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# A new off-line ion source facility at IGISOL

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## Abstract

An off-line ion source station has been commissioned at the IGISOL (Ion Guide Isotope Separator On-Line) facility. It offers the infrastructure needed to produce stable ion beams from three off-line ion sources in parallel with the radioactive ion beams produced from the IGISOL target chamber. This has resulted in improved feasibility for new experiments by offering reference ions for Penning-trap mass measurements, laser spectroscopy and atom trap experiments.

*Keywords:* Discharge ion source, surface ion source, IGISOL

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## 1. A new ion source facility at IGISOL-4

In this contribution, we present the latest addition to the IGISOL-4 (Ion Guide Isotope Separator On-Line) facility [1], a new off-line ion source station, see figure 1. The new ion source infrastructure consists of an ion source setup located on the second floor of the experimental hall and a beamline connecting the new system to the main IGISOL mass separator. The ion source station is designed to accommodate three ion sources simultaneously, two sources in the horizontal branches of the vacuum system and one vertically mounted.

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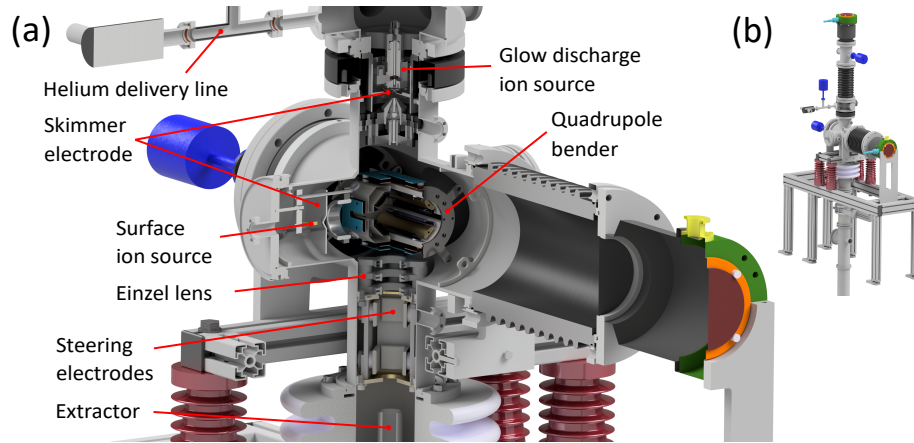


Figure 1: Internal structure of the new off-line ion source station (a) and the full station (b).

10 The new station houses electrostatic ion optics that can accept a beam from each of the three directions. Both ion sources presented in figure 1 utilize a skimmer electrode to form an ion beam which is injected into the quadrupole bender. The beam is focused with an Einzel lens, situated immediately after the quadrupole bender, and its alignment is adjusted using a set of steering  
 15 electrodes. The ions have  $800q\text{eV}$  of energy,  $q$  being the charge state of the ions, before entering the extractor electrode which further accelerates them to  $30q\text{keV}$ .

Subsequently, ions are transported to the lower floor of the IGISOL facility, deflected by  $90^\circ$  into the horizontal beamline and separated based on their  $m/q$   
 20 ratio using a dipole magnet. The deflector system consists of two sets of parallel plates, one curved set of plates that deflects the ions by  $65^\circ$  and another set with straight plates that can be used to deflect the ions by the remaining  $25^\circ$ . The system can accept beam from either the off-line ion source station or the IGISOL target chamber. Switching between these two sources is achieved by  
 25 alternating a voltage on the latter set of parallel plates.

In its present configuration, the ion source station houses two types of ion source, a surface ion source based on resistive heating and a glow discharge ion source. The former ionizes a mixture of potassium, rubidium and cesium,

whereas the latter source is a more flexible device that ionizes its cathode ma-  
30 terial via electric discharge through helium buffer gas. The ion source station  
is equipped with a cryogenic buffer gas purification system in order to provide  
beams with higher concentrations of the cathode material. Commissioning of a  
third ion source, a laser ablation ion source, is being planned.

## 2. Commissioning of the ion source station

35 After the first commissioning runs with  $^{63}\text{Cu}$  and  $^{133}\text{Cs}$ , the new ion source  
station has been employed in many experiments at IGISOL. The station was  
used to provide ion samples in parallel to the IGISOL system. This enabled the  
laser spectroscopy work [2] by making  $^{89}\text{Y}^{2+}$  ions available where they would  
not have been previously and made possible the Penning trap mass measure-  
40 ment campaign [3] conducted fully off-line using both the vertical and horizontal  
beamlines. Additionally, the ion source station has been used to provide well-  
known and identified reference ions for the on-line Penning trap mass measure-  
ments [4] and to provide  $^{133}\text{Cs}^+$  for demonstrating the operation of a new laser  
cooling and trapping facility for the production of ultra-cold atomic samples of  
45 caesium [5]. The new station has been proven to be a useful tool in preparing  
for on-line experiments through allowing initial tuning of both Penning trap and  
collinear laser systems without disrupting preparation of the IGISOL front end.

Operating parameters of the system were mostly the same during these ex-  
periments, with the exception of ion source settings. Typical values for the glow  
50 discharge ion source were 5 – 10 mbar helium pressure and 800 – 1400 V source  
voltage. Current used to heat the surface ion source was adjusted based on the  
amount of beam needed, typically being 1.5 – 1.8 A.

## 3. Conclusions

The new ion source infrastructure has been used in several experiments  
55 demonstrating additional flexibility in the operating modes of the IGISOL fa-  
cility, enabling novel experiments, such as [2], and the possibility to conduct

Penning trap mass measurement campaigns in a fully off-line operating mode. The off-line ion source station, with its two commissioned ion sources, provides a large variety of mass separated ion beams to experiments. Commissioning  
60 of a third ion source based on laser ablation would not only provide an increased number of ion species for experiments, but also a possibility to explore carbon cluster formation which would be of interest as reference ions for mass measurements.

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