Robustness of
SN04 prototype test results

3rd Meeting of Informal Group GTR9 Phase 2
Paris, May 29th and 30th, 2012

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Background

- At the 2nd meeting of the Informal Group GTR9 Phase 2 a report related to the long term robustness of the FlexPLI SN02 test results was given by BASt (Doc GTR9-2-04).

- As prototype SN02 was equipped with polyester bone core material, BASt was asked to carry out a similar study for a legform impactor containing the currently used vinylester bone core material.

- Basis of the present comparative study are results of inverse certification tests with Flex-GTR prototype SN04 that were entirely performed at BASt during a time period of approx. 2,5 years.

- Before the test series was started, the optional sensors including the aluminium brackets (July 2009) were removed. No further major exchange of parts nor calibration of particular sensors was noticed.

- During the entire test period, SN04 was equipped with vinylester bone core material.

- All inverse certification tests at BASt were performed with long rubber material.

Results

- **In total, 14 inverse certification tests w/ SN04 have been carried out at BASt**

- **Test period: July 2009 – February 2012**

- **Test result overview:**

Date	TA1	TA2	TA3	TA4	ACL	PCL	MCL
06.07.2009	267,9	249,4	176,5	112,9	10,6	6,1	21,3
06.09.2010	259,6	243,6	179,7	100,7	11,4	5,3	20,5
22.06.2011	255,1	240,4	176,5	98,7	10,3	5,7	20,0
06.09.2011	256,9	244,5	177,4	94,1	10,3	5,0	19,6
28.10.2011	254,2	240,0	176,7	92,9	10,7	5,4	19,8
16.11.2011	253,6	237,5	177,4	96,8	10,8	5,2	19,5
13.12.2011	256,4	240,1	178,9	99,3	11,1	5,2	19,4
03.01.2012	259,6	242,1	175,0	95,2	10,6	6,1	19,2
04.01.2012	254,7	239,2	177,6	95,4	10,5	5,2	19,5
04.01.2012	262,9	244,7	176,8	95,3	10,2	5,6	19,6
04.01.2012	259,6	242,2	172,6	91,4	10,3	5,6	19,5
23.01.2012	264,2	243,3	179,1	98,9	10,3	5,5	20,0
31.01.2012	251,5	236,2	177,3	99,5	10,3	5,2	19,4
24.02.2012	262,1	245,9	178,8	93,1	9,7	4,9	18,9

Inverse corridors:

| fail |

| pass |

Repeatability of test results

- **Tibia A1, A2, A3 (and MCL) with good repeatability (CV < 3%)**

- **Tibia A4, ACL and PCL with minor issues, but repeatability acceptable (CV < 7%)**

- **As usual, some scatter in ACL/PCL results; however, both acceptable**

- **Comparatively high scatter of Tibia A4 due to very first test (Test #1). In case of removing this outlier, CV @ approx. 3% (➜ good repeatability)**

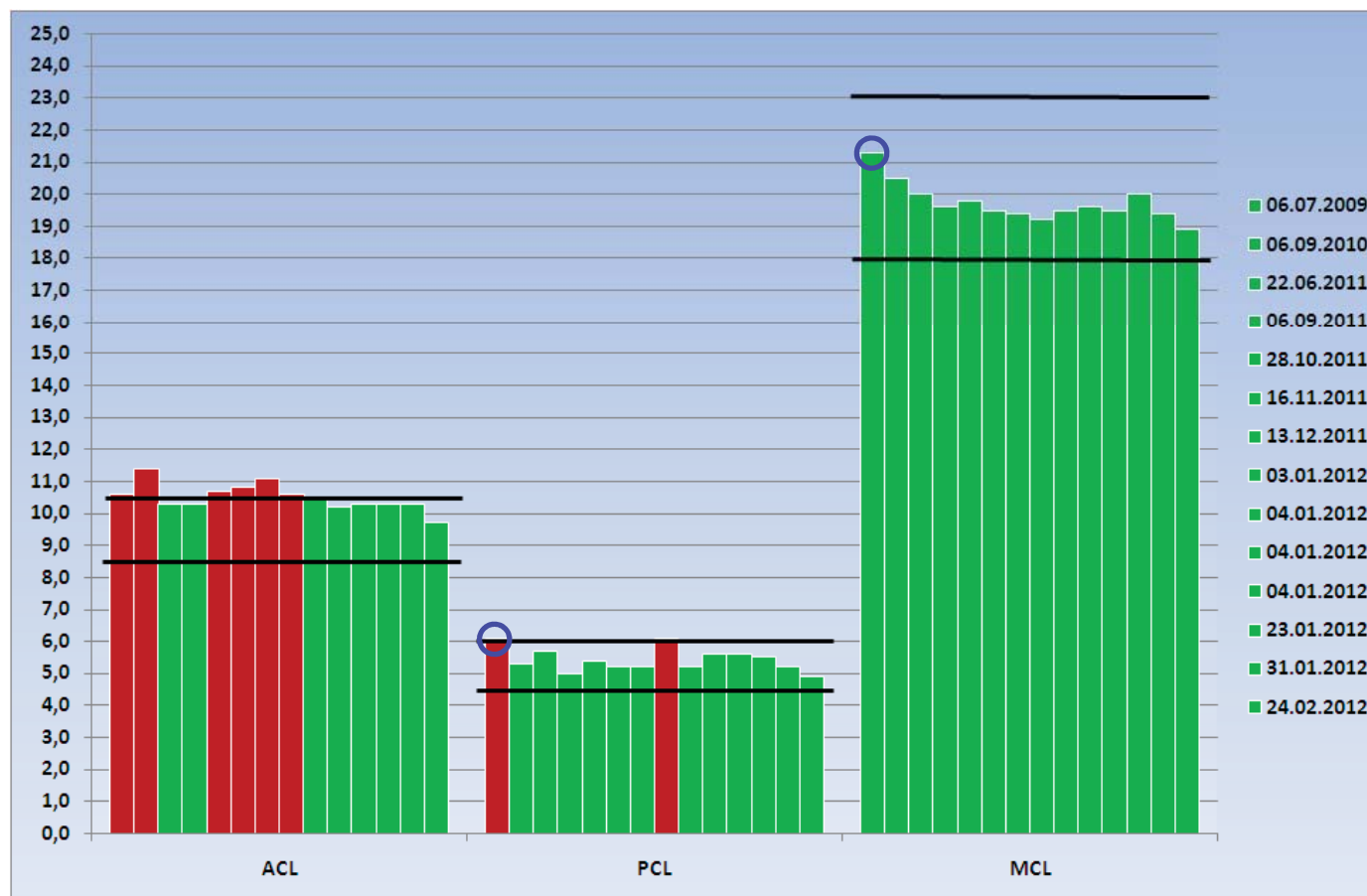|	TA1	TA2	TA3	TA4	ACL	PCL	MCL
Mean Value	258,45	242,08	177,16	97,44	10,51	5,43	19,73
Standard Deviation	4,65	3,50	1,82	5,28	0,42	0,36	0,59
Coefficient of Variation [%]	1,80	1,45	1,03	5,42	3,96	6,72	3,01
Maximum	267,90	249,40	179,70	112,90	11,40	6,10	21,30
Dev. from MV [%]	3,66	3,02	1,43	15,86	8,50	12,37	7,97
Minimum	251,50	236,20	172,60	91,40	9,70	4,90	18,90
Dev. from MV [%]	2,69	2,43	2,58	6,20	7,68	9,74	4,20
max. Dev. from MW	9,45	7,32	4,56	15,46	0,89	0,67	1,57
max. Dev. from MV [%]	3,66	3,02	2,58	15,86	8,50	12,37	7,97
Range	16,40	13,20	7,10	21,50	1,70	1,20	2,40

Certification corridors - Tibia

- **Almost all tibia A1-A3 results within inverse certification corridors**
- **Issues with tibia A3 and A4: test results always at the lower end of the corridors**
- **Tibia A4: 8 (14) test results out**
- **Test #1 providing the maximum result for three tibia segments**
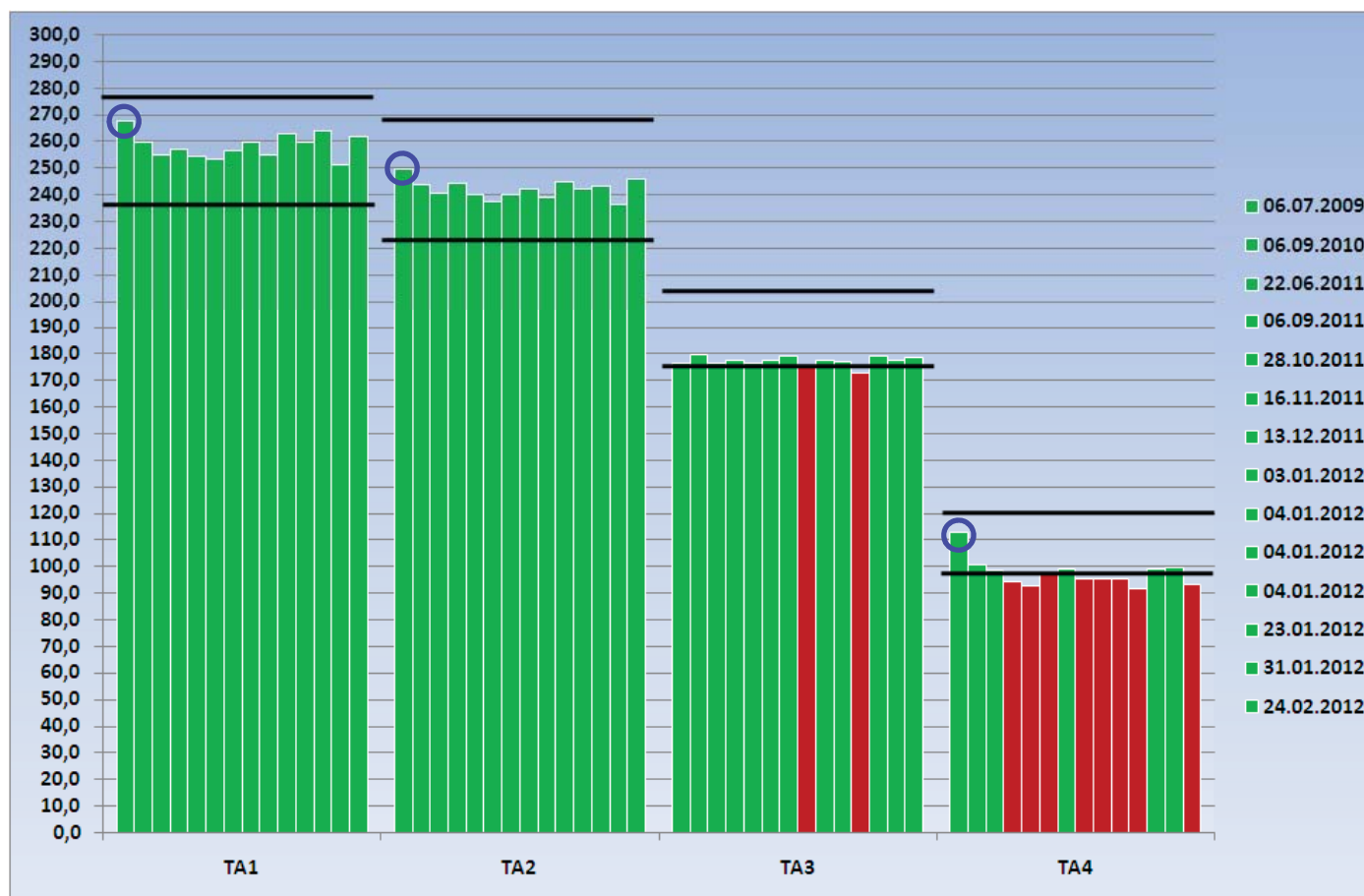
Certification corridors - Ligaments

- **All MCL and most PCL results within inverse certification corridors**
- **Issues with ACL: test results always at the upper end of the corridor**
- **ACL: 6 (14) test results out**
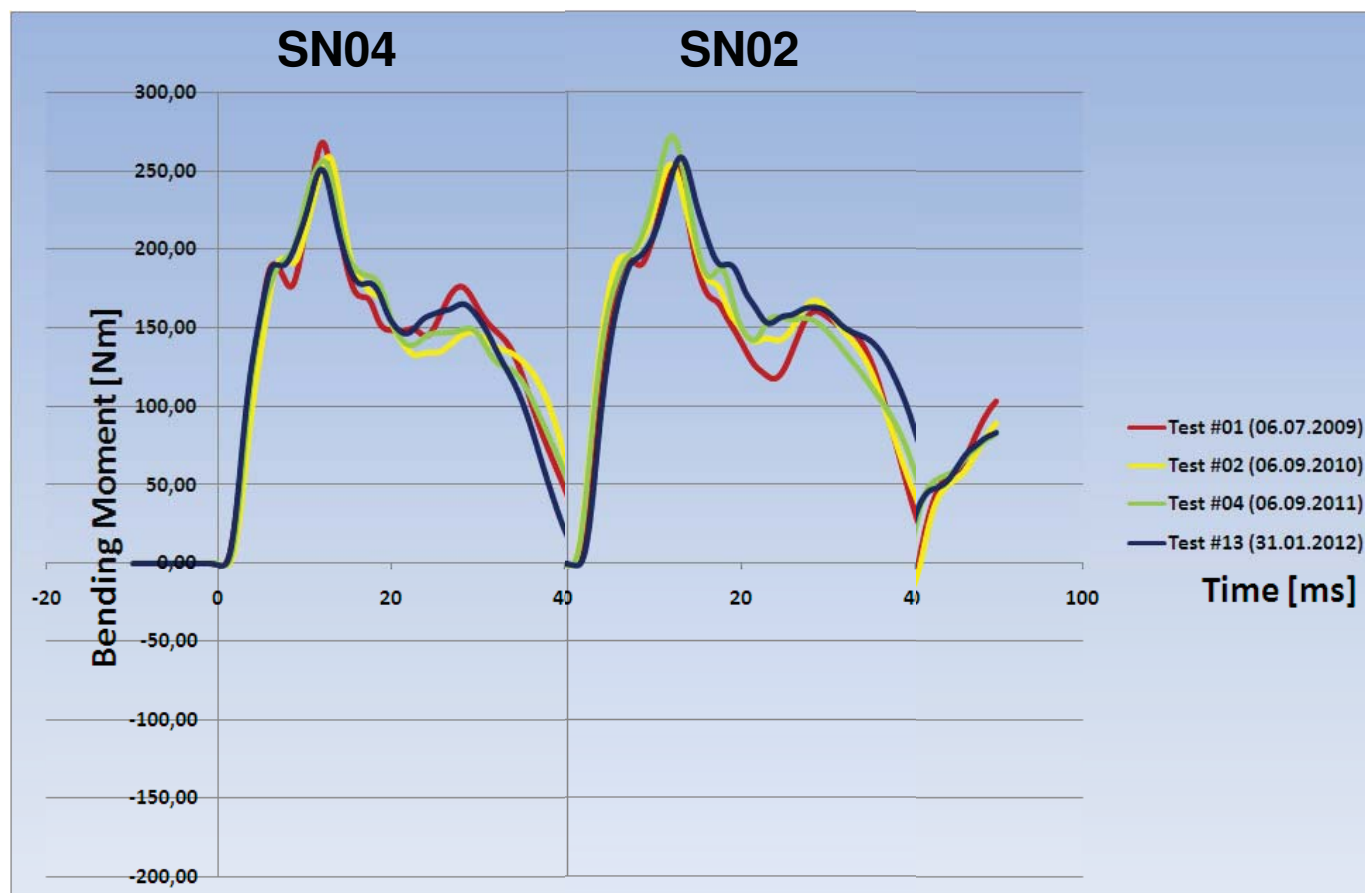- **Test #1 providing the maximum result for two string pots**

Time history curves

- **Comparison of time history curves**

Date	TA1	TA2	TA3	TA4	ACL	PCL	MCL
06.07.2009	267,9	249,4	176,5	112,9	10,6	6,1	21,3
06.09.2010	259,6	243,6	179,7	100,7	11,4	5,3	20,5
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Test #01 →
Test #02 →
Test #04 →
Test #13 →

Time history curves – Tibia A1

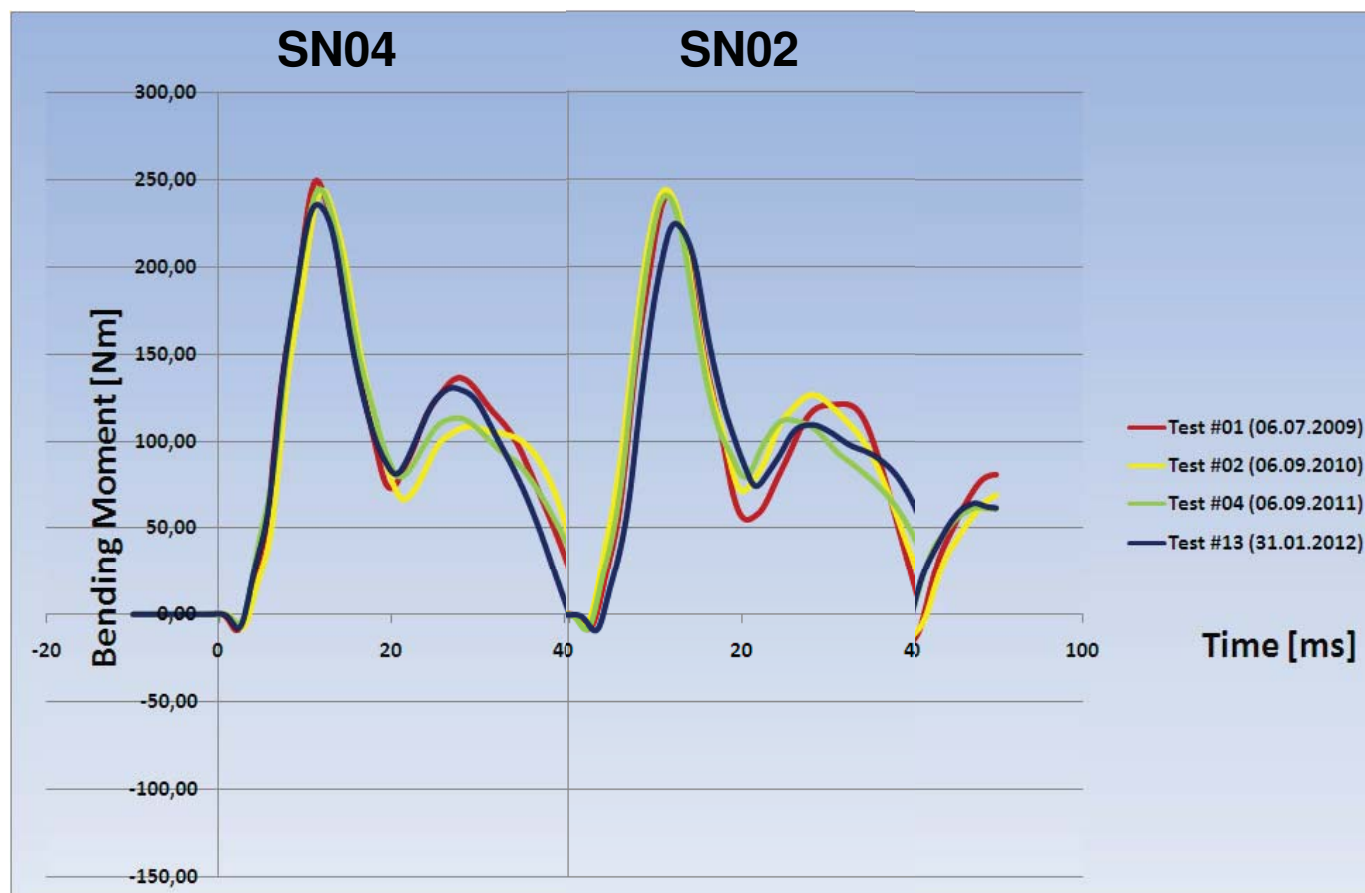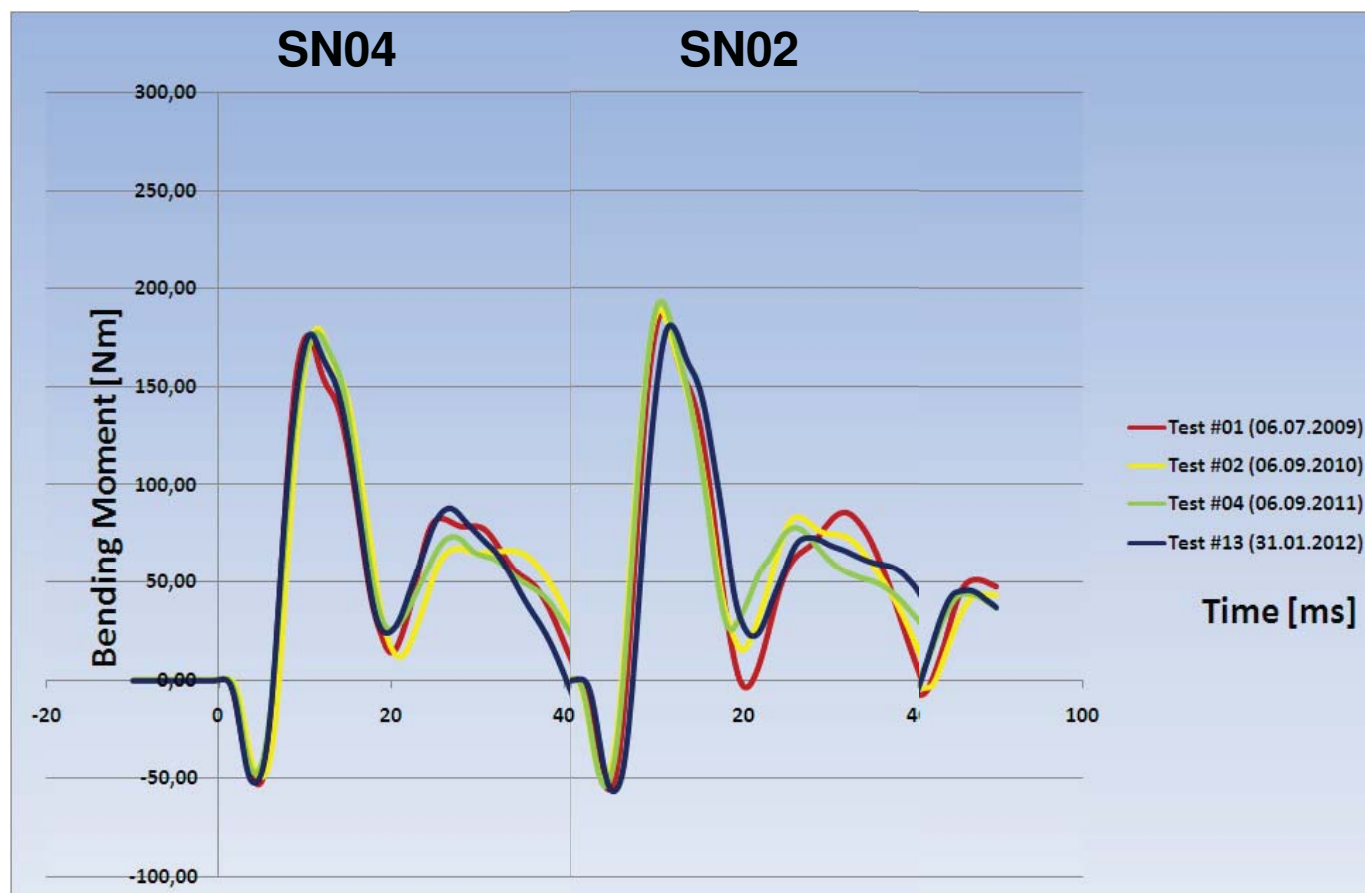**High repeatability during the primary impact phase**
Test #1 with maximum result
Test #2 with highest decay after first peak
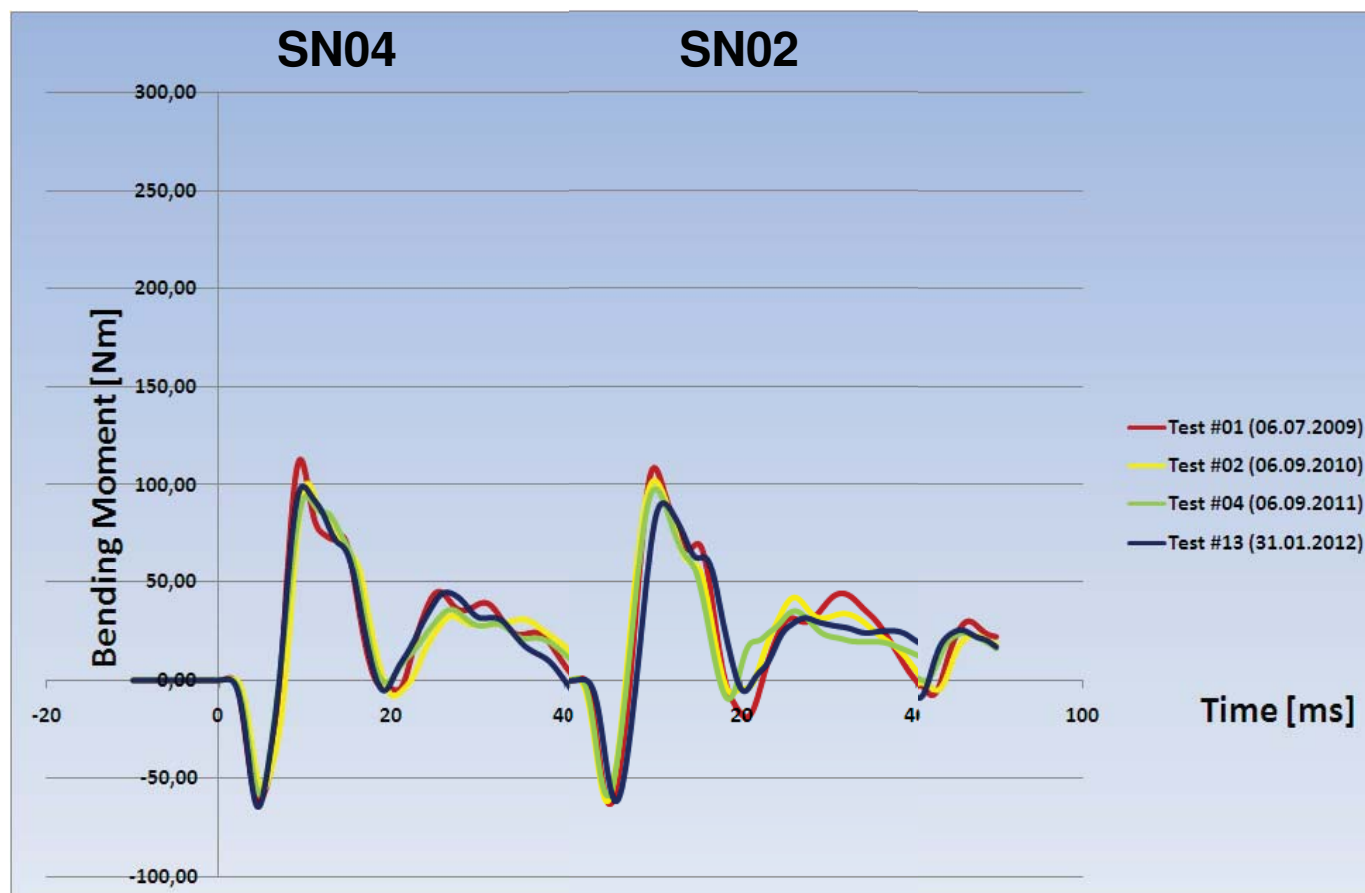**SN04 curve characteristics comparable to SN02 during the impact phase**

Time history curves – Tibia A2

High repeatability during the primary impact phase
Test #1 with maximum result
Test #2 with highest decay after first peak
SN04 curve characteristics comparable to SN02 during the impact phase

Time history curves – Tibia A3

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High repeatability during the primary impact phase
SN04 curve characteristics comparable to SN02 during the impact phase
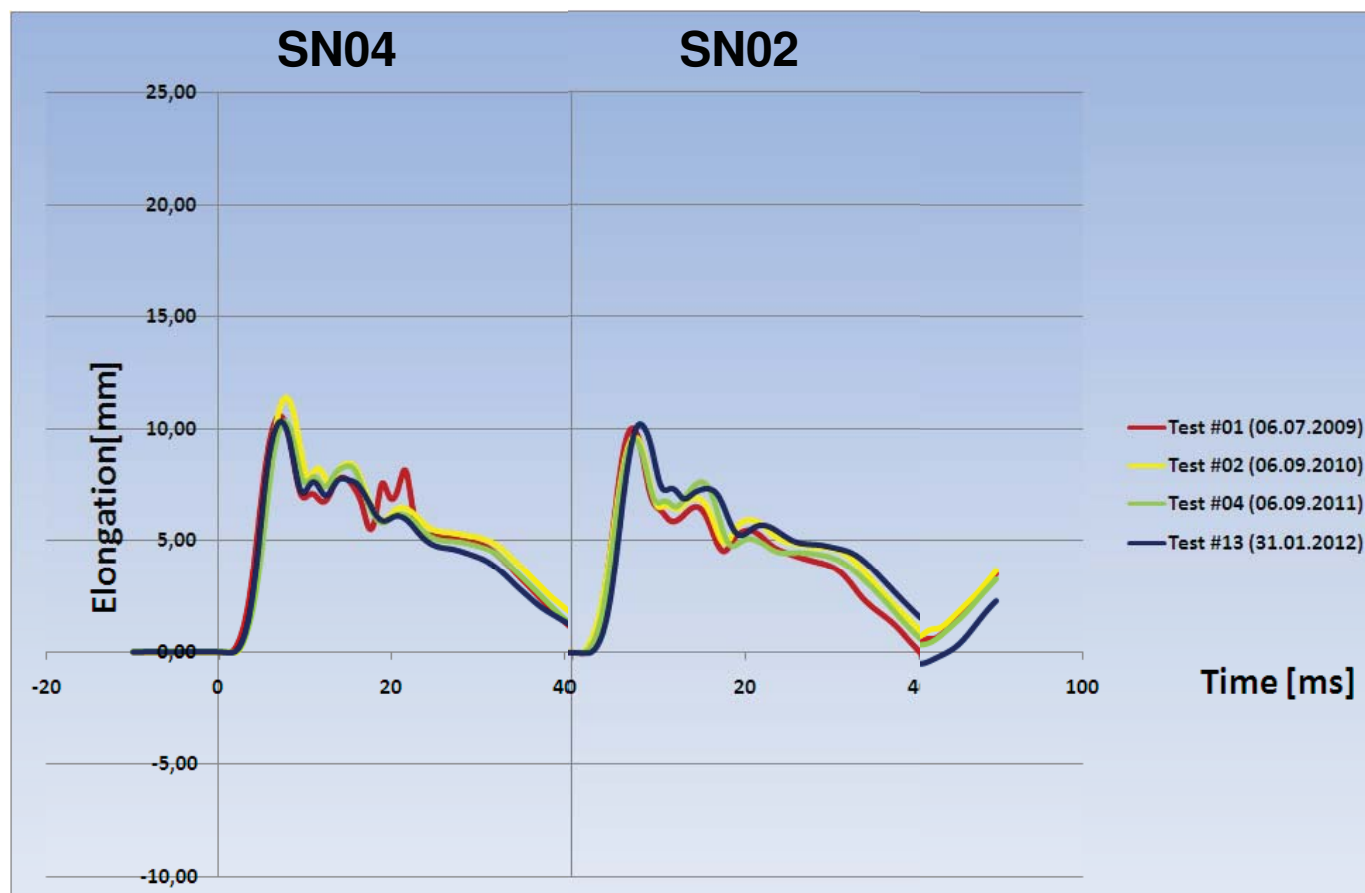
Time history curves – Tibia A4

Acceptable repeatability during the primary impact phase
Test #1 with maximum result
Test #1 causing a higher scatter (if removed ➔ CV @ 3% ➔ good)
SN04 curve characteristics comparable to SN02 during the impact phase
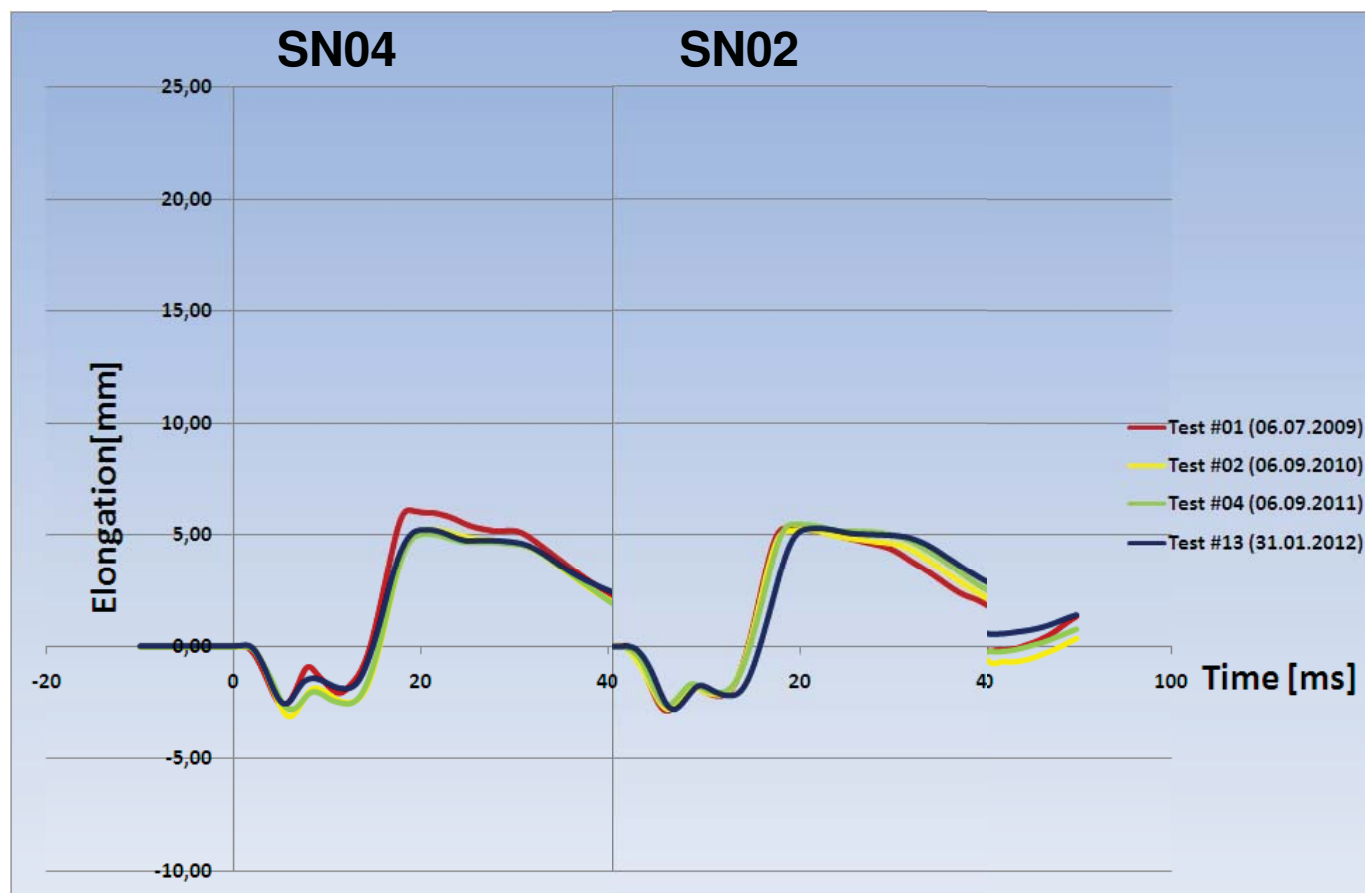
Time history curves – ACL

Acceptable repeatability during the impact phase
Test #1 with different curve characteristics after the first peak
SN04 curve characteristics comparable to SN02 during the impact phase
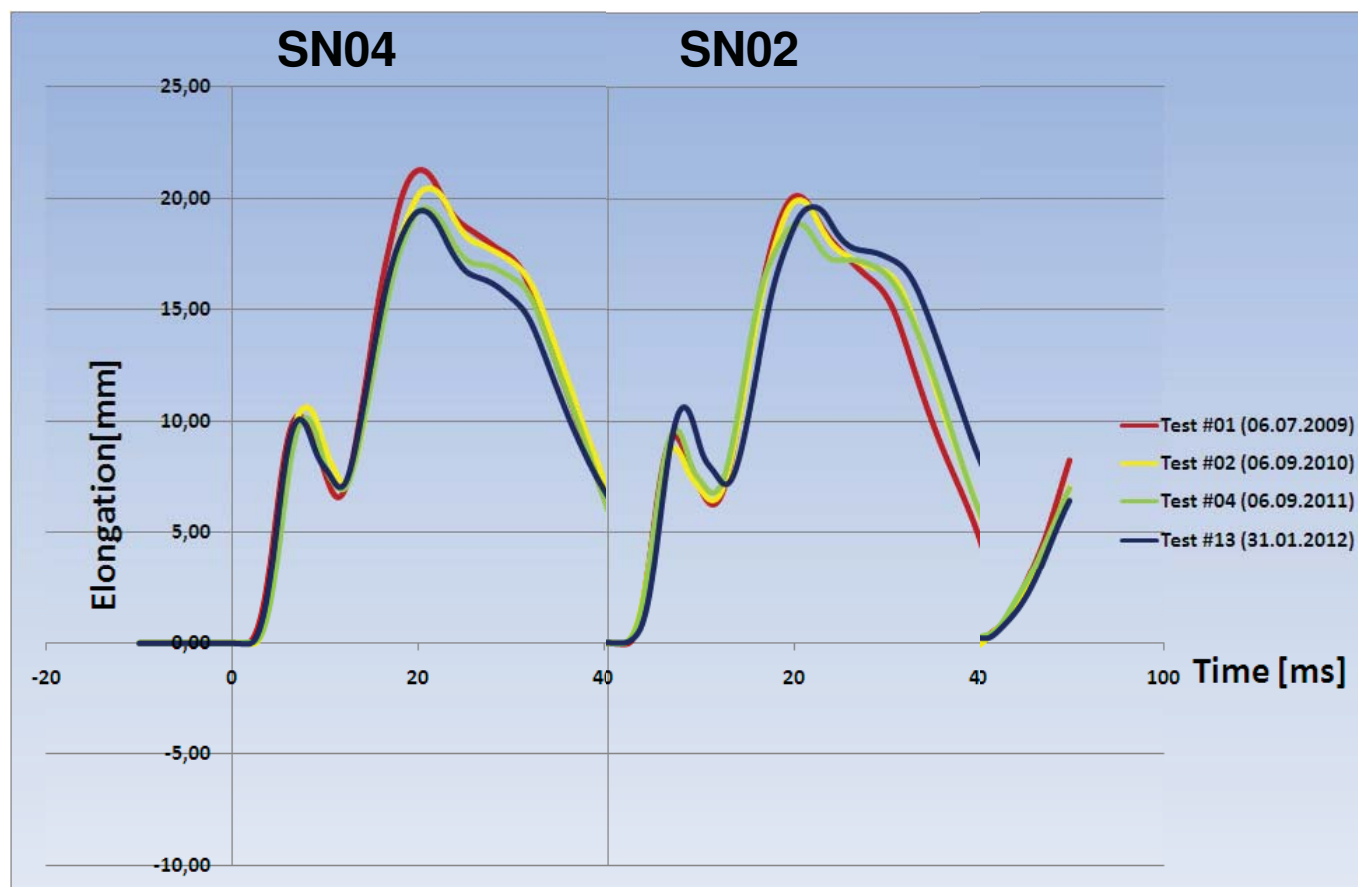
Time history curves – PCL

Acceptable repeatability during the impact phase
Test #1 with maximum result
Test #1 causing a higher scatter
SN04 curve characteristics comparable to SN02 during the impact phase

Time history curves – MCL

High repeatability during the impact phase
Test #1 with maximum result
Test #1 causing a higher scatter (if removed ➔ CV @ 2%)
SN04 curve characteristics comparable to SN02 during the impact phase

Conclusions

- 14 inverse certification tests with SN04 carried out at BASt during approx. 2,5 years

- Good repeatability of four (out of seven) segments

- Repeatability of ACL/PCL results naturally lower than most of the other segments

- Test #1 providing the maximum result of five (out of seven) segments

- Test #1 responsible for significant repeatability decrease of Tibia A4, PCL and MCL

- Therefore, test #1 could be considered to some extent as being an outlier

- On the other hand, test #1 describes the SN04 impactor condition before the vehicle tests carried out by OICA in August 2009 and reported within Doc GTR9-2-10

- All SN04 curve characteristics in general comparable to SN02 during the primary impact phase

Thank you !