



MBRDP mechanical behaviour in its fourth cooldown

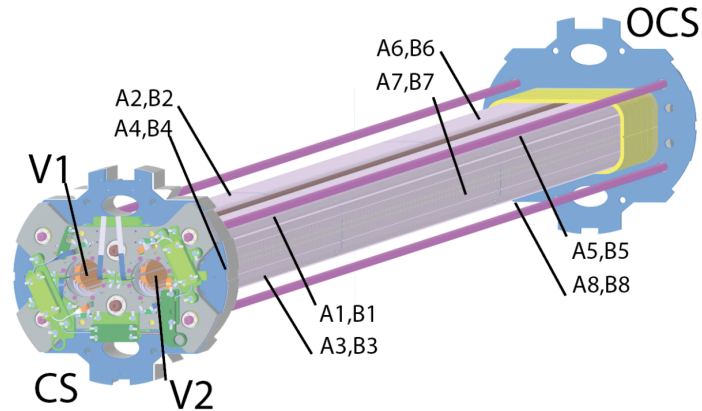
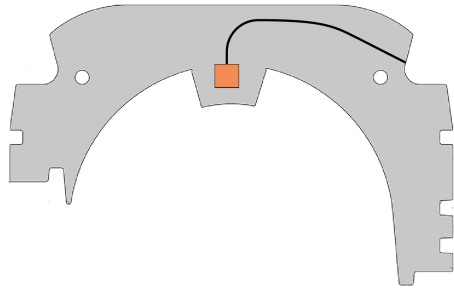
Andrea Bersani

Cool-downs summary

- First, October 2022
 - mainly devoted to training and overall performances
- Second, November 2022
 - mainly devoted to retraining, protection and performances
 - showed possible reduction of mechanical pre-stress
- Third, February 2023 (no energisations)
- Fourth, May 2023
 - mainly devoted to mechanical stability (plus retraining, magnetic measurements, etc.)
 - mechanical measurements are being thoroughly analysed

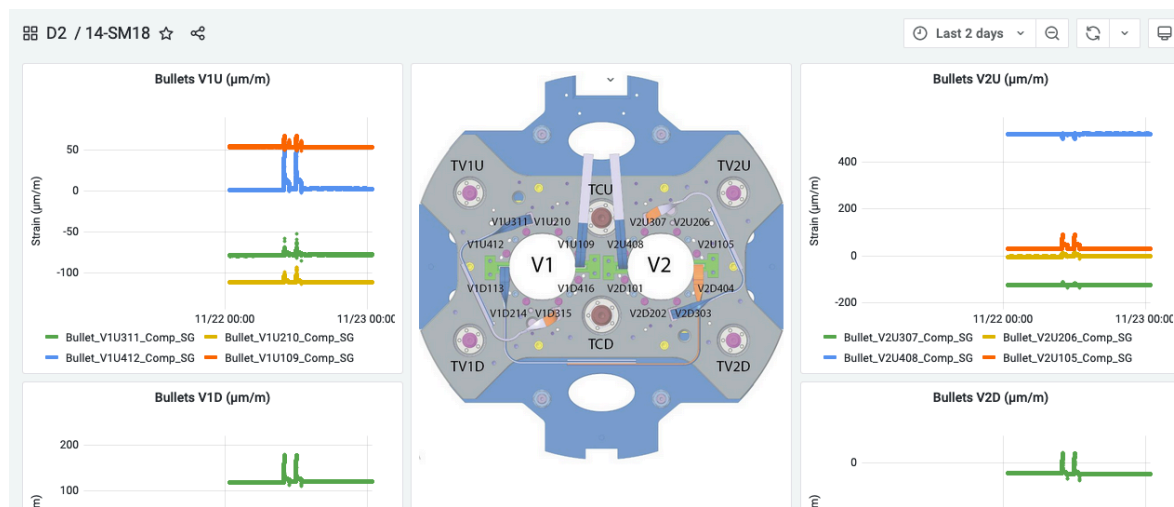
Strain gauges on the prototype

- Full bridge on each tie rod
- Full bridge on each bullet pushing the coils (1 not working)
- Half bridge on sleeves (only 1 working)
- Half bridge on collars (according to figure – not all could be read – actually best understood in couples)



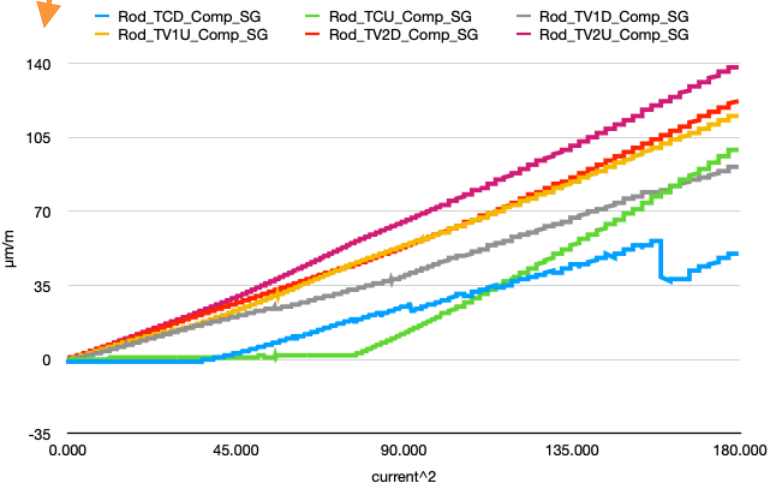
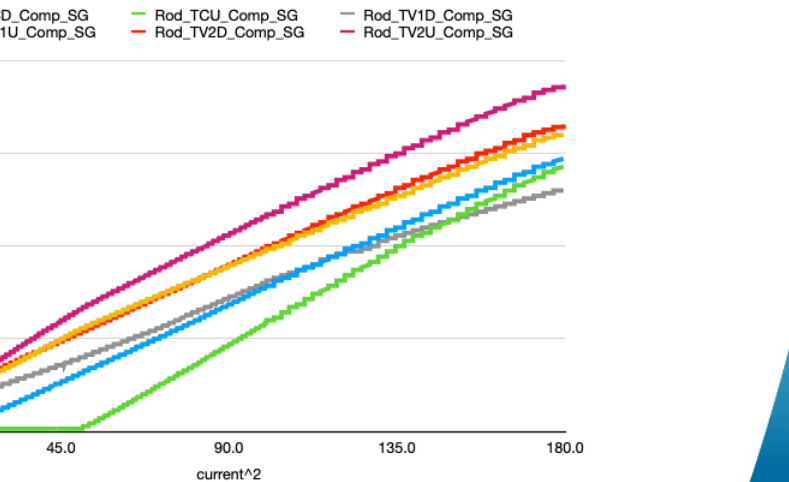
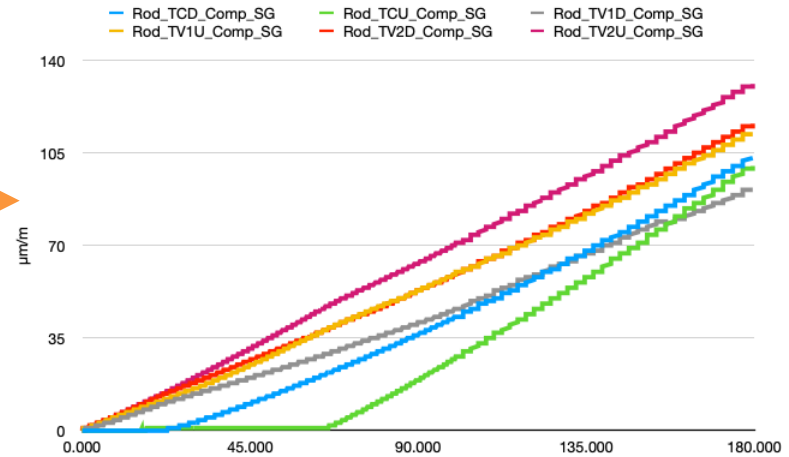
Measured data

- In the first two cool-downs, data mainly analysed by CERN EN-MME group (special thanks to M. Guinchard)
- Data made available online via real-time interface



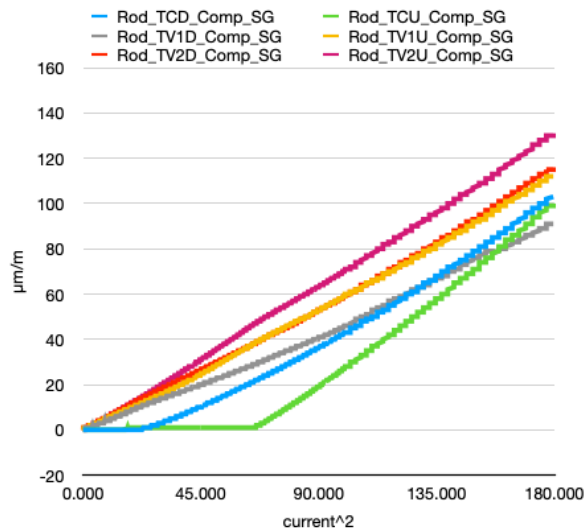
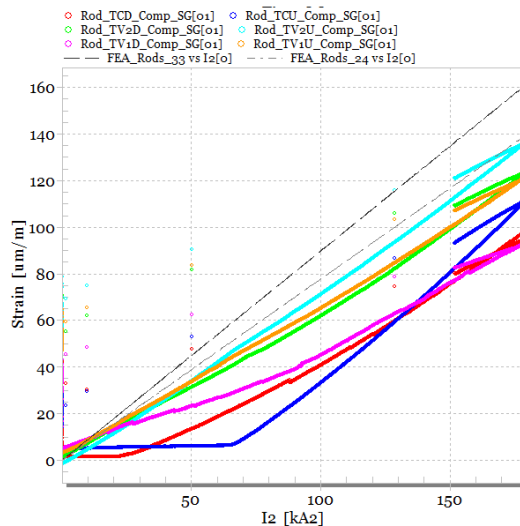
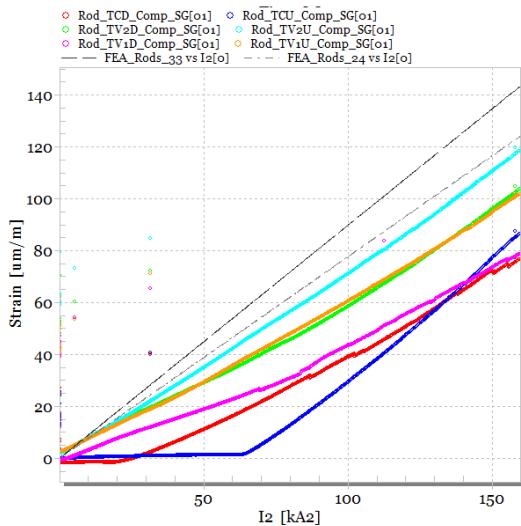
4th cool-down: tie-rods

- 1: first ramp up
- 2: last ramp up
- 3: last ramp down



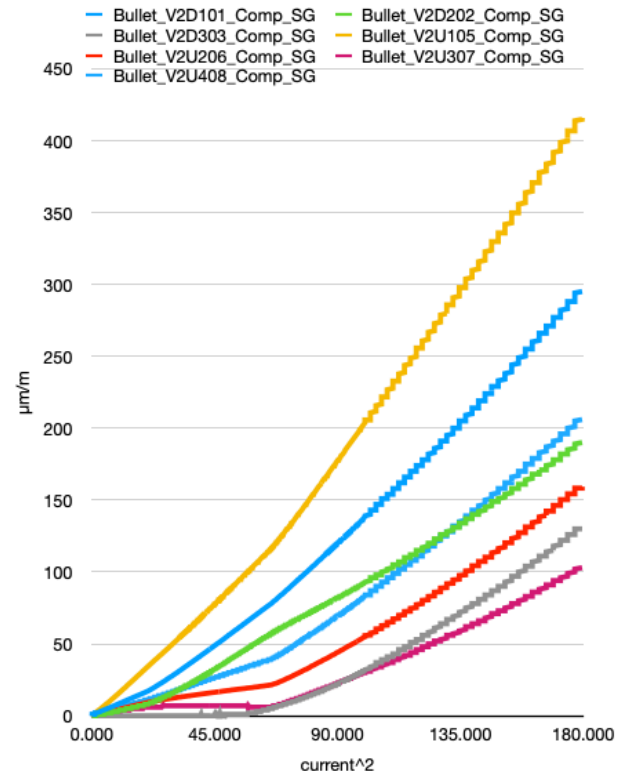
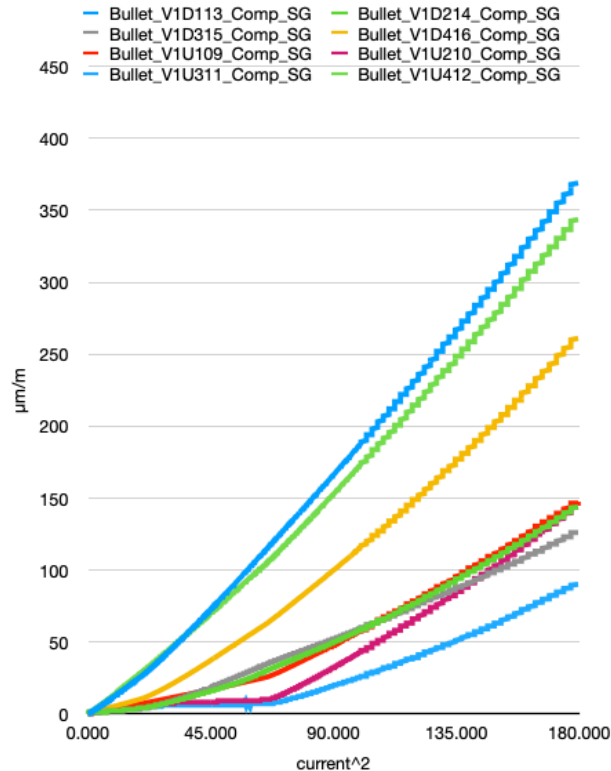
Comparison with previous cool-downs

- No significant variation has been observed
 - note that in first cool-down data ends at nominal current

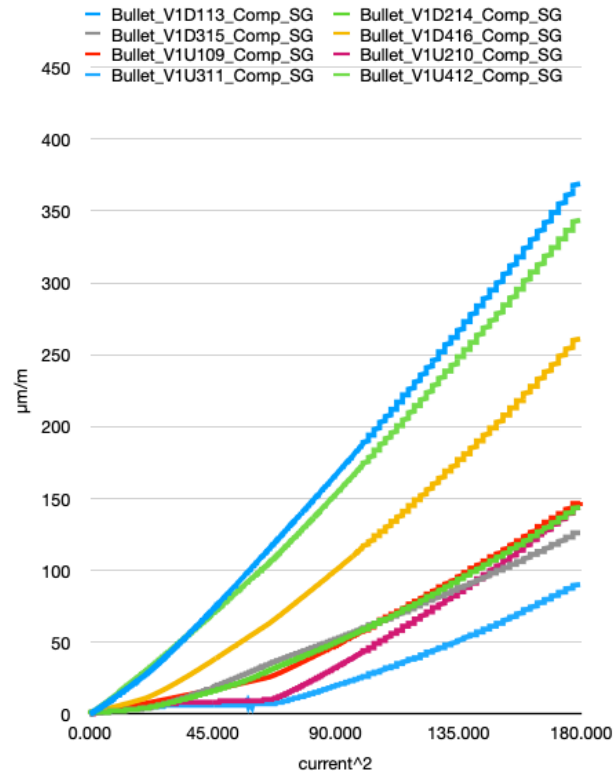
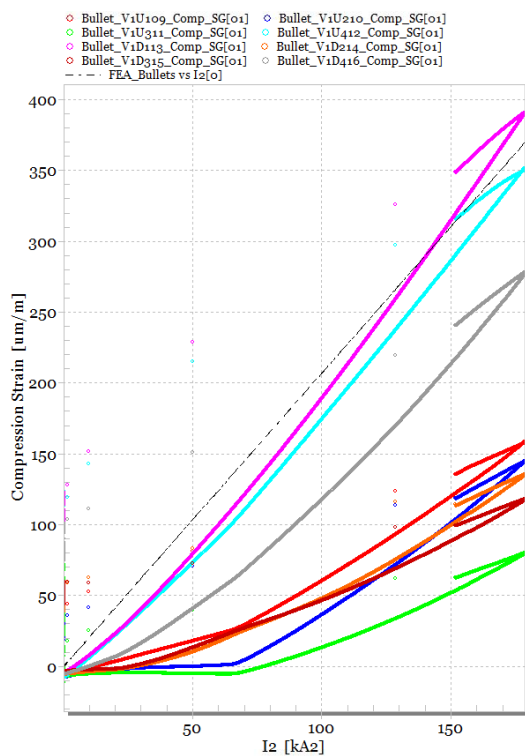
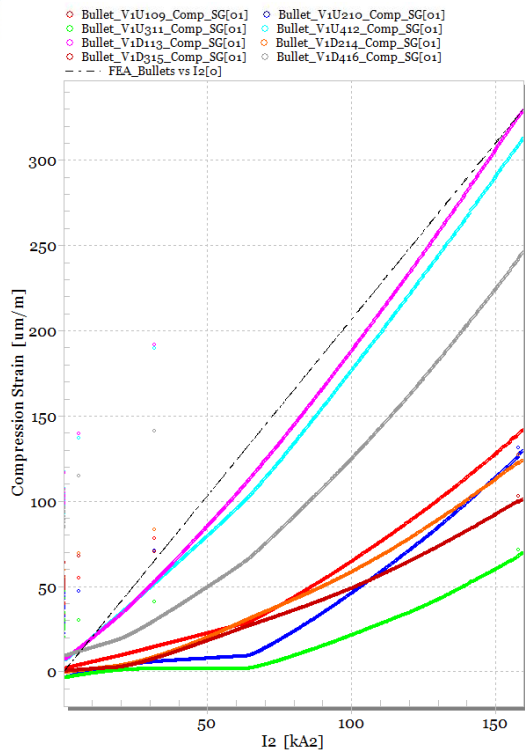


4th cool-down: bullet gauges

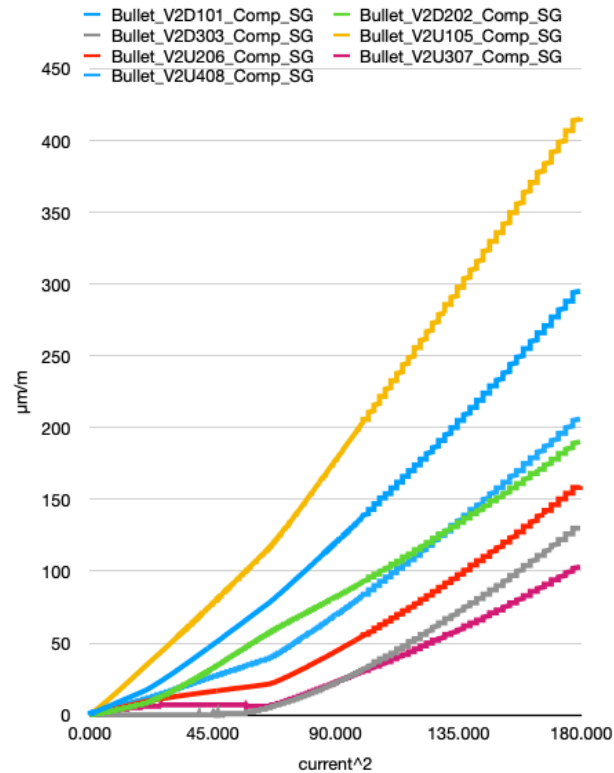
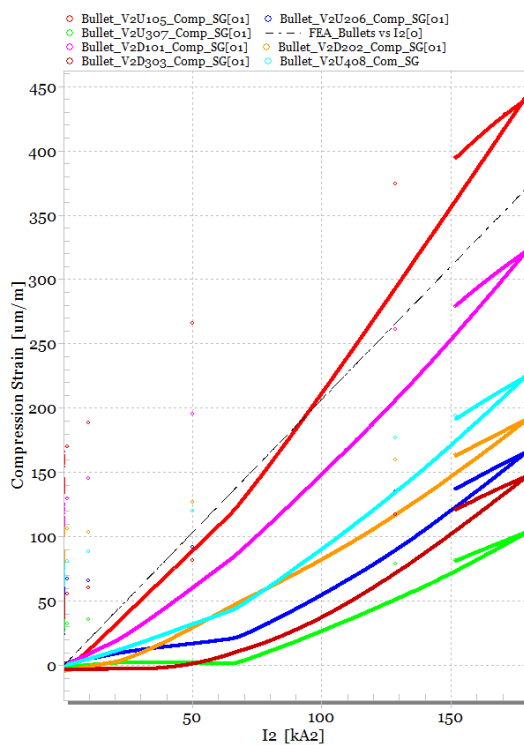
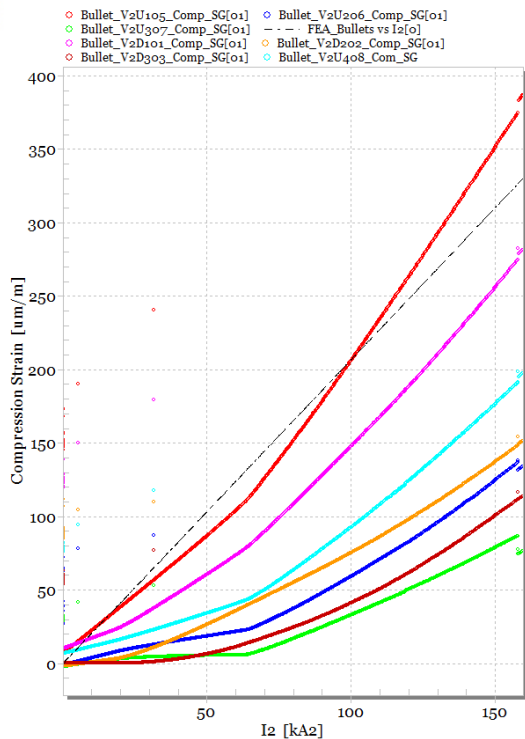
- Last current ramp up
- 1 is missing
- Goal strain is higher, some 370 $\mu\text{m}/\text{m}$



Comparison with previous cool-downs



Comparison with previous cool-downs

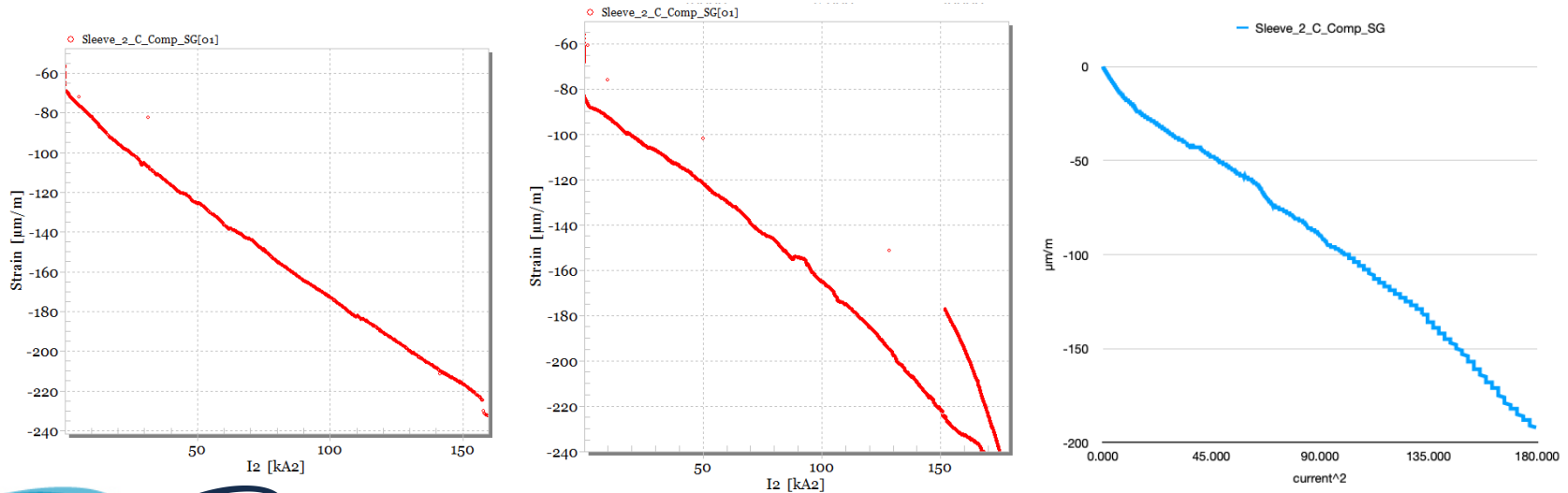


Longitudinal behaviour: summary

- The behaviour in the three cool-downs is reproducible
- Overall, lower than expected stress values have been measured
- Larger tie rods (TCD and TCU) show no load at 0 current
 - due to the fact that M33 and M24 rods have been tightened at the same torque – less strain in larger ones
 - will be addressed in the next magnets
- Some spread in bullet gauges behaviour has been observed

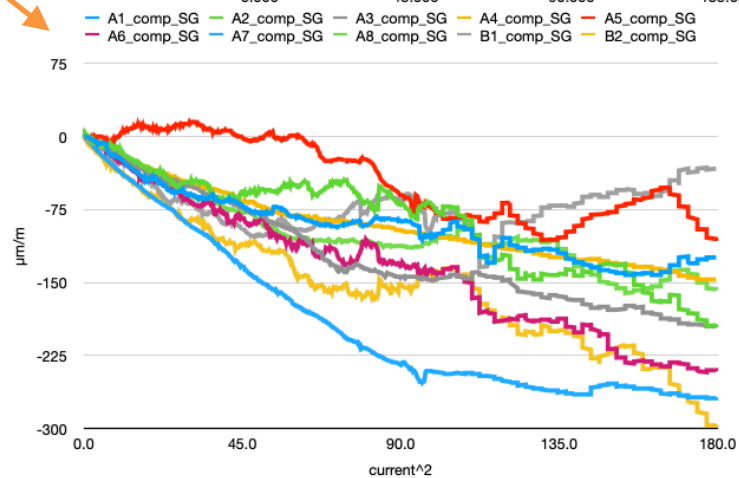
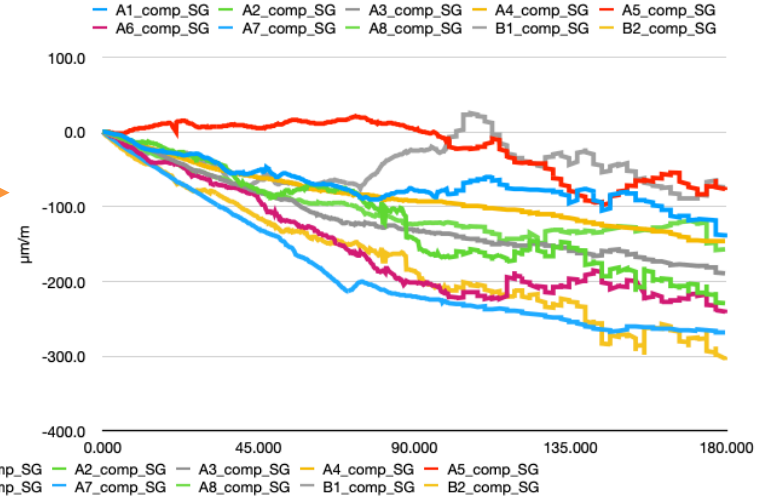
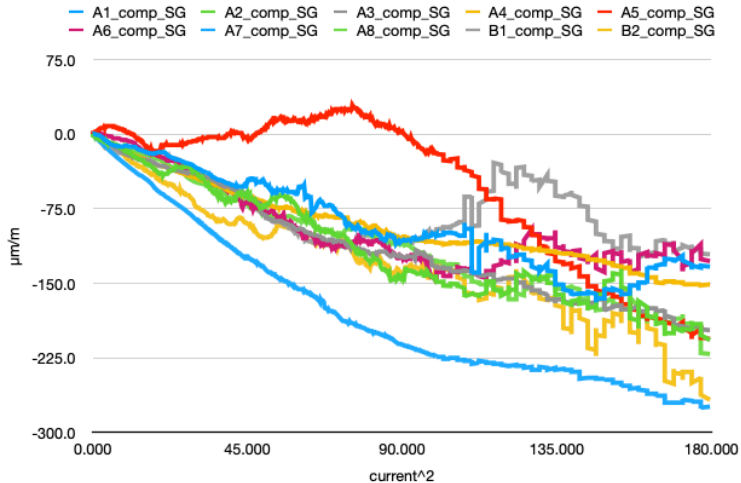
Azimuthal behaviour: sleeve

- Different zero setting in previous measurements
- No significant difference in the 3 cool-downs



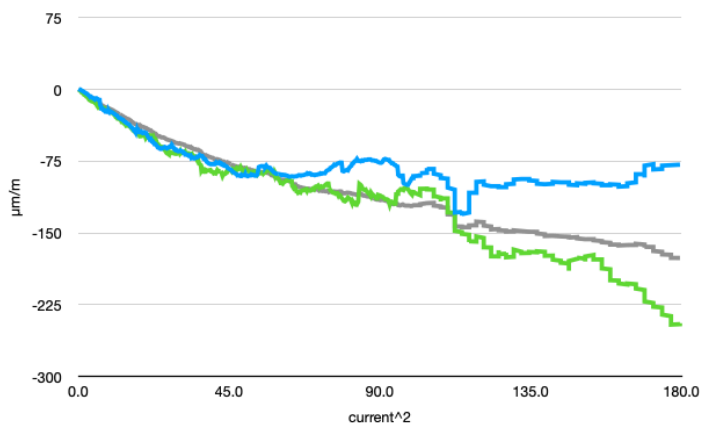
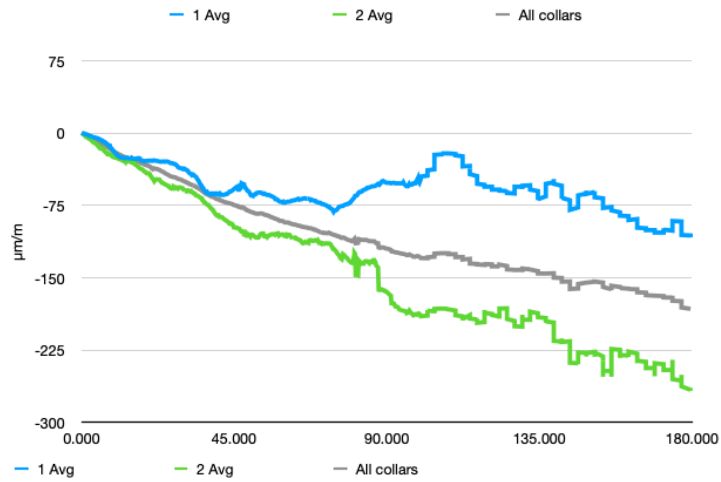
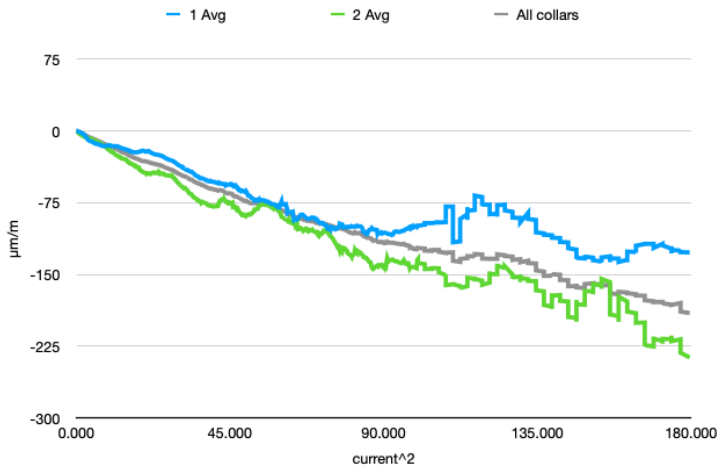
4th cool-down: collars

- 1: first ramp up
- 2: last ramp up
- 3: last ramp down

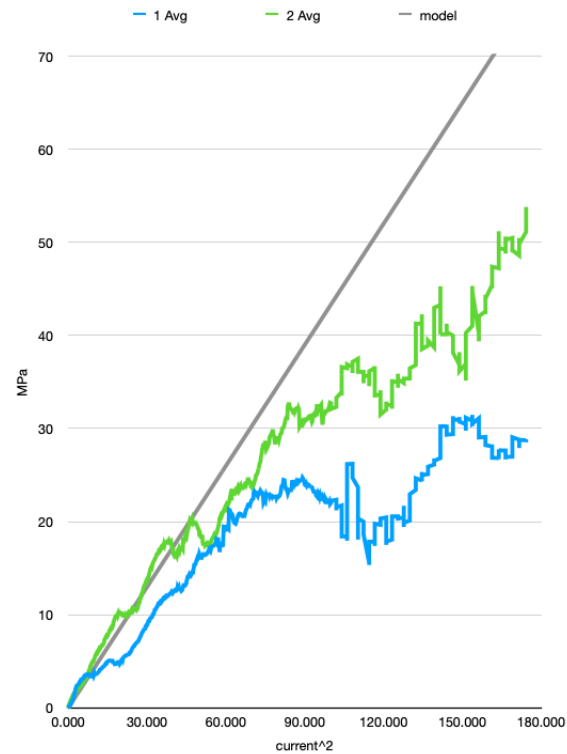
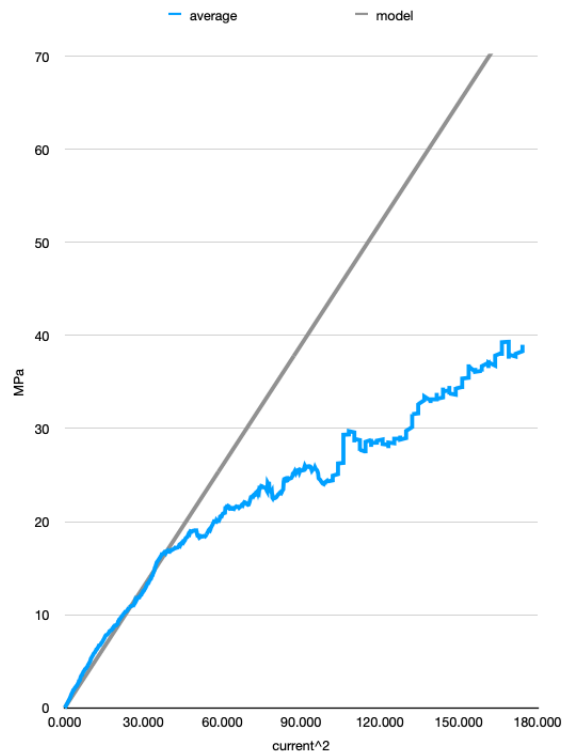
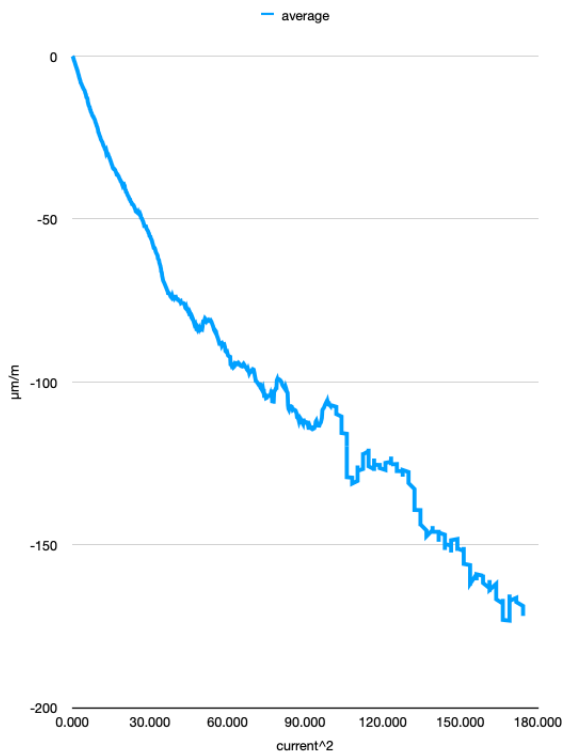


4th cool-down: collars couples

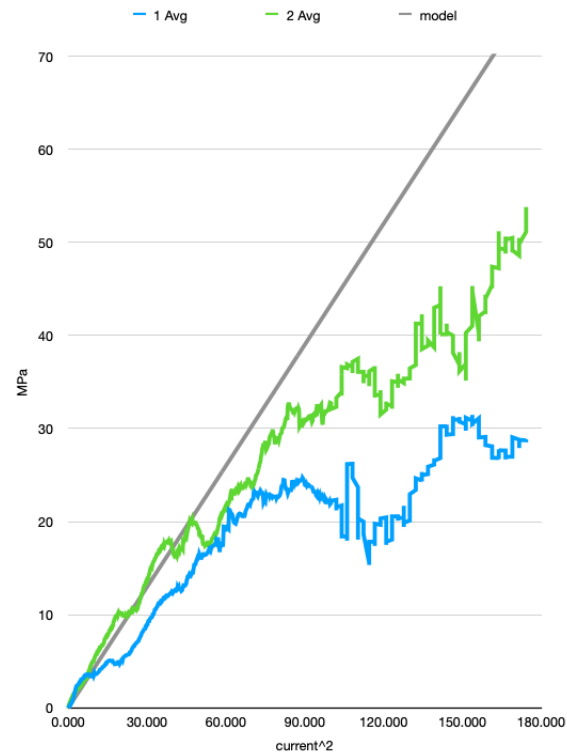
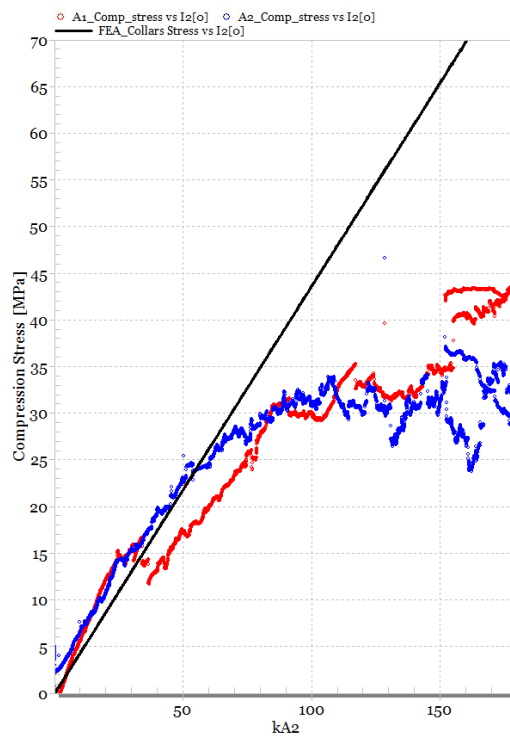
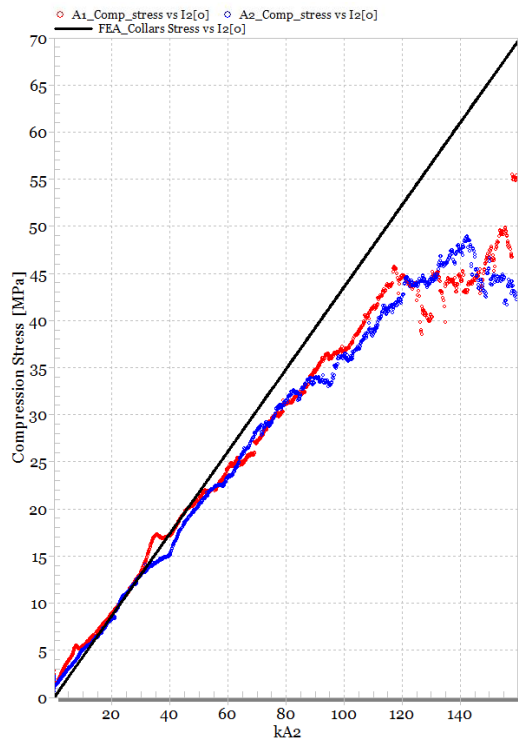
- 1: first ramp up
- 2: last ramp up
- 3: last ramp down



4th cool-down: collars averages



Comparison with previous cool-downs



Collars: discussion

- Apparently, a reduction of pre-stress occurred between cool-down 1 and 2
- No significant further reduction is evident between cool-down 2 and 4
- The average on more cycles possibly shows two slopes
 - further investigation on the full set is ongoing
 - more than 10 ramps available for cool-down 4
 - I will ask EN-MME to have all data from previous cool-downs
- In my opinion, no dangerous behaviour is observed

Conclusion

- A significant amount of data has been collected on MBRPD mechanical behaviour
- Three cool-downs allowed for a thorough investigation of the mechanical training of the magnet
- Data for most of the subsystems, tie rods, bullet gauges and sleeves, are stable and systematically below expectations
- Data from collars showed some change between cool-downs 1 and 2, and were stable between 2 and 4

Outlook

- Further analyses on MBRDP are possible
 - not all the ramps have been evaluated for cool-down 4
 - data from cool-downs 1 and 2 has been analysed mainly by CERN EN-MME group
- No further activity on MBRDP is foreseen
- Only strain gauges on tie rods will be installed on series magnets (and not be read after cryostat integration)
 - some spare instrumented collars have been installed on the first aperture of the first series magnet

Strain gauges installation on tie rods

- For the proper tightening of tie rods, SGs will be installed on series magnets
- The rods will be tightened at nominal torque with torque wrench at ASG Superconductors premises
- The magnets will be transferred to CERN
- Tie rods will be freed and instrumented by EN-MME group with their materials and technicians
- Tie rods will be tightened and fixated with glue afterwards, both with torque wrench and tie rods SGs readout