
bast

TRL/EC Test Programme - Results and Recommendations

Presented by David Hynd
20 March, 2012

Agenda

- Introduction to the programme
  - Objectives
  - Overview of the seat rig
- Baseline tests
  - 5 repeats with each of 4 dummies
    - Dummies 028, 068, 077 and 100
  - 3 repeats with outlying PDB dummies
    - Dummies 006 and 007
- Part-swap tests
- Tests with refurbished 068 and 077 dummies
- Bumper properties
- Kinematics from marker tracking
- Conclusions and recommendations

Introduction

Objectives

Primary

- Compare BioRID seat test responses with certification results
  - Evaluate repeatability and reproducibility (R&R) of the BioRID II
    - Using dummies to GTR-7 IG specifications
  - If R&R acceptable
    - Evaluate at a range of backsets
  - If R&R not acceptable
    - Determine correlation between certification and seat test results
    - Recommend updates to certification corridors to control seat test results

Secondary

- Evaluate kinematic measures with on-board and off-board cameras
- Evaluate camera calibration for reliable marker tracking

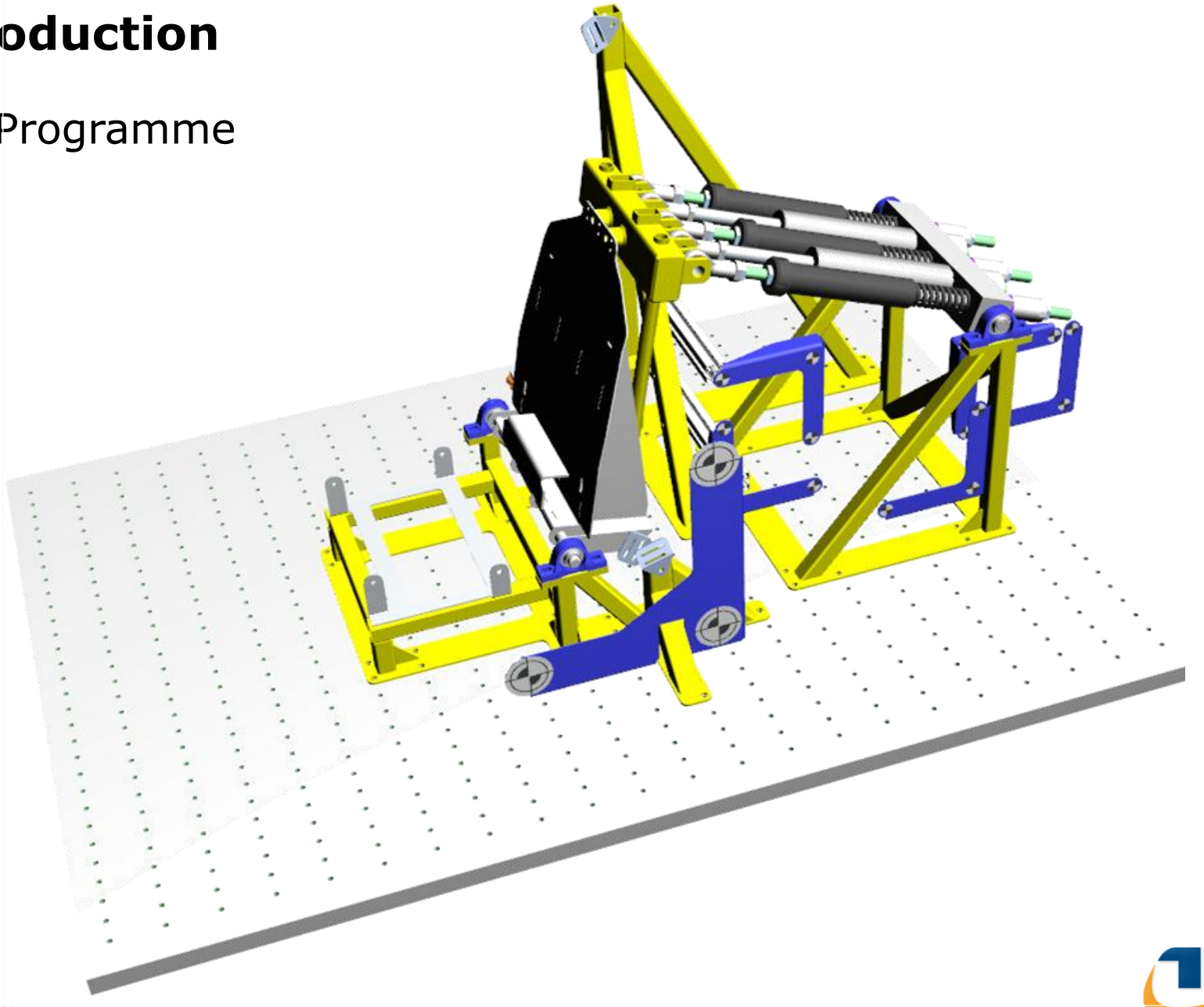
Introduction

Test Programme

- Developed a modified production car seat
  - Seat base
    - Mounted directly to sled
    - Otherwise unmodified
  - Seat back
    - Separated from seat base
    - Recliner mechanism replaced by a rigid pivot and external bearings
    - Seat back structure strengthened to allow repeated tests
    - Seat foam, cover, etc retained
    - Recline and rebound controlled by an external spring-damper mechanism
      - Springs on recline
      - Dampers only engaged for rebound
  - Head restraint
    - Rigidly mounted to seat back frame
    - Can be adjusted to give different backsets

Introduction

Test Programme



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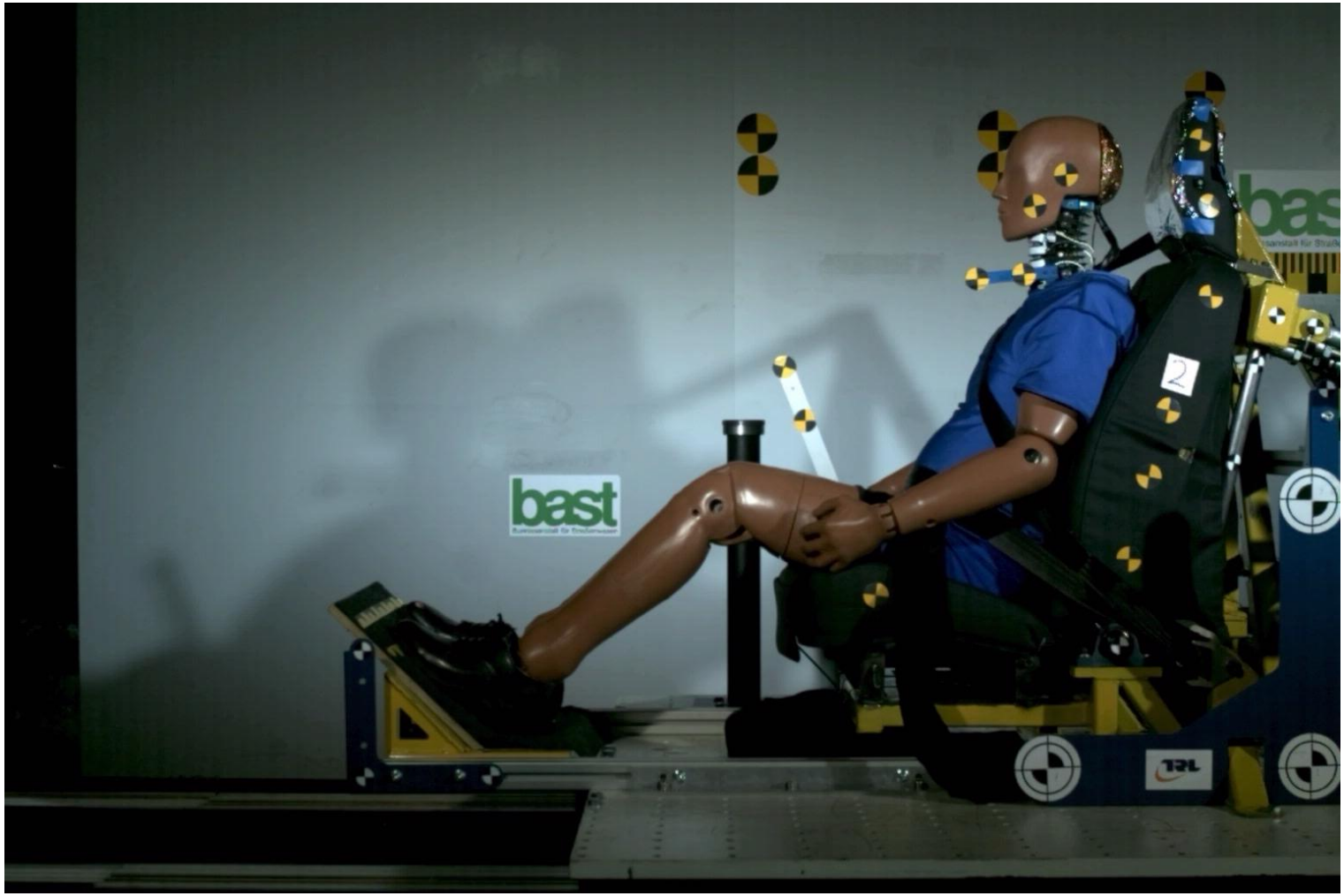

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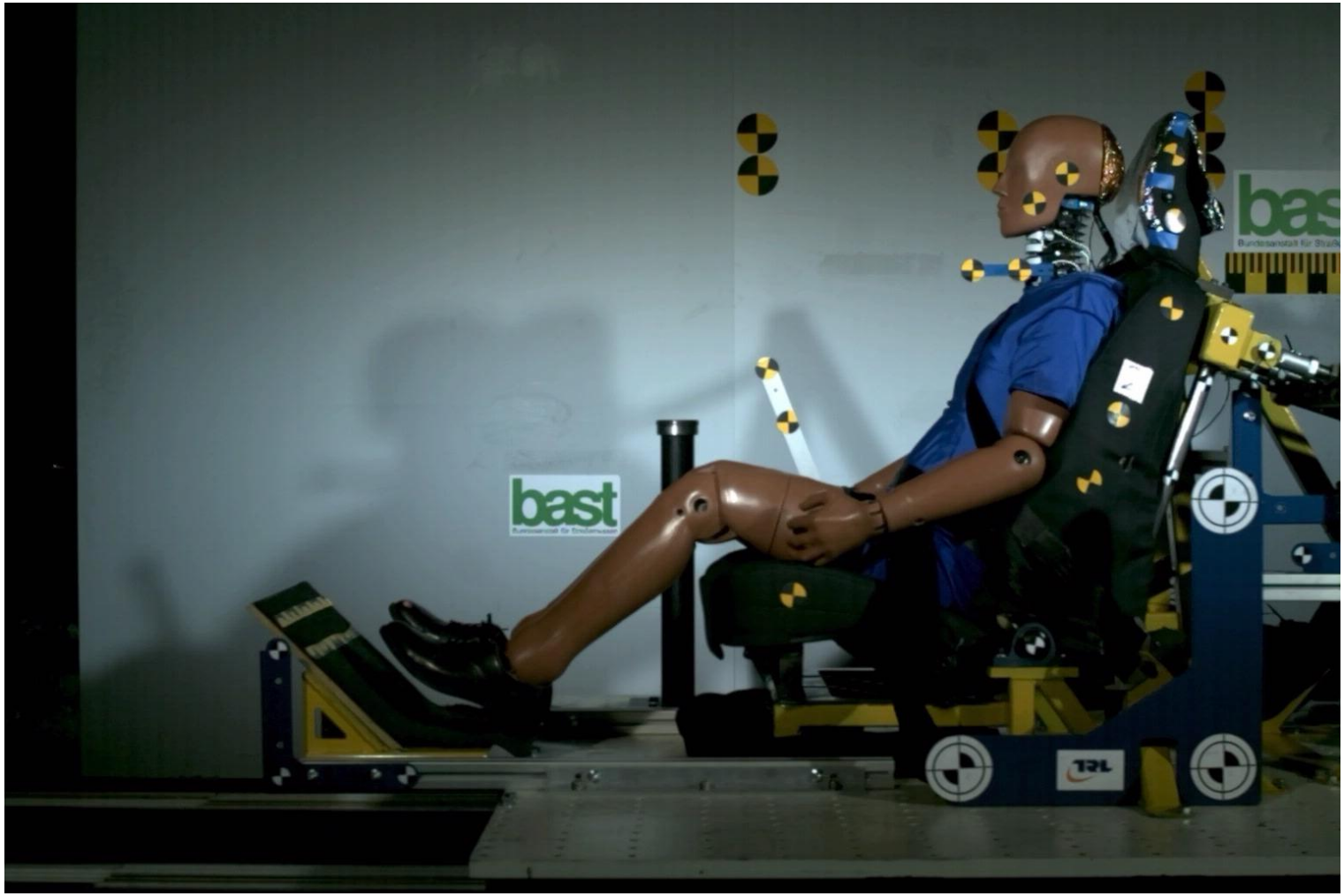

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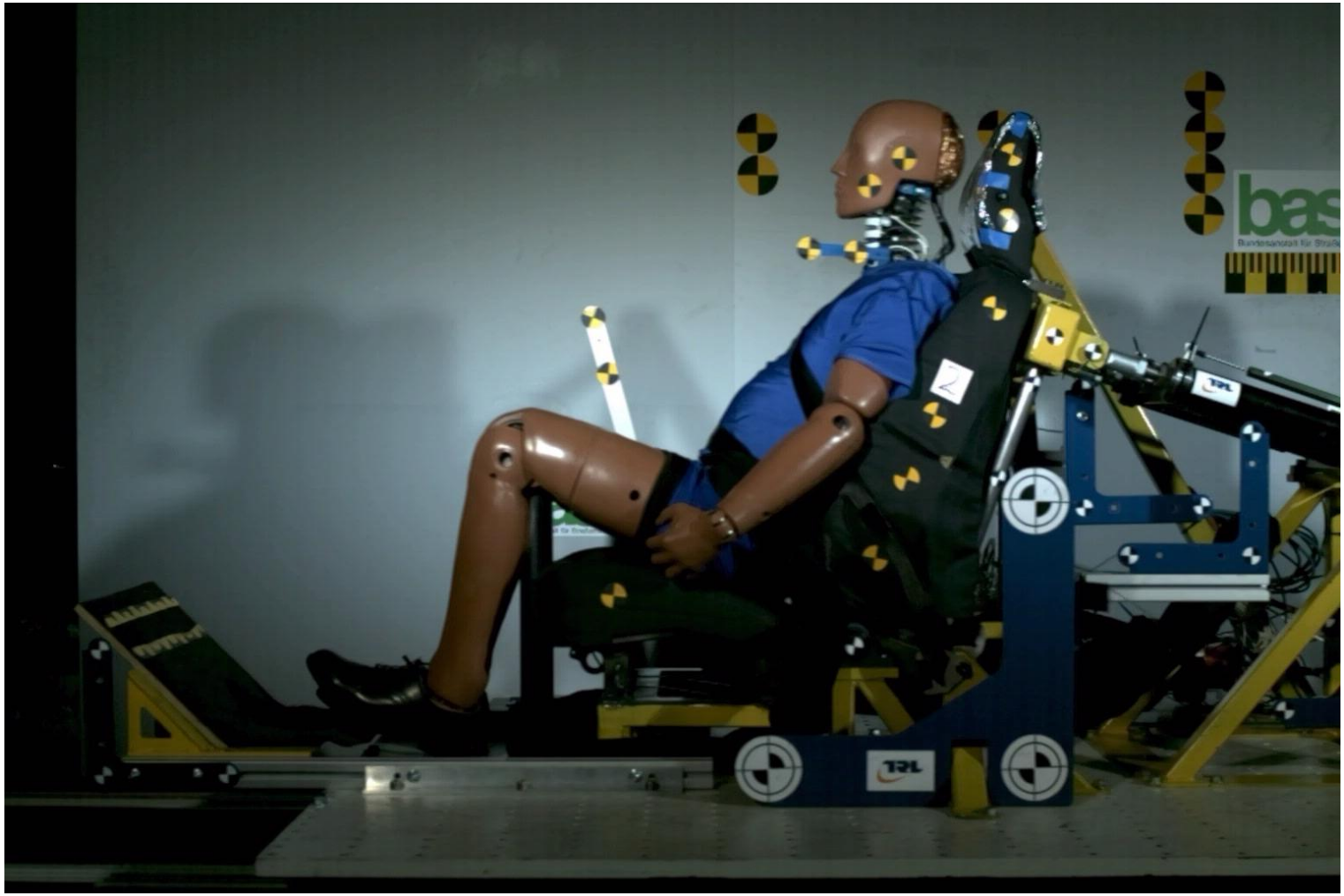

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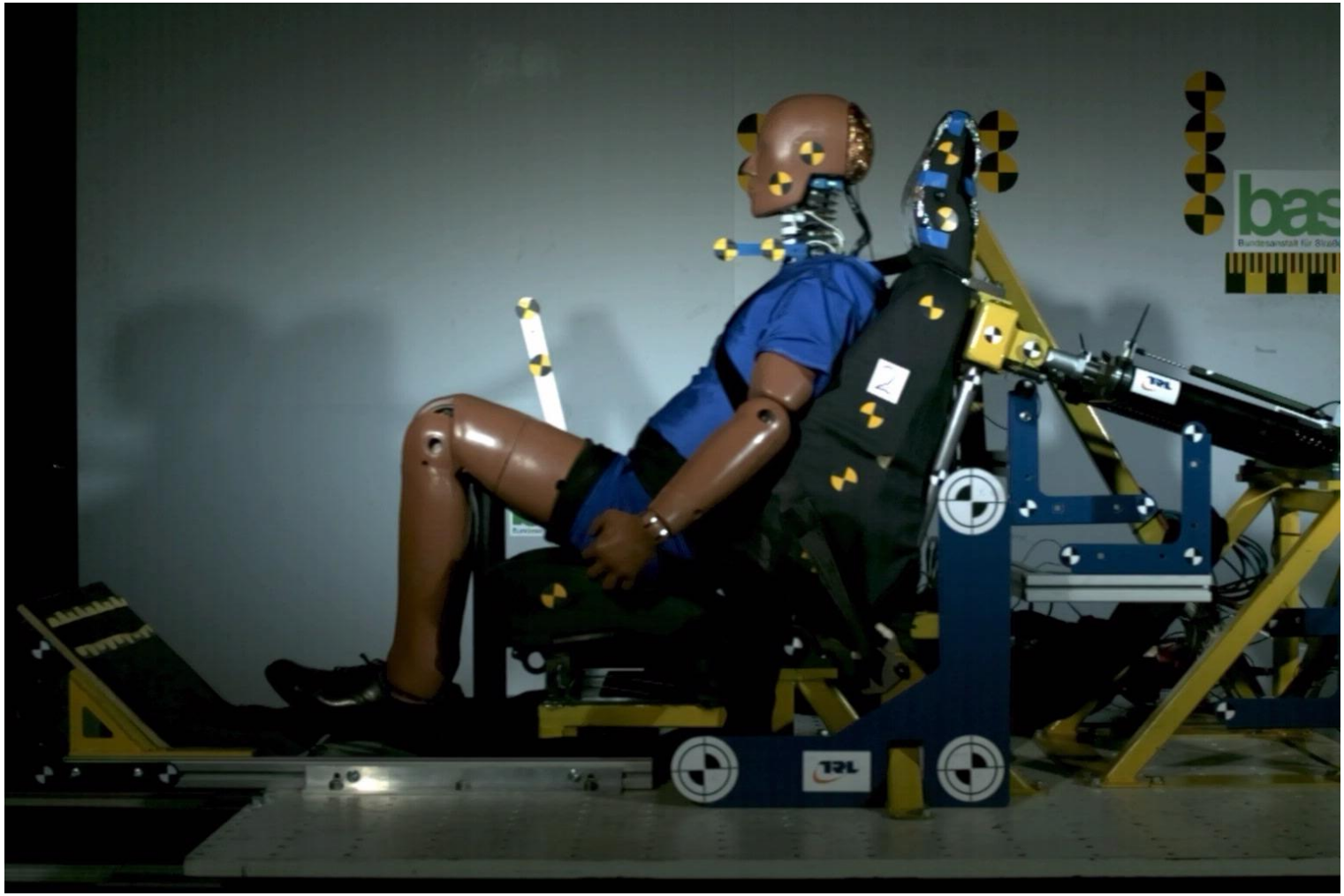

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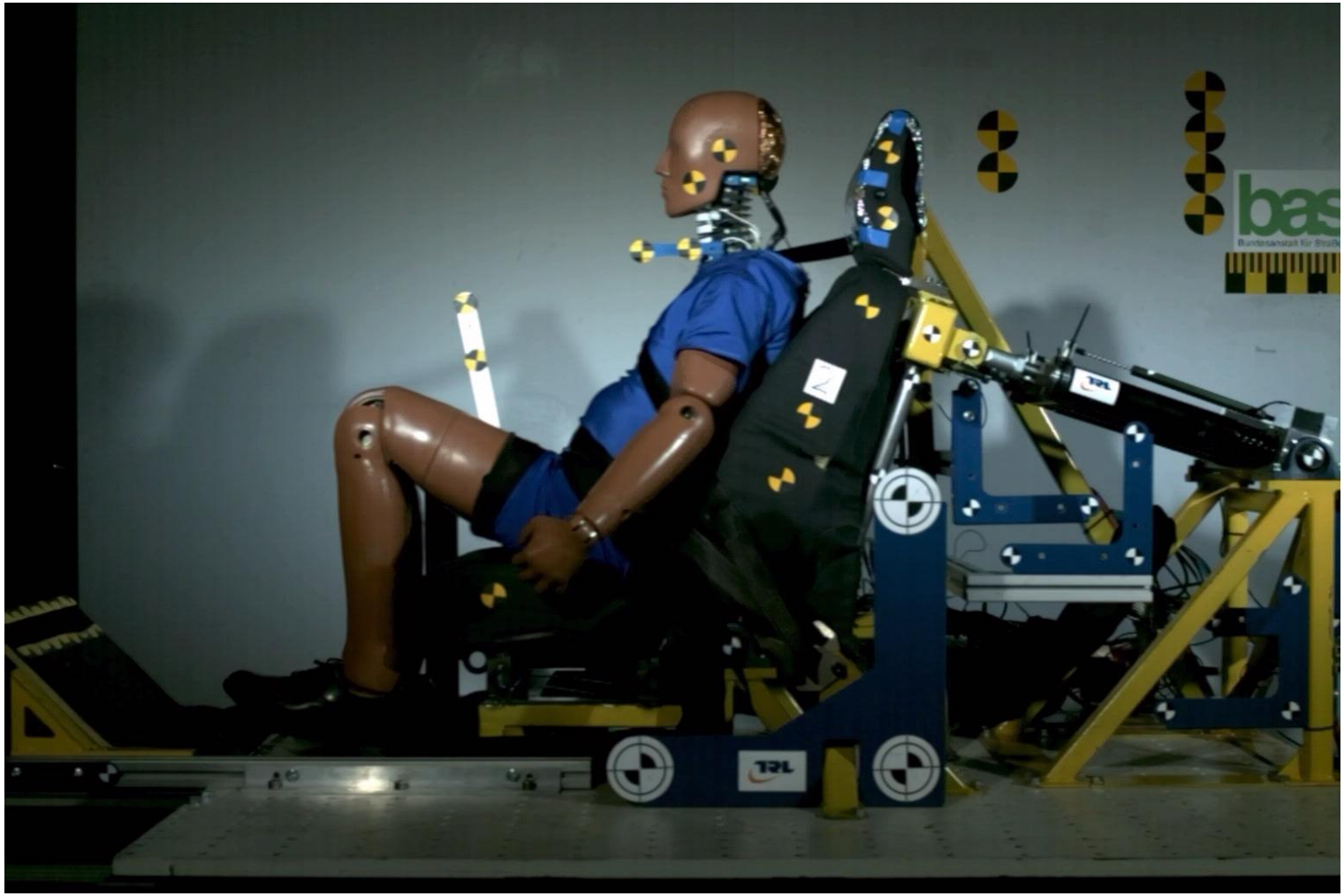

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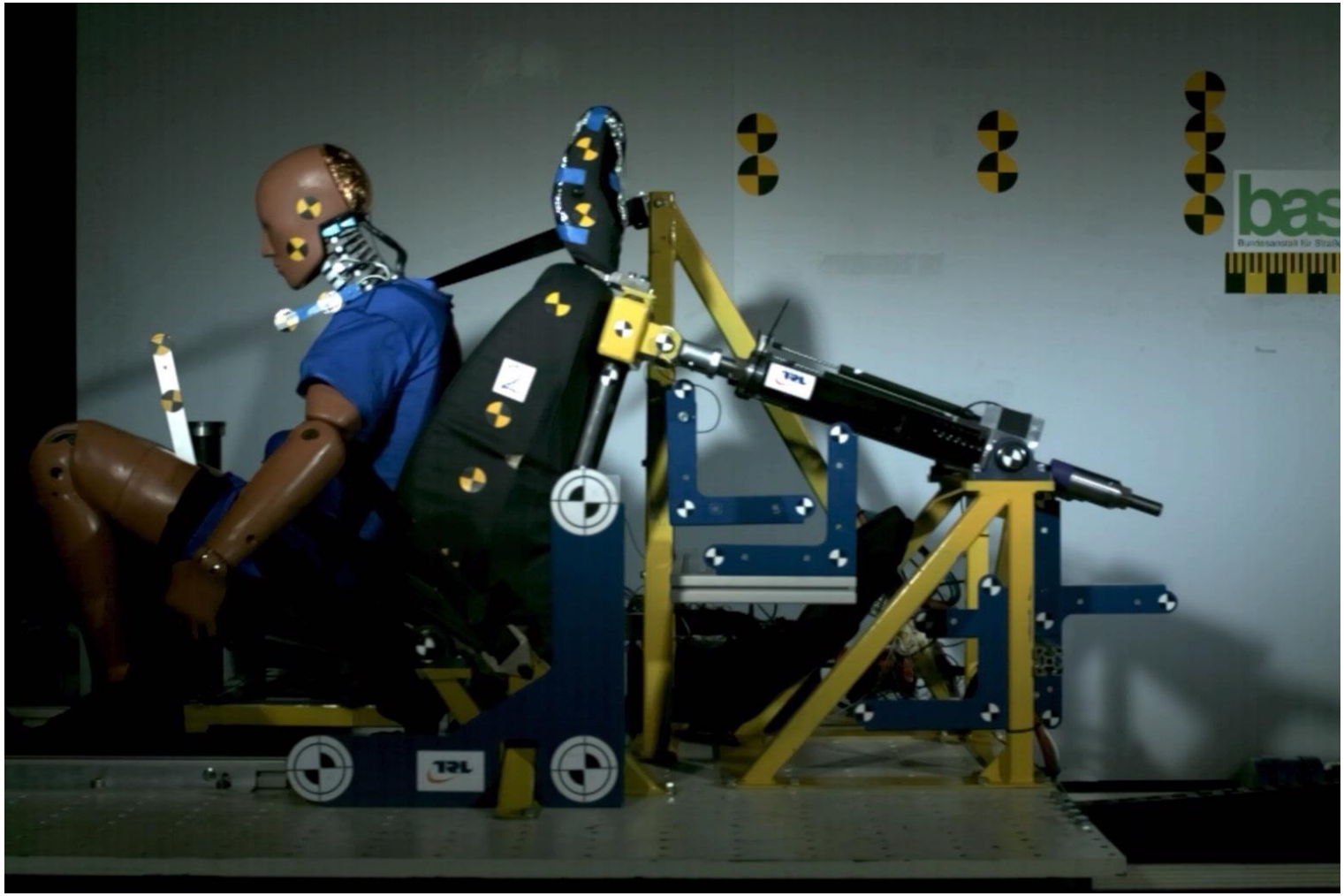

Introduction

Test Programme

Original Plan

- 5 tests each with 4 dummies
  - Far head restraint
  - Medium head restraint
  - Close head restraint
    - 60 tests!
- Additional tests with selected dummies
  - E.g. 6 tests with on–board camera
  - E.g. 9 tests with variations to the seating procedure

Introduction

Seating Procedure

BioRID Target Backset

- Determined three times and an average value used
  - Same technicians, 3D H-point machine and HRMD used for all tests
  - 3D H-point machine and HRMD were calibrated to Euro NCAP Gloria specification
- Procedure as defined in Euro NCAP procedure v3.1 June 2011
  - Except T-bar held when settling dummy back into the seat in step 5.3.18, as required in GTR7-06-10 Rev 1 (Feb 2012)
  - No assessment of the R&R of the target backset in this study
  - Target backset re-checked after 20 tests

Introduction

Seating Procedure

BioRID Installation

- Procedure as defined in Euro NCAP procedure v3.1 June 2012
  - GTR7-06-10 slightly cut-down compared to Euro NCAP
- BioRID and seat positions measured with CMM before every test
  - Head (2 markers)
  - OC and T1 pins
  - Shoulder left and right
  - T1 wand (2 markers)
  - Pelvis wand (2 markers)
  - H-point left and right
  - Knee joint left and right
  - Seat and head restraint markers as defined in Euro NCAP

Seat Test Results

20 baseline tests with 028, 068, 077 and 100

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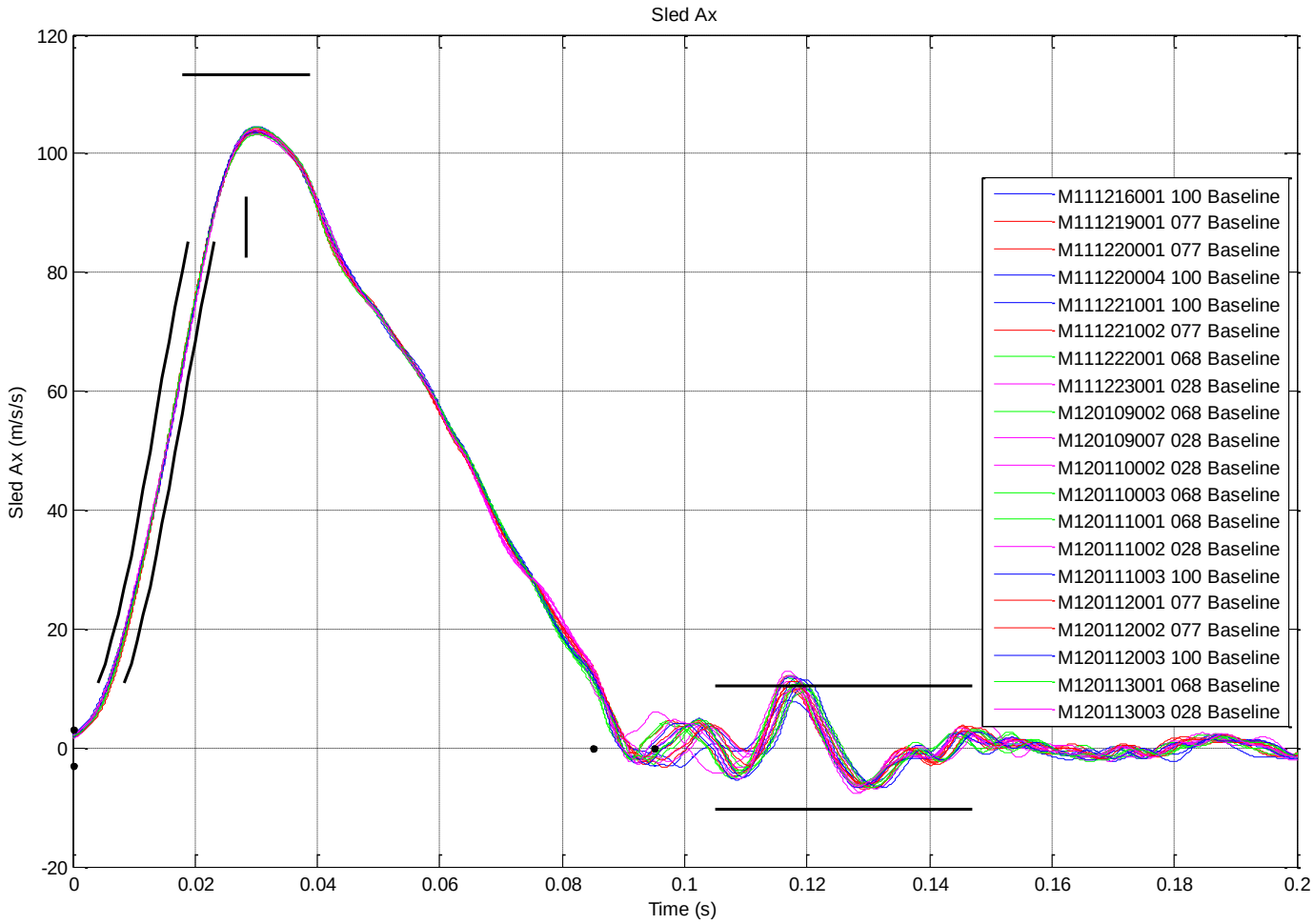

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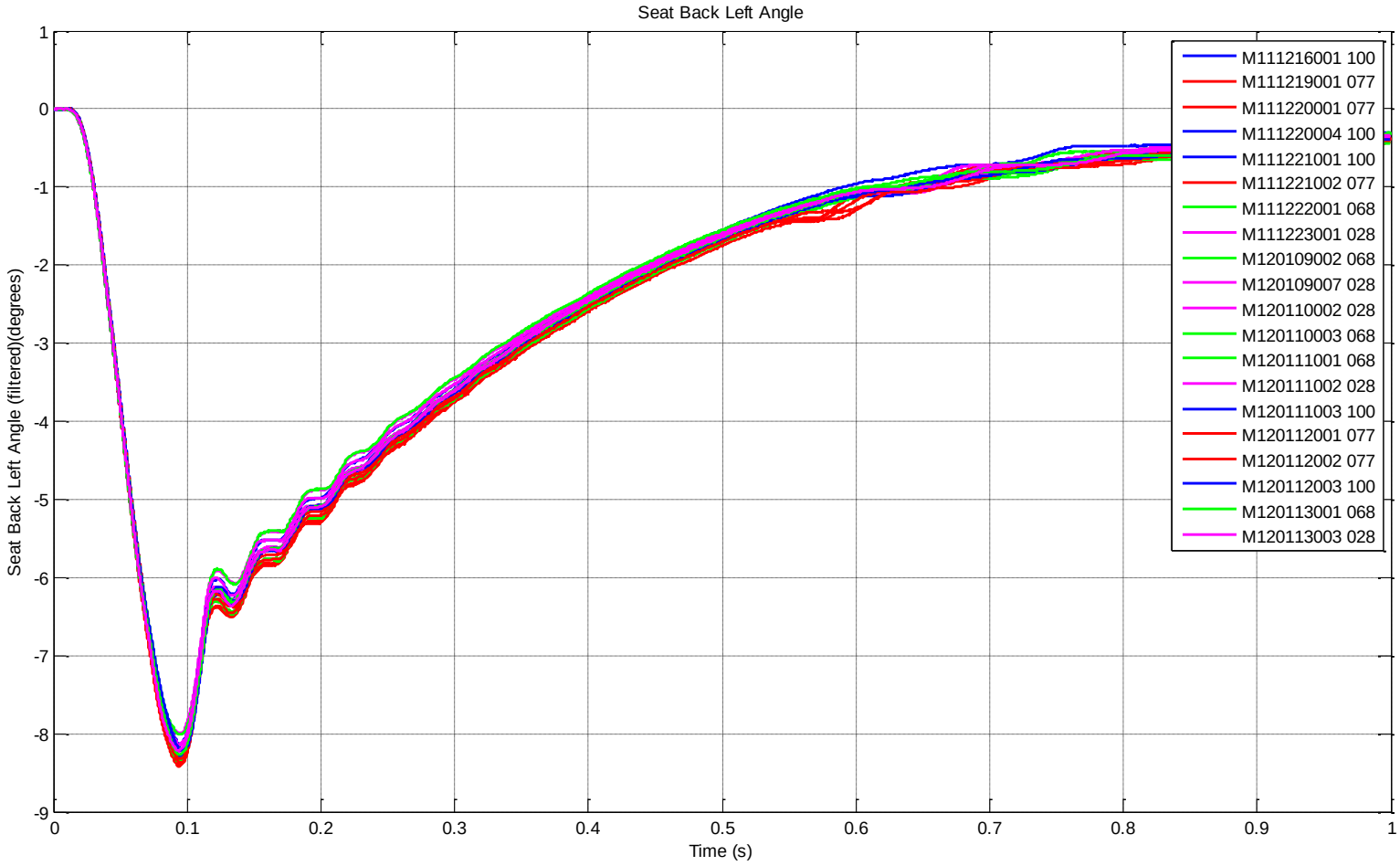

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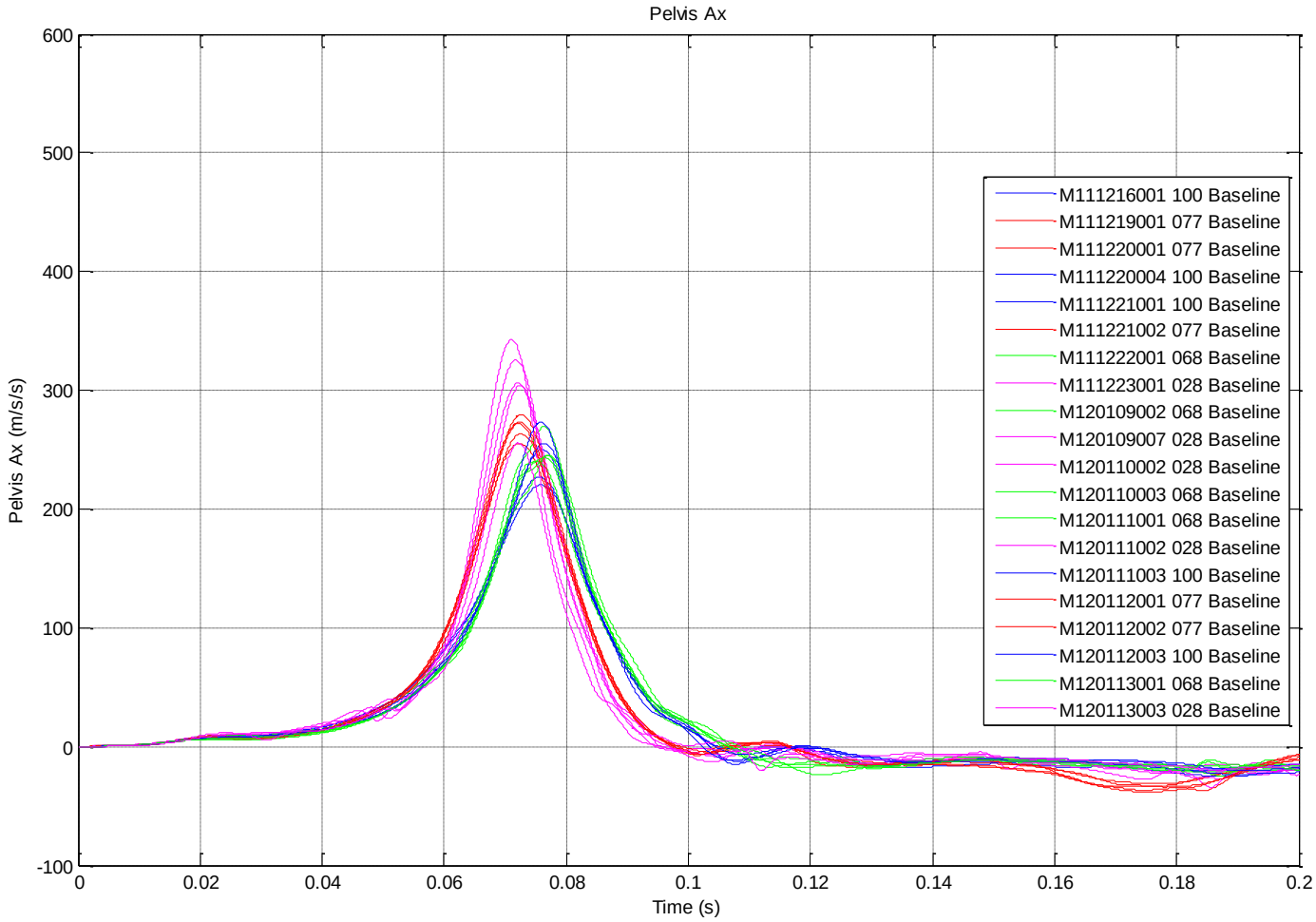

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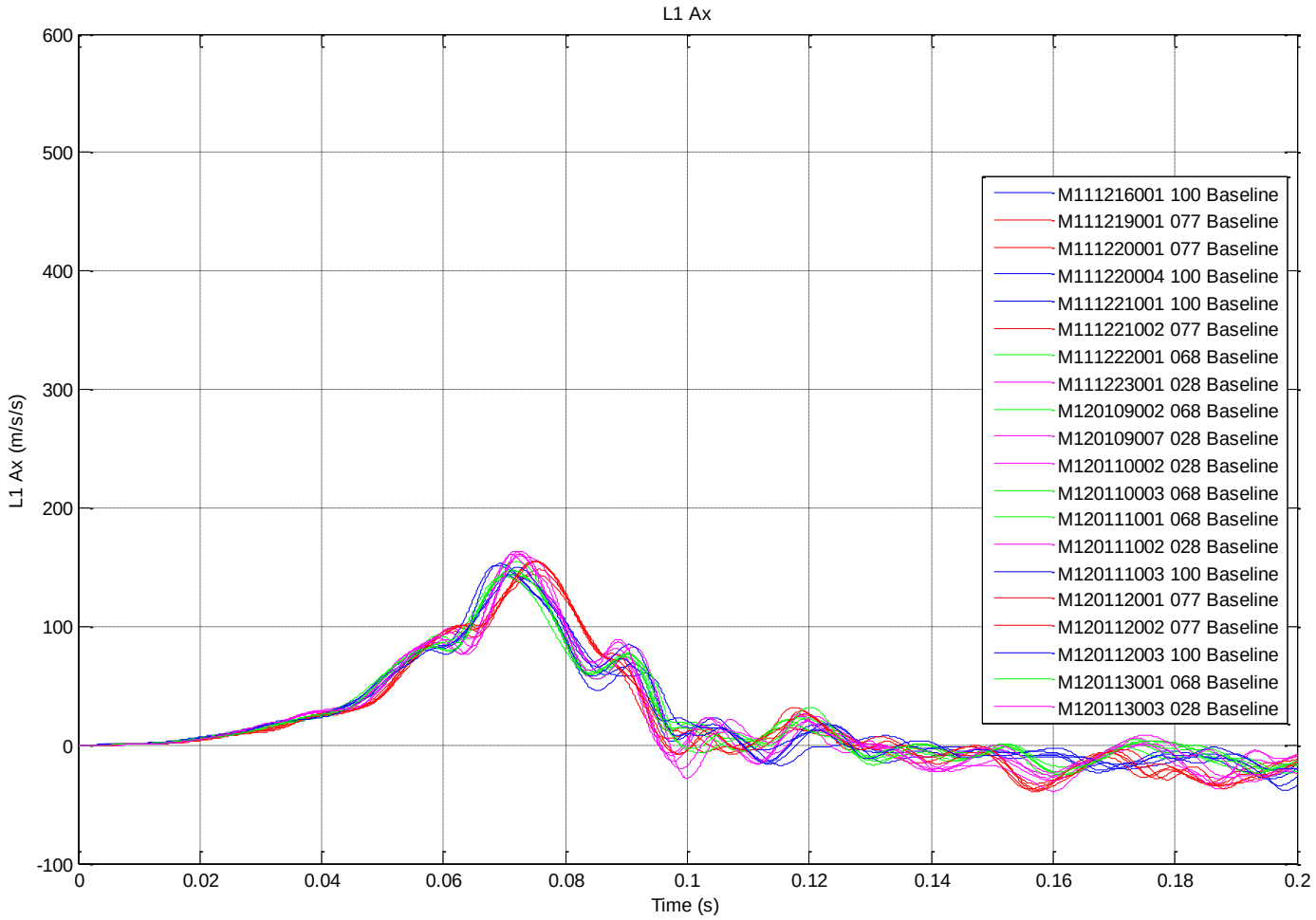

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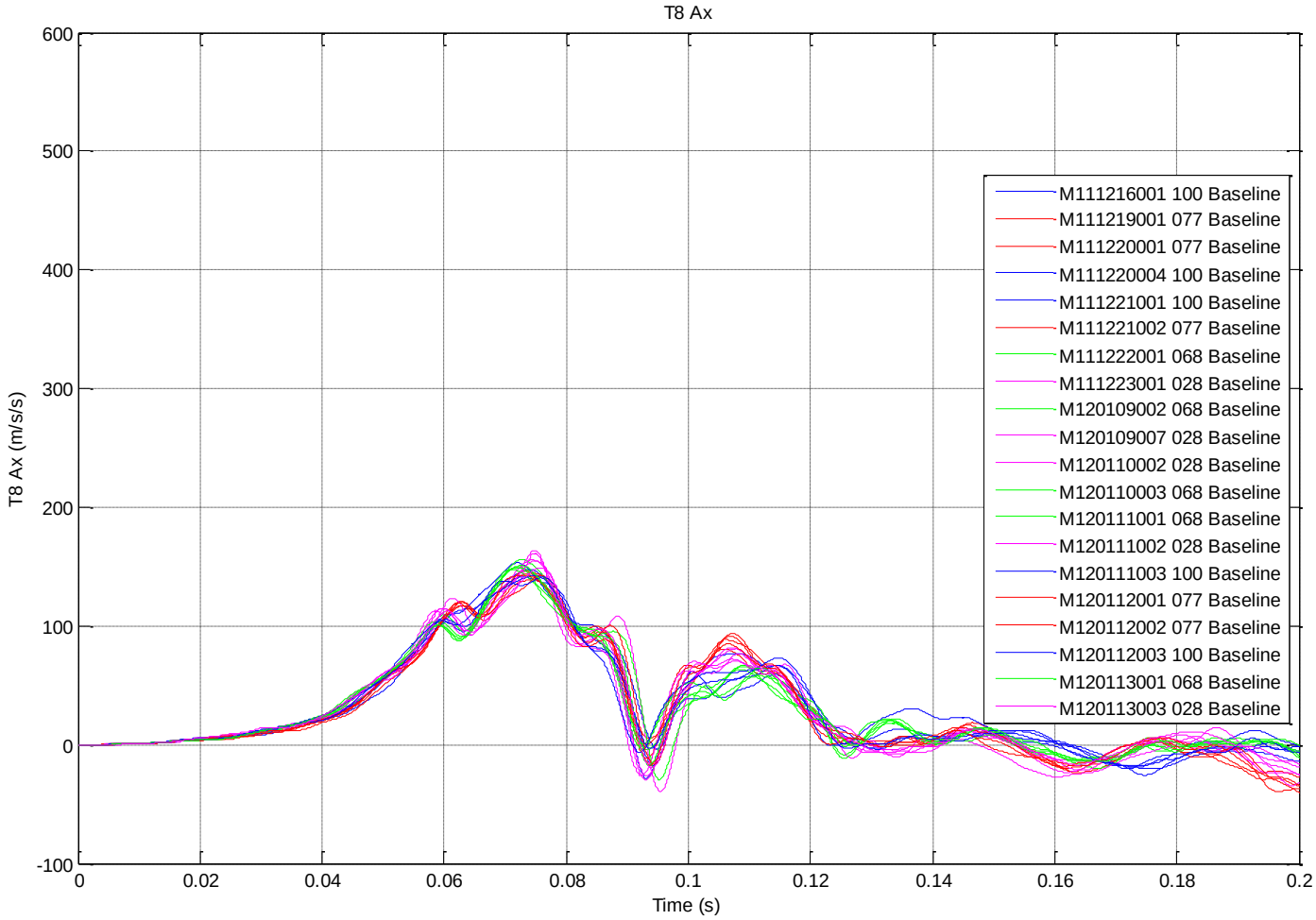

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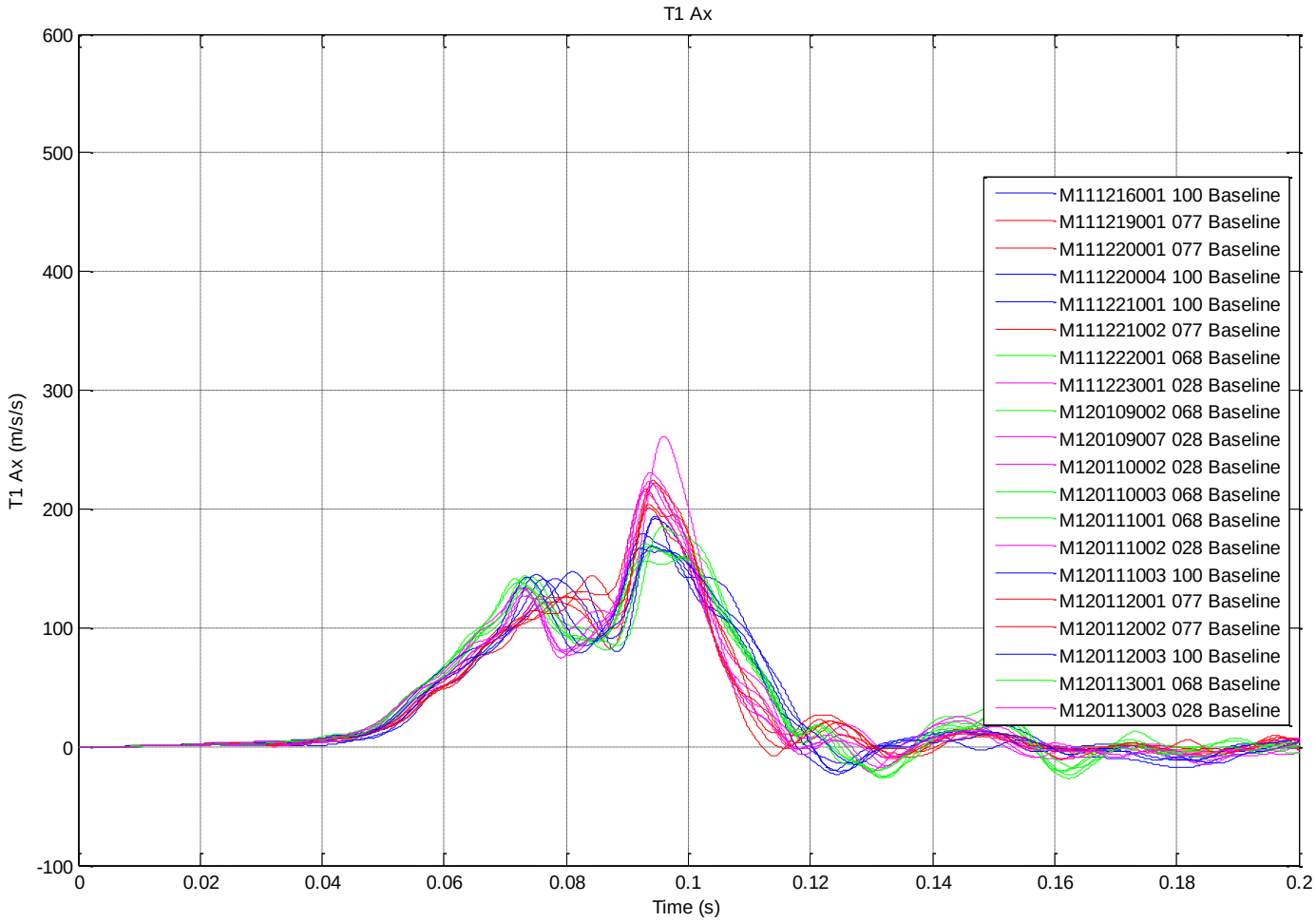

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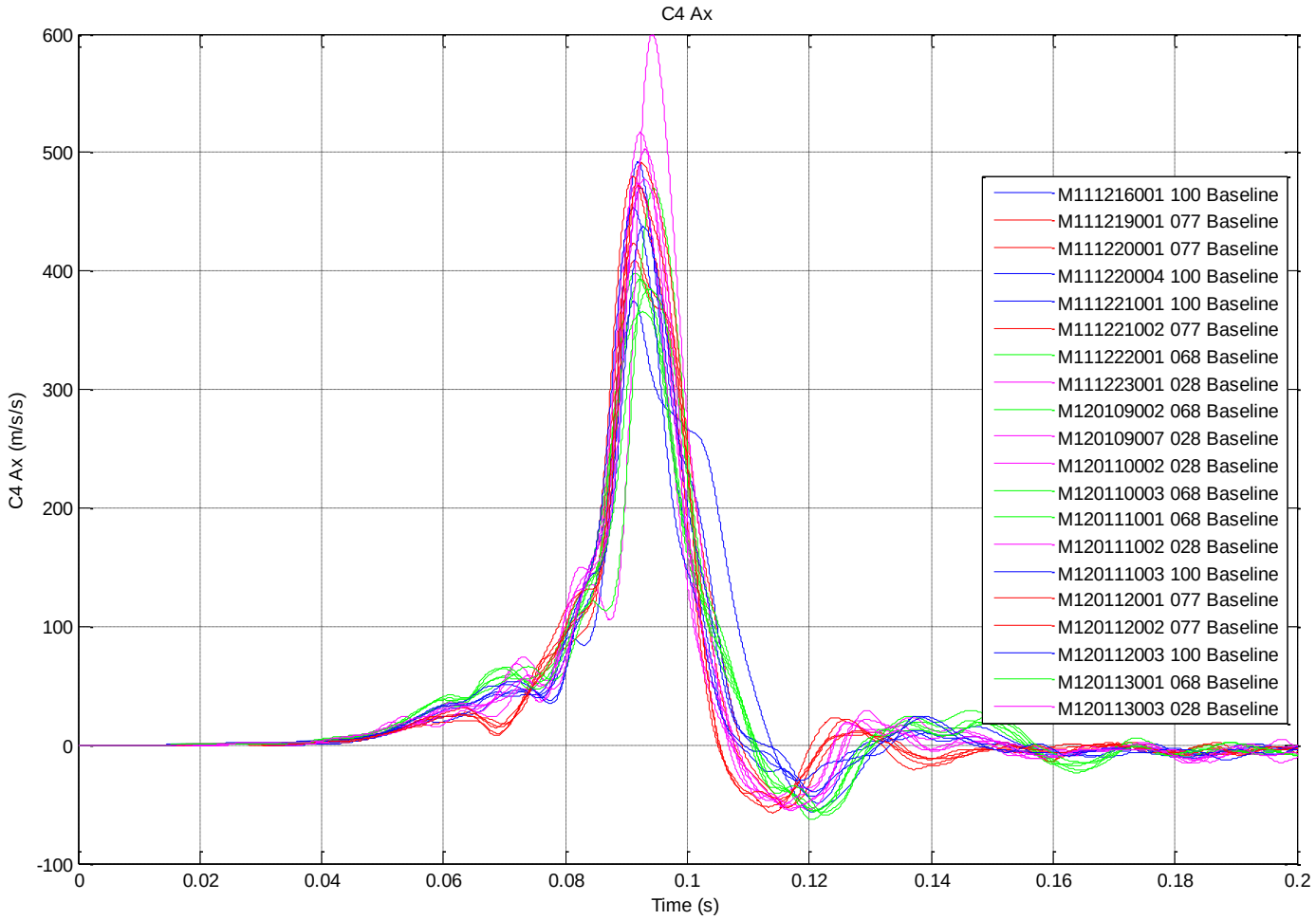

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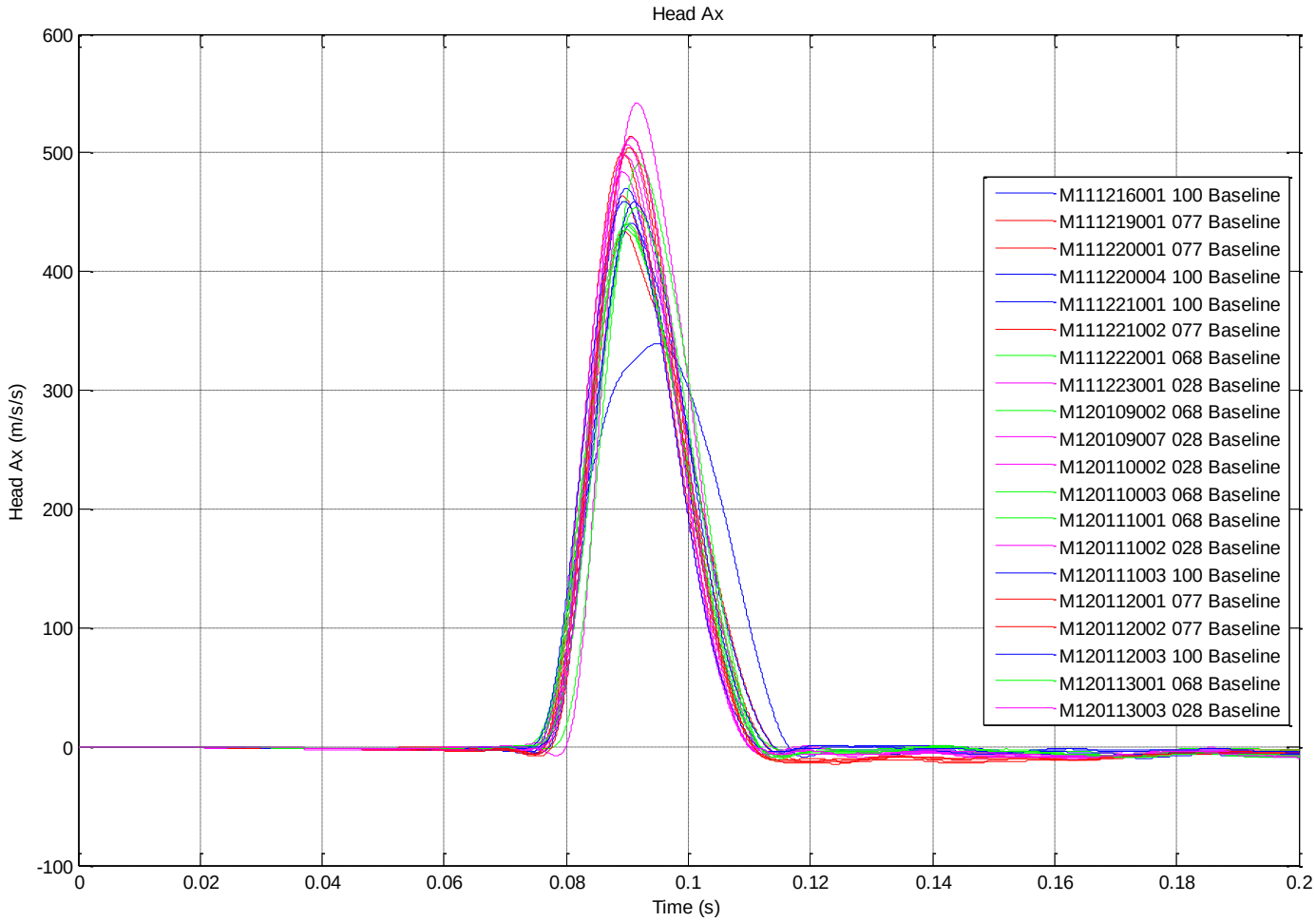

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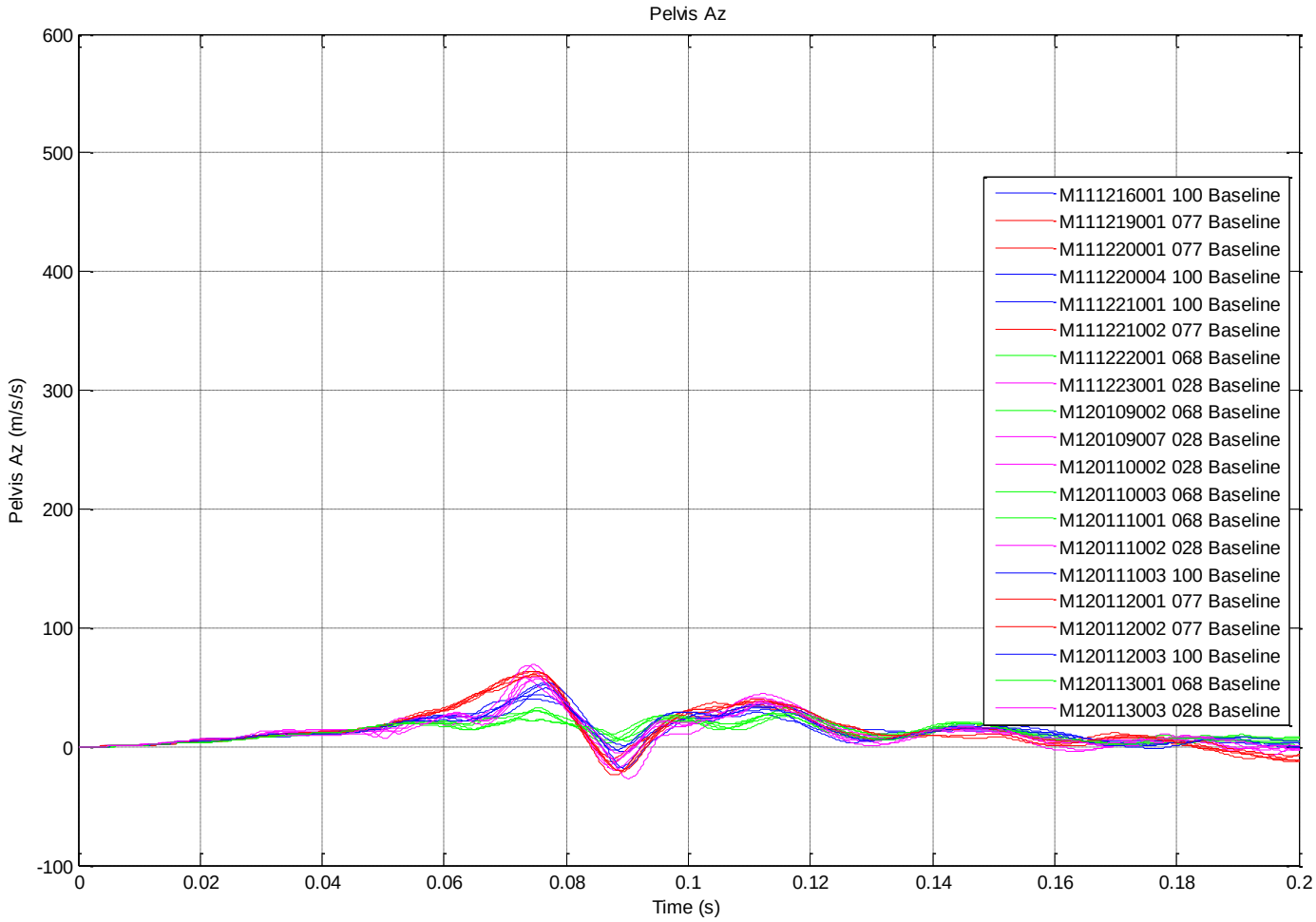

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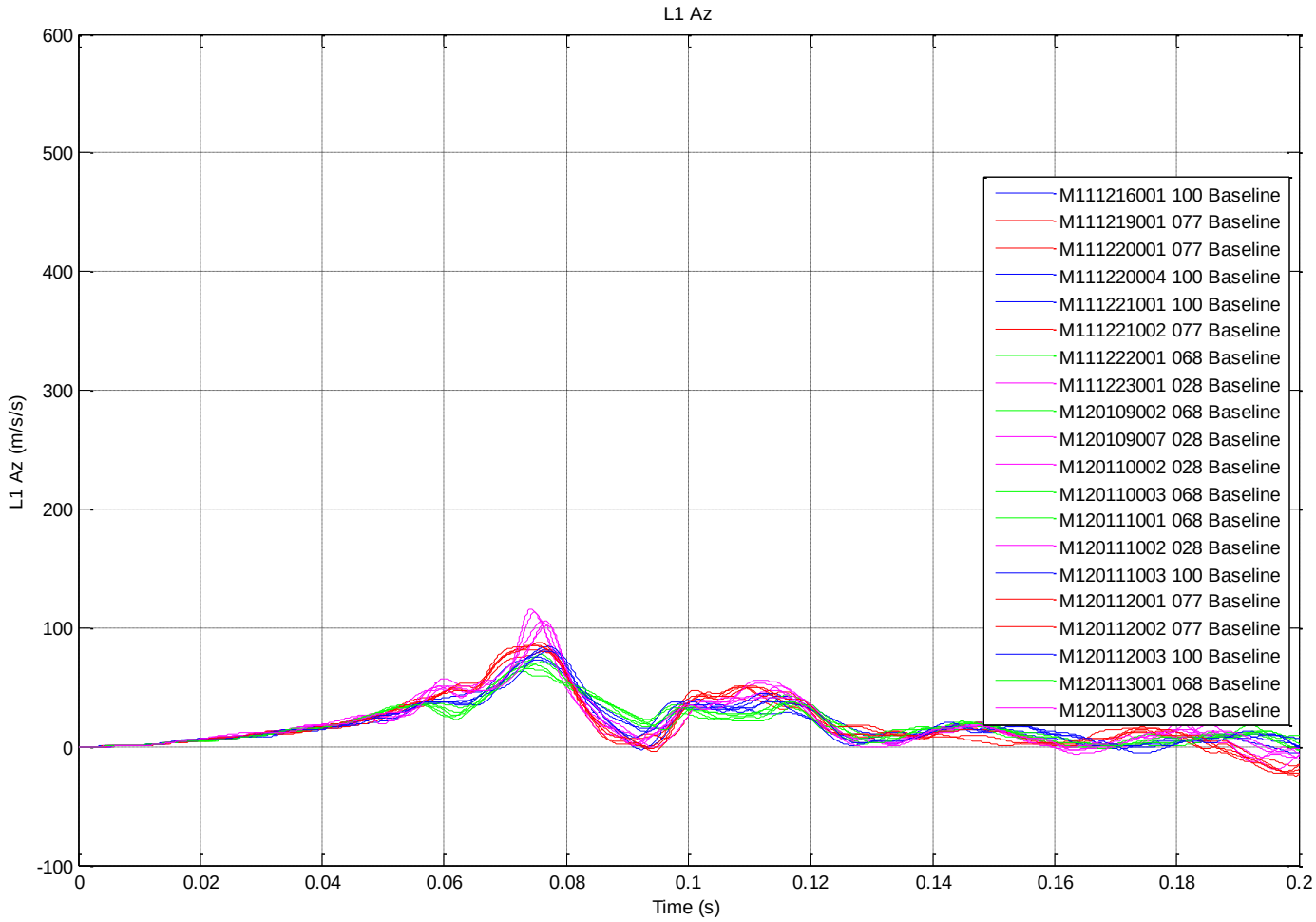

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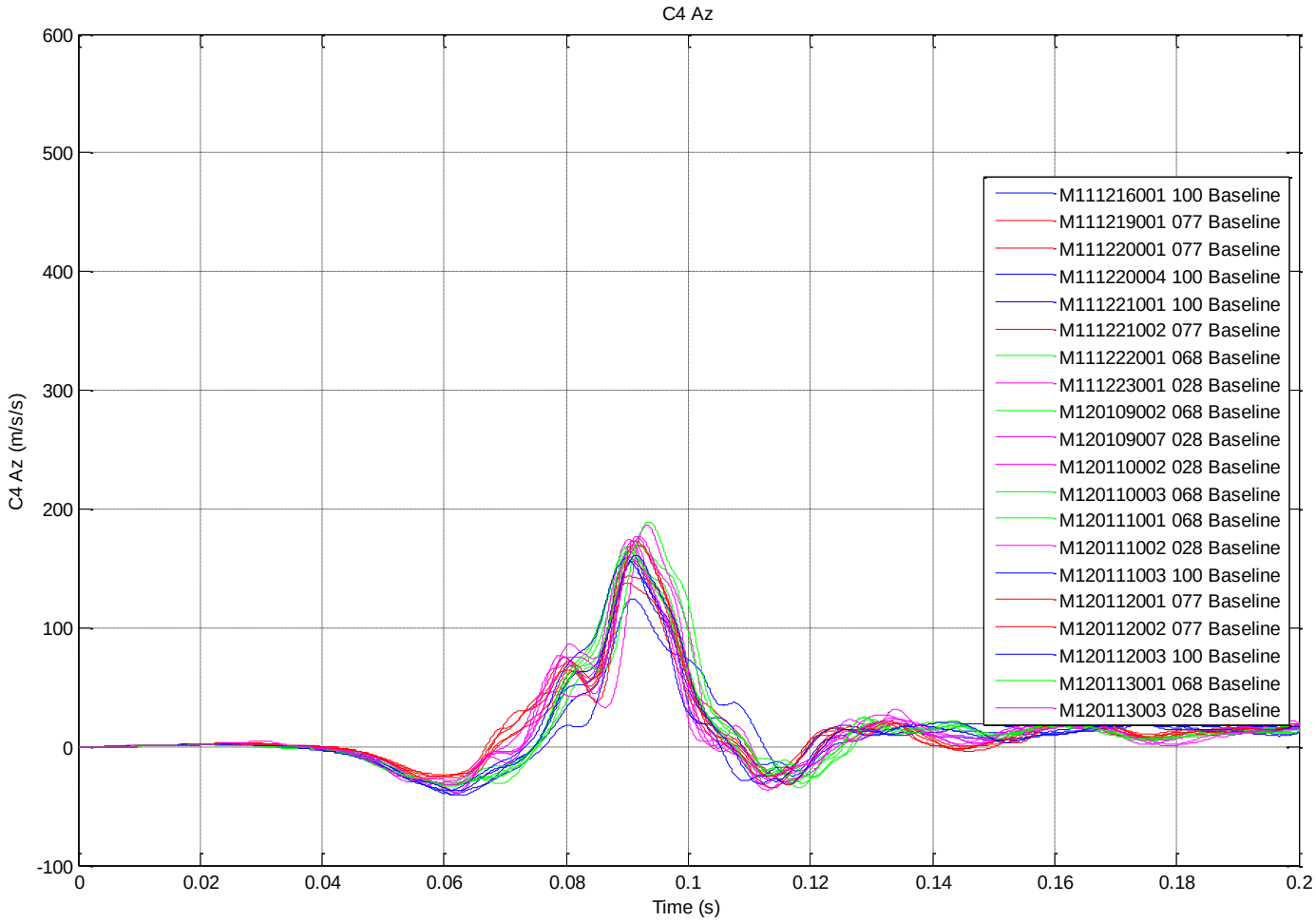

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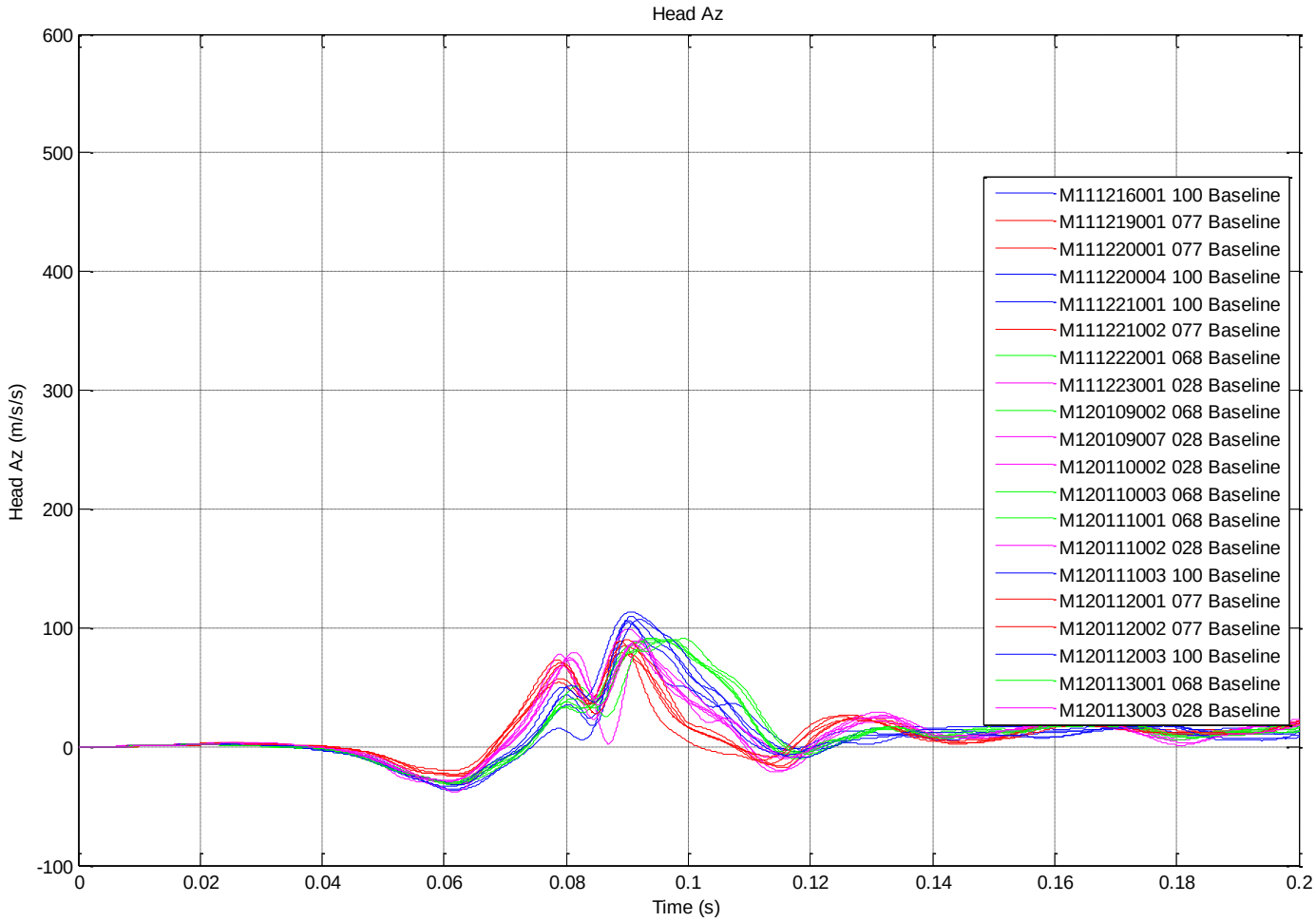

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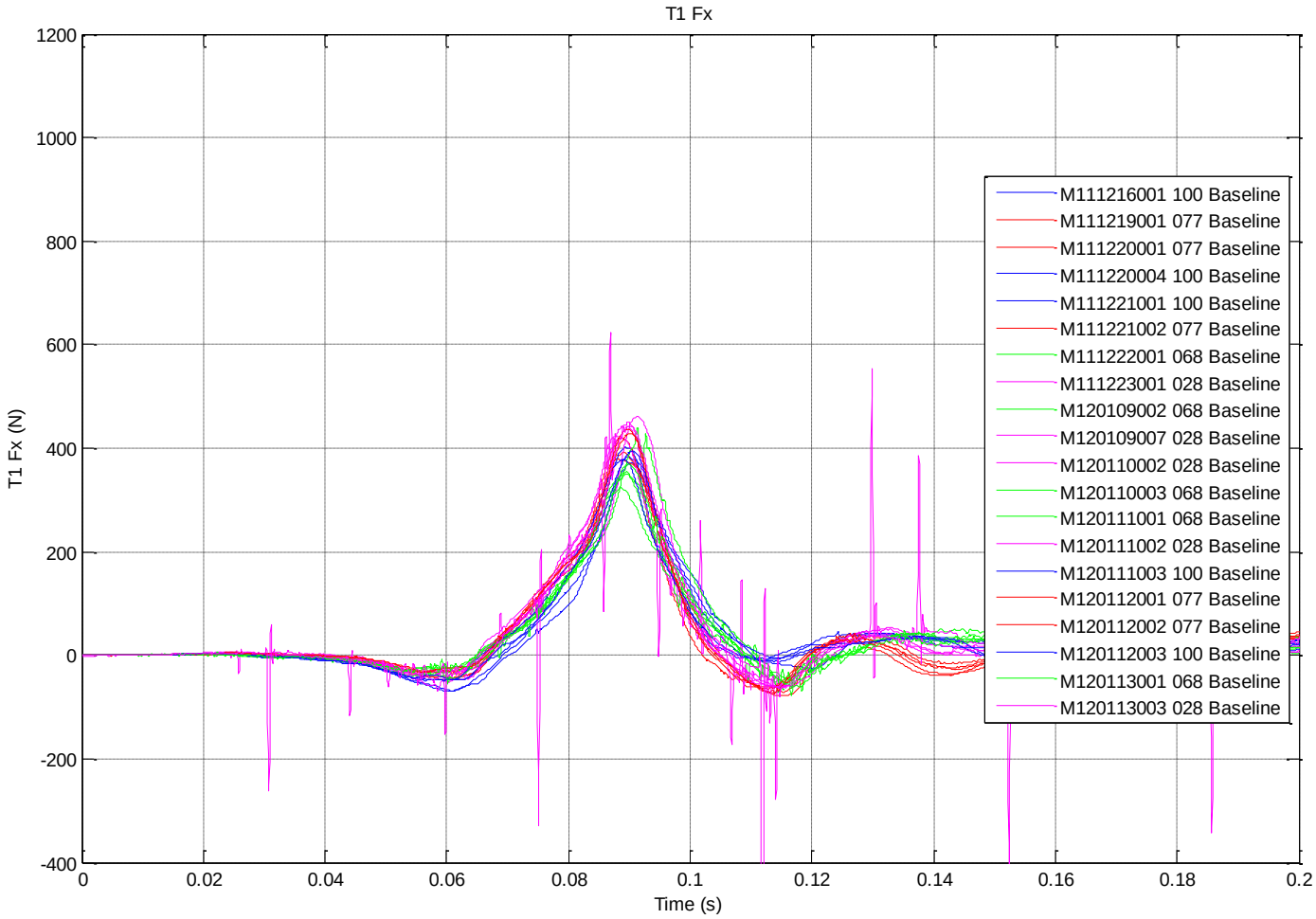

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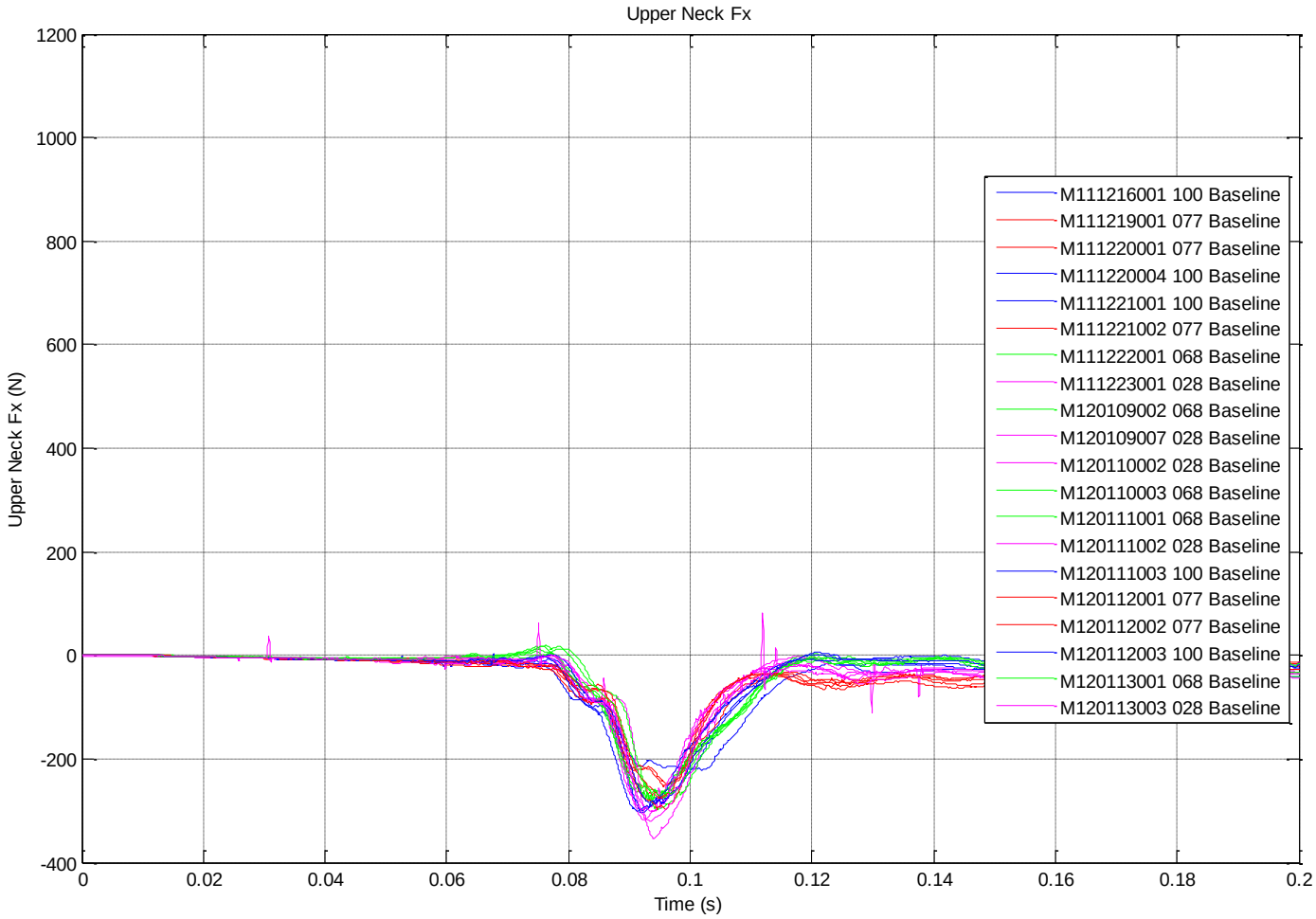

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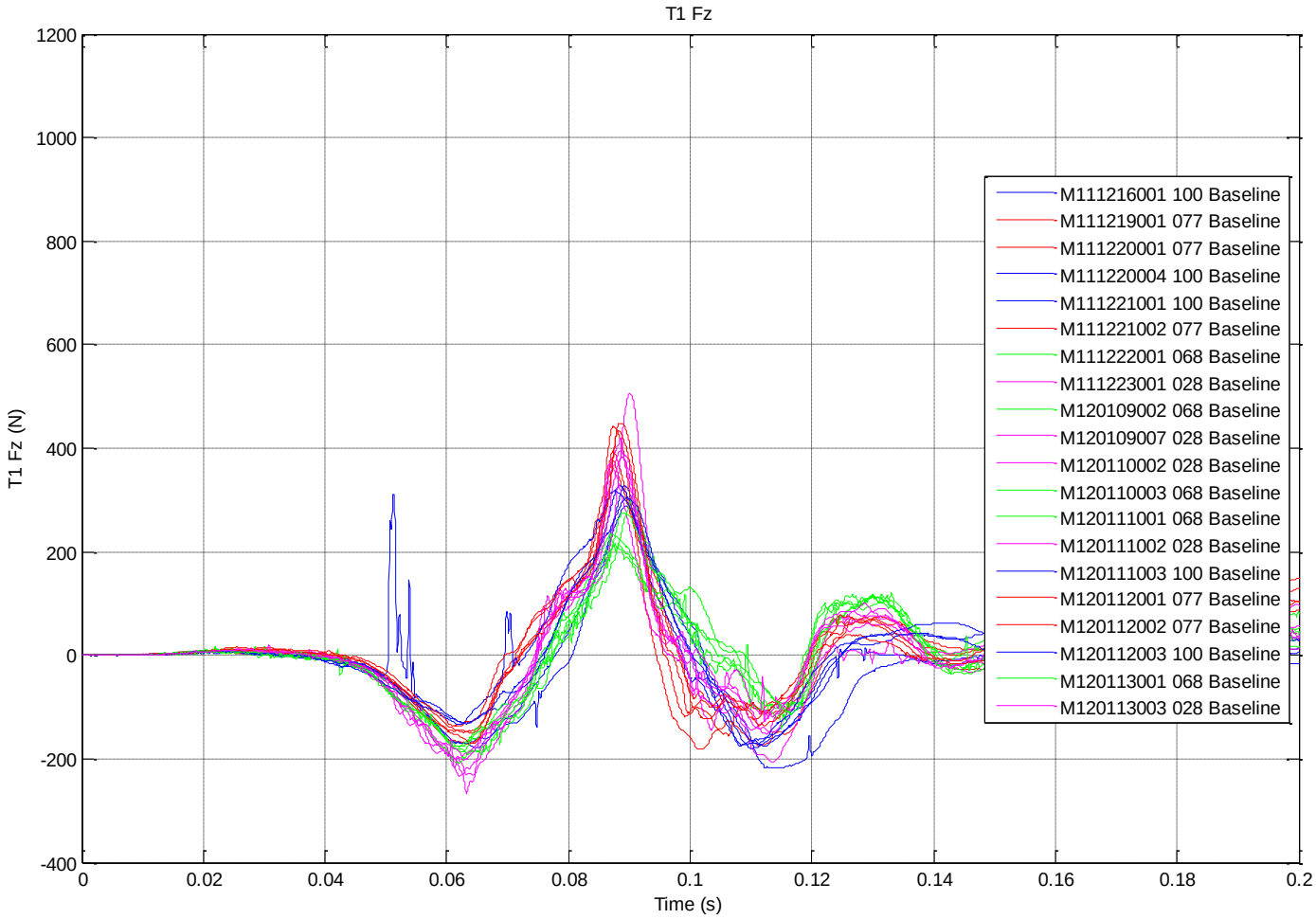

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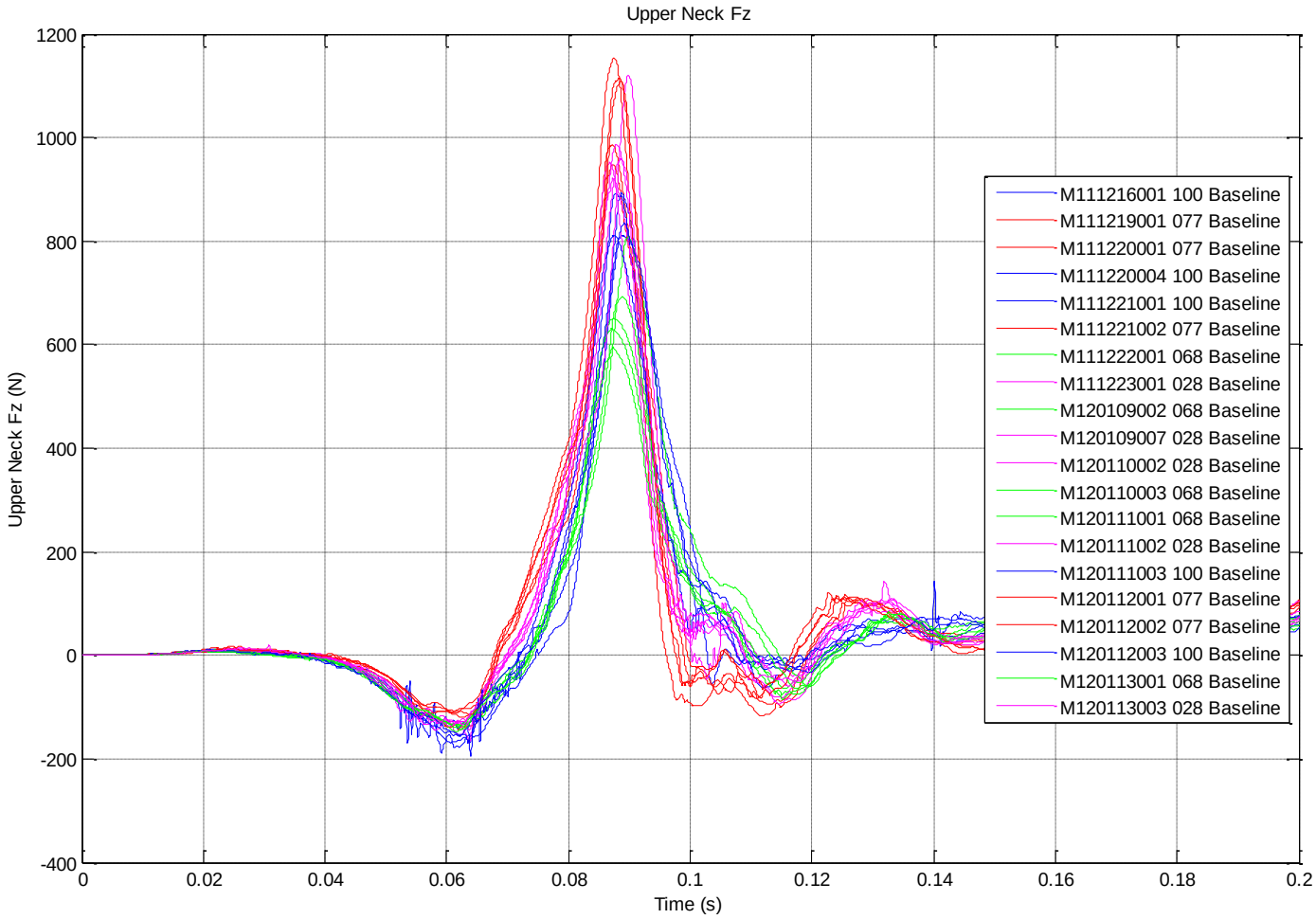

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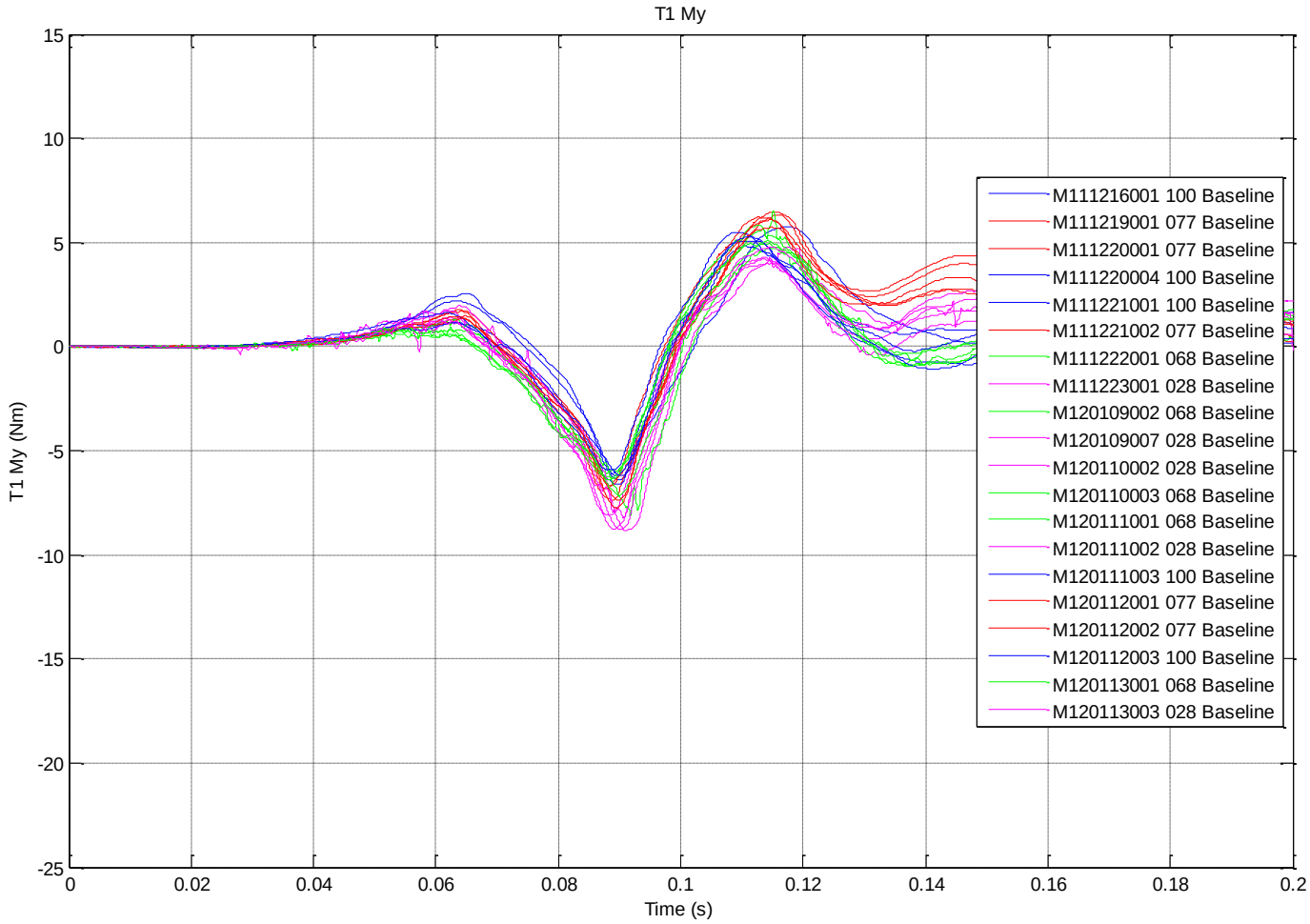

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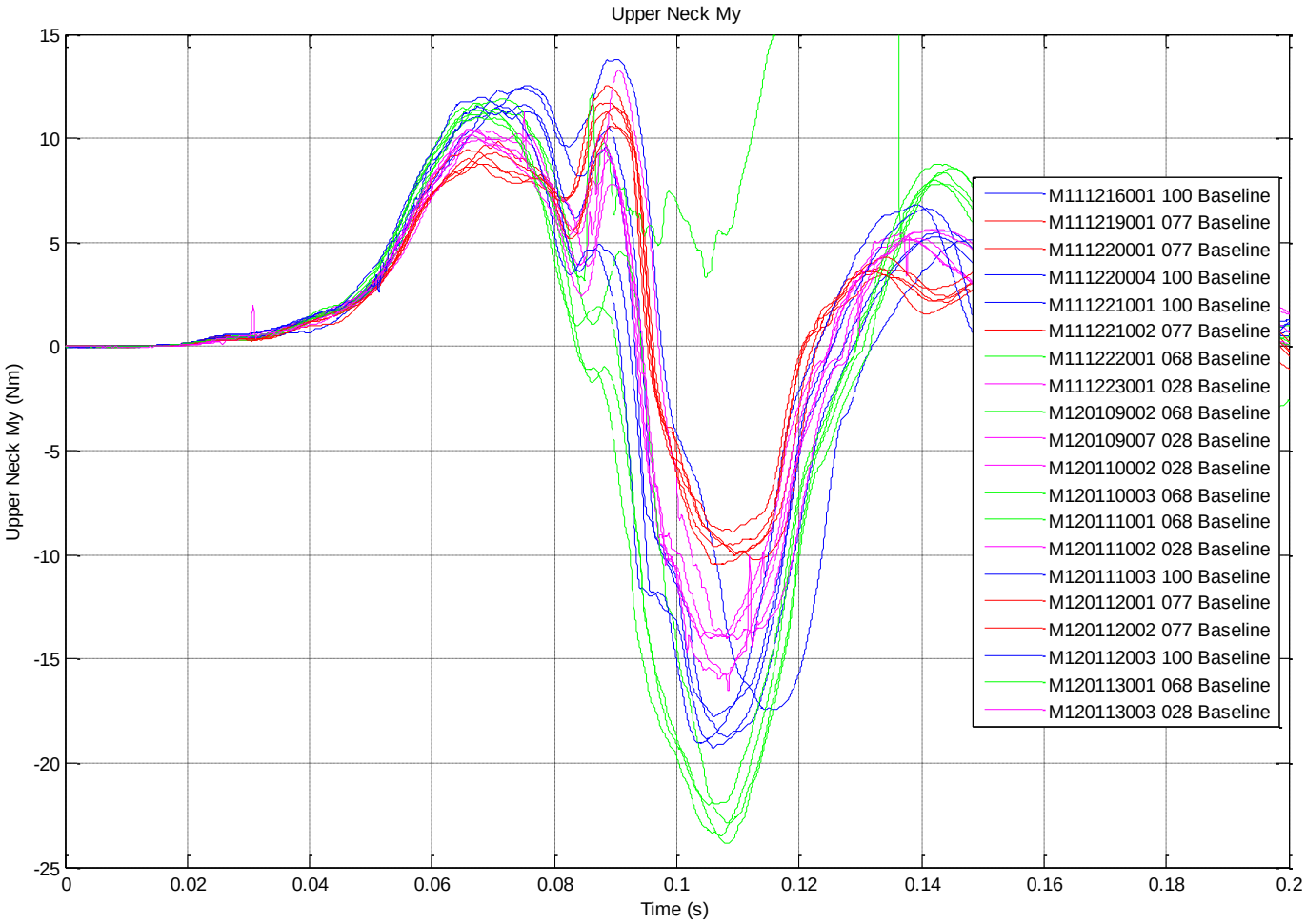

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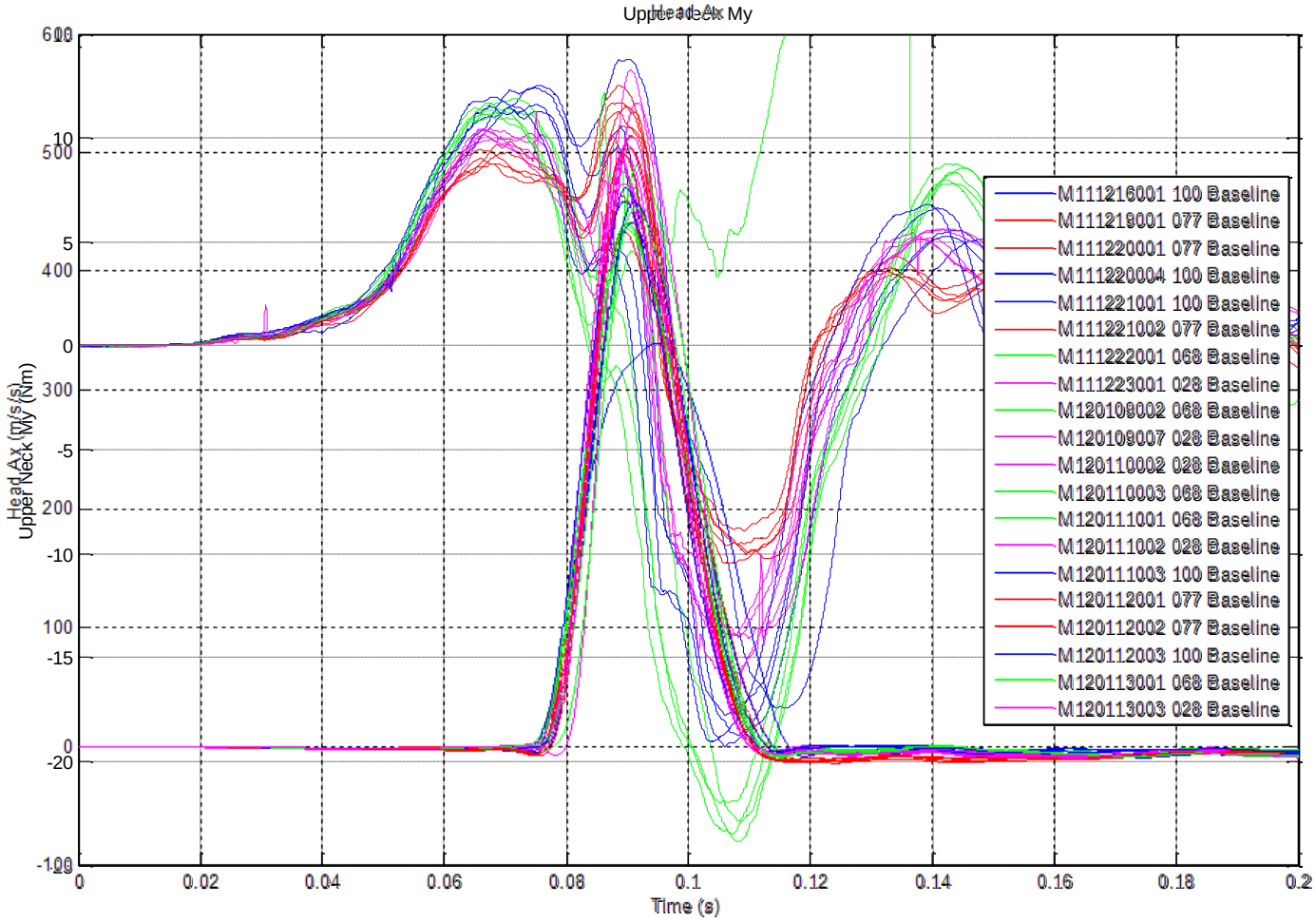


Seat Test Results

20 baseline tests with 028, 068, 077 and 100

Summary

- Good repeatability of the test condition
  - Pulse, seat back recline angle vs. time
- T1 and upper neck Fx, and T1 My, quite good repeatability and reproducibility
  - These measures appear insensitive to variations in ramping-up and head/neck angles – with a homogeneous head restraint
- T1 and upper neck Fz very variable
  - Not related to small changes in seat / head restraint over time because no change in phase of responses (phase change seen with different backset)
  - Also big oscillations in Fz in certification test
  - Fz difference correlate in time with pelvis Az differences
  - Recommend improving pelvis flesh reproducibility
- Upper neck My very variable
  - Correlates quite well with Pot A in no HR cert test and My in with HR cert test
  - Recommend much tighter control on Pot A response

Seat Test Results

20 baseline tests with 028, 068, 077 and 100

Updated test plan

- Based on the results of the baseline tests, the whole test matrix was re-arranged
  - Try to determine the cause of variations in upper neck My, and upper and lower neck Fz

Seat Test Results

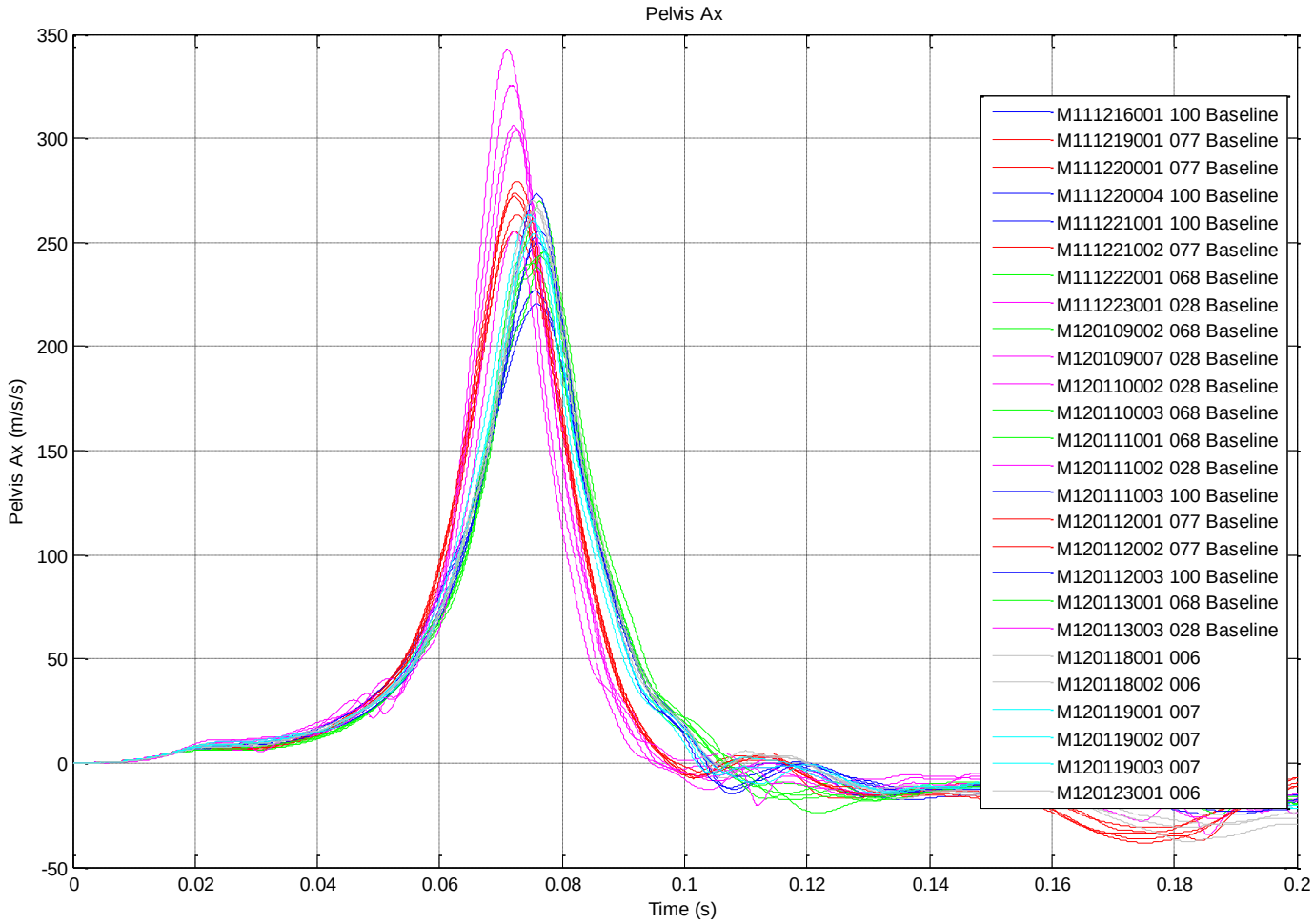
Baseline tests + refurbished 006 and 007

- Refurbishment included
  - All bumpers replaced with bumpers from the same batch
    - 6 bumper specifications in total
      - Cervical front and top three rear
      - Cervical rear
      - Thoracic front
      - Thoracic rear
      - Lumbar front
      - Lumbar rear
  - Vertebrae checked and replaced if spine pin hole not to specification
  - All spine pins replaced with GTR-spec stainless steel pins

  - Both dummies then recertified

Seat Test Results

Baseline tests + refurbished 006 and 007



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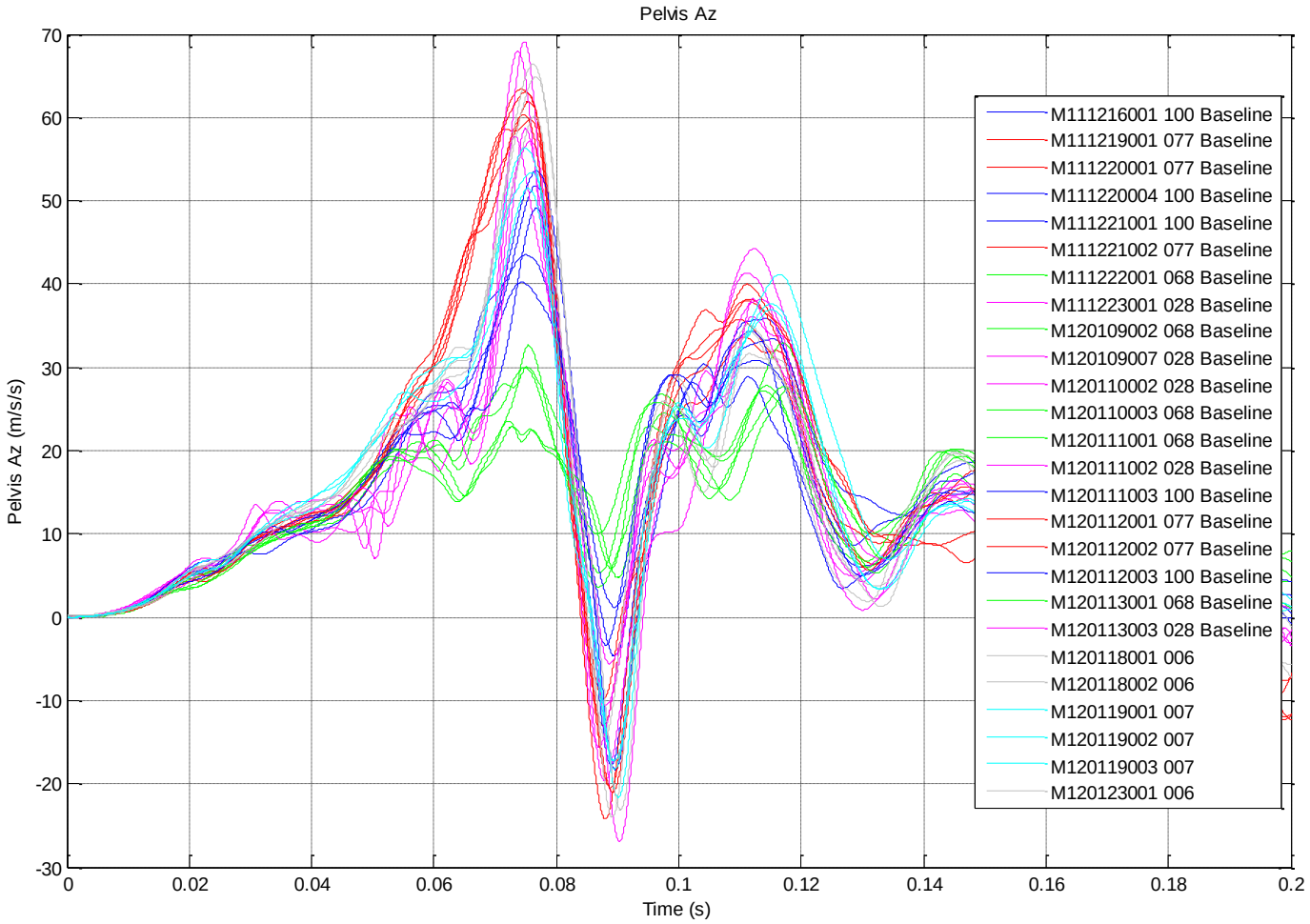

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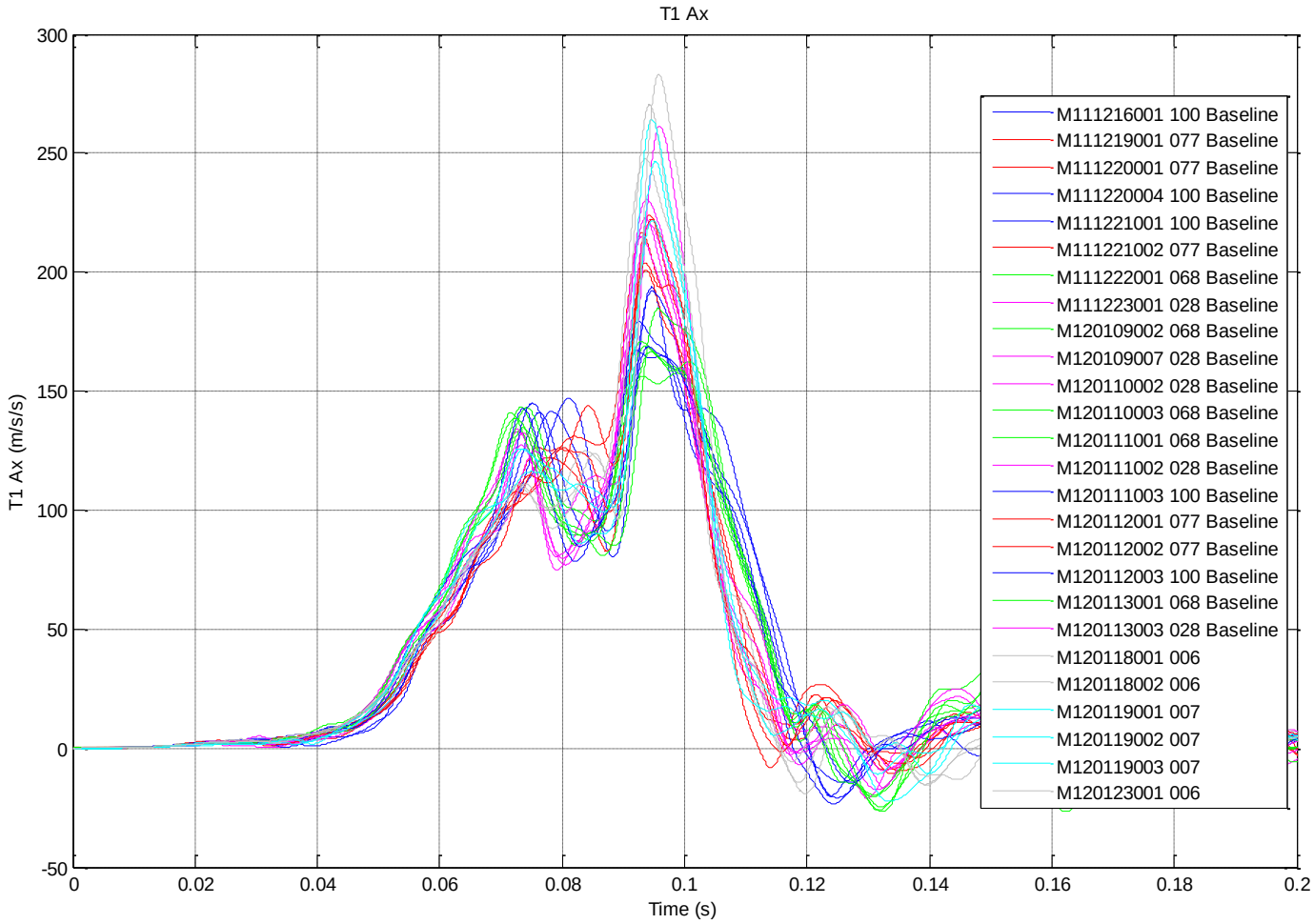

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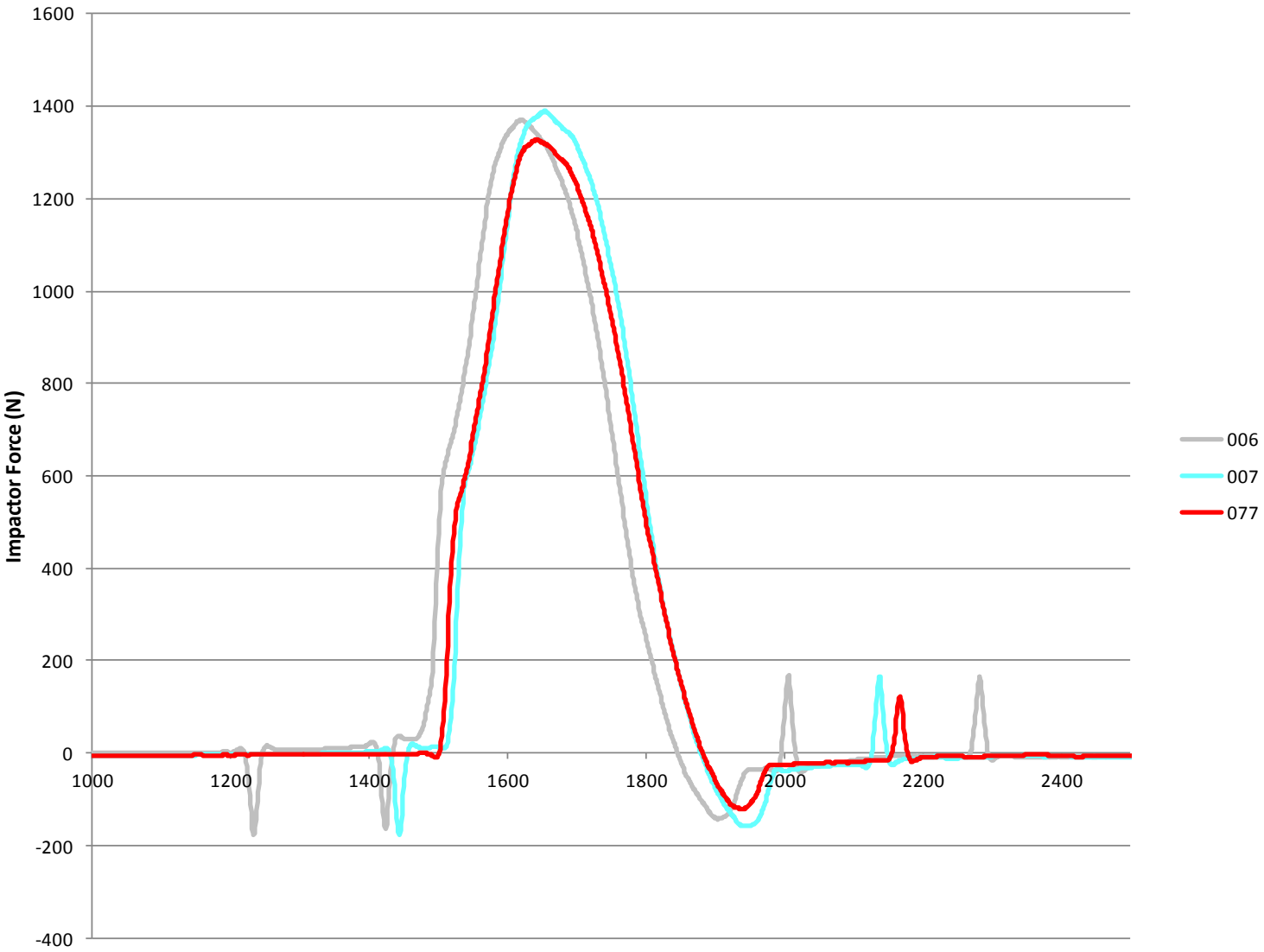

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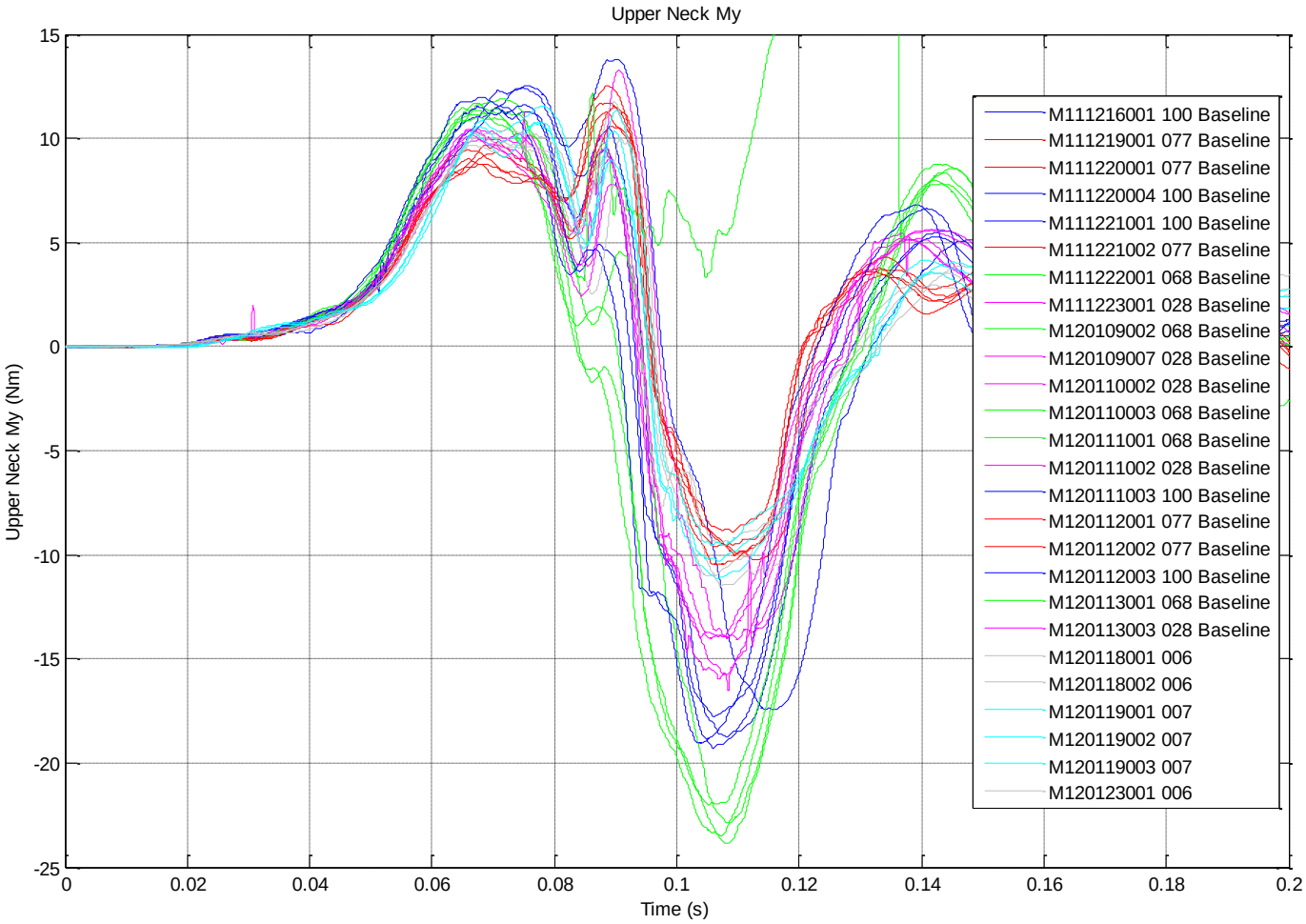

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Baseline tests with 068 and 077 + pelvis swap

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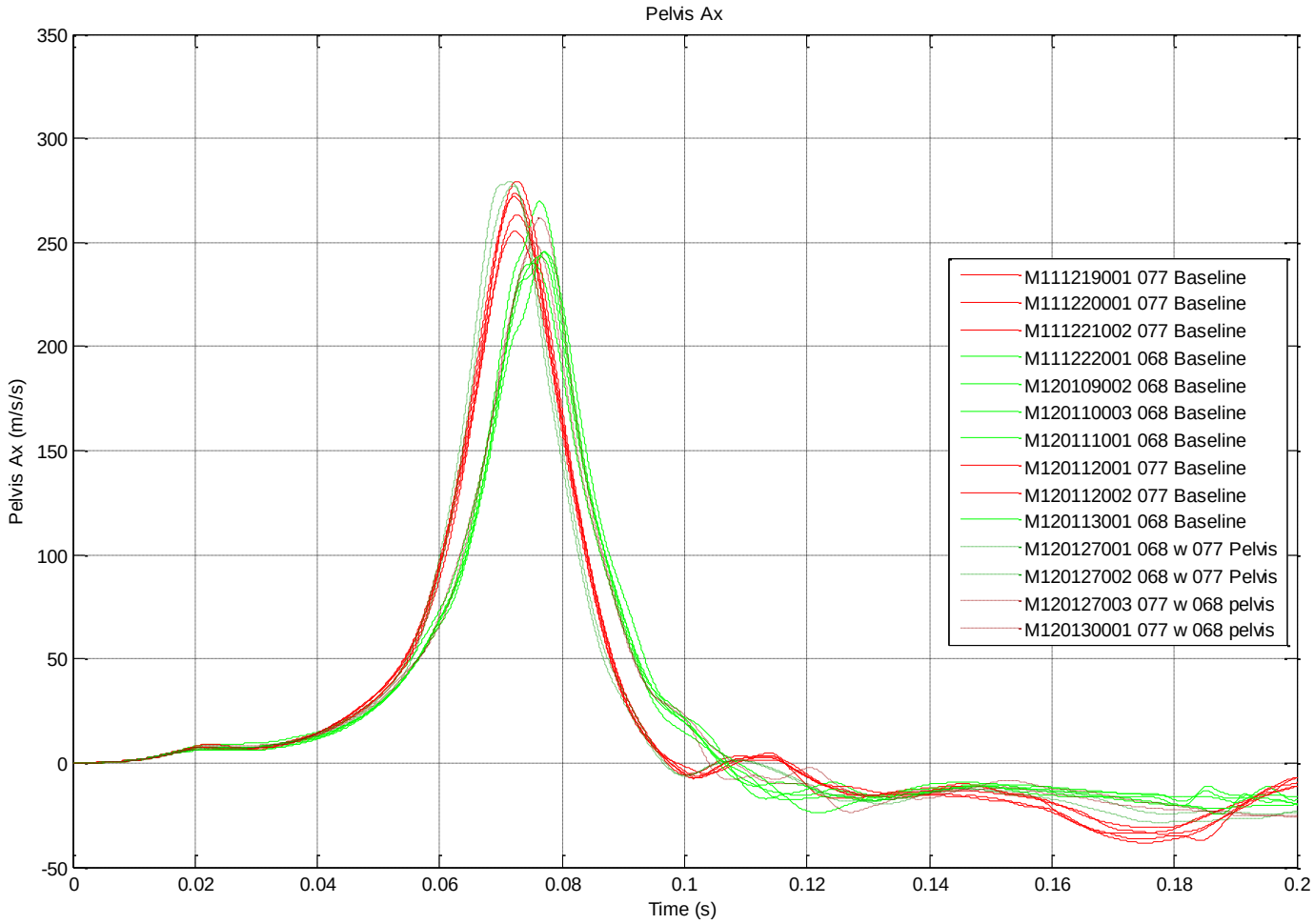

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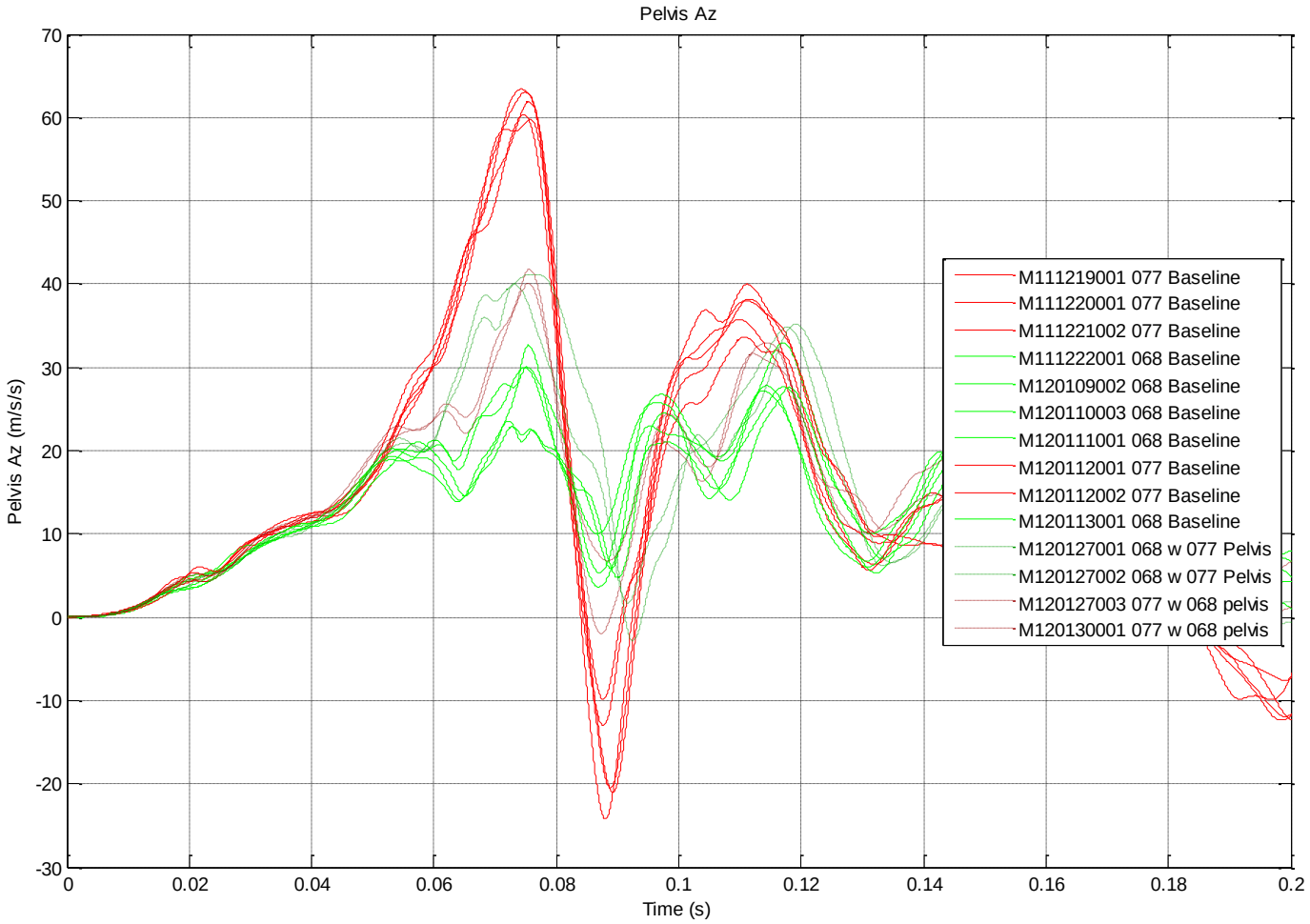

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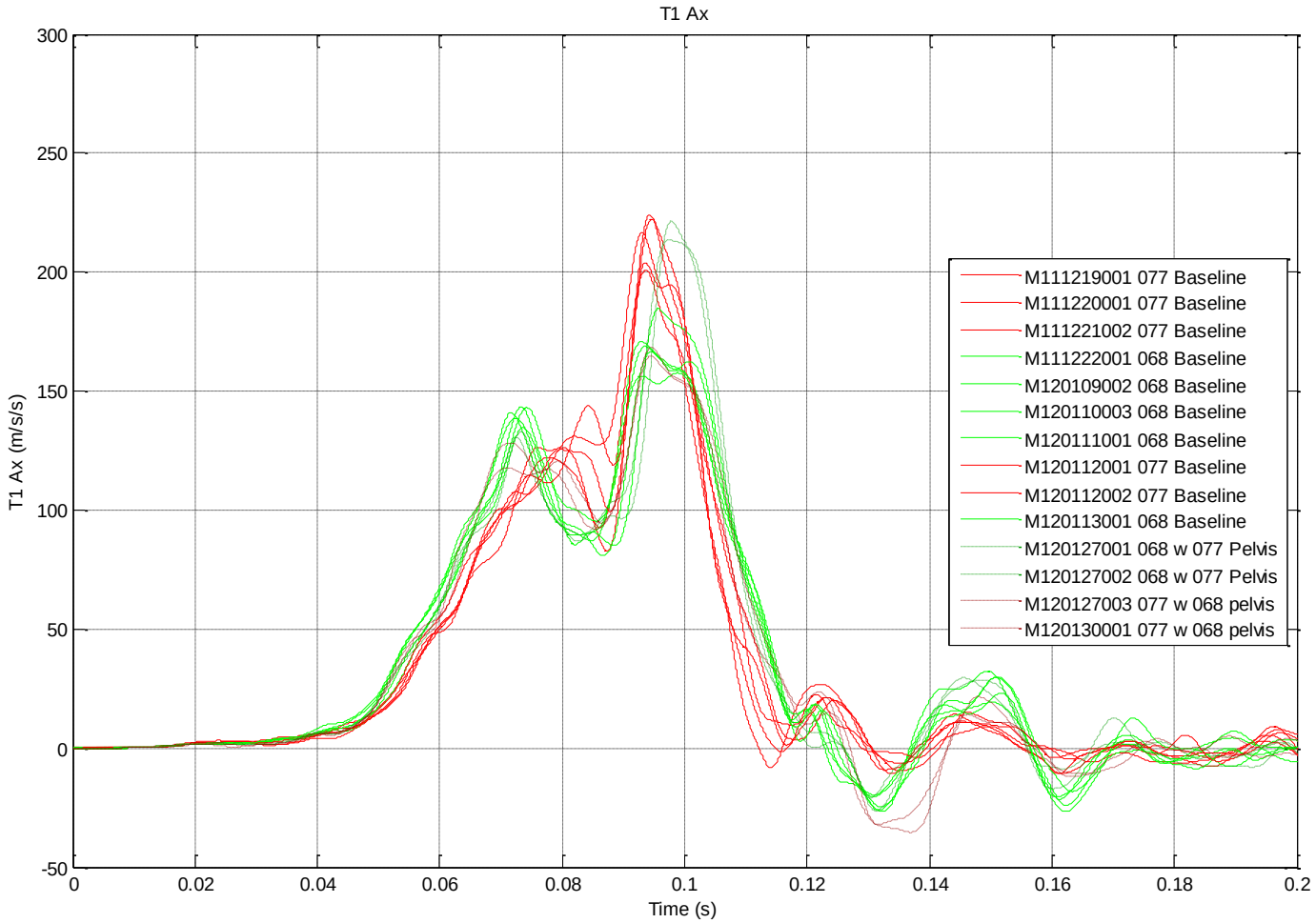

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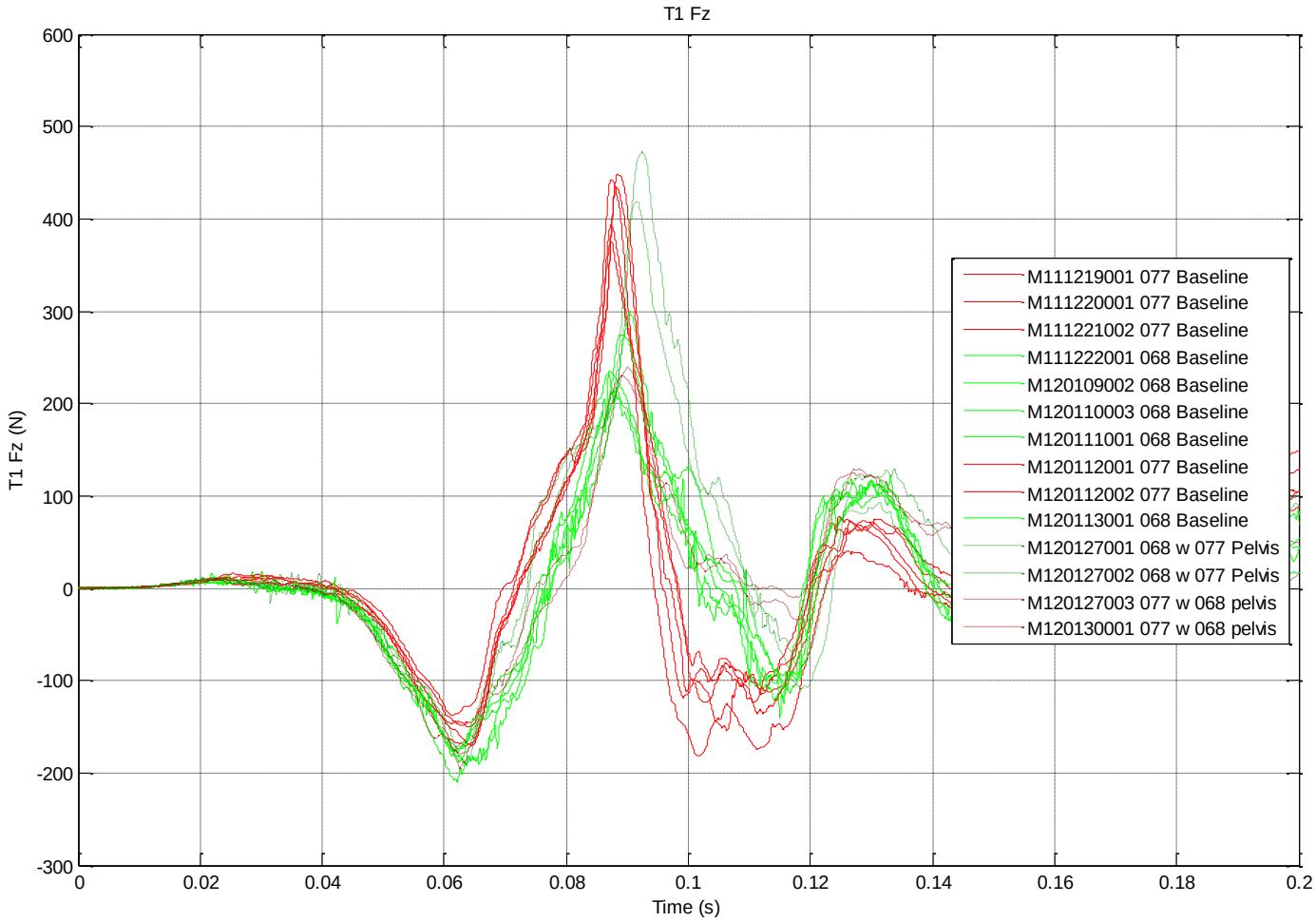

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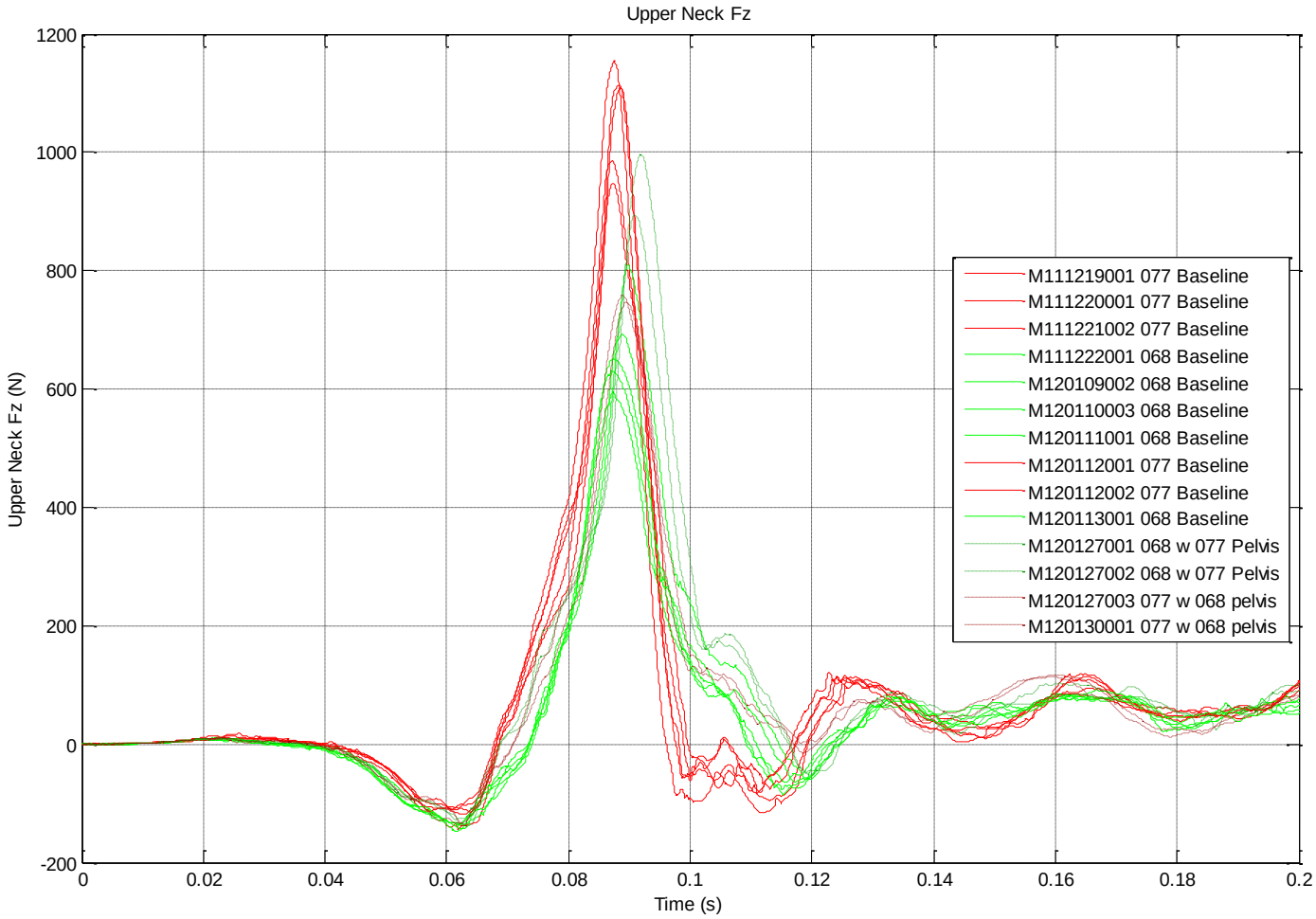

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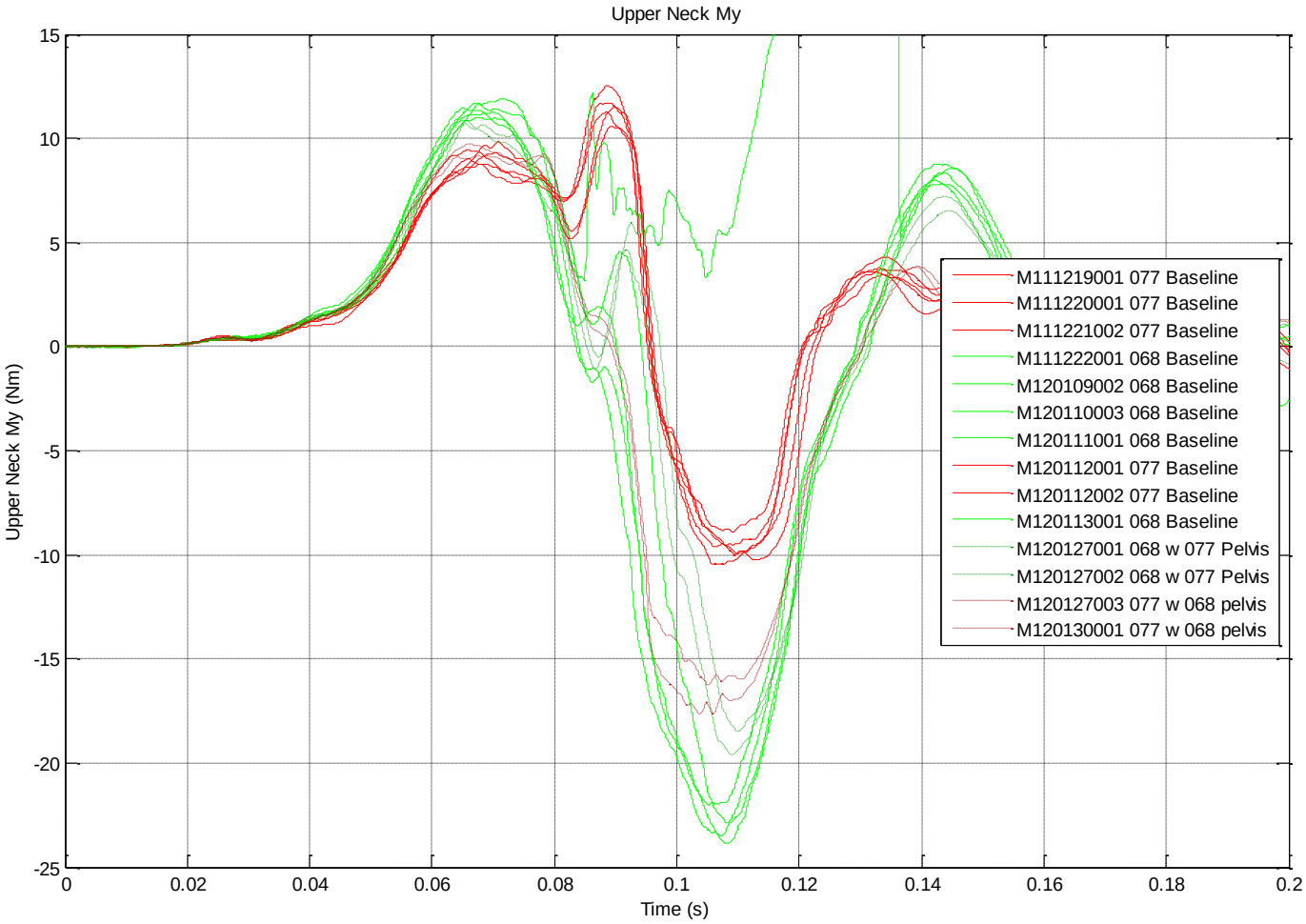

Seat Test Results

Baseline tests with 068 and 077 + pelvis swap

Summary

- Pelvis *and T1* Ax swapped when pelvis swapped
- Pelvis Az converged…
- … and so did upper neck My *extension*

Seat Test Results

Baseline tests with 068 and 077 + spine swap

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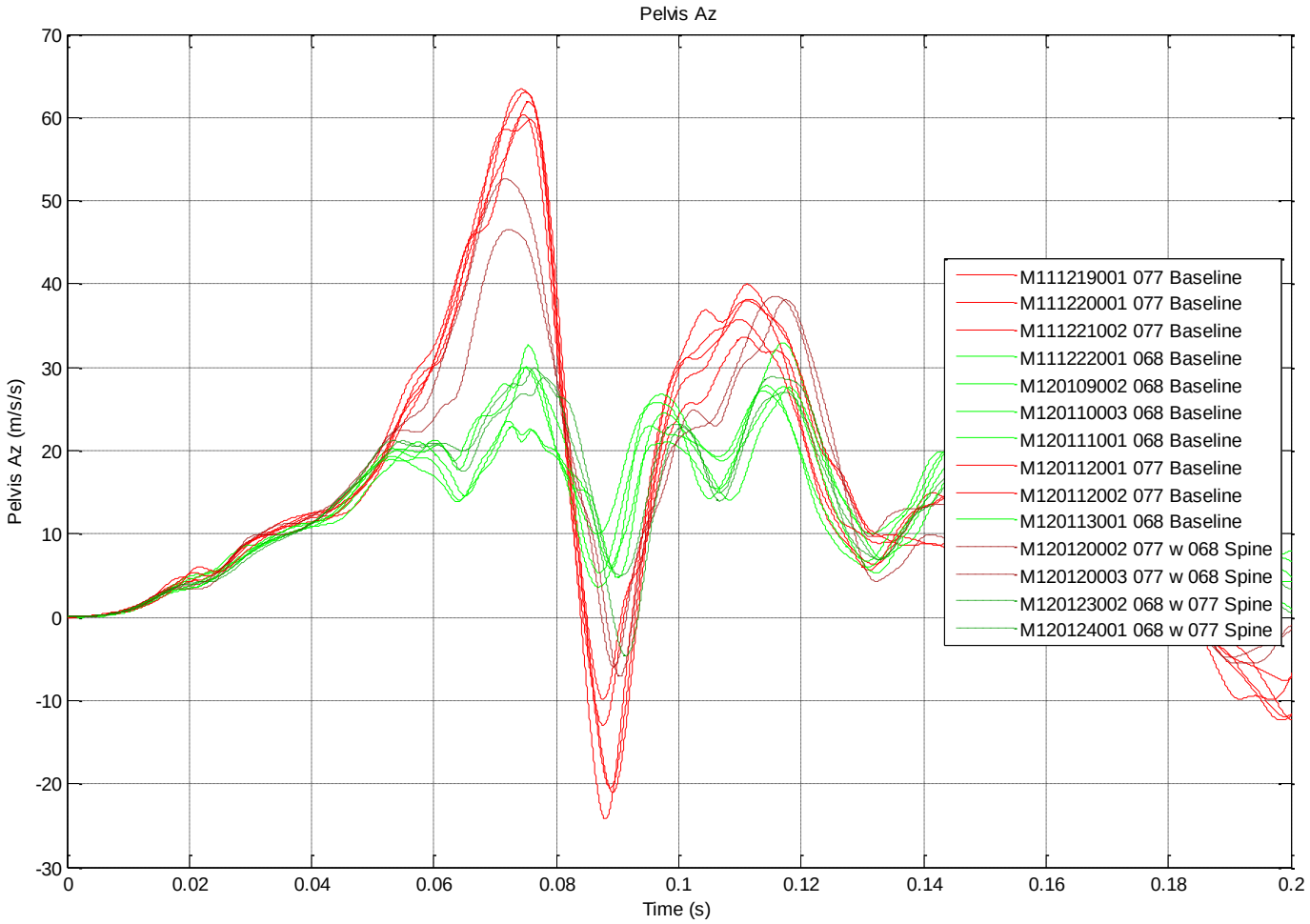
Baseline tests with 068 and 077 + spine swap



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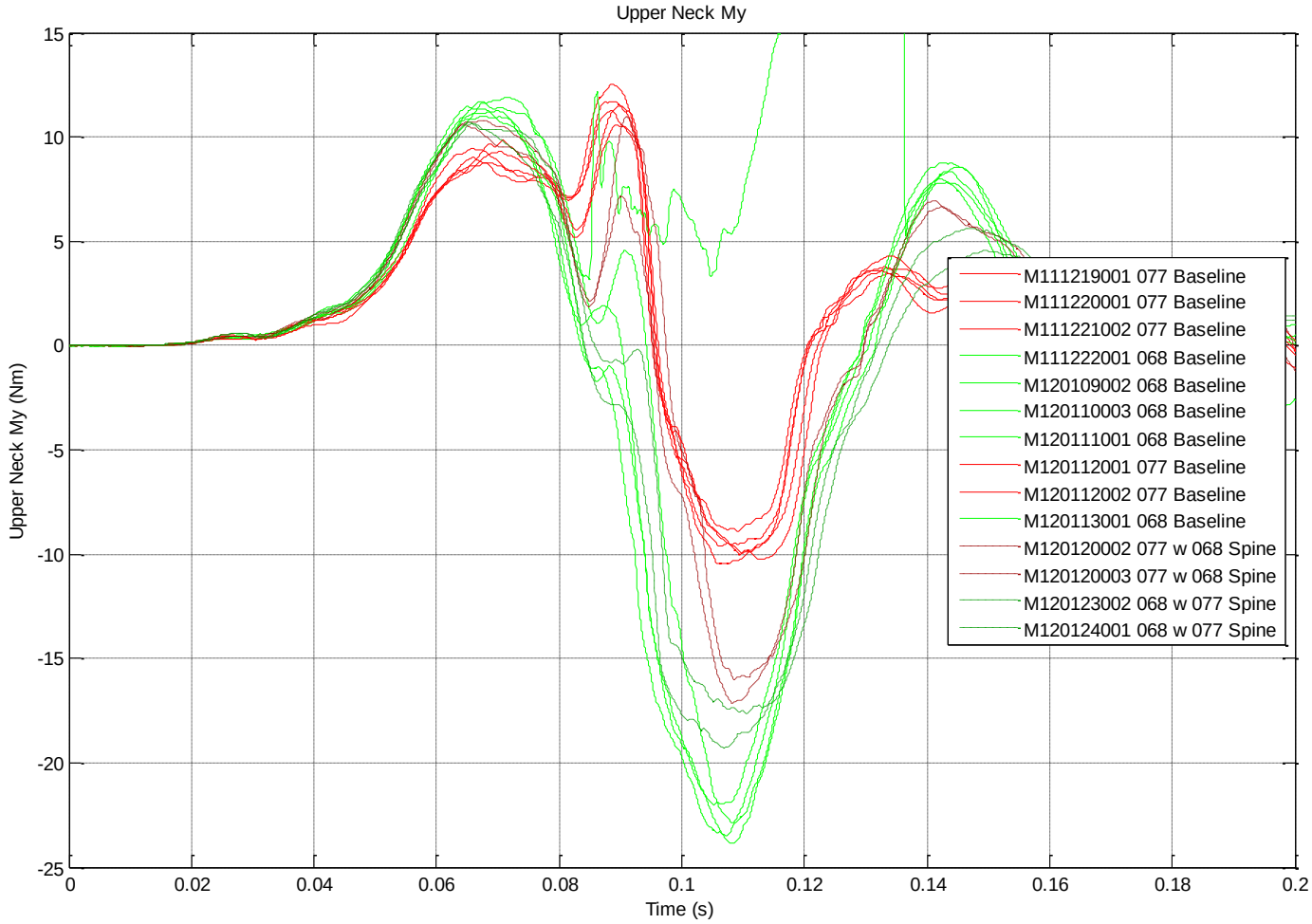

Seat Test Results

Baseline tests with 068 and 077 + spine swap

Summary

- Upper neck My *extension* 50% affected by spine swap
- Upper neck My flexion less affected
  - However, could be related to different bumper performance front and rear of neck
  - Pre-head-restraint-contact neck flexion moment very similar for swapped spines, but was quite different before
- Responses more affected by pelvis swap!
- However, current certification test focused on (upper) spine
  - So may not be so surprising that spine effect is smaller

Seat Test Results

Baseline tests with 068 and 077 + rebuilt

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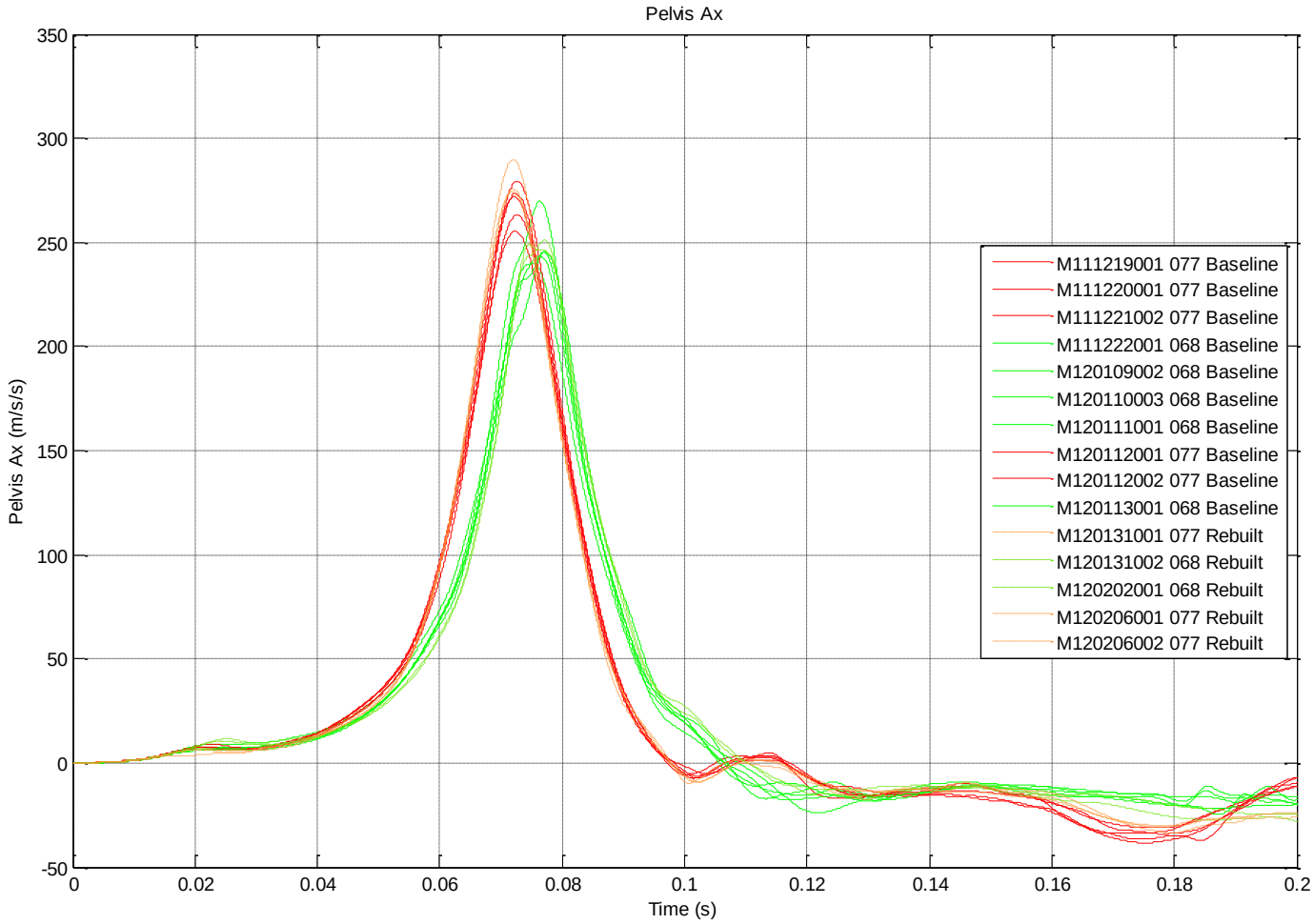
Baseline tests with 068 and 077 + rebuilt



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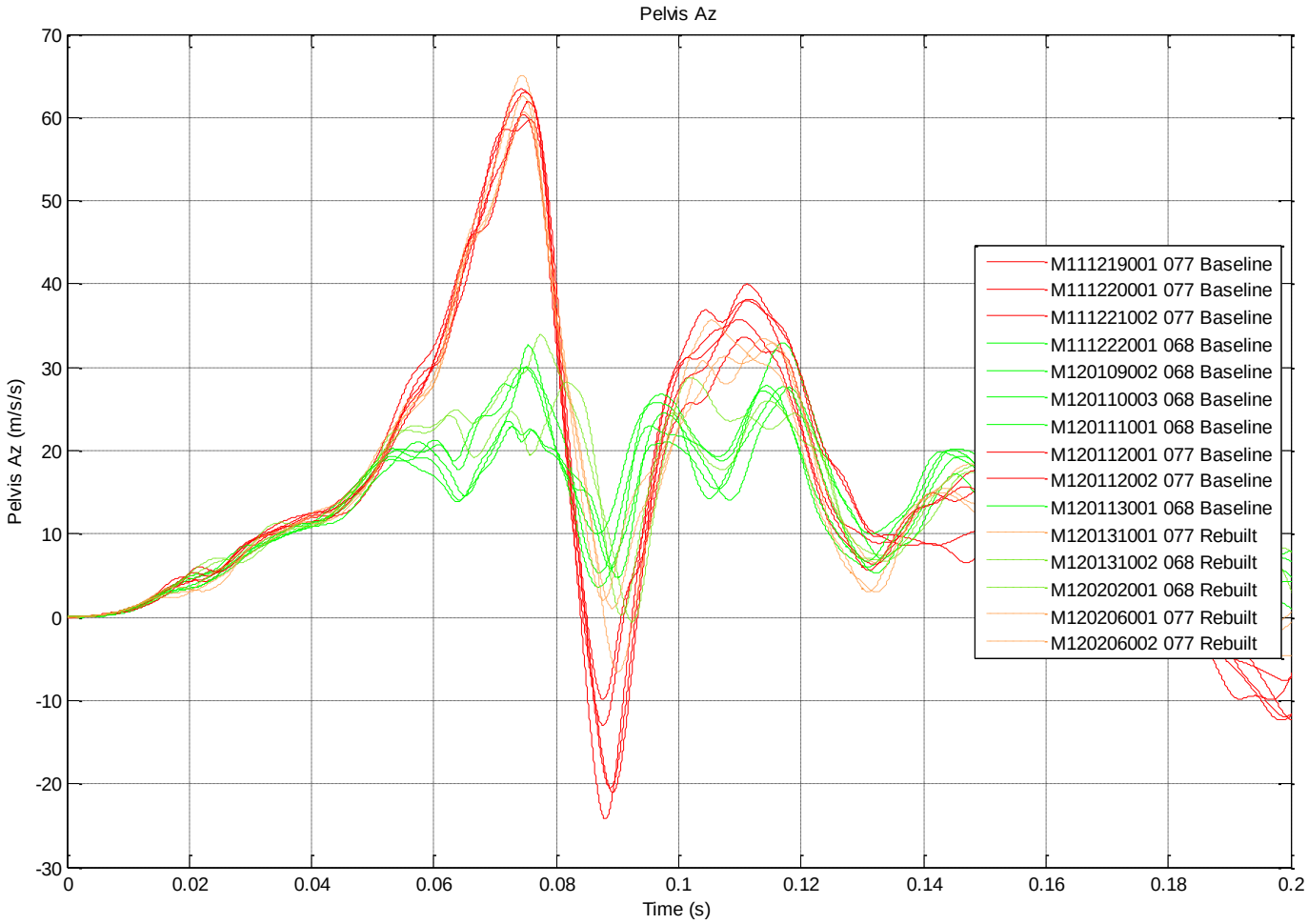

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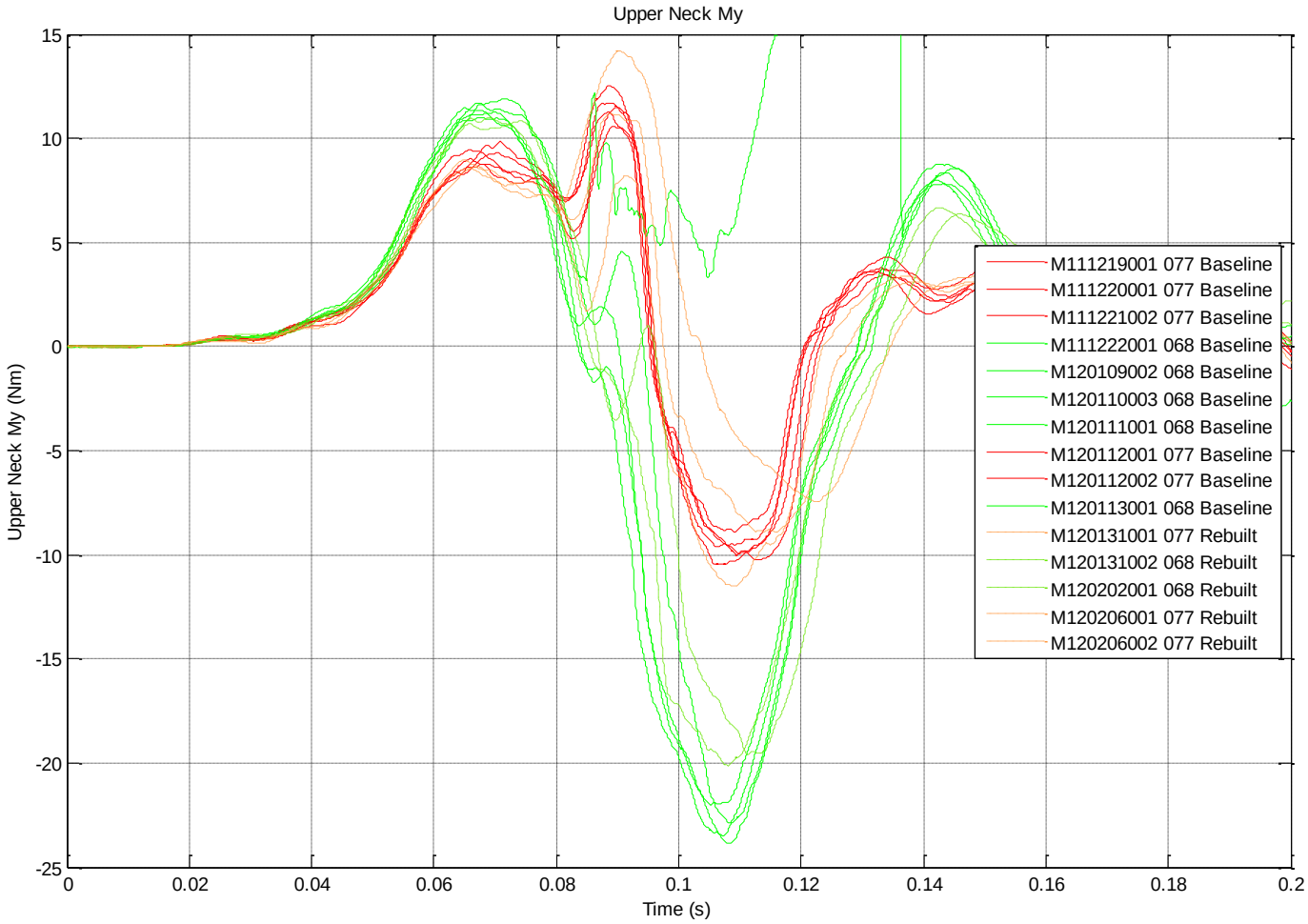

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006 and 007 with 068 and 077 pelvis

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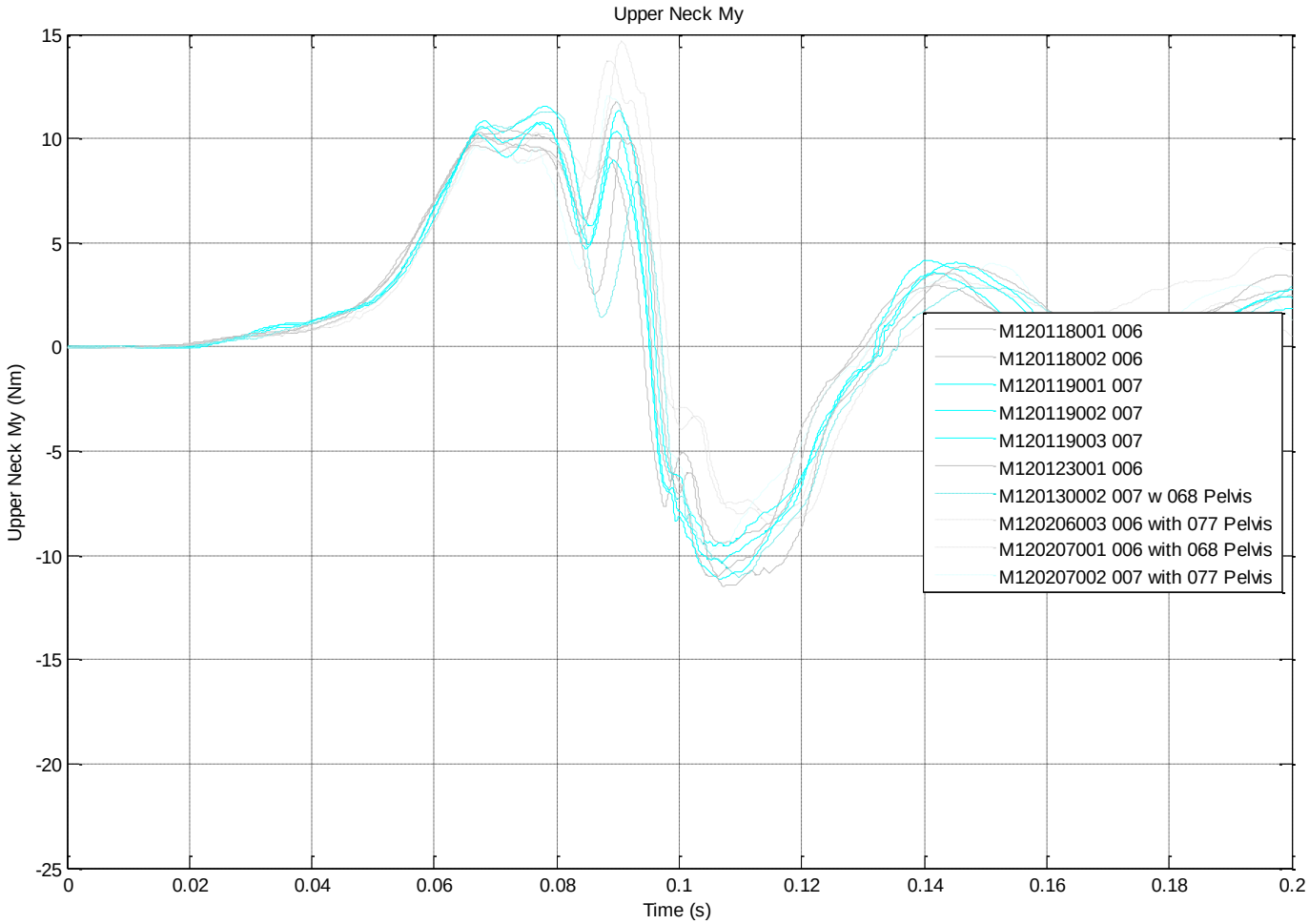
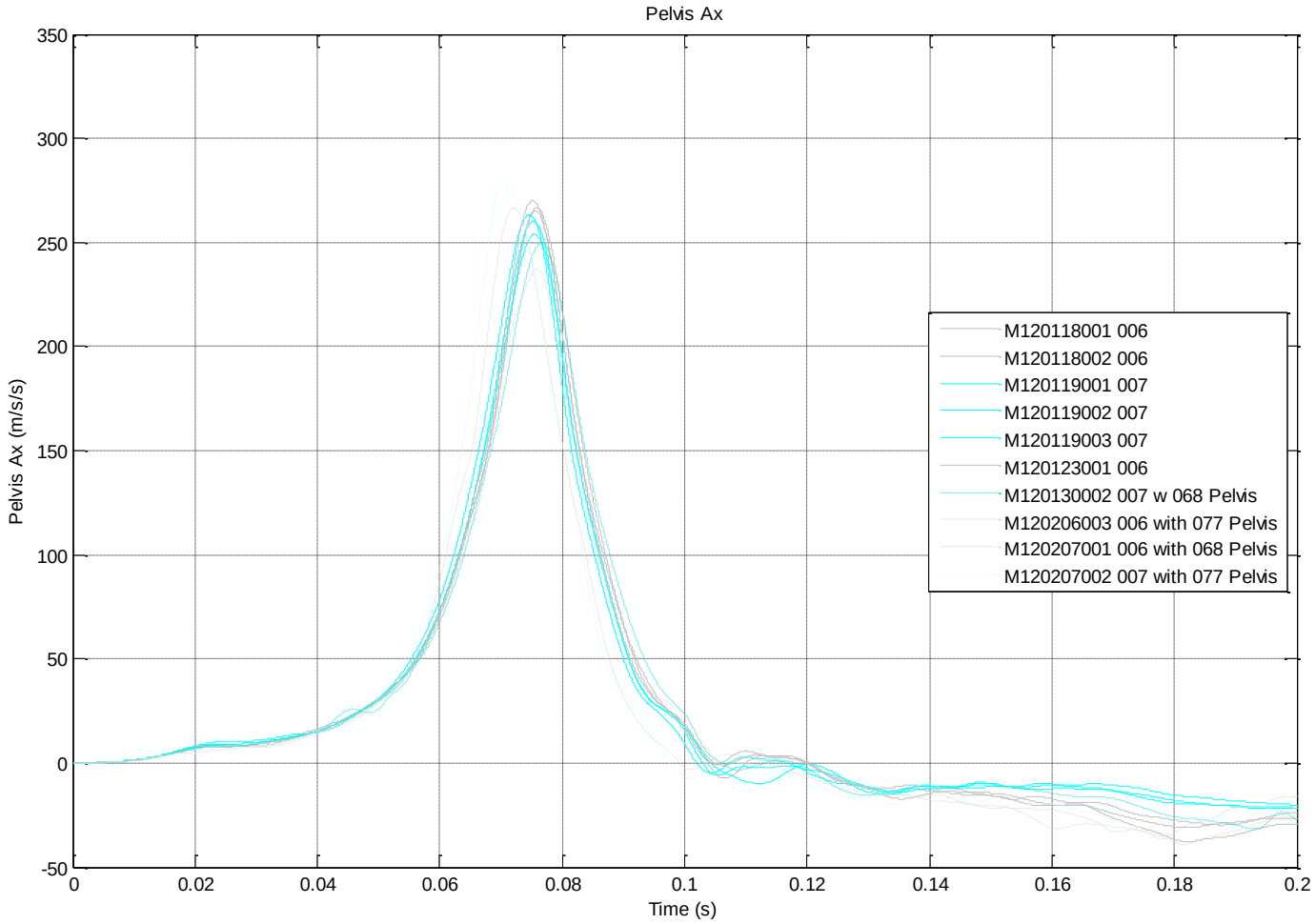


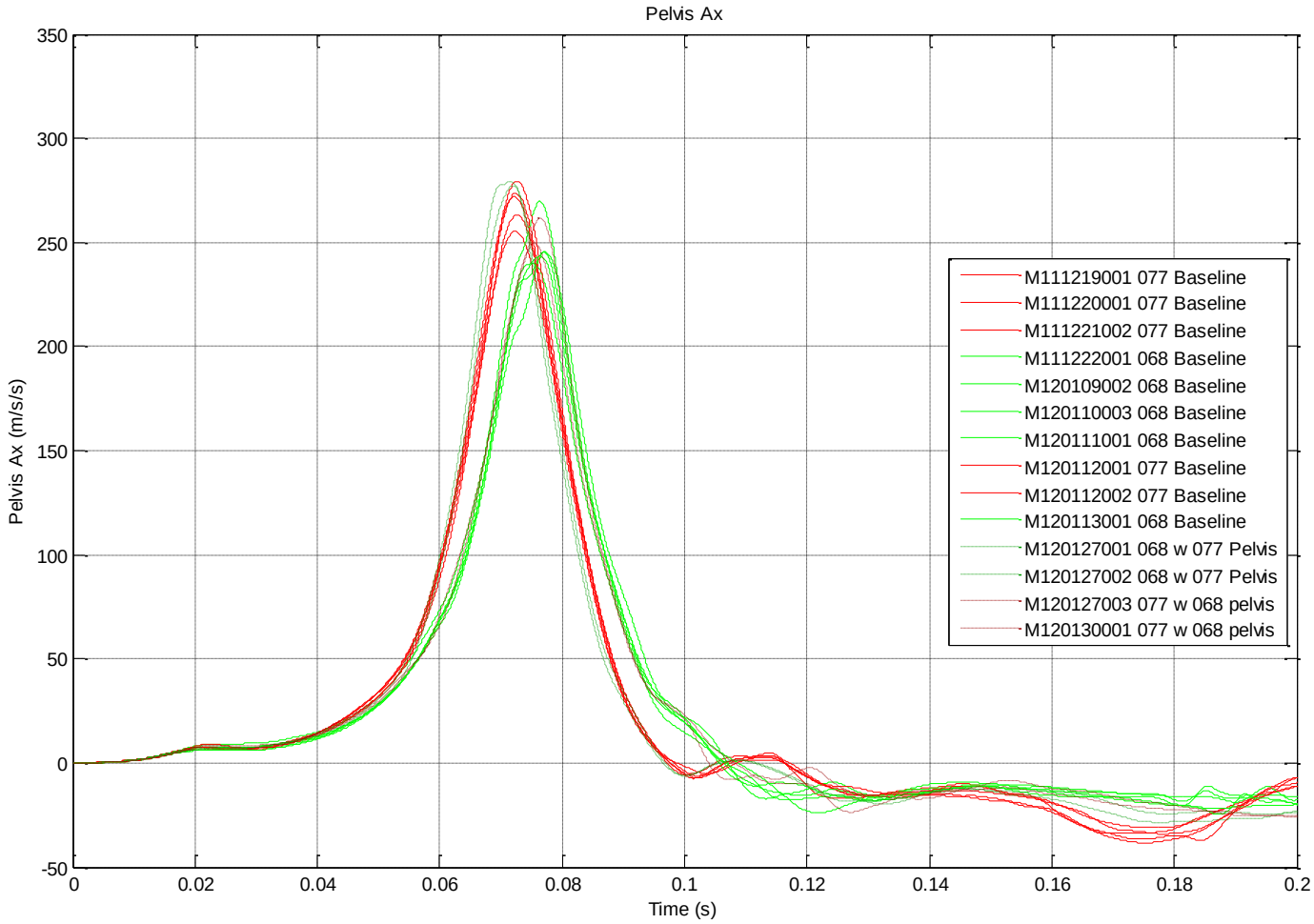
Seat Test Results

006 and 007 with 068 and 077 pelvis



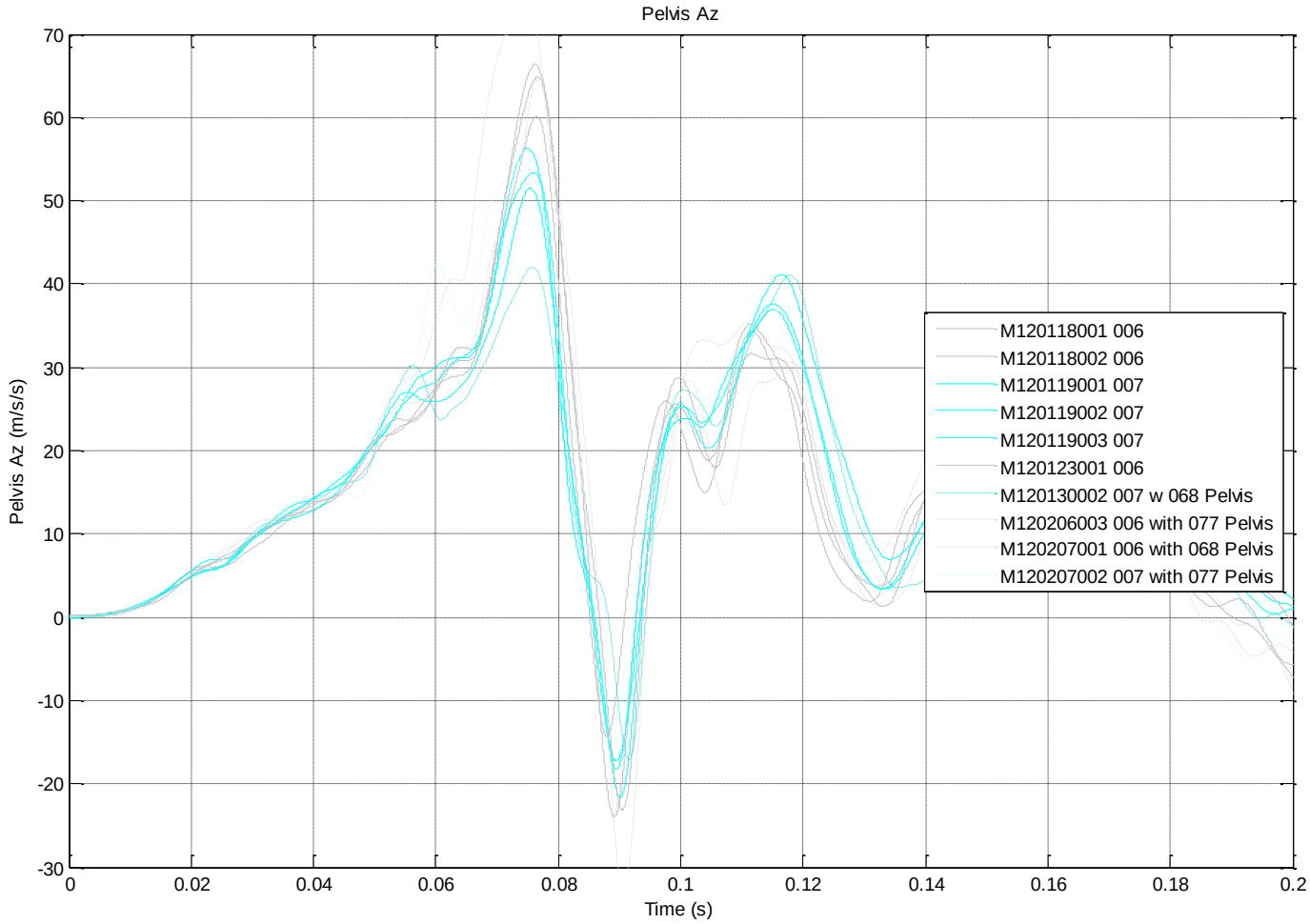
Seat Test Results

Baseline tests with 068 and 077 + pelvis swap



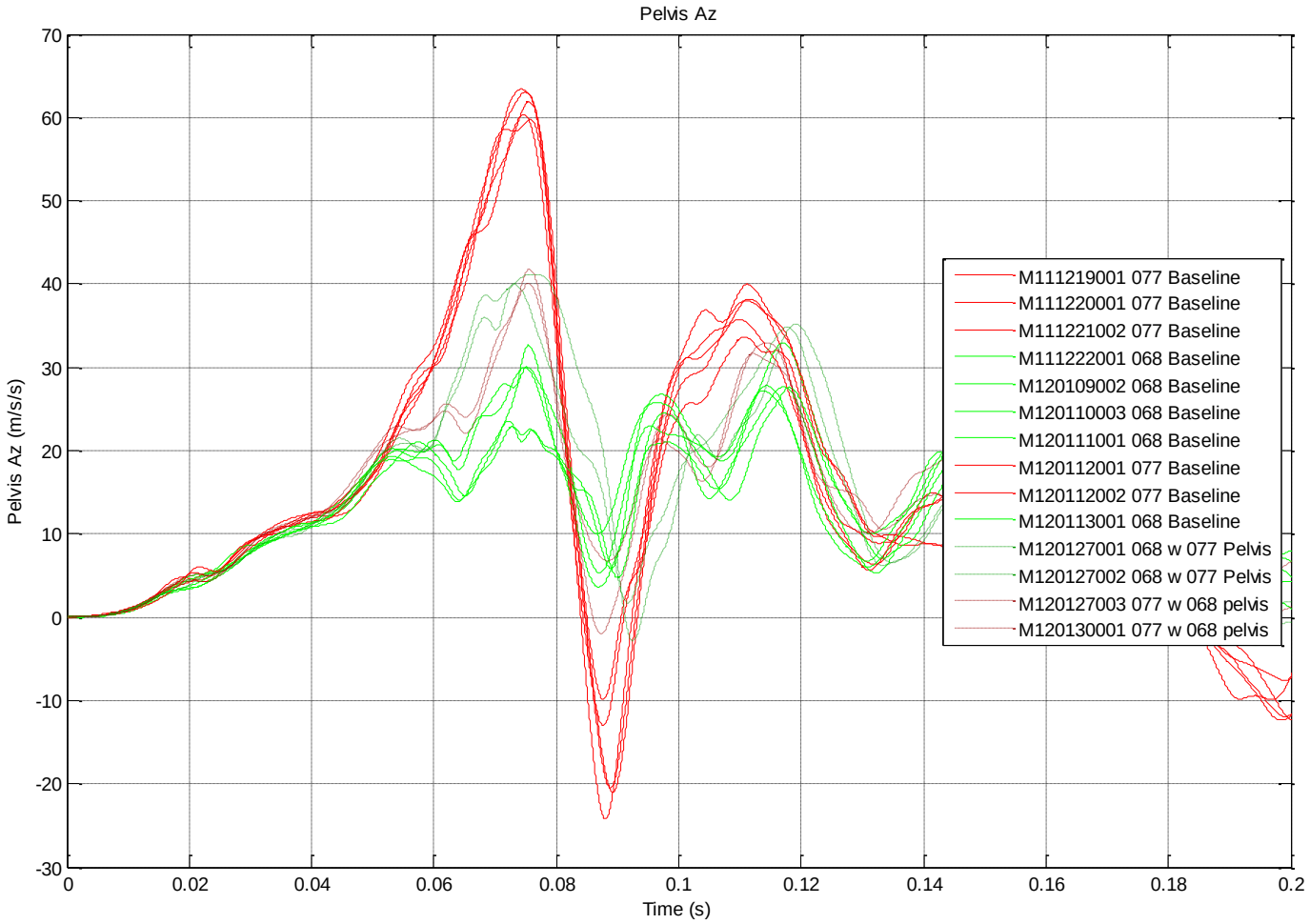
Seat Test Results

006 and 007 with 068 and 077 pelvis



Seat Test Results

Baseline tests with 068 and 077 + pelvis swap



Seat Test Results

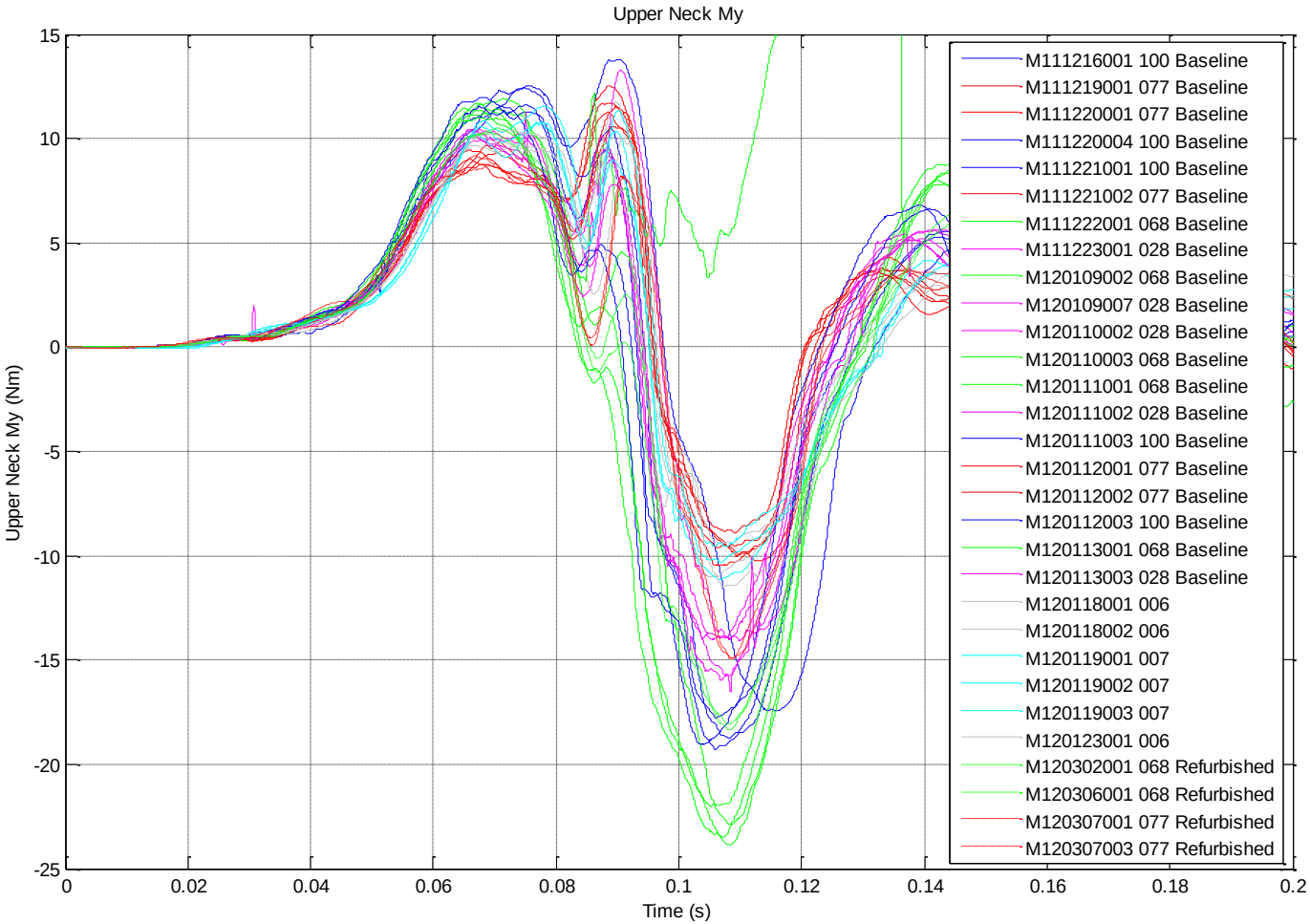
Refurbished 068 and 077

- Dummy 068 and 077 refurbished
  - 077 and 068 certified with refurbished spines
    - New bumpers from the same batch (different batch to 006 and 007)
    - Vertebrae checked and replaced as necessary
    - No pins replaced

- Two tests with each dummy

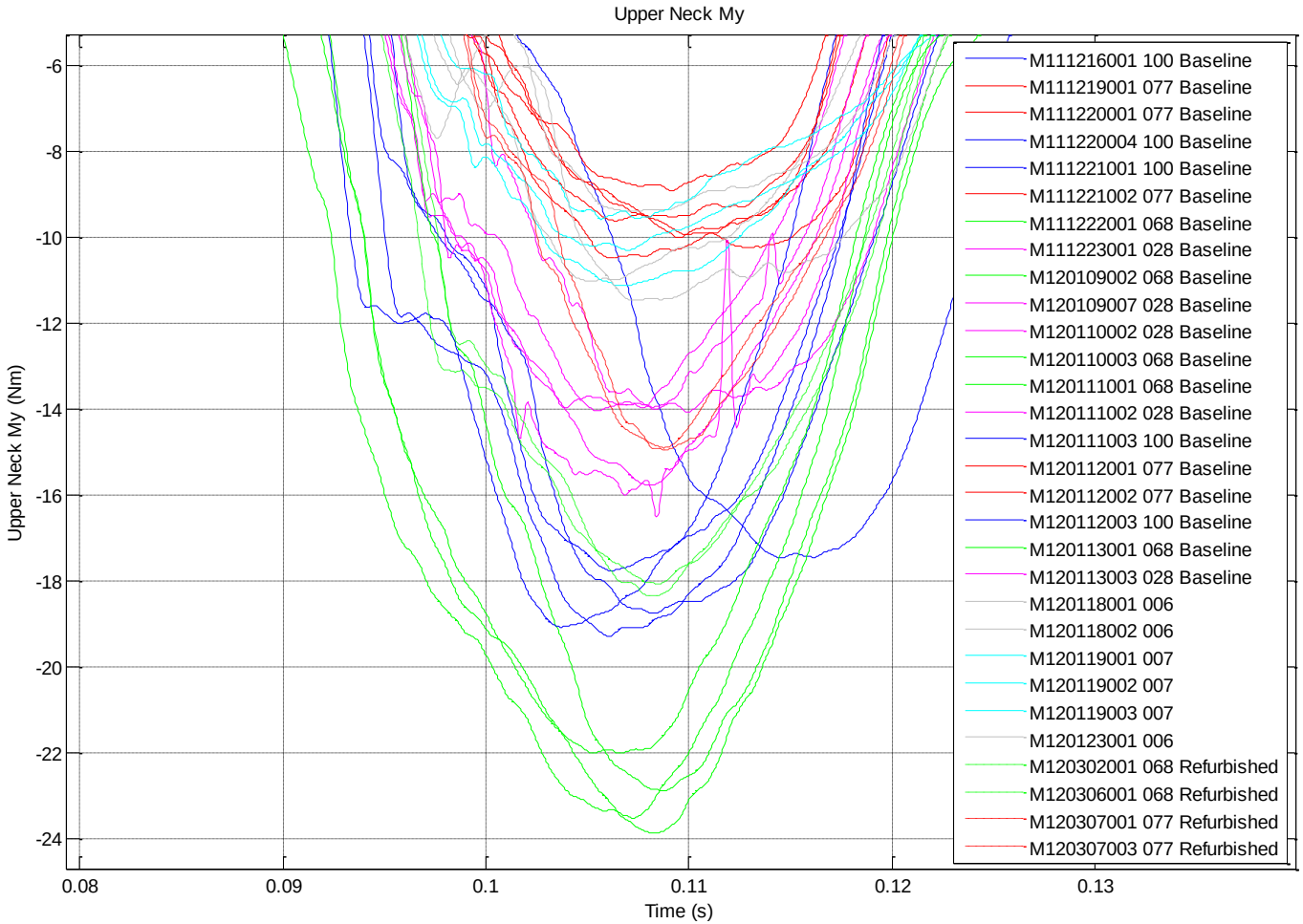
Sled Test Results

Refurbished 068 and 077



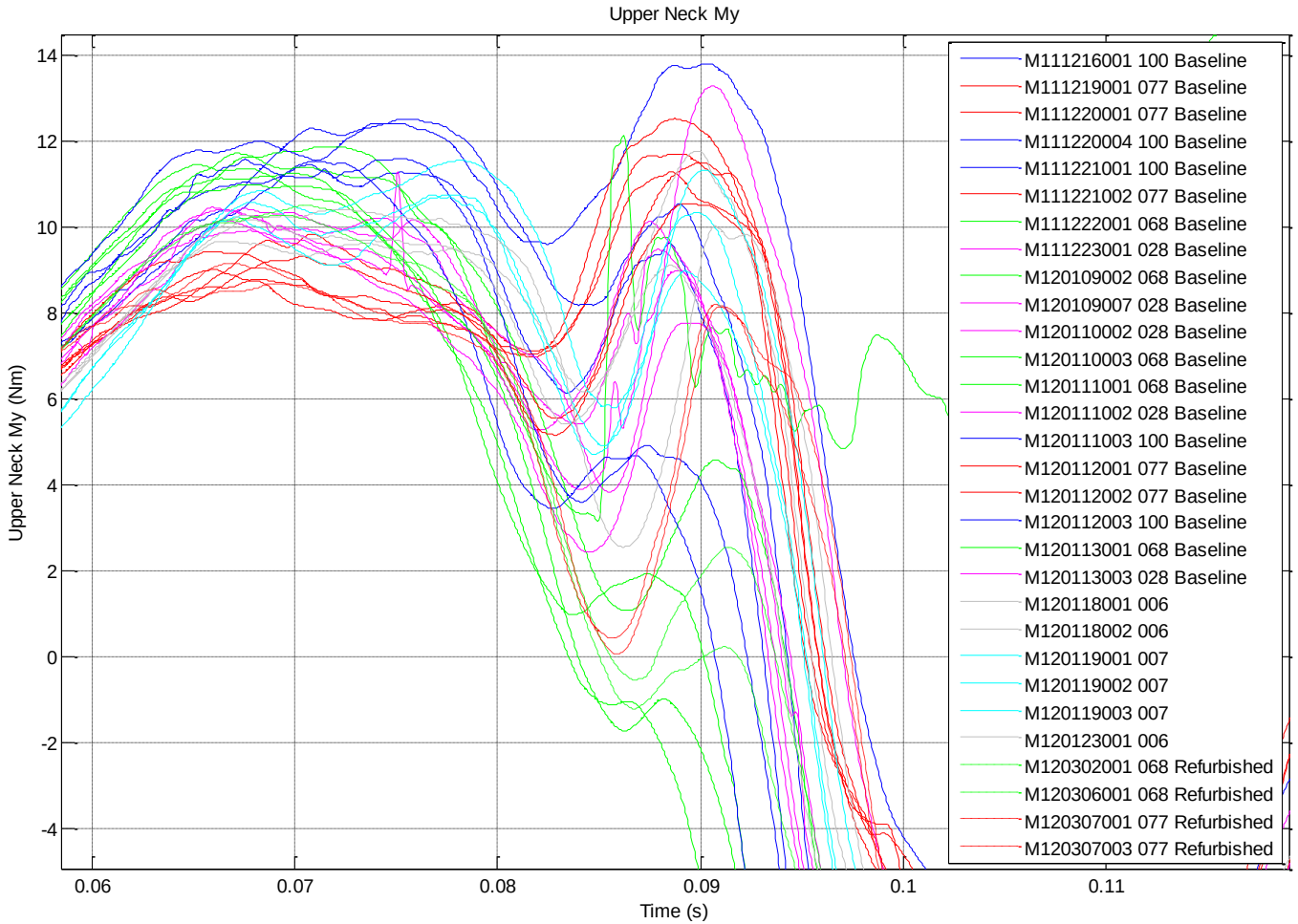
Sled Test Results

Refurbished 068 and 077



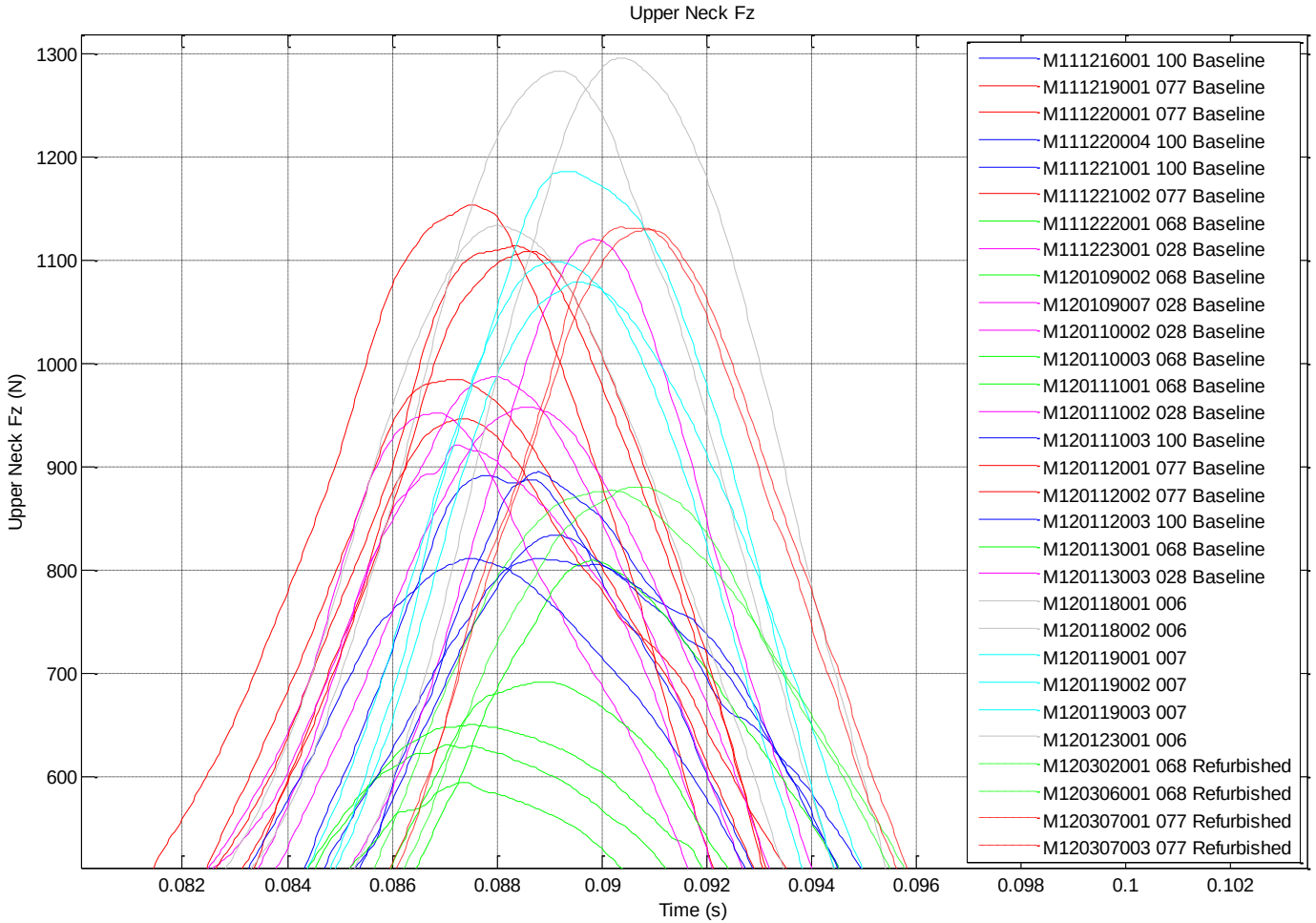
Sled Test Results

Refurbished 068 and 077



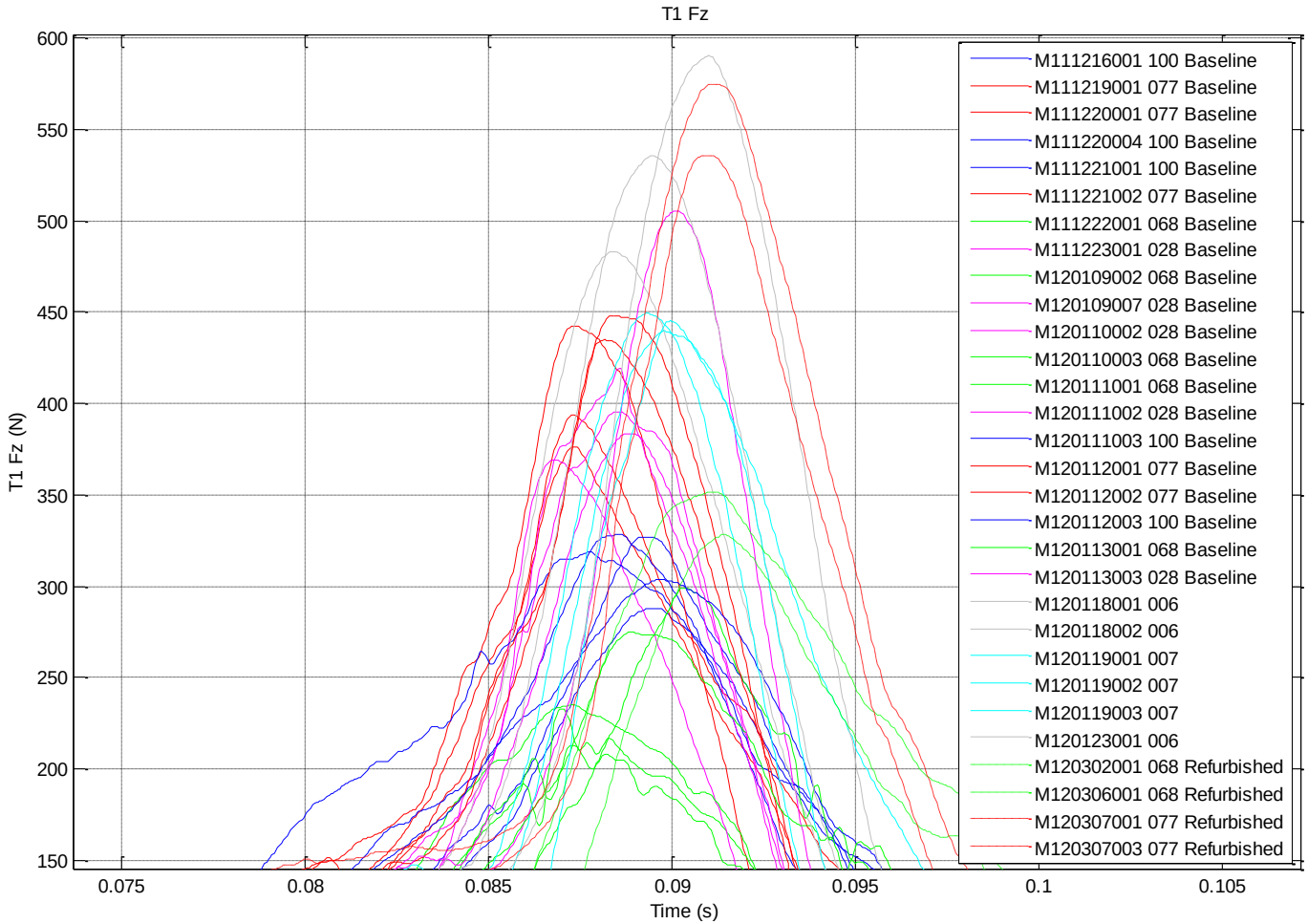
Sled Test Results

Refurbished 068 and 077



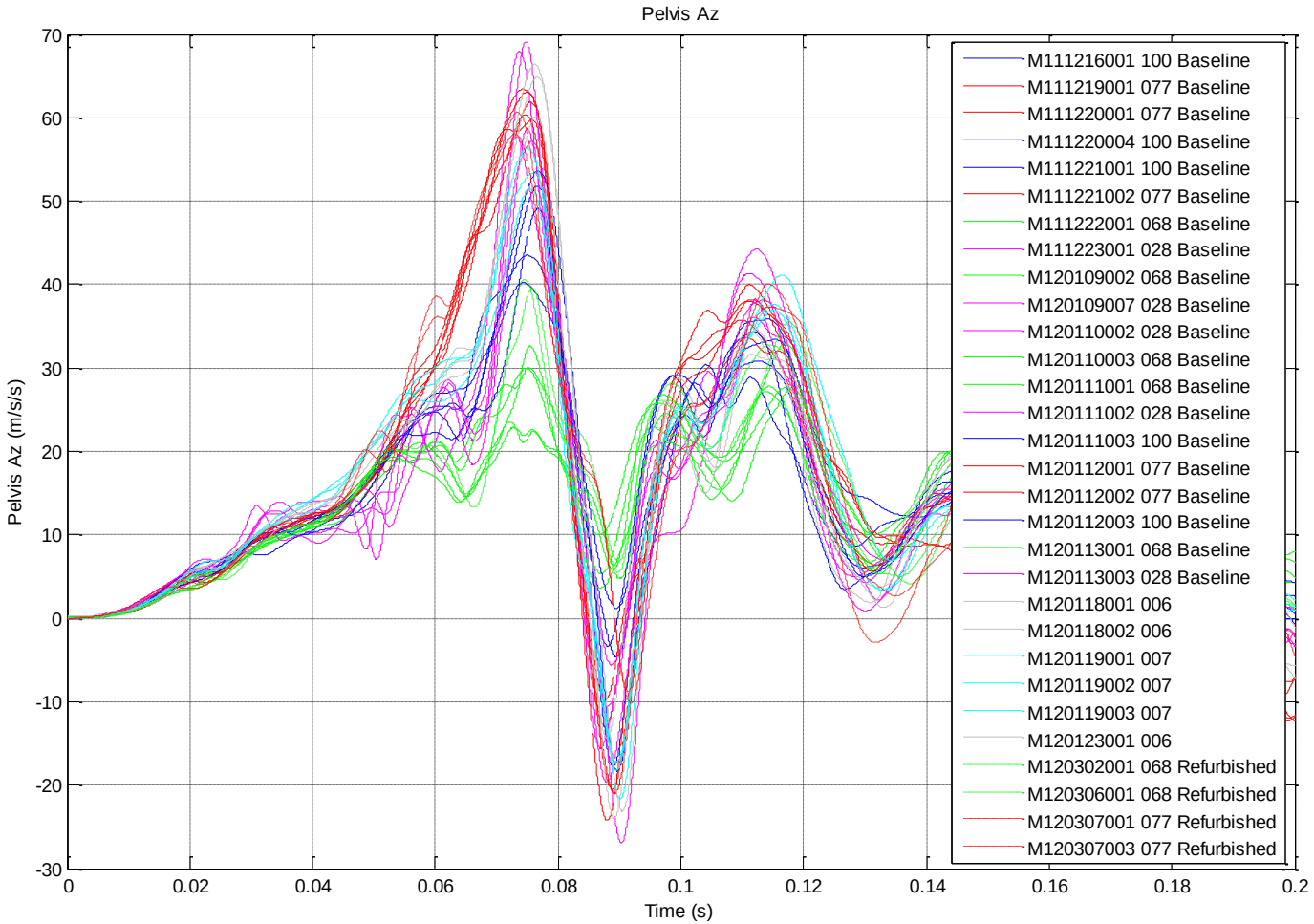
Sled Test Results

Refurbished 068 and 077



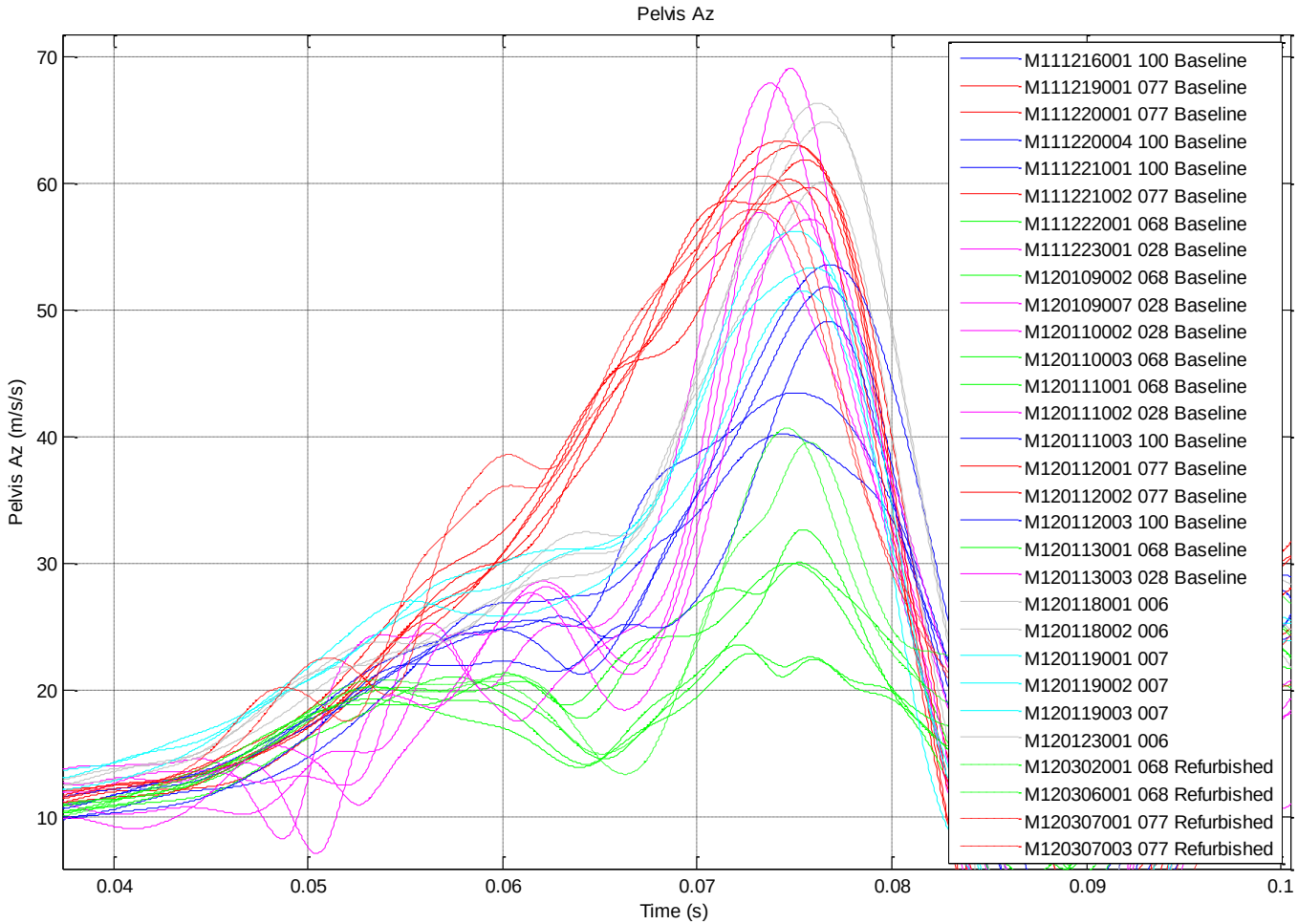
Sled Test Results

Refurbished 068 and 077



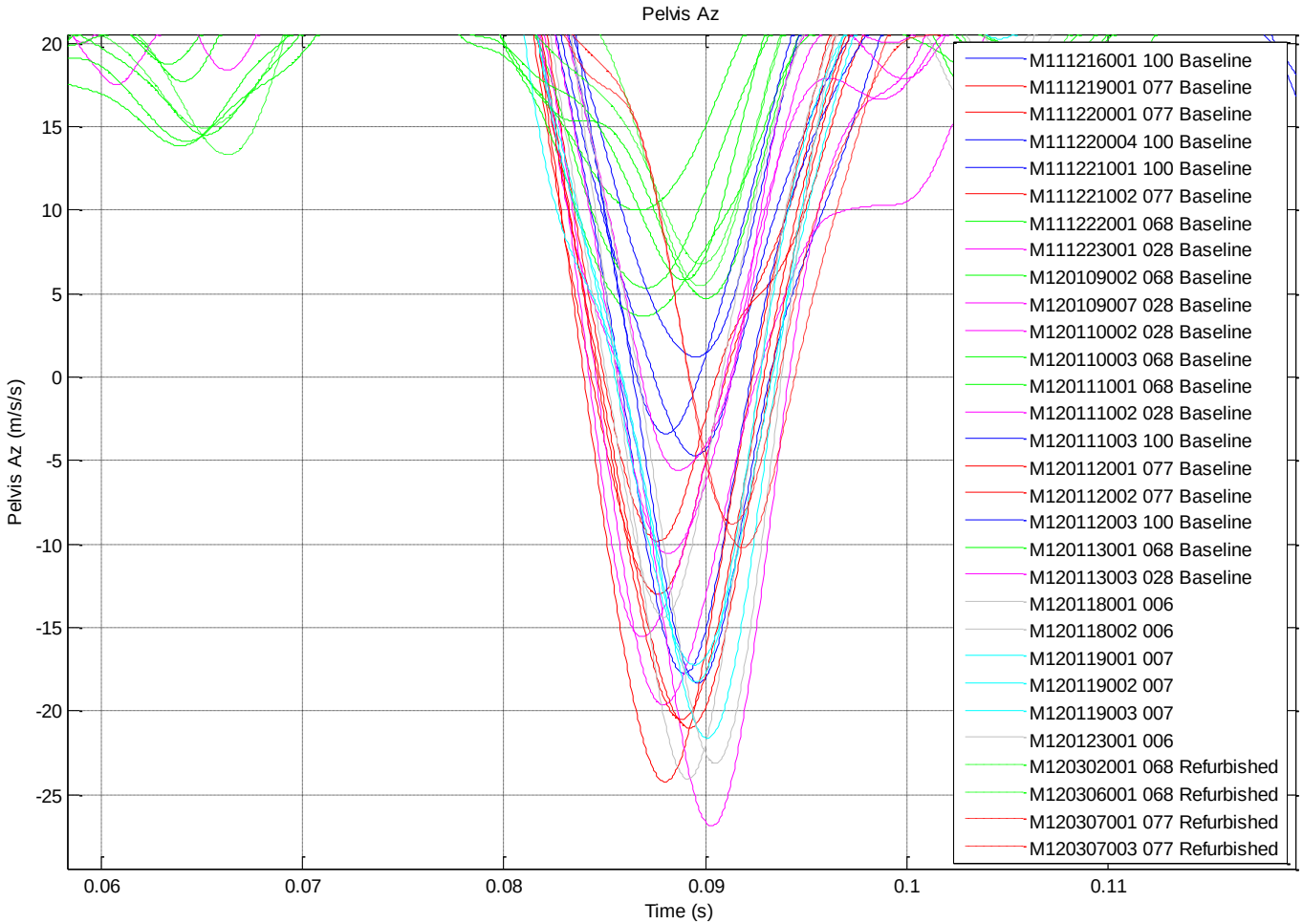
Sled Test Results

Refurbished 068 and 077



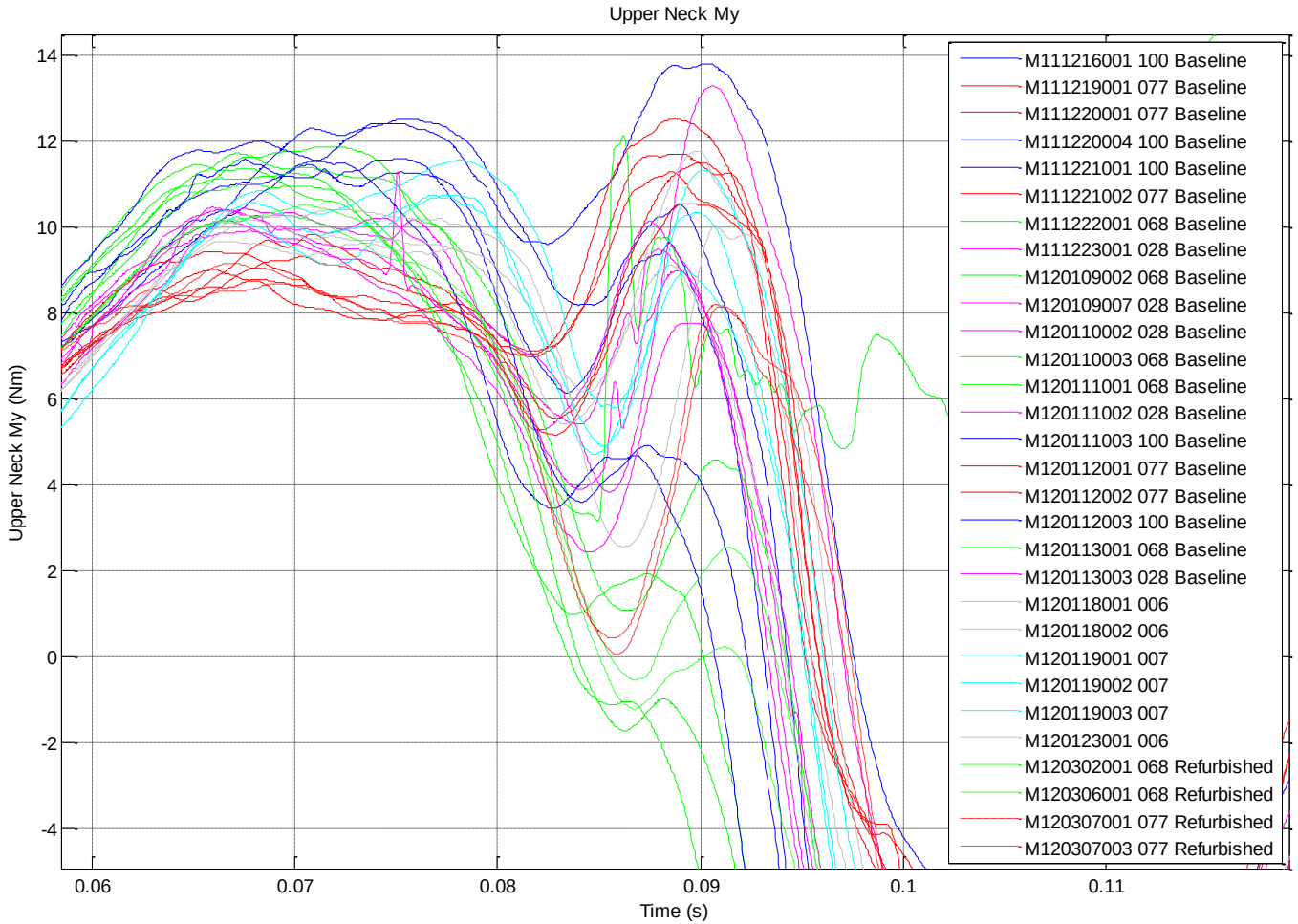
Sled Test Results

Refurbished 068 and 077



Sled Test Results

Refurbished 068 and 077



Spine Bumpers

Refurbished 068 and 077 cf. refurbished 006 and 007

- All dummy refurbished 068 and 077 bumpers from one manufacturing batch
- All dummy refurbished 006 and 007 bumpers from a different manufacturing batch

- Both manufacturing batches from the same batch of material

Spine Bumpers

Refurbished 068 and 077 cf. refurbished 006 and 007

TESTNUM	Part #	Dummies	Test Date	Peak Compr. (mm)	Avg Force During Cycles (N)
Black cervical	ARA-220	006/007	Average	2.03	64.90
front and rear			Std Dev	0.0179	1.2804
			CV%	0.9	2.0
	ARA-220	068/077	Average	2.03	63.26
			Std Dev	0.0150	1.1010
			CV%	0.7	1.7
		Average All ARA-220		2.03	64.08
		Std Dev All ARA-220		0.0164	1.4428
		CV % all ARA-220		0.8	2.3
		Diff. Batch 1 to 2 %		0.2	-2.5

Spine Bumpers

Refurbished 068 and 077 cf. refurbished 006 and 007

TESTNUM	Part #	Dummies	Test Date	Peak Compr. (mm)	Avg Force During Cycles (N)
Yellow cervical	ARA-227	006/007	Average	1.79	43.67
rear			Std Dev	0.0168	1.4648
			CV%	0.9	3.4
	ARA-227	068/077	Average	1.81	41.77
			Std Dev	0.0100	1.0813
			CV%	0.6	2.6
		Average All ARA-227		1.80	42.77
		Std Dev All ARA-227		0.0163	1.5955
		CV % all ARA-227		0.9	3.7
		Diff. Batch 1 to 2 %		1.0	-4.4

Spine Bumpers

Refurbished 068 and 077 cf. refurbished 006 and 007

TESTNUM	Part #	Dummies	Test Date	Peak Compr. (mm)	Avg Force During Cycles (N)
Yellow thoracic	ARA-381-30	006/007	Average	0.60	65.50
rear			Std Dev	0.0067	5.4048
			CV%	1.1	8.3
	ARA-381-30	068/077	Average	0.61	74.84
			Std Dev	0.0167	6.6114
			CV%	2.8	8.8
		Average All ARA-381-30		0.60	70.17
		Std Dev All ARA-381-30		0.0129	7.6132
		CV % all ARA-381-30		2.1	10.9
		Diff. Batch 1 to 2 %		0.9	14.3

Spine Bumpers

Refurbished 068 and 077 cf. refurbished 006 and 007

TESTNUM	Part #	Dummies	Test Date	Peak Compr. (mm)	Avg Force During Cycles (N)
Black thoracic	ARA-381-37	006/007	Average	0.57	108.57
front			Std Dev	0.0050	3.1505
			CV%	0.9	2.9
	ARA-381-37	068/077	Average	0.63	117.39
			Std Dev	0.0234	5.9409
			CV%	3.7	5.1
		Average All ARA-381-37		0.61	114.45
		Std Dev All ARA-381-37		0.0329	6.6400
		CV % all ARA-381-37		5.4	5.8
		Diff. Batch 1 to 2 %		9.8	8.1

Spine Bumpers

Refurbished 068 and 077 cf. refurbished 006 and 007

TESTNUM	Part #	Dummies	Test Date	Peak Compr. (mm)	Avg Force During Cycles (N)
Black lumbar	ARA-520	006/007	Average	1.23	616.56
rear			Std Dev	0.0126	22.8595
			CV%	1.0	3.7
	ARA-520	068/077	Average	1.23	793.92
			Std Dev	0.0040	38.5011
			CV%	0.3	4.8
		Average All ARA-520		1.23	705.24
		Std Dev All ARA-520		0.0100	96.0609
		CV % all ARA-520		0.8	13.6
		Diff. Batch 1 to 2 %		-0.7	28.8

Spine Bumpers

Refurbished 068 and 077 cf. refurbished 006 and 007

TESTNUM	Part #	Dummies	Test Date	Peak Compr. (mm)	Avg Force During Cycles (N)
Black lumbar	ARA-521	006/007	Average	0.80	347.82
front			Std Dev	0.0177	14.9848
			CV%	2.2	4.3
	ARA-521	068/077	Average	0.83	358.16
			Std Dev	0.0105	21.2501
			CV%	1.3	5.9
		Average All ARA-521		0.81	352.99
		Std Dev All ARA-521		0.0208	18.6664
		CV % all ARA-521		2.6	5.3
		Diff. Batch 1 to 2 %		3.7	3.0

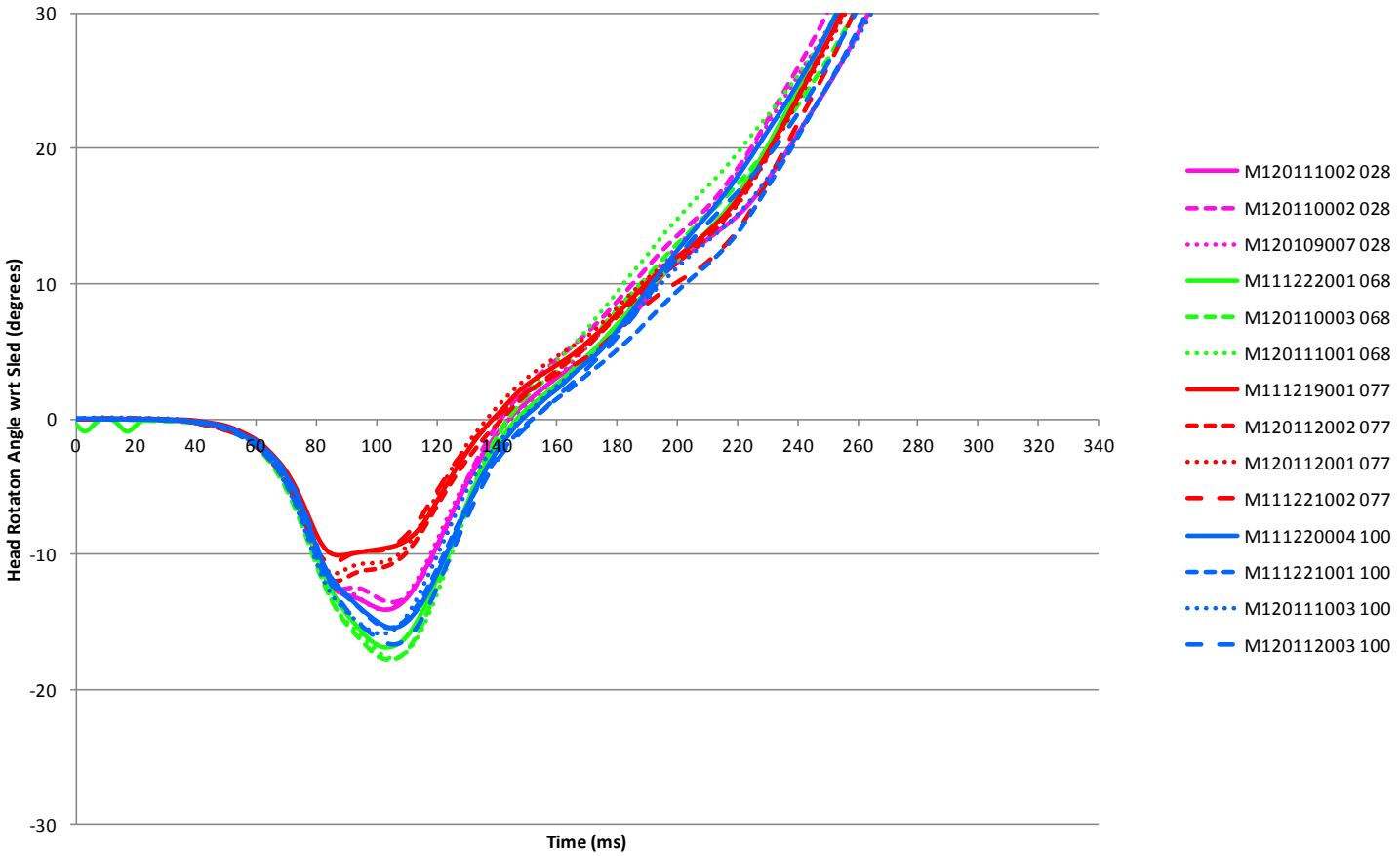
Kinematics

Baseline tests with 028, 068, 077 and 100

- Dummy kinematics from film analysis / marker tracking
  - Camera/lens distortion calibrated
  - Position and orientation of camera calibrated from known 3D co-ordinates of targets on the sled

Kinematics

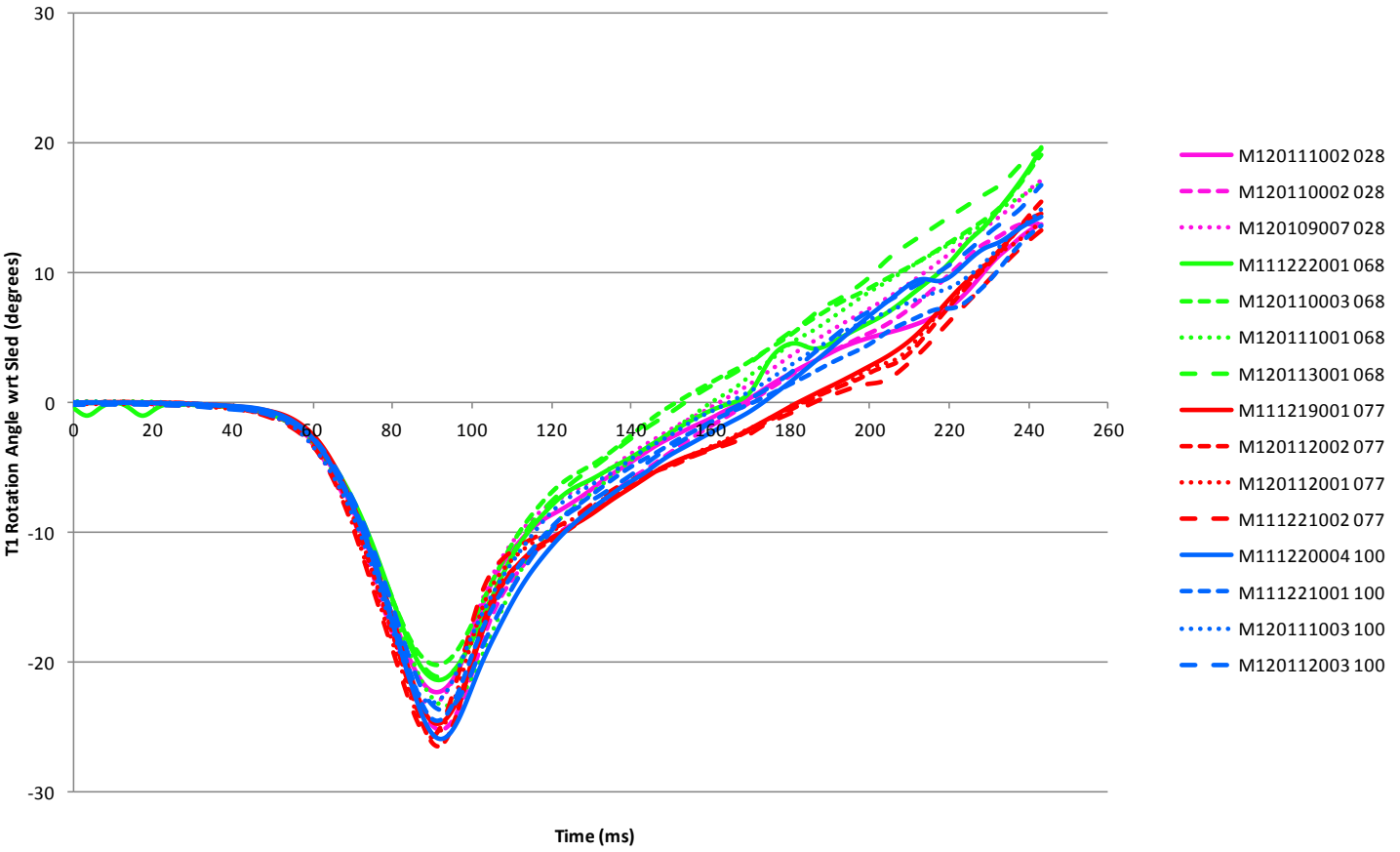
Baseline tests with 028, 068, 077 and 100



Head angle relative to sled

Kinematics

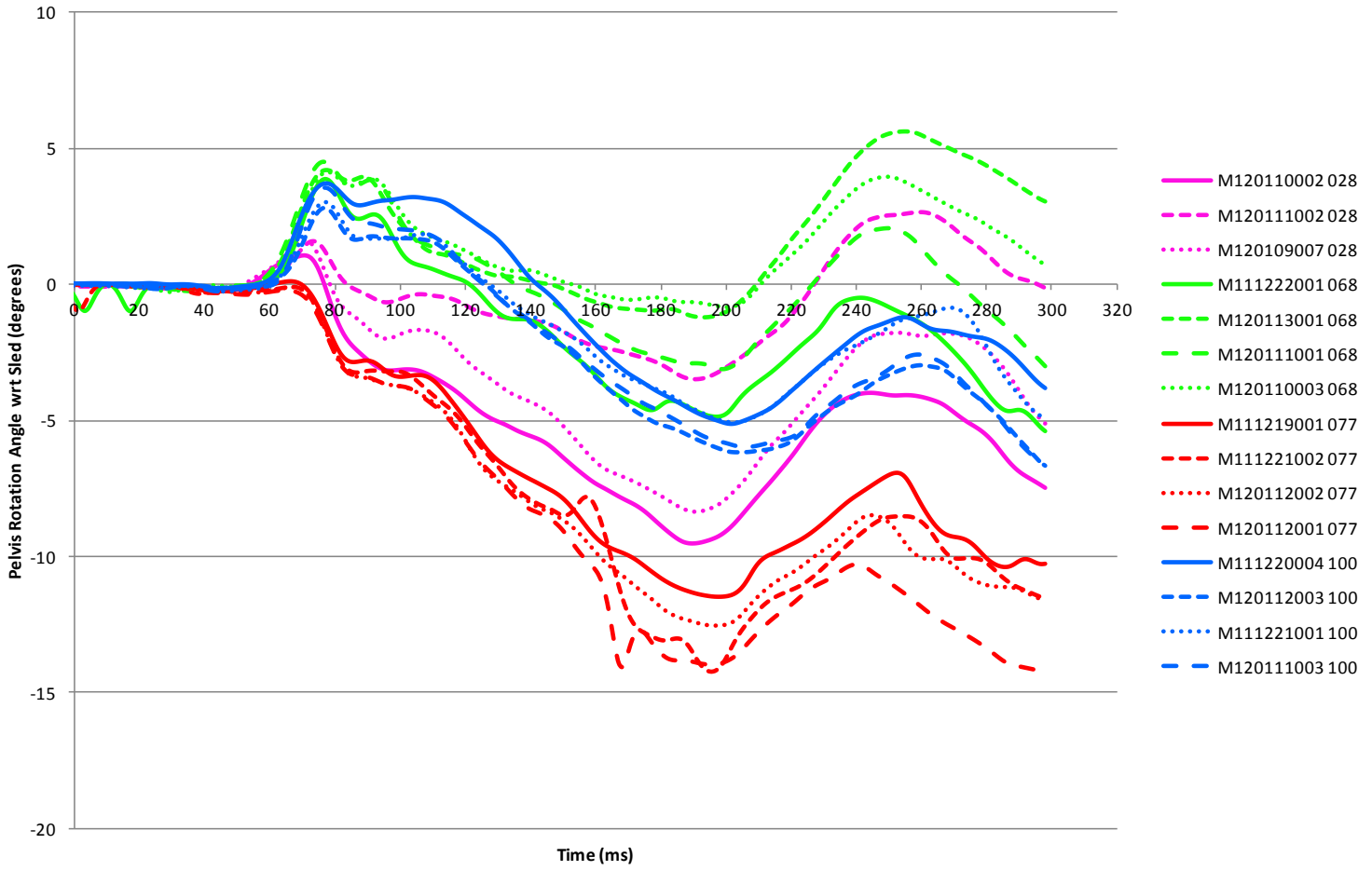
Baseline tests with 028, 068, 077 and 100



T1 angle relative to sled

Kinematics

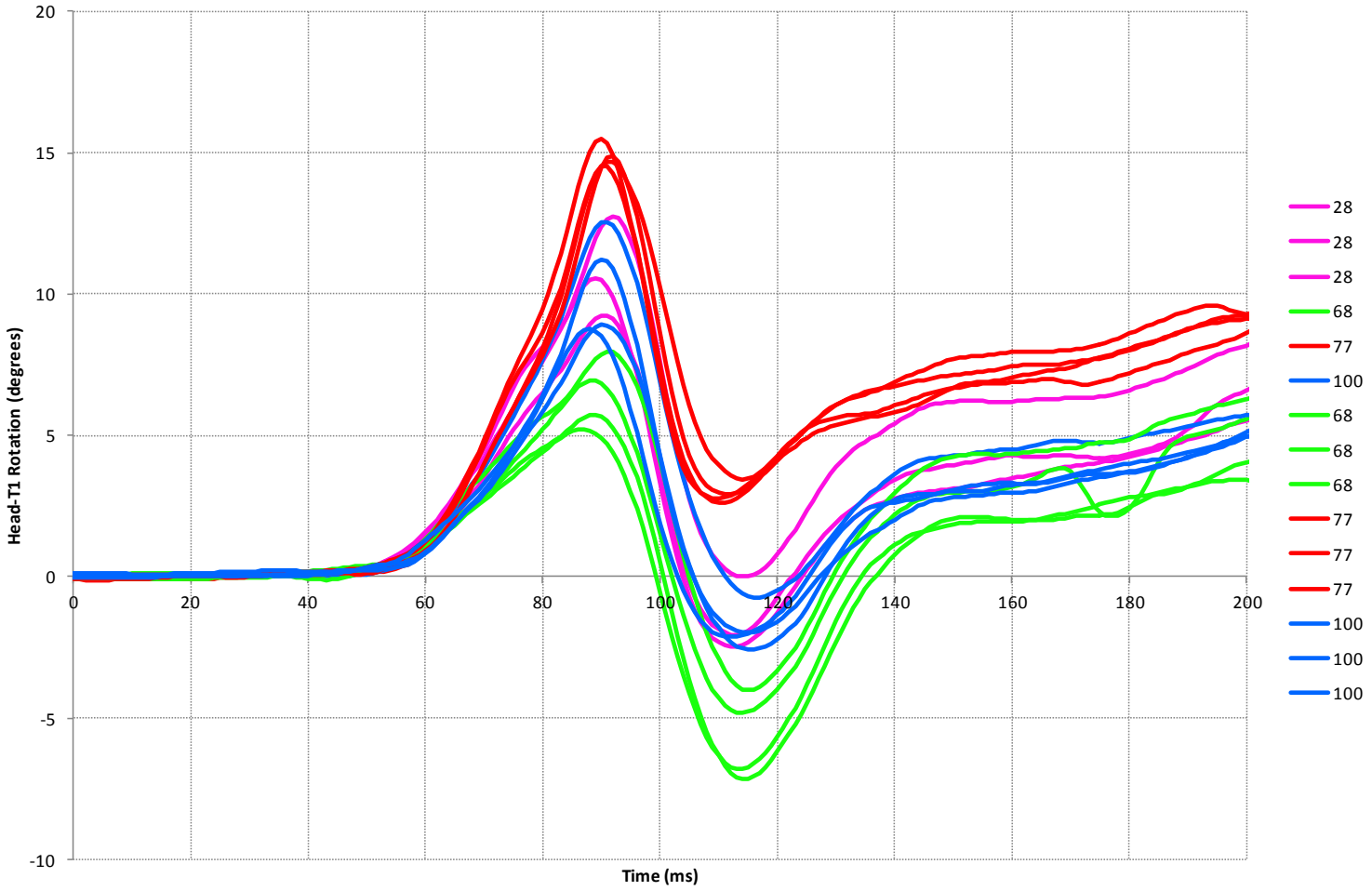
Baseline tests with 028, 068, 077 and 100



Pelvis angle relative to sled

Kinematics

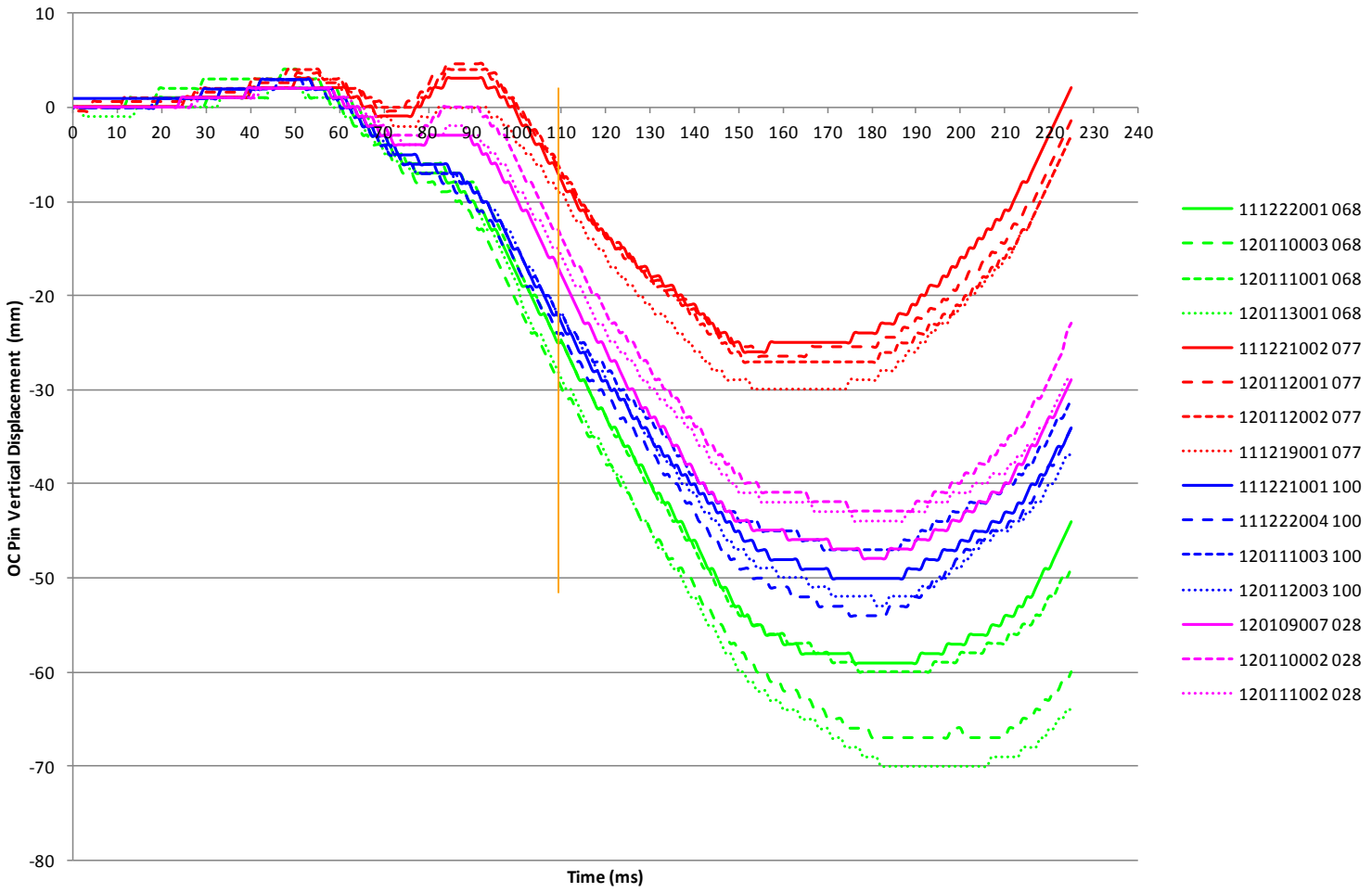
Baseline tests with 028, 068, 077 and 100



Head-T1 angle

Kinematics

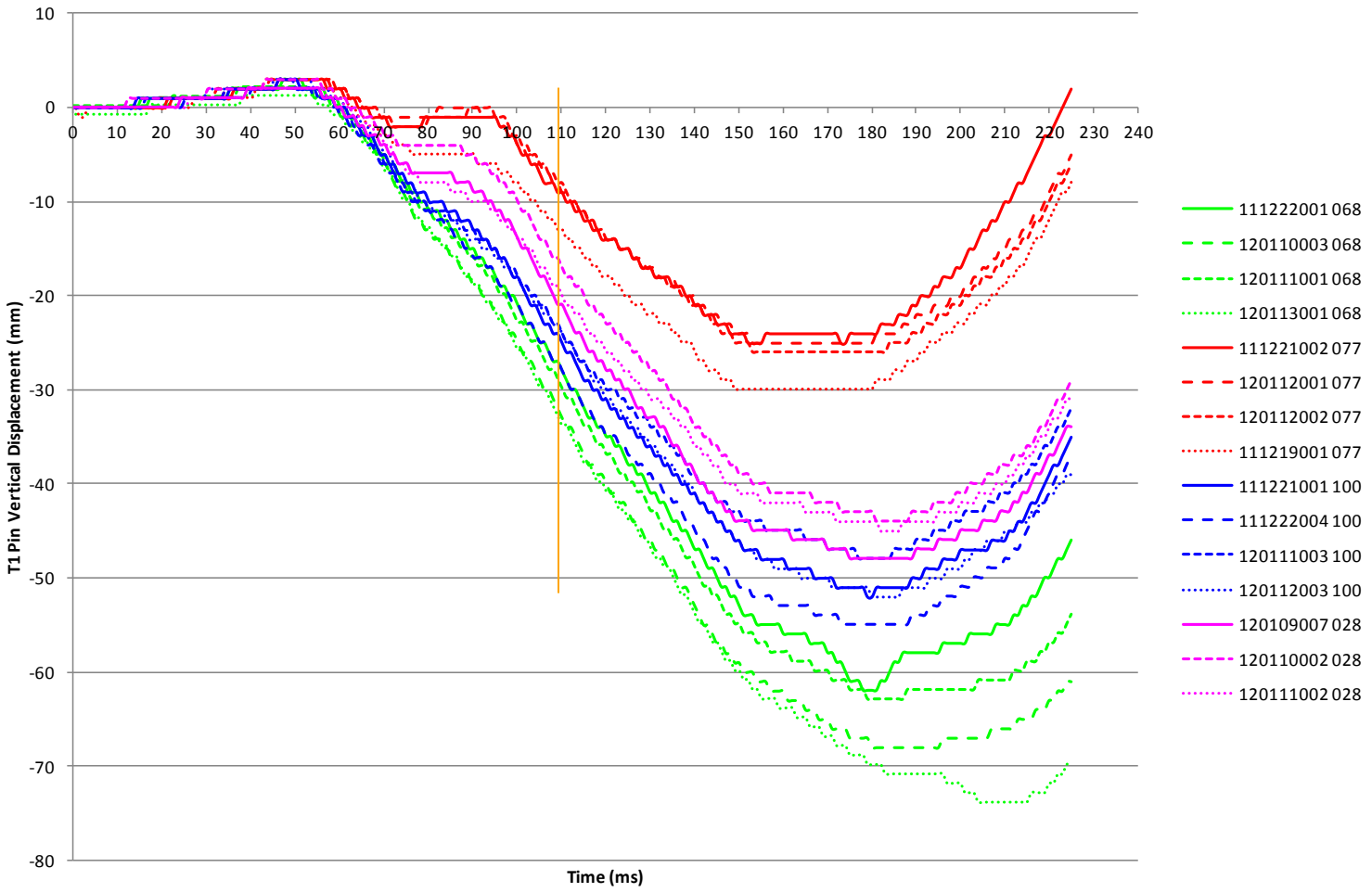
Baseline tests with 028, 068, 077 and 100



OC Z-axis displacement

Kinematics

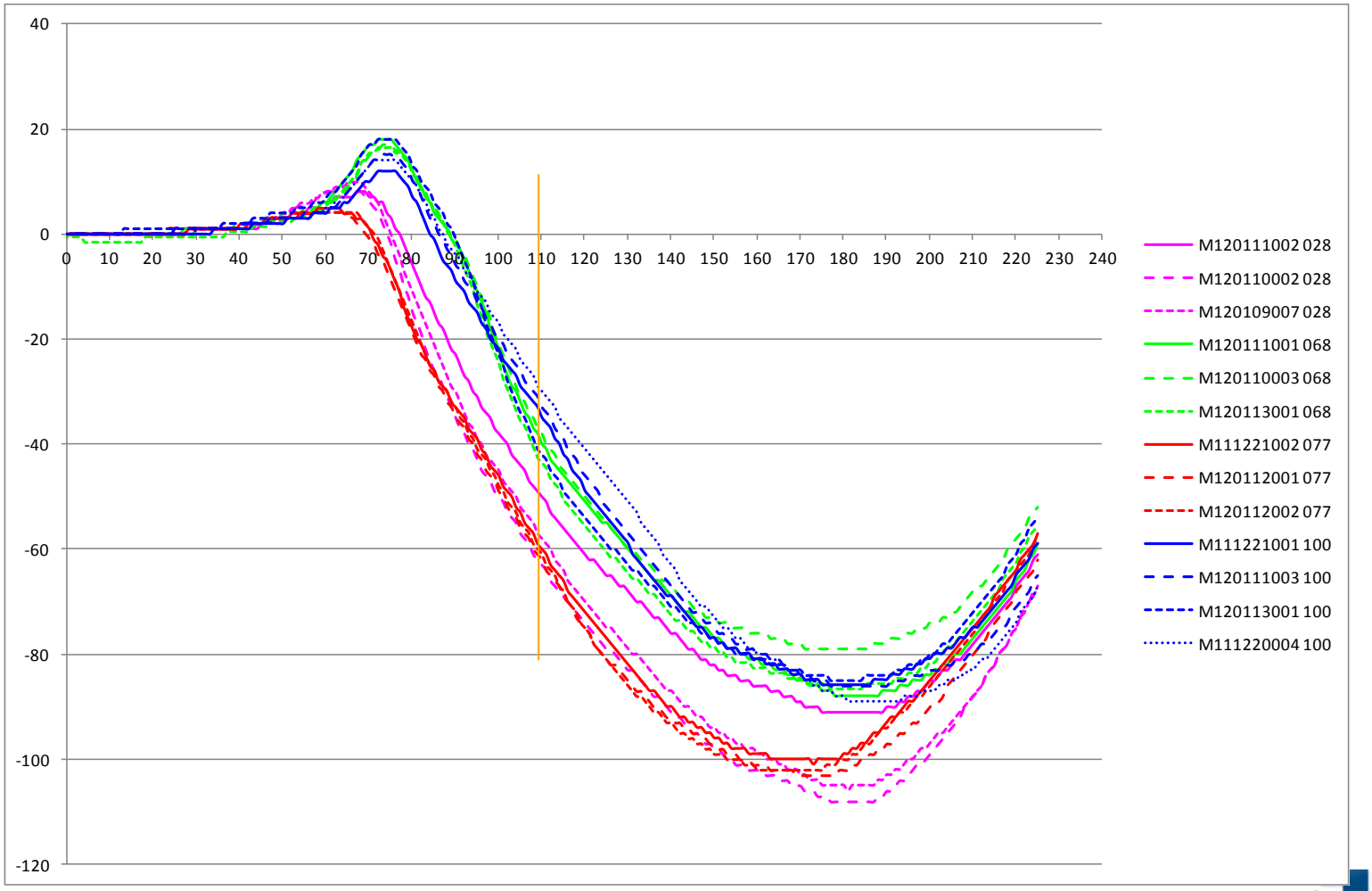
Baseline tests with 028, 068, 077 and 100



T1 Z-axis displacement

Kinematics

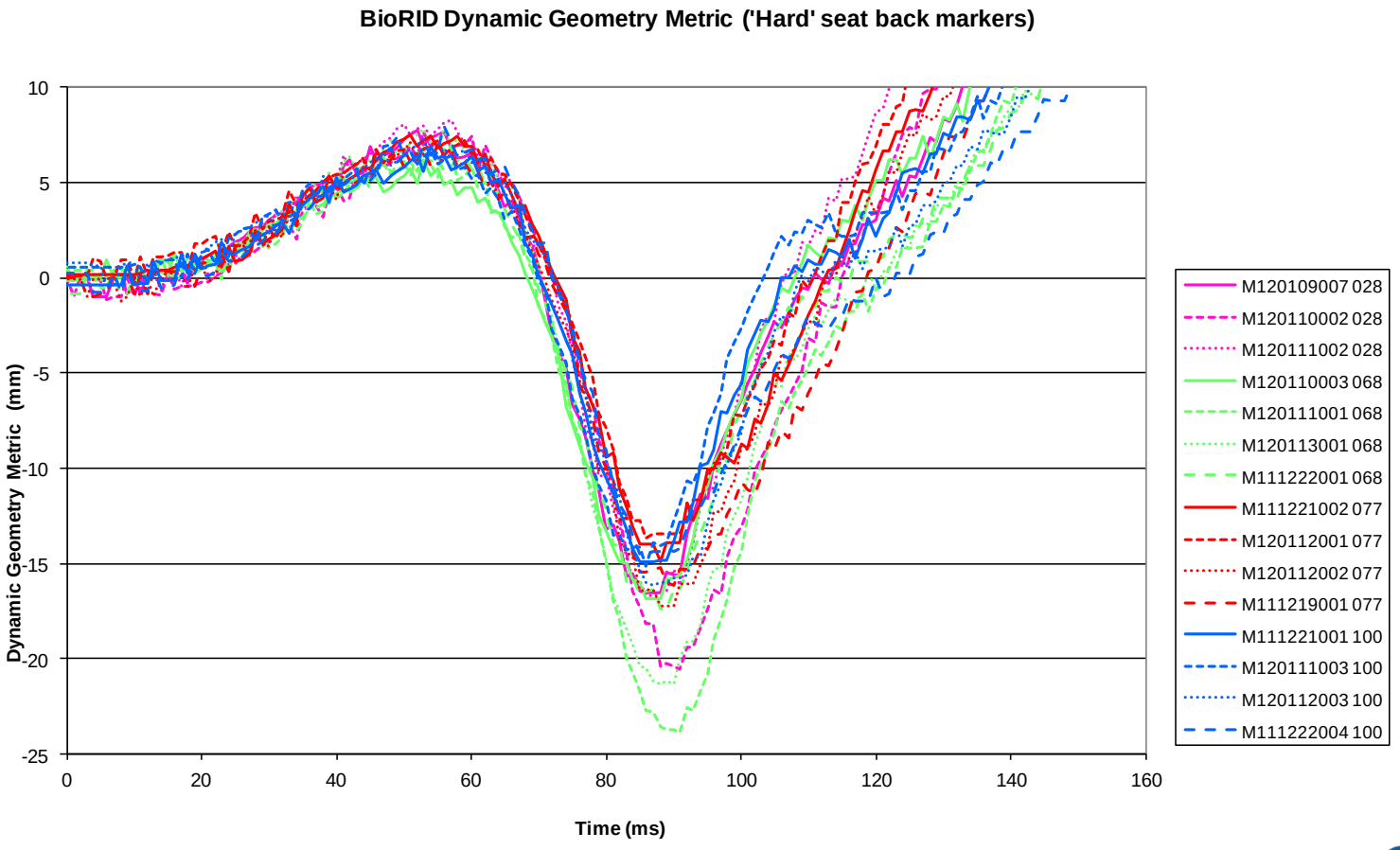
Baseline tests with 028, 068, 077 and 100



Pelvis wand (lower marker) Z-axis displacement

Kinematics

Baseline tests with 028, 068, 077 and 100



Head displacement relative to T1, seat back co-ordinate system

Conclusions

Sled Tests

- T1 and upper neck Fx quite good
- T1 My quite good
  - These measures appear insensitive to variations in ramping-up and head/neck angles – with a homogeneous head restraint
- T1 and upper neck Fz very variable
  - Not related to small changes in seat / head restraint over time because no change in phase of responses (phase change seen with different backset)
  - Also big oscillations in Fz in certification test
  - Fz difference correlate in time with pelvis Az differences
  - Recommend improving pelvis flesh reproducibility
- Upper neck My very variable
  - Correlates quite well with Pot A in no HR cert test and My in with HR cert test
  - Recommend much tighter control on Pot A response

Conclusions

Design

- Recommend smooth, biofidelic profile to rear of pelvis bone
  - Current profile OK provided any hard part in the seat not close to the step changes in profile
  - Would require alternative mounting for pelvis accels (if they are required)
    - Mount to base of spine?
  - (Currently modified Hybrid III part, so Hybrid III may have same issues in rear impact)

- Too much slack in H-point tool on some dummies
  - Could lead to variability in positioning dummies
  - Recommend improving fit of H-point tool

Conclusions

Certification

- Need pelvis flesh stiffness
- Looking at quasi-static spine stiffness test
- May need much tighter control of Pot A ***after*** initial peak which has the current corridor

Conclusions

Dummy Set-up / Seating Procedure

- Significant changes in dummy posture and backset had very little effect on upper neck My extension
  - Differences not likely to be due to dummy geometry or seating procedure
- T1 and upper neck Fz were affected by large changes
  - Not affected by any variations in the baseline 20 tests
  - Suggests seating procedure adequate to control this
    - Assumes dummy-to-dummy sources of variation are controlled
    - Assumes variations in BioRID target backset from 3D H-point machine and HRMD procedure are adequately controlled
- Small differences in H-point height between dummies
  - Possibly due to slack in H-point tool interface with dummy
  - Small effect on measurements compared with raising dummy 30 mm

Recommendations

Improved Control of Dummy Build

- Only one of the four baseline dummies had a jacket that complied with the draft corridor
  - Shown to be influential in certification (presentation from Japan)
  - Recommend ensuring compliance with corridor
  - Humanetics currently compiling jacket certification data to check corridor is representative of the mean response before finalising corridor
- Pelvis response seems to be influential to neck measurements
  - Varies between dummies
  - Pelvis stiffness also varies between dummies
  - Recommend re-introduce pelvis certification tests
  - Humanetics currently compiling pelvis certification data and running new tests in order to propose a suitable corridor

Recommendations

Improved Control of Dummy Build

- Bumper stiffness can be variable
  - Current no-head-restraint certification test probably controls rear bumper performance in large extension movements
  - Dummy neck response in the current seat tests is mostly *flexion!*
    - Not well controlled by no-head-restraint test procedure
  - With-head-restraint certification test seems to show differences between dummies for upper neck My
    - Tight corridor would be required
  - Recommend batch testing of bumper stiffness *before* fitting to dummies and running dummy certification tests
  - Particularly important for lumbar and lower thoracic bumpers
    - Not tested in current certification sled tests

Recommendations

Validation

- Need to build-up several dummies with
  - Jackets that comply with the draft corridors
  - Pelvises that have similarly well-controlled stiffness
  - Bumpers that are within e.g ±5
- Re-test on the TRL seat
- Also, tests with deliberately stiffer and less stiff bumpers recommended
  - To help set tolerance on bumper stiffness specification
  - Outside the scope of the current project

Acknowledgements

Many thanks to…

- European Commission for funding the work programme
- BASt for hosting us for over 70 tests!
  - Particularly Michael and Mark of BGS for performing all of the tests
- Dummy owners for providing dummies for the test programme
- PDB for providing dummies 006 and 007 for comparative testing
- Humanetics for all their support and certification
- Members of the TEG for all their comments, feedback and encouragement at numerous TEG meetings

Do You Have Any Questions?