MULTIFUNCTION TEST-BENCH FOR HEAVY ION SOURCES

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Abstract

The new test-bench for heavy ion sources has been created in ITEP. It is planned to equip test-bench with a set of measurement devices to cover wide range of beam widths, divergences, durations, currents etc. It will provide measurements of different heavy ion beams parameters, particularly, emittance and charge state distribution. The last parameter may be measured both by the time-of-flight method and with the magnet analyzer. Two emittance measurement devices will be installed. It will be possible to use both slit/grid and CCD based "pepperpot" methods, which will give advantages of combination of classical emittance measurements with performance of the CCD based devices. The detailed description of test-bench and its equipment is presented. The first results at MEVVA ion source and beam investigations are discussed.

TEST-BENCH STRUCTURE

The structure of heavy ion sources test-bench is shown on fig. 1. Two independent vacuum tanks are available for time-of-flight and magnet analyzer ion beam spectrum measurements. A 100 mA 20-80 kV high voltage source is shared between those chambers.

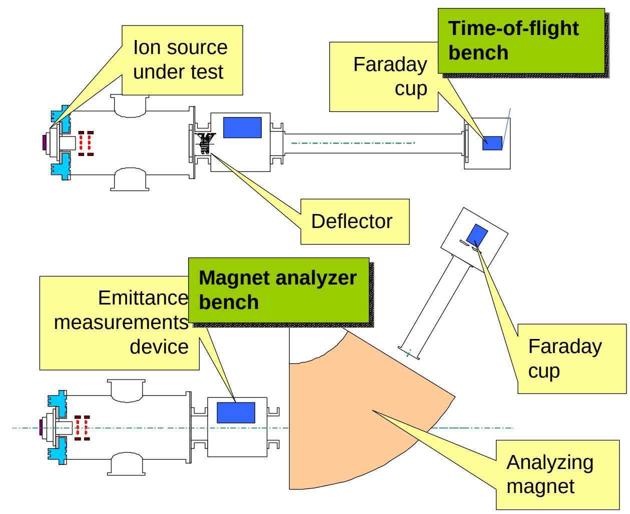

Fig. 1. Structure of the test-bench.

TOF ANALYZER

Time-of-flight (TOF) method allows measuring the charge state distribution (CSD) evolution during the ion beam pulse that can be used for investigation of process into ion source plasma [1].

The ITEP test-bench for TOF measurements includes: cylindrical deflector, drift channel and current detector

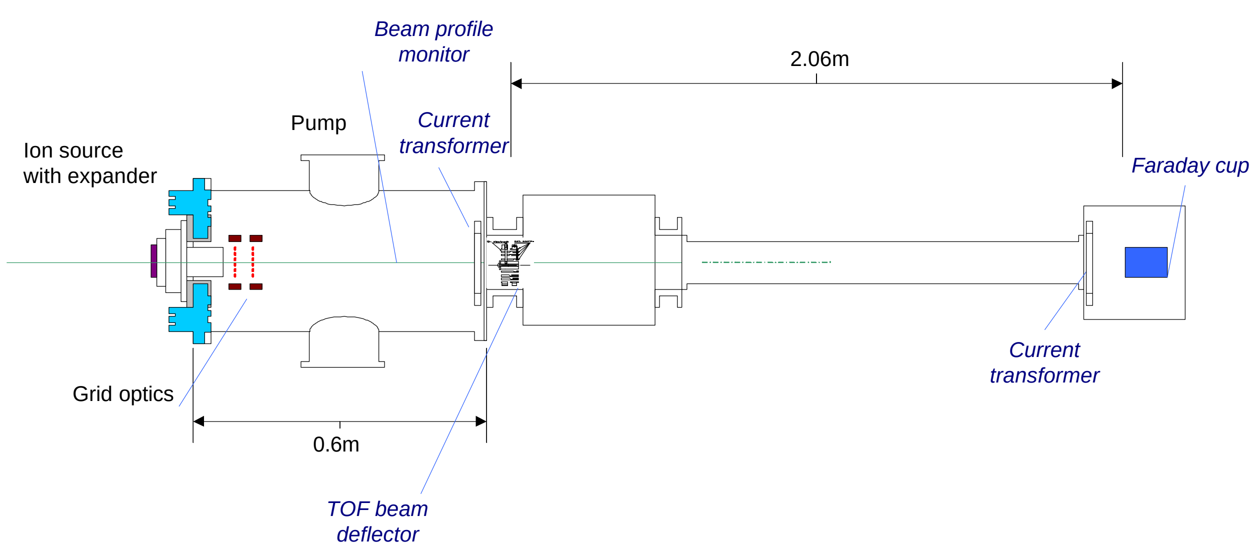

Fig. 2 Layout of TOF test-bench.

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(see Fig. 2). The deflecting voltage pulse has variable amplitude of 0 – 1.5 kV and duration of about 100 ns (Fig. 3). Distance between deflector and detector is 2.06 m length.

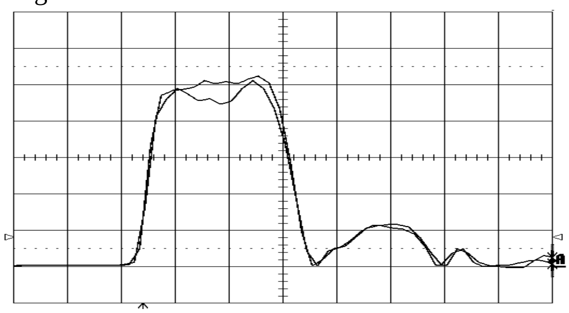

Fig.3. Gate pulse created by LC forming line with ρ=50Ω and thyratron switching unit. Sweep speed is –50 ns/division.

Cylindrical deflector is shown in the Fig. 2. There are two kinds of ring electrodes – grounded and potential. The length of all ground electrodes is 3cm. Deflector has 4 driving gaps with follows parameters:

N	h, mm	L, mm
1	4.4	5
2	7.3	11.4
3	4.3	10
4	4.6	13.6

where h is a gap width, L is a length of potential electrodes. These parameters were calculated for accelerating beam voltage Ubeam=30 kV and deflection voltage Udefl=1 kV. First test showed that accelerating beam voltage Ubeam=24kV and deflection voltage Udefl=1kV are optimal. Additional round plate is placed on the central ground electrode. It has diameter 25mm and in shadow of this plate the detector is placed.

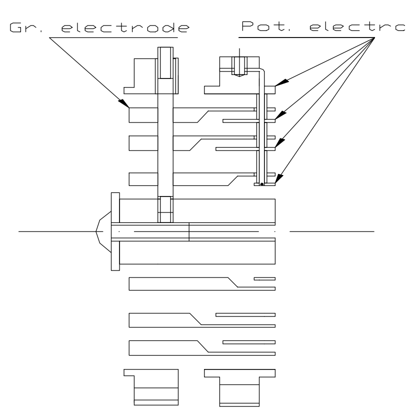

Fig.4. Construction of cylindrical deflector.

First measurements by TOF method at the ITEP test-bench were carried out with copper beam generated by MEVVA ion source. Total current of investigated beam was 25 mA. The typical measured CSD is shown in Fig.5

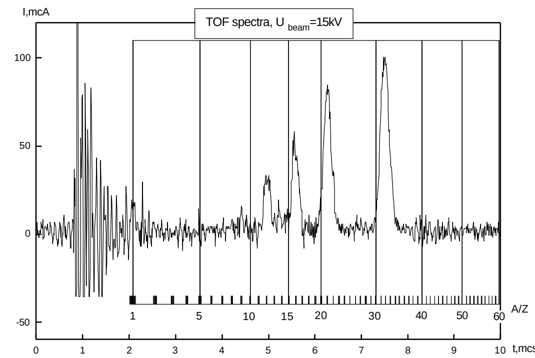

Fig.5. Copper ion beam time-of-flight spectrum measured at ITEP test-bench.

EMITTANCE MEASUREMENTS

Two emittance measurement devices are planned to be installed on this test bench. The classical slit-grid method will be equipped with single platform carrying both slit and grid frames. It allows to reduce number of mechanical feedthrows, diminish the requirements to the platform positioning accuracy and allows to produce compact design of slit-grid assembly. Quite simple configuration is supposed to be used at the beginning. To meet the requirements of wide range ion beams measurements it is planned to update this configuration up to 48 fine spaced commutated wires to increase the gauge performance. The advantages of the direct current measurements with harp detector led used this device for calibration purposes, for radioactive beam parameters measurements and for special measurements with high dynamic range requirements. For routine emittance measurements the ion current-to-image intensity conversion method will be used. This method already has been approved for commissioning measurements of few heavy ion sources in ITEP.

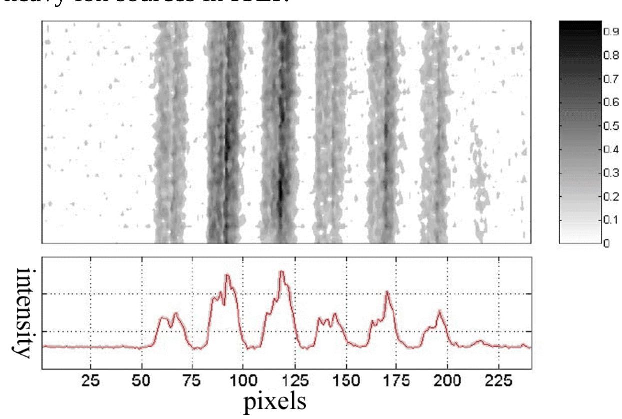

Fig.6. Image obtained in multislit-phosphor screen emittance measurement and integrated intensity values is used for beam emittance evaluation.

Similar device equipped with pepper-pot mask is used widely in ITEP for low energy proton beam diagnostic. On Fig. 6 the CCD image and integrated intensity value along vertical dimension are shown. In this case just simple phosphor screen has been used as ion density detector due to relatively high input ion beam current.

Wide parameters spectrum ion sources are foreseen to be tested on this equipment. A low current and short pulses devices are not excluded. To gain ability to cover parameters of such devices we envisage to use MCP assembly to intensify ion density distribution image.

	dimensions	resolution	Additional parameters
MCP	50x50 mm	0.05mm	Single stage with phosphor screen.
CCD	60x50 mm	0.05mm	Digital interface, 10 bit resolution

Using devices with parameters shown in Table 1 allows maximum six simultaneously operated slits used with phosphor screen with or without MCP to obtain compatible with harp method divergence resolution. Depending of the beam transversal dimension this number may be reduced down to 3 or 2 so few additional slit stepping possibility in transversal direction very desirable. Another configuration with increased slits number by cost of divergence resolution also will be used to provide 'single shot' measurement features.

REMOTE CONTROL AND AUTOMATION EQUIPMENTS

To be able to provide a series of measurements with good performance and high accuracy the automatic system status logging as well as remote device control are important. We consider the distribute chain of embedded front end microcontrollers as a basic configuration for our control system. Most of the needs of test-bench will be covered with set of 8 and 32 bit microcontrollers developed in ITEP and approved in different scientific and industrial applications. CAN bus is chosen as operating network to join microcontrollers and to connect them to the operators terminal. Due to high responsibility level of embedded devices there are no special requirements to the OS stability or hardware reliability of the terminal computer. A desktop PC and Windows OS were selected as basis for operators terminal.

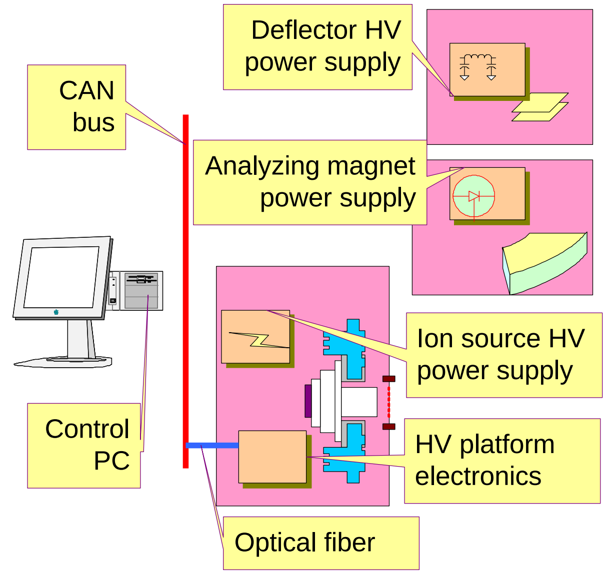

Fig.7. A block-scheme of controlled equipement.

CONCLUSIONS

Described test equipment is being constructing to meet the growing demands of the ion sources developers. Time-of-flight method is currently available. Next stage by stage commissioning stipulates that the possibilities of this test-bench will extends in time depending on number of participants and economical reasonability.

REFERENCE

[1] I.G. Brown, J.E. Galvin, R.A. MacGill, and R.T. Wright. Improved time-of-flight ion charge state diagnostic.RSI 58 (9), 1987, pp.1589 – 1592.