The CISe project

(Chemical Isobaric Separation)

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Outline

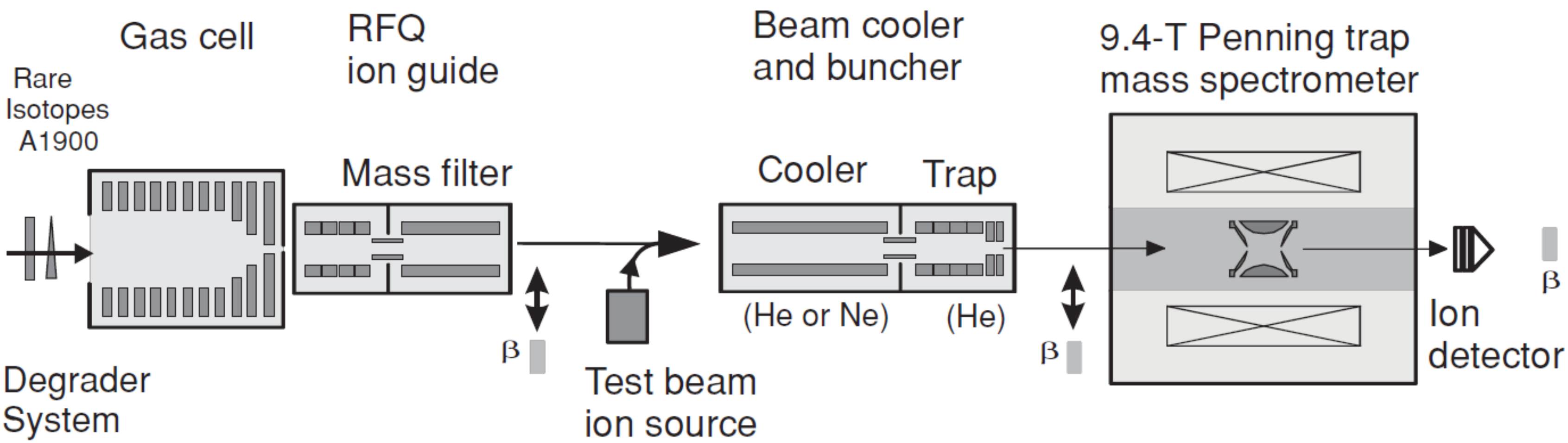
- Motivation – why do we want chemistry in a gas-catcher?
- First studies of ion chemistry of Sn, Ag, In and Cd in a collision cell
- A setup dedicated for Chemical Isobaric Separation (CISe)
- Summary & Outlook

Chemistry in a gas-catcher

Nothing new – but most times not wanted

But why not just making the best out of it?

Ion chemistry in a gas-catcher



Aim: $^{32}\mathbf{Si}^{+}$

Problem: O_2^{+}

Solution: H_2O in the buffer-gas

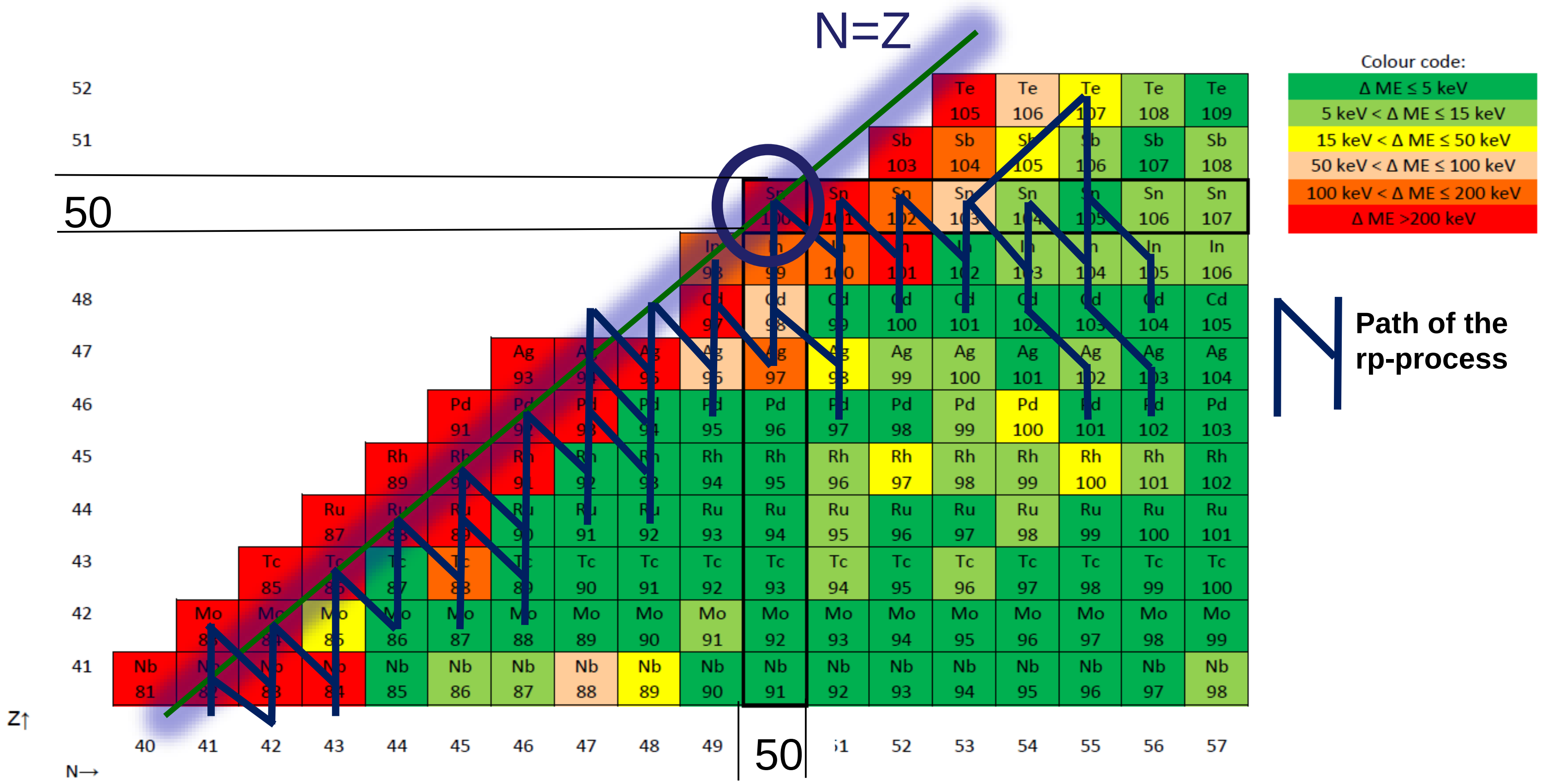
→ $^{32}\mathbf{SiOH(H_2O)}^{+}$ **M=67**

→ $^{32}\mathbf{SO_2H}^{+}$ **M=65**

R. Ferrer et al. Phys. Rev. C **81**, 044318 (2010)
A.A. Kwiatkowski et al. Phys. Rev. C**80**, 051302(R) (2009).

Are there more cases in which chemistry could be useful?

Hunting doubly-magic ^{100}Sn



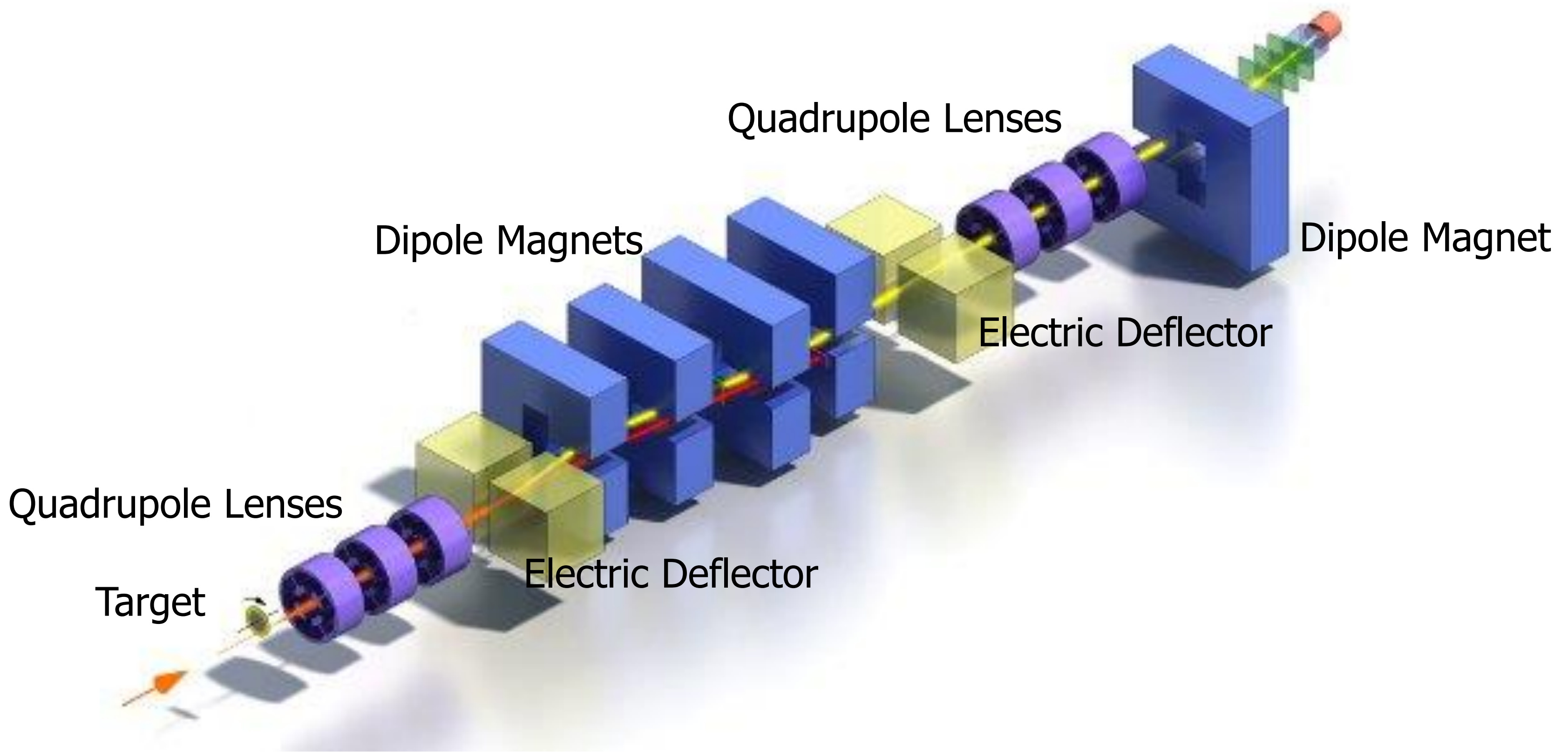
masses: AME 2012
rp-path: H. Schatz et al., Phys. Rev. Lett. 86(16), 3471 (2001)

How can we produce tin-100?

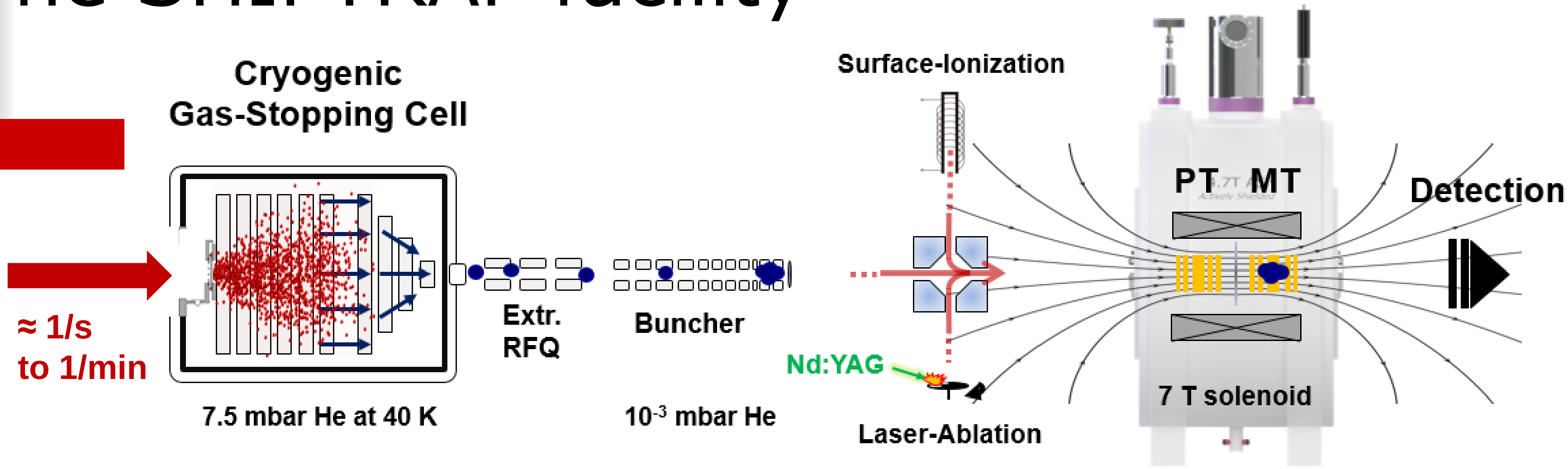
- ISOL: Not in reach yet
- Fragmentation
  - FRS [1]: ^{124}Xe @ 124 GeV, Be-target
    (5.8 ± 2.1) pb
  - BigRIPS[2]: ^{124}Xe @ 30.4 GeV, Be-target
    (0.75 ± 0.05) pb
- Fusion evaporation
  - CSS2 cyclotron at GANIL [3] :
    ^{58}Ni(^{50}Cr,α4n)^{100}Sn; 255 MeV
    40 nb

[1] C. Hinke et al., Nature **486**(7403), 341 (2012)
[2] I. Čeliković et al., Phys. Rev. Lett. **116**(16), 162501 (2016)
[3] M. Chartier, et al., Phys. Rev. Lett. **77**, 2400 (1996)

The velocity separator -SHIP



The SHIPTRAP facility



Stopping

Tansport & Bunching

Measurement

≈ 40 MeV

≈ 7 meters (23 feet)

≈ 1 eV

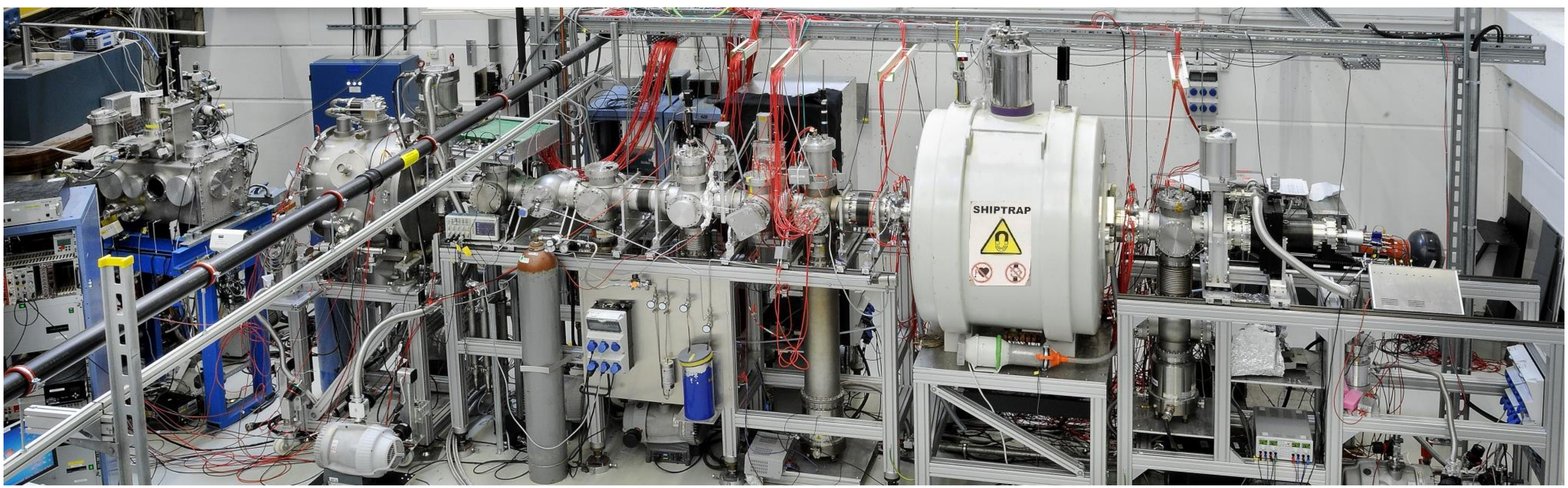


Photo: G. Otto, GSI

Why has this not been done, yet?

Expected rates behind SHIP

Assumption: Beam: $4 \cdot 10^{12}$ ^{58}Ni/s,
Target: 1 mg/cm^2 ^{50}Cr
Transmission through SHIP: 20%

	Cross section[1] [mbarn]	**Rate [ions/s]**
^{100}Sn	0.00004	~0.4

How can we separate Sn from Ag, In and Cd?

Witchcraft
or
Chemistry

Heksenketel voor het wegen van magische kernen krijgt subsidie

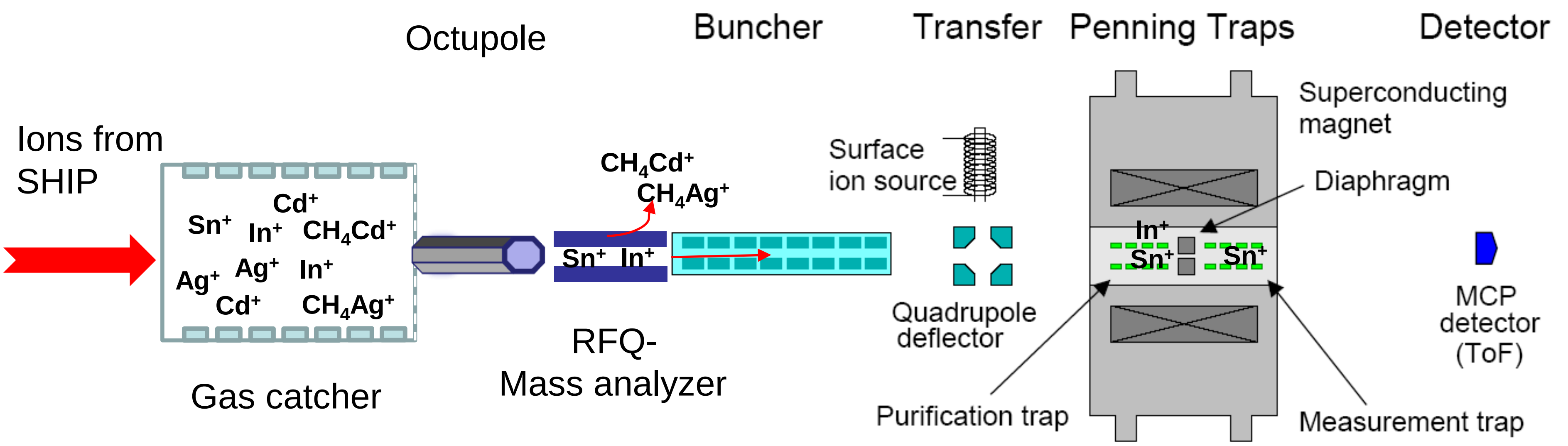
30 mei 2017

Haar methoden zijn een gruwel voor natuurkundigen, maar dankzij een chemische achtergrond kan Julia Even mogelijk een doorbraak forceren: het nauwkeurig vaststellen van de massa van exotische, instabiele atoomkernen. Zij heeft hiervoor onlangs een onderzoeksubsidie van 425.000 euro ontvangen van NWO.

Terug naar het nieuwsoverzicht

- Science LinX nieuws

CISE Chemical Ion SEparation



Potential chemical systems

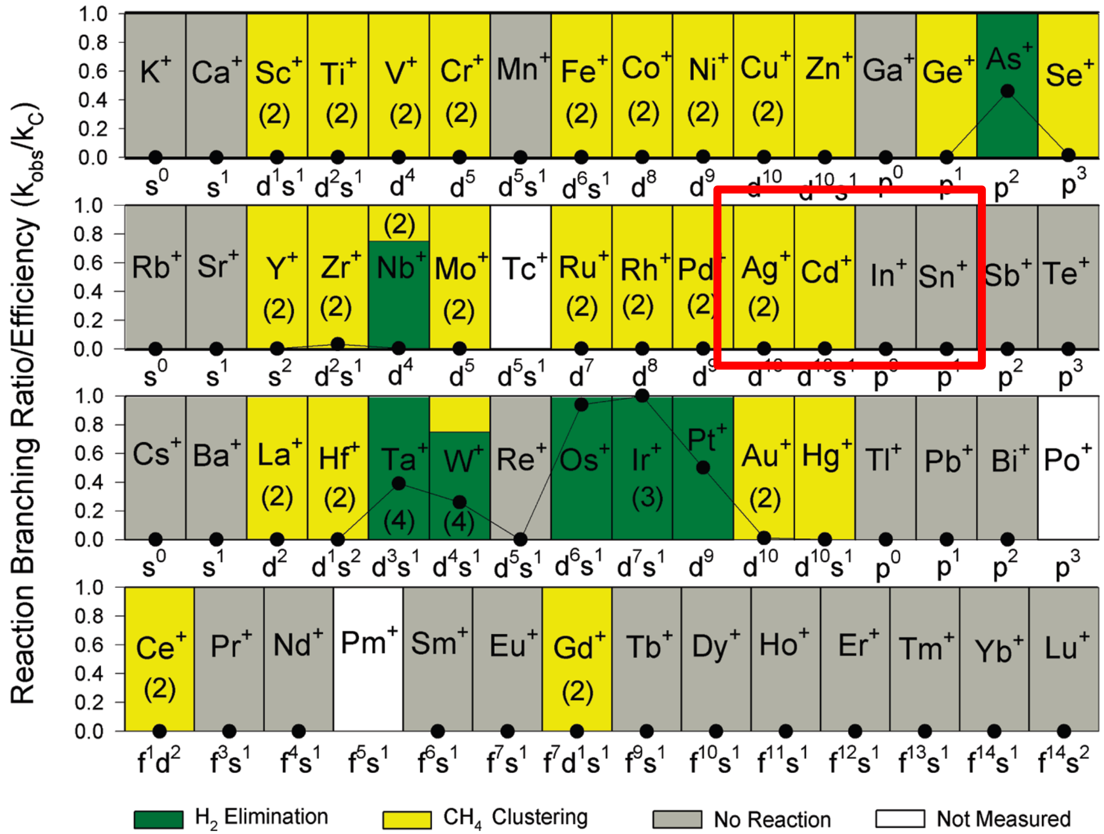
CS_2: extract Sn as SnS^+ [1)]

CH_4: separation of Sn^+ and In^+ from $Ag(CH_4)^+$ and $Cd(CH_4)^+$ [2)]

$Ag^+ + CH_4 \rightarrow Ag^+(CH_4)$

$Ag^+(CH_4) + CH_4 \rightarrow Ag^+(CH_4)_2$

$Cd^+ + CH_4 \rightarrow Cd^+(CH_4)$



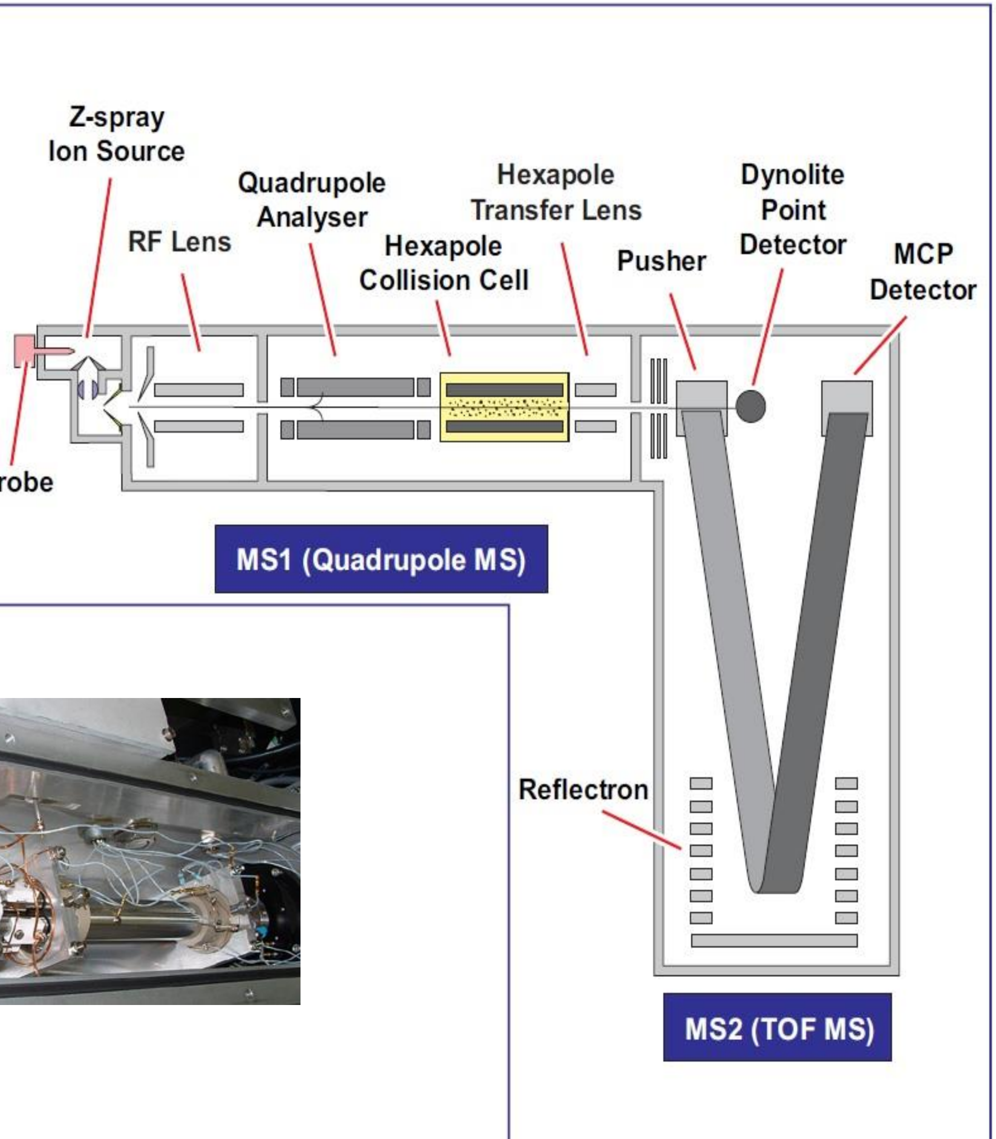
[1)] R. Kirchner, Nucl. Instr. and Meth. in Phys. Res. B **204** (2003) 179–190

[2)] A. Shayesteh, et al. J. Phys. Chem. A **113** (2009) 5602

First studies in a qToF II

Metal ions from the Z-spray-source:

Sn^{1+}, Sn^{2+}
In^{1+}, In^{2+}
Cd^{1+}, Cd^{2+}
Ag^{1+}



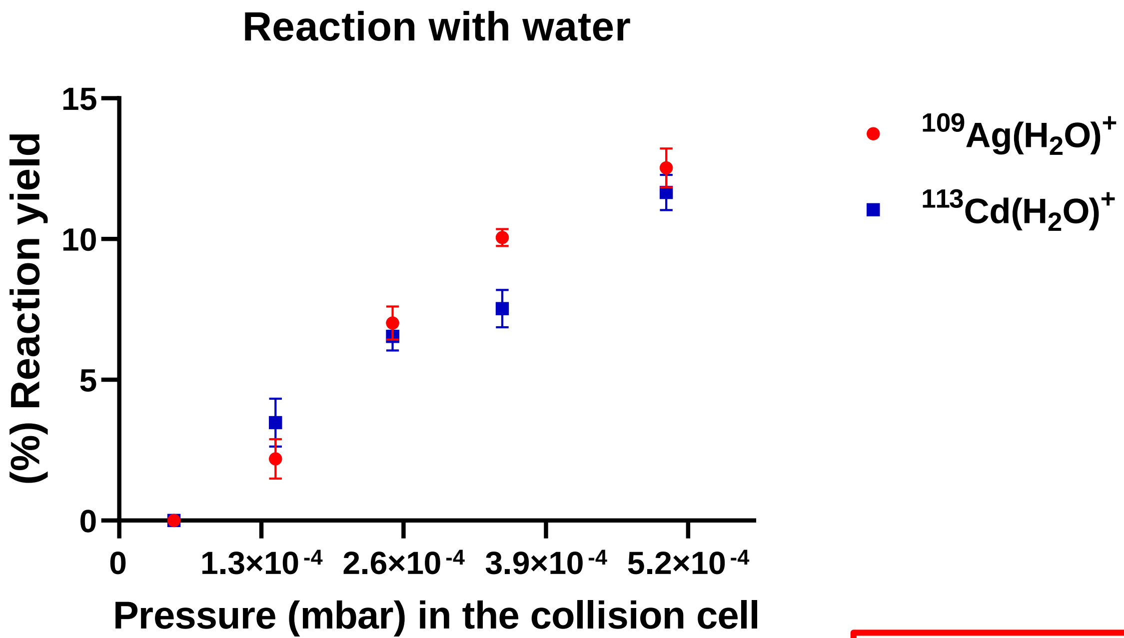
First studies with methane

- Sn^+ and In^+ do not react with methane
- Cd^+ forms $Cd(CH_4)^+$ clusters
- Ag+ forms $Ag(CH_4)^+$ and $Ag(CH_4)_2^+$

But reaction yields were below 5% ☹

However, there is one thing, you always get for free!

Impurity - Water

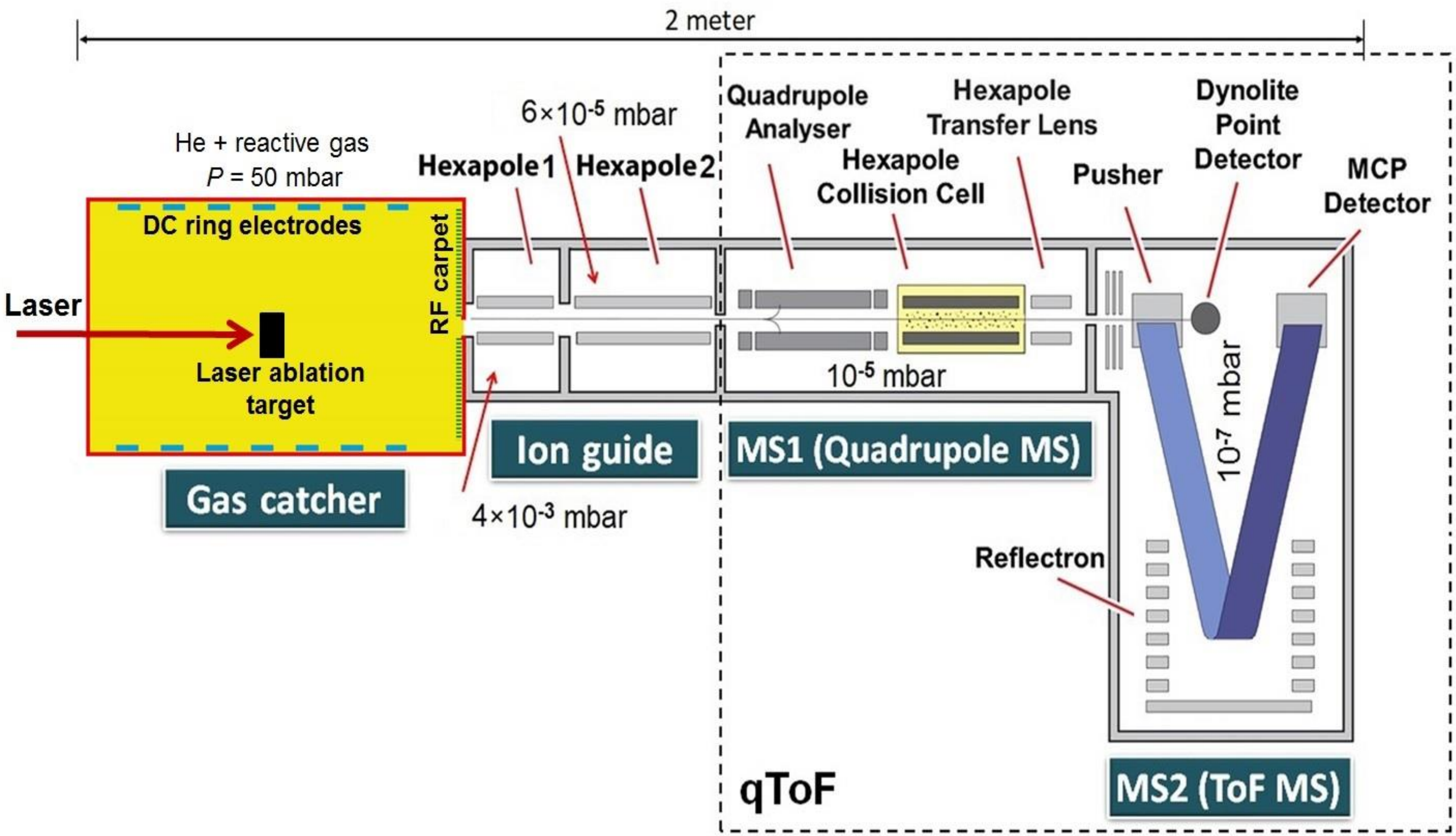


No reaction with In^+
Low reaction yields with Sn^+

Next steps

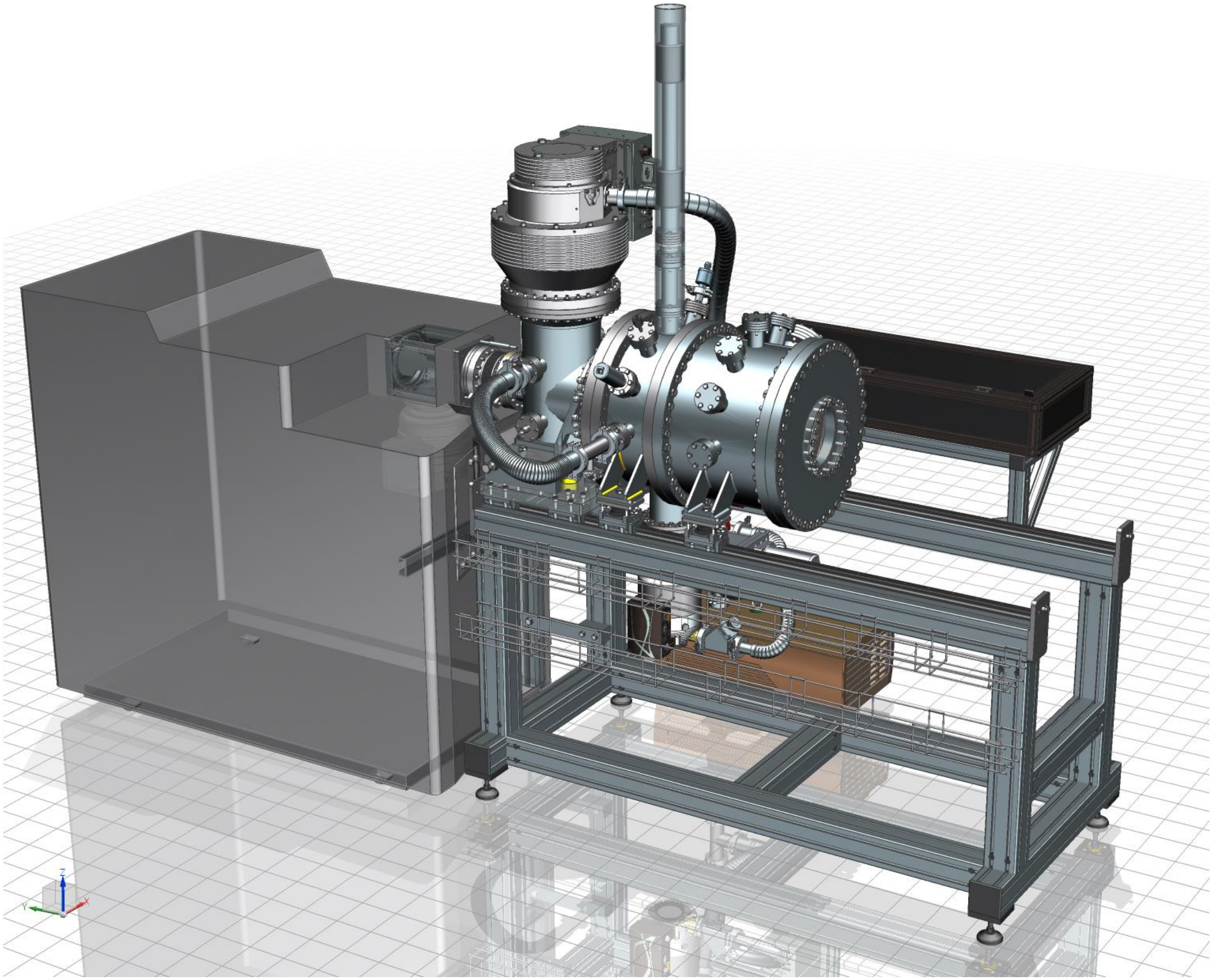
- Fixing the qToF
- Studies of the ions with charge state 2+
- Alternative reagents: CH_3Cl, OCS, CO
- Disassembling the qToF

Setup to develop CISe



A. Mollaebrahimi et al., Nucl. Instr. Meth. Phys. Res.B (2019) in press

Setup to develop CISe



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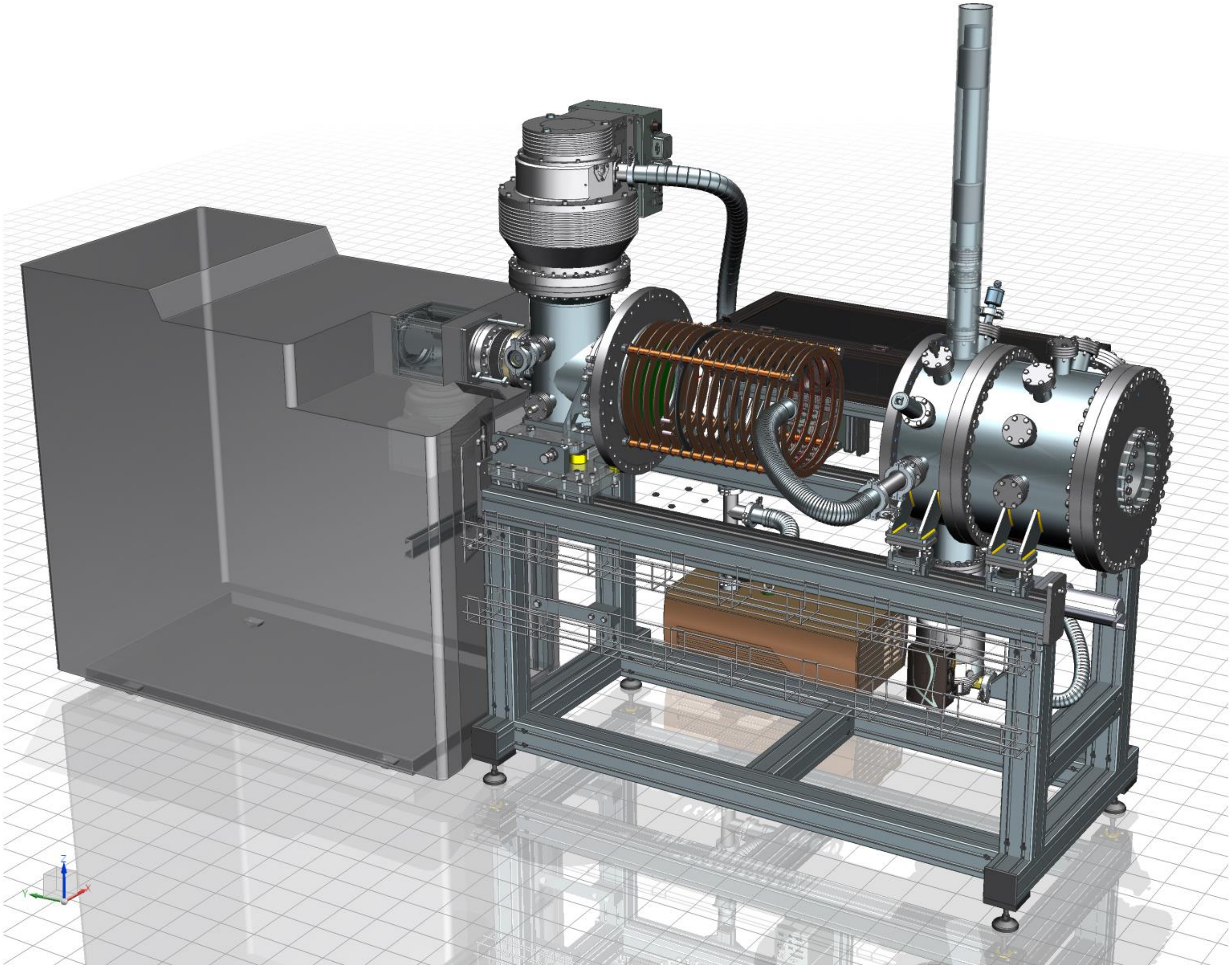

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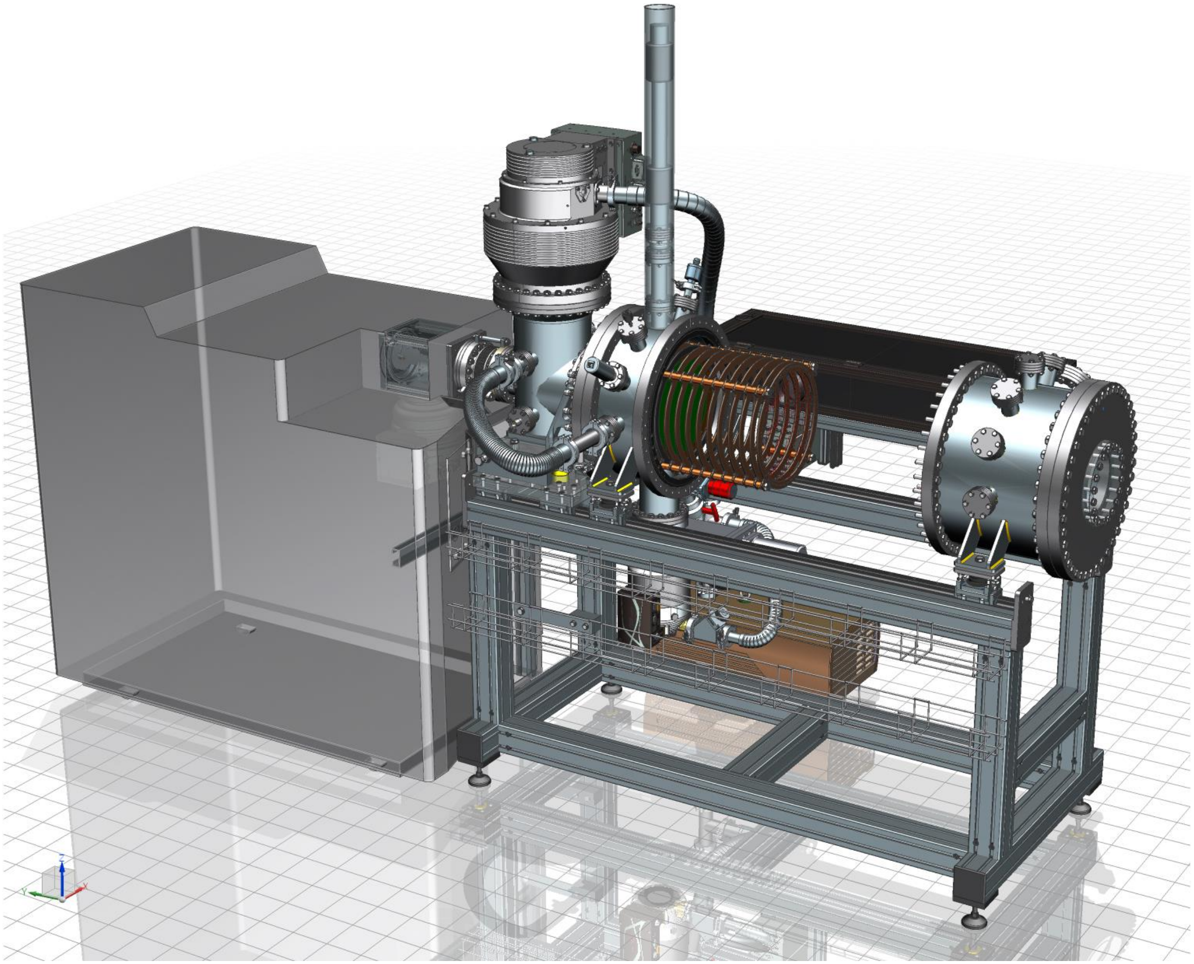

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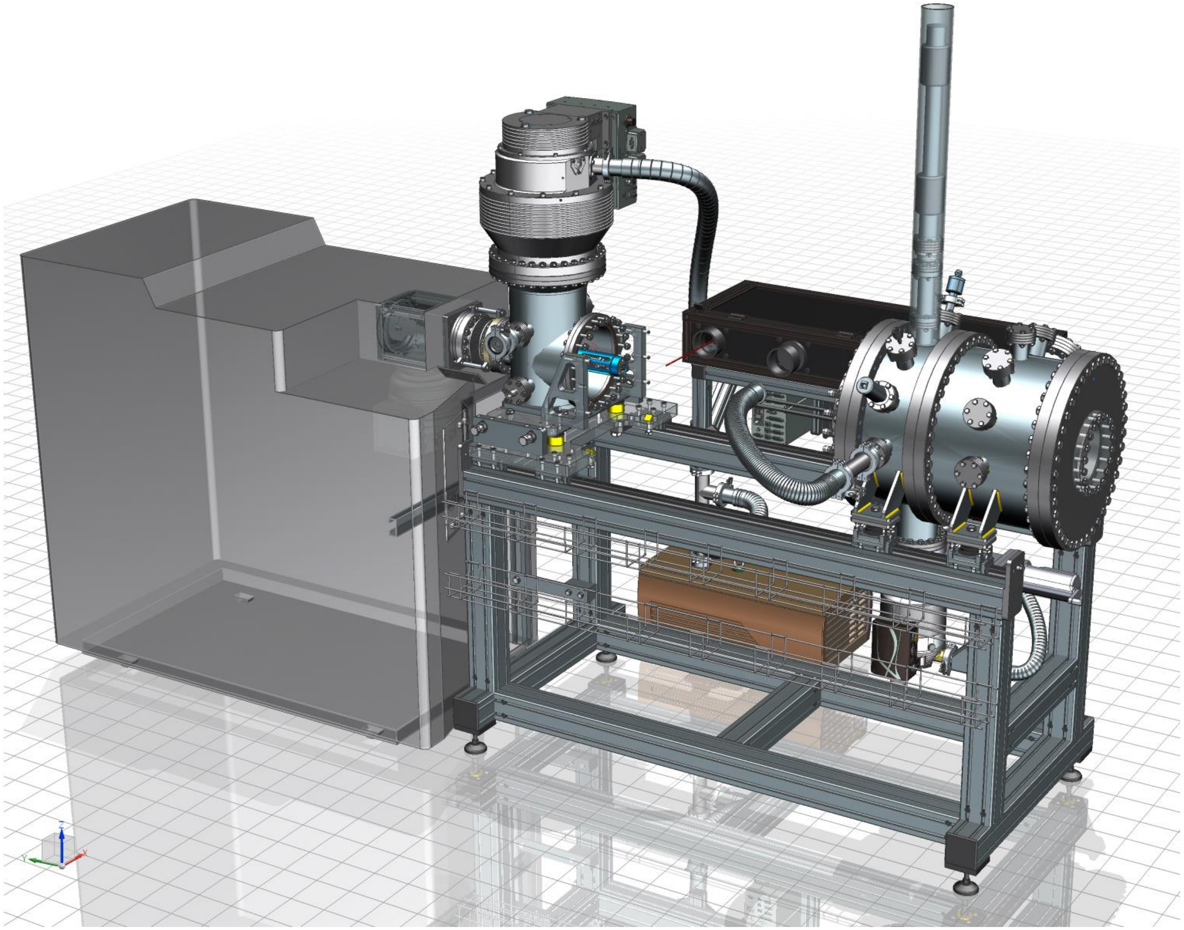
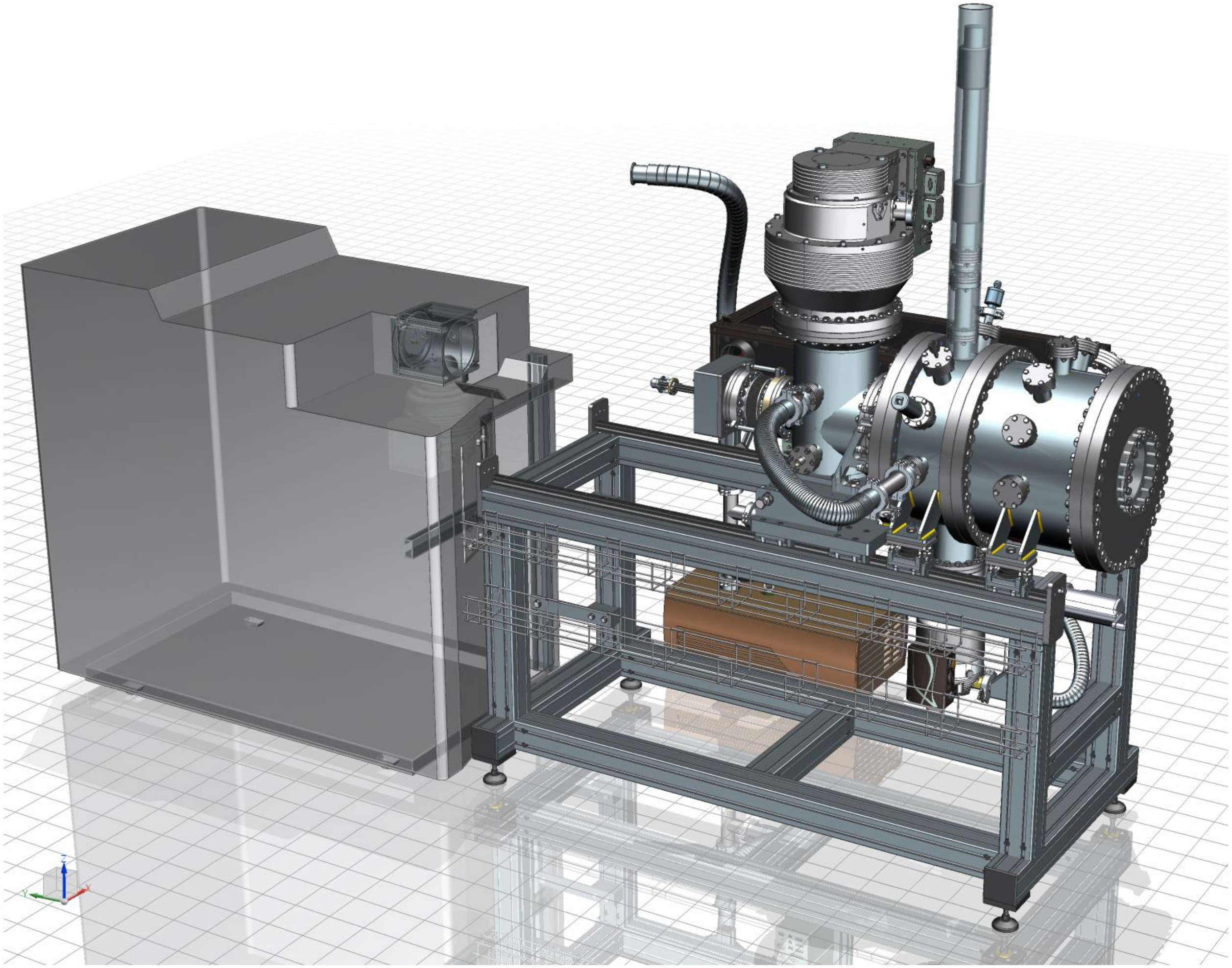
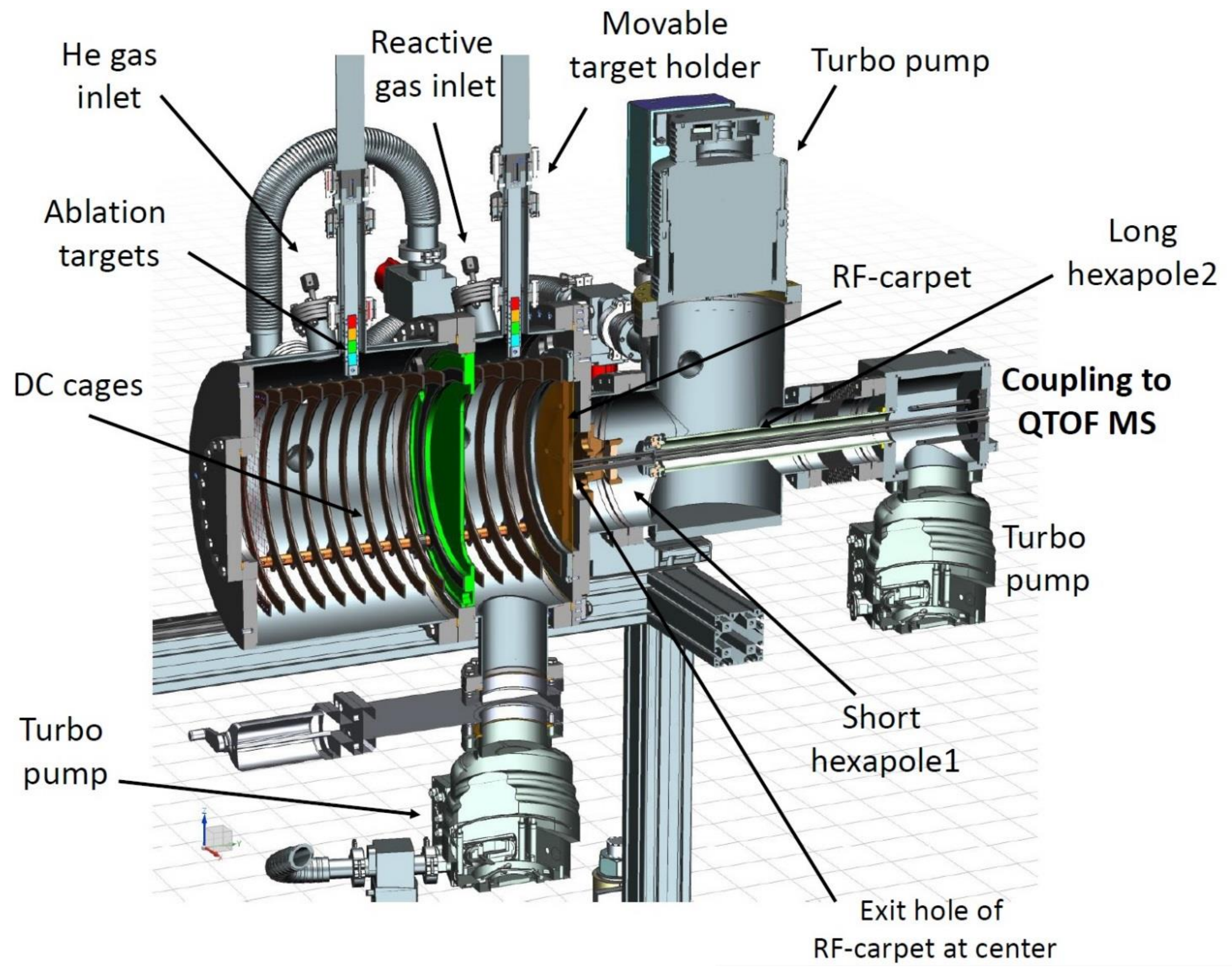


Setup to develop CISe

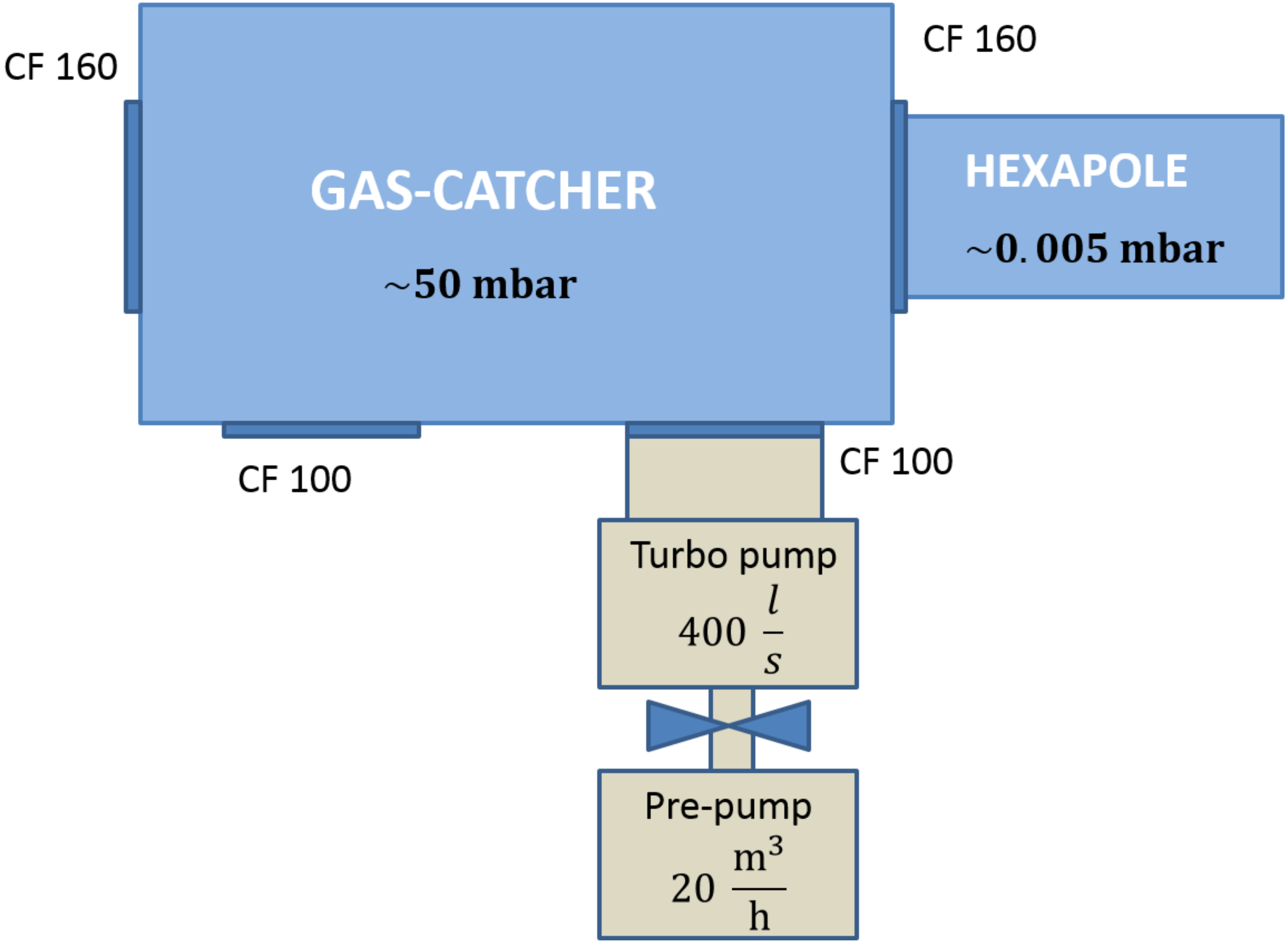


The gas-catcher

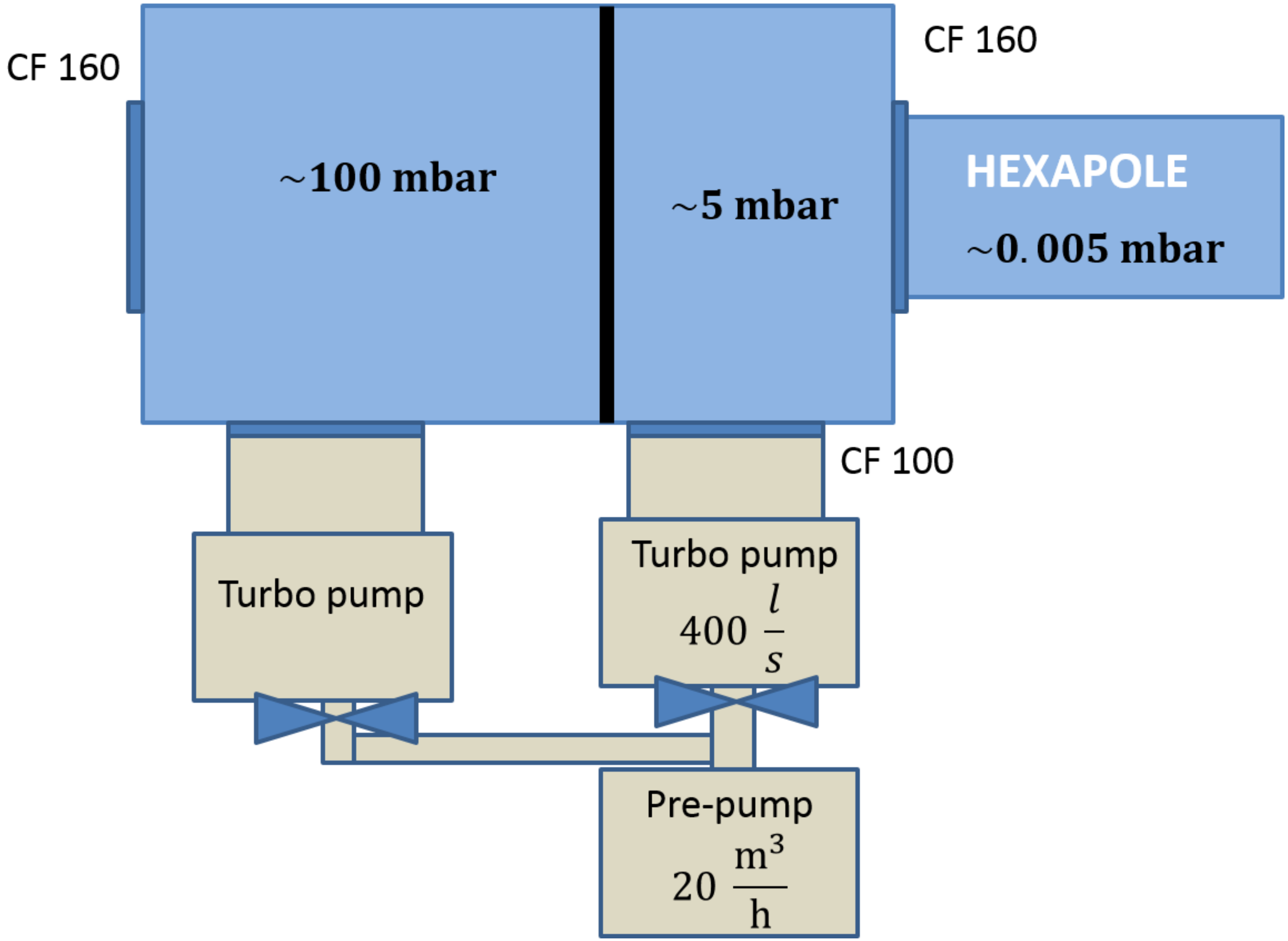


A. Mollaebrahimi et al., Nucl. Instr. Meth. Phys. Res.B (2019) in press

Gas-catcher – one carpet



Gas catcher – two carpets

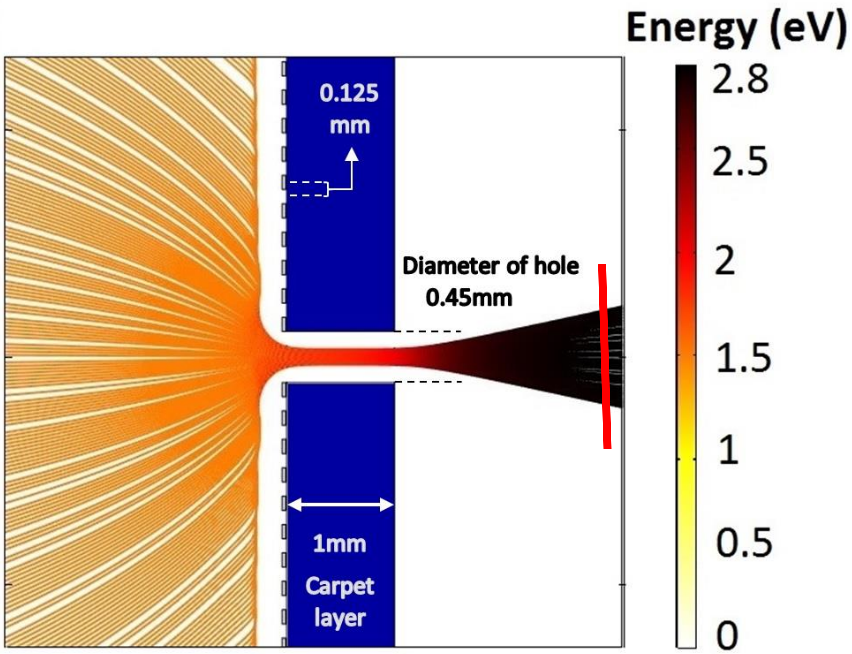


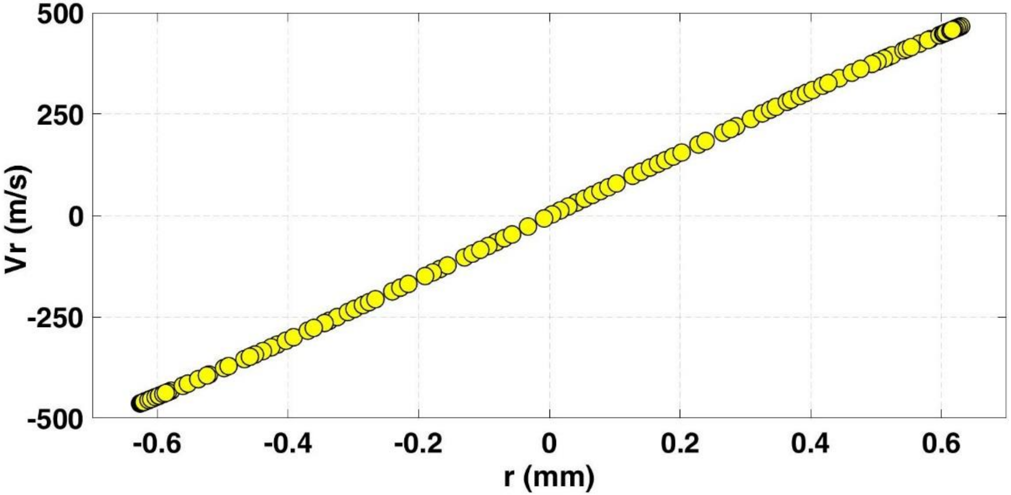
Gas catcher

Ring electrodes:
DC gradient 7 V/cm

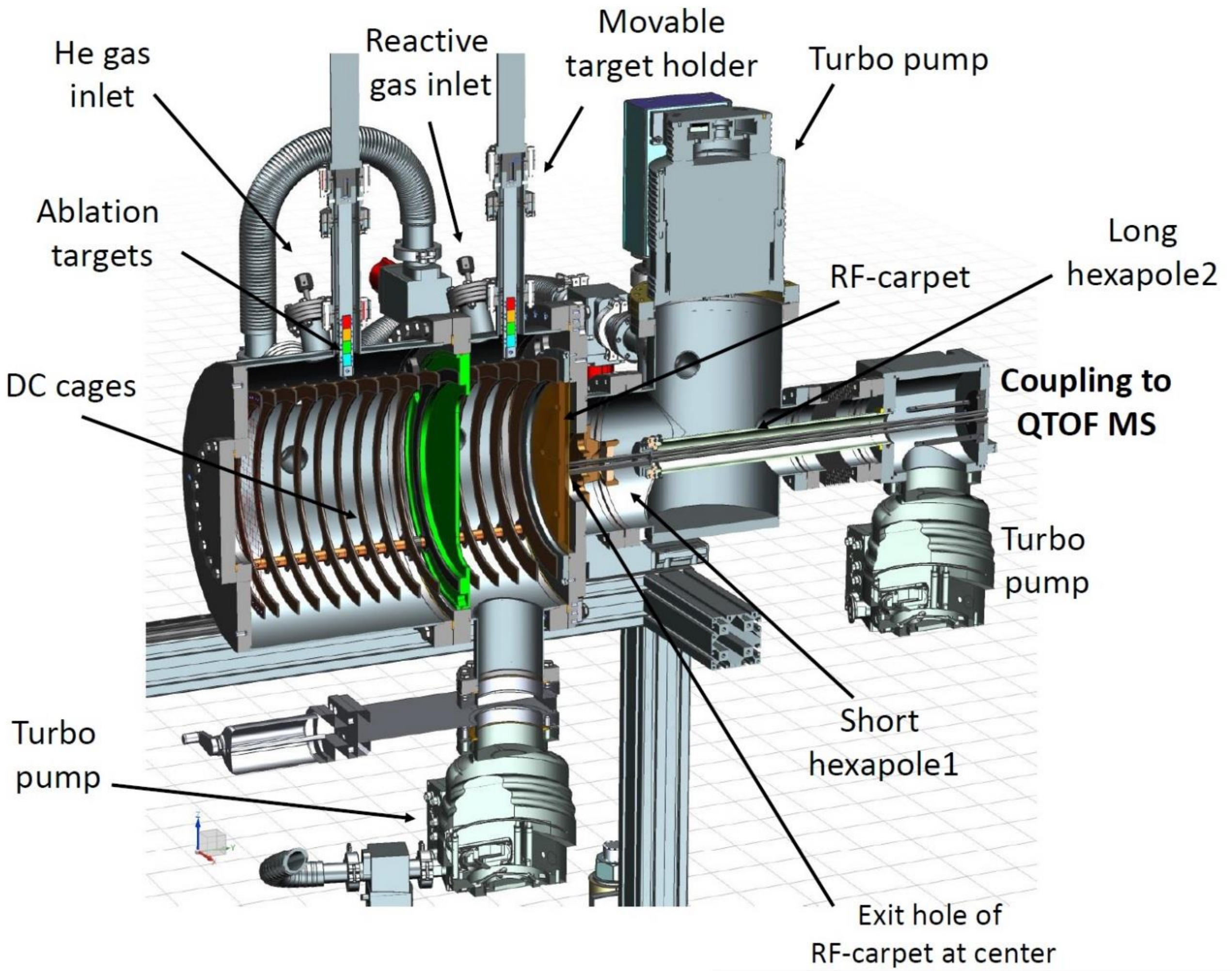
RF carpet
Printed circuit board.
0.125 mm gap between electrodes

DC gradient: 3 V/cm
RF: 100 V_{pp} , 10MHz





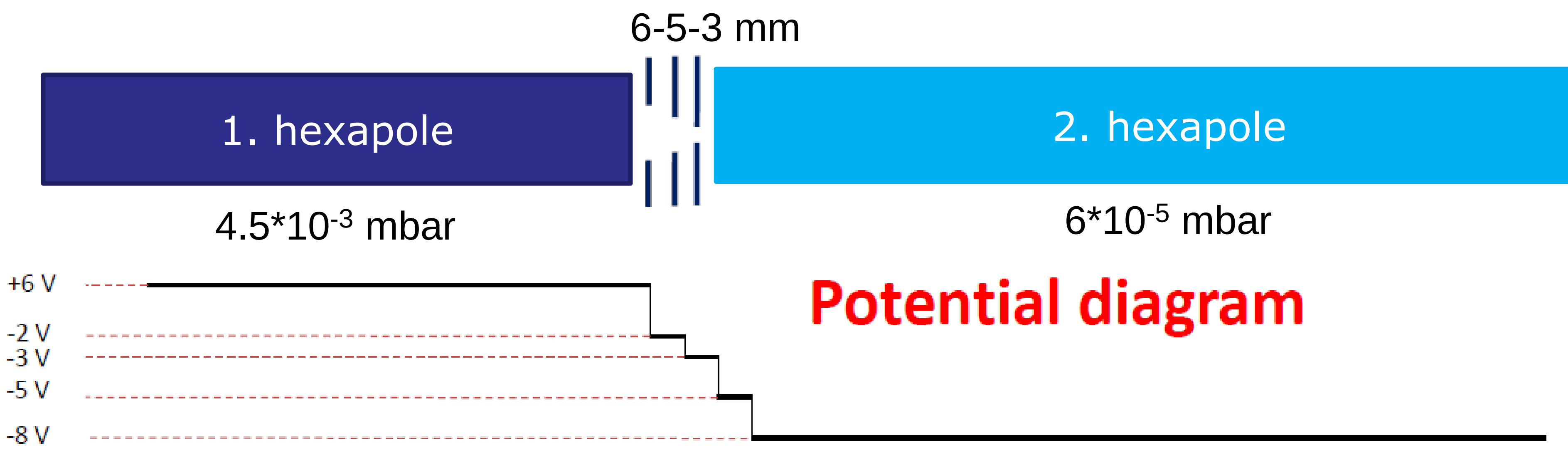
Setup - overview



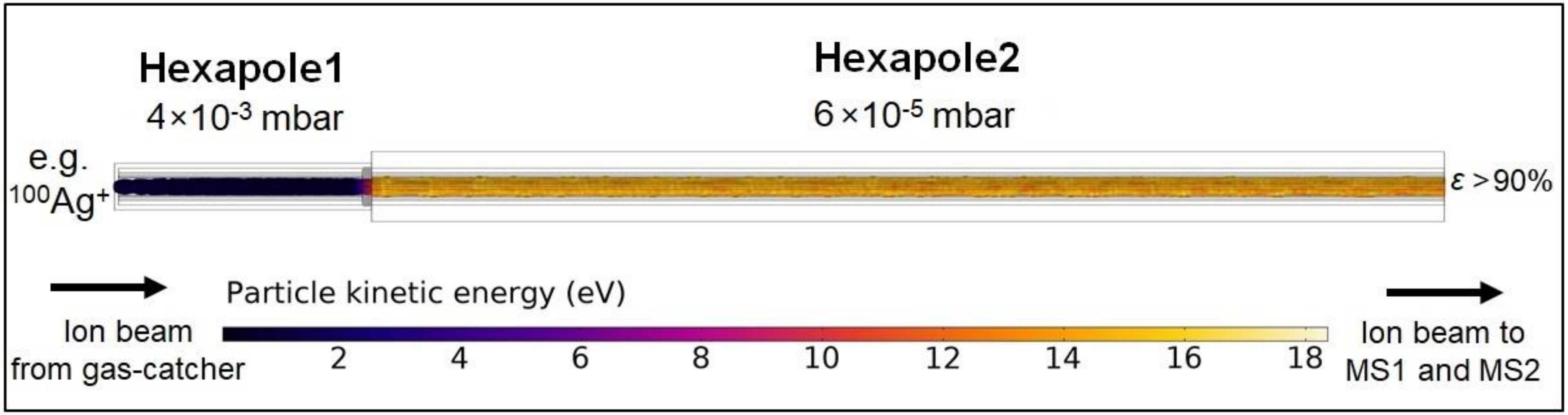
Ion-guide structure

Hexapoles:
Stainless steal rods 5mm diameter
Distance between two opposite rods: 13.9 mm
First hexapole: 125 mm length
Second hexapole 600 mm length
RF: 120 V_{pp}, 1 MHz

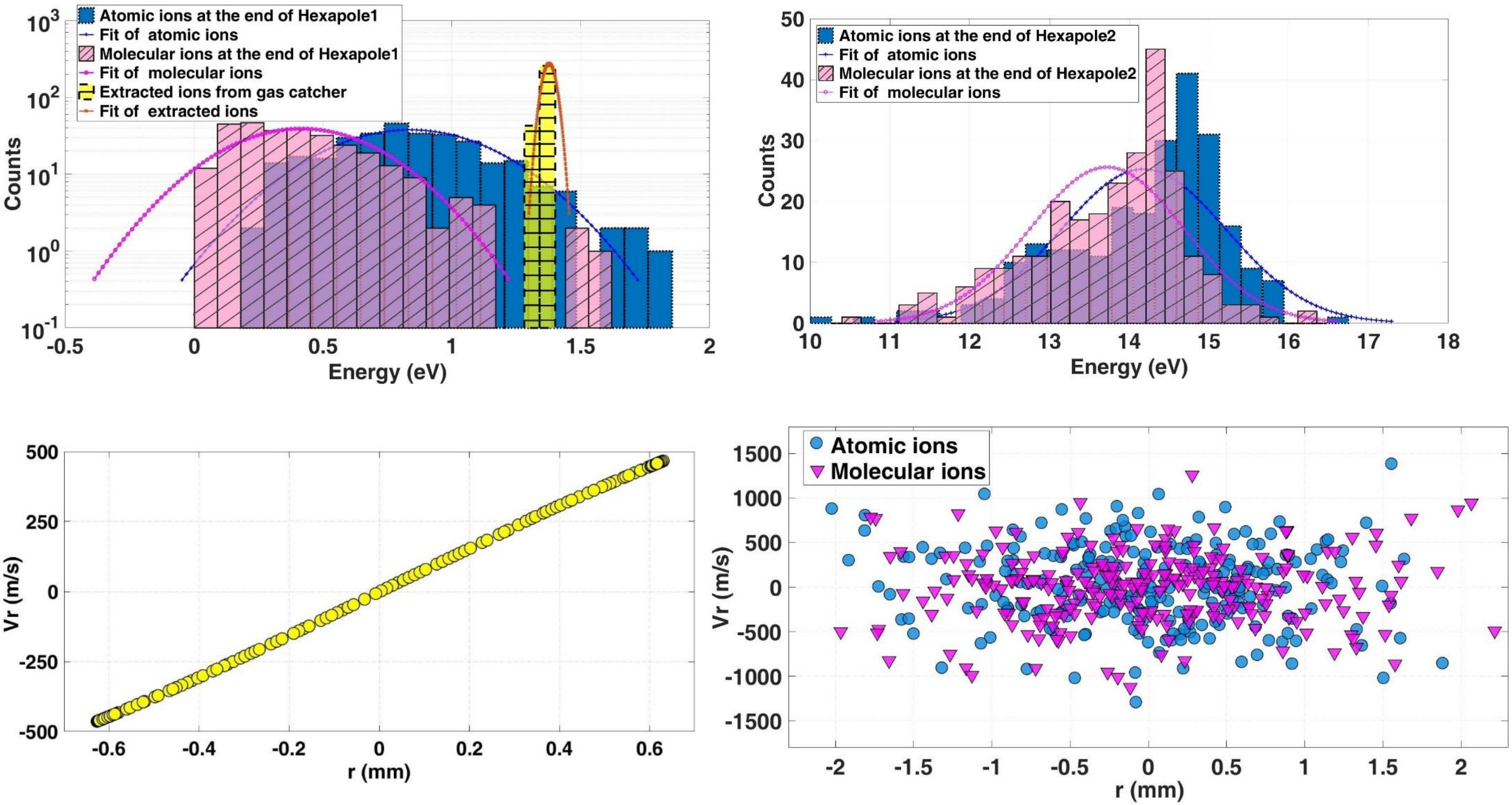
Ion guide



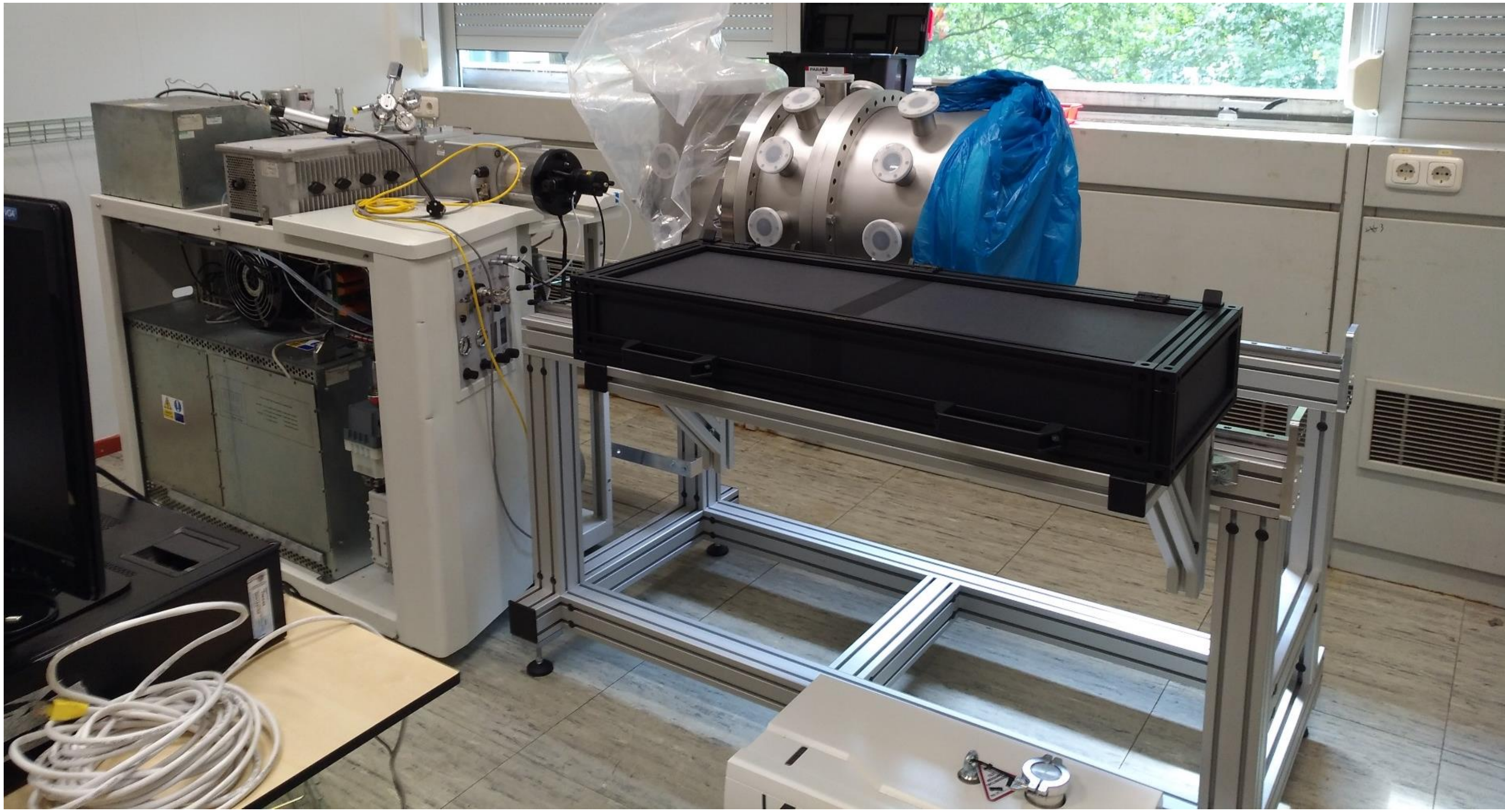
Potential diagram



Comsol simulation



Mounting in progress



Summary and outlook

- Chemistry is not necessary our enemy
- Gas chemical separation of Sn, In, Cd, and Ag is ongoing
- Setup for on- and offline experiments under construction

Next steps:

- Further chemistry studies in the collision cell (CH_4, H_2O, OCS, CH_3Cl, CO)
- Mounting and commissioning of the setup
- Chemistry studies in the catcher with the laser ablation source
- Chemistry studies at AGOR

Thanks to…

B. Anđelić[1,2], L.F. Arcila[1], A. Mollaebrahimi[1], M. Adams[1], M. Block[2,3,4], F. Giacoppo[2,3], N. Kalantar-Nayestanaki[1], O. Kaleja[3,4,5], H. R. Kremers[1], M. Laatiaoui[2,4], P. Lemmens[1], S. Raeder[2,3], H. Smit[1]

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[3] *GSI Helmholtz Center for Heavy Ion Research, Darmstadt, Germany*

[4] *Johannes Gutenberg University Mainz, Mainz, Germany*

[5] *Max Planck Institute for Nuclear Physics, Heidelberg, Germany*

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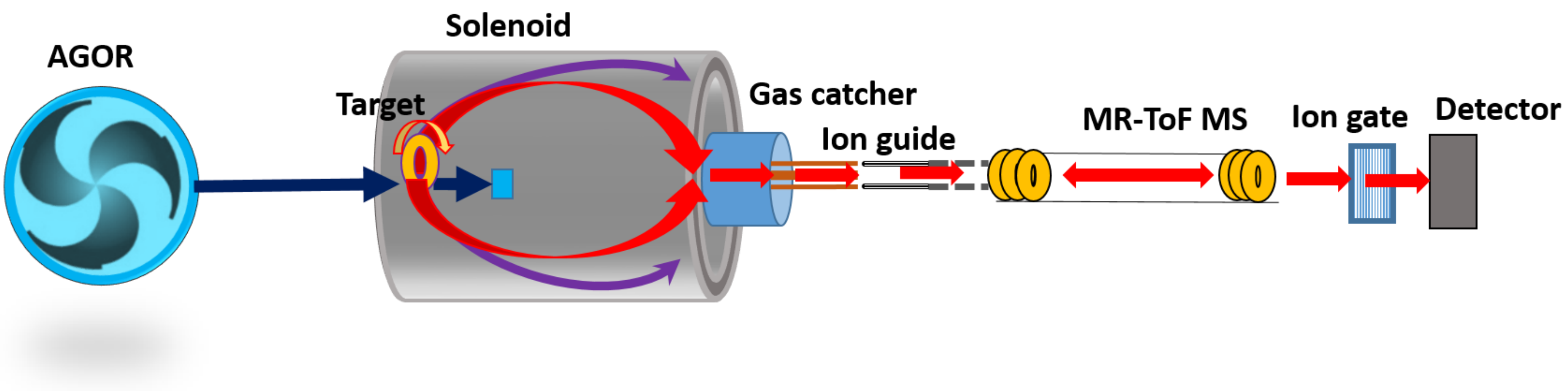
Thank you
for your attention!

Postdoc and PhD position available for NEXT!



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