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HQ02
Assembly summary and Next steps

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The HQ02 Team

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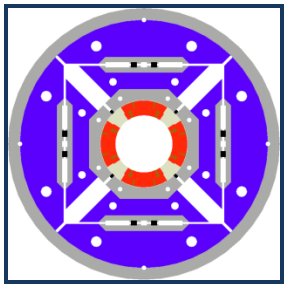
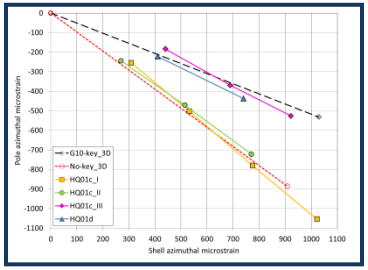
Outline



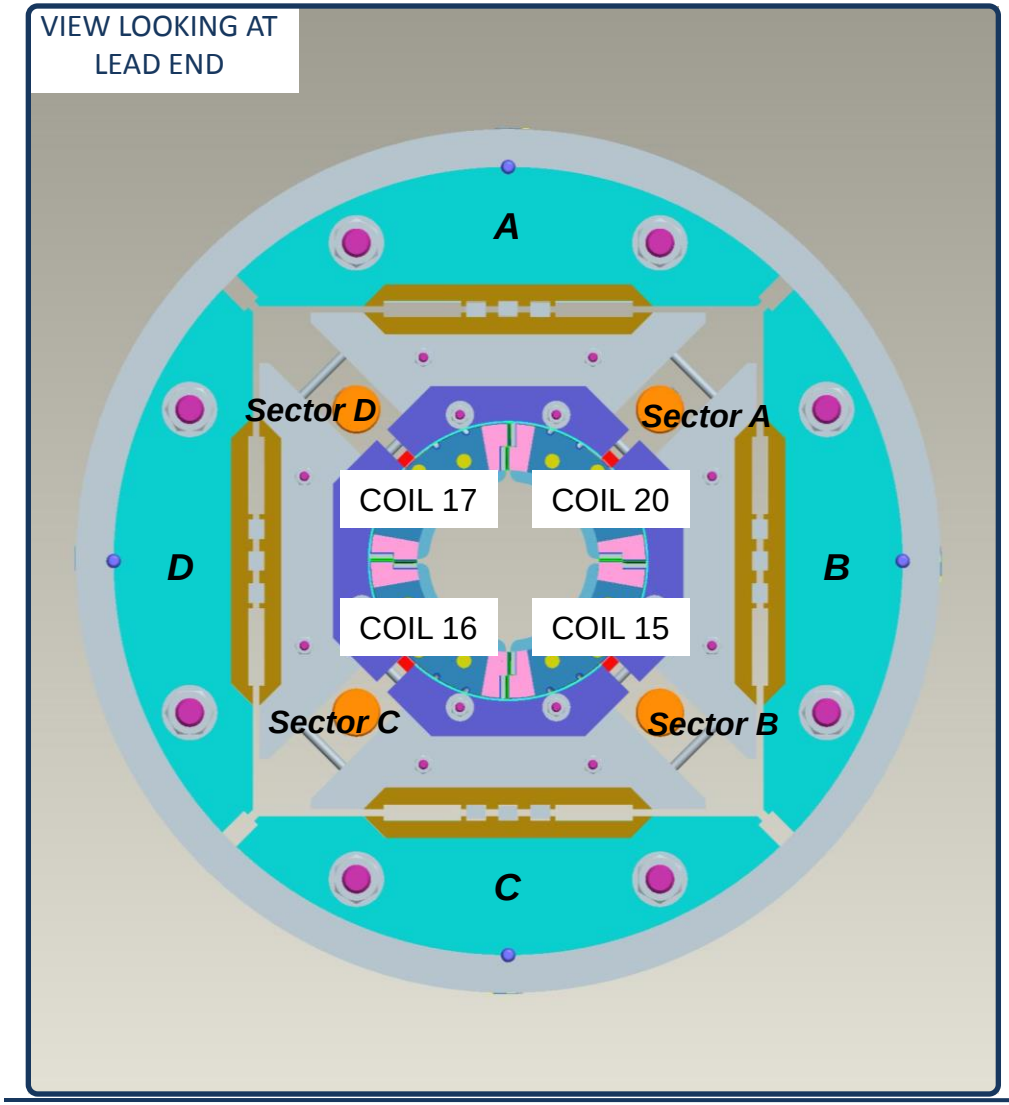
- Magnet Overview



- HQ02 Assembly Summary

- Next steps

HQ02 layout



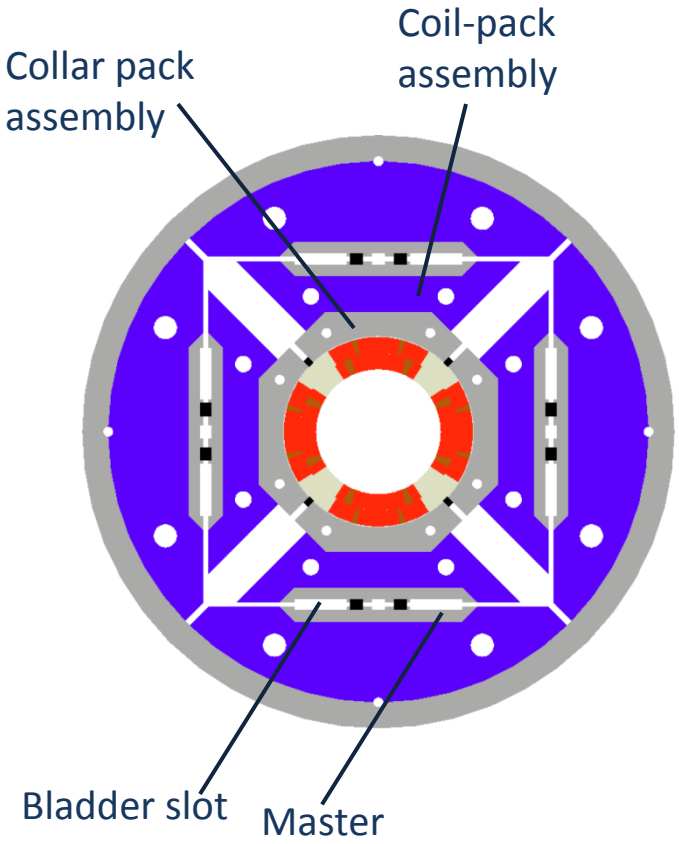
- "New" generation of HQ coils:
  - Coil 15, 16, 17 and 20
  - 108/127 conductor
  - SS core
  - 14.77 mm x 1.376 mm smaller cable
  - 1 spare coil in fabrication: coil 21
- *See Franck Borgnolutti's talk about HQ coil fabrication experience*
- Electrical sequence:
  - (-) 16 – 17 – 15 – 20 – (+)

HQ02 magnet parameters

- Based on extracted strands measurements from BNL and LBNL
- Coil 15, 16, 17 and 20 => 17 is the limiting coil
- Jc values at 12 T and 4.2 K with SF correction range from 2914 to 3098 A/mm^2

	HQ01e		HQ02	
	4.3 K	1.9 K	4.5 K	1.9 K
Typical I_{ss}	17.3 kA	19 kA	16.5 kA	18.26 kA
Gradient at I_{ss}	195 T/m	213 T/m	186 T/m	205 T/m
Peak Field at I_{ss}	13.6 T	14.8 T	13 T	14.2 T
Stored energy at I_{ss}	0.9 MJ	1.1 MJ	0.8 MJ	1 MJ
Fx per octant per unit length at I_{ss}	2.7 MN/m	3.15 MN/m	2.4 MN/m	2.9 MN/m
Fy per octant per unit length at I_{ss}	-3.9 MN/m	-4.7 MN/m	-3.5 MN/m	-4.3 MN/m
Fz per magnet end at I_{ss}	1.06 MN	1.28 MN	0.96 MN	1.18 MN

Structure and assembly steps overview



Collar-pack assembly

- 4 collars bolted against the full length G10 keys
- Shimming of the alignment key to ensure contact between collar and keys

Coil-pack assembly

- 4 pads bolted around the collars

Final assembly and loading

- Master/bladders and Keys stack is prepared based on coil-pack assembly
- Insertion of the coil-pack in the yoke shell sub-assembly by sliding on the bottom masters
- Insertion of the side and top masters
- Masters include load keys and bladders + pull shims

Key parameters we watched

- Preload distribution
- Alignment: collar and key must be in contact
- Preload uniformity among coils

Preload uniformity
Coil Dimensions (LBNL CMM)

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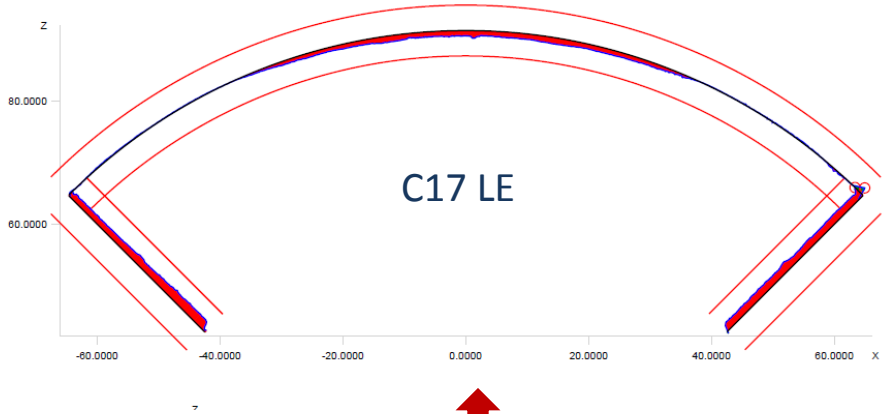
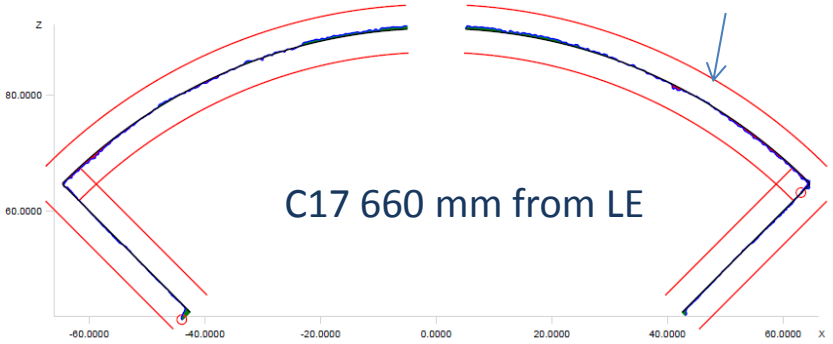
Example of HQ 17 "new generation"

+250 μm
~ 0.010"

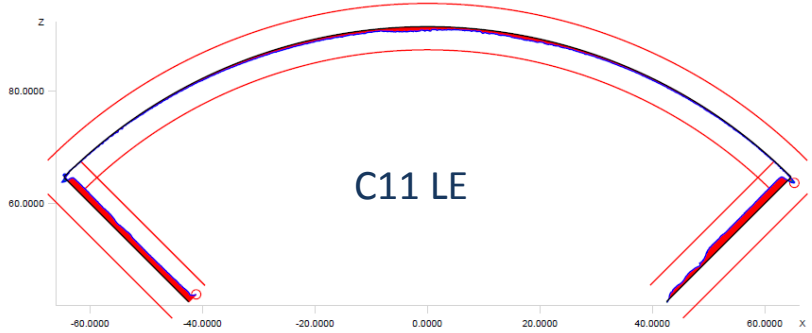


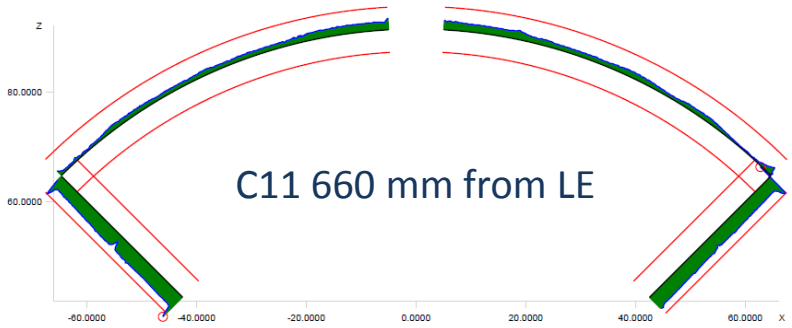


End-shoe shows same dimension

New coils much closer to nominal size

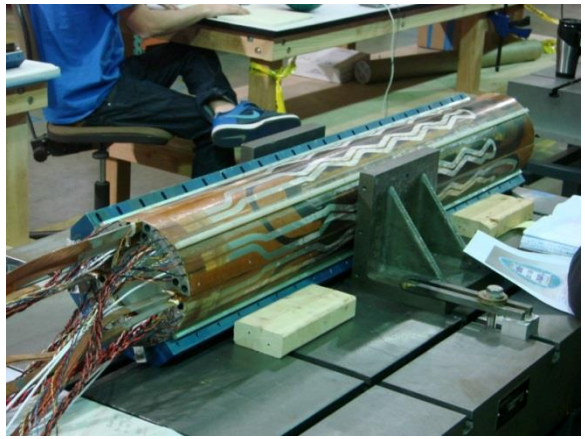
Example of HQ 11 "old generation"



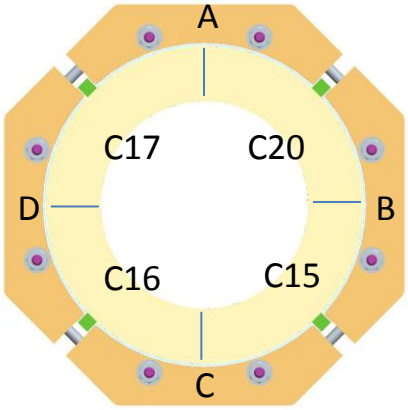


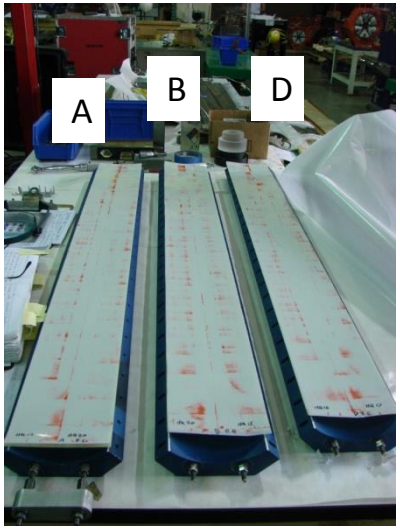
Preload uniformity
Fuji paper test

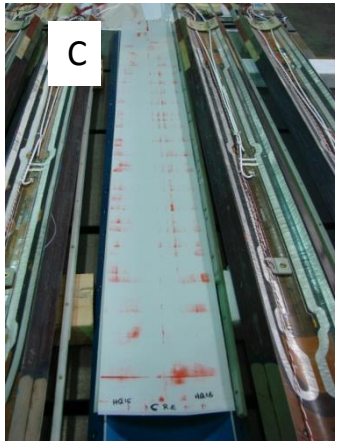
Collar-pack #1 used to assess radial shimming



- Radial shims chosen based on coil CMM measurements
- Fuji paper positioned radially
- Strain Gauge monitoring



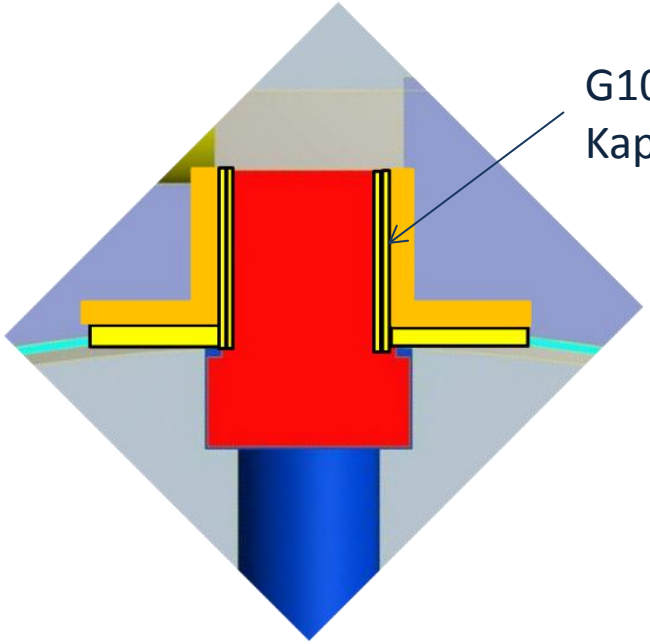


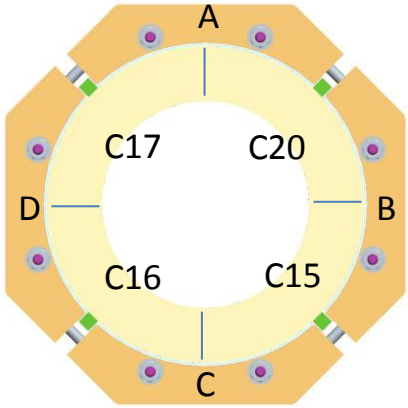


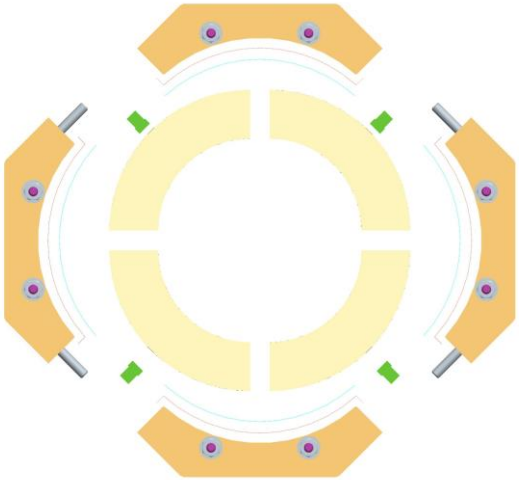
- Led to ground plane insulation scheme
  - G10: 500 μm
  - Kapton: 250 μm
  - Effective stack: 700 μm

Alignment

Collar-pack #2 and 3# used to assess pole key shimming







- Measurements with pins and feeler gauges to insure contact between keys and collars

Preload
Motivation for conservative targets

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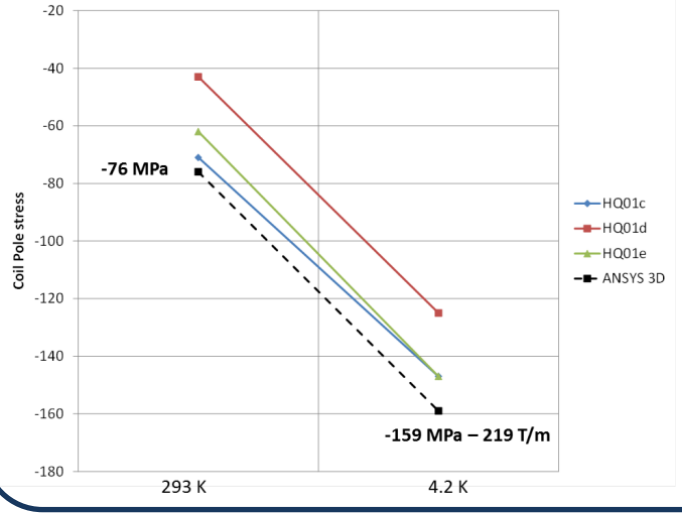
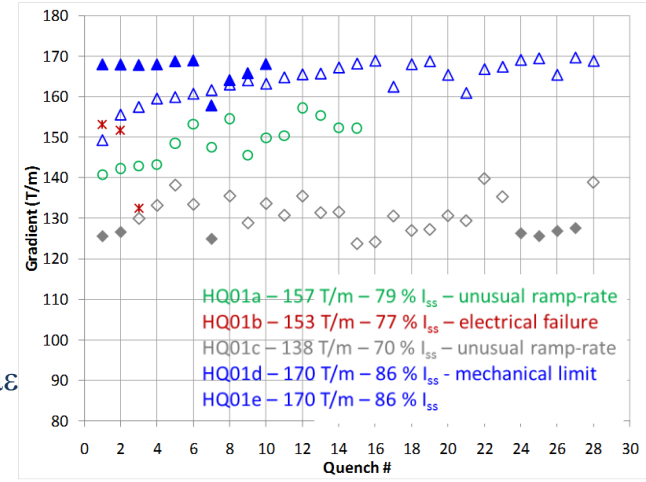


Azimuthal preload

Preload for ~ 200 T/m

Target Preload at 300 K:
- εθ shell / pole = 863 με / -450 με
- σθ shell / pole = 66 /-63 MPa

Target Preload at 4.2 K:
- εθ shell / pole = 1905 με / -720 με
- σθ shell / pole = 169 / -147 MPa



	4.5 K	1.9 K
Fz	0.96 MN	1.18 MN

Axial preload

Axial preload target:
- ~ 560 kN of axial preload
- ~ 58% of Fz at 4.5 K
- ~ 47 % of Fz at 1.9 K
- ~ 70 % of Fz at 15 kA

From Modeling point of view

Layer 1 (35 % of the total end force):
Contact pressure maintained >0 up to 219 T/m

Layer 2 (65 % of the total end force):
Contact pressure maintained >0 up to 180 T/m

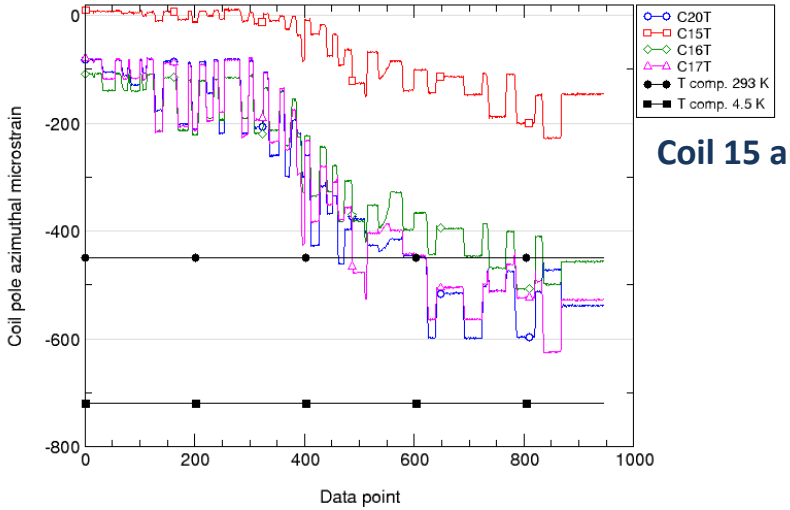
Preload

Strain gauge data – Coil Pole and Shell

Coil pole

Target: -450 με
Avg: -403 με
sigma: 181 με

Target: -63 MPa
Avg: -54 MPa
Sigma: 25 MPa

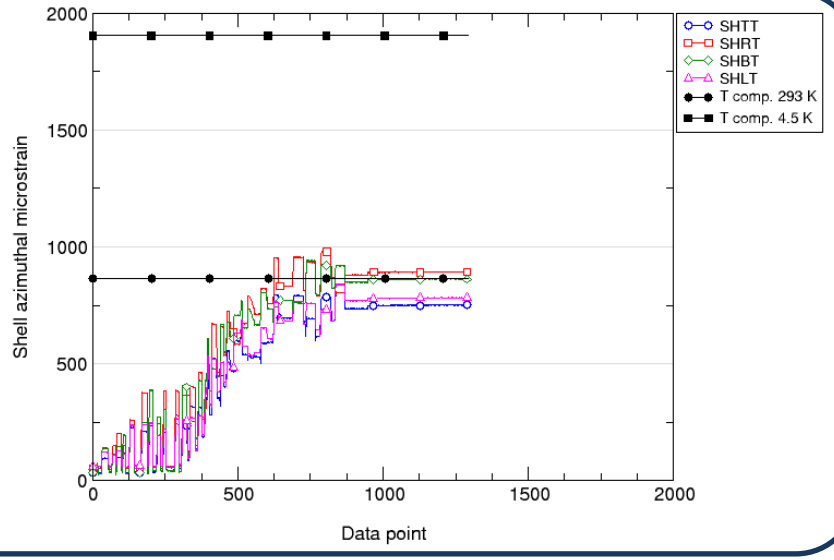


Coil 15 already tested

Shell

Target: 860 με
Avg: 822 με
sigma: 66 με

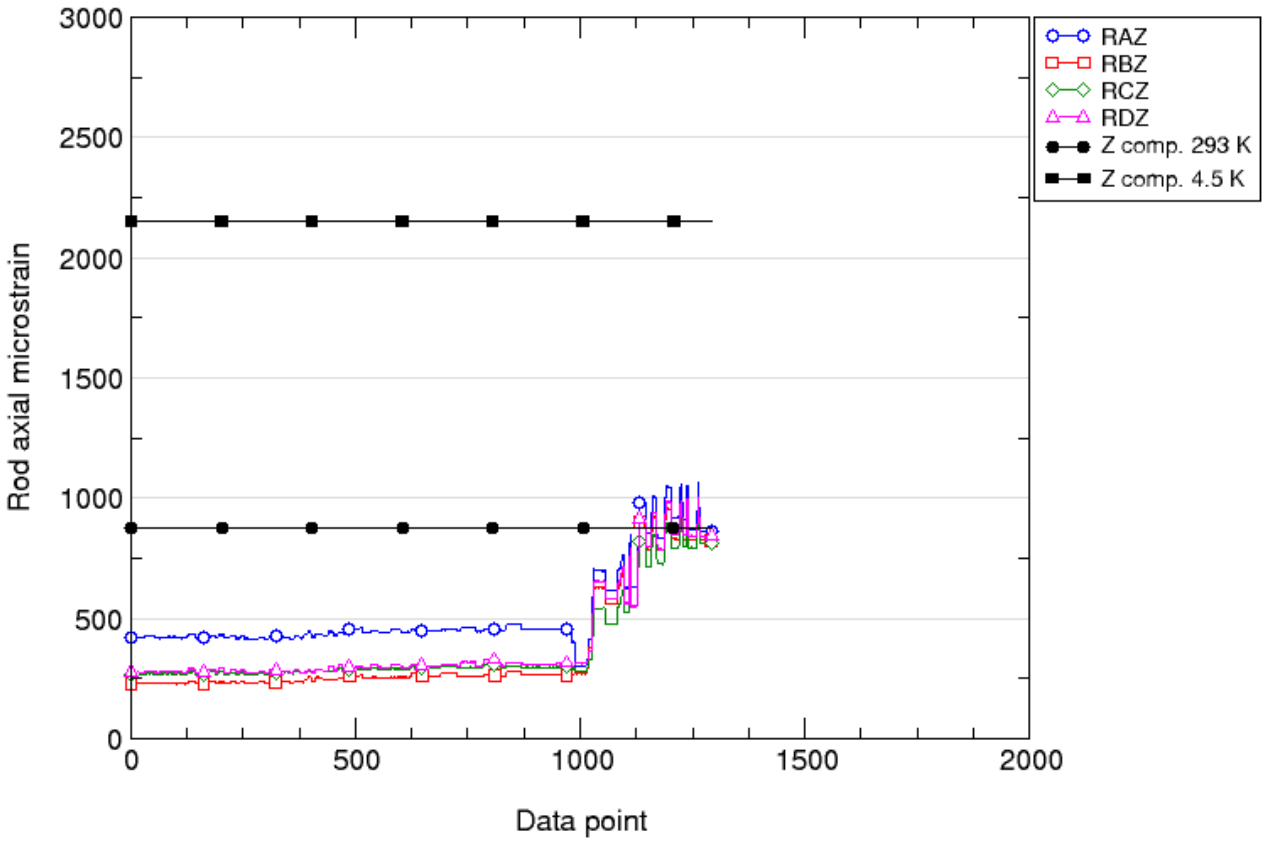
Target: 66 MPa
Avg: 68 MPa
Sigma: 6.6 MPa



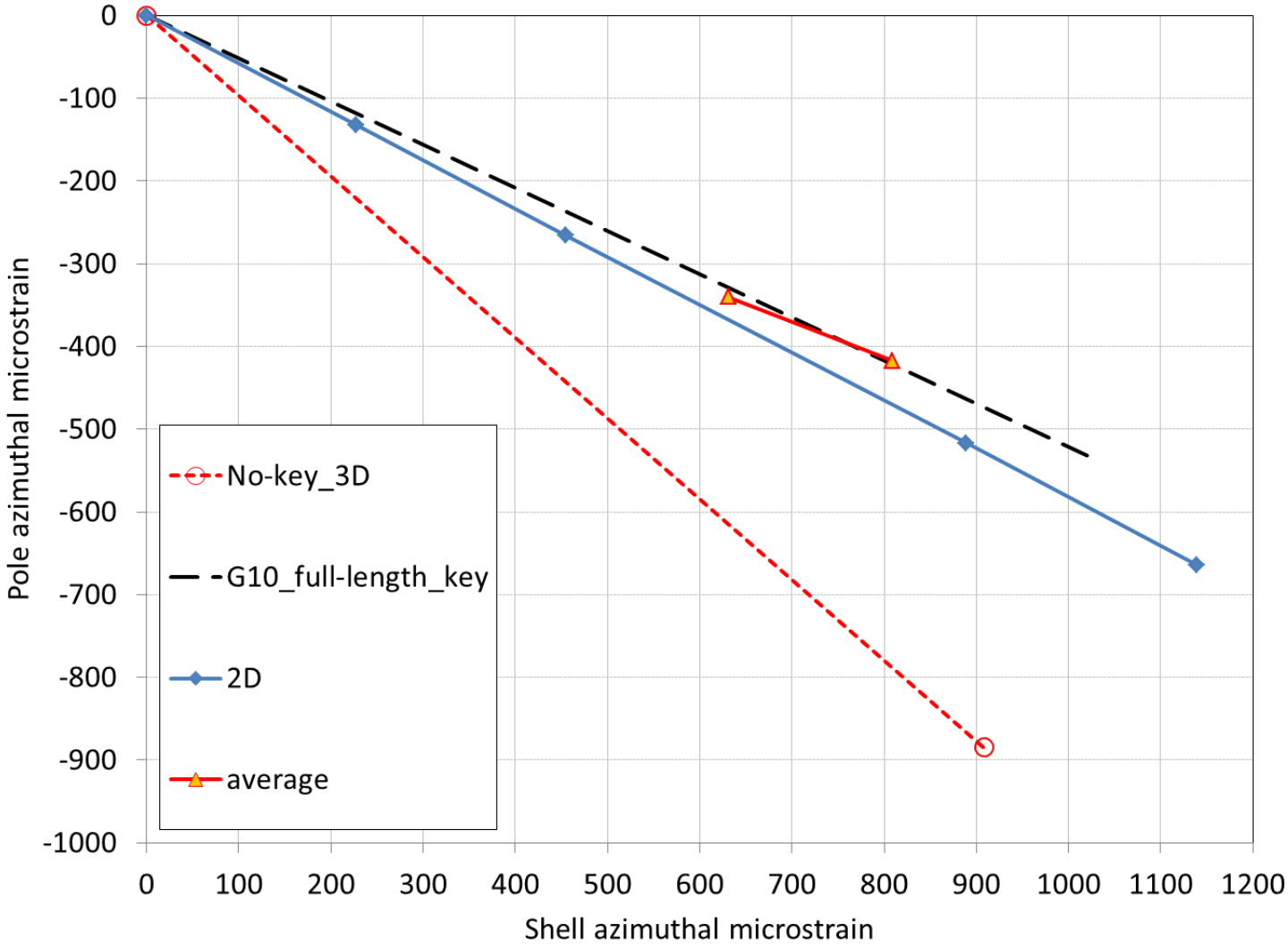
Preload
Strain gauge data - Rods

Rods
Target: 880 με
Avg: 833 με
sigma: 23 με

Target: 60 MPa
Avg: 58.5 Mpa
Sigma: 1.5 MPa



Comparison with Model

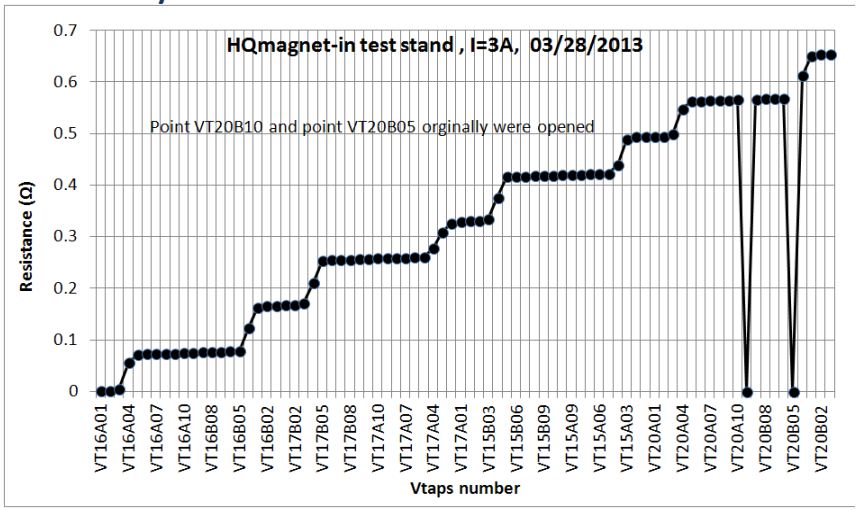


Electrical QA

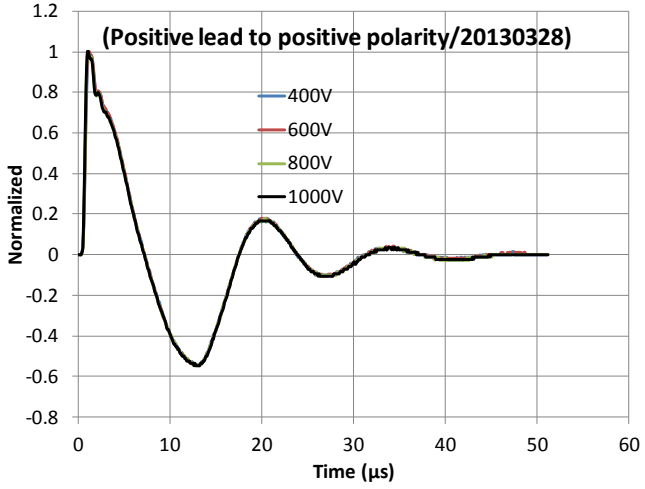
Electrical QA performed at various steps of the assembly

Final Electrical QA before shipping to FNAL

- Sequential R measurements



- Hipot
  - 1000V coil to components
  - 500 V components to components
  - All coils good to target except
    - HQ17 LE IL endshoe to IL PH
    - HQ16 LE IL / OL endshoe



- Impulse test to 1000 V

Next steps
HQ02 test

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Timeline

• HQ02 delivered at FNAL	April 2nd 2013
• Strain gauges reading check	April 4th 2013
• Magnet delivery to MTF	April 9th 2013
• Tentative date for cool-down start	Mid April 2013

Test set-up

- 1.9 K – 15 kA header will be used to give priority to 1.9 K testing
  - 90 % of I_{ss} at 4.5 K
  - 82 % of I_{ss} at 1.9 K
  - 169 T/m
  - Consistent with conservative preload approach

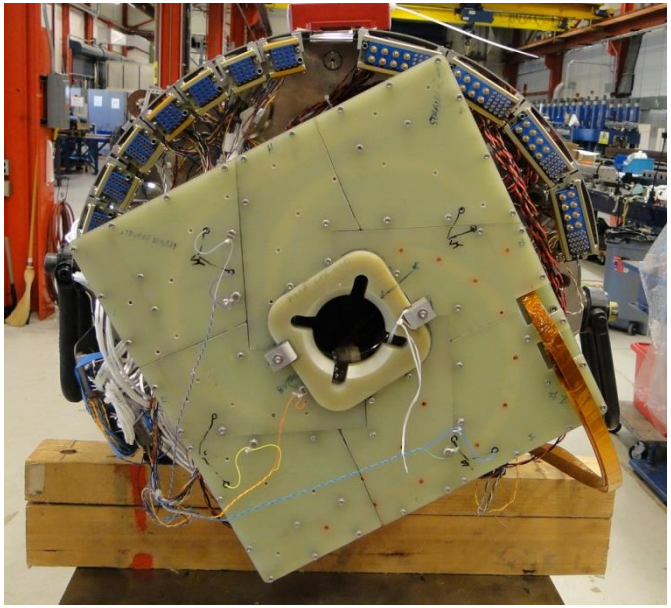
Test plan

- Under discussion
- Will include: magnetic measurements, training, conservative protection study

Post HQ02a test

Thermal cycle or HQ02b

- If preload looks appropriate => thermal cycle
- If preload too low or asymmetric
  - Preload adjustment at LBNL => HQ02b
  - New test at FNAL
- More aggressive protection study
- Spare coil 21 is also an option



HQ03:

- Decision to be taken in 1 to 2 months regarding new series of coils
  - Would implement last coil fabrication improvement (toward QXF)
    - *See Franck Borgnolutti's talk*
  - Would test reproducibility in performance and field quality