Radioactive Ion Beam (RIB) Production with a Forced Electron Beam Induced Arc Discharge (FEBIAD) ion source.

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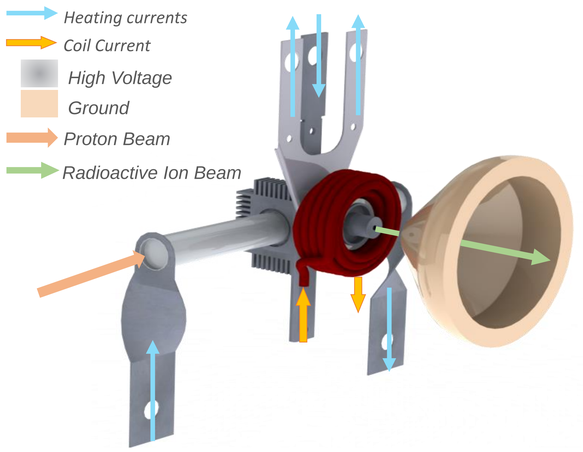


ISAC's Target Ion-Source unit to produce radioactive ion beams. Some of the elements are present only in a FEBIAD ion source.

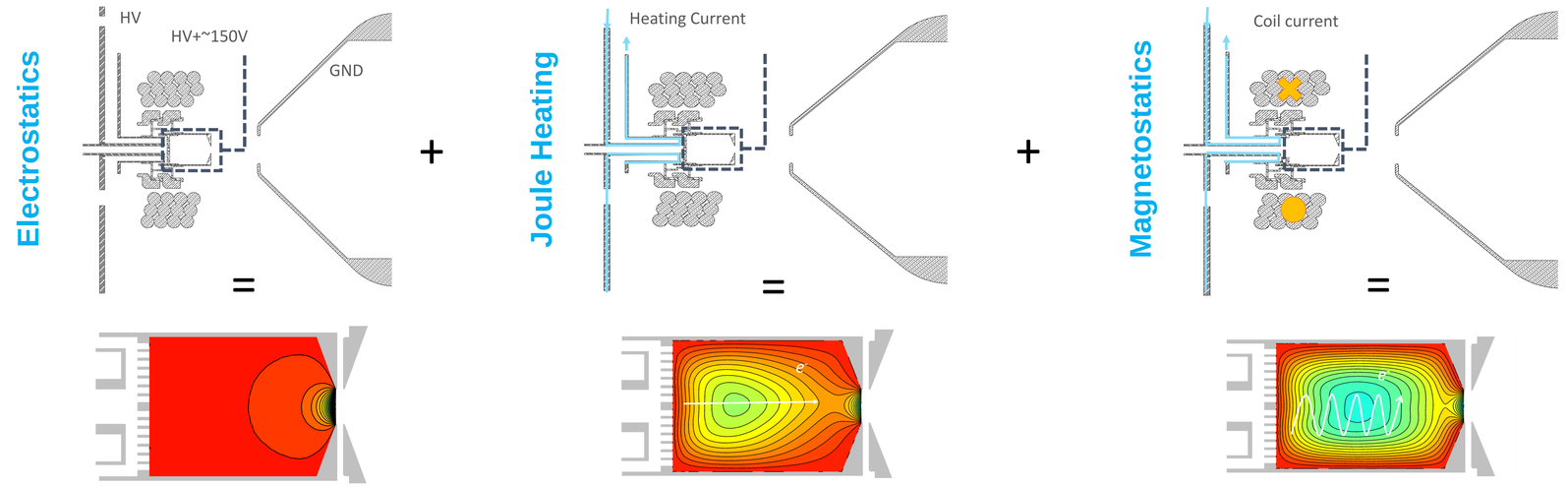
Introduction

RIBs are used for medicine, study nuclear structure and fundamental symmetries.
TRIUMF produces RIBs utilizing the Isotope Separation On-Line method, in which an ion source is a key component.
The FEBIAD ion source is typically used for noble gases, molecular and halogens RIBs, and is a baseline ion source for TRIUMF's new Advanced Rare IsotopE Laboratory (ARIEL).

In a FEBIAD ion source, a hot hollow cathode generate electrons that are accelerated into the anode volume via a grid. Thermalized nuclear reaction products from the target are ionized by electron impact inside the anode. A magnetic field provides focusing/confinement of the electrons.
So far, different facilities seem to exhibit different ionization regimes with no clear explanation on how, therefore limiting how we can exploit. the best regime for the future facilities.

To investigate this source, simulation and experimental studies, are ongoing for the ISAC and ARIEL FEBIAD ion sources. COMSOL Multiphysics software is being used in order to investigate the FEBIAD source parameters and the influence onto each other. To our knowledge this is the first simulation approach taking the magnetic field into consideration.

Multi-physics simulations



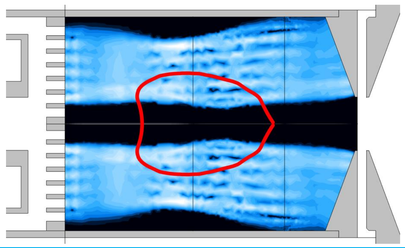
Electric potential inside the anode volume, defined by metal surfaces and apertures.

Electron emission from the hot cathode. The space charge changes the electric potential creating a potential well.

The magnetic force affects the electrons, as a consequence, the potential well in the anode volume can lengthen and/or widen.

Ionization Maps

- Electron transport simulations define the ion current inside the anode volume.
- For each parameter combination, a potential well defines the of effective volume from which ions can be extracted .
- By integrating the ionization rate in the volume outside the potential well, we obtain the ion current.



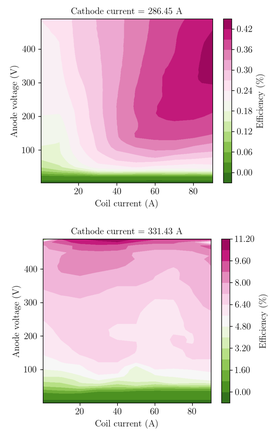
Experimental campaign

Preparation

- Scripts developed to automatize the measurements.
- New gas delivery system implemented and commissioned.

Efficiency

- Known gas flow used we compute the ionization efficiency as a function of all the parameters above.
- Different behaviors observed for each parameter combination



Efficiency contour plots as function of coil current and anode voltage.

Preliminary findings

- Thermo-mechanical limitations found in the heating system.
- Preliminary data analysis suggest different electron emission regimes which translates into different ionization regimes.
- The data compares well with a model that combines ionization in a hybrid electron impact and dc plasma environment
- **Analysis ongoing**

Conclusion

- ✓ A series of **multi-physics simulations** are conducted to understand the general behavior of FEBIAD ion sources.
- ✓ When the magnetic field is included, the simulation results qualitative matched experimental observations from the past.
- ✓ The experimental campagin provides a **massive amount of data** which is being used to understand how the ion source behaves beyond its design limits.
- ✓ With the data we can run **inverse model simulation** to fully understand the mechanism inside the ion source.
- ✓ **Aim to increase efficiency** not only for RIBs but also for Radioactive Molecular Beams.

Discovery, accelerated