



MQXFA08b, MQXFA13 and MQXFA14b Test Results

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Outline

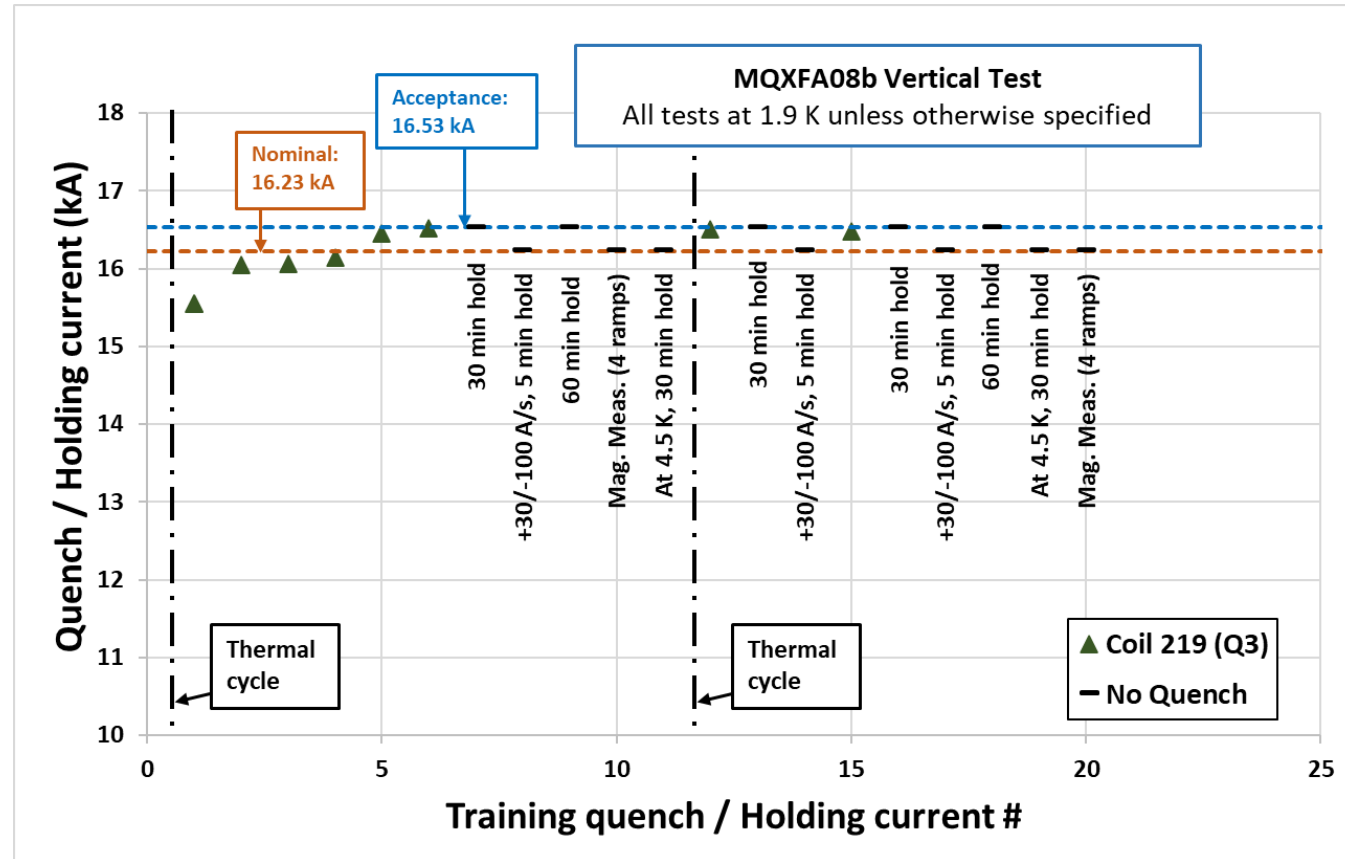
- Quench test results
 - MQXFA08b
 - MQXFA13
 - MQXFA14b
- Splice measurements
- Magnetic measurement results

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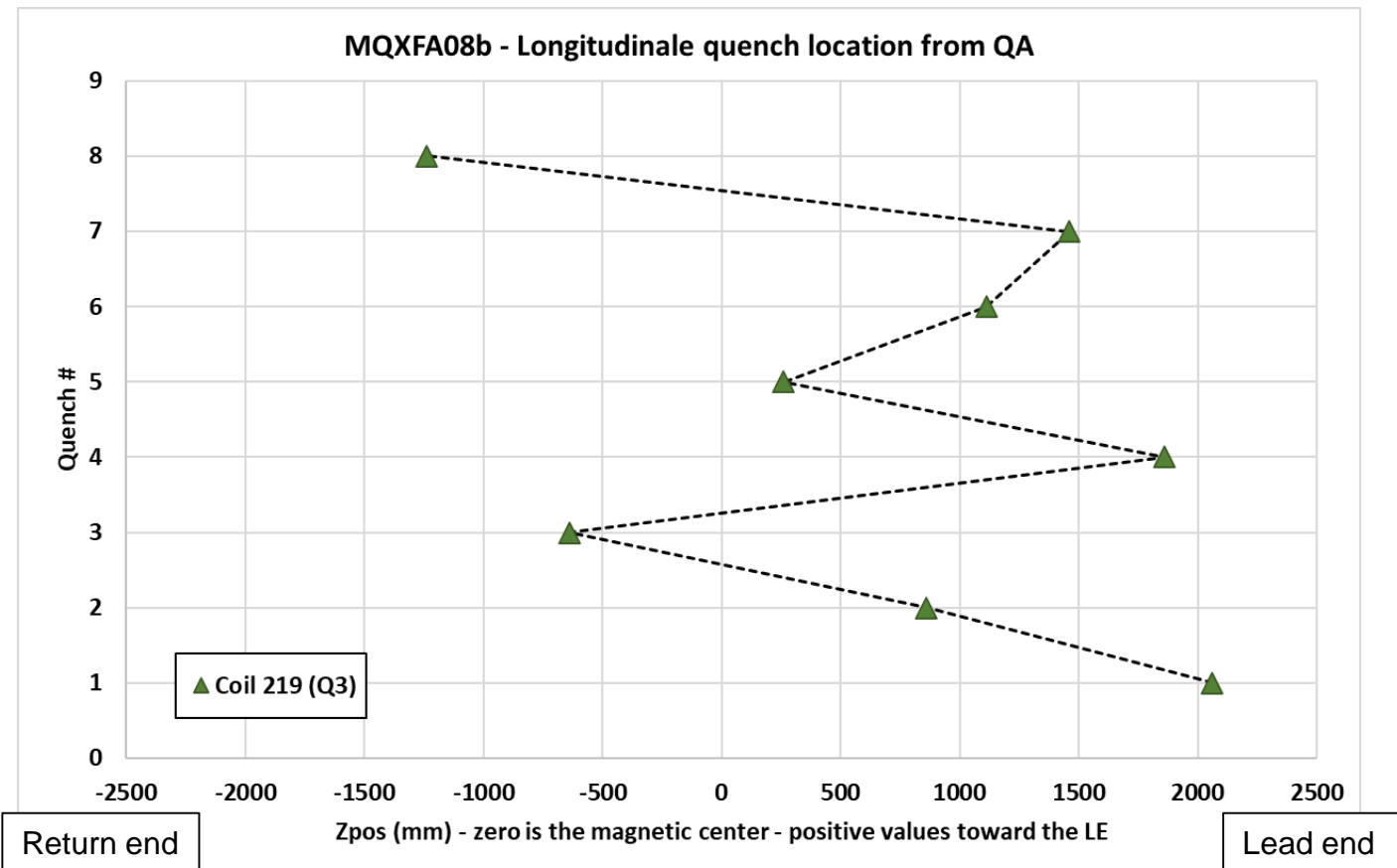
MQXFA08b

- First re-assembly: built by replacing the limiting coil (213) in MQXFA08 by a new coil (219) in quadrant 3.
- All quenches occurred in coil 219.
- After the thermal cycle 2 additional quenches above nominal current (at 16.51 kA and 16.48 kA)



MQXFA08b – Quench localization from the Quench Antenna Array

- First quench in the lead end of the coil.
- Following quenches in the straight section (no recurring location).

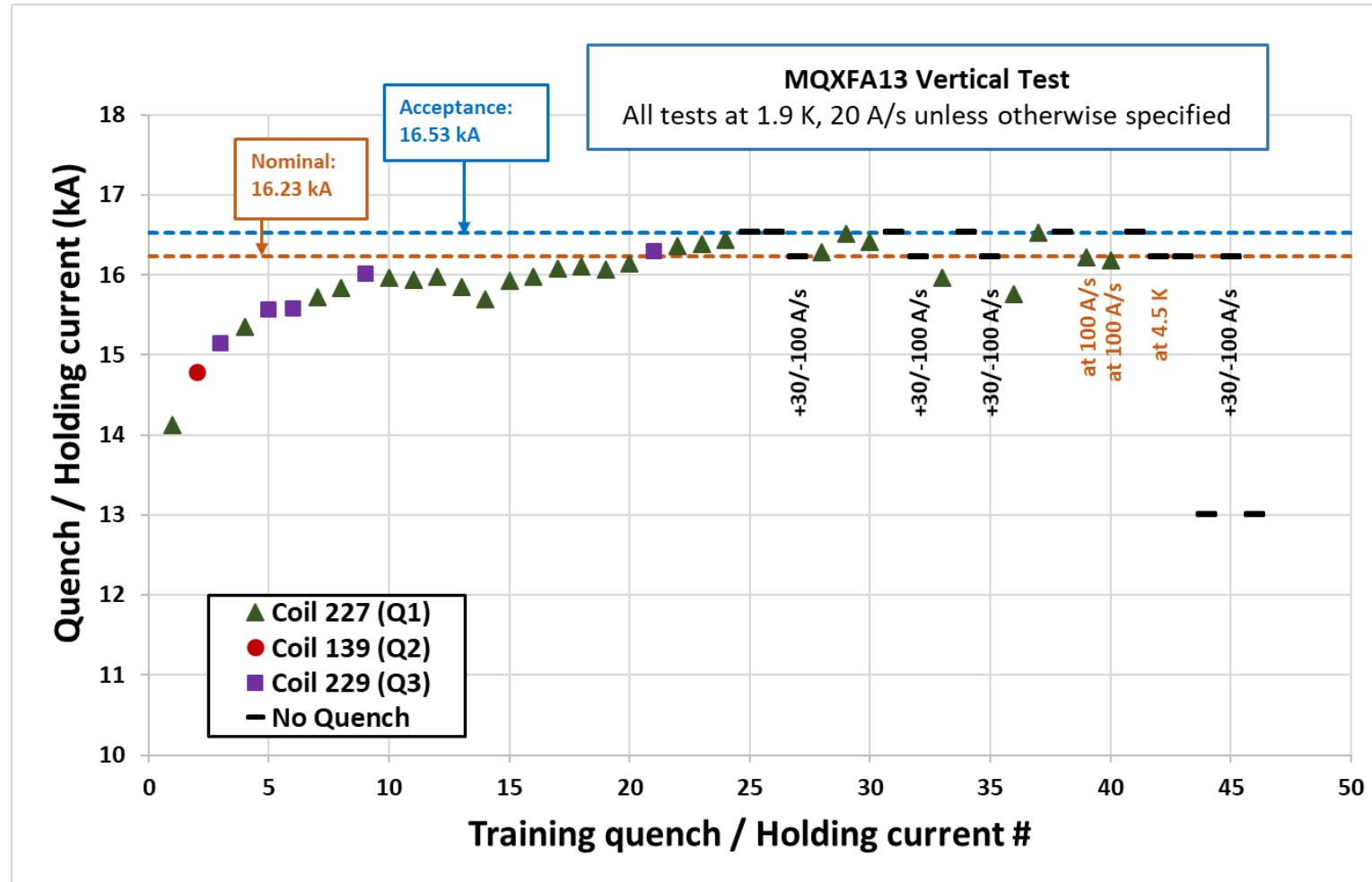


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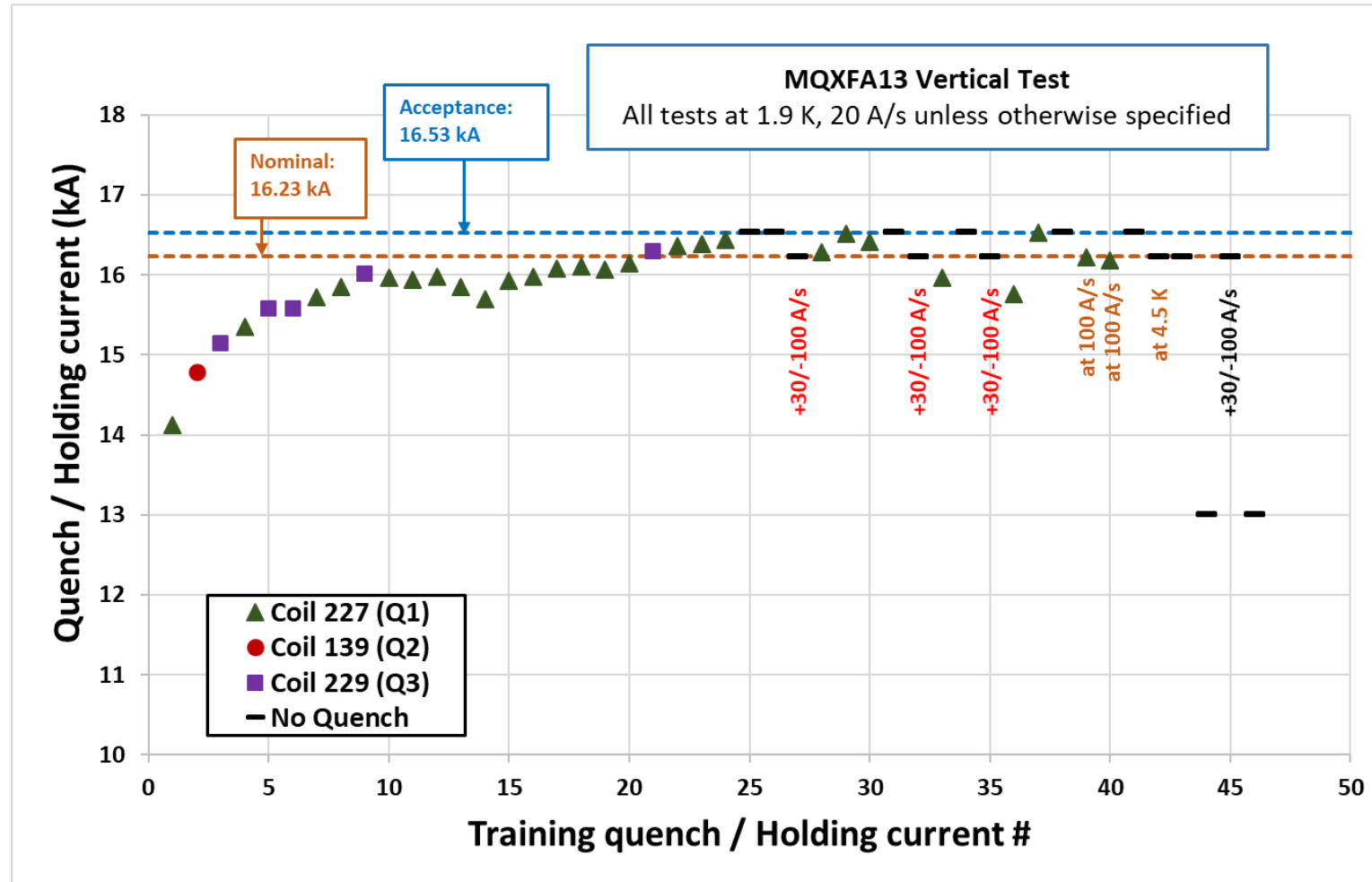
MQXFA13

- Training “typical” up to quench #9.
- Drop in quench current (315 A) between quench 10 and 14.
- Training continued from quench 15.
- Reached 16.53 kA on the 25th ramp.



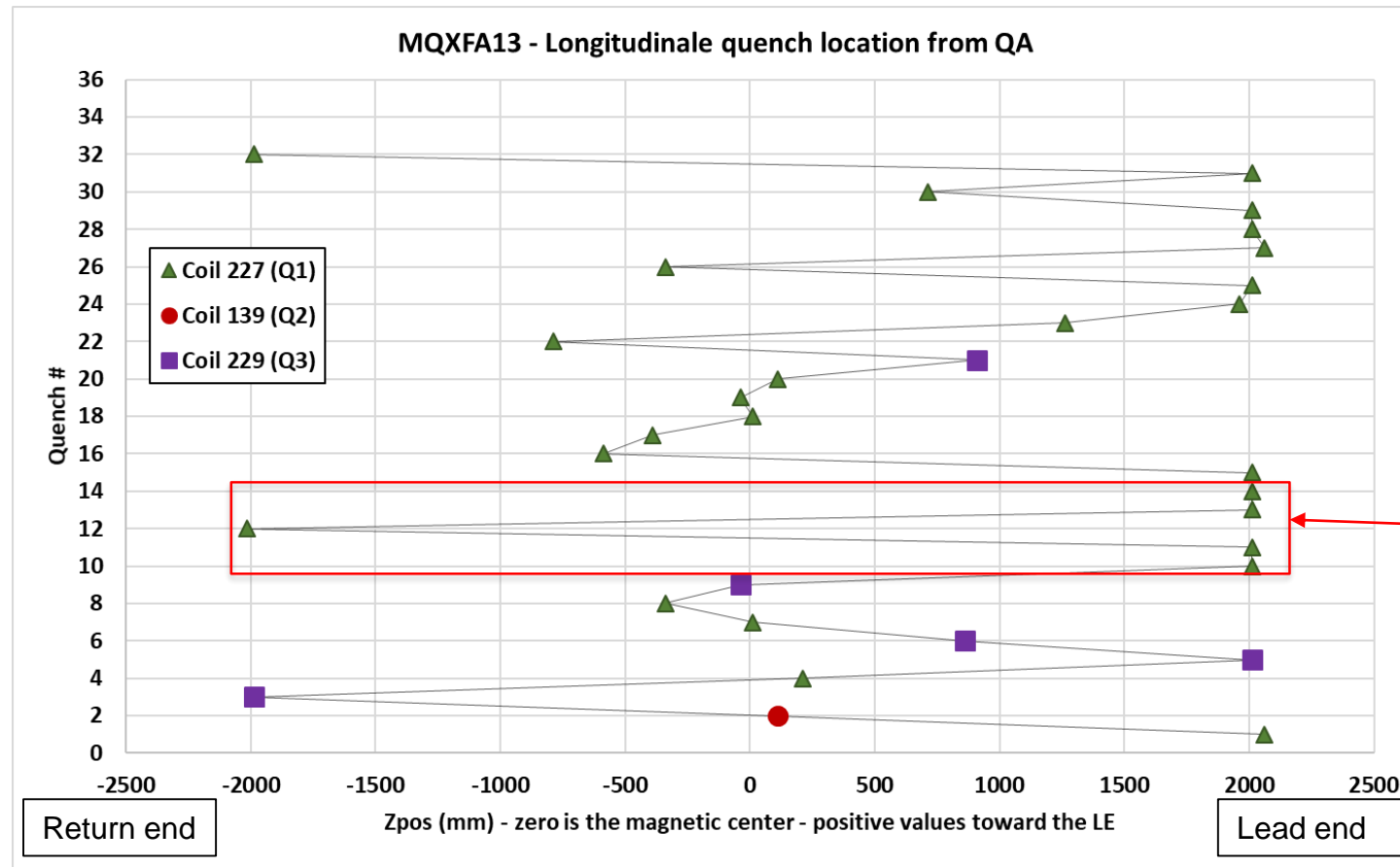
MQXFA13

- Following the ramp at +30/-100 A/s, there was a drop in quench current in the subsequent ramp at 20 A/s.
- Magnet trains back again to 16.53 kA.
- Behavior was repeatable 3 times.
- Ramps at 100 A/s showed lower quench current (16.22 and 16.21 kA).
- All these quenches occurred in coil 227 (Q1).



MQXFA13 – Quench localization from the Quench Antenna Array

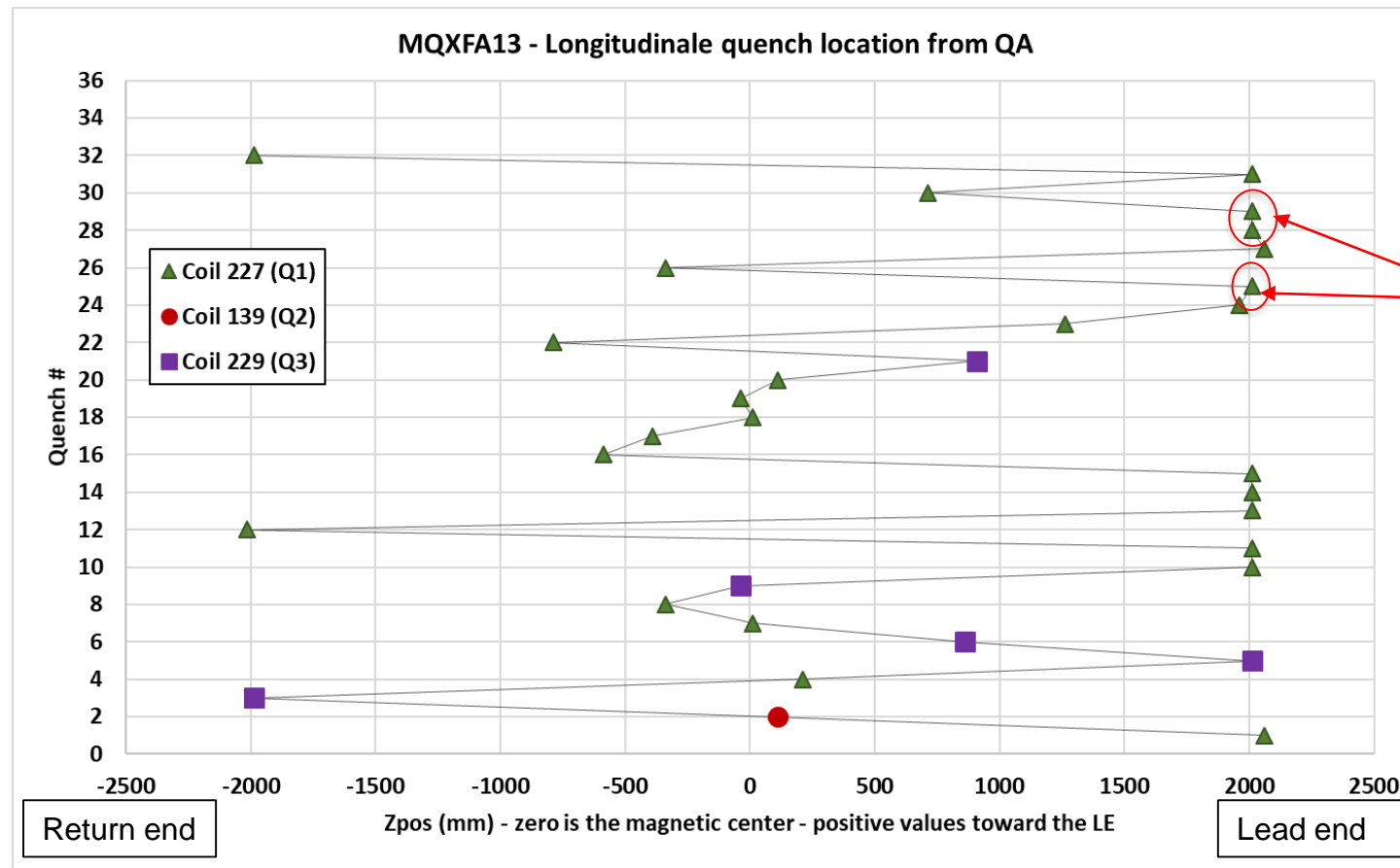
- Recurring quenches in the coil ends.



Quench 10 to 14

MQXFA13 – Quench localization from the Quench Antenna Array

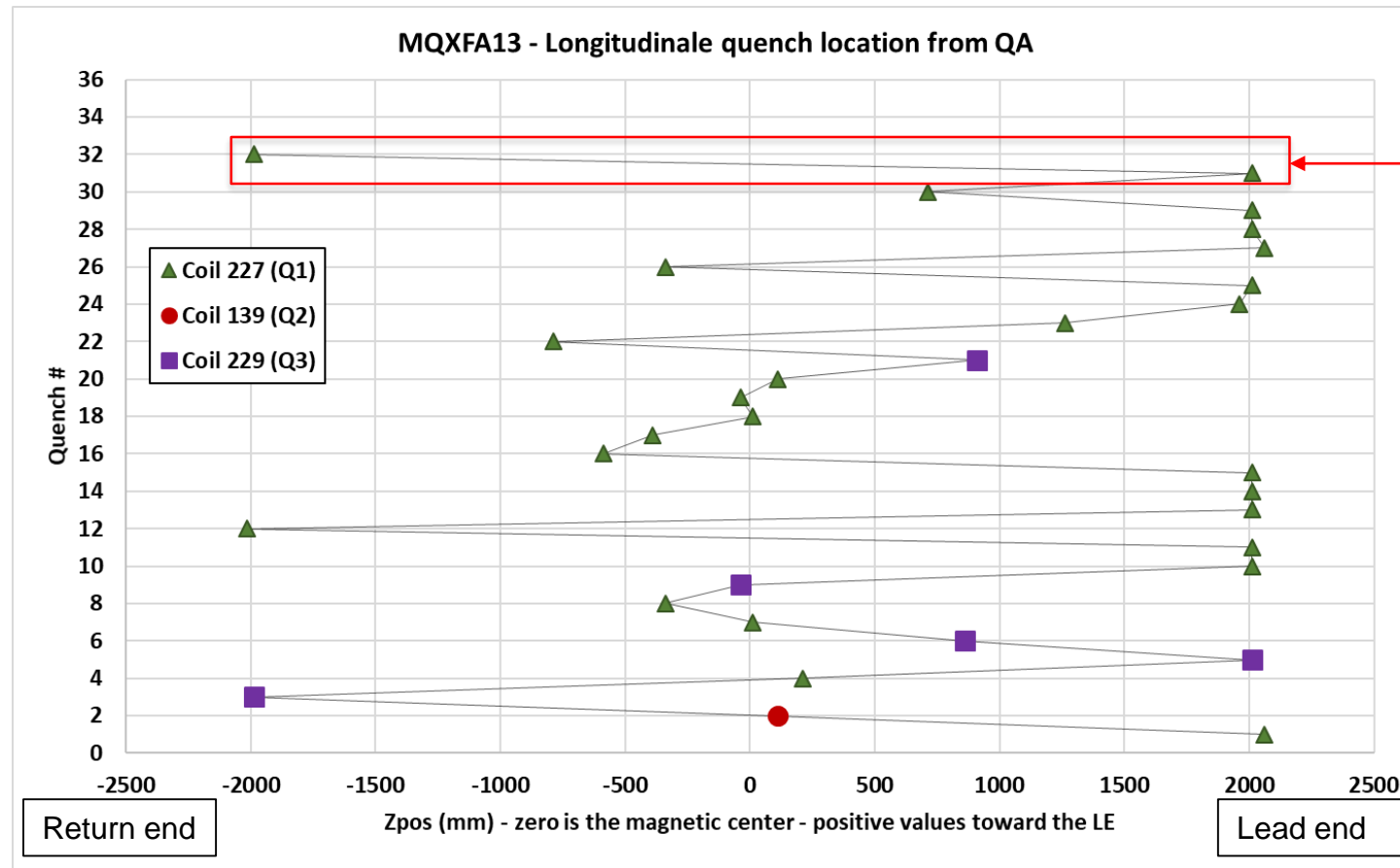
- Recurring quenches in the coil ends.



Quenches following the +30/-100 A/s ramp.

MQXFA13 – Quench localization from the Quench Antenna Array

- Recurring quenches in the coil ends.



Quenches at 100 A/s.

MQXFA13

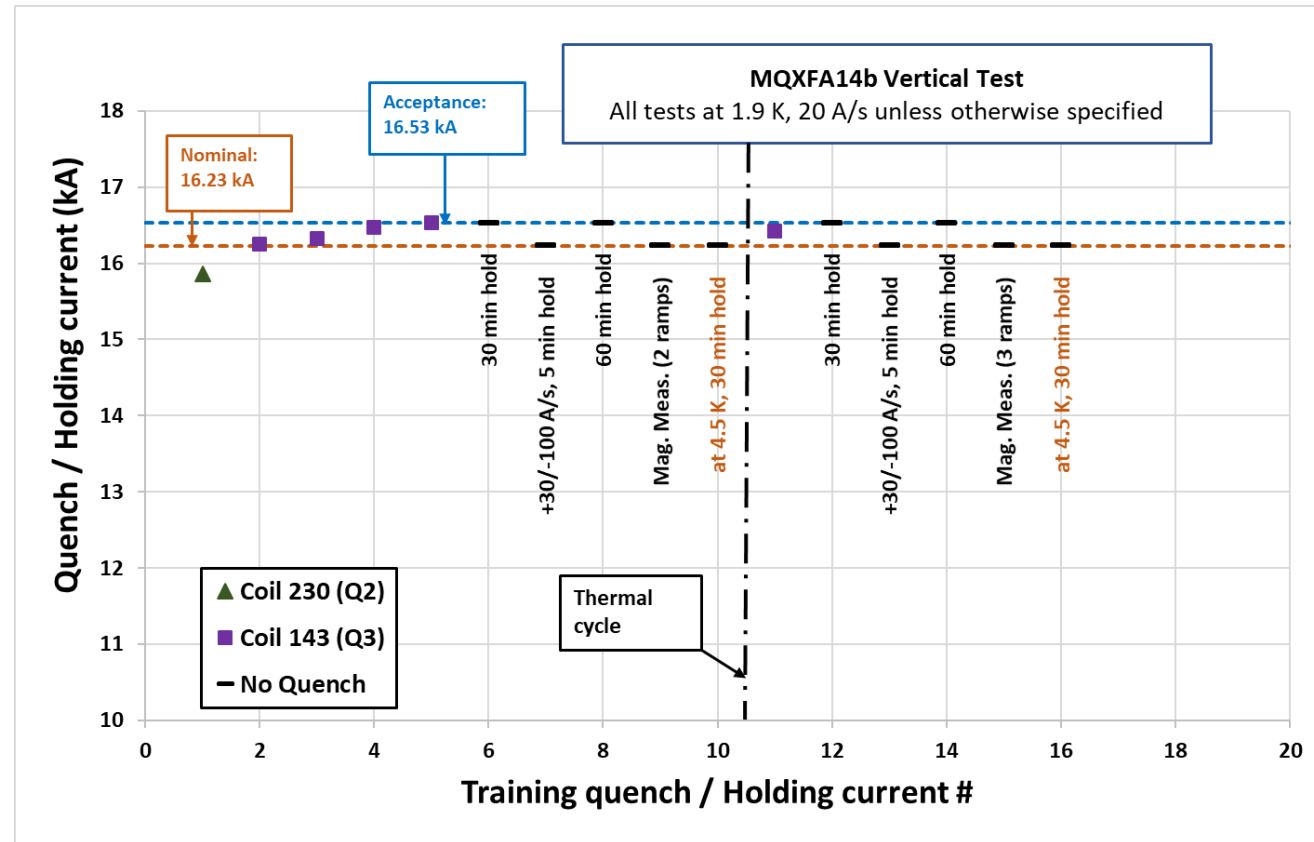
- Analysis of CMM data showed that all MQXFA13 coils had small arc-length in the ends, with coil 227 the smallest ever.
- FEM analysis of MQXFA13 as built showed risk of high strain with moderate prestress, and this issue may be prevented with higher local prestress.
- MQXFA13 test was stopped in order to replace coil 227 and avoid damage to the other coils.

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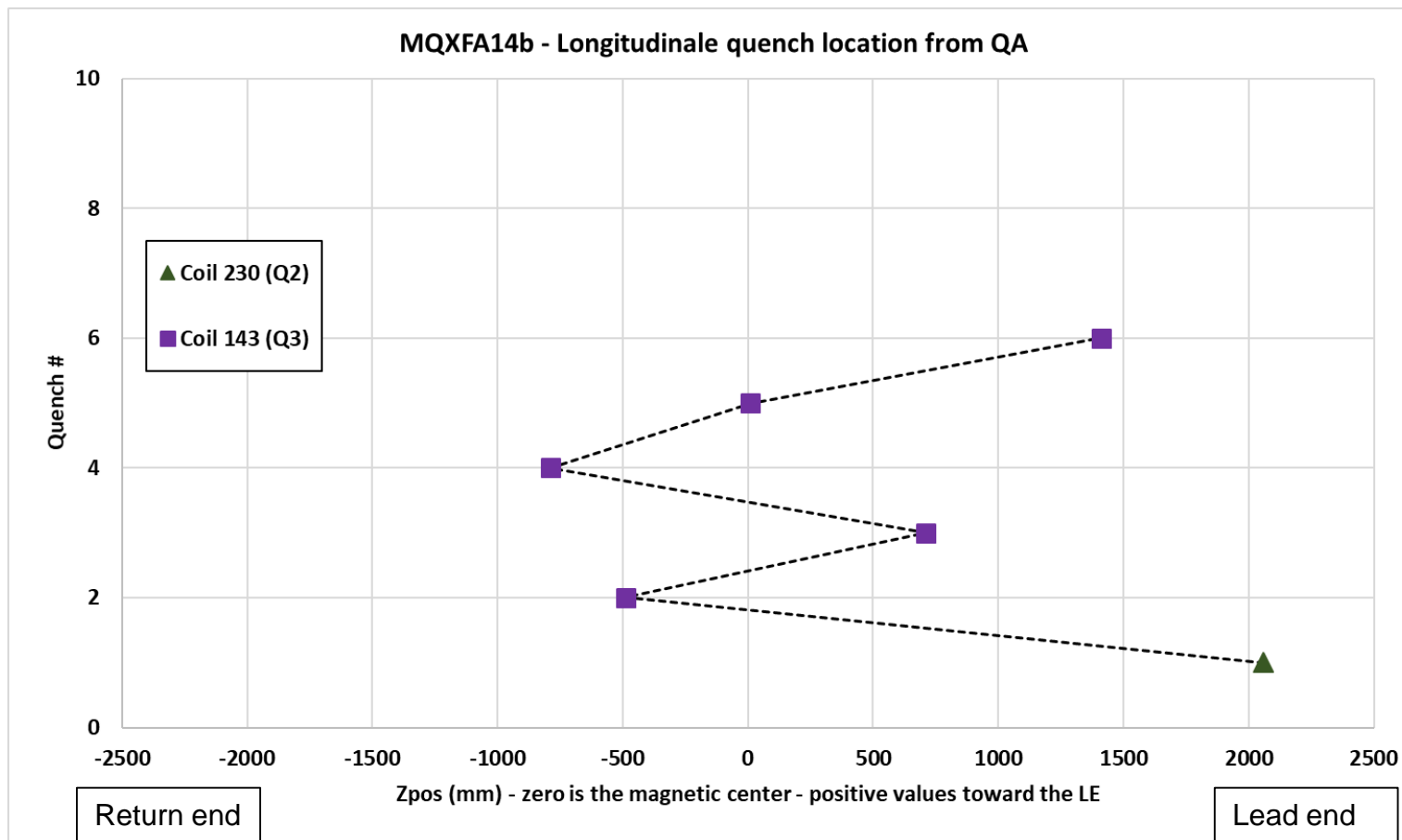
MQXFA14b

- Assembled using revised MQXFA specifications and targets.
- Achieved nominal + 300A after 5 quenches.
- All quenches except the first were in quadrant 3 (coil 143).
- After the thermal cycle
 - One quench at 16.42 kA.
 - 7 ramps without quench (2 to nominal + 300 A).



MQXFA14b – Quench localization from the Quench Antenna Array

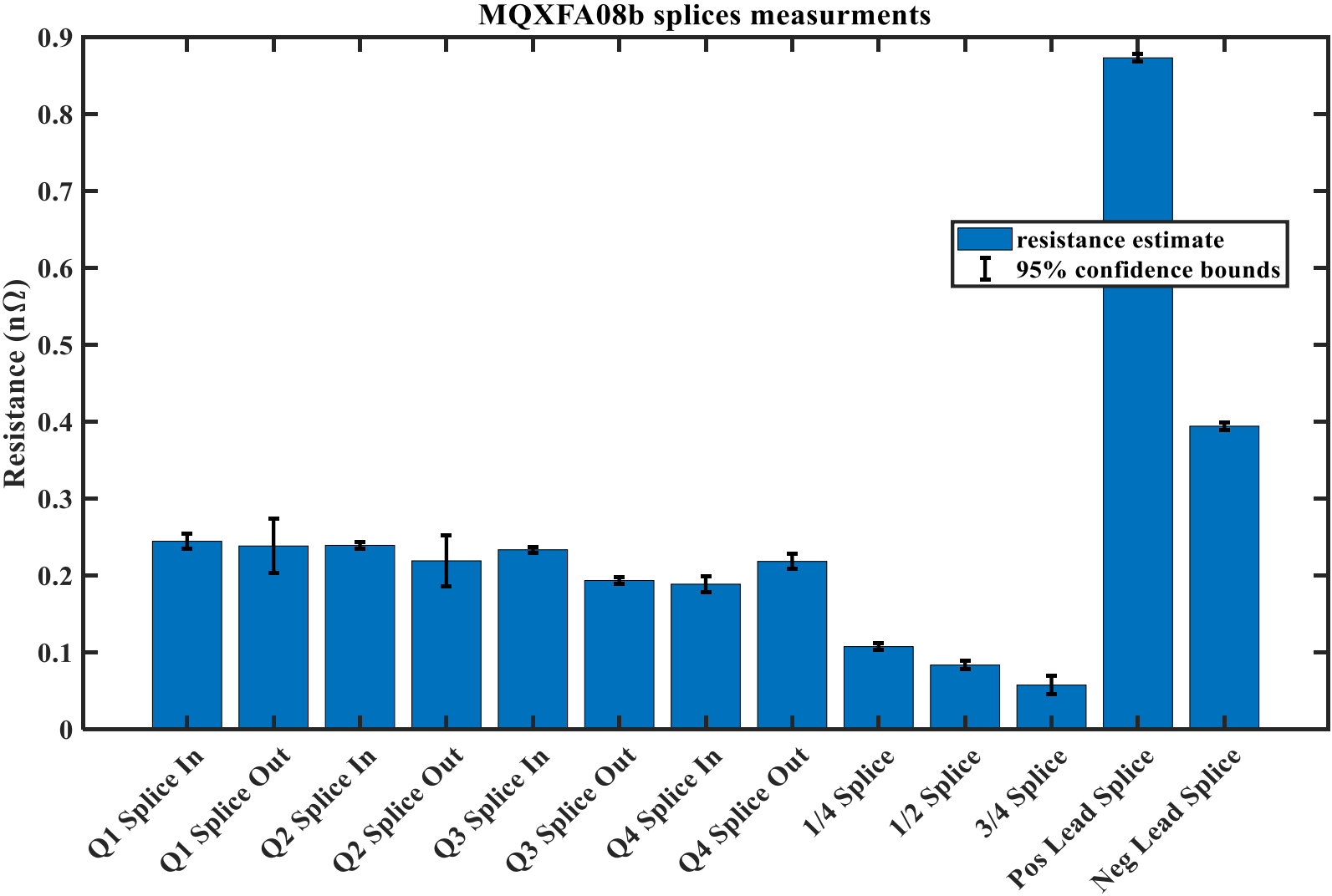
- No recurring quench location.



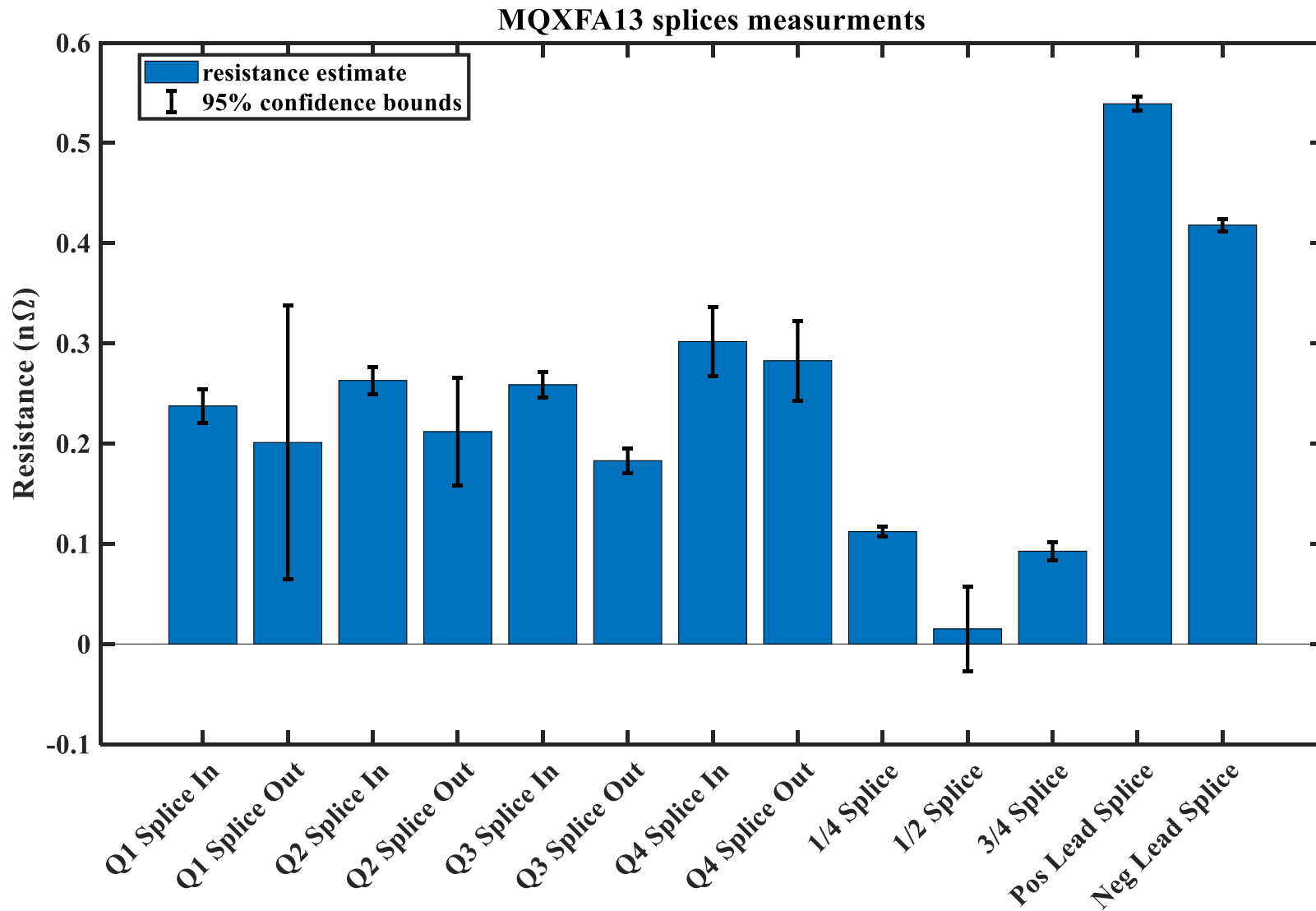
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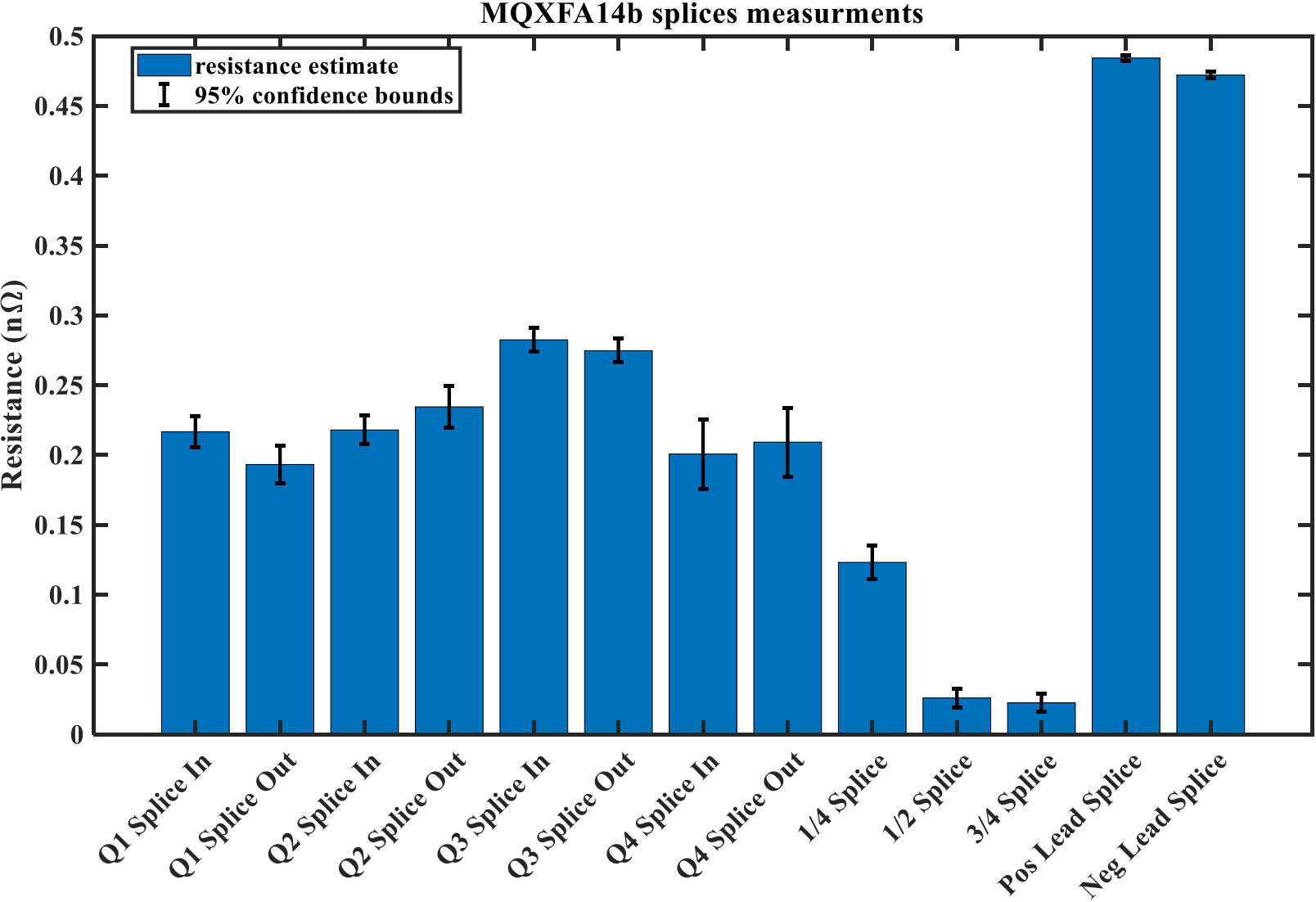
MQXFA08b – Splices measurements



MQXFA13 – Splices measurements



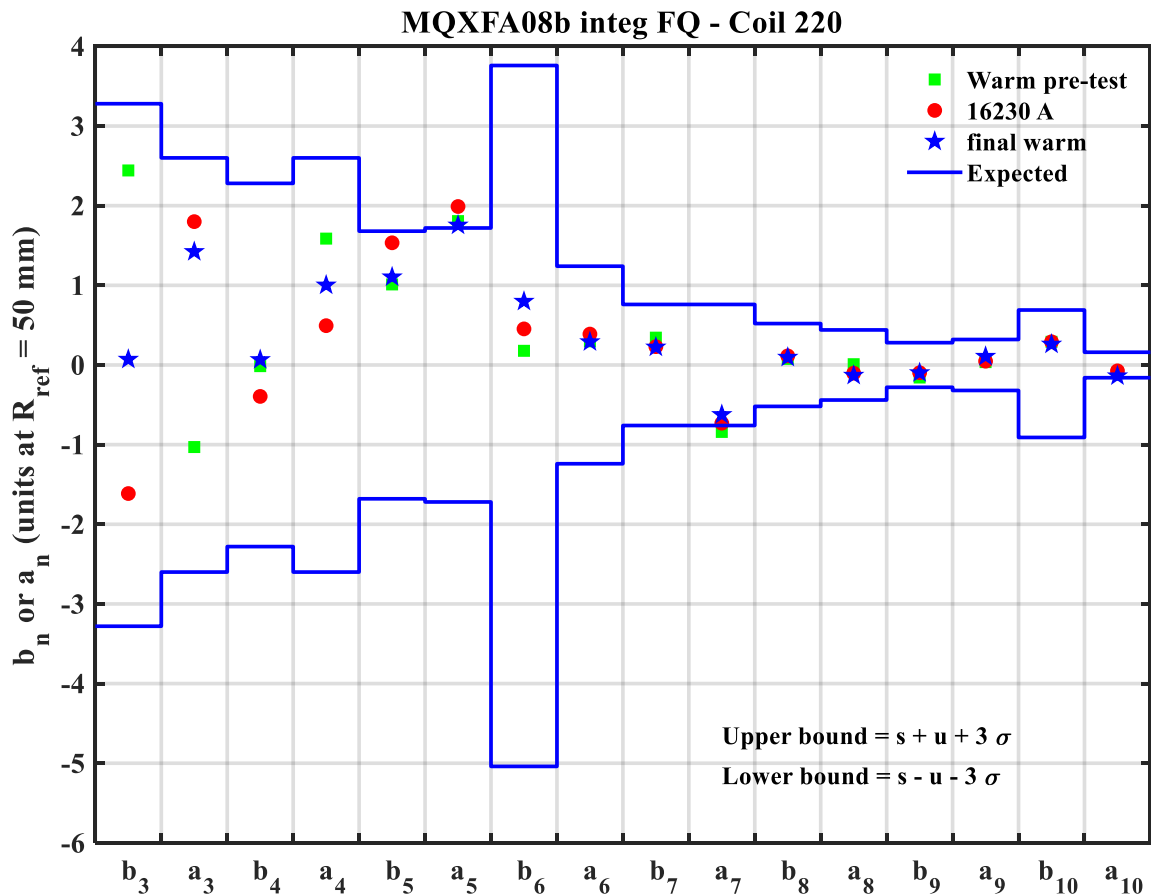
MQXFA14b – Splices measurements



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MQXFA08b

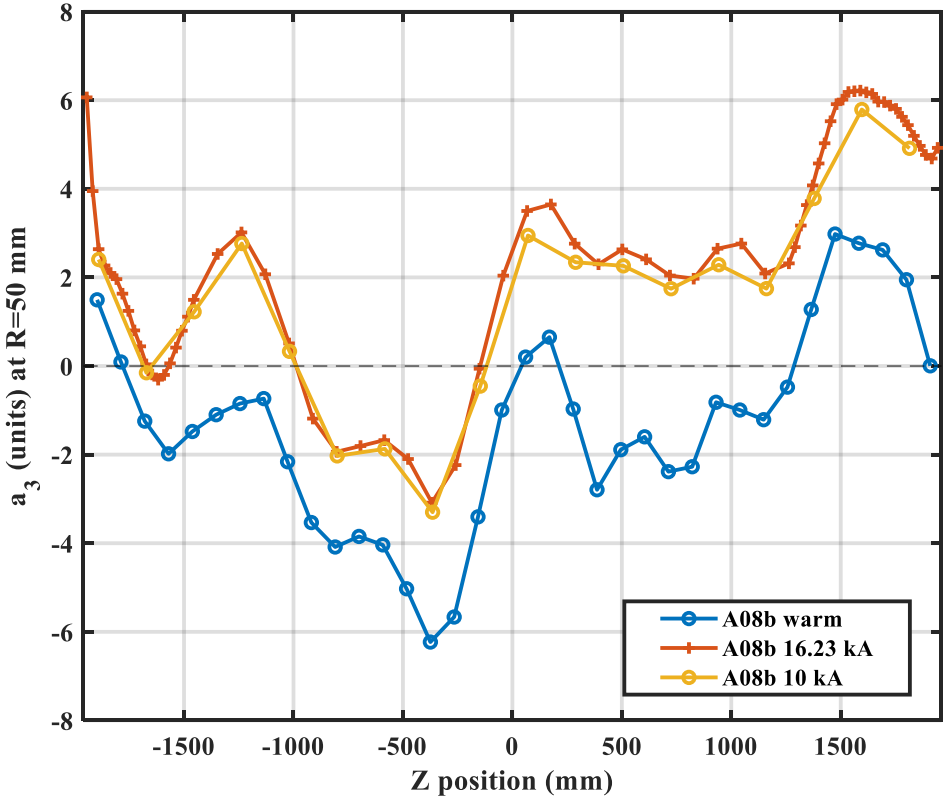
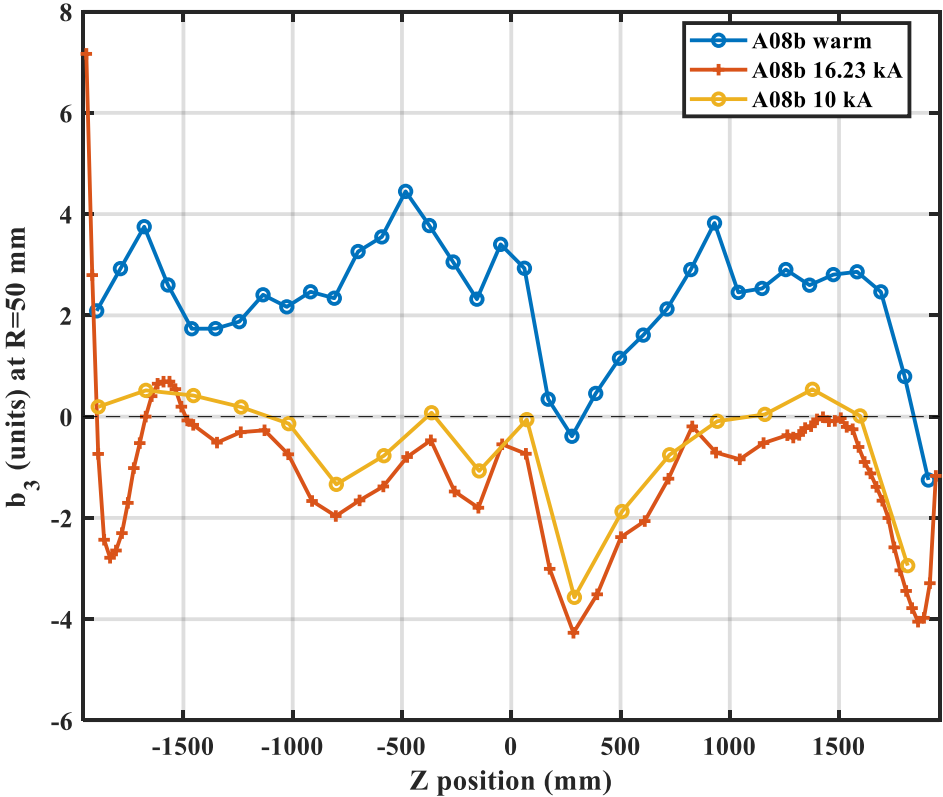


Measured integrated gradient at 16.23 kA: 562.41 T

- Mix of previously tested coil and one new coil (coil 219 in Q3).
- The field errors after loading were within the bounds, except for a_5 and a_7 that are on the boarder line.
- No magnetic shims installed.
- Change in the low order multipole from warm pre-test to cold to the final warm measurement.

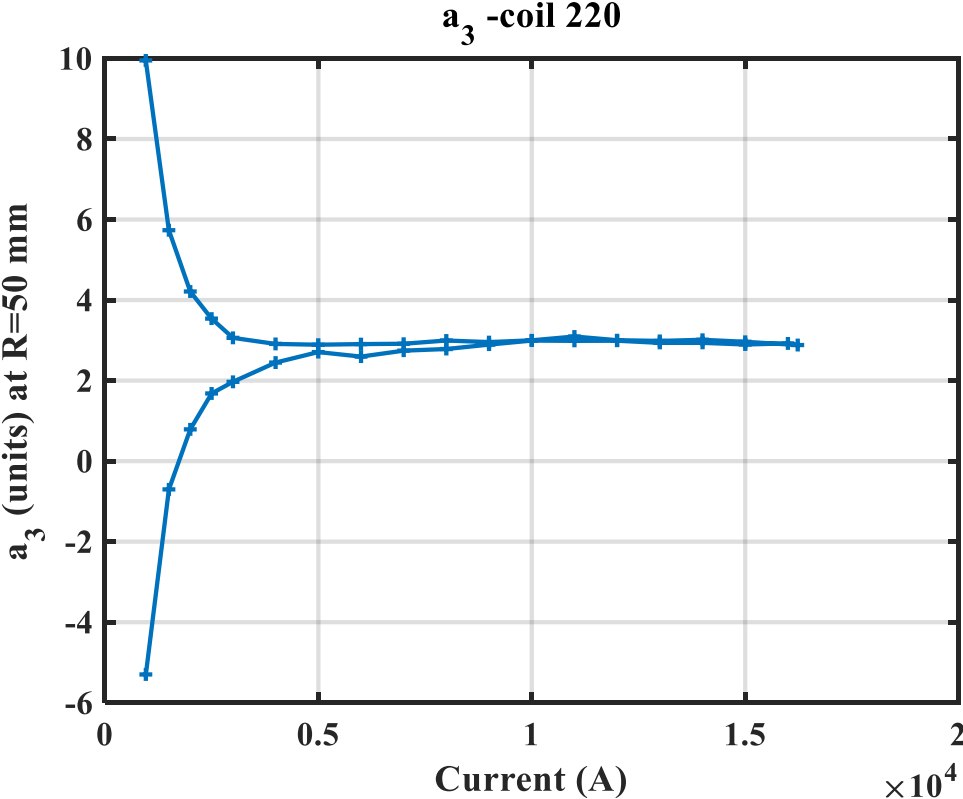
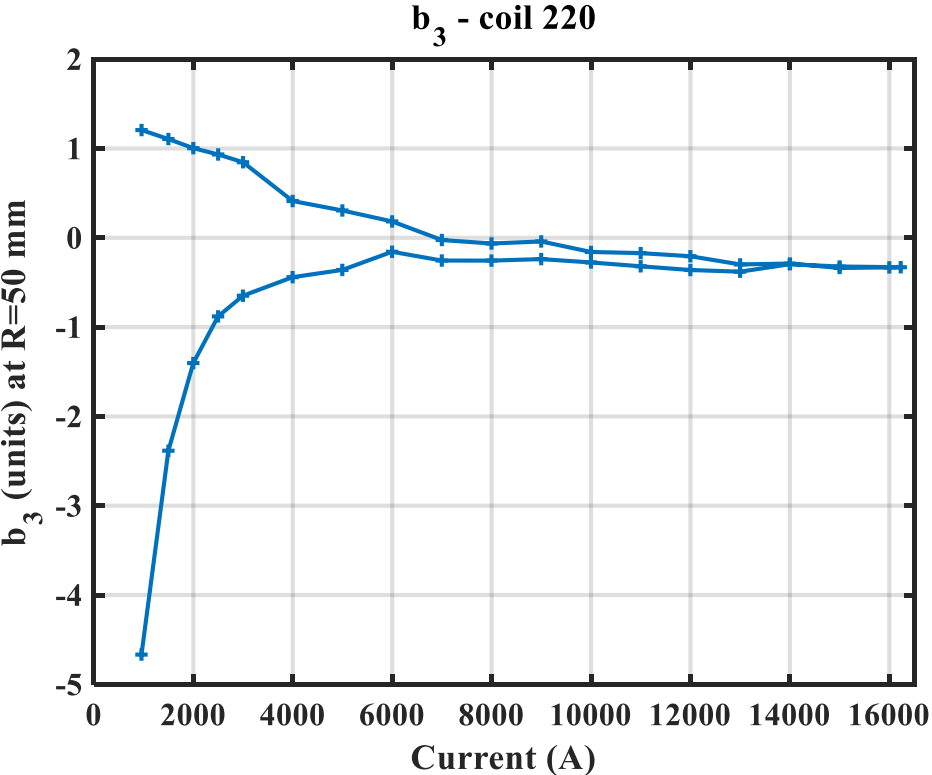
MQXFA08b

- Variation of a_3/b_3 along the length warm and cold measurements at 10 and 16.3 kA.



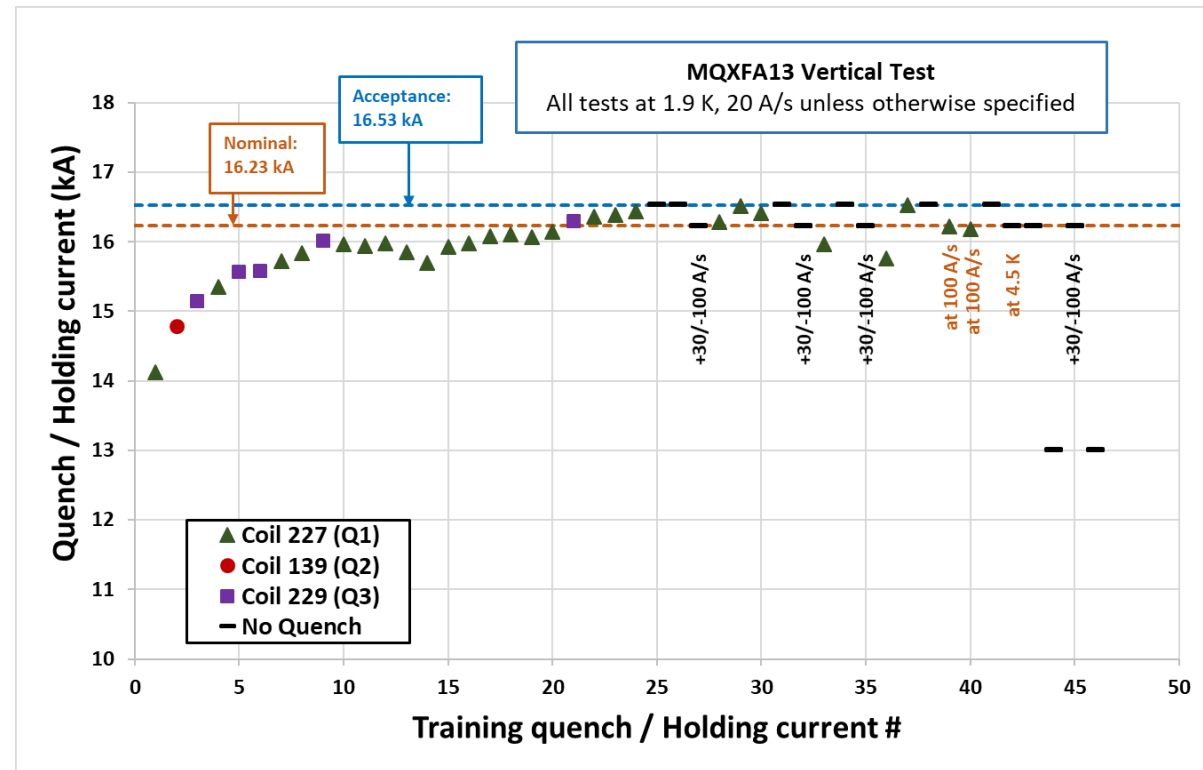
MQXFA08b

- Variation of a_3/b_3 vs current.



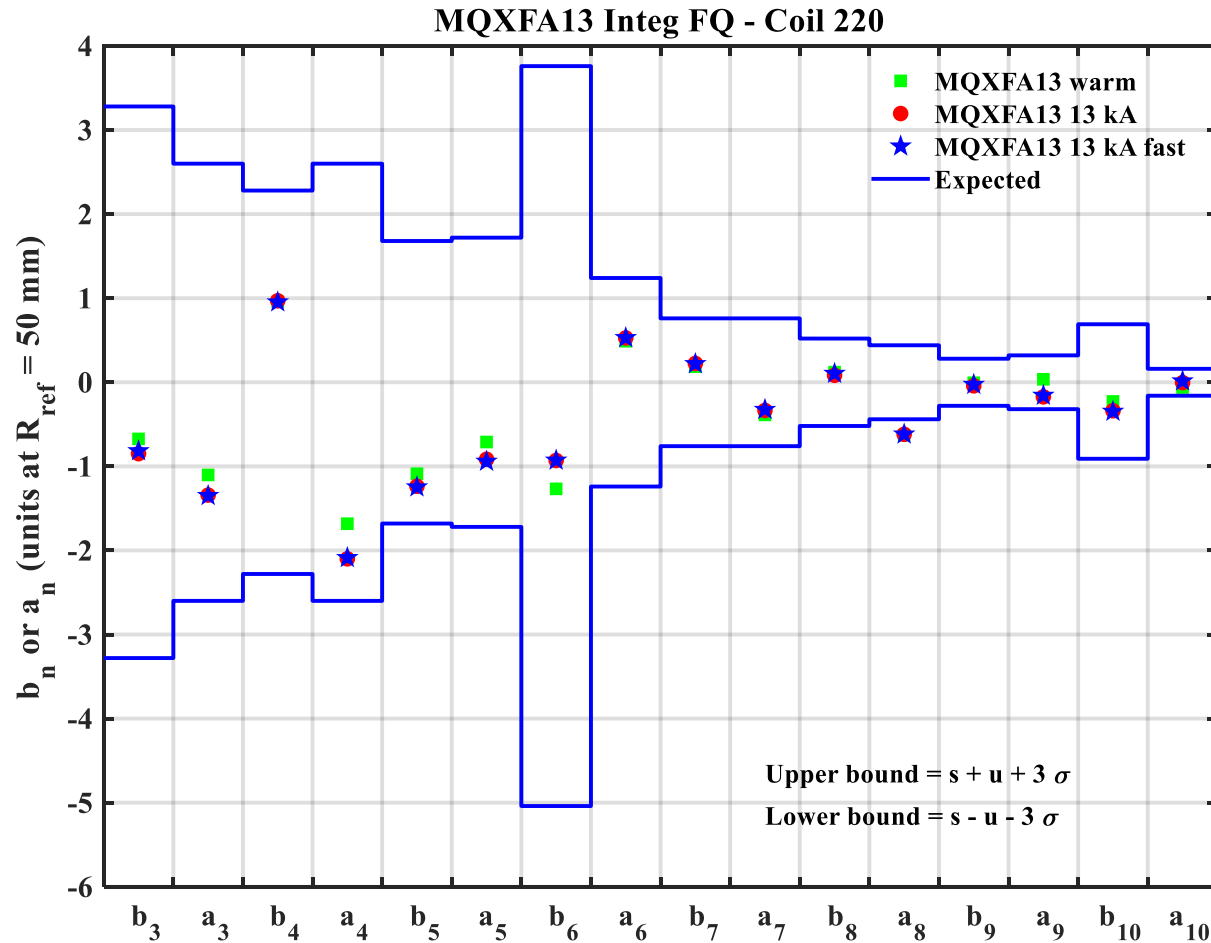
MQXFA13

- At the end of the quench tests, two sets of magnetic measurements were taken.
- The difference was in the pre-cycle:
 - 1st pre-cycle was at +/- 20 A/s.
 - 2nd pre-cycle was at +30/-100 A/s.
- The measurements were taken at 13 kA.



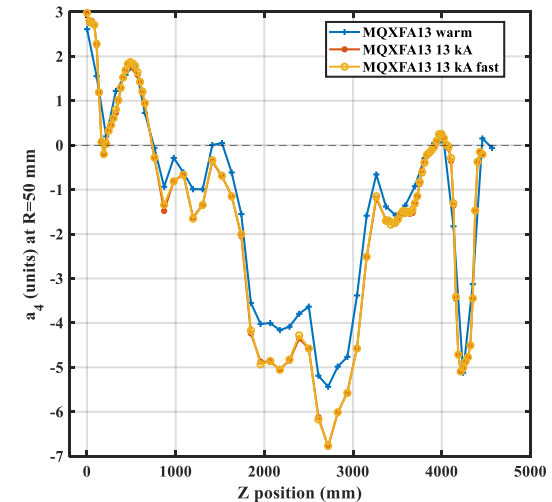
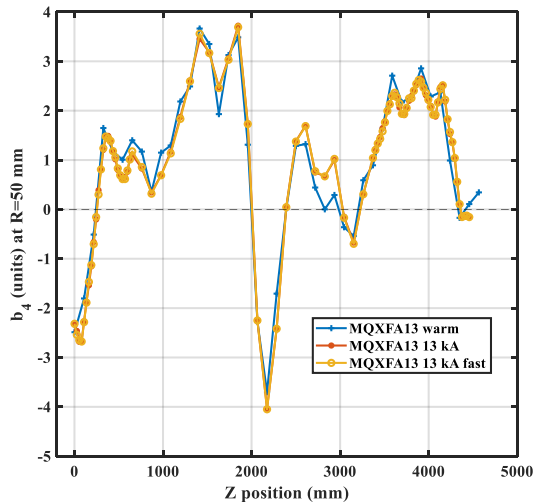
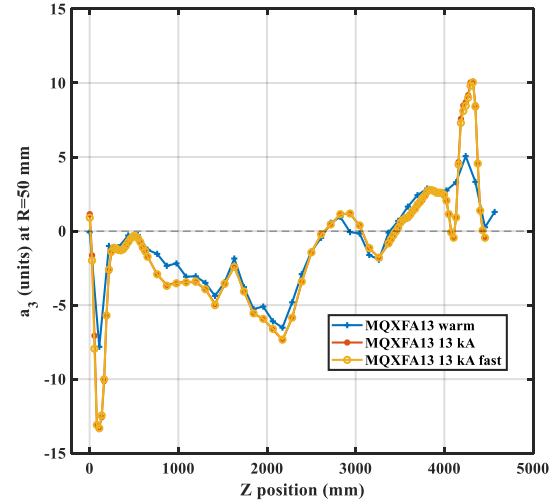
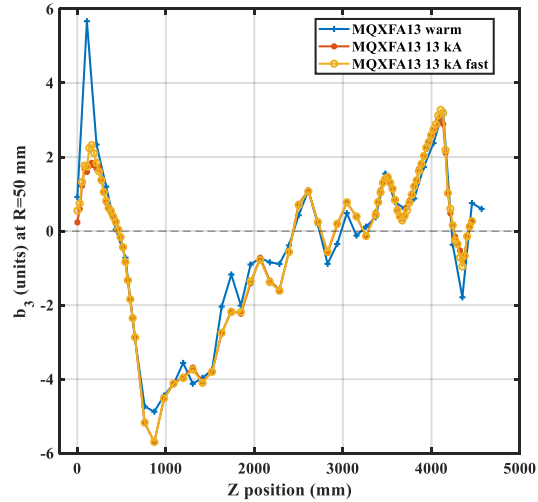
MQXFA13

- The two measurements were identical.
("fast" refers to the measurement with +30/-100 A/s pre-cycle).



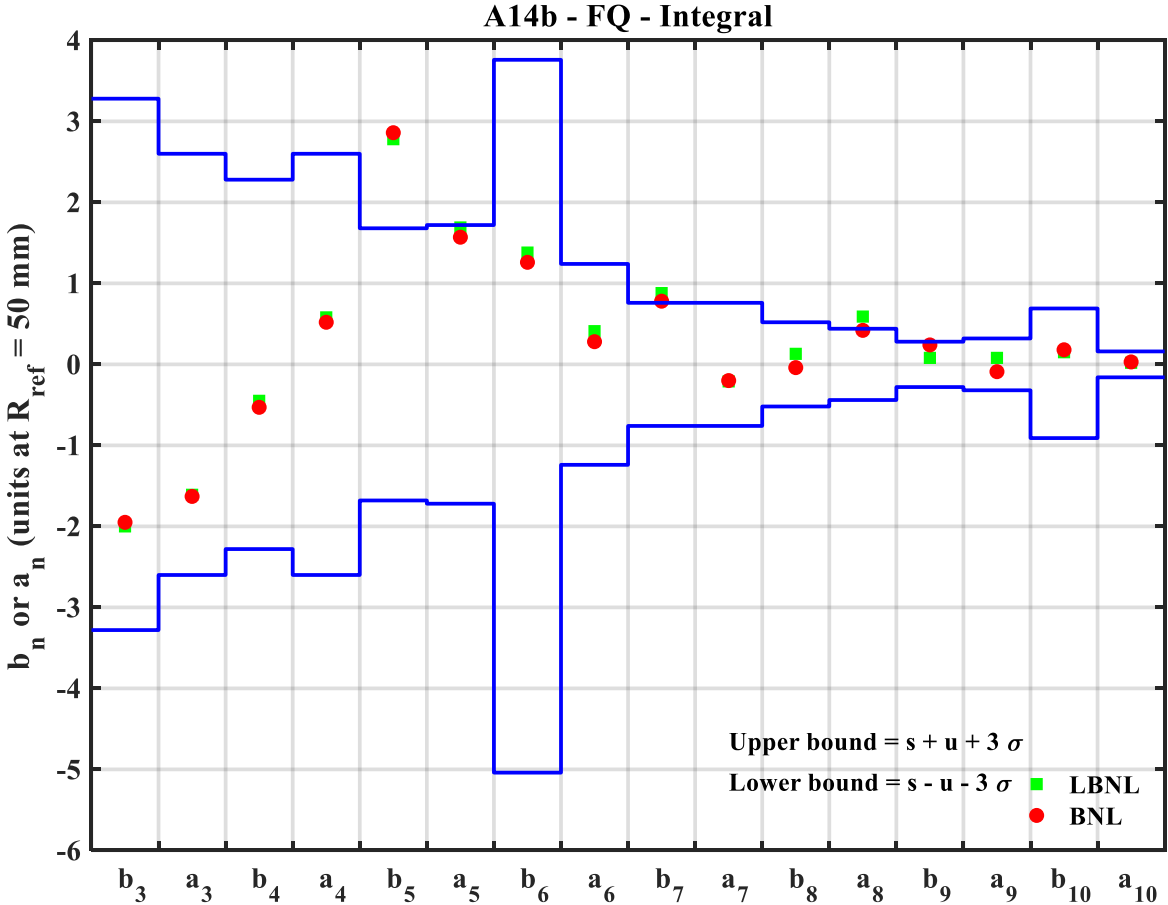
MQXFA13

- Example of the variation along the length.



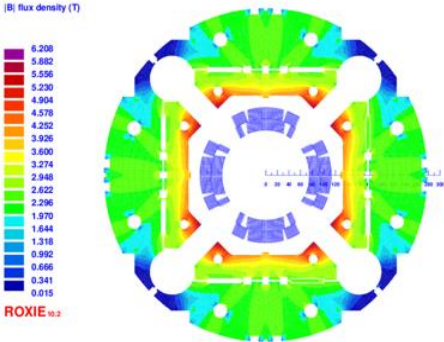
MQXFA14b

- Warm measurements and magnetic shim configuration.



Expected Correction

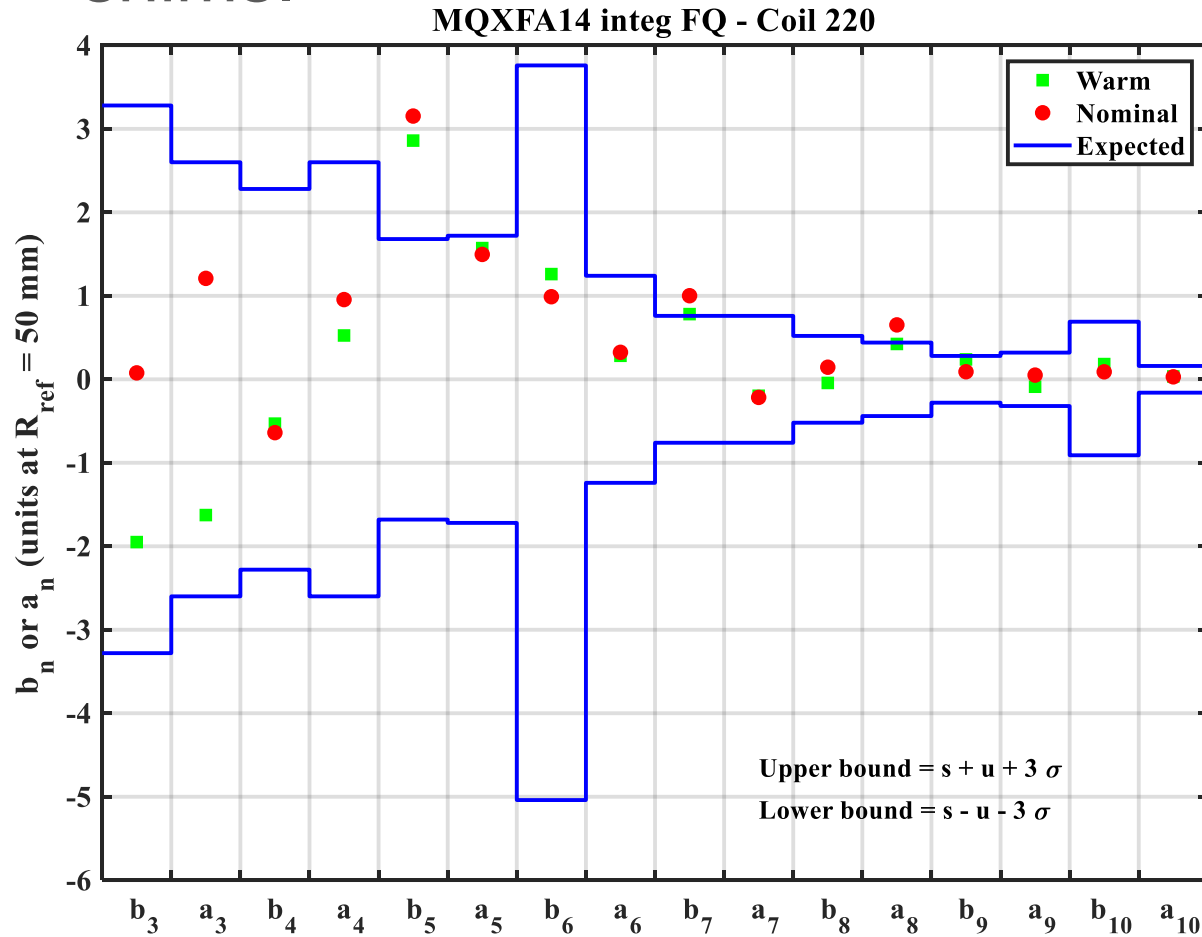
b3	1.57
b4	0.04
b5	0.08
b6	0.11
a3	2.50
a4	-0.01
a5	-0.29
a6	-0.07



- No correction of b5 – configurations that correct b5 would have a detrimental effect on other harmonics. Some improvement of b5 can be expected as an average for the cold mass (as long as b5 is not large and negative in the second magnet)

MQXFA14b

- Field quality at nominal current and change from the magnetic shims.



	Integ harmonics variation (unit)		
	Measured	Expected	Difference
b3	1.83	1.57	-0.26
a3	2.82	2.50	-0.32
b4	-0.06	0.04	0.10
a4	0.37	-0.01	-0.38
b5	0.38	0.08	-0.30
a5	-0.05	-0.29	-0.24
b6	0.77	0.11	-0.66
a6	0.06	-0.07	-0.13

**Measured integrated gradient
at 16.23 kA: 563.14 T**

Summary

- MQXFA08b:
 - First successful test of an MQXFA magnet after replacing a coil.
 - All quenches occurred in the new coil.
- MQXFA13:
 - Test stopped for replacing the coil showing ramp-rate dependence.
- MQXFA14b:
 - Assembled with revised specs and pre-load targets.
 - 5 quenches to reach acceptance current.
- Magnetic field measurements:
 - Field quality generally within the expected bound.
 - Correction from the magnetic shims in A14b in agreement with calculated values.
- All cold and warm high voltage withstand tests were successful.
- All magnet splices are less than 0.5 nΩ.

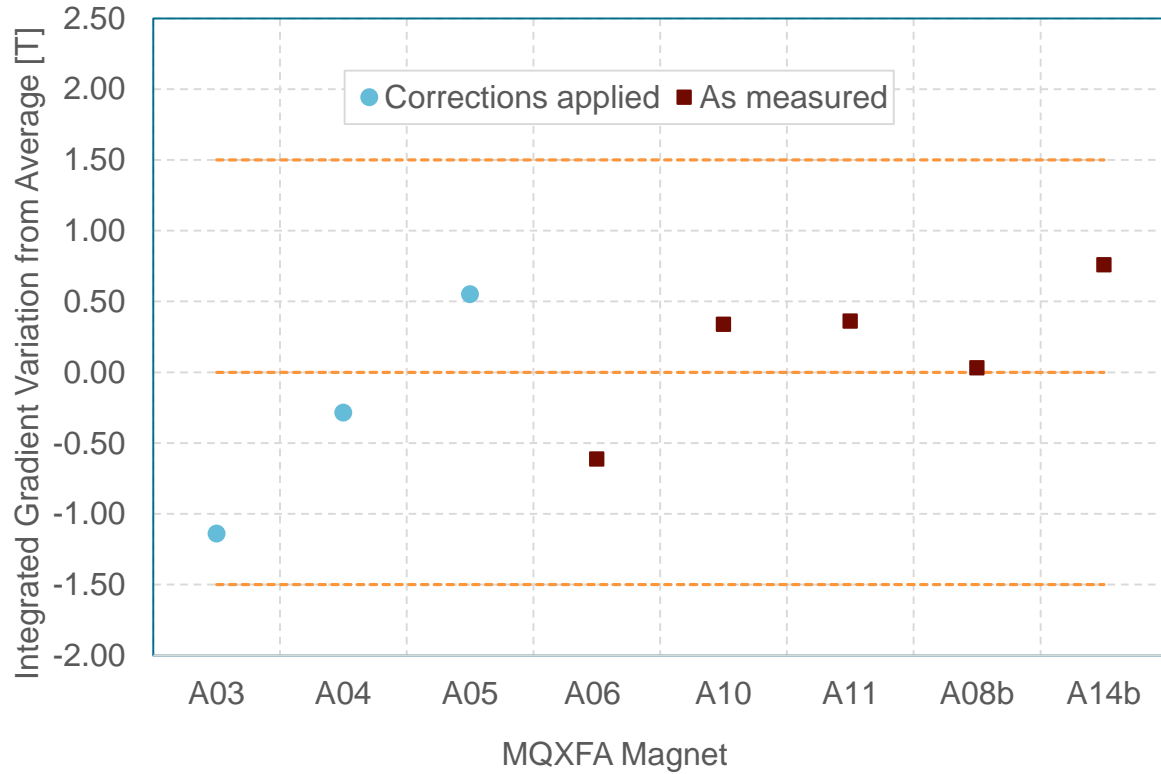
THANK YOU



Additional slides

Integrated Gradient and Field Quality

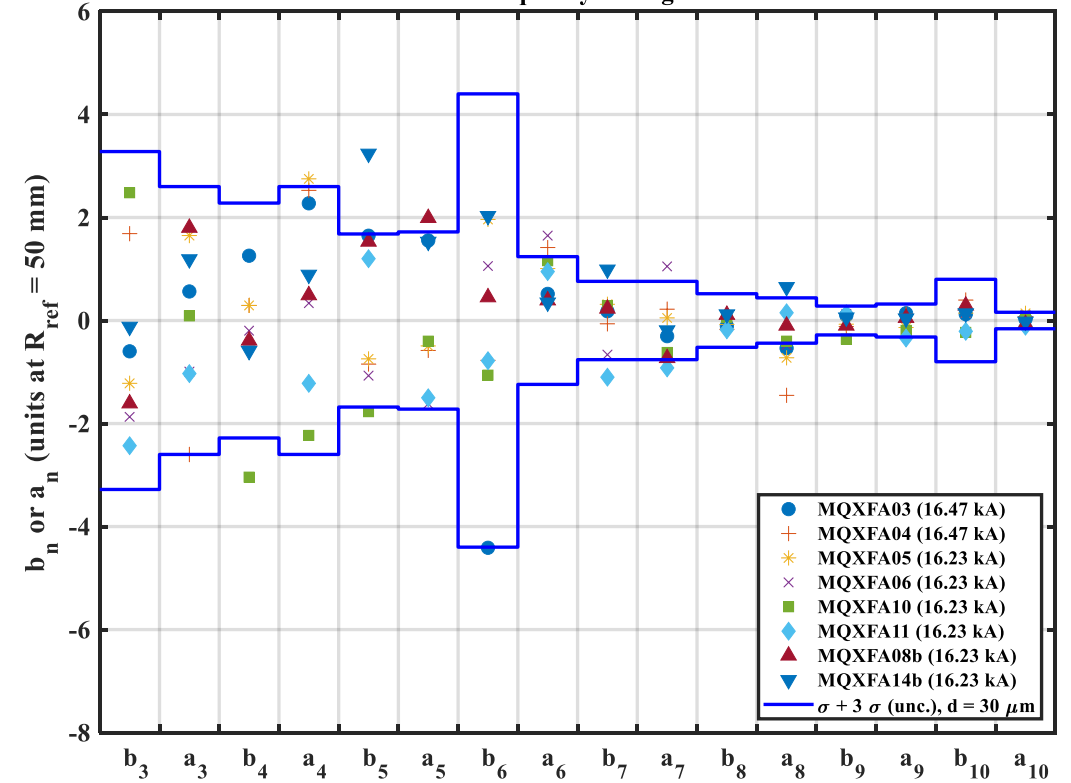
Integrated Gradient Variations in MQXFA Models



Average integrated gradient at 16.23 kA: 562.38 T

Correction factors applied to account for measurements taken at different currents as well as changes in the measurement setup and coil design.

Field quality - Integral



Field Quality – All tested magnets

