

Responses to review comments:

We sincerely appreciate the reviewer's careful review and constructive comments. Our response to each comment is listed in the following in bold letters. For convenience of reading, we repeat each review comment in front of our response.

Reviewer 1

I thank the authors for addressing each point raised in the reviews, and I believe the revised manuscript has been improved through the revision.

Response: We thank the reviewer for the careful and constructive comments. Please see our answers to each comment.

I still maintain some reservations on the analysis presented in this paper, particularly Figure 6 and the error values listed in Table 3. The results with and without interpolation are shown both with small angular error (30 to 89 urad), but differ from each other by 200 urad, which should result in an overall error estimate much larger (and a significant fraction of the mean value). It is not clear from the manuscript which factors are included in the error analysis. In addition, the results of the two methods used (noise magnitude and temporal pattern) do not agree to within several hundred microradians (see triangles in plots 6a-d and white regions in plots 6a,b). For example, the highest correlation value in Figure 6a is well outside of the lowest mean difference region. All of these uncertainties should be wrapped into the error calculation, which they do not seem to be.

Response: The standard deviation in Table 3 is calculated by taking all boresight directions where the correlation coefficient exceeds 70% of the maximum value (see lines 328–330). We agree that the difference between the interpolation and non-interpolation methods can be treated as uncertainty. While we believe the error for each analysis method should be treated separately, we documented the overall error by adding a row of the average for both methods to Table 3, adding a sentence to the caption, and including new descriptions at lines 333–336. It should also be noted that the highest correlation can co-exist with large absolute mean offsets (Figure 6a). However, as described at lines 316–330, such points are excluded when finding the most-likely boresight direction.

In addition, the new table 3 shows a boresight error closer to 800 urad rather than 700 urad as is listed in the text. This should be corrected throughout.

Response: Thank you for pointing out this value. Throughout the manuscript, the value is mentioned as “more than 700 urad”. This is consistent with Table 3 since both methods suggest a potential offset over 700 urad. We keep this phrase throughout the manuscript and revised line 314, where the value was not mentioned as “more than 700 urad” in previous versions.

Reviewer2

The manuscript presents a comprehensive analysis of the data taken from a GALA-Earth scan in 2024. The GALA detector noise level increased significantly as the GALA receiver field of view (FOV) overlap the sunlit Earth. The transition times of the detector noise is compared with the spacecraft altitude data to estimate the time offset and subsequently the GALA boresight shift. The noise amplitude during the overlap period is also used to estimate the possible GALA boresight offset in both the scan direction (X) and the transverse direction (Y). This is the second round of the peer review. The manuscript is much improved.

The major short coming in the data was the insufficient timing resolution of the spacecraft attitude data. It was given at 1 minute interval whereas the spacecraft orientation could change in seconds during the spacecraft maneuver. Several interpolation methods were used to bridge the data gap assuming the spacecraft slew rate was linear or changed smoothly during the transitions. The test data revealed an apparent timing offset between the GALA data and the spacecraft attitude data, which is then used to calculate the possible GALA boresight offset. There are no clear explanation about how other potential timing errors may affect the conclusion.

The data and the analysis are of interest to the people in space lidar community. I support the publication of the manuscript in EGU sphere provided the following comments are addressed.

Response: We thank the reviewer's careful and constructive comments. Please see our answers to each comment.

1. Provide the timing precision and accuracy of the spacecraft attitude data. The spacecraft attitude maneuver usually happens in a few seconds whereas the attitude data were timestamped at one minute interval. Please clarify if the attitude data represented the average value over the minute or the beginning or midpoint of the minute. Please also explain why the spacecraft attitude data were given at such a coarse interval during this test.

Response: The spacecraft attitude data show the actual attitude at the exact moment of data acquisition (as shown by points in Figure 1), not the average over one minute or specific timings within the one-minute interval. The one-minute interval is the default setting of attitude data acquisition. While the frequency can be increased upon reasonable requests, a high-resolution data acquisition was not conducted during the Earth-farewell campaign due to lack of such requests. We clarified both points at lines 138–141.

2. Provide the timing precision and accuracy or latency between the spacecraft time and the GALA data timestamp.

Response: As the GALA time stamps are referenced with respect to the spacecraft time, time delays between the two instruments are negligible compared to the timescale of noise variation. We clarify this point at lines 141–143.

3. Fig. 1 shows that the spacecraft attitude (green) changed prior the plan (red) at about 10:10, but normally the attitude change lags the command (plan). This indicates that either the spacecraft maneuver was not executed according to the plan or there was an error in the attitude data.

Response: As explained at lines 161–162, the commanded attitude can differ from the real attitude due to guidance error and attitude stabilization of the spacecraft, including possible delay unresolved due to the 1-min data acquisition interval. With the spacecraft housekeeping data, we have confirmed that the spacecraft maneuver was correctly executed.

4. There is an apparent discrepancy between the time span of the elevated GALA noise and that of the overlap of the GALA FOV and the sunlit Earth. The former is almost 1 minute longer according to Figs. 1, 5, and 7. This would suggest a 1-minute uncertainty in the spacecraft attitude data, since the GALA noise data were taken at a finer time interval and its time span was unlikely to be in error.

Response: As explained above, the timestamps of spacecraft attitude are accurate and do not have a 1-minute uncertainty. Therefore, the discrepancy in time lag between GALA noise increase and FOV-Earth overlap is not attributable to uncertainty in the data timestamps.

5. The scan path shown in Fig. 2 seems to indicate a continuous scan with the angle changing throughout the maneuver. To avoid confusion, the yellow scan path should be replaced by dots of attitude data. The image on the right should be further magnified to show a visible spread of the center of the GALA FOV during the dwell period.

Response: Thank you for your advice. We revised Figure 2, following the suggestions.

6. The legends of Fig. 5 indicate the black and gray curves are the boresight vectors, but I believe they are actually the simulated rms noise using the JUICE attitude data and the prelaunch GALA boresight vectors with the earth image from JANUS.

Response: It is correct that the black and gray lines are simulations assuming the pre-launch boresight. Following the suggestion, we changed the legends of Figures 5 and 7.

7. Line 80, "Confirming ... with an error of 510 urad.": Please explain if this was a measured angular offset or the uncertainty during the pre-flight measurement? If it is the former, please clarify if this angular offset was corrected in the Earth scan data.

Response: This is the verification error between two methods of boresight characterization during the pre-launch test, not a measured angular offset. The GALA boresight vector was characterized in the spacecraft alignment campaign via an optical cube, which is used as the default alignment in SPICE kernels and in our analyses. After this characterization, another test campaign was conducted using the optical ground support equipment (OGSE) that emits a pulse to the GALA telescope. In this test campaign, the OGSE scanned the GALA FOV by a raster scan pattern, checking whether GALA detects pulses from OGSE at each scan position. However, due to time constraints for this OGSE test, the OGSE characterization was not conducted at a sufficient resolution. As a result, the boresight vector is verified by two methods with an error of 510 urad. We revised the description on this value at lines 78–84, while more details may be referred to Hussmann et al. (2025).

8. Fig. 8: What is the date and time used to calculate the photon fluxes from other planetary bodies marked by the colored vertical dash lines? I would think Jupiter will become much brighter than the moon as JUICE gets close to the Jupiter system.

Response: In this calculation, no time information is required as an assumption. The calculated photon flux represents the expected maximum (i.e., when the GALA FOV is fully covered by planetary surfaces at local time of 12h). This condition will be met after

its arrival to the Jupiter system since the Juice spacecraft will be close enough to conduct such measurements for icy moons. We clarified this point at lines 400–401.

9. Line 356, “In addition, the offset induced by launch vibration was expected to be smaller than 700 urad by an order of magnitude”: Does this mean the expected shift due to launch vibration is <70 urad?

Response: Yes. In the revised manuscript, we keep the phrase as it is.

10. The font sizes on the figures are not consistent and uniform. The axis labels in Fig. 4 and 6 are difficult to read. Ideally, the font size of all axis labels should be kept the same throughout the manuscript with the figures in the same size as they will be in the printed paper.

Response: Thank you for your advice. We increased the font sizes in Figures 4 and 6 to increase readability. Note that the location of figures is changed during LaTeX compilation, but this will be fixed through the proof-reading process later.