AGA0414

High resolution spectroscopy: echelle

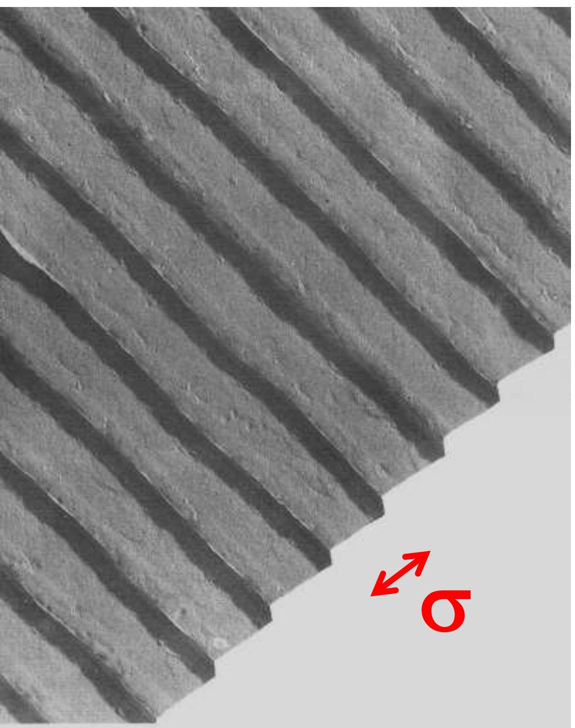
- Echelle spectrographs
- *Applications*

Prof. Jorge Meléndez

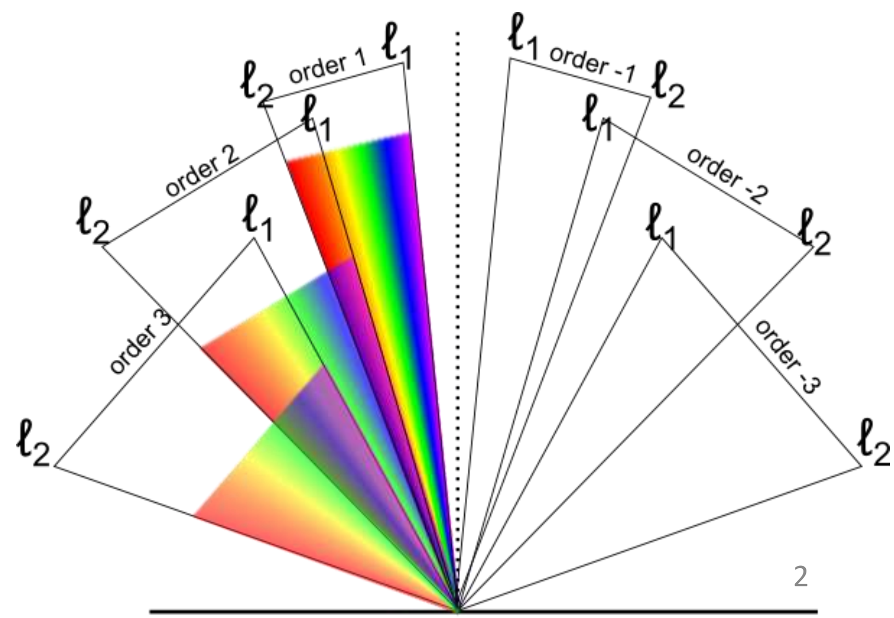
Para obter alta resolução espectral (alta dispersão) com uma rede :

$$R = \frac{\lambda}{\delta\lambda_0} = \frac{\lambda}{r_{an}} \frac{m}{\sigma \cos\theta} \frac{f_{COL}}{w_s}$$

1. Usar uma rede de maior resolução ou maior f_{COL}
2. Trabalhar em altas ordens m → echelle



This microscopic picture shows the rulings on a plane reflection grating having 1180 lines/mm. (Courtesy of Jarrell-Ash.)



High resolution 1: redes de difração with many lines/mm + increase f_{COL}

$$R = \frac{\lambda}{\delta\lambda_0} = \frac{\lambda}{r_{\mathrm{an}}} \frac{m}{\sigma \cos\theta} \frac{f_{\mathrm{COL}}}{w_{\mathrm{S}}}$$

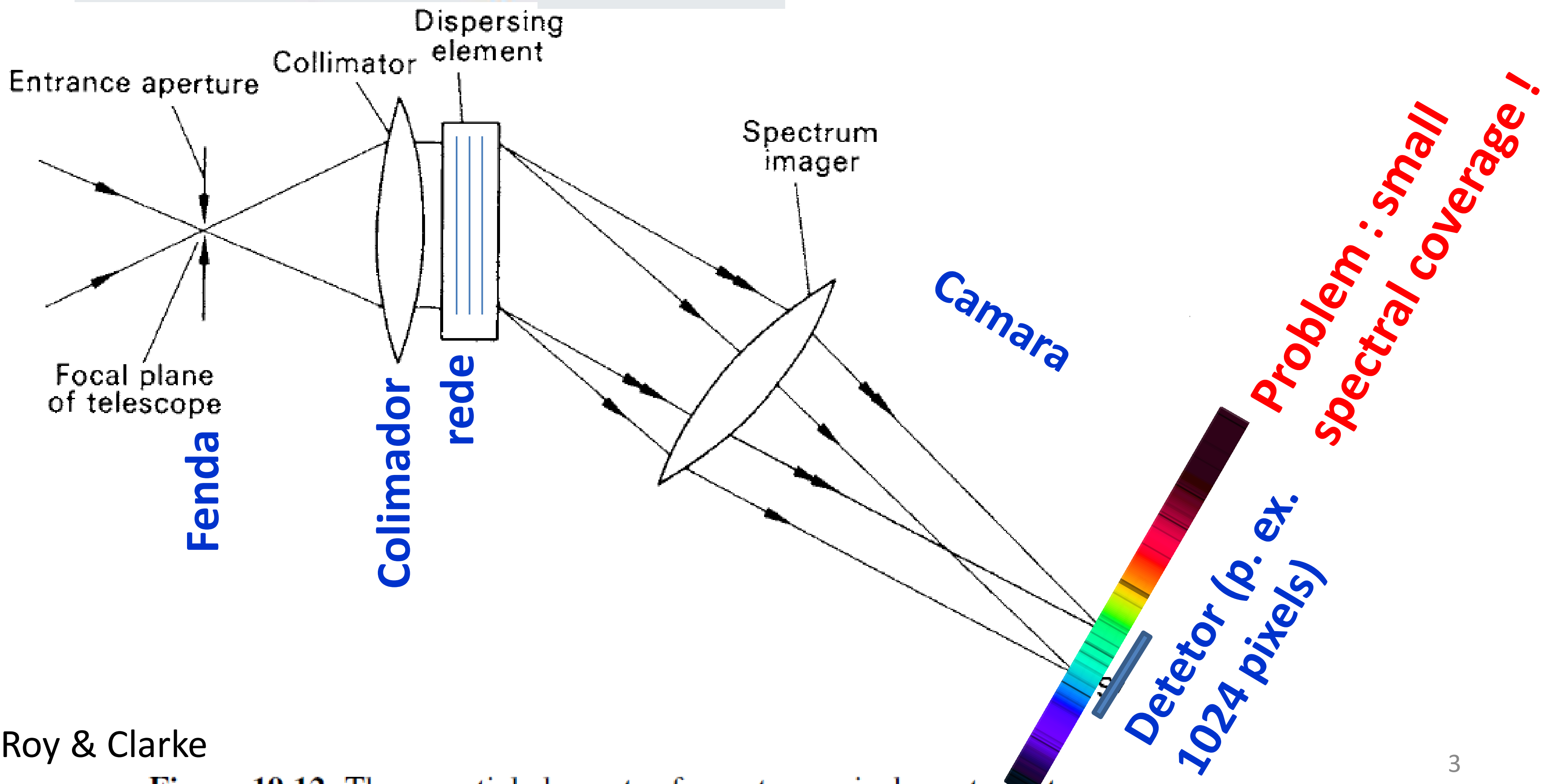


Figure 19.12. The essential elements of an astronomical spectrometer.

High resolution 1: redes de difração com muitas linhas/mm

Exemplo: espectrógrafo Coudé OPD (LNA)

$$R = \frac{\lambda}{\delta\lambda_0} = \frac{\lambda}{r_{\mathrm{an}}} \frac{m}{\sigma \cos\theta} \frac{f_{\mathrm{COL}}}{w_{\mathrm{S}}}$$

	Rede 1/mm – λ_c(nm)	CCD	Cobertura (nm)	Å	Dispersão (nm/pixel)	Resolução (FWHM, Å)	R (600nm)
1ª. ORDEM DIRETA	0600 - 650	098	113,0	1130	0,025	0,50	12 000
	1800 - 650	098	35,3	353	0,008	0,20	30 000
1ª. ORDEM INVERSA	0600 - 650	098	99,7	997	0,022	0,22	27 000
	1800 - 650	098	22,1	221	0,005	0,12	50 000
2ª. ORDEM DIRETA	0600 - 650	098	56,3	563	0,012	0,24	25 000
4ª. ORDEM INVERSA	0600 - 650	098	9,1	91	0,002	0,06	120 000

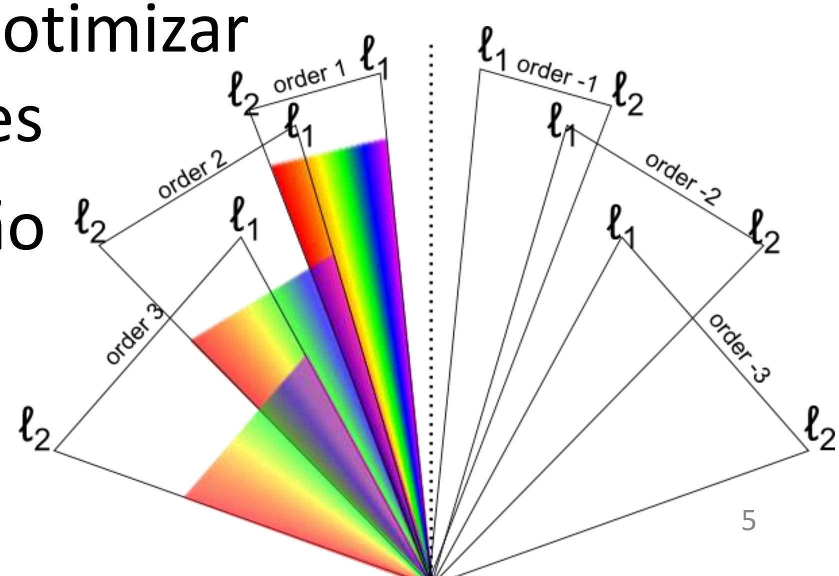
Comparação : Echelle HIRES cobertura 4000Å ou 40 X maior

High resolution 2: espectrógrafo tipo echelle

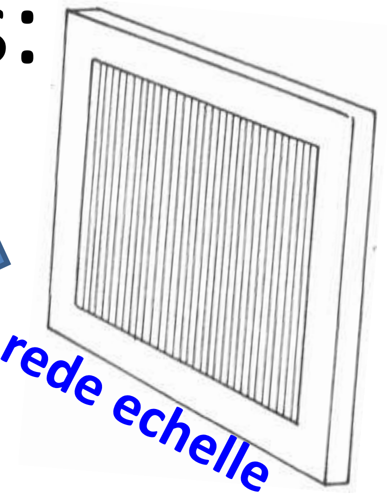
$$\frac{d\theta}{d\lambda} = \frac{m}{\sigma \cos \theta}$$

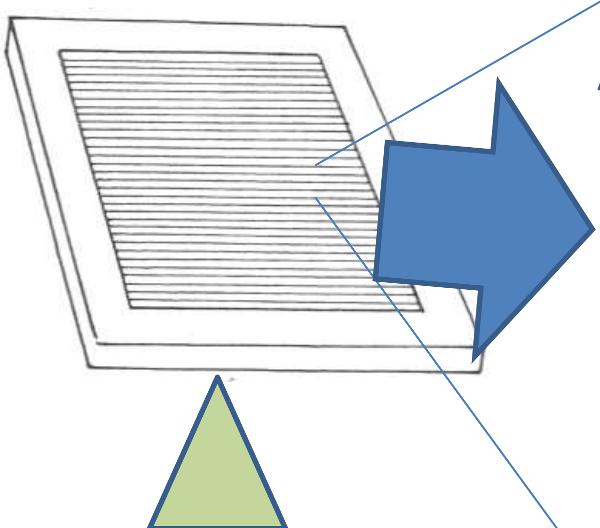
Figure 4.1.7. Enlarged view of an echelle grating.

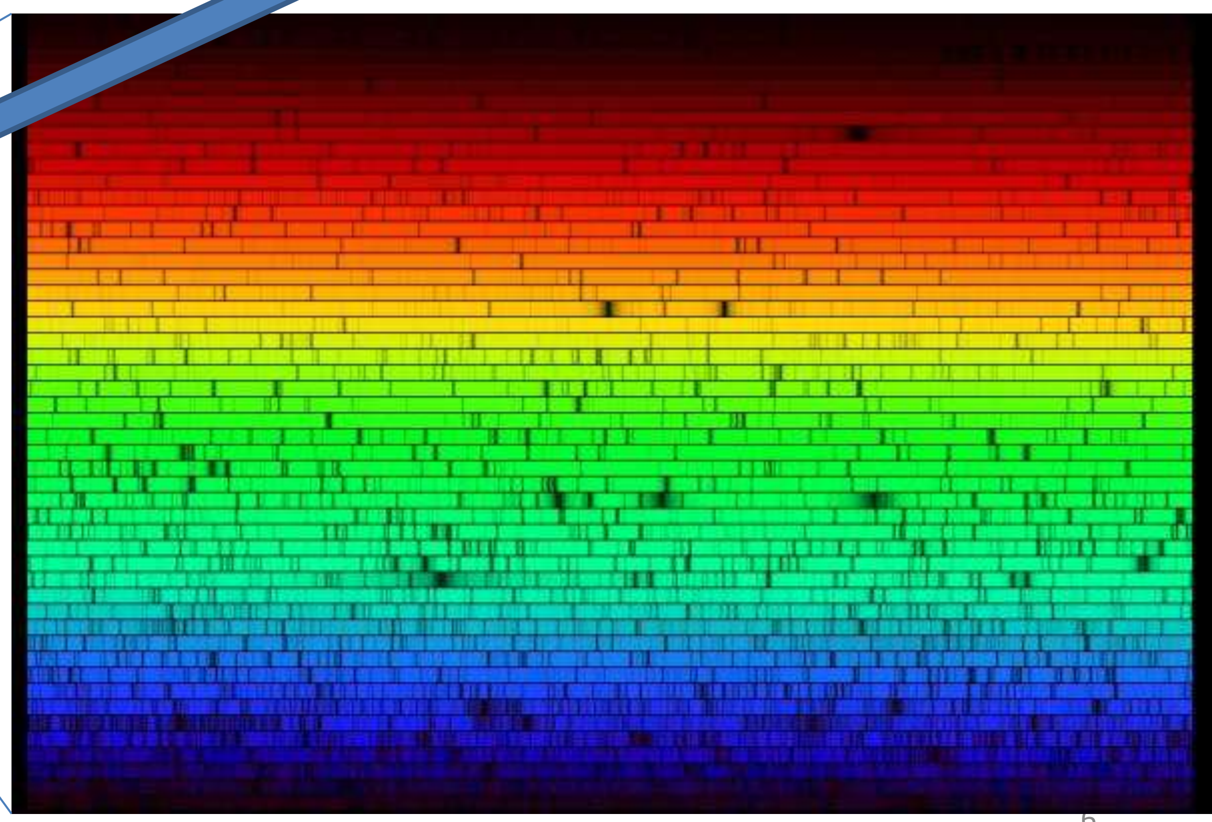
- Blazing angle is increased para otimizar a observação de ordens maiores (m ~ 30-150) → maior resolução
- Typical grating 31 lines/mm
- Problem : order overlapping?



Solução para mistura de ordens: **cross disperser** (pode ser um prisma ou uma rede)

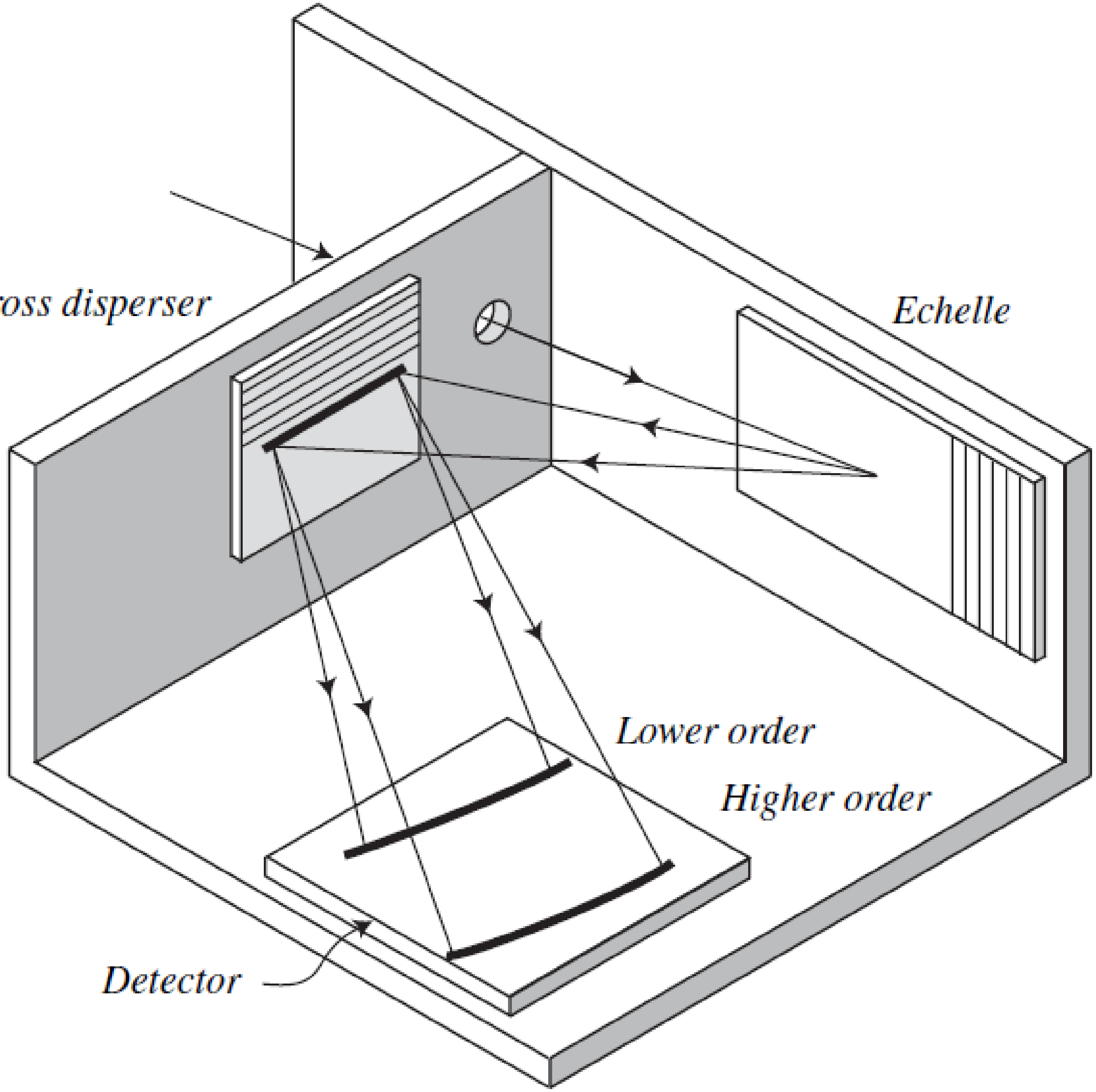






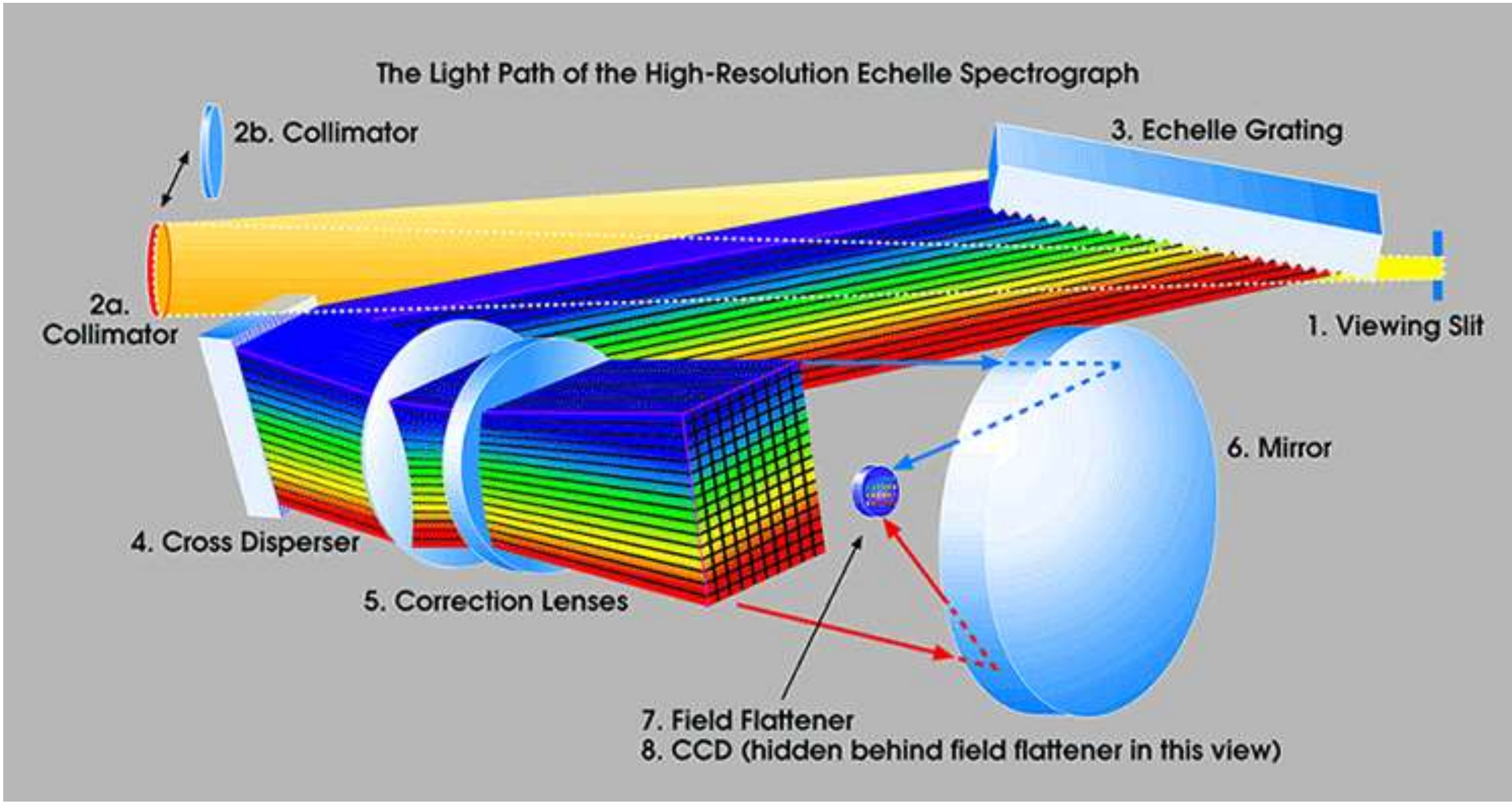
Echelle spectrographs

Cross disperser could be a grating or a prism. Serve para separar as ordens muito altas

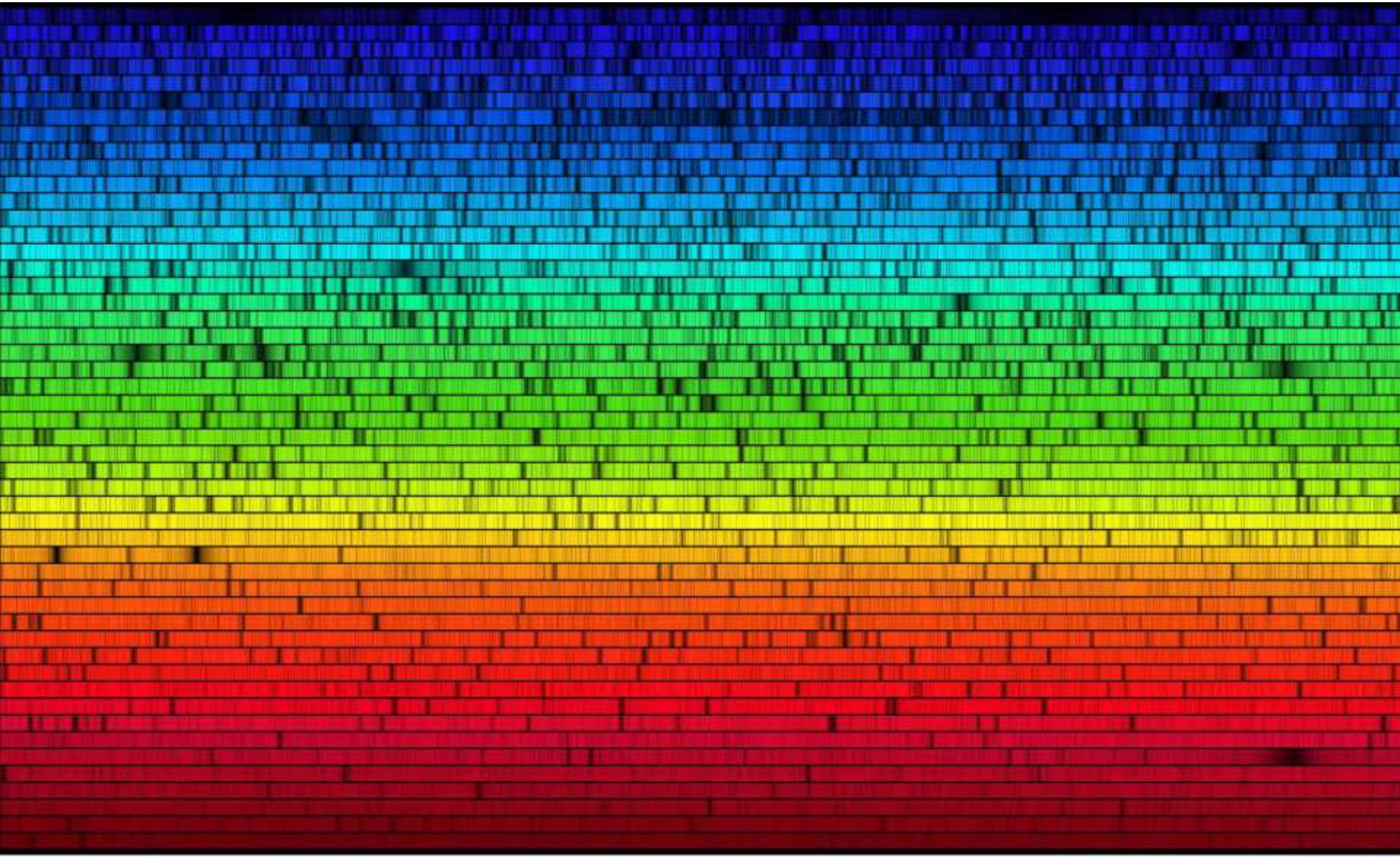


Exemplo : HIRES spectrograph no KECK

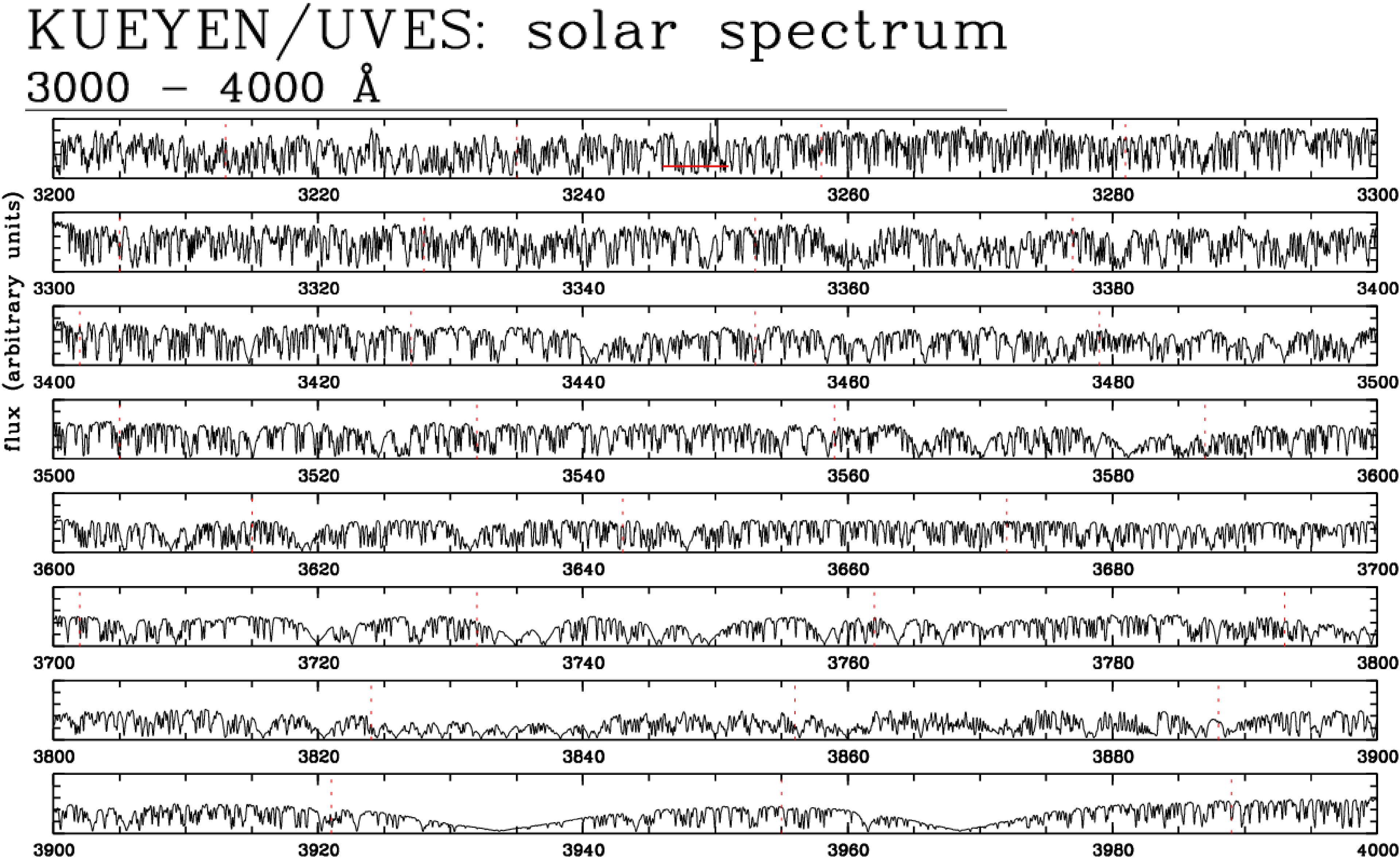
Cross disperser could be a grating or a prism. Serve para separar ordens muito altas.



Echelle orders



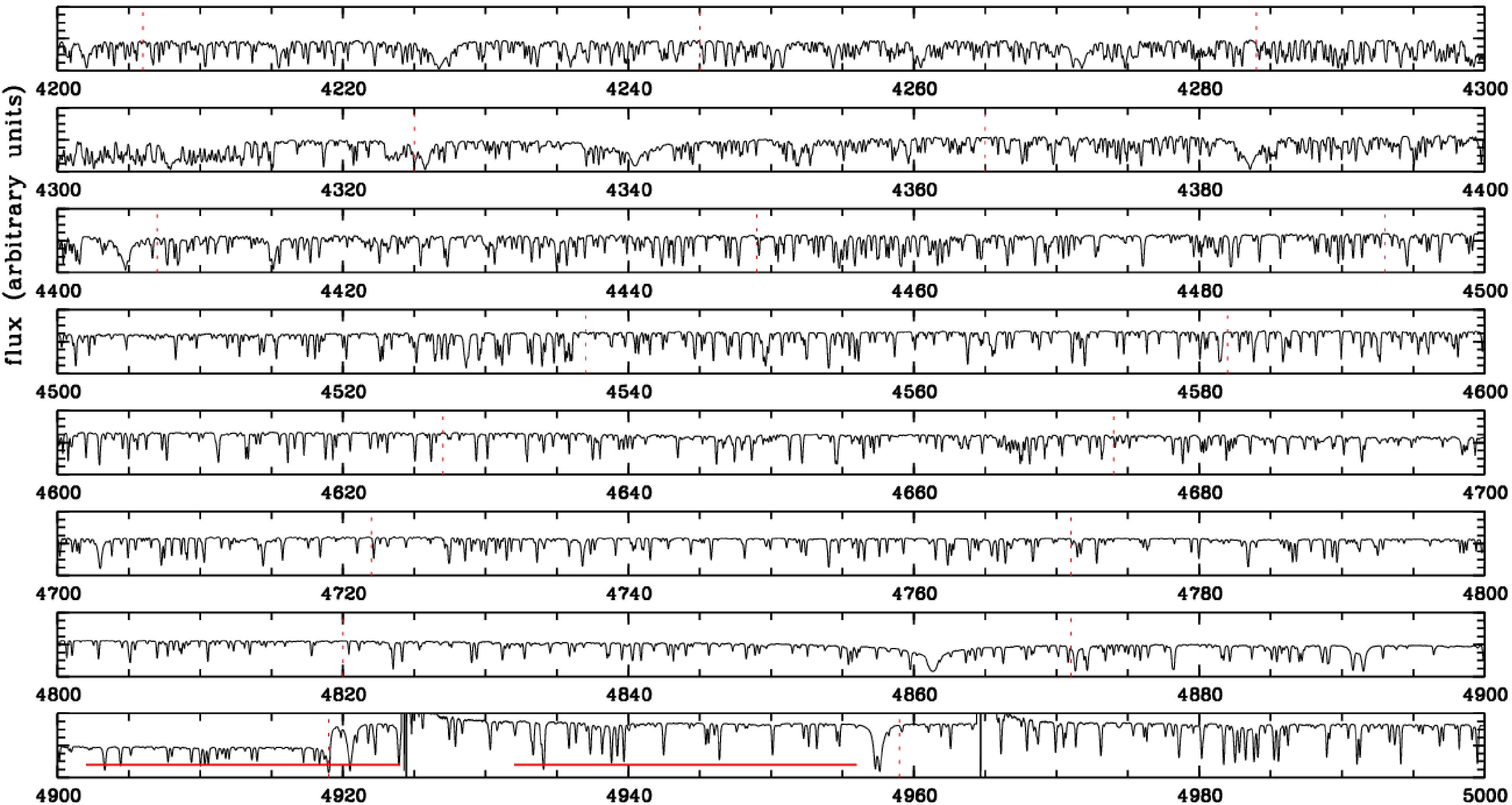
Echelle orders : extracted



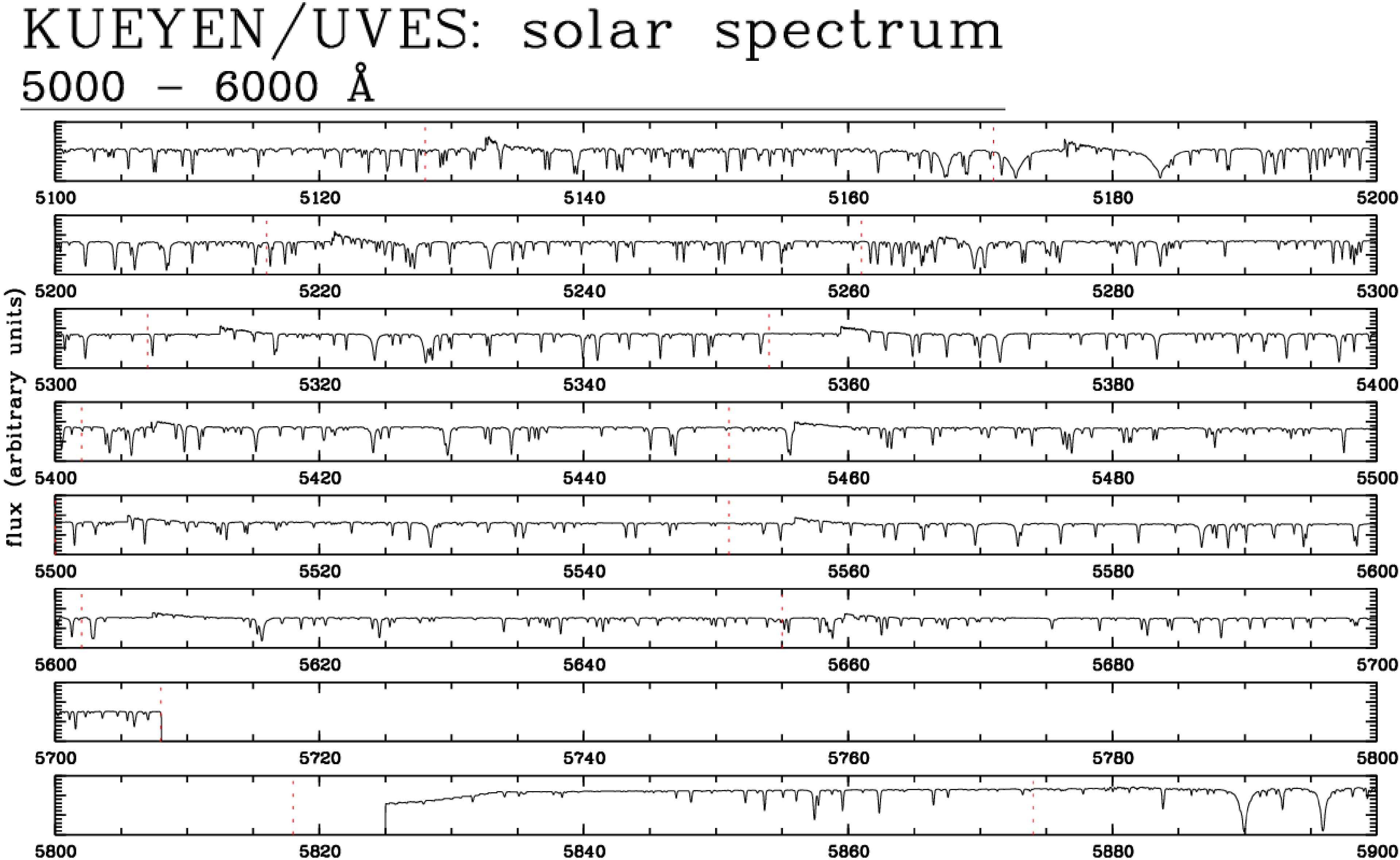
Echelle orders : extracted

KUEYEN/UVES: solar spectrum

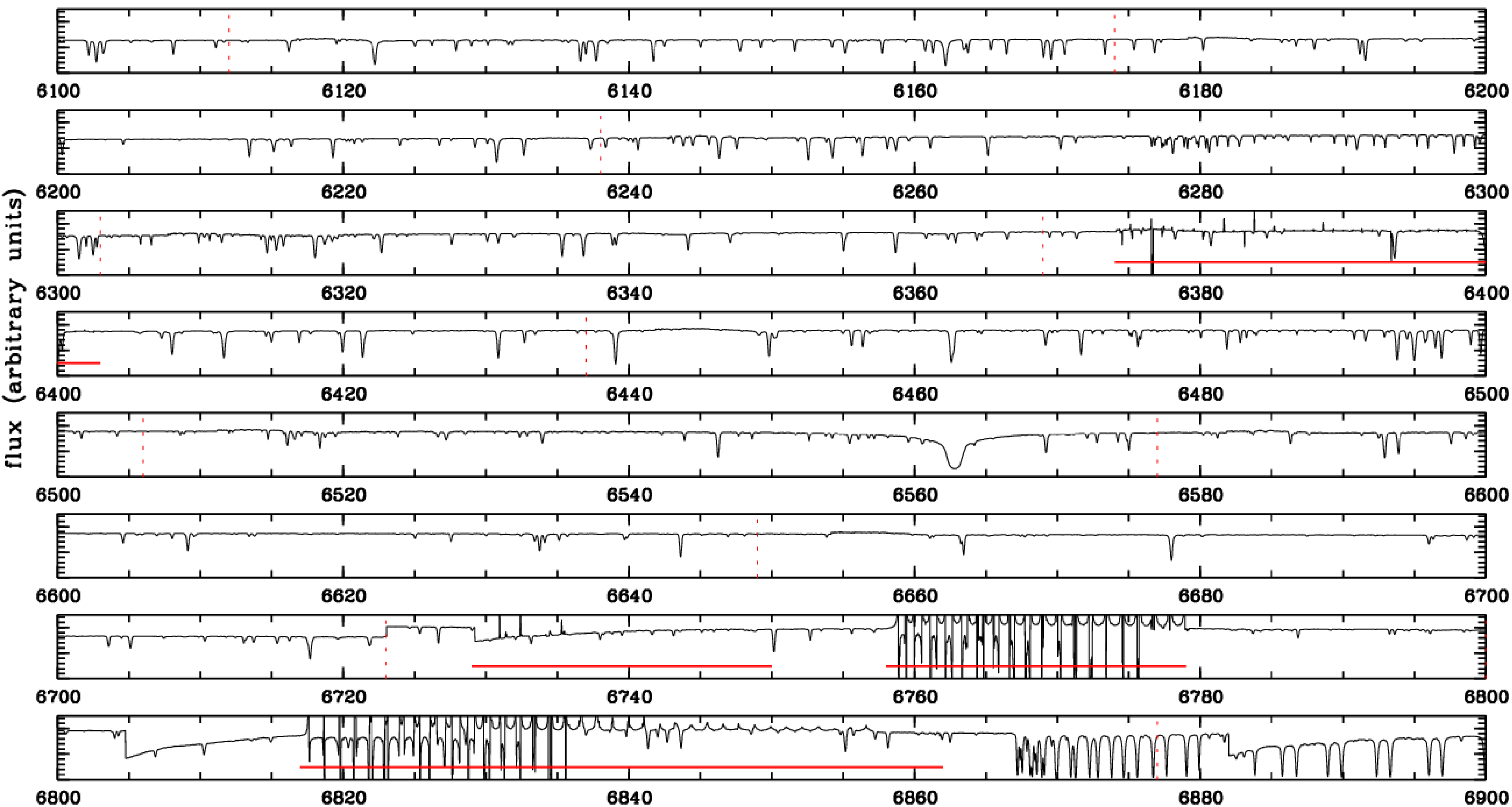
4000 – 5000 Å



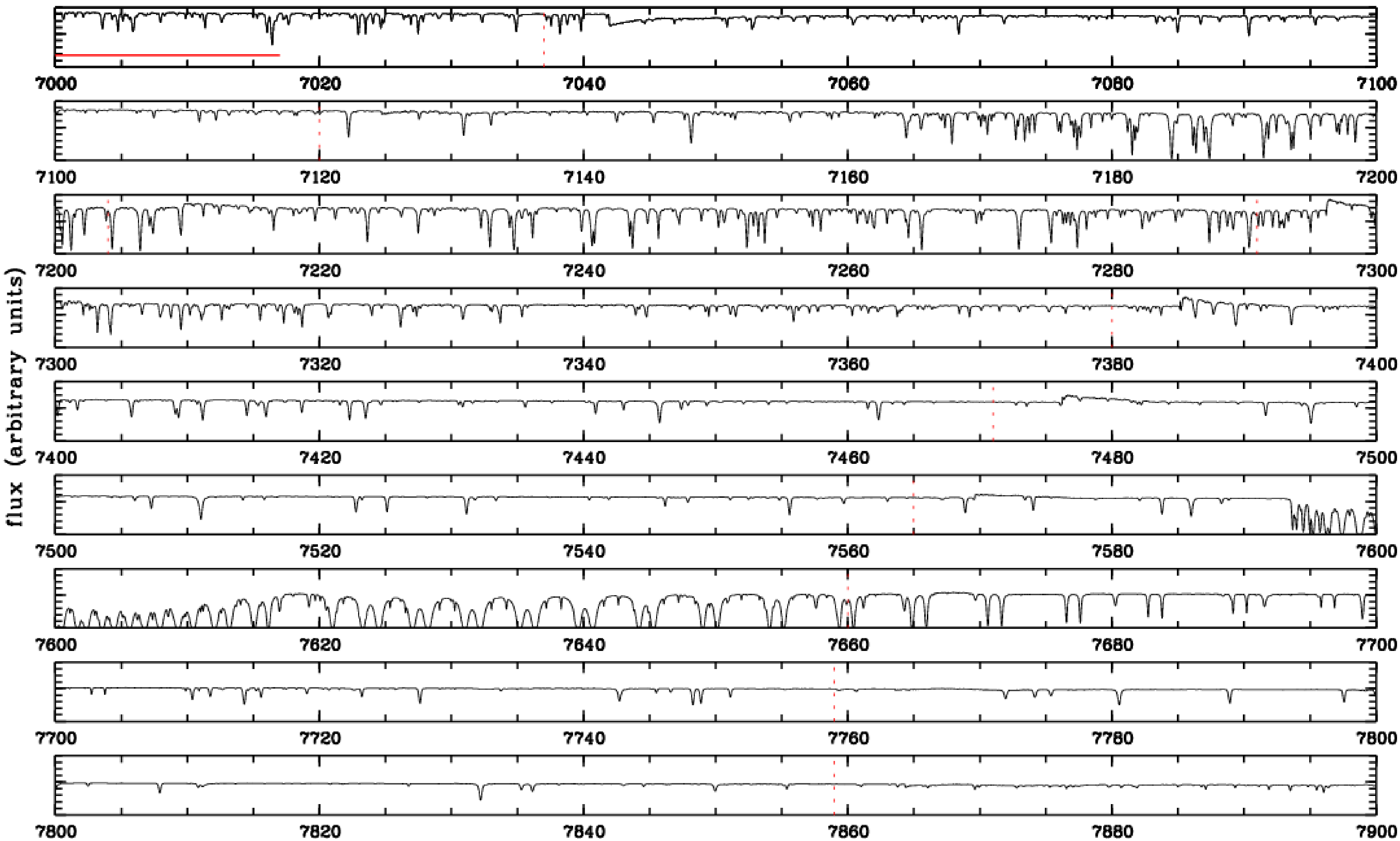
Echelle orders : extracted



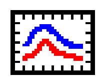
KUEYEN/UVES: solar spectrum
6000 – 7000 Å



KUEYEN/UVES: solar spectrum
7000 – 8000 Å



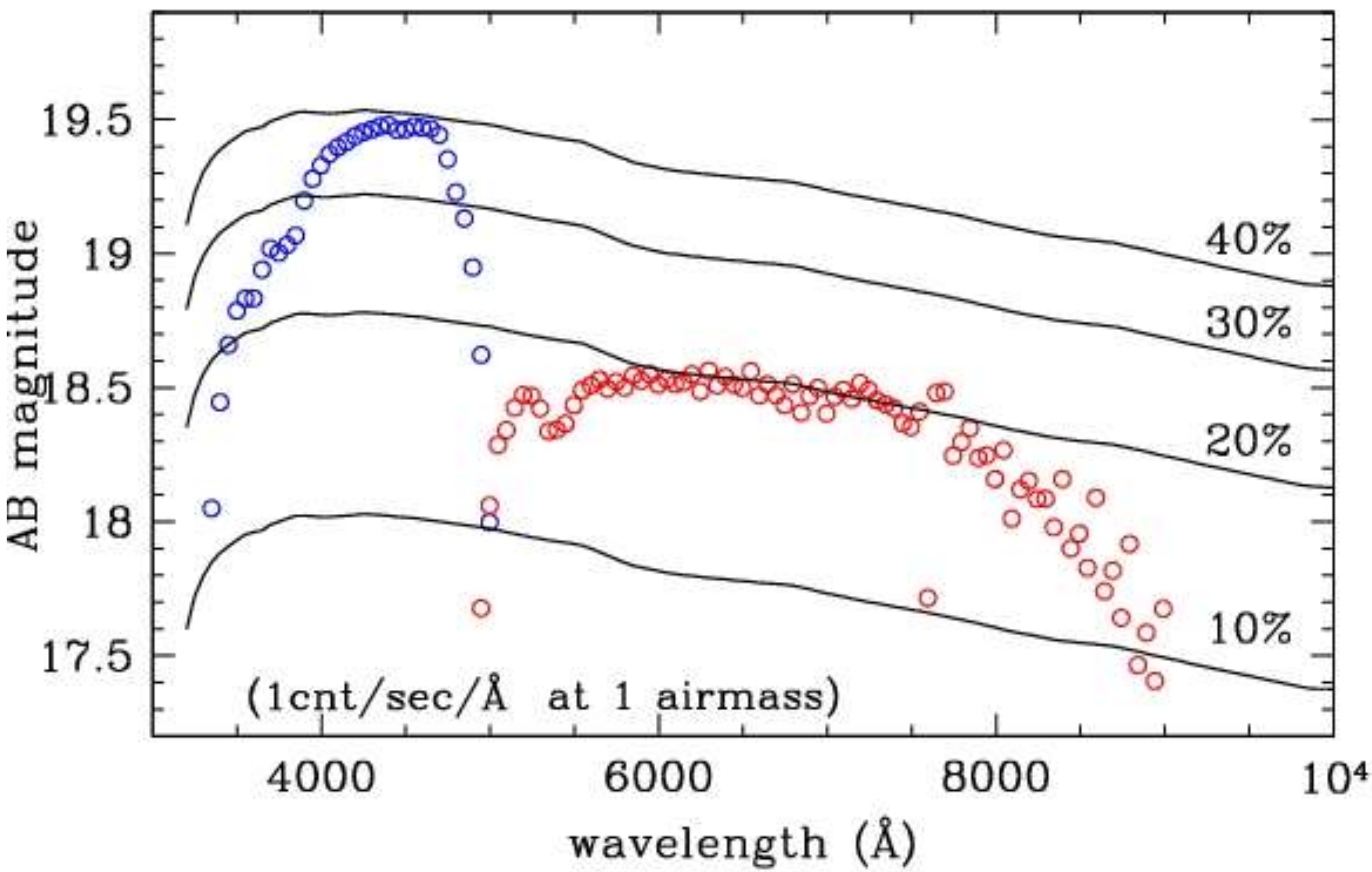
Mike Spectrograph at 6,5m Magellan (Las Campanas)

	Blue Side	Red Side
effective focal ratio	f/3.9	f/3.6
scale at CCD	8.2 pix/" (0.12"/pix)	7.5 pix/sec (0.13"/pix)
Å/pixel (unbinned)	~0.02	~0.05
detector	2048x4096 (15µm pix)	2048x4096 (15µm pix)
gain	~0.47 e-/DN	~1.0 e-/DN
Readnoise	~2 e-/pix	~3.5e-/pix
Dark current	~5 DN/pix/hr	~2 DN/pix/hr
CCD efficiency		Q.E.
Wavelength range*	3200 – 5000 Å	4900 – 10000Å
Resolution (0.35"slit)	83,000	65,000
Resolution (1.0" slit)	28,000	22,000

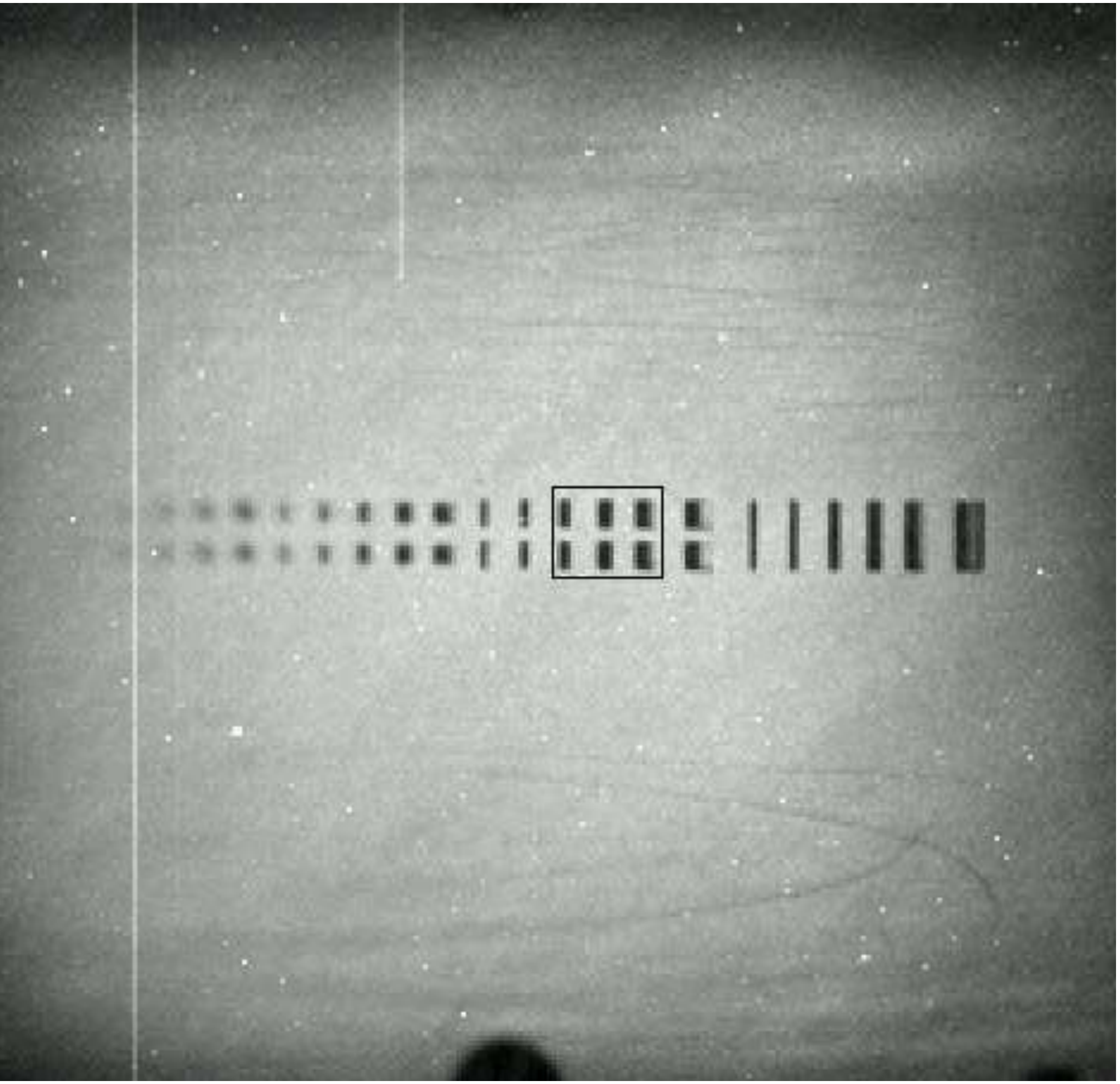
The tangent of the blazing angle = R#. Thus blazing angle for the R4 grating is 76 ^{o}

Echelle grating	R2.4	R2
Prism (cross-disperser)	Fused Silica (2 prisms)	PBM2 (1 prism)

Espectrógrafo MIKE tem 2 braços



Slits available at MIKE

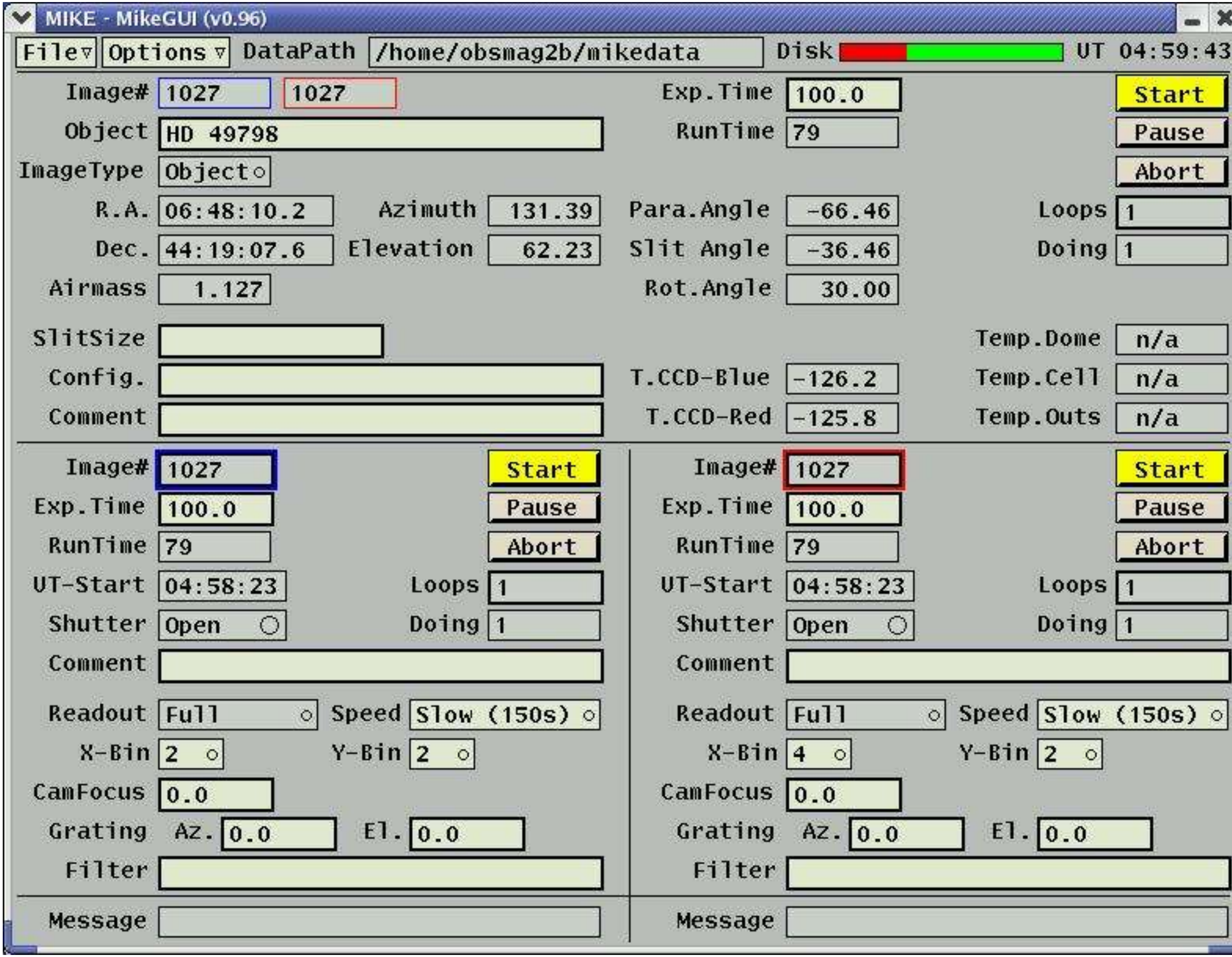


Aperture Pairs (separation 3"):

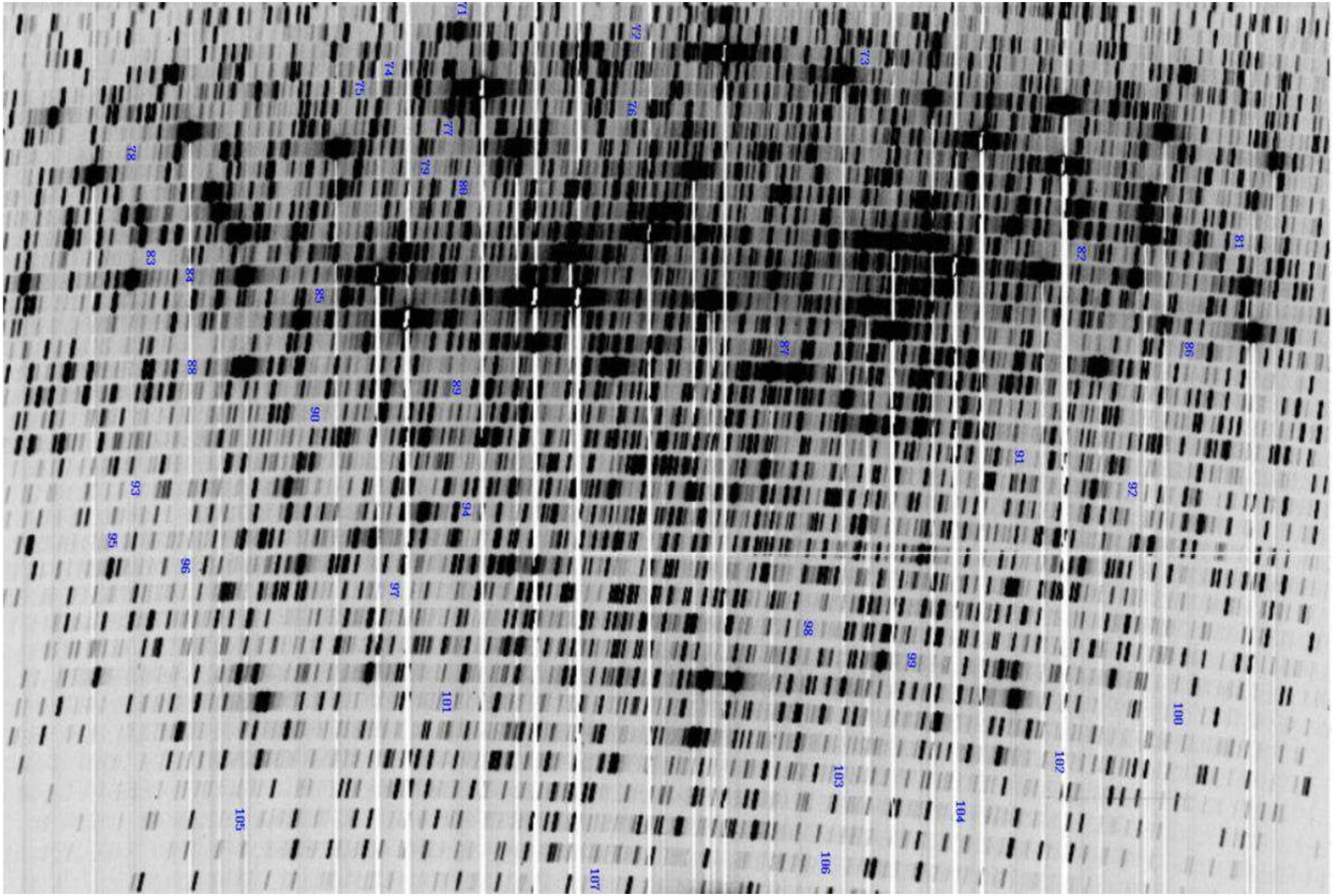
1 0.35 x 0.35 (for focusing)
2 1.00 x 0.35
3 1.00 x 0.50
4 1.00 x 0.70
5 1.00 x 1.00
6 1.50 x 0.35
7 1.50 x 0.50
8 1.50 x 0.70
9 1.50 x 1.00
10 1.50 x 1.50
11 2.00 x 0.35
12 2.00 x 0.50
13 2.00 x 0.70
14 2.00 x 1.00
15 2.00 x 1.50
16 2.00 x 2.00

Single Slits:

17 0.35 x 5.00
18 0.50 x 5.00
19 0.70 x 5.00
20 1.00 x 5.00
21 1.50 x 5.00
22 2.00 x 5.00


MIKE - MikeGUI (v0.96)
File
Options
DataPath
/home/obsmag2b/mikedata
Disk
UT 04:59:43
Image# 1027 1027
Exp.Time 100.0
Start
Object HD 49798
RunTime 79
Pause
ImageType Object
Abort
R.A. 06:48:10.2
Azimuth 131.39
Para.Angle -66.46
Loops 1
Dec. 44:19:07.6
Elevation 62.23
Slit Angle -36.46
Doing 1
Airmass 1.127
Rot.Angle 30.00
SlitSize
Temp.Dome n/a
Config.
T.CCD-Blue -126.2
Temp.Cell n/a
Comment
T.CCD-Red -125.8
Temp.Outs n/a
Image# 1027
Start
Exp.Time 100.0
Pause
RunTime 79
Abort
UT-Start 04:58:23
Loops 1
Shutter Open
Doing 1
Comment
Readout Full
Speed Slow (150s)
X-Bin 2
Y-Bin 2
CamFocus 0.0
Grating Az. 0.0 El. 0.0
Filter
Message
Image# 1027
Start
Exp.Time 100.0
Pause
RunTime 79
Abort
UT-Start 04:58:23
Loops 1
Shutter Open
Doing 1
Comment
Readout Full
Speed Slow (150s)
X-Bin 4
Y-Bin 2
CamFocus 0.0
Grating Az. 0.0 El. 0.0
Filter
Message

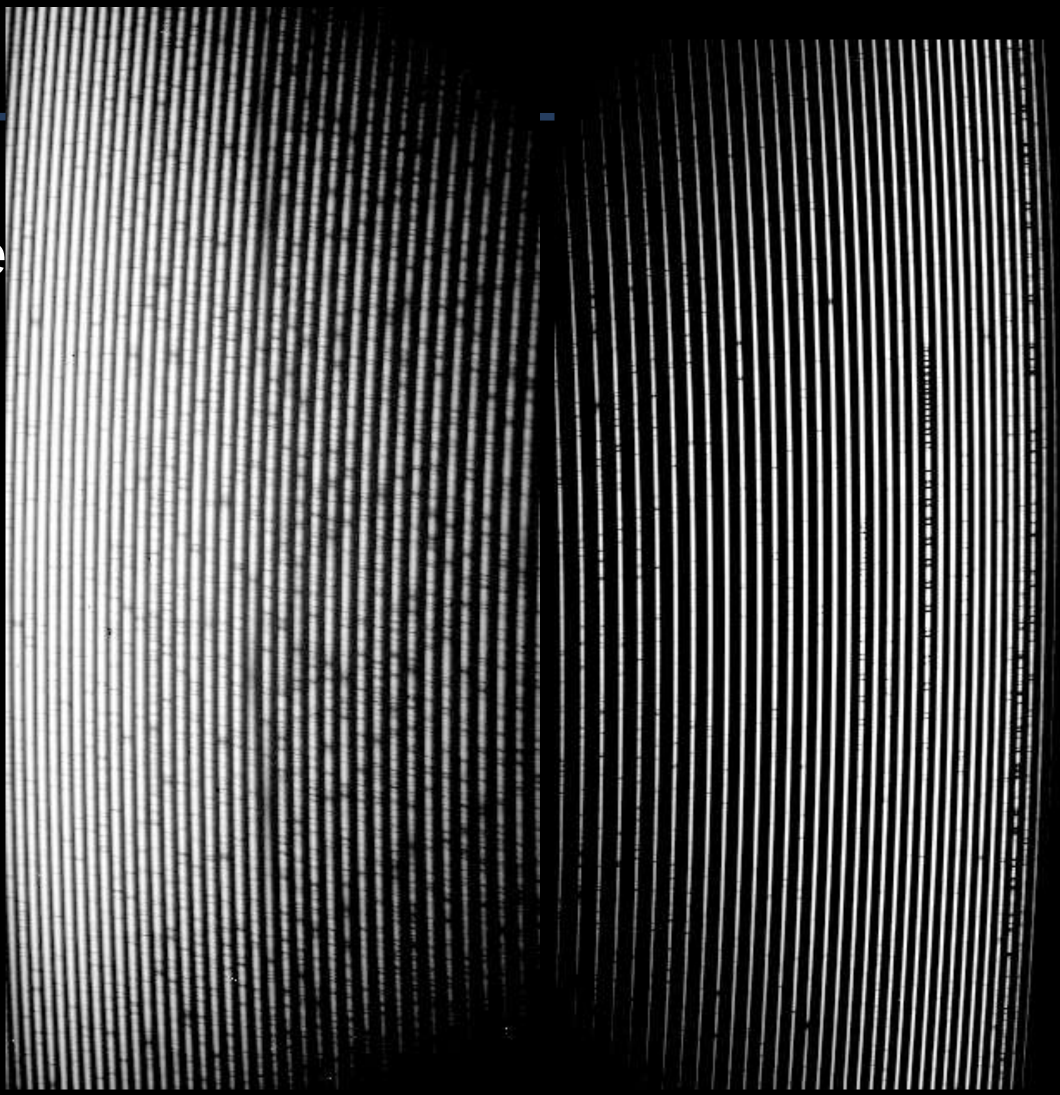
MIKE Blue ThAr calibration arc



Magellan ultra high precision study of solar twins

Magellan 6,5m Clay Telescope
& MIKE spectrometer
R = 65 000
S/N = 450 per pixel
coverage 335 – 1000 nm
- Solar spectrum: Vesta
- 3 nights of observations

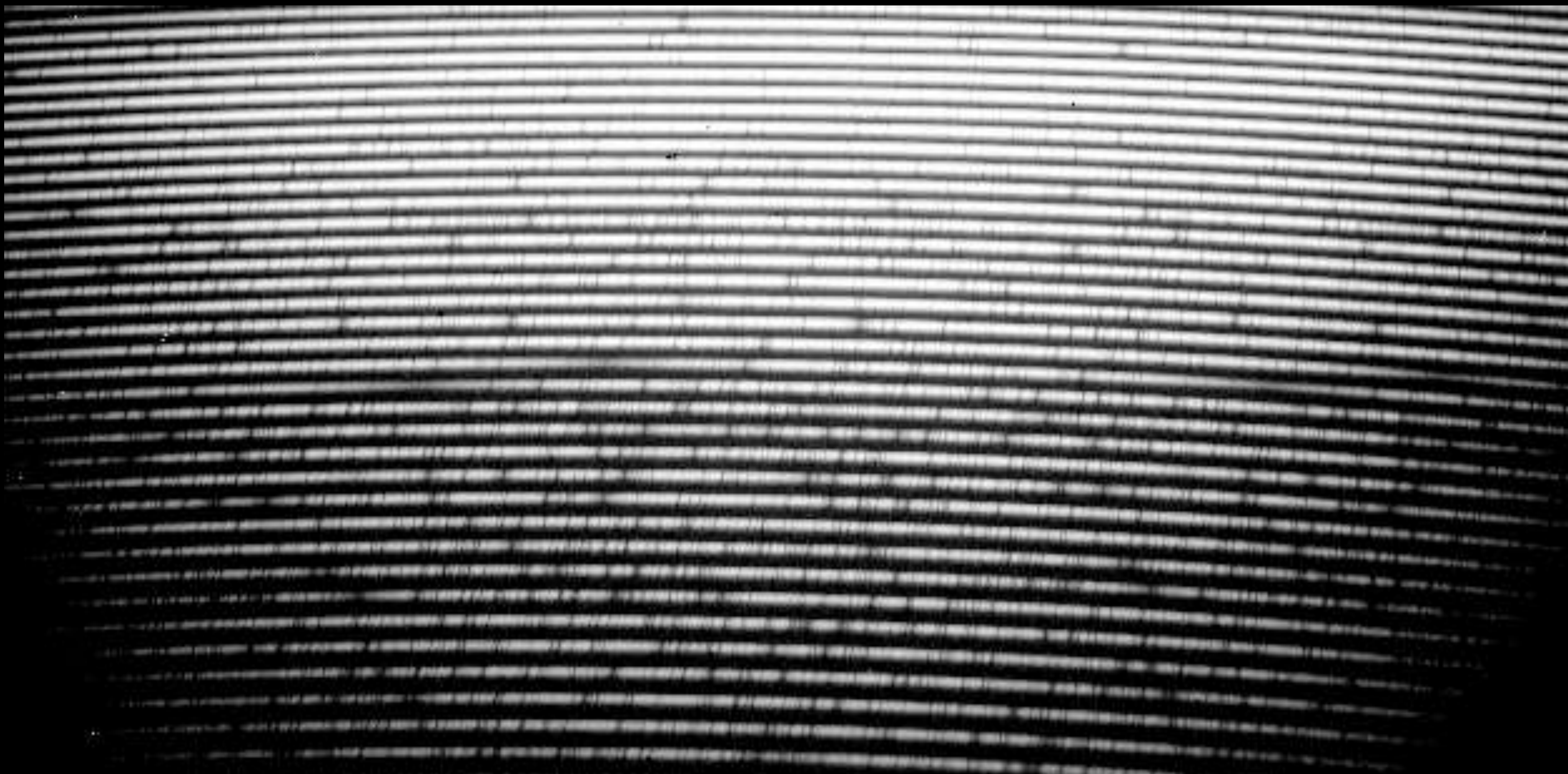
Observations of the solar twin 18 Sco



BLUE frame **RED frame**

Magellan ultra high precision study of solar twins

Observations of the solar twin 18 Sco



BLUE frame

Magellan ultra high precision study of solar twins

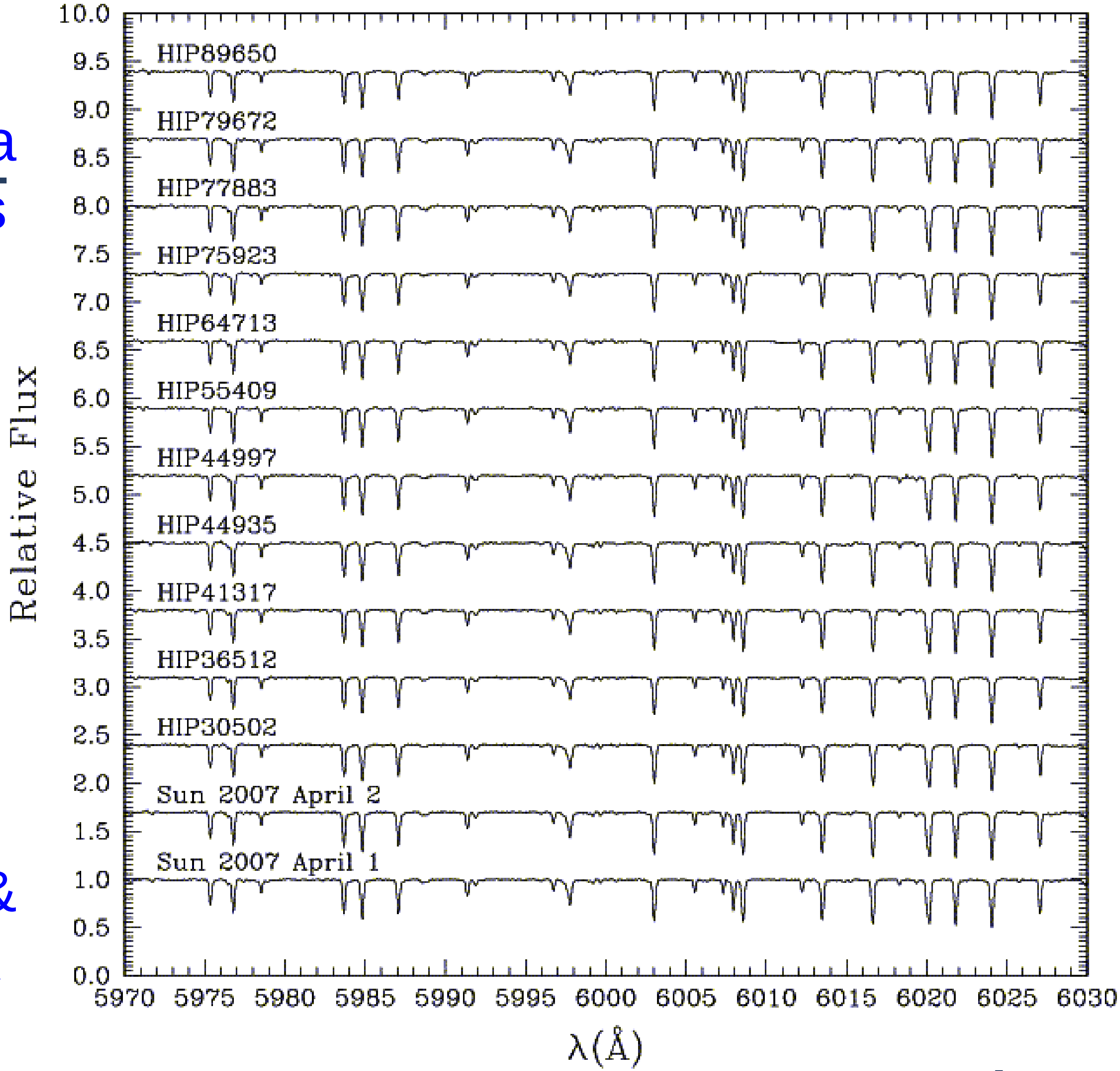
Observations of the solar twin 18 Sco

RED frame

Example of MIKE spectra

of solar twins

(total spectral coverage 3350 A -1μm)



Small part (597-603nm) of solar twin & Sun's spectra

Meléndez et al. 2009

Planning observations with echelle spectrographs

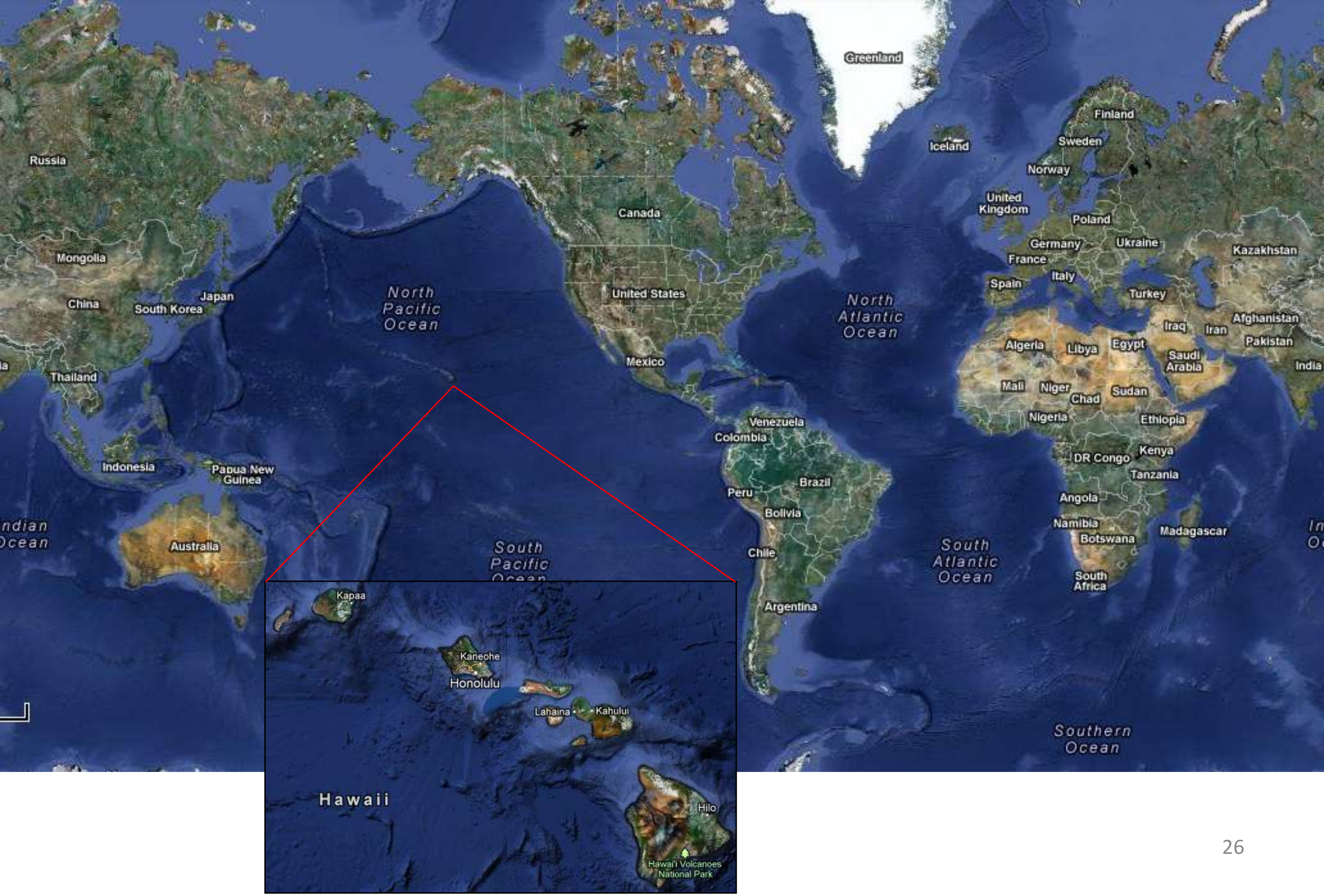
1. Spectral coverage : quais as linhas importantes a detetar ? 1 braço ou 2 braços ?

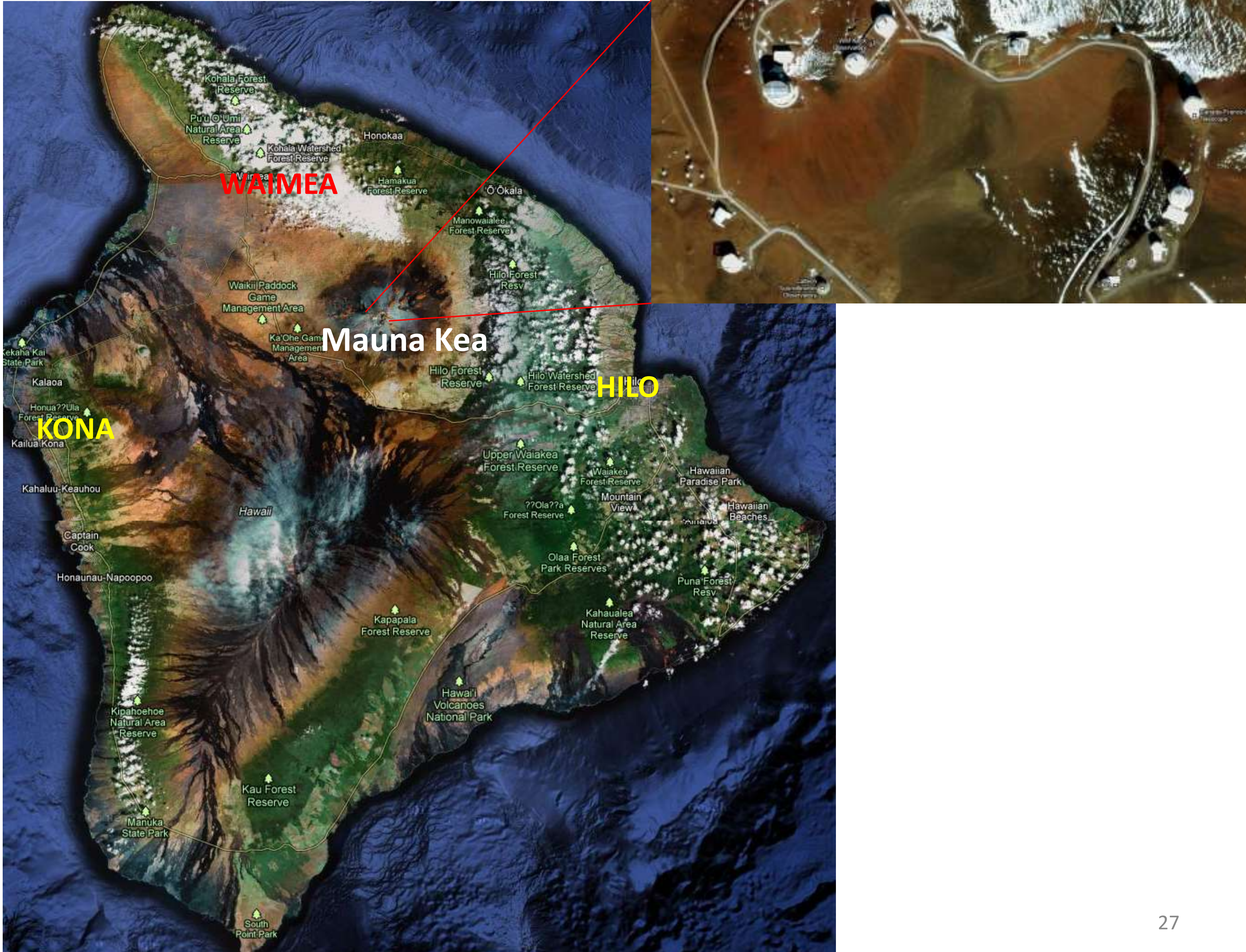
2. Resolving power : suficiente para resolver as linhas de interesse ? Se houver mais de 1 braço, verificar se o R é adequado em ambos

3. S/N : telescópio + instrumento são adequados?

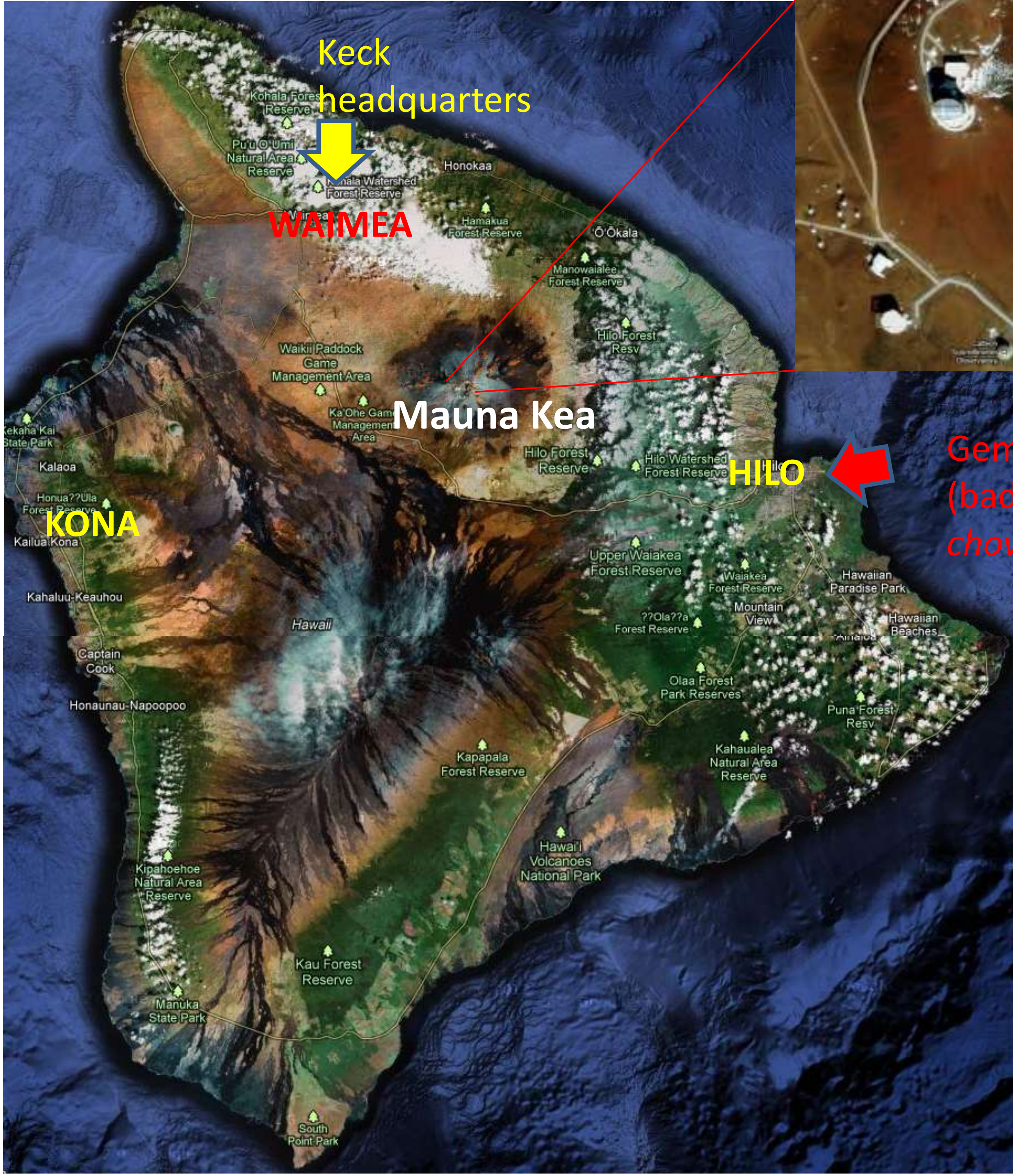
High resolution spectroscopy of solar twins with the Keck telescope.

Observation, undergrad research experience, publication, science popularization, and having a good time in Hawaii …

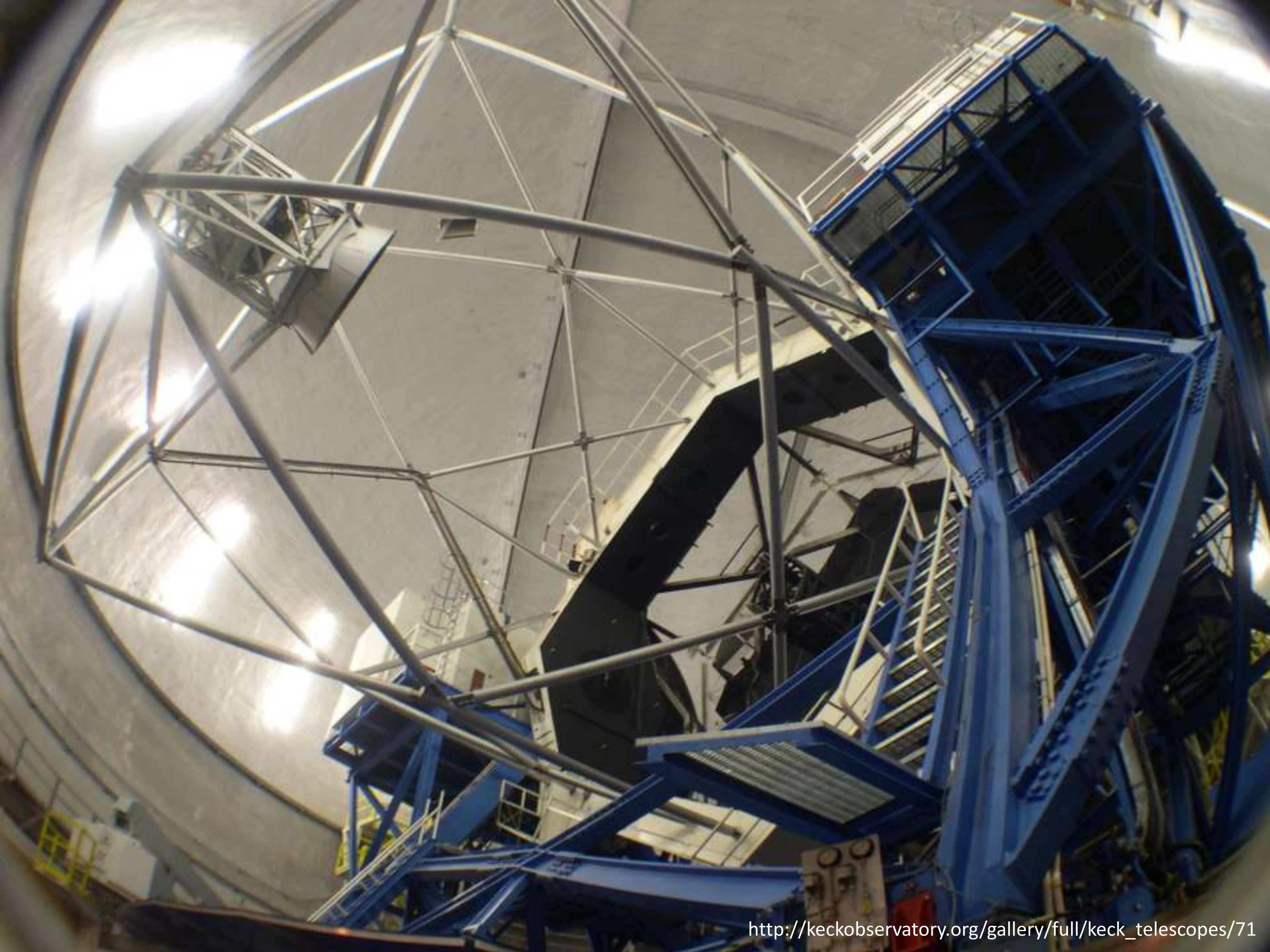

Greenland
Iceland
Finland
Sweden
Norway
Russia
United Kingdom
Poland
Canada
Germany
Ukraine
Kazakhstan
France
Mongolia
Italy
Spain
Turkey
Japan
China
South Korea
North Pacific Ocean
United States
North Atlantic Ocean
Iraq
Iran
Afghanistan
Algeria
Libya
Egypt
Pakistan
Saudi Arabia
Mexico
India
Thailand
Mali
Niger
Chad
Sudan
Nigeria
Ethiopia
Venezuela
Colombia
Indonesia
Papua New Guinea
DR Congo
Kenya
Tanzania
Brazil
Peru
Angola
Bolivia
Namibia
Madagascar
Indian Ocean
Botswana
Australia
Chile
South Pacific Ocean
South Atlantic Ocean
South Africa
Argentina
Southern Ocean
Kapaa
Kaneohe
Honolulu
Lahaina
Kahului
Hawaii
Hilo
Hawai'i Volcanoes National Park


WAIMEA
Mauna Kea
HILO
KONA
Kohala Forest Reserve
Pu'u O'Umi Natural Area Reserve
Kohala Watershed Forest Reserve
Honokaa
Hamakua Forest Reserve
Ō Ōkala
Manowaialee Forest Reserve
Hilo Forest Resv
Waikii Paddock Game Management Area
Ka'Ohe Game Management Area
Hilo Forest Reserve
Hilo Watershed Forest Reserve
Kekaha Kai State Park
Kalaoa
Honua??Ula Forest Reserve
Kailua Kona
Kahaluu-Keauhou
Hawaii
Upper Waiakea Forest Reserve
Waiakea Forest Reserve
Mountain View
Hawaiian Paradise Park
Hawaiian Beaches
??Ola??a Forest Reserve
Captain Cook
Honaunau-Napoopoo
Olaa Forest Park Reserves
Puna Forest Resv
Kapapala Forest Reserve
Kahaualea Natural Area Reserve
Hawai'i Volcanoes National Park
Kipahoehoe Natural Area Reserve
Kau Forest Reserve
Manuka State Park
South Point Park

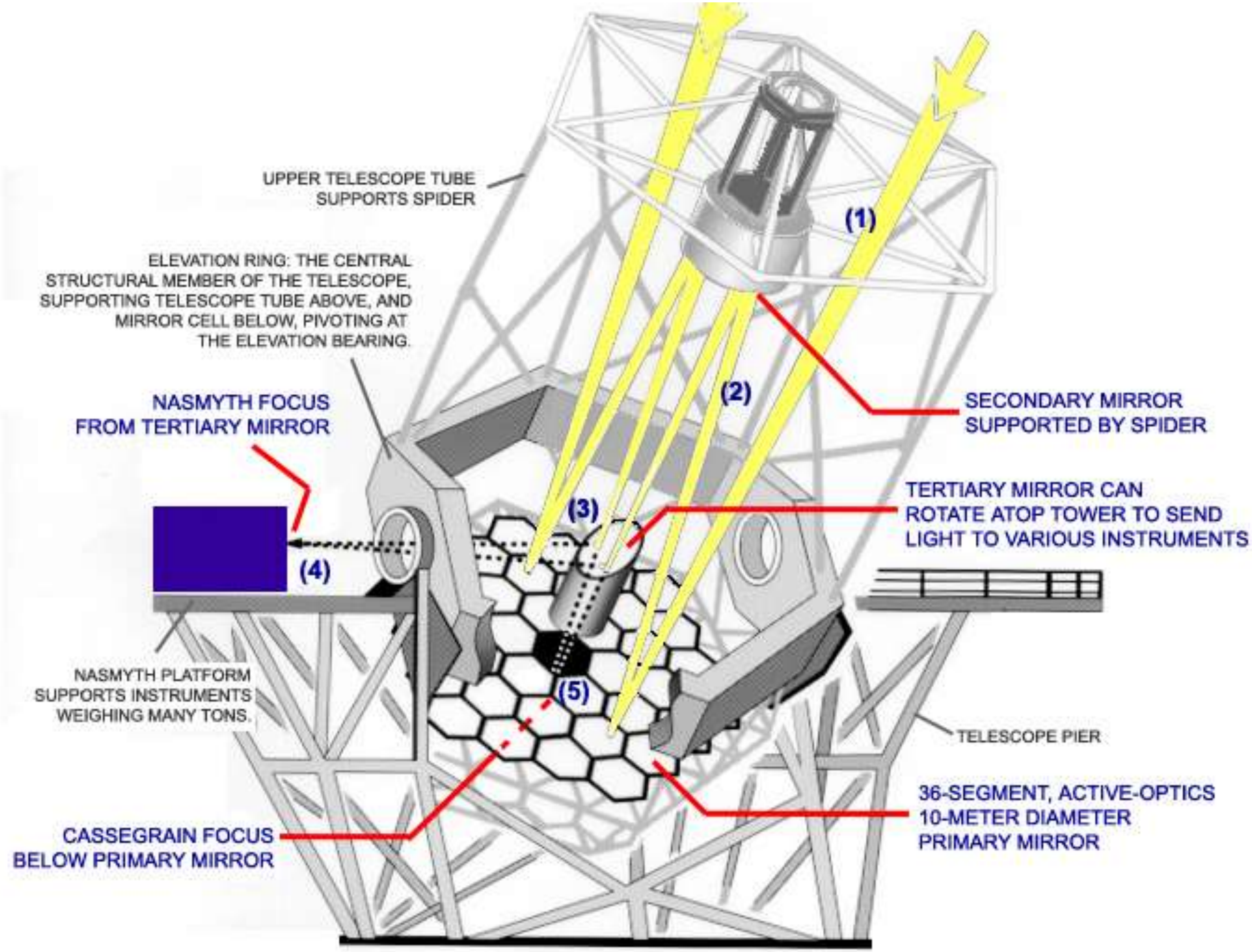

CFHT
Gemini N.
U. Hawaii
2.2m
UKIRT
NASA IRTF
Keck II
Keck I
Subaru



Gemini headquarters (bad side of Hawaii; *chove muito*)


http://keckobservatory.org/gallery/full/keck_telescopes/71

Keck telescope



Jorge (right) & student Damian Fabbian (left)
at the Keck prime focus cage


2006 05 06 20 45


2006 05 08 12 35

Sunset from Waikiki January 2006

HIRES no Keck I

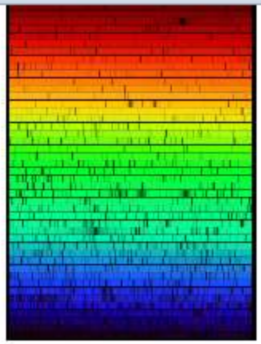
www2.keck.hawaii.edu/inst/hires/

Google

HIRES Contents

- Introduction
- News
- Pre-Observing
- Observing
- Post-Observing
- Technical Pages
- Keck Obs. Archive

- Keck Home Page
- Instruments Home Page



High Resolution Echelle Spectrometer

http://www2.keck.hawaii.edu/inst/hires/

HIRES is a grating cross-dispersed, echelle spectrograph capable of operating between 0.3 and 1.0 microns. Although adjustable slits are available by special request, almost all observers choose from a number of slit plates which provide resolutions between roughly 25,000 and 85,000. These slits are available in a variety of lengths since order separation varies between 6 and 43 arcseconds. HIRES does not currently have multi-slit capability.

Observers can request one of two configurations. HIRESb and HIRESr use different cross-dispersers and collimators, which are optimized for short and long wavelength observations respectively. The efficiency of the two is equal at approximately 4200 Angstroms. Switching between the two is not possible during the night.

Somente 1 braço : escolher HIRESb ou HIRESr

Spectral coverage is complete shortward of 6200 Angstroms. Longward of this, two different echelle settings are necessary to achieve complete coverage. Aside from the possible gaps in coverage at long wavelengths, the spectral span per exposure ranges from about 3000 Angstroms for short wavelength settings, to about 4500 Angstroms at long wavelength settings.

Since HIRES is mounted at a nasymth platform, fields will rotate during an exposure. If desired though, an image rotator can be introduced into the light path which will maintain the slit orientation at a particular PA or at the parallactic angle. This rotator is always available and can be moved into or out of the beam remotely. Other devices which observers can select at will are an exposure meter for accurate control of signal levels and an iodine cell for precise radial velocity work.

HIRES PRE-OBSERVING

Aloha awakea
(Good Midday!)
Today is Tuesday,
May 29, 2012.

Preparing Your Proposal

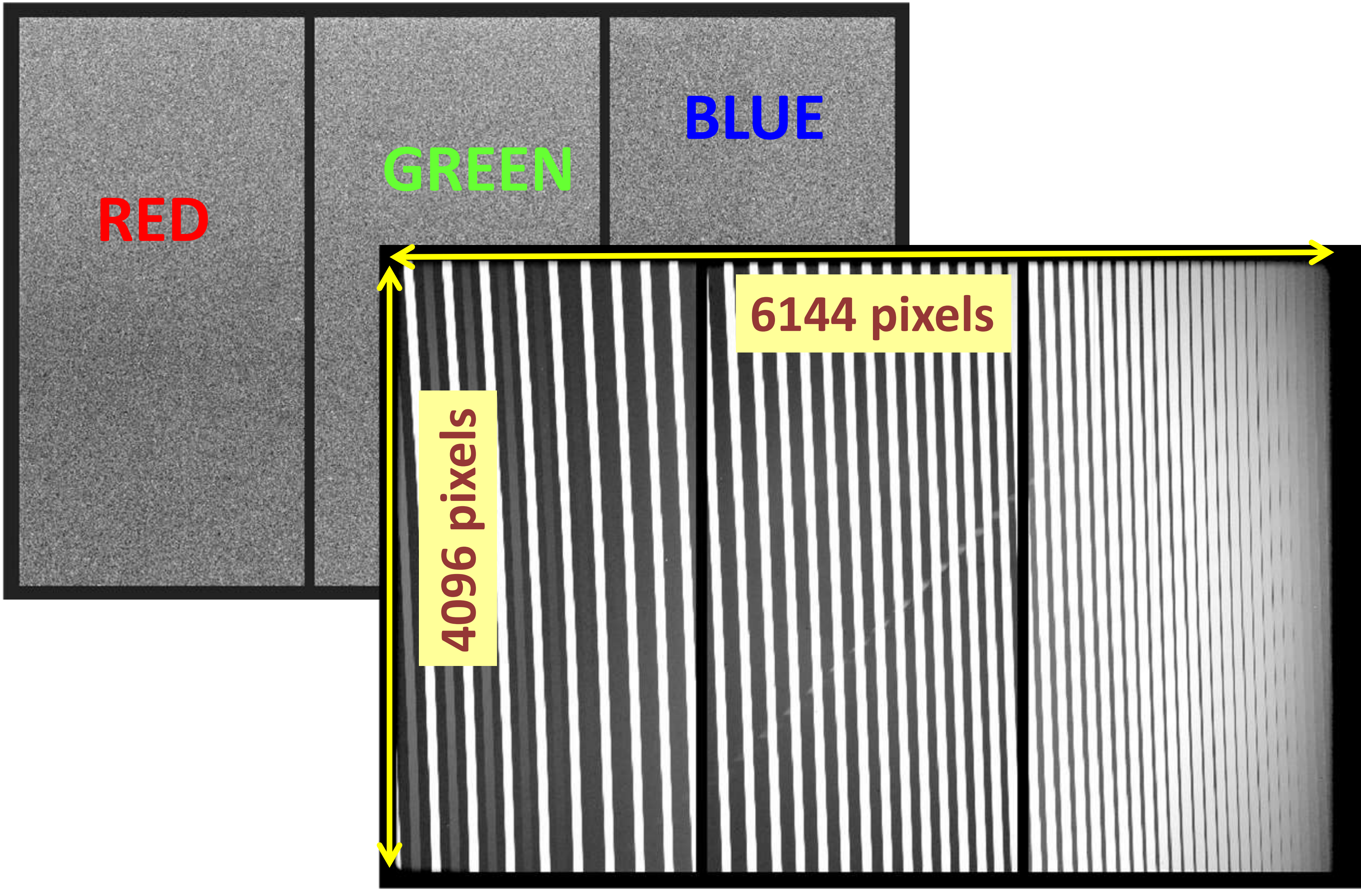
Where to Start	The observing information web page
Documents	HIRES Data Format
	User notes for the detectors
	Papers about HIRES
Proposal Preparation	Instrument Specifications
	Spectroscopic Efficiency (throughput)
	Exposure Time Calculator
	Echelle Format Simulator
	Choosing HIRESb or HIRESr
	General Telescope Info
	Telescope Pointing Limits
	Target Visibility Prediction Tool
	Split nights info
	HIRES Data Proprietary Period Policy
	Astronomer reference shelf

Planning Your Run

HIRES Configuration	Choosing high or low gain	
	Binning Options and Recommendations	
	Resolution vs. Slitwidth	
	Filter Choices	
	Rotator	
	Exposure Meter	
	Iodine Cell	
Logistics	Prepare your target list	
	Mainland Observing (policies and advice)	
	Reserve lodging for your observing run	
Questions ?	Telescope/Schedule	Barbara Schaefer
	Instrument	Scott Dahm
	Mainland Observing	Greg Wirth
	Summit visits	Gloria Martin

HIRES CCD data format

Mosaico de 3 CCDs, cada um de 2048 x 4096 pixels (1 pixel = 15um)



HIRES
Echelle Format Simulator

http://www2.keck.hawaii.edu/inst/hires/webech/efs.html

www2.keck.hawaii.edu/inst/hires/webech/1.0a/Jefs.1_0a.html

Hires Echelle Simulator

Version = 1.0a

Cross Disperser = red

Cross disperser (XD) angle = 0,247

Echelle angle = 0,0

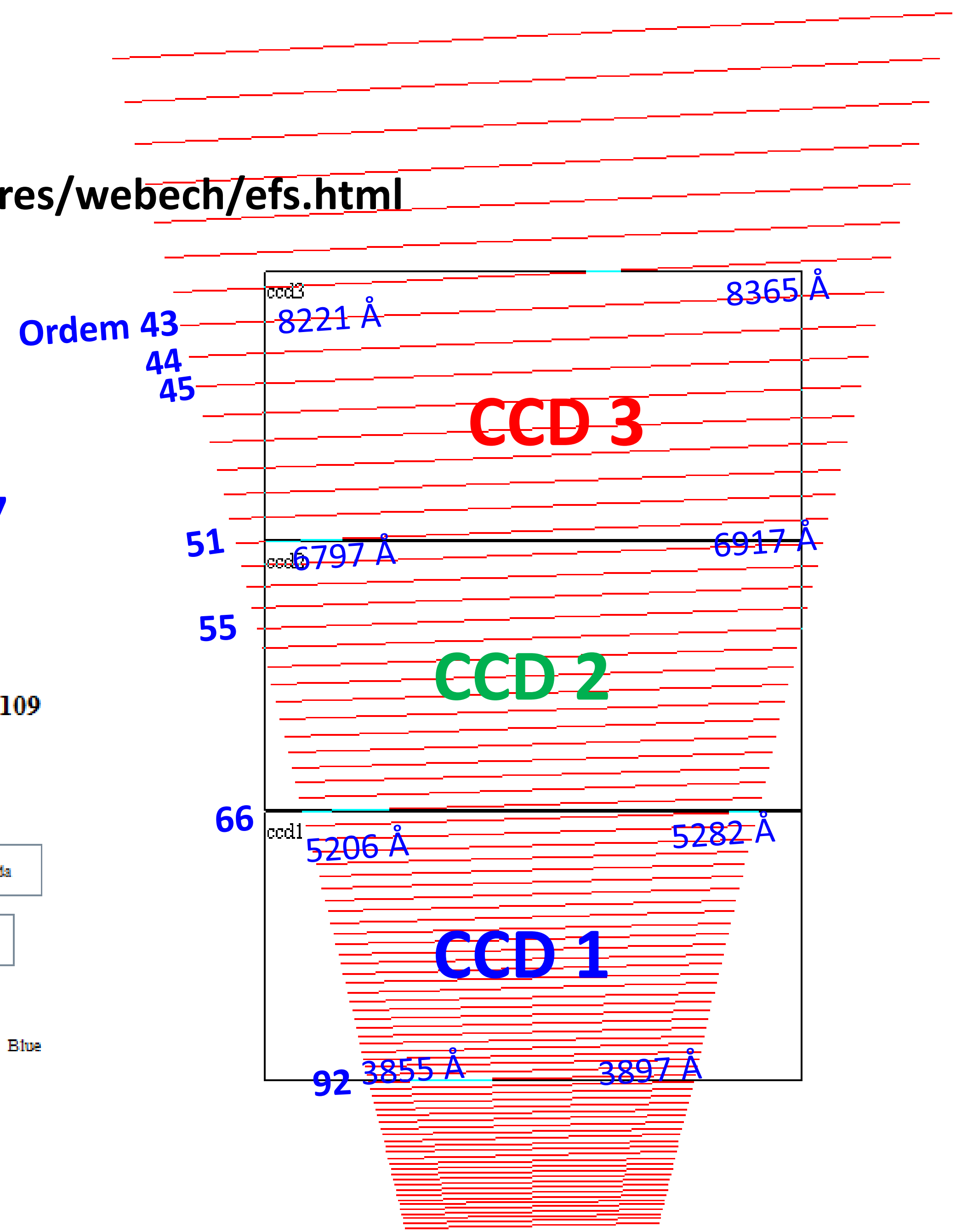
XDangle	**0.247**
Ecangle	**0.0**
Order	**55**
Lambda	**6707.109**

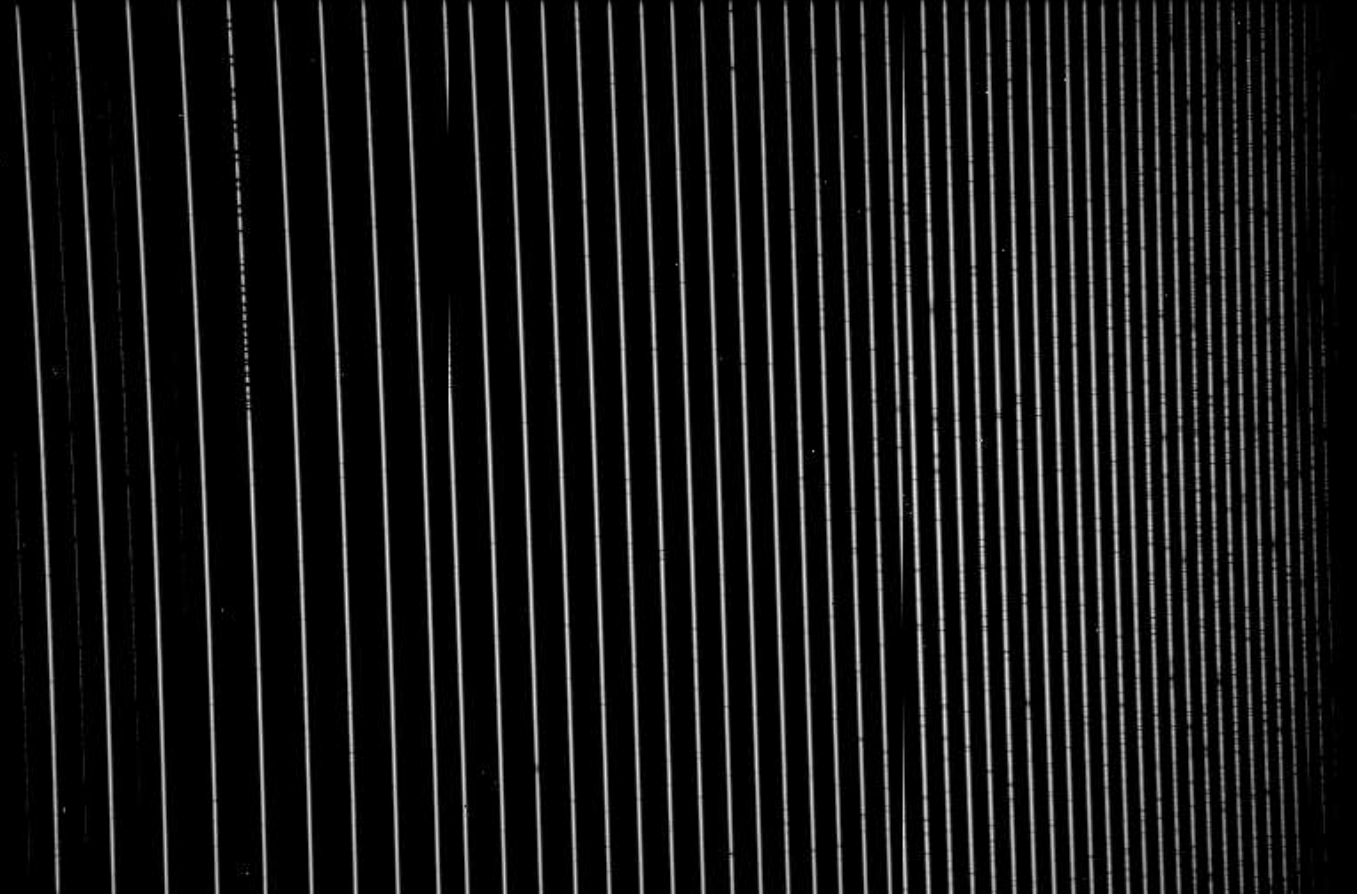
6563 Find Lambda

Delete Lambda Cursor

Red Blue

Reset Detector Pos.





HD 98618 : a minha primeira gêmea solar

Header da imagem hires1851.fits

- INSTRUME= 'HIRES'
- UTC = '12:22:40.24'
- DATE-OBS= '2006-01-20'
- **XDISPERS**= '**RED** '
- **XDANGL = 0.24900000**
- DEC = '+58:29:19.4'
- EQUINOX = '2000.0 '
- HA = '+22:37:54.36'
- RA = '11:21:28.26'
- ST = '09:59:45.87'
- AIRMASS = '1.33 '
- MJD = '53755.515760'
- TARGNAME= 'HD 98618'
- TELESCOP= 'Keck I ‘
- CCDGAIN = 'low '

- UTC-END = '12:25:11.39'
- DATE-END= '2006-01-20'
- CCDPSIZE= '[1:2048,1:4096]'
- OUTDIR = '/s/sdata125/hires5/19Jan2006'
- OUTFILE = 'hires '
- FRAMENO = 1851
- **EXPTIME = 150 seconds**
- OBSERVER= 'J. Melendez'
- OBJECT = 'hd 98618'
- DATE_BEG= '2006-01-20T12:22:39'
- DATE_END= '2006-01-20T12:25:09'
- **DECKNAME= 'E4 ' (fenda 0,40 x 7,0 ” define o poder resolvente)**
- ECHANGL = 0.00004228
- **FIL1NAME= 'kv389 '**

Resolving power vs. slit width ϕ_s

HIRES spectrograph on the 10m Keck I telescope

$$R = \frac{\lambda}{\delta\lambda_0} = \frac{\lambda}{r_{an}\phi_s}\frac{D_{COL}}{D_{TEL}}\frac{d\theta}{d\lambda}$$

Decker name	Length (")	Width (")	Resolution R (calculated)	Resolution R (measured*)	Resolution R (measured+)
B1	3.5	0.574	72,000	67,000	66,400
B2	7.0	0.574	72,000	67,000	66,400
B3	14.0	0.574	72,000	67,000	66,400
B4	28.0	0.574	72,000	67,000	66,400
B5	3.5	0.861	48,000	49,000	50,000
C1	7.0	0.861	48,000	49,000	50,000
C2	14.0	0.861	48,000	49,000	50,000
C3	28.0	0.861	48,000	49,000	50,000
C4	3.5	1.148	36,000	37,000	37,500
C5	7.0	1.148	36,000	37,000	37,500
D1	14.0	1.148	36,000	37,000	37,500
D2	28.0	1.148	36,000	37,000	37,500
D3	7.0	1.722	24,000	24,000	24,700
D4	14.0	1.722	24,000	24,000	24,700
D5	0.119	0.179	pinhole		
E1	1.0	0.400	103,000	84,000	86,600
E2	3.0	0.400	103,000	84,000	86,600
E3	5.0	0.400	103,000	84,000	86,600
E4	**7.0**	**0.400**	**103 000**	**84 000**	**86 600**
E5	1.0	0.800	51,000	52,000	52,000

DECKER serve para fixar o comprimento da fenda ou comprimento e largura. No ultimo caso reemplaza a fenda

* Using UV cross-disperser. Average of 5 Th/Ar lines near 4100 A.

\+ Using Red cross-disperser. Average of 4 Th/Ar lines near 5240 A.

Segundo minhas medições

R ~ 95000

The Astrophysical Journal, 752:5 (13pp), 2012 June 10

THE $UBV(RI)_C$ COLORS OF THE SUN

I. Ramírez[1], R. Michel[2], R. Sefako[3], M. Tucci Maia[4,5], W. J. Schuster[2], F. van Wyk[3], J. Meléndez[5], L. Casagrande[6], and B. V. Castilho[7]

HIP	$T_{\rm eff}$ (K)	$\log g$	[Fe/H]	V	$(B-V)$	$(U-B)$	$(V-R)$	$(V-I)$
55459	5838 ± 21	4.42 ± 0.03	0.038 ± 0.012	7.646 ± 0.004	0.644 ± 0.004	0.147 ± 0.010	0.338 ± 0.006	0.692 ± 0.006

simbad.u-strasbg.fr/simbad/sim-id?Ident=HD+98618&NbIdent=1&Radius=2&Radius.unit=arcmin&submit=submit+id

Basic data :

HD 98618 -- Star

query around with radius 2 arcmin

Other object types:	* (HD,AG,BD,GEN#,GSC,HIC,HIP,PPM,SAO,SKY#,SPOCS,TYC,UBV,uvby98,YZ) , IR (2MASS)
ICRS coord. (ep=J2000) :	11 21 29.07012 +58 29 03.7016 (Optical) [3.96 3.87 90] A 2007A&A...474..653V
FK5 coord. (ep=J2000 eq=2000) :	11 21 29.070 +58 29 03.70 (Optical) [3.96 3.87 90] A 2007A&A...474..653V
FK4 coord. (ep=B1950 eq=1950) :	11 18 36.06 +58 45 29.0 (Optical) [22.85 22.34 89] A 2007A&A...474..653V
Gal coord. (ep=J2000) :	143.3023 +54.9422 (Optical) [3.96 3.87 90] A 2007A&A...474..653V
Proper motions *mas/yr* [error ellipse]:	41.57 28.89 [0.44 0.45 0] A 2007A&A...474..653V
Radial velocity / Redshift / cz :	V(km/s) 16 [6.8] / z(~) 0.000053 [0.000023] / cz 16.00 [6.80] (~) D 1995A&AS..110..177D
Parallaxes *mas*:	24.96 [0.66] A 2007A&A...474..653V
Spectral type:	G5V D ~
Fluxes (5) :	B 8.265 [~] C ~ V 7.659 [~] C ~ J 6.448 [0.029] C 2003yCat.2246....0C H 6.142 [0.046] C 2003yCat.2246....0C K 6.061 [0.020] C 2003yCat.2246....0C

Identifiers (16):

HD 98618

HIP 55459

...

http://www2.keck.hawaii.edu/inst/hires/etc.html

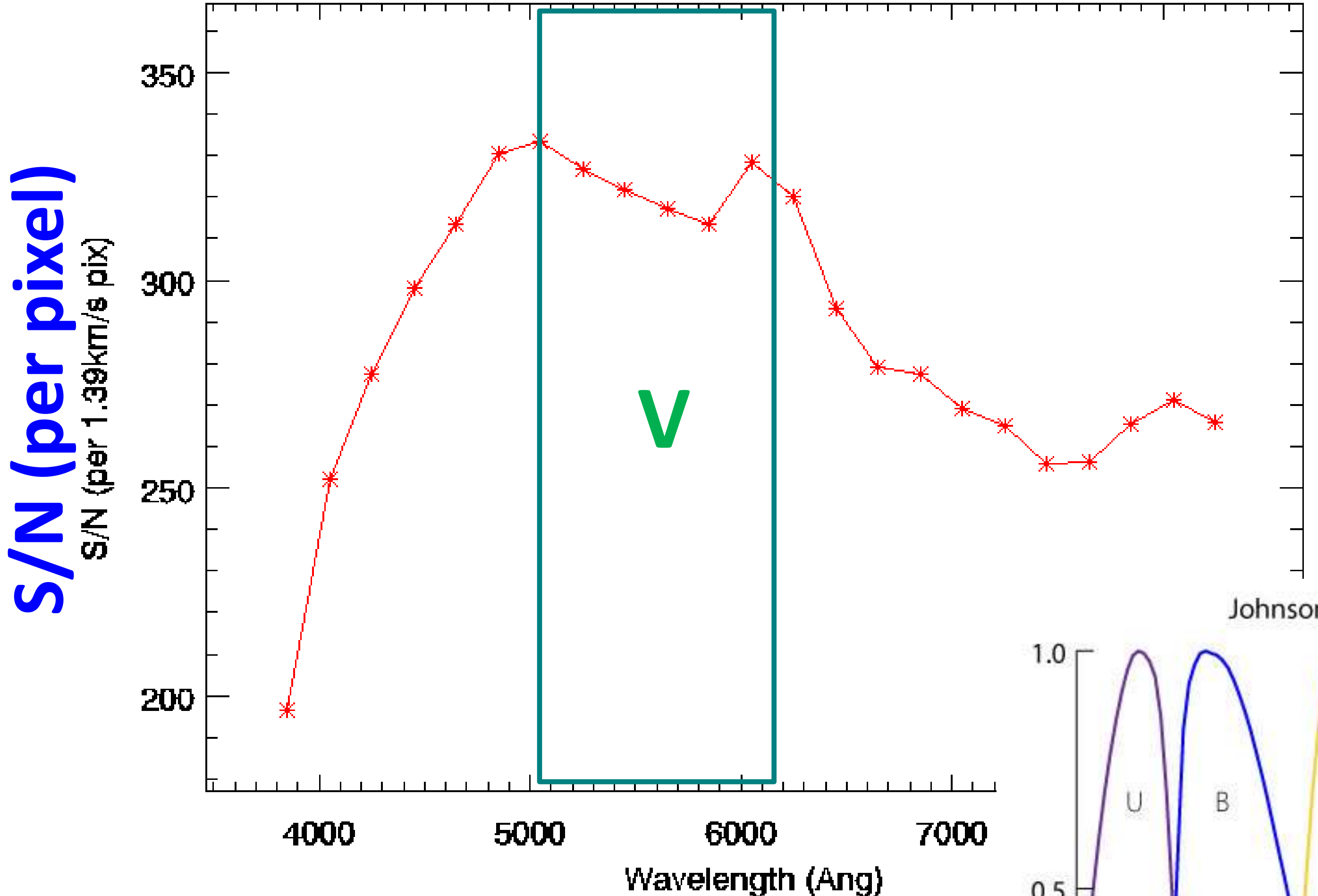
HIRES Signal-to-Noise Estimator

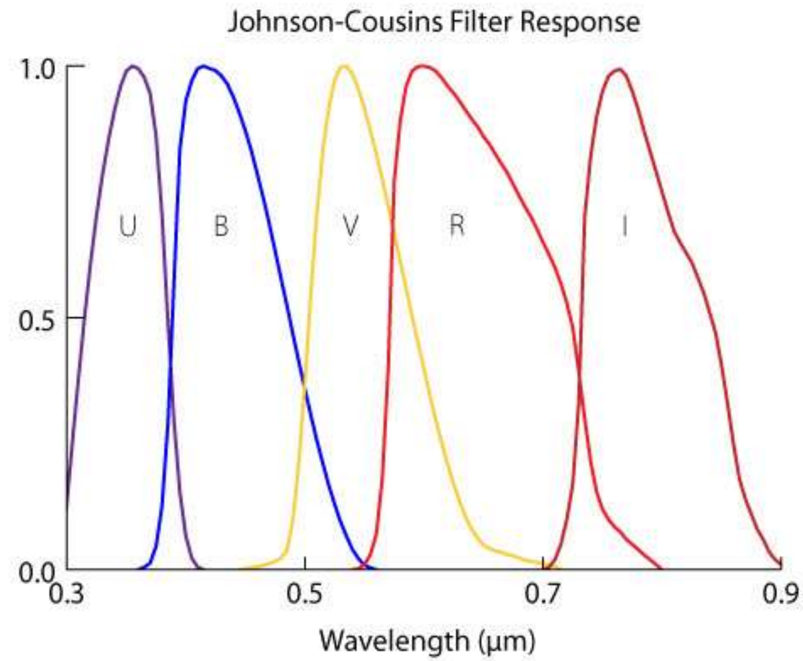
Plot Type	Binning	Parameters		
◉ S/N	◉ 1×1	AB Magnitude	7.646	
○ Efficiency	○ 2×1	Exposure time	150	sec
○ Noise	○ 3×1	Slit width	0.4	arcsec
○ Data Table	○ 2×2	Seeing FWHM	0.6	arcsec
		Airmass	1.3	
		Moon phase	7	days
		Min wavelength	3850	Å
		Max wavelength	8350	Å
		Increment	200	Å

Compute Reset Help By Xavier Prochaska (UCO/Lick)

We are adopting V = 7,646, but this is in the Johnson system. Be careful ! What we need are "AB" magnitudes, i.e., U_{AB},B_{AB},V_{AB}, R_{AB} , etc

V = 7,646 slit = 0,4” seeing 0,6” exptime = 150 s





To do it properly magnitudes should be in the AB system

THE ASTRONOMICAL JOURNAL VOLUME 108, NUMBER 4 OCTOBER 1994

GENERATING COLORS AND k CORRECTIONS FROM EXISTING CATALOG DATA

ZSOLT FREI AND JAMES E. GUNN

We present color–color relations on several systems as functions of redshift calculated using the galaxy energy distributions of Coleman *et al.* [ApJS, 43, 393 (1980)] which span the run of Hubble types. The system response curves of five different photometric systems {Johnson *UBV*, $B_J RI$ [Gullixson *et al.*, ApJS (in press) (1993)], Thuan–Gunn *gri*, Sloan Digital Sky Survey $u'g'i'r'z'$, and Cousins $R_c I_c$} and the absolute spectral energy distributions of spectrophotometric standard stars were used to tie the different systems together. We have calculated zero points on the AB79 system for all of these bands, $m-B$ colors for each band and each galaxy type as functions of redshift, and B k corrections for each galaxy type. To the extent that galaxies represent a one-parameter sequence in color space, a redshift and color in any pair of bands in any system can be used to estimate the colors in any other using the tables and graphs constructed here.

$$\Delta_b = m_b - AB_b$$

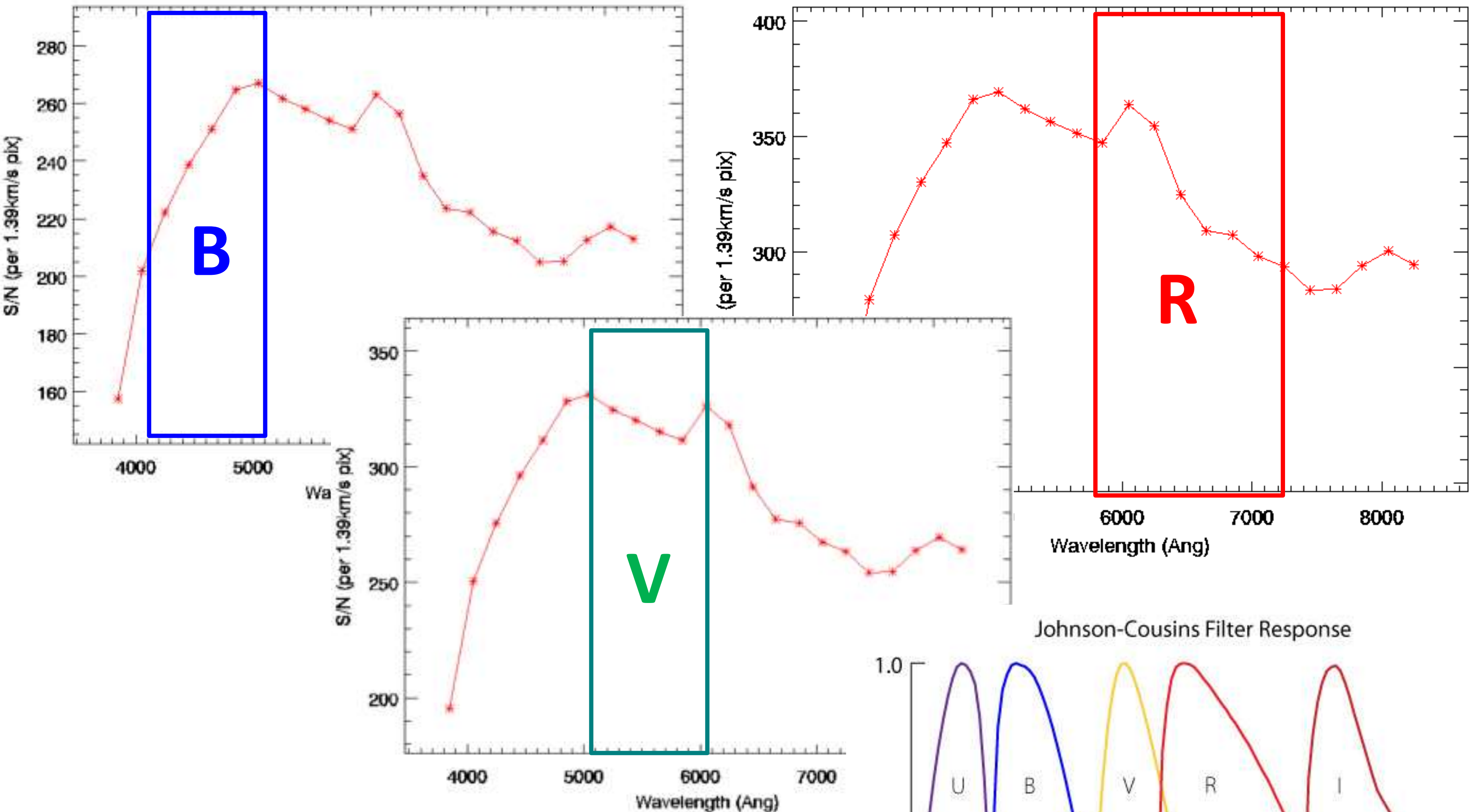
TABLE 2. AB offsets

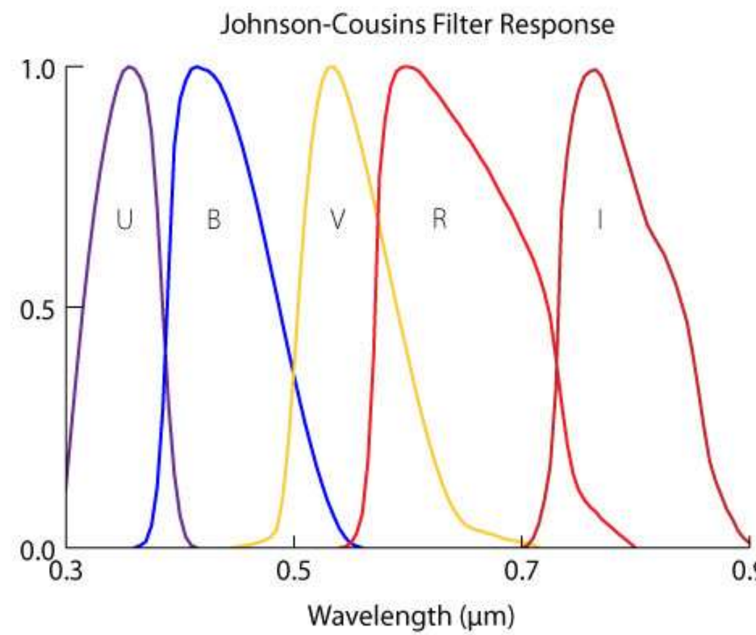
Band	Δ_b
V	0.044
B	0.163
B_J	0.139
R	−0.055
I	−0.309
g	0.013
r	0.226
i	0.296
u'	0.0
g'	0.0
r'	0.0
i'	0.0
z'	0.0
R_c	−0.117
I_c	−0.342

- V(AB) = V - 0.044 (+/- 0.004)
- B(AB) = B - 0.163 (+/- 0.004)
- Rc(AB) = Rc + 0.117 (+/- 0.006)
- Ic(AB) = Ic + 0.342 (+/- 0.008)

- V(AB) = 7.602
- B(AB) = 8.127
- Rc(AB) = 7.425
- Ic(AB) = 7.296

HD 98618
HIP 55459



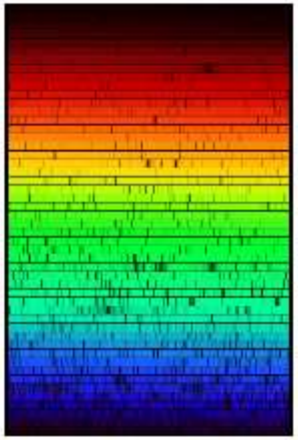


Here we are using AB magnitudes for HD98618

Header da imagem hires1851.fits

- INSTRUME= 'HIRES'
- UTC = '12:22:40.24'
- DATE-OBS= '2006-01-20'
- **XDISPERS**= '**RED** '
- **XDANGL = 0.24900000**
- DEC = '+58:29:19.4'
- EQUINOX = '2000.0 '
- HA = '+22:37:54.36'
- RA = '11:21:28.26'
- ST = '09:59:45.87'
- AIRMASS = '1.33 '
- MJD = '53755.515760'
- TARGNAME= 'HD 98618'
- TELESCOP= 'Keck I ‘
- CCDGAIN = 'low '

- UTC-END = '12:25:11.39'
- DATE-END= '2006-01-20'
- CCDPSIZE= '[1:2048,1:4096]'
- OUTDIR = '/s/sdata125/hires5/19Jan2006'
- OUTFILE = 'hires '
- FRAMENO = 1851
- **EXPTIME = 150 seconds**
- OBSERVER= 'J. Melendez'
- OBJECT = 'hd 98618'
- DATE_BEG= '2006-01-20T12:22:39'
- DATE_END= '2006-01-20T12:25:09'
- **DECKNAME= 'E4 ' (fenda 0,40 x 7,0 ” define o poder resolvente)**
- ECHANGL = 0.00004228
- **FIL1NAME= 'kv389 '**



http://www2.keck.hawaii.edu/inst/hires/filter_choices.html

High Resolution Echelle Spectrometer

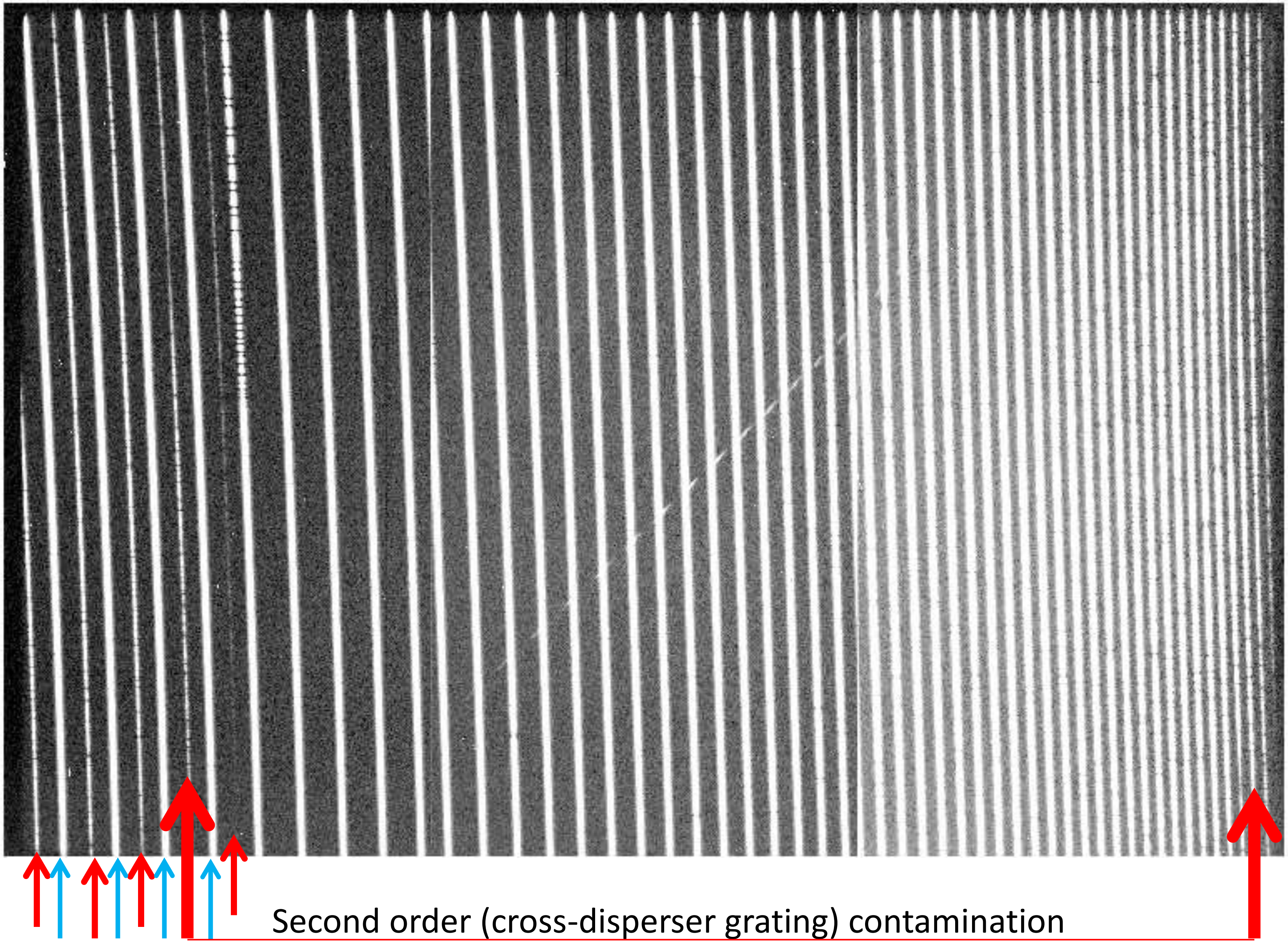
Filter Choices

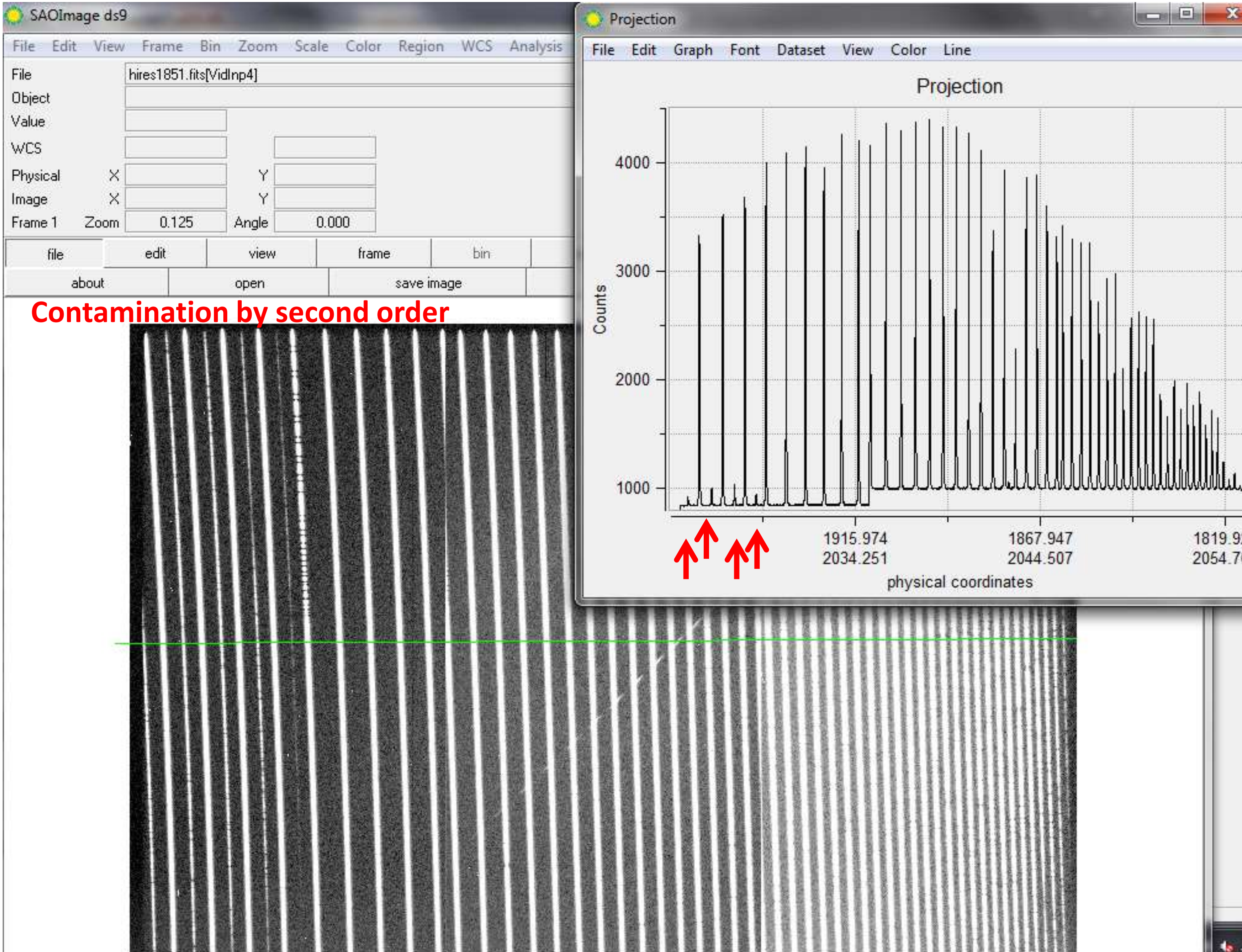
É possível observar H e K (394 nm) e ao mesmo tempo o tripleto de oxigênio em 777 nm e o dubleto de Al em 784 nm?

HIRES has two 12 position filter wheels that reside immediately behind the decker plate. Their primary function is to block unwanted orders from the cross-disperser. Each filter wheel has a "clear" position that is empty. Proper choice of blocking filters is critical for isolating particular regions of interest. The Table below gives some useful combinations of filter choice for given spectral regions. Note that each combination of filters requires refocusing of the collimator which is handled automatically if installed from the XHIRES GUI.

Cross-disperser Order	Wavelength (microns)	Filter Wheel 1	Filter Wheel 2
1	0.69 - 1.1	2 (OG610)	1 (clear)
1	0.63 - 0.95	3 (OG530)	1 (clear)
1	0.58 - 0.90	3 (OG530)	1 (clear)
1	0.53 - 0.85	4 (GG475)	1 (clear)
1	0.48 - 0.80	5 (KV418)	1 (clear)
1	0.44 - 0.75	6 (KV408)	1 (clear)
1	0.39 - 0.70	8 (KV380)	1 (clear)
1	0.35 - 0.65	9 (KV370)	1 (clear)
1	0.30 - 0.60	11 (WG335)	1 (clear)

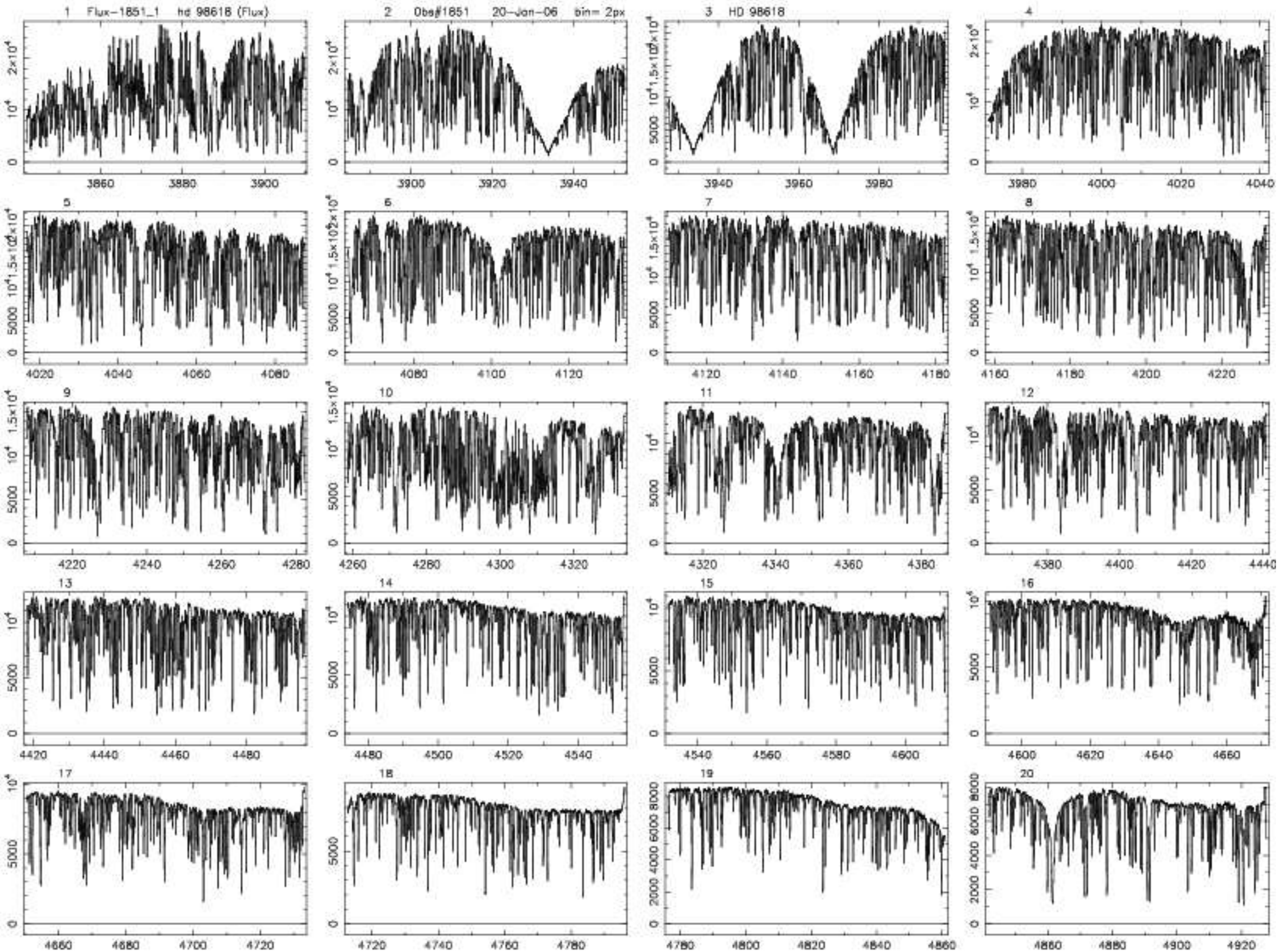
HIRES mosaic for solar twin HD 98618




SAOImage ds9
File Edit View Frame Bin Zoom Scale Color Region WCS Analysis
File hires1851.fits[VidInp4]
Object
Value
WCS
Physical X Y
Image X Y
Frame 1 Zoom 0.125 Angle 0.000
file edit view frame bin
about open save image
Contamination by second order
Projection
File Edit Graph Font Dataset View Color Line
Projection
Counts
4000
3000
2000
1000
1915.974
2034.251
1867.947
2044.507
1819.92
2054.76
physical coordinates

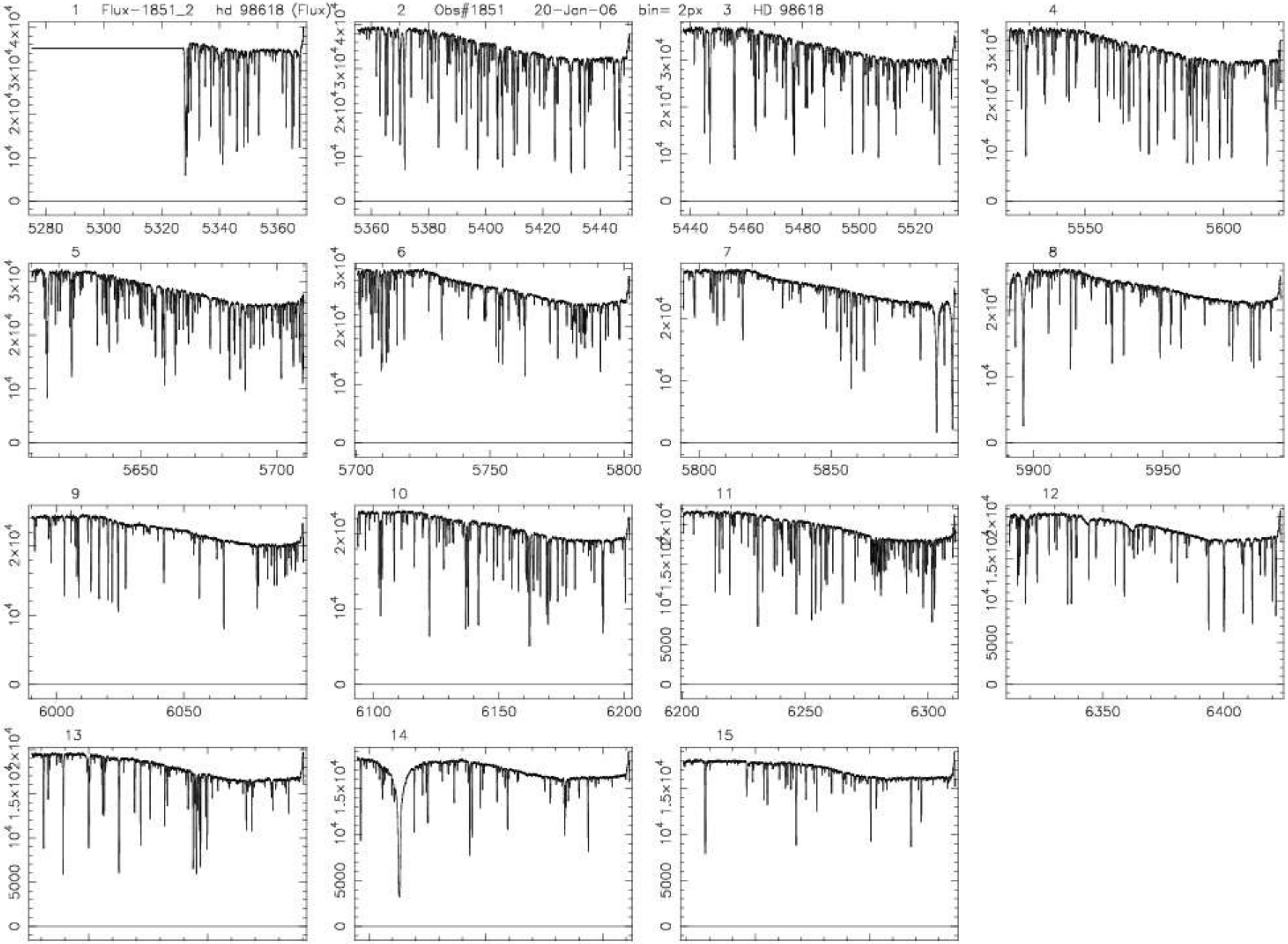
MAKEE hires pipeline (redução automática)

CCD 1 (faltam algumas ordens)



Wavelength (A)

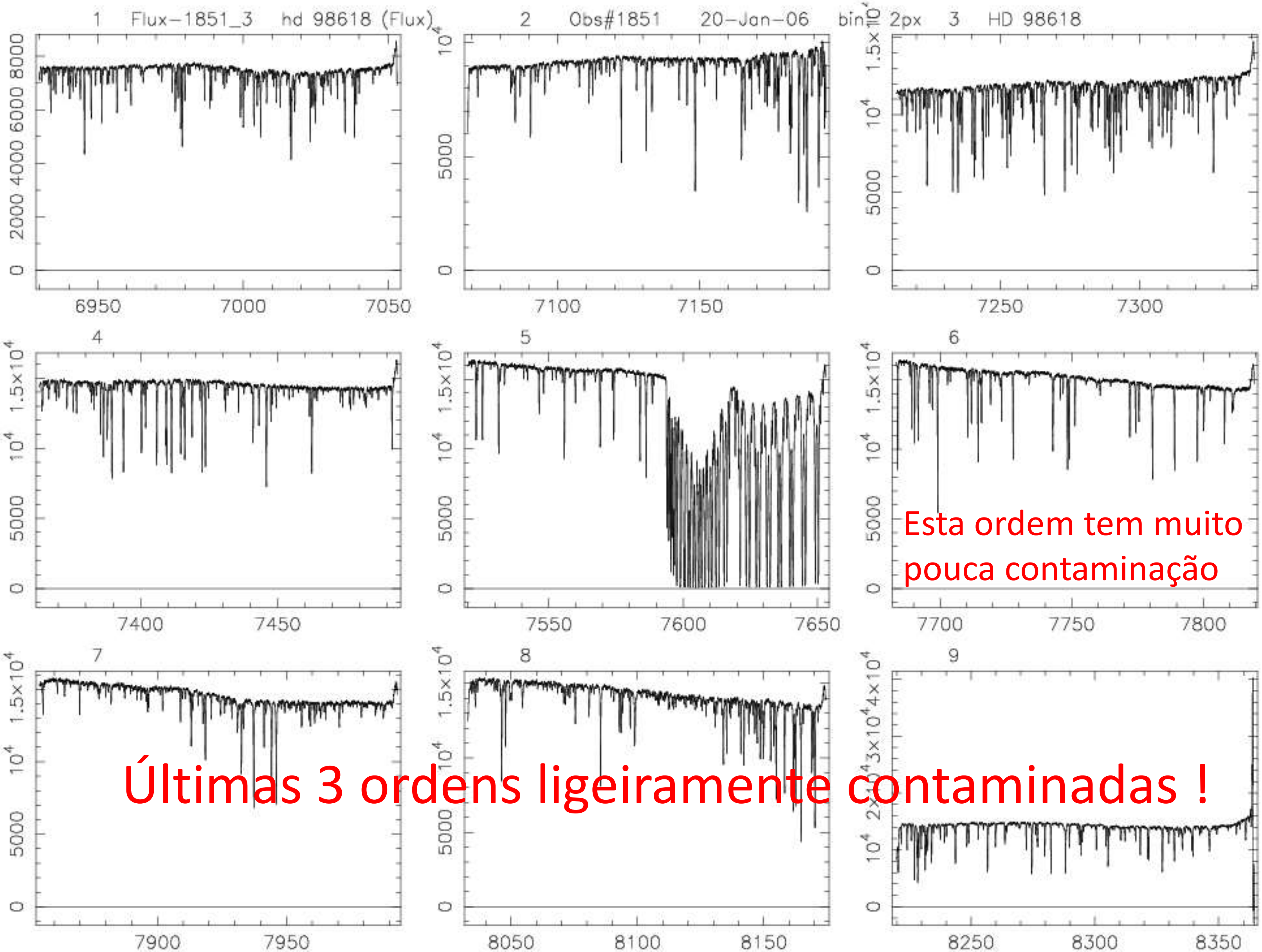
MAKEE hires pipeline (redução automática)



CCD 2

Wavelength (A)

MAKEE hires pipeline (redução automática)



CCD 3

Esta ordem tem muito pouca contaminação

Últimas 3 ordens ligeiramente contaminadas !

Wavelength (A)

Header da imagem hires1851.fits

- INSTRUME= 'HIRES'
- UTC = '12:22:40.24'
- **DATE-OBS= '2006-01-20'**
- **XDISPERS**= '**RED** '
- **XDANGL = 0.24900000**
- DEC = '+58:29:19.4'
- EQUINOX = '2000.0 '
- HA = '+22:37:54.36'
- RA = '11:21:28.26'
- ST = '09:59:45.87'
- AIRMASS = '1.33 '
- MJD = '53755.515760'
- TARGNAME= 'HD 98618'
- TELESCOP= 'Keck I ‘
- CCDGAIN = 'low '

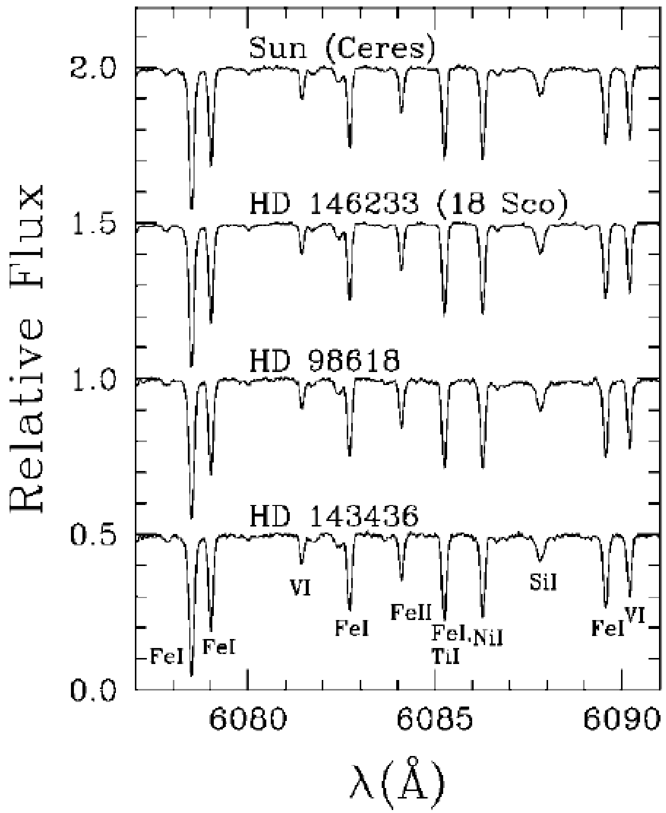
- UTC-END = '12:25:11.39'
- DATE-END= '2006-01-20'
- CCDPSIZE= '[1:2048,1:4096]'
- OUTDIR = '/s/sdata125/hires5/19Jan2006'
- OUTFILE = 'hires '
- FRAMENO = 1851
- **EXPTIME = 150 seconds**
- OBSERVER= 'J. Melendez'
- OBJECT = 'hd 98618'
- DATE_BEG= '2006-01-20T12:22:39'
- DATE_END= '2006-01-20T12:25:09'
- **DECKNAME= 'E4 ' (fenda 0,40 x 7,0 ” define o poder resolvente)**
- ECHANGL = 0.00004228
- **FIL1NAME= 'kv389 '**

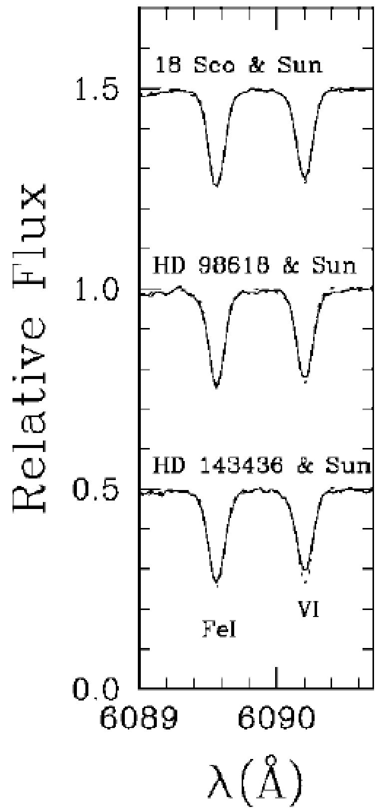
Stromlo Summer Scholar (Iniciação C.)

THE ASTROPHYSICAL JOURNAL, 641:L133–L136, 2006 April 20

HD 98618: A STAR CLOSELY RESEMBLING OUR SUN[1]

JORGE MELÉNDEZ,[2] KATIE DODDS-EDEN, AND JOSÉ A. ROBLES
Research School of Astronomy and Astrophysics, Mount Stromlo Observatory, Cotter Road, Weston Creek, ACT 2611, Australia;
jorge@mso.anu.edu.au, katie@mso.anu.edu.au, josan@mso.anu.edu.au
Received 2006 February 13; accepted 2006 March 6; published 2006 March 30



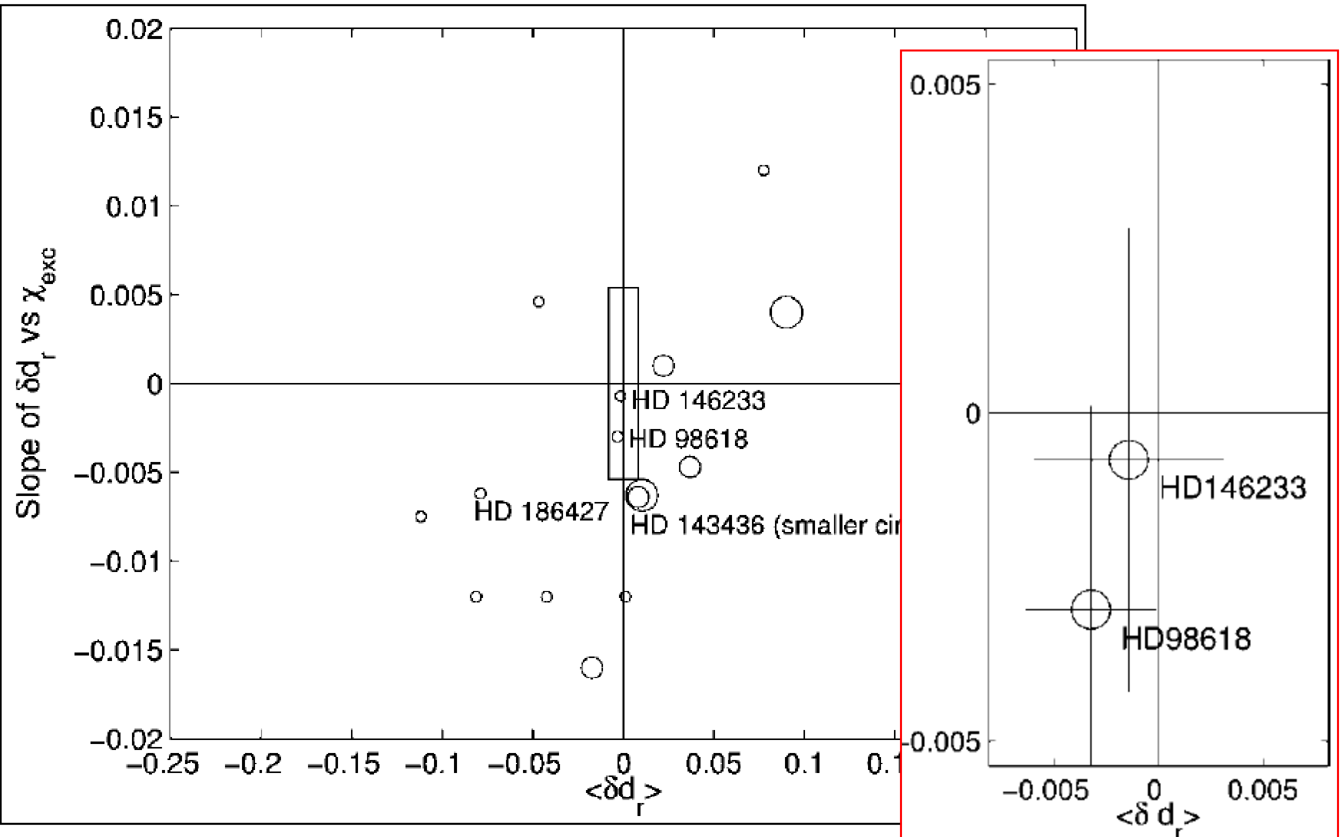


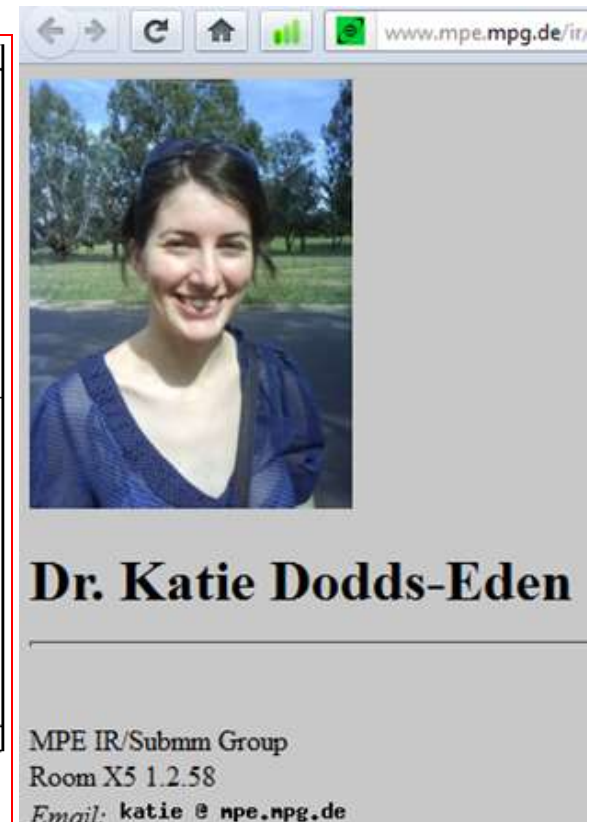
Observações feitas em 2006 January 20 !!!

The Astrophysical Journal, 641:L133–L136, 2006 April 20

HD 98618: A STAR CLOSELY RESEMBLING OUR SUN[1]

Jorge Meléndez,[2] Katie Dodds-Eden, and José A. Robles
Research School of Astronomy and Astrophysics, Mount Stromlo Observatory, Cotter Road, Weston Creek, ACT 2611, Australia;
jorge@mso.anu.edu.au, katie@mso.anu.edu.au, josan@mso.anu.edu.au
Received 2006 February 13; accepted 2006 March 6; published 2006 March 30





Iniciação (Summer Scholar): gêmeas solares
Mestrado de 1 ano (Honours): teoria MOND (alternativa a matéria escura)
Doutorado na Alemanha (observacional, centro Galáctico)

HD 98618: Destaque na imprensa

http://www.20minutos.es/noticia/107450/0/sol/estrella/astronomos/

Astrónomos australianos descubren una estrella idéntica al Sol

Se llama HD98618 y es prácticamente idéntica al Sol: tiene su misma edad, su mismo tamaño, su misma temperatura y su misma composición, según los científicos de la Escuela de Astronomía australiana.

El mellizo del
(Imagen: Web)

Los expertos esperan que este hallazgo ayude a

A Solar Twin in th

By Ken Croswell

March 10, 2006

A yellow star in the Big Dipper's bow
scientists search the star for signs of

Solar twins are stars with the same
more light than the typical star in th
extraterrestrial intelligence.

Jorge Meléndez, Katie Dodds-E
high-resolution spectra of HD 98
126 light-years from Earth, almo

Guaranteed to be 100% genuinely produced in Australia and wholly Australian owned – since 1988

THE 'NEW' SKY & SPACE

www.SkyandSpace.com.au

WEEKLY | NEWS IDEAS INNOVATION

NewScientis

8 April 2006 No2546 Australia $6.50 (inc.GST) New Zealand NZ$6.95 (inc.GST) Print Post Approved 230009/00015

SUN'S TWIN IS STRONG CANDIDATE FOR LIFE

Astronomers have found a twin of the sun, the first such star to be spotted in a decade and only the second ever. They say that these stars are our best bets for finding Earth-like planets with life on them.

Jorge Meléndez, Katie Dodds-Eden and José Robles of Mount Stromlo Observatory near Canberra, Australia,

have roughly the same concentratio of heavy elements as the sun. These elements are crucial to the formation Earth-like planets and the emergence of life (www.arxiv.org/astro-ph/060321

Another cause for optimism is the absence of "hot Jupiters", massive gas giants orbiting close to each star whose gravity could destabilise the orbits of

News Update

with Dave Reneke

New solar twin sheds light on twin Earth

Astronomers at the Australian National University (ANU) have discovered a nearby solar twin which may shed light on the search for Earth-like planets capable of supporting life.

and to the other closest Sun twin, a star known as 18 Scorpii, which was discovered a decade ago.

The spin-offs of this discovery are tantalising. Solar twins are ideal for the absolute calibration of astronomical measuring instruments. They can provide data useful in modelling the solar phenomena that may affect climate change and will help settle the argument about the uniqueness or otherwise of our Sun and Solar System.

With a number of sample stars to study, HD 98618 was one of the last on the list to be analysed. Team members were quite surprised when they discovered how it stood out from the other candidates along with 18 Scorpii. "It was very exciting – I had to blink twice to be sure I wasn't imagining it," Ms Dodds-Eden said.

The researchers made the discovery using the largest telescope in the world, the 10metre Keck I telescope on the summit of Hawaii's dormant Mauna Kea volcano. A paper detailing this amazing discovery is expected to be published shortly.

Source: ANU

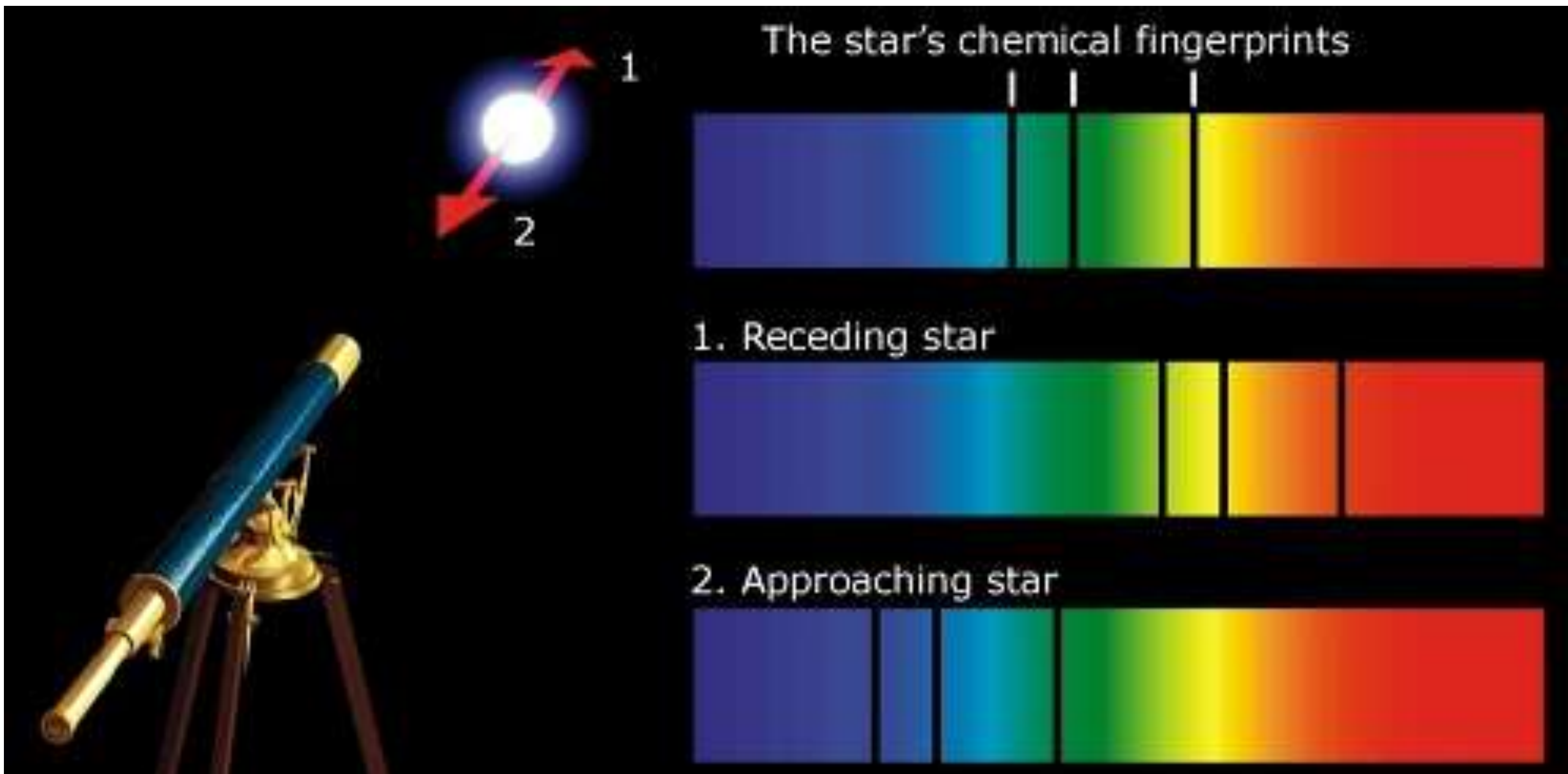
A colour-enhanced close-up around the newly discovered HD 98618, one of the most Sun-like stars

New 'earthly' planet found in our galaxy

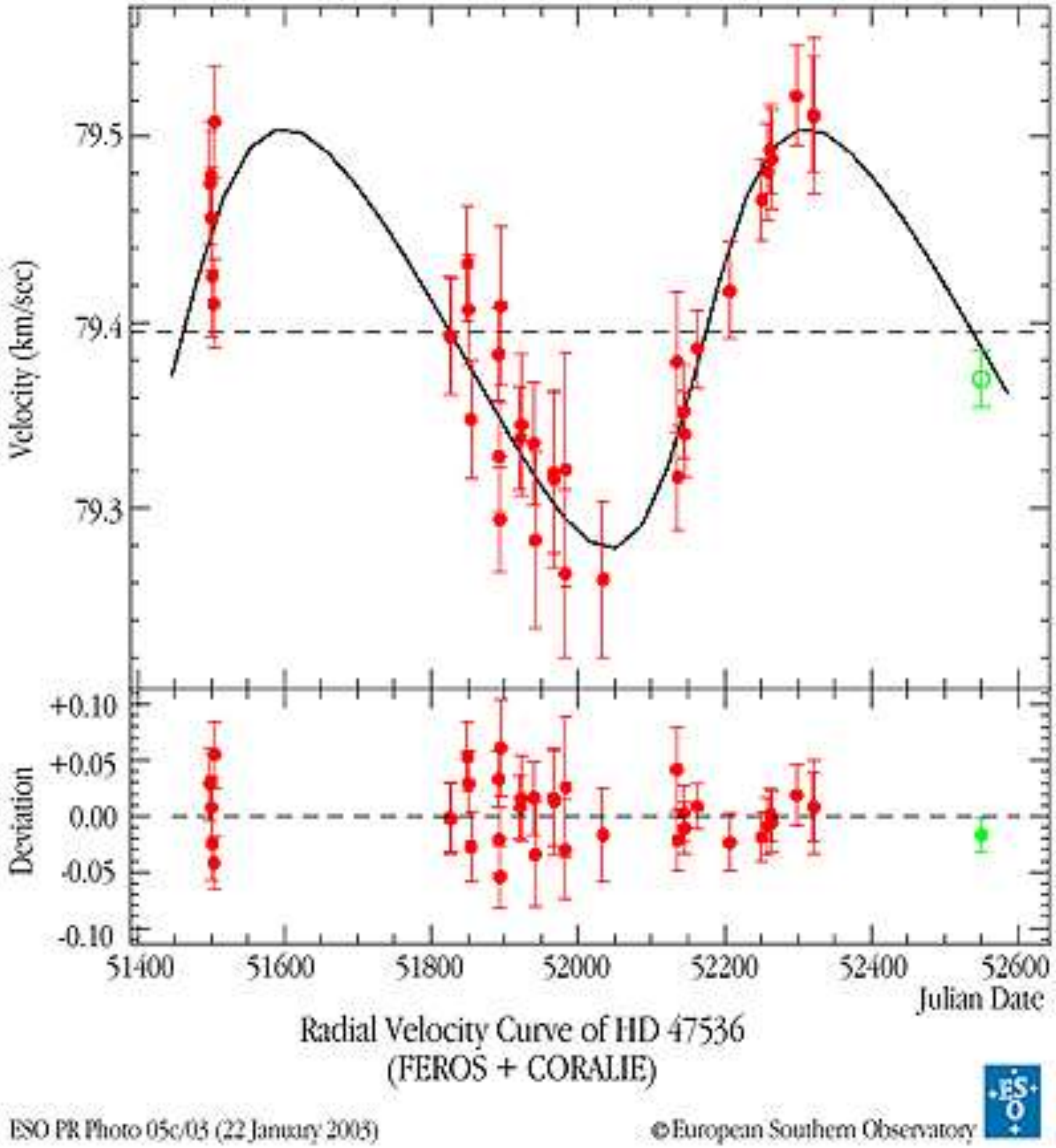
A ground-breaking discovery in the search for planets that may support life in our galaxy has been made by an international team of astronomers, with much critical data provided by

Radial velocity and planets

$$\frac{\lambda - \lambda_0}{\lambda_0} = \frac{\Delta\lambda}{\lambda_0} = \frac{v_R}{c}$$



Planeta em torno de HD 47536



Dois planetas around Ups And