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Correction of Galileos Energetic Particle Detector, Composition Measurement System

Zoe Lee-Payne[1], Manuel Grande[1], Peter Kollmann[2], Norbert Krupp[3]

1 – Aberystwyth University, UK **2** – John Hopkins Applied Physics Laboratory, Baltimore
3 – Max Planck Institute for Solar System Research, Göttingen, Germany

Abstract

Over the course of its 8-year mission the Energetic Particle Detector, launched in 1989 on the Galileo satellite, took data on the Jovian Particle environment. In the high radiation environment, the EPDs Composition Measurement System (CMS) visibly decayed; higher mass particles, specifically oxygen and sulphur, reading at far lower energies and count rates later in the missions. 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, a correction can be made. A model of dead layer build-up in semiconductor detectors is built, based on SRIM results, and then used to reverse the effects of the build-up. The result, assigns an estimation of dead-layer depth during the mission data recordings, and produces a corrected version of the high rate data and the count rate channels, for future use.

1. Introduction

This paper focuses on the data from the EPD; specifically, from the CMS telescope on the top of the instrument. Comparing data from the beginning of the mission to the final data retrieved [Figure 1] there is a clear discrepancy in the loci defining the elements. The uppermost is Sulphur (orange line) followed by Oxygen (yellow) beneath it, the green line in the box labelled TA1 is Helium and the final loci, Protons in blue.

The loci of these elements reveal that the detector is decaying in sensitivity. The amount of energy drop noted corresponds to the element in question; as a dead layer builds up on the front of the detector, the larger particles lose more energy passing through this layer than lighter elements. This thickening of the dead layer is caused by the radiation impacting onto the detector denaturing the sensitive volume.

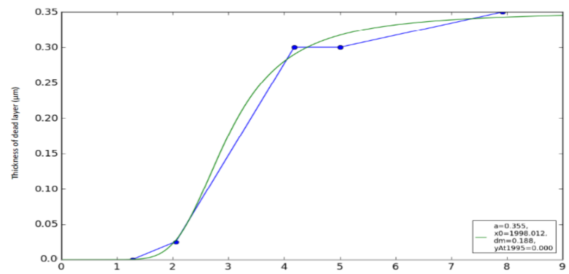

Figure 2: Dead Layer thickness evolution over time.

2. High Rate Data Correction

The High rate data is only available in short sections of the mission, mainly during the flybys and periods of interest. The correction of this data is based on the nature of the detector, and the build up of the dead layer. The dead layer thickness is estimated throughout the mission using calibration masses with a simulated depth of dead layer. The comparison between this and the real values gives the evolution of the dead layer thickness [Figure 2].

Knowing the thickness of the dead layer allows a correction to be made using a selection of masses and the known energy lost

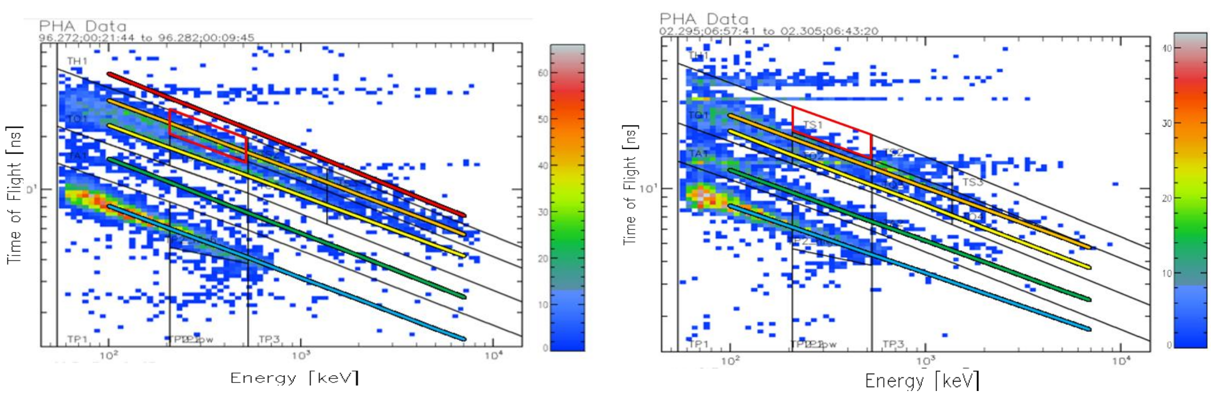

Figure 1: LEFT: EPD data beginning on the 29th Sep 1996 shortly after the arrival of Galileo in the Jovian system. RIGHT: EPD data beginning on the 22nd Oct 2002 nearing the end of the mission lifetime shortly before the demise of Galileo into Jupiter itself

for the dead layer present. The final correction is made by working backwards; starting with all the possible test masses, and calculating the energy loss of the particle passing through the established dead layer. This loss is the applied to the possible starting energies and a final comparison to real readings is made. This highlights the closest value of the original particle.

3. Count Channels Data Correction

Correcting the count rate channels requires a different approach; the dead layer thickness is used only in assessing the progress of the correction. Instead, this correction method uses comparative count rates from relative locations in the Jovian system at different times. This is used to calculate a value of the decay in terms of number of counts hitting the detector. By systematically applying this value to the counts registered by the detector brings the values closer to the true values (Figure 3).

dead layer thickness. It also fits well with ratioed data taken by Voyager across all elements [1].

The most common miss-allocation of the particles was a sulphur particle measured by the Oxygen channel. The nature of the movement of the particles through the channels means that as the Sulphur channel increases by the correction, then the Oxygen must decrease with the correction. Overall the change is significant, meaning that sputtering on the surface is far more sulphur dominant than originally believed.

The correction of the EPD data is proving to be invaluable in re-evaluating the conditions on the surface of Europa. Re-calculating the surface sputtering and erosion, gives a far more accurate estimate on the age of the surface. Where others previously have only been able to estimate for global coverage, new techniques may be possible to give dates to specific features and bridge time spans between main formation events.

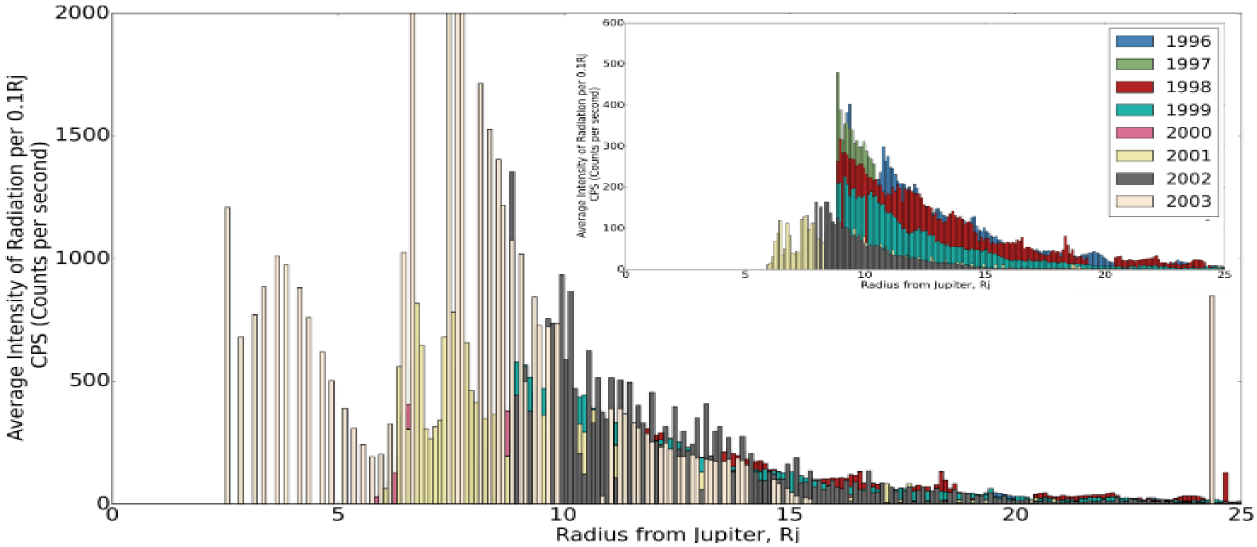

Figure 3: TOP RIGHT OVERLAY: Average count rate against radius for each year of the original TS1 Sulphur channel. MAIN IMAGE: Matching plot of corrected data from TS1 sulphur channel.

This is an intensive iterative process that encompasses the changing values of counts over the mission and the effects of efficiency dropping over the mission. Each individual count rate channel is processed in this manner.

3. Summary and Conclusion

The correction results are dramatic; both in the high rate data and the individual count rates. The count rates are greatly increased over the whole mission, particularly during the final years. The High rate data, whilst not accounting for efficiency drops, still offers a differing view of the environment composition. All the corrected data matches considerably better with calibration data, both for overall count rates and estimated

4. Acknowledgements

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5. References

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