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## ABSTRACT

For the project of accelerating polarized protons in KEK 12 GeV proton synchrotron, a polarized ion source, a 750 keV Cockcroft-Walton preaccelerator and a 750 keV beam line to the 20 MeV linac were constructed. In this 750 keV and the 20 MeV linac beam lines, high sensitive current monitors, profile monitors and polarimeters were installed. These beam diagnostic apparatus and the results on beam test of them are presented.

## INTRODUCTION

A three years project of the polarized preaccelerator was completed. An optically pumped polarized negative hydrogen ion source<sup>1)</sup>, a symmetric 750 kV Cockcroft-Walton generator with a high voltage terminal and a 40 m long beam transport line have been constructed. One of the technically difficult problems of the project is development of extremely high sensitive monitors<sup>2)</sup>. In routine operation of the 12 GeV proton synchrotron at KEK, 750 keV proton beam of 200 ~ 300 mA are injected to the linac and 130 ~ 150 mA are accelerated to 20 MeV. On the other hand, the polarized beam current is less than 1/10000 of the ordinary proton beam. It is obvious that all monitors for the proton beam are not sensitive to the polarized beam.

Therefore, high sensitive current monitor, profile monitor are developed. Polarimeters are also made for 750 keV and 20 MeV beam.

## CURRENT MONITOR

From parameters of polarized H<sup>-</sup> beam in Table 1, current monitors were designed to satisfy the next characteristics.

Resolution	:	< 0.3 $\mu$ A
Rise (fall) time	:	< 20 $\mu$ s
Sag	:	< 5 % (at 100 $\mu$ s)

The toroidal transformer consists of a Senpermax core (50  $\mu$ m thick, TOKIN Co. Ltd) wound with a 200 turn coil and is encased in a low carbon steel shield. In addition, the transformer is set outside of a ceramic beam pipe in the atmosphere. This is suitable for a high vacuum eliminating a out gas source, and makes its maintenance easy. It is fixed so that it has no mechanical contact with beam pipe to avoid noise from mechanical impacts and vibrations.

The amplifier of this current monitor is a simple three stage one with a low noise operational amplifier in the first stage. The current monitor installed in the beam line is shown in the right hand side of Fig. 1 and cross section of the transformer is in Fig. 2. In Fig. 1, aluminum foils wrap the transformer not for electromagnetic shield but for by-pass of noise currents on the beam pipe, so the foils must contact beam pipe as strongly as possible. The waveforms of the 750 keV polarized beam are shown in Fig. 3 and 4.

The main problems of this monitor were noise from AC lines and beam pipe currents. The former was reduced by use of a low carbon steel shield, the latter was by-passed with aluminum foils.

For the 20 MeV line, the same type monitor is used but the other noise problem appear. These noises come from the linac rf modulator and the pulsed power supplies for quadrupole magnets in drift tubes. The reduction of these noise signals is problem in future. Figure.5 shows the waveform at the 20 MeV line.

## PROFILE MONITOR

On the basis of the parameters of polarized beam

in Table 1, the aperture of the monitor must be much more than 40 mm, the resolution be more than 2 mm, and the measurement can be done at the total beam current of 1  $\mu$ A. Therefore, the monitor head was made to have an array of 32 horizontal and 32 vertical beryllium copper wires of which spacing is 2 mm. The diameter of the wires are 50  $\mu$ m and they are mounted on both side of a ceramic plate.

The electronics consists of 64 current to voltage converters with S/H, a 64 ch multiplexer and a control unit for the motor driver and the ratio (gain) selection of the current to voltage converters. The ratio (gain) of them is 11 V/1  $\mu$ A at low gain (ratio) and 220 V/1  $\mu$ A at high gain (ratio). Usually, they are used at low gain.

Fig. 6 and 7 show the profiles of 750 keV polarized beam. The lower trace is position marker signal.

The ratio of induced signal current on wire to (polarized) H<sup>-</sup> beam current colliding to wire is about 4.2 at 750 keV. On the other hand, the ratio of ordinary proton beam is about 5.0.

POLARIMETER<sup>3)</sup>

The polarization is measured from asymmetry of left and right particles scattered by the target.

Li<sup>6</sup> target is used for 750 keV polarimeter. The arrangement of this polarimeter is shown in Fig. 8. The backing foil on which Li<sup>6</sup> is evaporated ( $\sim$  30  $\mu$ g/cm<sup>2</sup>) is a thin carbon foil (120  $\mu$ g/cm<sup>2</sup>) to avoid elastically scattered protons by the target. As Li<sup>6</sup> is apt to be a nitride quickly in atmosphere, the target is preserved in naphtha in general. But this method is troublesome. We now plan to connect the evaporation chamber to the polarimeter chamber so as to avoid exposing the target to atmosphere. The polarization at the 750 keV line was about 60 %.

C<sup>12</sup> target is used for 20 MeV polarimeter. The target is a bundle of about a hundred carbon fibers of which diameter and density is 8  $\mu$ m, 1.8 g/cm<sup>3</sup>, respectively. The arrangement of this polarimeter is shown in Fig. 9. The polarization at the 20 MeV line was about 40 %.

## CONCLUSION

High sensitive current monitor and profile monitor are developed and used for polarized beam at 750 keV and 20 MeV beam lines. The toroidal current monitor has a resolution of 10 nA at the 750 keV line, while noise from the high power RF system and pulsed power supplies of Q-magnets in drift tubes should be reduced at the 20 MeV line. Beam profile is measured by the multi-wire profile monitor at 750 keV line.

Polarimeters are made for 750 keV and 20 MeV beam. At the 750 keV line, the target is Li<sup>6</sup>, and polarization was about 60 %. While the target is C<sup>12</sup>, a bundle of carbon fibers at the 20 MeV line and polarization is about 40 %.

## REFERENCES

- 1) K. Ikegami et al., "PRESENT STATUS OF KEK POLARIZED ION SOURCE", Proceeding of this symposium.
- 2) Z. Igarashi et al., "BEAM MONITORS FOR POLARIZED BEAM", Proceeding of the 4th symposium on accelerator science and technology. November 1982, pp.143 - 144.
- 3) Ge. Olsen, "Techniques of Polarization Measurement - A Survey", Int. Symp. on Polarization Phenomena of Nucleous., 1075, pp.287 - 305.

Beam current	:	~ 10 $\mu$ A
Beam width	:	< 100 $\mu$ S
Beam size (750KeV)	:	< 40mm
(from envelope function)		

Table.1 Parameters of polarized beam.

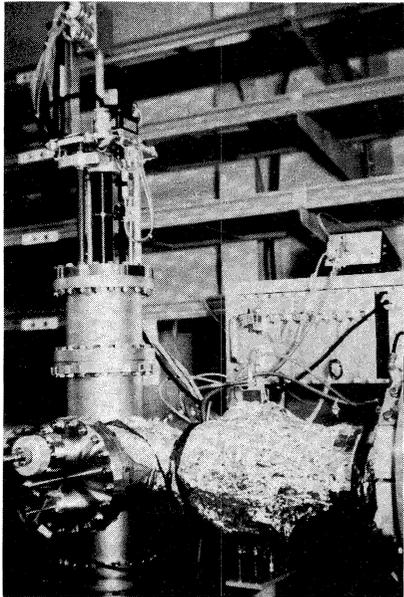


Fig.1 Current and profile monitor set in 750KeV line.

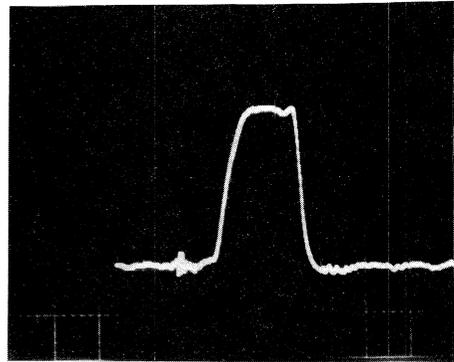


Fig.3 Current monitor NO.2 signal. (2.5 $\mu$ A/div , 50 $\mu$ S/div)

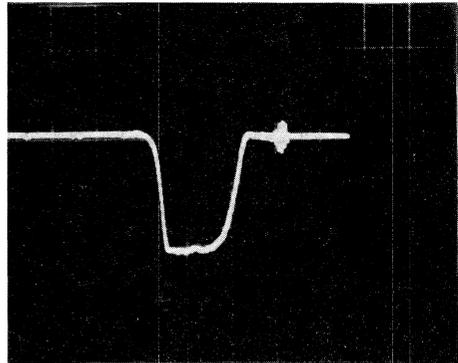


Fig.4 Current monitor NO.4 signal. (2.5 $\mu$ A/div , 50 $\mu$ S/div)

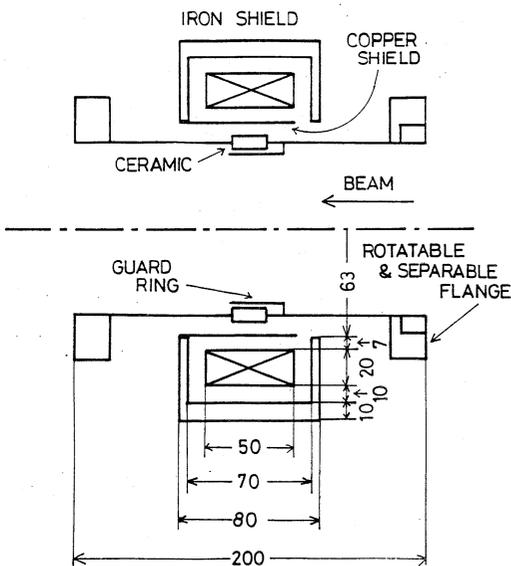


Fig.2 Cross section of the transformer.

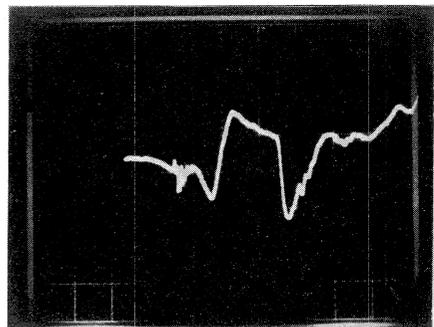


Fig.5 Current monitor (20MeV) signal overlapped with noise. (1 $\mu$ A/div , 50 $\mu$ S/div)

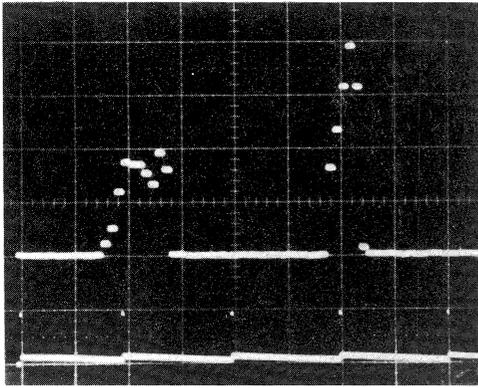


Fig.6 Profile monitor NO.3 signal.

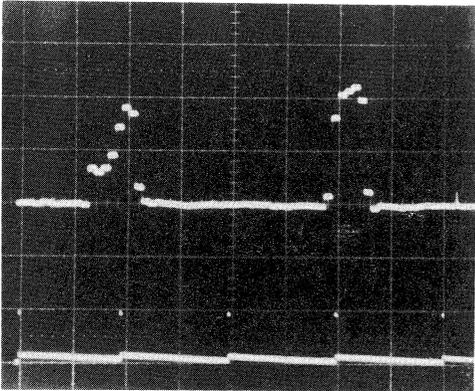
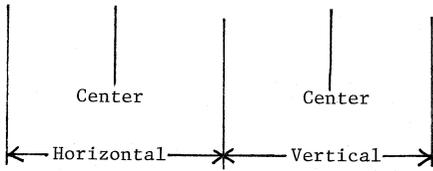


Fig.7 Profile monitor NO.8 signal.

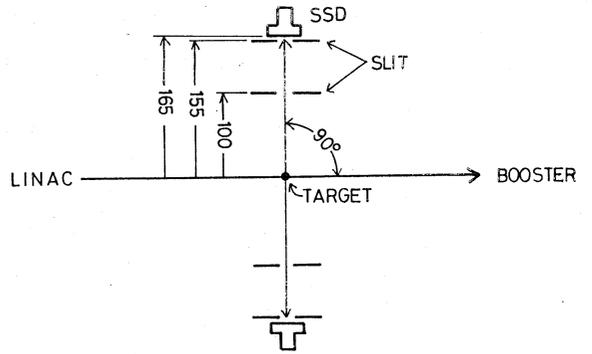


Fig.9 20MeV polarimeter.

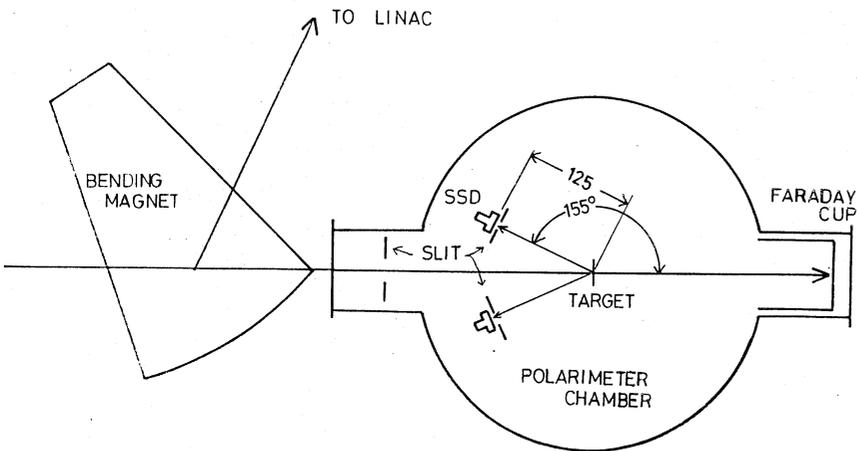


Fig.8 750KeV polarimeter.