

**GTR 7 Informal Working Group
21-22 September 2010
Berlin, Germany**

GTR-04-14

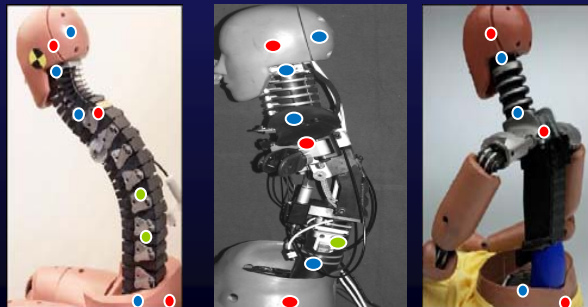
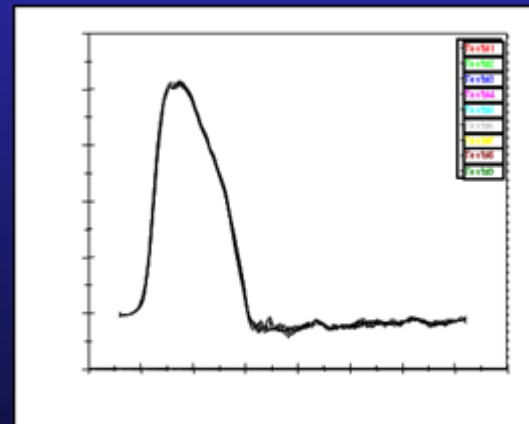
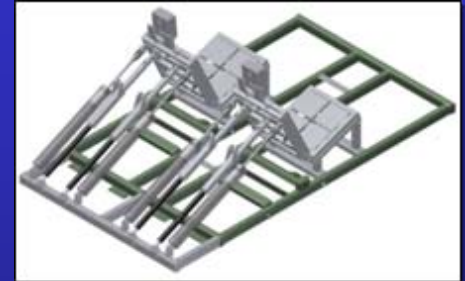
***BioRID II
Preliminary
Repeatability Assessment
&
Biofidelity Assessment***

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Bruce Donnelly, Ph.D.
NHTSA**



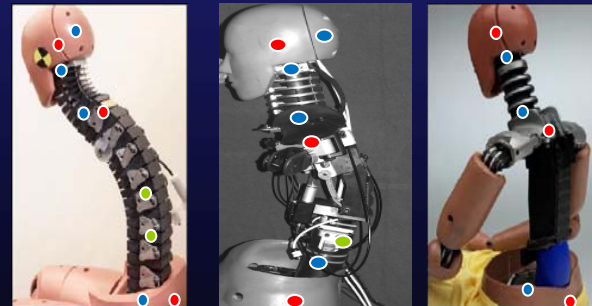
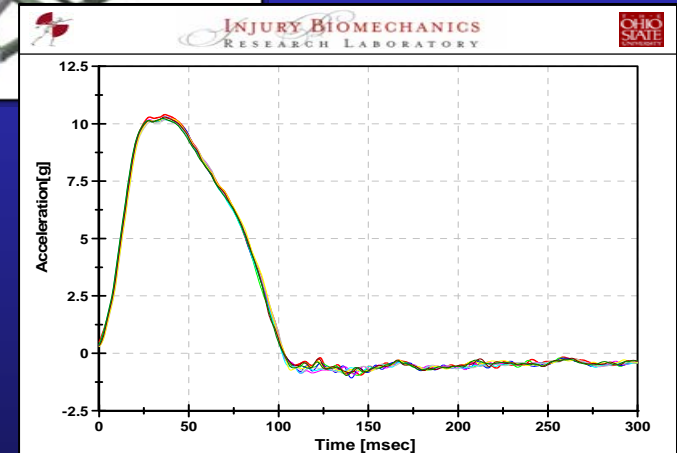
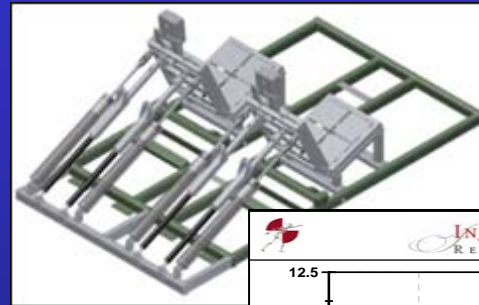
Repeatability Objective

- **Assess in a realistic repeatable mode**
 - “Yielding” seatback, 30° rotation
 - Two exposures
 - Low speed – 16.7 kph, 8.5 Gs
 - Mid speed – 24 kph, 10.5 Gs
- **Three dummies**
 - BioRID II
 - HIII
 - RID 3D



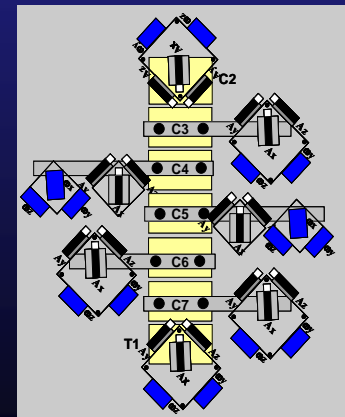
Biofidelity Objective

- **Assess biofidelity**
 - Two exposures: low & mid
 - Six PMHS at each speed
 - Low then Mid-speed
 - Internal biofidelity
 - External biofidelity
- **Analyze vertebral kinematics**
 - 6 DOF per vertebra

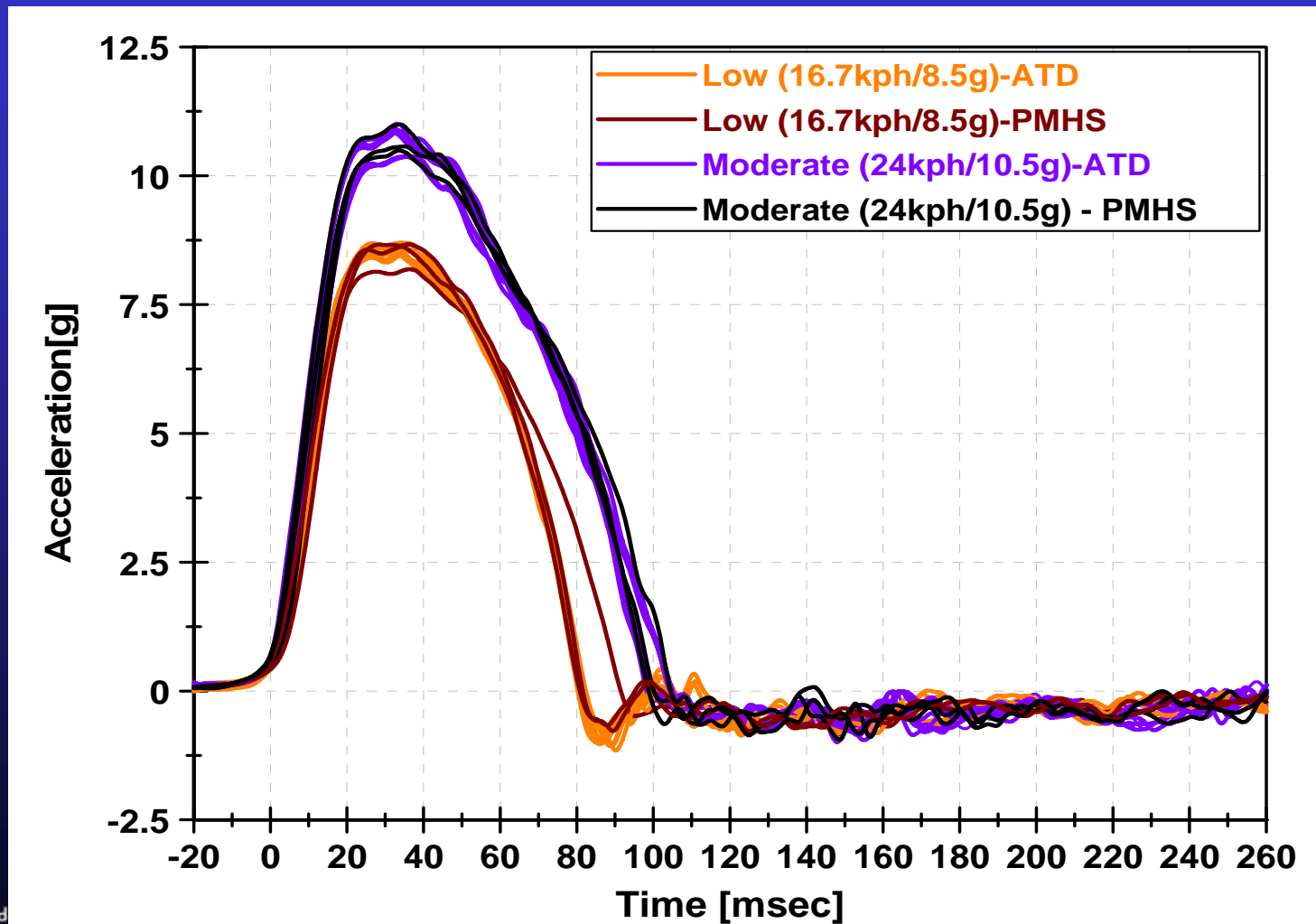


Injury Criteria Objective

- **Identify injurious kinematics**
 - Compare with values of non-injurious physiologic ROM (Panjabi et al, 1998; Panjabi et al, 2005)
 - Flexion and extension rotations
 - Shear and axial displacements
 - Determine likelihood and mode of injury at each vertebral level
- **Compare to various injury criteria and look for best predictor**
 - IV-NIC
 - NIC, N_{ij} , N_{km} , N_{te} , ND criterion, LNL index
 - Head-to-Torso rotation, upper & lower extension moment
 - Other??



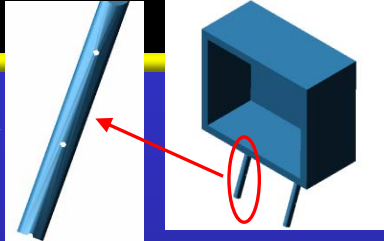
Pulses: Low & Mid-speed



Rear Impact Sled Seat

Head restraint

Diameter :17 mm



Mass : 5.5 kg

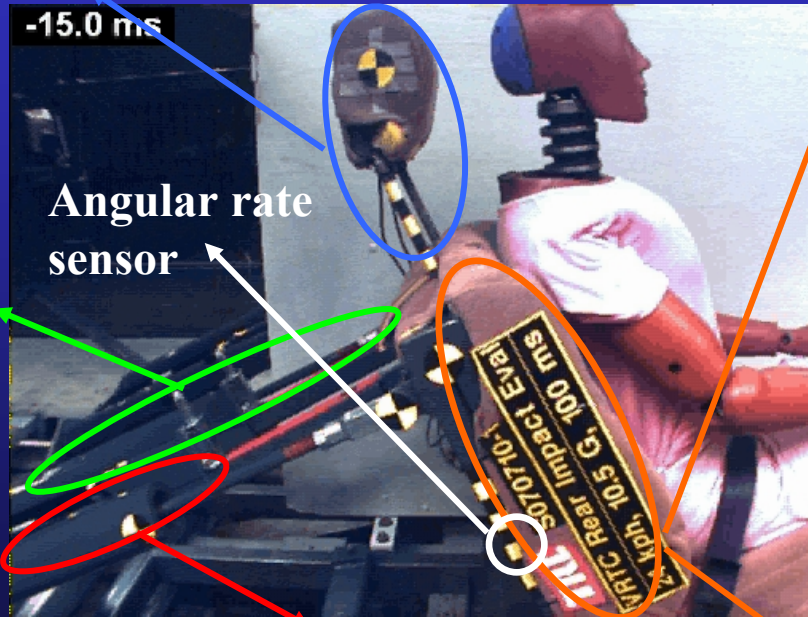
Seat

- Mass: 30 kg
- Padding/cushions/seat cover of 1999 Toyota Camry seat

Damper

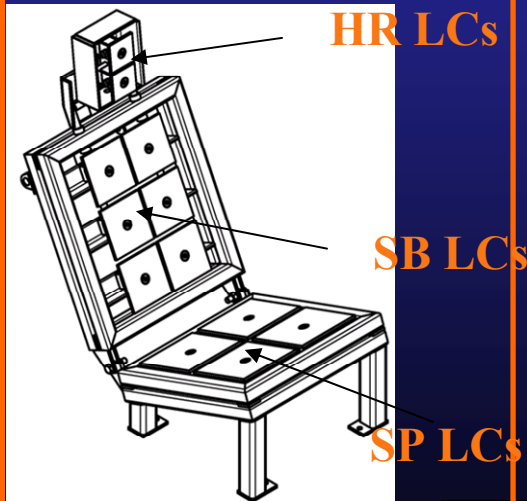


One-way damper (x2)



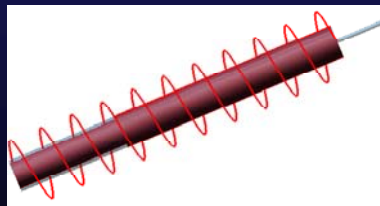
Angular rate sensor

Seat instrumentation



Spring

Stiffness:
13500 N/m (x2)



Repeatability Test Matrix

Test Number	Test Speed	Driver Side Dummy	Passenger Side Dummy
1	L	Hybrid III 50 th	BioRID II
2	L	Hybrid III 50 th	BioRID II
3	L	RID3D	BioRID II
4	L	RID3D	BioRID II
5	L	RID3D	Hybrid III 50 th
6	M	RID3D	Hybrid III 50 th
7	M	RID3D	Hybrid III 50 th
8	M	RID3D	BioRID II
9	M	RID3D	BioRID II
10	M	Hybrid III 50 th	BioRID II

L = Low Speed (8.5 g, 16.7 kph FMVSS 202)

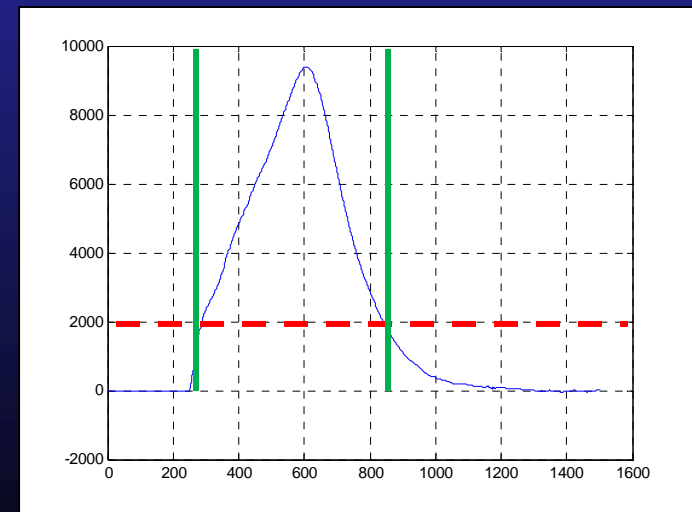
M = Moderate Speed (10.5 g, 24 kph)



Repeatability Methodology

- **Peak analysis** (Rhule 2005)
 - Coefficient of variation
- **Time based analysis**
 - Upper 80% only
 - Repeatability (J.Shaw 2006)
 - Cumulative C.V.
 - Confidence interval
 - Reproducibility (J. Shaw 2006)
 - Repeatability established
 - Hypothesis testing
 - t-statistic at 10% cum. C.V.

R&R rating	C.V. %
Excellent	0 to 5
Good	>5 to 8
Acceptable	>8 to 10
Poor	>10



EEVC Biofidelity Test Criteria

- ✓ • **Availability of data**
- ✓ • **Quality of set-up, instrumentation, subject quality**
- ✓ • **Reproducibility**
- ✓ • **Relevance of test conditions, loading conditions, ΔV**
- ✓ • **Distribution of subject anthropometry, gender, age**
- ✓ • **Number of tests and subjects**

Reference: Hynd, D., et. al., EEVC WG12 Report – Document Number 505A, Dummy Requirements and Injury Criteria for a Low-speed Rear Impact Whiplash Dummy, September 2007.



Biofidelity Analysis

- **Qualitative analysis**
 - **Overplots**
 - **“Eyeball” assessment**
- **Quantitative analysis**
 - **BioRank?**
 - **Objective Rating Method?**
 - **CORA?**
 - **Phase, Magnitude, Shape?**



Biofidelity Test Matrix

Test	24 kph	17 kph
1	1	
2		2
3	3	3
4	4	4
5	5*	5*
6		

* Tested 10-9-2010

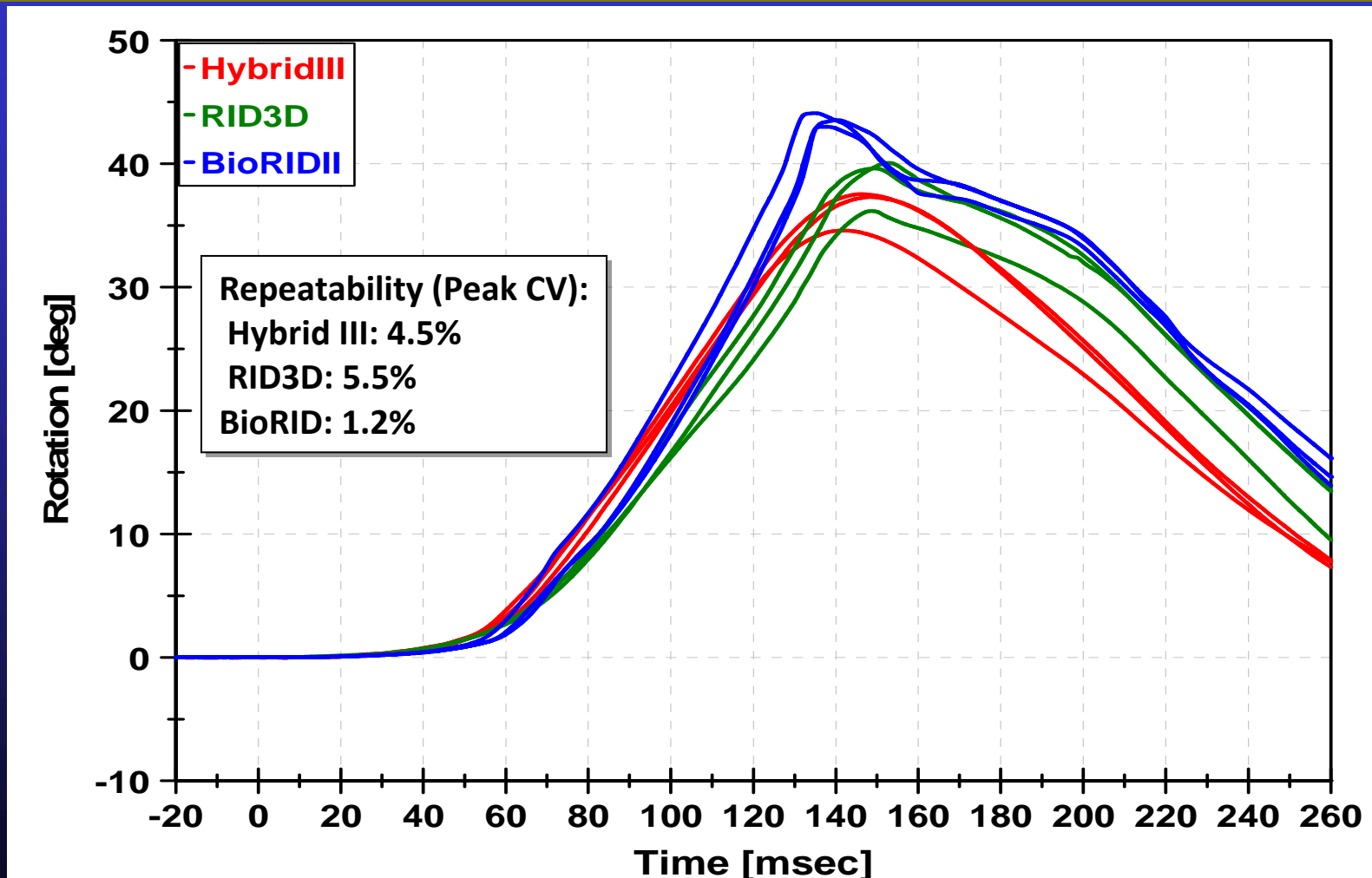


Internal Biofidelity Parameters

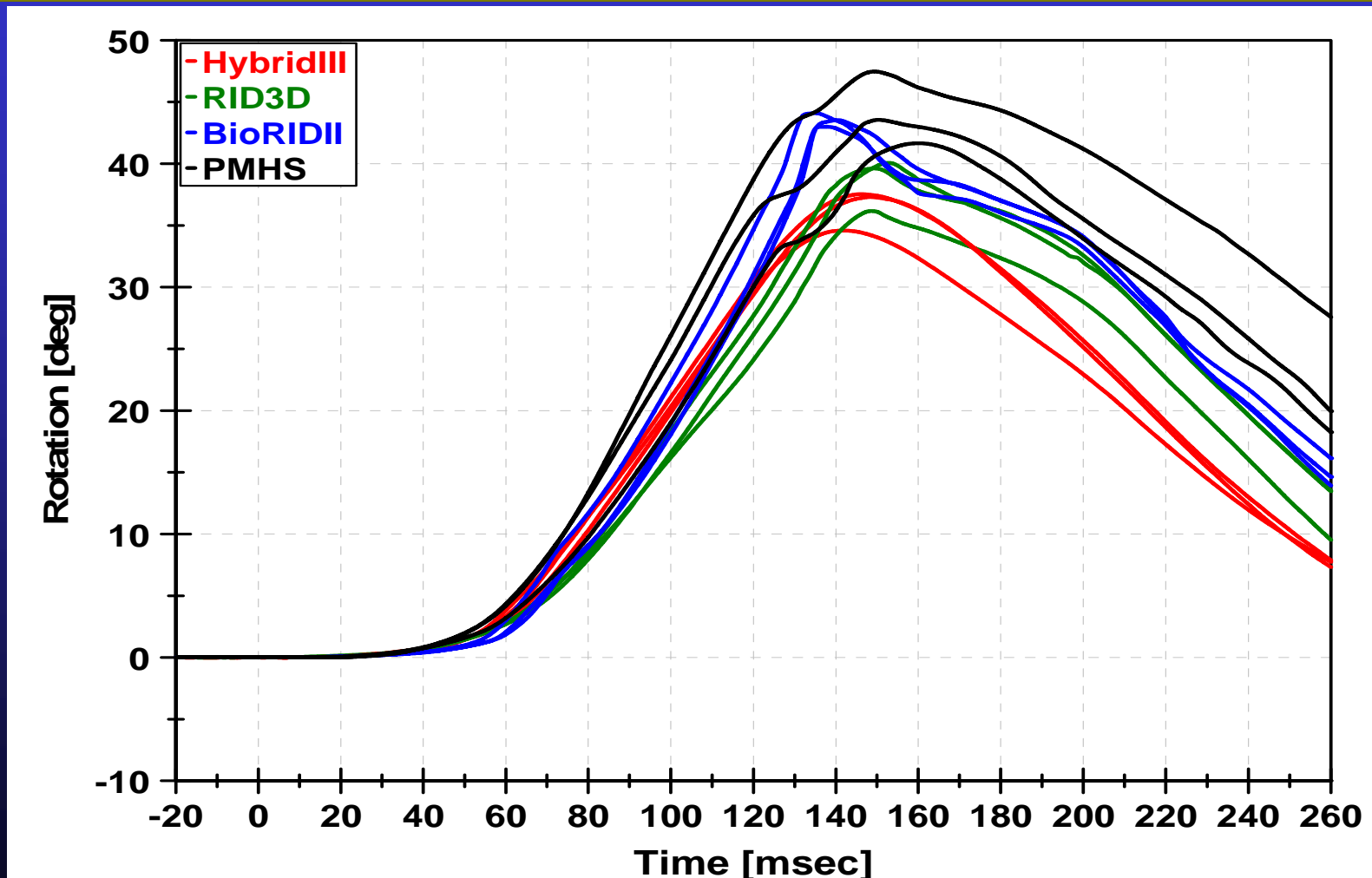
- **T1 angle w/r to sled**
- **T1 X-acceleration w/r sled**
- **Head angular displacement w/r to sled**
- **Head CG X-displacement w/r to sled**
- **Head angular displacement w/r to T1**
- **HIC₁₅**



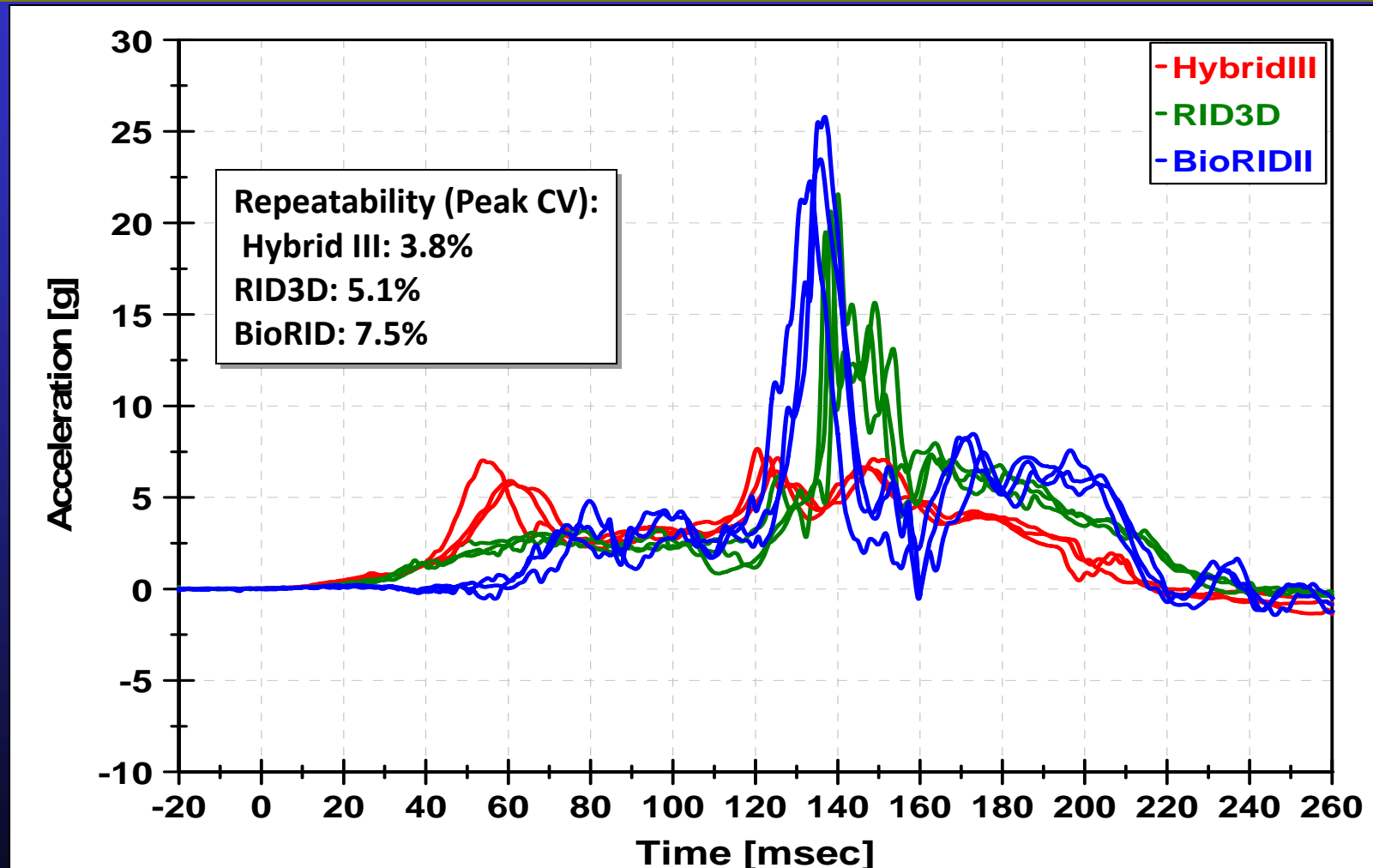
T1 angle w/r to sled-17 kph



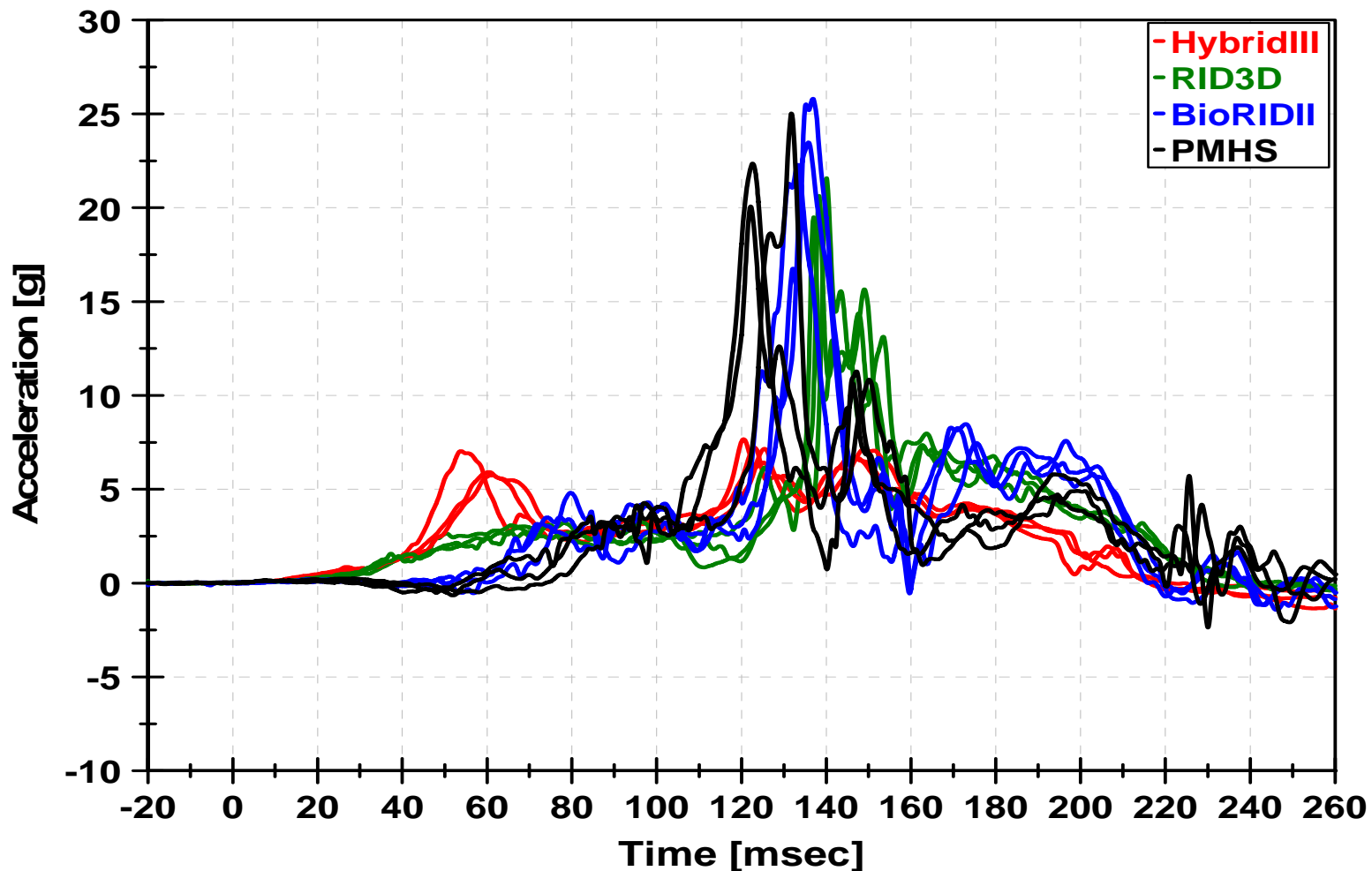
T1 angle w/r to sled-17 kph



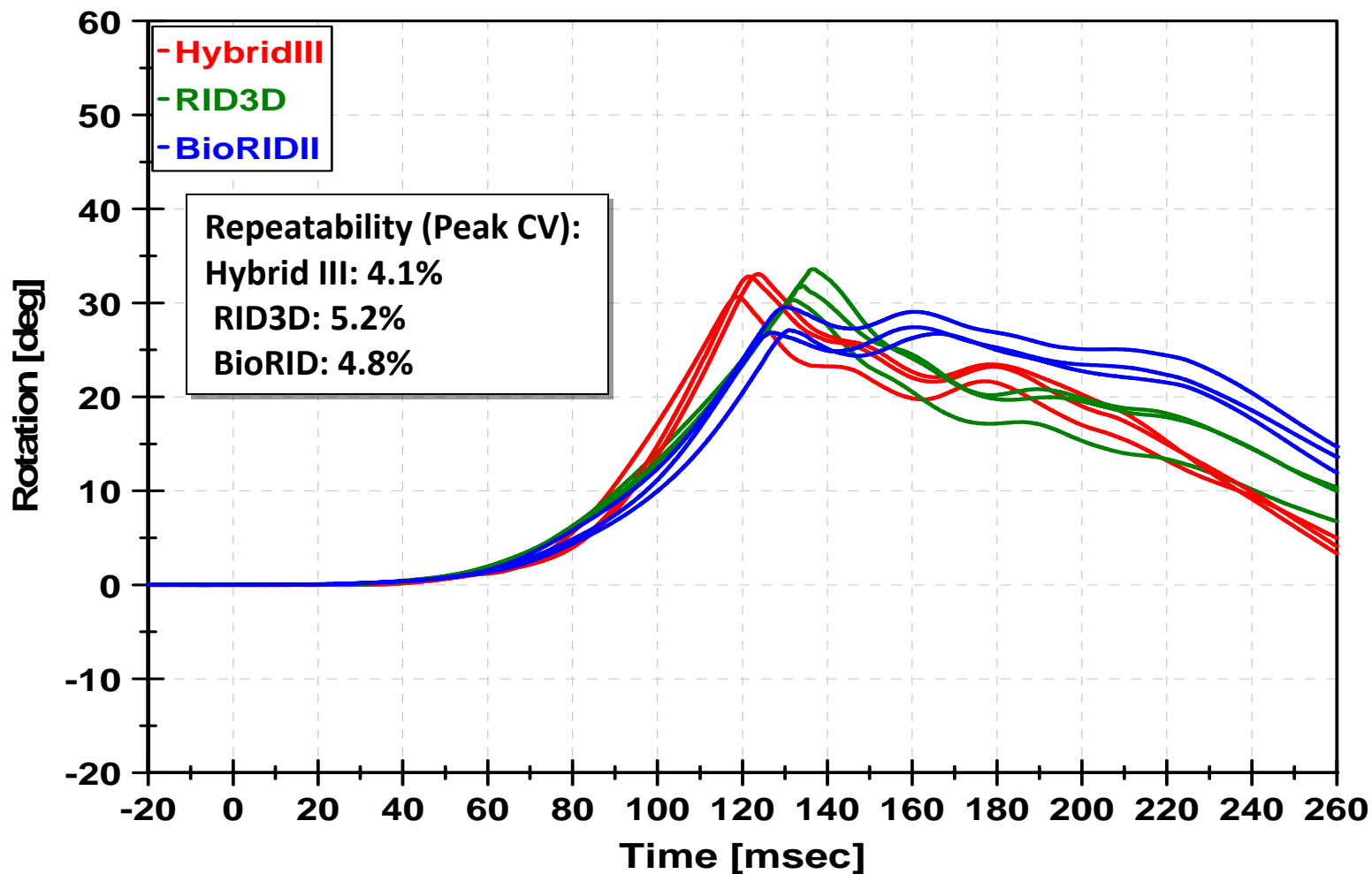
T1 X-acceleration w/r sled 17 kph



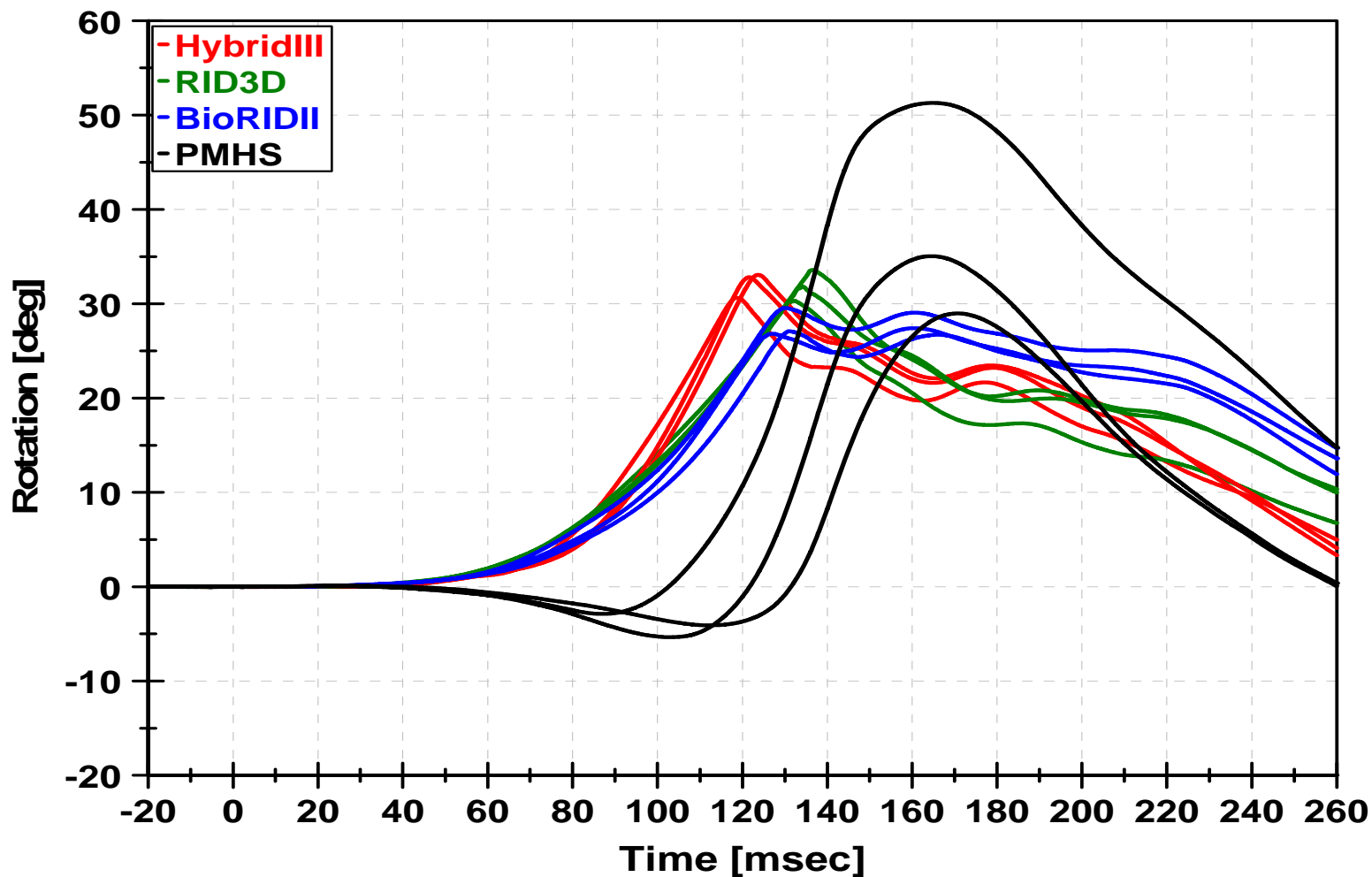
T1 X-acceleration w/r sled 17 kph



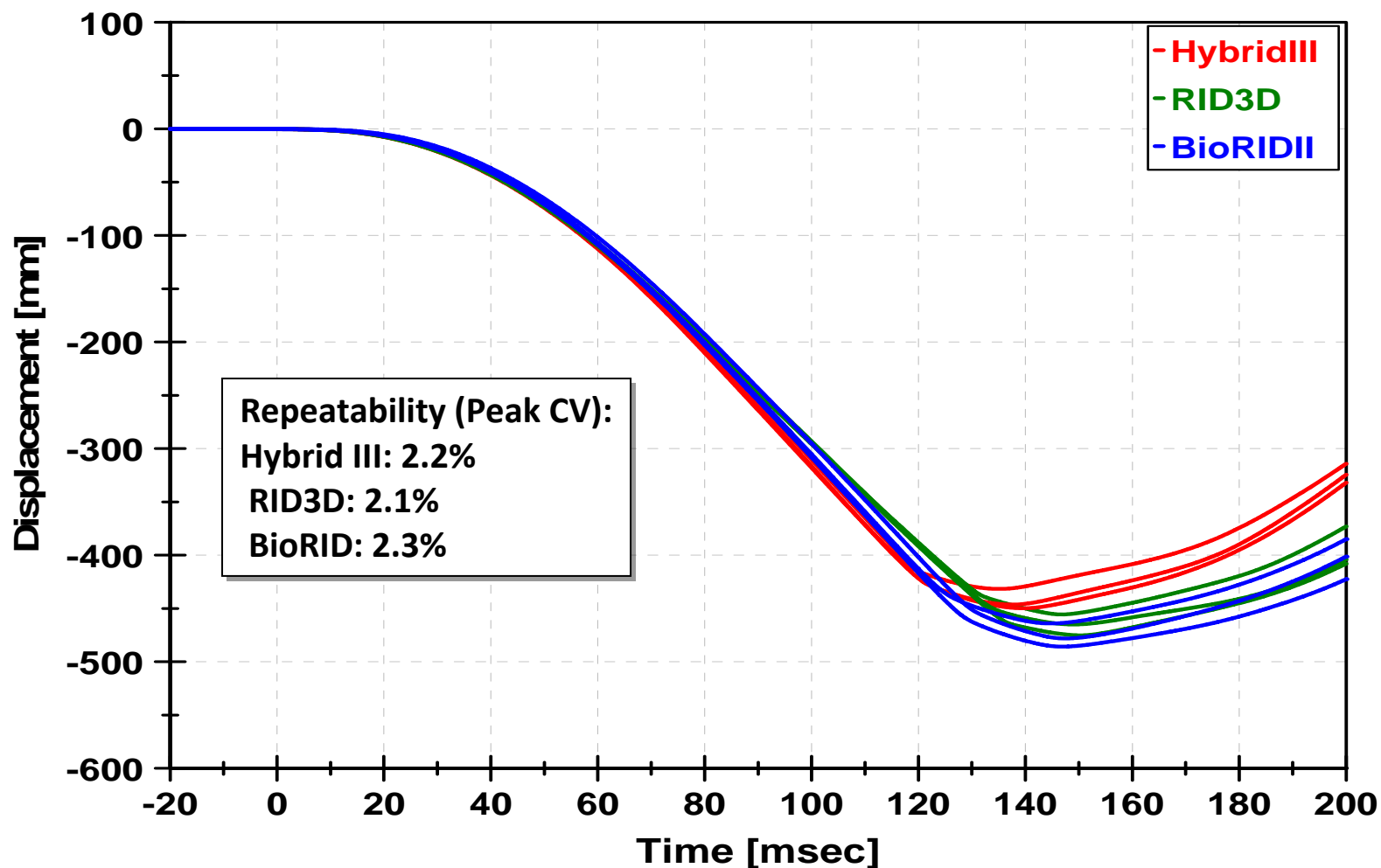
Head angular displacement w/r to sled – low speed



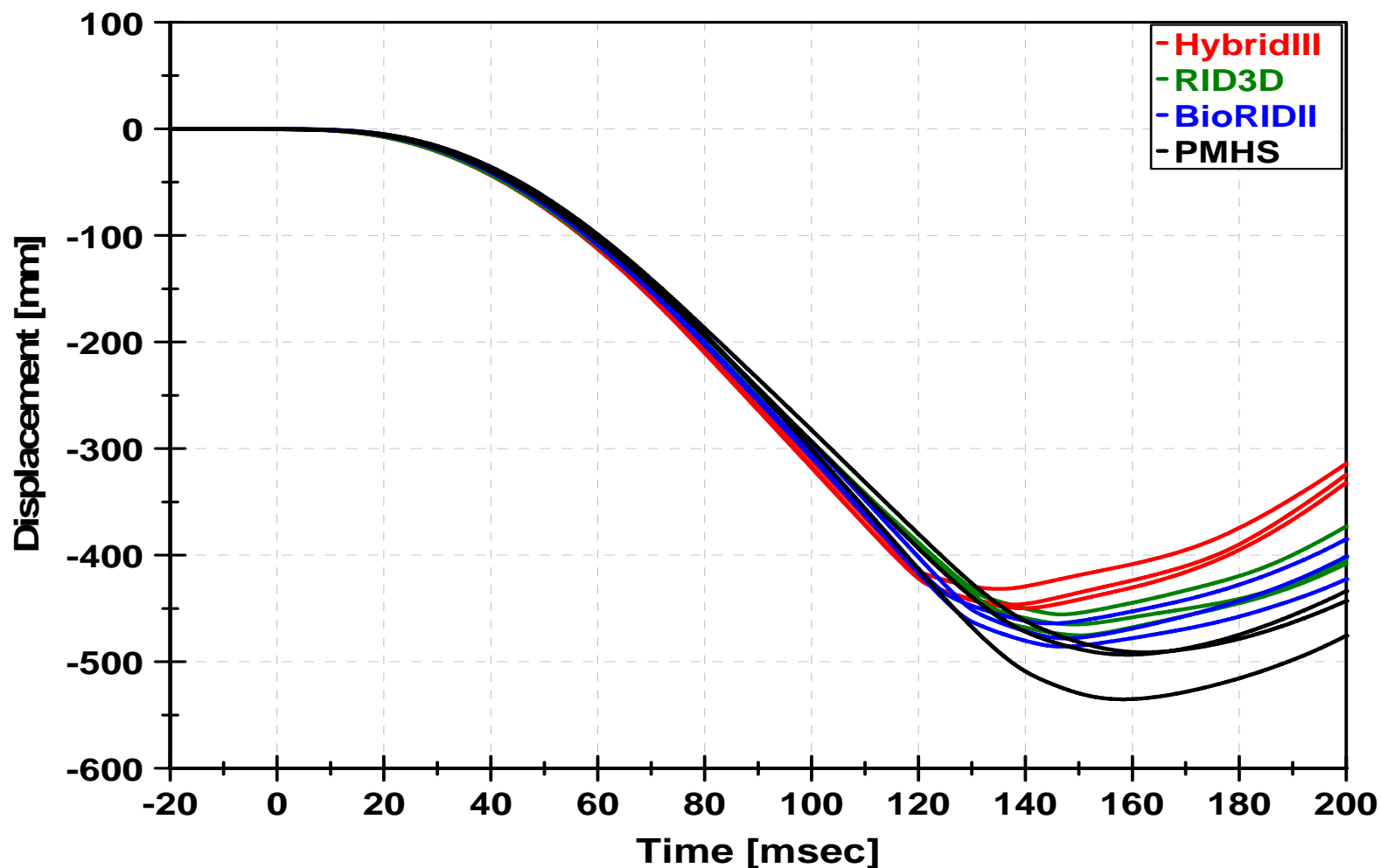
Head angular displacement w/r to sled – 17 kph



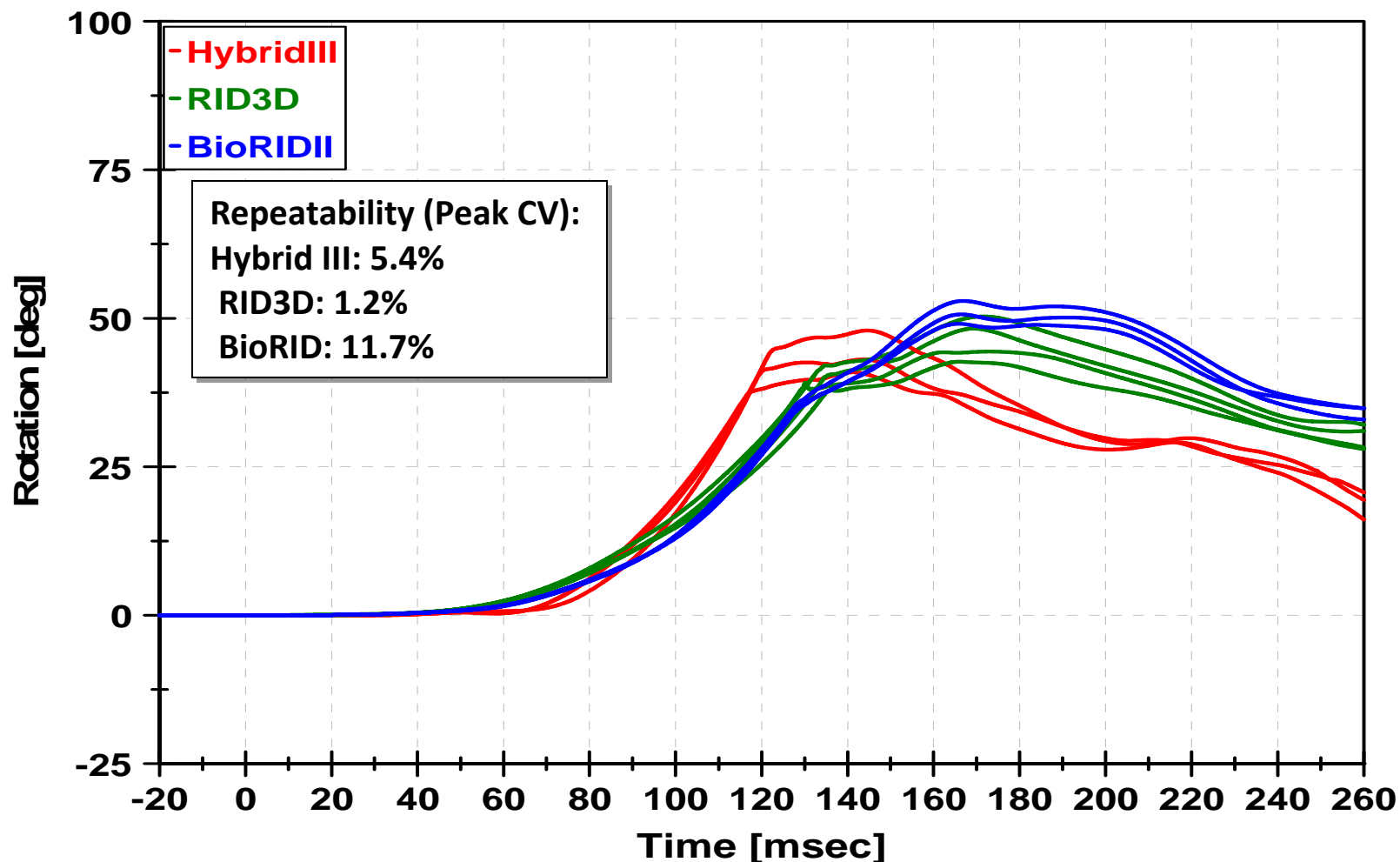
Head CG X displacement w/r to sled – 17 kph



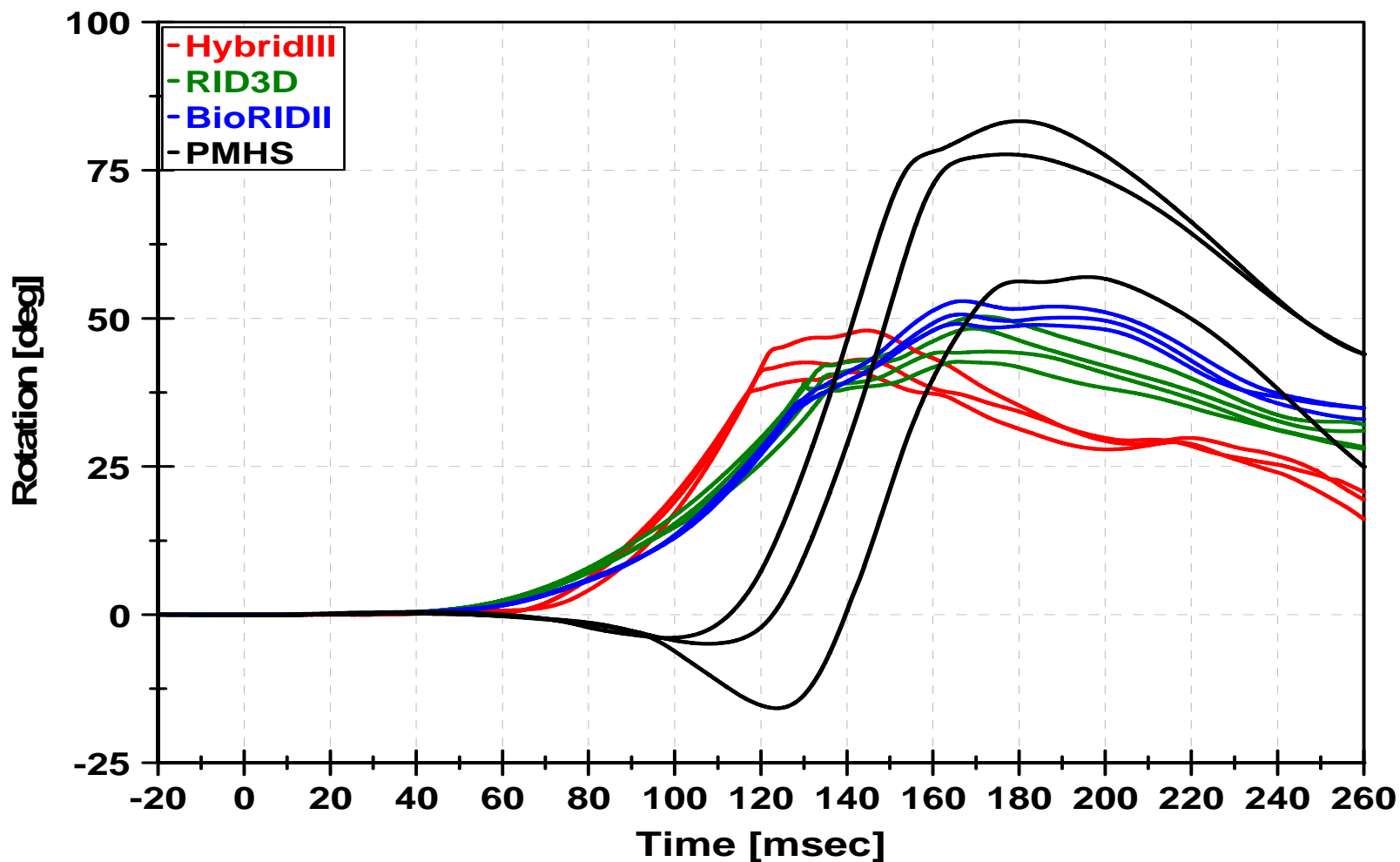
Head CG X displacement w/r to sled – 17 kph



Head angular displacement w/r to T1 – 17 kph



Head angular displacement w/r to T1 – 17 kph



HIC – 17 kph

Table 1 HIC15 – Hybrid III

	HIC15	Begin [ms]	End [ms]
Test#1	176.5	117.1	120.1
Test #2	183.3	119.7	122.6
Test #3	163.3	121.9	125.0

Table 2 HIC15 – RID3D

	HIC15	Begin [ms]	End [ms]
Test #1	175.6	130.1	132.8
Test #2	137.8	131.8	135.3
Test #3	281.7	134.8	137.4

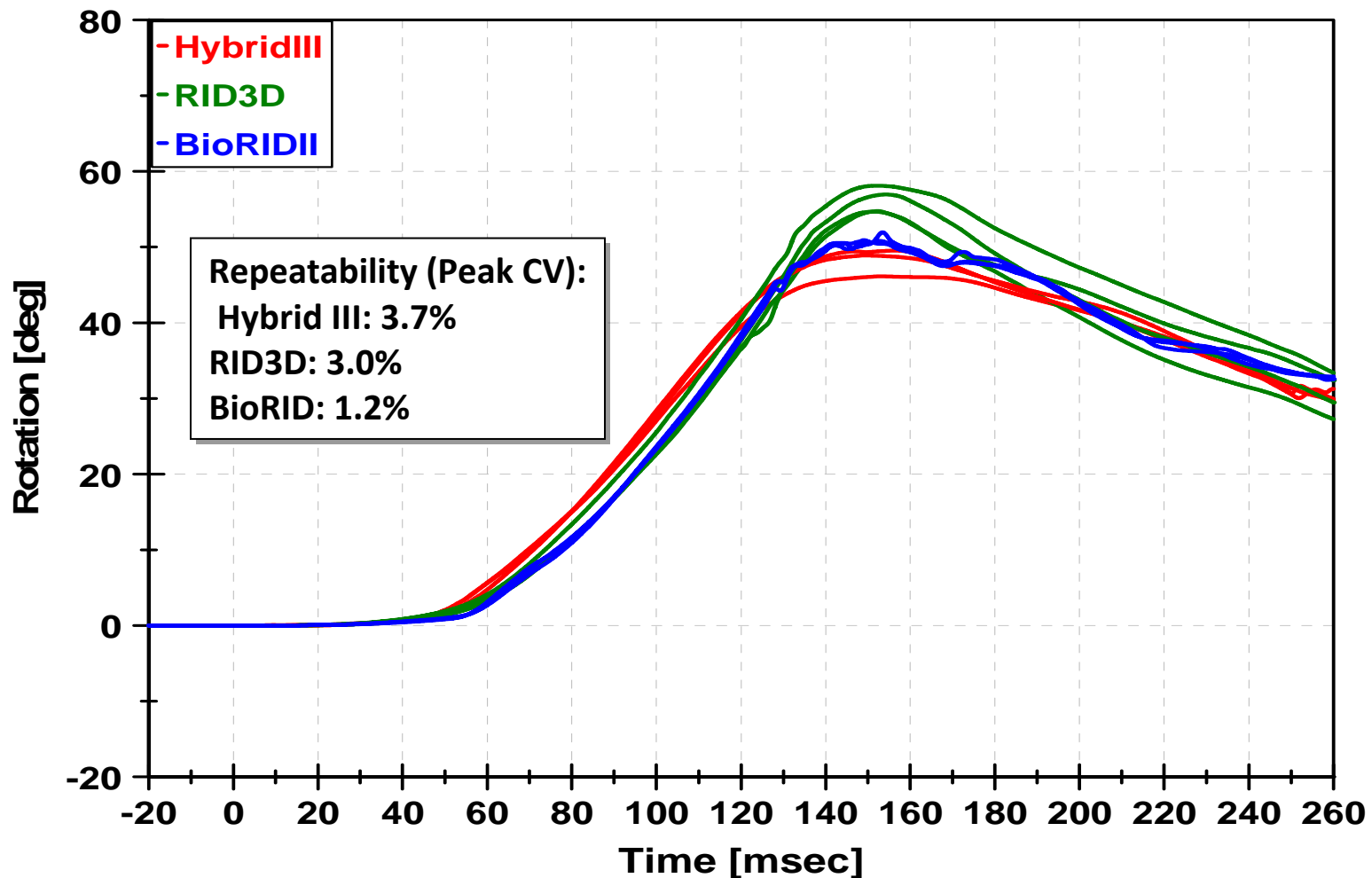
Table 3 HIC15 – BioRIDII

	HIC15	Begin [ms]	End [ms]
Test #1	136.3	123.3	126.9
Test #2	164.6	126.8	129.9
Test #3	177.8	128.4	131.3

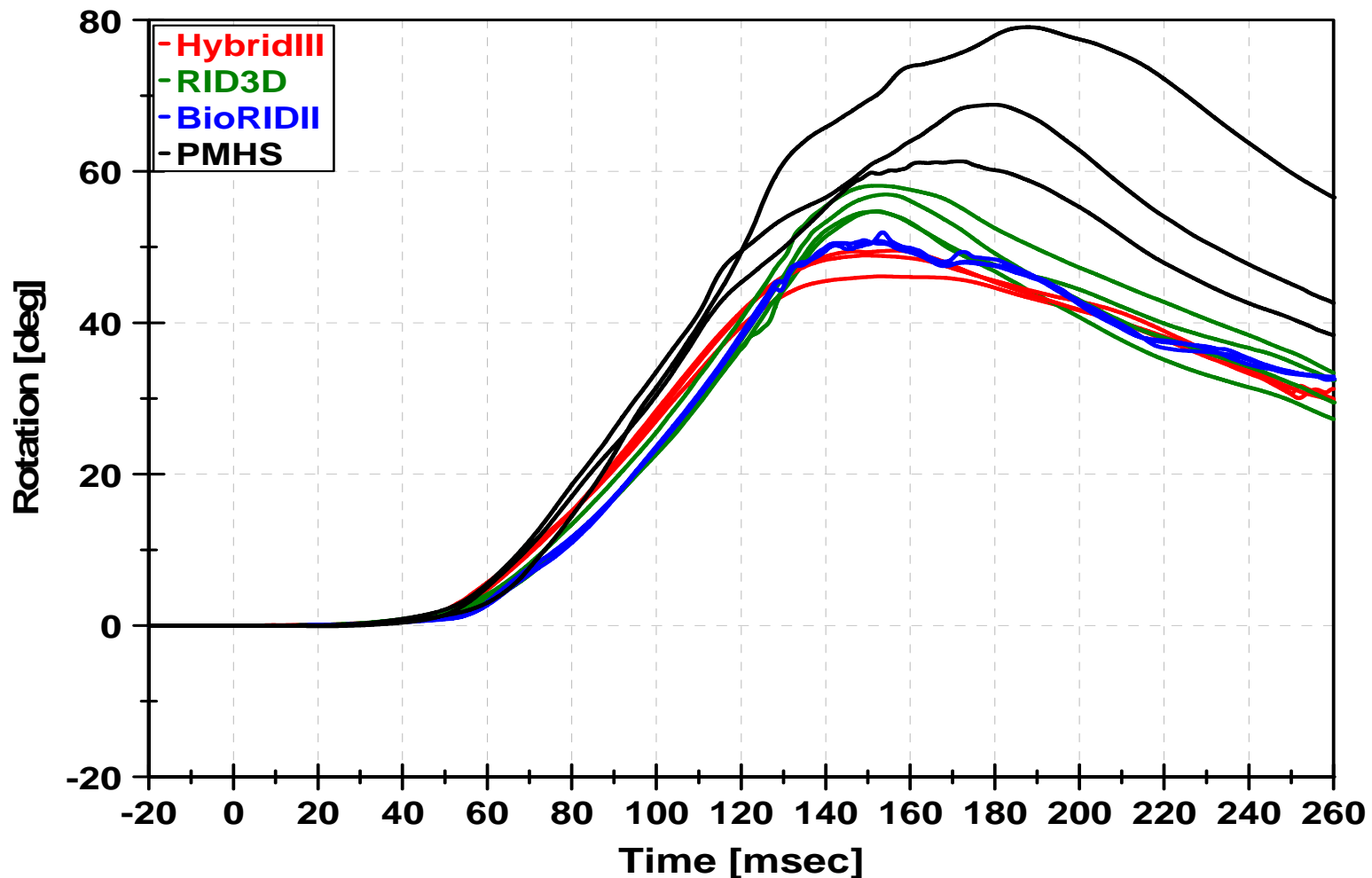
Table 4 HIC15 – PMHS

	HIC15	Begin [ms]	End [ms]
Test #1	58.1	129.8	159.6
Test #2	37.4	126.2	162.2
Test #3	36.1	128.6	164.6

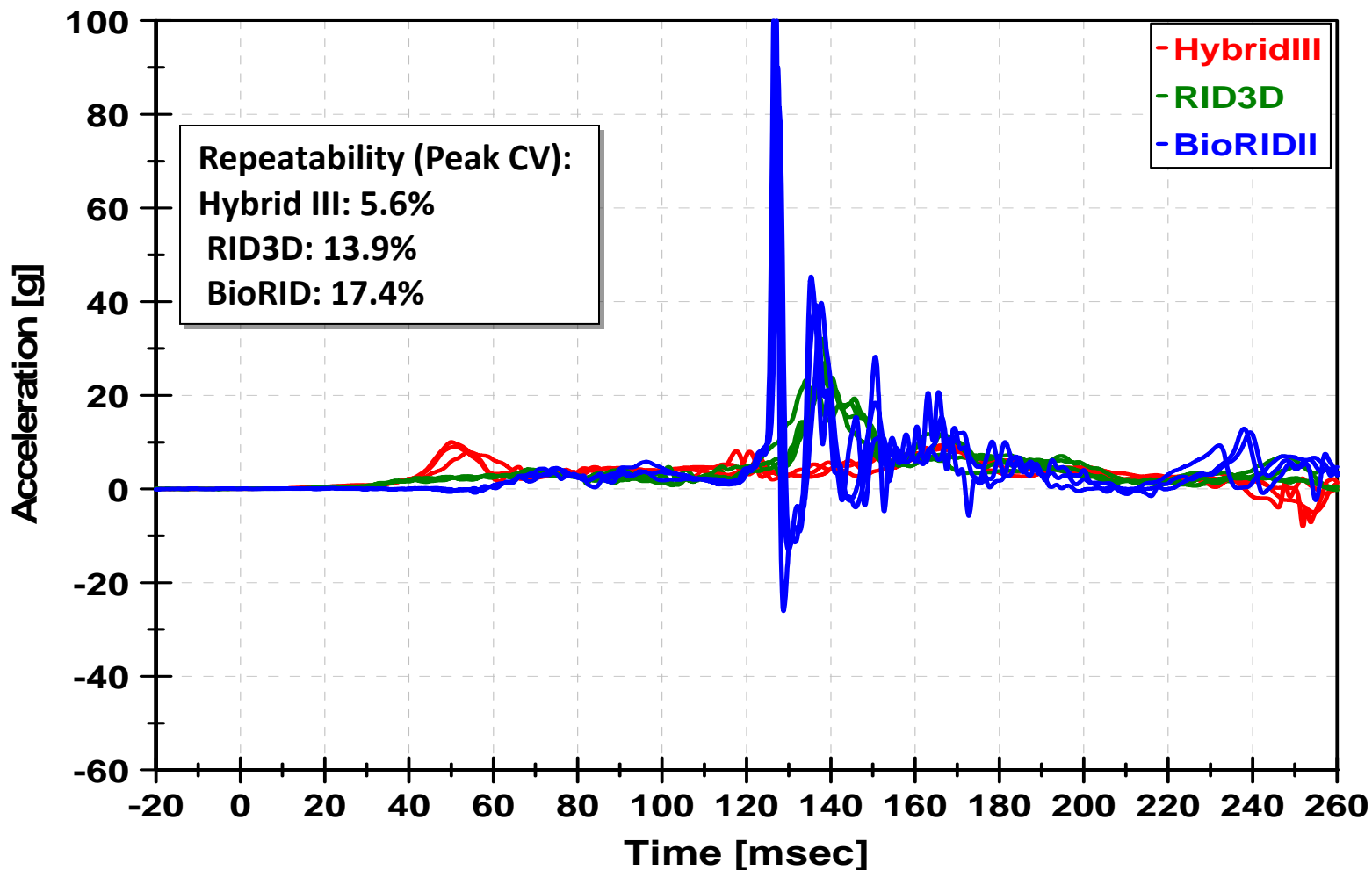
T1 angle w/r to sled-24 kph



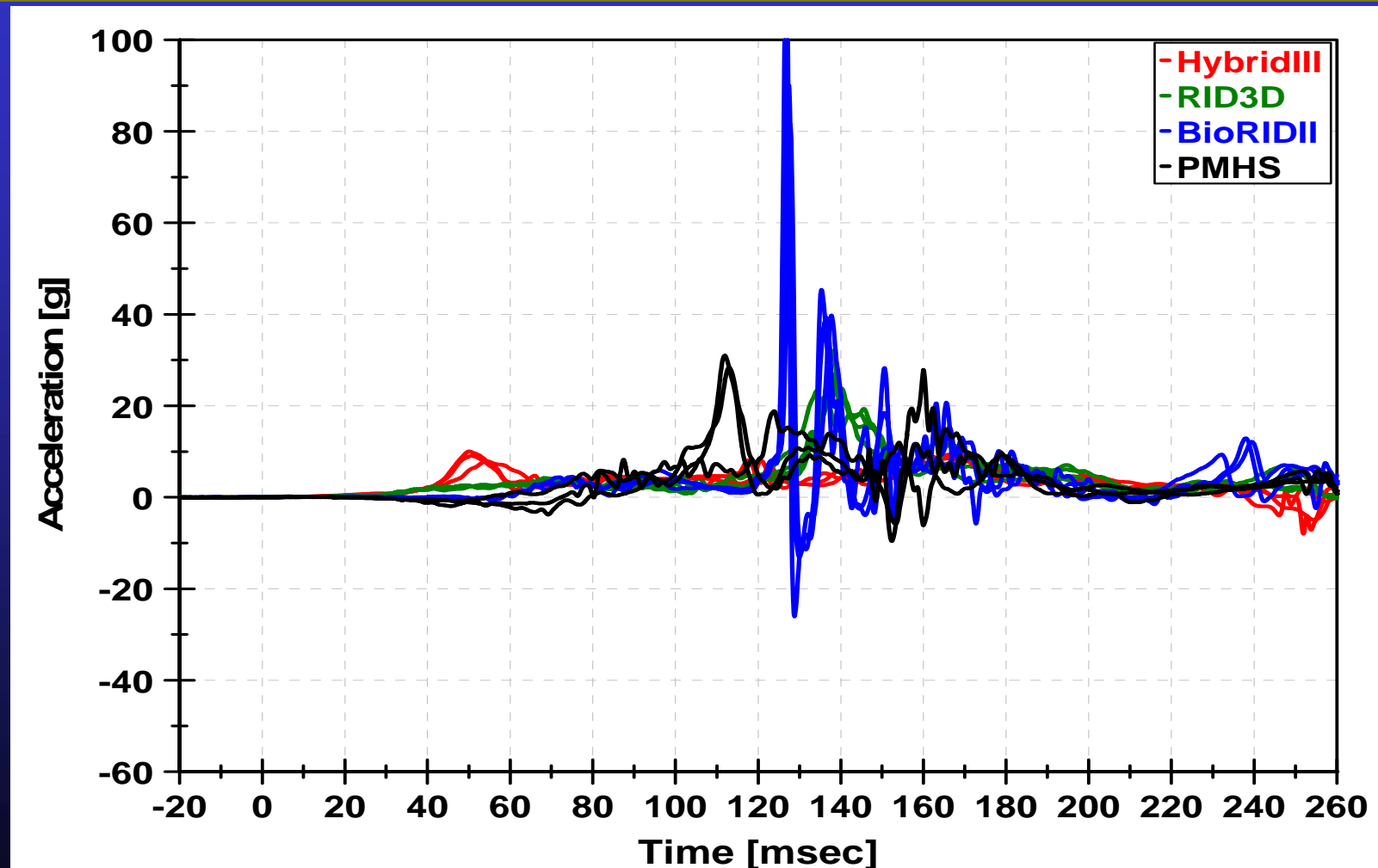
T1 angle w/r to sled-24 kph



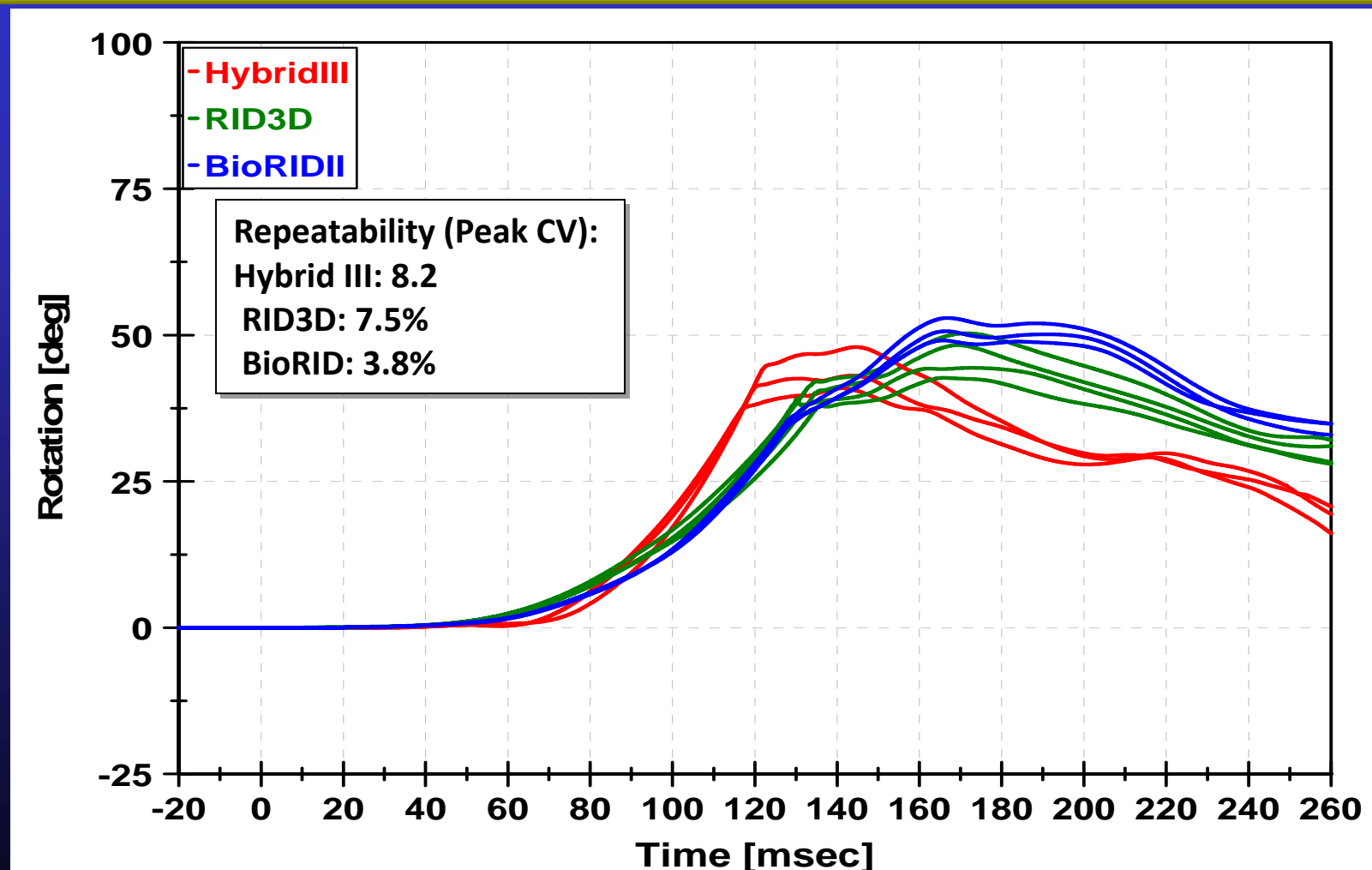
T1 X-acceleration w/r sled 24 kph



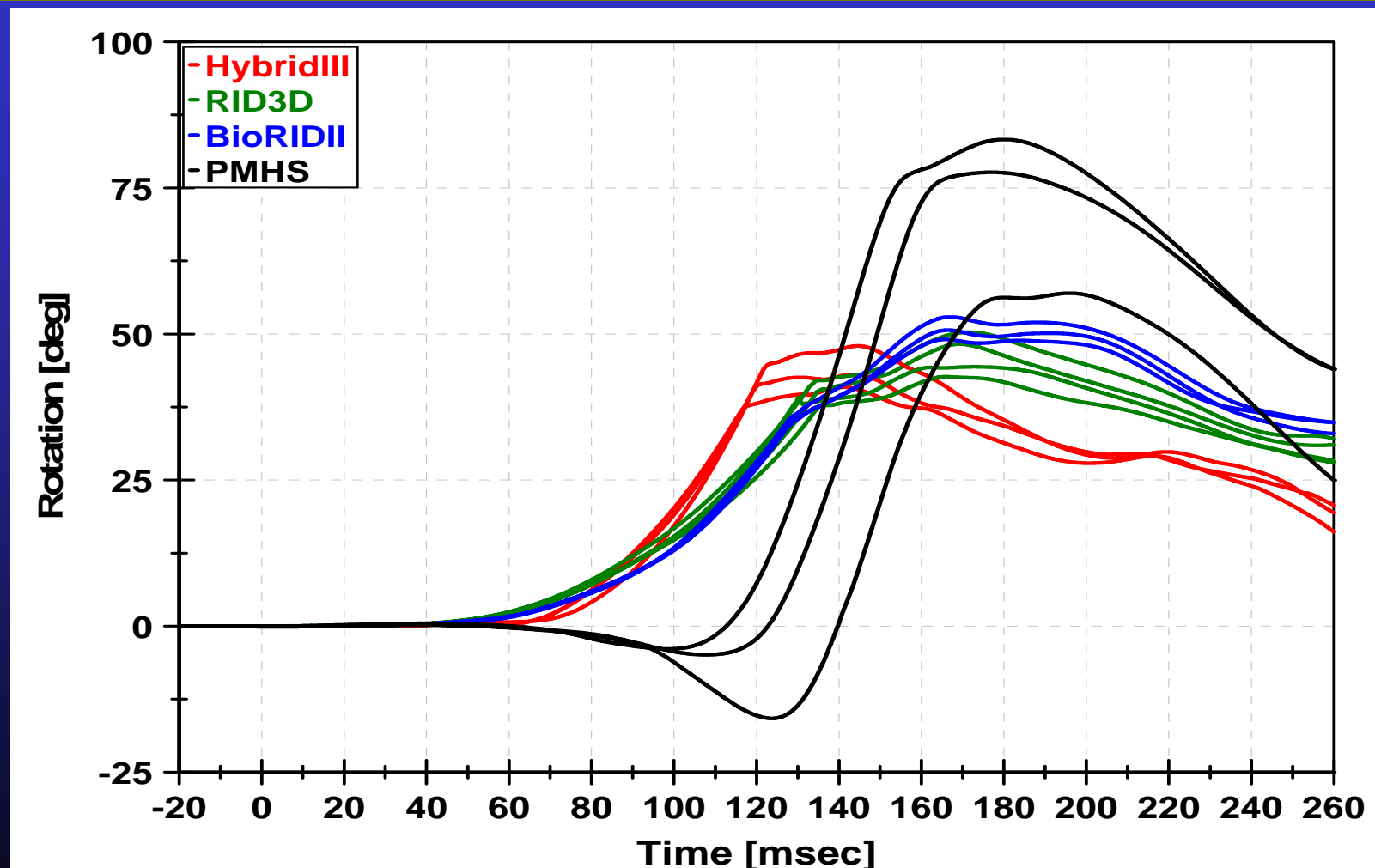
T1 X-acceleration w/r sled 24 kph



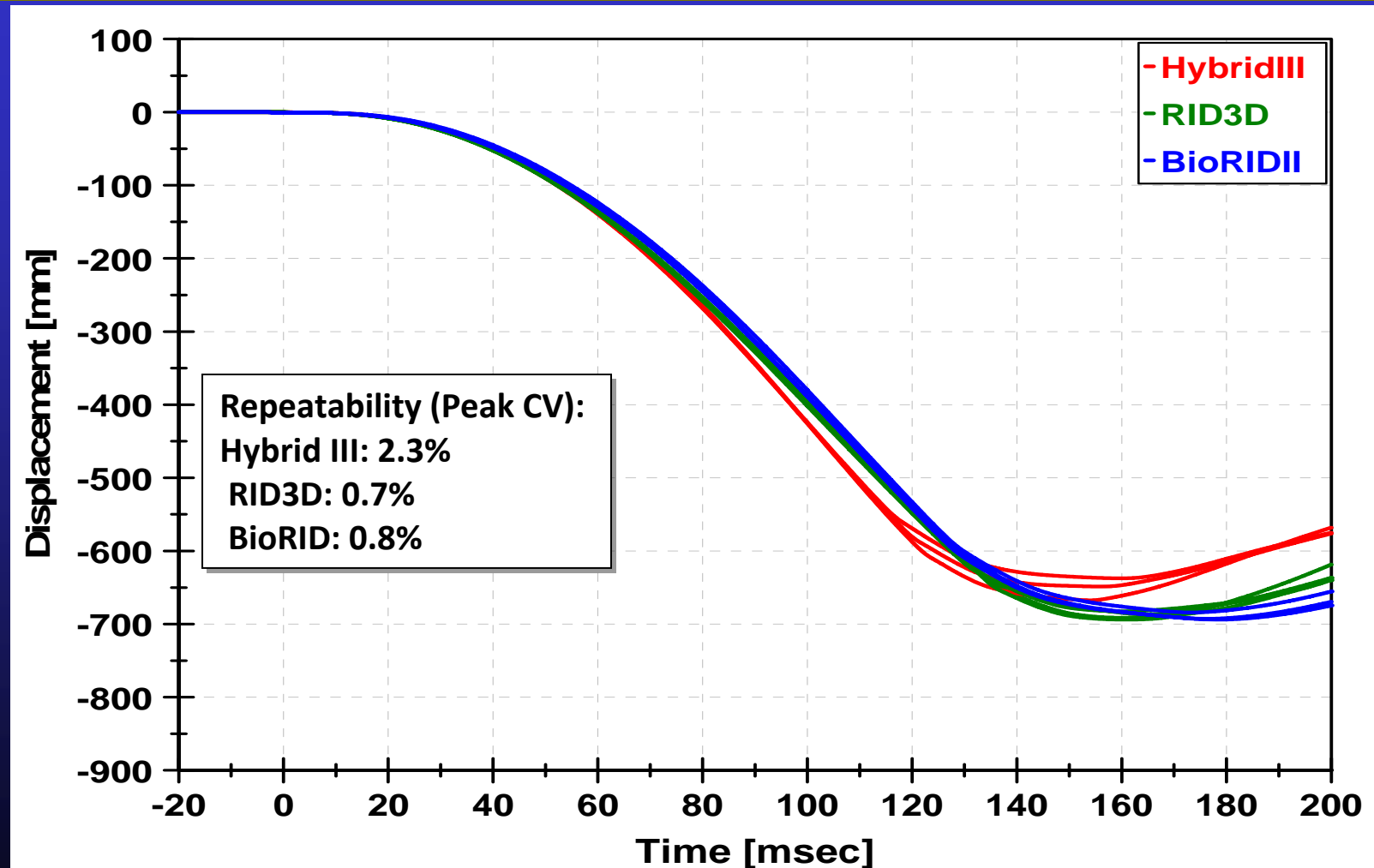
Head angular displacement w/r to sled – 24 kph



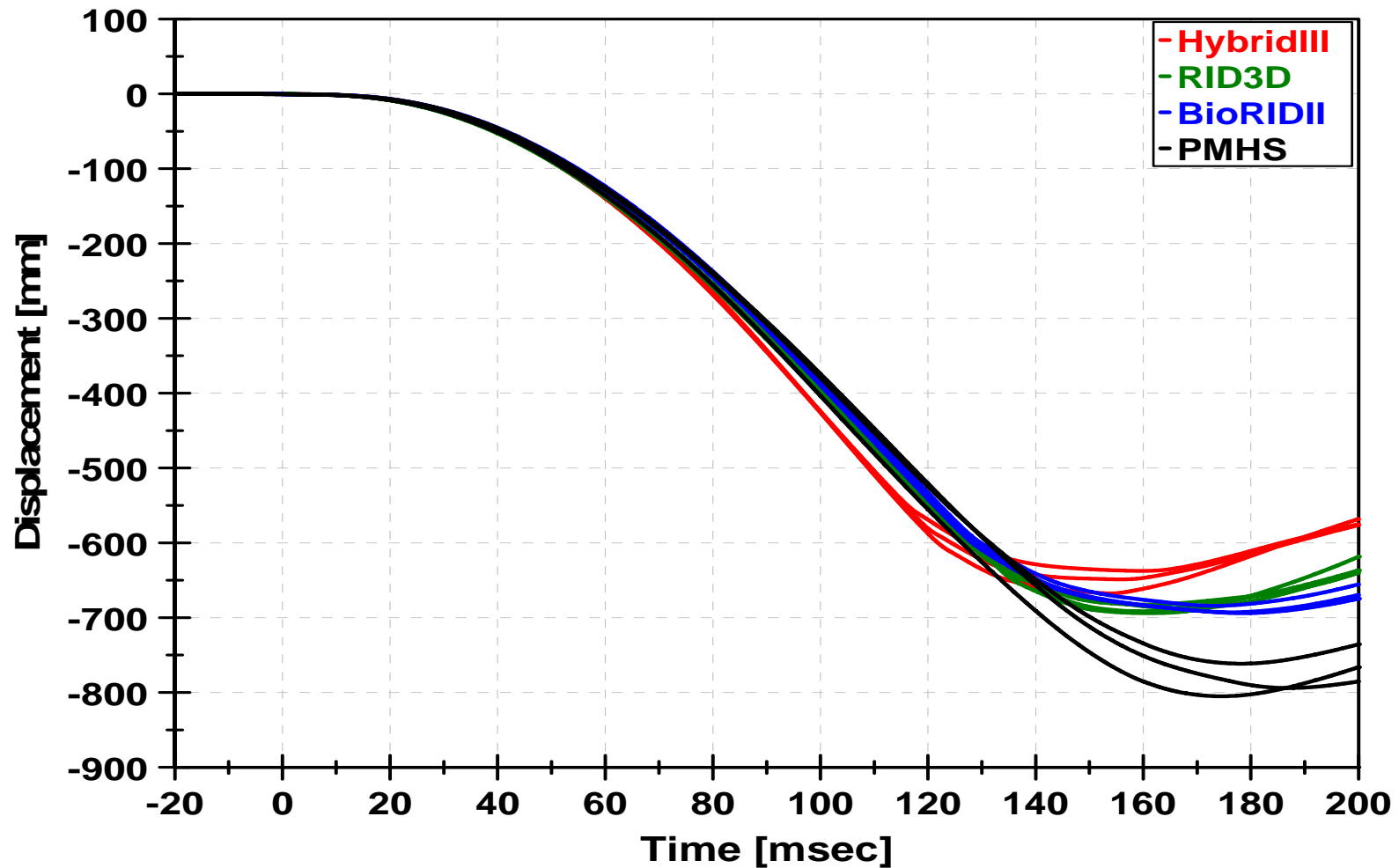
Head angular displacement w/r to sled – 24 kph



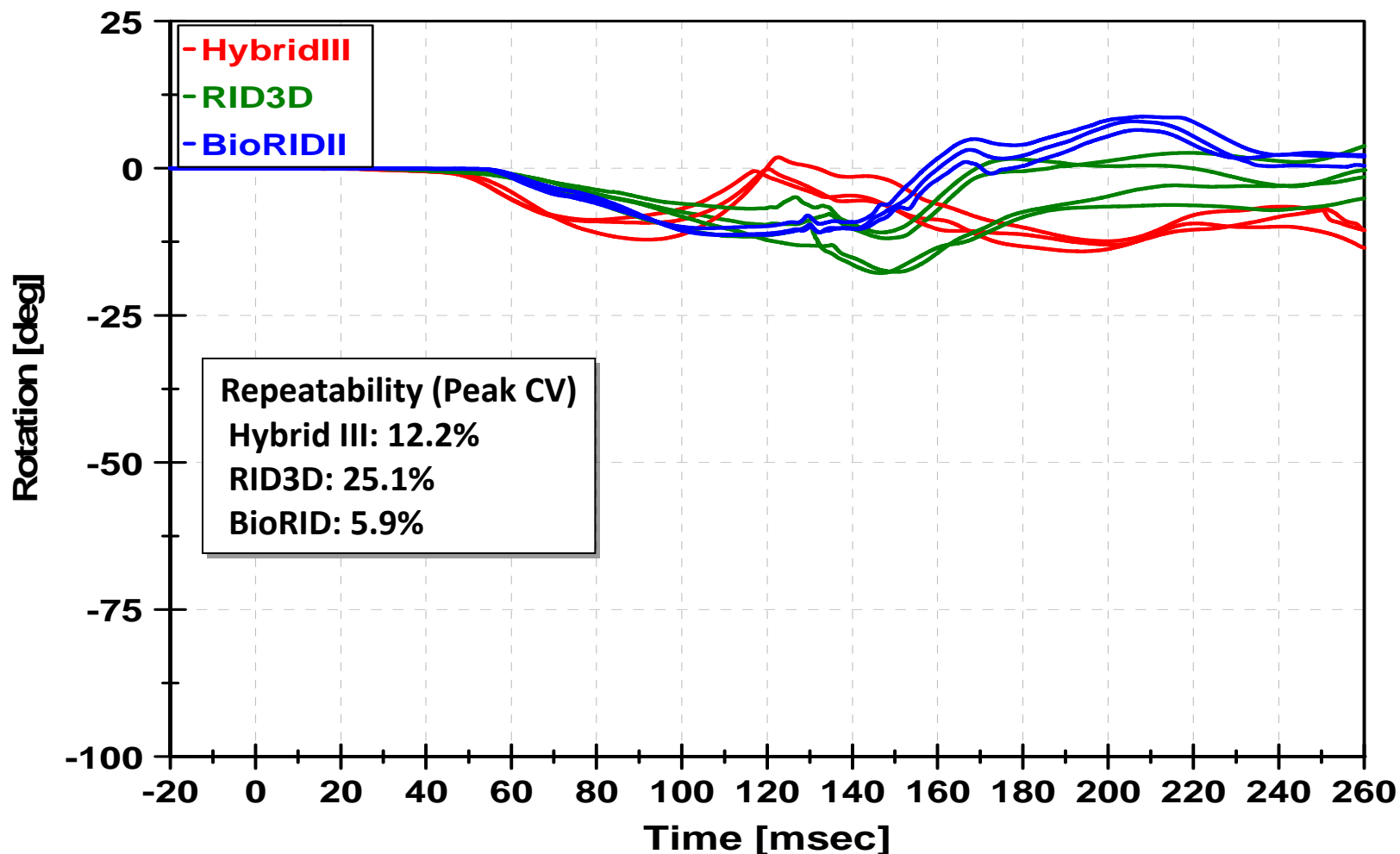
Head CG X displacement w/r to sled – 24 kph



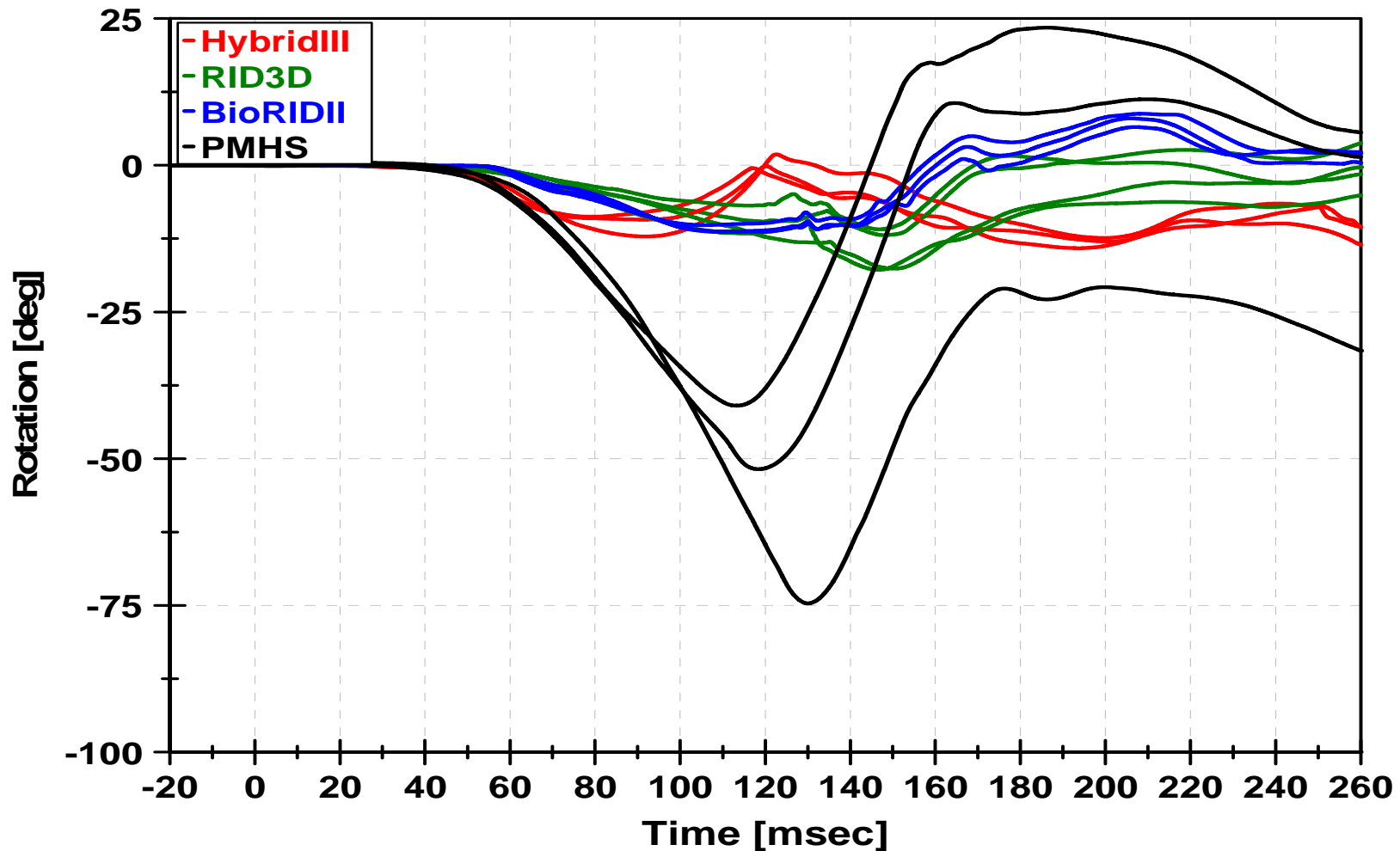
Head CG X displacement w/r to sled – 24 kph



Head angular displacement w/r to T1 – 24 kph



Head angular displacement w/r to T1 – 24 kph



HIC – 24 kph

Table 5 HIC15 – Hybrid III

	HIC15	Begin [ms]	End [ms]
Test #1	239.2	115.5	118.0
Test #2	385.1	118.9	121.2
Test #3	370.8	121.1	123.5

Table 6 HIC15 – RID3D

	HIC15	Begin [ms]	End [ms]
Test #1	470.3	133.7	136.3
Test #2	467.4	132.8	135.5
Test #3	613.3	134.2	136.6
Test#4	346.5	129.4	132.3

Table 7 HIC15 – BioRIDII

	HIC15	Begin [ms]	End [ms]
Test #1	193.9	126.8	129.5
Test #2	183.7	126.6	129.4
Test #3	139.3	126.2	129.4

Table 8 HIC15– PMHS

	HIC15	Begin [ms]	End [ms]
Test #1	77.0	141.4	154.6
Test #2	95.4	145.3	181.3
Test #3	90.7	148.2	184.2

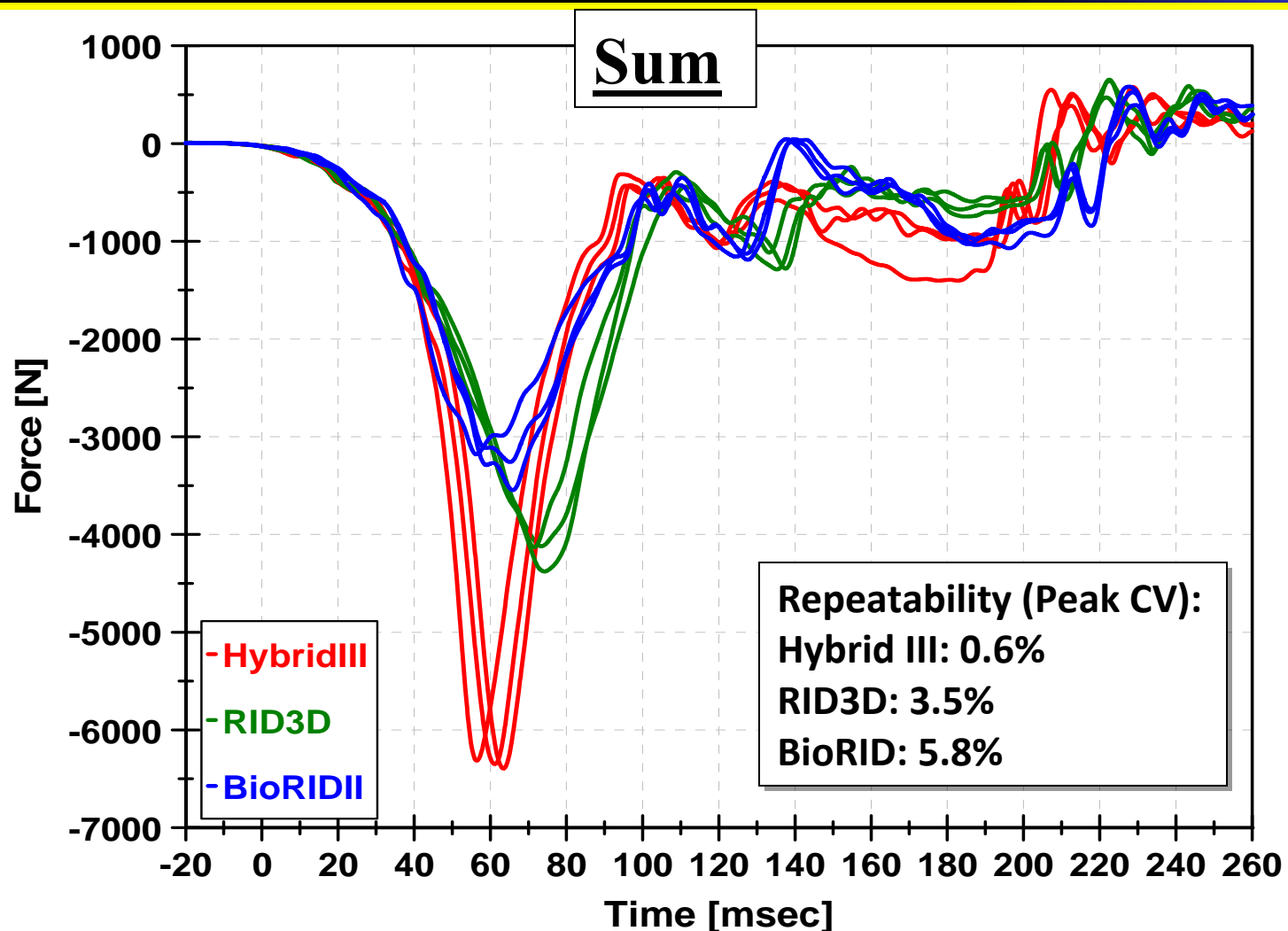


External Biofidelity

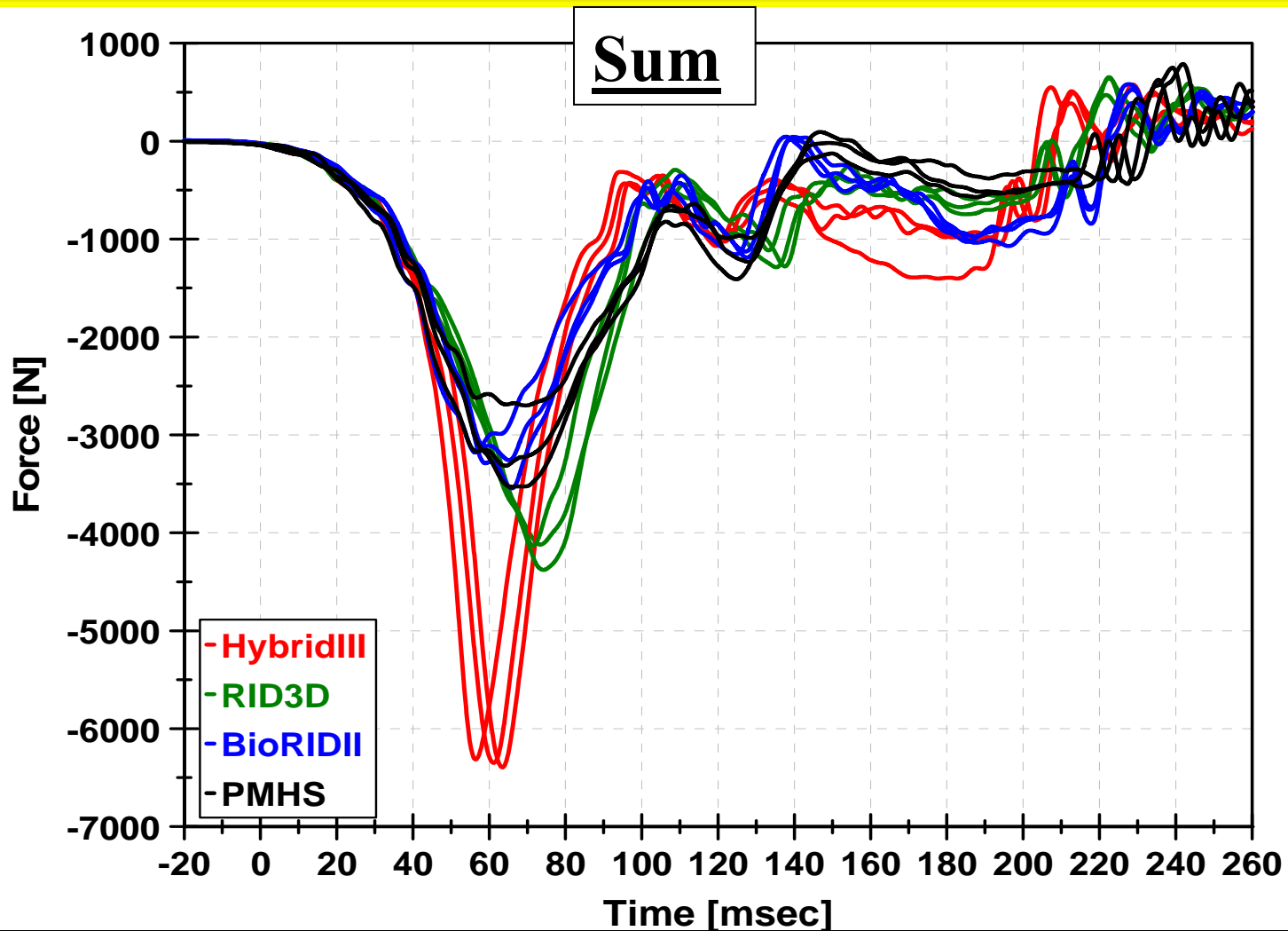
- **Seat back loads**
 - **Sum**
 - **Top**
 - **Middle**
 - **Lower**
- **Head restraint loads**
 - **Front**
 - **Top**



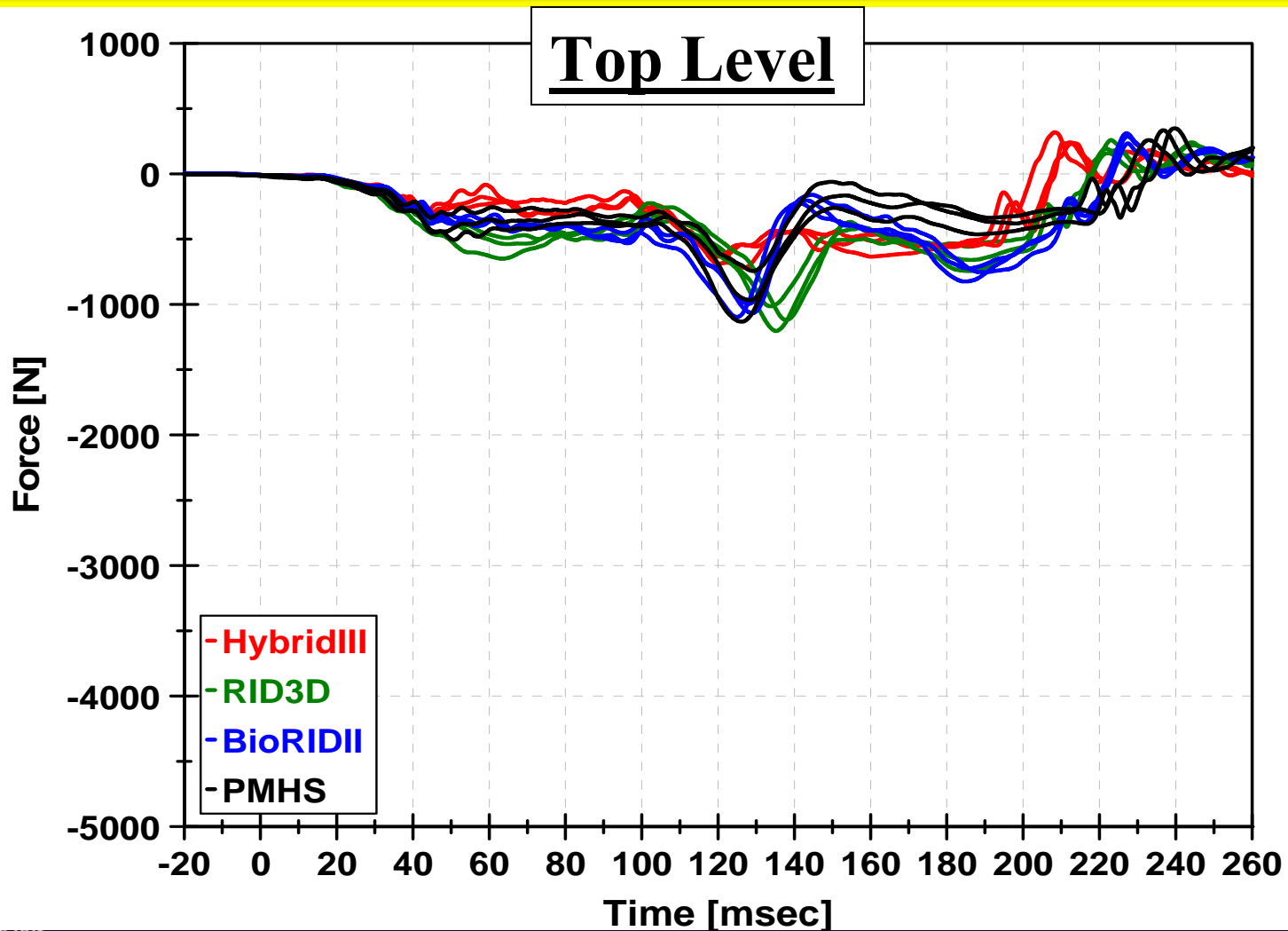
17 kph - Seatback Load



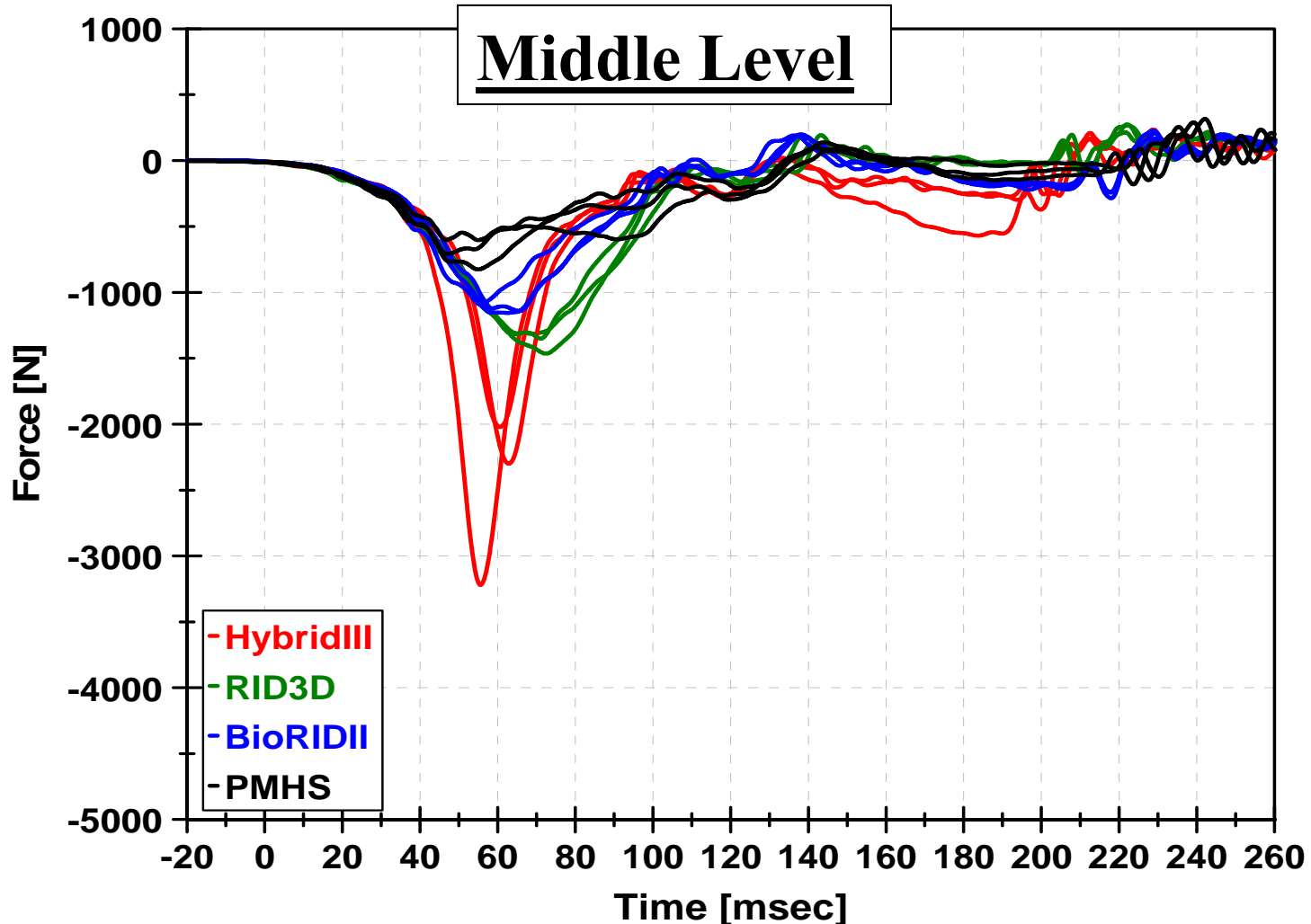
17 kph - Seatback Load



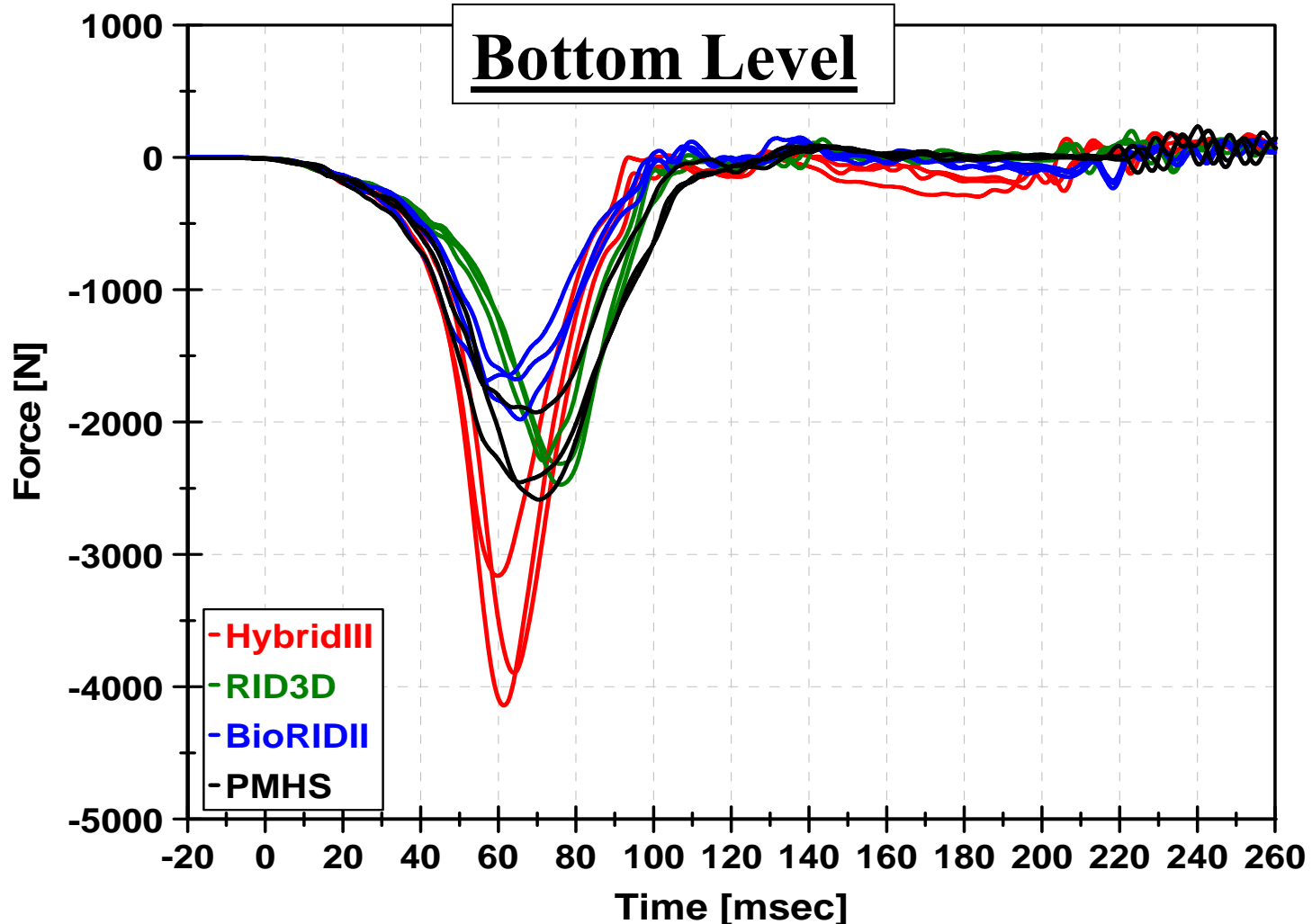
17 kph - Seatback Load



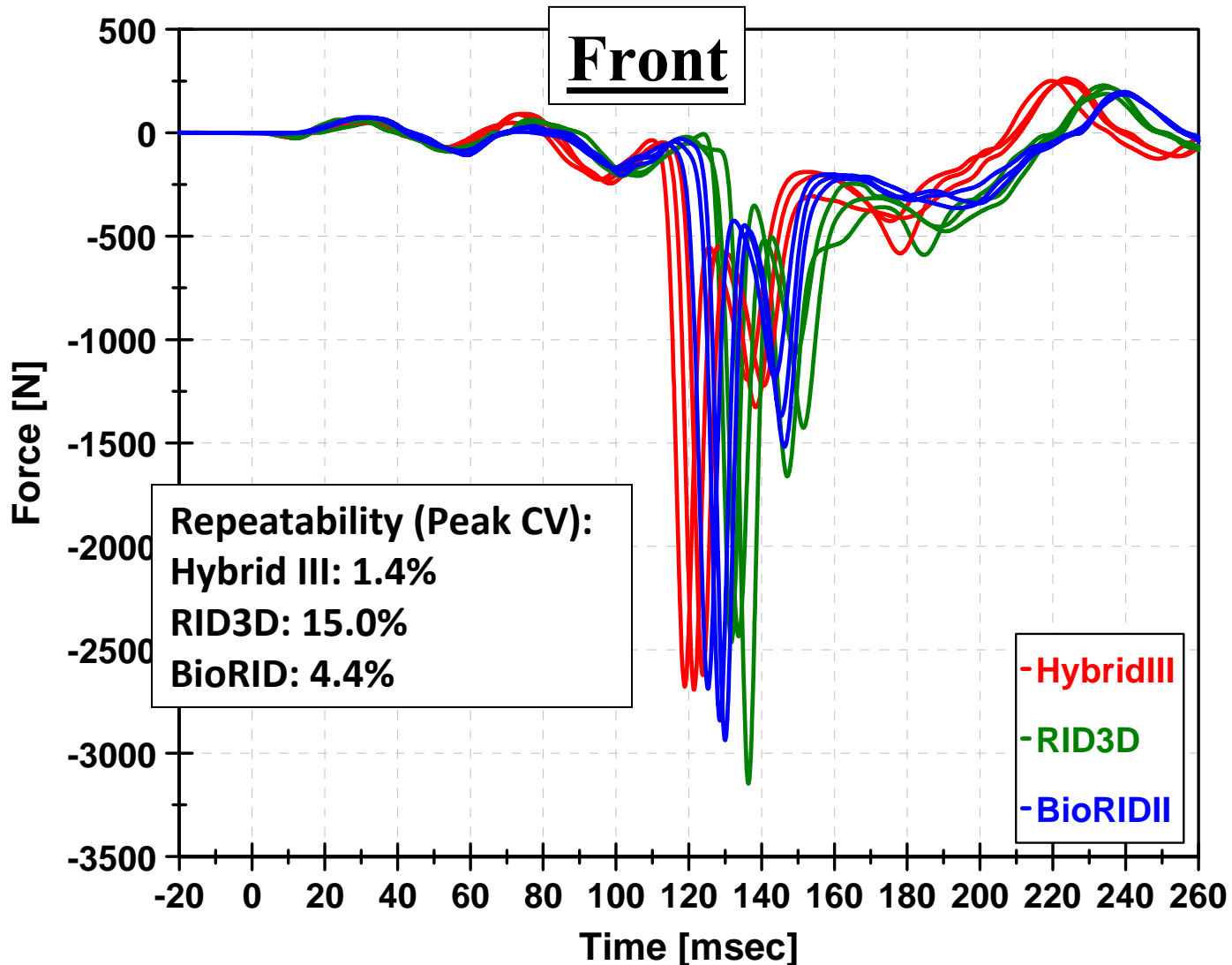
17 kph - Seatback Load



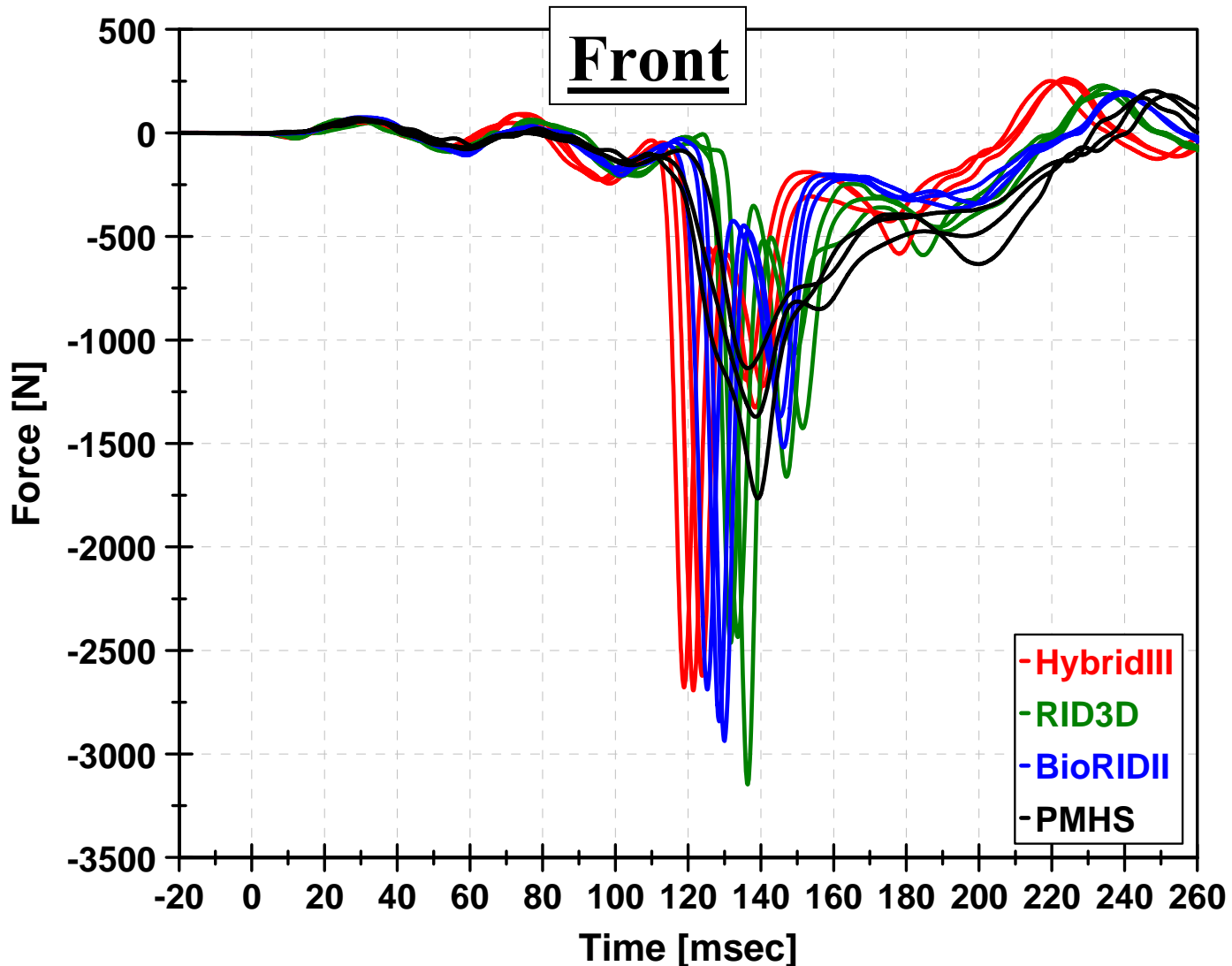
17 kph - Seatback Load



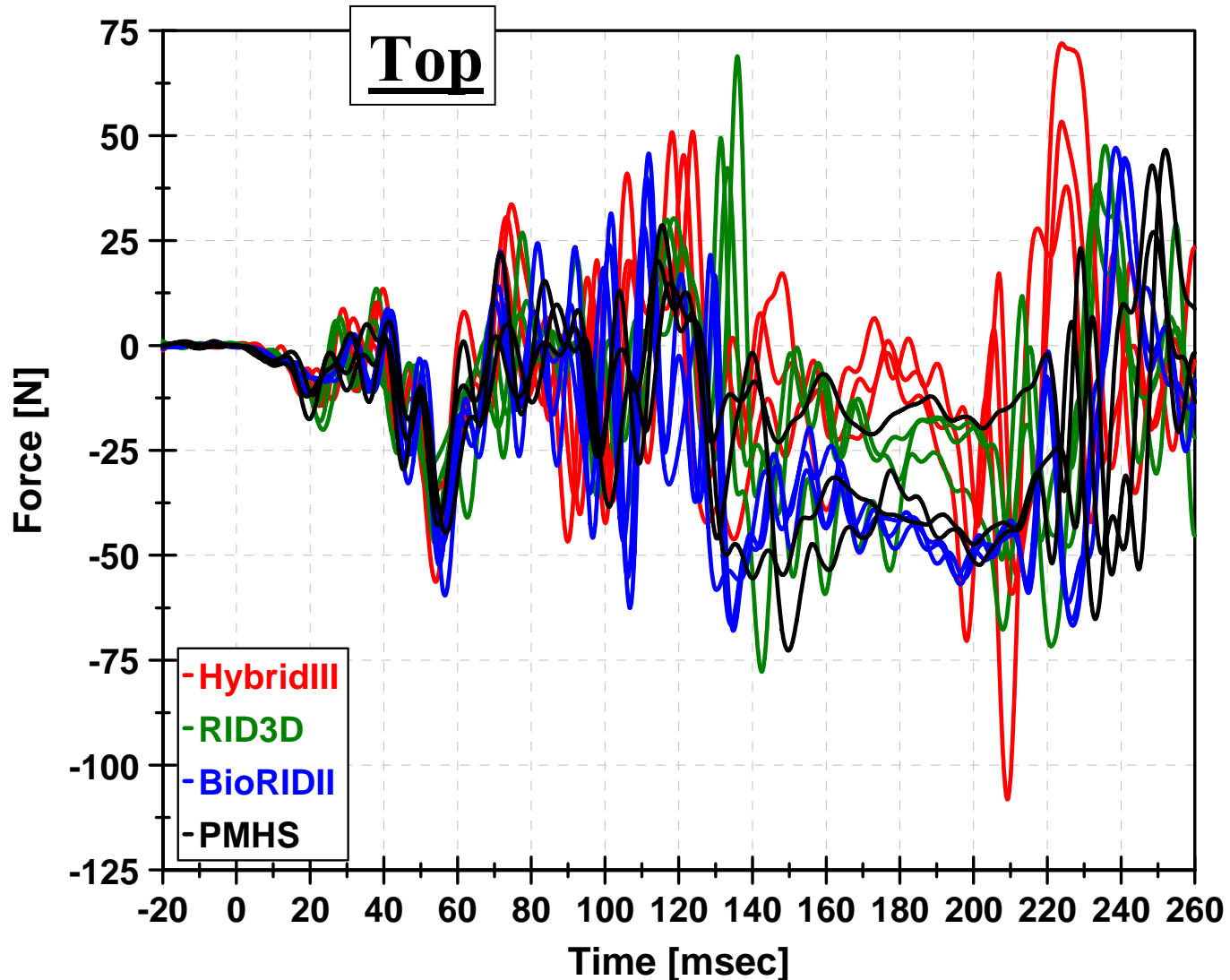
17 kph – Head Restraint Load



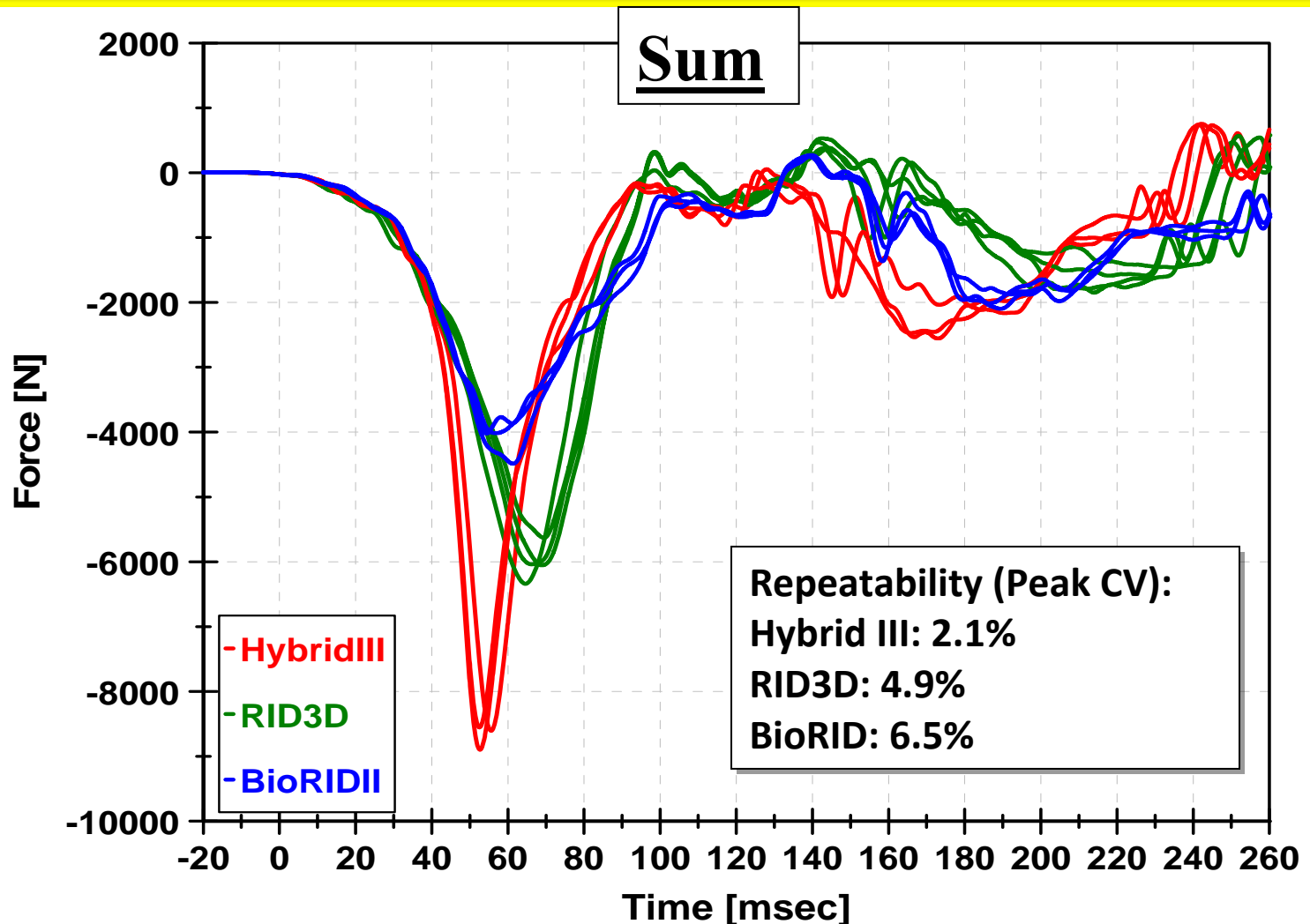
17 kph – Head Restraint Load



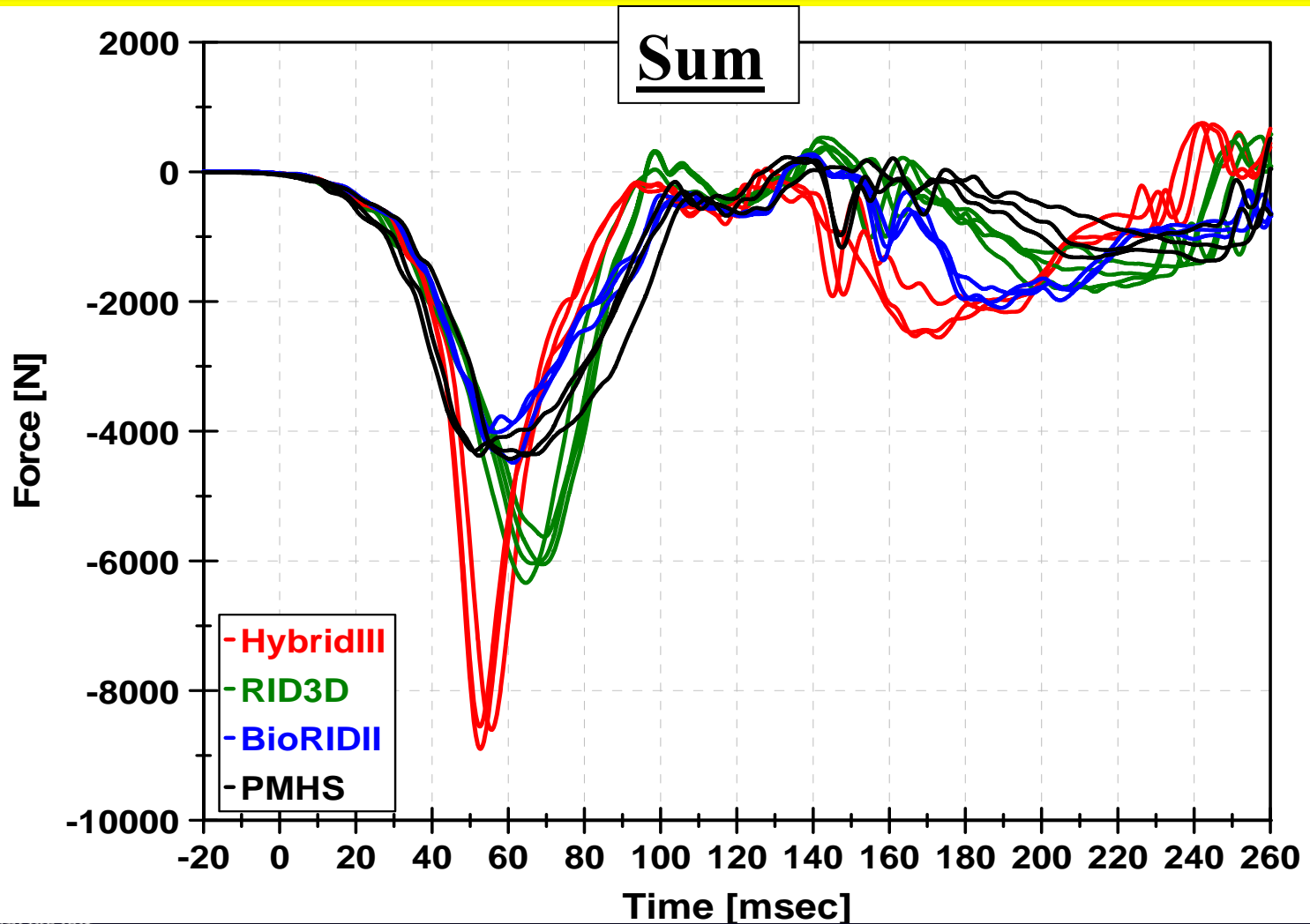
17 kph – Head Restraint Load



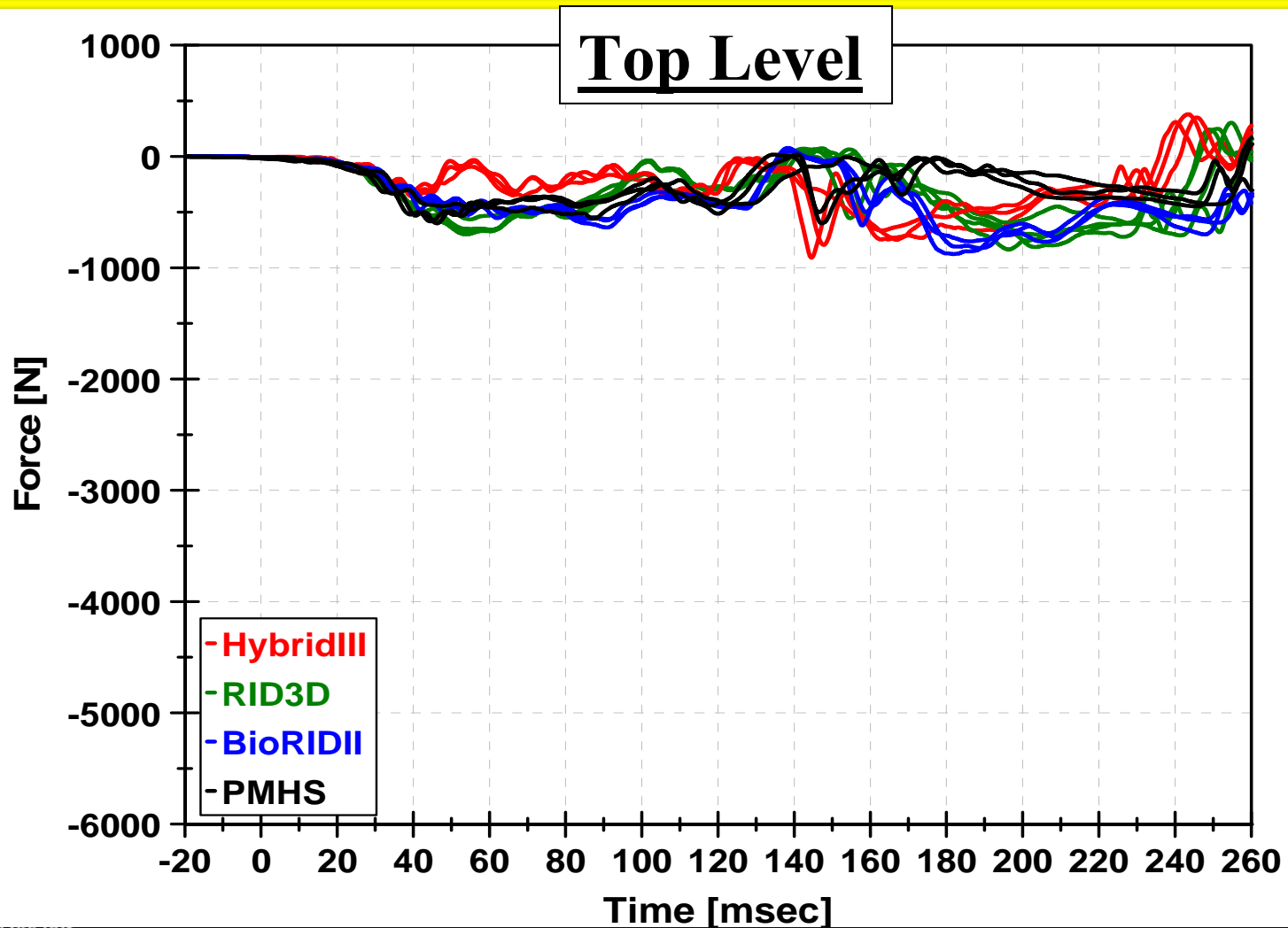
24 kph - Seatback Load



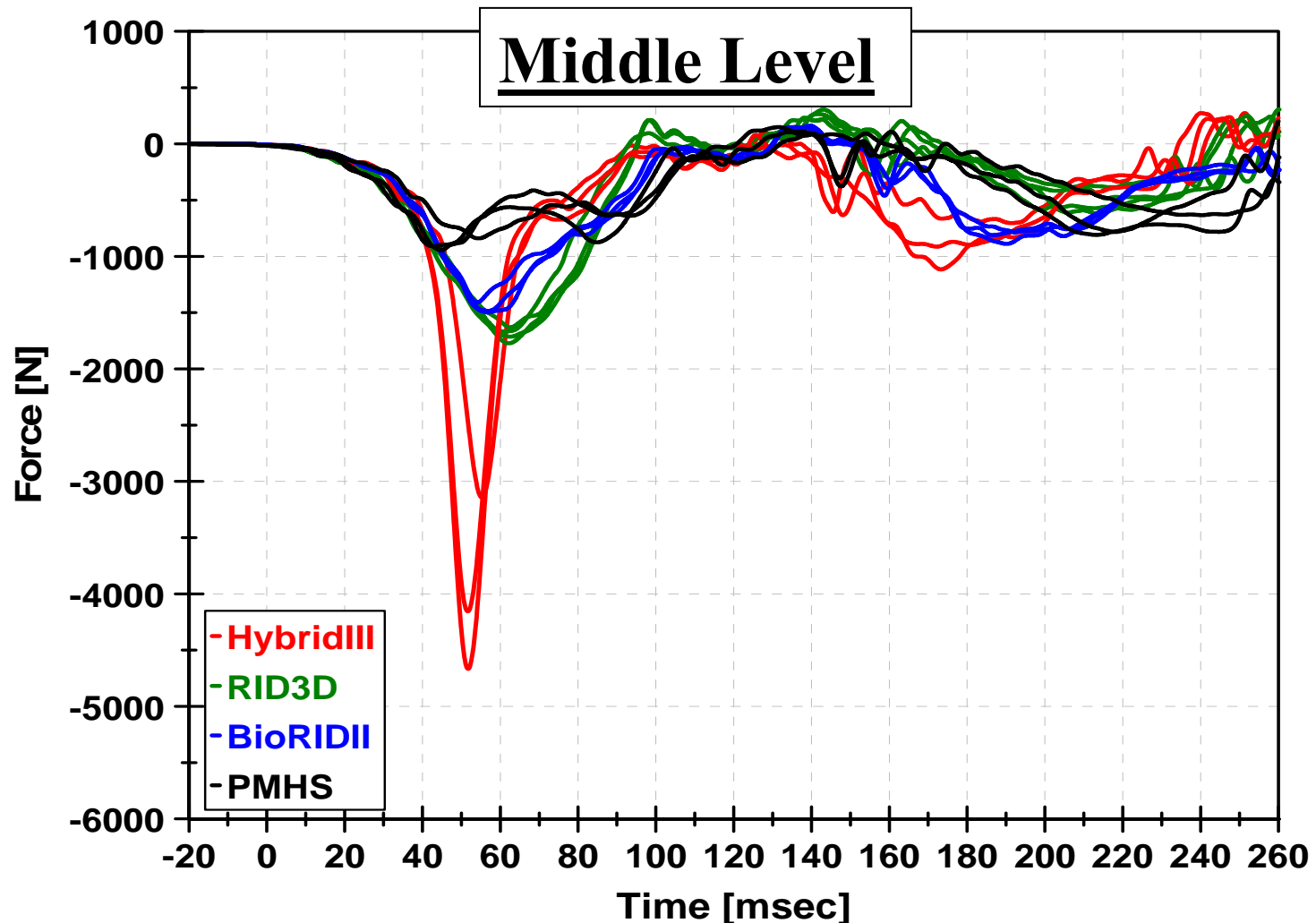
24 kph- Seatback Load



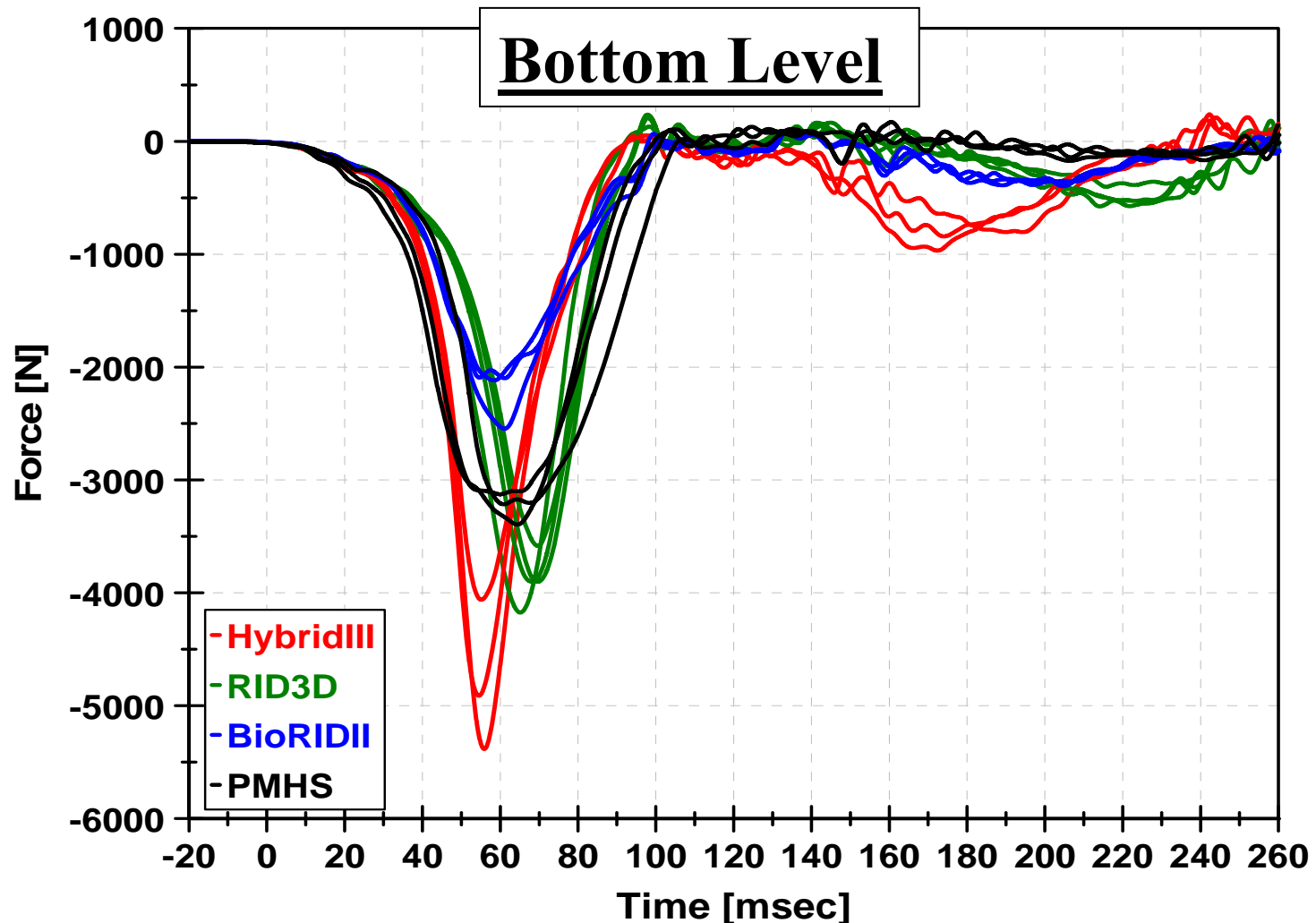
24 kph - Seatback Load



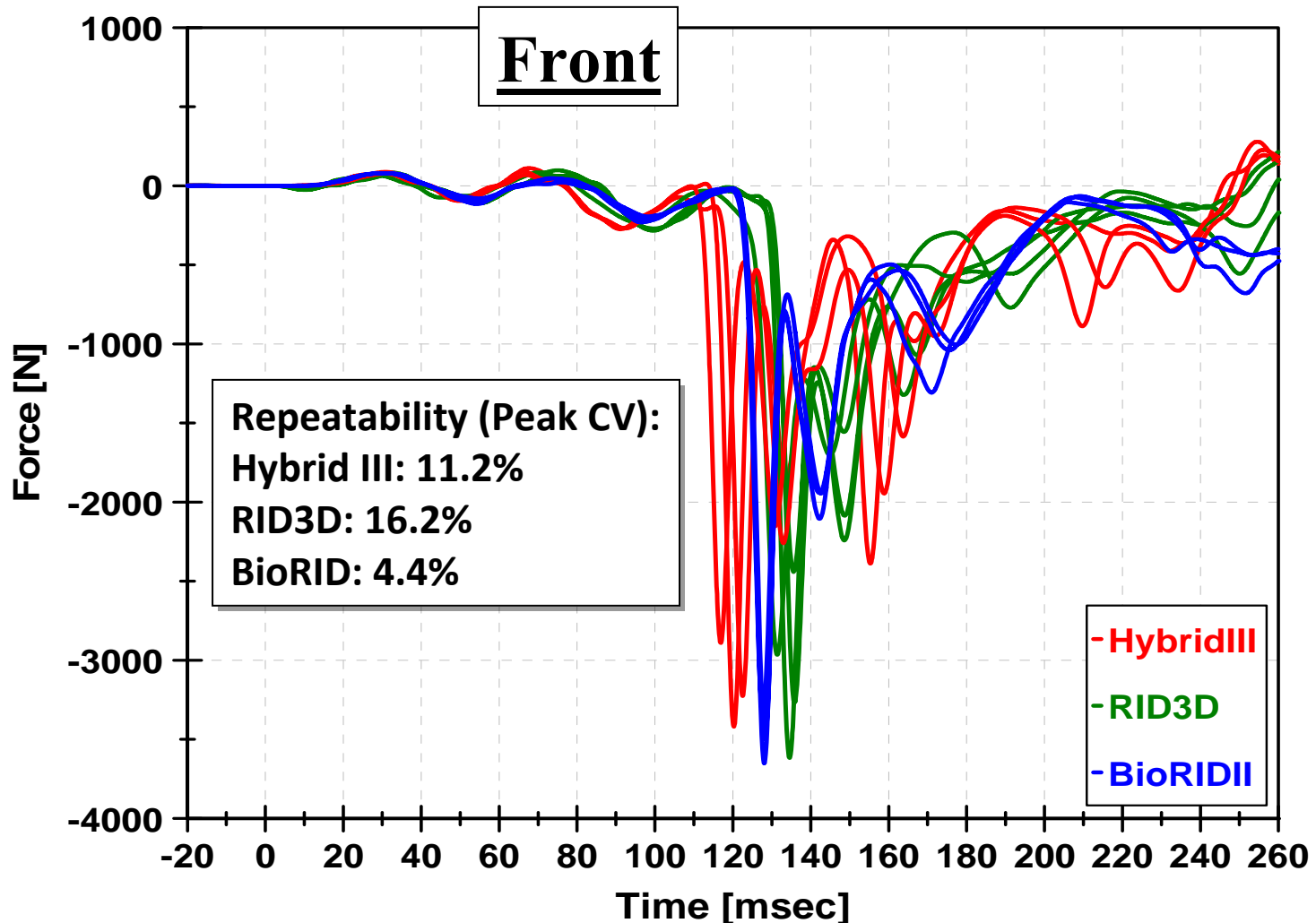
24 kph - Seatback Load



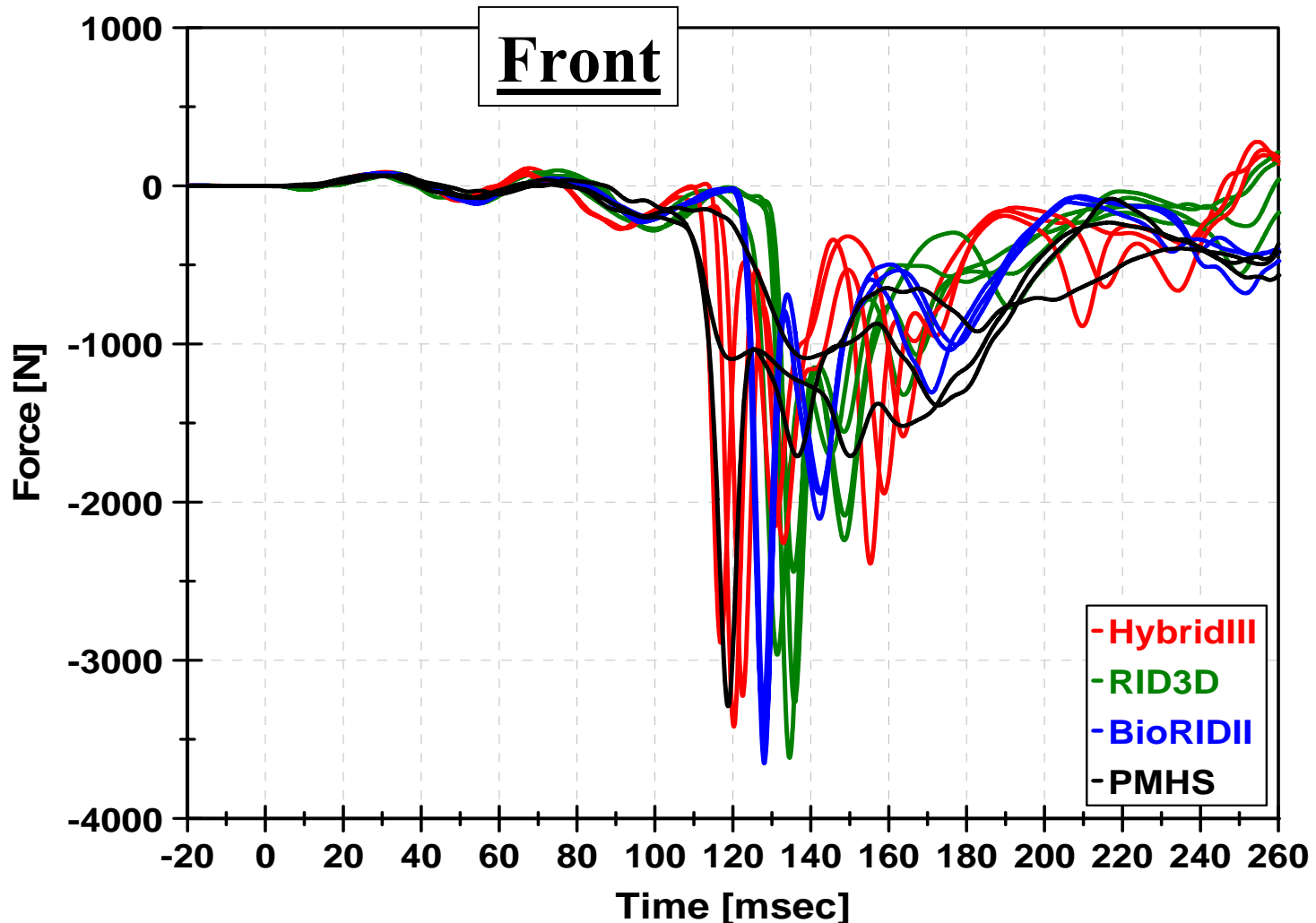
24 kph - Seatback Load



24 kph – Head Restraint Load



24 kph – Head Restraint Load



24 kph – Head Restraint Load

