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Calibration of Electrostatic Analysers to Study Planetary Magnetospheres and Icy Moons

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Abstract

Spherical electron and ion spectrometers allow to measure flux density, energy, entrance angles and mass per charge relations of plasma populations and particle jets. This makes them key tools to understand planetary magnetosphere's and their interaction with the solar wind and their moons.
We perform currently a detailed characterizing campaign of the planetary Ion Camera (PICAM) for BepiColombo and the Jovian Electron and Ion Spectrometer (JEI) for the Jupiter Icy Moons mission. Target is hereby to calibrate two space instruments in detail using the same test bench to allow a better comparison of the space born measurements.

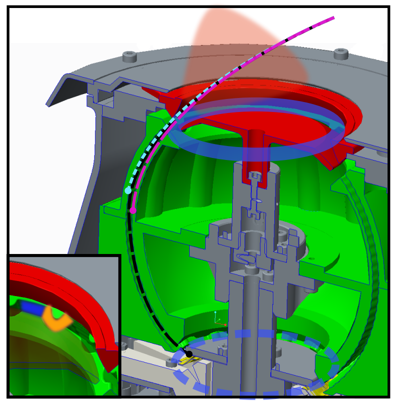

Figure 1: Principle of a spherical electrostatic analyser. Inner and outer(red) deflector select the acceptance angle of entering particles(polar). The charged spheres(green) select for energy per charge as the electric field forces them on a curved trajectory. 16 Channel Electron Multipliers (CEMs) allow to distinguish the azimuth direction (blue). Bottom left: Separator channels in-between (orange) suppress cross talk.

1 Introduction

BepiColombo gives the unique opportunity to perform bi-static measurements of another planet. The mission consists of two orbiting elements: Mercury Planetary orbiter provided by ESA and the Mercury Magnetospheric Orbiter built by JAXA. Both orbiters house a plasma sensor package. The orbiter provided by ESA carries PICAM as part of the Search for Exospheric Refilling and Emitted Natural Abundances detector package. PICAM is hereby dedicated to analyse Mercurys interaction with the solar wind by observing the planets magnetic field interaction. In addition, analysing the weak exosphere of Mercury will allow to draw conclusions on the sputtering and ionisation processes present. The sensor is capable of observing in an energy range of $1\mathrm{eV}$ to $3\mathrm{keV}$ with an resolution of up to 10%. The time-of-flight unit allows to resolve the incoming particles at a m/δm ratio of 100.

The Jupiter Icy Moons Explorer(JUICE) is designed to understand the Jupiter system as a reference model for gas giants and icy moons. The purpose of the Plasma Environment Package (PEP) on JUICE is to directly characterize Jupiter's magnetosphere and to observe the plasma environment of the icy moons. PEP will also deliver information on the interior structure of the moons due to their interaction with Jupiter's magnetosphere. Within PEP the spherical electrostatic analyser JEI is optimized to observe ions and electrons in the energy range 10eV to 60keV at an almost full hemispheric field of view (FOV) and with a high temporal resolution of 4s. The polar FOV and resolution is defined by the inner and outer deflector. They allow for a theoretical FOV in polar direction of $80°$. Due to 8 voltage steps the resolution is given as $10°$. The gap between the spheres is 2.5mm which results into an effective energy resolution of 8.3%.

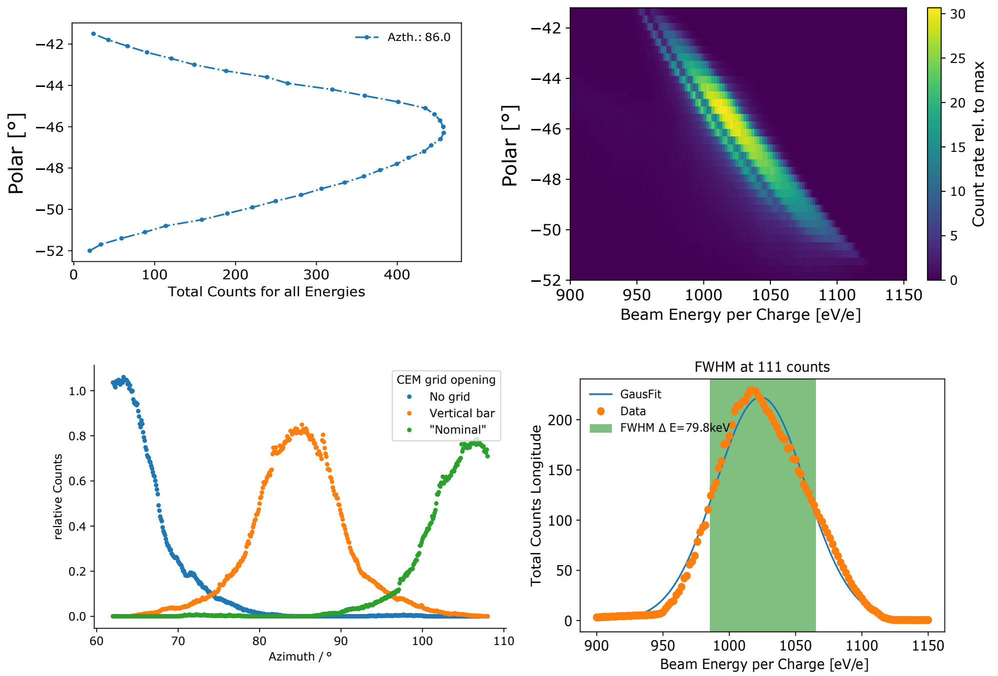

Figure 2: Determination of Energy and Field of view resolution. Top right: Sensor counts for Beam Energy vs. polar orientation. Top left: Collapsed counts of polar angle over all energies. Bottom right: Collapsed counts of beam energy over all polar angles. Bottom left: Counts over azimuth with neighbouring channels.

2. Calibration campaign

The JEI flight model is currently in the final assembly phase. Meanwhile the EM underwent a detailed characterisation. The measurements confirm an energy resolution 8.0%. As can be seen in Fig. 1 the acceptance angle for a ploar step is smaller than the actual stepping resolution of $10°$.

The results confirmed the theoretical values and motivated minor design optimisations for the spheres and entrance grids. Under optimal condition the beam focus horizontally and gets fully blocked by the entrance grid in front of the CEMs. This effect can bee seen by the count rate decline in top right of Fig. 1. Therefore the CEM entrance grid has been modified in order to avoid the resulting shadowing effect which can be seen . In the bottom left of Fig. 1 the azimuth acceptance showed no overlap. Therefore the separator gaps have been smoothed in order to increase the azimuth acceptance angles. This increases cross talk but also the overall count rates.

Ongoing work is aiming to validate the the modified performance of JEI and compare it with PICAM.

Acknowledgements

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