Subject APERTURE REQUIREMENTS AT INJECTION INTO THE NAL STORAGE RING

At the septum magnet we have the beam configurations shown in the figures. Figure A shows the situation when the closed orbit bump is excited by a pair of kicker magnets, figure B shows the situation without kicker magnets. The latter is valid for the whole machine circumference when the variation of beam size with β and X_p is taken into account. We note that the beam displacement due to the kickers is equal to the diameter of the injected beam.

Hence the following aperture is required:

i) 4 radii a of the multiturn injected beam where

$$a = \sqrt{\frac{E_H \beta_H}{\pi}} \quad .$$

ii) Space s for kicker stray field and screen. This is given by the geometry of the kicker magnet. The beam must be moved across this space by changing its momentum. The required change in momentum is

$$\left(\frac{\Delta p}{p}\right)_s = \frac{s + 2a}{X_p(K)} ,$$

where $X_p(K)$ is taken at the kicker magnet. In order not to lose aperture, the kicker magnet should be at a maximum of X_p . If this were not the case, the distance s would be magnified by the ratio of the X_p's somewhere else in the machine. At the

same time the momentum change during the stacking process becomes a minimum. We put s = 15-16mm as in the CERN ISR.

iii) Space w for the stacked momentum spread

$$w = X_p \left(\frac{\Delta p}{p}\right) .$$

iv) Space c for closed orbit distortions. One might adopt the view that one does not attempt stacking before the closed orbit is reasonably straight. In this case one can inject into the middle of the aperture and straighten the closed orbit with one injected pulse. Then one might consider a small allowance for the closed orbit to be sufficient. We put

$$c = 10 \text{ mm}.$$

It should be borne in mind that this procedure is quite questionable in the vertical direction where no extra space for beam handling is allowed for.

Inserting the numbers from FN-168

$$E_H = 5.4\,\pi\ \mu\text{rad m}$$

$$\beta_H = 50 \text{ m}$$

$$X_p = 3 \text{ m}$$

$$\Delta p/p = 10^{-3}$$

we find for the horizontal aperture A_H

$$A_H = 66 + 3 + 16 + 10 \text{ mm} = 95 \text{ mm}$$

This aperture is quite substantial and possibilities for reducing it should be looked for. A few of them are mentioned below.

1. Injection with phase plane interchange during transfer.

The injected beam now arrives in the storage ring with the following emittances

$$E_H = 0.4\pi \ \mu\text{rad m} ,$$

$$E_v = 1.0\pi \ \mu\text{rad m} .$$

Three-turn injection then yields the following figures:

$$E_H = 2.2\pi \ \mu\text{rad m} ,$$

$$E_v = 1.0\pi \ \mu\text{rad m} .$$

The aperture A_H then becomes

$$A_H = 42 + 3 + 15 + 10 = 70 \text{ mm} .$$

This change in injection technique has the following side effects:

i) The stored beam becomes almost round. This is quite desirable from the point of view of horizontal-vertical coupling due to machine imperfections and space charge.

ii) The vertical beam radius goes up and the luminosity goes down. The new figures are

$$b = 0.32 \text{ cm},$$

$$\mathcal{L} = 0.24 \times 10^{32} \text{ cm}^{-2} \text{ s}^{-1} .$$

2. Full aperture kicker magnets

If one adopts full aperture kicker magnets one can dispense with screens and stray fields altogether. It is clear that in this case the stacked beam is also kicked about and that the

tolerances on the kicker magnet amplitudes, pulse lengths and timing are correspondingly tight. Because of the short filling time of the storage ring this may, however, not be a serious drawback of the scheme.

Figures C and D show this situation. In the kicked position the stacked beam is just permitted to scrape the edge of the septum. In this case 3 radii of the stacked beam are sufficient. The required aperture becomes

$$A_H = 31.5 + 3 + 10 \approx 45 \text{ mm}.$$