

Presentation 27

Bunch Equalisation at 45 GeV using the Injection Kickers

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27.1 The proposed method

In order to avoid flip-flop effects in the beam-beam forces between LEP bunches, the bunch intensities must be made equal to within 1% before collision [1]. For this purpose it is proposed to tailor downwards LEP bunch intensities at collision energy by kicking individual bunches with the fast injection kicker system against a special scraper block.

The scraper is placed at the crest of the positron injection bump near quadrupole QF21 and can be used for both electron and positron bunches. The scraper block can be moved horizontally with respect to the central beam line.

The scraping principle is shown schematically in Figure 27.1. The bunch to be tailored is kicked by about 20 mm ($\approx 6\sigma_h$) against the horizontal scraper. The scraper position is chosen according to the fraction of the bunch current that one intends to cut away per single kick. A scraper positioned at $3\sigma_h$ outwards from the position of the kicked bunch, would reduce the bunch current by a fraction of about $1 \cdot 10^{-3}$ for a Gaussian beam distribution. At this position the scraper block stays at least $9\sigma_h$ away from the center of the circulating beams, which is sufficient to ensure no current losses of the bunches that are not kicked.

As the amplitude of the fast injection bump cannot be changed easily between kicker pulses, a constant bump amplitude will be used during the entire process. The amount of scraping for individual bunches is adjusted by multiple scraping of the same bunch. Between two successive scrapings of the same bunch sufficient time must be left for the bunch tails to be re-populated (about one damping time).

The relatively long time needed to communicate via the control system with the hardware (kicker magnets, timing system, intensity monitors etc.) makes an iteration of the scraping process on individual bunch intensities very slow. To speed up the equalization of bunch intensities it is proposed to scrape all bunches, that need it, successively by a pre-calculated number of shots for each bunch and to re-measure bunch intensities only after such a sequence of scraping actions. If needed, further groups of shots will be programmed and sent to the hardware, etc., until all bunch intensities are within tolerances.

In case large initial intensity differences exist, the process can be speeded-up by adjusting the scraper position against the constant kicker bump amplitude in order to increase the initial intensity reduction per shot from a standard $1 \cdot 10^{-3}$ up to several 10^{-2} . Of course, while reducing the distance of the scraper to the circulating bunches, one must make sure that these bunches do not suffer intensity losses on the scraper.

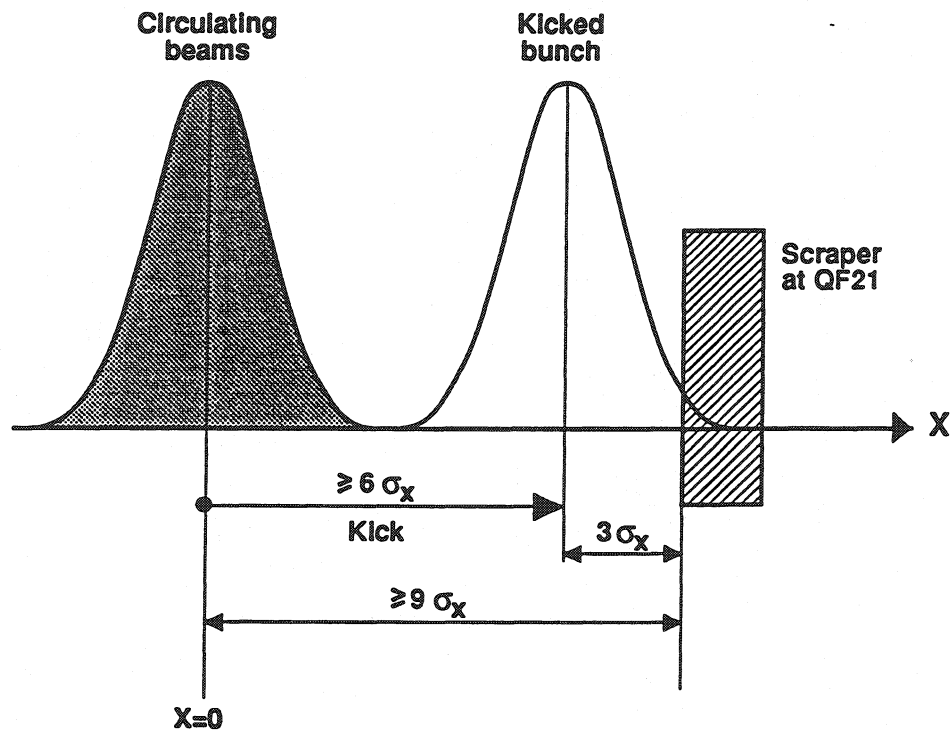


Figure 27.1: Bunch intensity equalisation with the injection kicker system

The proposed method has been simulated on a computer in the presence of systematic and random errors related to scraping and current measurement. It was shown that convergence is reached within a minute in all cases, even when very large errors were assumed.

27.2 Hardware requirements

The LEP injection kickers allow to kick a 22 GeV beam by 57 mm to the injection septum [2], which corresponds to a maximum kick amplitude of 25.8 mm at the scraper location at 55 GeV. The highest repetition frequency for the kicker system with constant kicker amplitude is of the order of 10 per second, which is well adapted to the proposed process. No new hardware is required for the kicker system.

Two horizontal scrapers are already installed in LEP. Scraper SRAP.QF21.R1, in the positron injection region, can be used to equalise both types of bunches. A second scraper SRAP.QF21.L1 in the electron injection bump region is available as alternative. They consist of a 18 cm long aluminium block, motorised with a stepping motor for horizontal movements.

The required timing procedure becomes relatively complicated, in particular if the multi-bunch scraping mode is wanted. However, no new timing modules must be designed, the system can be constructed from existing SPS timing modules [3]. In order to ensure complete independence from the SPS timing and in particular the SPS cycle, it is proposed to install an additional cable from the SPS RF cave to the SR1 building, where the kicker electronics are located.

References

- [1] S. Myers, Simulation of the beam-beam effect for e^+e^- storage rings. CERN-ISR/RF/82-06
- [2] G. Schröder, private communication
- [3] P. Baudrenghien, private communication