



# LABORATORY XRD DETERMINATION OF RESIDUAL STRESS IN EASI-STRESS BENCHMARKS

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**BSSM Residual Stress Meeting**

**27 September, 2023**



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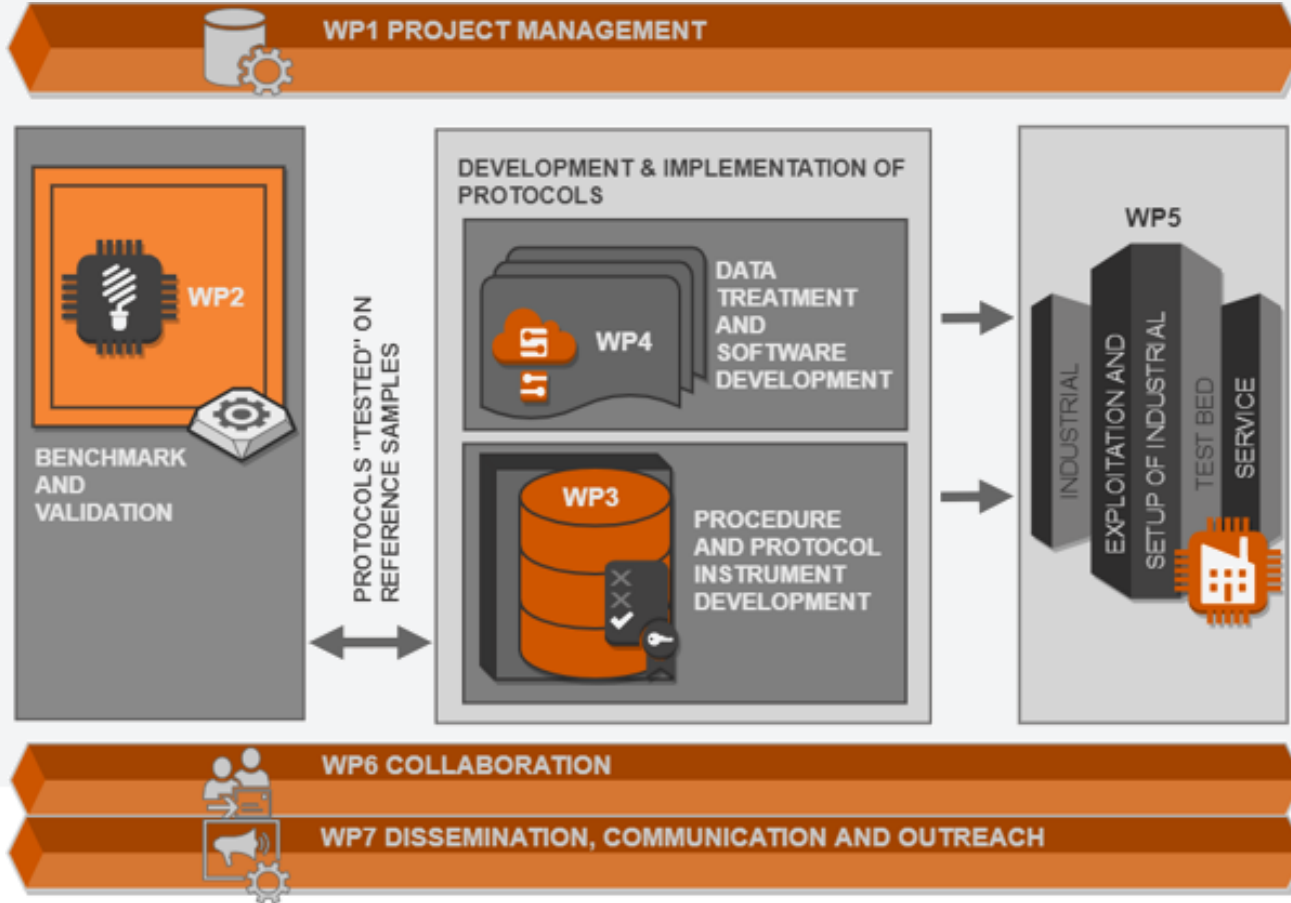
# AGENDA

1. Introduction to EASI-STRESS
2. Context
3. Benchmarks
4. Selected XRD results (to date)



**EASI-STRESS**

# EASI-STRESS PROJECT STRUCTURE



**"EASI-STRESS will remove the barriers for industry to adopt the techniques into their quality control systems and to validate materials simulation models."**

[www.easi-stress.eu](http://www.easi-stress.eu)

# EASI-STRESS CONSORTIUM

RTOs and  
Universities



**DANISH  
TECHNOLOGICAL  
INSTITUTE**  
(Coordinator)



Advanced Research Facilities



Centre for  
Energy Research

Standardisation  
Body



Industry

**VOLUM-e**  
3DComplexProduction



Rolls Royce PLC

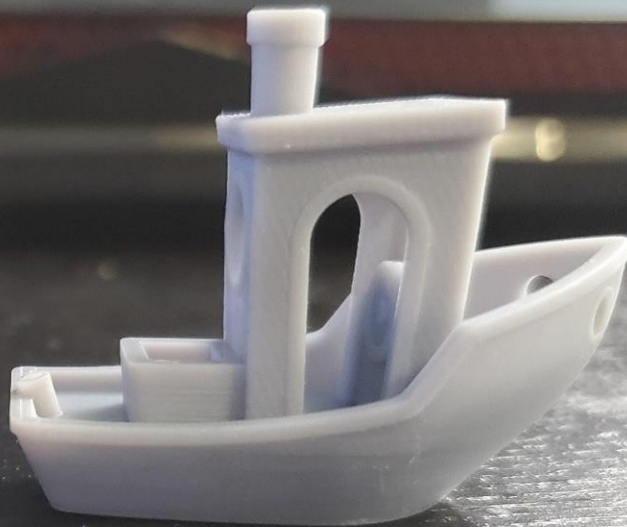
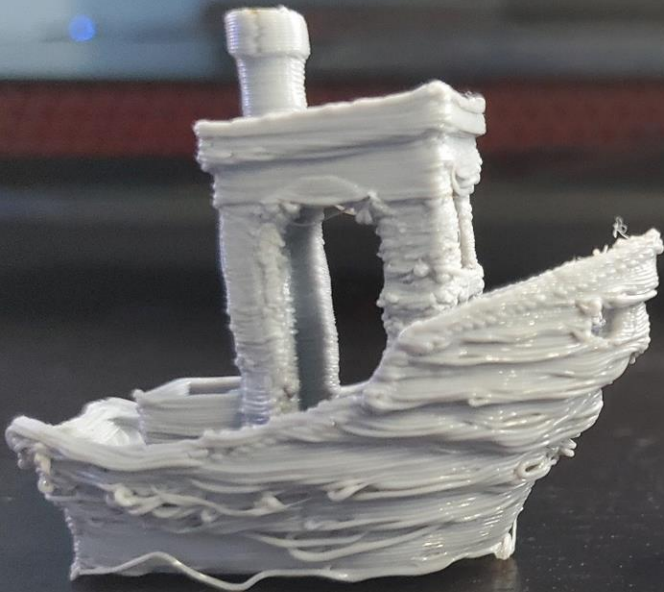


# SPECIFIC GOALS

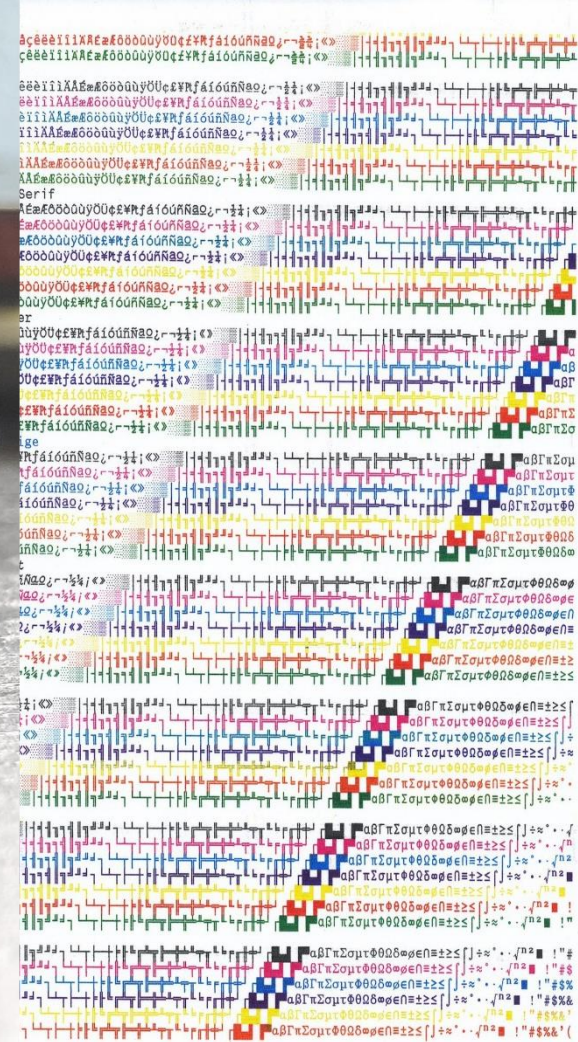


- 1) To design and manufacture industrially relevant reference samples suitable for cross comparison between laboratory and high energy x-ray and neutron diffraction techniques.
- 2) To develop and demonstrate best practices for correlating experimentally resolved stresses and process models.
- 3) To establish the variance between resolved residual stresses stemming from diffraction techniques based on current best practices.






# BENCHMARKS



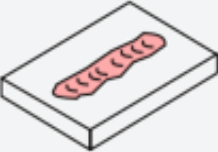
# SPECIFIC SAMPLES CONSIDERED

Plane stress 

Plane strain 

Surfacing 

Additive 

Welds 

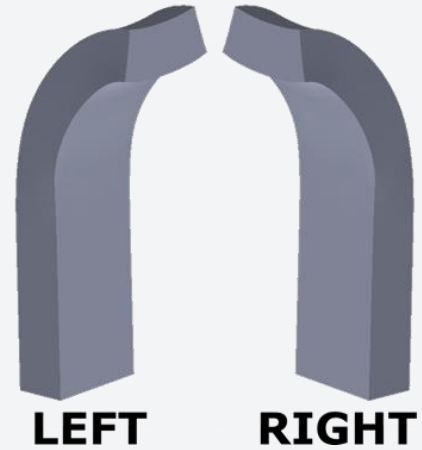
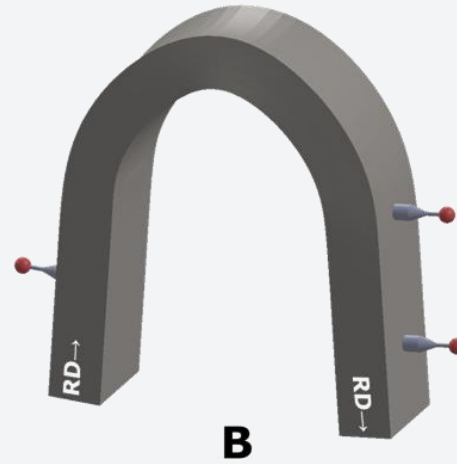
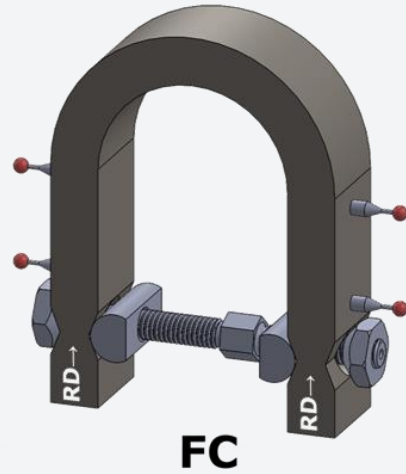
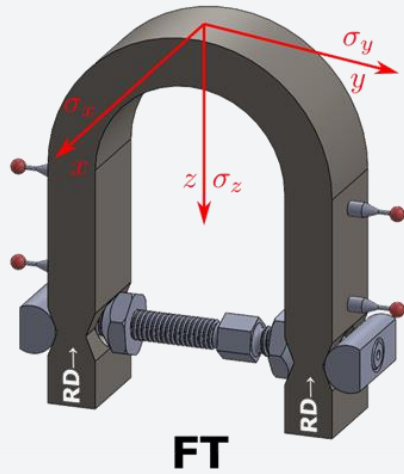
Castings 

- i. Ferritic steel U-forms**
- ii. Powder-derived stainless steel additively manufactured arches**
- iii. TG6 Inconel gas tungsten arc welded (GTAW) three pass welded plates**
- iv. Cast and quenched aluminium wedges**

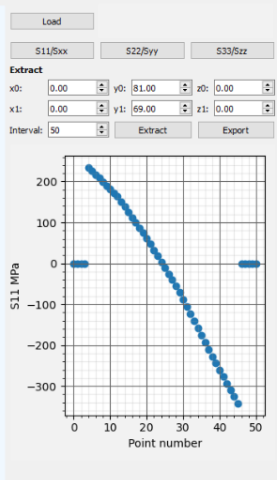
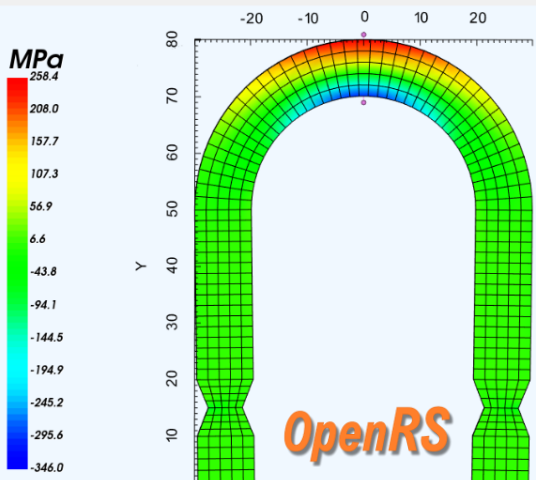
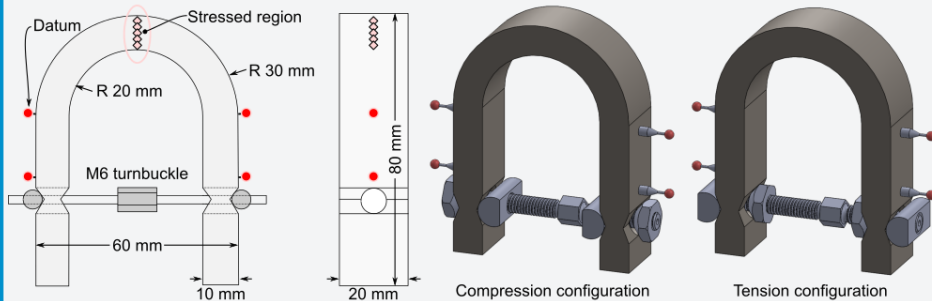
Surfacing effects are not specifically targeted, but manifest as part of the course of measurements take place.



# U-FORM SAMPLES CONSIDERED

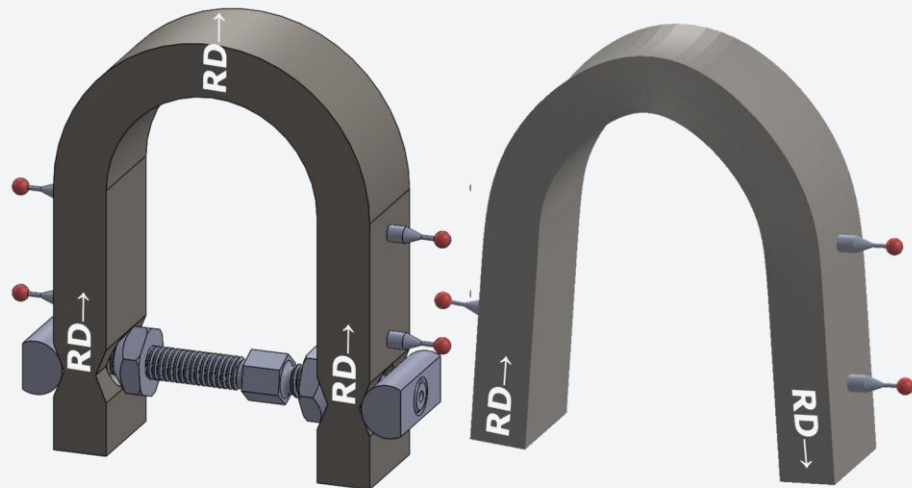


# U-FORMS: FLEXURES



EN 10025: S355 J0 Z35+N Steel,  
electrodischarge machined

# U-FORMS: BENDS

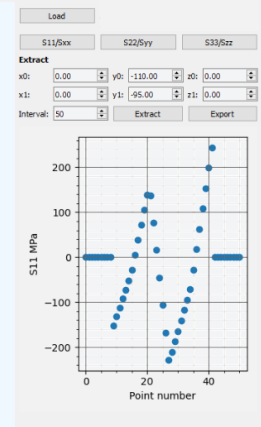
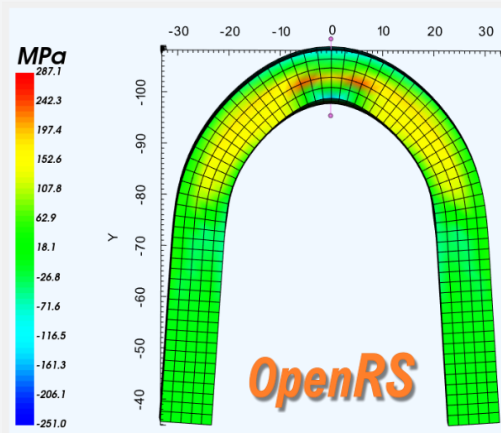
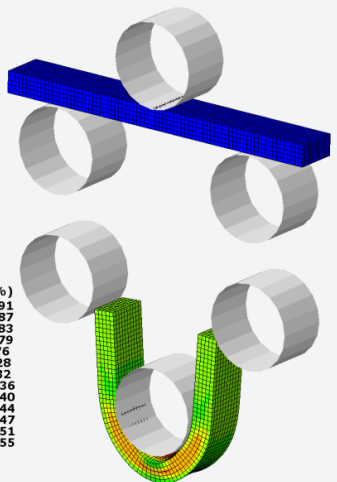
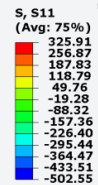
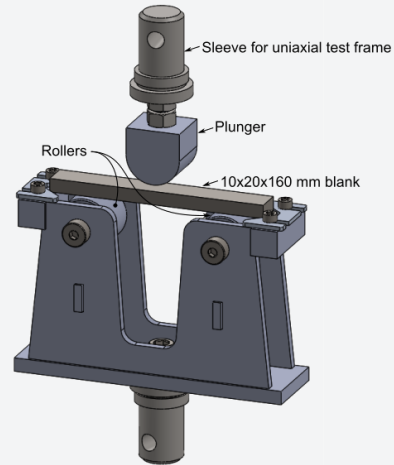


Flexure (tension)

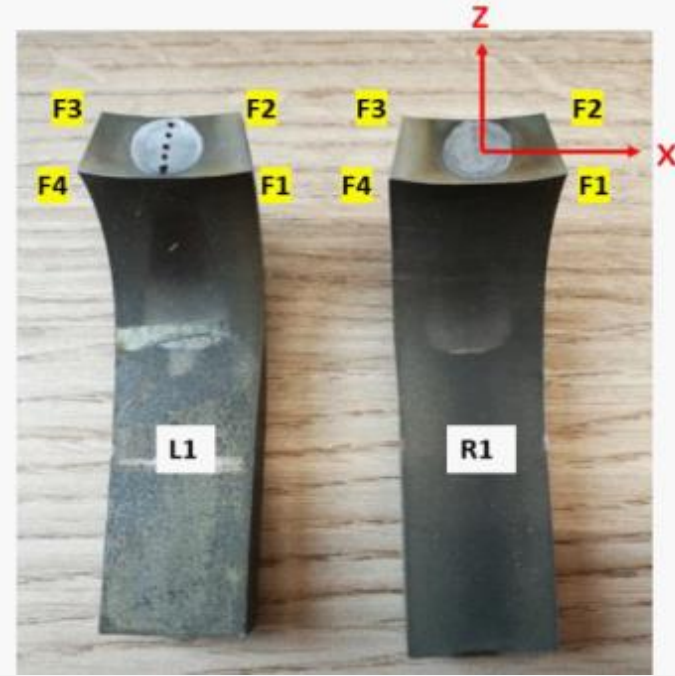
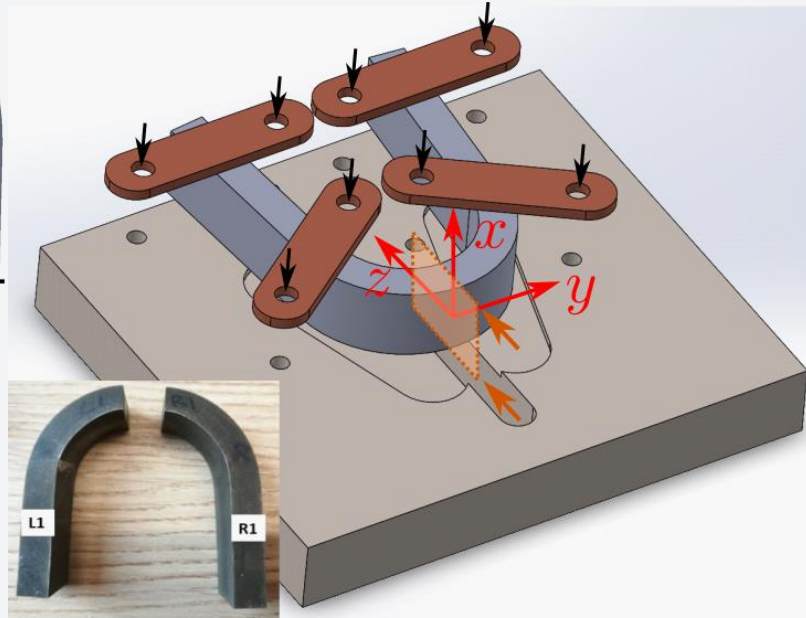
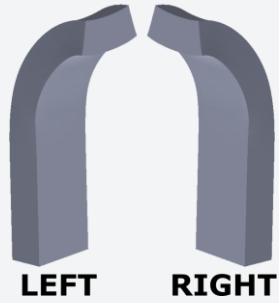
Deformed

Internal stress → Residual stress

3 point bending corresponding to ISO 5173



# LXRD SAMPLE FABRICATION





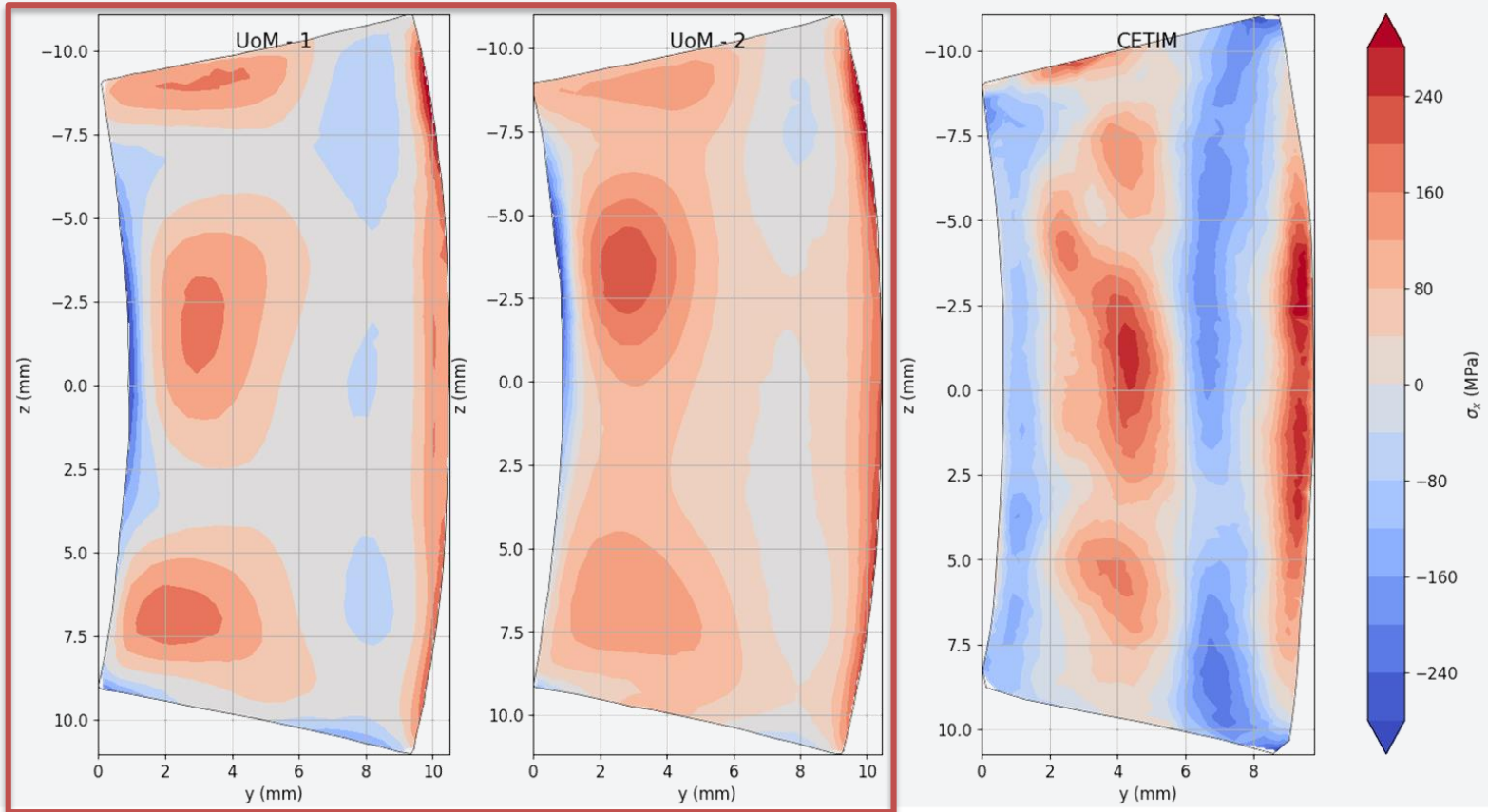
# RESULTS







# U-FORMS: CONTOUR RESULTS FOR BENDS

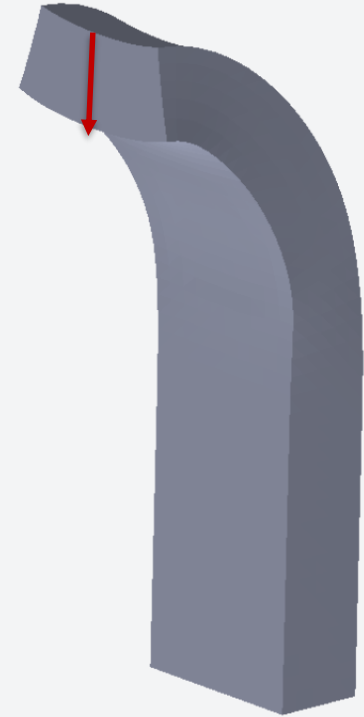
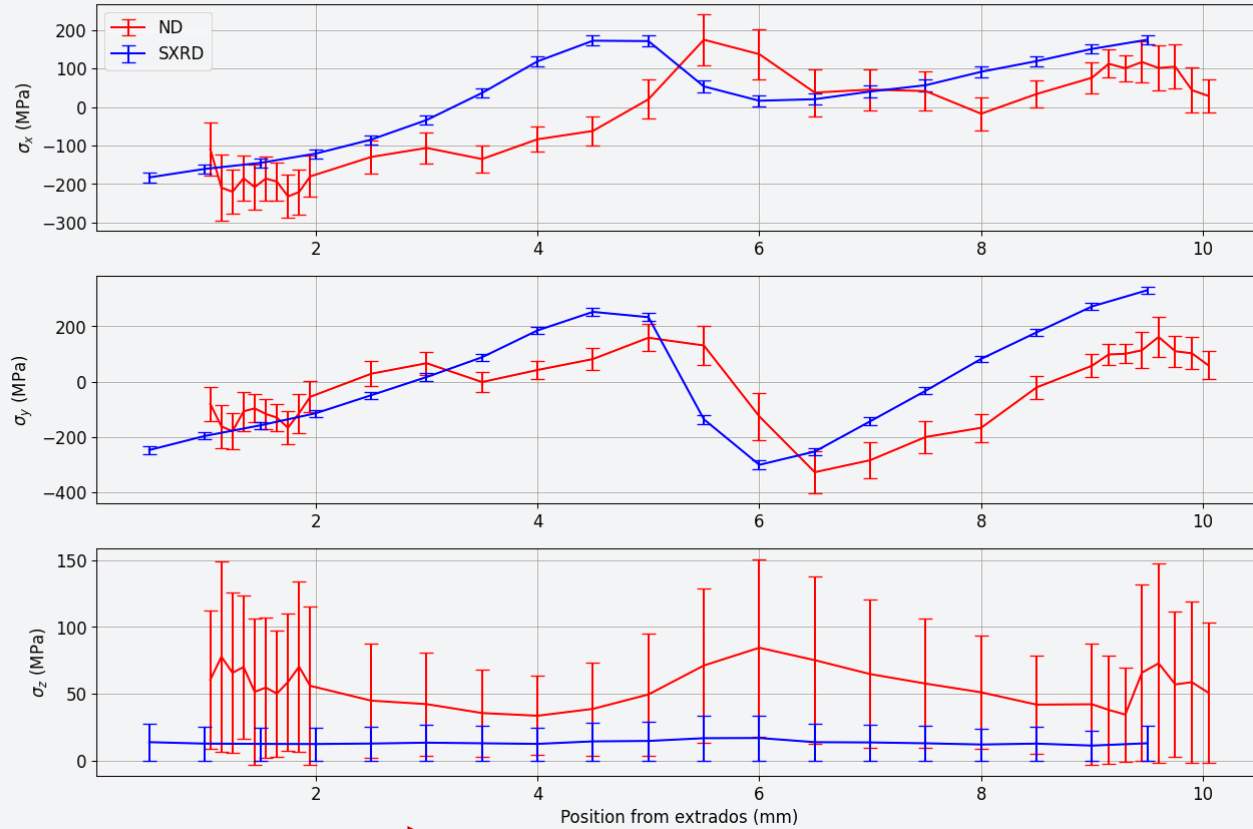


B1

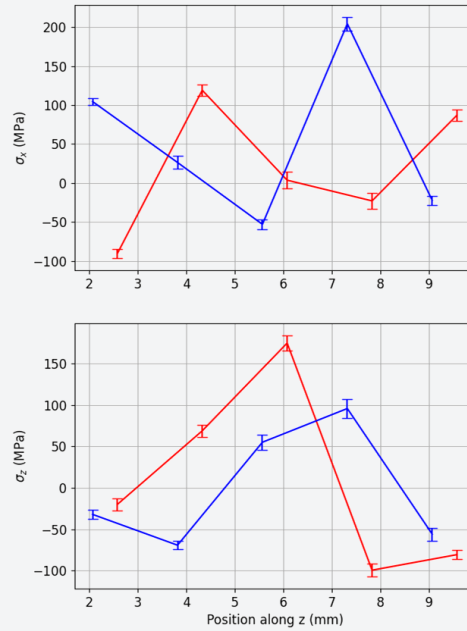
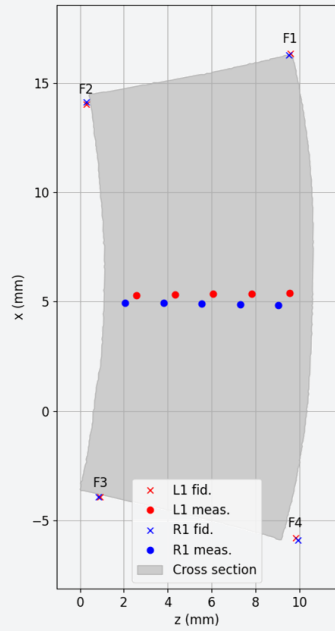
B2

B3

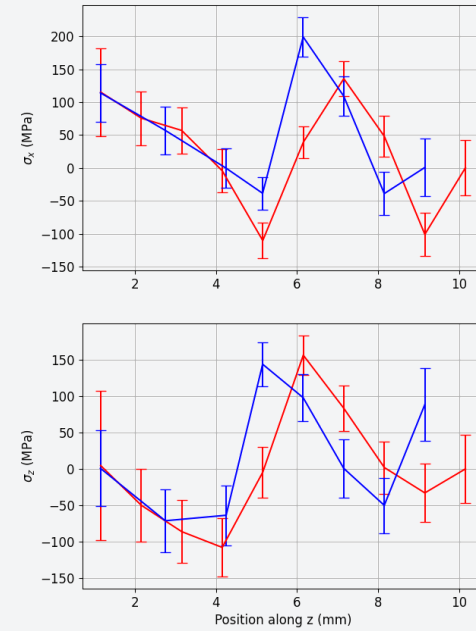
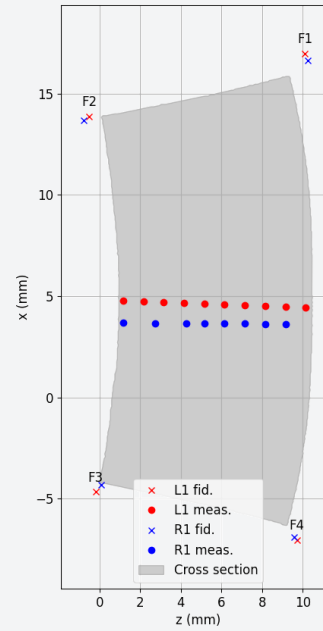
# U-FORMS: NEUTRON AND SXRD RESULTS FOR BENDS



# LXRD RESULTS – B1

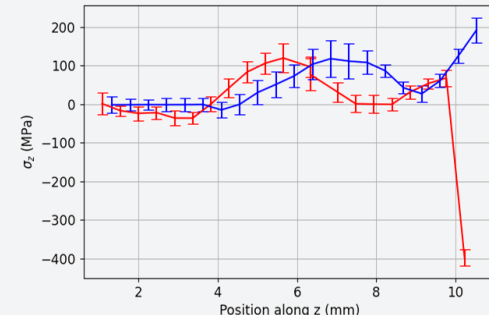
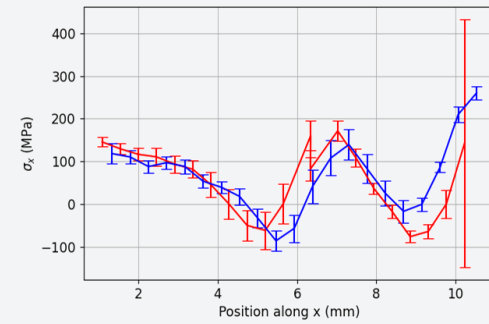
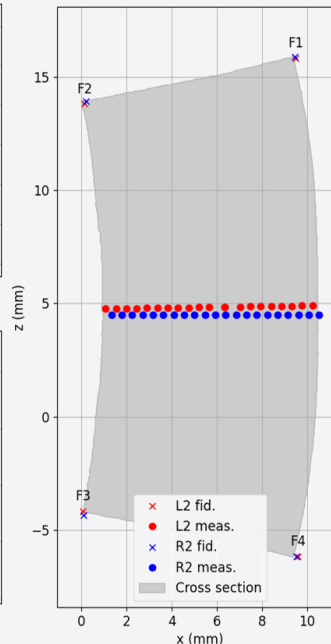
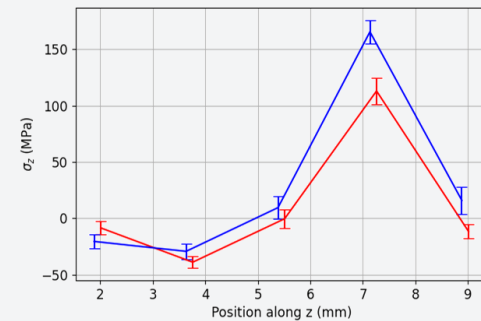
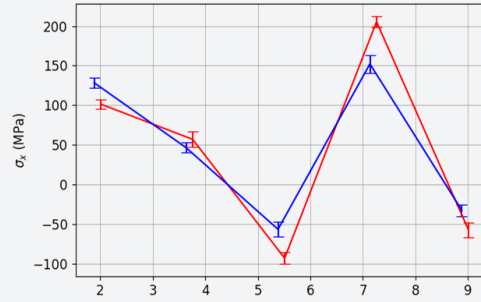
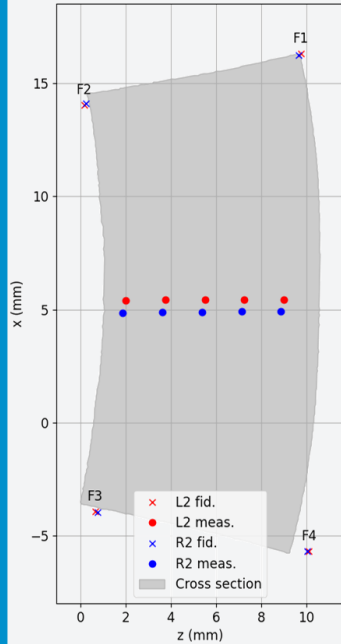


LAB 1



LAB 2

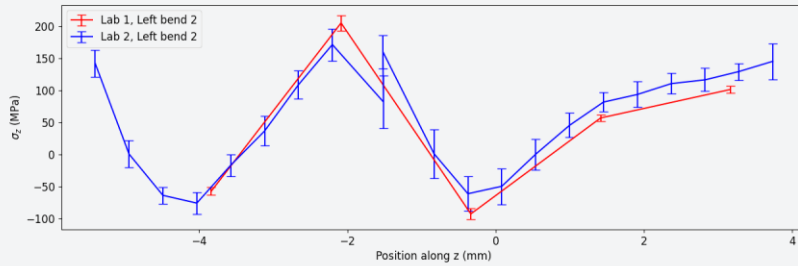
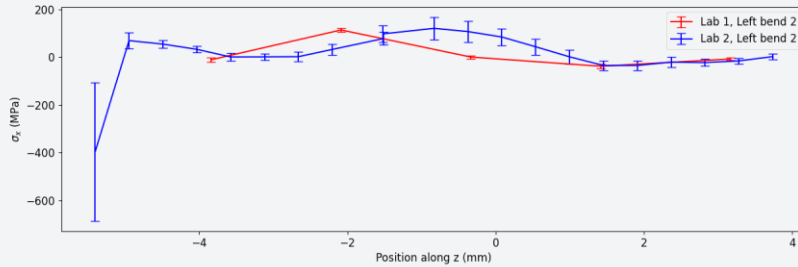
# LXRD RESULTS – B2



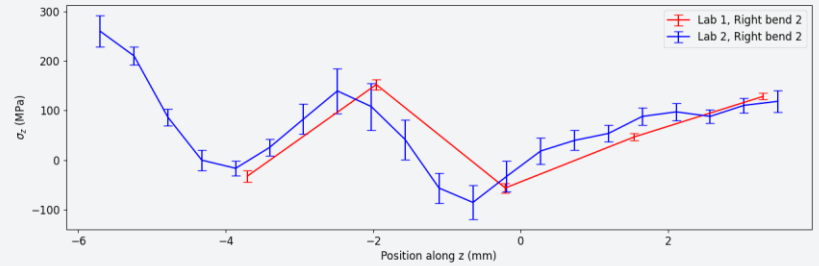
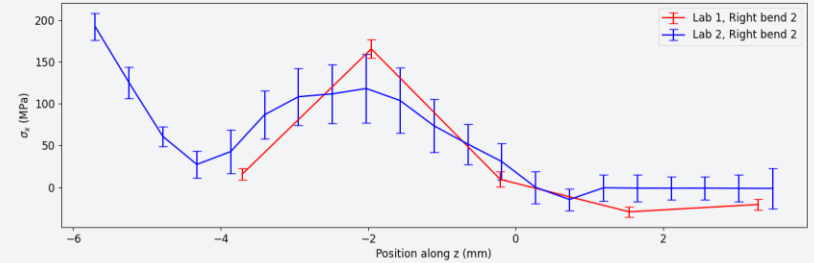
LAB 3

LAB 4

# EXTRA-LAB COMPARISON: B2



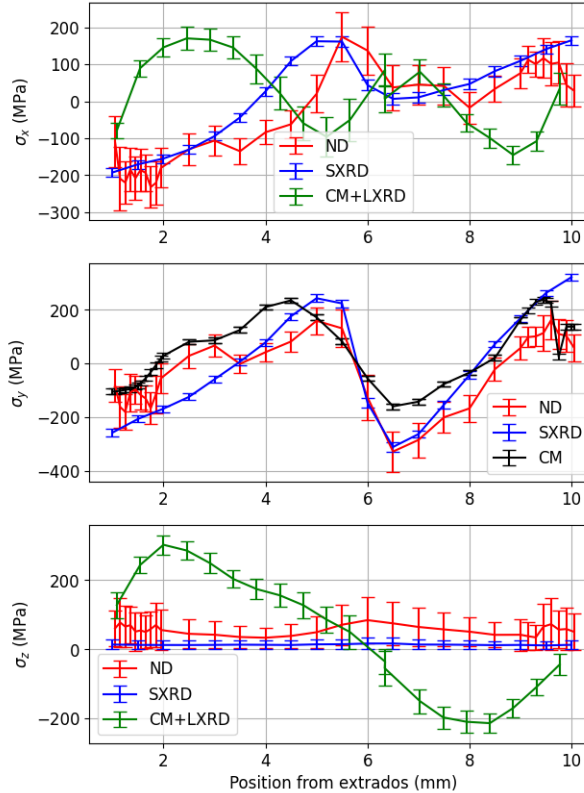
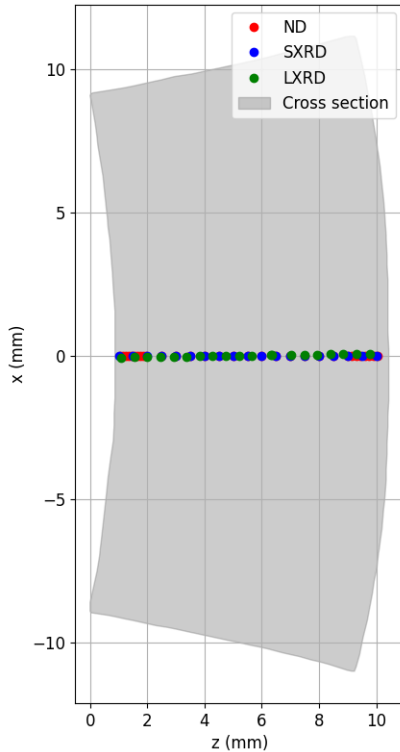
LEFT



RIGHT



# PUTTING IT ALL TOGETHER:



For superposition comparison the following was used:

CM:

$\sigma_{x,z}$ : B2

$\sigma_y$ : B3

LXR:

$\sigma_{x,z}$ : B2



# CONCLUSIONS

**XRD results on these parts were subject to the following issues:**

- 1) Surface removal was  $\sim 100\mu\text{m}$ , depth of EDM effects  $\sim 200\ \mu\text{m}$  or more (see Pagliaro et al. or forthcoming EASI-STRESS publication)**
- 2) Positioning seemed to be the biggest issue in cross-comparison between practitioners, even with specified datums.**
- 3) Study was carried out to determine variation intra- and extra-lab. Differences ranged from a few to 100 MPa.**
- 4) Wide range of errors reported employing the same techniques, often with the same equipment.**



# ACKNOWLEDGEMENTS & CONTRIBUTORS

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Peter Staron - Hereon

<https://easi-stress.eu/>



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