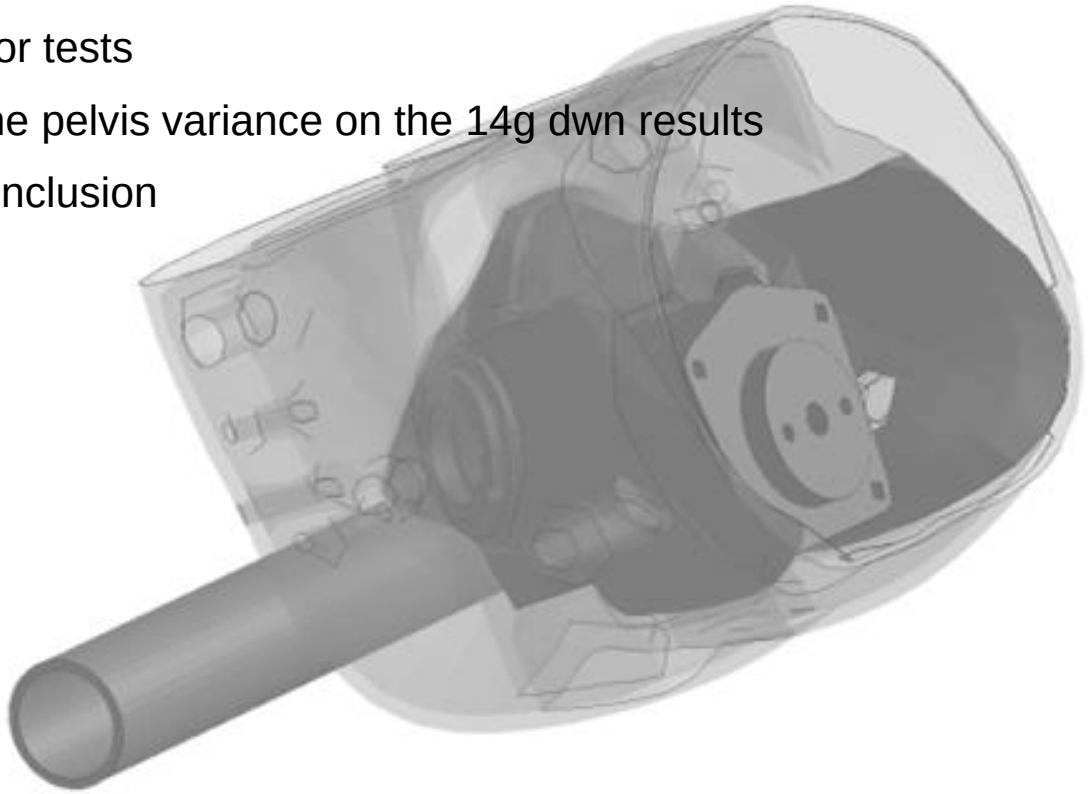
INFLUENCE OF THE PELVIS IN A 14G DWN SCENARIO

Dirk Goetze, Dietmar Schmeer

AGENDA

1. Background
2. Linear impactor setup
3. Linear impactor tests
4. Influence of the pelvis variance on the 14g dwn results
5. Summary / conclusion



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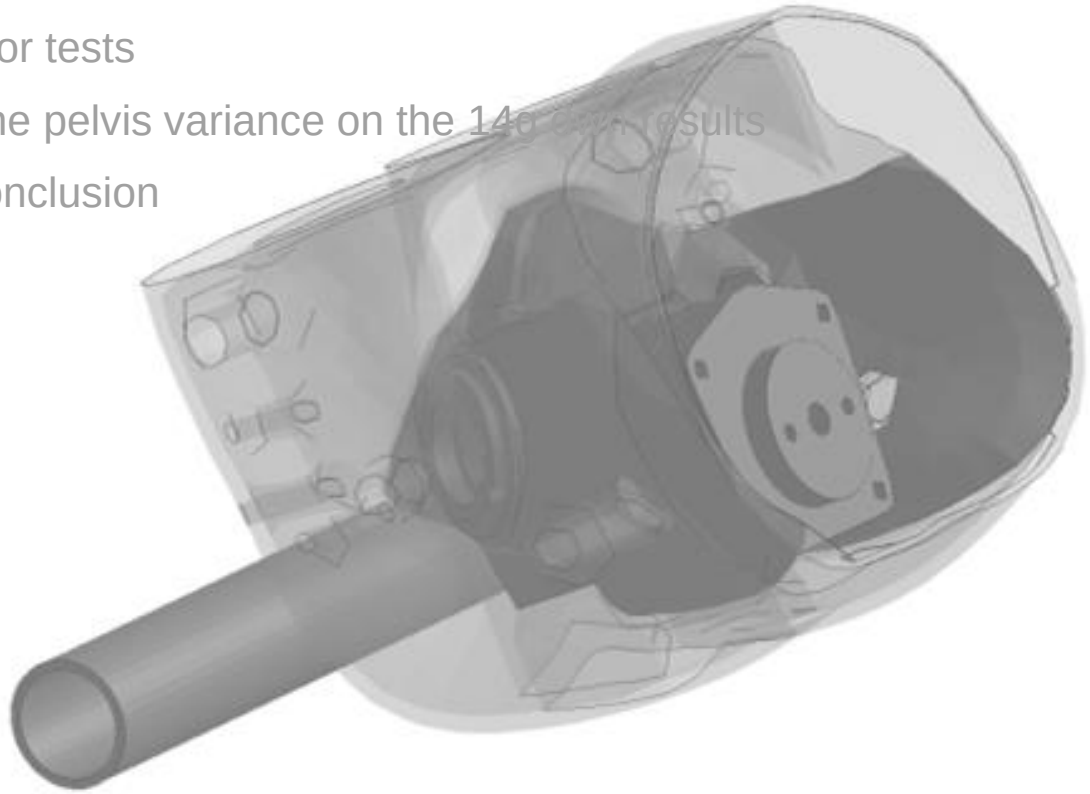

Status quo

- Results from 14g dwn tests with the same seat can scatter, especially when the ATD changes
- Scattering mostly results from the seat cushion, the ATD and the initial ATD position
- ATD calibrated, but no calibration method for whole measurement chain exists
- Different pelvis properties of calibrated ATDs can be observed by testing personal, when touching the pelvis
- Level of confidence shall be reduced to get good predictability and repeatable test results

Example full rigid seat program

- Twelve 14g dwn tests using a rigid seat with 5 different dummies were performed within one week to analyze dummy variance
- Pulses correlate within 2% (S&G) / 6% (peak) / 1% (SPUL)
- Cushion of same manufacturing date
- Cushion static compression force within 5%
- Initial ATD position within 10 mm

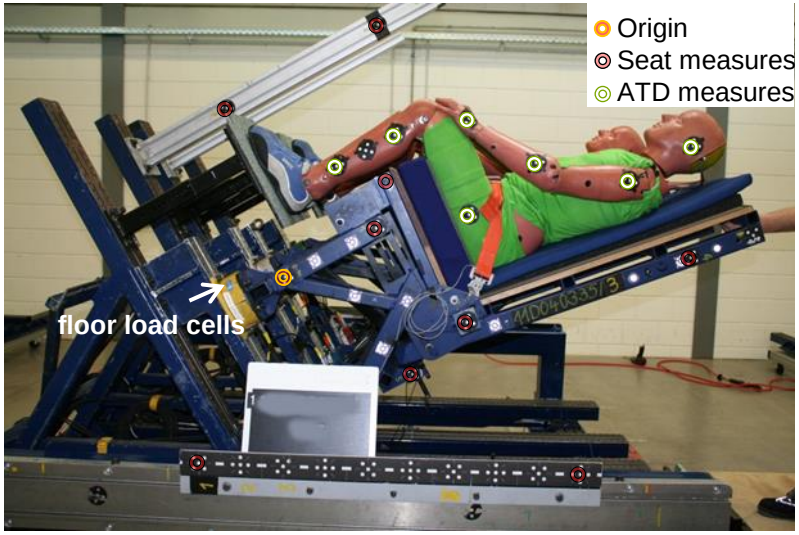

Fig. 5-1: 14g dwn test setup

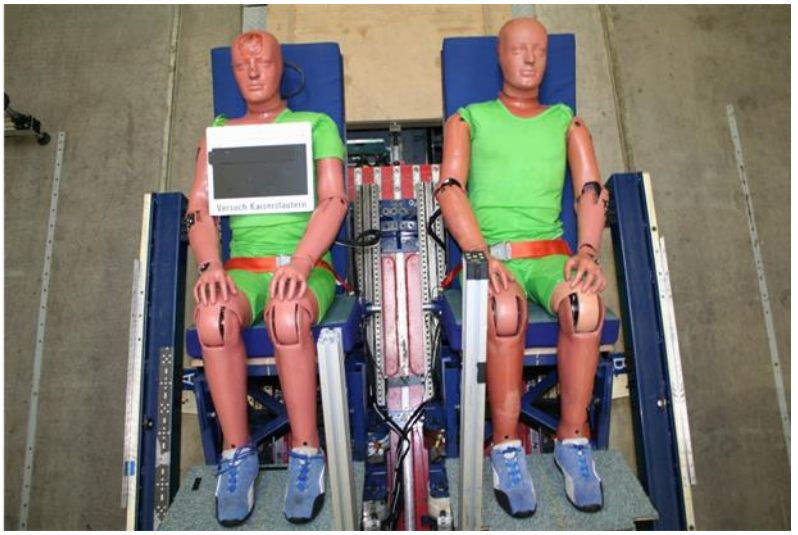

Fig. 5-2: 14g dwn test setup

Example full rigid seat program

Comparison of ATD lumbar loads

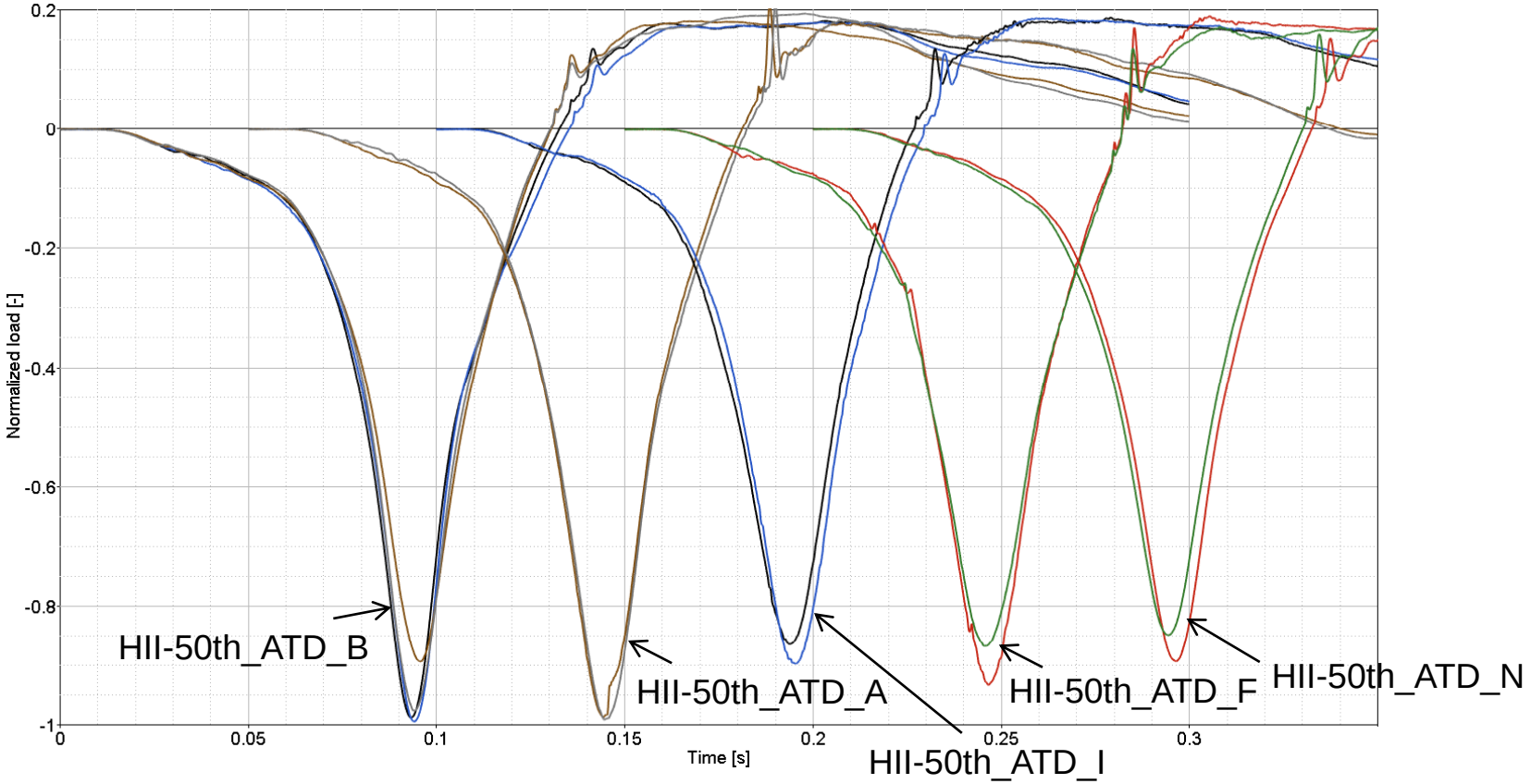

Fig. 6-1: Lumbar loads (ATD A to N offset n x 50 ms)

Example full rigid seat program

In a simplified 14g dwn test, the lumbar load can vary by approx. 10% - 15% from the ATD

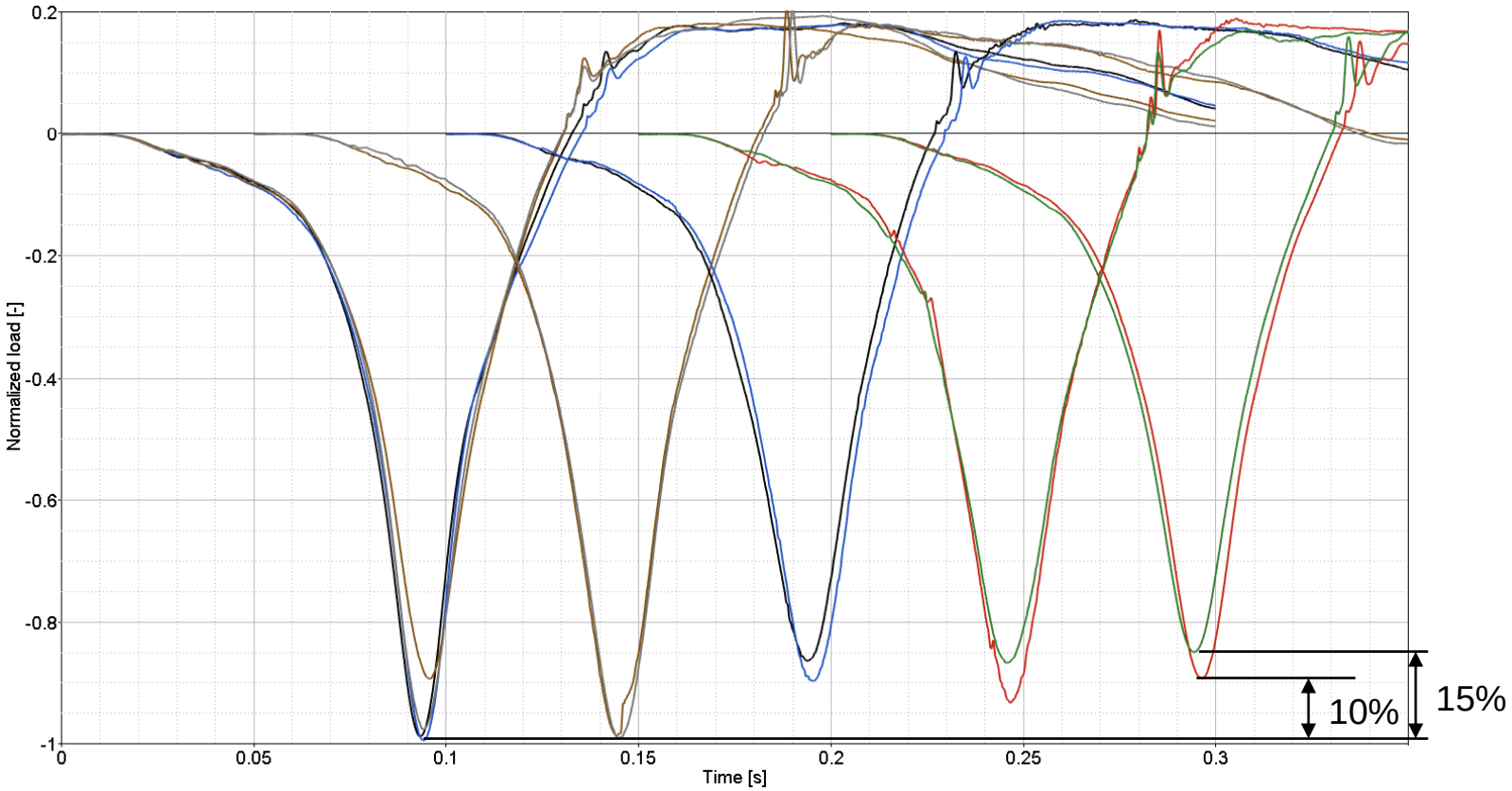

Fig. 7-1: Lumbar loads (ATD A to N offset n x 50 ms)

Results from the full rigid seat test campaign

- In a simple full rigid seat environment the lumbar loads can vary by 10% even when the seat, the dummy seating and the foam parameters are strictly controlled.
- It can be assumed that the variation will increase with a real aircraft seat with additional influencing parameters (dynamic seat behavior, ATD interaction, armrest contact)
- One of the influencing parameters seems to be the pelvis

→ The pelvis shall be analyzed more detailed in a first step

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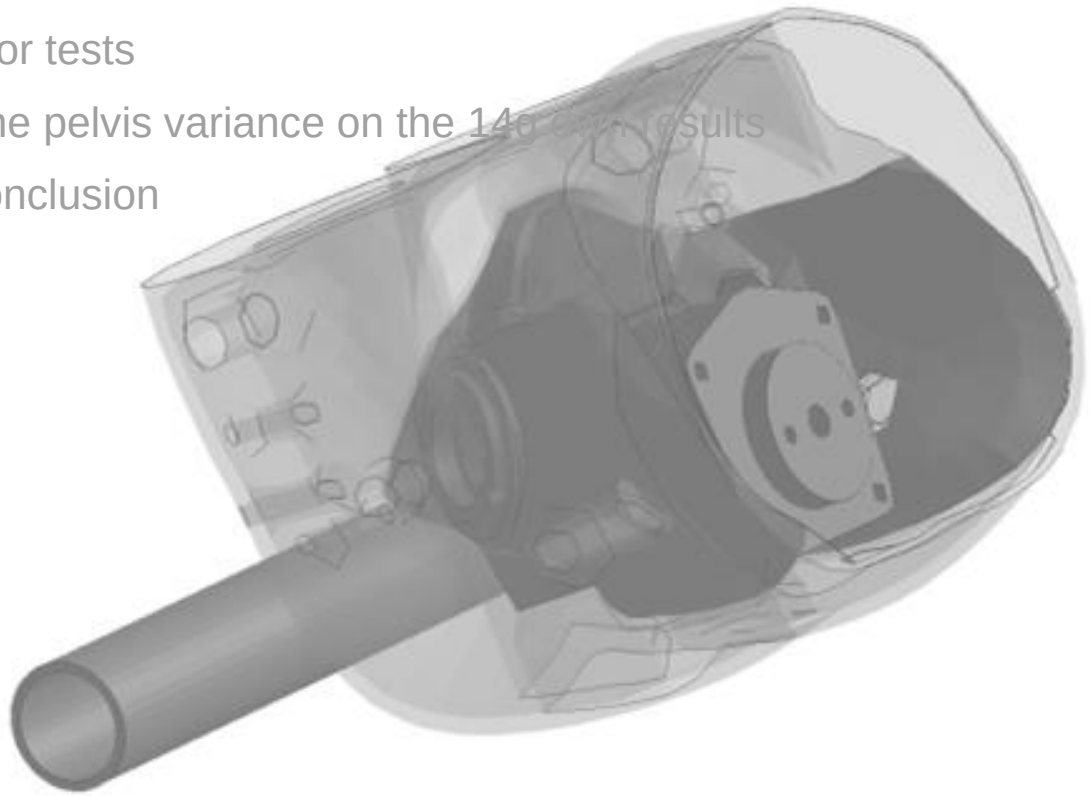

Requirements for the test bench

- Representative for a 14g dwn test
- Simplified test setup to reduce the influencing parameter
- Analyze the dynamic behavior of the pelvis
- Available test bench shall be used

Definition of the test conditions

- Test specimen: pelvis foam, skin, bone and lumbar spine load cell
- Round impactor profile similar to seat tube
- Impactor impacts along the z-axis of the lumbar load cell
- Desired impact force: 6.7 kN
- Desired impactor mass m_{imp}~ 17 kg
- Desired impactor speed v_{imp} ~ 2.5 m/s

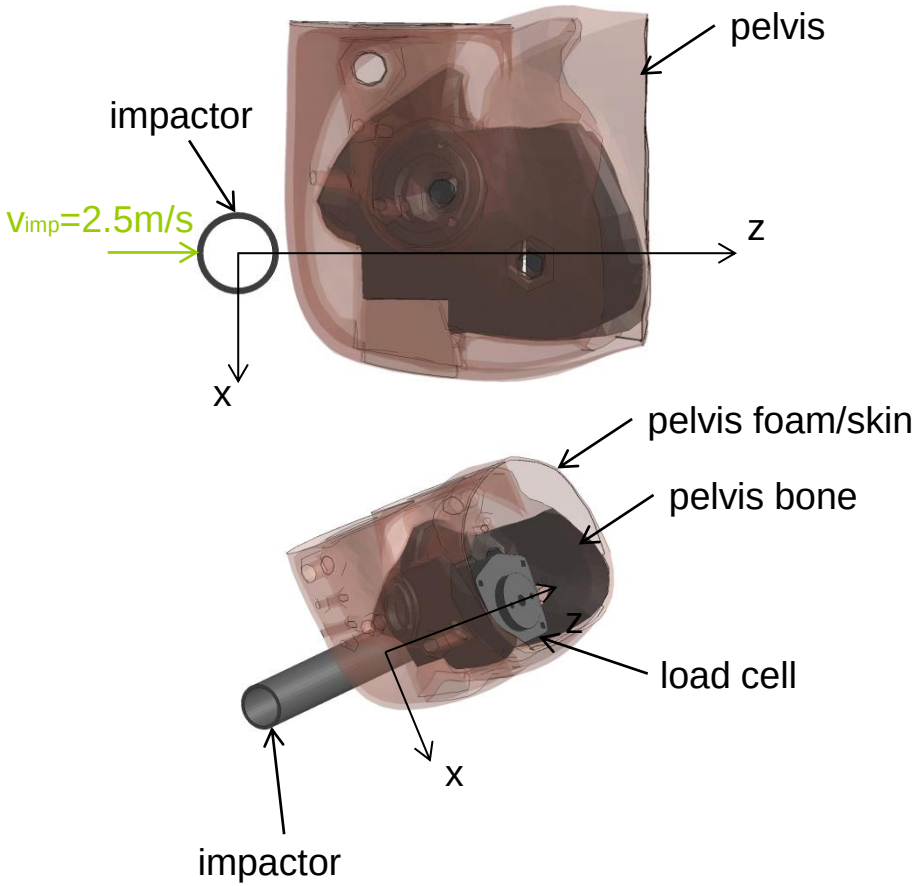

Fig. 11-1: Test setup

Sensitivity analysis (impact velocity and mass)

- Test setup robust regarding impact mass and velocity
- Force range from 5.0 – 7.75 kN
- Similar influence of mass and velocity in the area of interest
- Influence of the speed can be linearized in the velocity range from 2.3 – 2.6 m/s

- Realized impactor mass m_{imp}=15 kg
- Realized impactor speed v_{imp}=2.5 m/s
- E_{kin}= 46.9 J

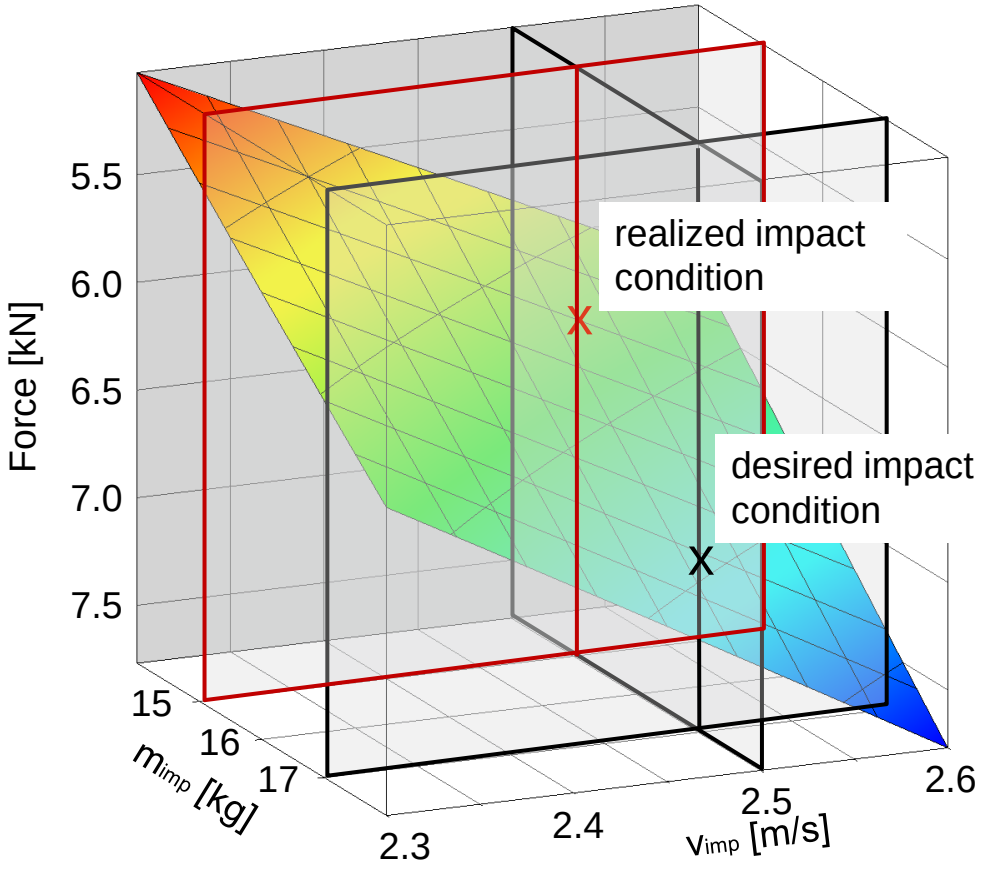

Fig. 12-1: Response surface

Influence of the impact offset

- Test setup can be sensitive regarding misalignment of the ATD pelvis
- A positioning tolerance of +/- 5 mm leads to a lumbar load variance of +/- 0.3 kN
- Impact out of zero position can be seen in resulting F_X and M_Y

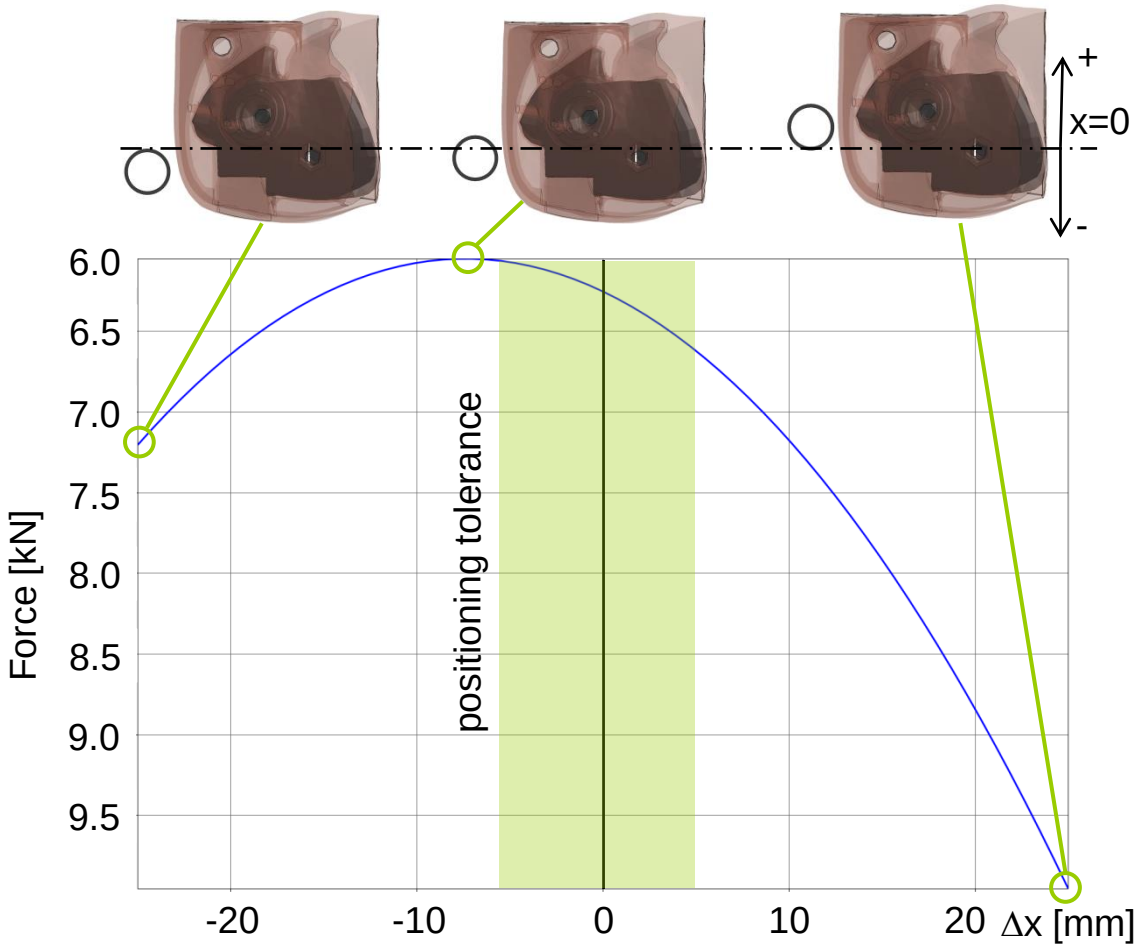

Fig. 13-1: Influence of the impact location on the lumbar loads

Linear impactor test bench

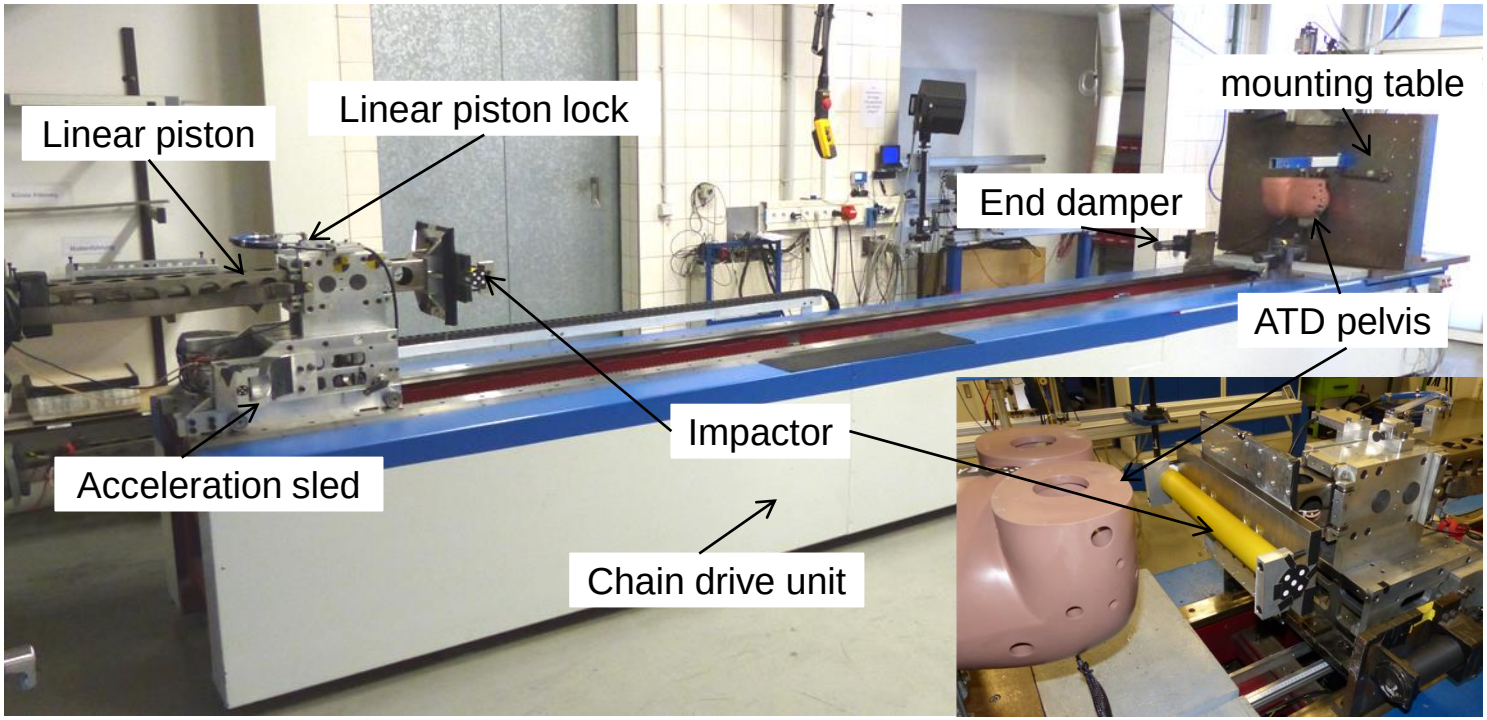

Fig. 14-1: Linear impactor test bench

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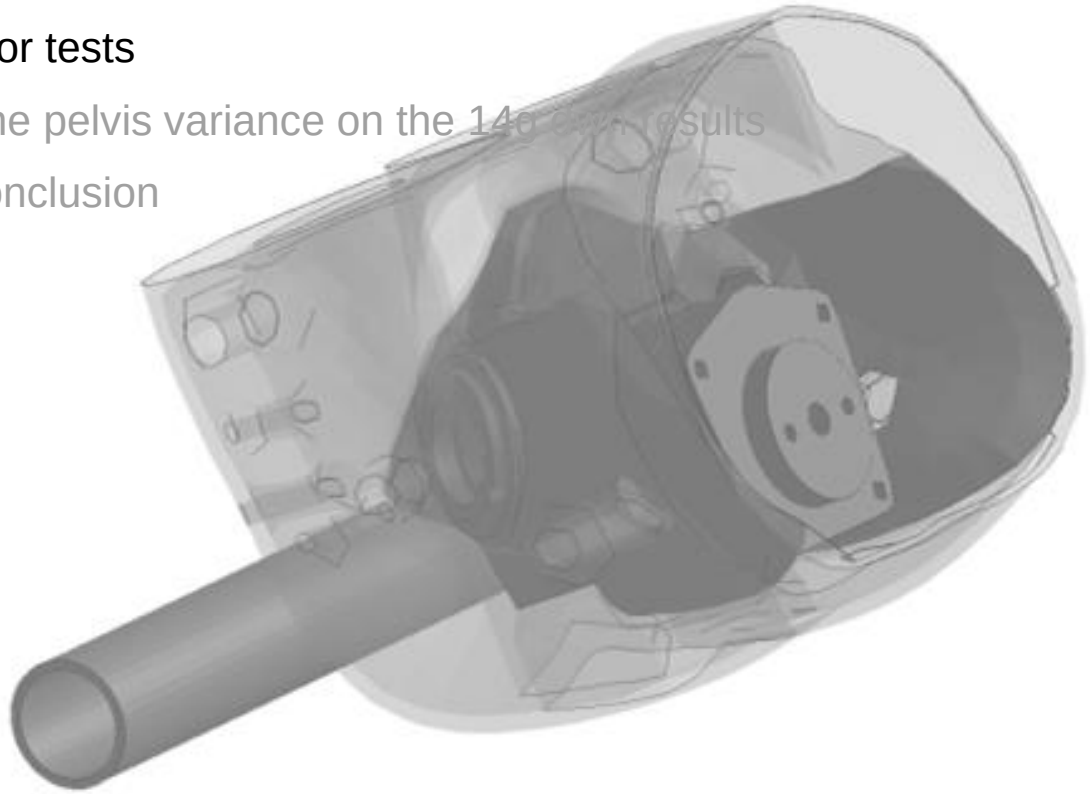

Linear impactor test matrix

- Five different pelves were analyzed
- Two different manufacturers
- New and used pelves
- Test was repeated one to three times with one day in between
- Measurement of forces, moments, displacements and accelerations in any direction

Pelvis	Manufacturer	Status	Condition
1	A	new	soft skin and foam
2	A	used	hard foam and skin
3	B	new	middle hard skin and foam
4	B	new	middle hard skin and foam
5	A	used	middle soft skin an foam

Tab. 16-1: Linear impactor tests

Linear impactor video

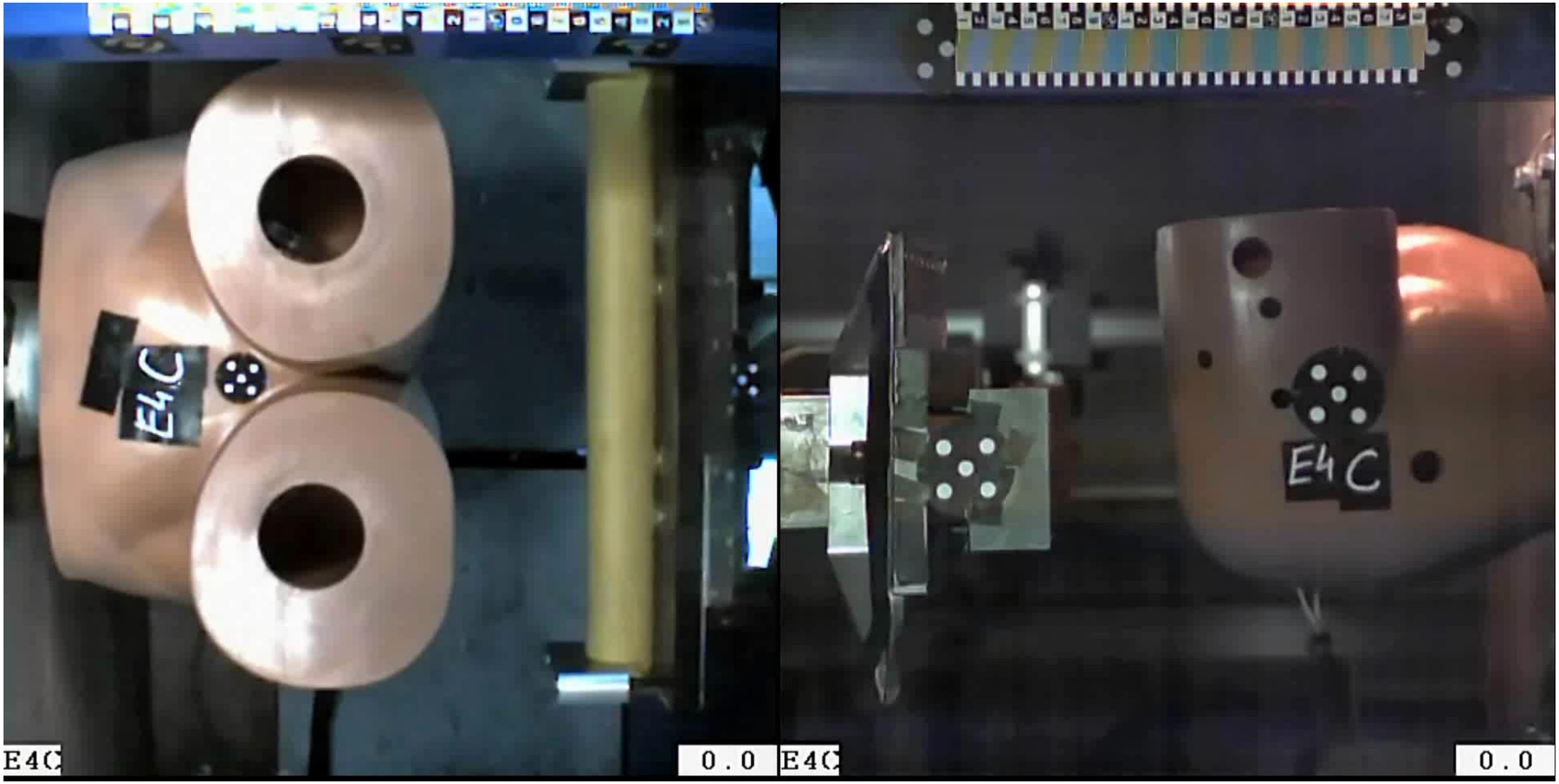

Fig. 17-1: Linear impactor video

Linear impactor results

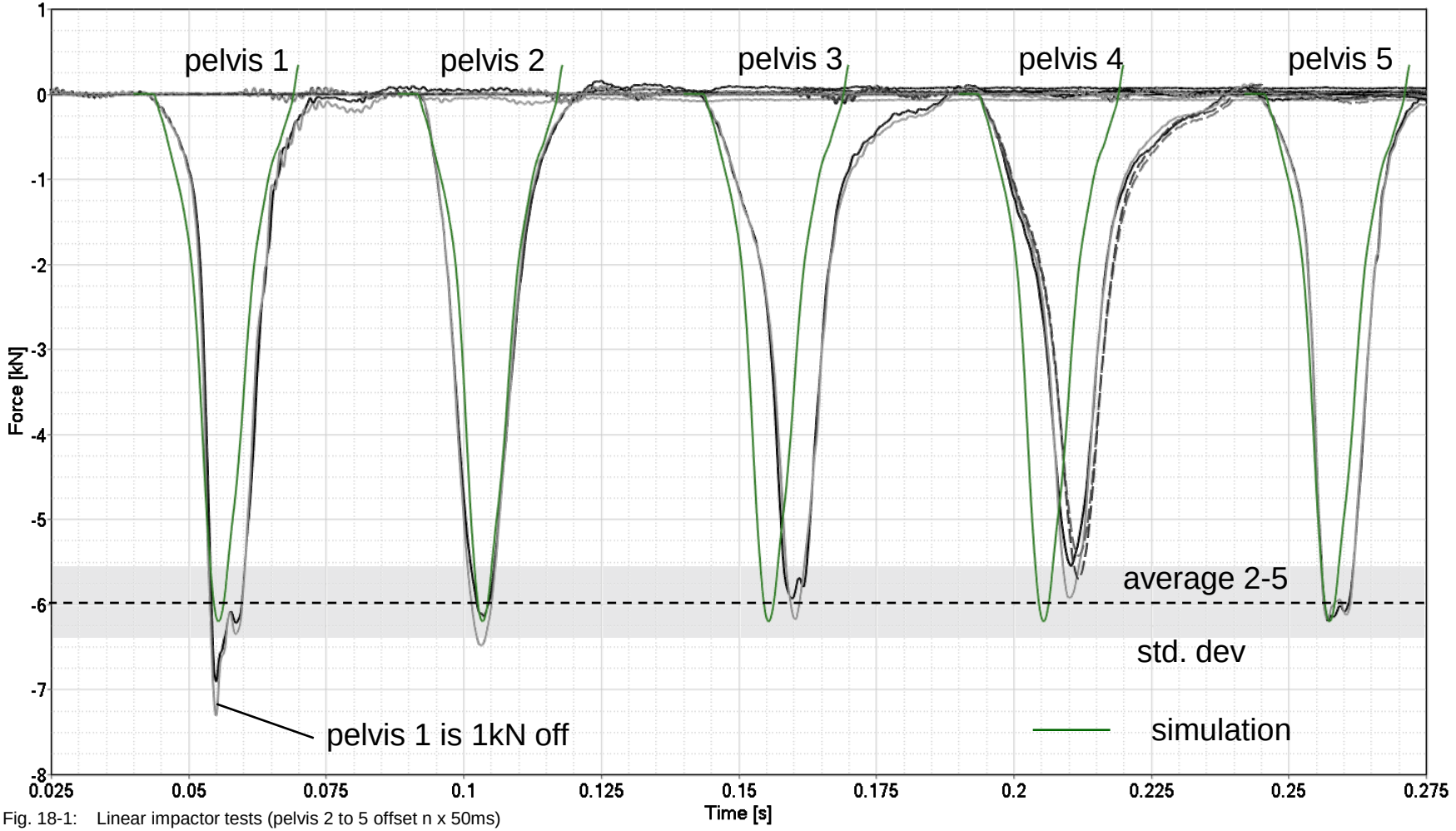

Fig. 18-1: Linear impactor tests (pelvis 2 to 5 offset n x 50ms)

Clustering of linear impactor test results

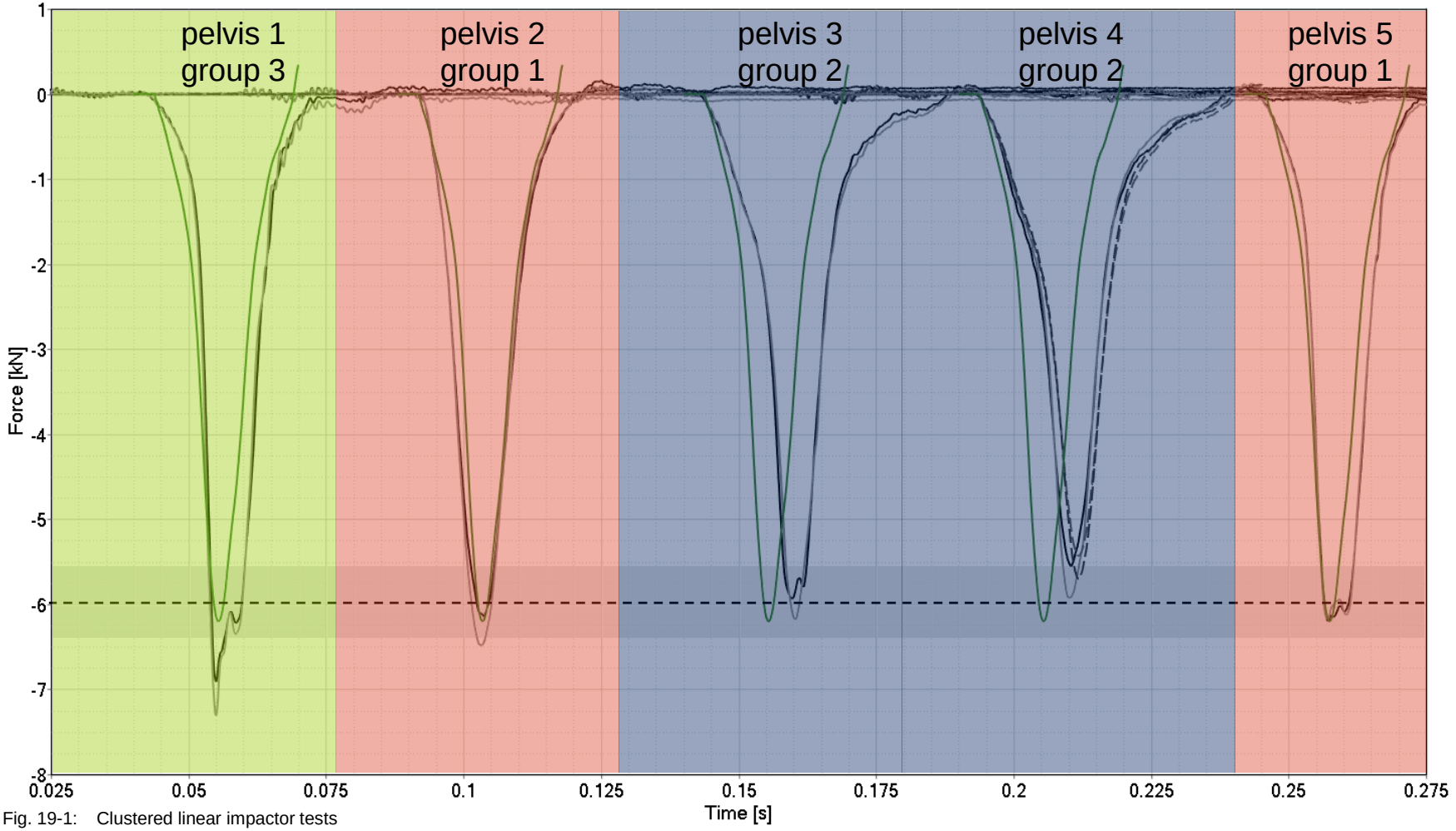

Fig. 19-1: Clustered linear impactor tests

Linear impactor force vs disp

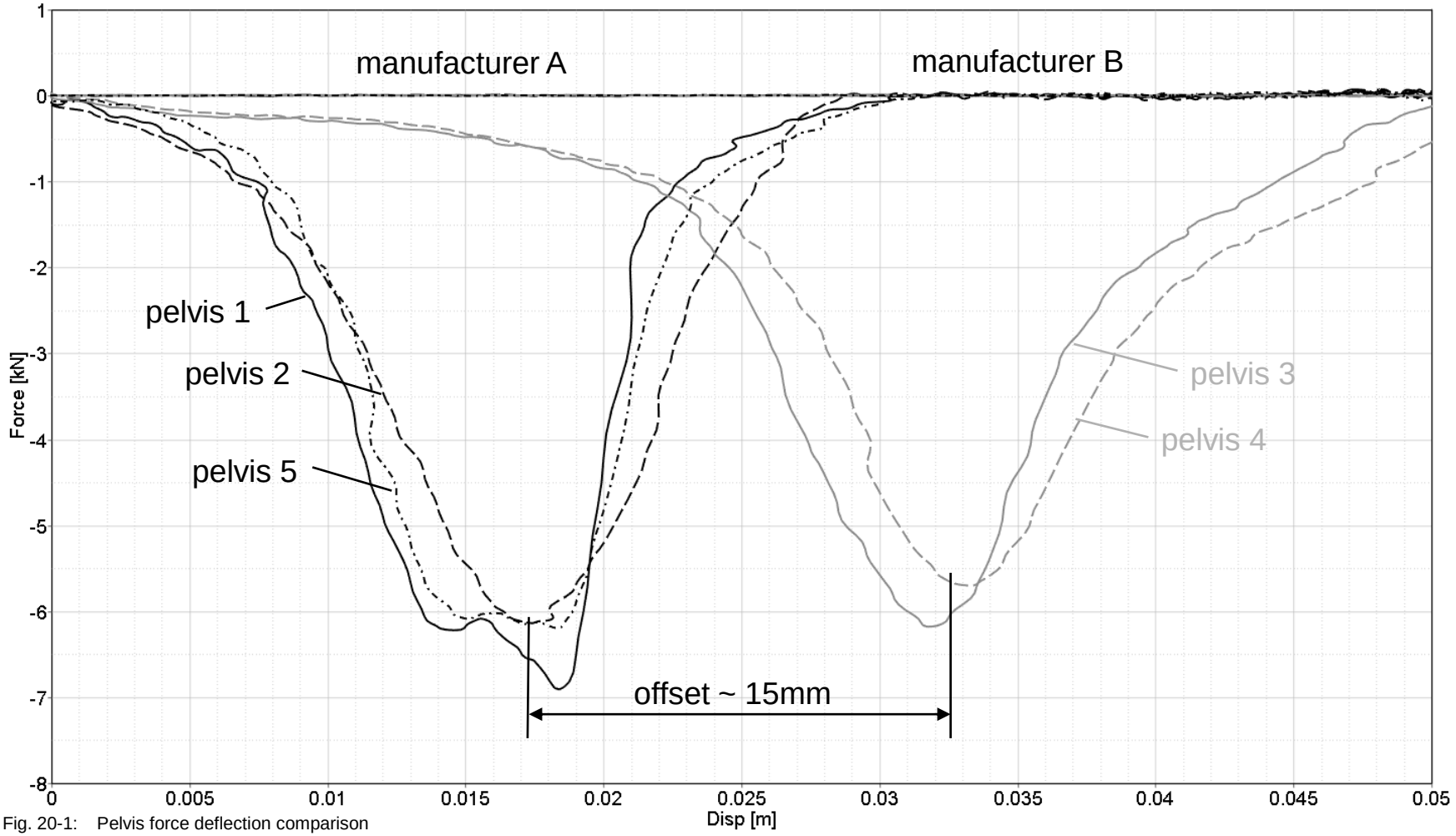

Fig. 20-1: Pelvis force deflection comparison

Linear impactor summary

- Pelvis 1 (brand new) shows a different behavior than pelves 2 – 5
- The load is about 1 kN higher than of the other pelves
- Pelves 2 – 4 show a comparable maximum load of about 6 kN +/- 0.4 kN.
- Neither the age nor the load history of pelvis 2 - 5 has a significant impact on the max. loads
- Also the maximum loads from different manufactures is comparable
- A different loading path can be observed with pelves from different manufacturers
- The pelves of manufacturer B shows 15 mm or approx. 50 % more deformation which results in an offset in the load-time history
- Comparing with the v-ATD pelves of manufacturer A show a better correlation than pelves of manufacturer B
- Pelves can be clustered into three different groups:
  - group 1 : (std. pelvis) good correlation of phase and peak load
  - group 2 : offset of phase, but good correlation of peak load
  - group 3 : high peak

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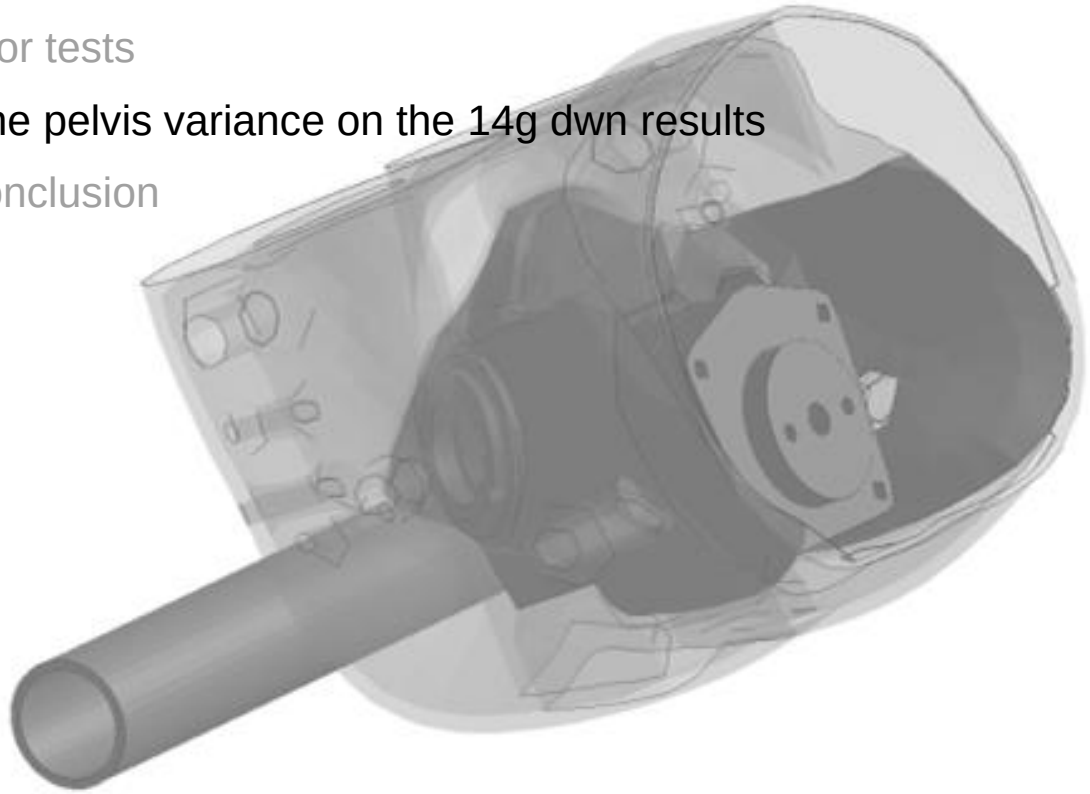
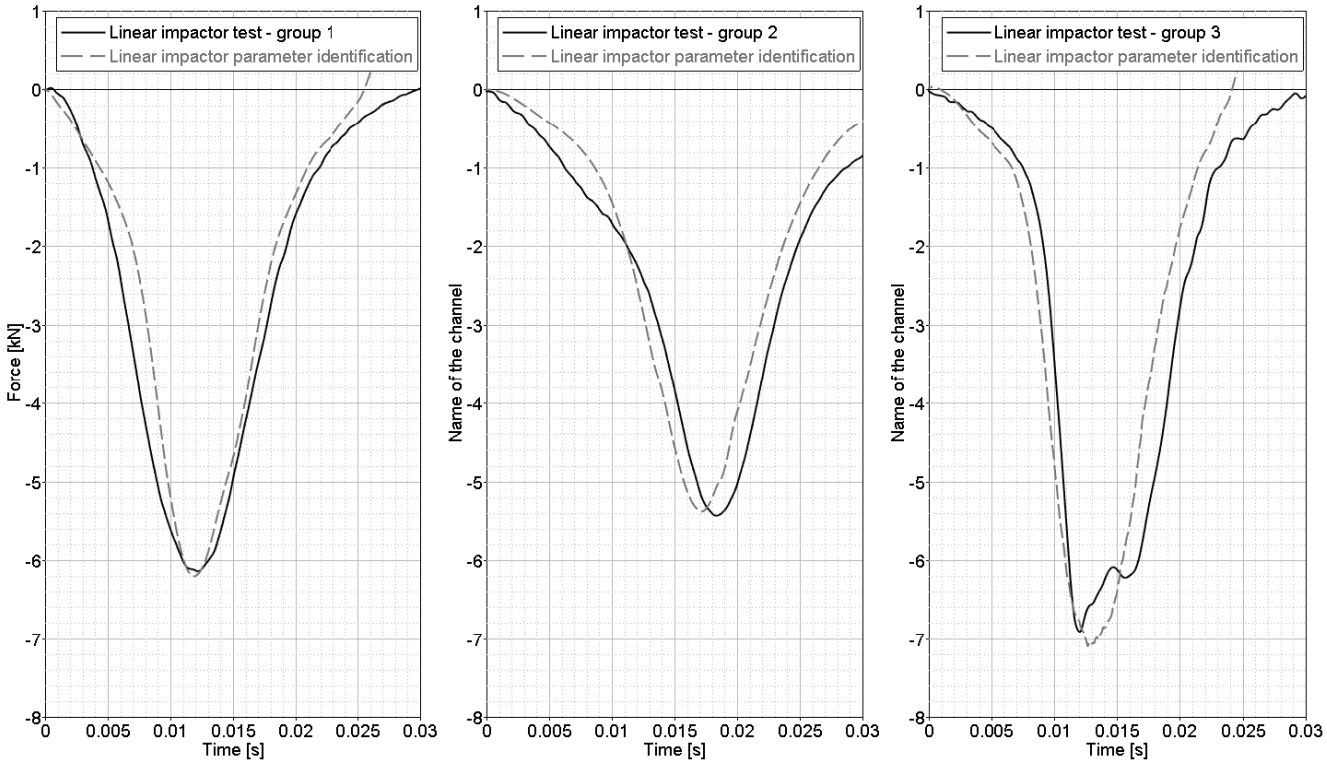


Parameter identification based on the linear impactor tests

- Material models for the pelvis flesh and foam of the three pelvis groups in LS-Dyna were generated using reverse engineering

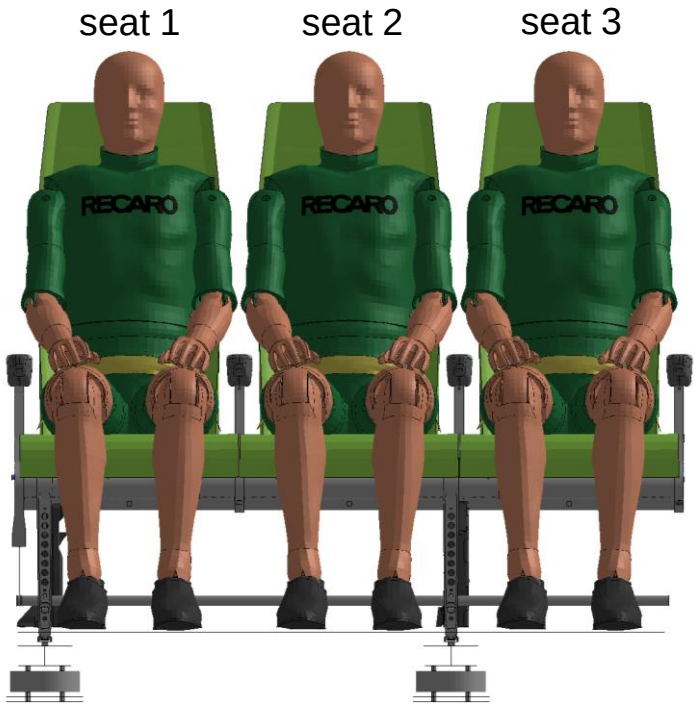


Tab. 23-1: Linear impactor tests

- 14g dwn simulations on a FE seat were performed with the three pelves materials

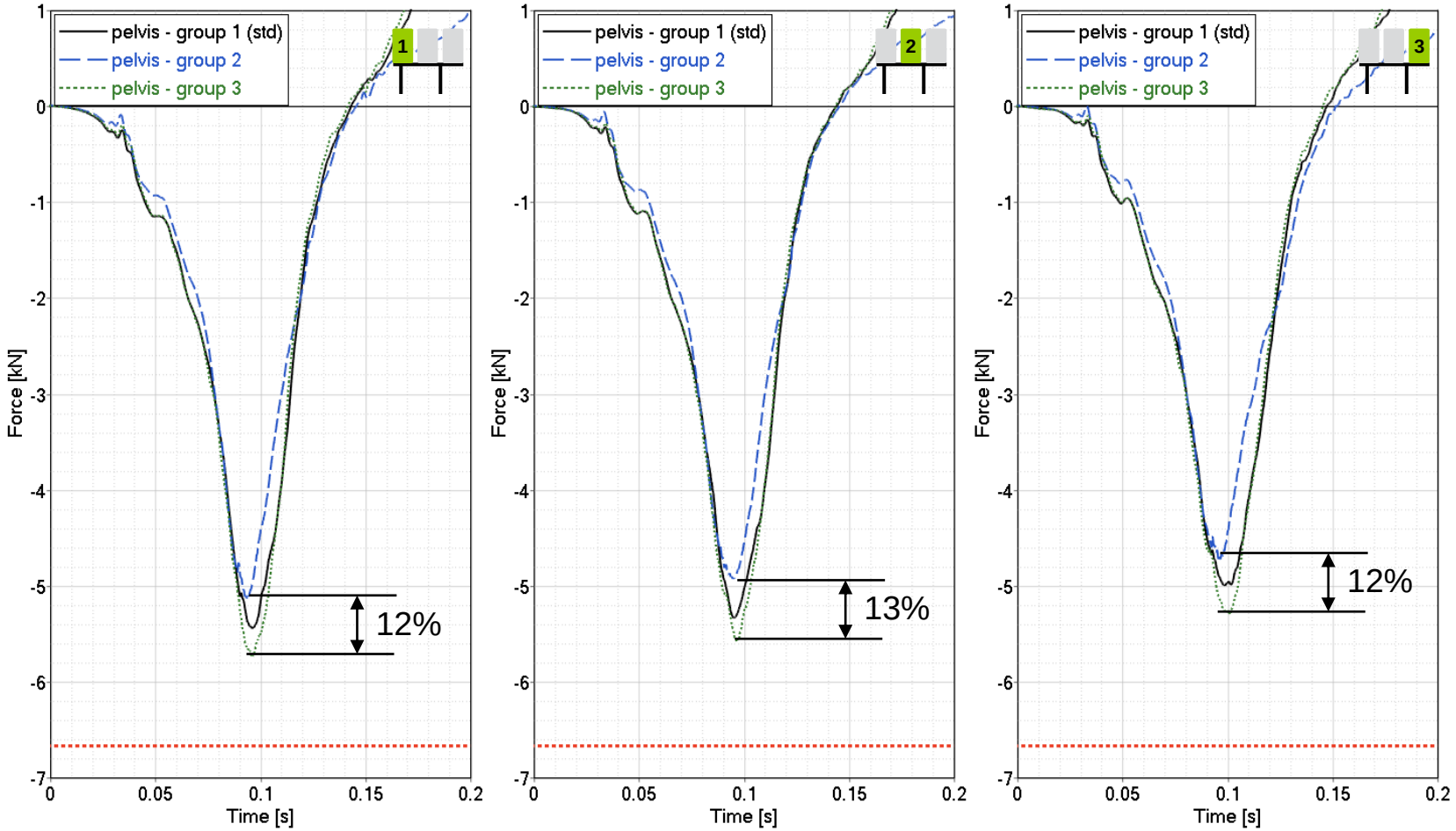
Simulation model

- Simulation model taken from customer project
- HII-50% v-ATD used
- Simulation model validated in a 14g dwn scenario
- Three simulations with three pelvis groups were performed
- All other parameters remained unchanged
- Using FE simulation is only method to identify the influence of a single parameter change



Tab. 24-1: 14g dwn simulation model

Comparison of lumbar loads



Tab. 25-1: 14g dwn simulation model

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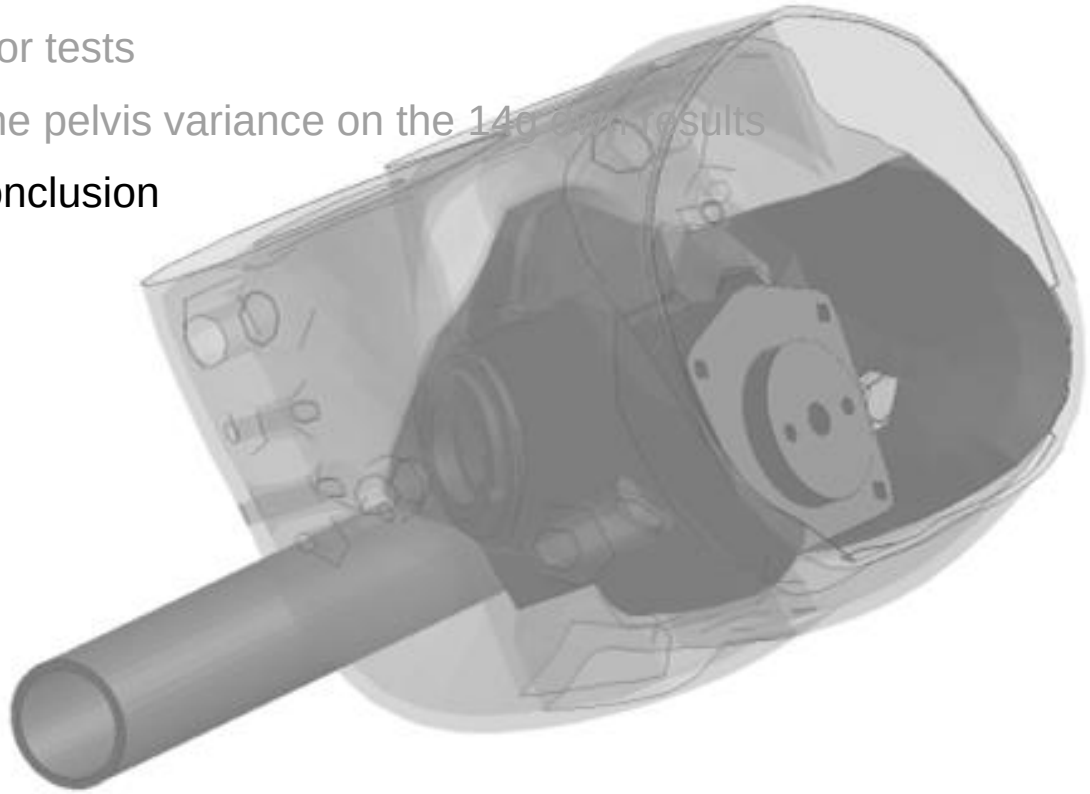

Summary

- 14g dwn tests with a full rigid seat shows a lumbar load variance of 10%
- It is assumed that the pelvis is one reason for the variance
- A very simple test setup was realized to analyze the dynamic performance of the pelvis
- The pelves 2 – 5 showed a good correlation regarding the maximum forces
- Only the new pelvis did show about 1kN higher loads in the impactor tests
- Material models for three different pelves are generated
- In a 14 g dwn simulation the different pelves lead to a total lumbar load variance of 12 %

Conclusion

- Linear impactor tests are one method to analyze the dynamic behavior of the pelvis
- Further simple tests of the ATD pelvis with and without lumbar spine shall be performed to get a more detailed understanding of the components that influence the lumbar load
- The initial pelvis positioning shall be monitored more detailed to reduce test variability
- A calibration test for the measuring chain is recommended to improve ATD to ATD correlation

THANK YOU FOR YOUR ATTENTION

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