GAS IONIZATION TYPE BEAM POSITION AND INTENSITY MONITOR

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Beam position and intensity have been measured by application of the non-destructive profile monitor.[1]

Primary protons traverse an ionization chamber which was installed in a short straight section in the KEK 12 GeV proton synchrotron. The ions produced by the proton beam were accelerated to the grounded grid, whichserved as an electrostatic shield, and collected on a diagonally cut electrode. The electrode was 320 mm wide, 300 mm long and 100 mm high. The grid aperture was 120 mm by 100 mm. The grid consists of 0.1 mm diameter wire 2 mm apart spaced 10 mm from the collector. The diagonally cut rectangular electrode was 170 mm wide and 120 mm long. The applied voltage was 1 kV which corresponded to an electric field of about 140 V/cm. To improve the uniformity of the electric field, dividing electrodes and resistors were installed. A thick stainless steel window frame whose inner dimension was smaller than the aperture of the electrodes was placed upstream of the electrodes to absorb secondary electrons produced by high energy protons collide with the vacuum chamber walls. The ion collectors were electrostatically screened by a thin stainless steel sheet. The beam position is given by $\Delta R = K(A - B)/(A + B)$ where K is constant due to the geometry of collection electrodes, and A and B are the output of the outside and the inside of the ion collector. K is 85. The beam positions of the main ring by the gas ionization type position monitor and the ordinary electrostatic pickup type position monitor are shown in Fig.1. It is under testing to use the gas ionization monitor for the signal source of R feedback for RF cavity. This gas ionization monitors are insensitive to bunched or debunched of beam.

Assuming the ion collection efficiency and vacuum pressure are constant, output signal is proportional to $(A + B) \propto I_p\sigma(E)$ where $\sigma(E)$ is ionization cross section of residual gas and I_p is the output the slow current transformer. Typical sum signal from the ionization chamber and the beam current of the main ring are shown in Fig.2. To obtain the beam current from the output of the ionization chamber the correction is necessary as follows. $I_p \propto (A + B)/\sigma(E)$ Then precise relative ionization cross section of residual gas in accelerator would be desirable.[2]

The relative ionizaton cross section therefore given by $\sigma(E) \propto (A + B)/I_p$. An automatic pressure controller (Granville-Phillips Co.) was installed in the monitor vacuum chamber. The pressure was set to 2×10^{-6} torr. Pressure variation was within 1 % over the time taken for a measurement. The signals from the ion collectors were fed to the amplifier and cable driver which were near the detector. Signals from the adder corresponding to the output of the ionization chamber and the output of the slow current transformer were fed to a transient recorder Biomation 8100, and two transient recorders were interfaced to mini-computer[3]. The accuracy of the relative ionization cross sections is approximately 1 %. The smaple number was 970 from acceleration start to acceleration start to acceleration stop. The ionization cross section of air for protons was displayed on the graphic terminal Tektronix 4010 as shown in Fig.3. Ionization cross section of H_2, He, N_2, Ar, and CO_2 were measured for protons of kinetic energies 0.5 - 8 GeV. In particular, air was measured for protons of kinetic energies 0.02 - 8 GeV. Comparison was made between the measured value and Sternheiner's[4] calculated value for air as shown in Fig.4.

The design and construction of the slow current transformer of main ring accelerator due to the efforts of Dr. S. Hiramatsu.

Reference

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2. W.H. Deluca, High Energy Particle Accelerator Conference, NS-16, no.3, '69.
3. N. Katoh, et al., Control Computer System for KEK Proton Synchrotron, 1977 Particle Accelerator Conference, Chicago.
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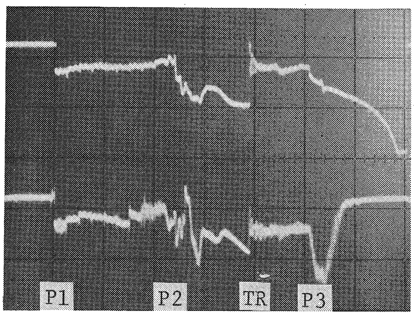

Fig. 1. upper: Beam position of the main ring by the gas ionization monitor.
lower: Beam position by ordinary electrostatic pickup. 10 mm/div. 0.2 sec/div.

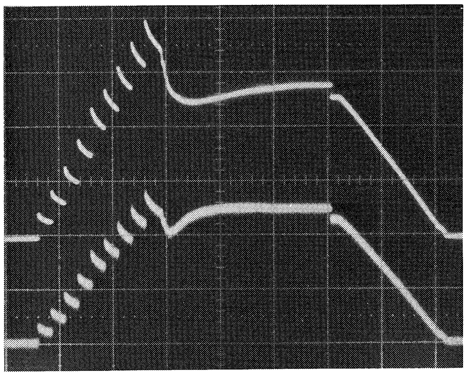

Fig. 2. upper: Sum signal from the ionization chamber.
lower: Beam current of the main ring by current transformer.
0.2 sec/div.

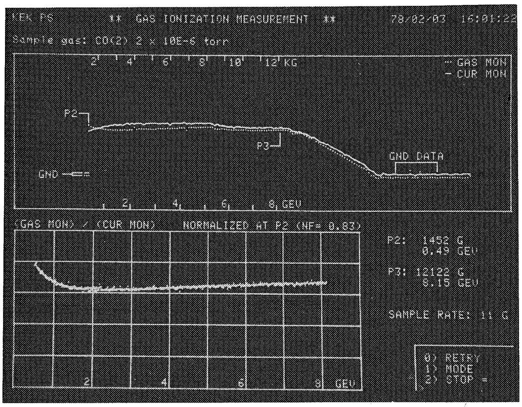

Fig. 3. Ionization cross section of CO_2 for protons of kinetic energies 0.5 - 8 GeV.

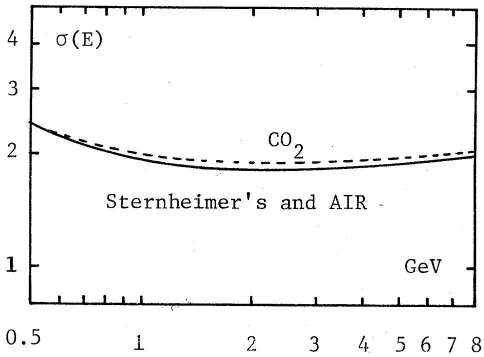

Fig. 4. Measured relative ionization cross sections and Sternheimer's calculated value. Solid line is calculated curve and measured curve of air. They are agreed within the experimental error. Dotted line is measured curve of CO_2.