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# Application of Surface Physics for Instruments in Space Science

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vorgelegt von
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## Abstract

# Contents

# List of Acronyms

| | |
|---|---|
| **BCVD** | Boron-doped Chemical Vapour Deposition |
| **DLC** | Diamond-Like Carbon surface |
| **EMG** | Exponentially Modified Gaussian |
| **ENA** | Energetic Neutral Atoms |
| **FWHM** | Full Width at Half Maximum |
| **IBEX** | Interstellar Boundary EXplorer |
| **ILENA** | Imager for Low Energetic Neutral Atoms |
| **IMAP** | Interstellar Mapping and Acceleration Probe |
| **JNA** | Jovian Neutral Atom Analyser |
| **JUICE** | JUpiter ICy moon Explorer |
| **L1** | Lagrange 1 |
| **LISM** | Local InterStellar Medium |
| **MCA** | MultiChannel Analyzer |
| **MCP** | MultiChannel Plate |
| **PA** | PostAcceleration voltage |
| **PEP** | Particle Environment Package |
| **RPA** | Retarding Potential Analyser |

# 1 Introduction

JUICE PEP NIM

# 2 Theory

## 2.1 Requirements

## 2.2 Basic Theory about a TOF masspectrometry

This chapter explains the function of a TOF instruments. A TOF mass spectrometer consists of, an ion-source, a mass analyser and a detector.
In the ion source, the ions are produced and get all accelerated to the same energy. This is achieved by applying a high voltage pulse on the grid. Depending on the initial position and velocity of the particles, they get a different amount of energy because they don't spend the same amount of time in the extraction field. These processes have a direct impact on the mass resolution.

## 2.3 Ion Optical Design, NIM specific elements

A time of flight mass spectrometer consists of, an ion-source, a mass analyser and a detector.

The NIM instrument is able to measure neutrals and ions. Neutral particles get ionised by electron ionisation. A filament is heated up until it emits electron. Ions enter the ion source directly. All ions then get accelerated to the same energy and fly through the mass analyser. Light particles fly faster through the spectrometer than heavier ones. The different particle species arrive at different times at the detector. To enlarge the flight distance, an ion-mirror, which reflects the ions and leads them back to the detector. The used detector is a MCP detector.

### 2.3.1 Ion-source

To calculate the number of ions produced in the ion source we use:

$$I_{ion} = \beta \cdot Q_{ion} \cdot L \cdot n \cdot I_{em} \tag{1}$$

With $\beta$ the extraction efficiency which is 1, $L$ as the effective ionising path in our case 4 mm, $n$ the particle density, $I_{em}$ the electron emission current from the filament and $Q_{ion}$ the ionising cross section. The cross sections of species used in our calibration can be found in table

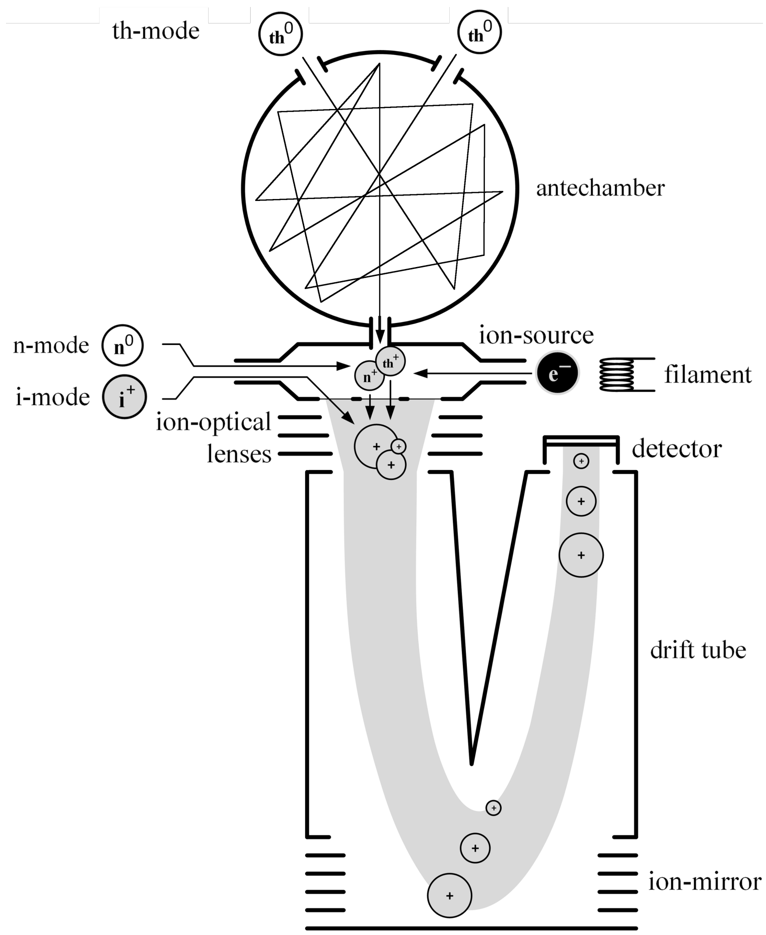


**Figure 1:** Schematics of the NIM mass spectrometer. Adapted from [2].

# 3 Setup

## 3.1 NIM Instrument

### 3.1.1 Prototype

### 3.1.2 Protoflight Model

## 3.2 Test facilities/ Test Tools

# 4 Experiments

In this section , the different tests are described to develop the NIM instrument. All measurements were performed in the STROFIO vacuum chamber.

## 4.1 Reflectron

The NIM prototype reflectron was exchanged through the flight like reflectron, which was tested. The NIM prototype reflectron consisted of 12 ring electrodes connected with each other with resistors in between them. On the first, 5th and 12th electrode, a voltage can be applied. With the different resistors, a linear voltage gradient in the reflectron is generated.
The flight reflectron consists of a ceramic tube with two resistance spirals on its inner walls. There are three electrodes, where the voltage can be applied. The electrodes are connected via resistance spirals with each other. The two reflectrons can be seen in Fig. 2. This kind of reflectron was also used in the RTOF mass spectrometer which flied in ROSINA [3] and the in the NGMS [1].
Therefore, the two reflectrons are from the electrical point of view the same.

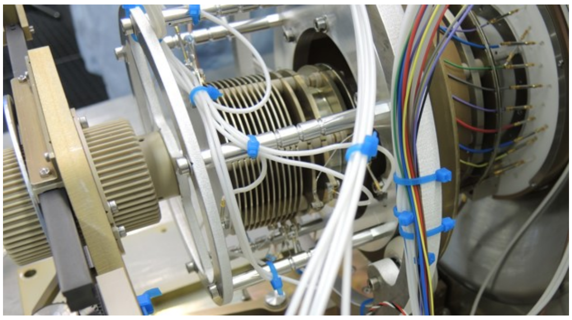
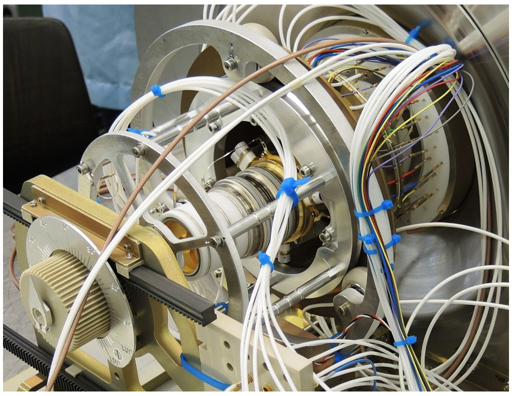

**Figure 2:** Left: Prototype reflectron with ringelectrodes. Right: Flight reflectron

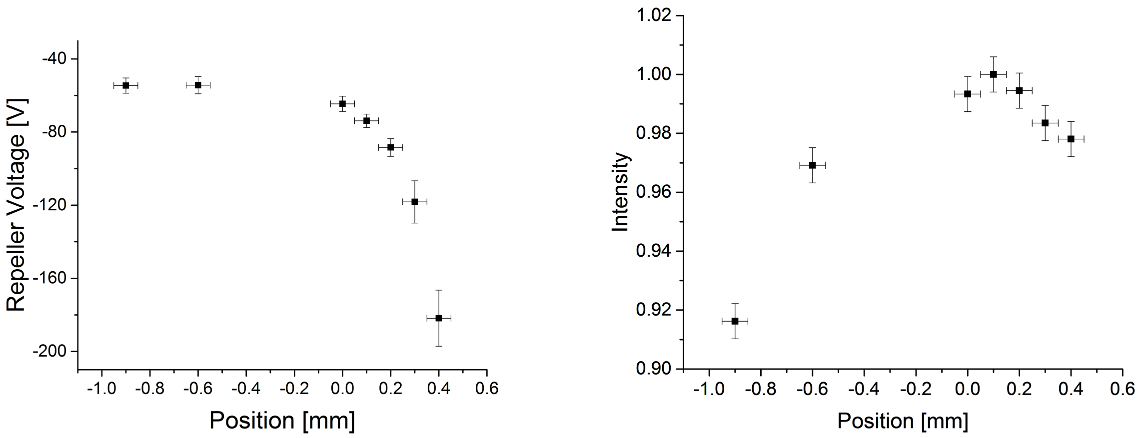


**Figure 3:** Left: The filament repeller voltage to reach the maximum electron intensity over the volume of the neutral particles. Right: Electron intensity normed on the intensity at position 0.

### 4.1.1 Measurement Principle

### 4.1.2 Discussion

## 4.2 CASYMIR-D/-E

## 4.3 Simulations

## 4.4 Pulser

## 4.5 Detector Tests

## 4.6 Ionoptics

# 5 Conclusion

# 6 Outlook

# References

[1] L. Hofer. Development of the gas chromatograph – mass spectrometer to investigate volatile species in the lunar soil for the Luna-Resurs mission. Universität Bern, 2015.

[2] S. Meyer. Development of a Neutral Gas-and Ion-Mass Spectrometer for Jupiter's Moons. Universität Bern, 2017.

[3] S. Scherer. Design of a high-performance Reflect:ron Time-of-Flight mass spectrometer for space applications. Universität Bern, 1999.

# 7 Appendix

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# Erklärung

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