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Development of a new large gas cell with electric field guidance for IGISOL (Task 1.1.2.)

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Description of the work:

The JYU will improve the quality of the neutron induced fission product collection at IGISOL by the design of a new gas cell with electric field guidance. This new device will allow better efficiency which is expected to be of the order of 100 compared to what exist today. This improvement will benefit greatly for the fission products studies.

What has been done:

- The capability of the means of faster ion extraction studied utilising simulations
- The site specific constraint at IGISOL (space, radiation, high voltage) surveyed
- Suitable means for IGISOL adopted
- Detailed technical drawings will be produced

- D.1.2 “Report on the design of the large gas cell for IGISOL”, due M24 – delayed, delivered 1.11.2023, M51

- Gao, Z., et al., (2023). "New design and simulation of the ion guide for neutron-induced fission products at the IGISOL facility", proceedings of the 15th International Conference on Nuclear Data for Science and Technology (ND2022), 21-29 July 2022, online. EPJ Web of Conferences, 284, Article ID 04011.

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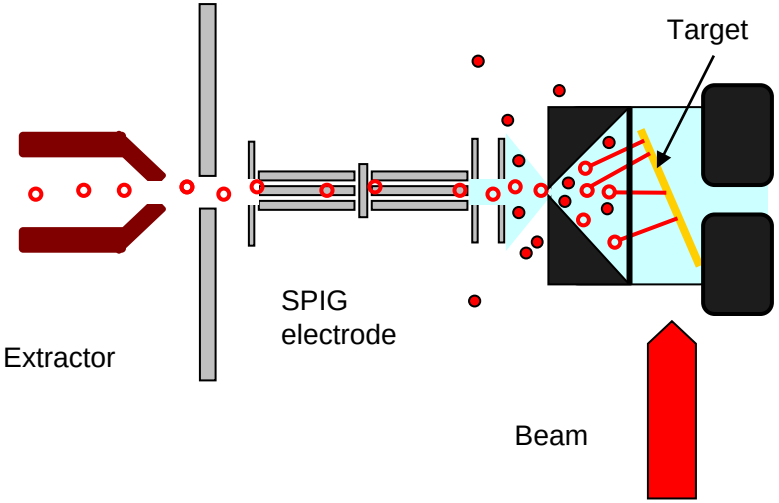
In the ion guide technique, reaction products are stopped in helium as ions and transported as ions to further analysis.

At the IGISOL the ions are transported with the gas flow alone. This limits the size of gas cell: bigger gas cell is not better, since the ion survival time is limited.

Stopping efficiency for the **fission products** in the current fission ion guide is ≈ 0.75 %, and their mean extraction time is ≈ 100 ms.

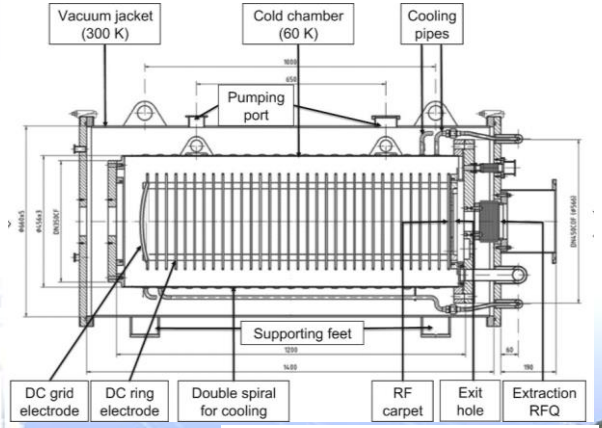
Needed:

higher stopping efficiency
faster extraction.



Possible solution: large stopping gas cell with **electric field guidance**

GSI cryogenic gas cell



NIMA 770 (2015) 87

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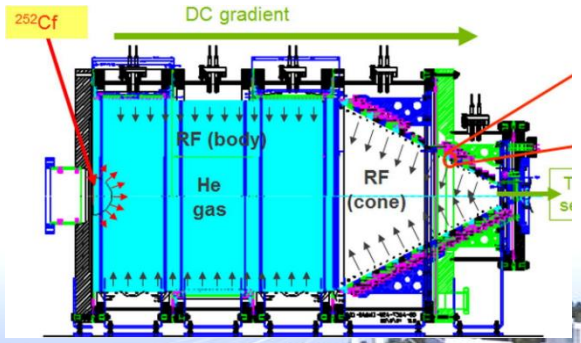
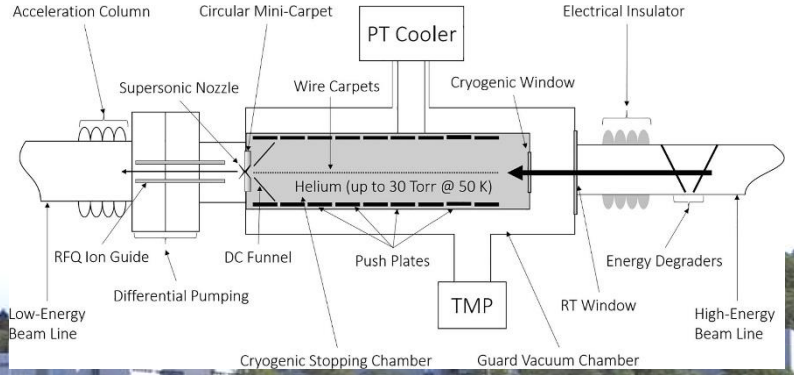


NIMB 376, (2016) 246

ACGS (Advanced Cryogenic Gas Stopper) at NSCL



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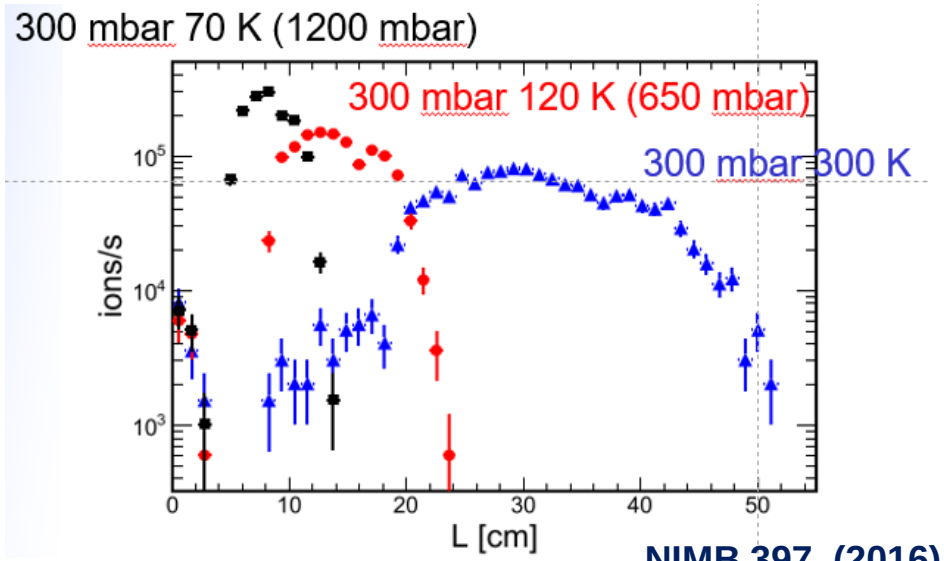
Cryogenity? …eventually, no.

- **Benefit**:
- higher gas density, **so better stopping efficiency**
- Freesing of impurities
- Operation of RF carpets easier in lower pressure

- **Challenge**:
- Technically complicated, space consuming
- Combining with neutron production target (heat and cryo dont mix well)
- Denser space charge

- **It is not only stopping, extraction matters as well:**
- Ion mobility $\propto T$, while density $\propto 1/T$ so extraction time



NIMB 397, (2016) 1

Table 3. The fraction of fission products stopped in U targets and in the Helium gas.

	V1	V2	V3	V4
	293 K, 400 mbar Ø = 6 cm, l = 7 cm	280 K, 400 mbar Ø = 25 cm, l = 40 cm	80 K, 400 mbar Ø = 25 cm, l = 40 cm	80 K, 115 mbar Ø = 25 cm, l = 40 cm
Uranium targets	70%	72%	72%	72%
Helium gas	0.87%	9%	12%	9%

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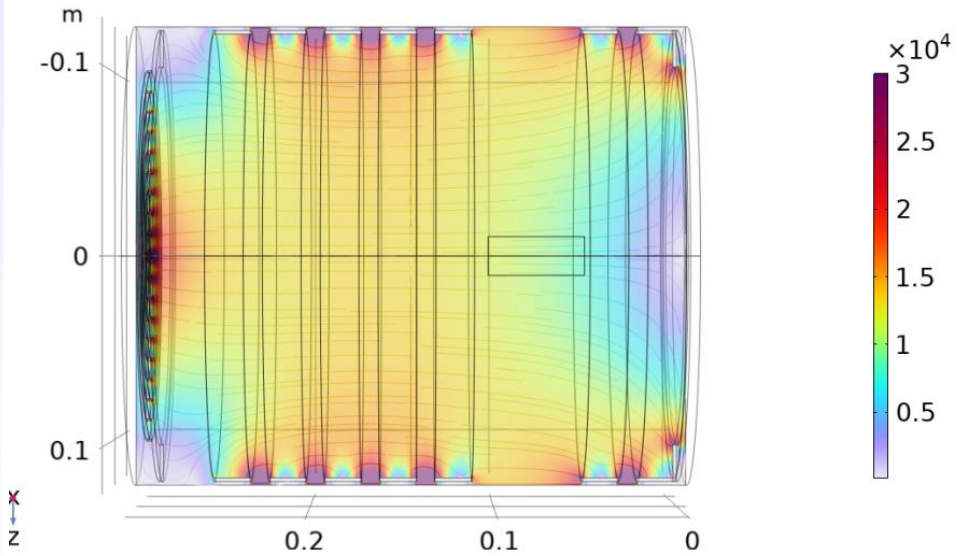

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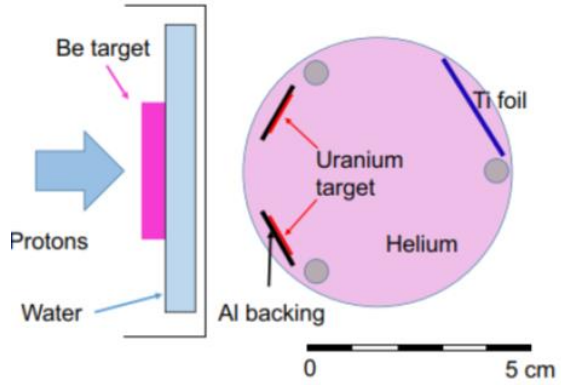
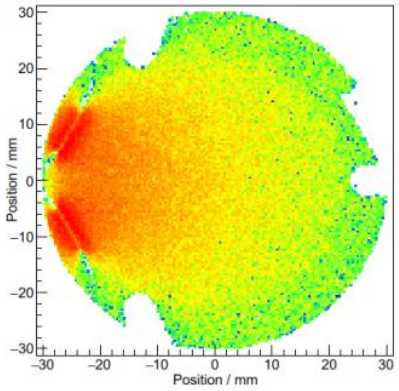
Electric field simulations:

- 25 by 30-40 cm cylinder ring electrodes to generate DC field;
- RF-carpet on the end of the cylinder; RF-field about 6 MHz; 10 concentrig rings to enhance the electric field towards the exit nozzle
- here n-induced fission similar as performed with modified current fission ion guide (see below).





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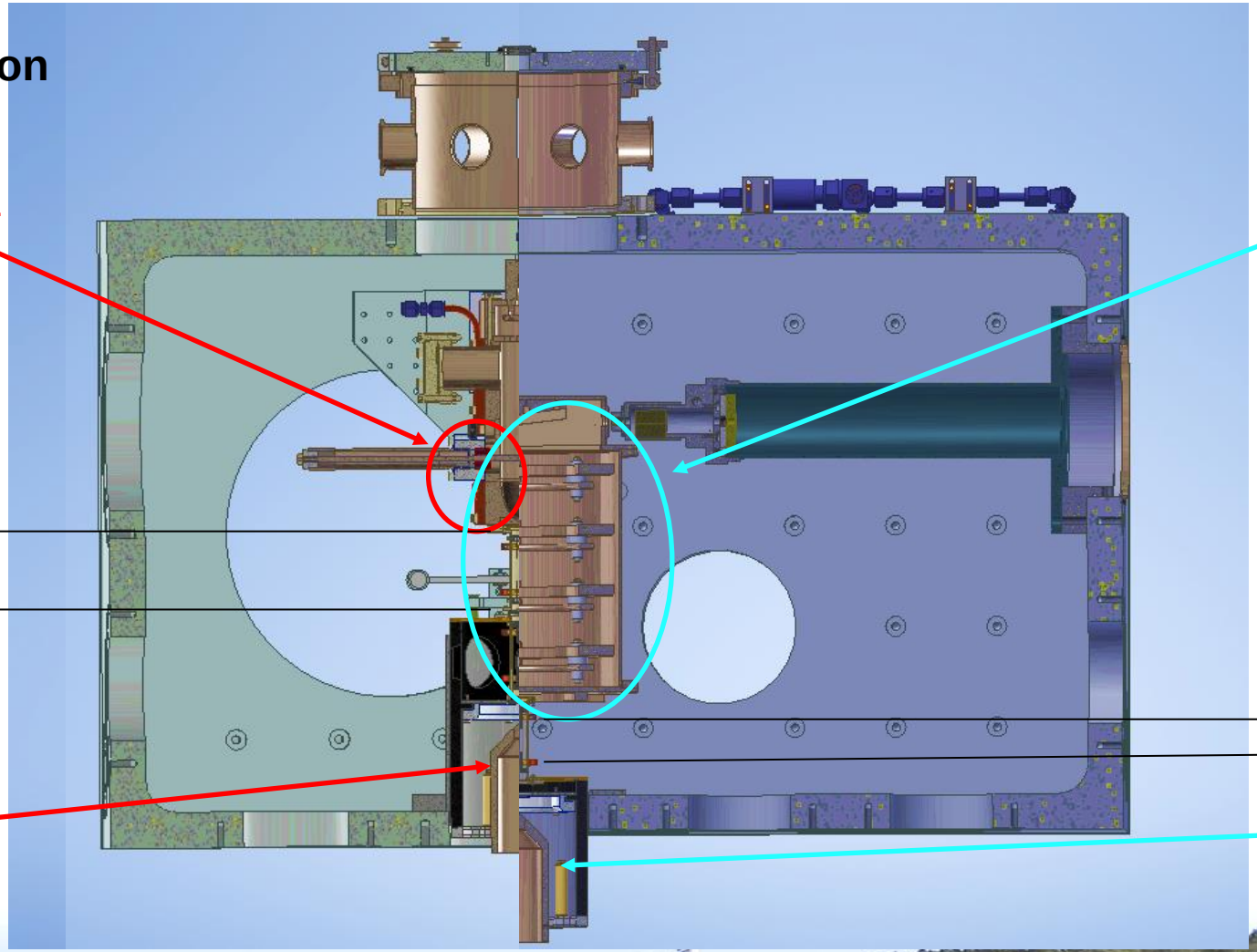
Proton induced fission



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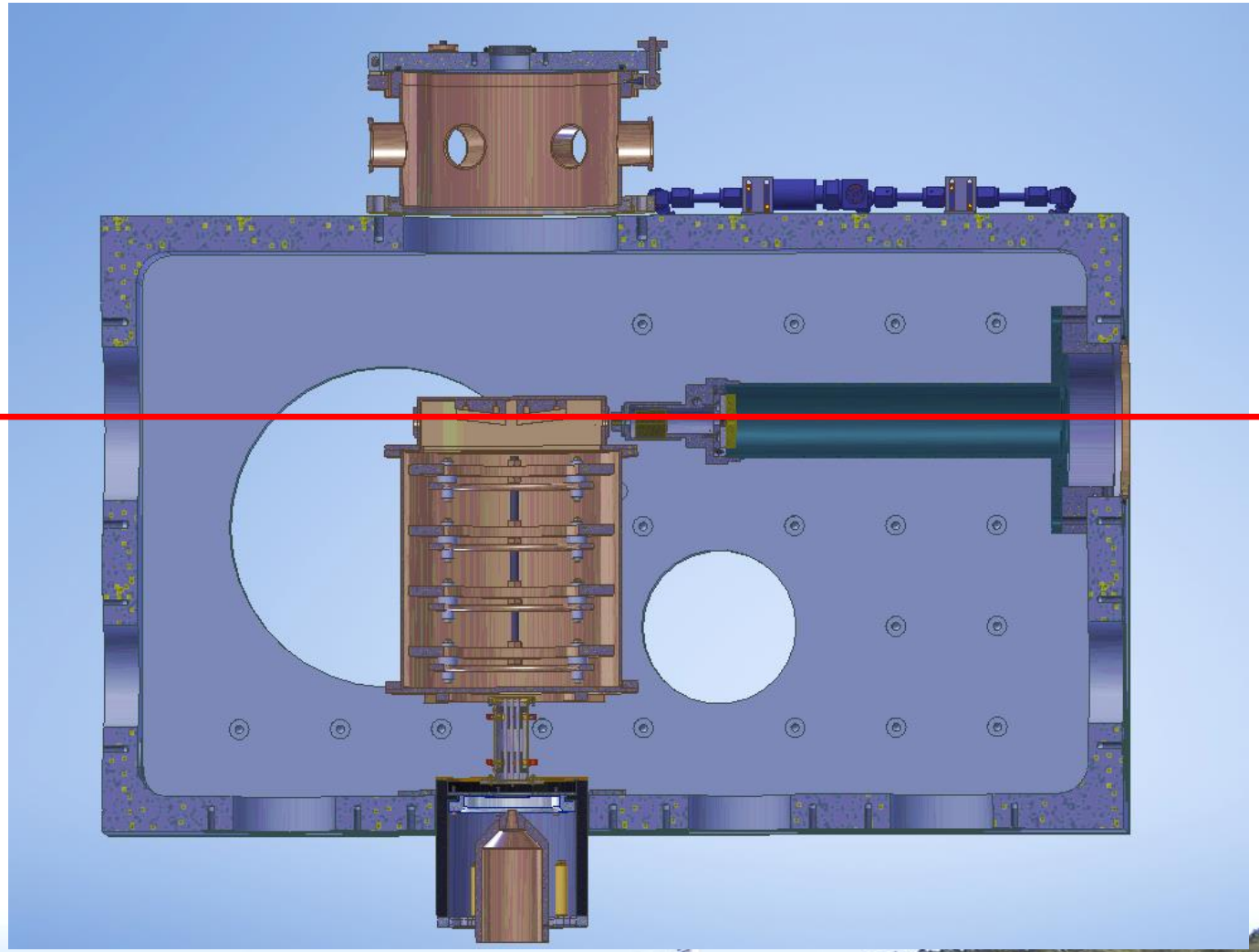

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