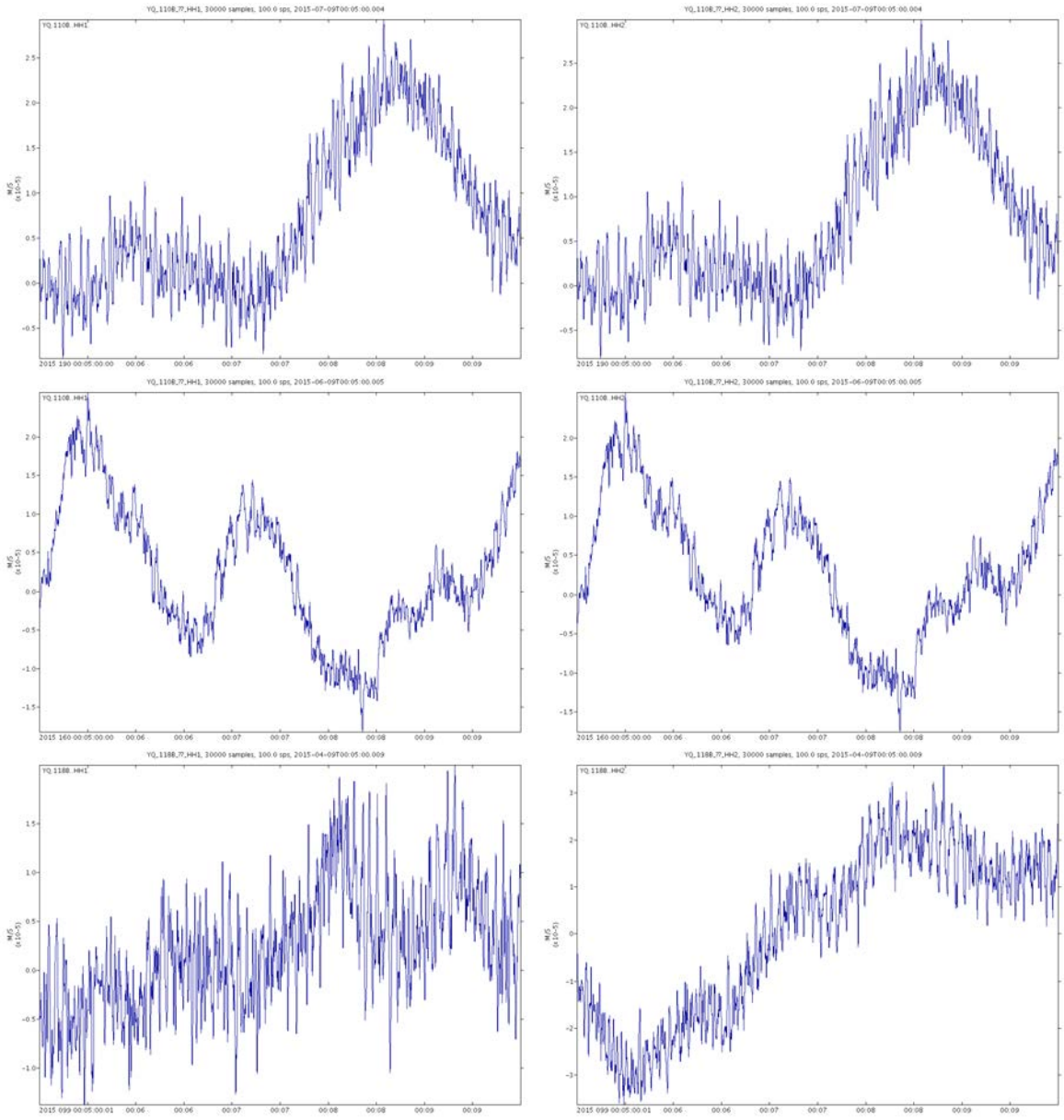
2015 Shilington – Malawi LP4x4 Deployment
Network Code: YQ
Site 110B Data Assessment

Initial observation/assessment:
Sensor-Ball 48 (containing Trillium-240 serial number 145) appears to have duplicating data on the two horizontal channels. Need to test and evaluate SB-48 (T-240 s/n 145) once it returns from Collier-Antilles deployment.

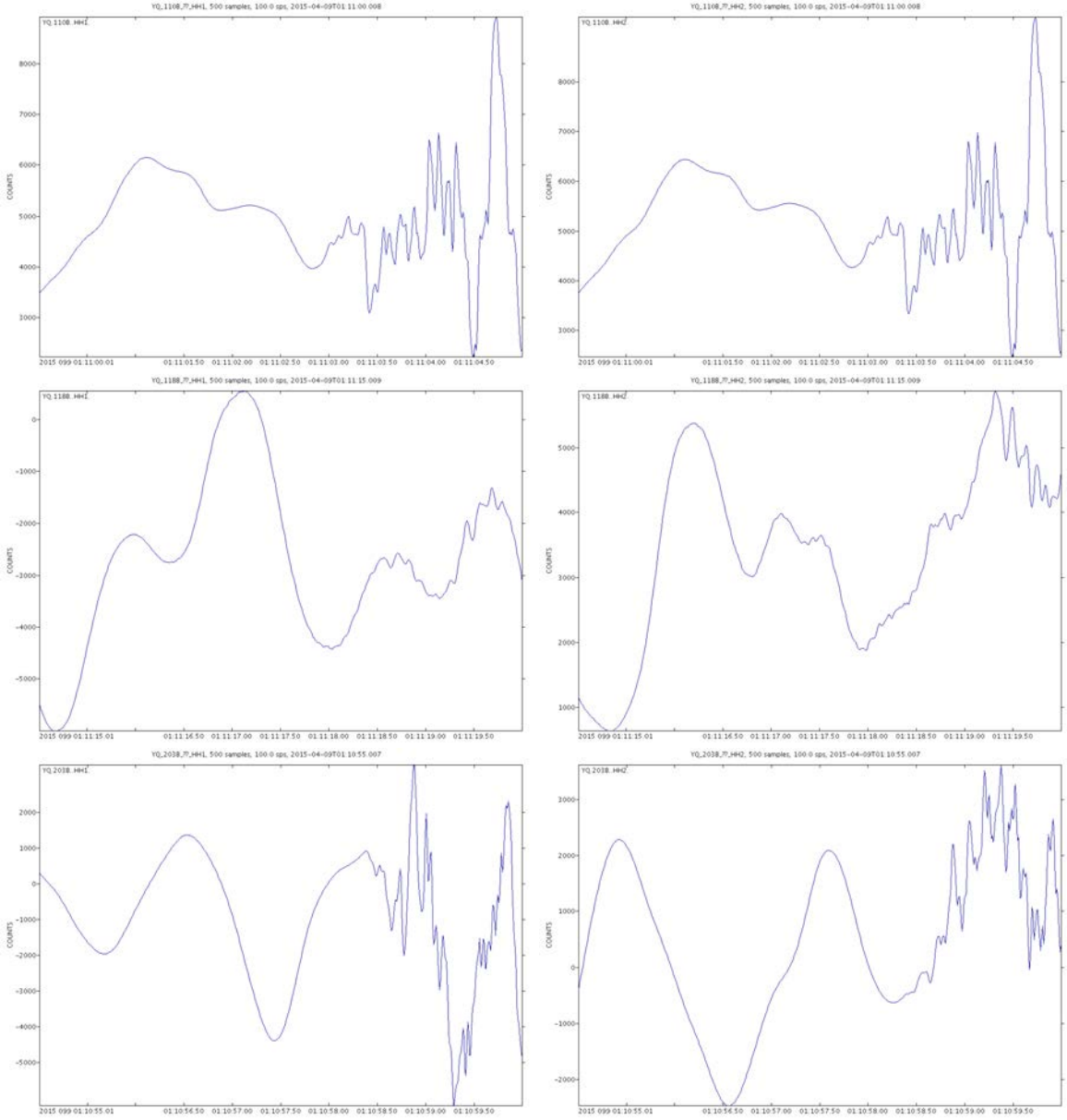
DMC Data Observation:
Kasey Aderhold provided the following observations for the Shillington-Malawi data in the "Upload Verification Form -- Experiment Name: SEGMeNT/Malawi":

Figure 5 shows two five minute segments of data from the horizontal components of station 110B, with a five minute segment from station 118B for comparison. The 110B horizontals are not exactly identical, but they are very similar.

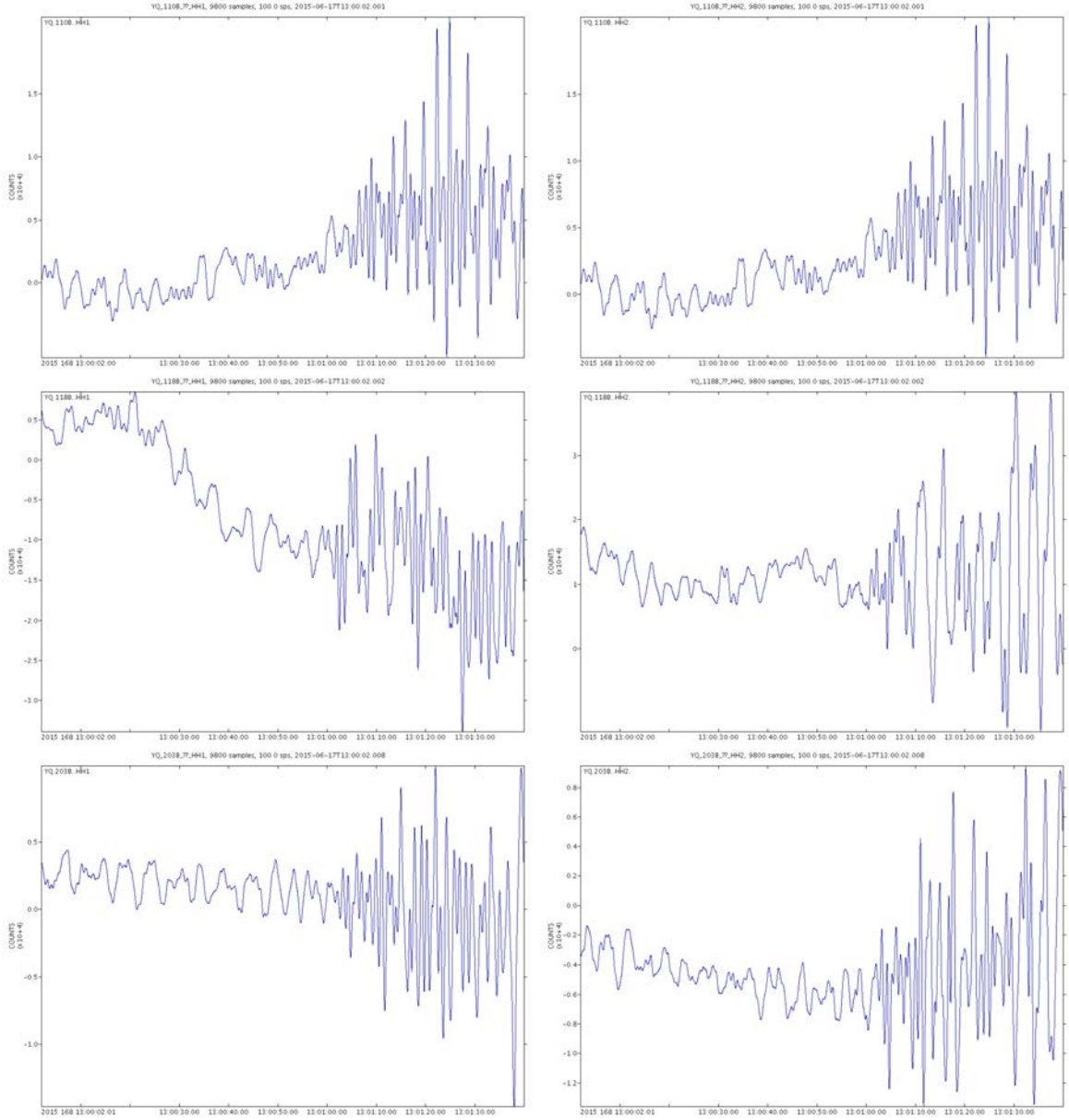
Upload Verification Form – Figure 5: Five minutes of recording on Station 110B Horizontals (top and middle) and Station 118B (bottom) for comparison. HH1 left, HH2 right.



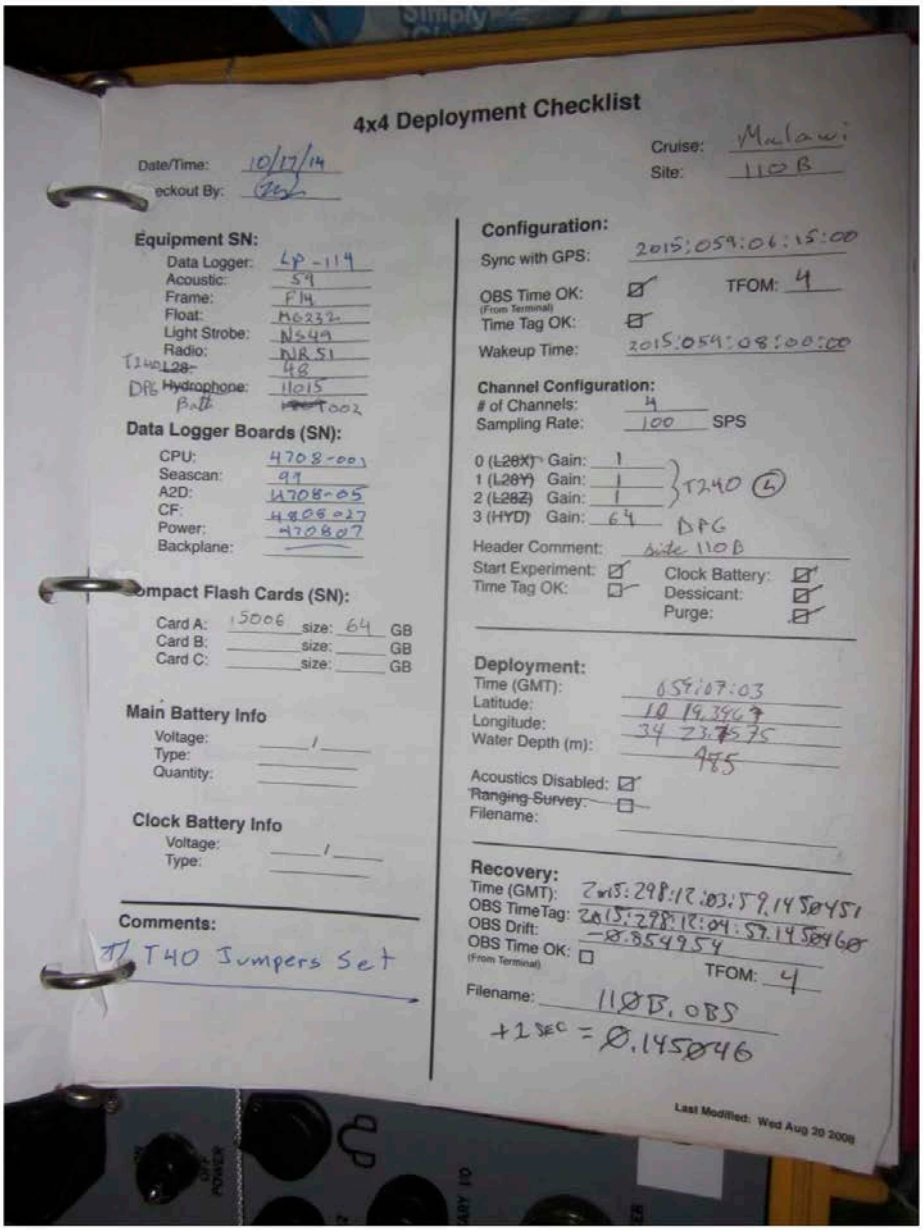
Upload Verification Form – Figure 6. Beginning (5s) of a local event on 4/9/15 on Station 110B horizontals (top), Station 118B (middle), and Station 203B (bottom) for comparison. HH1 left, HH2 right. Event was a M4.0 on 4/9/15 at 01:10:39 in Tanzania.



Upload Verification Form – Figure 7. Beginning (1m 40s) of a teleseismic event on 6/17/15 on Station 110B horizontals (top), Station 118B (middle), and Station 203B (bottom) for comparison. HH1 left, HH2 right. Event was a M7.0 on 6/17/15 at 12:51:32 in the South Atlantic.



SIO Lab Observations, Tests, Analysis, and Assessment:
Based on initial observations provided by Kasey it does appear that the horizontals have repeating/duplicate data. Initially, we used information from the 4x4 Deployment Checklist for Malawi Site 110B to trace the data backward through various components/processes in data collection.



4x4 Deployment Checklist

Date/Time: 10/17/14
Checkout By:
Cruise: Malawi
Site: 110B

Equipment SN:
Data Logger: LP-114
Acoustic: 59
Frame: FH
Float: M6232
Light Strobe: N549
Radio: NR51
T240 ~~L28~~ 48
DPG Hydrophone: 11015
Batt ~~Batt~~ 002

Data Logger Boards (SN):
CPU: 4708-001
Seascan: 99
A2D: 4708-05
CF: 4808027
Power: 470807
Backplane:

Compact Flash Cards (SN):
Card A: 15006 size: 64 GB
Card B: size: GB
Card C: size: GB

Main Battery Info
Voltage: /
Type:
Quantity:

Clock Battery Info
Voltage: /
Type:

Comments:
T40 Jumpers Set

Configuration:
Sync with GPS: 2015:059:06:15:00
OBS Time OK: ☑ TFOM: 4
(From Terminal)
Time Tag OK: ☑
Wakeup Time: 2015:059:08:00:00

Channel Configuration:
# of Channels: 4
Sampling Rate: 100 SPS

0 (~~L28X~~) Gain: 1
1 (~~L28Y~~) Gain: 1
2 (~~L28Z~~) Gain: 1
} T240 (4)
3 (HYD) Gain: 64 DPG
Header Comment: Site 110B
Start Experiment: ☑ Clock Battery: ☑
Time Tag OK: ☐ Dessicant: ☑
Purge: ☑

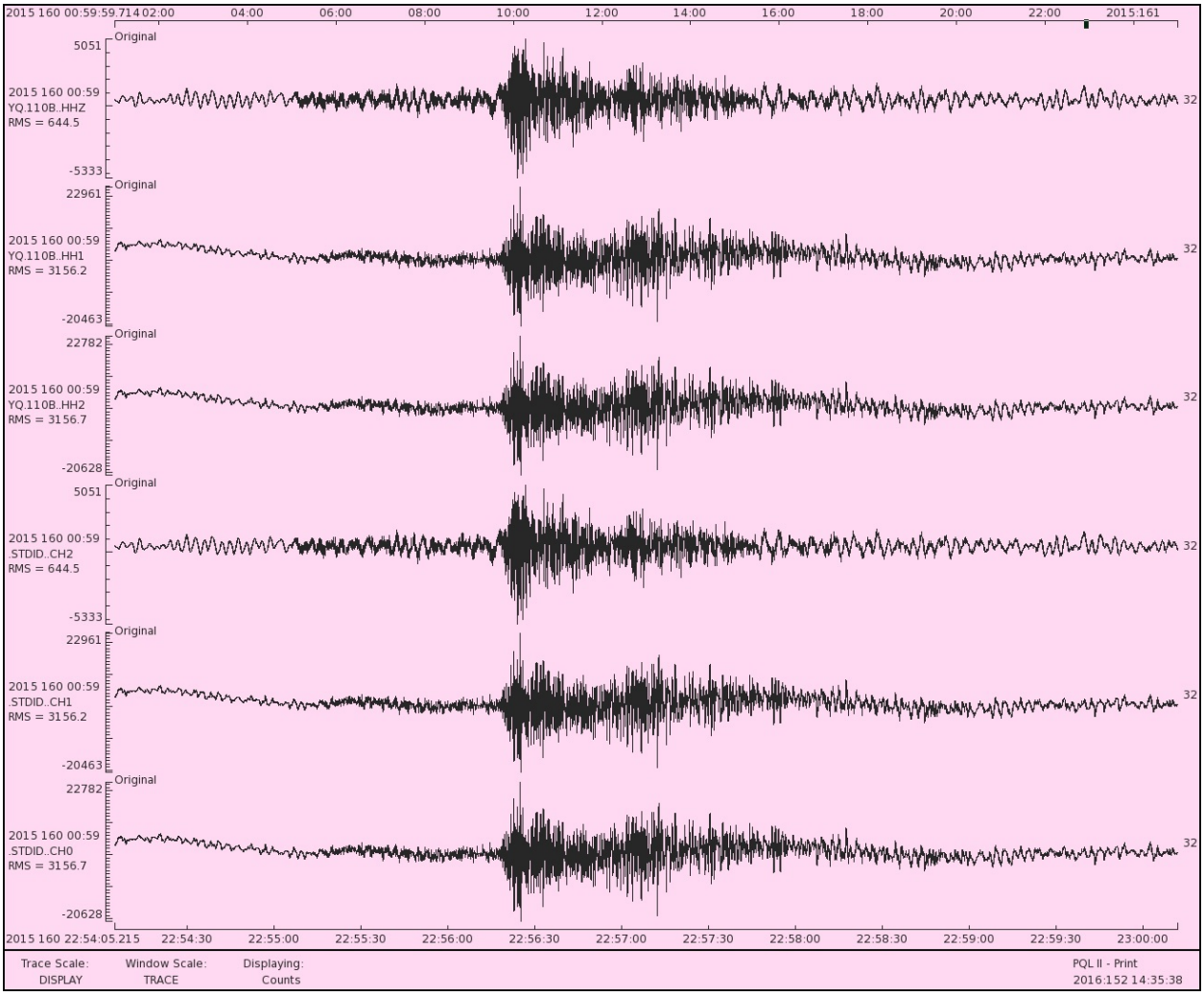
Deployment:
Time (GMT): 05:07:03
Latitude: 10 19.3467
Longitude: 34 23.7575
Water Depth (m): 485
Acoustics Disabled: ☑
~~Ranging Survey~~: ☐
Filename:

Recovery:
Time (GMT): 2015:298:12:03:59.145845
OBS TimeTag: 2015:298:12:04:57.145960
OBS Drift: -0.854954
OBS Time OK: ☐ TFOM: 4
(From Terminal)
Filename: 110B.OBS
+1 SEC = 0.145846

Last Modified: Wed Aug 20 2008

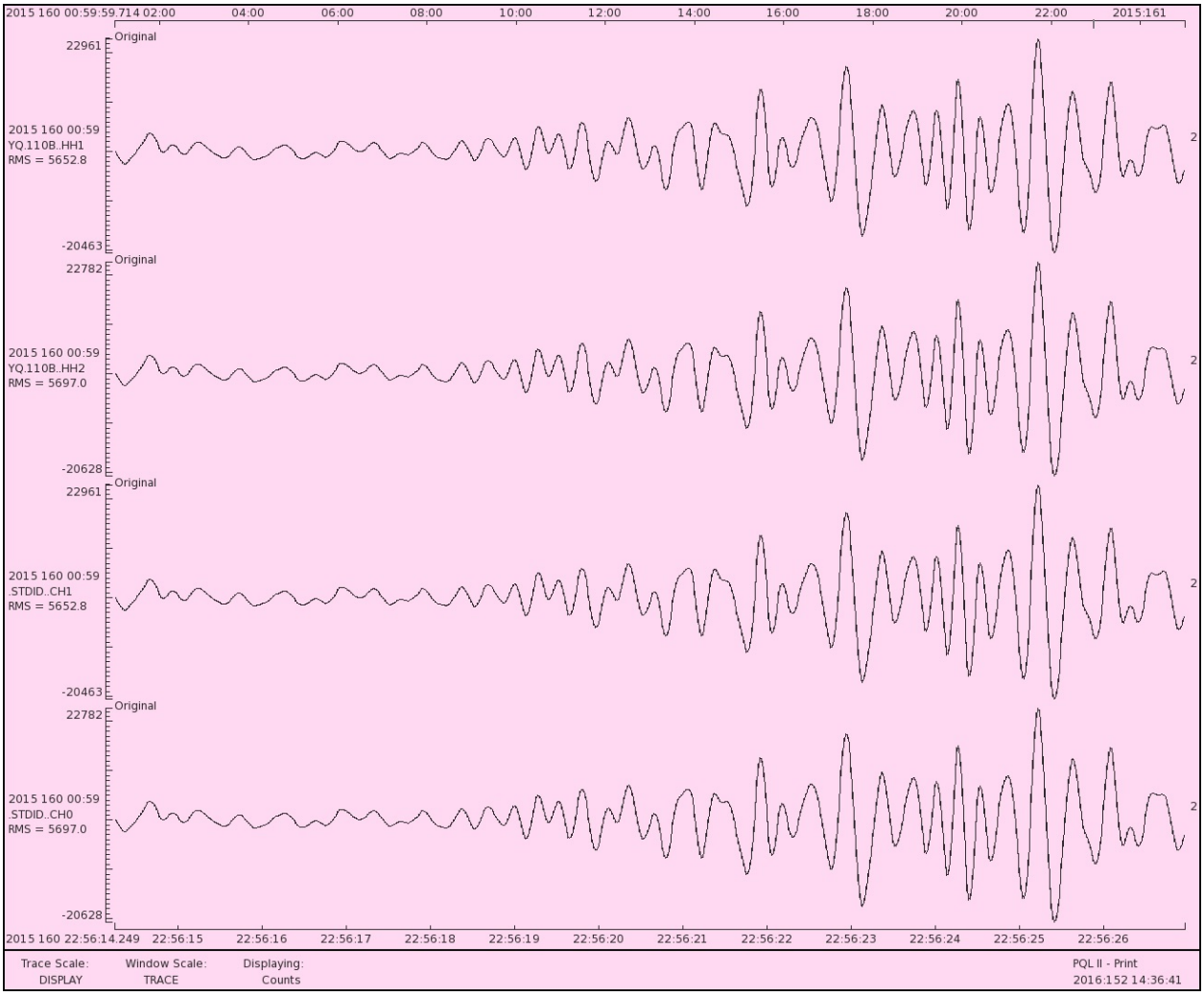
Possible places within the entire OBS data collection system causing "repeating" horizontal data include:
1) data processing/upload
2) logger 114 electronic errors
3) LP frame 14 cable/connector malfunction
4) sensor ball 48 cabling / Trillium-240 s/n 145 malfunction

1) Data processing/upload tests:
To reconfirm that both the field and SIO data archive versions of the data exhibited "duplicate" data on horizontals a few example record sections were viewed. A small local event on 2015, day 160 was used as a comparison:



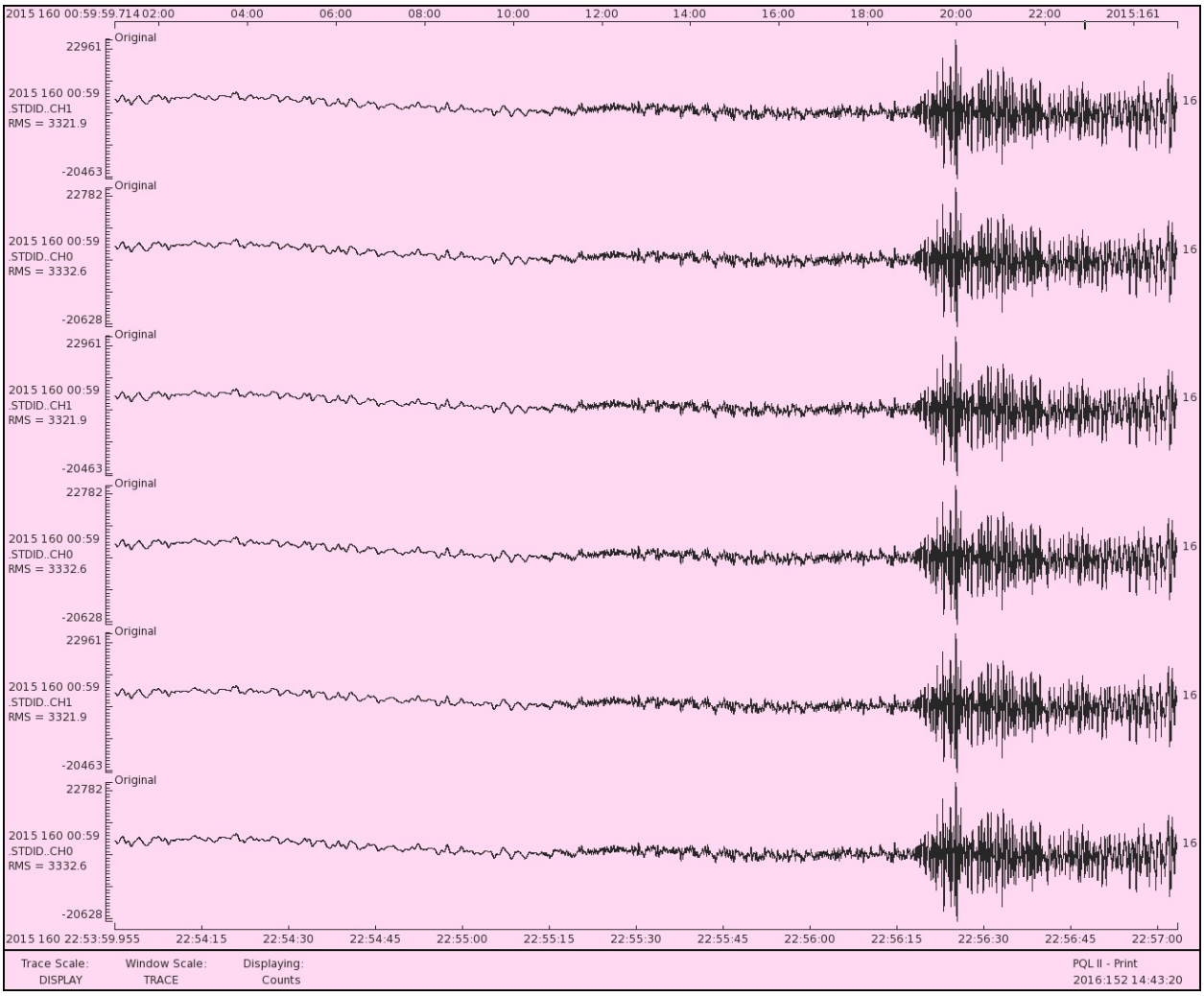
Malawi-site110B-2015-160-reprocess-comp.jpg: The bottom three traces CH0, CH1, and CH2 correspond to the X, Y, and Z components of the Trillium-240 seismometer (right-handed data). The top three traces in the above plot are the SIO archive version of "fixed" data (HH2, HH1, and HHZ) and are the identical mapping of these channels to a left-handed coordinate system. This data is subsequently uploaded to the DMC.

A closer inspection of horizontal data for these data show what appear to be “duplicate” data in the horizontal channels, and confirm that all SIO archived data have the same characteristics as data in the DMC archive.



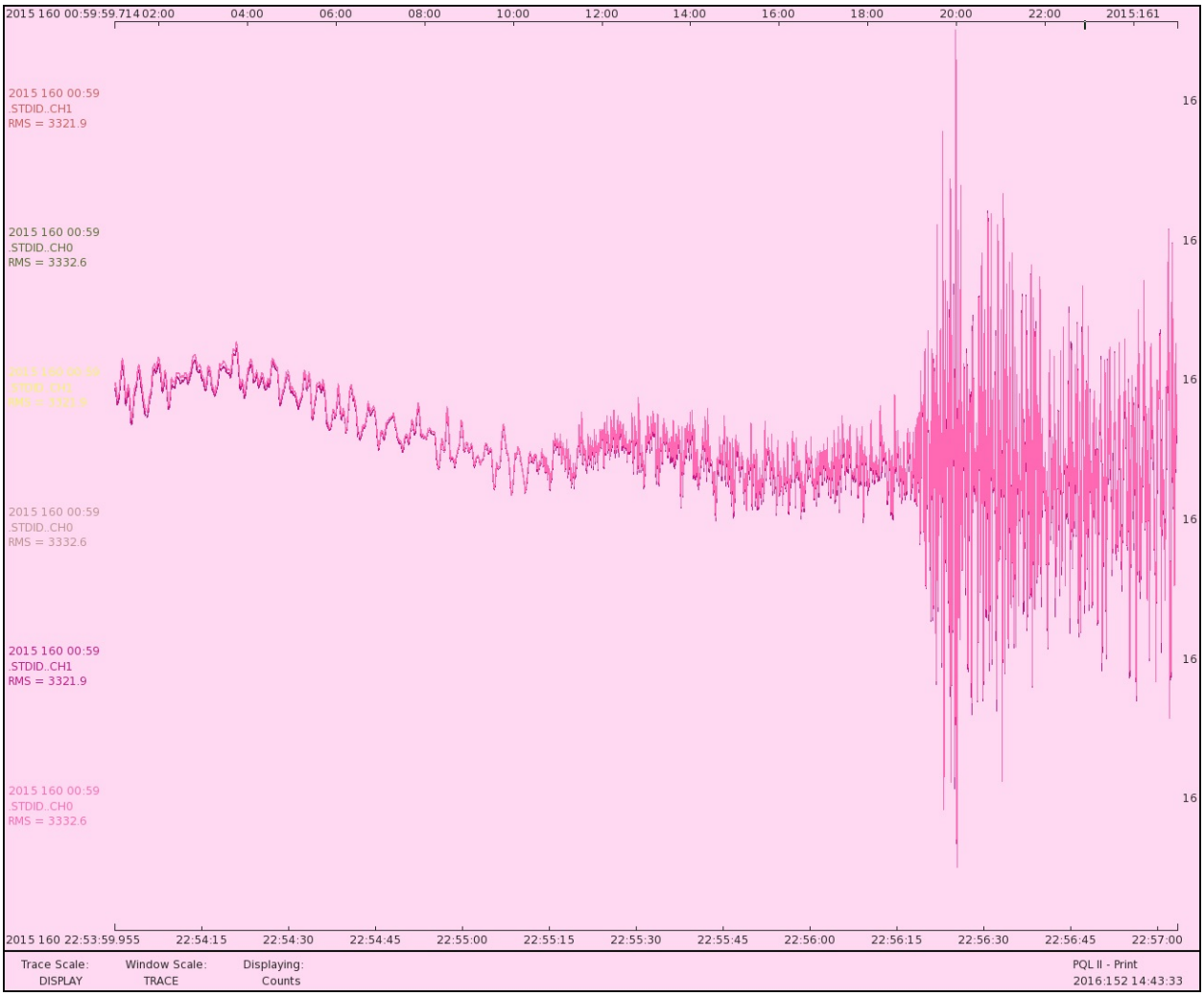
Malawi-site110B-2015-160-reprocess-comp2.jpg

An initial though was that the reprocessing routine used to convert data from a RAW format output from the data logger to mSEED format may have introduced redundant horizontal data. Data for site 110B was reprocessed from the RAW data collected on the field archive drive to mSEED, which yielded the same duplicate horizontal data. Data was also reprocessed form the original CF card through to mSEED format and also showed no change in duplicate data observations (see plots below).



Malawi-site110B-2015-160-reprocess-comp.jpg:

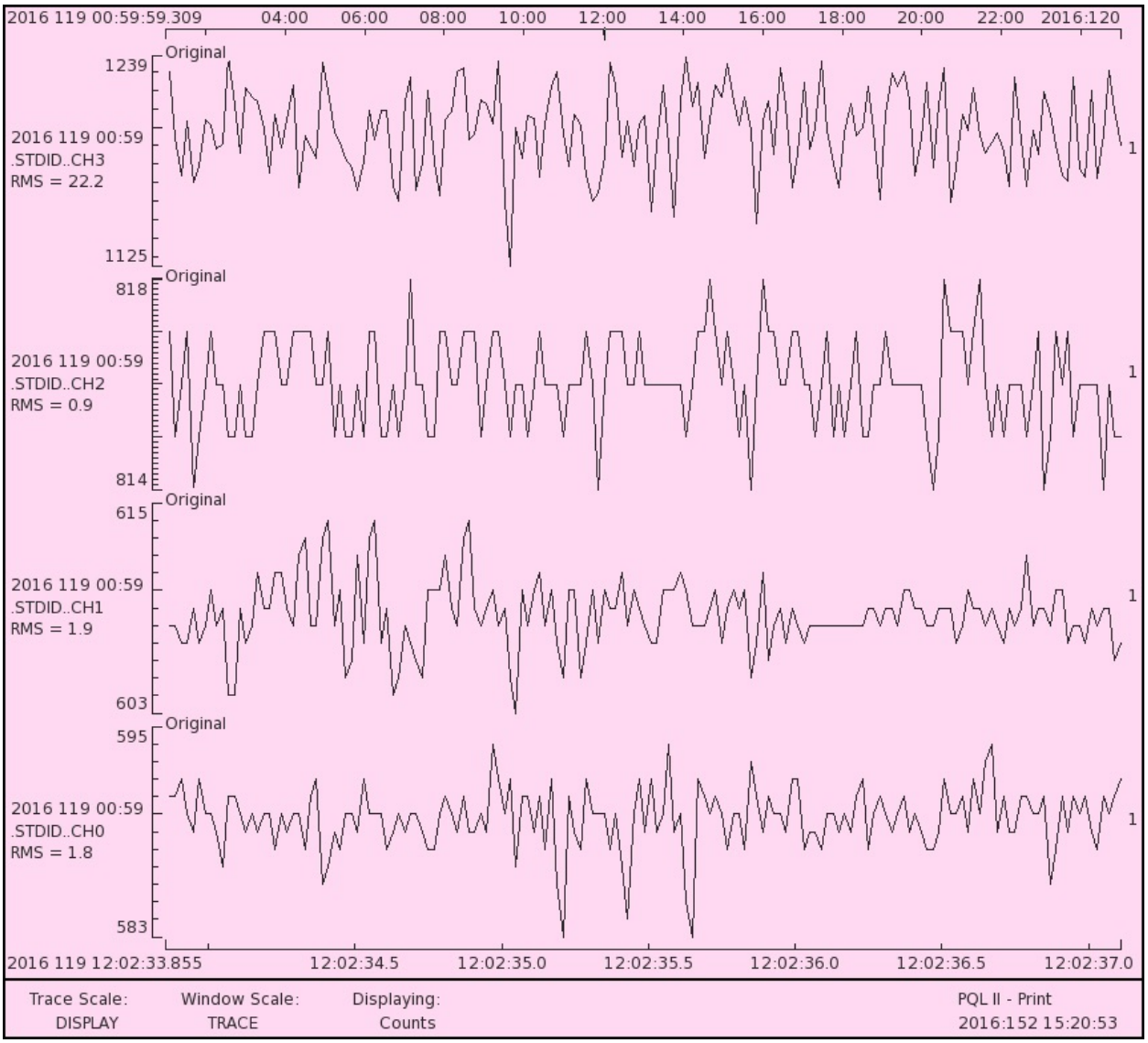
Bottom two traces → original field data
Middle two traces → reprocessed form RAW field archive
Tope two traces → reprocessed from original CF card



Malawi-site110B-2015-160-reprocess-comp2.jpg: Same data as shown in previous plot with all six traces in overlay mode.

These efforts confirmed that the root of duplicate data could not be traced to data processing or upload efforts.

2) Datalogger 114 testing and analysis:
Next, focus turned to datalogger testing and analysis. The question here is whether SIO datalogger 114 (used for Malawi site 110B) produced repetitive data from any the A/D output streams. Logger 114 was set up in a data taking mode in the lab (with an open input) and logged data for ~3-days (see figure below). After inspection of the data it was concluded that datalogger 114 was performing to specification.



LP114-benchtest-data.jpg: All four A/D channels for datalogger 114 showed unique data output.

3) LP Frame 14 data cable/connector tests:
Next the cables/connector from Frame 14 (used for Malawi site 110B) were tested for any possible malfunction.

From Ernie Aaron:

Begin forwarded message:
From: "Aaron, Ernest" <eaaron@ucsd.edu>
Subject: RE: obs data
Date: April 7, 2016 at 4:20:23 PM PDT
To: "Babcock, Jeffrey" <jbabcock@ucsd.edu>

Sounds good. I found the LP frame in the basement today that carried logger LP114 (site 110B). It had the trillium cable still zipped to it, so I pulled it off to inspect. I couldn't find anything wrong with it. I thought that maybe a pin got bent over and shorted to a neighboring pin, but that wasn't the case.

From Sean McPeak:

Begin forwarded message:
From: Sean McPeak <smcpeak@ucsd.edu>
Subject: LP cable (from duplicate channel system) meg ohm meter test results
Date: May 18, 2016 at 12:44:33 PM PDT
To: Jeff Babcock <jbabcock@ucsd.edu>, "Ernest L. Aaron" <eaaron@ucsd.edu>, MARK GIBAUD <mgibaud@ucsd.edu>
Cc: martin rapa <mrapa@ucsd.edu>

Hi guys,

Martin and I tested the LP sensor cable with the meg ohm meter today. This is the cable that Ernie gave me from the system that recorded duplicate signals on 2 of the channels. The cables insulation rating is 600V. I used a Fluke 1520 meg ohm meter borrowed from Lloyd's group. I set the meter to the 500V output voltage level and tested each pin on both sides of the connector to all the other pins. The meg ohm meter generated 544V and measured > 2000 Megohms for each pair of pins tested. During the testing we made sure to flex either end of the cable near the molding. The output of the meg ohm meter was solid and did not indicate any shorts. So I don't think the cable is the source of the duplicate channels.

-Sean

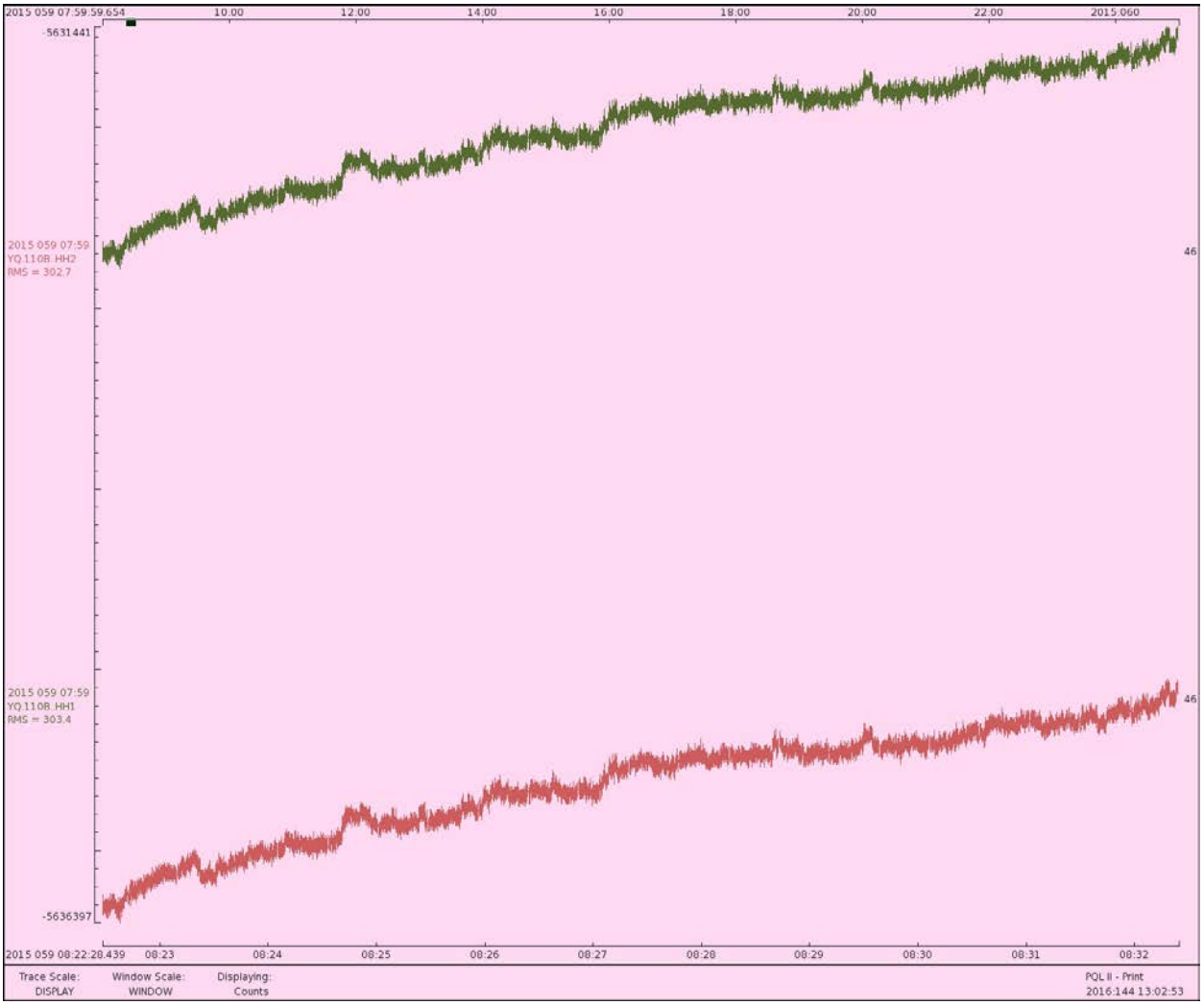
Based on these tests the cables/connectors from LP Frame 14 were deemed not to be the cause of the duplicated data generated.

4) Detailed data analysis and assessment:
A more thorough analysis of data from site 110B was then undertaken. Instrument 110B was deployed @ 2015:059:07:03 (see deployment checksheet above). The sensor ball run plug is one of the last steps done on deck before deployment, suggesting it was inserted near 2015:059:06:45. The first level check and re-leveling event occurs ~2-hours from run plug insertion. During the duration of the deployment the duty cycle for gimbal/mass level checking (and re-centering if necessary) is 7-days from sensor ball run plug insertion.

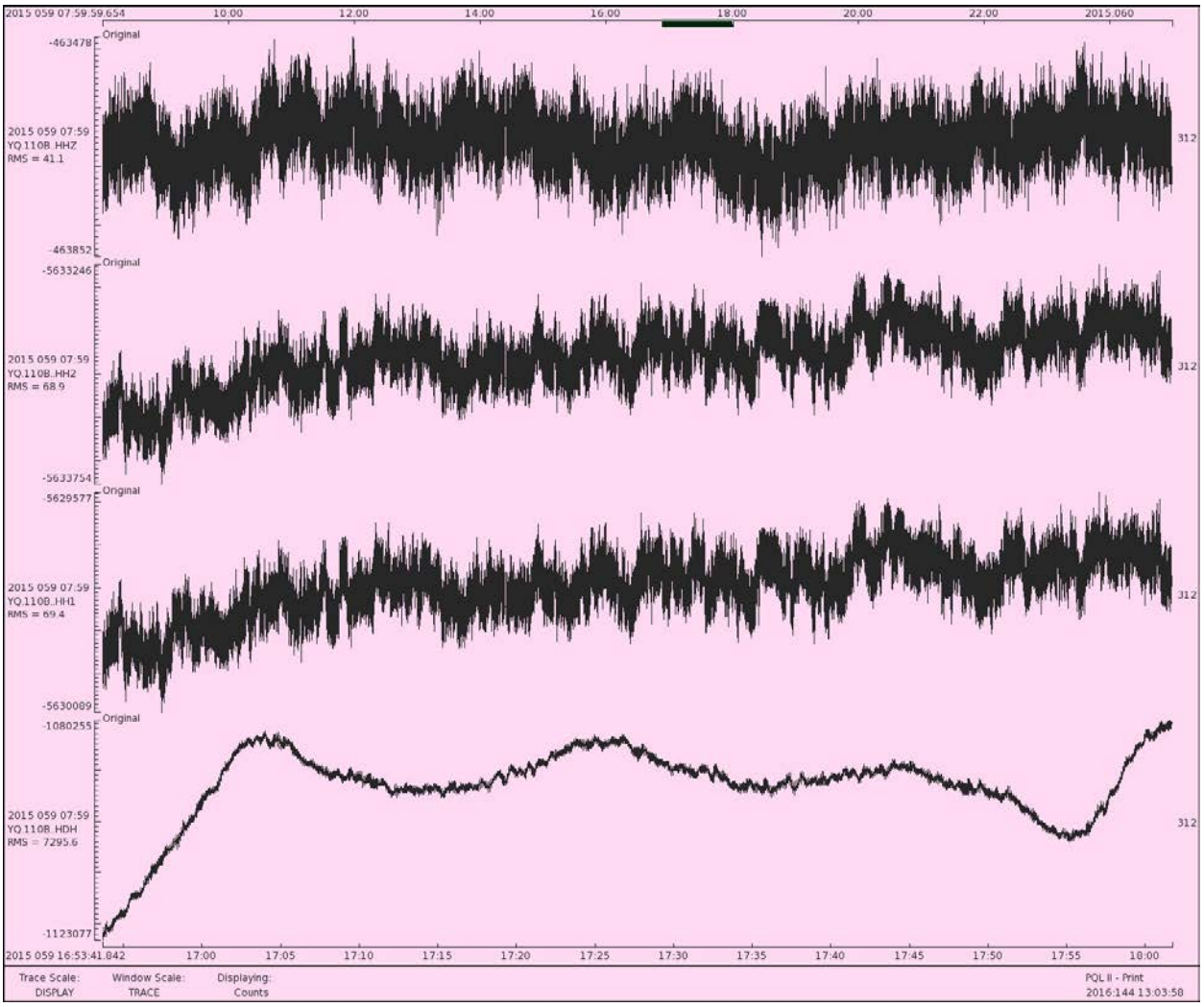
First observation was the initial sensor-ball leveling event with the OBS unit on the lake bottom:

Malawi-site110B-2015-059-horiz-comp2.jpg: First re-level event @ ~2015:059:08:21, which occurred ~2-hours after deployment.

After the initial gimbal/seismometer leveling event the two horizontal channels show nearly identical output characteristics (with an observed DC offset of ~3500 counts).



Malawi-site110B-2015-059-horiz-comp3.jpg: Horizontal channels in overlay mode, ~5-minutes after initial leveling sequence.

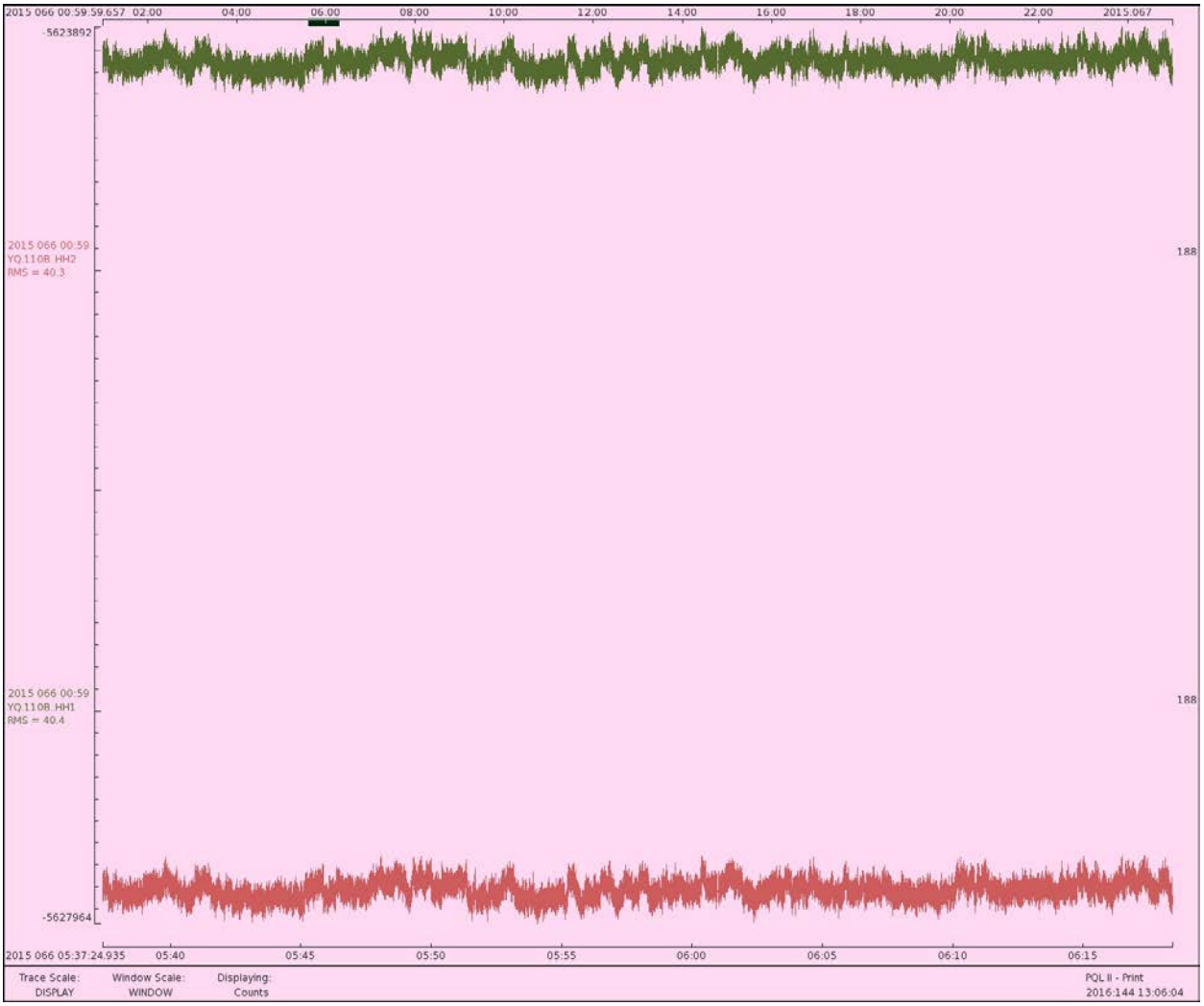


Malawi-site110B-2015-059-all-comp.jpg: Site 110B near day 59 hour 17. Horizontal channels show a similar waveform.

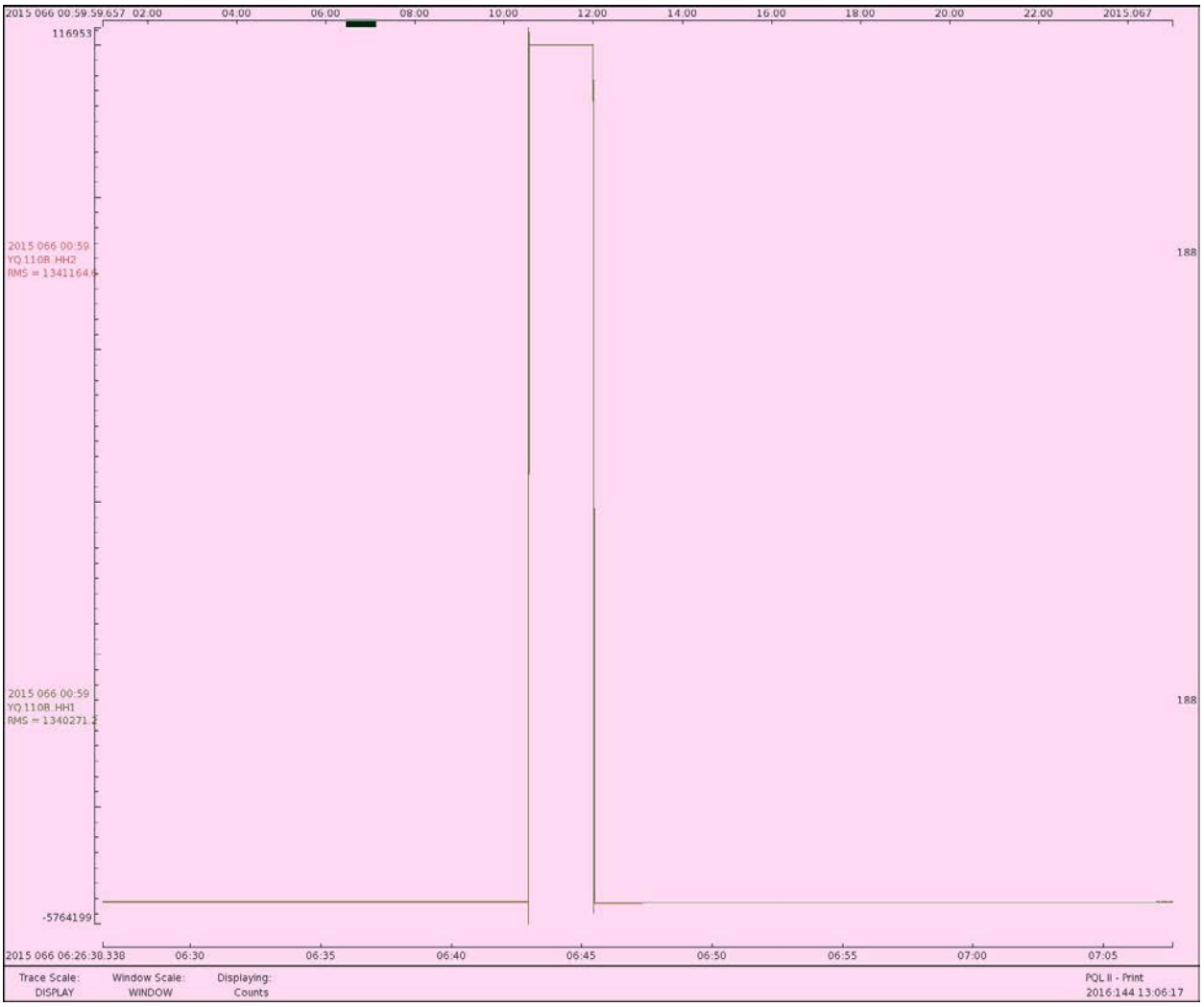
After a sensor ball startup time of ~2015:059:06:45 the next re-level check occurs after ~1-week on day 066. The leveler board logfile shows a gimbal recenter event occurred at this 1-week juncture, near 2015:066:06:43.

```
@D1,   10,     605645,  1983,  1851, 14.115 (3560), Relevel Required
@D2,                0,     0,     0,     0,     0,     0
@D1,   11,     605891,  1958,  1958, 14.249 (3594), Gimbal Recenter Occurred
@D2,              464,   465,  -523,  3010,  -148,  -1584
@D1,   12,     605897,  1958,  1955, 14.253 (3595), No Relevel Required
@D2,              506,   504,  -557,  3010,  -148,  -1584
```

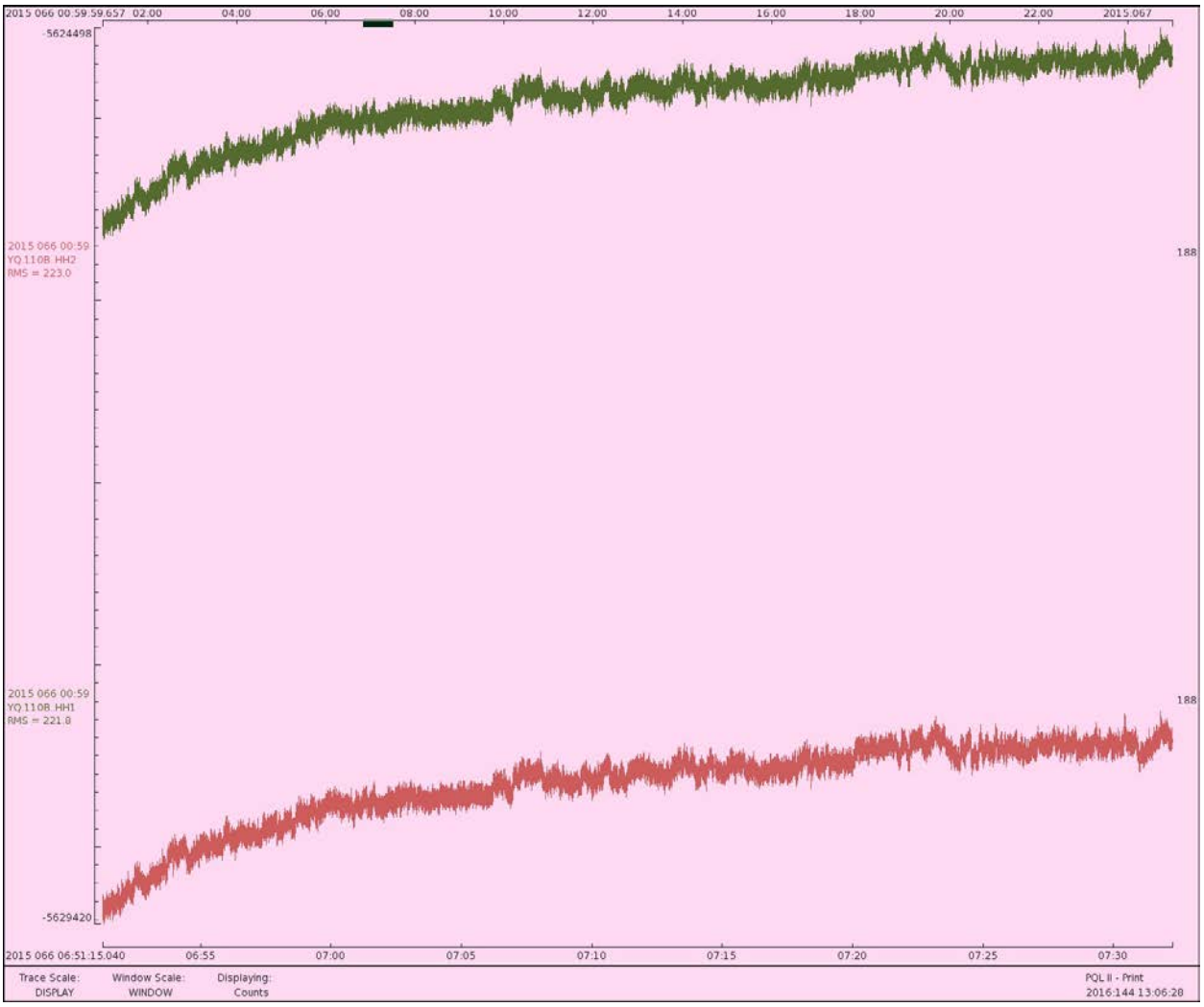
Checking data near this event to see if character of horizontal signal changes around this event shows no observed change in "duplicating" horizontal channel data output:



Malawi-site110B-2015-066-horiz-comp1.jpg: Horizontal channel data stream before gimbal recenter event shows the previously observed "identical" output (with DC offset).



Malawi-site110B-2015-066-horiz-comp2.jpg: Gimbal recenter event near 2015:066:06:43.

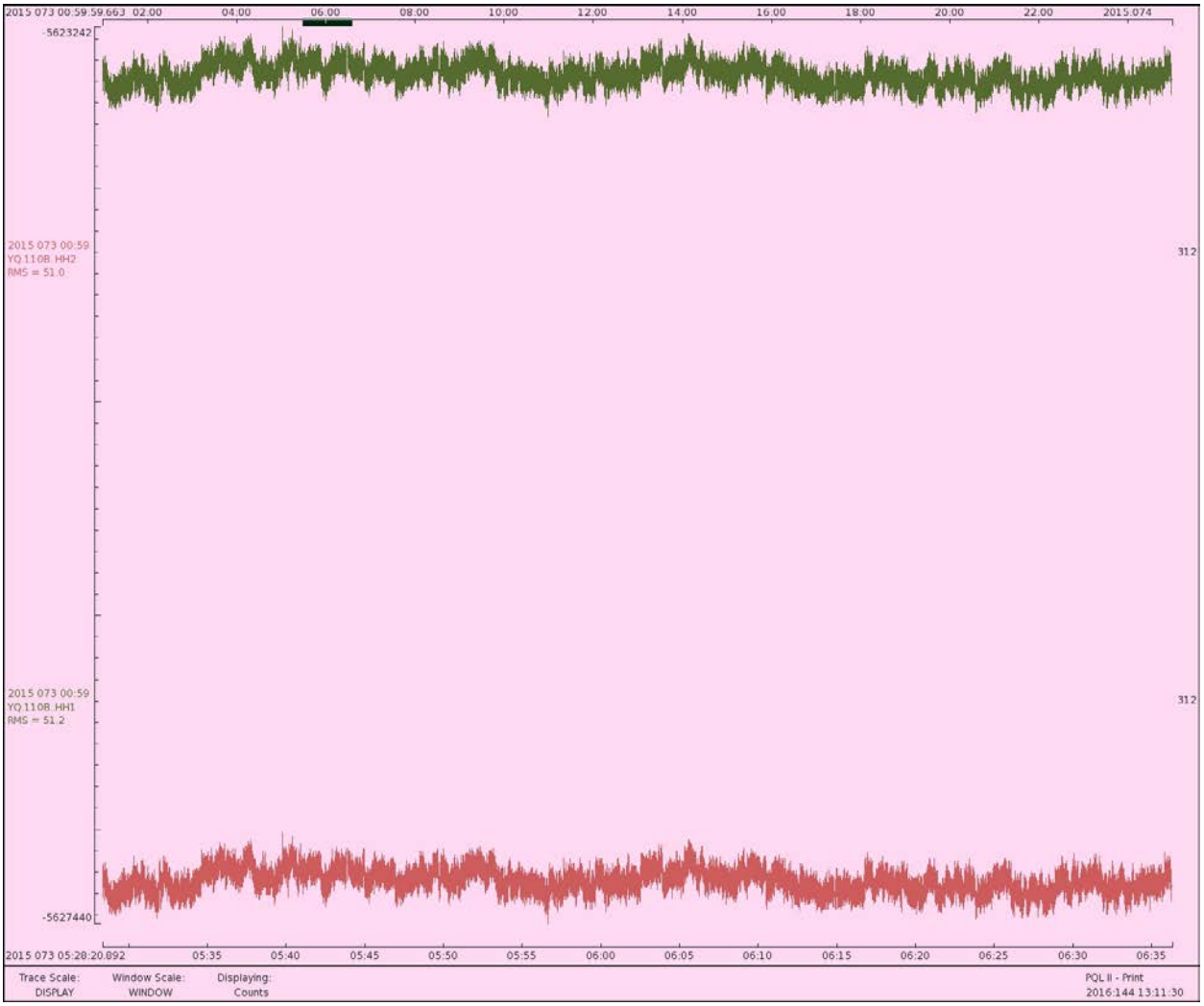


Malawi-site110B-2015-066-horiz-comp3.jpg: Horizontal channel data stream after gimbal recenter event shows the previously observed "identical" output (with ~3500 count DC offset).

The next gimbal/mass check in the sensor ball should occur one-week later on day 073. The leveler board logfile shows a trillium mass recenter event occurred at this 1-week juncture, near 2015:073:06:48.

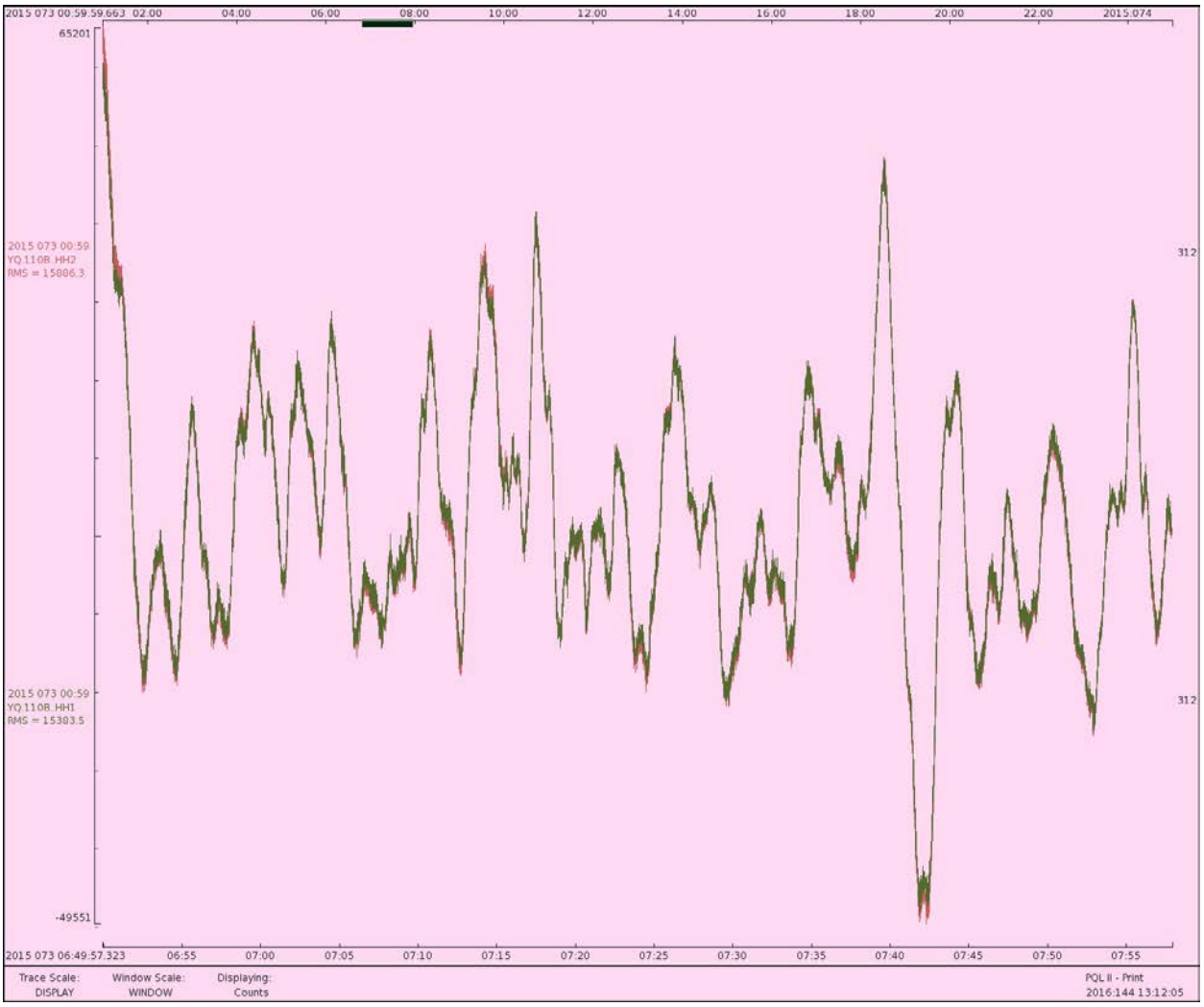
@D1, 13, 1210720, 1958, 1951, 13.302 (3355), Relevel Required
@D2, 1708, 1716, -1934, 3010, -148, -1584
@D1, 14, 1210868, 1959, 1954, 13.540 (3415), Trillium Recenter Occurred
@D2, -11, -11, -12, 792, -873, 609
@D1, 15, 1815691, 1954, 1955, 13.635 (3439), No Relevel Required
@D2, 420, -670, -83, 792, -873, 609

Checking data stream before and after the mass recenter event does not show any change in the "duplicating" character of horizontal data streams.



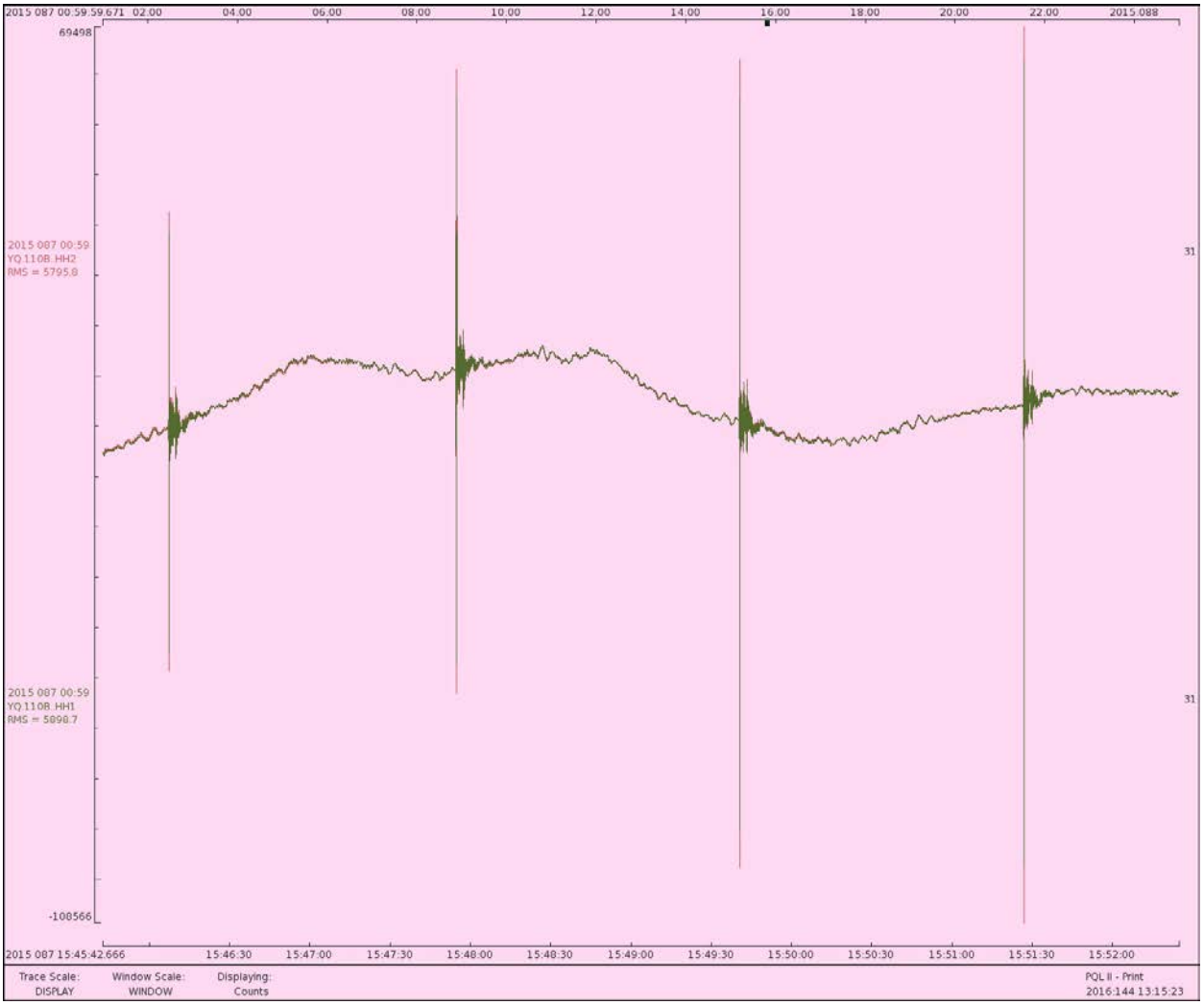
Malawi-site110B-2015-073-horiz-comp1.jpg: Horizontal channel data stream before trillium mass recenter event shows the previously observed "identical" output (with DC offset).

Malawi-site110B-2015-073-horiz-comp2.jpg: Gimbal recenter event near 2015:073:06:48.



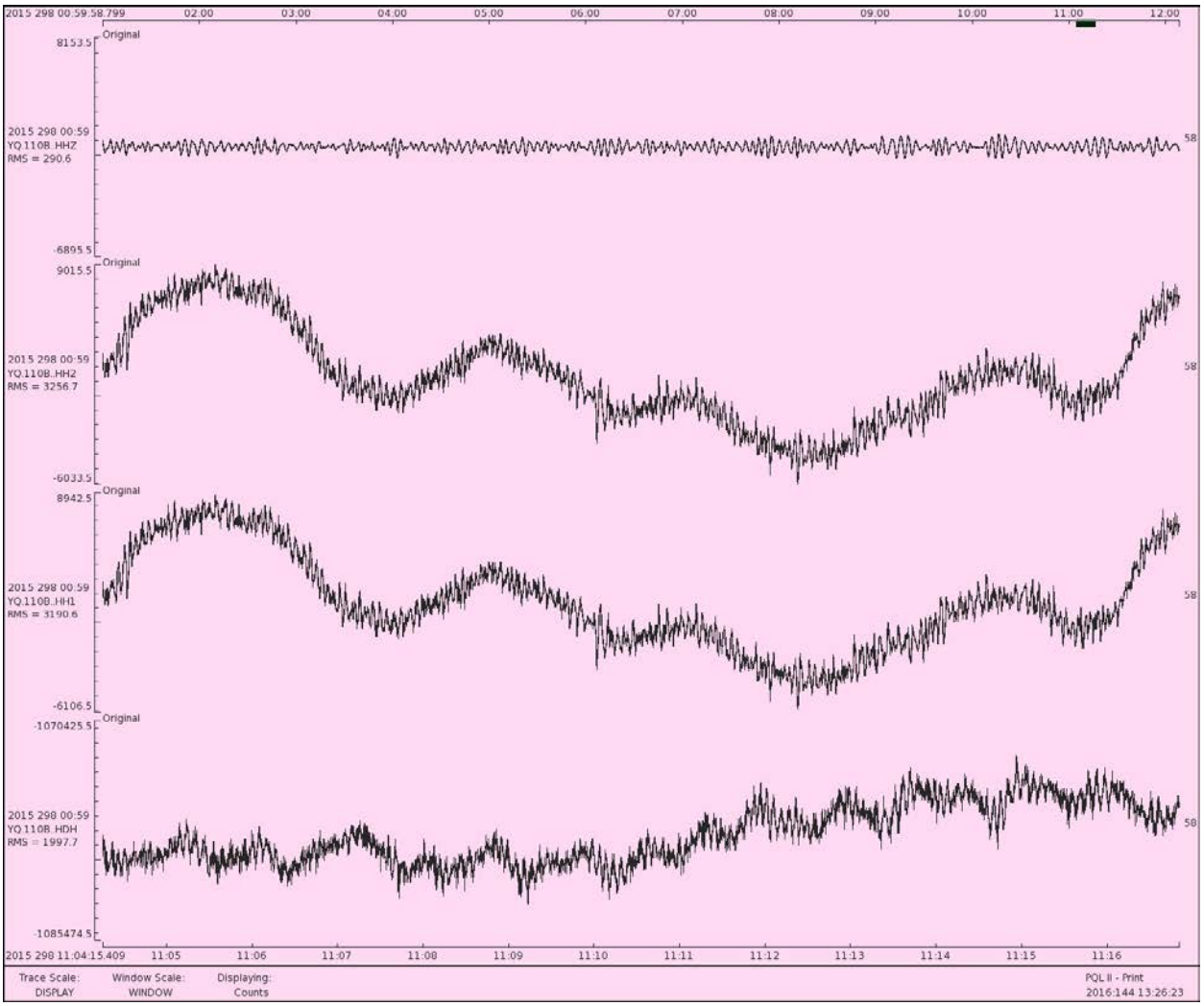
Malawi-site110B-2015-073-horiz-comp3.jpg: Horizontal channel data stream after trillium mass recenter event shows the previously observed "identical" output (with slight DC offset).

Checking horizontal channel out during shooting phase of experiment again shows “duplicate” output:

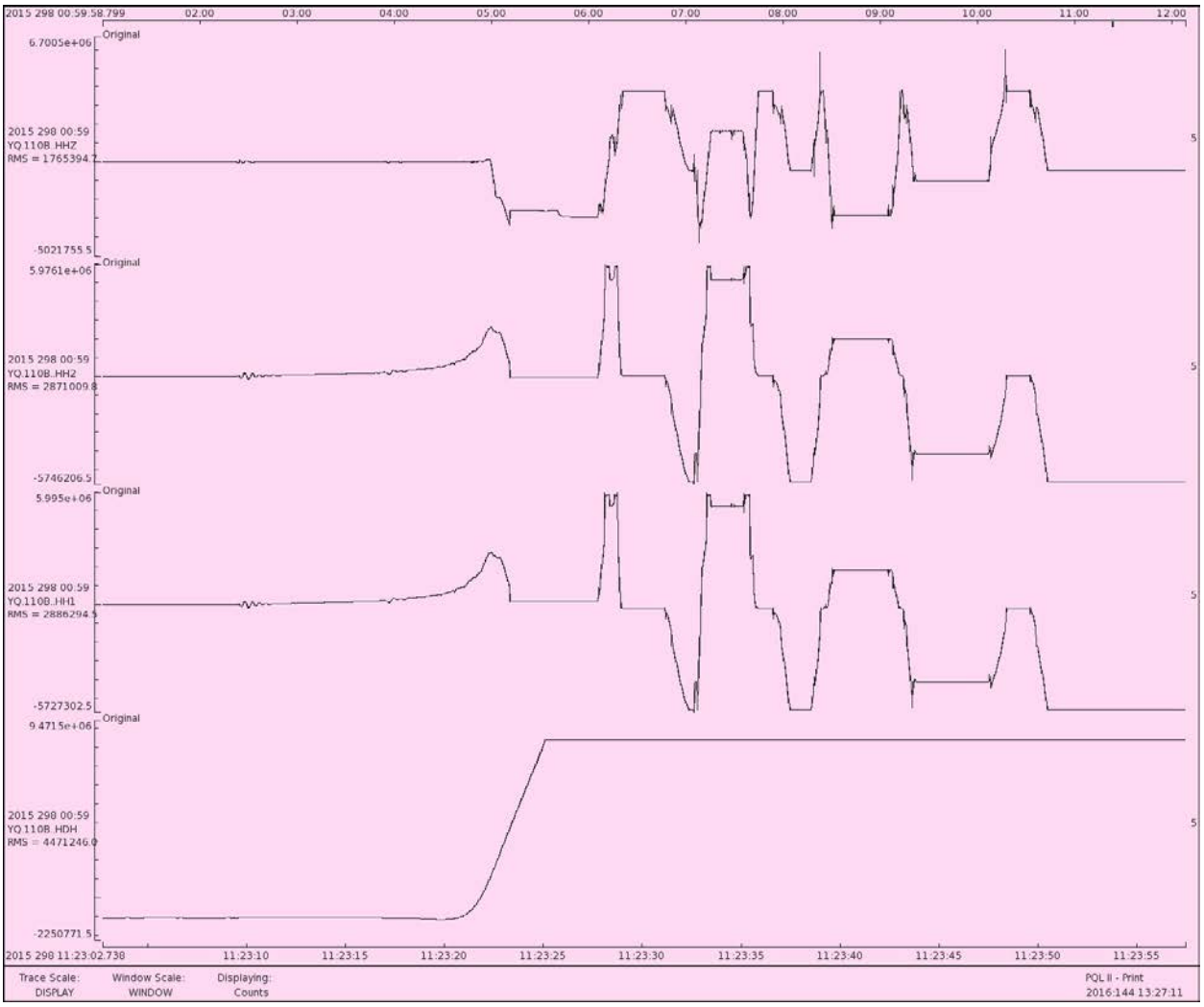


Malawi-site110B-2015-087-horiz-comp.jpg: Airgun shots recorded on horizontal channels near 2015:087:15:45.

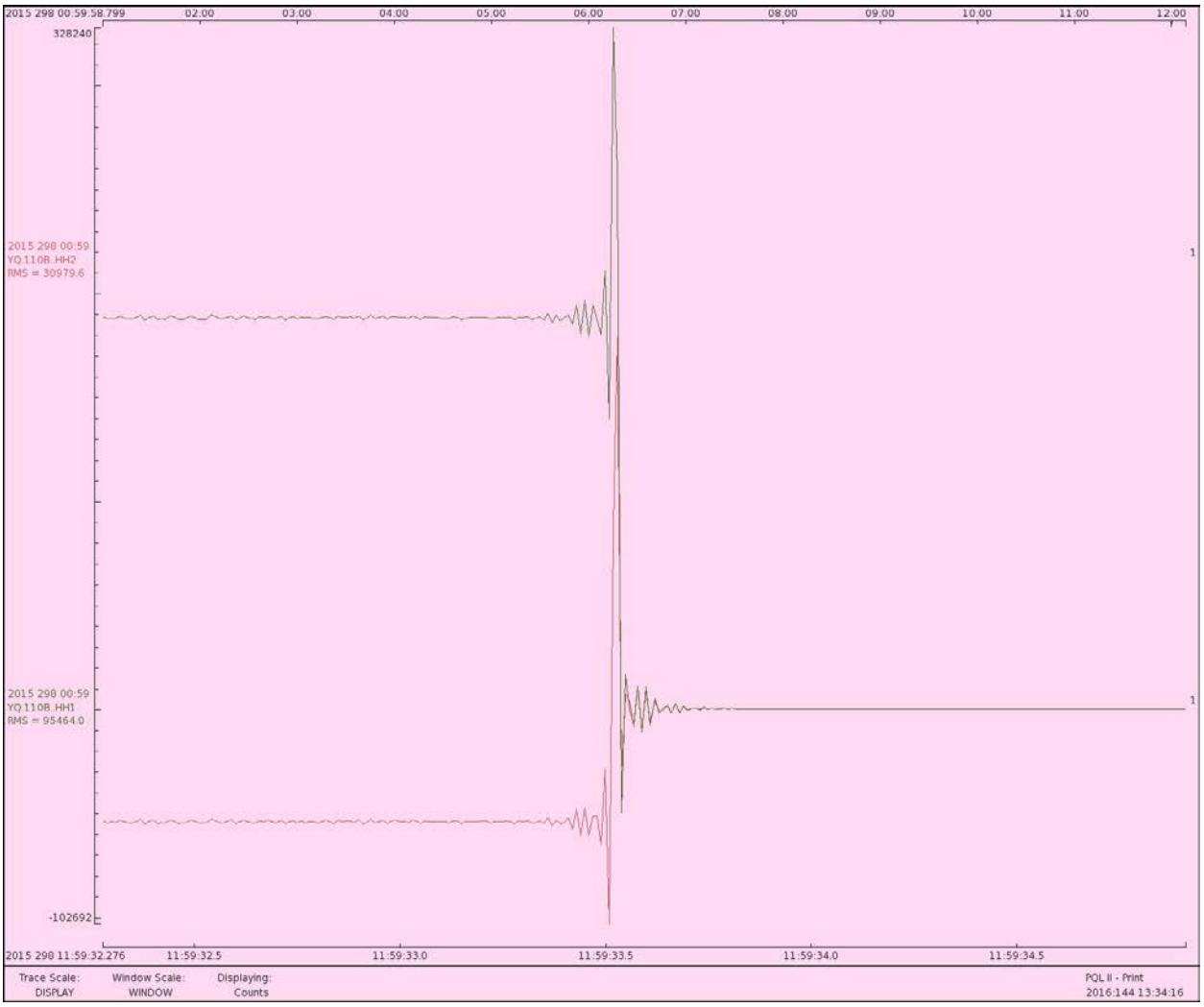
From the deployment checksheet (above), post-recovery time-check comparisons to GMT for instrument 110B occurred near 2015:298:12:03:59. A time check for oscillator drift is the first step in the post-recovery instrument check, and typically occurs with ~10-15 minutes after the instrument is brought onboard. This suggests that recovery on deck occurred near 2015:298:11:50. After the instrument is brought onboard the seismometer power/data cable is unplugged from the datalogger pressure case, before the instrument is brought into the ship's lab for post-recovery checkout. If the source of "duplicate" recording on horizontal channels lies within the sensor ball or data cable, it would suggest that a check of the data stream after the sensor ball power/data cable was removed might reveal a different character in the recoded data. Once this cable is removed the datalogger is essentially recording "open-ended" signal until the instrument is powered down in the lab.



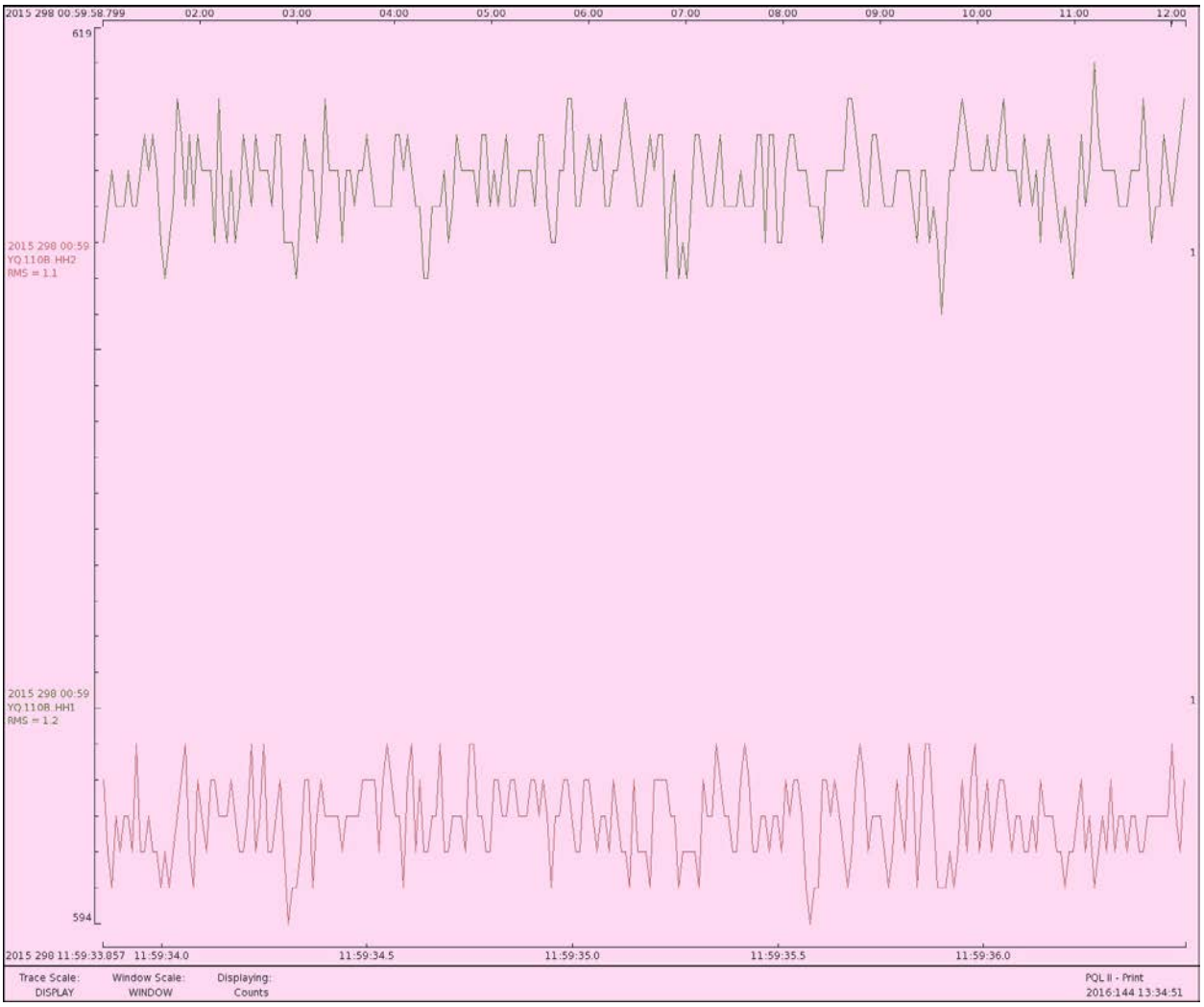
Malawi-site110B-2015-298-all-comp.jpg: Sample data for site 110B near 2015:298:11:05, prior to recovery from the seafloor. The "mirrored" signal in the horizontal channels HH1 and HH2 is still present.



Malawi-site110B-2015-298-horiz-comp.jpg: Polymorph burn cycle completion and lift-off form the lake floor appear to occur near 2015:298:11:23:20.



Malawi-site110B-2015-298-horiz-comp2.jpg: With OBS site 110B securely on deck, the sensor ball power/data cable is unplugged near 2015:298:11:59:33.

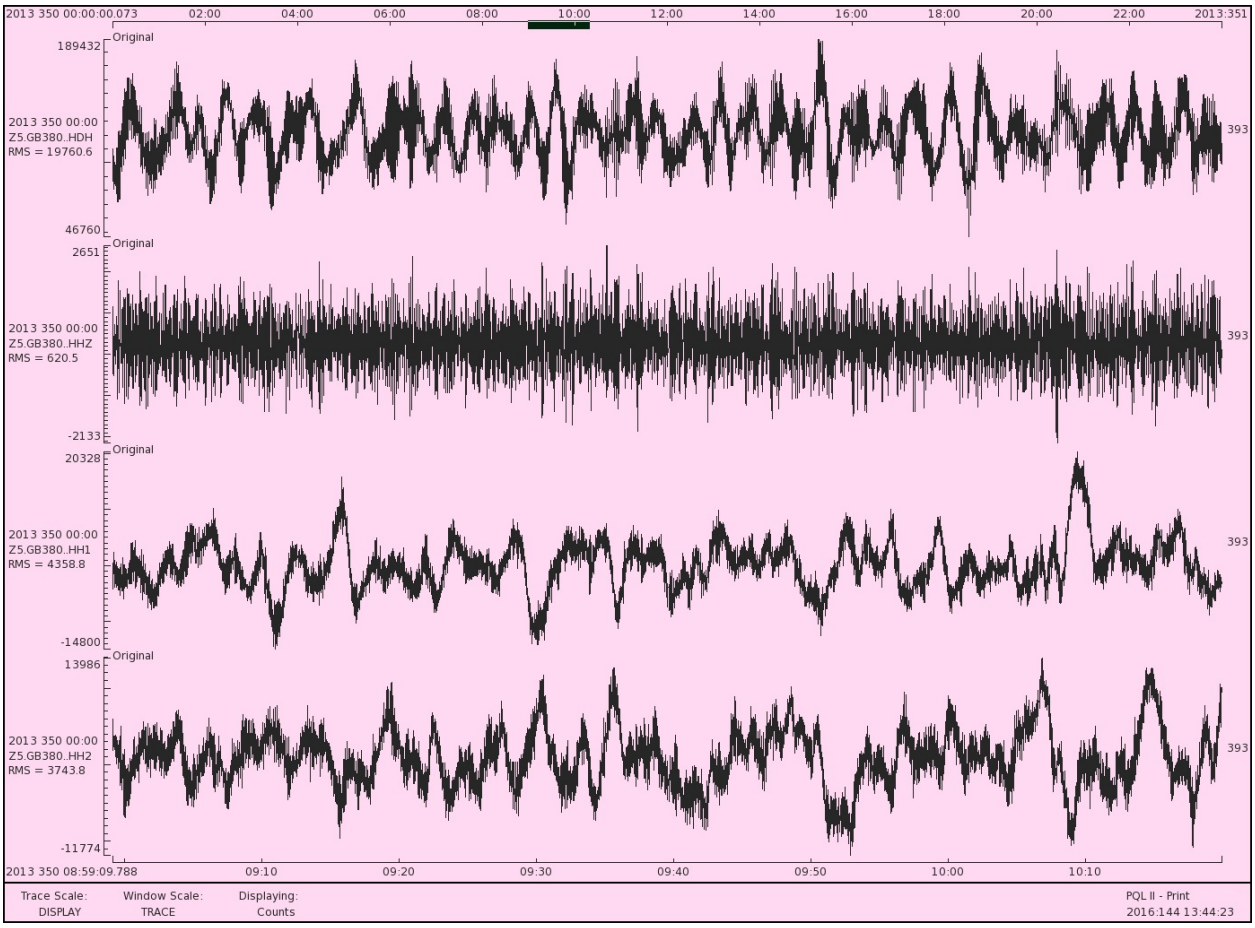


Malawi-site110B-2015-298-horiz-comp3.jpg: Data streams for horizontal channels near 2015:298:11:59, "after" sensor ball power/data cable is unplugged, shows "unique" data streams. At this point the data logger is recording open-ended signal. This suggests that data logger 114 is functioning properly and also implies that the source of the "duplicating" horizontal channel data is coming from sensor ball 48.

Malawi-site110B-2015-298-horiz-comp4.jpg: Open-ended data recorded near 2015:298:12:07 confirms that data streams for horizontal channels "after" sensor ball power/data cable is unplugged shows "unique" data streams.

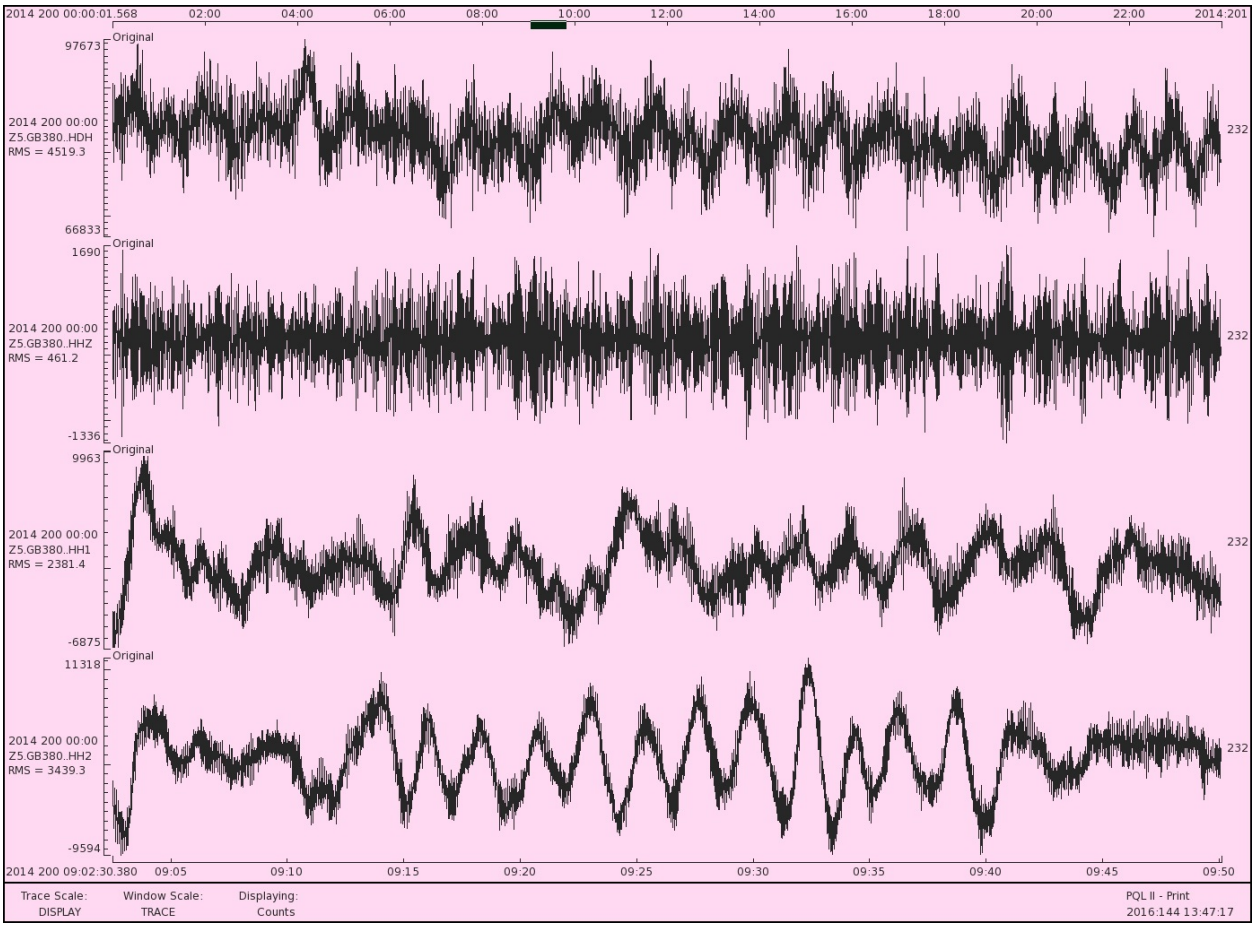
At this point the data logger is recording open-ended signal. This suggests that data logger 114 is functioning properly and suggests that the source of the "duplicating" horizontal channel data is coming from sensor ball 48 (Trillium-240 s/n 145).

Observations form previous deployments:
To investigate if this "repeating" horizontal data issue existed prior to Malawi deployments we traced the previous usage from experiment deployment sheets and info. Sensor ball 48 was used at site GB380 on the 2013-2014 Nabelek-Gorda experiment. Data examples follow:

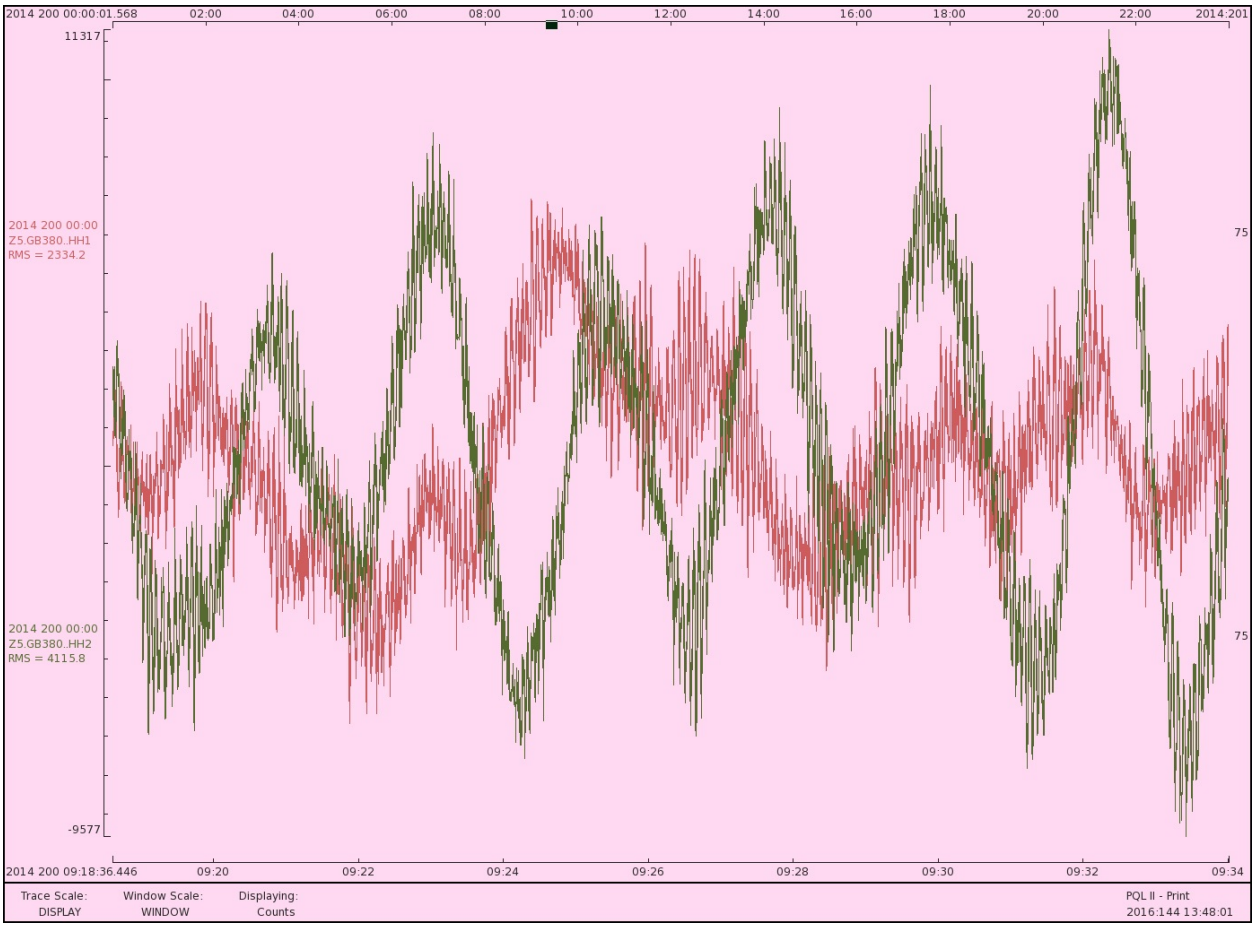


Z5-2013-2014-GB380-SBall48-example.jpg

Z5-GB380-2013-350-SB48-horiz-example.jpg



Z5-GB380-2014-200-SB48-example.jpg



Z5-GB380-2014-200-SB48-horiz-example.jpg

Observations from these select data segments during the Nabelek-Gorda deployment do not exhibit the same "repeating" behavior in horizontal channel data. All data from this previous deployment is "unique" and show no signs of any issues. This suggests that the problem with sensor ball 48 (Trillium-240 s/n 145) could be either new or episodic in nature. Lab testing and analysis of sensor ball 48 wiring and Trilium-240 seismometer s/n 145 will need to be done to isolate the potential source.

Unfortunately the issue was not discovered until after the redeployment of Sensor Ball 48 on another project. Sensor ball 48 was deployed on the Collier-Antilles project (site OBS2) on 2016:068:16:58 and will not be recovered until ~April/May 2017. Thus, no lab testing can be performed on sensor ball unit #48 or T-240 s/n 145 until that unit is recovered and brought back to SIO. Based on data observations from the previous Nabalek-Gorda deployment, it is not clear that the issue will persist in the current Collier-Antilles deployment. Nonetheless, no definite conclusion can be reached until after the OBS is returned to SIO in the summer of 2017.