Advances in the Plasma Diagnostics Capabilities at FOTEC

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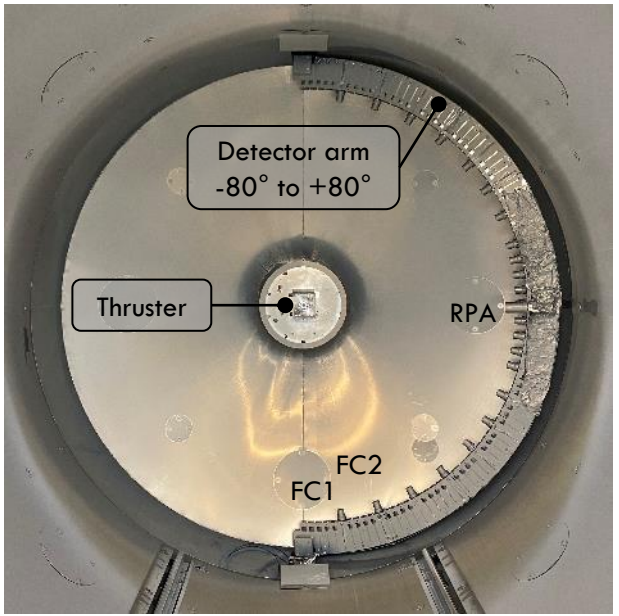
EP Thruster Characterization

- Measurement of plume divergence
- Determination of thrust vector and off-axis angle
- Verification of plume shaping means (focus electrodes, plume shields, etc.)
- Comparison of indirect thrust measurement (plasma diagnostics) with direct thrust measurement (FOTEC's thrust balance)

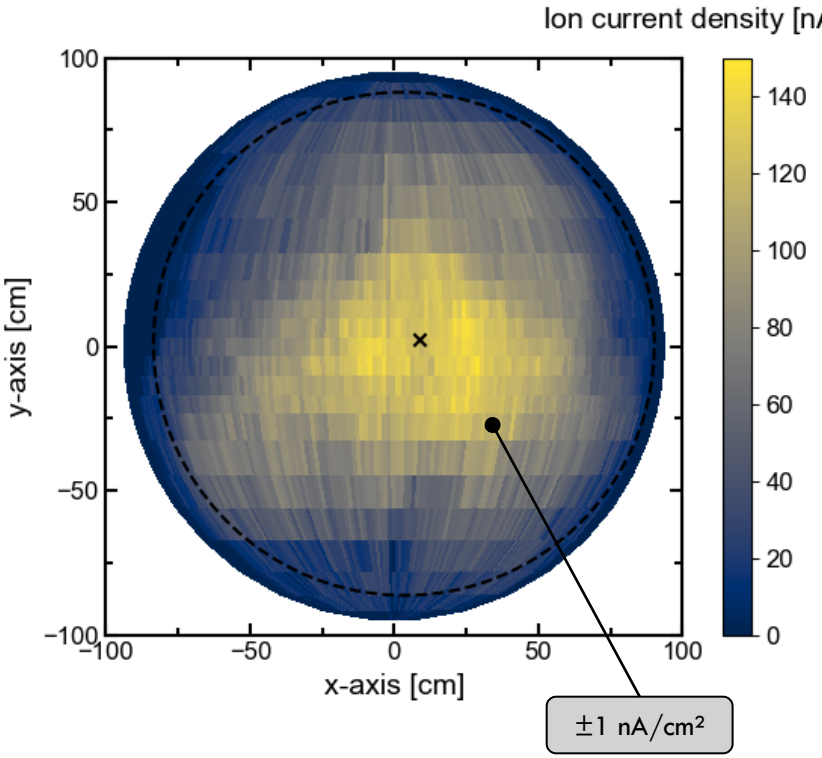
Introduction

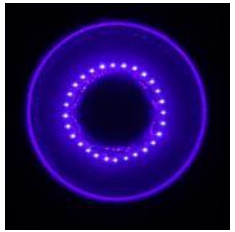
FOTEC's High-Vacuum Facility and Plasma Diagnostics



Introduction

Faraday Cup Measurements

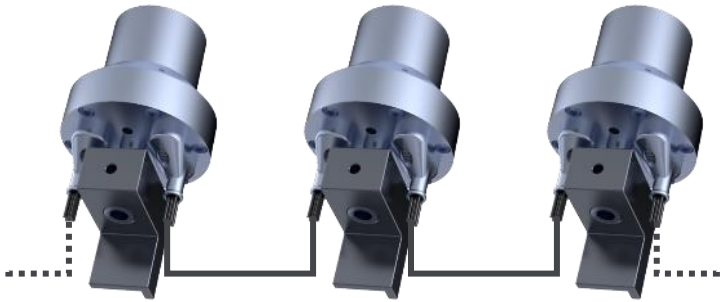




Digital Faraday Cup

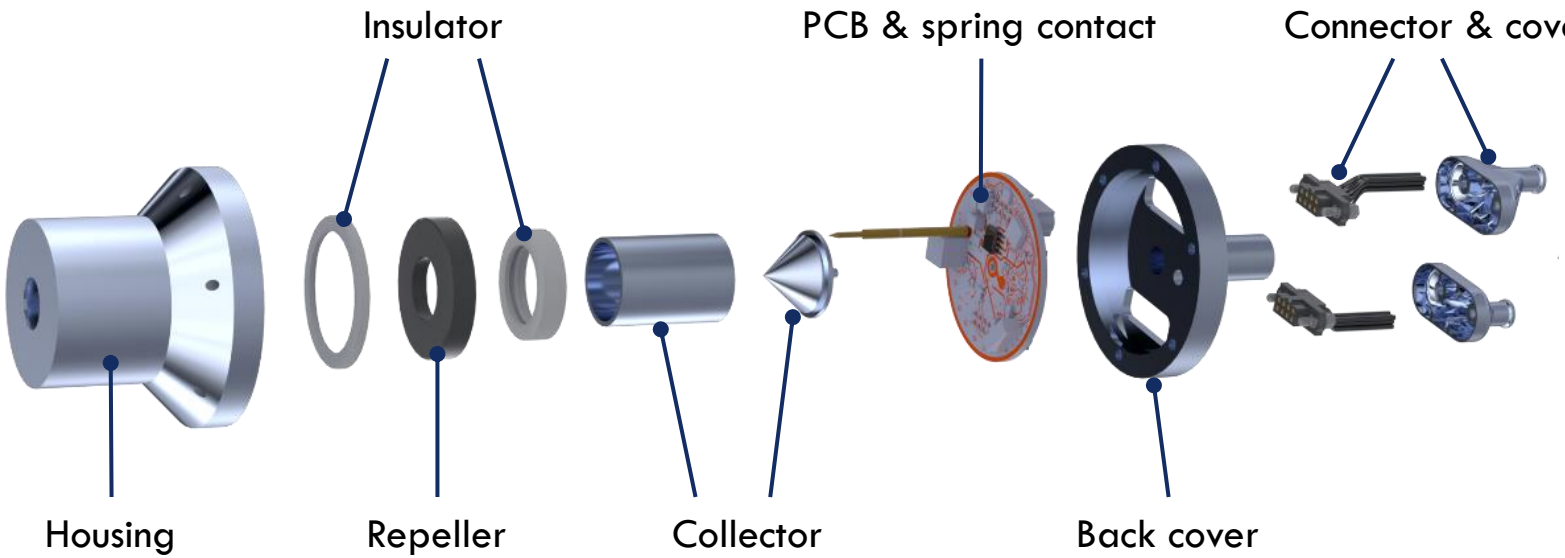
Electrical Properties

- 24-Bit Analog-to-Digital Conversion is done inside the probe (no long cables!)
- Programmable gain amplifier for different current ranges up to 3 µA
- Sampling frequency up to 3.5 kHz
- Software-programmable repeller voltage (0 to -100V)
- Digital communication bus (RS-485) allows daisy-chaining of probes
- Software-based synchronization (trigger signal)



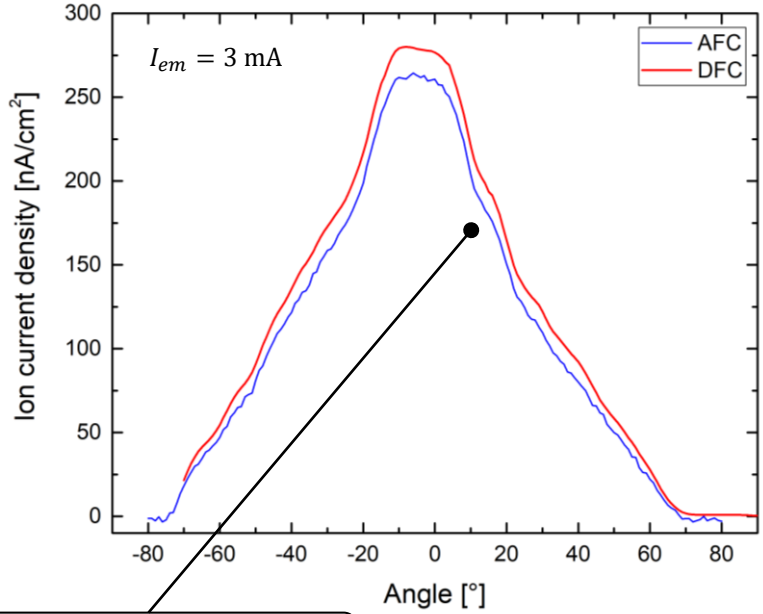
Digital Faraday Cup

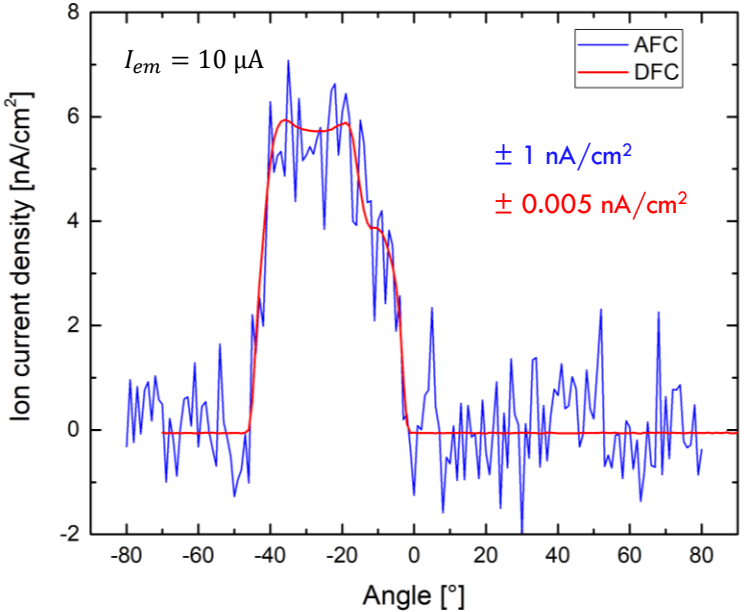
Mechanical Design



Digital Faraday Cup

Measurements and Comparison



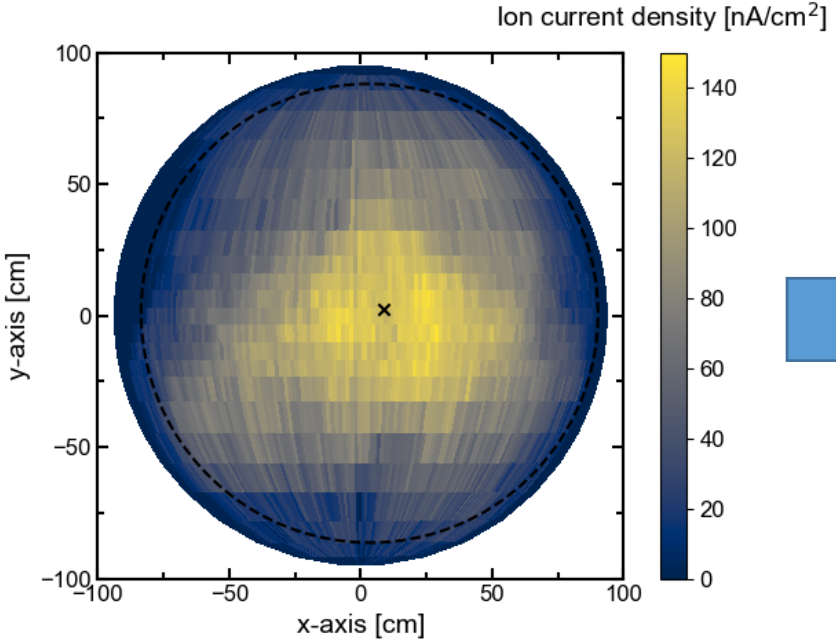


Increased collector current due to mechanical improvements

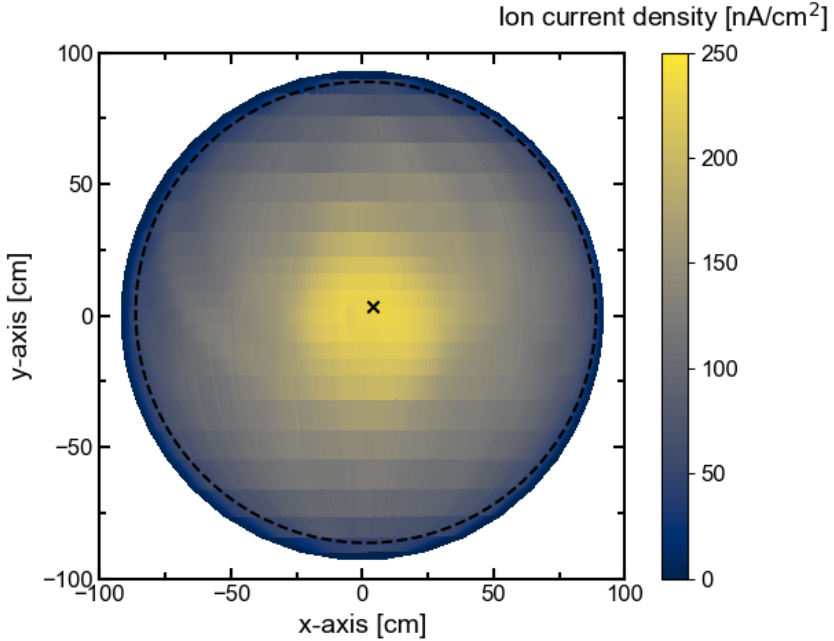
Analog (AFC), Digital (DFC)

Digital Faraday Cup

Measurements and Comparison (cont'd)



Analog (AFC)



Digital (DFC)

Digital Faraday Cup

Summary

Advantages:

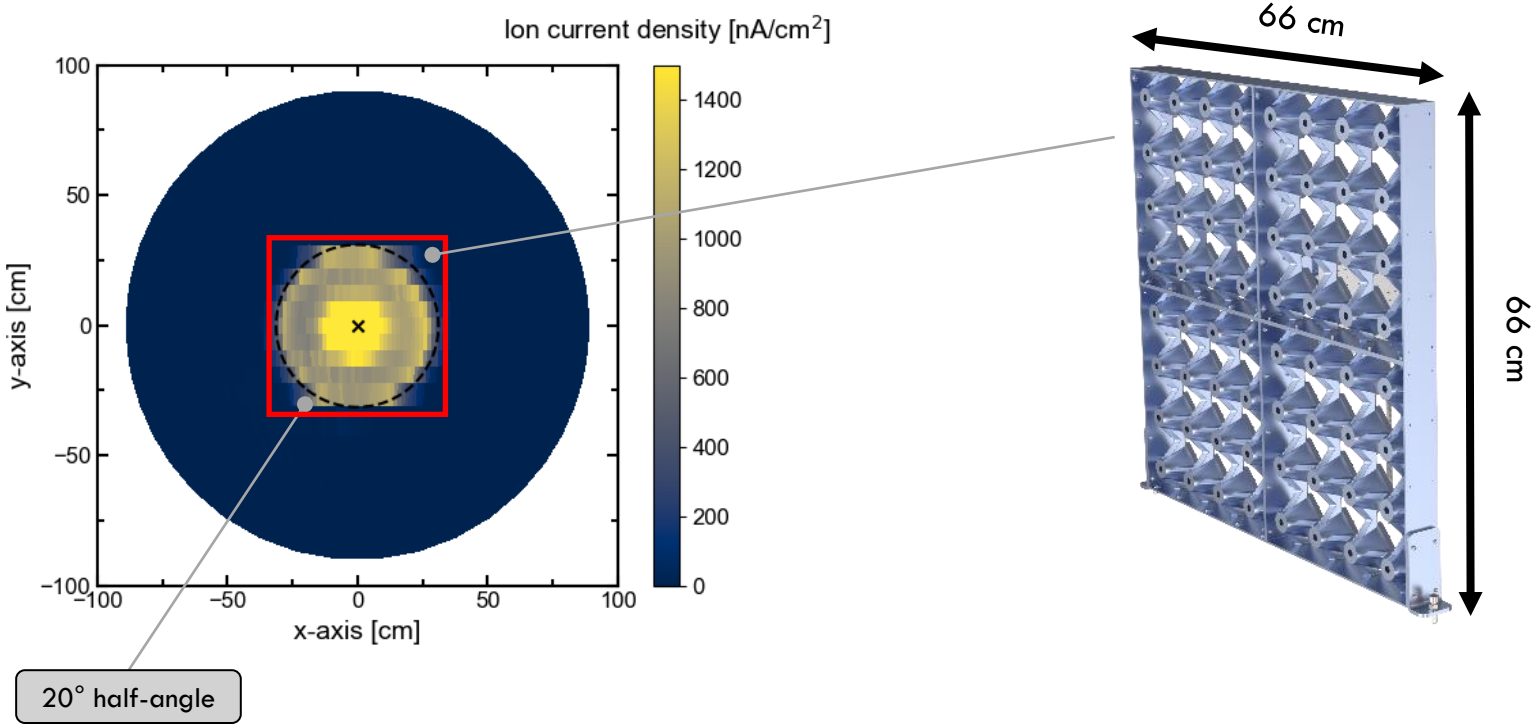
- Excellent horizontal resolution: down to 0.1° spacing
- Good vertical resolution: 4° spacing near the thruster axis
- Programmable gain amplifier including auto-ranging capability
- Excellent signal-to-noise ratio: > 110 dB full-range, 5 pA p-p noise
- Adjustable repeller voltage
- Digital shared communication interface

Disadvantages:

- Long scanning time: several minutes (depending on horizontal resolution)
- **Insufficient temporal resolution to assess frequency-dependent thruster noise**

Digital Faraday Cup

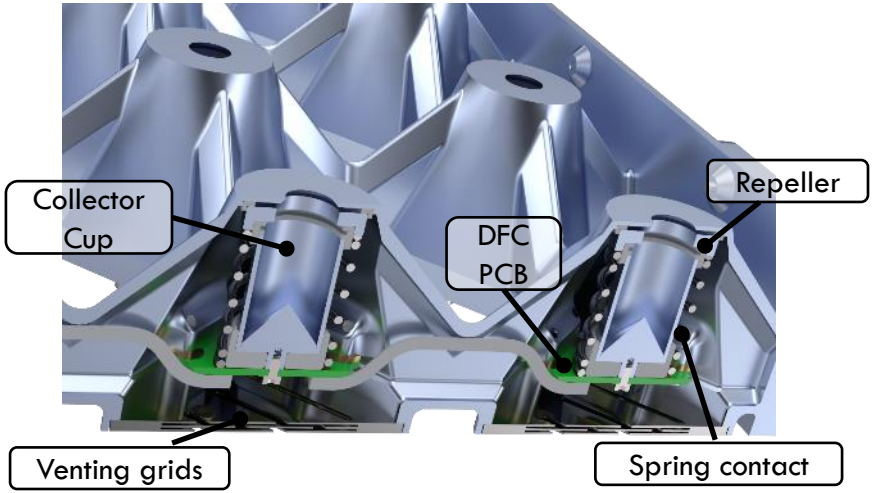
Motivation

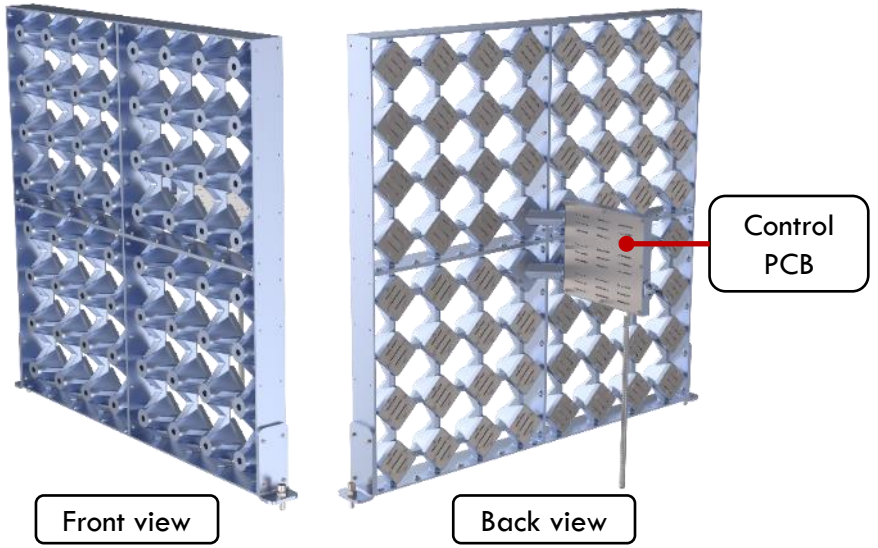


Digital Faraday Cup Array

Mechanical Design

- 8x8 DFCs with fast readout capability (~50 Hz)
- Common repeller potential
- Grid structure → minimise back sputtering
- Common PCB for all DFCs based of DFC DAQ





Digital Faraday Cup Array

Results – Animated probe data

Data processing:

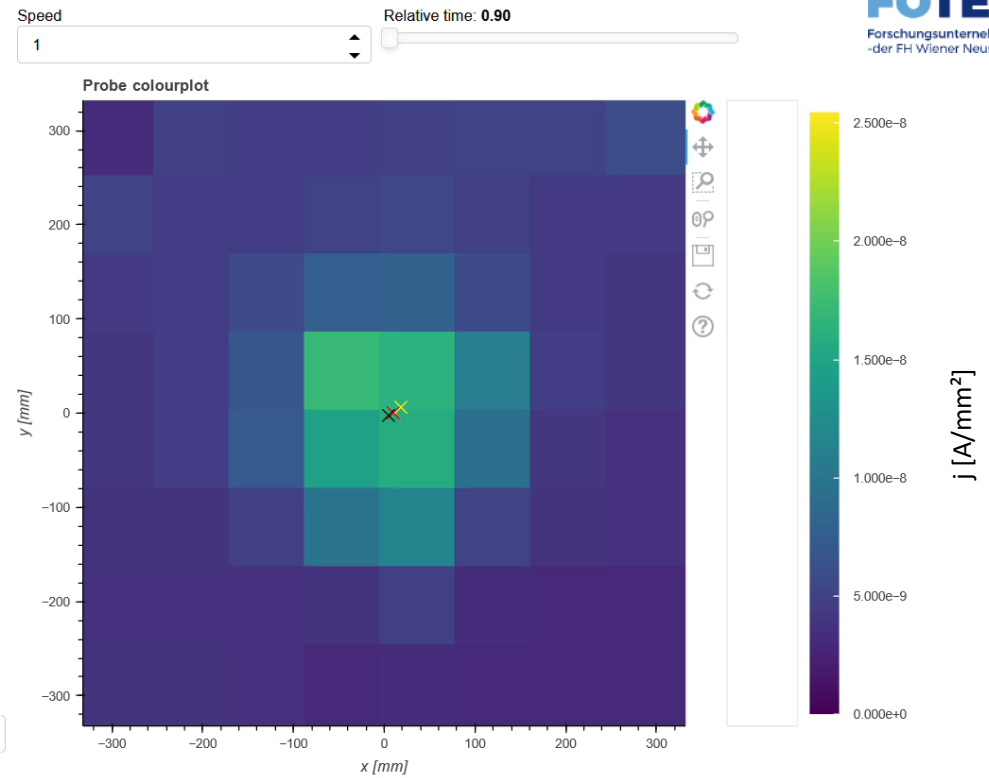
- Analog signal processing and digital conversion
- Spherical projection to compute current density (to get correct area elements)

Real-time display:

- Thrust vector is updated every 50 ms
- Visualization on the plane of the array

Additional information:

- Comparison with conventional DFC scans

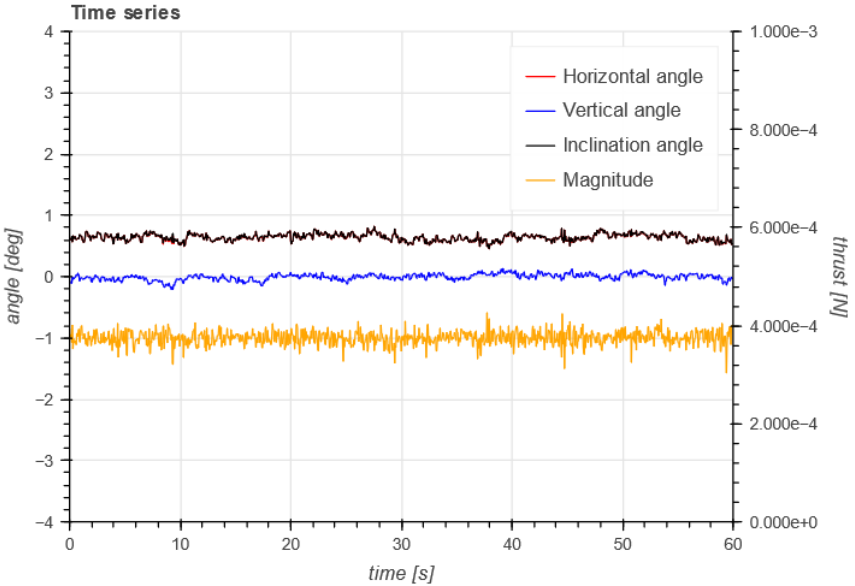


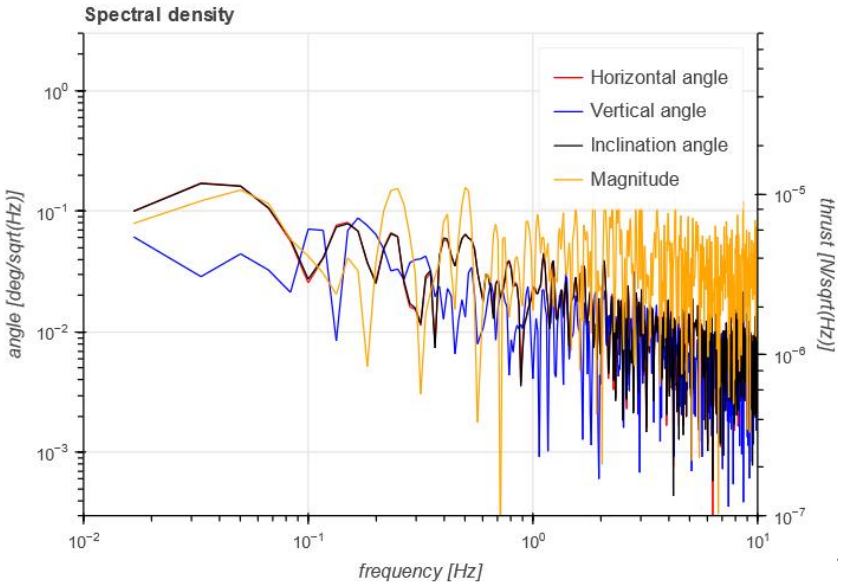
x … scan x … DFCA x … scan (DFCA area)

Digital Faraday Cup Array

Results – Post Processing

- Calculation of angles (horizontal, vertical, absolute) and thrust magnitude
- Applying Welch's FFT algorithm to both → power spectral density

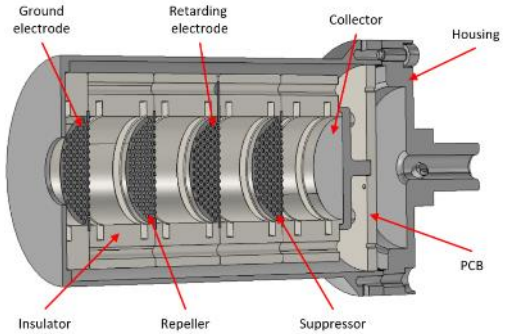


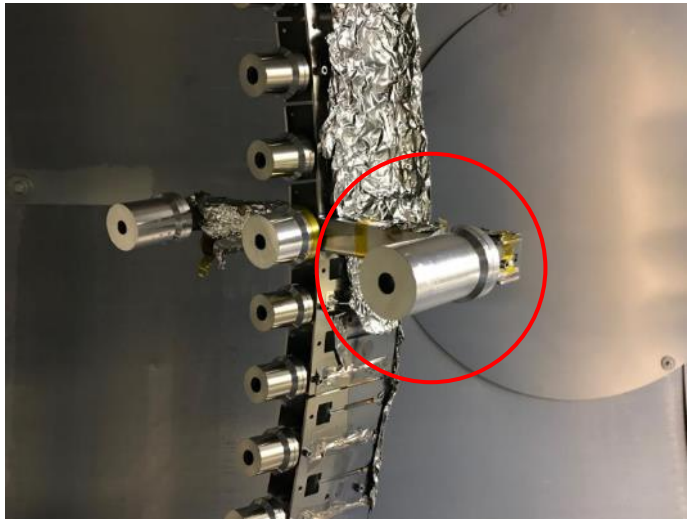


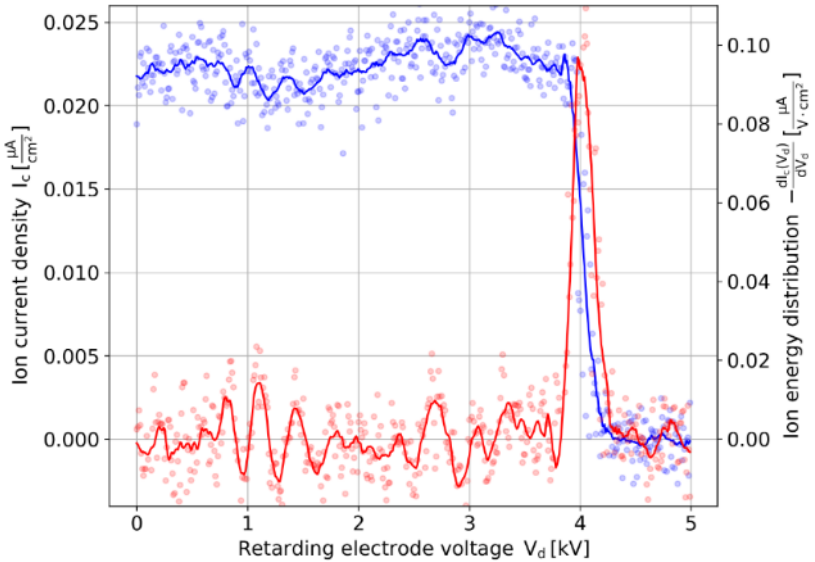
Retarding Potential Analyzer

Motivation

- Measure the energy (spread) of expelled ions
- Assess accuracy of indirect vs. direct thrust measurement







Thank you for your attention

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