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faculty of science and engineering
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Ion optical simulations for the *NEXT* solenoid separator

Arif Soylu
University of Groningen, VSI

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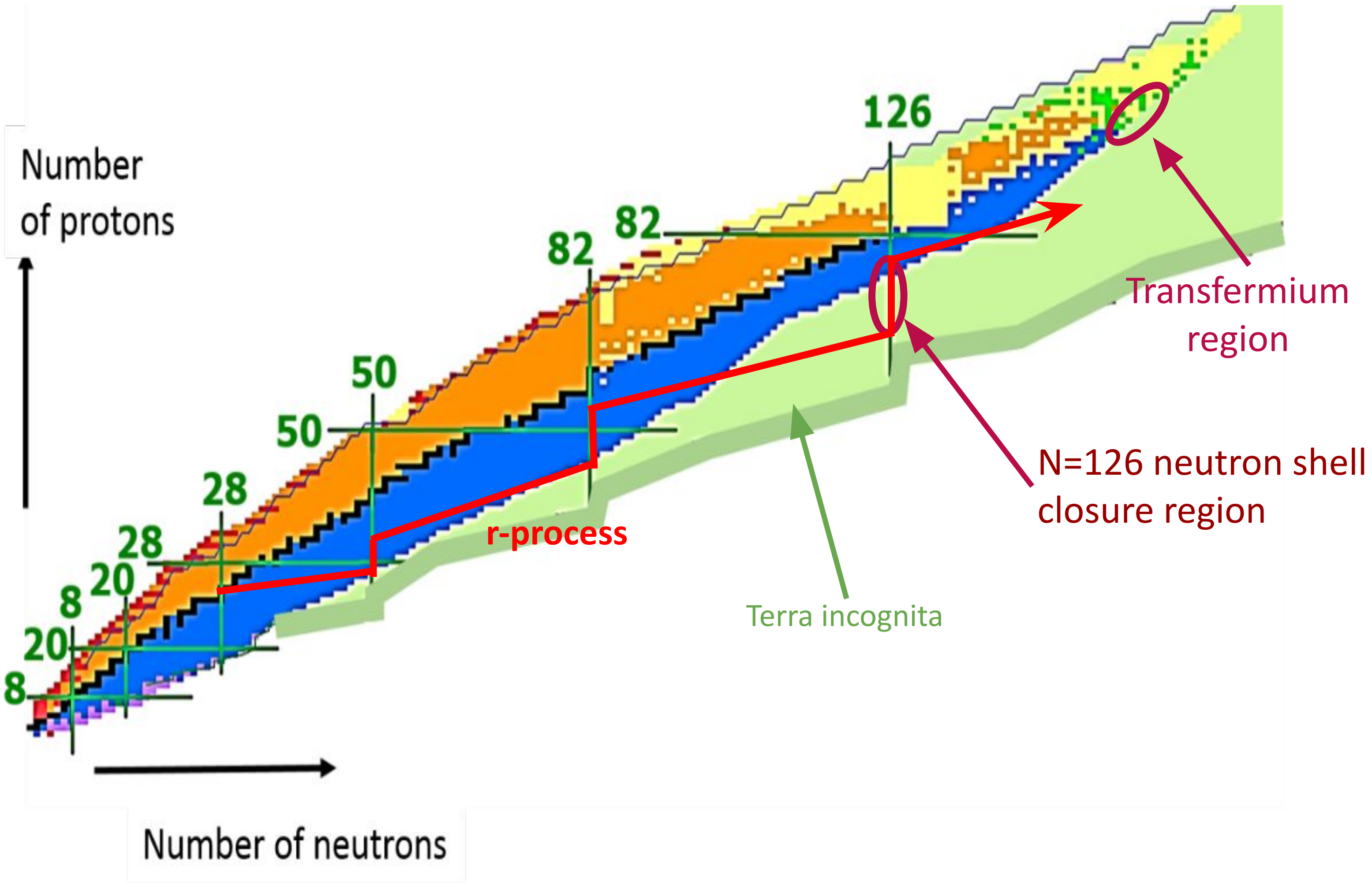
Lunteren, 4 November 2022

NEXT

(**N**eutron-rich, **EX**otic, heavy nuclei produced in multi-nucleon **T**ransfer reactions)



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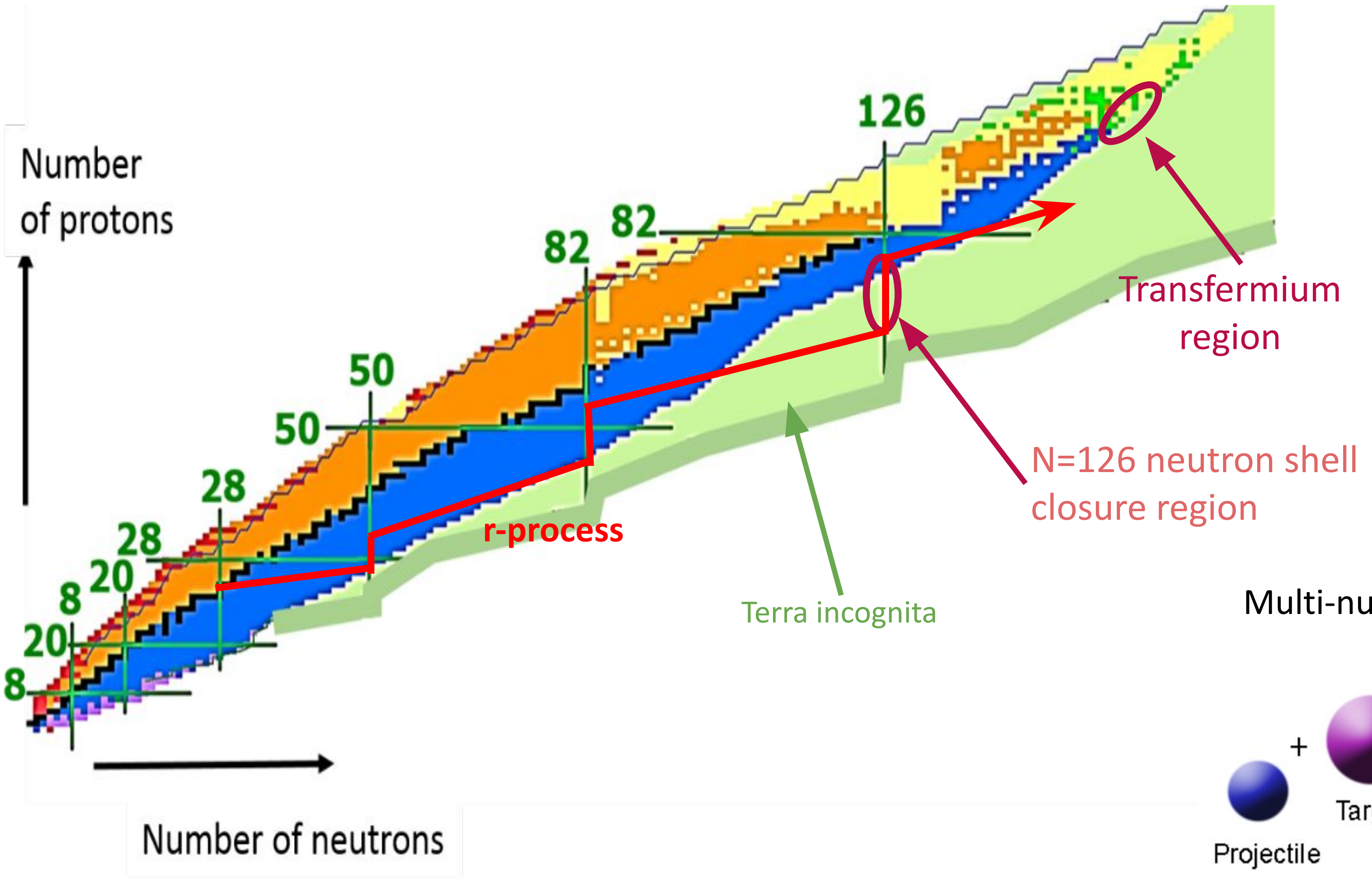

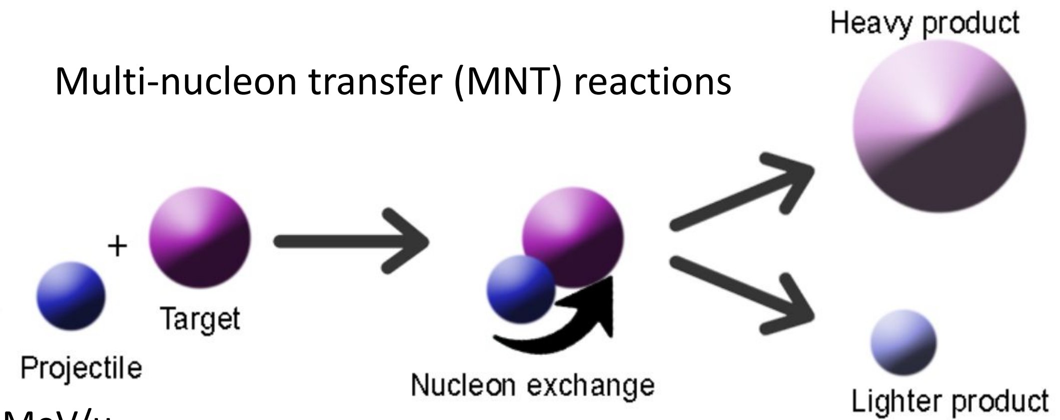

E_{LAB} = 6-8 MeV/u

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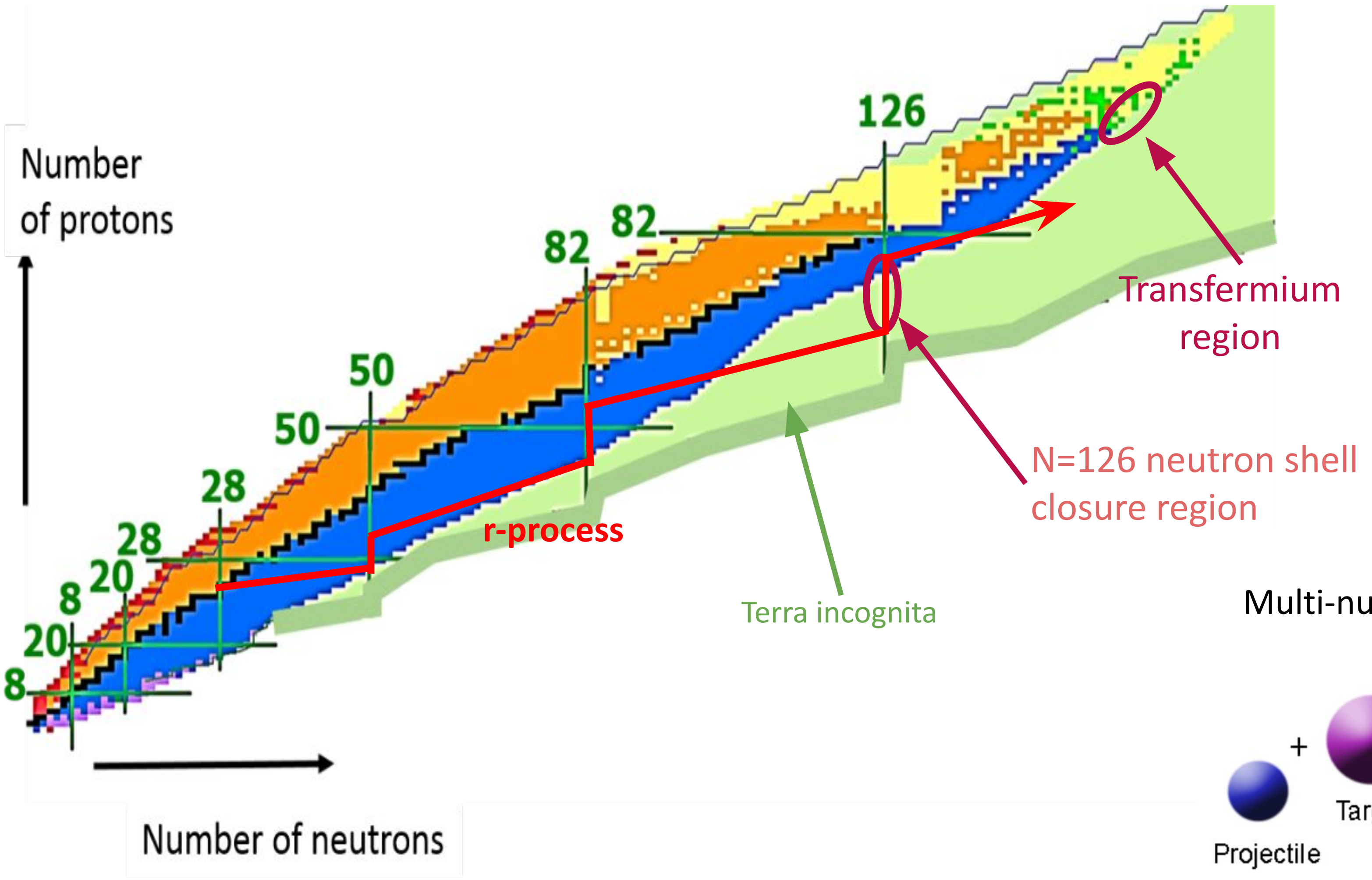
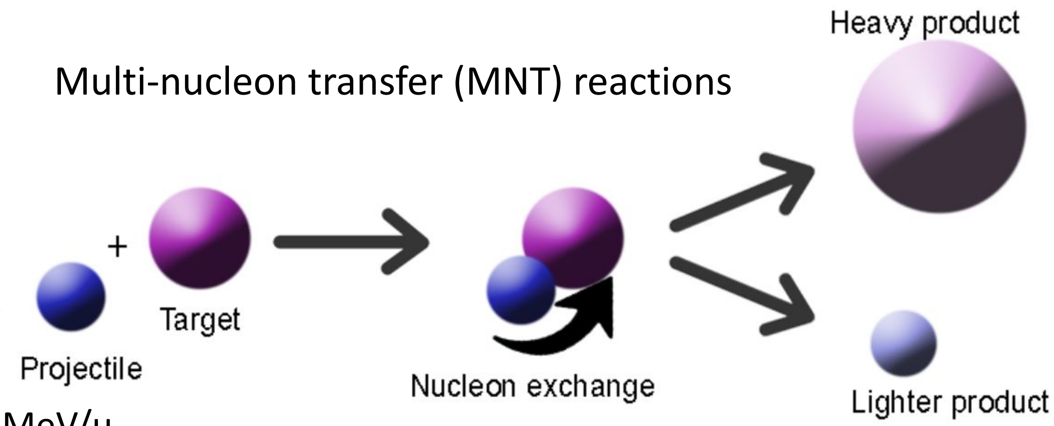


Experimental challenges:

- ➢ Wide angular distribution of transfer products
- ➢ Isotope separation and identification

Multi-nucleon transfer (MNT) reactions



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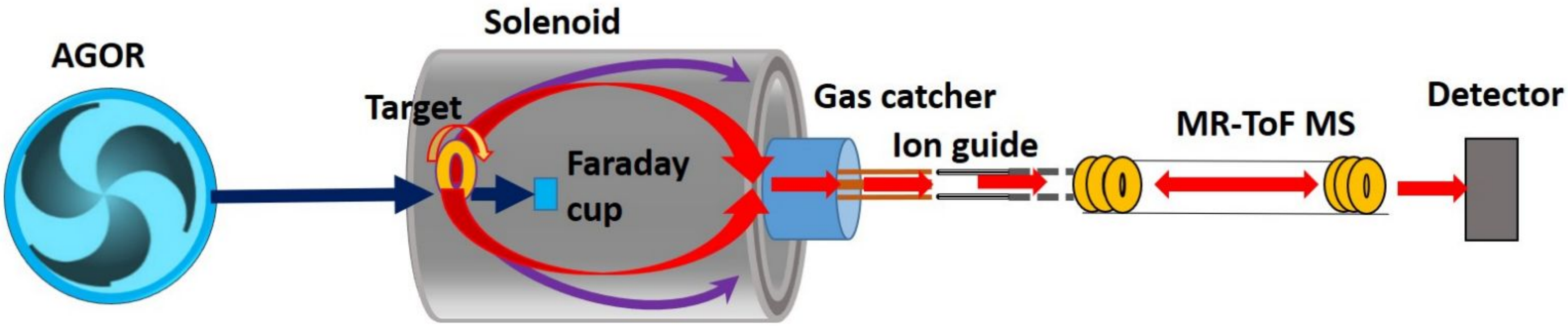
NEXT setup



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M. Schlaich, Master thesis, TU Darmstadt 2021.

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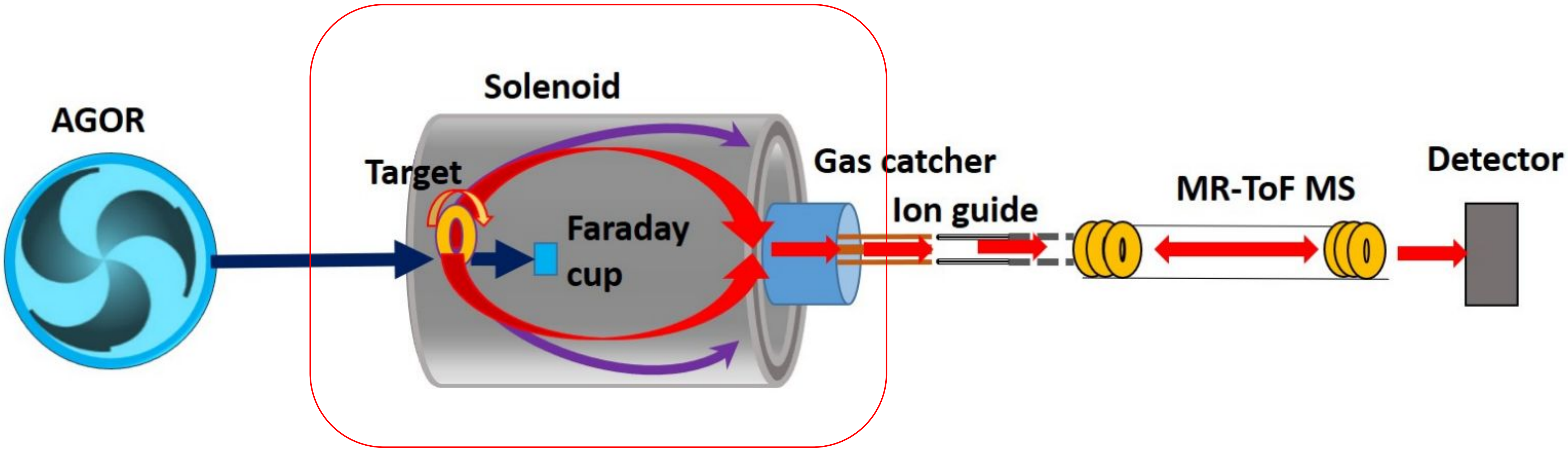

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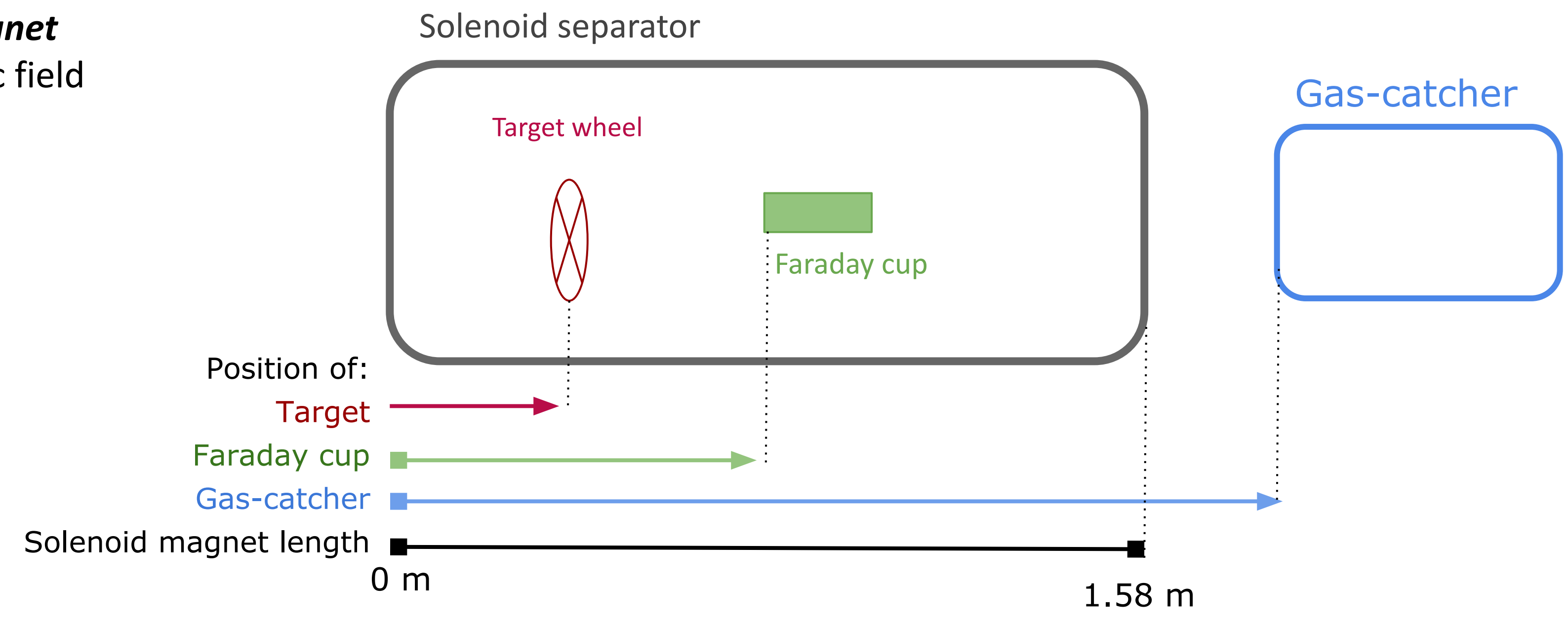
Solenoid separator

Technical information of solenoid magnet

- Max. 3 T homogeneous magnetic field
- 87 cm bore
- 1.58 m long



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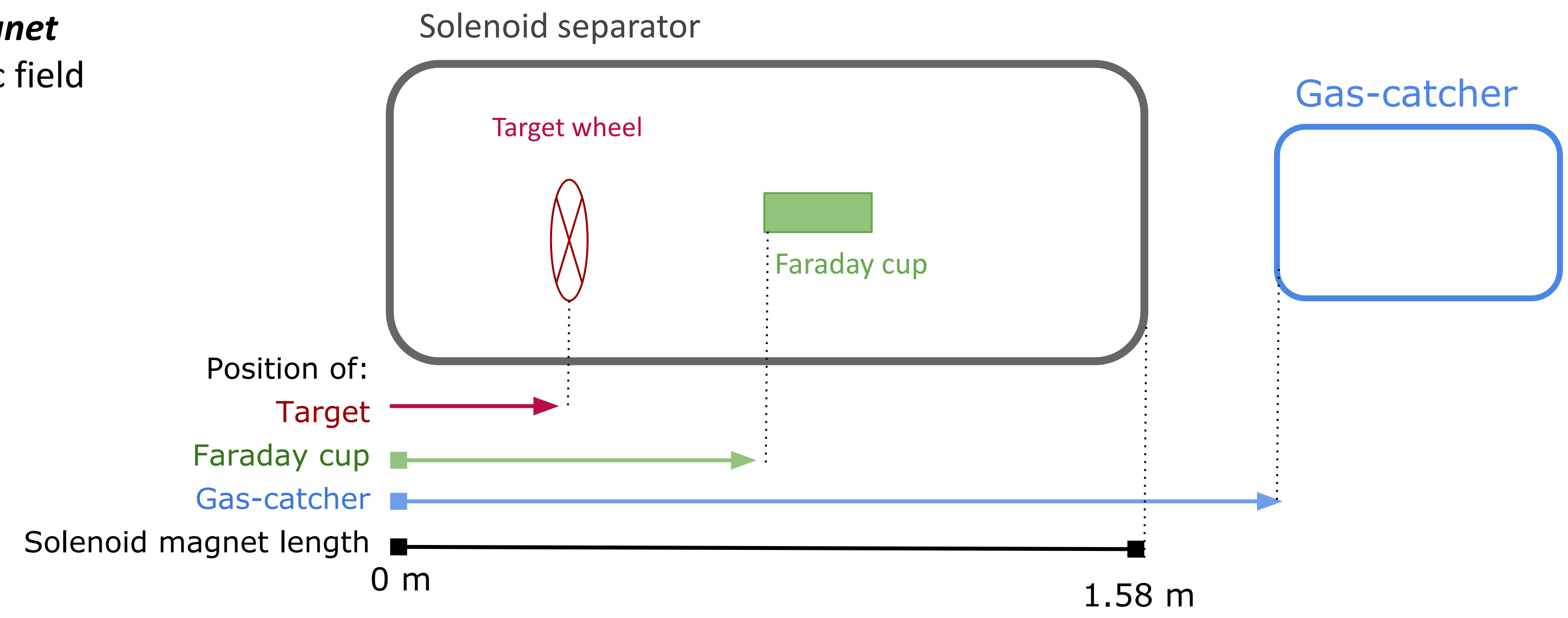


- ➢ Determine the optimum positions of the target wheel, Faraday cup and, the gas-catcher.
- ➢ Maximize the transmission yield, and optimize the background suppression.

Ion optical simulations

New *Python* code has been developed for ion optical simulations.

Ion optical simulations

New *Python* code has been developed for ion optical simulations.

Requirements:

- ➔ Reconstruction of a realistic magnetic field of the solenoid magnet
- ➔ Integration of the theoretical predicted kinematic data

^{136}Xe + ^{198}Pt @ 6 MeV/u [1]
^{48}Ca + ^{251}Cf @ 6.1 MeV/u [2]

- ➔ Calculation of the atomic charge state distribution

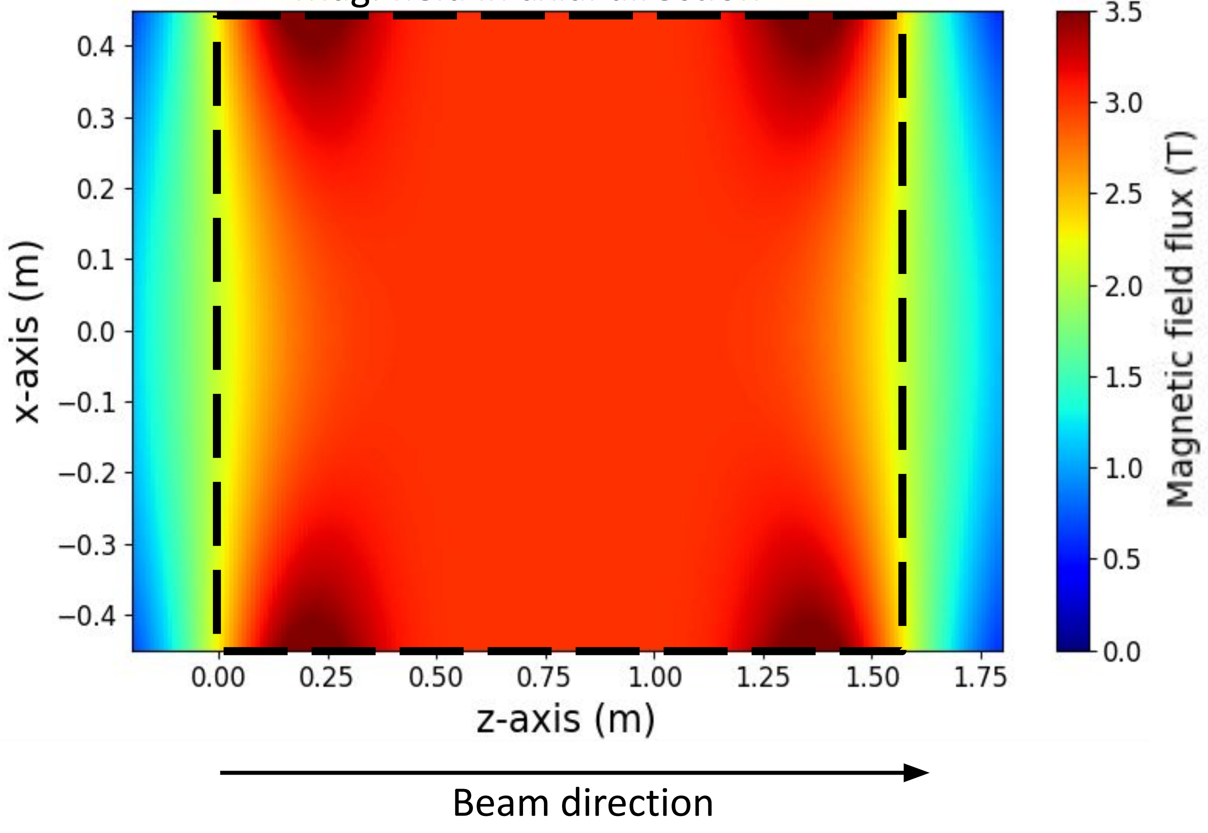
[1] A. Karpov and V. Saiko, EPJ Web Conf. 163, (2017).
[2] A. Karpov and V. Saiko, Phys. Part. Nucl. Lett. 16, 667 (2019).

Magnetic field definition

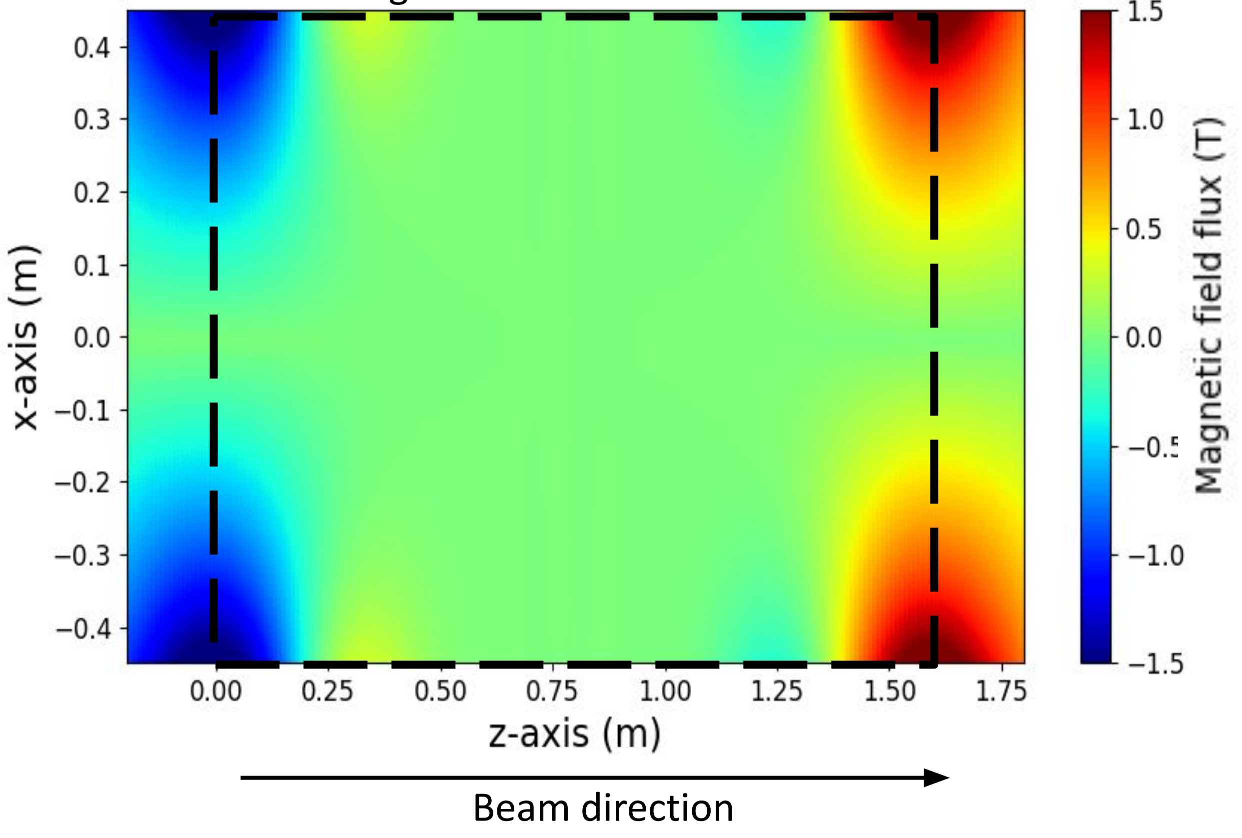
Axially symmetric expansion method has been used to reconstruct the magnetic field of the solenoid magnet.

$$\mathbf{B} = B_r(r,z)\hat{\mathbf{r}} + B_z(r,z)\hat{\mathbf{z}}$$

Mag. field in axial direction

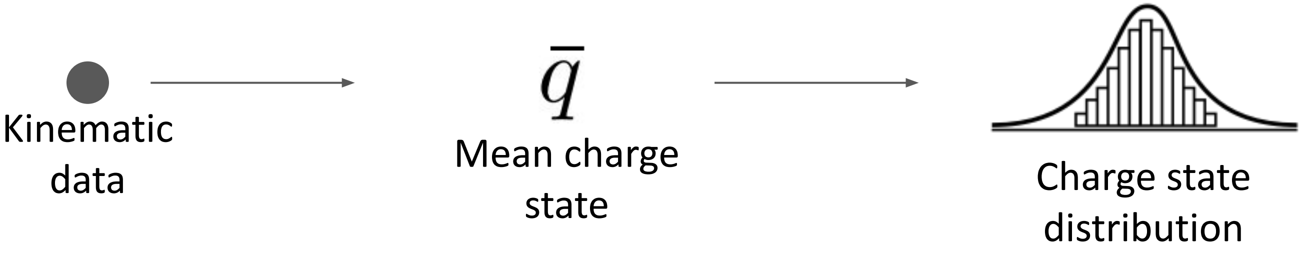


Mag. field in radial direction



K. T. Mcdonald, Expansion of an Axially Symmetric, Static Magnetic Field in Terms of Its Axial Field, 08544, 1 (2011).

Charge state distribution



$$\bar{q} = [1 - exp(-1.25X + 0.32X^2 - 0.11X^3)][1 - 0.0019(Z_t - 6)\sqrt{X} + 0.00001(Z_t - 6)^2 X]$$

$$X = \frac{v}{v' Z_p^{0.45}} \quad ,$$

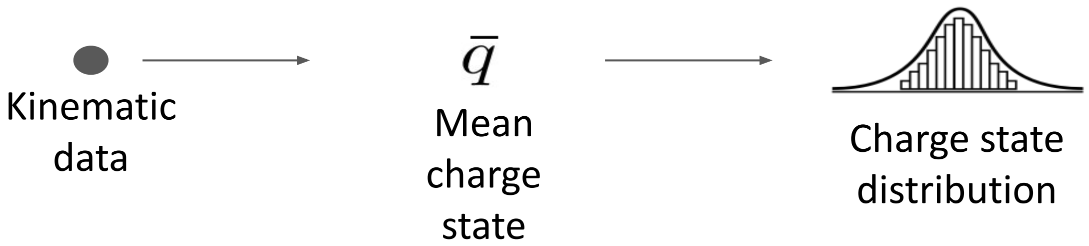
Z_p : Proton number of projectile
Z_t : Proton number of target material
v : Ion velocity
v': Bohr velocity

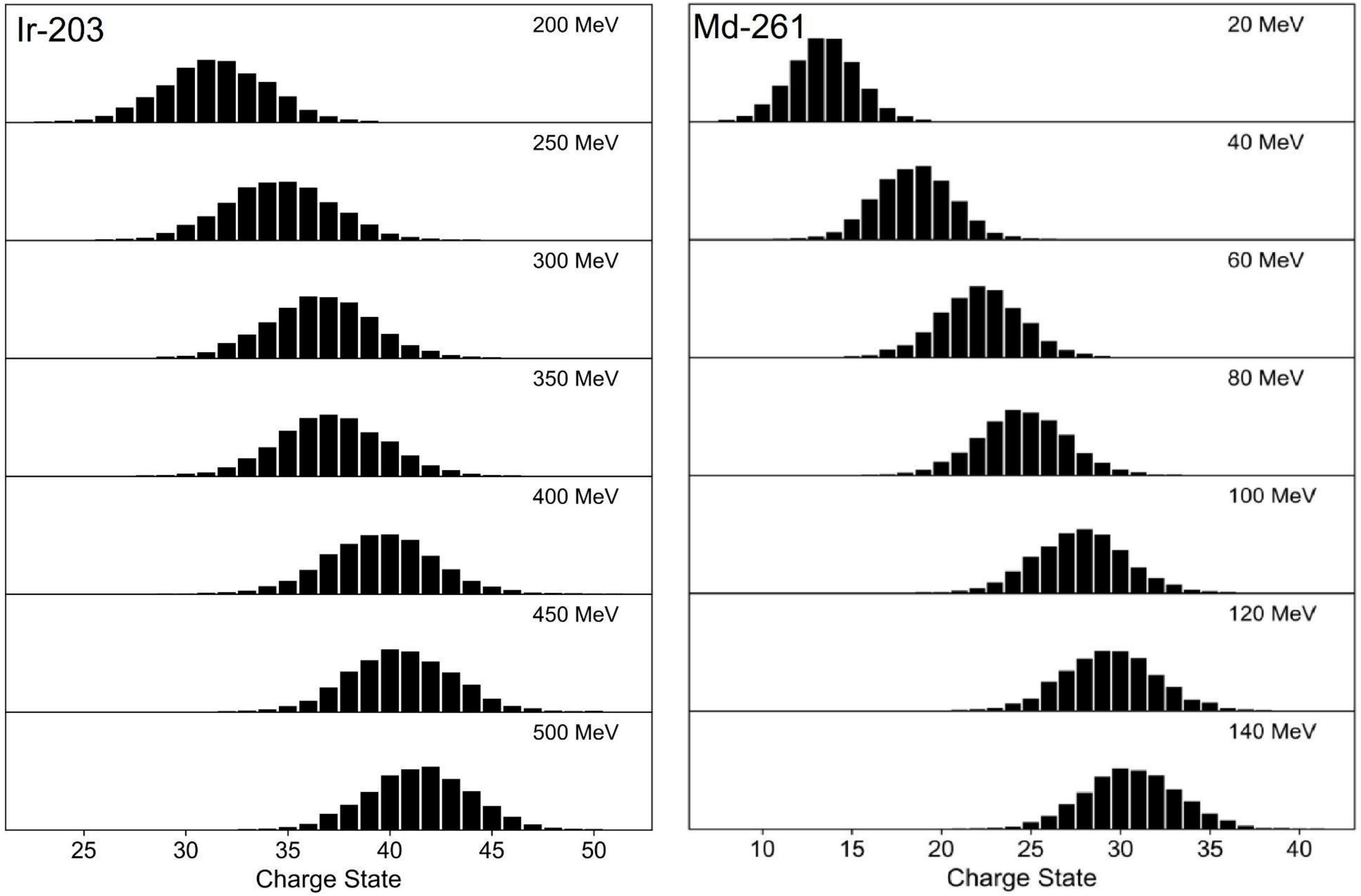
$$d_q = d_0 \sqrt{\bar{q}[1 - (\bar{q}/Z_p)^{1/k}]}$$

d_q : Width of the distribution, **d_0, k**: Empirical constant

V. S. Nikolaev and I. S. Dmitriev, Phys. Lett. A 28, 277 (1968).
K. Shima, et al., NIM B, 200 (1982) 605-608.

Charge state distribution





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Acceptance regions

$$\vec{B}\rho = \frac{\vec{v}m}{q}$$

B: Magnetic field strength

ρ: Bending radius

v: Velocity

m: Mass

q : Charge state

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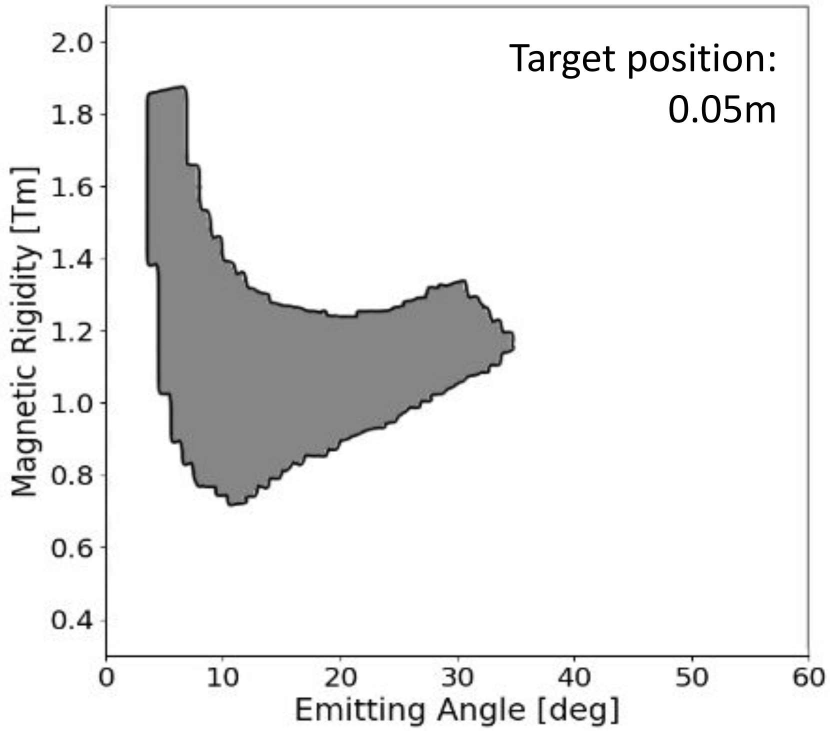

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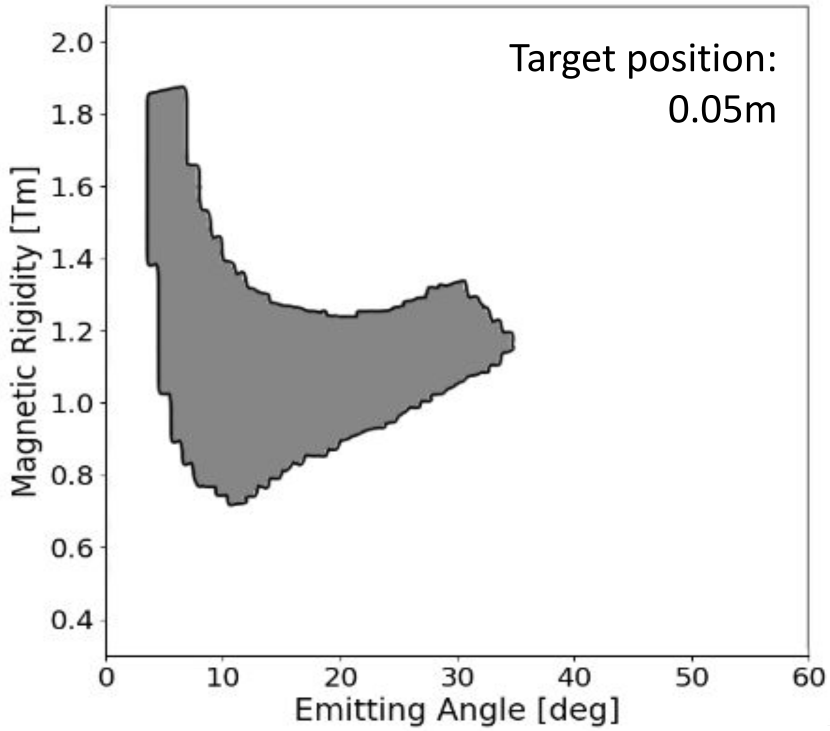

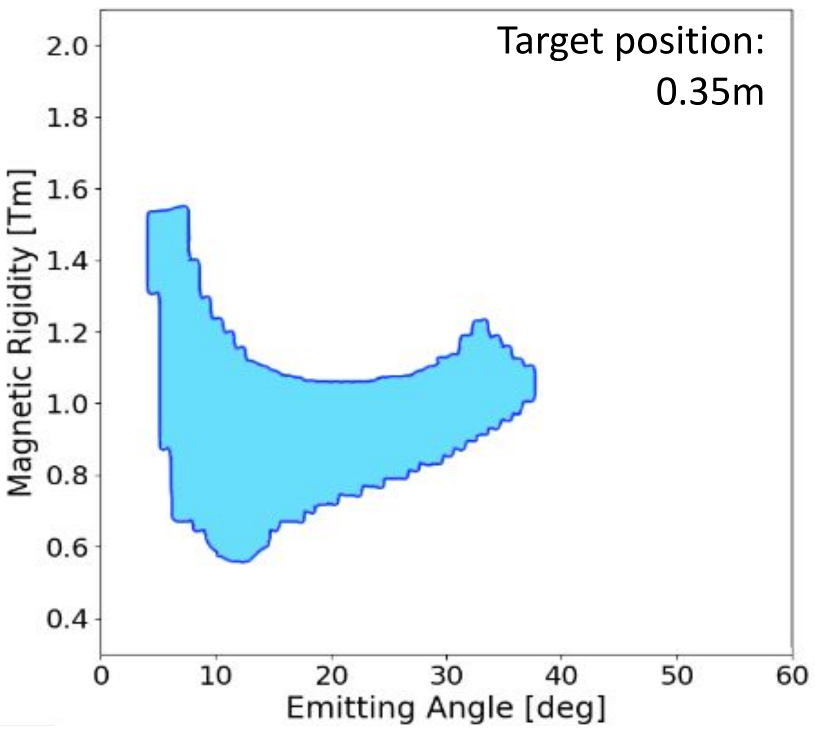

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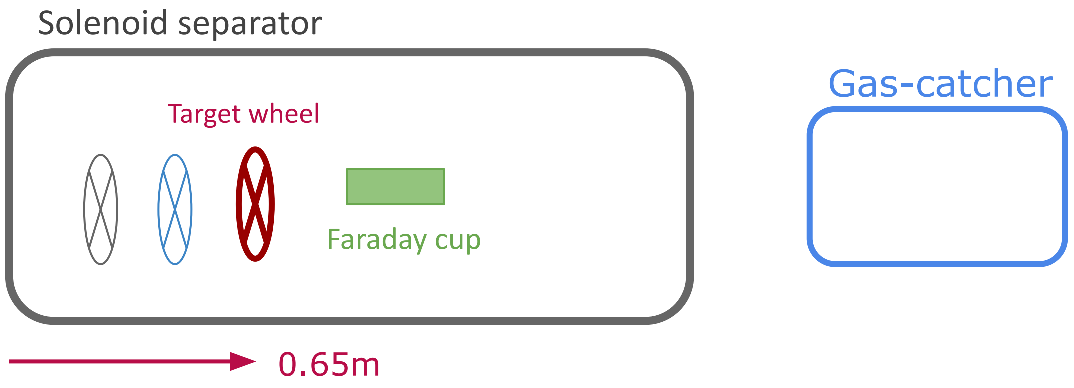
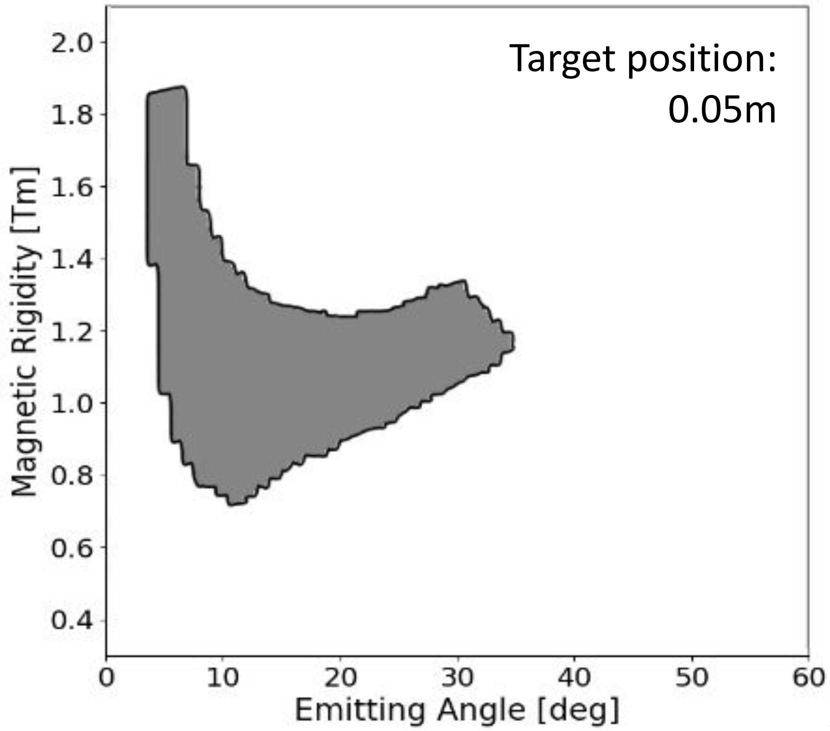
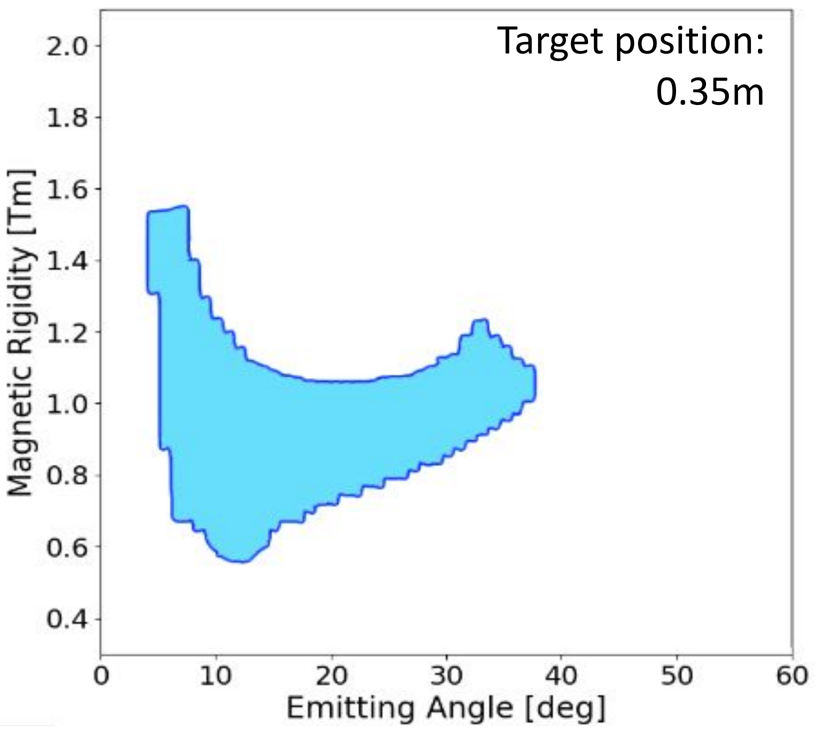
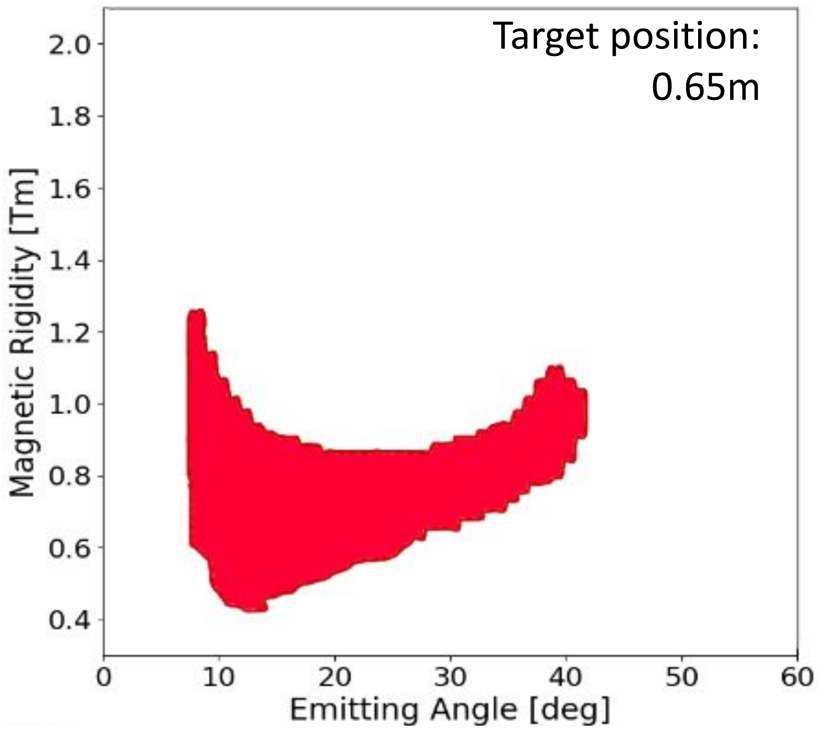
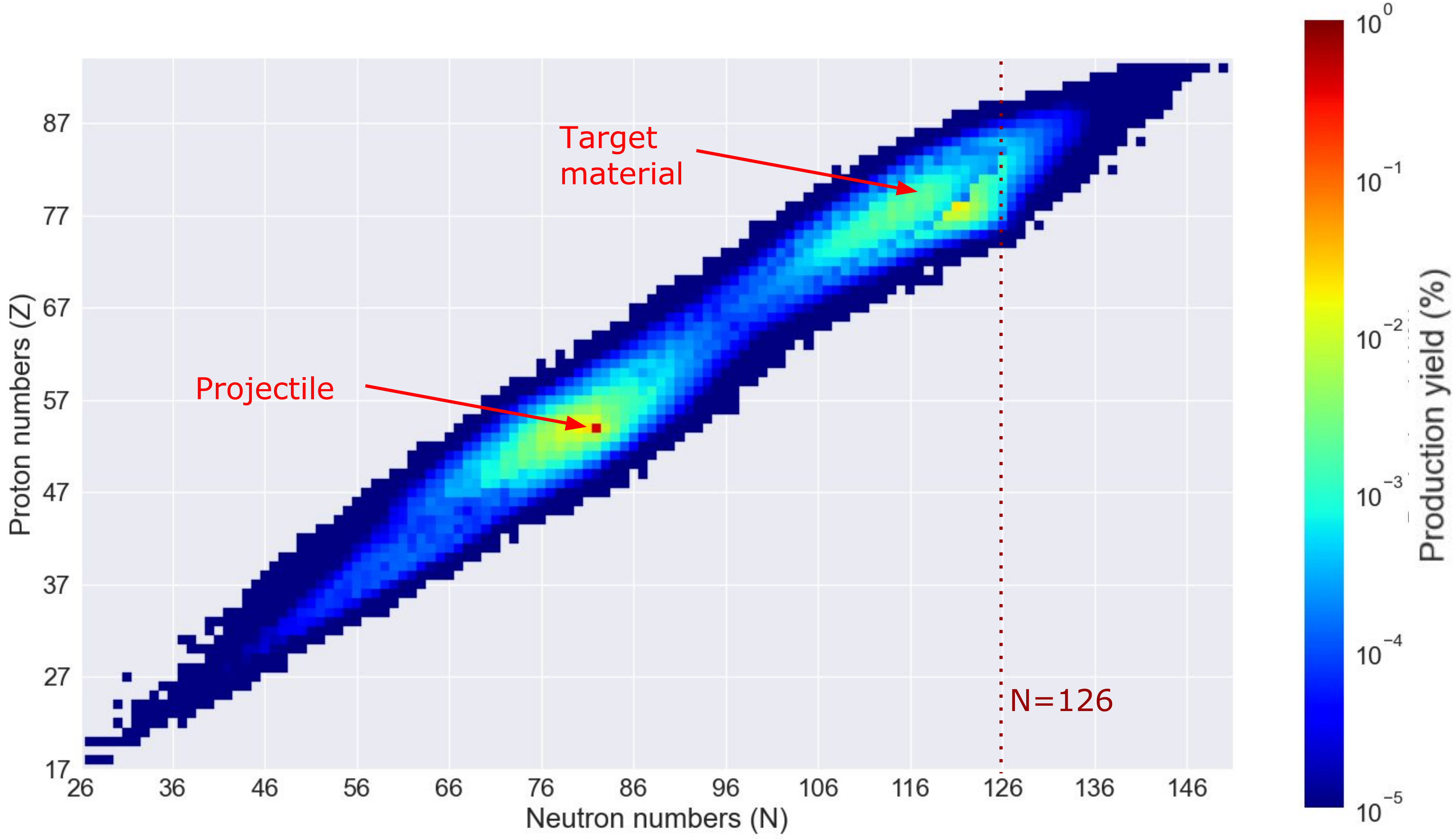




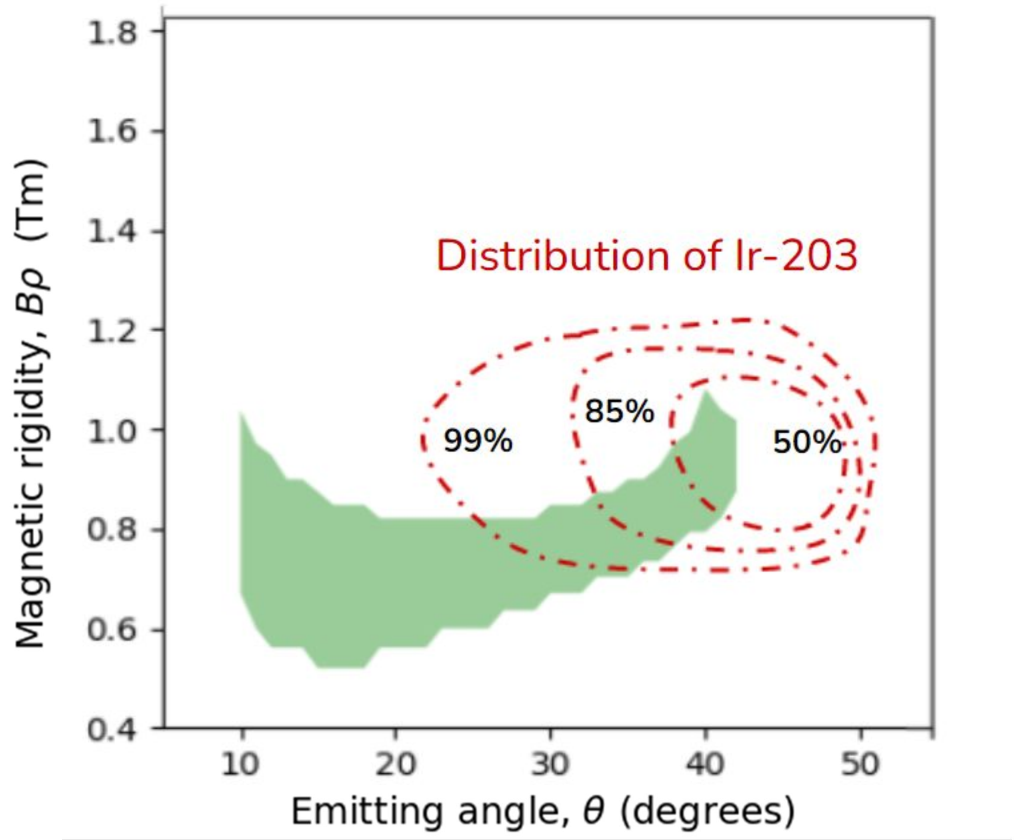


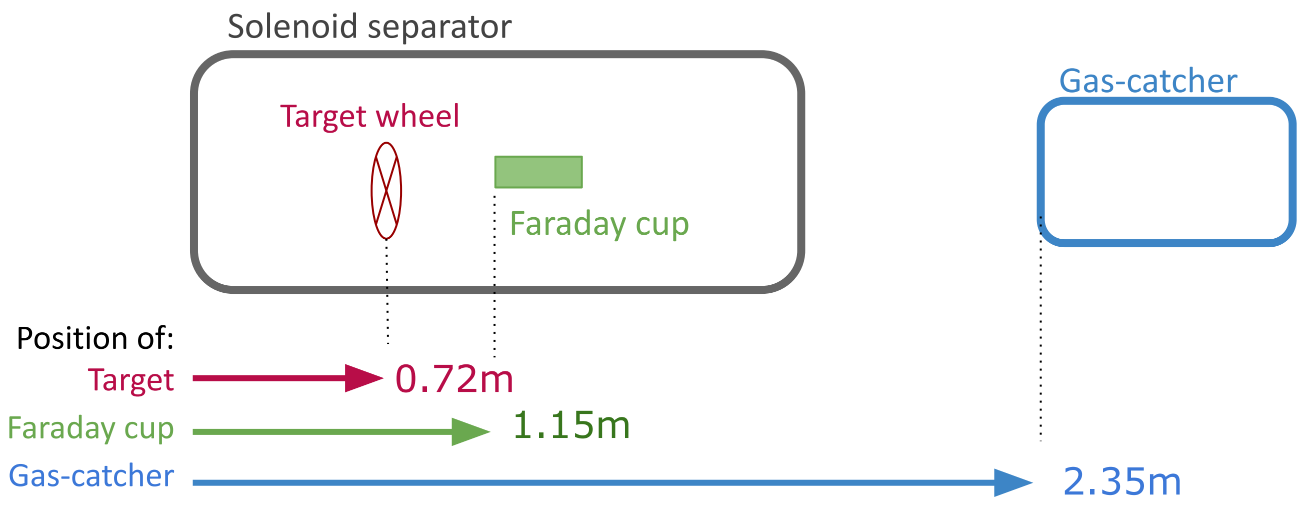


$^{136}Xe+^{198}Pt$ @ 6 MeV/u - Production yield

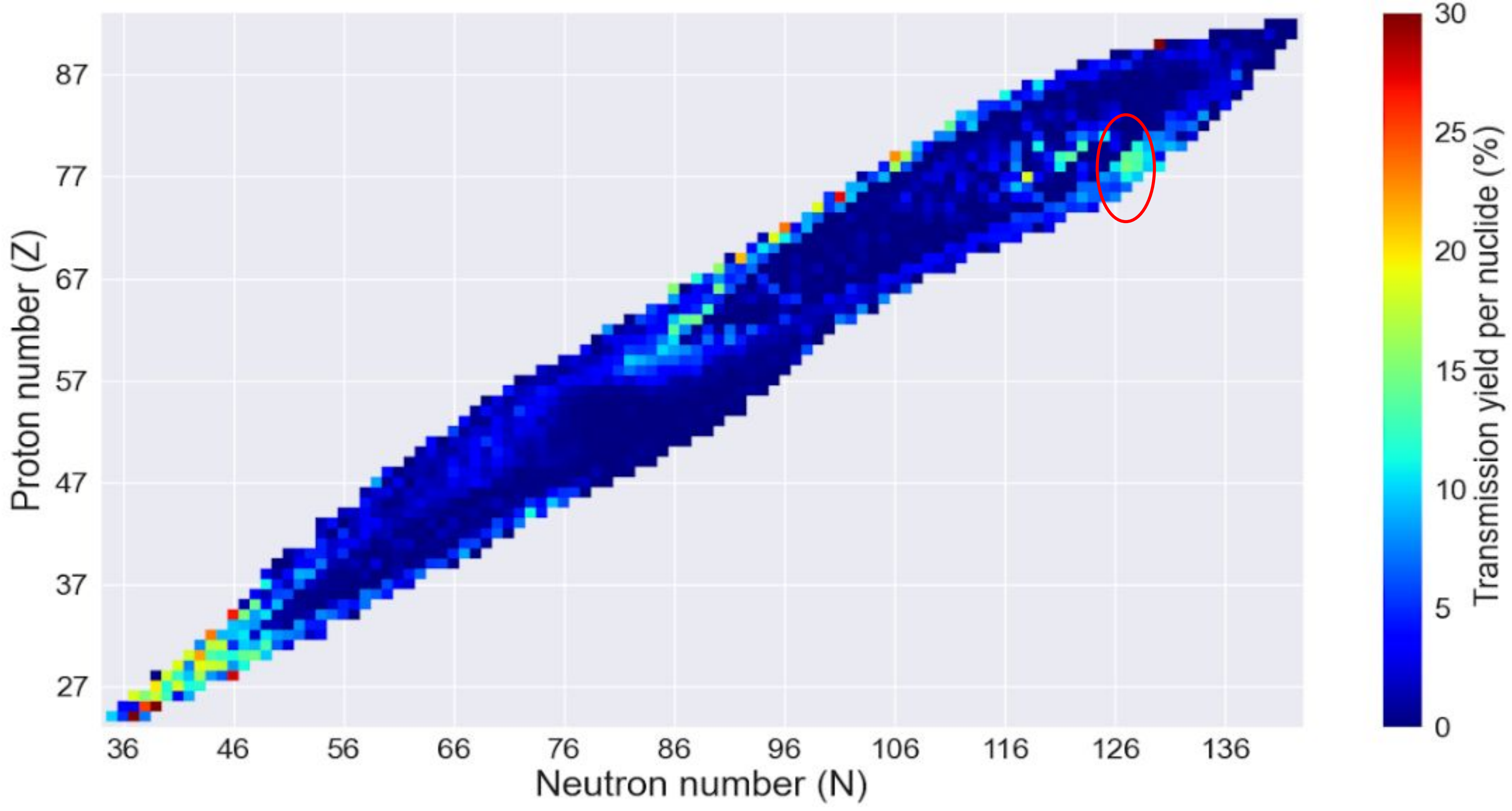


^{136}Xe+^{198}Pt @ 6 MeV/u - Separator setup

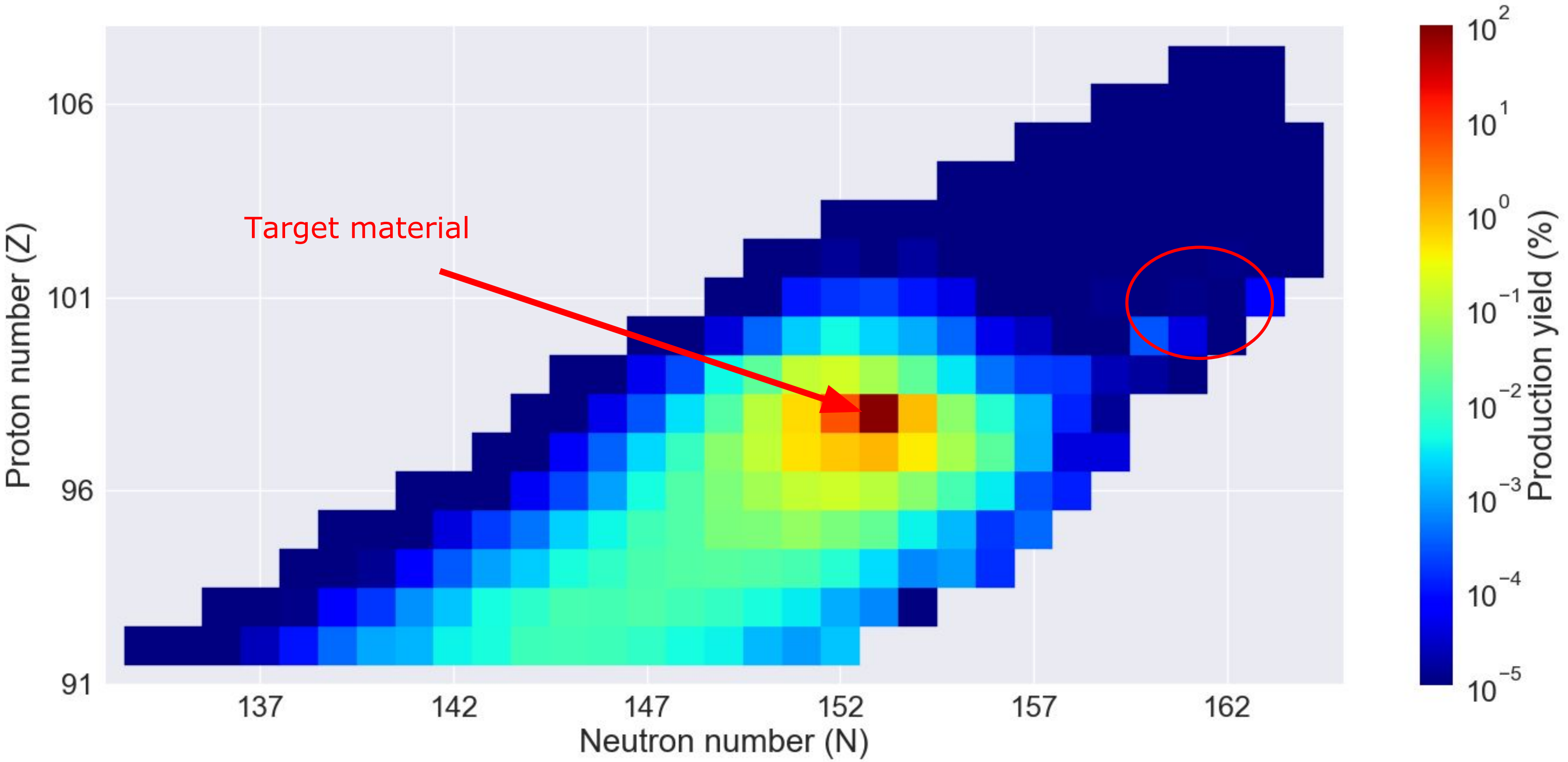




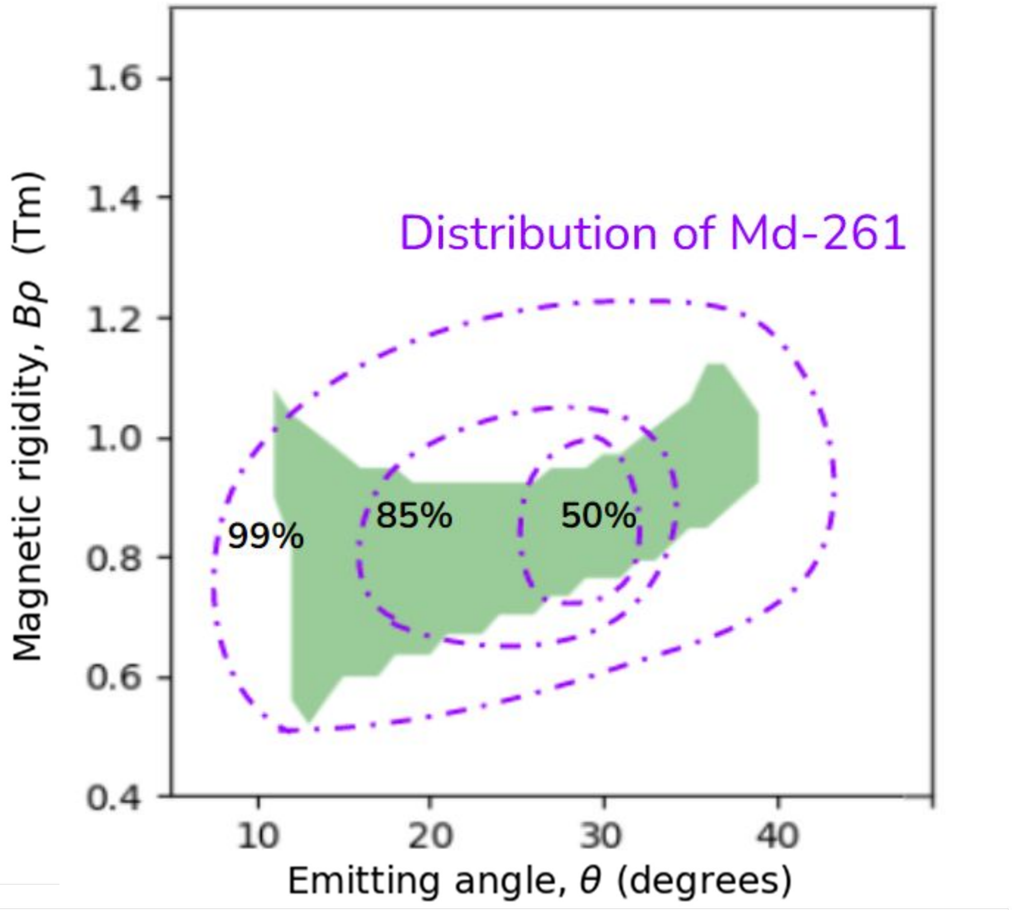
$^{136}Xe+^{198}Pt$ @ 6 MeV/u - Transmission yield

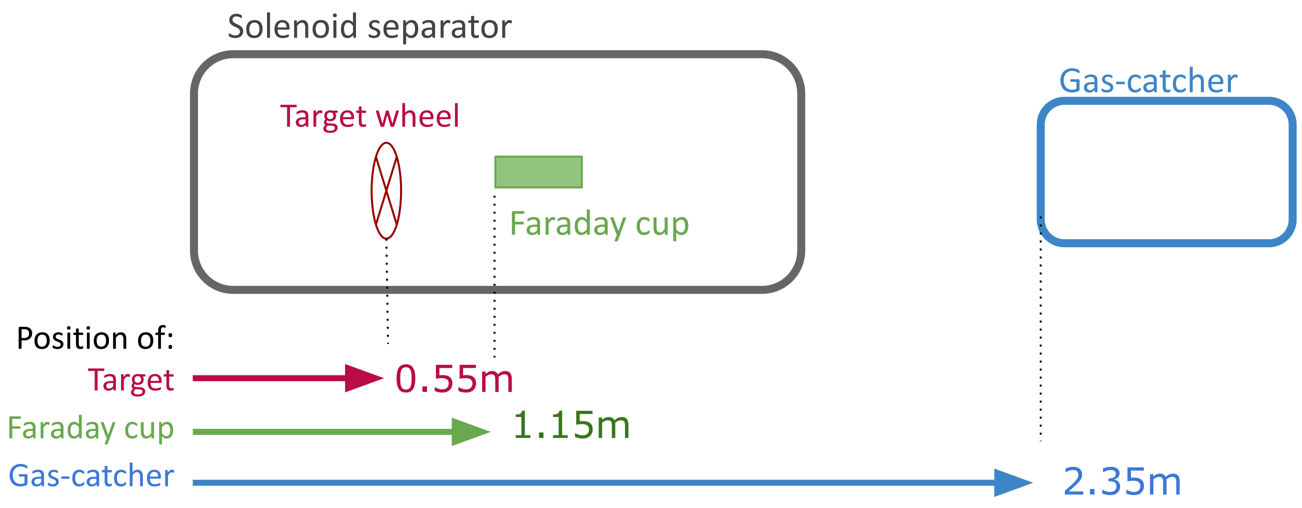


$^{48}Ca+^{251}Cf$ @ 6.1 MeV/u - Production yield



$^{48}Ca+^{251}Cf$ @ 6.1 MeV/u - Separator setup





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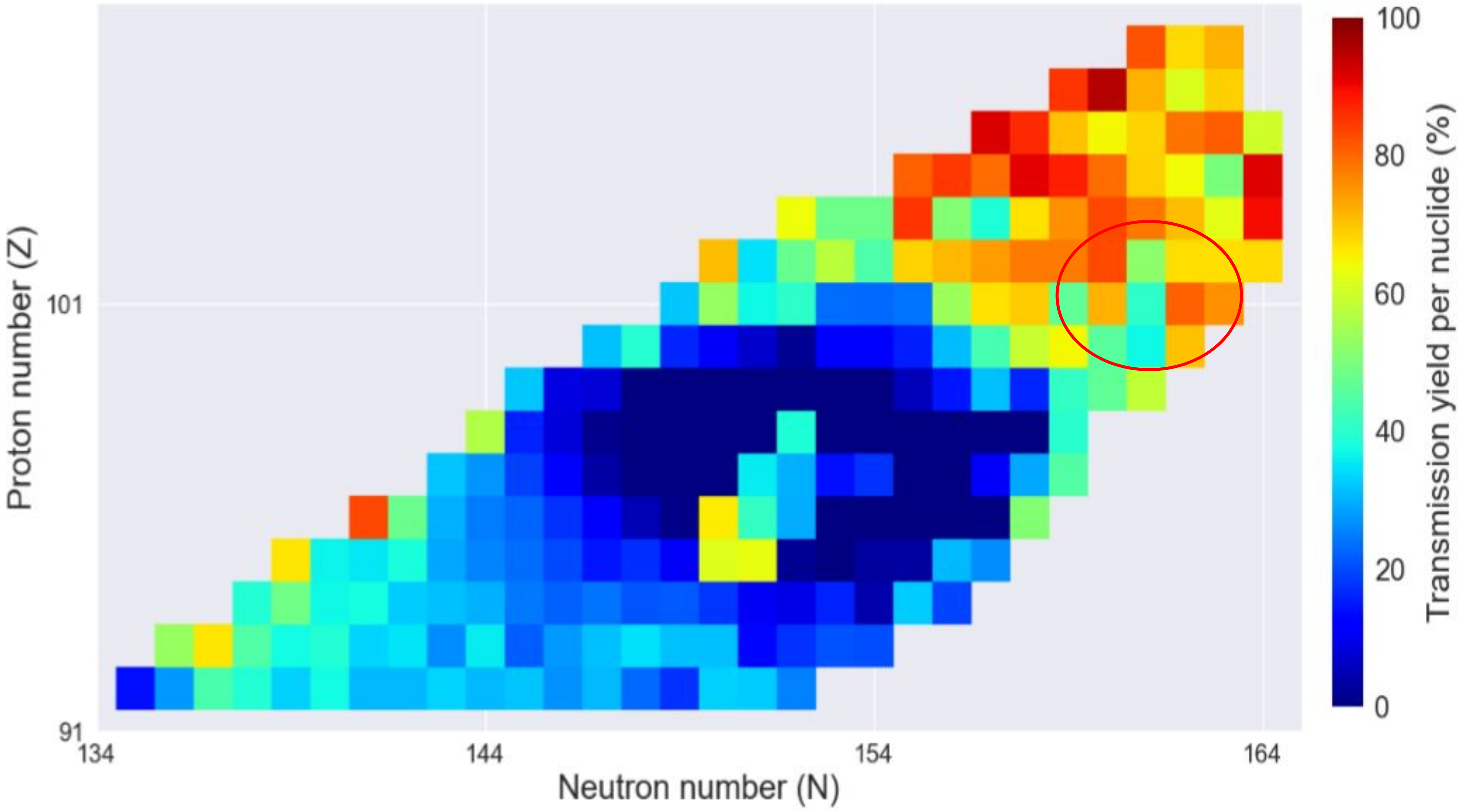


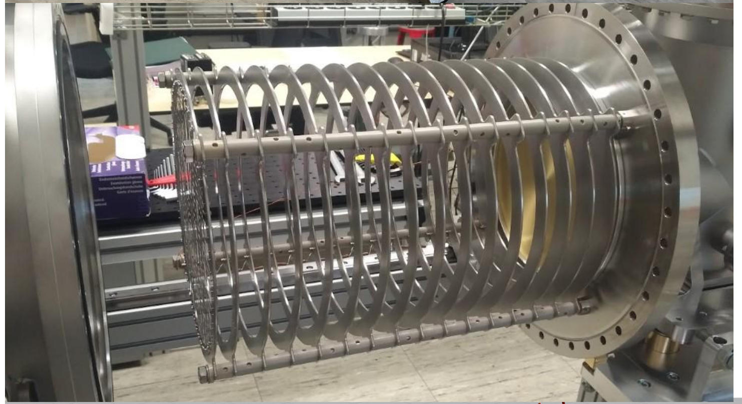
Summary & outlook

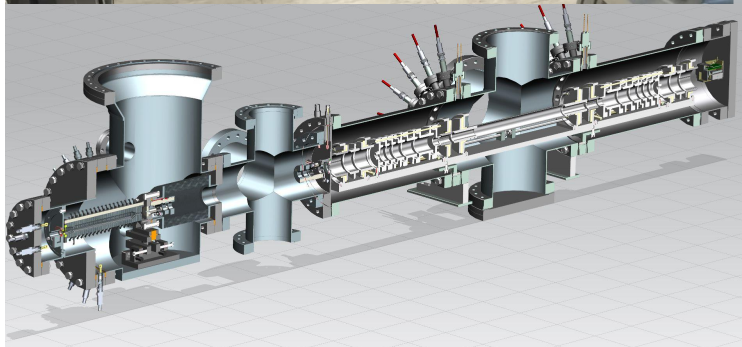
- An ion optical simulation code has been developed to simulate the ion traces through a solenoid magnetic field.

- The solenoid separator has been optimized for:
    - High transmission yield
    - Good background suppression

- The technical design of the solenoid separator will be finalized.

- The solenoid separator will be placed at the AGOR facility.





Acknowledgement

Thanks to…

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Collaborators:

- X. Chen (RUG)
- J. Even (RUG)
- A. Karpov (JINR)
- V. Saiko (JINR)
- J. Sarén (JYU)
- J. Uusitalo (JYU)
- L. v. d. Werff (RUG)
- J. B. Cipagauta Mora (RUG)
- B. D. Hartigan (RUG)
- N. N. Moorrees (RUG/UMCG)

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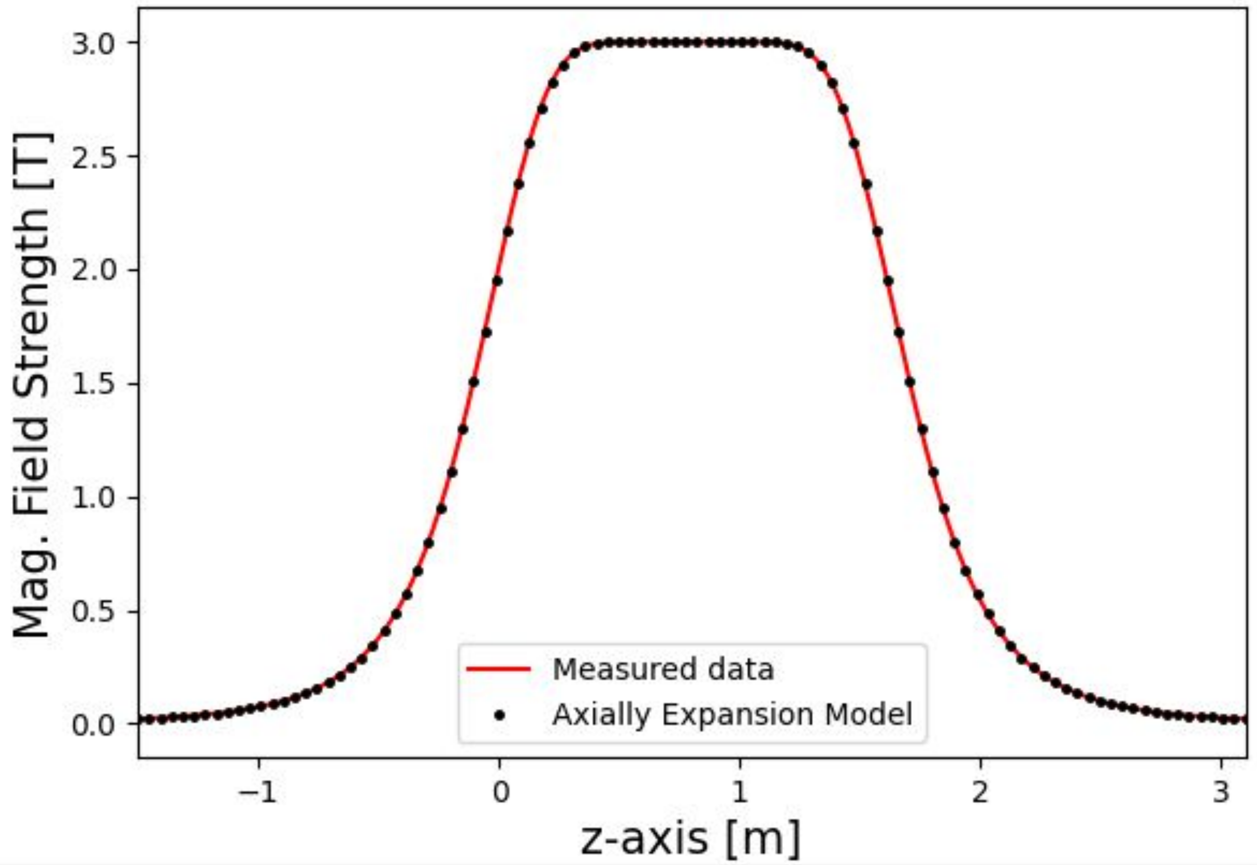
Thanks for your attention!

Extras



3.0
2.5
2.0
1.5
1.0
0.5
0.0
Mag. Field Strength [T]
−1
0
1
2
3
z-axis [m]
Measured data
Axially Expansion Model

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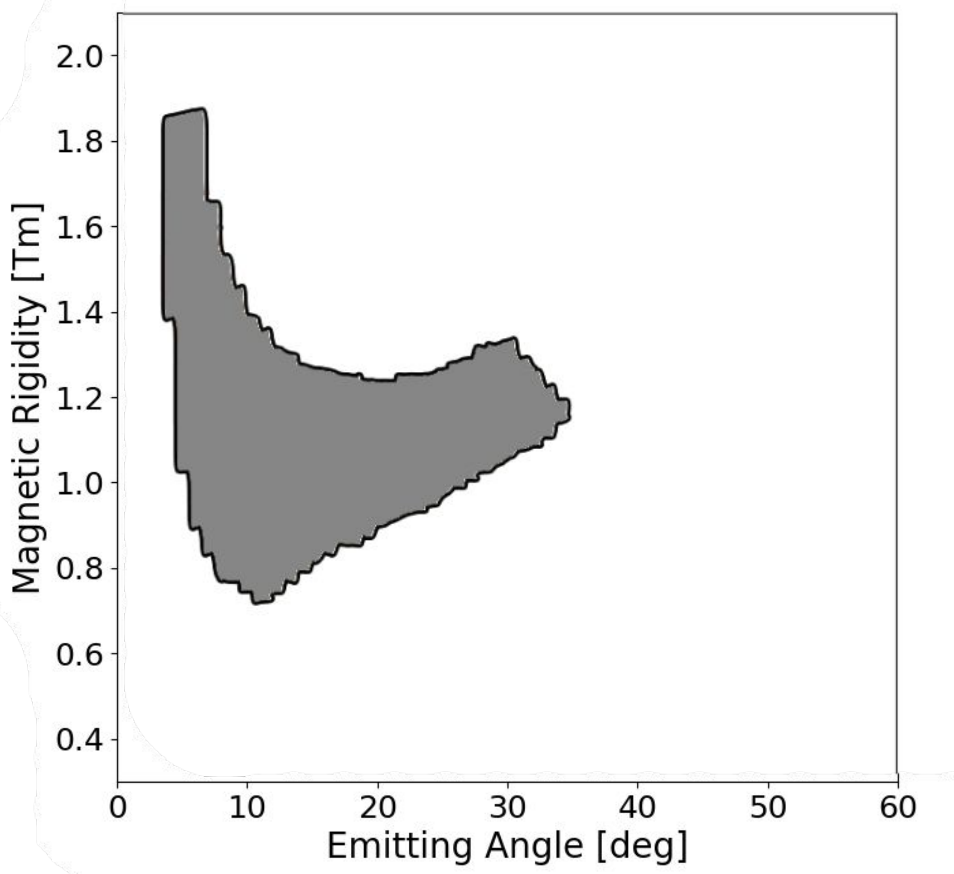

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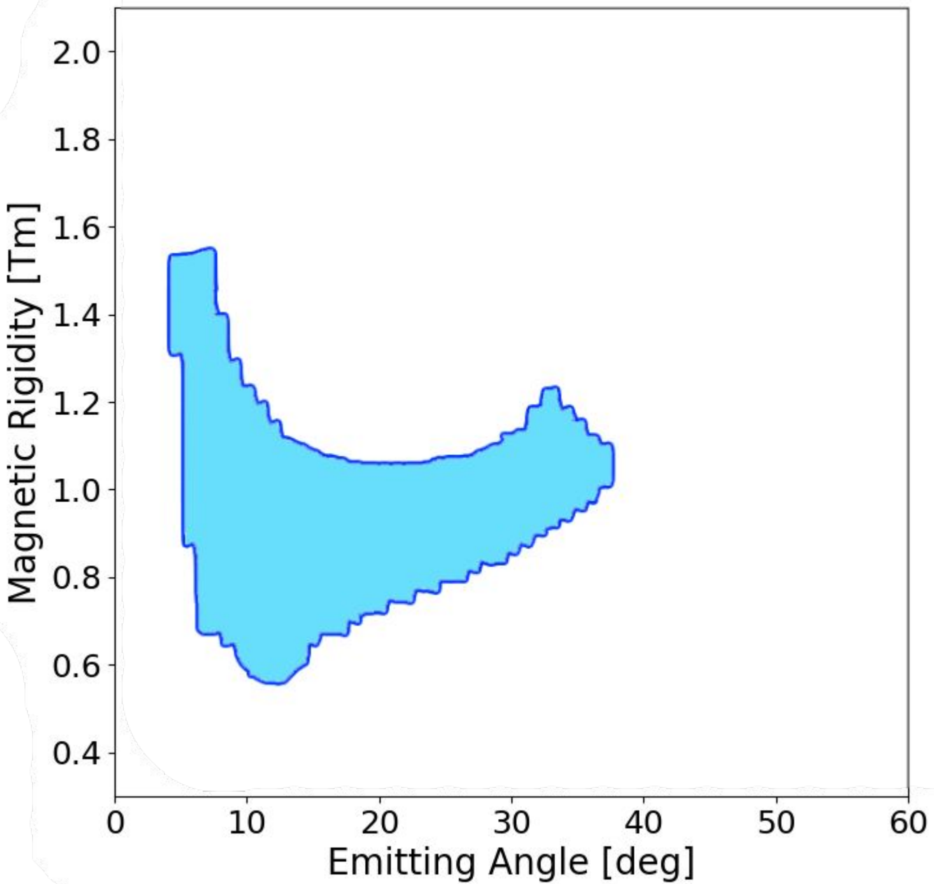

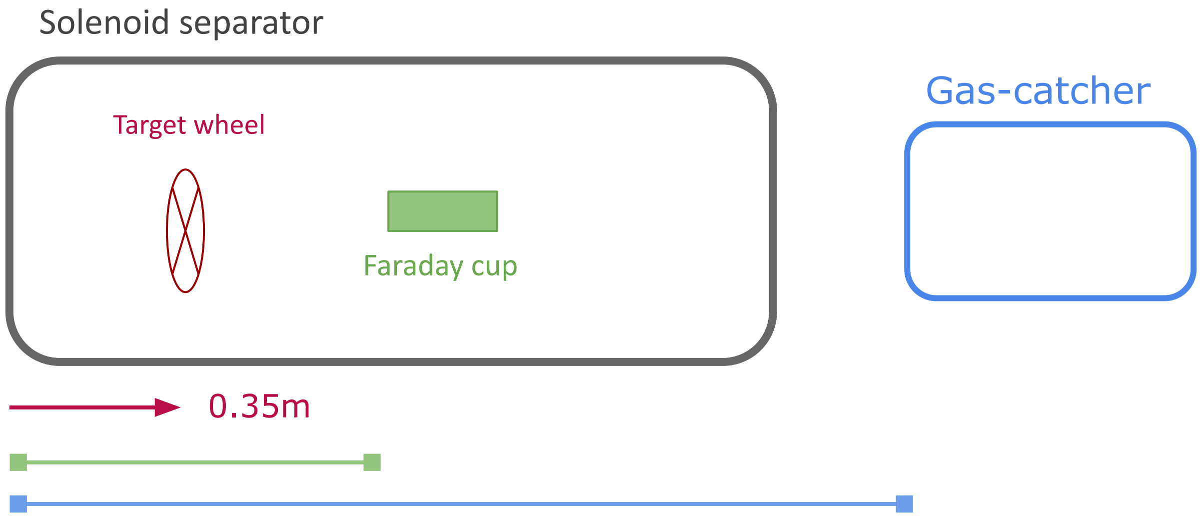

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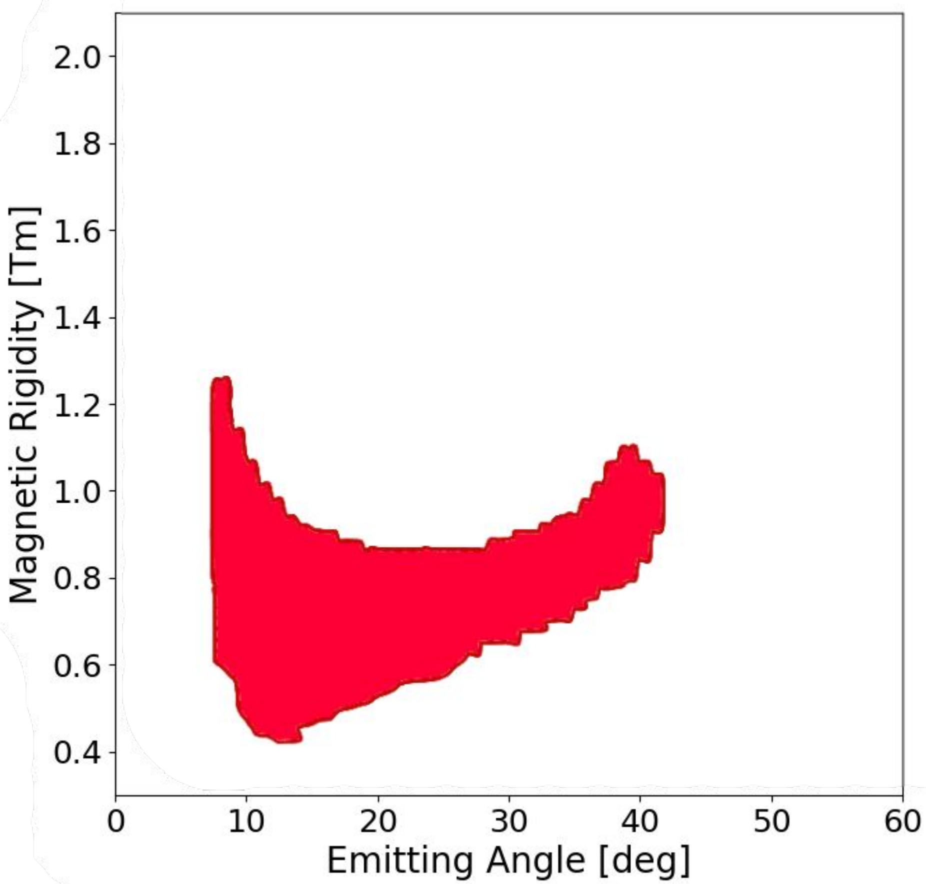

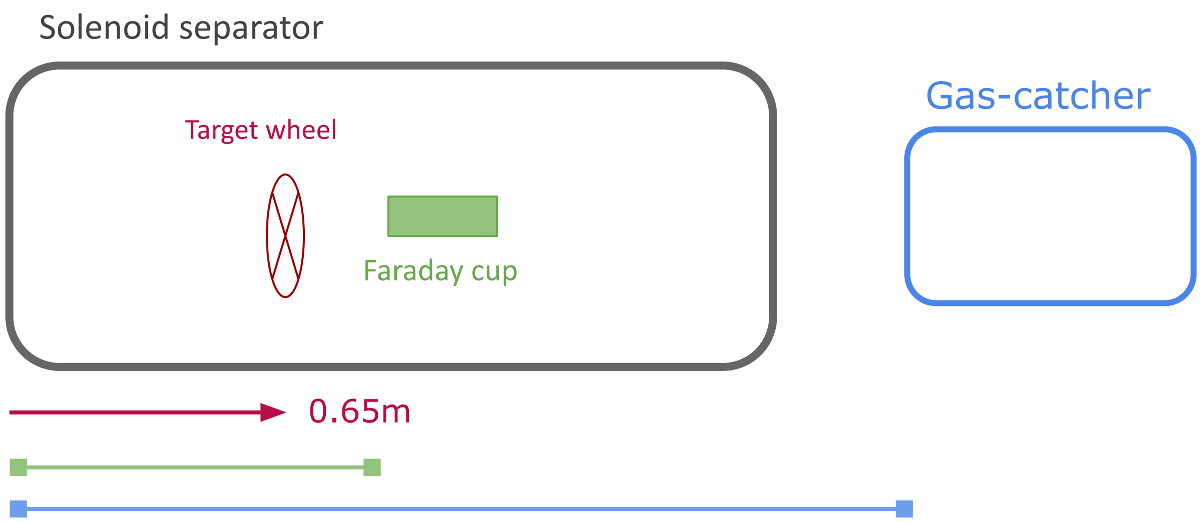

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