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LHC-b - UX85
Outer Tracker – T2-Q02 (C frame B2 position)
August, the 31st 2006

The EDMS document, **id: 771336** containing this report can be found at the address:

<https://edms.cern.ch/document/771336>

1 T2-Q02 – Introduction:

The aim of the measurement was to adjust and control the C-frame on the rail B2 (for the name of the rail, see the document EDMS <https://edms.cern.ch/document/756237>). This C-frame is called T2-Q02-XU.

The C-frame was adjusted on the right position.

After adjustment, all points were measured and also points on the surface to estimate if there is any deformations on this plane.

2 LHC-b Survey Co-ordinate System

- Origin: Interaction Point IP;
- Z_{SU} axis: **vertical**, positive to the top;
- X_{SU} axis: beam projection in the **horizontal** plane, positive from cavern to IP;
- Y_{SU} axis: **horizontal**, perpendicular to the XZ plane, positive to the LHC centre

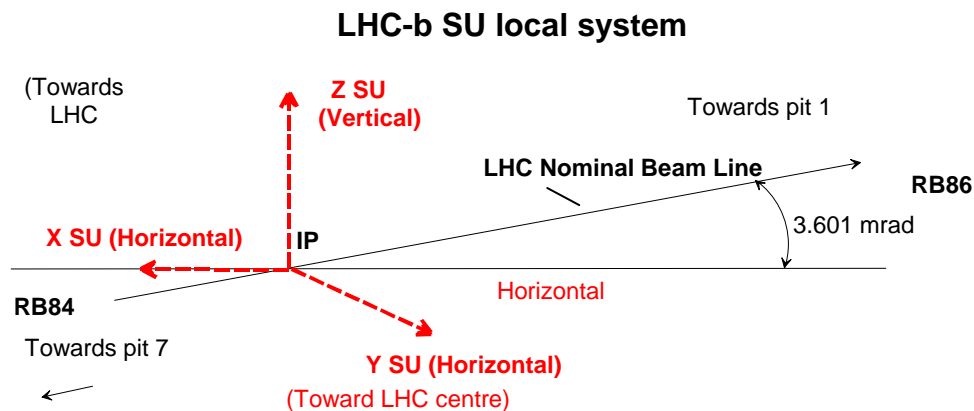


Figure 1 : LHCb Co-ordinate systems

3 C frame point positions and names:

3.1 Point names:

Point names are **B2_LVnB** or **B2_LVnT** with:

- **V**: Side of the frame, LV is on the magnet side. For this frame, it was just possible to measure the LV side.
- **n**: Chamber number on the frame, from 1 (Cryo side), to 9 (PZ side)
- **B or T**: for Bottom or Top

Example: B2_LV5T is on the magnet side, on the chamber 5, on the top.

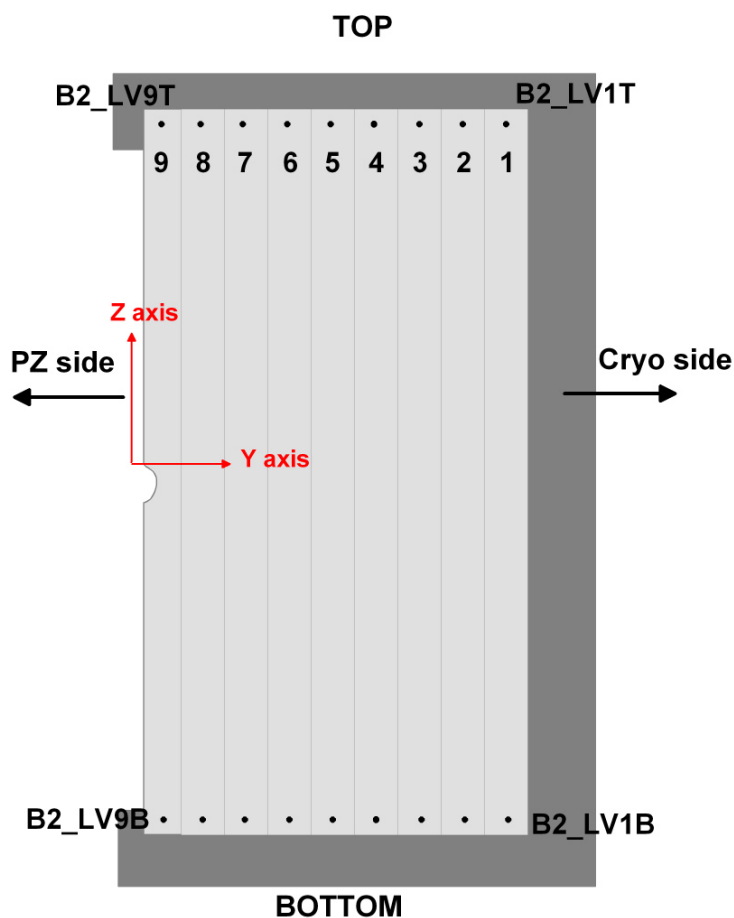


Figure 2 : point positions – LV side

3.2 Measured points

The coordinates are given at the centre of the Survey target, at a horizontal distance of **30mm** from the contact surface, see figure 3.

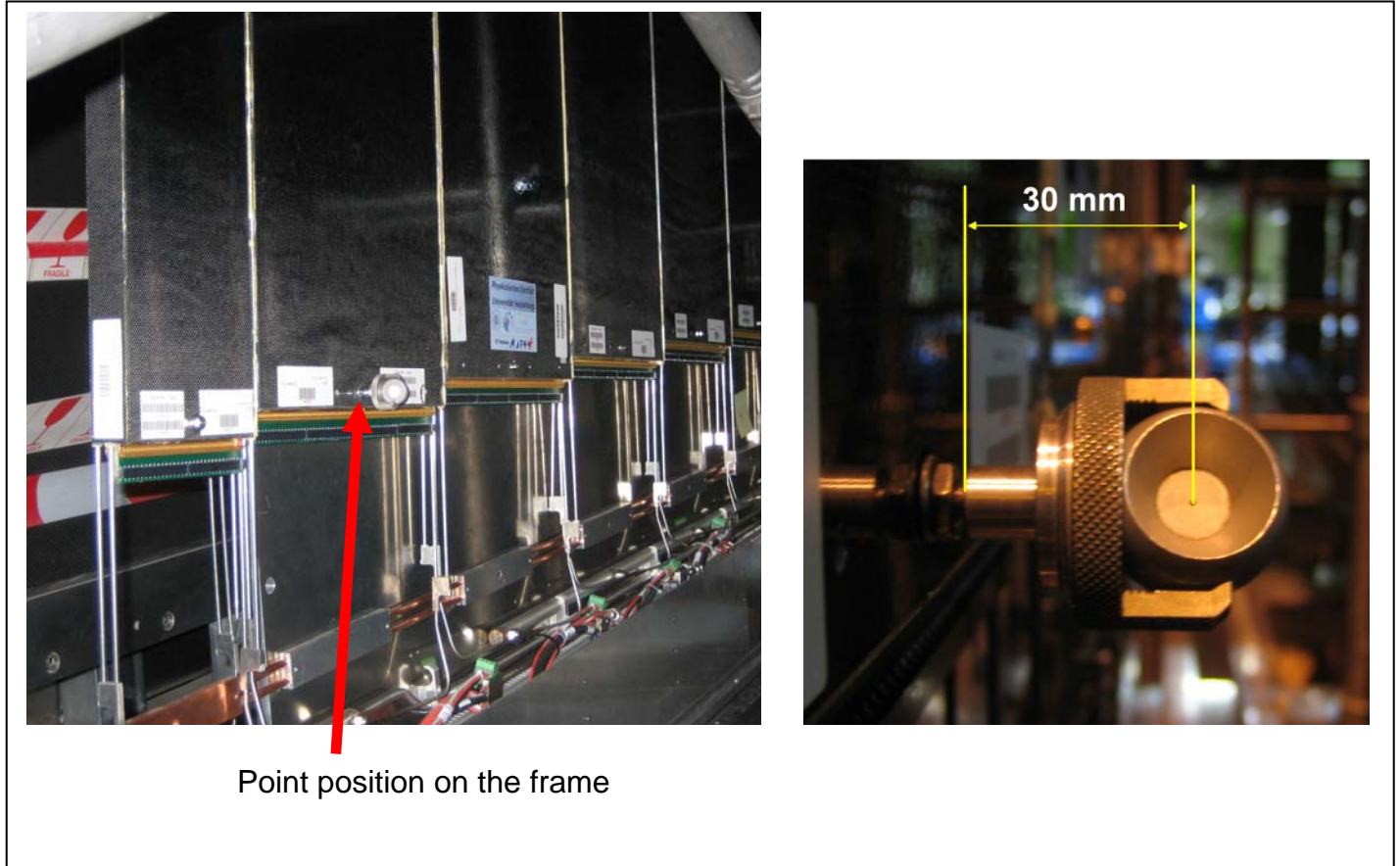


Figure 3 : Point position and target

4 Repeatability test

4.1 Point positions

In order to adjust the C-frame, we measured the point on each corner of the frame:

- B2_LV9B, on the left bottom corner
- B2_LV1B, on the right bottom corner
- B2_LV9T, on the left top corner
- B2_LV1T, on the right top corner

4.2 Results

The coordinates are given at the centre of the Survey target, at a distance of 30mm from the contact surface, see figure 3. The accuracy of the measurement is: 0.5mm at 1 sigma level.

	Point	X (m)	Y (m)	Z (m)
Iteration 1	B2_LV9B	-8.4905	0.1672	-2.4201
	B2_LV1B	-8.4901	2.8138	-2.4206
	B2_LV9T	-8.4923	0.1682	2.4816
	B2_LV1T	-8.4889	2.8150	2.4795
Iteration 2	B2_LV9T	-8.4929	0.1683	2.4818
	B2_LV1T	-8.4906	2.8151	2.4795
Iteration 3	B2_LV9B	-8.4903	0.1675	-2.4203
	B2_LV1B	-8.4901	2.8139	-2.4205
	B2_LV9T	-8.4912	0.1684	2.4815

5 Points after adjustment

The coordinates are given in the survey reference system at the center of the target.

Precision of the coordinates along X, Y and Z axis is 0.5 mm at 1 sigma level.

Layer V (magnet side)			
Point on the bottom of the frame			
	X (m)	Y (m)	Z (m)
B2_LV1B	-8.4902	2.8140	-2.4205
B2_LV2B	-8.4901	2.4728	-2.4205
B2_LV3B	-8.4900	2.1313	-2.4203
B2_LV4B	-8.4899	1.7902	-2.4201
B2_LV5B	-8.4896	1.4489	-2.4204
B2_LV6B	-8.4899	1.1077	-2.4202
B2_LV7B	-8.4893	0.7664	-2.4202
B2_LV8B	-8.4900	0.4250	-2.4207
B2_LV9B	-8.4905	0.1674	-2.4202

Layer V (magnet side)			
Point on the top of the frame			
	X (m)	Y (m)	Z (m)
B2_LV1T	-8.4905	2.8152	2.4795
B2_LV2T	-8.4901	2.4740	2.4799
B2_LV3T	-8.4902	2.1325	2.4798
B2_LV4T	-8.4901	1.7913	2.4800
B2_LV5T	-8.4899	1.4500	2.4805
B2_LV6T	-8.4901	1.1088	2.4805
B2_LV7T	-8.4903	0.7674	2.4809
B2_LV8T	-8.4910	0.4261	2.4813
B2_LV9T	-8.4911	0.1685	2.4815

6 Plane

6.1 Points positions

The points were taken on the surface of LV side with an offset of 52.3 mm in the X direction (see figure 4).



Figure 4 : Offset

6.2 Points names

To measure the “banana”, points were taken on the chambers 1, 4, and 8.

Points are *B2_PLn_pC* or *B2_PLn_pZ* with:

- C or Z for the Cryo side or the Z side
- *n*, the chamber number (see figure 5)
- *p* the position on the chamber, from 1 (on the bottom), to 5 (on the top).

As the chamber 2 is composed by 2 plates, joined on the middle, 2 points were taken, on just above this plane variation, and one below. As a consequence, there is B3_PL2_3A and B3_PL2_3B.

For the point positions, see the figure 5.

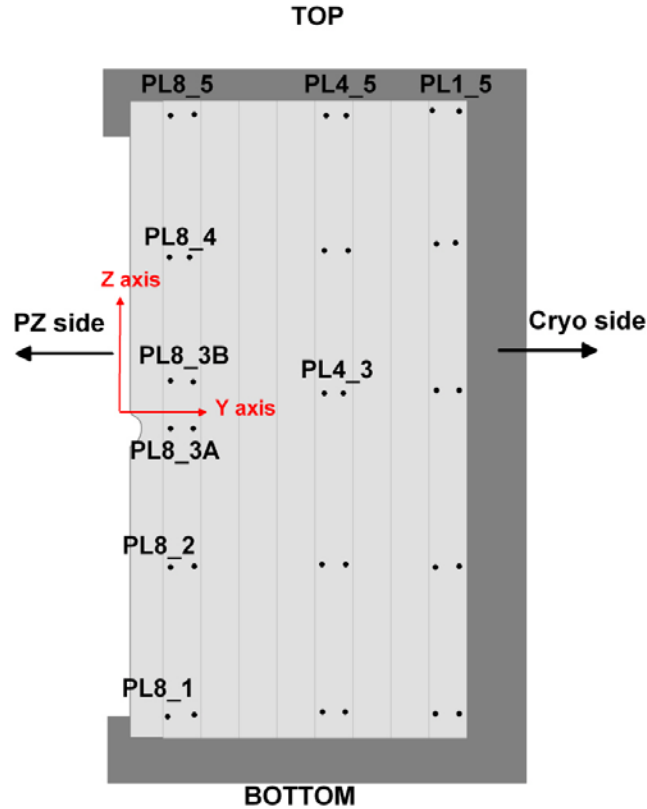


Figure 5 : Point positions

6.3 Plane fitting and results

6.3.1 Global plane

Results of Plane Fitting - Centroid Method

Date of
Calculation:

8/31/2006

Equation and Direction Cosines of the Plane :

Eqn of a Plane: $X + B*Y + C*Z + D = 0$

B	-0.000321	sig_B	0.093	mm/m
C	-0.000083	sig_C	0.056	mm/m
D (m)	8.47473	sig_D	0.177	mm

Hence for Eqn of the form: $a*x + b*y + c*z + d = 0$ with a, b, c : Dir. Cosines of perp. Line to the Plane

a	1.000000
b	-0.000321
c	-0.000083
d (m)	8.47473

Bearing and Vertical Angle of the Vector from the origin to the plane

Bearing (Grades)	100.0204
Vertical Angle (Grades)	100.0053
Dist from the origin to the plane (m)	8.47473

Observed Coords (m)					Dist	dX	dY	dZ
Name	X (m)	Y (m)	Z (m)	Weight	(mm)	(mm)	(mm)	(mm)
B2_PL8_1Z	-8.4746	0.3077	-2.3587	1.0000	-0.28	-0.28	0.00	0.00
B2_PL8_1C	-8.4745	0.5602	-2.3486	1.0000	-0.22	-0.22	0.00	0.00
B2_PL8_2Z	-8.4751	0.3212	-1.3168	1.0000	0.33	0.33	0.00	0.00
B2_PL8_2C	-8.4751	0.5560	-1.3092	1.0000	0.41	0.41	0.00	0.00
B2_PL4_1C	-8.4744	1.9176	-2.3295	1.0000	0.12	0.12	0.00	0.00
B2_PL4_1Z	-8.4741	1.6658	-2.3342	1.0000	-0.34	-0.34	0.00	0.00
B2_PL4_2C	-8.4740	1.9370	-1.3429	1.0000	-0.21	-0.21	0.00	0.00
B2_PL4_2Z	-8.4745	1.6774	-1.3313	1.0000	0.16	0.16	0.00	0.00
B2_PL1_1C	-8.4741	2.9422	-2.3501	1.0000	0.14	0.14	0.00	0.00
B2_PL1_1Z	-8.4745	2.6862	-2.3384	1.0000	0.42	0.42	0.00	0.00
B2_PL1_2C	-8.4745	2.9547	-1.3500	1.0000	0.61	0.61	0.00	0.00
B2_PL1_2Z	-8.4746	2.6797	-1.3477	1.0000	0.65	0.65	0.00	0.00
B2_PL1_3C	-8.4733	2.9609	0.0520	1.0000	-0.50	-0.50	0.00	0.00
B2_PL1_3Z	-8.4740	2.6802	0.0370	1.0000	0.15	0.14	0.00	0.00
B2_PL4_3C	-8.4742	1.9318	0.0404	1.0000	0.07	0.06	0.00	0.00
B2_PL4_3Z	-8.4740	1.6673	0.0218	1.0000	-0.23	-0.23	0.00	0.00
B2_PL8_3CA	-8.4745	0.5646	-0.0999	1.0000	-0.11	-0.11	0.00	0.00
B2_PL8_3CB	-8.4745	0.5623	0.1658	1.0000	0.00	0.00	0.00	0.00
B2_PL8_3ZA	-8.4743	0.2994	-0.0943	1.0000	-0.38	-0.38	0.00	0.00
B2_PL8_3ZB	-8.4749	0.2950	0.1621	1.0000	0.32	0.32	0.00	0.00
B2_PL8_4C	-8.4742	0.5594	1.3058	1.0000	-0.28	-0.28	0.00	0.00
B2_PL8_4Z	-8.4740	0.2944	1.2999	1.0000	-0.52	-0.52	0.00	0.00
B2_PL4_4C	-8.4731	1.9367	1.3081	1.0000	-0.89	-0.89	0.00	0.00
B2_PL4_4Z	-8.4729	1.6565	1.3096	1.0000	-1.17	-1.17	0.00	0.00
B2_PL1_4C	-8.4730	2.9537	1.3289	1.0000	-0.66	-0.66	0.00	0.00
B2_PL1_4Z	-8.4730	2.6768	1.3442	1.0000	-0.79	-0.79	0.00	0.00
B2_PL1_5C	-8.4744	2.9532	2.4296	1.0000	0.85	0.85	0.00	0.00
B2_PL1_5Z	-8.4740	2.6719	2.4362	1.0000	0.33	0.33	0.00	0.00
B2_PL4_5C	-8.4742	1.9411	2.4321	1.0000	0.34	0.34	0.00	0.00
B2_PL4_5Z	-8.4740	1.6485	2.4362	1.0000	0.00	0.00	0.00	0.00
B2_PL8_5C	-8.4750	0.5672	2.4432	1.0000	0.69	0.69	0.00	0.00
B2_PL8_5Z	-8.4754	0.2846	2.4400	1.0000	1.00	1.00	0.00	0.00

Dist = 'Signed' Dist. to Plane : (Sign - : Origin & Pt on same side / Plane)

(Sign + : Origin & Pt on opp. side / Plane)

dX, dY, dZ = Diff. co-ordinates : (Diff. co-ordinates = Pt. proj. - Pt. obs.)

Equation of the plane

$$1.000000 * x + -0.000321 * y + -0.000083 * z + 8.47473 \text{ (m)} = 0$$

Largest Distance from Plane on + side (mm)

0.996 At Point B2_PL8_5Z

Largest Distance from Plane on - side (mm)

-1.168 At Point B2_PL4_4Z

Dist = 'Signed' Dist. to Plane (- => Origin & Pt on same side / Plane, + => Origin & Pt on opp. side / Plane)

6.3.2 PL8 plane

This plane just takes into account the points belonging to the PL8 chamber.

Results of Plane Fitting - Centroid Method

Date of Calculation: 8/31/2006
Time of Calculation: 5:08:28 PM

Equation and Direction Cosines of the Plane :

Eqn of a Plane: $X + B*Y + C*Z + D = 0$

B	0.000309	sig_B	1.044	mm/m
C	0.000029	sig_C	0.087	mm/m
D (m)	8.47480	sig_D	0.470	mm

Hence for Eqn of the form: $a*x + b*y + c*z + d = 0$ with a, b, c : Dir. Cosines of perp. Line to the Plane

a	1.000000
b	0.000309
c	0.000029
d (m)	8.47480

Bearing and Vertical Angle of the Vector from the origin to the plane

Bearing (Grades)	100.0197
Vertical Angle (Grades)	99.9981
Dist from the origin to the plane (m)	8.47480

Observed Coords (m)					Dist	dX	dY	dZ
Name	X (m)	Y (m)	Z (m)	Weight	(mm)	(mm)	(mm)	(mm)
B2_PL8_1Z	-8.47455	0.30766	-2.35869	1.0	-0.086	-0.086	0.000	0.000
B2_PL8_1C	-8.47452	0.56016	-2.34862	1.0	-0.039	-0.039	0.000	0.000
B2_PL8_2Z	-8.47506	0.32116	-1.31684	1.0	0.398	0.398	0.000	0.000
B2_PL8_2C	-8.47507	0.55604	-1.30923	1.0	0.480	0.480	0.000	0.000
B2_PL8_3CA	-8.47445	0.56463	-0.09987	1.0	-0.173	-0.173	0.000	0.000
B2_PL8_3CB	-8.47453	0.56231	0.16584	1.0	-0.101	-0.101	0.000	0.000
B2_PL8_3ZA	-8.47426	0.29940	-0.09430	1.0	-0.445	-0.445	0.000	0.000
B2_PL8_3ZB	-8.47494	0.29504	0.16208	1.0	0.227	0.227	0.000	0.000
B2_PL8_4C	-8.47416	0.55940	1.30581	1.0	-0.505	-0.505	0.000	0.000
B2_PL8_4Z	-8.47401	0.29435	1.29987	1.0	-0.737	-0.737	0.000	0.000
B2_PL8_5C	-8.47503	0.56720	2.44316	1.0	0.334	0.334	0.000	0.000
B2_PL8_5Z	-8.47543	0.28463	2.44000	1.0	0.647	0.647	0.000	0.000

Dist = 'Signed' Dist. to Plane : (Sign - : Origin & Pt on same side / Plane)
 (Sign + : Origin & Pt on opp. side / Plane)
 dX, dY, dZ = Diff. co-ordinates : (Diff. co-ordinates = Pt. proj. - Pt. obs.)

Summary of the data in the Calculated Co-ordinate Axis

Original Axis Conversion

X Calculated Co-ordinate Axis = X Observation Axis

Y Calculated Co-ordinate Axis = Y Observation Axis

Z Calculated Co-ordinate Axis = Z Observation Axis

Equation of the plane

$$1.000000 * x + -0.000309 * y + 0.000029 * z + 8.47480 \text{ (m)} = 0$$

Largest Distance from Plane on + side (mm)

0.647 At Point B2_PL8_5Z

Largest Distance from Plane on - side (mm)

-0.737 At Point B2_PL8_4Z

Dist = 'Signed' Dist. to Plane (- => Origin & Pt on same side / Plane, + => Origin & Pt on opp. side / Plane)

Bearing and Vertical Angle of the Vector perpendicular to the plane

Bearing (Grades)

100.0197

Vertical Angle (Grades)

99.9981

6.3.3 PL4 plane*Results of Plane Fitting - Centroid Method**Date of**Calculation:*

8/31/2006

Time of

Calculation:

5:07:44 PM

Equation and Direction Cosines of the Plane :**Eqn of a Plane: $X + B*Y + C*Z + D = 0$**

B	0.000442	sig_B	1.220	mm/m
C	-0.000125	sig_C	0.096	mm/m
D (m)	8.47314	sig_D	2.199	mm

Hence for Eqn of the form: $a*x + b*y + c*z + d = 0$ with a, b, c : Dir. Cosines of perp. Line to the Plane

a	1.000000
b	0.000442
c	-0.000125
d (m)	8.47314

Bearing and Vertical Angle of the Vector from the origin to the plane

Bearing (Grades)

99.9719

Vertical Angle (Grades)

100.0080

Dist from the origin to the plane (m)

8.47314

Observed Coords (m)					Dist	dX	dY	dZ
Name	X (m)	Y (m)	Z (m)	Weight	(mm)	(mm)	(mm)	(mm)
B2_PL4_1C	-8.47443	1.91761	-2.32946	1.0	0.148	0.148	0.000	0.000
B2_PL4_1Z	-8.47405	1.66580	-2.33419	1.0	-0.121	-0.121	0.000	0.000
B2_PL4_2C	-8.47401	1.93695	-1.34291	1.0	-0.157	-0.157	0.000	0.000
B2_PL4_2Z	-8.47446	1.67741	-1.33127	1.0	0.409	0.409	0.000	0.000
B2_PL4_3C	-8.47417	1.93181	0.04040	1.0	0.178	0.178	0.000	0.000
B2_PL4_3Z	-8.47396	1.66733	0.02181	1.0	0.083	0.083	0.000	0.000
B2_PL4_4C	-8.47311	1.93666	1.30806	1.0	-0.726	-0.726	0.000	0.000
B2_PL4_4Z	-8.47292	1.65648	1.30958	1.0	-0.792	-0.792	0.000	0.000
B2_PL4_5C	-8.47424	1.94107	2.43211	1.0	0.543	0.543	0.000	0.000
B2_PL4_5Z	-8.47400	1.64847	2.43615	1.0	0.433	0.433	0.000	0.000

Dist = 'Signed' Dist. to Plane : (Sign - : Origin & Pt on same side / Plane)

(Sign + : Origin & Pt on opp. side / Plane)

dX, dY, dZ = Diff. co-ordinates : (Diff. co-ordinates = Pt. proj. - Pt. obs.)

Largest Distance from Plane on + side (mm) 0.543 At Point B2_PL4_5C

Largest Distance from Plane on - side (mm) -0.792 At Point B2_PL4_4Z

Dist = 'Signed' Dist. to Plane (- => Origin & Pt on same side / Plane, + => Origin & Pt on opp. side / Plane)

6.3.4 PL1 plane

Results of Plane Fitting - Centroid Method

*Date of
Calculation:*

8/31/2006

Time of

Calculation:

5:06:52 PM

Equation and Direction Cosines of the Plane :

Eqn of a Plane: $X + B*Y + C*Z + D = 0$

B	-0.000571	sig_B	1.472	mm/m
C	-0.000154	sig_C	0.116	mm/m
D (m)	8.47555	sig_D	4.149	mm

Hence for Eqn of the form: $a*x + b*y + c*z + d = 0$ with a, b, c : Dir. Cosines of perp. Line to the Plane

a	1.000000
b	-0.000571
c	-0.000154
d (m)	8.47555

Bearing and Vertical Angle of the Vector from the origin to the plane

Bearing (Grades)	100.0363
Vertical Angle (Grades)	100.0098
Dist from the origin to the plane (m)	8.47555

Observed Coords (m)

Name	X (m)	Y (m)	Z (m)	Weight	Dist (mm)	dX (mm)	dY (mm)	dZ (mm)
B2_PL1_1C	-8.47412	2.94222	-2.35013	1.0	-0.115	-0.115	0.000	0.000
B2_PL1_1Z	-8.47448	2.68618	-2.33839	1.0	0.101	0.101	0.000	0.000
B2_PL1_2C	-8.47450	2.95466	-1.35004	1.0	0.426	0.426	0.000	0.000
B2_PL1_2Z	-8.47463	2.67971	-1.34774	1.0	0.399	0.399	0.000	0.000
B2_PL1_3C	-8.47327	2.96088	0.05204	1.0	-0.585	-0.585	0.000	0.000
B2_PL1_3Z	-8.47401	2.68016	0.03701	1.0	-0.008	-0.008	0.000	0.000
B2_PL1_4C	-8.47301	2.95368	1.32893	1.0	-0.653	-0.653	0.000	0.000
B2_PL1_4Z	-8.47297	2.67683	1.34419	1.0	-0.849	-0.849	0.000	0.000
B2_PL1_5C	-8.47443	2.95318	2.42963	1.0	0.936	0.936	-0.001	0.000
B2_PL1_5Z	-8.47400	2.67193	2.43621	1.0	0.346	0.346	0.000	0.000

Dist = 'Signed' Dist. to Plane : (Sign - : Origin & Pt on same side / Plane)

(Sign + : Origin & Pt on opp. side / Plane)

dX, dY, dZ = Diff. co-ordinates : (Diff. co-ordinates = Pt. proj. - Pt. obs.)

Equation of the plane

$$1.000000 * x + -0.000571 * y + -0.000154 * z + 8.47555 (m) = 0$$

Largest Distance from Plane on + side (mm) 0.936 At Point B2_PL1_5C

Largest Distance from Plane on - side (mm) -0.849 At Point B2_PL1_4Z

Dist = 'Signed' Dist. to Plane (- => Origin & Pt on same side / Plane, + => Origin & Pt on opp. side / Plane)