Southern African Large Telescope

Title: **RSS gain problems during 2018–2019**

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ABSTRACT

*In this report I present results of my systematic study of RSS gain problems during period 2018–2019. I used ALL available set of flat-fields (427 sets of flats) for RSS spectral observations, that were obtained during studied period. I am showing that SALT science community is **constantly** living with **wrong** RSS CCD mosaic gains which are different from the optimal values **up to 3%** in the most used mode (FAST+SLOW) and **up to 60%** in other modes. Finally, I suggest **the plan** to resolve this issue with **(1)** the past, **(2)** the current and **(3)** the future RSS data.*

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1 Introduction

RSS CCD mosaic consist of six different CCD amplifiers. Generally, we know that some problems exist related to the stability of work all these amplifies together. These problems appeared as different amount of effects during all years of work with this mosaic. Some of these problems were fixed and never appeared again, where others exist up to now. One of the very important is an effect of sudden gain variations with time for each amplifier, which results to the difference of background levels of amplifiers for RSS CCD mosaic after the standard gain correction procedure.

Additional comment to those people who DOES NOT FILL the problem – **the error of 1% in the measurement of emission line flux in the high quality scientific spectrum results to the final error up to 5–10 TIMES of determinations of abundances of chemical elements. After that ALL TIME such an astronomer spent on the proposal writing, Phase 2 filling and submission, data reduction, data analysis and paper writing is ... big amount of trash.** I do not want to say that all such taken data are crap, but there are a lot of scientific areas, where such types of errors are crucial.

It is well known that for RSS CCD mosaic gain variates sometime during some hours, so the standard procedure of gain re-calibration does not help, generally say. Fortunately, since the absolute flux calibration is not feasible with SALT, someone can try to correct the level of each amplifier multiplying it to some coefficient to make background level uniform for all amplifiers.

So, in my previous report I presented very simple algorithm to check correctness of used gains for the RSS CCD mosaic. In this report I make study of the used gains values that were measured using standard software which was developed by Steve Craword (SC hereafter). The result of such study, please, see below.

2 Suggestions

First, I would like to repeat THE MAIN suggestions of my following analysis:

1. I suggest that all Gain-correction coefficients between different amplifiers are THE SAME in Y-direction (along columns)

2. I suggest that the gain for the **THIRD** amplifier (#3) **is correct**. All others gains needs to be corrected to the Amplifier #3.

Selection of the **correct** Amplifier is NOT random. Since the final error for each next Amplifier is the sum of errors, it is much better to select Amplifier #3 or #4 as the **correct** one. In this case, for example, the final error for the $\#1 = \sqrt{(\#12^2 + \#23^2)}$, where #23 - is the error of the gain-correction coefficient determination between Amplifiers #3 and #2, and #12 - is the error of the gain-correction coefficient determination between Amplifiers #2 and #1.

3 Setting the Task

To detect possible variations of gains values for the RSS CCD mosaic I used, first, MIDAS implementation of the algorithm I presented in my previous report (Kniazev, 2019). Wrapping up this MIDAS program and some additional IRAF tasks into UNIX Shell script I was able in short time (about five working days) develop software, which goes over the requested range of dates at SALT archive and produces next steps:

1. Analyse all observed RSS files obtained during the specific date and creates the list of flats in case they exist;

2. Group the list of taken flats into amount of sub-groups on the base of used gain mode, read-out mode, binning and time;

3. Average each sub-group with median to reject possible cosmic and producing master-flat for this group of flats;

4. Analyse each this master-flat with algorithm from Kniazev (2019);

5. Writing all calculated gain-correction coefficients into FITS-table, adding errors for each gain-correction coefficient, name of the first flat in this group, gain mode, read-out mode, binning and Julian Date (JD hereafter) of the first flat. Result of analysis of one set of flats uses one row of this table.

4 Following Analysis

The final analysis could be done looking into Figures 1–5. Each figure shows gain-correction coefficients for one Amplifier of the RSS CCD mosaic during period 2018–2019. Each black point shows gain-correction coefficient calculated for one set of flats. The errors for each calculated coefficient are shown with vertical bars. Only those points are used where errors for gain-correction coefficient are less of 0.05% of the level 1. The correction coefficient 1 (studied gain is correct) is shown with horizontal solid black line. The vertical green dash-dot lines shows start and end of 2018 and 2019 years. The vertical magenta long-dash lines shows dates when recalculations of gains using standard software was done. The last set of such gain calculations was done on 20181008 and these gains we are using currently. The average level of gain-correction coefficient **after** 20181008 is shown with the horizontal red line, where its rms are shown with horizontal blue short-dash lines.

As it is possible to see from all these figures, even before the middle of 2018 gains for **many** amplifiers WERE NOT correct. Anyway, in the middle of 2018 astro-team started active games to understand the procedure to calculate correct gain values on the base of standard RSS gain-calibrations. Huge amount of vertical magenta lines reflects the fact, that new calculated gain values results to the different non-uniform amplifier's levels and the standard RSS gain-calibrations procedure was started again and again. Additional problem was that the standard software from SC's legacy DID NOT WORK AT ALL and Dr. Itu

Monagen make a huge effort trying to identify error in the python code. In two weeks time the code was fixed and we were able to calculate new gain values, but it does not help to the general problem of using WRONG gain values as the result of using "legacy code".

As a result of my analysis I present Table 1, where I show currently used gain values for different amplifiers and different modes, my calculated gain-correction coefficients with their errors calculated during the same period of time **after** 20181008 and the final "true" gain values as multiplication of the current values and calculated corrections. Correction coefficient 1. means that used gain value is correct for 100%. Coefficient 1.01 means that difference from the correct value is 1%. Coefficient 1.593 means that difference from the correct value is 59%.

5 Who's to Blame and What Is to Be Done?

This section title cinsist of **TWO MAIN** question of all Russian people and was discussed a lot in the Russian classical literature. For those readers who could be interested, please read couple of paragraphs in the Appendix section, where I tried to summarise some initial steps of this large philosophical problem. Unfortunately, I do not have space to discuss in details all aspects of this problem in this report... :-).

6 The Final Notes and Subsequent Steps

Looking into presented Figures I am suggesting that we POSSIBLY see the mixture of two problems there:

- The current "SC's legacy code" for the determination of gains values is not accurate enough and we have final numbers with large but unknown uncertainties. These uncertainties are much large we would like to have. As I know, this code NEVER been tested or results of of such tests never been shown to astro-obs.

  So, to solve this problem, ideally, we need a new code, which has to be developed and properly tested.

- Unfortunately, independent from the problem one, amplifiers of the RSS CCD mosaic shows random variation of gain values, which is **impossible** to correct with knowledge of global correct gain values only.

  I suggest that many points that are located outside of the general trend could belong to this situation but I did not check them yet.

From all above I suggest some steps to correct this problem for old, current and future RSS data:

1. I would suggest to replace currently used gain values with the final gain values presented in this report (Table 1). This step will correct all current global shifts during our primary reduction I believe.

2. Unfortunately, this step will not prevent us from the problem of random variations of gain values. From my personal point of view, the most safe way is to observe flats at the end of each observational block to check its level during primary reduction. We can advice this to all SALT users during Phase2.

3. Each time we need to re-calibrate the RSS CCD mosaic gains we need to use the current "legacy code" and intensively check its numbers with sets of flats obtains specifically for the correction of this problem. The creation of a new gain-calculation code is desirable, but not necessary.

4. For the previously taken RSS data we either can describe gain problem to the SALT community, where we need to say that it could relate to all/many previously taken RSS data. Otherwise, we can just try to CORRECT all these data by ourself in this or that way.

References

Kniazev A. Y., 2019, SALT report RSS0000019, 1

A "Who is to blame?" and "What is to be done?" – the psychological underlying theme of two important Russian questions

There are two famous Russian questions – "Who is to blame?" and "What is to be done?". They became well known phrases of Russian literature and Russian mentality in general. It is believed that these questions point to the moralism of Russian mentality, concern for its moral problems ("practical reason", according to Kant), and at the same time they refer to the issues of social order. The increased moralism of the Russian mentality was reflected in this super-personal appeal, in the concern for the general destinies, especially the fate of the people. In this connection, there is talk of moral socialism, of moral justification of socialist ideology in Russia. This applies only to "Russian", that is, folk or peasant, or - in Marxist terms - to utopian socialism, which sought and found moral justification in the so-called subjective sociology (Mikhailovsky). Subjective in this context means moral, based on the will of man, on the demands of his moral mentality, and not on any kind of objectivistic or quasi-scientific substantiation, with a claim to what Marxism has claimed to have done, marking a radical change of the socialist paradigm. All this is well known, and I returned to these subjects only to remind the context in which the famous formulas of Russian literature were considered, and to take them out of this context, or rather to return them to their true context.

The questions "Who is to blame?" and "What is to be done?" are, first of all, very concrete: these are the names of two Russian novels written by Herzen and Chernyshevsky,

Table 1: Gains for the different RSS CCD amplifiers

Amplifier Number (1)	Current gain values calculated by existed programs (2)	Corrections calculated in this work (3)	The final gain values (4)
	SLOW *** FAINT		
#1	1.590±unknown	1.009±0.007	1.604±0.007
#2	1.730±unknown	0.968±0.006	1.675±0.006
#3	1.710±unknown	1.000±0.000	1.710±0.000
#4	1.620±unknown	1.011±0.004	1.638±0.004
#5	1.560±unknown	0.991±0.009	1.546±0.009
#6	1.490±unknown	1.000±0.010	1.490±0.010
	SLOW *** BRIGHT		
#1	3.620±unknown	1.002±0.002	3.627±0.002
#2	3.810±unknown	0.994±0.006	3.787±0.006
#3	3.880±unknown	1.000±0.000	3.880±0.000
#4	3.570±unknown	1.043±0.002	3.724±0.002
#5	3.540±unknown	0.995±0.002	3.522±0.002
#6	3.330±unknown	1.021±0.002	3.340±0.002
	FAST *** FAINT		
#1	3.000±unknown	0.990±0.002	2.970±0.002
#2	3.190±unknown	0.974±0.002	3.107±0.002
#3	3.170±unknown	1.000±0.000	3.710±0.000
#4	2.900±unknown	1.044±0.002	3.028±0.002
#5	2.860±unknown	0.997±0.002	2.851±0.002
#6	2.710±unknown	1.022±0.003	2.770±0.003
	FAST *** BRIGHT		
#1	11.530±unknown	1.019±0.002	11.749±0.002
#2	10.900±unknown	1.045±0.002	11.391±0.002
#3	11.810±unknown	1.000±0.000	11.810±0.000
#4	7.490±unknown	1.593±0.003	11.932±0.003
#5	10.040±unknown	0.980±0.003	9.839±0.003
#6	7.440±unknown	1.295±0.003	9.635±0.003

respectively. If we go back from the general considerations of the fate of Russian socialism to these novels and their authors, it seems to me that we will be able to deepen the understanding of this very socialism - to find out its very interesting psychological roots.

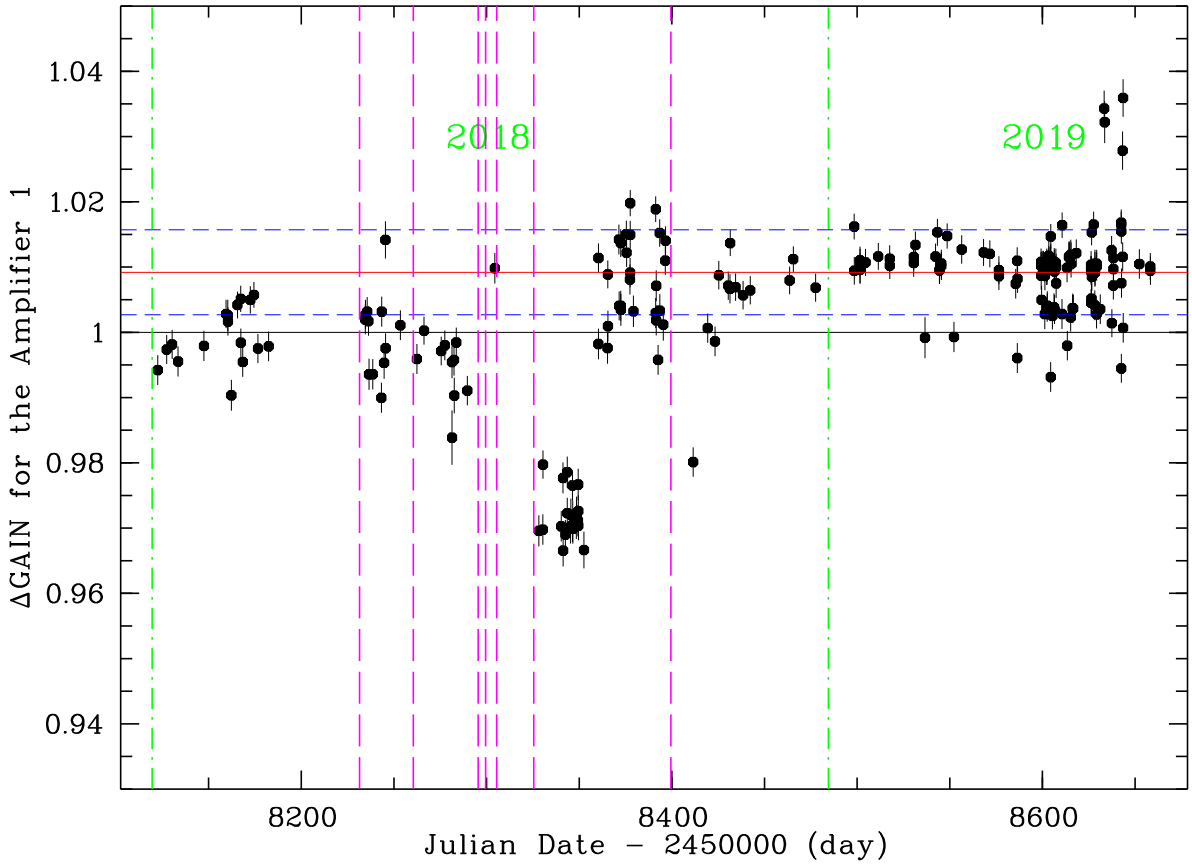

Figure 1: The Gain-correction coefficient for the Amplifier #1 depending on the time during period 2018–2019. Each black point shows gain-correction coefficient calculated for one set of flats. The errors for each calculated coefficient are shown with vertical bars. Only those points are shown where errors for gain-correction coefficient are less of 0.05%. The correction coefficient 1 (studied gain is correct) is shown with horizontal solid black line. The vertical green dash-dot lines shows start and end of 2018 and 2019 years. The vertical magenta long-dash lines shows dates when recalculations of gains using standard software from SC's legacy was done. The last set of such gain calculations was done on 20181008 and these gains we are using currently. The average level of gain-correction coefficient **after** 20181008 is shown with the horizontal red line, where its rms are shown with horizontal blue short-dash lines. The average level is about 1% out of the correct value 1.

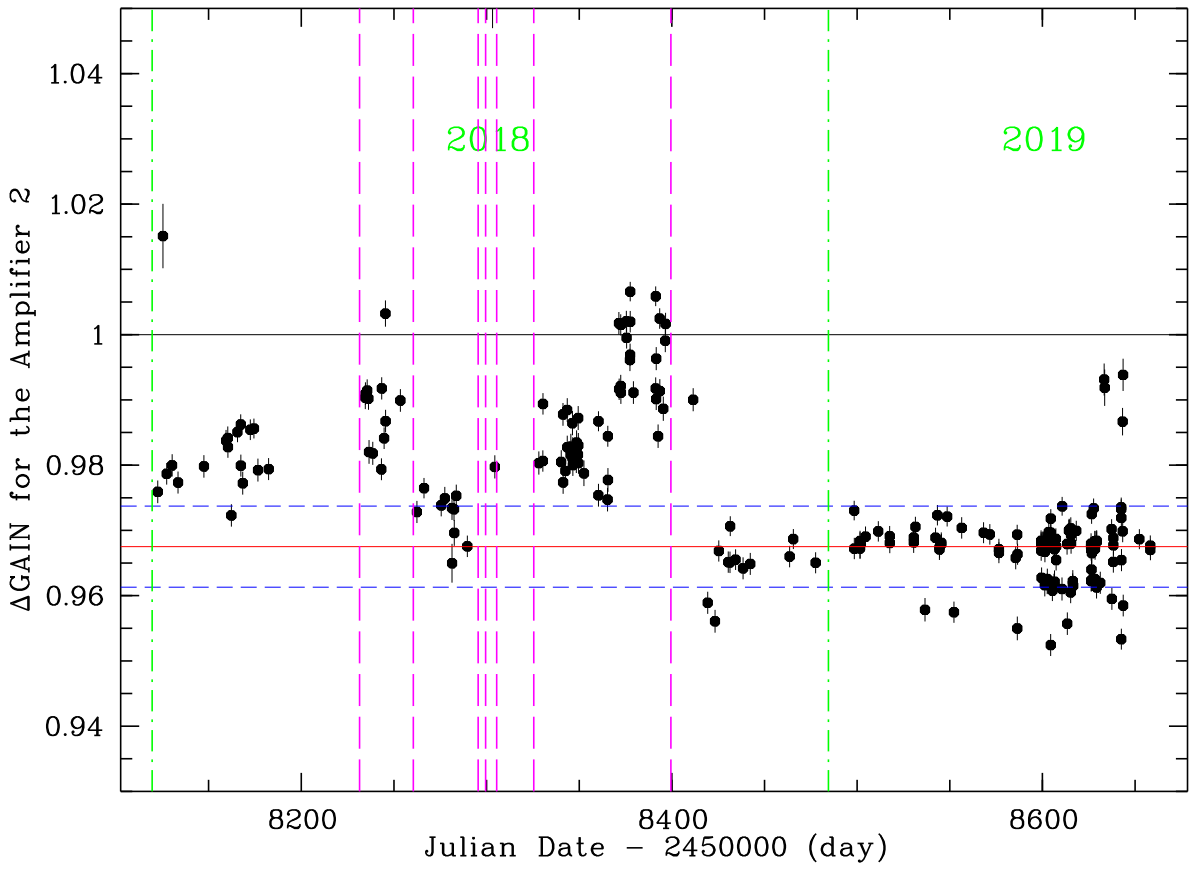

Figure 2: The Gain-correction coefficient for the Amplifier #2 depending on the time during period 2018–2019. See description from Figure 1 for more details. The average level is about 3.3% out of the correct value 1.

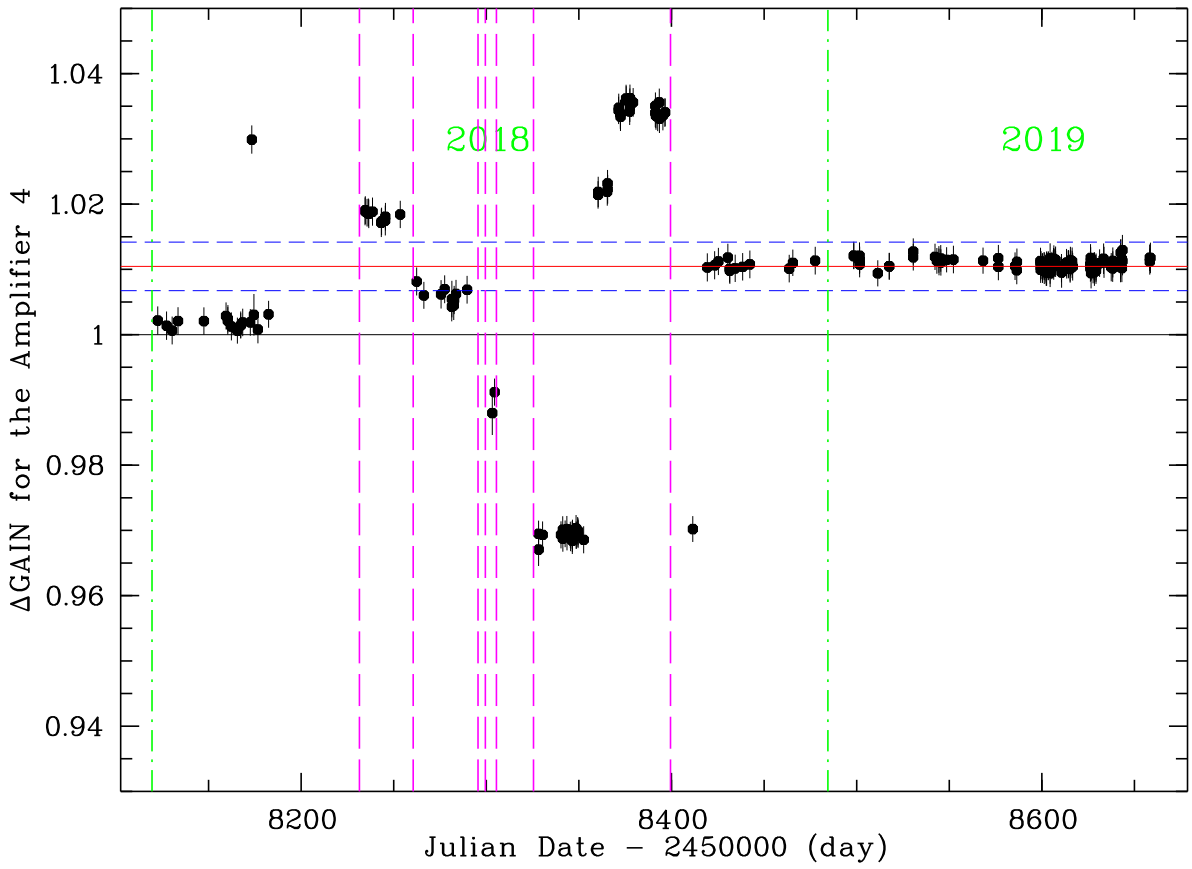

Figure 3: The Gain-correction coefficient for the Amplifier #4 depending on the time during period 2018–2019. See description from Figure 1 for more details. The average level is about 1% out of the correct value 1.

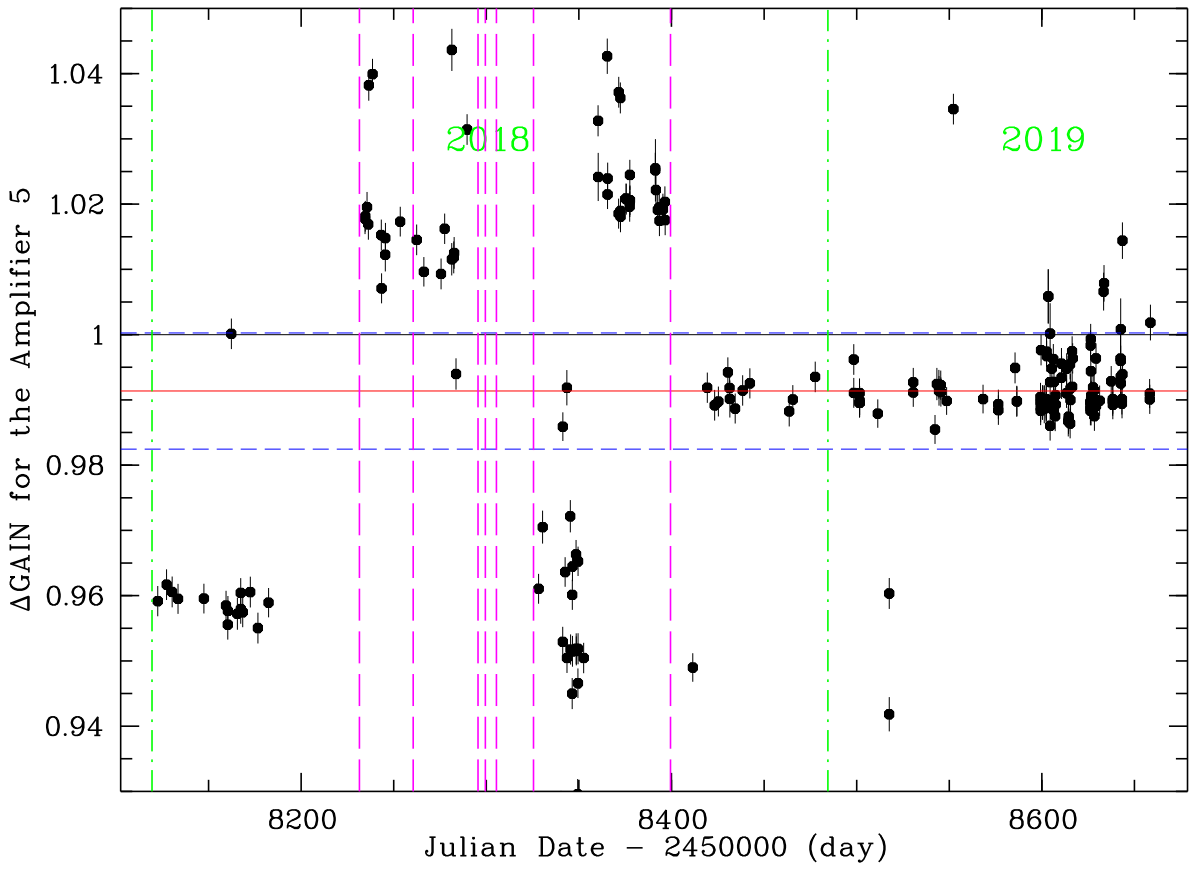

Figure 4: The Gain-correction coefficient for the Amplifier #5 depending on the time during period 2018–2019. See description from Figure 1 for more details. The average level is about 1% out of the correct value 1.

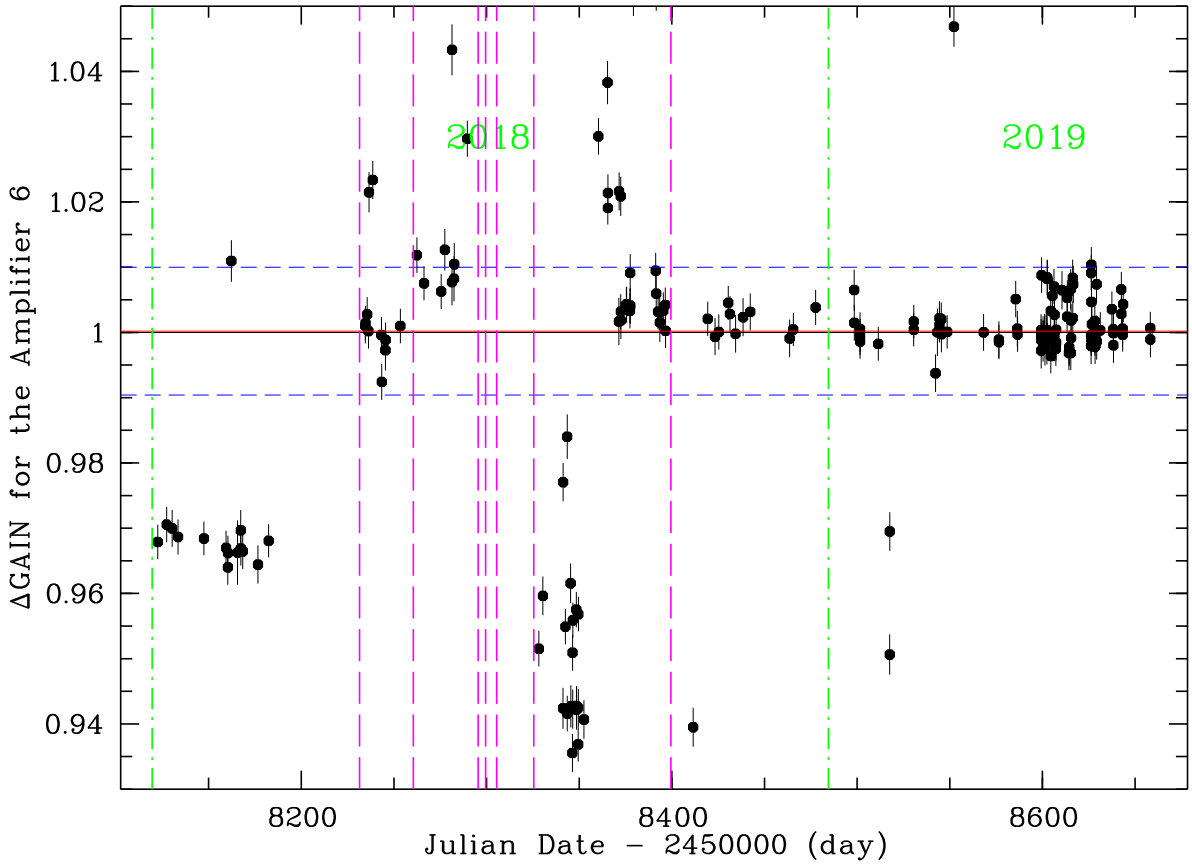

Figure 5: The Gain-correction coefficient for the Amplifier #6 depending on the time during period 2018–2019. See description from Figure 1 for more details. The average level is coinciding with correct value 1.