NHTSA

NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

Biofidelity Evaluation of WorldSID-05F with Mod Kit and SID-IIs BLD

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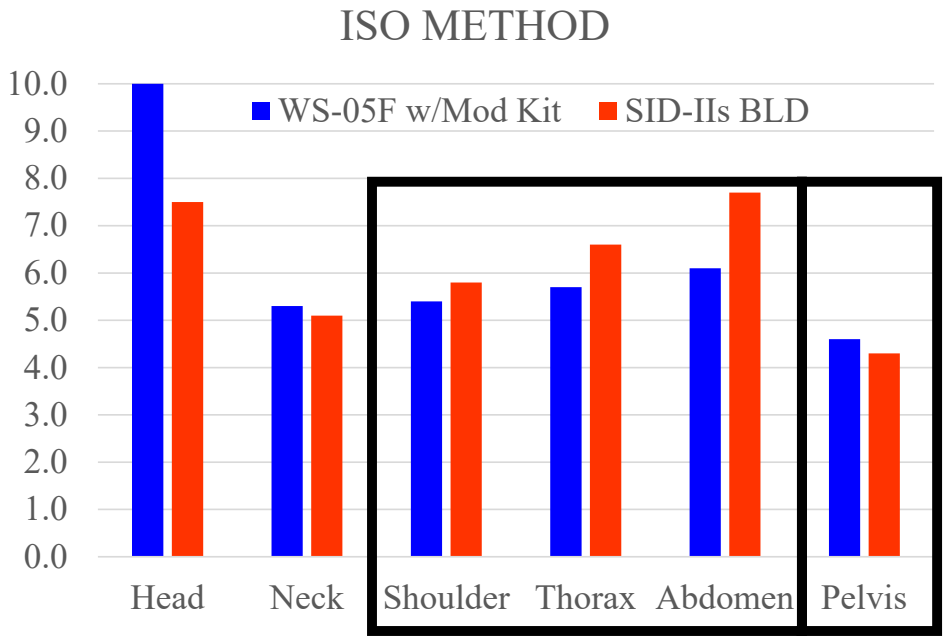
SAE Government Industry Meeting
January 20, 2022

Biofidelity Using ISO 9790 Ranking System

Higher score is better

Biofidelity Score	ISO Biofidelity Rating
8.6 ≤ B ≤ 10	Excellent
6.5 ≤ B < 8.6	Good
4.4 ≤ B < 6.5	Fair
2.6 ≤ B < 4.4	Marginal
0.0 ≤ B < 2.6	Unacceptable

Overall score	
WS-05F	SID-IIs
6.2	6.2



WorldSID-05F with Mod Kit biofidelity needed to be improved

- WorldSID-05F scores ref: WorldSID 5th Biofidelity Improvement Task Group meeting, 10/18/2016, attachment "ISO WS 5th Biofidelity Testing OSRP Update Plots and Scores 2NOV2016.pdf"
- SID-IIs scores ref: minutes of OSRP SID-IIs Upgrade Task Group meeting, 5/25/2006

NHTSA Biofidelity Evaluation Methods

NHTSA Biofidelity Evaluation Methods

3 tests in each test condition
- WorldSID-05F Mod Kit
- SID-IIs BLD

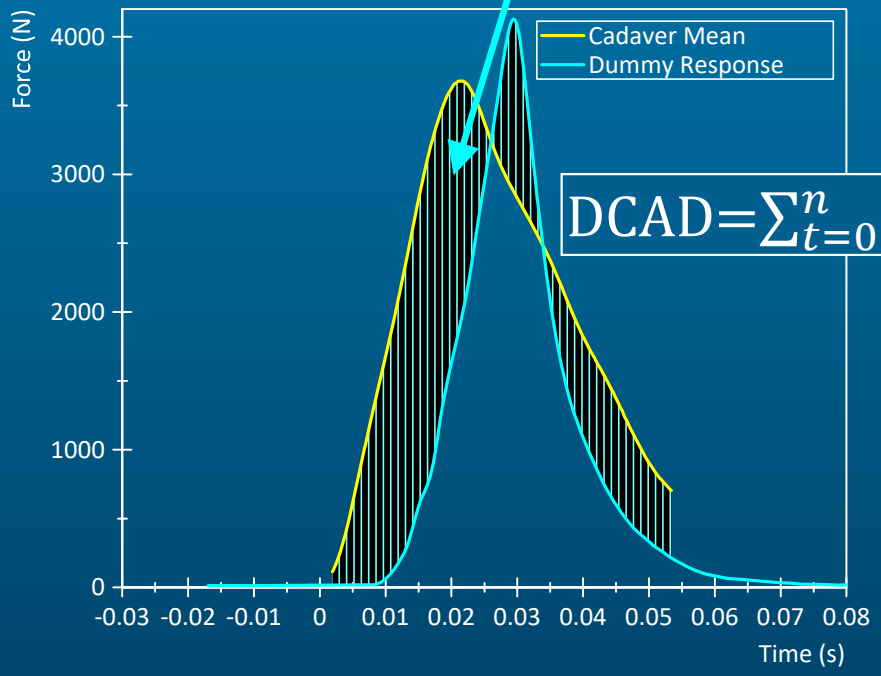
Scaled from 50th male to 5th female:
- Impactor mass & size
- Sled walls

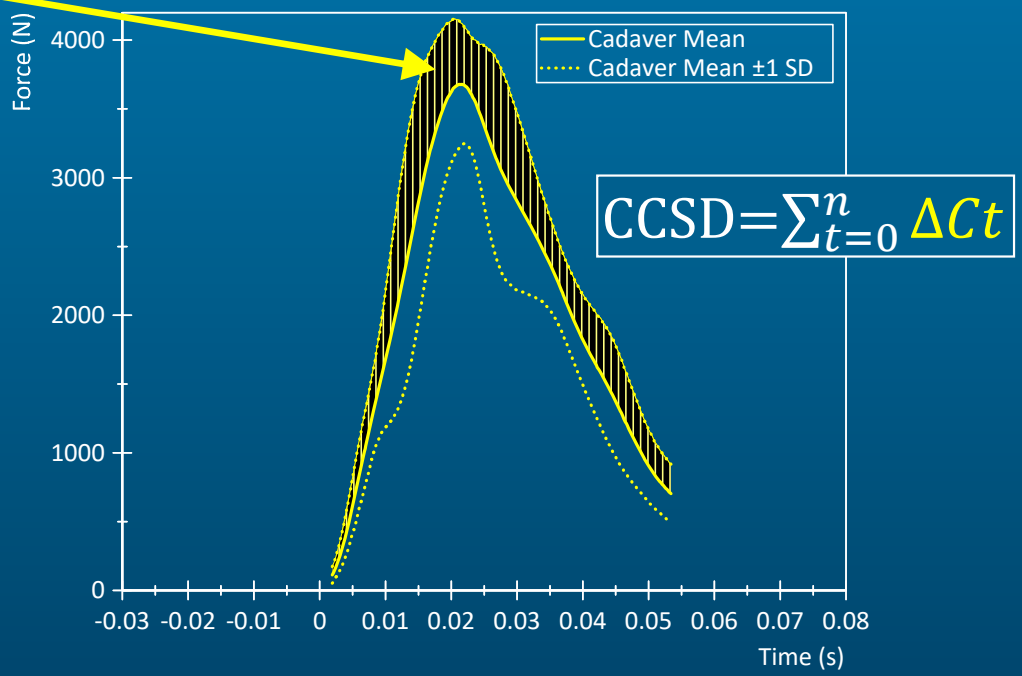
New side impact biofidelity targets for small female
- New normalization methods
- New response scaling methods

Body Region	Test Condition
Shoulder	4.4 m/s Bolte Lateral Impact
Thorax	2.5 m/s Shaw Lateral Impact
	2.5 m/s Shaw Oblique Impact
	4.5 m/s Rhule Lateral Impact
	4.5 m/s Rhule Oblique Impact
	6.7 m/s Rigid-Wall Sled Test
	6.7 m/s Padded-Wall Sled Test
	8.9 m/s Padded-Wall Sled Test
Abdomen	6.7 m/s Rigid-Wall Sled
	6.7 m/s Padded-Wall Sled
	8.9 m/s Padded-Wall Sled
	6.7 m/s Abdomen-Offset Sled
Pelvis	6.7 m/s Rigid-Wall Sled
	6.7 m/s Padded-Wall Sled
	8.9 m/s Padded-Wall Sled
	6.7 m/s Pelvis-Offset Sled

NHTSA Biofidelity Evaluation Methods

$$BRS\ score = \frac{DCAD}{CCSD} = \frac{Dummy\ Cumulative\ Absolute\ Difference}{Cadaver\ Cumulative\ Standard\ Deviation}$$





Lower BRS score means better biofidelity

NHTSA Biofidelity Evaluation Methods

$$BRS\ score = \frac{DCAD}{CCSD} = \frac{Dummy\ Cumulative\ Absolute\ Difference}{Cadaver\ Cumulative\ Standard\ Deviation}$$

- BRS calculation period = t_0 → time of the cadaver mean peak
- Dummy curve phase aligned
- If dummy curve peak was not included → calculation period was increased
- BRS score calculated
- Supplemental information → dummy phase shift, cadaver max & avg phase shifts

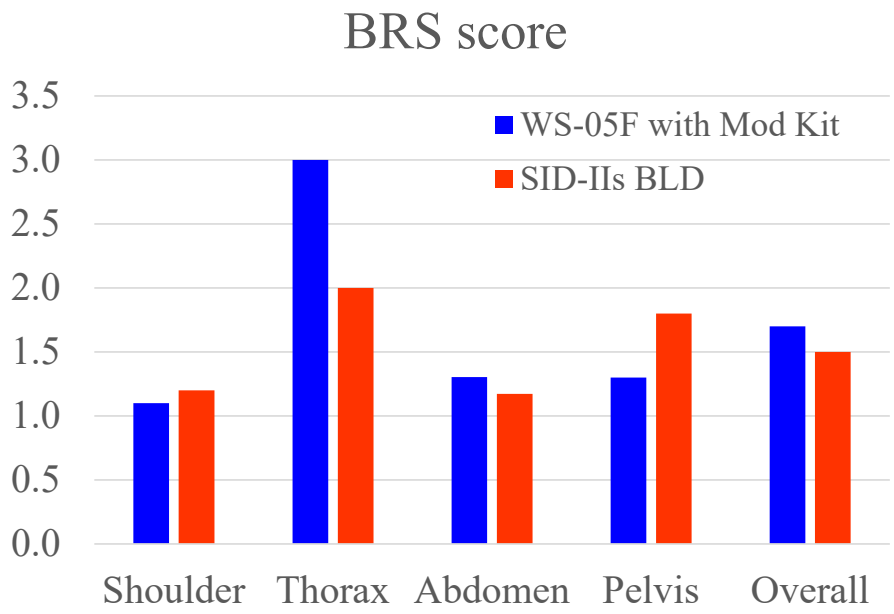
$$Peak\ only\ score = \frac{Abs(Dummy\ Response\ Peak - Cadaver\ Mean\ Peak)}{Cadaver\ Std.Dev._{Avg\ upper\ 80\%\ of\ Cadaver\ Mean}}$$

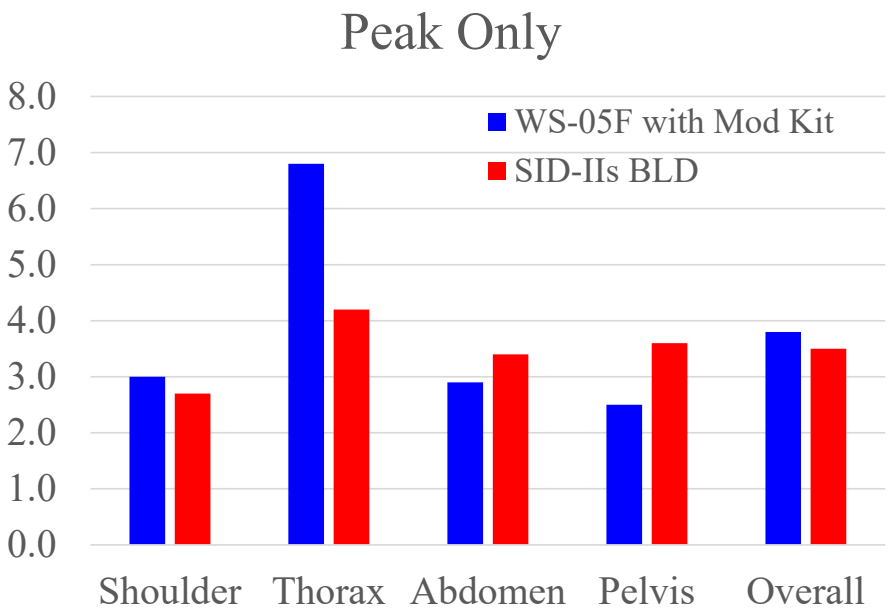
- No phase alignment of dummy curve
- Supplemental information → difference between cadaver and dummy peak times

NHTSA Biofidelity Evaluation Results

NHTSA Biofidelity Evaluation Results

Lower score is better

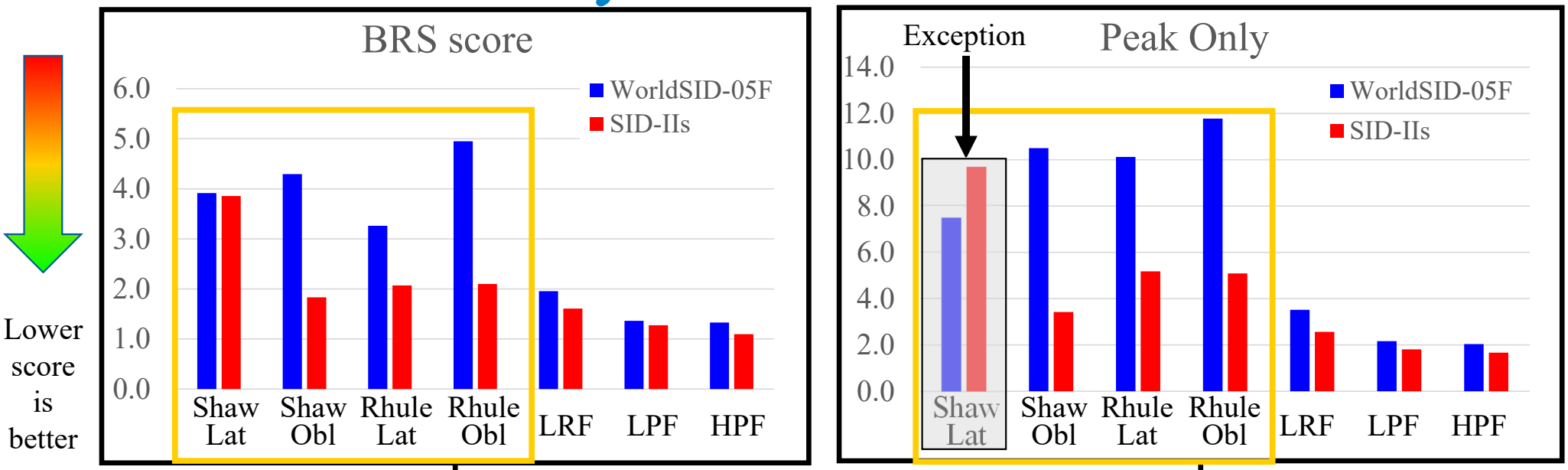




WorldSID-05F thorax needs improved biofidelity

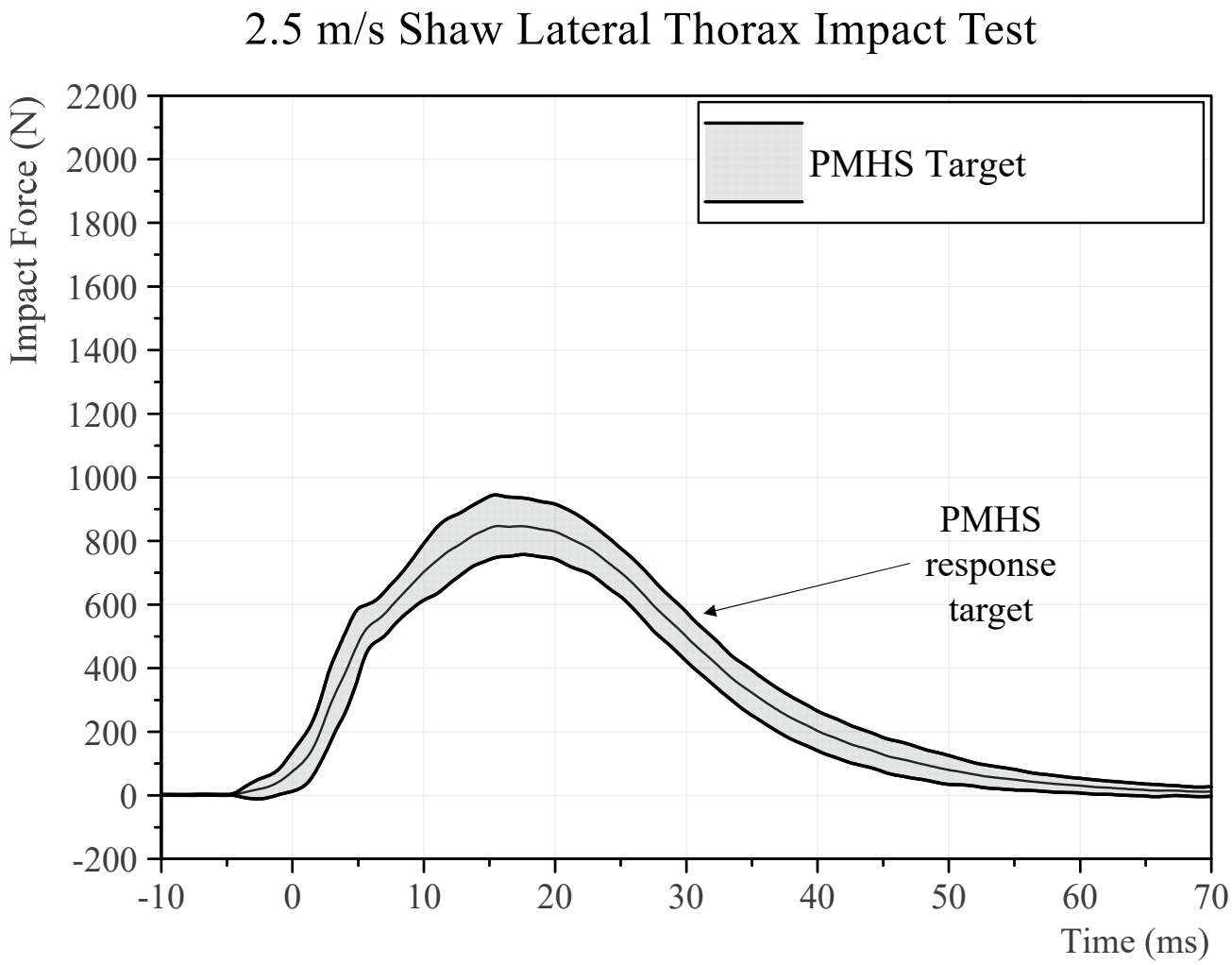
Thorax Biofidelity Results

Thorax Biofidelity Results

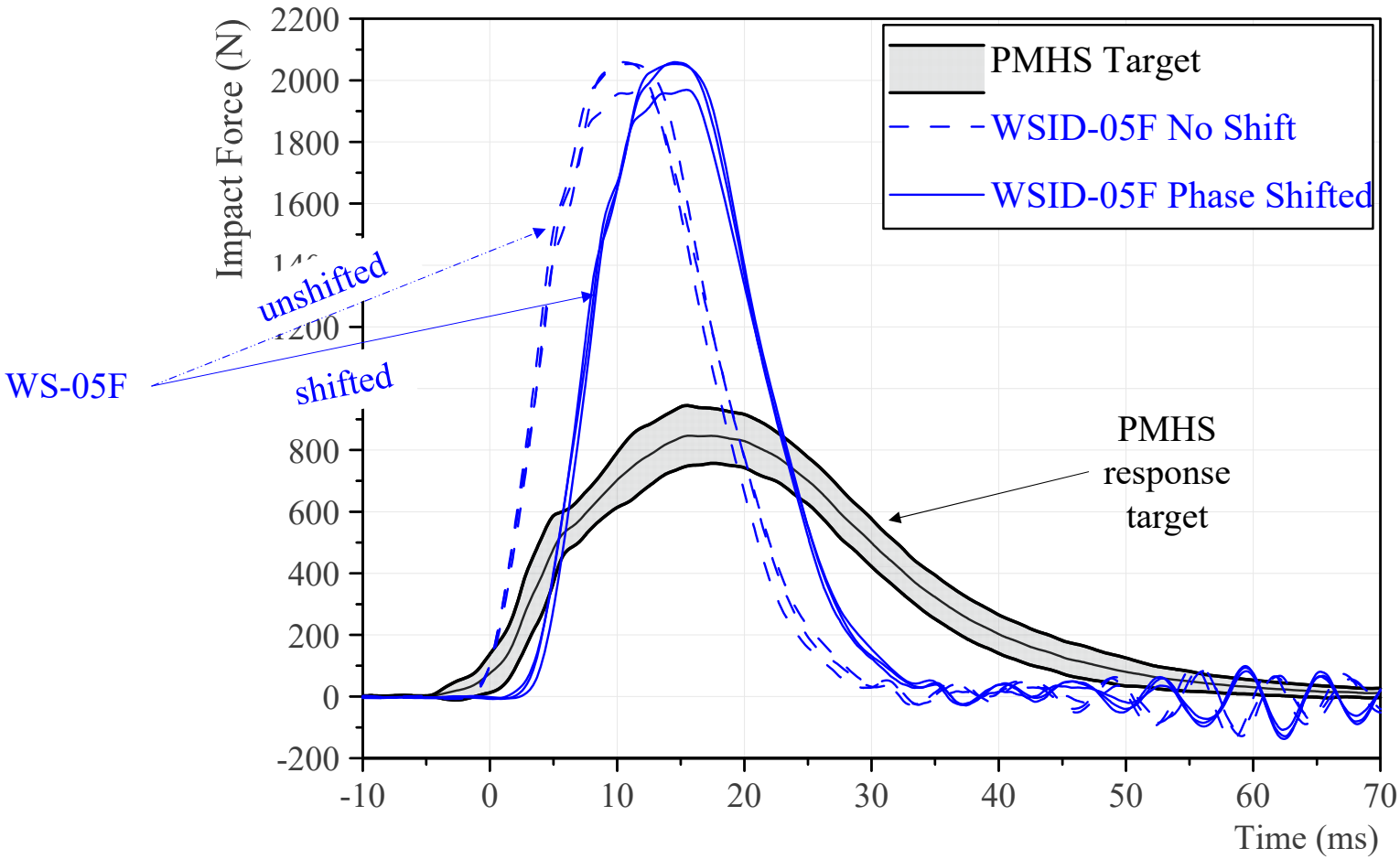


Overall Thorax Body Region scores

BRS score		Peak Only	
WS-05F	SID-IIs	WS-05F	SID-IIs
3.0	2.0	6.8	4.2


2.5 m/s Shaw Lateral Thorax Impact Test
Impact Force (N)
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
-200
-10
0
10
20
30
40
50
60
70
Time (ms)
PMHS Target
PMHS
response
target

2.5 m/s Shaw Lateral Thorax Impact Test



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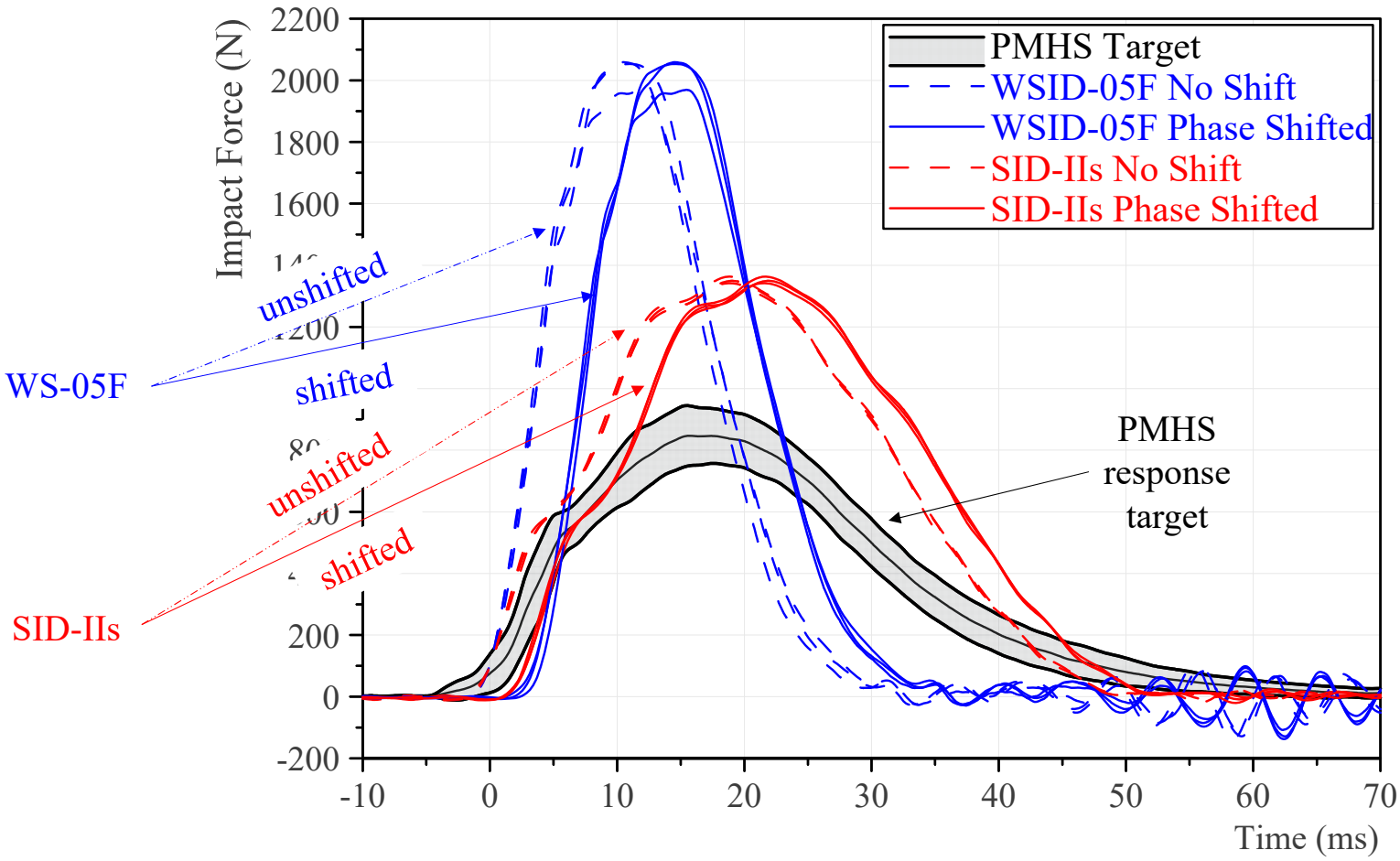

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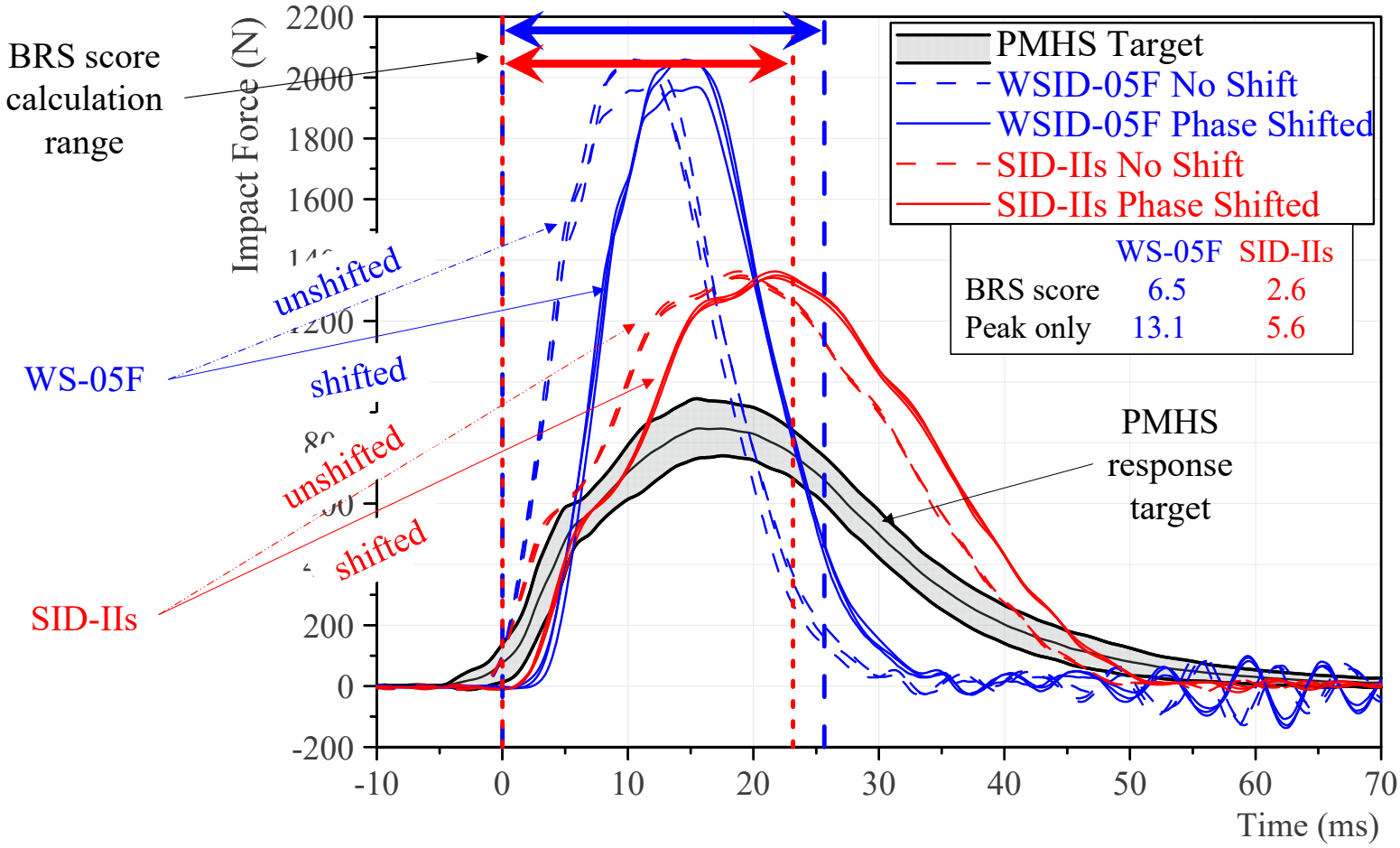

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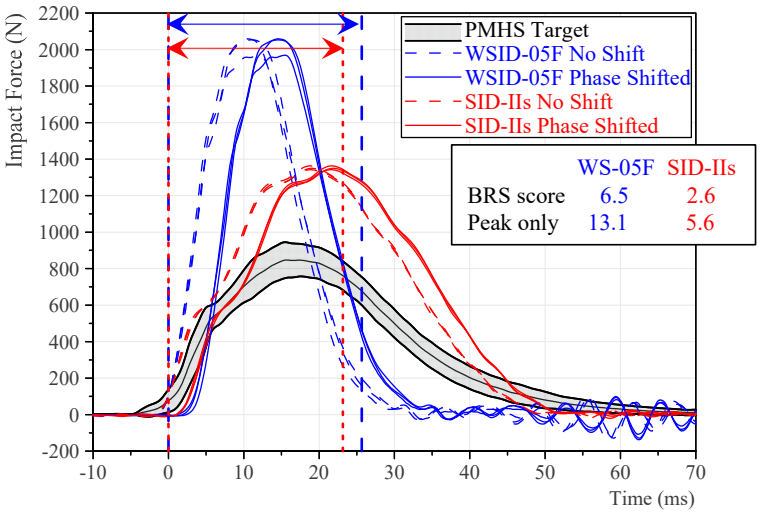
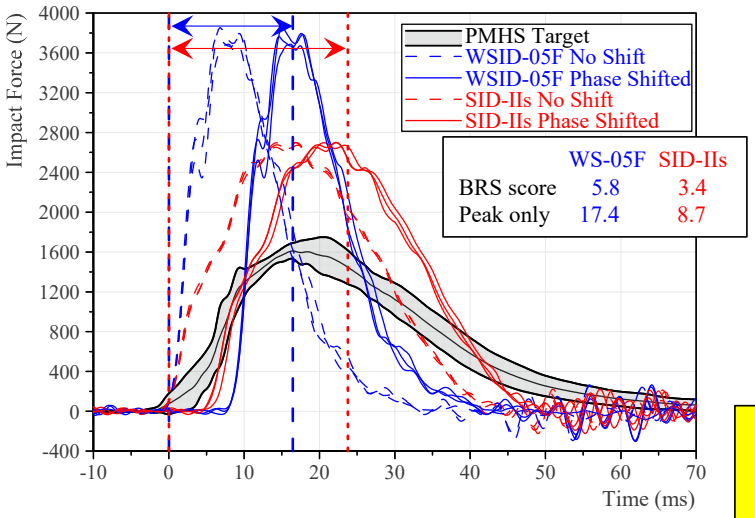
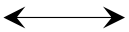


4.5 m/s Rhule Lateral Thorax Impact Test

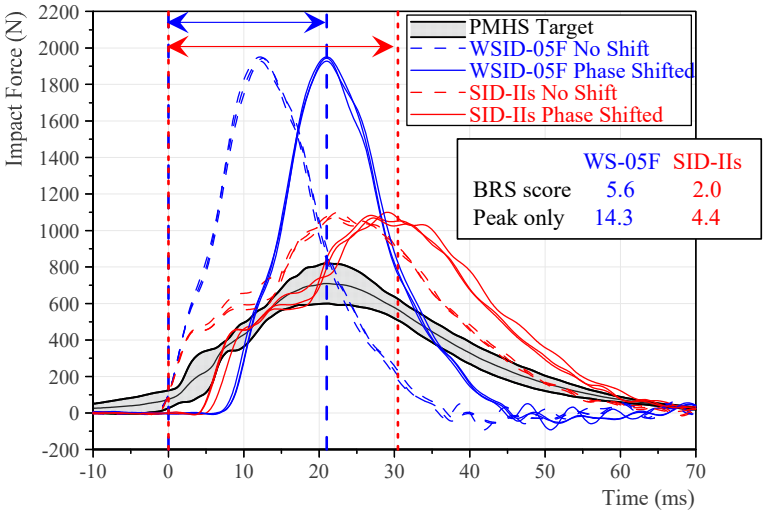


BRS score calculation Range



WorldSID-05F thorax is too stiff

2.5 m/s Shaw Oblique Thorax Impact Test



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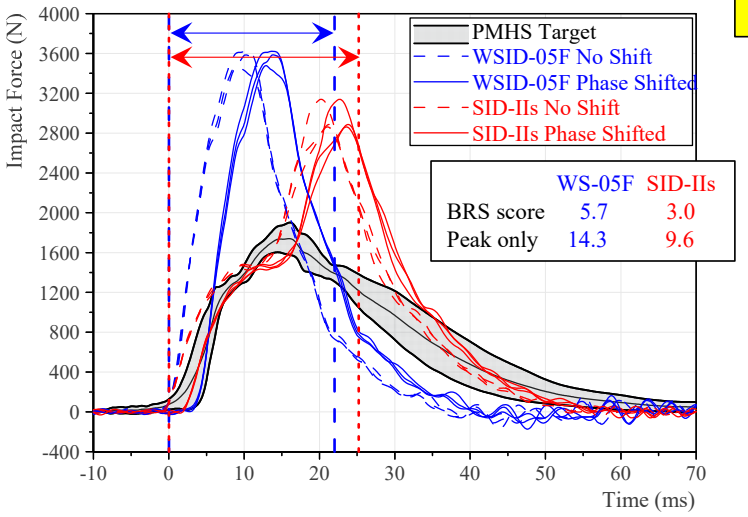

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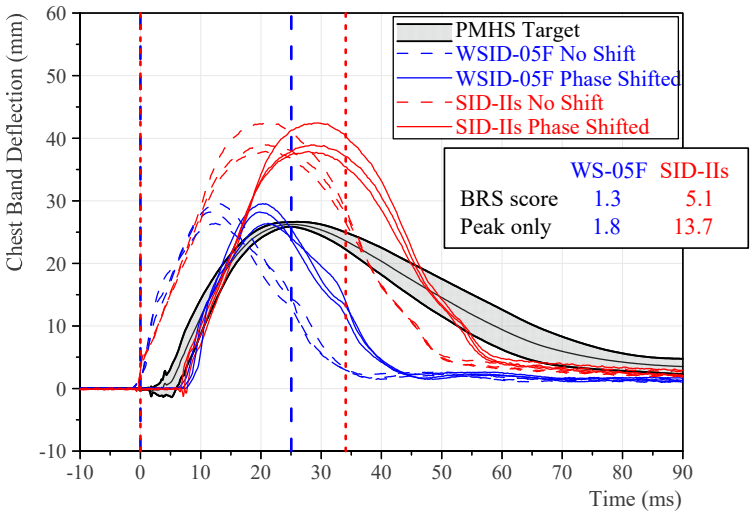

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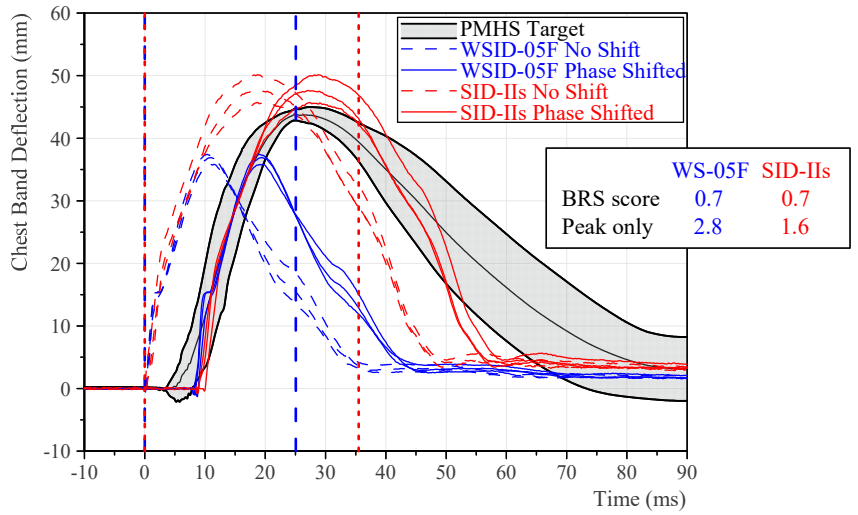

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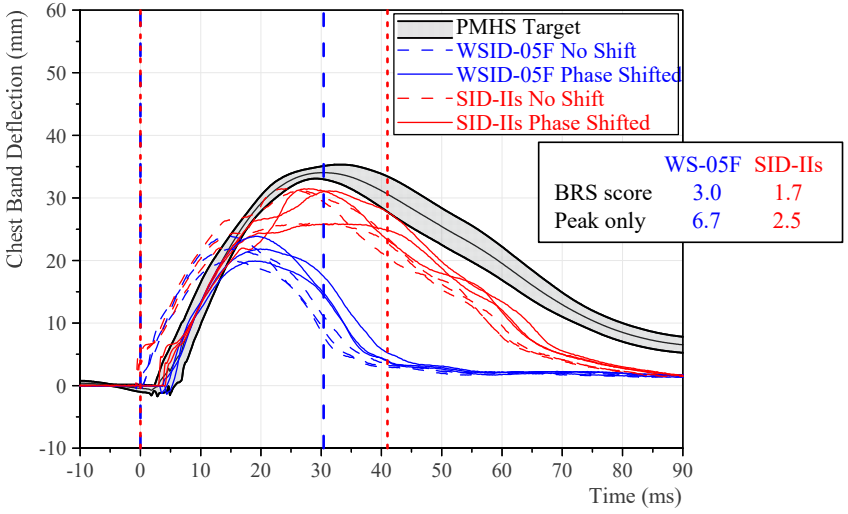

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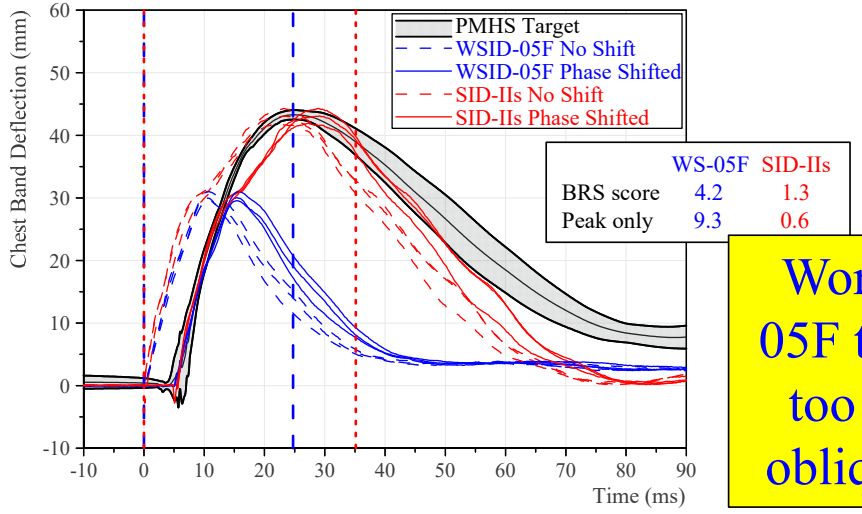
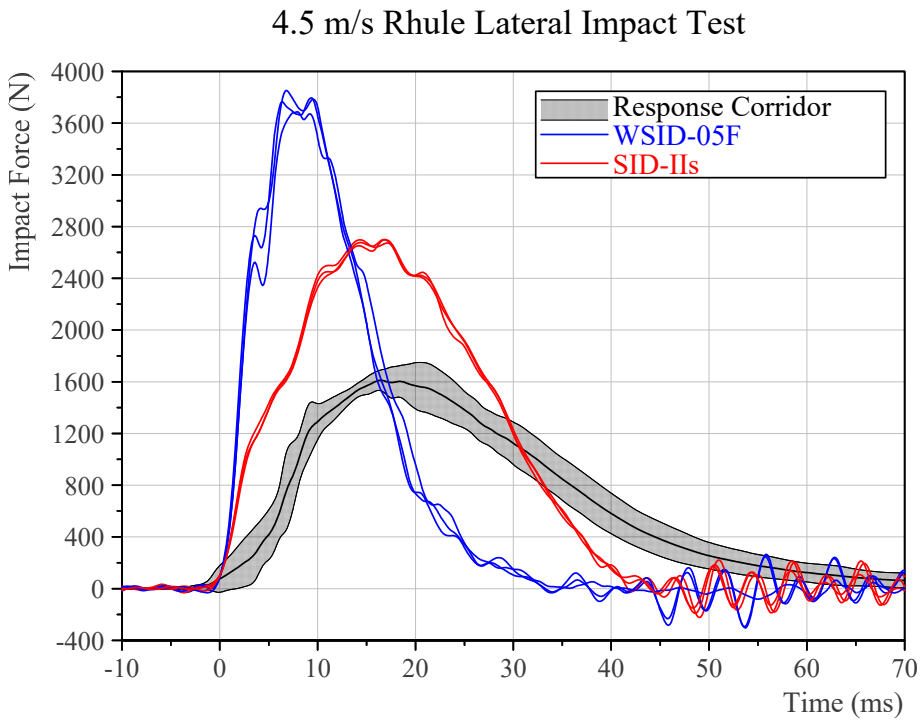


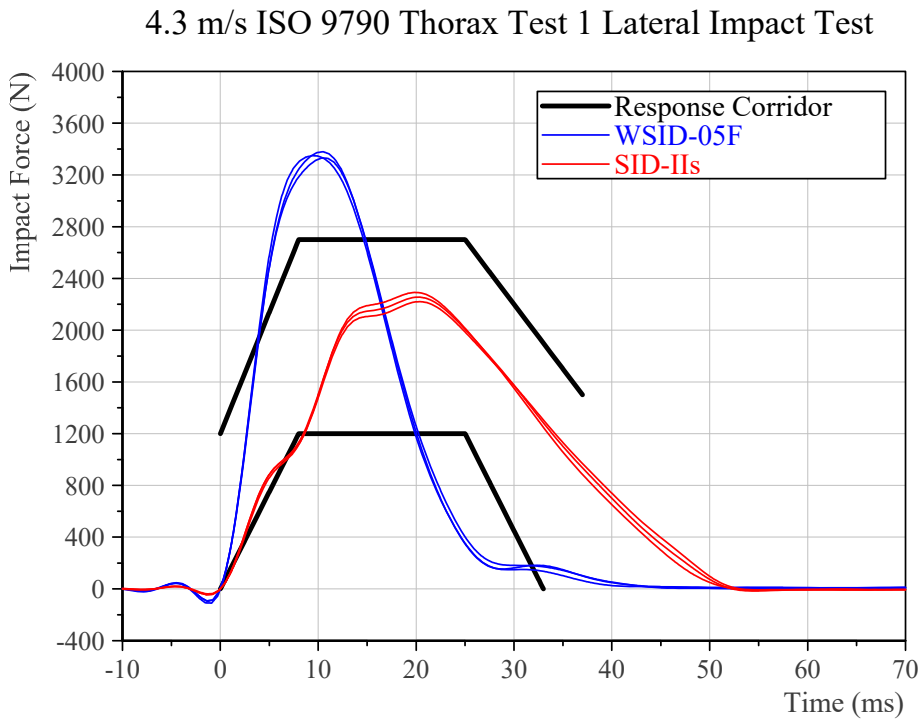
WorldSID-05F thorax is too stiff in oblique tests

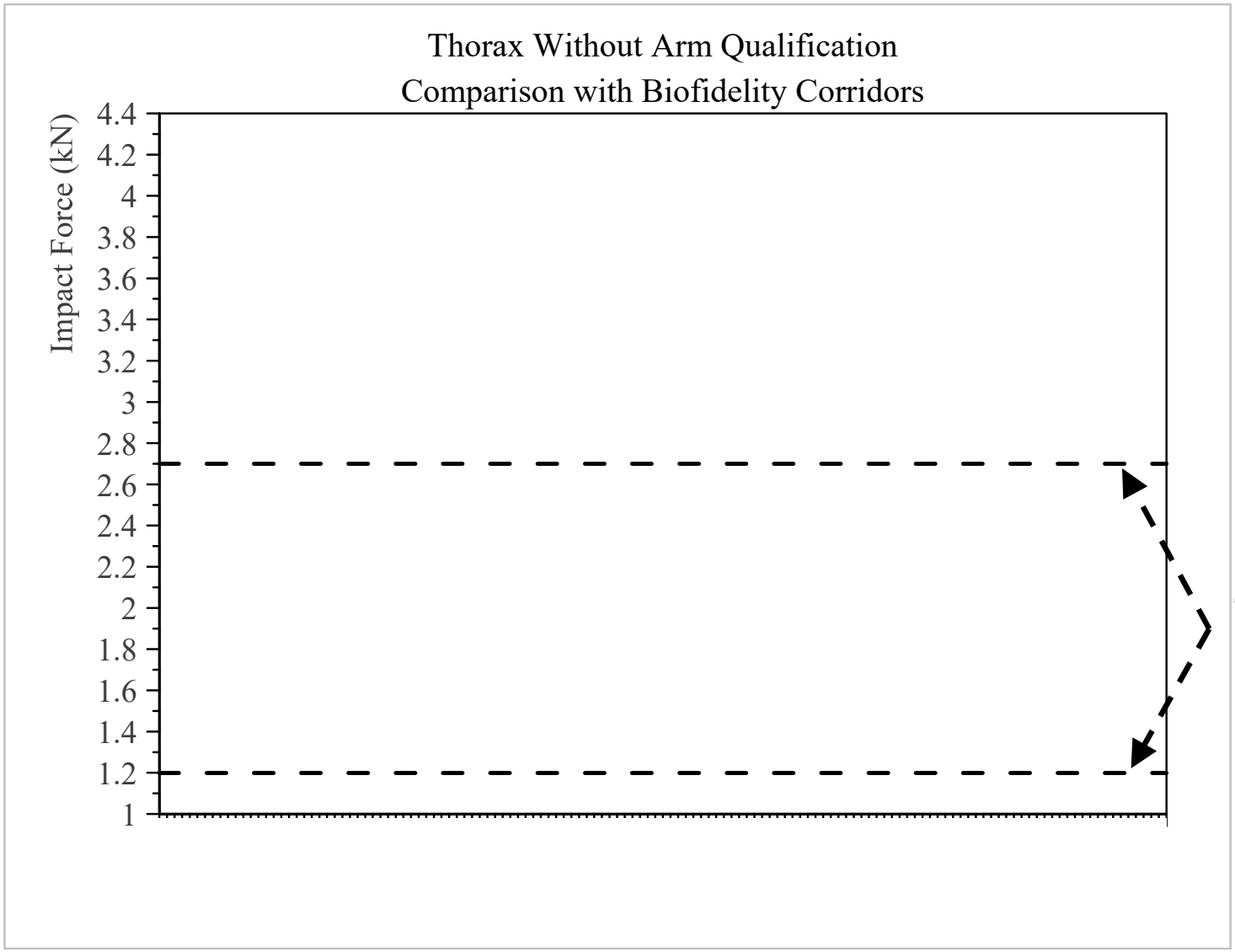
Thorax Qualification Response Over Time and Corridor Comparisons

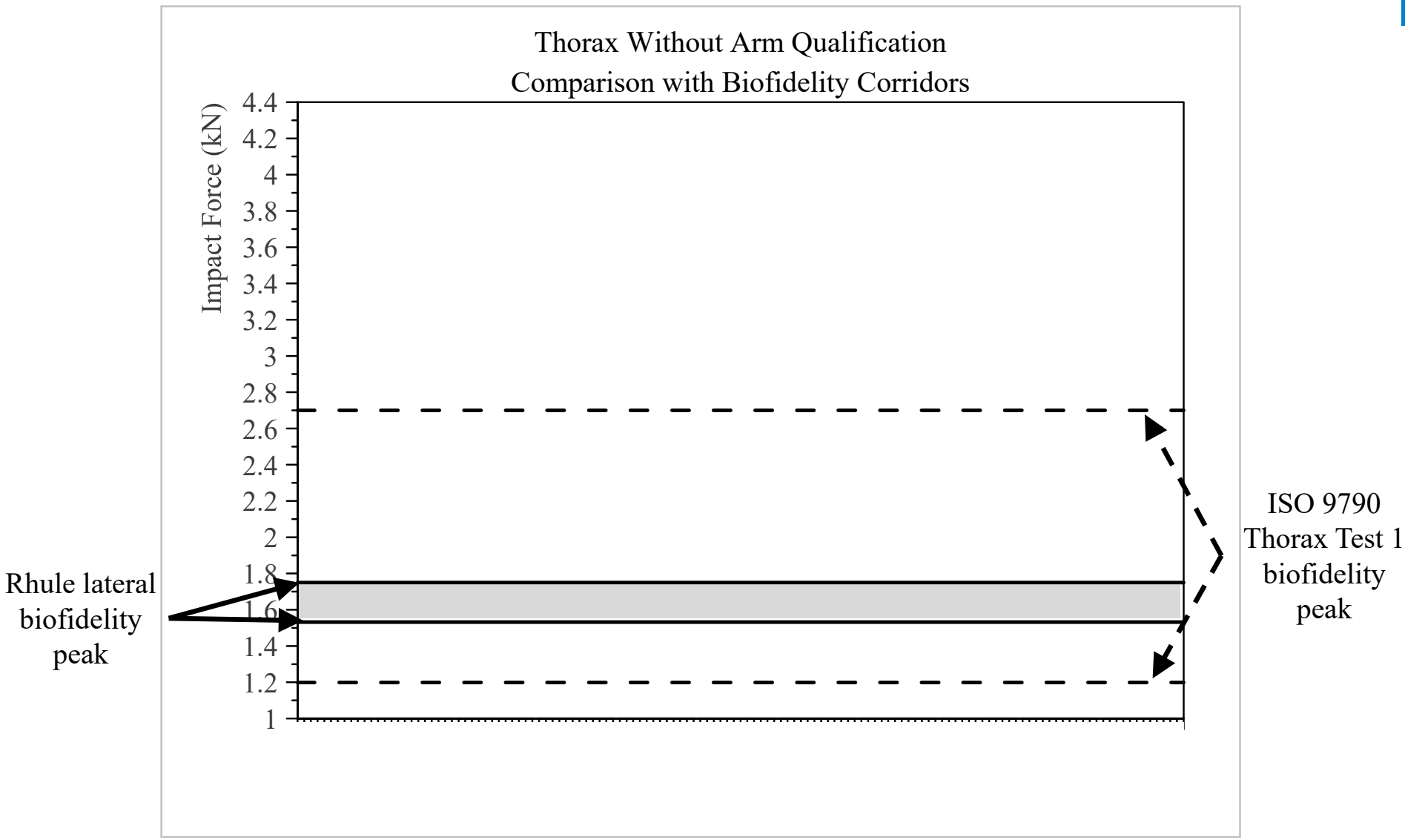
Test	Mass (kg)	Face (mm)	Impact speed (m/s)
Thorax without arm qualification test	13.97 +/- .023	120.7 ± 0.25	4.2-4.4
ISO 9790 Thorax Test 1 biofidelity test	14.0	125	4.3
Rhule lateral thorax impact biofidelity test	13.8	125 high x 305 wide	4.5

NHTSA & ISO Lateral Thorax Impactor Biofidelity Tests






Thorax Without Arm Qualification
Comparison with Biofidelity Corridors
Impact Force (kN)
4.4
4.2
4
3.8
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
ISO 9790
Thorax Test 1
biofidelity
peak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4.4
4.2
4
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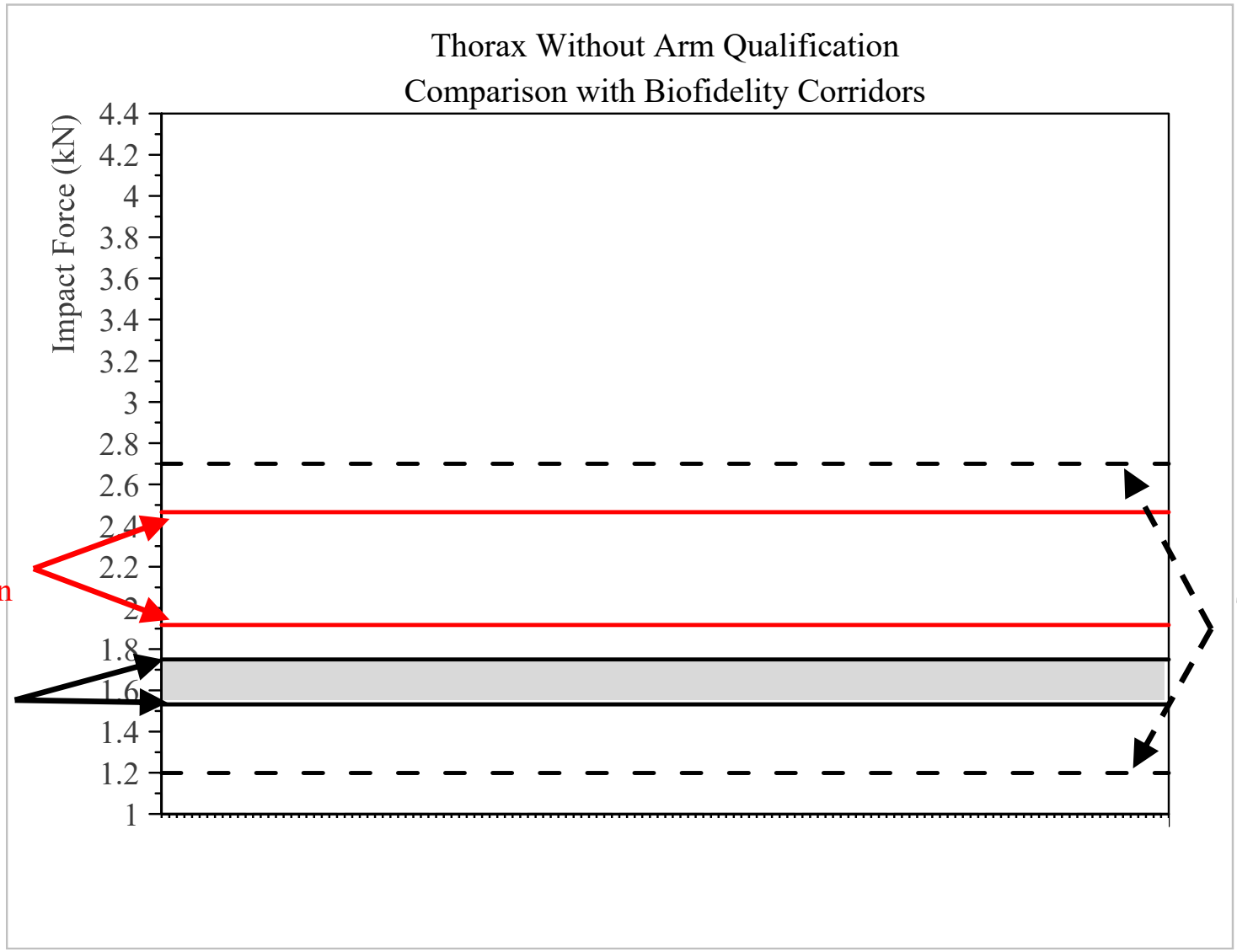
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
Rhule lateral biofidelity peak
ISO 9790 Thorax Test 1 biofidelity peak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4.2
4
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3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
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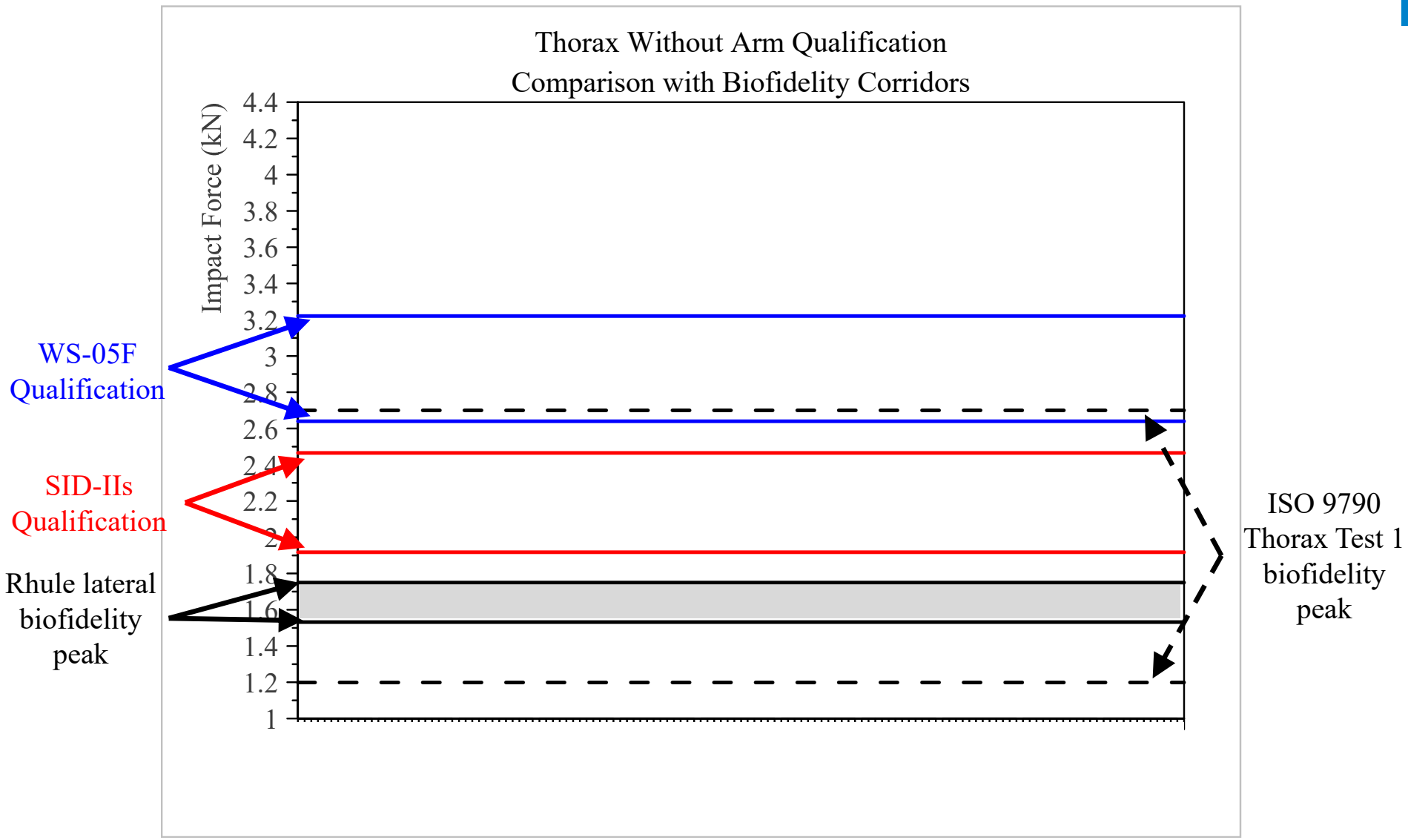
1.8
1.6
1.4
1.2
1
SID-IIs Qualification
Rhule lateral biofidelity peak
ISO 9790 Thorax Test 1 biofidelity peak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WS-05F Qualification
SID-IIs Qualification
Rhule lateral biofidelity peak
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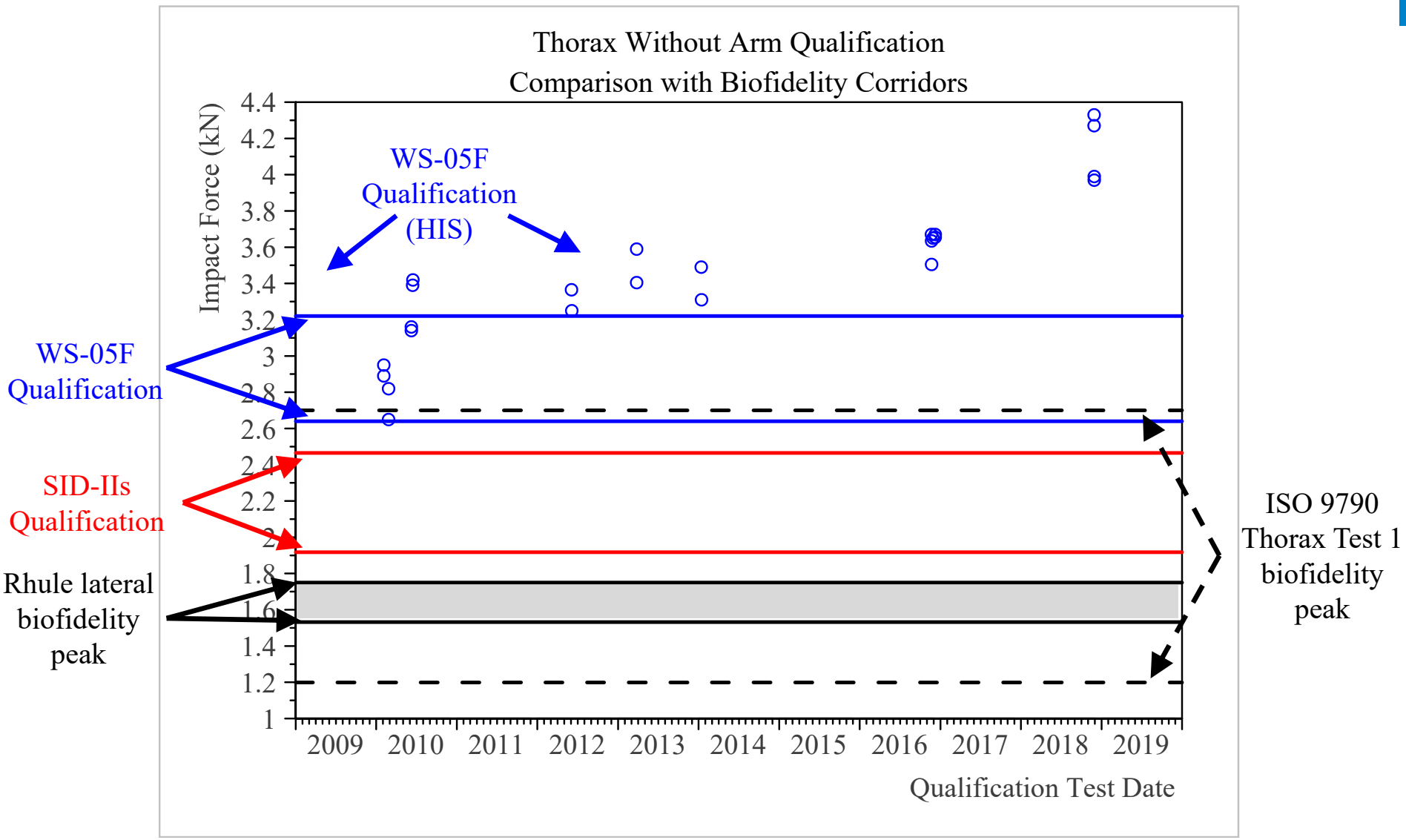
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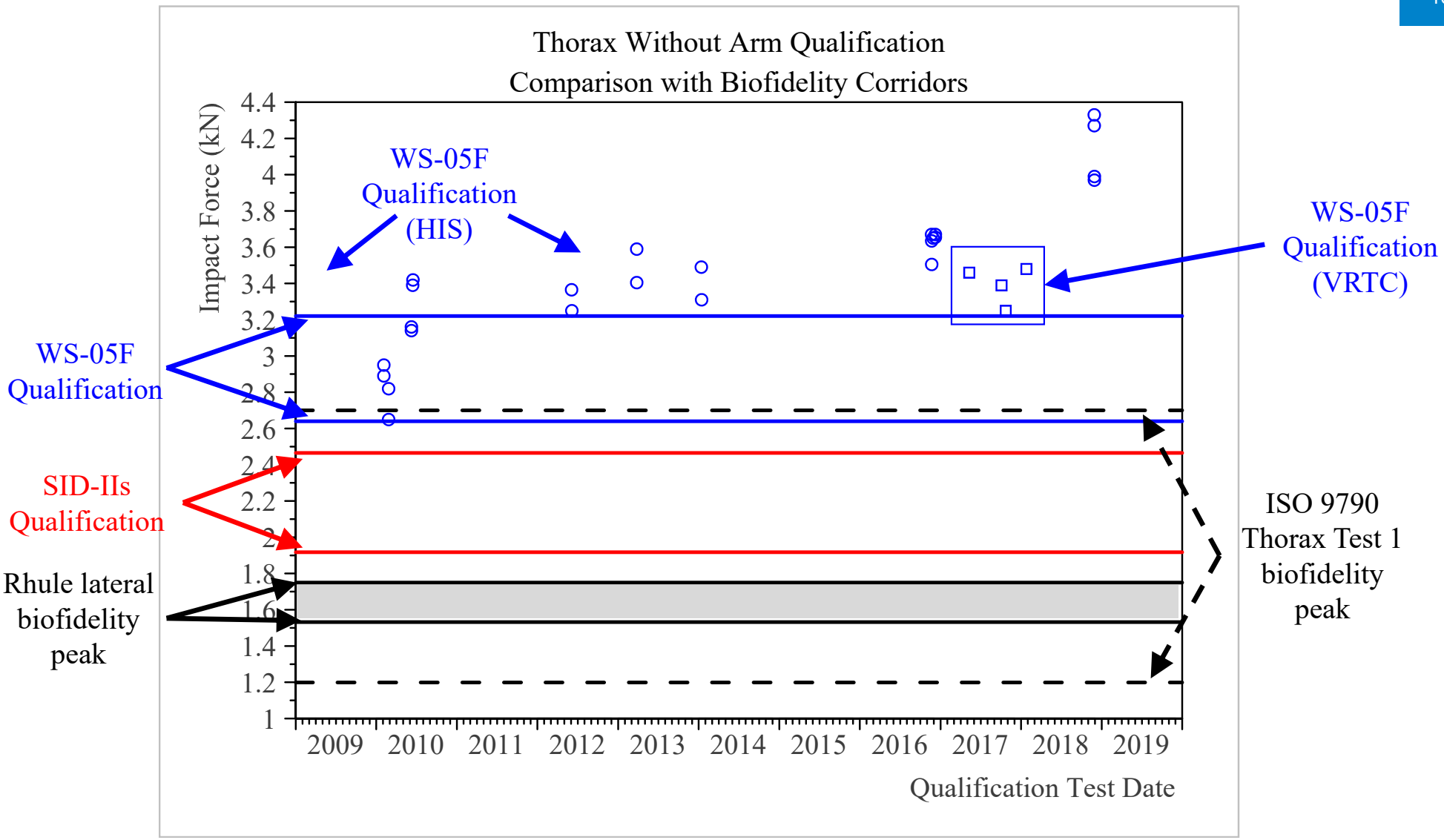
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
Qualification Test Date
WS-05F Qualification (HIS)
WS-05F Qualification
SID-IIs Qualification
Rhule lateral biofidelity peak
ISO 9790 Thorax Test 1 biofidelity peak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4.4
4.2
4
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3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
Qualification Test Date
WS-05F Qualification (HIS)
WS-05F Qualification (VRTC)
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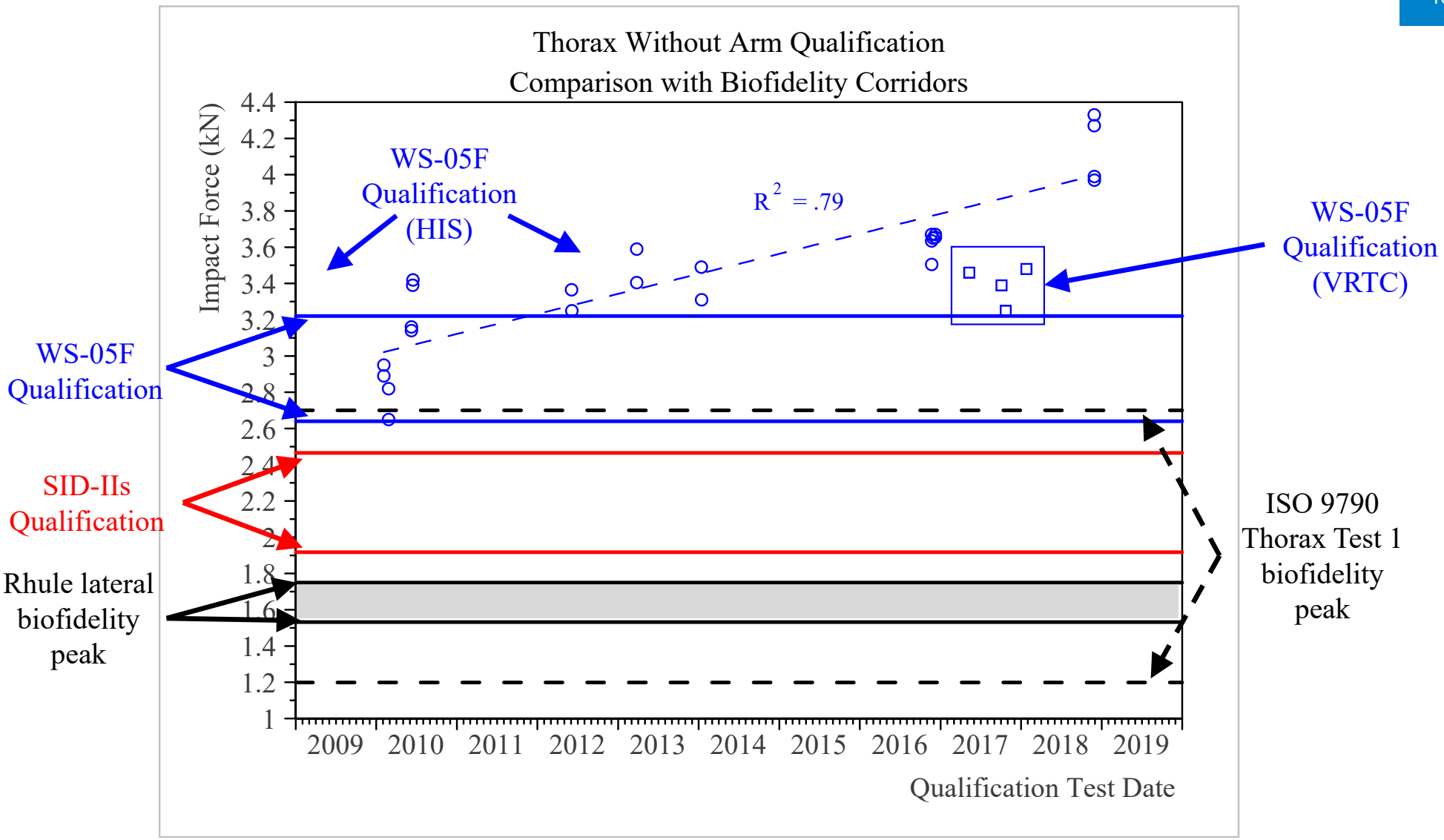
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3.8
3.6
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3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
Qualification Test Date
WS-05F Qualification (HIS)
R 2 = .79
WS-05F Qualification (VRTC)
WS-05F Qualification
SID-IIs Qualification
Rhule lateral biofidelity peak
ISO 9790 Thorax Test 1 biofidelity peak

Summary

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  - NHTSA results → thorax
    - Thorax too stiff, especially in impactor tests

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  - NHTSA results → thorax
    - Thorax too stiff, especially in impactor tests
- WorldSID-05F qualification corridor is too stiff
- WorldSID-05F qualification responses have been getting stiffer over time

NHTSA

NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

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