BEAM SIZE MEASUREMENT OF BOOSTER SYNCHROTRON BY FAST ROTARY SCRAPER

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Beam profile of accelerating beam was measured by non-destructive monitor.[1] But we have a problem of the expansion of profile by space charge effect of high intensity beam. Quantitative interpretation of space sharge effect for the profile monitor and precise profile measurement have been desired. New type beam size measurement by rotary scraper has been under testing.

A schematic diagram of the measurement for the beam size in booster synchrotron is shown in Fig.1. Beam current and beam loss are monitored by the current transformer[2] and the ionization type coaxial loss monitor.[3] The situation of scraped beam in the phase space diagram is shown in Fig.2. Scraping time for beam is the order of msec. The period of the betatron oscillation of beam is the order of 10 μsec. The shadow region corresponds to the output of the current transformer of survival beam and the dotted region corresponds to the output of the beam loss monitor by the lost beam. The region of the decreasing curve of beam intensity gives the information of beam profile. The time interval Δt of the decreasing curve of beam intensity gives the half beam size. The beam loss by the scraper is due to the energy loss and the scattering. The beam scattering by the scraper is main part. The beam loss raise slowly, the order of 1 msec transit time is suitable for beam size measurement.

The scraper consists of a thin stainless steel tube driven by four-pole pulse motor (PF4-36, Japan pulse motor Co.) synchronized to an external trigger pulse. Revolution frequency is 10 Hz. The scraper is externally controllable such that it can be stopped at any desired position azimuthally in 36 steps, even perfectly in line with the beam axis. The dimension of the scraper is 0.5 mm outer and 0.25 mm inner diameter , respectivly, and 110 mm length. The velocity of the scraper is measured by the parallel light and five small photodiode. The average velocity is 10 mm/ms ± 10 %.

The beam size was observed with varing the timing of transit time of scraper as shown in Fig.3. Vertical beam size and vertical beam emittance vs. time during acceleration is shown in Fig.4. Dotted line shows estimated curve which agree with the result of the vertical single wire scanner.[4] Non-agreement at near the injection is interpreted as follows: the thin simple rotary scraper is not an ideal vertical scraper. Especially near the injection stage, horizontal beam size is wide, so the present rotary scraper does not interest with the beam vertically. The coupling of the horizontal and vertical component is not negligible with present structure. The sensitively of the loss monitor vary widely from 20 MeV to 500 MeV, because of the energy dependence of the gas ionization cross section of the loss monitor and the transparency of the vacuum chamber and the loss monitor. Beam size measured by observing the loss monitor was not easy. In the near future improved vertical scraper should be applied as shown in Fig.5. Signal processing and display for beam profile will be performed with a transient recorder which is interfaced to a mini-computer in the near future.

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References

1. H. Ishimaru, Z. Igarashi, K. Muto and S. Shibata, Beam profile measurement for KEK 12 GeV proton synchrotron, 1977 Particle Accelerator Conference, 1977, K-29.
2. S. Hiramatsu, K. Muto and S. Shibata, Beam intensity monitor for KEK proton synchortron, of this meeting.
3. S. Hiramatsu, et al, Beam loss monitor of ion chamber type. of this meeting.
4. H. Sasaki, I. Satoh and H. Ishimaru, Booster S-1 vertical injection profile measurement, KEK-ASN-94, 1977.

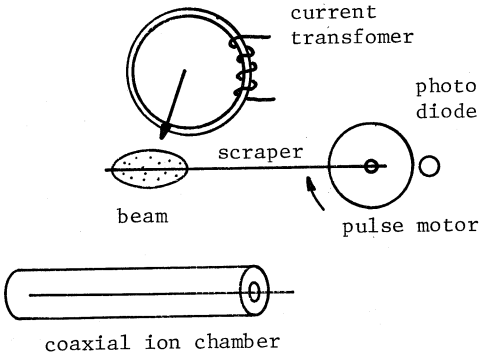

Fig. 1. A schematic diagram of the measurement for the vertical beam size in the booster synchrotron.

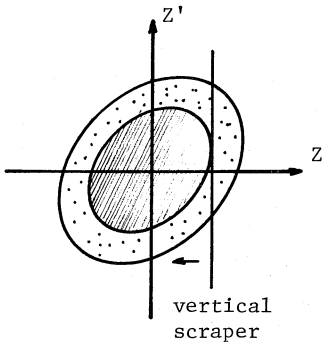

Fig. 2. A situation of the scraped beam in the vertical phase space diagram.

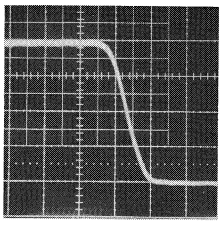

Fig. 3. A beam intensity variation at transit of the vertical scraper.

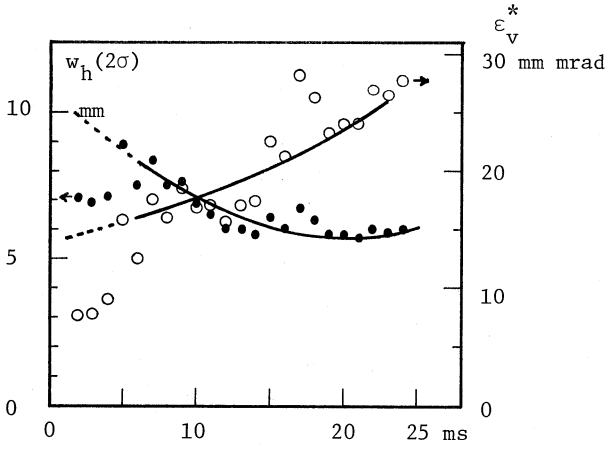

Fig. 4. Vertical beam size and vertical beam emittance vs. time during acceleration. Dotted line shows estimated curve. Beam blow up is apeared at 17 ms. Emittance grows continuously during acceleration.

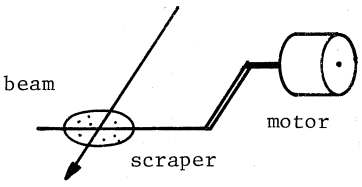

Fig. 5. A structure of the improved vertical scraper.