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The Jovian Plasma Dynamics and Composition Analyzer - Performance evaluation

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Abstract

The Jovian plasma Dynamics and Composition analyzer (JDC), a new instrument design currently tested at the Swedish Institute of Space Physics will explore Jupiter and the Galilean moons as part of the Particle Environment Package (PEP) on board of the JUICE spacecraft. During the design phase of this sensor extensive simulations were run. The results of these simulations are now compared to the behavior and response of the technological model of JDC. This comparison shows excellent agreement between measurements and simulations.

1. Introduction

On board of ESAs JUpiter ICy moons Explorer (JUICE) is the Particle Environment Package (PEP)[1]. PEP consists of six instruments, which measure the plasma environment around Jupiter and its icy moons. The technological model of one of these instruments, called the Jovian plasma Dynamics and Composition analyzer (JDC), was fully assembled in the first half of 2019 at the Swedish Institute of Space Physics (IRF). There the technological model is currently undergoing intensive tests which are compared to the expectations from prototypes and simulations[2].

2. Scientific Objectives

With measuring mass resolved positive and negative ions as well as electrons in an energy range of 1eV/q-40keV/q in a hemispheric field of view JDC addresses the following science objectives. It is studying the structure, creation and maintenance of the Jovian magnetodisc as well as four properties of the four Galilean moons. These properties are (1) the interaction of the Jovian magnetosphere with the moons, (2) the exospheric composition of Ganymede, Callisto and Europa, (3) the precipitating plasma populations on the surfaces of Ganymede and Callisto and (4) the 3D continuous plasma moments to investigate the interior of Ganymede.

3. Instrument

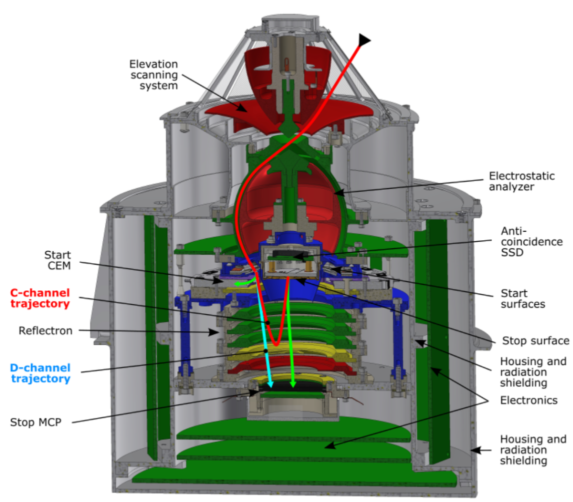

Figure 1: Cross section of JDC with typical particle trajectories indicated.

A typical incoming particle will enter the sensor through the elevation scanning system, pass the wedge shaped electrostatic anaylzer and will enter the time of flight section in the reflectron by hitting a start surface, shown in Figure 1. At this collision a secondary electron is produced which will trigger a start signal. The left over particle will eventually trigger a stop signal after some time depending on its charge and velocity. To get the optimal ion path through the instrument, each ion-optical sub system was optimized for its properties with help of a Simion [4] ion optical simulation. During this optimization process the performance values, shown in Table 1, were calculated.

Currently the technological model of the instrument is assembled and tested. This model is a flight like design, which has to undergo extensive mechanical, ther-

Table 1: Expected performance of JDC[3]

Parameter	Performance
Particle species	(i+),(i-),(e)
Energy range	1 eV - 40 keV
Energy resolution	12%
Mass range	1 amu - 70 amu
Mass resolution	2 - 3 (D-channel) ≥ 20 (C-channel)
Field of view	90° x 180° ($<$ 25 keV) $<$ 90° x 180° ($>$ 25 keV)
Angular resolution	5.5° x 19.5°
Time resolution	2D per 0.8 s 3D per 11 s
G - Factor	Total: $8 \times 10^{-3} \frac{\mathrm{cm^2 sr eV}}{\mathrm{eV}}$ Pixel: $5.6 \times 10^{-4} \frac{\mathrm{cm^2 sr eV}}{\mathrm{eV}}$

mal and functional tests. With the data obtained during these tests it was verified that the instrument matches the predicted properties (Table 1).

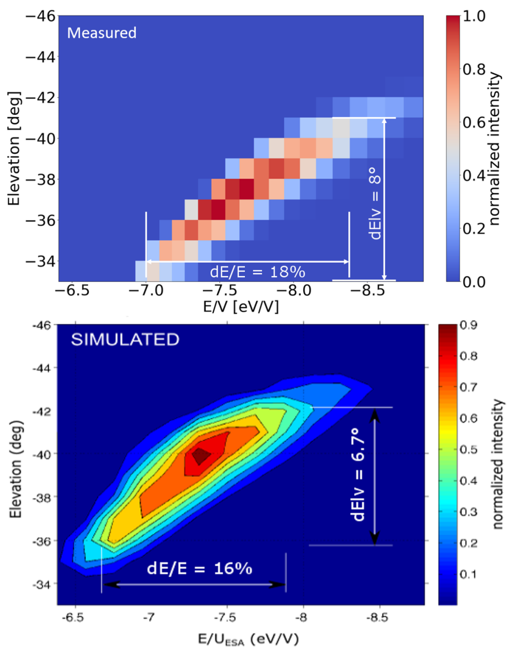

Figure 2: Instrument response to a 3keV hydrogen beam meassured(top) and simulated (bottom). The normalized energy is shown on the x-axis, the y-axis shows the elevation angle (90° Elevation corresponds to a direction parallel to the symeetry axis of the instrument).

Figure 2 shows a comparison between the simulated and measured elevation angle dependent energy response of JDC. A 3keV H+ ion beam was used to characterize the response of the technological model. The measured energy resolution and elevation resolution are in excellent agreement with the corresponding simulated and predicted values.

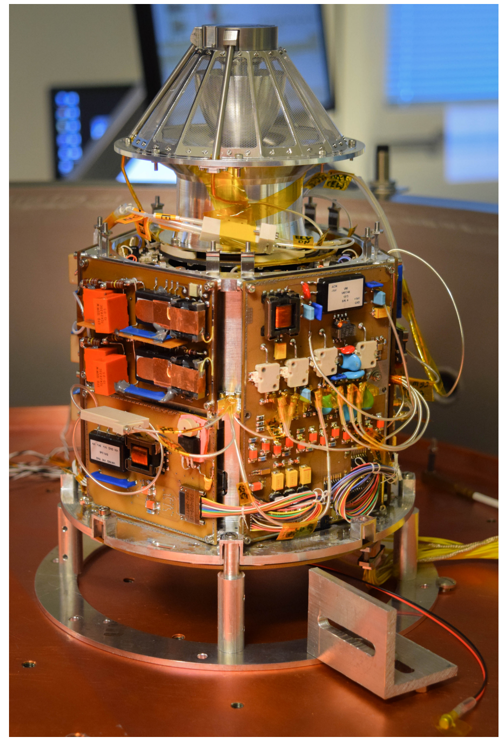

Figure 3: JDC technological model assembled in the thermal vacuum chamber.

References

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