

# Biorid II R&R Evaluation Series



# Agenda

## ▶ Biorid II Repeatability and Reproducibility Study

- Background
- Goals
- Study description
- R&R results
- All Plots
- Conclusions

## ▶ Certification Test Correlation

- Goals
- Results
- Next steps

# **BIORID II REPEATABILITY AND REPRODUCIBILITY STUDY**

# Biorid R&R: Background

## ▶ Study early 2012

- Report by Dr. David Hynde
- Testing at BAST on TRL lab seat
- 4 dummies tested
  - ▶ Showed unacceptable reproducibility of some channels
- Reproducibility source investigated
  - ▶ Jacket, pelvis, and bumper stiffness all seemed to contribute significantly to dummy to dummy differences
  - ▶ Hypothesis: rebuild dummies with matching bumpers, jackets, pelvises to get good reproducibility

# Biorid R&R: Goals

- ▶ Demonstrate that acceptable R&R is possible by rebuilding dummies with matching jackets, pelvises, bumpers
- ▶ Develop corridors that distinguish the matching and different dummies

# Biorid R&R: study description

- ▶ Rebuild 4 dummies with matching jackets, pelvises, and bumpers
  - Dummies
    - ▶ 3 are from original study: 0068, 0077, 0100
    - ▶ 1 additional dummy: 0054
  - Jackets
    - ▶ Impact test jackets and find matching ones
      - 3 are new jackets: 0054, 0068, 0077
      - 1 original jacket matched others: 0100
  - Pelvises
    - ▶ Remold bones to have new flesh/foam
    - ▶ Impact test bottom and back to see how well they match

# Biorid R&R: study description

- ▶ Rebuild 4 dummies with matching jackets, pelvises, and bumpers
  - Bumpers
    - ▶ Make all new bumpers
      - Each type all made from same batch of material
    - ▶ Compression test every bumper to quantify stiffness
    - ▶ All bumpers in each dummy replaced
  - Pre and post rebuild certifications
    - ▶ Jacket impact
    - ▶ Pelvis back and bottom impact
    - ▶ Without head restraint certification
    - ▶ With head restraint certification
    - ▶ Spine quasi-static bending stiffness test

# Biorid R&R: study description

- ▶ Seat testing with dummies
  - All testing at BAST
  - TRL lab seat used
  - GTR 7 sled pulse
  - 6 tests per dummy, some alternating of dummies
- ▶ R&R analyses requested by TEG
  - Overlay plots
  - Traditional CV's for R&R
  - CV as % of evaluation criteria
  - Time based average CV (from ESV 07-0228 paper)

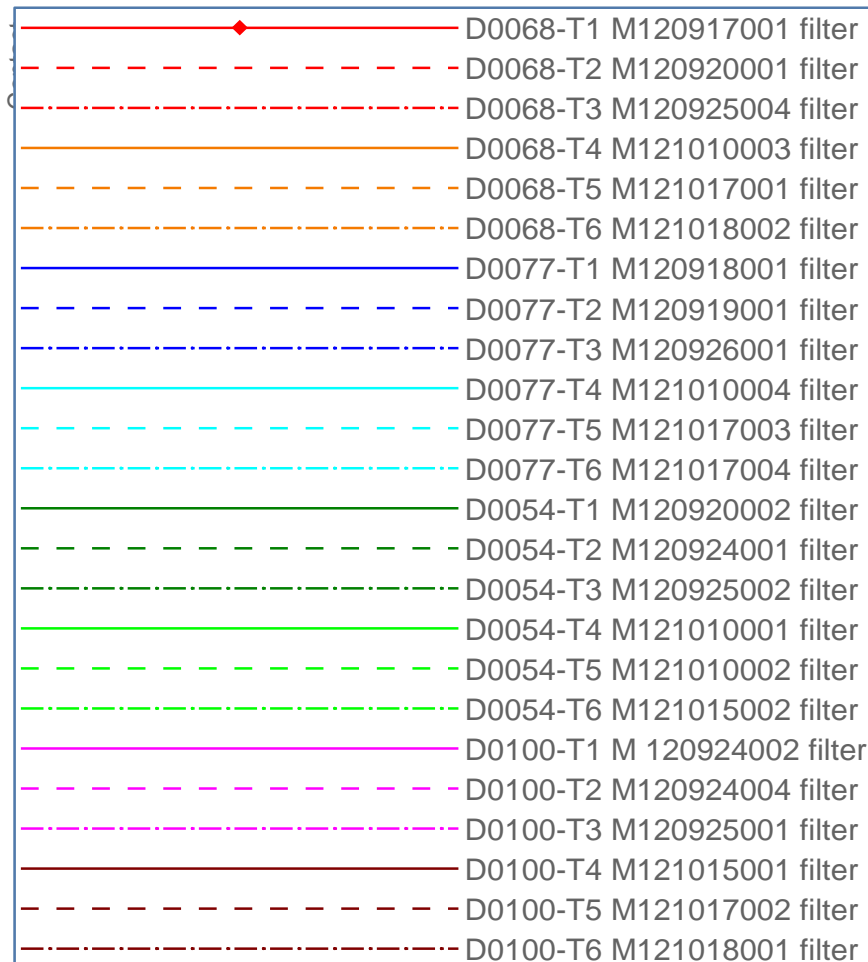


# Biorid R&R Results

- ▶ Show critical plots with CV values
- ▶ Show table of all CV values
- ▶ Show variations as % of evaluation criteria
- ▶ Show all plots
- ▶ Time based average CV
  - Analysis not yet completed
- ▶ Tables of all averages, standard deviations, max & min values

# Biorid R&R critical channel plots

## Legend



# Biorid R&R critical channel plots

## Traditional CV:

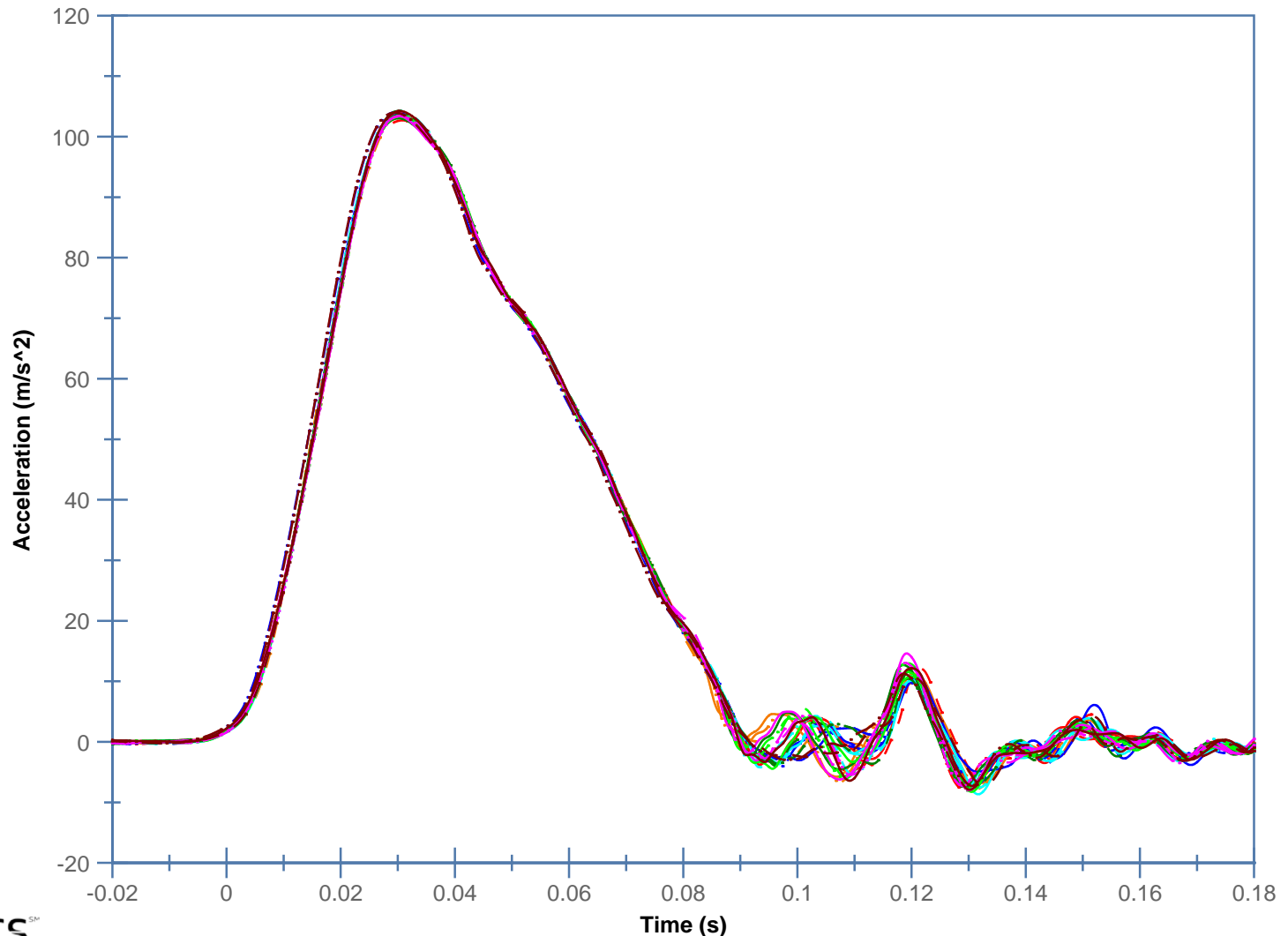
Worst dummy  
repeatability:

**0.4%**

Reproducibility:

**0.4%**

### Sled Acceleration

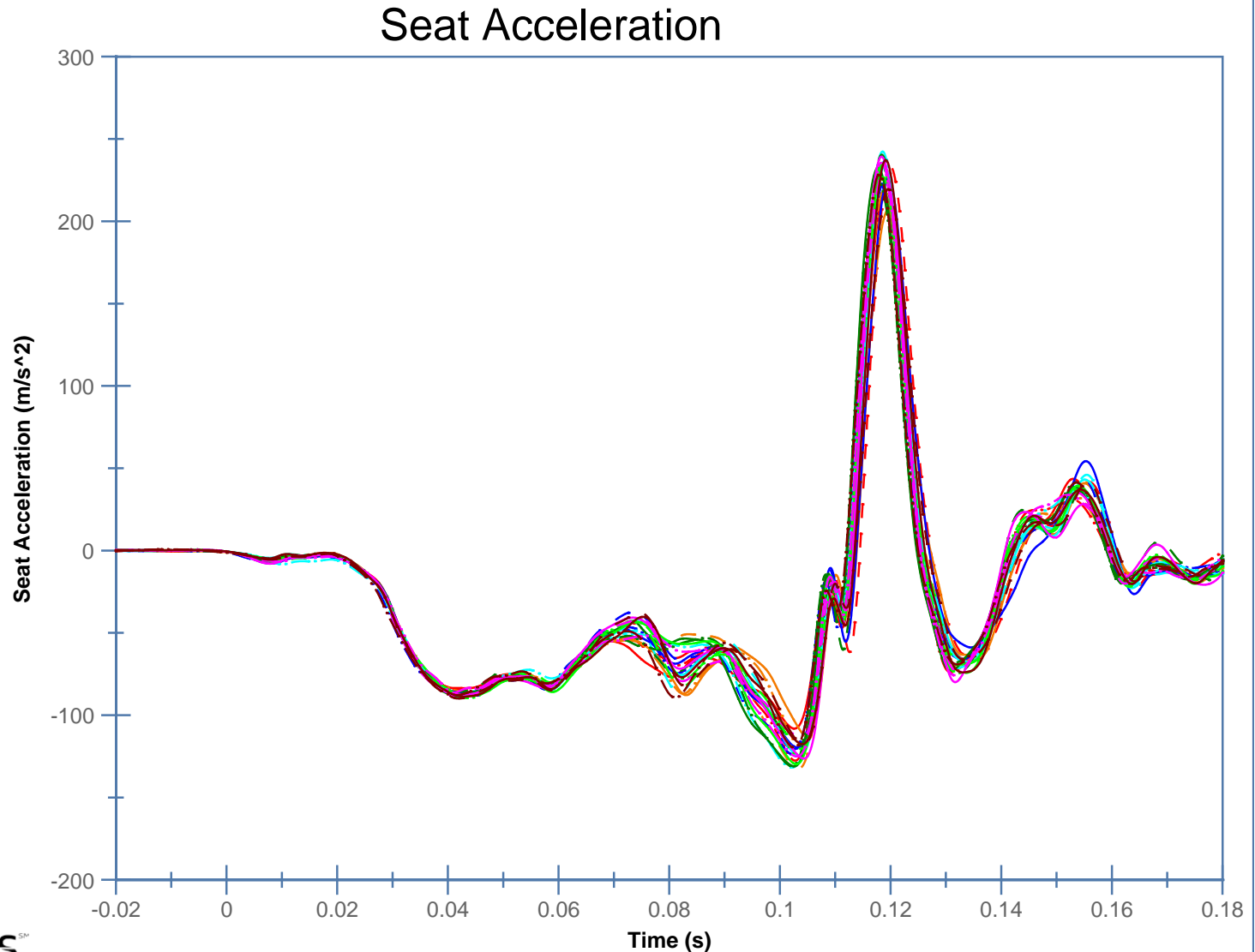


# Biorid R&R critical channel plots

## Traditional CV:

Worst dummy  
repeatability:  
**-7.7%**

Reproducibility:  
**-5.2%**



# Biorid R&R critical channel plots

## Traditional CV:

Worst dummy  
repeatability:

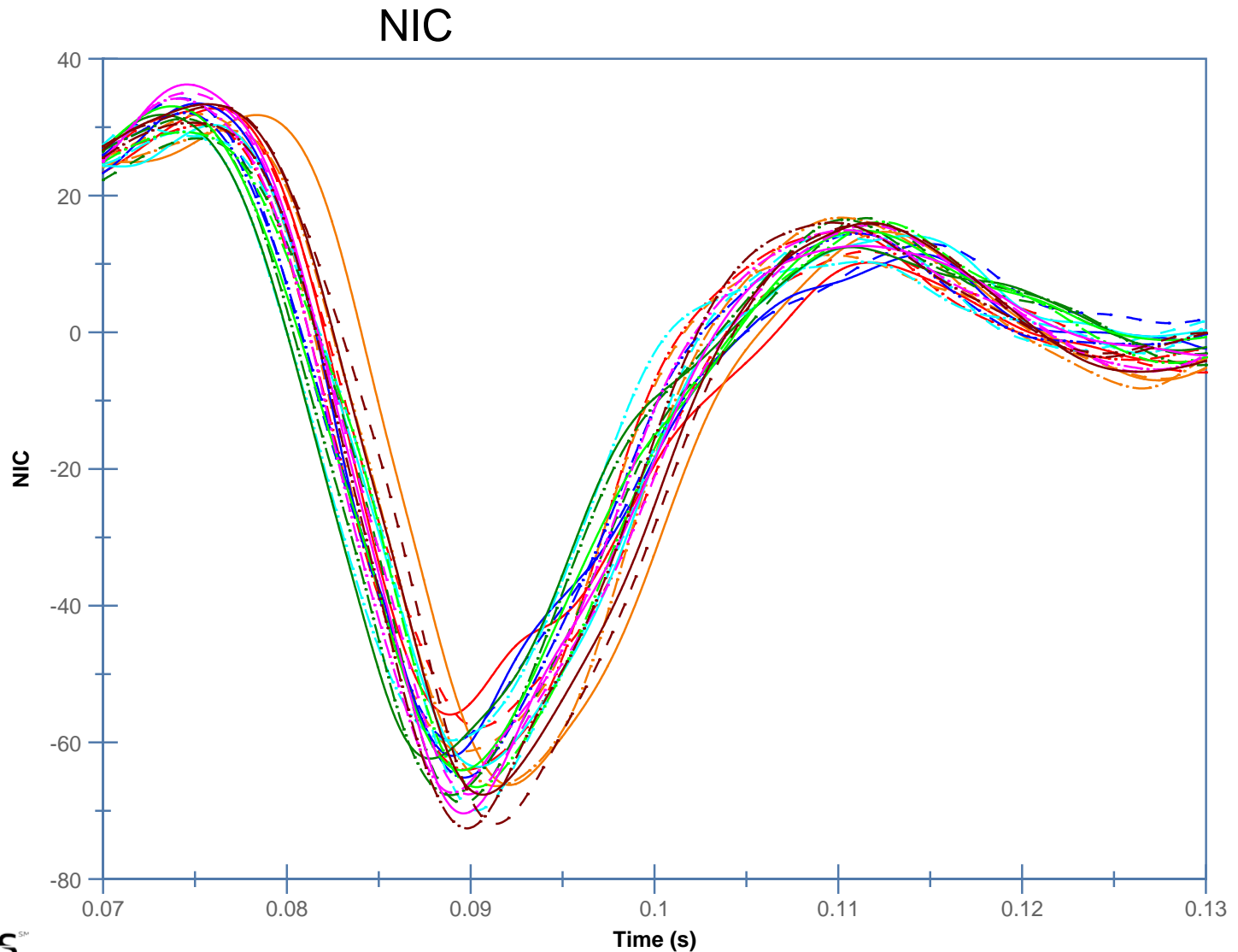
**+6.3%**

**-7.1%**

Reproducibility:

**+6.3%**

**-6.8%**

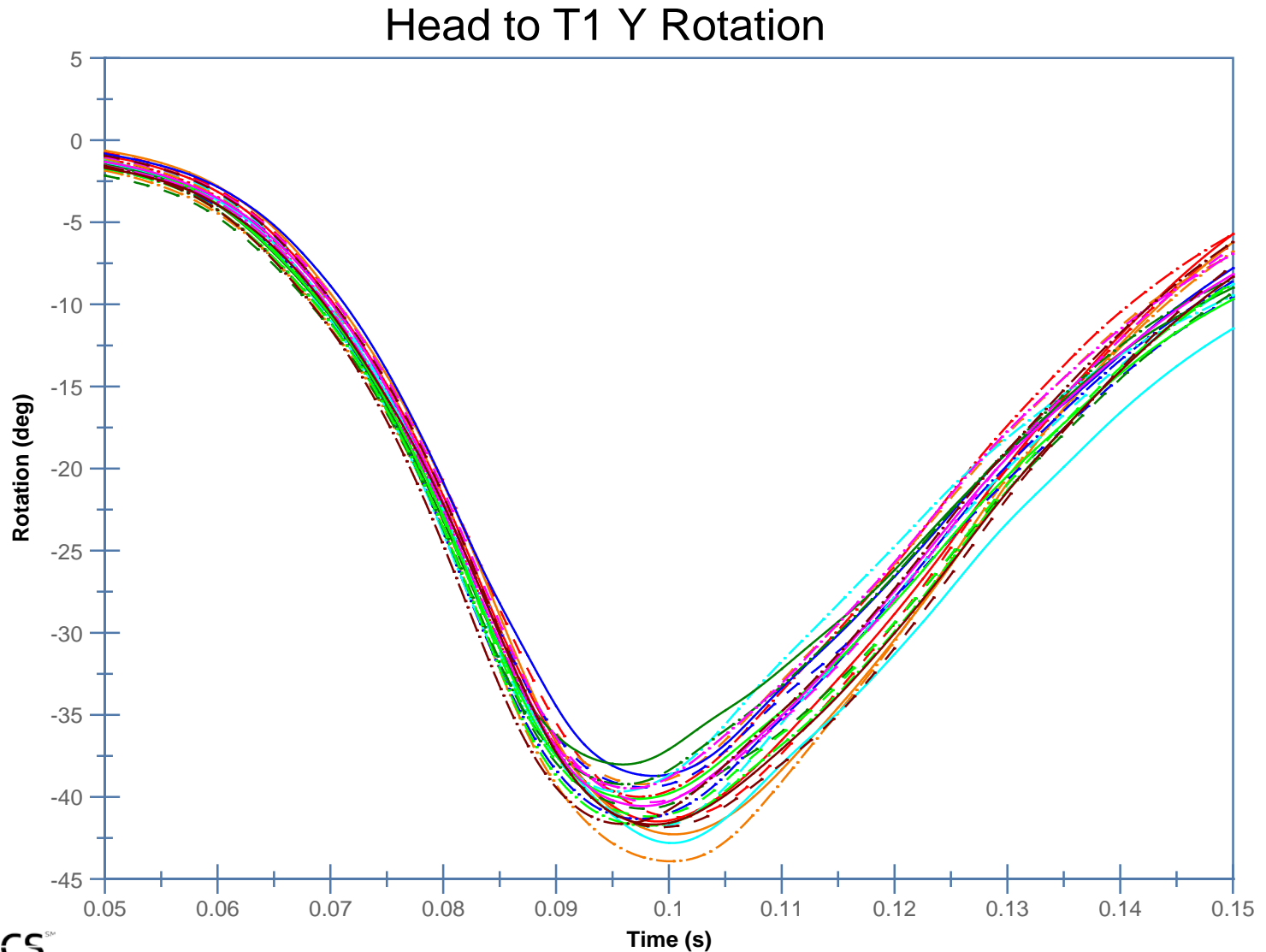


# Biorid R&R critical channel plots

## Traditional CV:

Worst dummy  
repeatability:  
**-4.0%**

Reproducibility:  
**-3.4%**

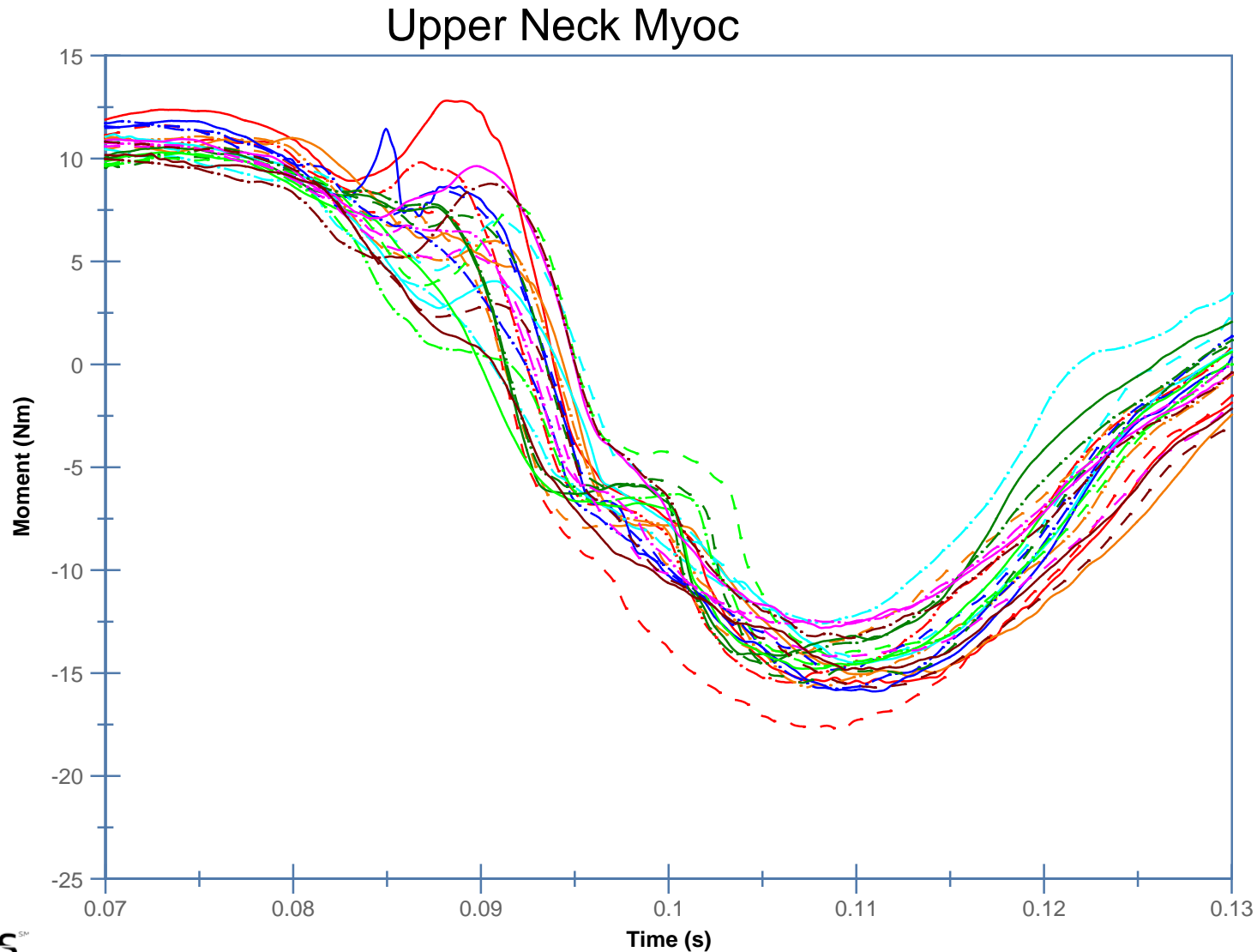


# Biorid R&R critical channel plots

## Traditional CV:

Worst dummy  
repeatability:  
**-8.8%**

Reproducibility:  
**-8.1%**

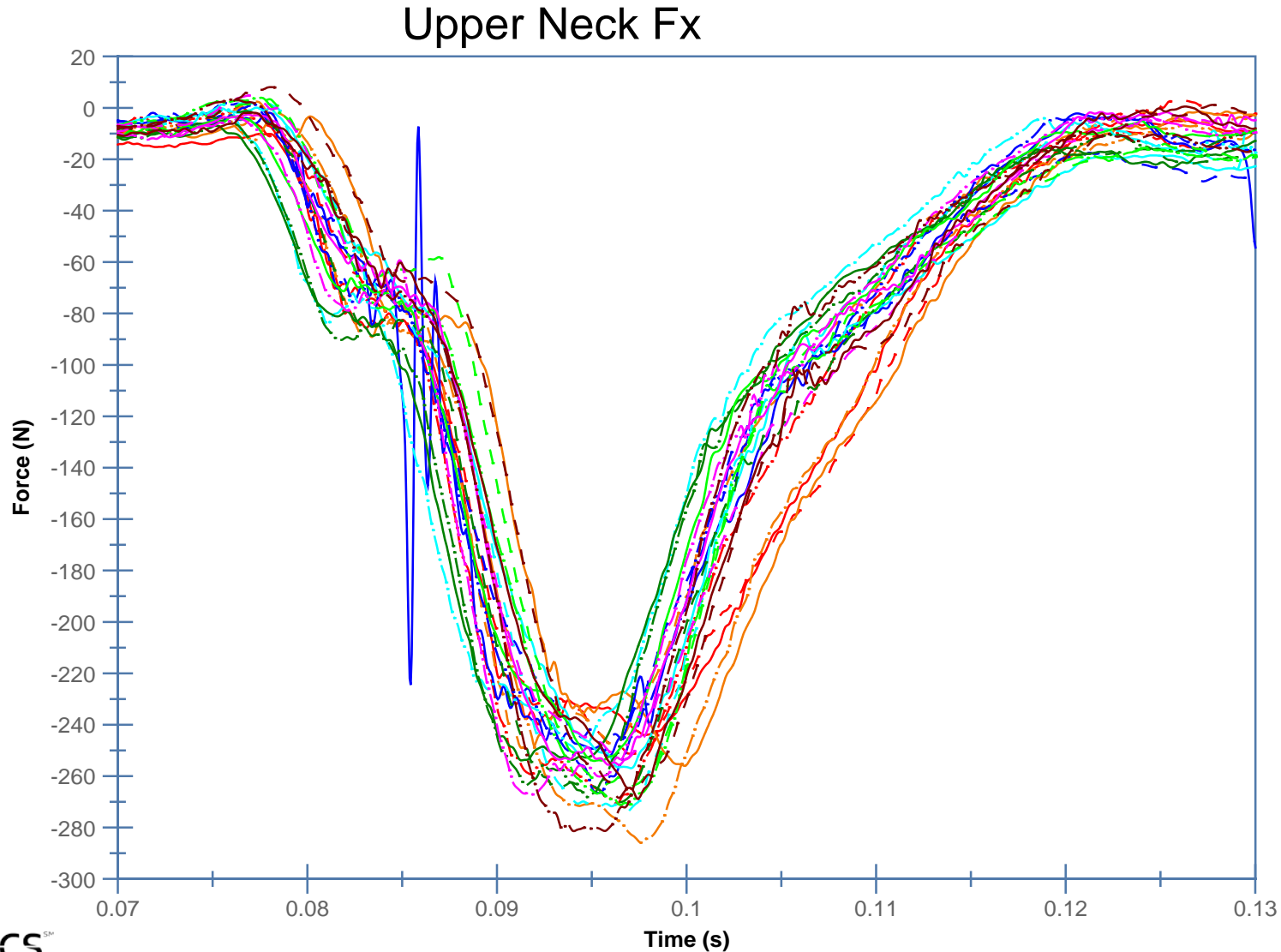


# Biorid R&R critical channel plots

## Traditional CV:

Worst dummy  
repeatability:  
**-6.0%**

Reproducibility:  
**-4.1%**



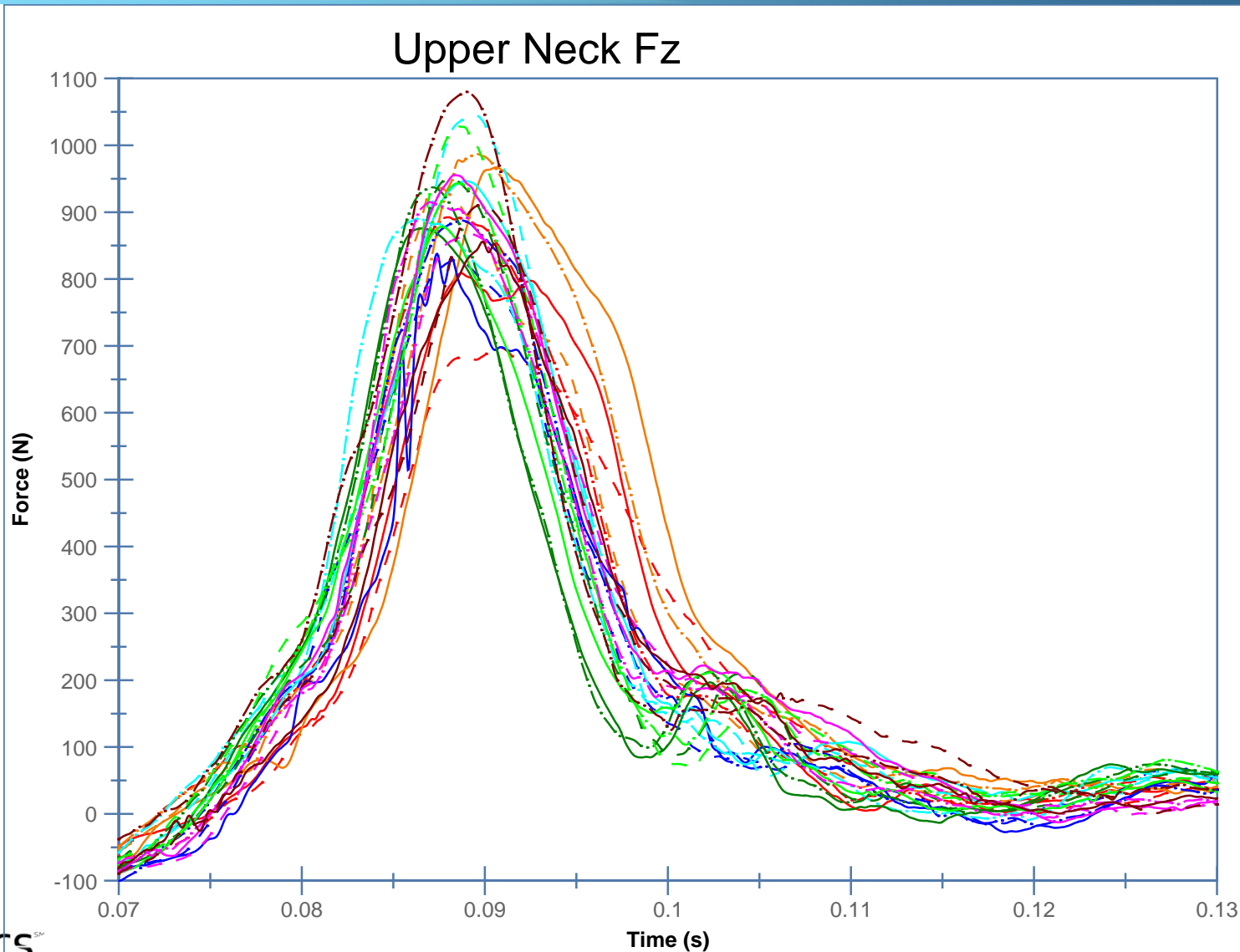


# Biorid R&R critical channel plots

## Traditional CV:

Worst dummy  
repeatability:  
**12.5%**

Reproducibility:  
**8.9%**



# Biorid R&R critical channel plots

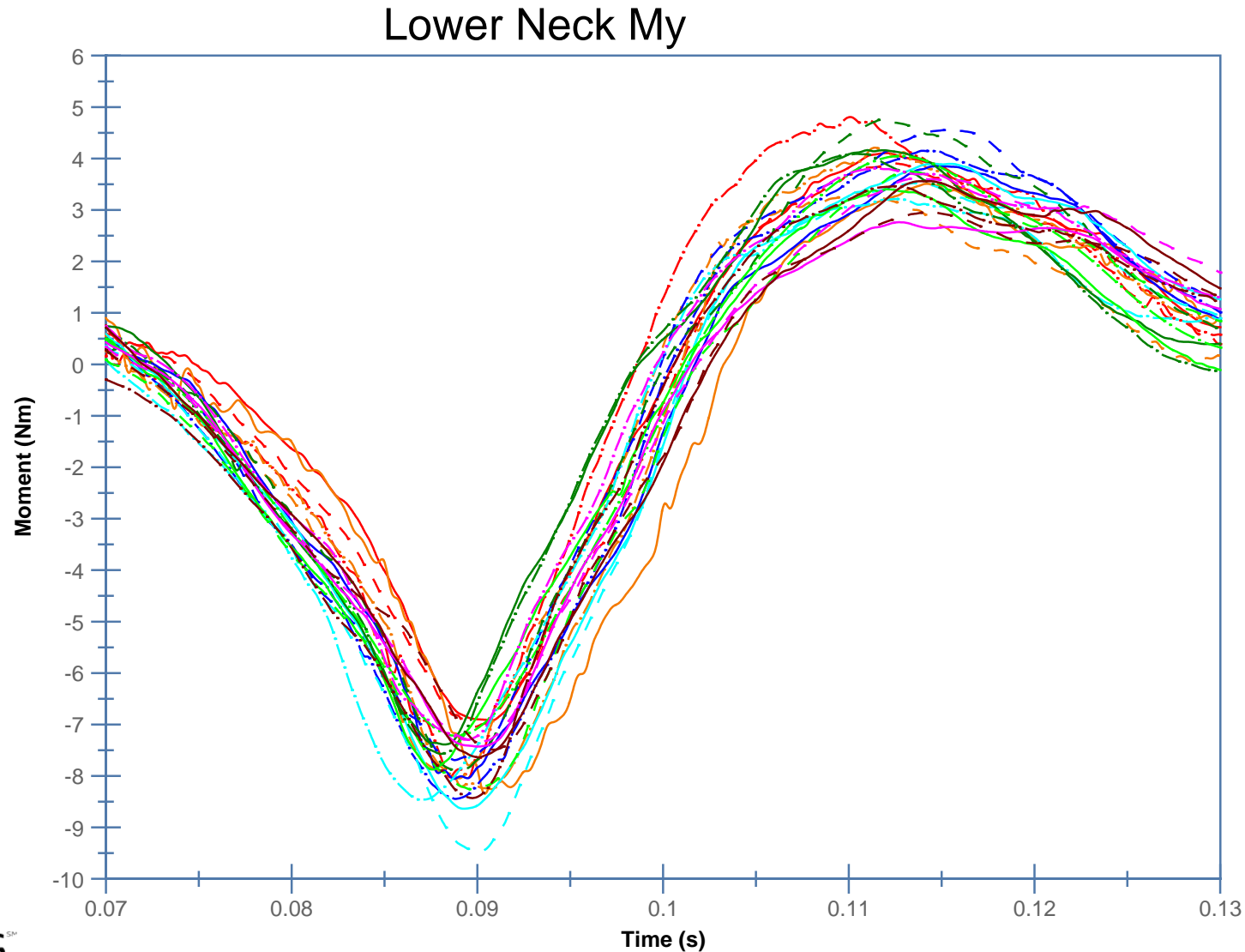
## Traditional CV:

Worst dummy  
repeatability:

**-8.0%**

Reproducibility:

**-7.5%**

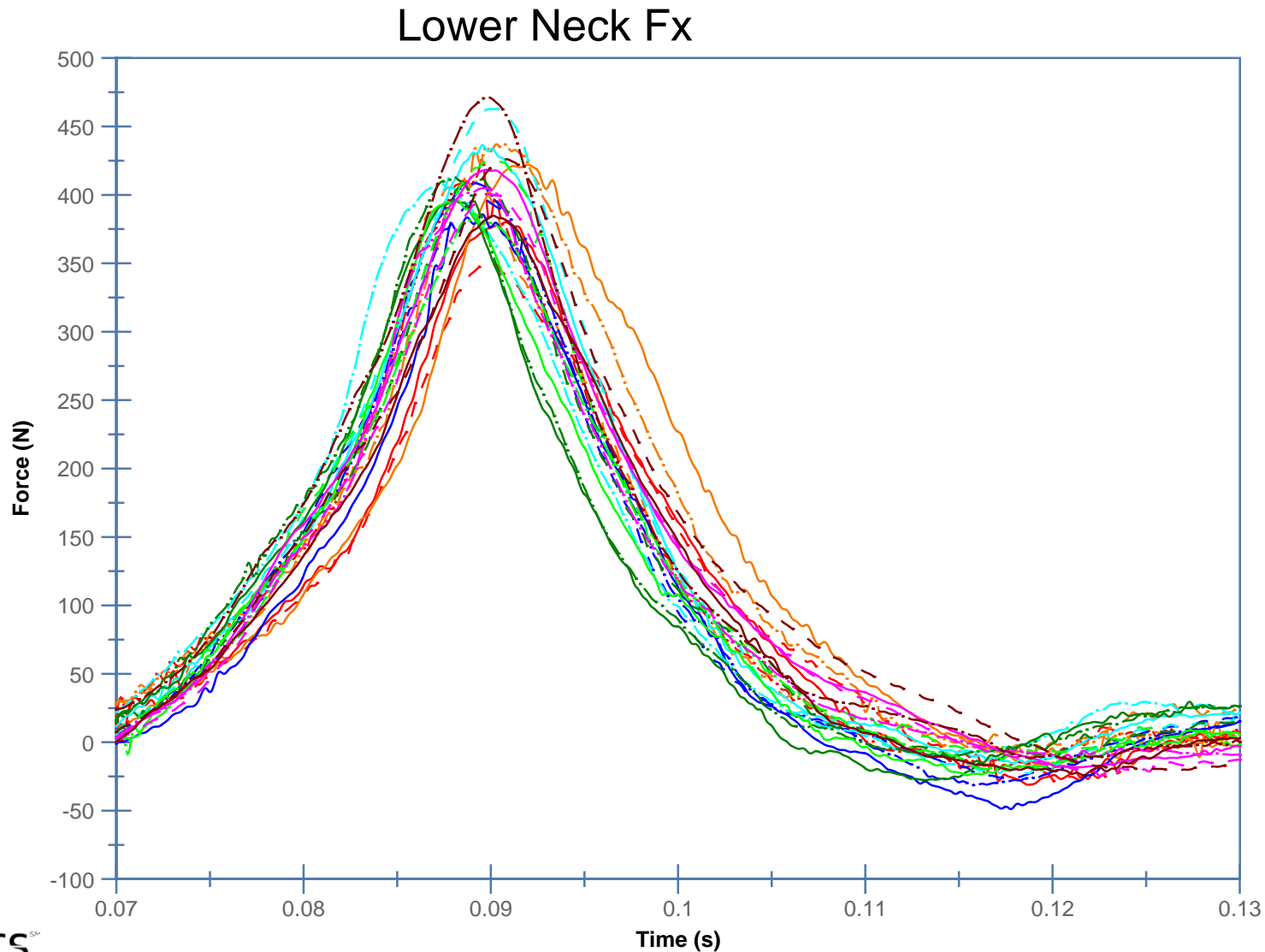


# Biorid R&R critical channel plots

## Traditional CV:

Worst dummy  
repeatability:  
**8.1%**

Reproducibility:  
**6.4%**



# Biorid R&R critical channel plots

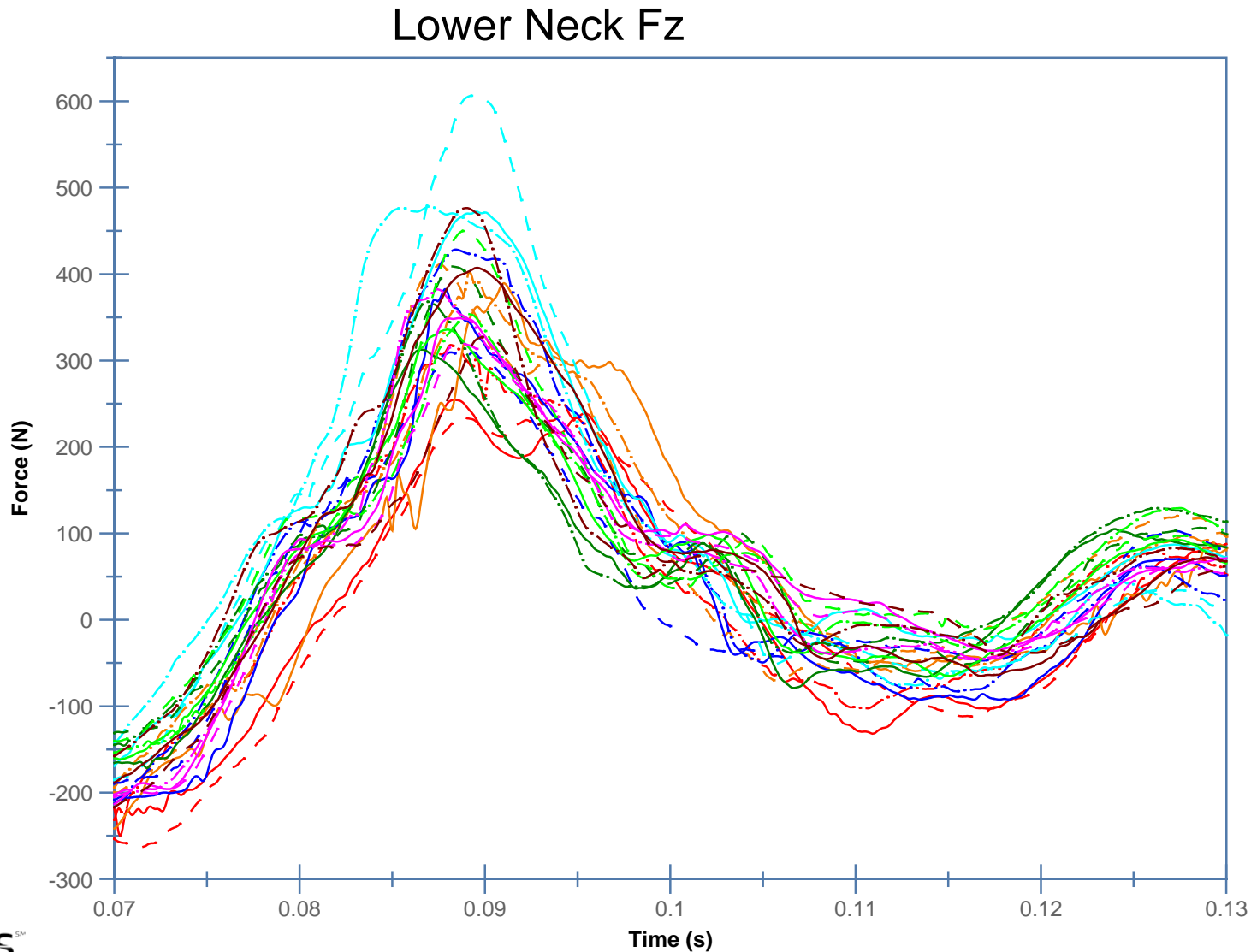
## Traditional CV:

Worst dummy  
repeatability:

**22.8%**

Reproducibility:

**21.0%**



# Biorid R&R: all CV page 1 of 2

ChnDesc	D0054 CV	D0068 CV	D0077 CV	D0100 CV	All CV
Sled Acceleration	0.4	0.4	0.3	0.4	0.4
Sled Velocity	0.3	0.3	0.4	0.3	0.3
Seat Accel +	2.7	4.6	3.4	3.2	3.7
Seat Accel -	-4.4	-7.7	-3.5	-3.9	-5.2
Seat Back Angle	-0.6	-0.7	-0.7	-0.9	-0.9
Head X accel.	2.7	6.9	5.0	3.6	5.1
Head Z accel.	1.8	4.6	3.5	6.1	5.9
C4 X accel.	5.8	4.4	5.0	7.6	6.3
C4 Z accel.	2.7	3.0	3.9	4.5	10.6
T1 X accel.	3.3	7.5	6.6	8.2	7.1
T1 Z accel.	4.9	6.5	7.7	7.9	9.9
T8 X accel.	3.4	3.8	4.0	1.5	3.6
T8 Z accel.	5.8	14.5	9.8	14.1	11.4
Lumbar X accel.	1.3	4.4	1.8	2.3	6.4
Lumbar Z accel.	4.5	14.0	10.7	7.2	11.6
Pelvis X accel.	5.4	11.5	5.0	3.6	9.7
Pelvis Z accel. +	6.5	19.8	19.3	13.6	18.9
Pelvis Z accel. -	-54.3	-208.4	-57.2	-130.2	-89.6
Head Resultant Accel.	2.6	6.6	4.9	3.5	5.0
Pelvis Resultant Accel.	5.2	11.6	5.1	3.3	10.0
NIC +	6.2	4.2	6.3	5.6	6.3
NIC -	-4.0	-7.1	-6.1	-3.4	-6.8
Upper Neck Fx Force	-3.0	-6.0	-3.7	-3.8	-4.1
Upper Neck Fz Force	6.0	12.5	8.9	8.7	8.9
Up Neck My +	1.9	5.0	5.1	3.0	5.5
Up Neck My -	-3.6	-8.0	-8.4	-8.1	-8.6
Upper Neck Myoc +	2.1	6.8	4.8	2.9	6.1
Upper Neck Myoc -	-3.3	-8.0	-8.1	-8.8	-8.1

# Biorid R&R: all CV page 2 of 2

ChnDesc	D0054 CV	D0068 CV	D0077 CV	D0100 CV	All CV
Low Neck Fx	3.6	8.1	6.8	7.2	6.4
Low Neck Fz +	13.6	22.8	22.5	15.5	21.0
Low Neck Fz -	-3.4	-8.4	-10.8	-7.5	-16.5
Low Neck My +	11.3	13.2	12.2	12.2	13.5
Low Neck My -	-5.0	-8.0	-7.1	-5.6	-7.5
Head Rot. Vel.	-6.0	-5.0	-4.9	-4.4	-5.1
C4 Rot. Vel. +	2.1	5.0	5.4	5.9	5.5
C4 Rot. Vel. -	-9.5	-14.3	-10.4	-6.0	-10.0
T1 Rot. Vel. +	1.6	3.2	6.8	3.3	4.5
T1 Rot. Vel. -	-5.4	-4.2	-4.1	-3.1	-5.6
Pelvis Rot. Vel. +	13.0	30.6	11.2	9.1	18.7
Pelvis Rot. Vel. -	-8.3	-9.6	-15.0	-13.7	-11.5
Head-T1 Rot. Vel.	-3.4	-3.4	-4.8	-3.1	-3.5
Head-C4 Rot. Vel.	-3.0	-4.0	-2.3	-3.0	-3.7
C4-T1 Rot Vel.	-10.6	-15.5	-20.0	-11.6	-19.0
T1-Pelvis Rot. Vel. +	3.6	12.0	6.9	4.5	7.4
T1-Pelvis Rot. Vel. -	-8.4	-5.9	-4.6	-3.0	-9.4
Head Rotation	-4.3	-4.7	-4.6	-6.3	-5.2
C4 Rotation	6.9	6.5	4.4	6.3	5.9
T1 Rotation	2.9	4.5	5.3	2.8	3.8
Pelvis Rotation	-19.9	-9.7	-19.3	-16.3	-23.6
Head-T1 Rot.	-3.4	-4.0	-3.9	-2.3	-3.4
Head-C4 Rot.	-5.9	-5.6	-2.7	-5.4	-5.0
C4-T1 Rot.	-5.0	-11.3	-17.4	-8.1	-11.5
T1-Pelvis Rot.	3.3	5.9	5.7	1.6	5.5
Head Contact Fx	2.8	6.7	4.8	3.5	4.8
Head Contact Fz	-10.5	-16.4	-14.8	-14.1	-14.9
Head Contact Resultant	2.8	7.0	5.0	3.4	4.9
Head Contact Angle	-9.7	-9.1	-12.6	-10.0	-14.0

# Biorid R&R: % evaluation criteria

Parameter	Std. Dev.	Average	CV%	Evaluation Limit	Std Dev % of Eval. Limit	Avg % of Eval. Limit
NIC+	2.0	31.9	6.3	30	6.7	106
NIC-(?)	4.4	-65.2	-6.8	30?	14.7	217
Upper Neck Myoc	1.2	-14.7	-8.1	40	3.0	49
Upper Neck Fx	10.9	-261.8	-4.1	730	1.5	36
Upper Neck Fz	81.6	913.7	8.9	1130	7.2	81
Lower Neck My	0.6	-7.9	-7.5	40	1.5	20
Lower Neck Fx	26.3	410.9	6.4	730	3.6	56
Lower Neck Fz	80.2	382.6	21.0	1480	5.4	26

# Biorid R&R: all plots

▶ See separate file:

“D54 D68 D77 D100 eval plots all 6 08DEC12.pdf”



# Biorid R&R: all avg/std dev: pg 1 of 2

ChnDesc	D0054 Avg	D0054 StdDev	D0068 Avg	D0068 StdDev	D0077 Avg	D0077 StdDev	D0100 Avg	D0100 StdDev	All Avg	All StdDev
Sled Acceleration	103.5	0.4	103.5	0.4	103.8	0.3	103.9	0.4	103.7	0.4
Sled Velocity	17.8	0.0	17.7	0.1	17.8	0.1	17.8	0.1	17.8	0.1
Seat Accel +	231.7	6.1	222.3	10.3	230.5	7.9	231.2	7.4	228.9	8.5
Seat Accel -	-126.0	5.6	-119.5	9.2	-124.0	4.3	-120.4	4.7	-122.5	6.4
Seat Back Angle	-8.2	0.1	-8.2	0.1	-8.1	0.1	-8.1	0.1	-8.1	0.1
Head X accel.	466.6	12.5	441.3	30.5	455.1	22.8	467.8	16.6	457.3	23.3
Head Z accel.	97.7	1.8	103.9	4.8	105.2	3.6	94.8	5.8	100.4	5.9
C4 X accel.	390.5	22.7	388.8	17.0	369.6	18.5	403.7	30.6	388.1	24.6
C4 Z accel.	145.5	3.9	146.2	4.4	183.3	7.1	154.3	6.9	157.3	16.6
T1 X accel.	166.6	5.5	176.1	13.1	167.3	11.0	160.5	13.1	167.6	11.8
T1 Z accel.	128.3	6.3	120.7	7.8	142.1	11.0	144.1	11.4	133.8	13.2
T8 X accel.	149.3	5.0	145.7	5.5	150.0	6.0	153.2	2.3	149.6	5.4
T8 Z accel.	59.5	3.4	54.7	7.9	54.4	5.3	53.8	7.6	55.6	6.3
Lumbar X accel.	155.9	2.1	132.8	5.8	144.6	2.6	150.4	3.4	145.9	9.4
Lumbar Z accel.	81.8	3.7	71.3	10.0	85.6	9.2	86.1	6.2	81.2	9.4
Pelvis X accel.	264.7	14.2	246.3	28.2	281.5	14.0	300.8	11.0	273.3	26.6
Pelvis Z accel. +	49.2	3.2	34.4	6.8	46.3	8.9	48.4	6.6	45.0	8.5
Pelvis Z accel. -	-7.2	3.9	-2.6	5.4	-8.4	4.8	-3.7	4.8	-5.6	5.0
Head Resultant Accel.	476.4	12.3	450.1	29.9	467.0	23.0	477.3	16.8	467.3	23.3
Pelvis Resultant Accel.	268.1	14.0	241.9	28.0	284.3	14.5	303.4	10.0	275.8	27.6
NIC +	30.7	1.9	31.5	1.3	31.6	2.0	33.7	1.9	31.9	2.0
NIC -	-65.9	2.7	-61.9	4.4	-63.4	3.8	-69.6	2.4	-65.2	4.4
Upper Neck Fx Force	-263.5	7.8	-259.7	15.7	-258.5	9.6	-265.7	10.1	-261.8	10.9
Upper Neck Fz Force	935.8	56.1	881.5	110.3	906.2	80.2	931.4	81.3	913.7	81.6
Up Neck My +	10.2	0.2	11.2	0.6	11.2	0.6	10.5	0.3	10.8	0.6
Up Neck My -	-16.3	0.6	-17.8	1.4	-16.0	1.3	-15.4	1.3	-16.4	1.4
Upper Neck Myoc +	10.3	0.2	11.4	0.8	11.3	0.5	10.7	0.3	10.9	0.7
Upper Neck Myoc -	-14.6	0.5	-15.6	1.2	-14.7	1.2	-13.9	1.2	-14.7	1.2

# Biorid R&R: all avg/std dev: pg 2 of 2

ChnDesc	D0054 Avg	D0054 StdDev	D0068 Avg	D0068 StdDev	D0077 Avg	D0077 StdDev	D0100 Avg	D0100 StdDev	All Avg	All StdDev
Low Neck Fx	405.0	14.4	404.2	32.9	416.6	28.3	417.9	29.9	410.9	26.3
Low Neck Fz +	371.5	50.4	335.8	76.5	446.2	100.4	377.1	58.5	382.6	80.2
Low Neck Fz -	-173.8	5.9	-256.8	21.6	-229.1	24.7	-247.3	18.4	-226.7	37.3
Low Neck My +	4.0	0.5	4.0	0.5	3.9	0.5	3.4	0.4	3.8	0.5
Low Neck My -	-7.7	0.4	-7.8	0.6	-8.5	0.6	-7.6	0.4	-7.9	0.6
Head Rot. Vel.	-12.7	0.8	-12.8	0.6	-12.5	0.6	-13.1	0.6	-12.8	0.6
C4 Rot. Vel. +	13.4	0.3	13.7	0.7	13.6	0.7	14.4	0.9	13.8	0.8
C4 Rot. Vel. -	-13.8	1.3	-13.3	1.9	-13.8	1.4	-14.3	0.9	-13.8	1.4
T1 Rot. Vel. +	16.6	0.3	16.2	0.5	17.0	1.2	16.2	0.5	16.5	0.7
T1 Rot. Vel. -	-13.2	0.7	-12.5	0.5	-13.8	0.6	-12.6	0.4	-13.0	0.7
Pelvis Rot. Vel. +	5.1	0.7	5.6	1.7	6.2	0.7	6.4	0.6	5.8	1.1
Pelvis Rot. Vel. -	-6.5	0.5	-6.7	0.6	-6.1	0.9	-6.4	0.9	-6.4	0.7
Head-T1 Rot. Vel.	-29.2	1.0	-28.9	1.0	-29.1	1.4	-29.0	0.9	-29.0	1.0
Head-C4 Rot. Vel.	-25.3	0.8	-26.1	1.0	-25.4	0.6	-26.7	0.8	-25.9	1.0
C4-T1 Rot Vel.	-7.4	0.8	-9.9	1.5	-10.3	2.0	-8.9	1.0	-9.1	1.7
T1-Pelvis Rot. Vel. +	19.8	0.7	19.5	2.3	18.9	1.3	18.8	0.9	19.2	1.4
T1-Pelvis Rot. Vel. -	-14.0	1.2	-16.2	1.0	-16.2	0.7	-13.8	0.4	-15.0	1.4
Head Rotation	-19.1	0.8	-19.6	0.9	-18.7	0.9	-19.8	1.3	-19.3	1.0
C4 Rotation	16.5	1.1	16.5	1.1	16.8	0.7	17.1	1.1	16.7	1.0
T1 Rotation	23.7	0.7	23.2	1.0	23.7	1.3	23.6	0.7	23.6	0.9
Pelvis Rotation	-3.8	0.8	-6.1	0.6	-4.3	0.8	-4.7	0.8	-4.7	1.1
Head-T1 Rot.	-40.2	1.4	-41.4	1.7	-40.6	1.6	-40.9	0.9	-40.8	1.4
Head-C4 Rot.	-32.1	1.9	-33.0	1.9	-32.5	0.9	-33.3	1.8	-32.7	1.6
C4-T1 Rot.	-10.7	0.5	-11.3	1.3	-10.6	1.8	-10.0	0.8	-10.7	1.2
T1-Pelvis Rot.	26.1	0.9	27.7	1.6	25.2	1.4	26.0	0.4	26.2	1.5
Head Contact Fx	2344.6	64.5	2239.7	150.8	2287.4	108.8	2354.7	82.4	2304.9	111.5
Head Contact Fz	-520.0	54.6	-457.9	75.1	-515.1	76.4	-560.4	78.8	-513.3	76.7
Head Contact Resultant	2369.7	66.7	2283.3	160.5	2315.1	114.8	2387.6	82.2	2337.6	114.2
Head Contact Angle	-16.2	1.6	-13.6	1.2	-16.9	2.1	-17.7	1.8	-16.1	2.2

# Biorid R&R: all max/min: page 1 of 2

ChnDesc	D0054 Min	D0054 Max	D0068 Min	D0068 Max	D0077 Min	D0077 Max	D0100 Min	D0100 Max	All Min	All Max
Sled Acceleration	103.0	104.2	102.7	103.8	103.4	104.3	103.4	104.2	102.7	104.3
Sled Velocity	17.7	17.9	17.7	17.8	17.7	17.8	17.7	17.8	17.7	17.9
Seat Accel +	222.9	240.2	207.5	233.2	222.2	242.2	219.4	239.1	207.5	242.2
Seat Accel -	-131.2	-118.4	-132.7	-108.1	-131.9	-119.7	-126.6	-114.2	-132.7	-108.1
Seat Back Angle	-8.2	-8.1	-8.3	-8.1	-8.2	-8.1	-8.2	-8.0	-8.3	-8.0
Head X accel.	453.6	479.3	396.1	471.0	428.6	492.6	453.1	498.0	396.1	498.0
Head Z accel.	95.5	99.8	96.0	109.0	100.7	109.4	86.1	102.8	86.1	109.4
C4 X accel.	348.9	408.3	365.8	410.4	348.5	401.8	364.8	443.7	348.5	443.7
C4 Z accel.	142.2	153.0	142.2	153.1	170.7	188.2	145.4	163.0	142.2	188.2
T1 X accel.	158.7	173.1	157.4	196.0	151.9	183.8	151.2	184.3	151.2	196.0
T1 Z accel.	122.4	136.5	113.6	132.2	130.1	158.2	132.4	157.4	113.6	158.2
T8 X accel.	143.3	156.3	139.3	154.7	141.4	156.8	149.5	155.4	139.3	156.8
T8 Z accel.	54.5	62.6	45.2	64.6	50.4	64.2	43.7	65.2	43.7	65.2
Lumbar X accel.	153.2	158.7	125.7	140.0	140.8	148.4	144.9	154.0	125.7	158.7
Lumbar Z accel.	76.6	87.7	56.6	82.7	74.2	97.4	80.4	96.9	56.6	97.4
Pelvis X accel.	246.7	283.0	212.5	275.6	255.5	292.7	289.3	315.6	212.5	315.6
Pelvis Z accel. +	43.8	53.4	28.0	43.0	36.4	58.0	42.9	59.2	28.0	59.2
Pelvis Z accel. -	-10.7	0.1	-8.3	4.3	-16.5	-1.6	-11.5	3.0	-16.5	4.3
Head Resultant Accel.	463.4	488.9	405.2	479.0	440.7	504.8	462.8	508.3	405.2	508.3
Pelvis Resultant Accel.	251.2	286.0	212.9	271.6	257.8	297.0	292.8	316.3	212.9	316.3
NIC +	28.3	33.0	29.5	32.8	29.3	34.2	30.6	36.2	28.3	36.2
NIC -	-68.9	-62.4	-66.4	-55.9	-70.0	-59.7	-72.6	-67.4	-72.6	-55.9
Upper Neck Fx Force	-271.1	-253.8	-285.9	-244.0	-273.8	-250.3	-281.3	-253.6	-285.9	-244.0
Upper Neck Fz Force	875.9	1028.5	697.3	987.1	829.5	1045.5	856.2	1080.5	697.3	1080.5
Up Neck My +	10.0	10.4	10.6	12.1	10.3	11.7	10.1	10.8	10.0	12.1
Up Neck My -	-17.3	-15.6	-20.2	-15.9	-17.3	-13.7	-17.3	-14.2	-20.2	-13.7
Upper Neck Myoc +	10.0	10.6	10.6	12.8	10.5	11.8	10.2	11.0	10.0	12.8
Upper Neck Myoc -	-15.5	-14.1	-17.8	-14.0	-15.9	-12.6	-15.7	-12.6	-17.8	-12.6

# Biorid R&R: all max/min: page 2 of 2

ChnDesc	D0054 Min	D0054 Max	D0068 Min	D0068 Max	D0077 Min	D0077 Max	D0100 Min	D0100 Max	All Min	All Max
Low Neck Fx	386.5	426.0	350.2	437.1	385.8	463.0	385.0	471.5	350.2	471.5
Low Neck Fz +	312.5	450.4	239.3	411.2	309.5	606.3	321.5	476.2	239.3	606.3
Low Neck Fz -	-179.4	-164.1	-284.2	-226.2	-257.0	-195.9	-264.4	-220.4	-284.2	-164.1
Low Neck My +	3.4	4.8	3.3	4.8	3.2	4.6	2.8	3.8	2.8	4.8
Low Neck My -	-8.3	-7.2	-8.3	-6.9	-9.5	-7.7	-8.4	-7.3	-9.5	-6.9
Head Rot. Vel.	-13.8	-11.6	-13.9	-12.2	-13.1	-11.5	-13.9	-12.4	-13.9	-11.5
C4 Rot. Vel. +	13.0	13.7	12.8	14.6	12.9	14.8	12.9	15.4	12.8	15.4
C4 Rot. Vel. -	-15.4	-12.3	-15.7	-10.1	-15.5	-11.8	-15.7	-13.5	-15.7	-10.1
T1 Rot. Vel. +	16.2	16.9	15.3	16.6	15.5	18.0	15.6	17.1	15.3	18.0
T1 Rot. Vel. -	-14.2	-12.0	-13.3	-12.0	-14.6	-13.2	-13.4	-12.3	-14.6	-12.0
Pelvis Rot. Vel. +	4.3	6.0	3.8	8.2	5.1	7.0	5.8	7.4	3.8	8.2
Pelvis Rot. Vel. -	-7.2	-5.7	-7.4	-5.5	-7.7	-5.2	-7.2	-4.9	-7.7	-4.9
Head-T1 Rot. Vel.	-30.6	-27.7	-30.4	-27.5	-30.3	-26.9	-30.6	-28.3	-30.6	-26.9
Head-C4 Rot. Vel.	-26.4	-24.2	-27.6	-24.7	-26.0	-24.3	-28.0	-25.9	-28.0	-24.2
C4-T1 Rot Vel.	-8.3	-6.4	-12.2	-8.2	-12.9	-8.0	-10.4	-7.4	-12.9	-6.4
T1-Pelvis Rot. Vel. +	19.0	20.9	16.4	22.9	17.3	20.8	17.9	20.4	16.4	22.9
T1-Pelvis Rot. Vel. -	-15.5	-12.3	-17.5	-14.9	-17.2	-15.3	-14.4	-13.4	-17.5	-12.3
Head Rotation	-20.4	-18.0	-21.0	-18.4	-20.1	-17.6	-21.5	-18.7	-21.5	-17.6
C4 Rotation	15.2	17.8	15.3	17.8	15.6	17.5	16.2	19.2	15.2	19.2
T1 Rotation	22.6	24.6	22.1	24.6	22.4	25.4	23.0	24.7	22.1	25.4
Pelvis Rotation	-5.0	-2.8	-7.1	-5.3	-5.5	-3.3	-5.5	-3.5	-7.1	-2.8
Head-T1 Rot.	-41.8	-38.0	-43.9	-39.2	-42.8	-38.7	-41.9	-39.5	-43.9	-38.0
Head-C4 Rot.	-34.4	-29.6	-35.6	-31.2	-33.4	-31.3	-36.5	-31.5	-36.5	-29.6
C4-T1 Rot.	-11.5	-10.1	-13.3	-9.6	-13.3	-7.8	-11.0	-8.6	-13.3	-7.8
T1-Pelvis Rot.	25.0	27.0	26.0	30.1	23.2	26.8	25.4	26.4	23.2	30.1
Head Contact Fx	2274.7	2415.2	2020.4	2397.7	2178.5	2472.7	2277.3	2508.7	2020.4	2508.7
Head Contact Fz	-612.9	-453.5	-526.8	-327.3	-612.3	-429.4	-687.4	-474.6	-687.4	-327.3
Head Contact Resultant	2294.8	2441.1	2060.9	2451.4	2191.9	2507.2	2311.7	2542.5	2060.9	2542.5
Head Contact Angle	-19.1	-14.9	-14.5	-11.2	-20.8	-14.9	-20.2	-15.4	-20.8	-11.2

Lower Neck

# CERTIFICATION TEST CORRELATION

# Agenda

## ▶ Biorid II Repeatability and Reproducibility Study

- Background
- Goals
- Study description
- R&R results
- All Plots
- Conclusions

## ▶ Certification Test Correlation

- Goals
- Results
- Next steps

# Certification Test Correlation: Goals

- ▶ Examine certification data from 4 dummies used in R&R study to determine certification test corridors to ensure R&R of dummies
  - Find differences between pre & post rebuild testing that contain rebuilt dummies but exclude pre test dummies unless performance in seat is the same

# Certification Test Correlation: Results

- ▶ Jacket impact
  - Separates jackets, see plots with corridors
- ▶ Pelvis impact (back & bottom)
  - Bottom *might* separate pelvises
  - Could be pelvis remodels varied too much
- ▶ Certification without head restraint
  - Unable to detect differences
  - *Still needed to setup damper*
- ▶ Certification with head restraint
  - Due to communication error we do not have pre rebuild data
  - *Don't know if this can detect*
- ▶ Spine quasi-static bending
  - Analysis not complete



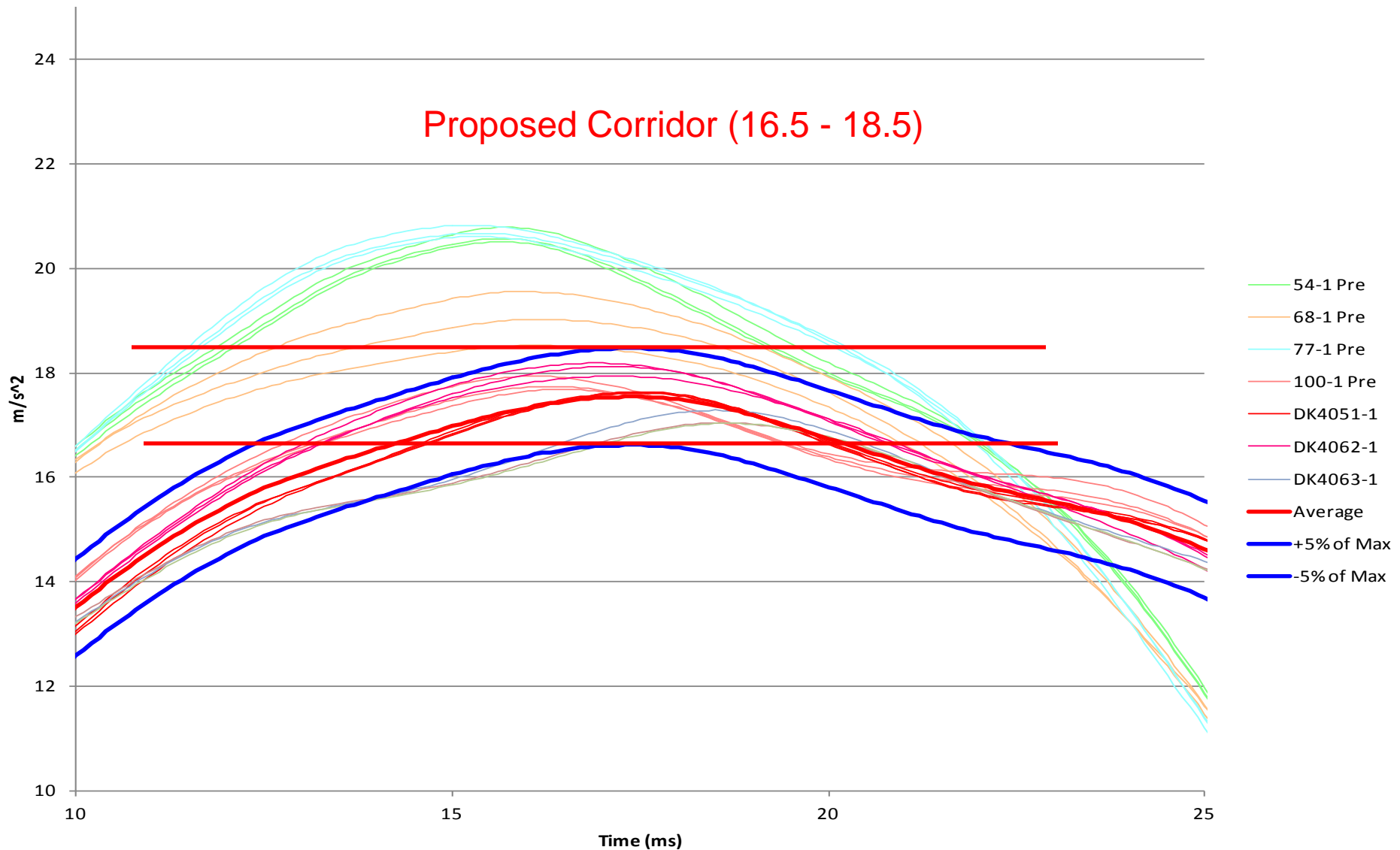
# Certification: Jacket Impact

- ▶ Jacket mounts to front of sled
- ▶ Impacted with H-III5F thorax probe



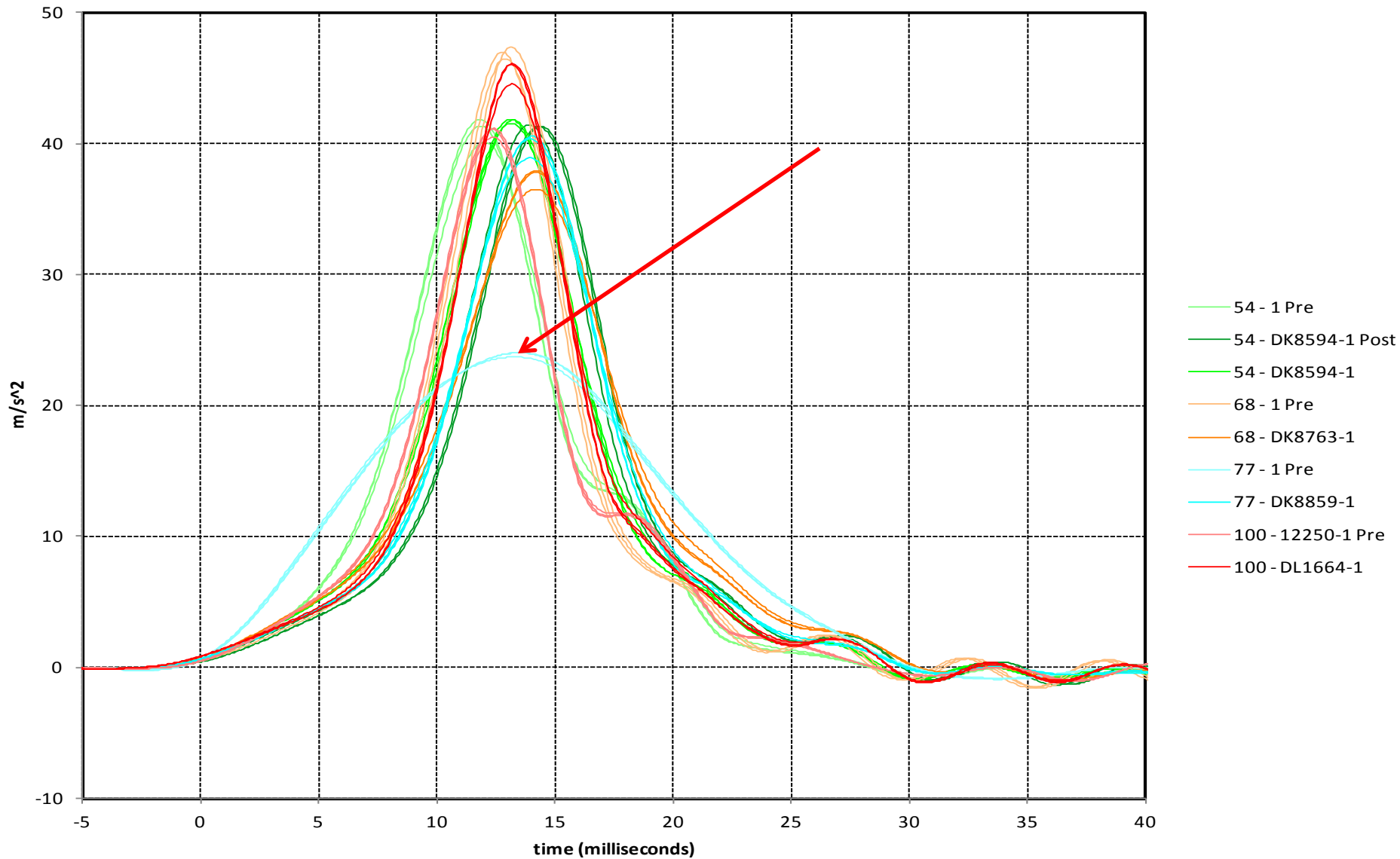


# Jacket Impact - Sled Acceleration

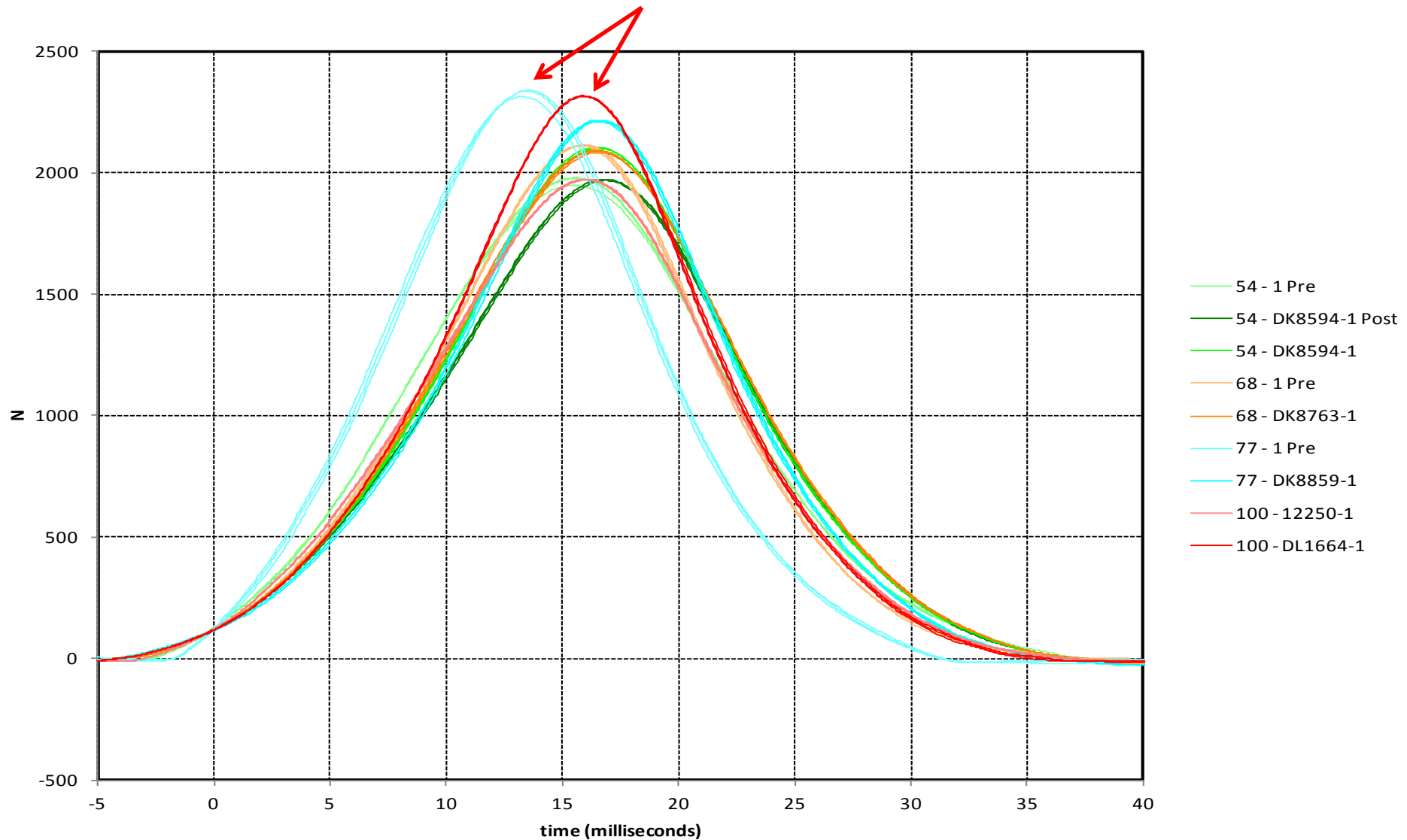




# Pelvis Bottom - Sled Acceleration



# Pelvis Back - Pendulum Force



# Certification Correlation – Next Steps

## ▶ Pelvis & jacket

- Compare to historical population data
- Try correlating peaks to seat test results with regression

## ▶ Spine quasi-static bending

- Finish analysis comparing pre to post
- Try correlating any perceived differences to seat test results

## ▶ Certification without head restraint

- Reduce corridors to just those needed to set damper and cables
- Examine historical population and try to tighten corridors (+/-10% max)

# Certification Correlation – Next Steps

- ▶ Certification test with head restraint
  - Build spines with know differences in bumpers and see if test detects this
  - Evaluate data from earlier seat series from HIS Germany to see if any correlations can be found or verified
- ▶ Look at possible new tests
  - Direct bumper stiffness measurements on vertabrae
  - Mini-sled with back support and ramping
  - Evaluate new tests with known bumper and jacket variation



# Possible new certification

- ▶ Allows spine straightening and ramping
- ▶ Load cells behind each section
- ▶ Possibly tilt head restraint to force flexion

