

# CHIRON efficiency after upgrade

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file: prj/bme/chiron/recommission/efficiency.tex

In January-February 2012, the CHIRON spectrometer had been upgraded. A more efficient echelle grating was installed, housed in a vacuum enclosure. The cross-dispersion prism was AR-coated. A new, supposedly better octagonal fiber replaced the previous fiber with round core. However, that fiber had a problem (light propagation in the cladding). It was provisionally replaced by a standard fiber on March 27, 2012. Then on May 28, 2012 the new octagonal fiber was installed.

Observations of three A-stars were taken by R. Hernandez and M. Giguere on June 5, 2012. The sky was clear, the seeing unknown (the site monitor at Tololo is out of service). The spectra passed quality control, the guider was working. Data on those stars and airmass of observation are listed here. HR 5881 is a close resolved binary.

Star	Sp	B	V	Airmass
HR 4802	A2V	3.907	3.852	1.071
HR 4933	A0V	4.857	4.830	1.070
HR 5881	A0V	3.529	3.549	1.311

Three spectra of each star in fiber mode (4x4 binning) were taken. They were processed by the standard pipeline extracting 62 orders. The FITS files contain, for each order, the wavelength and the pixel flux in photo-electrons (the gain is accounted for).

##	Obj	Texp	Flux(5000)	Eff.%	Peak,%
1113	HR 4802	30	27636.	2.87	3.1
1114	HR 4802	90	101304.	3.51	4.0
1115	HR 4802	90	130884	4.54	5.2
1116	HR 4802	90	116242	4.02	4.5
1117	HR 4933	30	16700	4.28	5.3
1118	HR 4933	60	42912	5.49	6.5
1119	HR 4933	60	47530	6.08	7.3
1120	HR 4933	60	41854	5.35	6.4
1154	HR 5881	45	112230	5.88	6.0
1155	HR 5881	45	121409	6.36	6.4
1156	HR 5881	45	111981	5.86	5.9

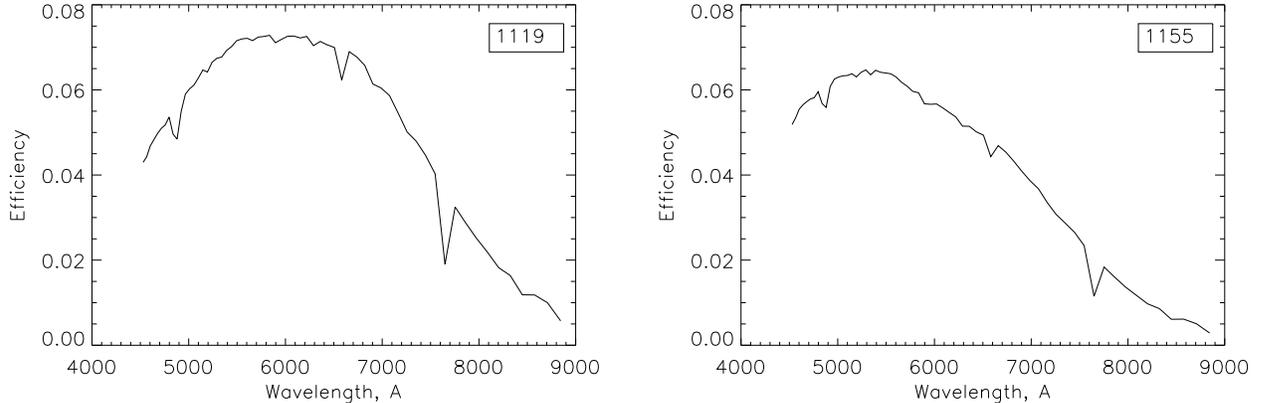


Figure 1: Efficiency vs. wavelength for HR 4933 (left) and HR 5881 (right).

The total efficiency (ratio of recorded flux to the stellar flux outside atmosphere) was estimated in two ways. First, a crude estimate was made using the flux around blaze peak in order #12 (5000Å) and assuming that a  $V = 0$  star gives  $10^3$  phot/(cm<sup>2</sup> s Å) outside atmosphere. This method was used to evaluate CHIRON efficiency before the upgrade and lead to its estimates around 5%.

In the second step, we used the spectral flux density outside atmosphere for a  $V = 0$  star of A0 type as tabulated in Allen’s “Astrophysical Quantities”. The  $F_\lambda$  in erg/(cm<sup>2</sup> s Å) is listed there. Its logarithm is a smooth function of the wavelength  $\lambda$  in Å, well represented by a quadratic polynomial:

$$\log_{10} F_\lambda \approx -6.6884 + (-4.125E - 4)\lambda + (1.70E - 8)\lambda^2. \quad (1)$$

This polynomial differs from the tabulated values by no more than 0.01 and gives correct flux for the  $V = 0$  and  $B = 0$  stars also listed by Allen ( $\log_{10} F_\lambda$  of  $-8.43$  and  $-8.17$ , respectively).

Flux near the blaze peak in each order is averaged over 40-pixel swath, compared to the flux outside atmosphere calculated from the  $V$  magnitude, and used to compute the efficiency  $e(\lambda)$ . The telescope diameter 1.5 m with 0.507 central obstruction is assumed. The pixel scale in each order in Å is determined from the wavelength solution in the reduced spectra.

Figure 1 give two representative efficiency curves. The dip around 7600Å is caused by atmospheric absorption, other dips are produced by the Bahlmer lines that happen to be near the blaze peak.

The Table above lists the image number, object, exposure time, flux around 5000Å, rough and peak efficiency in percent. The peak efficiency does not exceed 7%, but typically is about 6%. There is a good agreement between crude estimates and  $e(\lambda)$ .

In conclusion, the 5% efficiency assumed in computing the signal-to-noise curves is realistic and describes the real CHIRON performance.

The efficiency estimates for  $\alpha$  Cen posted at [http://exoplanets.astro.yale.edu/~jspronck/chiron/CHIRON\\_EFFICIENCY.html](http://exoplanets.astro.yale.edu/~jspronck/chiron/CHIRON_EFFICIENCY.html) do not show improvement after May 28 (fiber replacement), ranging between 2% and 4% in this period and showing a large scatter prior to it. These estimates were obtained by a different method, they do not correspond to signal count near the blaze peak and are not directly comparable to the “true” efficiency estimated here.