Multidimensional characterization of a FEBIAD ion source and its web-interface implementation for RIB development.

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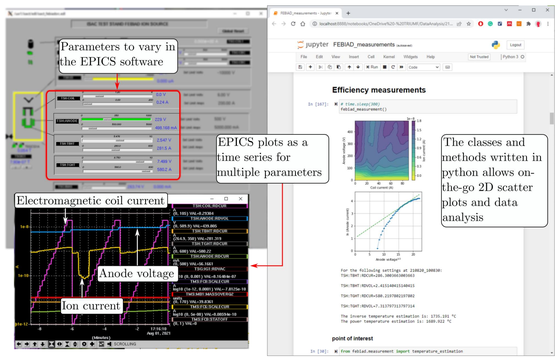
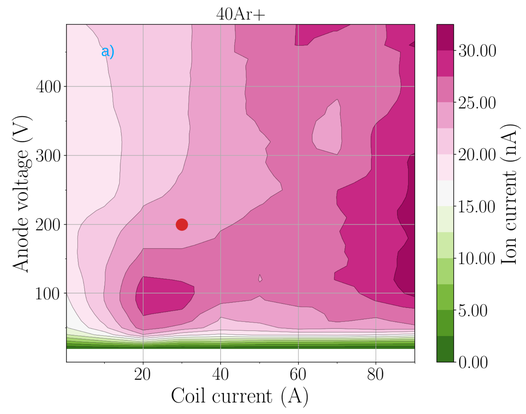
The large operational parameter space of the FEBIAD [1] ion source prevented systematic studies even for a single species. Measurements were typically presented as a time series without the possibility of in-depth analysis on the go. Thanks to the High Level Application (HLA) implementation, a web-app has been developed to implement systematic measurements [2].

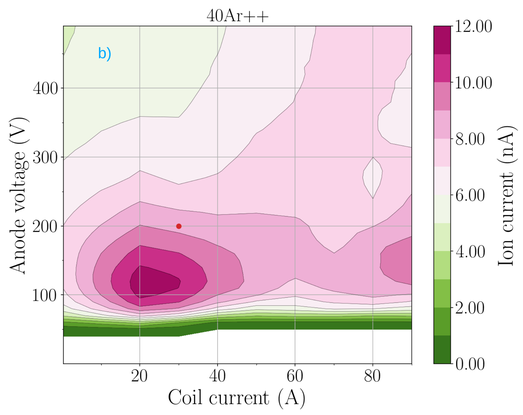
Offline implementation

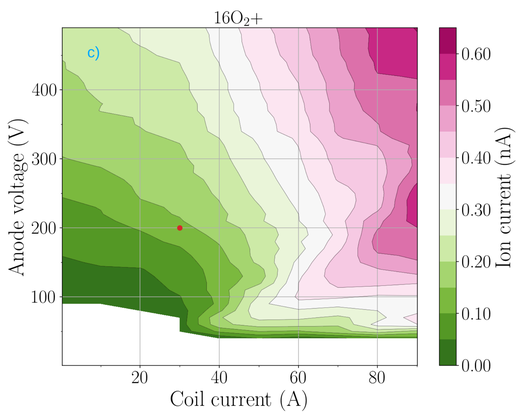
Due to the variability in manufacturing, each FEBIAD might present different optimal operational parameters. Results indicate that optimal parameters for an injected gas species of interest do not necessarily apply to higher charge states or molecules and hence this type of study can dive into chemistry reactions to suppress or enhance certain species.



EPICS, plotted variables, and jupyter notebook for initial offline tests





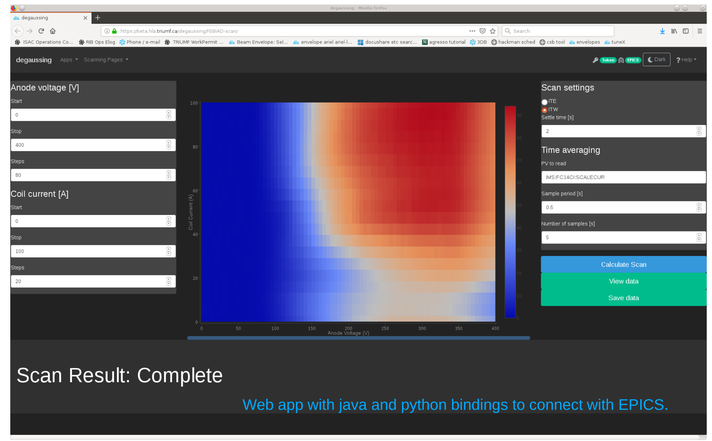


Ion current as a function of anode voltage and coil current at cathode temperature ≈1700 ºC. Identical parameter combinations provide different contours for either singly charged (a), doubly, charged (b), or molecular (c) species. Red point indicate typical parameters used. The contours change for different temperatures. The measurements can further inform the numerical models developed [2-4]

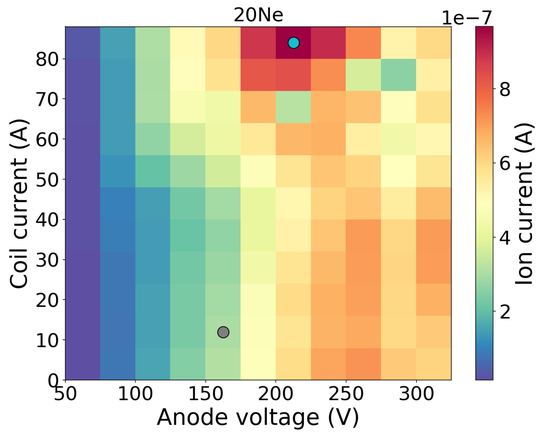
Online implementation

The offline implementation on a jupyter notebook required experienced users to safely use the app, especially given the risks of changing parameters online. By wrapping the functions behind a user friendly web app (right), operational personnel can perform a scan thanks to the safe policies implemented by the HLA group.

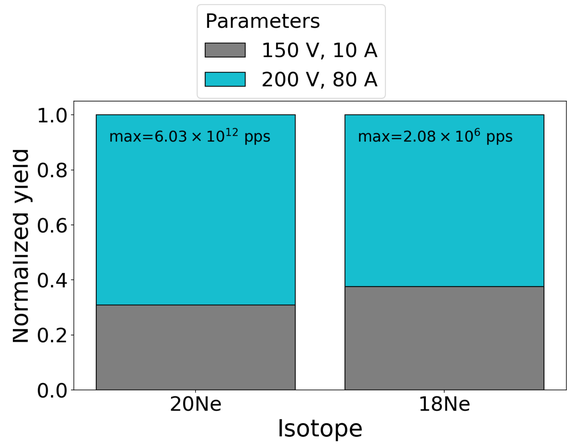
The first online results for Neon (below) show how a rather quick scan (121 data points) presents a maximum for stable 20 Ne (below left). Yield measurements (below right) were taken for 18Ne at the optimal setting (cyan point) and another settings (gray point). The yields share the same ratio and prove that optimal values can be found for a radioactive species.



20Ne++ measurement. 1600 data points measured automatically in just under two hours.



Anode-and-coil scan for stable neon finds optimal and suboptimal values



Radioactive 18Ne operating at 20Ne optimal and suboptimal values.

A recent online run (Jul 2023) used the scan program to improve the signal-to-noise-ratio of 34Ar with a strong 34Cl background (in preparation).

- ✓ Scanning each target unit guarantees optimal performance.
- ✓ Stable ions useful for radioactive ion beam optimization.
- ✓ Halogens, molecules, 2+ states exhibit different ionization dependencies, and this has been exploited for cleaner signals.

[1] Kirchner R and Roeckl E. "A novel isol ion source". Nucl. Instruments Methods 39(C) 1976, pp. 291–296.
[2] Maldonado Millan F. "Comprehensive Ionization Model Development for the FEBIAD Ion Source and Its Application for TRIUMF's Radioactive Ion Beam Program". PhD thesis. University of Victoria, 2022.
[3] Maldonado Millan F, Day Goodacre T, and Gottberg A. "Multiphysics simulation of a FEBIAD ion source". NIMB 463 2020, pp. 302–304.
[4] Maldonado Millan F, Babcock C, Day Goodacre T, and Gottberg A. "Anomalous Ionization Regime in a Forced Electron Beam Induced Arc Discharge Ion Source for Singly Charged Radioactive Ion Beam Production". J. Phys. Conf. Ser. 2244(1) 2022, p. 012074.

Discovery, accelerated