ISR-OP/SM/svw 3rd April, 1973

ISR PERFORMANCE REPORT

RUN 290 - 24th March, 1973

RING 2 - 26.6 GeV/c - 20 Bunches 5C26

Variations of Longitudinal Density Measured by Spill-Out

Summary

The longitudinal density in the final RF bucket is dependent to a large extent on the distance previously accelerated in the large bucket. Over the aperture range of the 5C26 working line the variation in density is around 35 %.

1. Purpose

The main purpose of this experiment was to gain an insight into some of the operational problems recently experienced during stacking in Ring 2. In particular, to ascertain if the longitudinal density is a function of the stacked position of the pulses. There were also three secondary purposes :

(i) to measure the effect of varying degrees of shaving on the density,

(ii) to continue with the observations already started in measuring density as a function of the final bucket size, and

(iii) to gain experience in the measurement of spill-out with a view towards making such measurements an operational procedure.

2. Method

The longitudinal density was evaluated using the method of spill-out measurement*. In order to simulate stacking conditions, (without actually stacking) normal RF stacking parameters were used and the outer scraper was placed approximately at the position of "RF OFF".

* PERC REPORT "Determination of Longitudinal Density by Spill-Out Experiments" 30.1.73 - K. Hübner, M. de Jonge, S. Myers.

The position of "start decay" was varied across the aperture and the outer scraper was moved in phase. Spill-out was measured as the average of about 7 pulses for each point.

For the measurement of the dependence of density on the degree of shaving, the multi-purpose scraper was used to shave varying amounts off the injected pulses. In this test spill-out was measured with a start decay corresponding to about +7 mm (average) and the outer scraper was positioned at + 25 mm (average

3. Data

(i) V_{INJ} = 16 KV ε = 0.015 V_f = 700 V Γ = 0.4
no shaving

TABLE 1 - VARIATION WITH RADIAL POSITION

INJECTED I(mA)	SPILLED OUT I_s(mA)	BUCKET CURRENT I_b(mA)	% SPILLED OUT	START DECAY (mms)	DENSITY
71.8	3.2	68.6	4.5	- 22.7	.156
71.5	9.2	62.3	12.8	- 2.5	.142
72.2	16.2	56.0	22.3	+ 7.1	.127
72.5	21.5	51.0	29.7	+ 17.7	.116
72.0	24.7	47.3	34.3	+ 28.1	.107
71.8	25.5	46.3	35.7	+ 36.9	.105

(ii) R.F. parameters as in (i) + f_{START} = 2800 Hz.

I_{INJ} = 72.2 mA.

TABLE 2 - VARIATIONS WITH SHAVING

ACCELERATED (mA)	SHAVED (mA)	SHAVED (%)	FINAL BUCKET (mA)	% SPILLED OUT	DENSITY
72.2	0	0	56.1	22.3	.127
61.7	10.7	14.8	55.8	9.5	.127
51.6	20.6	28.5	48.3	6.4	.110
41.3	30.9	42.8	38.2	7.5	.087

(ii) R.F. parameters as in (i) with the exception that V_F was varied from 1 KV to 200^V.

- no shaving.

TABLE 3 - VARIATIONS WITH FINAL VOLTAGE

INJECTED $\bar{I}$ (mA)	% SPILL-OUT	FINAL BUCKET CURRENT $\bar{I}_b$ (mA)	FINAL BUCKET VOLTAGE	FINAL BUCKET AREA	DENSITY
71.4	12.6	62.4	1000	2.73	.115
71.4	14.4	61.1	800	2.44	.125
72.0	20.5	57.4	700	2.28	.125
71.7	25.2	53.6	600	2.11	.127
71.4	38.1	44.2	400	1.73	.128
71.7	27.8	51.8	200	1.22	.212

4. Discussion of Results

Figure 1 shows the variation in longitudinal density as a function of the radial position of "start decay" (OR the distance accelerated in the large bucket). It can be seen from this plot that the density decreases almost linearly with radial position of "start decay". Two possible explanations have been postulated for this phenomenon. The first and apparently more likely is that bunch oscillations gradually produce blow-up inside the large buckets. Since such blow-up is certainly time dependent it is not difficult to see that the density will decrease as a function of the time spent in the large buckets.

The second explanation is that blow-up is produced when the bunches cross the 5th order resonances on the 5C26 line. This seems less likely for the following reasons :

(i) the time actually spent on each resonance is quite small when accelerating with large RF voltage,

(ii) there is a noticeable density reduction at points taken before any resonances are encountered.

and,

(iii) the observed effect appears to be predominant in Ring 2, although an identical working line exists in Ring 1.

Figure 2 shows the variation of final bucket density with the degree of injection shaving. Since time existed for only four points the interpretation of results may be somewhat precarious, however, it appears that the density remains substantially constant until the degree of shaving exceeds about 15%.

Figure 3 shows the average density in the final bucket as a function of the final bucket area. In the range of V_F from 1KV to 400 V there is only a slight gradual increase in density, However, at V_F = 200 V there is a marked increase in density. Although it is unwise to attach too much importance to a single point on a plot, it may be said that the density appears to be increasing towards the PS density (.32). For this reason it would be interesting to redo this particular test with many more points around the region of interest.

5. Conclusions

If it can be assumed that the relationship between density and radial position is unaffected by the presence of a stack, then such relationships may be used to evaluate the amount of shaving necessary at various radial positions in order to obtain a stack with uniform density distribution. However, if the degree of shaving is to be kept constant throughout stacking, as is considered good practice, then a stack with a wedge shaped density distribution will be produced.

The variation of density with degree of shaving shows that little is to be gained in terms of stack density by heavy shaving. The plot also indicates that under certain M.D. conditions where the vertical height of the stack is not of prime importance, then shaving of around 15% is the optimum amount.

S. Myers

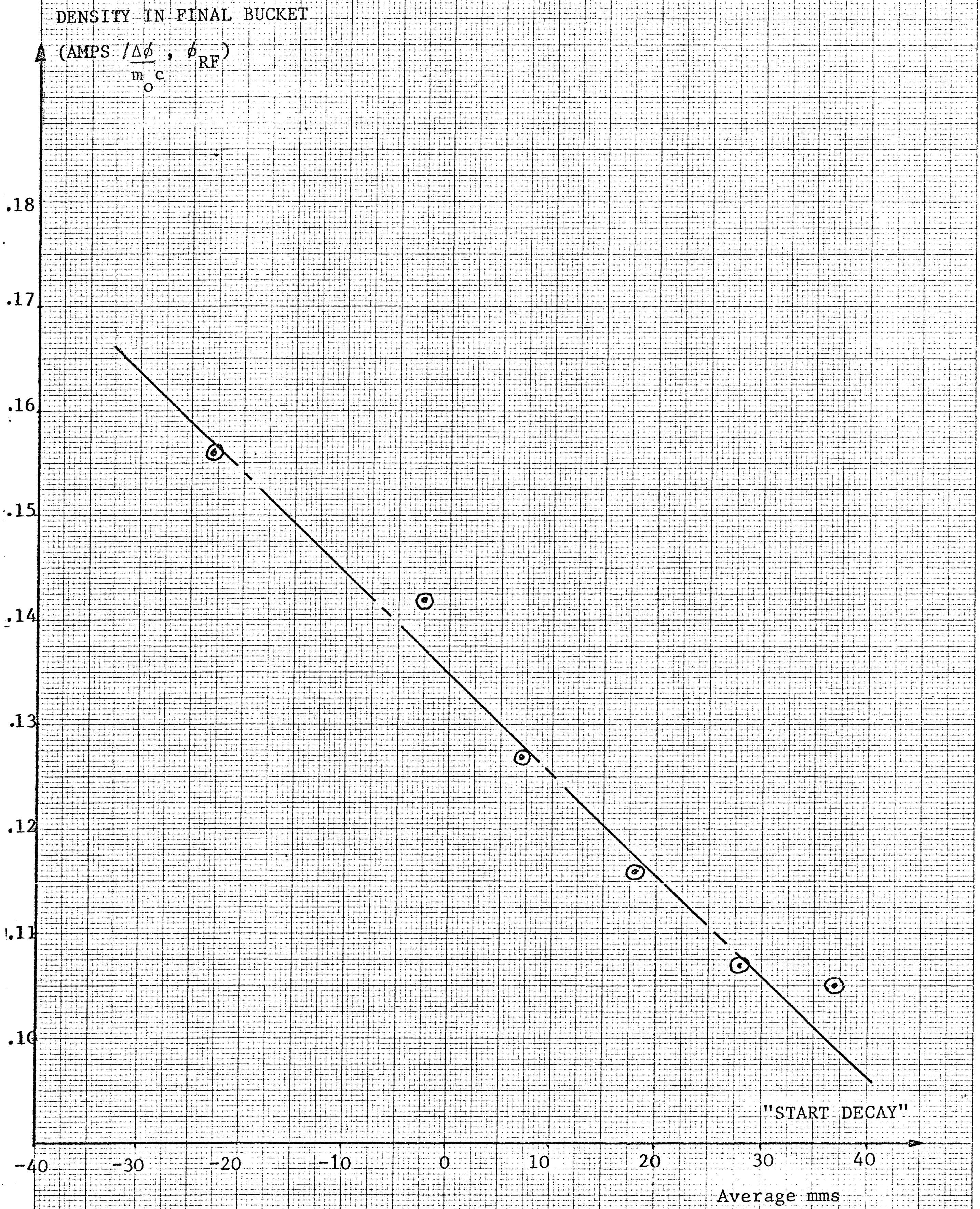
DENSITY IN FINAL BUCKET
(AMPS /Δφ/m₀c , φ_RF)
.18
.17
.16
.15
.14
.13
.12
.11
.10
"START DECAY"
-40
-30
-20
-10
0
10
20
30
40
Average mms

FIG. 1

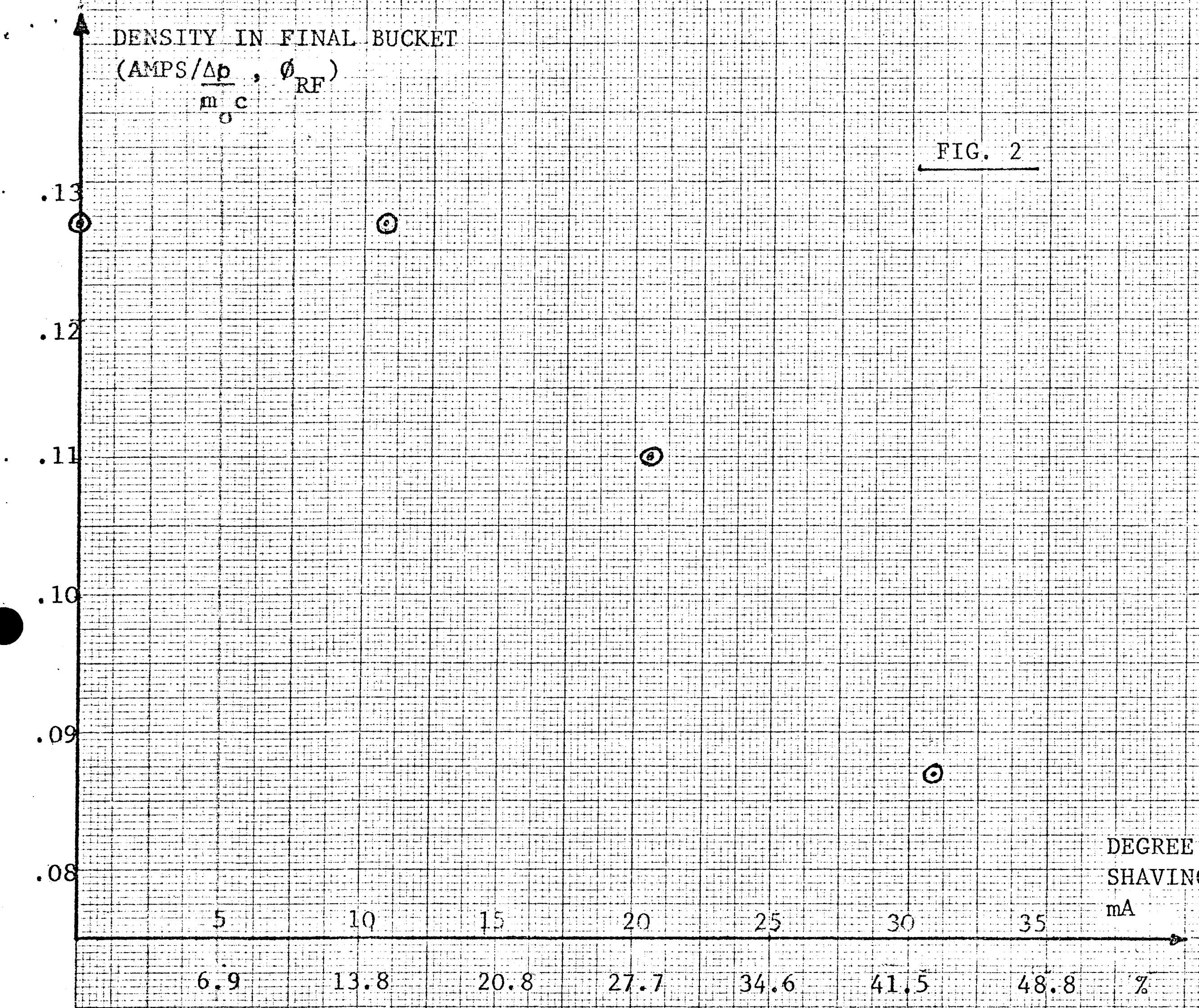
DENSITY IN FINAL BUCKET
(AMPS/$\frac{\Delta p}{m_o c}$, ϕ_{RF})
.13
.12
.11
.10
.09
.08
DEGREE OF
SHAVING
mA
5
10
15
20
25
30
35
6.9
13.8
20.8
27.7
34.6
41.5
48.8
%

FIG. 2

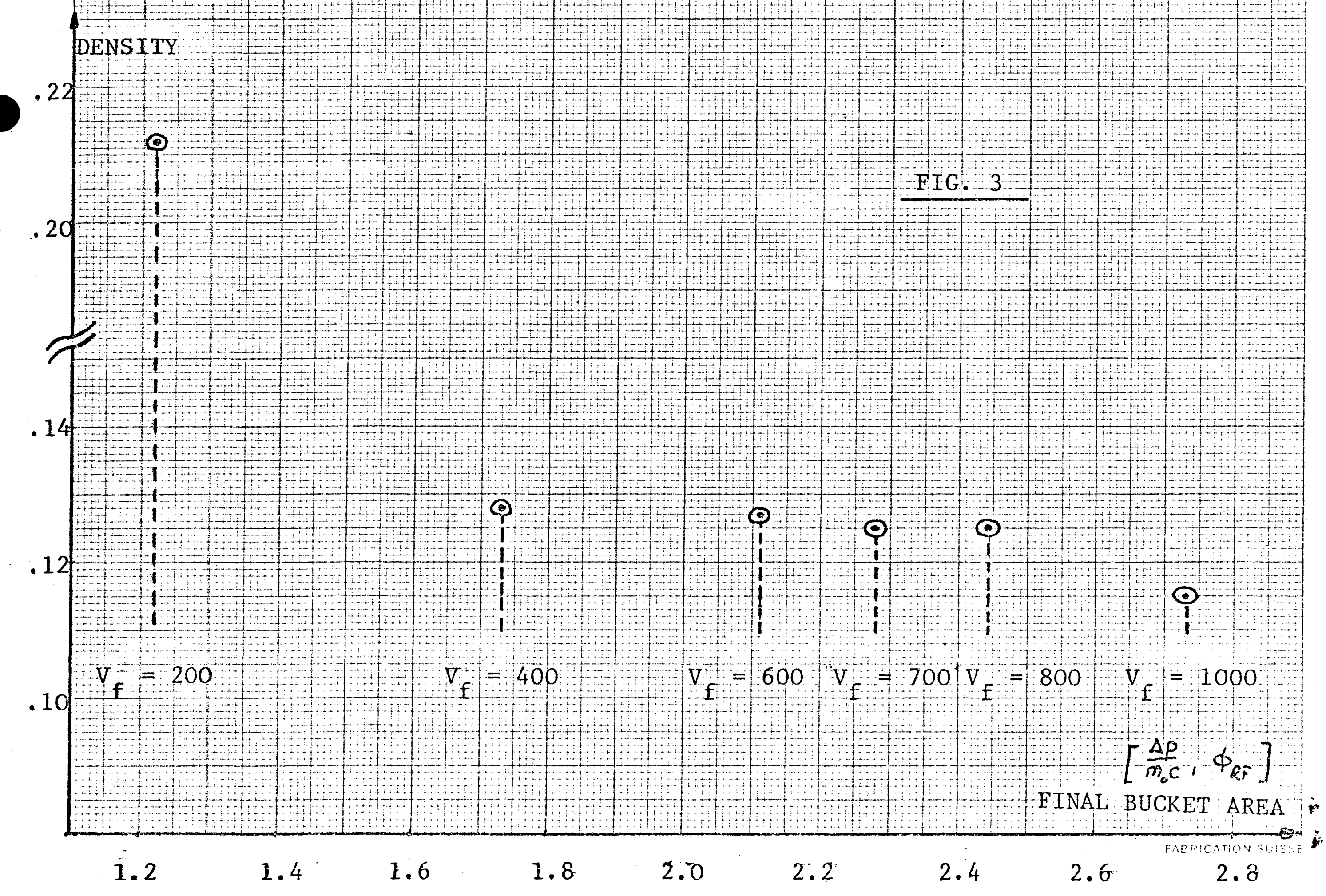
DENSITY
.22
.20
.14
.12
.10
V_f = 200
V_f = 400
V_f = 600
V_f = 700
V_f = 800
V_f = 1000
$\left[\frac{\Delta p}{m_o c}, \phi_{RF}\right]$
FINAL BUCKET AREA
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8

FIG. 3