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Status of an R&D project of a positron gun at "Horia Hulubei" NIPNE Bucharest

Angela Vasilescu [a,*], L. Craciun [a], Ionica A. Ghita [a], O. Constantinescu [a], F. Constantin [a], Catalina Chiojdeanu [a], C.N. Zoita [b], A. Kiss [b], D. Bojin [c], P.M. Racolta [a]

[a] National Institute for Physics and Nuclear Engineering "Horia Hulubei", Bucharest, 077125 Magurele, POB MG-6, Romania
[b] National Institute for Optoelectronics, Bucharest, 077125 Magurele, POB MG-5, Romania
[c] Polytechnic University Bucharest, 060042 BUCHAREST, POB 16-04, Romania

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ABSTRACT

A new positron gun (PG) will enable high sensitivity measurements in applications of positron annihilation spectroscopy in Romania. Some data concerning the design of a modular system for focussing, transport and acceleration of mono-energetic positrons in the range 0.8–50 keV have been obtained and experimenting on moderators and CDBS was performed. We present a short overview of the present status of the project and preliminary results from Coincidence Doppler Broadening Spectroscopy with a $^{22}NaCl$ source, on Al samples. The entire positron gun system will be designed as a high-vacuum dedicated extension operating with two options: a 50 mCi $^{22}NaCl$ source and in-line with the NIPNE cyclotron or a new intense compact cyclotron.

1. Introduction

A novel project for a positron gun (PG), scheduled for October 2006–December 2008, will enable the development of a positron annihilation laboratory at NIPNE-HH Bucharest, to be used for material studies and applications using mainly CDBS. At present, parallel studies are in course referring to various aspects: design and construction of sub-assemblies, including the experimental set-up, the positron gun facility and the techniques and solutions to be chosen. The PG will be built as a high-vacuum dedicated extension operating with two options: a 50 mCi $^{22}NaCl$ source and in-line with the NIPNE cyclotron or a new intense compact cyclotron.

2. The positron source

For DBS and CDBS measurements we use a "home-made" positron source, produced by separation without carrier from the radioisotope produced at NIPNE. ^{22}Na was obtained at our cyclotron by bombarding a metallic magnesium target with 14 MeV protons, and separated radiochemically by column cation exchange chromatography: after irradiation with protons, the metallic Mg disk with 0.5 cm diameter was dissolved progressively in warm 2 ml 6 M HCl, with periodic control (at different time intervals) of the activity—the goal being to pass as much of ^{22}Na activity without dissolving more than the necessary Mg, from which it has to be separated in the next step, with least ballast possible. After a total time of about 30 min of surface contact between the magnesium disk and the solution, about 93% of the initial ^{22}Na activity was passed into the solution. The solution was evaporated to dryness under an infrared lamp, and the residue dissolved on 0.075 M HCl. Further, 2 ml of the solution was passed through a glass chromatographic column (10 cm long and 0.7 cm diameter), filled with Bio-Rad AG-50 cationic resin (200–400 mesh) in H-form, with a flow rate of 3 drops/min. The column has been preconditioned with 0.075 M HCl. After absorption, the column was washed with 5 ml 0.1 MHCl, and samples of 0.5 ml were taken and measured with a multichannel analyser. No significant activity was found in the eluate. Selective elution of ^{22}Na was done with a 0.2 M HCl, measuring the activity of each 0.5 ml eluate. The whole activity was eluted in about 5 ml solution. A next step was the IR evaporation followed by the dissolution with a small volume of deionized water.

A ^{22}Na of 1.7 μCi test source was prepared, through IR evaporation of 10 μl of this aqueous solution, on a 7 μm thick mylar foil fixed on an aluminum frame. The source was covered then with a similar mylar foil. The activity was measured with a HPGe spectrometer.

For the future we plan to prepare another ^{22}Na source of about 1 mCi for testing, and to acquire a 20–50 mCi source for the positron gun. We are envisaging to study the possibilities to obtain

* Corresponding author.
E-mail address: angela@nipne.ro (A. Vasilescu).

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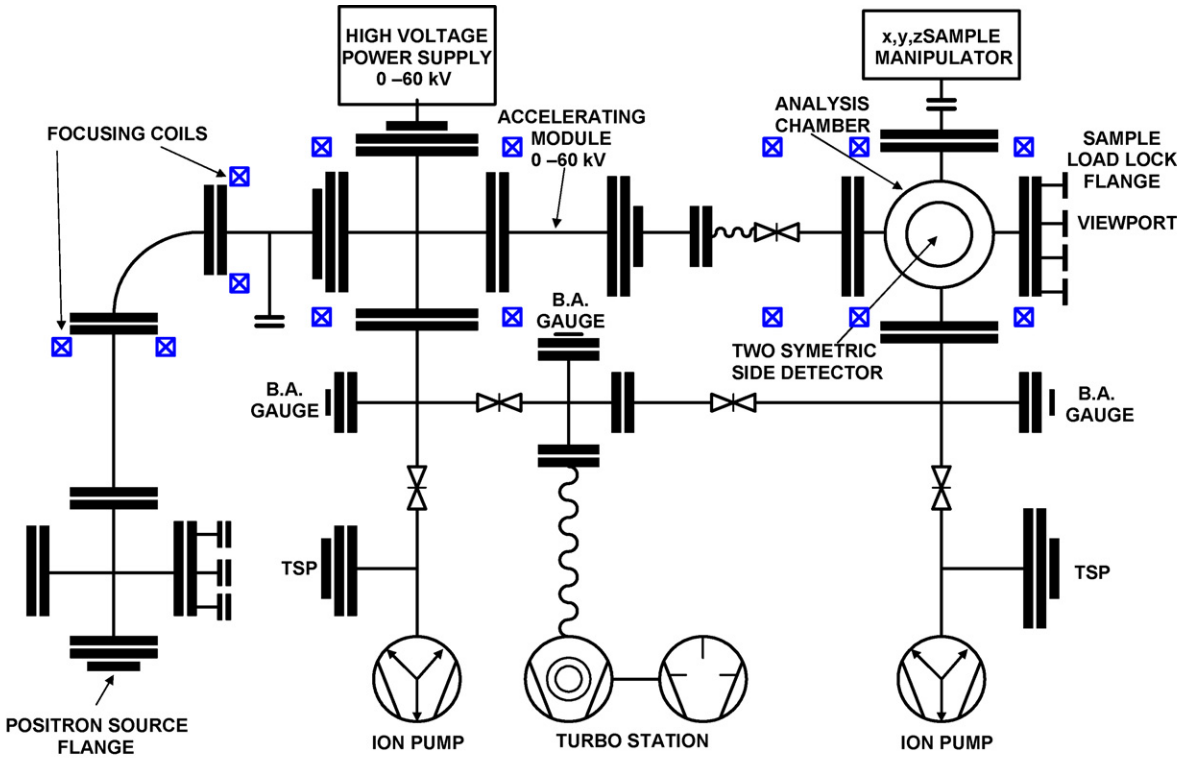

Fig. 1. The schematic of the positron gun.

also in-line sources (^{18}F, ^{27}Si) for the positron gun, using a compact cyclotron, producing 16–18 MeV protons and 8–9 MeV deuterons.

3. The design of the positron gun

The PG is designed as a modular system for focusing, transport and acceleration of monoenergetic positrons in the energy range 0.8–60 keV, based on the model presented in ref. [1].

The constructive solution for the beamline is given in Fig. 1. The system consists of two main modules, the accelerating and focusing module and the sample analysis module. In order to maintain the pressure below 10^{-8} mbar, each module is fitted with its own pumping system consisting of an ion pump and a titanium sublimation pump. Both modules share the same turbo station which is used to pump down the system and the sample load lock from atmosphere pressure to 10^{-7} mbar.

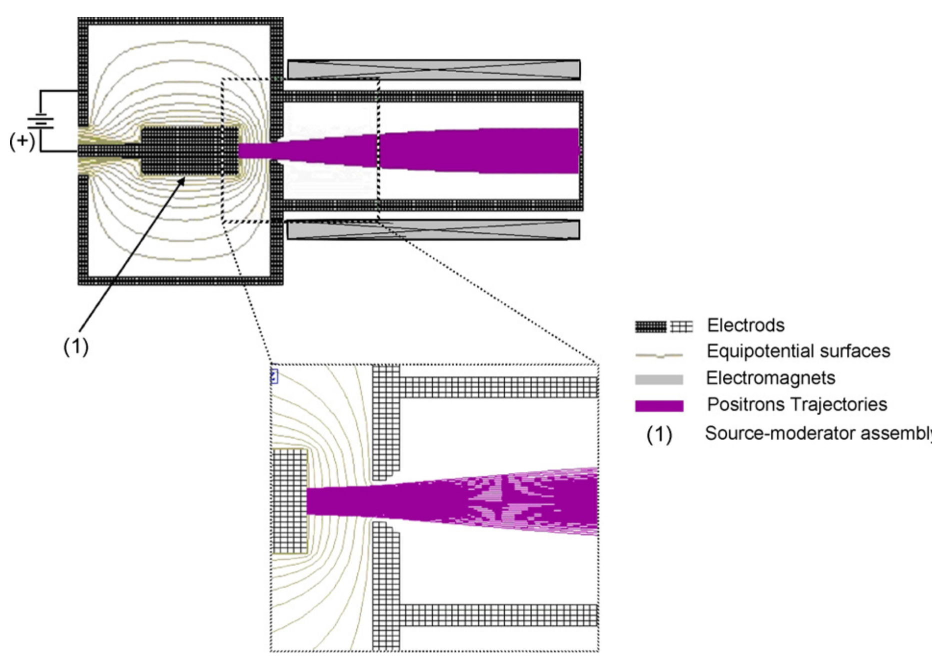

Fig. 2. Simulation of the positron trajectories in the PG acceleration region.