Southern African Large Telescope

Title: RSS CCD mosaic gains up to now

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ABSTRACT

In this report I present results of my systematic study of the RSS CCD mosaic gains starting from 2012 year. I used all available sets of flat-fields (∼4600 sets of flats) for RSS spectral observations, that were obtained during studied period. With the analysis of these flats I show that SALT science community used not very correct gains ***(sometimes up to 5–6% level)*** *most of the time till the middle 2019. The situation was changed starting from the middle of 2019 year and up to now the* ***RELATIVE*** *gain levels are within 0.5% accuracy for the most of RSS data. To reduce RSS science data obtained during 2012–2019 years I recommend either to use my database of the gain correction coefficients* ***or*** *to advice PIs to calculate such corrections for the each RSS observational block using flats.*

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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 RSS 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 calibration procedure.

In my previous reports (Kniazev 2019a,2019b) I presented simple algorithm to check correctness of used gains for the RSS CCD mosaic and make study of the used gain values during 2018–2019 years. In this study I report about situation with gains of the RSS CCD mosaic during practically the whole period of official observations with RSS starting from 2012 year and show its current state.

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 the Amplifier #3 or #4 as the **correct** one. In this case, for example, the final error for the #13 = $\sqrt{\#12^2 + \#23^2}$, 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, 2019a). Wrapping up this MIDAS program and some additional IRAF tasks into UNIX Shell script I have developed software, which goes over the requested range of dates at SALT archive and produces following steps:

1. All observed RSS files obtained during the specific date analysed and creates the list of flats in case they were observed;
2. All taken flats are grouped into amount of sub-groups on the base of used gain mode, read-out mode, binning and time;

3. Each sub-group is averaged using median to reject possible cosmic and master-flat for this group of flats is created;

4. Each master-flat is analysed using algorithm from Kniazev (2019);

5. All calculated gain-correction coefficients are written into FITS-table, with their errors, the name of the first flat in this group, the gain mode, the read-out mode, the binning and Julian Date (JD hereafter) of the first flat. Result of analysis of one set of flats is written in one row of this FITS-table.

4 Following Analysis

The final analysis could be done looking into Figures 1–8. Figures 1–5 show gain-correction coefficients for one Amplifier of the RSS CCD mosaic during period 2012–2020 in the most used FAINT+SLOW mode. 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 than 0.05% of the level 1. The correction coefficient 1 is shown with the horizontal solid black line and shows the situation when the studied gain is correct and does need any additional correction. The vertical green dash-dot lines show start and end of each year. The vertical blue dash-dot line shows the date of the gains modifications with use of the algorithm described by Kniazev (2019). The average level of gain-correction coefficient **after** this date and up to now is shown with the horizontal red line and 1σ rms are shown with horizontal blue short-dash lines. Figures 6–8 show gain-correction coefficients for all Amplifiers, but for one mode from BRIGHT+FAST or BRIGHT+SLOW or FAINT+FAST during the same period 2012–2020.

As it is possible to see from all these figures, before the middle of 2019 gains for **many** amplifiers were not correct and the difference from the level 1. was sometimes up to 5–6% depending on the observational mode and amplifier. Usually gains changed with jumps for all amplifiers, but values of these jumps were different for all gains. It looks to me that all these jumps correlates with dates of gain checks by the SALT Astronomy Operations team, that correlates with technical problems of RSS CCD or the technical interventions to RSS CCD. Altogether it means that previously used algorithm for the RSS CCD gains calculations **is either not very correct or produces not enough accuracy**.

5 Conclusions

I see three main conclusions from my work:

1. Generally say, the RSS CCD gain values used for the science data reduction were not correct **most of the time** during 2012–2019 years and started to be correct after middle 2019. Unfortunately, even after that time there are some flats showing jumps in gains up to 2% that means the SALT Astronomy Operations team bf needs to advise to all PIs to include flats observations in each their block of observations with RSS mosaic

during Phase 2 in case their science depends on the knowledge of the background level with accuracy better of 5%.

2. To reduce RSS science data obtained during 2012–2019 years I recommend either to use my database of the gain correction coefficients **or** to advice PIs to calculate such corrections for the each RSS observational block using flats.

3. We (the SALT Astronomy Operations) need to study the way of re-determination of the absolute gain values for the RSS CCD mosaic.

References

Kniazev A. Y., 2019a, SALT report RSS0000019, 1
Kniazev A. Y., 2019b, SALT report RSS0000020, 1

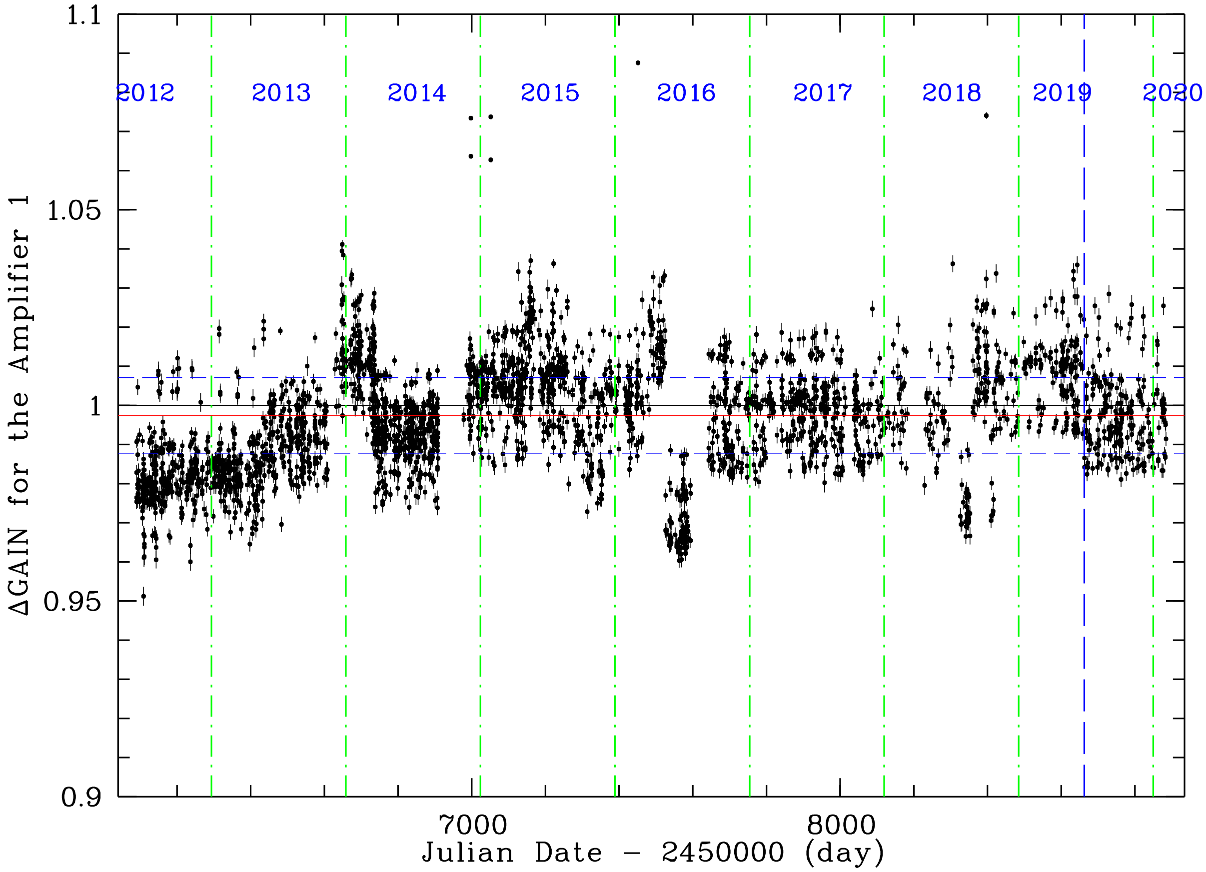

Figure 1: The Gain-correction coefficient for the Amplifier #1 for the FAINT+SLOW mode depending on the time during period 2012–2020. Each black point shows gain-correction coefficient calculated for one set of flats. The errors for each calculated coefficient are shown with vertical bars. Only those points are shown where errors for gain-correction coefficient are less of 0.05%. The correction coefficient 1 is shown with the horizontal solid black line and shows the situation when the studied gain is correct and does need any additional correction. The vertical green dash-dot lines show start and end of each year.

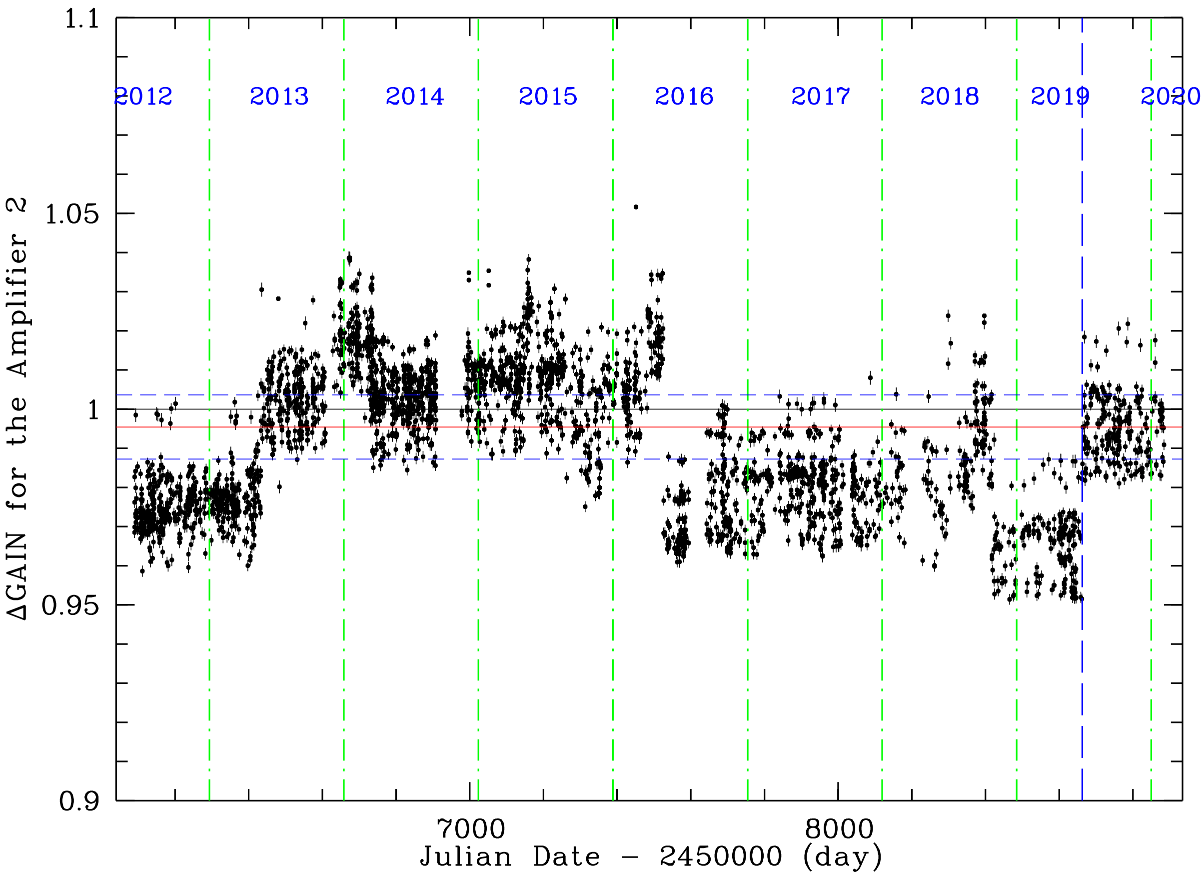

Figure 2: The Gain-correction coefficient for the Amplifier #2 for the FAINT+SLOW mode depending on the time during period 2012–2020. Each black point shows gain-correction coefficient calculated for one set of flats. The errors for each calculated coefficient are shown with vertical bars. Only those points are shown where errors for gain-correction coefficient are less of 0.05%. The correction coefficient 1 is shown with the horizontal solid black line and shows the situation when the studied gain is correct and does need any additional correction. The vertical green dash-dot lines show start and end of each year.

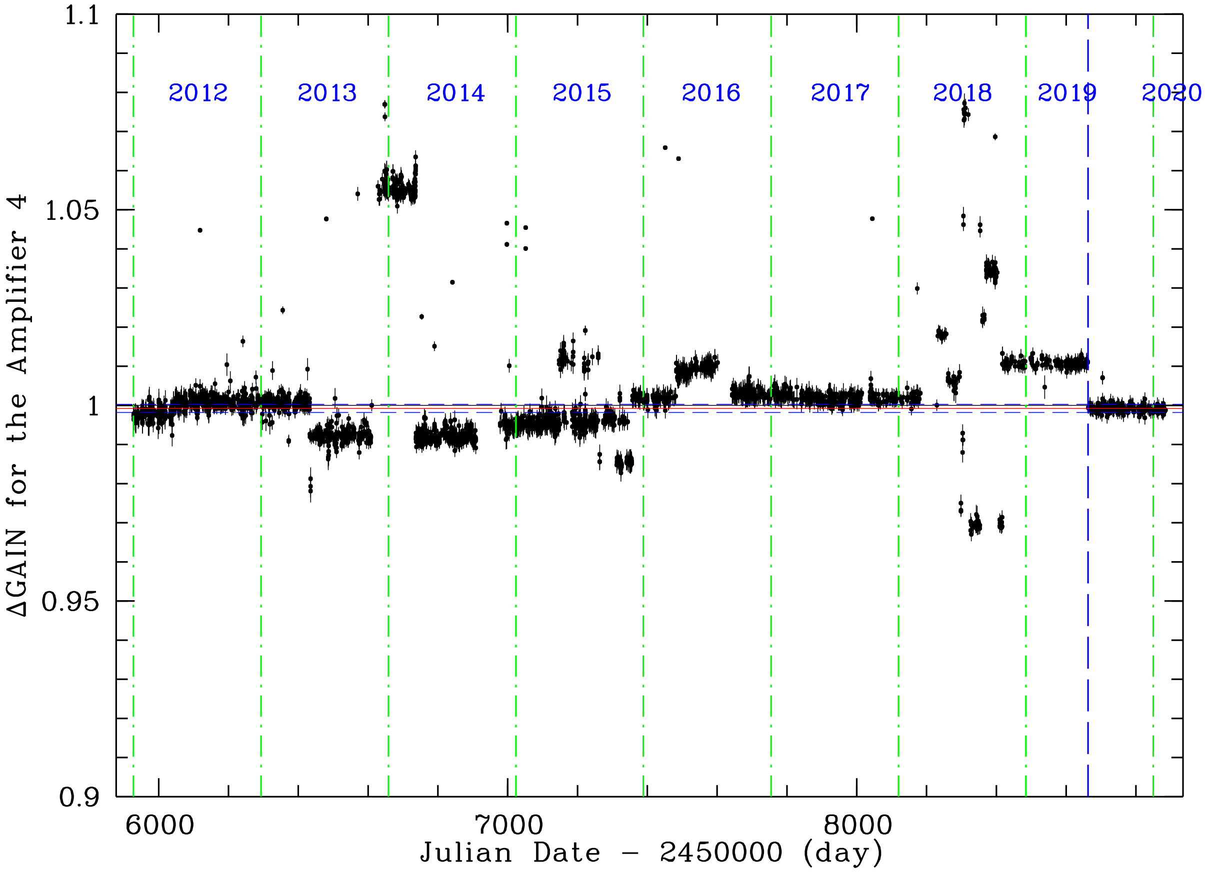

Figure 3: The Gain-correction coefficient for the Amplifier #4 for the FAINT+SLOW mode depending on the time during period 2012–2020. Each black point shows gain-correction coefficient calculated for one set of flats. The errors for each calculated coefficient are shown with vertical bars. Only those points are shown where errors for gain-correction coefficient are less of 0.05%. The correction coefficient 1 is shown with the horizontal solid black line and shows the situation when the studied gain is correct and does need any additional correction. The vertical green dash-dot lines show start and end of each year.

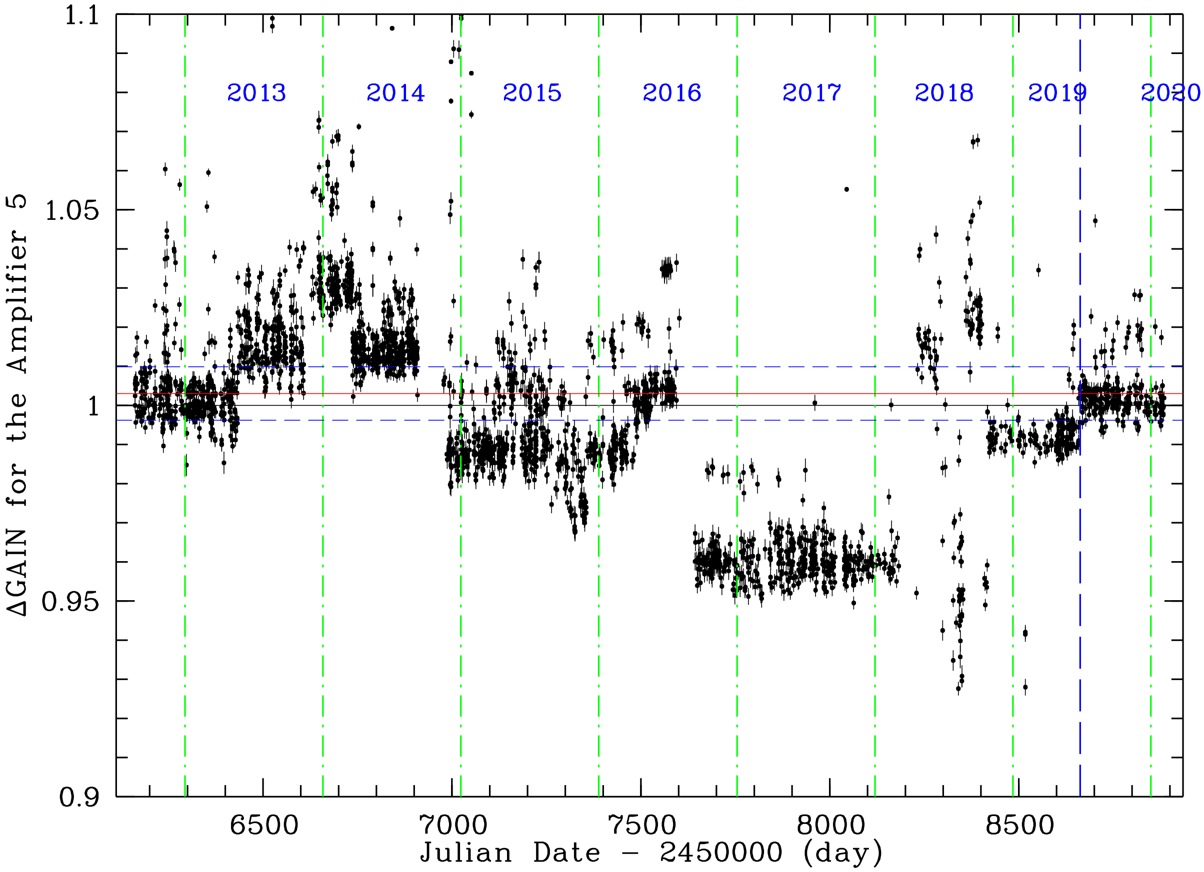

Figure 4: The Gain-correction coefficient for the Amplifier #5 for the FAINT+SLOW mode depending on the time during period 2012–2020. Each black point shows gain-correction coefficient calculated for one set of flats. The errors for each calculated coefficient are shown with vertical bars. Only those points are shown where errors for gain-correction coefficient are less of 0.05%. The correction coefficient 1 is shown with the horizontal solid black line and shows the situation when the studied gain is correct and does need any additional correction. The vertical green dash-dot lines show start and end of each year.

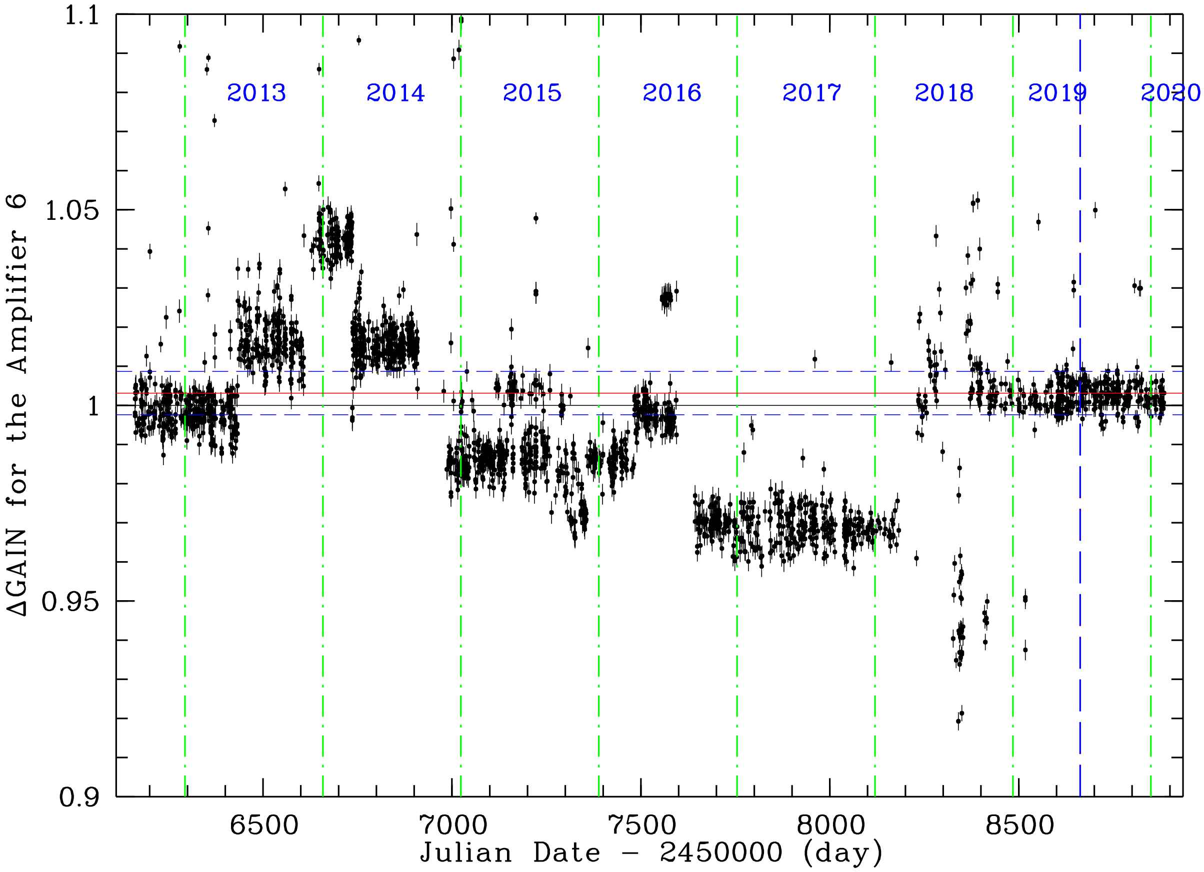

Figure 5: The Gain-correction coefficient for the Amplifier #6 for the FAINT+SLOW mode depending on the time during period 2012–2020. Each black point shows gain-correction coefficient calculated for one set of flats. The errors for each calculated coefficient are shown with vertical bars. Only those points are shown where errors for gain-correction coefficient are less of 0.05%. The correction coefficient 1 is shown with the horizontal solid black line and shows the situation when the studied gain is correct and does need any additional correction. The vertical green dash-dot lines show start and end of each year.

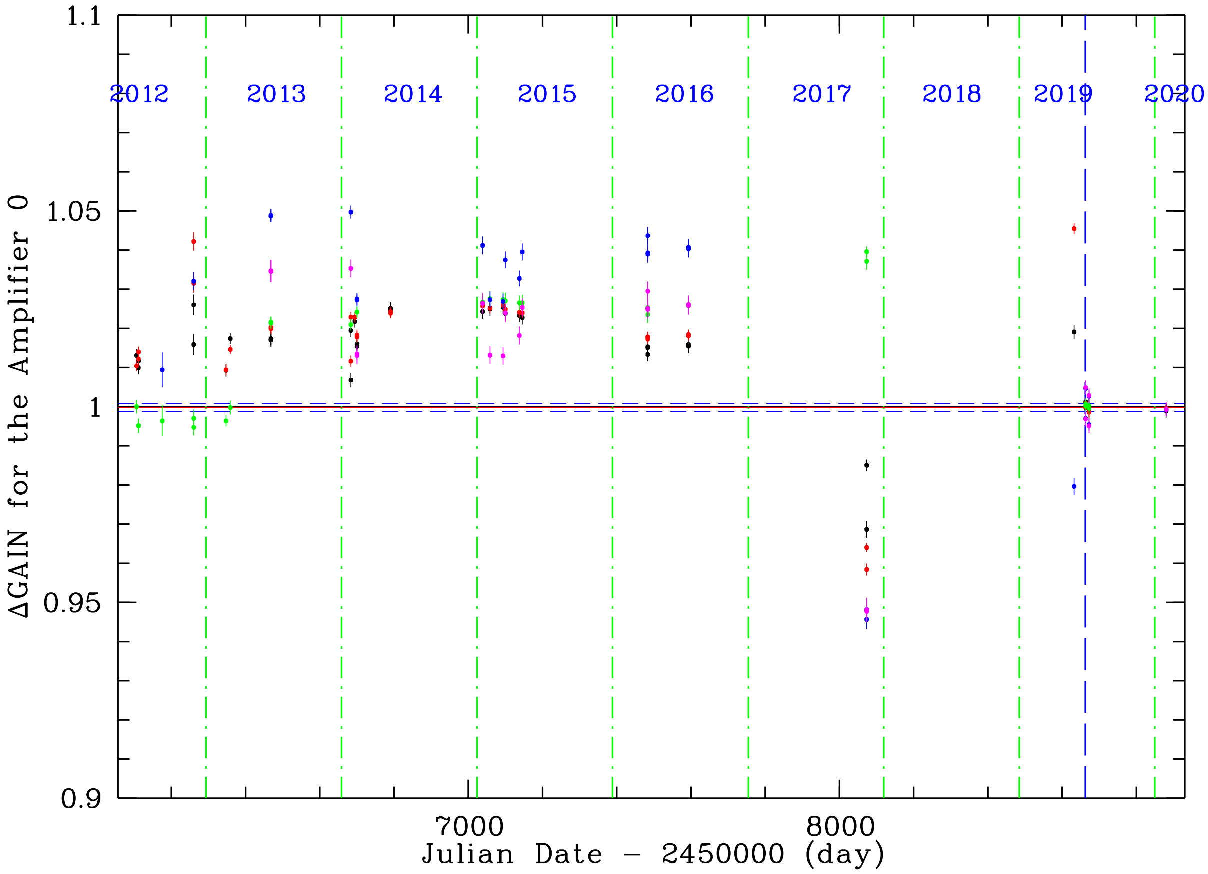

Figure 6: The Gain-correction coefficient for the Amplifiers #1–#6 for the BRIGHT+FAST mode depending on the time during period 2012–2020. Designations are the same as in Figures 1–5, except that data for each amplifier are shown with different colors: #1 is black, #2 is blue, #4 is green, #5 is red and #6 is magenta.

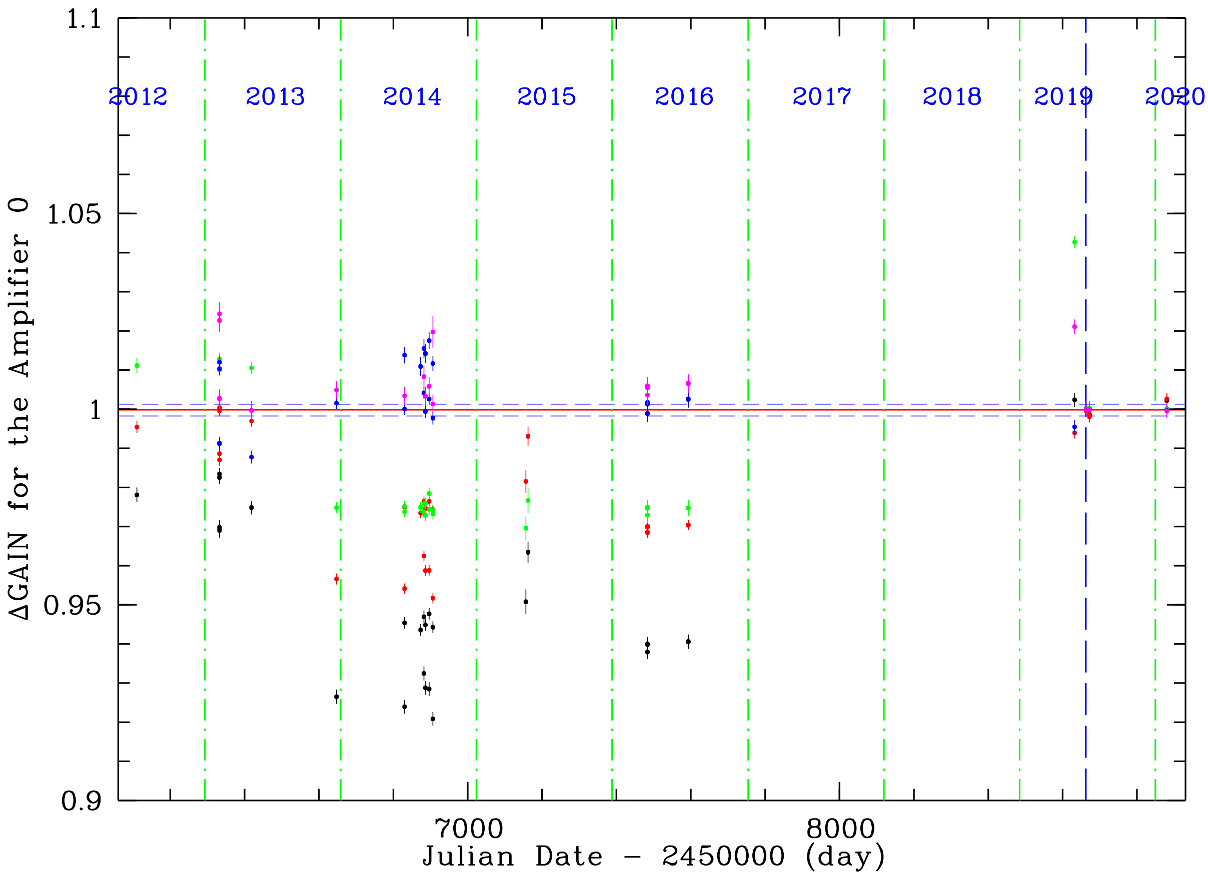

Figure 7: The Gain-correction coefficient for the Amplifiers #1–#6 for the BRIGHT+SLOW mode depending on the time during period 2012–2020. Designations are the same as in Figures 1–5, except that data for each amplifier are shown with different colors: #1 is black, #2 is blue, #4 is green, #5 is red and #6 is magenta.

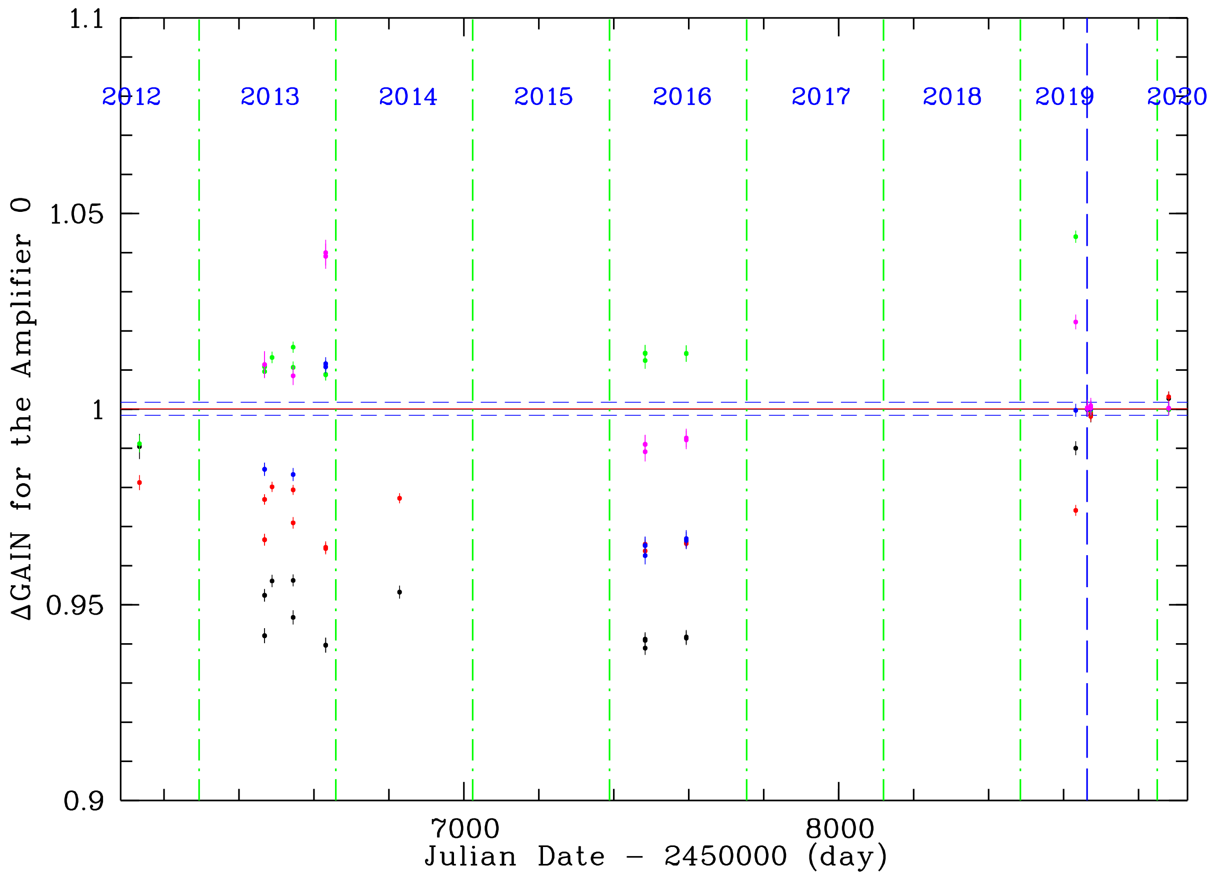

Figure 8: The Gain-correction coefficient for the Amplifiers #1–#6 for the FAINT+FAST mode depending on the time during period 2012–2020. Designations are the same as in Figures 1–5, except that data for each amplifier are shown with different colors: #1 is black, #2 is blue, #4 is green, #5 is red and #6 is magenta.