Beam Physics Note
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Beam Centering through EACA cavity

Hui Wen Koay

TRIUMF

Abstract: This document reports the beam centering through EACA cavity. The results are also compared with TRANSOPTR and GPT simulations using a beam without any space charge (SC) considerations.

4004 Wesbrook Mall, Vancouver, B.C. Canada V6T 2A3 · Tel: 604 222-1047 · www.triumf.ca

1 Introduction

The e-Linac beamline experienced a dependence of BPM readings on the beam energy. This is especially significant in BPM downstream of EACA. For instance, Figure 1 compares the BPM noise level at difference locations of the beamline. We see that the noise level of BPMs before EACA is around 0.01 mm, while the BPMs after EACA is at least order of magnitudes larger (~ 0.1 mm) than the noise level of BPMs before EACA. Consequently, this can easily lead to unnecessary trips due to the beam swaying away from time to time with the fluctuation of beam energy when the BPMs are engaged at high power.

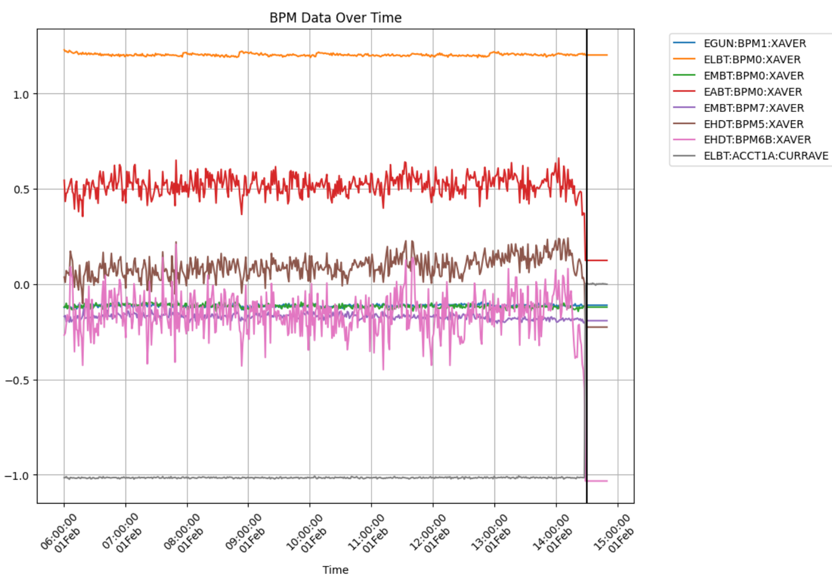
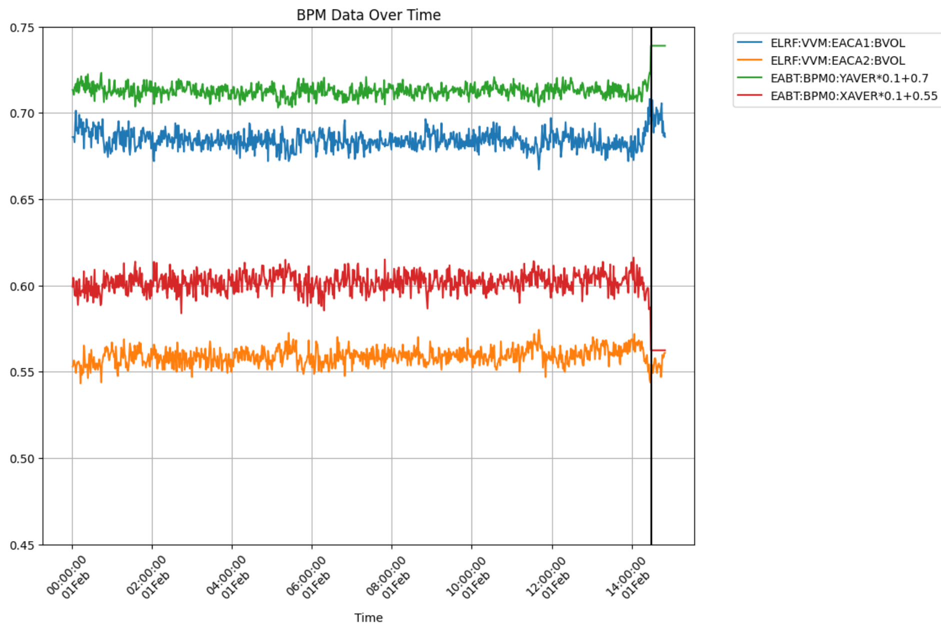


Figure 1: Horizontal BPM signals (in mm) at important locations, i.e. after egun; before EINJ; after EINJ; before first bends; after first bends etc..

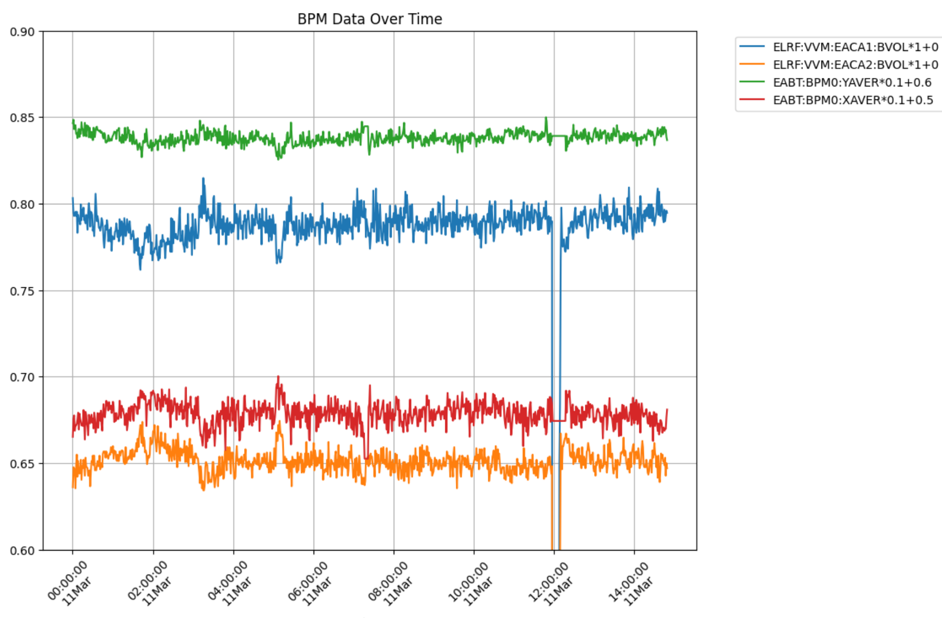
2 Actual data of BPM noise

Figure 2 shows the reading from the first BPM (EABT:BPM0) after EACA with ELRF:VVM:EACA:BVOL. Both the X and Y readings match well with the fluctuation of EACA bvol. It is a strong evidence showing EACA setpoint fluctuation is kicking the beam as it is likely off-centered. When EACA bvol drifts more than ± 0.02, it usually results in a trip in the EHDT:BPM6B, which is the last BPM in the beamline.

I tried to center the beam as much as possible before entering EACA (only for Y), so that it is less sensitive to any fluctuation from Bvol. Figure 2b shows the results after improvement. The effect is not very significant from the plot. If we take the standard deviation of the fluctuation from 0:00 to 06:00 for both cases to avoid any trip, we obtained Table 1. Despite having similar error in EABT:BPM0:YAVER of ± 0.4 mm, the error from EACA Bvol is 0.3% more than the case before centering. Overall, the noise level is slightly improved by about 2.4 mm of offset correction in Y.



(a) Before attempt to correct EACA centering in Y



(b) After attempt to correct EACA centering in Y

Figure 2: Comparing the signal from ELRF:VVM:BVOL from EACA1 (blue) and EACA2 (orange) with the first BPM (EABT:BPM0) (green and red) right after EACA cavities. Note that the BPM readings are scaled according to the legends to allow a fair comparison. The parentheses on the last column indicates the percentage with respect to its mean value.

PV	Mean	Standard deviation
Before centering		
ELRF:VVM:EACA1:BVOL	0.685	0.005 (0.7%)
ELRF:VVM:EACA1:BVOL	0.558	0.005 (0.9%)
EABT:BPM0:YAVER [mm]	0.13	0.04 (28.6%)
After centering		
ELRF:VVM:EACA1:BVOL	0.785	0.008 (1.0%)
ELRF:VVM:EACA1:BVOL	0.653	0.007 (1.0%)
EABT:BPM0:YAVER [mm]	2.38	0.04 (1.7%)

Table 1: Comparing the average and standard deviation of EACA bvols with EABT:BPM0:YAVER.

3 Simulations

To understand whether it is possible to have such an error induced from an off-centered beam, I did a quick check using TRANSOPTR using the following input for TRANSOPTR in data.dat.

```
9.0 0.0 0.0 0.510999 -1.0 0.0e-12
-1 5 1 0.0001
0 0.0 1.0 0.0
0.2  0.001  0.2 0.001  0.06 0.000173
1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0
3
1 2  0.0   3 4  0.0 5 6 0.0
9
0.1         -10.0      10.0       0 ! xc1
0.0         -10.0      10.0       0 ! yc1
0.0         -10.0      10.0       0 ! xpc1
0.0         -10.0      10.0       0 ! ypc1
31.65       -180.0     180.0      0 ! ELRF:VVM:BUNCH:PHASE RFP2 deg
0.695       0.0        10.0       0 ! ELRF:VVM:EACA1:BVOL RFA3 V
58.97       -360.0     360.0      0 ! ELRF:VVM:EACA1:PHASE RFP3 deg
0.57        0.0        2.0        0 ! ELRF:VVM:EACA2:BVOL RFA4 V
-94.06      -360.0     360.0      0 ! ELRF:VVM:EACA2:PHASE RFP4 deg
0.0001 900
10 0.0 0.95 20
```

The result is double checked with macro particle tracking code GPT (Figure 3.

If the beam centroid is determined at EABT:BPM0, which is the first BPM after EACA, the centroid offset can be plotted against the input offset, as shown in Figure 4, for about ± 0.02 of EACA bvol, which is close to its 2σ during normal operation.

In order to result in an offset of about 0.1 mm at EABT:BPM0, the input beam will have to be off-centered by about 2.0 mm. However, offset shown in Figure 2 did not show any significant improvement in the noise level of EABT:BPM0:YAVER. I suspect that the cavity is not shifted, but tilted by an angle.

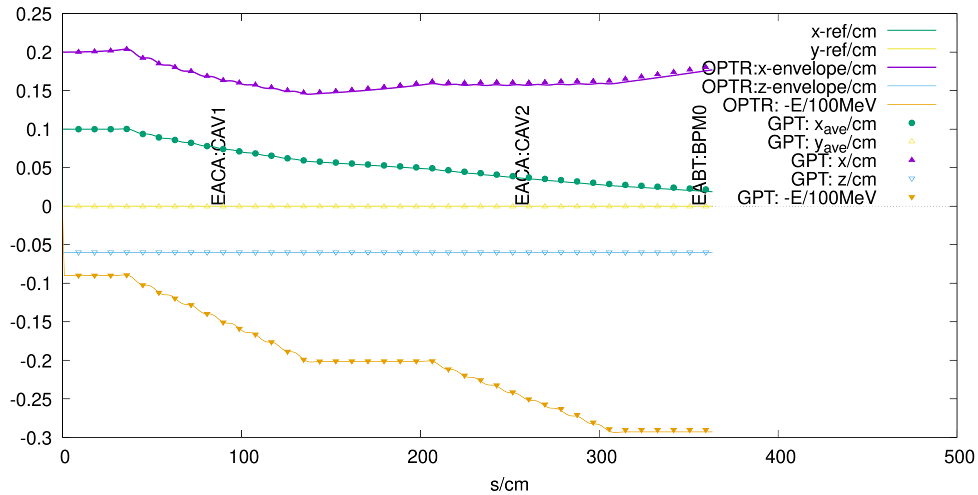


Figure 3

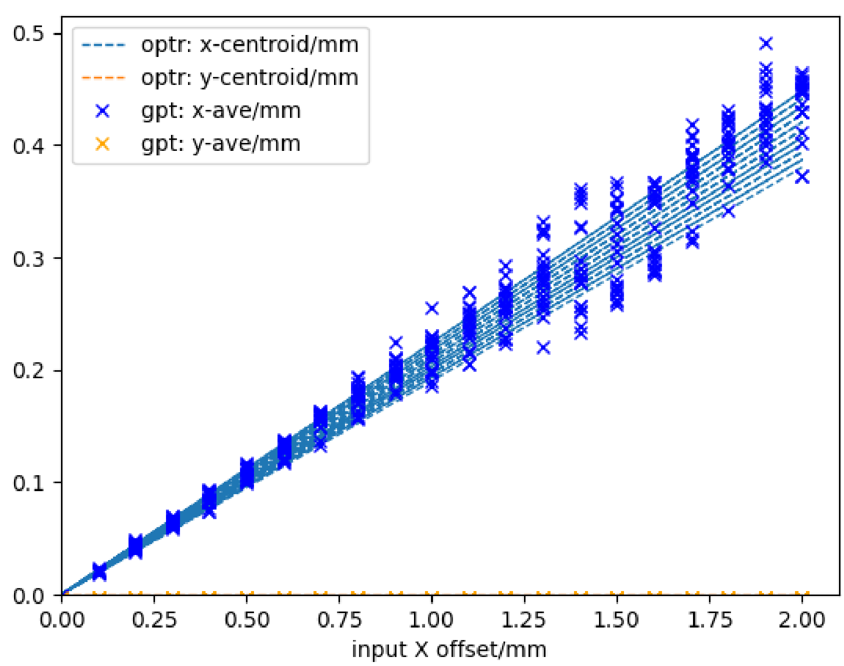


Figure 4: Change of the x/y-centroid at different input offset before EACA. The dashed lines are results from TRANSOPTR, while the crosses are from GPT. Different lines corresponds to the uncertainty of EACA:BVOL= ± 0.02.