

Continuing Evaluation of THOR for Reclined Postures – Pelvis Motion and Lap Belt Interaction in Frontal Collisions

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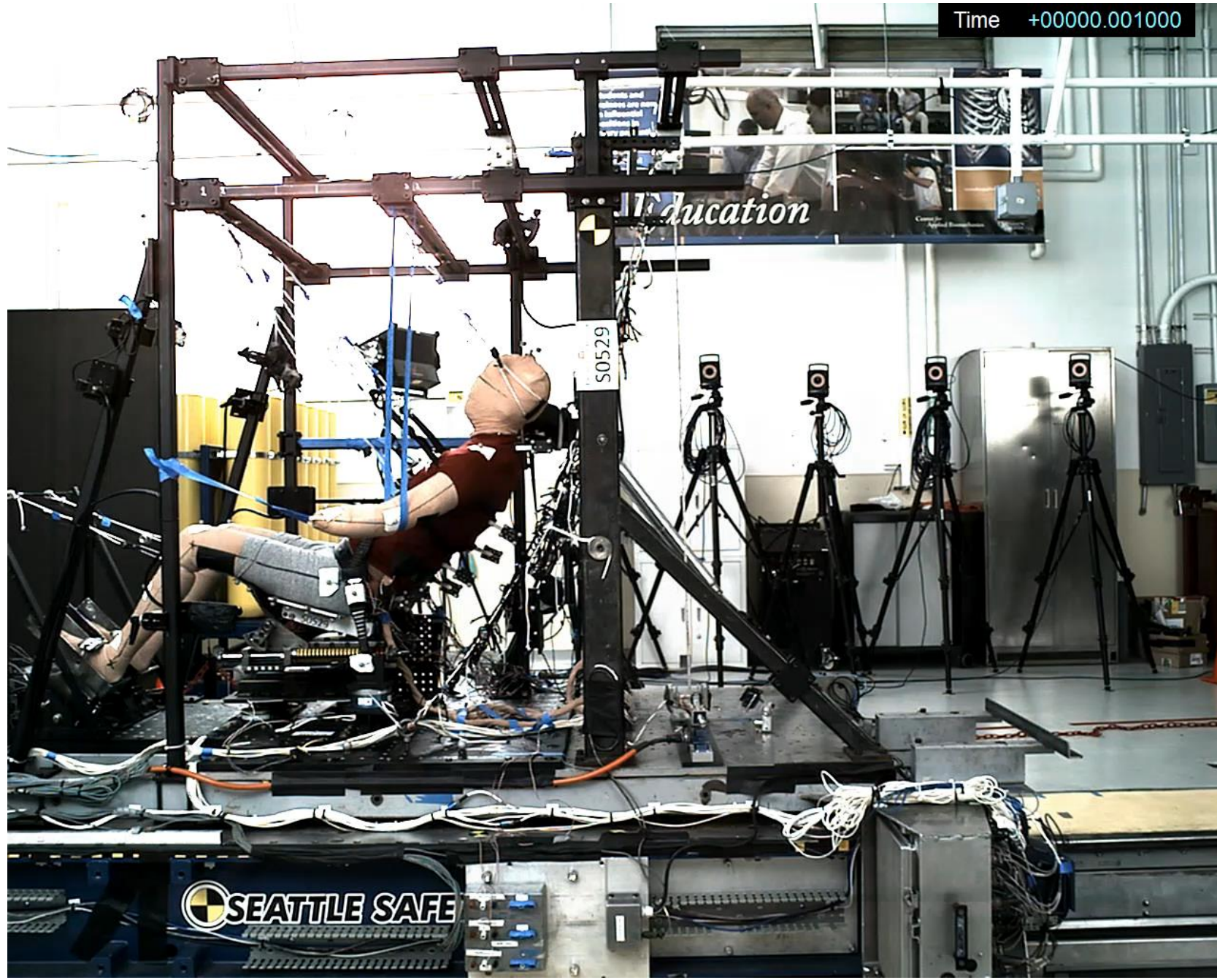
Present

Future - Highly Automated Vehicle (HAV)



UVA Recline Test Series

Richardson et al. 2019

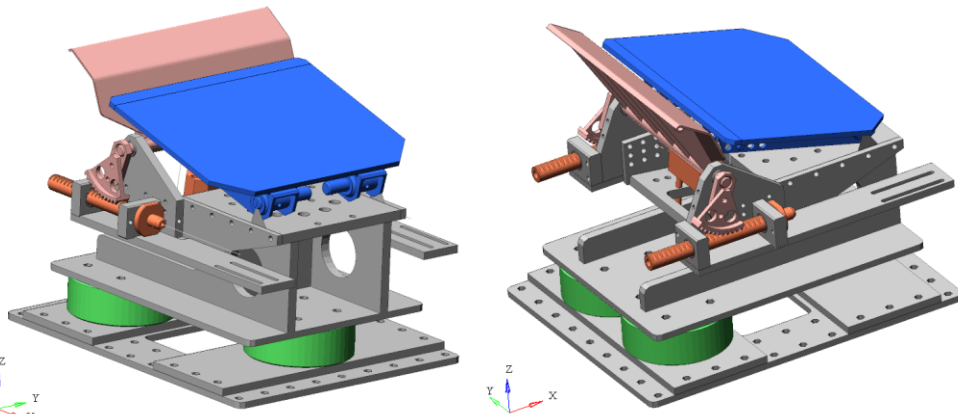
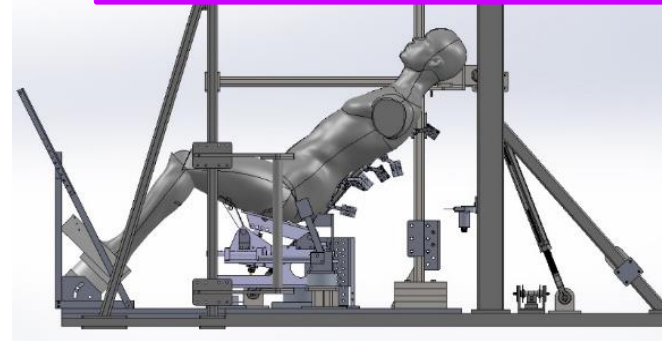


Reclined PMHS Tests

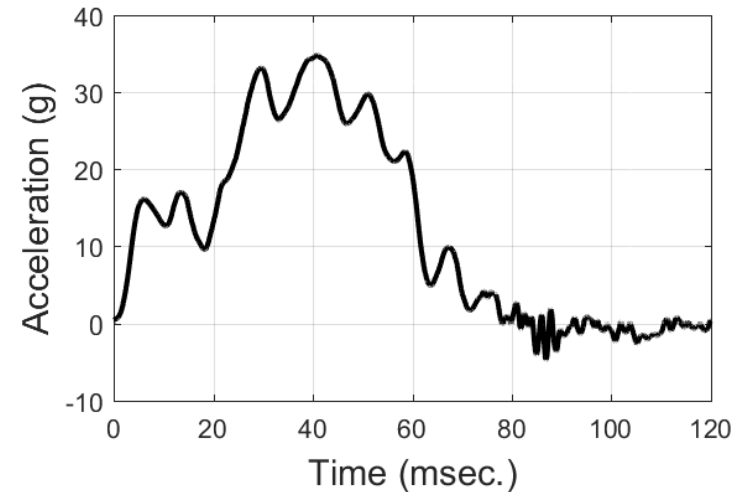
Richardson et al. 2019



50° recline to the vertical



LAB generic, deformable seat
(Uriot et al. 2015)

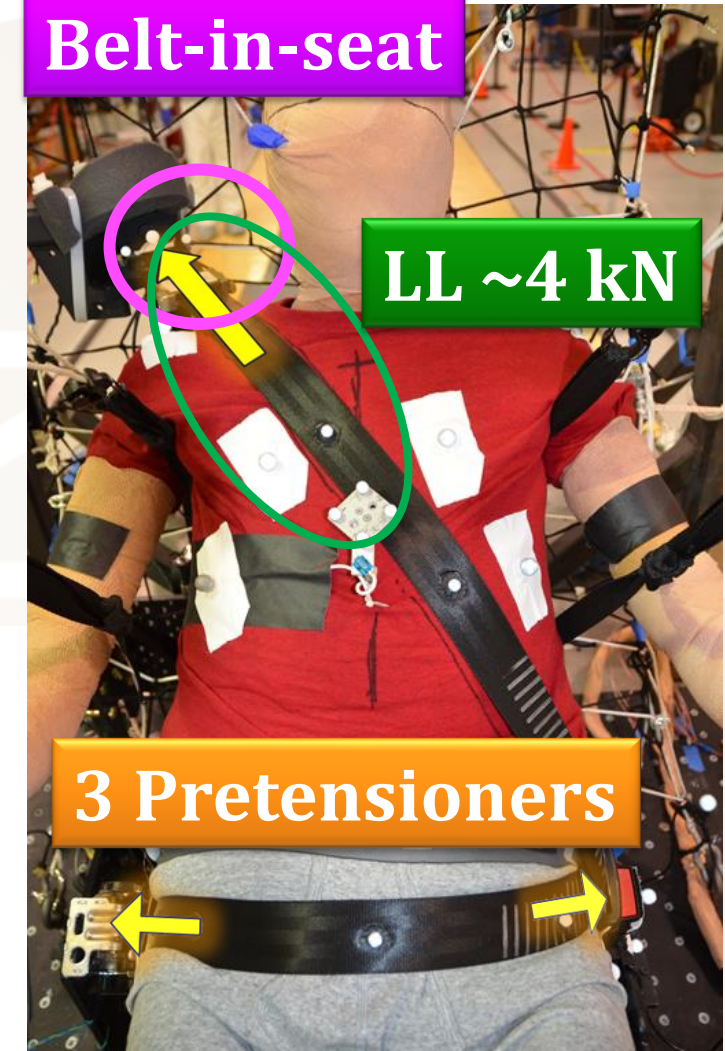


30 g pulse (50 km/h ΔV)
Uriot et al., 2015

Belt-in-seat

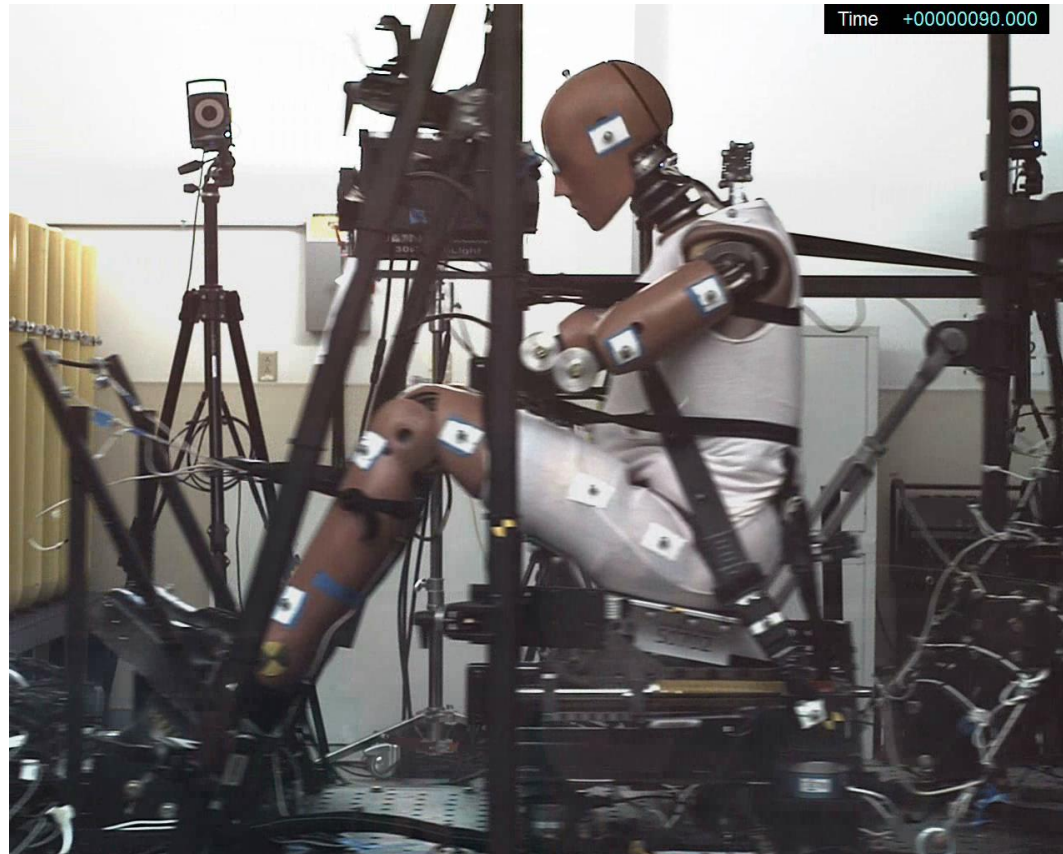
LL ~4 kN

3 Pretensioners



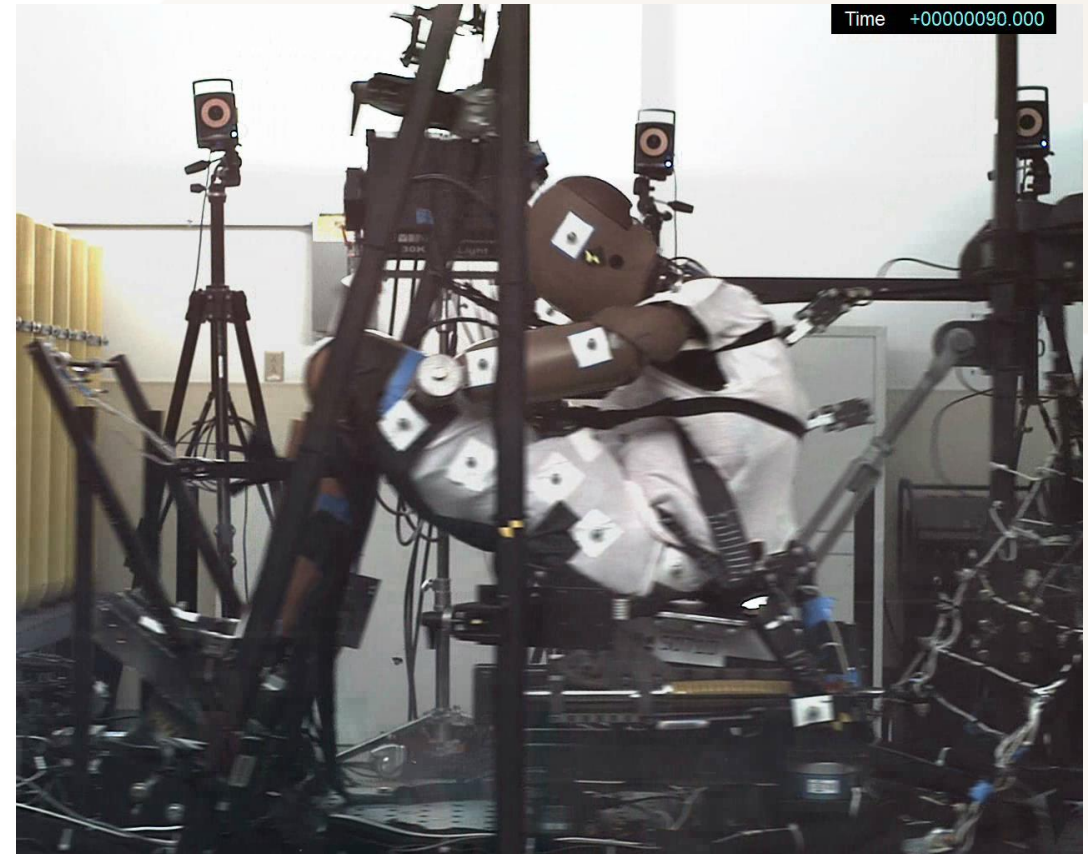
H-III

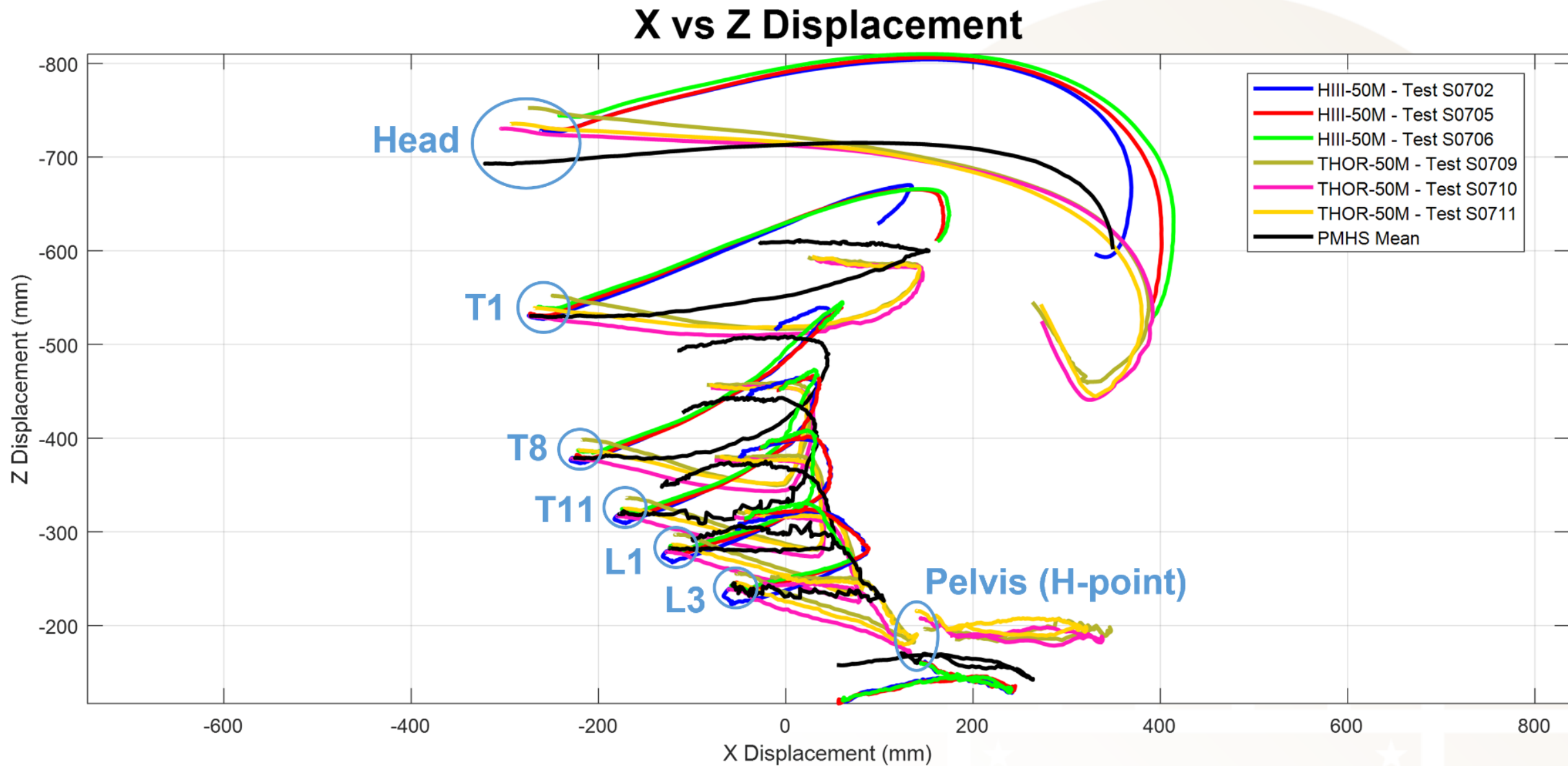
80 ms



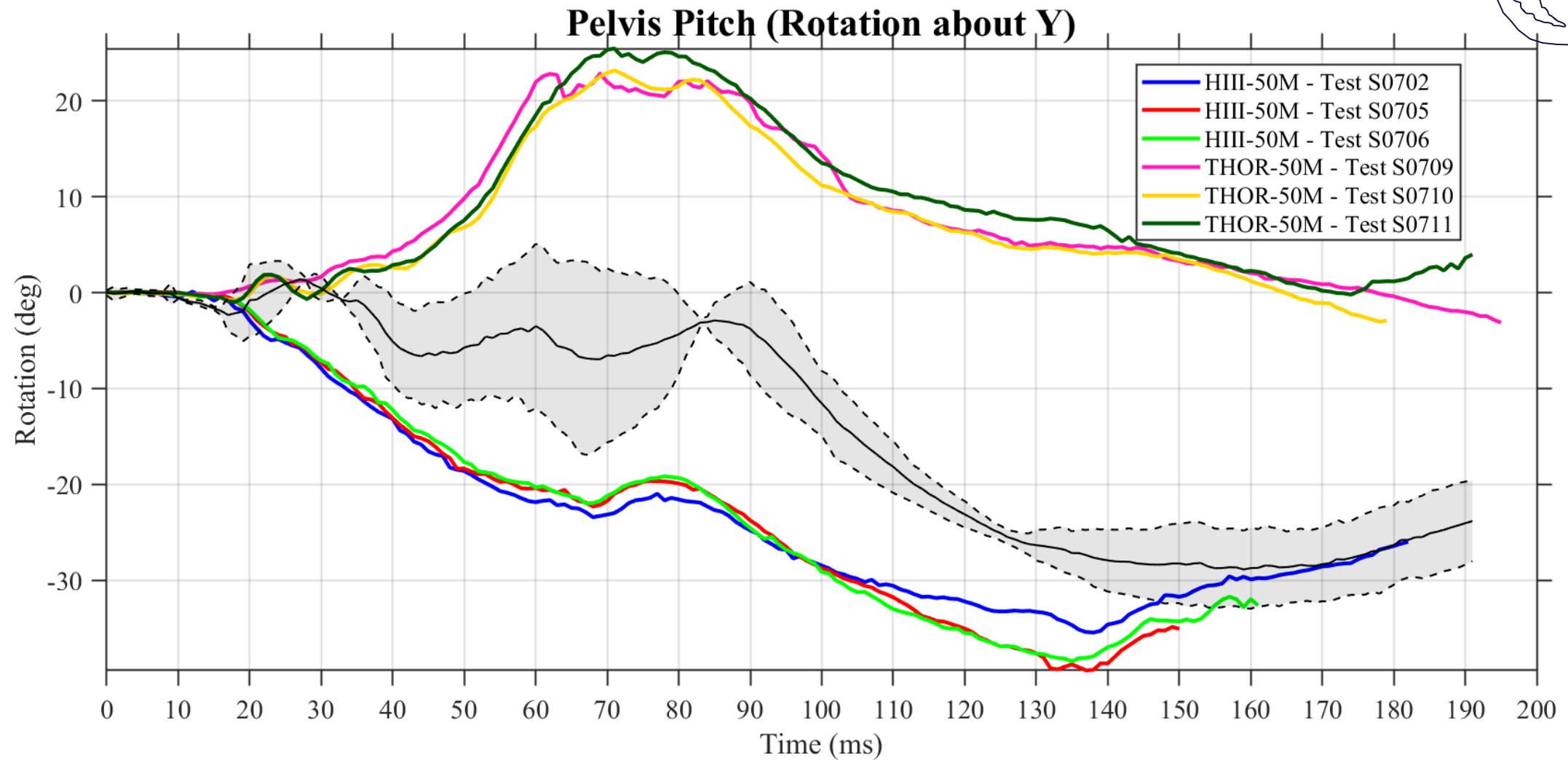
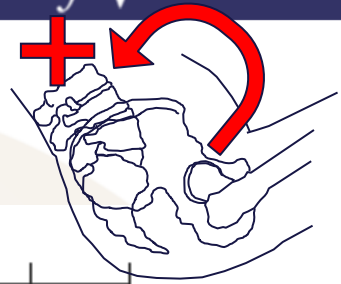
THOR

80 ms





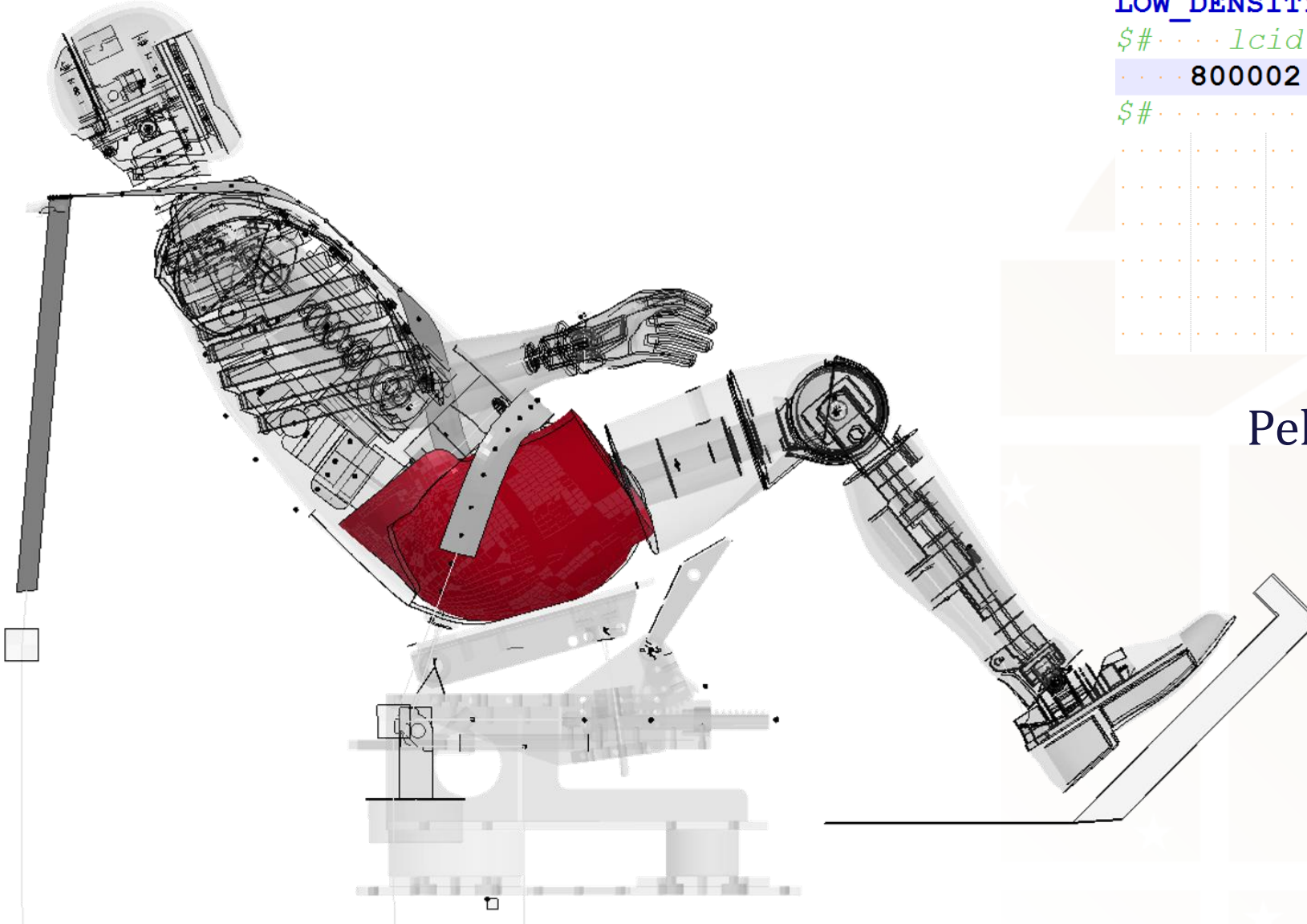
PELVIS PITCH ROTATION



GOAL ...

... Investigate the modifications of THOR and their impact on pelvis motion and lap belt interaction in frontal collisions

Pelvis Flesh Stiffness

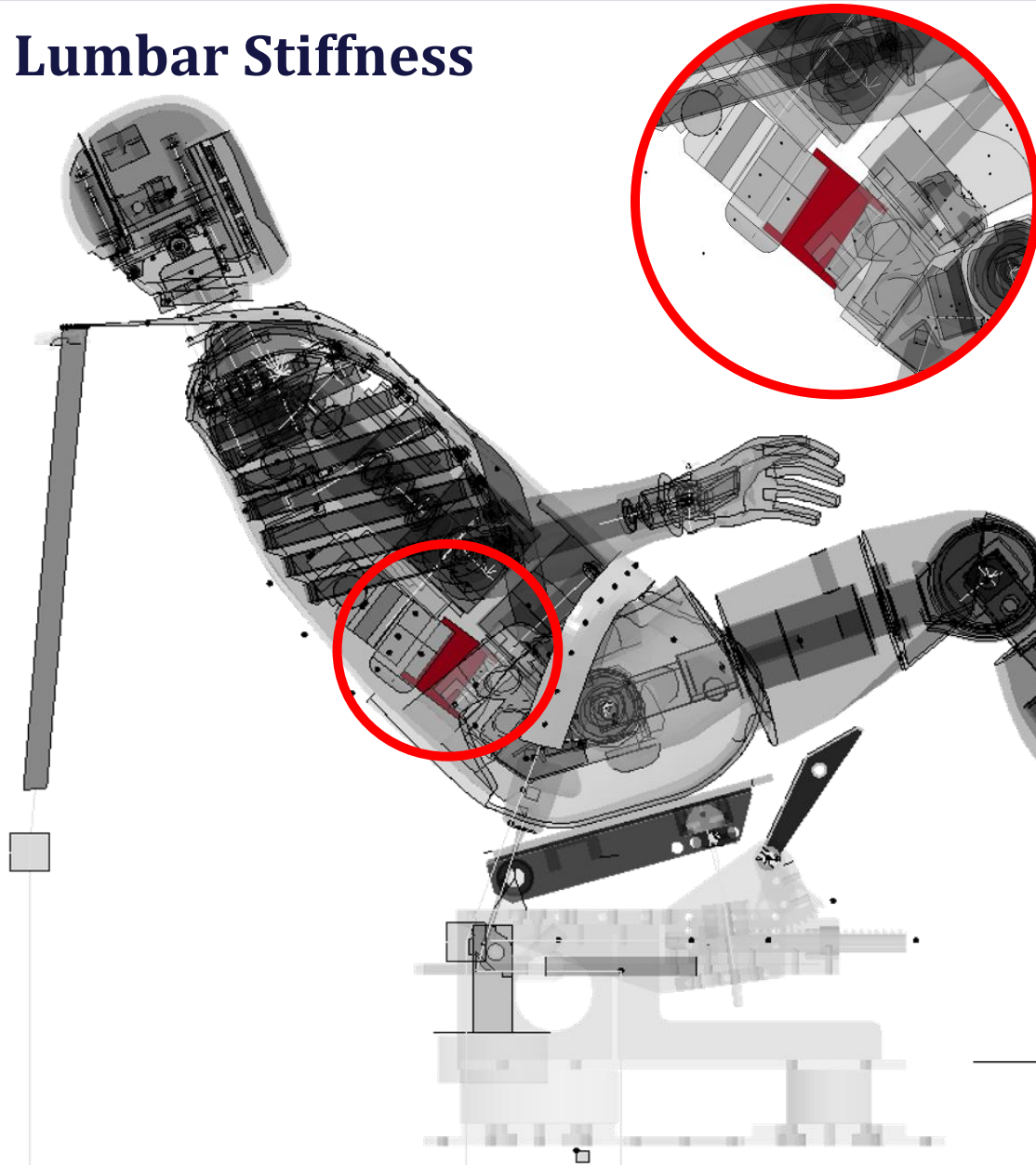


```

*DEFINE_CURVE_TITLE,LE
LOW_DENSITY_FOAM,LE
$#.....lcid.....sldr.....sfa.....sfo.....
.....800002.....0.....1.0&pelvfoam.....
$#.....a1.....o1.....LE
.....0.0.....0.0LE
.....0.05.....0.008LE
.....0.45.....0.0173LE
.....0.8.....0.1LE
.....0.9.....2.0LE
.....0.95.....100.0LE
  
```

Pelvfoam = (0.5, 1.0, 2.0)

Lumbar Stiffness

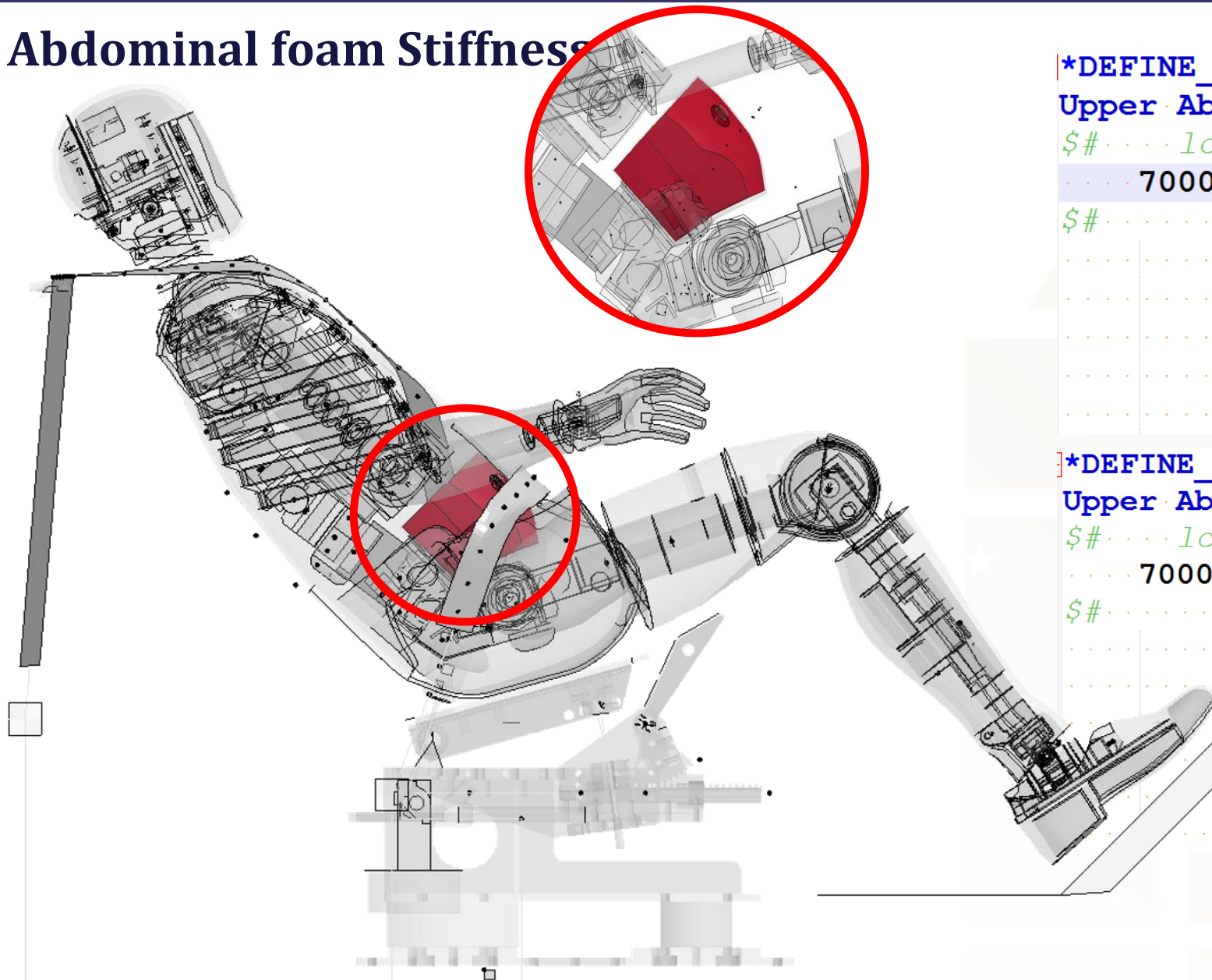


```
*DEFINE_CURVE_TITLE
BUTYL RUBBER 0.1 STRAIN RATE_LOADING
$# lcid sidr sfa sfo offa
700007 0 1.0 lumbrub 0.0
$# a1 o1
-0.77 -50.0
-0.74 -42.506
-0.7197 -37.167
-0.6967 -30.802
-0.6721 -25.463
```

```
*DEFINE_CURVE_TITLE
BUTYL RUBBER 100.0 STRAIN RATE_LOADING
$# lcid sidr sfa sfo offa
700030 0 1.0 lumbrub 0.0
$# a1 o1
-0.77 -132.652
-0.7368 -120.742
-0.6541 -82.548
-0.5591 -51.541
0.4626 -33.471
-0.3661 -22.177
```

Lumbrub = (0.5, 1.0, 2.0)

Abdominal foam Stiffness



```
*DEFINE_CURVE_TITLE
```

```
Upper Abdomen Front Foam
```

```
$# lcid sidr sfa sfo
700063 0 1.0&abrfoam
$a1 o1
0.0 0.0
0.013028 9.6543401014e-04
0.067328 0.003086
0.135551 0.004524
0.207952 0.00513
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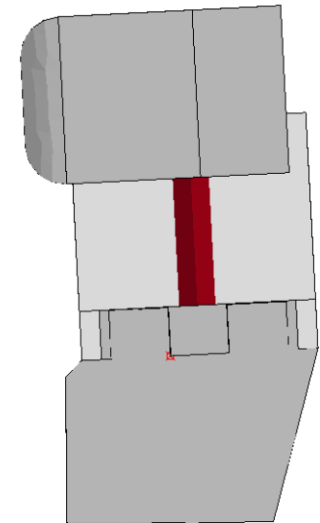
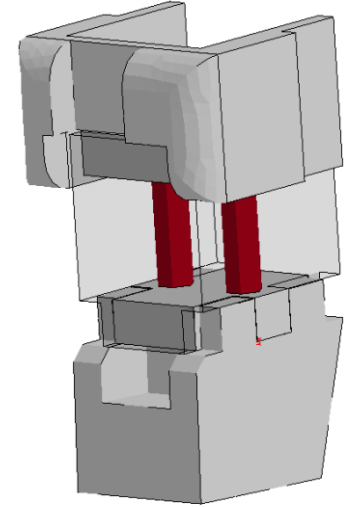
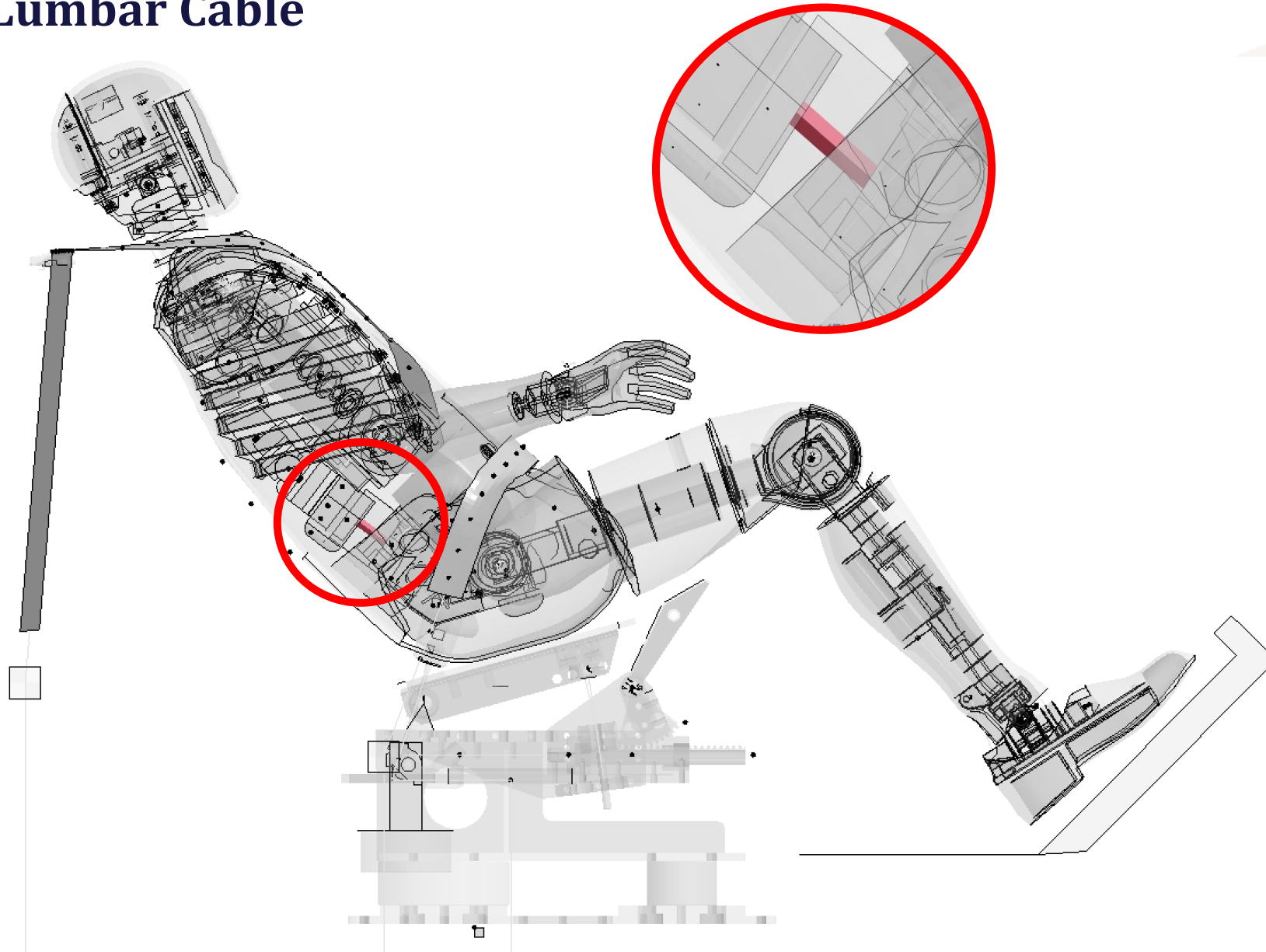
```
*DEFINE_CURVE_TITLE
```

```
Upper Abdomen Rear Foam
```

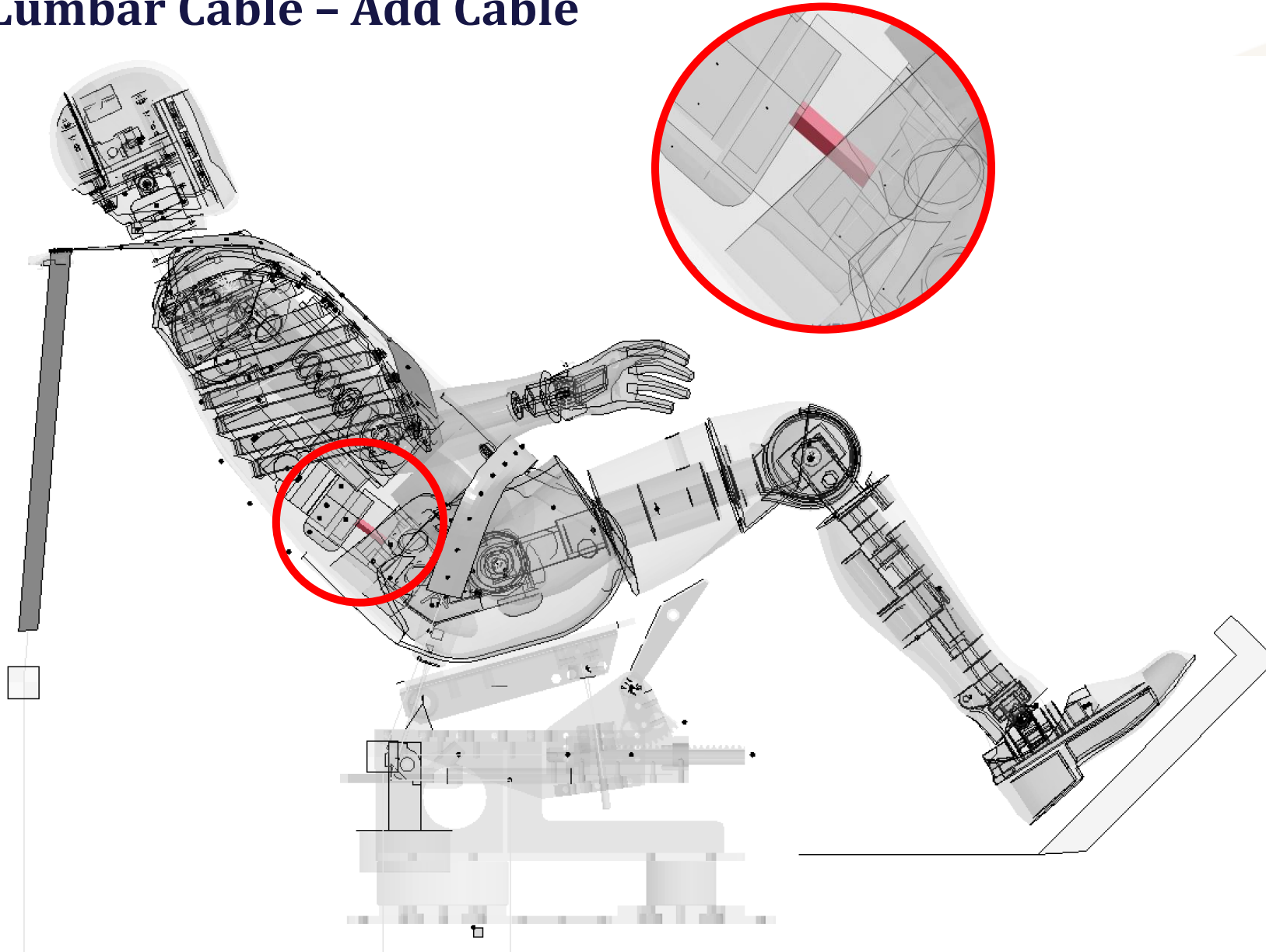
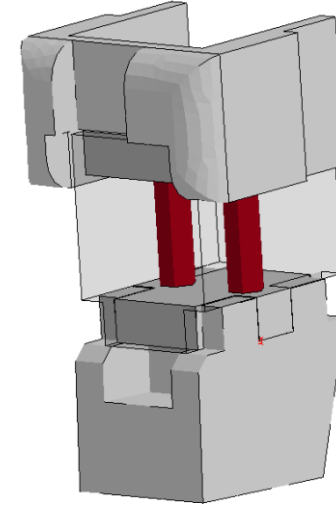
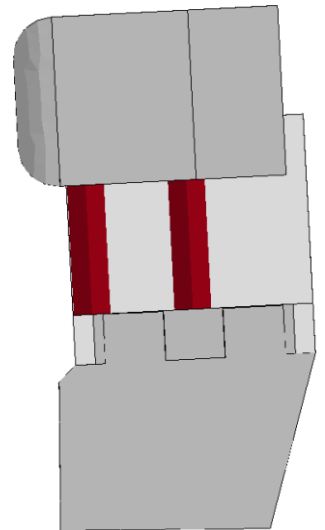
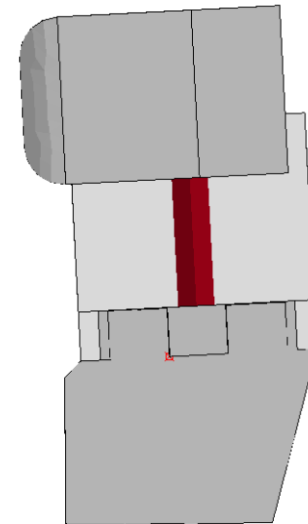
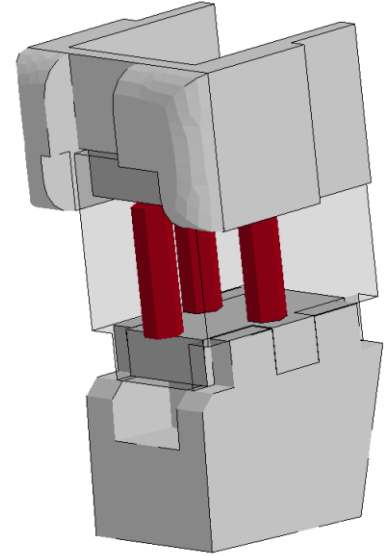
```
$# lcid sidr sfa sfo
700062 0 1.0&abffoam
$a1 o1
0.0 0.0
0.008624 2.8087801184e-04
0.019025 0.001545
0.029289 0.003932
0.039477 0.004775
0.050046 0.005898
```

Ab*foam = (0.5, 1.0, 2.0)

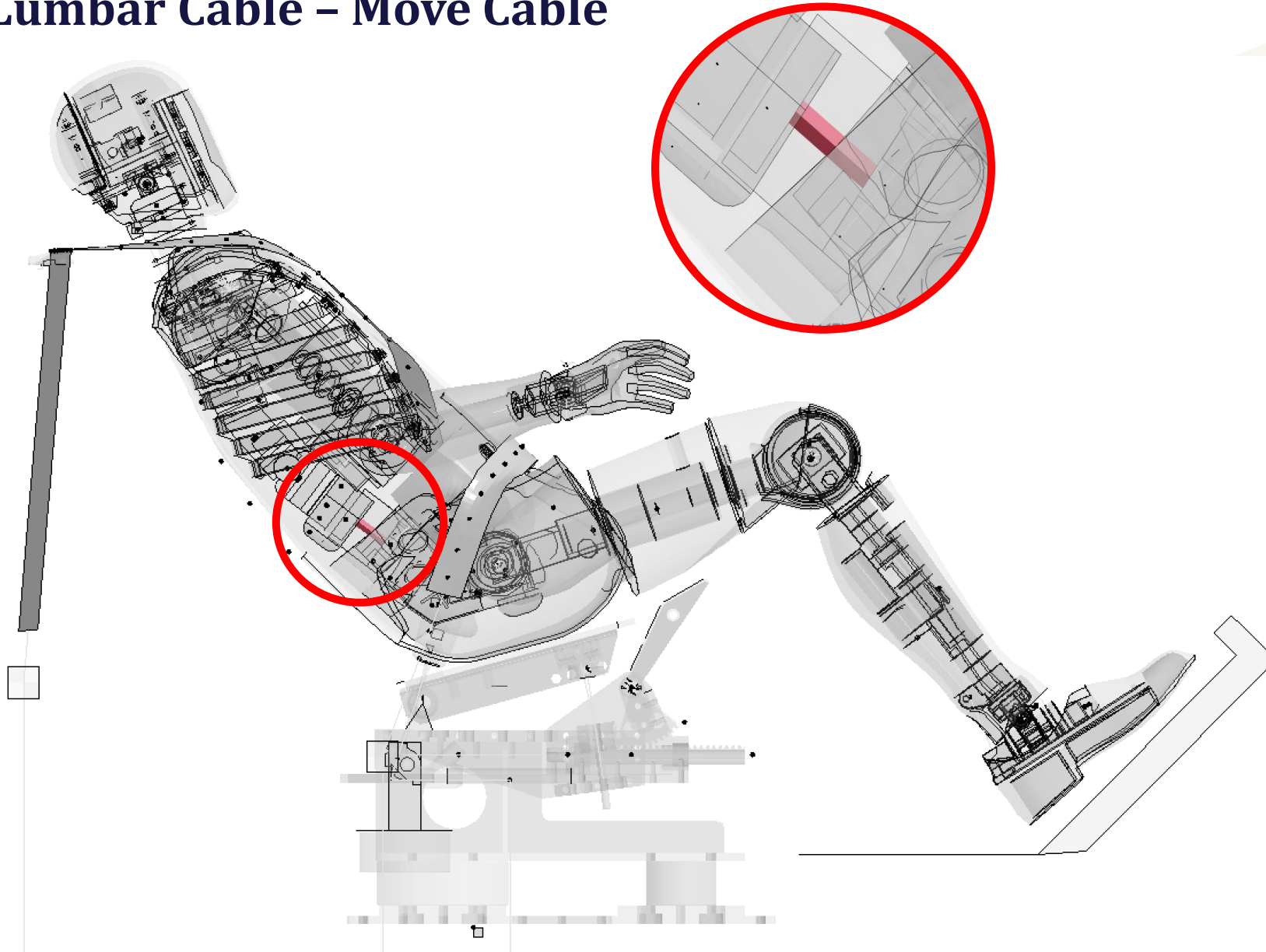
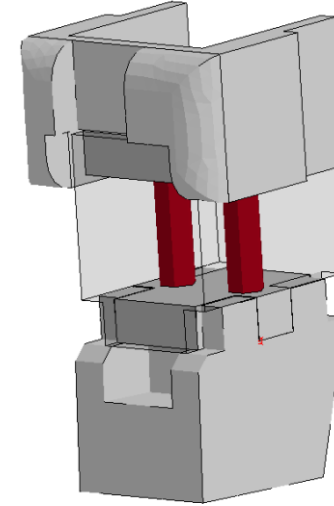
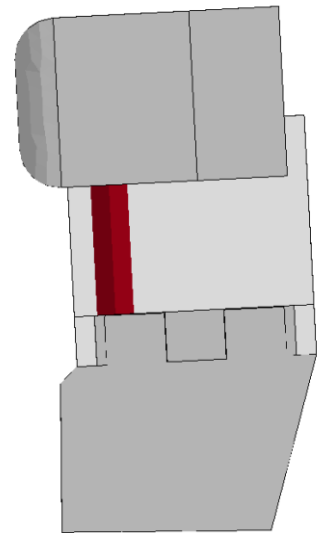
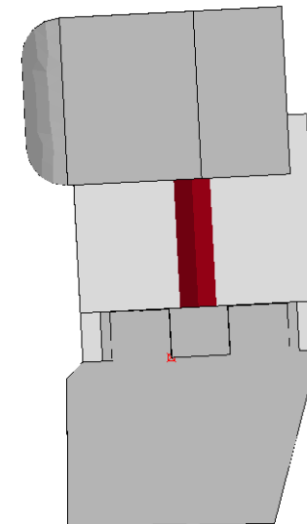
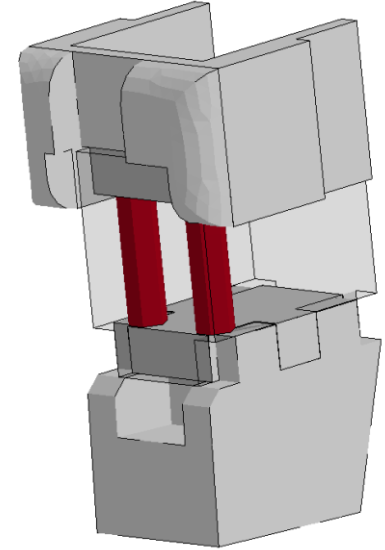
Lumbar Cable



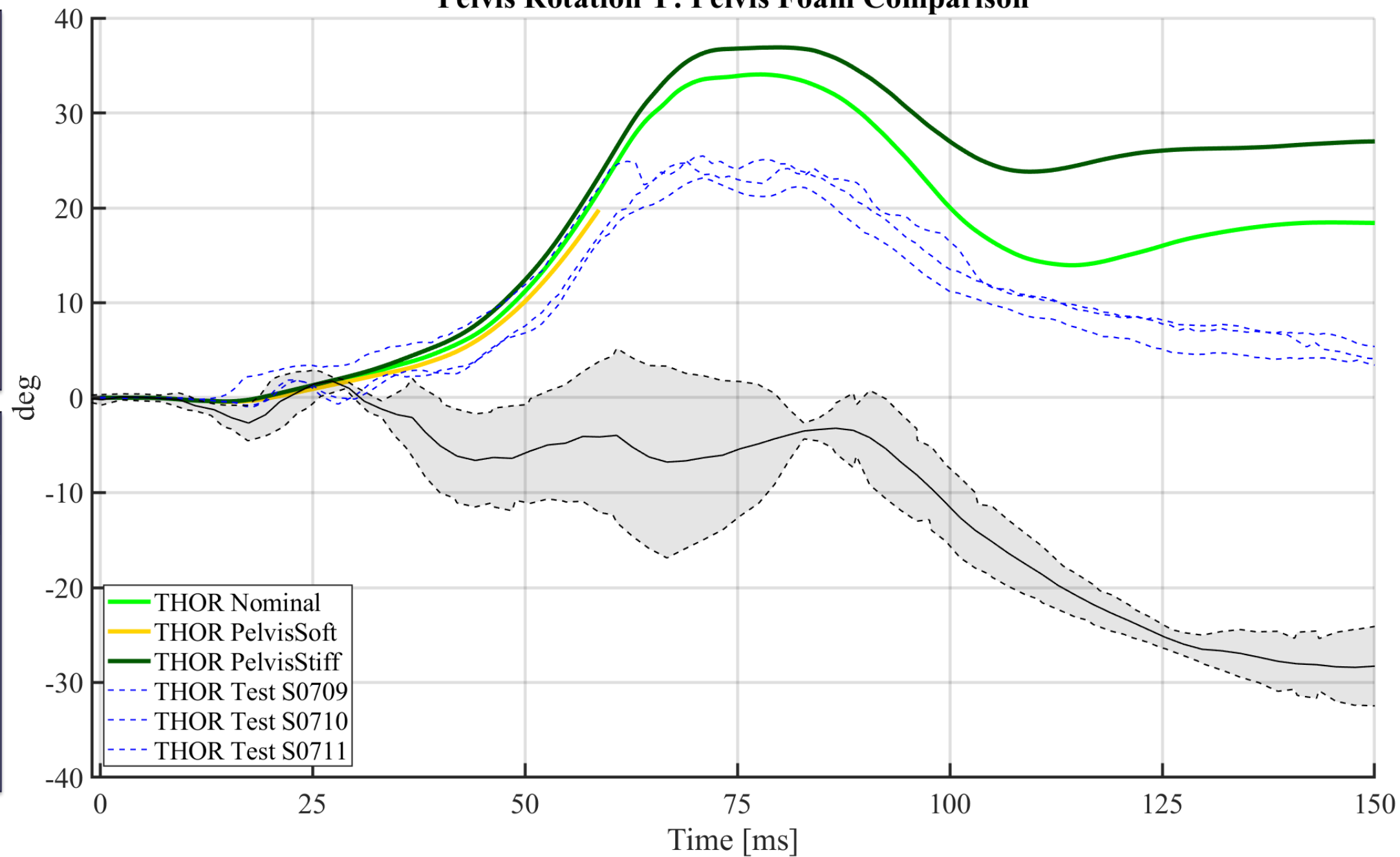
Lumbar Cable – Add Cable

**Org.****Mod.**

Lumbar Cable – Move Cable

**Org.****Mod.**

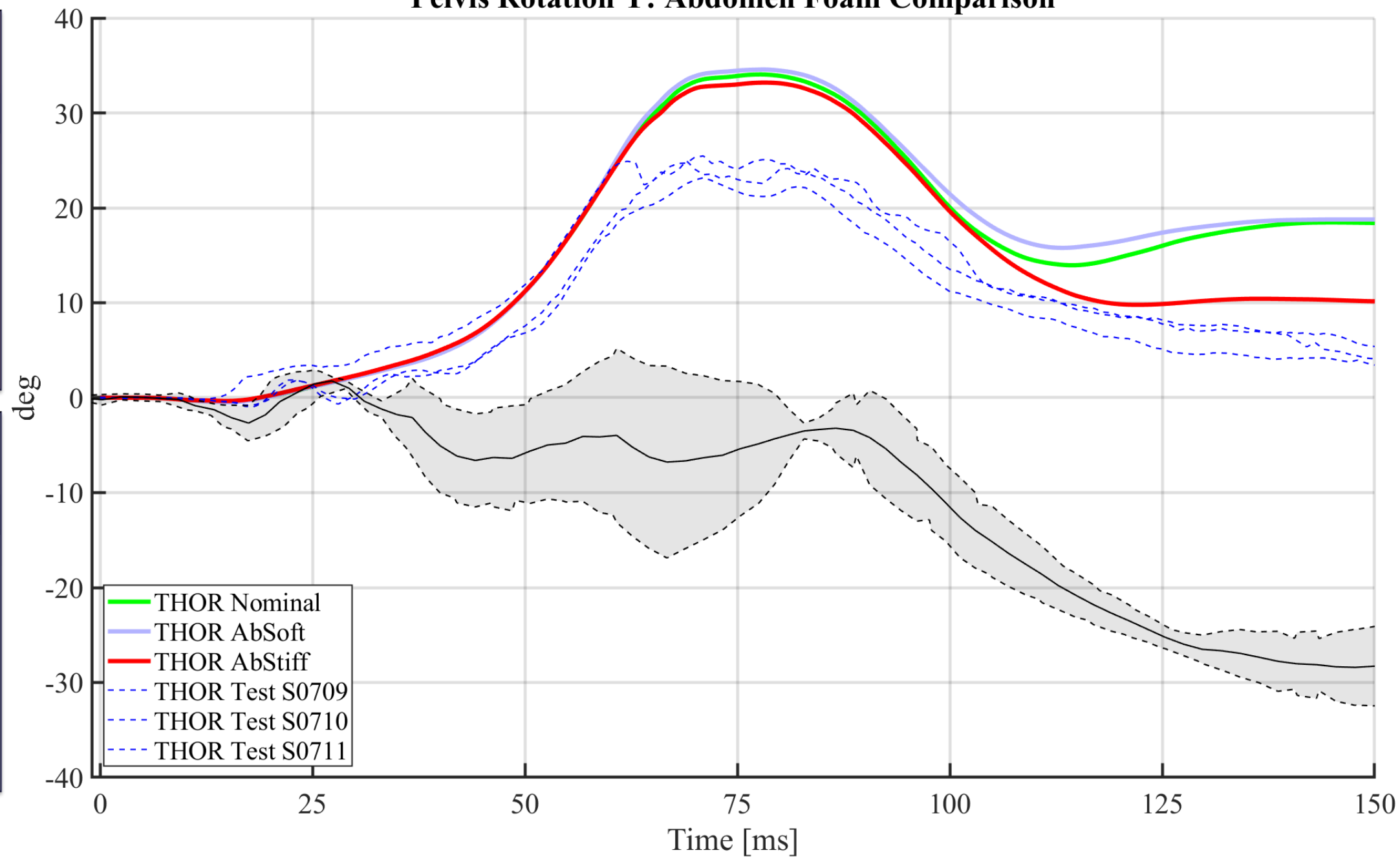
Pelvis Rotation Y: Pelvis Foam Comparison



Baseline

Baseline

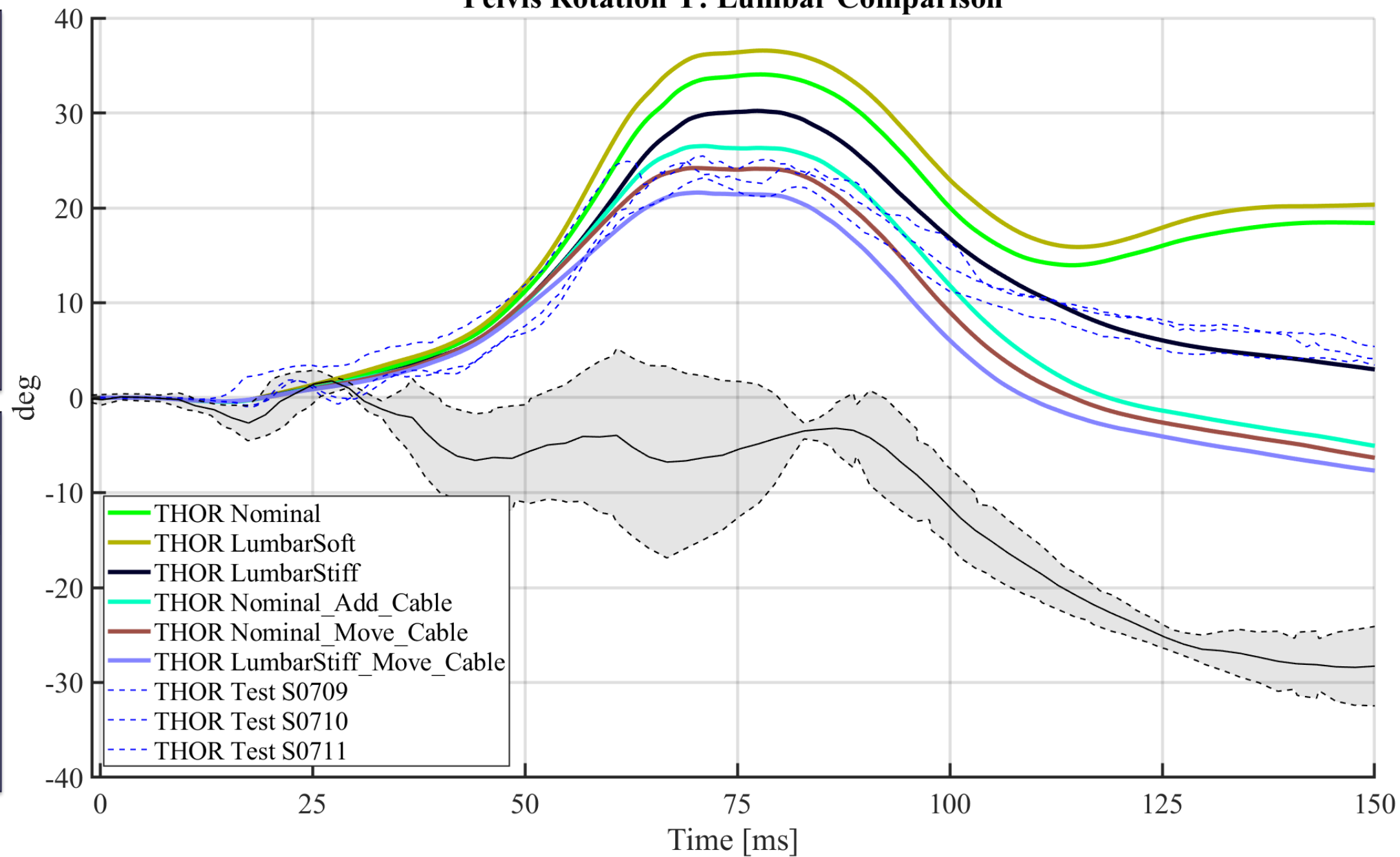
Pelvis Rotation Y: Abdomen Foam Comparison



Baseline

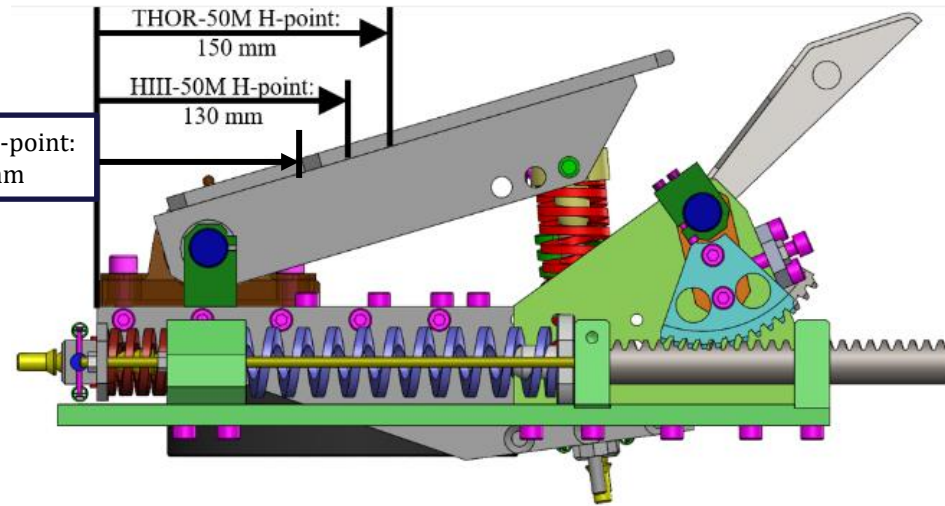
Baseline

Pelvis Rotation Y: Lumbar Comparison



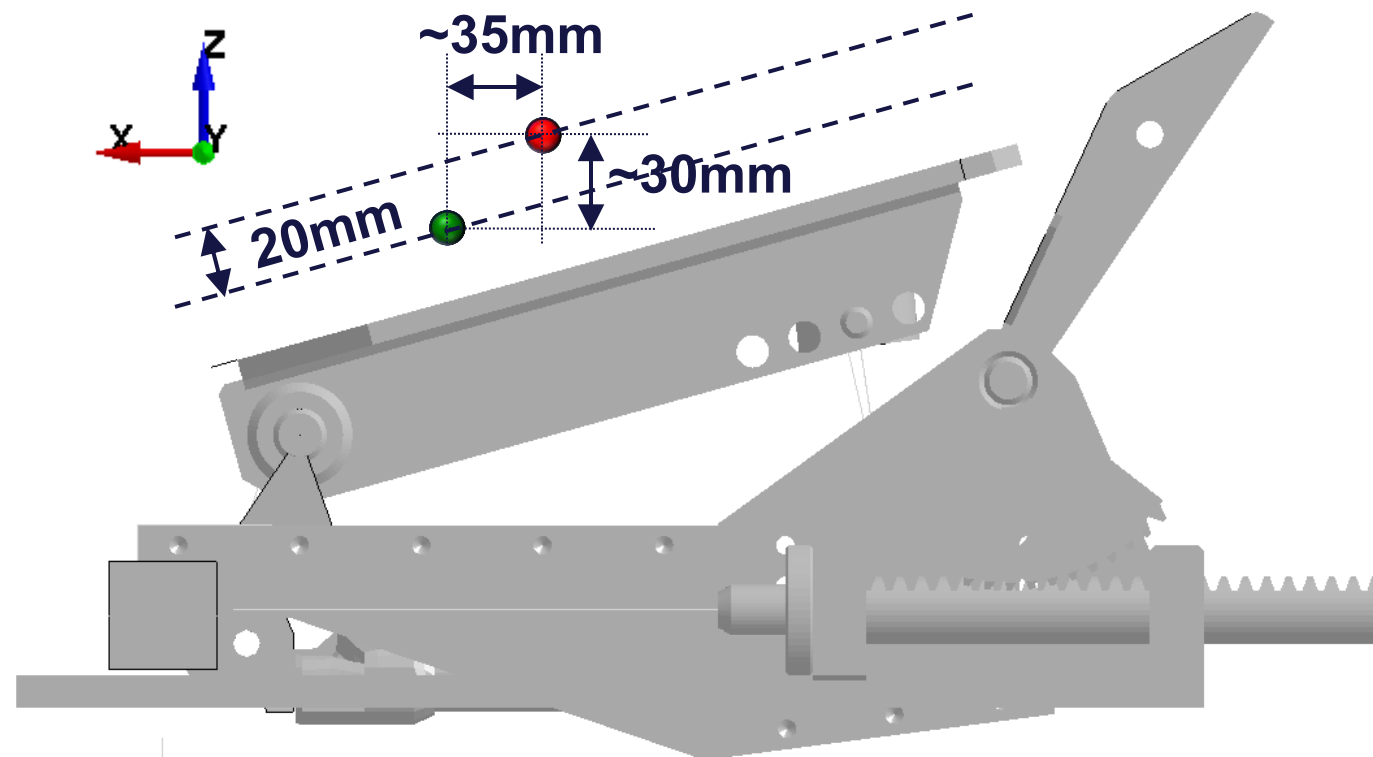
Baseline

Baseline



Surrogate	X	Y	Z		X	Z
PMHS	3077.4	0.0	643.3	SD	3.4	1.0
THOR	3044.1	0.0	672.1	SD	1.6	3.1
Difference	33.3	0.0	-28.8			

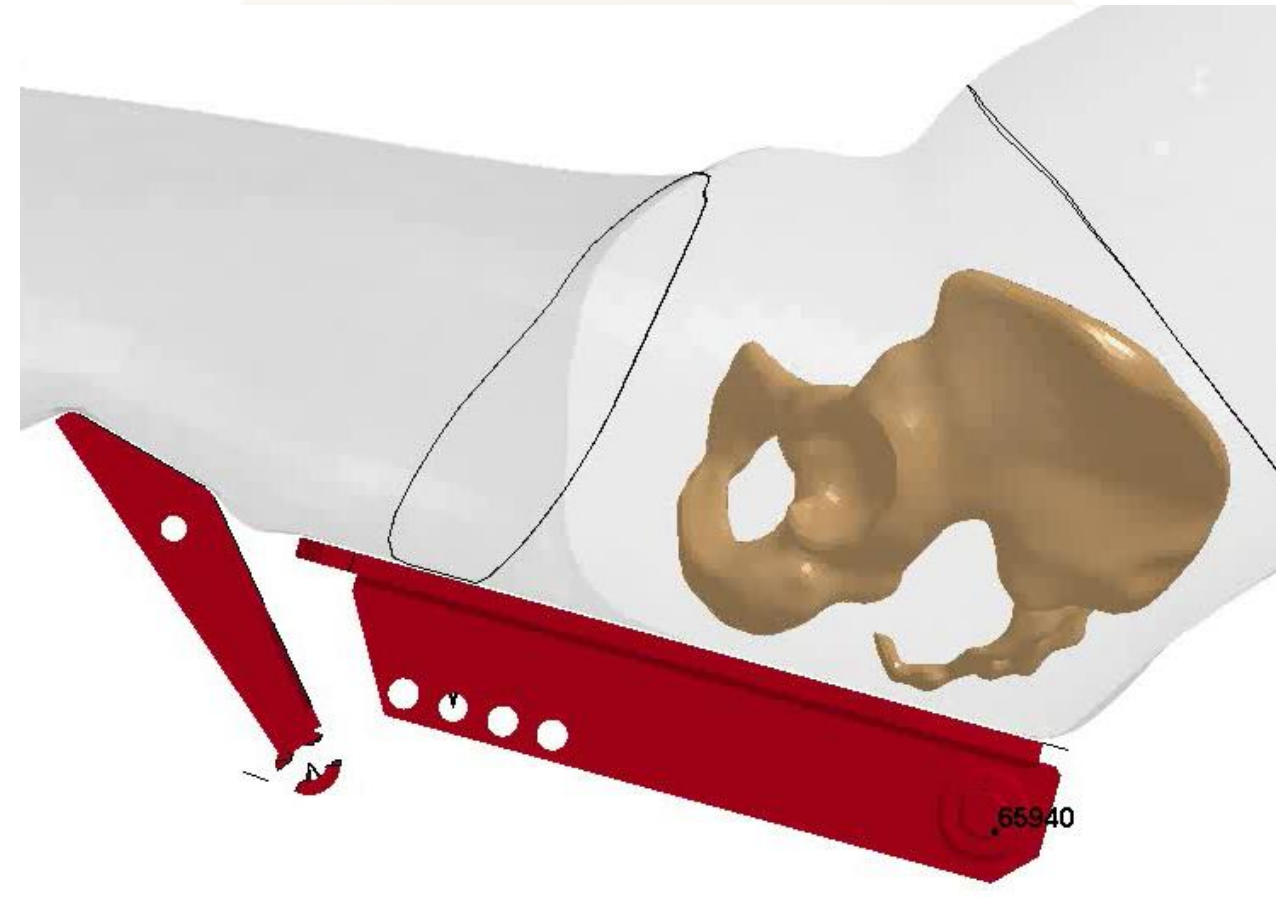
- THOR was positioned 20 mm in front of H-III due to SAE positioning guidelines – pertains to differences in pelvis/ pelvis flesh geometry



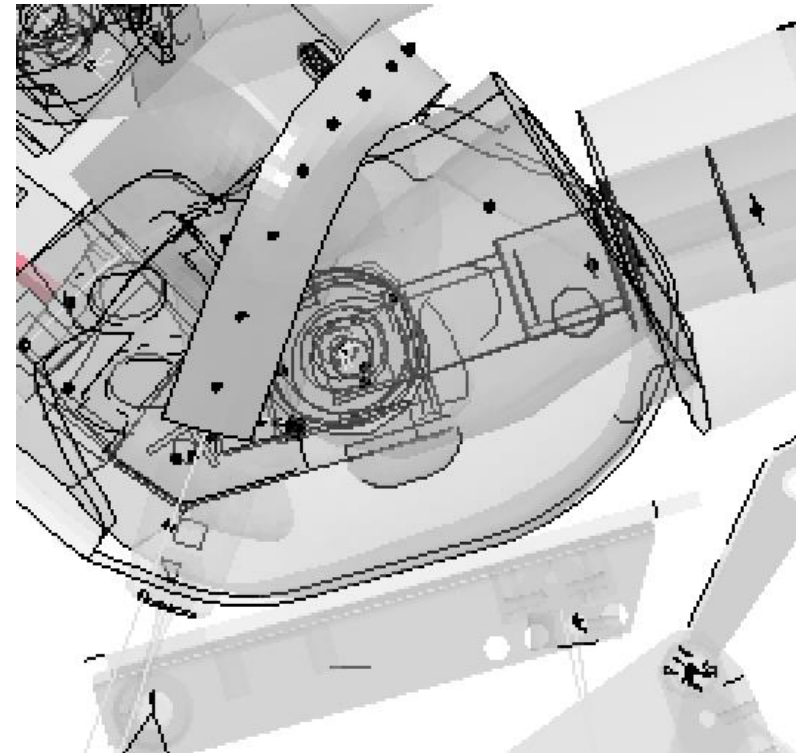
GHBMC Nominal



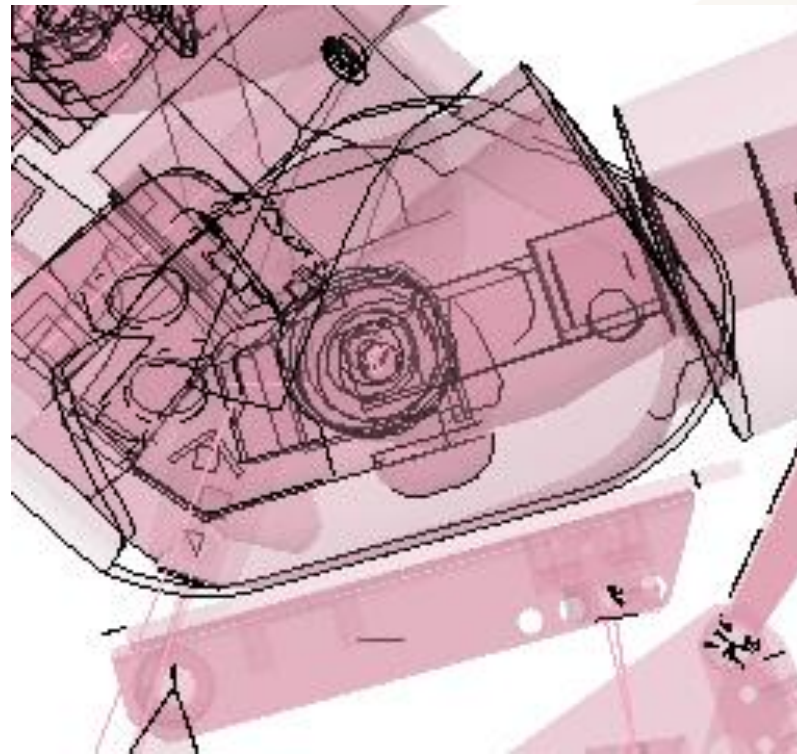
GHBMC dz -20mm



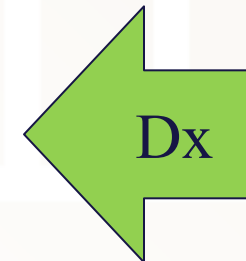
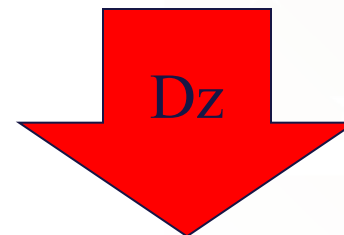
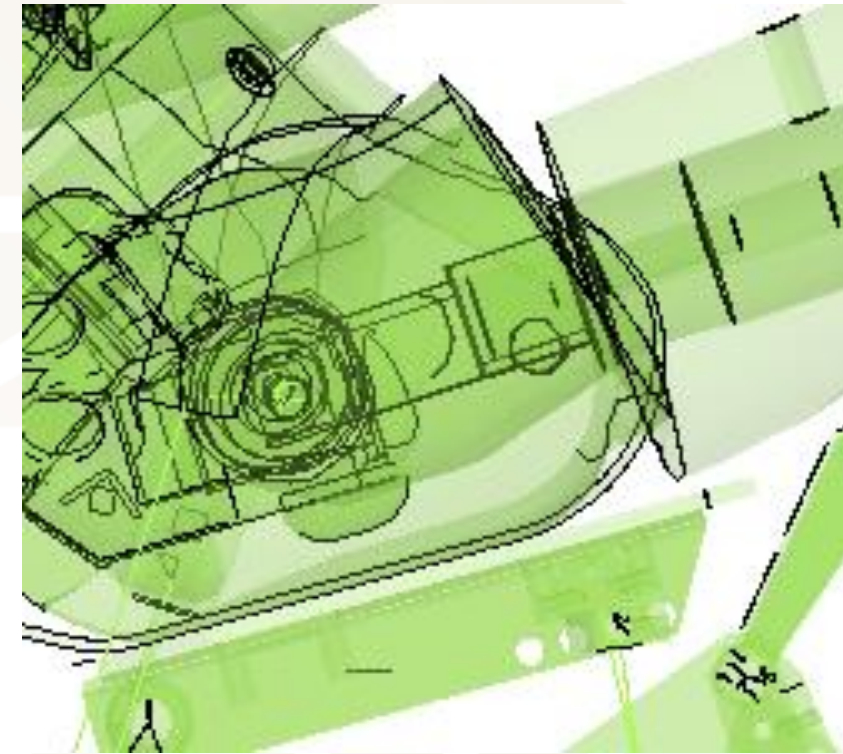
Nominal



Dz



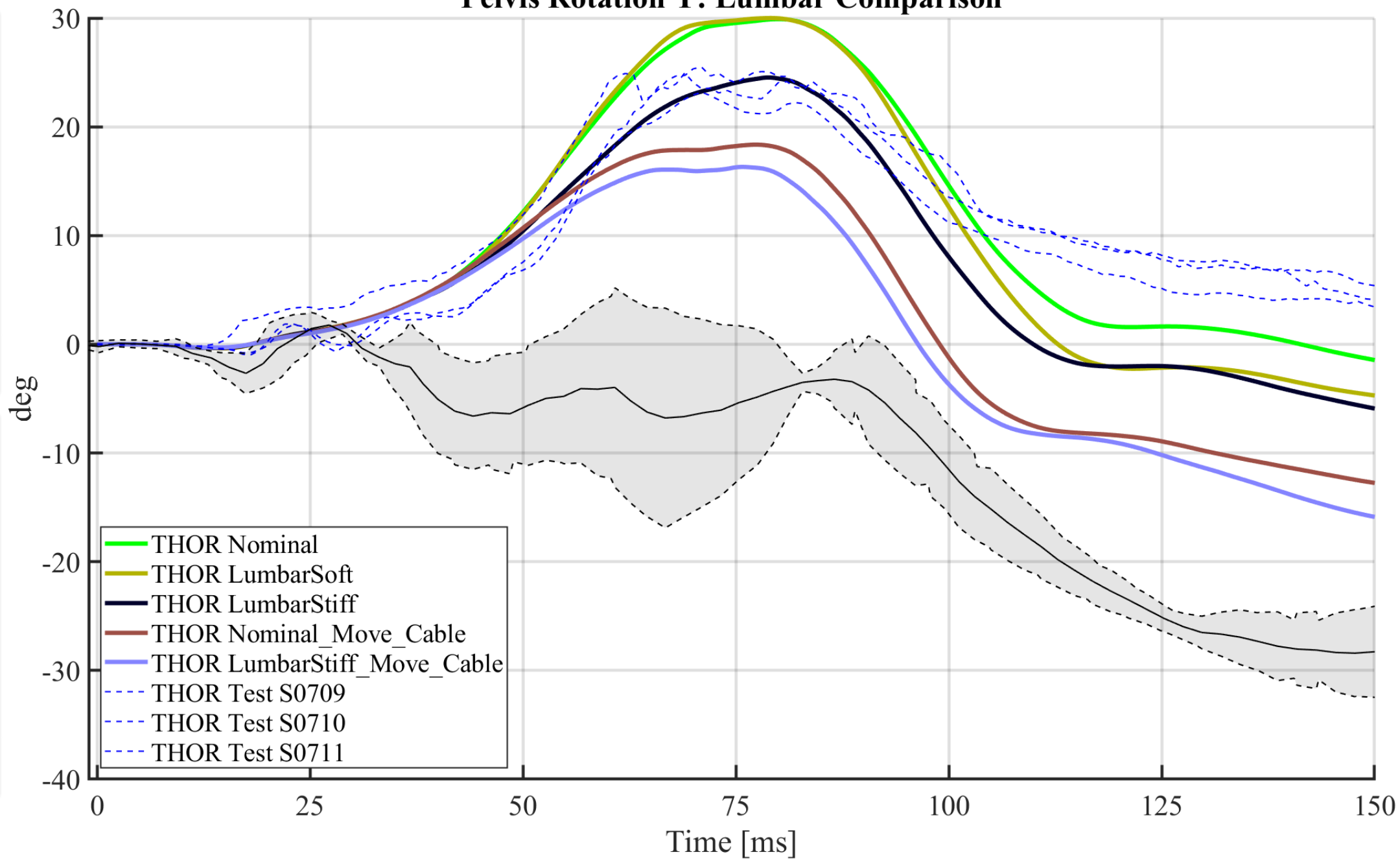
Dx Dz



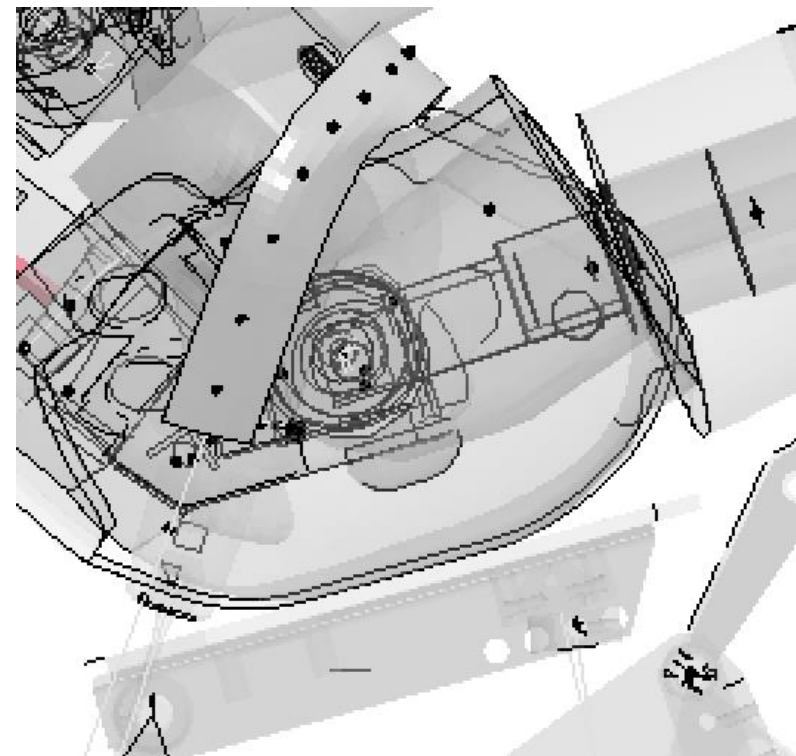
Dz

Baseline

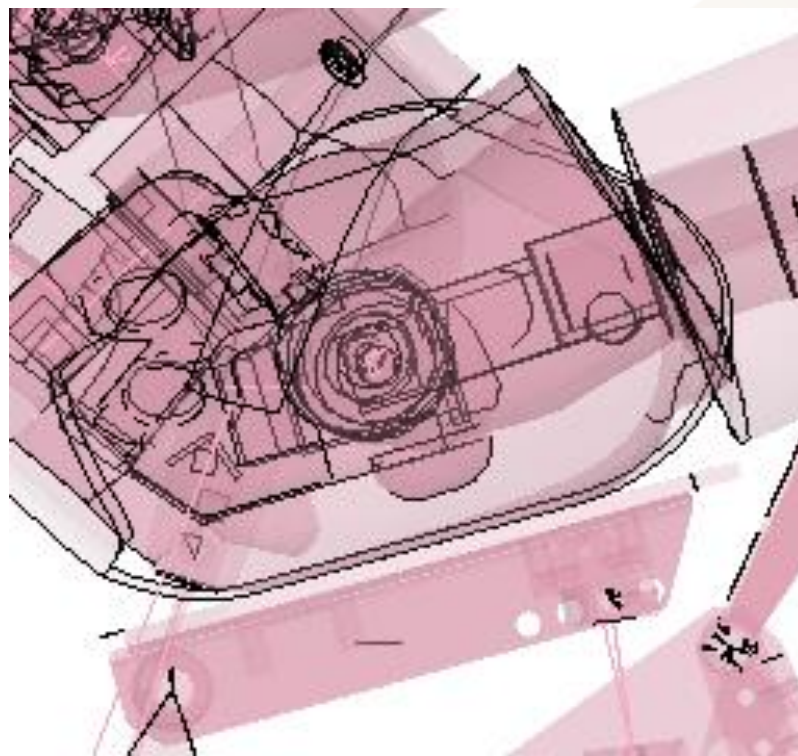
Pelvis Rotation Y: Lumbar Comparison



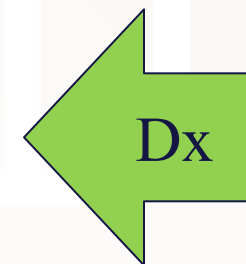
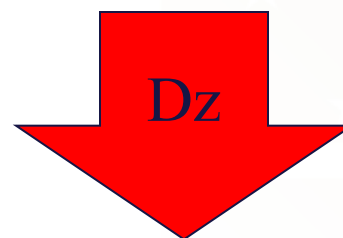
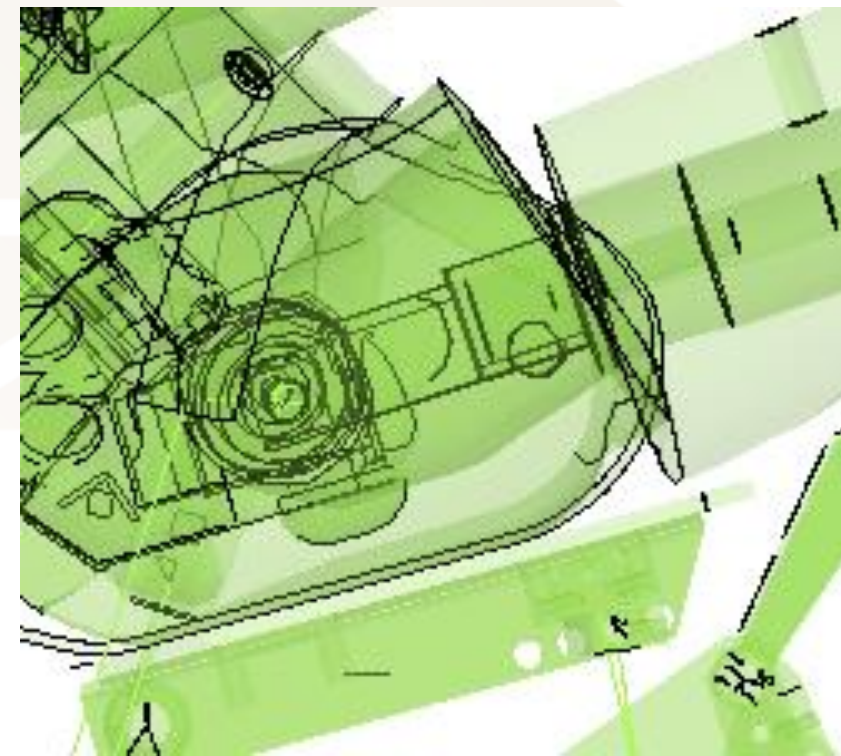
Nominal



Dz



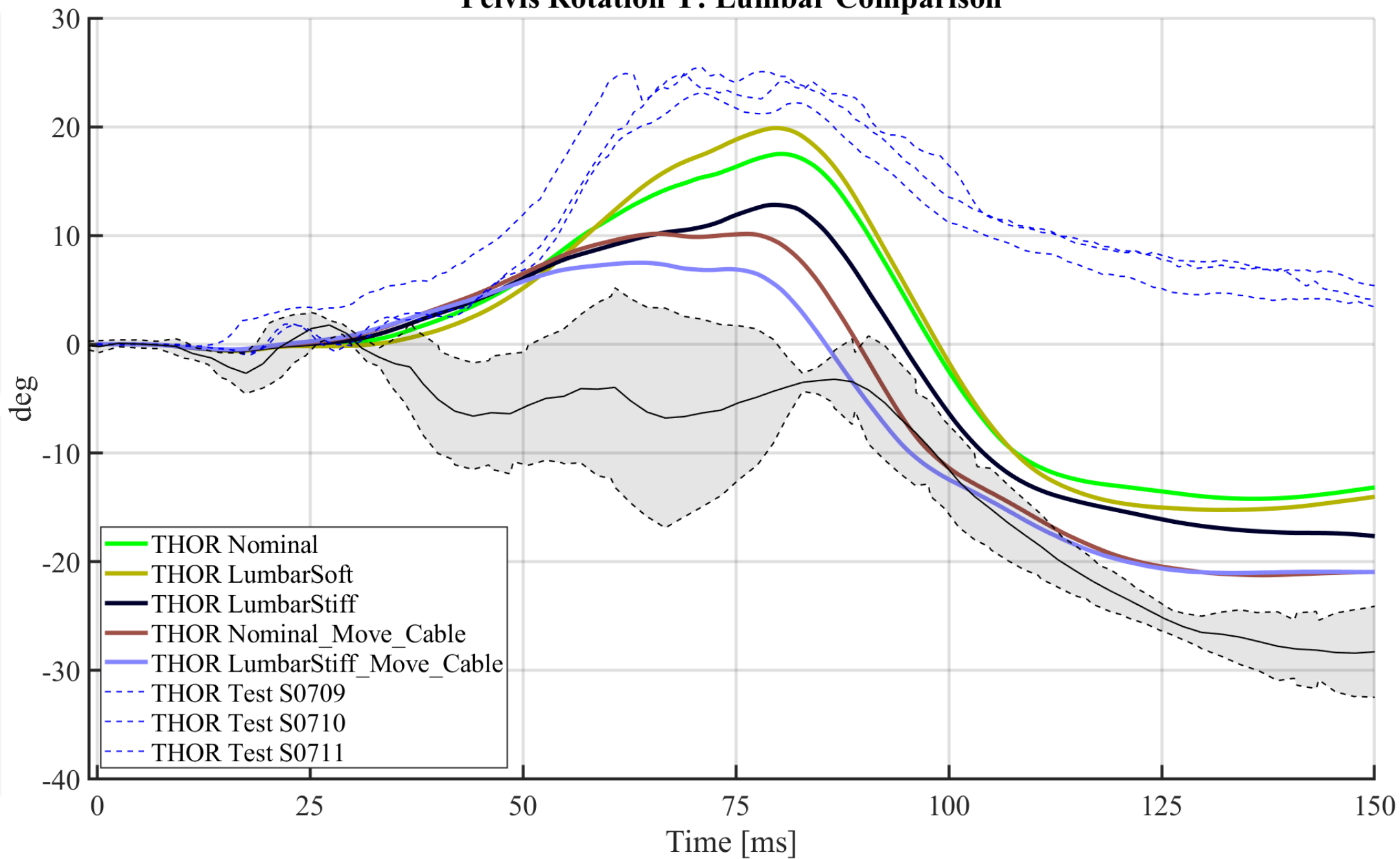
Dx Dz



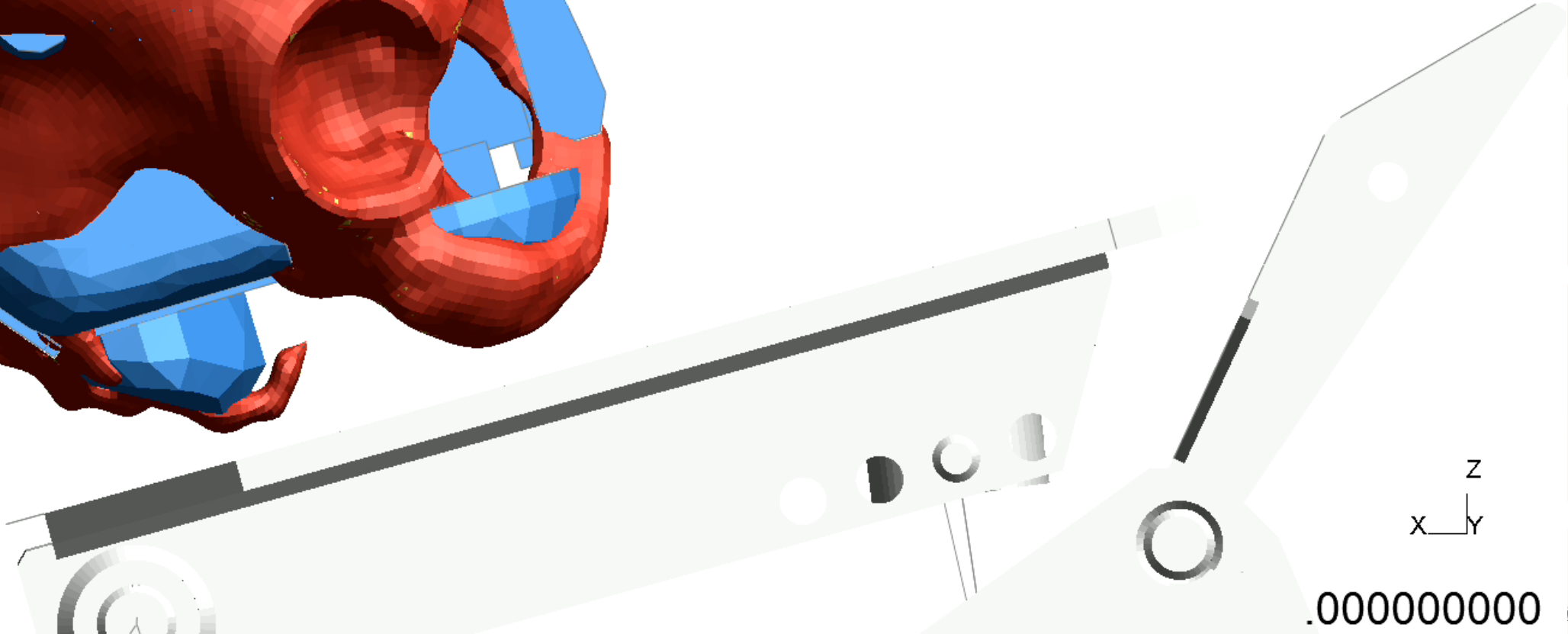
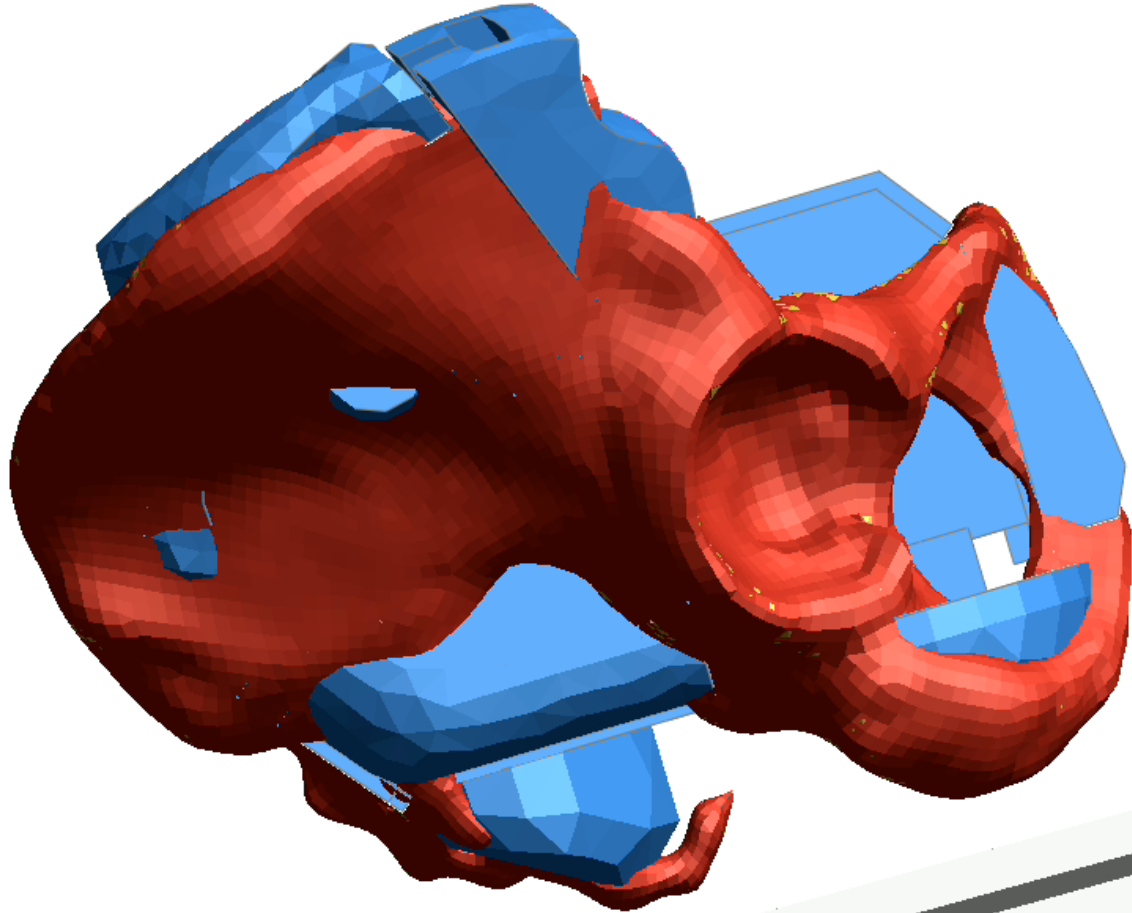
Dx, Dz

Baseline

Pelvis Rotation Y: Lumbar Comparison

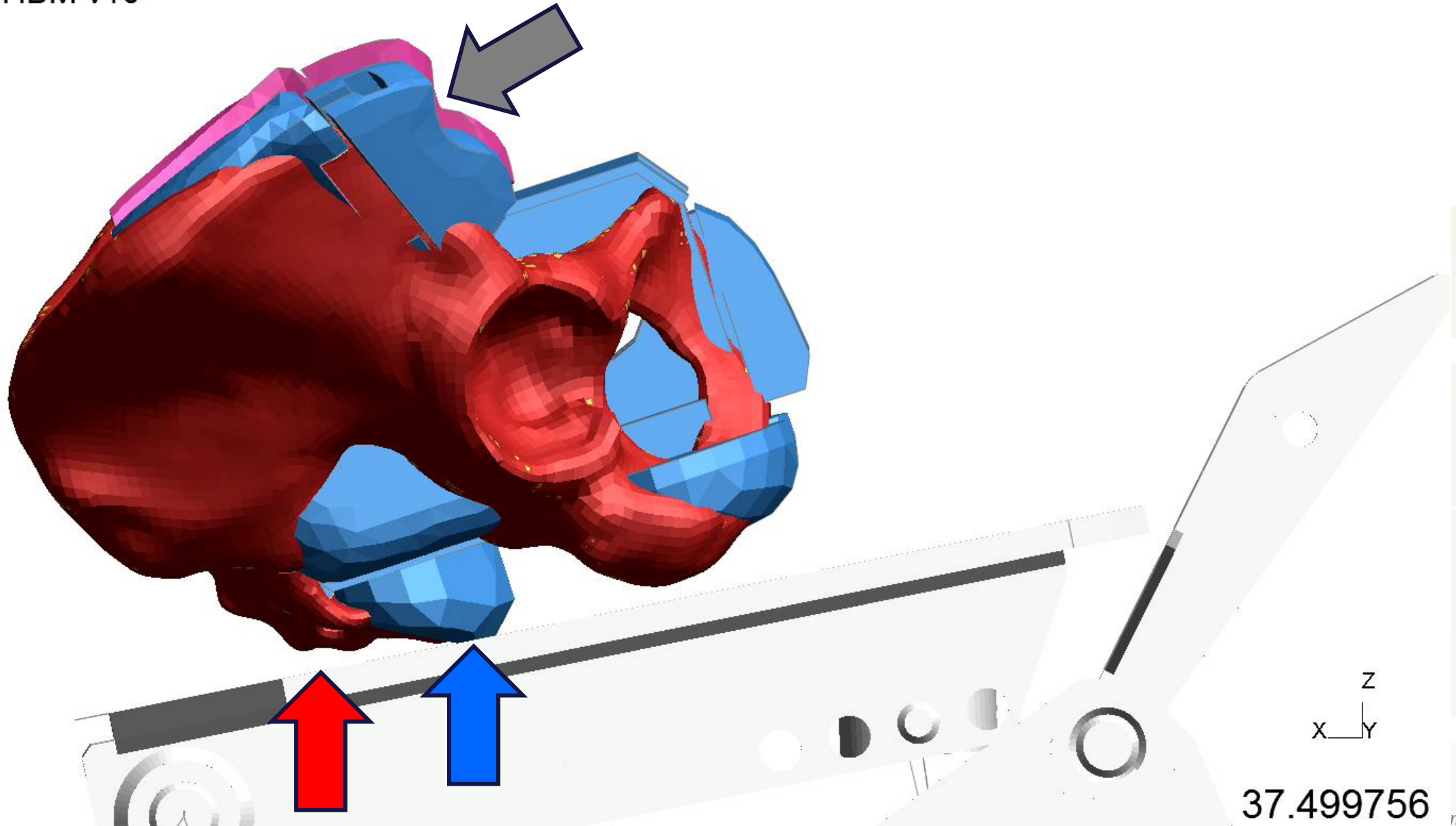


D3PLOT: M1: LS-DYNA keyword deck by LS-PrePost
M2: HBM v10

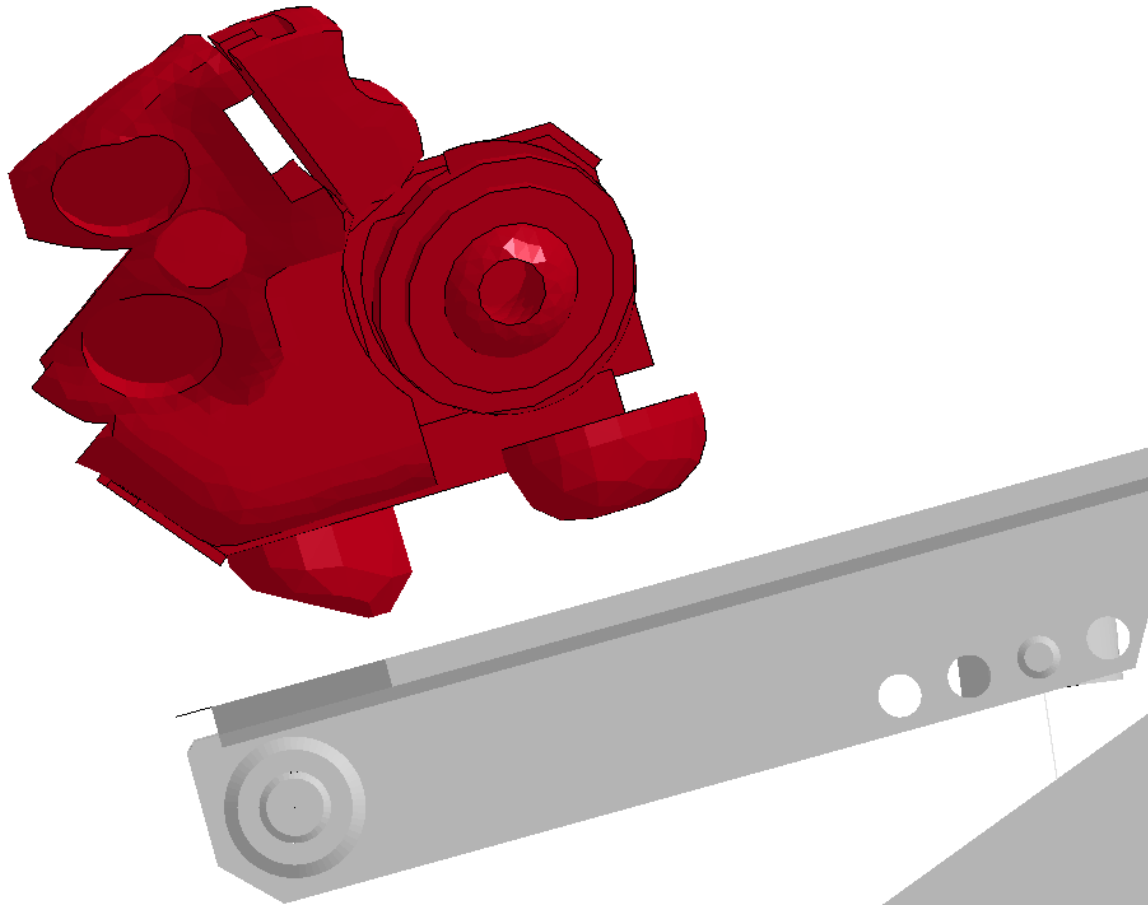


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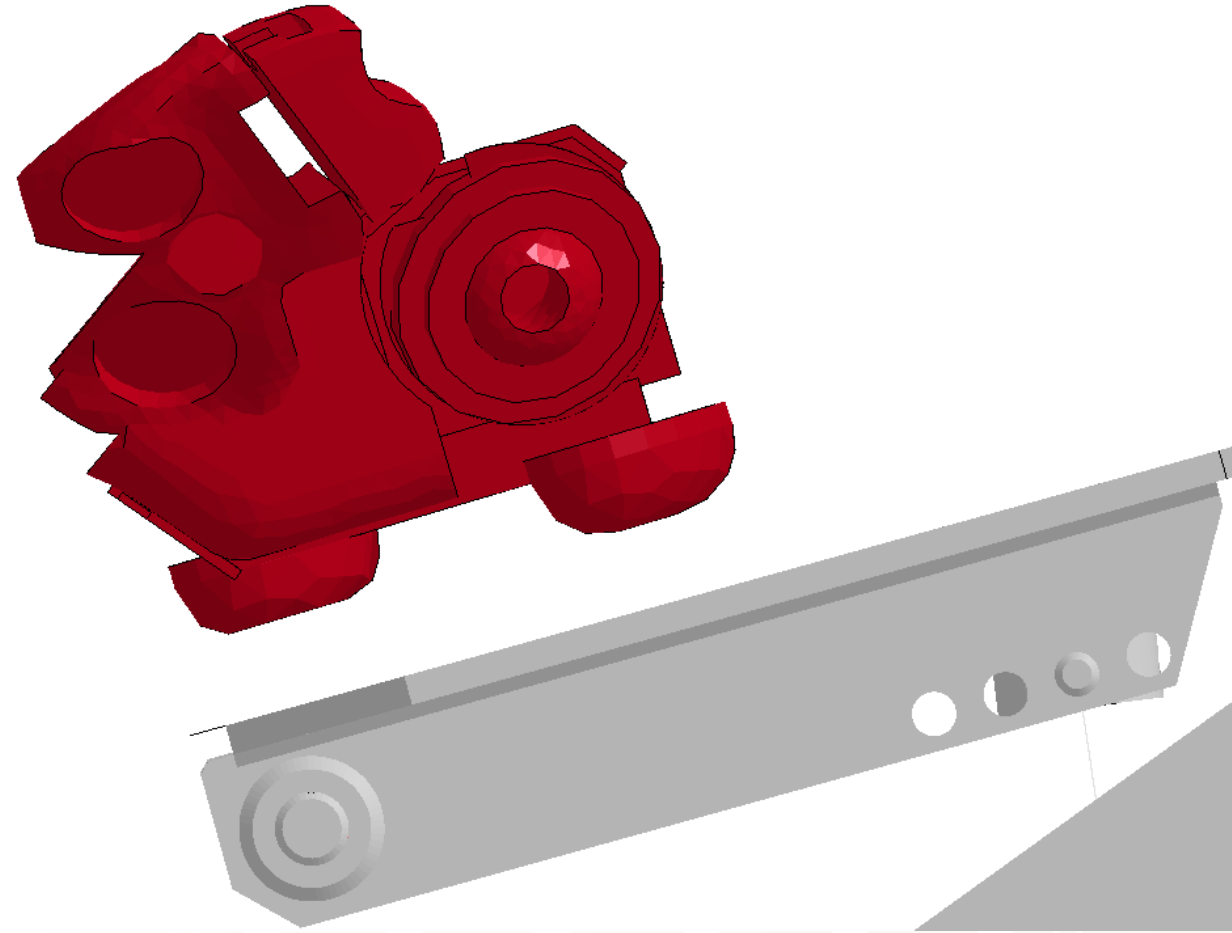
D3PLOT: M1: LS-DYNA keyword deck by LS-PrePost
M2: HBM v10



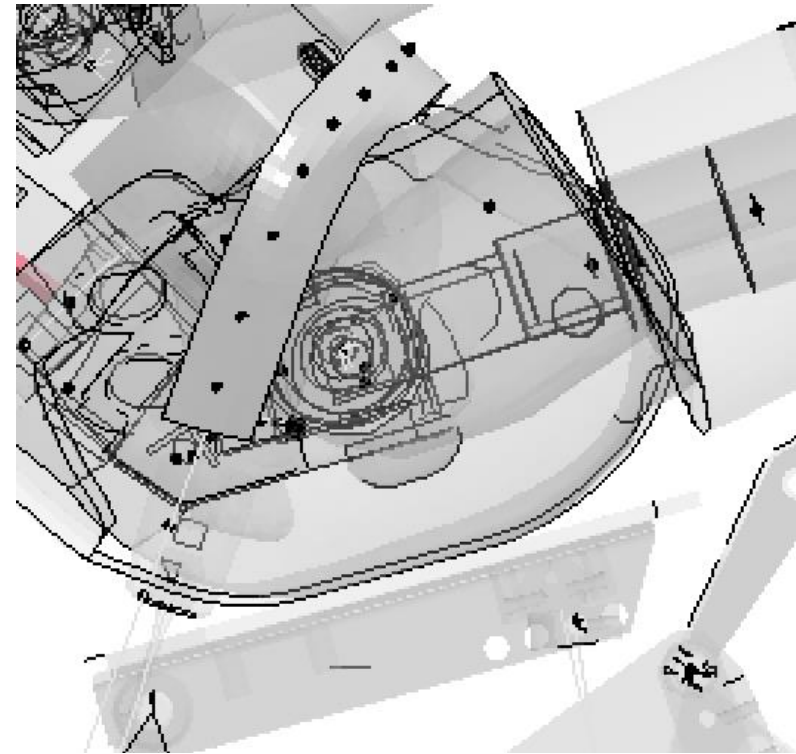
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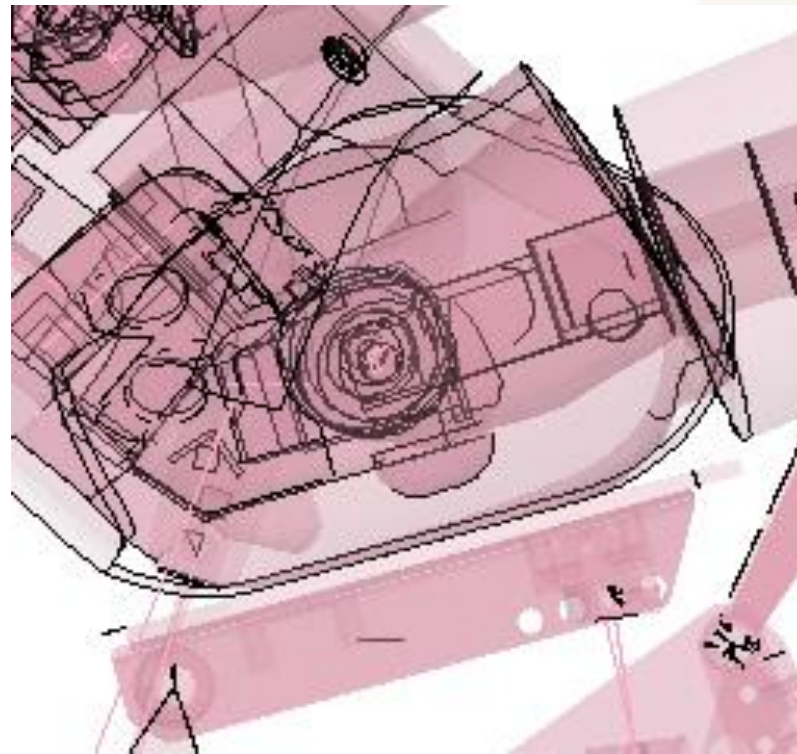
Sacrum mod.



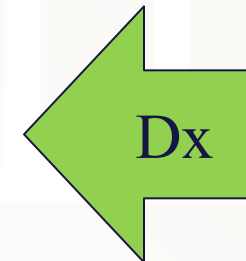
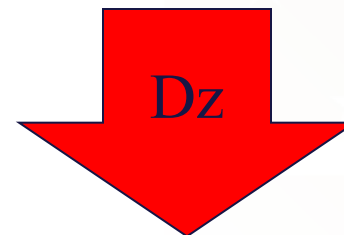
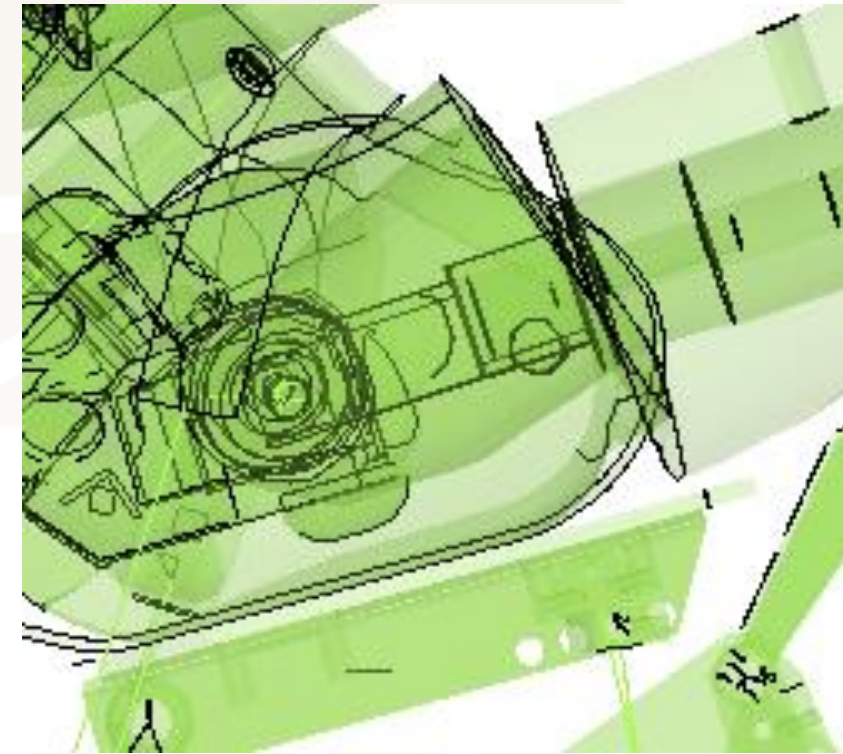
Nominal



Dz



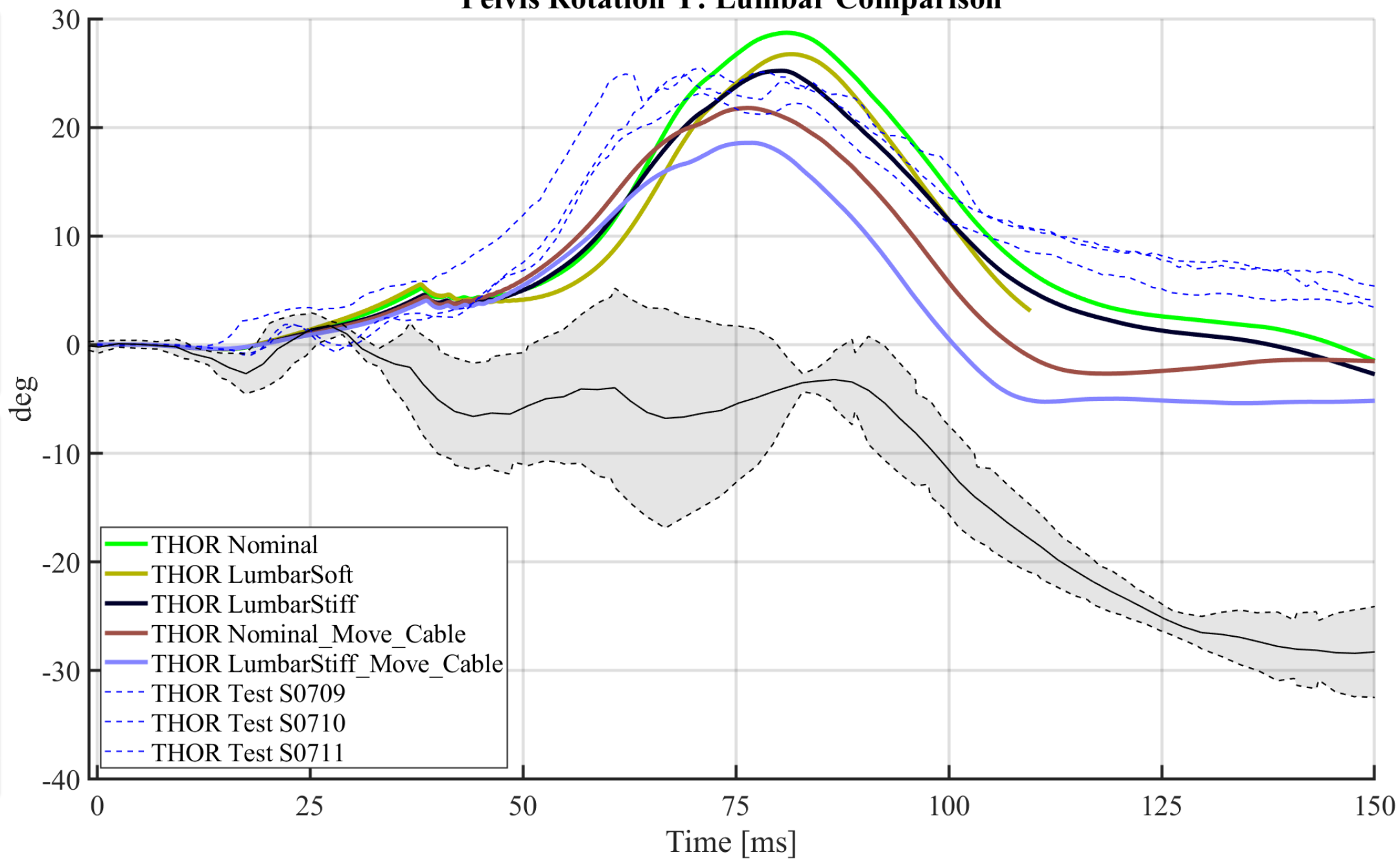
Dx Dz



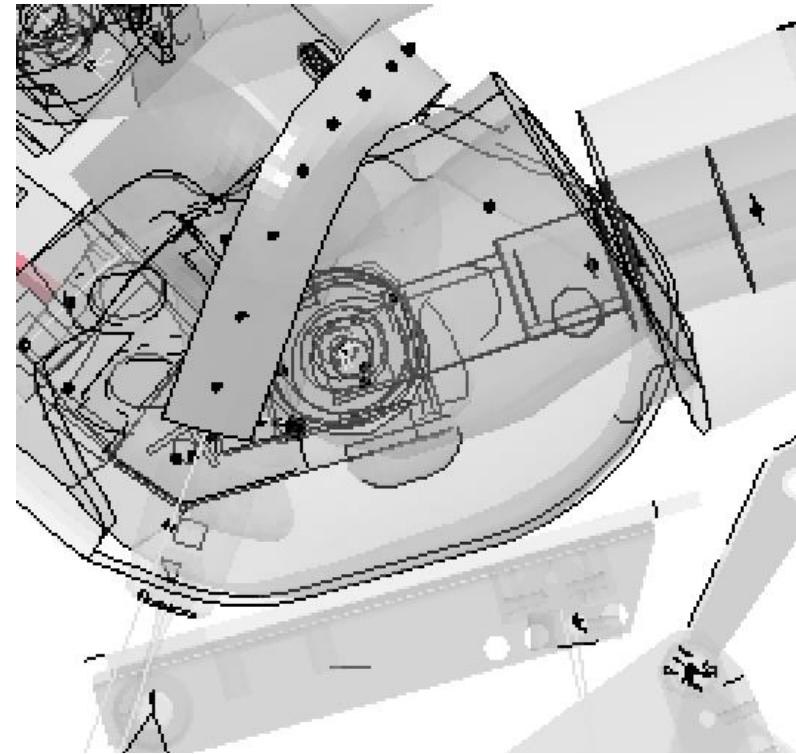
Baseline

New Sacrum

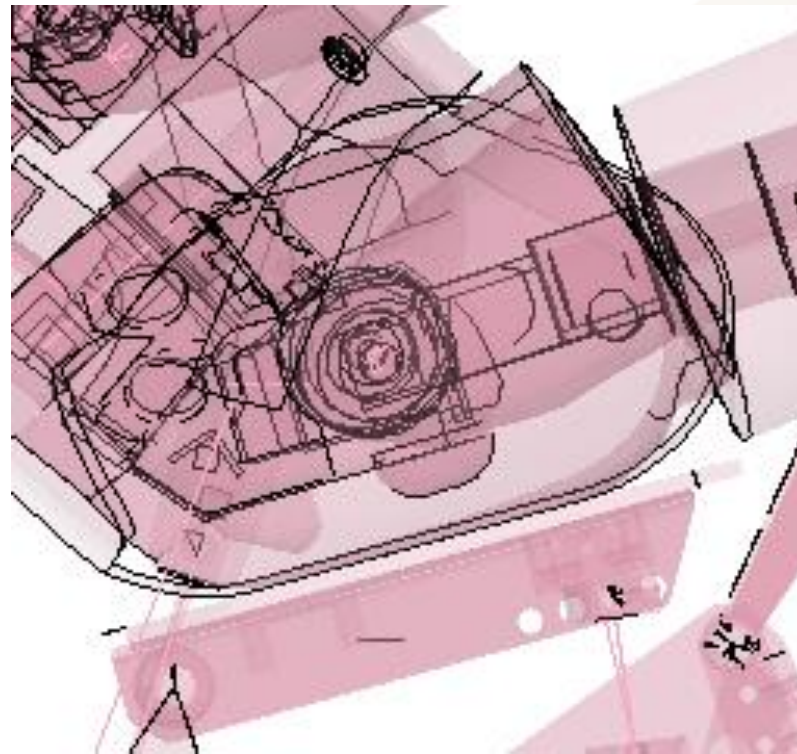
Pelvis Rotation Y: Lumbar Comparison



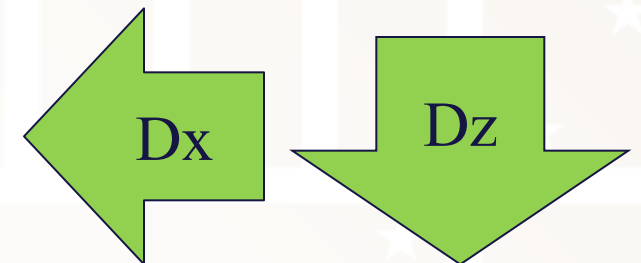
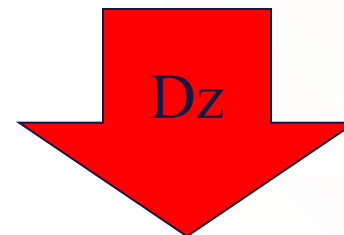
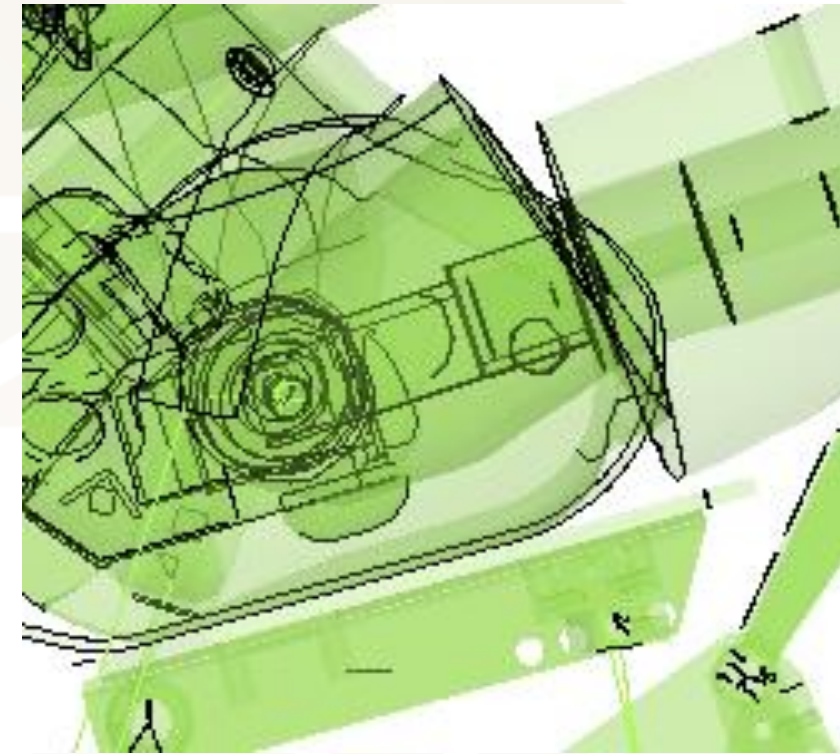
Nominal



Dz



Dx Dz

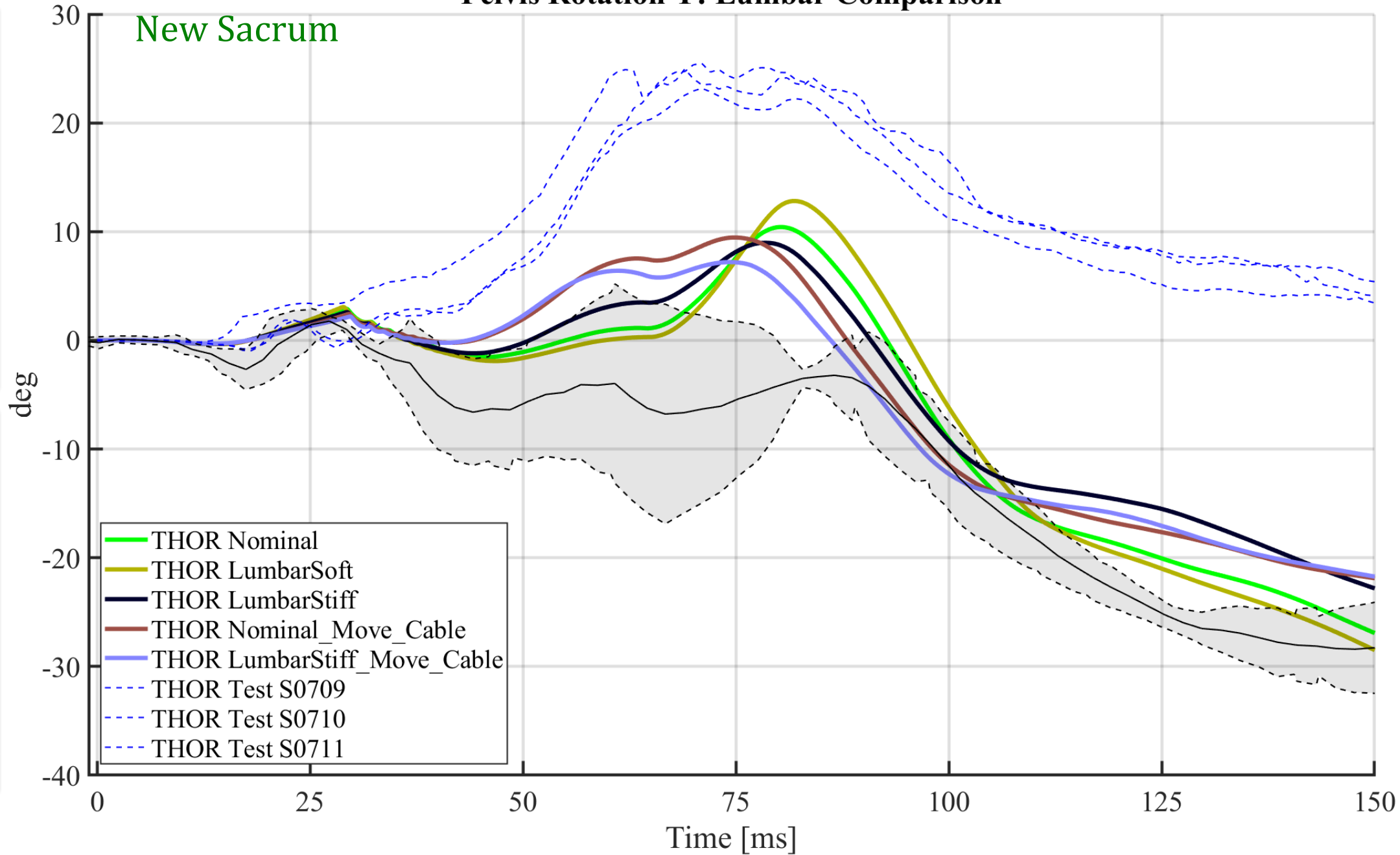


Dz

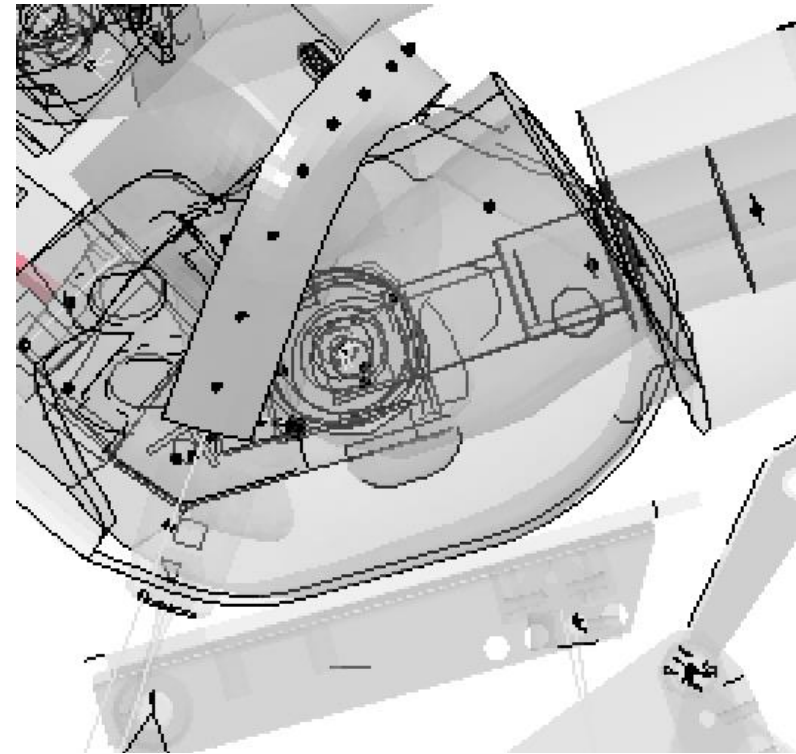
New Sacrum

Pelvis Rotation Y: Lumbar Comparison

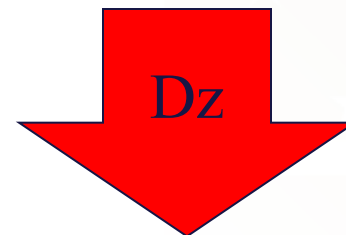
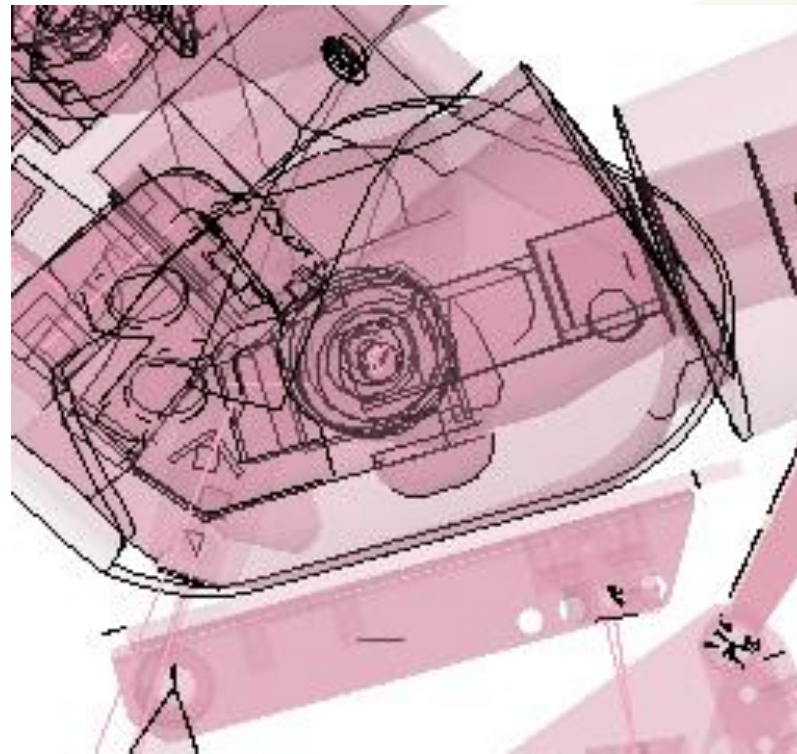
DZ
New Sacrum



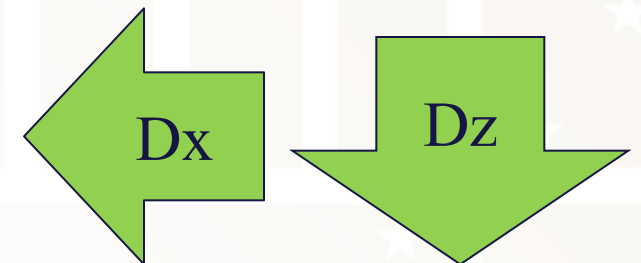
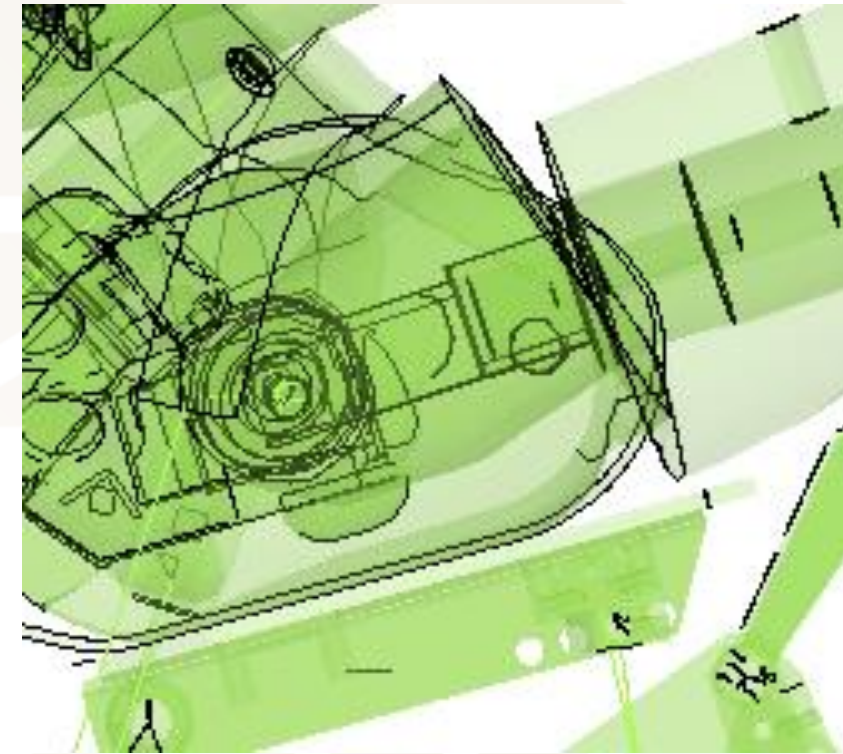
Nominal



Dz



Dx Dz



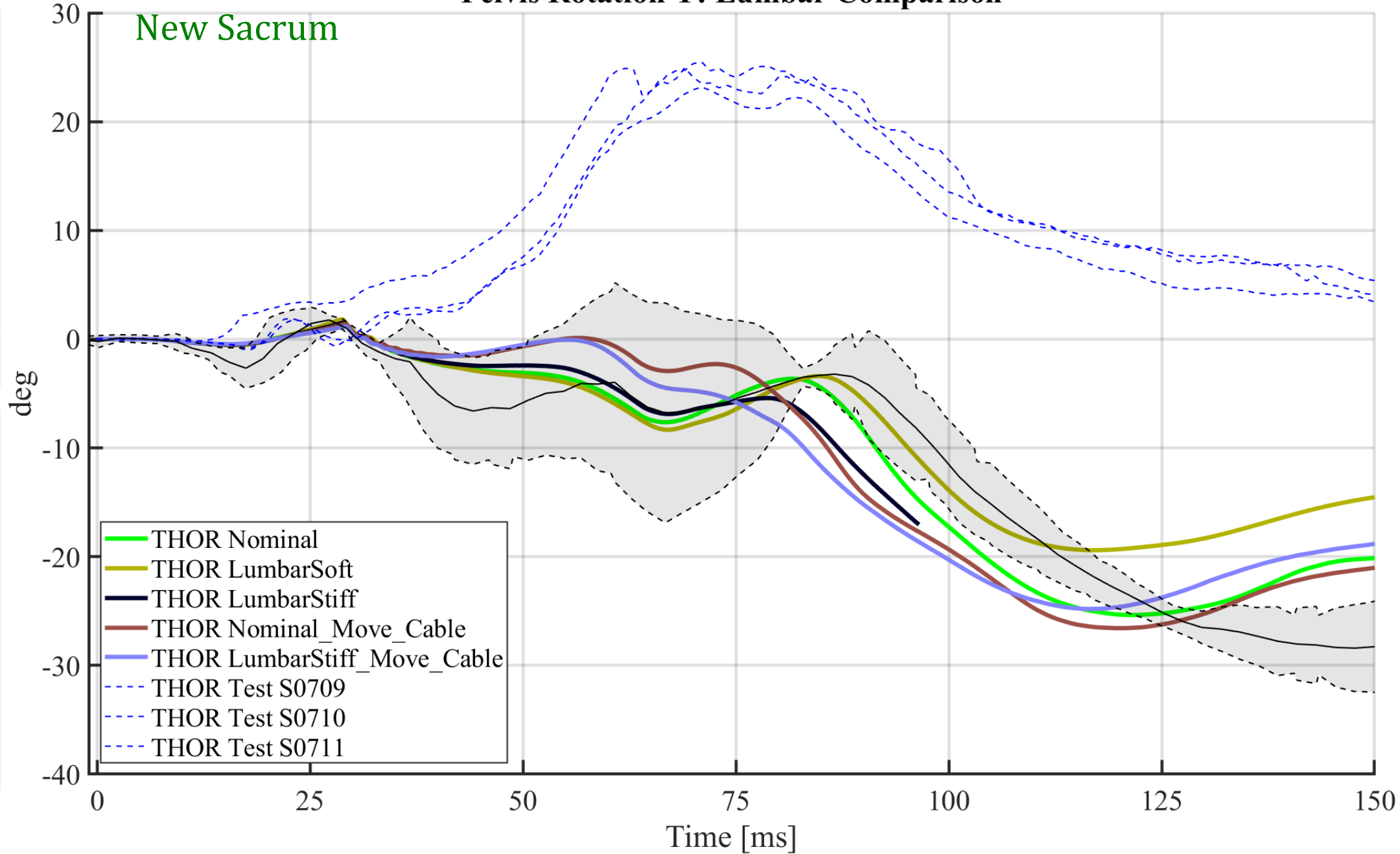
Dx, Dz

New Sacrum

Pelvis Rotation Y: Lumbar Comparison

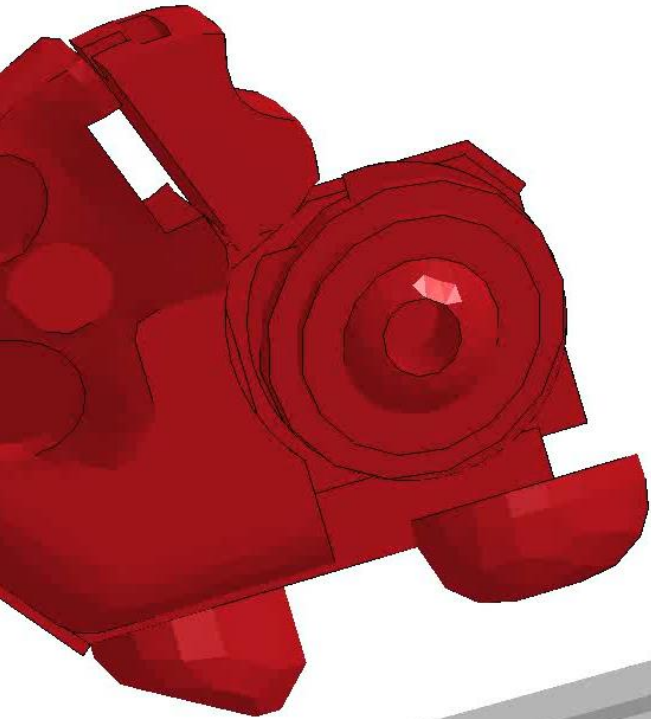
DXDZ

New Sacrum

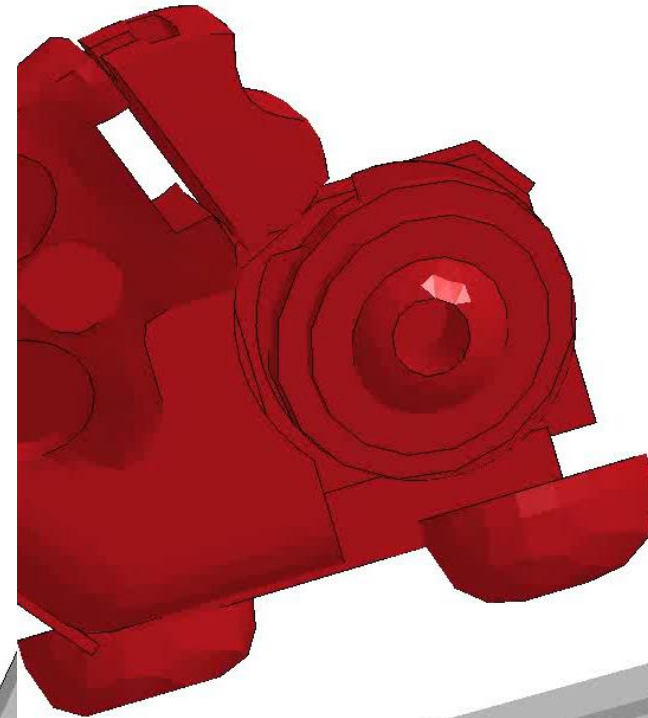


Nominal

PrePost



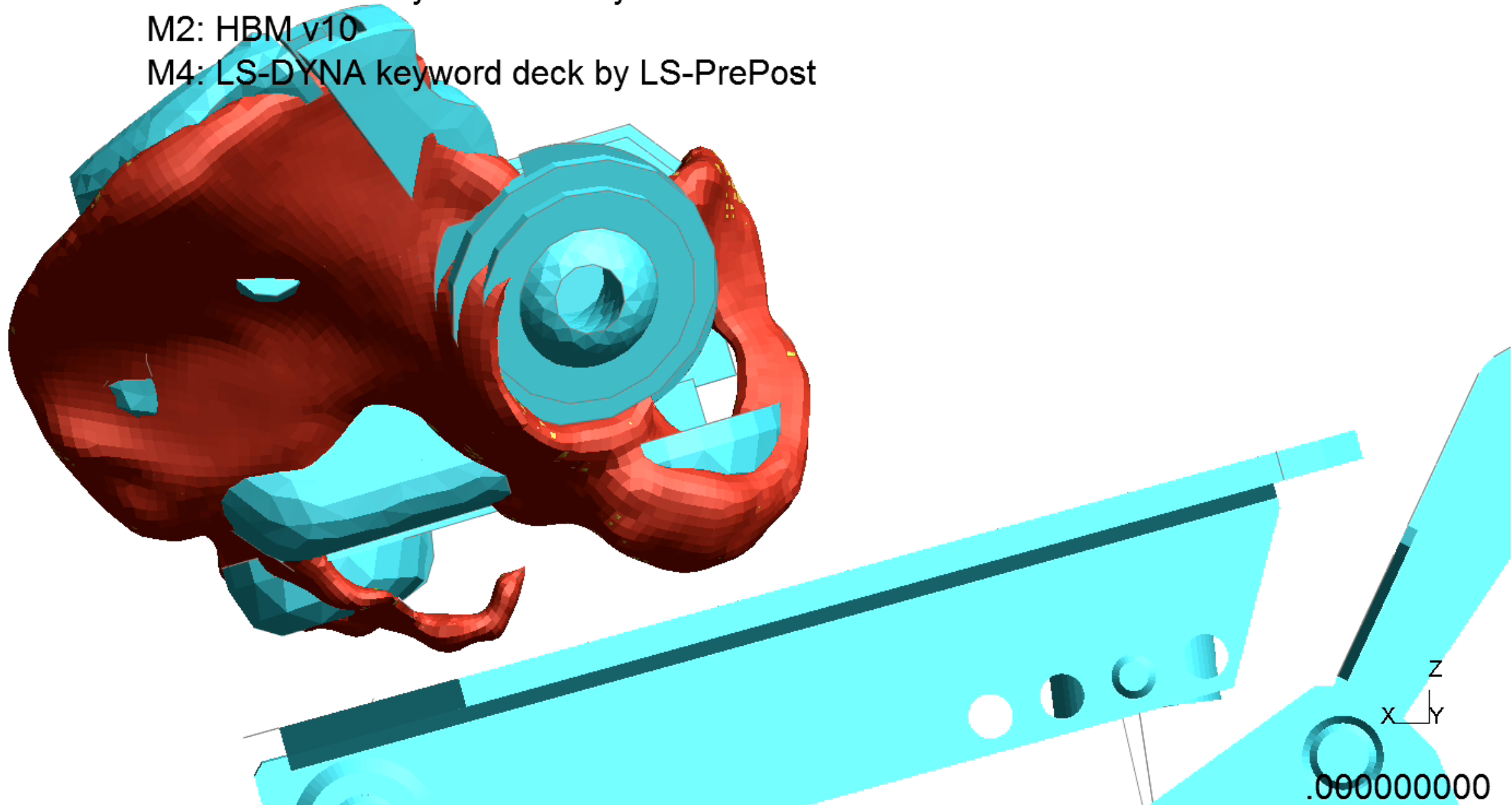
Sacrum mod.



85090

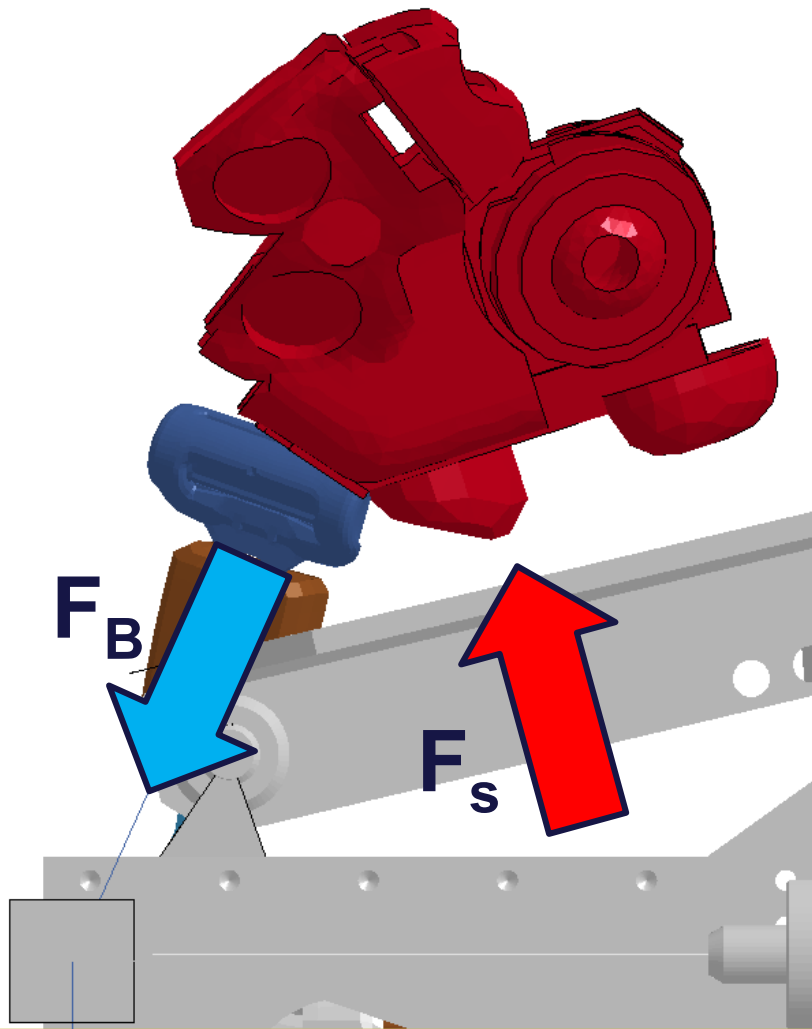
85139

D3PLOT: M1: LS-DYNA keyword deck by LS-PrePost
M2: HBM v10
M4: LS-DYNA keyword deck by LS-PrePost

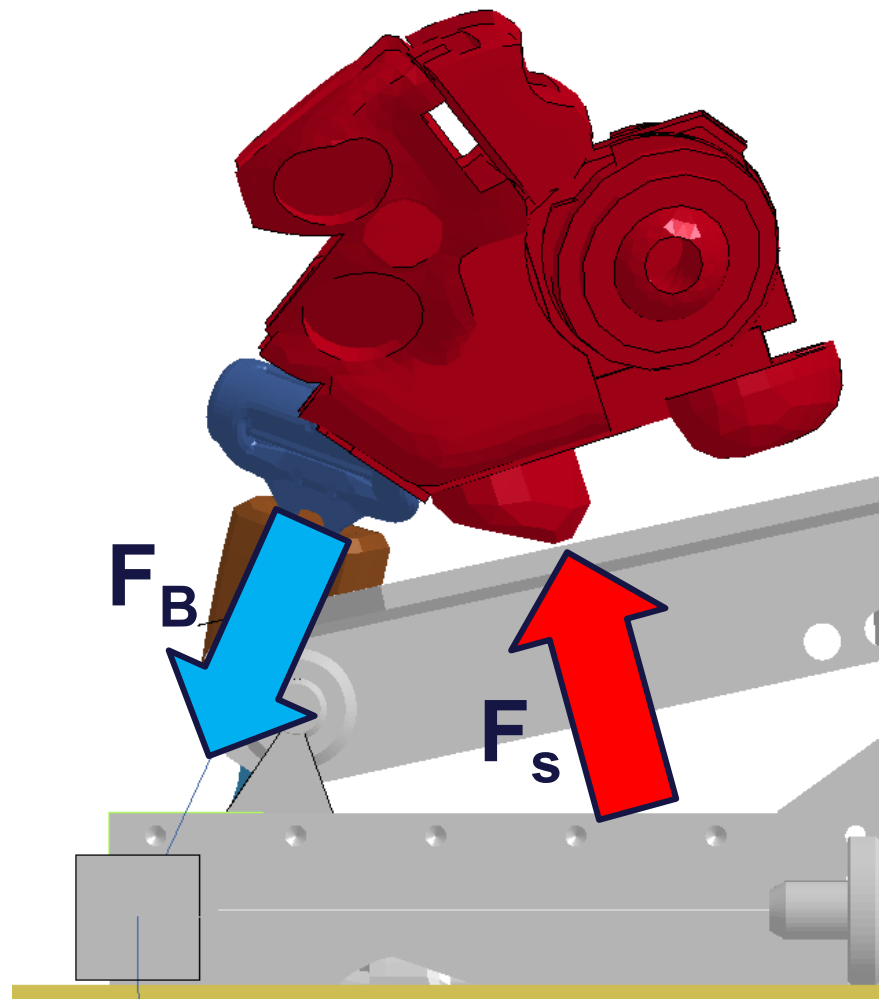


$t=25\text{ms.}$

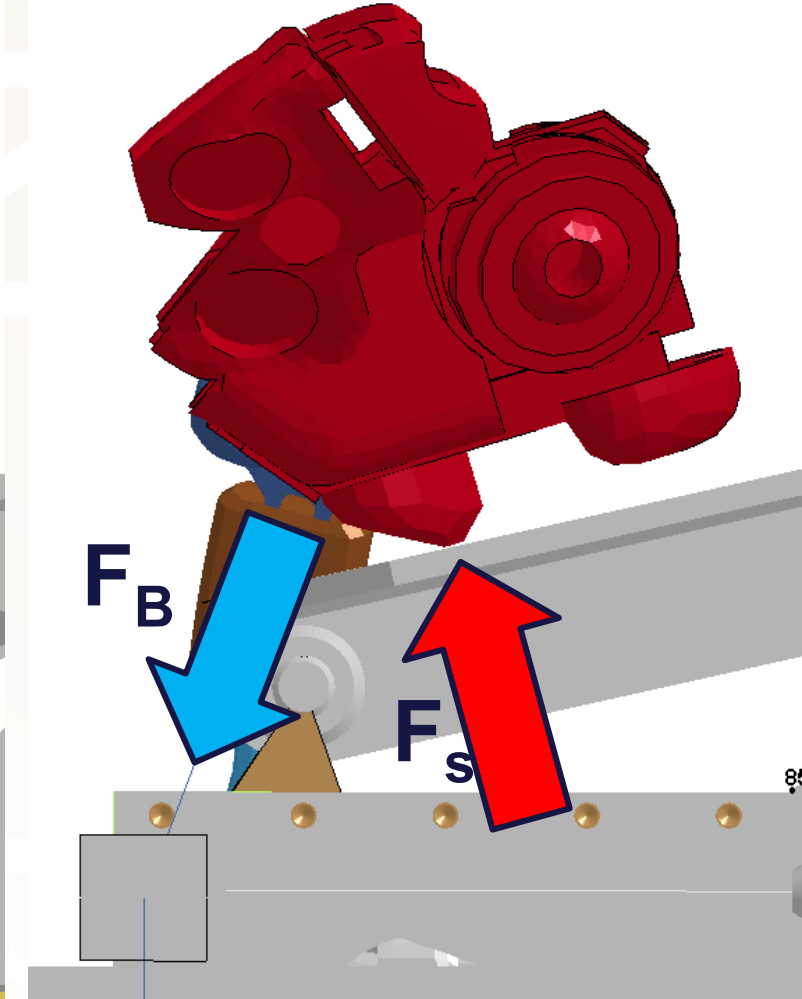
Nominal



Dz

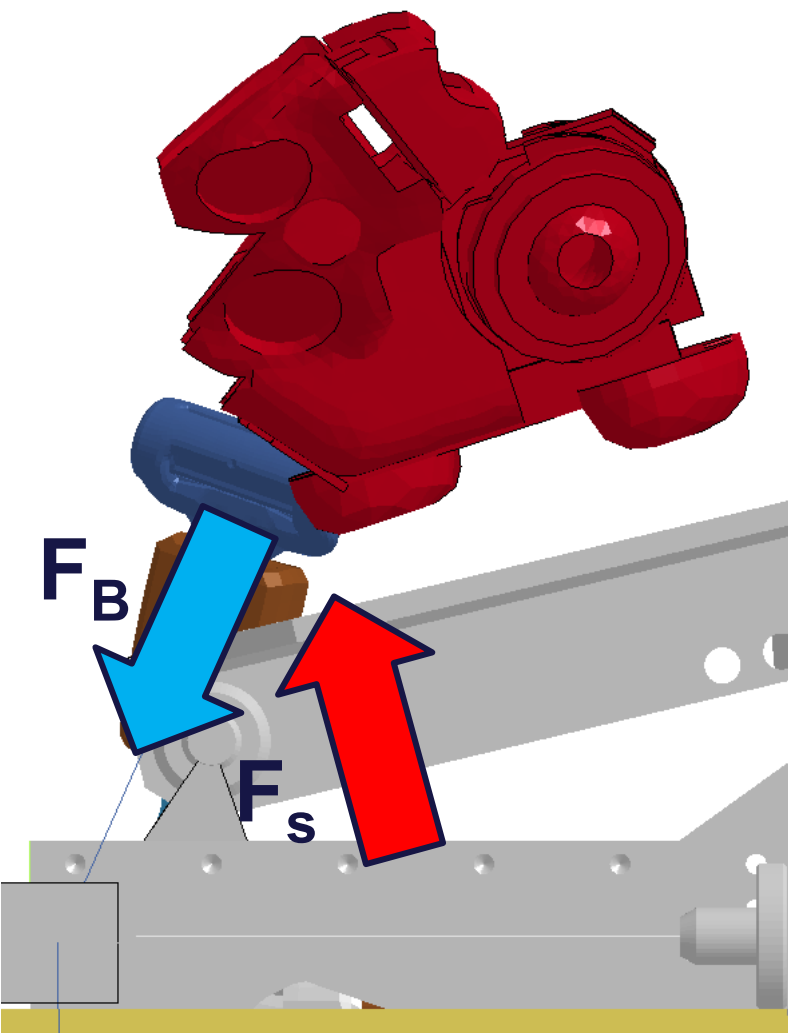


Dx Dz

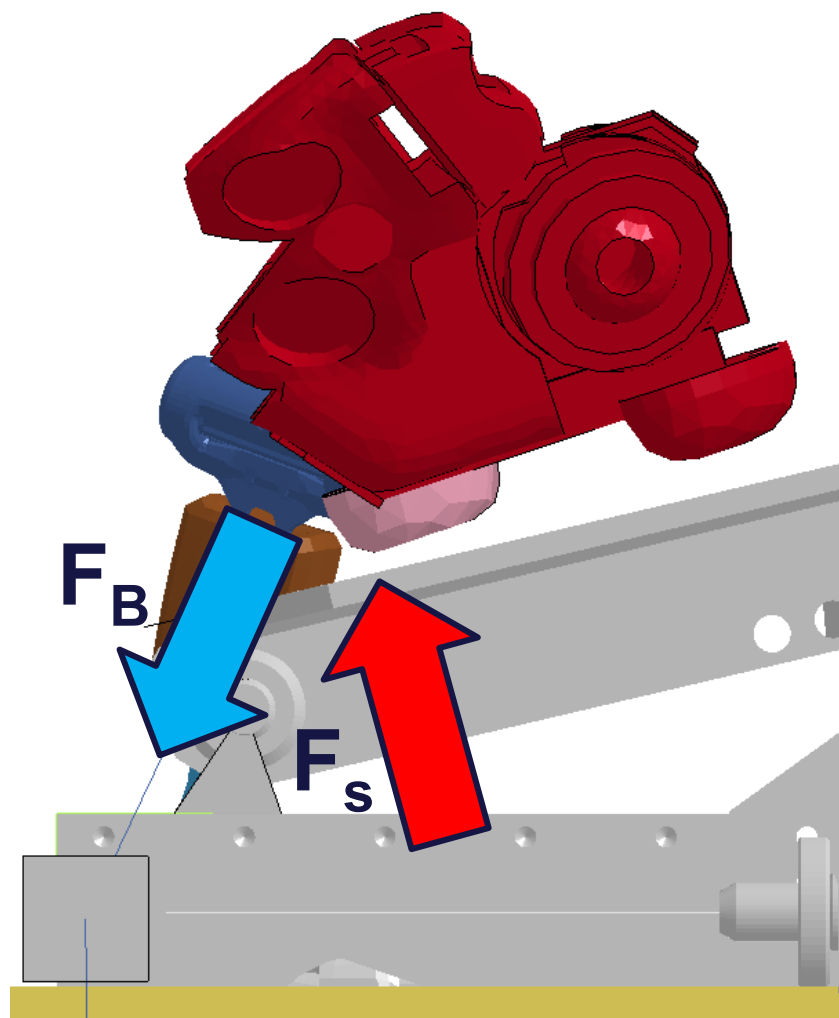


New Sacrum $t=25\text{ms}$.

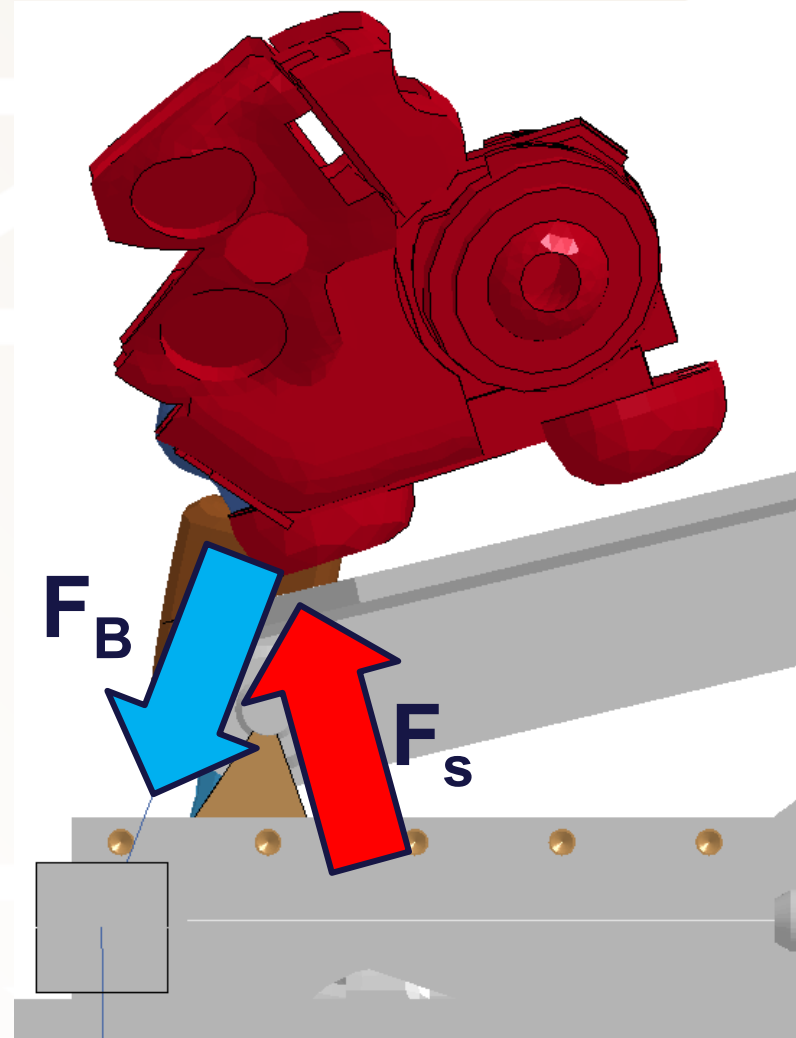
Nominal



Dz

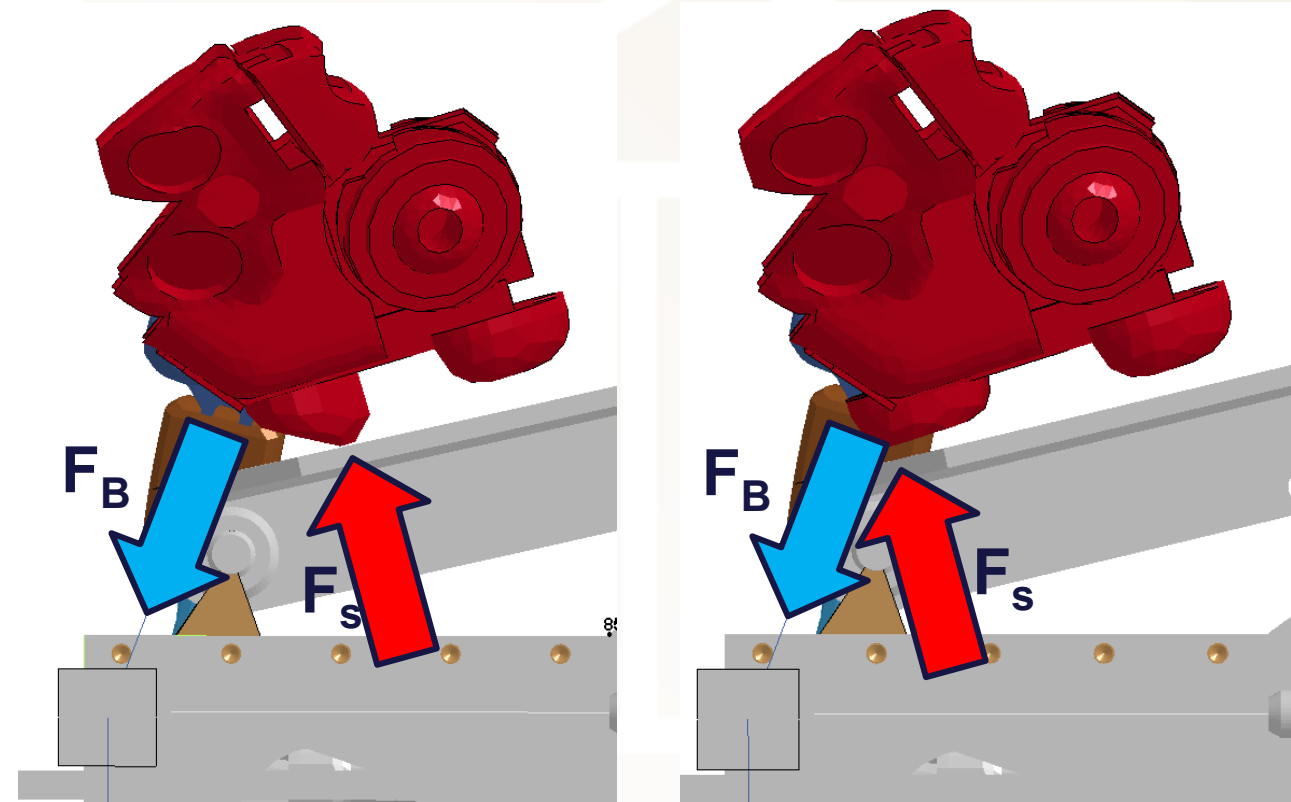


Dx Dz



Factors influencing THOR pelvis motion in recline

- ▶ Pelvis flesh thickness/stiffness
- ▶ Sacrum shape
- ▶ Other parameters had a secondary effect on pelvis motion



Thank You!

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