BNL-104159-2014-TECH

AGS.SN283;BNL-104159-2014-IR

Calibration of the Booster F6 Ejector Septum

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April 1993

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USDOE Office of Science (SC)

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AGS Complex Machine Studies

(AGS STUDIES REPORT Number 283)

Calibration of the Booster F6 Ejector Septum

Study Period:	10 April 1993
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Reported by :	M. Tanaka
Machine:	Booster_Extraction @ t_0 = 85 ms
Beam:	User3, 4.7 x 10^{11} ppp (20 turns injection) at E_k =1.2 GeV
Tools:	MW006 @LtB, IPM @Booster
Aim:	***To Calibrate the F6 Ejector Septum***

I. Introduction

The ejector septum with an effective thickness of 5.1 mm is located 47.1 mm from the central orbit at ssF6. The septum kicks the beam horizontally 143 mrad away from the ring to the BtA line.

II. Setup and Data Taking

The standard setup commands for the booster extraction were reloaded and executed:

1) {30 mm,-2 mrad} 4-magnet extraction bumps
2) FKF3.SP = 27.5 kV
3) SMF6.SP = 8989 A ! The actual current is SMF6.SP x 2.

The orbit data just before extraction and FKF3 vs F6_loss scan data confirmed that we had the standard extraction setup. The horizontal and vertical beam positions x_h, x_v and their FWHM values were measured at the first muti-wire beam profile monitor MW006 in the BtA line, as a function of the SMF6.SP(setpoint) value. Beam losses at F6 and at F7-F9 were also recorded on the GPM monitor. The value of SMF6.SP was increased untill the horizontal beam profile started to disappear from the MW006 display range. However, we could not lower SMF6.RB below 8800 A due to a preset hardware limit. Since SMF6.RB (readback) values appeared to fluctuate about 50 A, we consistently took a higher value except for the first several points. Figure 1 shows the SMF6.RB vs SMF6.SP with a linear fit:

$$SMF6.RB = 0.6120*SMF6.SP + 3336 \text{ [A]}.$$

✍ A small dip just around SMF6.SP = 9030 A is a artifact mentioned above.

III. Results and Analysis

Figure 2 shows the results from MW006. It displays x_h, FWHM(x_h), x_v and FWHM(x_v) as a function of SMF6.SP. The x_h postion sweeps from -1.2 mm to +21.8 mm as the SMF6.SP value increases from 8820 to 9340 A, while all others stay essentially constant. Any noticeable changes in both horizontal and vertical beam profiles were not observed during this study. A linear fit to x_h gives

$$x_h\,[\text{mm}] = 0.02780*\text{SMF6.SP[A]} - 250.86 \quad \text{at MW006.}$$

The beam losses at F6(F6_loss) and at F7-8(Fds_loss) vs x_h are shown in Figure 3. F6 _loss starts to increase at x_h = 8 mm and reaches the maxmium at x_h = 15 mm The increase of Fds_loss is a reflection of beam losses in the LtB line rather than ones at SMF6 since F6_loss increased only slightly at x = 5 mm, and the beam profiles were not changed at MW006.

We compare the transverse beam emittance estimated from the beam width (1 σ) measured by IPM just before extraction and one estimated from the average beam width (FWHM=2.354 σ) measured by MW006. The 95 % normalized emittance is defined as

$$\varepsilon^n(95\%) = \frac{6\cdot\sigma^2}{\beta}(\beta\gamma)_{rel}\,\pi\,[\text{mm - mrad}]$$

where $(\beta\gamma)_{rev}$ (= 2.05) is the usual relativistic parameter, σ is the r.m.s. beam size (betatron amplitude) and β is the lattice β function. The contribution from Dx·(dp/p) is ignored.

Parameter	IPM	MW006	Unit
β_h	9.08	3.14	m
β_v	7.74	15.29	m
D_x	2.29	0.63	m
x_h	2.10	-1 to 22	mm
x_v	1.58	0.78 ± 0.10	mm
σ_h	4.90	1.81 ± 0.09	mm
σ_v	3.84	4.03 ± 0.17	mm
$\varepsilon^n_h(95\%)$	30.72	12.97	π mm-mrad
$\varepsilon^n_v(95\%)$	22.14	13.06	π mm-mrad

Both IPM ε^n_h and ε^n_v values are much higher than the MW006 values. If we assume that $\varepsilon^n_h = \varepsilon^n_v = 22\ \pi$ mm-mrad, then $(dp/p)_{full} = \pm 0.25$ % , which is rather high.

✍ The errors quoted in the table are only statistical errors.

IV. Conclusions

We have calibrated the SMF6 by measuring the beam position at MW006 in the BtA line as a function of the septum strength at E_k = 1.2 GeV. As the SMF6.SP value is increased up to 10 % above the nominal setting, the horizontal beam position moved from -1.2 mm to 21.8 mm at MW006 while the vertical position, transverse beam profiles and beam loss at F6 stay unchanged.

The normalized horizontal and vertical emittances measured by IPM are about 70 % higher than ones estimated from the MW006 beam widths.

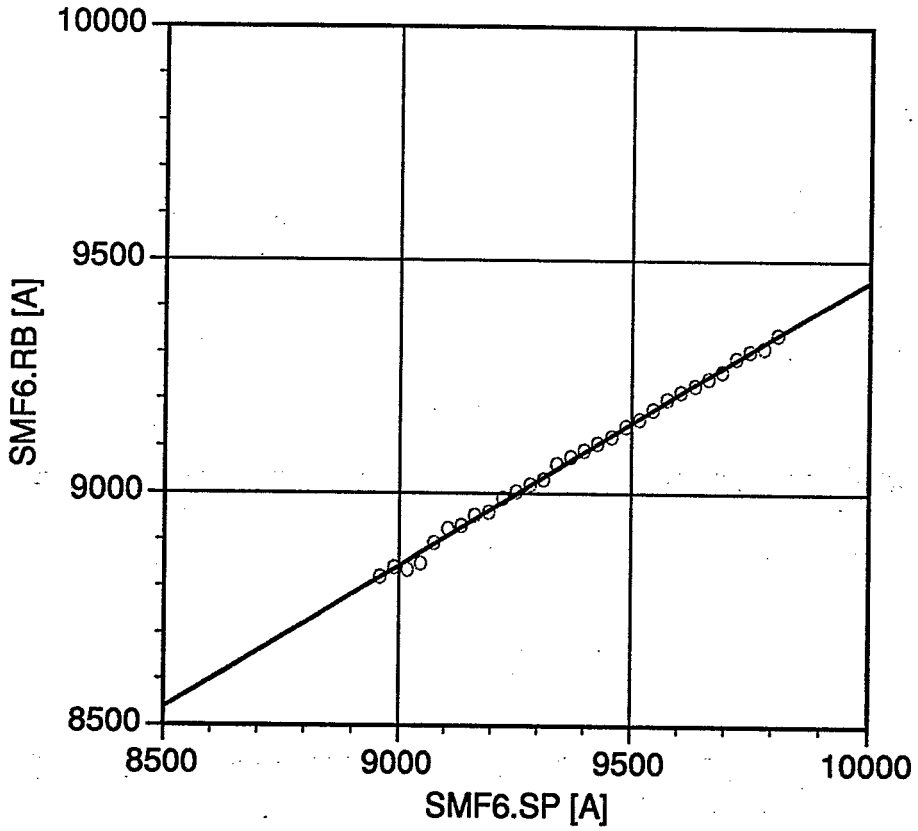

Fig.1. SMF6.RB vs SMF6.SP

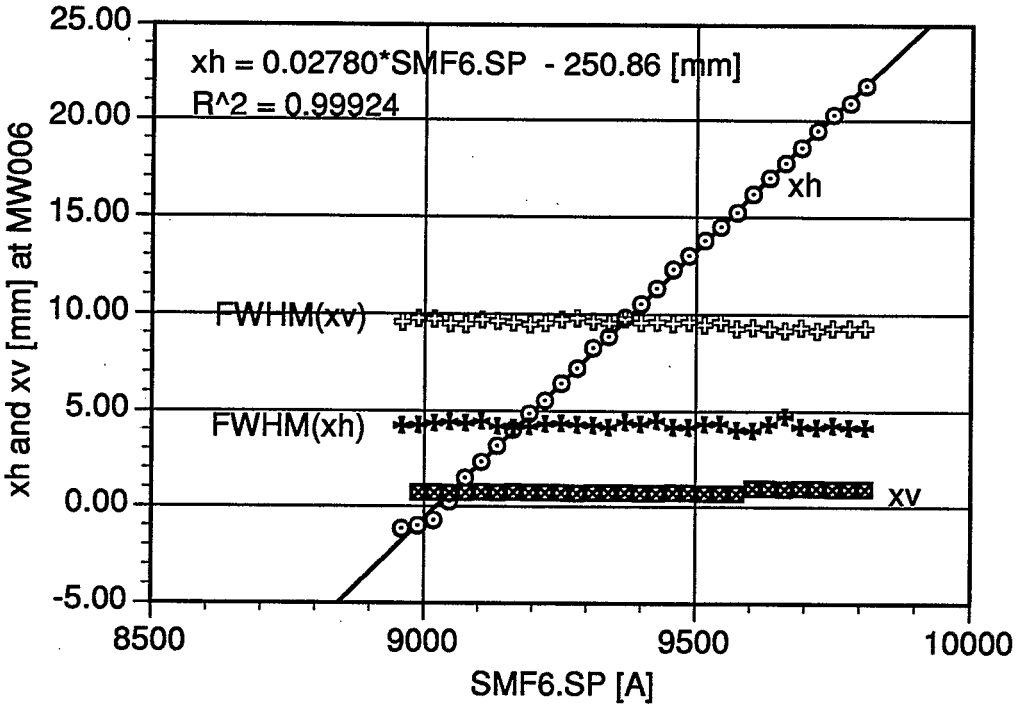

Fig. 2. xh and xv vs SMF6.SP

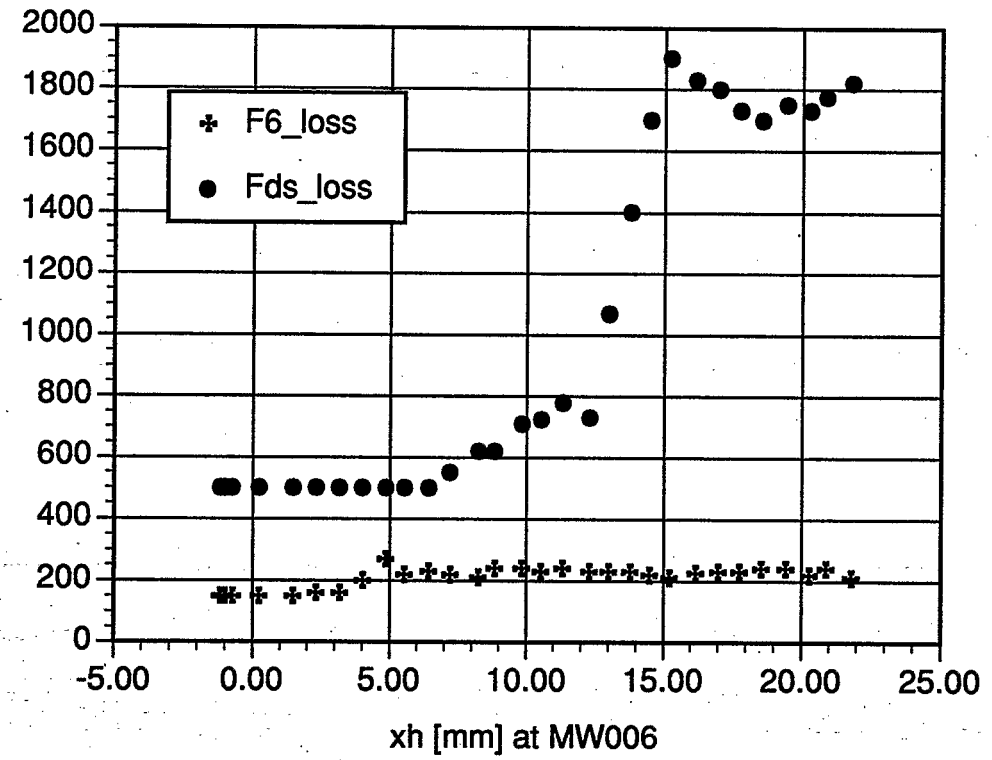

Fig.3. Beam losses vs xh