DETECTORS FOR SLOWLY EXTRACTED IONS IN HIRFL-CSR*

R.S. Mao#, J.W. Xia, T.C. Zhao, Z.G. Xu, B. Tang, Z.G. Hu, J.X. Wu, H.S. Xu, G.Q. Xiao, Y.J. Yuan, J.H. Zheng, IMP, Lanzhou, China

Abstract

This paper gives the detectors used for slowly extracted heavy ions from CSR. The beam profiles are measured with viewing screens and anode-striped ion-chambers. The currents are determined with scintillators and ion-chambers. The signal processing system and the measurement results are also presented.

INTRODUCTION

HIRFL-CSR [1] is a double cooling-storage-ring system with a main ring (CSRm) and an experimental ring (CSRe). The beam is accumulated, cooled and accelerated in CSRm, and will be extracted in slow extraction [2] mode for many external-target experiments. The ions can be accelerated to 200~1100MeV/u and the number of stored ions ranges between 10^6 and 10^9. The spill length will be several seconds (actually during the CSR commissioning it was always set to three seconds), so the beam current is about 106 ~ 109pps. In this range, the typical detectors such as the ionization chamber (IC), the scintillator, the diamond monitor or secondary electron monitor (SEM) can be used for beam intensity measurements [3], the gas filled grids and viewing screens for beam profile measurements. These devices are commonly used for many years in GSI, CERN, etc [4][5]. In HIRFL-CSR, the anode-striped ion-chamber is installed to measure the beam profile, and the scintillation screen with CCD to measure beam profile directly for high intensity beam. For beam intensity measurement (lower than 10^9pps), the use of the IC together with scitillator filled the measurement requirements. For the convenience of the commissioning, we installed the scintillator detectors as beam loss monitors on the upside, downside, left side and right side of the beam tube to monitor the beam transmission status and help to judge the beam direction. In Jan. 2008, the beam extracted by RF-knock out method was measured for the first time. The detectors and some results are given below.

IONIZATION CHAMBER AND SCINTILATOR

In the beam line, the IC and scintillator are installed together(similar to the detector of GSI [4]) into the pockets [6] with 60mm×60mm entrance window (50µm stainless-steel), shown in Fig.1. To prevent the detector from radiation damage, it will be pulled in only if it is necessary. The anode-stripped ion-chamber is chosen so that the beam intensity and profile could be measured simultaneously. The plate of the anode and the cathode are made of ultra-thin printed circuit board with the thickness of 0.1mm. The schematic of detector is shown in Fig. 2.

*Work supported by the center government of China and NSFC
#maorsh@impcas.ac.cn

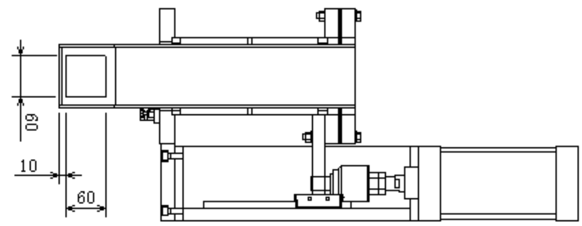

Figure 1: Detector pockets driven by pneumatics (CF150).

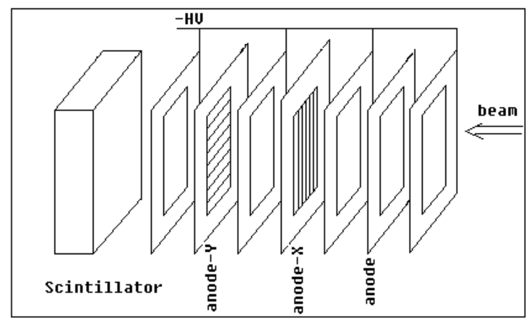

Figure 2: Structure of detector in pocket.

Taking one detector in the beam line as an example, the width of the anode strip is 2.7mm and the interval is 0.3mm, the space between the two plates is 3mm. The sensitive area is 45mm*45mm. At present, the detector gas is air (except one detector filled with nitrogen), but in the future it will be nitrogen for all. The voltage is about -10V~-400V and can be adjusted during measurement process. The current produced by the strip or whole anode of IC is converted to voltage signal using I/V converter and then sampled directly with NI-PXI-6133 A/D card [7]. The real time beam profiles or intensity can be given using the LabVIEW. One of the results is shown in Fig.3 (one strip signal is lost because of the broken cable).

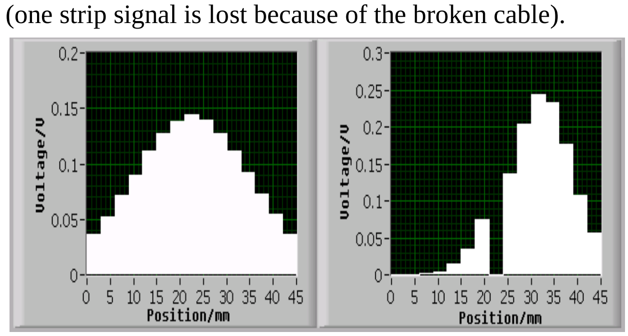

Figure 3: Beam profile left: profile x, right: profile y.

The detector at the experiment terminal is installed in air without pocket, the structure is similar to which installed in beam line, except the sensitive area, the width and the number of the anode strip.

For convenience and low cost, the scintillator is manufactured with the CSI (T1) by IMP. The data acquisition system is based on the NI-PXI-6602 and the LabVIEW software. One of the measurement results of the spill is shown in Fig.4. From that we can see clearly that the frequency of substructure is 50Hz.

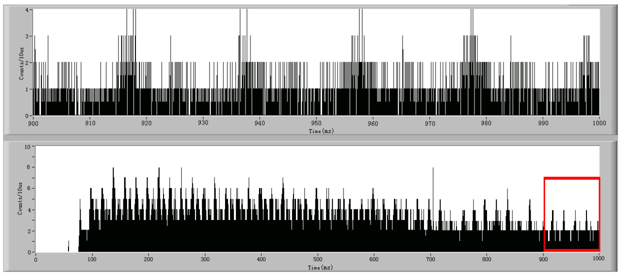

Figure 4: Spill structure (zoomed and total) measured by scintilator (sampling rate is 100 kHz, C6+, 200 MeV/u).

BEAM LOSS MONITOR

At the first commissioning of slow extraction, we installed four scintilators to measure the beam losses. The detectors were located at up, down, left and right position of beam tube, at the point where the pipe is narrow. Normally the counts from four channels will be very low and nearly equal if the beam is at the center of beam tube. Figure 5 shows the counts from the detectors.

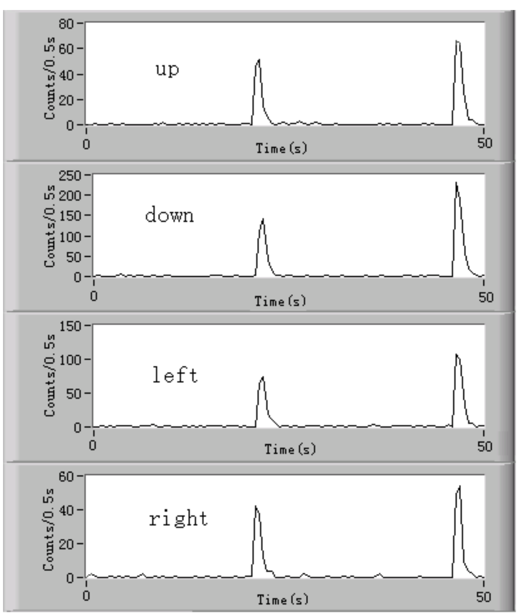

Figure 5: Counts from four scintilators.

VIEWING SCREEN

The chromolux screen with a CCD camera for observation of the light spots is a very simple, reliable profile monitor. Figure 6 is one of the measurement results with slow extraction.

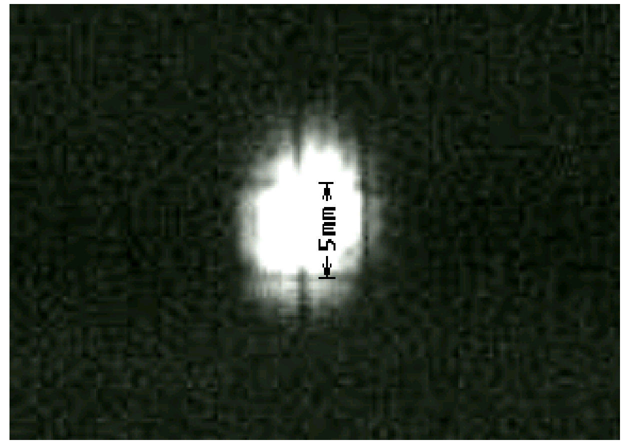

Figure 6: Beam profile (C6+, 200MeV/u).

NEXT STEPS OF DEVELOPMENT

Calibration has to be done for high precision measurement. MWPC for profile measurement of weak beam, such as secondary ions, is still under development. The current-to-frequency converter now is available, and will be used in IC signal processing system soon.

ACKNOWLEGMENT

The authors want to thank all the colleagues at GSI who gave us valuable information and contributed to our work.

REFERENCES

[1] J.W. Xia, et al, “Construction and commissioning of the HIRFL-CSR”, APAC’04, Indore, India, p.534;
[2] Y.J. Yuan, et al, “Design of slow extraction for HIRFL-CSR”, APAC’01, Beijing, China, p.484;
[3] Peter Strehl, “Beam instrumentation and diagnostics”, Springer, 2006;
[4] P. Fork, T. Hoffmann, A. Peters, “Detectors for slowly extracted heavy ions at the GSI facility”, DIPAC’97, Frascati, Italy, p.165.
[5] Peter Fork, “Lecture notes on beam instrumentation and diagnostics”, Joint University Accelerator School, January – March 2008.
[6] O. Klepper, et al, “First steps towards radioactive beams in the experimental storage ring at GSI”, NIMB, Vol70, Issue 1-4, p.427.
[7] http://www.ni.com.