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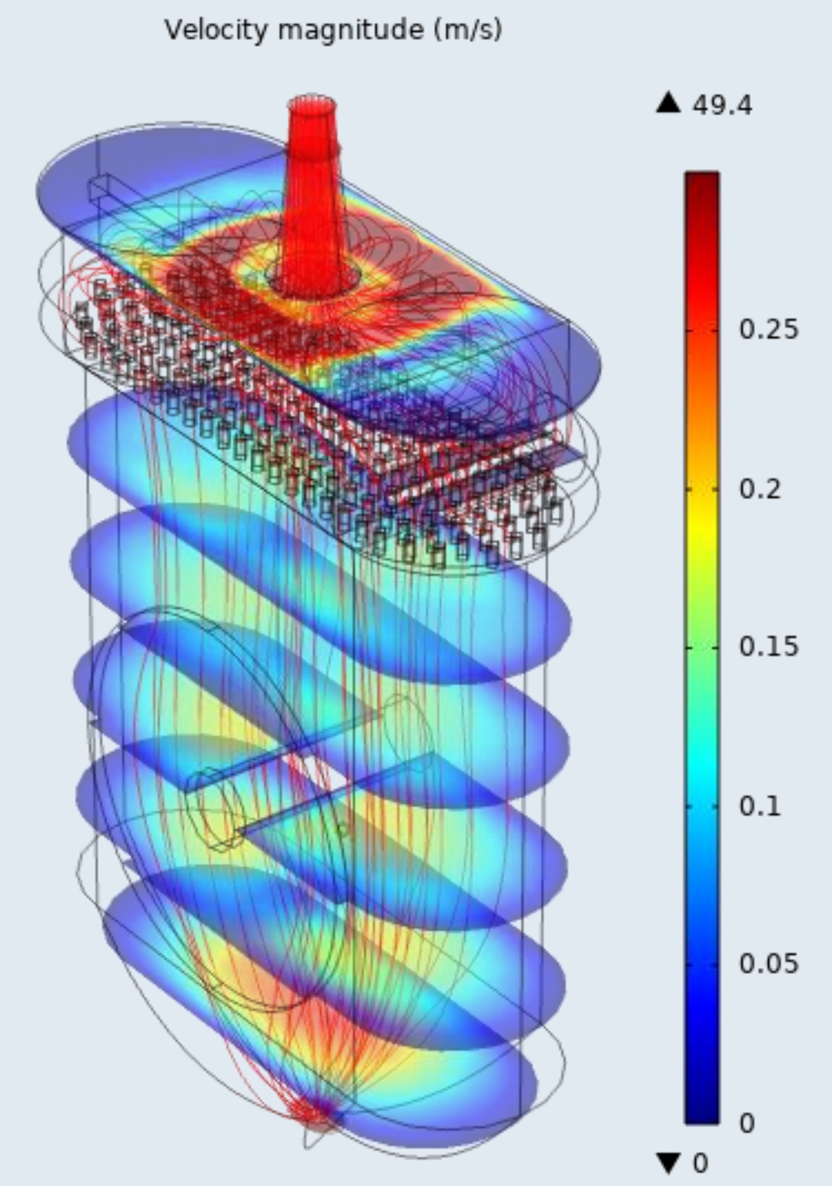

Numerical Calculations of Gas Flows for Nuclear Physics Studies

High efficiency and short evacuation time are essential for studies of exotic nuclei produced in various types of nuclear reactions, as they are often produced in small quantities (< few counts per second) and have short half-lives (< 1 second).

This work presents results of optimization of subsonic helium and argon gas flows using the CFD Module of COMSOL® and comparison of numerical calculations with measurements.

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Introduction & Goals

One of the commonly used approaches to stop and thermalize nuclear reaction products is to use gas cells filled with high-purity noble gases, such as helium or argon. Studying the properties of nuclei produced in various types of nuclear reactions is challenged by small production yields and short half-lives of isotopes of interest, therefore making **high efficiency and fast timing essential parameters** of the experimental setups.

At the Ion Guide Isotope Separator On-Line (IGISOL) facility [1] in the JYFL Accelerator Laboratory, a number of ongoing projects involve usage of various gas cells for stopping, thermalization and transportation of nuclear reaction products by subsonic gas flow. Mass Analysing Recoil Apparatus Low-Energy Branch (MARA-LEB) and Multinucleon-transfer(MNT) reaction studies and are amongst these projects, both of which are using **gas cells designed using CFD Module** of COMSOL Multiphysics®.

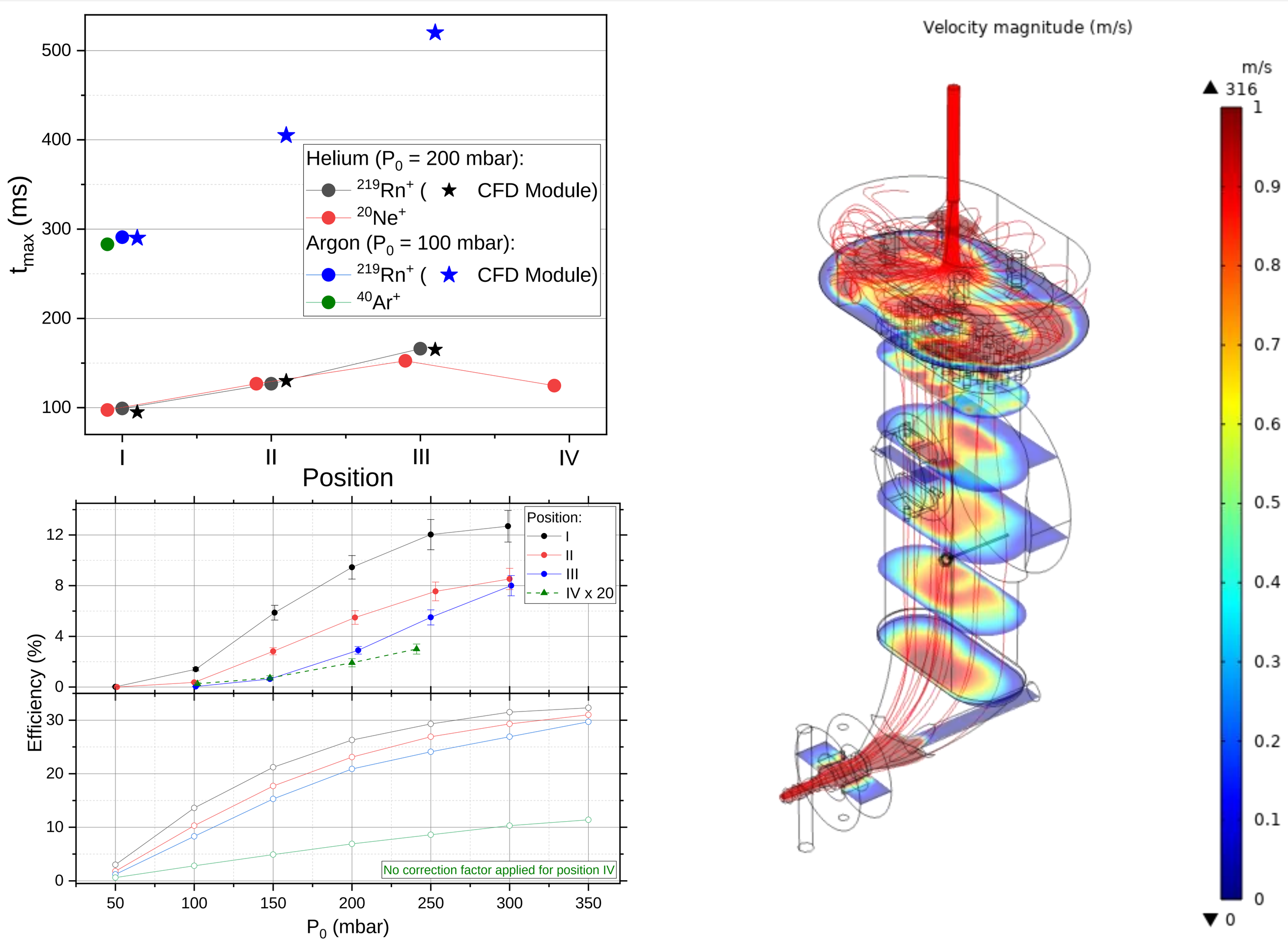

FIGURE 1. Comparison of numerical calculations and measurements for evacuation time and efficiency of MARA-LEB gas cell [2].

Methodology

Subsonic helium and argon gas flows inside gas cells were modeled at room temperature, in 3D. Geometry of gas cells was optimized to produce uniform gas flow, which is critical for high efficiency and fast timing.

The Laminar Flow and Transport of Diluted Species physics interfaces were used for the cases of stationary and time dependent studies.

Numerical calculations for efficiency and evacuation time were then compared to measurements with ^{223}Ra α-recoil source placed at various positions inside the newly commissioned gas cells (see Fig. 1 for results with MARA-LEB gas cell).

Results

The gas cells were designed using CFD Module of COMSOL, commissioned and characterized at the IGISOL facility. For both gas cells, MARA-LEB and MNT, the evacuation time and efficiency were measured and compared to numerical calculations performed in the CFD Module. Good agreement between measurements and simulations was found for evacuation time. However, there is some discrepancy between simulations and measurements for efficiency, the reason is under investigation and is possibly due to presence of additional loss mechanisms and/or caused by the measurement technique.

The first beamtime with the new MNT gas cell was successfully performed, and showed an increase of the measured count rates compared to our earlier results [3] by a factor of 3 (Fig. 2).

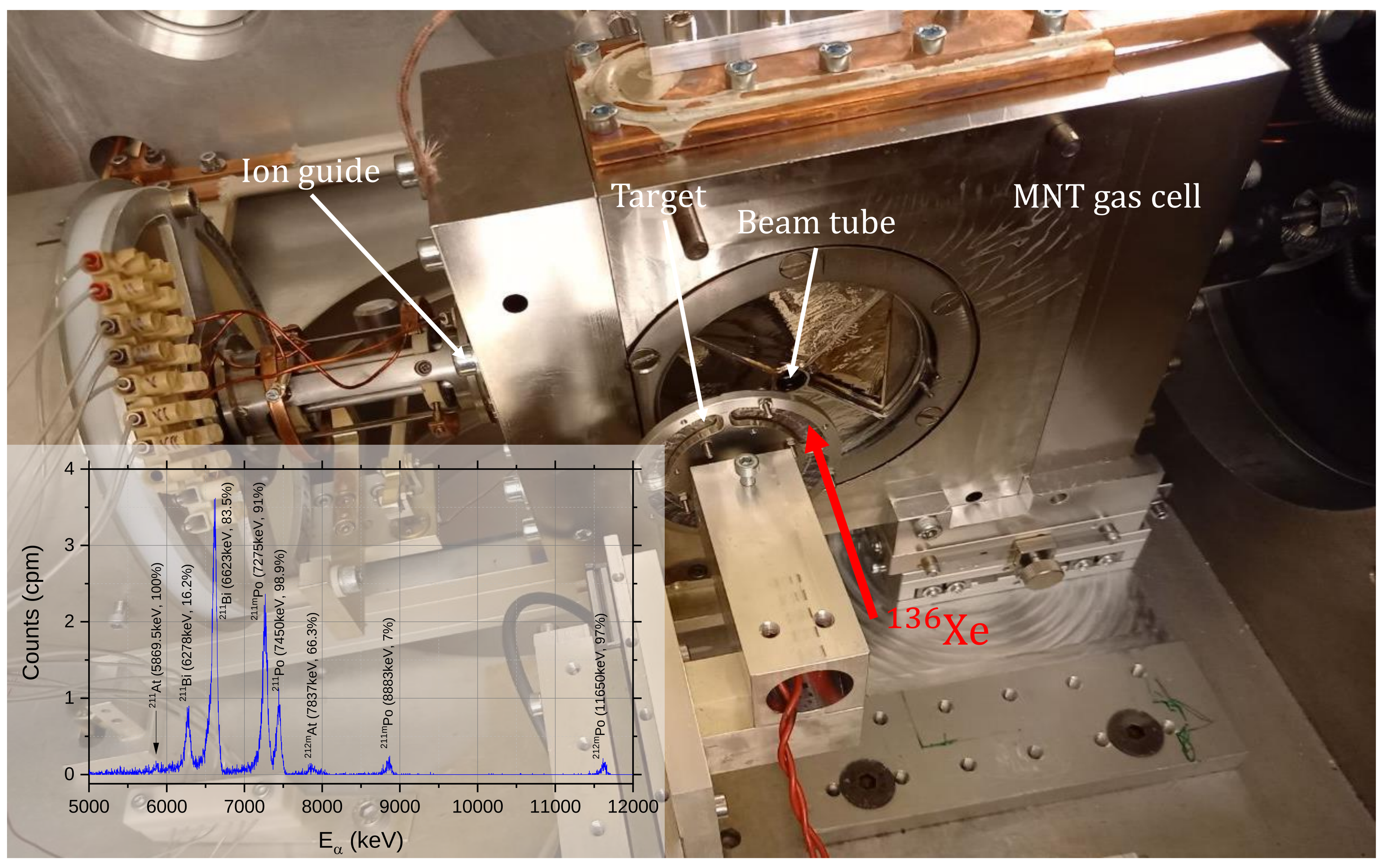

FIGURE 2. Beamtime with MNT gas cell using accelerated ^{136}Xe beam and ^{209}Bi target. Measured alpha spectrum is shown in the inset.

REFERENCES

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[2] A. Zadvornaya et al., Offline commissioning of a new gas cell for the MARA Low-Energy Branch, NIM B, 539 (2023) 33-42
[3] A. Spataru et al., Production of Exotic Nuclei via MNT Reactions Using Gas Cells, Acta Phys. Polon. B 51 (2020) 81

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