NuMI Operations Tuning Guide
May 12, 2005 (Updated 3/3/06)

A. Cold Start Procedure

Experience has shown that it is rare that the power supply ramp cards lose their ramp tables. Thus, getting the NuMI $23 events in the timeline and checking that the Beam Permit System (BPS) makes up (with the NuMI switch off on one of the beam switch sum boxes) should indicate that the major bend and quadrupole magnets are ramping properly. Then, with the beam intensity at a low value (see later), successful running of the NuMI Autotune program should indicate that the trim magnets are set properly. Inability to get the BPS to make up or Autotune running properly should be investigated. If there is indication that power supply ramp tables deviate from the settings that satisfy either the BPS or Autotune, experts should be consulted.

B. Beam Permit System

Figure 1 shows the region of the E Index Page in which all the NuMI-specific applications are located. The Beam Permit System (BPS), supported by pages E39 and E40 as indicated, checks a wide variety of devices, and it is intended that if and only if a permit is present will the line be ready for beam. There are three levels of checks:

- Some devices are checked continuously. If any of these is in a bad state, E39 will indicate it even without NuMI cycles running.
- A next set of devices is checked immediately before NuMI beam is extracted. As soon as there is a NuMI module in the timeline, these devices will be checked, even with the beam switch inhibiting extraction.
- The final set of devices is checked immediately after beam is delivered, and will prevent subsequent extractions after one bad one.

The active settings of the Permit System can be compared with the nominals by a process referenced from the Numi Beamline logbook Memo Pad.

C. NuMI Parameters

There is one NuMI Parameter Page, E38. Figure 2 shows the subpage menus.

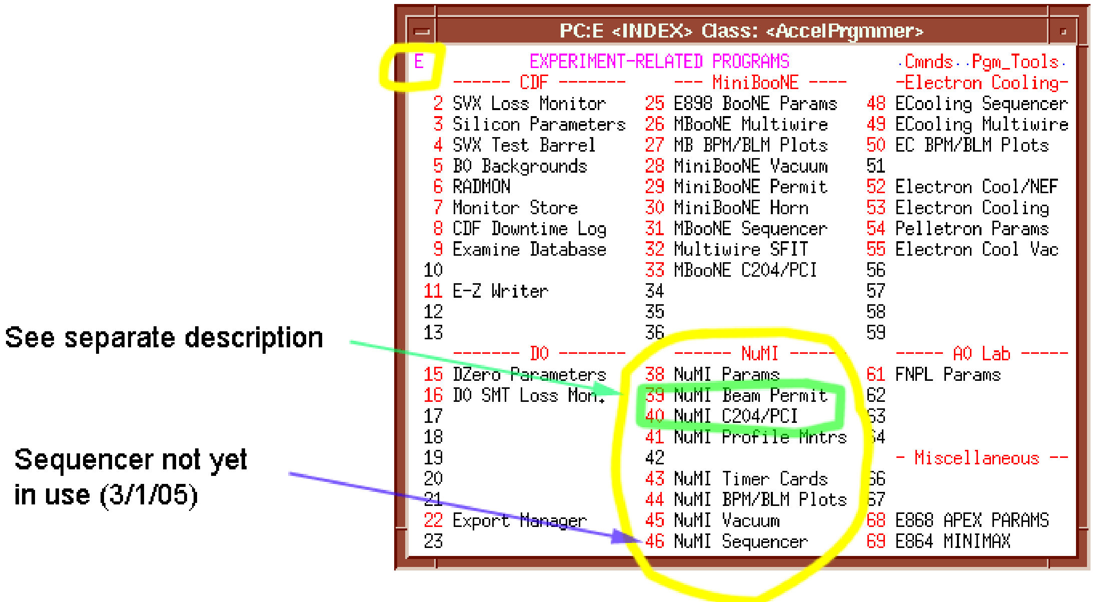

Figure 1 NuMI Programs on the E Index Page

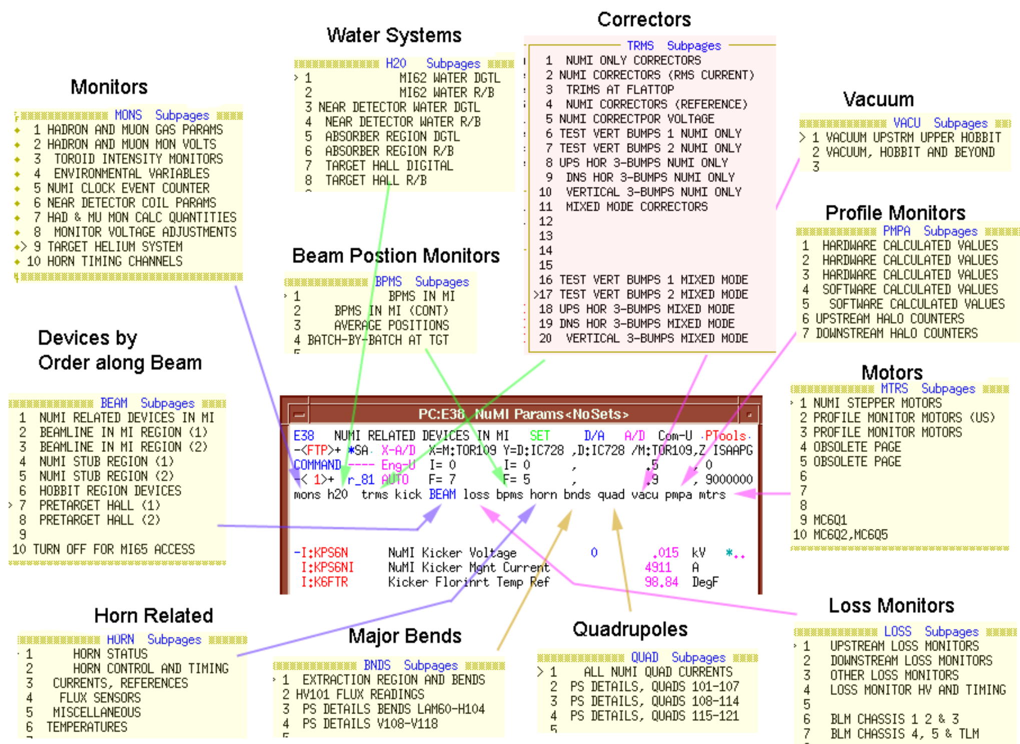

Figure 2 The E38 subpage menus (*Correctors Menu updated 3/3/06*)

D. Beamline startup

There will be on file with the crew chiefs the current mode of NuMI operations. This will include timeline modules, desired cycle rate and desired intensity. If stacking is in progress, NuMI will run with five Booster batches, if no stacking then with six. On startup from an extended downtime or M & D period, it is wise that the pulse rate be kept initially low, one or two cycles per minute. Similarly the NuMI intensity will start out low, two Booster turns. Go, in a few steps, from the low starting intensity to the desired value. If no BPS trips occur, one can be fairly certain that the line is running smoothly. At this point the cycle rate may be changed to the desired maximum.

Whenever no beam has been extracted to NuMI for two hours or greater, NuMI beam intensity should be set down to two Booster turns for the first pulses. If, in that state there are no BPS trips and Autotune has lined up the beam properly for targeting, higher intensity may resume.

E. Instrumentation

Instrumentation available for tuning includes profile monitors, BPMs and loss monitors.

α. Profile Monitors Profile monitors provide both profile and position information; the display at PMTGT should look like that in Figure 3. Although the NuMI monitors represent far less material in the beam than do the traditional ones, nonetheless they should be removed for high intensity running (except for PMTGT, which should remain in the beam). While a profile monitor is being moved IN or OUT of the beam, greater beam loss is experienced, due to more material in the clearing field foils. Therefore, the beam switch should typically be off when making such movements.

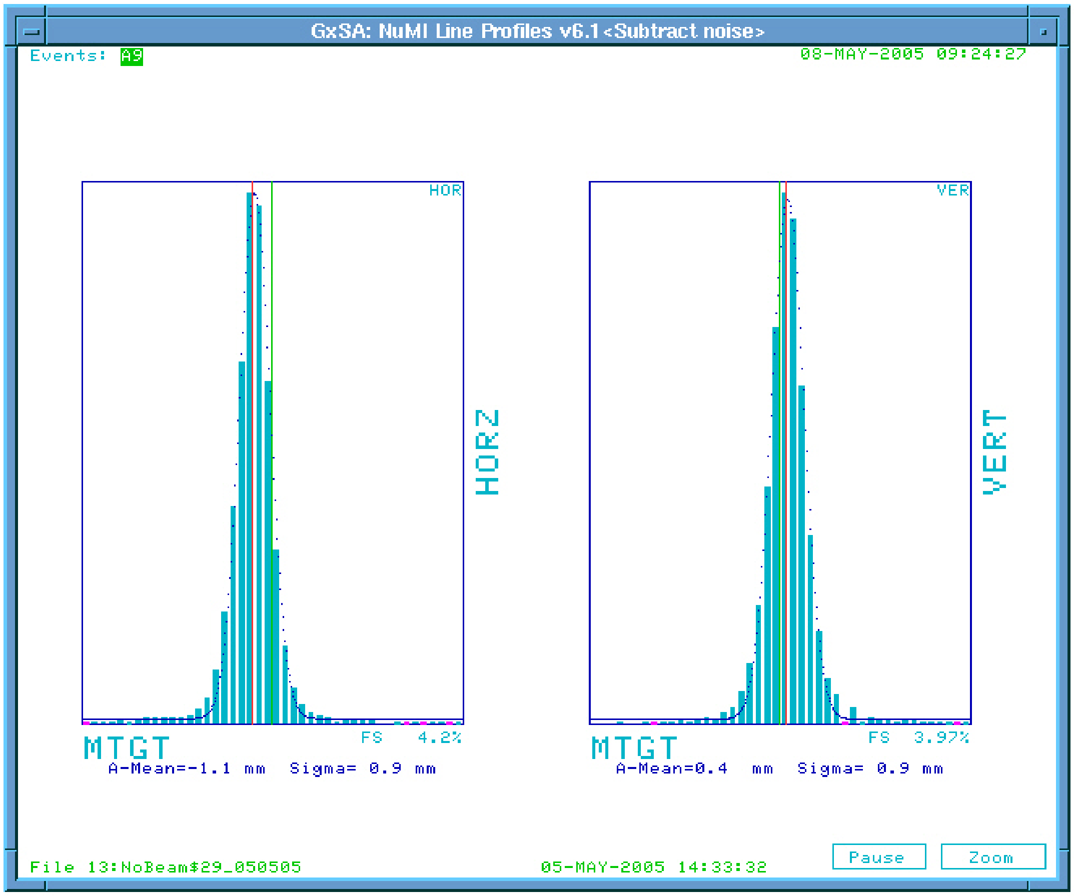

Figure 3 Profile monitor display

β. <u>Beam Position Monitors</u> Typical BPM traces are shown in Figure 4 for a nominal state. Notice the big position excursion seen in the upstream region, especially in the horizontal. This part of the plot is the extraction bump in the Main Injector itself and is supposed to look as shown. Deviations from these traces will be observed if the kicker pulse is not nominal or if a magnet current has drifted. Only a beam line physicist should adjust the kicker, a quadrupole or a major bend. Note that it is possible to plot the BPM traces in several ways: traces for all batches, one trace that is an average of the batches or a trace for any single batch--see Figure 5. This plot can be used to check for kicker effects that affect the different batches differently.

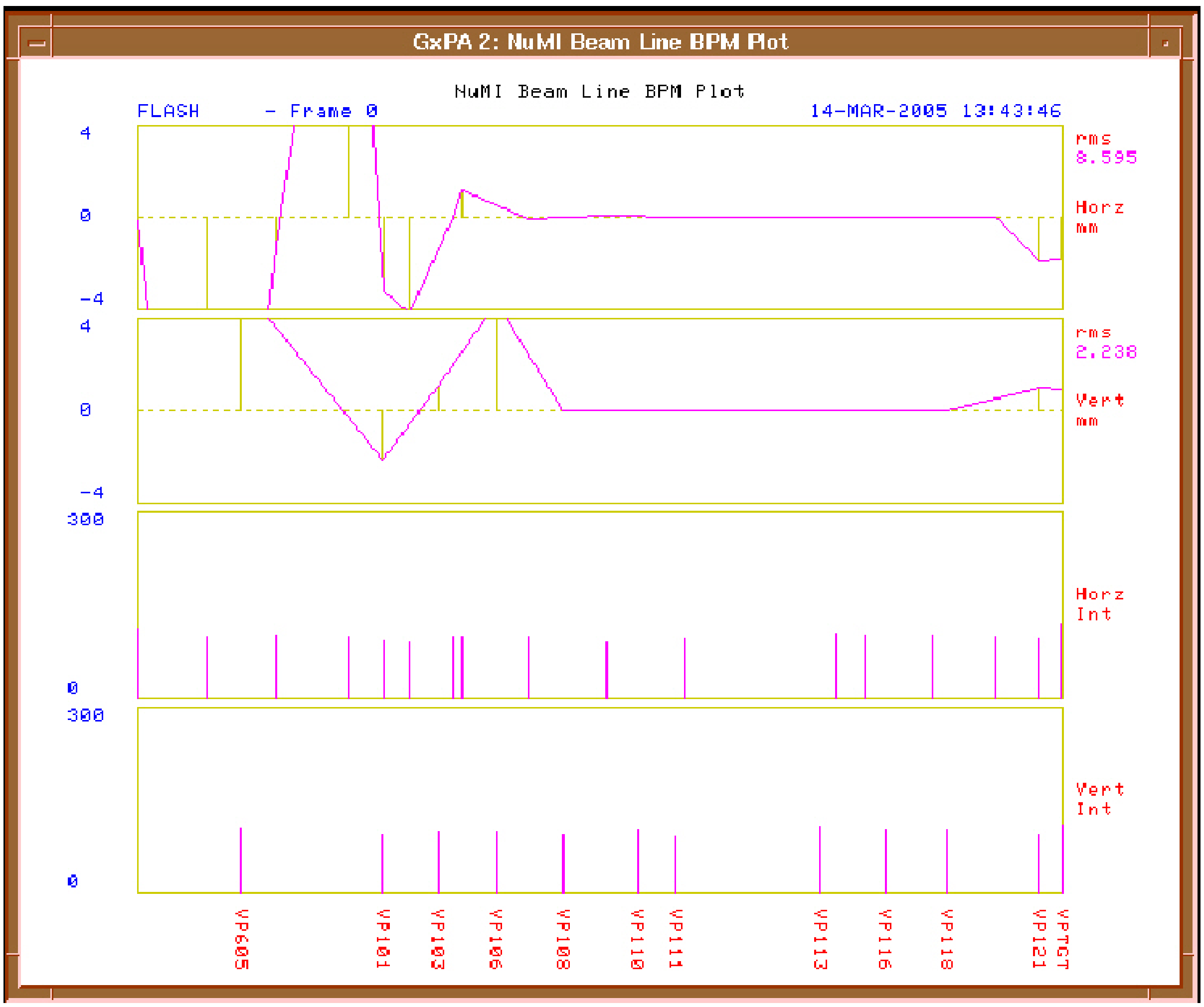

Figure 4 BPM traces for tuned beam.

BPM traces for tuned beam. Note that in the horizontal the beam hits the target at -1.8 mm while in the vertical it hits at +1.0 mm. These nominals may change by small amounts for different target postions. The Autotune program has these targeting parameters built into it. See Figure 6.

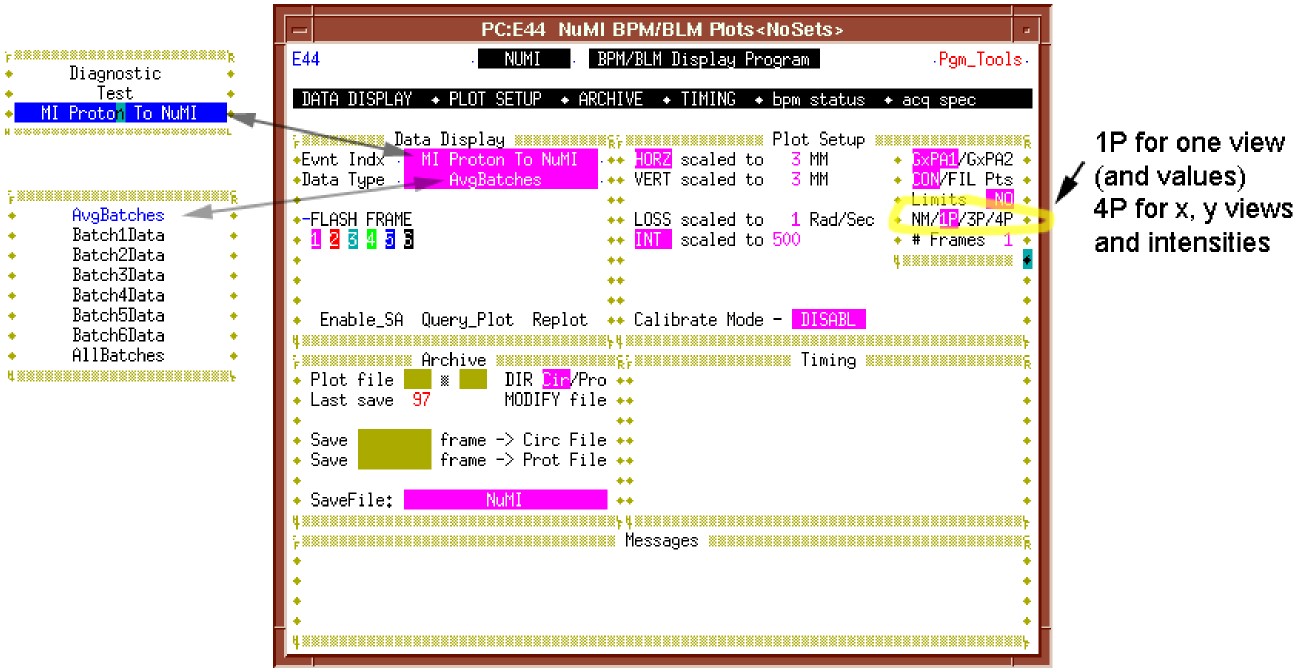

Figure 5 BPM page. Note the selection of single batches or average position.

γ. <u>Loss Monitors</u> The loss monitors can be examined on E38 and can be plotted with the BPM traces. Loss monitors can show significant non-zero readings when profile monitors are in the beam. With profile monitors out readings should be at a very low level. Most loss monitors are set to trip the BPS at readings of 5 rads/sec, but would indicate the existence of a problem before reaching that level. Some of the total loss monitors are set higher than this. There is also a Radiation Safety 'scarecrow' device near quad 113. This is set to pull the safety system and BPS if its limit is exceeded. This device is read in ACNET as G:RD1224. A safety system trip also takes out the Critical Devices – these are E:LAM60, E:LAM61 and E:HV101.

F. Autotune

Tuning of the trims in the line is done exclusively with the NuMI Autotune program (*3/3/06 update—there are now two Autotunes, one for NuMI only and the other for NuMI – Pbar mixed running*). There is a link to this program in the logbook Memo Pad. The page heading of the Autotune window should be 'Operational mode' (see Figure 6). This is the name of the control file that is running. If some other file is active the proper one should be run in its place: Click Servlet<List/Edit Control File and then select the most recent version of 'Operational mode' and activate it. The Octagon at the top of the window should be green, indicating that the automatic tuning is activated. If it is red--indicating "read only" operation--click on the Octagon to turn it green. Under normal conditions, the tuning procedure will converge, indicated by all green traces in its display, within a few cycles. If it does not, this indicates that some component is drifting unacceptably or has gone out of range.

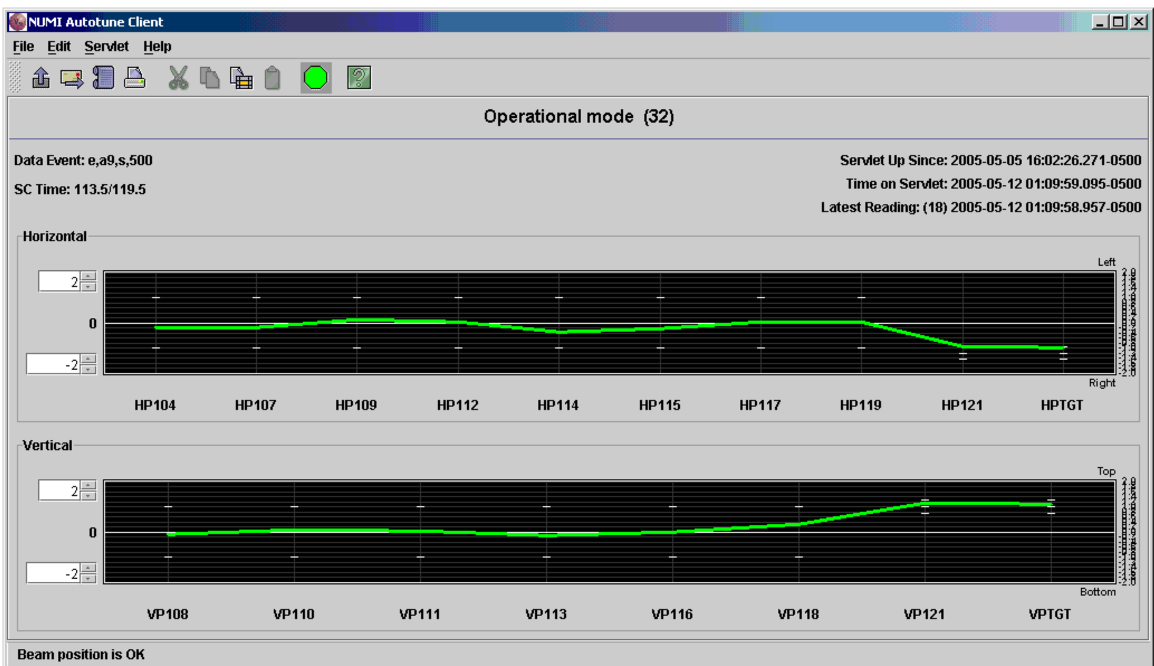

Figure 6 Autotune Plot

G. Target

The NuMI target has developed a small leak between the RAW cooling water piping and the "vacuum" space surrounding the target. To keep water from leaking into that space, it is currently filled with helium at a pressure that is higher than the pressure on the other side of the leak opening. The situation has been monitored over a period of time, by Lumberjack plots exemplified by Figure 7 (which exists as "tgtLeakMon" in the D44 collection of files under Data Source "NuMI (DUE41)"), and by dedicated target scans that look for the effect of water filling the "vacuum" space. The helium overpressure arrangement has been successful in keeping the RAW cooling water where it belongs, and away from where it doesn't belong. The existence of the leak opening isn't limiting the NuMI beam intensity.

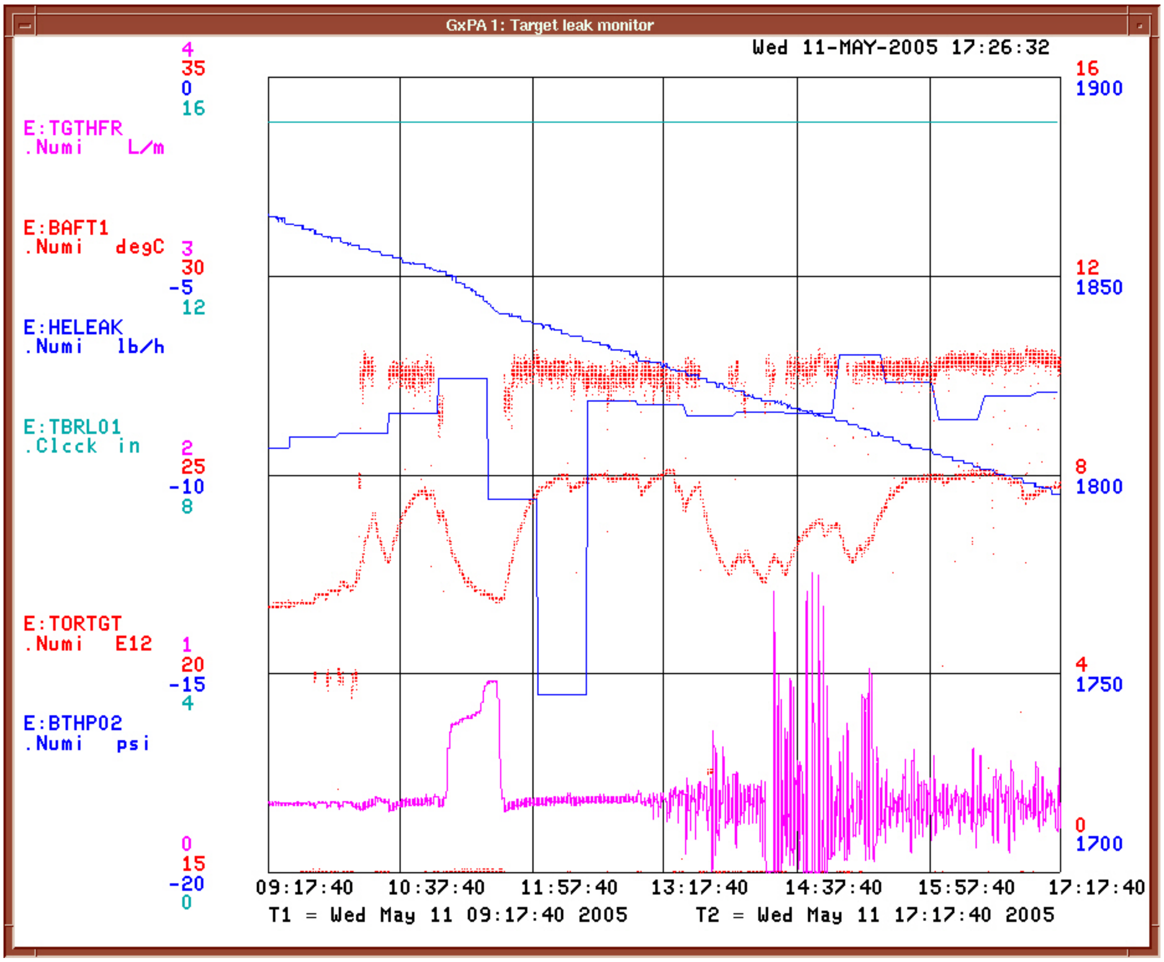

Figure 7 Target Parameters of interest

Figure 7 shows monitoring of the helium bottle pressure (E:BTHP02), protection baffle temperature (E:BAFT1), rate of change of helium bottle pressure (E:HELEAK), RAW system expansion tank level (E:TBRL01), helium flow (E:TGTHFR) and beam intensity

(E:TORTGT). It doesn't show another variable that is often plotted, the helium pressure in the "vacuum" space (E:BTHP01). The helium flow rate (E:TGTHFR) that is seen also has a contribution from a leak at one of the fittings in the helium piping. The quantities represented by two of these variables are being monitored by the BPS: E:BTHP01 and E:TGTHFR. The bottle pressure (E:BTHP02) has an acknowledgeable alarm if it drops below 500 psi. The rate of change of helium bottle pressure (E:HELEAK) is associated with an analog alarm that has priority 5 (not acknowledgeable).