A Guide for Analyzing the Muon Monitor Signals

(not comprehensive)

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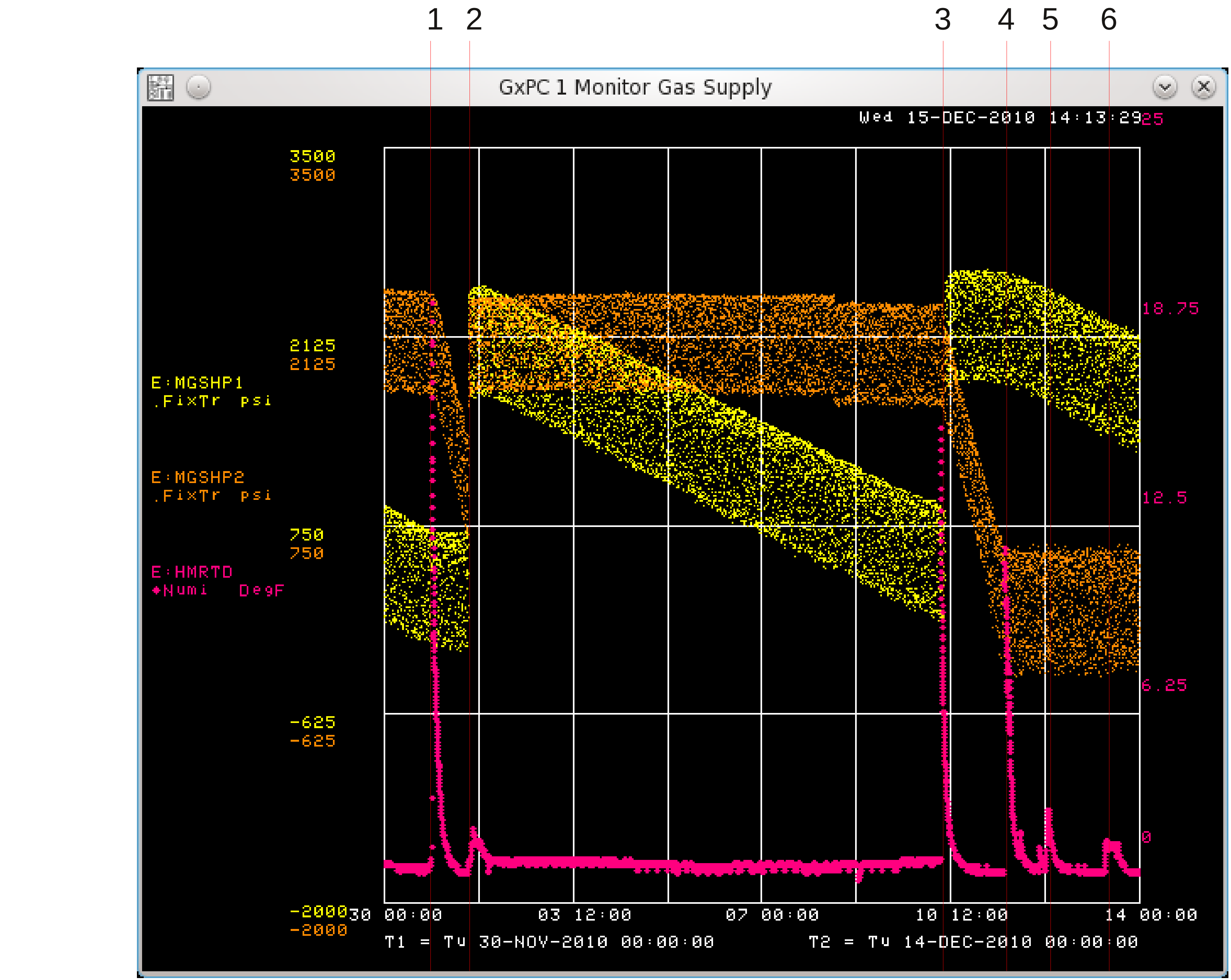
The following pages describe Typical Gas Contamination Incidents

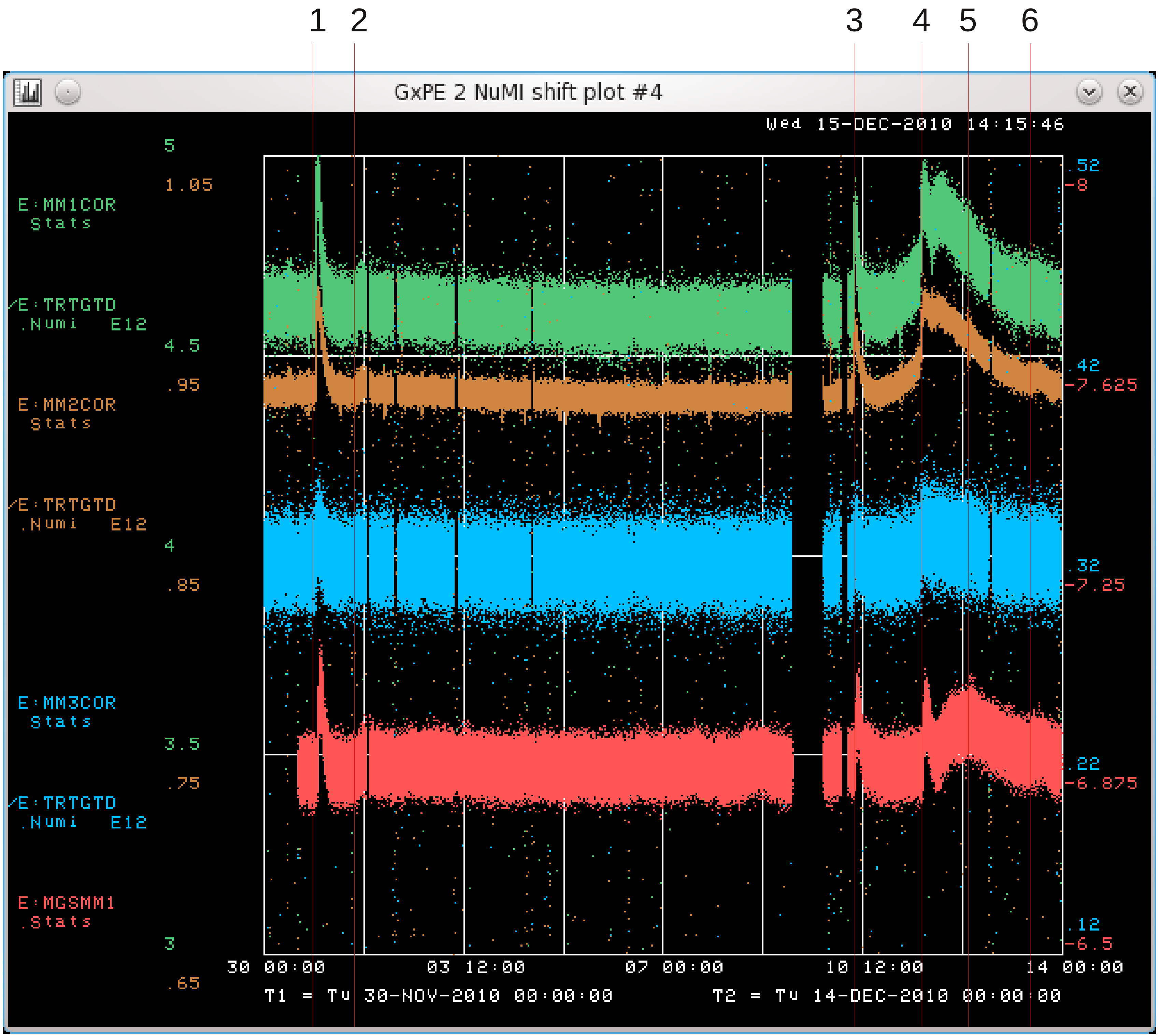
- The following plots shows “typical” gas contamination incidents which typically corresponds to gas cylinder exchanges.

- The beam is in LE010z-185i during the time shown (Nov 30- Dec 14 2010).

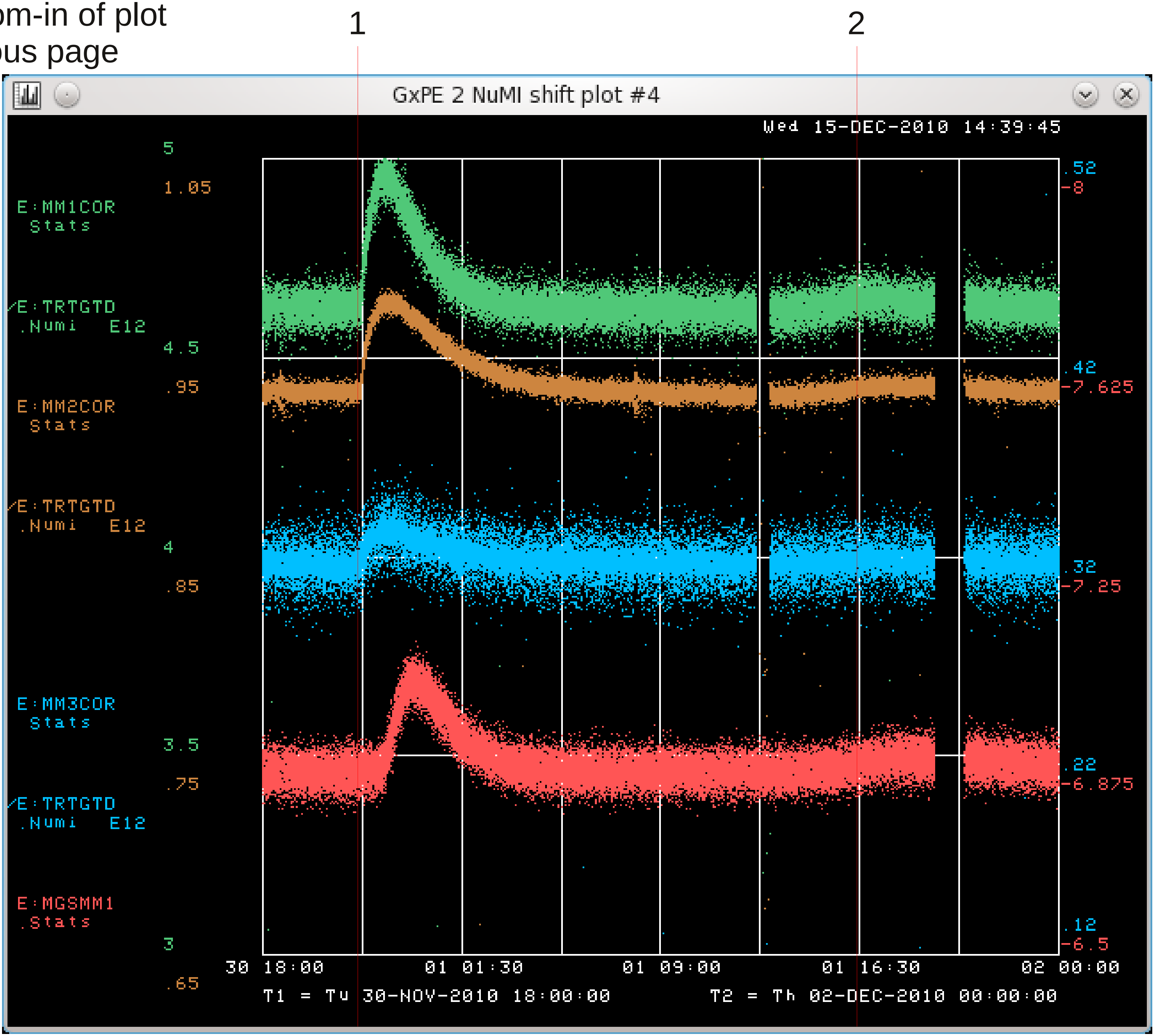
- The devices plotted are....
  - E:MGSHP1 – The pressure from the 8-pack of bottles/cylinders supplying the system with gas. Units are psi.
  - E:MGSHP2 – The pressure from the single Spare bottle/cylinder supplying the system with gas. Units are psi.
  - E:HMRTD – Despite the name, this is the Oxygen Analyzer located in the gas line just before the fan-out to each monitor. Units are ppm.
  - E:MM1COR/E:TRTGTD – The POT normalized signal from Muon Monitor 1(mm1). (E:MM1COR is pressure and pedestal corrected.) Units are Volts.
  - E:MM2COR/E:TRTGTD – The POT normalized signal from Muon Monitor 2(mm2). (E:MM2COR is pressure and pedestal corrected.) Units are Volts.
  - E:MM3COR/E:TRTGTD – The POT normalized signal from Muon Monitor 3(mm3). (E:MM3COR is pressure and pedestal corrected.) Units are Volts.
- E:MGSMM1 – The Gas Calibration Monitor signal from the gas calibration monitor in the gas exhaust line of MM1. (E:MGSMM1 is pressure corrected.) Units are Volts.

- The pages that follow describe the circumstances corresponding to each red numbered line shown on the plot.


1
2
3
4
5
6
GxPC 1 Monitor Gas Supply
Wed 15-DEC-2010 14:13:29
25
3500
3500
2125
2125
750
750
-625
-625
-2000
-2000
E:MGSHP1
.FixTr psi
E:MGSHP2
.FixTr psi
E:HMRTD
◆Numi DegF
18.75
12.5
6.25
0
30 00:00
03 12:00
07 00:00
10 12:00
14 00:00
T1 = Tu 30-NOV-2010 00:00:00
T2 = Tu 14-DEC-2010 00:00:00


1
2
3
4
5
6
GxPE 2 NuMI shift plot #4
Wed 15-DEC-2010 14:15:46
E:MM1COR Stats
E:TRTGTD .Numi E12
E:MM2COR Stats
E:TRTGTD .Numi E12
E:MM3COR Stats
E:TRTGTD .Numi E12
E:MGSMM1 .Stats
5
1.05
4.5
.95
4
.85
3.5
.75
3
.65
.52
-8
.42
-7.625
.32
-7.25
.22
-6.875
.12
-6.5
30 00:00
03 12:00
07 00:00
10 12:00
14 00:00
T1 = Tu 30-NOV-2010 00:00:00
T2 = Tu 14-DEC-2010 00:00:00

Time Zoom-in of plot on previous page



- Line 1: Prior to line 1 the system is drawing from the 8-bottle pack (indicated by E:MGSHP1 (yellow)). At line 1 the system automatically switches from drawing from the 8-pack (which is now empty) to drawing from the spare bottle (E:MGSPH2 (orange)). As is typical when a bottle exchange/automatic switch occurs there is gas contamination indicated by the jump in the Oxygen monitor (E:HMRTD) at the same time. The Muon Monitor signals and the Gas calibration monitor signal also jumps in response to the increase in O2 level within the gas. Note that there is a short (~1/2 hour) delay in the jump in the muon monitor signals compared to the gas calibration chamber signal due to the fact that the gas calibration chamber is in the exhaust gas line of muon monitor 1, several hundered feet from from the mm1 itself. The signals start to decrease within a few hours as the contamination leaves the system.

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- Line 2: All of the gas bottles are replaced with new, full, bottles. The system starts drawing from the 8-pack. The oxygen analyzer records a small jump in the impurity level. Upon very close inspection, the muon monitor signals also show a very small jump(most evident in mm1 signal) in response to the O2 contamination but it is almost not noticeable.

- Line 3: The system switches from drawing from the 8-pack to the spare bottle. There is gas contamination indicated by the jump in the Oxygen monitor (E:HMRTD) at the same time. The Muon Monitor signals(not very noticeable in MM3 signal) and the Gas calibration monitor signal also jumps in response to the increase in O2 level. Also at line 3 the bottles in the 8-pack are exchanged but the system remains. Drawing from the spare bottle until line 4.

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- In between line 3 and line 4: There is a distinct “spike” from the O2 contamination. But after the spike(increase and quick decrease) the muon monitor signals seem to be slowly increasing, but without evidence to suggest a reason for this.

- Line 4: The system automatically switches to the 8-pack from the spare bottle. The O2 monitor jumps as do the Monitor signals indicating gas contamination. Shortly thereafter the signals start to decrease back down to “pre-contamination” levels.

- Lines 5 and 6: The O2 monitor spikes indicating a jump in O2 levels at these instances. The explanation is as follows: The 8 bottles are connected to a manifold that merges into a single gas line into the system. The bottles that are at a higher pressure prevent the lower pressure bottles from contributing gas to the manifold. Once the higher pressure bottles reach the same pressure as the lower pressure bottles then the lower pressure bottles will start contributing gas to the system. The spikes at lines 5 and 6 are most likely lower pressure bottles that start contributing gas to the system now that the pressure of the initially higher pressure bottles have decreased to the level of the lower pressure bottles.

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The following pages describe Rare Gas Contamination Incidents

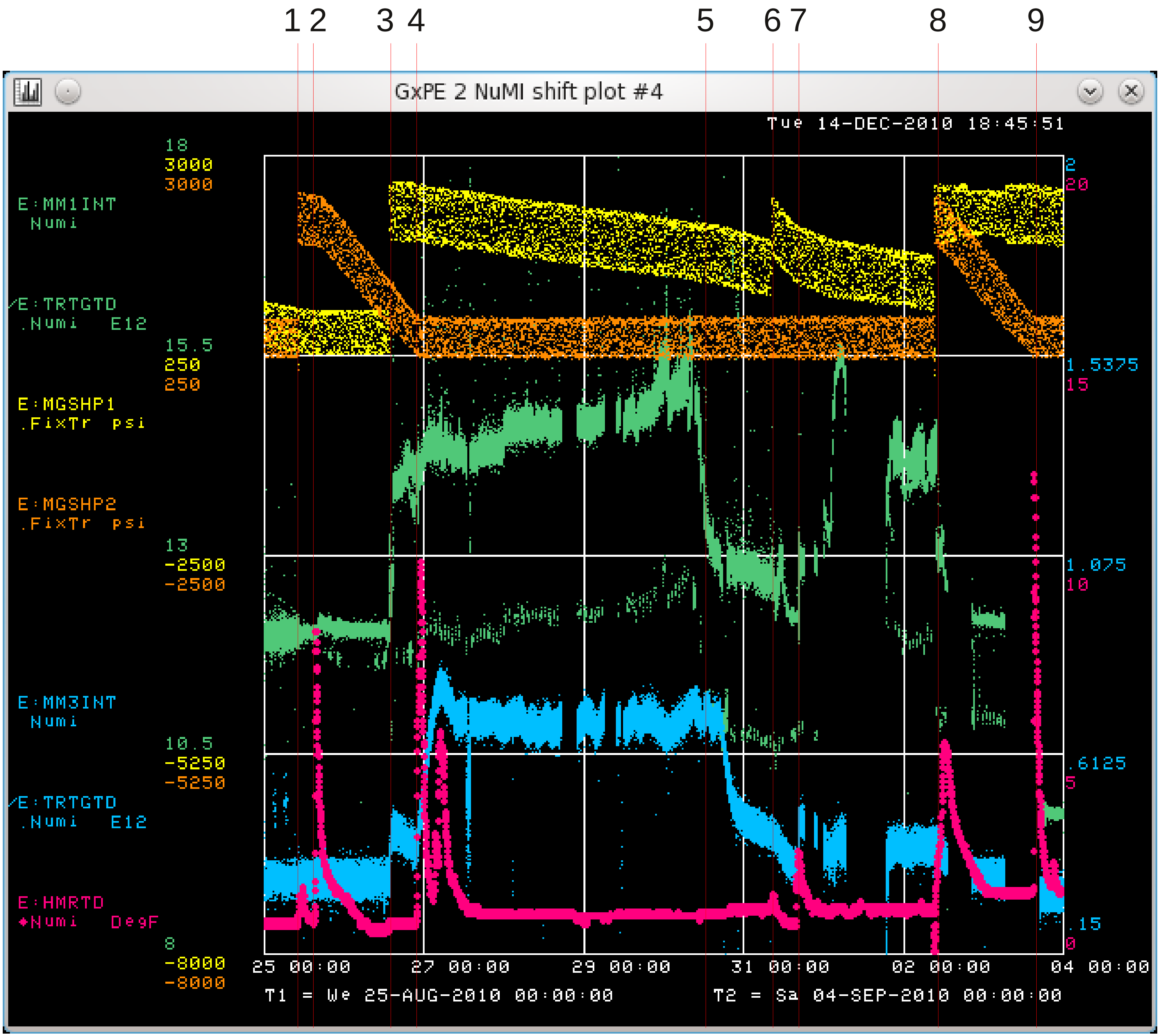
- The following plot is a particularly complicated instance of “bad” gas in the monitor system. The gas system uses a total of 9 “High Purity Grade” Helium commercial cylinders. In this instance some of the cylinders in the system were not in fact Helium but Nitrogen. In a previous incident there was an Argon cylinder placed in the system.

- The beam is in LE100z200i through 2010/09/03 12:30pm. After this time it is in LE100z-200i.

- The devices plotted are....
  - E:MM1INT/E:TRTGTD – The POT normalized signal from Muon Monitor 1(mm1). Units are Volts.
  - E:MM3INT/E:TRTGTD – The POT normalized signal from Muon Monitor 3(mm3). Units are Volts.
  - E:HMRTD – Despite the name, this is the Oxygen Analyzer located in the gas line just before the fan-out to each monitor. Units are ppm.
  - E:MGSHP1 – The pressure from the 8-pack of bottles/cylinders supplying the system with gas. Units are psi.
  - E:MGSHP2 – The pressure from the single Spare bottle/cylinder supplying the system with gas. Units are psi.

- The gas calibration monitors were not functioning during the time shown in the plot.

- The pages that follow describe the circumstances corresponding to each red numbered line shown on the plot.



1 2 3 4 5 6 7 8 9
GxPE 2 NuMI shift plot #4
Tue 14-DEC-2010 18:45:51
E:MM1INT Numi
E:TRTGTD .Numi E12
E:MGSHP1 .FixTr psi
E:MGSHP2 .FixTr psi
E:MM3INT Numi
E:TRTGTD .Numi E12
E:HMRTD Numi DegF
18 3000 3000
15.5 250 250
13 -2500 -2500
10.5 -5250 -5250
8 -8000 -8000
2 20
1.5375 15
1.075 10
.6125 5
.15 0
25 00:00
27 00:00
29 00:00
31 00:00
02 00:00
04 00:00
T1 = We 25-AUG-2010 00:00:00
T2 = Sa 04-SEP-2010 00:00:00

- Line 1: Both the spare bottle and the 8-pack are almost empty and require exchange. The Spare bottle only is exchanged. This is probably because there were not enough helium cylinders to replace all 8 bottles in the 8 pack. The system continues drawing from the 8-pack. The oxygen analyzer records a small jump in the impurity level

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- Line 2: The system switches from drawing from the 8 pack to the spare bottle. The oxygen analyzer records a small jump in the impurity level. The muon monitor signals also shown a jump in response to the O2 contamination but on the scale of the plot it is not noticeable.

- Line 3: The 8-pack is replaced, but the system is still drawing from the spare bottle as is evident from the continued drop in the E:MGSHP2 reading after line 3. However at this same time the monitor signals experience a large jump. This jump is consistent with (looks like) gas contamination but the O2 monitor does not indicate O2 contamination. However the O2 monitor will only respond to O2 levels not other gases like Nitrogen, which is the largest component of Air.

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- Line 4: The system switches from drawing from the spare bottle to the 8-pack. A large jump in the O2 impurity level is recorded by the O2 monitor. Muon monitor 3 signal experiences a very large jump. A short time later the O2 monitor records a few other jumps in the O2 level probably because at those instances other bottles within the 8-pack a starting to contribute to the system*. From my experience, three things indicate that this is not just a case of O2 contamination:
    1. The size of the jump in the signals (~70% jump in MM3).
    2. The severe non-linearity in MM1 signal.
    3. The signals do not begin to drop within a few hours.

  Subsequent inspection of the gas cylinders showed that one of the bottles was Nitrogen not Helium.

*The 8 bottles a connected to a manifold that merges into a single gas line into the system. The bottles that are at a higher pressure prevent the lower pressure bottles from contributing gas to the manifold. Once the higher pressure bottles reach the same pressure as the lower pressure bottles then the lower pressure bottles will start contributing gas to the system.

- Line 5: The beam intensity drops. Because MM1 is experiencing severe non-linearity the signal drops significantly in response to the decrease in beam intensity. Shortly thereafter the Nitrogen bottle is valved off from the system. Thus the drop in MM3 signal a few hours later.

- Line 6: The Nitrogen bottle is replaced with helium. The signals drop faster.

- Line 7: There is a jump in the O2 level and the monitor signals jump up and remain there. Most likely this is what happened: The new helium bottle was at the highest pressure of all of the bottles so between lines 6-7 it was supplying the system alone*. At line 7 that bottle reaches the same pressure as the other 7 bottles and so all of the bottles start to contribute gas to the system. The fact that at this time the signal jumps up seems to suggest that there is some sort of contamination(another one of the bottles is nitrogen, or the purity of one of the helium bottles is not “high purity grade”) in one or more of the other 7 bottles. More than this, there is no definite explanation.

- Line 8: Due to the fact that the signals are still not back to “normal”, I schedule a gas bottle exchange of the all of the bottles in the system. This occurs at line 8. The system starts drawing from the newly replaced spare bottle.

- Line 9: The spare bottle is used up and the system automatically switches to the 8-pack. The O2 monitor jumps. Unfortunately at the exact instant this happens the beam is off. When the beam returns the beam is now in LE100z-200i, prior to line 9 it was in LE100z-200i. The muon monitor signals are changed due to the change it beam configuration so after line 9 cannot be compared to before line 9. Now one can only monitor the signals to make sure that they are stable(i.e. Flat, no jumps). For the time after line 9 (not shown), the signals are stable indicating the gas problem has been remedied.

The following pages attempt to guide the reader in Monitoring the Horns and diagnosing Horn Problems

The following plots are horn scans taken in LE100z200, LE100z-200, LE250z200, LE250z-200 and beam configurations (LE010z185 and LE010z-185 needed).

The muon monitor signals change with different beam configurations so knowing the “typical” signal levels of the muon monitors during each beam configuration is important.

Trying to analyze the muon monitor signals for monitoring the horns and diagnosing horn problems is complicated by problems of gas contamination.

It is impossible to say that the muon monitor signal should be within X% of a certain value in a given beam configuration because of the large signal variation with gas quality.

One thing to note from the previous discussion of gas contamination is that gas contamination causes the signal level to increase not decrease (unless there is already contamination and one is taking measures to remedy it, then putting more pure gas(helium) in the system will lower the signal).

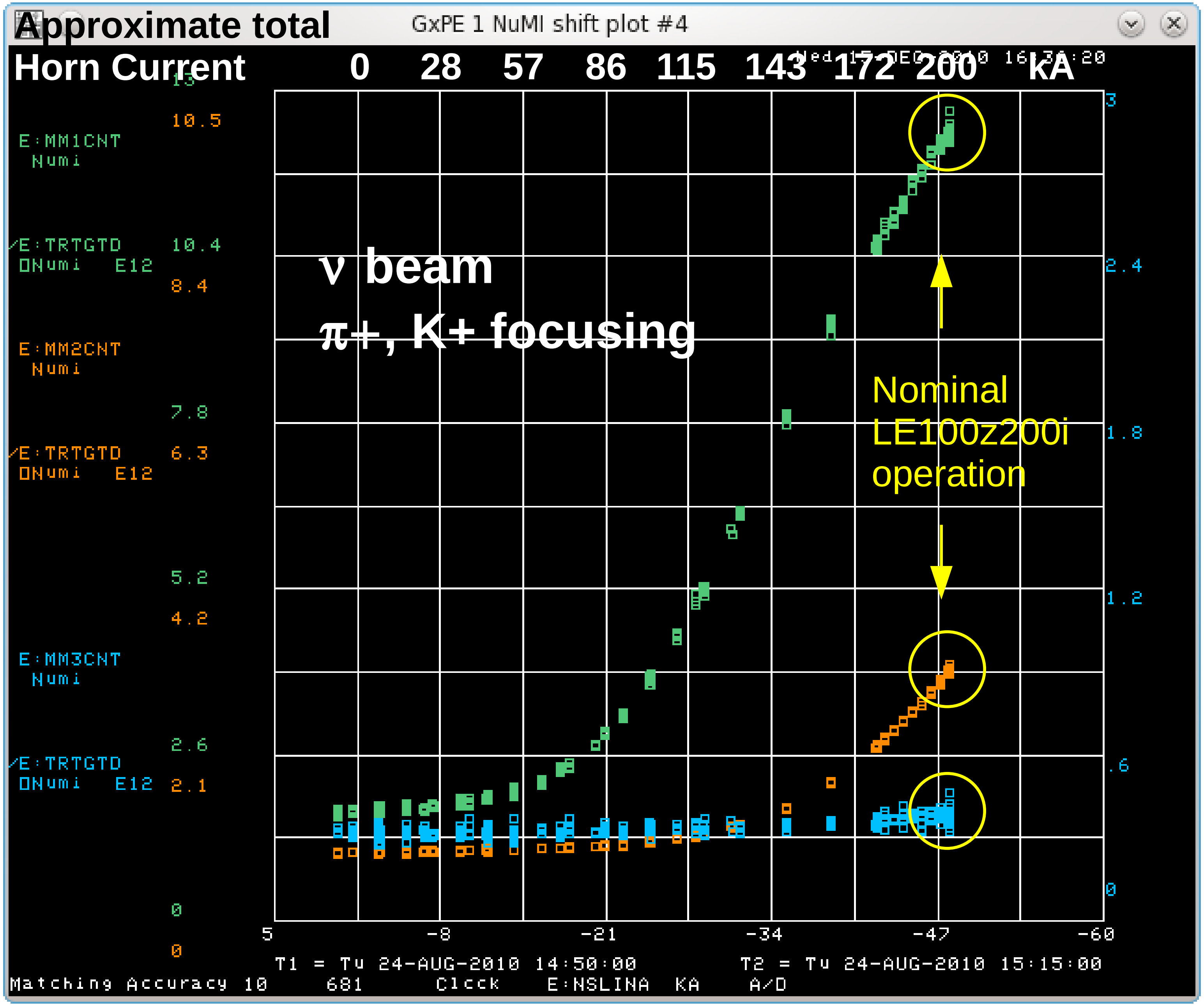
One fortunate result of this, is that if there is a failure of the horns, i.e. it trips off or just some failure that would cause it not to produce any magnetic field, the muon monitor signals will decrease drastically. This type of failure will be easily detectable using the muon monitors.

LE100z200i (ν) Horn Scan

MM1

MM2

MM2

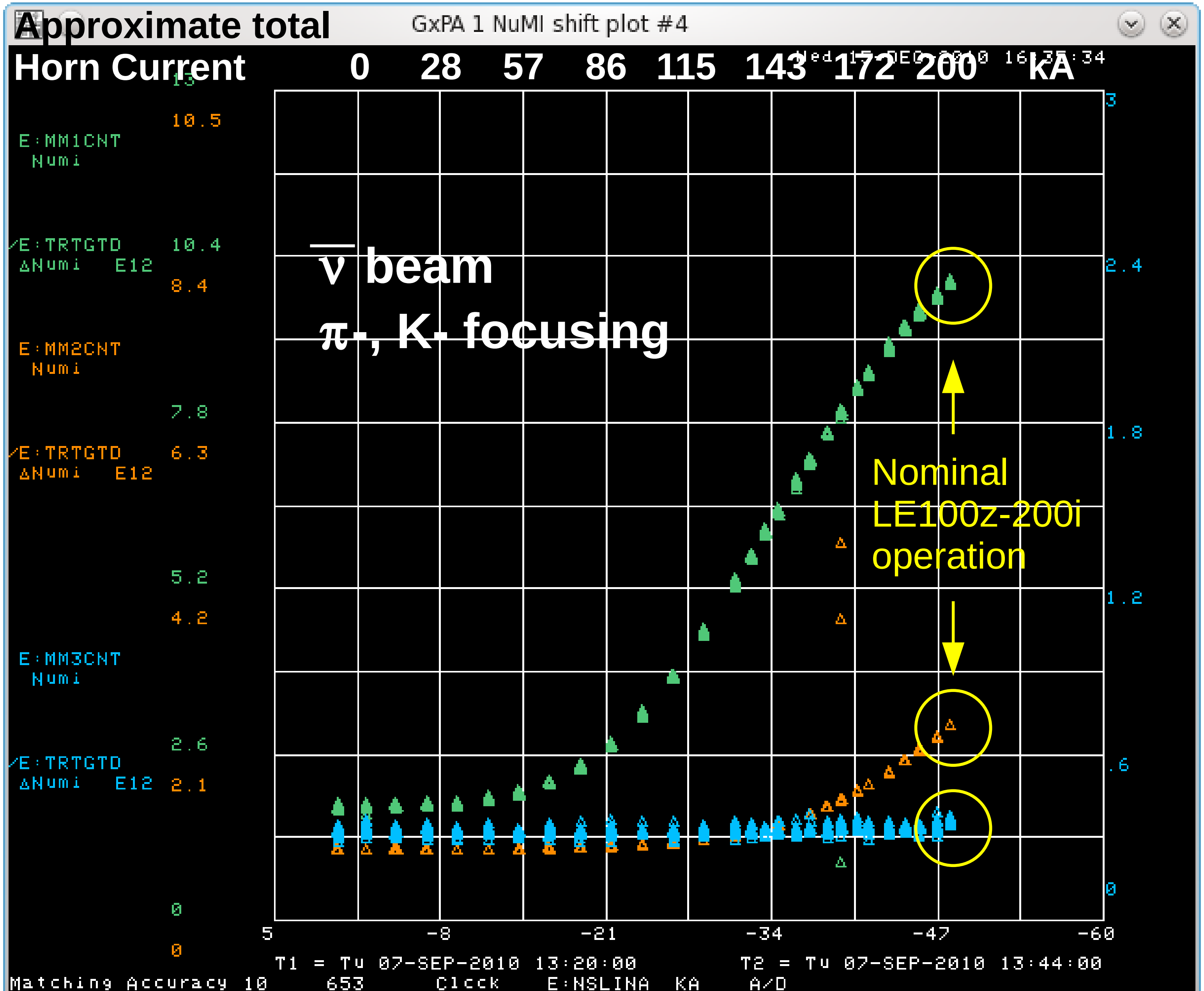


LE100z-200i ($\bar{\nu}$) Horn Scan

MM1

MM2

MM2



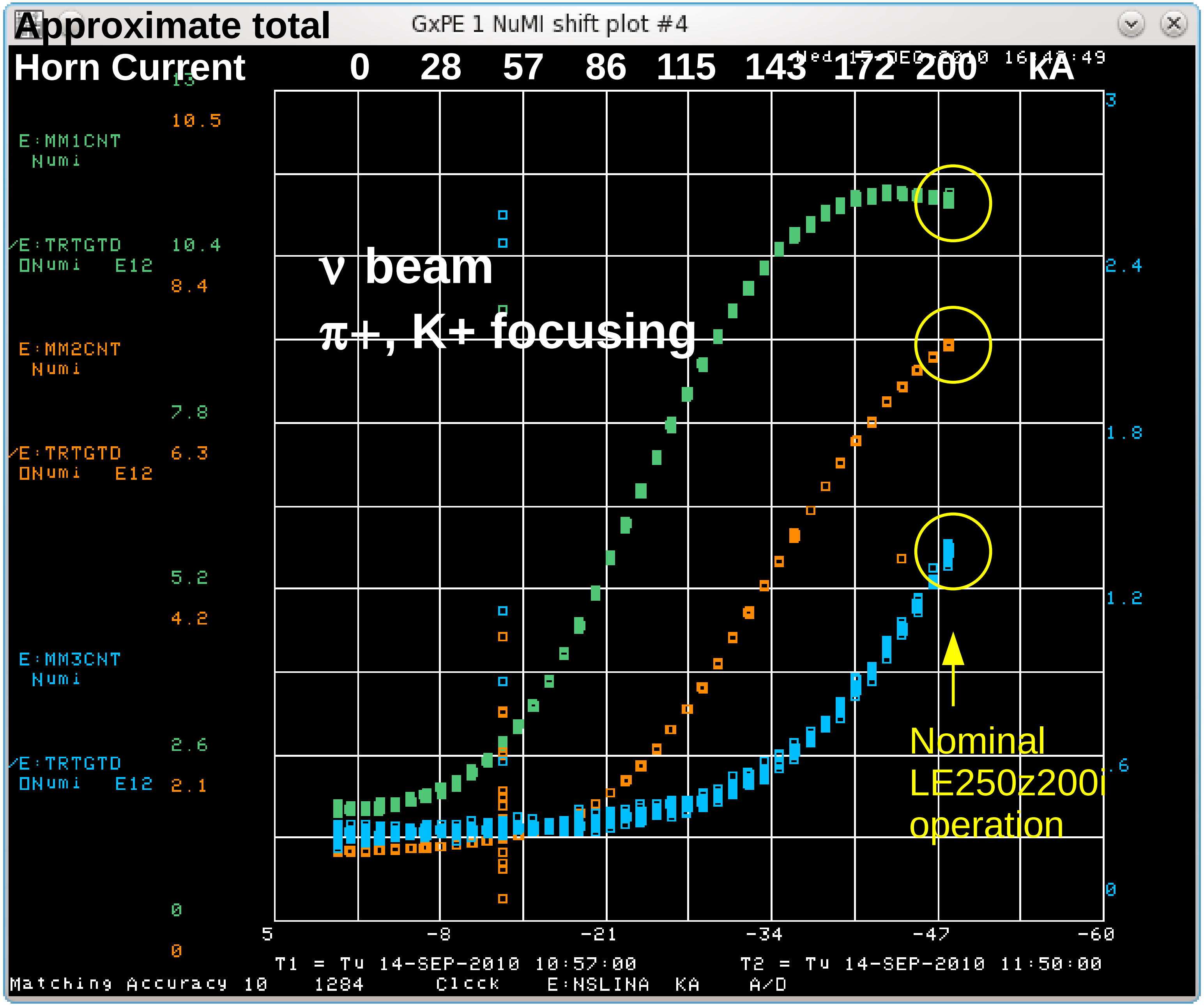
* Ignore points not lying on the curve

LE250z200i (ν) Horn Scan

MM1

MM2

MM2



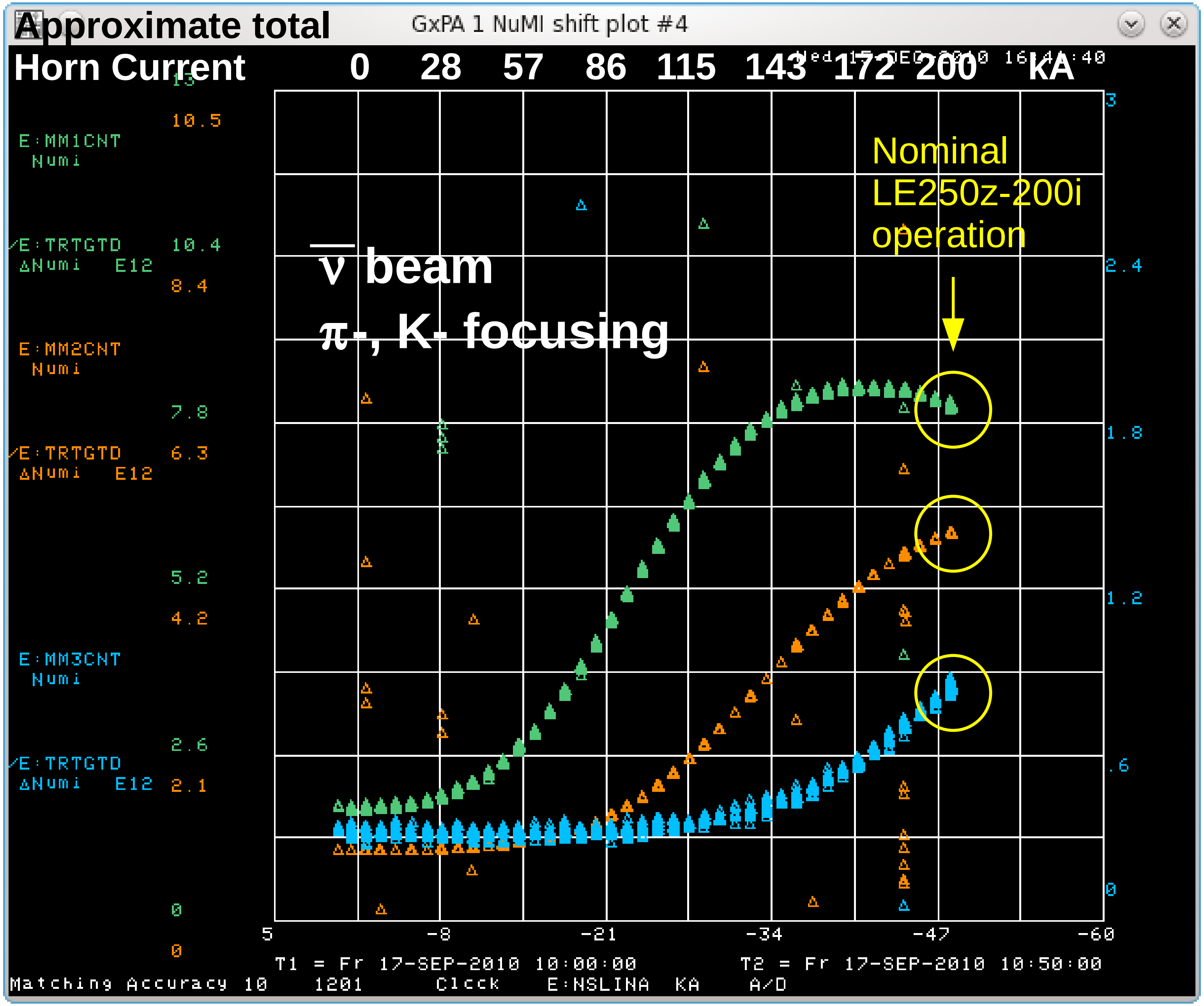
* Ignore points not lying on the curve

LE250z-200i ($\bar{\nu}$) Horn Scan

MM1

MM2

MM2



* Ignore points not lying on the curve

As can be seen from the horn scans, if there is a failure of the horns, i.e. it trips off or just some failure that would cause it not to produce any magnetic field, the muon monitor signals will decrease drastically. This type of failure will be easily detectable using the muon monitors.

Compare the current signal from the muon monitors* with the nominal configuration signal value from the appropriate beam configuration horn scan plot above. If the current muon monitor signal is significantly(hard to say what exactly significantly is) different than the signal value from the appropriate plot above and there is no indication of gas contamination (especially if the current muon monitor signal is *lower than* the nominal signal in the appropriate plot above) then this *could* indicate a problem with the horns. Contact an expert for further examination.

*Use acnet to determine the current signal from each muon monitor. Shift Plot #4 plots the same muon monitor quantities as show in the above plots.