

Date: November 9, 2020
From: John ZuHone and the ACIS Operations Team
To: Chandra Operations Team
Subject: Raising the 1DEAMZT Planning, Yellow, and Red Limits

1 Abstract

Two of the thermal limits which affect tail-Sun attitudes on the *Chandra* spacecraft are those of 1DPAMZT and 1DEAMZT, which are thermistors on the +Z-side of the DEA and DPA electronics boxes. The 1DPAMZT thermal limits have been raised on several occasions, as it is the more restrictive of the two temperatures. The ACIS Operations team has determined that further increases to the 1DPAMZT limit will necessitate increases to the 1DEAMZT limit as well, since they are both affected by solar heating at the same attitudes. In this case, raising all three limits—planning, caution/yellow, and warning/red, will be required. This memo outlines the proposed limit increases, the reasoning behind them, and the evidence supporting the safety of taking this action.

2 Introduction

The deteriorating thermal situation on the *Chandra* spacecraft requires the occasional raising of thermal limits, as permitted by considerations from previous thermal testing of components. One of the more restrictive thermal limits at tail-Sun attitudes is that of 1DPAMZT, a thermistor on the +Z-side of the Digital Processor Assembly (DPA) box on ACIS. The DPA box contains the BEP and FEP boards. Another relevant ACIS thermistor, though in practice less restrictive, is 1DEAMZT, which is on the +Z-side of the Digital Electronics Assembly (DEA). The DEA box contains the ACIS video boards.

The DEA and the DPA are both located in the ACIS instrument on the Integrated Science Instrument Module (ISIM), on opposite sides of the ACIS focal plane (see Figure 1). So, while both the 1DEAMZT and 1DPAMZT temperatures rise with increasing tail-Sun pitch, their dependence of solar heating on the off-nominal roll angle is different, depending on the sign.

Since 1DPAMZT is the more restrictive of the two, and since its temperature has been consistently increasing on average, it has been necessary to raise its planning and yellow high limits a number of times over the past ~ 8 years (see the left panel of Figure 2). More recently, in 2019 it was also necessary to raise the 1DPAMZT red high limit. This was done on the basis of two considerations: a) the maximum 1DPAMZT temperature reached

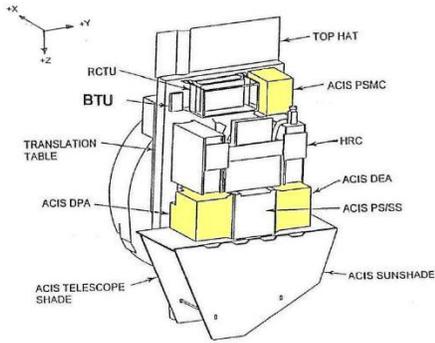


Figure 1: Schematic drawing of ACIS components on the back of the ISIM, showing the locations of the DEA, DPA, and PSMC. The DEA and DPA are on opposite sides of the ISIM, so they have different dependences of solar heating on the sign of the off-nominal roll angle.

in instrument (as opposed to spacecraft) thermal vac tests, and b) the fact that the most important instrumented temperatures for the safe operation of the DPA are those on the BEP and FEP boards, and there is margin between the current operating temperatures and the yellow and high limits for these boards. In tandem with this, the 1DEAMZT planning and yellow high limits have also been raised twice each over the past ~ 8 years.

Because these two temperatures track either other well on average, raising the 1DPAMZT limit inevitably leads to increases in the 1DEAMZT temperature. Figure 3 shows 1DEAMZT vs. 1DPAMZT for roughly the last year's worth of data. The left panel shows all of the data, clearly demonstrating the two temperatures track one another closely, but 1DEAMZT is typically lower. The right panel shows the highest temperatures, showing that further increases to the 1DPAMZT limit will most likely entail frequent violations of the current 1DEAMZT limit. Thus, if the 1DPAMZT limits are to be raised in the future, the 1DEAMZT limits must also be raised, if the limit increase is to have any utility for mission planning.

3 Proposal

The current yellow/red high limits on 1DEAMZT are $+38.5/+40.5$ °C. The ACIS Operations team proposes to raise the yellow/red high limits to $+39.5/+42.5$ °C. Raising both limits is necessary because raising only the yellow high limit would result in a 1 °C margin between the two, whereas this proposal results in a margin of 3 °C. Given that the margin between the planning high limit and the yellow high limit is for 1DEAMZT is 2 °C, this will raise the former from $+36.5$ °C to $+37.5$ °C.

4 Rationale

The current yellow and red high limits on 1DEAMZT reflect the maximum temperatures reached during observatory-level thermal vac testing, during which 1DEAMZT only got

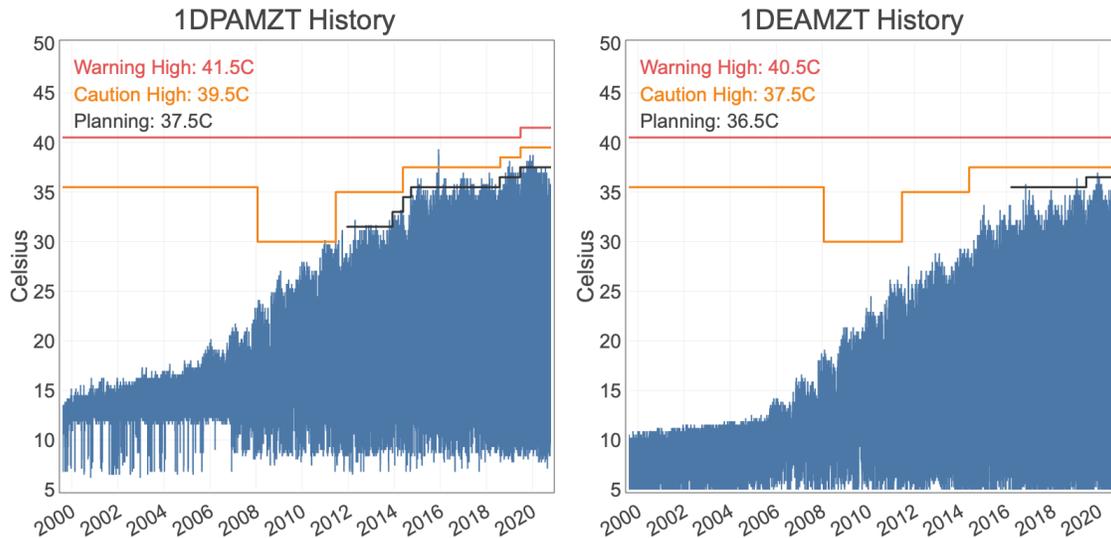


Figure 2: Left: History of 1DPAMZT temperatures and limits from the beginning of the mission. Right: History of 1DEAMZT temperatures and limits from the beginning of the mission.

up to $+38.0\text{ }^{\circ}\text{C}$. The revised limits we propose reflect the maximum temperature reached during ACIS instrument-level thermal vac testing, which was $+43\text{ }^{\circ}\text{C}$. This rationale for raising limits is similar to that used when the 1DPAMZT limits were raised, as the current limits for 1DPAMZT are higher than the observatory-level thermal vac high temperatures but not those at the instrument-level.

These proposed changes are conservative because they only raise the planning high and yellow high limits by one degree. We also set the red/caution high limit at $+42.5\text{ }^{\circ}\text{C}$, $0.5\text{ }^{\circ}\text{C}$ less than the $+43\text{ }^{\circ}\text{C}$ maximum temperature reached, for extra conservatism, noting that for 1DEAMZT the temperature resolution is $0.59\text{ }^{\circ}\text{C}$, giving 5 bit flips between the yellow and red high limits. The telemetered values of the temperature in this range are 39.25, 39.87, 40.5, 41.14, 41.80, 42.46, and 43.15.

Based on the results of the instrument-level thermal vac tests and this cautious approach, the ACIS Operations team is very confident that raising the limits to these proposed levels is safe for the operation of the ACIS instrument. It should be noted that the temperatures that can be measured on the components inside the DEA are only available when 10 video boards are on and the boards are not clocking. These data are of limited or no use.

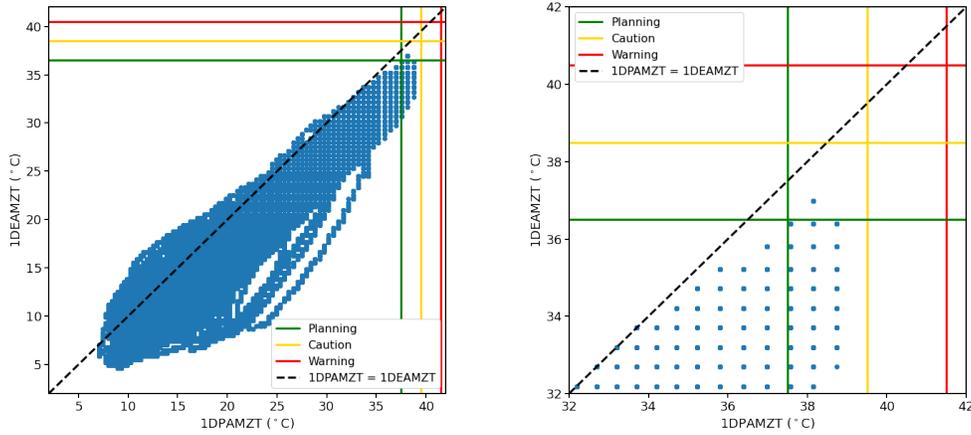


Figure 3: Left: Scatterplot of 1DEAMZT vs. 1DPAMZT data from 2019:300 to 2020:300. Green, yellow, and red lines show planning, caution, and warning limits for both temperatures. The dashed black line shows where both temperatures would be equal. Right: Zoomed-in version of the left panel near the highest temperatures.

5 Summary

- Further increases to the 1DPAMZT limits will inevitably cause 1DEAMZT to reach its limits
- We propose to raise the 1DEAMZT yellow high limit from +38.5 °C to +39.5 °C, and the red high limit from +39.5 °C to +42.5 °C. This permits raising the 1DEAMZT planning limit from +36.5 °C to +37.5 °C.
- Raising the yellow and red high limits to these values are justified by the temperatures reached during instrument (not spacecraft) level thermal vac tests for 1DEAMZT.
- We are taking a conservative approach on the planning and yellow high limits by raising them by only one degree each.