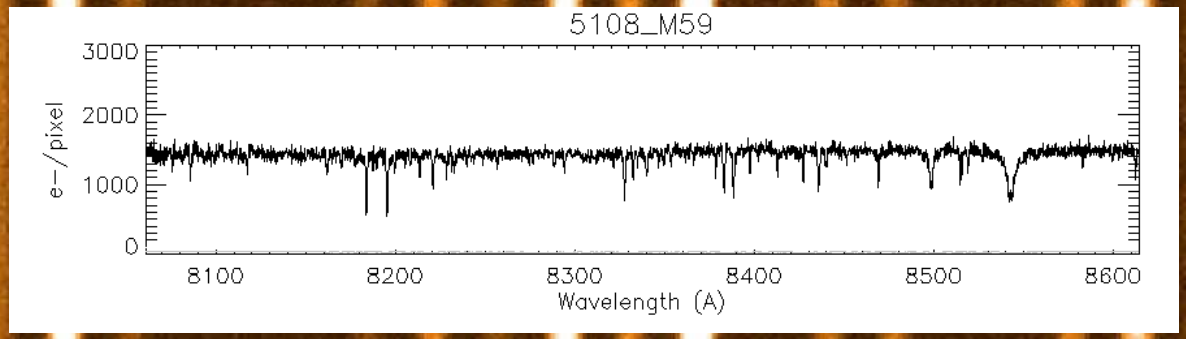
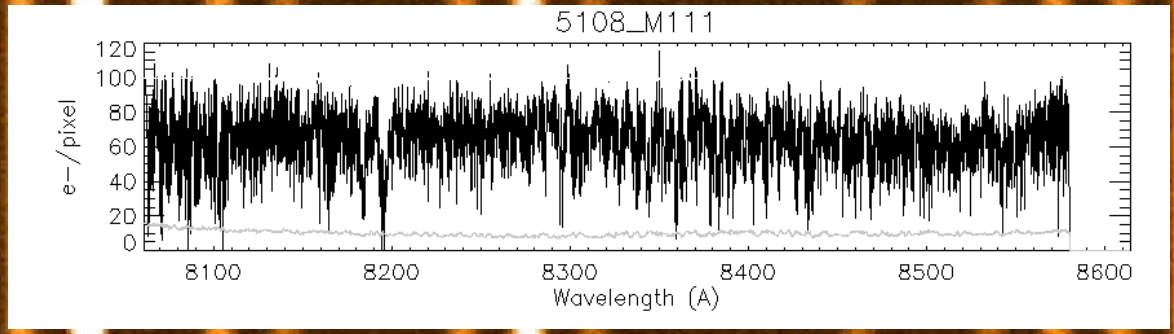
Extracting velocities and chromospheric activity indices from fibre spectroscopy in the far-red

Rob Jeffries & Richard Jackson (Keele University, UK)

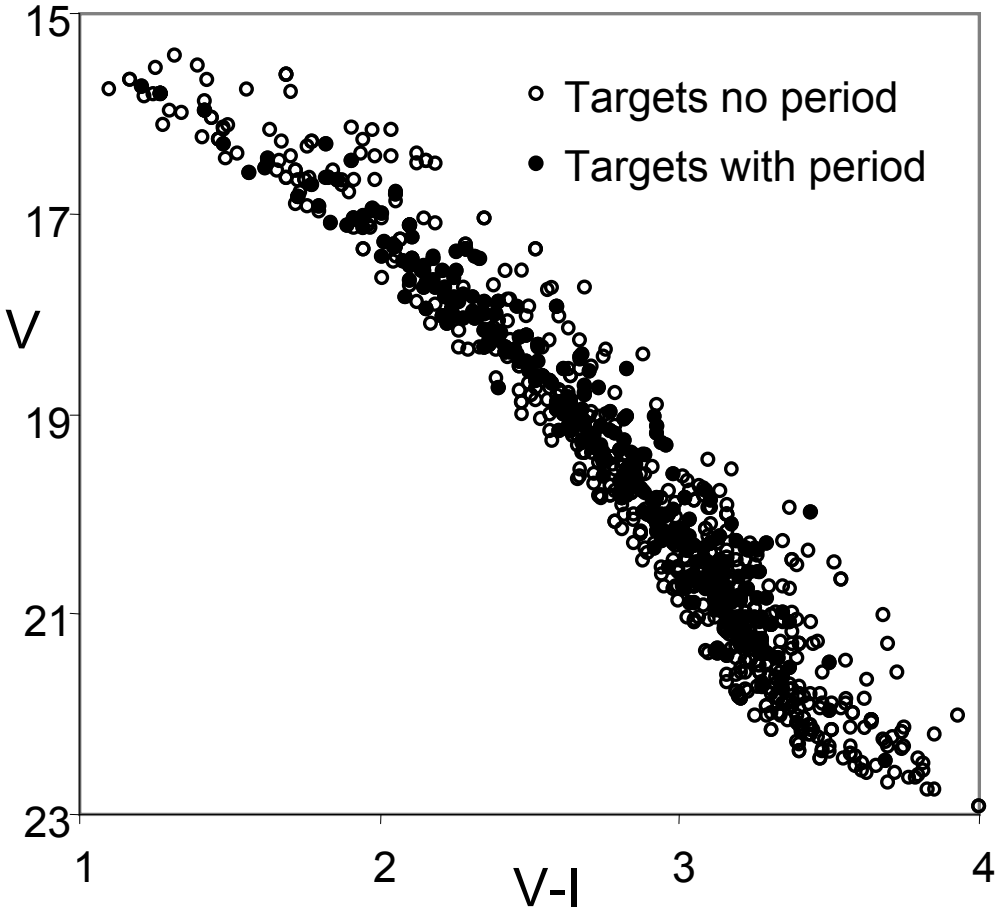




Extracting velocities and chromospheric activity indices from fibre spectroscopy in the far-red

Rob Jeffries & Richard Jackson (Keele University, UK)

1. spectroscopy of faint low-mass stars -> far-red
2. a new IDL-based pipeline for GIRAFFE (and others)
3. techniques for sky-subtraction, telluric correction etc.
4. RVs, vsin(i) and chromospheric activity



NGC 2516

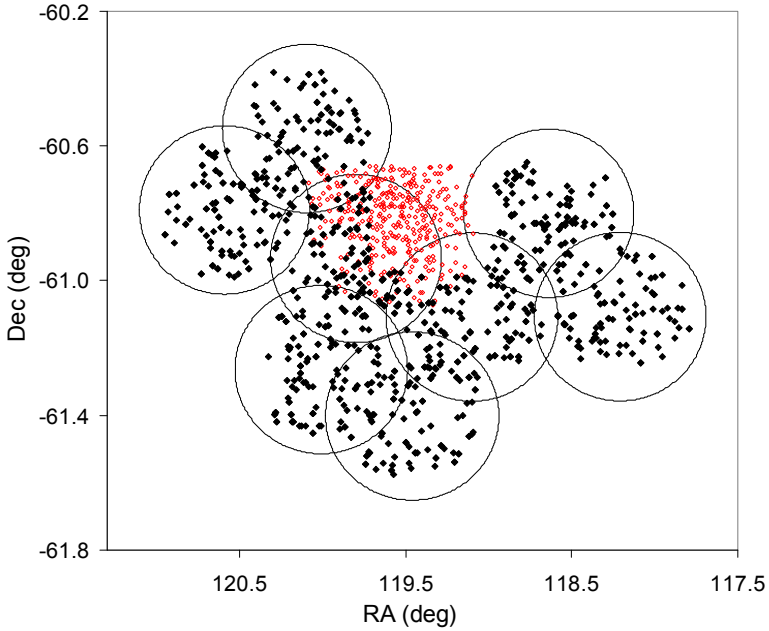
824 targets in 8 fields

14.5<I<18.5

1 field observed twice

16 targets in >1 field

UVES fibres placed on bright, early-types

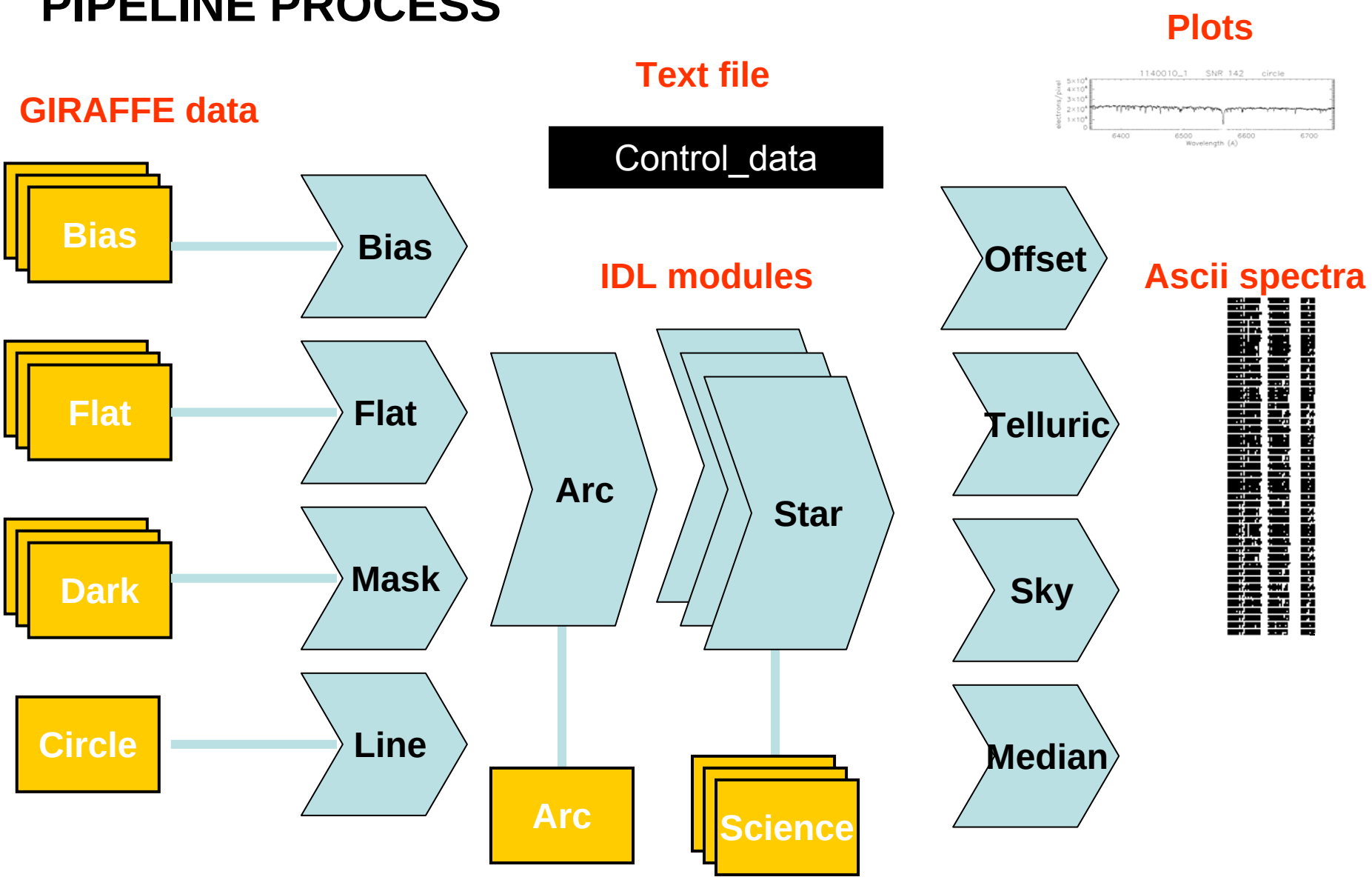


GIRAFFE + Medusa + HR20A (old CCD)

807-863nm at R=16000

1 hour OBs – 2×21min exposures

PIPELINE PROCESS



OBSERVATION SET

CepOB3:01

Export

DATA FILES USED

No. of bias files	11
First bias file No.	1076469
No. of dark files	1
First dark file No.	1076491
No. of flat files	5
First flat file No.	1076324
Arc file number	1076323
Circle setup file	1076294
No. Science files	3
Science file (1)	1076334
Science file (2)	1076335
Science file (3)	1076336
Science file (4)	
Science file (5)	

ARC DATA AND OUTPUT TYPE

ARCLINES	Avg. pixel Low	Avg. pixel Hi	Wavelength (A)
Arcline (1)	460	510	8082
Arcline (2)	615	665	8136
Arcline (3)	1330	1380	8378
Arcline (4)	1450	1500	8418
Arcline (5)	1690	1740	8495
Arcline (6)			
Arcline (7)			
Arcline (8)			
Arcline (9)			
Arcline (10)			

ARC DATA

Curvature for initial fit	0
Min pixel initial fit	1200
Max pixel initial fit	1500
Width for line selection	30
Min pixel offset spectra	90
Max pixel offset spectra	100
Order of curve fit	4
Curvature allowance	8

OUTPUT SPECTRA

Width line on raw image	16
Smooth in y for profile	10
Max sigma for extraction	5
Min wl output spectra (A)	8000
Max wl output spectra (A)	8540
No. steps in wavelength	10001
Wavelength axis type	1
Sky subtraction type	3
No. interations extraction	1

SYSTEM DATA

CCD DATA

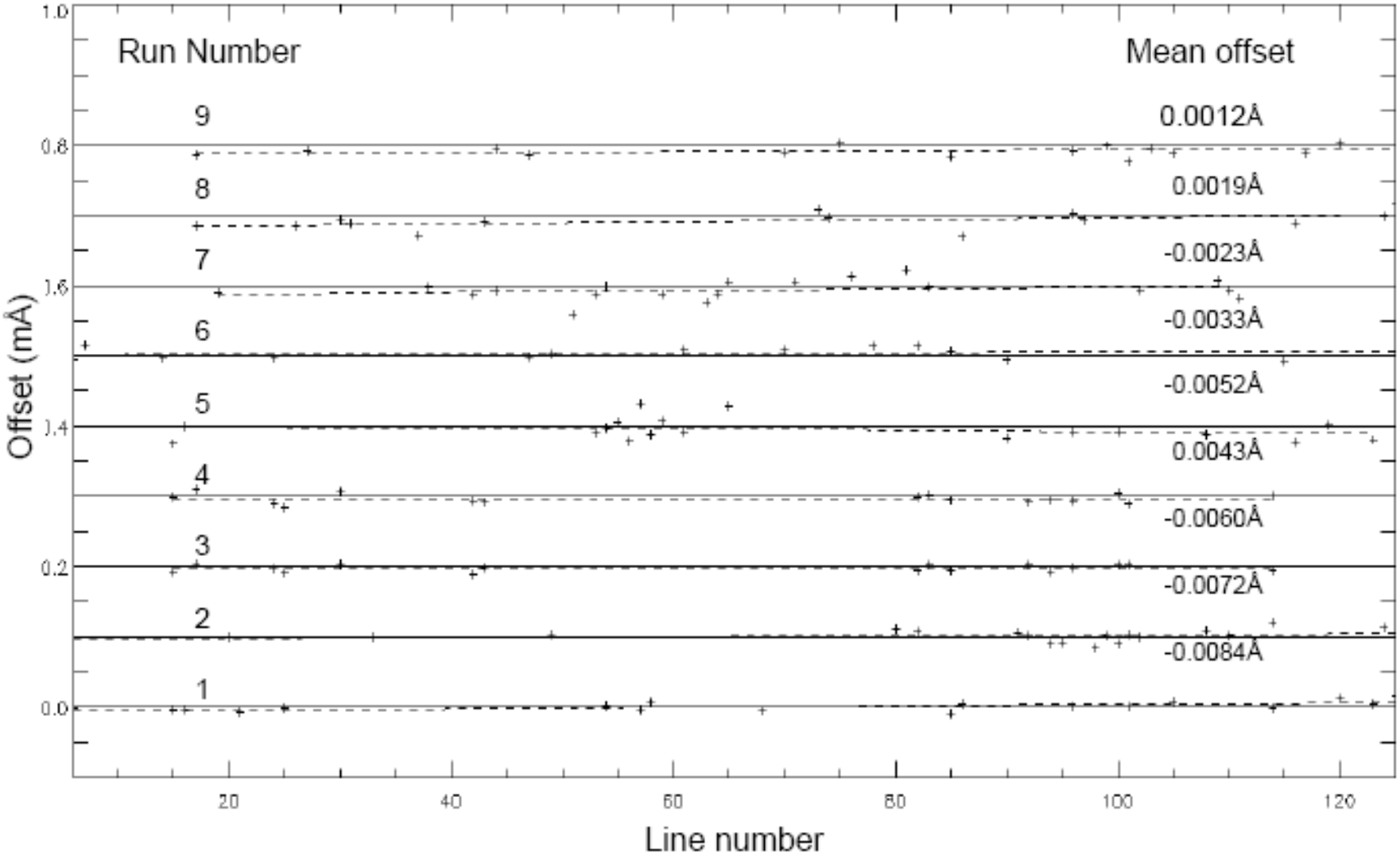
CCD read out noise	4.2
CCD gain e/count	0.9
Max valid y pixel No.	1920
Zero offset for count	32768
Useful width overscan	15
x pixel overscan (1)	4
x pixel overscan (2)	1056
x pixel overscan (3)	1082
x pixel overscan (4)	2132

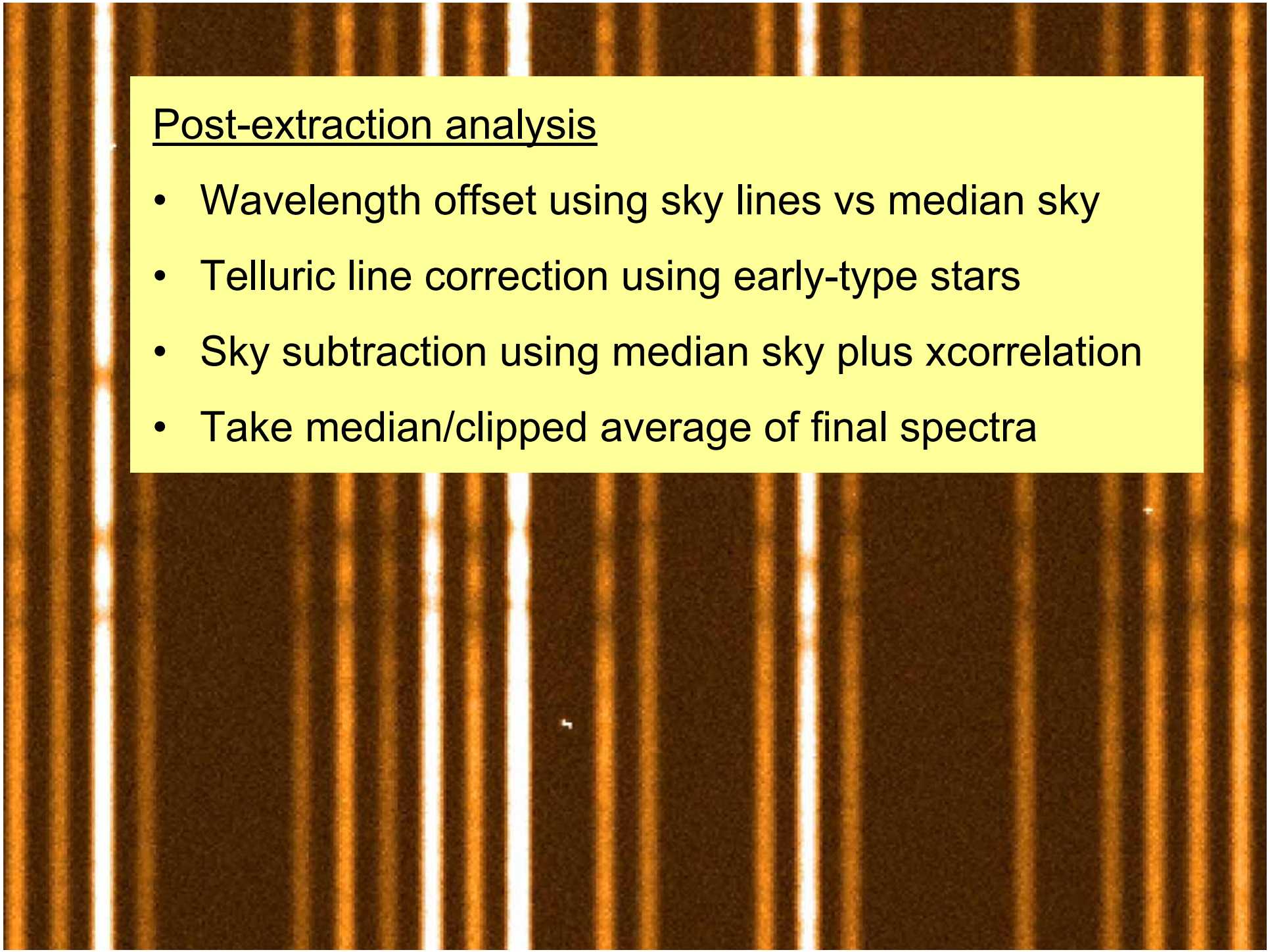
FIBER DATA

Total No. filbers	160
No. fibers used	143
Dead fiber (1)	25
Dead fiber (2)	37
Dead fiber (3)	82
Dead fiber (4)	83
Dead fiber (5)	117
Dead fiber (6)	136
Dead fiber (7)	145
Dead fiber (8)	
Dead fiber (9)	

DATA EXTRACTION

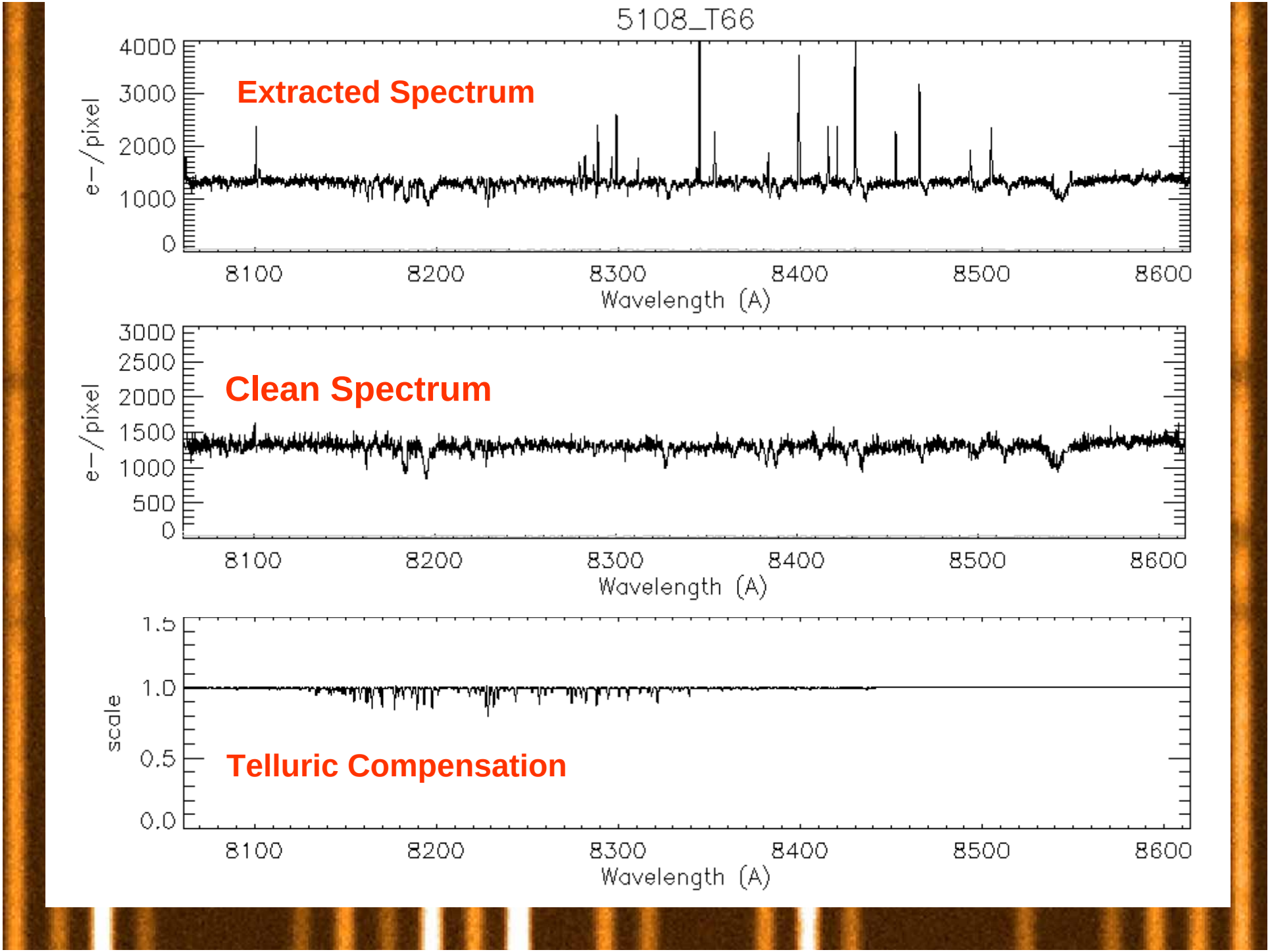
Dark file exposure time (s)	3600
Max level mask table	100.0
No. levels of mask table	20
Mask level used (count/hr)	20.0
No. levels for line fit	6
Step length in y direction	300
Smoothing trace for line fit	2
Zero offset trace for line fit	0.025

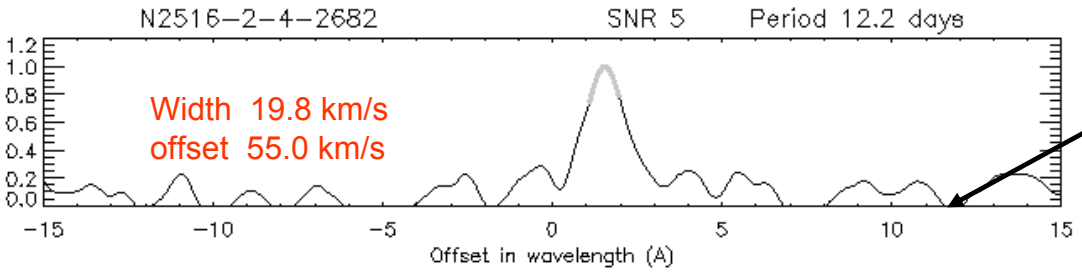

Run Number
Mean offset
9
0.0012Å
8
0.0019Å
7
-0.0023Å
6
-0.0033Å
5
-0.0052Å
4
0.0043Å
3
-0.0060Å
2
-0.0072Å
1
-0.0084Å
Offset (mÅ)
1.0
0.8
0.6
0.4
0.2
0.0
20
40
60
80
100
120
Line number

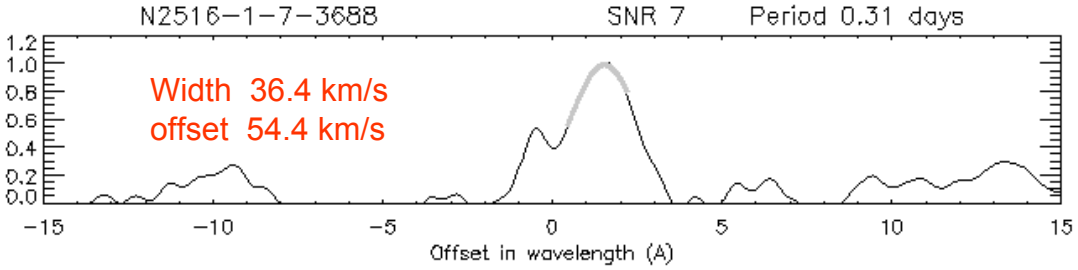


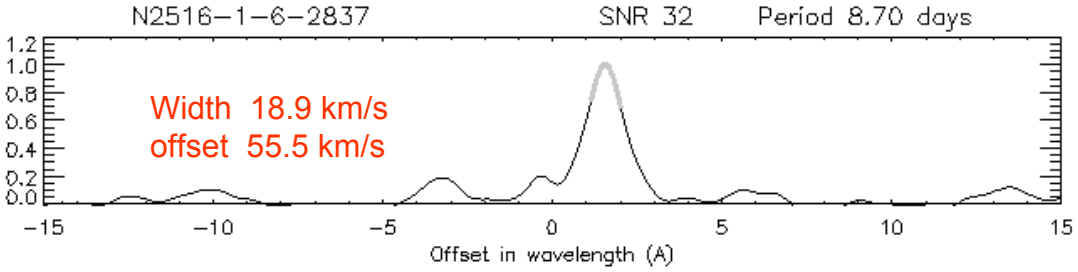
Post-extraction analysis

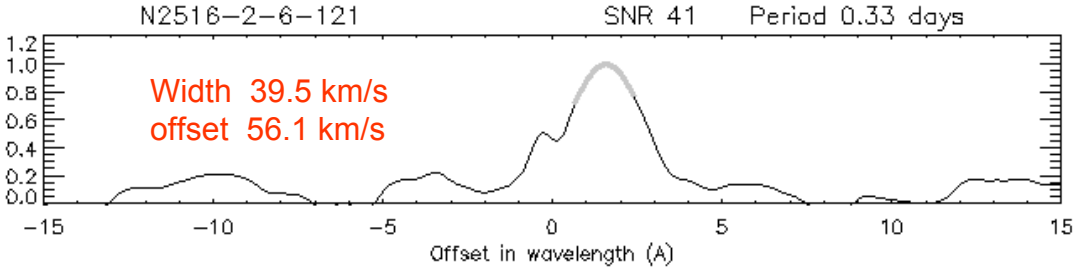
- Wavelength offset using sky lines vs median sky
- Telluric line correction using early-type stars
- Sky subtraction using median sky plus xcorrelation
- Take median/clipped average of final spectra

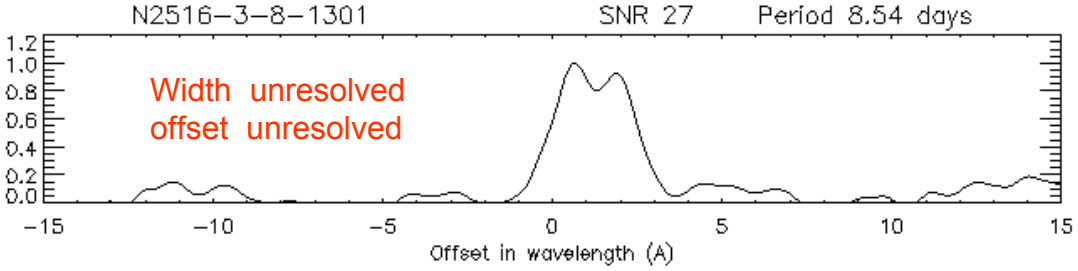

5108_T66
Extracted Spectrum
e−/pixel
4000
3000
2000
1000
0
8100
8200
8300
8400
8500
8600
Wavelength (A)
Clean Spectrum
e−/pixel
3000
2500
2000
1500
1000
500
0
8100
8200
8300
8400
8500
8600
Wavelength (A)
Telluric Compensation
scale
1.5
1.0
0.5
0.0
8100
8200
8300
8400
8500
8600
Wavelength (A)











CCFs (Lag in Angstroms)

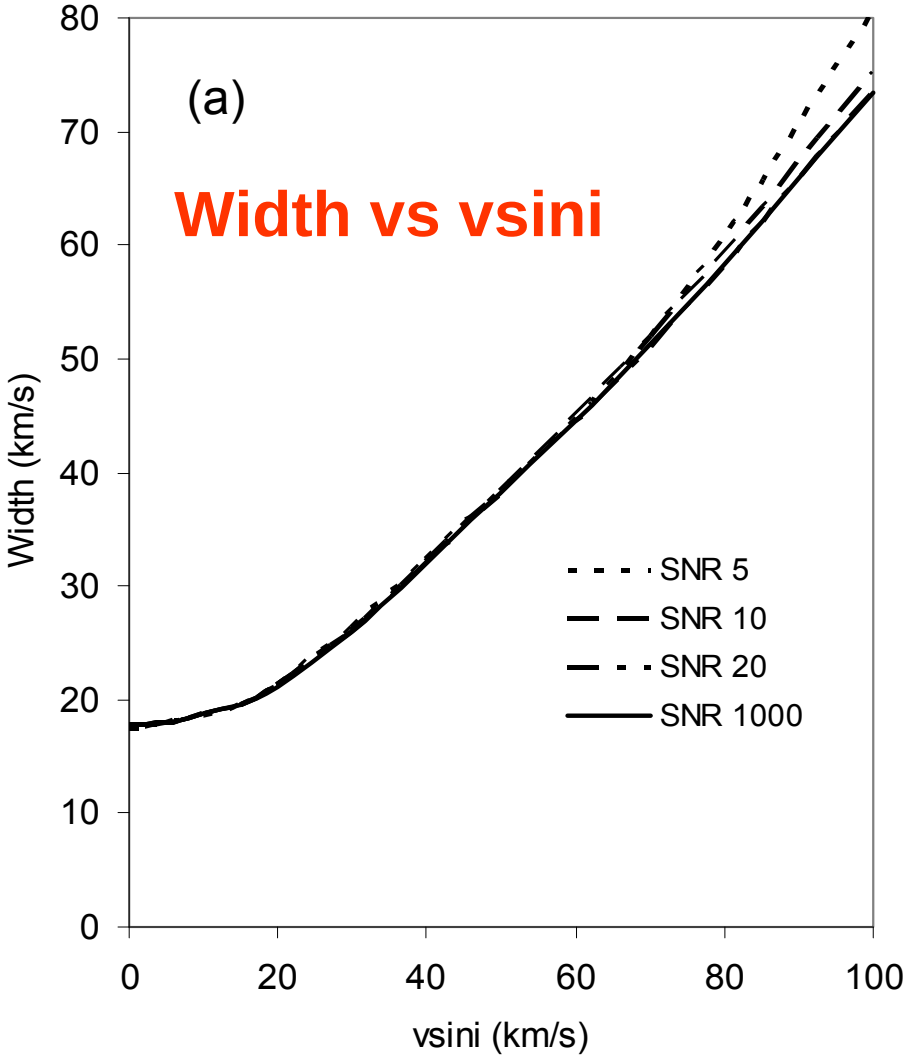
Low SNR low Vsini

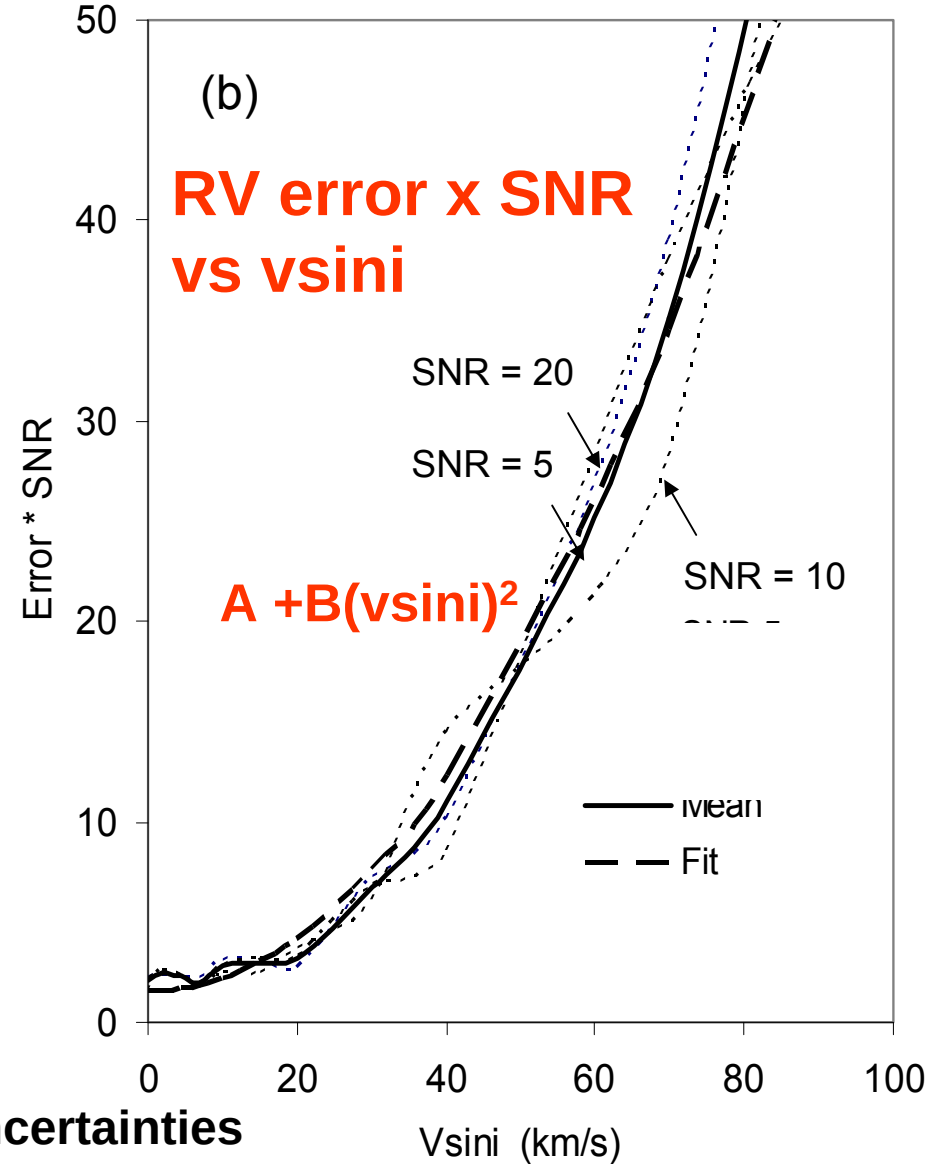
Low SNR high Vsini

High SNR low Vsini

High SNR high Vsini

Unresolved RV



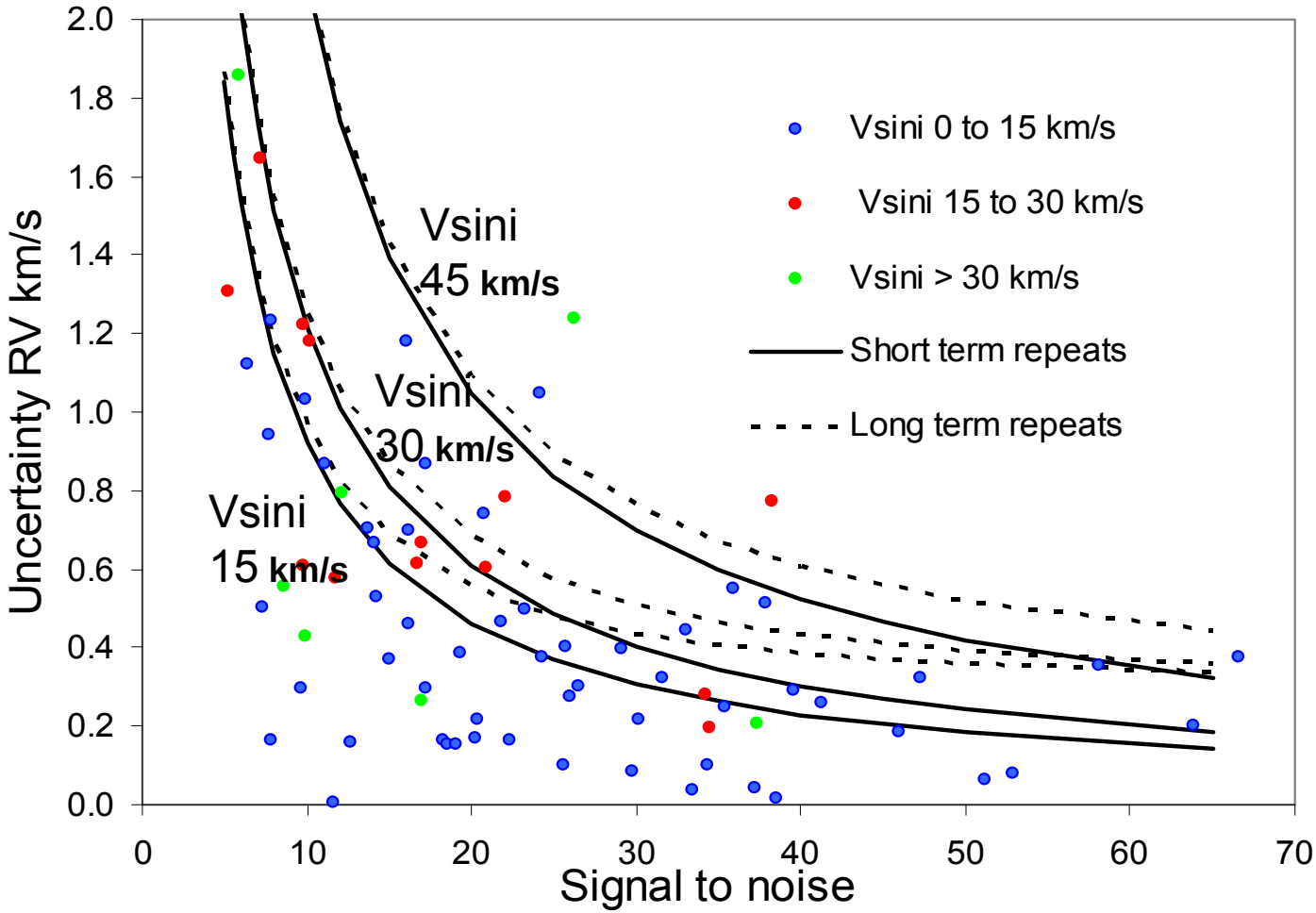


Simulations yield functional form of uncertainties

$$\sigma(RV) = ([A + B(vsini)^2]^2/SNR^2 + C^2)^{0.5}$$

Repeat measurements used to calibrate model parameters

$$\sigma_{RV} = \sqrt{(9.2 + 0.013(v \sin i)^2)^2 / SNR^2 + 0.31^2} \quad \mathrm{km\,s^{-1}}$$



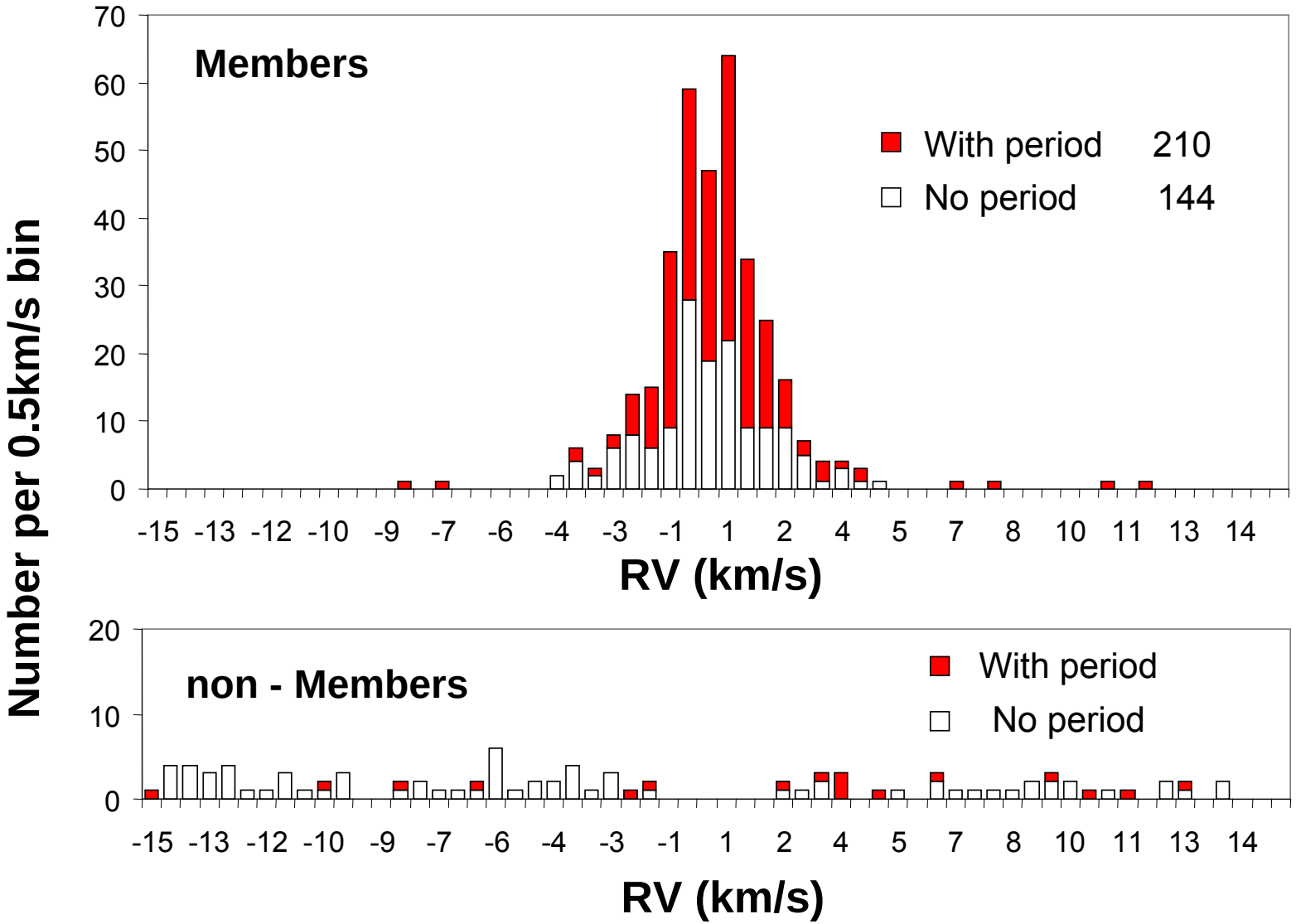
A=9.2

B=0.013

C=0.31 km/s

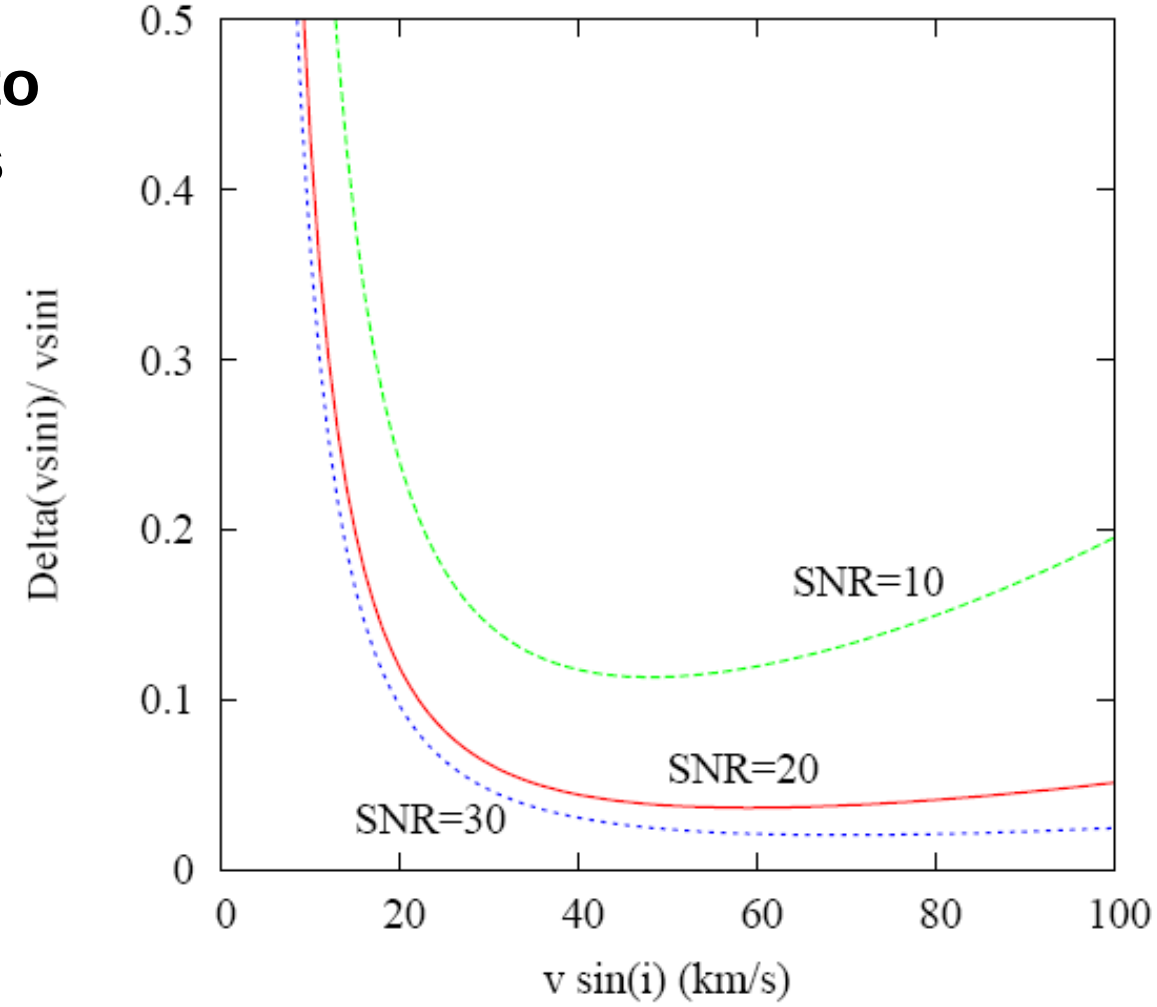
σ(RV) <0.2 km/s for high SNR, same config., **but limited to 0.3 km/s otherwise**

Cluster membership



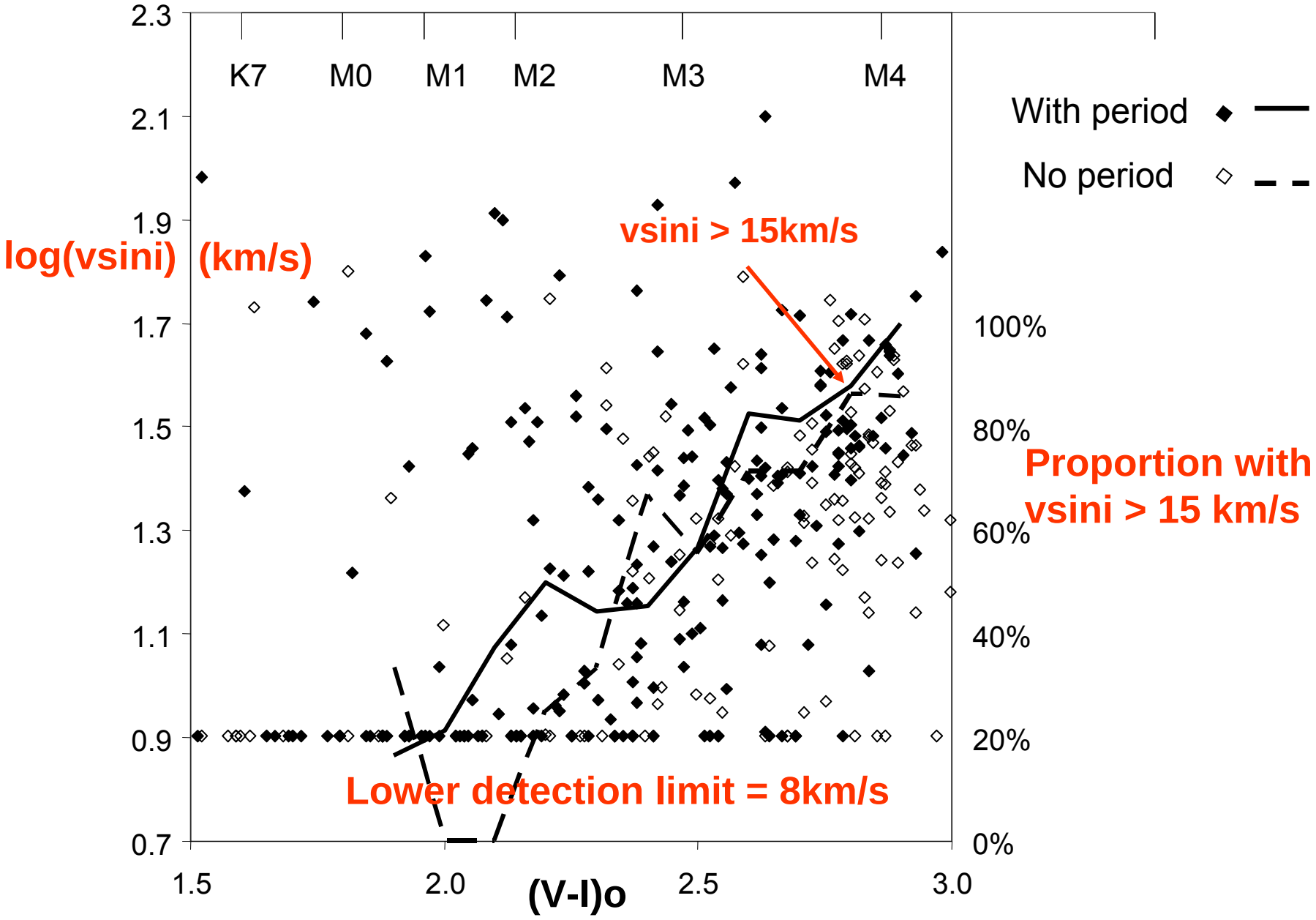
Similar approach to vsini uncertainties

Depends on SNR and resolution of spectra

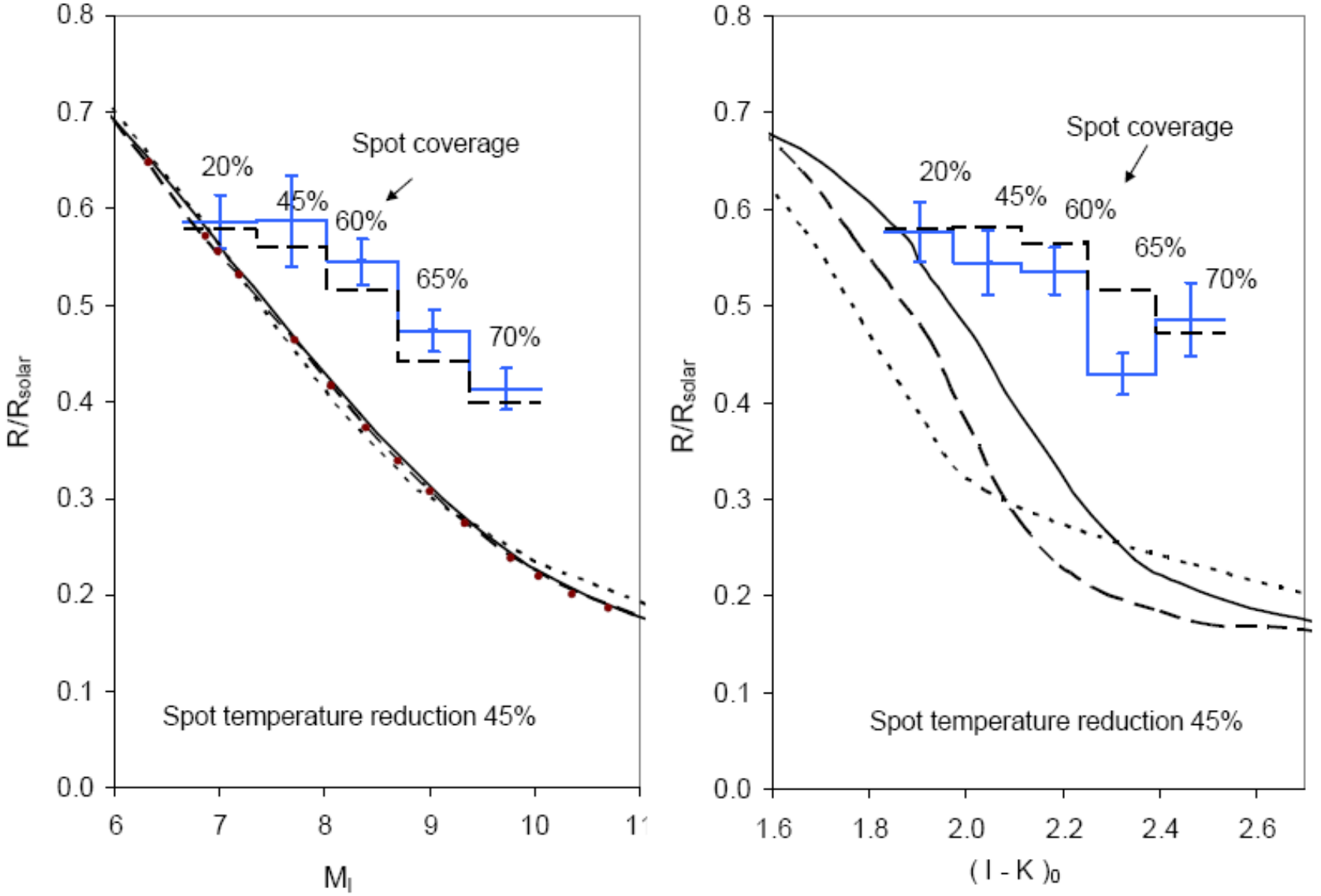


$$\sigma_W = \sqrt{(8.8 + 0.005(v \sin i)^2)^2 / SNR^2 + 0.40^2} \ \ \mathrm{km\,s^{-1}}$$

$$\sigma_{v \sin i} = v \sin i \sqrt{\sigma_W^2 + \sigma_K^2} / [2(W - K)] \ \ \mathrm{km\,s^{-1}} \qquad K = 19.14 \pm 0.64 \ \mathrm{km/s}$$

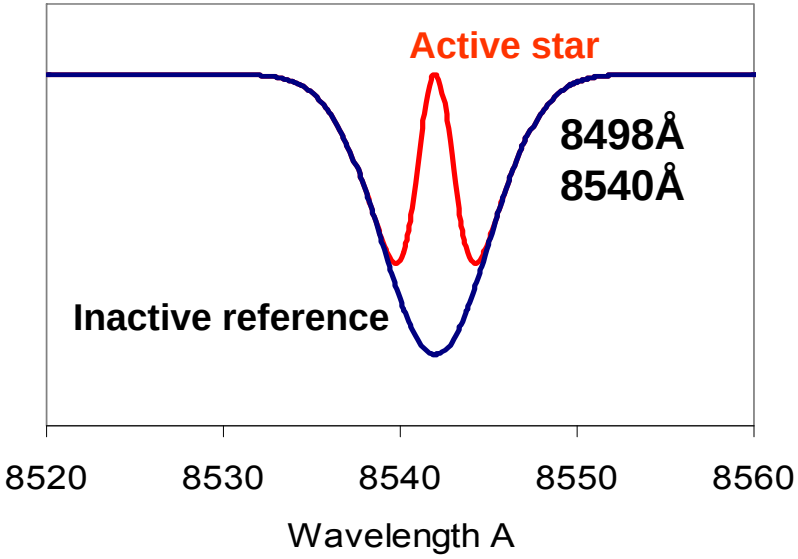

2.3
2.1
1.9
1.7
1.5
1.3
1.1
0.9
0.7
K7
M0
M1
M2
M3
M4
log(vsini) (km/s)
vsini > 15km/s
With period
No period
100%
80%
60%
40%
20%
0%
Proportion with vsini > 15 km/s
Lower detection limit = 8km/s
1.5
2.0
2.5
3.0
(V-I)o

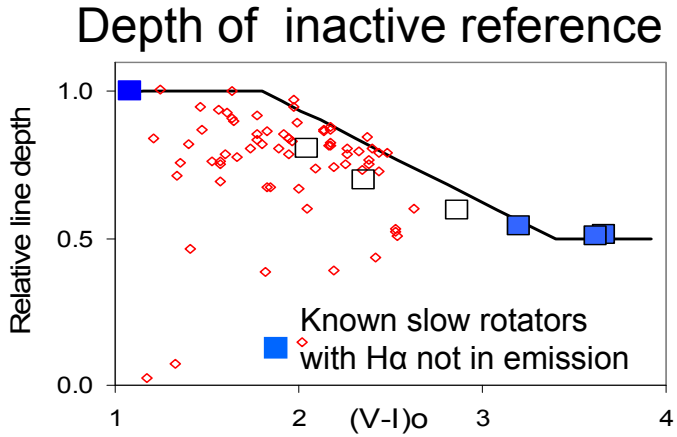
Rsin(i) = 0.02 P vsin(i) - average radii **much** larger than models > **STARSPOTS**

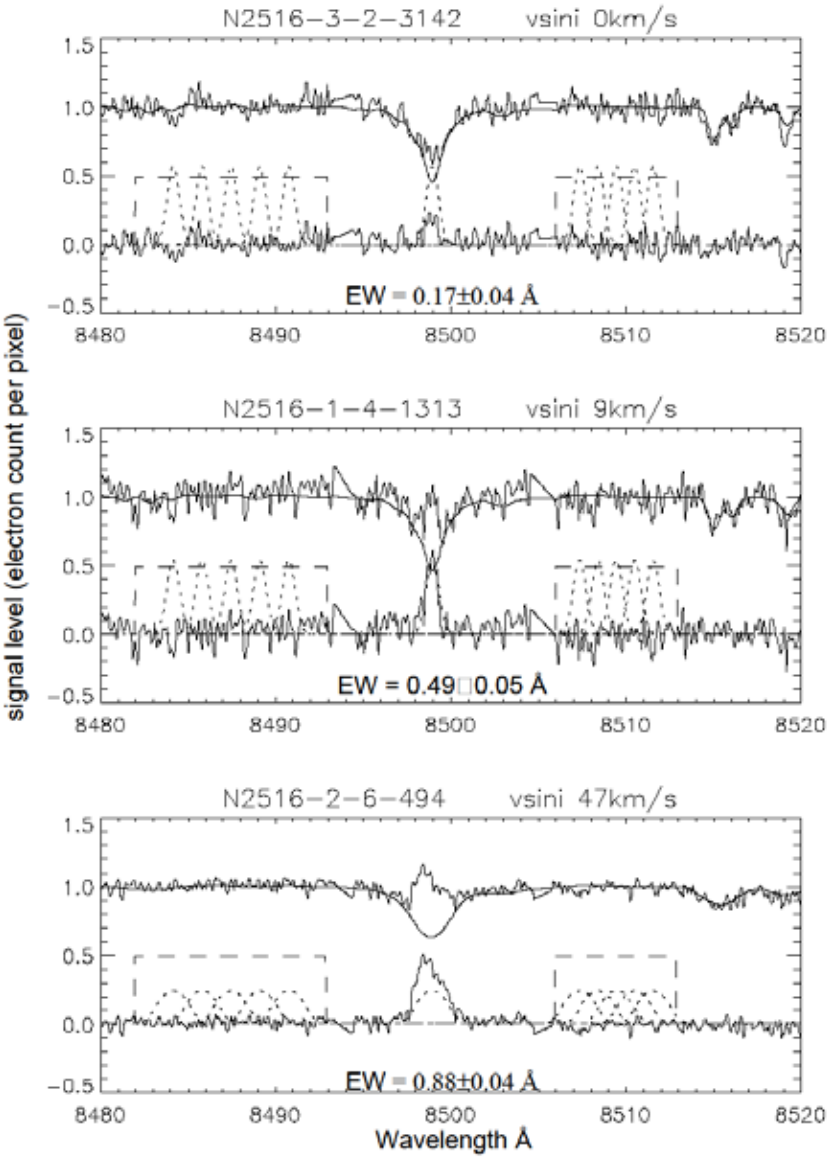


Chromospheric emission - CaII infrared triplet emission index

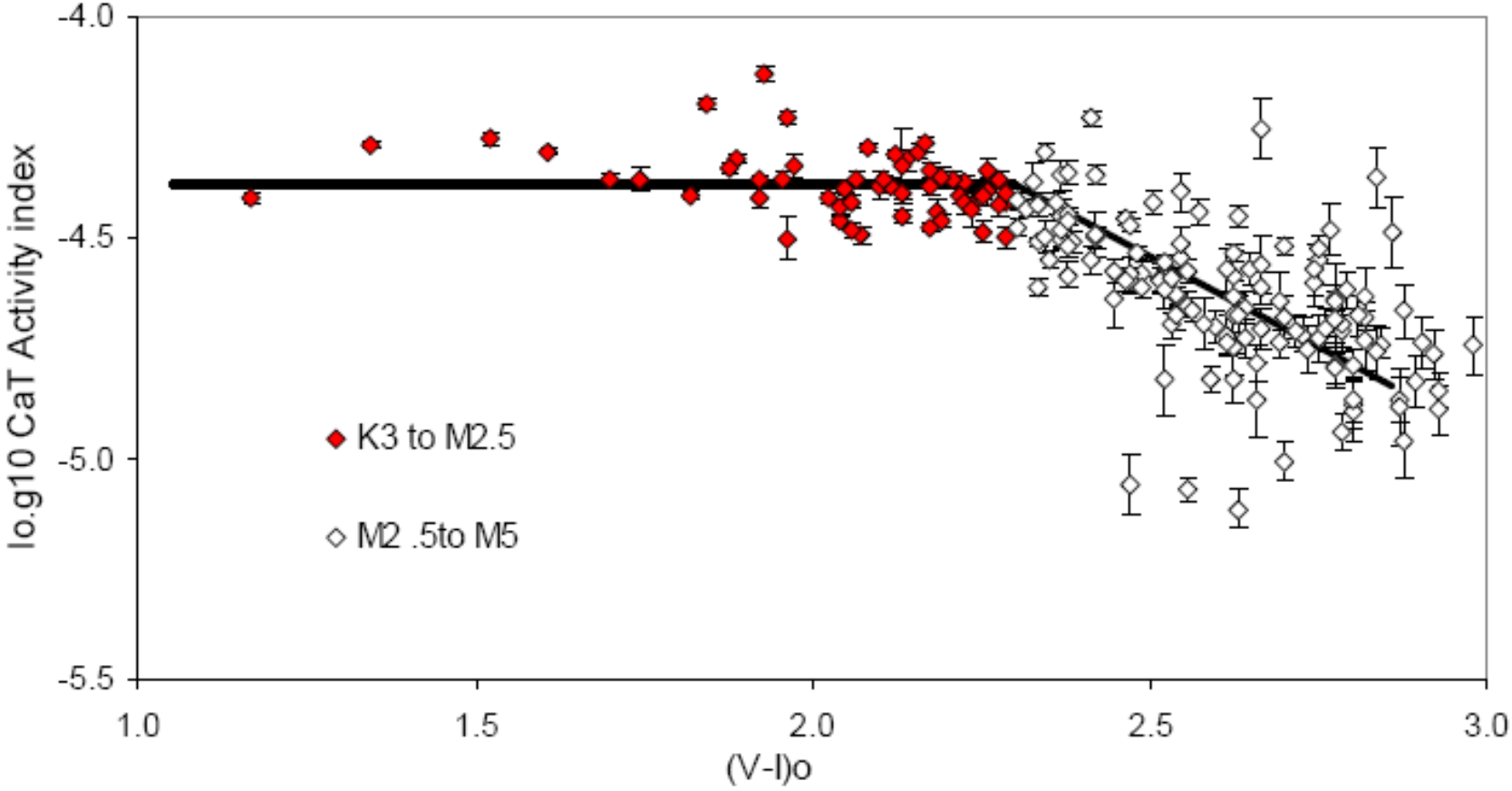
Spectral subtraction technique







Turnover of saturated activity level as stars become fully convective

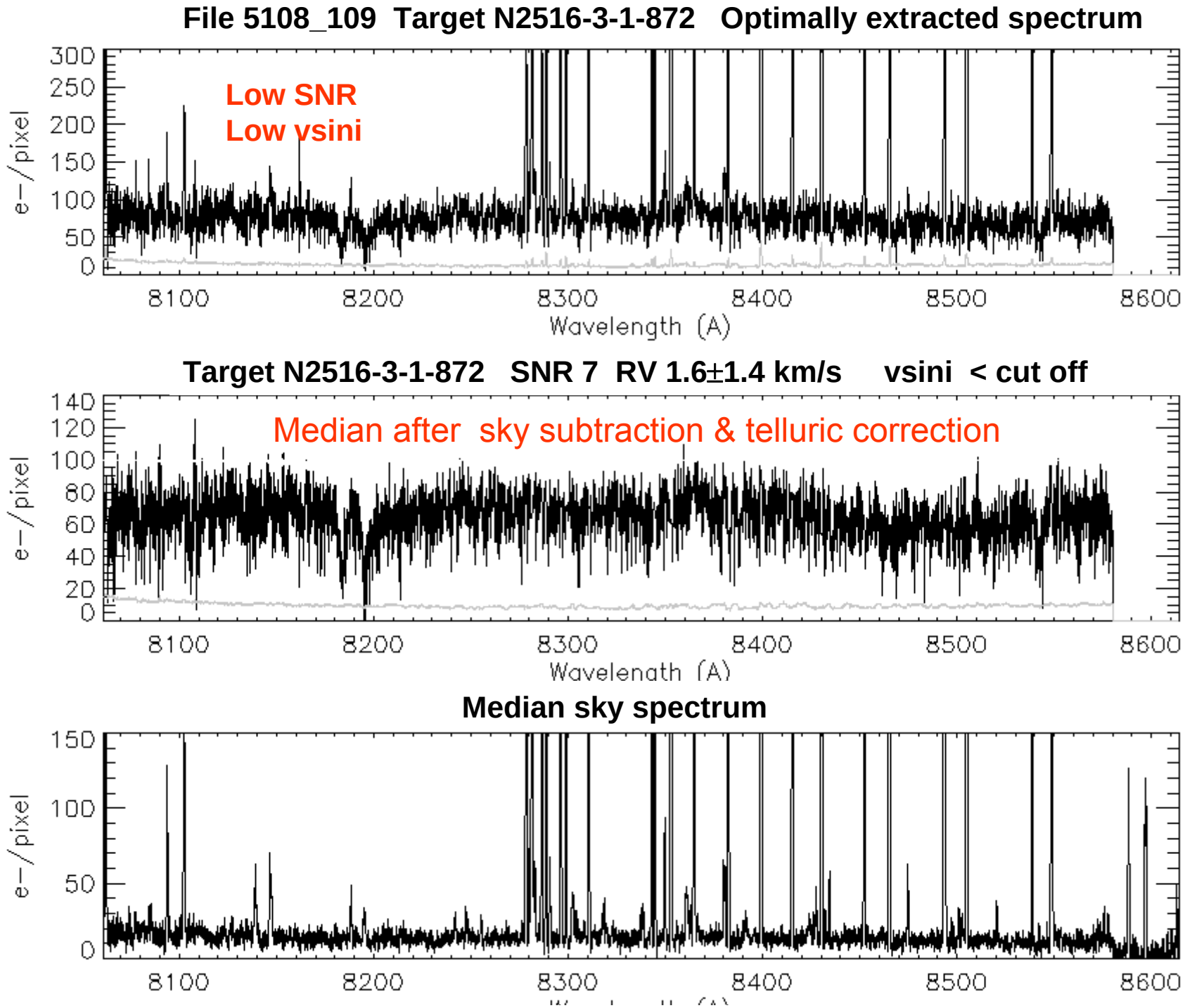


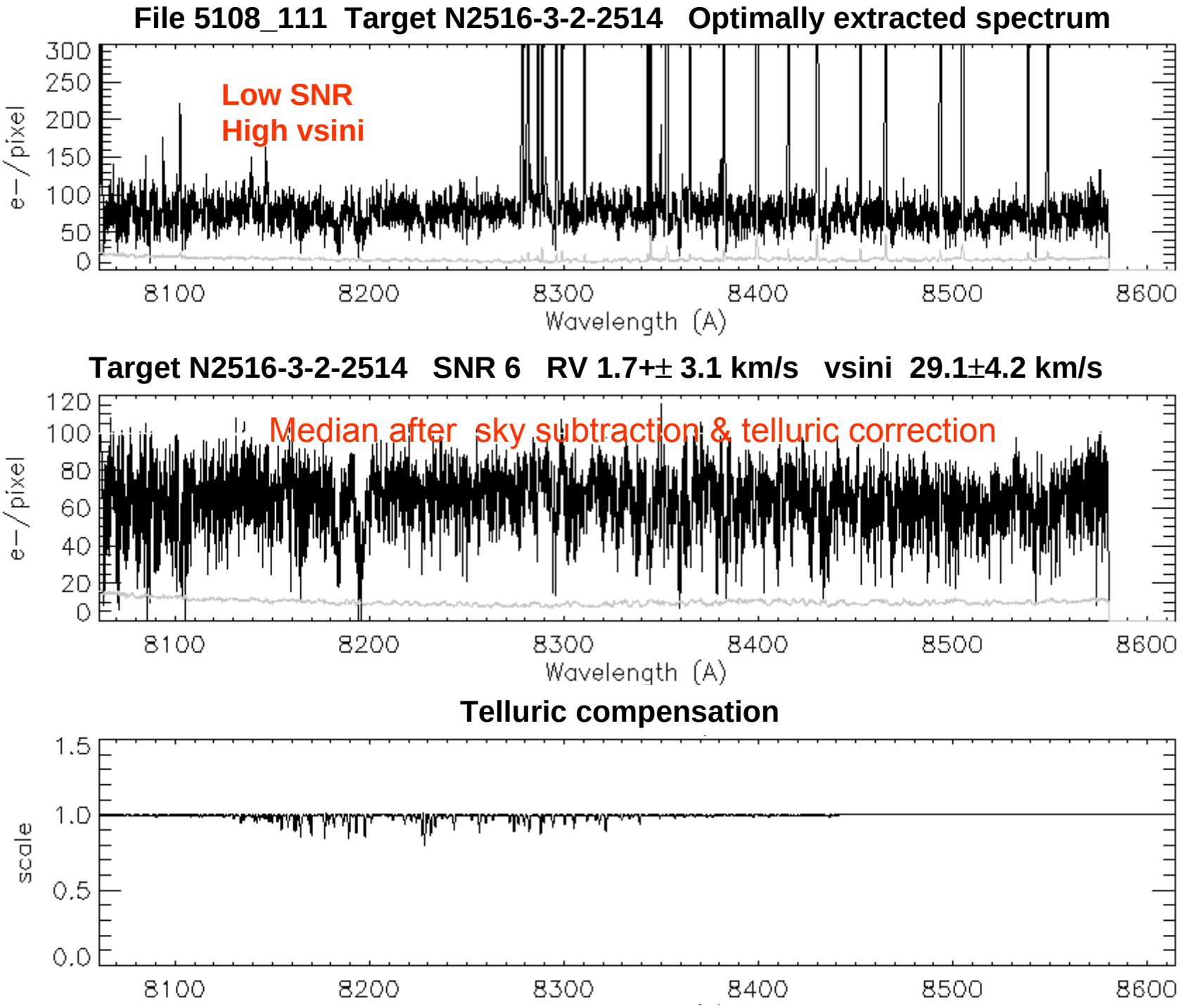
Conclusions

1. RVs, vsini, chromospheric activity can be successfully extracted from noisy, far-red spectra
2. A new pipeline has been developed for Giraffe (and other fibre spectrographs)
3. Giraffe capable of giving RVs to 300 m/s and vsini to 5% (for vsini>10 km/s) with SNR>30 (I~17 in 40 mins)

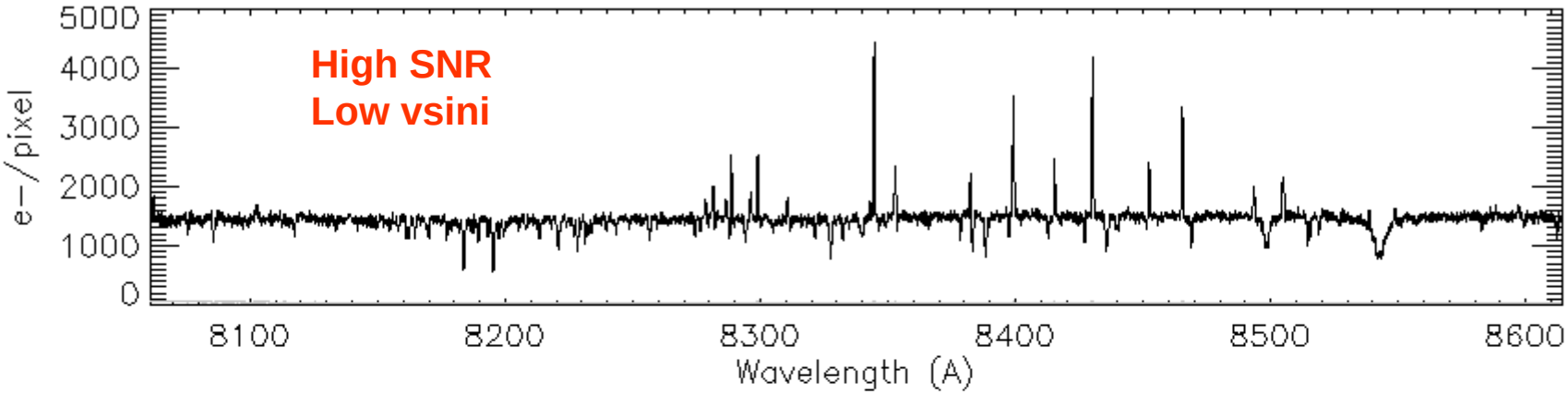
   …and about 1000 m/s and 20% in quite unpromising data with SNR~10. (I~18.5 in 40 mins)

More details: ***Jackson & Jeffries 2010, MNRAS, 407, 465;***
Jackson, Jeffries & Maxted, 2009, MNRAS, 399, L89

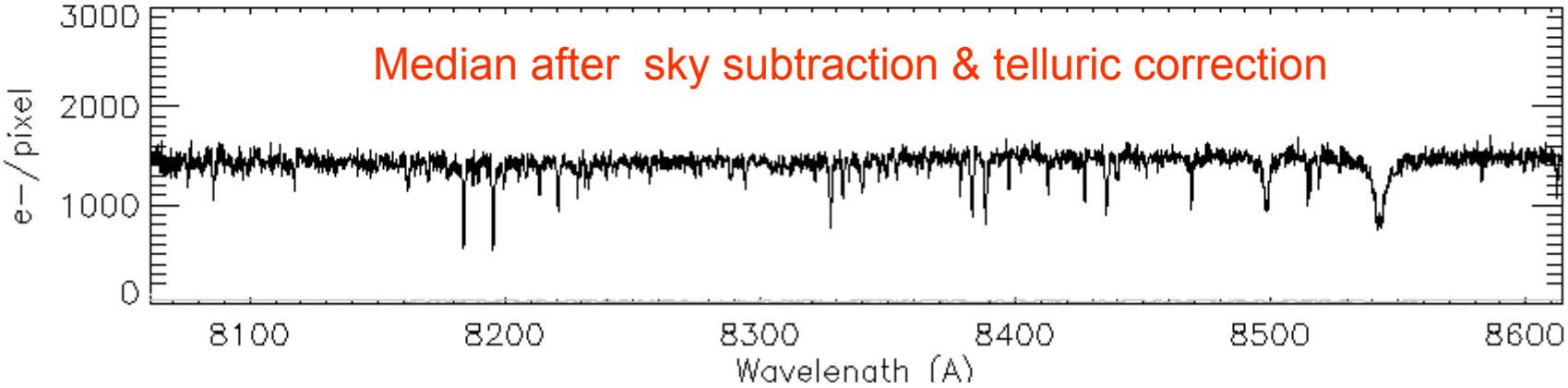

File 5108_109 Target N2516-3-1-872 Optimally extracted spectrum
Low SNR
Low vsini
e−/pixel
Wavelength (A)
Target N2516-3-1-872 SNR 7 RV 1.6±1.4 km/s vsini < cut off
Median after sky subtraction & telluric correction
e−/pixel
Wavelength (A)
Median sky spectrum
e−/pixel


File 5108_111 Target N2516-3-2-2514 Optimally extracted spectrum
Low SNR
High vsini
e−/pixel
Wavelength (A)
Target N2516-3-2-2514 SNR 6 RV 1.7+± 3.1 km/s vsini 29.1±4.2 km/s
Median after sky subtraction & telluric correction
e−/pixel
Wavelength (A)
Telluric compensation
scale

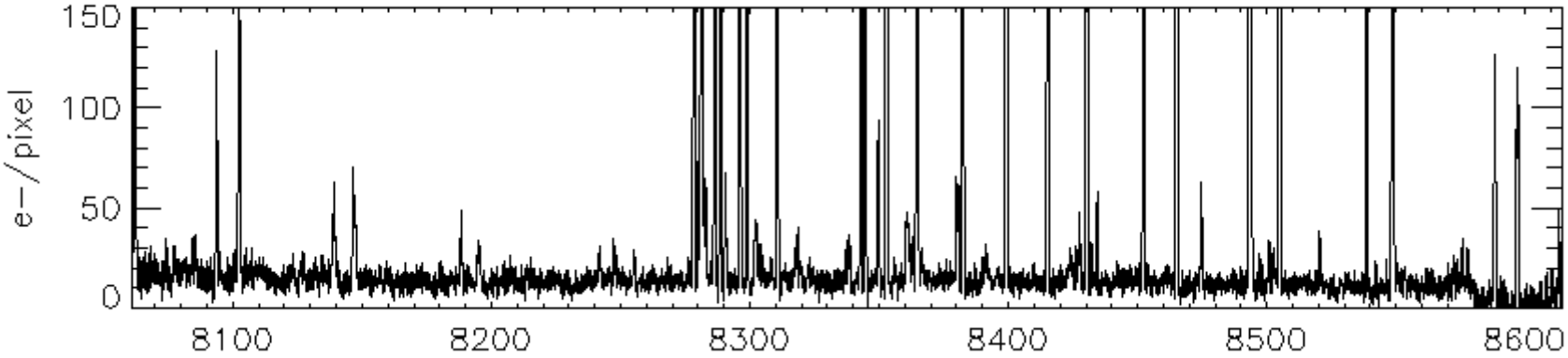
File 5108_59 Target N2516-3-5-998 Optimally extracted spectrum



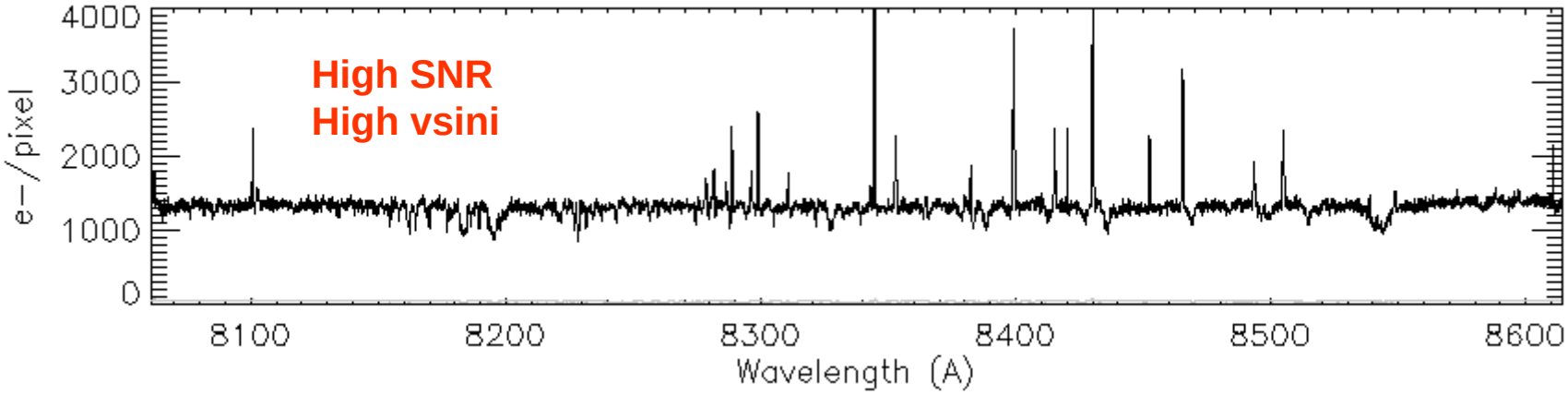
Target N2516-3-5-998 SNR 49 RV 0.6±0.4 km/s vsini < cut off



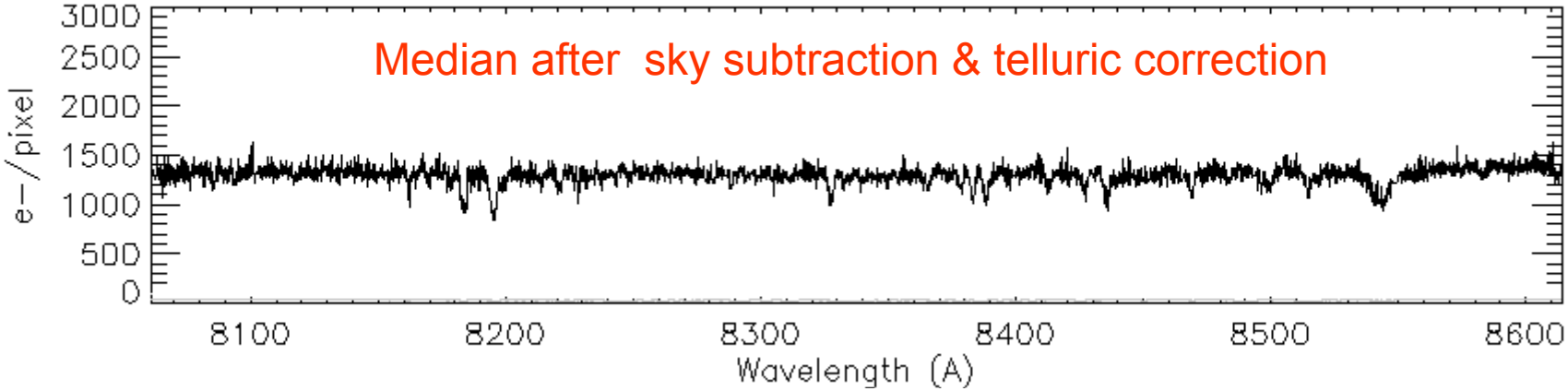
Median sky spectrum



File 5108_66 Target N2516-3-5-453 Optimally extracted spectrum



Target N2516-3-5-453 SNR 43 RV 1.7±1.0 km/s vsini 49.4±1.1 km/s



Telluric compensation

