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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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28 April 1993

<p align="center"><b><i>AGS Complex Machine Studies</i></b></p> <p align="center">(AGS STUDIES REPORT Number <u>283</u>)</p> <p align="center"><b><u>Calibration of the Booster F6 Ejector Septum</u></b></p>	
<b>Study Period:</b>	10 April 1993
<b>Participants:</b>	M. Tanaka, R. Thern, K. Zeno
<b>Reported by :</b>	M. Tanaka
<b>Machine:</b>	Booster_Extraction @ $t_0 = 85$ ms
<b>Beam:</b>	User3, $4.7 \times 10^{11}$ ppp (20 turns injection) at $E_k = 1.2$ GeV
<b>Tools:</b>	MW006 @LtB, IPM @Booster
<b>Aim:</b>	<i>To Calibrate the F6 Ejector Septum</i>

## 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 multi-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 until 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:

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

✎ 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  $x_h$ ,  $\text{FWHM}(x_h)$ ,  $x_v$  and  $\text{FWHM}(x_v)$  as a function of SMF6.SP. The  $x_h$  position 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

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

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 maximum 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 ( $1 \sigma$ ) measured by IPM just before extraction and one estimated from the average beam width ( $\text{FWHM}=2.354 \sigma$ ) measured by MW006. The 95 % normalized emittance is defined as

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

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

Parameter	IPM	MW006	Unit
$\beta_h$	9.08	3.14	m
$\beta_v$	7.74	15.29	m
$D_x$	2.29	0.63	m
$x_h$	2.10	-1 to 22	mm
$x_v$	1.58	$0.78 \pm 0.10$	mm
$\sigma_h$	4.90	$1.81 \pm 0.09$	mm
$\sigma_v$	3.84	$4.03 \pm 0.17$	mm
$\epsilon_h^n(95\%)$	30.72	12.97	$\pi \text{ mm} \cdot \text{mrad}$
$\epsilon_v^n(95\%)$	22.14	13.06	$\pi \text{ mm} \cdot \text{mrad}$

Both IPM  $\epsilon_h^n$  and  $\epsilon_v^n$  values are much higher than the MW006 values. If we assume that  $\epsilon_h^n = \epsilon_v^n = 22 \pi \text{ mm} \cdot \text{mrad}$ , then  $(dp/p)_{\text{full}} = \pm 0.25 \%$ , 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.

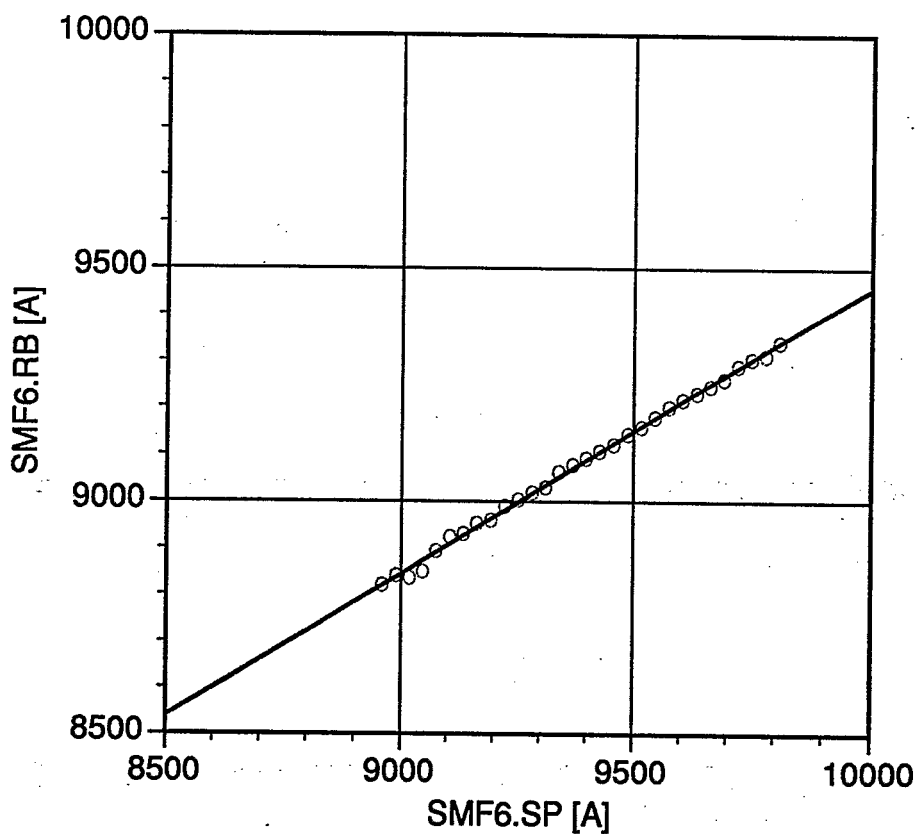


Fig.1. SMF6.RB vs SMF6.SP

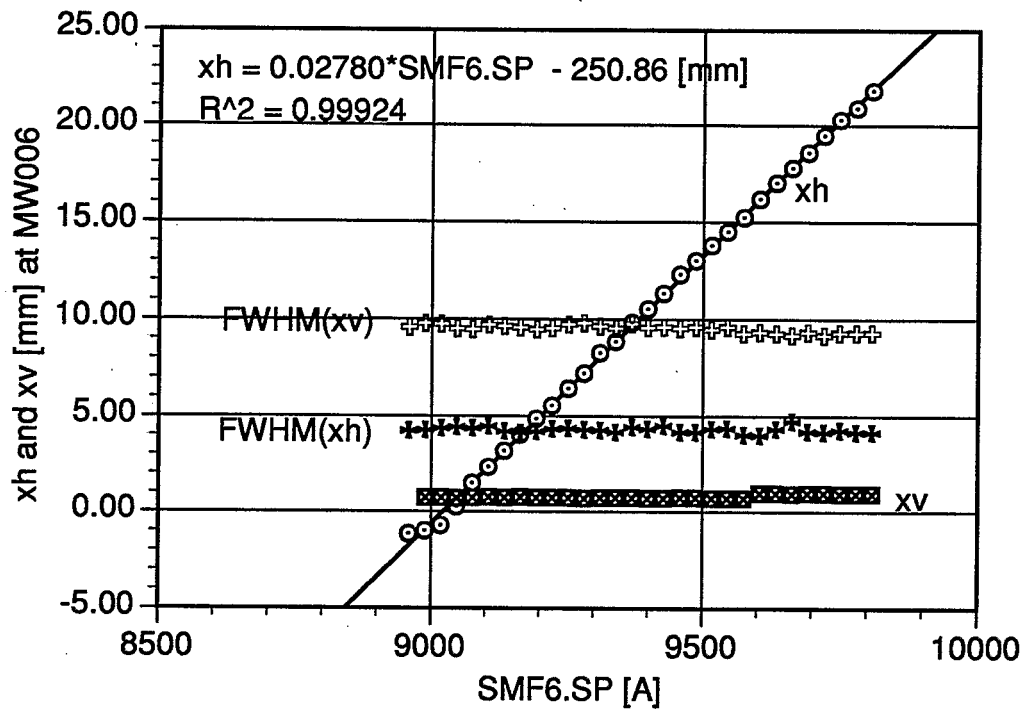


Fig. 2. xh and xv vs SMF6.SP

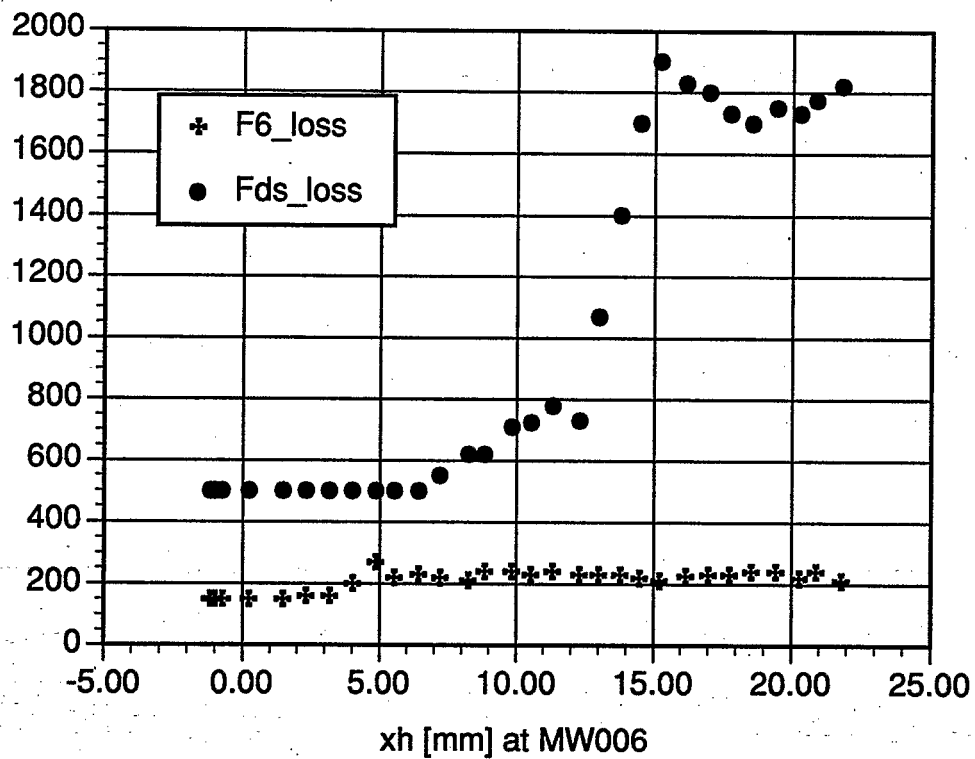


Fig.3. Beam losses vs xh