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Proposal for Main Injector 2.5MHz Transition Board Gain Settings

The MI BPM specification sets requirements for measuring pbar bunches with intensities ranging between 5E9 and 150 E9 per 2.5 MHz bunch. The BPM raw data mode was used to measure the signal amplitude observed by the EchoTek digitizers for a known intensity and a given transition board gain setting.

Measurements were made of the beam signal from BPM HP404, a standard 4-stripline MI BPM pick-up. This BPM has short cables to the service building, about 143 feet. Measurement data figures are included at end of this note.

These measurements showed digitizer readings of about 130 counts peak (as displayed on I43 raw data display) per 1E9 per bunch near coalescing time from HP404 with a transition board gain setting of 0X8005, a gain of 20 db. Note that full range is ± 32K counts as displayed on I43 raw data display (although digitizer itself is only 14 bits).

Typical transfers to Tev are now 50E9 per bunch, 20E10 total in four bunches, and yield about 6500 counts peak.

The useful dynamic range of the EchoTek for position measurement is conservatively a factor of 50. This note will discuss intensities that can provide signals to fill one-half the digitizer range; this allows overhead for off-center beam signals. Signals from BPMs with longer cables will provide signals at ~2/3 amplitude. These “safety” factors use up about 1/3 the total range of 50 leaving a factor of 16 for acceptable intensity variation.

The 16-bit transition board gain setting is interpreted as follows:
The second least significant bit controls the 12 db post-amplifier; 0 for disable, 1 for enable. The other bits of the lower byte are usually set so that 05 and 07 are the two common meaningful byte values; 05 disables post-amp, 07 enables post-amp.
The most significant byte of the gain setting word controls 40 db of gain. The gain in db is proportional to the setting value; FF is maximum 40 db gain and 00 is minimum 0 db gain. Step size is 40/255 db (about 1/6 db) per setting count.

Proposal

“Low” Gain Setting

Set “Low” gain setting for ½ range in digitizer for 150E9/2.5 MHz bunch (some overhead needed for off-axis positions and for potentially marginally higher intensity bunches).
This condition calls for a gain setting of 16000/150E9 = 106 counts per 1E9, about 84% (-1.5 db) of that used in the measurements.
Minimum useful intensity at this gain setting is 10E9/bunch.

“Medium” Gain Setting

Set “Medium” gain setting for ½ range for 75E9/2.5MHz bunch. This gives 1/3 full range for the signals at typical present pbar intensity of 50E9/bunch and allows a 50% pbar intensity increase without saturation concerns.
This calls for 6db (factor of 2) gain relative to “Low” setting.
Minimum useful intensity at this gain setting is 5E9/bunch.

“High” Gain Setting

Set “High” gain setting for ½ range for 15E9/2.5 MHz bunch.
This calls for 14db (factor of 5) gain relative to “Medium” setting.

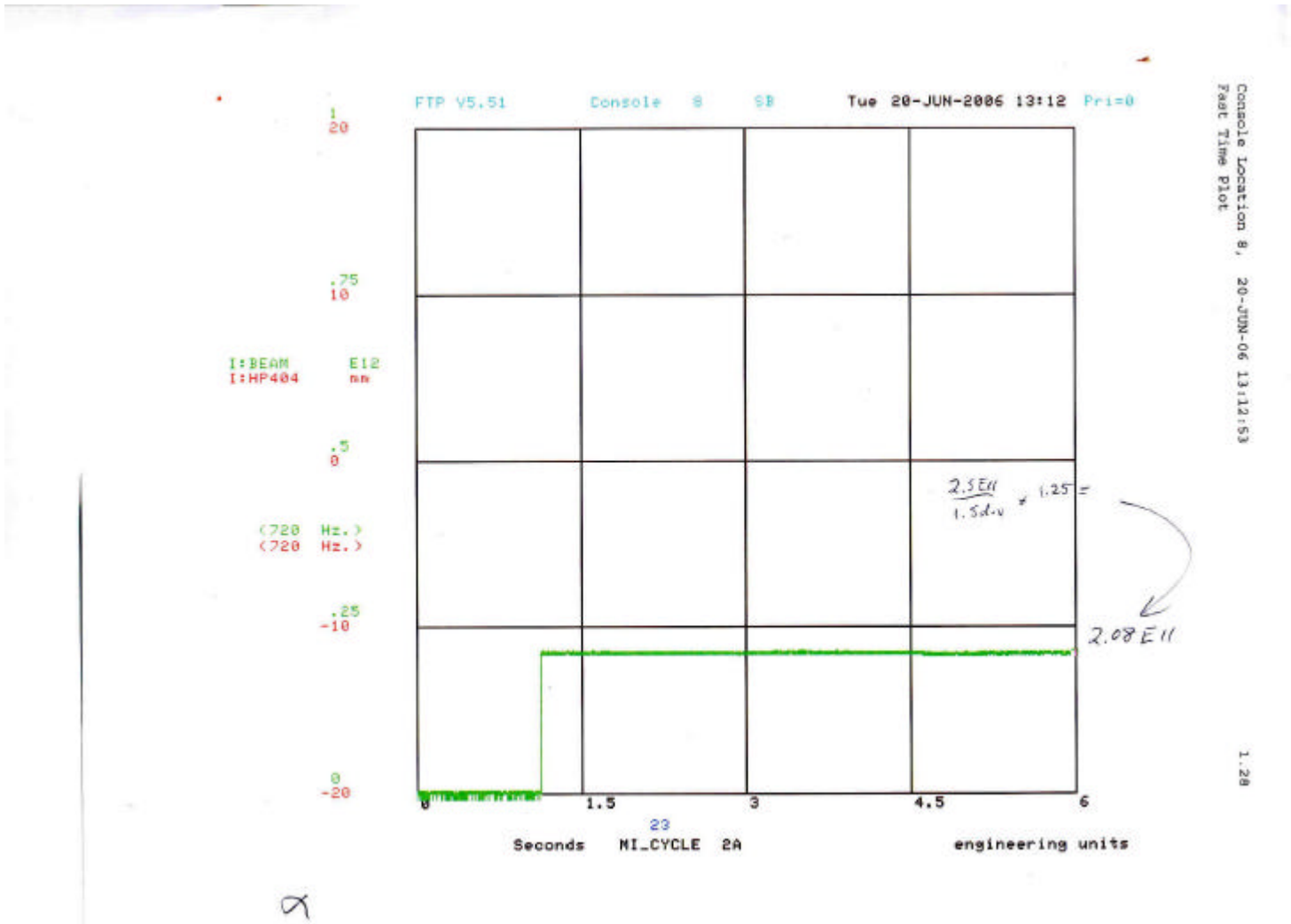
Determining Gain Settings

0x8005 gain setting was measured to give 130 peak counts/1E9 per bunch. To get 16Kcounts peak at 150E9, the gain setting should be lowered by factor of 16/19 = 0.84. This is about -1.5 db or 10 units, so “low” gain setting should be 0X7605. Medium setting is 6 db (36 units) higher, $9A05. High setting is an additional 14 db (84 units), $EE05.

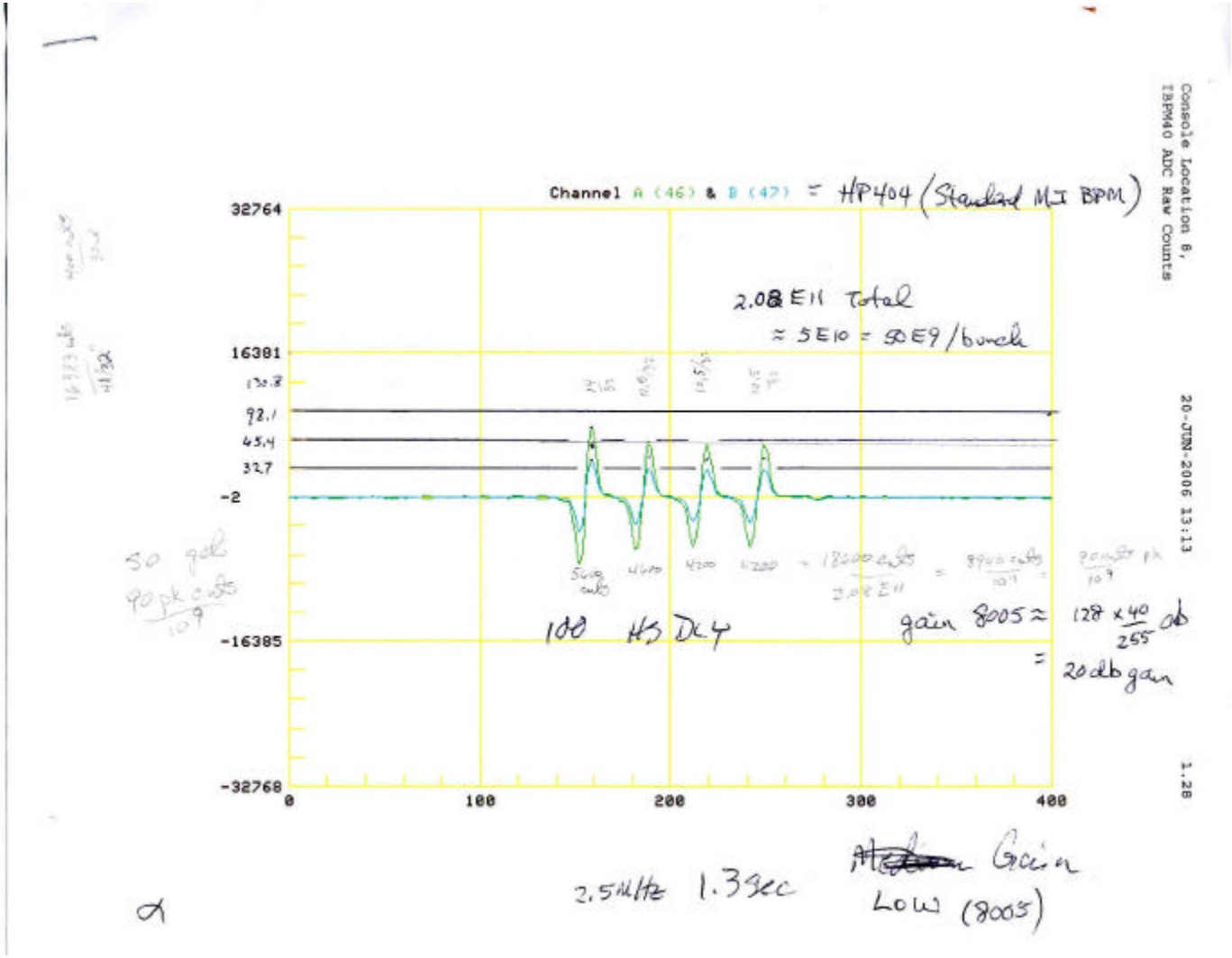
Summary Table as Proposed

Gain Setting	Half-Range Intensity	Useful Low-end Intensity
Low (0X7605)	150E9 / 2.5MHz bunch 60E10 total 4 bunches	10E9 / 2.5MHz bunch 4E10 total 4 bunches
Medium (0X9A05)	75E9 / 2.5MHz bunch 30E10 total 4 bunches	5E9 / 2.5MHz bunch 2E10 total 4 bunches
High (0XEE05)	15E9 / 2.5MHz bunch 6E10 total 4 bunches	1E9 / 2.5MHz bunch 0.4E10 total 4 bunches

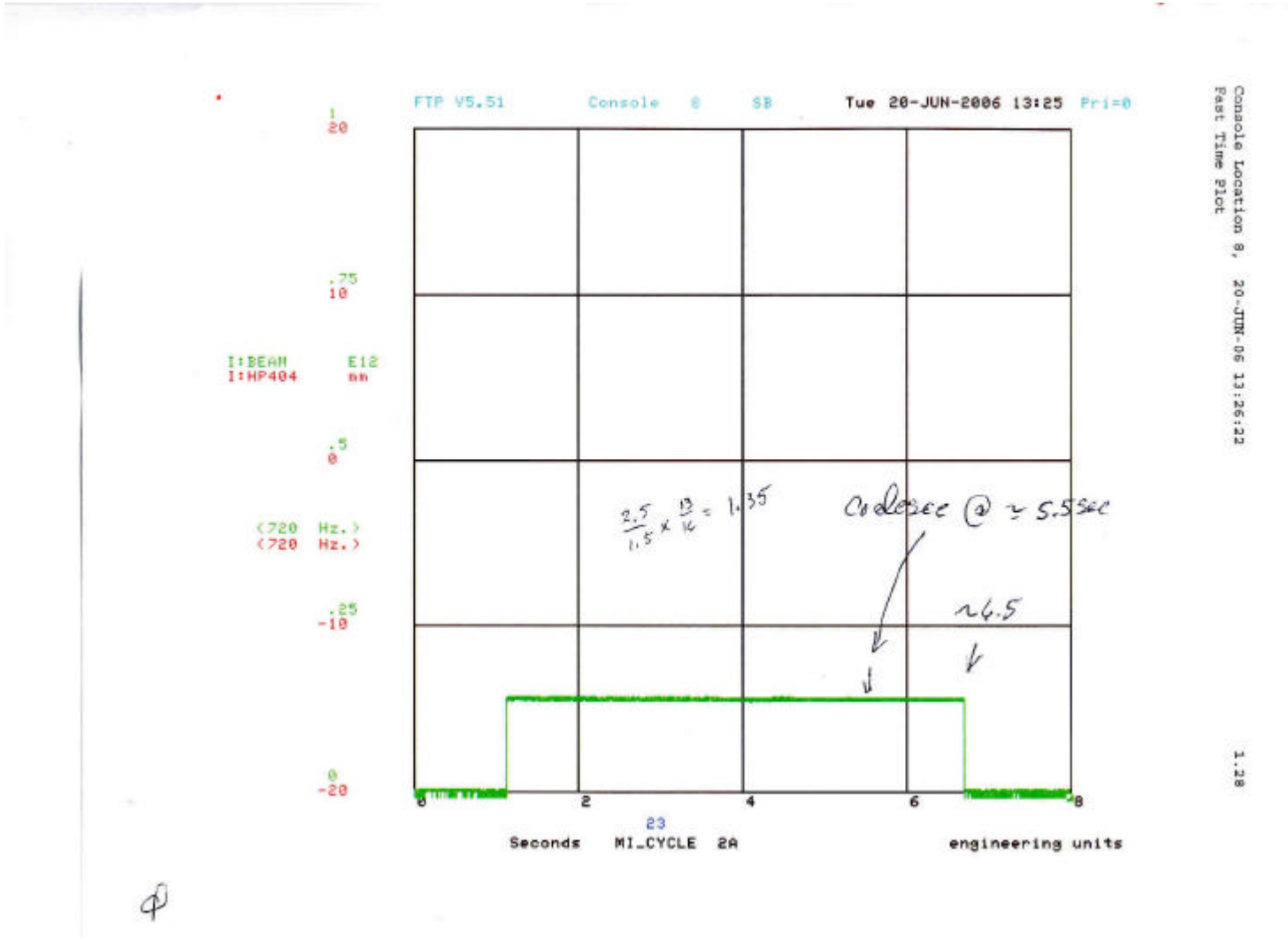
Plot 1, Shot Alpha, Beam Current Measurement



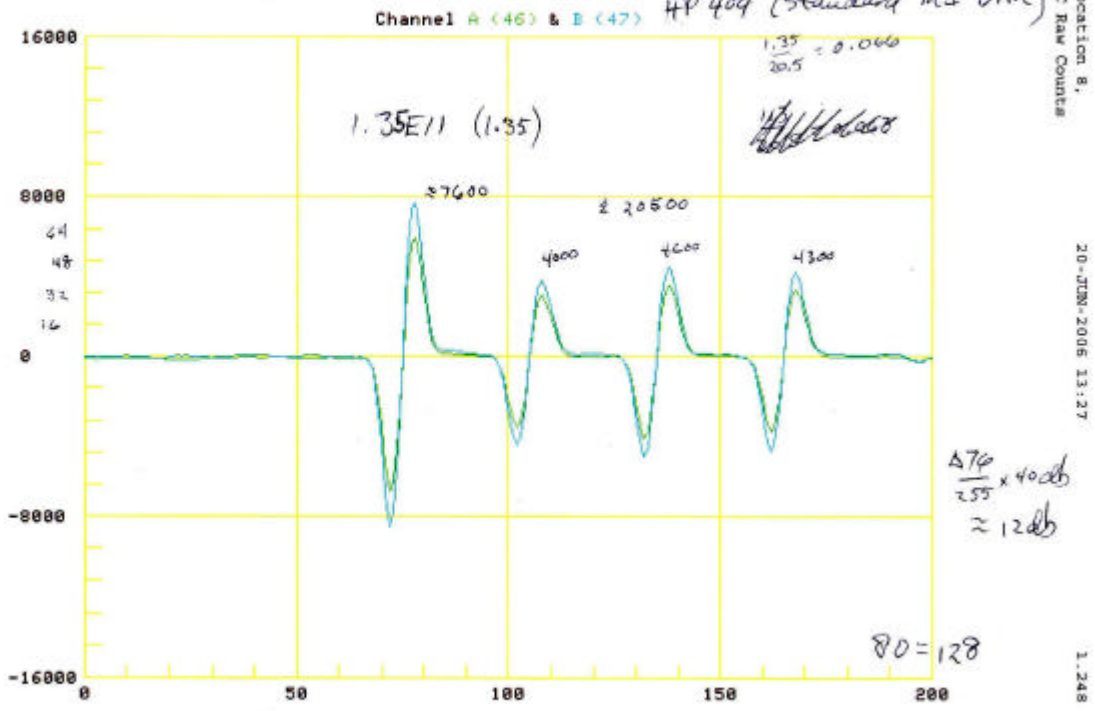
Plot 2, Shot Alpha, BPM HP404 Raw Data at 1.3 Seconds on 2A Cycle Pbars to Tev



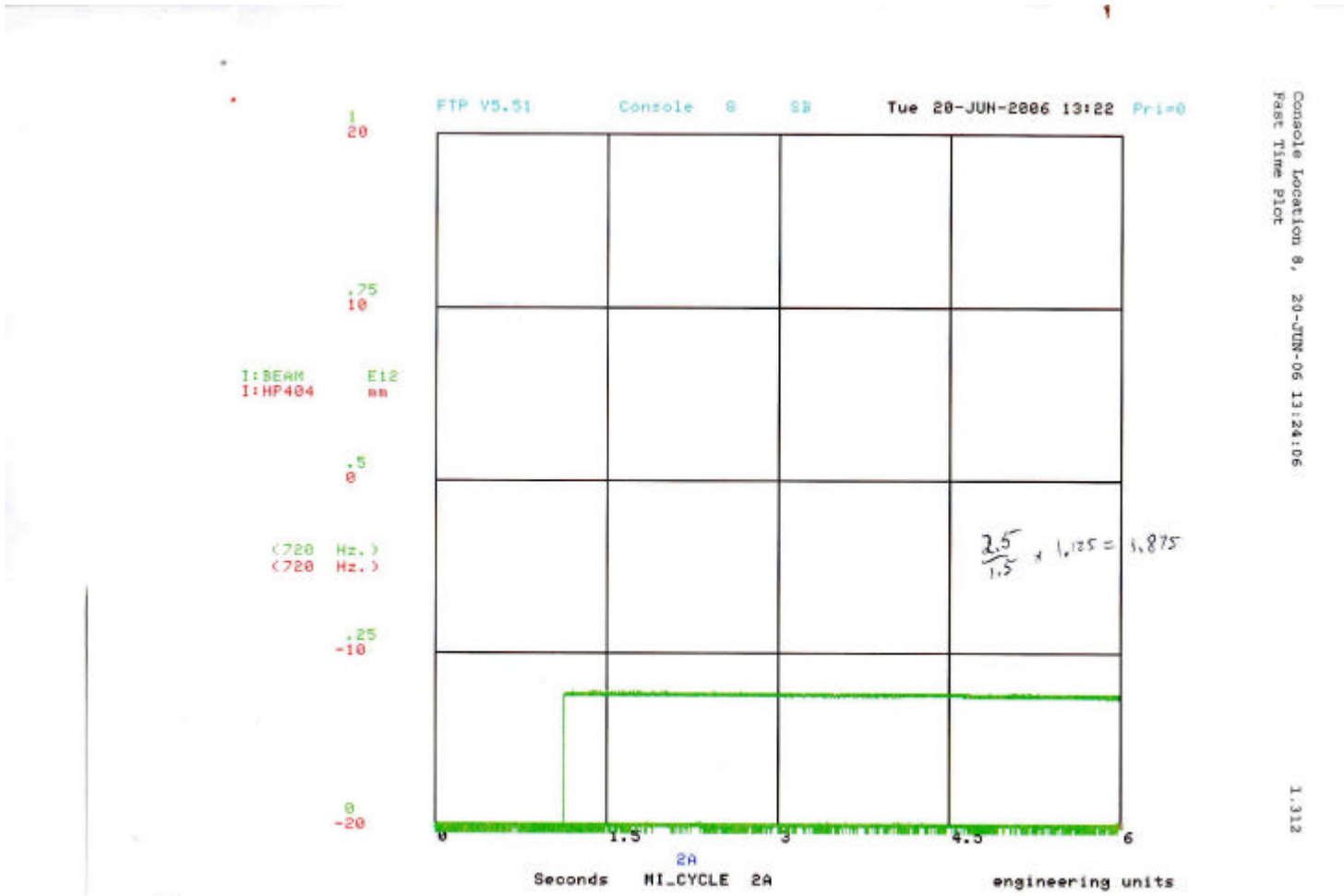
Plot 3, Shot Phi, Beam Current Measurement



Plot 4, Shot Phi, BPM HP404 Raw Data at 5.5 Seconds on 2A Cycle Pbars to Tev



Plot 5, Shot Rho, Beam Current Measurement



Plot 6, Shot Rho, BPM HP404 Raw Data at 5.5 Seconds on 2A Cycle Pbars to Tev