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Construction Of Novel CERTification methOds
and means of compliance for disruptive technologies

Simulation Strategy for Liquid Hydrogen Composite Pressure Vessel

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22nd European Conference on Composite Materials (ECCM22), 22-06-2026

Co-funded by
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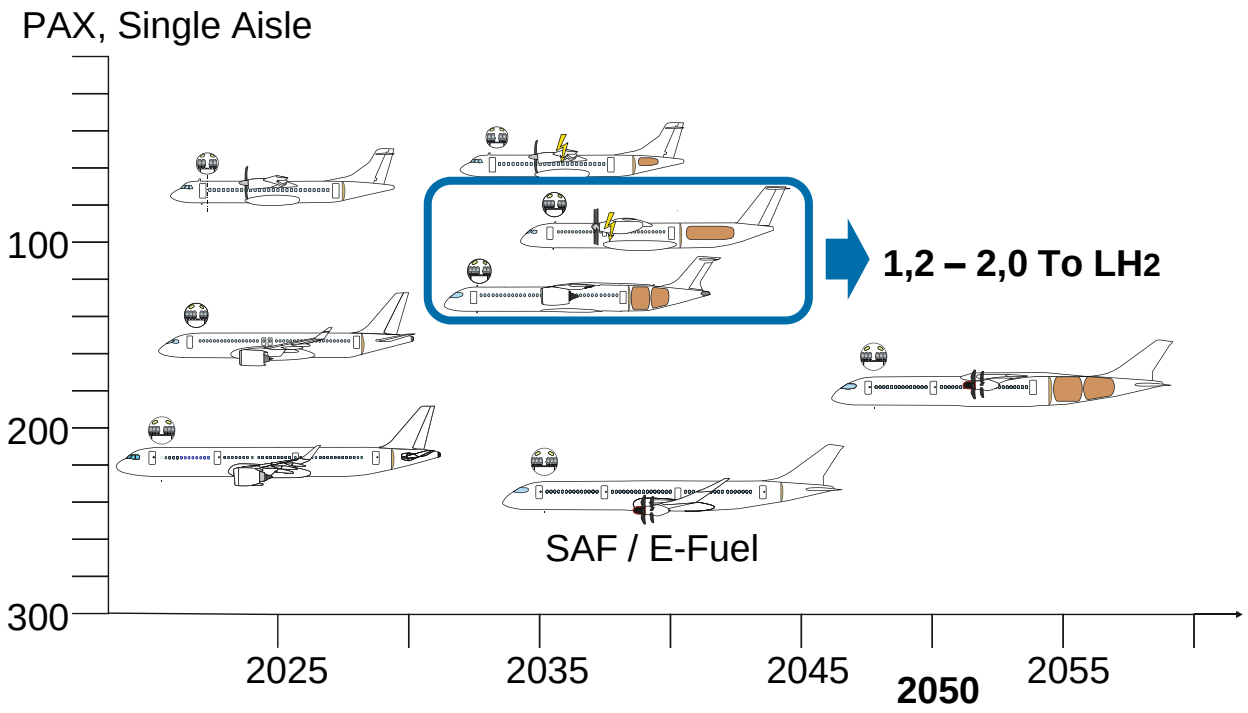
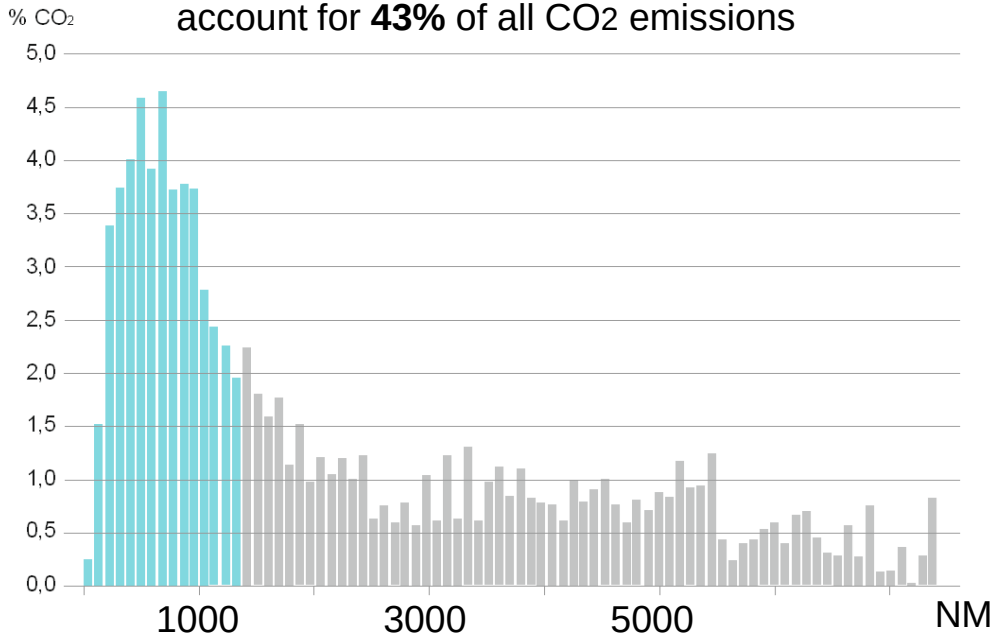
Motivation



Flights up to **1350 NM** (2000 km) account for **43%** of all CO_2 emissions



100% equals 1,01 Megatons of carbon dioxid in 2019 Source: European Environmental Agency (EAA), International Energy Agency (IEA), OAG Aviation Worldwide; McKinsey analyses

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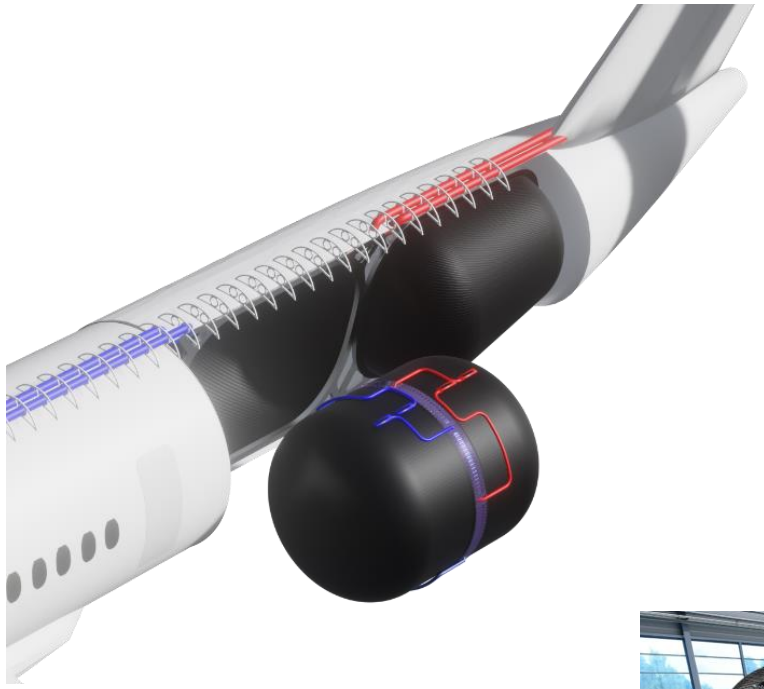
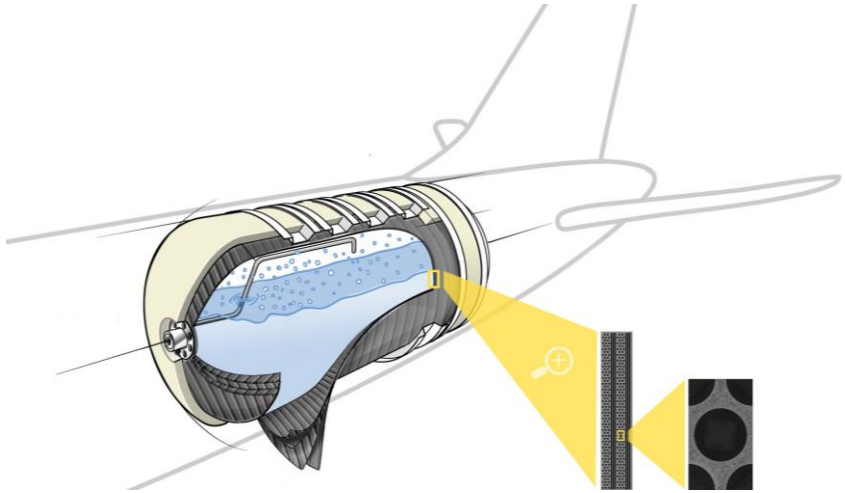
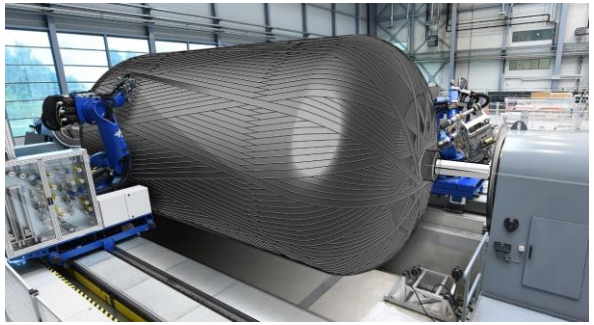
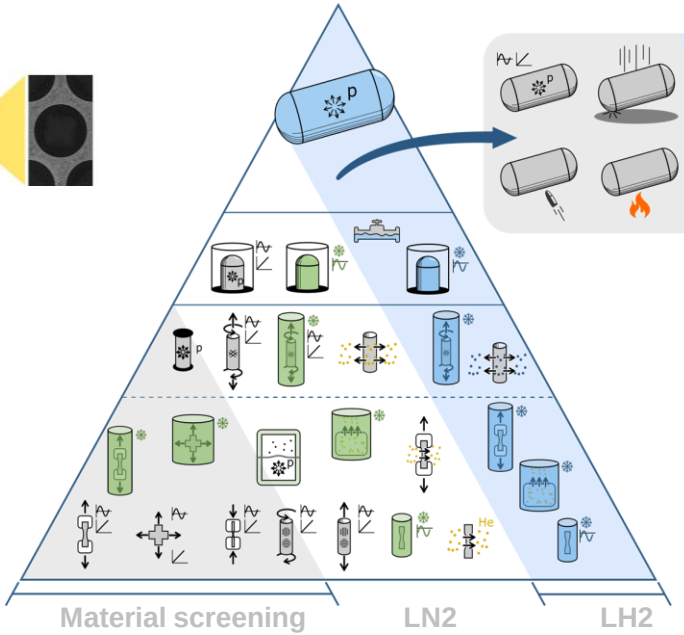








Objective

- ## CONCERTO Project:

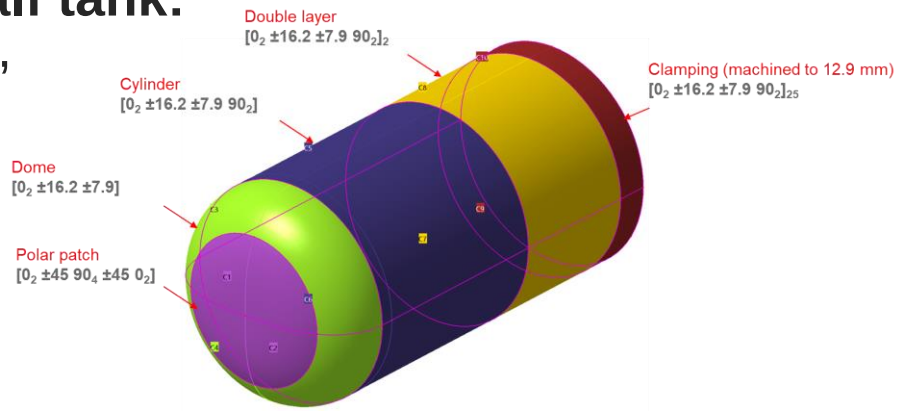
  Construction **O**f **N**ovel **CERT**ification meth**O**ds and means of compliance for disruptive technologies

- ## CONCERTO‘s H2 Tank Use Case:

  Predict **onset of leakage** of CFRP cryogenic tanks under representative mechanical and thermal loading conditions

  Demonstrate and validate by **scaled half tank:**
  Diameter 400mm, isotensoid dome,
  AFP process, thin ply prepreg,
  77 K, 8 bar leakage onset

  Contribute to **means of compliance** for certification requirements



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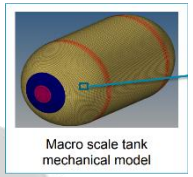
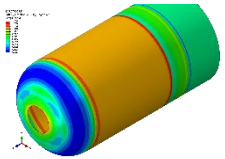
Overall Analysis Chain

Tank sizing and hot-spot analysis



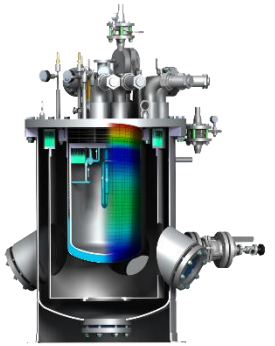
Crit. Elements/ laminates



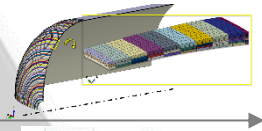
Half tank virtual testing/ leakage verification (macro-scale)

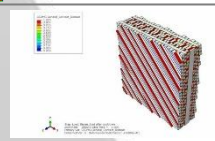
Leakage model and assessment criteria

Half tank testing and validation



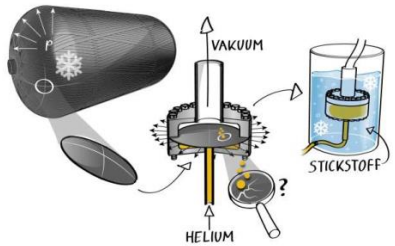
Half tank testíng at DLR





Meso-scale analysis of cut-outs/ coupons and leakage modeling

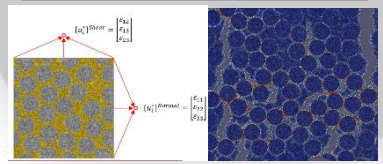
Bulge testing for leakage model validation



Bulge testing at DLR

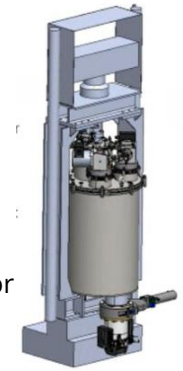
Mat. properties incl. Uncert.

Micro-mechanical analysis (RVE)



Material characterisation and model validation

Mode I testing and Cryostat for material testing at UdG



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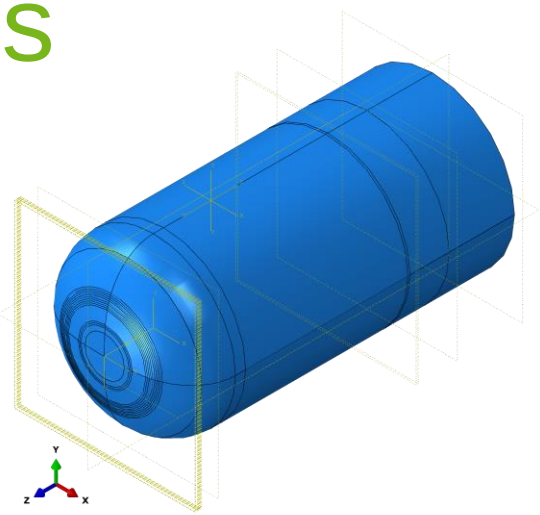
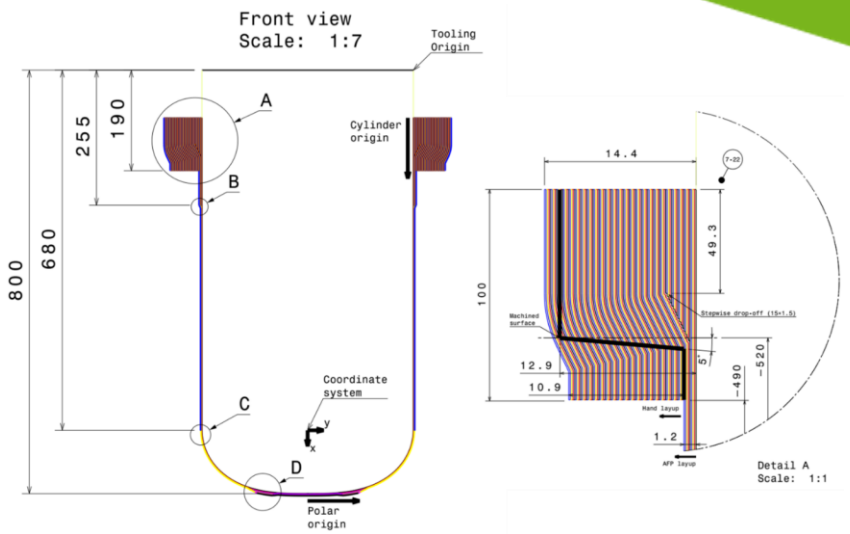
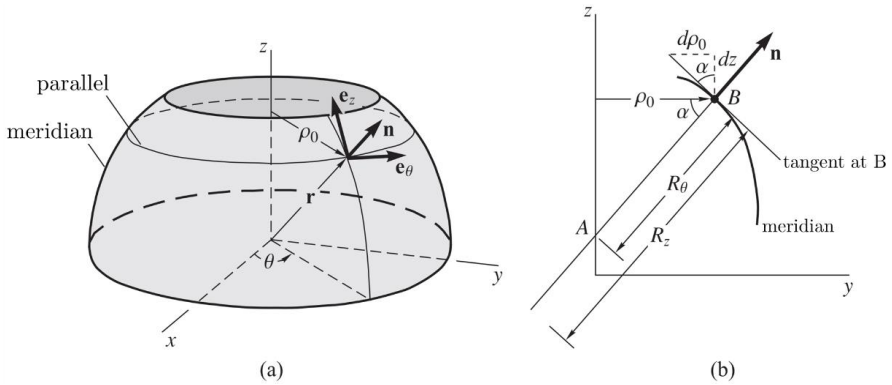
Structural Analysis

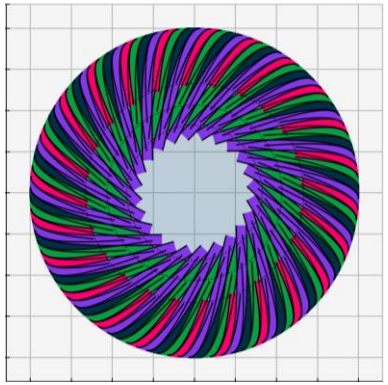
- Tank geometry from half tank test



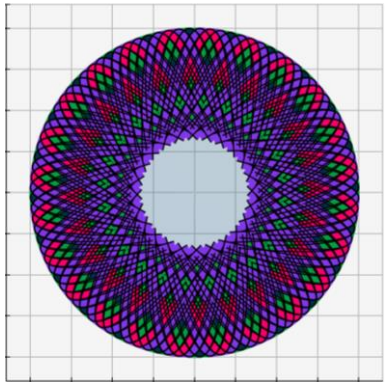


- Analytical AFP simulation to derive detailed fibre architecture

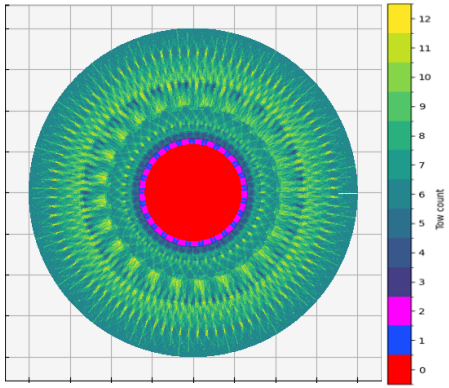




Effect of tow overlap



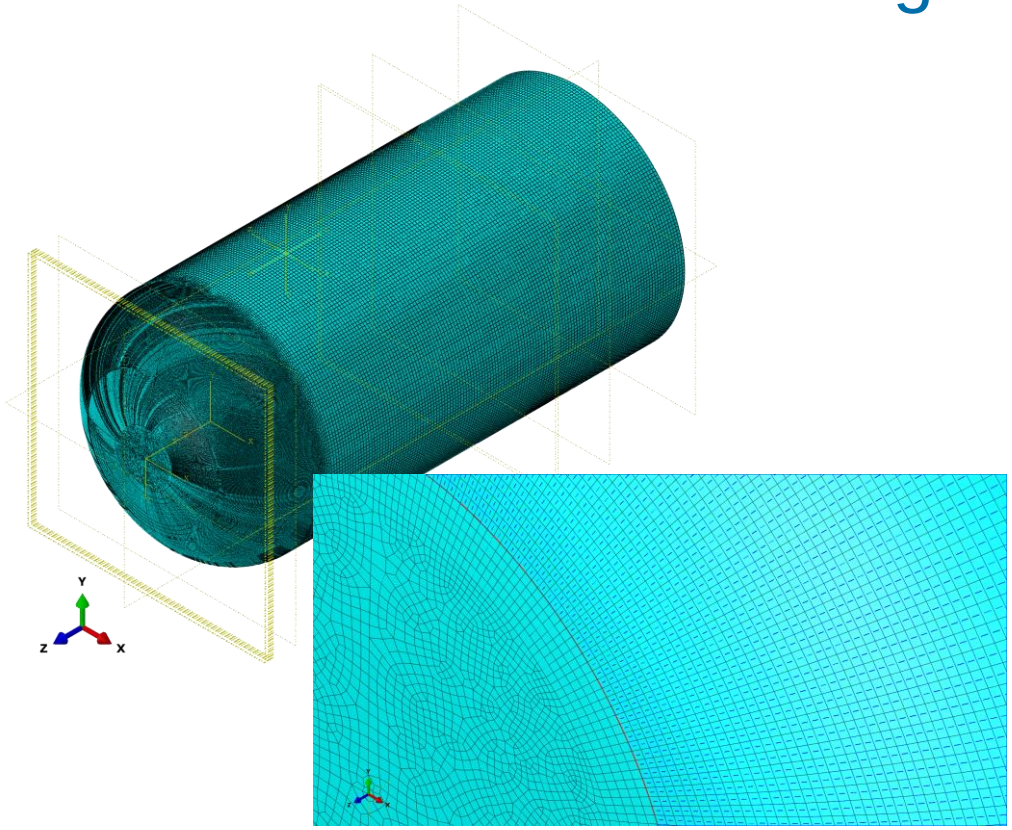
Effect of phase shifts



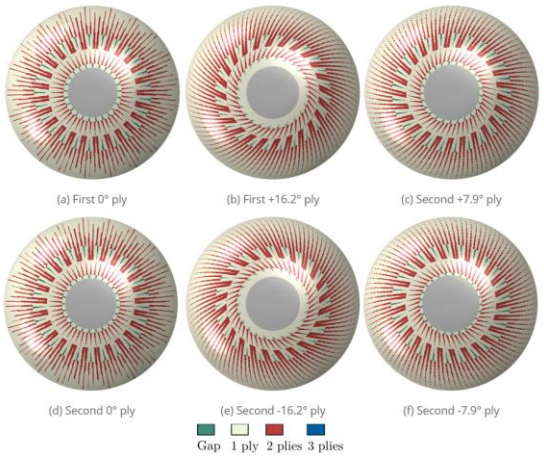
Total ply count distribution

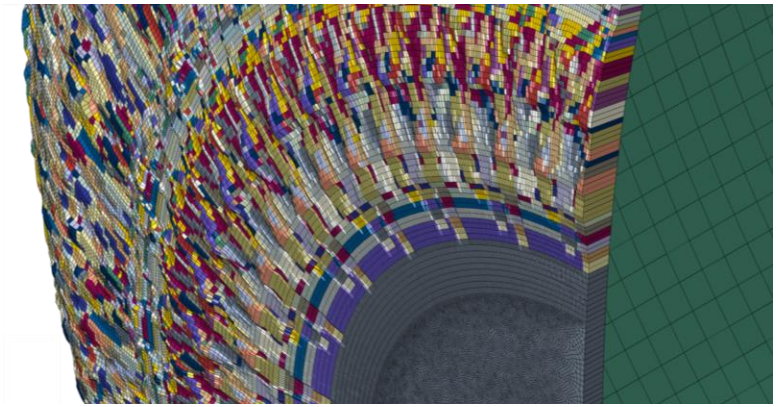
Structural Analysis

- Finite Element Modelling



Shell model

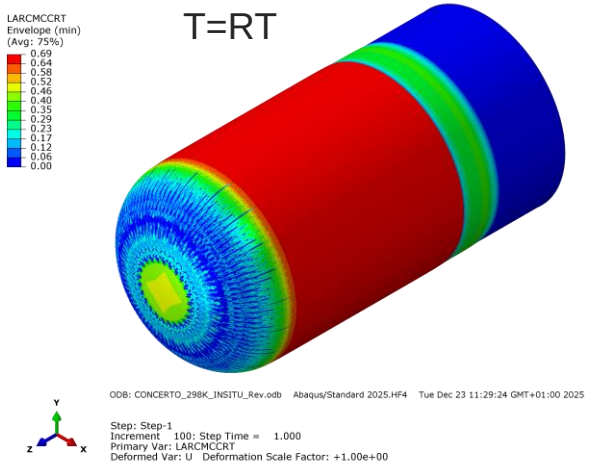


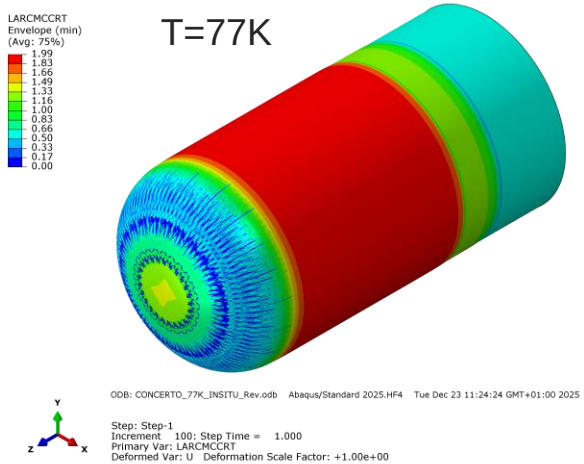


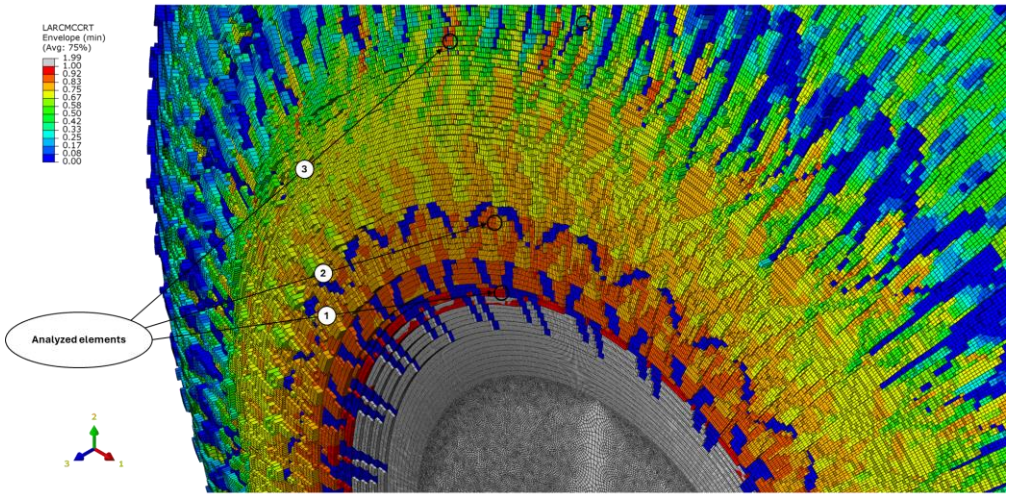
Mapped layup
(rendered thickness)

Structural Analysis

- Structural analysis and hotspot identification







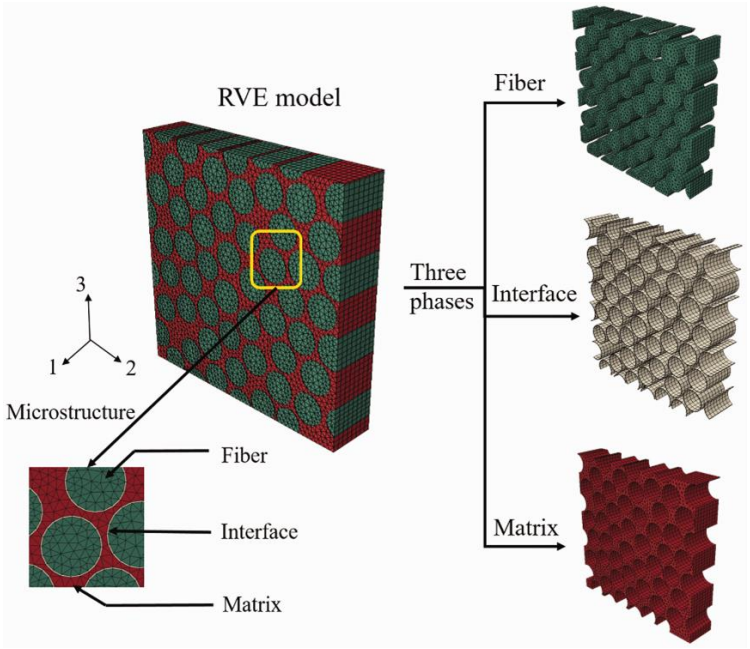
	T = RT		T = 77 K	
Ply	$p_{0\% MS}$	MS_{20bar}	$p_{0\% MS}$	MS_{20bar}
1	-	30.7%	6.6 bar	-
2	-	10.2%	7.6 bar	-
3	10.3 bar	-	7.7 bar	-
4	14.1 bar	-	5.4 bar	-

→ LARC05 matrix cracking failure index
→ T=77K: onset of leakage at ~7-8 bar

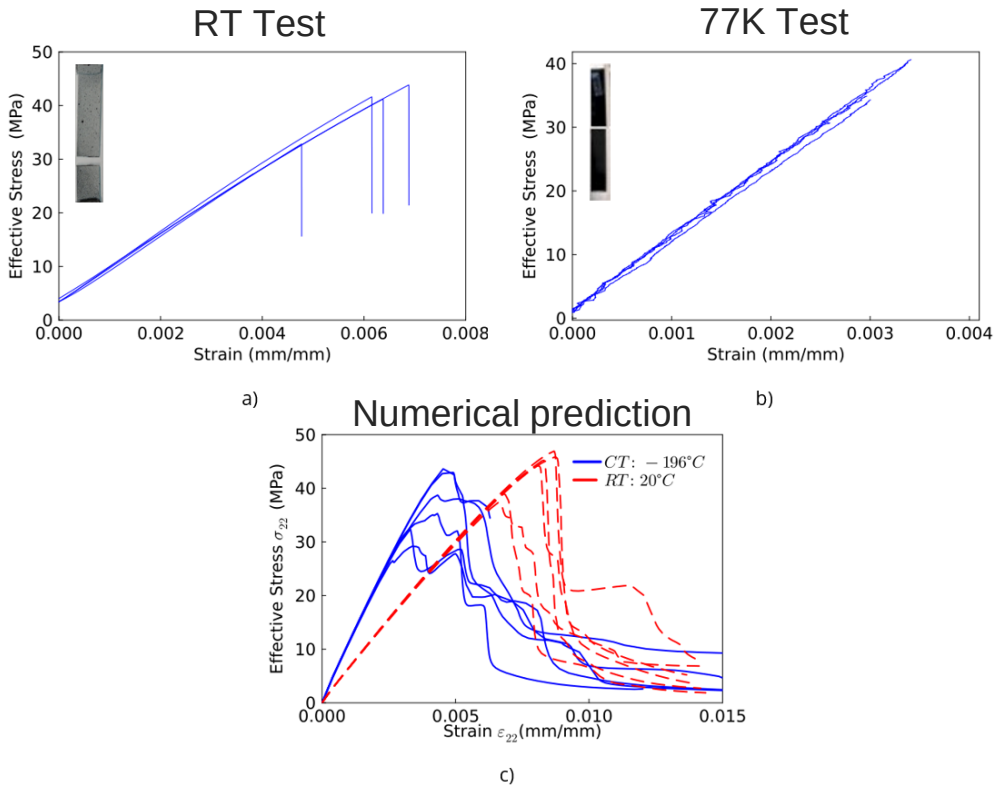
Micromechanical Analysis

- Virtual Material Characterization

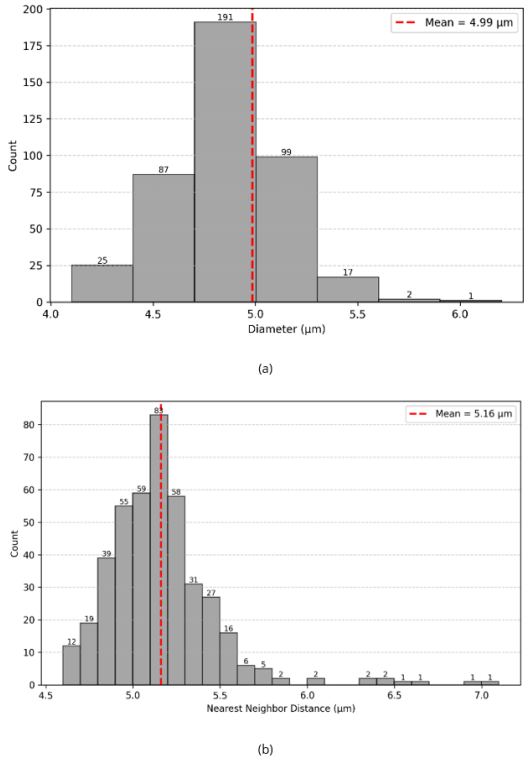
Parametric modelling



Experimental validation



Statistical metrics of microstructure



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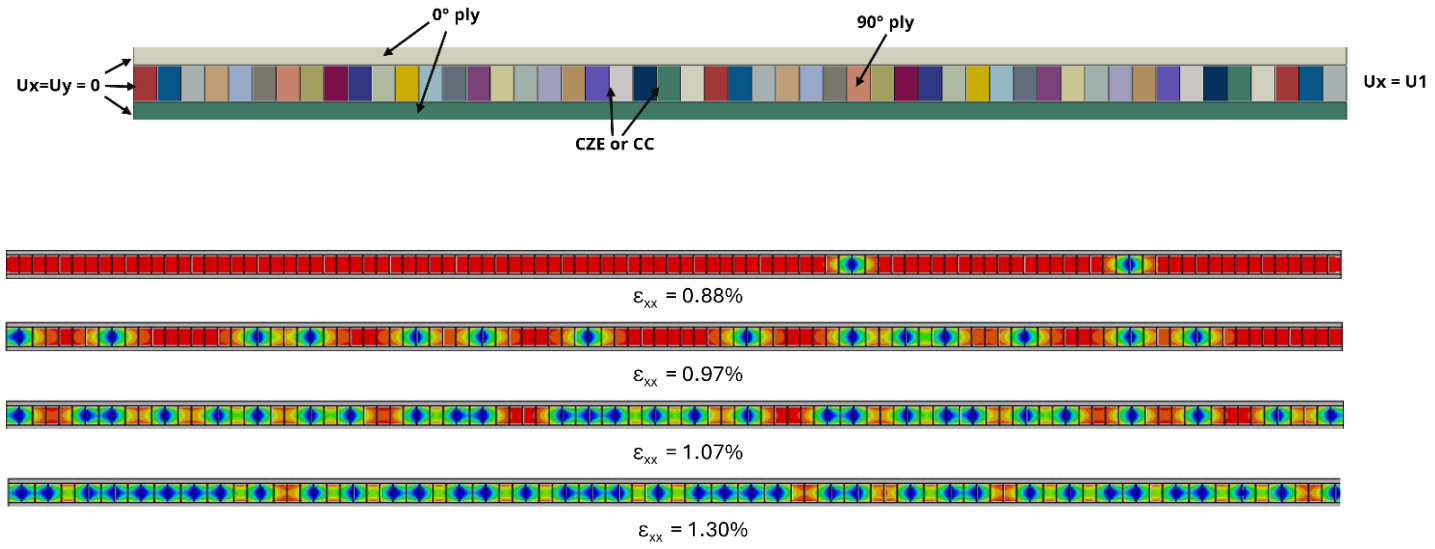
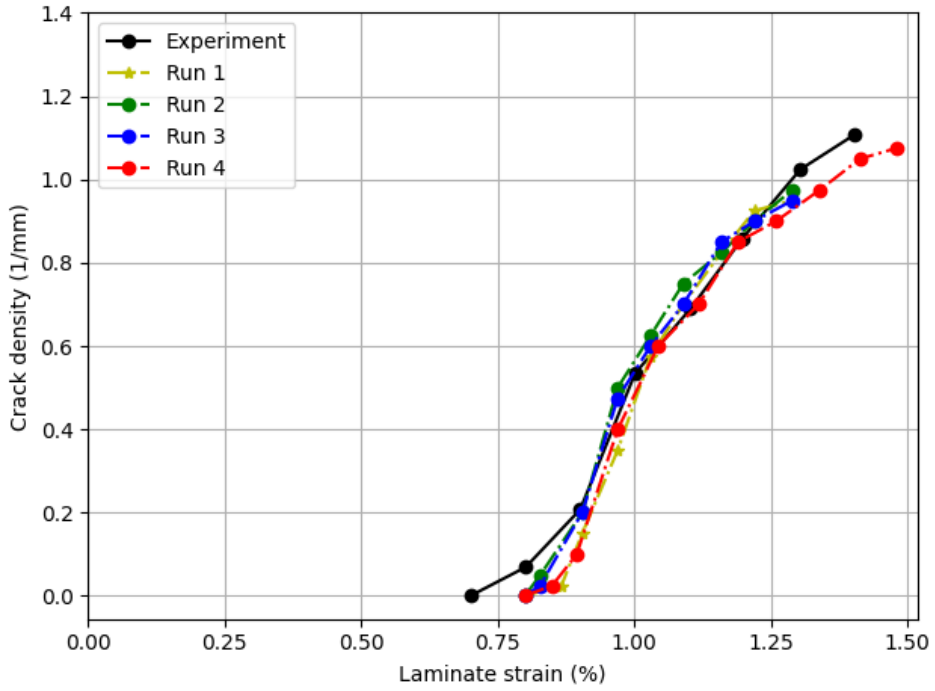
Meso-scale Modelling

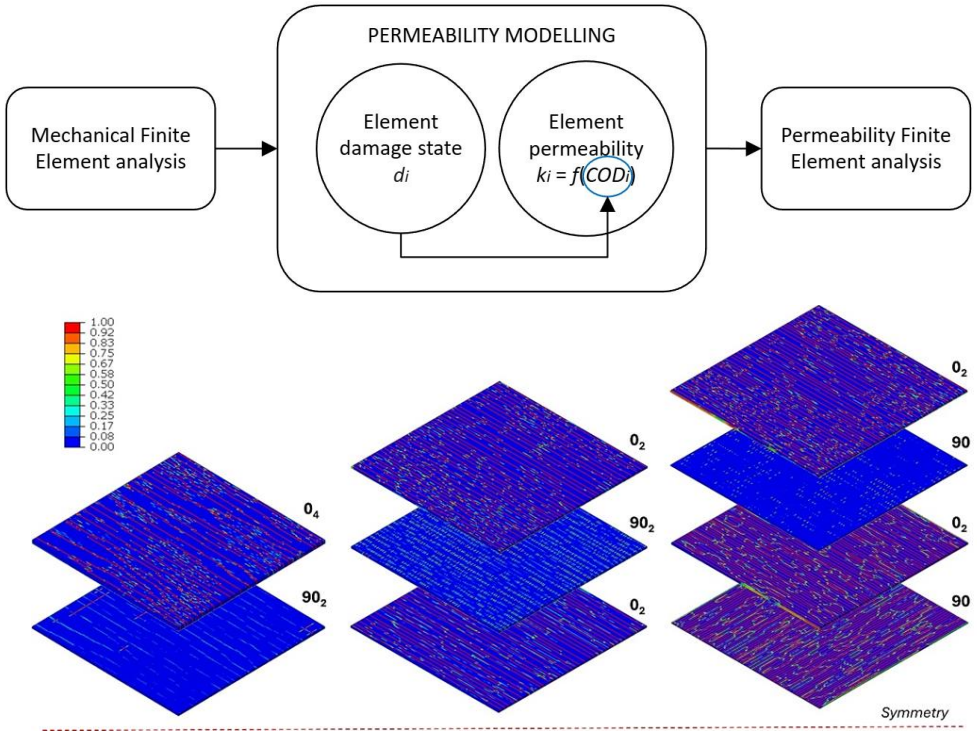
- Crack density prediction using discrete damage mechanics (DDM)

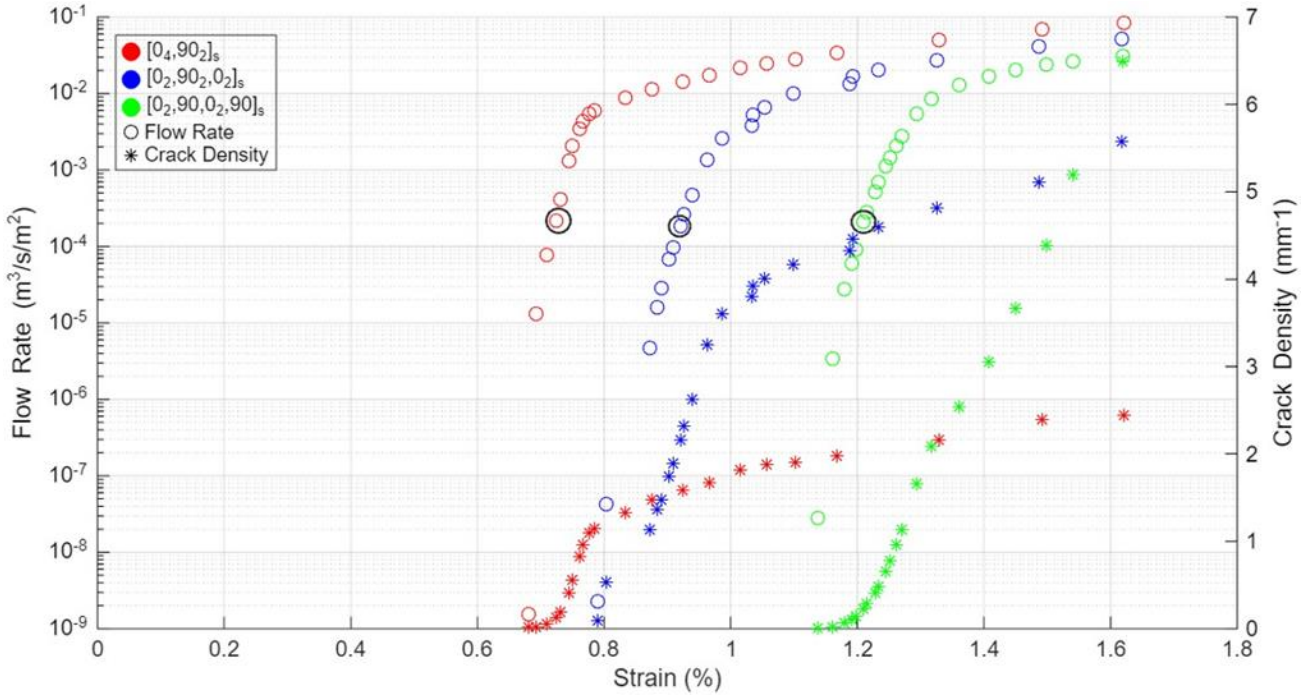




Meso-scale Modelling

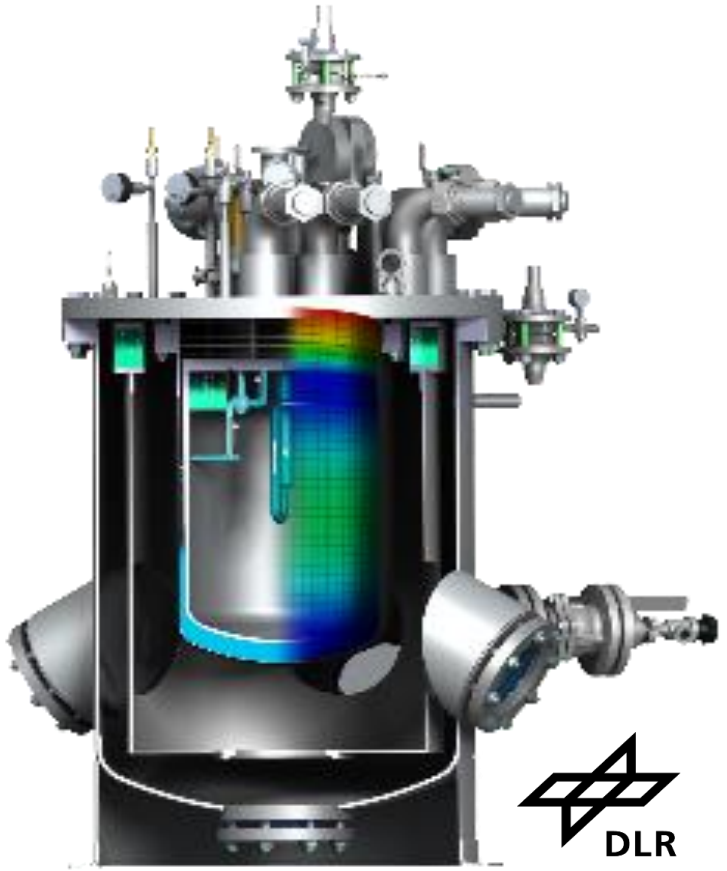
- Leakage analysis based on continuum damage mechanics (CDM)





Summary and Outlook

- Simulation strategy for cryogenic tanks derived
- Novel analysis methods developed and demonstrated
- Uncertainty quantification and propagation methods established and currently being extended from coupon to structural scale
- Coupon-level validation completed, structural testing ongoing



Thank You

- Acknowledgements

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