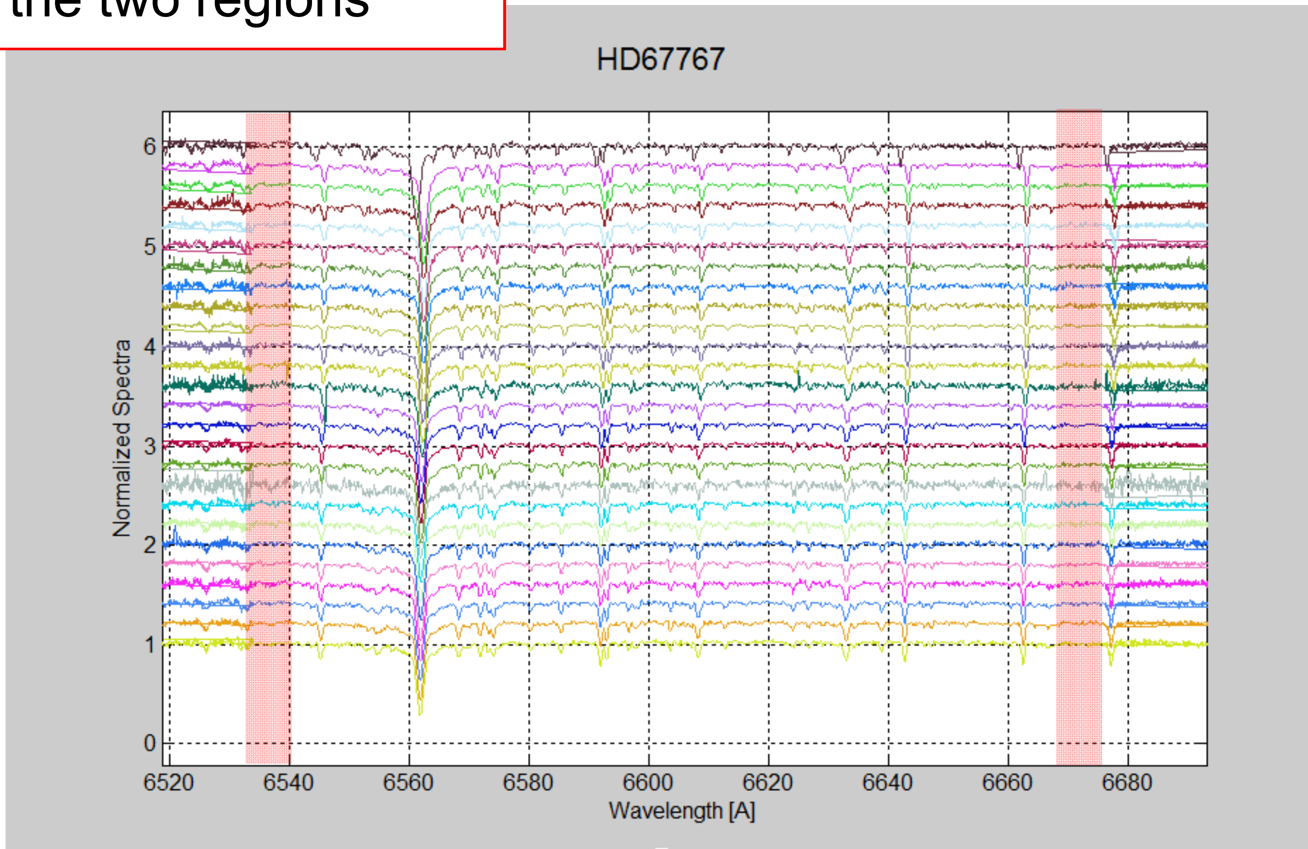
Calculation of Total Signal

ΣP_1A_order_i
i=first order (30) to last order (50)

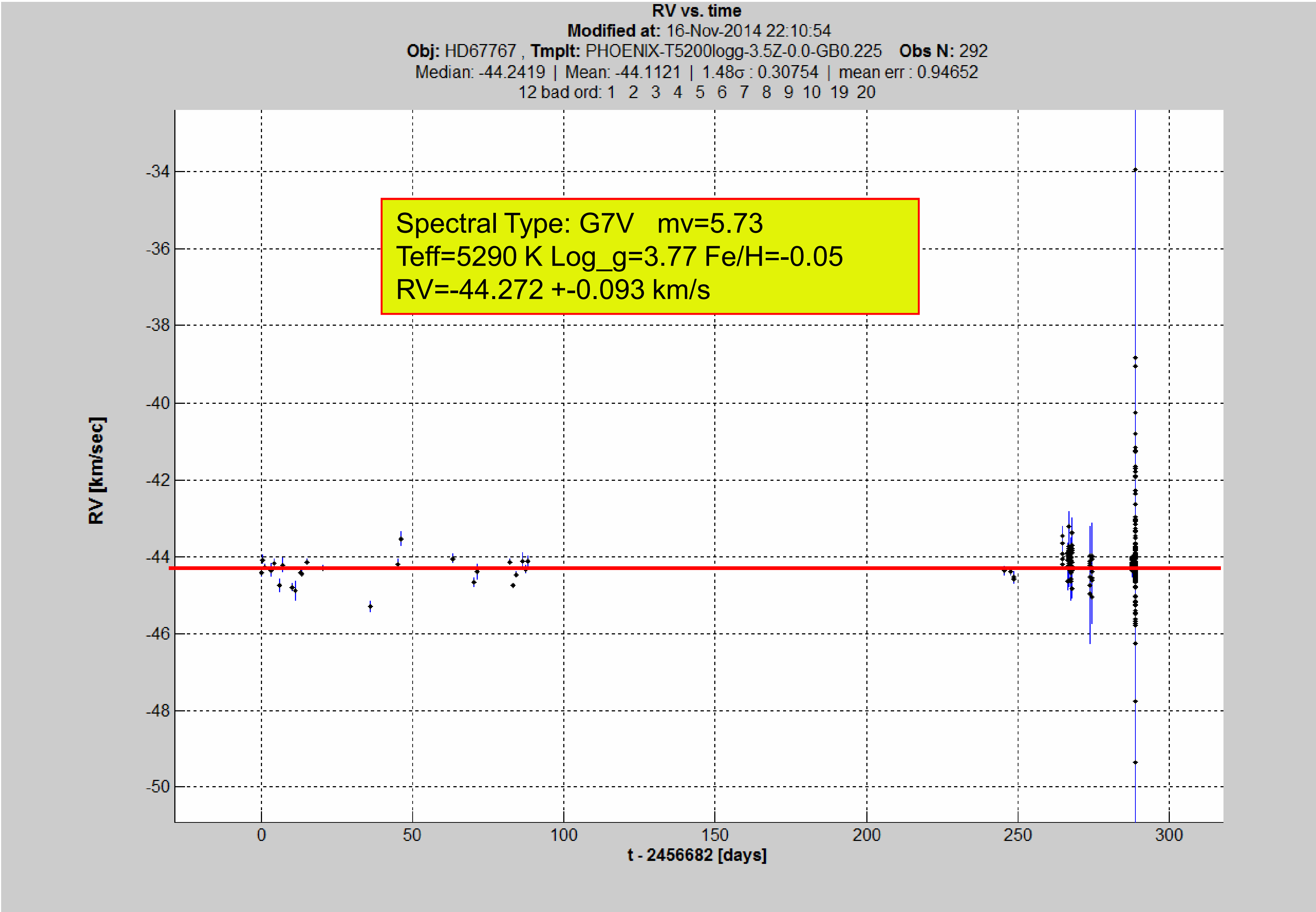


Calculation of SNR (SNR/pixel)

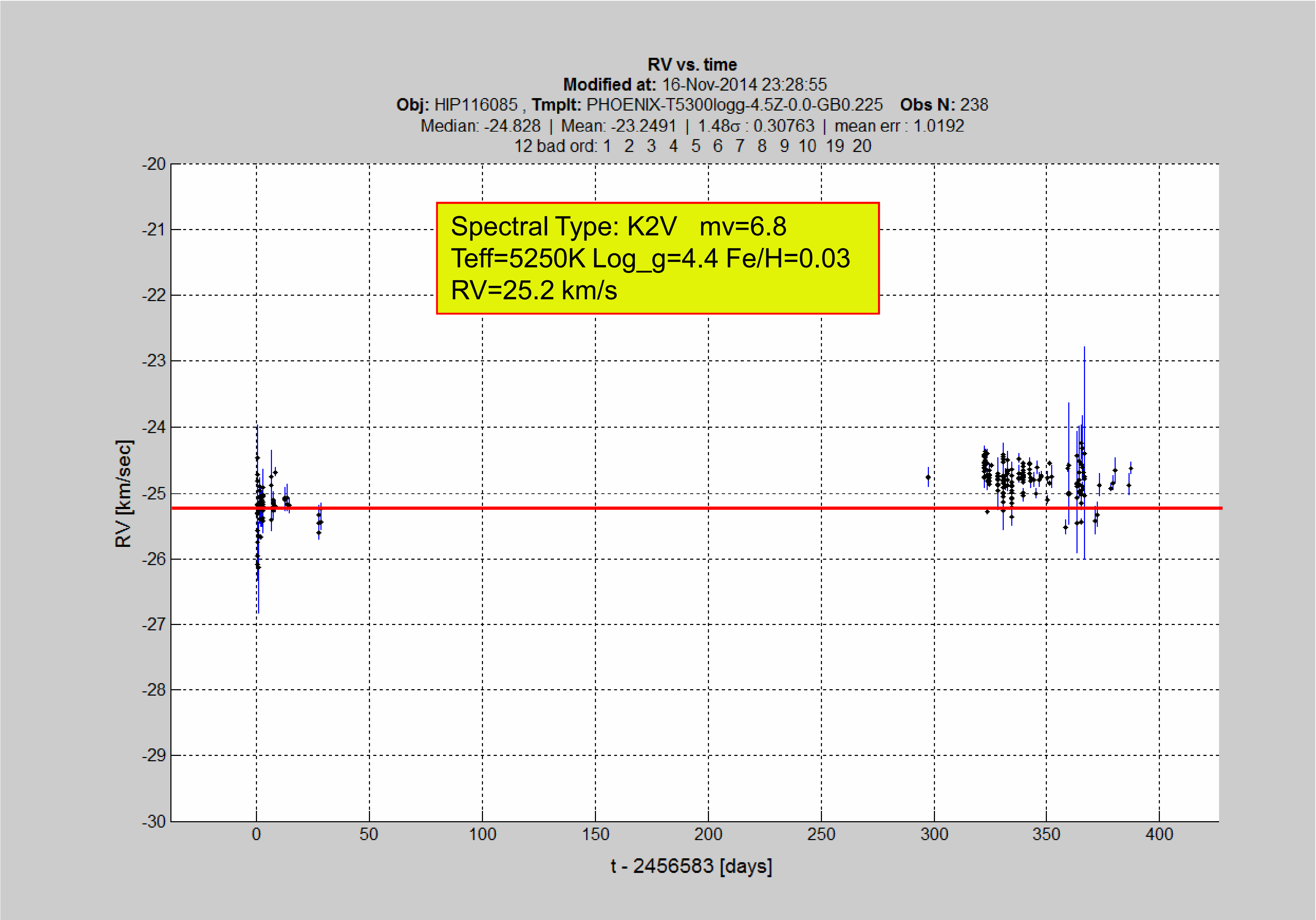
- 2 ranges:
  - 6535A-6540A
  - 6670A-6675A
  - $SNR=mean(S_i)/std(S_i)$
- Mean of SNR for the two regions



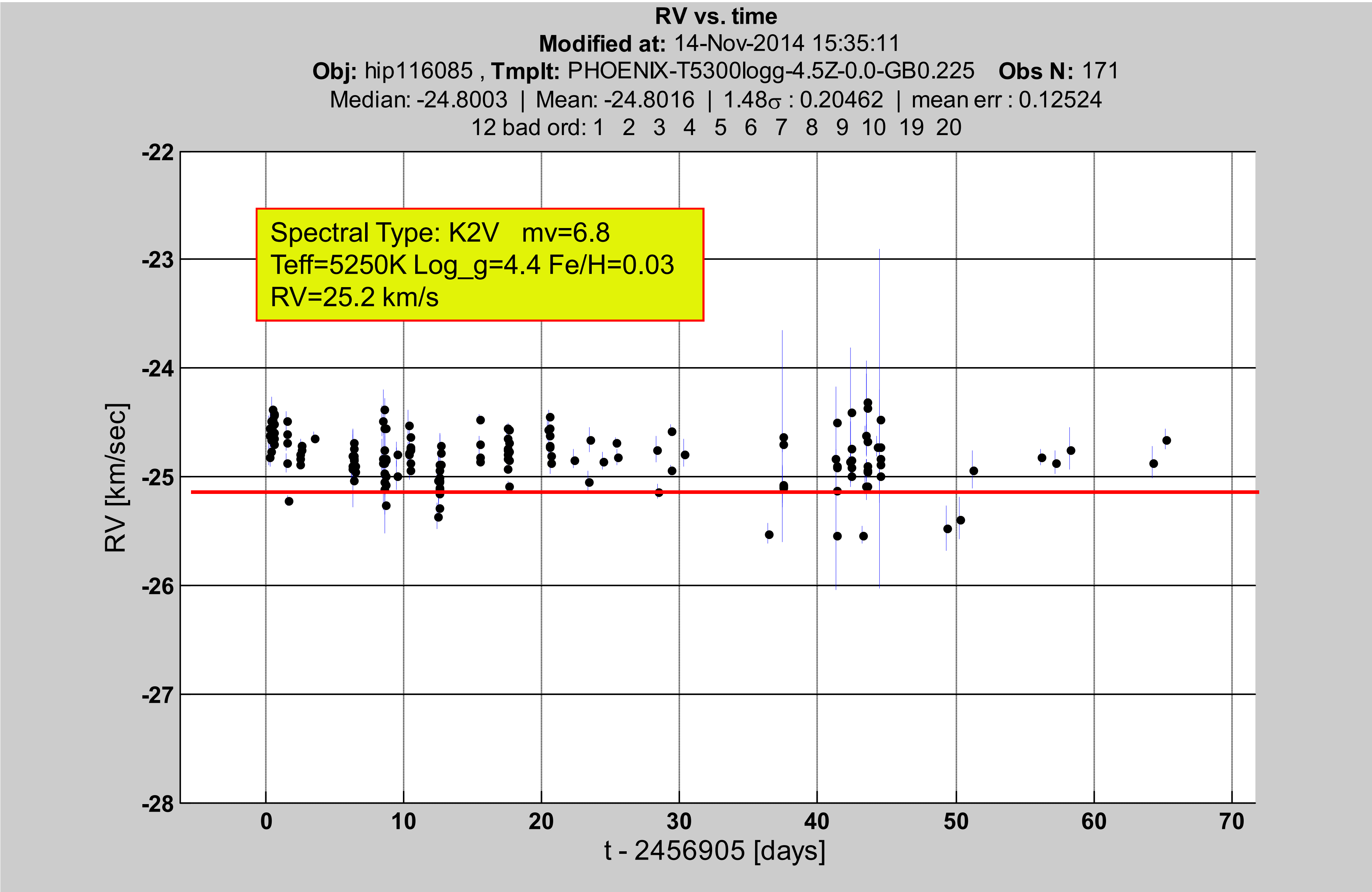
RV Measurements HD67767



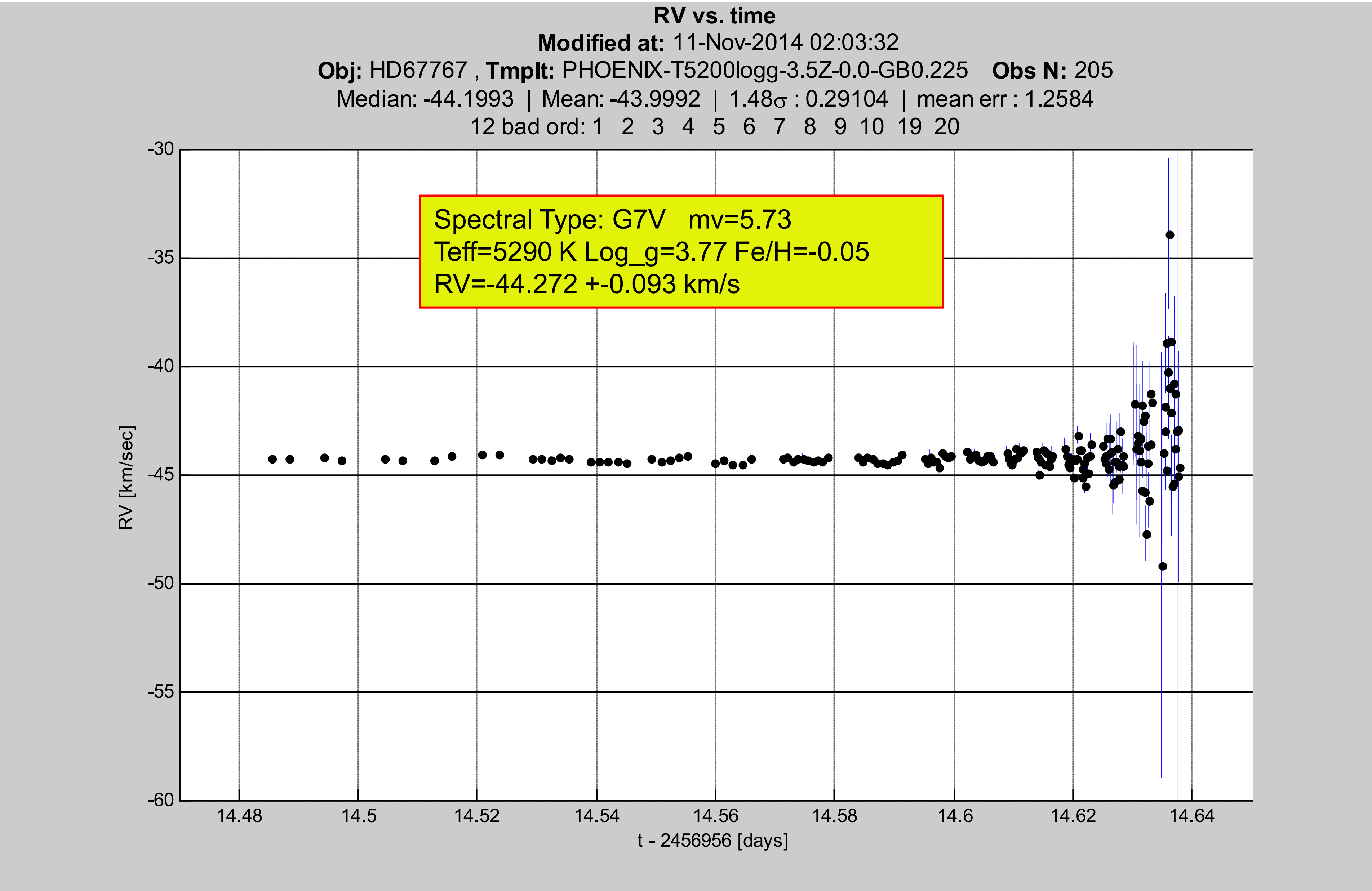
HIP116085 (HD221354)

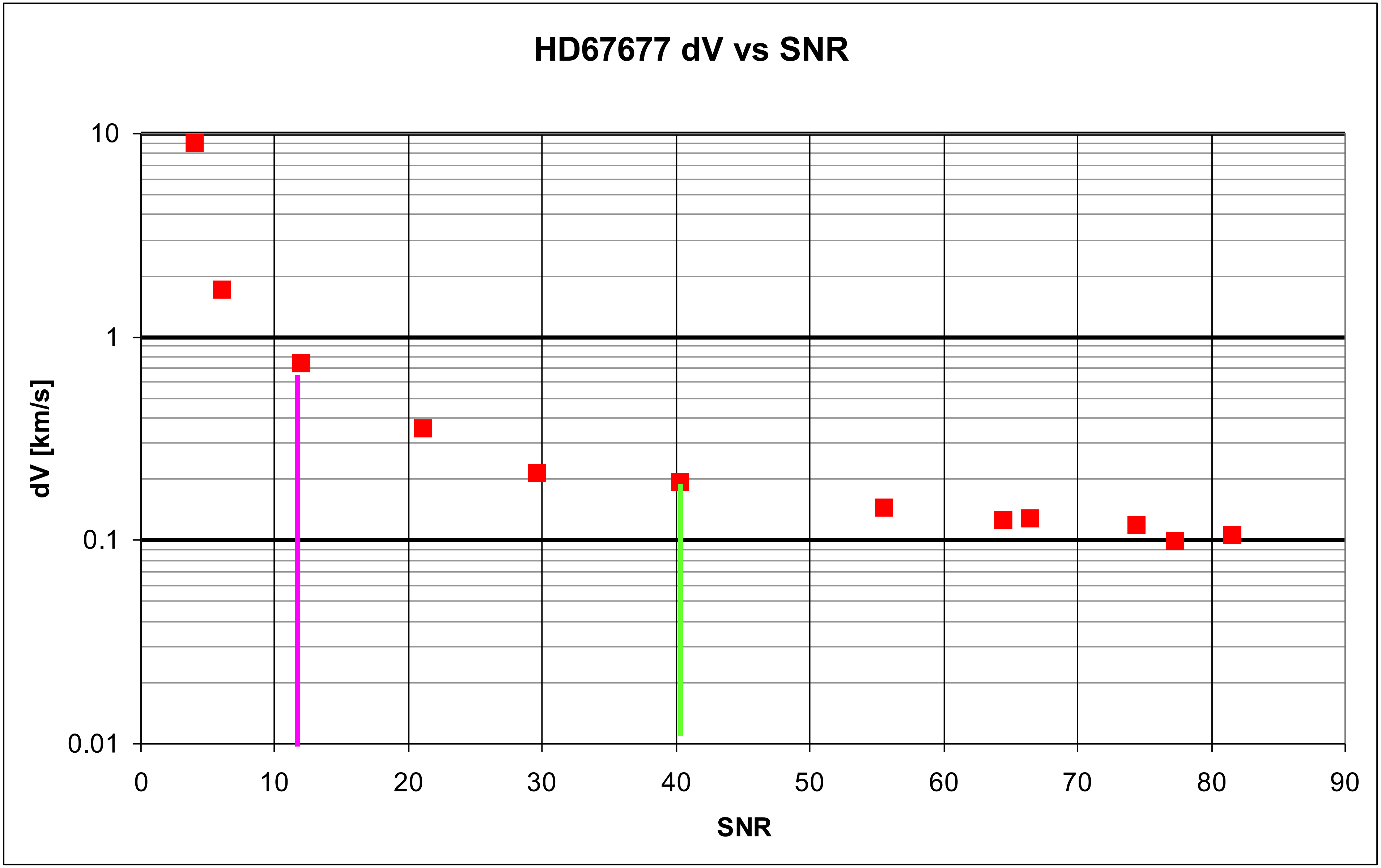


HIP116085 last measurements



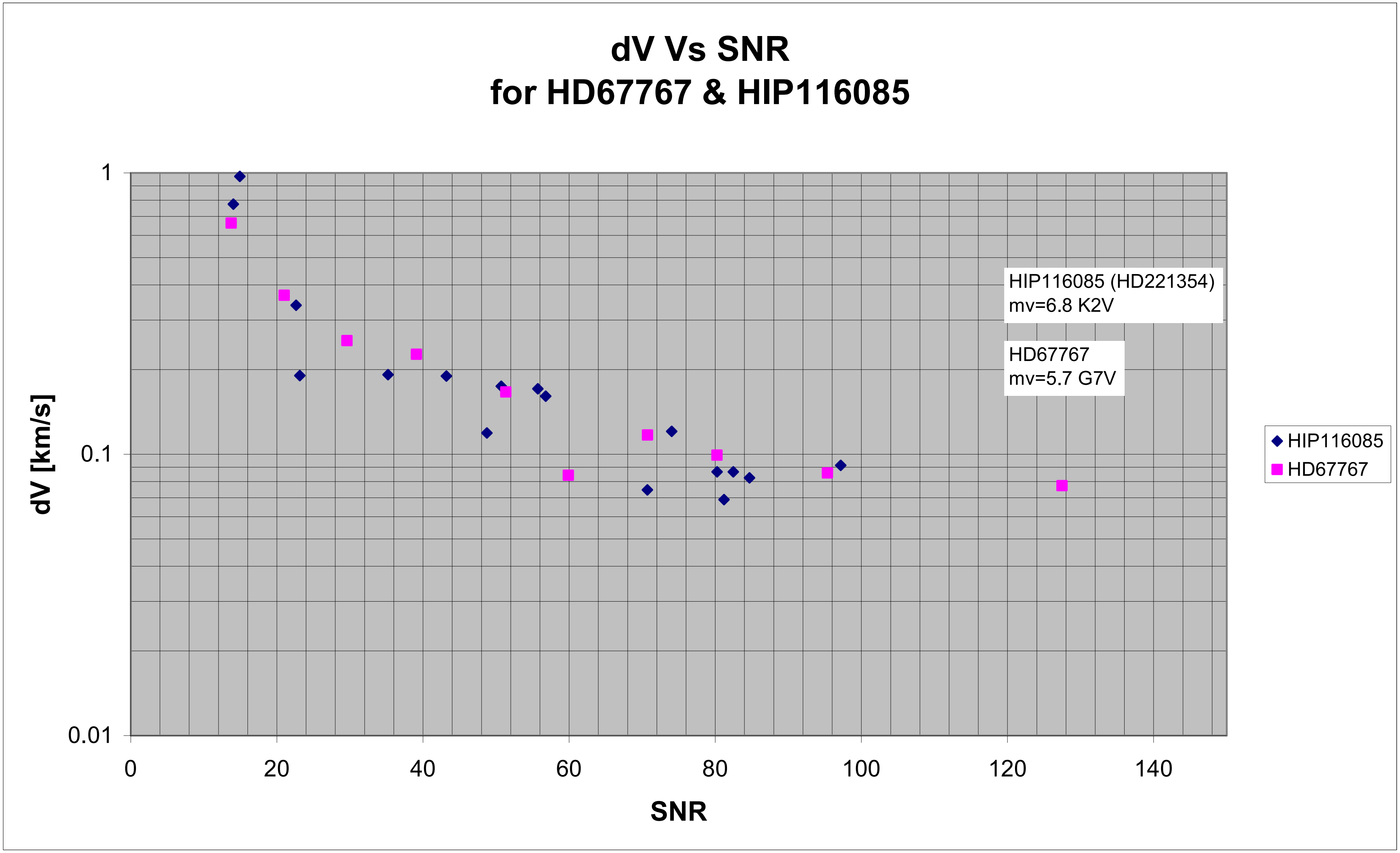
SNR Test Results for HD67767 8/11/14





One Night

dV vs SNR Curve



Several Nights

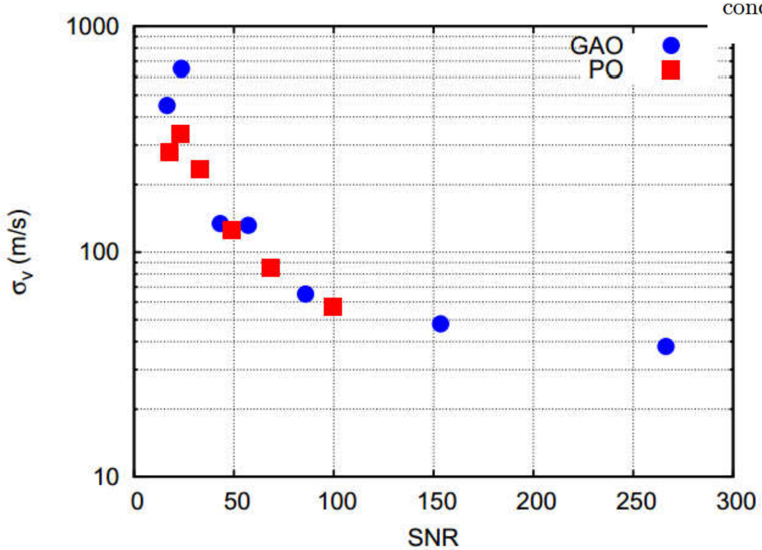
eShel dV vs. SNR in Hungary

Affordable spectroscopy for 1m-class telescopes: recent developments and applications

B. Csák[1,2], J. Kovács[1,2], Gy.M. Szabó[1,2,3], L.L. Kiss[2,3], Á. Dózsa[1,2], Á. Sódor[3] and I. Jankovics[1,2]

[1] *Gothard Astrophysical Observatory and Multidisciplinary Research Center of Loránd Eötvös University*
[2] *ELTE Gothard-Lendület Research Group*
9700 Szombathely, Szent Imre herceg u. 112., Hungary
[3] *Konkoly Observatory, Research Centre for Astronomy and Earth Sciences, Hungarian Academy of Sciences*
1121 Budapest, Konkoly Th. M. út 15-17., Hungary

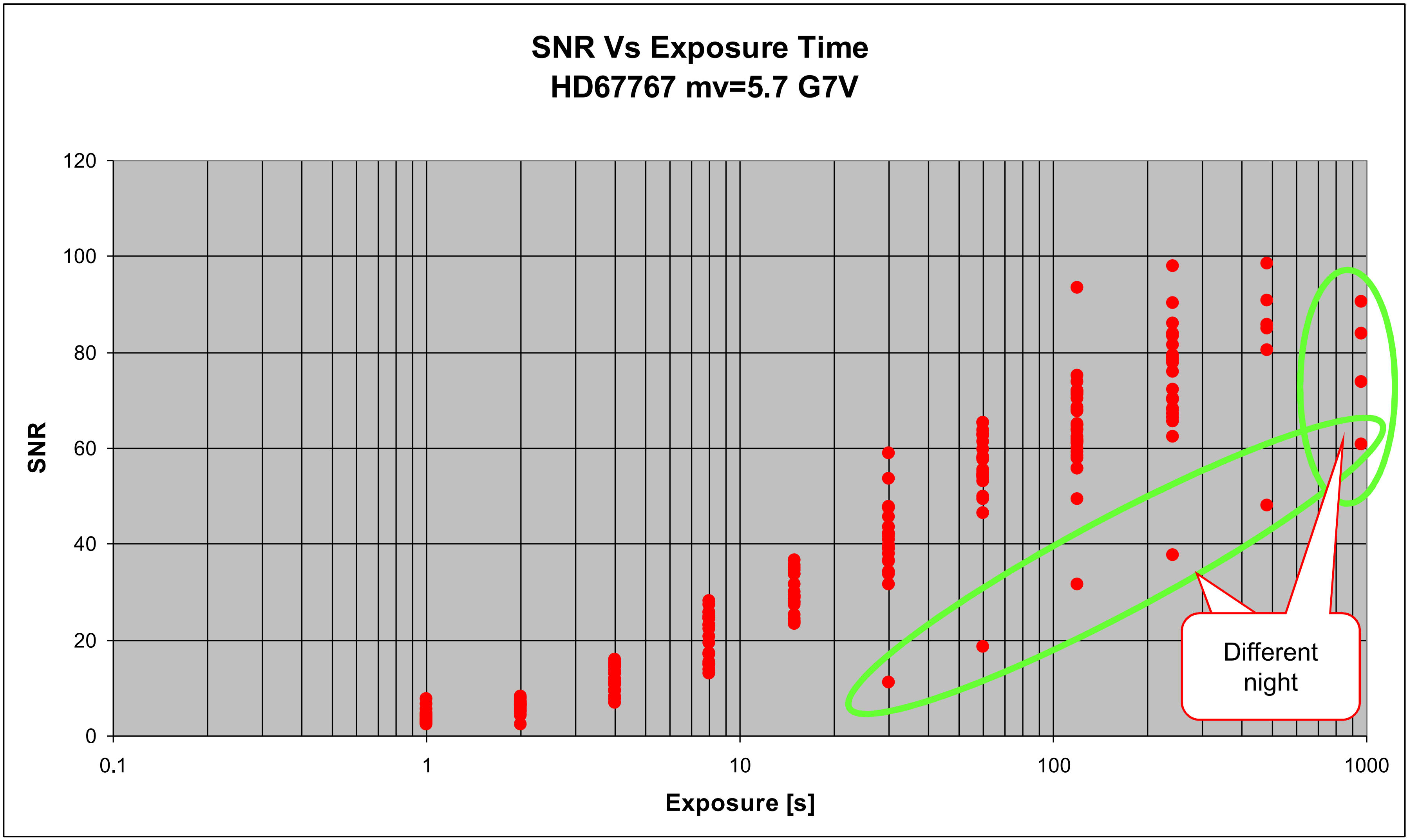
Figure 1. *Left*: The 0.5m RC telescope of GAO used exclusively for spectroscopic observations. *Center*: The eShel echelle spectrograph and its accessories: the QSI 532ws CCD camera and the ThAr unit with its power supply box in a thermally isolated concrete room below the 0.5m RC telescope at GAO. *Right*: 1m RCC telescope of PO.



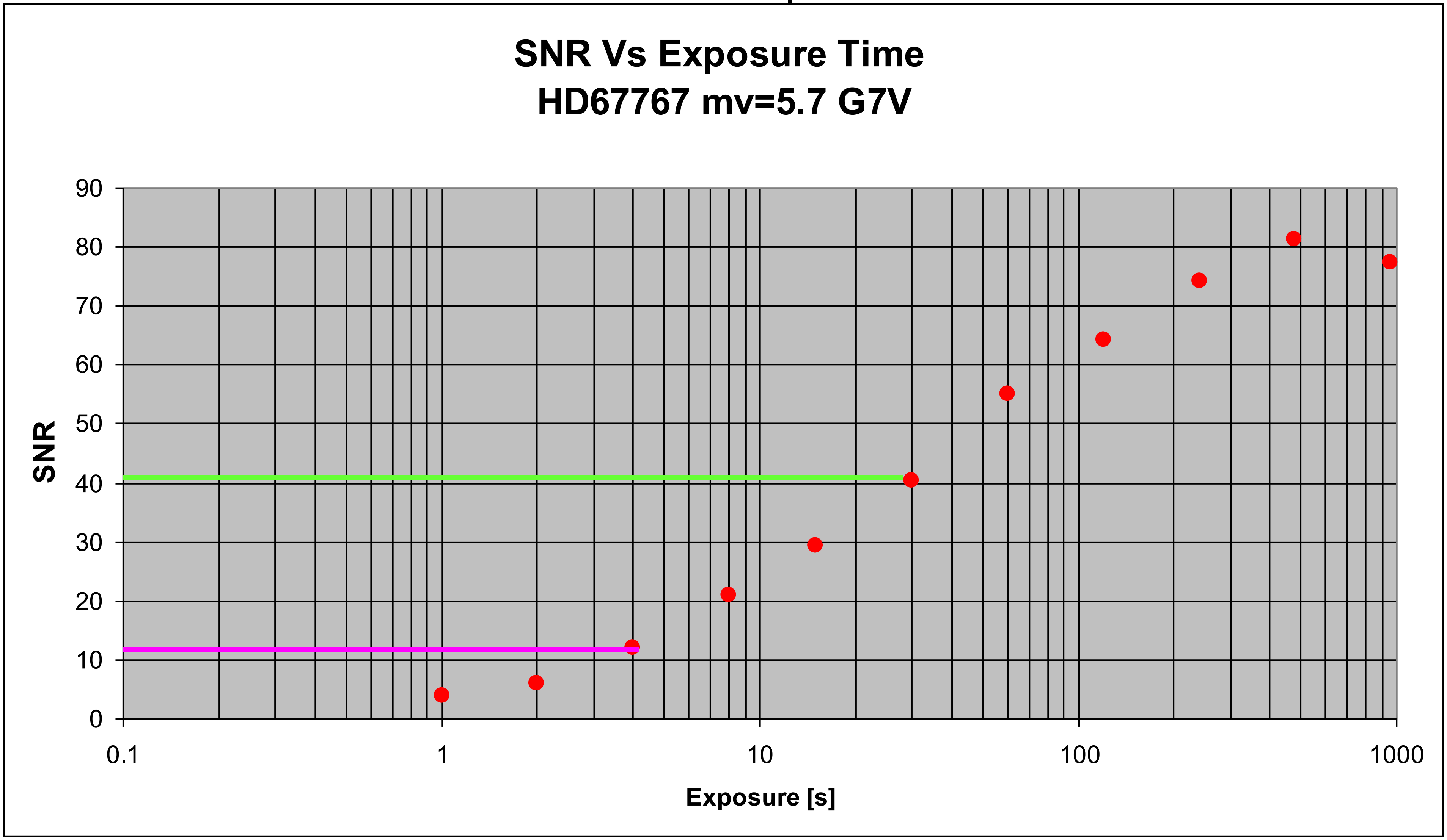
β Virgini
m_v=3.6
Type F9V

Figure 2. Errors of the radial velocities plotted against the signal to noise ratios. The values were derived from the series of spectra with increasing exposure time of radial velocity standard star β Vir. It can clearly be seen that SNR values higher than 150 give no further significant decrease in the RV error.

SNR vs Exposure Time



SNR Vs Exposure

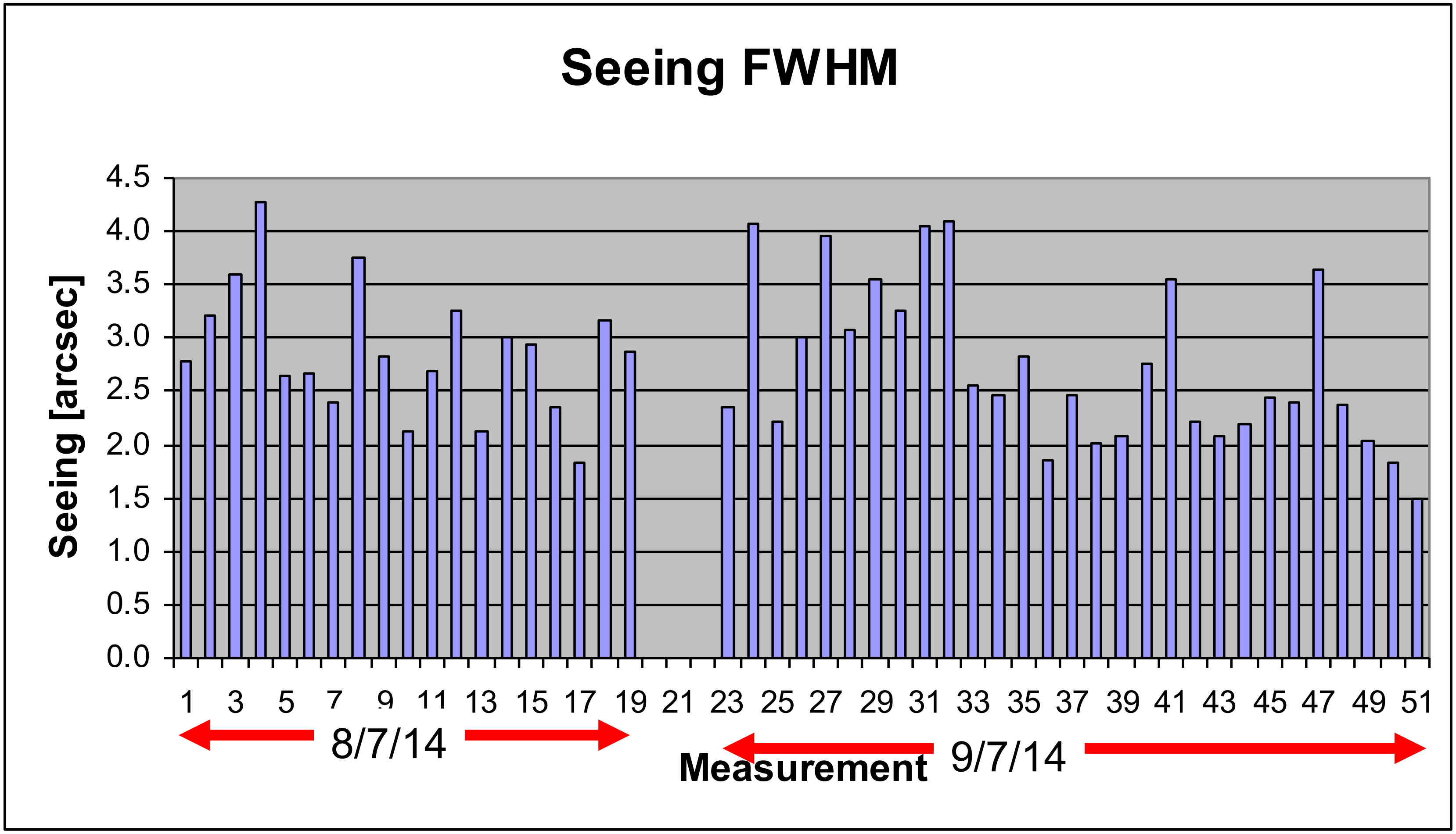


30s → 200m/s → m_v=12 2.8 hr
4s → 800m/s → m_v=12 0.37 hr=22min
For the same spectral type

Efficiency

$$\delta V_{RMS} = \frac{c}{Q \cdot \sqrt{N_{e^-}}}$$

Seeing Variations During Two Nights



Fiber diameter on the sky with the focal reducer is 2”

The role of the Focal Reducer

Double Achromat Focal Reducer

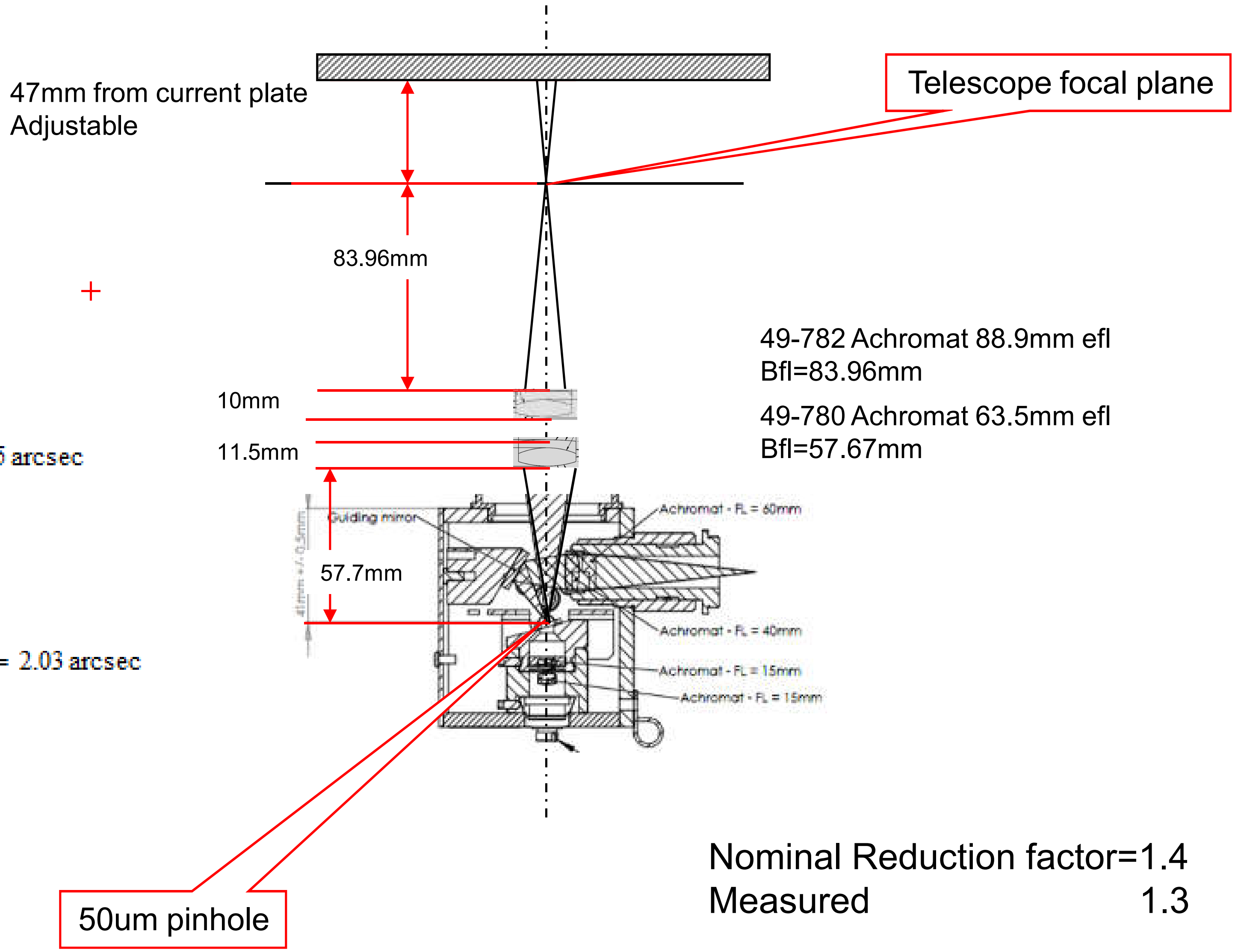
Focal Reducer

$$D_{fiber} := 50\mu m$$

$$\alpha_{fiber} := \frac{D_{fiber}}{f_{tel}} = 1.45\ \text{arcsec}$$

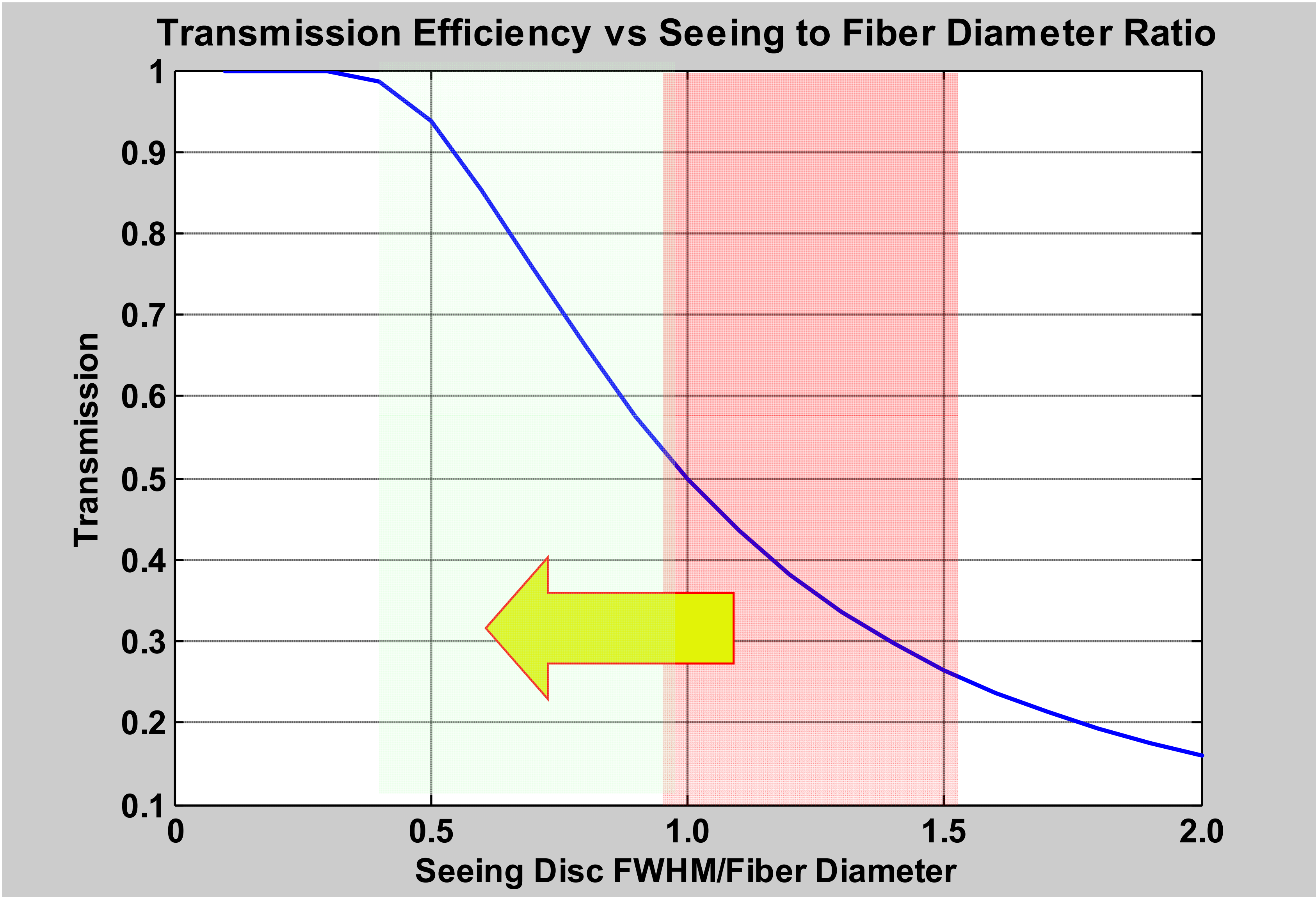
$$FR := 1.4$$

$$\alpha_{fiber\_R} := \frac{D_{fiber} \cdot FR}{f_{tel}} = 2.03\ \text{arcsec}$$



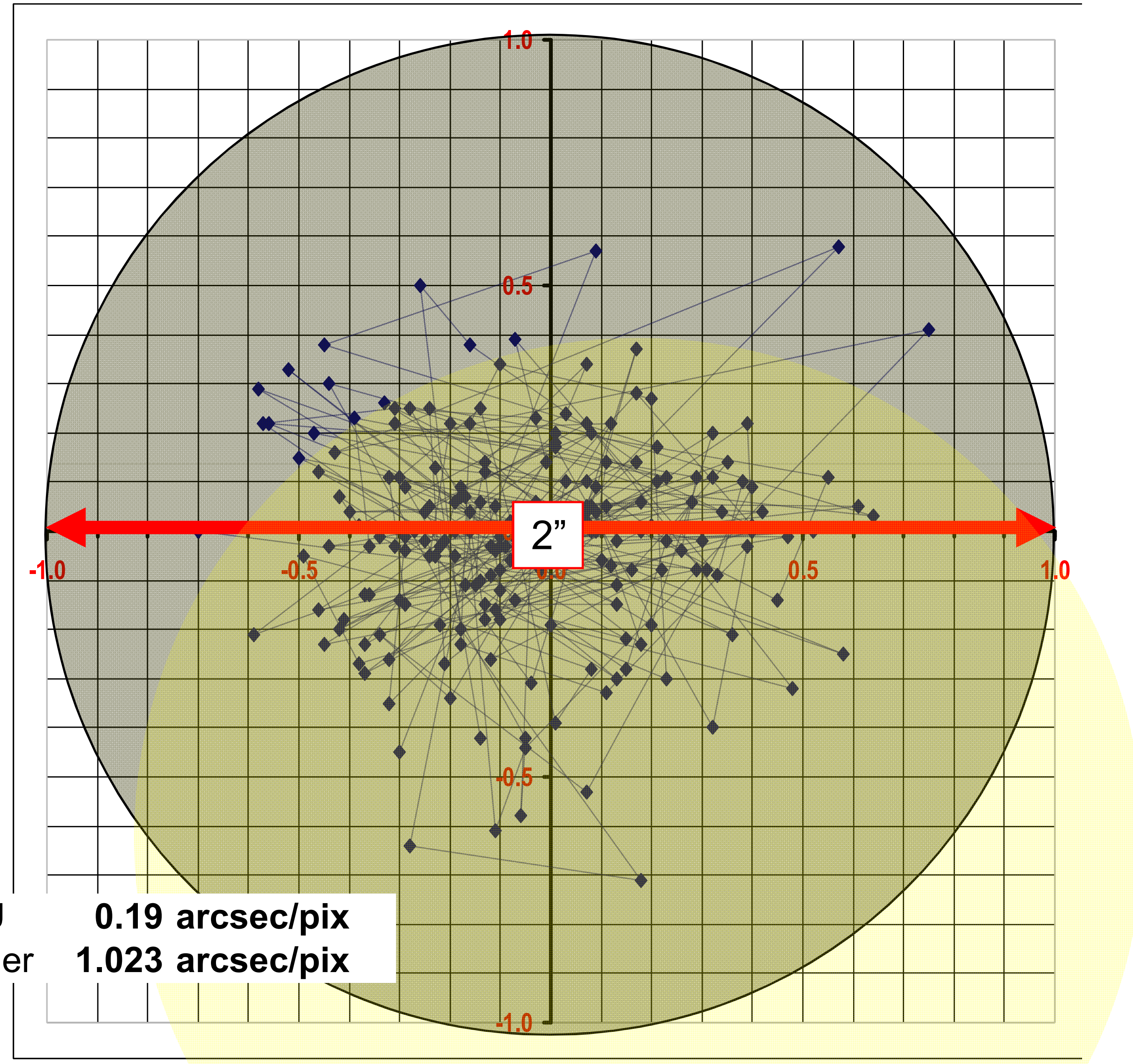
Nominal Reduction factor=1.4
Measured 1.3

FIGU Coupling efficiency to the telescope



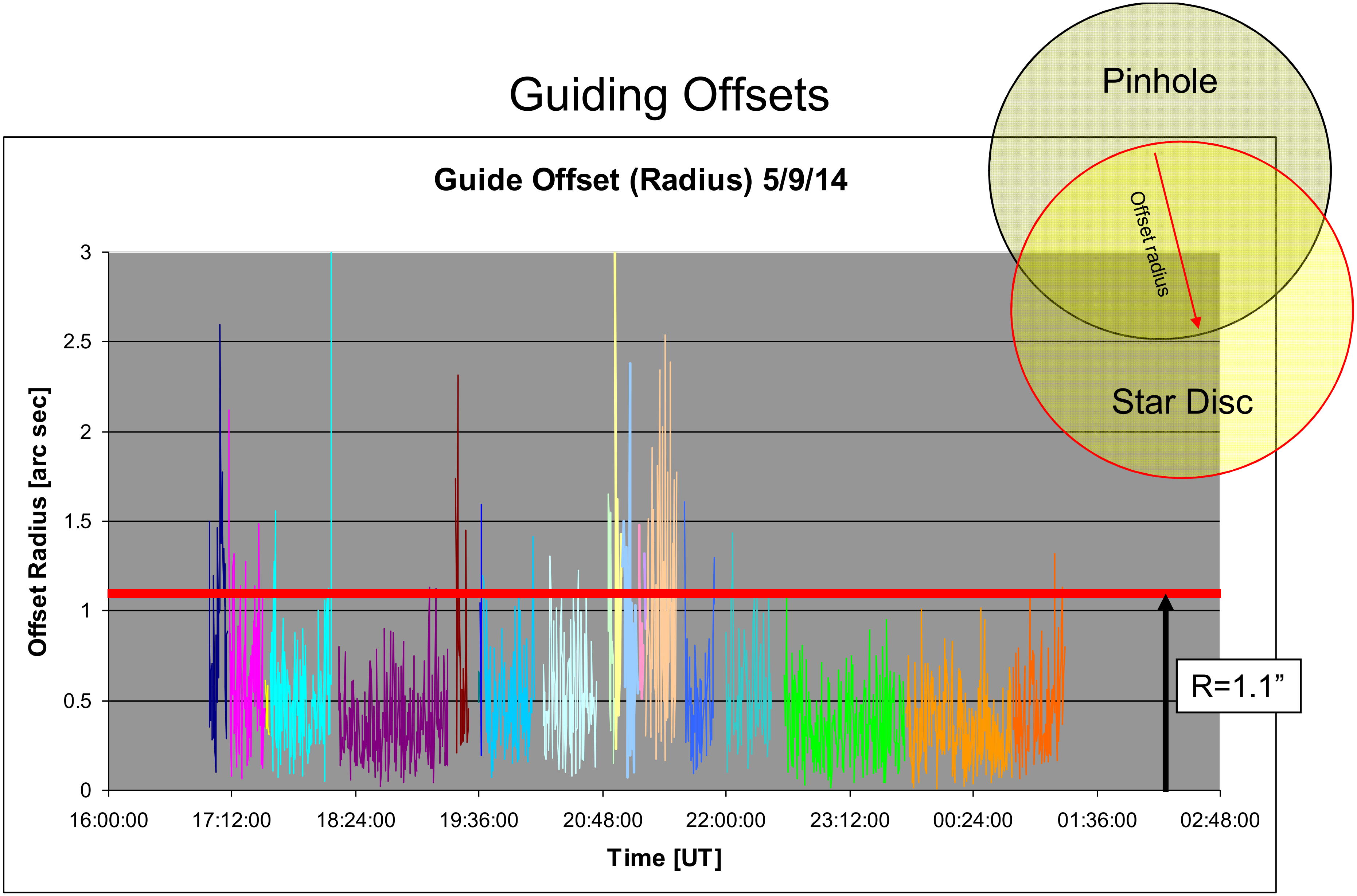
Coupling efficiency 50% ~20% Here we can gain x2-4

Guiding Errors

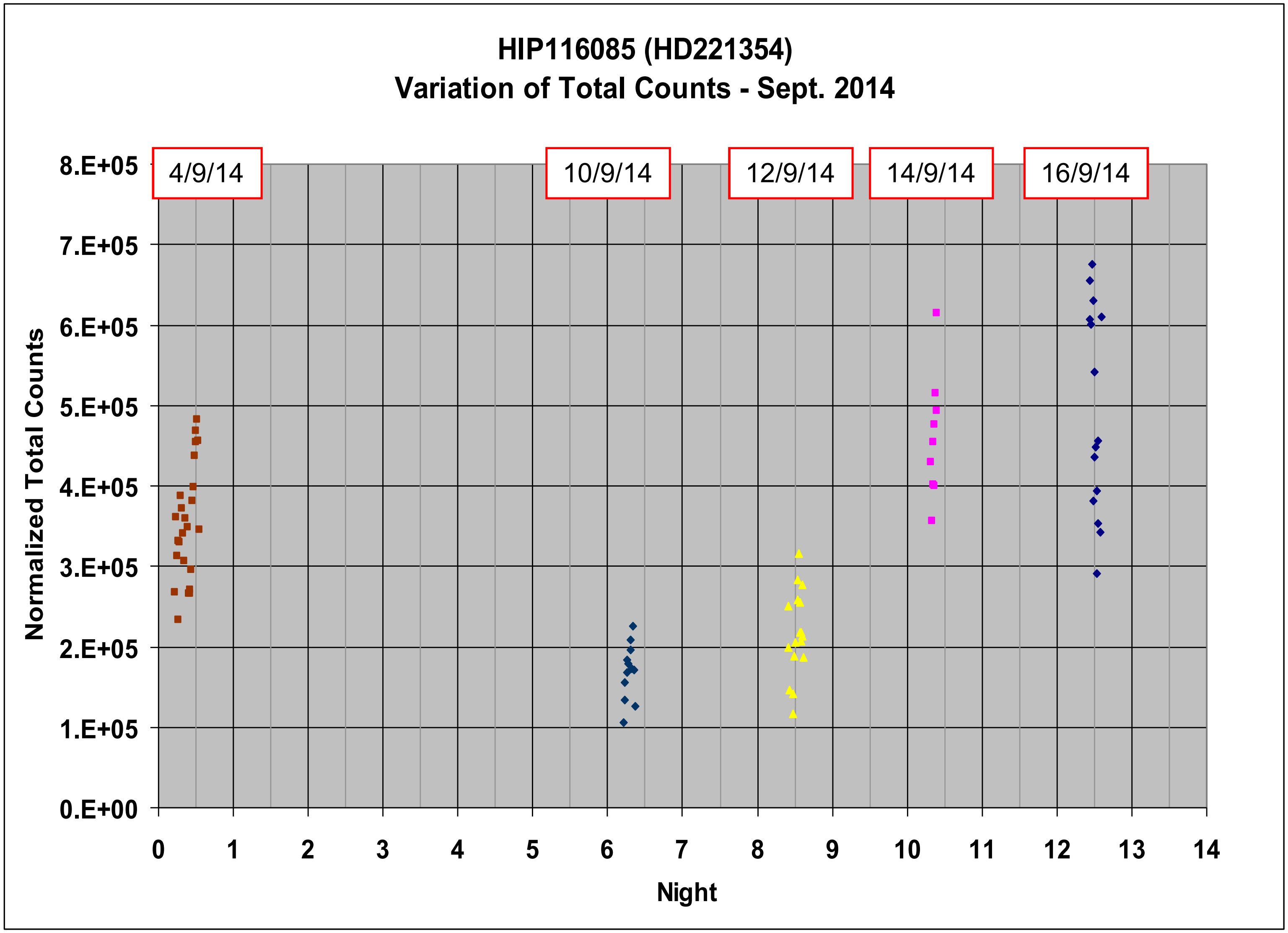


scale at FIGU **0.19 arcsec/pix**
scale @ Guider **1.023 arcsec/pix**

Guiding Offsets



Signal Variations



Variations of X2 in the total number of counts of the same star during a night

Estimating the Efficiency of the Spectrograph

- We can estimate the efficiency of the setup

$$\text{Efficiency} = \frac{\text{number of counts on the CCD}}{\text{Number of incident photon at focal plane}}$$

Estimate of the Photon Flux Above the Atmosphere

Spectral flux in photons/cm^2/s/A

$$f(\lambda, m_b, T_{eff}) := \frac{C_3 \cdot 10^{-0.4 \cdot m_b}}{T_{eff}^{4} \cdot \lambda^{4} \cdot \left(e^{\frac{C_2}{\lambda \cdot T_{eff}}} - 1 \right)}$$

$$C_3 := 8.48 \cdot 10^{34} \cdot \frac{K^4 \cdot Angstrom^3}{cm^2 \cdot s}$$

$$C_2 := 1.44 \cdot 10^{8} \cdot Angstrom \cdot K$$

Calculation for HIP116085 HD221354

- Spectral type K2V Teff=5250 m_v=6.8

$m_v := 6.8 \quad BC := -0.2$

$m_{b0} := m_v + BC = 6.6$

$\lambda_{es1} := 4500 \cdot Angstrom$

$\lambda_{es2} := 7600 \cdot Angstrom$

$$\Phi_{star} := \int_{\lambda_{es1}}^{\lambda_{es2}} f\left(\lambda, m_{b0}, T_{eff0}\right) d\lambda = 2.2 \times 10^{11} \cdot \frac{1}{m^2 \cdot hr}$$

Taking in the Atmosphere and the Telescope

Atmosphere

$k_V := 0.24$

for airmass the extinction is:

$airmass := 1$

$$\tau_{atm} := 10^{-0.4 \cdot k_V \cdot airmass} = 0.80$$

Telescope

$D_{prim} := 1016mm$

$D_{sec} := 508mm$

$$A_{tel} := \frac{\pi}{4} \cdot \left(D_{prim}^{\ 2} - D_{sec}^{\ 2}\right) = 0.61\,m^2$$

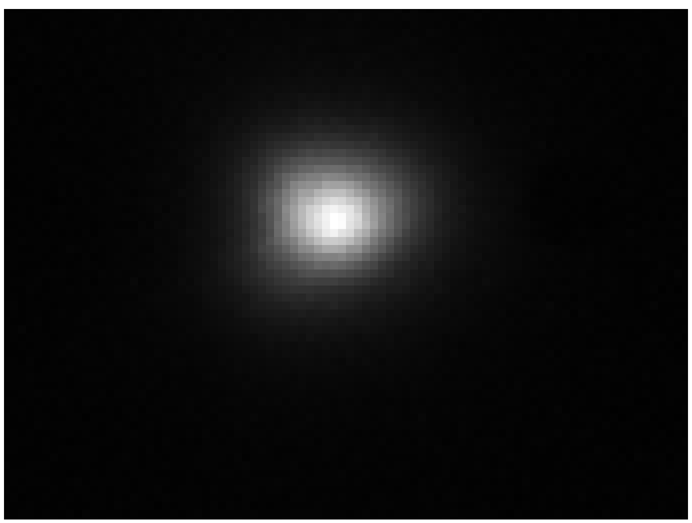
Telescope efficiency

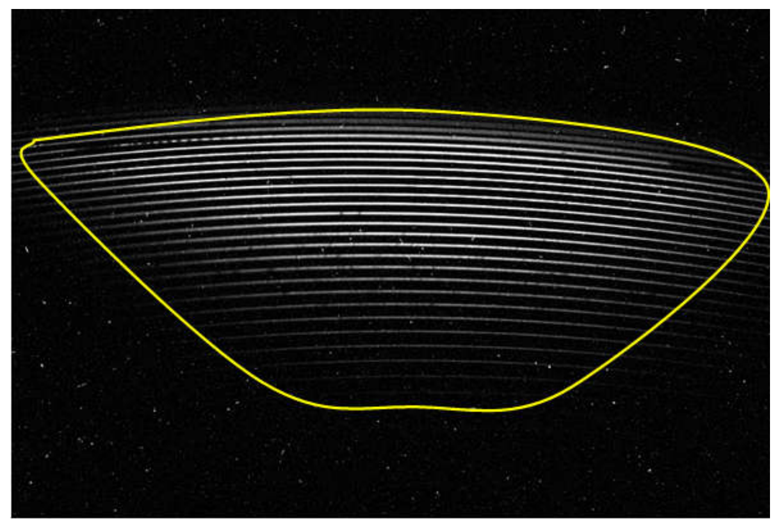
$$\eta_{tel} := R_{prim} \cdot R_{sec} \cdot t_{corr\_lens} = 0.94$$

Calculate the Photon rate at the Focal Plane

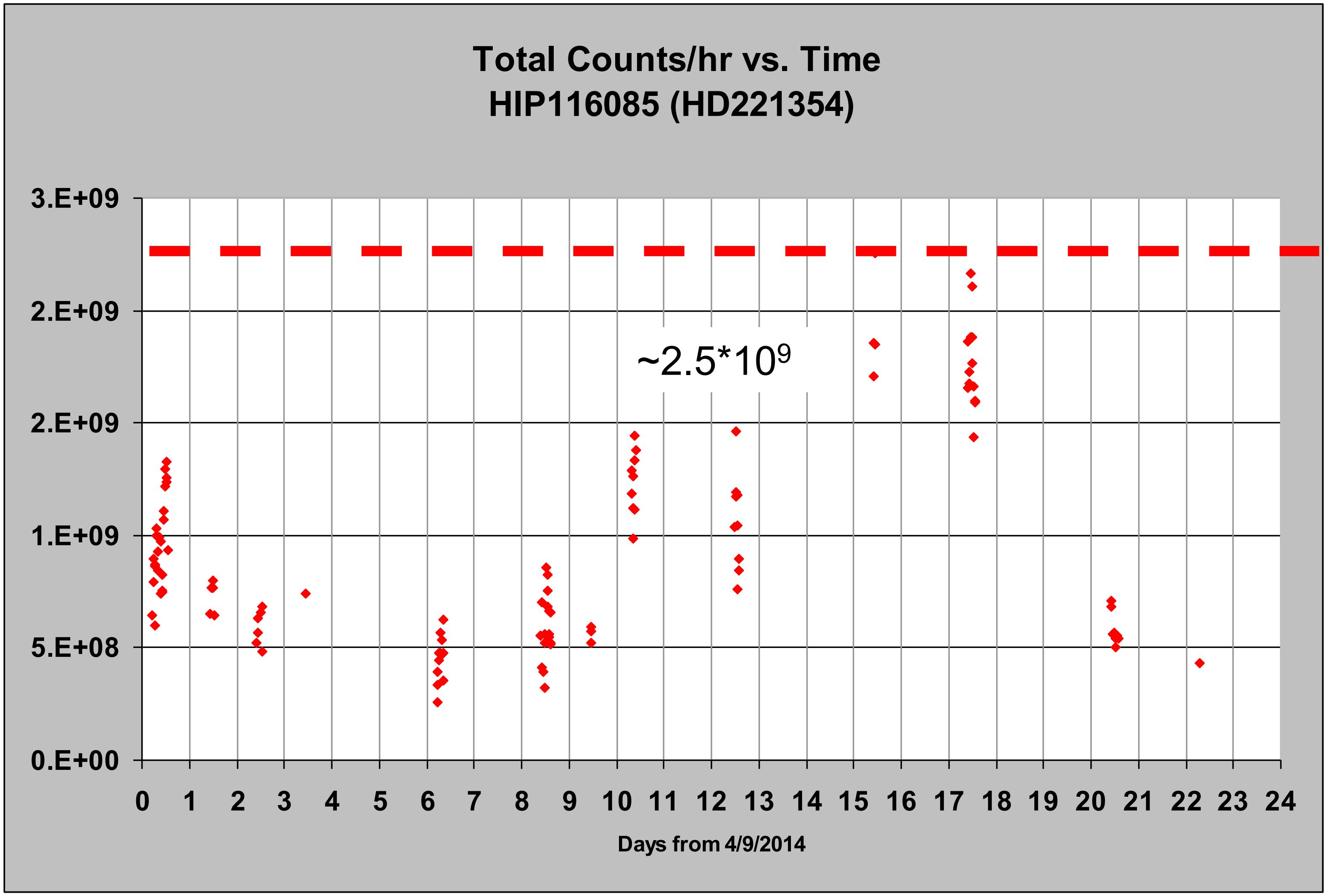
$$Photon_{rate} := \Phi_{star} \cdot \tau_{atm} \cdot \eta_{tel} \cdot A_{tel} = 1 \times 10^{11} \cdot \frac{1}{hr}$$

Measure the photon count per each exposure
and Calibrate it to total counts measure





Measurements of the Total Counts



$$N_{countsHIP116085\_hr} := 2.5 \times 10^{9}$$

$$\eta_{spec} := \frac{N_{countsHIP116085\_hr} \cdot CCD_{gain}}{N_p} = 0.032$$

eShel efficiency estimate ~3%

From Shelyak Data

Component	Efficiency
FIGU	0.57
Fiber	0.7
spectrograph	0.25
CCD	0.75
Total	0.075 =7.5%

We are a factor of ~2-3 below the expected performance

- We can gain
- ~x1.5÷2 signal by improving the guiding
- >x2 signal by better coupling – collecting diameter ≥ 2* seeing disc

Next Steps

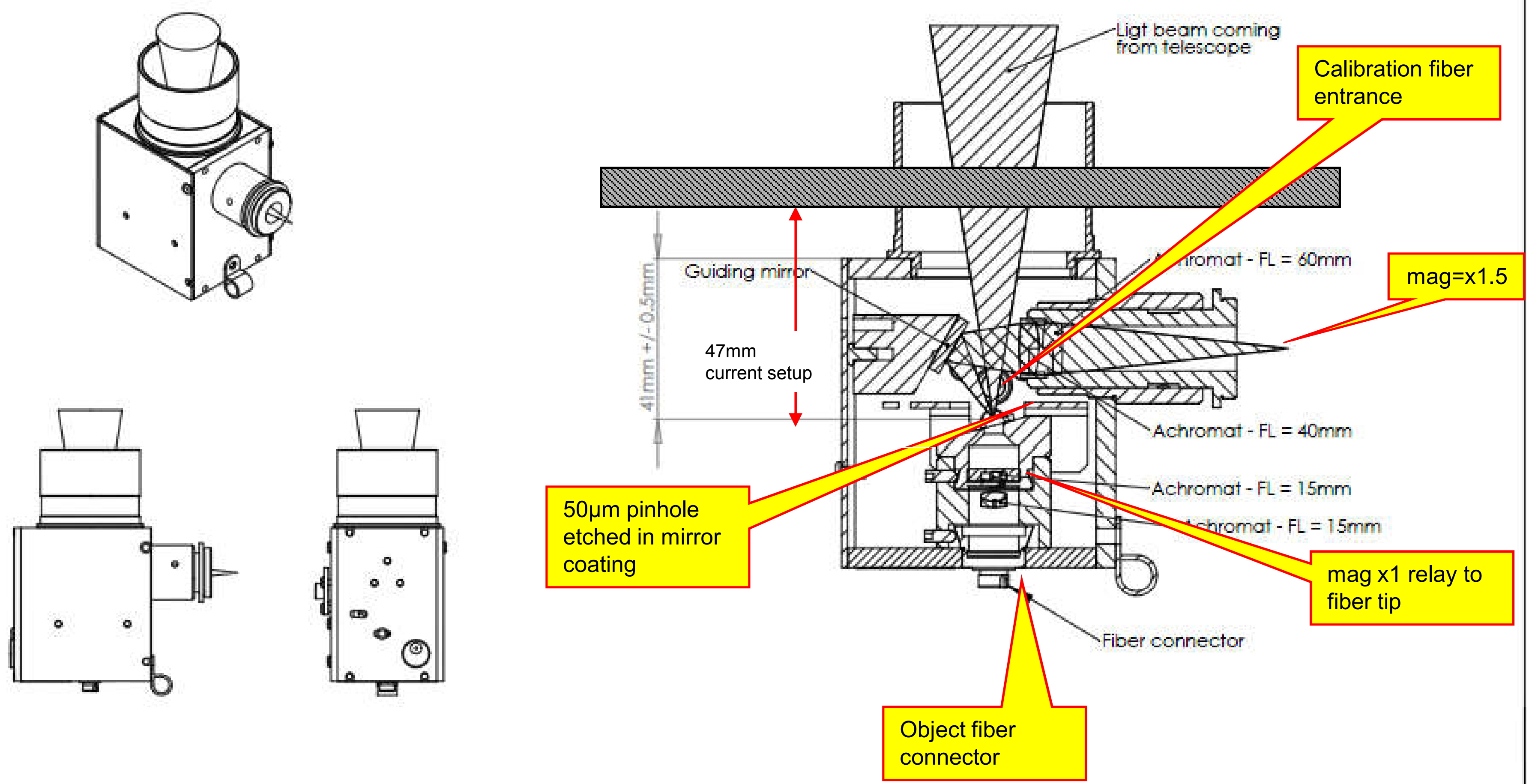
- Complete dV vs SNR measurements for fainter stars
- Improve guiding – guide on target star
- Calibrate exposure – Exposure calculator
  - pre exposure estimate of total counts → dV
- Monitor temperature at the eShel – correlation to calibration drifts ?

Possible Actions/Options for Improvement

	Action	R	Flux Gain	Actions	Cost
1)	Improve guiding	10000	X1.5	Change guiding to STi camera	*
3)	Change FR to F/3.5	10000	X2	Focal reducer to F/3.5	*
3)	New Shelyak Spectrograph eShel+	30000 10000		Use two fiber configuration •Low res •High res	***

The End

Original setup at f/7 focus



REV.	DATE	PAR - BY	DESCRIPTION
A	13/03/2013	F. Cochard	First draft, to show main optical dimensions

Bonnette de guidage
Guiding Unit

Shelyak INSTRUMENTS

Matière

Ech 1:2 | A3 | Folio 1/1

Ref PF0008B

Specs

Technical Specifications

Fiber Injection & Guiding Unit

Optimal telescope F/D	**F/6**
Mirror hole & fiber core diam.	**50 µm**
Telescope adaptation	M42*0.75 (T standard)
Back focus	40.8 mm
Total efficiency	60%
Weight without camera	500 gr
Size without camera	10 x 7 x 8 cm
Guiding port adaptation	C mount standard
Optional Guiding camera	Watec 120N+ recommended

Telescope diameter	F/6 focal	Fibre Size
20 cm	1.2 m	8.3 "
40 cm	2.4 m	4.2 "
60 cm	3.6 m	2.8 "
80 cm	4.8 m	2.1 "
1 m	6.0 m	1.7 "
1.2 m	7.2 m	1.4 "

Spectrograph

Input	50 µm FC fiber
Collimator F/D	5
Grating	R2 echelle
Cross disperser	Prism
Objective	Canon EOS (85mm f/1.8)
Spectral range	**430-710 nm**
Power of Resolution	**R > 10 000**
Resolution (Hα)	0.065 nm
Total efficiency	25%
Standard fiber's length	20 m (calibration & object)

Optional CCD Camera	**QSI516ws**	**QSI532ws**
Chip (Kodak)	KAF1603me	KAF3200me
Size	13.8x9.2 mm	14.9x10.3 mm
Pixel size	9 µm	6.8 µm
Max QE	77%	82%

Calibration Unit

Calibration lamp	**Thorium-Argon**
Flat lamp	LEDs
PC interface	RS232
Dimensions	22 x 13 x 27 cm
Calibration	**Automated**

Software

Operating System	MS Windows
Platform	AudeLA
Scirpting/Language	Tcl/Tk
Licensing	Open Source
Processing	**Fully Automated**
File format	FITS
Export	ASCII, BeSS

Performance

Limiting Magnitude

	S/B = 20	S/B = 50	S/B = 100
D=20 cm F/D=5.9 (Celestron 8)	8.9	8.0	7.1
D=28 cm F/D=5.9 (Celestron 11)	9.6	8.7	7.7
D=35 cm F/D=5.9 (Celestron 14)	10.0	9.0	8.1
D=40 cm F/D=4.0 (Dobson)	10.3	9.2	8.4
D=60 cm F/D=3.5	11.0	10.0	9.1
D=100 cm F/D=3.5	11.5	10.5	9.6

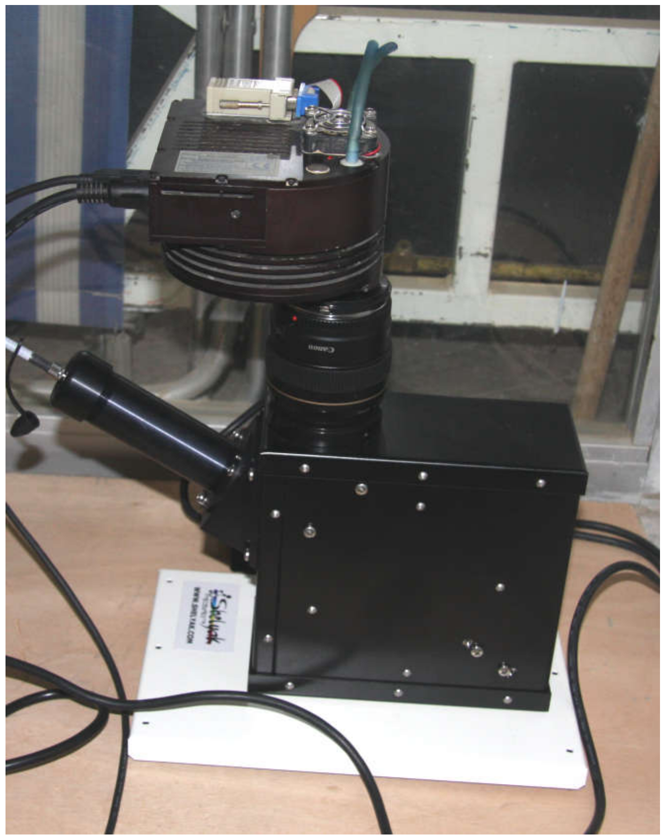
1 hr exposure

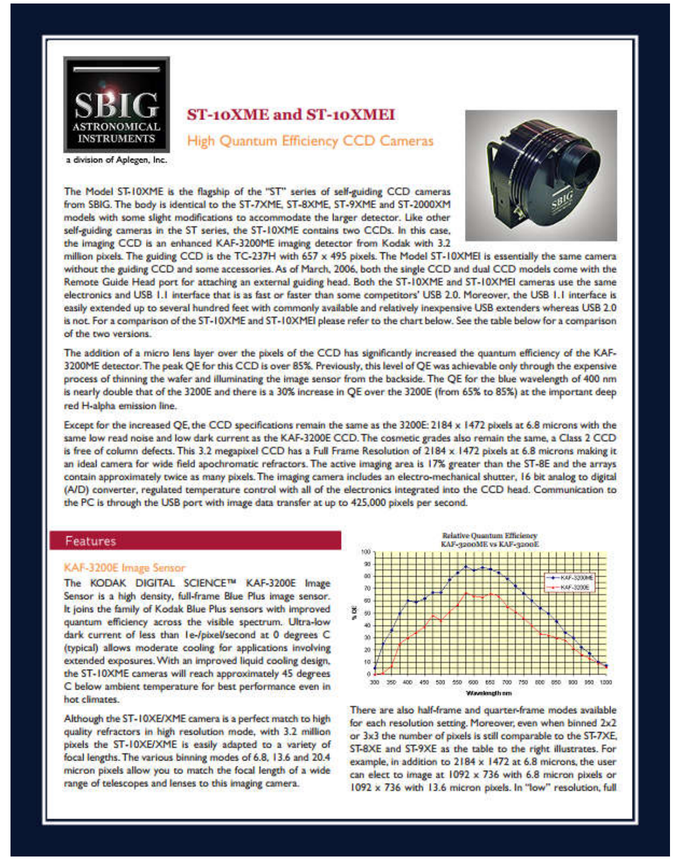
Radial Velocities performances

Magnitude	Celestron 11 - f/5.9	60 cm - f/3.5
3	37 m/s	18 m/s
4	56 m/s	28 m/s
5	95 m/s	46 m/s
6	175 m/s	75 m/s
7	360 m/s	140 m/

Spectrograph and Calibration Unit

The CCD camera: SBIG ST-10XME





SBIG ASTRONOMICAL INSTRUMENTS

a division of Aplegen, Inc.

ST-10XME and ST-10XMEI

High Quantum Efficiency CCD Cameras

The Model ST-10XME is the flagship of the "ST" series of self-guiding CCD cameras from SBIG. The body is identical to the ST-7XME, ST-8XME, ST-9XME and ST-2000XM models with some slight modifications to accommodate the larger detector. Like other self-guiding cameras in the ST series, the ST-10XME contains two CCDs. In this case, the imaging CCD is an enhanced KAF-3200ME imaging detector from Kodak with 3.2 million pixels. The guiding CCD is the TC-237H with 657 x 495 pixels. The Model ST-10XMEI is essentially the same camera without the guiding CCD and some accessories. As of March, 2006, both the single CCD and dual CCD models come with the Remote Guide Head port for attaching an external guiding head. Both the ST-10XME and ST-10XMEI cameras use the same electronics and USB 1.1 interface that is as fast or faster than some competitors' USB 2.0. Moreover, the USB 1.1 interface is easily extended up to several hundred feet with commonly available and relatively inexpensive USB extenders whereas USB 2.0 is not. For a comparison of the ST-10XME and ST-10XMEI please refer to the chart below. See the table below for a comparison of the two versions.

The addition of a micro lens layer over the pixels of the CCD has significantly increased the quantum efficiency of the KAF-3200ME detector. The peak QE for this CCD is over 85%. Previously, this level of QE was achievable only through the expensive process of thinning the wafer and illuminating the image sensor from the backside. The QE for the blue wavelength of 400 nm is nearly double that of the 3200E and there is a 30% increase in QE over the 3200E (from 65% to 85%) at the important deep red H-alpha emission line.

Except for the increased QE, the CCD specifications remain the same as the 3200E: 2184 x 1472 pixels at 6.8 microns with the same low read noise and low dark current as the KAF-3200E CCD. The cosmetic grades also remain the same, a Class 2 CCD is free of column defects. This 3.2 megapixel CCD has a Full Frame Resolution of 2184 x 1472 pixels at 6.8 microns making it an ideal camera for wide field apochromatic refractors. The active imaging area is 17% greater than the ST-8E and the arrays contain approximately twice as many pixels. The imaging camera includes an electro-mechanical shutter, 16 bit analog to digital (A/D) converter, regulated temperature control with all of the electronics integrated into the CCD head. Communication to the PC is through the USB port with image data transfer at up to 425,000 pixels per second.

Features

KAF-3200E Image Sensor

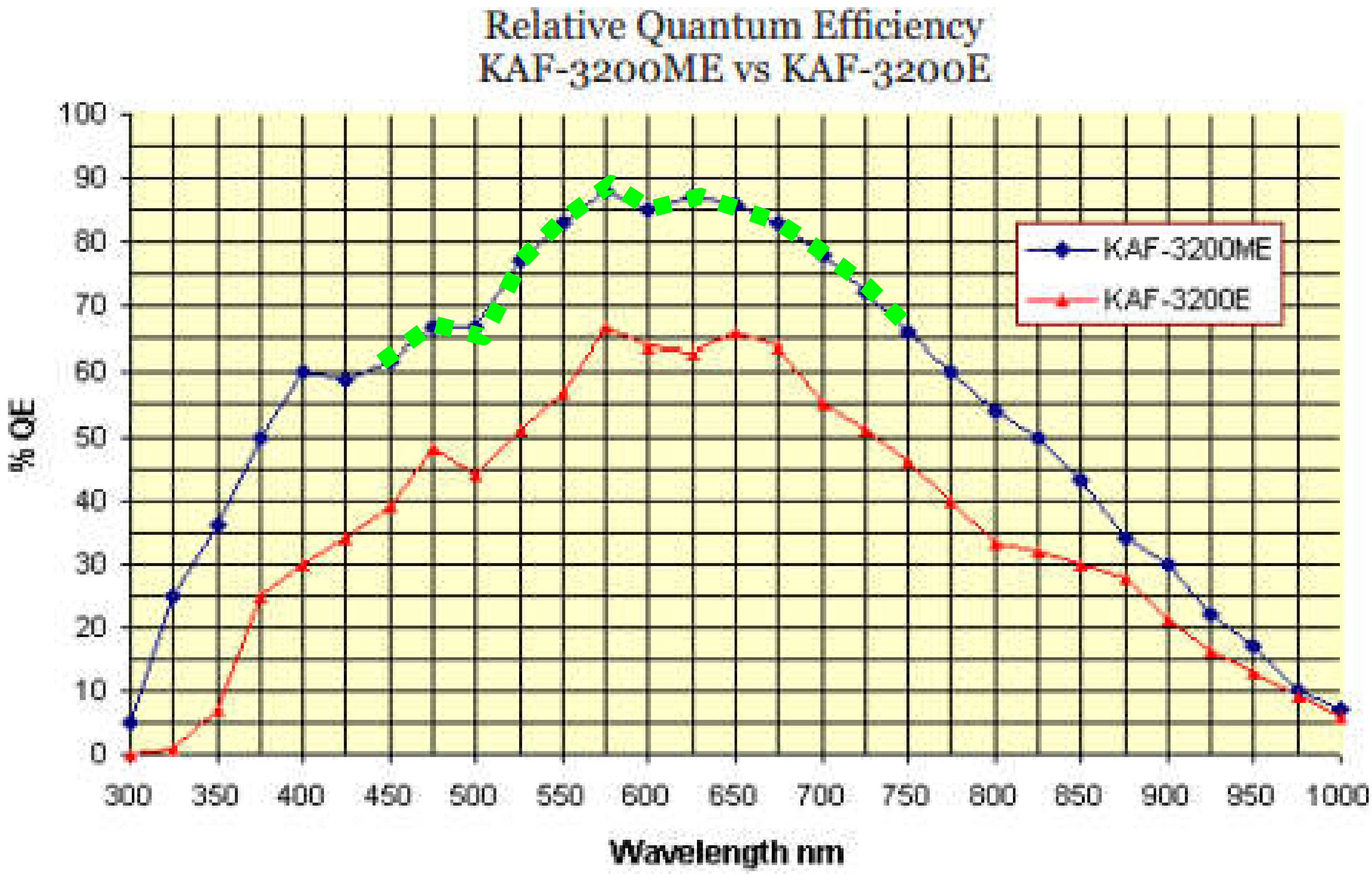
The KODAK DIGITAL SCIENCE™ KAF-3200E Image Sensor is a high density, full-frame Blue Plus image sensor. It joins the family of Kodak Blue Plus sensors with improved quantum efficiency across the visible spectrum. Ultra-low dark current of less than 1e-/pixel/second at 0 degrees C (typical) allows moderate cooling for applications involving extended exposures. With an improved liquid cooling design, the ST-10XME cameras will reach approximately 45 degrees C below ambient temperature for best performance even in hot climates.

Although the ST-10XE/XME camera is a perfect match to high quality refractors in high resolution mode, with 3.2 million pixels the ST-10XE/XME is easily adapted to a variety of focal lengths. The various binning modes of 6.8, 13.6 and 20.4 micron pixels allow you to match the focal length of a wide range of telescopes and lenses to this imaging camera.

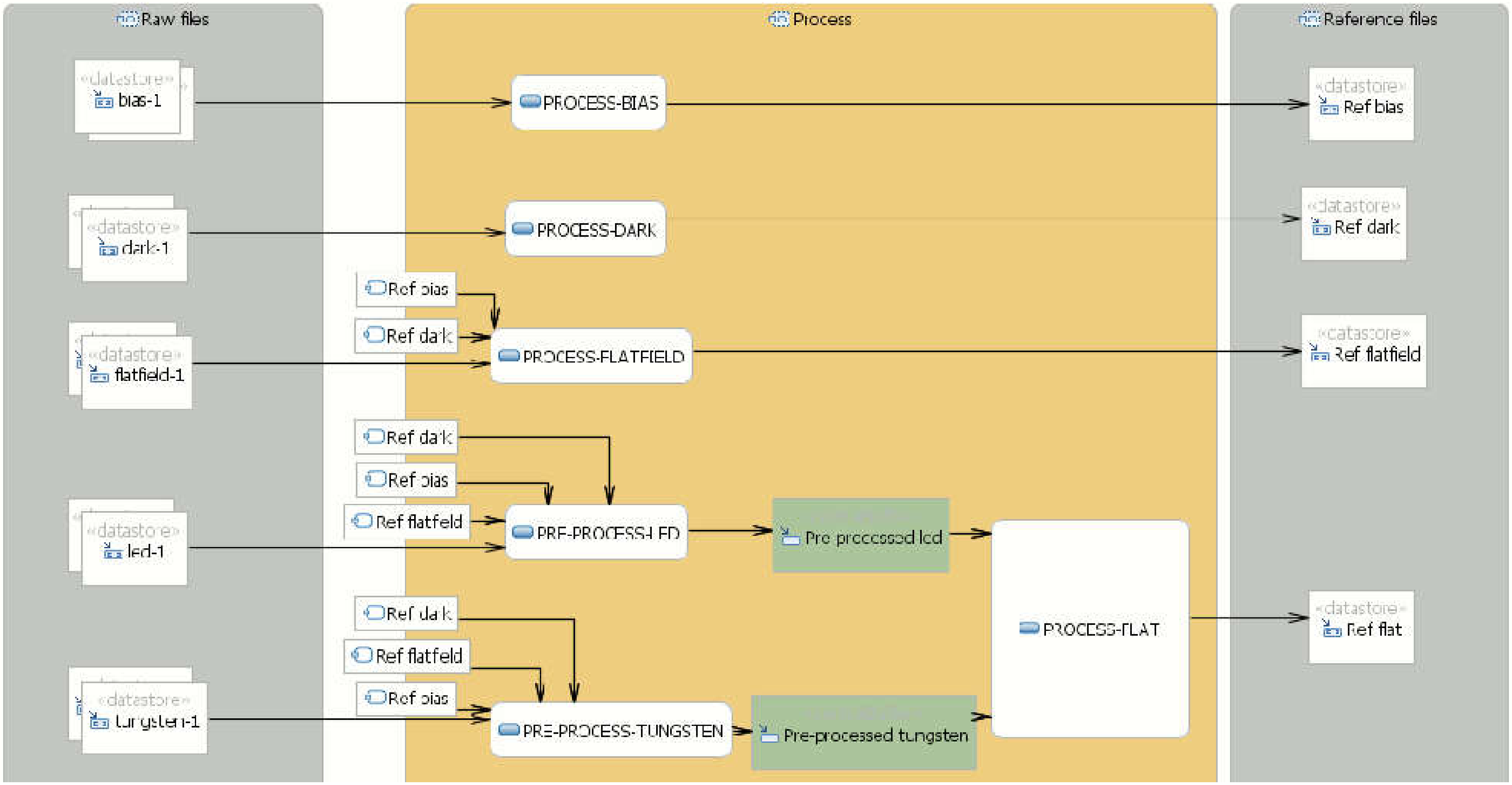
Relative Quantum Efficiency
KAF-3200ME vs KAF-3200E

There are also half-frame and quarter-frame modes available for each resolution setting. Moreover, even when binned 2x2 or 3x3 the number of pixels is still comparable to the ST-7XE, ST-8XE and ST-9XE as the table to the right illustrates. For example, in addition to 2184 x 1472 at 6.8 microns, the user can elect to image at 1092 x 736 with 6.8 micron pixels or 1092 x 736 with 13.6 micron pixels. In "low" resolution, full

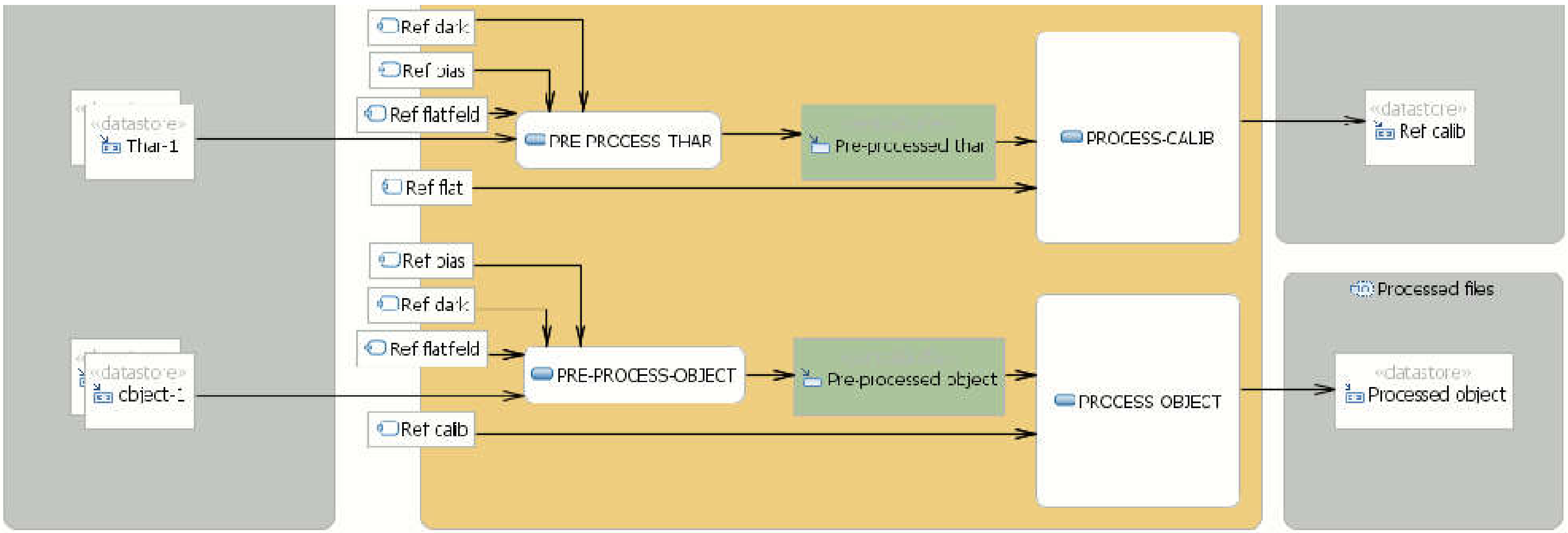
Quantum Efficiency



Audela Processing flow chart- BIAS/DARK/FLAT



Audela Processing flow chart- CALIB, OBJECT



Assessing the Performance of the eShel for RV Measurements

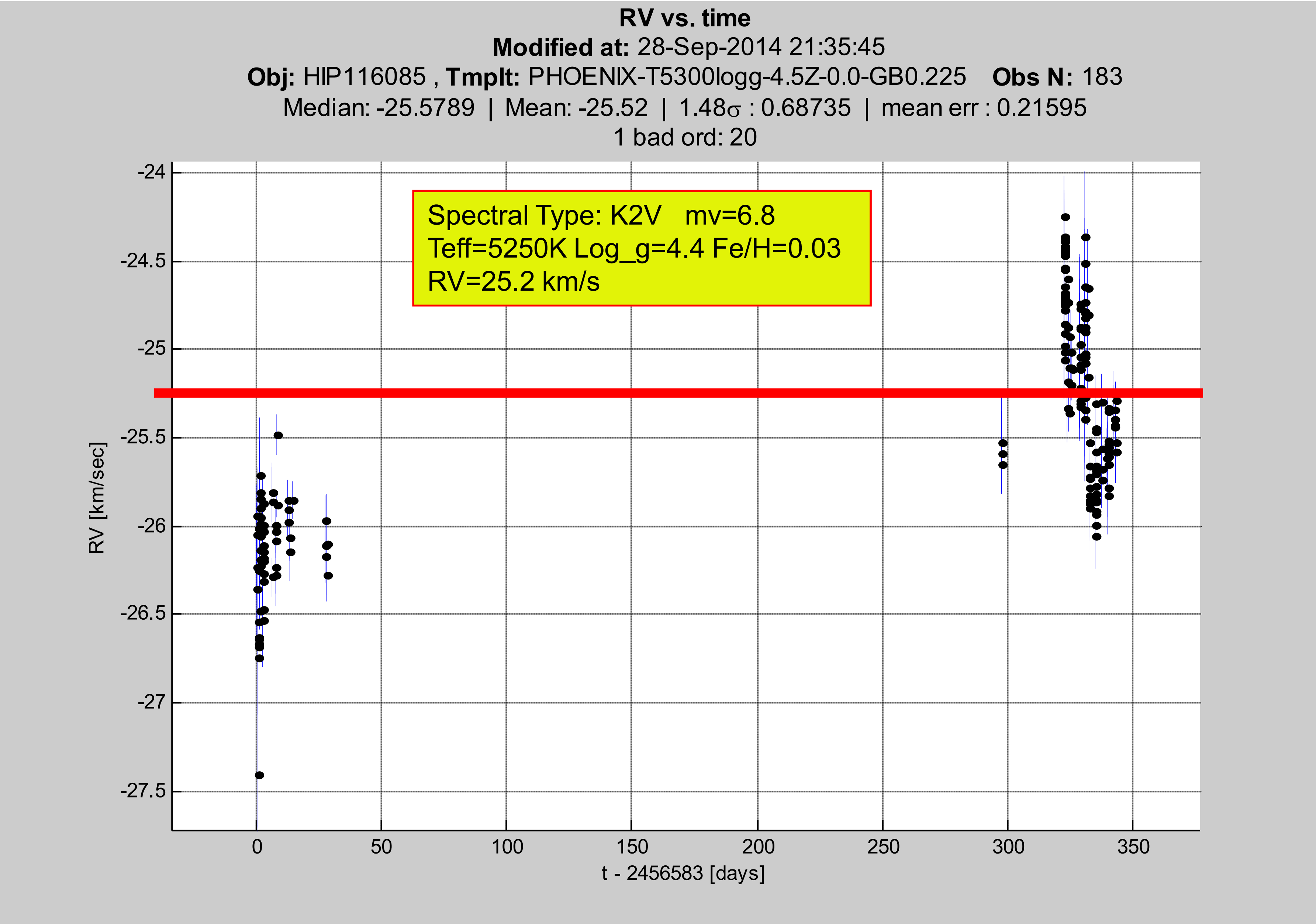
- Measure standard RV stars
  - Study precision / accuracy and stability of the instrument
  - Monitor stability along with measurement campaignst

1207.6212v2 PRECISE RADIAL VELOCITIES OF 2046 NEARBY FGKM STARS AND 131 STANDARDS.pdf
C. Chubak, G. Marcy, D. A. Fischer, A. W. Howard, H. Isaacson, J. A. Johnson, J. T. Wright
HD67767
HD88230

New ELODIE-CORAVEL high-precision standard stars
http://obswww.unige.ch/~udry/std/stdnew.dat
HD221354 (HIP116085)

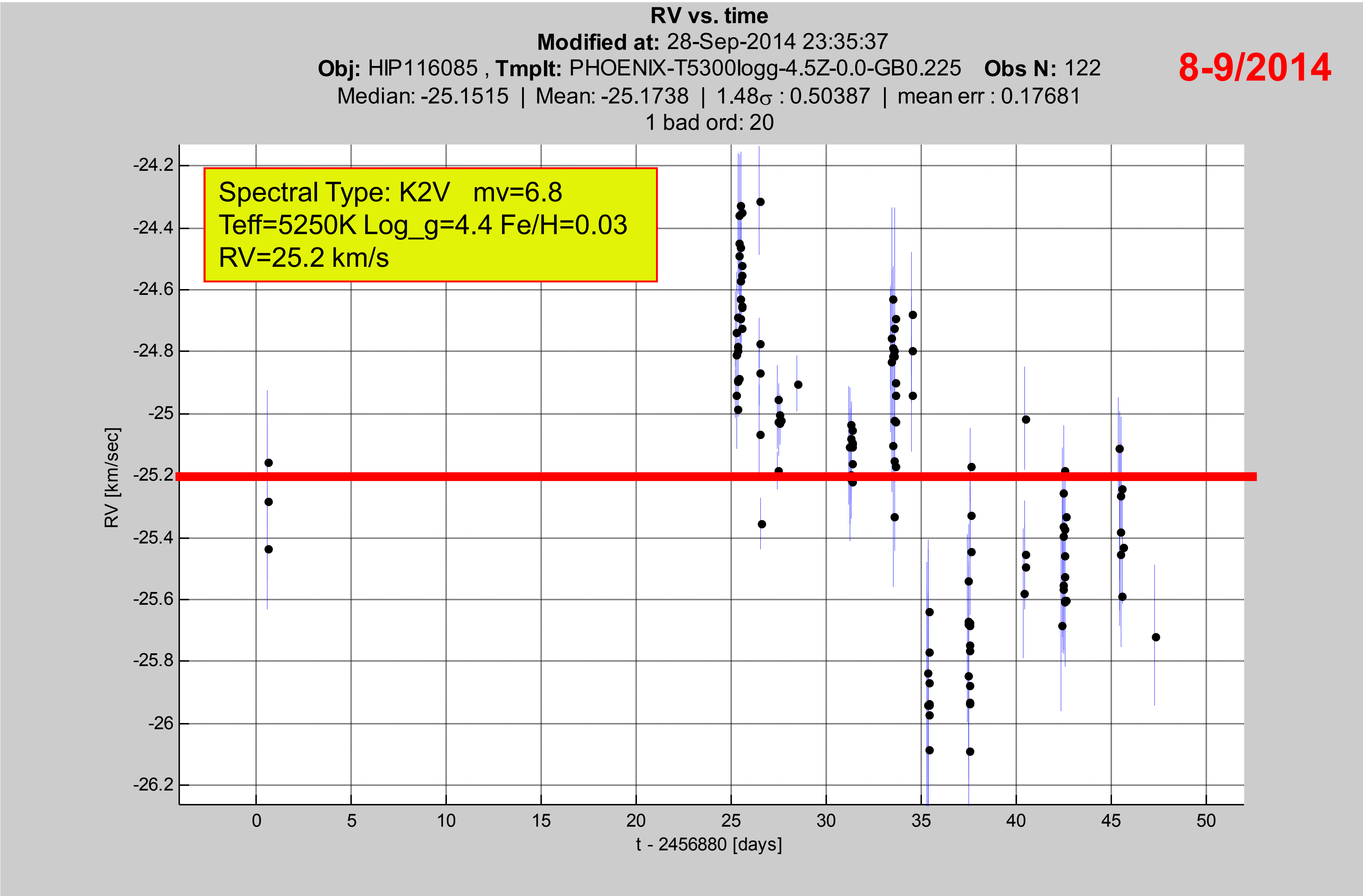
RV Measurements HIP116085 (HD221354)

http://obswww.unige.ch/~udry/std/stdnew.dat



RV Measurements HIP116085 (HD221354)

http://obswww.unige.ch/~udry/std/stdnew.dat



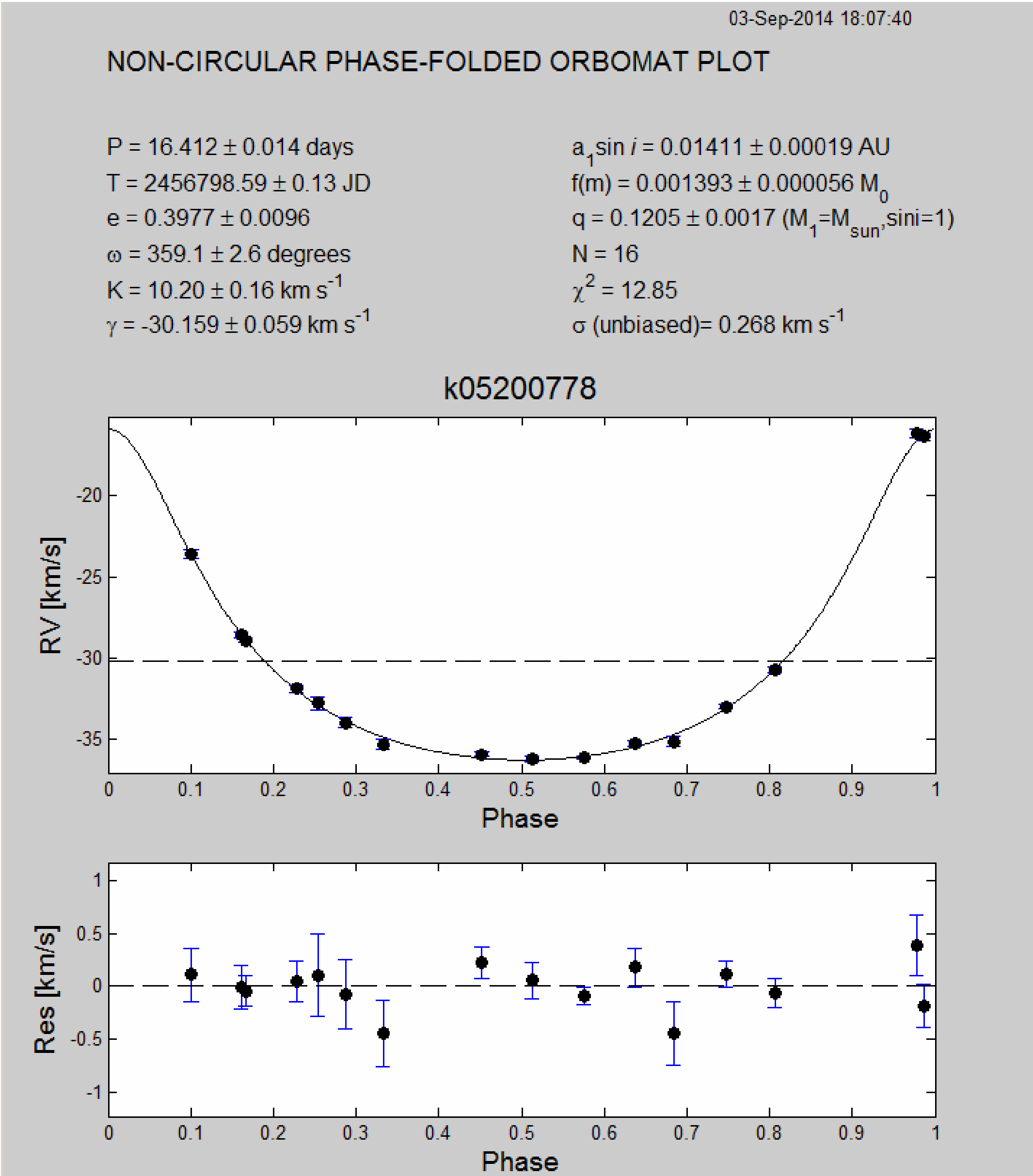
Motivation

- We want to estimate what should be the exposure time to get a certain δV
  - Estimate the location of the eShel setup on δV vs SNR curves

  - Evaluate the Q factor for the eShel for the spectral type
  - Estimate the performance – plot δV vs. exposure plots
- Use this data to predict the performance of the propose eShel+ spectrograph

eShel Science Projects

Projects: Confirmation of BEER candidates



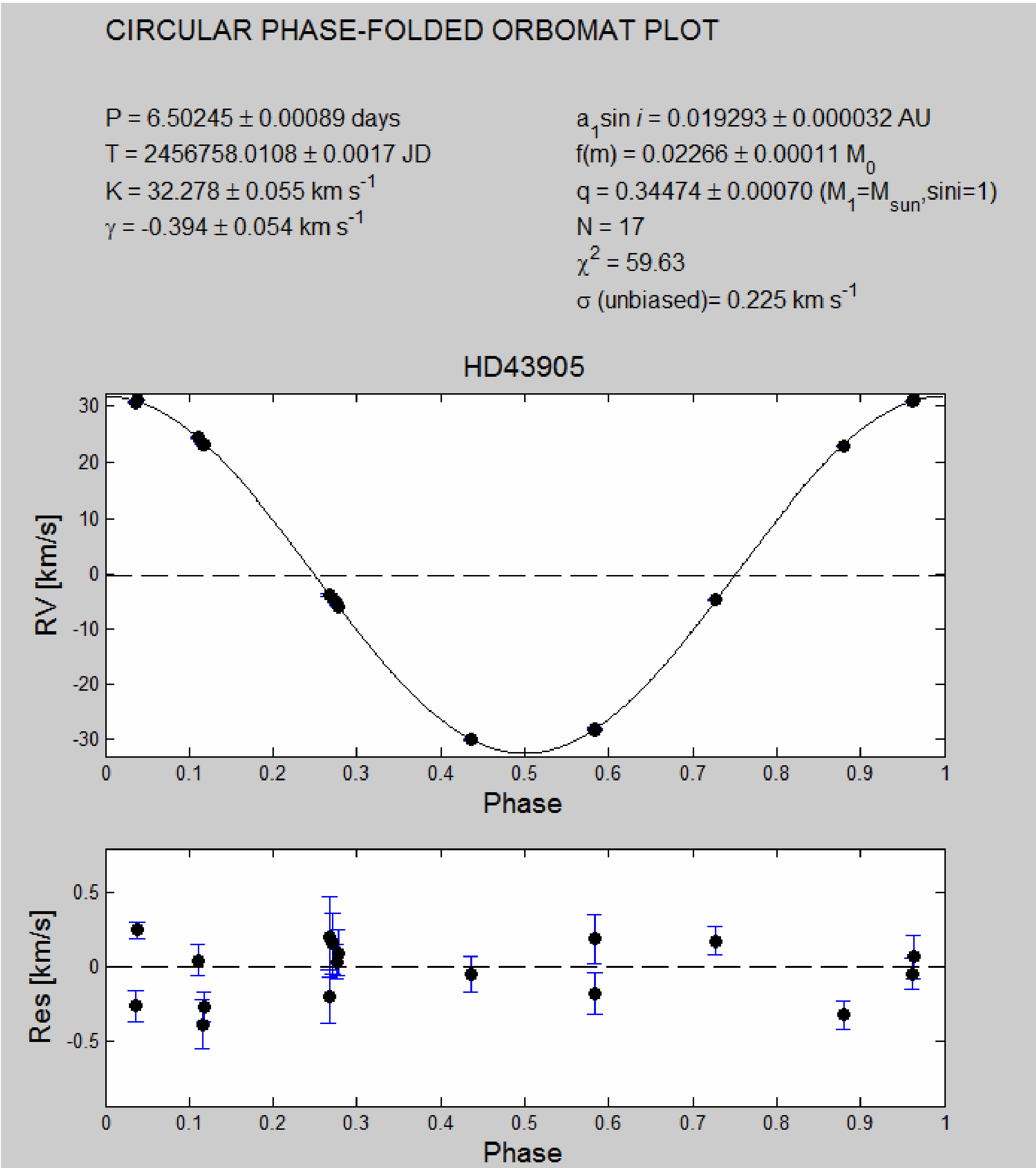
Non eclipsing binaries were detected in the Kepler catalogue

Detection based on BEER algorithm

Follow up measurements with the eShel confirmed 3 candidates so far

mv	9.5
Type	NA
Teff	6500
Log_g	4.5
Fe/H	-0.5
Tmp	lte65-4.5-0.5.Cond.txt
Nobs	18
dV_av [km/s]	**0.51**
Kexp [km/s]	**4.4**
Pexp [d]	**16.36**

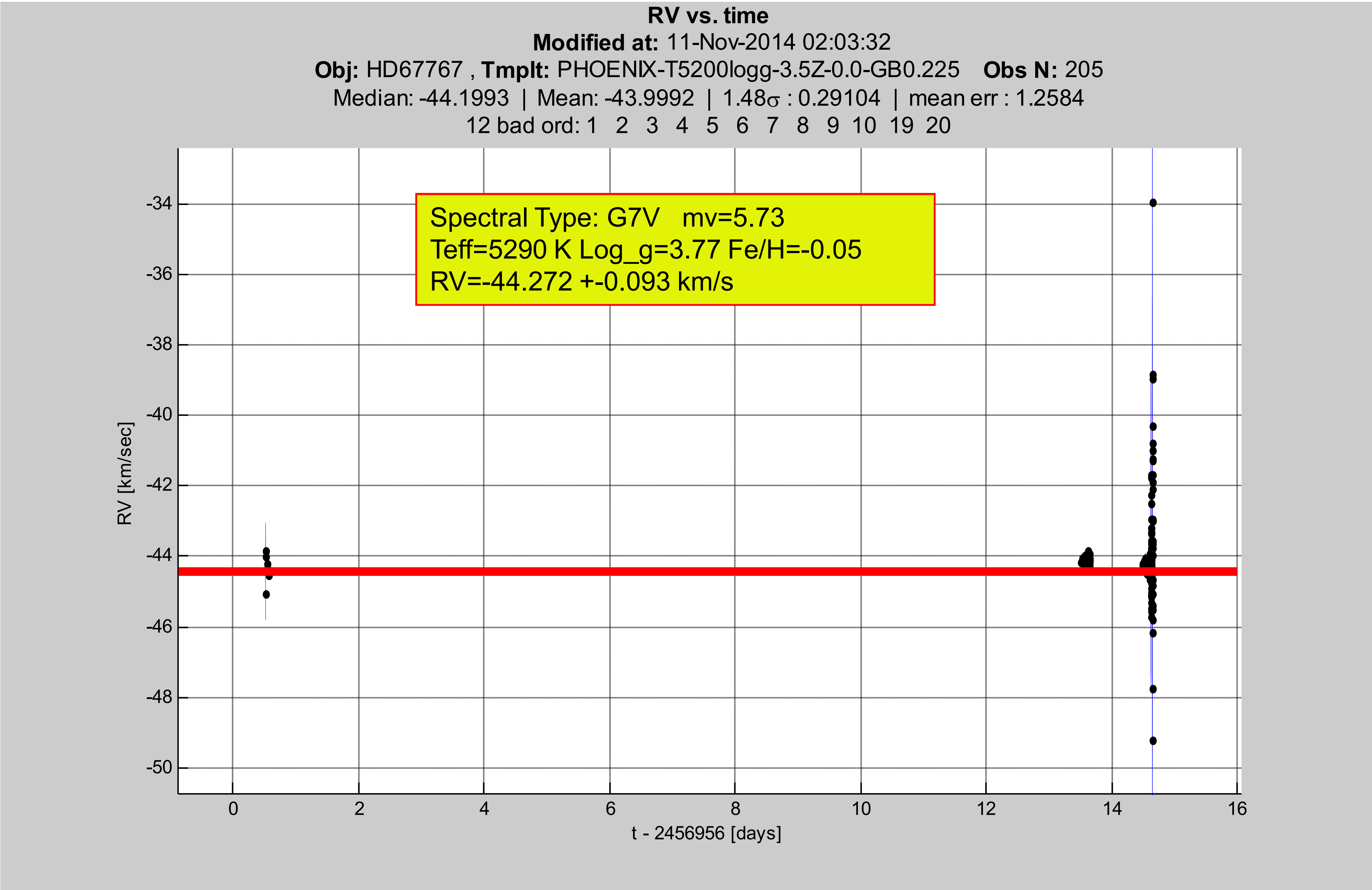
Projects: Binaries Survey for Orbit Variations
Finding Triple Systems



K_{old}=32±0.2km/s

K_{new}=32.3 ±0.06km/s

RV Measurements HD67767



This is how they do it…

2.2.1. Radial velocity measurements

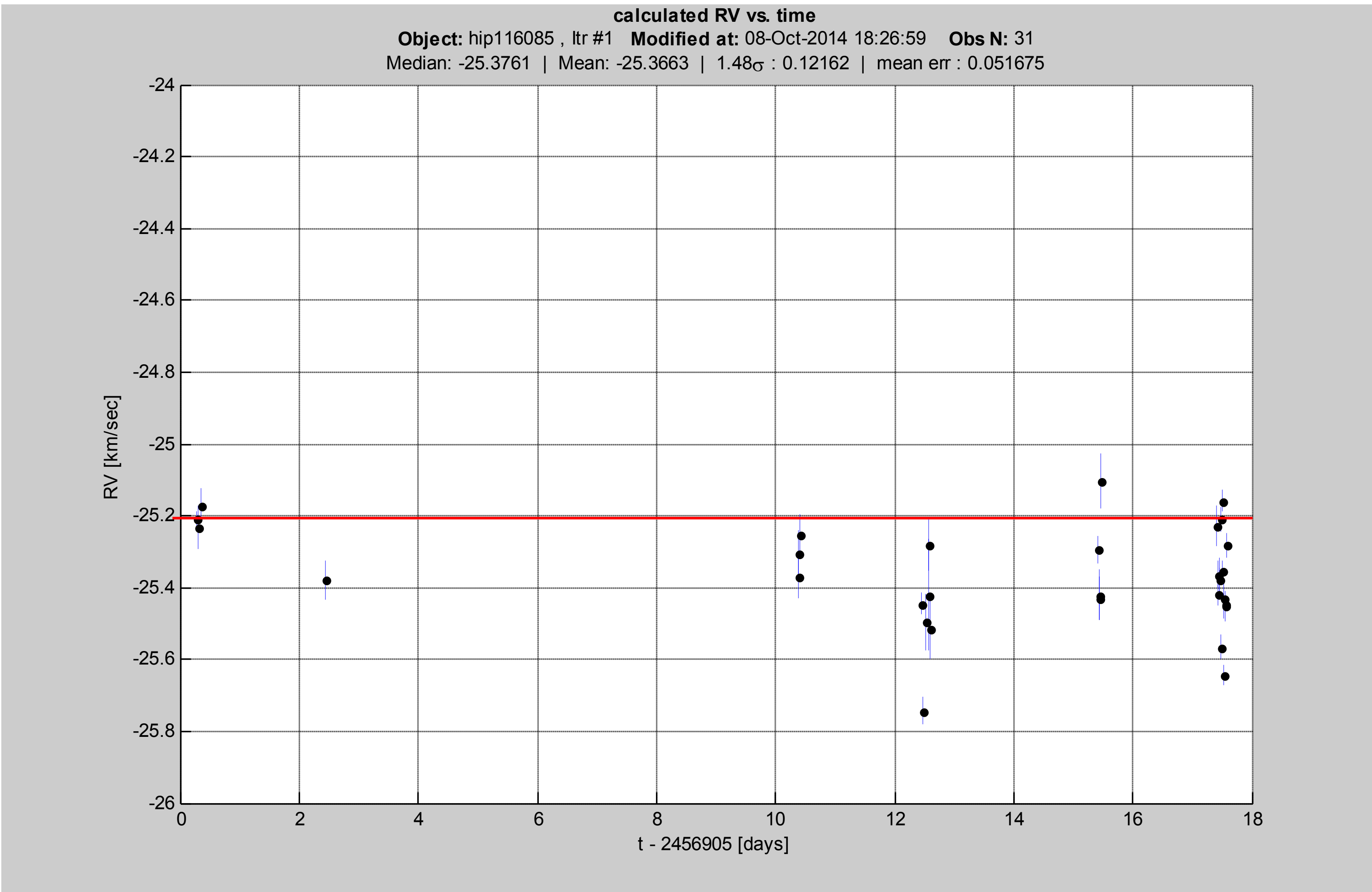
For radial velocity measurements we use the IRAF `rv.fxcor` task. Our spectra are cross correlated by templates from the synthetic library by Munari et al. (2005). The resolution of these templates is about 11 500, almost exactly the same as that of our spectra, therefore this library is ideal for us. Usually we chose the template that has nearly the same effective temperature and metallicity values as the object, but its $\log g$ and $v \sin i$ values are minimal. The CCR function is calculated between 4 900 and 6 500 Å, excluding sodium doublet and telluric regions. The radial velocity and its error is estimated from a parabola fitting to the CCR function around its maximum. For checking the stability of our mount each night at least one radial velocity standard star is also observed.

2.2.2. Signal to noise ratio

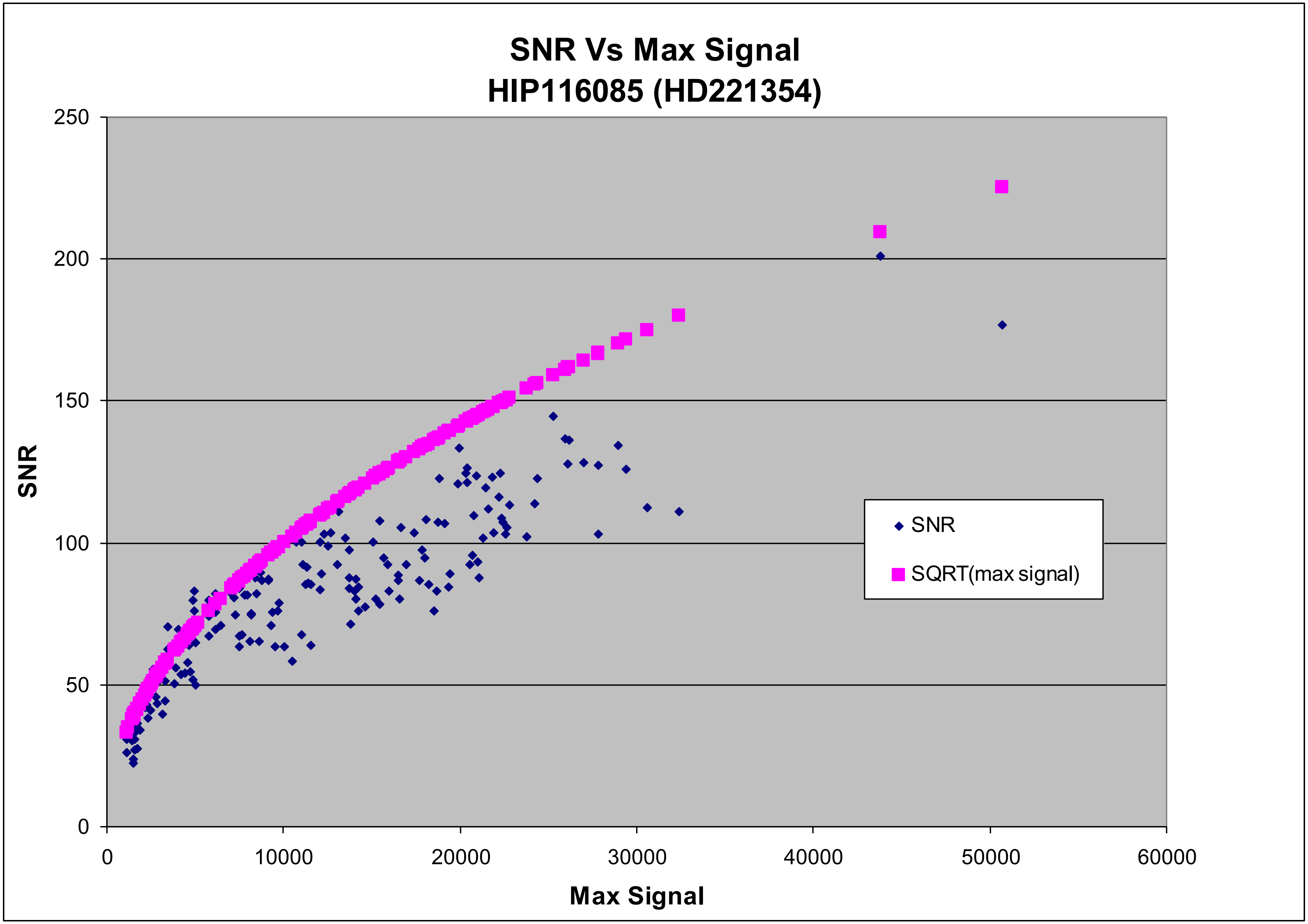
Estimating the signal to noise ratio of our spectra is not a trivial task because of the many spectral orders and lines. The SNRs were measured in a relatively line-free spectral region between 6 774 Å and 6 780 Å as the root-mean-square of the deviations from the maximum flux. By good seeing conditions we can reach SNR of about 100 for an F9 V star of $V = 3.6^{\mathrm{m}}$ with 1 min exposure time using the spectrograph on our 0.5m RC telescope. The limiting magnitude is about $V = 10.5^{\mathrm{m}}$ with the 0.5m telescope and $V = 12^{\mathrm{m}}$ with the 1m telescope. To record spectra of such faint stars with still acceptable SNR, at least 1 hour of exposure time is needed. The accuracy of the derived RVs as a function of the SNR is shown in Figure 2.

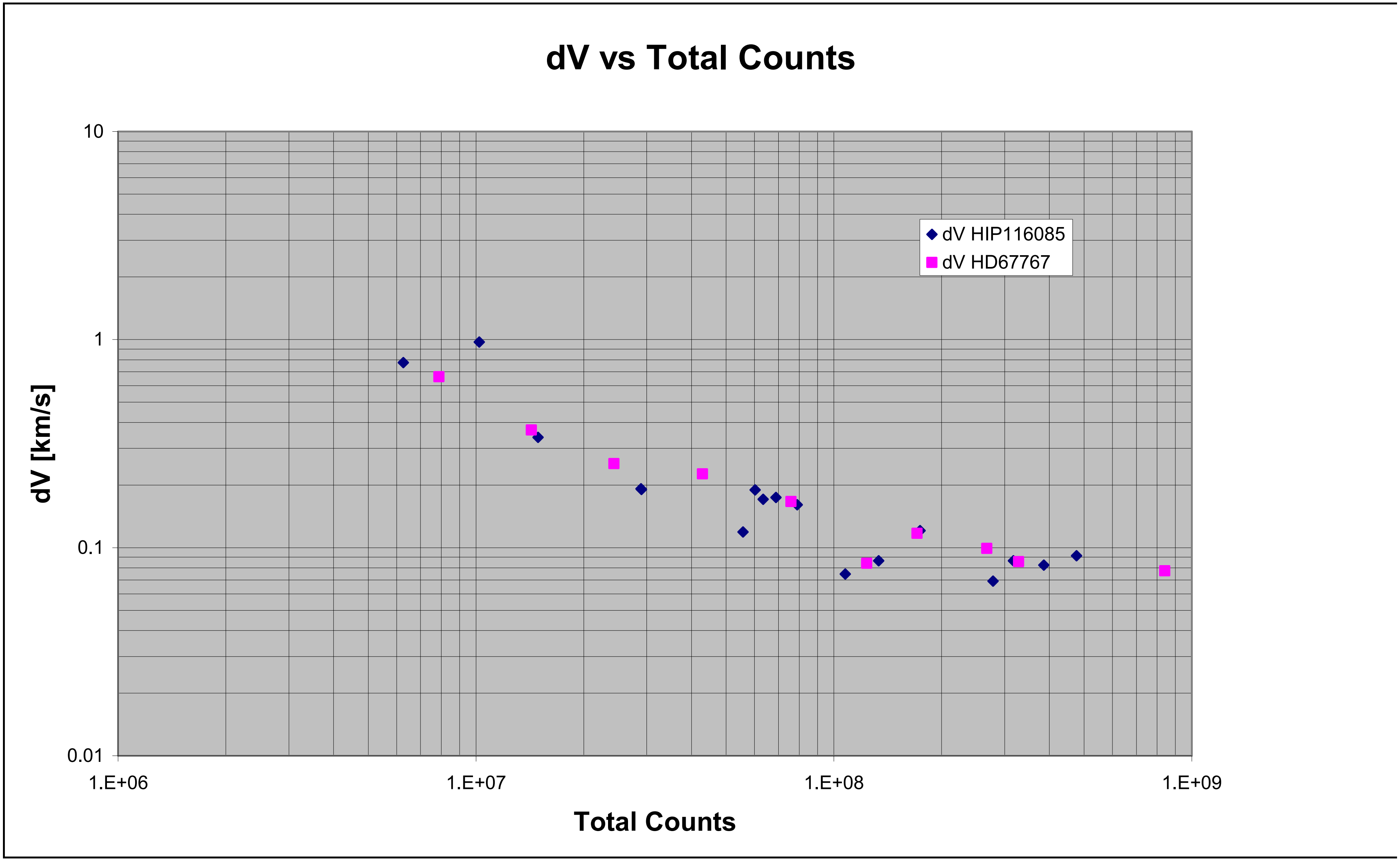
Taking The Best of the Best

- SNR>100
- Use only “stable” orders

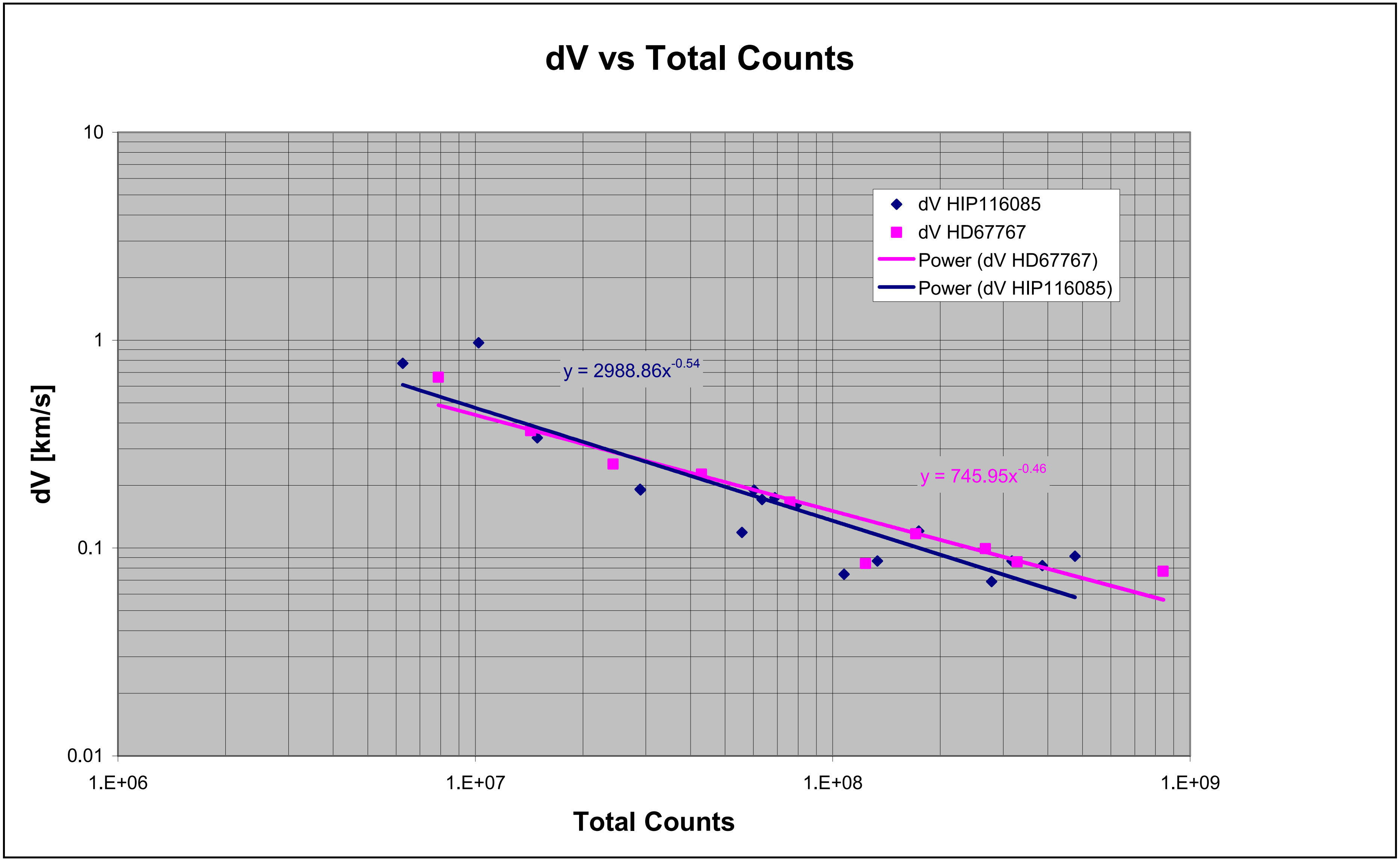


Noise – SNR vs. Signal




dV vs Total Counts
10
1
0.1
0.01
1.E+06
1.E+07
1.E+08
1.E+09
dV [km/s]
Total Counts
dV HIP116085
dV HD67767

dV vs Total Counts



Calculation of Max Signal

- Max Signal =
  - median of the smoothed (continuum) signal in the strongest order

Max(median(smoothed-P_1A_order_i))
i=first order (30) to last order (50)