1. INTRODUCTION

Starting at about GMT 2022-12-03, 3337/12:16, two NASA astronauts conducted an Extravehicular Activity (EVA) or spacewalk outside the International Space Station (ISS) that would last just over 7 hours. Assisted by Canadarm 2, Josh Cassada and Frank Rubio installed an ISS Roll-Out Solar Array (iROSA) for use with the 3A power channel on the starboard truss of the ISS. This installation marked the third such iROSA to be attached to the space station since a power augmentation program to add at least six new sets of arrays to the ISS began in 2021. A subsequent EVA to install a fourth iROSA, this time to the 4A power channel on the port truss of the ISS, is currently scheduled for later in December of 2022. See Figure 1 for an artistic rendering of the iROSAs – 3 outlined in magenta.

The spacewalkers undid bolts and installed cables and at GMT 17:37, the array was deployed to start tapping into the Sun's radiation to generate electrical power. As part of get-ahead tasks, they prepared the 4A array for the next spacewalk, demated the 1B array, broke torque on the P4 electronic boxes, and installed cables along the truss to be mated at the end of EVA 4. This spacewalk faced a delay when Cassada's suit did not power up initially. Troubleshooting steps were done and power was restored to Cassada's suit.

The iROSAs are part of a plan by NASA to increase the ISS's power generation capability back to what it essentially was when the eight original solar array wings were launched between 2000 and 2009. With the placement of six iROSAs on the station, the orbital lab will once again be capable of producing 215 kW of power for its scientific and operational needs. The original arrays, as expected, degraded in efficiency over time and are now only capable of generating approximately 160 kW. Each new iROSA will contribute approximately 10 kW of power to the ISS.

For the microgravity acceleraiton environment analysis using Space Acceleration Measurement System (SAMS) data in this document, we consider the hour subset from GMT 13:00 to 19:00 for a few days leading up to the EVA, the day of the EVA, and a few days after the EVA to give some comparison context.

2. QUALIFY

The spectrogram of Figure 3 on page 3 was calculated from SAMS sensor 121f08 acceleration measurements made in the Columbus module. This plot focuses on a lower-frequency portion of the acceleration spectrum usually dominated by vehicle structural modes and crew activity such as exercise, or in this case push-offs, torques, and landings by the crew on external structures of the ISS during the EVA. This plot includes a white annotation (that is probably not needed) to show the impact mainly below 2 Hz, where large structures' natural flexing/bending/twisting modes tend to dominate the vibratory regime. We see clearly in the spectrogram from about GMT 10:54 to about 19:17 that the large structures of the ISS were moving and vibrating more energetically as they were impinged by the crew's locomotion and activity. This shows up as horizontal streaks that turn red (more energetic) during the EVA compared to yellow (less energetic) before and after the EVA.

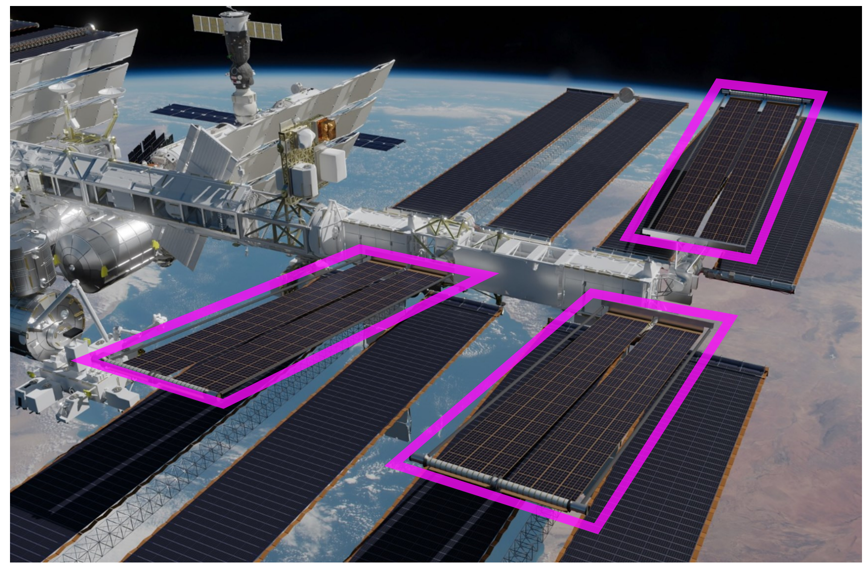

Fig. 1: Rendering of ISS Roll-Out Solar Arrays (iROSAs), 3 outlined in magenta
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3. QUANTIFY

In order to quantify the impact of the EVA, we will focus our attention below 6 Hz and show statistical summaries over several days from a relatively large volume of SAMS measurements in that span. We will consider 5 SAMS sensor heads distributed throughout the space station and compare and contrast across sensor locations and also compare results below 6 Hz to corresponding measurements up to 200 Hz.

Before we present those statistical results, we outline and describe the signal processing chain in order to provide the foundation for our analysis for each day considered:

1) read entire day of data into 2d array; 4 columns: time, x-, y-, & z-axis accel.
2) keep rows where time is between GMT 13:00 and 19:00
3) compute per-axis 5-stat summary: 1st, 25th, 50th, 75th, & 99th percentiles
4) subtract off median value (50th percentile) on per-axis basis
5) boxplot the percentiles as depicted in Figure 2 on per-axis, per-day basis for the hours of interest; with a boxplot for each of **red** = x-axis, **green** = y-axis, and **blue** = z-axis results

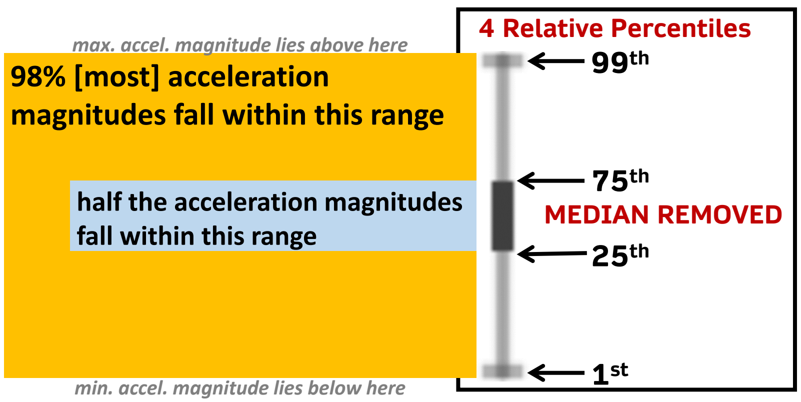

Fig. 2: Legend for Statistical Summaries

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4. Conclusion

The analysis results from 5 SAMS sensor heads distributed across all 3 main labs of the ISS over 9 days centered on the day of the EVA and for the hours in the span from GMT 13:00 to 19:00 each day are shown for:

- 6 Hz data sets (*micro-g scale*) in Figures 4 through 8 (pages 4 through 8)
- 200 Hz data sets (*milli-g scale*) in Figures 9 through 13 (pages 9 through 13)

The spectrogram in Figure 3 along with the boxplot results in Figures 4 through 13 showed the following notable features:

- despite statistical results shown below 6 Hz, it is clear from our spectral analysis the main impact of this EVA was concentrated below 2 Hz (for convenience, we tapped into pre-existing 6 Hz data sets)
- results below 6 Hz show obvious Z-axis acceleration correlation between "strong Z" on the EVA day vs. "less so" on the non-EVA days considering the GMT span from 13:00 to 19:00
- results below 200 Hz do not show obvious correlation (as expected) since the primary impact of crew activity such as this (and, in general) lies in the lower-frequency vibratory regime whereas higher-frequency vibrations are more localized and typically result from equipment operations nearby the sensor head being considered
- the very large magnitude, higher-frequency vibrations manifest in SAMS 121f03 data, primarily aligned with the Z-axis (see Figure 12) were attributable to a narrowband disturbance near 60 Hz most likely from equipment in ER-2 (LAB1O1)

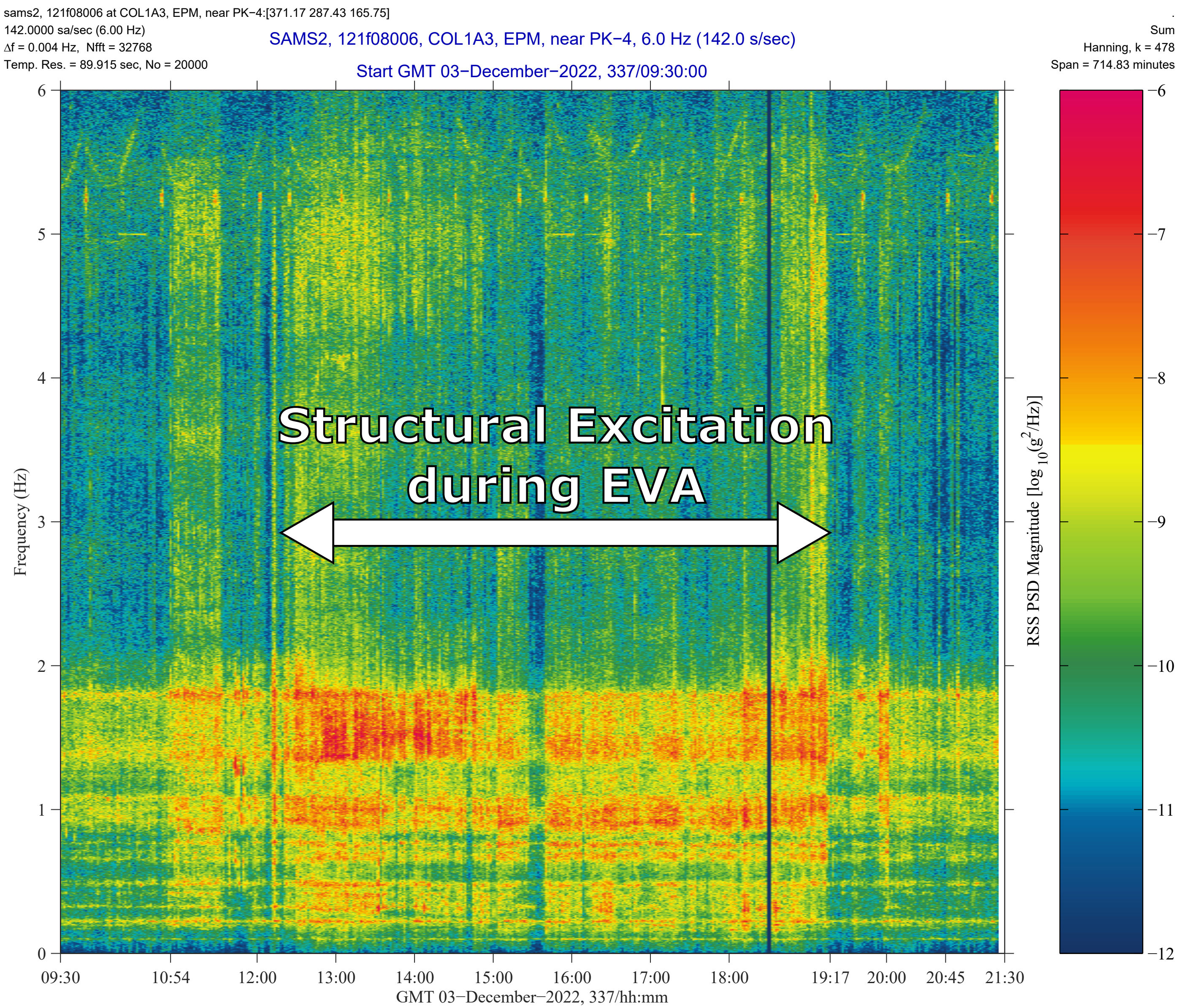

Fig. 3: **10-Hour Spectrogram Below 6 Hz, SAMS Sensor 121f08 (COL1A3)**, EVA on GMT 2022-12-03.

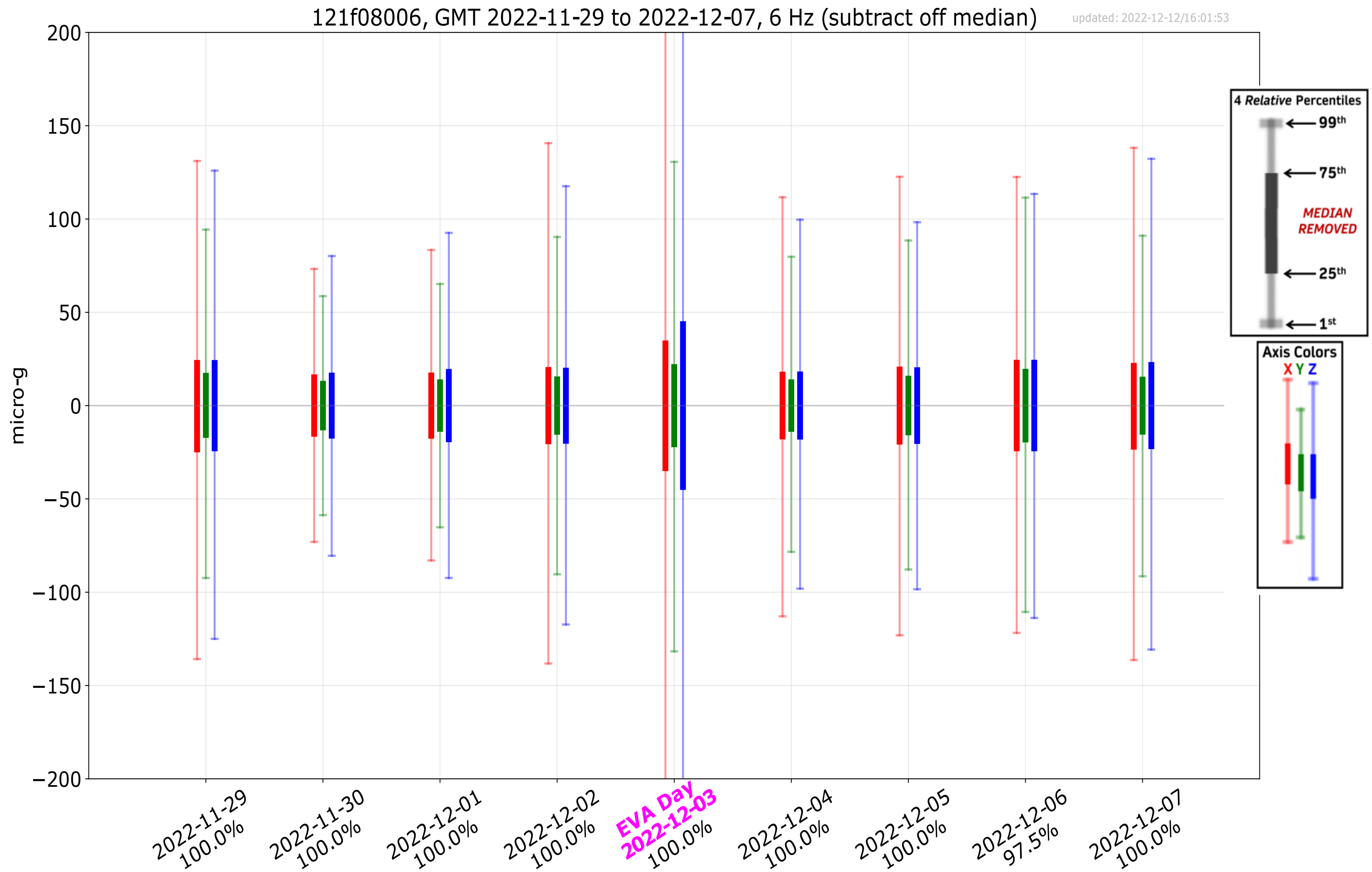

Fig. 4: **9-Day Per-Axis Acceleration Percentiles Below 6 Hz, SAMS Sensor 121f08 (COL1A3)**, EVA on GMT 2022-12-03.

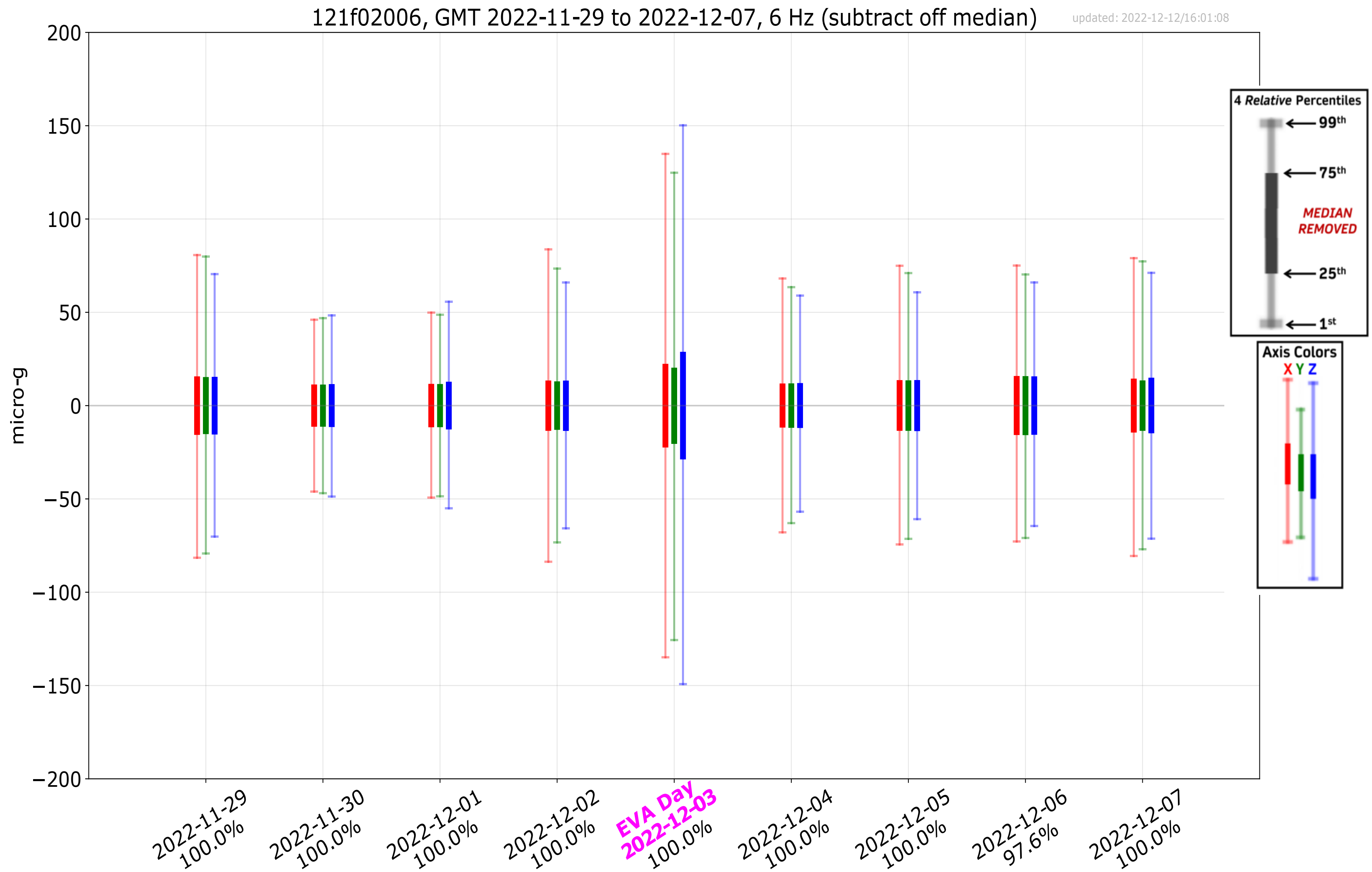

Fig. 5: **9-Day Per-Axis Acceleration Percentiles Below 6 Hz, SAMS Sensor 121f02 (COL1A1)**, EVA on GMT 2022-12-03.

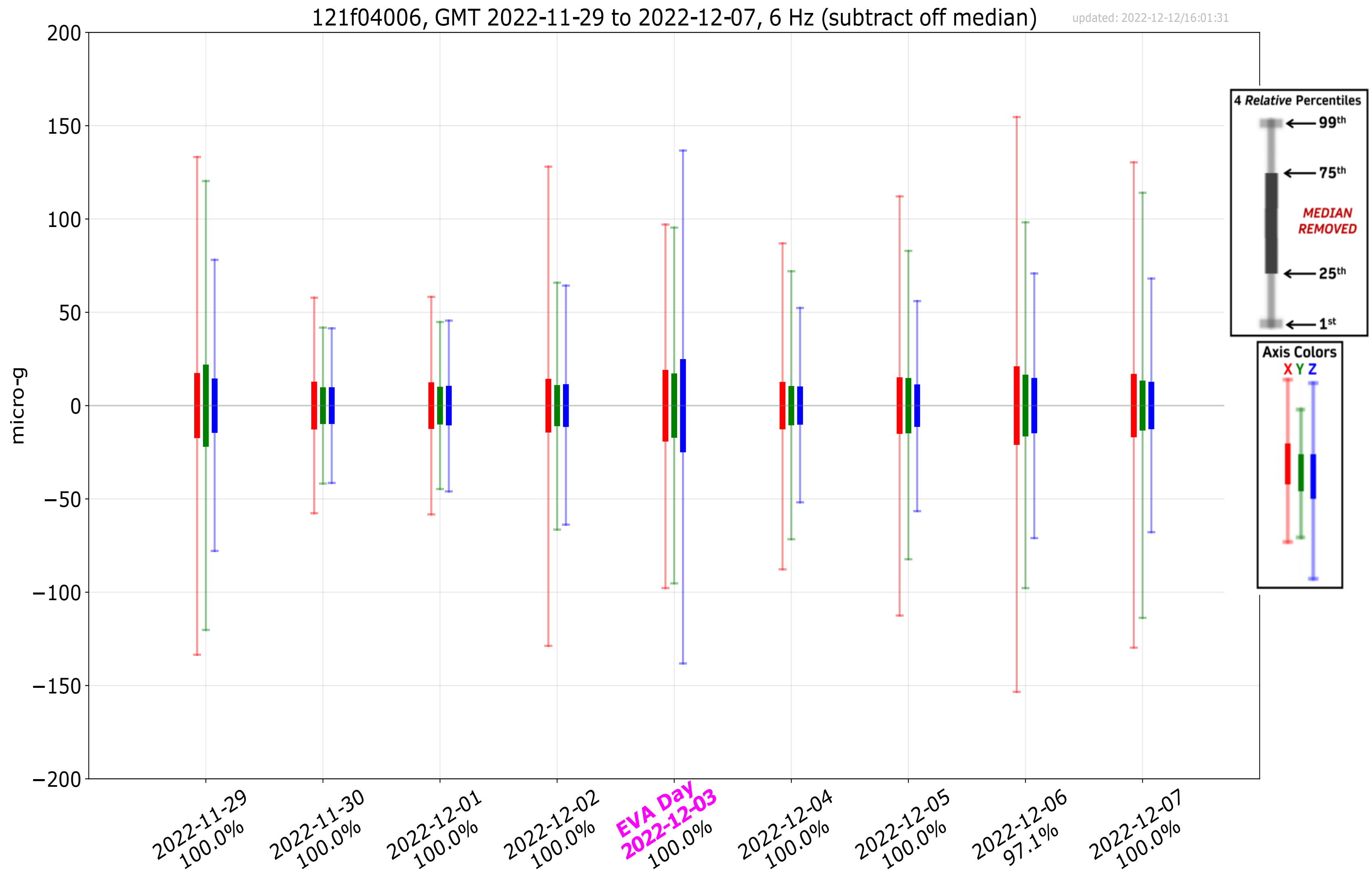

Fig. 6: **9-Day Per-Axis Acceleration Percentiles Below 6 Hz, SAMS Sensor 121f04 (LAB1P2)**, EVA on GMT 2022-12-03.

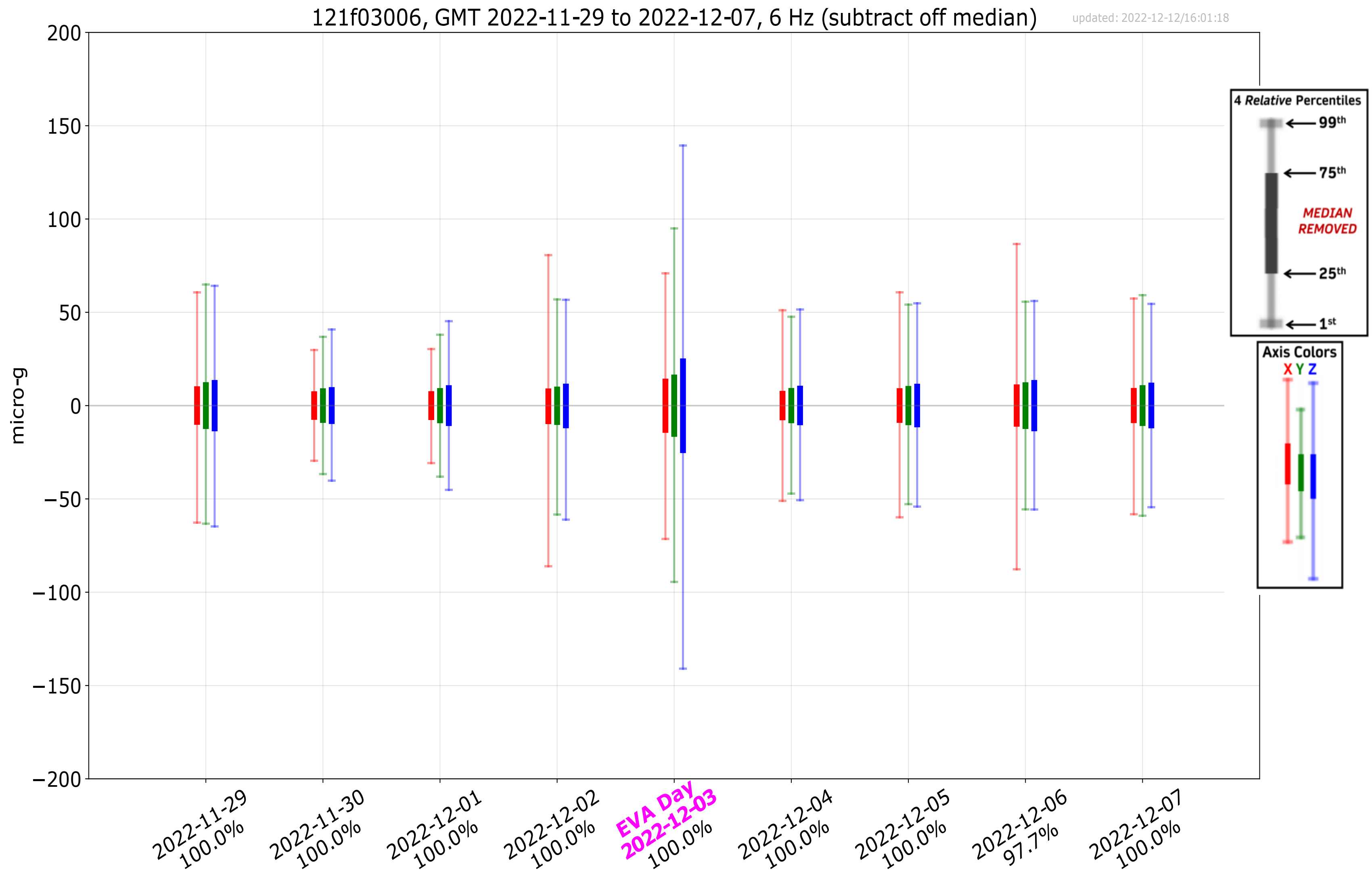

Fig. 7: **9-Day Per-Axis Acceleration Percentiles Below 6 Hz, SAMS Sensor 121f03 (LAB1O1)**, EVA on GMT 2022-12-03.

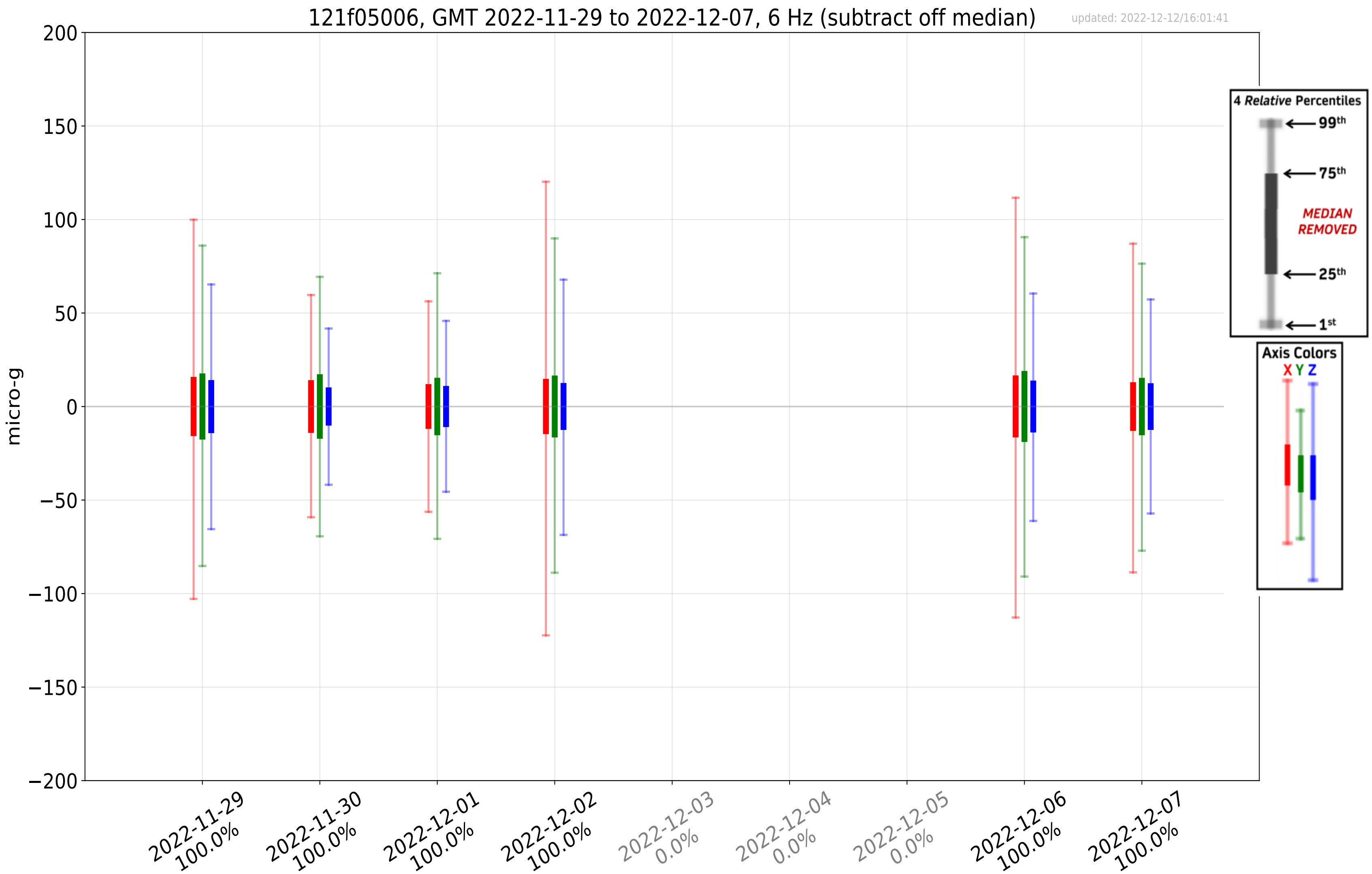

Fig. 8: **9-Day Per-Axis Acceleration Percentiles Below 6 Hz, SAMS Sensor 121f05 (JPM1F1)**, EVA on GMT 2022-12-03.

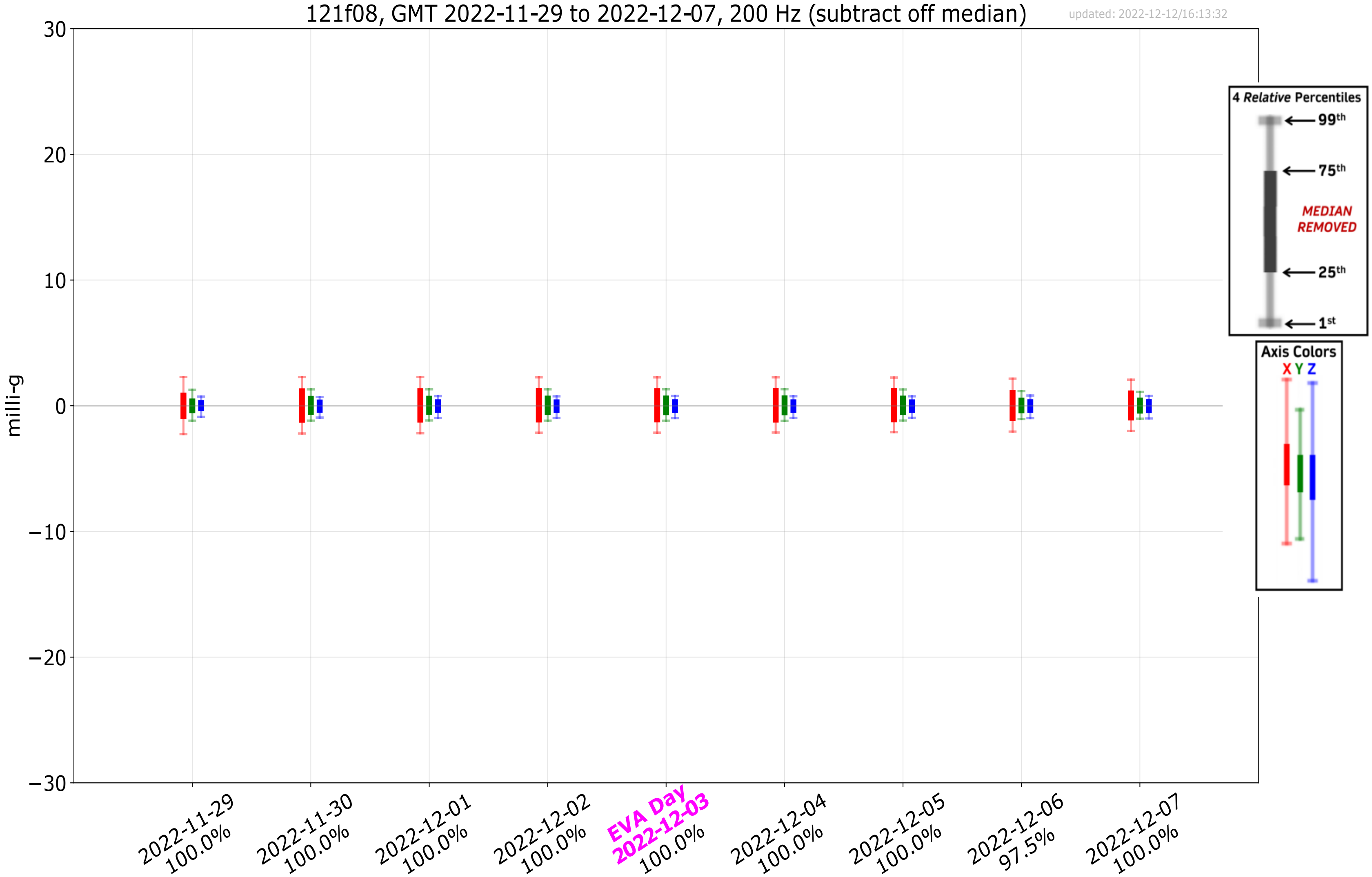

Fig. 9: **9-Day Per-Axis Acceleration Percentiles Below 200 Hz, SAMS Sensor 121f08 (COL1A3)**, EVA on GMT 2022-12-03.

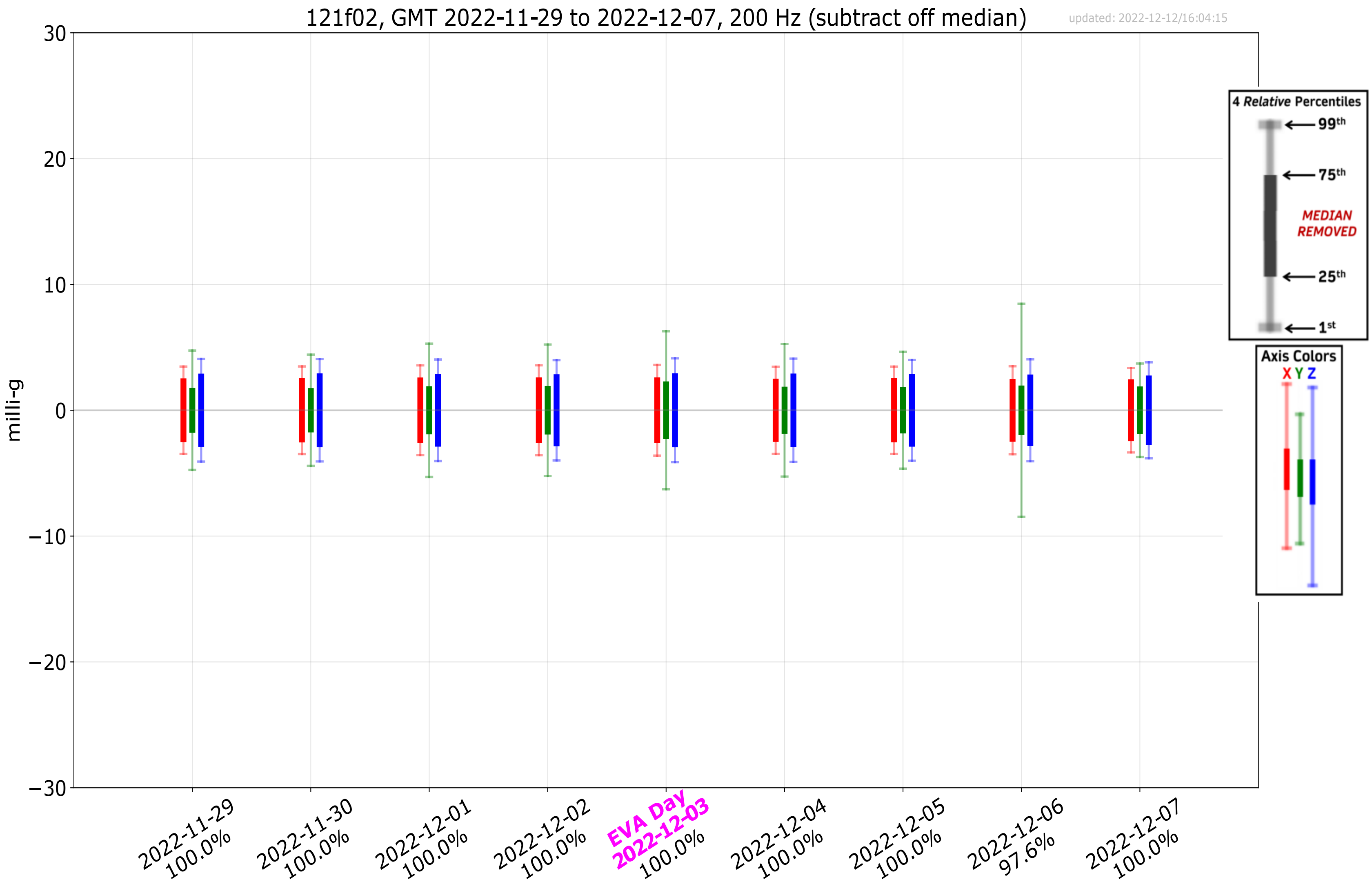

Fig. 10: **9-Day Per-Axis Acceleration Percentiles Below 200 Hz, SAMS Sensor 121f02 (COL1A1)**, EVA on GMT 2022-12-03.

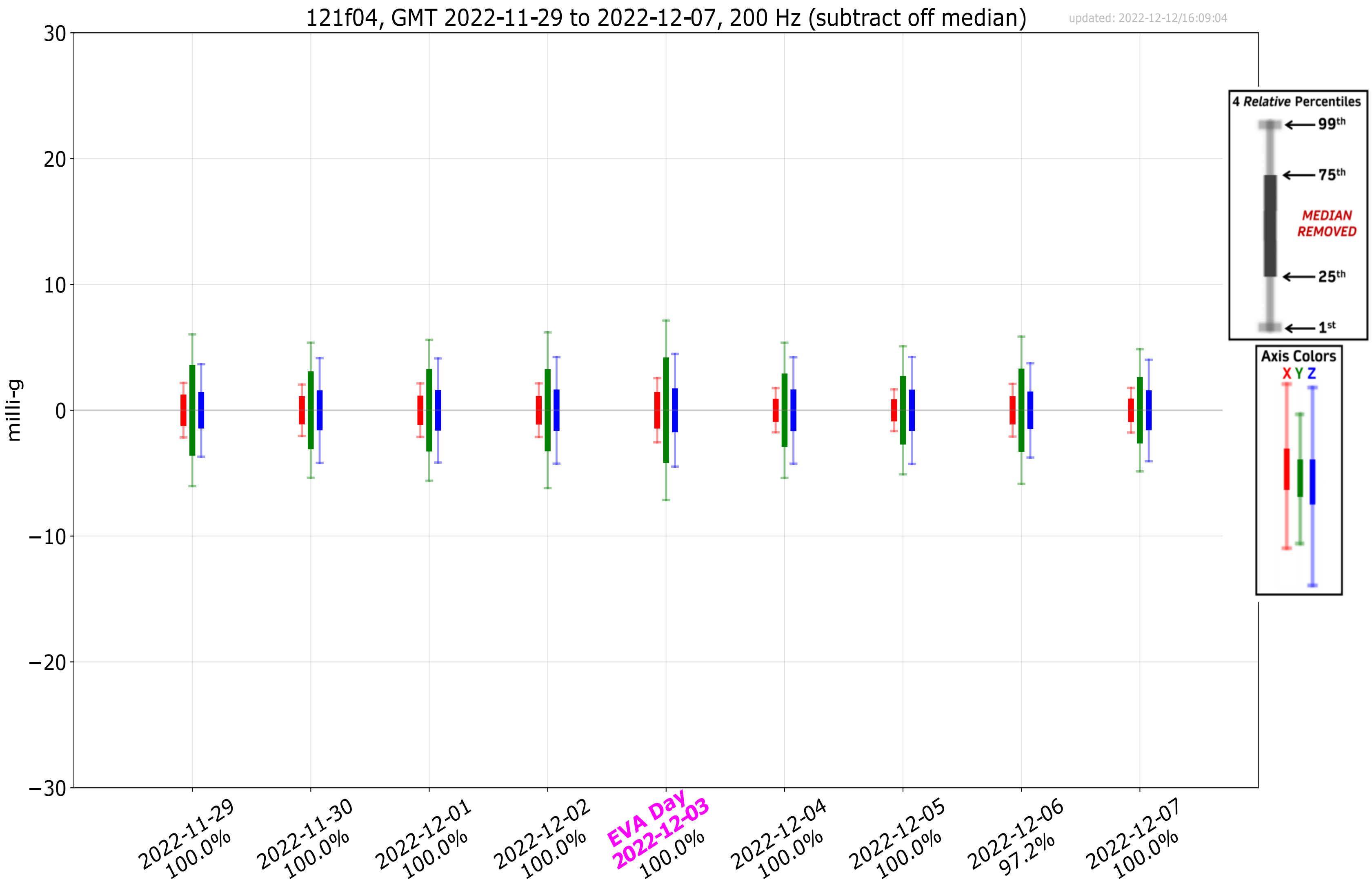

Fig. 11: **9-Day Per-Axis Acceleration Percentiles Below 200 Hz, SAMS Sensor 121f04 (LAB1P2)**, EVA on GMT 2022-12-03.

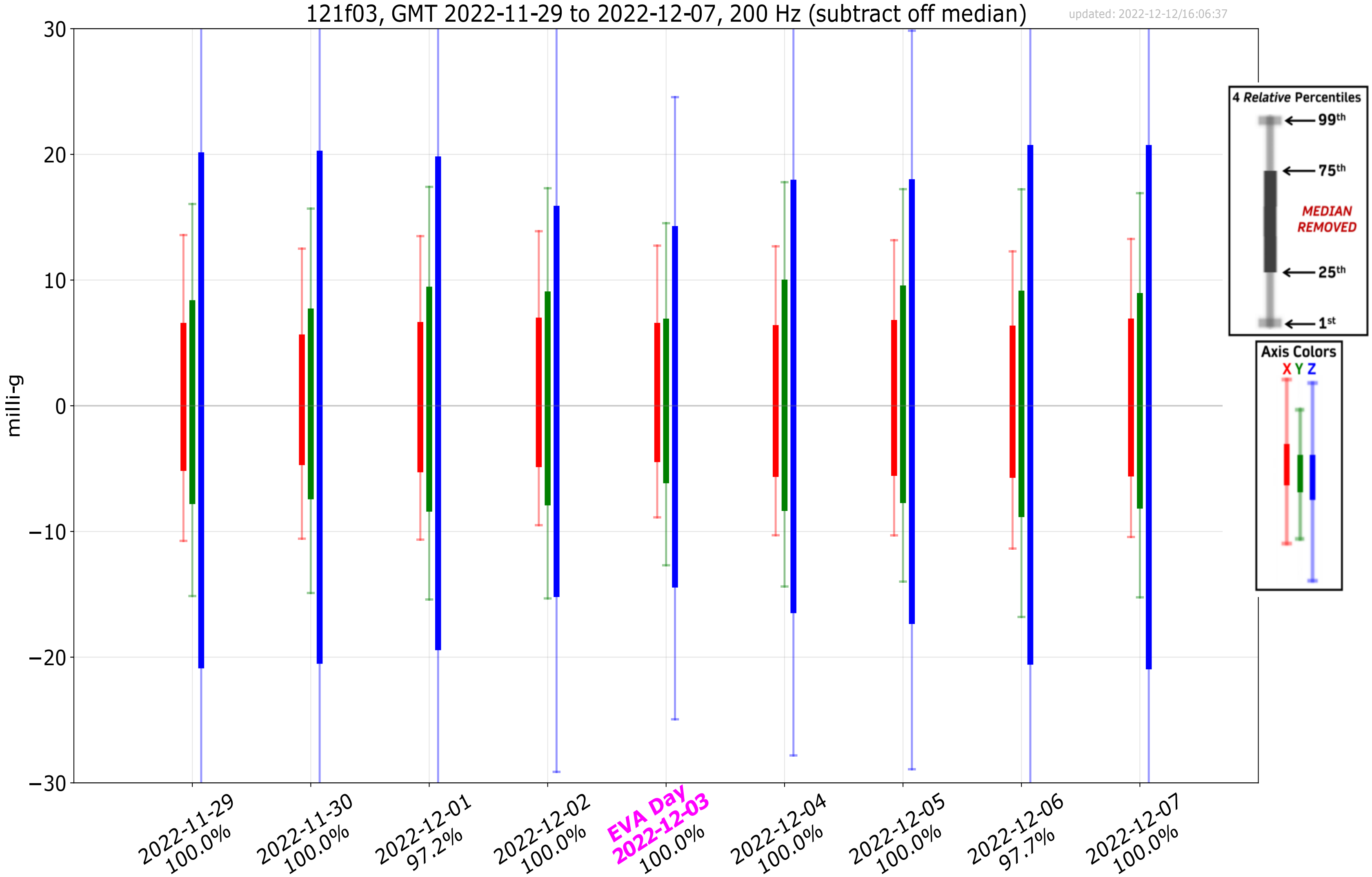

Fig. 12: **9-Day Per-Axis Acceleration Percentiles Below 200 Hz, SAMS Sensor 121f03 (LAB1O1)**, EVA on GMT 2022-12-03.

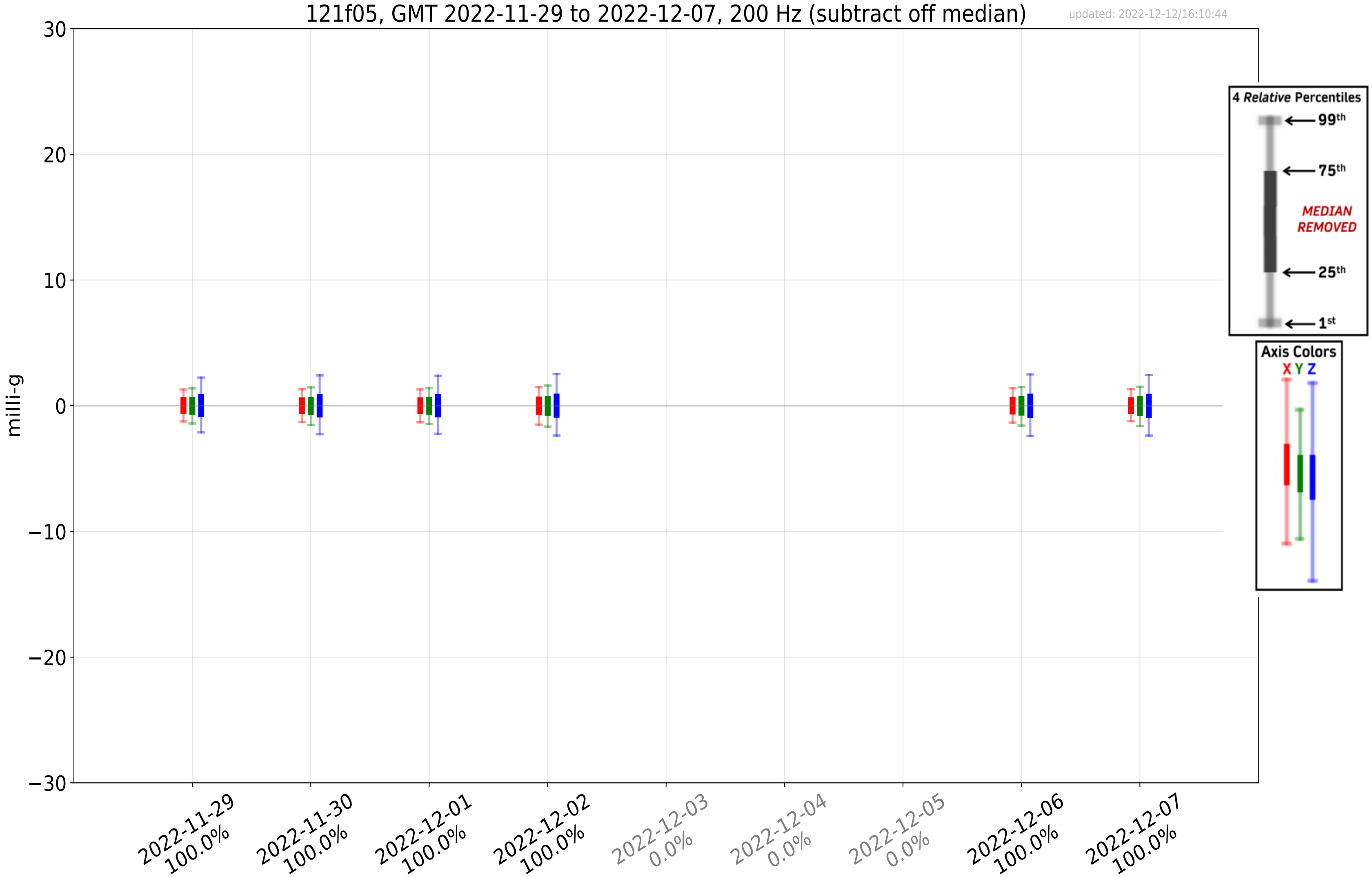

Fig. 13: **9-Day Per-Axis Acceleration Percentiles Below 200 Hz, SAMS Sensor 121f05 (JPM1F1)**, EVA on GMT 2022-12-03.