To: J.Carwardine
A. Hillman
cc: M. Borland
R. Gerig
S. Milton
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From: J. Lewellen

Re: Results of individual bunch pattern analysis on corrector slew rate

Folks,

During one of our interleaving measurement runs, I tracked the beam position in the PAR and booster bypass as a function of the particular linac beam bunch selected. This, combined with the measured response matrices for the PAR and booster bypass lines, yields the required change in corrector current from one bunch to another. This can be used both to determine directly the required corrector slew rate, and to compare with the previously presented results (summarized below in Table 1.)

Corrector	Max. corrector deflection (A)	
	325 MeV	217 MeV
PTB:H3*	0.08	0.12
PTB:H4*	0.15	0.17
BB:H2†	0.03	0.03
BB:V1†	0.06	0.05
BB:V2†	0.02	0.02

Table 1: max. corrector deflections required for a true 6 Hz beam rate (bunches 00, 10, 20) with booster ramping.

If I simply take the maximum deflection measured above, and multiply by 6 Hz, I get a maximum current slew rate of around an amp (for PTB:H4). Since this rate cuts "across" the peak of the booster ramp, however, I wanted to check that the shortest possible bunch-to-bunch spacing yields the same results.

Figures 1 through 4 show the calculated corrector responses based on the measured controllaw matrices. Figures 1 and 2 show, respectively, the response for the listed horizontal and vertical correctors in Table 1. Figures 3 and 4 show the responses of the remaining horizontal and vertical correctors, respectively. Theoretically each ½-second the linac can generate 15 bunches, labeled even numbers 00 … 30, however in practice, bunches with higher numbers than 24 are disallowed by the control system due to PAR accumulation limits.

* LET-type corrector
† Booster Bypass-type corrector

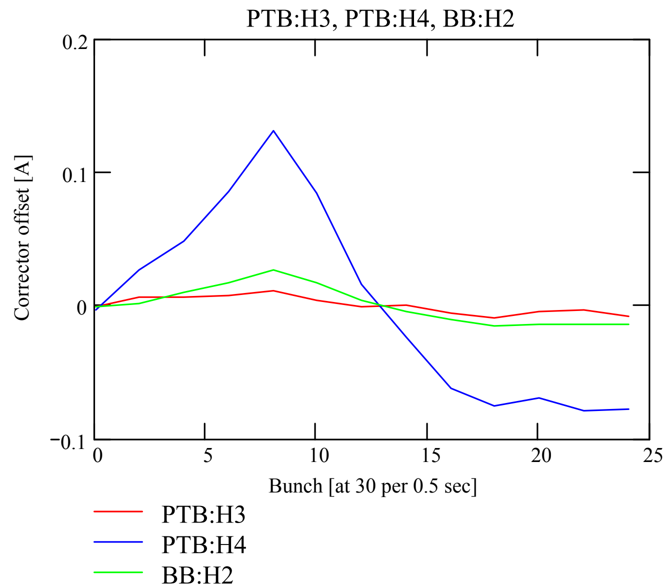

Figure 1: calculated response, listed horizontal correctors

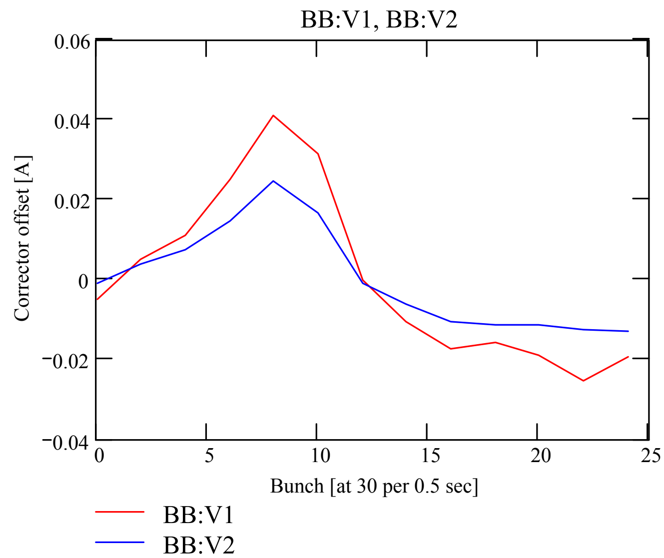

Figure 2: calculated response, listed vertical correctors

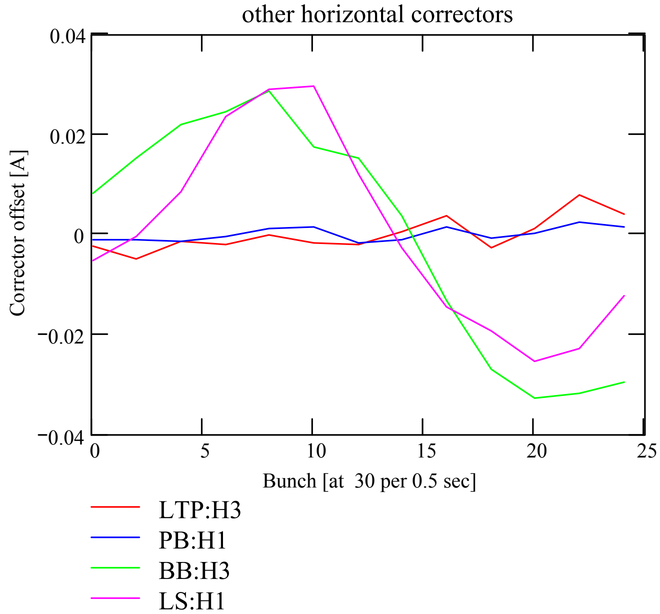

Figure 3: calculated response, other horizontal correctors in the transport line

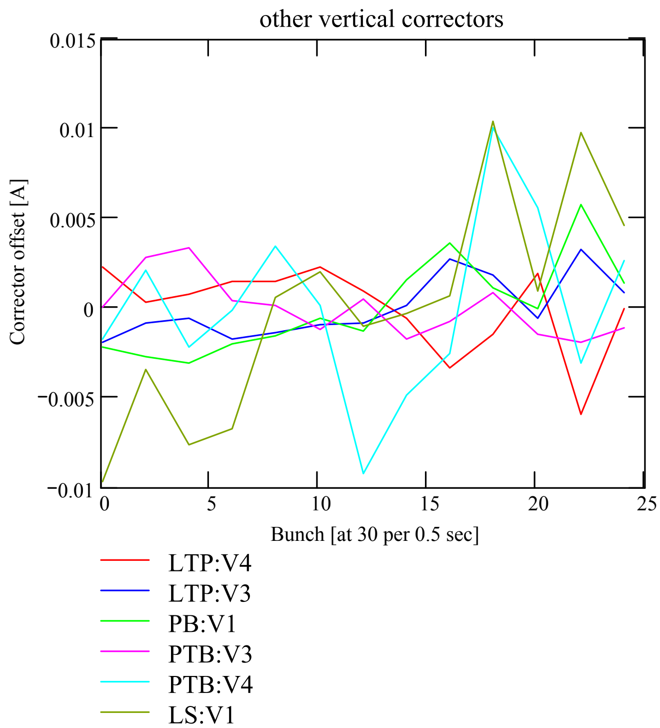

Figure 4: calculated response, other vertical correctors in the transport line

The max. required slew rate can be found by effectively taking the derivative of these slopes (or, more accurately, the difference in current offset between bunches n and n+1, multiplied by 30 Hz). This yields a maximum required slew rate of about 1 A, and is consistent with the ballpark estimation derived above. I suggest we double this, because while what data we have suggest the ramp rates won't increase strongly with higher energies, we want to increase the beam energy by about a factor of 4; this at least gives us some overhead.

These plots are more or less what one would have expected from the data in the table. Although it does appear as if two of the "other" horizontal correctors should have fast-ramping correctors, I do not believe this is so, for two reasons. First, the correction required at PTB:H4 is large compared to the others, and located upstream of the ones showing significant deflection; I think the indicated deflections are the result of some imperfections in the response matrix measurement; it wouldn't take much. Second, in the tests with controllaws left on continuously, these correctors returned to their original current settings almost exactly (within the limits of noise of the BPM readback, probably) after a reasonable settling time. That leads me to believe that despite the plot above they really aren't required to correct for the booster trajectory. Still, time, budget and parts availability permitting, it might not be a bad idea to have a fast-ramping corrector supply prepared for BB:H3.

This system is intended to correct for the effects of the booster synchrotron ramping upon the beam trajectory in the PAR bypass, booster bypass, and undulator beamlines. Therefore, the correctors will be required to sweep through the desired correction pattern at 2 Hz. Finally, at the moment, as mentioned above the linac can potentially generate 15 bunches (or bunch trains) per booster cycle time of ½-sec. Therefore, if the correctors have 15 uniformly-spaced setpoints per cycle then this system should be able to correct the trajectory of any potential bunch pattern the linac can produce.

Fast-Ramping Corrector Specifications

	LET correctors	Booster Bypass correctors
current stability[‡]	+/- 0.5 mA[§]	+/- 0.8 mA[**]
setpoint resolution	14-bit (min.)	14-bit (min.)
max. & min. current limits	2 A (as existing)	12 A(as existing)
max. ramp rate for fast-response component[††]	2 A / sec	2 A / sec
repeatability	+/- 0.5 mA over 10 sec	+/- 0.8 mA over 10 sec
setpoints per cycle	15, uniformly spaced	15, uniformly spaced
maximum cycle rate	2 Hz	2 Hz

[‡] based on 1µrad tolerance per corrector
[§] tolerance provided by M. Borland
[**] based on a field strength of 13.38 Gauss m / amp, at 325 MeV
[††] The fast-ramp corrector rate was calculated in two ways. First, the max. change in current listed above was multiplied by the beam rate to obtain the required correction rate at 6 Hz operation. Second, the individual BPM readbacks as a function of linac bunch were analyzed, and the required bunch-to-bunch correction was determined. The two rates thus calculated are in good agreement. A safety factor was added to allow for potentially greater corrector swings as beam energy is increased.