FE model results and strain gauge measurements

P. Ferracin, J. E. Munoz Garcia

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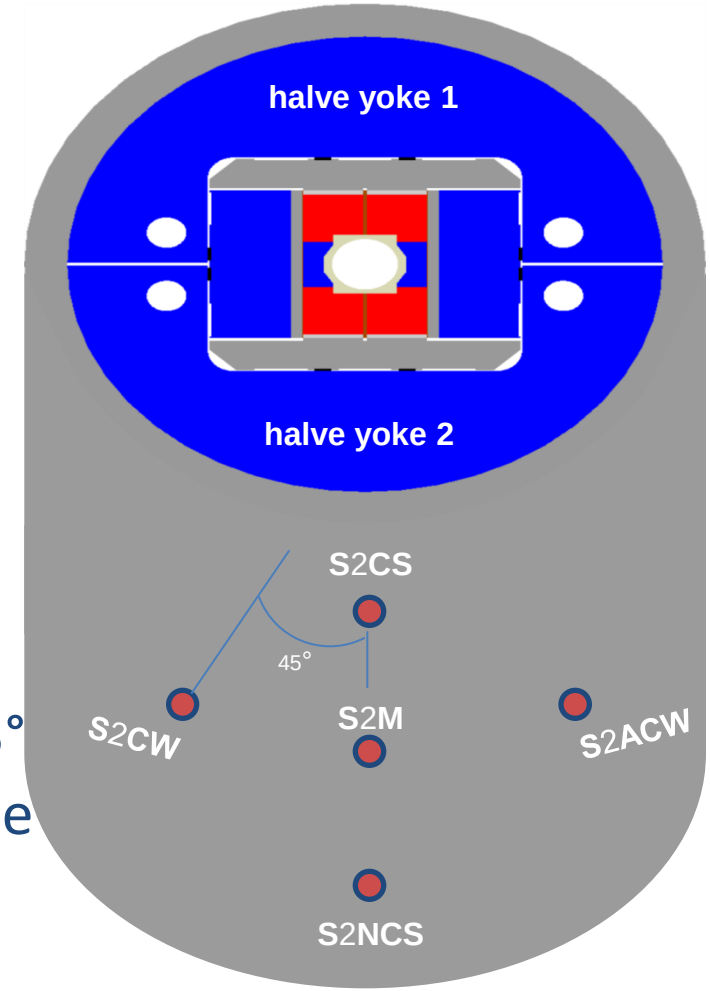
Outline

- Strain gauges location
- FE model predictions
- Strain gauge measurements
- Conclusions

Shell strain gauges

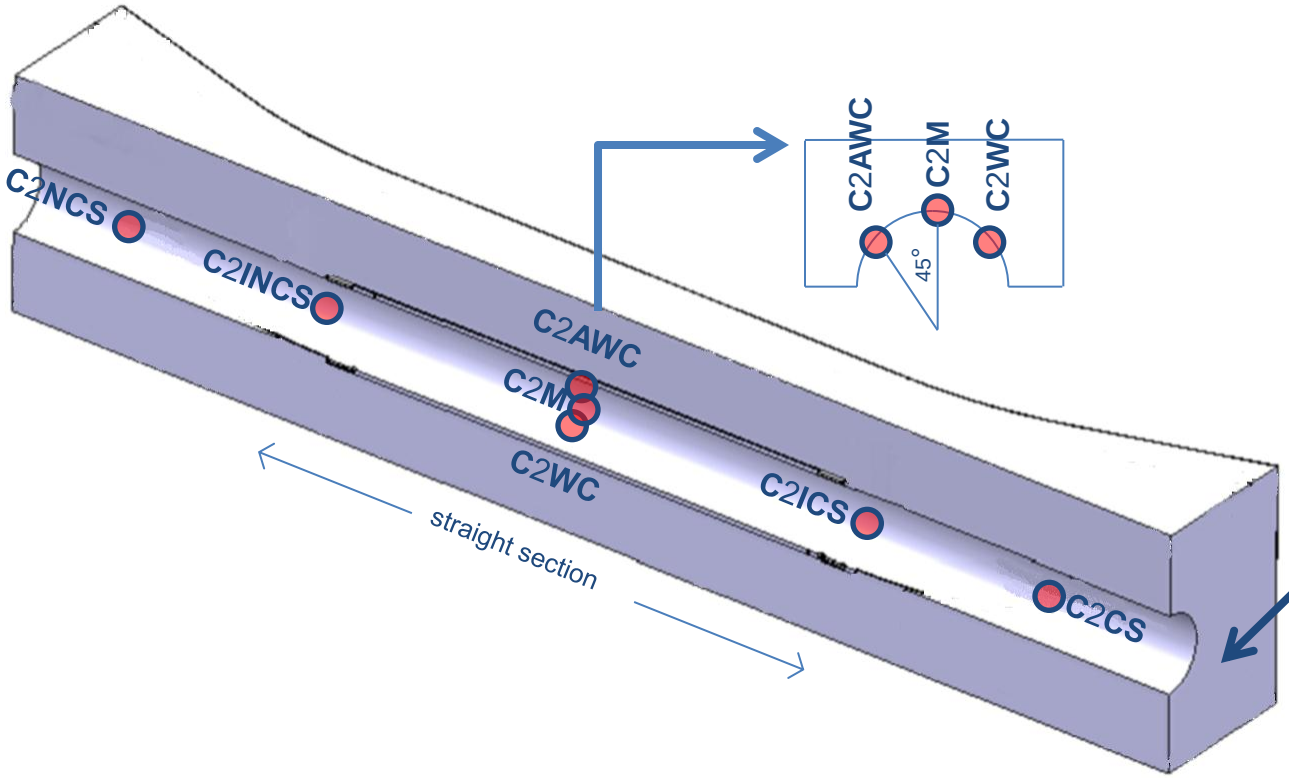
- Gauges
  - 10 azim.
  - 10 axial
  - Each with T compens.
- Locations
  - Longitudinal center of the shell: 0° to ±45°
  - Near-end of the structure



gauges S1

gauges S2

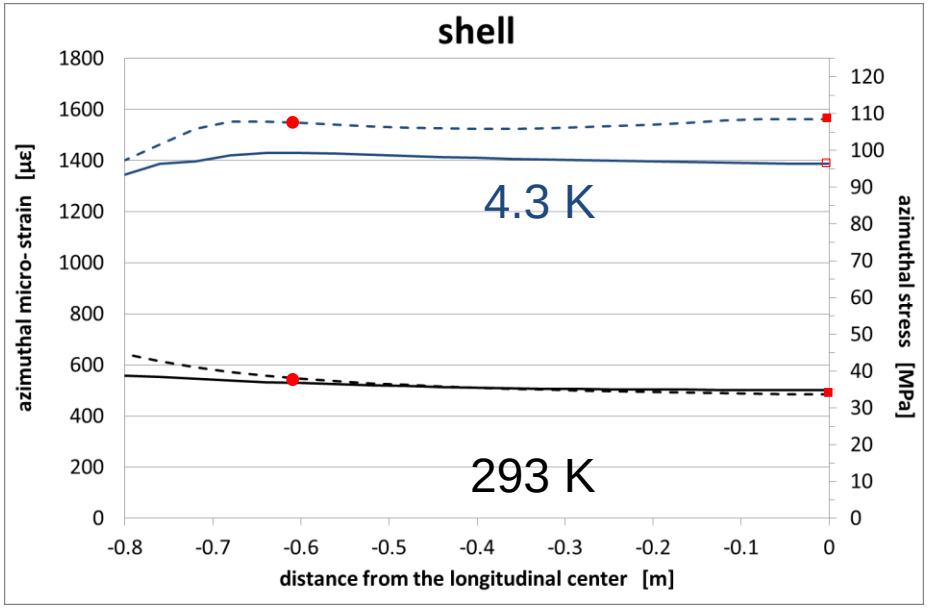
Dummy coil strain gauges

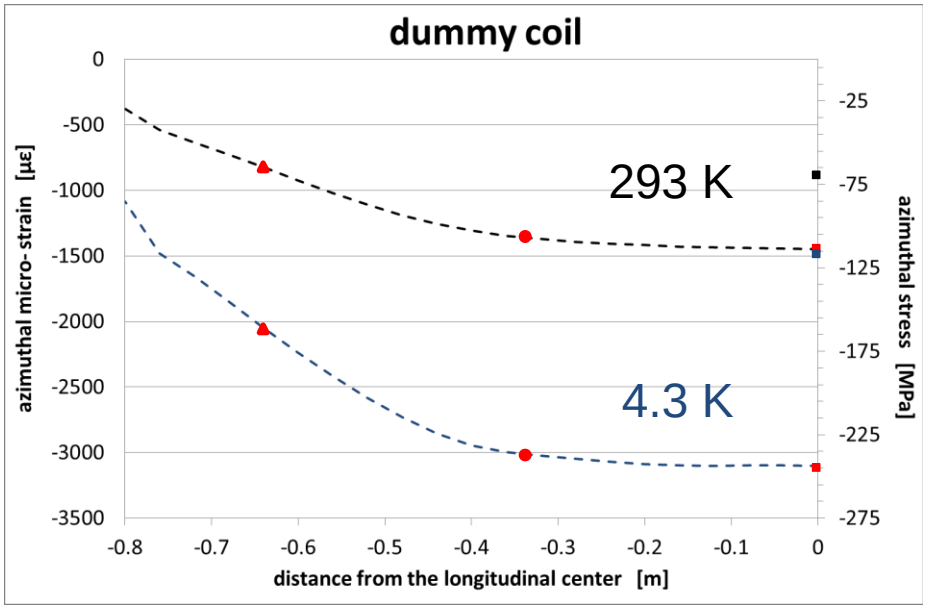


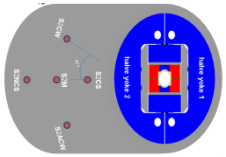
- Gauges
  - 14 azimuthal
  - 14 axial
  - 2 external Temperature compensators
- Locations
  - Longitudinal center of the dummy: 0° to ±45°
  - End of the straight-section
  - Near-end of the structure

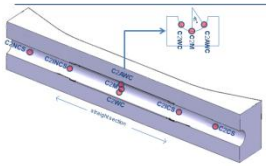
Shell and dummy coil: FE model predictions

- Shell: azimuthal ε and σ
  - 293 K: +500 µstrain / +36 MPa
  - 4.3 K: +1580 µstrain / +108 MPa
- Dummy coil: azimuthal ε and σ
  - 293 K: -1450 µstrain / -115 MPa
  - 4.3 K: -3100 µstrain / -235 MPa

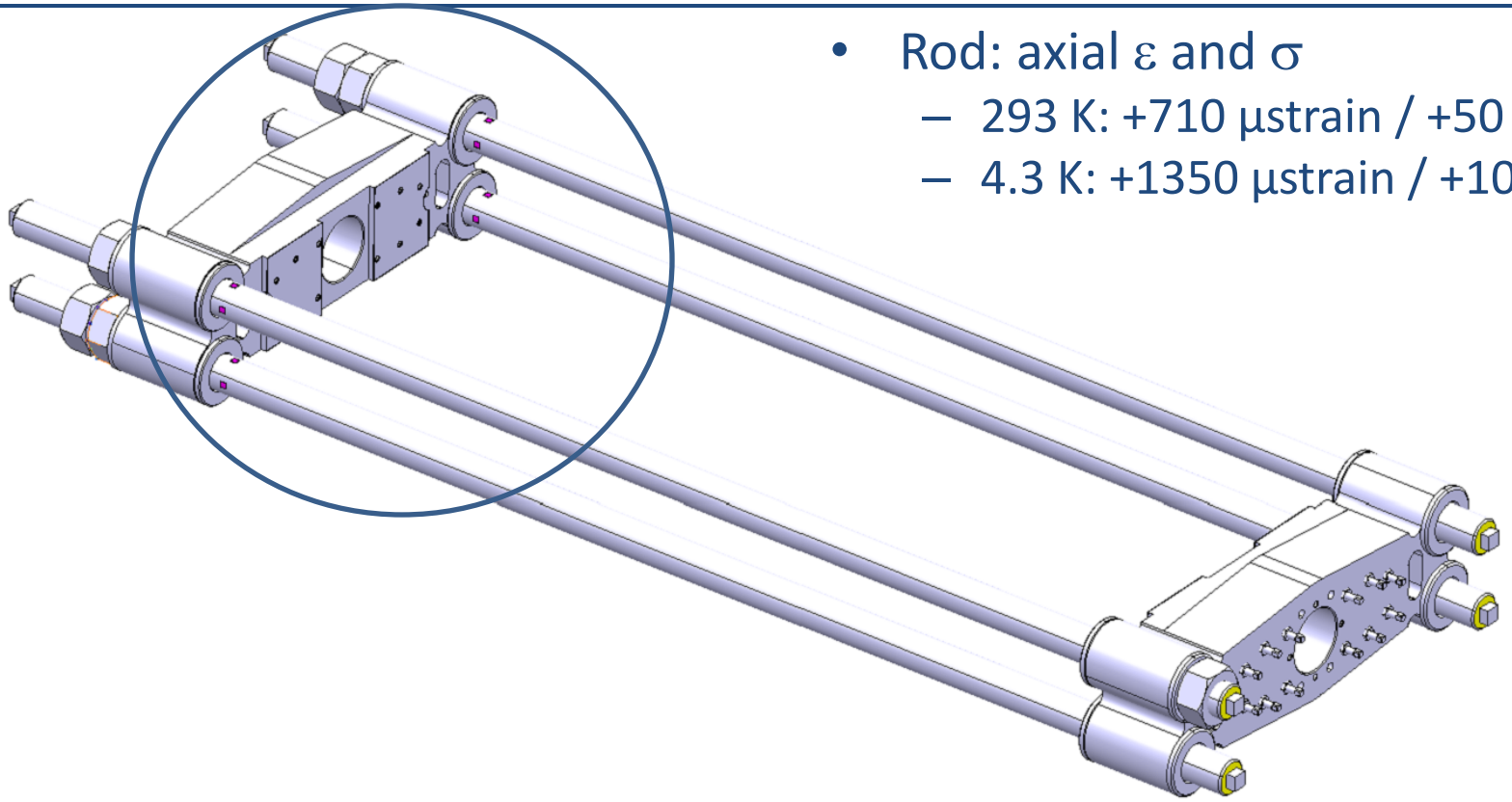








Axial rod strain gauges and FE model predictions



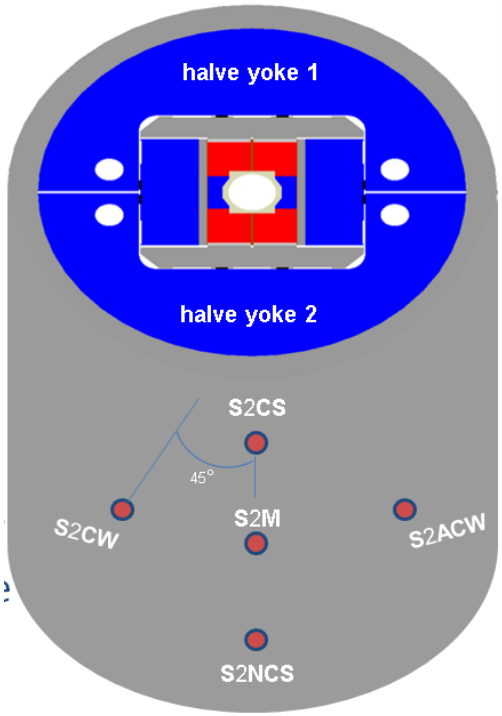
- Rod: axial ε and σ
  - 293 K: +710 µstrain / +50 MPa
  - 4.3 K: +1350 µstrain / +105 MPa

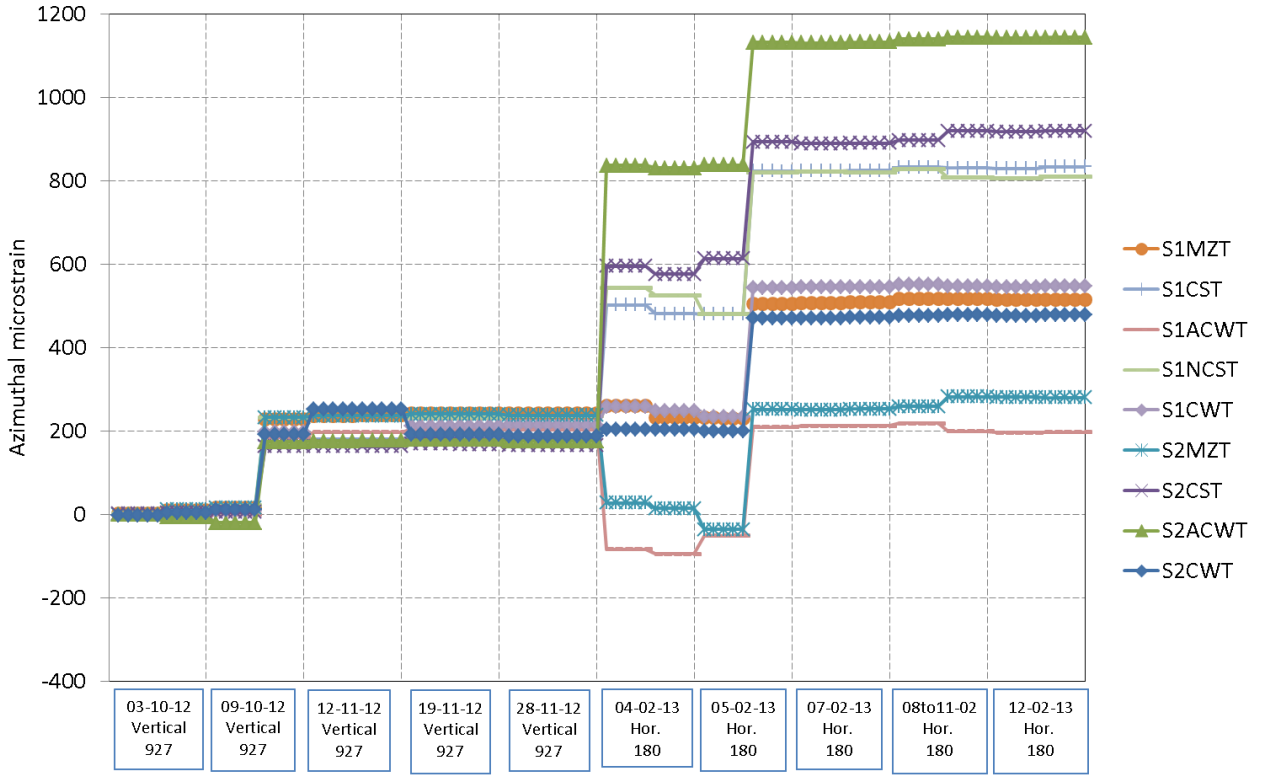
- Four gauges wired as a full-bridge to compensate for bending and temperature
  - 2 axial + 2 azimuthal

Shell azimuthal strain vs. time Overview

- 200 µstrain reached after “yoke loading”
- Large variations from build. 927 to 180
- Consistent increase during bladder operation

100 µstrain = 7 MPa

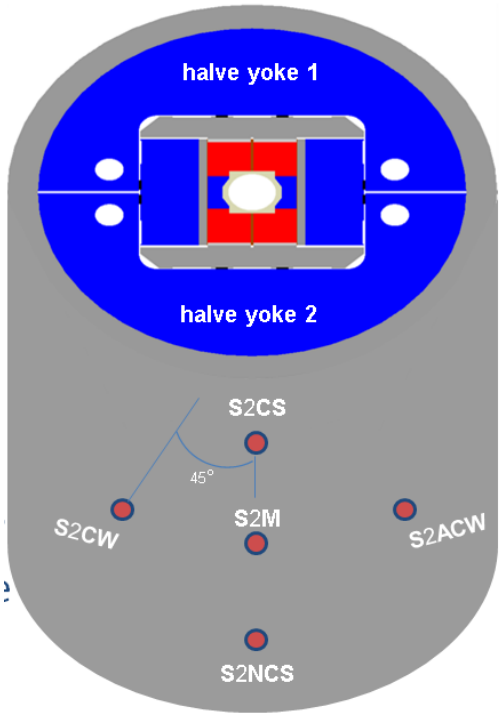


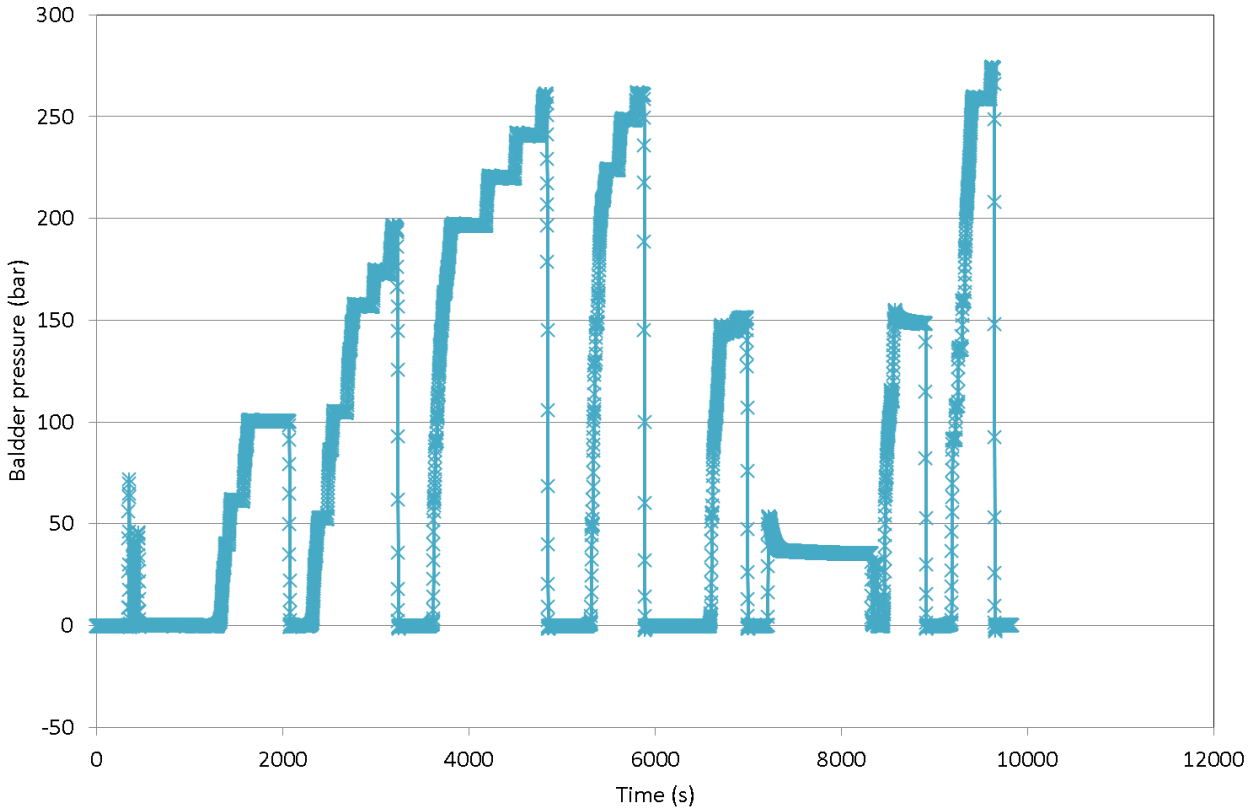


Bladder operation

- 7 bladder inflations
- Max pressure: 280 bars

100 µstrain = 7 MPa

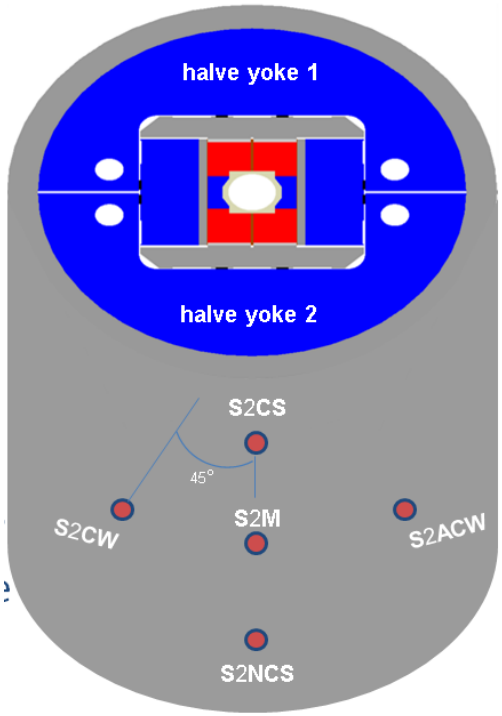


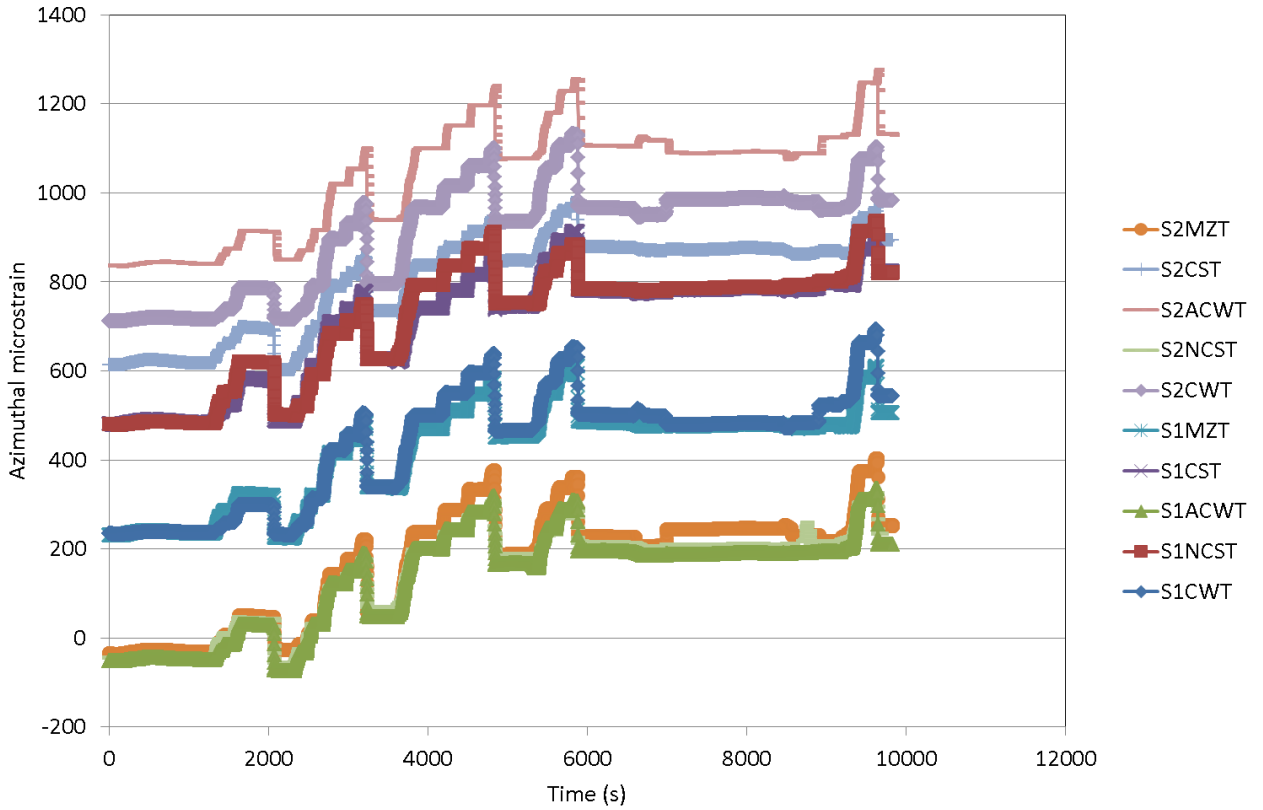


Shell azimuthal strain vs. time
Bladder operation

- Consistency in strain increase
  - About 250-300 µstrain
- Spread constant during bladder operation

100 µstrain = 7 MPa

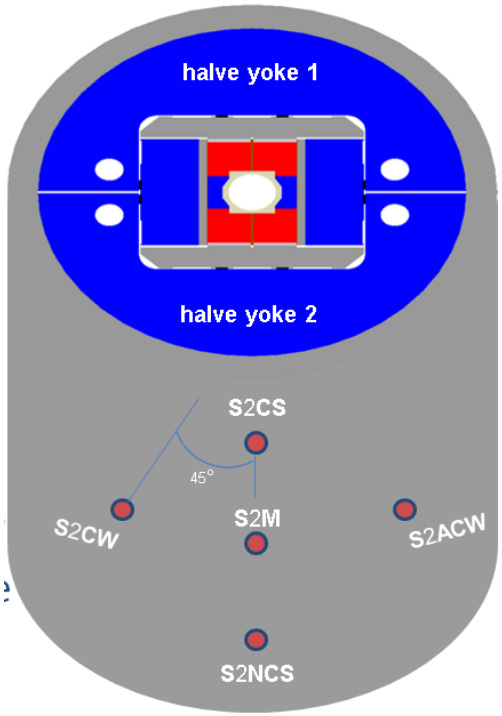


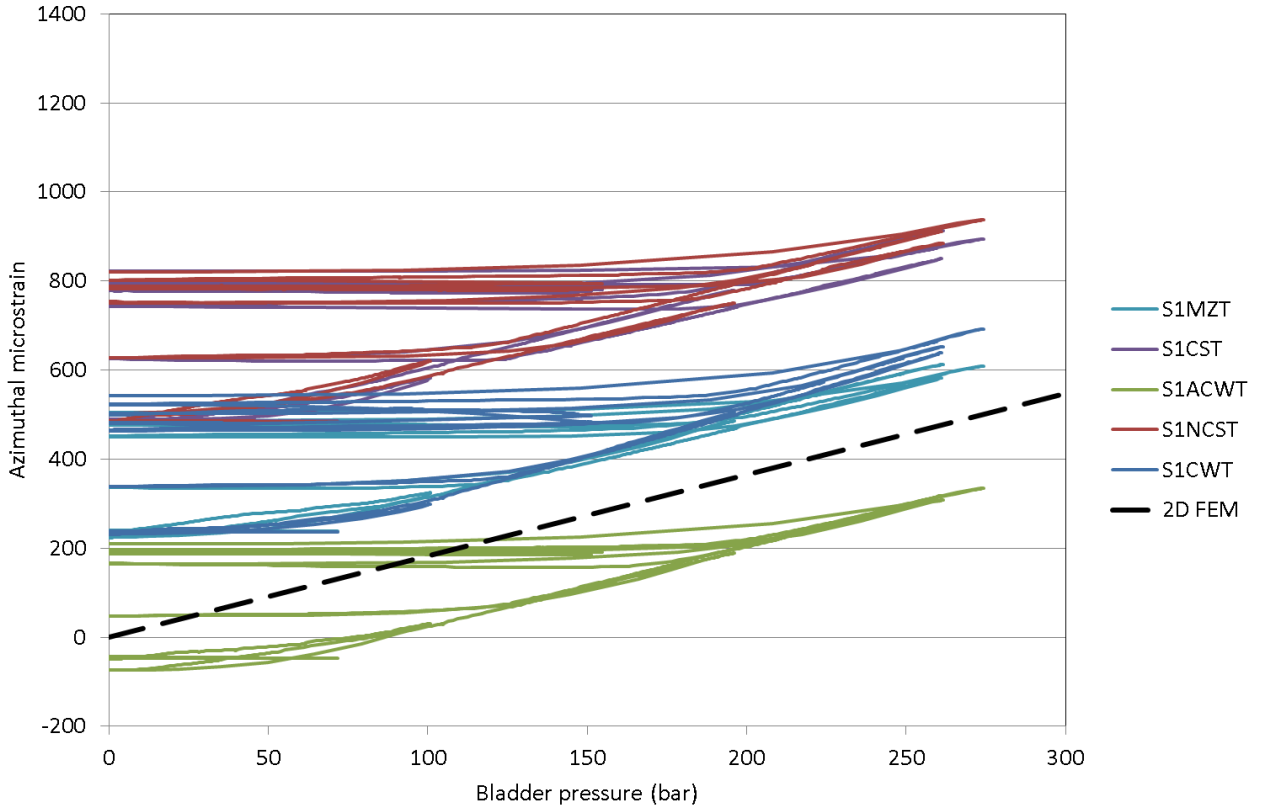


Shell azimuthal strain vs. bladder pressure
Bladder operation

- Agreement with computed slope
- Offset maintained

100 µstrain = 7 MPa

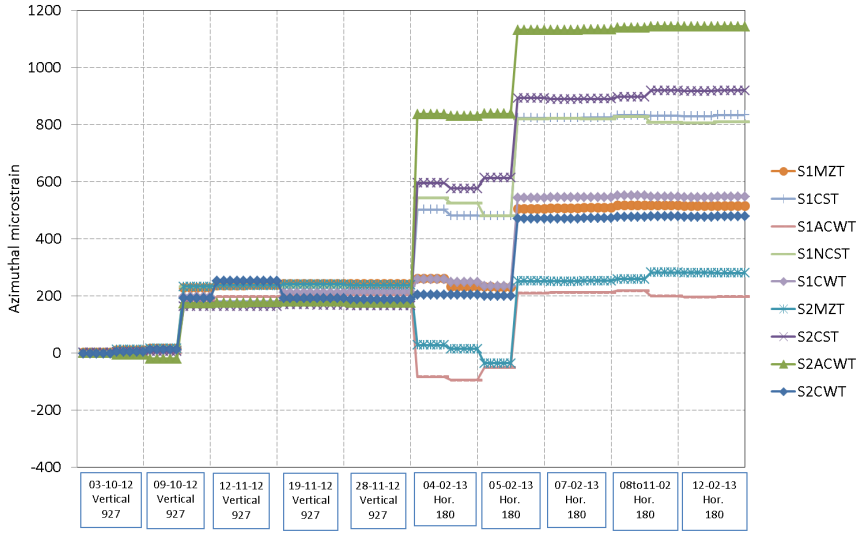


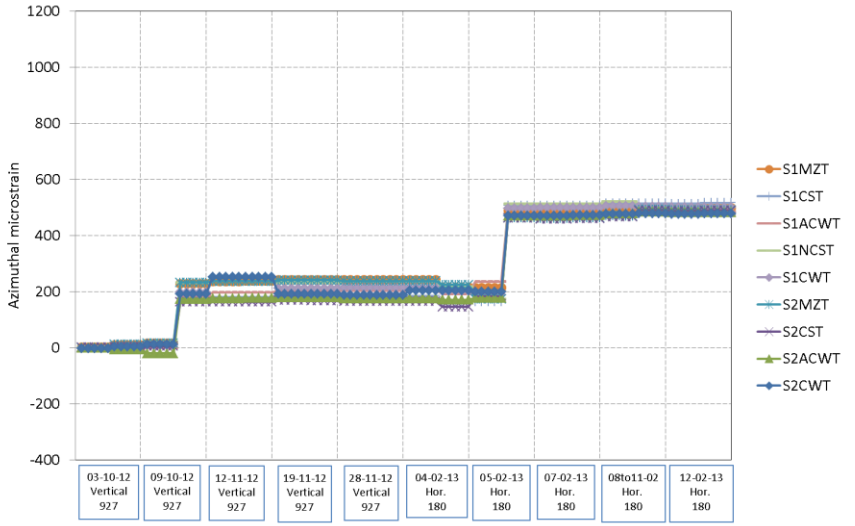


Shell azimuthal strain vs. time Overview

- Assumption: new offsets applied to values starting on 04/02/13

100 µstrain = 7 MPa

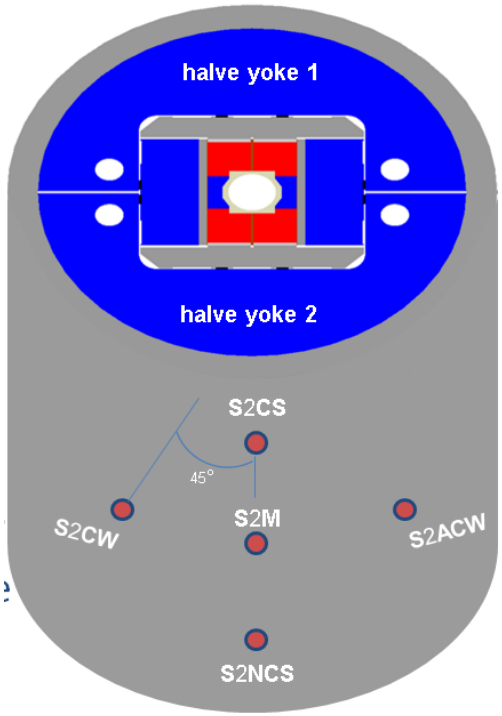


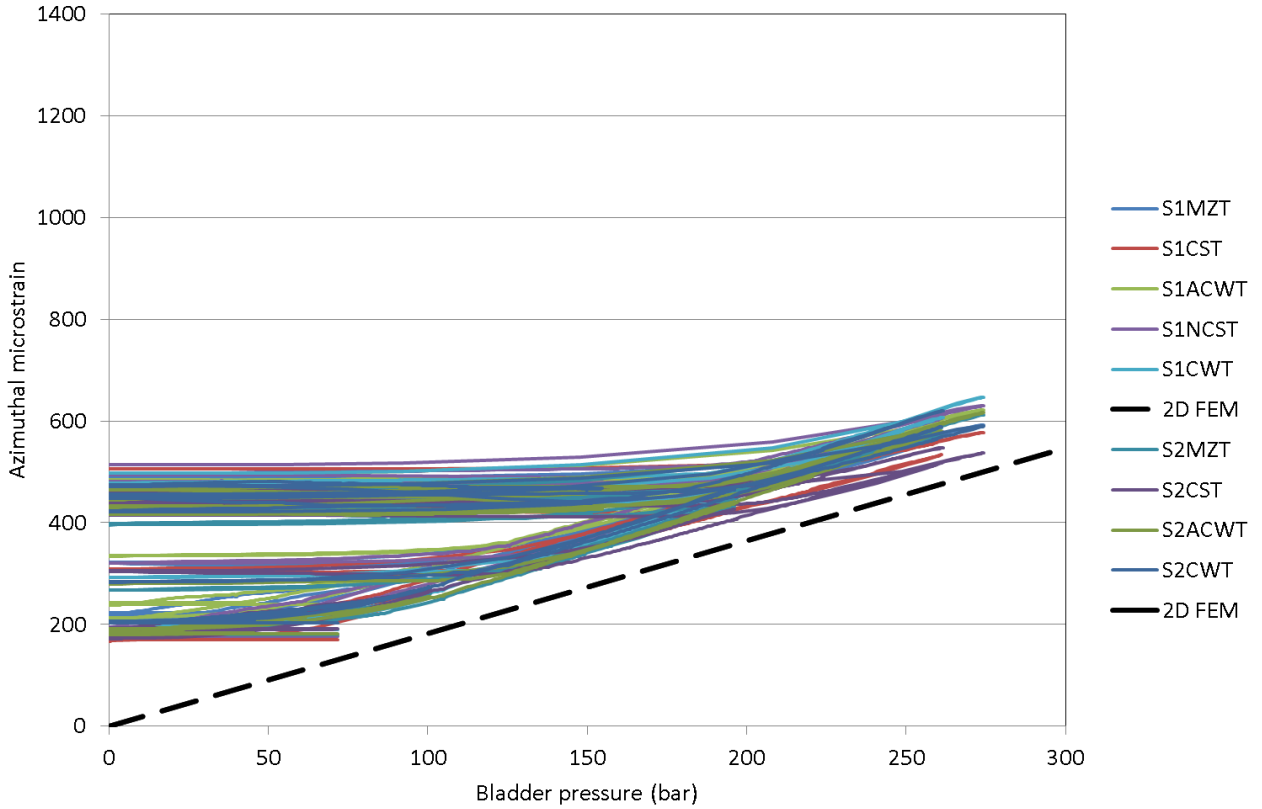


Shell azimuthal strain vs. bladder pressure Bladder operation

- New data in agreement with computed slope and absolute values

100 µstrain = 7 MPa

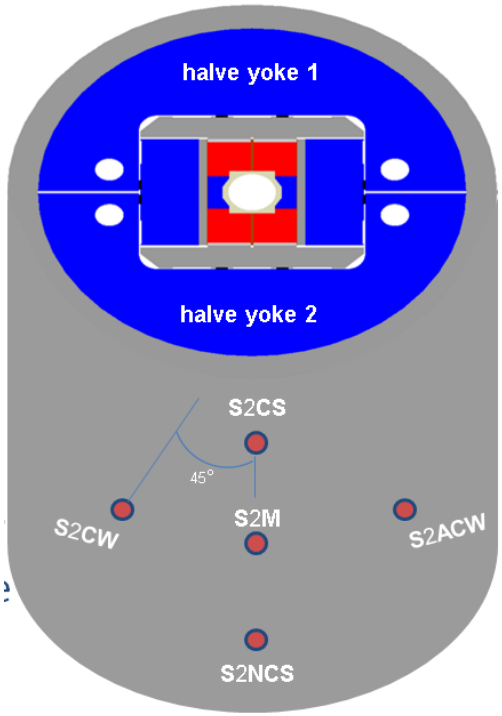


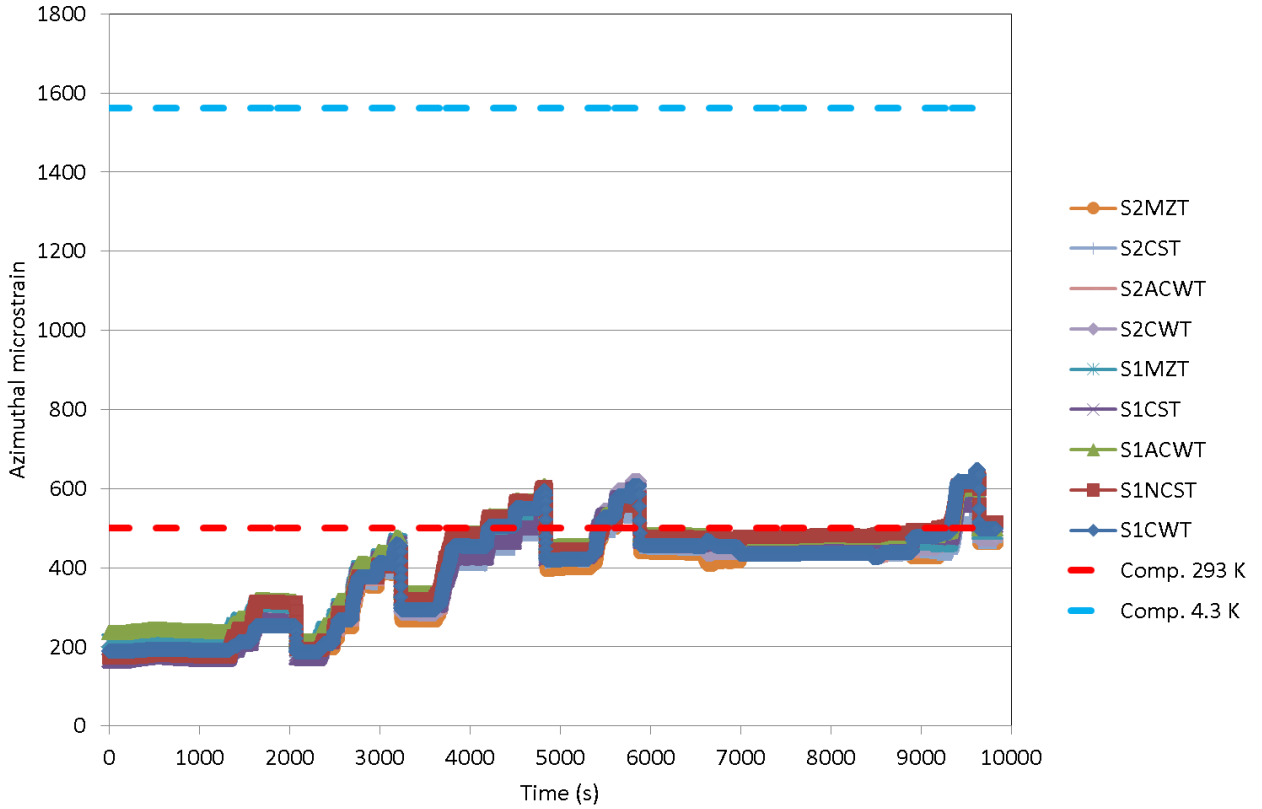


Shell azimuthal strain vs. time
Offsets corrected

- Target of +500 µstrain reached
- Spread: ~50 µstrain

100 µstrain = 7 MPa

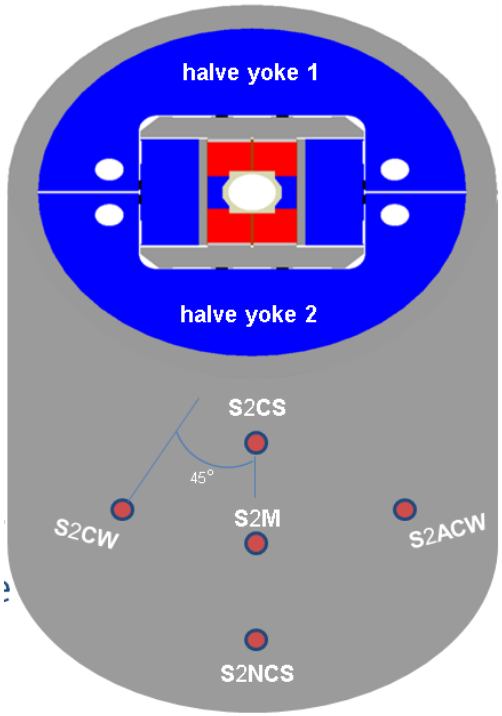


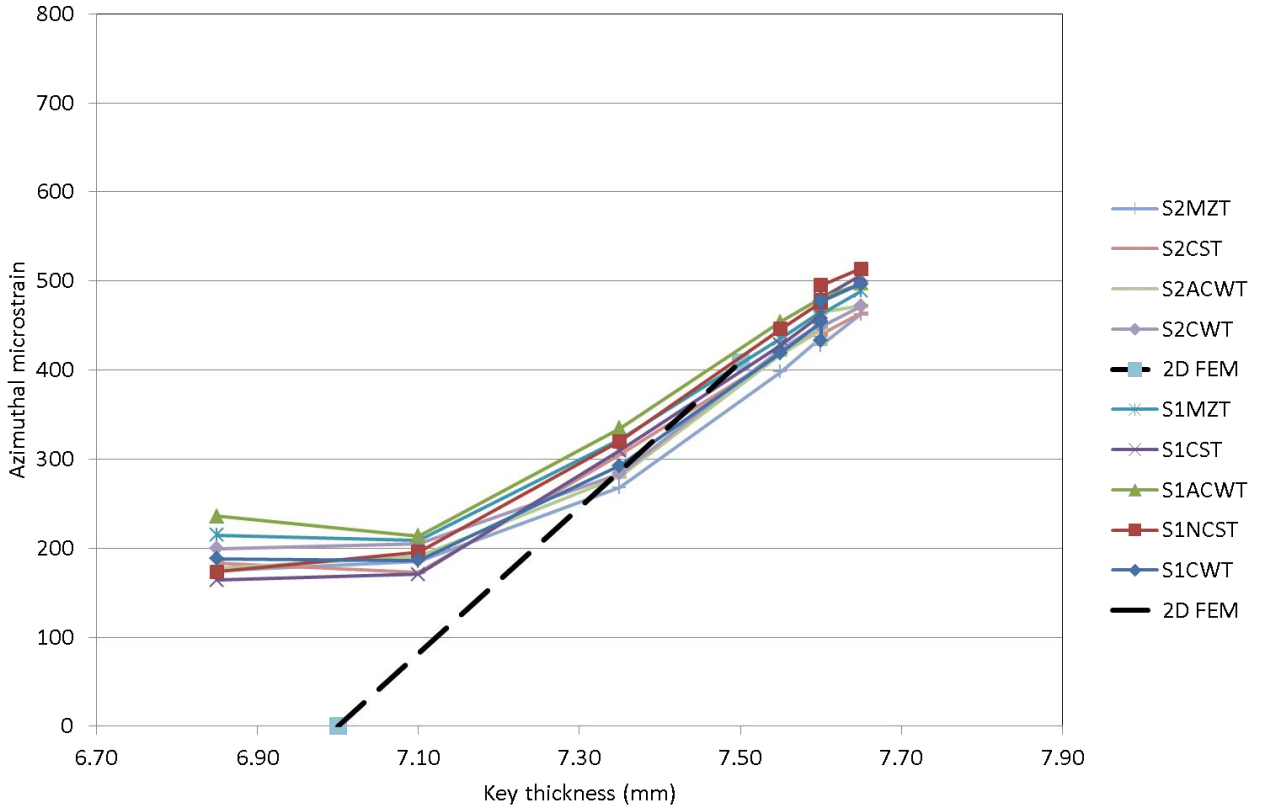


Shell azimuthal strain vs. shim thickness

- Slope consistent with computations
- Zero stress key size: 7 mm

100 µstrain = 7 MPa

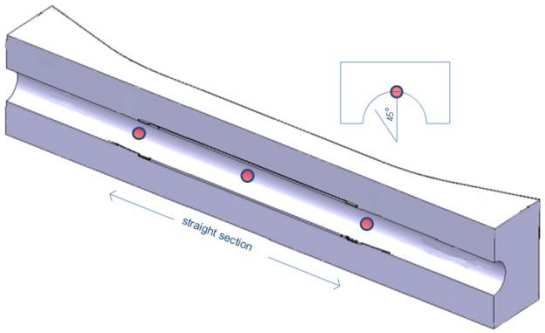


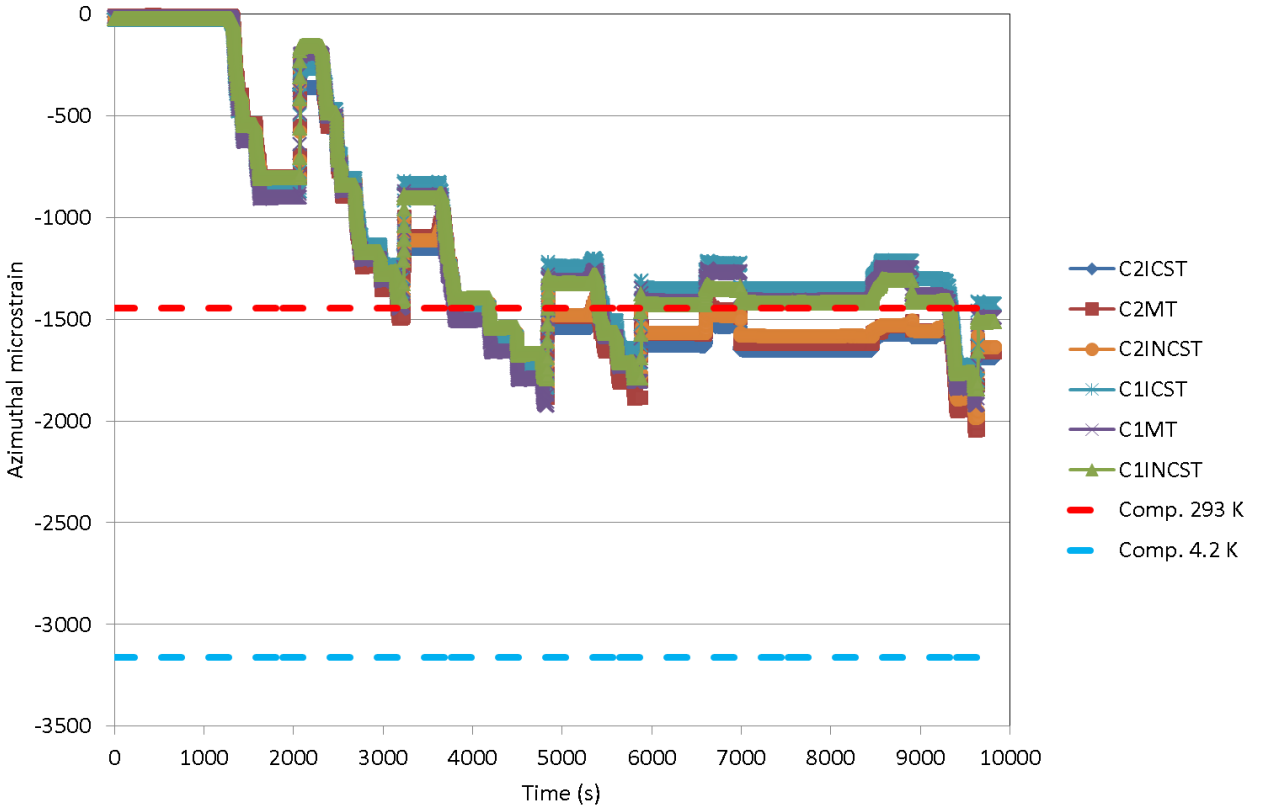


Dummy coil azimuthal strain vs. time
Straight section

- Target of +1500 µstrain reached
- Spread: ~250 µstrain

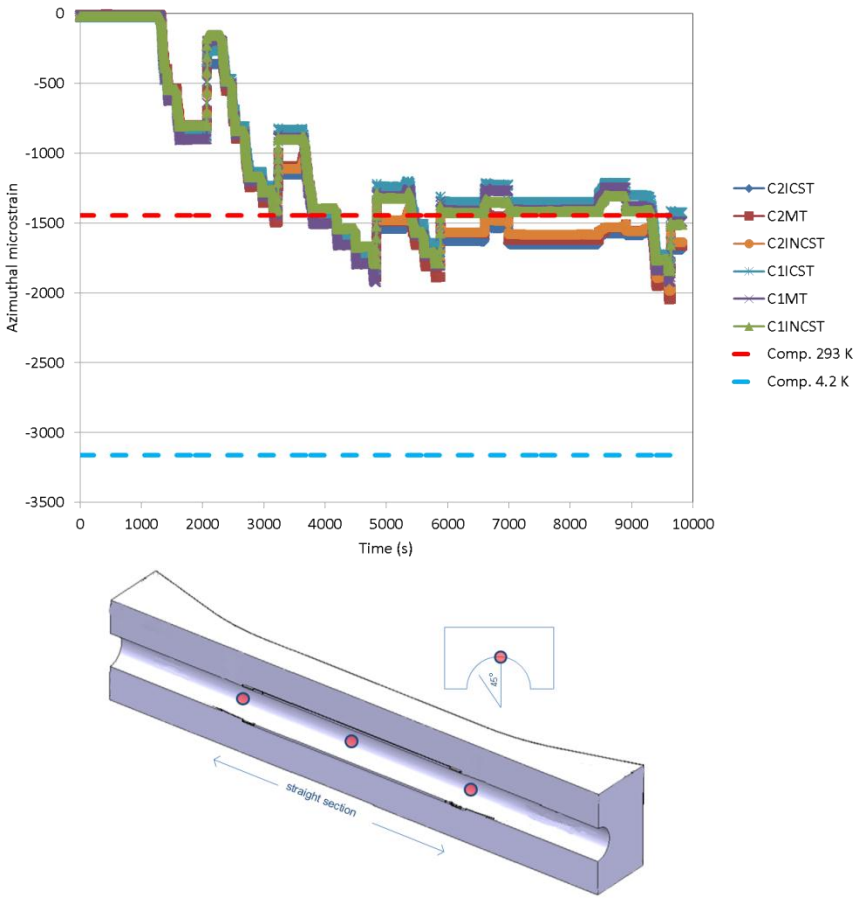
100 µstrain = 7 MPa



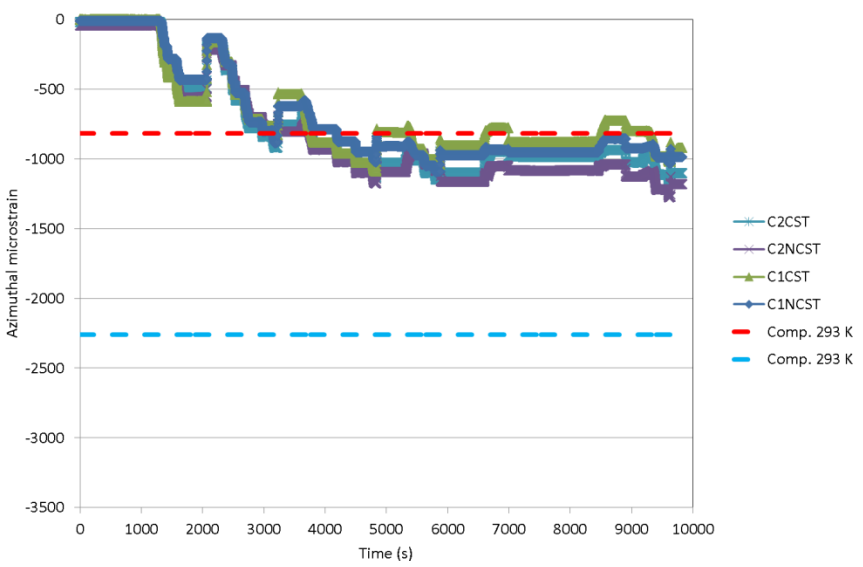


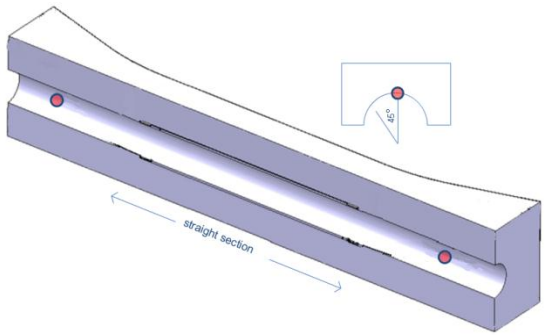
Dummy coil azimuthal strain vs. time

- Straight section



- End region

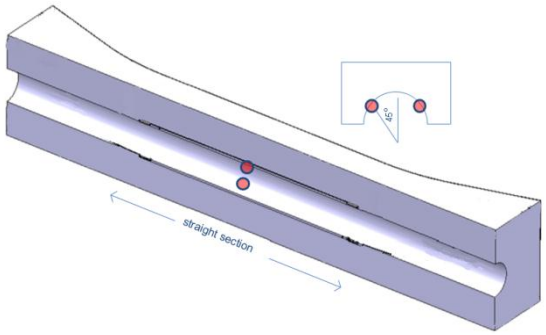


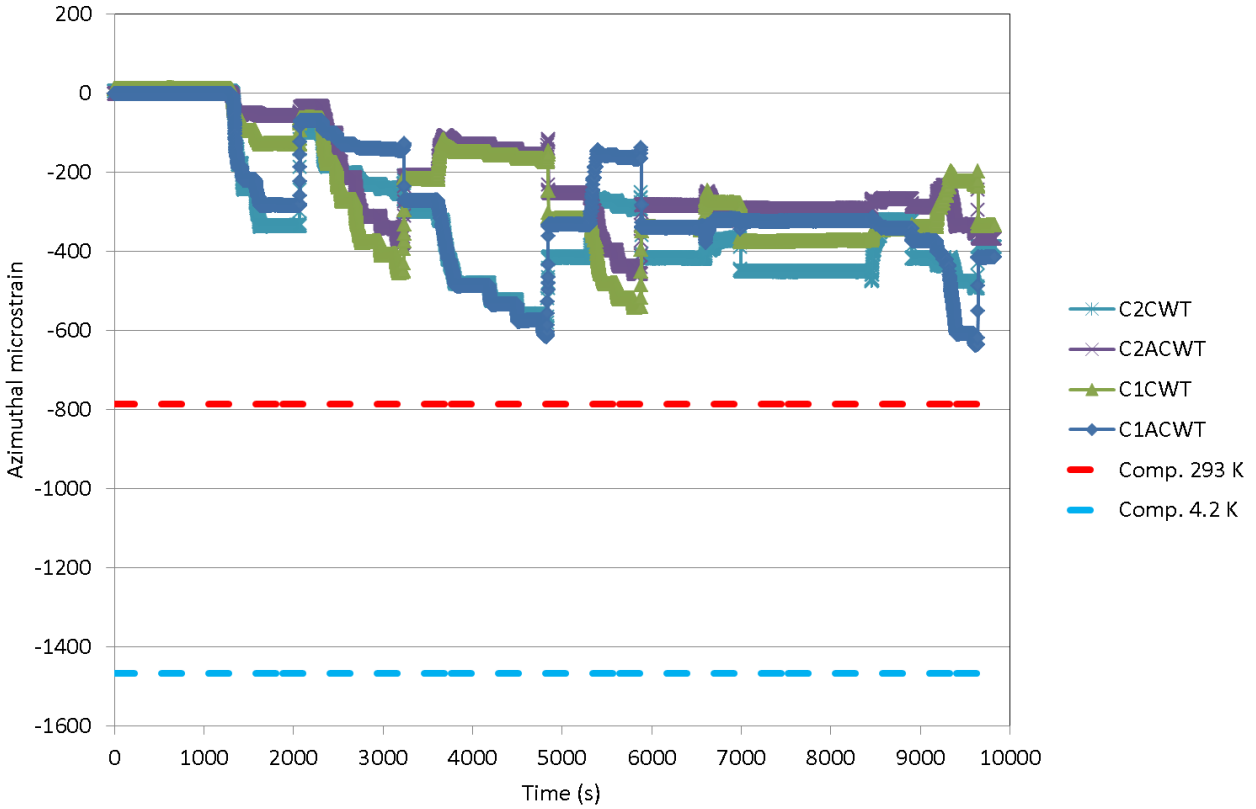


Dummy coil azimuthal strain vs. time
"Side" gauges

- Measured value lower than predicted
  - Lower vertical pre-load? To be analysed
- Small spread

100 µstrain = 7 MPa

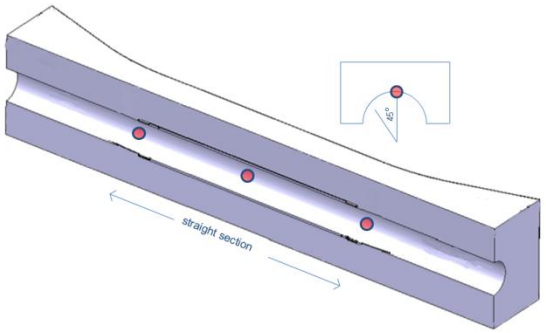


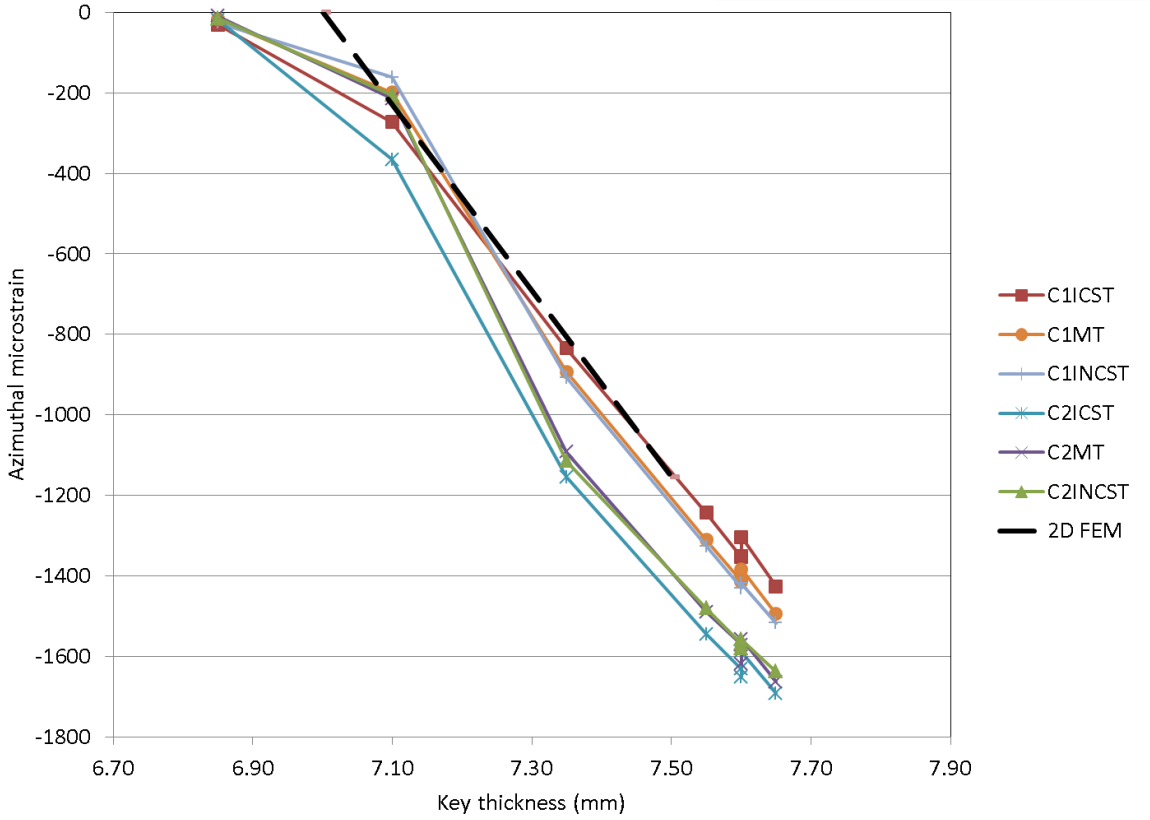


Dummy coil azimuthal strain vs. shim thickness

- Slope consistent with computations
- Zero stress key size: 7 mm

100 µstrain = 7 MPa

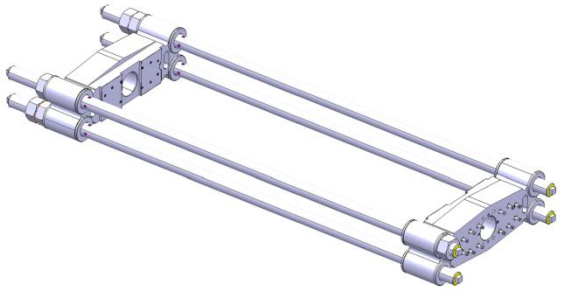


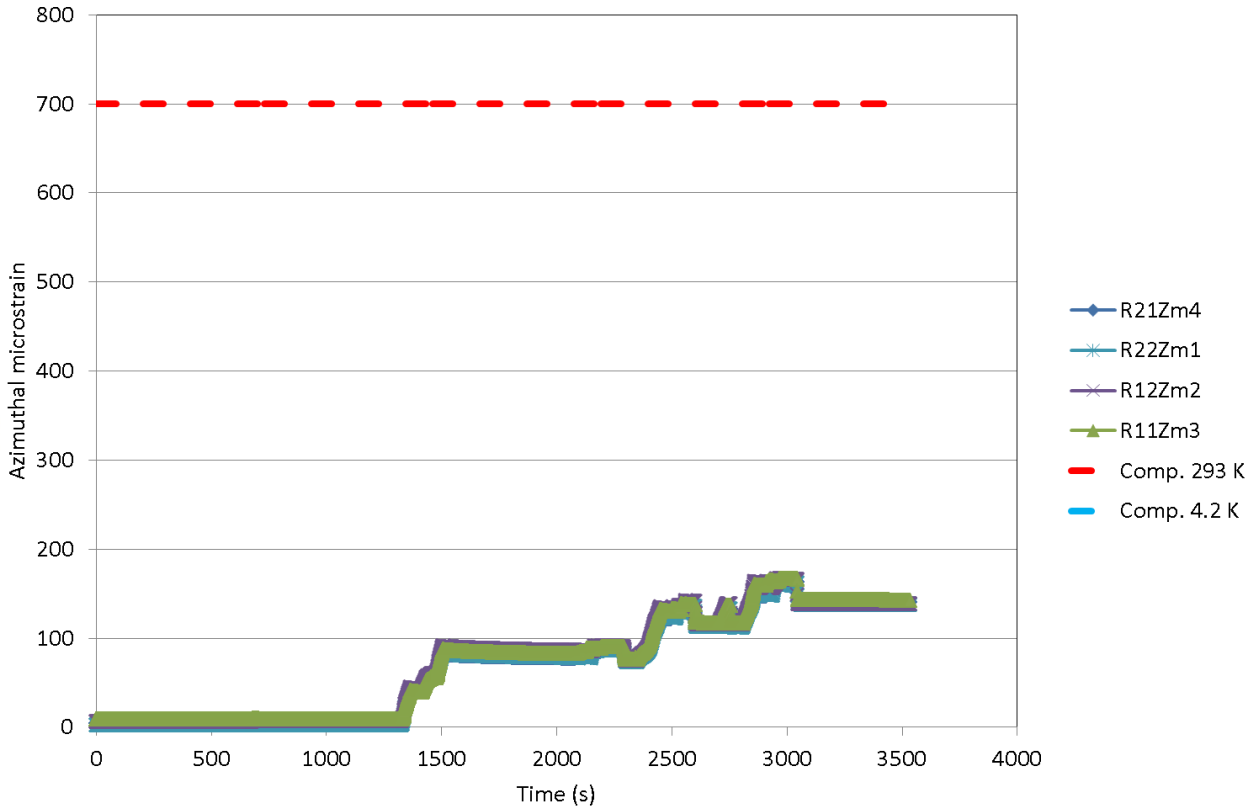


Rod axial strain vs. time

- About a factor 4 discrepancy with respect to expectations
  - To be verified during cool-down and after disassembly (wiring?)
- Minimum spread

100 µstrain = 7 MPa





Conclusions

- A total of 64 gauges mounted on the structure
  - 20 on the shell
  - 28 on the dummy coils
  - 16 on the rods
- Shell gauges
  - Sensitivity on bladder pressure and shim thickness in agreement with computations
  - Assuming offset correction → targets met and low spread
- Excellent data from coil gauges
- Rod data far from expected values and under investigation
  - Still, minimum spread achieved