COLD MASS GEOMETRY REPORT

ITP20 STATUS

Period: 01/10/2004 – 01/12/2004

Authors: M. Bajko, J. Beauquis,G. BevillardR, Chamizo, E. Wildner

Summary

Production: During the reference period, 74 dipole cold masses were delivered to CERN. The corresponding geometry data is available in the geometry data base.
Sagitta: In Firm 1 the average sagitta increased by about 1 mm in November 2004. For two magnets, an error exceeding 2 mm is observed. An intervention on the welding press geometry was done by the end of December 2004 to reduce the sagitta. In Firm 2, the sagitta has been stable, 1 mm above nominal. In Firm 3 the spread seems dominant over the trend.
The corrector magnets: Their alignment appears to be under control, with very small individual offsets and small spread of the order of 0.05 mm rms in any of the 3 companies.
The end flanges: A temporary significant increase of the vertical miss-position is observed on 4 cold masses in Firm 2, albeit within tolerance. This is being followed up.
Non Conformities:
From both Firm 1 and Firm 3, two critical non conformities were reported to CERN. All non conforming magnets could be accepted to be "used as is".
MEB classification regarding the beam aperture:

Table 1: MEB classification

		Golden	Silver	Other	Critical NC
Firm1		5	11	6	2
Firm2		1	15	3	0
Firm3		17	14	2	2
Total		23	40	11	4
	%	31	54	15	5

Globally :
Most of the geometrical parameters appear to be well under control, except the sagitta in Firm 1 and Firm 2 with either a trend or an offset. The causes of those changes require further investigations.

1 Introduction

The dipole cold mass geometry is checked during the assembly and is reported to CERN cold mass by cold mass through the geometry traveler (ITP20). The measurements are checked with respect to the assembly. This is made automatically by software. The data is registered in the CERN Data Base only if all tolerances are respected or if the non-conformance is accepted after having been submitted for acceptance to a panel at CERN.

This report shows a subset of the geometry parameters that we consider particularly important. The measurements we refer to are measurements made after complete assembly and before shipping to CERN. Every two months, a summary of these data is made to spot trends and anomalies and to give feed back to the magnet producers.

2 Production

The list of 74 magnets that were assembled in the reference period and the date of the ITP20 measurements are listed in the Annex 1.

3 Sagitta

The sagitta summary is given in Fig 1 and details in Fig A1 to A3.
The sagitta is used to characterize the magnet shape but is not part of the parameters with contractual tolerances.

In Firm 1 the average sagitta over the reference period is about 0.8 mm larger than that of the whole production and about 0.7 mm above nominal. A trend is clearly visible in Fig A1. In Firm2, the two figures are respectively -0.6 mm and -1.0 mm with respect to nominal. The production is very stable (Fig A2). The average sagitta in Firm 3 is slowly decreasing (Fig A3).
For the three firms, there is some decrease of the spread of the sagitta. The lowest spread observed in Firm2 makes it possible to attempt changes in the production to correct the average sagitta deviation.

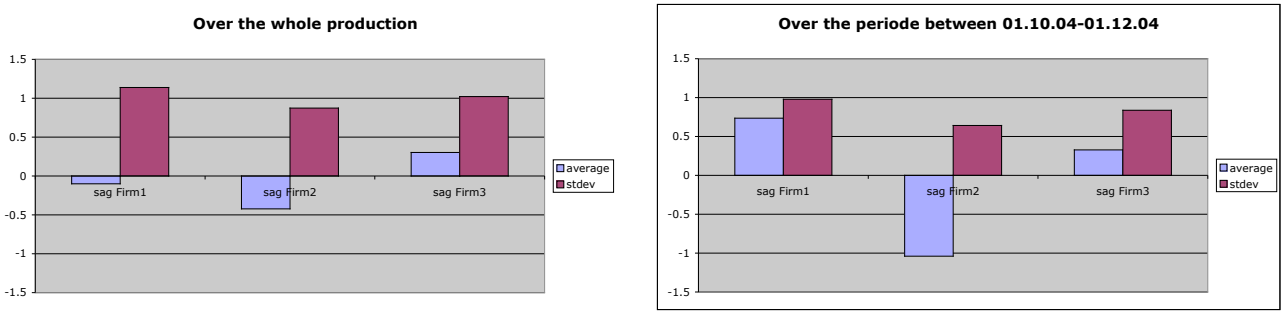

Figure 1. Delta sagitta. Average and Stdev

An intervention on the welding press geometry was done at the end of the reference period. Its result will be reported in the next report.

4 Position of corrector magnets

At ITP20, the localization of the mechanical center of the correctors (Figures 2, A4 to A21) is good and better than specified (0.3 mm). The larger uncertainties observed for the decapole/octupoles correctors may not be significant and due to their smaller number.

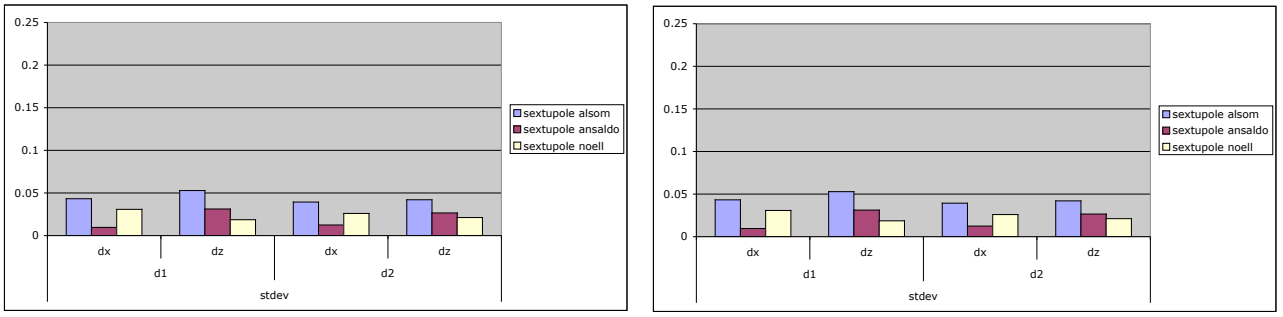

Figure 2. Corrector magnets. Spread over the last two-month production.

5 Position of the extremity flanges

Overall, the localization of the flange centers (Fig A22 to A32) respects well the tolerance of 0.6 mm. One should note however that the control of the positioning is somewhat better in Firm 2 and Firm 3 by about 0.1 mm. It should be underlined that the ideal position of the flanges shall be 0 only if the sagitta is nominal. In case it is not, the criterion shall be to minimize the local deformation of the cold bore tube rather than centering exactly the flanges.

A temporary significant increase of the vertical mis-position is observed on 4 cold masses in Firm 2, albeit within tolerance. This is being followed up.

6 Twist

In all Firms the twist is small compared to tolerances and stable (Fig A31 to A33).

7 Non Conformities

7.1 FIRM 1:

Over the 21 magnets assembled during the reference period by Firm 1 we get 2 NCR's. (Non-Conformance Report).

The first was on magnet nr. 1169, (https://edms.cern.ch/document/523024/1) reporting about a shape tolerance that was exceeded in the horizontal plane, at the two extremities of the dipole. (See Figure 3.). Concerning the NC we remarked that: the NCR was declared as critical and accepted to "used as is". This magnet shall be reserved for the less critical mid-cell positions.

Figure 3. Shape error on cold mass 1169

The second similar NCR was on magnet 1173 (https://edms.cern.ch/document/526817/1) reporting about the same shape tolerance exceeded in the horizontal plane at the two extremities of the dipole. (See Figure 4). Like for magnet 1169, the NCR was declared critical and accepted "used as is". This magnet shall be reserved for the less critical mid-cell positions.

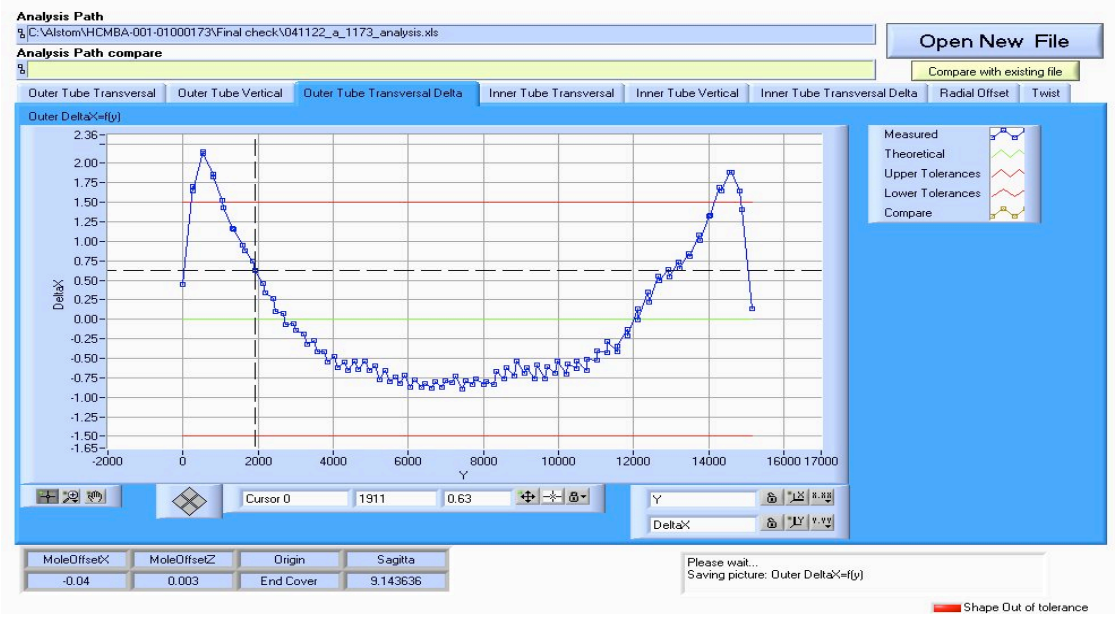

Figure 4. Shape error on cold mass 1173

This type of errors is due to a curvature higher than nominal, but acceptable for the body of the magnet where the tolerance is +/-1.5mm. The ends however were adjusted to satisfy the tighter tolerances of 0.6mm on the radius. (See Figure 5.)

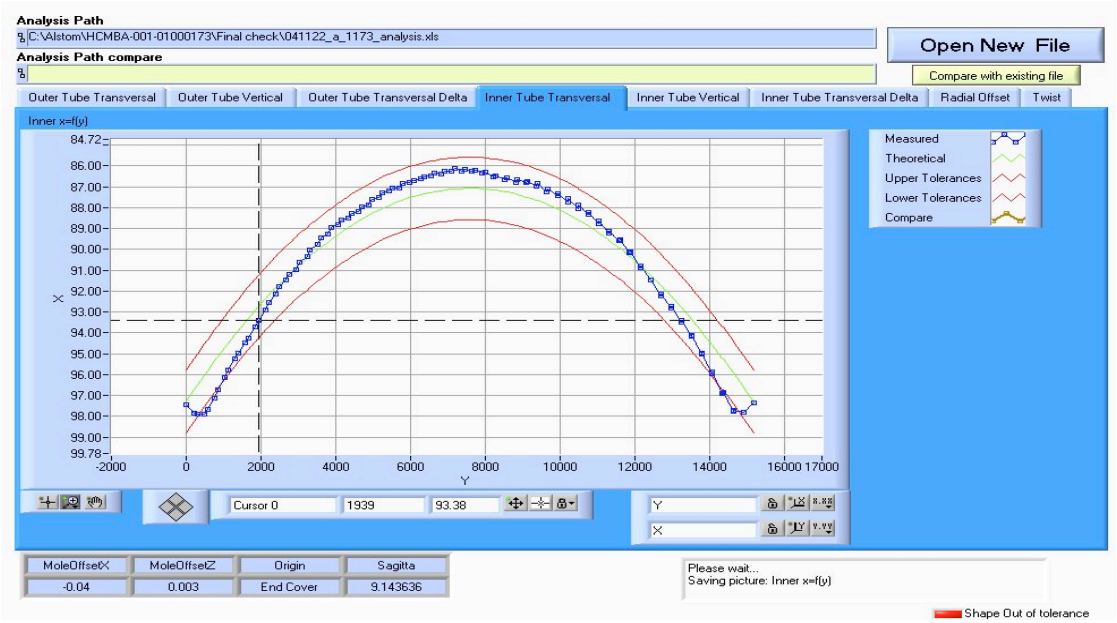

Figure 5. Magnet with high curvature, adjusted to tolerances at the extremities

In fact all magnets between 1169 and 1175 seem to have the same distortion of their shape. Most of them are inside the tolerances as Figure 6 shows. After the non conforming magnets 1169 and 1173 we have the best of the series, which could indicate an action not confirmed by Firm1.

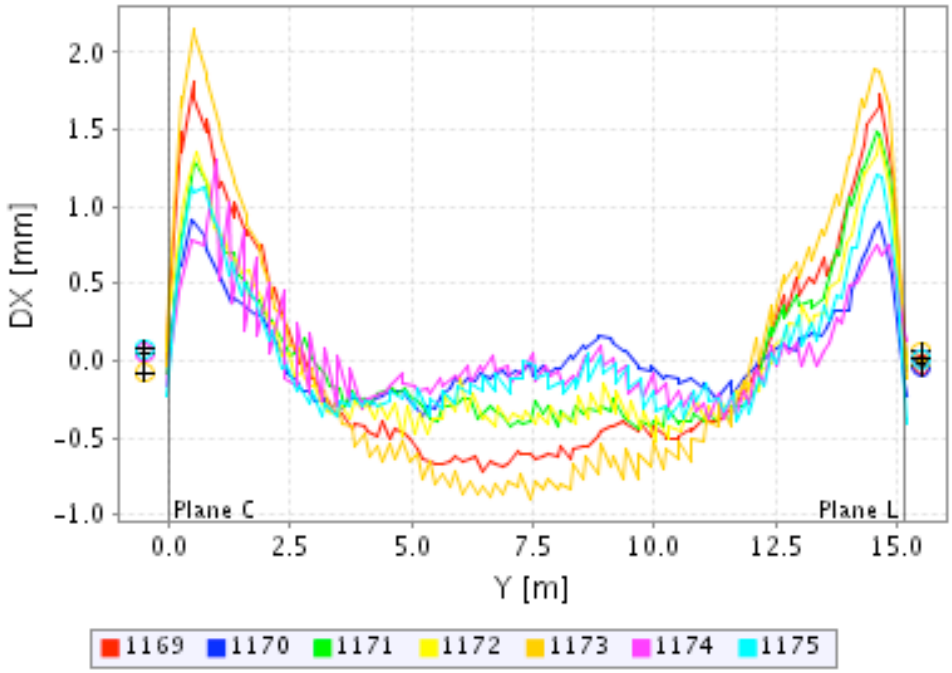

Figure 6. Error of the shape on the Firm 1 magnets

7.2 FIRM 2 :

During the reference period no NCR was submitted to CERN from Firm 2 regarding the geometry of the 19 magnets produced.

7.3 FIRM 3 :

During the reference period 2 CRITICAL NCRs were submitted for 33 magnets built and approved by the committee.

The first NCR is linked to the magnet nr 3175 (https://edms.cern.ch/document/521329/1 but is a general NCR that is covering several magnets. The error is on the machining of the reference holes on the decapole corrector support plate. This non conformity could be overcome by defining at CERN an appropriate assembly procedure of the correctors for this limited magnet series requiring a manual implementation. This solution was accepted only for a limited number of magnets, period in which Firm 3 would find a solution to correct those supports and/or buy others.

The second NCR is linked to the magnet 3250 (https://edms.cern.ch/document/525802/1) and concerns the correction of the above-mentioned supports and the dimensional control of the reworked supports.

8 MEB Classes

The geometrical shape of the magnet along the axis has an impact on the aperture of the collider. More or less strict requirements on the magnets are necessary according to their final positioning in the machine. The magnets can, by using these different requirements, be classified into three categories that we call golden (critical positions in the machine), silver, and other (magnets that can go into the less critical mid-cell positions). The classification is only valid when applied to the final measurement before installation. We use this criterion also for the measurements in industry to have a preliminary idea of the quality of the magnet shape.

The classification of the magnets (Table 1: MEB classification) is based on the shape of the magnets and is not including the interconnecting pieces as: end cover; cold bore tube ends of position of the cold feet pads.

A magnet that is classified golden is a magnet that is not exceeding errors bigger than 0.8mm in the horizontal plane and 0.5mm in the vertical plane with respect to the theoretical geometry with a sagitta of 9.14mm. A magnet-classified silver can exceed the limits of the golden by 0.25 mm in the vertical plane and up to 0.75mm in the horizontal plane. The shape of the silver limit is a race-track with a gap of 0.8mm and a radius of 0.75mm (See Figure 7).

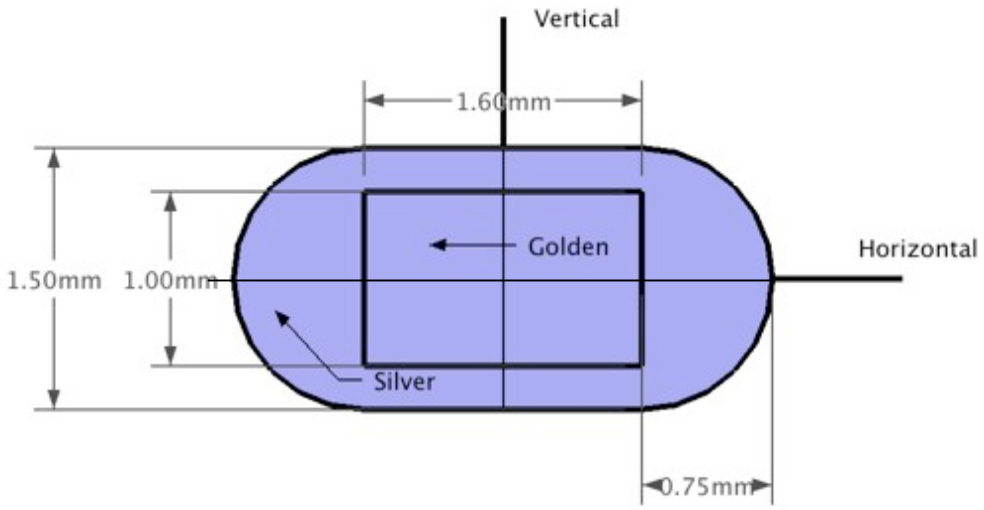

Figure 7. Golden and Silver classes. Limits

9 Concluding remarks

During the reference period most of the parameters studied appeared to be globally stable and mostly within the requested tolerances.
Concerning the sagitta we have remarked that in case of two firms there is a change by up to 1mm. Several magnets are just on the limit of the tolerance and in two cases out of it. The initial working conditions and the respect of the assembly procedure have to be checked and corrections should be applied. The first one, change of the sagitta of the welding press from 13.5mm to 13.2mm has been implemented. The result will be reported in the next report.

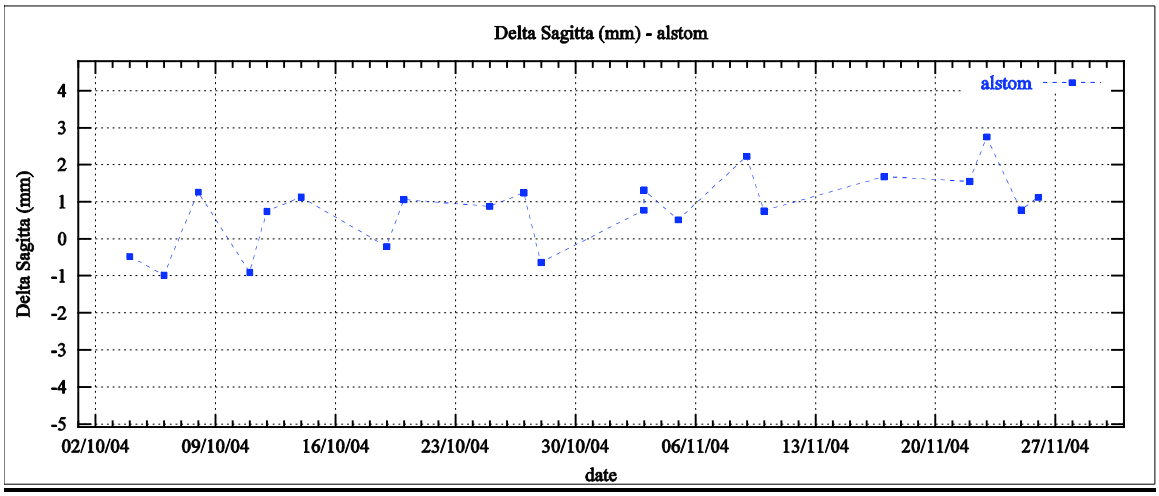

Figure A1 Sagitta in Firm 1

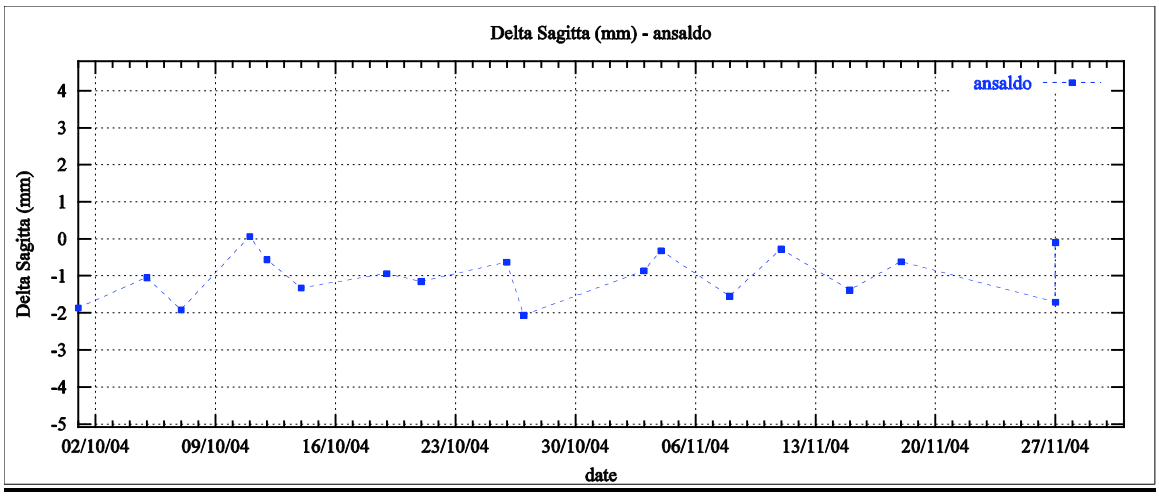

Figure A2 Sagitta in Firm 2

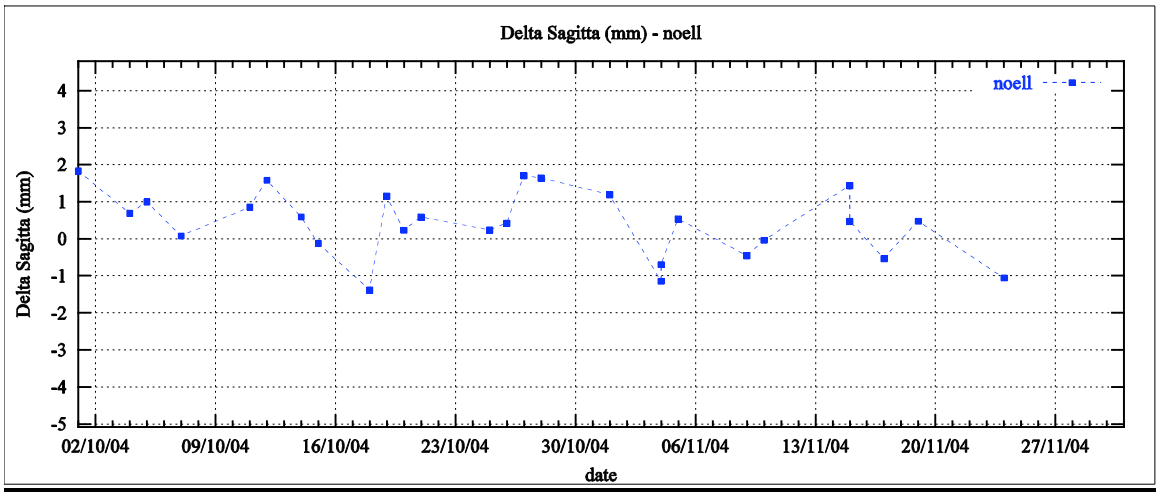

Figure A3 Sagitta in Firm 3

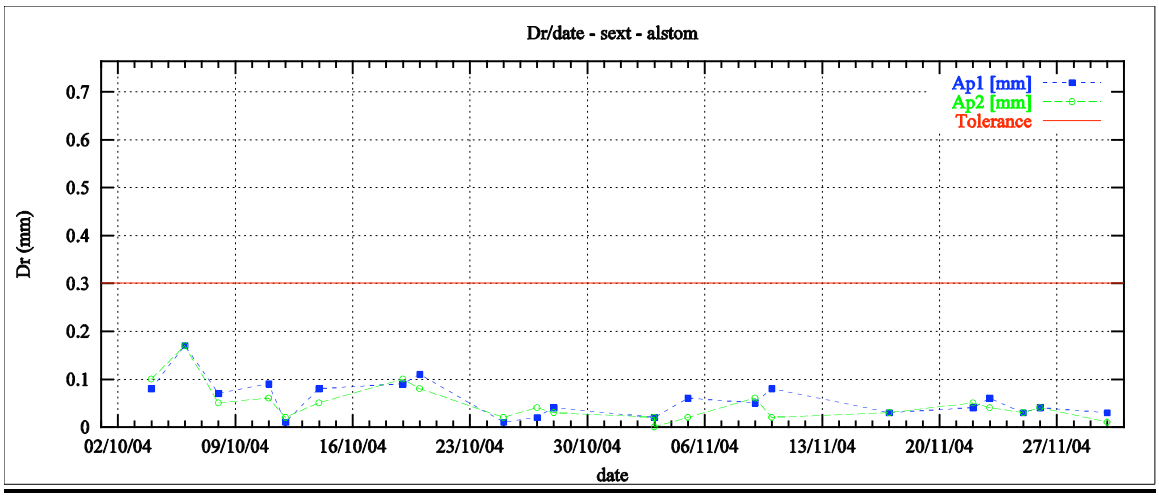

Figure A4 Sextupole deltaR in Firm 1

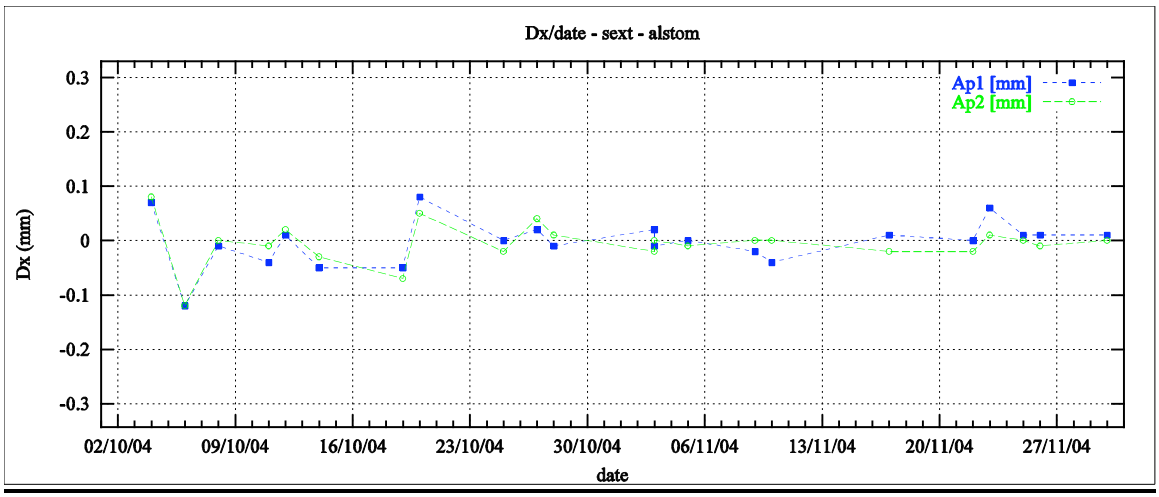

Figure A5 Sextupole deltaX in Firm 1

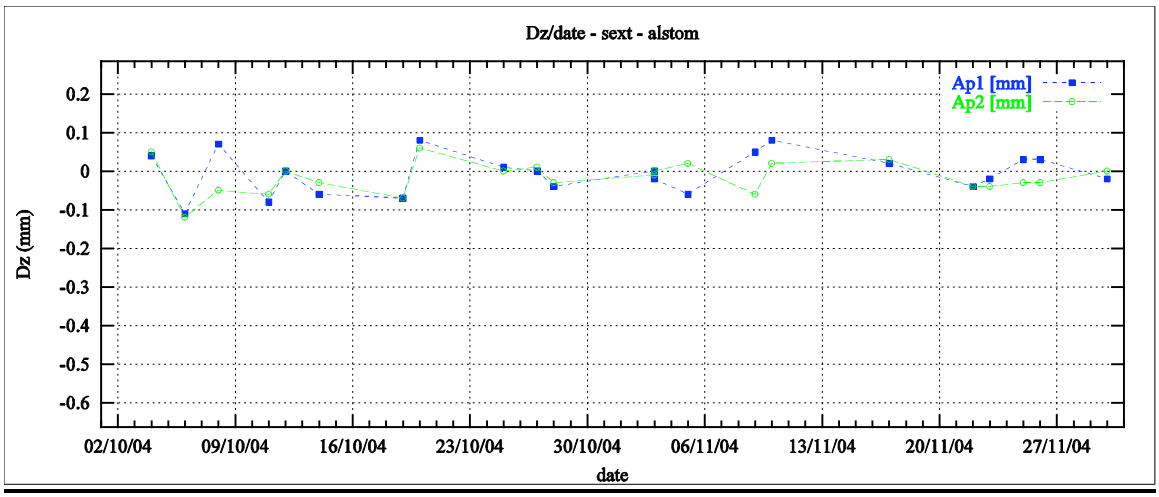

Figure A6 Sextupole deltaZ in Firm 1

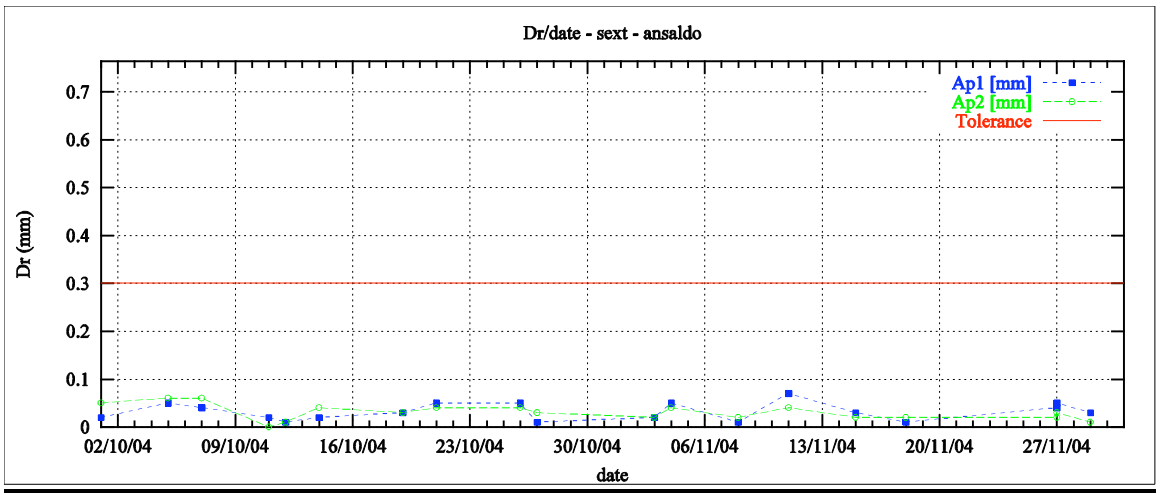

Figure A7 Sextupole deltaR in Firm 2

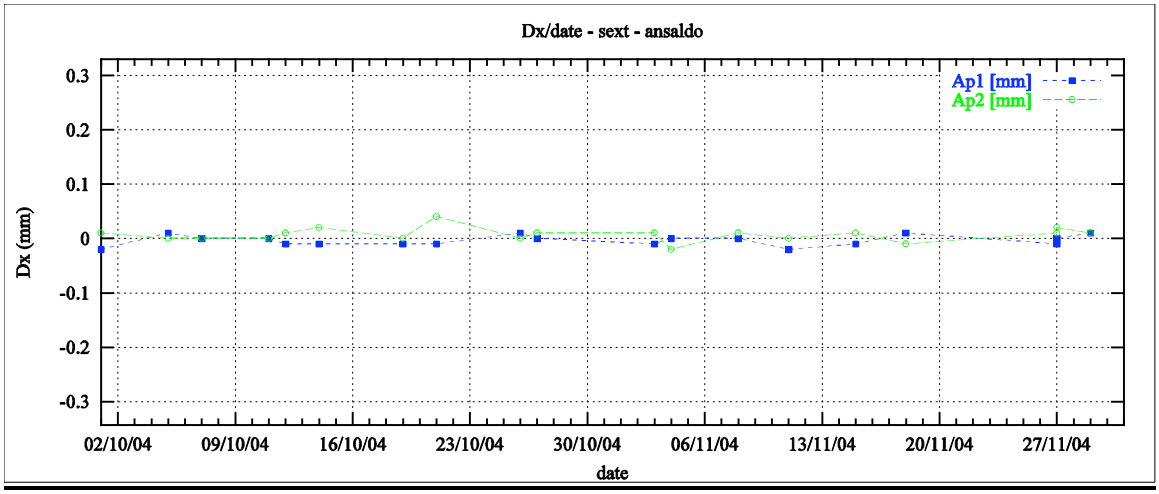

Figure A8 Sextupole deltaX in Firm 2

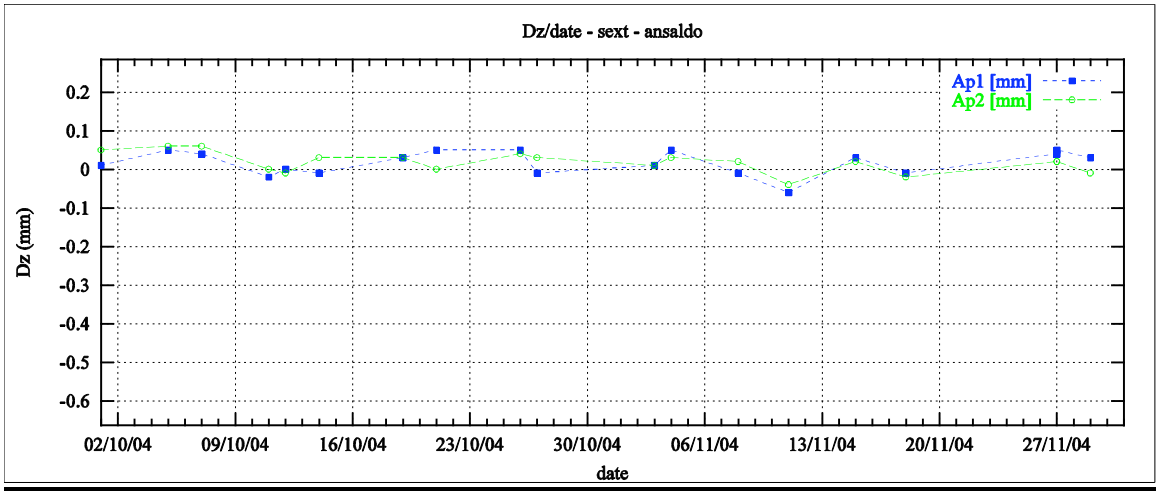

Figure A9 Sextupole deltaZ in Firm 2

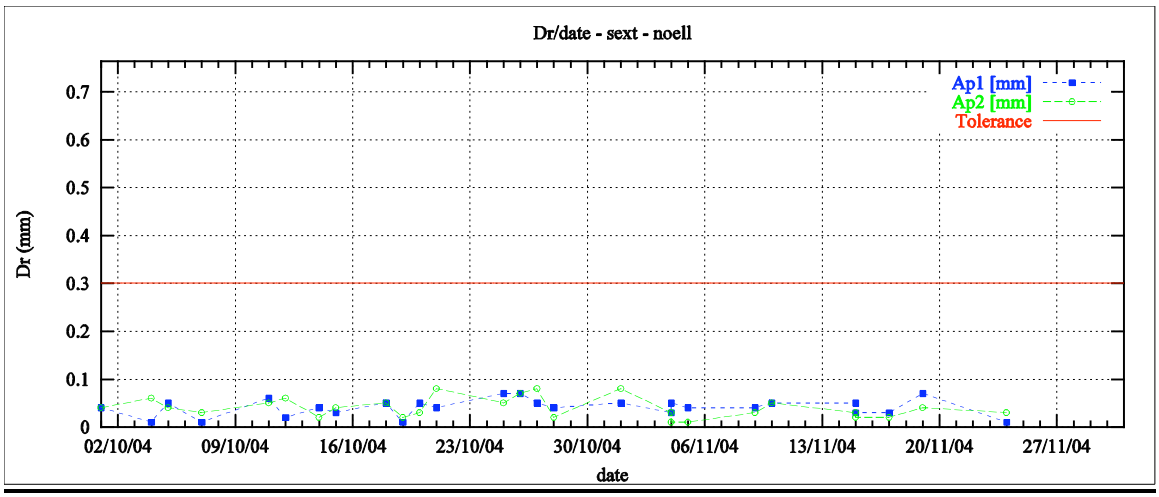

Figure A10 Sextupole deltaR in Firm 3

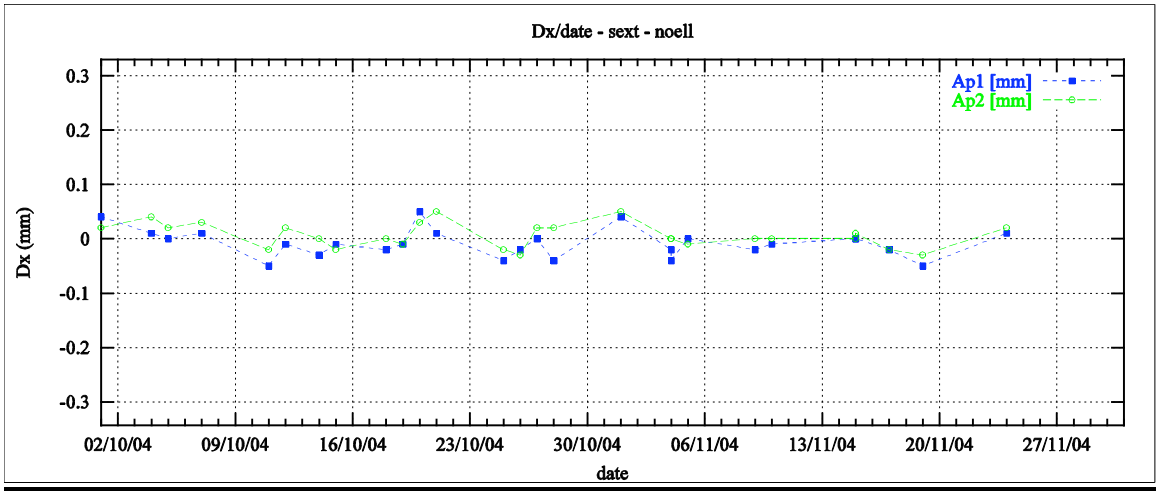

Figure A11 Sextupole deltaX in Firm 3

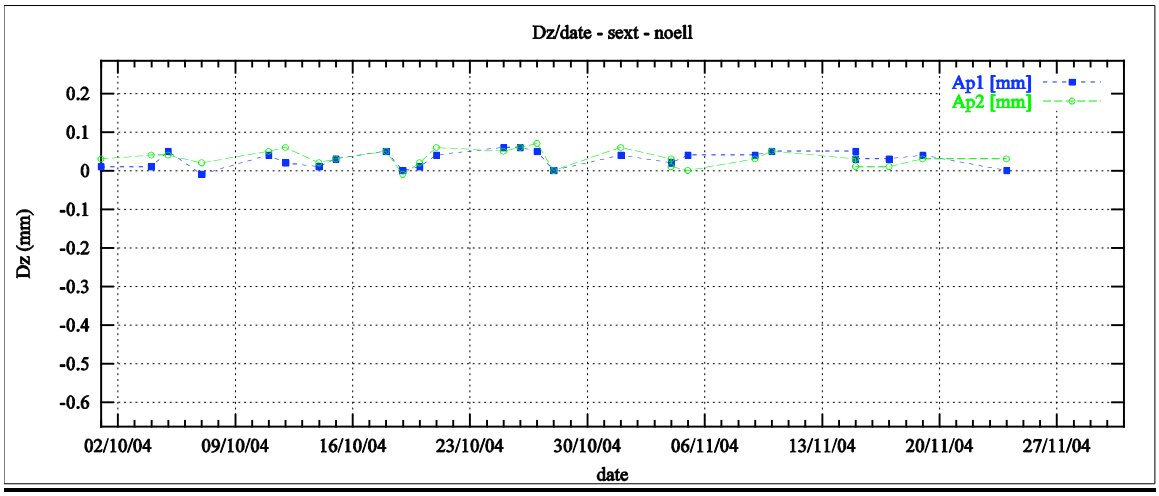

Figure A12 Sextupole deltaZ in Firm 3

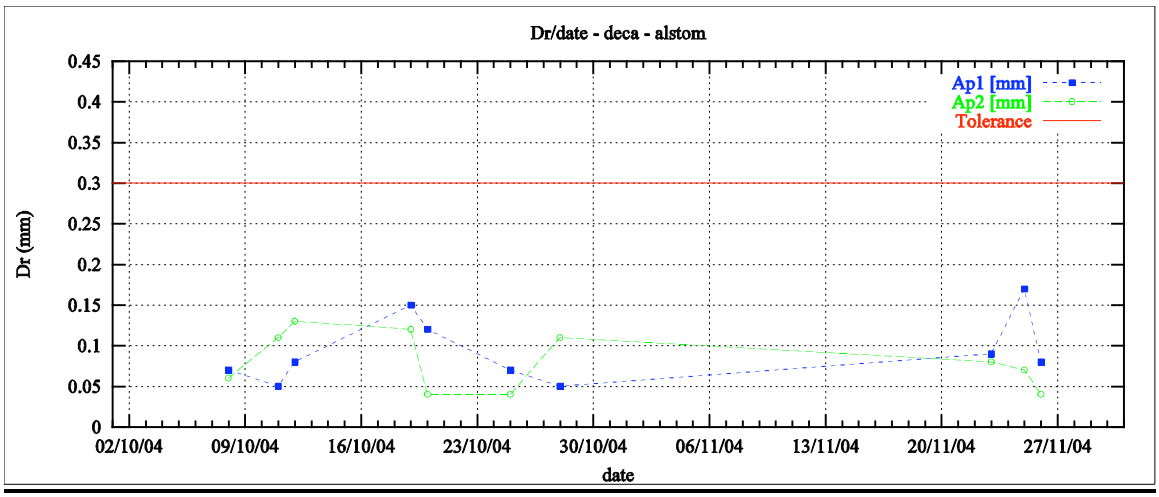

Figure A13 Deca-/Octupole deltaR in Firm 1

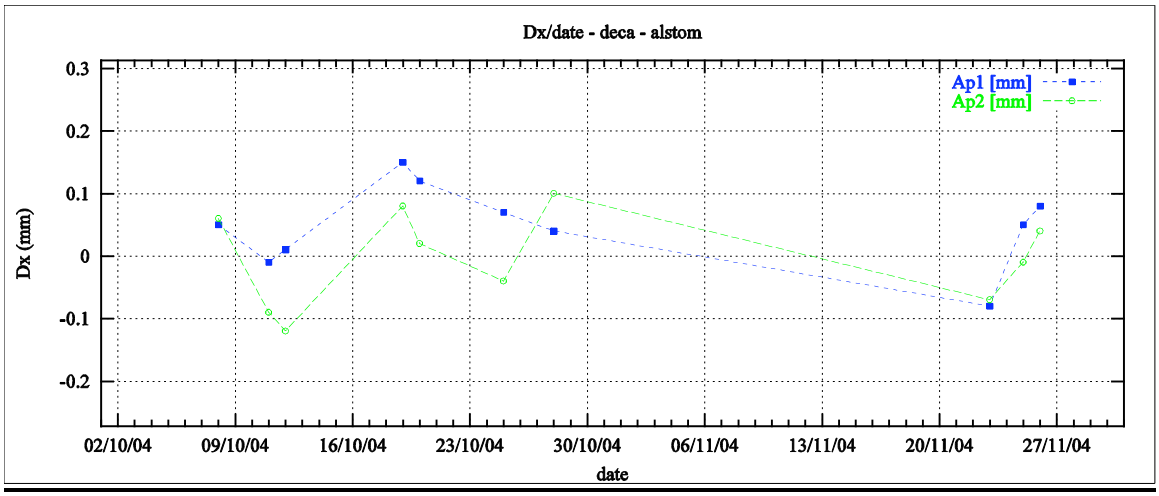

Figure A14 Deca-/Octupole deltaX in Firm 1

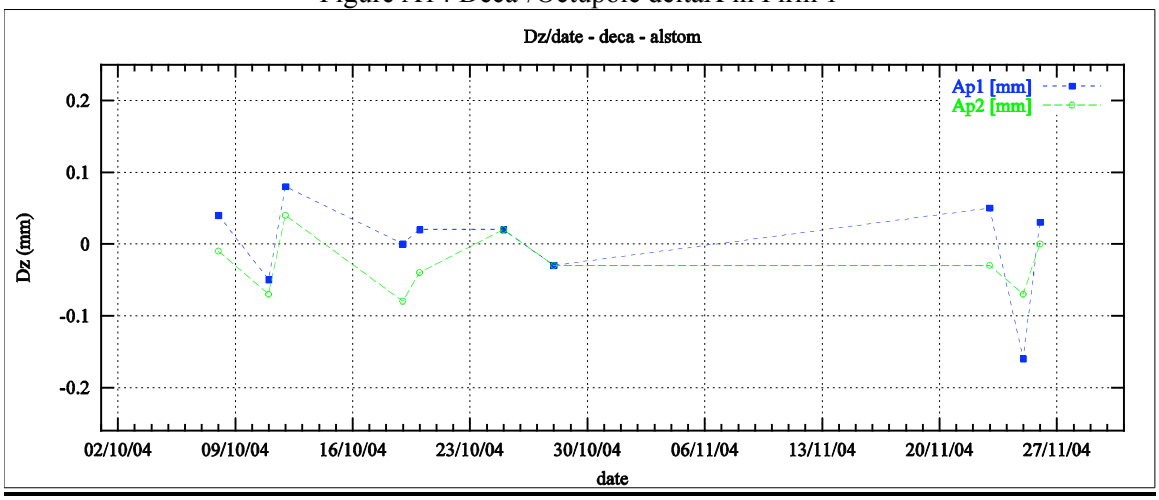

Figure A15 Deca-/Octupole deltaZ in Firm 1

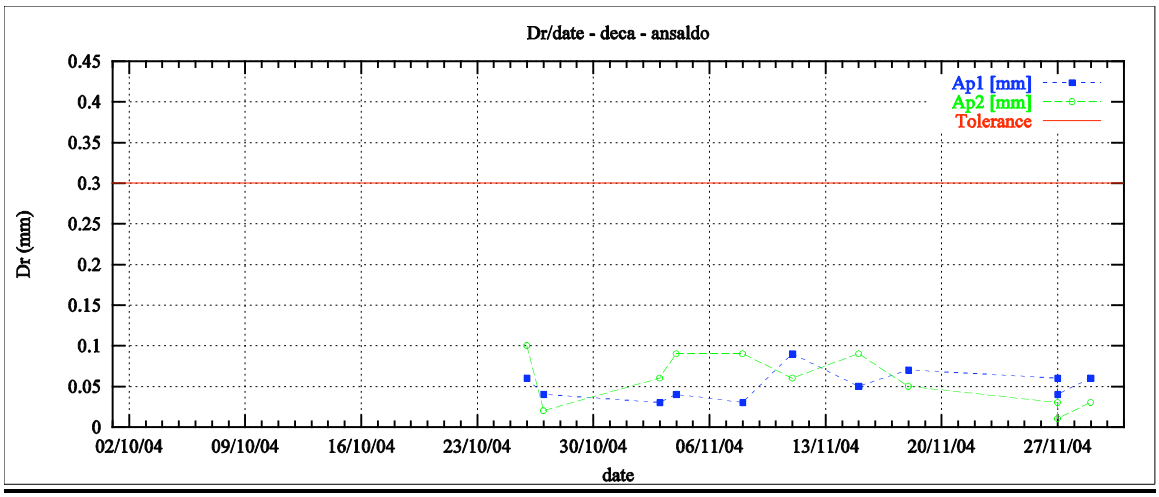

Figure A16 Deca-/Octupole deltaR in Firm 2

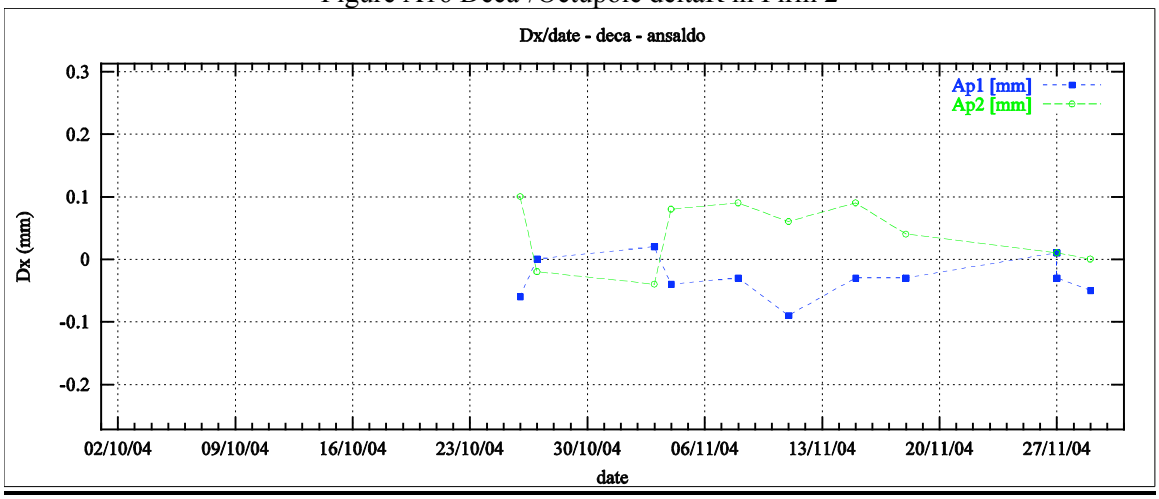

Figure A17 Deca-/Octupole deltaX in Firm 2

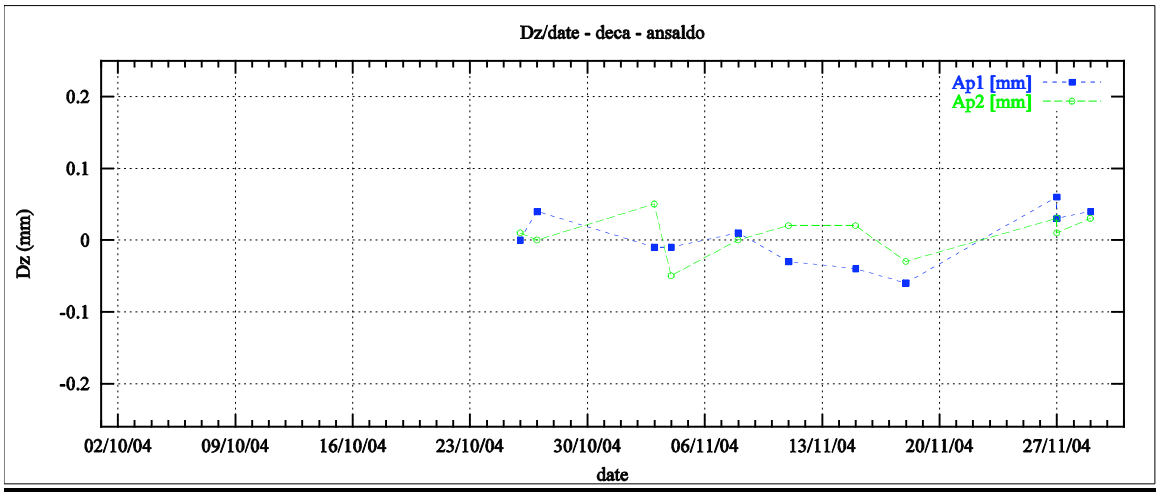

Figure A18 Deca-/Octupole deltaZ in Firm 2

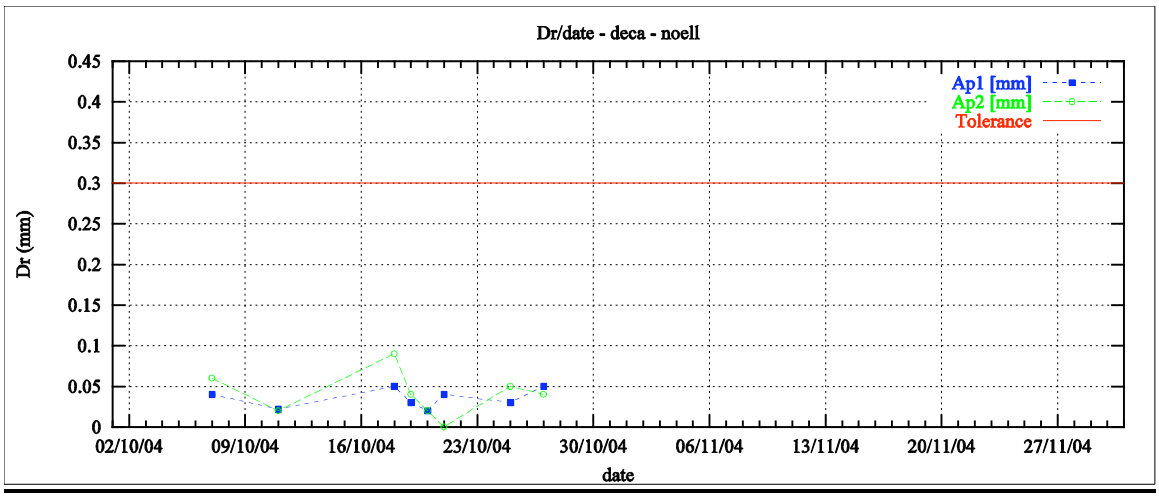

Figure A19 Deca-/Octupole deltaR in Firm 3

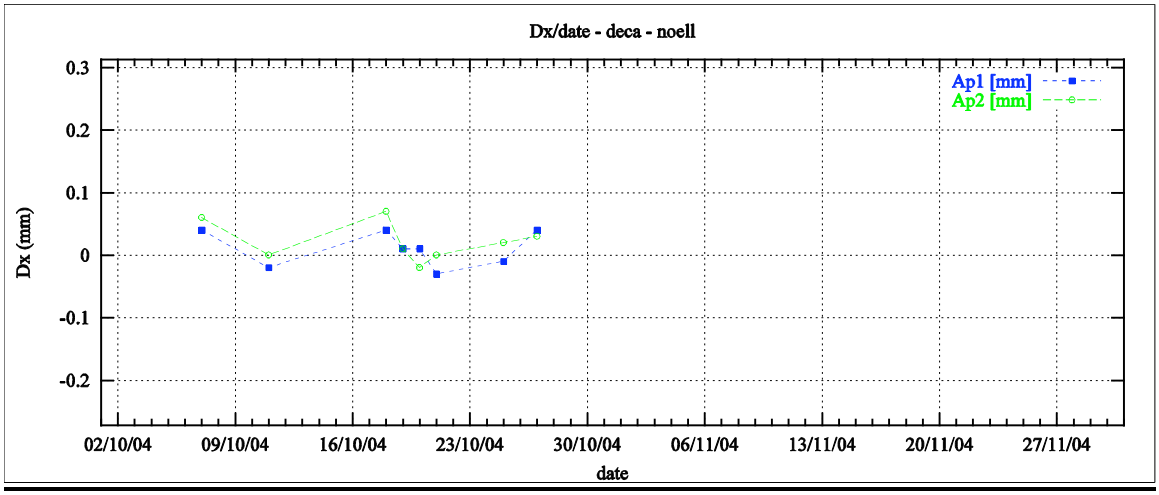

Figure A20 Deca-/Octupole deltaZ in Firm 3

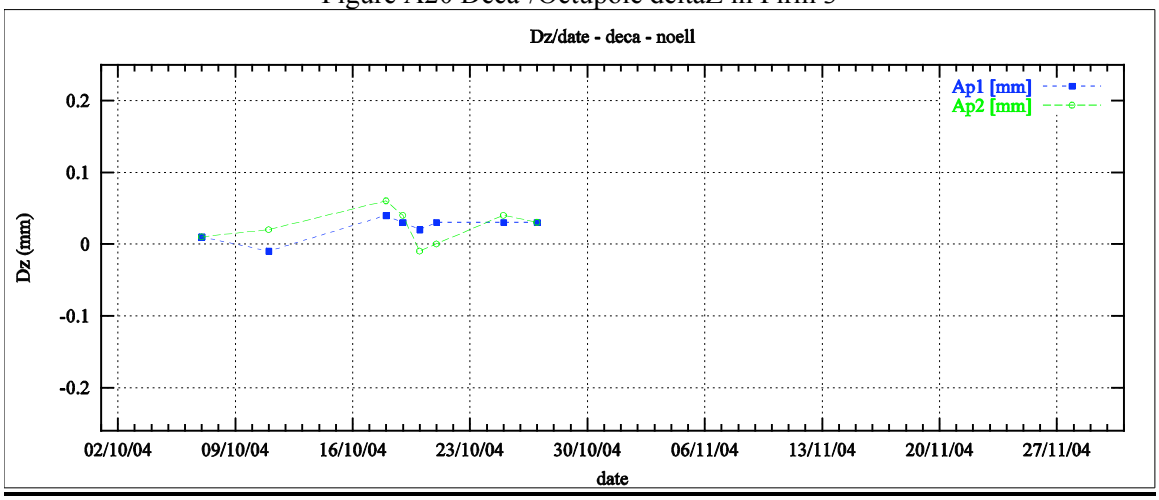

Figure A21 Deca-/Octupole deltaZ in Firm 3

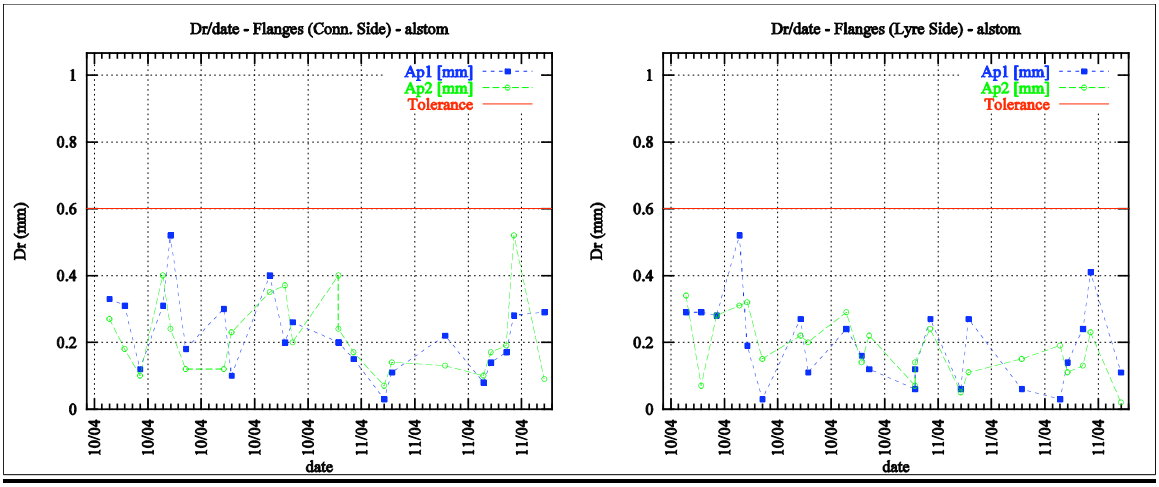

Figure A22 Extremity Flanges: V1 V2, deltaR in Firm 1

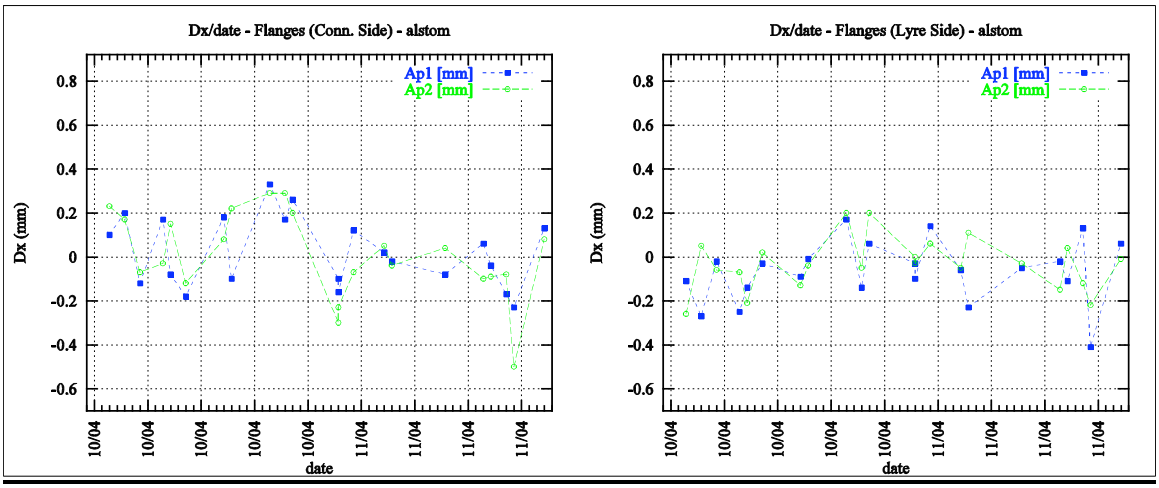

Figure A23 Extremity Flanges: V1 V2, deltaX in Firm 1

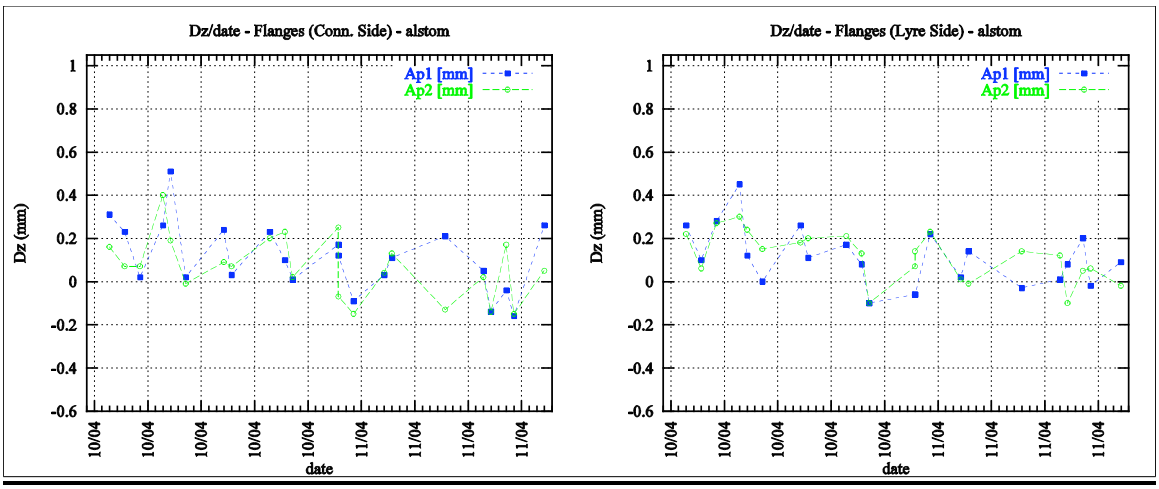

Figure A24 Extremity Flanges: V1 V2, deltaZ in Firm 1

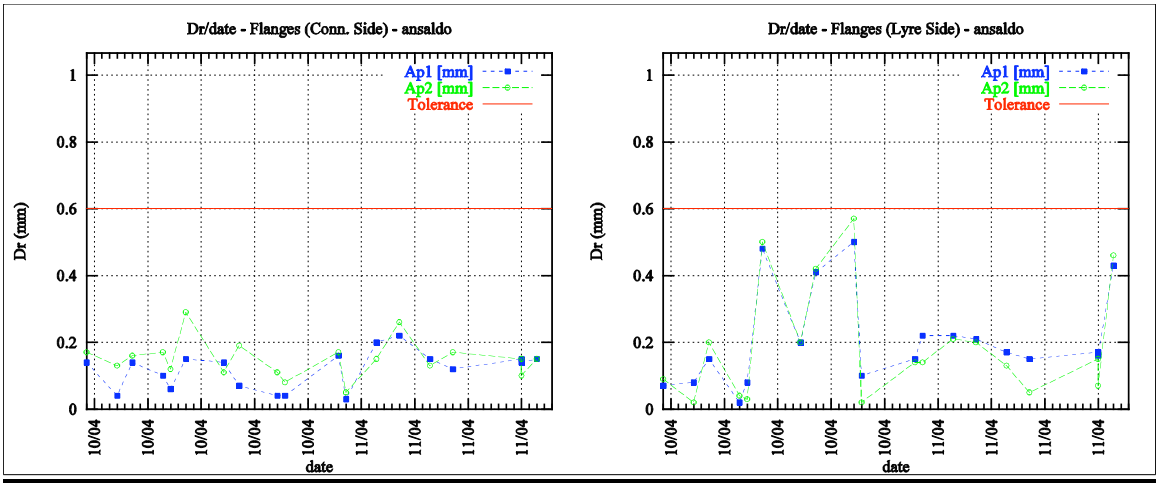

Figure A25 Extremity Flanges: V1 V2, deltaR in Firm 2

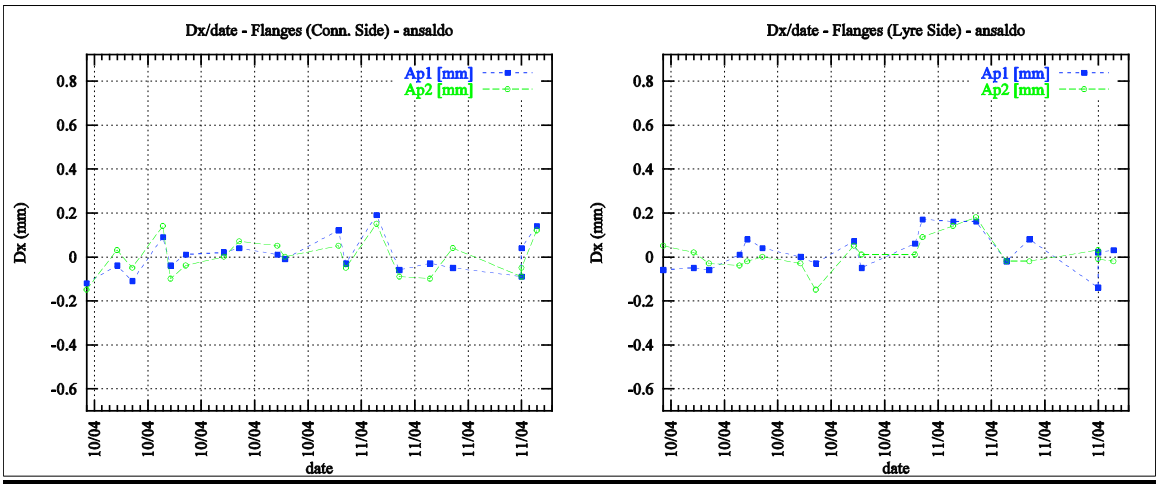

Figure A26 Extremity Flanges: V1 V2, deltaX in Firm 2

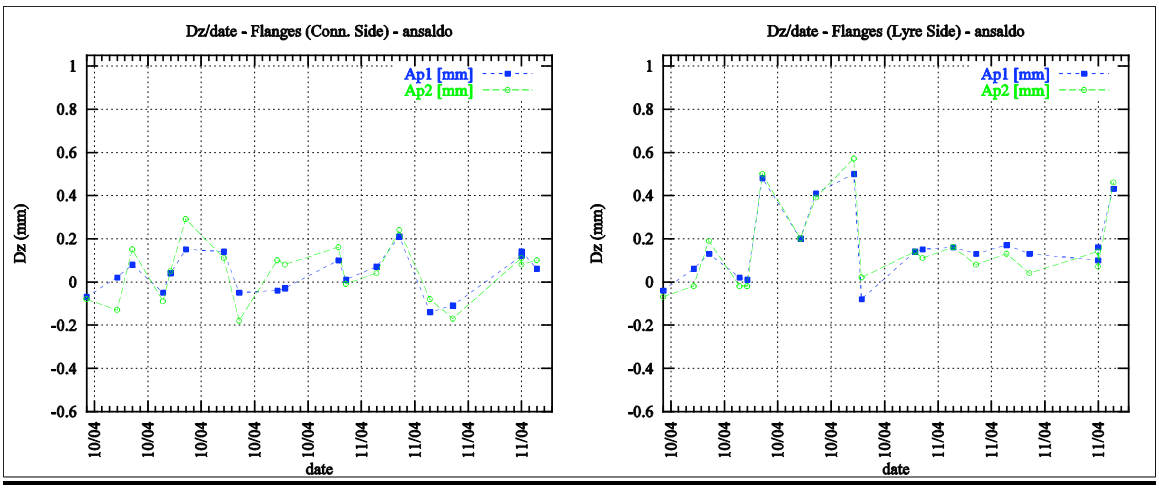

Figure A27 Extremity Flanges: V1 V2, deltaZ in Firm 2

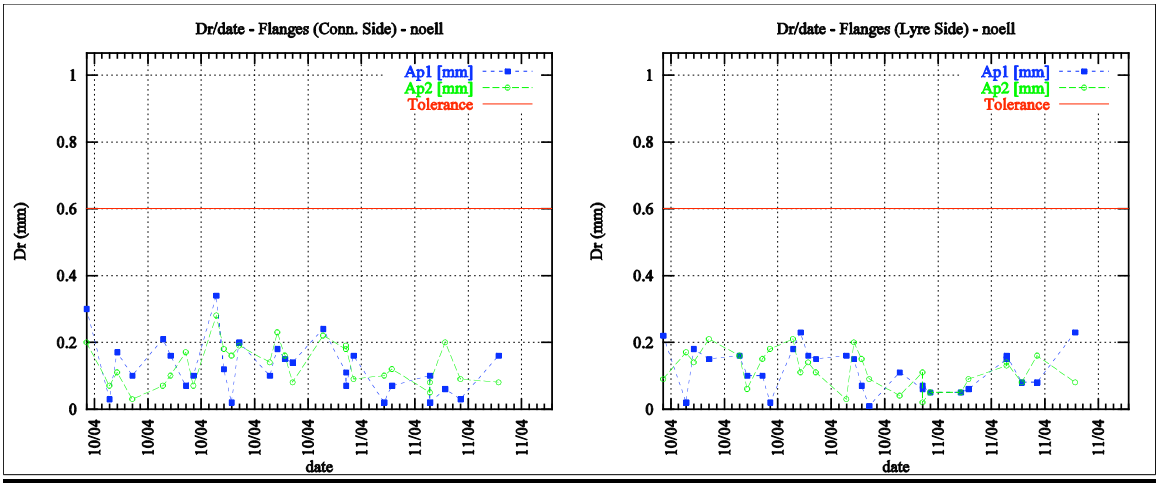

Figure A28 Extremity Flanges: V1 V2, deltaR in Firm 3

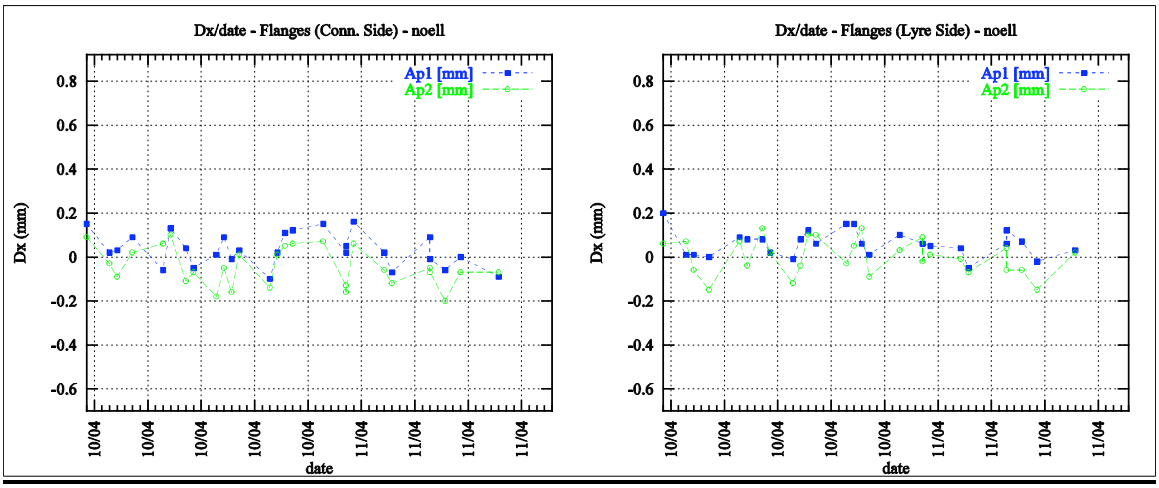

Figure A29 Extremity Flanges: V1 V2, deltaX in Firm 3

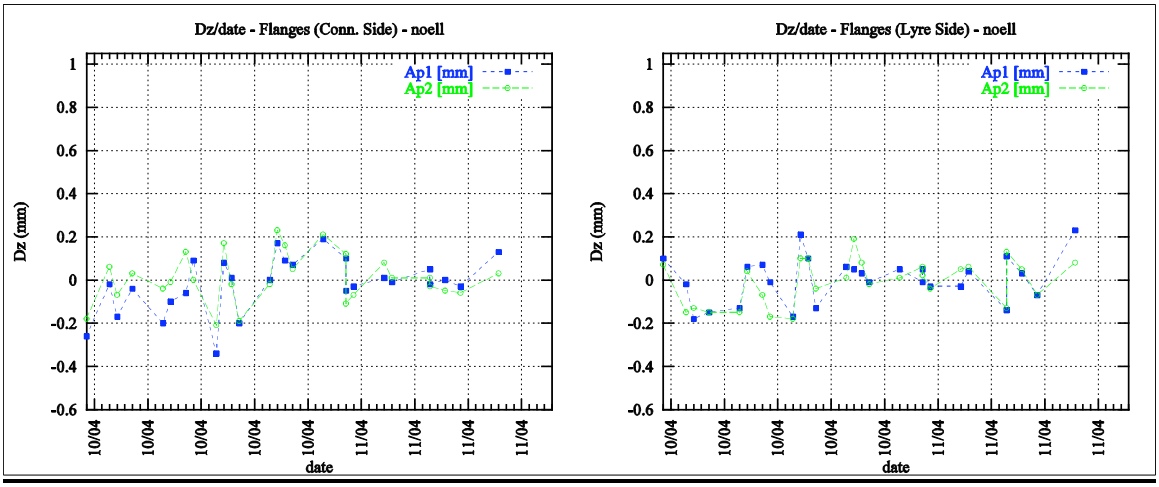

Figure A30 Extremity Flanges: V1 V2, deltaZ in Firm 3

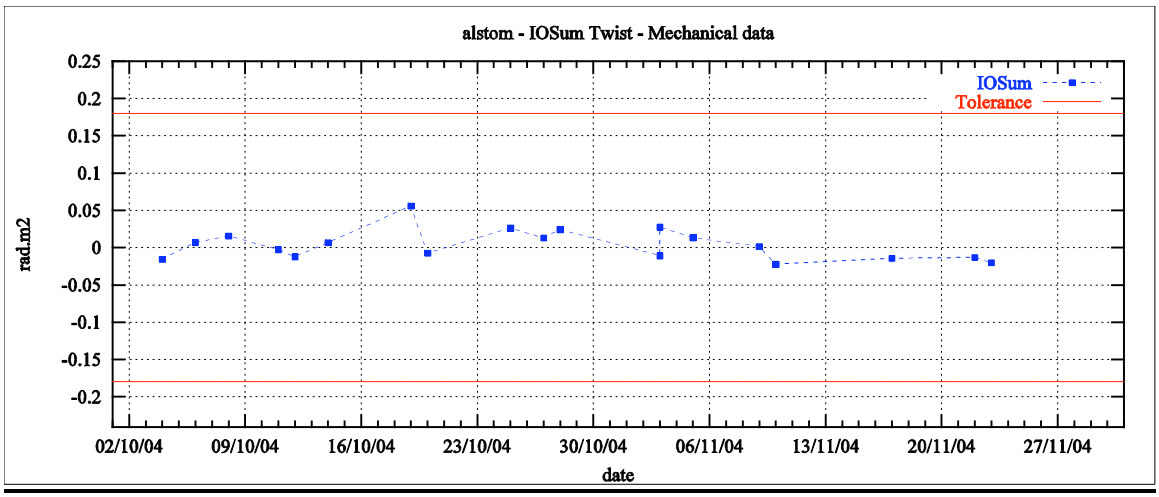

Figure A31 Mechanical Twist in Firm 1

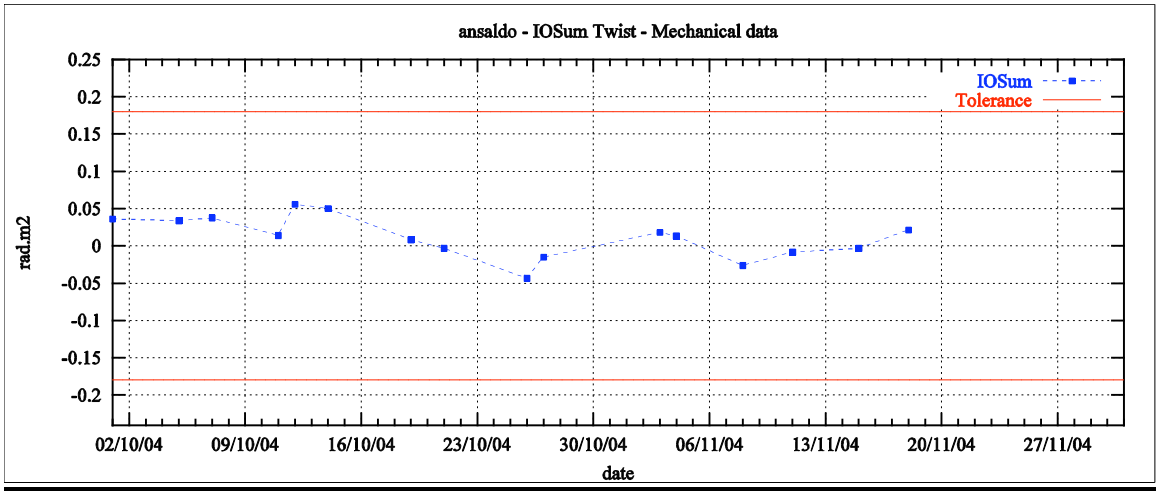

Figure A32 Mechanical Twist in Firm 2

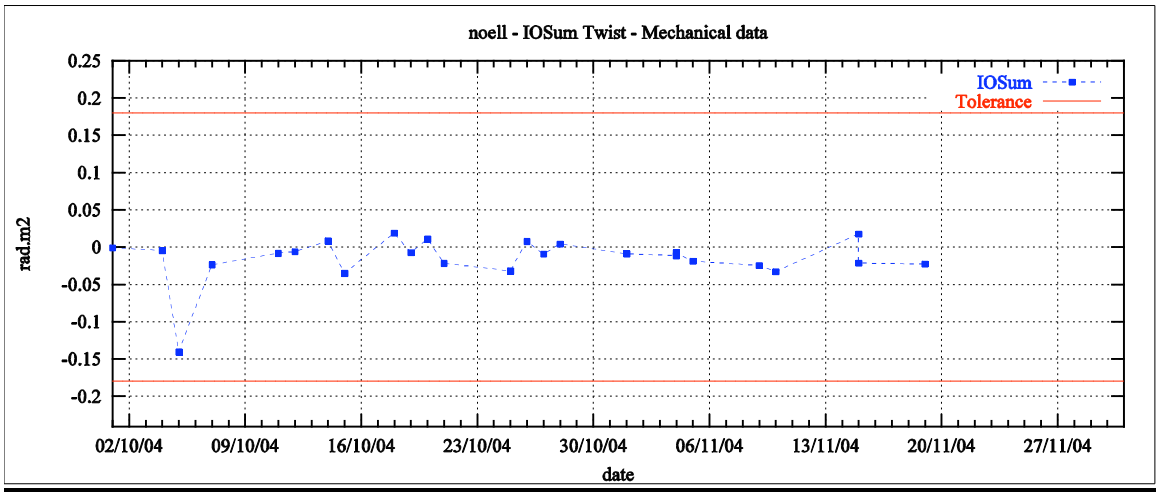

Figure A33 Mechanical Twist in Firm 3

ANNEX 1

List of dipole cold masses assembled in the reference period

FIRM 1	date
1145	10/4/04
1128	10/6/04
1158	10/8/04
1160	10/11/04
1157	10/12/04
1163	10/14/04
1094	10/19/04
1159	10/20/04
1161	10/25/04
1164	10/27/04
1162	10/28/04
1166	11/3/04
1167	11/3/04
1168	11/5/04
1169	11/9/04
1170	11/10/04
1171	11/17/04
1172	11/22/04
1173	11/23/04
1174	11/25/04
1175	11/26/04

FIRM 2	date
2098	10/1/04
2114	10/5/04
2112	10/7/04
2115	10/11/04
2116	10/12/04
2113	10/14/04
2118	10/19/04
2119	10/21/04
2117	10/26/04
2124	10/27/04
2122	11/3/04
2120	11/4/04
2125	11/8/04
2127	11/11/04
2123	11/15/04
2128	11/18/04
2129	11/27/04
2131	11/27/04
2130	11/29/04

FIRM 3	date
3243	10/1/04
3244	10/4/04
3245	10/5/04
3231	10/7/04
3175	10/11/04
3241	10/12/04
3237	10/14/04
3238	10/15/04
3200	10/18/04
3204	10/19/04
3253	10/20/04
3248	10/21/04
3257	10/25/04
3259	10/26/04
3247	10/27/04
3260	10/28/04
3261	11/1/04
3262	11/4/04
3263	11/4/04
3264	11/5/04
3265	11/9/04
3266	11/10/04
3235	11/15/04
3246	11/15/04
3270	11/17/04
3271	11/18/04
3267	11/19/04
3272	11/22/04
3269	11/24/04
3274	11/24/04
3268	11/25/04
3250	11/30/04
3275	11/30/04
3251	12/1/04