MFIG – a Mass Filtered Ion Gauge

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Introduction

MFIG (shown in **Figure 1**) is a metrology tool for detecting low levels of contamination (Volatile Organic Compounds (VOC) and Airborne Molecular Contamination (AMC)).

MFIG consist of an ion source followed by an electrostatic lens for beam focus control. After the electrostatic lens mass separation is achieved with a static magnet field (shown in **Figure 2**). Detection is done by a Faraday cup.

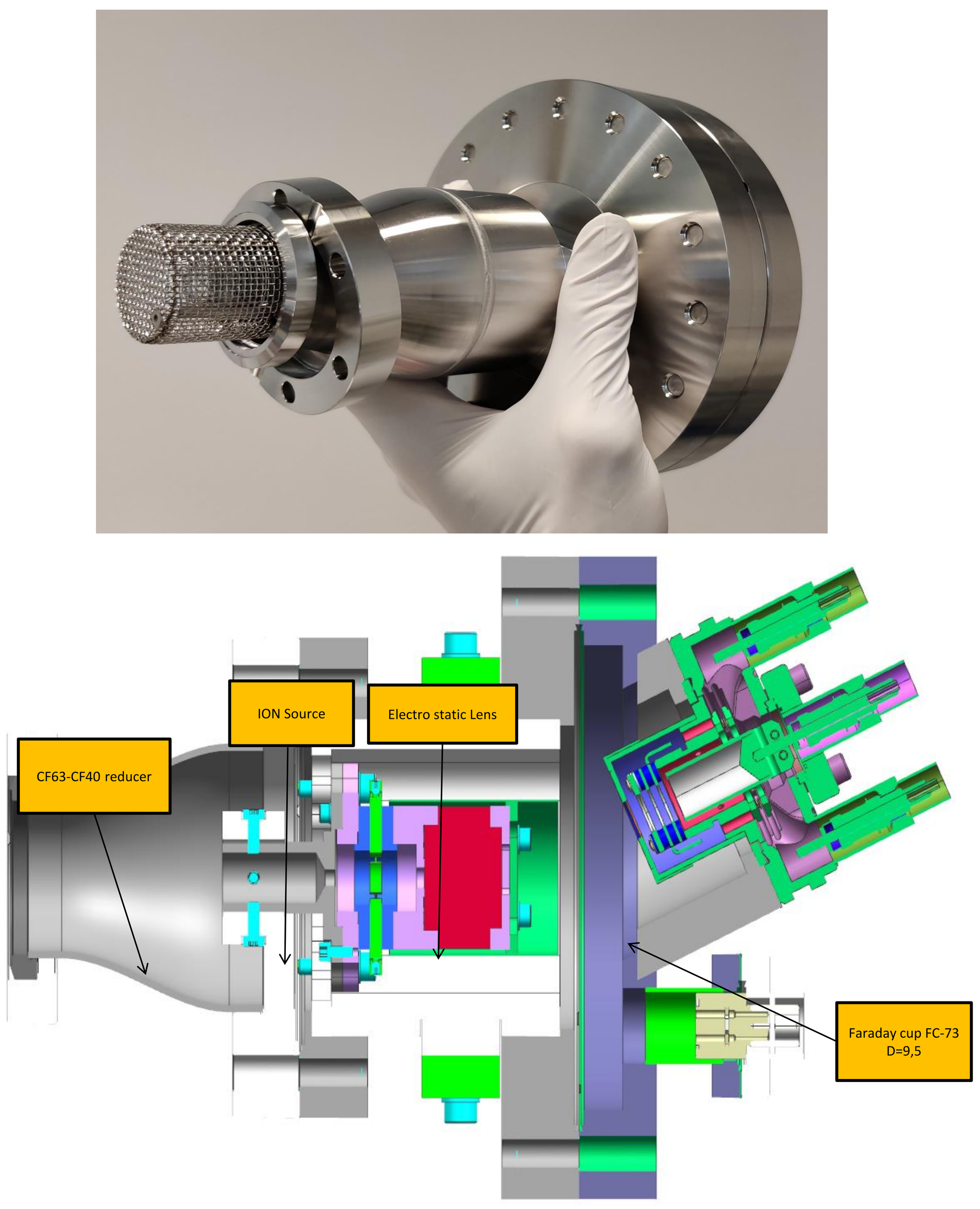

Figure 1: Top: MFIG ready for install on a high vacuum system, with open ion source visible on the left. Bottom: cross-cut through MFIG in CAD model.

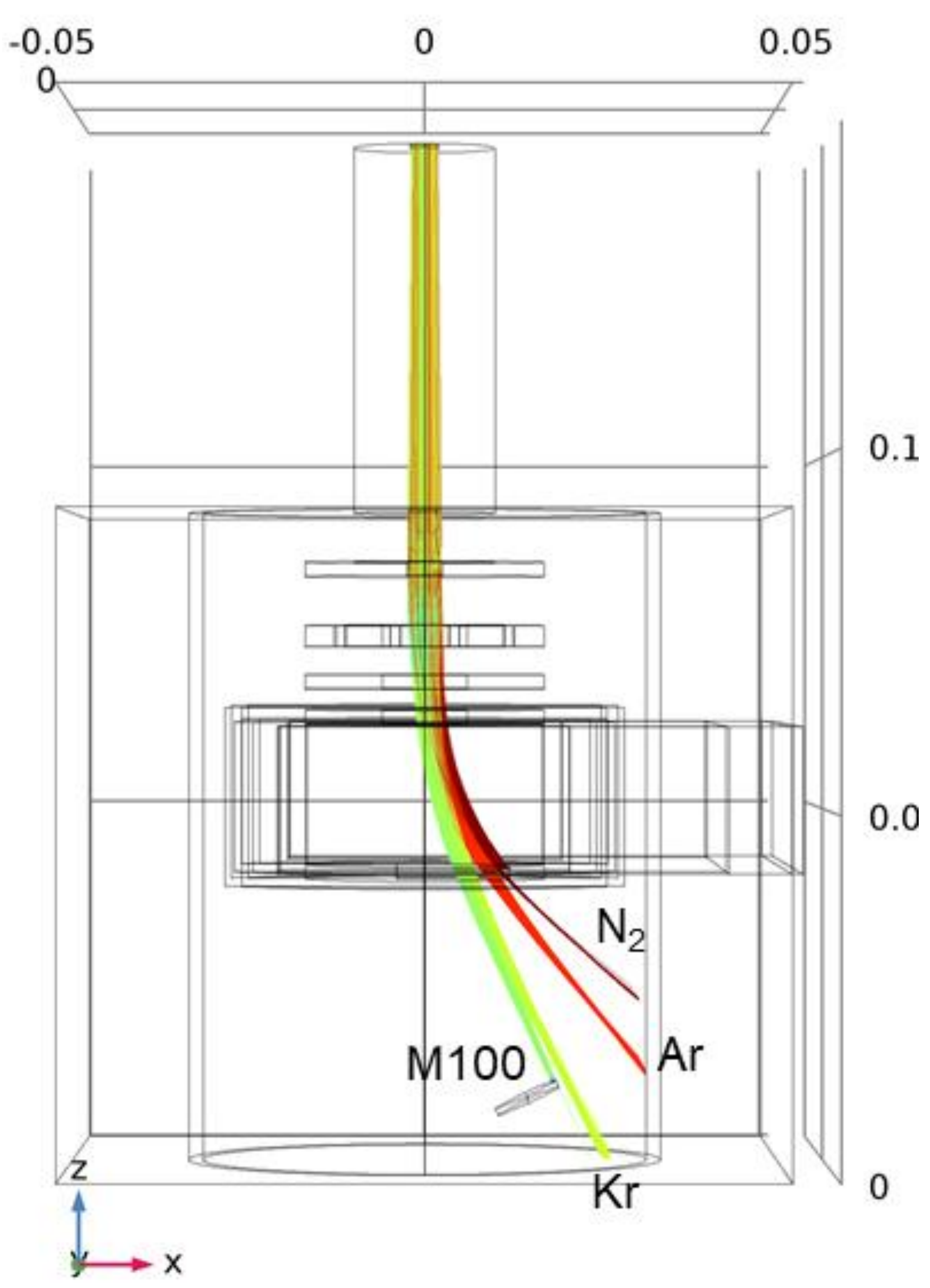

Figure 2: Ion beam trajectories in MFIG showing mass separation due to magnetic deflection. Only masses heavier than 100 amu will be detected, lighter ions will be deflected too much and will not hit the detector.

Modelling

To optimize performance and characteristic an extensive modelling study was undertaken using COMSOL, see **Figure 3**. Based on the outcome of the modelling study the MFIG was designed.

Two focus points for modelling:

- **Ion source output**
  For optimized MFIG mass selectivity the ion beam should be homogeneous in both ion energy and cross-sectional distribution:
  1. Ion energy distribution;
  2. Beam cross-sectional distribution.

- **MFIG sensor design**
  To optimize <u>sensitivity</u>: suppress detection of low-mass ions due to scattering.
  To optimize <u>selectivity</u>: steepen mass cut-off by focusing the ion beam at detector:
  1. Ion beam focusing by electrostatic lens;
  2. Mass separation by magnetic field.

Unique selling points

Detecting short bursts and transients is only one of the Unique Selling Points (USP's) coupled to time resolution. Because MFIG is also more sensitive than a state-of-the-art Residual Gas Analyzer (RGA) you can also detect contamination earlier, which is a second USP.

Performance

In **Figure 4** we have measured the ion current detected by MFIG for three test gasses. N_2, Xenon and Krypton. We have varied the electrostatic (North-South-dipole) voltage. As a result, we are shifting the masses of the N_2, Xe, Kr ions in and out of the mass range of MFIG. Analysis of the curves in **Figure 4** gives the graph in **Figure 5**, showing the 50% cut-off lines where masses are either magnetically or electrostatically dispersed from the sensor. This in the end gives the mass range that MFIG detects.

As can be seen from **Table 1**, MFIG is more than 100 times faster than state-of-the-art RGA both running in Faraday mode. At a Xe partial pressure of 2.5e-10 mbar MFIG only needs one second to detect the Xe. MFIG is in this situation 126 times faster than the state-of-the-art RGA. At the same time, we see that MFIG can already detect Xe at a partial pressure of 2e-11 mbar, a factor 10 lower than the RGA, which is a factor 10 more sensitive.

Table 1: Comparison MFIG with state-of-the-art RGA

				MFIG		RGA		
	total pressure (mbar)	partial Xe corrected bg (mbar)	partial N2 corrected bg (gas inlet) (mbar)	signal (pA)	time (s)	time (s)	signal (mbar)	speed settings
Background	5.0E-09	0	0	0.045			-	
	7.0E-09	2.0E-11	1.98E-09	0.065	1	126	-	8
	1.0E-08	5.0E-11	4.95E-09	0.135	1	126	-	8
	3.0E-08	2.5E-10	2.48E-08	0.41	1	126	2.0E-10	8

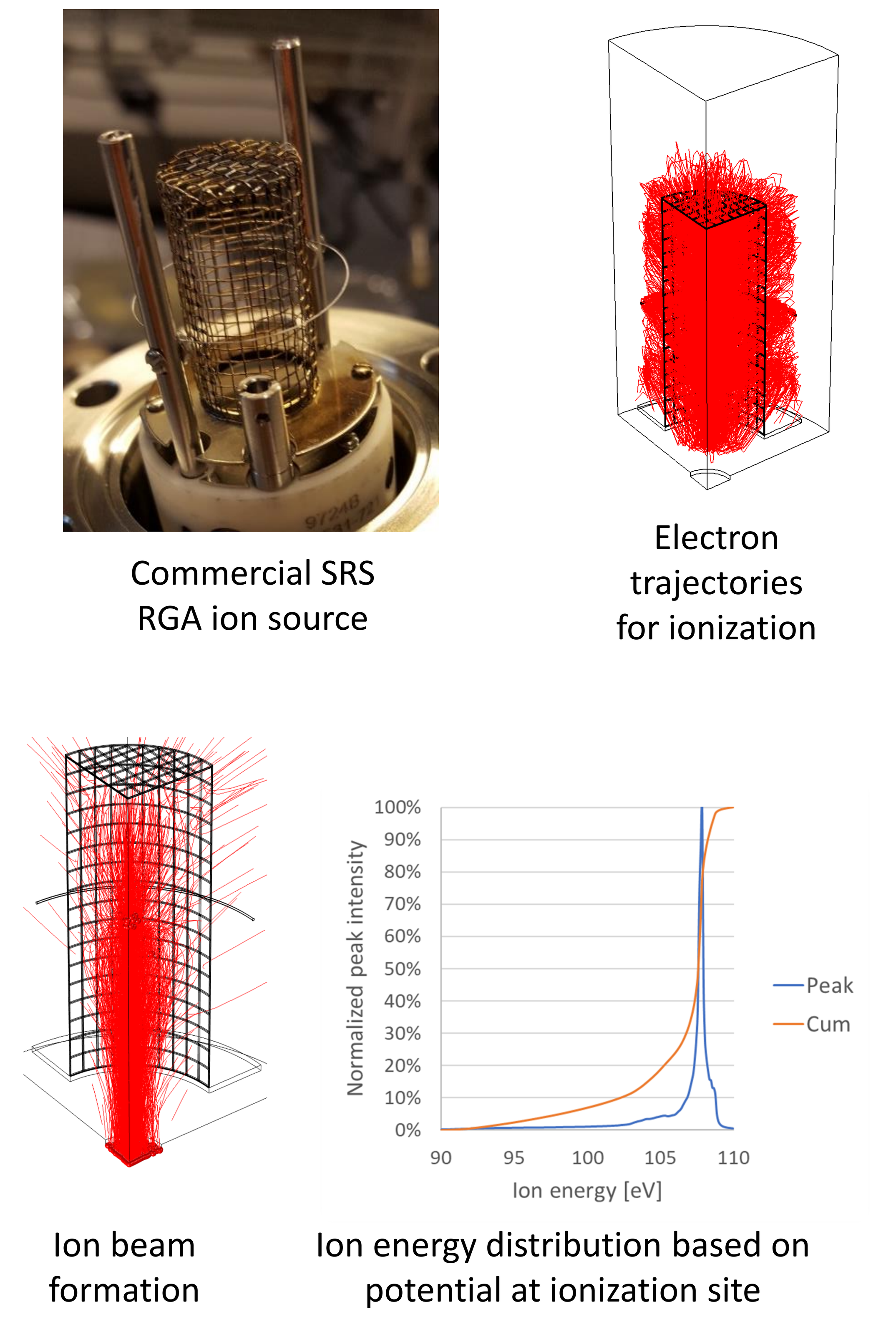

Figure 3: MFIG ion source (top left) with model results from COMSOL

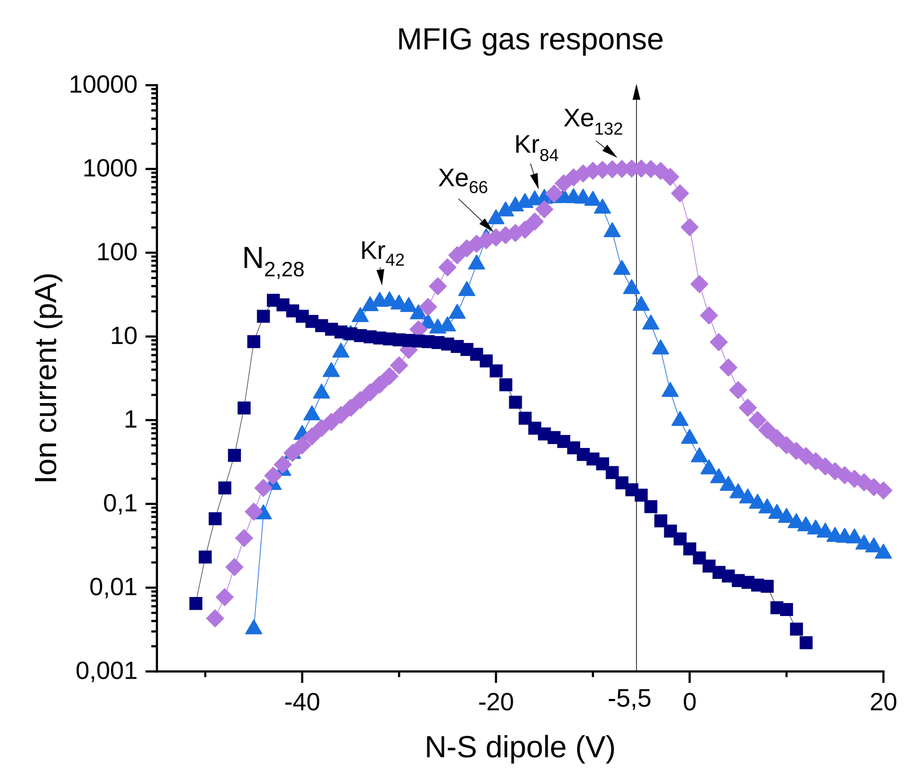

Figure 4: MFIG detected ion signal as function of electrostatic lens voltage for various gasses/isotopes.

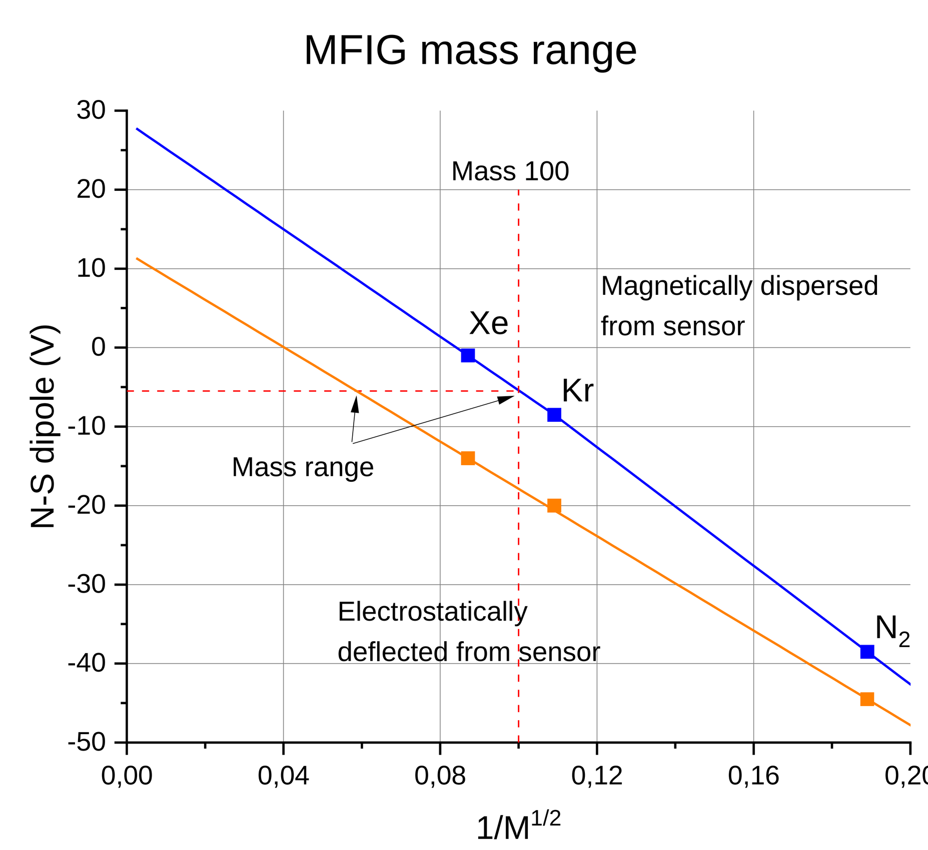

Figure 5: MFIG mass range.

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