

## A compact high yield isotope enrichment system

Highly enriched isotopes such as  $^{10}\text{B}$ ,  $^{98}\text{Mo}$ , and  $^{100}\text{Mo}$  are in great demand for the manufacturing of radioactive isotopes for medical diagnostic imaging studies and therapeutic applications. In order to produce useful quantities of the medical radioisotopes, it is essential to enrich the target sample with the desired isotope. The most common method for eliminating the isotopic impurity is electromagnetic (EM) mass separation. In this approach, a single ion beam containing all the naturally occurring isotopes is extracted from an ion source. The ion beam then passes through an electro-magnet where the isotopic ions are separated into different trajectories due to their difference in mass. However, as only a single beamlet can be employed, the amount of the desired isotope that can be collected is limited by the intensity of the ion source and the operation time.

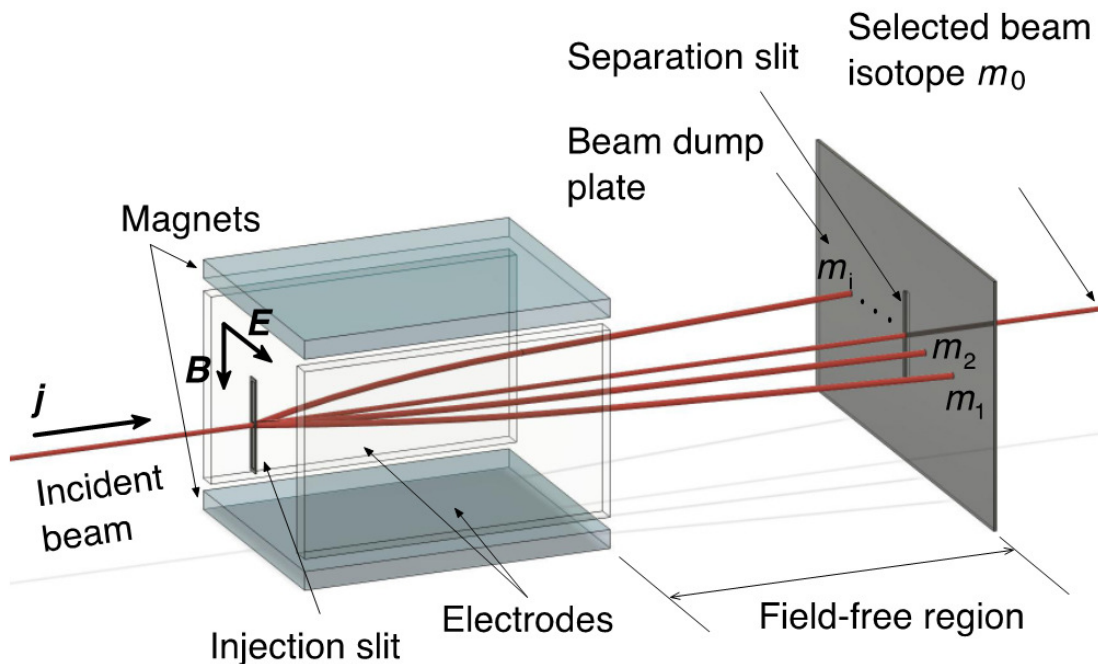


Fig. 1. Schematic diagram of a permanent-magnet E x B filter for mass separation.

Recently, a compact isotope enrichment system has been developed which can greatly enhance the yield of a range of commercially desirable isotopes with low energy consumption. The new electro-magnetic scheme employs a compact permanent-magnet operated E x B or “Wien” filter (Fig. 1). The E x B filter consists of a pair of electrically-biased electrodes and a pair of permanent magnets. The E (electric) and B (magnetic) fields generated by these elements are perpendicular to each other which in turn are perpendicular to the incoming ion beam which indicated as  $j$  in Figure 1. The E-field strength is adjusted so that only the ions with mass  $m_0$  will have a straight trajectory. In order to increase the mass separation from  $m_0$ , a field-free or drift region is employed after the E x B field. After leaving the field-free region, ions with mass  $m_0$  will exit from the

separation slit and are captured by a collector electrode while the other isotope ions are collected by the beam dump plate. To maintain the compactness of the isotope separator, the drift region should be kept as short as possible.

A single E x B filter can only provide a limited quantity of a particular isotope. In order to enhance the enrichment efficiency, multiple E x B filters are employed with multiple ion beams extracted from a large RF-driven multicusp plasma source (Fig. 2). By using permanent-magnet confinement, the multicusp plasma generator is capable of producing large volumes of uniform and high density plasma. The plasma generator can be rectangular in shape with intense ion beams extracted from opposite ends of the chamber. The RF antenna is inserted into the chamber through the side wall and plasma is produced by 13.5 MHz induction discharge. With this multi E x B filter arrangement, the isotope enrichment efficiency can be increased by three orders of magnitude. The combined RF-driven ion source and multi E x B filter system has a small footprint and it requires very low power for operation.

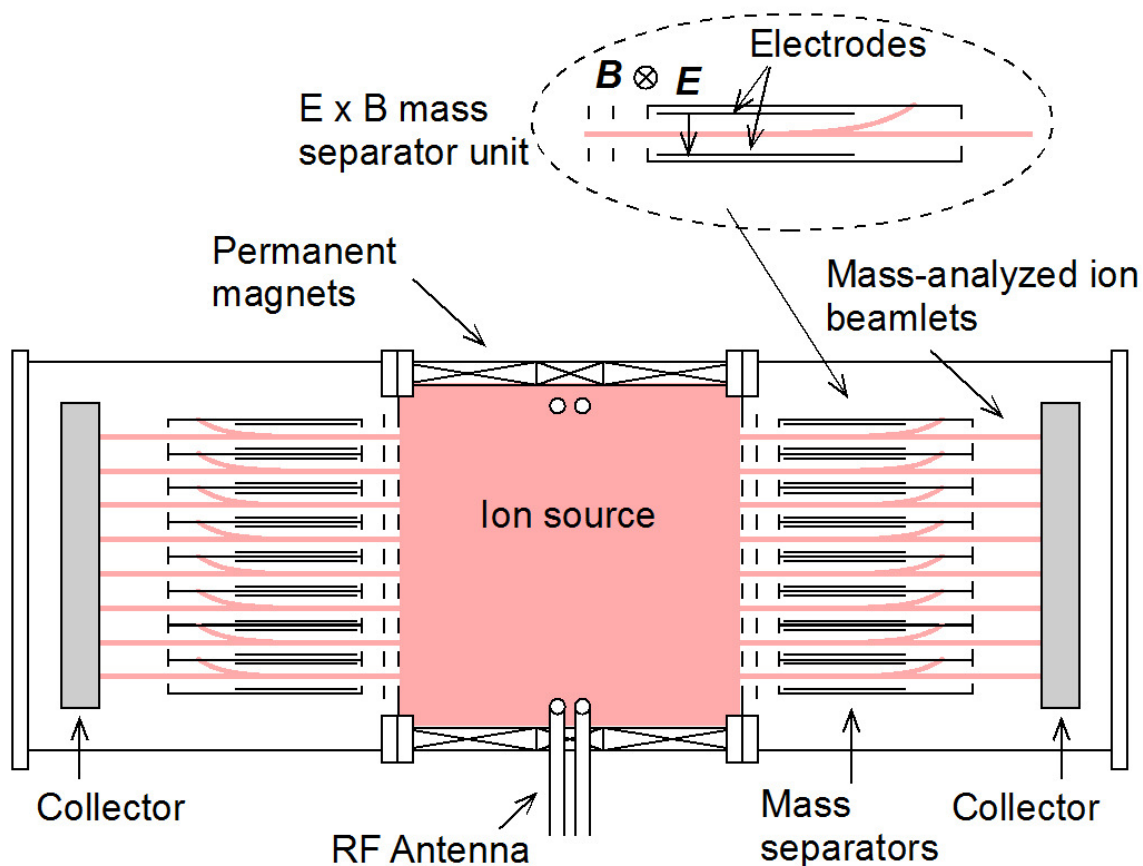


Fig. 2. Schematic of a multi E x B filter system. The ions are extracted from both sides of the RF ion source with multi aperture grids. Each beamlet enters a E x B separator unit and single isotopic ions are collected.

With the availability of enriched isotopes, many useful medical radioisotopes can then be produced by neutron irradiation (for example, the generation of  $^{99}\text{Mo}/^{99\text{m}}\text{Tc}$  by irradiating  $^{98}\text{Mo}$  or  $^{100}\text{Mo}$  with neutrons). This multi E x B filter enrichment tool can be conveniently housed and operated in tandem with a compact neutron generator to produce many useful medical isotopes in a hospital or a clinical facility.

***Ka-Ngo Leung***<sup>1,2</sup>, ***Nozomi Tanaka***<sup>3</sup>

<sup>1</sup>*Nuclear Engineering Department, University of California, Berkeley, CA 94720, USA*

<sup>2</sup>*Berkion Technology, Berkeley, CA 94707, USA*

<sup>3</sup>*Institute of Laser Engineering, Osaka University, Osaka, 565-0871, Japan*

## **Publications**

### [A multi E x B filter system for isotope enrichment application](#)

Ka-Ngo Leung, Nozomi Tanaka

*Appl Radiat Isot.* 2020 Jan

### [Feasibility study on medical isotope production using a compact neutron generator](#)

Ka-Ngo Leung, James K Leung, Graeme Melville

*Appl Radiat Isot.* 2018 Jul