Mlle P. SHINNIE E-6

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ISR PERFORMANCE REPORT

Run 836 : 26 GeV, ELSA, R1 + R2

Run 838 : 26 GeV, low-β, R1

Switching off the I1 Solenoid and maintaining circulating beams in the ISR

1. SUMMARY

Since the I1 superconducting solenoid was not regarded to be completely stable over long periods of time, it was considered necessary to be able to switch off the solenoid and still maintain circulating beams during physics runs. A computer program has been written which adjusts the currents in the compensating dipole magnets (LBC's) so as to correct for the change in dipolar field as the current of the solenoid is reduced. Thus, both beams should be kept at their correct positions in the vacuum chamber. The program was tested during a machine development period using stacks of 8.6 Amps (R1) and 6.5 Amps (R2) and only 38 mA and 9 mA respectively were lost. The program was run again at the end of Run 838 (with the low-β insertion) and this time only 6 mA were lost from the stack of 20.5 Amps (R1). The program may now be used in normal operations, provided that sufficient warning can be given to the Control Room.

2. DATA FOR THE MAGNETS

The nominal bending forces (B.1) for the compensating magnets are shown in Table 1 and the computer program takes individual values for each of the magnets - 1LBC1, 1LBC3, 2LBC2, 2LBC4, the differences being < 0.2%. When the current in the solenoid is reduced, the currents in all four LBC magnets are adjusted so that :

$$(B.\ell)_1 = (B.\ell)_0 \left(\frac{I_{S1}}{I_{Smax}}\right) + (B.\ell)_{bump}$$

where : $(B.\ell)_1$, $(B.\ell)_0$ and $(B.\ell)_{bump}$ represent respectively the bending force at a given instant, the bending force corresponding to the compensation for the Solenoid and the bending force for the required vertical orbit bump.

I_{S1}, I_{Smax} refer to the Solenoid current.

It is necessary to maintain the currents in the LBC magnets accurate to within 0.2% of the maximum value, so that residual vertical orbit distortions remain less than 0.4 mm (peak-to-peak). In this manner, the small excursions in the horizontal orbit ($\simeq$ 1 mm peak to peak) and the effects of coupling are ignored, however.

3. DETAILS OF THE PROGRAM

The computer program SORD (SOlenoid Run-Down) reads the Solenoid at fixed intervals of time which may be specified beforehand. The maximum sampling rate corresponds to once every ~ 0.5 seconds or in the event of a necessary change in magnet current, once every ~ 1.5 secs. Whenever the Solenoid current is found to have changed by a given amount, the compensator magnet currents are adjusted accordingly. This tolerance is a parameter for the program and a value of 0.1% change is recommended. During the actual "rundown", both beam currents and all magnet current values are recorded and may be printed concurrently or at the end of the manoeuvre. Again the frequency of this logging may be specified, e.g. once per 2% change in Solenoid current.

The tracking algorithm will take into account any vertical bumps which have been applied previously. The magnitude of the bumps are calculated in mms and the operator is given the option of whether to remove the bump before the "rundown" or to leave them in. Timing complications may arise, however, if a polarity change of any LBC magnet is incurred, i.e. around 20 seconds; hence, the removal of a bump may be important. The nominal compensation values for the LBC's are retained in the memory of the Argus computer and these may be accessed via the DAYFILE facility during normal operations (see Table 2). Conversion from bending force to magnet current is performed by interpolation between the values given in Table 1.

4. MACHINE EXPERIMENTS

a) Run 836 - 8.6A (R1) x 6.5 A (R2) - ELSA.

A normal machine set-up was carried out :

1) A correct working line ELSA measured

2) vertical closed orbit variation 2.7 mm (R1) 4.3 mm (R2) at <O> (unfortunately, octant 8 pick-ups were all faulty)

3) small stacks made covering all the stacking aperture, i.e. <+40> to <-20>, with both stacks aperture limited horizontally against the chamber protector scrapers

4) initial beam loss rates (1 ± 1 ppm)

5) all vertical aperture limitations removed, i.e. ID + 2 mm, coll. ± 12 and both beams were "cleaned" by vertical scraping.

The variation of the magnet current settings and the change in beam currents are shown in Fig. 1. Several measurements of the mean beam position in I5 were made using the new detector in I5. The sudden loss of ~ 12 mA in R1 could not be correlated with any irregularities in magnet current or beam position. One possible explanation is that the small change in horizontal closed orbit could have brought the beam closer to its outer horizontal aperture limitation. Measurement of closed orbits in the stack showed an effective change of ~ 0.8 mm (peak-to-peak) in the vertical closed orbit due to the "switch-off" procedure. The final background conditions at the intersection seemed very low with beam loss rates of less than 3 ppm.

b) <u>Run 838</u> - 20.5 A (R1) x 0.0 (R2) - ELSA, low-β. At the end of a 36 hour physics run, the test was repeated under different machine conditions, i.e. low-β. Unfortunately, the test could only be scheduled with one beam, which had been centered in the vacuum chamber, i.e. extrema <±30> mm. The "switch-off" procedure resulted in only a <u>6 mA</u> loss from the stack. The sharp loss of current which was observed after 11 minutes during the previous test was not reproduced. In collaboration with the I1 experimental group, the evolution of the background rates was monitored. The initial and final conditions were considered to be almost identical, whilst the I1 group judged that <u>during</u> the "switch-off", the background was just over the limit of being acceptable for physics data collection.

5. <u>FURTHER DEVELOPMENTS</u>

a) The operation of removing and re-introducing vertical bumps by the program still requires some attention.

b) In principle, the program can be used for switching on the solenoid if specifically requested.

c) The possibility of using the program in an automatic manner has not been considered; this would require some detailed study of the performance of the Argus 500 operating system.

d) If the power supply of the solenoid were to be controlled by the Argus computer, it should be possible to improve on the controlled "run-down" time of 29 minutes.

K. Brand J. Gamble D. Lewis

TABLE 1

(B.ℓ) values for the compensator (dipole) magnets (T.m)

I %	1LBC1	2LBC2	1LBC3	2LBC4
0	0.0	0.0	0.0	0.0
50	.13569	.13554	.13564	.13573
55	.14916	.14898	.14910	.14920
60	.16263	.16242	.16256	.16268
65	.17600	.17579	.17593	.17607
70	.18913	.18890	.18905	.18919
75	.20197	.20166	.20185	.20194
80	.21416	.21377	.21400	.21400
85	.22518	.22476	.22500	.22495
90	.23543	.23500	.23524	.23513
95	.24516	.24472	.24497	.24481
100	.25429	.25385	.25409	.25392

TABLE 2

COMPENSATION SETTINGS FOR LOW-BETA

```
/XOUT(LOWB)    TIME:16H57M09S     DATE:77-04-27
/XKEE-RUN:0    XINP/XKEE-TIME:14H49M41S     DATE:77-04-18
/MAIN
/   DT
/   PF
/   H
    1LBC1    +47.41        1LBC3    +59.91
    2LBC2    +47.41        2LBC4    +59.91
/   CR
/ END OF DATA
```

COMPENSATION SETTINGS FOR NORMAL ELSA

```
OUT(ELSA)    TIME:16H49M11S     DATE:77-04-27
/XKEE-RUN:0    XINP/XKEE-TIME:14H41M40S     DATE:77-04-18
/MAIN
/   DT
/   PF
/   H
    1LBC1    +57.52        1LBC3    +72.19
    2LBC2    +57.62        2LBC4    +72.14
/   CR
/ END OF DATA
```

DAYFILE (for Machine Operations)

```
DAY FILE                                                08H39M12S 77-04-28
G.P.                         RING 1                     RING 2
+............................+..........................+........................
RUN       =      843         BEAM1    =    PROT         BEAM2    =    PROT
SFMFILE   =     26XS         WCR1     =      SB         WCR2 ,   =      SB
LOWBFILE  =     LB26         PC1      =       0         PC2      =       0
|SOLNSTAT =     LOWB|                        SET   UP
SIGMFILE  =     ****         BTS3     =    DA26         BTS4     =    DA26
                             WLR1     =    LB26         WLR2     =    LB26
                             COR1     =    LB26         COR2     =    LB26
```

Fig. 1 LOG OF INFORMATION RECORDED BY THE COMPUTER PROGRAM SORD

Run 836 ELSA, 26 GeV/c

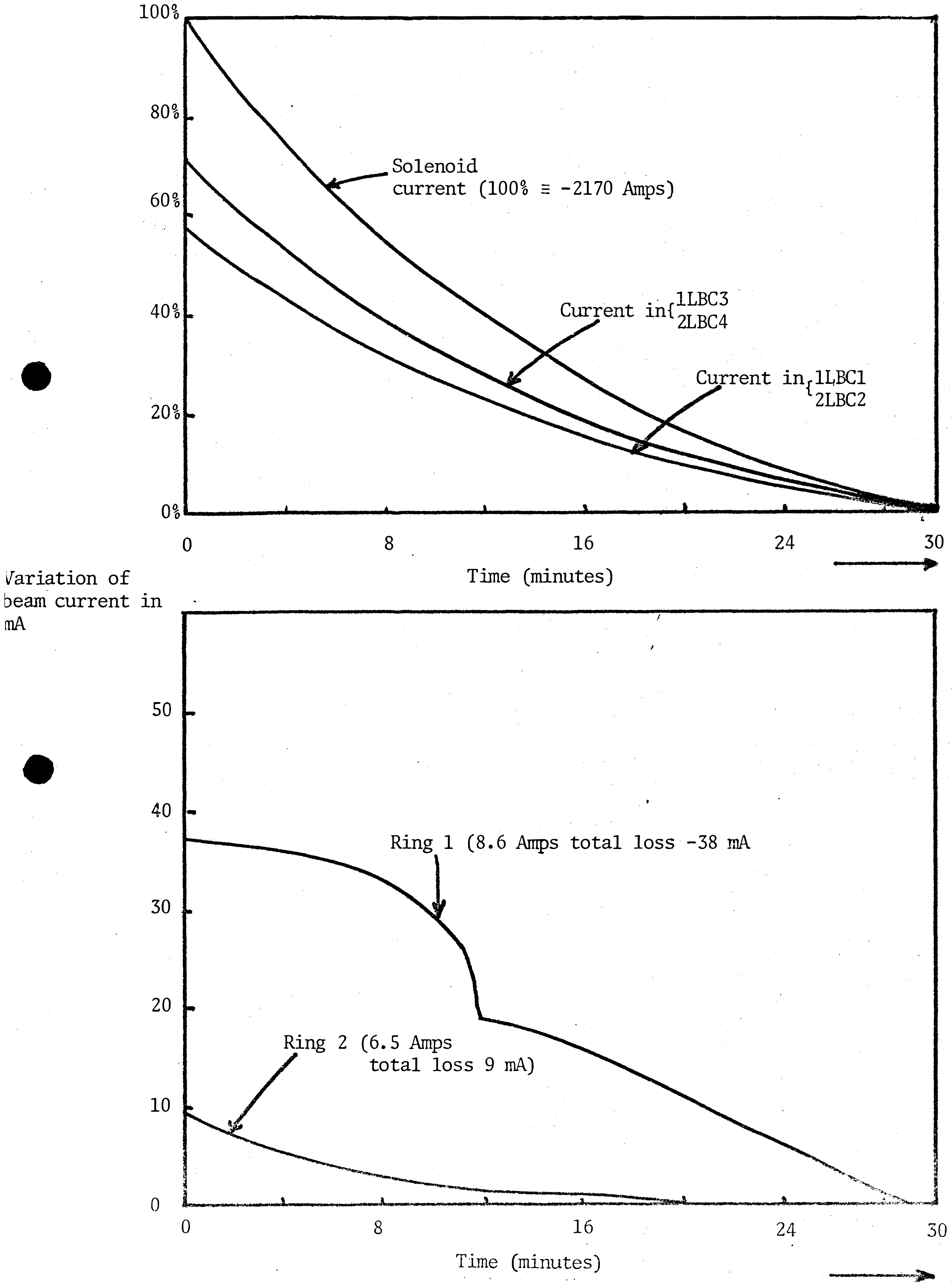

Fig. 2 VARIATION OF VERTICAL BEAM POSITION IN I5 (20.5 Amps)
Run 838, R1 ELSA, Low-β, 26 GeV/c