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Calibration of the Booster F3 Kicker and Measurements of Horizontal Dynamical Aperture at the F6 Ejector

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AGS Complex Machine Studies

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Calibration of the Booster F3 Kicker Magnet and Measurements of Horizontal Dynamical Aperture at the F6 Ejector

Study Period:	24 March 1993
Participants:	E. Bleser, M. Tanaka, R. Thern, MCR
Reported by :	M. Tanaka
Machine:	Booster_Extraction @ t_0 = 85.5 ms
Beam:	User3, low intensity proton beam (1 turn injection) at E_k =1.2 GeV
Tools:	Orbit, Orbit _Control, RLM and IPM
Aim:	***To Calibrate the F3 Fast Kicker and to Measure Horizontal Dynamical Aperture at the F6 Ejector Septum .***

I. Introduction

The Booster fast extraction system consists of a full aperture fast kicker (FKF3) at ssF3 and an ejector magnet(SMF6) at ssF6 with local 4-magnet extraction bumps (TDHF2, F4, F7, A1)[1]. The 5.1 mm thick septum is located at 47.1 mm from the central orbit[2].

II. Setup and Data Taking

The beam losses around SMF6 and in the BtA line were measured as a function of the FKF3 strength at SMF6.SP= 8820.5 A for various extraction bump amplitudes:

1). {15 mm, -0.5 mard} ! $F2^-$, $F4^+$, $F7^-$, $A1^+$
2). {25 mm, -1.5 mrad} ! Saved file for 2) was lost.
3). {30 mm, -2.0 mrad}
4). {45 mm, -3.5 mard}

In Figure 1, the readback value of the kicker (FKF3.RB) vs its setpoint value (FKF3.SP) is shown. As seen, FKF3.RB appears to fluctuate between two values, one of which is close to FKF3.SP and one of which is systematically 2 kV lower. Therefore, we use the setpoint values as a parameter in the following analysis.

Figure 2 shows the variations of the setptum current readback (SMF6.RB) and one of the 4 bump trim dipole current readbacks (TDHF4.RB) during a measurement for the {-30 mm, 2 mrad} bump setup. The average values stay constant although the SMF6.RB fluctuates 8780 ± 20 A and TDHF4.RB fluctuates 374 ± 4 A.

III. Results and Analysis

The results are shown in Figures 3, 4 and 5 for 1) 15 mm, 2) 30 mm and 3) 45 mm bump setups, respectively. In each figure, the relative beam losses a) at F4, F5, F5ds, F6,,, A2 around SMF6, and b) at BtA2, 4, 6, 8 (045', 114', 160', 206') are plotted as a function of FKF3.SP in the BtA line.

As the F3 kicker strength increases, the beam moves outward and hits the septum, causing big beam losses downstream. Once the beam jumps the septum, the beam is extracted from the ring, therefore the beam losses around the septum disappear and the beam losses in the BtA line show up. As the kicker strength increases further, the beam starts to scrape the vacuum chamber wall with a limited aperture at F5ds and one at the septum magnet. For the 45 mm bump, the beam is already scraping the septum and the vacuum chamber wall at F8 where the bump amplitude is a maximum (60 mm) before the kicker is fired. Based on 15 mm and 30 mm bump data (Figures 3 and 4) we can calibrate the FKF3 kicker as

$$\Delta x_h = (1.8 \pm 0.2)[\text{mm/kV}] \times \text{FKF3.SP[kV]} \text{ at F6}$$

for E_k=1.2 GeV(p=1.92 GeV/c). We also have estimated the 1 σ beam width from the FWHM (=8.0 kV) of the beam loss profiles at the septum in Figure 3 to be x_{rms} = 6.1± 1.0 mm. The IPM measured the 1 σ normalized emittance ε^n_{rms} = 4.0 π mm-mrad which corresponds to x_{rms} = 4.9 mm at F6, neglecting Dx*dp/p. The IPM 99% full beam width (2x3x4.9 =29.6 mm) is consistent with one from the beam loss profiles (36.6 ± 0.6 mm) if one considers the effects due to the finite septum thickness(5 mm). Using the IPM value and a clearance of 15.0 mm we have at the septum for this beam, we find that the *dynamical horizonatl aperture at the F6 septum is* ***44.4 mm.*** It implies that *the maximum 95 % normalized horizontal emittance without losing more than 1% of the beam at the septum is* ***52 π mm-mrad,*** *allowing* $(dp/p)_{full} \leq 0.2$ %.

✍ The physical apertute at the septum (first section) is h x v= 71.1 mm x 27.4 mm. The sharp rise of the F5ds and F6 loss monitor readings indicate that the vacuum chamber wall at F5ds limits the available aperture at the septum.

IV. Conclusions

We have calibrated the FKF3 by measuring the beam loss profiles around the septum as a function of the kicker strength for various bump settings at E_k = 1.2 GeV. The maximum normalized horizontal emittance (95%) without losing more than 1% of the beam at the septum is ***52 π mm-mrad*** *and the allowed closed orbit distortion is $x_{co} \leq 24$ mm at the septum.*

References

[1] M. Tanaka, AGS Studies Report No. 278
[2] M. Tanaka, AGS Studies Report No. 283

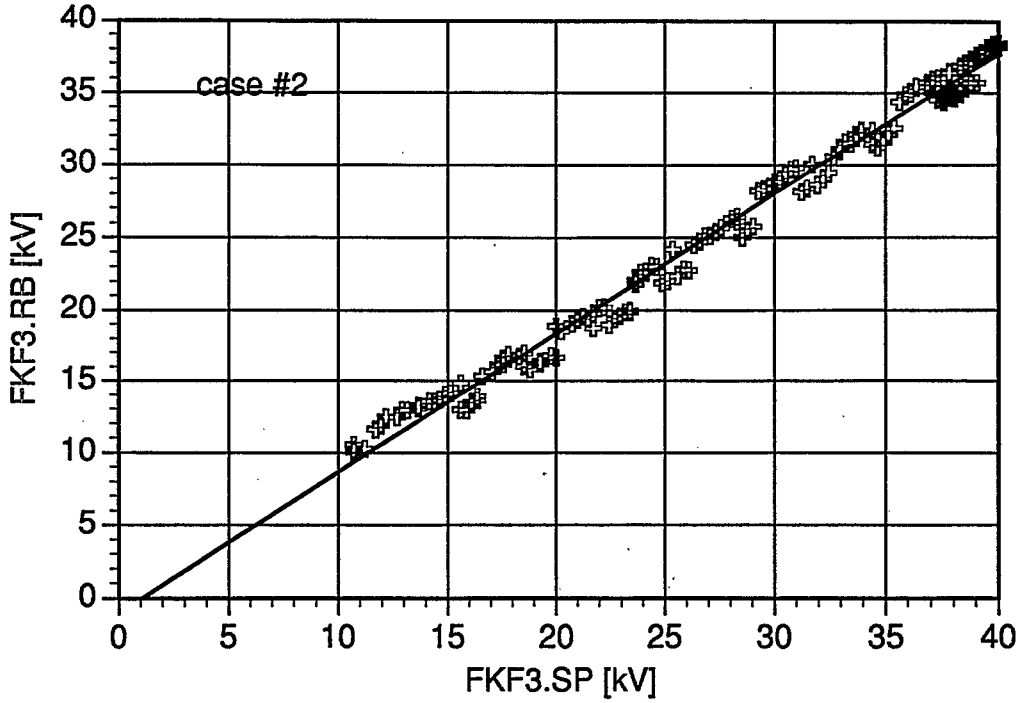

Fig.1. FKF3.RB vs FKF3.SP

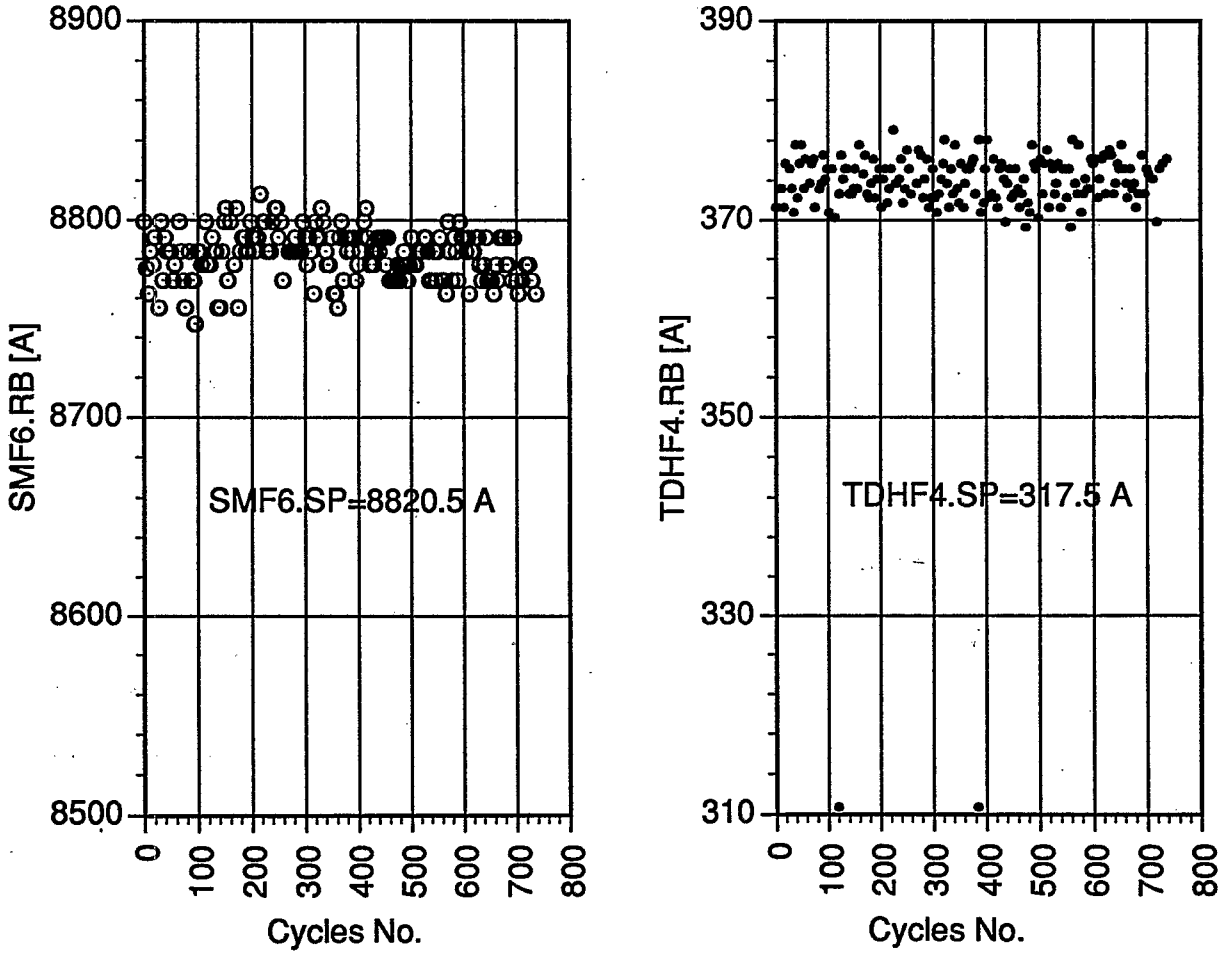

Fig.2. SMF6.RB and TDHF4.RB variations

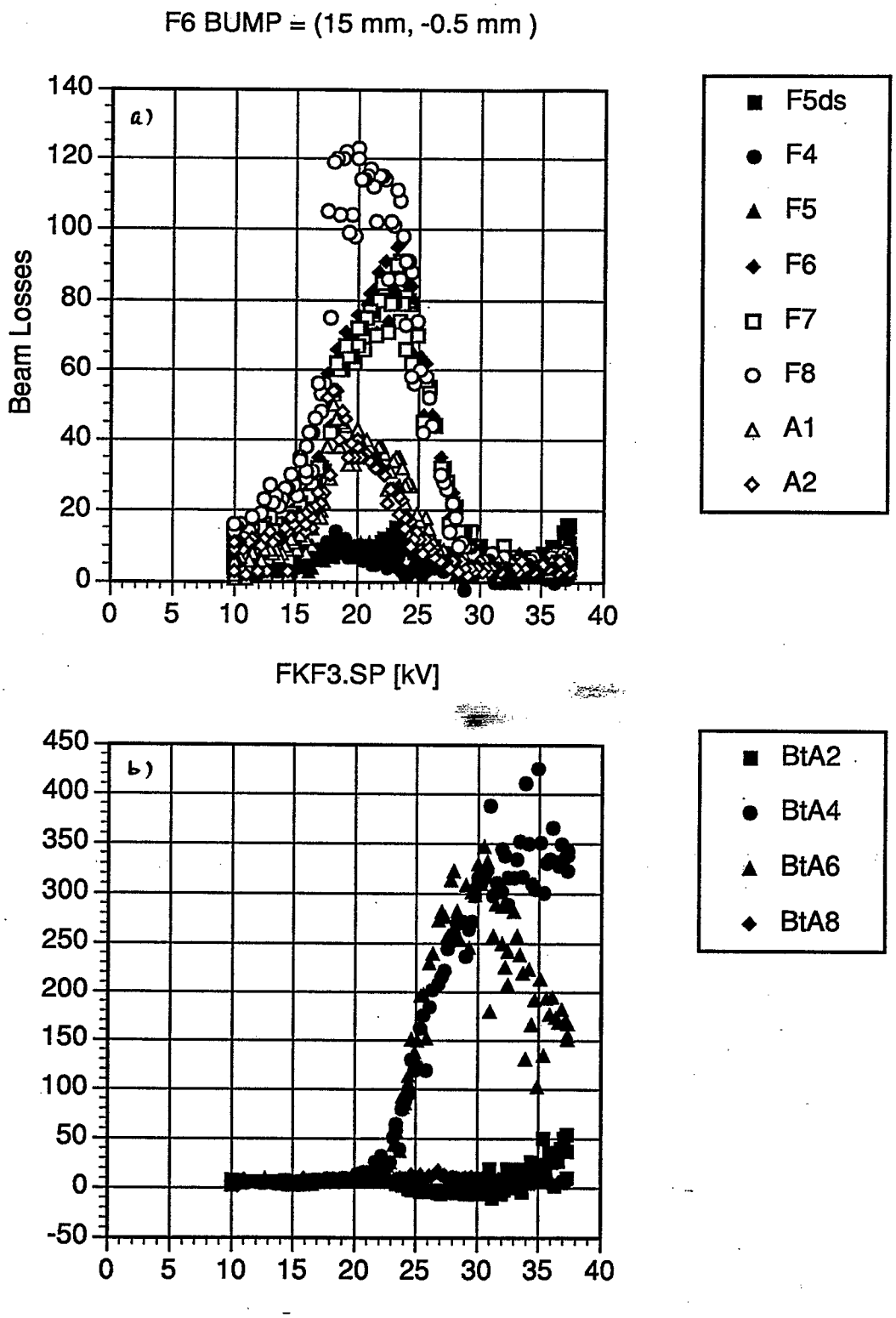

Fig.3. Beam losses vs FKF3.SP for the 15 mm bump.

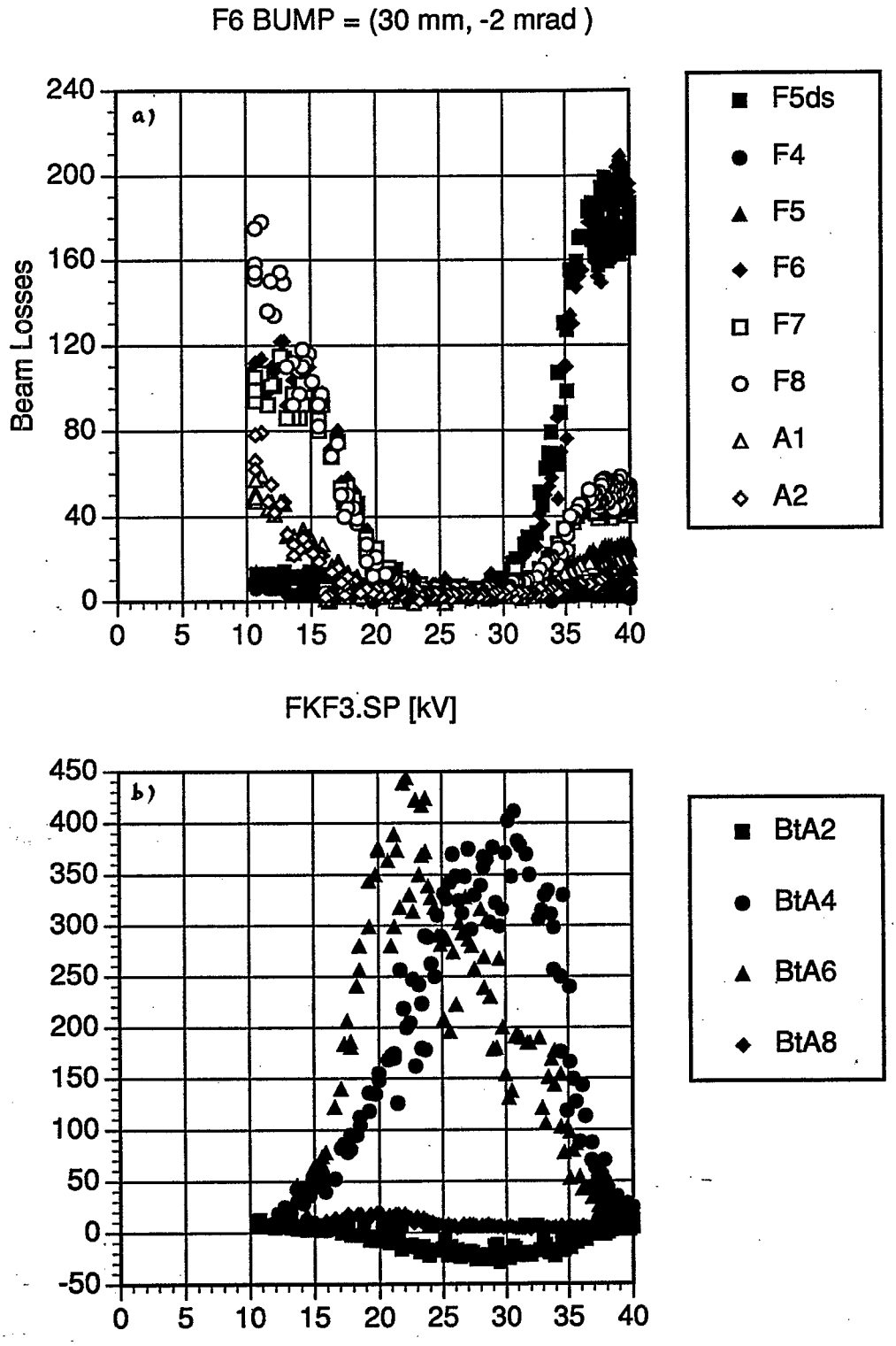

Fig.4. Beam losses vs FKF3.SP for the 30 mm bump.

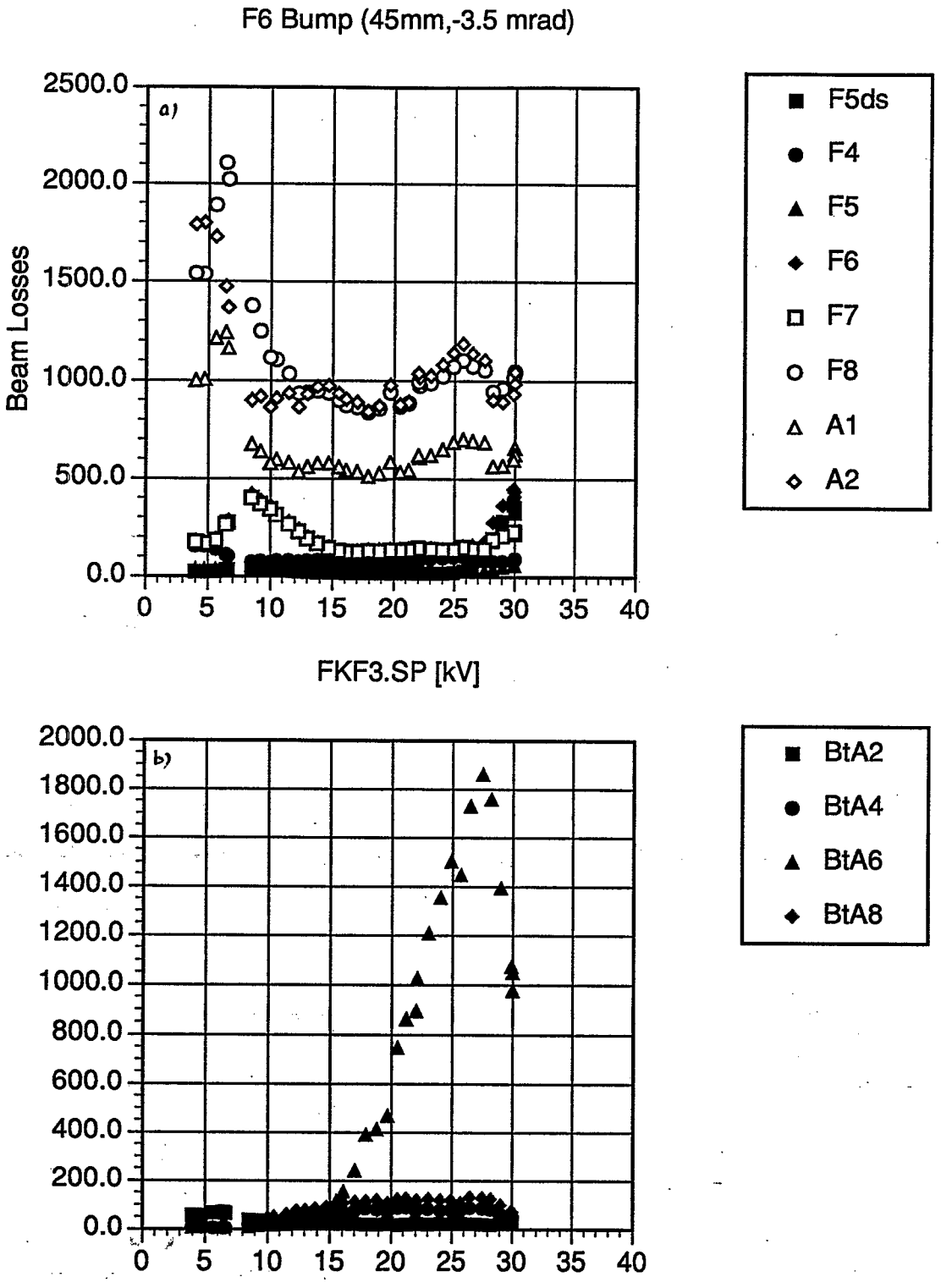

Fig.5. Beam losses vs FKF3.SP for the 45 mm bump.