AMS-02: TRDTN5

Octagon Support Structure

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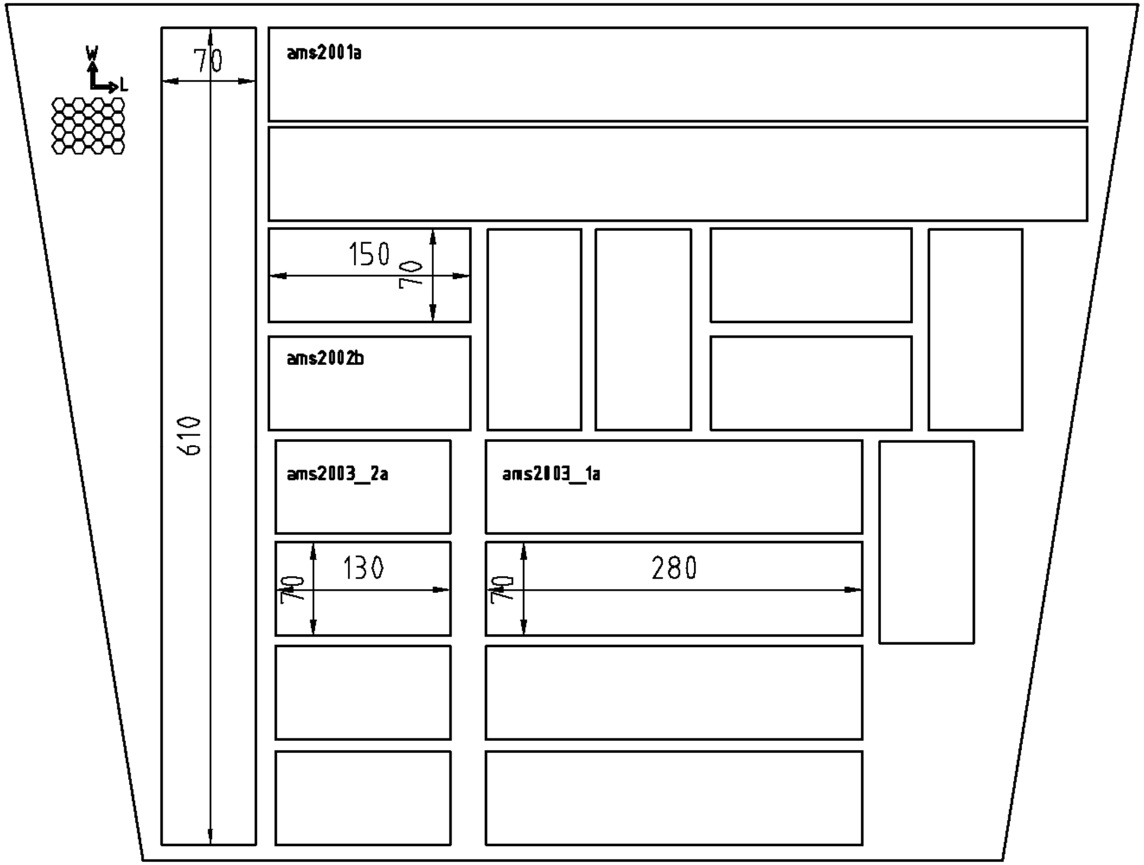
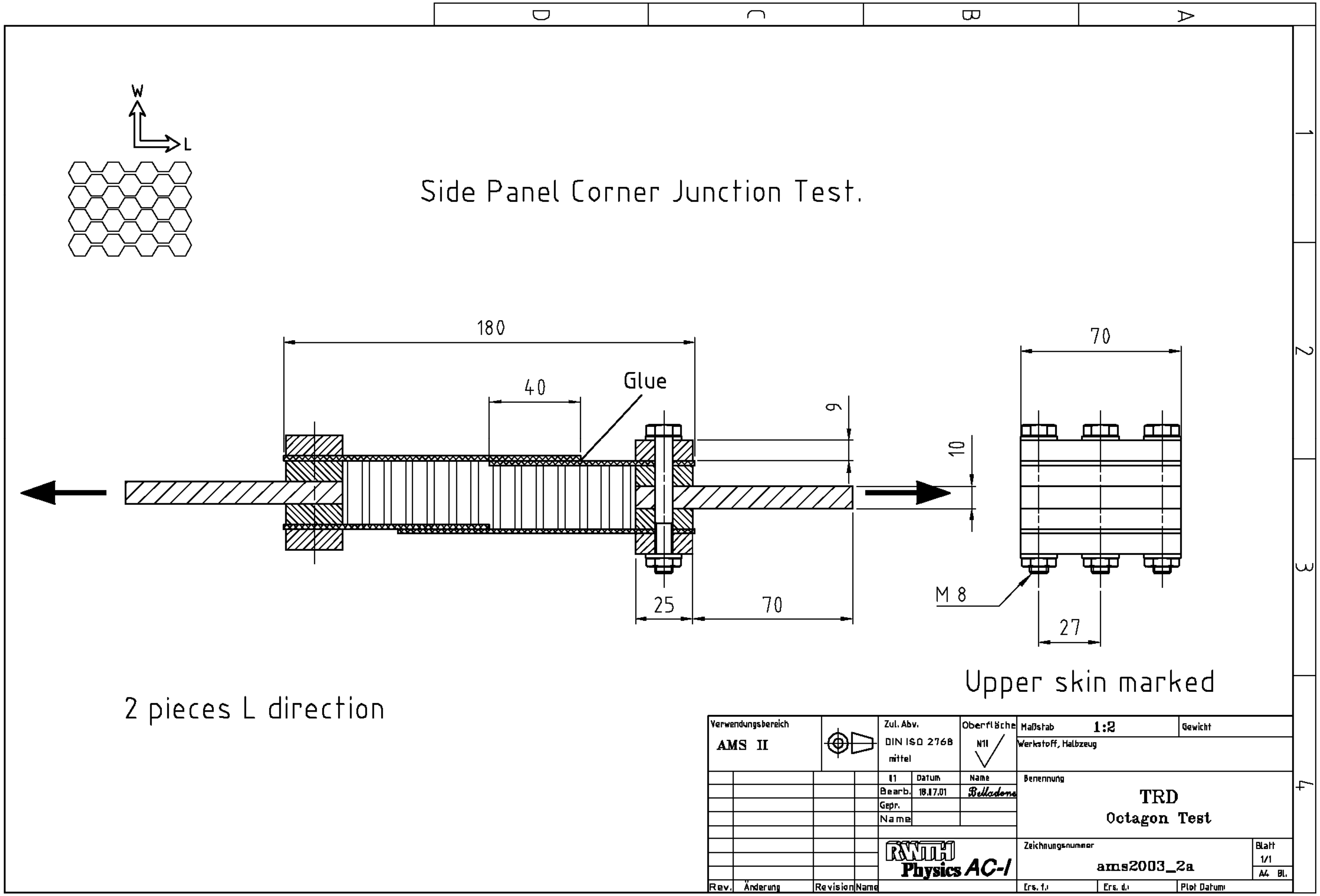
Aachen, 13th January 2009

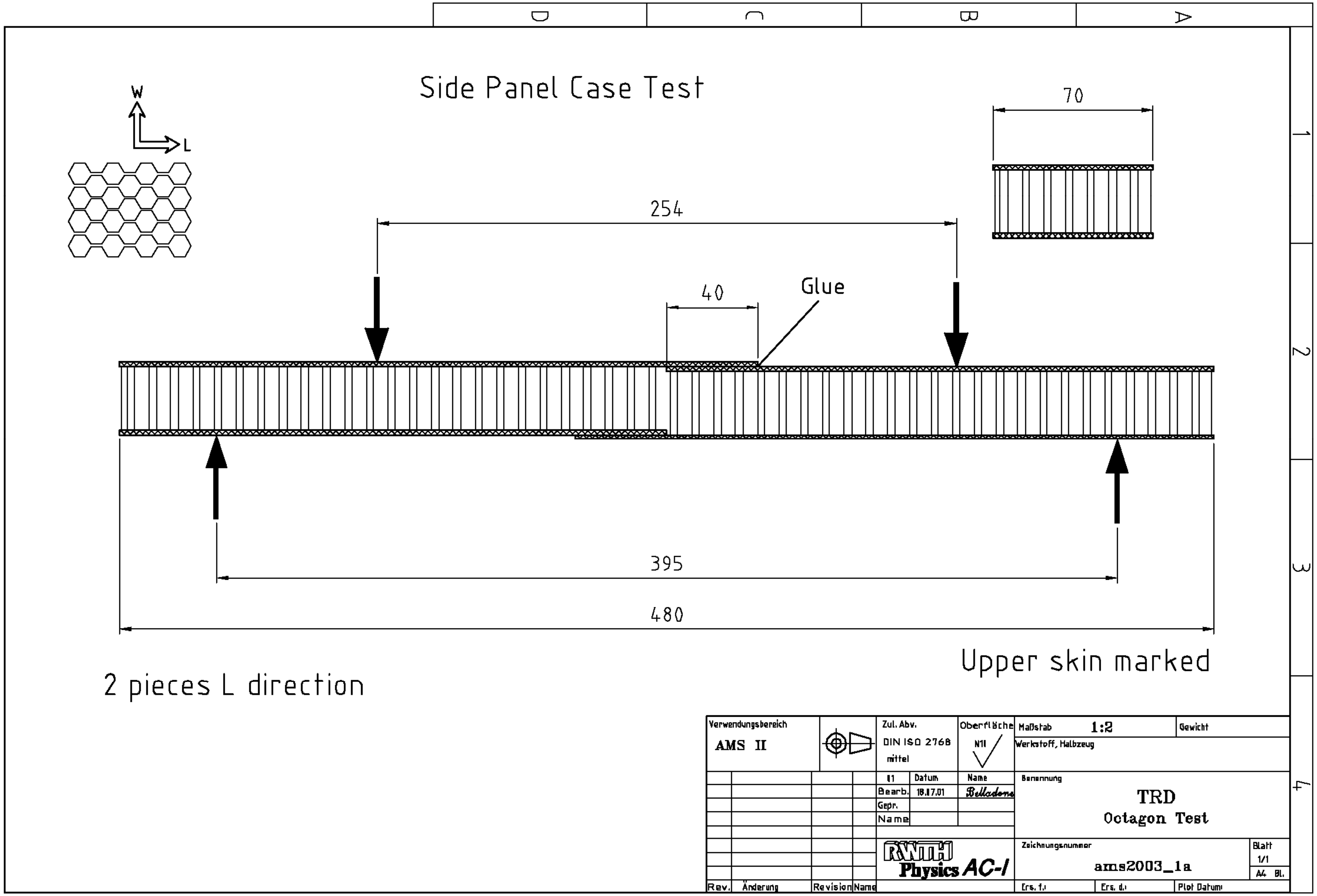
TRD Octagon Support Structure Mechanical Tests

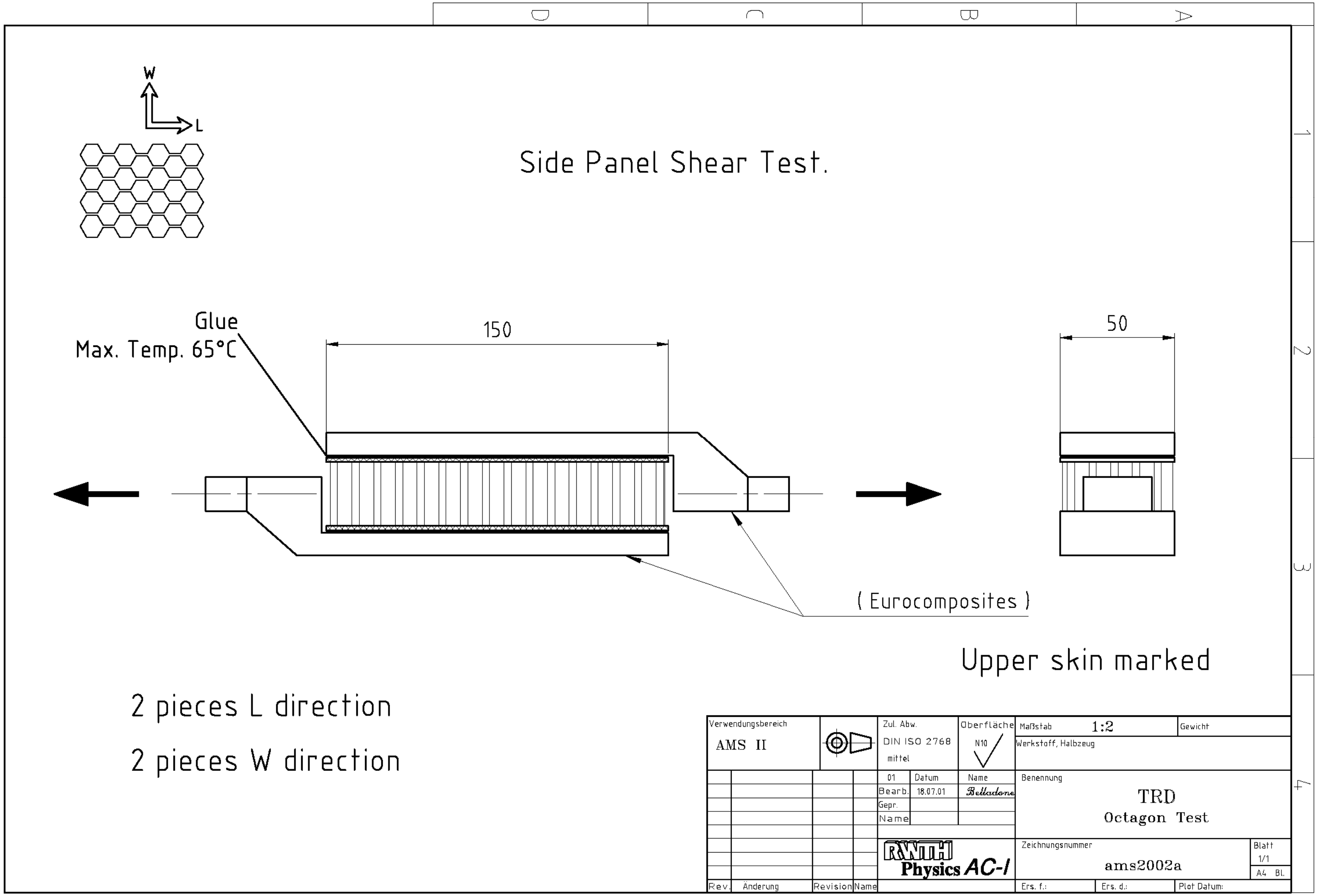
TRD Octagon Support Structure
Octgon Side Panel Tests



Octagon Sidepanel Test Specimen


W
L
Side Panel Corner Junction Test.
180
40
Glue
9
10
70
25
70
M 8
27
Upper skin marked
2 pieces L direction
Verwendungsbereich
AMS II
Zul. Abw.
DIN ISO 2768
mittel
Oberfläche
Maßstab 1:2
Gewicht
Werkstoff, Halbzeug
Datum
Name
Bearb. 18.07.01
Gepr.
Name
Benennung
TRD
Octagon Test
Physics AC-I
Zeichnungsnummer
ams2003_2a
Blatt 1/1
Rev.
Änderung
Revision
Name
Plot Datum


Side Panel Case Test
W
L
70
254
40
Glue
395
480
Upper skin marked
2 pieces L direction
Verwendungsbereich
AMS II
Zul. Abw.
DIN ISO 2768
mittel
Oberfläche
N11
Maßstab 1:2
Gewicht
Werkstoff, Halbzeug
Datum
Name
Bearb. 18.17.01
Gepr.
Name
Benennung
TRD
Octagon Test
Physics AC-I
Zeichnungsnummer
ams2003_1a
Blatt
1/1
A4 Bl.
Rev.
Änderung
Revision
Name
Ers. f.:
Ers. d.:
Plot Datum:


W
L
Side Panel Shear Test.
Glue
Max. Temp. 65°C
150
50
(Eurocomposites)
Upper skin marked
2 pieces L direction
2 pieces W direction
Verwendungsbereich
AMS II
Zul. Abw.
DIN ISO 2768
mittel
Oberfläche
N10
Maßstab
1:2
Gewicht
Werkstoff, Halbzeug
Datum
Name
Bearb.
18.07.01
Gepr.
Name
Benennung
TRD
Octagon Test
Physics AC-I
Zeichnungsnummer
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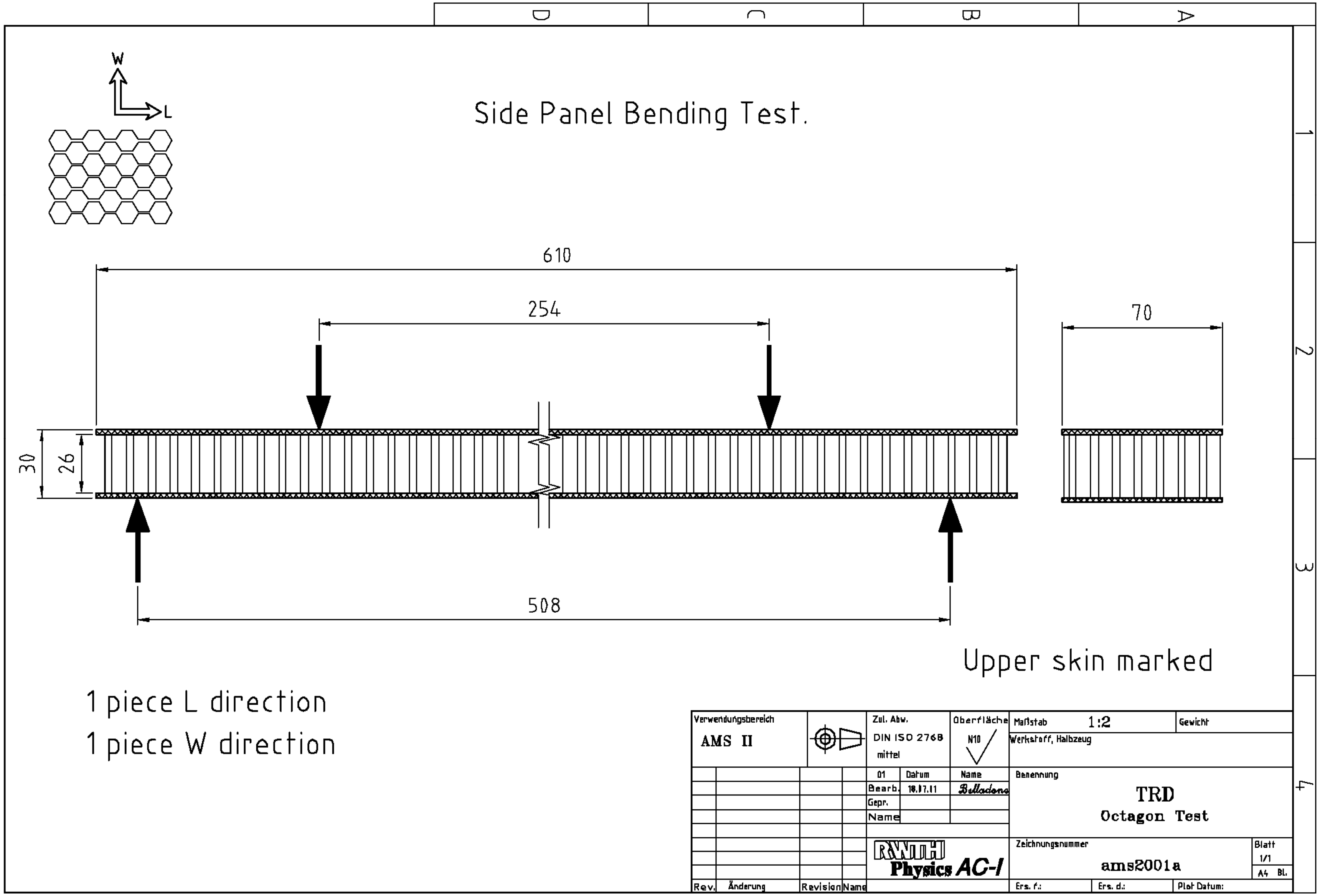
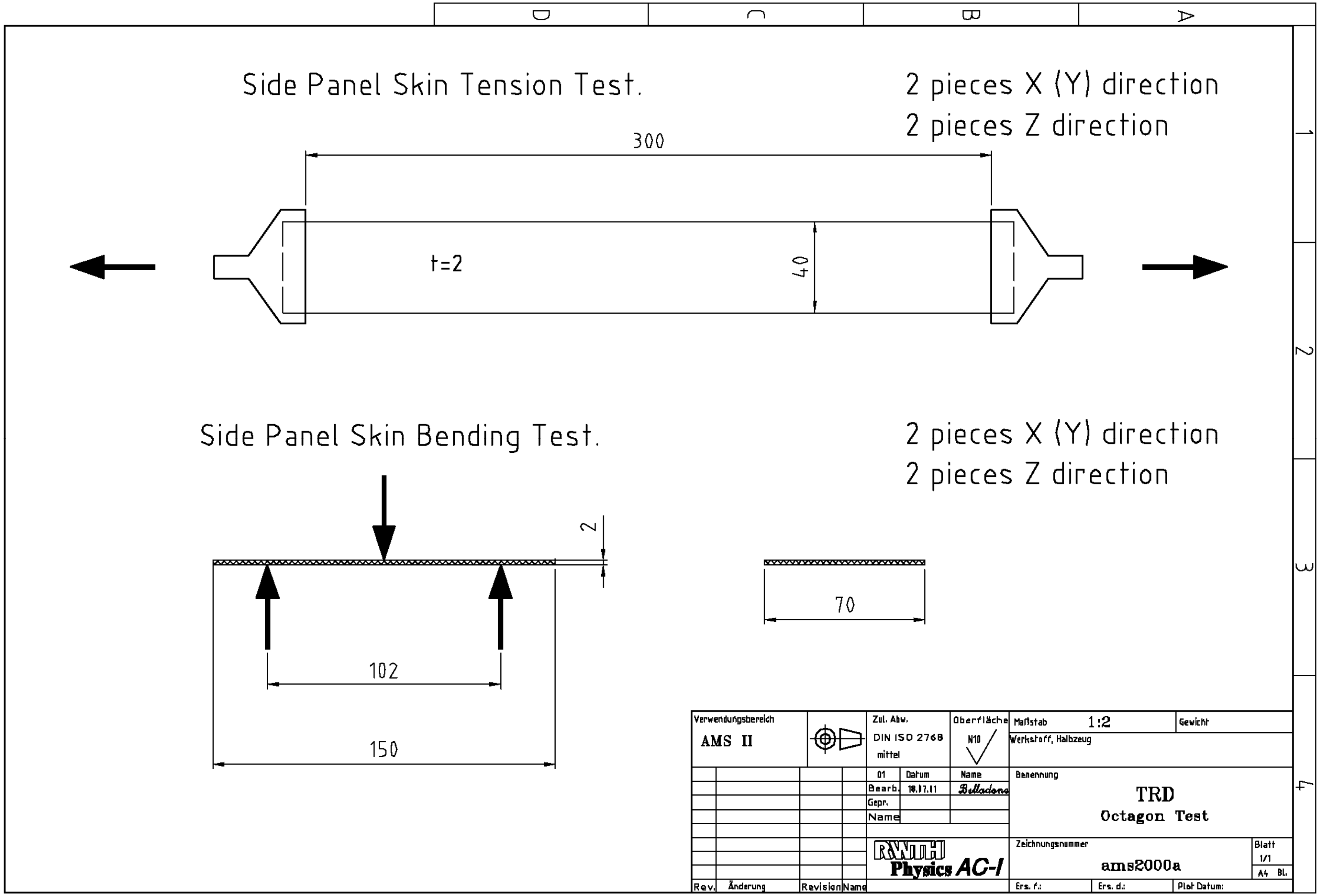
Blatt
1/1
Rev.
Änderung
Revision
Name
Ers. f.:
Ers. d.:
Plot Datum:


Side Panel Bending Test.
W
L
610
254
70
30
26
508
Upper skin marked
1 piece L direction
1 piece W direction
Verwendungsbereich
AMS II
Zul. Abw.
DIN ISO 2768
mittel
Oberfläche
N10
Maßstab
1:2
Gewicht
Werkstoff, Halbzeug
Benennung
TRD
Octagon Test
Zeichnungsnummer
ams2001a
Blatt
1/1
Physics AC-I
Rev.
Änderung
Revision
Name
Datum
Bearb.
Gepr.
Ers. f.:
Ers. d.:
Plot Datum:


Side Panel Skin Tension Test.
2 pieces X (Y) direction
2 pieces Z direction
300
t=2
40
Side Panel Skin Bending Test.
2 pieces X (Y) direction
2 pieces Z direction
2
102
150
70
Verwendungsbereich
AMS II
Zul. Abw.
DIN ISO 2768
mittel
Oberfläche
N10
Maßstab
1:2
Gewicht
Werkstoff, Halbzeug
Datum
Name
Bearb.
Gepr.
Benennung
TRD
Octagon Test
Physics AC-I
Zeichnungsnummer
ams2000a
Blatt
Rev.
Änderung
Revision
Name

AMS-02

Octagon Side Panel Mechanical Tests

	Test Item	Specs.	Drawing #	Test #	Force [N]	Tension [N/mm2]	Modulus [N/mm2]	Defl.(Load) [mm] (450N)	Defl.(Cent.) [mm] (450N)	Defl.(Break) [mm]	Corresponding Calculation Results/ Comments	Model, Method
1.	Skin Tension	AMS-z-Dir.	2000a	S/N 2 / 3	13414 12840 av.13127	Failure Load Failure Load Failure Load					Fiber Volume Fraction Vf=54% (nominal: 60%)	Specimen volume + mass measured with fiber area weight and density of fiber and matrix determination of fiber volume fraction
	#1 lead to fibre volume fraction of Vf=54%											
2.	Skin Tension	AMS-x-y-Dir.	2000a	S/N 1 / 4	68418 59468 av.63943	Failure Loac Failure Load Failure Load					Max. Stress in Fiber Direction: >1350 MPa (1000 MPa conservatively used for strength assessment in structural verification)	FE-Model w/ Laminate with Individual Layers with Orthotropic Material of Vf=54% , *Tension* Load of 63943N used in FEA; Layerwise Postprocessing
	#2 lead to ultimate tensile strength of Ftu=1350 MPa, which would increase the MoS in the TRD SVP Rev.2, where 1000MPa were used											
3.	Skin Bending	AMS-x-y-Dir.	2000a	S/N 5 / 6	1922 1987 av.1955					9.2 9.6 av.9.4	Reaction F.=1607N (82%)	FE-Model w/ Laminate, Orthotropic Material of Vf=54% ,*Imposed Displacement 9,4mm*, Reaction Force Evaluated
	#3 result: Stiffness of the Overall TRD FE-Model is on the Conservative Side (Vf is therefore higher than 54%)											
4.	Skin Bending	AMS-z-Dir.	2000a	S/N 7 / 8	946 951 av.949					7.2 11.1 av.9.2	Reaction F.=985N (104%)	FE-Model w/ Laminate, Orthotropic Material of Vf=54% ,*Imposed Displacement 9,2mm*, Reaction Force Evaluated
	#4 result: The FE-Model Result matches within the Error Bounds with the Experimental Results											
5.	Panel-Shear	L-Dir. (AMS-x-y-Dir.)	2002a	S/N 13 / 14		1.30 1.42 av.1.36	197.2 210.2 av.203.6				Overall Shear Modulus of Sandwich Panel	
6.	Panel-Shear	W-Dir. (AMS-z-Dir.)	2002a	S/N 11 / 12		0.83 0.82 av.0.83	117.3 112.9 av.115.1				Overall Shear Modulus of Sandwich Panel	
	#5&6 result: The resulting Global Shear Values are not used in the FE-Model											
7.	Core -Shear	L-Dir. (AMS-x-y-Dir.)				1.67 1.66 av.1.67	341.3 255.8 av.298.6				Elastic Properties of HC Core	G_{LT}=299MPa (nominal: 315 MPa)
	#7 result: The Nominal Value of 315 MPa in the FE-Model is in Agreement with the Measured Range											
8.	Core -Shear	W-Dir. (AMS-z-Dir.)				0.96 1.04 av.1.00	143.9 150.3 av.147.1				Elastic Properties of HC Core	G_{WT}=147MPa (nominal: 138 MPa)
	#8 result: The Nominal Value of 138 MPa in the FE-Model is within Errors of the Measured Range											

050624 AMS 02 TRD-Side Panel Test plus Strength.xls K.L.28.10.200712:12

	Test Item	Specs.	Drawing #	Serial #	Force [N]	Tension [N/mm2]	Modulus [N/mm2]	Defl.(Load) [mm] (450N)	Defl.(Cent.) [mm] (450N)	Defl.(Break) [mm]	Corresponding Calculation Results/ Comments	Model, Method
9.	Panel Bending	L(508)-Dir. (AMS-x-y-Dir.)	2001a	S/N 9 / 10	5713 6134 av.5924	Failure Load Failure Load Failure Load		0.2 0.3 av.0.3	0.3 0.3 av.0.3	2.3 2.4 av.2.4		Core Failure
10.	Panel Bending (Overlap)	L(395)-Dir. (AMS-x-y-Dir.)	2003-1a	S/N 15 / 16	5689 5979 av.5834	Failure Load Failure Load Failure Load		0.2 0.3 av.0.3	0.1 0.1 av.0.1	0.9 0.8 av.0.9	W/ Glued Connection Same Force Level as no. 9 !	Core Failure
	#9&10 result: The Failure Load With and Without Overlap is Identical											
11.	Panel Corner Junction	L-Dir. (AMS-x-y-Dir.)	2003-2a	S/N 17 / 18	45296 54730 av.50013						Ultimate Average Shear Stress: 8,9 MPa (= 50013N / 5600mm²)	Shear Stress handcalculated, value represents lower bound due to overall failure
	#11 result: Overall Failure Load Limited by Failure in Fixation Holes (compared to #2) #2: Area=2x40=80mm² --> Nominal Stress = Force/Area = 63943N/80mm²=870 MPa #11: Area=2x2x70=240mm² --> Nominal Stress = Force/Area = 50013N/240mm²=208 MPa											

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TRD Octagon Support Structure
Side Panel Pull Test

RHEINISCH-
WESTFÄLISCHE
TECHNISCHE
HOCHSCHULE
AACHEN

Ist Physics Institute B

Klaus Lübelsmeyer
Arndt Schultz von Dratzig
2005/03/15

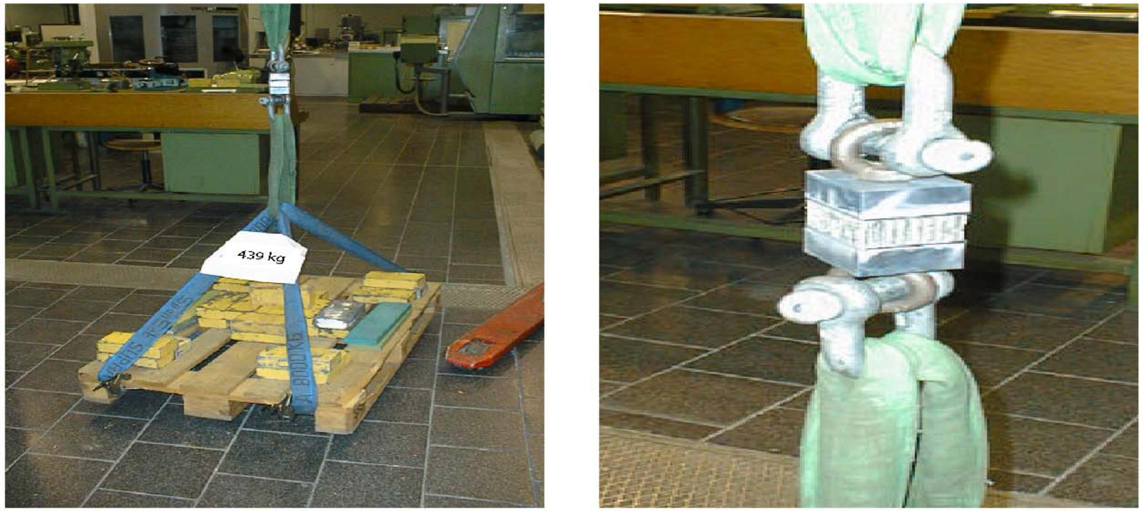
Pull Test of Honeycomb Panels

Two kinds of honeycomb panels have been tested

- TRD octagon side panels
- TRD Tracker plate 1 panel

The side panels have core material made of type Hexel 1/8-5056-0.0007P. It is perforated. The panels have holes on the outside of the octagon 1 mm in diameter to enable venting of the core. The plate 1 panel of the tracker has honeycomb type Hexel 3/16-5056-0.001P. It is perforated too and the circumference is not closed hermetically.
Since a theoretical model for the venting procedure during ascension of the shuttle is extremely difficult because numerous assumptions have to be made concerning the venting channels and possible obstructions another approach to solve the problem was chosen.

1. A sample cut-off of the TRD octagon side panel with dimensions 50 mm by 60 mm was glued at both faces to two pieces of aluminum of same dimensions. One of these aluminum pieces was hooked to a crane the other one carried a wooden pallet on to which bricks of lead were loaded. The experiment was finished at a mass of 439 kg. Until this load no failure could be recognized (see Fig. 1).



(a) Total Sight of Pull Experiment

(b) Detail of Pull Experiment

Figure 1: Pull Test Experiment of TRD Octagon Panels

As a worst case the honeycomb is assumed not to be vented at all. Then inside the honeycomb cells there is a pressure of (inside 1 bar, outside 0 bar)

$$P = 0.1\,\mathrm{N/mm^2}$$

Thus a force of

$$F = P \cdot 50 \cdot 60 = 300\,\mathrm{N}$$

acts on the face sheets of the honeycomb. On the other hand the applied load of $439\,\mathrm{kg} \cdot 9.81\,\mathrm{m/s^2} = 4306\,\mathrm{N}$, i.e. $\sigma = 4306/3000 = 1.44\,\mathrm{N/mm^2}$, leads to a minimum margin of safety of (assuming the applied load as ultimate load and using a safety factor of 2)

$$MS = \frac{1.44}{2 \cdot 0.1} - 1 = 6.2$$

(a) Total Sight of Pull Experiment

(b) Detail of Pull Experiment

Figure 2: Pull Test Experiment of Tracker Plates 1 and 5

-

2. For the honeycomb panels of the upper and lower plates of the tracker a similar sample cut-off of dimensions 50 mm × 60 mm has been tested showing no failure up to a load of 500 kg (see Fig. 2). In accordance with the above procedure this leads to a margin of safety of

$$MS = \frac{1.64}{2 \cdot 0.1} - 1 = 7.2$$

TRD Octagon Support Structure Side Panel Static Load Test

AMS02 TRD
TRD Octagon Panel
Static Load Test

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19 - 23 Jan 2004

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19 Jan 04

Folie 1

Octagon Panel Static Load Test

Acoustic Load	9,0 g
Static Load	5,7 g
Total Load	**10,7 g**
Mass of Panel	4,9 kg
Add. Static Load	**47,5 kg**

19 Jan 04 Overview Slide 2

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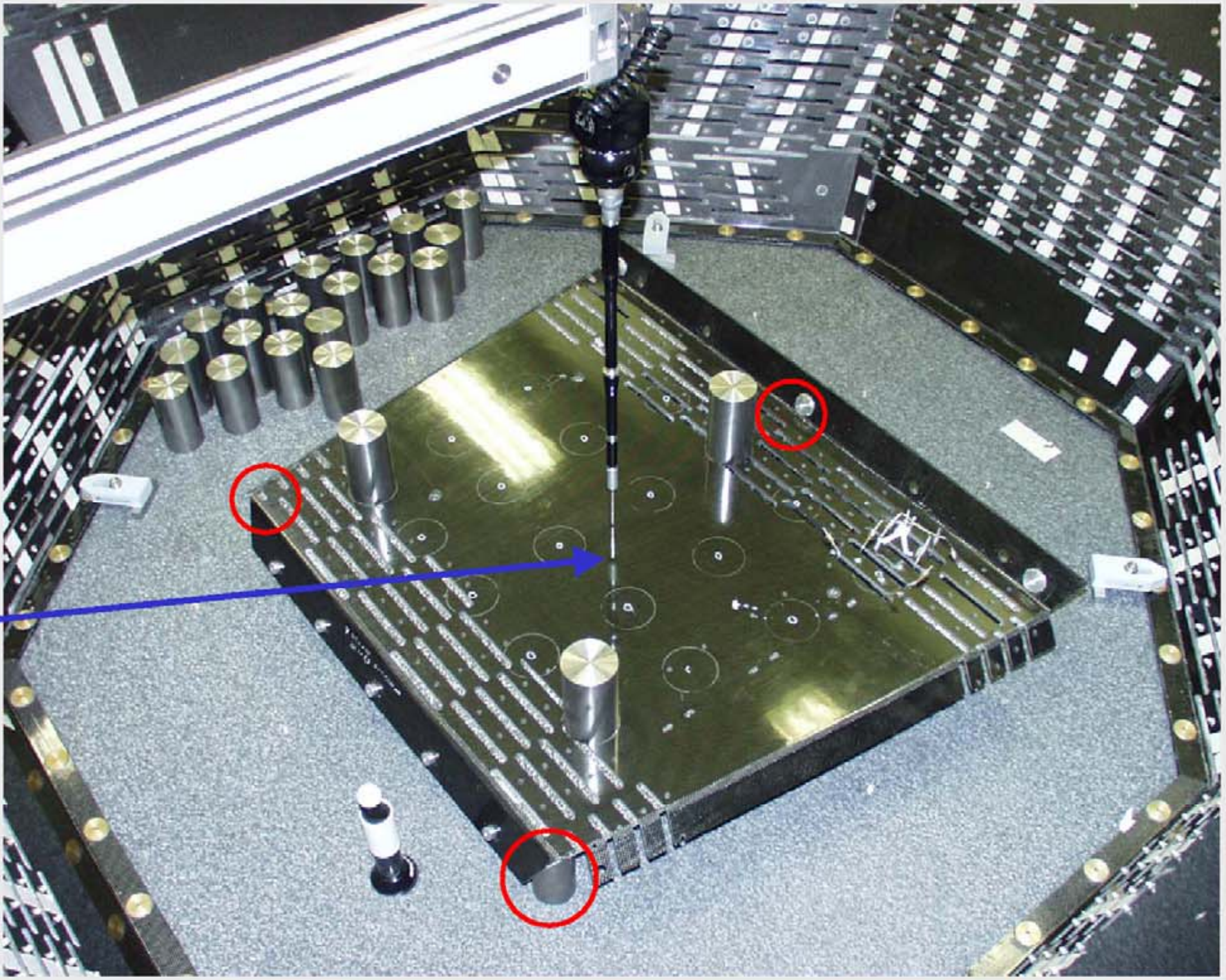

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Load Case 3/20 w/ Support Points

Slide 3

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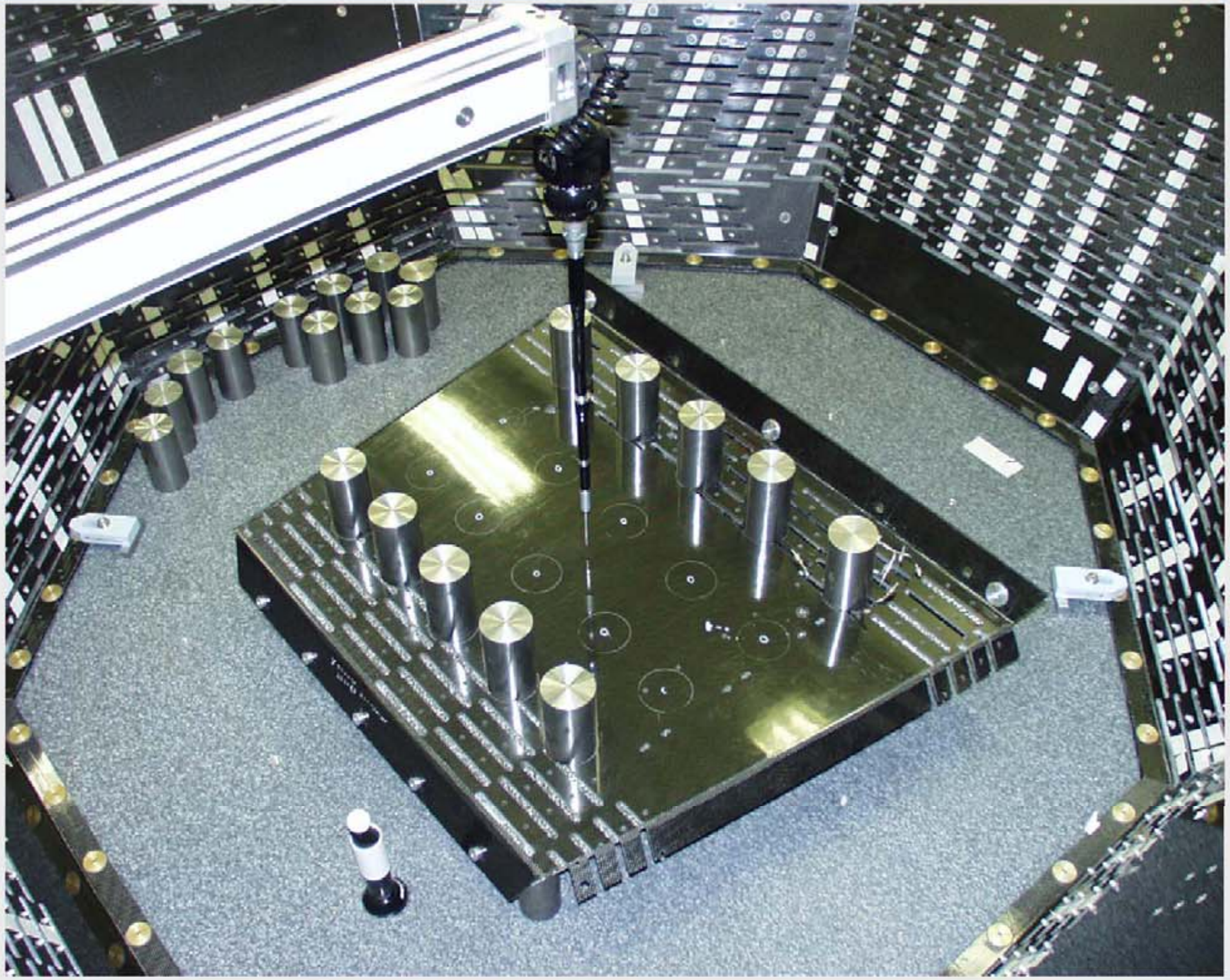

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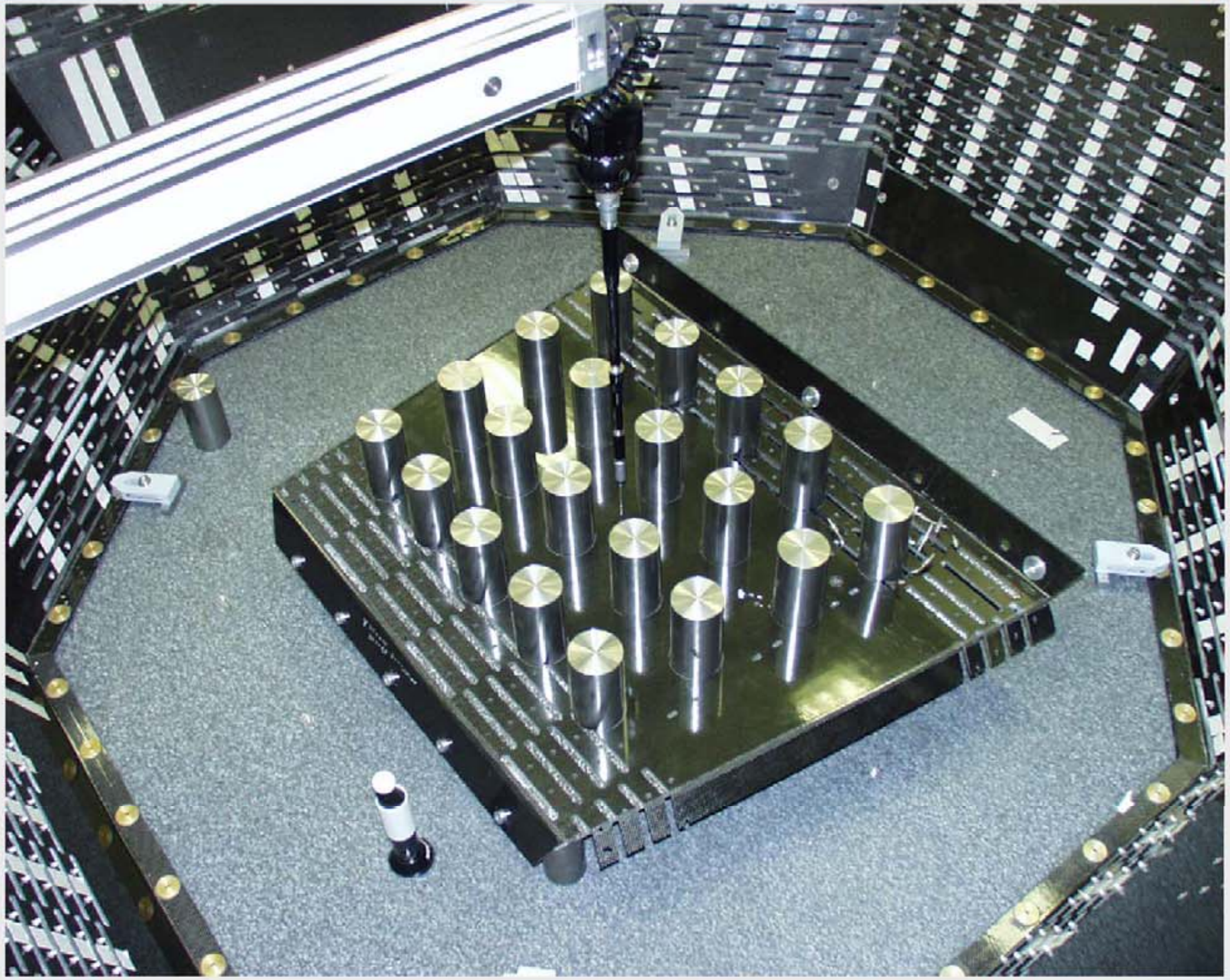
19 Jan 04

Load Case 10/20

Slide 4



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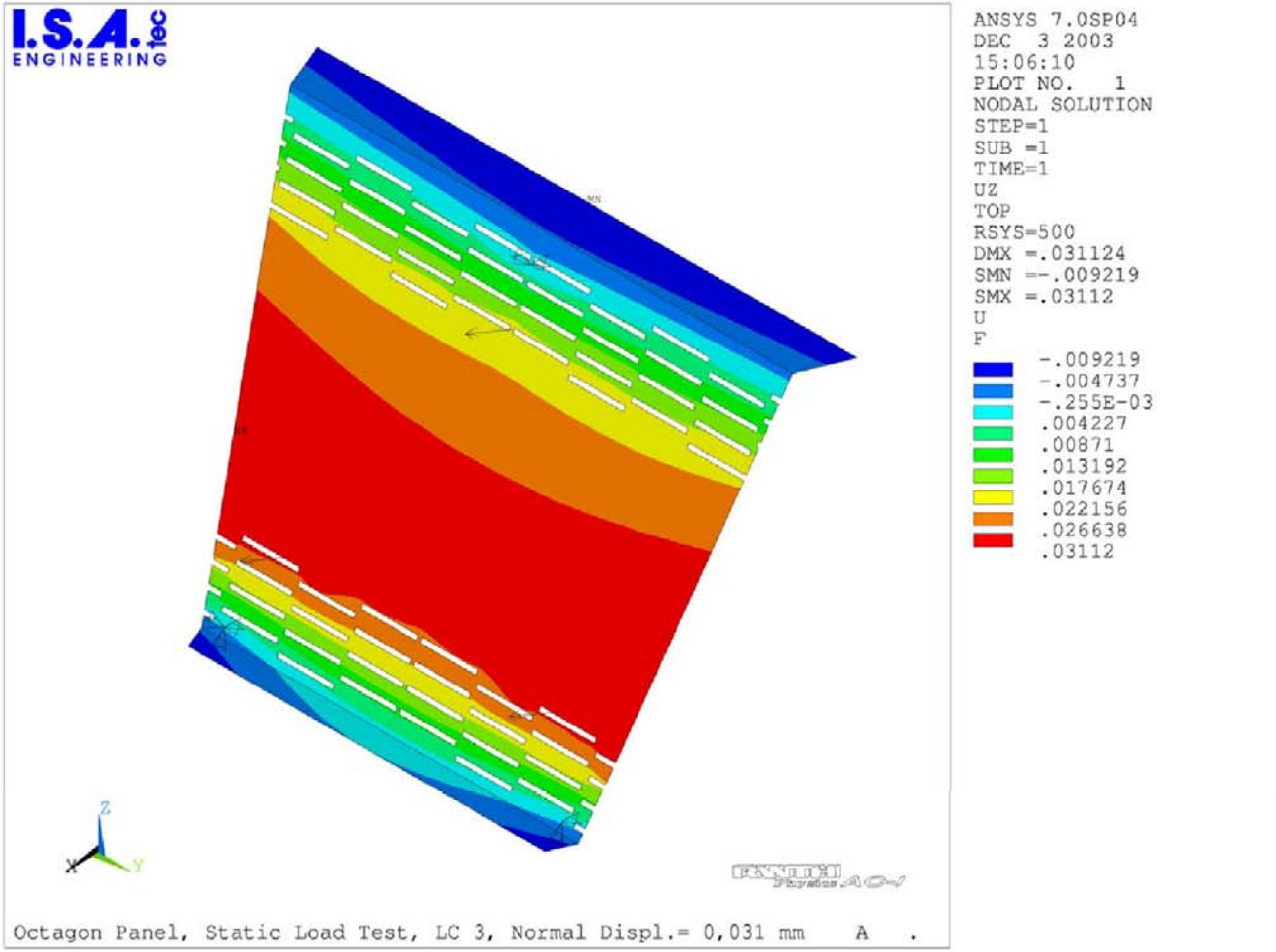
19 Jan 04

Load Case 20/20

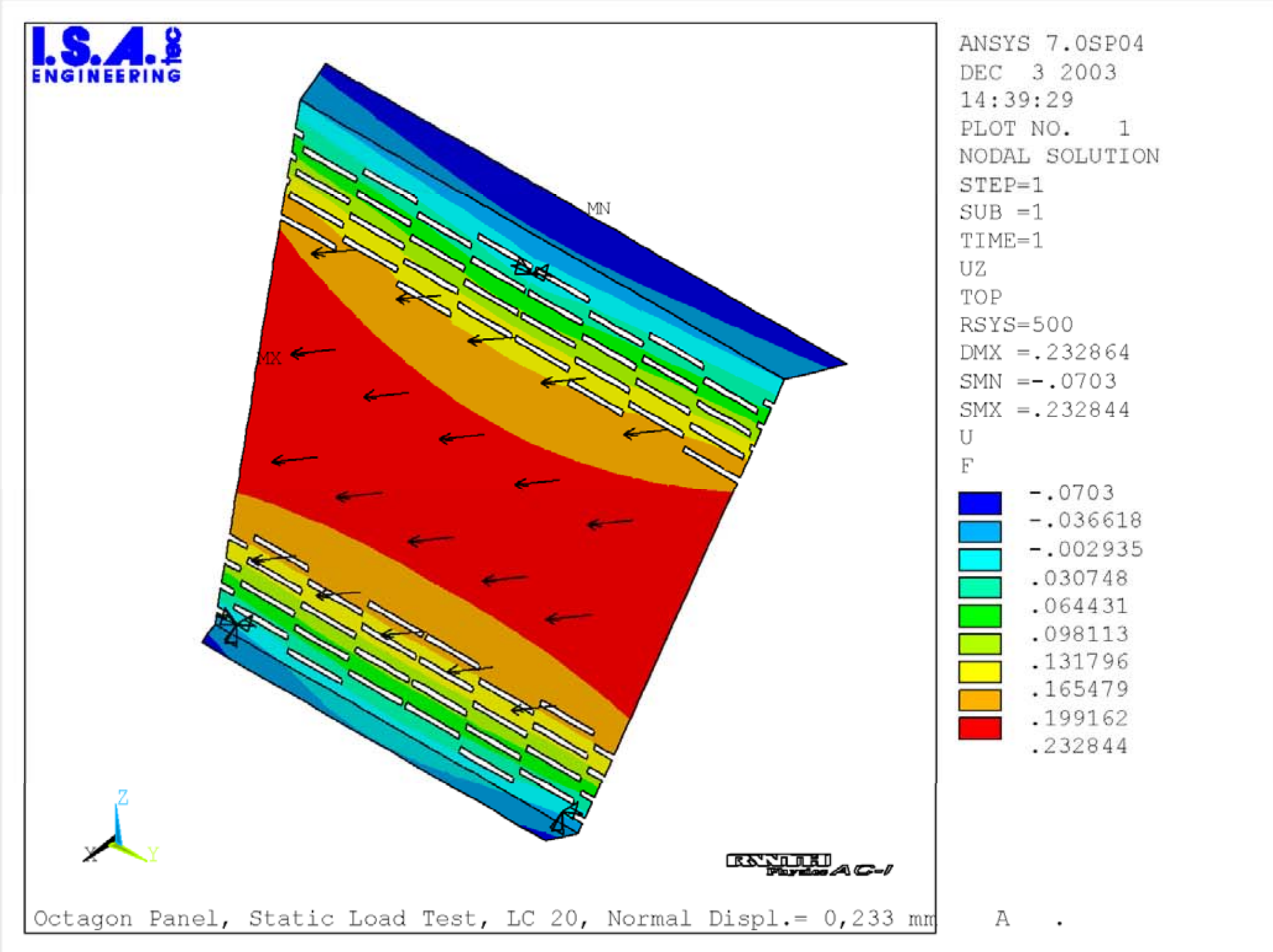
Slide 5



19 Jan 04

FEA w/ Load Case 3/20

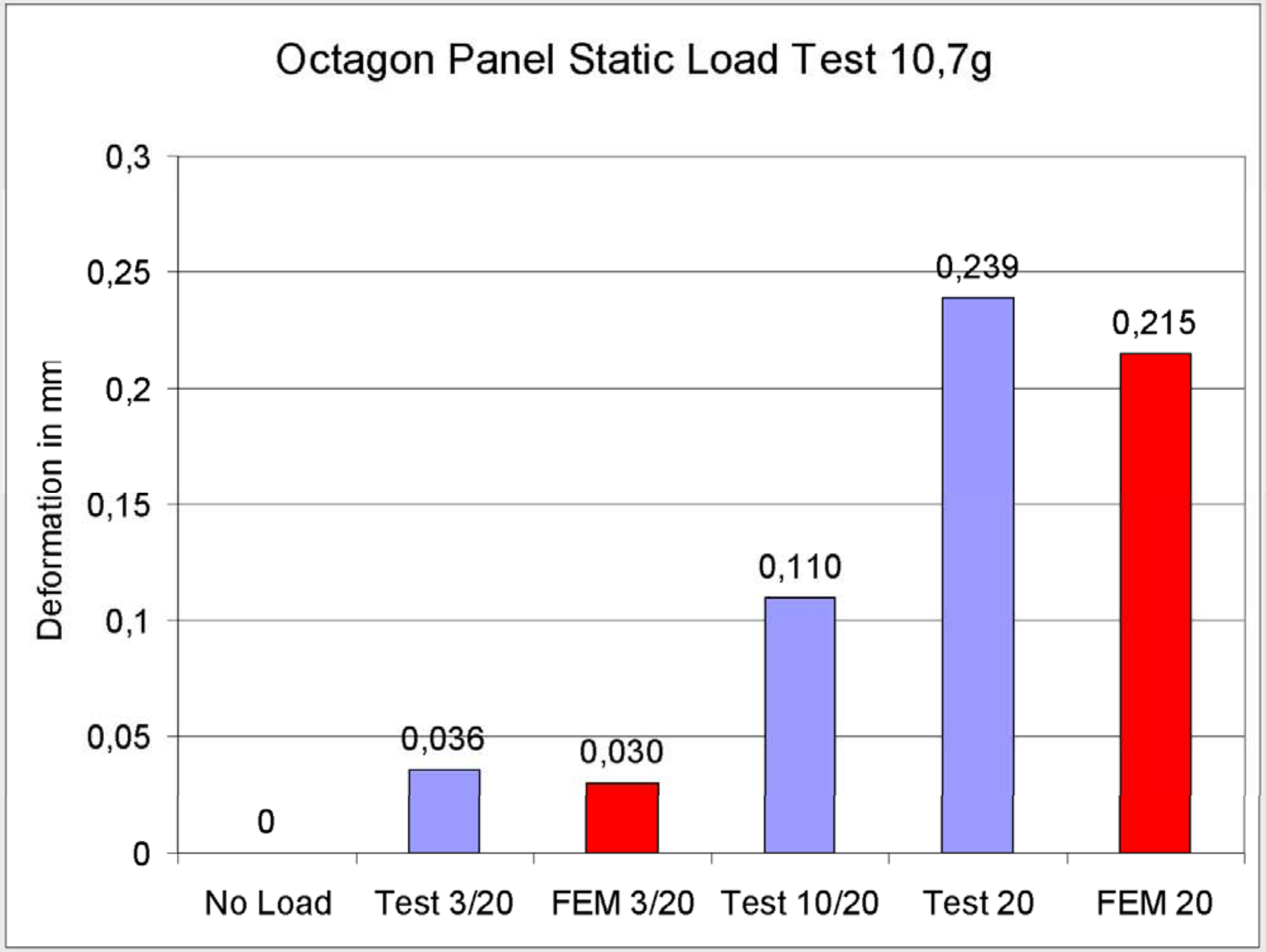
Slide 6



19 Jan 04

FEA w/ Load Case 20/20

Slide 7

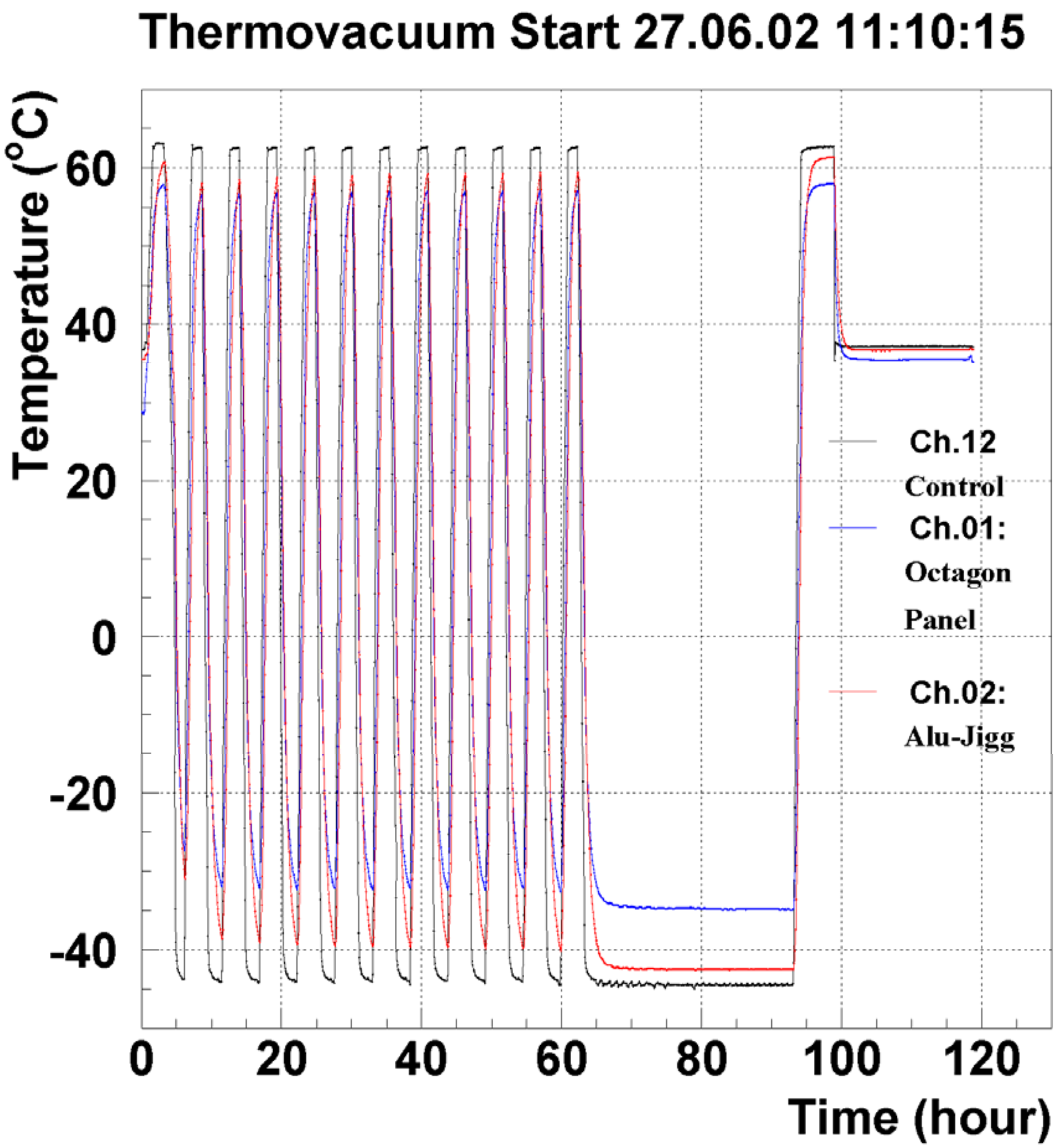


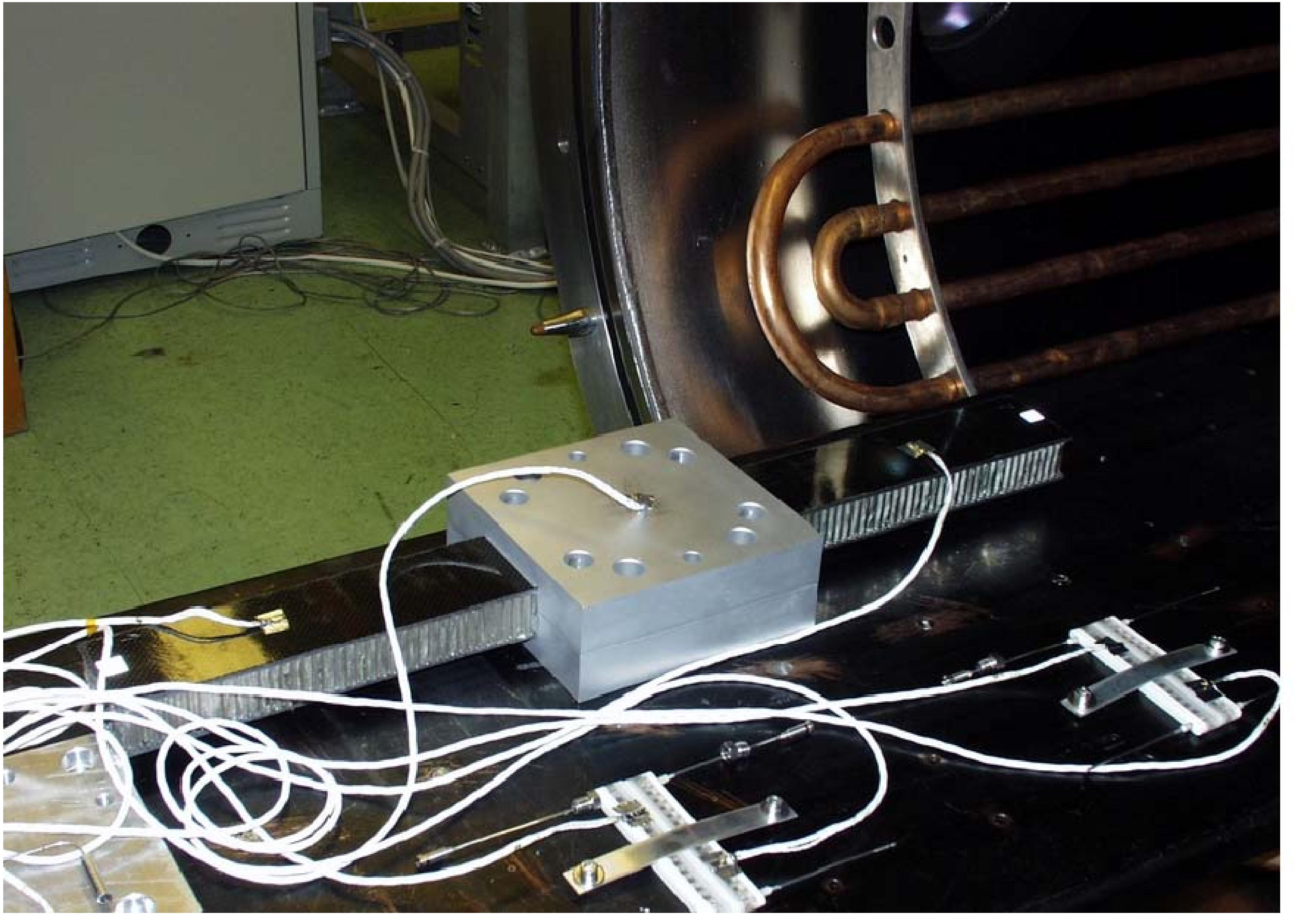
19 Jan 04

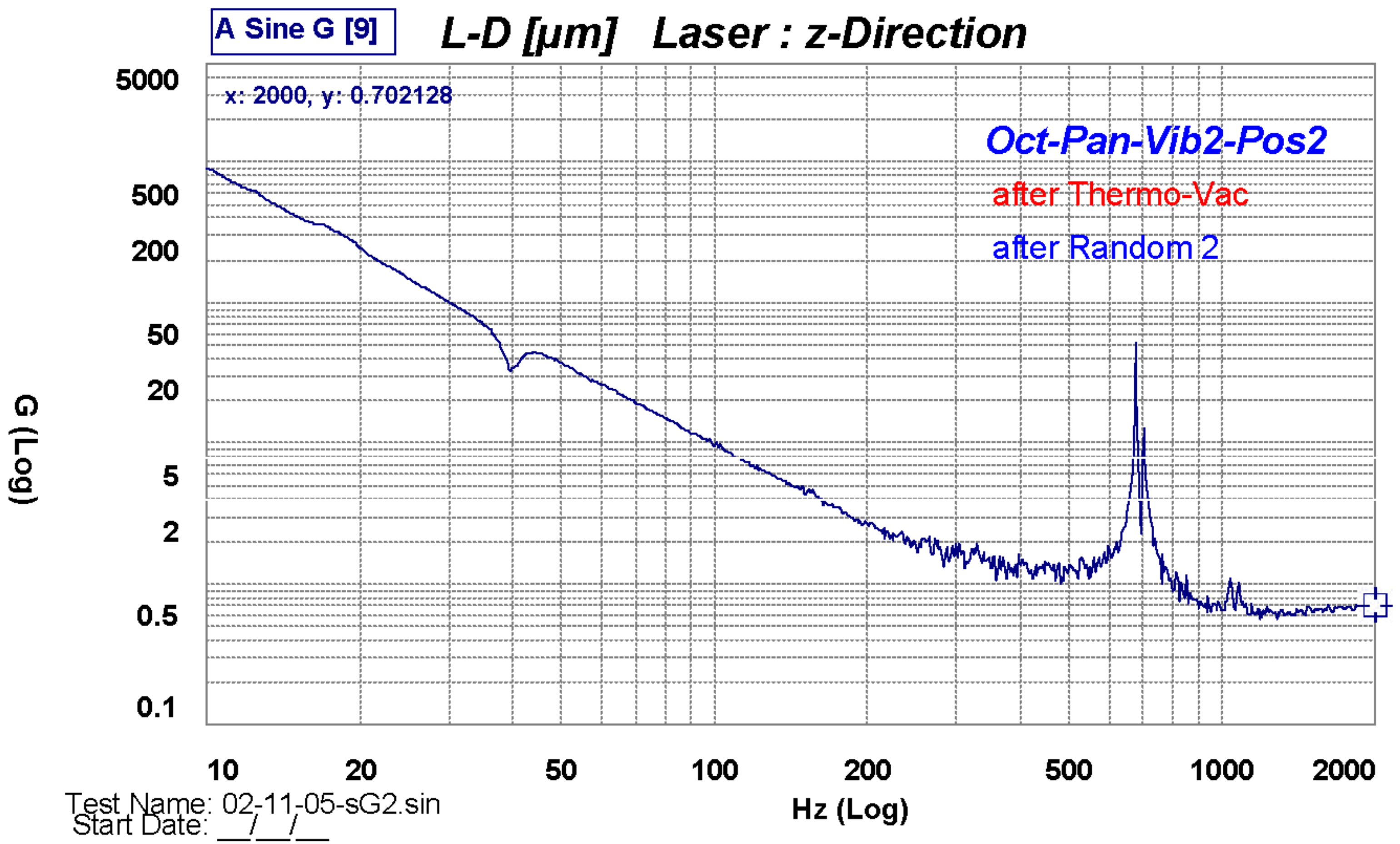
Results & Comparison

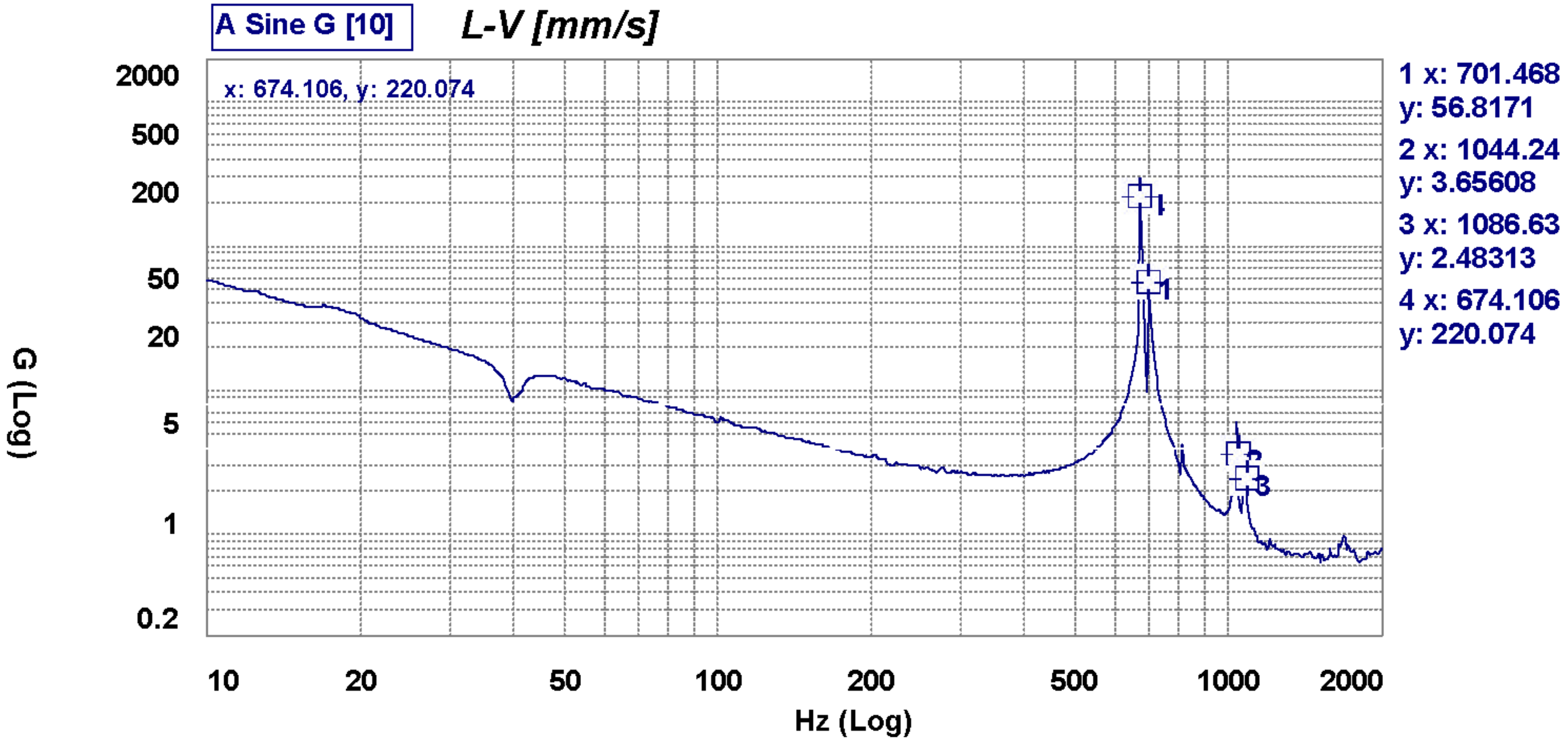
Slide 8

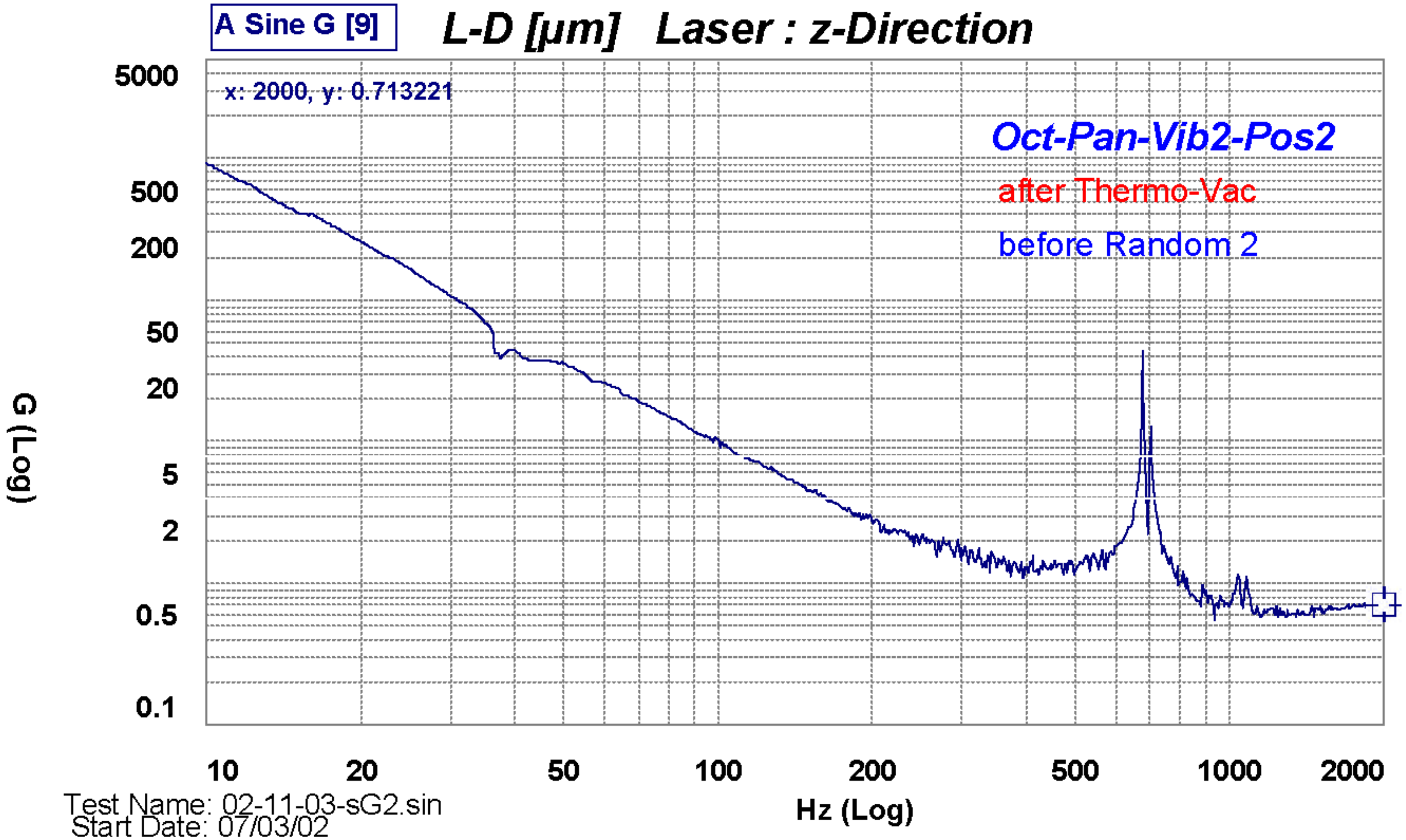
TRD Octagon Support Structure
Side Panel Vibration Tests

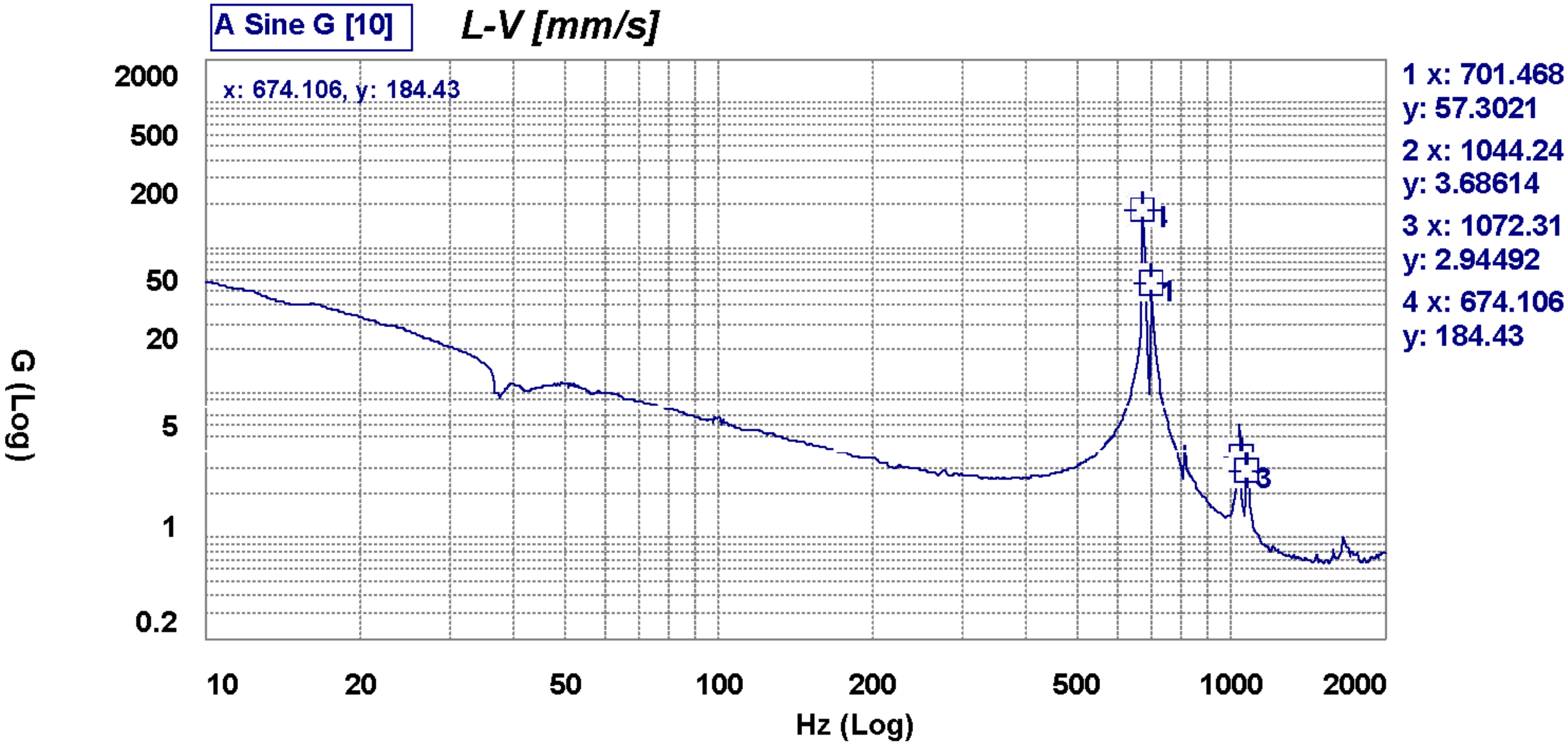

Thermovacuum Start 27.06.02 11:10:15
Temperature (°C)
60
40
20
0
-20
-40
0
20
40
60
80
100
120
Time (hour)
Ch.12
Control
Ch.01:
Octagon
Panel
Ch.02:
Alu-Jigg

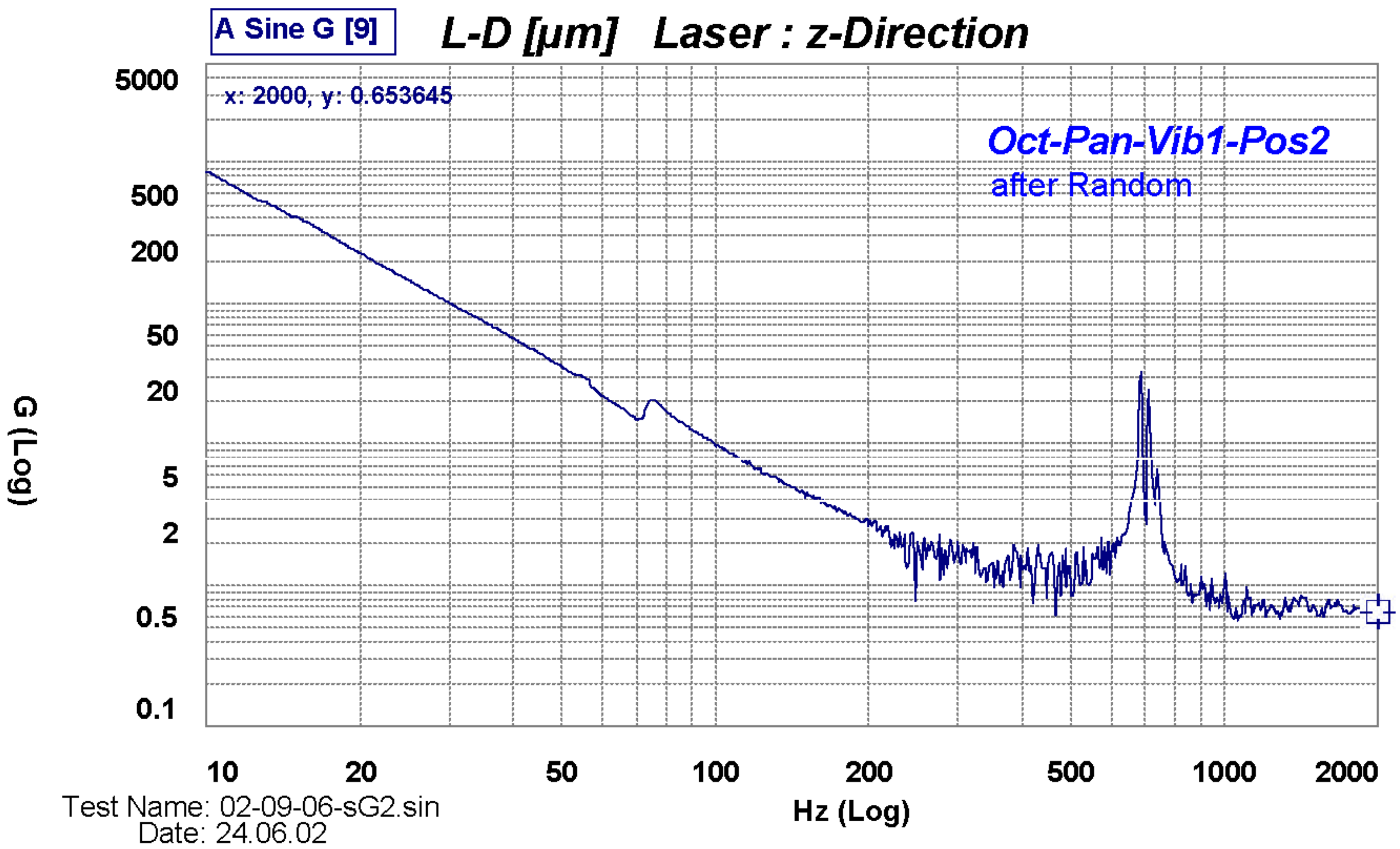



A Sine G [9]
L-D [µm] Laser : z-Direction
x: 2000, y: 0.702128
Oct-Pan-Vib2-Pos2
after Thermo-Vac
after Random 2
5000
500
200
50
20
5
2
0.5
0.1
G (Log)
10
20
50
100
200
500
1000
2000
Hz (Log)
Test Name: 02-11-05-sG2.sin
Start Date: __/__/__

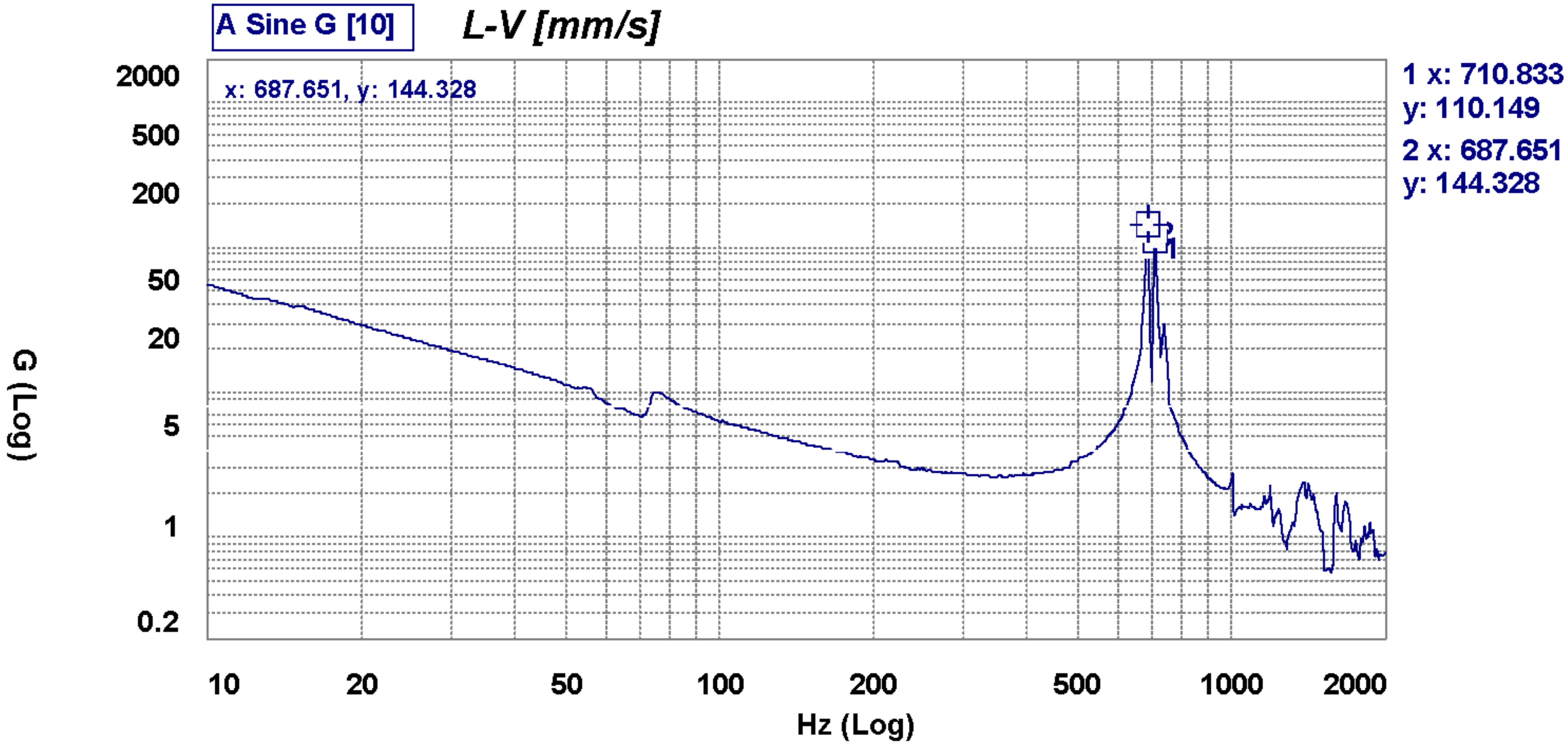

A Sine G [10]
L-V [mm/s]
x: 674.106, y: 220.074
1 x: 701.468
y: 56.8171
2 x: 1044.24
y: 3.65608
3 x: 1086.63
y: 2.48313
4 x: 674.106
y: 220.074
2000
500
200
50
20
5
1
0.2
G (Log)
10
20
50
100
200
500
1000
2000
Hz (Log)

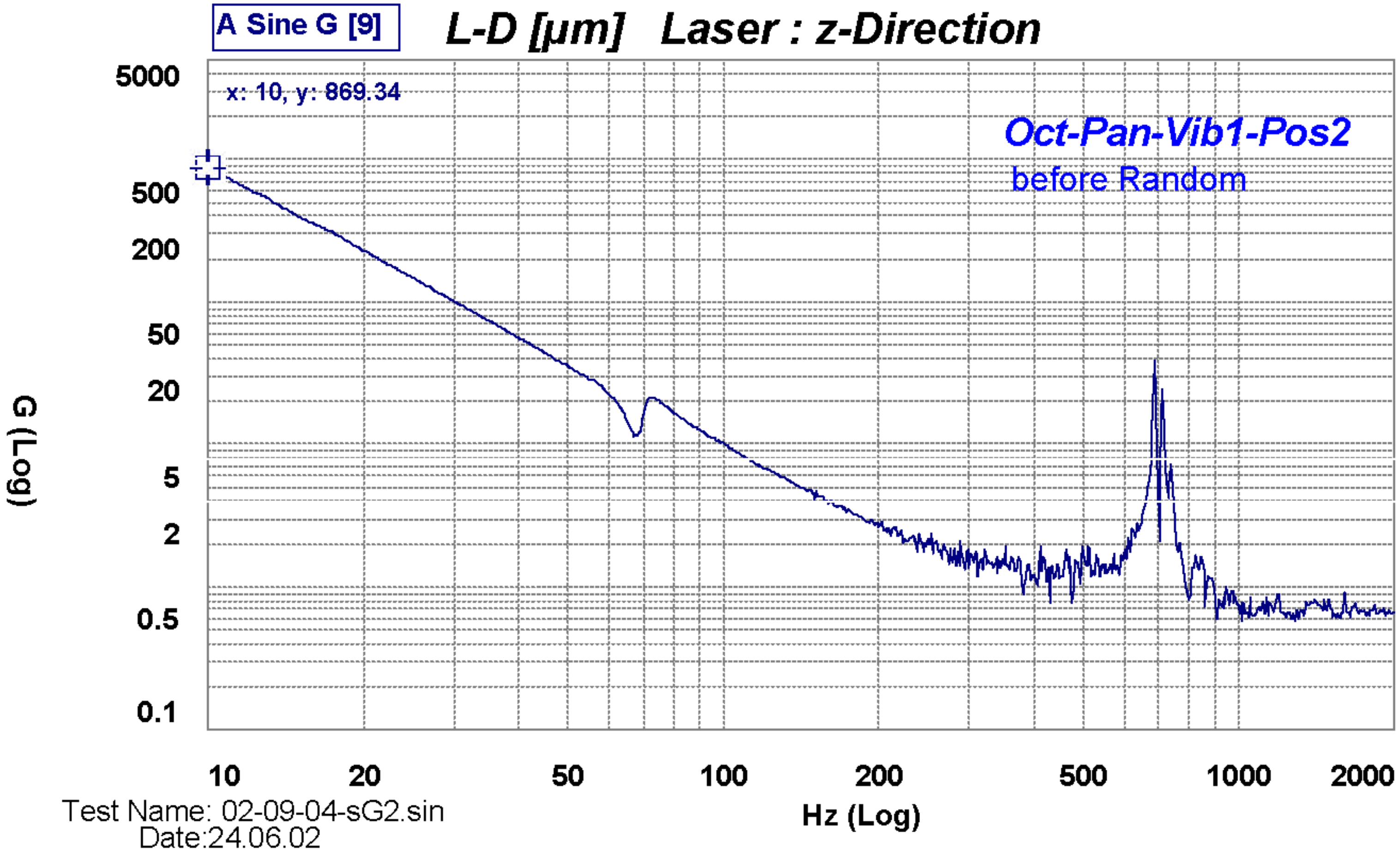

A Sine G [9]
L-D [µm] Laser : z-Direction
x: 2000, y: 0.713221
Oct-Pan-Vib2-Pos2
after Thermo-Vac
before Random 2
5000
500
200
50
20
5
2
0.5
0.1
G (Log)
10
20
50
100
200
500
1000
2000
Hz (Log)
Test Name: 02-11-03-sG2.sin
Start Date: 07/03/02

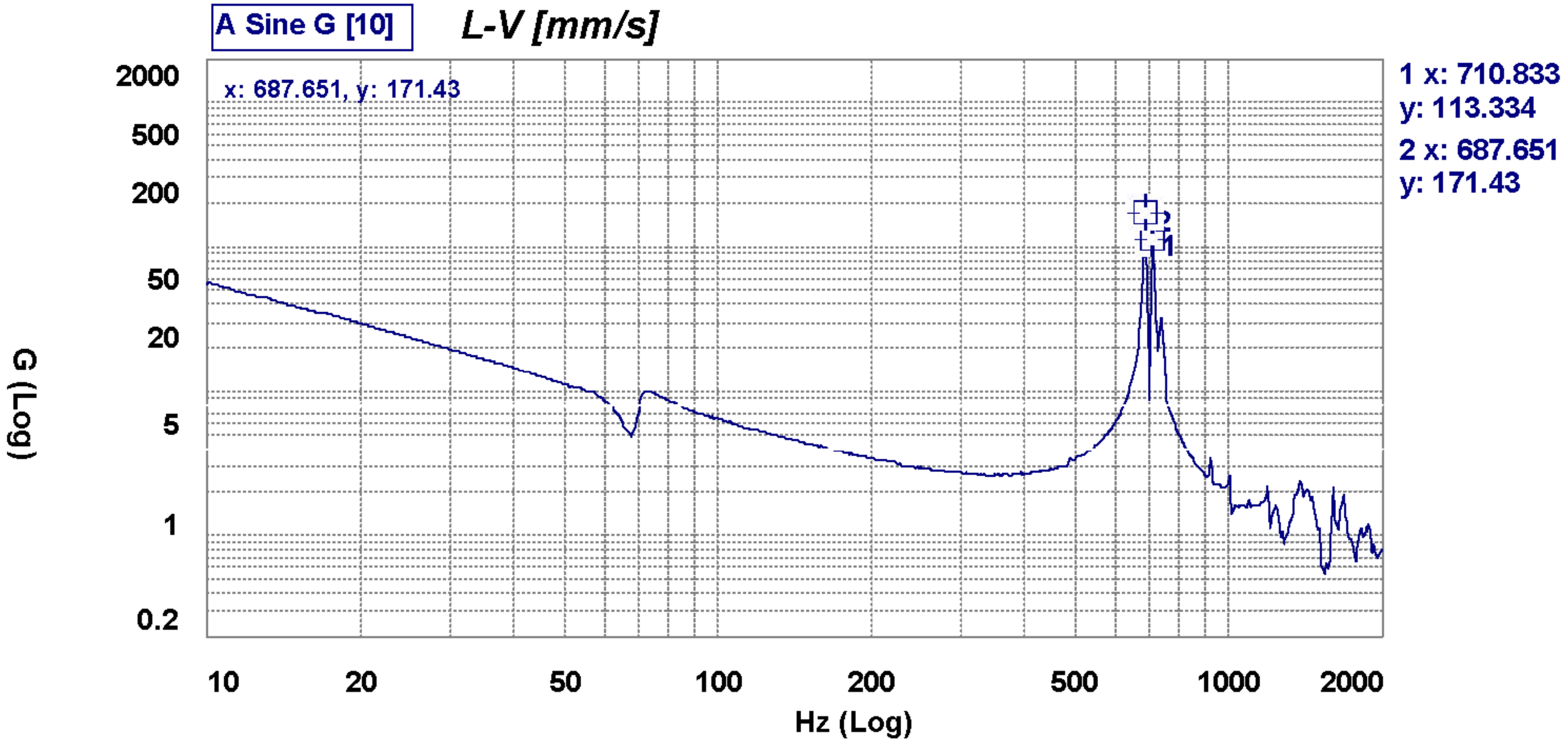

A Sine G [10]
L-V [mm/s]
x: 674.106, y: 184.43
2000
500
200
50
20
5
1
0.2
G (Log)
10
20
50
100
200
500
1000
2000
Hz (Log)
1 x: 701.468
y: 57.3021
2 x: 1044.24
y: 3.68614
3 x: 1072.31
y: 2.94492
4 x: 674.106
y: 184.43



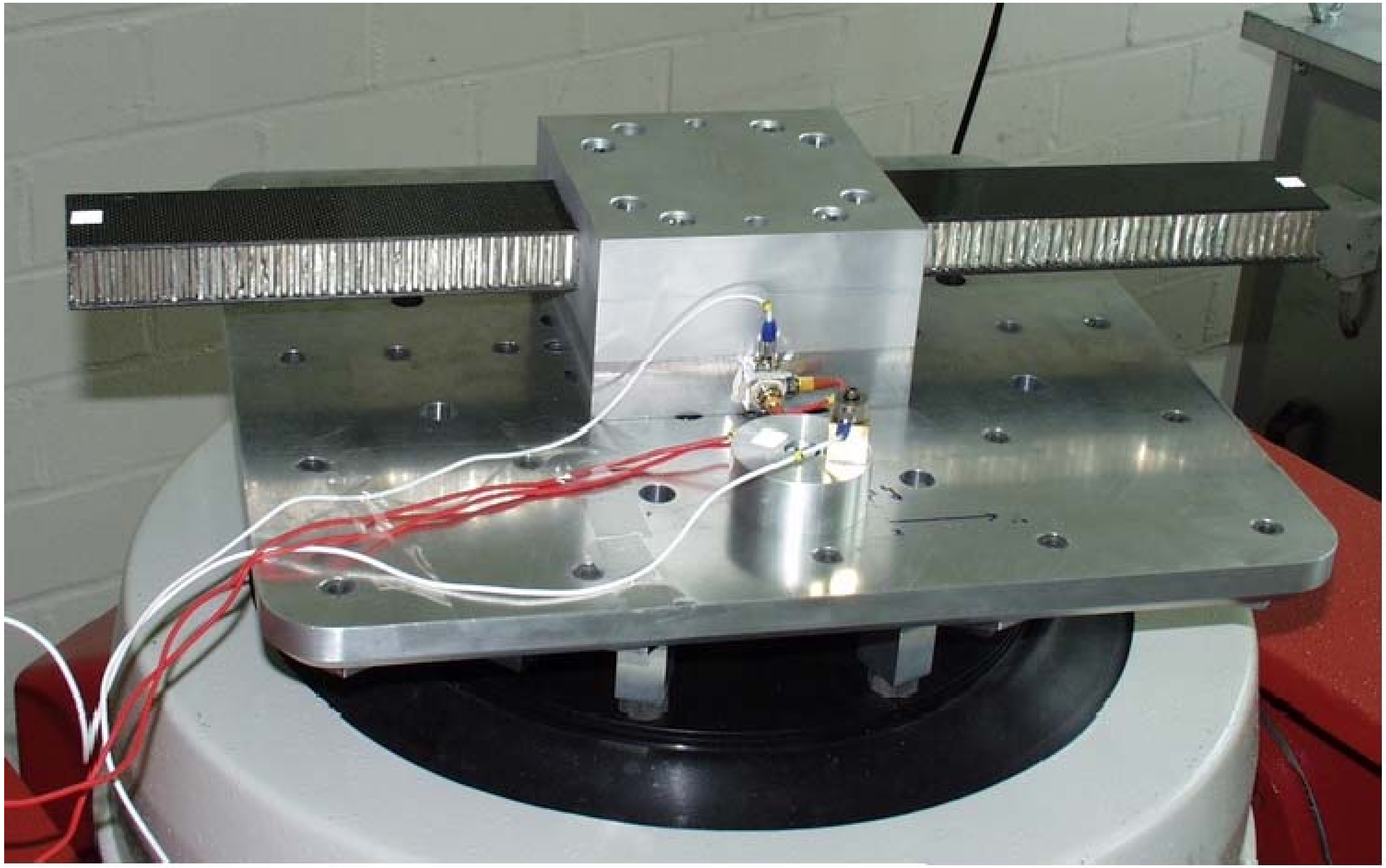
A Sine G [9]
L-D [µm] Laser : z-Direction
x: 2000, y: 0.653645
Oct-Pan-Vib1-Pos2
after Random
5000
500
200
50
20
5
2
0.5
0.1
G (Log)
10
20
50
100
200
500
1000
2000
Hz (Log)
Test Name: 02-09-06-sG2.sin
Date: 24.06.02


A Sine G [10]
L-V [mm/s]
x: 687.651, y: 144.328
1 x: 710.833
y: 110.149
2 x: 687.651
y: 144.328
2000
500
200
50
20
5
1
0.2
G (Log)
10
20
50
100
200
500
1000
2000
Hz (Log)


A Sine G [9]
L-D [µm] Laser : z-Direction
x: 10, y: 869.34
Oct-Pan-Vib1-Pos2
before Random
5000
500
200
50
20
5
2
0.5
0.1
G (Log)
10
20
50
100
200
500
1000
2000
Hz (Log)
Test Name: 02-09-04-sG2.sin
Date:24.06.02



A Sine G [10]
L-V [mm/s]
x: 687.651, y: 171.43
1 x: 710.833
y: 113.334
2 x: 687.651
y: 171.43
2000
500
200
50
20
5
1
0.2
G (Log)
10
20
50
100
200
500
1000
2000
Hz (Log)



TRD Octagon Support Structure
Octagon Deformation Test

1.1 TRD Octagon Sag Measurements

The TRD Octagon rigidity is verified with 1 g static load sag measurements.
The octagon is resting on the lower-flange inserts on a precision granite table as shown in fig 1.1 and the heights of the upper-flange inserts are measured with a 3D measuring device with a reproducability of 10 μm depending on the insert-surface.
To determine the sag, two measurements are compared: The unshimmed octagon serves as reference and is subtracted from a measurement where the lower-flange center-insert of one wall is shimmed with a 2 mm steel strip. This assures that the octagon rests only on the shimmed insert and on all inserts of the opposite wall.
The height changes DZ (shimmed minus unshimmed) for all measured upper inserts are used for a two-dimensional plane-fit. Plotted are the deviations of the upper inserts height changes with respect to this plane (DEV = DZ - DZfit).
This analysis will show any deviation of the octagon upper flange from an ideal plane under 1 g static load and is not influenced by a rigid-body tilt.
These measurements are shown in fig. 1.2 and 1.3. They are compared with corresponding finite-element-calculations as shown in fig. 1.6 and 1.7.
The FE calculations show a 10 μm sag when the octagon is supported below walls 1/5 compared to 20 μm with the support below walls 3/7. This is due to the larger bulkheads connecting walls 1 and 5, giving more stiffness in this direction.
The measured sags are within 20 μm confirming the rigidity of the assembled TRD octagon.

Figure 1.1: TRD Octagon on the granite-table with 3D measuring device

1

Plane–Fit a with Wall 5 supported by 2mm

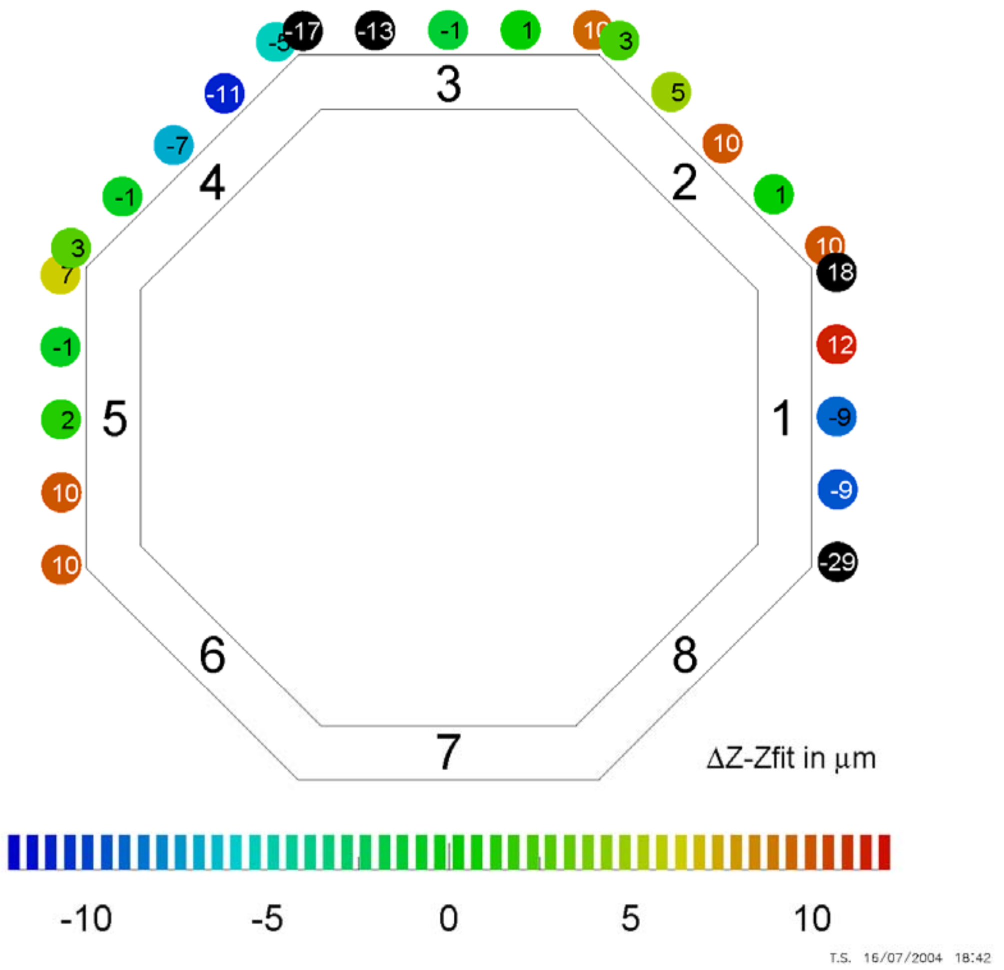


Figure 1.2: Planefit deviations for 3D Measurement on granite-table with 2 mm strip below wall-5-center-insert

Plane-Fit a with Wall 5 supported by 2mm

i	X/mm	Y/mm	DZ/mu	DZfit/mu	DEV/mu
1	-1068.4	-405.6	2318.0	2308.0	10.0
2	-1069.4	-206.6	2294.0	2283.8	10.3
3	-1069.7	-5.8	2260.0	2258.4	1.6
4	-1071.2	193.8	2234.0	2234.6	-0.6
5	-1071.4	394.1	2216.0	2209.3	6.7
6	-1041.9	467.8	2166.0	2163.0	3.0
7	-900.8	609.9	1968.0	1968.6	-0.6
8	-759.3	751.7	1767.0	1773.6	-6.6
9	-618.7	893.9	1569.0	1579.8	-10.8
10	-477.4	1035.7	1380.0	1385.2	-5.2
11	-404.0	1066.3	1273.0	1289.7	-16.6
12	-204.0	1067.2	1027.0	1039.8	-12.8
13	-3.2	1068.4	788.0	788.9	-0.9
14	196.8	1068.6	540.0	539.1	0.9
15	396.9	1069.3	299.0	289.1	9.9
16	470.2	1039.3	204.0	201.4	2.6
17	611.8	898.2	48.0	42.6	5.4
18	754.3	757.2	-107.0	-117.1	10.1
19	895.7	616.3	-275.0	-275.6	0.6
20	1037.2	475.3	-424.0	-434.3	10.3
21	1068.6	401.4	-446.0	-463.9	18.0
22	1069.0	201.4	-427.0	-438.8	11.8
23	1069.0	2.0	-422.0	-413.2	-8.8
24	1070.9	-198.9	-399.0	-389.9	-9.1
25	1071.3	-398.2	-394.0	-364.9	-29.1

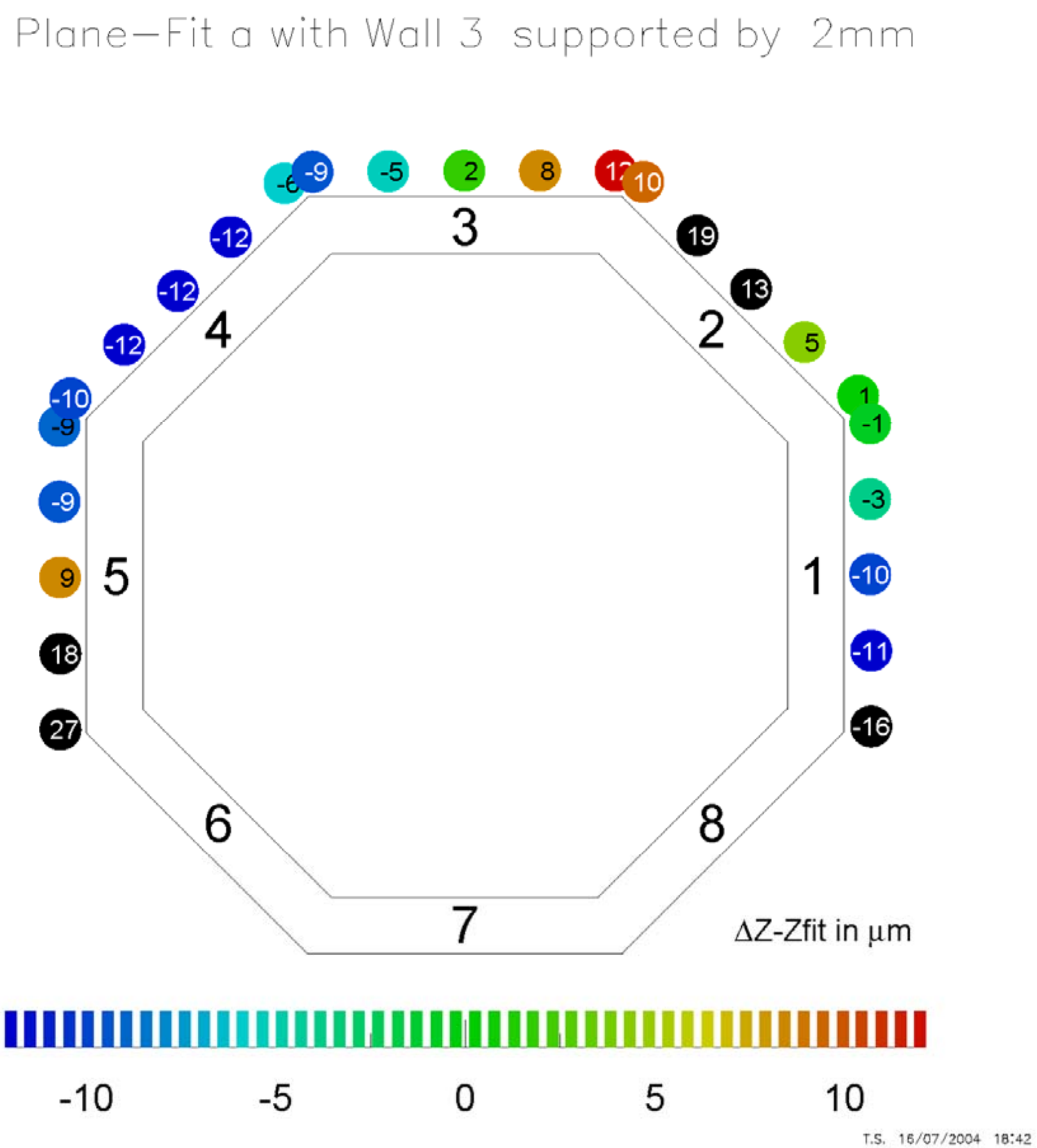


Figure 1.3: Planefit deviations for 3D Measurement on granite-table with 2 mm strip below wall-3-center-insert

Plane-Fit a with Wall 3 supported by 2mm

i	X/mm	Y/mm	DZ/mu	DZfit/mu	DEV/mu
1	-1068.4	-405.6	437.0	409.7	27.3
2	-1069.4	-206.6	642.0	624.1	17.9
3	-1069.7	-5.8	849.0	840.2	8.8
4	-1071.2	193.8	1046.0	1055.2	-9.2
5	-1071.4	394.1	1262.0	1270.8	-8.8
6	-1041.9	467.8	1337.0	1346.8	-9.8
7	-900.8	609.9	1472.0	1483.9	-11.9
8	-759.3	751.7	1609.0	1620.6	-11.6
9	-618.7	893.9	1746.0	1757.9	-11.9
10	-477.4	1035.7	1889.0	1894.7	-5.7
11	-404.0	1066.3	1910.0	1919.4	-9.4
12	-204.0	1067.2	1893.0	1898.0	-5.0
13	-3.2	1068.4	1879.0	1876.8	2.2
14	196.8	1068.6	1863.0	1854.5	8.5
15	396.9	1069.3	1845.0	1832.9	12.1
16	470.2	1039.3	1802.0	1792.4	9.6
17	611.8	898.2	1644.0	1624.6	19.4
18	754.3	757.2	1470.0	1456.9	13.1
19	895.7	616.3	1294.0	1289.5	4.5
20	1037.2	475.3	1123.0	1121.8	1.2
21	1068.6	401.4	1038.0	1038.8	-0.8
22	1069.0	201.4	820.0	823.5	-3.5
23	1069.0	2.0	599.0	608.8	-9.8
24	1070.9	-198.9	381.0	392.4	-11.4
25	1071.3	-398.2	162.0	177.8	-15.8

ISATEC Finite Element Calculations FEA1 and FEA2

```
Finite Elemente Analysen (FEA) des TRD Oktagons unter Eigengewicht
==================================================================

Das Oktagon wurde fuer die unterschiedlichen FEA jeweils an
1 + 5 Inserts der unteren Flansche aufgelegt:

Lagerung FEA 1:  1 x Mitte Flansch (-X(AMS), || Y(AMS))
                 5 x Flansch       (+X(AMS), || Y(AMS))

Lagerung FEA 2:  1 x Mitte Flansch (-Y(AMS), || X(AMS))
                 5 x Flansch       (+Y(AMS), || X(AMS))

-----------------------------------------------------------
```

FEM Knoten	AMS X	AMS Y	Ergebnis FEA 1 Verschiebung in AMS Z-Richtung	Ergebnis FEA 2 Verschiebung in AMS Z-Richtung
	[mm]	[mm]	[mm]	[mm]
22500	0.00	1071.23	-0.0797	-0.0149
22535	753.57	761.37	-0.0343	-0.0370
22561	1009.17	505.77	-0.0144	-0.0531
22567	1071.23	0.00	-0.0086	-0.0719
22587	1071.23	198.90	-0.0087	-0.0652
22603	1071.23	353.50	-0.0090	-0.0596
22607	1071.23	400.90	-0.0093	-0.0580
22617	397.40	1071.23	-0.0579	-0.0151
31908	210.99	1071.23	-0.0681	-0.0148
31917	479.88	1035.06	-0.0530	-0.0176
31920	508.90	1006.04	-0.0511	-0.0194
31932	617.02	897.92	-0.0441	-0.0271
31974	896.32	618.62	-0.0232	-0.0465
31995	1044.72	470.22	-0.0117	-0.0551
32068	352.15	1071.23	-0.0603	-0.0149
37142	-753.57	761.37	-0.1184	-0.0381
37168	-1009.17	505.77	-0.1271	-0.0545
37174	-1071.23	0.00	-0.1282	-0.0733
37194	-1071.23	198.90	-0.1283	-0.0666
37210	-1071.23	353.50	-0.1286	-0.0610
37214	-1071.23	400.90	-0.1290	-0.0595
37224	-397.40	1071.23	-0.1021	-0.0157
46434	-210.99	1071.23	-0.0916	-0.0151

46443	-479.88	1035.06	-0.1064	-0.0183
46446	-508.90	1006.04	-0.1078	-0.0202
46458	-617.02	897.92	-0.1130	-0.0280
46500	-896.32	618.62	-0.1233	-0.0477
46521	-1044.72	470.22	-0.1284	-0.0566
46594	-352.15	1071.23	-0.0995	-0.0154
51762	0.00	-1071.23	-0.0797	-0.0884
51797	753.57	-761.37	-0.0343	-0.0886
51823	1009.17	-505.77	-0.0144	-0.0865
51847	1071.23	-198.90	-0.0087	-0.0781
51863	1071.23	-353.50	-0.0090	-0.0827
51867	1071.23	-400.90	-0.0093	-0.0842
51877	397.40	-1071.23	-0.0579	-0.0887
61114	210.99	-1071.23	-0.0681	-0.0883
61123	479.88	-1035.06	-0.0530	-0.0887
61126	508.90	-1006.04	-0.0511	-0.0884
61138	617.02	-897.92	-0.0442	-0.0884
61180	896.32	-618.62	-0.0232	-0.0878
61201	1044.72	-470.22	-0.0118	-0.0861
61273	352.15	-1071.23	-0.0603	-0.0885
66394	-753.57	-761.37	-0.1184	-0.0895
66420	-1009.17	-505.77	-0.1271	-0.0878
66444	-1071.23	-198.90	-0.1283	-0.0795
66460	-1071.23	-353.50	-0.1286	-0.0840
66464	-1071.23	-400.90	-0.1290	-0.0856
66474	-397.40	-1071.23	-0.1021	-0.0892
75630	-210.99	-1071.23	-0.0916	-0.0886
75639	-479.88	-1035.06	-0.1064	-0.0892
75642	-508.90	-1006.04	-0.1078	-0.0890
75654	-617.02	-897.92	-0.1129	-0.0892
75696	-896.32	-618.62	-0.1233	-0.0890
75717	-1044.72	-470.22	-0.1284	-0.0874
75789	-352.15	-1071.23	-0.0995	-0.0889

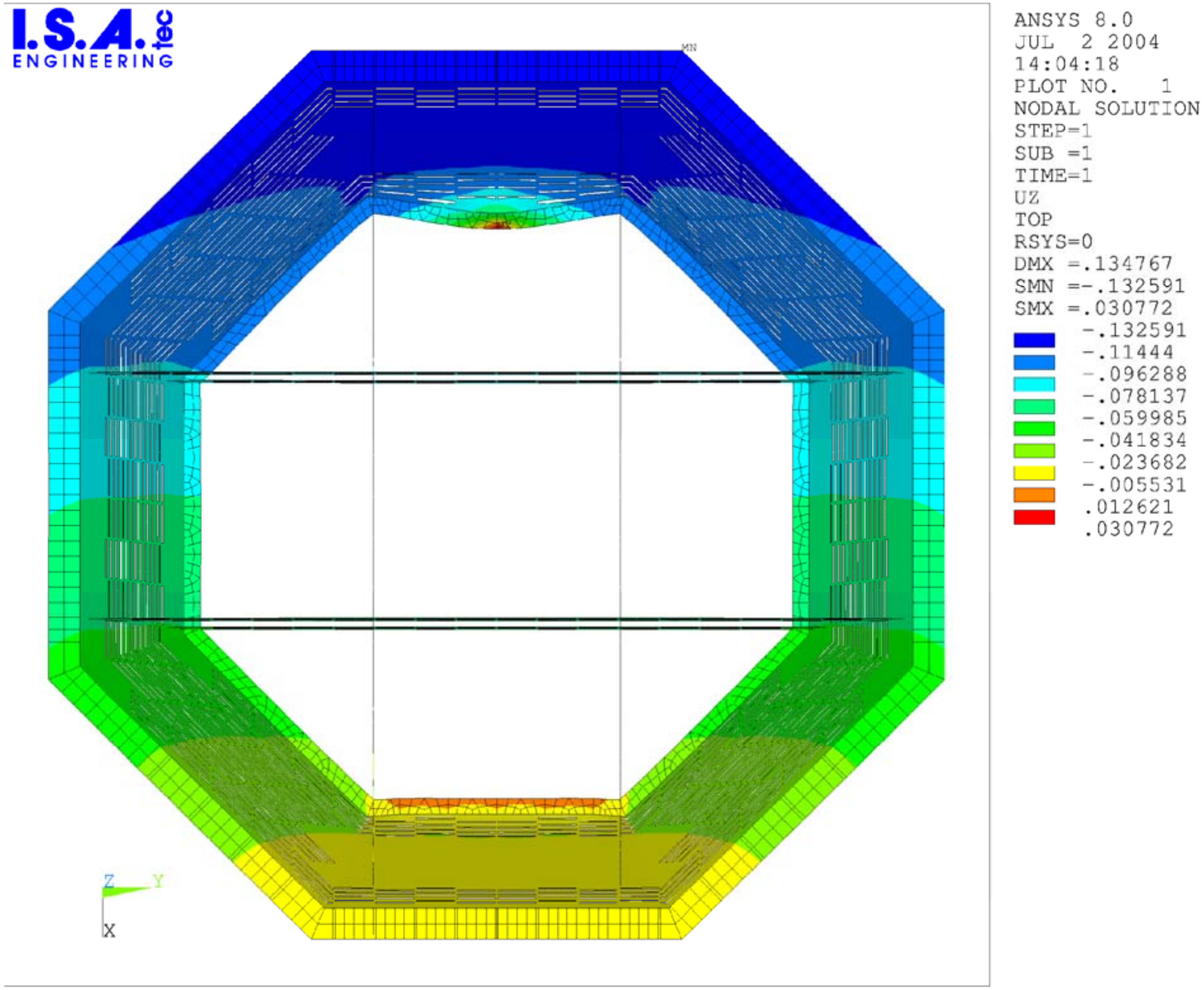


Figure 1.4: ISATEC FE-Calculation FEA1 with Octagon supported below wall-5-center-insert and all wall-1-inserts

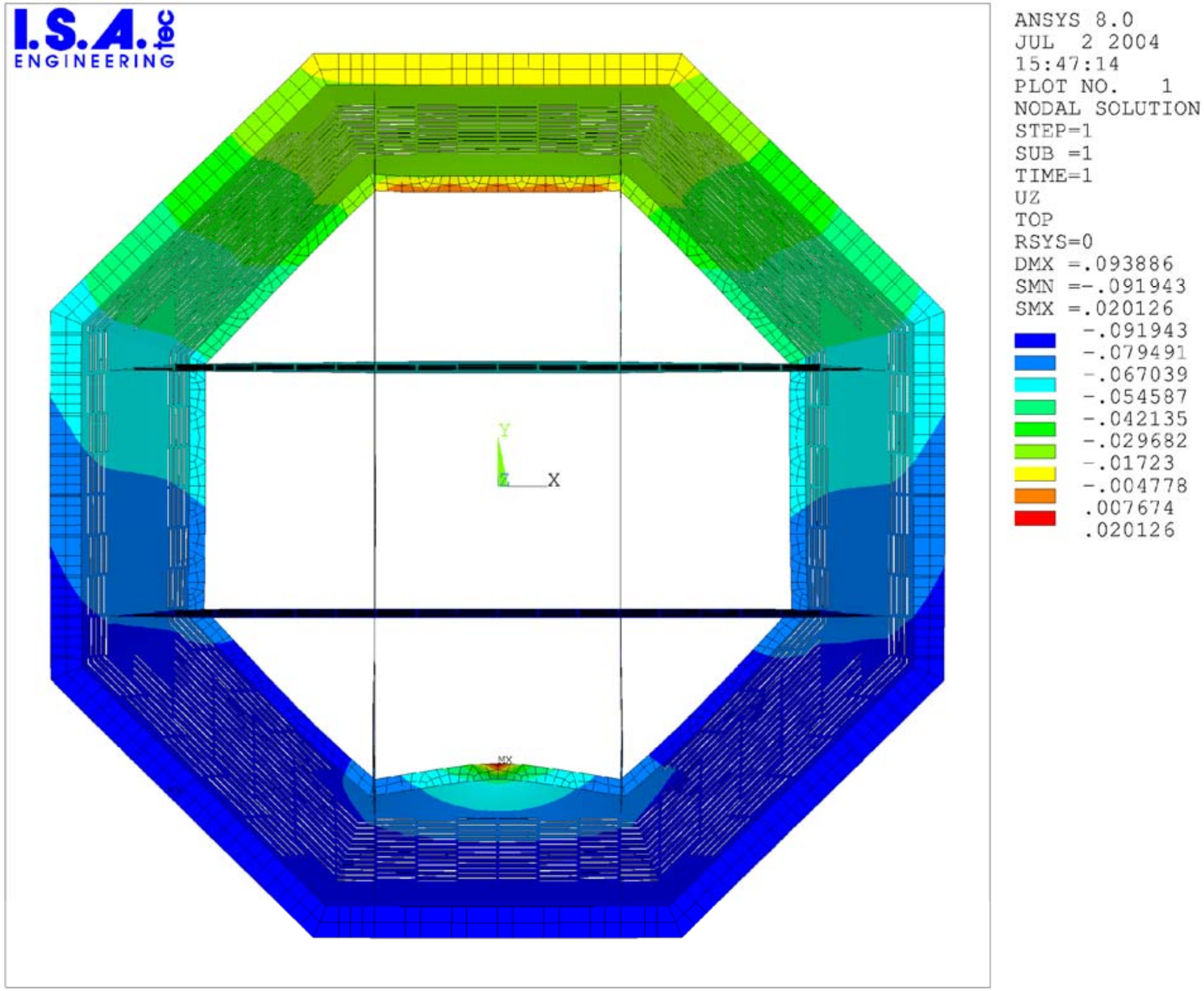


Figure 1.5: ISATEC FE-Calculation FEA2 with Octagon supported below wall-7-center-insert and all wall-3-inserts

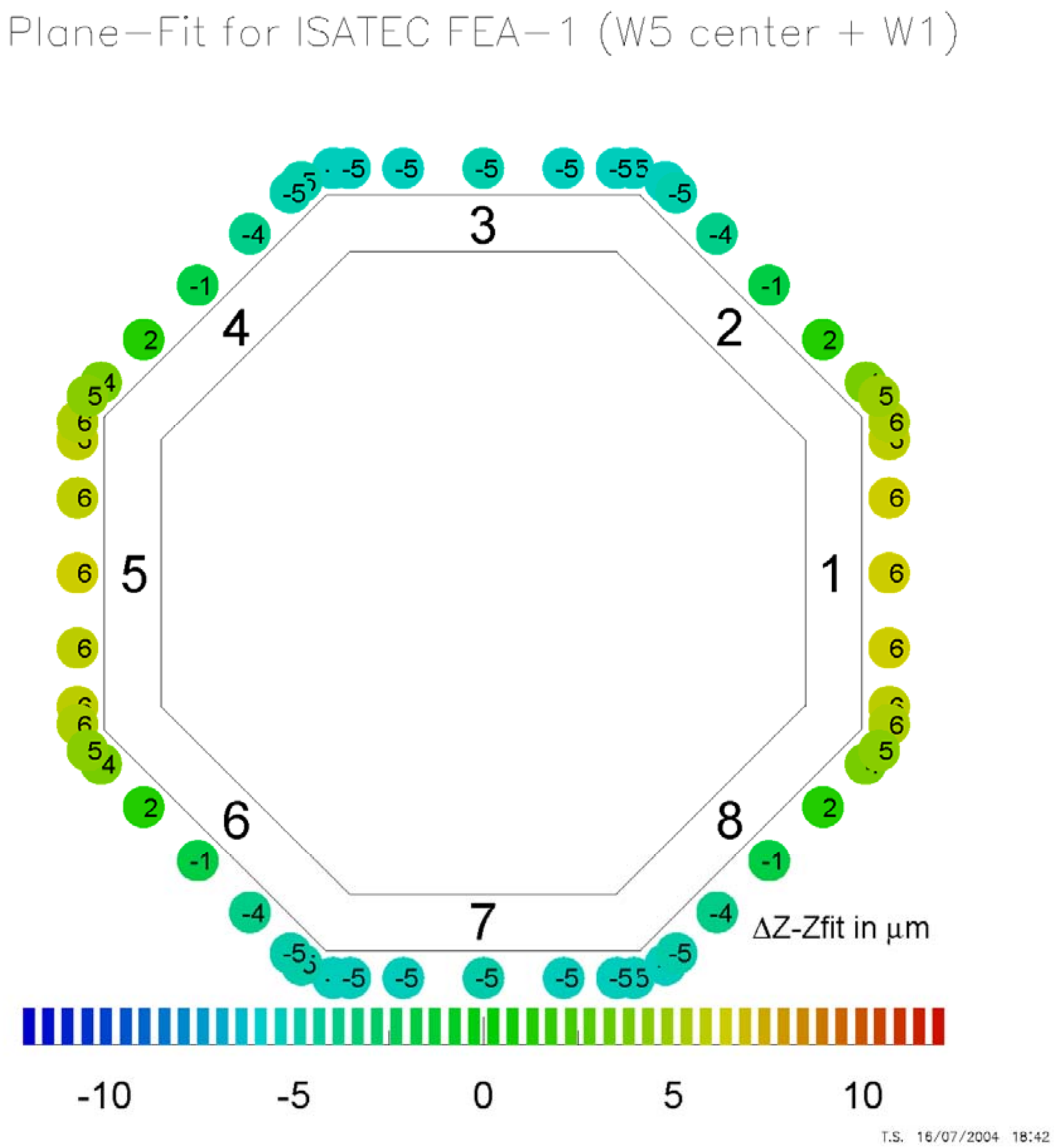


Figure 1.6: Planefit deviations for ISATEC FE-Calculation with Octagon supported below wall-5-center-insert and all wall-1-inserts

Plane-Fit for ISATEC FEA-1 (W5 center + W1)

i	X/mm	Y/mm	DZ/mu	DZfit/mu	DEV/mu
1	0.0	1071.2	-79.7	-74.9	-4.8
2	753.6	761.4	-34.3	-32.8	-1.5
3	1009.2	505.8	-14.4	-18.6	4.2
4	1071.2	0.0	-8.6	-15.1	6.5
5	1071.2	198.9	-8.7	-15.1	6.4
6	1071.2	353.5	-9.0	-15.1	6.1
7	1071.2	400.9	-9.3	-15.1	5.8
8	397.4	1071.2	-57.9	-52.7	-5.2
9	211.0	1071.2	-68.1	-63.1	-5.0
10	479.9	1035.1	-53.0	-48.1	-4.9
11	508.9	1006.0	-51.1	-46.5	-4.6
12	617.0	897.9	-44.1	-40.4	-3.7
13	896.3	618.6	-23.2	-24.9	1.7
14	1044.7	470.2	-11.7	-16.6	4.9
15	352.1	1071.2	-60.3	-55.2	-5.1
16	-753.6	761.4	-118.4	-116.9	-1.5
17	-1009.2	505.8	-127.1	-131.2	4.1
18	-1071.2	0.0	-128.2	-134.7	6.5
19	-1071.2	198.9	-128.3	-134.7	6.4
20	-1071.2	353.5	-128.6	-134.7	6.1
21	-1071.2	400.9	-129.0	-134.7	5.7
22	-397.4	1071.2	-102.1	-97.1	-5.0
23	-211.0	1071.2	-91.6	-86.7	-4.9
24	-479.9	1035.1	-106.4	-101.7	-4.7
25	-508.9	1006.0	-107.8	-103.3	-4.5
26	-617.0	897.9	-113.0	-109.3	-3.7
27	-896.3	618.6	-123.3	-124.9	1.6
28	-1044.7	470.2	-128.4	-133.2	4.8
29	-352.1	1071.2	-99.5	-94.5	-5.0
30	0.0	-1071.2	-79.7	-74.9	-4.8
31	753.6	-761.4	-34.3	-32.8	-1.5
32	1009.2	-505.8	-14.4	-18.6	4.2
33	1071.2	-198.9	-8.7	-15.1	6.4
34	1071.2	-353.5	-9.0	-15.1	6.1
35	1071.2	-400.9	-9.3	-15.1	5.8
36	397.4	-1071.2	-57.9	-52.7	-5.2
37	211.0	-1071.2	-68.1	-63.1	-5.0
38	479.9	-1035.1	-53.0	-48.1	-4.9
39	508.9	-1006.0	-51.1	-46.5	-4.6
40	617.0	-897.9	-44.2	-40.4	-3.8
41	896.3	-618.6	-23.2	-24.9	1.7
42	1044.7	-470.2	-11.8	-16.6	4.8
43	352.1	-1071.2	-60.3	-55.2	-5.1
44	-753.6	-761.4	-118.4	-116.9	-1.5
45	-1009.2	-505.8	-127.1	-131.2	4.1
46	-1071.2	-198.9	-128.3	-134.7	6.4
47	-1071.2	-353.5	-128.6	-134.7	6.1
48	-1071.2	-400.9	-129.0	-134.7	5.7
49	-397.4	-1071.2	-102.1	-97.1	-5.0
50	-211.0	-1071.2	-91.6	-86.7	-4.9
51	-479.9	-1035.1	-106.4	-101.7	-4.7
52	-508.9	-1006.0	-107.8	-103.3	-4.5
53	-617.0	-897.9	-112.9	-109.3	-3.6
54	-896.3	-618.6	-123.3	-124.9	1.6
55	-1044.7	-470.2	-128.4	-133.2	4.8
56	-352.1	-1071.2	-99.5	-94.5	-5.0

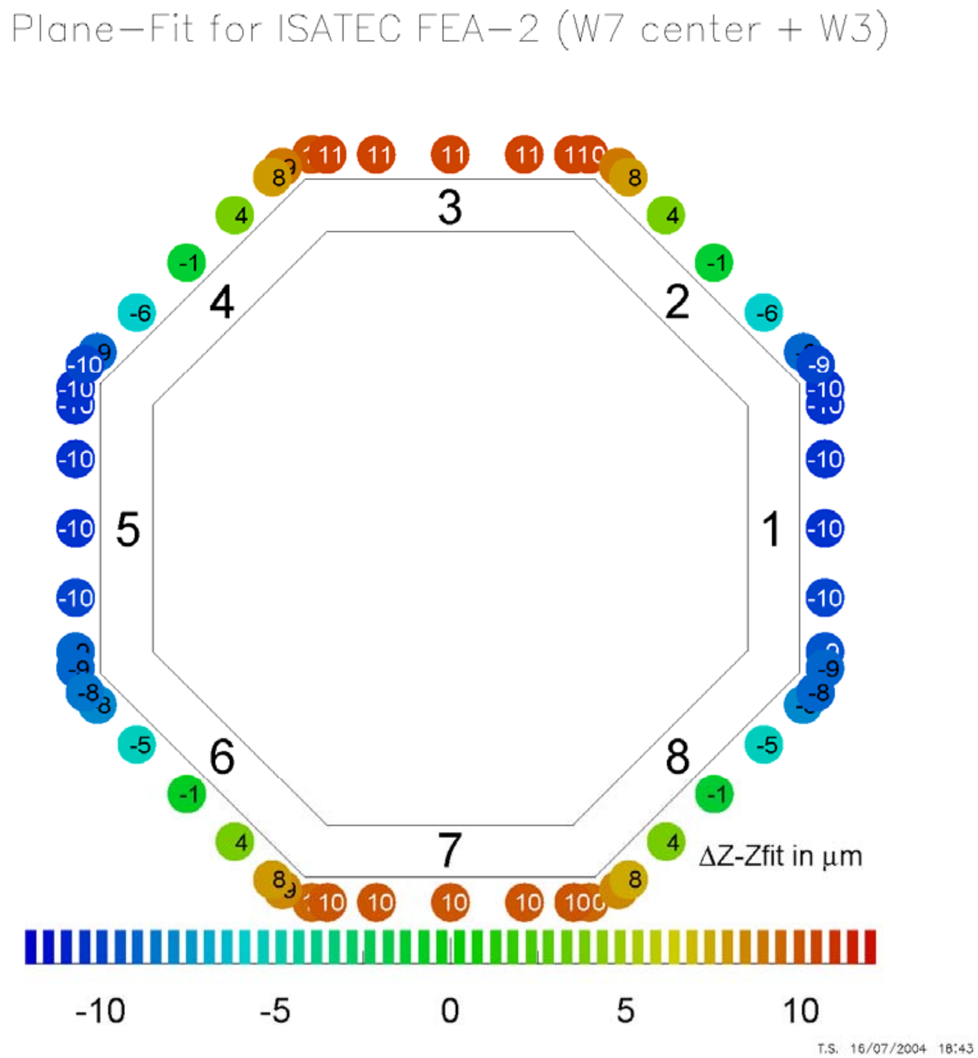


Figure 1.7: Planefit deviations for FE-Calculation with Octagon supported below wall-7-center-insert and all wall-3-inserts

Plane-Fit for ISATEC FEA-2 (W7 center + W3)

i	X/mm	Y/mm	DZ/mu	DZfit/mu	DEV/mu
1	0.0	1071.2	-14.9	-25.8	10.9
2	753.6	761.4	-37.0	-35.9	-1.1
3	1009.2	505.8	-53.1	-44.4	-8.7
4	1071.2	0.0	-71.9	-61.6	-10.3
5	1071.2	198.9	-65.2	-54.8	-10.4
6	1071.2	353.5	-59.6	-49.6	-10.0
7	1071.2	400.9	-58.0	-48.0	-10.0
8	397.4	1071.2	-15.1	-25.6	10.5
9	211.0	1071.2	-14.8	-25.7	10.9
10	479.9	1035.1	-17.6	-26.7	9.1
11	508.9	1006.0	-19.4	-27.7	8.3
12	617.0	897.9	-27.1	-31.3	4.2
13	896.3	618.6	-46.5	-40.7	-5.8
14	1044.7	470.2	-55.1	-45.6	-9.5
15	352.1	1071.2	-14.9	-25.6	10.7
16	-753.6	761.4	-38.1	-36.9	-1.2
17	-1009.2	505.8	-54.5	-45.8	-8.7
18	-1071.2	0.0	-73.3	-63.0	-10.3
19	-1071.2	198.9	-66.6	-56.3	-10.3
20	-1071.2	353.5	-61.0	-51.0	-10.0
21	-1071.2	400.9	-59.5	-49.4	-10.1
22	-397.4	1071.2	-15.7	-26.1	10.4
23	-211.0	1071.2	-15.1	-26.0	10.9
24	-479.9	1035.1	-18.3	-27.4	9.1
25	-508.9	1006.0	-20.2	-28.4	8.2
26	-617.0	897.9	-28.0	-32.1	4.1
27	-896.3	618.6	-47.7	-41.8	-5.9
28	-1044.7	470.2	-56.6	-47.0	-9.6
29	-352.1	1071.2	-15.4	-26.1	10.7
30	0.0	-1071.2	-88.4	-98.8	10.4
31	753.6	-761.4	-88.6	-87.8	-0.8
32	1009.2	-505.8	-86.5	-78.9	-7.6
33	1071.2	-198.9	-78.1	-68.4	-9.7
34	1071.2	-353.5	-82.7	-73.7	-9.0
35	1071.2	-400.9	-84.2	-75.3	-8.9
36	397.4	-1071.2	-88.7	-98.6	9.9
37	211.0	-1071.2	-88.3	-98.7	10.4
38	479.9	-1035.1	-88.7	-97.3	8.6
39	508.9	-1006.0	-88.4	-96.3	7.9
40	617.0	-897.9	-88.4	-92.5	4.1
41	896.3	-618.6	-87.8	-82.8	-5.0
42	1044.7	-470.2	-86.1	-77.7	-8.4
43	352.1	-1071.2	-88.5	-98.6	10.1
44	-753.6	-761.4	-89.5	-88.8	-0.7
45	-1009.2	-505.8	-87.8	-80.2	-7.6
46	-1071.2	-198.9	-79.5	-69.8	-9.7
47	-1071.2	-353.5	-84.0	-75.1	-8.9
48	-1071.2	-400.9	-85.6	-76.7	-8.9
49	-397.4	-1071.2	-89.2	-99.1	9.9
50	-211.0	-1071.2	-88.6	-99.0	10.4
51	-479.9	-1035.1	-89.2	-97.9	8.7
52	-508.9	-1006.0	-89.0	-96.9	7.9
53	-617.0	-897.9	-89.2	-93.3	4.1
54	-896.3	-618.6	-89.0	-84.0	-5.0
55	-1044.7	-470.2	-87.4	-79.0	-8.4
56	-352.1	-1071.2	-88.9	-99.1	10.2

TRD Octagon Support Structure FEA of Deformation Including Detector Modules

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AMS02 TRD
mit neuer Modulnachbildung
LC 4058

RWTH PhysicsAC-I

7 Okt 04

Folie 1

Nachbildung der 6-Stringer-Module durch Stabelemente mit:

Querschnitt = 6 x Stringerquerschnitt = 18 mm²
E-Modul = E-Modul (Stringer) = 200 GPa

resultierende (Feder-)Steifigkeit bei einer Länge von 1750 mm =
c_M (1750 mm) = 2057 N/mm

Die neue Modulnachbildung berücksichtigt auch Trapezbleche mit:

(Feder-)Steifigkeit = $c_T = c_M/4$

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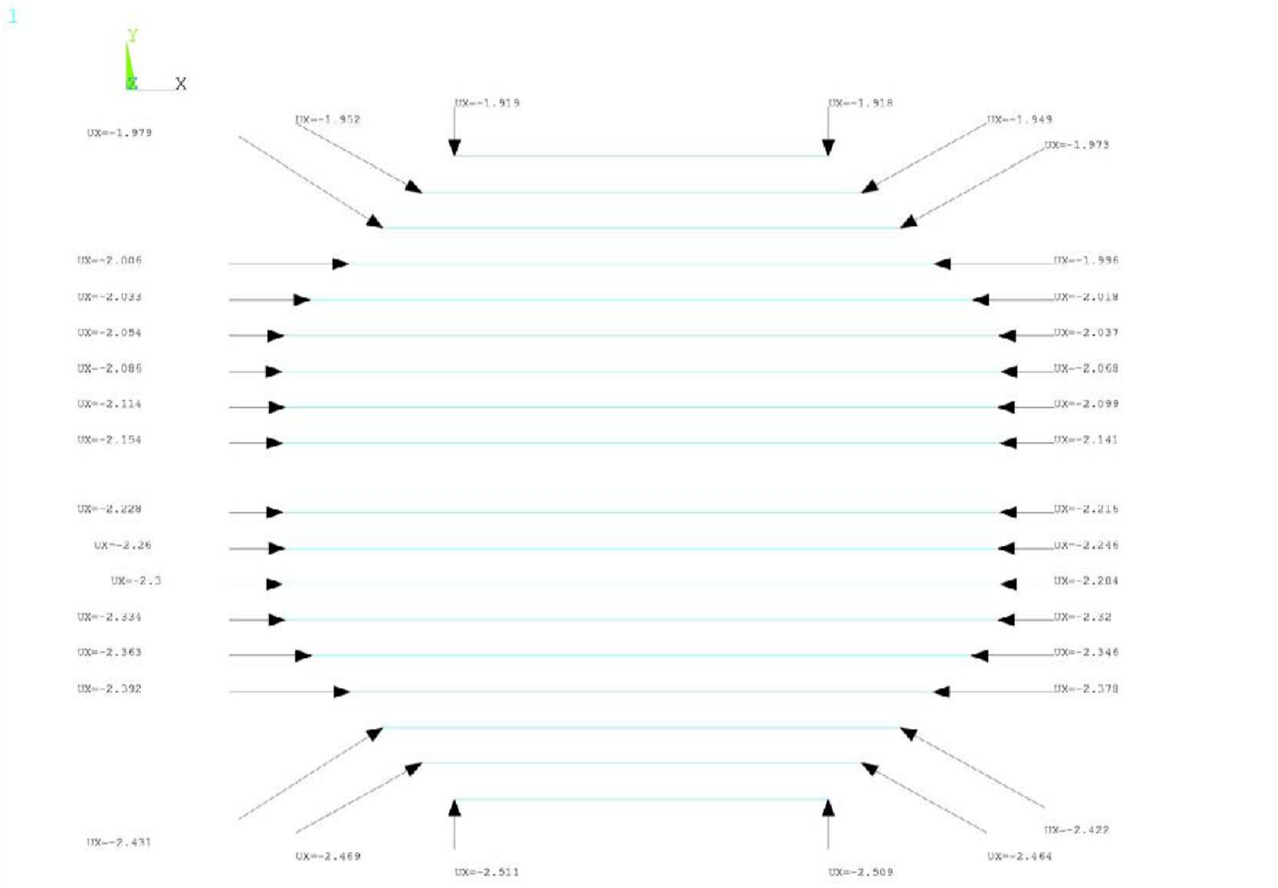
7 Okt 04

Neue Modulnachbildung

Folie 2



x-Verschiebungen [mm] der Modulendpunkte (oberste Module || x)

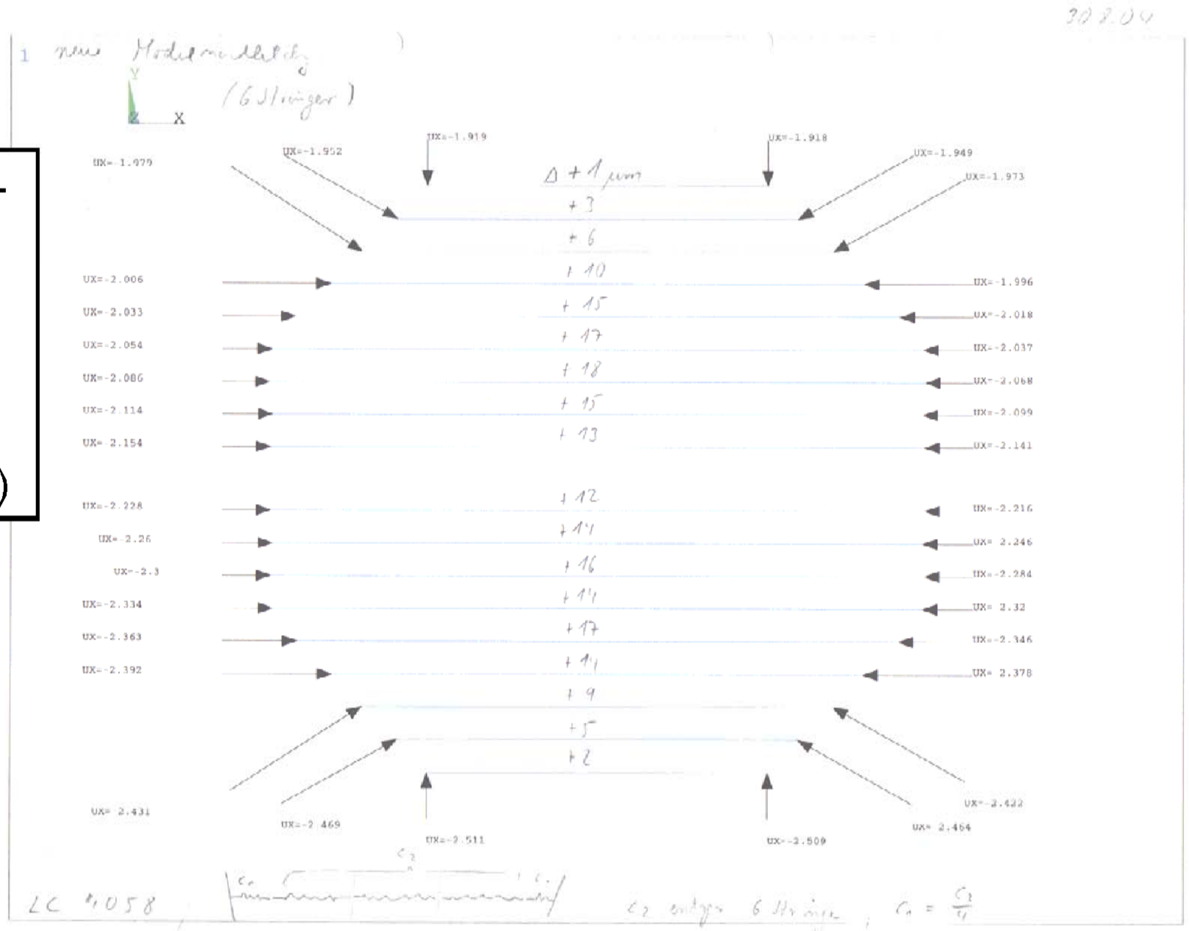
7 Okt 04

LC 4058, FEA mit neuer Modulnachbildung

Slide 3

In der Mitte handschriftlich eingetragen: x-Relativverschiebungen (= Längung) [µm] der Modulendpunkte

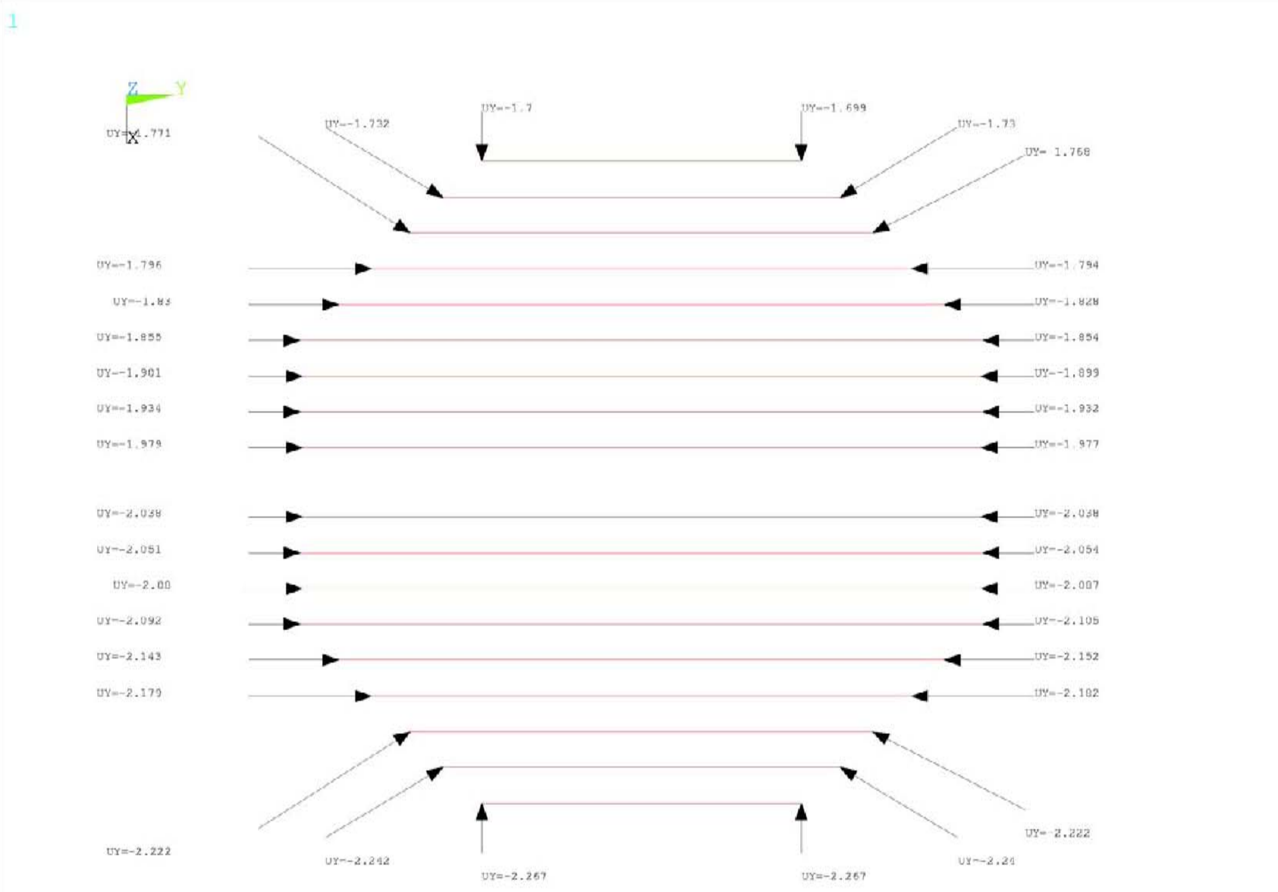
(für oberste Module || x)



7 Okt 04

LC 4058, FEA mit neuer Modulnachbildung

Slide 4



y-Verschiebungen [mm] der Modulendpunkte (oberste Module || y)

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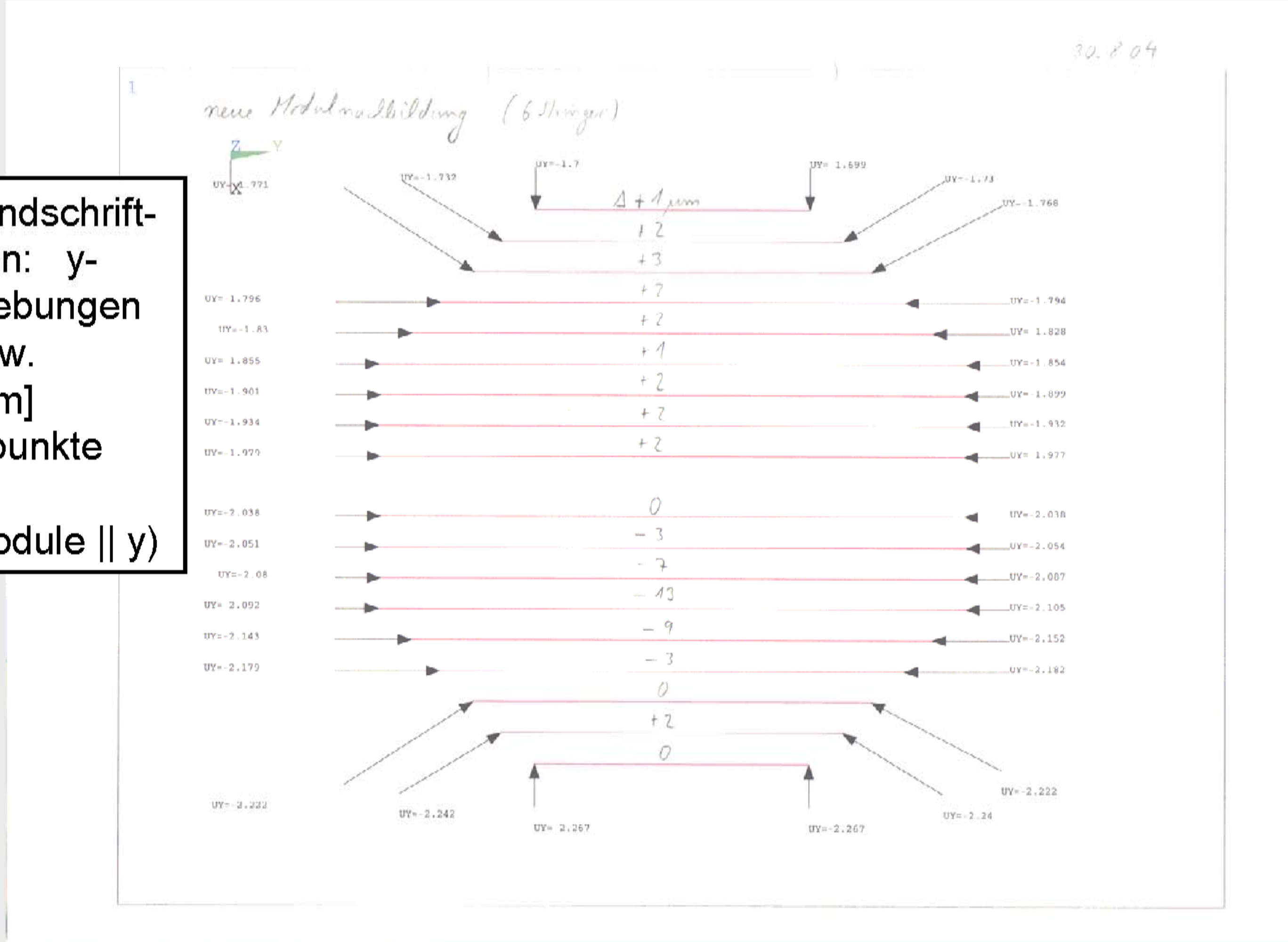
LC 4058, FEA mit neuer Modulnachbildung

7 Okt 04

Slide 5

In der Mitte handschriftlich eingetragen: y-Relativverschiebungen (= Längung bzw. Stauchung) [µm] der Modulendpunkte

(für oberste Module || y)



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LC 4058, FEA mit neuer Modulnachbildung

Slide 6

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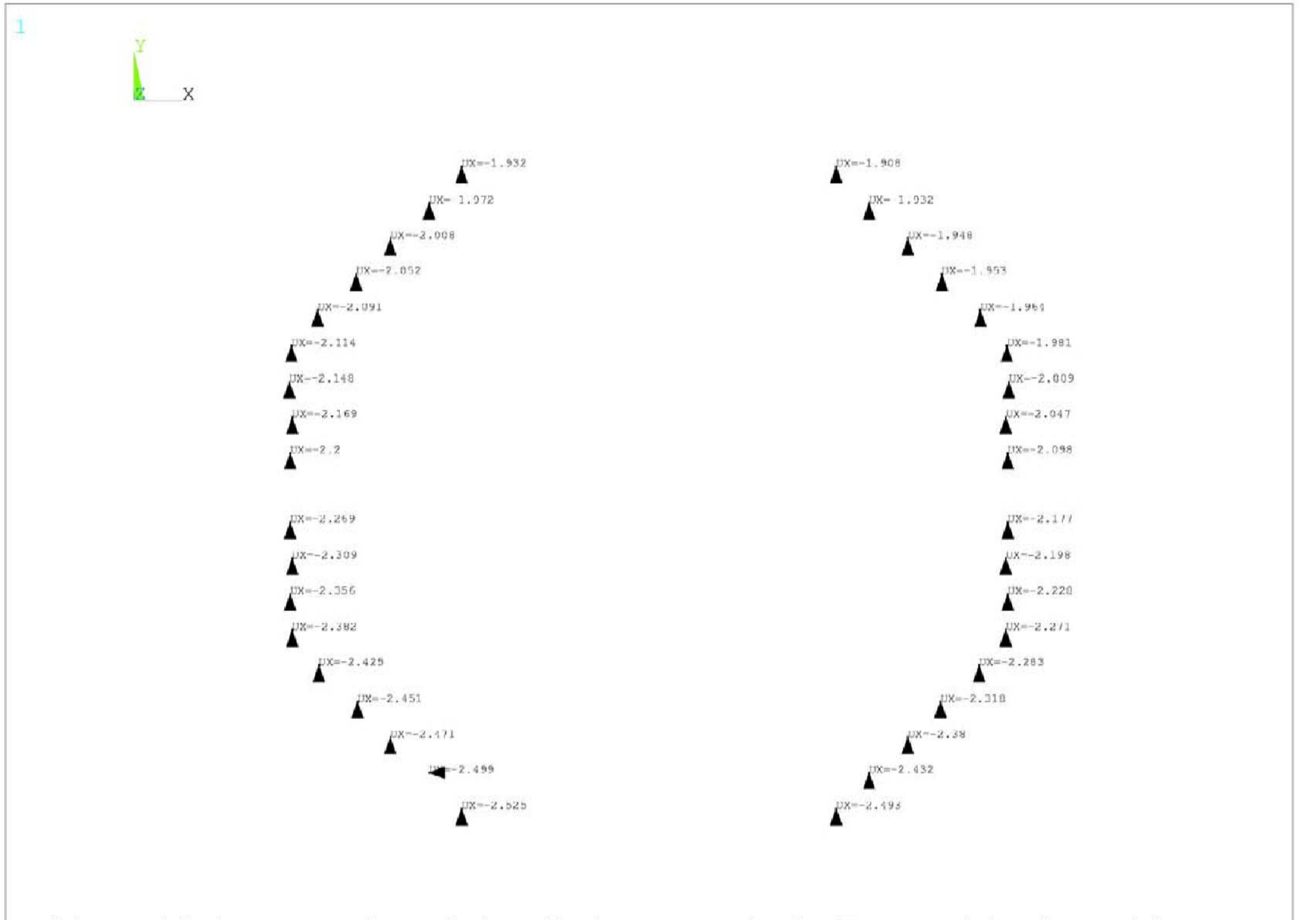

x-Verschiebungen [mm] der Seitenwände in Trapezblechpositionen

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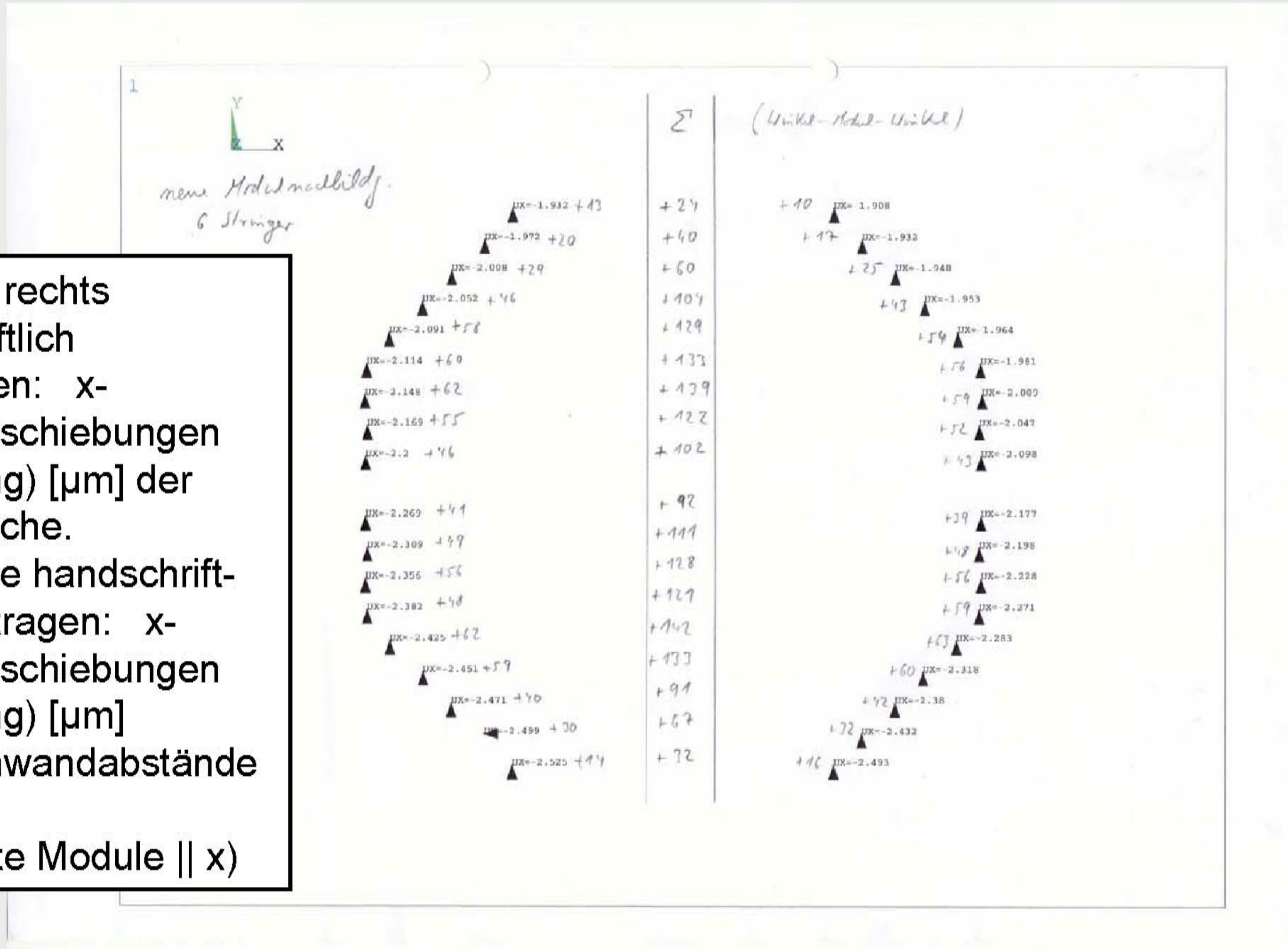
7 Okt 04

LC 4058, FEA mit neuer Modulnachbildung

Slide 7



Links und rechts handschriftlich eingetragen: x-Relativverschiebungen (= Längung) [µm] der Trapezbleche.
In der Mitte handschriftlich eingetragen: x-Relativverschiebungen (= Längung) [µm] der Seitenwandabstände

(für oberste Module || x)

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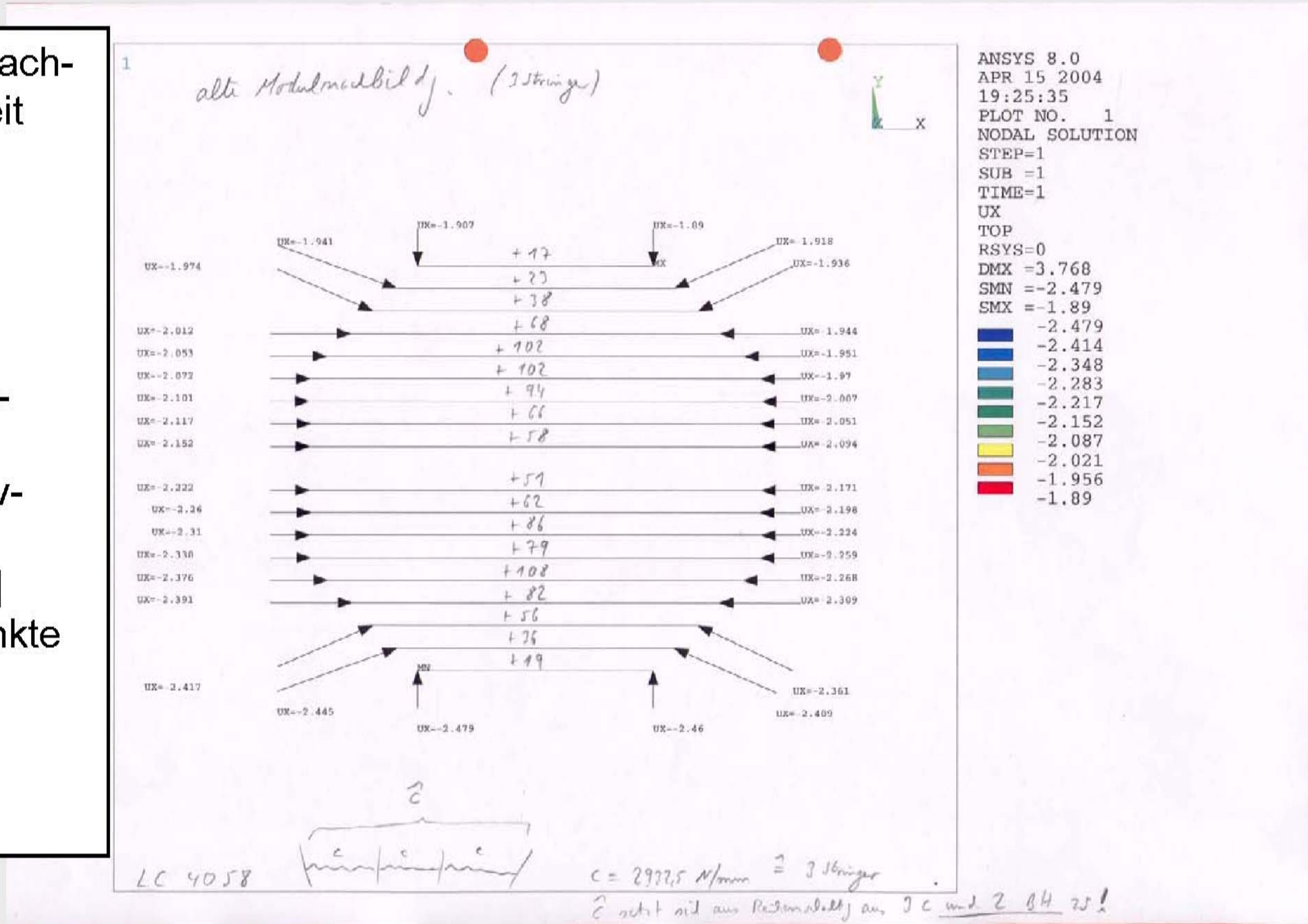
LC 4058, FEA mit neuer Modulnachbildung

Slide 8

Die alte Modulenach-
bildung (Steifigkeit
entspechend 3
Stringer) berück-
sichtigte keine
Trapezbleche.

In der Mitte hand-
schriftlich einge-
tragen: x-Relativ-
verschiebungen
(= Längung) [µm]
der Modulendpunkte

(für oberste
Module || x)



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LC 4058, FEA mit alter Modulnachbildung (zum Vergleich)

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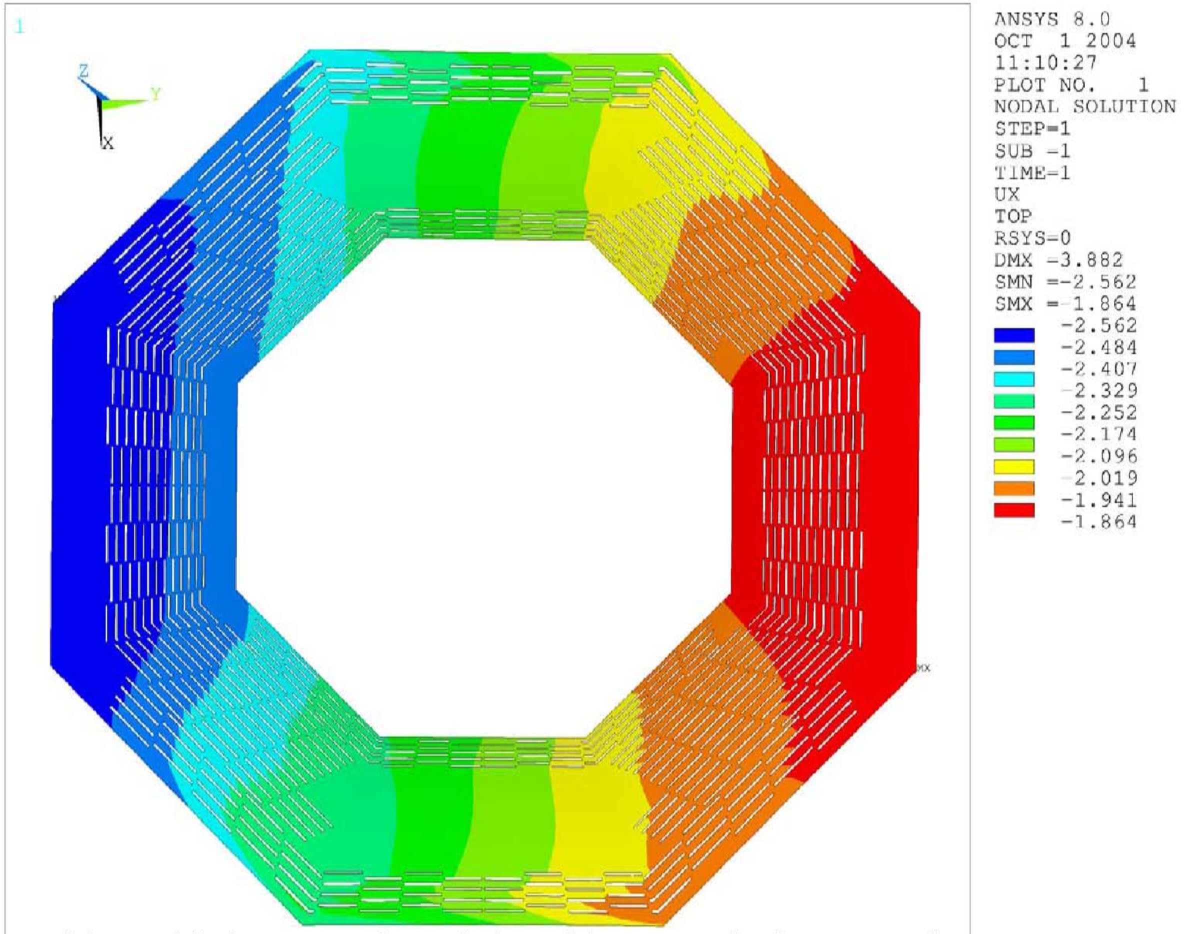
Folie 1



x-Verschiebungen [mm] der Oktagon-Seitenwände

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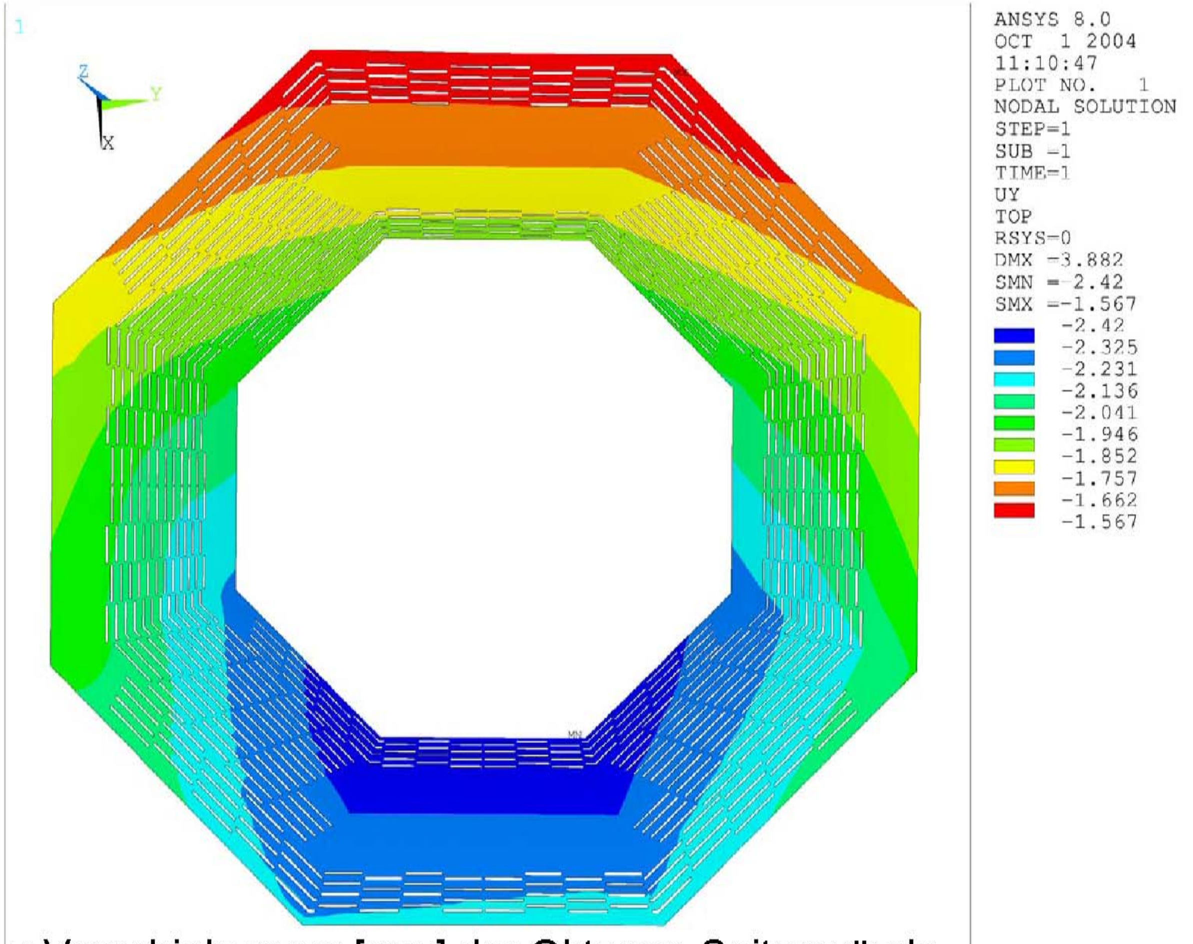
Slide 2



y-Verschiebungen [mm] der Oktagon-Seitenwände

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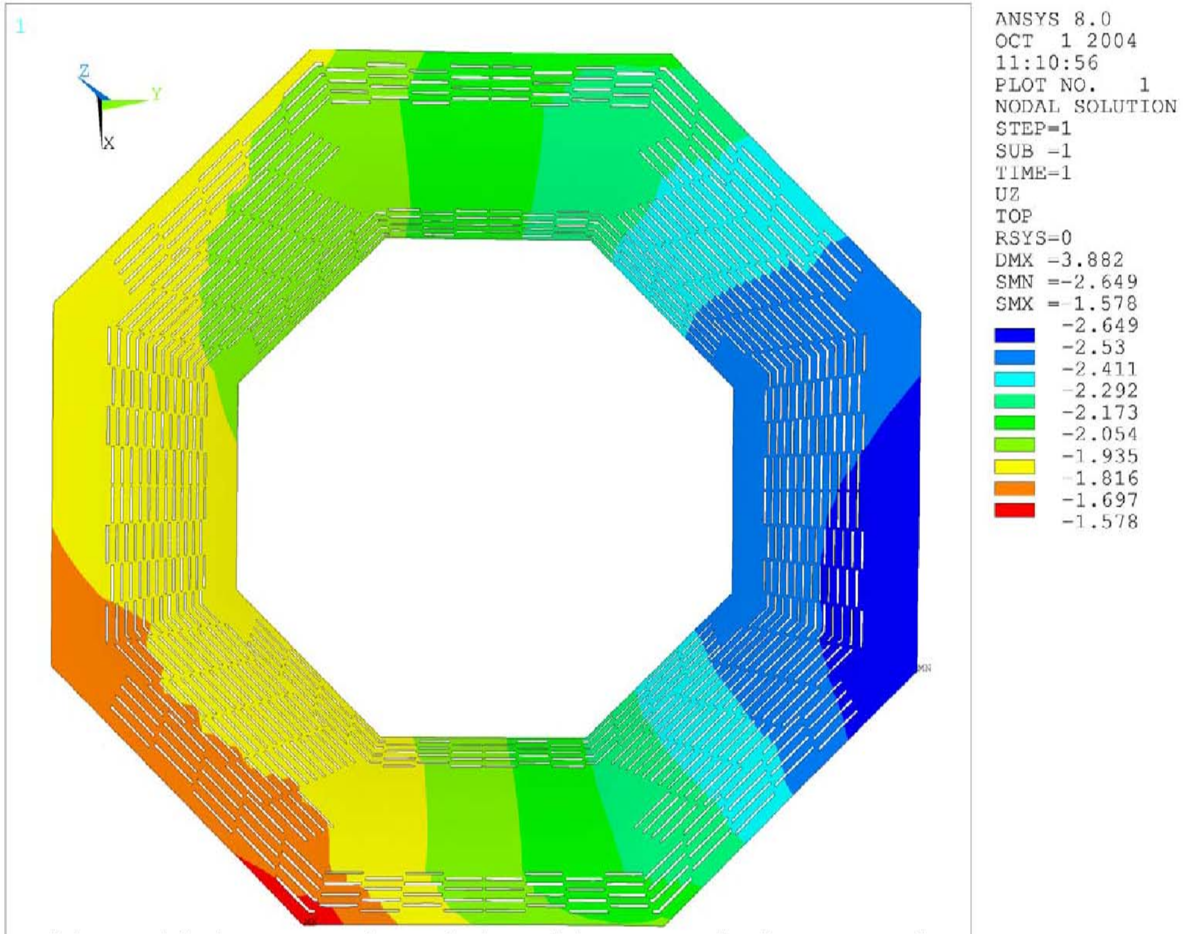
Slide 3



z-Verschiebungen [mm] der Oktagon-Seitenwände

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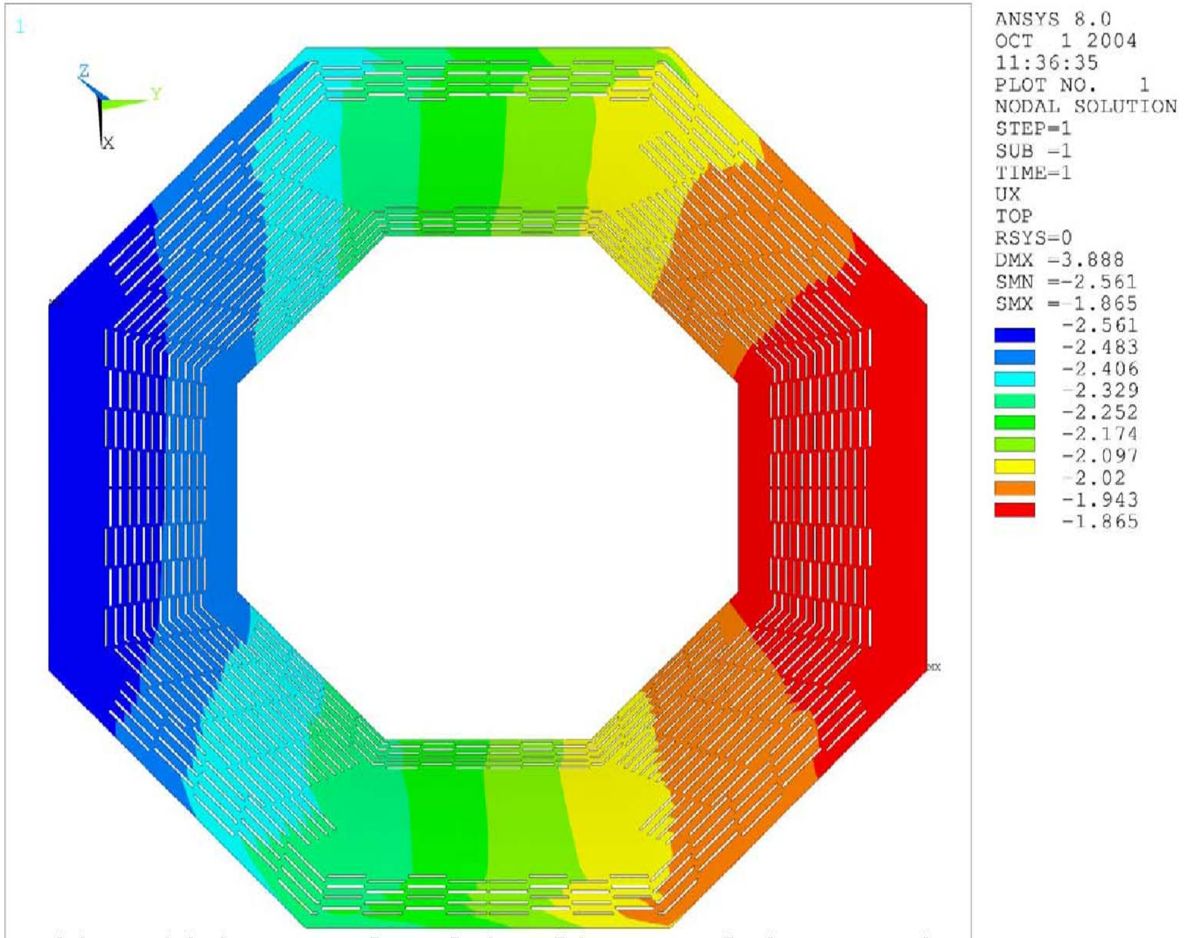
LC 4058, FEA mit neuer Modulnachbildung

Slide 4



x-Verschiebungen [mm] der Oktagon-Seitenwände

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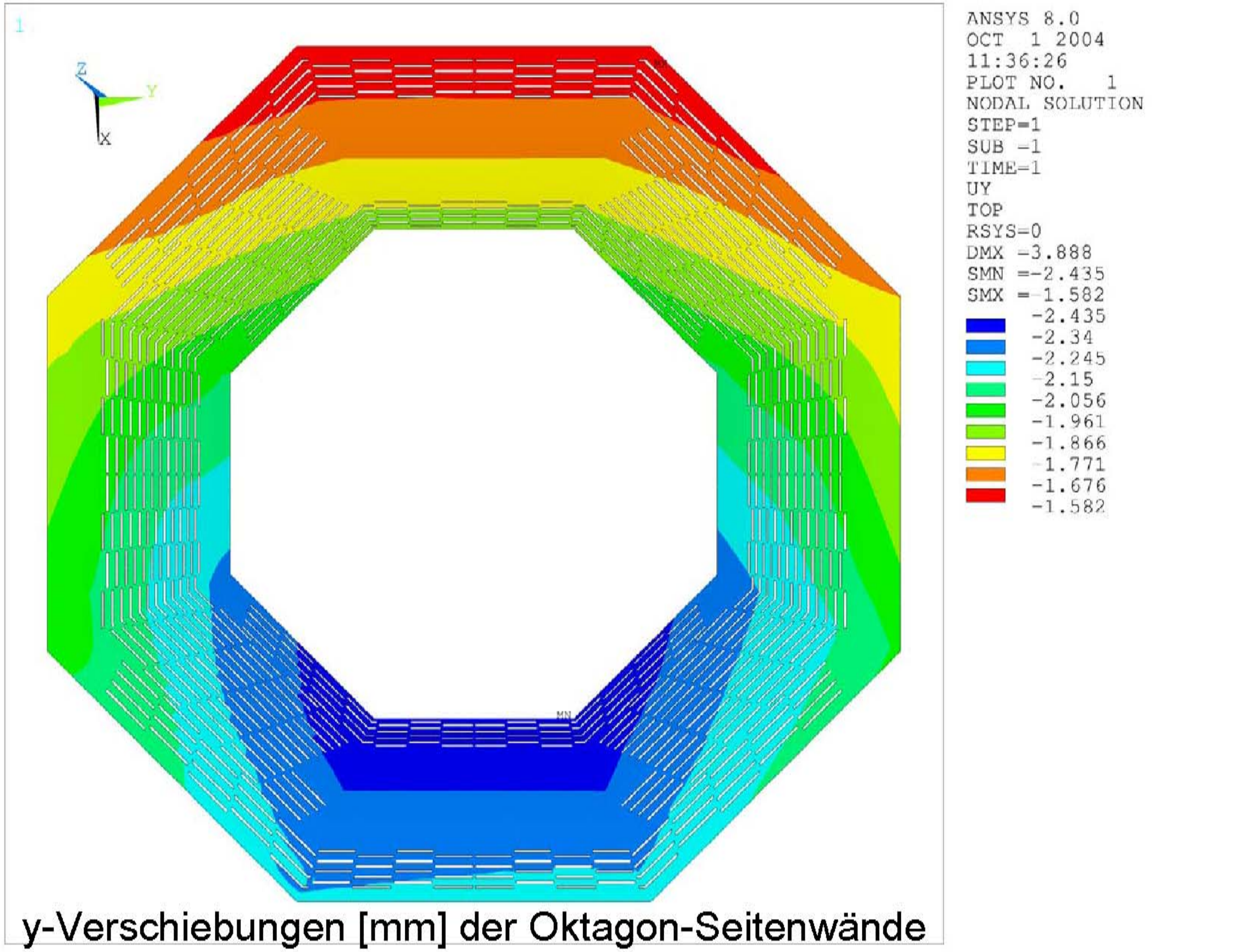
LC 4058, FEA mit alter Modulnachbildung

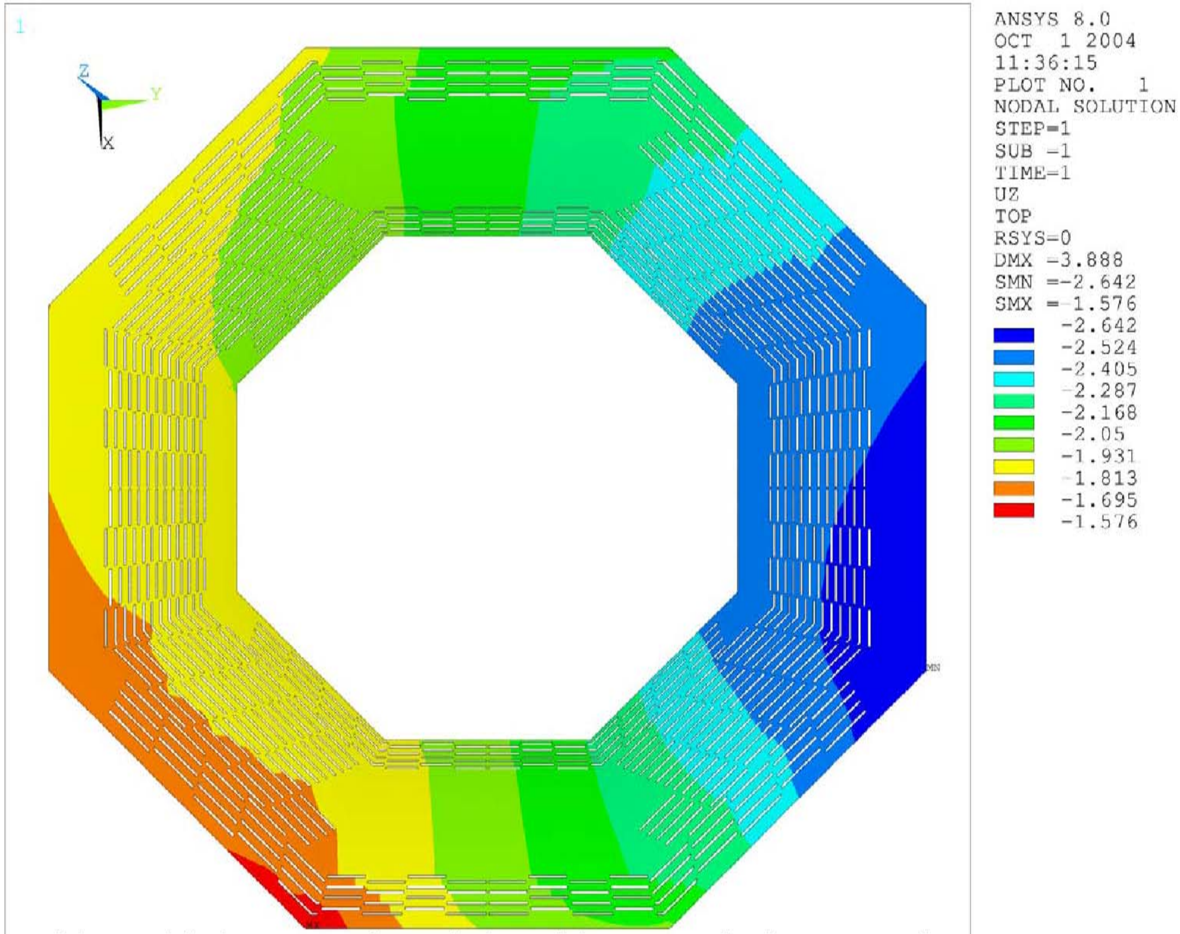
Slide 5



13 Okt 04

LC 4058, FEA mit alter Modulnachbildung

Slide 6



z-Verschiebungen [mm] der Oktagon-Seitenwände

13 Okt 04

LC 4058, FEA mit alter Modulnachbildung

Slide 7