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Beam Position Monitoring System for Fermilab's Muon Campus

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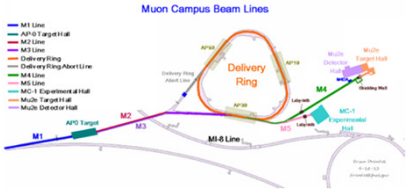
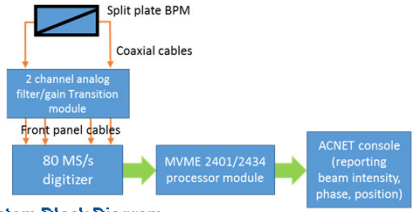
Abstract

A Beam Position Monitor (BPM) system has been designed for Fermilab's Muon Campus shown below. The BPM system measures Turn-by-Turn orbits as well as Closed Orbits (average of multiple turns). While in the early commissioning phase of this program, preliminary measurements have been made using these BPMs.

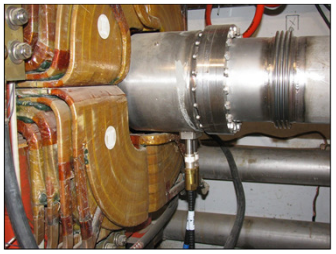


Parameter	Requirement	Unit
Maximum intensity	1×10^{12}	protons
Revolution Frequency (central orbit)	590018	Hz
Bunch Length (rms)	35	nsec

A BPM system is required for providing transverse position. A split plate style BPM system is implemented to provide such measurements. The BPM pickups are characterized to know the relationship between beam location and differences between signal levels seen at the pick-ups.

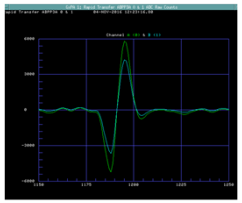


BPM System Block Diagram



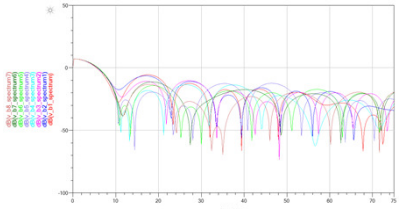
Beam Position Monitor Split Plate Pick-ups

The plot below shows what the signals from the output of the split plate BPM look like. For the transfer line BPMs, this signal is digitized and the absolute value of the signal is integrated to get a magnitude for signals A and B. Beam position is calculated by a difference over sum of channel A and B magnitudes and this ratio is multiplied by a scaling factor.

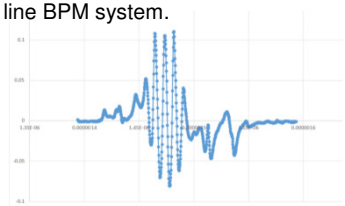


The mu2e Delivery Ring BPM design relies on using a 5 MHz bandpass filter to allow the signal coming from the BPM to produce a ringing effect. The signal is amplified, digitized and processed.

The plot below shows the spectrum of the beam signal with different traces representing different bunches. 5MHz is approximately the highest frequency before signal level drops appreciably and bunch to bunch signal level varies noticeably. As a result, a 5MHz analog bandpass filter is used in this design.



The 5MHz signal coming from the analog electronics is shown below. This signal gets processed in the digitizer and goes through digital filtering to output a signal magnitude for channels A and B. Position is calculated from these magnitudes in a manner similar to the transfer line BPM system.

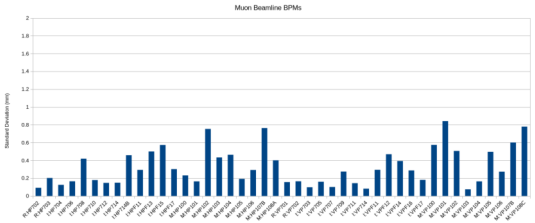


BPM Electronics Rack (left: transfer line, right: Delivery Ring)

All electronics for a system fit within one rack. Analog transition boards are in-house custom designs which allow for flexible, low-cost and compact designs. The digitizers were made by Echotek and controlled by Motorola MVME 2401 (Delivery Ring) and Motorola MVME 2434 (Transfer line) processor boards.

Measurements

As the beam through the transfer line maintains its parameters, position data is taken to quantify measured beam position variation. Standard deviation across BPMs is shown below. Future work lies in understanding and possibly reducing the variation.



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