

Memo on Preliminary Values of Polynomial Coefficients in Algorithm for Computation of Beam Position with Various Main Injector BPM Pick-ups

Bob Webber
October, 2005

This is the text of an email dated November 24, 2004, sent to Duane Voy, Peter Prieto, and others establishing an algorithm for computing beam position from measured 'difference-over-sum' values for the NuMI and related BPM system instances where Main Injector style BPM pick-ups are used.

The parameter values cited here were obtained from the combined data of original response measurements of many Main Injector BPMs on the BPM test stand. The values are reasonable estimates for the response of the 'average' MI BPM with beam on-center in the orthogonal plane; response in the presence of orthogonal position offsets is not considered. The proper documentation of how these values were obtained from the measurement data has yet to be completed.

I am working to produce an intelligible write-up on the use of polynomial functions to compute beam positions from difference-over-sum values for Main Injector BPMs. That overall write-up effort has been slow in reaching conclusion, so this message offers preliminary coefficients to be used until the full context is presented. I do not expect the ultimate values to change much from these preliminary ones.

There are different sets of coefficients for: 1) normal MI BPMs measuring vertical position, 2) normal MI BPMs measuring horizontal position, and 3) wide aperture MI BPMs. Except for the k_0 terms, the coefficients are the same for all like-style BPMs, that is, they are not unique for each individual BPM location.

The function is of the form:

$$\text{position(mm)} = K_0 + K_1 \cdot \text{dos} + K_2 \cdot \text{dos}^2 + K_3 \cdot \text{dos}^3 + K_4 \cdot \text{dos}^4 + K_5 \cdot \text{dos}^5$$

where $\text{dos} = (A-B)/(A+B)$ = difference over sum

A is amplitude of signal from INSIDE (or BOTTOM) electrode(s)

and B is amplitude of signal from OUTSIDE (or TOP) electrode(s).

Peter Prieto has supplied location-specific electrical offset values that should be used for the K_0 terms.

Even-term coefficients are small by virtue of the BPM symmetry and setting them to identically zero appears to result in negligible errors; nevertheless, the option for including non-zero values should not be precluded.

The initial coefficients are:

MI Horizontal

K1 = -20.17

K2 = 0

K3 = +4.12

K4 = 0

K5 = -37.96

MI Vertical

K1 = -27.61

K2 = 0

K3 = -34.20

K4 = 0

K5 = +40.72

MI Wide Aperture (608 location only in the NuMI BPM system)

K1 = -43.88

K2 = 0

K3 = -12.55

K4 = 0

K5 = -3.97

October 2005 NOTE: this is for 4-electrode "wide aperture" BPM with electrodes oriented at 45 degrees from level and plumb. These BPMs are expected to be replaced by 'extra-wide-aperture' (5.5 inch electrode ID) BPMs during winter 2005-6 shutdown.