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Interactive comment on "A novel rocket borne ion mass spectrometer with large mass range: instrument description and first flight results" *by* Joan Stude et al.

Joan Stude et al.

joan.stude@dlr.de

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Dear Referee #1 Thank you very much for your helpful review. Answers and actions to your comments are provided below.

"Line 30/31. Particles with masses of 'tens: : :of atomic mass units' are called MSP particles. I would think that these masses would fall under atomic or molecular ions, instead of MSPs"

CHANGED: hundreds to millions of atomic mass units [u]

We refer to Huntens bin sizes starting at 0.2 nm radius. With the different density

assumptions, this leads to a minimum of 40 u which is probably more a "molecular ion" than a MSP.

"Fig. 1. I find it strange to talk about the density of particles with masses down to 10u."

CHANGED: Figure reprinted to fit 0.2 to 10 nm. The line from Bacher et al. was adjusted to his actual measurements (start from 3022 u)

"Line 107. Perhaps it would be better talking about fractions (e.g. percentages) of ions passing through the quadrupole, instead of 'few ions'."

CHANGED: ... only small fractions of ions above 10e4 ...

"Line 134. The unit of data rate would be kbits/sec. Either call it data volume, or provide the actually rate."

CHANGED: ...the data volume per spectrum is about 10 kbyte."

"Line 144. m/z 5 – 2075. The = sign is missing."

CHANGED: ...peak height was determined with about 17.5 (5 u peak width for Kr) and the mass range from m/z 5 to m/z 2075.

"Line 160. It would be useful to provide some key information about the conditions for the launch. For example, the Sun elevation angle, or the orientation of the payload wrt to the Sun. Later in the manuscript scattered UV photons are mentioned."

ADDED: At the given time and location a solar zenith angle of 61.6° is calculated, the direction of the launch was 330° azimuth.

"Line 172. Maybe I have missed it, but was there a numerical analysis that considered the effect of the angle of attack on the transmission of ions through the quadrupole filter? This would be useful to discuss to some extent."

The simulations carried out should only show that the RF-only mode is not simply a high-pass mode. In general the increasing AoA reduces the amount of incident ions (see eq. 3). More refined trajectory simulations would require more detailed assumptions on the incident particles properties and a higher geometric detail. Albeit this is very interesting, it would go beyond the scope of the paper.

"Fig. 6&7 and the text describing them present the data in the units of count rates. It would be useful to provide an estimate how to such rates convert to number density."

ADDED: additional section 3.5 Charge balance at 70 km altitude

In principle these count rates can be converted to ion densities (N=c/(A v). c as counts, A as intake area, v rocket speed. This leads to ion densities of N+ = 32 cm-3 and N- =379 cm-3, however some factors are not considered (see below).

"As a general comment, I have missed some level of discussion of how the CEM detection probability varies with the mass of the ions. Is there any information on this? Apologies if it is there and I have missed it."

ADDED: additional section 3.5 Charge balance at 70 km altitude

The working principle of a CEM detector is the generation of secondary electrons at the cone of the CEM. This mainly depends on the incident particle (mass, speed, angle) and the material of the cone (secondary electron yield). There are numerous publications on detection efficiency for atomic ions like noble gases, hydrogen and oxygen but little or none for heavy molecules. Thus for example C. A. Keller, and B. H. Cooper for positive and negative oxygen report 0.6 to 0.7 at 2 keV (ROMARA has 1.8 keV). Or Krems et al reporting similar values (2 keV) for oxygen 0.75 and 0.15 for xenon, reaching 1 with sufficient post acceleration. For micro channel plates, that use the same electron multiplying principle, Gilmore reported efficiencies of about 0.02 for 2352 u at 2 keV. For electrons a MgO coated CEM was tested by Manalio et al. to be about 3 times more efficient than uncoated.

"Lines 208 and 244: It appears that the instrument measures significantly more negatively charged ions/particles than positively charged ones. This is a potentially signifi-

cant issue that in my opinion needs to be treated carefully. In particular, the quasineutrality of the plasma is not discussed. What would possibly be the cations or positive charge carriers that remain undetected?"

ADDED: additional section 3.5 Charge balance at 70 km altitude

For 69/70 km: Quasineutrality requires: N+ = N- + Ne. Measured electron densities: SAURA: $\sim$ 500 e/cm3 (Latteck 2019). With: c+ $\sim$26 kHz and c- $\sim$300 kHz (200 kHz light ions + 100 kHz heavy ions): N+ = 32 cm-3 and N- =379 cm-3. Payload charging to positive values in the sunlight could explain this discrepancy, as the positivly charged rocket would attract negativly charged particles and repel positivly charged.

"I am not sure if I can agree with the statement starting on line 244 that the neutralization of positive MSPs due to free electrons is a viable mechanism. The large number of negative particles already suggest that the electrons are scavenged from plasma."

The electron density is measured to be about 500 e/cm3 (Latteck 2019) and thus electrons would be availabe for neutralization of positive MSPs.

"Several models have been published on the charge balance of MSPs that could provide some guidelines on how to interpret the observation for the given condition (solar elevation angle, for example). It is probably a good idea to briefly mention or discuss these models, just to provide a background for reader. If there is a significant disagreement between the models and the data, it should be stated."

In this instrument paper we wanted to focus on the instrument and first results. We are working on a follow-on paper, where we compare our measurements to the Sodankylä Ion Chemistry Model (SIC) See: Verronen et al. 2005, doi:10.1029/2004JA010932

"Another general comment: I am not sure if I have seen a discussion how heavy neutral MSP particles could possibly affect the measurements. Such particles may pass through the Q/m filter unaffected and be detected. Any information of this that is worth discussing? My guess is that at higher altitude and the corresponding higher angles of attack this become less of an issue, but perhaps at the lowest $\sim$2 degree angle they have a direct path to the detector from the orifice."

A neutral particle requires an angle of attack below 0.85° (angle between center and apertures) to pass the intake orifice and the exit aperture of the quadrupol. Heavy particles have a low angular spread at mesospheric temperatures. Thus the probability to enter is low for AoA>1°. Further, any neutral particle effects both, positive and negative ion measurements. Thus a neutral particle signal should be present during positive and negative ion mode. However, in negative ion mode secondary electrons from neutral particles might be detected. To briefly test that, we used UV LEDs to stimulate the CEM, independent on the applied voltages for the different ion modes. We measured a 3 times higher count rate in negative ion mode as in positive ion mode. As the photons generate secondary electrons in front of the CEM cone, these electrons are more easily captured in negative ion mode. However, we do not measure a heavy ion signature in positive ion mode that is in the order of 3 lower than in negative ion mode.

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