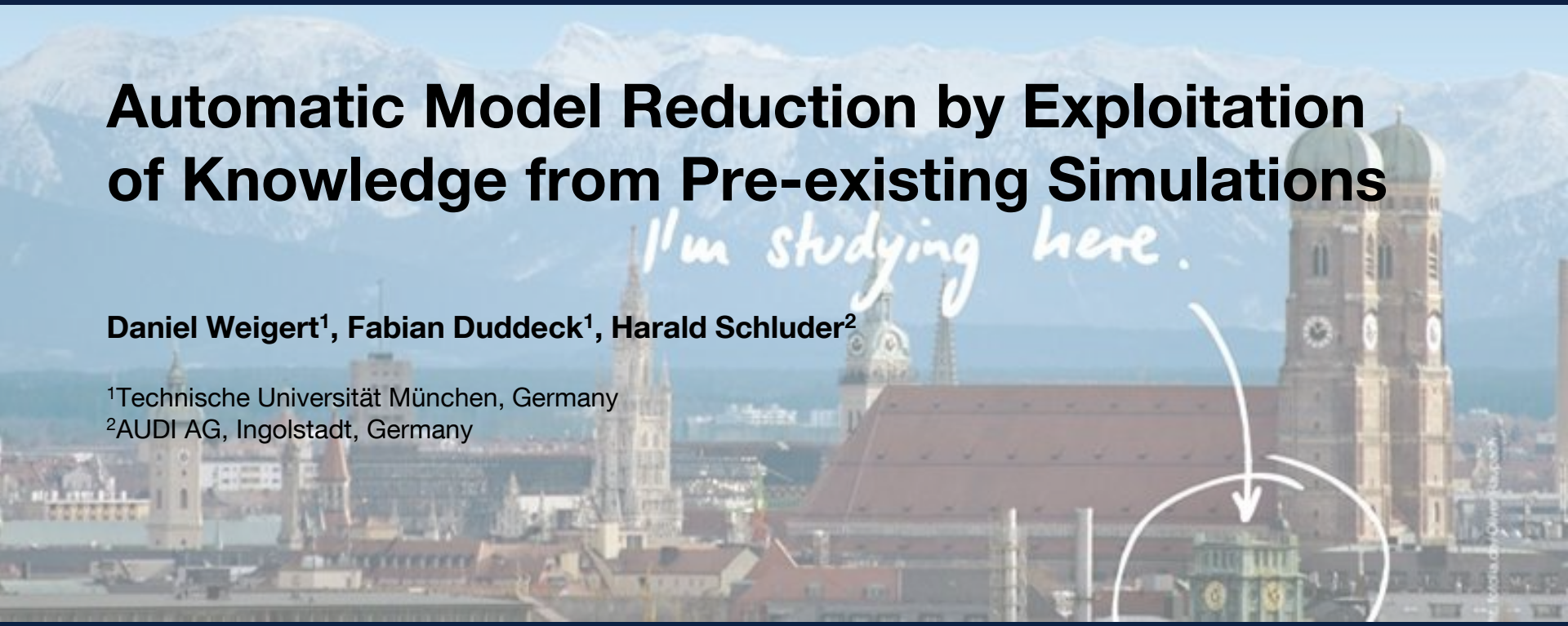
Chair of
Computational Mechanics
Prof. Dr.-Ing. habil. Fabian Duddeck

Technische Universität München

Automatic Model Reduction by Exploitation of Knowledge from Pre-existing Simulations



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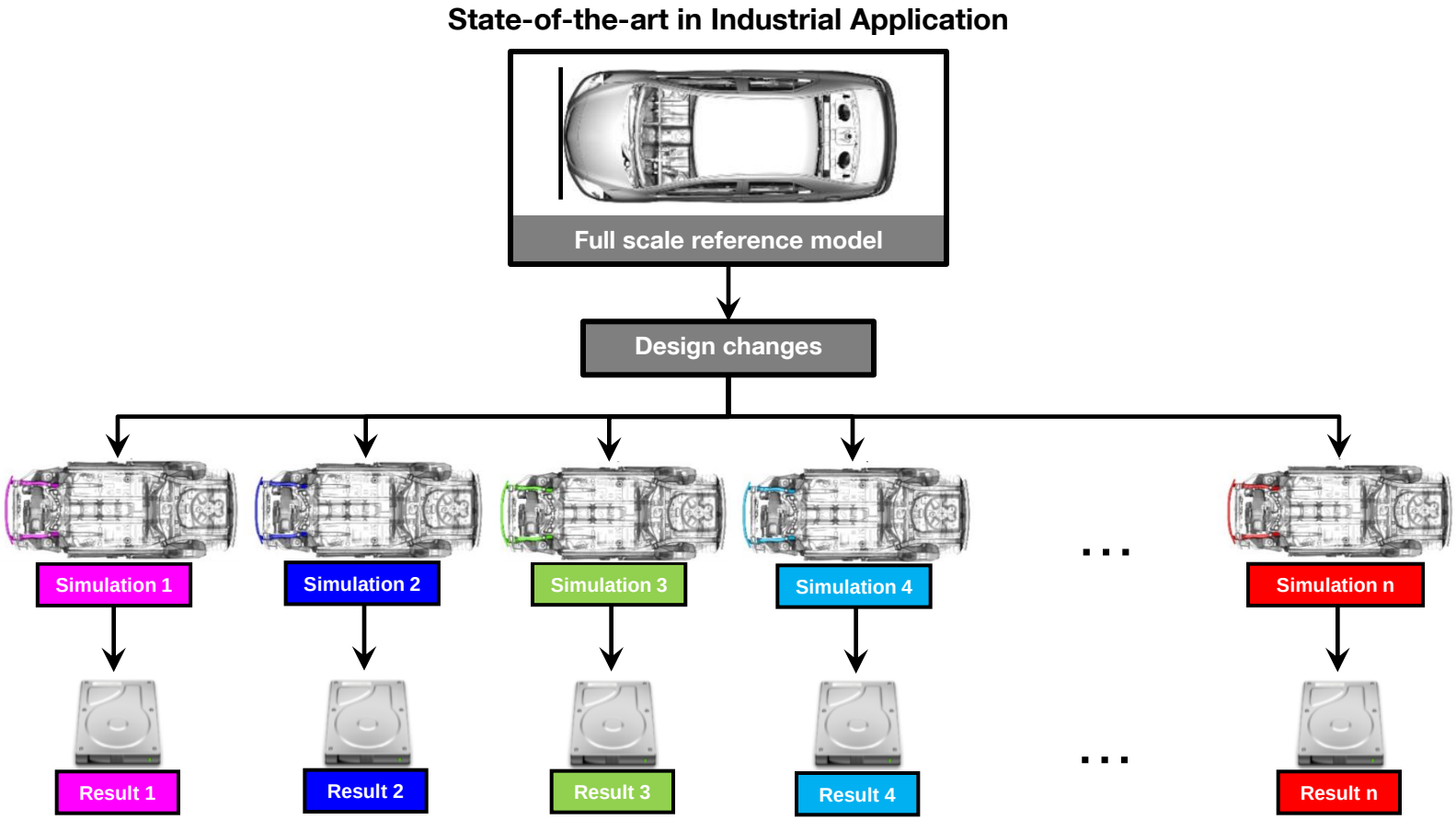
Outline

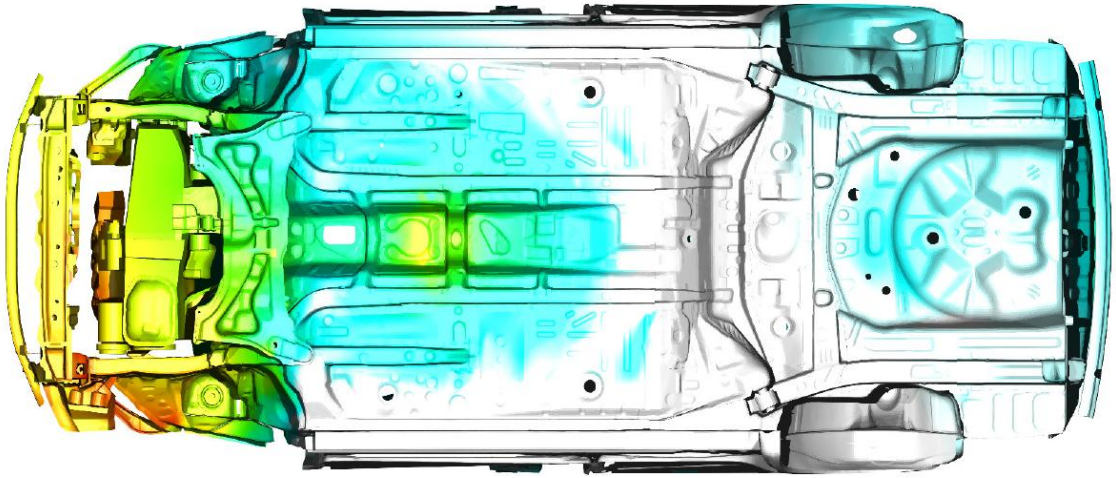
1. Motivation for Model Reduction in Crashworthiness Analysis
2. Sub-Structuring Approach
3. Knowledge-Based Sub-Structuring Approach
4. Application Example
5. Conclusions & Outlook

Motivation for Model Reduction Methods in Crash Simulation

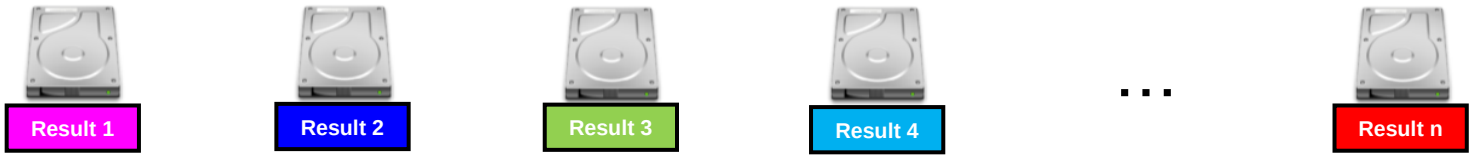


Motivation for Model Reduction Methods in Crash Simulation

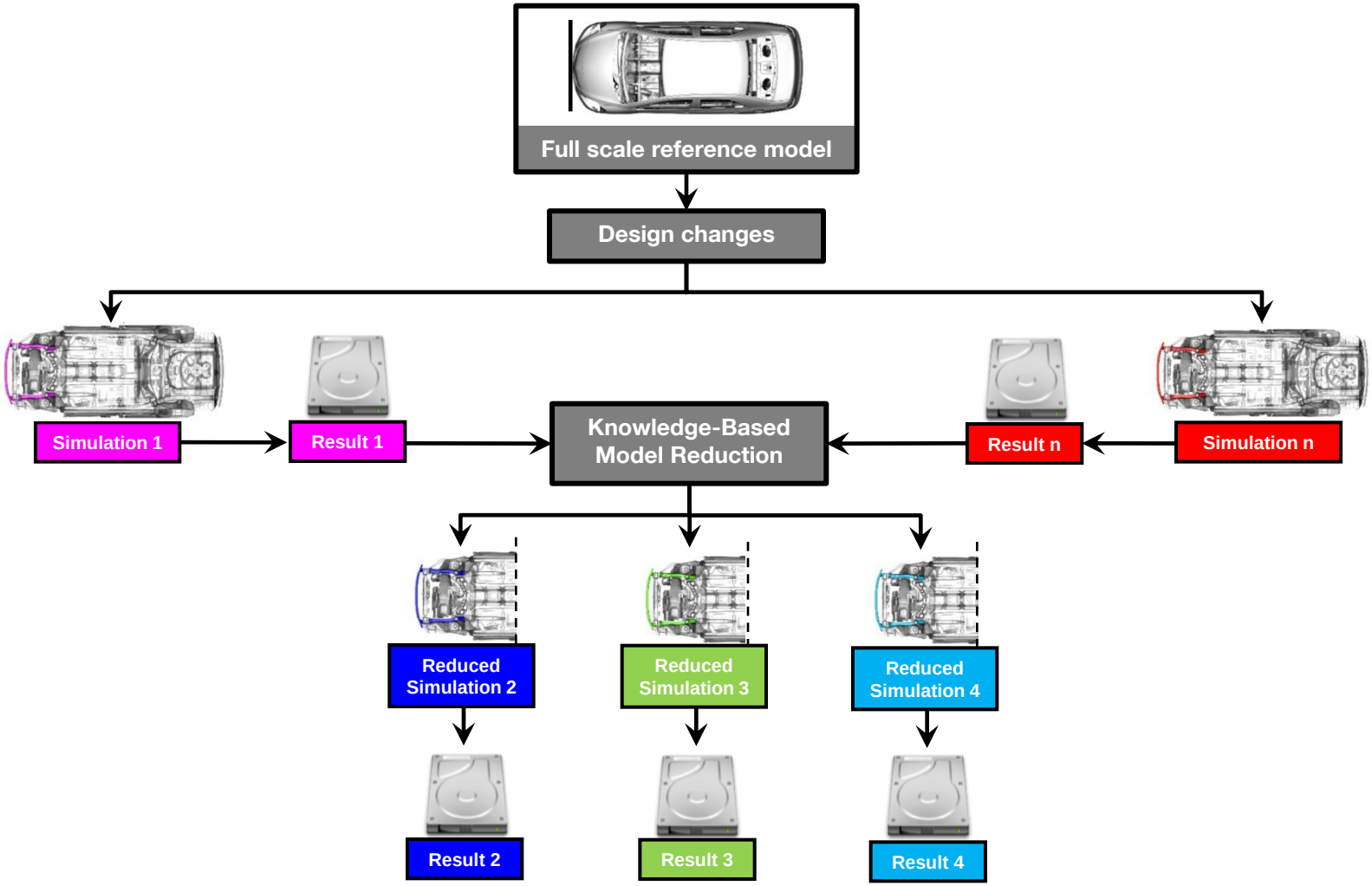
Why running all simulations on full vehicle models?
Use pre-exisiting / gained results to speed up simulations.



Full frontal high-speed loadcase
Reference impact velocity v = 56 km/h
Variation of velocity v: +/-10 %
46 full scale simulations

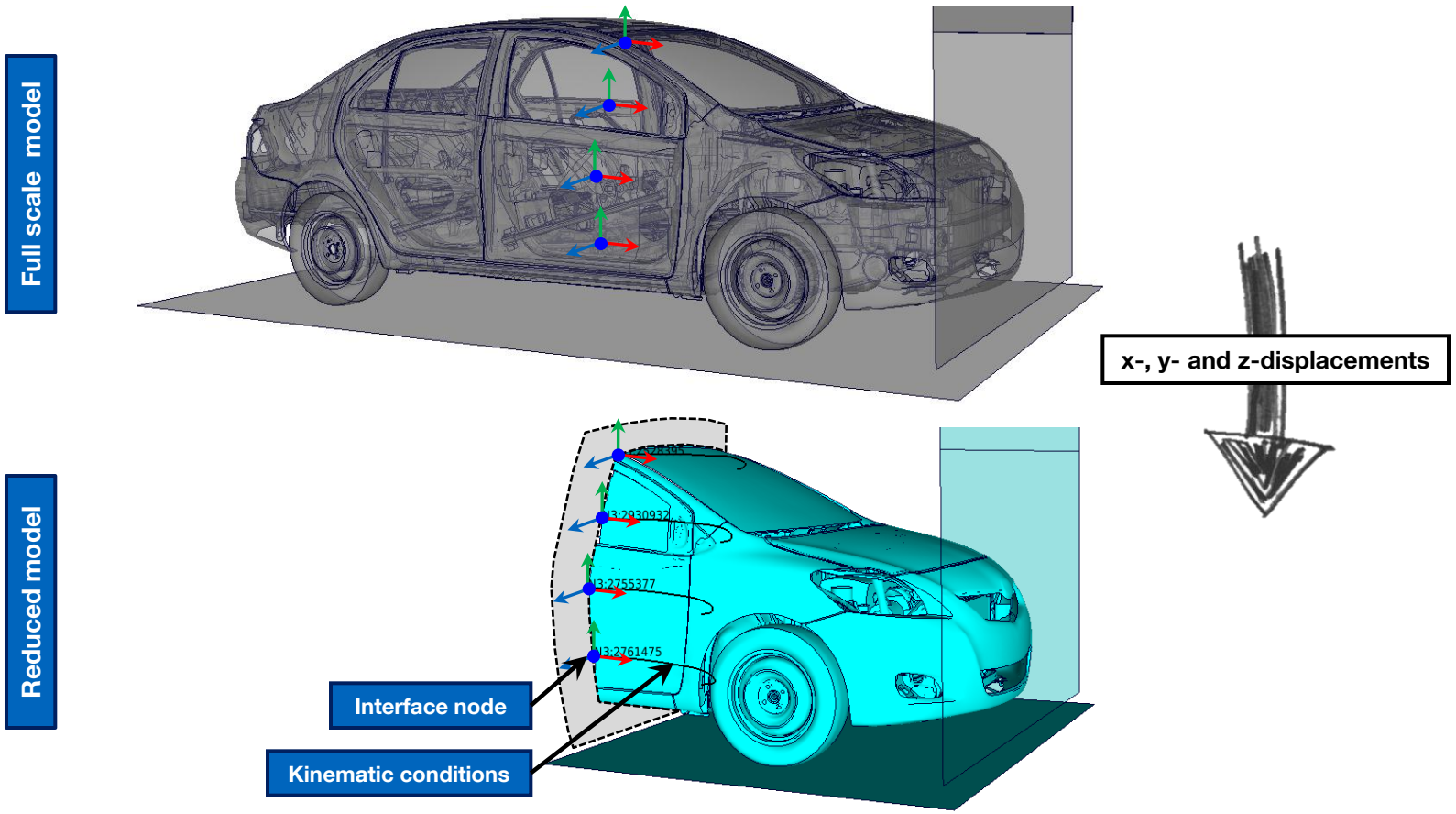


Knowledge-Based Model Reduction



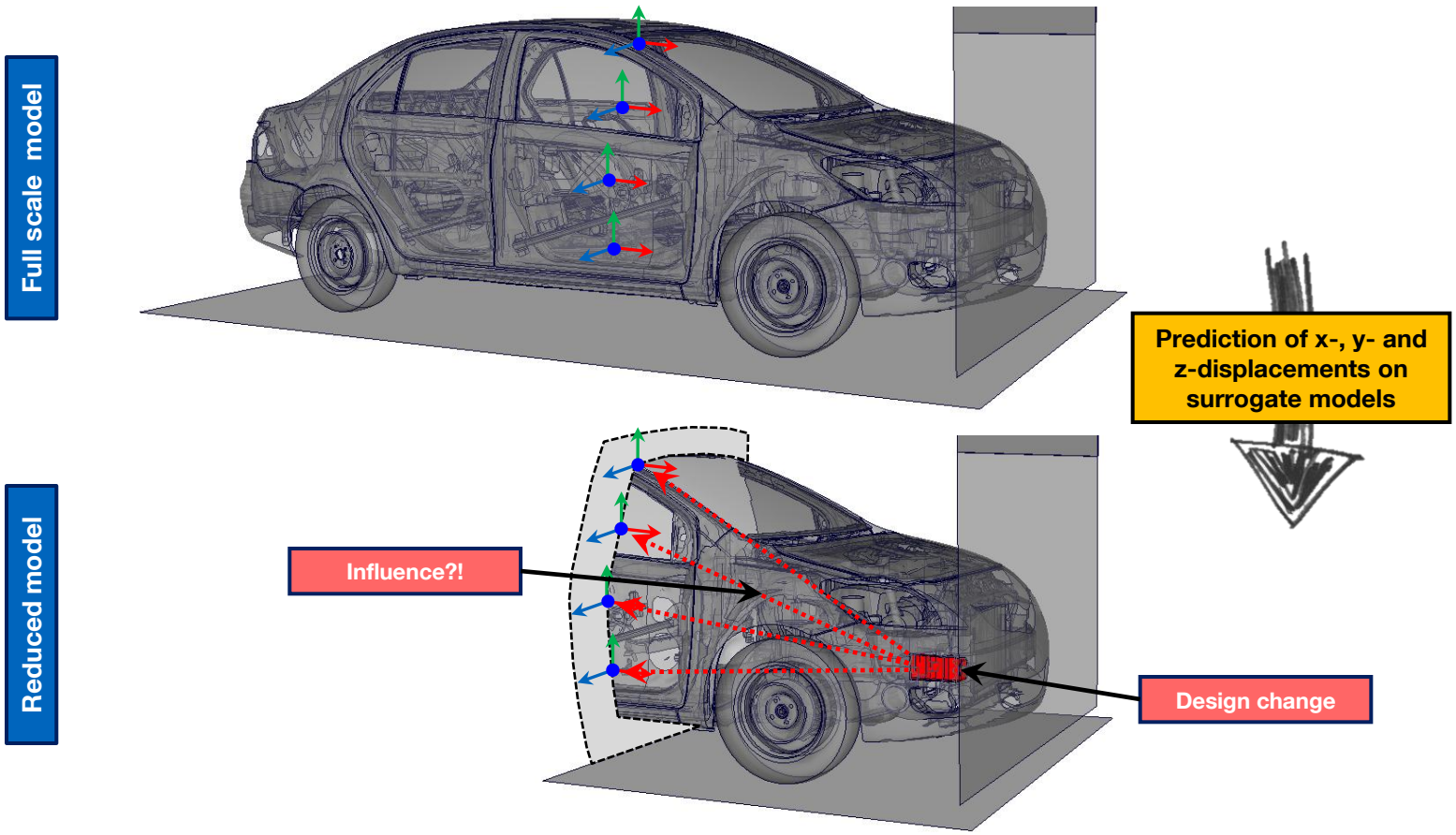
Sub-Structuring Approach for Model Reduction

Model reduction: Computational reduction of original simulation models to a sub-model by applying kinematic conditions (KC‘s) to the interface nodes.

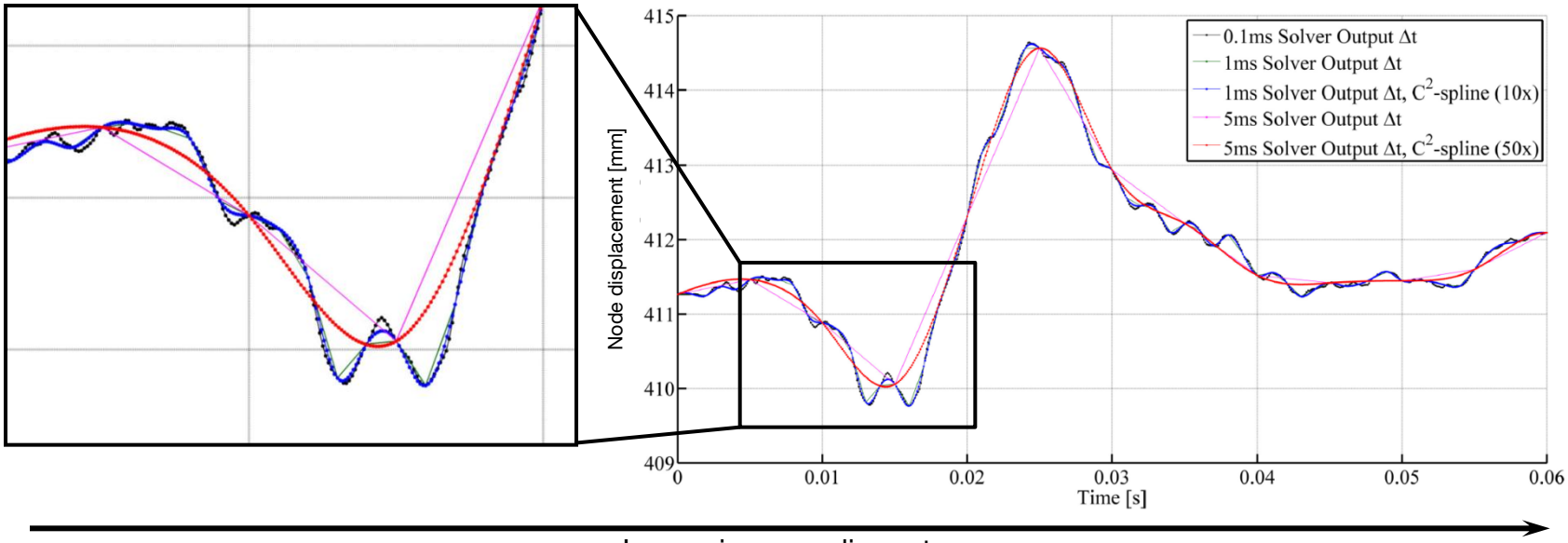


Knowledge-Based Sub-Structuring Approach

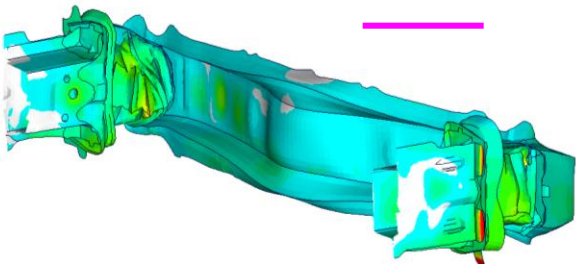
Knowledge-Based Sub-Structuring: Kinematic conditions for new variants are predicted on pre-exisiting knowledge.



Achievable Accuracy by Using the Sub-Structuring Approach

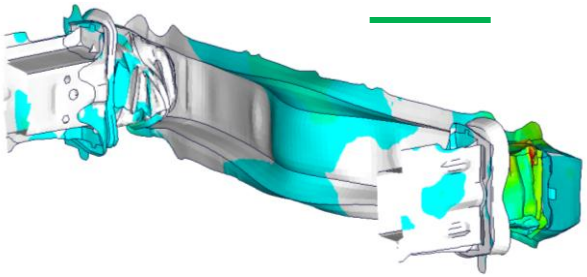


Increasing sampling rate



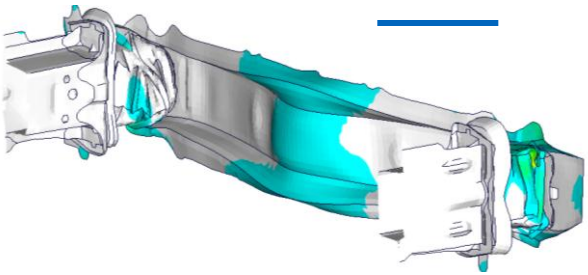
Used solver output every 5 ms

Max nodal differences ~12 mm



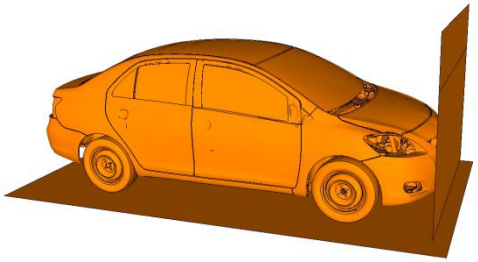
Used solver output every 1 ms

Max nodal differences ~6 mm



Used solver output every 1 ms
(10 interpolation points added)
Max nodal differences ~4 mm

Application Example

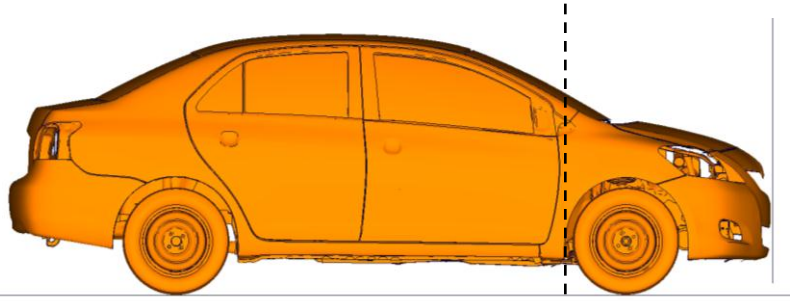


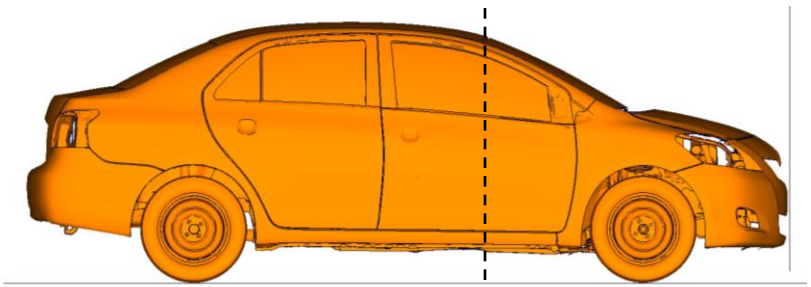
2010 NCAC Toyota Yaris full scale model
Full frontal crash configuration
974.561 elements

Impact velocity variation +/- 10%

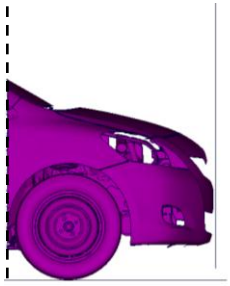
Low-speed 15 km/h	High-speed 56 km/h
[13.5km/h .. 16.5km/h]	[50.8km/h .. 62.1km/h]

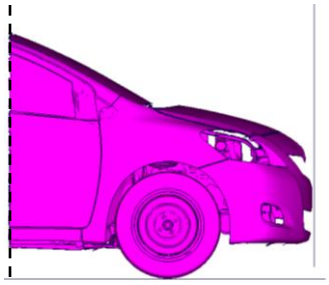
Full scale model



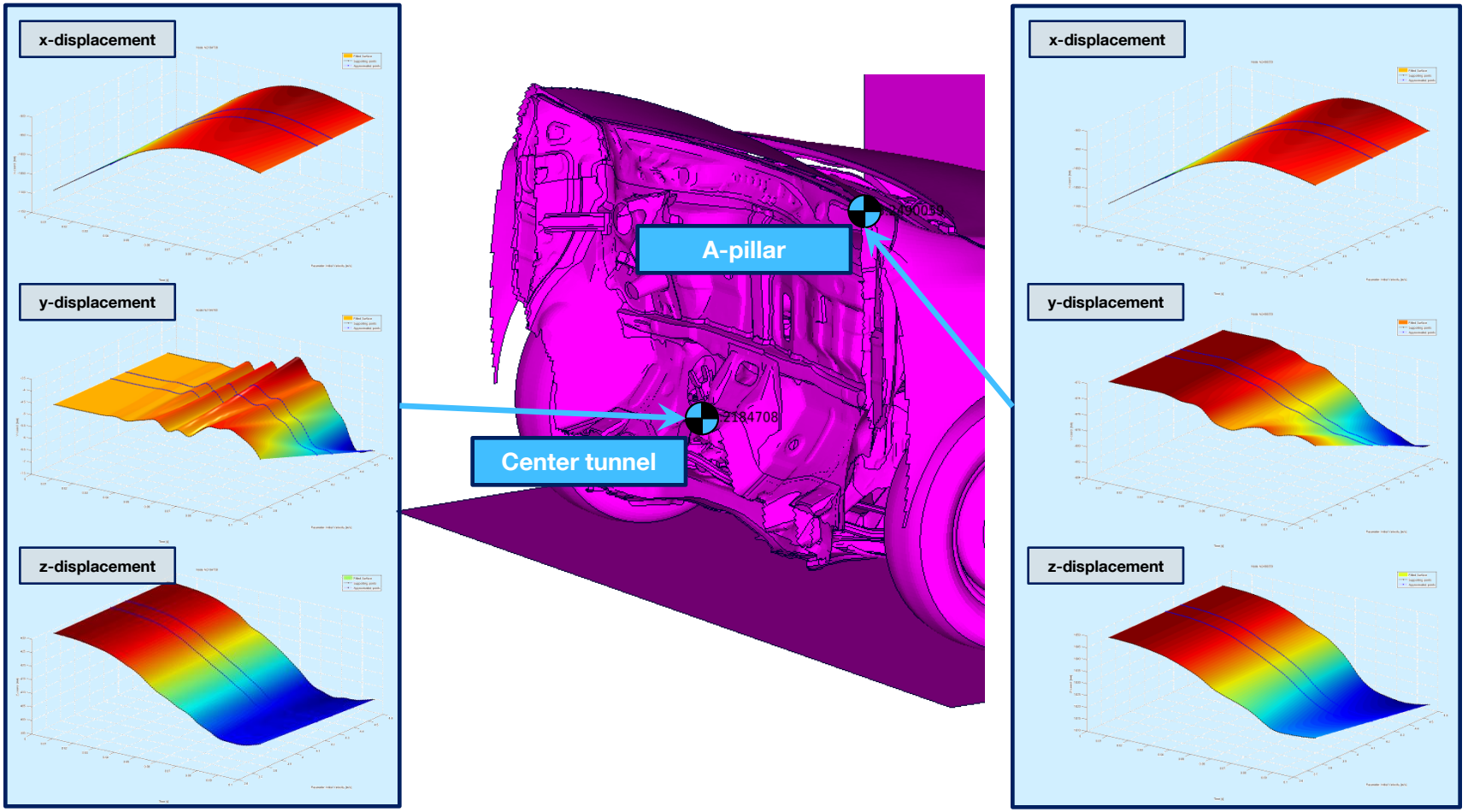


Reduced model



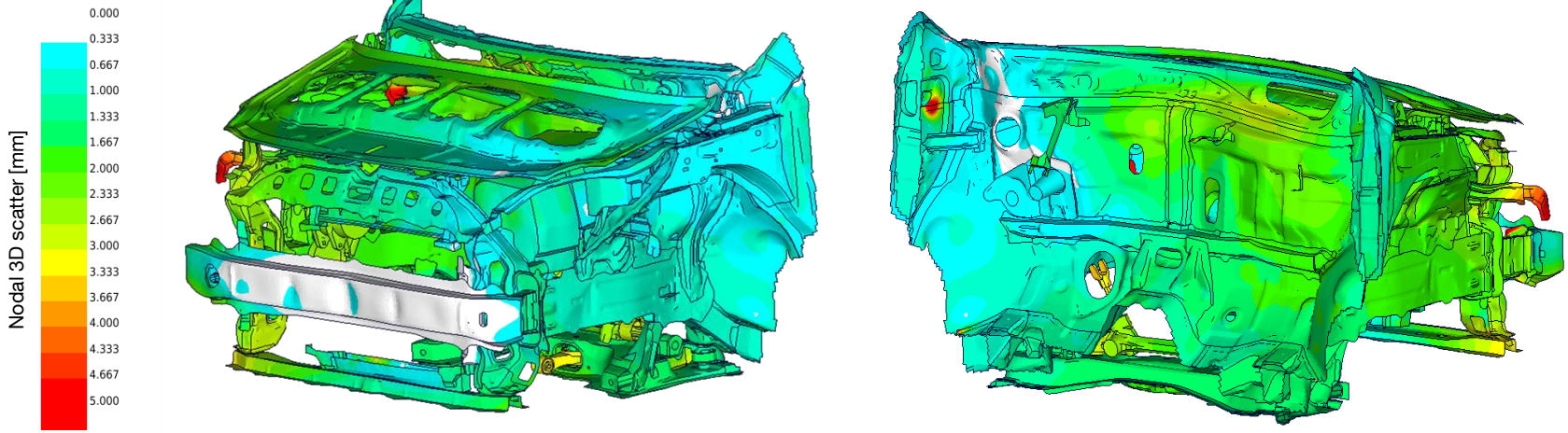


Surrogate Models for Selected Interface Nodes



Low-speed

Results for Low-Speed on Reduced Model at 14.9 km/h



Front view (75 ms)

Rear view (75 ms)

2 full simulations for surrogate models used
at **10.5 km/h** and **16.5 km/h**

Reduced model built up for **v=14.9 km/h**
5 ms output with 50 interpolation points used

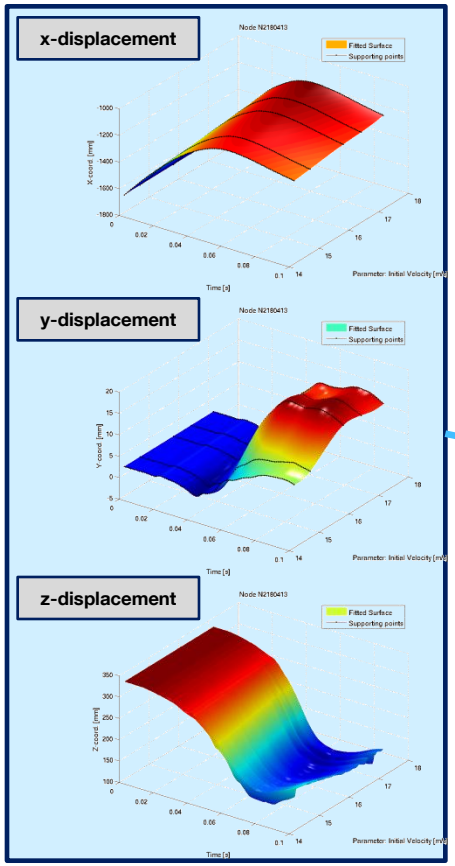
Very good agreements

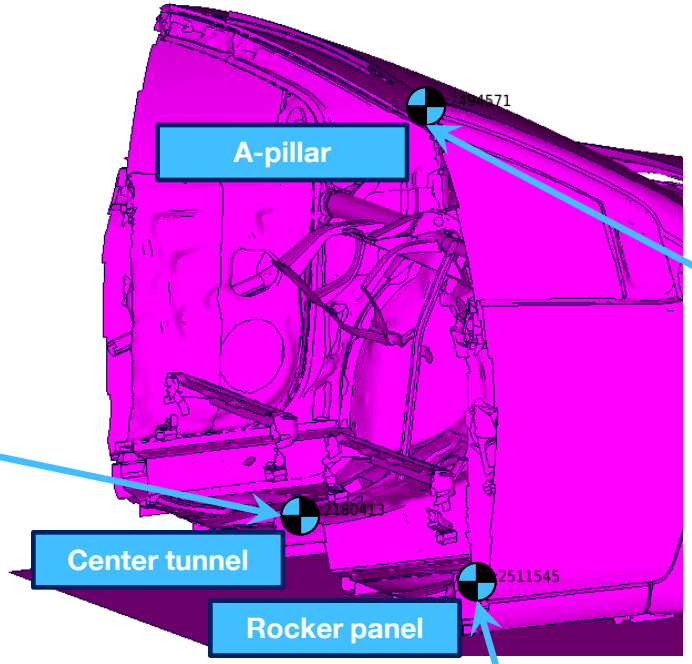
		Number of elements	Computation time [s]
Low-speed	Full scale model	974.561	67.857
	Reduced model	260.378	17.512 + 1.344*
Reduction		**73.3 %**	**72.2 %**

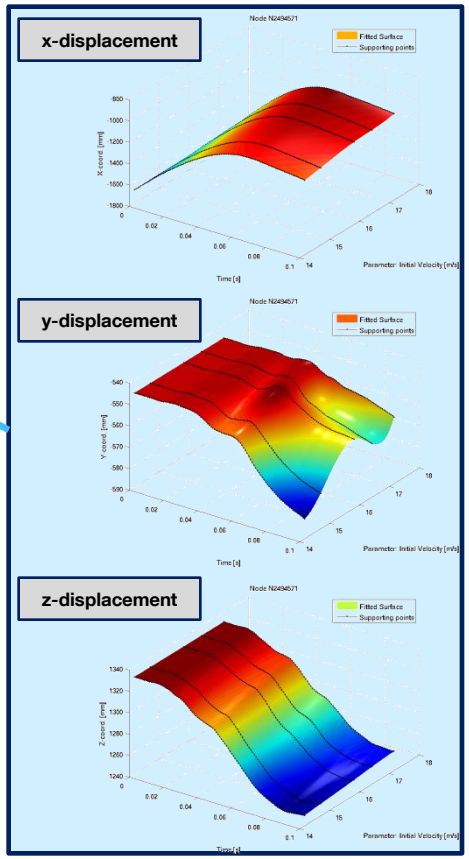
** Time for creation of reduced model*

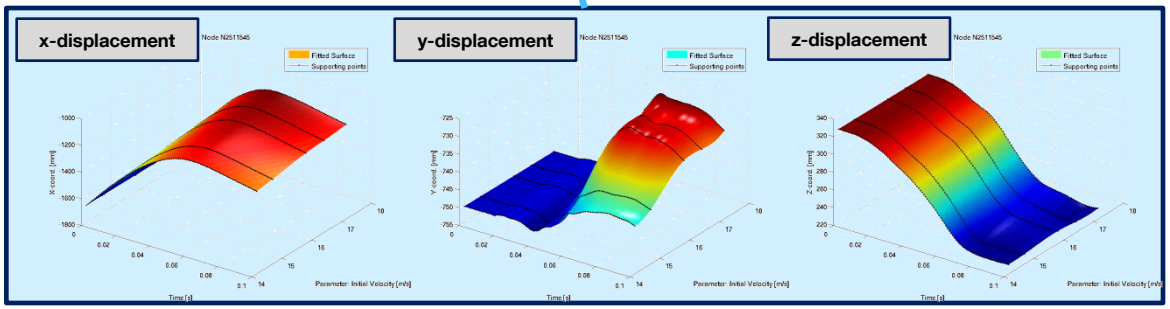
Low-speed

Surrogate Models for Selected Interface Nodes



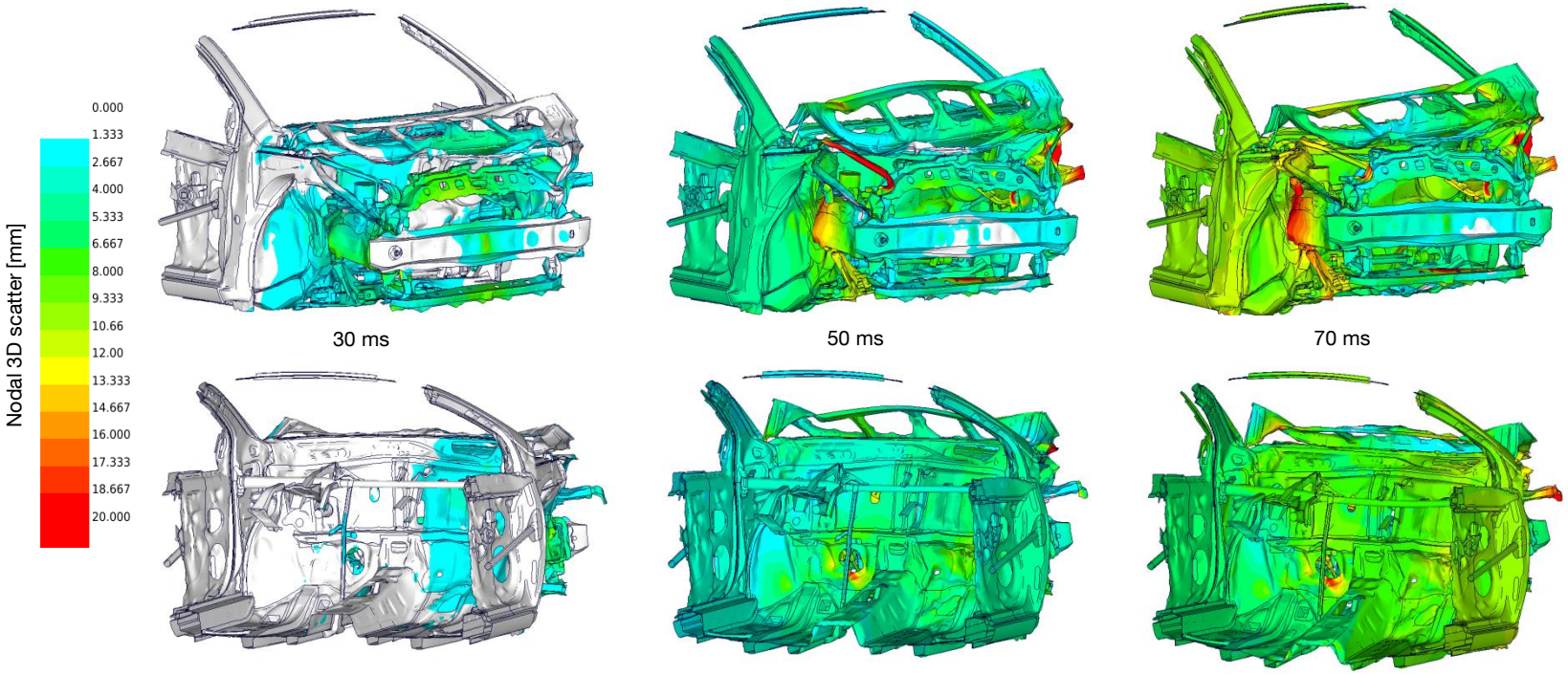






High-speed

Results for High-Speed on Reduced Model at 54.9 km/h



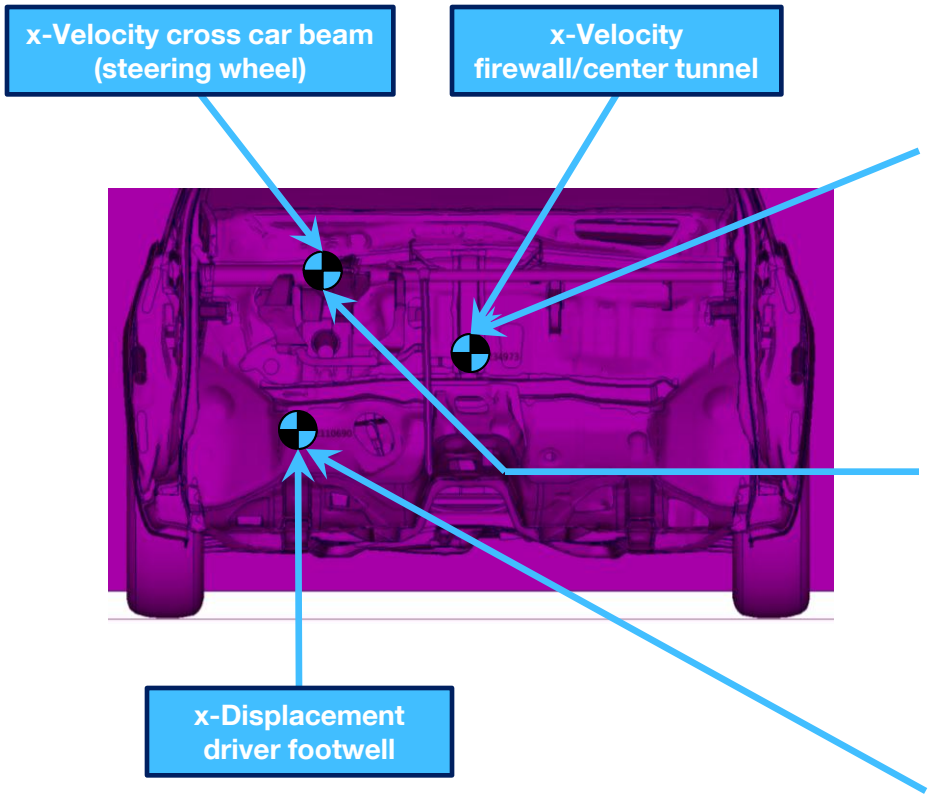
High-speed

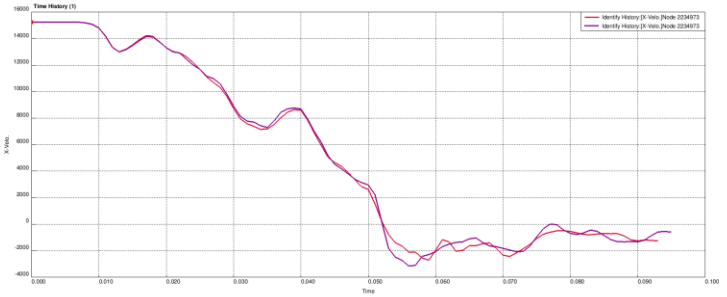
5 full simulations for surrogate models used
at **51.0 km/h, 52.9 km/h, 56.9 km/h, 59.1 km/h** and **61.8 km/h**

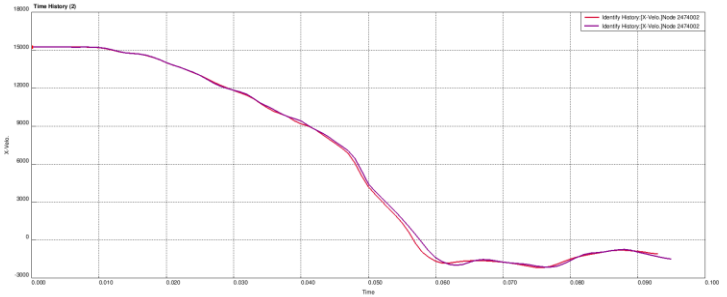
Satisfying agreements

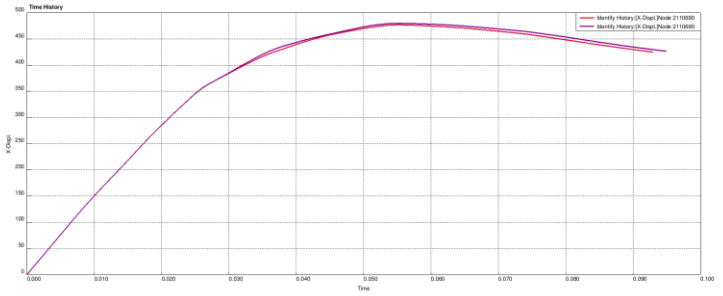
Reduced model built up for **v=54.9 km/h**
5 ms output with 50 interpolation points used

Results for High-Speed on Reduced Model at 54.9 km/h









		Number of elements	Computation time [s]
High-speed	Full scale model	974.561	64.288
	Reduced model	383.453	26.498 + 2.594*
Reduction		**60.6 %**	**54.7 %**

** Time for creation of reduced model*

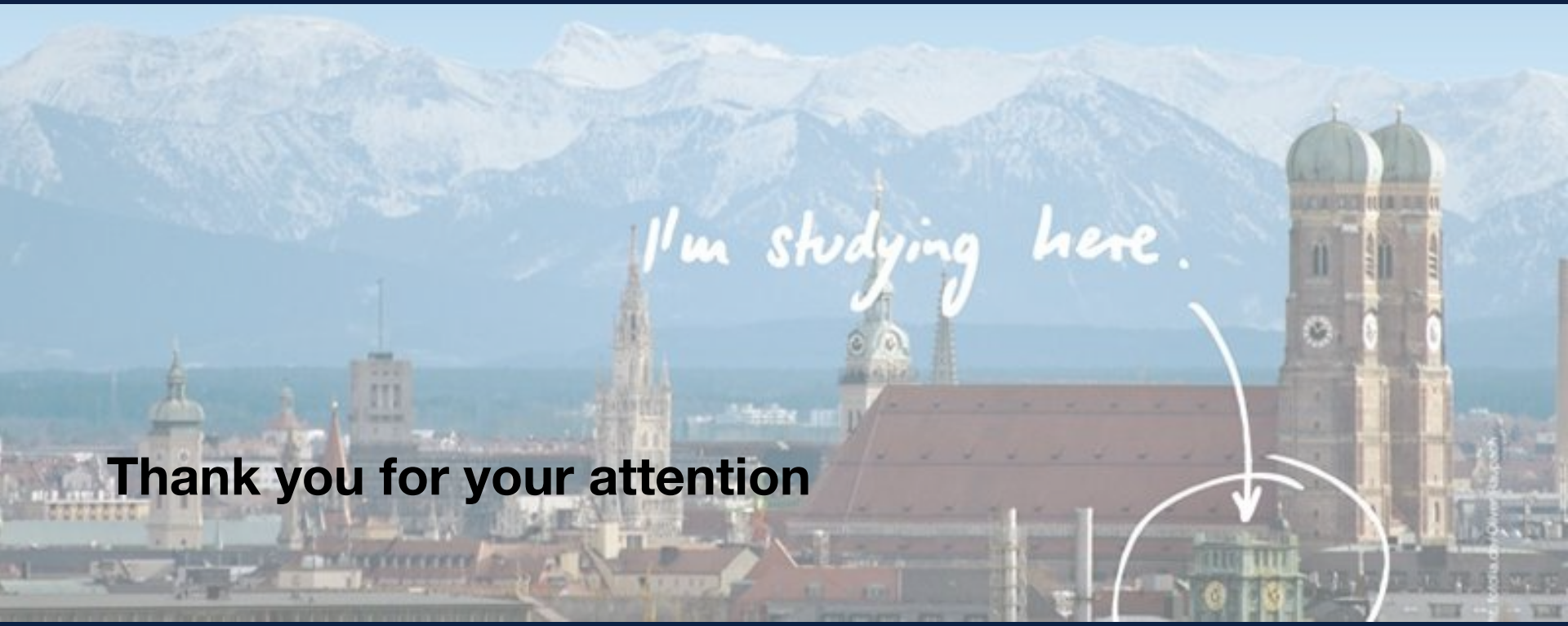
Conclusions & Outlook

Conclusions

- Sub-structuring technique can be used as a suitable technique for model reduction in crash
- Estimation of interface conditions by use of surrogate models
- Very good acurracy for low-speed crash / satisfying accuracy for high-speed at the moment
- Knowledge-based identification of suitable interface position needed

Outlook

- Use of surrogate models also for non-parametric design changes
- Improvement of surrogate models by the use of further pre-exisiting results
- Data-Mining on pre-existing simulation results in SDM systems
- Error analysis at the interfaces needed to judge on correctness of selected interface position



Thank you for your attention