NEW BEAM PROFILE MONITORING SYSTEM AT EXTRACTION FROM U-70

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In the course of upgrading Instrumentation of extracted beams at IHEP the new beam profile monitoring system has been developed and commissioned. It incorporates many improvements towards lower amount of monitor substance to be placed in the beam path, lower cable expenses, higher radiation and noisy resistance, wider dynamic range. New circuitry allows one to measure profiles separately for each extraction in one machine cycle. The system has a capability for multiple measures of beam profile during the slow extraction for exploring dynamic effects. The paper describes hardware and software of system.

INTRODUCTION

At IHEP fixed target-based physical experiments require 70 GeV extracted proton beams ranging from $10^7$ to $3 \times 10^{13}$ ppp. One-turn fast extraction (FE) supplies beams at $5 \times 10^{11}$ to $3 \times 10^{13}$ ppp intensity range. Beam spill time of 0.7 to 2 s has been achieved with slow extraction (SE), resonant ($5 \times 10^{11}$ to $3 \times 10^{13}$ ppp) and bent crystal-based SE [2] ($10^6$ up to $10^{12}$ ppp). Typically, arbitrary combinations of these extractions at the accelerator cycle is used and a time interval from each other is of 200 ms. Last years some improvements of extraction system have been performing to respond to the new needs for experimental physics and many features of the system are in a state of flux. Some sophisticated phenomena inherent at SE cause the distortion of the spill and instability of space parameters of the extracted beam. The IHEP Extraction Area with transportation lines is rather extended (more than 450 m). Here there are high electromagnetic noises (50 Hz line, magnets power supply, vacuum equipment, etc.) and high radiation field because of the beam losses near the septum magnets and internal targets. A successful operation of extraction under circumferences given above requires a good, reliable beam instrumentation tools, first of them is the Beam Profile Monitor (BPM) System. The obsolete non-uniform stand alone BPM System was not able to meet the new more stringent requirements. The new BPM System commissioned in March '02 has been designed with following challenges in mind:

- Wide dynamic range and prompt sensitivity adaptation when different modes of extracting are used at the single accelerator cycle;
- Multiple measurements taken over the single spill are very useful for investigating dynamic processes accompanying SE;
- High noise and radiation immunity;
- Run under the U-70 Control System;
- And, finally, high reliability, an easy of maintenance and upgrading, low cost.

The basic data of this system were given in [1]. This paper presents more detail description of components of the new BPM System.

GENERAL

The BPM System is the distributed one and is composed of two levels as shown in Fig.1.

- The first level comprises beam profile monitors (PM) located upstream of each septa and at other places of interest with an associated Front End Electronics (FEE) packaged in miniature home made crates. FEE performs parallel writing and sequential reading signals from monitor electrodes. The crates are located at the tunnel basement where the radiation levels are low;

- The second level is the Back End Electronics (BEE) performing the main bulk of signal processing. In addition, BEE produces all the control signals and receives a number of status information and, finally, implements communication with the U-70 Control System. BEE is located at the Extraction Control Room.

Cable set of the BPM System has been chosen to meet a good compromise between an acceptable noise influence and cable cost and flexibility for the development of the System. The adjacent FEE crates are combined in 6 groups (capacity of the group is 8 crates). Each group is supplied with the separate screened multicore cable from the BEE, then daysy chaining from the crate to crate is used. Multiplexed signals from each FEE crate are fed via an individual matched coaxial cable to the BEE.

Fig.1: Simplified block diagram of the Beam Profile Monitor System at Extraction from U-70
To cope with full range of beam intensity described
system has 6 grades of gain factors with 13dB step. Gain
preselection for each used extraction is done at will in
dependence on expected intensity of the extracted beam.
Gain setting over magnetic cycle is shown in Fig.2,
illustrating the basic stages of functioning the system.
Note, offset measurements are done when no the beam at
the ring. Also, selected parameters of the System are the
gate duration, number of measurements over the spill, as
well combination of the activated PM’s.

Monitors
Location and basic features of the Profile Monitors (PM)
are given in Table 1. There are three versions of the PM
design:
- Thin wall (30 µm) capillary tubes of nickel, 0.5
  and 1.5mm diameter, are used as electrodes. They
  are very simple and cheap.
- Electrodes are composed of thin Al strips
  sputtered on a Capton film. That s very low density
  of the matter placed in the beam path. Both versions
  harness the second emission effect.
- Ionization air filled grids under pressure of 1 to
  10 Torr. They (LIPM) cover the low intensity part of
  range and are located at the transportation Lines 8,
  22, one per Line.
Majority of PM are movable. The actuators produces
monitor positioning and provide status bits delivered from
Limit Switches (LS). Any number of the PM’s can be put
on simultaneously because of weak influence on the
beam. Detailed description of these PM’s is given in [3].

Front End Electronics
A simplified block diagram of the FEE is shown in Fig.3.
Currents from the PM electrodes are fed via composite
thin coaxial cables to the current integrator assembly. It
consists of 32 identical charge-to-voltage amplifiers
followed Track-and-Hold circuitries. Three feedback
integrating capacitors (51pF-1nF-20nF) allow one to
change gain as 52dB-26dB-0dB. Low input bias current
and offset voltage OP Amps as well as low leakage
switches for resetting and selecting feedback capacitors
are used to measure pA current. Outputs of amplifiers are
proportional to the integral of the input currents over the
gate interval are fixed when the gate is off. Then holded
levels are time multiplexed by TTL inputs containing the
binary channel number. Multiplexed voltage is amplified
by factor 0 or 13dB. That amplifier has an output current
buffer with cable driving capability to ensure high noise
immunity. A special current booster is used to drive the
PM actuator (PM Drive). Auxiliary electronics comprises
level changers, decoders, status signal receivers, test
devices, etc. To keep high radiation resistance components with MOS structure are no in use. FEE has
been made in a plug-in fashion for easy replacement. The
FEE crate with connected cables is shown in Fig. 4.
Software

Software of the BPM System as a part of the U-70 Control System [5] includes the application programs of both upper and low levels. The application software of the low level executes the control of the Electronics and data acquisition. The upper level of software performs controlling System, services dialog function allowing one to choose and display measured data, to set the system parameters, to show and change the status of the apparatus, to store the data. Software interaction is arranged via the Data Base. More detail description of the software will be published later. Below the typical beam profiles are given as an illustration.

Table 1: PM basic features

<table>
<thead>
<tr>
<th>Location or Nickname</th>
<th>Using</th>
<th>Number of electrodes</th>
<th>Step, mm</th>
<th>Amount of matter mg/cm²</th>
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REFERENCES