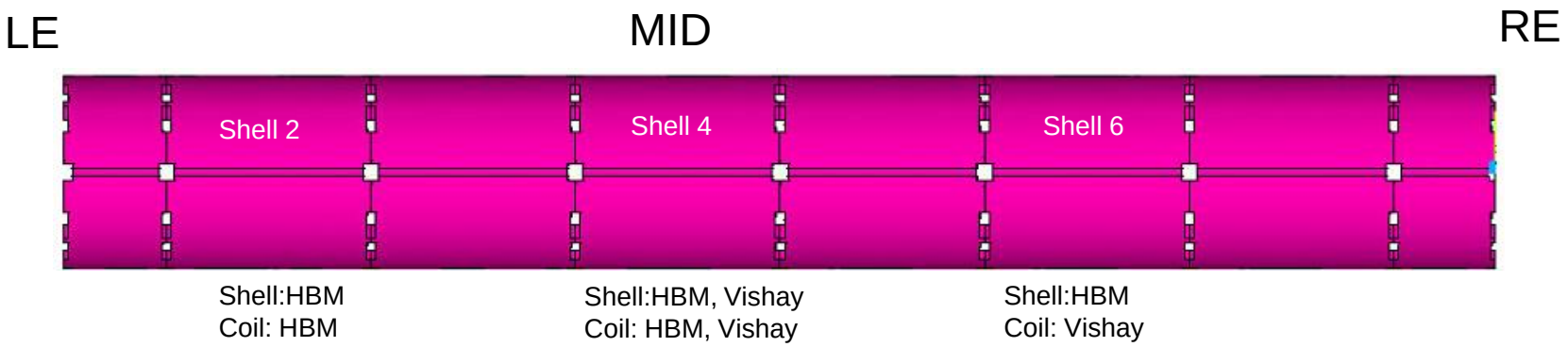
MQXFAP2 SG Readings ---Update (up to quench #13)

H. Pan
10/18/2018
LBNL

MQXFAP2 SG Gauges Overview



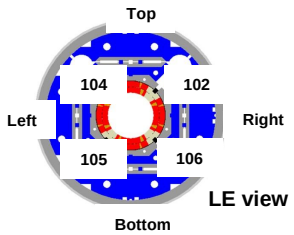
- Three axial locations:
  - Shell gauges (T & Z): on shell 2, 4 & 6
    - HBM gauges: Shell 2,4,6
    - Vishay gauges: Shell 4
  - Coil gauges (T & Z): on axial location of 740 mm (LE), 1940 mm (MID) and 3140 mm (RE) from LE.
    - HBM gauges: Coil LE and MID
    - Vishay gauges: Coil MID and RE
- Most of the strain gauges stay alive in the quench tests.
    - HBM shell 6 Top axial, Coil 102 azimuthal LE initially were found wire broken before cool-down.

US HL-LHC AUP

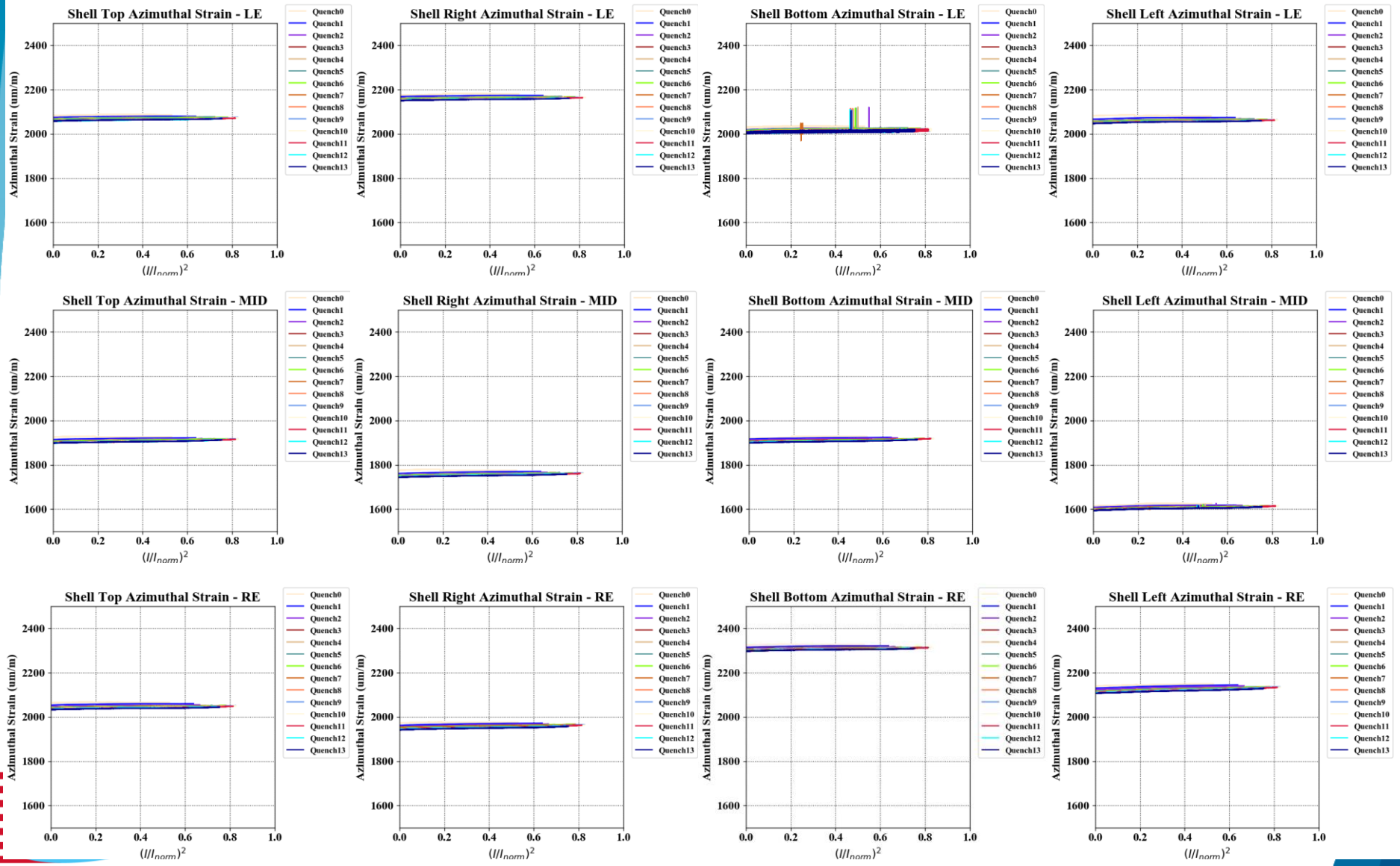
HBM Gauge Readings---Shell Azimuthal

Note: "Quench 0" = 12 kA ramp prior to training

HBM Shell Azimuthal Strain



- **Quench#0 is the 12 kA ramp. (The name is not easily changed because the legend is made in a loop.)**

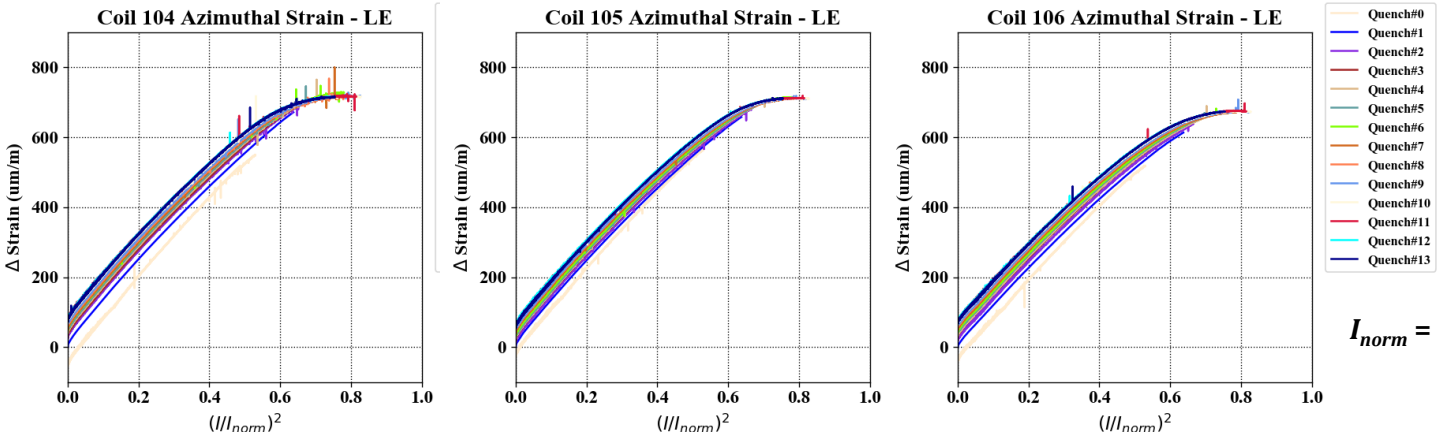


HBM Gauge Readings---Coil Azimuthal

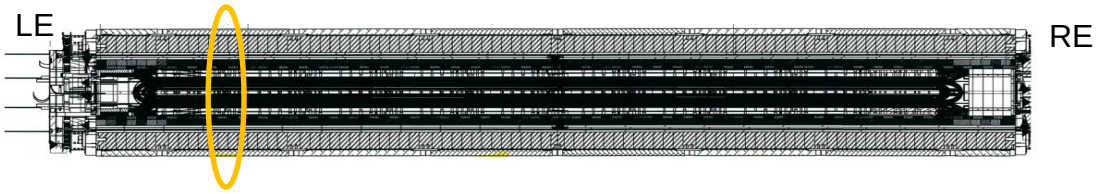
Note: “Quench 0” = 12 kA ramp prior to training

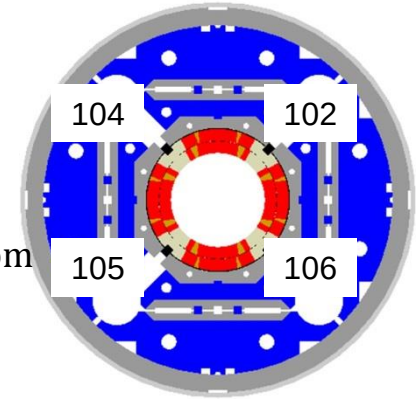
US HL-LHC AUP

HBM Gauge Readings---Coil Azimuthal LE



I_{norm} = 16.47 kA

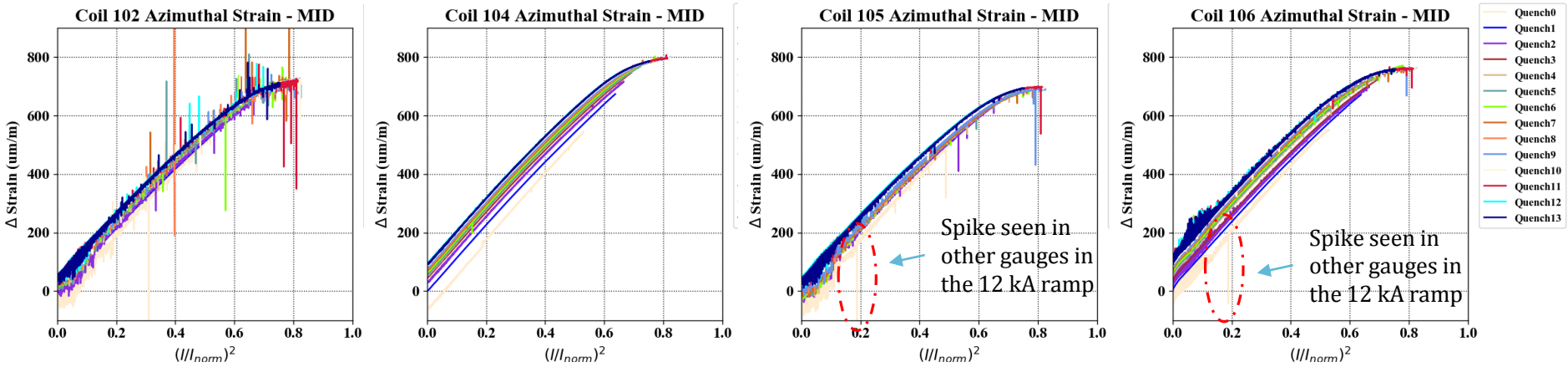


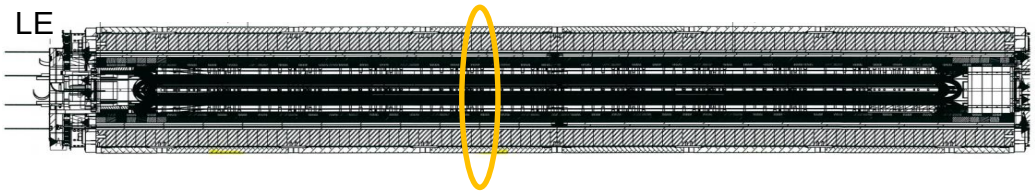


LE view

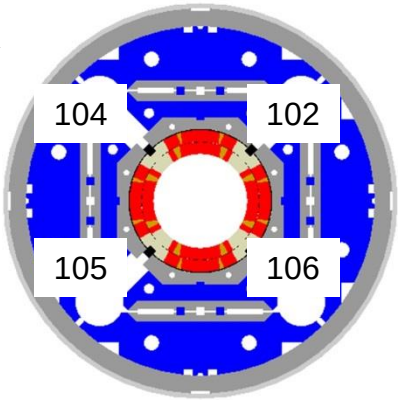
- Coil 102 LE is gone before cooldown
- The slope of the available gauges are similar which is about 1000 με from 0A to nominal current.
- Coil 104 LE seems to be the 1st one to show slope change.
- Ratchet effect is observed: coil azimuthal strain without current creeps towards less loading over quench tests.

HBM Gauge Readings---Coil Azimuthal MID





I_{norm} = 16.47 kA

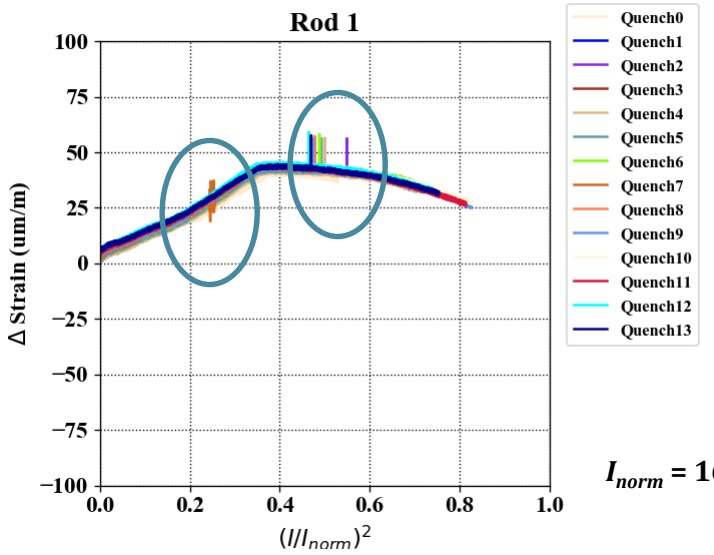


LE view

- The slope of the middle coil gauges are close, which is about 1000 με from 0A to nominal current.
- Unstable signals were observed in C102, C105 and C106.
- Ratchet effect is observed: coil azimuthal strain without current creeps towards less loading over quench tests.

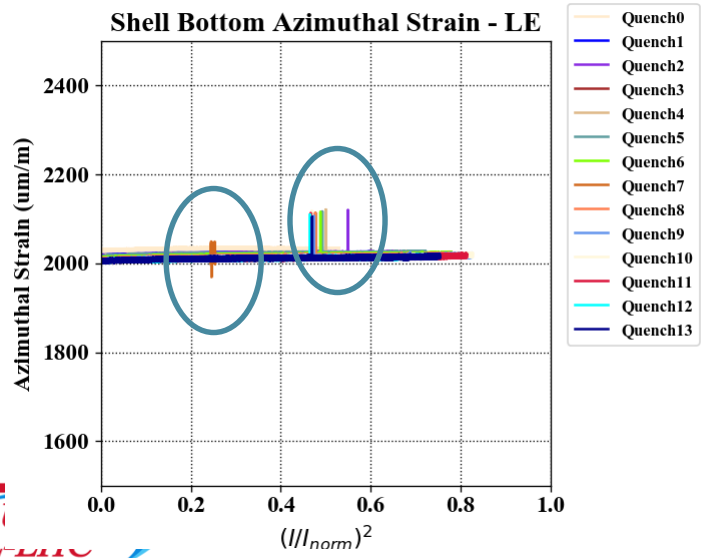
US HL-LHC AUP

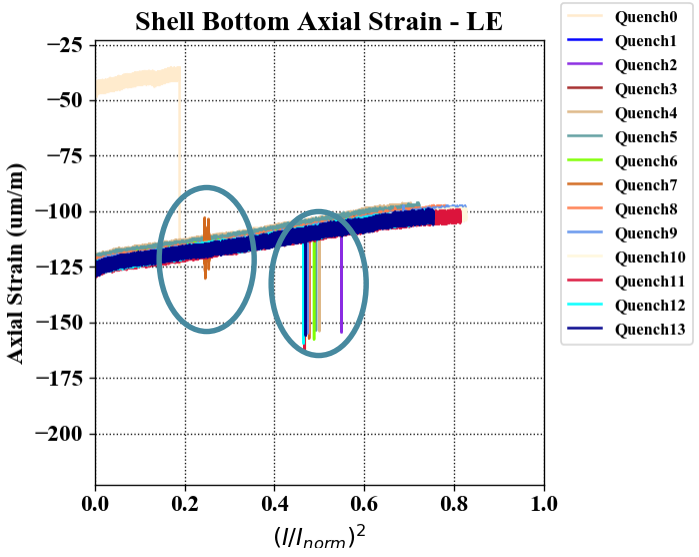
Some Suspicious Phenomenon-spikes



- Quench #0 represents the 12 kA ramp.
- Those spikes are clearly correlated;
- The other signals do have those spikes;
- The connectors of those signals are not close.

I_{norm} = 16.47 kA





A “global” event seen during the 12 kA ramp

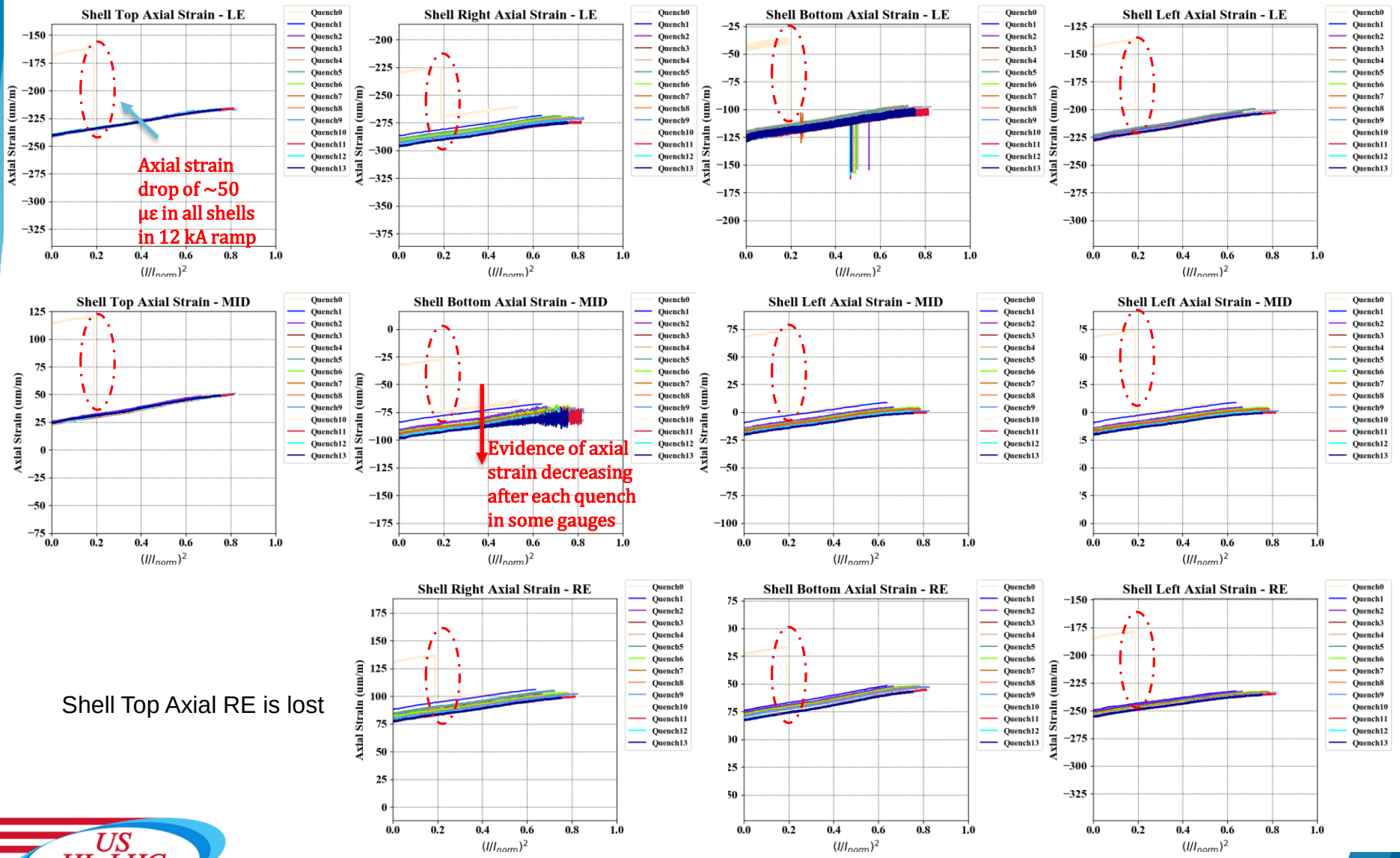
“Quench 0” prior to training

US HL-LHC AUP

Some Suspicious Phenomenon--axial strain drop at 12kA ramp

Shell Axial Strains

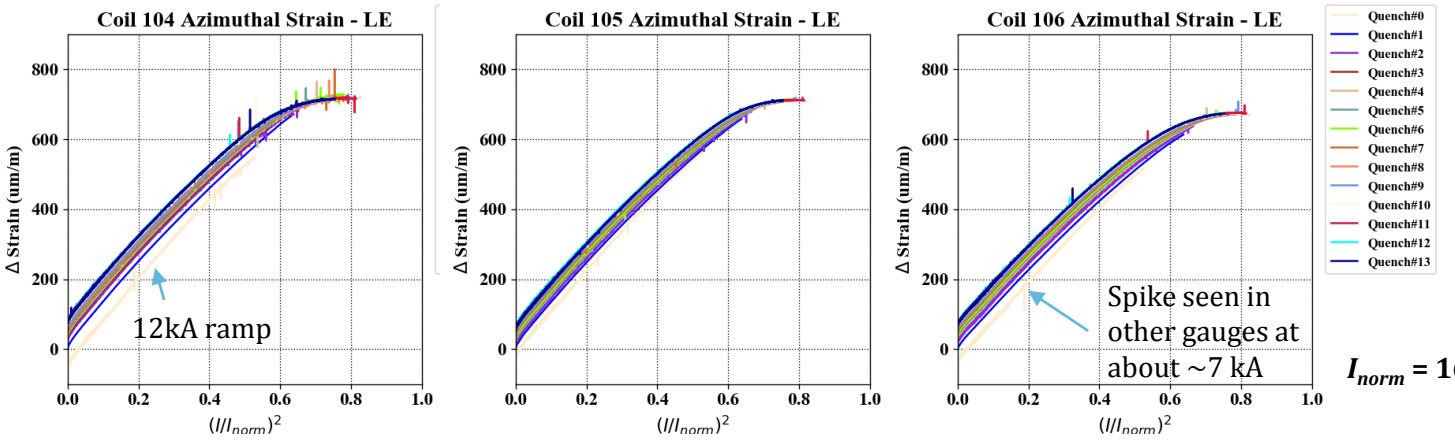
I_{norm} = 16.47 kA



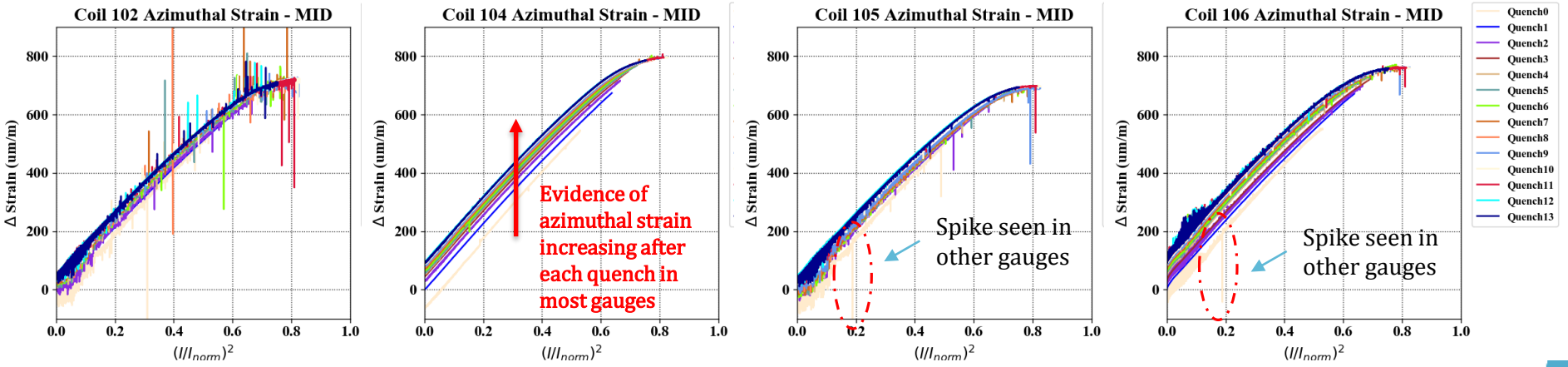
Shell Top Axial RE is lost

Some Suspicious Phenomenon--axial strain drop at 12kA ramp

Coil Azimuthal Strains



I_{norm} = 16.47 kA



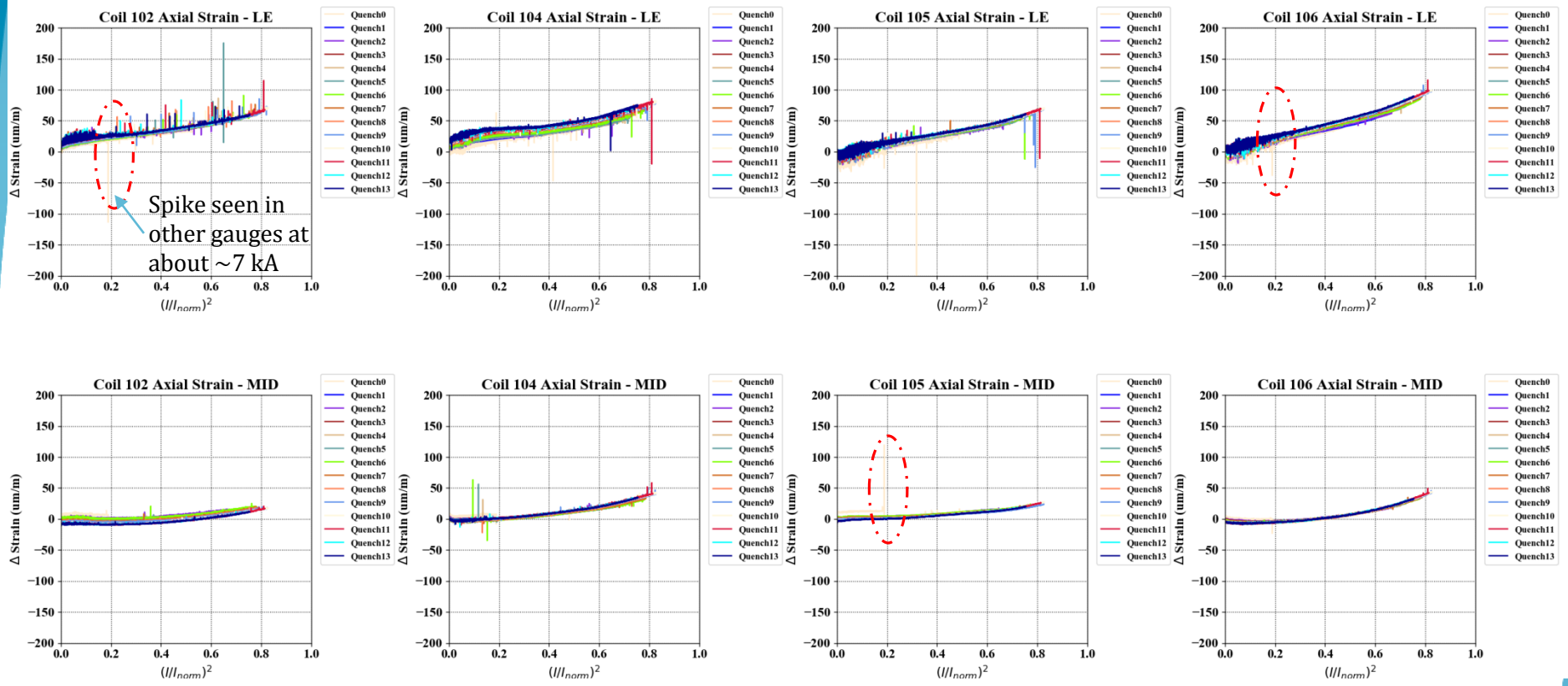
- There seems to be a global event in the 12 kA ramp

US HL-LHC AUP

Some Suspicious Phenomenon--axial strain drop at 12kA ramp

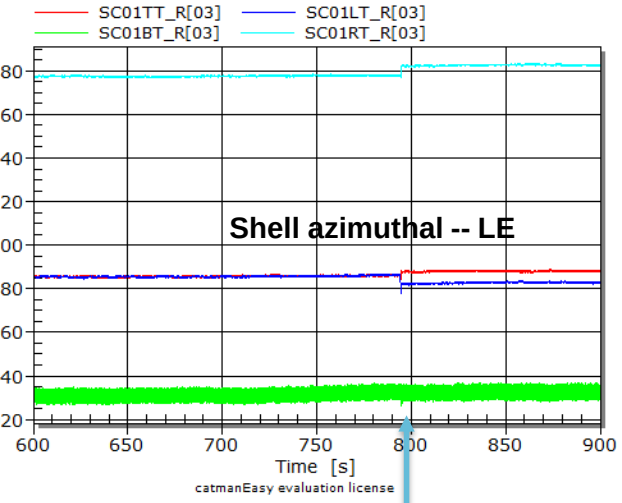
Coil Axial Strains

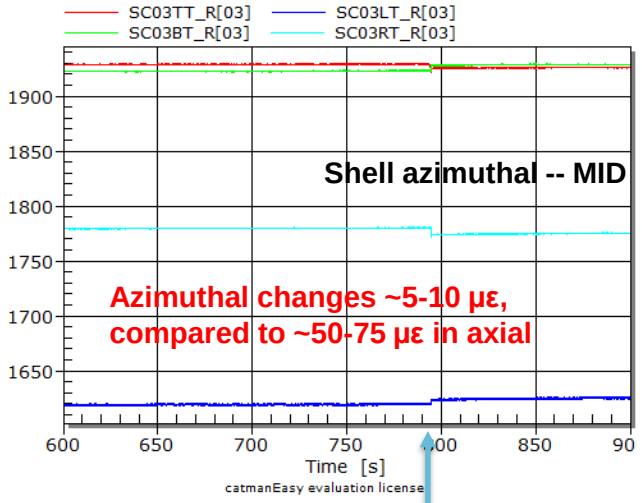
I_{norm} = 16.47 kA

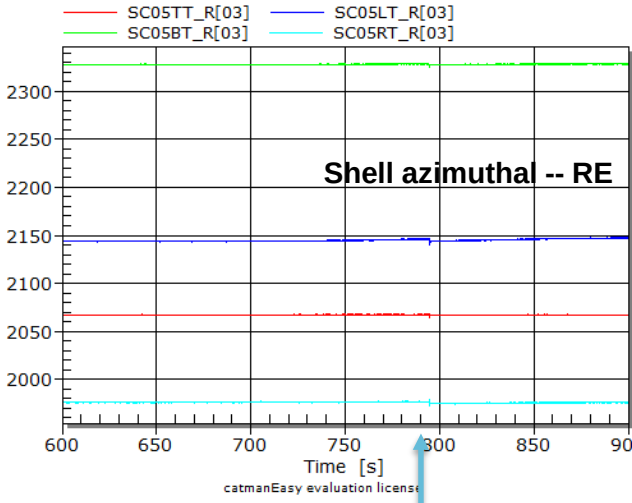


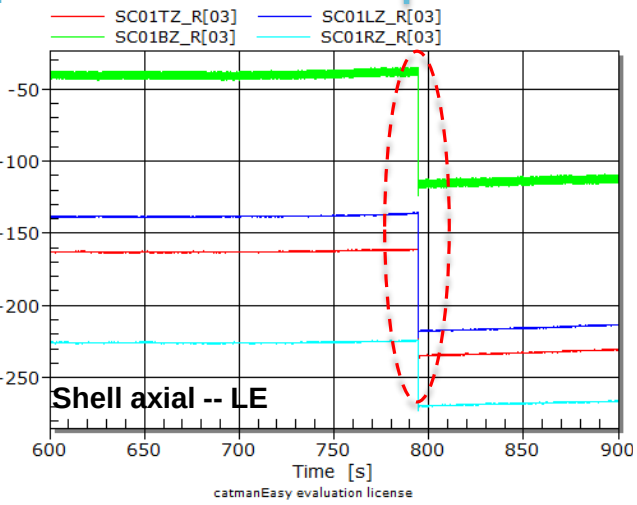
- There seems to be a global event in the 12 kA ramp

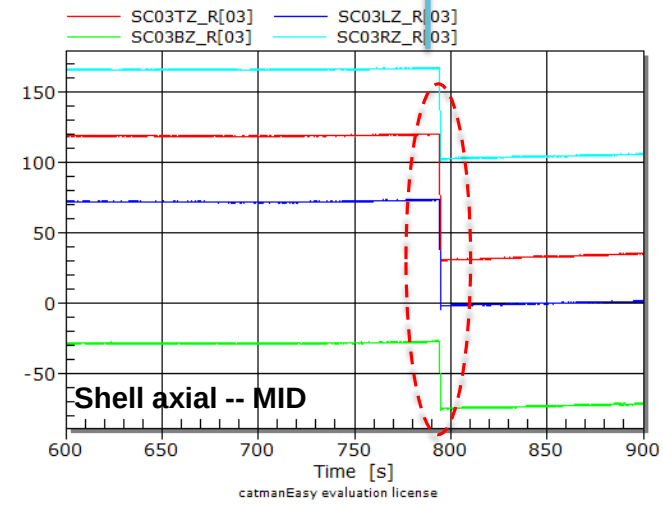
Additional Shell Strain during 12 kA ramp

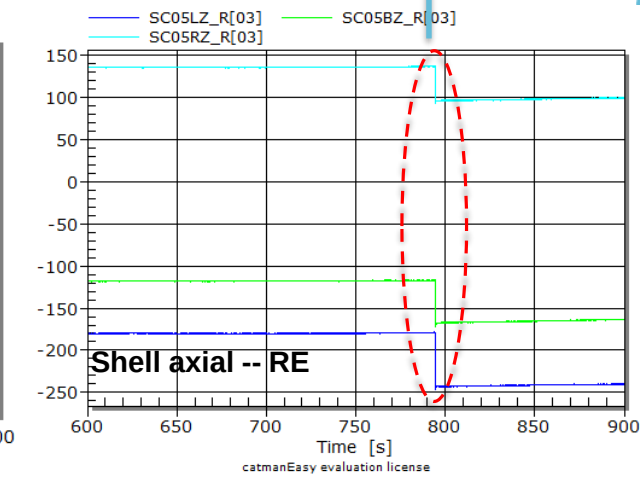






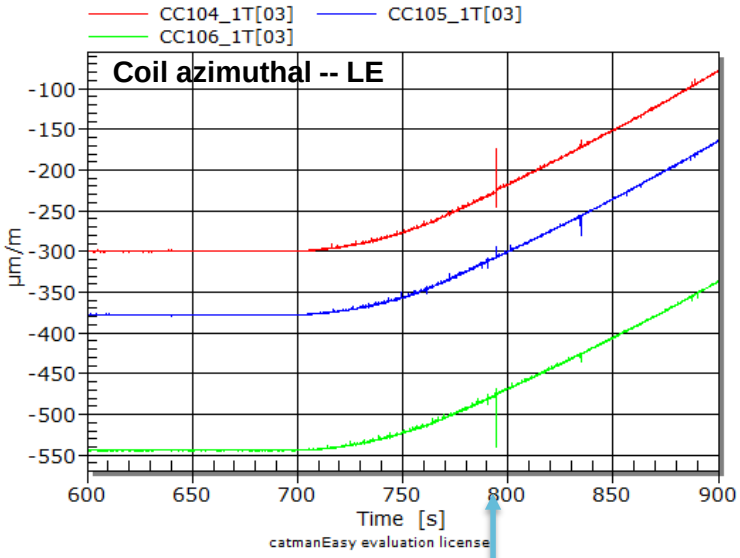


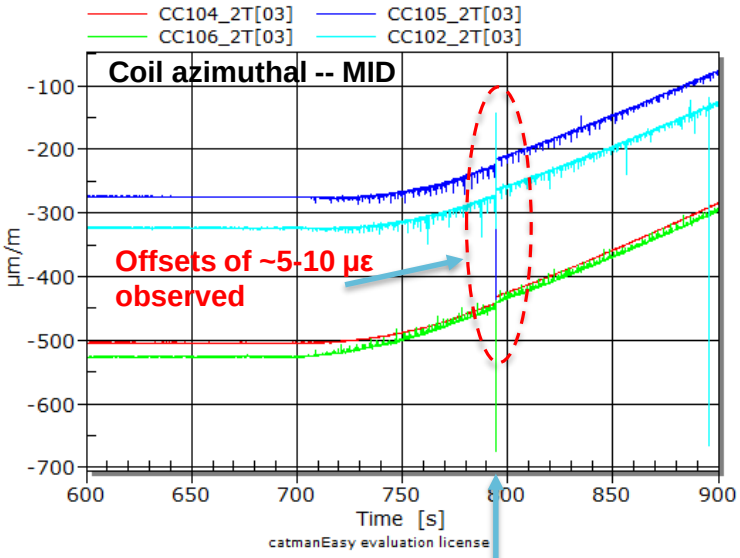


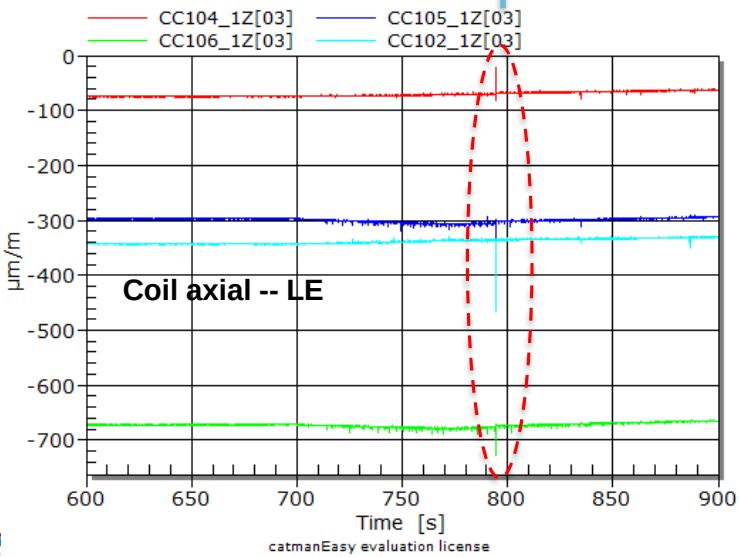


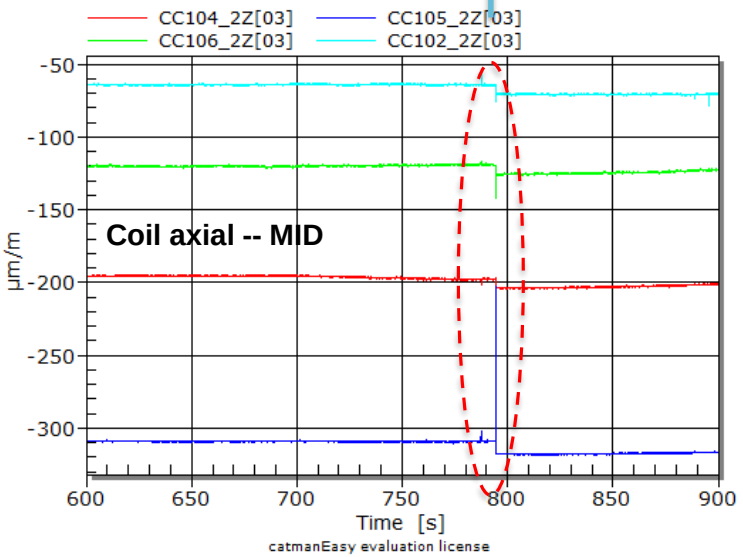
- Both LE and MID shells have the signs of "slip"

Additional Coil Strain at 12 kA ramp







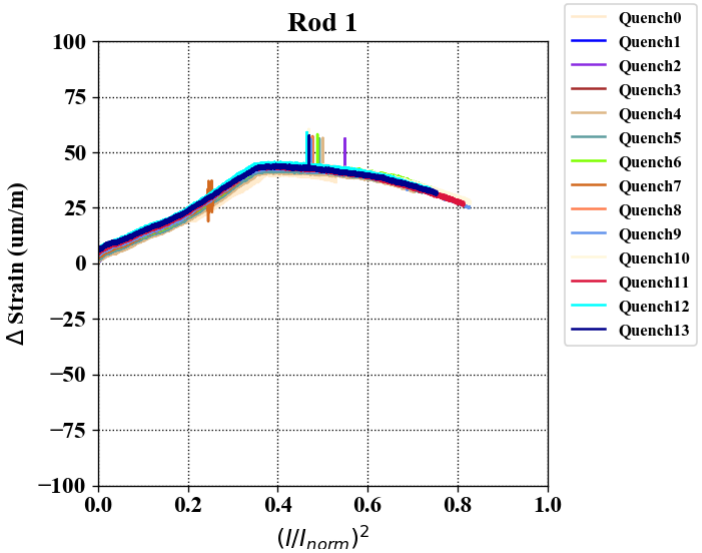


- Both LE and MID Coils show signs of event; only MID gauges showed offsets

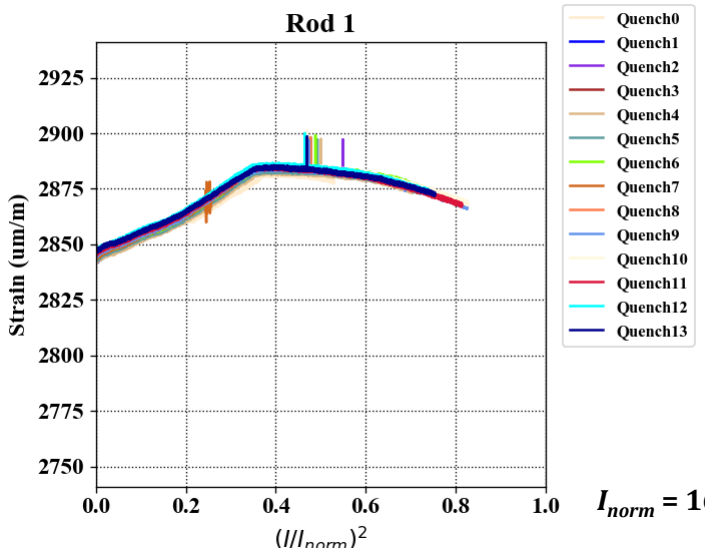
HBM Rod Strain

- Quench #0 represents the 12 kA ramp.
- The absolute strain is much offset from the value it's ought to be.
- The delta strain in ramps is close to the magnitude of FEA predictions.
- The kink is not explainable at this moment.

Delta Strain

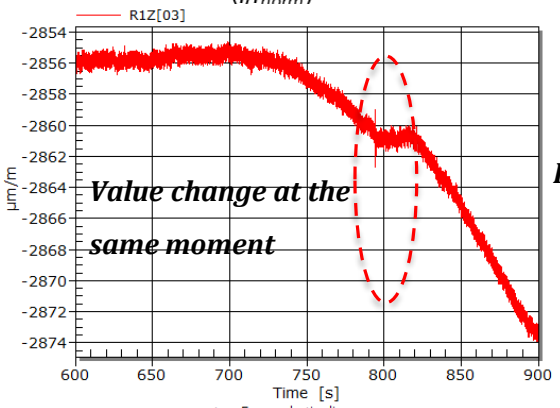


Actual Strain



I_{norm} = 16.47 kA

Raw data from 12kA ramp



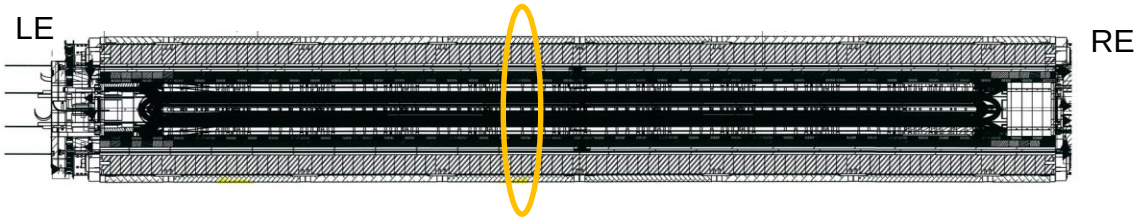
Polarity is reversed;

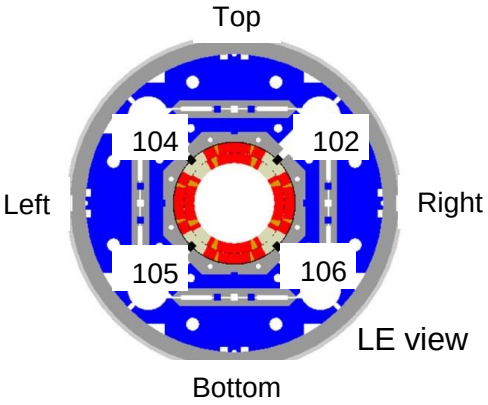
US HL-LHC AUP

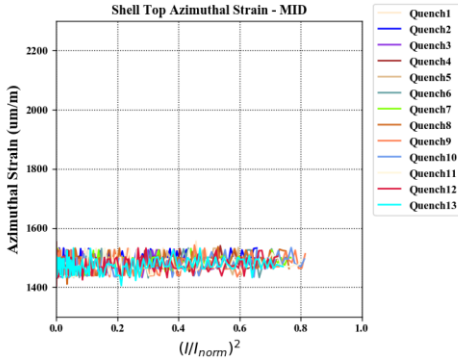
Vishay Gauge Readings---Shell Azimuthal

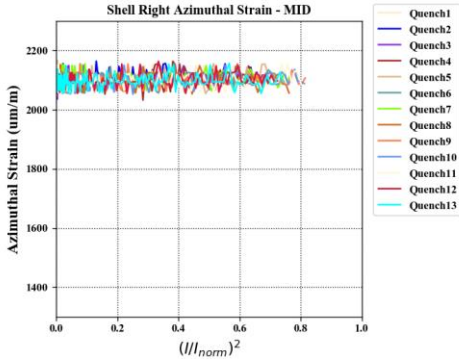
Note: No "Quench 0" shown here

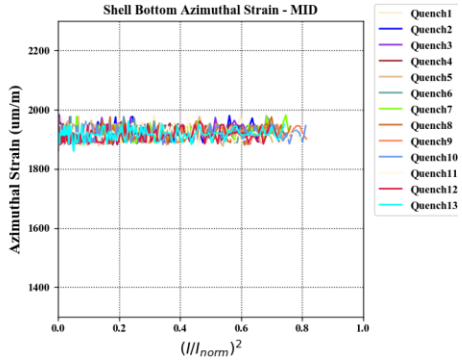
Vishay Gauge Readings---Shell Azimuthal MID

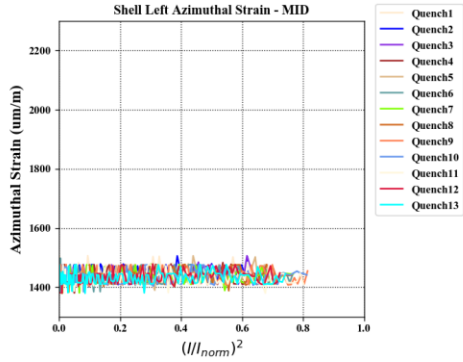








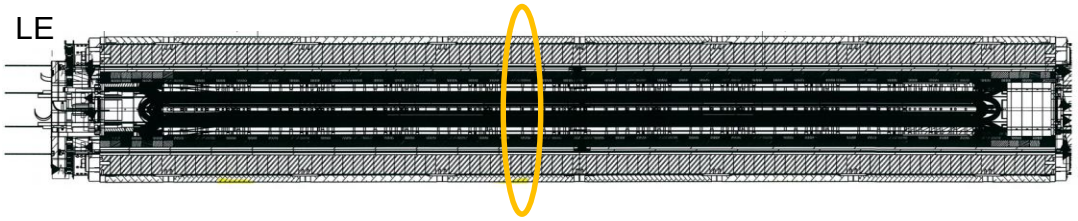


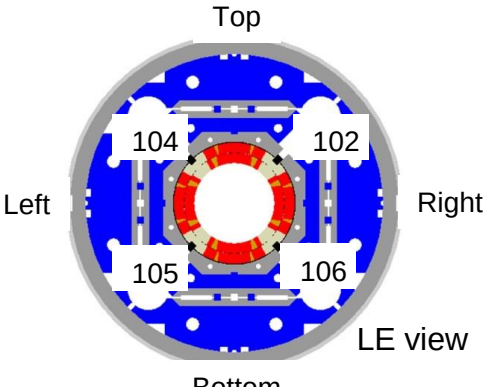


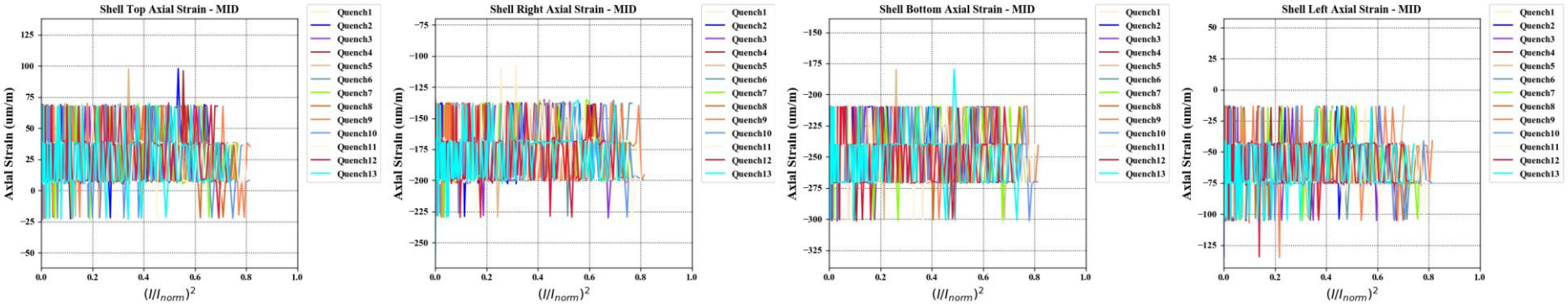
I_{norm} = 16.47 kA

- MID shell azimuthal gauges behave as expected in trainings.
- No obvious slope change or offsets observed.

Vishay Gauge Readings---Shell Axial MID







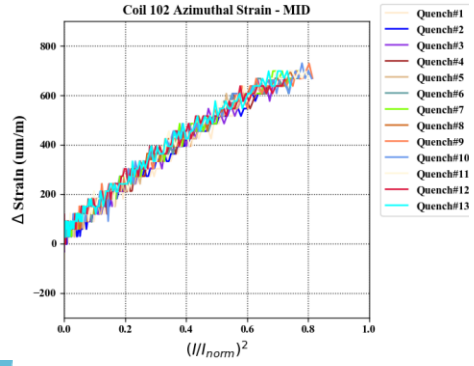
I_{norm} = 16.47 kA

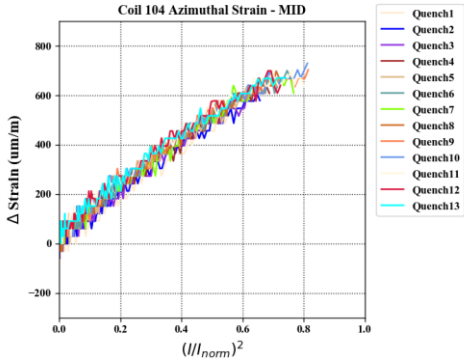
- MID shell azimuthal gauges behave as expected in trainings.
- No obvious slope change observed.

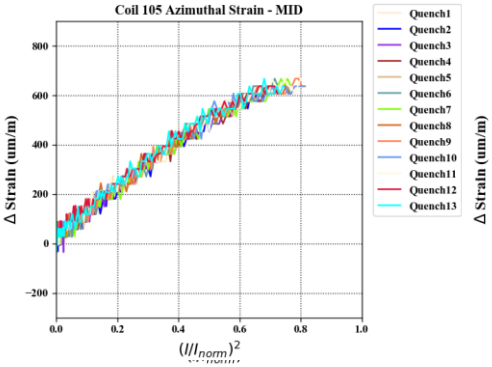
Vishay Gauge Readings---Coil Azimuthal

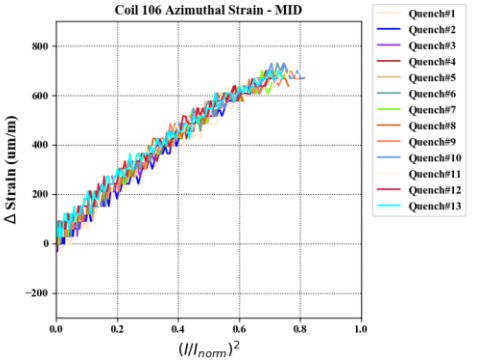
Note: No "Quench 0" shown here

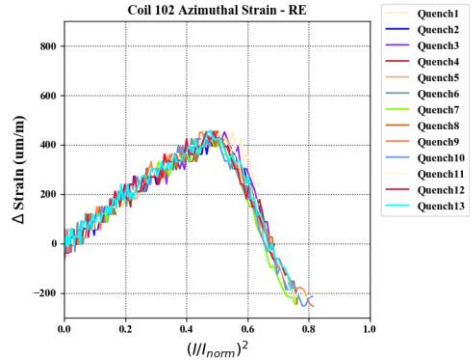
Vishay Gauge Readings---Coil Azimuthal

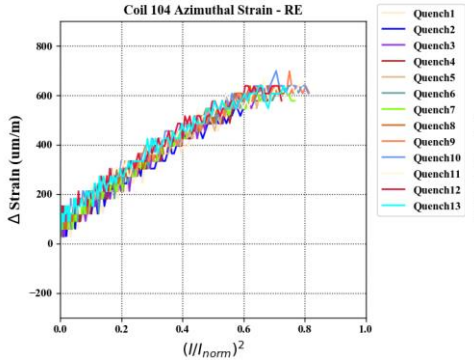


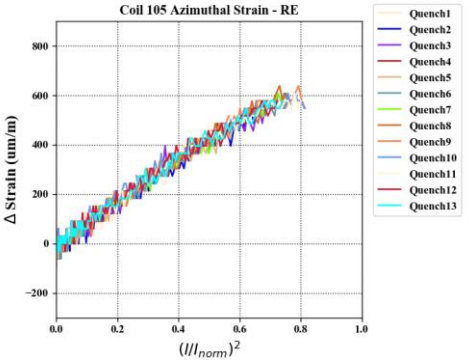


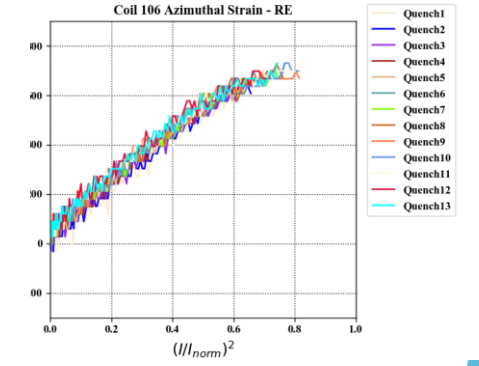








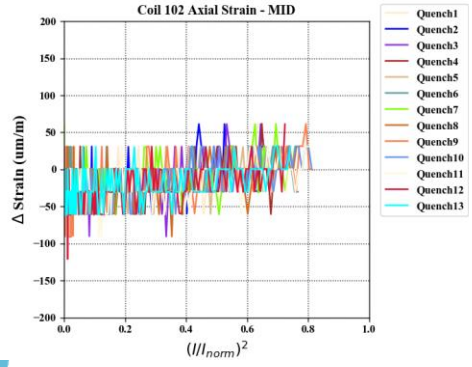


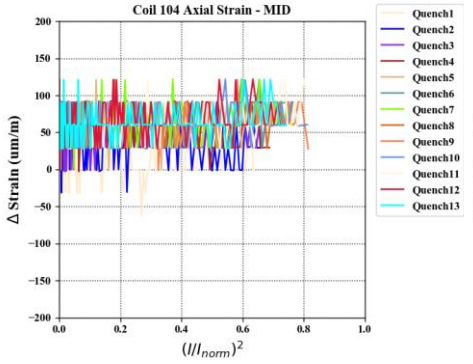


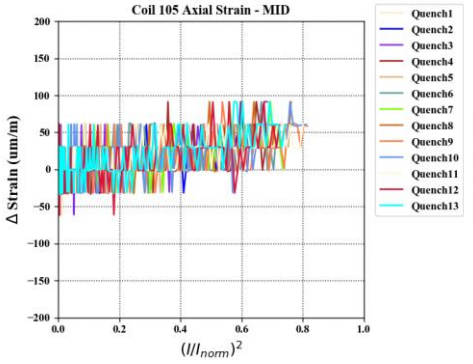
I_{norm} = 16.47 kA

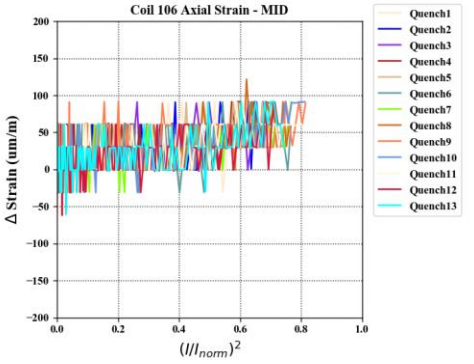
- The linear slope of the middle coil gauges are close, which is about 1000 με from 0A to nominal current.
- Slope change is observed.

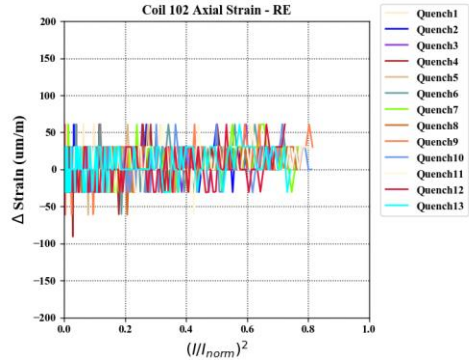
Vishay Gauge Readings---Coil Axial

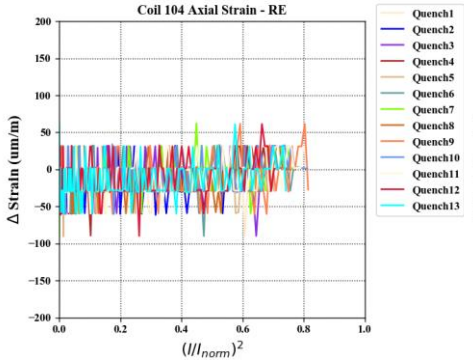


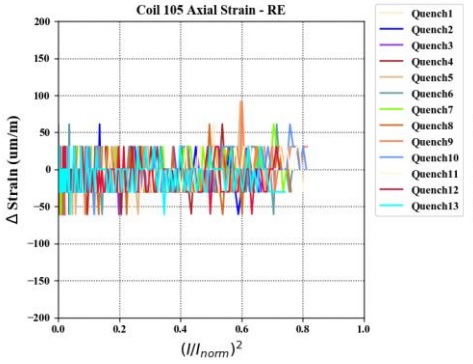


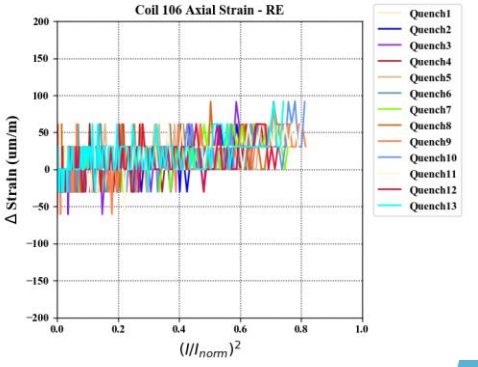












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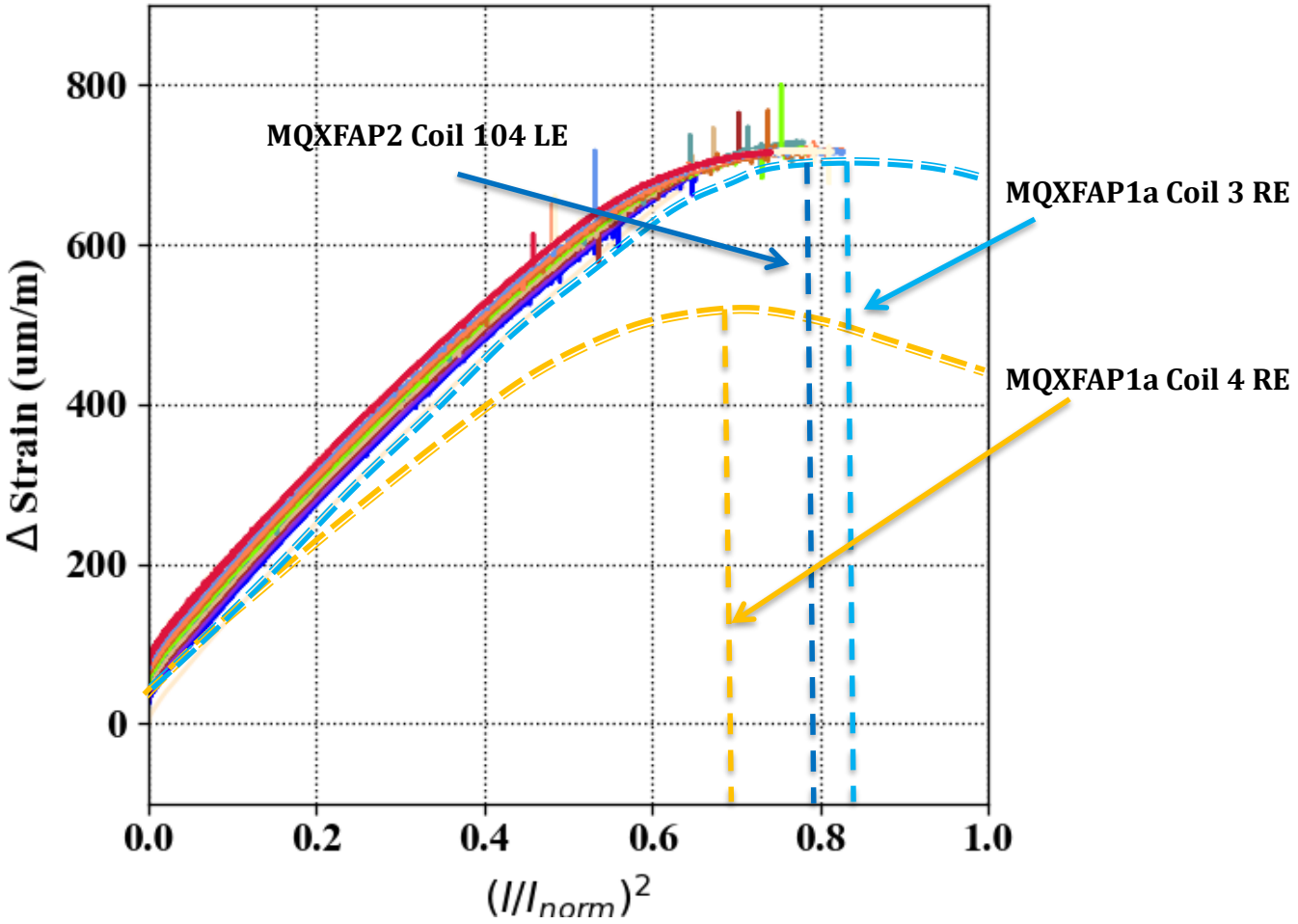
Compare with MQXFAP1 Coil Strain

- Coil 104 LE seems to be the 1st one to show slope change.
- The pre-stress of MQXFAP2 seems to be slightly higher than MQXFAP1a.



Rod Gauge Readings

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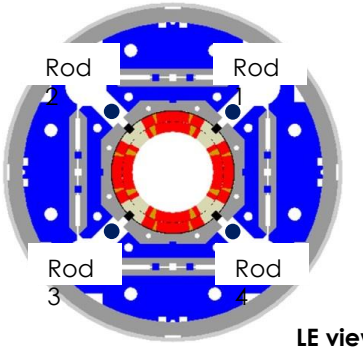
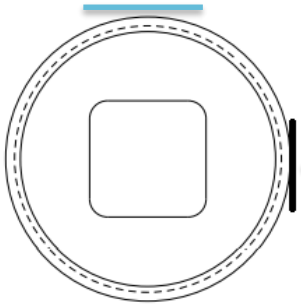
Rod Gauge Readings



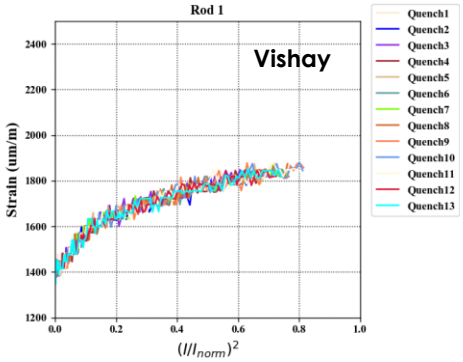
LE view

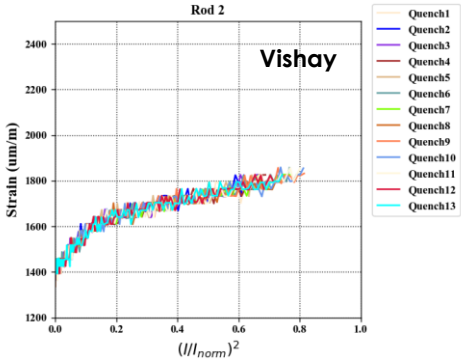
HBM gauges --- only available on Rod 1

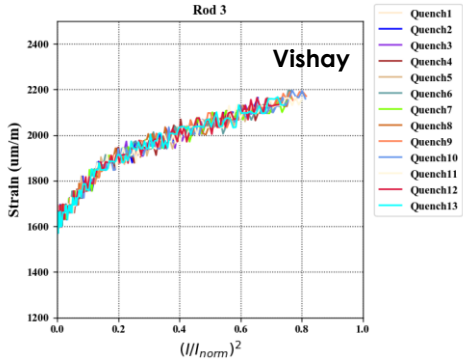


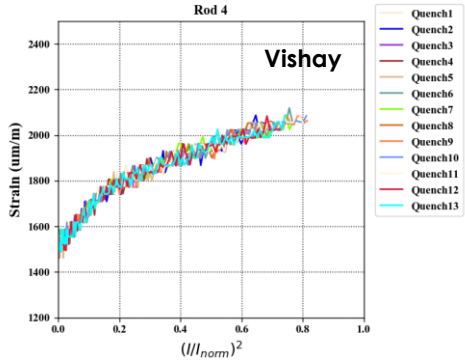
- 5.1" from the rod end (lead end)

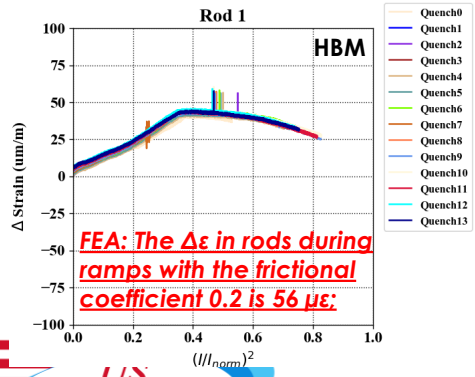
Vishay gauge --- always facing radially outward in the magnet









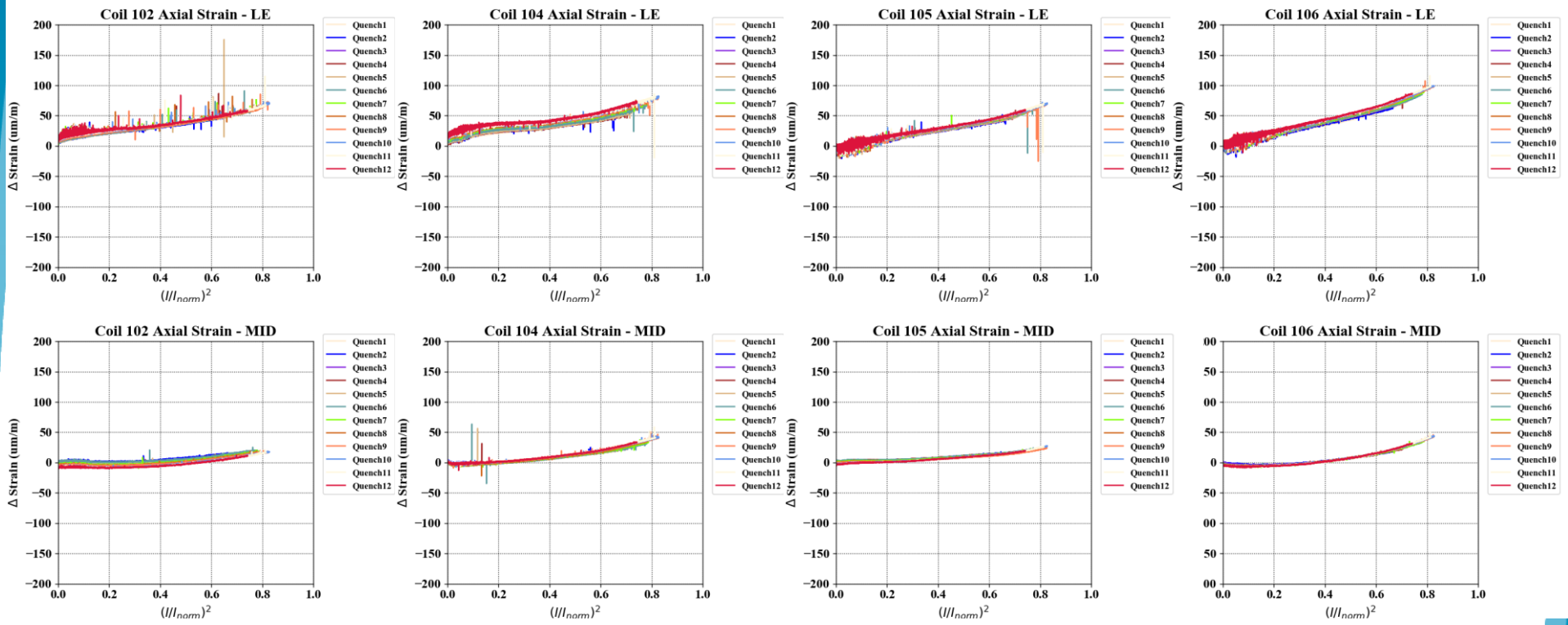


FEA: The Δε in rods during ramps with the frictional coefficient 0.2 is 56 με;

- The HBM gauge are 90 degree with respect to the Vishay gauge on the same rod.
  - HBM gauge is on the natural position if there is bending or end effect on the rod.
- The HBM reading is close to the FE prediction.
- Slope changes were observed in both type of gauges. However, the slope changes did not take place at the same moment on the two positions.

Extra

HBM Coil Axial Strain



- To verify the magnet axial stretch in ramps, the coil axial strain in all stations is close to the calculation.
- The magnet axial stiffness is as predicted.
  - The measured rods' strain is likely to be very local according to the magnet axial stretch in the trainings.
  - Detail analysis in underway on the rod behavior.

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