

Comparison of occupant load in a frontal collision with different degrees of belt usage

Dipl.-Phys. Annika Kortmann

9th expert seminar - September 03-04, 2020



0:00:00:21



Structure

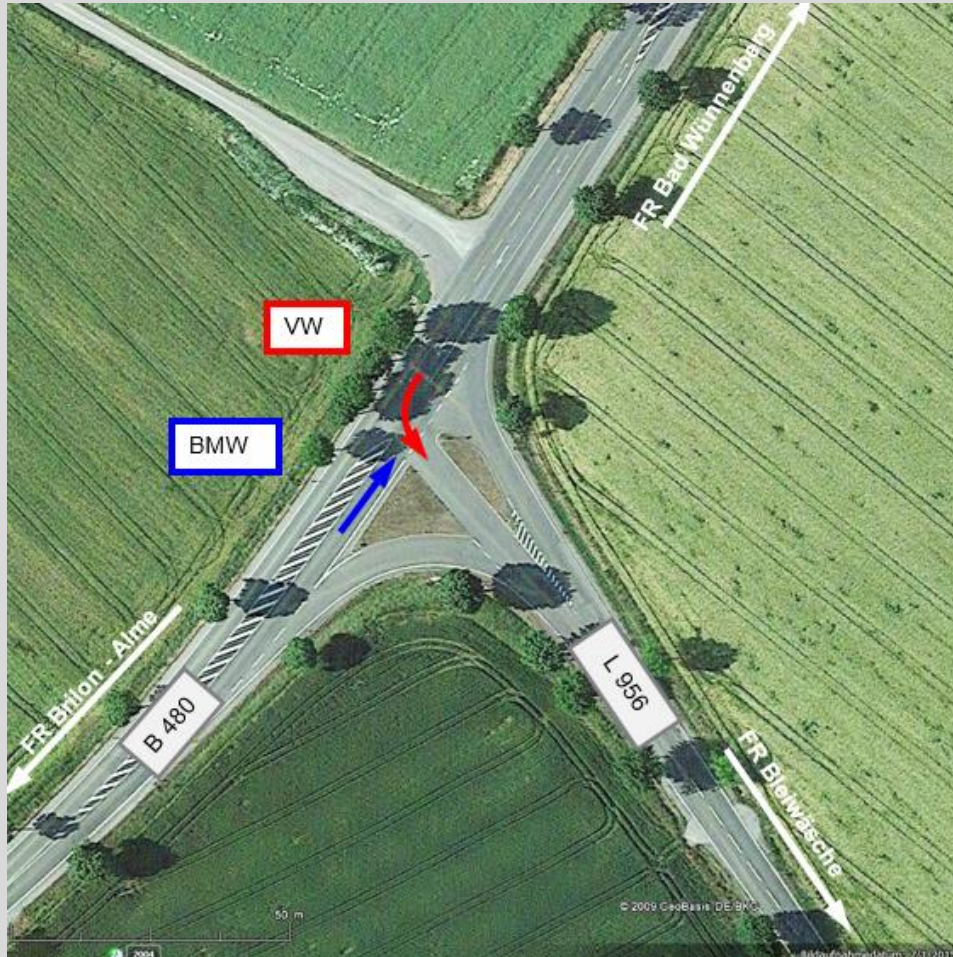
- "Do the injuries of the occupant in the head-on collision indicate that he was strapped in or not?" -
Example of a real accident
- Possibilities of motion analysis
- Comparison of occupant loads in a collision with a tree with airbag deployment - own tests (not fastened, poorly fastened, well fastened)
- Injury pattern of the occupant
- Summary

"Do the occupant's injuries in the head-on collision indicate that he was strapped in or not?"



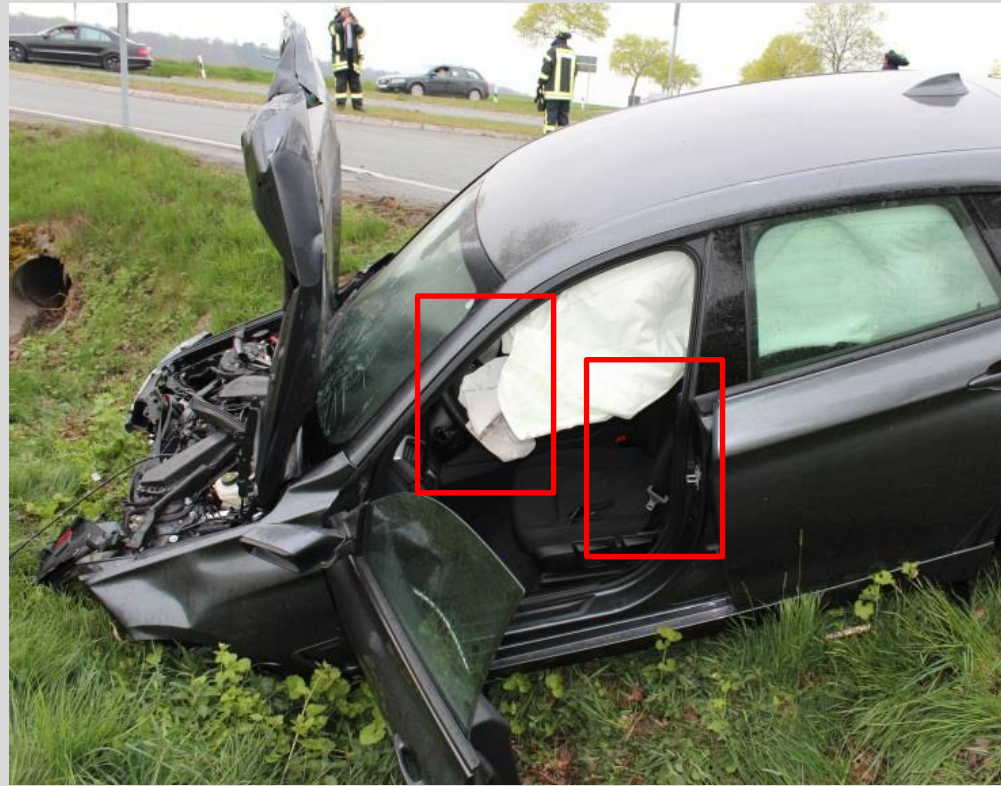
A case example

- Accident on the country road due to slowly turning vehicle in oncoming traffic



A case example

- Question: Was the occupant in the BMW wearing seat belts? If not, would his injuries have been comparable if the seat belt had been used correctly, taking the airbag into account?

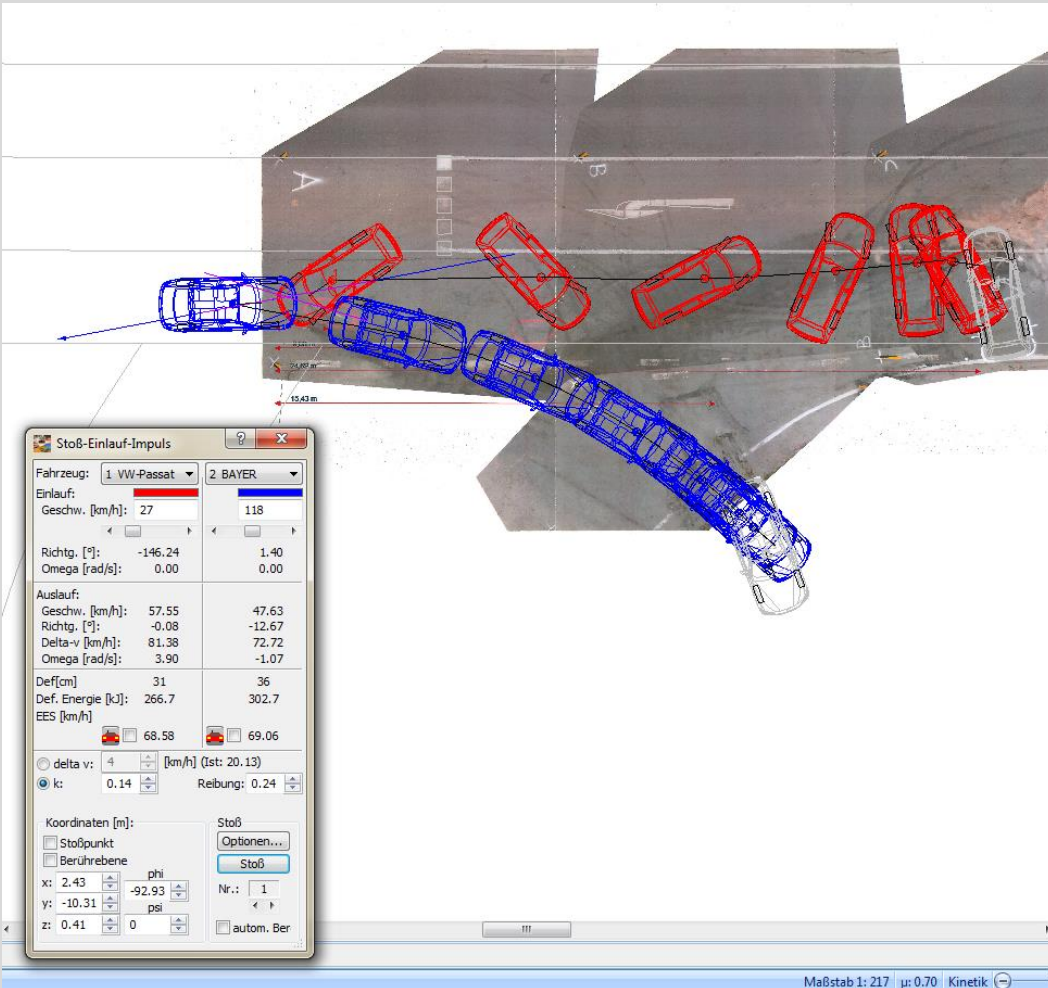


A case example

- Reconstruction of the collision speeds from the damages and the vehicle end positions:

$$V_{\text{BMW}} \approx 120 \text{ km/h}, V_{\text{VW}} \approx 30 \text{ km/h}$$

- Occupant stress in the BMW:
 $\Delta v \approx 80 \text{ km/h}$

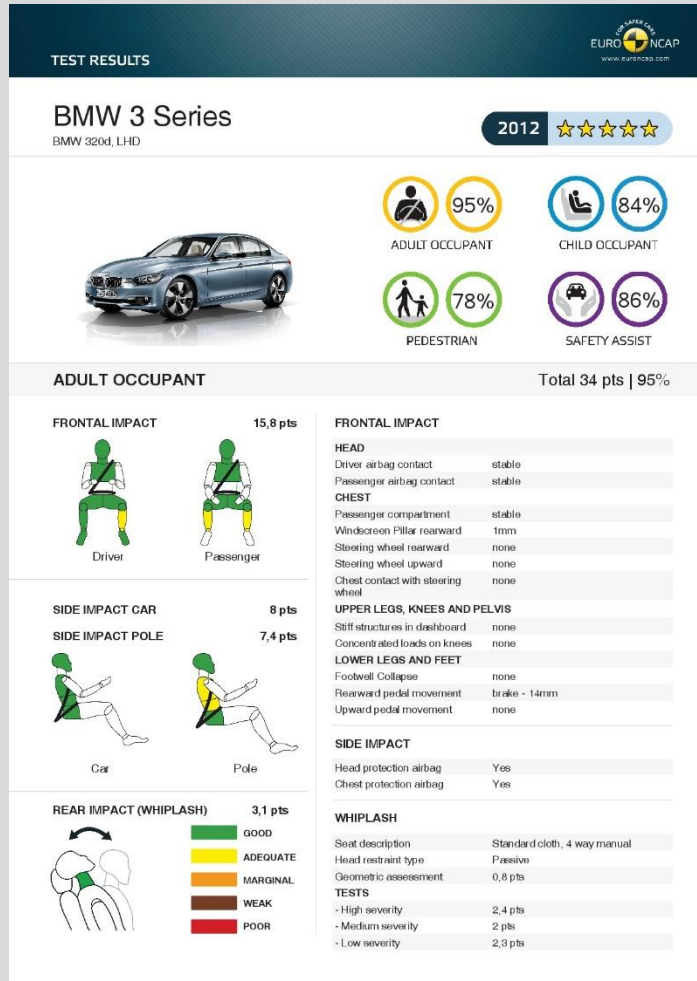


Observed injuries to the occupant:

- Torso contusion right
- Knee contusion right
- Complex fracture of the foot skeleton of the tarsal bones and the metatarsophalangeal joint

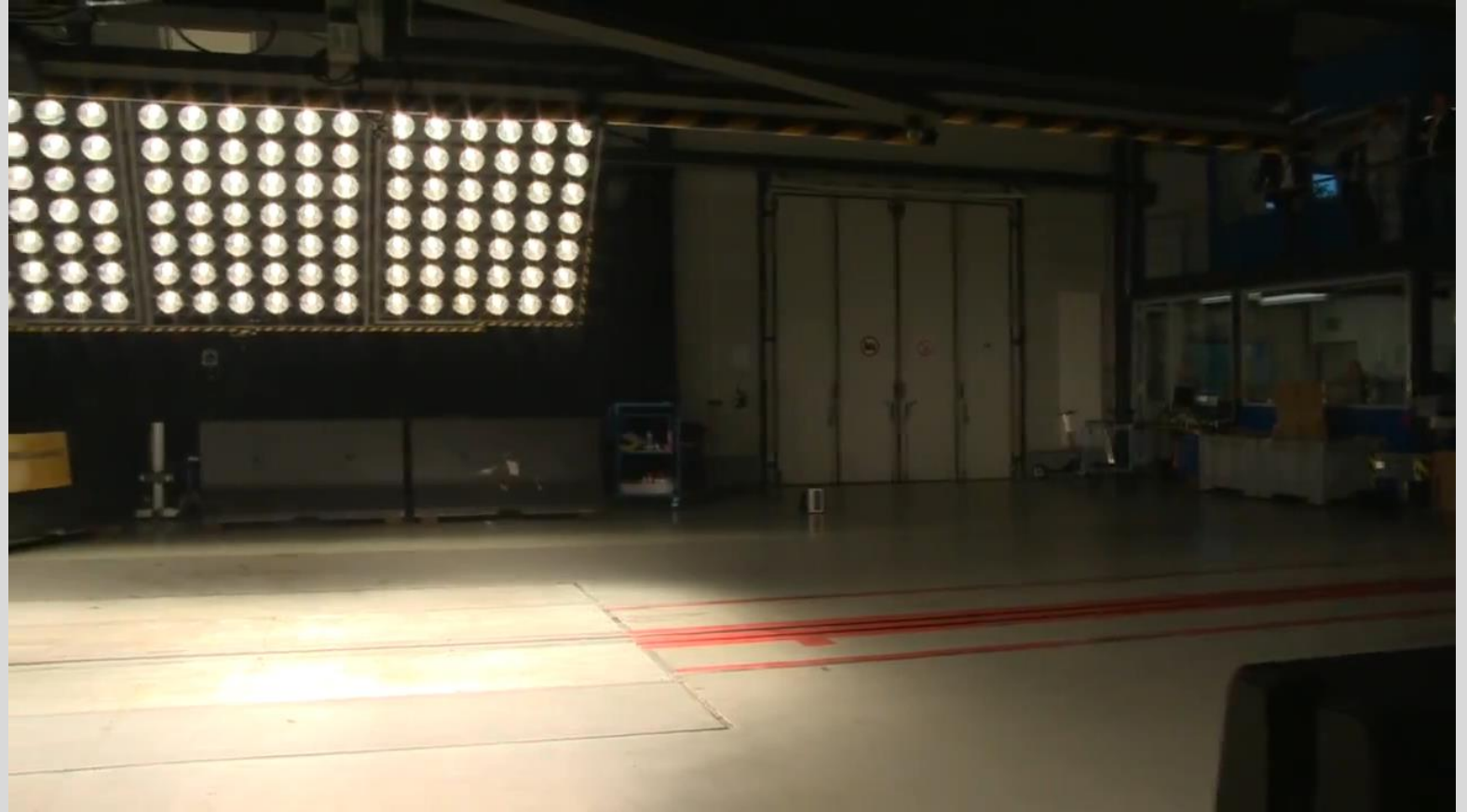
Possibilities of motion analysis

- EuroNCAP - belted driver



Possibilities of motion analysis

- ADAC - unbelted driver



Possibilities of motion analysis

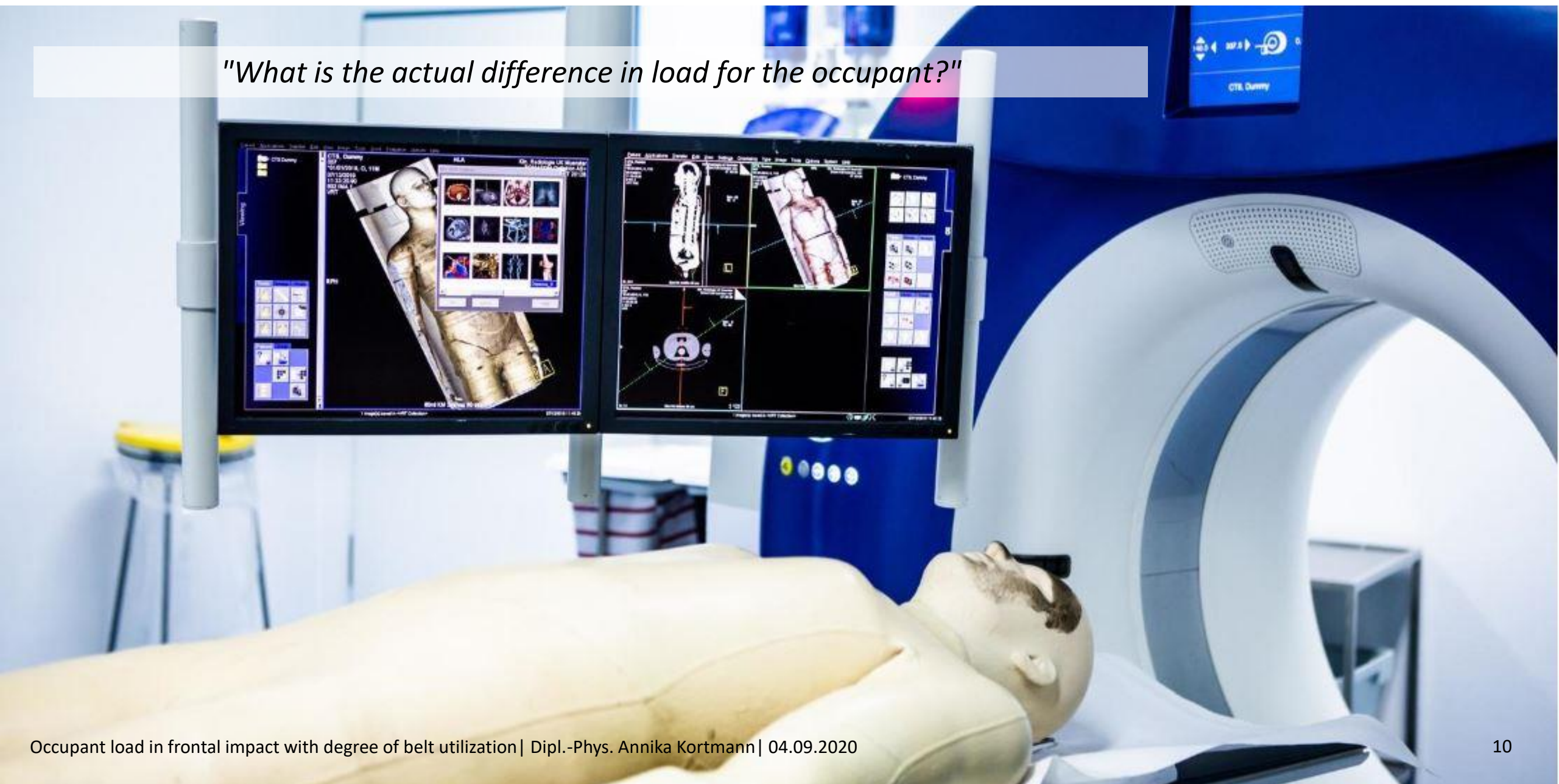
- EuroNCAP – belted driver



- ADAC - unbelted driver

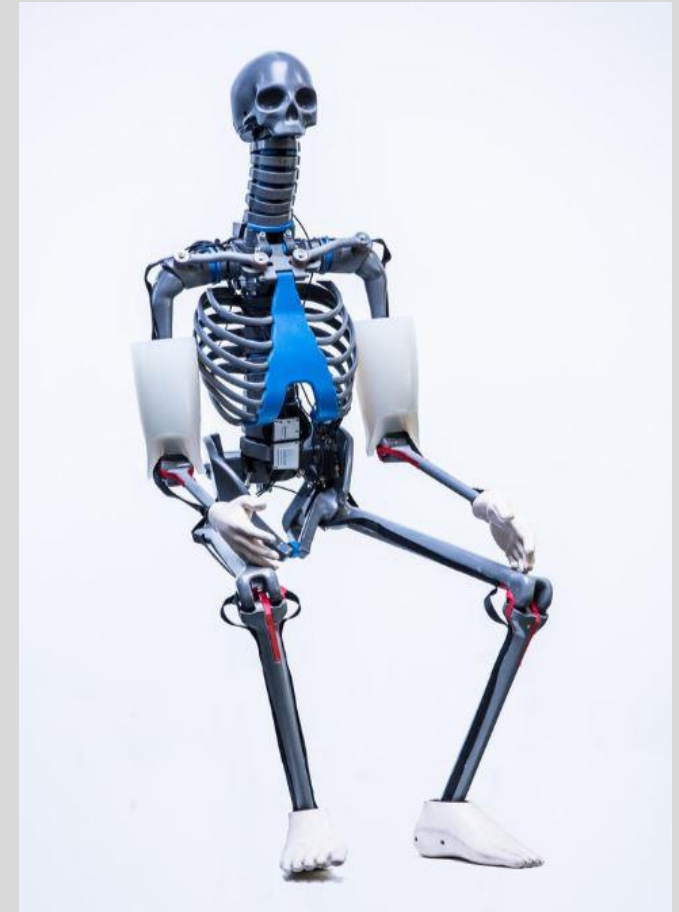


"What is the actual difference in load for the occupant?"



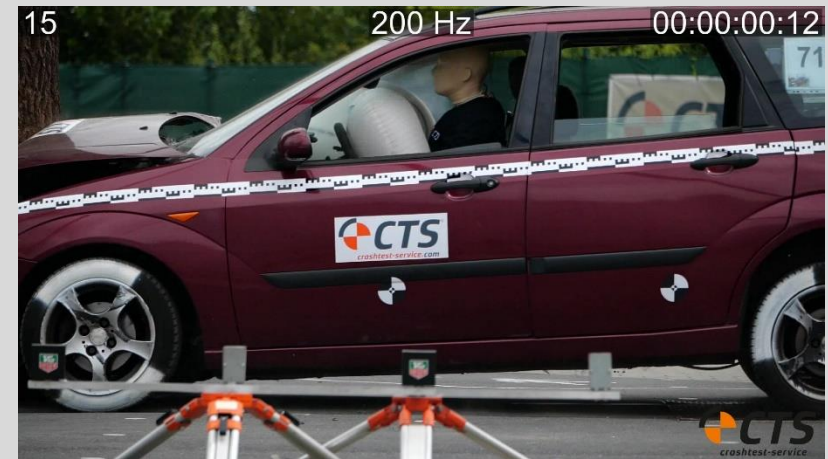
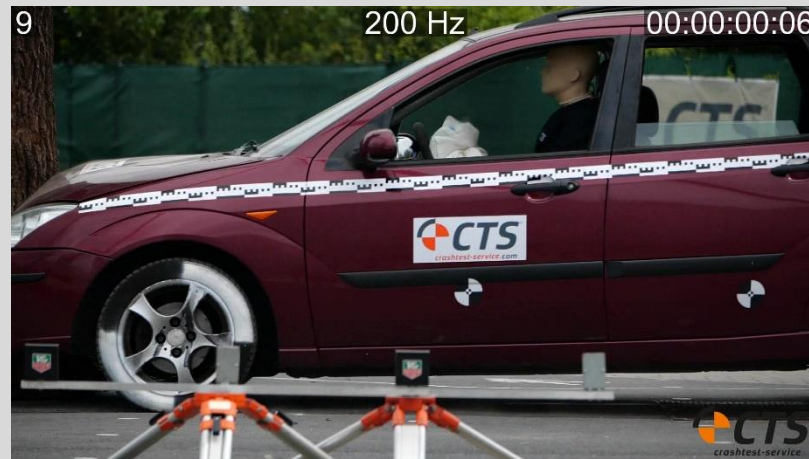
Execution of experiments

- 3 crash tests under the same impact configuration/collision speed and vehicle model
- Frontal collision with a tree at 50 km/h
- Airbag deployment during all tests
- Occupant is PRIMUS breakable with triaxial accelerometers in
Head/chest/hip
- Degree of belt usage:
belted, poorly belted
belt (lap belt only),
not strapped
- Autopsy of the dummy after
each collision



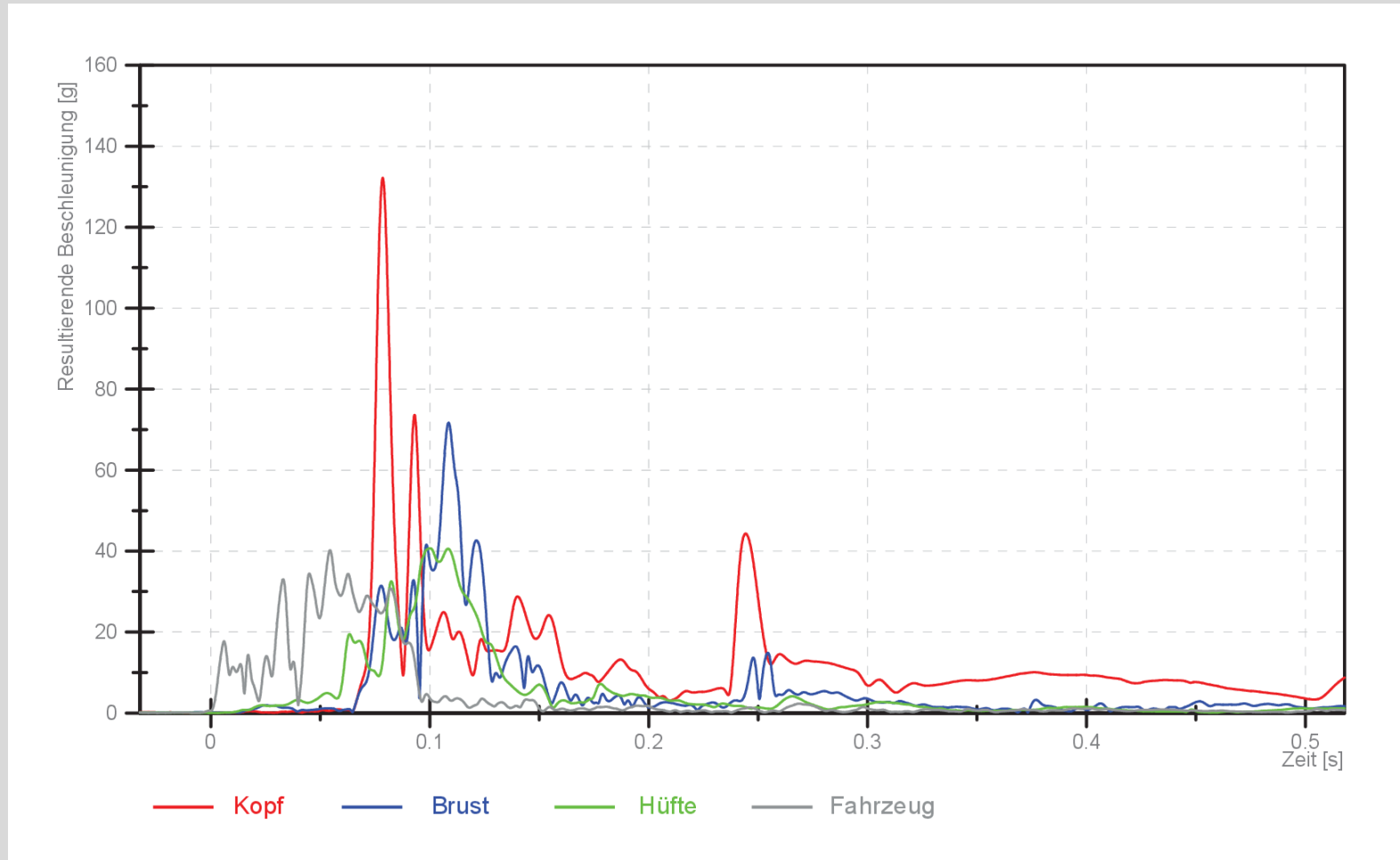
Non-belted occupant

- Motion sequence of the occupant in single images



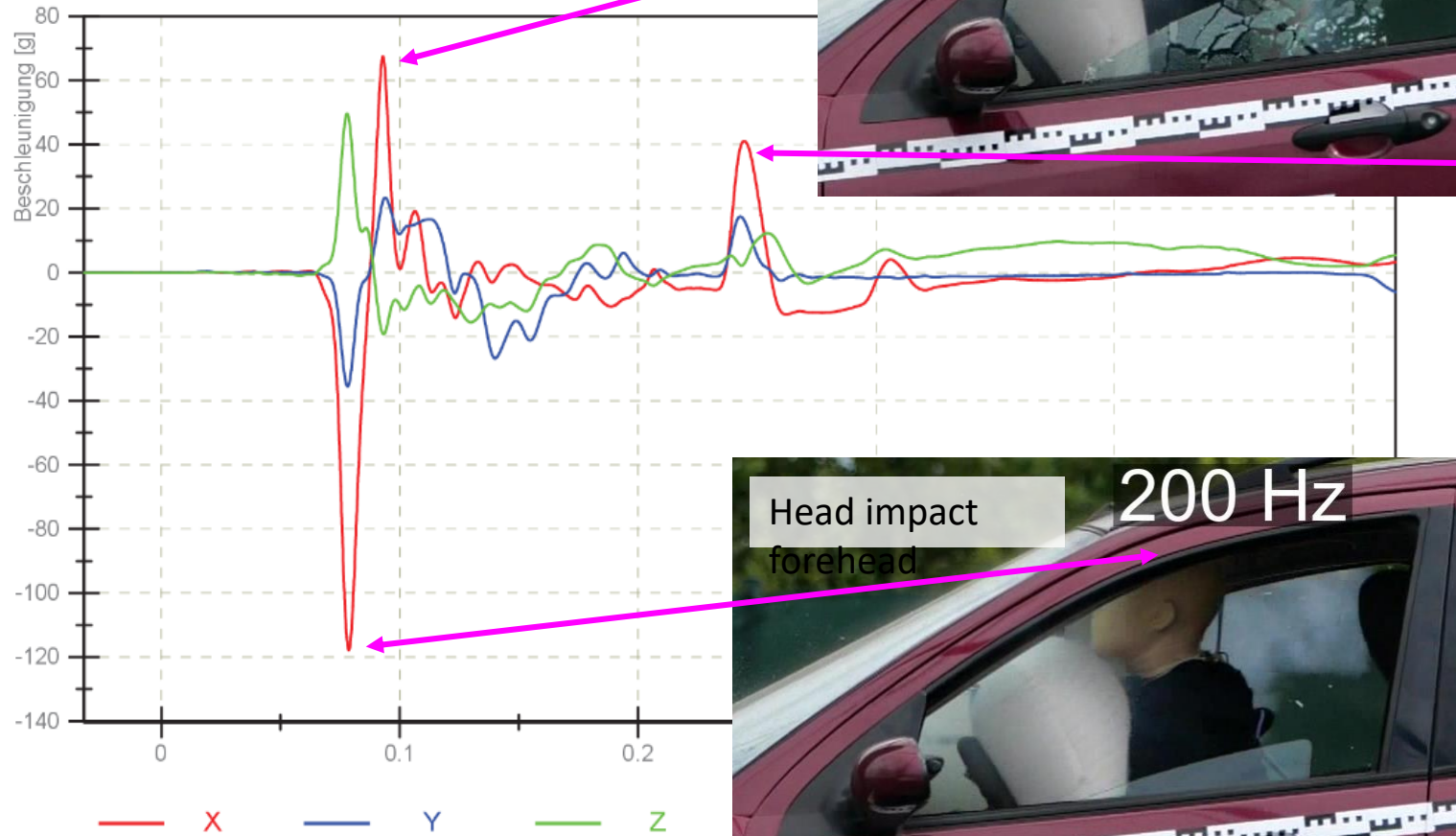
Non-belted occupant

- Resulting accelerations (CFC60 filtering)



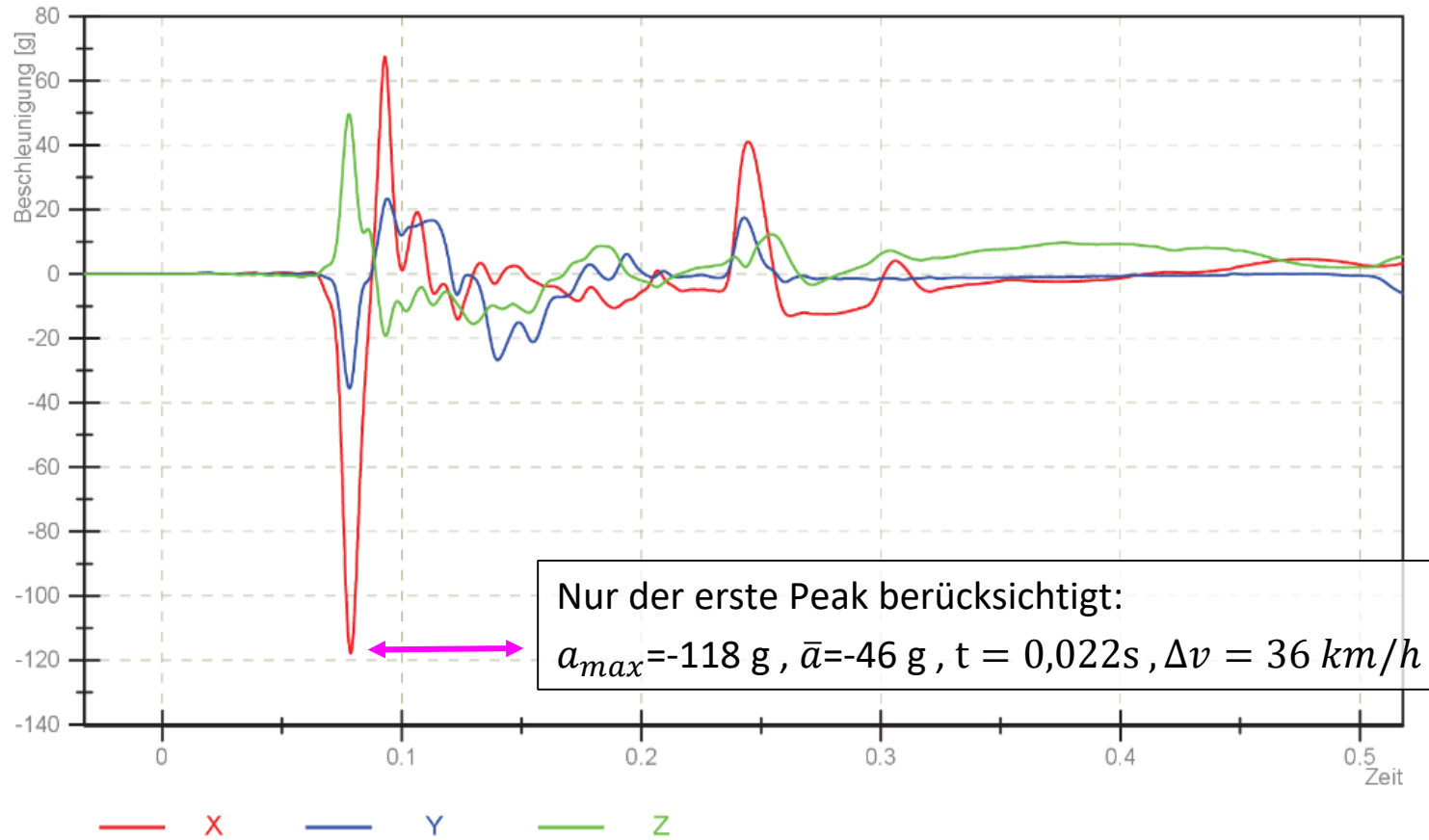
Non-belted occupant

- Accelerations of the head (x,y,z)



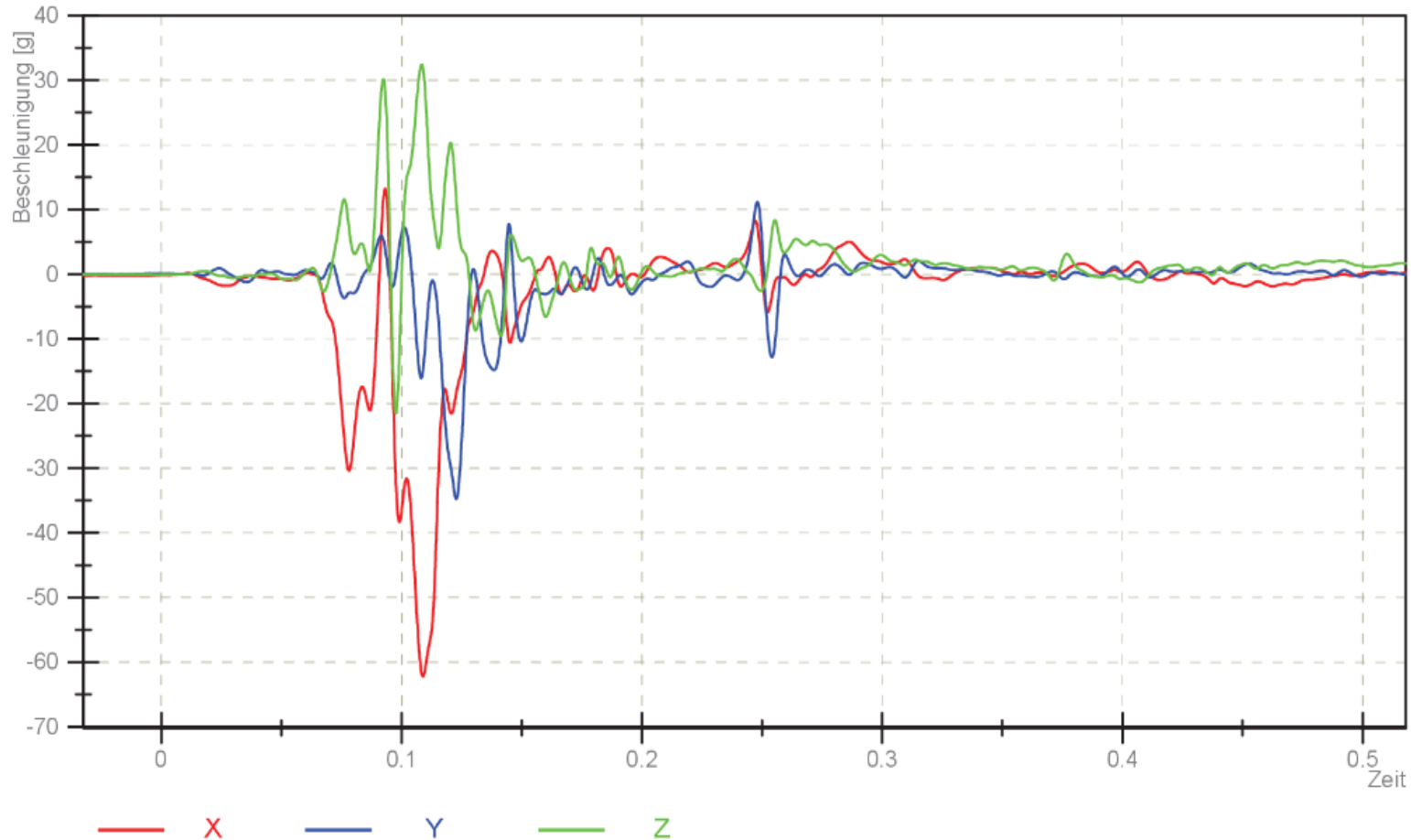
Non-belted occupant

- Accelerations of the head (x,y,z)



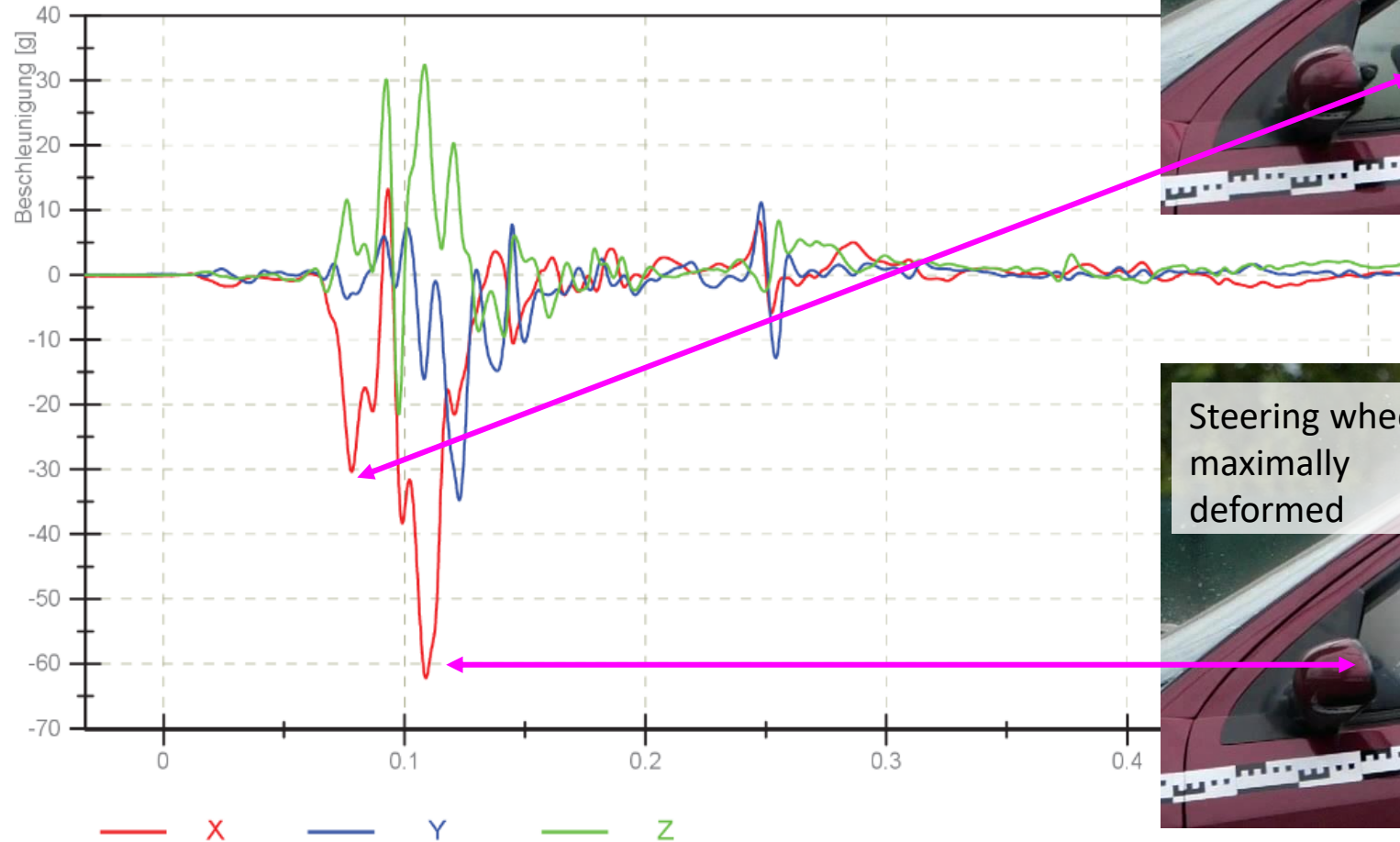
Non-belted occupant

- Accelerations of the chest (x,y,z)



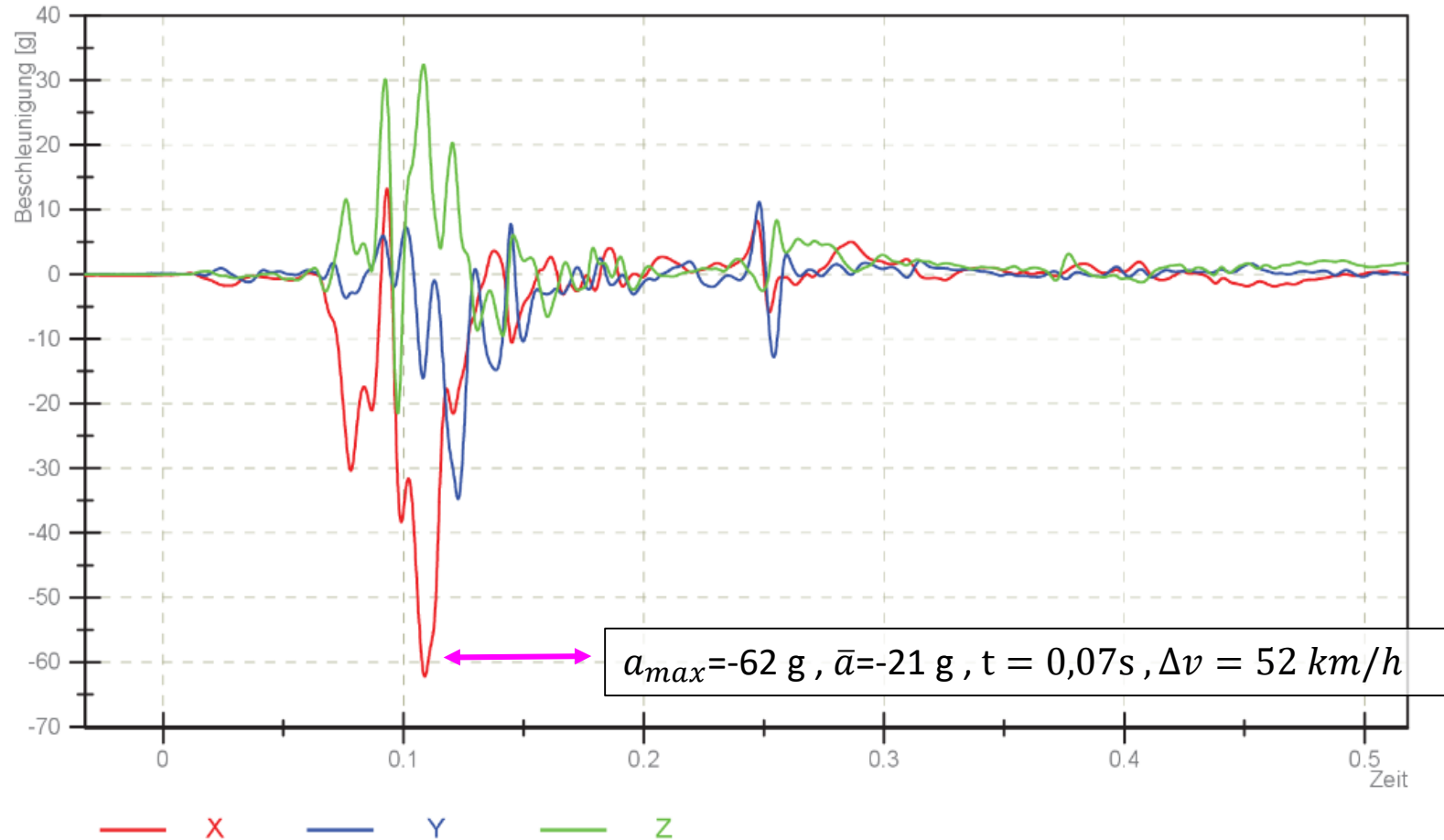
Non-belted occupant

- Accelerations of the chest (x,y,z)



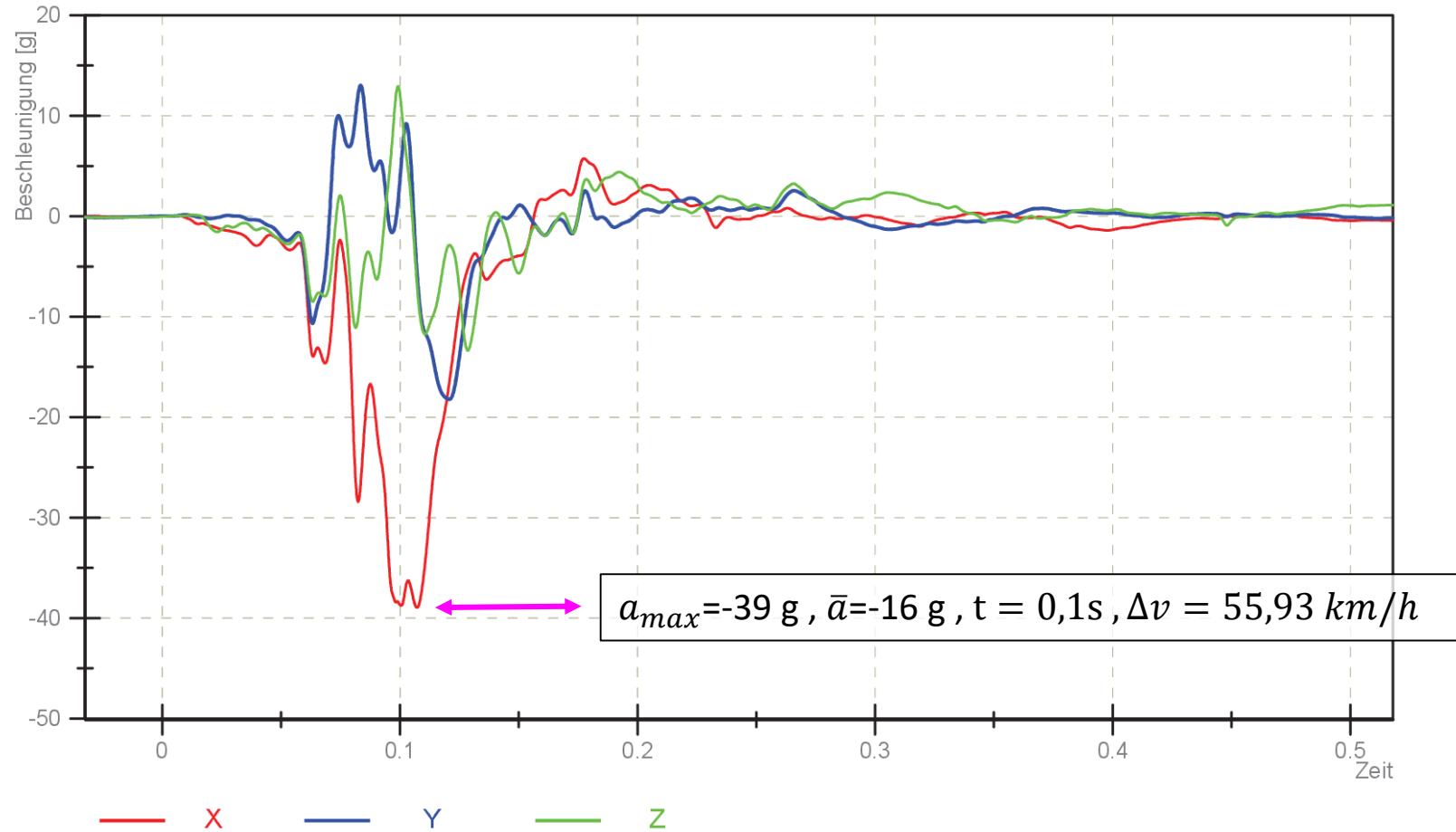
Non-belted occupant

- Accelerations of the chest (x,y,z)



Non-belted occupant

- Accelerations of the hip (x,y,z)



Badly belted occupant (lap belt only)

- Examples of incorrect use of the 3-point safety belt



Badly belted occupant (lap belt only)



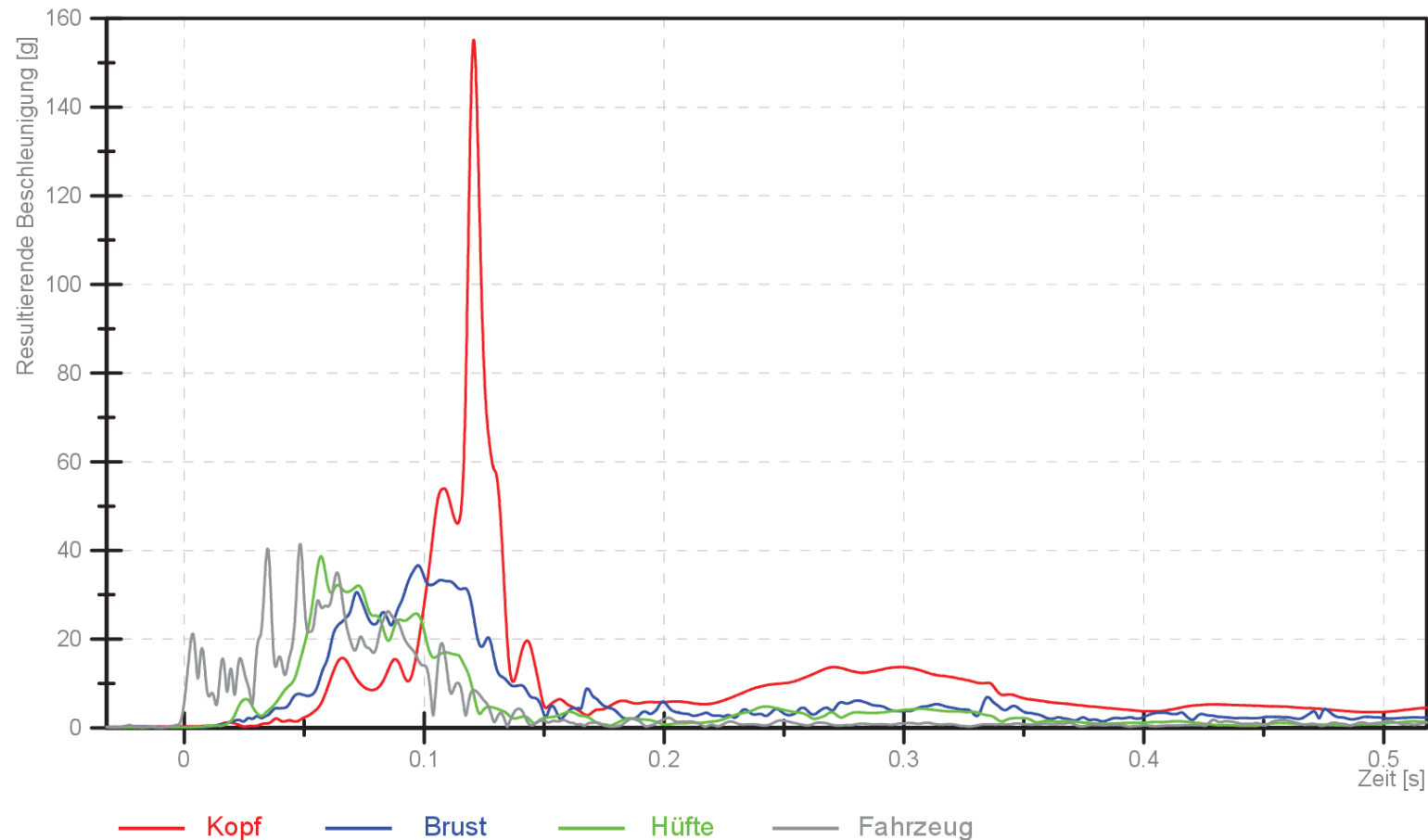
Badly belted occupant

- Motion sequence of the occupant in single images



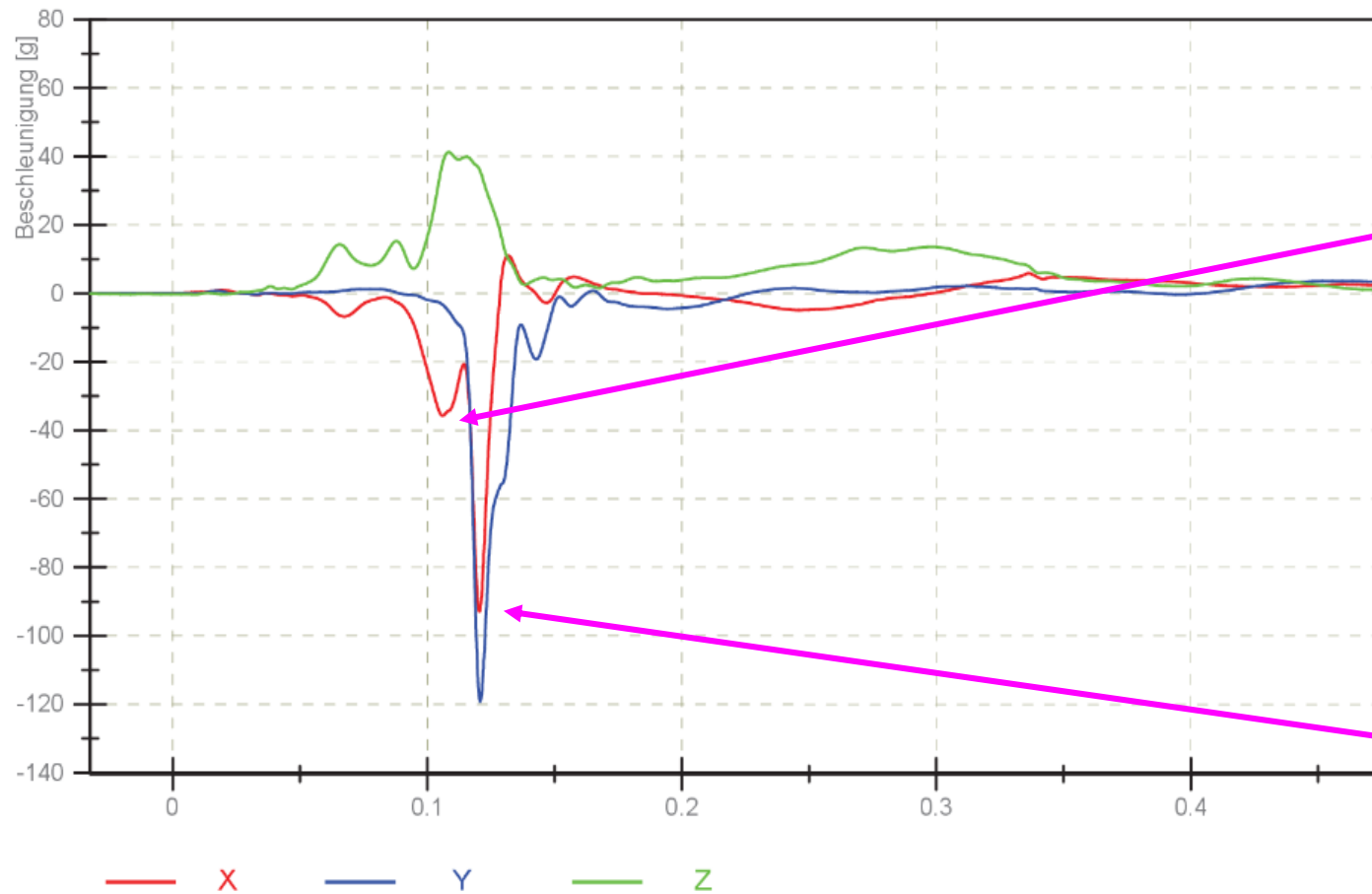
Badly belted occupant (lap belt only)

- Resulting accelerations



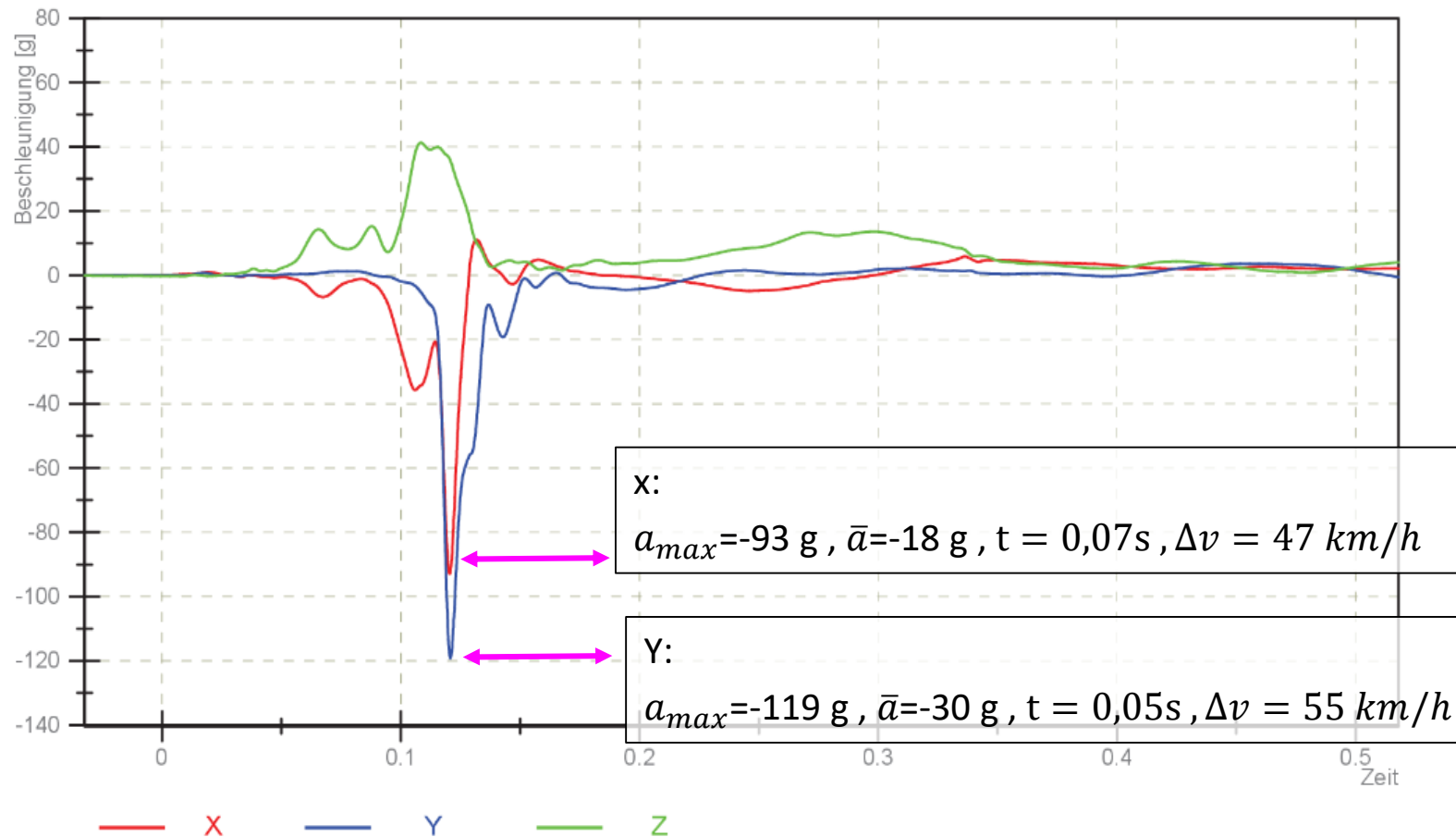
Badly belted occupant (lap belt only)

- Accelerations of the head (x,y,z) - head impact recognizable

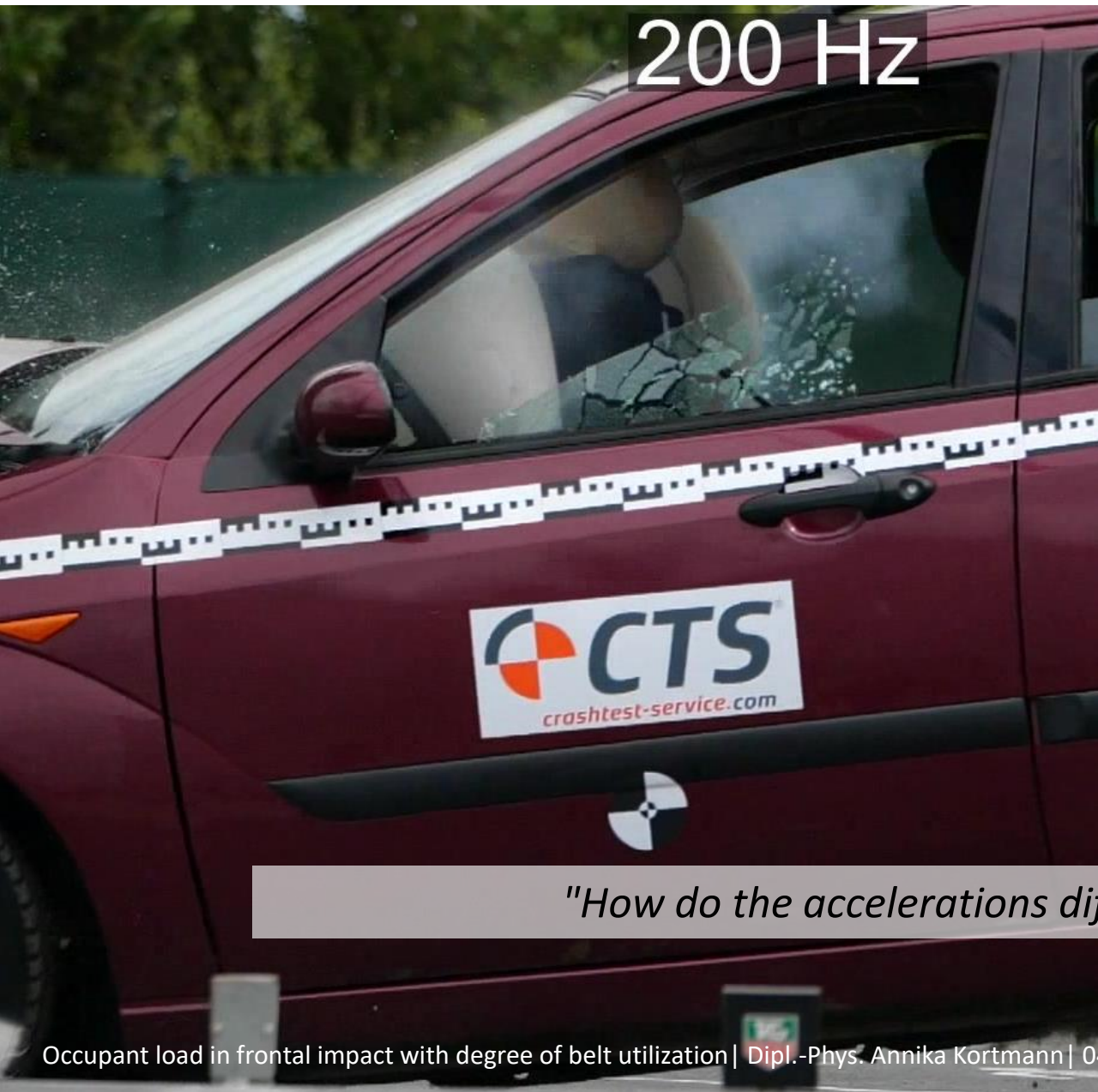


Badly belted occupant (lap belt only)

- Accelerations of the head (x,y,z) - head impact recognizable



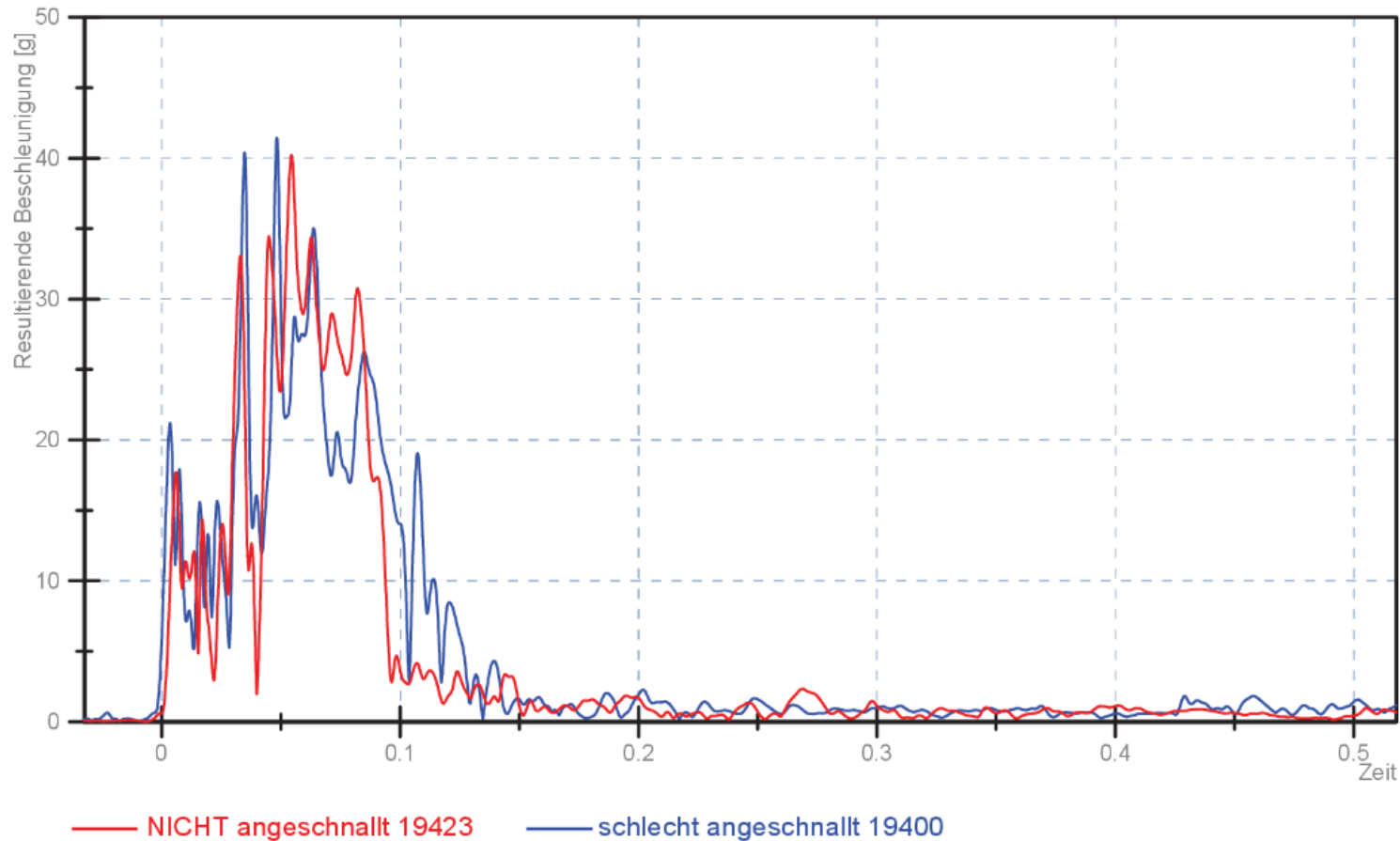
200 Hz



"How do the accelerations differ for the occupant?"

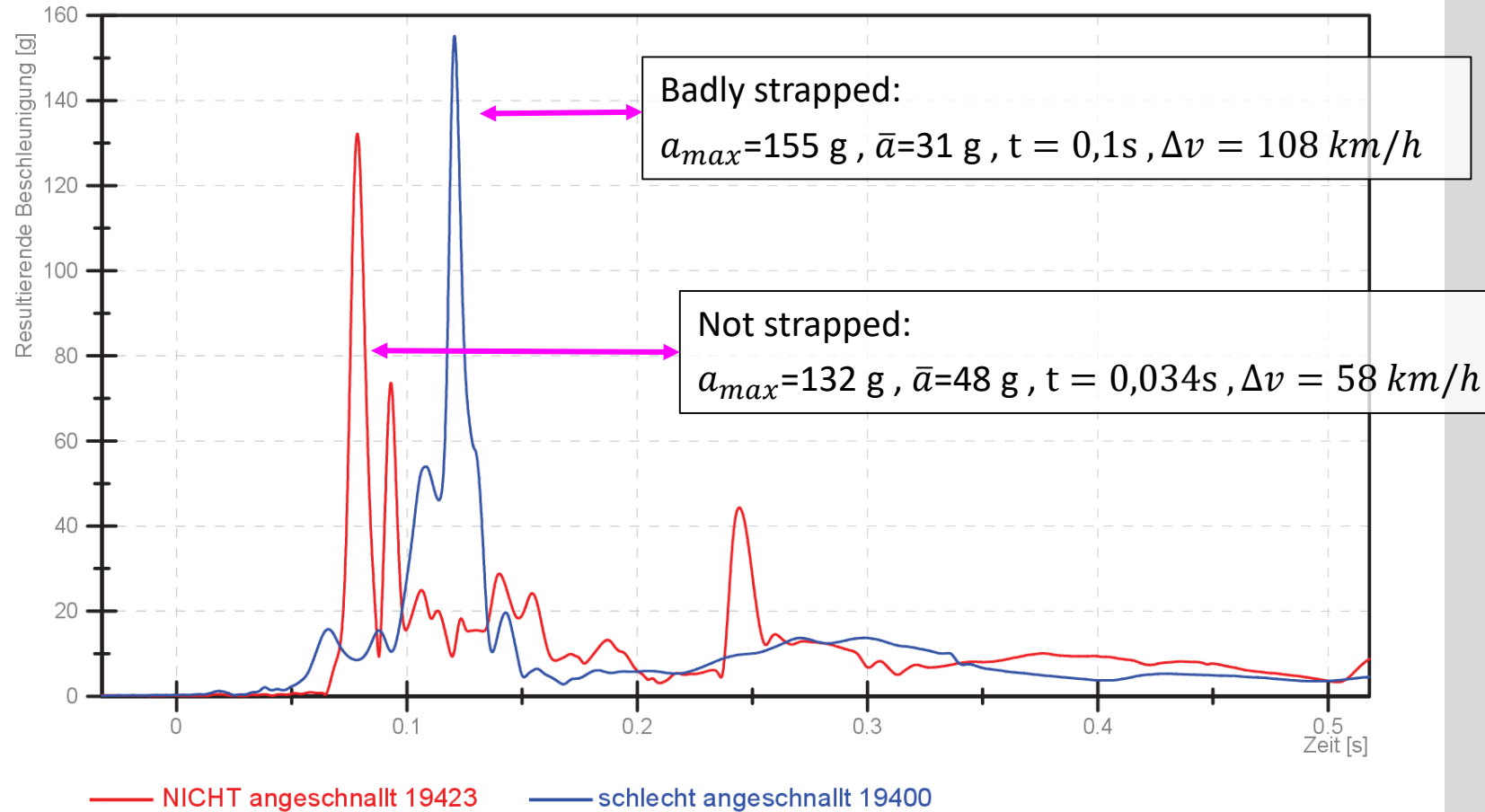
Comparison of unbelted / badly belted occupant

- Direct comparability given, due to almost identical passenger cell acceleration



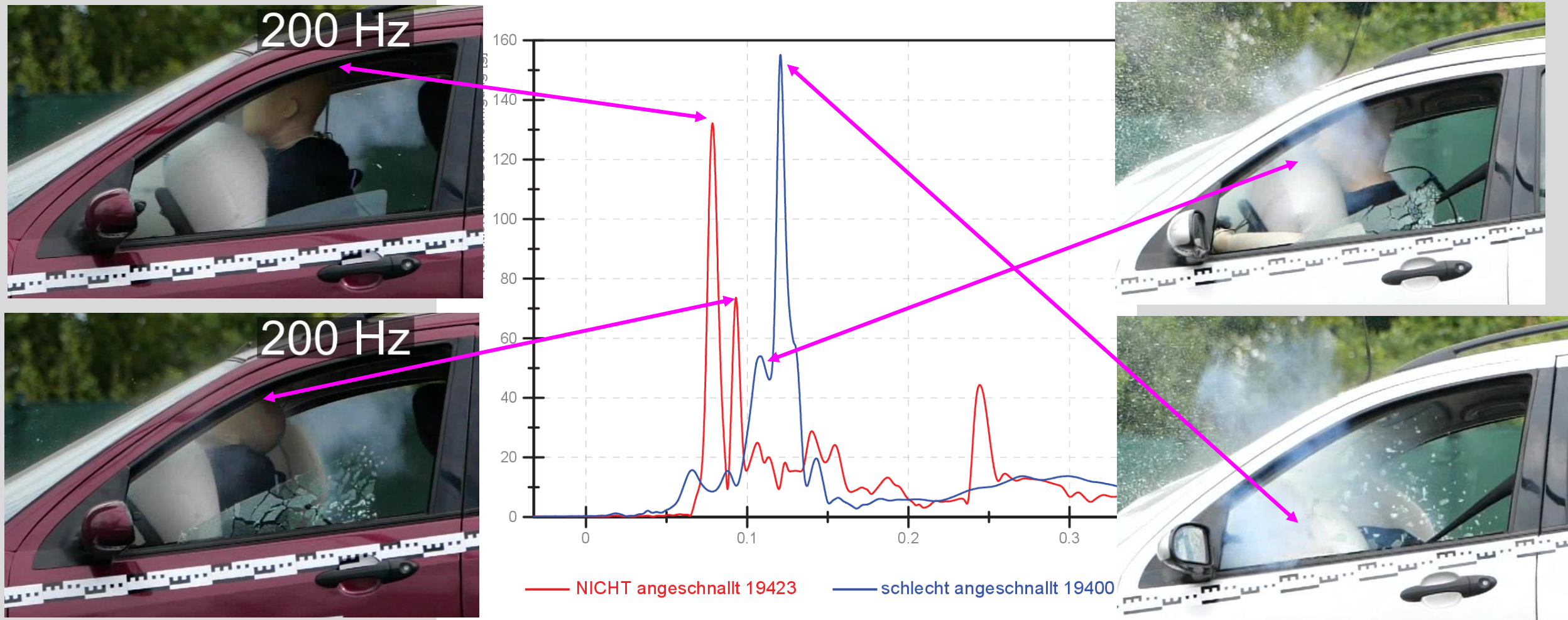
Comparison of unbelted / badly belted occupant

- Accelerations of the head (resulting)



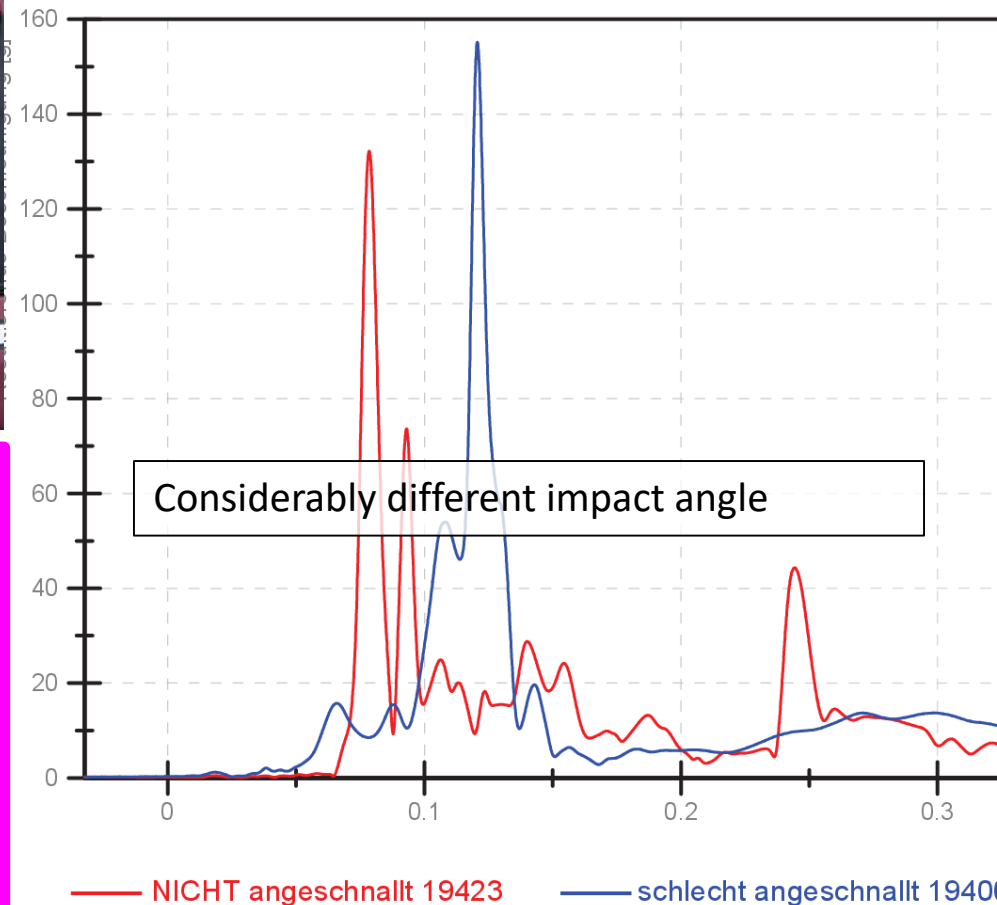
Comparison of non- / badly belted occupant

- Accelerations of the head (resulting)



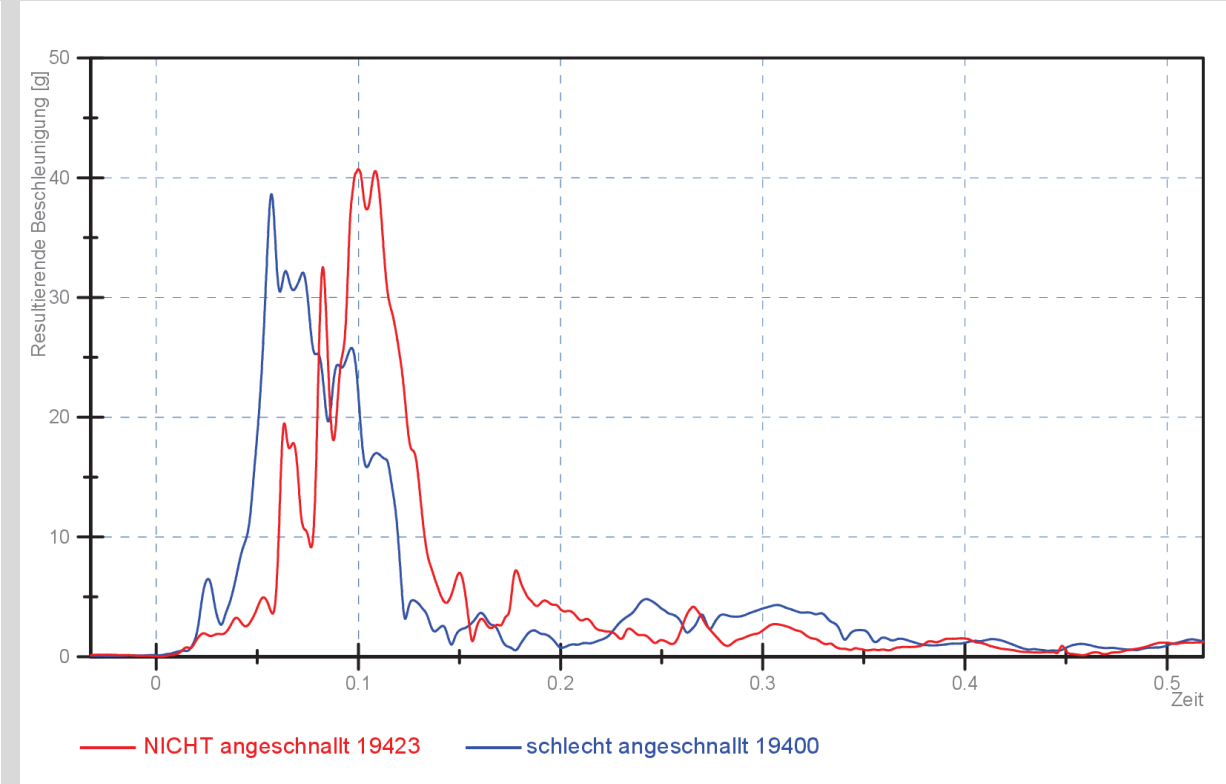
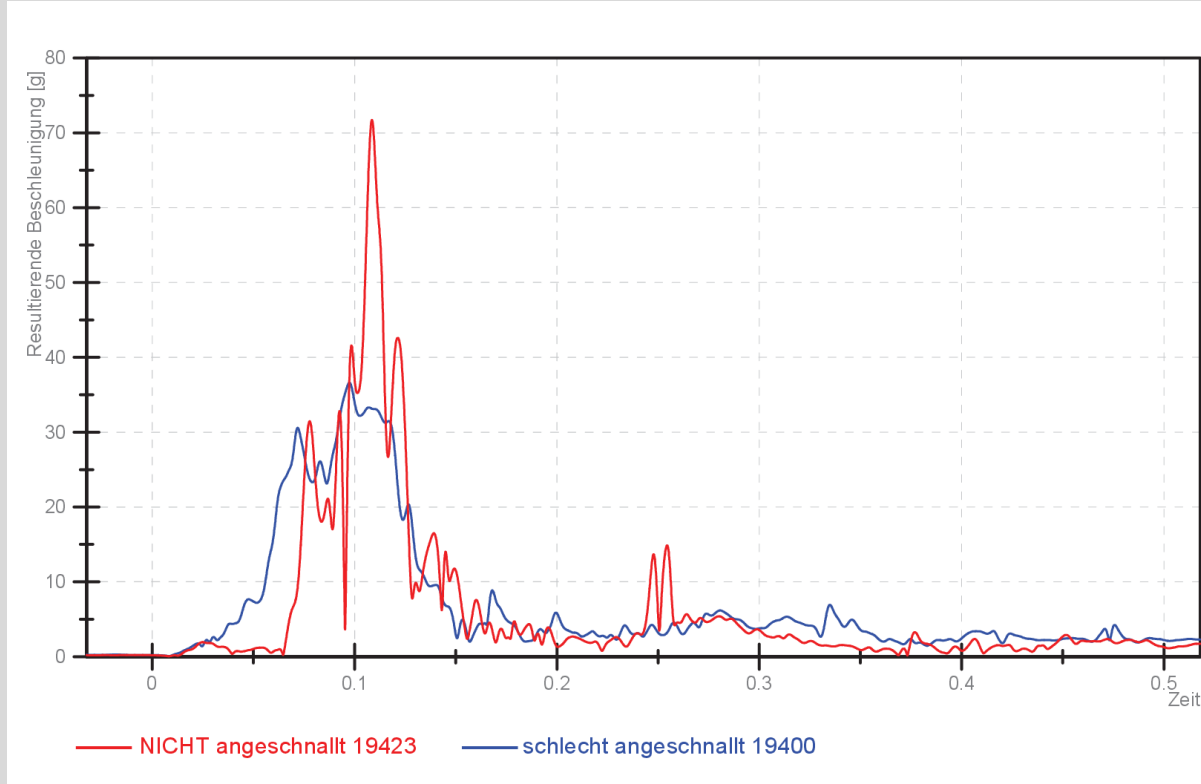
Comparison of unbelted / badly belted occupant

- Accelerations of the head (resulting)



Comparison of non- / badly belted occupant

- Accelerations of the breast (resulting)
- Accelerations of the hip (resulting)



Properly fastened seat belt

- Motion sequence of the occupant in single images



Comparison of the motion sequence

- Motion sequence of the occupant in single images (temporal resolution)



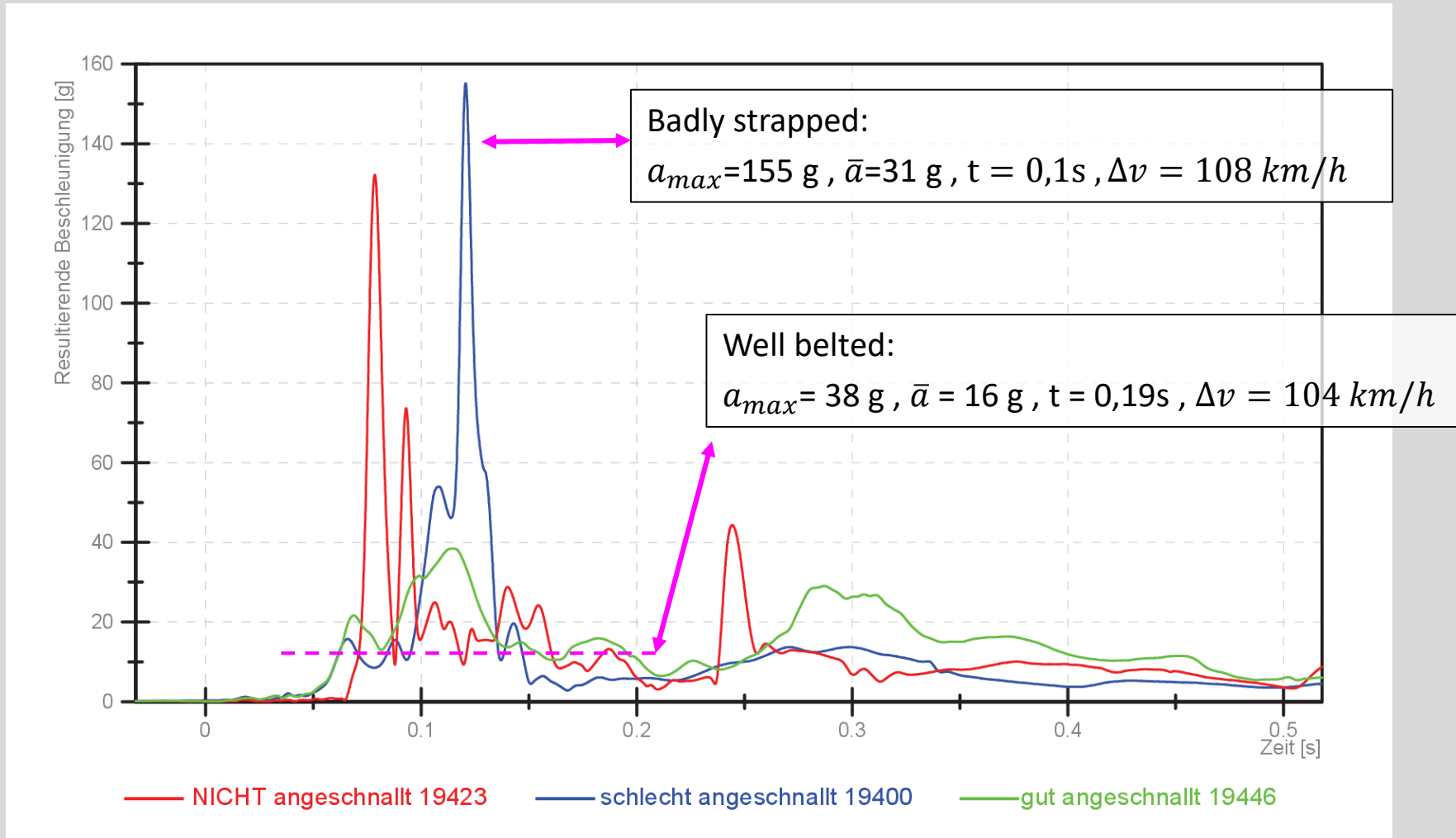
200 Hz



Comparison of occupant stress in all three tests

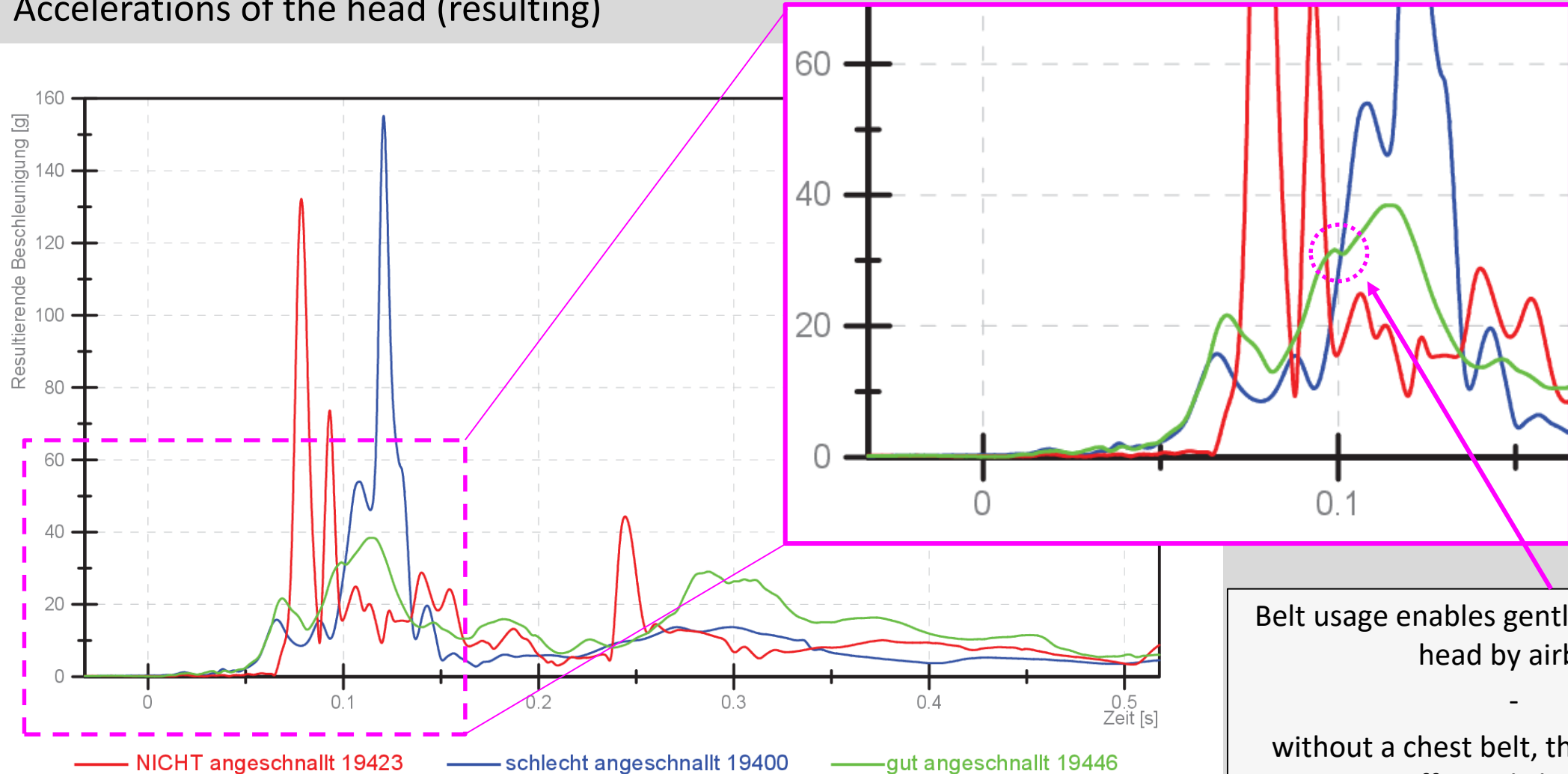
Comparison of occupant stress in all tests

- Accelerations of the head (resulting)



Comparison of occupant stress in all tests

- Accelerations of the head (resulting)

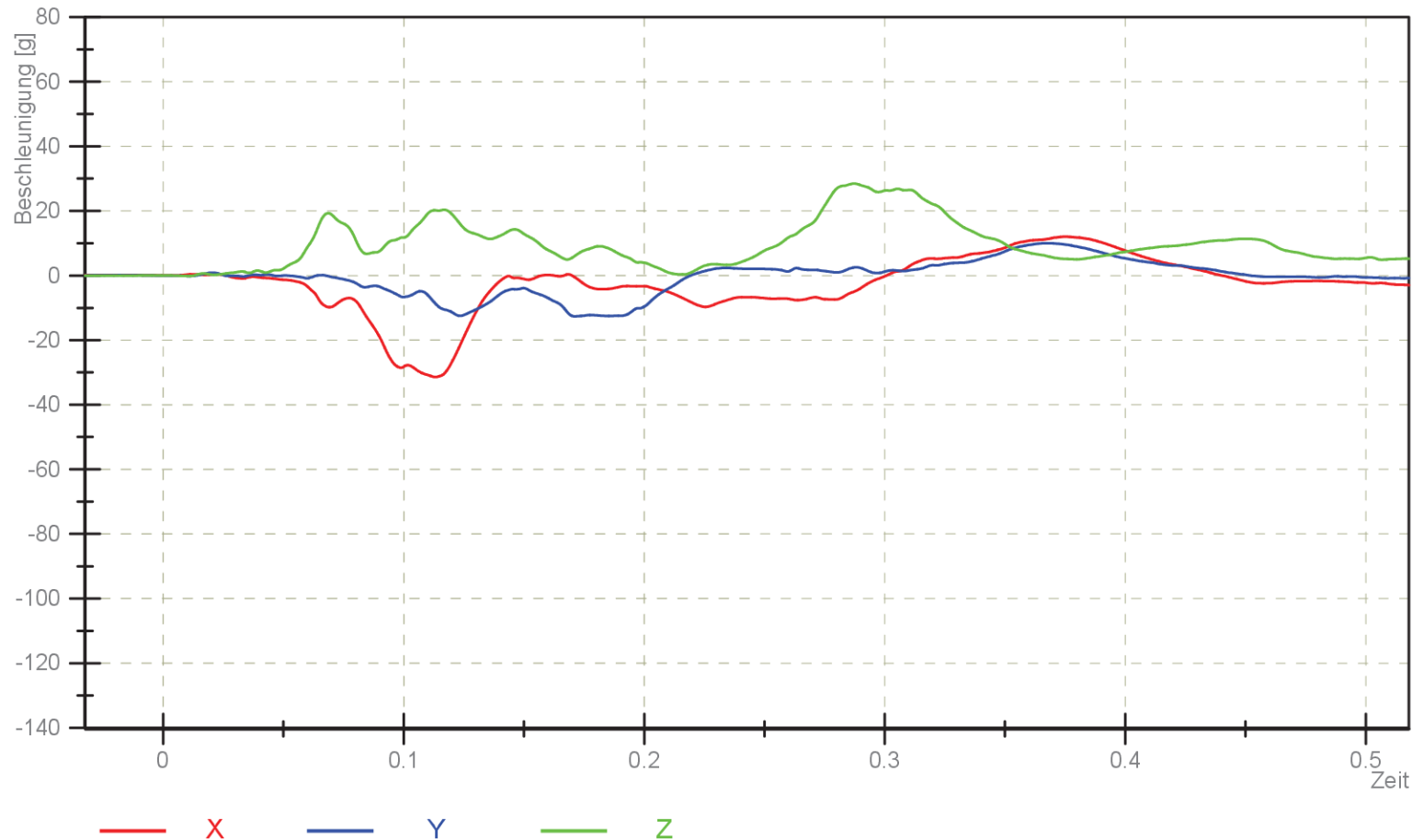


Belt usage enables gentle braking of the head by airbag

without a chest belt, the airbag alone cannot sufficiently break the head

Comparison of occupant stress in all tests

- Accelerations of the head (x,y,z) - correctly strapped



Comparison of occupant stress in all tests

- Motion sequence - correctly strapped dummy



Comparison of occupant stress in all tests

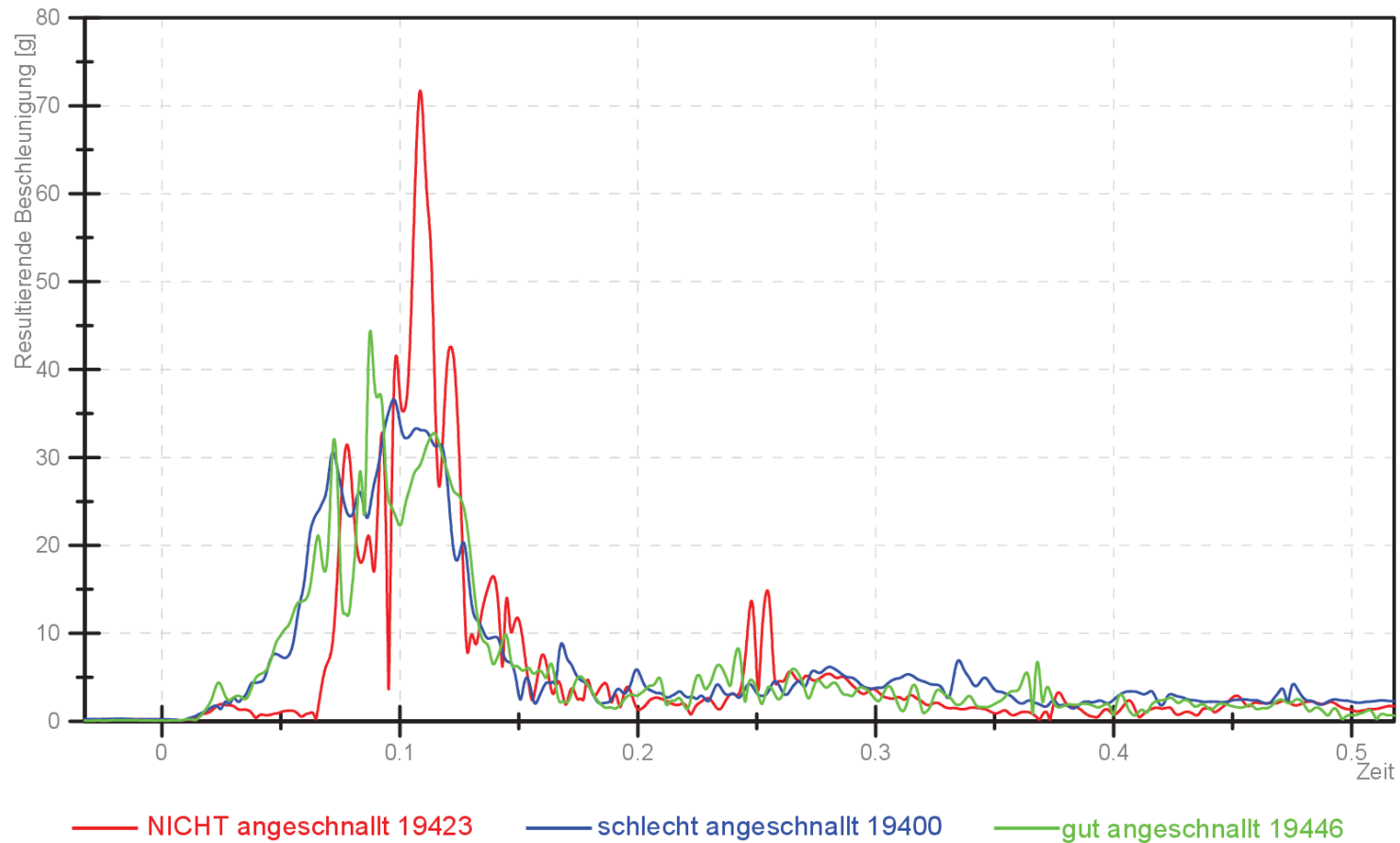
- Motion sequence - correctly strapped dummy



Considerable head twisting when diving into the airbag - more realistic behavior than the otherwise known tests?

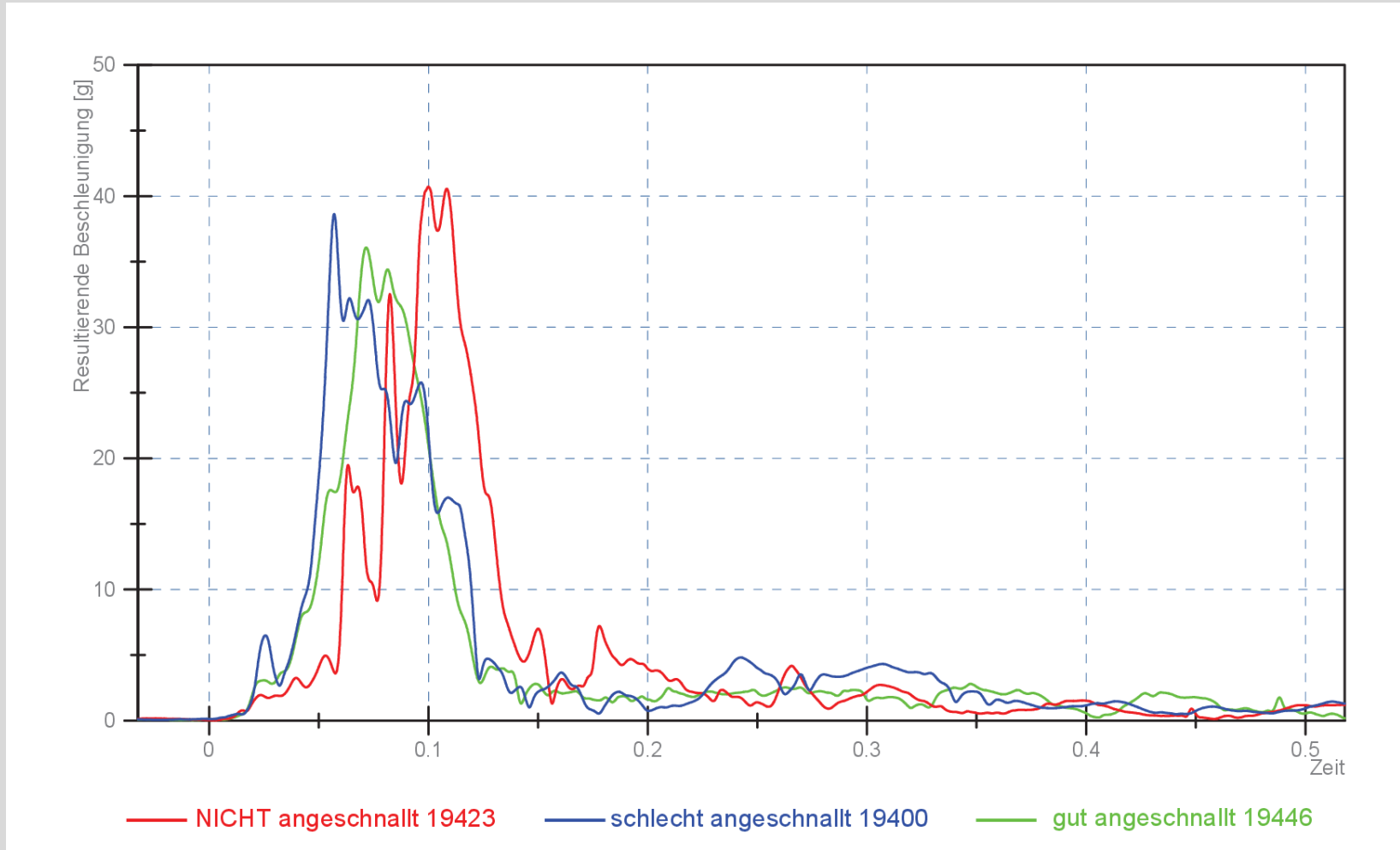
Comparison of occupant stress in all tests

- Accelerations of the breast (resulting)



Comparison of occupant stress in all tests

- Accelerations of the hip (resulting)

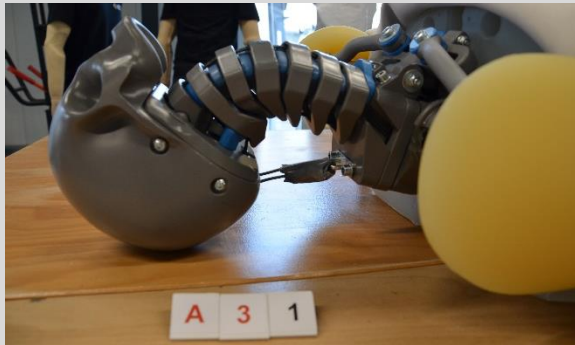


Comparison of the injury pattern

- Not strapped

Massive overstretching of the cervical spine

Opening vertebrae of the thoracic spine



- Badly belted

Two broken ribs left

Tape elongation

Elbow joint right

Ligament extension knee joint right

Ligament extension knee joint left



- Well belted

Two broken ribs left

Sternal Fracture

Summary

- Essential differences in the motion sequence in a frontal impact 50 km/h against a tree
 - not strapped in: double head impact, compression of the neck vertebrae, chest impact on the steering wheel
 - Poorly fastened seat belts: head impact on the steering wheel despite airbag, significant steering wheel deformation
 - well fastened seat belts: no steering wheel impact, longer dwell time in the airbag
- Similarities in the acceleration process
 - Hip acceleration comparable in intensity and course in all experiments
 - Chest acceleration with bad/good belting comparable, since no impact
 - Head impact when not/badly strapped in comparable intensity
- Significantly lower head load due to airbag and correct use of seat belt, as less $\bar{a}$ over twice the time - Primus dummy shows considerable rotation of the head when immersing into the airbag

Protection Airbag only in combination with 3-point safety belt!

Comparison of occupant load in a frontal collision with different degrees of belt usage

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Many thanks for your attention!

