

# Design methodology for automotive steel wheel

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## 1. State of the Art

- Tyre behaviour is deeply investigated in literature (MF, FEM, etc.).
- Wheel must follow **ETRTO** and vehicle manufacturer requirements (impact ISO 7141, cornering, rim rolling, biaxial fatigue test, etc.)
- In vehicle dynamics wheel is mainly considered as a **rigid body**
- Not consistent test benches models when the tyre is present
- Interest in smart, deformable, reconfigurable wheels

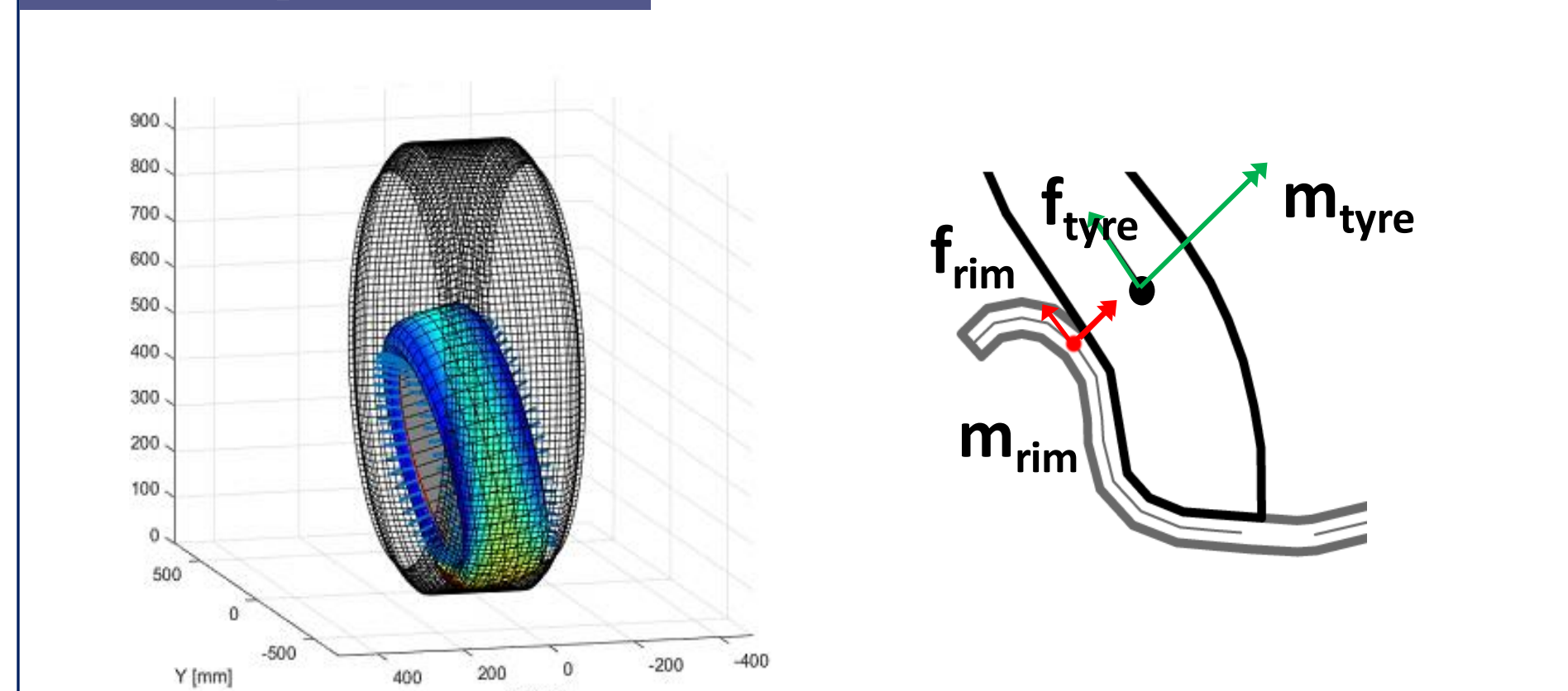
## 2. Objectives

To develop a **robust model** to describe **static** and **dynamic** behaviour and life assessment of steel wheels in loading conditions obtainable on rim rolling, cornering and biaxial test benches

## 3. Enriched FE model

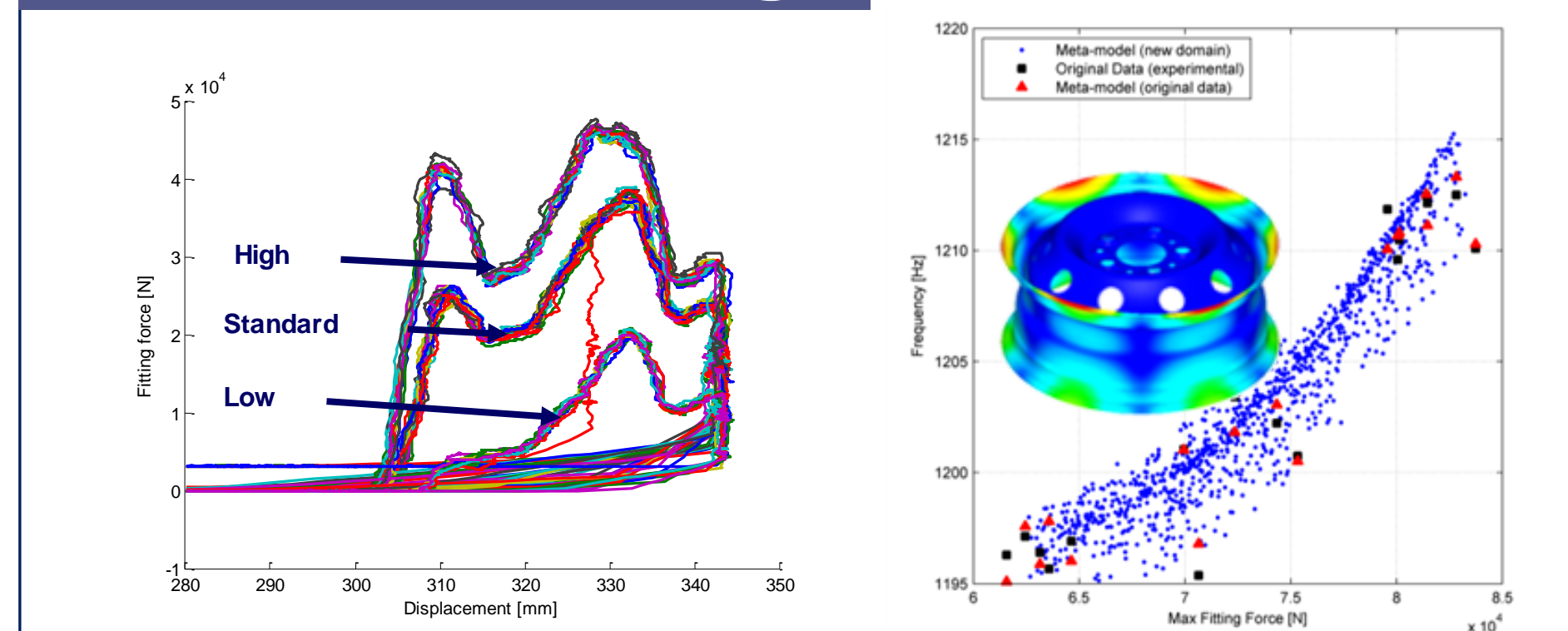
A finite element model is developed, embedding features to better describe critical zones for stress concentration and variation

### Load profiles



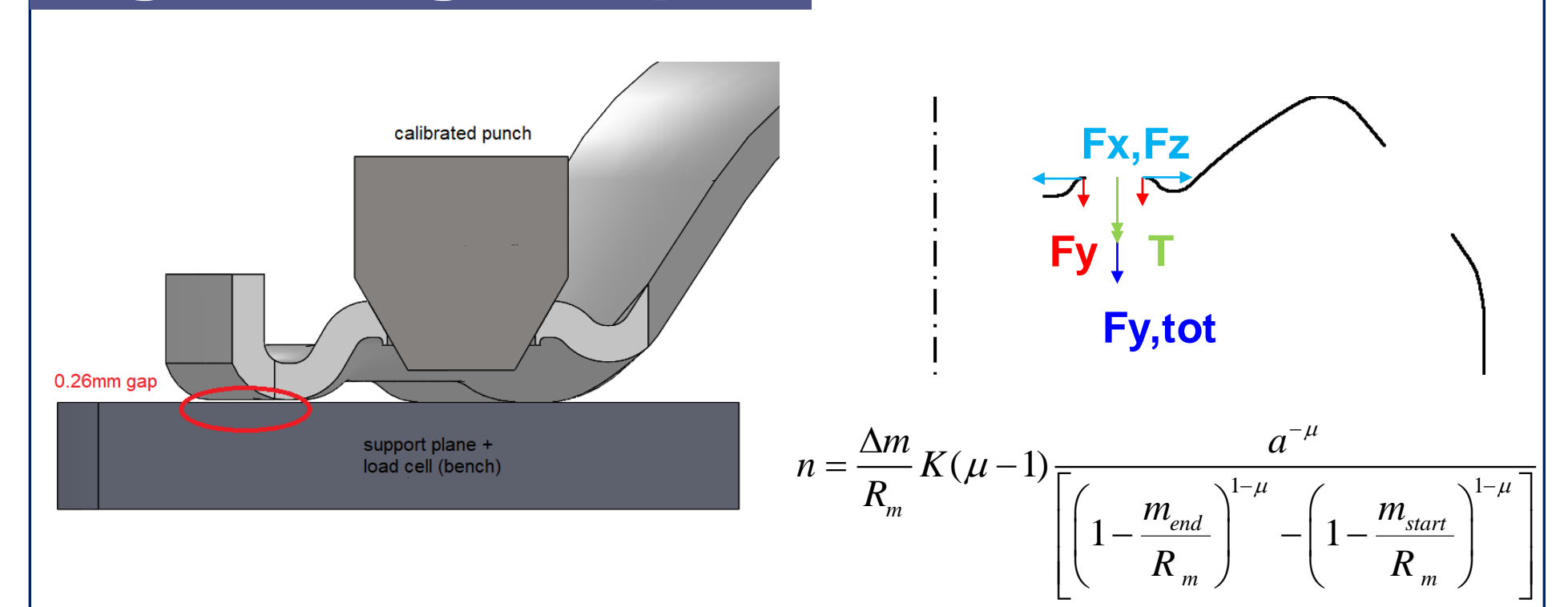
- **CDTire** deformable tyre analysis
- Loads are interpolated to fit wheel mesh

### Disc-to-Rim fitting



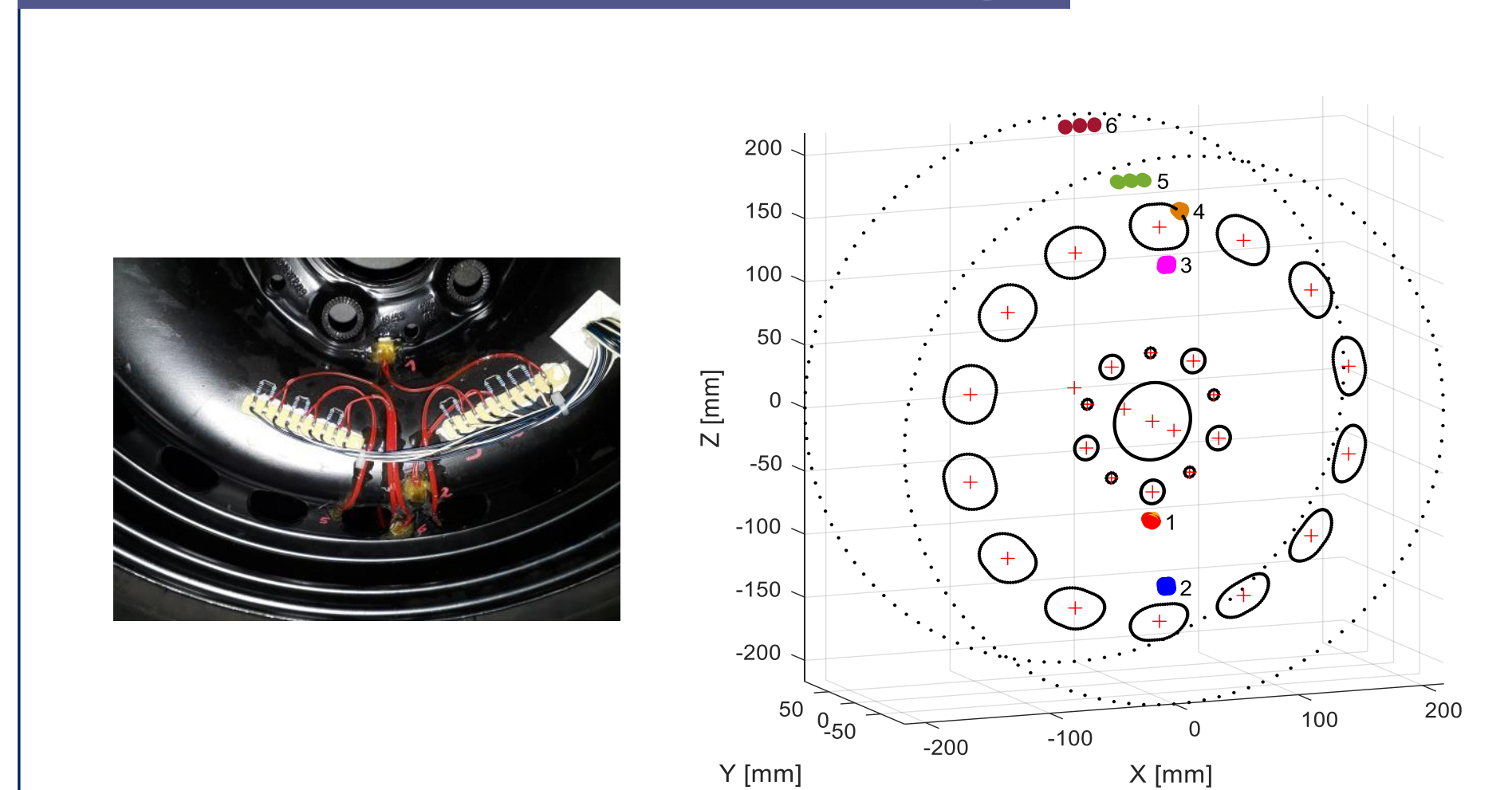
- Fitting force depends on geometry variance
- Fitting effect is estimated through PCE surrogate models based on **stiffening effect** on structural properties

### Tightening torque



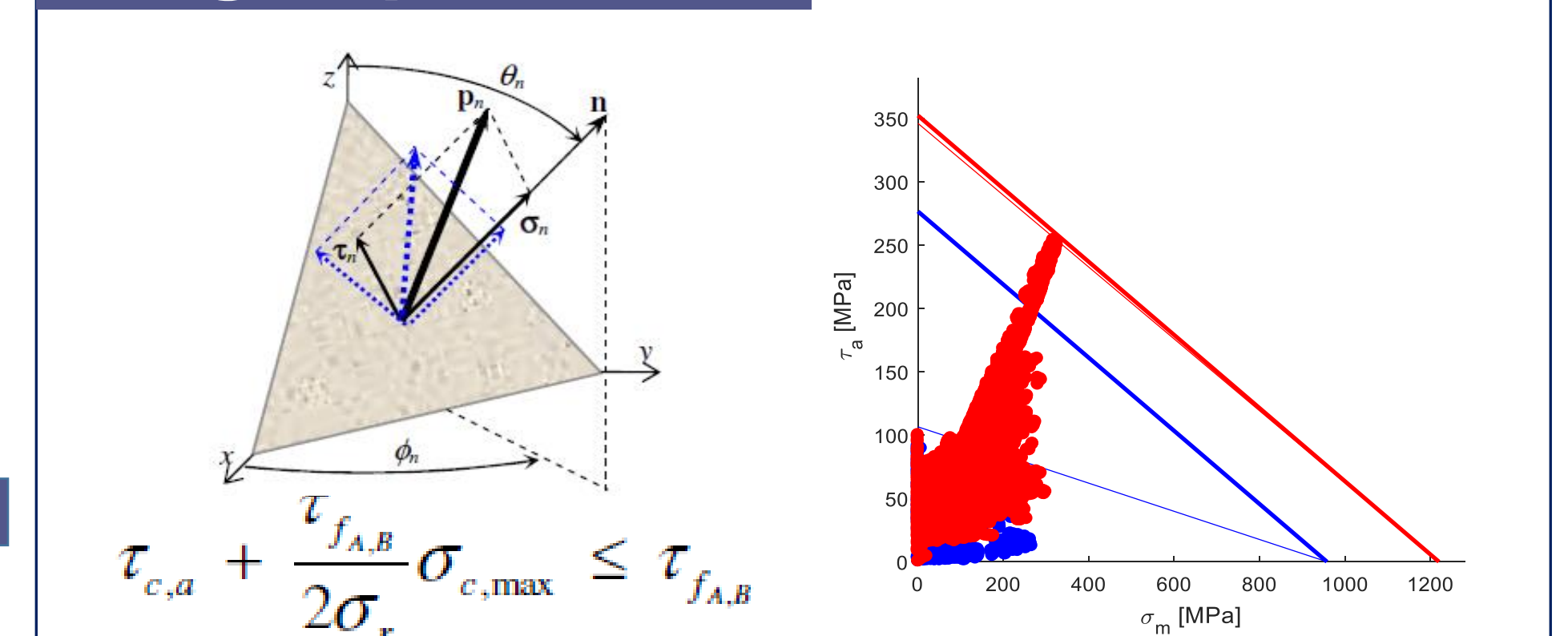
- Tightening torque is converted in equivalent nodal force
- Tightening loss effect on life is performed through integrated Miner rule

### Stress-strain monitoring



- Strain gage measurements are compared by stress tensor transformation

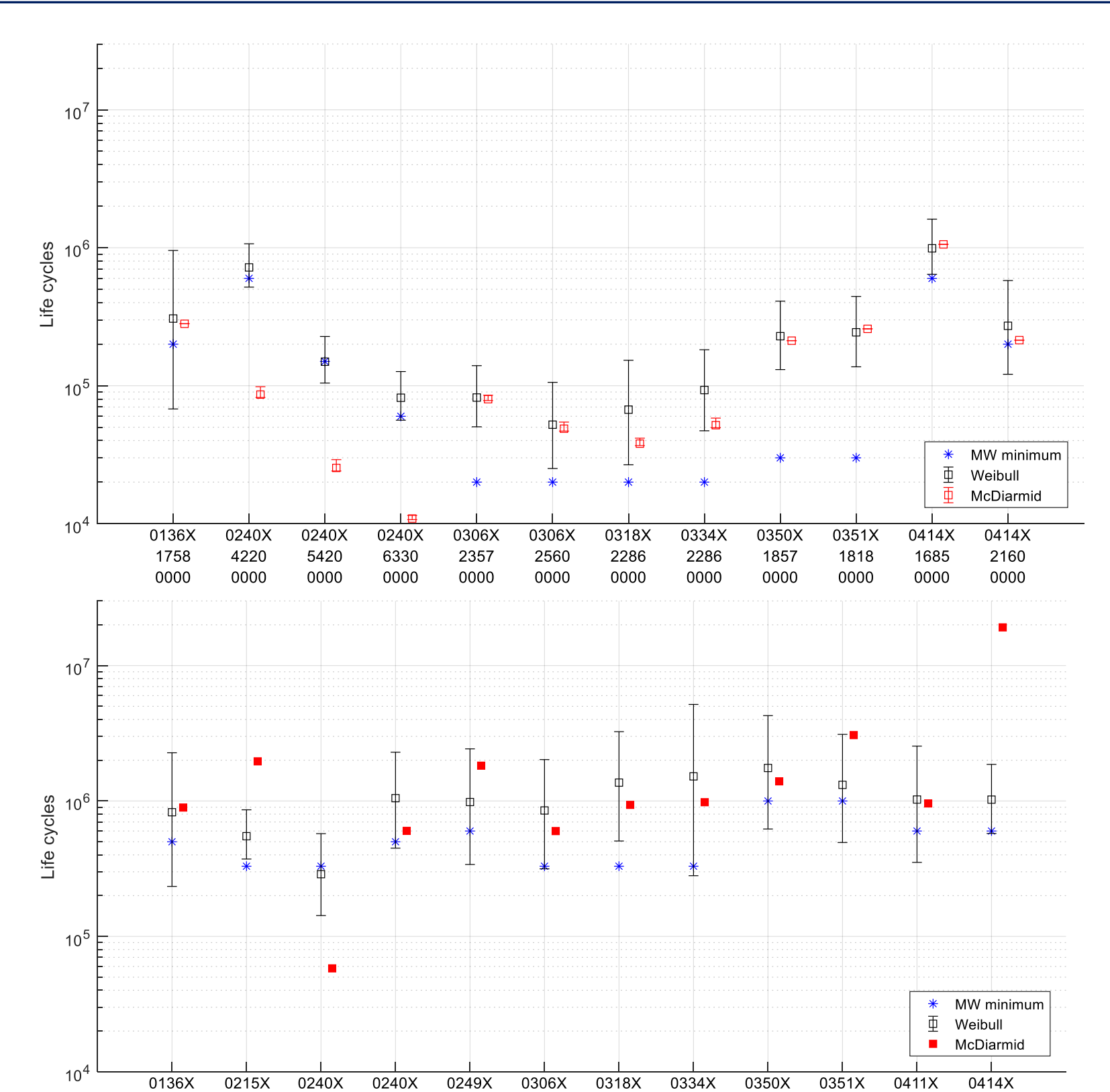
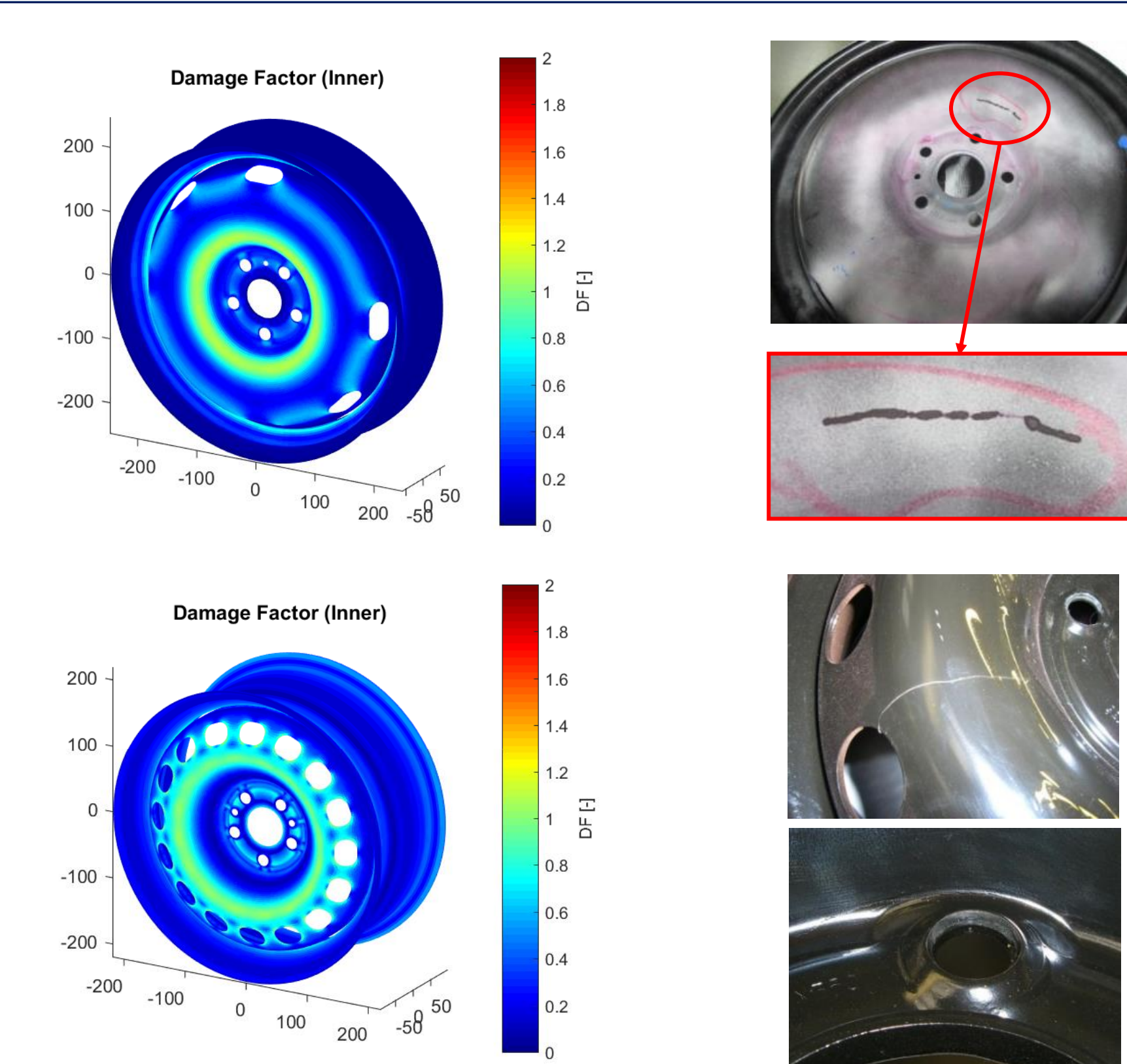
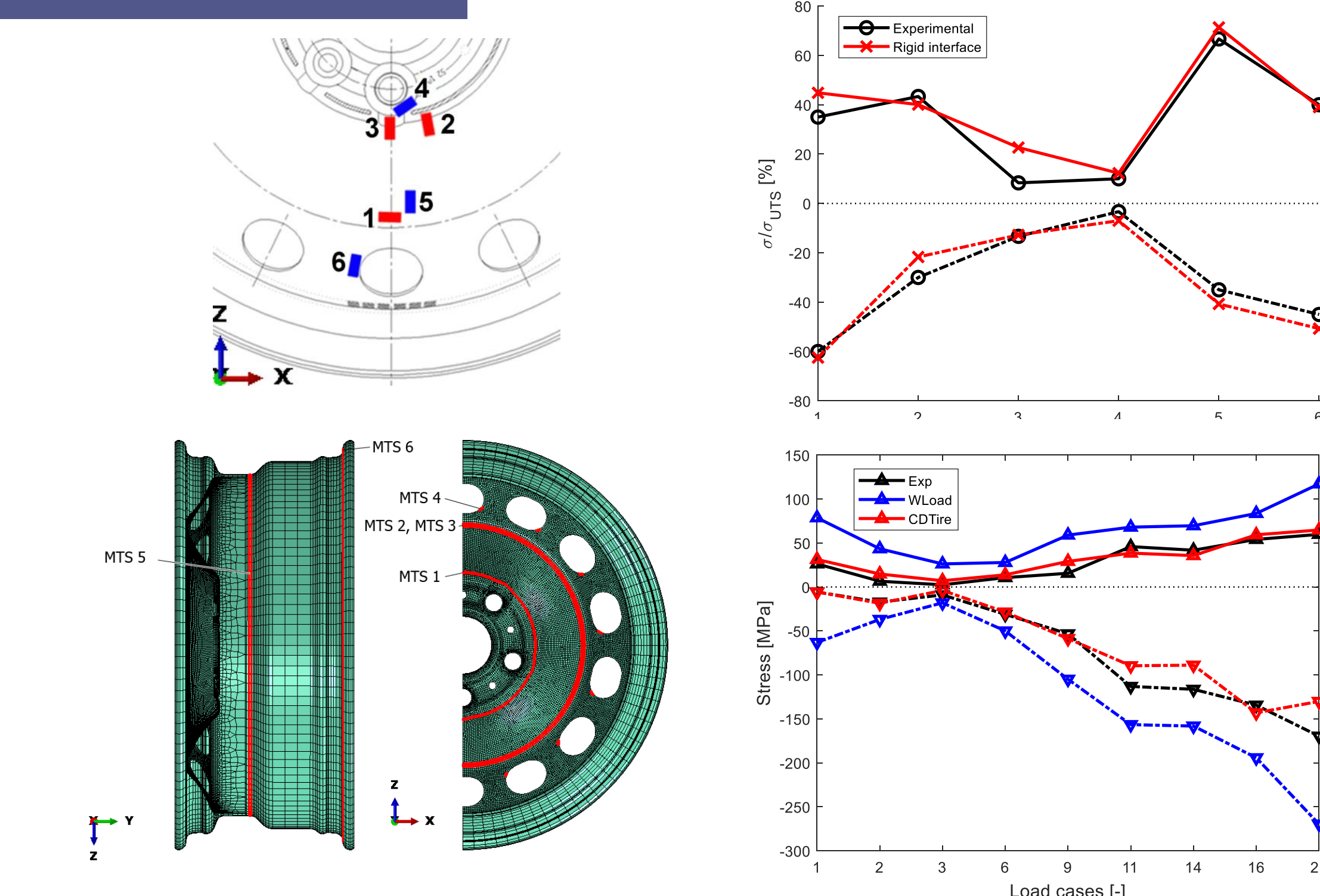
### Fatigue prediction



- **McDiarmid** approach
- Assessment on envelope of elemental stress at Gauss points

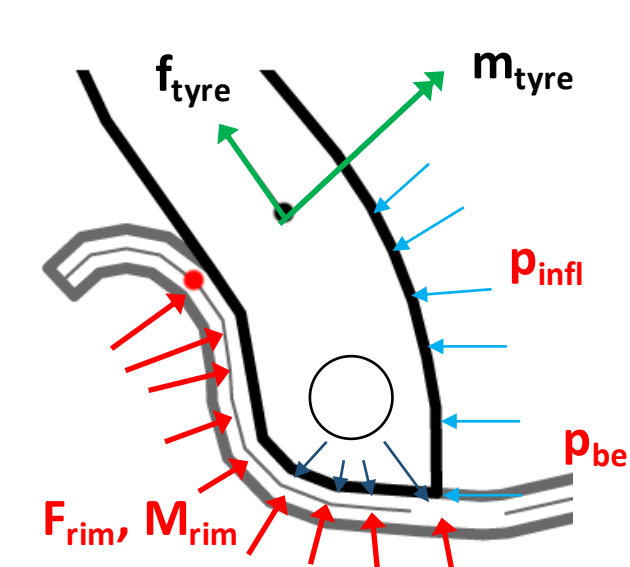
## 4. Results

Strain gage and life cycle comparisons



## 5. Future works

- bead pretension
- inflation pressure
- load field to the middle rim surface



## Publications

- Venturini S., Bonisoli E., "Design of a spherical pendulum didactic test rig", *International Journal of Mechanics and Control*, **19**(1), 2018, ISSN: 1590-8844, pp. 69-76.
- Iuso G., Virone G., Cafiero G., Bonisoli E., Lisitano D., Venturini S., "Aeroelastic-structural coupling in antenna prototype for windy open-space", *8th International Conference on Computational Methods for Coupled Problems in Science and Engineering, Coupled Problems 2019*, 2019, Sitges, Barcelona, Spain, June 3-5, pp. 481-492.
- Bonisoli E., Rosso C., Venturini S., Rovarino D., Velardocchia M., "Improvements on design and validation of automotive steel wheels", *Advances in Mechanism and Machine Science, Proceedings of the 15th IFTOMM World Congress on Mechanism and Machine Science*, Vol. **73**, 4248 pp., 2019, Springer, ISSN: 2211-0984, Online ISSN: 2211-0992, DOI: 10.1007/978-3-030-20131-9\_162, pp. 1639-1649.