Coupling H^- ions beam line for tandem accelerator

S. Konstantinov, A. Krjutchkov, A. Kudryavtsev, O. Myskin, I. Sorokin, M. Tiunov

Budker Institute of Nuclear Physics, Novosibirsk, Russia

Development of tandem low energy beam-line

The problem of H^- beam transportation from ion source to tandem accelerator and that of transport line output adjusting with accelerator input are of great importance.

There have been considered two versions of beam line optical system: by using axially symmetrical electrostatic or magnet lenses. Finally, the magnet lenses were chosen, in spite of their large energy consumption. Magnet lenses allow transporting fully compensated beam of negative hydrogen ions, and allow matching their positions along the transport line without changing its construction.

We assume to try two methods for adjusting of the 25 kV beam input into accelerator: with strong focusing or with weak focusing by the accelerator electric fields. For the case of strong focusing a compensation of focusing action of input electrostatic lens is obtained due to injection of the beam with large divergence and small radius. Such beam can be produced only by extra-focusing with the help of magnet lens placed just in front of the accelerator input. For the case of weak focusing the action of input lens is strongly reduced due to smooth increasing of the electric field at the accelerator input. In this case the angle of slope of beam envelope curve at the accelerator input is close to zero, and beam radius is chosen so, that focusing action of weak input electrostatic lens is almost fully compensated by the beam space charge transverse forces (equilibrium beam radius).

Since each of these methods has its own advantages or disadvantages, with their optical geometry differing slightly, the design of beam line is chosen in the way allowing experimental test of both strong and weak beam focusing.

The concept of the low energy beam-line, results of the work performed from the start of the project and planned next steps of the further development are presented below.

Concept development

The layout of the H^- source, beam-line, pumping system, and tandem entrance is shown on Fig. 1.

Due to large amount of gas flowing out the ion source two sets of pumps are used. First set comprises the pair of turbovacs with total pumping speed about 1200 l/sec (for hydrogen) connected through the gate valve to the source output chamber. Second pumping system provides differential pumping to decrease amount of gas in beam-line and to prevent beam stripping losses inside the beam-line. It consists of one turbovac and gate valve. Pumping speed of this system is about 700 l/sec.

The ion source has it's own magnetic field (extraction of the ions is made across magnetic field lines) and, consequently, there is a small angle between the source axis and beam-line axis. The output chamber mechanical design is made taking into account known value of this angle, and possible inaccuracy should be compensated by special correction coils located in proper place of beam-line vacuum channel.

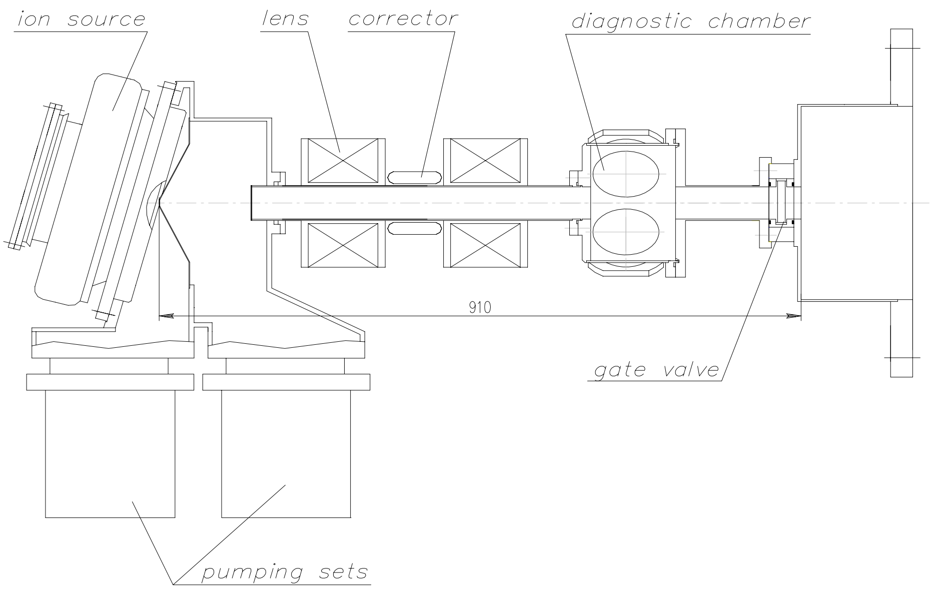

Fig. 1.

Set of two magnet lenses are used in the beam-line to adjust optical properties of the beam with the accelerating system and, especially, with the input gap of the tandem. This procedure is necessary to provide accurate passing of the beam through the long and narrow stripping cell, placed in the middle of the tandem.

All parameters of magnet lenses and electric field profiles in the duct were calculated and computer simulations of the beam particle trajectories were made taking into account beam space charge potential in the region with negative potential in tandem accelerating channel. The view of the field profiles, beam trajectories for two values of H^- current (5 mA and 10 mA), and main elements of ion beam-line and accelerating channel is presented on Fig. 2.

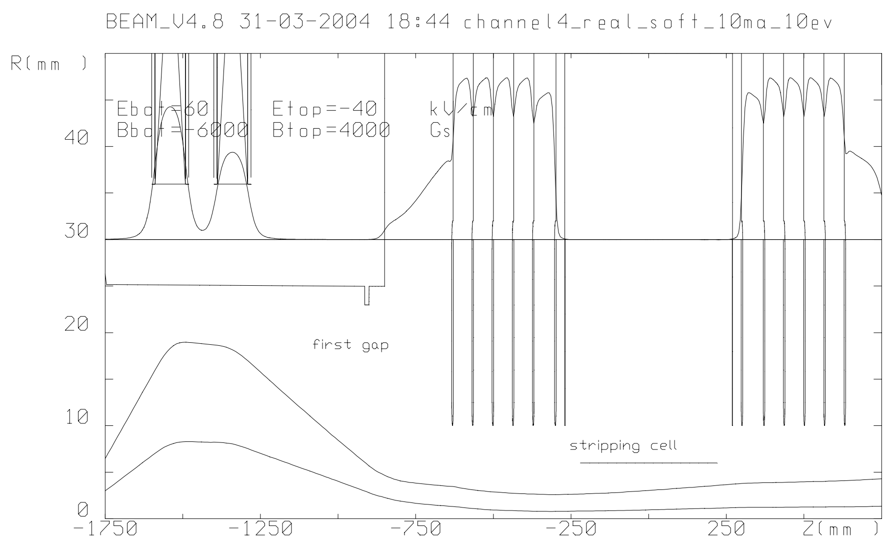

Fig. 2.

General view of the beam-line and source output chamber was designed. The set of detailed drawings is ready for transferring to machinery shop.

Special diagnostic chamber will be installed into beam-line. The chamber is equipped with movable Faraday cup, combined with multi-electrode beam profile meter (64 separate detectors), movable apparatus for the beam emittance measurements, and non-invasive detector of total beam current. These measured beam parameters are very important for accurate adjustment of the beam to pass through the narrow stripping cell.

Diagnostic chamber and almost all elements of diagnostic system are designed and made.

The layout of diagnostic chamber with two movable holders is shown on Fig. 3; Fig. 4 - photo of the chamber with Faraday cup moved in.

Multi-electrode beam profile meter is presented on Fig. 5 (from the left to the right – Faraday cup end with 64 small holes, suppressing electrode, 64 isolated current probes), and Fig. 6 – assembled Faraday cup.

The arrangement for beam emittance measurements is designed and made also (Fig. 7-9). Set of necessary electronic modules is under development.

Main parameters of the pumping system were analyzed and it's general view was designed. The process of detailed drawings production is under way.

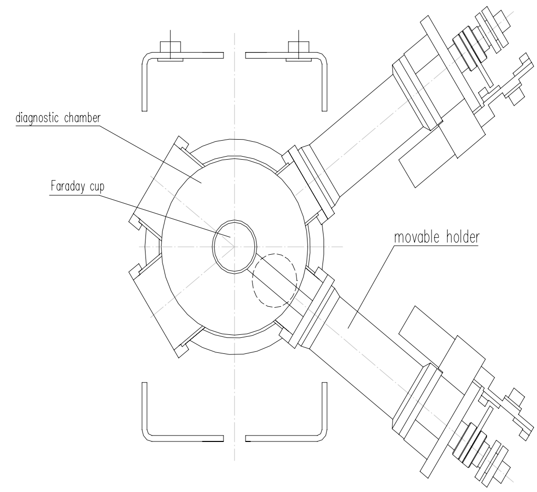

Fig. 3.

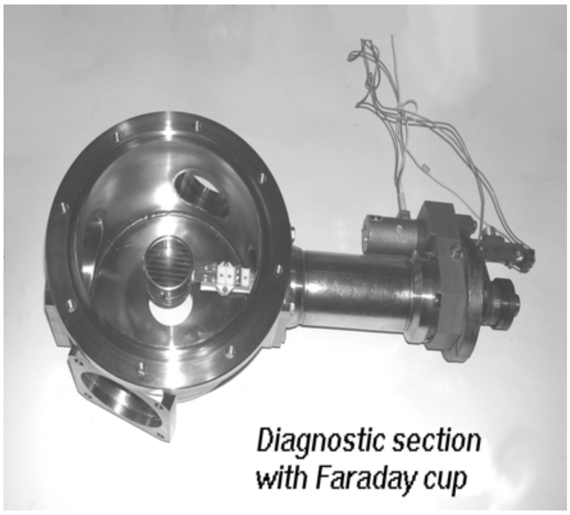

Fig. 4.

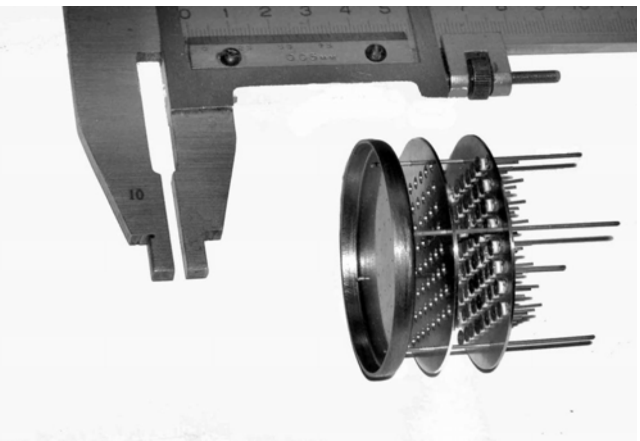

Fig. 5.

Fig. 6.

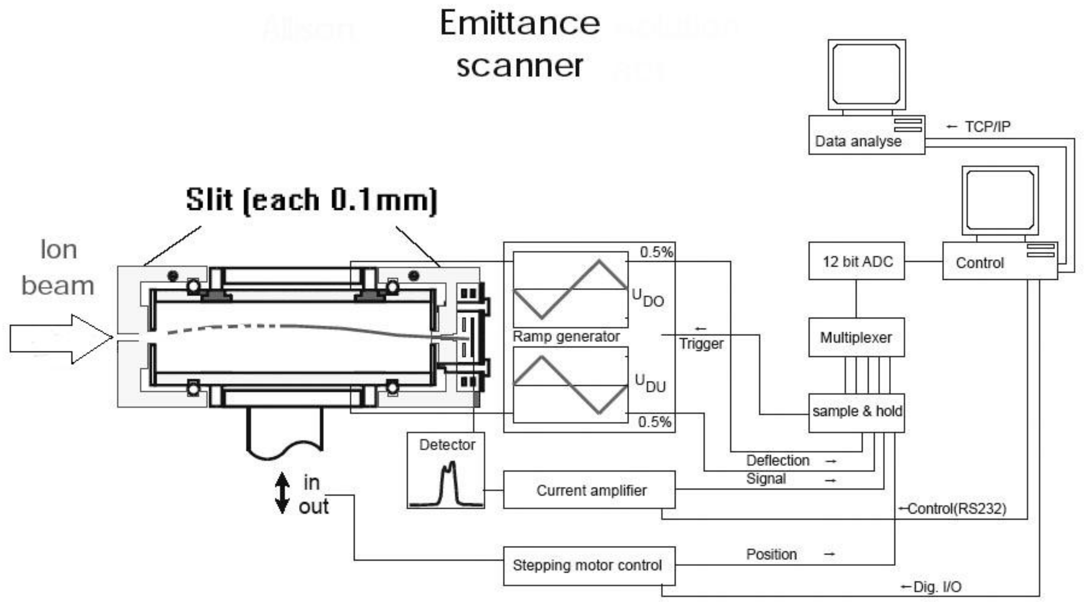

Fig. 7. Scheme of emittance measurement.

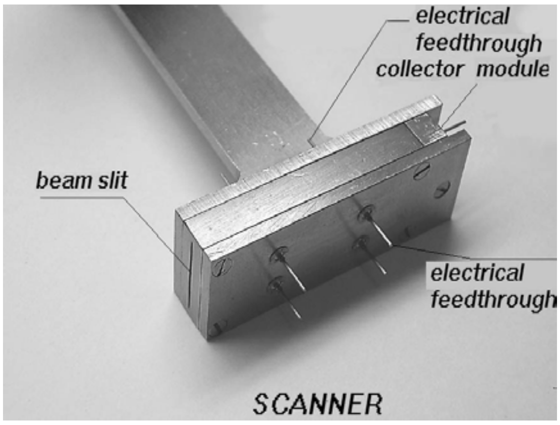

Fig. 8. Photo of assembled scanner.

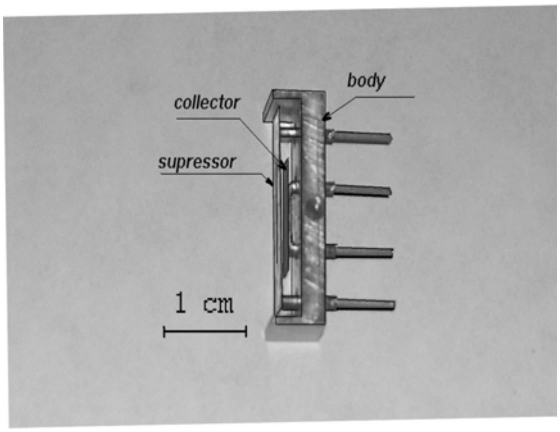

Fig. 9. Collector module.