SWAP Calibration Information

This document describes the calibration incorporated into the data pipeline (level 3), and information included in the SWAP calibration directory, which is necessary for further data processing (level 4 and higher). Currently, the pipeline includes calibration information to perform the background subtraction for all plan 0 and plan 3 measurements, and to calculate the energy labels for the spectrograms. The energy bins were calculated using an instrument model, which combined all the calibration information discussed in this document. Since the energy bins were calculated assuming ions entered the instrument in the center of the instrument, and the energy does not depend on some quantities such as the geometric factor, the energy bin calculations are primarily a function of the RPA and ESA response curves. The additional information discussed required for further data processing include: the instrument field of view, angular responses of the RPA and ESA, deflector calibration, and geometric factor. Much of the calibration data is discussed in the SWAP instrument paper, the instrument paper is included in the document directory in the file swap_ssr.pdf. We refer to some figures in the instrument paper, and provide some further details necessary to work with our data. We refer to some figures in the instrument paper using reference [MCCOMASETAL2008], this paper is the file swap_ssr.pdf.

1) Retarding Potential Analyzer (RPA)

Figure 1 shows the general shape of the RPA response over the full voltage range. Normalized coincidence is plotted as a function of the RPA voltage/beam energy. Because the individual RPA grids have a finite thickness, they act as a series of electrostatic lenses. The features in this figure, including maximum near 0.945 ~~keV~~, are due to the focusing properties.

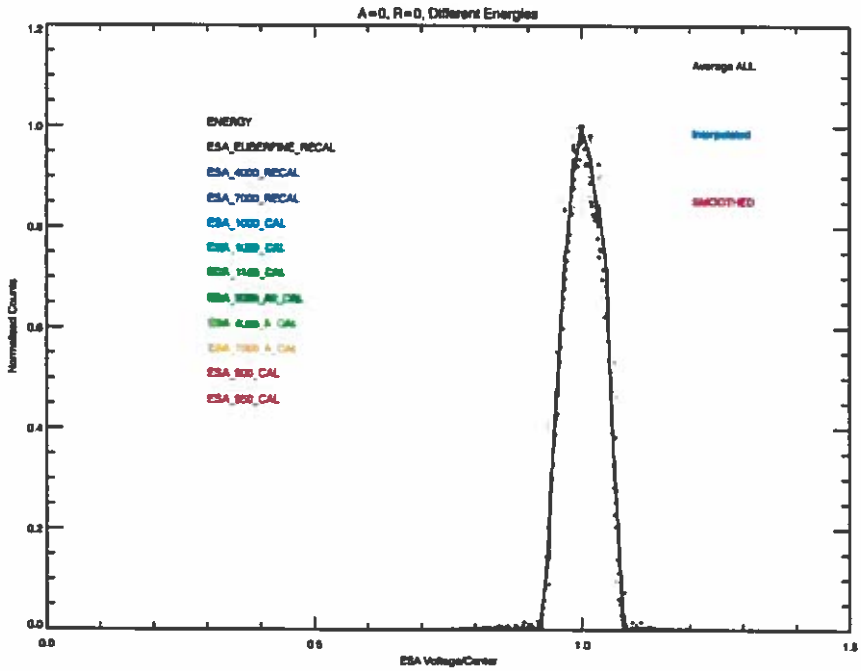

Figure 4: ESA Response function: Normalized counts versus ESA voltage normalized by the ESA voltage at the peak response.

ESA

The ESA width varies with azimuth angle. We fit many ESE response curves taken at different energies and azimuth angles, and found the full width at half max as a function of azimuth angle. We then normalized the widths by the ESA voltage (center of the ESA response) and averaged over many tests taken at different energies. Below we show these averages plotted as a function of azimuth angle (Figure 5), and we show the results in tabular form in Table 1.

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The energy bin peak response depends on the voltage settings of the RPA, ESA, DFL and the angle the ion enter. For science observations in the Jupiter phase, the deflector voltage was zero except during the angle test. Since we do not know ~~what~~ the angle the ions enter, at which we assume the ions enter the center of the instrument; this assumption limits the uncertainty in the location of the center of the ESA passband to about 10% for ions 7 Figure 5: Diagram defining the roll (φ) angle. The view is looking at the top of the instrument towards the spacecraft. entering anywhere in the 10° instrument Field-Of-View (see Figure 31 of [MCCOMASETAL2008]). We then use the RPA and ESA voltage setting to calculate the center of the combined response. We have the energy of the peak response for each RPA and ESA voltage setting in the onboard voltage tables. In the calibration directory we list the filenames of the precalculated energy bin centers and the time periods over which they are valid in the list_energy_files.tab file. Each energy bin file (i.e., esa_rpa_v19_energy_binsf.csv, filename suffix extension is .tab in PDS data sets) lists the plan number, sweep, number, ESA DAC, RPA DAC, ESA voltage, RPA voltage, the crossing ratio (ratio of the RPA voltage to the ESA center energy), energy at the peak response, energy width (FWHM), minimum energy, and maximum energy. These energy tables are used to determine the energy in the spectrograms.

5) Detectors

Ions that pass through the sensor then pass through a thin carbon foil and are measured by the PCEM. Secondary electrons liberated from the carbon foil are attracted to the SCEM. Events that are measured by both the PCEM and SCEM within 100 nanoseconds time are recorded as coincidence (COIN) events.

We determined the operation voltage for PCEM and SCEM by sweeping the voltage while illuminating the instrument with a constant intensity 1 keV proton source. Figure 7 shows the response of the PCEM, SCEM, and the COIN rate as a function of voltage. For the data shown here, the voltage applied to the PCEM and SCEM were equal. From these tests, we selected a nominal operation voltage of 2100 V at start of mission, which is well ~~out on~~ the saturation ~~part~~ of the CEM gain curves. The high voltage power

into region