

## 1. INTRODUCTION

International Space Station (ISS) Flight Controllers monitor for unusual rates. Unusual rates are defined as vehicle rotational rates exceeding 5 mdeg/s for five or more oscillations with a period between 2 and 10 seconds. If these criteria are met, then a log entry is created, and the crew will be quickly polled with questions regarding activities at the time.

## 2. QUALIFY

Figure 1 shows spectral calculation results from measurements made by the Space Acceleration Measurement System (SAMS) sensor head (S/N 121f08) in the Columbus module for a 6-minute span around the time of the unusual rate signature detected at about GMT 2024-04-28/20:03:53. Note the excitation (red, horizontal streak) at just under 0.2 Hz and lasting just over a minute or so.

Similar to the event noted in the figure above, Figure 2 shows corresponding results from the same sensor head, for an 8-hour span that includes an unusual rate signature detected at about GMT 2024-07-19/16:21:00. Note the more distinctive red, horizontal streak again just under 0.2 Hz.

In both this and the previous case, this frequency corresponds to a global structural mode that tends to be excited with crew activity, with enough vigor and at such a rate as to excite structures natural frequencies.

## 3. QUANTIFY

The 2 acceleration power spectral density (PSD) traces on the plot of Figure 3 serve to compare the impact, only crudely quantified in PSD units, between the 2 unusual rate signature events on GMT 2024-04-28 (brown trace) versus that from GMT 2024-07-19 (blue trace). Note that the briefer event on the earlier date imparted somewhat more energy dissipated through ISS structure via resonance at just about 0.19 Hz. In PSD magnitude terms (not an intuitive quantity), the earlier date's spectral peak at 0.19 Hz was about 3 times higher than the later date, albeit for shorter duration.

Figure 4 on page 5 and Figure 5 on page 6 show PSDs for 4 SAMS sensor heads during the unusual rate detected on GMT 2024-04-28. From these 4 figures, we note that the 2 sensor heads in the Columbus module registered the same PSD magnitude at 0.19 Hz, while the sensor head in the LAB was notably weaker at that

frequency, and the sensor head in the JEM was about double the PSD magnitude of the two in the Columbus module.

Figure 6 on page 7 and Figure 7 on page 8 for the unusual rate signature on GMT 2024-07-19 show a similar pattern in terms of PSD magnitude across the various laboratory modules for the same 4 sensor head locations discussed in the previous paragraph.

## *Per-Axis Comparison of Unusual Rate Signatures*

The PSD plots discussed above were in the form of root-sum-of-squares whereby we combine per-axis PSDs to yield the overall effect regardless of direction. In this brief subsection, we now turn our focus to per-axis PSDs to reveal directionality of the structural response to crew excitation activity.

Figure 8 on page 9 and Figure 9 on page 10 show per-axis (directional) PSDs for 4 SAMS sensor heads during the unusual rate detected on GMT 2024-04-28. From these 4 figures, we note that the 2 sensor heads in the Columbus module registered the 0.19 Hz structural vibration as oriented primarily on the YZ-plane. This alignment is in agreement with the other sensor heads in the LAB and in the JEM, albeit with different PSD magnitudes, weaker in the LAB and stronger in the JEM.

The unusual rate signature event that was triggered by crew activity on GMT 2024-07-19, however, showed primarily Z-axis alignment across all SAMS sensor heads. This may have been due to location of crew activity (stimulus) input in contrast to the event from GMT 2024-04-28.

## 4. CONCLUSION

There can occasionally be crew activity (most likely in the JEM) that triggers unusual rate signatures at just under 0.2 Hz. This activity has the tendency to induce resonance in large space station structures, that while not catastrophic, can be deleterious to the longevity of the ISS in terms of degrading structural integrity/life (e.g. main structure metal fatigue). Flight controllers monitor for such events to help remind the crew of this impact.

See also [this document](#) for an unusual rate signature event on GMT 2024-09-03.

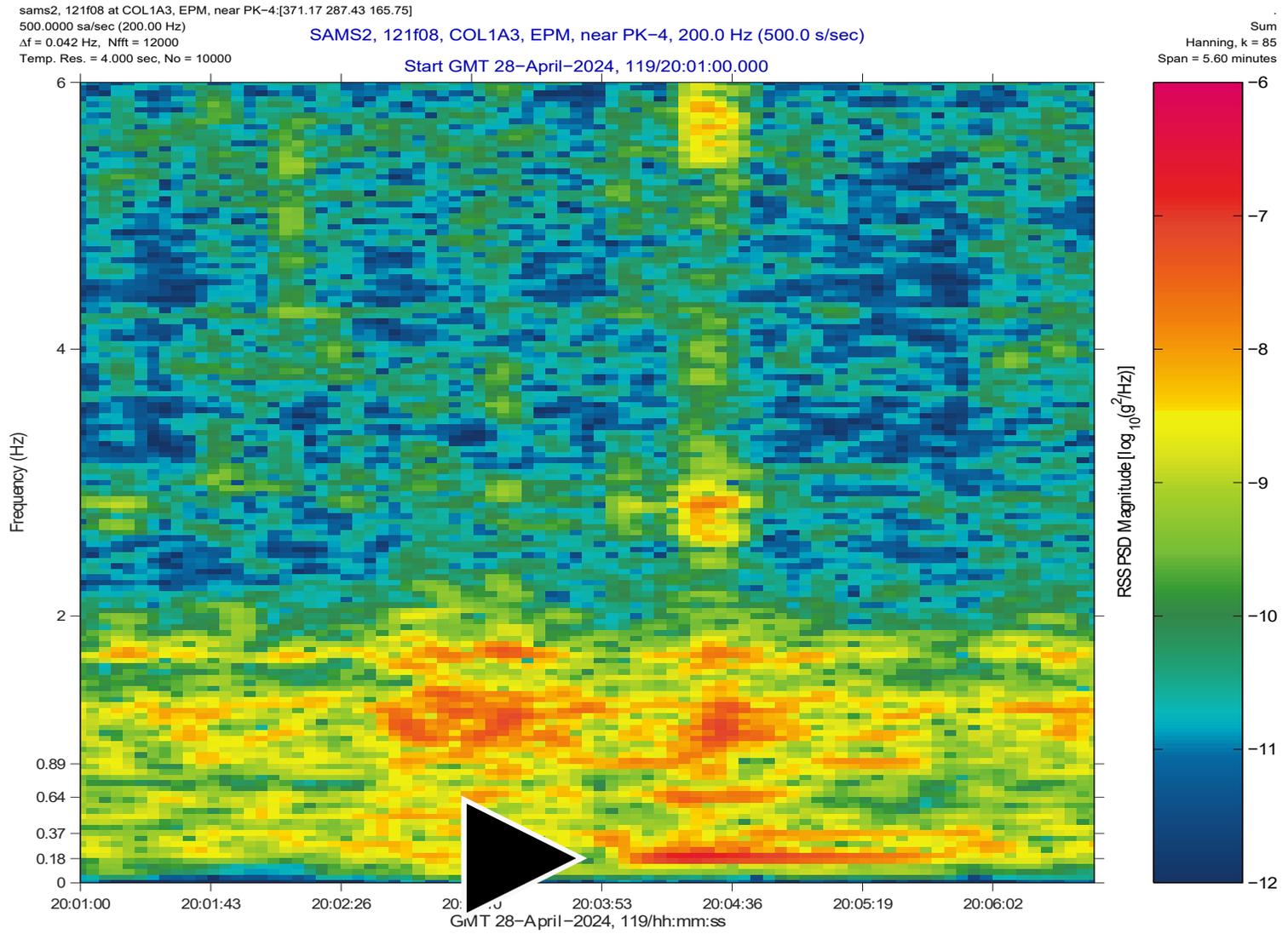


Fig. 1: 6-Minute Spectrogram, SAMS Sensor 121f08 (COL), Shows 2-Minute Excitation Starts at ~GMT 2024-04-28/20:03:53.

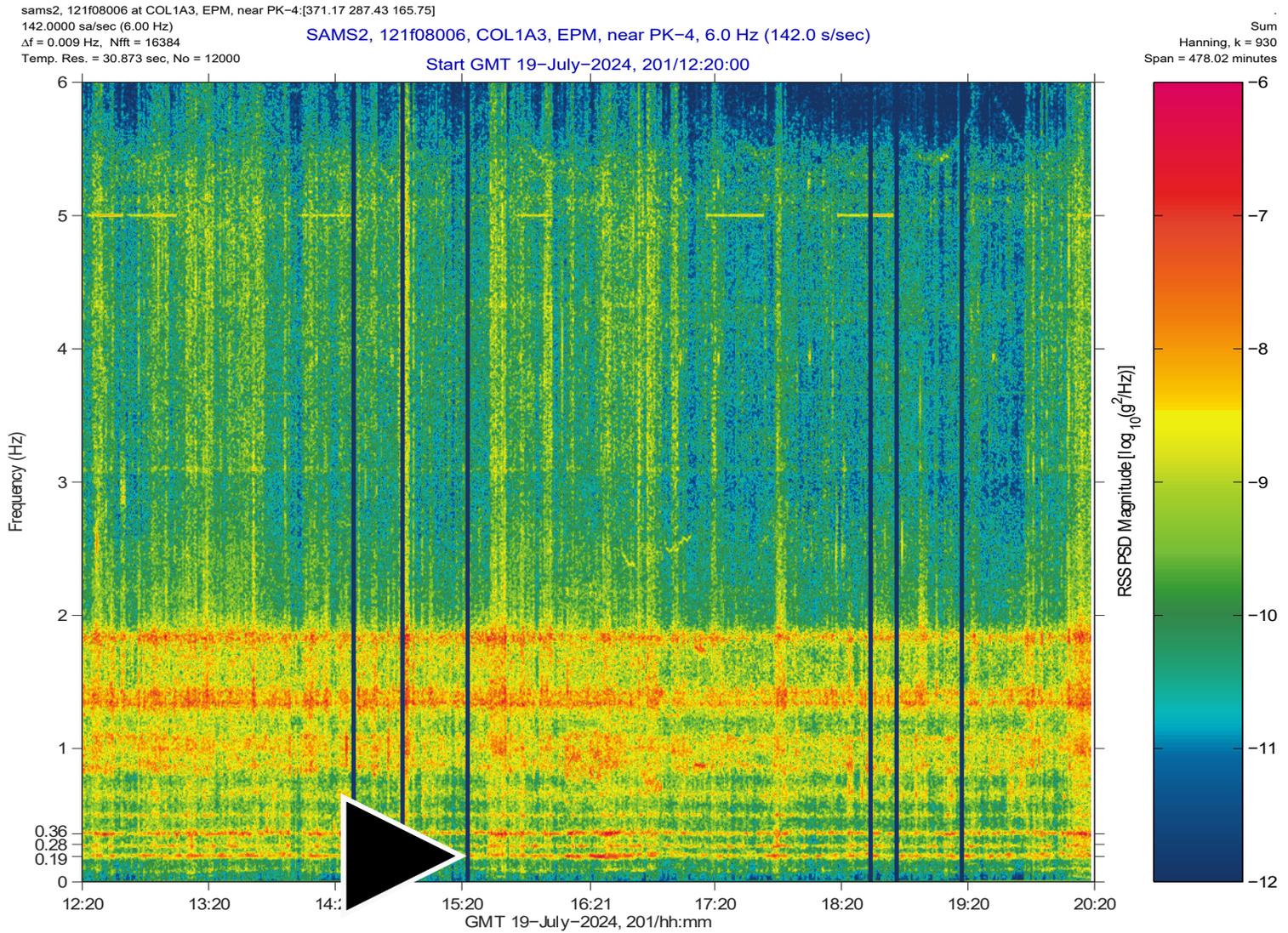


Fig. 2: 8-Hour Spectrogram, SAMS Sensor 121f05 (JEM), Shows Several Minutes Excitation Reaching Peak at ~GMT 2024-07-19/16:21:00.

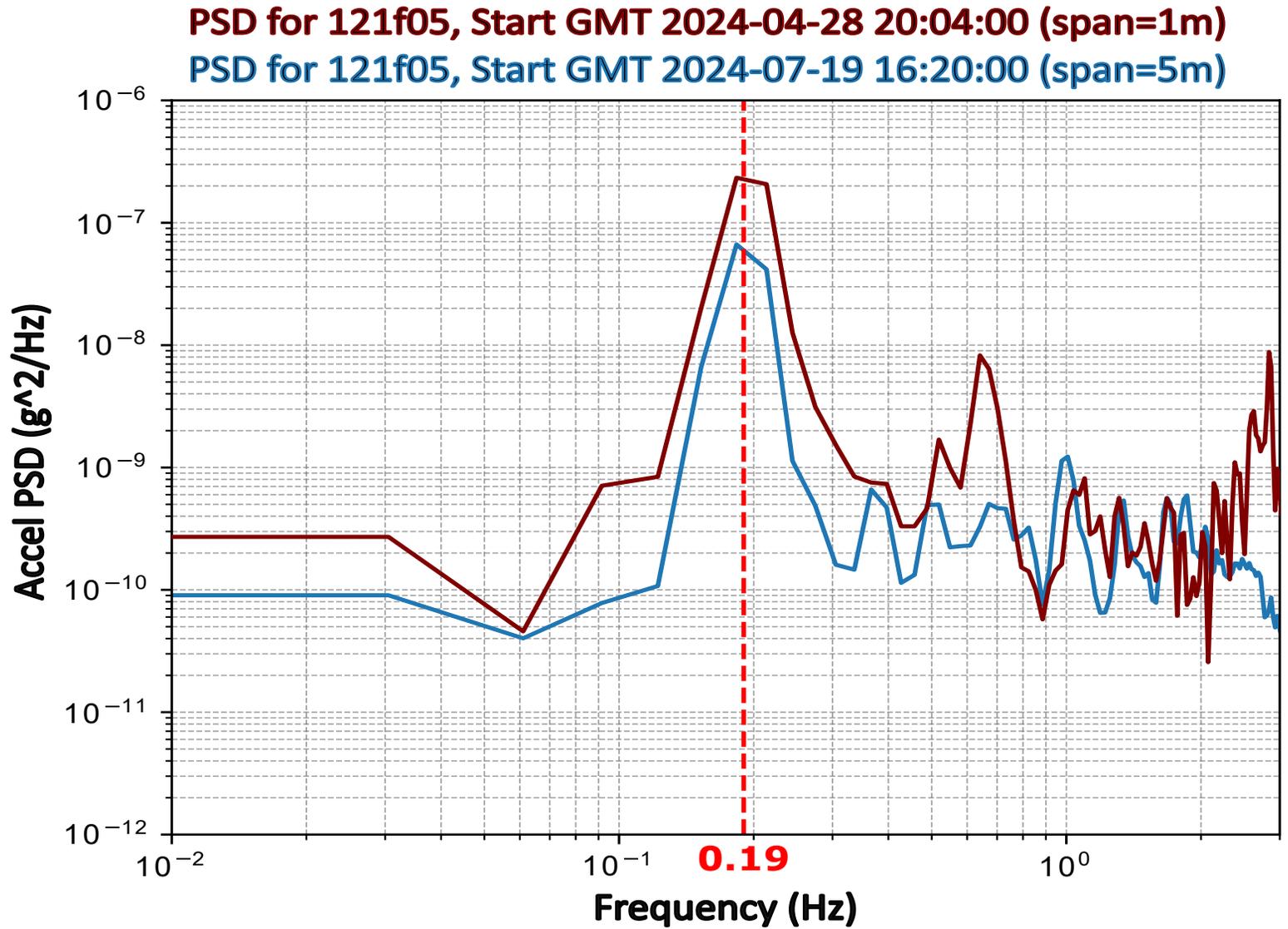


Fig. 3: Comparison of Accel. PSDs via SAMS Sensor 121f05 (JEM) for Two Distinct Unusual Rate Periods in 2024.

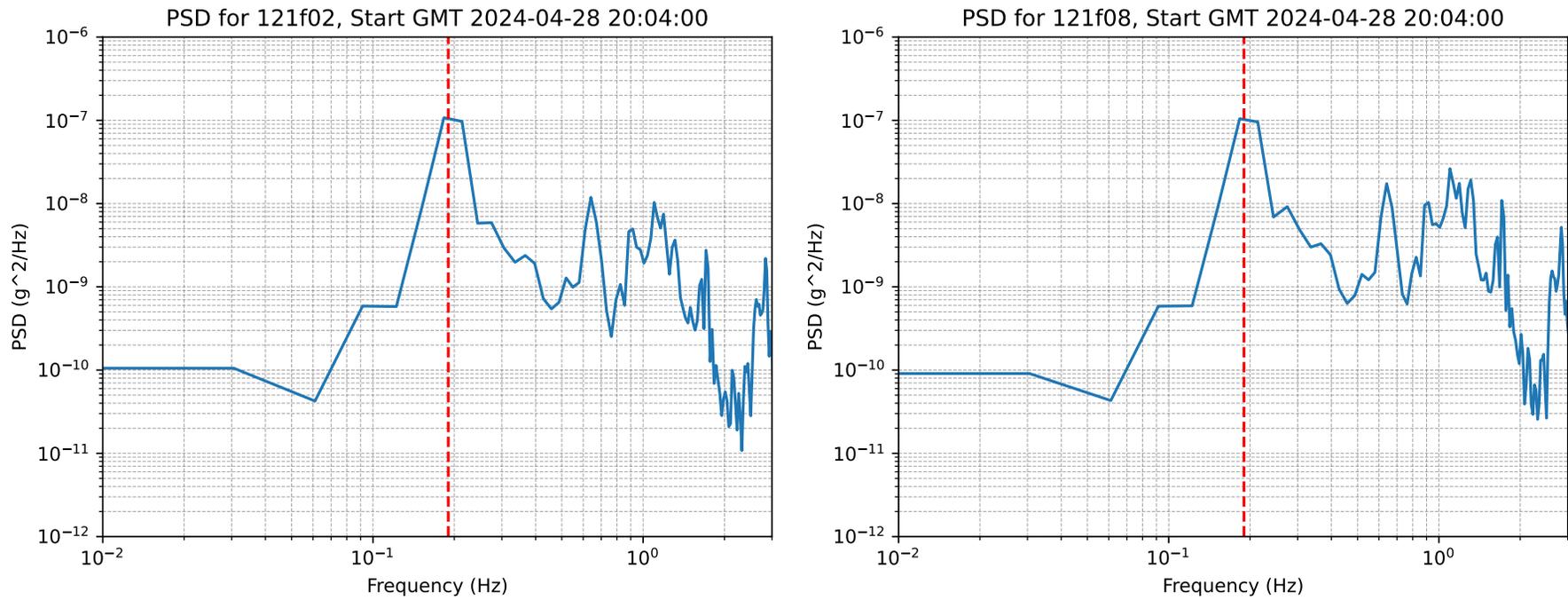


Fig. 4: 80-Second PSDs for (left) SE-F02, ER-3 & (right) SE-F08, EPM, Comparing Unusual Rate Signature Below 3 Hz on GMT 2024-04-28.

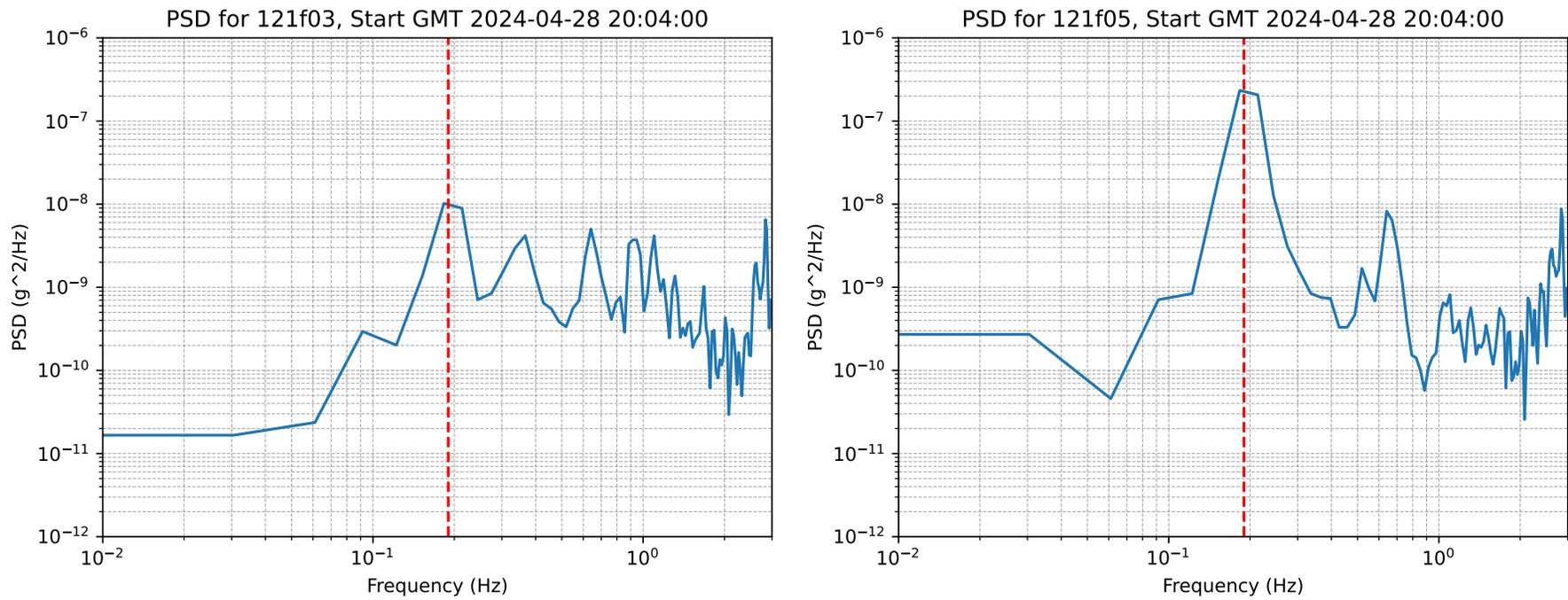


Fig. 5: 80-Second PSDs for (left) SE-F03, ER-2 & (right) SE-F05, ER-5, Comparing Unusual Rate Signature Below 3 Hz on GMT 2024-04-28.

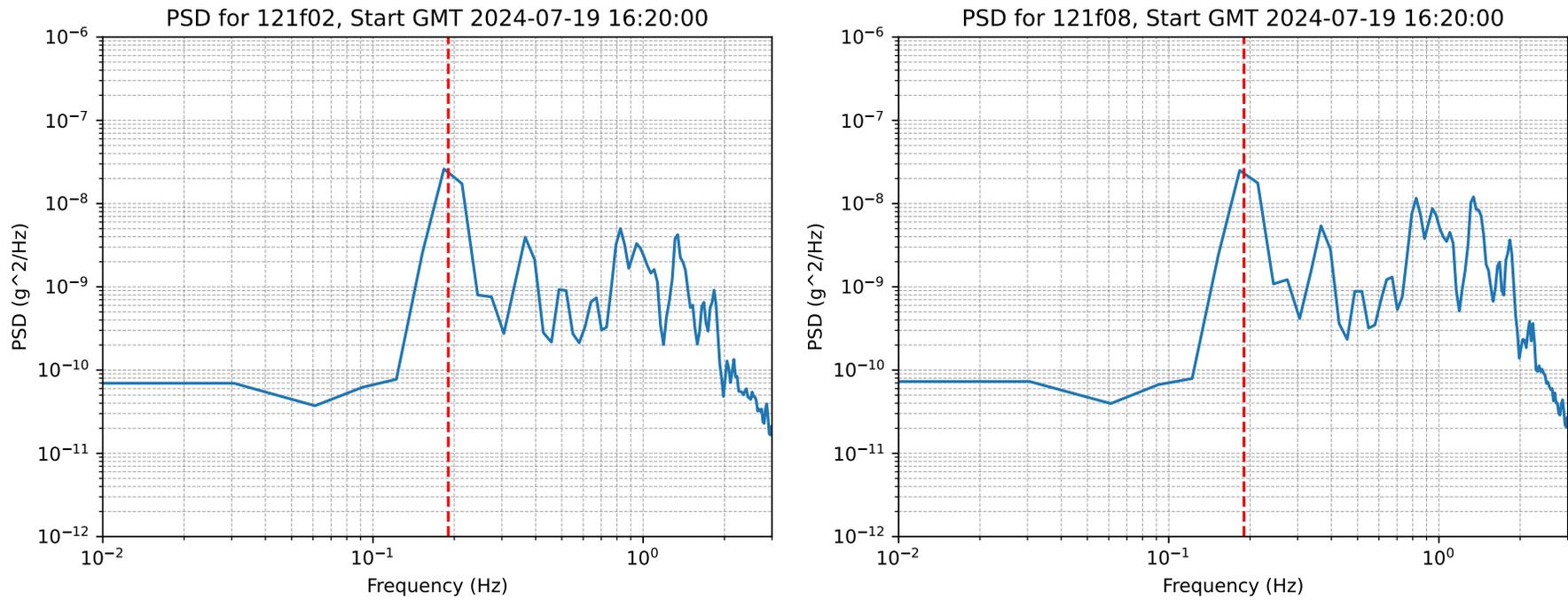


Fig. 6: 5-Minute PSDs for (left) SE-F02, ER-3 & (right) SE-F08, EPM, Comparing Unusual Rate Signature Below 3 Hz on GMT 2024-07-19.

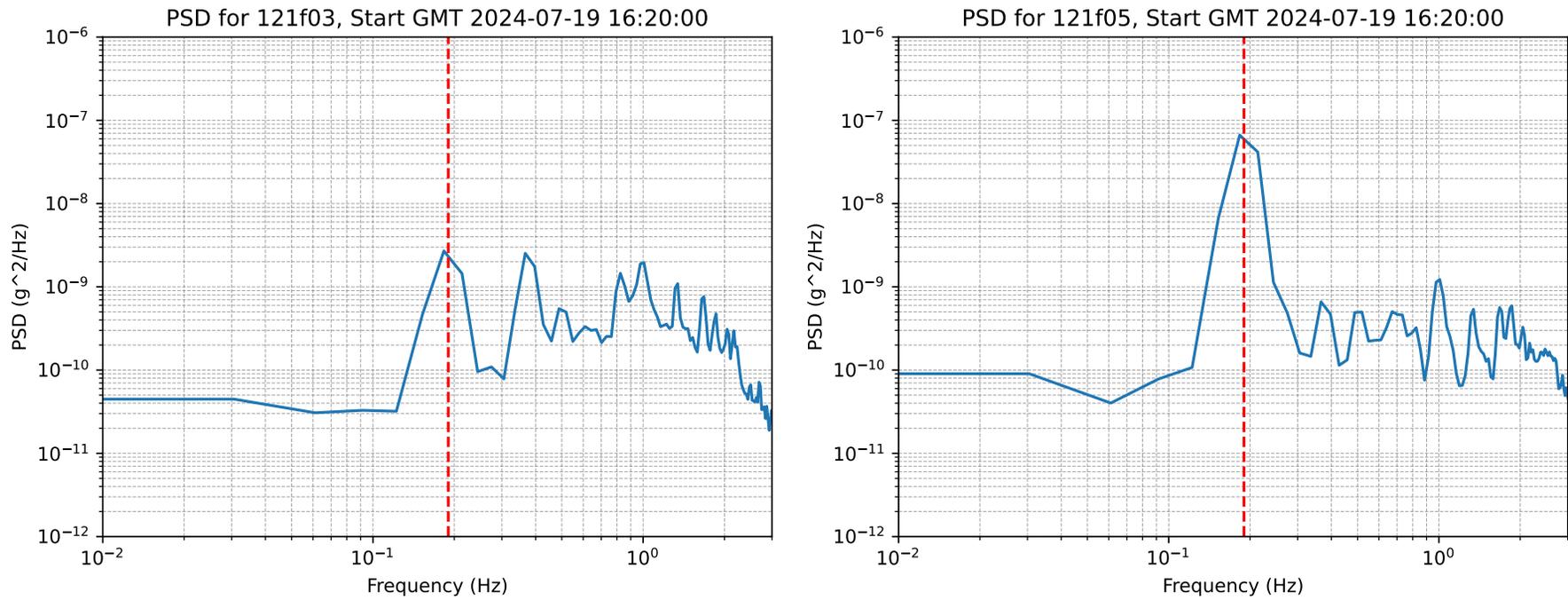


Fig. 7: 5-Minute PSDs for (left) SE-F03, ER-2 & (right) SE-F05, ER-5, Comparing Unusual Rate Signature Below 3 Hz on GMT 2024-07-19.

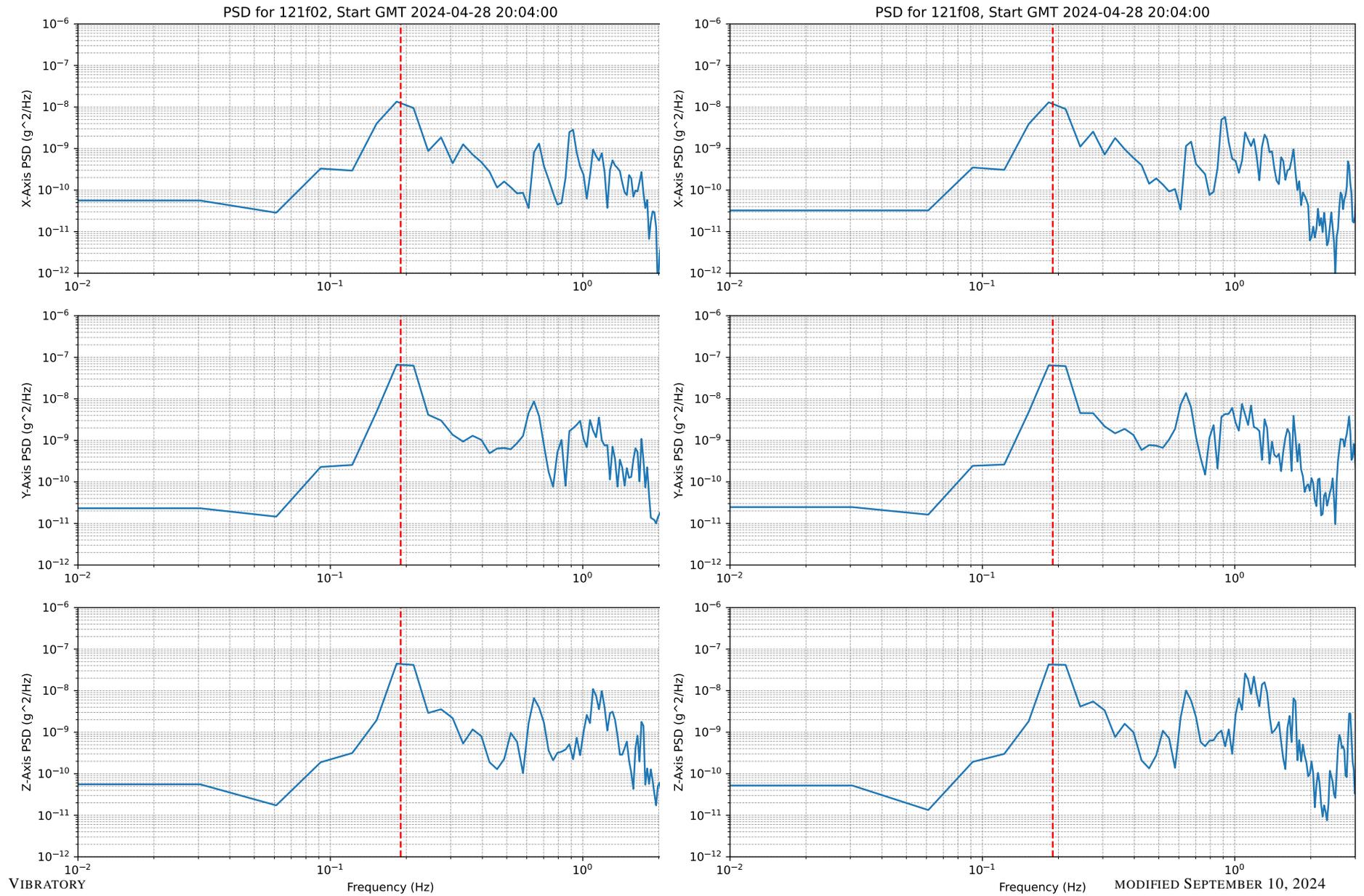


Fig. 8: 80-Second PSDs for (left) SE-F02, ER-3 & (right) SE-F08, EPM, Comparing Unusual Rate Signature Below 3 Hz on GMT 2024-04-28.

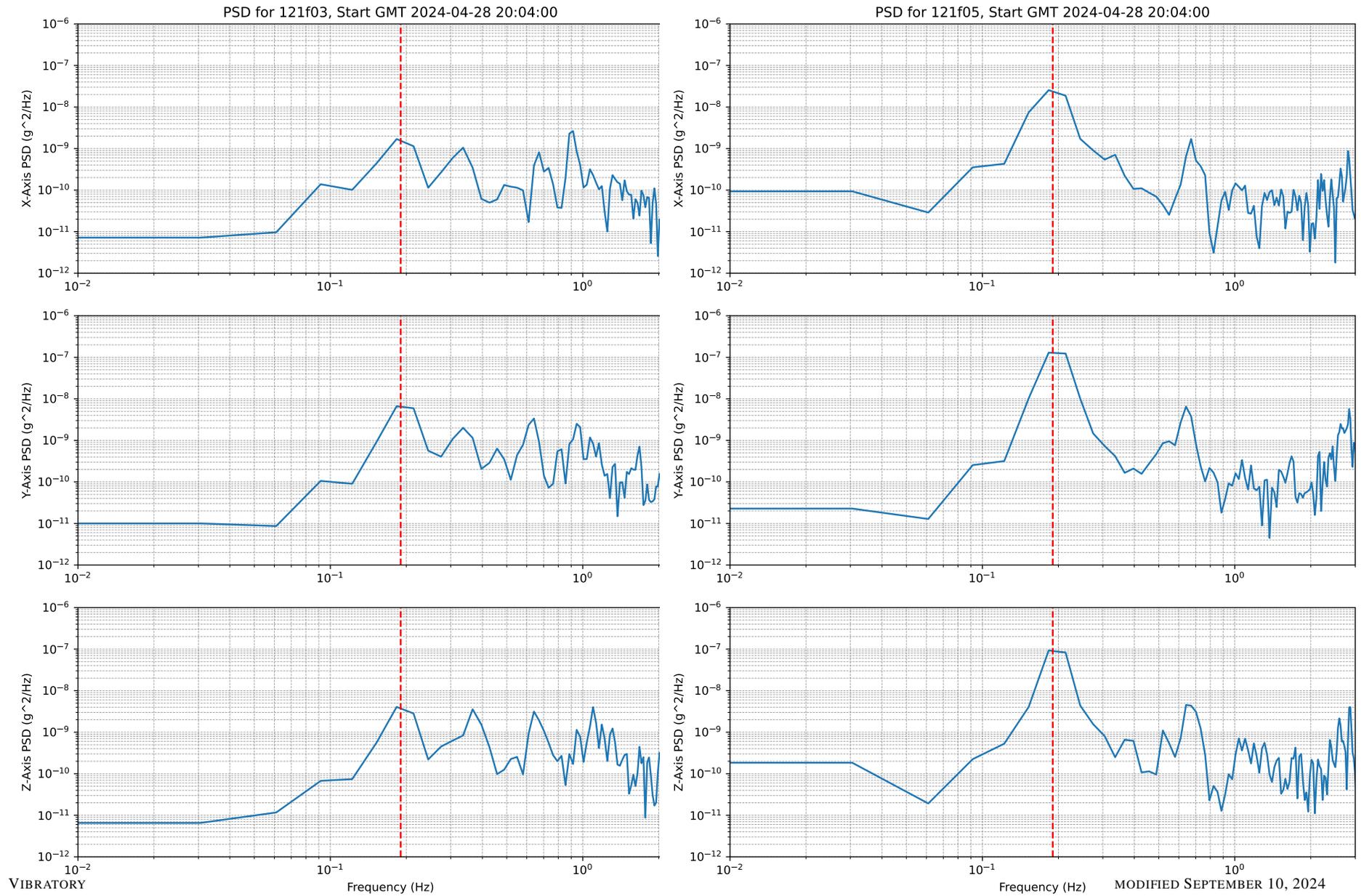


Fig. 9: 80-Second PSDs for (left) SE-F03, ER-2 & (right) SE-F05, ER-5, Comparing Unusual Rate Signature Below 3 Hz on GMT 2024-04-28.

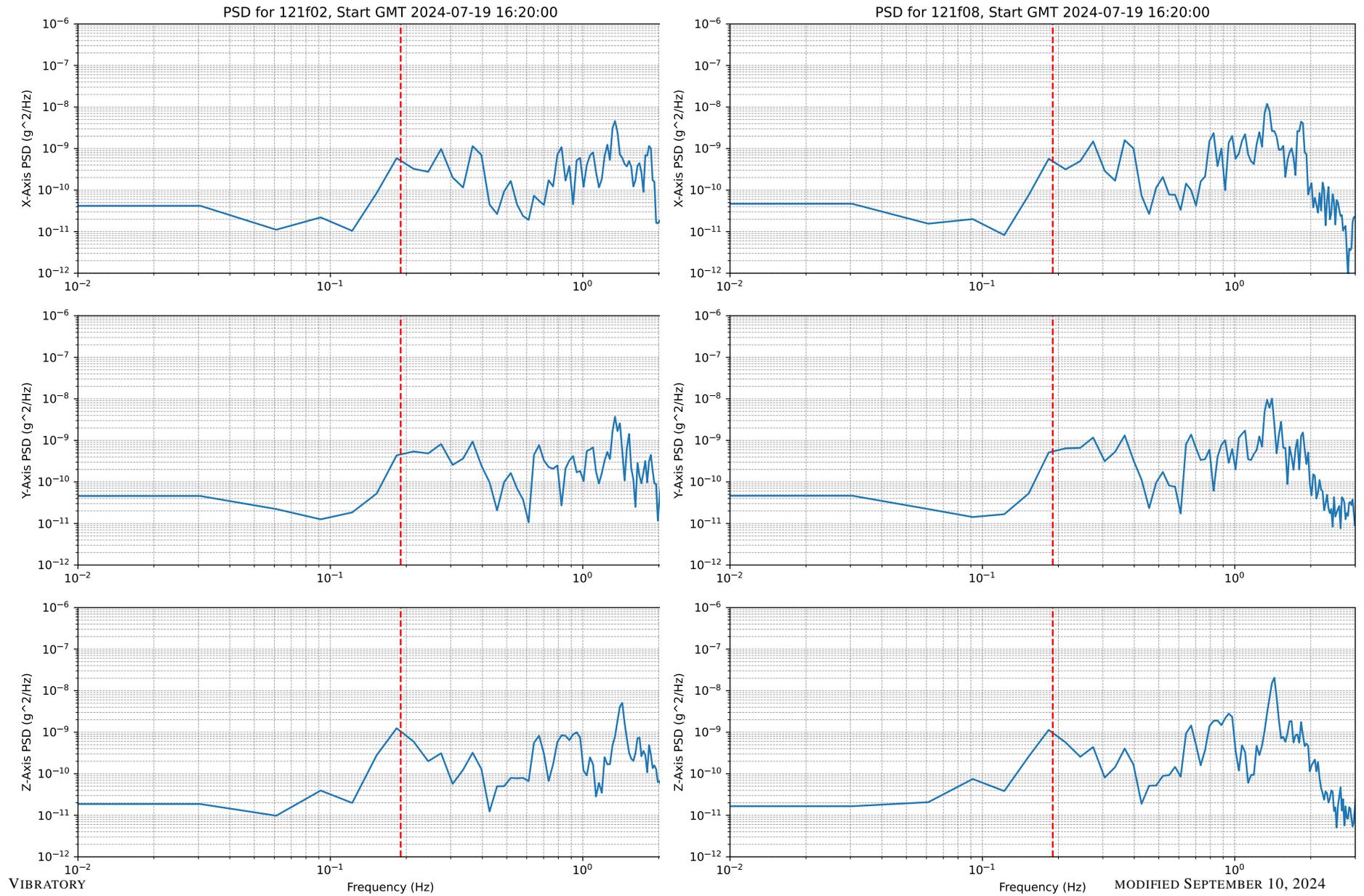


Fig. 10: 5-Minute PSDs for (left) SE-F02, ER-3 & (right) SE-F08, EPM, Comparing Unusual Rate Signature Below 3 Hz on GMT 2024-07-19.

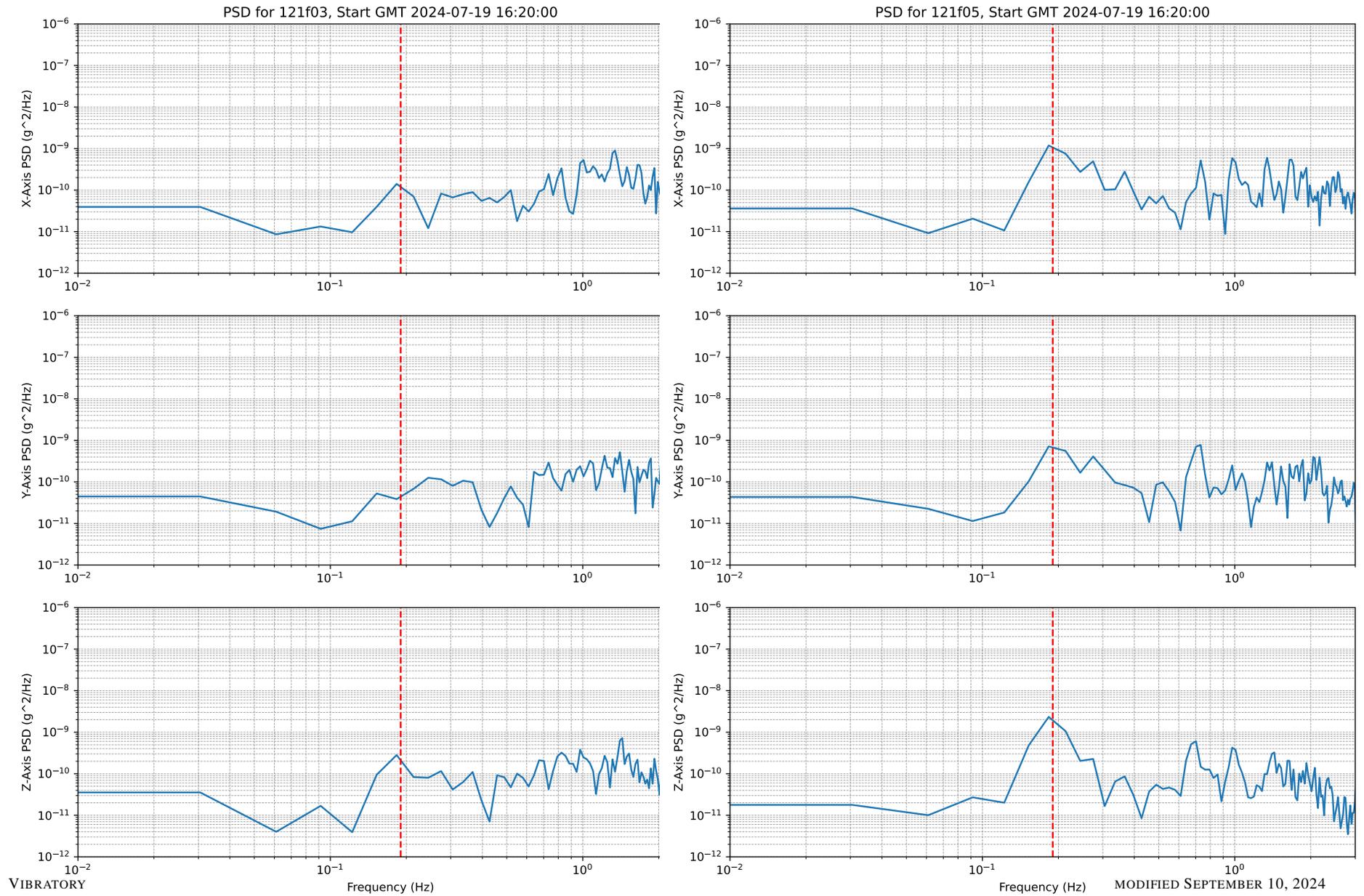


Fig. 11: 5-Minute PSDs for (left) SE-F03, ER-2 & (right) SE-F05, ER-5, Comparing Unusual Rate Signature Below 3 Hz on GMT 2024-07-19.