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Proposal draft

Metrology of completed modules - Supplement

abstract

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Distribution List

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History of Changes

Rev. No.	***Date***	***Pages***	***Description of changes***
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1 Introduction

In the SCT barrel module FDR document, SCT-BM-FDR-7 Section 3.2.2 and Appendix 1, the out-of-plane survey is described. The measured points are those of 5x5 matrix on four sensors and of three areas which are mounting the modules kinematically and defining the module plane: the two points in the cooling tab and the 3rd mounting point in the far-end tab. Those points are defined because the primary concern of the module shape is the surface of the sensors.

In the module fabrication and survey, it is realized that the shape of the cooling tab is also a critical parameter for the contact of the cooling block, specially the parallelism of the cooling tab to the module plane which is defined by the kinematic mounting points, together with the concavity of the cooling contact area. The parallelism of the cooling tab is governed by the accuracy of the process of mounting hybrids on the cooling tab of the sensor-baseboard assembly. The parallelism also gives information on how the 3rd mounting point is displaced when the module is held at the cooling tab by the module mounting robot. The survey of the surfaces of the cooling and far-end tabs also gives information on the thickness of the tabs and asymmetry of glue layers of the sensors from the difference of the thickness centres of the sensors and the tabs.

2 Out-of-plane survey

2.1 Surface of sensors

The surfaces of the sensors are to be measured at a matrix of 5x5 points in each sensor, as shown in Figure 1. The coordinates of the points are defined by the fiducial marks "A", 1 to 16 in the front (=upper) and 51 to 66 in the back (=lower) side. Points below the hybrids are avoided in analysis programs. The z-coordinates within these areas are to be interpolated from the neighbouring points: in the columns of 9-15 and 10-14 in the front (=upper), and, 59-66 and 60-64 in the back (=lower) side.

These surface measurements allow the maximum deviations in the upper and the lower side to be derived, in the "module plane" defined from the three points in the tabs. The maximum deviations must be within a value set by the mechanical requirement of the stay-clear separation of the adjacent modules in the completed barrel assembly. The most effective use of these 100 points in every module in reconstruction, i.e., 100 points times 2112 barrel modules requires no further parameterization nor out-of-plane tolerance. This, however, cannot be regarded as a practical solution. Also, to have no requirement of the z metrology data requires the module surfaces to be flat within a value allowed from the physics requirements which is less than about 50 µm. From the experience of the modules constructed, this is not a practical solution either as there is intrinsic bowing in the sensors and in the baseboards which are bigger than 50 µm.

Appendix 1 of SCT-BM-FDR-7 adopted the "minimum (or optimal) use" of z data with a procedure carried out in two steps:

(1) The average plane of the upper and the lower surfaces, the "mid-plane", is fitted, separately in the left and the right side of the module, to the plane equation, $z = ax + by + c$. These (a, b, c) parameters per module-side express non-planarity of the module in the left and the right-hand side.

(2) The average z values at each point of the 100 points out of many modules derive the "common profile" of the module surfaces. Thus, the 100 points of the "common profile" express the

bowing of the sensors, common to all modules which use the sensors from a particular vendor.

After the above parameterization, the residuals are regarded as the errors in z-flatness, which maximum is called "optimal max Z error" and the r.m.s. "optimal rms Z error", which should be smaller than the tolerance from the physics requirements.

Furthermore, the survey of the surfaces of the sensors in the front (=upper) and the back (=lower) side allows the derivation of quality parameters of the module fabrication, in the sensor area: thickness and concavity of the module. The concavity of the module is defined in the x and y directions: in x-direction by taking the height differences of the mid-planes of the rows (1-7, 11-13) and the rows (3-5, 9-15); in y-direction the mid-planes of the rows (1-11, 7-13) and the row (8-12). These concavities are direct parameters, where the "fitted mid-plane" parameters, (a, b, c)'s, are indirect.

2.2 Surface of tabs

The surfaces of the far-end and the cooling tabs are to be measured at 17 (lower) and 15 (upper) points, b1 to b17 in the back (=lower) and f1 to f15 in the front (=upper) side, as shown in Figure 1. These points in the surfaces of the tabs are located in the same positions so that the thickness of the tabs can be derived. The front (=upper) side has two points less where the surface is shadowed by the pigtail of the hybrid. In order to clarify, the far-end and the cooling tab areas of the back (=lower) side are expanded in Figure 2 and Figure 3, respectively.

The 3rd mounting point is to be measured three times with a slight shift of the locations: b1 to b3, through the "peephole (2 mm diameter)" in the survey frame, in order to increase the accuracy. The hole and slot areas are to be measured at four points each: b4, b5, b8 and b9, and b10, b11, b14, and b15. These points are 2 mm away from the hole/slot washers so that the points are not affected by the adhesive fillet around the washers. The average of (b4, b5, b8, b9) defines the z-coordinate of the hole, Z1; the average of (b10, b11, b14, b15) the z-coordinate of the slot, Z2; and the average of (b1, b2, b3) the z-coordinate of the 3rd mounting point, Z3.

The points b4-b6, b7-b9, b10-b12, and b13-b15 are to be used to derive the parallelism of the cooling tab to the module plane. The points b5, b6, b16, b17, b13, and b14 are to be used to derive the concavity of the cooling tab. The tab-corner points, b6 and b13, are to be measured through the "peepholes (2 mm diameter)" in the survey frame.

The correlation of the front (=upper) and the back (=lower) points defines the thicknesses and the centre heights of the tabs. The thickness of the tabs together with the thickness of the module in the sensor area allows the derivation of the thickness of the adhesives between the baseboard and the sensors. The heights of the centre of the tabs and the centre of the sensors derive the asymmetry of the adhesives in the front (=upper) and the back (=lower) between the baseboard and the sensors. Thus, the survey of the tabs allows the derivation of many quality parameters of the module fabrication.

2.3 Survey frame

A concept of a survey frame is drawn in the figures. The frame is constructed from two equivalent halves with the front (=upper) and the back (=lower) pieces held together with screws in the frame peripheral once a module is placed inside. The frame has "peepholes" where the module-holding arms are required: at the 3rd mounting point in the far-end tab and at the tab-corners in

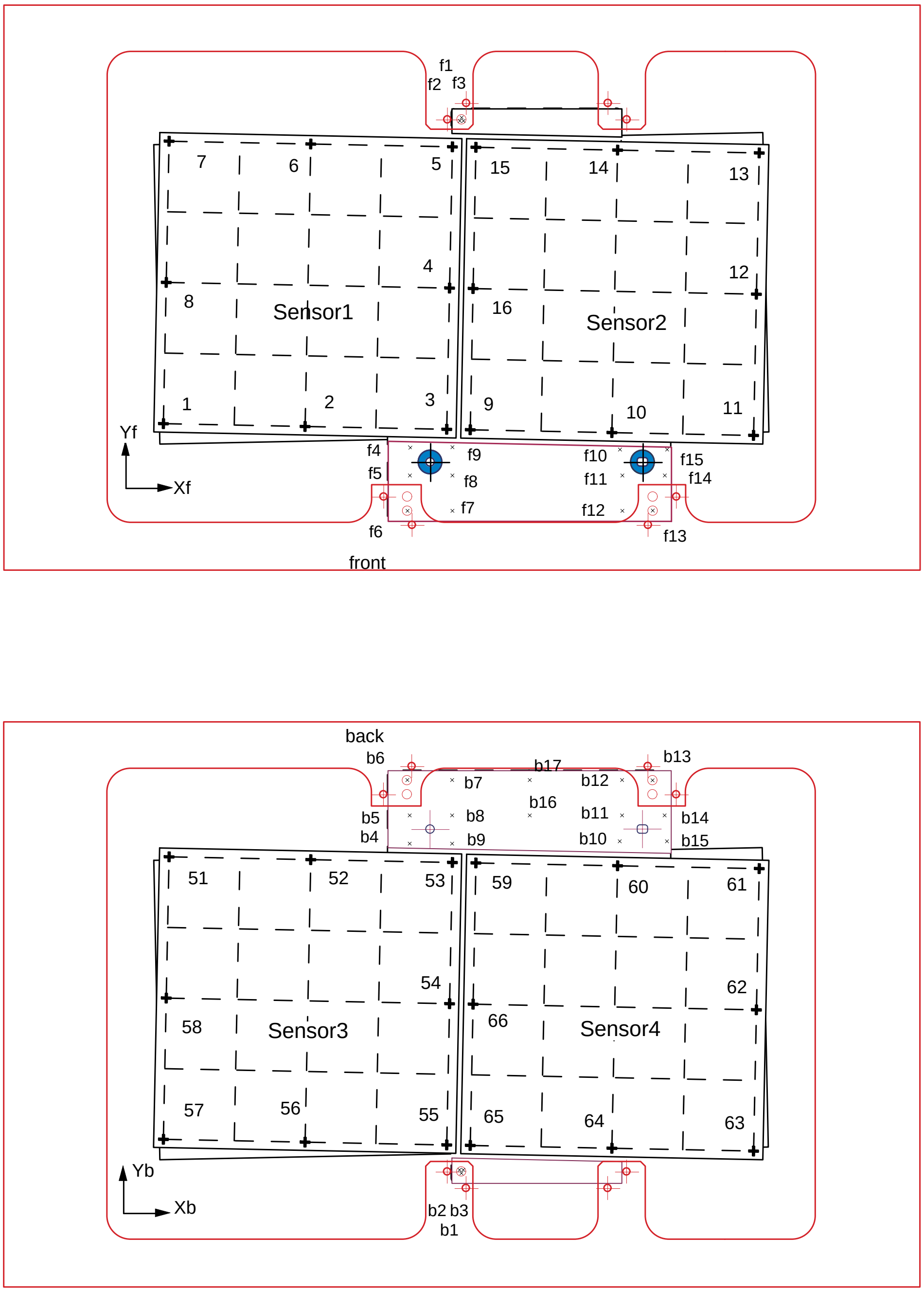

Figure 1 Survey points of the barrel module (with hybrids erased): 5x5 matrix on sensors and 17 points on the far-end and cooling tabs (15 points on the front (=upper) side). Sensors 1 and 2 are on the front (=upper) side and 3 and 4 the back (=lower) side. Sensors1 and 3 are on the left when the module is held in the conventional orientation (i.e., hybrid on the right side). A survey frame has "peepholes" at the 3rd mounting point in the far-end tab and at the tab-corners in the cooling tab. The opposite arm to the 3rd mounting point of the far-end tab in the survey frame is made retracted in height so that the module is held kinematically at the three points, two points in the arms of the cooling tab and the 3rd mounting point in the arm of the far-end tab.

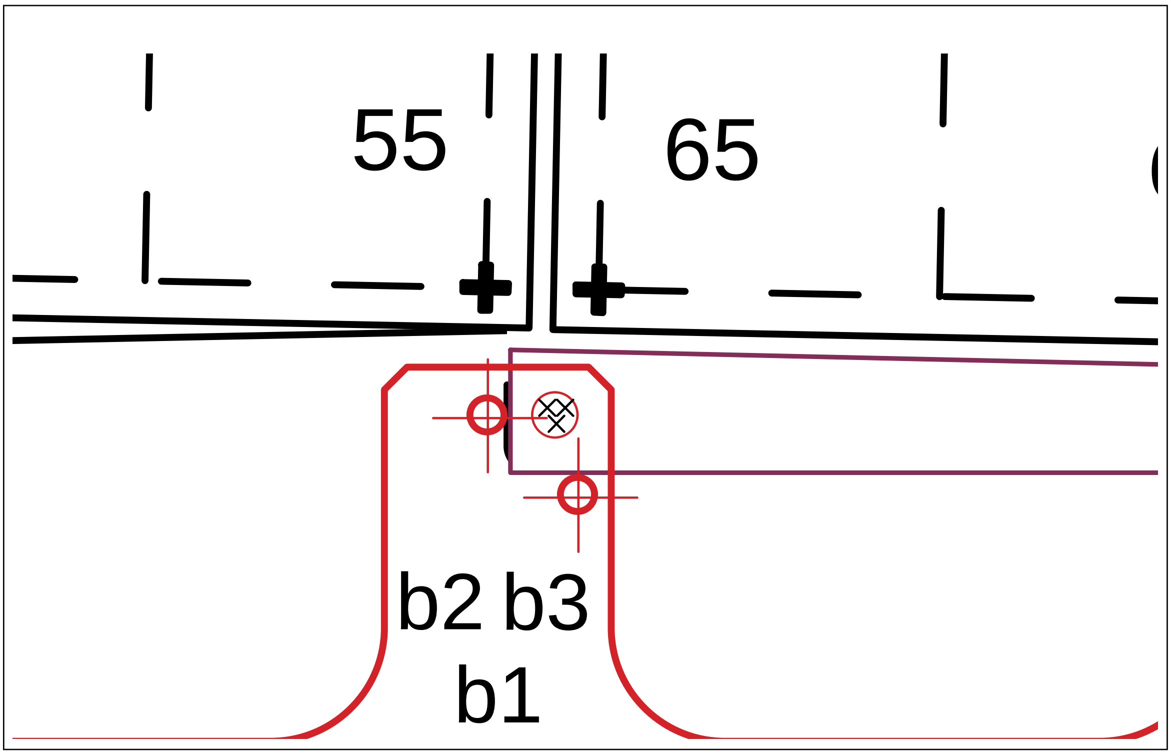

Figure 2 Expanded view of the far-end tab area of the back (=lower) side. The 3rd mounting point is to be measured three times with a slight shift of the locations: b1 to b3, through the "peephole (2 mm diameter)" in the survey frame.

the cooling tab. Once holes are made in these arms, it is impossible to use a screw or an equivalent to clamp the tabs in the area. An alternative to the screw is to use vacuum, through the holes. By using the correlation method developed at KEK, the "edge" method, it is irrelevant whether the module "moves or not" when the frame is flipped. The vacuum is switched from the back (=lower) side to the front (=upper) side when the module is flipped for the measurement of the front (=upper) side to the back (=lower) side, respectively. The strength of the vacuum is to hold the module such that it does not move while a side is being measured. There are pins around the corners of the tabs in the frame to hold the module while the vacuum is off. The pins are planted in the back (=lower) frame and the front (=upper) has female holes to mate the pins.

The opposite arm to the 3rd mounting point of the far-end tab in the frame is made recessed in height so that the module is held kinematically at the three points, two points in the arms of the cooling tab and the 3rd mounting point in the arm of the far-end tab.

2.4 Coordinates of the survey points

The x-y coordinates of the survey points in the module coordinate are summarized in Table 1. The points 1 to 50 are of the sensors, 51-53 of the 3rd mounting point in the far-end tab, and 54-67 in the cooling tab. The centre of the coordinates is the origin of the module, i.e., the centre of the four sensors.

2.5 Derived parameters and tolerances

The module parameters derived from the measurements of the surfaces of the sensors and the

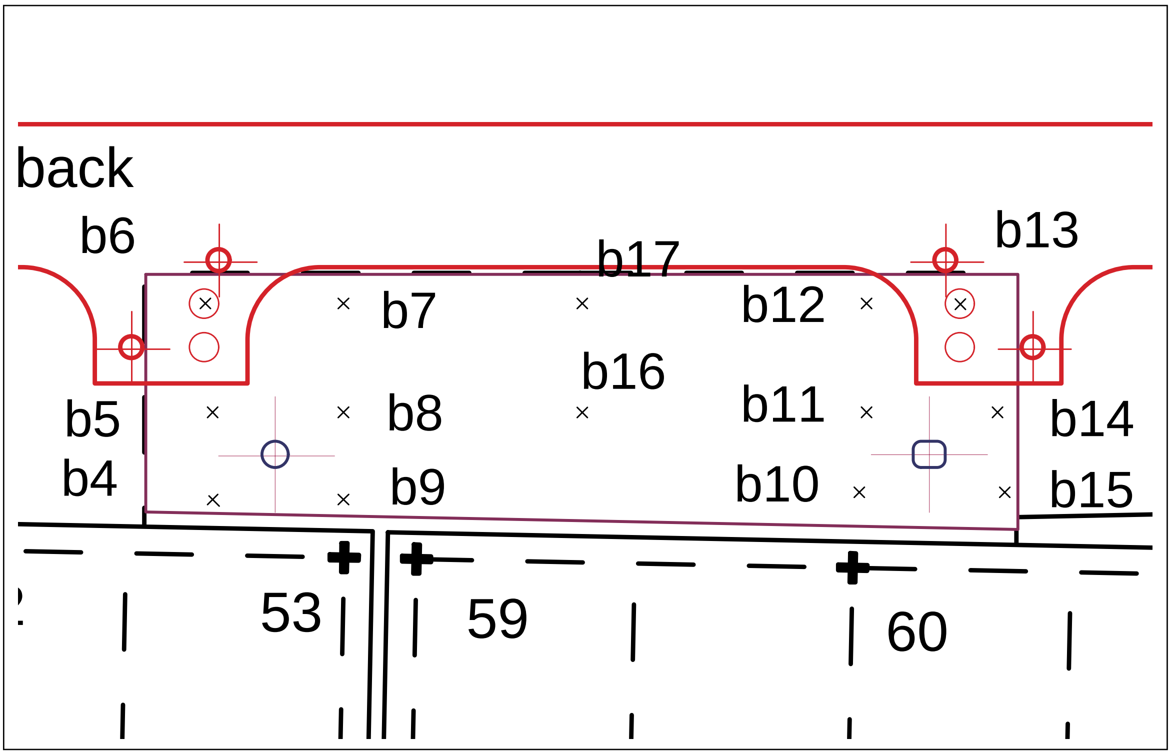

Figure 3 Expanded view of the cooling tab area of the back (=lower) side. The hole and slot areas are measured at four points each: b4, b5, b8 and b9, and b10, b11, b14, and b15. The points b4-b6, b7-b9, b10-b12, and b13-b15 are to be used to derive the parallelism of the cooling tab to the module plane. The points b5, b6, b16, b17, b13, and b14 are to derive the concavity of the cooling tab. The tab-corner points, b6 and b13, are to be measured through the "peepholes (2 mm diameter)" in the survey frame.

tabs are summarized in Table 2. The nominal values of the parameters are listed in the table, together with tolerances being proposed. The analysis program (spreadsheet) is available from the web page [1]. An example of the datasheet of the metrology is shown in Table 3.

References

[1] Y. Unno, Survey-in-Z, v2.3, http://jsdhp1.kek.jp/~unno/SCTSGmod/production/surveyZ_idAction2.3.xls

Table 1 The x-y coordinates of the survey points in the module coordinate. The points 1 to 50 are of the sensors, 51-53 of the 3rd mounting point in the far-end tab, and 54-67 in the cooling tab. The centre of the coordinates is the origin of the module, i.e., the centre of the four sensors.

	Lower		Upper	
point	x	y	x	y
1	-63.151	32.820	-64.413	-30.268
2	-47.279	32.502	-48.541	-30.585
3	-31.408	32.185	-32.670	-30.903
4	-15.536	31.867	-16.798	-31.220
5	0.336	31.550	-0.926	-31.538
6	-63.467	17.048	-64.098	-14.496
7	-47.595	16.730	-48.226	-14.814
8	-31.723	16.413	-32.354	-15.131
9	-15.851	16.095	-16.482	-15.448
10	0.021	15.778	-0.610	-15.766
11	-63.782	1.276	-63.782	1.276
12	-47.910	0.958	-47.910	0.958
13	-32.039	0.641	-32.039	0.641
14	-16.167	0.323	-16.167	0.323
15	-0.295	0.006	-0.295	0.006
16	-64.098	-14.496	-63.467	17.048
17	-48.226	-14.814	-47.595	16.730
18	-32.354	-15.131	-31.723	16.413
19	-16.482	-15.448	-15.851	16.095
20	-0.610	-15.766	0.021	15.778
21	-64.413	-30.268	-63.151	32.820
22	-48.541	-30.585	-47.279	32.502
23	-32.670	-30.903	-31.408	32.185
24	-16.798	-31.220	-15.536	31.867
25	-0.926	-31.538	0.336	31.550
26	0.926	31.538	-0.336	-31.550
27	16.798	31.220	15.536	-31.867
28	32.670	30.903	31.408	-32.185
29	48.541	30.585	47.279	-32.502
30	64.413	30.268	63.151	-32.820
31	0.610	15.766	-0.021	-15.778
32	16.482	15.448	15.851	-16.095
33	32.354	15.131	31.723	-16.413
34	48.226	14.814	47.595	-16.730
35	64.098	14.496	63.467	-17.048
36	0.295	-0.006	0.295	-0.006
37	16.167	-0.323	16.167	-0.323
38	32.039	-0.641	32.039	-0.641
39	47.910	-0.958	47.910	-0.958
40	63.782	-1.276	63.782	-1.276
41	-0.021	-15.778	0.610	15.766
42	15.851	-16.095	16.482	15.448
43	31.723	-16.413	32.354	15.131
44	47.595	-16.730	48.226	14.814
45	63.467	-17.048	64.098	14.496
46	-0.336	-31.550	0.926	31.538
47	15.536	-31.867	16.798	31.220
48	31.408	-32.185	32.670	30.903
49	47.279	-32.502	48.541	30.585
50	63.151	-32.820	64.413	30.268
51	0	-36	0	36
52	-0.4	-35.3	-0.4	35.3
53	0.4	-35.3	0.4	35.3
54	-11	34	-11	-34
55	-11	40	-11	-40
56	-11.5	47.5	-11.5	-47.5
57	-2	47.5	-2	-47.5
58	-2	40	-2	-40
59	-2	34	-2	-34
60	33.5	34.5	33.5	-34.5
61	34	40	34	-40
62	34	47.5	34	-47.5
63	40.5	47.5	40.5	-47.5
64	43	40	43	-40
65	43.5	34.5	43.5	-34.5
66	14.5	40		
67	14.5	47.5		

Table 2 Derived module parameters, nominal and tolerance values, and descriptions

Parameters	Nominal	Tolerance	Description
maxZlower [mm]	0	abs()<0.2	lower sensor maximum deviation from ModulePlane
maxZupper [mm]	0	abs()<0.2	upper sensor maximum deviation from ModulePlane
midplaneHeight [mm]	0.45		z in LoFacingFrame (z=0)
moduleThickness [mm]	1.15	diff<0.1	
optimalMaxZerrorLower [mm]	0	abs()<0.05	lower sensor maximum deviation from CommonModuleProfile
optimalMaxZerrorUpper [mm]	0	abs()<0.05	upper sensor maximum deviation from CommonModuleProfile
optimalRmsZerrorLower [mm]	0	abs()<0.025	lower sensor RMS deviation from CommonModuleProfile
optimalRmsZerrorUpper [mm]	0	abs()<0.025	upper sensor RMS deviation from CommonModuleProfile
moduleConcavity x [mm]	0		bow of the midPlane along the module
y	0		bow of the midPlane across the module
sensorSkew x [mm]	0		difference of z along the module at two ends
y	0		differnece of z across the module at two ends
coolingTabThickness [mm]	0.92		cooling-side tab thickness including baseboard and adhesive
farTabThickness [mm]	0.92		far-side tab thickness including baseboard and adhesive
halfTabThickness [mm]	0.460		mean half-tab thickness of cooling- and far-side
tabSkew y [mm]	0		non-zero if coolingTabThickness and farTabThickness are different
adhesiveThicknessTotal [mm]	0.160		total adhesive thickness, I.e., twice the thickness per side
adhesiveAsymmetry [mm]	0		difference of the adhesive thickness of two sides
loCoolingFacing a [mrad]	0	abs()<0.5	lower cooling facing angle along the module, 30 um over 60 mm
b [mrad]	0	abs()<3	lower cooling facing angle across the module, 30 um over 10 mm
loCoolingFacingConcavity [mm]	0	abs()<0.03	lower cooling facing concavity along x, 30 um over dowel hole/slot

Table 3 An example of data in the metrology datasheet

atlasPartsId	mech#1
eventDescription	SURVEY_Z-INITIAL-test1
date [dd/mm/yyy]	6/12/2001
location [instituteCode(DB)]	KEK
personInitial	TKr
problem [YES/NO]	NO
pass [YES/NO]	YES
comments	Edge
temperature [C]	26.5
measurementJigID	<data>
maxZlower [mm]	-0.014
maxZupper [mm]	0.003
midplaneEq	z=ax+by+c
Left a	0.000121198
b	-1.35874E-05
c	0.471374198
Right a	-0.000293079
b	-8.05776E-05
c	0.470954917
midplaneHeight [mm]	0.471
moduleThickness [mm]	1.150
optimalMaxZerrorLower [mm]	0.022
optimalMaxZerrorUpper [mm]	0.015
optimalRmsZerrorLower [mm]	0.007
optimalRmsZerrorUpper [mm]	0.005
moduleConcavity x [mm]	0.013
y	-0.002
sensorSkew x [mm]	-0.012
y	-0.003
coolingTabThickness [mm]	0.936
farTabThickness [mm]	0.937
halfTabThickness [mm]	0.468
tabSkew y [mm]	0.000
adhesiveThicknessTotal [mm]	0.143
adhesiveAsymmetry [mm]	-0.003
loCoolingFacing a [mrad]	0.026
b [mrad]	0.153
loCoolingFacingConcavity [mm]	-0.004