Injection of 3/2 CPS-pulses into ISR
and sharing of pulses between the two storage rings

The purpose of this note is to record our present ideas about beam transfer from the CPS to the ISR.

1) RF considerations

As the circumference of the ISR is 3/2 times that of the CPS we intend to inject 1/2 CPS-pulses into each of the ISR before starting a stacking cycle. This will be done the following way:

First a full CPS pulse (20 bunches) or one half CPS pulse (10 bunches*) are transferred to one of the storage rings. This leaves either 1/3 or 2/3 of the storage ring circumference (either 10 or 20 buckets) empty. At the end of the next CPS cycle the missing bunches - either 10 or 20 - are added to the same ring. In order to add the second set of bunches at the correct places and correct energy the CPS and the storage ring must be synchronized and magnetic field tolerances of the order of $10^{-5}$ must be respected for the second beam transfer.

It is planned to share every third (on average) CPS pulse between the two storage rings, so that each ring receives 10 bunches of the same CPS pulse. This will be done the following way:

The CPS fast ejection system first ejects 10 bunches. A switching magnet at the Y-point of the CPS-ISR beam-transfer channels sends the 10 bunches towards one of the storage rings. Then the switching magnet is switched to the alternate position, and the CPS fast ejection system ejects the remaining 10 bunches which have been kept in the CPS at constant energy at the "flat-top" of the magnet cycle. The time required for switching the magnet at the Y-point is estimated at a few tens of milliseconds.

* If the missing-bunch phase lock system (CERN 65-31) is employed there are only 9 instead of 10 bunches.
For optimum filling of both ISR there is a unique sequence of operations that is shown on the attached figure.

This has the following advantages:

a) if T is the CPS cycle time both ISR get 30 bunches each in an ISR-cycle time of 3T

b) the time available for the stacking-process is 2T which is the maximum possible compatible with condition a)

c) before a CPS pulse is shared between two rings the injection orbit of one ring is always empty. Therefore, one never needs to synchronize all three rings simultaneously.

2) Implications for the injection system

An error of 1°/o in the strength of the fast kicker magnet gives rise to a betatron oscillation with a maximum amplitude of about 0.8 mm. It is therefore also of some interest to consider the effect of different filling procedures on the errors caused by the kicker magnet.

The tail that remains after the pulse in the fast kicker magnet and which is due to losses in the cables that constitute the pulse forming network, depends on the duration of the pulse. If we accept the idea of one missing bunch and take into account the filling time of the fast kicker, the relevant quantity is the tail that remains about 150 nsec after the end of the pulse. The calculated figures are as follows:

<table>
<thead>
<tr>
<th>type of cable</th>
<th>relative kicker error</th>
<th>betatron amplitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 ohm, 1 μ sec pulse</td>
<td>1.9°/o</td>
<td>1.5 mm</td>
</tr>
<tr>
<td>14 ohm, 2.1 μ sec pulse</td>
<td>4.0°/o</td>
<td>3.2 mm</td>
</tr>
<tr>
<td>2x28 ohm in parallel, 1 μ sec pulse</td>
<td>1.1°/o</td>
<td>0.9 mm</td>
</tr>
<tr>
<td>2x28 ohm in parallel, 2.1 μ sec pulse</td>
<td>2.5°/o</td>
<td>2.0 mm</td>
</tr>
</tbody>
</table>
The last column gives the betatron oscillation amplitude of the first bunch after the missing bunch. The following bunches will be progressively less perturbed.

Although the errors for the 2x28 ohm cables in parallel are probably acceptable it is nevertheless useful to remark that the injection errors are smallest if the 10 bunches are injected after the 20 bunches, so that in the scheme proposed under 1) Ring 2 is better off. For minimum injection errors in both rings the sequence should be: 20 bunches in Ring 2, 10 bunches in Ring 2, 20 bunches in Ring 1, 10 bunches in Ring 1 etc. Every second pulse, 10 bunches would then remain in the CPS. If these could be used for internal targeting in the CPS, the scheme just described would also make full use of all the available protons.

Which of the two filling procedures would be used, need not be decided now, but can be chosen later after some actual experience with ISR operation has been obtained.

B. de Raad, W. Schnell

Distribution: (closed) AR and ISR Scientific Staff