Southern African Large Telescope

Title: **FWHM and $\lambda/\delta\lambda$ for HRS with MIDAS pipeline**

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ABSTRACT

In this report I present study of FWHM and $R = \lambda/\delta\lambda$ for LR, MR and HR modes of HRS. The main conclusion of this report is that the current version of the MIDAS pipeline produces FWHM and R, which are very close to the declared values only for LR mode. Unfortunately, both MR and HR have distributions of FWHMs and R that are worse of their declared predictions. I show that such a problem with very high probability appears due to not taking into account with the current version of the HRS MIDAS pipeline of **the tilted nature of lines in HRS spectra**.

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1 Introduction

HRS is very useful instrument for those science cases, where we need the whole spectral region simultaneously with high resolution. The region of scientific usability of such instrument is very high. Unfortunately, up to now, we still did not study properly many parameters of this science instrument or its data after the standard pipeline reduction.

For my science I was need to correct my HRS LR data for the instrumental FWHM and for that reason I was need to study distributions of FWHMs and resolution R = $\lambda/\delta\lambda$ for data obrained with LR mode and reduced with HRS MIDAS pipeline (Kniazev, Gvaramadze & Berdnikov, 2016). I extended such study to MR and HR modes as well and show these results below.

2 Method

I used totally reduced reference spectra for each mode to study distributions of FWHMs and R depending on the wavelength. The result of the work of HRS MIDAS pipeline is not only the wavelength calibrated spectra themself, but some tables, which consist of information, for example, which lines from the reference spectrum were used for the final calculation of the wavelength solution. I have used this information and fit gauss function to only these lines, using preliminary information about their wavelength positions.

The distribution of FWHMs was fitted after that with the first order polynomial and R was calculated as $\lambda/\delta\lambda$, where $\delta\lambda$ is the fitted FWHM distribution.

3 Results

All calculated distributions FWHM and R for different HRS modes are plotted in Figures 1–6. Table 1 shows my results in very short form, where R declared in our **"Call for Proposals" document** are compared to the calculated values.

It is very interesting to see that calculated R is slightly better ($\sim$ 7% for the Blue channel and $\sim$ 15% for the Red channel) for LR mode, but started to be slightly worse for MR ($\sim$ 13% for the Blue channel and $\sim$ 2.5% for the Red channel) and much worse for HR mode ($\sim$ 44% for the Blue and $\sim$ 59% for the Red). The only explanation of this effect I see in the fact that the current version of HRS MIDAS pipeline does not taken into account the tilted nature of lines in HRS spectra.

It is easy to check such an effect in the simple geometrical model. Lets suggest that each line has pure reactangular shape with **width A** and **height B**. Since HRS MIDAS pipeline just summarises all counts in the direction of its height (perpendicular to the direction of dispersion), the width of any line will be **A** ONLY in case that lines are not tilted. In case of any tilt (call this angle α), the projection of the line to the direction of dispersion will be A + B $*$ $\tan\alpha$. If we suggest that α is constant for the different HRS modes, $B * \tan\alpha$ will increase with increase of the ratio B/A, that is exactly the case of HRS, where effect of resolution appears in the way to have more narrow lines with increase of resolution. For

Table 1: Comparison of declared and calculated R for HRS

Mode & Arm	Declared R	Calculated R
(1)	(2)	(3)
LR Blue	15000	16200–15800
LR Red	14000	16450
MR Blue	43000	36500–38500
MR Red	40000	39000
HR Blue	65000	44000–46000
HR Red	74000	47500–45500

example, if we suggest B=2, A=1 and $\alpha = 7°$ for MR the total projection will be 1.25 or 25% worse. In case of HR mode B will be about 4 and the totall projection is 1.49 that is about the case shown in Table 1.

4 Conclusions

I have presented study of FWHM and $R = \lambda/\delta\lambda$ for LR, MR and HR modes of HRS. I have calculated these parameters and show their current distributions for each studied HRS mode. The main conclusion of this report is that the current version of the HRS MIDAS pipeline produces FWHM and R, which are very close to the declared values for LR mode only. Unfortunately, both MR and HR reduced data have distributions of FWHMs and R, that are worse of their declared values. It is only about 10% worse for MR, but it is much worse (about 50%) for HR. Such problem is the result of not taking into account the tilted nature of lines in HRS spectra and has to be the important step for HR and for the future reduction of HS mode as well.

References

Kniazev A. Y., Gvaramadze V. V., Berdnikov L. N., 2016, MNRAS, 459, 3068

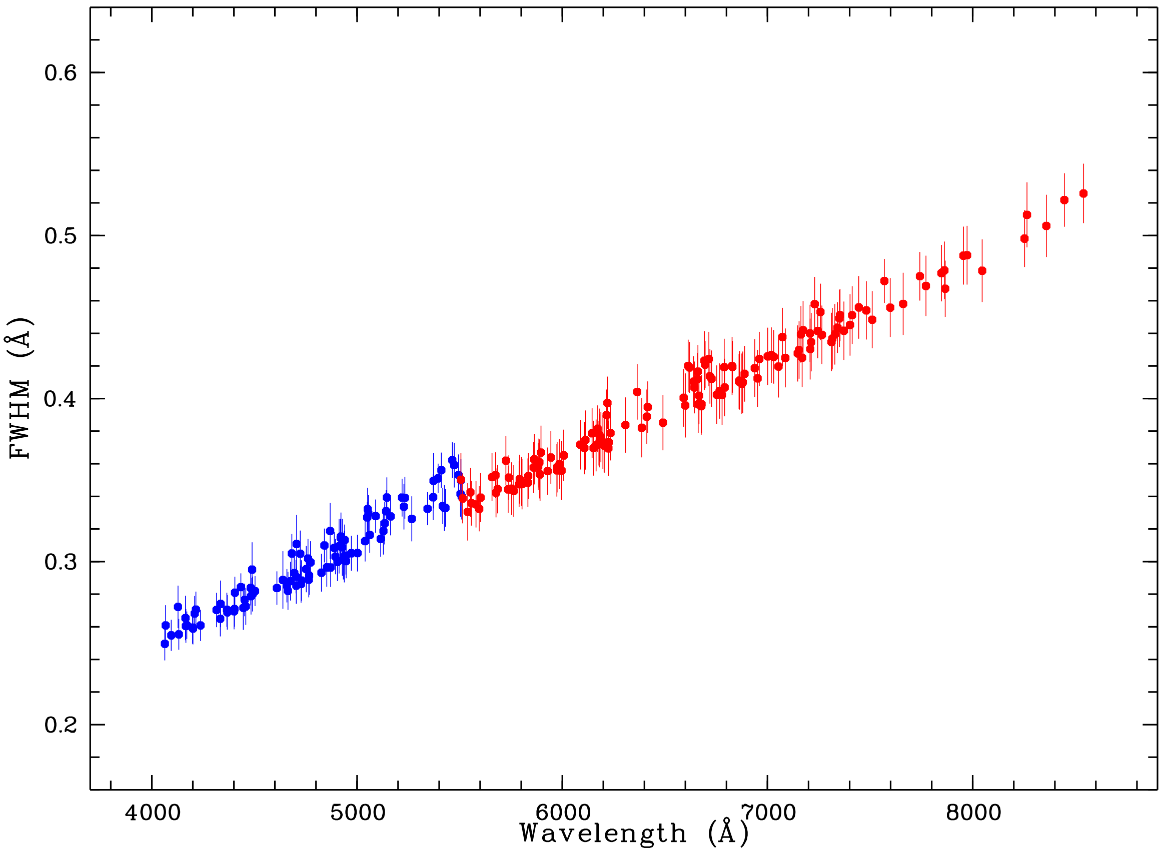

Figure 1: The distribution of FWHM for LR mode. Measurement for the Blue channel are shown with blue color, where measurement for the Red channel are shown with red color. $\pm 1\sigma$ errors each line are shown. Adopted from Kniazev et al. (2018, in preparation).

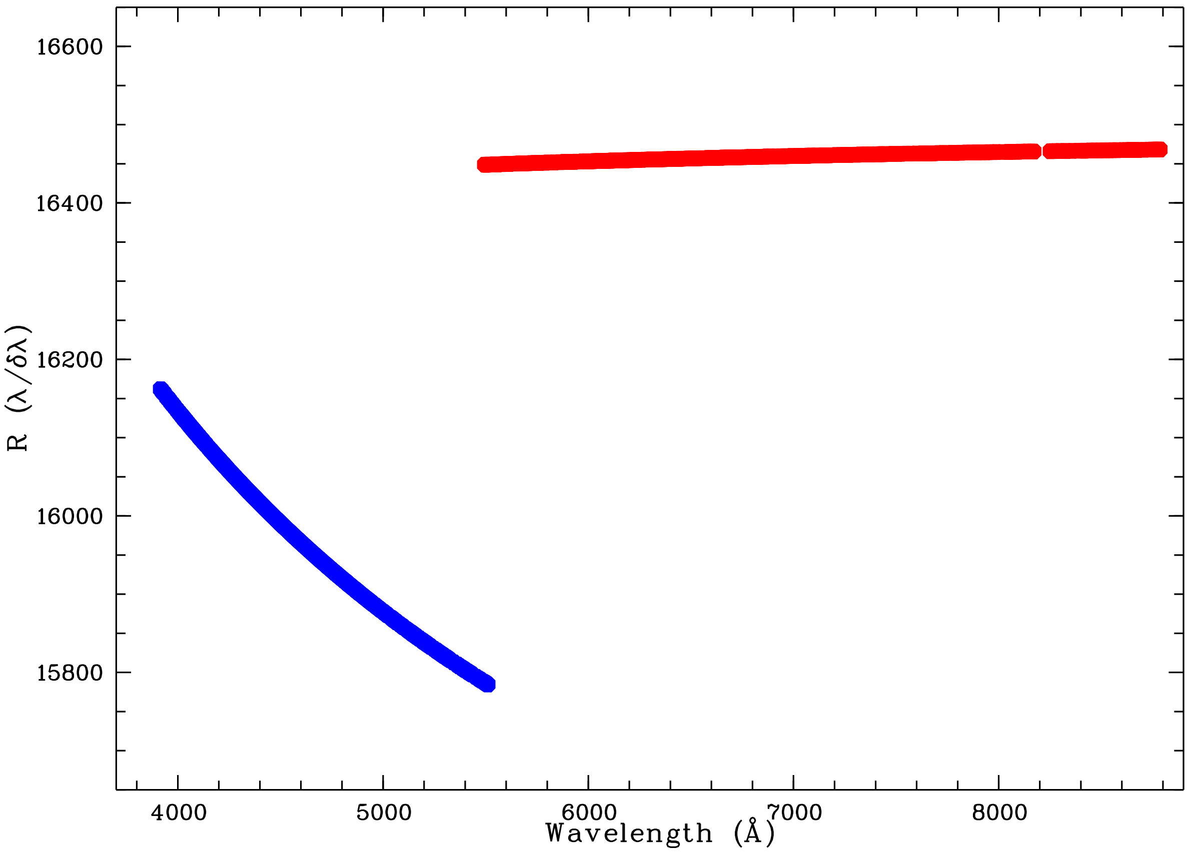

Figure 2: The distribution of $R = \lambda/\delta\lambda$ for LR mode. Measurement for the Blue channel are shown with blue color, where measurement for the Red channel are shown with red color. Adopted from Kniazev et al. (2018, in preparation).

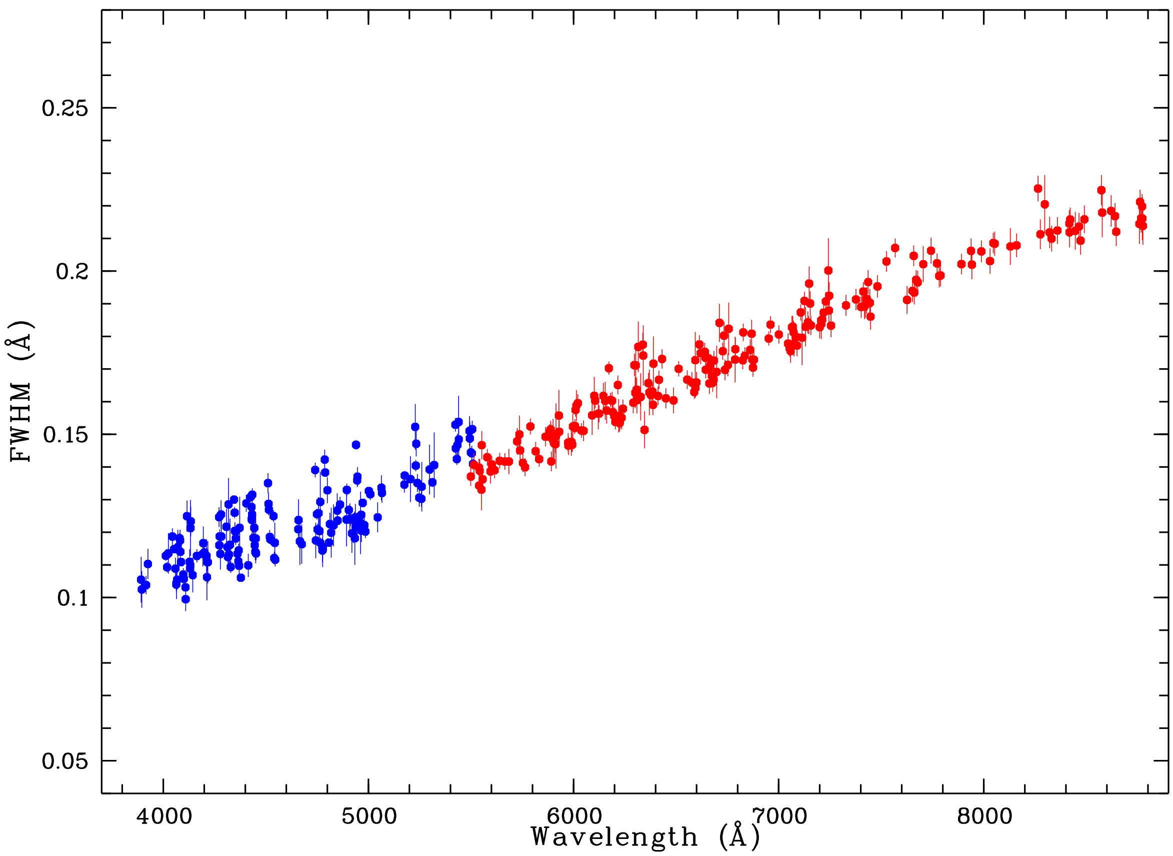

Figure 3: The distribution of FWHM for MR mode. Measurement for the Blue channel are shown with blue color, where measurement for the Red channel are shown with red color. $\pm 1\sigma$ errors each line are shown.

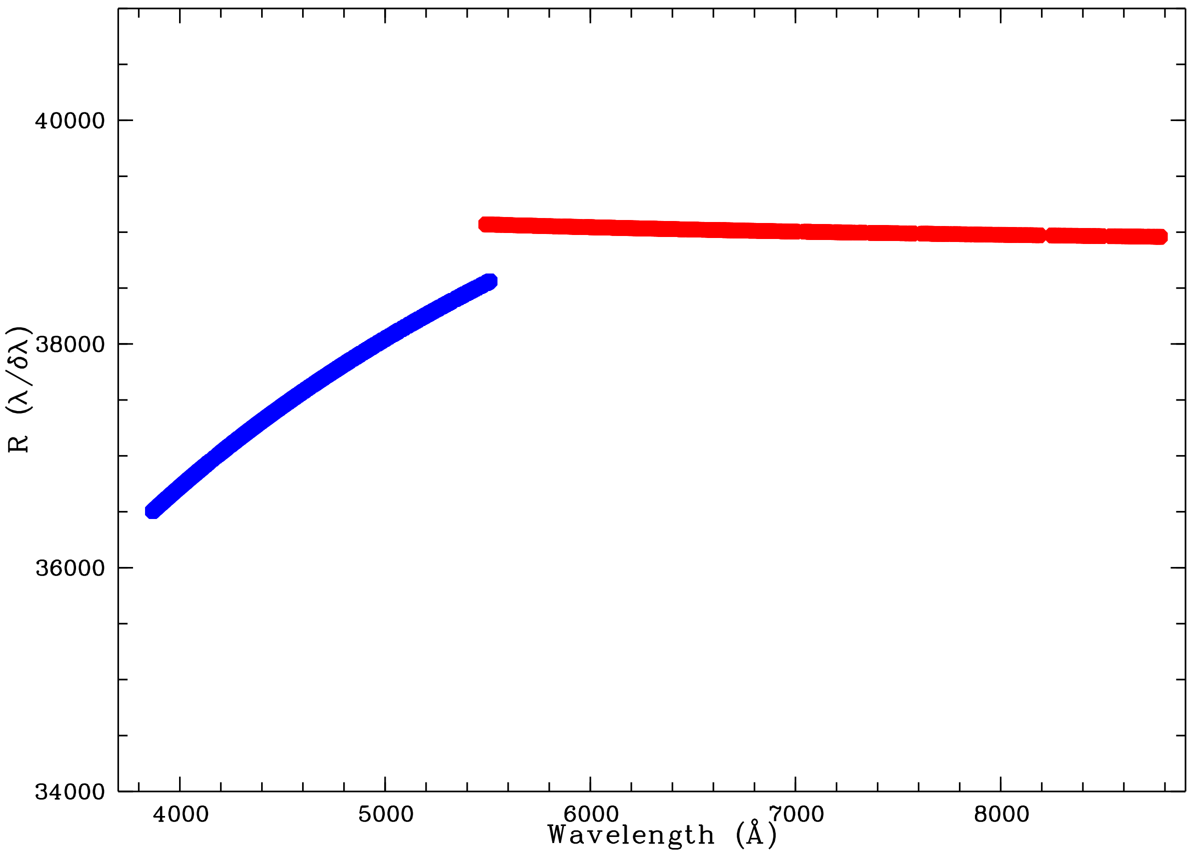

Figure 4: The distribution of R = $\lambda/\delta\lambda$ for MR mode. Measurement for the Blue channel are shown with blue color, where measurement for the Red channel are shown with red color.

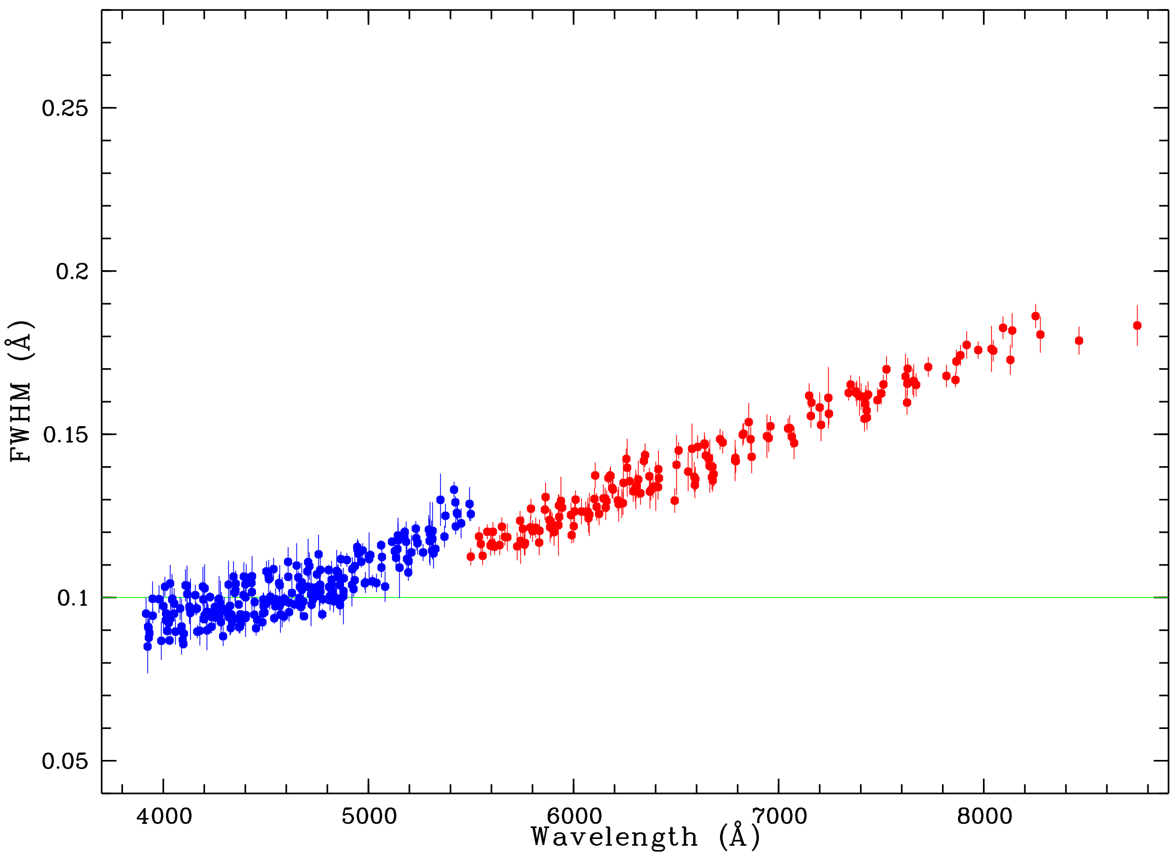

Figure 5: The distribution of FWHM for HR mode. Measurement for the Blue channel are shown with blue color, where measurement for the Red channel are shown with red color. $\pm 1\sigma$ errors each line are shown.

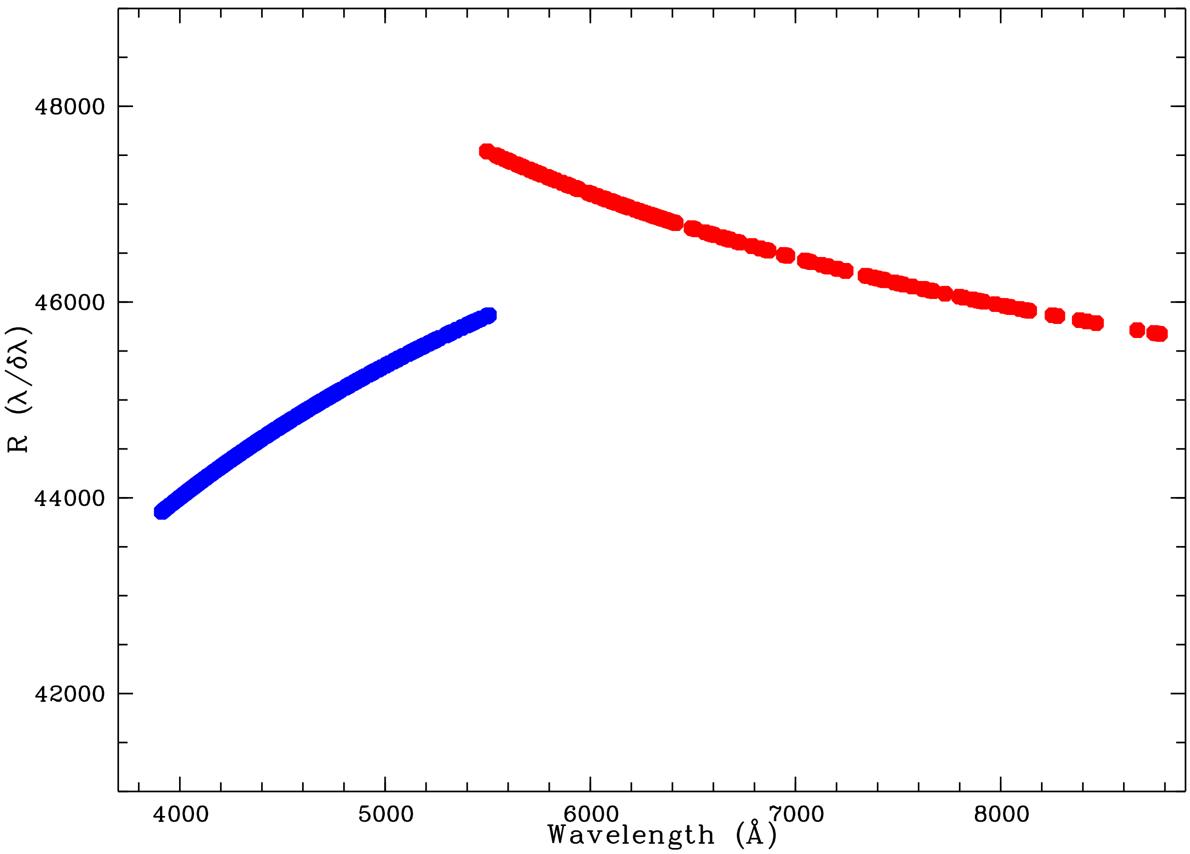

Figure 6: The distribution of R = $\lambda/\delta\lambda$ for HR mode. Measurement for the Blue channel are shown with blue color, where measurement for the Red channel are shown with red color.