

debriefing MBHDP101

mechanics – FE calc. stress in the coil

C. Löffler

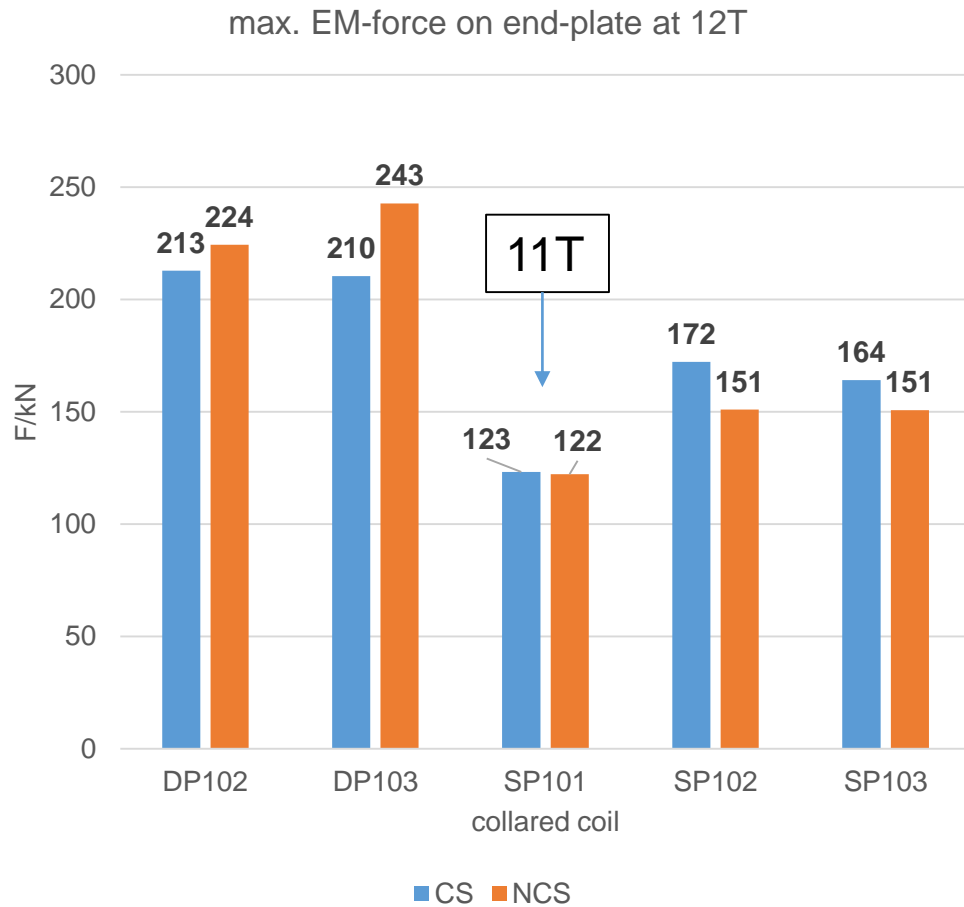


Mechanical instrumentation and measurements
where carried out by our colleagues from EN-MME
Michael Guichard <michael.guichard@cern.ch>
Philippe Grosclaude <philippe.grosclaude@cern.ch>

02 March 2016

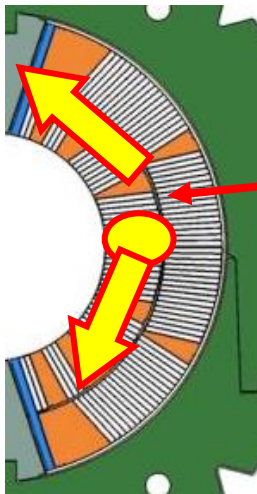
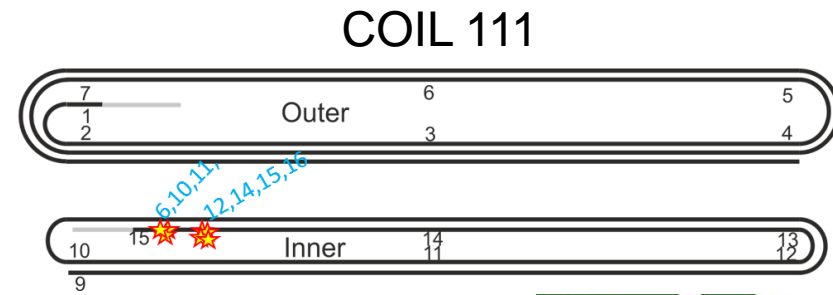
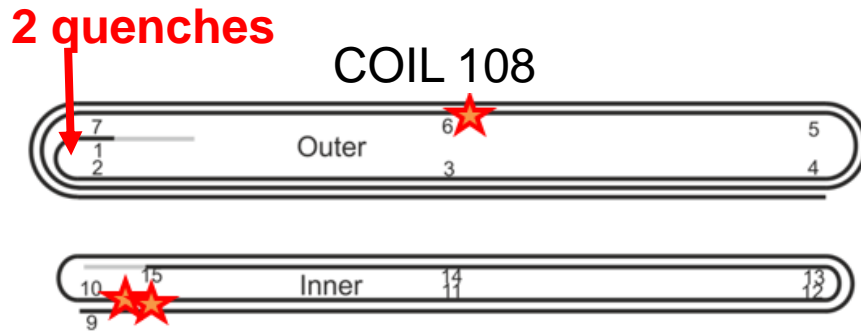
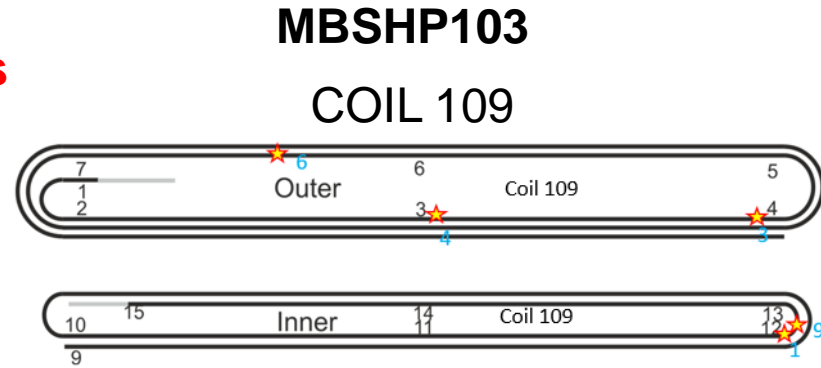
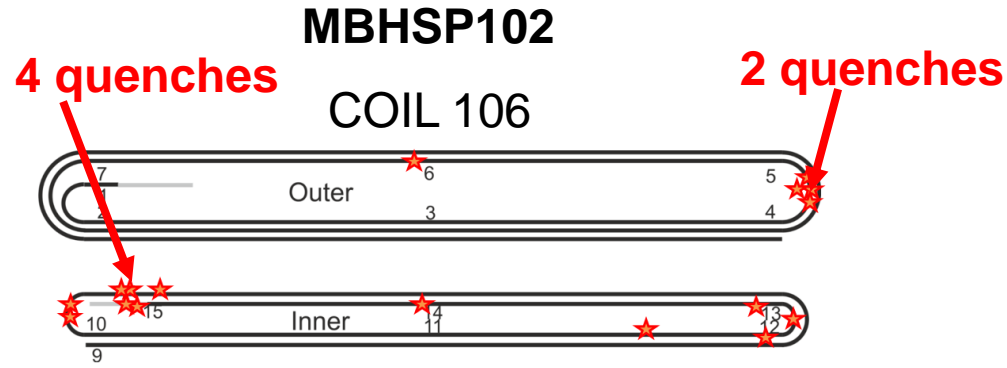


Bullets - Extremities DS11T at 12T

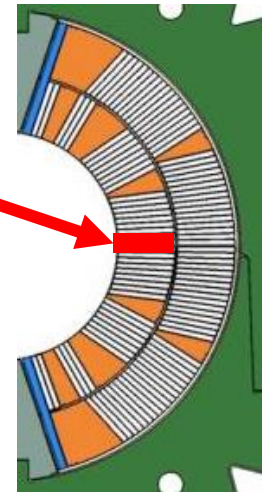


- Max. measured force is on the *2in1*
- The max. EM-force per aperture is **400kN**
- A force of **250kN** in the *2in1* is a coil movement of **0.65mm**
- **60% 2in1 & 45% 1in1** of total force seen in the end-plate (expected was 25%)

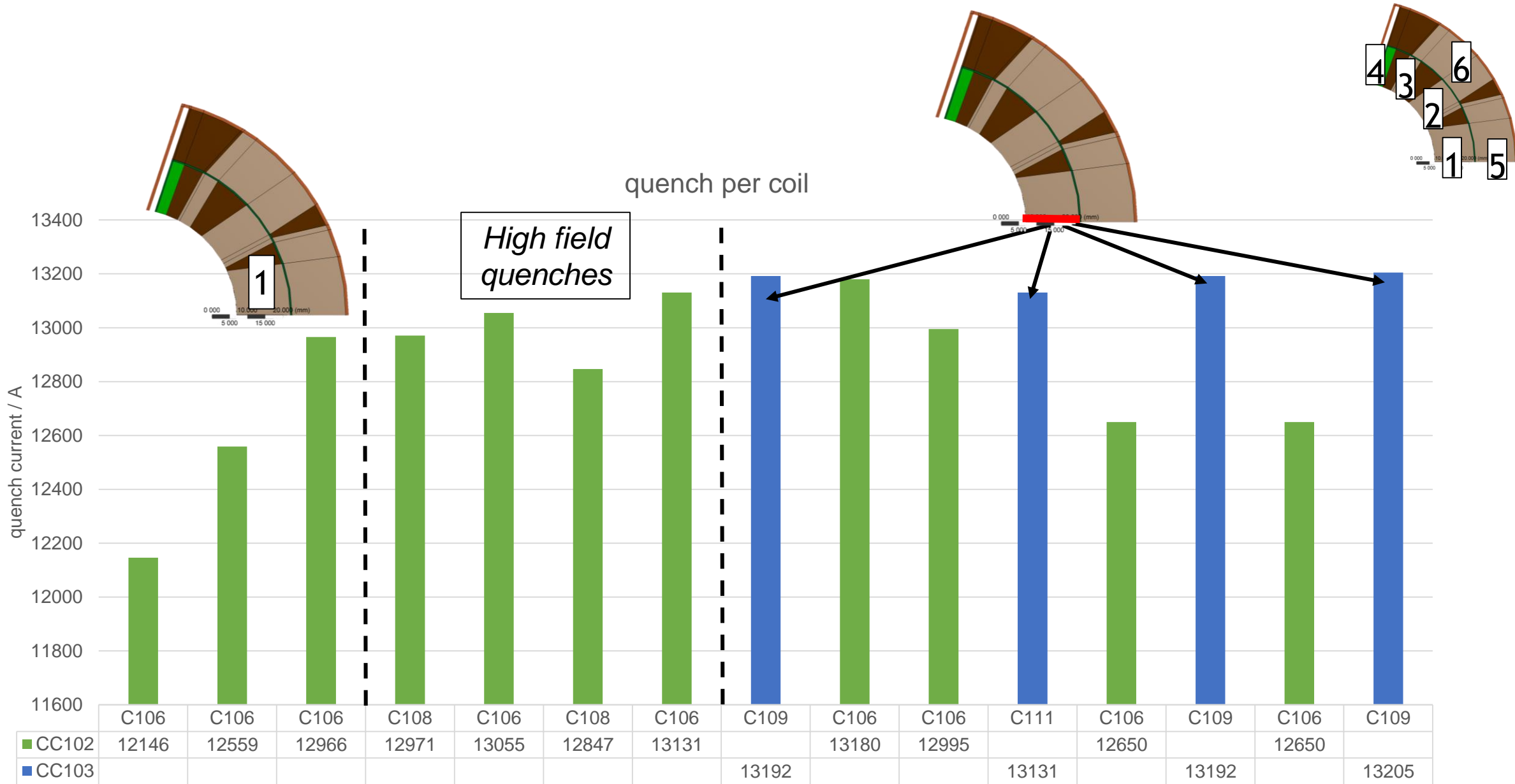
Quench locations (red text) at 1.9 K in comparison to single aperture quenches



3 quenches Midplane/block coil 109, 111
Coil 106/108

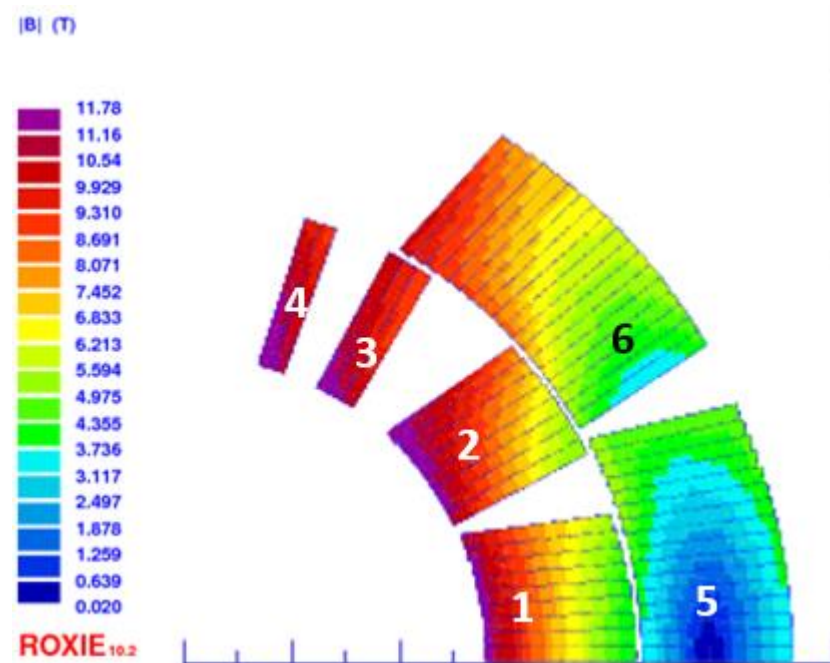


4 quench in the midplane turn,

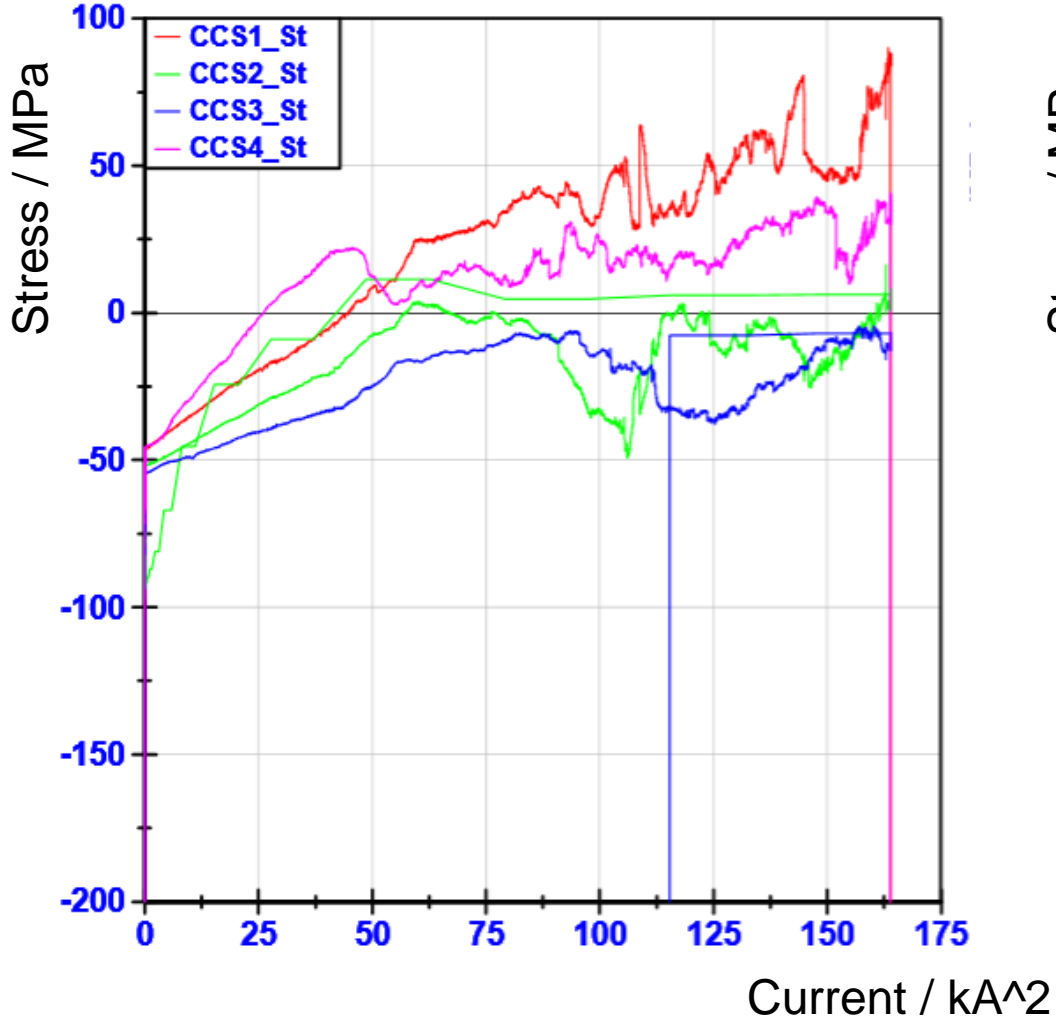


Performance CC102

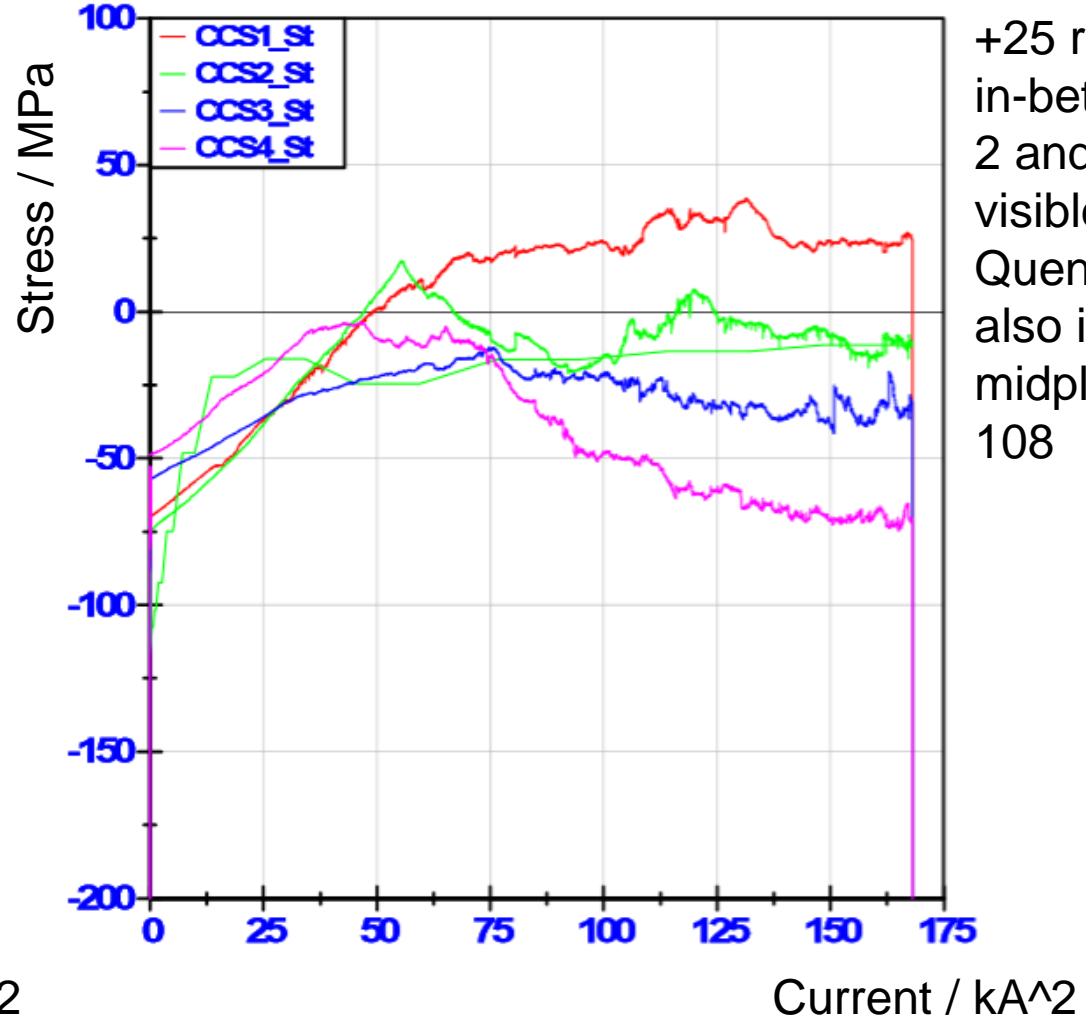
- First three quenches in the midplane link to mechanics?
- Why is the performance increased compared to the 1in1? (first high field quench above 12T)



CC102 – connection side – collar noses SG



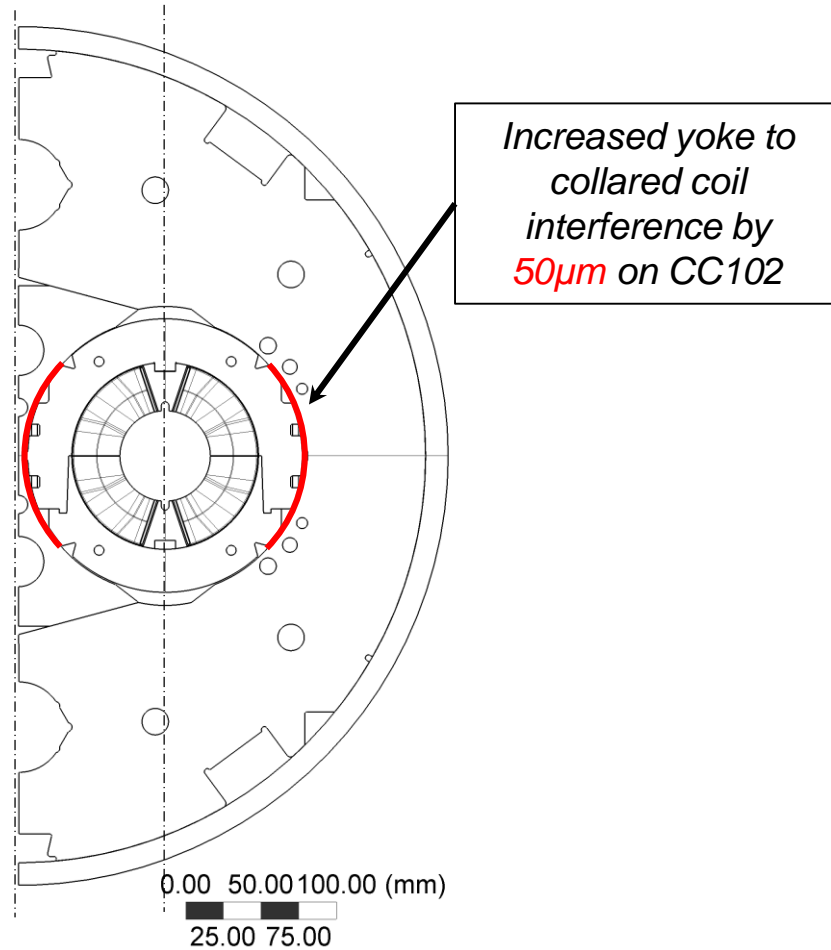
Quench 2



Quench 3

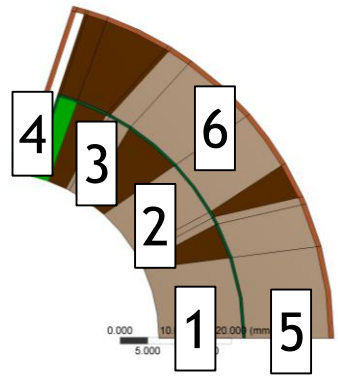
+25 ramps to 11T in-between quench 2 and 3. Settling is visible. Still Quench #3 was also in the midplane of 106-108

Change on CC102

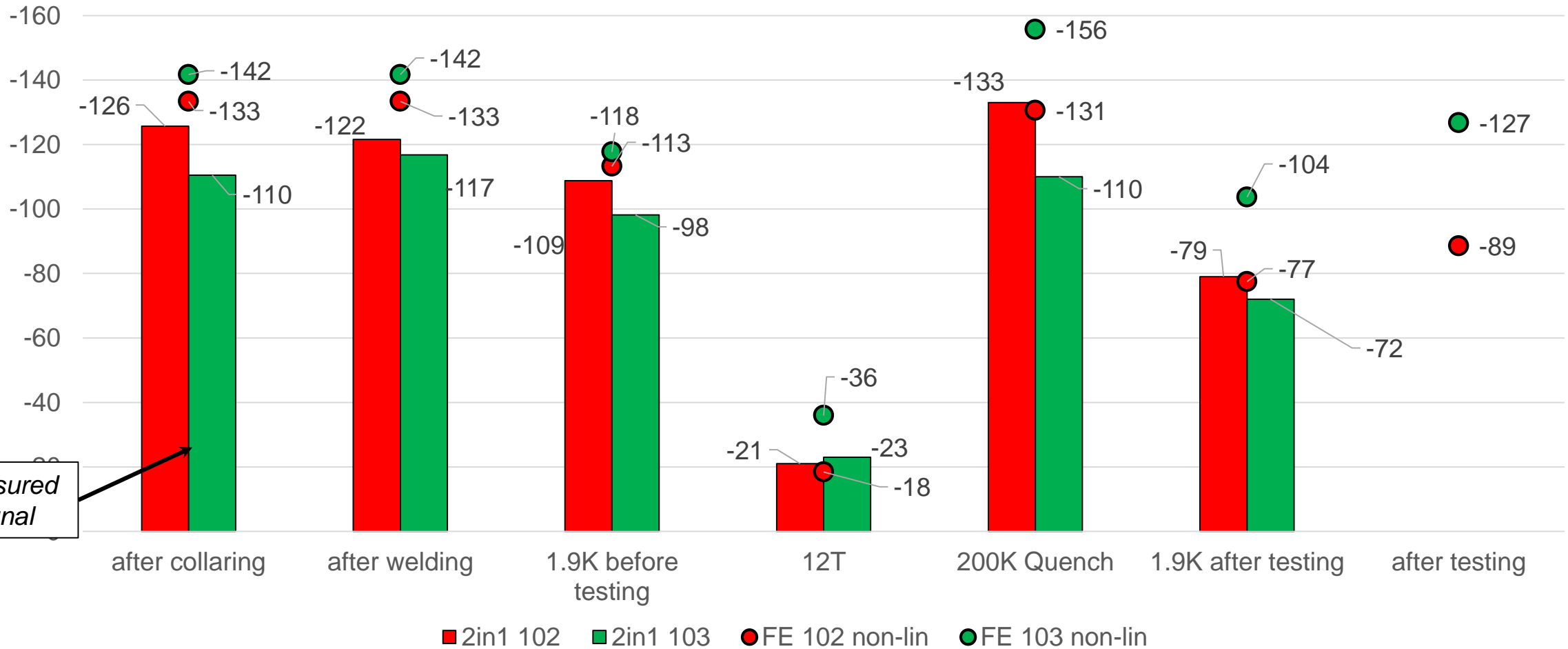


In the 1in1 assembly CC102 never reached stable 12T. Most of the quenches were in coil block 4 and one in the midplane (coil block 1 @ 12.2kA).

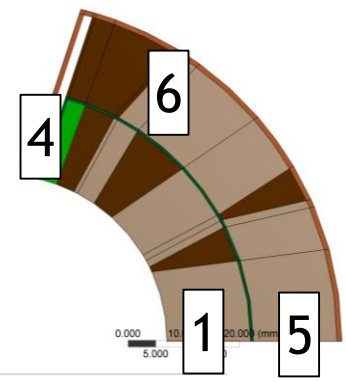
To increase the pre-load in coil block 4 the collared coil to yoke shim was increased by $50\mu\text{m}$. (radial change of $50\mu\text{m} \sim 300\mu\text{m}$ azimuthal)



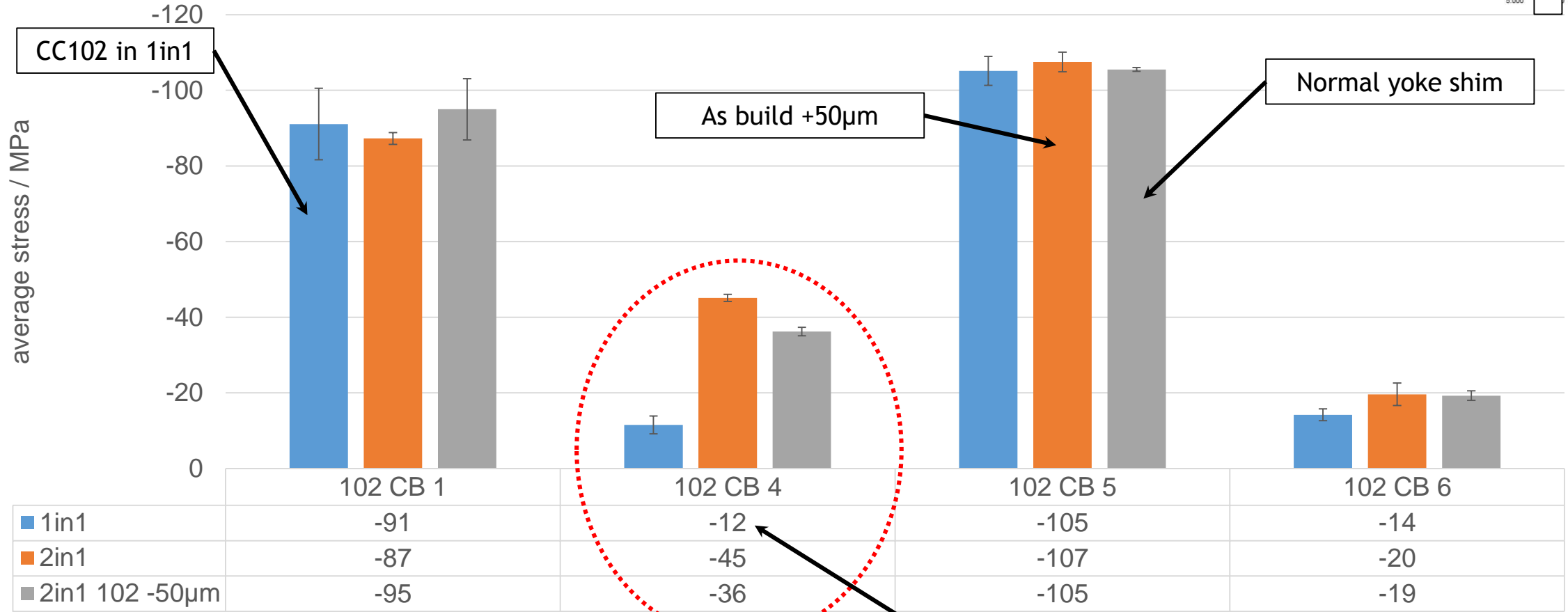
Overview collared coils - 2in1- stresses in the collar nose



CC102-FE_analysis



average azimuthal stress first cable of block at 12T



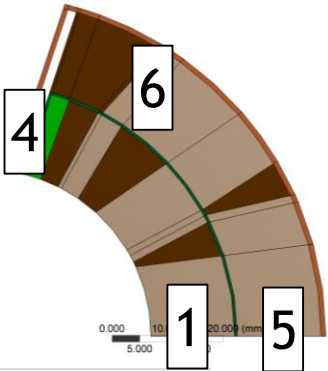
9MPa increase in CB4 with 50µm shim on yoke

Limiting block for MBHSP102 (MBHSP103 CB4 -22MPa)

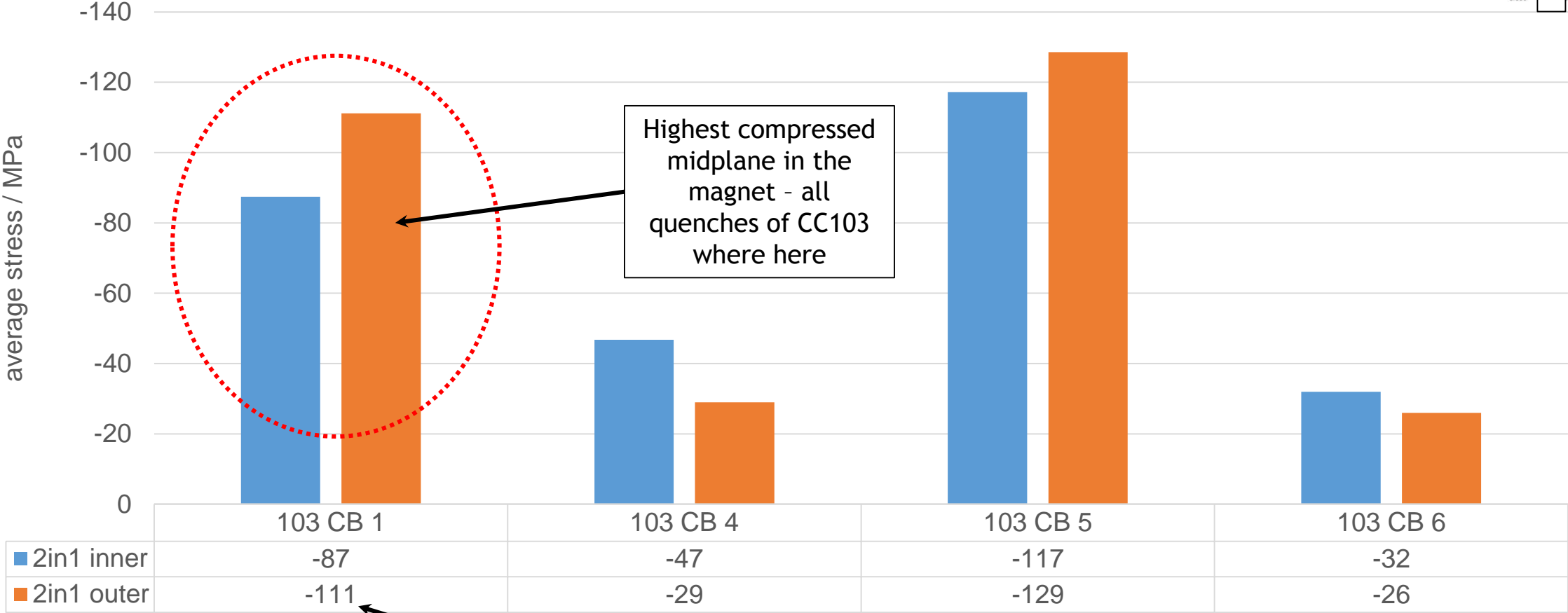
Performance CC103

- First quench at 13.2kA
- All quenches in this collared coil where in the midplane (both coils where quenching at the same time)
- Always the outer midplane was quenching

CC103-FE_analysis



average azimuthal stress first cable of block at 12T

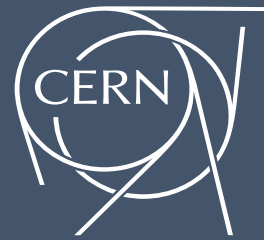


At 12T

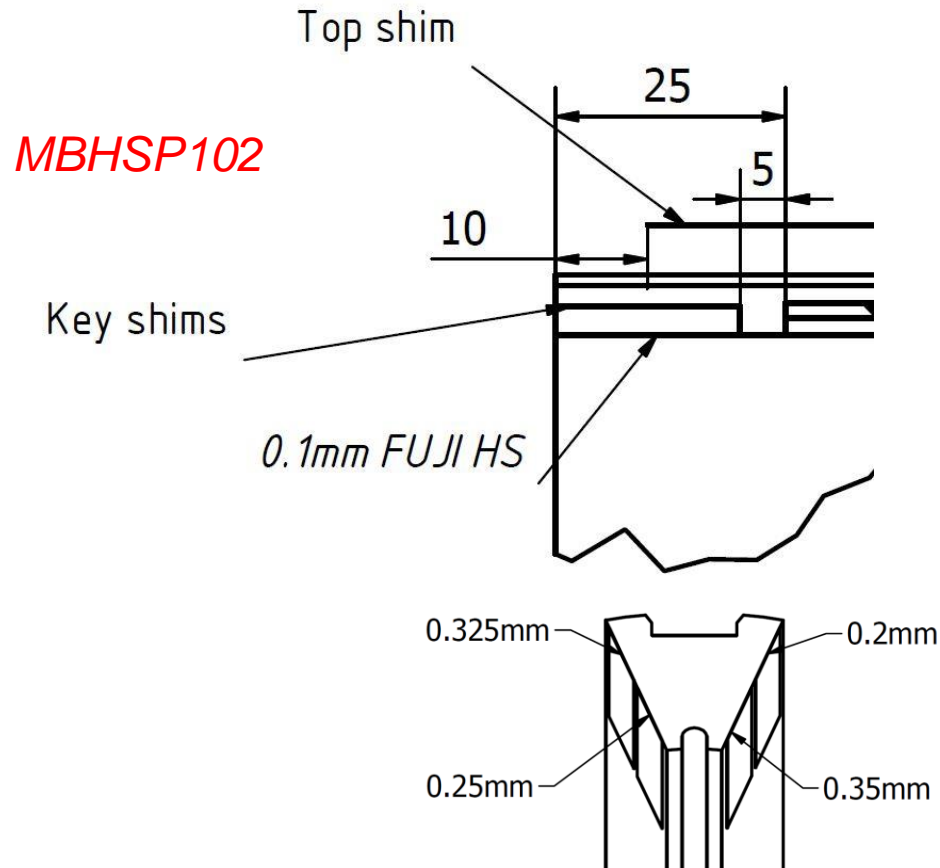
Inner = close to the insert
Outer = close to the shell

Lesson learned

- Coil block 4 needs to be with 30MPa in compression (azimuthal) to go above 12T
- Coil block 5 Starts quenching under 120MPa (at 13.2kA in CC103)

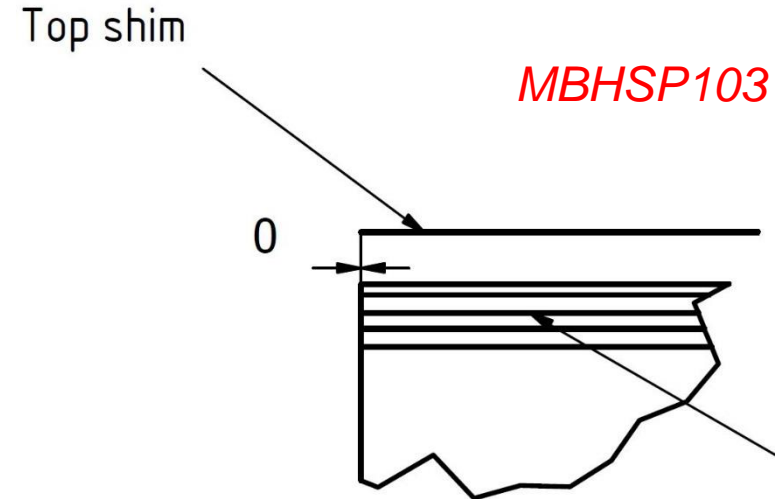


Changes for MBHSP103



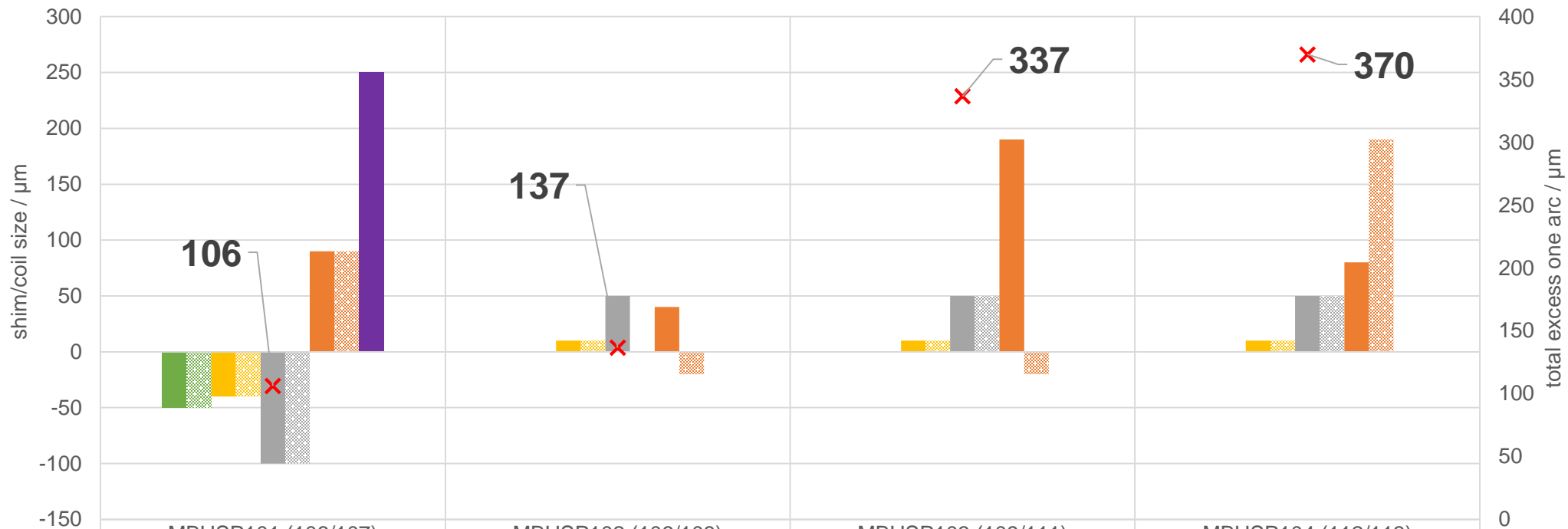
Each key leg individually shimmed

*Top shim = 50μm
2 x reduction every
20-30mm*



Only adaption in the transition region with the top shim

11T-model collared coil - shimming summary - difference to "as designed case" (520μm)

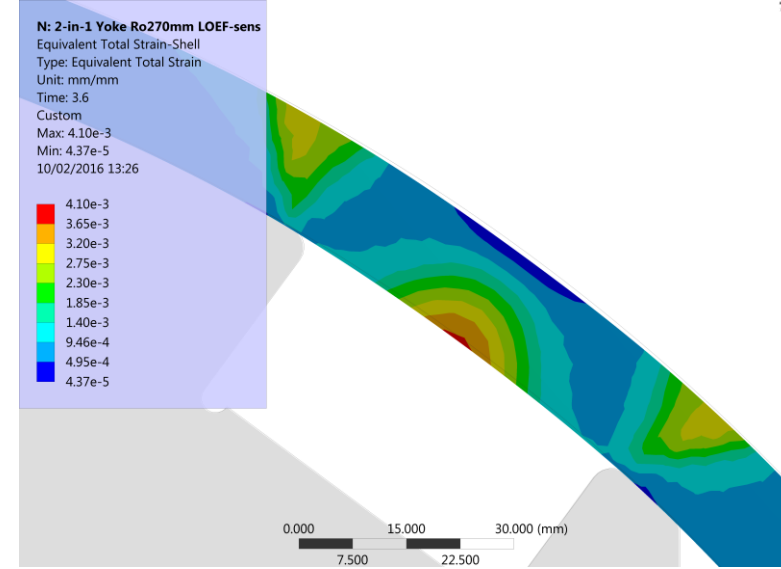


	MBHSP101 (106/107)	MBHSP102 (106/108)	MBHSP103 (109/111)	MBHSP104 (112/113)
■ top collar-diameter	-50	0	0	0
■ bottom collar-diameter	-50	0	0	0
■ top collar-yoke	-40	10	10	10
■ bottom collar-yoke	-40	10	10	10
■ top pole-coil	-100	50	50	50
■ bottom pole-coil	-100	0	50	50
■ top coil size	90	40	190	80
■ bottom coil size	90	-20	-20	190
■ midplane shim	250	0	0	0
✗ total azimuthal excess	106	137	337	370

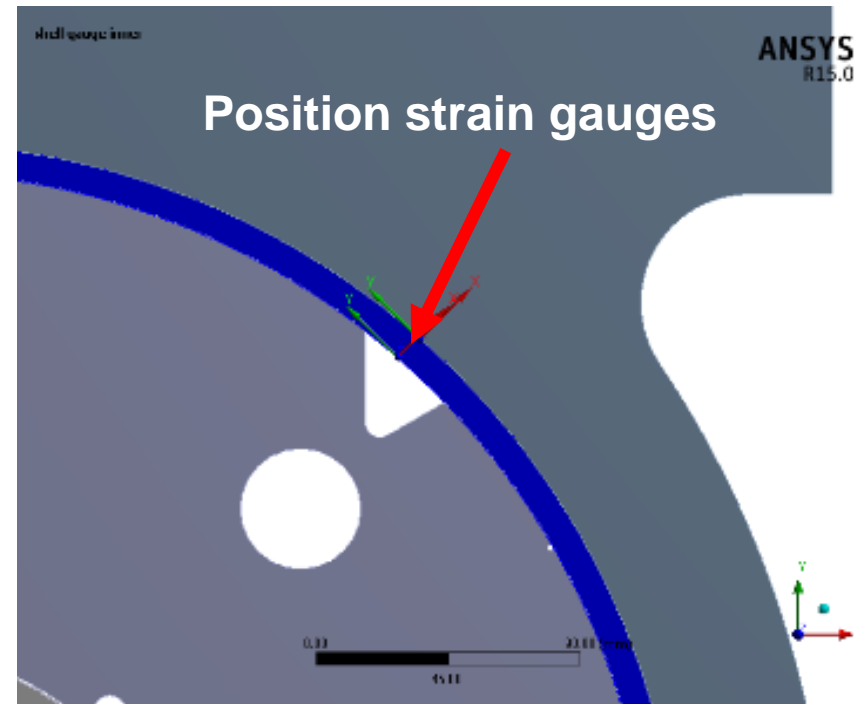
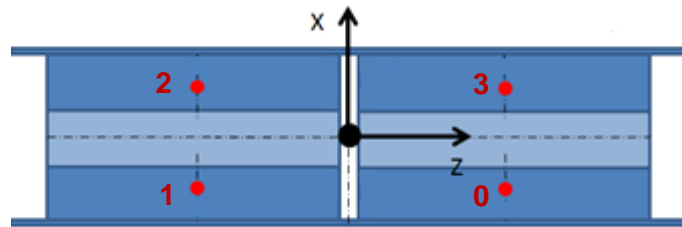
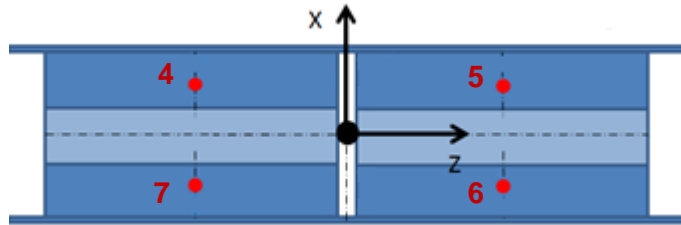
11T welded shell – instrumentation and results

- Four models have been instrumented on the shell
- *MBHSM101* was **MIG/MAG** welded
- *MBHSP101-4* & *MBHDP101* were **TIG** welded
 - One of the goals of **TIG** welding is to increase the pre-stress in the shell

Instrumentation – 11T Shell

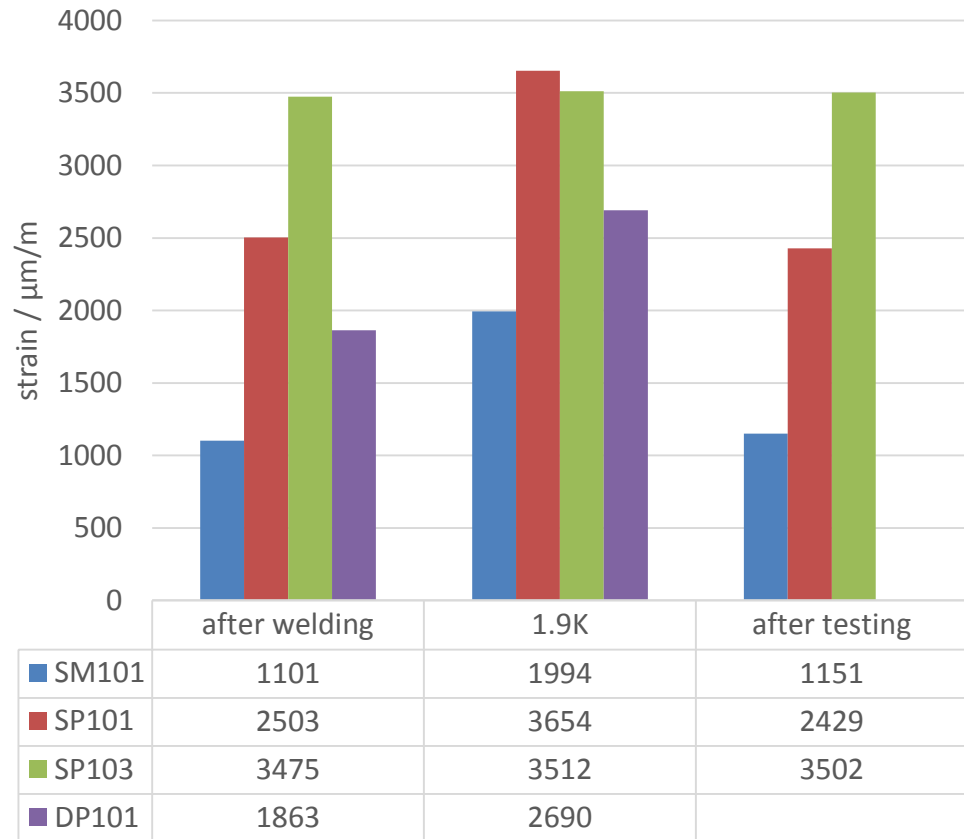


Shell:
-8 pairs of strain gauges on the inner and outer shell
-Double quarter bridge with thermal compensator

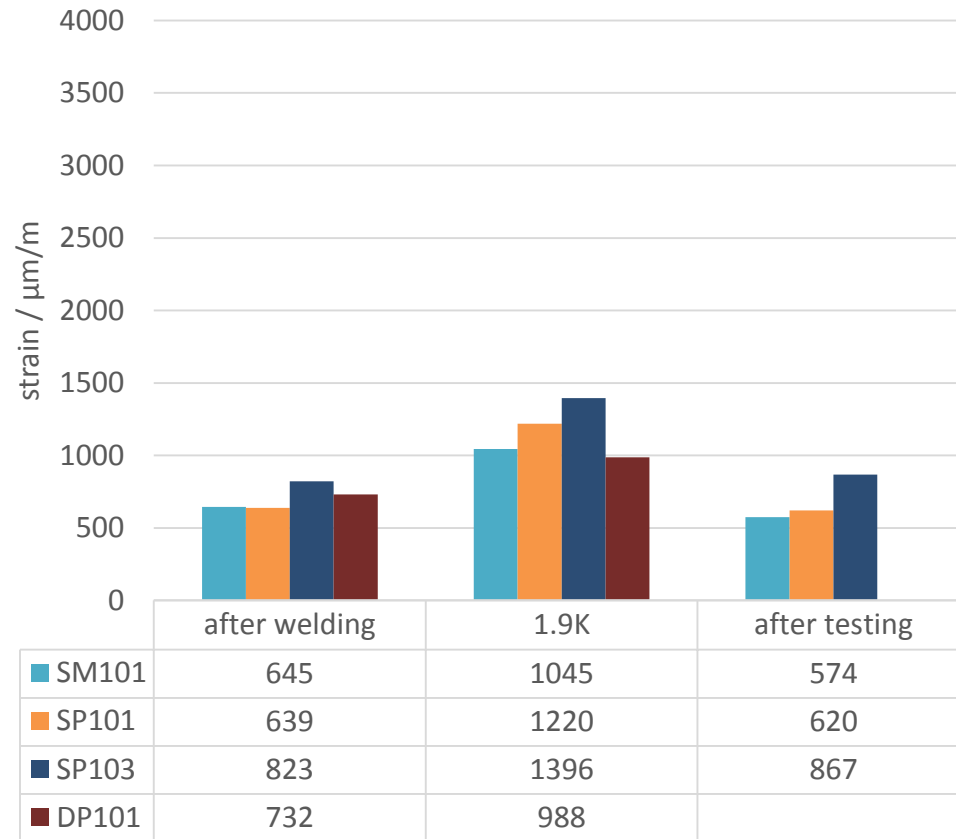


Measured strain – 11T Shell

measured strain inner shell

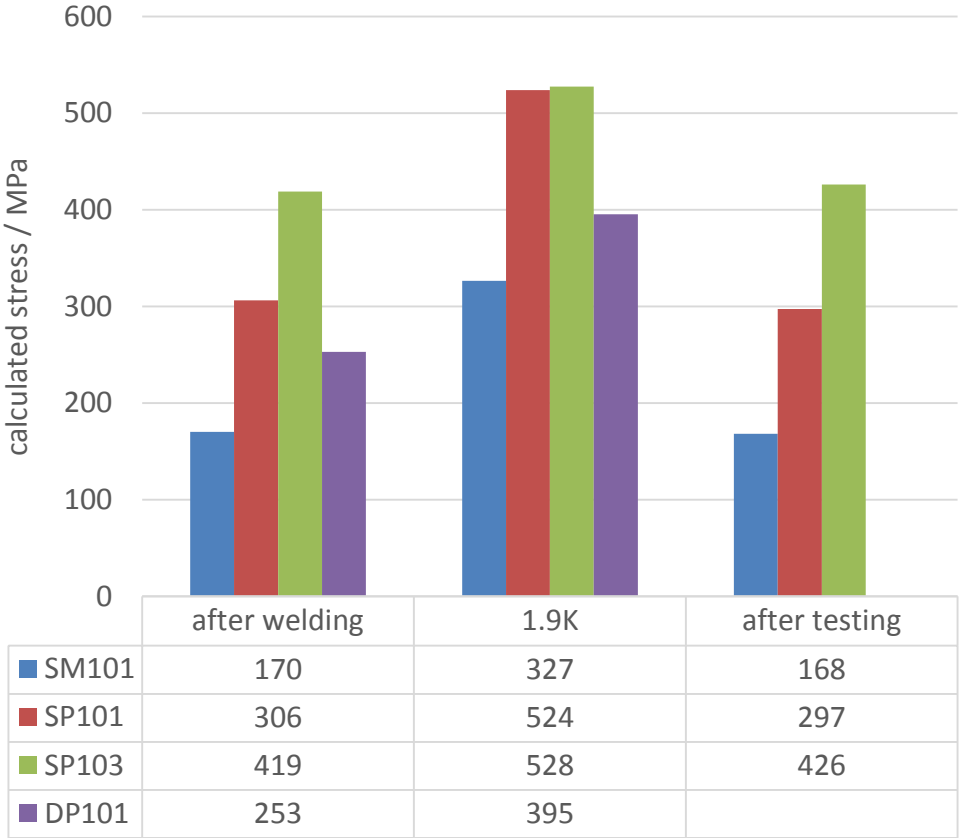


measured strain outer shell

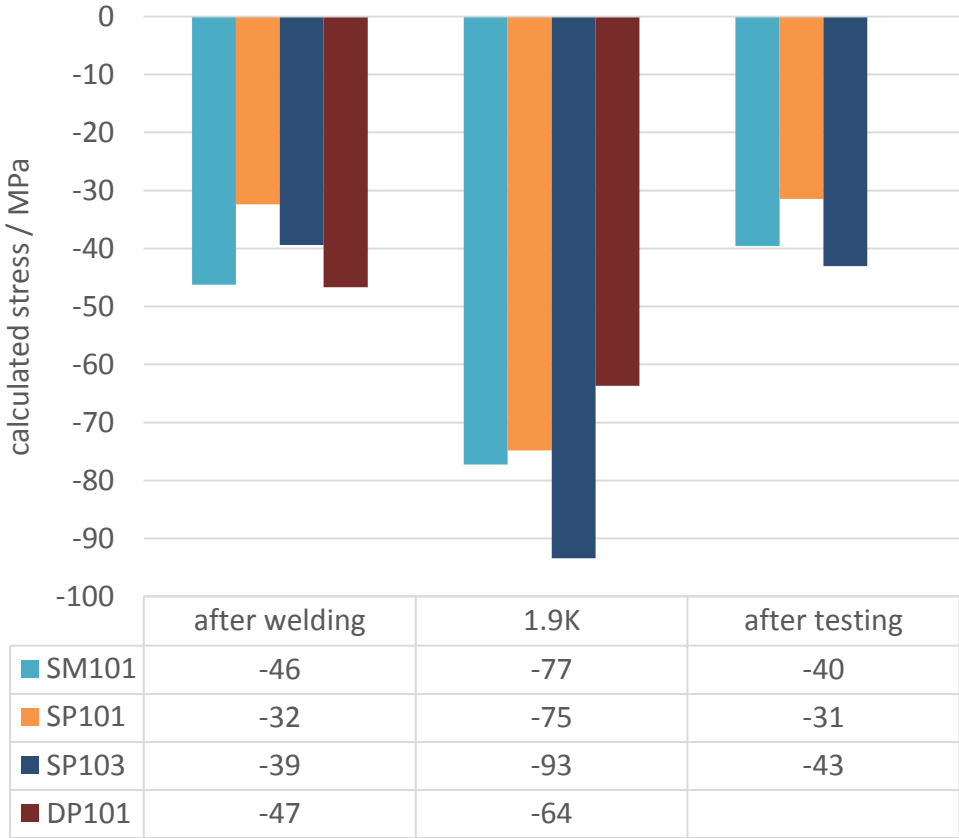


Calculated stress – 11T Shell

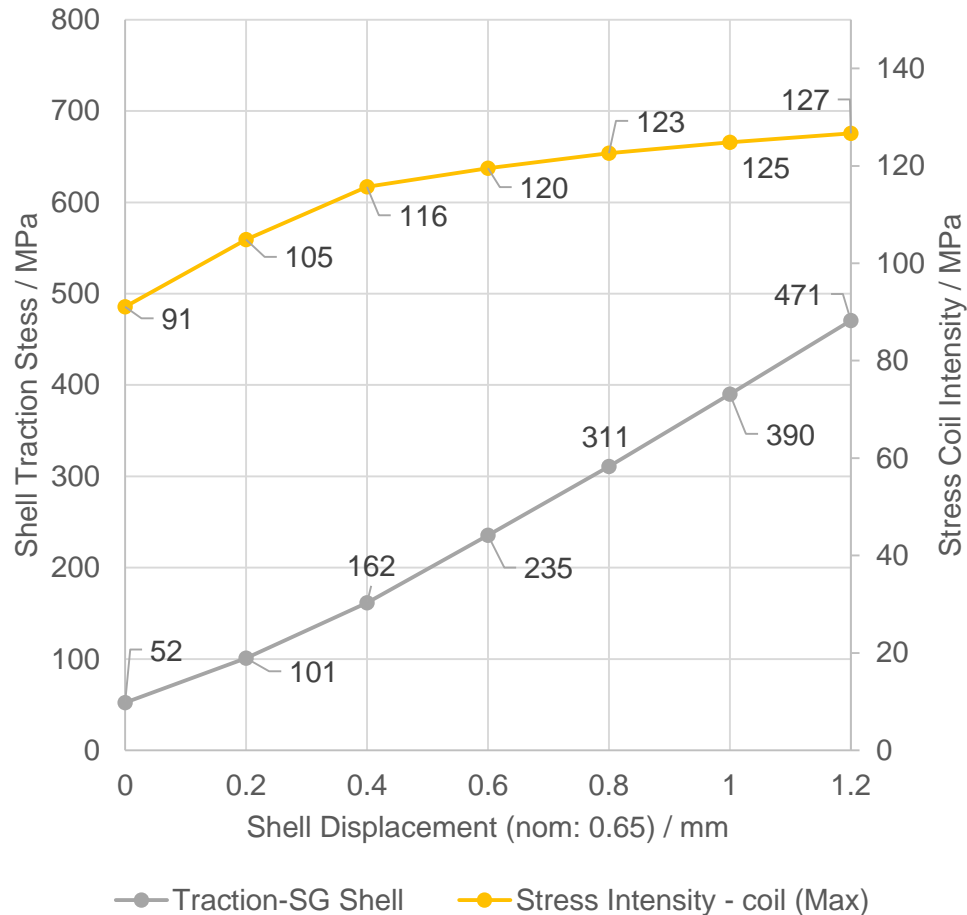
calculated traction stress



calculated bending stress

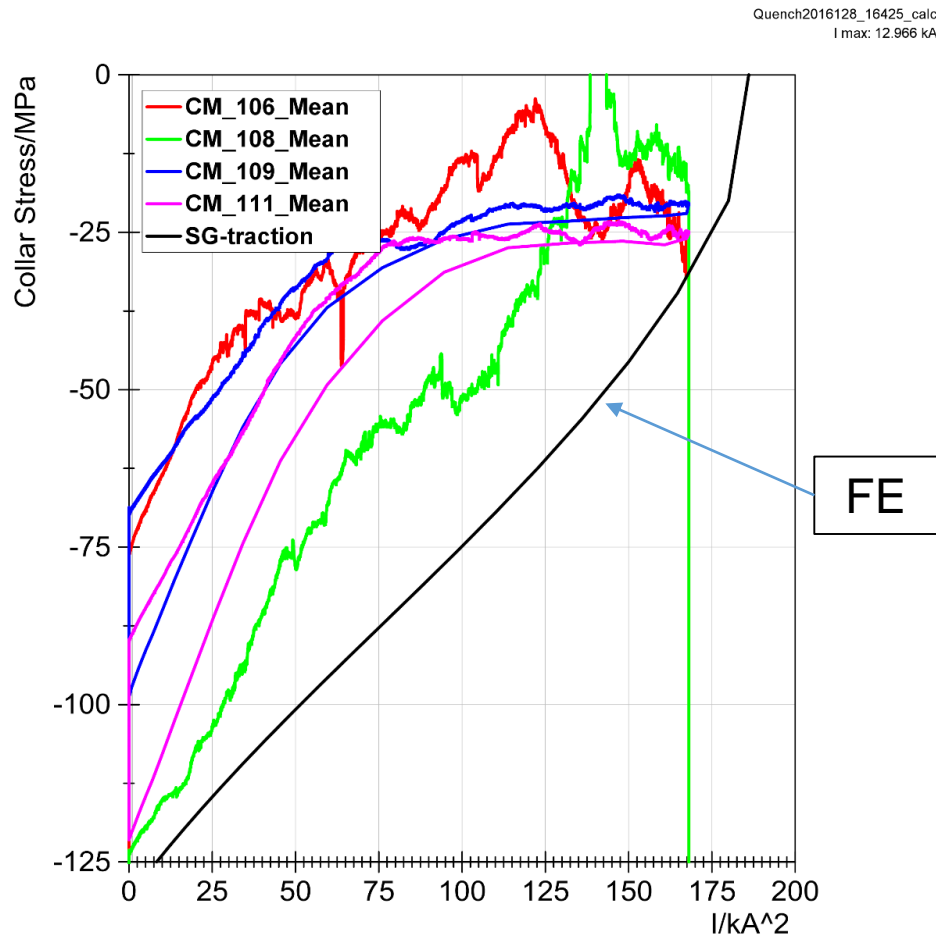


FE - 2in1 - Shell to Coil - stress relation (warm)



- As soon as the yoke gap is closed most force are transmitted in the yoke
- Manageable risk to not over stress the coil during the welding operation

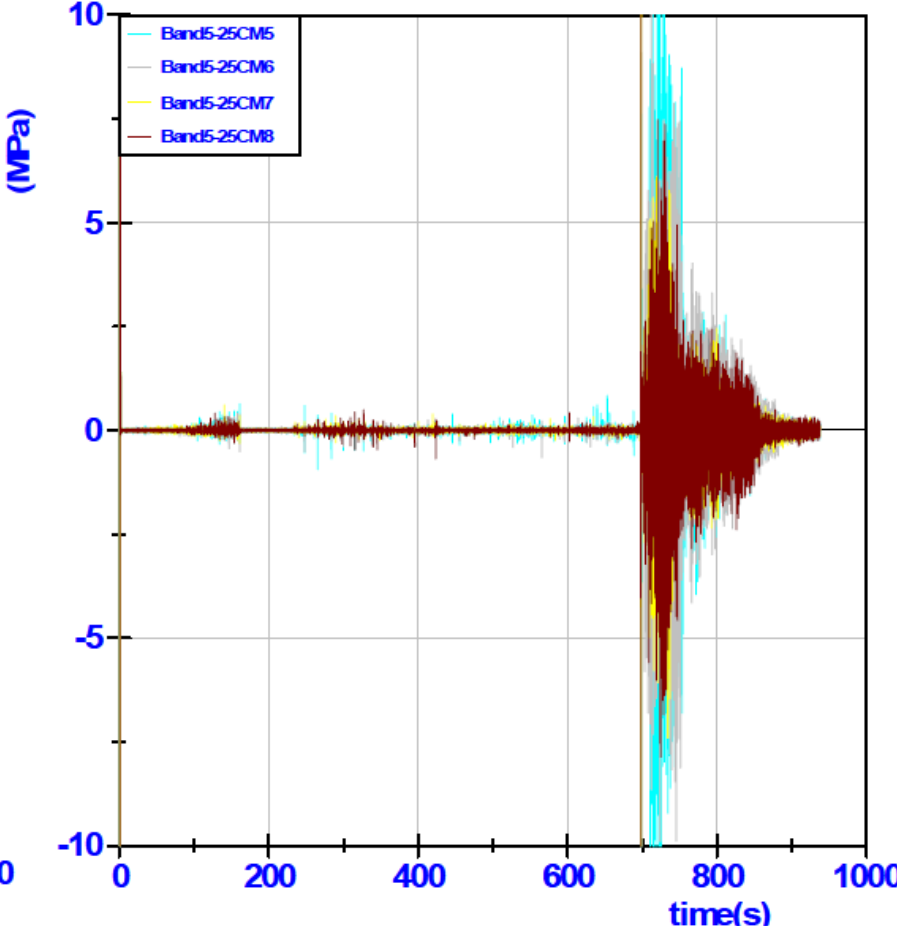
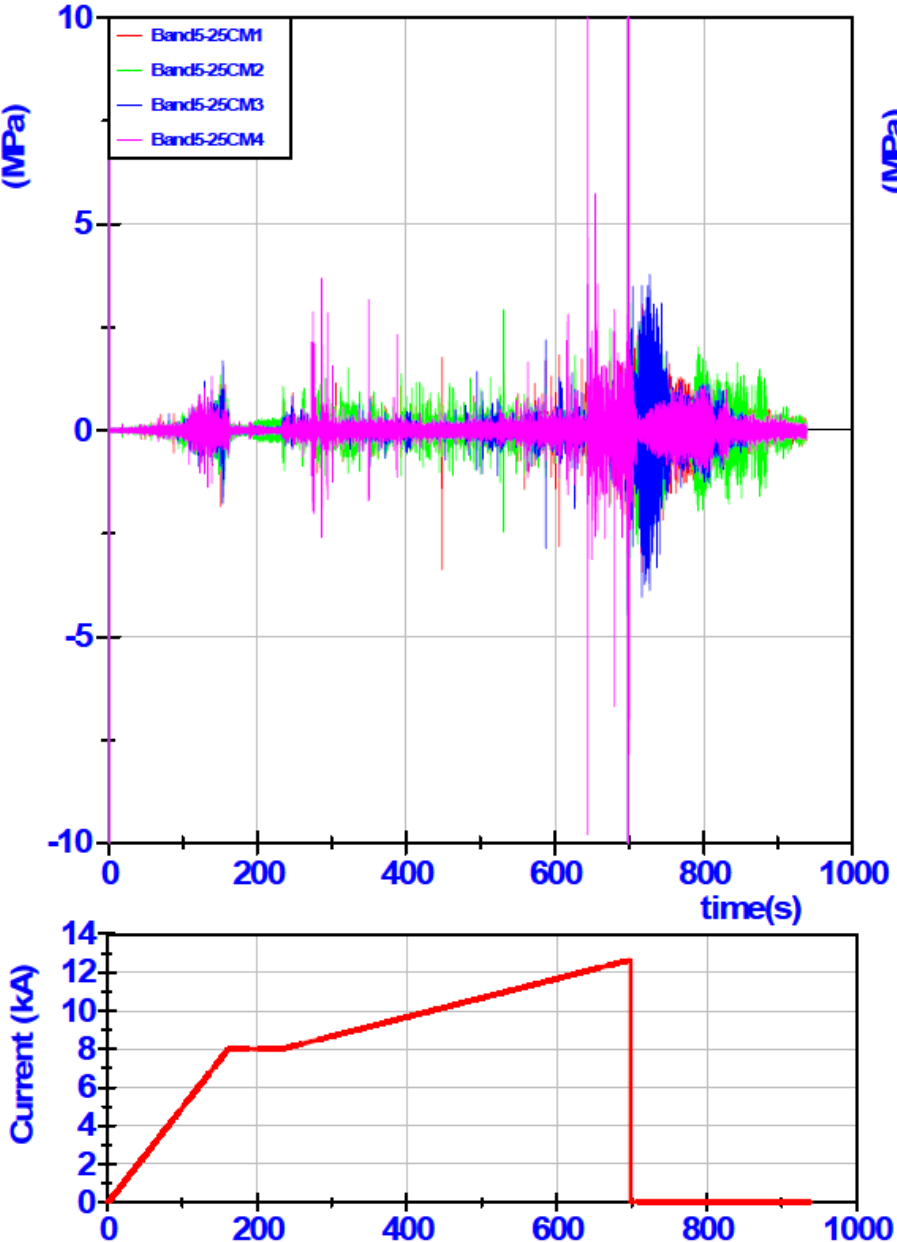
Measured and FE-prediction – 12T_2in1



- The unloading is not linear in reality
- FE values on average for one turn
 - Midplane CC103
 - IL : -105MPa
 - OL: -84MPa
 - Pole
 - IL: -14MPa
 - OL: -18MPa

Additional slides

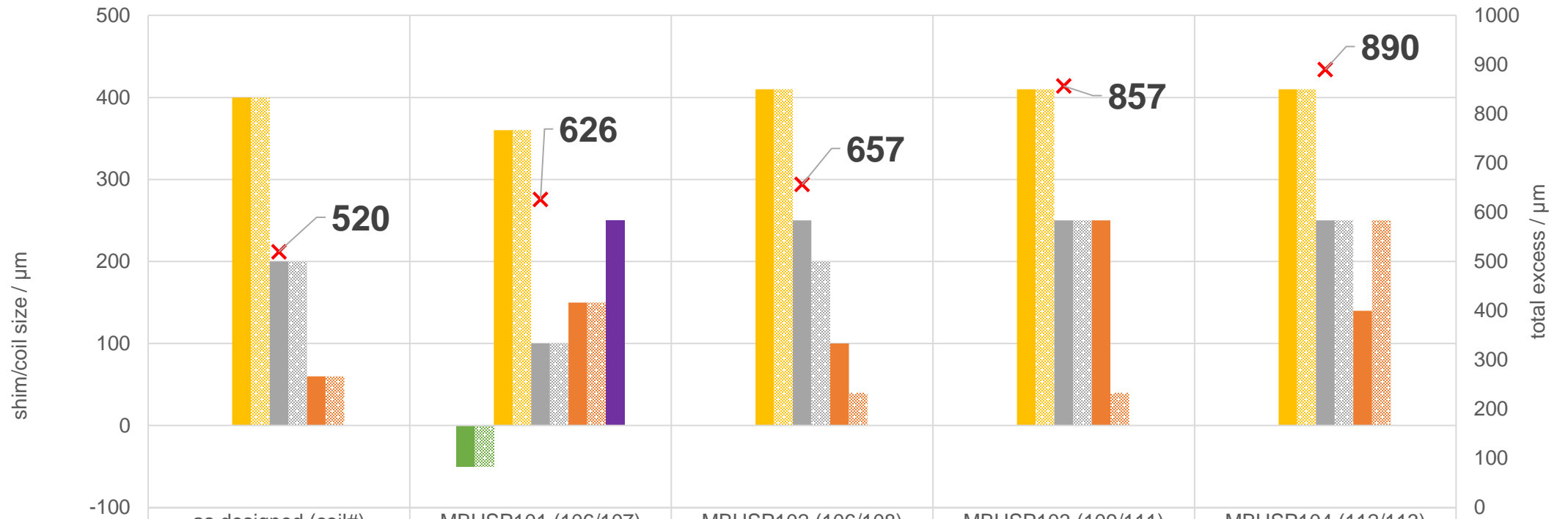
Oscillation seems to be a function of the current ramp in CC102



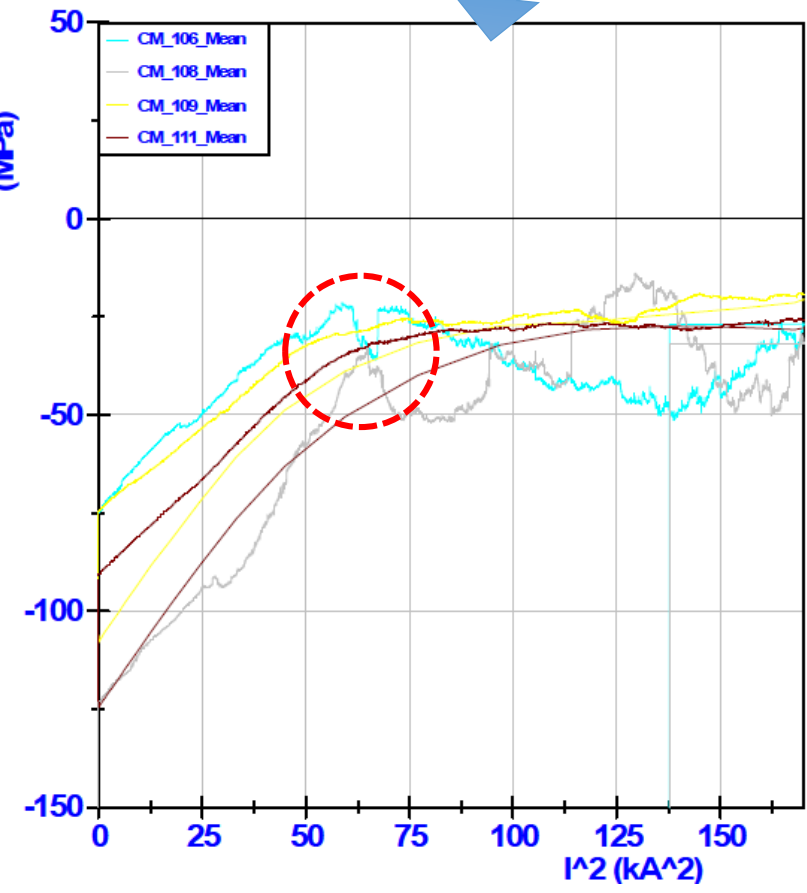
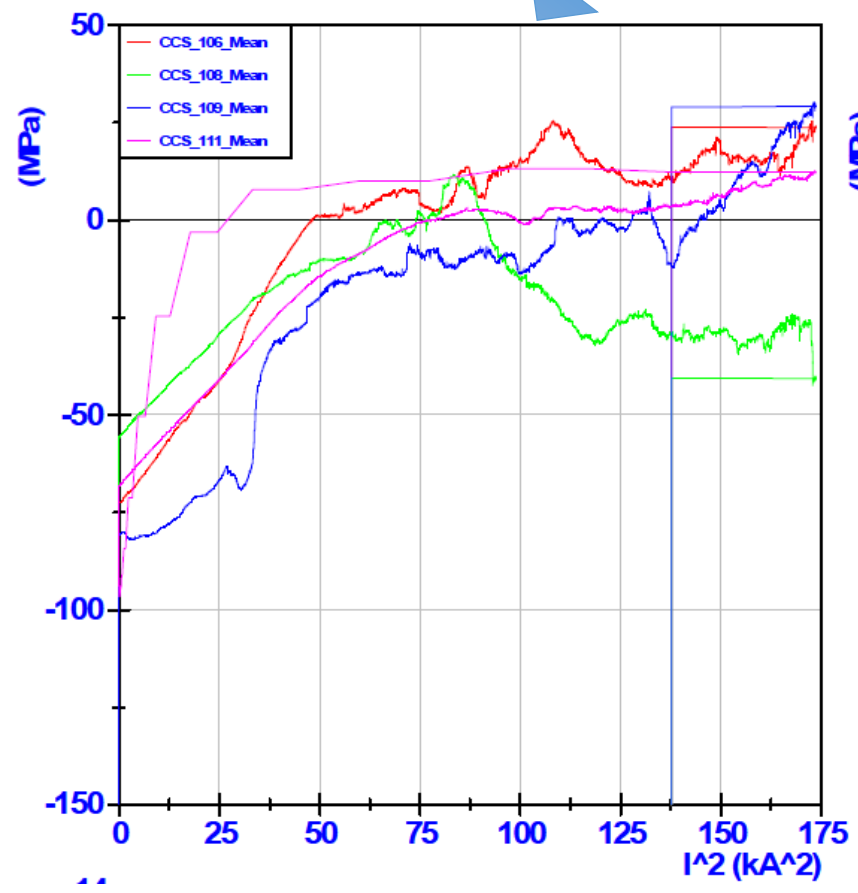
MBHDP101

Quench201624_9448

11T-model shimming summary



	as designed (coil#)	MBHSP101 (106/107)	MBHSP102 (106/108)	MBHSP103 (109/111)	MBHSP104 (112/113)
■ top collar-diameter	0	-50	0	0	0
■ bottom collar-diameter	0	-50	0	0	0
■ top collar-yoke	400	360	410	410	410
■ bottom collar-yoke	400	360	410	410	410
■ top pole-coil	200	100	250	250	250
■ bottom pole-coil	200	100	200	250	250
■ top coil size	60	150	100	250	140
■ bottom coil size	60	150	40	40	250
■ midplane shim	0	250	0	0	0
✗ total azimuthal excess	520	626	657	857	890



- The gradient changes in both collared coils at the same current of 8kA