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# Calibration of Booster Extraction Bumps

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# AGS Complex Machine Studies

(AGS STUDIES REPORT Number 278)

## Calibration of Booster Extraction Bumps

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| **Study Period:** | 19, 24 March 1993 |
| **Participants:** | L. Ahrens, E. Bleser, M. Tanaka, R. Thern + MCR |
| **Reported by :** | M. Tanaka |
| **Machine:** | AB_Extraction |
| **Beam:** | User3, low intensity proton beam(1 turn injection) at $E_k$ =1.2 GeV |
| **Tools:** | Booster_Orbit (BPMs) and Booster_Orbit_Control Programs, RLM |
| **Aim:** | ***To calibrate the 4 magnet extraction bumps (F2/F7 -Inward, F4/A1-Outward)*** |

## I. Introduction

A new functionality for extraction bump controls was recently implemented for the Booster Orbit Control Program by L. Ahrens and A. Abola so that the program automatically loads and executes the setpoint command for each magnet based on the requested beam position/angle at F6 (SPTMF6), the bump configuration, and the assumed machine conditions ($Q_{h,v}$ and dB/dt etc.). Then, the program predicts the beam position and angle {x, x'} at F6, as well as the orbit residuals outside the bumps from the actual readback currents of the magnets

## II. Setup and Data Taking

The various beam positions and angles {x,x'} at F6 were requested by the Booster Orbit Control Program for the 4 magnet bump configuration (F2(-),F4(+),F7(-) and A1(+)). For each request, the corresponding data were measured at $t_o$ =85.5 ms, and the beam loss data at F6 were recorded on the GPM monitor.

Figure 1 shows the requested {x,x'} and those calculated {x,x'} values from the readback magnet current readings [TDHFn.SPRB]. A good agreement between the requested and calculated values indicates that the offsets in the readback values are well under control. In Figure 2, the magnet current readback values are plotted for various requested {x,x'} values .

✍ Due to a minor technical reason associated with the original modeling coordinate system, the sign of {x,x'} in the Booster Orbit Control program is reversed so that you have to request {-x,-x'} for {x,x'} in the program. This will be corrected.

✍ Sometimes one of the readback current values (e.g.,TDHF2.SPRB) on spreadsheet oscillates between the correct and the incorrect ones,but the analog signal does not appear to vary. If the program picks up the wrong readback value, then it will predict a wrong {x,x'} too. This problem should be investigated.

✍ Sometimes the program seems to wander off giving setting corresponding to [x,x'}'s very diffrent from requests. In such cases, all magnet setpoints should be reset by sending zero commands through the program. Since the zero command does not disconnect the bump power supplies from the main ones, there is still the substantial induced currents on magnets as seen in Figures 2 and 3.

✍ The calculated and real residuals outside the bumps are very small (~0.5 mm). Large residuals usually mean that the program picked up a wrong readback value.

## III. Results and Analysis

The results are summarized in Figure 3. When the beam moves to about 35 mm from the central orbit (x = 35 mm) at F6, it starts scraping the 5 mm thick F6 septum located at x = 47 mm, causing a sharp increase of the F6 beam loss and a distortion of the measured beam position at F8 (x_mea(F8)). In the range 15 < x_req[mm] < 45, the x_cal(F6) line is essentially parallel to the x_mea(F8) line. Since there is no BPM at F6, the beam position at F8 is extrapolated from the calculated $\{x, x'\}_{F6}$, using the known beta functions and phase advance :

$$\begin{pmatrix} x \\ x' \end{pmatrix}_{F8} = \begin{pmatrix} 2.000, 10.356 \\ 0.294, 2.008 \end{pmatrix} \begin{pmatrix} x \\ x' \end{pmatrix}_{F6}$$

In Figure 4, we show that x_mea(F8) vs x_cal(F8) for the linear repose region. The solid line is a simple linear fit to the data points, which is given by

x_mea(F8) = 1.0015·xcal(F8) + 2.3434 [mm]

✍ x_mea(F8) is actually the orbit difference at F8 taken between t=75 ms (no bumps) and 85.5 ms.

✍ Even if the bump magnet power supplies were turned off, x_mea(F8) still read 3.00 mm. It indicates that the actual offset is not 2.34 mm but -0.66 mm.

## IV. Conclusions

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| The Booster Orbit Control Program can properly produce the requested 4 magnet extraction bumps as demonstrated in Figure 5. Due to its usefulness, the following improvement would be desirable: 1) list the calculated and measured(BPM) beam positions at F4 and F8 too, 2) fully implement dB/dt effects, 3) adapt the standard sign(x) convention. |

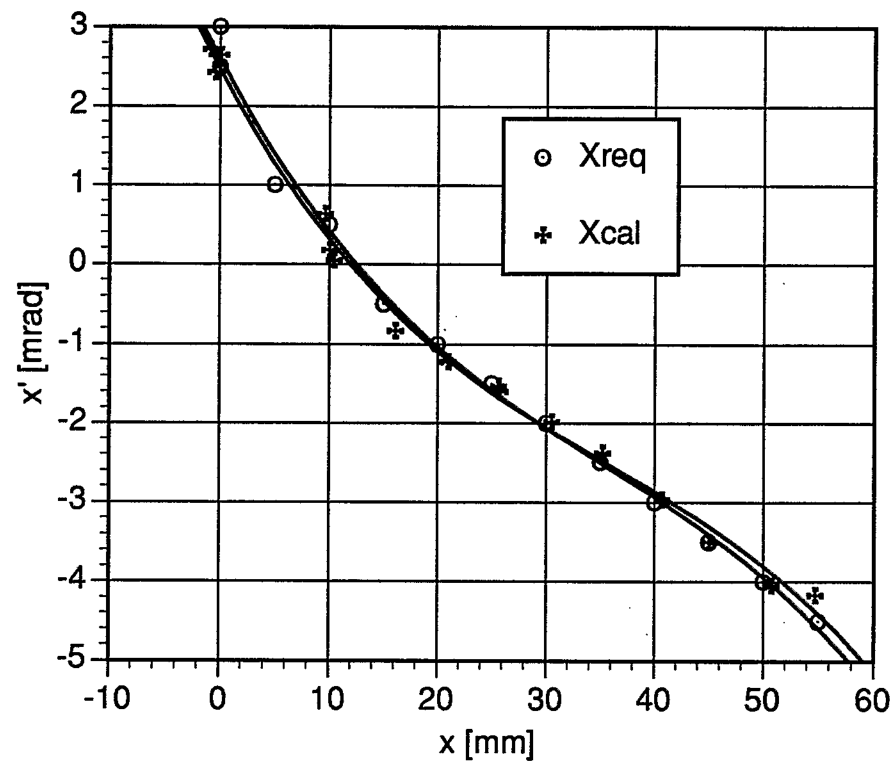


Fig. 1. {x, x'} at F6 for the requested and calculated values.

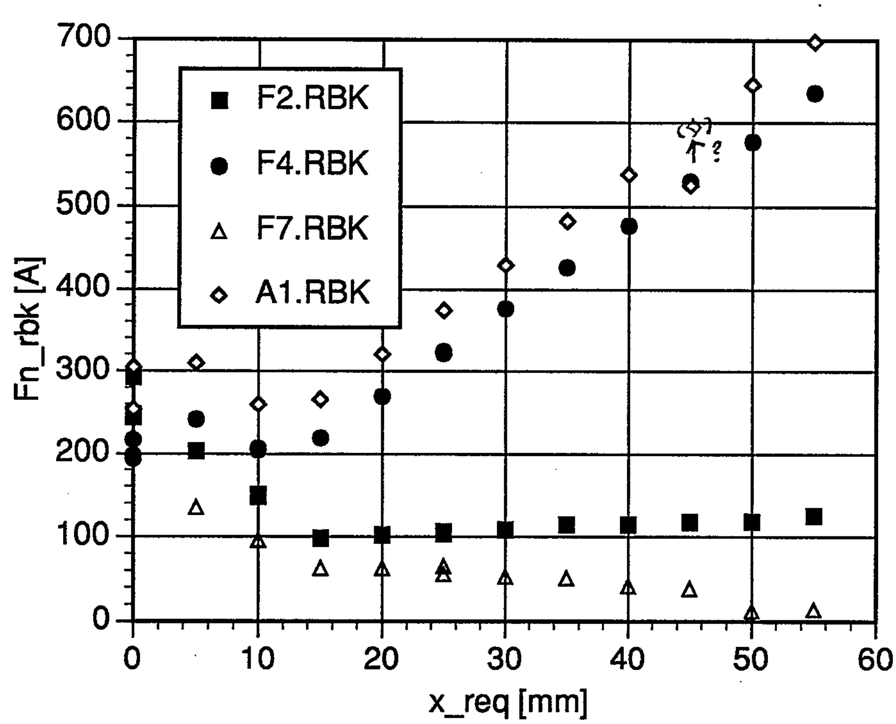


Fig.2. Magnet current readback values as a function of the requested {x,x'} values.

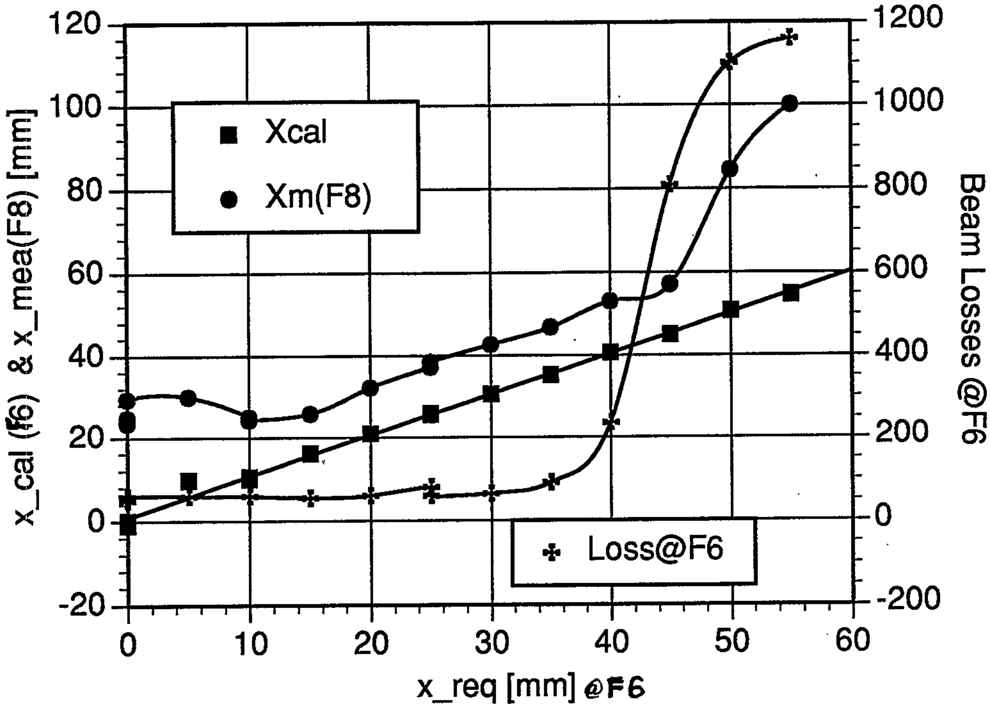


Fig.3. Calculated x (F6), measured x(F8) and beam loss (F6) vs the requested x(F6).

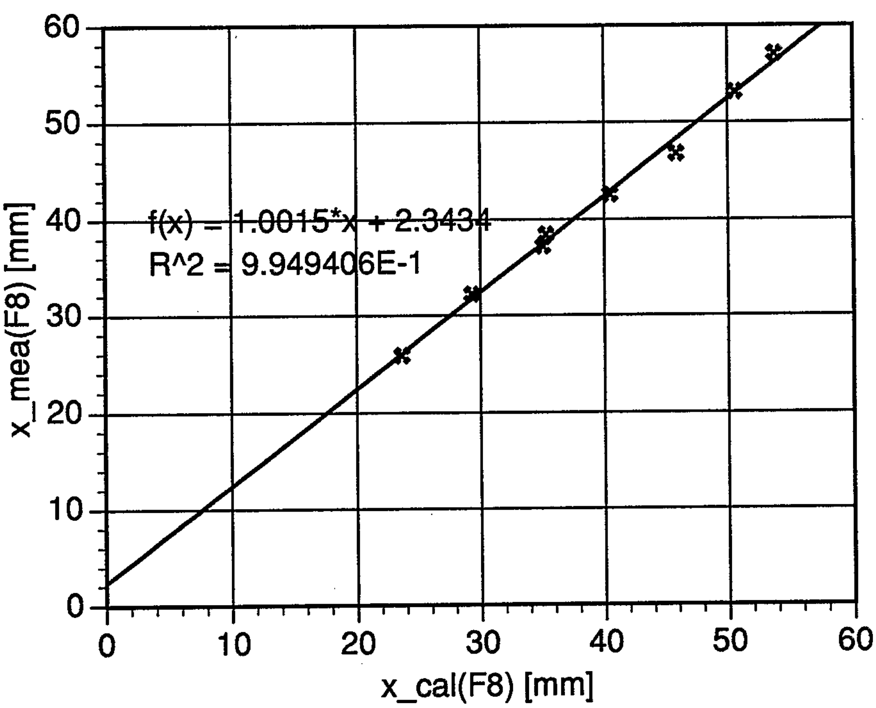


Fig.4. Measured x(F8) vs predicted x(F8) from {x,x'} (F6).

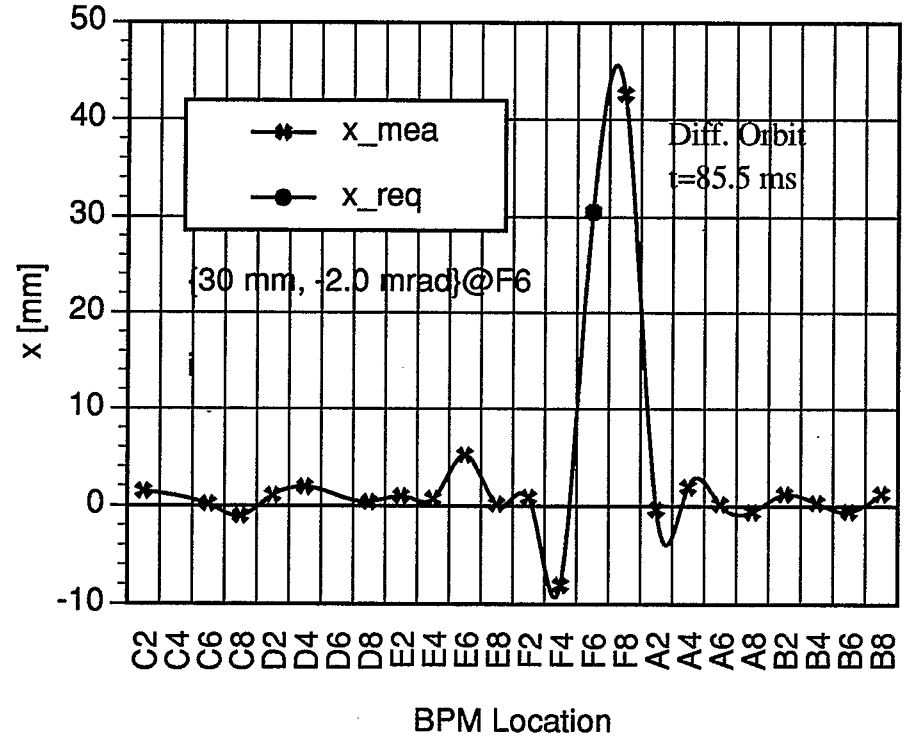


Fig.5. Measured 4 magnet extraction bumps at the norminal setting.