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Re-evaluating Galileo Energetic Particle Detector data based on radiation detector decay; for use in estimating Sputtering Erosion rates on Europa.

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Abstract

The Energetic Particle Detector (EPD) launched in 1989 on the Galileo satellite took data on the Jovian Particle environment for 6 years before its demise [1]. Over the course of the mission the detectors in the Composition Measurement System (CMS) have visibly decayed with higher mass particles, specifically Oxygen and Sulphur, reading far lower energies at later epochs. By considering the non-steady accumulation of damage in the detector, as well as the operation of the priority channel data recording system in place on the EPD, an evolving correction can be made. Adjusting the data to account for the damage to the detectors will improve our understanding of the Jovian radiation environment. In particular, we can use the revised fluxes to re-evaluate the effect of the particle environment on the surfaces of the icy moons.

1. Introduction

This paper focuses on the PHA data from the EPD detector; specifically from the CMS telescope on the top of the instrument. The instrument uses foil films to detect time of flight of the incoming particle before they impact on the silicone semi-conductor detector at the end. This data has been analysed and can be displayed using ILD as a Pulse Height Analysis (PHA) graph as shown in Figure 2. The distinct loci visible in Figure 2 define the elements that were detected in the Jovian system, the uppermost is Sulphur followed by Oxygen, the faint line in the box labelled TA1 is Helium and the final loci is formed from Protons.

The loci of these elements reveal, when compared to those from near the end of the mission (Figure 2), that the detector is decaying in sensitivity. Figure 2 shows the same plot type from the 22nd October 2002, near the end of Galileo's mission. The same loci from Oxygen, Sulphur and Helium have all dropped in energy in varying amounts. The amount of energy drop corresponds to the element in question; as the dead layer of the semi-conductor detector thickens.

This thickening of the dead layer is the physical aspect of the decay and is caused by the radiation impacting onto the detector. This causes either the build-up of the silicone dead layer itself, or a build-up of sedimentation on the surface of the detector in addition to the dead layer. This affects only the energy readings of the composition measurements. The time of flight measurements stayed consistent during the mission; this makes the identification of element amounts in the Jovian plasma disk less accurate.

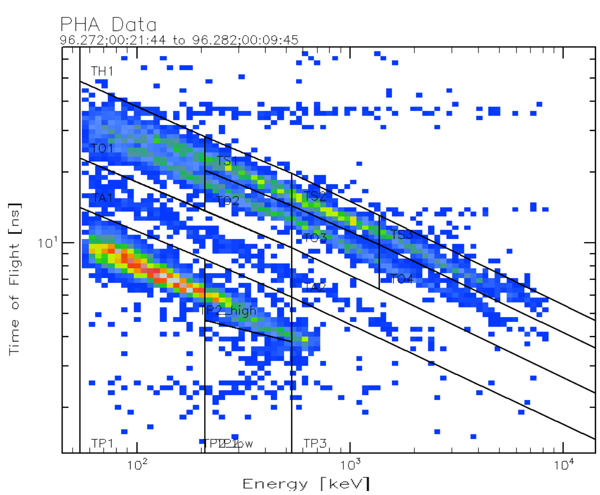

Figure 2: Pre-analysed EPD data beginning on the 29th Sep 1996 shortly after the arrival of Galileo in the Jovian system.

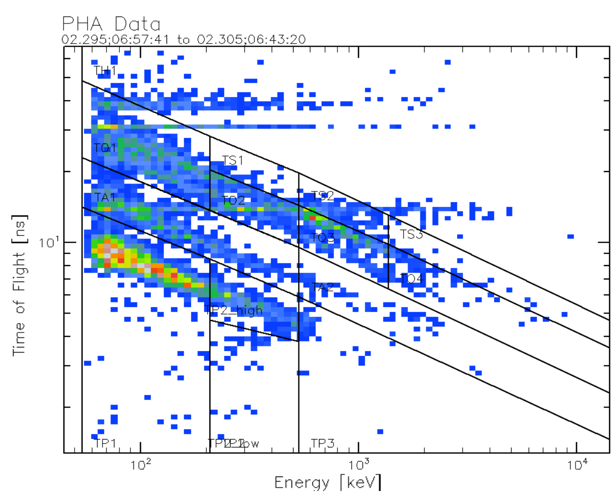

Figure 2:Pre-analysed EPD data beginning on the22nd Oct 2002 nearing the end of the mission lifetime shortly before the demise of Galileo into Jupiter itself.

There are many uses for having corrected data values for the radiation composition and energy levels in Jupiter's plasma disk. One of which is for analysing the effect of radiation on the surface of the Jovian moons. The corrected values will be the basis for sputtering calculations on the surface of Europa, updating the current estimates of the erosion rates as found in [2]. The new data could also be applied to current models, updating the estimates used in radiation analysis.

2. Correcting the data for radiation damage.

The data can be corrected by assuming a non-steady accumulation based on the position of the spacecraft and the time it has been in flight. By assigning a value to the amount of damage caused by a certain intensity of radiation incident on the detector, the value can be used to sum the decay based on the intensity and flight time.

The flight time of the spacecraft is important when the orbit path is observed in terms of an average intensity (Figure 4) (counts per second) incident on the detector (Figure 3). When plotted as intensity against the radius there is a clear distance from Jupiter which has far higher intensity than further out distances.

Europa's orbit is positioned at the peak R_J of the radiation intensity, $8R_J$. With the correction added to these values it can be seen how much the surface interactions can be changed.

For the data set available there are missing sections of data (Figure 4) for both intensity and position of spacecraft. These will have to be estimated to accurately compile the full amount of damage on the detector; even when there was

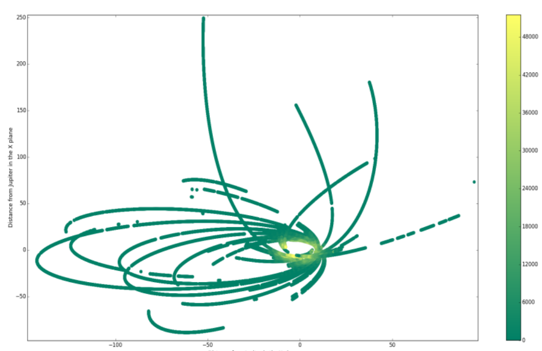

Figure 4: An orbit plot of Galileo's flight path around Jupiter. The colour bar signifies the CPS incident on the detector.

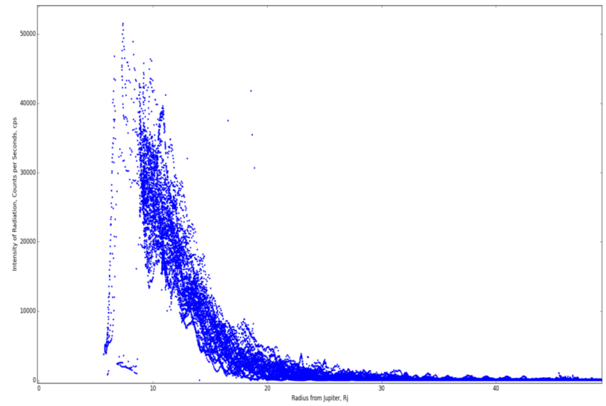

Figure 3: plot of the radiation intensity as a function of radius away from Jupiter in R_J. The intensity is plotted as counts per second incident on the detector.

no data being taken there would have still been particles hitting the detector. This is also true for the journey time to the Jovian system as well; there were recorded solar storms and flares that Galileo could have encountered on its journey that will have to be accounted for. This will most likely be a set value of damage that will carry some systematic error into the values, but that cannot be avoided.

3. Summary and Conclusion

The correction of the Galileo Jovian radiation data will be greatly useful in the areas of exploration, radiation analysis and also surface radiation interactions. The corrected values will allow far more detailed and accurate estimates to be made for the radiation erosion on Europa and on the other moons. It will also allow for better analysis of the surface composition of the moons, with the knowledge of what may have been artificially added to the surface from impacting and sputtered particles.

4. Acknowledgements

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5. References

[1] D. J. Williams, R. W. McEntire, S. Jaskulek, and B. Wilken, Space Science Reviews **60** (1-4), 385 (1992).

[2] C. Paranicas, B. H. Mauk, K. Khurana, I. Jun, H. Garrett, N. Krupp, and E. Roussos, Geophysical Research Letters **34** (15) (2007).