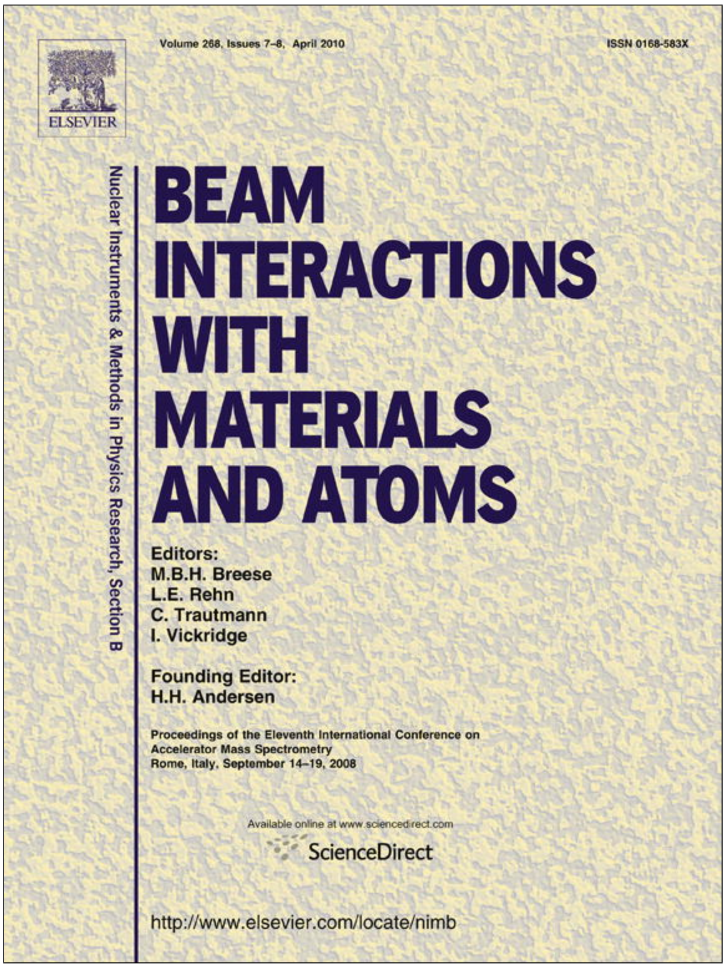
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The new injection beamline at VERA

Alfred Priller *, Karl Melber, Oliver Forstner, Robin Golser, Walter Kutschera, Peter Steier, Anton Wallner

Vienna Environmental Research Accelerator (VERA), Fakultät für Physik, Universität Wien, Austria

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ABSTRACT

VERA has been operated for 12 years with one 40-cathode SNICS ion source. Since the number of isotopes investigated at VERA increased steadily, we decided to install a second ion source. Due to space restrictions, a new injection line had to be built and merged into the existing one. The major task was to build an electrostatic analyzer assembly to accommodate injection from two ion sources.

1. Introduction

At the Vienna Environmental Research Accelerator Laboratory (VERA) the number of isotopes investigated increased steadily. In order to reduce the amount of time consumed to switch between different isotopes, and to reduce time losses due to source maintenance or repair, we decided to install a second negative-ion sputter source (S2). A further motive was that a second source should also facilitate source development. Space restrictions at the source area forced us to build a rather complex new beam line including an electrostatic analyzer assembly (ESA switcher) to merge the beam coming from source S2 into the existing injection beamline.

2. Description of components

2.1. Source S2

The new negative-ion source S2 is a MCSNICS II (5.56″ housing, option 0) having 40 positions, and a pneumatic sample changer. Ion source, extractor/einzel lens assembly, and the preacceleration section, as well as the source deck sitting on an insulation transformer were built by NEC, Wisconsin, USA.

All source high-voltage power supplies are built by Glassman (Glasman High Voltage Inc., New Jersey, USA), except the current power supplies for the ionizer, the Cs-oven and the Cs-supply line, which are of Delta SM800 series (Delta Electronika BV, Zierikzee, The Netherlands) or self-made. Typical source-operation parameters are: $U_{Extraction}$ = 15 kV, $U_{Cathode}$ = 5 kV, $U_{Preaccel}$ = 50 kV, $T_{Cs\text{-}ofen}$ = 150 °C, $P_{Ionizer}$ = 170 W, $I_{Lineheater}$ = 30 A. Customary petroleum is used as source cooling liquid.

2.2. Source S2 and ESA switcher beamlines

Please refer to Fig. 1 for explanation of the abbreviations used. Two einzel lenses (designed at VERA based on papers from Gillespie and Brown [1,2]), 'EL S2-1' and 'EL S2-2', which are 1.45 m apart from each other are installed between source S2 and the ESA switcher (consult Fig. 1). All electrodes of both lenses are 50 mm long and have an inner diameter of 50 mm. The gaps between the electrodes are 7 mm. For a telescopic beam transport without focus between the two lenses the voltage applied to both is ~28 kV.

Slits (*x* and *y*) used for beam diagnosis or as beam defining aperture, are placed at the first waist after the source ('SLT S2-1') and at the object waist of the ESA switcher ('SLT S2-2'). Before the first slits *x*- and *y*-steerers are mounted ('ESX S2-1' and 'ESY S2-1'). A second *y*-steerer 'ESY S2-2' is put between 'EL S2-2' and the object slits of the ESA switcher. For tuning of the S2 beamline up to the entrance of the ESA switcher a beamprofile monitor 'BPM S2-1' is mounted after einzel lens 'EL S2-2' in front of the slits 'SLT S2-2'. To get information on the distances between the individual elements see Fig. 3.

For beam diagnosis the S2 beamline has got one Faraday-cup behind slits 'SLT S2-1'. The next cup 'FC 02-1' is located after the injector magnet 'BM 01-1'. Unfortunately, there was no space for a Faraday-cup behind the slits 'SLT 01-1' at the exit waist of the ESA assembly. To cope with this deficit, the jaws forming the *x*-slit (or *y*-slit) were connected to a current preamplifier (Stanford Research SRS570). Tuning of the beam through the slightly opened slits is done by reading the current from the jaws looking for a minimum.

* Corresponding author. Tel.: +43 1 42 77 51 703; fax: +43 1 42 77 95 17.
E-mail address: alfred.priller@univie.ac.at (A. Priller).

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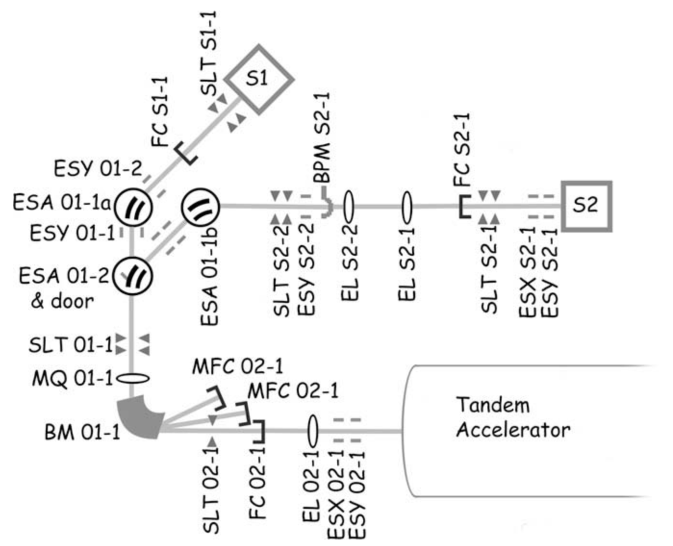

Fig. 1. Mimic diagram depicting the layout of the low-energy section of VERA. Major components have got name tags facilitating their identification. Legend: FC Faraday-cup; MFC offset Faraday-cup SLT slit assembly; ESX, ESY electrostatic steerer assemblies; ESA electrostatic analyzer (spherical); EL einzel lens; MQ magnetic quadrupole; BM 90° double-focusing bending magnet.

2.3. ESA switcher assembly

The ESA switcher consists of three identical spherical electrostatic analyzer (ESA) modules. The design of the ESAs is based on papers by Wollnik and Ewald [3,4]. 'ESA 01-2' has got a door (the resulting clearance hole has 40 mm in diameter), which is opened during injection from source S1, and closed when ions from source S2 are injected. It can be automatically moved and locked from outside the ESA switcher box (Fig. 2) without breaking the vacuum. Three dogs assure the correct position of the closed door. The default orbit of the individual ESA is 300 mm; its spherical electrodes are 200 mm high having a 50 mm gap. The electrodes are made of aluminum. Inside the assembly, both injection lines have got a pair of *y*-steerers to enable correcting for some direction and position offset of the ion beam. In order to omit high-voltage switches, the positive (negative) electrodes of 'ESA 01-1a' and 'ESA 01-1b' as well as upper (lower) electrodes of the *y*-steerers 'ESY 01-1' and 'ESY 01-2' are connected in parallel, respectively. This necessitates shields between the individual ESA modules, which prevent leakage of the electric fields at the path of the ions injected. All parts of the ESA assembly were designed and manufactured at VERA (the vessel containing the three electrostatic analyzers and the two pairs of *y*-steerers was welded by an outside company). Beamline stands, vacuum tubes, and einzel lenses were manufactured at VERA's workshop.

2.4. Control and read-out

For the new source S2 and the beamline an additional switch and fuse control cabinet was built expanding the original control cabinet built by NEC. This cabinet houses all safety, control and emergency features for a safe operation of beamline S2 including the ESA switch. All signal lines for read-out and control parameters are fed into the accelerator control system (AccelNET) via an additional CAMAC interface box and RS232 connections, respectively.

The display on the main control console of VERA as well as the control program was modified to fulfill the additional monitoring and control demands. In addition, all computer programs for automated measurement were adapted to match the expanded operating requirements.

3. Output of simulation calculations

The paths of the ions through the new beamline S2 were simulated using SIMION 7.0 (1999 Bechtel BWXT Idaho, LLC) and PRILLION, a program written at VERA, using transport matrices (Fig. 3). For 70 keV ions the assumed emittance at the start point was 7π mrad mm, which was set identical to the emittance of the beam from the old source S1 at slits 'SLT S1-1'. Aim of the simulation was to get same beam properties for both, S1 and S2 beamline, at the

Fig. 2. 3D-view of the ESA switcher vessel. The name tags are explained in Fig. 1. The shields preventing leakage of the electric fields at the path of the ions are not shown. Ions coming from source S1 (upper left) are bent 45° by 'ESA 01-1a' and can pass through 'ESA 01-2' having its door opened. If the ions come from source S2 (upper right), they are bent 45° twice, by 'ESA 01-1b' and 'ESA 01-2' shown its door closed. The lid of the ESA switcher vessel has got a window allowing for visually checking the proper position of the door. The vessel has also got some additional ports of different dimensions so that additional devices (e.g. a beam attenuator assembly) can be brought into the ion beam's path.

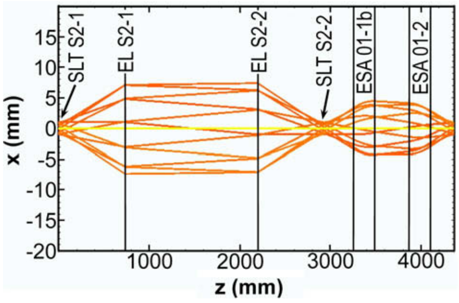

Fig. 3. Output of the ionbeam transport program PRILLION for a beam having at slits SLT S2-1 an emittance of 9π mrad mm. The two einzel lenses 'EL S2-1' and 'EL S2-2' are represented by their corresponding principle planes. *X* represents the distance of an individual ion from the default orbit of the beamline. *Z* is the distance from the start at 'SLT S2-1' for an ion traveling on the default orbit.

object slits 'SLT 01-1' of the injector magnet. After installation of the beamline, measurements of the beam emittance at slits 'SLT S2-1' by using these slits and beam profile monitor 'BPM S1-1' resulted in an emittance of about 9π mrad mm.

4. Final remarks

One benefit of having a second source was the drastic reduction of the time needed for changing the target wheel and starting a new measurement session. Source opening, mounting the wheel, roughing the source, pumping down, and waiting for stable ion beam from the source including presputtering of the individual samples, consumed about 4 h time. Now, equipped with a second ion source, all this work can be done in advance, parallel to a running measurement.

Source S2 has not seen too many different isotopes (beryllium, carbon, aluminum, iron (catalyst), silver (additive for increasing heat and electrical conductance), aluminum (sample holder), copper, sample holder), cesium, tantalum, and other source construction materials), yet, and is still a 'clean' source compared to our working horse source S1. This could give us the possibility to perform AMS at masses, which were constricted by stable background interferences when using source S1.

^{14}C dating showed that mounting the ESA switcher did not influence reproducibility and precision using the source S1 beamline. Concerning source S2 beamline, a variety of isotopes were injected and we performed commercial ^{14}C dating. Source S2 has a lower negative-ion output under stable operating conditions (30 μA $^{12}C^-$ compared to at least 60 μA from source S1) resulting in a longer measurement time. This lower ion current output could have its origin in a two-collimator assembly incorporated in the extraction electrode of S2, which is assumed to reduce the ^{13}C/^{12}C-ratio variations from cathode-to-cathode into the 0.1% region. In addition, there is still a lack of beam diagnosis, which makes tuning more demanding when using the source S2 beamline.

We are still in the process of knowledge development. Nevertheless, we think that the additional source will lead to a more efficient use of the facility, and possibly allow opening the way to further expansion of the injector system of VERA.

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