



GENEVE, SUISSE

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Date: 5th December 2007

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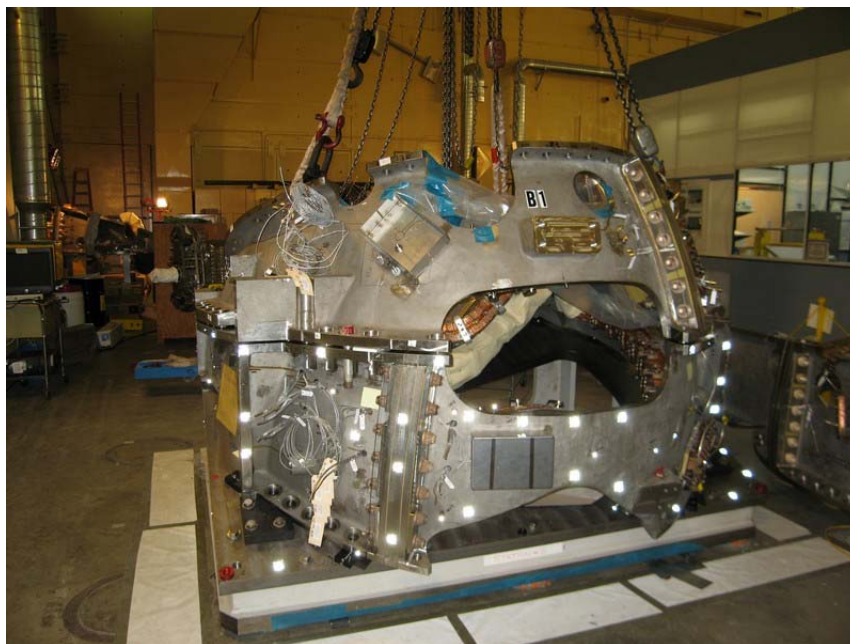
PH/CMI

EDMS : 884992

NCSX

VALIDATION OF PHOTOGRAMMETRY FOR NCSX EXPERIMENT AT PPPL

PPPL – NOVEMBER 2007



Module A1 and B1 during photogrammetry measurements (27/11/2007)

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1 Introduction

1.1 Needs

Following M.E. Viola's request a validation of photogrammetry for NCSX assembly stages was performed during week 48 at Princeton Laboratory for Plasma Physics.

The purpose of this collaboration was to determine whether photogrammetry technique was able to improve the accuracy of the final assembly by reducing time compared to LTD technique.

1.2 Measurements

Seven measurements were done at PPPL on the 27th and 28th of November 2007.

**Average accuracy of each project (RMS / XYZ) : 0.04 mm 1 SIGMA
3D coordinates correspond to the center of photogrammetric targets
ALL IN MM**

Measurements performed the 27th of November:

1. Equipment of module A1 and wedge with 110 coded targets and 23 non-coded targets in the module reference holes ~ 1H
2. Photogrammetry of the full object (~ 200 pictures) + Final Bundle Adjustment ~ 20 min
3. Installation of module B1 on the top of module A1
4. Photogrammetry of the full object (~ 200 pictures) + FBA ~ 20 min
5. Removing of module B1
6. Photogrammetry of the full object (~ 200 pictures) + FBA ~ 20 min
7. Photogrammetry of the full object with PPPL D2X camera (~ 200 pictures) + FBA ~ 20 min
8. Best-fit transformation + deformation analysis for the four projects ~ 10-15 min

Four PG projects:

1 hour for targeting, 1H20min for measurements, 800 pictures, 15 min for analysis

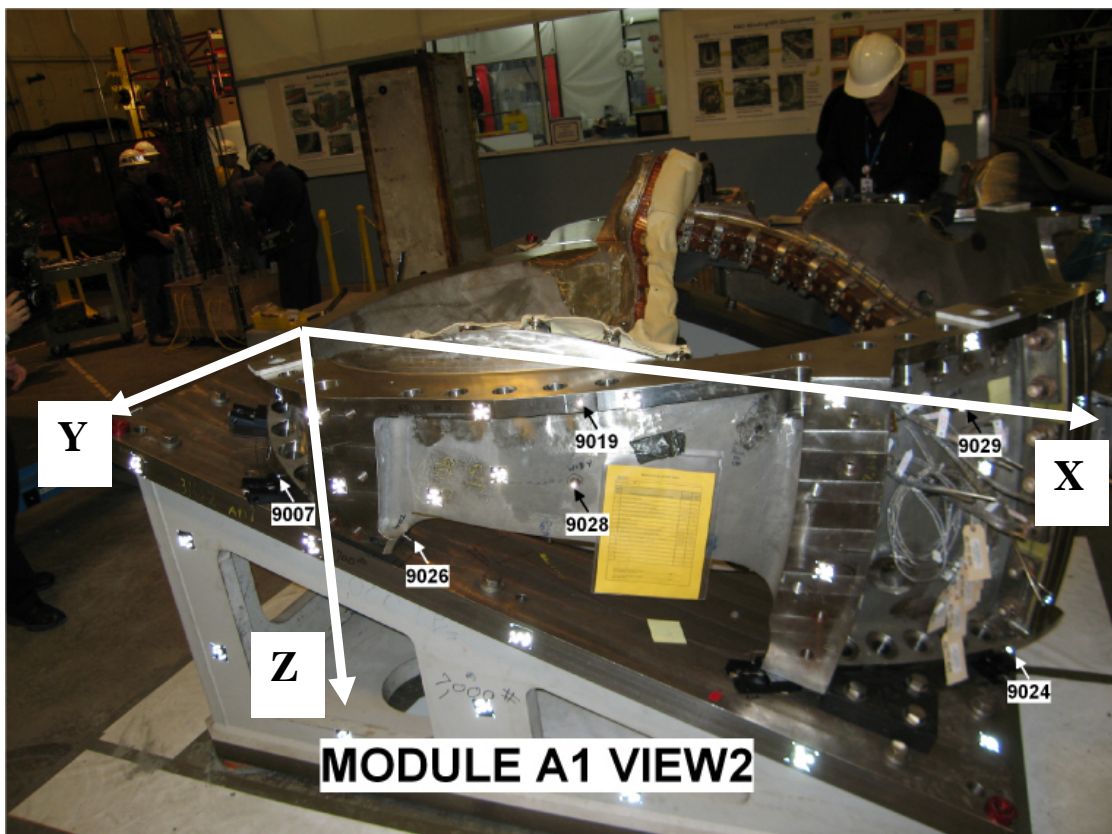
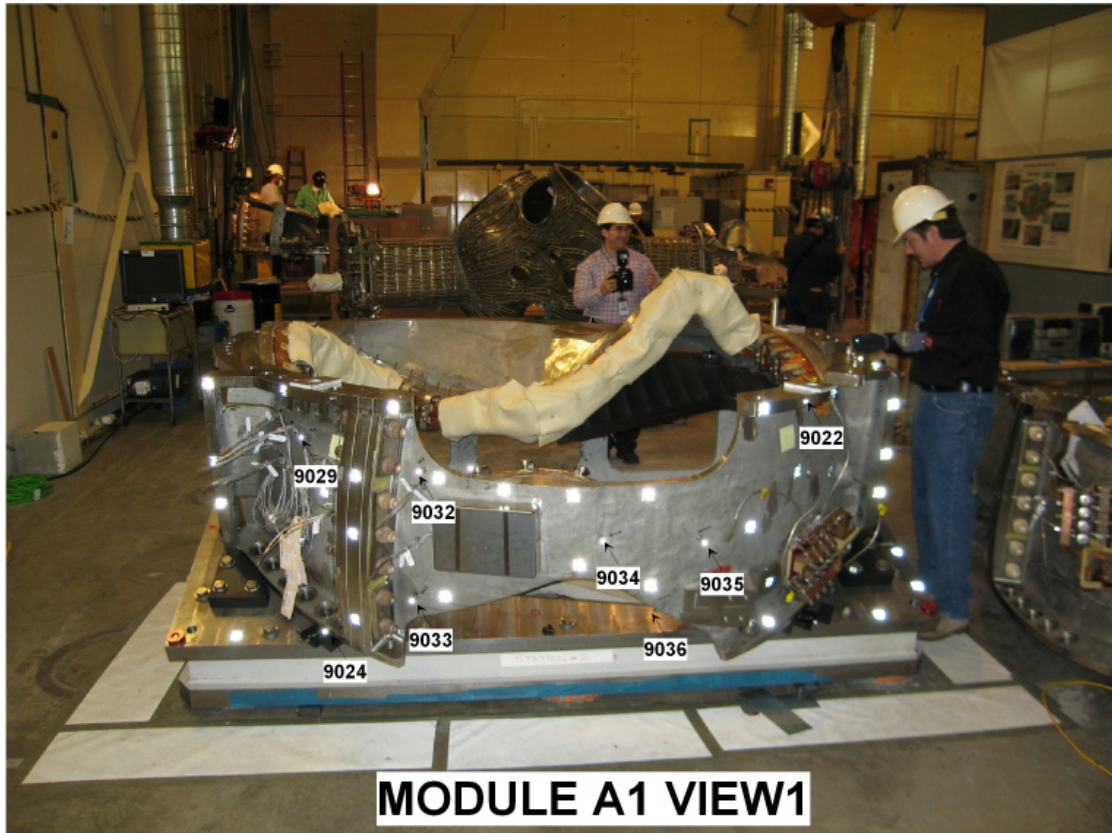
Measurements performed the 28th of November:

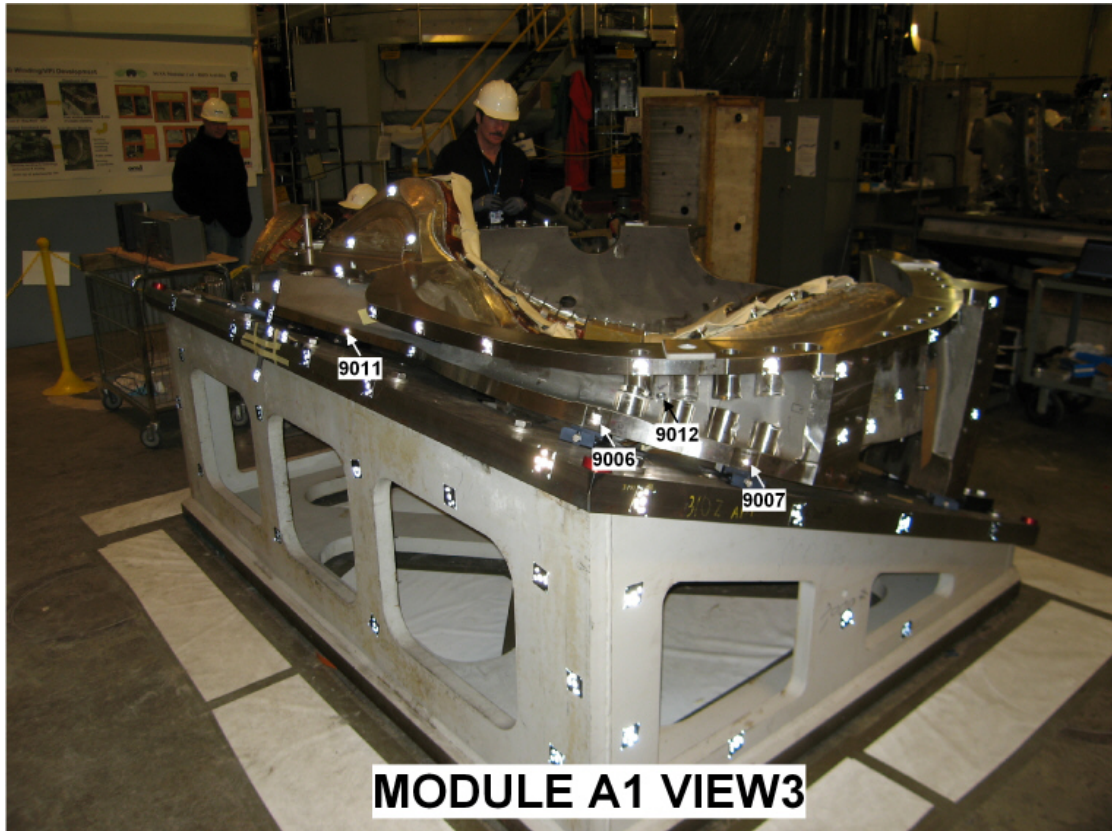
1. Equipment of module B3 and wedge with 130 coded targets and 22 non-coded targets in the module reference holes and 25 non-coded targets on the wedge ~ 1H
2. Photogrammetry of the full object (~ 200 pictures) + Final Bundle Adjustment ~ 20 min
3. Un-racking of the module B3
4. Photogrammetry of the full object (~ 200 pictures) + FBA ~ 20 min
5. Re-racking of the module B3
6. Photogrammetry of the full object (~ 200 pictures) + FBA ~ 20 min
7. Best-fit transformation + deformation analysis for the three projects ~ 10-15 min

Three PG projects:

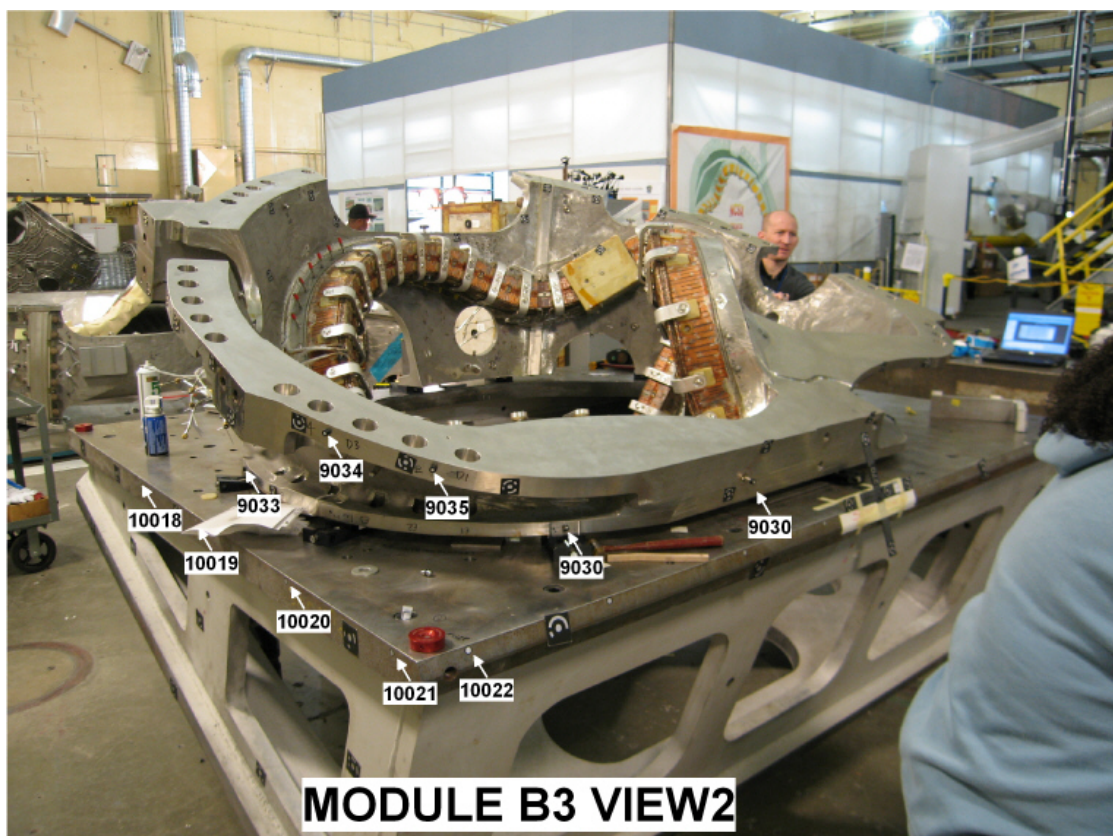
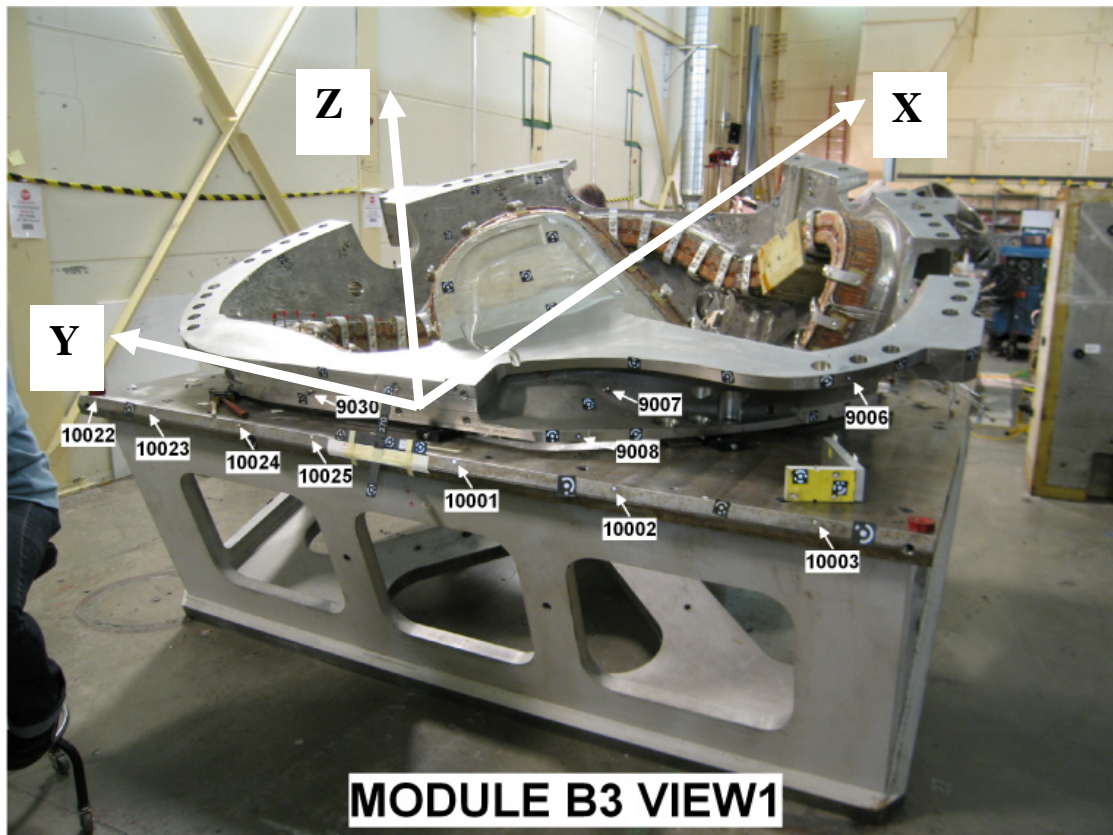
1 hour for targeting, 1H for measurements, 600 pictures, 15 min for analysis

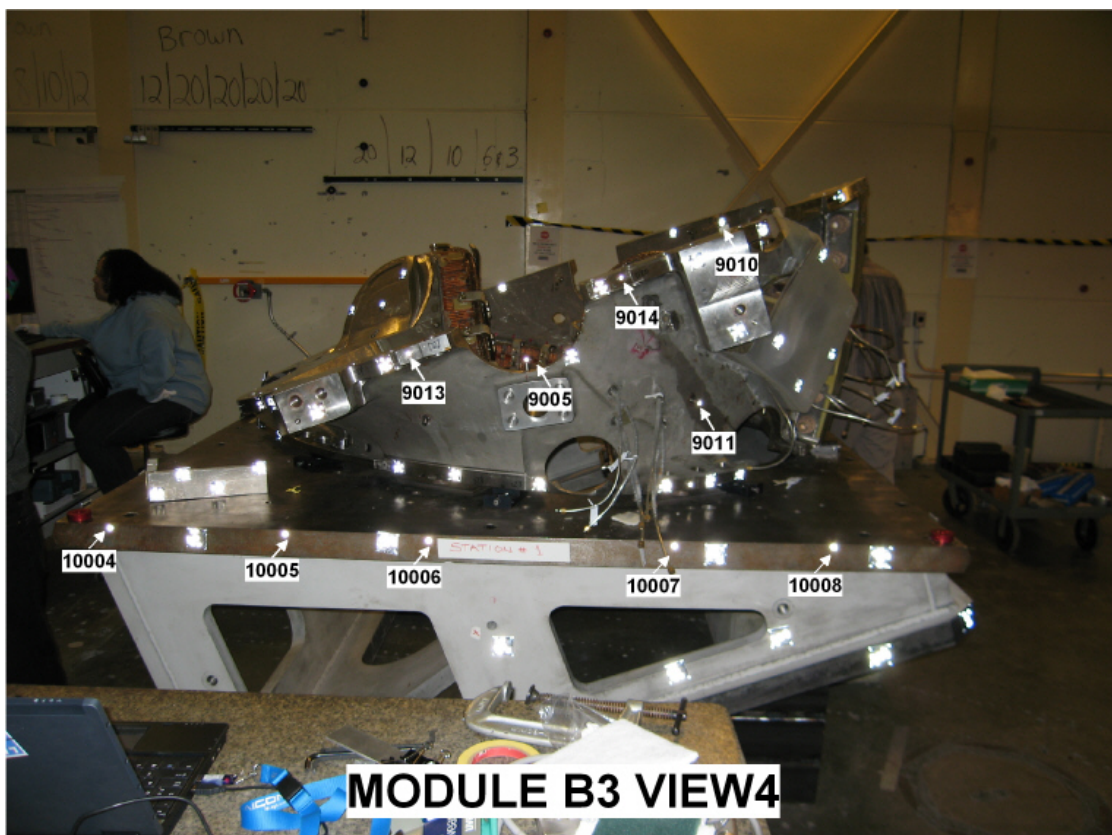
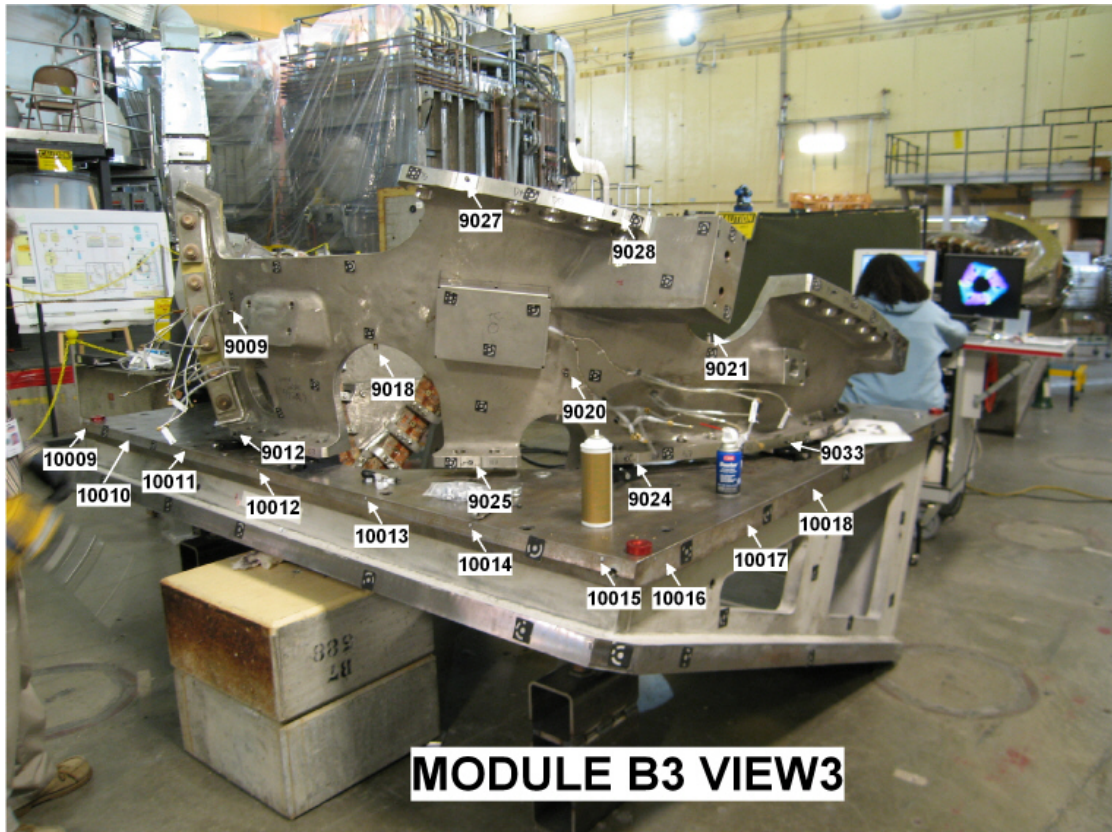
2 Point numbering, module A1





3 Point numbering, module B3





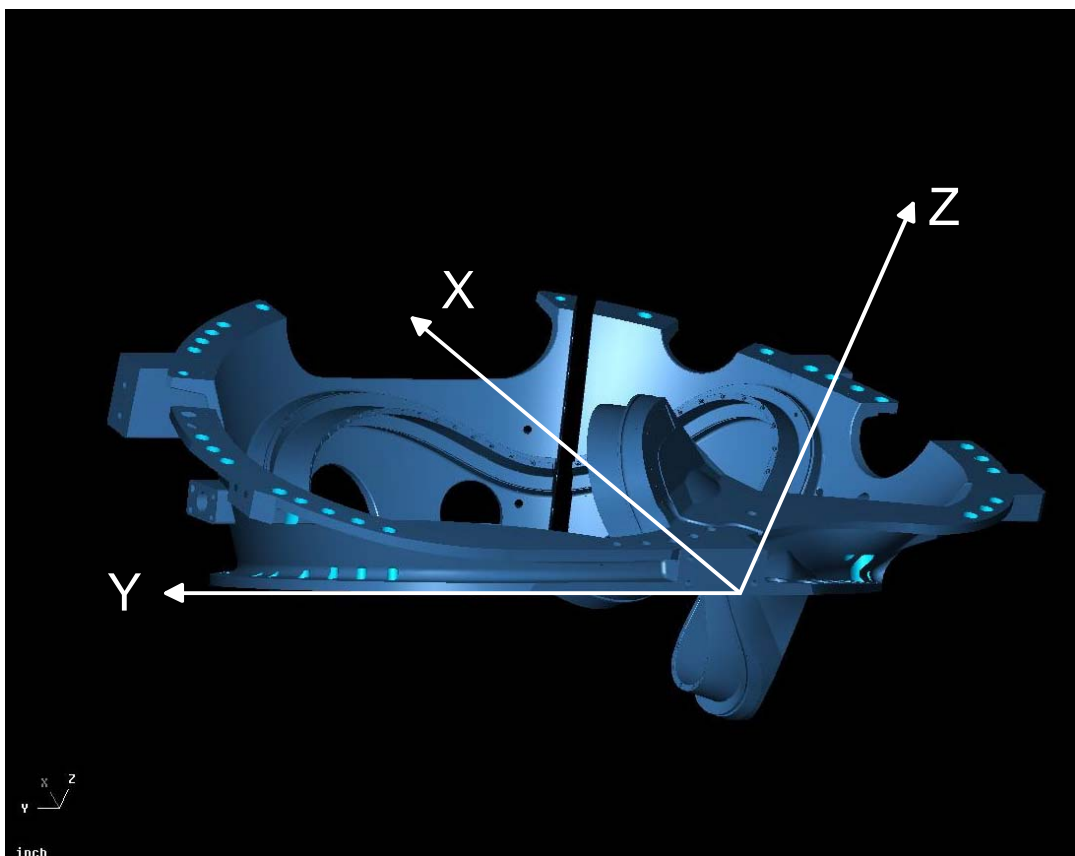
4 Co-ordinate system

The coordinate system chosen has been defined by PPPL and is attached to the geometry of each module.

A network of reference points measured by LTD is known in this system:

- REF-A1 for module A1
- REF-B3 for module B3

All the points measured by digital photogrammetry are given in this coordinate system by doing a best-fit transformation on the reference points.







Coordinate system of B module

5 Geometrical checks

5.1 Module A1:

- Comparison with the set of reference coordinates from LTD measurements for each configuration:

<p>Measurement 1 : module A1</p> <p>Comparison MEAS1 vs REF-A1</p>	
<p>Measurement 2 : module A1 with module B1</p> <p>Comparison MEAS2 vs REF-A1</p>	
<p>Measurement 3 : module A1</p> <p>Comparison MEAS3 vs REF-A1</p>	
<p>Measurement 4 : module A1 with PPPL D2X camera</p> <p>Comparison MEAS4 vs REF-A1</p>	

- Reference coordinates from LTD provided by PPPL, REF-A1:

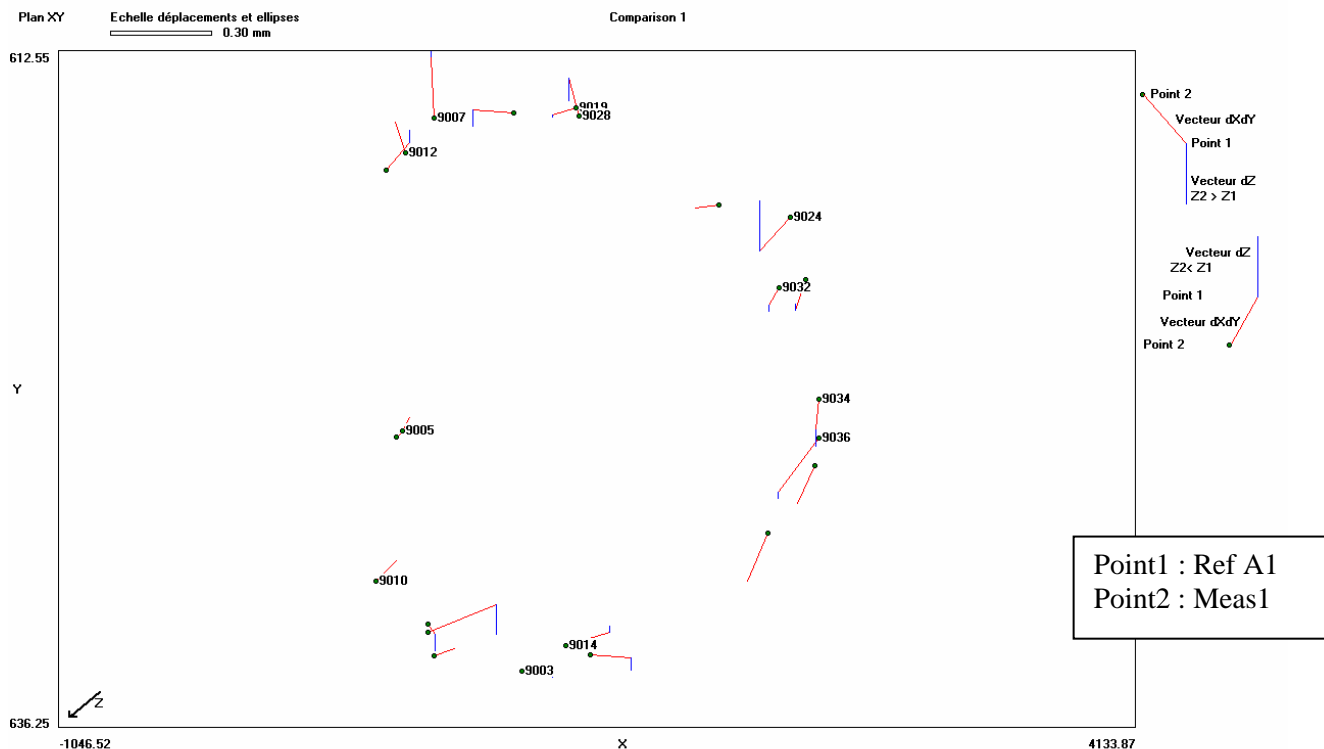
Name	X (mm)	Y (mm)	Z (mm)
9001	634.371	1236.129	-205.289
9002	1658.716	-1254.097	-578.206
9003	1182.114	-1365.519	-404.840
9004	729.823	-1178.599	-240.358
9005	606.225	-211.123	-195.257
9006	524.461	1042.666	-23.789
9007	755.036	1293.581	-23.711
9008	2155.880	-1113.629	-24.009
9009	755.211	-1293.856	-24.204
9010	475.915	-933.327	-24.195
9011	577.157	-240.271	-24.000
9012	620.809	1126.606	-113.735
9013	1509.736	-1289.639	-328.090
9014	1390.487	-1242.285	-413.005
9015	1437.504	-1287.844	-140.558
9016	1141.904	-1317.914	-24.090
9017	729.774	-1141.482	-146.528
9018	573.763	156.834	-100.146
9019	1440.438	1341.794	-498.491
9020	2045.791	972.869	-718.771
9021	2240.921	747.699	-789.785
9022	2363.703	-701.709	-834.542
9023	2155.854	1113.106	-23.782
9024	2473.144	816.686	-23.612
9025	2469.716	-823.215	-24.022
9026	1141.749	1317.980	-24.903
9027	1432.987	1288.246	-139.372
9028	1457.002	1304.566	-305.809
9029	2130.836	877.042	-574.237
9030	2146.526	939.502	-422.717
9031	2241.040	916.305	-233.481
9032	2417.715	477.904	-636.658
9033	2544.601	515.461	-225.668
9034	2609.339	-60.107	-510.776
9035	2592.792	-376.327	-475.411
9036	2611.373	-243.291	-202.657

**3D coordinates correspond to the center of photogrammetric targets
 or tooling balls**

- Comparison MEAS1 vs REF-A1

Name	X (mm)	Y (mm)	Z (mm)	VX (mm)	VY (mm)	VZ (mm)	VXYZ (mm)
9003	1182.02	-1365.52	-404.82	-0.09	0.00	0.02	0.10
9004	729.63	-1178.68	-240.27	-0.20	-0.08	0.09	0.23
9005	606.20	-211.16	-195.26	-0.02	-0.04	0.00	0.04
9006	524.39	1042.59	-23.83	-0.07	-0.08	-0.04	0.11
9007	755.05	1293.40	-23.80	0.01	-0.18	-0.09	0.20
9009	755.15	-1293.87	-24.21	-0.06	-0.02	0.00	0.06
9010	475.86	-933.39	-24.19	-0.06	-0.06	0.00	0.08
9011	577.13	-240.29	-23.99	-0.03	-0.02	0.01	0.03
9012	620.84	1126.52	-113.74	0.03	-0.09	0.00	0.09
9013	1509.61	-1289.63	-328.05	-0.12	0.01	0.04	0.13
9014	1390.36	-1242.33	-413.02	-0.13	-0.04	-0.02	0.14
9017	729.75	-1141.46	-146.48	-0.02	0.03	0.05	0.06
9019	1440.50	1341.82	-498.48	0.07	0.02	0.01	0.07
9022	2363.77	-701.57	-834.54	0.06	0.14	0.00	0.15
9024	2473.24	816.78	-23.76	0.09	0.10	-0.15	0.20
9026	1141.87	1317.97	-24.85	0.12	-0.01	0.05	0.13
9028	1457.03	1304.46	-305.73	0.03	-0.11	0.07	0.14
9029	2130.91	877.05	-574.24	0.07	0.01	0.00	0.07
9032	2417.75	477.96	-636.64	0.03	0.05	0.02	0.06
9033	2544.63	515.55	-225.69	0.03	0.09	-0.02	0.10
9034	2609.35	-60.02	-510.72	0.01	0.09	0.05	0.10
9035	2592.84	-376.22	-475.41	0.05	0.11	0.00	0.12
9036	2611.49	-243.13	-202.63	0.12	0.16	0.02	0.20

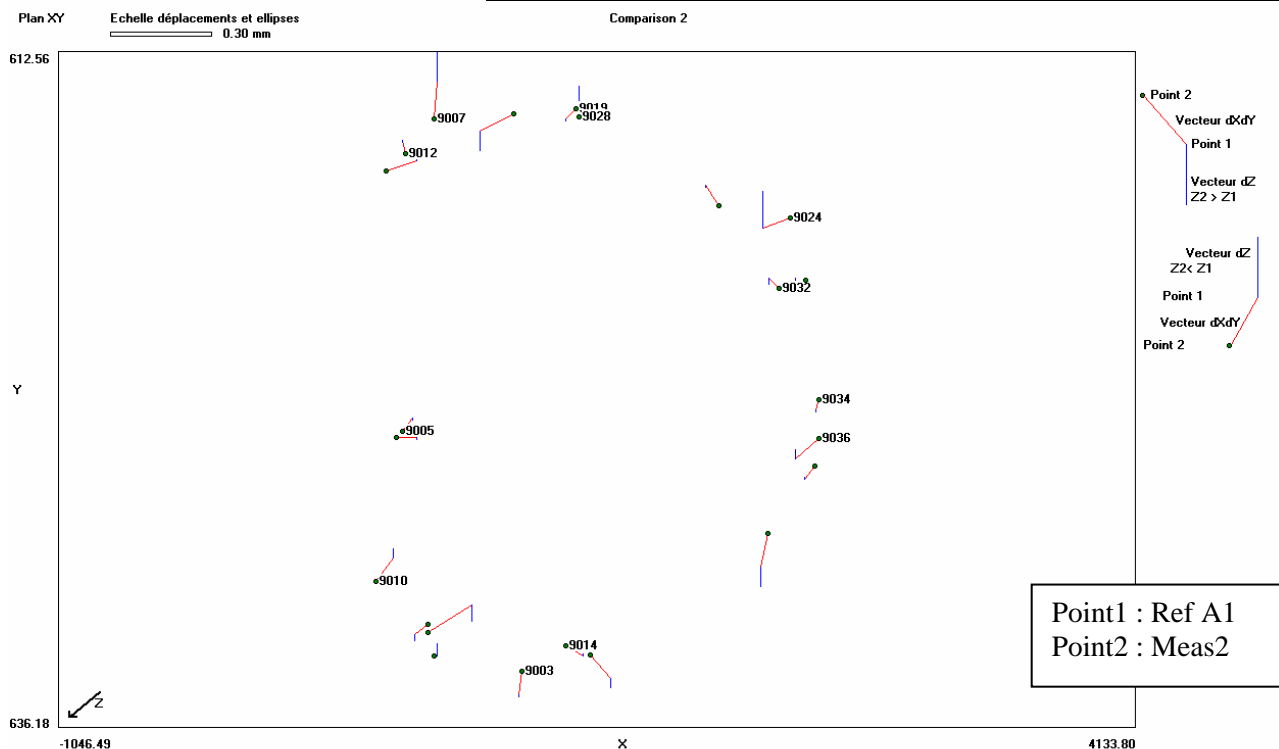
	VX (mm)	VY (mm)	VZ (mm)	VXYZ (mm)
MAX	0.12	0.16	0.09	0.23
MIN	-0.20	-0.18	-0.15	0.03
STDEV	0.08	0.08	0.05	0.05



- Comparison MEAS2 vs REF-A1

Name	X (mm)	Y (mm)	Z (mm)	VX (mm)	VY (mm)	VZ (mm)	VXYZ (mm)
9003	1182.13	-1365.45	-404.83	0.01	0.07	0.01	0.07
9004	729.69	-1178.68	-240.31	-0.13	-0.08	0.05	0.16
9005	606.19	-211.16	-195.25	-0.03	-0.04	0.01	0.05
9006	524.37	1042.63	-23.82	-0.09	-0.03	-0.03	0.10
9007	755.03	1293.47	-23.80	-0.01	-0.11	-0.09	0.14
9009	755.20	-1293.86	-24.24	-0.01	0.00	-0.04	0.04
9010	475.87	-933.40	-24.23	-0.05	-0.07	-0.03	0.09
9011	577.10	-240.27	-23.99	-0.06	0.00	0.01	0.06
9012	620.82	1126.57	-113.73	0.01	-0.04	0.01	0.04
9013	1509.68	-1289.57	-328.06	-0.06	0.07	0.03	0.10
9014	1390.43	-1242.26	-413.02	-0.05	0.03	-0.01	0.06
9017	729.81	-1141.45	-146.51	0.04	0.03	0.02	0.05
9019	1440.46	1341.83	-498.48	0.03	0.03	0.01	0.04
9022	2363.73	-701.61	-834.48	0.02	0.10	0.06	0.12
9024	2473.22	816.71	-23.73	0.08	0.03	-0.11	0.14
9026	1141.85	1318.03	-24.85	0.10	0.05	0.06	0.12
9028	1457.01	1304.47	-305.74	0.00	-0.09	0.07	0.12
9029	2130.87	876.98	-574.23	0.04	-0.06	0.01	0.07
9032	2417.74	477.88	-636.64	0.03	-0.03	0.02	0.04
9033	2544.63	515.48	-225.69	0.03	0.02	-0.03	0.04
9034	2609.35	-60.07	-510.76	0.01	0.03	0.01	0.04
9035	2592.82	-376.29	-475.43	0.03	0.04	-0.01	0.05
9036	2611.44	-243.23	-202.69	0.07	0.06	-0.03	0.10

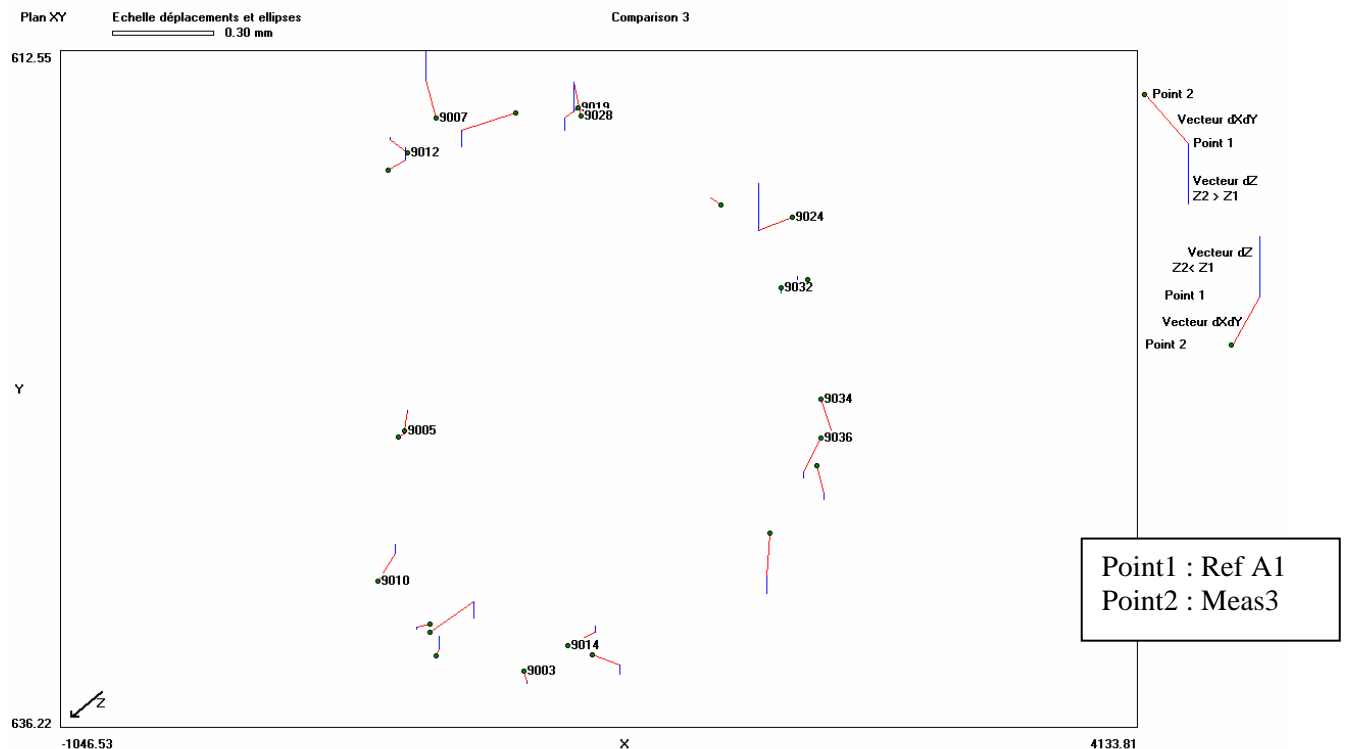
	VX (mm)	VY (mm)	VZ (mm)	VXYZ (mm)
MAX	0.10	0.10	0.07	0.16
MIN	-0.13	-0.11	-0.11	0.04
STDEV	0.05	0.06	0.04	0.04



- Comparison MEAS3 vs REF-A1

Name	X (mm)	Y (mm)	Z (mm)	VX (mm)	VY (mm)	VZ (mm)	VXYZ (mm)
9003	1182.10	-1365.49	-404.83	-0.01	0.03	0.01	0.03
9004	729.69	-1178.69	-240.31	-0.13	-0.09	0.05	0.17
9005	606.21	-211.18	-195.25	-0.01	-0.06	0.01	0.06
9006	524.42	1042.64	-23.83	-0.05	-0.03	-0.04	0.07
9007	755.06	1293.47	-23.80	0.03	-0.11	-0.09	0.14
9009	755.20	-1293.88	-24.24	-0.01	-0.02	-0.04	0.05
9010	475.86	-933.41	-24.22	-0.05	-0.08	-0.03	0.10
9011	577.09	-240.31	-24.00	-0.07	-0.04	0.00	0.08
9012	620.86	1126.56	-113.75	0.05	-0.04	-0.01	0.07
9013	1509.66	-1289.61	-328.06	-0.08	0.03	0.03	0.09
9014	1390.41	-1242.32	-413.02	-0.08	-0.04	-0.02	0.09
9017	729.81	-1141.47	-146.52	0.04	0.01	0.01	0.04
9019	1440.48	1341.82	-498.45	0.04	0.03	0.04	0.06
9022	2363.71	-701.58	-834.50	0.01	0.13	0.05	0.14
9024	2473.24	816.72	-23.75	0.10	0.04	-0.14	0.17
9026	1141.90	1318.03	-24.86	0.16	0.05	0.05	0.17
9028	1457.02	1304.47	-305.72	0.02	-0.10	0.09	0.13
9029	2130.87	877.02	-574.23	0.03	-0.02	0.00	0.04
9032	2417.72	477.91	-636.65	0.00	0.01	0.01	0.01
9033	2544.63	515.51	-225.71	0.03	0.04	-0.05	0.07
9034	2609.31	-60.02	-510.75	-0.03	0.09	0.03	0.10
9035	2592.77	-376.25	-475.39	-0.02	0.08	0.02	0.08
9036	2611.42	-243.19	-202.64	0.05	0.10	0.02	0.11

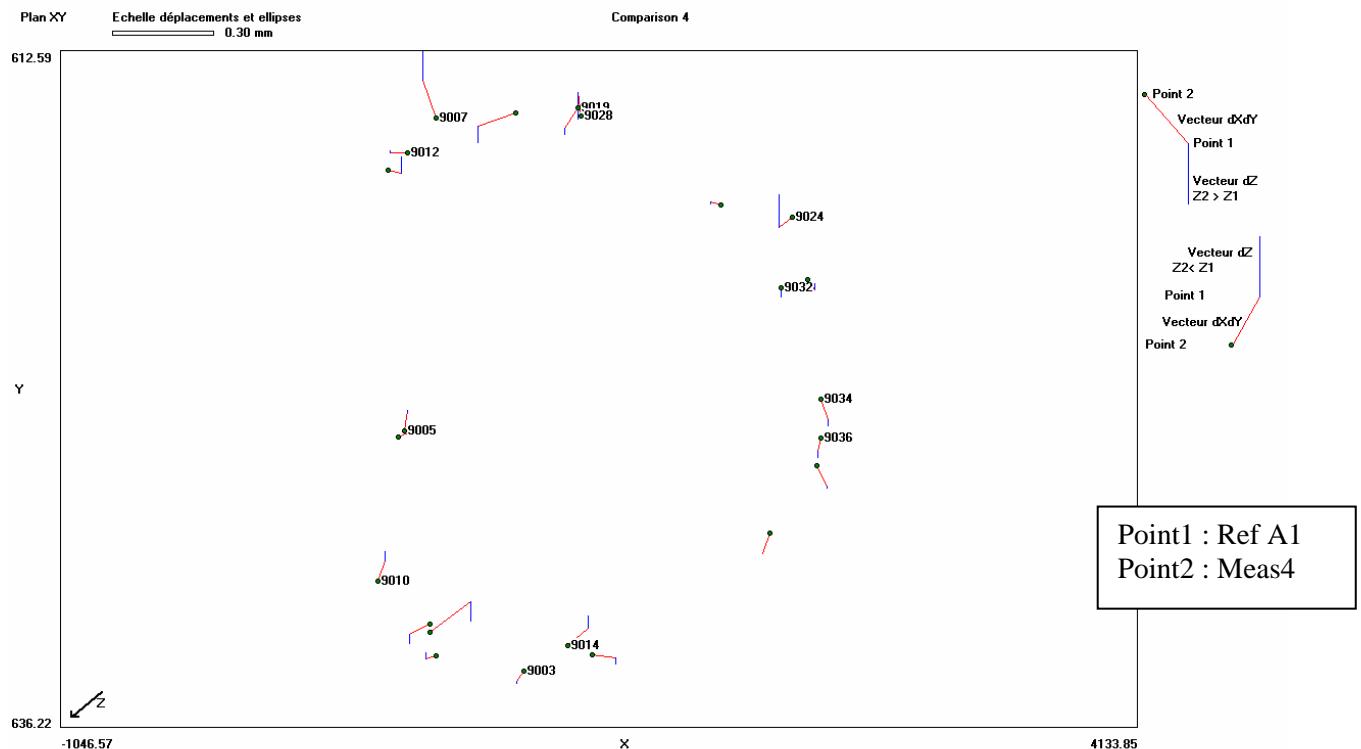
	VX (mm)	VY (mm)	VZ (mm)	VXYZ (mm)
MAX	0.16	0.13	0.09	0.17
MIN	-0.13	-0.11	-0.14	0.01
STDEV	0.06	0.07	0.05	0.04



- Comparison MEAS4 vs REF-A1

Name	X (mm)	Y (mm)	Z (mm)	VX (mm)	VY (mm)	VZ (mm)	VXYZ (mm)
9003	1182.13	-1365.49	-404.83	0.02	0.03	0.01	0.03
9004	729.71	-1178.69	-240.30	-0.12	-0.09	0.06	0.16
9005	606.21	-211.18	-195.25	-0.01	-0.06	0.01	0.06
9006	524.42	1042.68	-23.84	-0.04	0.01	-0.05	0.06
9007	755.07	1293.47	-23.80	0.04	-0.11	-0.09	0.14
9009	755.24	-1293.84	-24.22	0.03	0.01	-0.02	0.04
9010	475.90	-933.39	-24.22	-0.02	-0.06	-0.03	0.07
9011	577.09	-240.30	-24.00	-0.07	-0.03	0.00	0.07
9012	620.86	1126.61	-113.74	0.05	0.00	-0.01	0.05
9013	1509.67	-1289.63	-328.07	-0.07	0.01	0.02	0.07
9014	1390.42	-1242.33	-413.04	-0.06	-0.05	-0.04	0.09
9017	729.83	-1141.46	-146.50	0.06	0.03	0.03	0.07
9019	1440.48	1341.86	-498.47	0.04	0.06	0.02	0.08
9022	2363.72	-701.65	-834.54	0.02	0.06	0.00	0.06
9024	2473.18	816.71	-23.71	0.04	0.03	-0.10	0.11
9026	1141.86	1318.02	-24.86	0.11	0.04	0.05	0.13
9028	1457.01	1304.49	-305.72	0.01	-0.07	0.08	0.11
9029	2130.86	877.03	-574.23	0.03	-0.01	0.01	0.03
9032	2417.72	477.91	-636.64	0.00	0.01	0.02	0.02
9033	2544.58	515.49	-225.69	-0.02	0.03	-0.02	0.04
9034	2609.32	-60.05	-510.76	-0.02	0.06	0.02	0.07
9035	2592.76	-376.27	-475.40	-0.03	0.06	0.01	0.07
9036	2611.38	-243.25	-202.63	0.01	0.04	0.02	0.05

	VX (mm)	VY (mm)	VZ (mm)	VXYZ (mm)
MAX	0.11	0.06	0.08	0.16
MIN	-0.12	-0.11	-0.10	0.02
STDEV	0.05	0.05	0.04	0.04

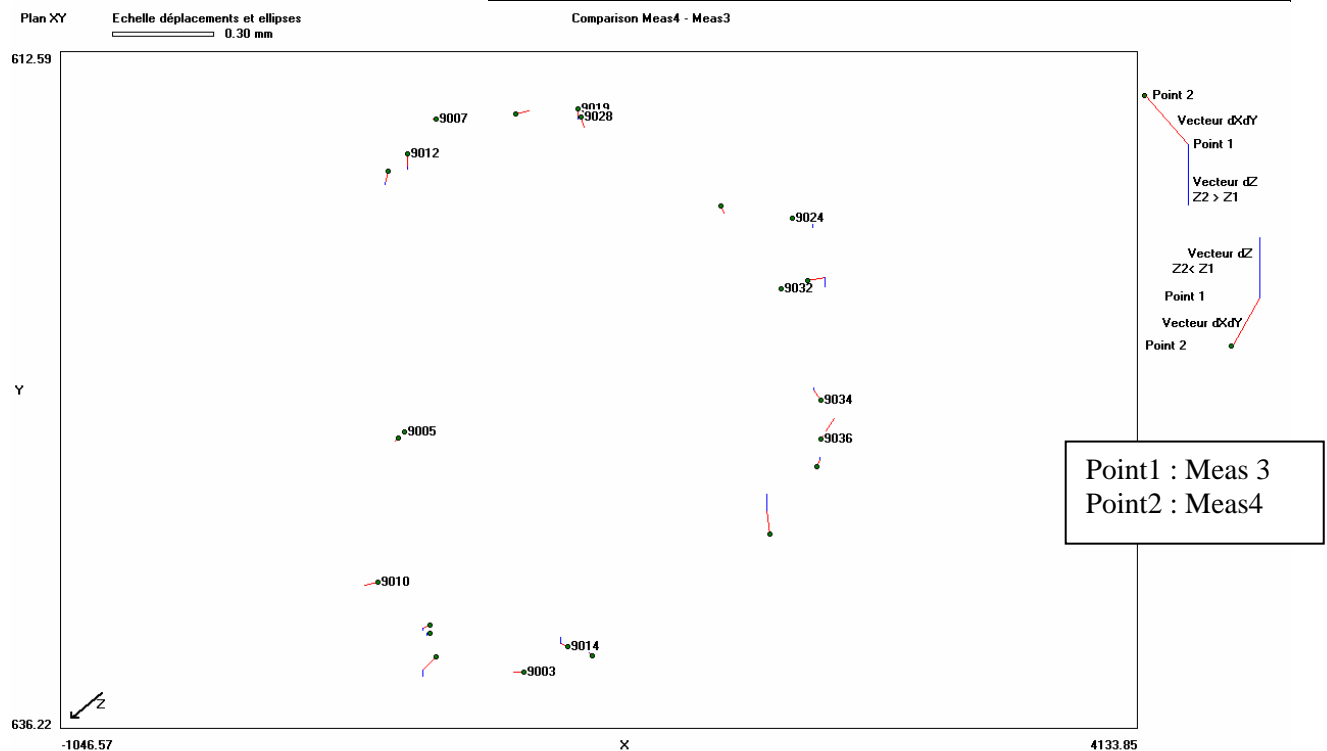


- Comparison between Measurement4 and Measurement3 :

This comparison gives a good idea of the repeatability of the technique using different cameras.




Name	X (mm)	Y (mm)	Z (mm)	VX (mm)	VY (mm)	VZ (mm)	VXYZ (mm)
9003	1182.13	-1365.49	-404.83	0.03	0.00	0.00	0.03
9004	729.71	-1178.69	-240.30	0.01	0.00	0.01	0.02
9005	606.21	-211.18	-195.25	0.00	0.00	-0.01	0.01
9006	524.42	1042.68	-23.84	0.01	0.04	-0.01	0.04
9007	755.07	1293.47	-23.80	0.01	0.00	0.00	0.01
9009	755.24	-1293.84	-24.22	0.04	0.04	0.02	0.06
9010	475.90	-933.39	-24.22	0.04	0.01	0.00	0.04
9011	577.09	-240.30	-24.00	0.01	0.01	0.00	0.01
9012	620.86	1126.61	-113.74	0.00	0.04	0.01	0.05
9013	1509.67	-1289.63	-328.07	0.01	-0.01	-0.02	0.02
9014	1390.42	-1242.33	-413.04	0.02	-0.01	-0.02	0.03
9017	729.83	-1141.46	-146.50	0.02	0.01	0.01	0.03
9019	1440.48	1341.86	-498.47	0.00	0.03	-0.01	0.04
9022	2363.72	-701.65	-834.54	0.01	-0.07	-0.05	0.09
9024	2473.18	816.71	-23.71	-0.06	-0.01	0.04	0.07
9026	1141.86	1318.02	-24.86	-0.04	-0.01	0.00	0.04
9028	1457.01	1304.49	-305.72	-0.01	0.03	0.00	0.03
9029	2130.86	877.03	-574.23	-0.01	0.02	0.00	0.02
9032	2417.72	477.92	-636.64	0.00	0.00	0.00	0.00
9033	2544.58	515.49	-225.69	-0.05	-0.01	0.03	0.06
9034	2609.32	-60.05	-510.76	0.02	-0.03	-0.01	0.03
9035	2592.76	-376.27	-475.40	-0.01	-0.02	-0.01	0.02
9036	2611.38	-243.25	-202.63	-0.04	-0.06	0.00	0.07

	VX (mm)	VY (mm)	VZ (mm)	VXYZ (mm)
MAX	0.04	0.04	0.04	0.09
MIN	-0.06	-0.07	-0.05	0.00
STDEV	0.03	0.03	0.02	0.02



5.2 Module B3:

Comparison with the set of the 25 reference points stuck on the wedge (10001 to 10025) :

<p>Measurement 1 : module B3 racked</p>	
<p>Measurement 2 : module B3 un-racked</p>	
<p>Measurement 3 : module B3 re-racked</p>	

The 25 reference points were calculated in the wedge coordinate system of measurement1 (points 10001 to 10025).

Measurements 2 and 3 were best-fitted to this set of coordinates in order to observe movements and deformation of the coil w.r.t. the wedge (considered as a fix and stable element)

- Reference coordinates from LTD provided by PPPL, REF-B3:

Name	X (mm)	Y (mm)	Z (mm)
8001	1012.256	-1107.104	-610.826
8002	788.258	-899.611	-633.003
8003	1862.565	-205.619	-1394.394
8004	2004.074	-851.073	-807.679
8005	1330.949	-1128.529	-641.255
8006	654.555	-1080.732	-261.945
8007	587.244	-430.154	-331.913
8008	391.503	-424.868	-299.891
8009	2138.190	-304.281	-1219.755
8010	1597.338	-965.246	-1034.919
8011	1445.061	-1023.045	-1184.156
8012	1847.184	-374.193	-1521.517
8013	1164.443	-1357.876	-447.634
8014	1640.331	-1247.082	-621.107
8015	2237.800	-843.596	-838.529
8016	2250.929	-19.802	-1054.034
8017	2138.233	-304.289	-1219.704
8018	1971.450	296.068	-1222.715
8019	1589.490	713.328	-1178.123
8020	1714.621	778.959	-1089.052
8021	1133.839	1205.961	-669.620
8022	691.128	1150.171	-418.135
8023	1091.359	1184.729	-887.103
8024	1470.589	911.975	-1205.149
8025	1706.568	583.445	-1403.240
8026	1847.211	-374.145	-1521.446
8027	2270.036	673.110	-849.674
8028	2025.143	969.133	-760.886
8029	1722.763	-690.986	-1249.653
8030	346.008	429.193	-213.141
8031	411.765	879.531	-316.870
8032	719.123	1194.046	-574.877
8033	1091.313	1184.720	-887.099
8034	707.734	1287.174	-281.588
8035	546.156	1160.158	-222.687

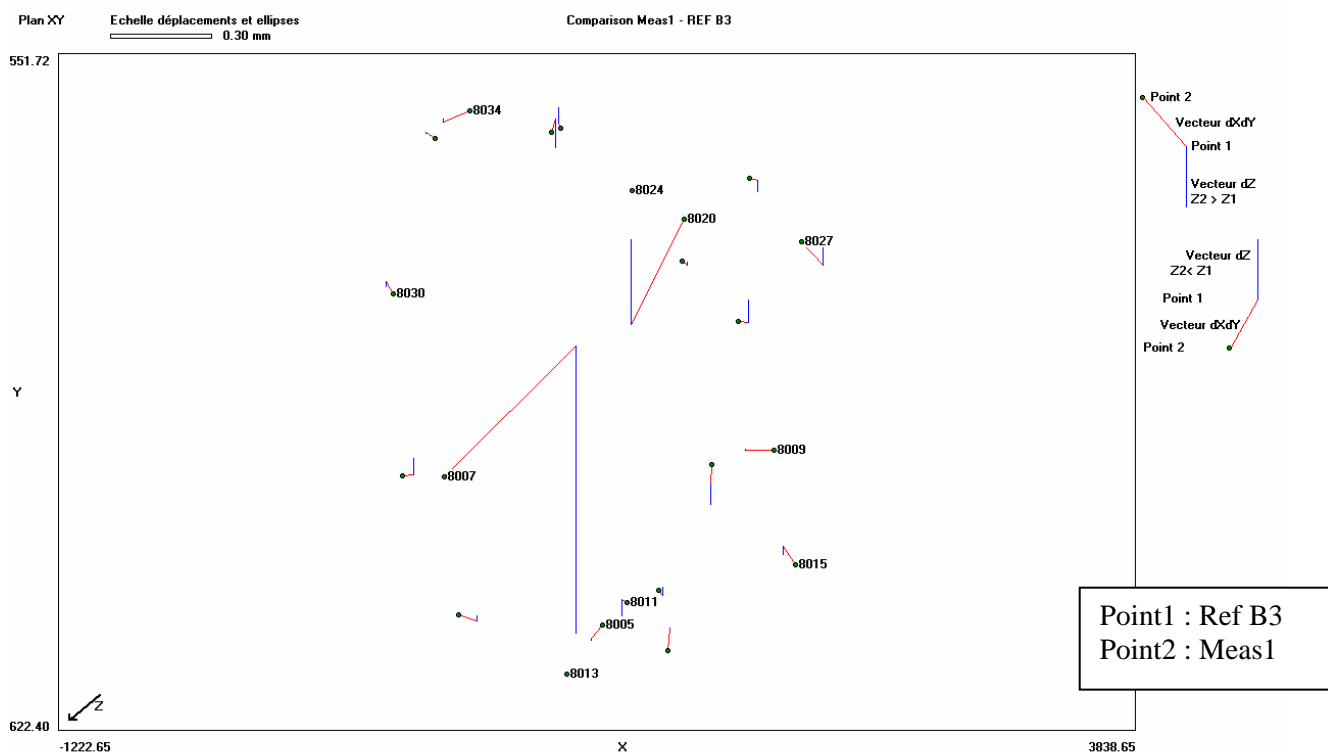
**3D coordinates correspond to the center of photogrammetric targets
 or tooling balls**

- Comparison MEAS1 vs REF-B3

Name	X (mm)	Y (mm)	Z (mm)	VX (mm)	VY (mm)	VZ (mm)	VXYZ (mm)
8005	1330.98	-1128.49	-641.25	0.03	0.04	0.01	0.05
8006	654.50	-1080.71	-261.96	-0.05	0.02	-0.02	0.06
8007 (*)	586.86	-430.54	-331.07	-0.39	-0.38	0.85	1.01
8008	391.47	-424.87	-299.94	-0.03	0.00	-0.05	0.06
8009	2138.27	-304.28	-1219.76	0.08	0.00	-0.01	0.08
8010	1597.33	-965.23	-1034.95	-0.01	0.01	-0.03	0.03
8011	1445.08	-1023.05	-1184.11	0.01	-0.01	0.05	0.05
8012	1847.19	-374.14	-1521.45	0.00	0.06	0.06	0.09
8013	1164.41	-1357.89	-447.61	-0.04	-0.01	0.02	0.04
8014	1640.32	-1247.15	-621.10	-0.01	-0.07	0.00	0.07
8015	2237.83	-843.65	-838.50	0.04	-0.06	0.03	0.07
8018	1971.42	296.07	-1222.79	-0.03	0.00	-0.07	0.08
8020 (*)	1714.78	779.27	-1089.31	0.16	0.31	-0.25	0.43
8021	1133.84	1205.94	-669.67	0.01	-0.02	-0.05	0.05
8024	1470.58	911.98	-1205.16	-0.01	0.00	-0.01	0.02
8025	1706.55	583.46	-1403.25	-0.01	0.01	-0.01	0.02
8027	2269.97	673.18	-849.73	-0.06	0.07	-0.06	0.11
8028	2025.12	969.14	-760.85	-0.02	0.01	0.04	0.04
8030	346.03	429.16	-213.12	0.02	-0.04	0.02	0.04
8033	1091.30	1184.68	-887.01	-0.01	-0.04	0.09	0.10
8034	707.81	1287.21	-281.60	0.08	0.03	-0.01	0.08
8035	546.18	1160.14	-222.68	0.03	-0.02	0.01	0.03

	VX (mm)	VY (mm)	VZ (mm)	VXYZ (mm)
MAX	0.08	0.07	0.09	0.11
MIN	-0.06	-0.07	-0.07	0.02
STDEV	0.04	0.03	0.04	0.02

(*) Point rejected by best-fit transformation, point not in contact with reference surface, not fully seated due to tight clearance



- Reference points 10001 to 10025 from PG of measurement 1:

Name	X (mm)	Y (mm)	Z (mm)
10001	196.41	-170.11	-209.23
10002	194.98	-618.64	-207.86
10003	192.63	-1094.02	-206.99
10004	303.15	-1346.45	-302.17
10005	644.05	-1348.55	-586.85
10006	907.72	-1350.07	-813.16
10007	1351.73	-1352.76	-1182.19
10008	1643.50	-1354.66	-1420.88
10009	1895.54	-1296.57	-1632.28
10010	1896.62	-986.75	-1633.71
10011	1898.23	-525.39	-1635.87
10012	1899.54	-45.88	-1638.74
10013	1901.66	482.35	-1639.17
10014	1903.10	878.67	-1639.66
10015	1904.04	1273.92	-1641.56
10016	1847.82	1362.20	-1595.49
10017	1587.51	1363.54	-1377.29
10018	1262.54	1365.33	-1108.68
10019	928.41	1367.51	-827.80
10020	554.10	1369.99	-512.74
10021	257.92	1371.91	-265.83
10022	202.10	1281.26	-213.26
10023	201.04	980.72	-212.28
10024	199.05	602.20	-211.53
10025	198.34	314.56	-210.53

3D coordinates correspond to the center of photogrammetric stickers

- Comparison MEAS2 vs MEAS1

Name	X (mm)	Y (mm)	Z (mm)	VX (mm)	VY (mm)	VZ (mm)	VXYZ (mm)
10001	196.38	-170.10	-209.22	-0.03	0.01	0.01	0.03
10002	194.98	-618.65	-207.88	0.00	-0.01	-0.02	0.02
10003	192.62	-1094.08	-207.00	-0.01	-0.05	-0.01	0.05
10004	303.18	-1346.46	-302.23	0.03	-0.01	-0.06	0.07
10005	644.08	-1348.57	-586.88	0.04	-0.02	-0.03	0.05
10006	907.74	-1350.09	-813.14	0.02	-0.02	0.02	0.03
10007	1351.74	-1352.75	-1182.19	0.01	0.01	0.00	0.02
10008	1643.51	-1354.67	-1420.88	0.01	0.00	0.00	0.01
10009	1895.53	-1296.52	-1632.25	-0.01	0.04	0.03	0.05
10010	1896.61	-986.74	-1633.69	0.00	0.01	0.02	0.02
10011	1898.22	-525.40	-1635.86	-0.01	-0.01	0.01	0.02
10012	1899.56	-45.92	-1638.76	0.02	-0.04	-0.01	0.05
10013	1901.64	482.31	-1639.18	-0.02	-0.04	-0.01	0.04
10014	1903.10	878.66	-1639.67	0.00	-0.02	0.00	0.02
10015	1904.03	1273.92	-1641.57	-0.01	0.00	-0.01	0.01
10016	1847.78	1362.17	-1595.51	-0.04	-0.03	-0.02	0.05
10017	1587.50	1363.53	-1377.28	-0.01	0.00	0.00	0.01
10018	1262.53	1365.32	-1108.65	-0.01	-0.01	0.03	0.03
10019	928.39	1367.51	-827.77	-0.01	0.00	0.03	0.03
10020	554.10	1370.01	-512.70	0.00	0.02	0.03	0.04
10021	257.93	1371.95	-265.82	0.01	0.04	0.01	0.04
10022	202.11	1281.28	-213.26	0.02	0.02	0.00	0.02
10023	201.06	980.74	-212.29	0.02	0.02	-0.01	0.03
10024	199.06	602.25	-211.55	0.00	0.06	-0.01	0.06
10025	198.33	314.60	-210.53	-0.02	0.04	0.01	0.04

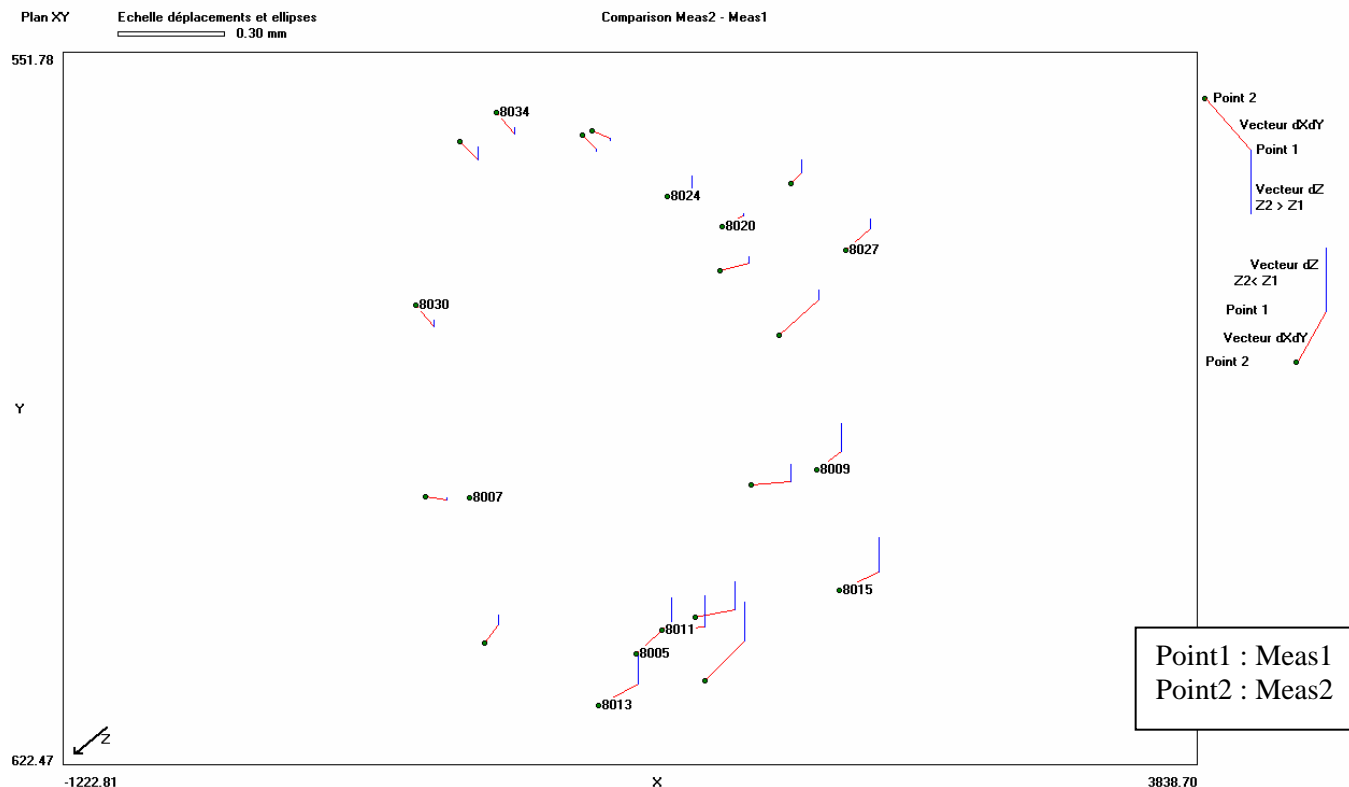
	VX (mm)	VY (mm)	VZ (mm)	VXYZ (mm)
MAX	0.04	0.04	0.03	0.07
MIN	-0.04	-0.04	-0.06	0.01
STDEV	0.02	0.02	0.02	0.02

This comparison highlights the good stability of the points stuck on the the wedge. This local reference network is stable enough to measure any deformation and movement of the coil during racking.

Name	X (mm)	Y (mm)	Z (mm)	VX (mm)	VY (mm)	VZ (mm)	VXYZ (mm)
8005	1330.89	-1128.58	-641.32	-0.10	-0.09	-0.07	0.15
8006	654.46	-1080.77	-261.99	-0.04	-0.05	-0.03	0.07
8007	586.81	-430.54	-331.08	-0.05	0.00	-0.01	0.05
8008	391.41	-424.86	-299.95	-0.06	0.01	-0.01	0.06
8009	2138.20	-304.34	-1219.84	-0.07	-0.05	-0.08	0.12
8010	1597.22	-965.25	-1035.02	-0.11	-0.02	-0.08	0.13
8011	1444.95	-1023.06	-1184.20	-0.12	-0.01	-0.09	0.15
8012	1847.08	-374.14	-1521.51	-0.11	-0.01	-0.05	0.12
8013	1164.30	-1357.95	-447.71	-0.11	-0.06	-0.09	0.15
8014	1640.21	-1247.25	-621.21	-0.11	-0.11	-0.11	0.19
8015	2237.73	-843.70	-838.60	-0.11	-0.05	-0.10	0.15
8018	1971.30	295.98	-1222.82	-0.11	-0.10	-0.03	0.15
8020	1714.72	779.24	-1089.32	-0.06	-0.03	-0.01	0.07
8021	1133.80	1205.97	-669.66	-0.05	0.02	0.01	0.05
8024	1470.51	911.96	-1205.20	-0.07	-0.02	-0.04	0.08
8025	1706.48	583.44	-1403.27	-0.08	-0.02	-0.02	0.08
8027	2269.91	673.12	-849.76	-0.07	-0.06	-0.03	0.09
8028	2025.09	969.11	-760.89	-0.03	-0.03	-0.04	0.06
8030	345.98	429.22	-213.15	-0.05	0.06	-0.02	0.08
8033	1091.26	1184.72	-887.00	-0.04	0.04	0.01	0.06
8034	707.76	1287.26	-281.62	-0.05	0.06	-0.02	0.08
8035	546.13	1160.19	-222.72	-0.05	0.05	-0.04	0.08

	VX (mm)	VY (mm)	VZ (mm)	VXYZ (mm)
MAX	-0.03	0.06	0.01	0.19
MIN	-0.12	-0.11	-0.11	0.05
STDEV	0.03	0.05	0.04	0.04

The comparison highlights deformation + movement up to 0.19mm after un-racking.



The indicators placed near the points 9008, 9011, 9012, 9025, and 9033 recorded similar movements within +/- 0.04 mm

- Comparison MEAS3 vs MEAS1

Name	X (mm)	Y (mm)	Z (mm)	VX (mm)	VY (mm)	VZ (mm)	VXYZ (mm)
10001	196.39	-170.14	-209.20	-0.01	-0.03	0.03	0.04
10002	194.98	-618.69	-207.87	0.00	-0.04	-0.01	0.04
10003	192.64	-1094.05	-207.00	0.01	-0.02	0.00	0.02
10004	303.21	-1346.38	-302.24	0.05	0.07	-0.07	0.11
10005	644.06	-1348.52	-586.88	0.01	0.03	-0.03	0.04
10006	907.73	-1350.05	-813.14	0.01	0.01	0.02	0.02
10007	1351.72	-1352.75	-1182.15	-0.01	0.01	0.04	0.04
10008	1643.48	-1354.68	-1420.86	-0.01	-0.02	0.02	0.03
10009	1895.47	-1296.53	-1632.23	-0.07	0.04	0.05	0.09
10010	1896.59	-986.73	-1633.69	-0.03	0.02	0.02	0.04
10011	1898.23	-525.40	-1635.88	0.00	-0.02	-0.01	0.02
10012	1899.58	-45.91	-1638.76	0.04	-0.03	-0.02	0.05
10013	1901.70	482.30	-1639.21	0.04	-0.04	-0.05	0.08
10014	1903.15	878.67	-1639.71	0.05	0.00	-0.05	0.07
10015	1904.05	1273.96	-1641.58	0.01	0.03	-0.02	0.04
10016	1847.82	1362.22	-1595.51	0.00	0.01	-0.02	0.02
10017	1587.52	1363.54	-1377.29	0.01	0.01	-0.01	0.01
10018	1262.54	1365.35	-1108.66	0.00	0.01	0.02	0.02
10019	928.41	1367.51	-827.78	0.00	-0.01	0.01	0.02
10020	554.10	1369.98	-512.73	0.01	0.00	0.01	0.01
10021	257.91	1371.92	-265.81	-0.02	0.01	0.02	0.03
10022	202.06	1281.26	-213.25	-0.03	0.00	0.01	0.04
10023	201.04	980.70	-212.29	-0.01	-0.02	0.00	0.02
10024	199.03	602.19	-211.51	-0.02	-0.01	0.02	0.04
10025	198.33	314.53	-210.53	-0.02	-0.03	0.01	0.03

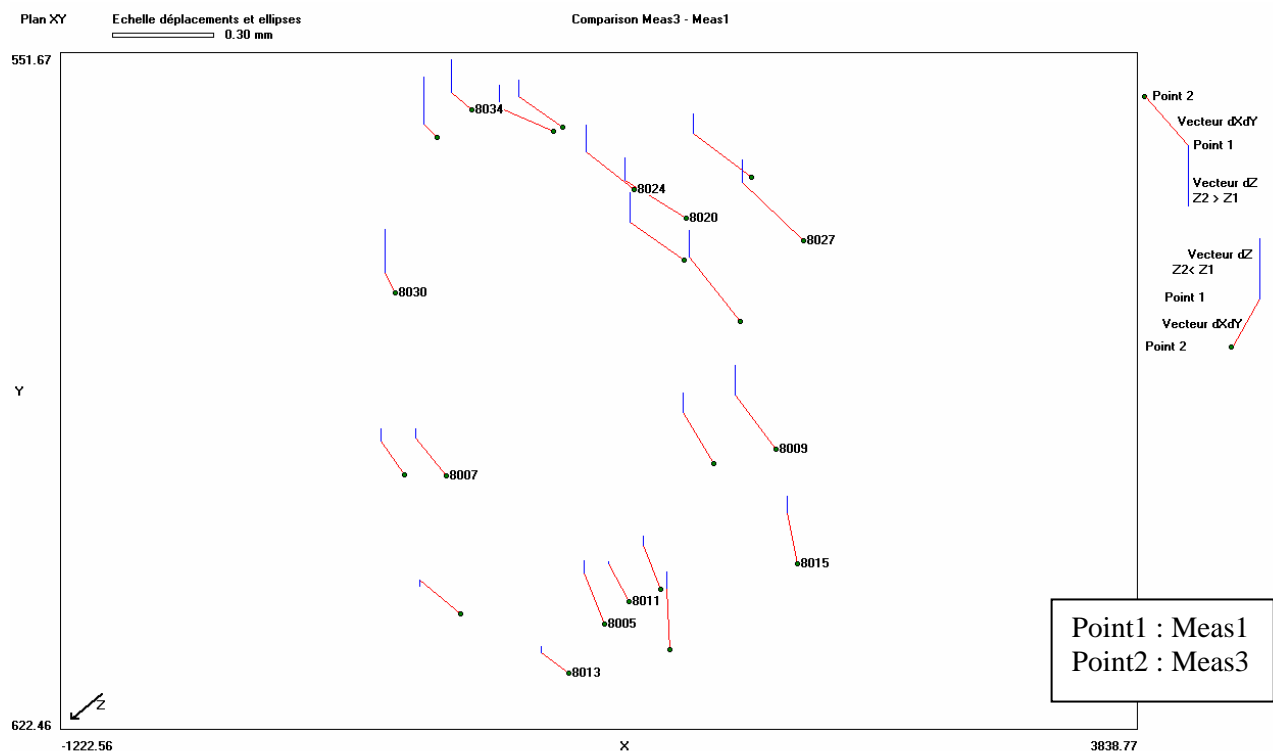
	VX (mm)	VY (mm)	VZ (mm)	VXYZ (mm)
MAX	0.05	0.07	0.05	0.11
MIN	-0.07	-0.04	-0.07	0.01
STDEV	0.03	0.03	0.03	0.03

This comparison highlights the good stability of the points stuck on the wedge. This local reference network is stable enough to measure any deformation and movement of the coil during racking.

Name	X (mm)	Y (mm)	Z (mm)	VX (mm)	VY (mm)	VZ (mm)	VXYZ (mm)
8005	1331.04	-1128.64	-641.28	0.06	-0.15	-0.04	0.17
8006	654.63	-1080.81	-261.94	0.12	-0.10	0.02	0.16
8007	586.95	-430.65	-331.10	0.09	-0.11	-0.03	0.15
8008	391.54	-424.98	-299.98	0.07	-0.10	-0.04	0.13
8009	2138.39	-304.44	-1219.85	0.12	-0.16	-0.09	0.22
8010	1597.37	-965.37	-1034.98	0.05	-0.13	-0.03	0.14
8011	1445.14	-1023.16	-1184.12	0.06	-0.11	-0.01	0.12
8012	1847.27	-374.28	-1521.51	0.09	-0.15	-0.06	0.18
8013	1164.49	-1357.95	-447.63	0.08	-0.06	-0.02	0.10
8014	1640.34	-1247.32	-621.16	0.01	-0.18	-0.05	0.18
8015	2237.86	-843.80	-838.56	0.03	-0.15	-0.05	0.16
8018	1971.57	295.88	-1222.87	0.15	-0.19	-0.08	0.25
8020	1714.96	779.16	-1089.38	0.18	-0.11	-0.07	0.23
8021	1133.97	1205.86	-669.72	0.13	-0.09	-0.05	0.16
8024	1470.72	911.86	-1205.24	0.14	-0.11	-0.08	0.20
8025	1706.72	583.35	-1403.34	0.16	-0.11	-0.09	0.22
8027	2270.15	673.01	-849.80	0.18	-0.17	-0.07	0.26
8028	2025.28	969.01	-760.91	0.17	-0.13	-0.06	0.22
8030	346.06	429.09	-213.26	0.03	-0.06	-0.13	0.15
8033	1091.46	1184.61	-887.08	0.16	-0.07	-0.07	0.19
8034	707.87	1287.16	-281.70	0.06	-0.05	-0.10	0.13
8035	546.22	1160.10	-222.82	0.04	-0.04	-0.14	0.15

	VX (mm)	VY (mm)	VZ (mm)	VXYZ (mm)
MAX	0.18	-0.04	0.02	0.26
MIN	0.01	-0.19	-0.14	0.10
STDEV	0.05	0.04	0.04	0.04

The comparison highlights a movement of the coil w.r.t. the wedge after re-racking up to 0.26 mm



The position of the coil has been measured with LTD before and after photogrammetry on two points. The same movement is observed within +/- 0.05mm