Analysis of MQXFA11 accelerometer data during truck incident

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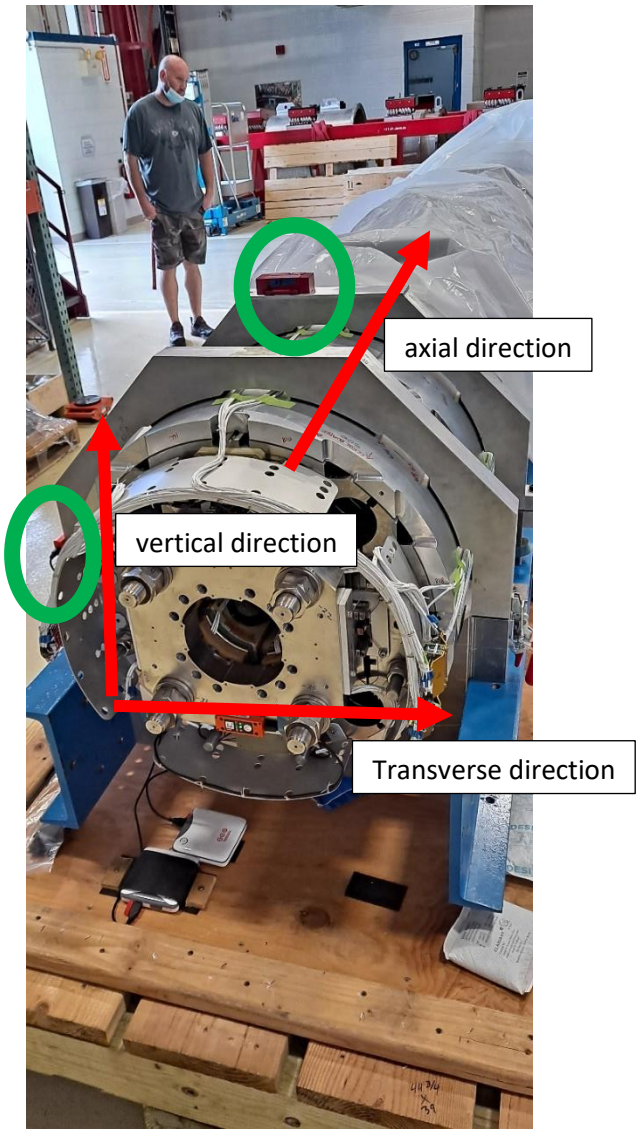
The truck transporting MQXFA11 from LBNL to BNL was involved in an accident on 7/20/22. It was rear ended by another truck. Both drivers are OK.

The truck was hit by another truck on the right back corner.

The truck with MQXFA11 was towed to a tow yard in Rockdale, IL (~50 min drive from Fermilab). Subsequently, it was put on another truck and moved to Fermilab. Fermilab employees added 3 accelerometers on the crate before it was moved on the new truck and attended all loading/unloading operations at the tow yard and at FNAL.



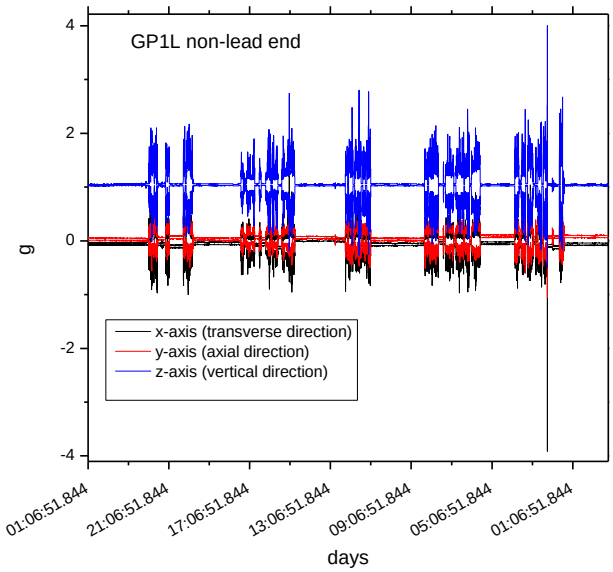
This is a picture of the Magnet after arriving at FNAL. GP1L devices were installed on top the fixture clamp. Slamstick devices were installed on the end plate/on top of the lead end and on the side of the non-lead end fixture clamps (green circle). The memory of the device on the end plate/lead end fixture clamp was full the day before the accident.

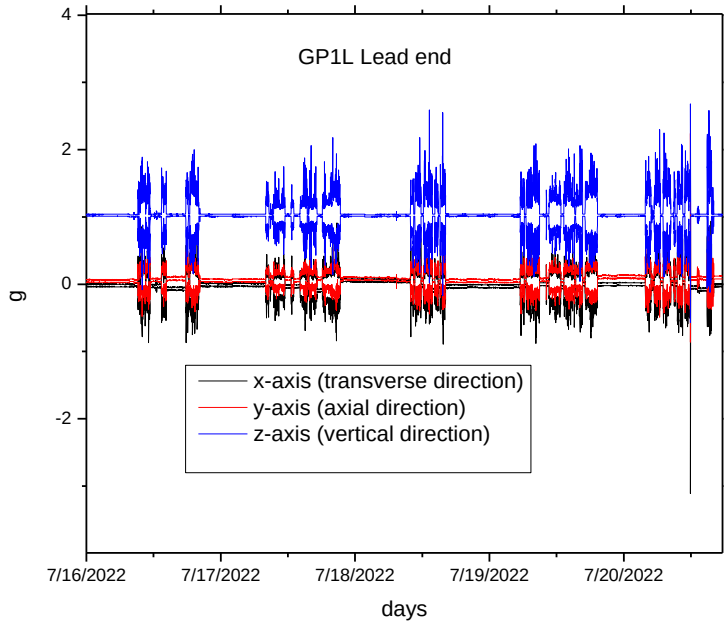
Three devices were collecting data during the accident. The two GP1L device and the one slamstick on the non-lead end. The axes of the accelerometers are oriented in a different way depending on the device position. Therefore, to avoid any confusion, the reader should refer to the directions defined in the picture above. Those directions are the same for the GP1L and the slamstick devices.

Results obtained with the GP1L devices installed on LE and NLE fixture clamps

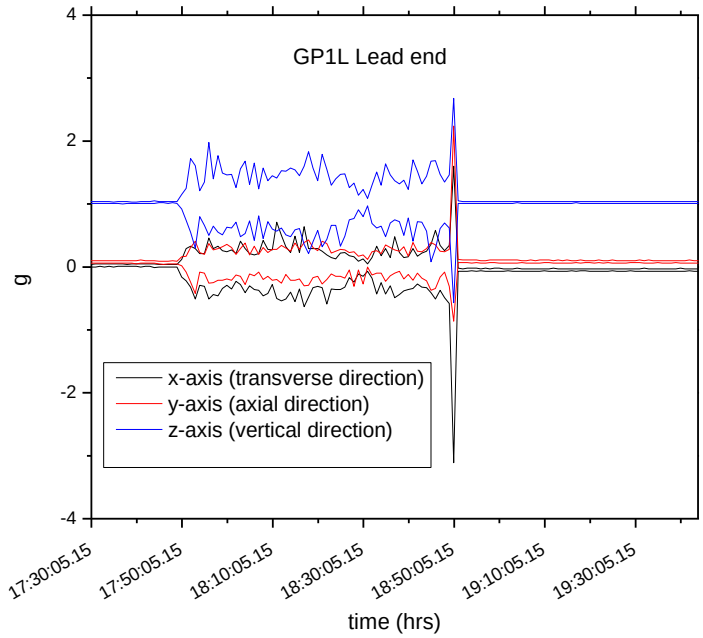
Sample rate 100 Hz, frequency response 50 Hz. Maximum measurable shock is 6.7 g

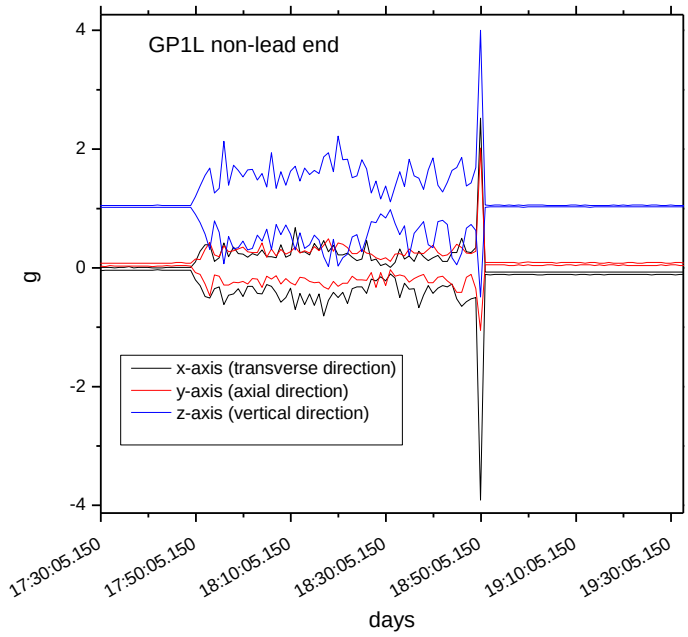
The two plots below are a snapshot of the entire trip up to the accident. The incident takes place on July 20th at 18:50 UTC. No saturation is observed over the entire trip. The highest shocks (a little bit over 4g) are observed in the vertical and transverse direction in the non-lead end device. No vertical high shock is observed on the lead and device.



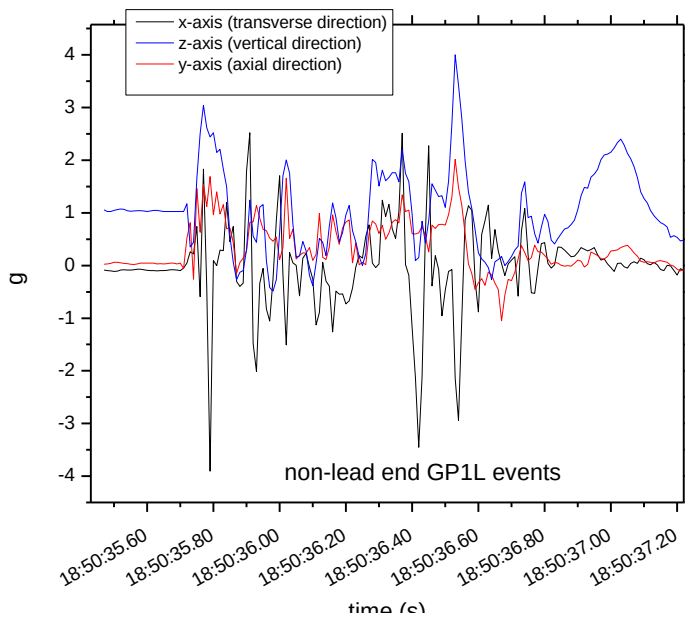


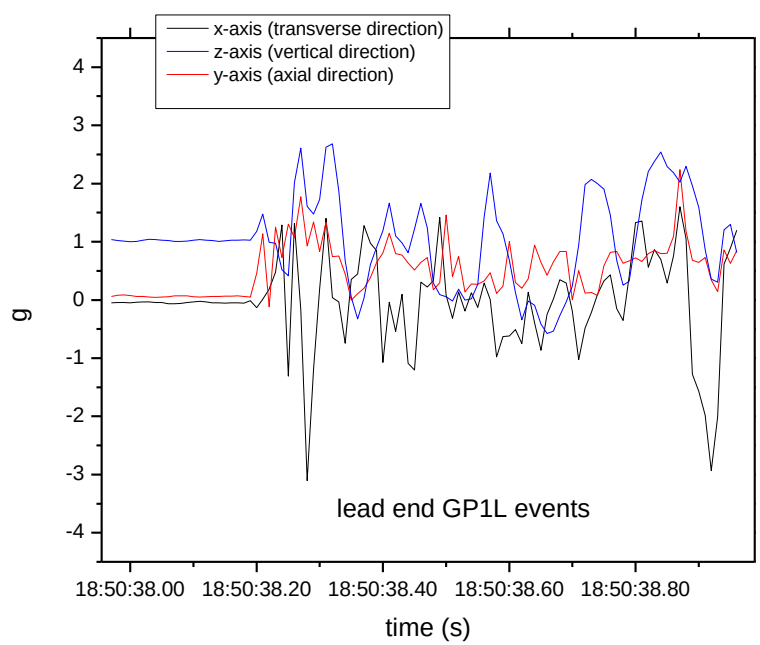
Zoom in of previous plots. Below you find a zoom in of the trip snapshot to highlight the incident shocks





GP1L device allow to record event when g > 3g. The data are collected 0.3 sec before of the event and 0.7 sec after the event. Each event is 1 sec long. Only two >3g events were recorded during the incident. They occur one after the other in a two second timeframe. The two events are plotted together for each device (lead end and no- lead end). No shocks above 4g are recorded. Highest shocks are along the transverse and vertical direction which is consistent with the fact that the non-lead end of the crate moved a few inches toward the right.





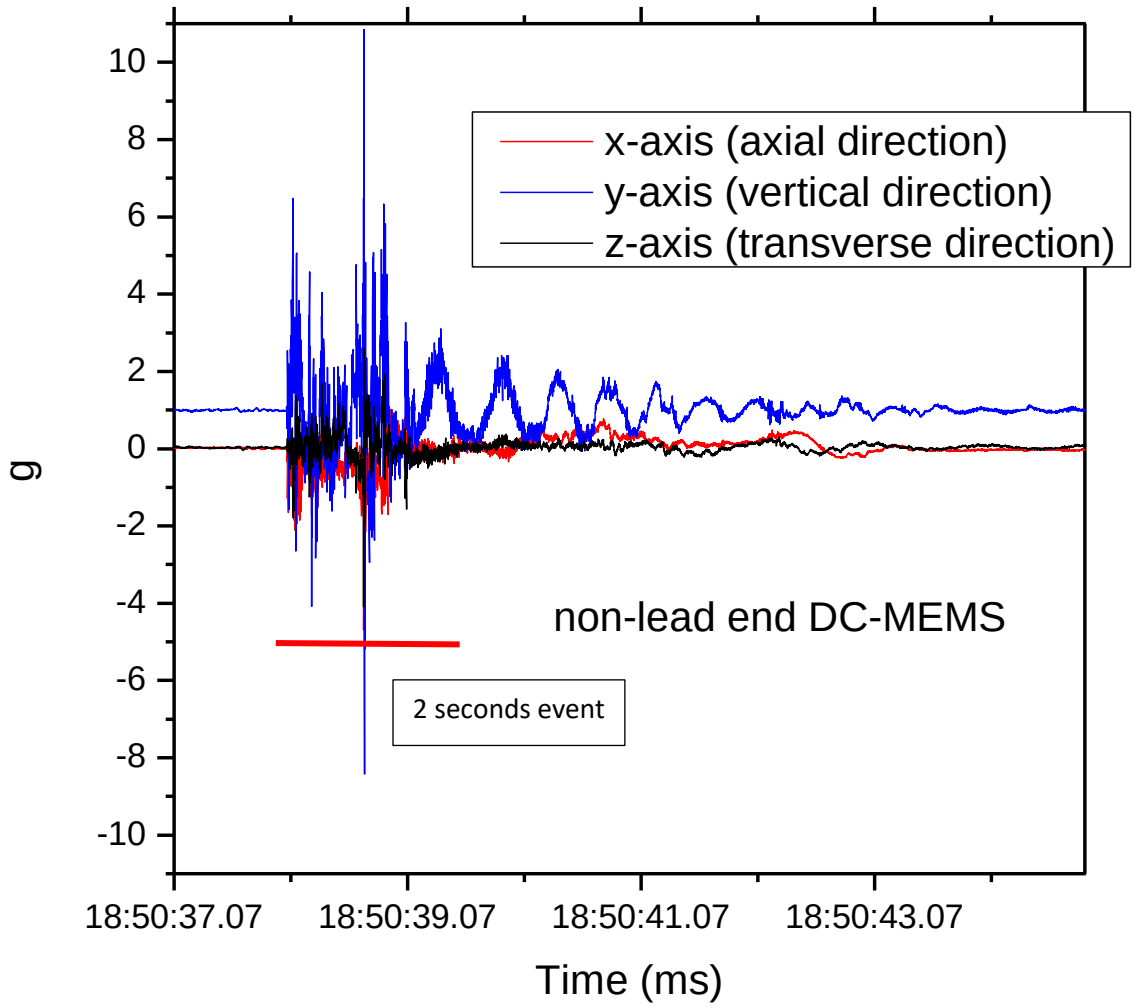
Slamstick data

Slamstick device was installed on the non-lead end fixture clamp on the left side (see green circle in the magnet picture). Those devices have a piezo and a DC-MEMS accelerometers. Below there are the devices settings:

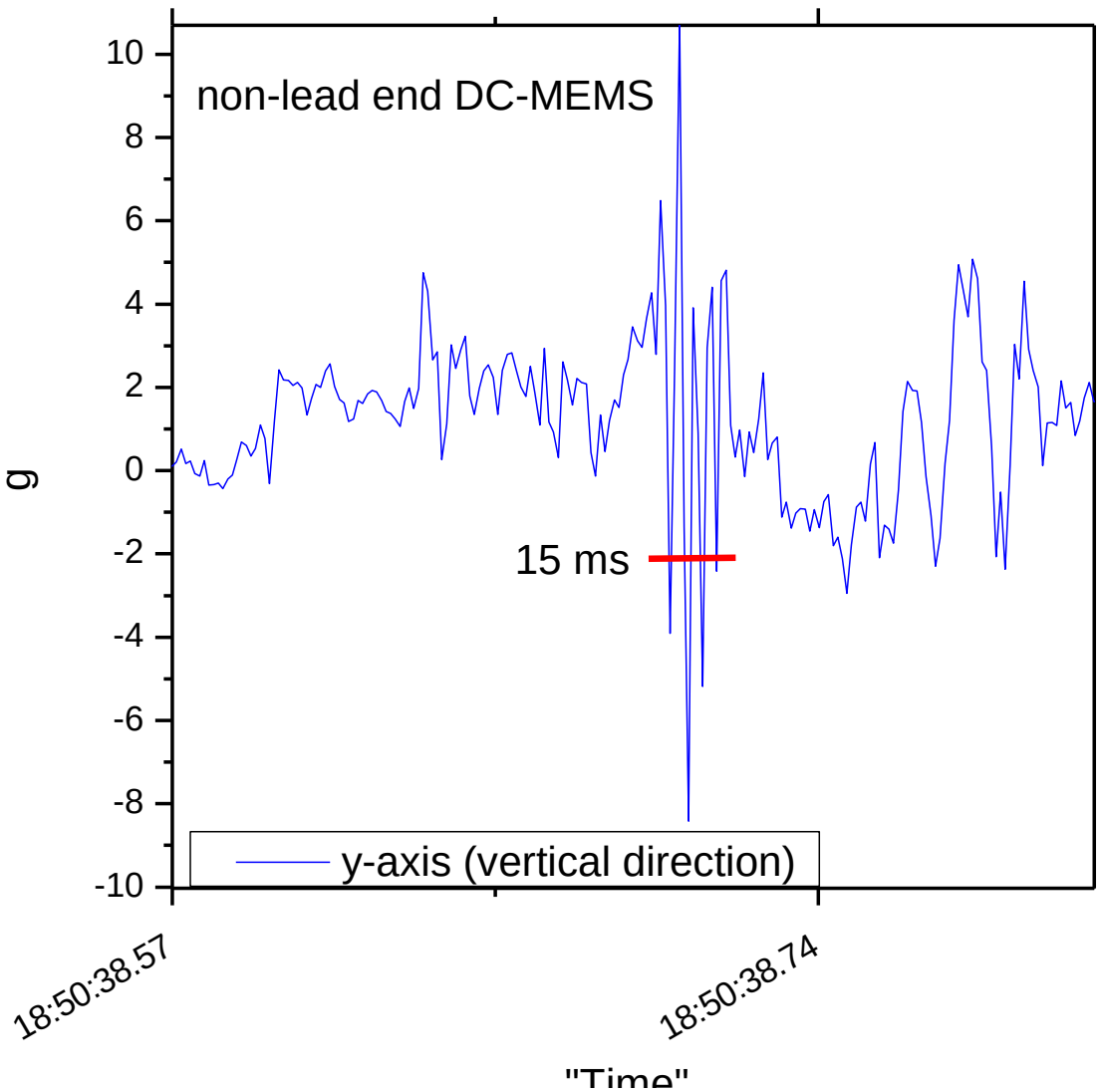
Piezo 25g maximum sample rate 1000 Hz

DC-MEMS 15g maximum sample rate 800 Hz

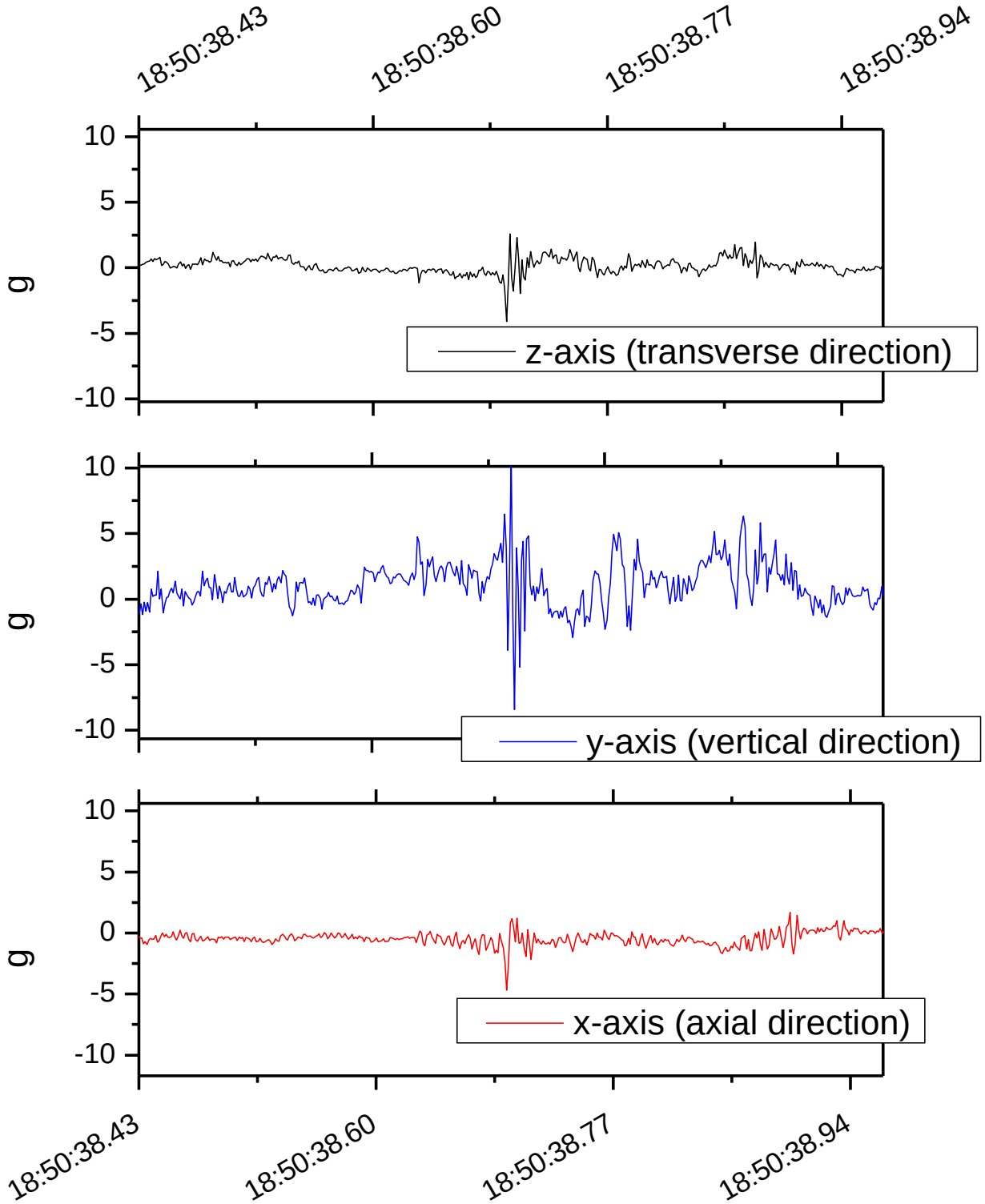
Each data set is 10 min long so the incident was captured in one data set. Below there is a snapshot of the shock vibration collected during the accident with the DC-MEMS. The data are in good agreement with what is observed with the GP1L. Shocks above 3g cover a 2 second time window. The large oscillations observed in the plot are consistent with the incident dynamic and the detachment of the truck axle. The highest shock reaches 10g along the vertical direction.



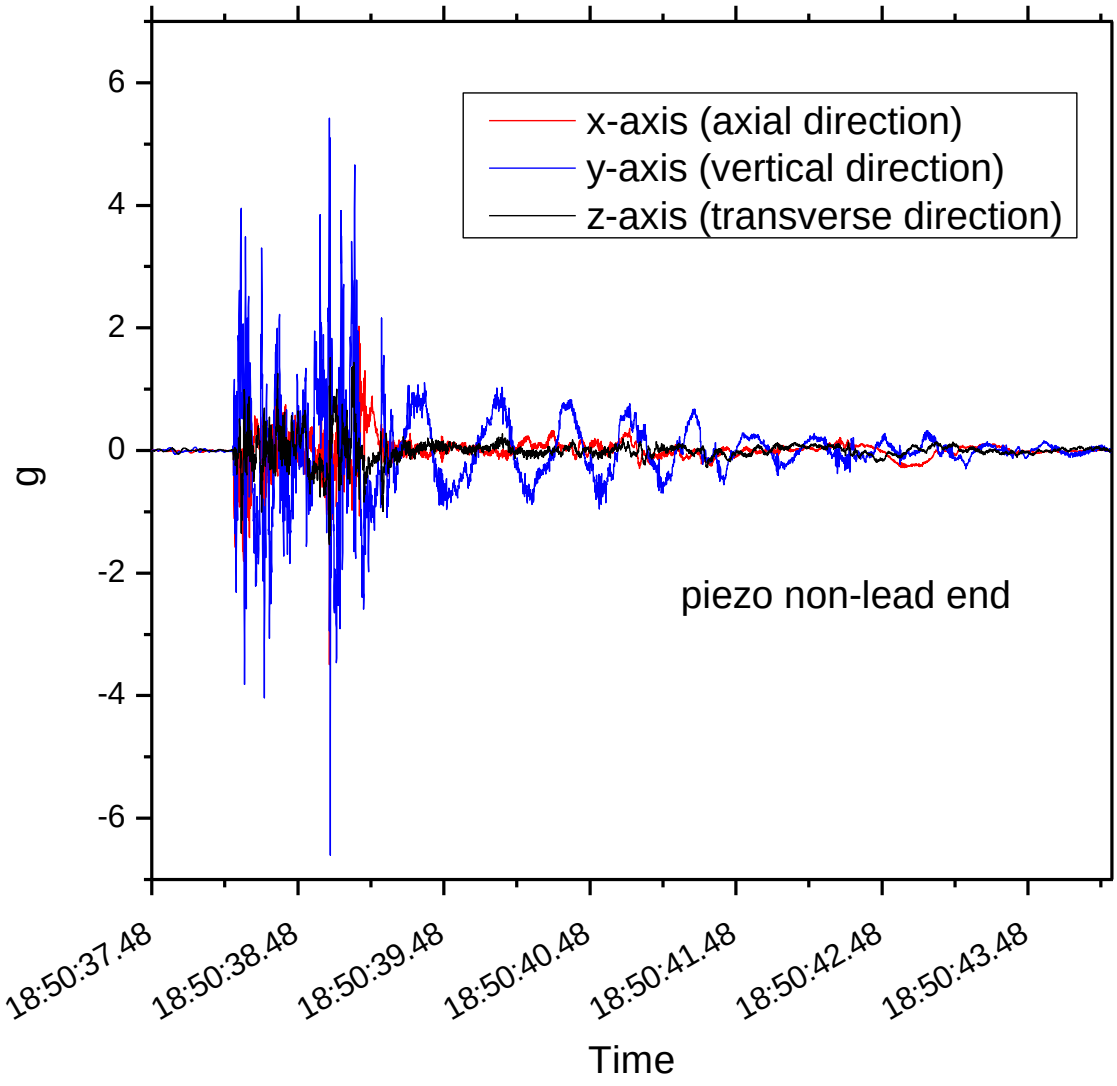
In the picture below, there is a zoom view of the highest recorded shocks. It is a kind of high frequency oscillation that lasts around 15 ms. The highest peak (10g) is 2 ms long. The oscillation frequency is around 500Hz. This event could not be properly captured by the GP1L since its sample rate is around 10 ms.



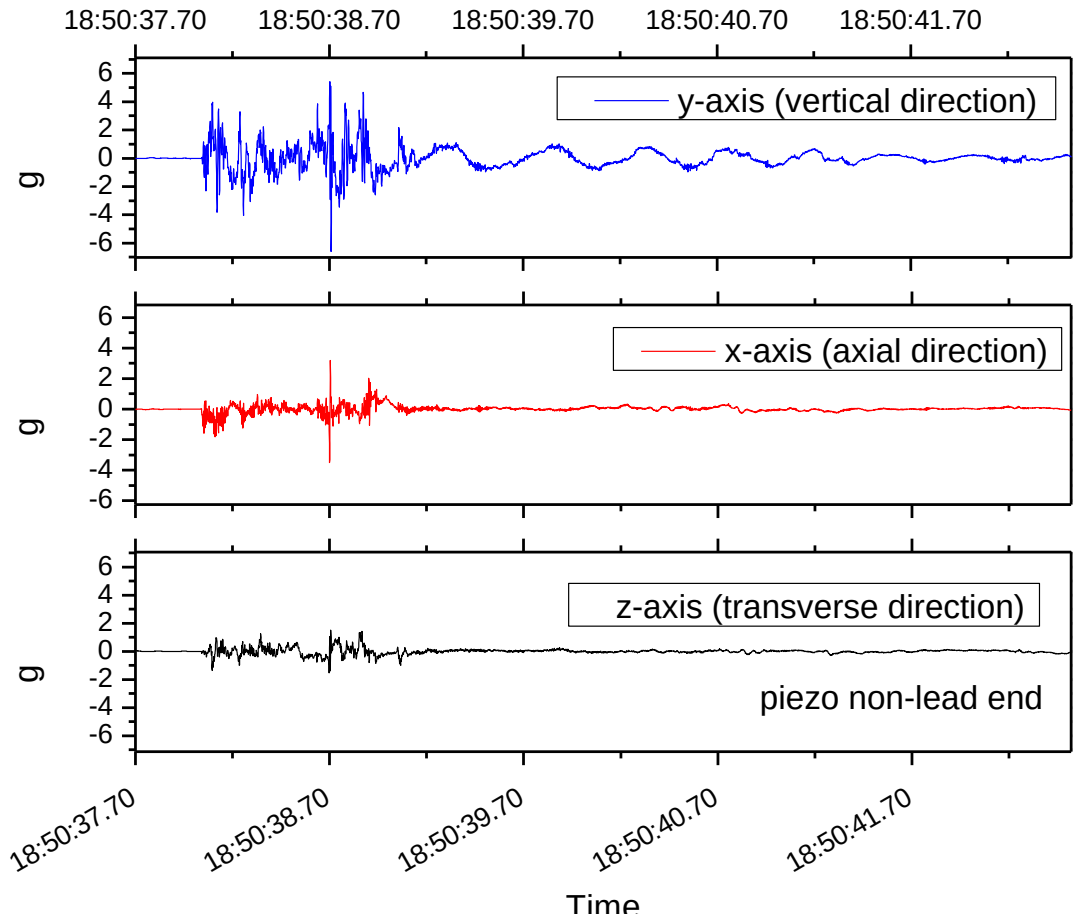
In the picture below, a time snapshot of 50 ms is displayed for each DC-MEMS accelerometer direction. No shocks above requirements (5g) are observed along the transverse and axial direction.



In the plot below, the data collected with the piezo are shown. The data are consisted with the DC-MEMS. The highest shock is slight above 6 g in vertical direction.



In the picture below, a time snapshot of 5 seconds is displayed for each piezo accelerometer direction. No shocks above requirements (5g) are observed along the transverse and axial direction.



Conclusions:

Shocks above requirements were observed along the vertical direction on a slamstick device installed on a clamp close to MQXFA11 non-lead end.

The largest shock is in vertical direction. Its amplitude is ~6 g according to the piezo accelerometer, and 10 g according to the DC-MEMS accelerometer.

This shock event is a high frequency oscillation (500Hz) that lasted 15 ms.