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An Analysis of the G-factor for All Operational Modes on QuikScat X

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An Analysis of the G-factor for All Operational Modes on QuikSCAT

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Abstract

The accuracy of the X-table with respect to range gate clipping is examined. Errors are less than 0.1 dB for slices 2 through 11 if the effects of range gate clipping are ignored. To improve the accuracy by use of the G-factor, it is recommended that the *Xfactor* program be altered to compute G for the centroid of the slices.

1 Introduction

The retrieval of the normalized radar backscatter (σ^0) includes the implementation of a table of values for X where $\sigma^0 = P_r/X$ and P_r is the power returned to the satellite. The equation to obtain X from the table is

$$X = X_{nom} + A + B \cdot \Delta f + C \cdot \Delta f^2 + D \cdot \Delta f^3 + 10 \log(G) \tag{1}$$

where Δf is the base band frequency shift and the other variables are found on the table. The term containing G, is to compensate for range gate clipping. Following is an evaluation of the accuracy of this approximation for both the inner and outer beams of all 8 operational modes for QuikSCAT.

2 Accuracy of the G-factor

The so called G-factor, as derived by Stephen Richards [1], approximates the loss of power due to range gate clipping at the center of each slice. The value of X for each slice can then be scaled by this factor.

The equation for G is

$$G = \frac{W_{pulse} + \frac{1}{2} W_{eg} - |T_{slice} - T_0|}{W_{pulse}}. \tag{2}$$

mode	effective gate width (ms)
1	0.0
2	0.1
3	0.2
4	0.3
5	0.4
6	0.5
7	0.6
8	0.7

Table 1: The effective gate width for the 8 operational modes of QuikSCAT.

If this calculation yields $G > 1$ then $G = 1$, or if this calculation yields $G < 0$ then $G = 0$. The time width of the pulse is $W_{pulse} = 1.5$ ms for QuikSCAT, and the effective gate width is $W_{eg} = W_{gate} - W_{pulse}$ where W_{gate} is the width of the range gate. The effective gate width is different for each mode as shown in Table 1. T_0 is the round trip flight time (rtft) to the electrical bore sight, and T_{slice} is the rtft to either the slice center or centroid.

In his report, Richards analyzed the accuracy of this approximation for modes 4 and 6. I used the same method described by Richards to include the range gate clipping for calculating X. This is what I used as the correct value in my analysis. I used 3 different methods for calculating G to correct the non-G X-table. To evaluate the accuracy of the correction, for each beam of each mode I used 50 Gaussian distributed random orbit and attitude perturbations. The orbit times and azimuth angles are also random, having a uniform distribution.

For my first test, I calculated G for the **center** of each slice. I checked the accuracy of X with and without the G correction. For each individual mode and beam, the accuracies were similar. Plots of the average errors are shown in Fig. 1. The major error in X due to range gate clipping is in the outer slices, as expected. Although for some modes the average error of the outer slices is as large as 0.5 dB, in general the average error is much less than 0.1 dB. For the outer slices it appears that the G correction decreases the accuracy of X by over correcting. The error for the inner slices caused by range gate clipping is very small in comparison to other possible sources of error.

Richards mentions that the problem of overcorrection can be fixed by calculating G for the **centroid** of each slice. For my second test this is the method that I used. Figure 2 shows that this does eliminate the overcorrection problem. Figure 3 does not show the error for the outer slices for the purpose of better illustrating the inner slice errors. Figure 3 suggests that no G correction is needed.

For the third test, I checked whether the accuracy of the G correction could be increased by approximating G as function of Δf in order to correct for perturbations. The results are shown in Fig. 4. The improvement in accuracy is not large enough to be notable, and thus not worth the extra complication of using a function to approximate G.

3 Conclusion

The effects of range gate clipping on the accuracy of X is minimal. The error appears to be less than 0.1 dB for slices 2 through 11. For the inner slices the error is less than 0.02 dB. This analysis includes all 8 modes, both beams. Thus, no G correction is needed. Even so, X accuracy can be improved by including the G-factor. If it is intended that G be included in the X calculation, then it is recommended that the *Xfactor* code be modified to calculate G for the **centroids** of the slices. This will have little impact on the speed of *Xfactor* because the current version already includes most of the calculations necessary.

Figure 1: Error in X (dB) if G is calculated using the slice centers. The errors shown in each plot are the averages of 50 cases. The cases had a random perturbations with a Gaussian distribution over the small perturbation range. The azimuth angles and orbit times were also randomly distributed.

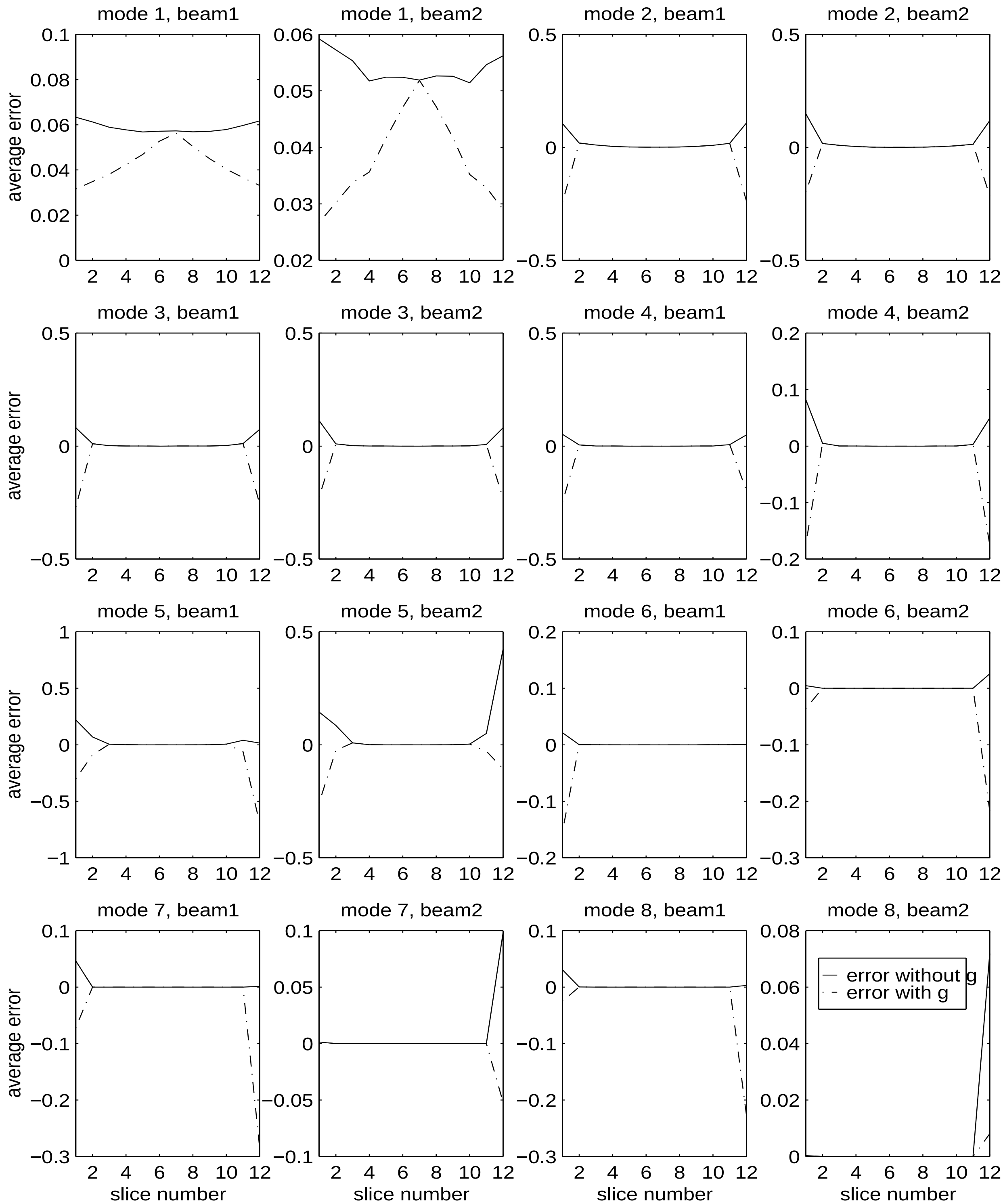


Figure 2: Error in X (dB) if G is calculated using the slice centroids.

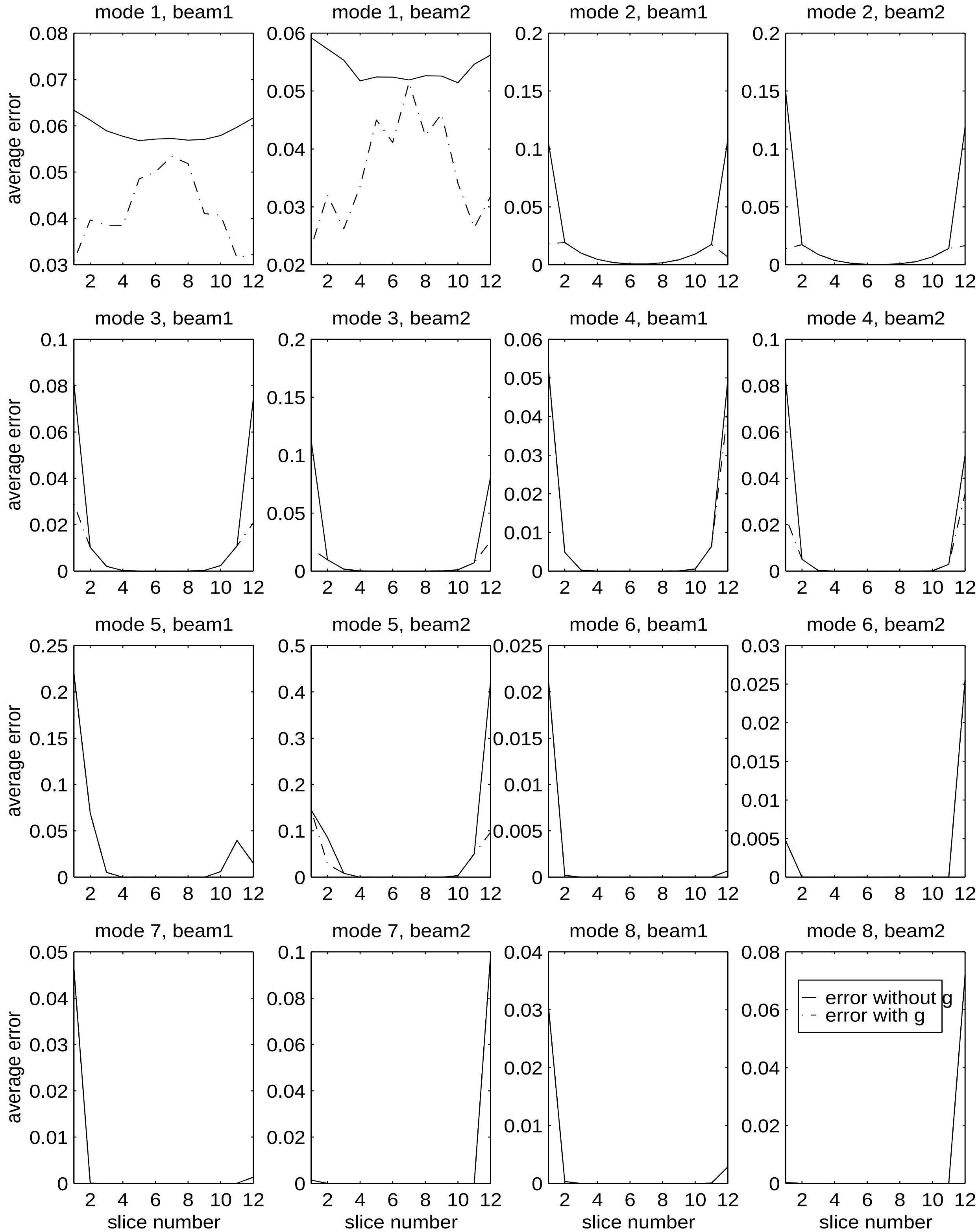


Figure 3: Error in X (dB) if G is calculated using the slice centroids. Slices 1 and 12 are not shown so that the scale of the error of the inner slices can be seen.

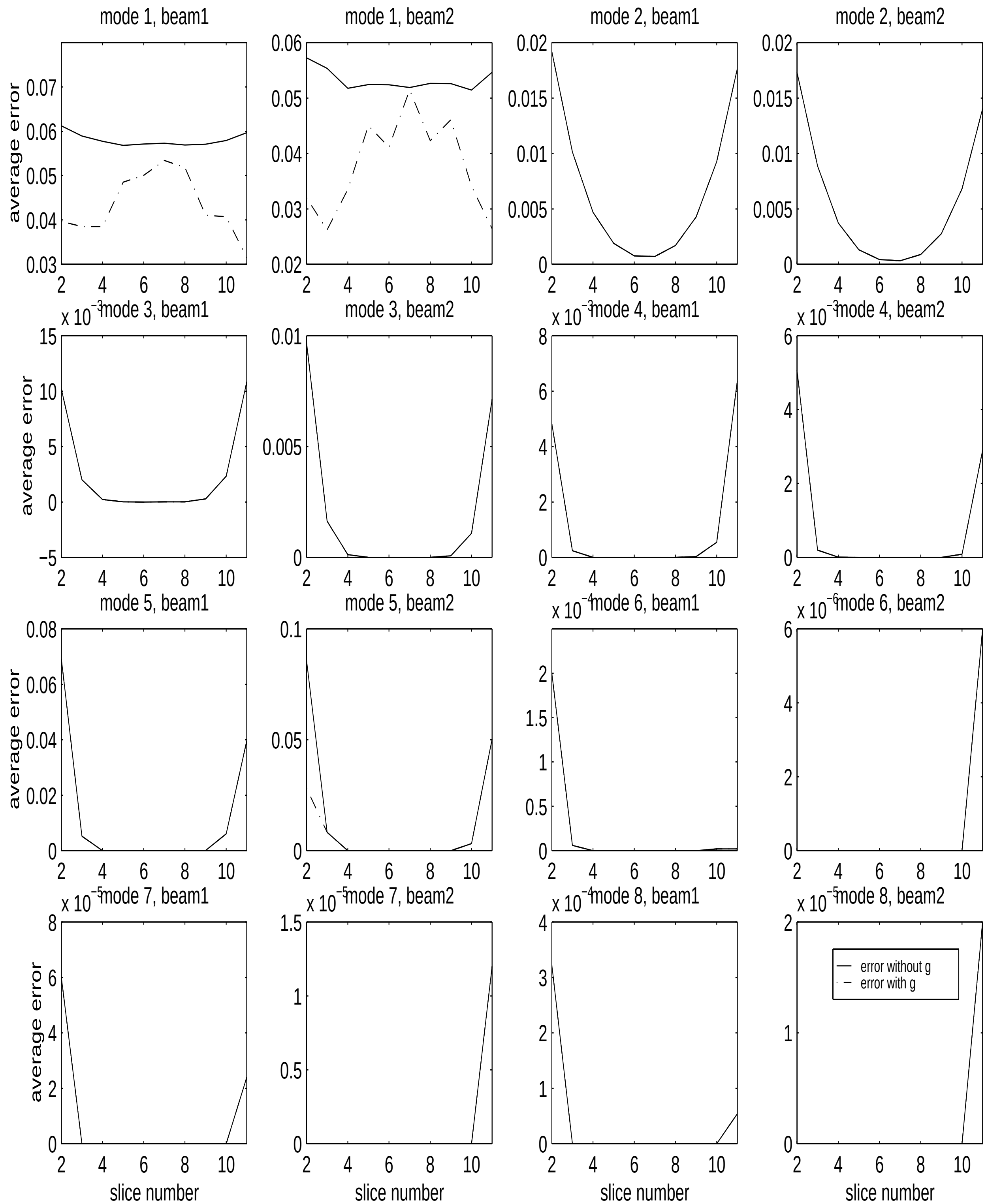
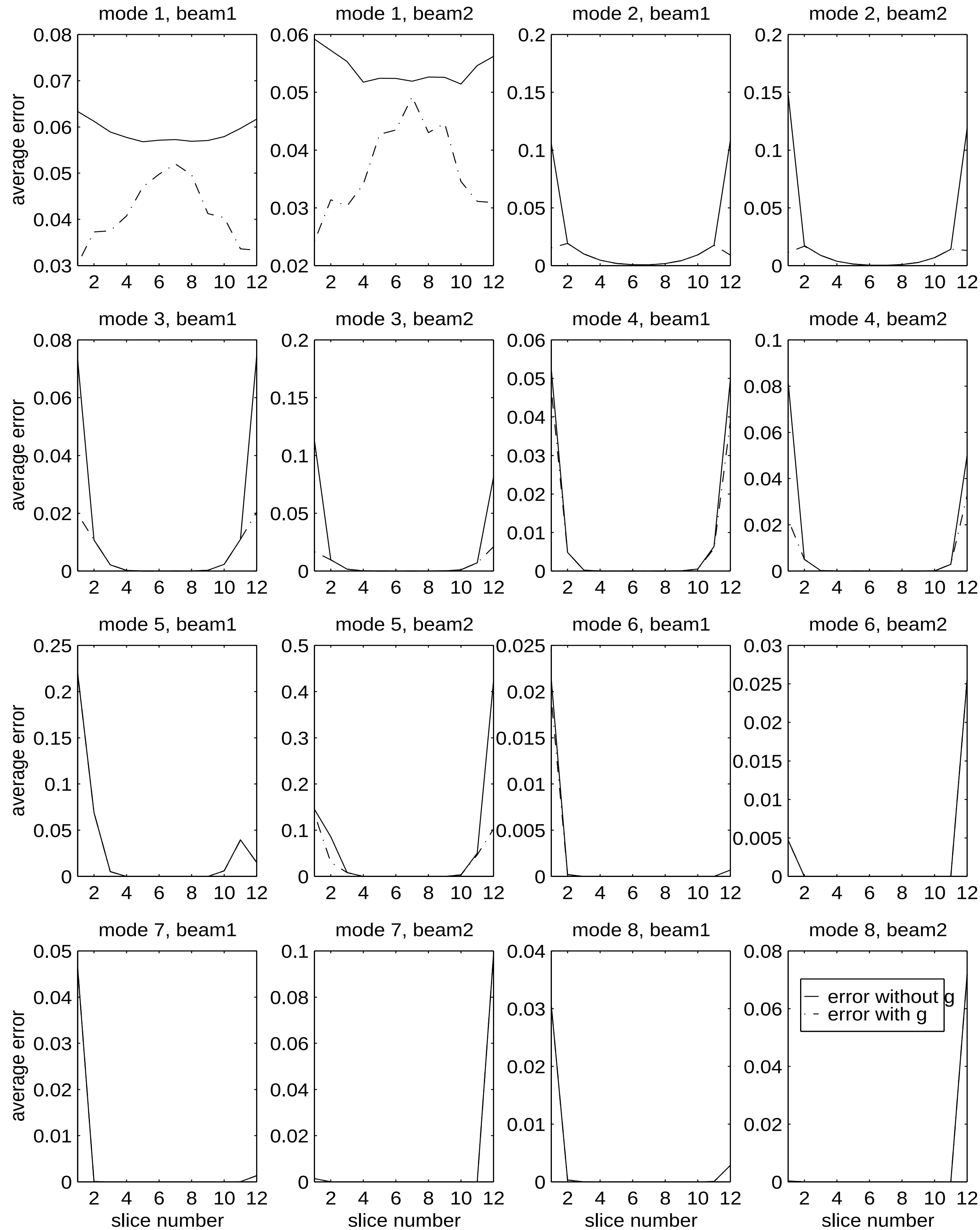


Figure 4: Error if G is calculated using the slice centroids, and G is corrected for perturbations.



4 Additional Figures

Following are some figures that include information that may be of interest. Data for the slices 1, 2, 11, and 12, and the egg are shown. Because the errors for the inner slices are negligible, they are not shown. Figure 10 shows the type of frequency shifts expected for QuikSCAT perturbations.

Figure 5: Histograms of the uncorrected error in X due to range gate clipping for slice 1. Each plot covers 50 random cases.

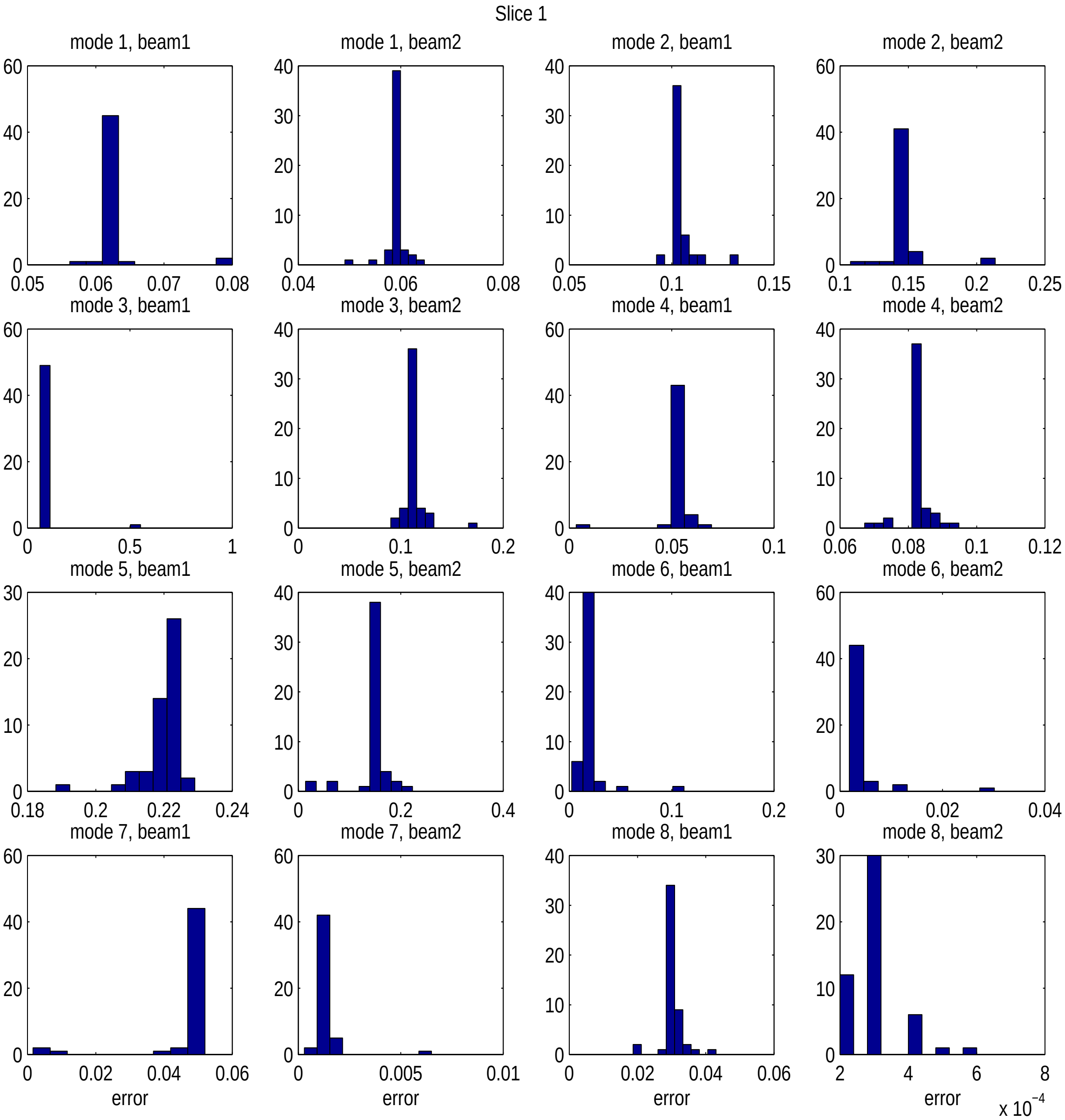


Figure 6: Histograms of the uncorrected error in X due to range gate clipping for slice 2. Each plot covers 50 random cases.

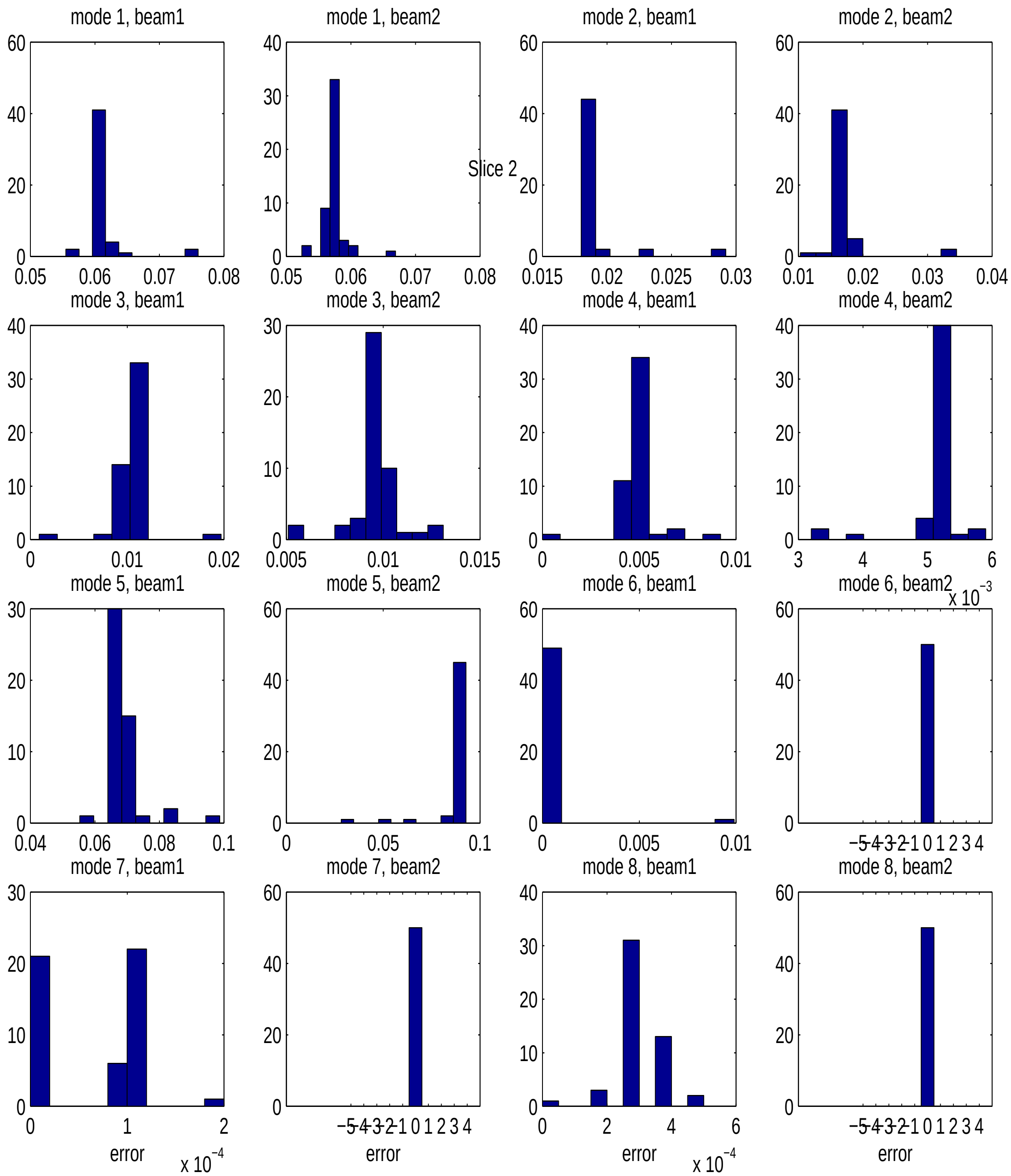


Figure 7: Histograms of the uncorrected error in X due to range gate clipping for slice 11. Each plot covers 50 random cases.

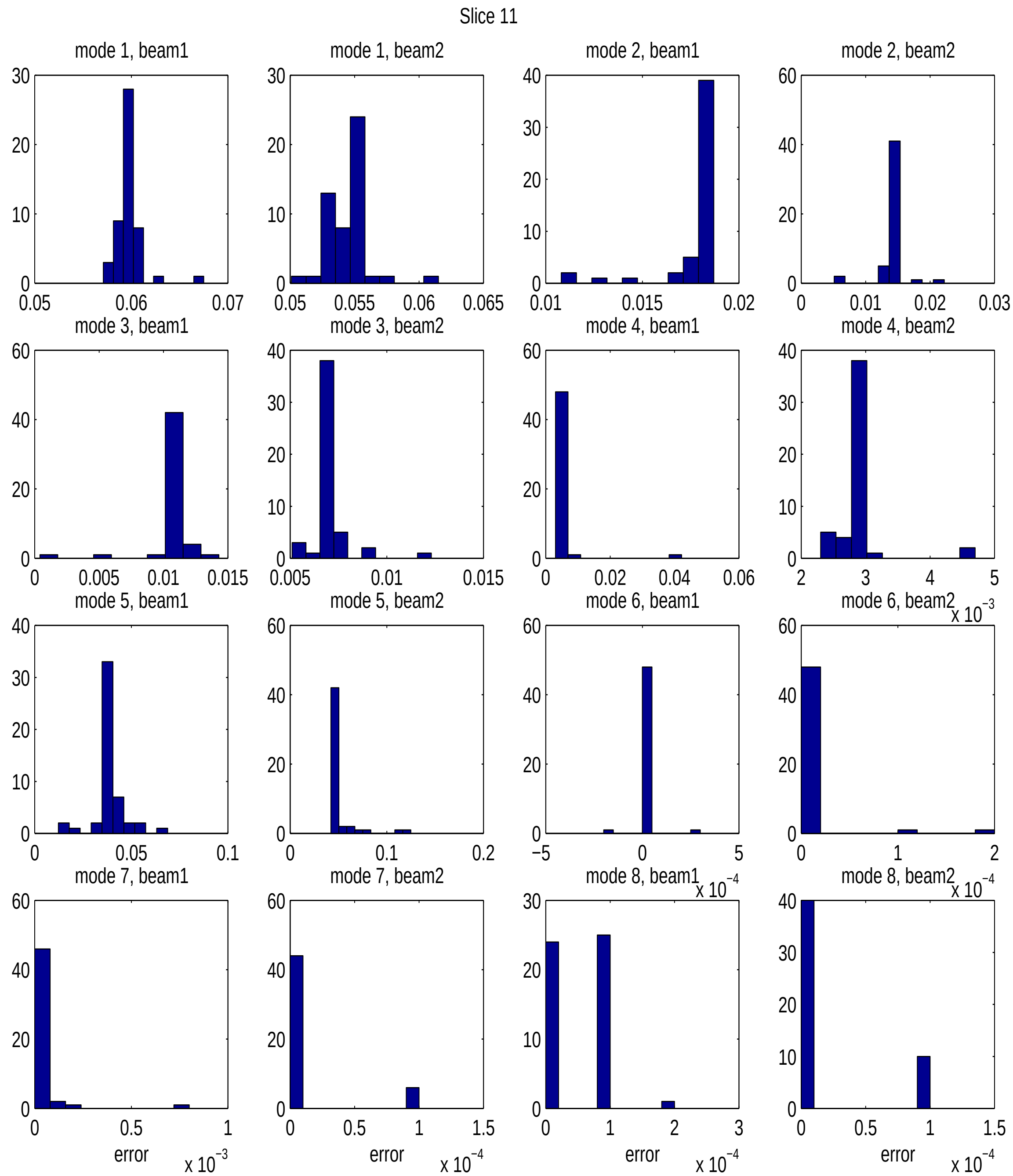


Figure 8: Histograms of the uncorrected error in X due to range gate clipping for slice 12. Each plot covers 50 random cases.

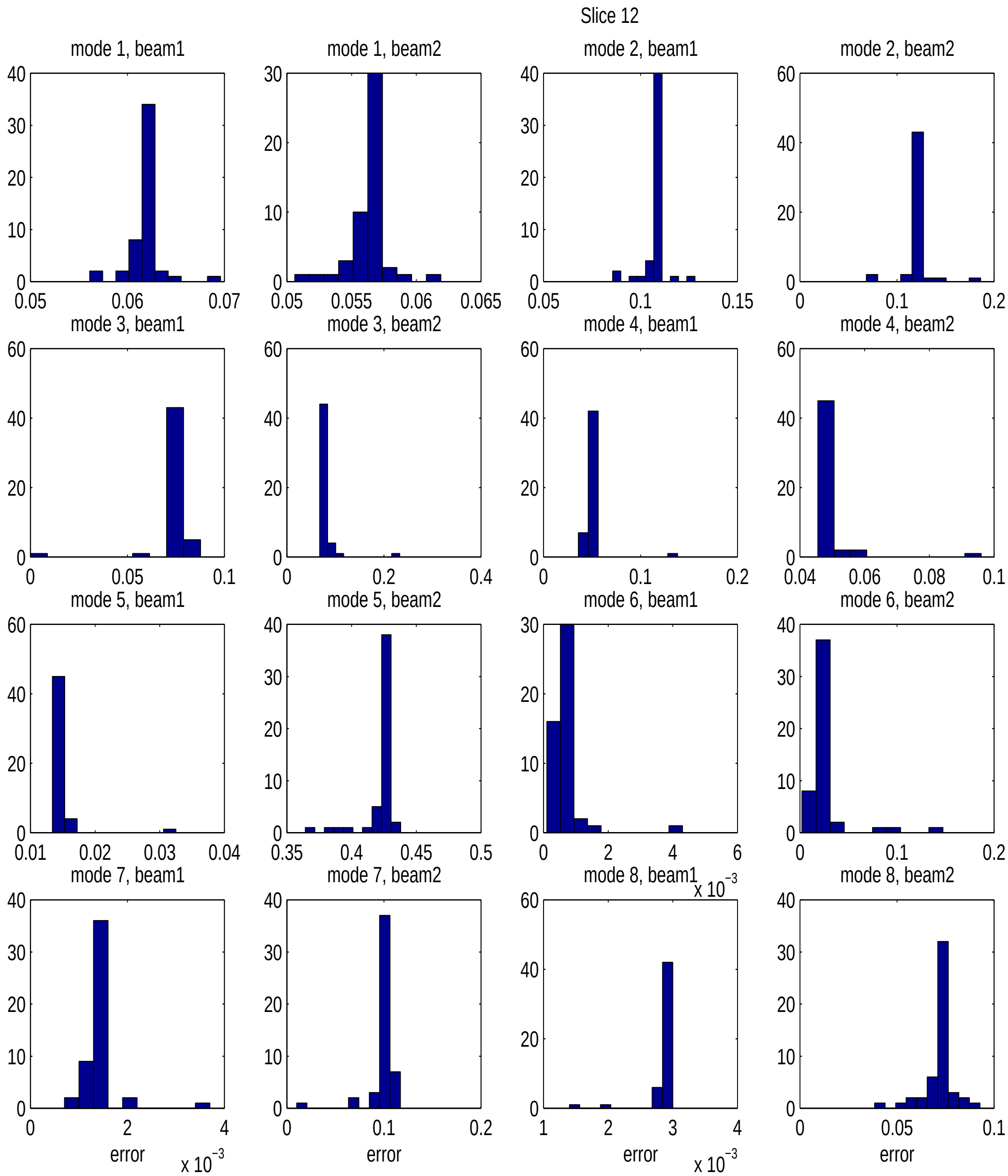


Figure 9: Histograms of the uncorrected error in X due to range gate clipping for the egg. Each plot covers 50 random cases.

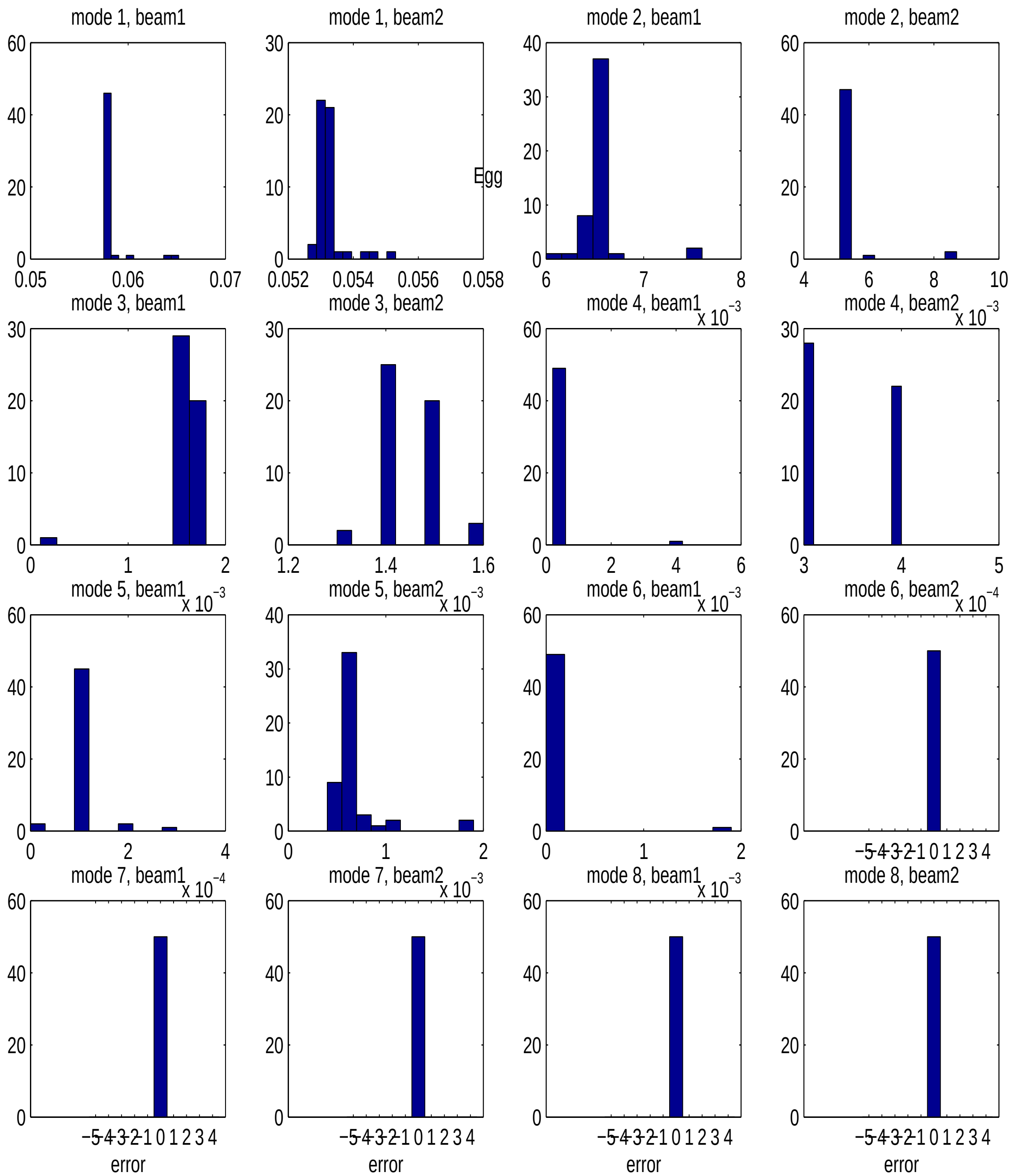
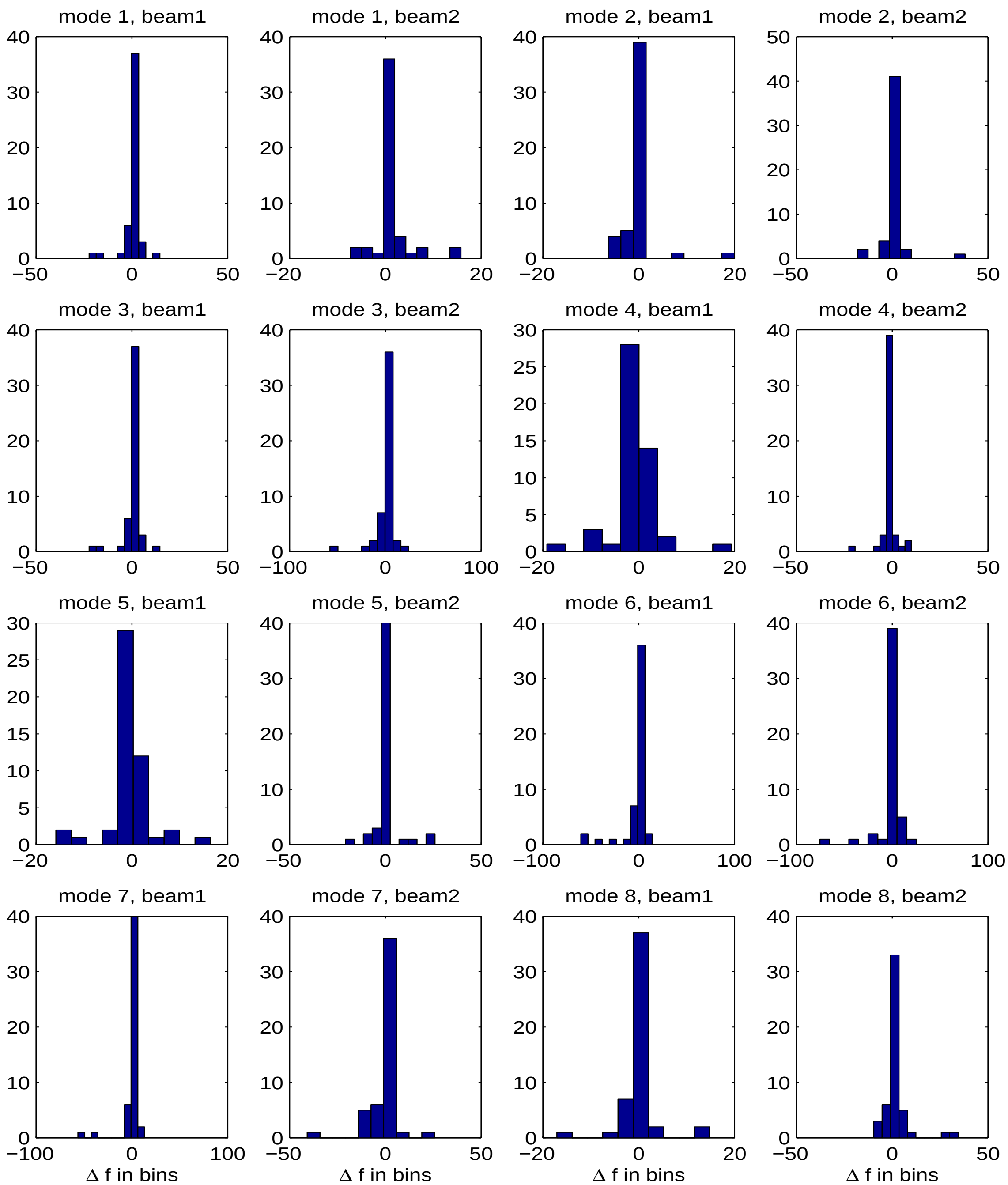


Figure 10: Histograms of Δf for each of the tests. This indicates what kind of frequency shifts can be expected for QuikSCAT. The frequencies are all in frequency bins where 1 bin≈462 Hz.



References

[1] Richards, Stephen L: *Effects of Range Gate Clipping*, Brigham Young University, 11 May, 1998.