Around the Laboratories

CERN
Producing radioactive beams

Accelerating radioactive beams has long been of interest at CERN's ISOLDE on-line isotope separator - the possibility was discussed at a CERN Workshop on intermediate energy physics as early as 1977. Meanwhile, as was highlighted in the 1991 report of the Nuclear Physics European Collaboration Committee (NuPECC - March 1992, page 1), widespread scientific interest in these beams has developed and a range of projects are proposed, under construction or operational throughout the world.

The bottleneck in these projects is the production of multiply-charged radioactive ions beams, since the efficiency and cost of an accelerator is directly related to the charge/mass ratio of the ions to be accelerated.

While most projects are installing an Electron Cyclotron Resonance (ECR) ion source in the rather hostile environment of the production target, the ISOLDE group, in collaboration with specialists from Stockholm's Manne Siegbahn Laboratory, Saclay's Saturne Laboratory and the Max Planck Institut at Heidelberg, is contemplating a different approach. Here the low-energy ISOLDE beams would be injected into an Electron Beam Ion Source (EBIS) system acting a charge state breeder and - in some cases - as an ion buncher.

In an EBIS system, a dense electron beam focussed by a strong magnetic field radially confines the ions, which are controlled axially by voltages applied to cylindrical electrodes. Particles undergo successive further ionizations by electron impact, increasing the ionic charges. Extraction can be precisely timed, giving a good handle on the output ionic charge. These sources are widely used in atomic physics and as injectors.

In the new ISOLDE scheme, the low-energy singly-charged beams would be injected into an EBIS system in the experimental hall. After charge state breeding the multiply charged ions are extracted and injected into an accelerator consisting a 4-rod RFQ followed by a matching section and a linac with five 108 MHz 7-gap resonators (similar to the high current injector of MPI Heidelberg). The RFQ takes ions from 10 to 500 keV/nucleon, while the linac can furnish beams from 0.5 to 2 MeV/nucleon.

In this scheme, low-energy singly-charged ion beam production builds on the vast ISOLDE experience and obviates the need to install delicate equipment like high charge state ion sources in the hostile high-radiation environment around the target of an on-line separator.

The improved ISOLDE yields at the 1 GeV Booster for isotopes far from the line of stability add substantially to the physics potential.

The EBIS device and the external ion injection scheme have been initially tested at the Manne Siegbahn Laboratory, Stockholm, using 100 microsecond pulses of nitrogen 1^+ ions. After being trapped for about 200 milliseconds, the nitrogen ions are effectively fully stripped of electrons.

The efficiency, defined as the fraction of injected ions finally extracted was a useful 14.5%. More recently these results have been confirmed at Saclay using beams of argon as well as nitrogen.

Schematic of a proposed scheme to produce energetic radioactive beams at CERN's ISOLDE on-line isotope separator, with the low-energy ISOLDE beams injected into an Electron Beam Ion Source (EBIS) system (right) acting a charge state breeder and ion buncher.