THE DEVELOPMENT OF THE IONISATION DETECTORS FOR MEASURING THE MAIN PARAMETERS OF THE ACCELERATED IONISING BEAMS.

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Abstract

Some results of the testing of proposed before multiparameter accelerated beam crossection image detectors (BCID) are presented. A non-destructive BCID was constructed for the measurement of the parameters of the low energy beams, typical for the ion sources. Experimental estimation of the deflector voltage influence on the detector parameters was carried out. The specialised BCID construction was developed which performs the on-line measurement of the beam position shift in the ion transporting lines. The time-of-flight system for the operative determination of the cyclotron beam energy with the accuracy better than 1% was constructed. The prototypes of the detectors were prepared for the investigation of their applicability on the synchrotron radiation (SR) beams. Qualitative results of this model testing with the SR beam on DCI (Orsay) are described.

1 INTRODUCTION.

Ionisation beam crossection image detector (different to usual ionisation profilometer [1]) was developed and investigated at Russian Research Centre “Kurchatov Institute” (RRC KI) [2,3] (Fig. 1).As well as in usual profilometer BCID detects the distribution of the residual gas ions along the slit L, perpendicular to the beam axis.

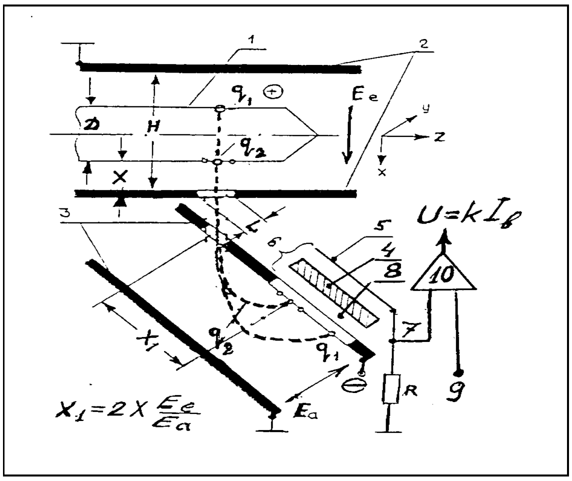


Fig. 1 Simplified scheme of the beam crossection ionisation detector. 1 - the beam under investigation; 2 - extractor; 3 - analysator; 4 - MCP; 5 - scinscilating screen; 6 - opened ICT; 7- output signal for the beam current monitoring; 8 - additional accelerating interval; 9 - corrective signal; 10 - regulated amplifier

Besides, the energy distribution along the X axis, perpendicular to the slit and to the beam axis is analysed according to the expression (see Fig. 1) :

$$X_1 = 2 \times X \times \frac{E_e}{E_a}$$

A resolution of such detector is defined by the slit width. The image of the real distribution of the beam

Table 1

Facility	Institute	Country	Particle type	Energy, MeV	Sensitivity threshold nA/cm^2
Tandem	PH E I	Obninsk, Russia	O_4^{16}	15	1
Cyclotron	RRC KI	Moscow	Li_3^6	90	5
Cyclotron	RRC KI	Moscow	P	30	10
Cyclotron	JINR	Dubna, Russia	O_4^{16}	200	10
UNILAC	GSI	Darmstadt, Germany	Se_{12}^{82}	360	10

crossection is formed in the plane of analysator output plate. Through the opened image converter tube with two micro channel plates the image is recorded by the commercial TV camera and processed by the computer. The example of the beam crossection registration and its processing are presented on Fig. 2.

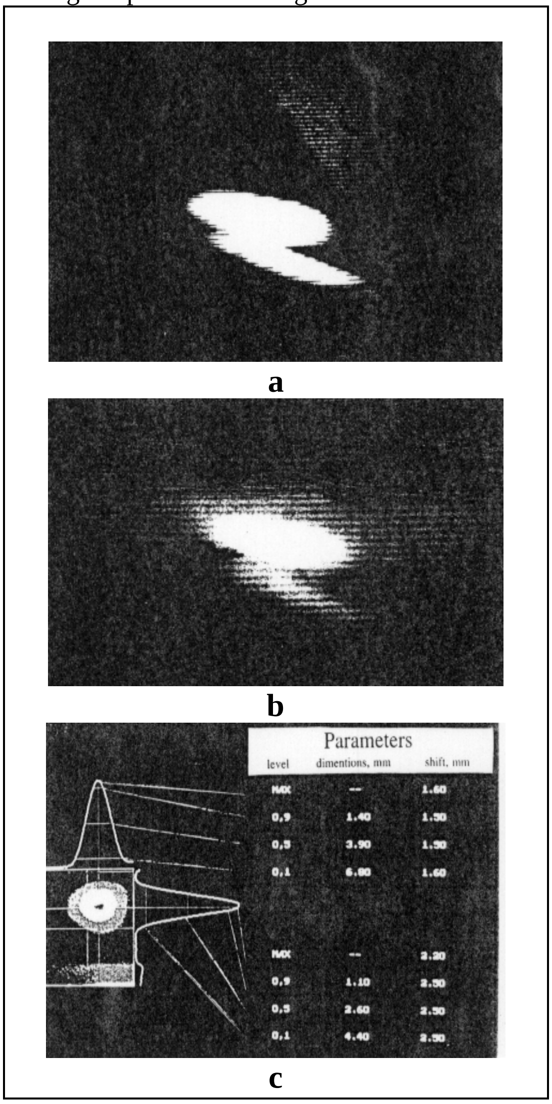


Fig. 2 TV image of the beam crossection. a - by the intercepting detector; b - by the non invasive detector; c - example of the computer representation of the beam crossection;

2 EXPERIMENTAL RESULTS. THE WORKS DEVELOPMENT.

The BCID were tested and are used in the ion transporting lines under pressure of 10^{-5} - 10^{-7} Torr. The sensitivity threshold for the used structures (BCID, image converter tube (ICT) and TV camera) is defined by the pressure of the residual gas, ionisation radiation type and its energy. Table 1 presents the sensitivity threshold for different ion sources:

Such BCID are used for several years in Rossendorf research centre (Germany) and at the cyclotron of University in Yuvaskule , Finland. Four BCID are in use at RRC KI cyclotron and seven more are now under installation. The comparative tests of the beam size and position were implemented for the BCID and orthogonal wire detector at UNILAC (GSI, Darmstadt, Germany) [4]. Many hour exposition with 360 MeV Se_{12}^{82} beam and the current 10 nA - 5 mkA showed good accordance in the size and the position of the beam and proved the BCID stability.

The additional signal from a vacuumetr was used for the correction of the output current of the ICT (Fig. 1, pos. 9). The amplification coefficient is determined to be $K \sim 1/P$ where P is the residual gas pressure.

The ICT scintillation screen is divided into four isolated one from another quadrants. Thus there exists an opportunity through measuring separately of the quadrant currents and further processing by the summing and differential amplifiers to obtain the signal proportional to the up-down and left-right shifts of the beam crossection centre. This signal can be used for the on-line control of the beam correctors.

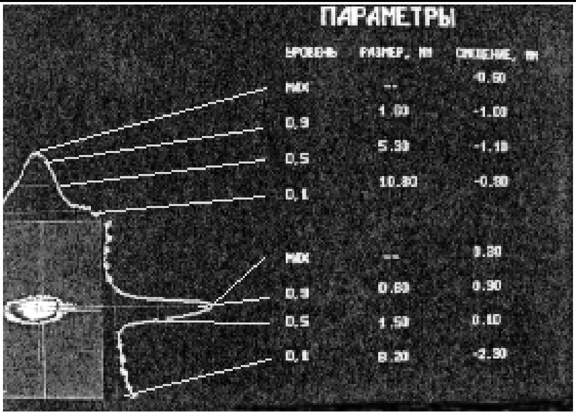
The tests of the BCID with the compensators of the low energy (10-100 keV) beam shift in the extractor field were carried out. The visual beam monitoring for the proton beam with the energy 20-25keV shows that the outcomming beam practically returns on the beamline axes. The decreasing of the extractor voltage from 2kV/cm down to 200V/cm reduced the beam shift in the extractor to the tenth part of the mm. But this leads to the diminishing of the effectiveness of the residual gas ions registration by the micro channel plate (MCP) likewise [5,6]. In order to keep the effectiveness consistent while decreasing the beam deviation in the observation area it was proposed to add another accelerating interval between the output plate and the input MCP of the ICT (Fig. 1, pos. 8).

Microbunch monitoring for the structurised beams [2,3] (such as cyclotron ones) was advanced in construction and resolution. In this case the ionisation electrons are registered, because they have much smaller time of flight in the detector. The accumulating and processing of the output ICT current signals from the different microbunches makes it possible to obtain the integral mirobunch shape Three such devices are installed at the RRC “Kurchatov Institute” cyclotron for the microbunch parameters monitoring during the time-of-flight experiments. On the 12 m time-of-flight base the energy measurements accuracy is better than 0.5%.

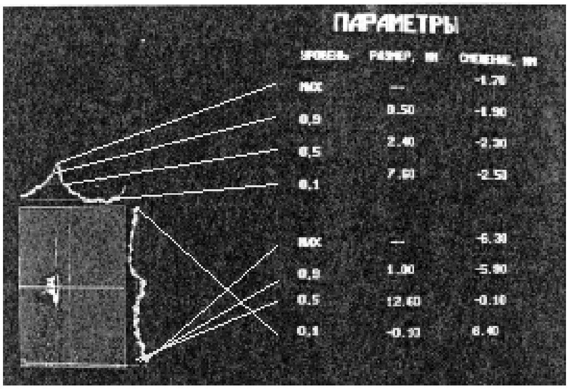
3 SYNCHROTRON RADIATION MONITORING.

Evidently, the BCID can be used for the registration of any kind of the ionising radiation, including synchrotron radiation (SR). The first experiment of the SR registration was taken place at the DCI beam (LURE

Orsay). The specialised BCID inside an isolated box with an individual pumping was prepared. The working chamber is separated from the beamline or atmosphere by two transparent for x-rays Be foils, 200 micron thickness each with the window size 50×10 mm. The first experiments were carried out under the following conditions: the mean DCI beam current 200mA, the distance from the SR source 15.5m, SR was filtered by the 620mkm of Be in the beamline and the detector input window. The vertical and the horizontal collimators were situated at a distance of 1.5m before the detector. Photoemission scanners before the BCID makes it possible to check the horizontal and vertical beam profiles. As was expected according to the estimations the sensitivity of the air filled BCID was low. So the research was performed with the BCID filled by Argon at the pressure $P = 2 \times 10^{-5}$ Torr.



a



b

Fig. 3 a - the example of the SR beam density distribution along its crossection, presented by the computer. b - the image of the beam which partly goes through the closed slit

Fig. 3a shows the SR beam density distribution along its crossection, presented by the computer. The beam was collimated by the slits to 5mm in vertical and 10mm in horizontal direction. It is necessary to mention that the results are in good agreement with the photoemission detector ones. High sensitivity of the detector is illustrated by the Fig. 3b. The horizontal collimator was completely closed. It can be seen that in this case the radiation partly goes through the closed slit. The existing photoemission scanner didn’t registrate this fact.

4 THE WORK DEVELOPMENT MAINSTREAMS.

1. The expanding of the intensities and energy bands, investigated by the ionisation diagnostics. 2. The further increasing of the sensitivity and the resolution, the development of the computer processing and the representation of the information about the beam parameters. 3. The application of the ionisation diagnostics for the wider accelerator types. 4. The construction of the basic detector model for the wider use. 5. The development of the ionisation detectors for a registration of SR beam parameters.

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