ENERGY SPREAD MEASUREMENTS FOR 400 MEV LINAC BEAM AT FERMILAB BOOSTER USING A LASER NOTCHER SYSTEM*

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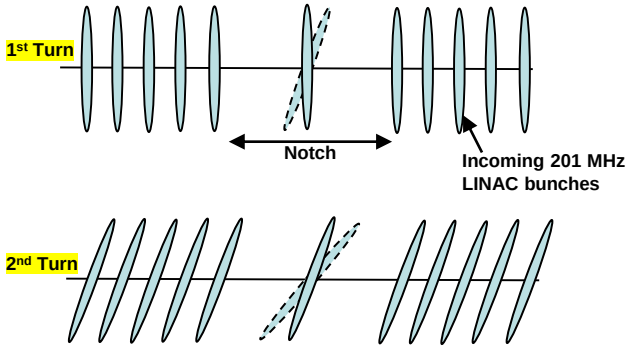
ABSTRACT

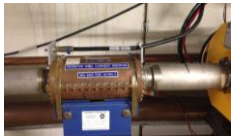
To mitigate 8 GeV beam losses at extraction in the Fermilab Booster synchrotron, a LASER chopper system for multi-turn injection that produces a beam free gap, aka "notch" in the LINAC beam pulse at 750 keV is developed. These notches in the LINAC pulse are spaced with the 400 MeV injection revolution period of the Booster. Recently, a dedicated notching pattern that keeps a single 201 MHz LINAC bunch in the middle of a notch is developed to measure the beam energy spread by studying the time evolution of this bunch in the Booster. A method complementary to this has also been realized by injecting <2 Booster turn beam and studying the time evolution of the multiple 201 MHz LINAC bunches. In this paper we present the general principle of the method and results from our measurements.

A Schematic view of a LASER Notch in the injected LINAC beam into the Booster



Measurement Method

We used



Wall Current Monitor

&

A Tektronix, TDS7154B Digital Phosphor Oscilloscope of type 1.5GHz 20GS/s in Booster to collect the WCM data

$$\Delta E = \frac{\beta^2 E_s}{|\eta|}\left[\frac{W_{turn2} - W_{turn1}}{T_{Rev}}\right]$$

β - Relativistic velocity (0.713 for 400 MeV proton)

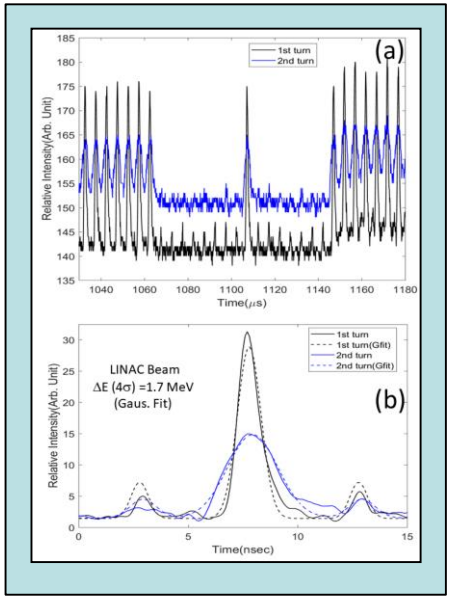
E_s - Synchronous energy of the beam (1338.3 MeV),

η - Slip factor (0.9543)

W - Width of the bunch,
$W(4\sigma)$~2.1 ns – 1st turn
$W(4\sigma)$~4.6 ns – 2nd turn

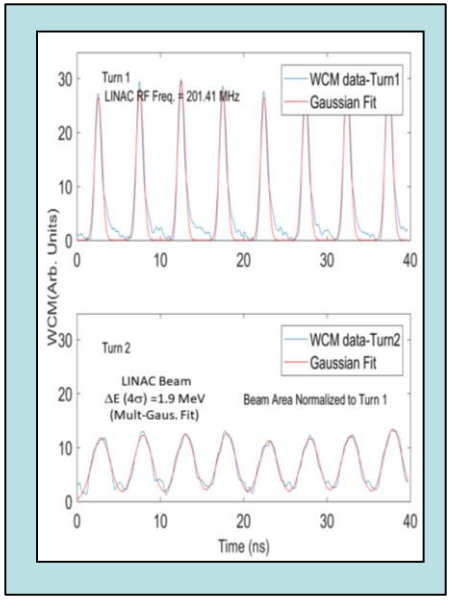
Analysis

Single untouched LINAC bunch in the gap



$\Delta E = 1.7 \pm 0.2$ MeV

Non-overlapping multiple LINAC bunches in Booster



$\Delta E = 1.9 \pm 0.2$ MeV

Conclusions

We have presented a method to measure LINAC beam energy spread using LASER notcher system. We have presented the results from two slightly different methods. Within the uncertainty of the measurements the results agree quite well.

One of the advantages of the first method is, it can be used to measure beam energy spread distribution along a long LINAC beam pulse by leaving one or two bunches in the middle of every 2nd or 3rd notch.

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