ISR-MA/PJB/rh

23rd August 1973

ISR PERFORMANCE REPORT

Run 344 - 9 August 1973

Rings 1 and 2 - 26 GeV/c - 20 bunches

SFM Running-in (No. 3 - 26FP with SFM at 1.0 T)

Conclusions

For the first time, the full closed orbits were measured with and without the SFM in the same run. In both Ring 1 and Ring 2, the SFM contributes ± 0.5 mm peak-to-peak horizontally to the distortion but fortuitously, this reduces the overall distortion in both cases. Vertically the peak-to-peak value increases slightly in Ring 1 and not at all in Ring 2, but in both cases the r.m.s. value increases by 0.1 mm.

The modified vertical orbit bump for I4 was measured with the position monitor and found to be (1.3 ± 0.5) % too large.

No corrections were needed for the 'FP' working lines and two stacks of 7 and 8 A were made with final decay rates of 14 and 10 ppm/min.

A full luminosity measurement in I5 and I4 gave: $L_{I5} = 1.41 \times 10^{30} cm^{-2}s^{-1}$ and $L_{I4} = 1.14 \times 10^{30}\ cm^{-2}s^{-1}$. No beam-beam blow-up was observed during these measurements.

Measurements and results

1. Closed orbit

For the first time, the closed orbit distortions were measured in the two rings (at injection) both with and without the SFM in the same run. The results are summarized in Table 1.

In the horizontal plane, where the SFM is most likely to cause an orbit distortion, the peak-to-peak and r.m.s. values of the distortion are less with the SFM than without it. This residual distortion, which fortuitously corrects the ISR orbit, is approximately ± 0.5 mm in both rings. A correlation programme has been written to analyze by how much each compensator is contributing to the distortion. In the present case, the residual distortion is so small at the pick-ups, which can "see" a difference between the large and small compensators, that a meaningful correlation was not possible.

TABLE 1

Closed orbit distortions at injection with and without the SFM (26FP, SFM 1.0 T)

	Ring 1				Ring 2			
	horizontal		vertical		horizontal		vertical	
	pk-to-pk	r.m.s.	pk-to-pk	r.m.s.	pk-to-pk	r.m.s.	pk-to-pk	r.m.s.
Without SFM	9.9	2.5	8.7	1.8	6.2	1.4	6.0	1.4
With SFM	8.7	2.2	9.0	1.9	5.3	1.2	6.0	1.5

2. 26FP working line

The working line 26FP was checked in Ring 2. Figure 1 shows the line to be slightly shifted from its ideal position but still quite serviceable. No corrections were made.

3. Calibration of the vertical orbit bump in the SFM

Although the SFM has remarkably little effect on the ISR, the original calculations showed that the vertical bumps would be affected. For the even intersections changes of 1 - 2 % are required in the magnet excitation currents while for the odd intersections the changes are small enough to be neglected. A full set of excitation coefficients have been calculated, but the new bumps are not yet available in the LUMS programme.

The position monitor was used to calibrate the modified SFM bump. In order to obtain a precision better than 1 %, it is necessary to apply corrections for the finite dimensions of the beam. Therefore, a well defined beam was made by scraping a 5 A beam both horizontally (inner and outer scrapers) and vertically (upper and lower beam probes). The final test beam had the following characteristics (after scaling to the position of the magnetic beam detector):

Intensity	:	0.8 A
Width (constant density beam)	:	$\sim$12 mm
Height (scraped to 60 % of the initial intensity)	:	$\sim$ 5 mm

The corrections with respect to a filamentary beam are negligible for the height and of the order of 1 % for the width of the beam; they have been incorporated in the following results:

Applied bump	mm	0	-4	-8	0	+4	-8	0
Vertical beam position in the SFM	mm	+3.66	-0.31	-4.42	+3.67	+7.71	-4.39	+3.67

The line which fits these points has a slope of 1.009, and the points measured deviate from this line by a maximum of 5/100 mm which is the actual precision resulting from the noise produced by the SFM in the magnetic detector.

Therefore, at the position monitor the bumps are systematically too large by (0.9 $\pm$ 0.5) %. However, the bumps are not exactly flat topped inside the SFM (see Figure 2). When this correction is included, the bumps are found to be (1.3 $\pm$ 0.5) % too large.

4. Stacking

In the present run, two stacks were made on the 26FP working lines with the parameters in Table 2. A Schottky scan of both stacks directly after stacking and scraping is shown in Figure 3.

TABLE 2

Stack parameters

	Ring 1	Ring 2
Top of stack mm	+ 20	+ 20
Bottom of stack mm	- 14	- 11
No. of pulses	134	137
Shaved to mA/pulse	60	60
Final current A	6.91	8.73

These stacks were used for luminosity measurements in I4 and I5. The evolution of the decay rates is summarized below in Table 3.

TABLE 3

Evolution of decay rates

Conditions	I_1 A	I_2 A	dI_1/dt ppm/min	dI_2/dt ppm/min
After stacking and scraping	6.90	8.51	7	0
After luminosity measurements in I4 and I5	6.89	8.49	27	43
Beams re-scraped	6.88	8.43	10	14

Before the stacks were dumped, the feedback stabilization system was switched on in each ring for a short period. No effects could be seen on the dI/dt recordings.

5. Luminosity measurements with the SFM

A standard luminosity calibration was made in intersections I4 and I5. The normal 4-magnet bumps were used with 0.5 mm increments in opposite directions in the two intersections.

These bumps are expected to be in error by 1 - 2 % in I4 and, although the I5 bumps are unchanged, an error will be seen due to the residual distortion from the uncorrected I4 bump (again 1 - 2 %). The calibration curves obtained are shown in Figure 4. In I4, beam 2 gave a high background when moved positively but a reasonably precise calibration was still possible. As shown in Figure 4, the values of the effective height obtained in I4 and I5 agree to about 1 % and the I5 monitor constant σ = 1.23 mb is within 2 % of the accepted value. A comparison of monitor constants in I4 is meaningless because of the influence of the field on the monitor acceptance.

The luminosity is calculated using the normal expression

$$L = \frac{1}{e^2 \, c \, \tan\left(\frac{\alpha}{2}\right)} \cdot \frac{I_1 \, I_2}{h_{eff}} \quad cm^{-2} s^{-1} \; .$$

With the normal crossing angle $\alpha = 14.773^o$, the first term is 1.002×10^{28} sec. cm^{-1} $coulomb^{-2}$. In the SFM, with a field of 1.0 T and 26.588 GeV/c beams, the crossing angle, α, is 17.971^o and this constant becomes 0.8217×10^{28} sec. cm^{-1} $coulomb^{-2}$.*

The agreement in the values of h_{eff} is all the more surprising in view of the currents which were about twice those typically used for luminosity calibrations.

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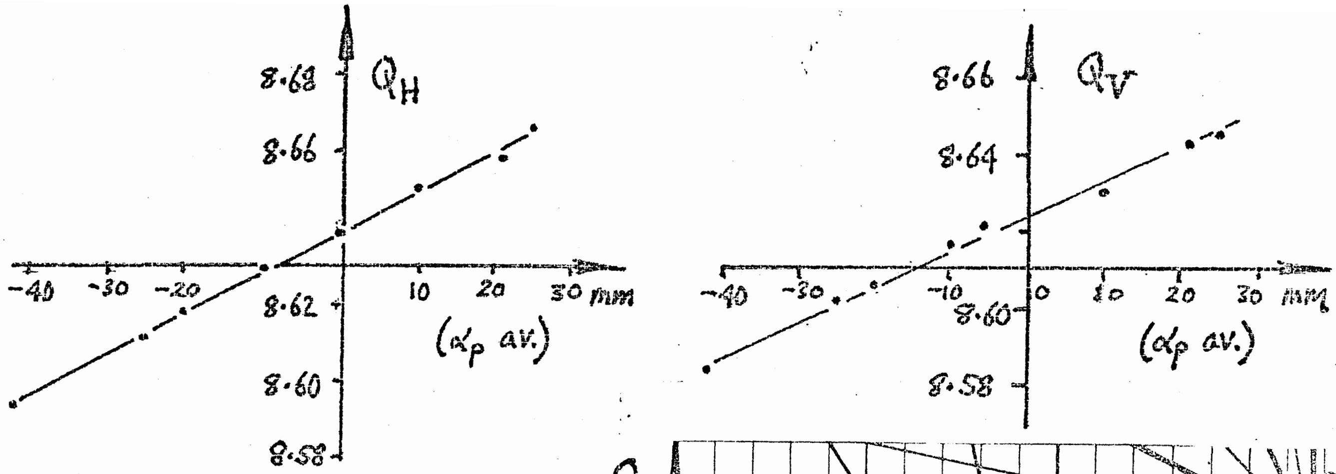
* In both cases, the protons have been assumed to be completely relativistic. At 11.8 GeV/c, the error in this assumption is 0.36 %, at 26 GeV/c it is 0.07 %.



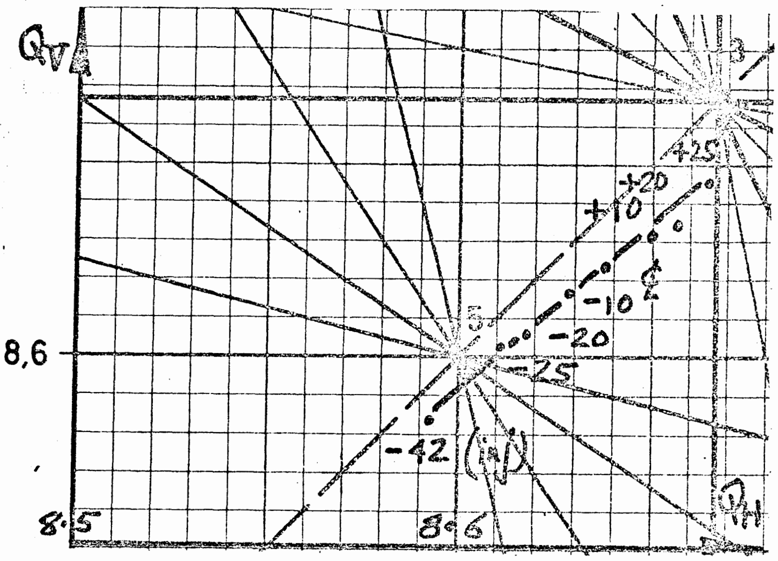


FIGURE 1

26FP working line in Ring 2
for the SFM at 1.0 Tesla

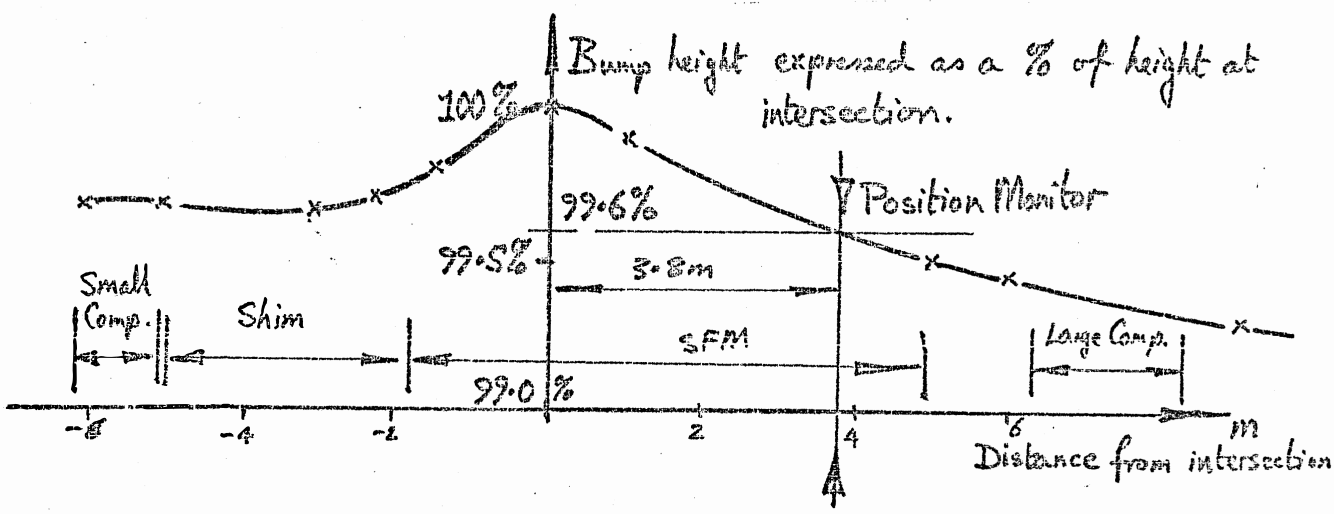
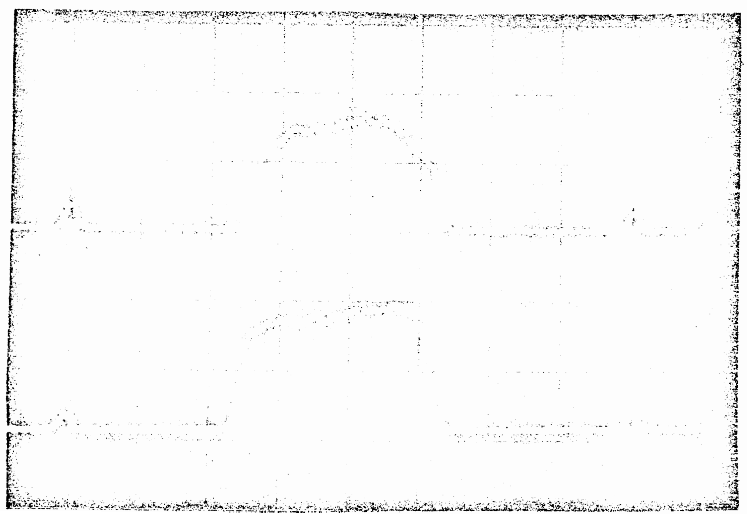


FIGURE 2 - Longitudinal profile of special SFM bump showing the relationship of the position monitor to the intersection.

FIGURE 3

Schottky scans directly after stacking (R1 - 6.9 A upper trace and R2 - 8.7 A lower trace).



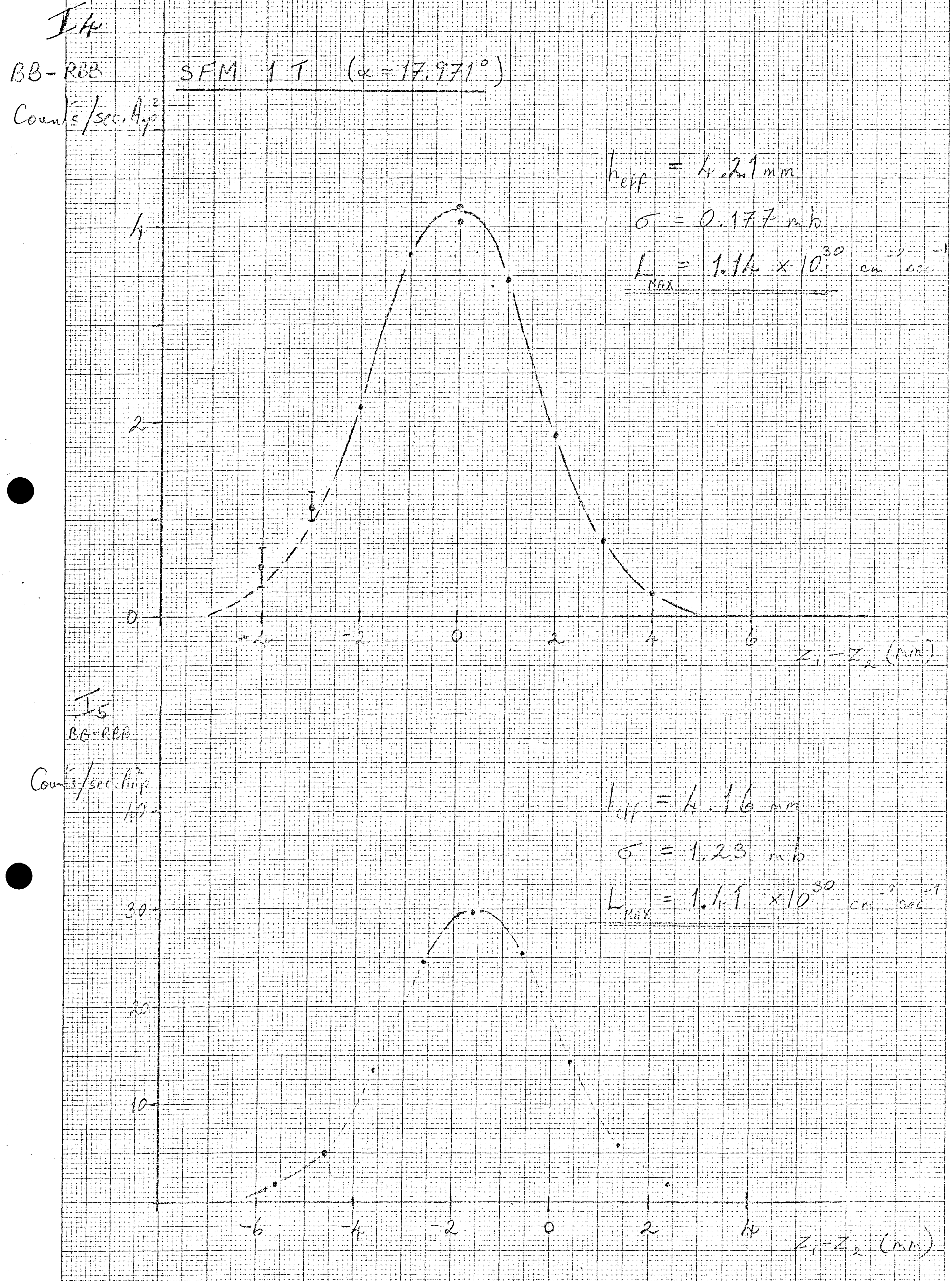


FIGURE 4 - Luminosity calibration curves obtained in Intersections 4 and 5