A) **PRELIMINARY REPORT ON RESONANCE AND LIFETIME TESTS DURING RUN 7**

1. **Introductory remarks**

   The purpose of these experiments was to observe the influence of sextupole and octupole fields on the behaviour of the beam when crossing resonances and on the decay of a stack.

   All experiments were performed using a 4 bunch beam, which was injected on the so-called "reference" injection orbit. The exact position of this orbit is not known, because of the uncertainty in momentum definition of the FS beam, but it is believed to be at an average radial distance of about ±13 mm from the central orbit.

   Q measurements could be performed only on the injection orbit and therefore the measured values are influenced by the presence of sextupole or octupole fields. Moreover, the accuracy of the measurements made with 4 bunches depends on the amplitude of the coherent oscillations induced at injection and the reproducibility was not better than ± 0.005. Therefore, a very accurate definition of the position of the working point as a function of radial beam position is not possible. The displacements of the working point produced by the operation of the PFWs end of the different lenses can also be computed (within limits) and the gradients produced by the PFWs are measured inside the reference units. While waiting for the outcome of the process of finding the best fit between all computations and measurements of momentum, positions and betatron frequencies, this report refers only to the settings during each experiment.

2. **Sextupole experiments**

   Two experiments were performed with PFw current settings giving \( \Delta Q_V = 0.05 \); \( \Delta Q_H = 0 \) and \( \Delta Q_V = 0.04 \); \( \Delta Q_H = 0.02 \), respectively, and with all sextupoles powered to +10% of their maximum currents, whereby they should have produced \( \Delta Q_H = 1.26 \Delta p/p \) and \( \Delta Q_V = 1.32 \Delta p/p \).
In both cases, scans made across the radial aperture showed losses within the stacking region (see graphs fig. 1). Stacks of 180 mA made under these conditions had initial decay rates of 0.4 % and 0.22 % min.\(^{-1}\), respectively, which grew to a maximum of 3.7 % min.\(^{-1}\) after 8 min.

3. Octupole experiments

The Terwilliger quadrupoles \(T_{D1}\) were excited to -12 % of their maximum current and in addition an octupole strength of 6 T/m was created in each magnet block by means of the PFW.

After that an aperture scan showed the effectiveness of the octupole field in allowing to cross resonances without losses in a given direction and not in the opposite (see fig. 2 - Exp. 3). A 180 mA stack was made in a region which the scan had proved to be lossless in both directions.

The rate of decay was initially 0.012 % min.\(^{-1}\) during 3 minutes, but then it increased progressively and reached 4 % min.\(^{-1}\) after 8 minutes.

B) LIFETIME TESTS DURING RUN 8

1. Introductory remarks

The purpose of these experiments was to observe the decay rate of intense beams in relatively "good" Q regions. The influence of a weak sextupole excitation on the decay of a 1 A stack was also studied.

All experiments except the scans were performed using a 20 bunch beam, which was injected on an injection orbit at an average radial distance of about -33 mm from the central orbit. The aperture scans were made with a 4 bunch beam.

\(\Delta Q_H = -0.022\); \(\Delta Q_V = +0.030\)
2. **Low momentum tail detection**

A scan made by moving a 4 bunch injected beam towards the shutter of the inflector showed that a low-momentum tail is present even on a weak beam and immediately after injection (fig. 3 - Exp. 1). The loss of particles from beam tails may account for some of the minor initial losses experienced by beams circulating on the injection orbit.

3. **86 mA injected beam decay experiment**

An 86 mA injected beam was kept circulating on the injection orbit, on which the values $Q_v = 8.646$, $Q_h = 8.817$ were measured. The decay rate was about constant at $0.06 \%\min^{-1}$ from 1 to 9 minutes, then it increased progressively to reach $4 \%\min^{-1}$ at 15 minutes, and then it decreased again progressively. The experiment was stopped after 42 minutes, at which time the current was 61 mA, and the decay rate was $0.6 \%\min^{-1}$ and still decreasing.

4. **1 A lifetime experiments**

Two 1 A stacks were made with the Terwilliger quadrupoles $T_{D1}$ excited to -12 % of their maximum current, in a region which aperture scans by field variation had shown to be free of losses (see graph fig. 3 - Exp. 2).

These stacks had small decay rates during the initial 20 seconds (between 0.3 % and 0.6 % min.$^{-1}$), then started to accelerate and reached 25 % min.$^{-1}$ after 2 minutes (800 mA level). (See figs. 4 and 5)

A stack of 220 mA made with 3 pulses of 20 bunch beam, under identical conditions, had an initial decay rate of 0.05 % min.$^{-1}$ during about 80 seconds, which grew to 4 % min.$^{-1}$ between 3 and 4 minutes (see fig. 6).

Finally a 1 A stack was made with the additional excitation of the sextupoles to +5 % of their maximum current. It showed the same initial behaviour as the other 1 A stacks (see fig. 7).

*perhaps related to the fact that a small fraction at the top was entering a resonance, as RF scans seem to show.*
Its decay rate at 150 mA level was $3.6 \% \text{ min}^{-1}$, about the same as for the 160 mA stacks made previously in the sextupole and octupole experiments.

5. Exploration of vertical-horizontal betatron coupling

No coupling of induced horizontal coherent oscillations into the vertical plane was observed under ordinary conditions of magnet operation. Coupling was excited by powering the skew quadrupoles to 5% of their maximum current.

Mr. X : K. Johnsen
S. Van der Meer
L. Resegotti

Distribution:
ISR Parameter Committee
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Engineers-in-Charge
Sc-staff ISR-MA
Circulating Current

Exp. 1

Exp. 2

Injecting heat removed

Run 7 - 13 Nov, 1472
Experiments with sextupole correction
SF = 50 = 10%

Exp. 1 \( \Delta R_H = 0 \) \( \Delta R_V = 0.05 \) \( R_V = 2.49 \)

Exp. 2 \( \Delta R_H = 0.02 \) \( \Delta R_V = 0.07 \) \( R_V = 2.63 \)

on inj. heat

FIG. 2
Figure 12

Circulating current

### Experiments with octopole correction

**Exp. 3**
- TD1 at -12%
- $V_y = 8.833$ cm/m
- $V_x = 8.579$ cm/m orbit
- Octopole $-67/m$

**Exp. 4**
- TD1 at -16%
- $V_y = 8.797$ cm/m
- $V_x = 8.679$ cm/m orbit
- Octopole $-67/m$
Starting 240V.

500 mA full scale
50 mA per inch

RF off 2x 1 A