Prospect of the fast extraction from KEK-PS for the long base line neutrino experiment

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Single turn extraction from KEK-PS and beam intensity upgrade has been investigated. Big motivation is the long base line experiment with neutrino beam. In this presentation, new fast extraction system which has been under consideration will be described.

I. Motivation

To meet the need of new physics research, there are several objectives for the PS upgrade, such as, to increase the proton intensity in the main ring, to accelerate the various ions and then the multifunctional operation of PS. Especially, an intensity upgrade is coming to the urgent problem for the Long Baseline Neutrino Oscillation experiment.[1] This means the fast extracted high intensity beam creates the high current neutrino beam and the neutrino beam will be injected to Super-Kamiokande which is about 250km west from KEK. Present nominal intensity is 4 $\times 10^{12}$ppp for 4 sec main ring operation cycle, but the requested intensity is five times of the present intensity/operation cycle for 500 events per year.

II. Feasibility of the fast extraction using slow extraction equipments

The fast extraction system of the KEK proton synchrotron had been operated until July 1981 for the bubble chamber experiments and these were situated in EP1 beam line, [2],[3] which is used for the second slow extraction at this present.[4],[5],[6] A circulating beam orbit is locally deformed outward by the electrostatic septum inflector (ESS) situated in the straight section of II-IF and by the magnetic septa (C,D,E) situated in the straight section of II-2F. A set of four bump magnets located in I-7F, I-7D, II-3F and II-3D is excited with 15ms wide half sine pulse currents to adjust the maximum bump orbit displacement, comes close to the ESS wire plane. A pair of fast bump magnets, are located in I-7F and II-5D, are excited with 20μs wide half sine pulse currents to displace across the 50μ thick tungsten wire of ESS and a fraction of circulating beam were inflected into the aperture of the magnetic septa. These were the shaving extraction but new fast extraction must extract an entire beam at once.

Distribution of the bump magnet for slow extraction system is almost the same as old fast extraction system as shown in Figure 1. If the rise time of fast bump magnets is 100μs, magnets can be made by thin steel without using ferrite.

Unfortunately, there are no space in the ring to set the powerful kicker magnet to move the entire beam toward the septum magnets. Then, sophisticated method has been considered using distributed several small kicker magnets.

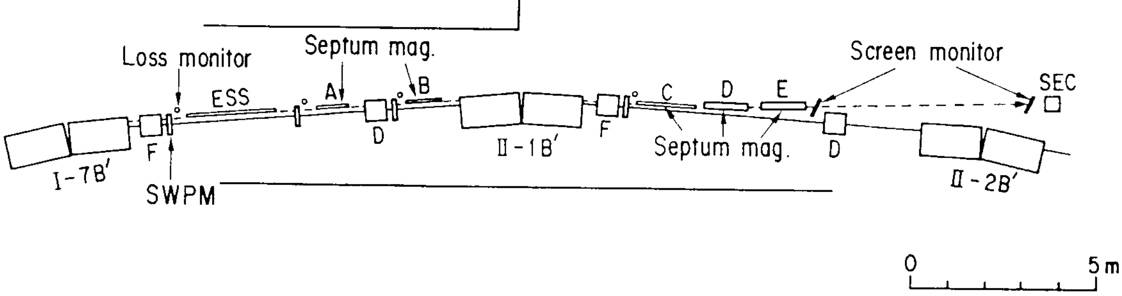

Figure 1 Layout of present slow extraction system for EP1 beam line.

Table I Specification of Kicker Magnets

Position (mr)	I-2F	I-5D	I-6F	I-7D	ESS
Request kick angle (mm)	-3.0	-1.0	-0.3	0.5	0.5
Gap width (mm)	80	75	120	65	65
Gap height (mm)	55	55	55	55	55
Number	2	1	1	1	1
Total length (m)	2.4	1.3	0.9	0.56	0.3
Total kick angle (mm)	3.0	2.73	0.9	3.21	1.62
Type	W-frame	W-frame	W-frame	W-frame	C type

One of solutions is that two kicker magnets are situated in I-2F and four kicker magnets are situated in I-5D, I-6F, I-7D and one kicker is situated at ESS position. Last one is a C-type magnet and set on the opposite side of ESS as face to face. Others are all window frame type magnet. Specification of these kicker magnets are shown in Table 1. The field quality of a test magnet has been reported to be satisfactory. Construction of the prototype, but full scale magnet, will be started soon. Figure 2 shows a beam excursion by these kicker and conventional bump magnets. This solution is still not optimized one and has some problems. One problem is that these orbit excursion causes a possibility of significant beam loss. A beam profile measurement suggests we can take enough aperture of kicker magnets to avoid the beam loss even if the kickers have to be made as compact as possible. However, there is a touch of uneasiness in that the beam profile will become larger when high intensity beam circulate, so we should know how much margin of this aperture we should take. Study to make clear the ring aperture is under going.

There is still another severe problem in this schema. As shown in Figure 2, an orbit excursion is very large at a position of II-2F such as 110mm. Good field region of the main ring qudrupole magnets is about 70mm so the extracted beam must pass through the strong non linear field region. This effect causes the deformation of extracted beam emittance. In order to avoid this problem, four quadrupole magnets at 2F section at each super period should be replaced to large aperture magnet. This causes an increase of load for a magnet power supply so a new isolated power supply which must be excited by tracking to lattice magnet current, has to be needed.

As mentioned above, there is a feasibility of fast extraction using the slow extraction system, however the significant device replacement and construction should be necessary.

III. Discussion

If the EP1 line will be able to use exclusively for fast extraction operation during neutrino experiment, there is a possibility of rather simple method. ESS as shown in Figure 1 will be replaced by strong kicker magnets, which move the entire beam toward the septum magnets. This schema will save a complex beam excursion, however the need for large aperture magnet is still remain and is not considered in detail yet.

Which method we will adopt, the time space between the beam bunches of 30ns is too short for the rise time of fast kicker magnet. PS is operating nine RF harmonic number, then if one bunch is taken out to obtain the time space for rise time of kicker magnet. It makes sufficient of 155ns time space as shown in Figure 3. However, this means the number of circulating beam bunches decreases to eight so the beam intensity is reduced to eight ninth.

Further detailed study and design works have to be continued in hurry and vigorously.

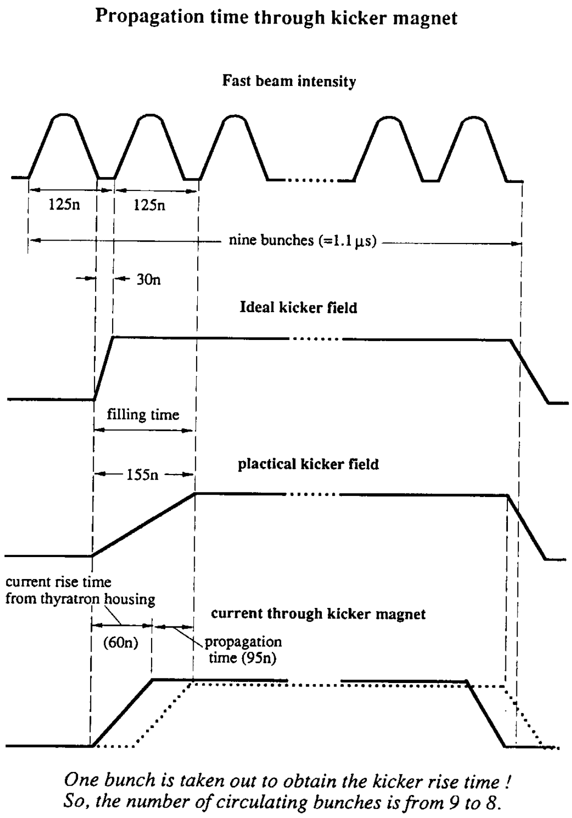

Figure 2   Kicker Rise time and Bunch Spacing.

Acknowledgments

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REFERENCES

[1] K.Nishikawa et al., KEK Preprint 93-55/INS Report 297-93-9

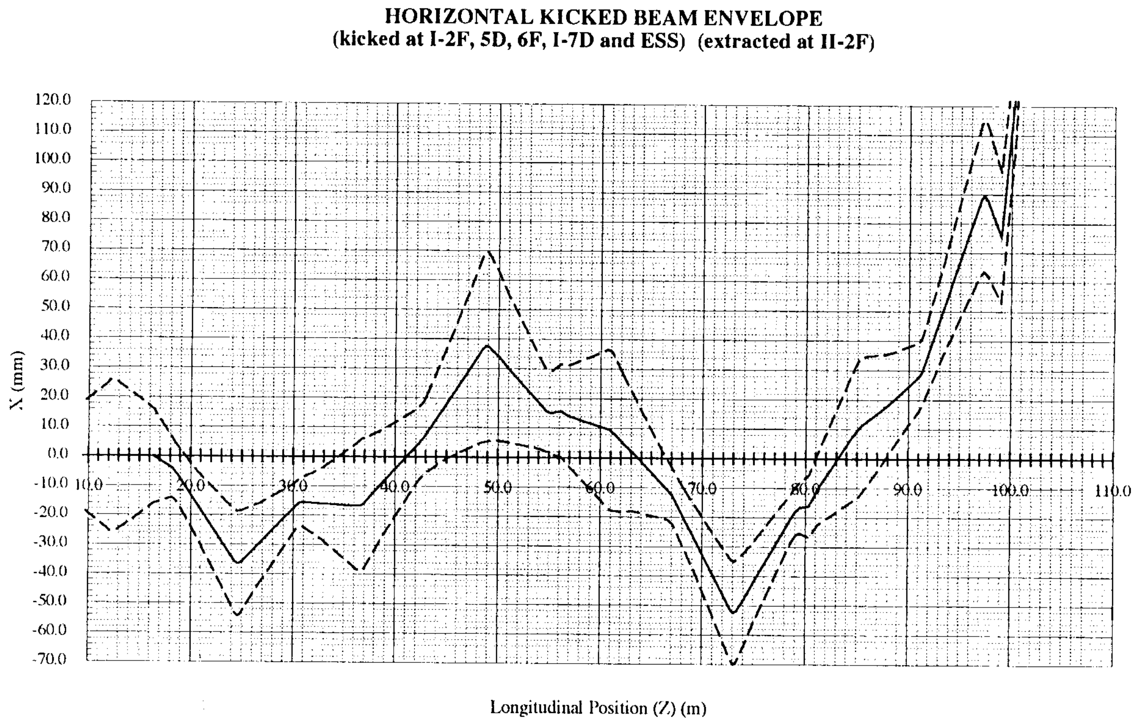
[2] E. Endo and C. Steinback, KEK-77-13.

[3] C. Steinback and K. Endo, KEK-77-18.

[4] K. H. Tanaka, Proc. of the Workshop on Science at the Kaon Factory,Vancouver, 1990, p.1.

[5] Y. Shoji et al., Proc. of the 8th Symp. on Accelerator Science and Technology, 1991, Saitama, Japan, p.281.

[6] Y. Shoji et al., KEK Report 93-10 A



I-2F I-5D I-6F I-7D ESS Septa-C

Figure 3 Orbit excursion by the distributed kicker magnets.