Reconditioning of the Leuven Isotope Separator as a test bench for radioactive ion beam development

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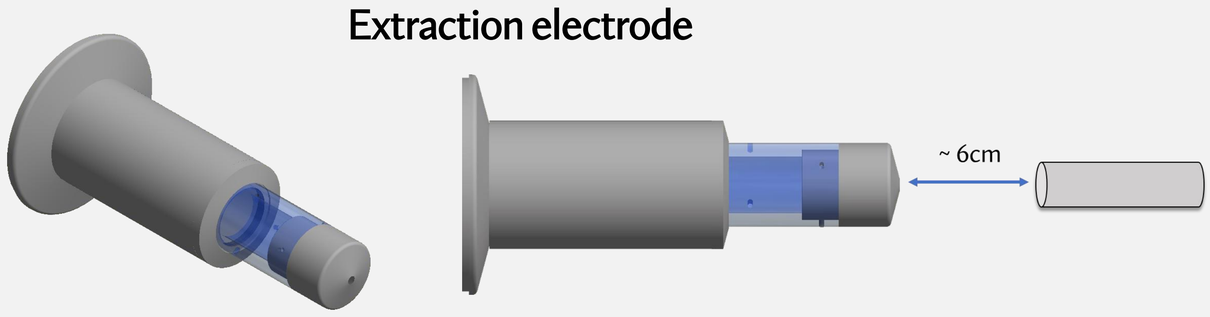
ABSTRACT

Radionuclides have already revolutionised the field of nuclear medicine. Some of the novel radionuclides can only be produced using the Isotope Separation Online technique (ISOL) combined with mass separation to obtain the required purity [1]. In order to optimize the production of novel radionuclides, it is key to understand the ion sources used. They need to operate not only with high efficiencies but should also be able to handle high throughputs required for medical samples. At KU Leuven, we are working on refurbishing the Leuven Isotope Separator (LIS), previously used for Mössbauer spectroscopy [2]. In the past couple of years, the machine has undergone significant updates and has been adapted to integrate the target ion source units used the radioactive ion beam facilities ISOLDE [3] and MEDICIS at CERN [1].

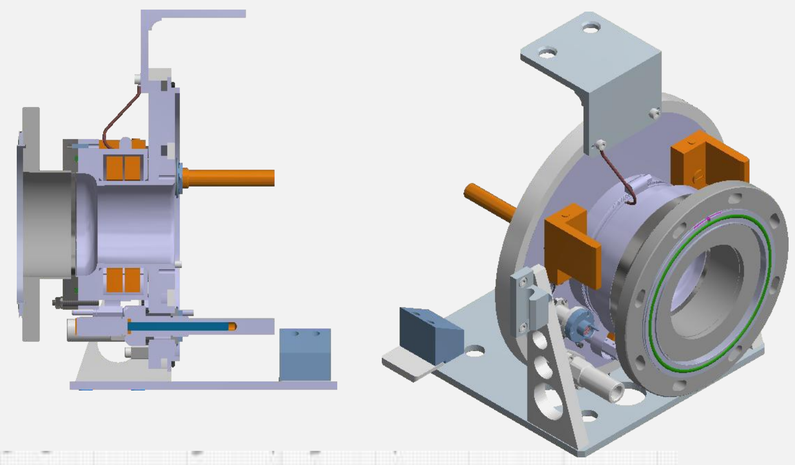
FRONT END UPDATES

Extraction electrode

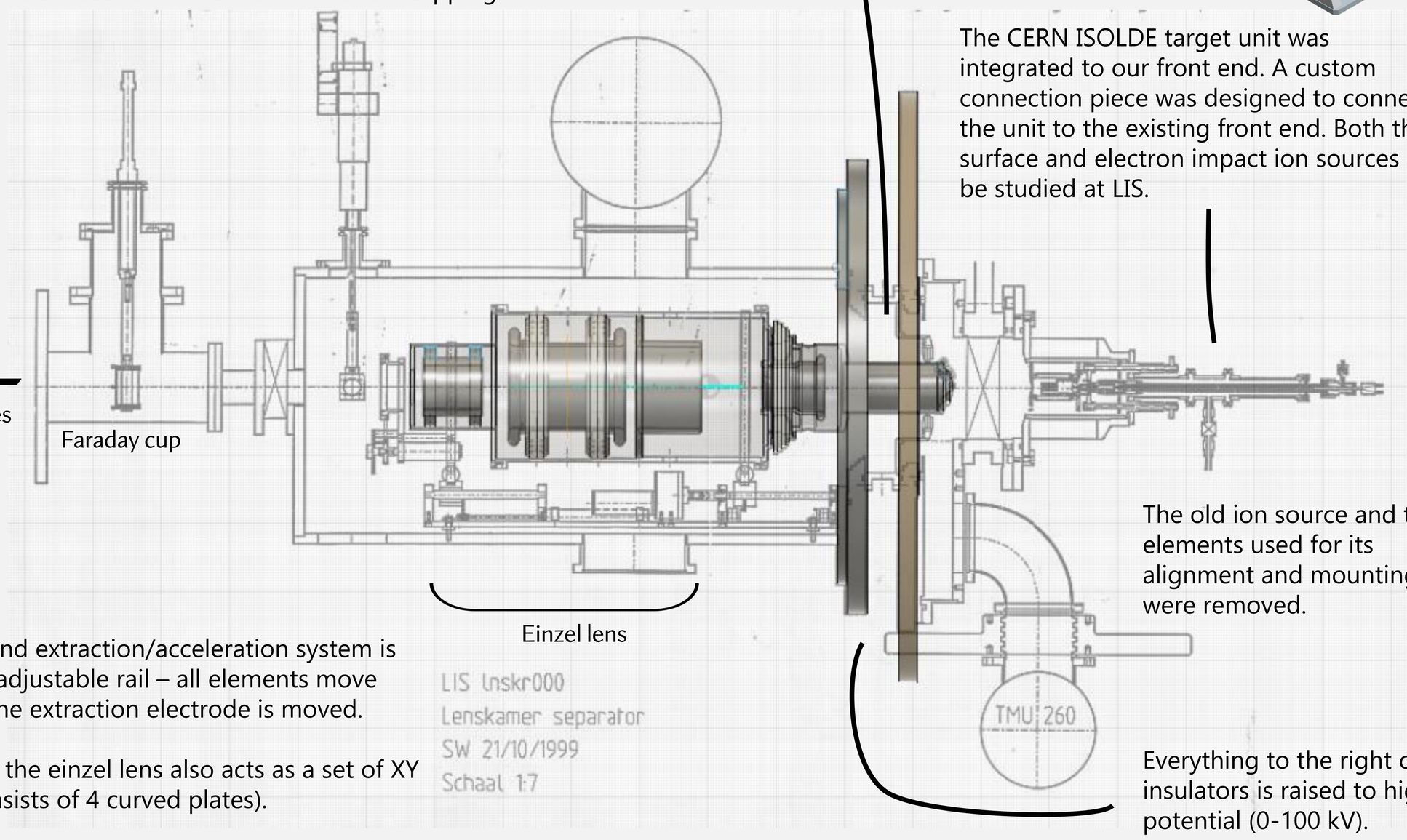


The shape of the extraction electrode was adapted to find a compromise between the original design and the shape of the electrode tip used at ISOLDE. The elongated shape allows for the distance between the extraction and source apertures to be the optimal 6cm. The wider second cone ensures no beam clipping.

Ion source unit



The CERN ISOLDE target unit was integrated to our front end. A custom connection piece was designed to connect the unit to the existing front end. Both the surface and electron impact ion sources can be studied at LIS.



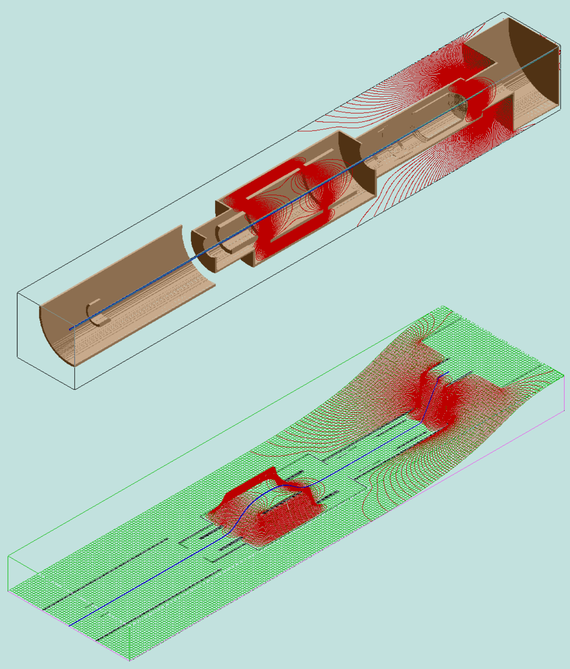
The old ion source and the elements used for its alignment and mounting were removed.

The einzel lens and extraction/acceleration system is mounted on an adjustable rail – all elements move together when the extraction electrode is moved.

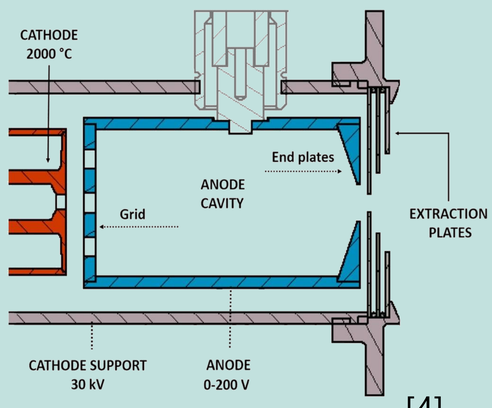
The third part of the einzel lens also acts as a set of XY deflectors (it consists of 4 curved plates).

Everything to the right of the insulators is raised to high potential (0-100 kV).

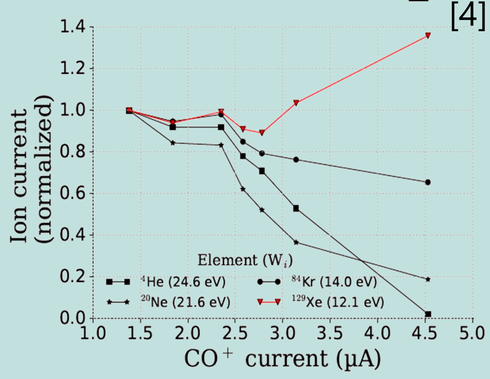
SIMULATIONS



SIMION simulations were performed in order to obtain initial parameters needed to get the beam through the machine. The source was built and tested at CERN, and the parameters used at the ISOLDE OFFLINE 1 separator were then used as the starting point of the simulations. The whole system was built using geometry (.GEM) files so that any possible misalignments can be investigated, and any modifications can be implemented easily.



[4]



OUTLOOK

In the future the machine is planned to be used for radioactive ion beam development. Particularly, systematic studies on the FEBIAD ion source developed at CERN are planned once the machine is characterized.
One of the systematic studies planned is looking at the effect of the buffer gas on the beam and the relationship between their ionization potentials [4].
LIS is also intended to be used as a test bench for the sources developed for ISOL@MYRRHA [5] and to investigate radioactive sample separation, such as ^{40}K for muon spectroscopy [6].

References:

[1] C. Duchemin et al. “CERN-MEDICIS: A Review Since Commissioning in 2017” Frontiers of Medicine 8 (2021)

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[3] Catherall, R., et al. "The ISOLDE facility." *Journal of Physics G: Nuclear and Particle Physics* 44.9 (2017): 094002.

[4] Y. Martinez Palenzuela “Enhancing the extraction of laser-ionized beams from an arc discharge ion source volume” *Nuclear Inst, and Methods in Physics Research B* 431 (2018) 59–66

[5] Abderrahim, Hamid Aït, et al. "MYRRHA, a multipurpose hybrid research reactor for high-end applications." *Nuclear Physics News* 20.1 (2010): 24-28.

[6] A. Knecht on behalf of the muX collaboration: progress report R-16-01.1 at the PSI BVR53 01/2022: https://indico.psi.ch/event/12027/