# 11 T Task Force Meeting
# Coil Size and Rigidity

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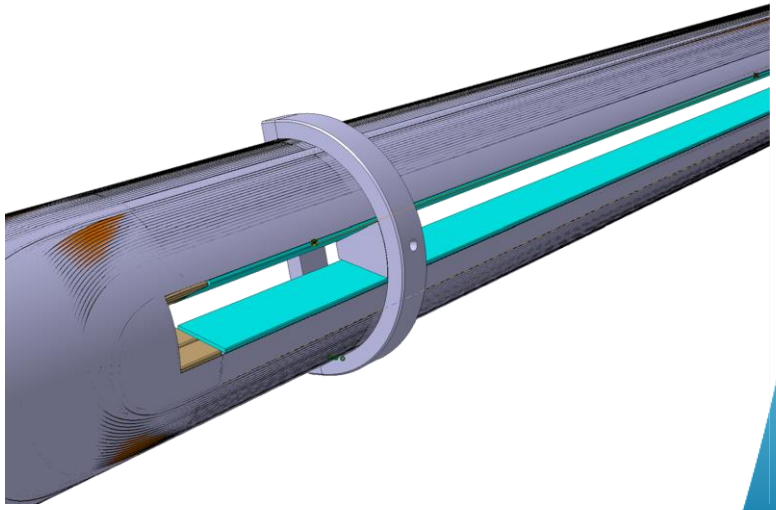
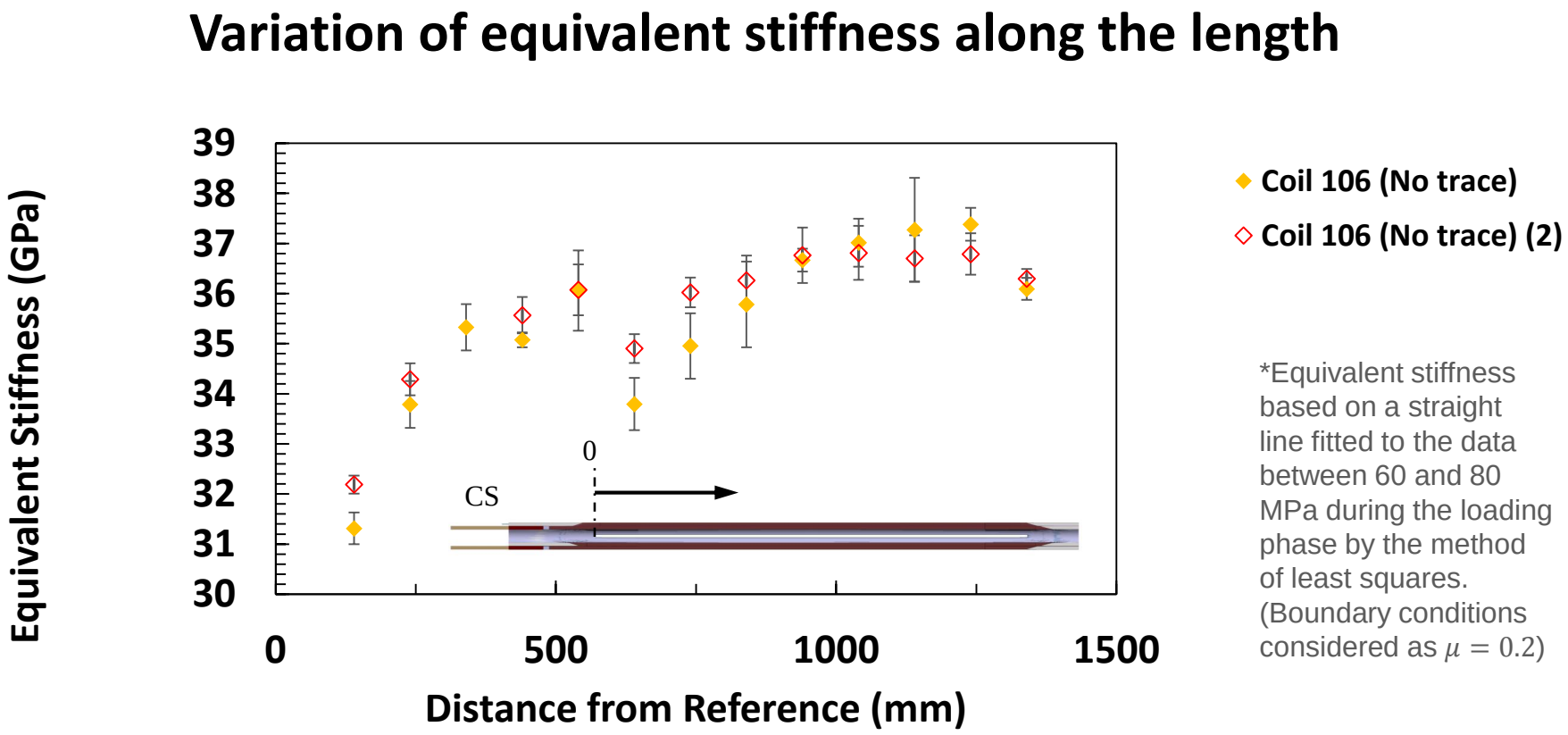
# Faro Arm Measurements – CR03

- Loading plates completely detached form the coil due to the cutting operations.
- Two options:
  - OPTION 1: Re-glue the loading plates (additional ~ 0.1 mm of glue, i.e., soft material that will impact the faro arm measurements vs. E-modulus)
  - OPTION 2: Build a small tool to keep in place the loading plate during the faro arm measurements.
    - We should be able to keep in place the loading plate even if it is not-glued to the coil during the E-modulus measurements and collaring mock-up
    - We decided to go for this option, we should be ready to measure next week.



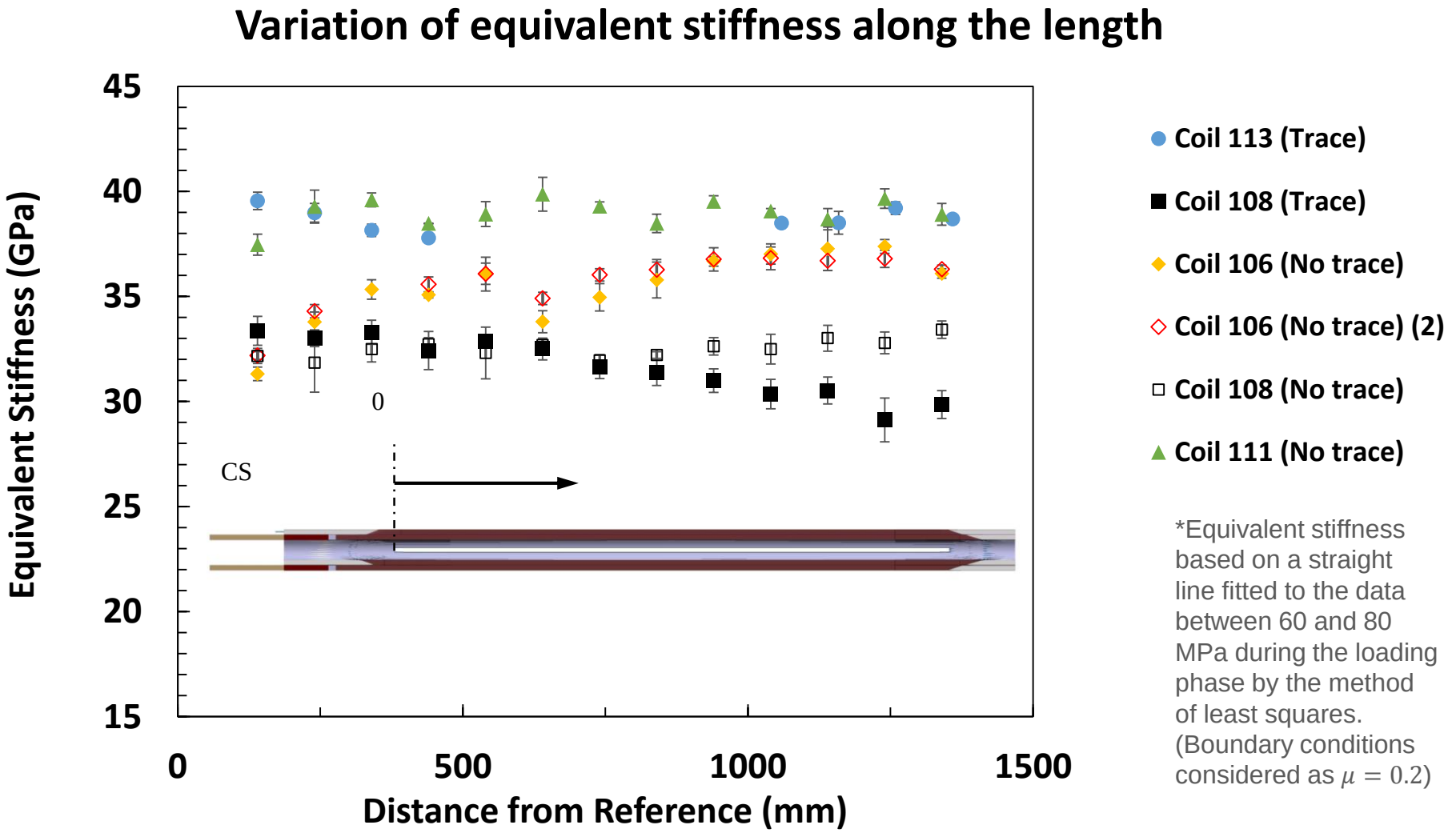
# Coil stiffness – Variation along the length

- Coil 106 was re-measured to confirm the 20 % variation of coil stiffness along the coil length.
- Measurements are consistent, meaning that the measurements are reliable and the difference on stiffness is related to the coil




*Equivalent stiffness based on a straight line fitted to the data between 60 and 80 MPa during the loading phase by the method of least squares. (Boundary conditions considered as $\mu = 0.2$)

# Coil stiffness – Difference among coils

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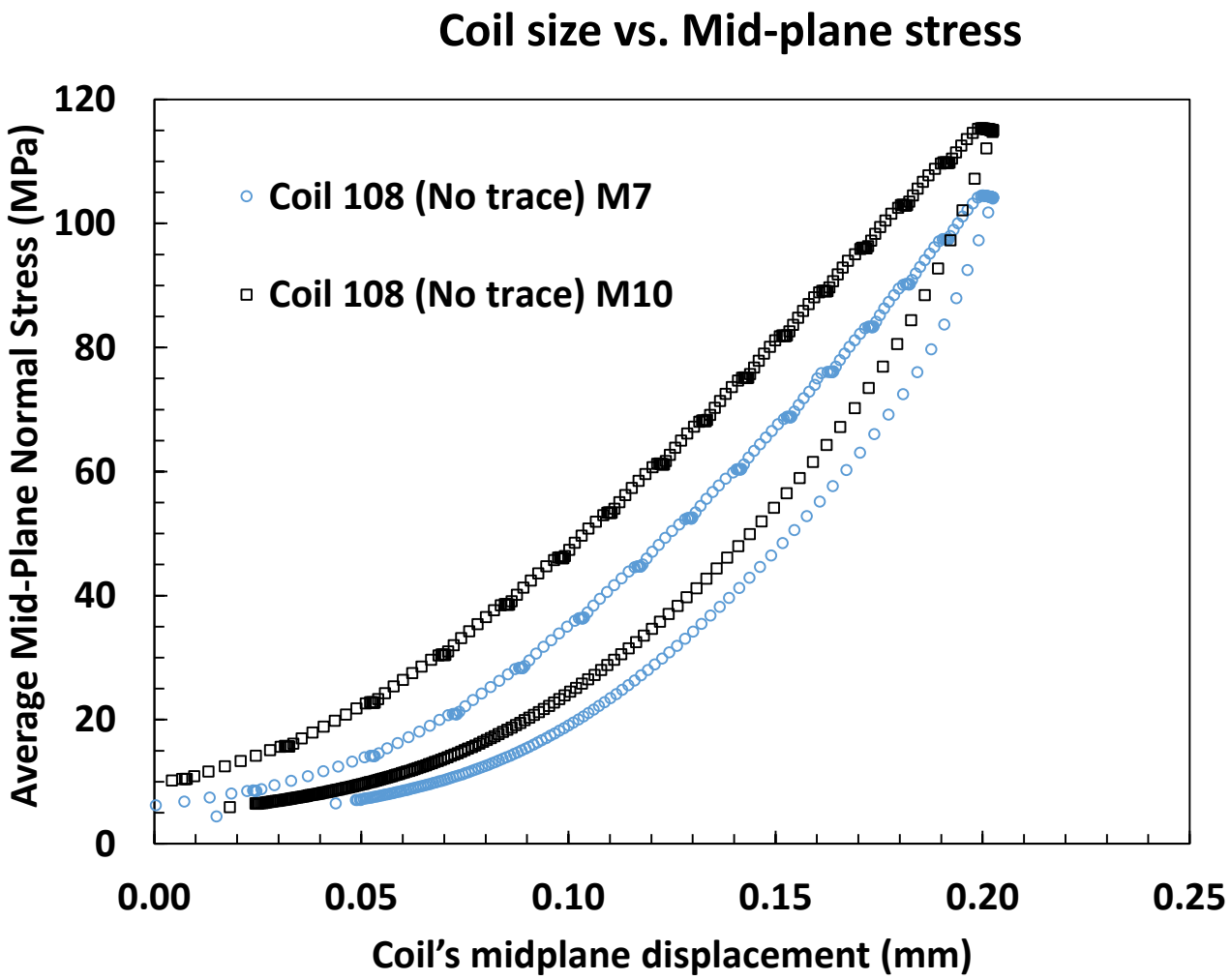
# Coil stiffness – Difference among coils

| | Magnet | Strand lay out | cu/sc | Glass heater-coil mm | Azimuthal oversize* L, mm | R, mm | Interlayer Quench Heater | End Saddles | Wedges Type | End Spacers | Eq. Stiffnes* [GPa] w.o. trace | w. trace |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Coil 105 | MBHSM101 | RRP 108/127 | 1.22 | 0.1 | -0.282 | -0.319 | no | SLS 316LN | 2 segments | SLS 316LN | 35 | 34 |
| Coil 106 | MBHSP101<br>MBHSP102<br>MBHDP101 | RRP 108/127 | 1.22 | 0 | -0.059 | -0.138 | no | G11 | 2 segments | SLS 316LN | 36 | |
| Coil 107 | MBHSP101 | RRP 108/127 | 1.22 | 0.1 | -0.053 | -0.105 | no | G11 | 2 segments | SLS 316LN | | |
| Coil 108 | MBHSP102<br>MBHDP101 | RRP 132/169 | 1.22 | 0.1 | -0.076 | -0.040 | no | G11 | 2 segments | SLS 316LN | 33 | 32 |
| Coil 109 | MBHSP103<br>MBHDP101<br>MBHDP102 (ap SP104b) | RRP 132/169 | 1.27 | 0 | -0.041 | -0.085 | no | G11 | 2 segments | SLS 316LN | | |
| Coil 111 | MBHSP103<br>MBHDP101 | RRP 132/169 | 1.27 | 0.1 | -0.216 | -0.171 | no | G11 | 2 segments | SLS 316LN | 39 | |
| Coil 112 | MBHSP104<br>MBHDP102 (ap SP104b) | RRP 132/169 | 1.27 | 0.08 | -0.148 | -0.141 | no | G11 | full length | SLS 316LN | | |
| Coil 113 | MBHSP104 | RRP 132/169 | 1.27 | 0.08 | -0.053 | -0.258 | no | G11 | full length | SLS 316LN | | 39 |
| Coil 114 | MBHSP105<br>MBHDP102 (ap SP105b) | RRP 150/169 | 0.98 | 0 (heaters imprg) | -0.108 | -0.222 | no | G11 | full length | SLS 316LN | | |
| Coil 115 | MBHSP105<br>MBHDP102 (ap SP105b) | RRP 150/169 | 0.97 | 0 (heaters imprg) | -0.097 | -0.174 | no | G11 | full length | SLS 316LN | | |
| Coil 116 | MBHSP106 | RRP 150/169 | 0.97 | 0 (heaters imprg) | -0.191 | -0.094 | yes | G11 | full length | SLS 316LN | | |
| Coil 117 | MBHSP106 | RRP 150/169 | 0.97 | 0 (heaters imprg) | -0.096 | -0.136 | yes | G11 | full length | SLS 316LN coated | | |
| Coil 110 | Test coil | RRP 132/169 | | 0 (heaters imprg) | -0.274 | -0.303 | yes | G11 | full length | SLS 316LN | | |
| Coil 201 | Test coil | PIT | | 0 (heaters imprg) | -0.096 | -0.136 | yes | G11 | full length | | | |

*Negative means bigger than nominal

** Equivalent stiffness based on a straight line fitted to the data between 60 and 80 MPa during the loading phase by the method of least squares. (Boundary conditions considered as $\mu = 0.2$)

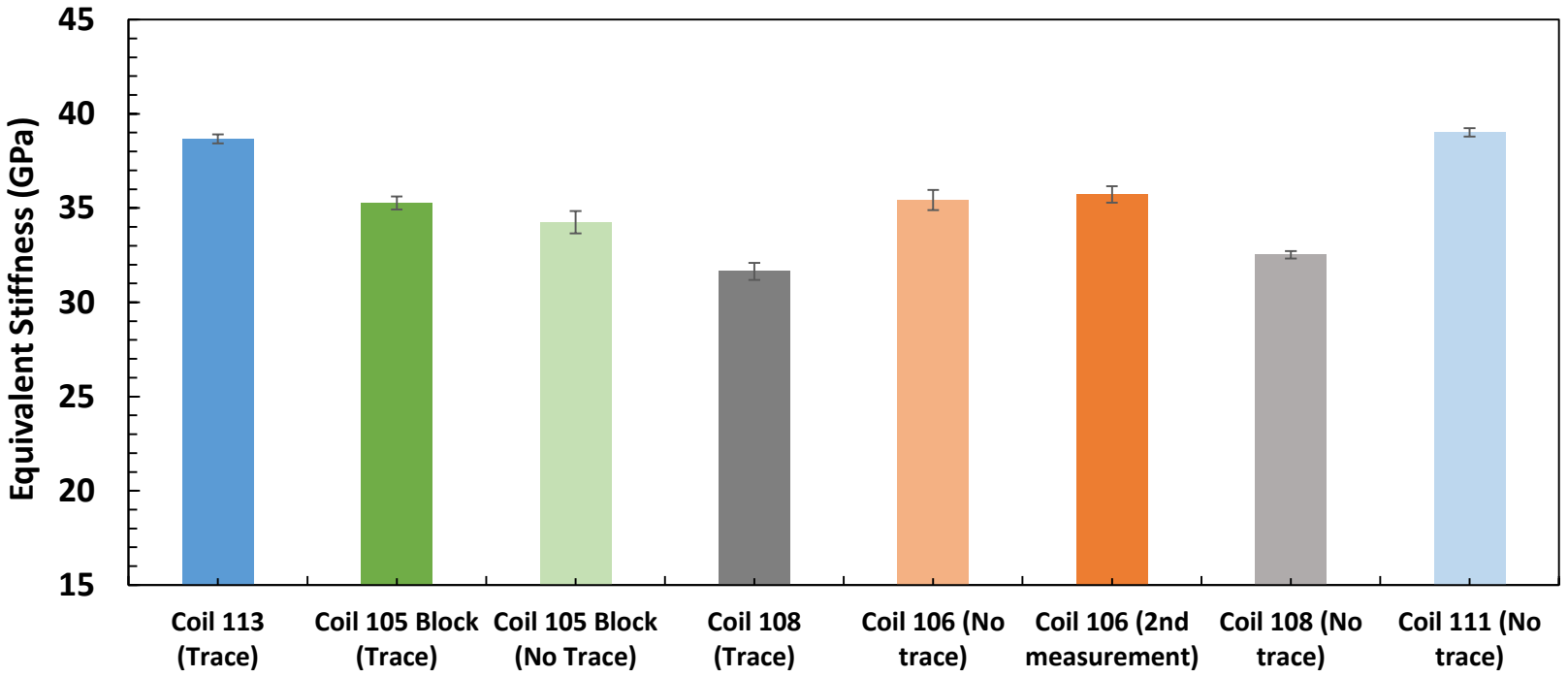
# Mid-plane displacement vs. average stress




"Coil mid-plane displacement 0" represents the nominal size of the calibration steel block at 5 MPa.

Positive mid-plane displacement corresponds to compression of the coil.


# Additional slides

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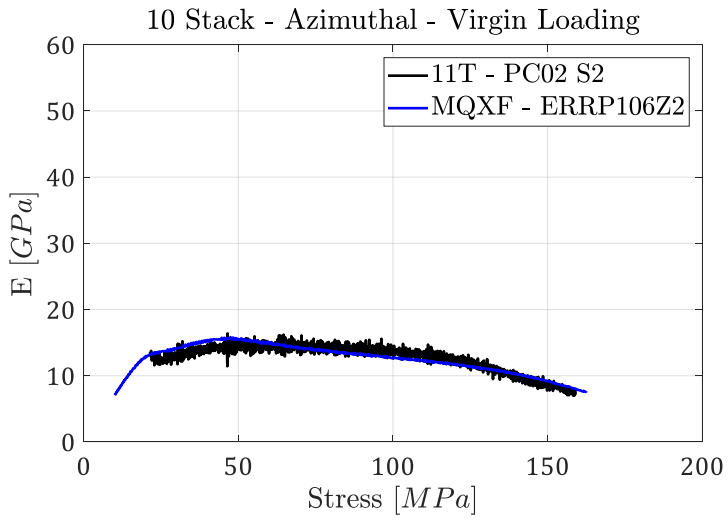
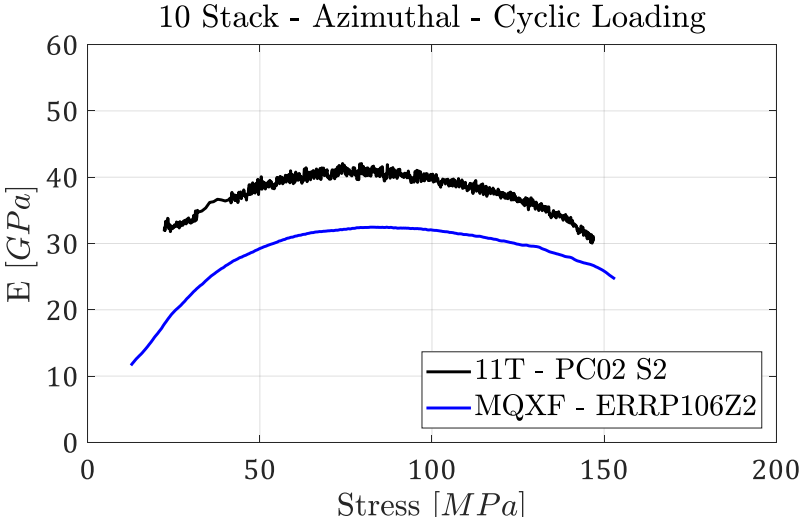
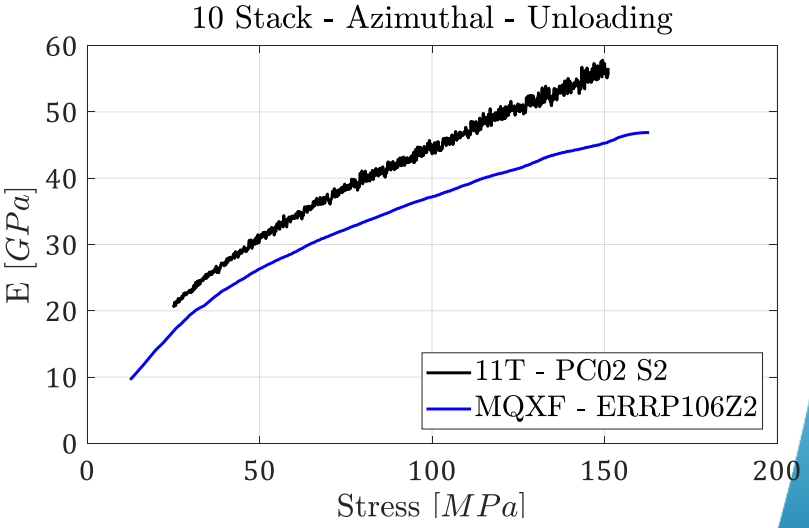
# Ten stacks – MQXF vs 11 T



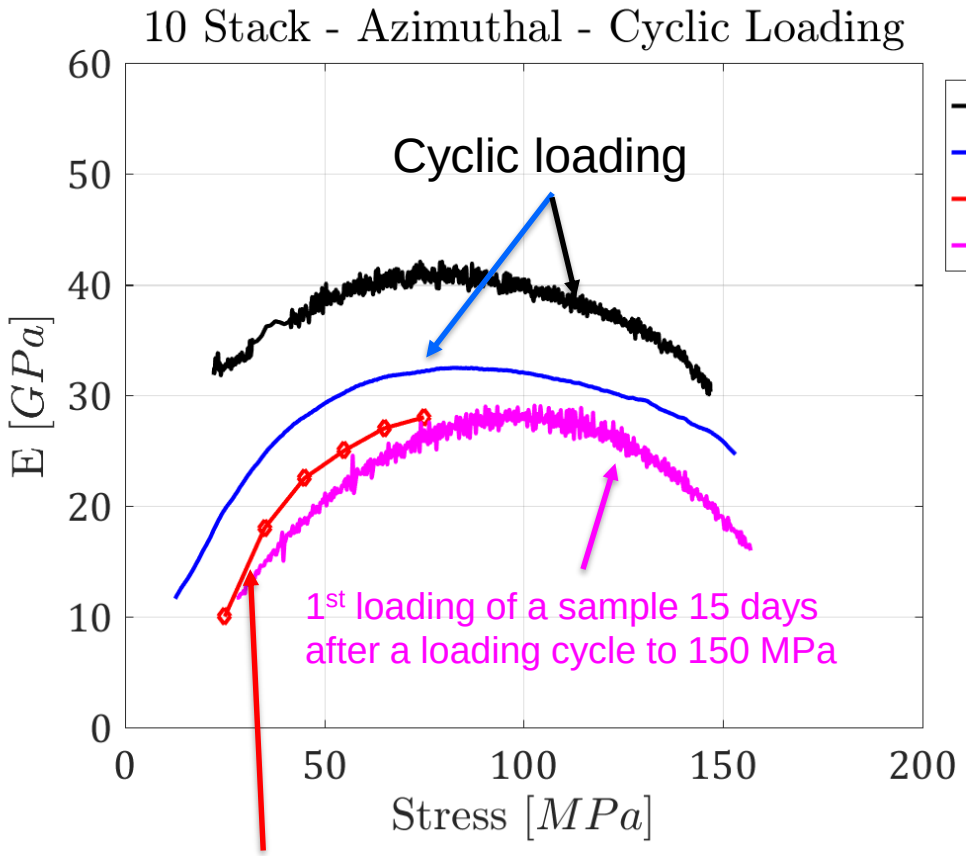



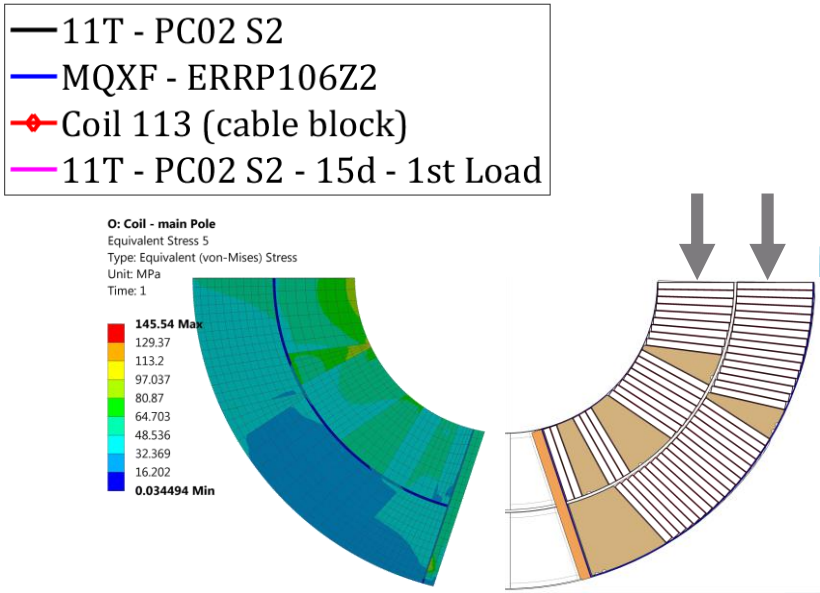




- Incredible superposition for virgin loading
  - Explained by copper hardening?
- Cycling behaviour:
  - The ‘shape’ is very similar
  - The 11T specimen are slightly stiffer ~5-10 GPa

# Ten Stacks vs Coil Measurements

- Results on coil measurements need further thinking. We will have a better view once we measure a virgin coil segment.

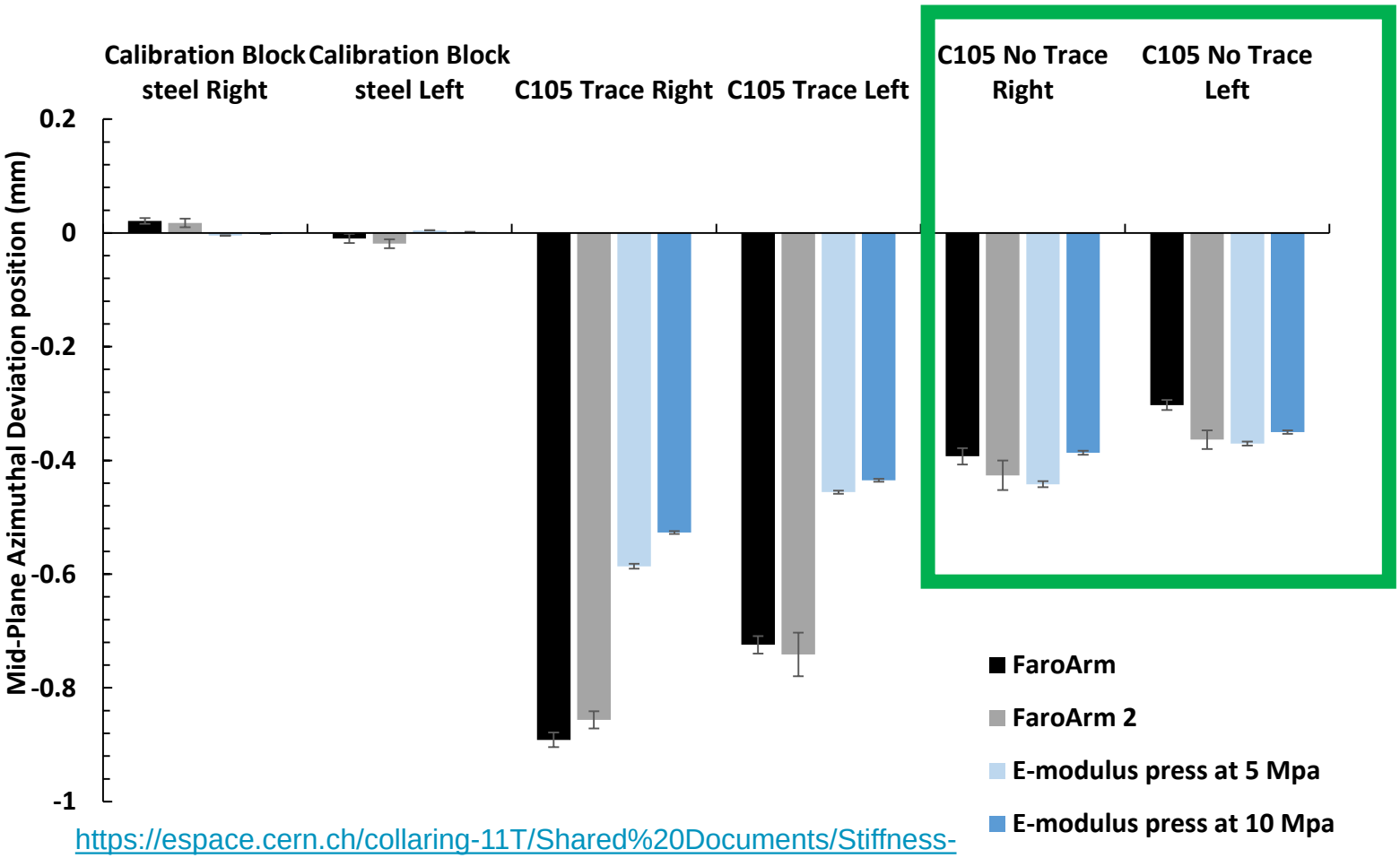



Coil (cold powered tested), shows similar rigidity in the first loading than ten stacks cyclic reloading (but loading goes only to 70 MPa)

# Coil Size Measurements

- Faro arm measurements vs coil measurements under 5-10 MPa are very consistent!! ☺☺
  - More coils are being measured to obtain statistics




https://espace.cern.ch/collaring-11T/Shared%20Documents/Stiffness-coils/2017-12-07_JLRF_-_Emodulus-press_Collaring.pptx?Web=1

# Additional activities & Plans

- Faro arm and CMM measurements on coil segments and parts for 1st collaring set up (see Paolo's presentation).
- E-modulus & coil size measurements in the press on-going on available short model coils (108/111/106) for statistics.
- As soon as CR003 coil segments are available, full characterization for the 2nd collaring mock up test.
  - This is an important test, since it is the first time we are going to be able to measure a virgin coil
- 10 stacks measurements on cable stacks (old vs new insulation lay-out in final conductor layout)
- Pressure uniformity test on samples with 25 vs 31 mm of mica.