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The First Three TILECAL Submodule Assembly in Prague

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Abstract

Three submodules for module 0 of ATLAS TILECAL hadronic calorimeter were assembled in Prague in 12. - 27. February 96. Iron plates degreasing and cleaning is described. Two methods for glueing were tested, the method using templates for glue deposit was found better. The results of measurement of submodule heights after dry stacking, glueing and welding are presented.

1 Iron Plates Measurement

For the construction of the three submodules 98 master plates, stamped at ANL Chicago, and 12×50 spacers, laser cut and polished at JINR Dubna, were delivered to Prague. We have measured plate thickness in 13 points for masters and in 6 points for spacers, as illustrated in Fig. 1, after mechanical removal of the oil film from the plate surface. For the measurement we have used simultaneously two micrometers MITUTOYO connected on line to PC.

The mean value of thickness distribution

$$T_m^P = 4.97 \pm 0.03\,\mathrm{mm}$$

of the master plates is in good agreement with measurement done at ANL [1]

$$T_m^A = 4.959 \pm 0.026\,\mathrm{mm}.$$

The mean thickness of the spacers

$$T_s^P = 4.115 \pm 0.025\,\mathrm{mm}$$

is in accord with specifications for the steel thickness produced at Kraluv Dvur [2], [3], [4]. Thickness of individual spacers are in Tab. 1.

2 Dry Stacking

Three submodules PRAG 1, PRAG 2 and PRAG 3, were stacked. Masters and spacers with extremal thickness were used for the submodule PRAG 1, i.e. thick masters were combined with thin spacers and vice versa, whereas the two remaining submodules were stacked from randomly chosen plates. All three submodules were stacked without glue and measured in points 1 - 14 (Fig. 2) and submodule PRAG 2 also for various compression moments of force of stacking bolts 40, 100, 150 Nm. The compression moment 100 Nm was chosen for dry stacking.

Heights of all three submodules of dry stacks are in Tab. 5. The mean measured value H of height of all submodules is

$$H = 290.74\,\mathrm{mm}.$$

The results of plates thickness measurement can be used for a prediction of dry stack height. The mean height h calculated from measured values for dry stacking of the three submodules is :

$$h = 32 \times (T_m^P + T_s^P) = 290.72\,\mathrm{mm},$$

which is in good agreement with the experimentally measured value. The estimated necessary thickness of glue for target final submodule height of 293.20 mm for submodule PRAG 1, PRAG 2 and PRAG 3 was

$$(293.20 - 290.74)\,\text{mm} \;/\; 63\,\text{layers} \;=\; 37\,\mu\text{m},$$

39 μm and 41 μm, respectively.

3 Plates Cleaning

The cleaning procedure consisted of the following steps :

1. Manual cleaning with detergent COLON and abrasive sponge.
2. Rinsing in the cold water.
3. Immersion in the solution of APC (All Purpose Cleaner) and demineralized water 1:12, at temperature 38°C for 5 - 10 min.
4. Last immersion in ethyl-alcohol and demineralized water 1:4, at room temperature 20°C.
5. Removal of liquid drops from surface with a rubber wiper.
6. Drying with compressed cold air.

Detergents COLON and APC are common cleaners easily available in shops. Masters were washed piece by piece. For spacers two special frames (11 spacers/frame) were constructed, as illustrated in Fig. 3. The frames were used for immersion, drying and the glue application procedures. The spacers were simply inserted into the frame using the trapezoidal shape. The spacer no. 6 was treated separately.

4 Submodule Glueing

The submodules were glued in order PRAG 3, PRAG 1 and PRAG 2. We tested and used two different technologies for submodule glueing. In both cases we have used the same frames, as for plates cleaning, that allowed us to compose in each frame spacers for the whole period. The glue type Araldite AW 106 with Hardener HV 953U was applied equally on both sides of spacers, by flipping the whole frame.

a) Specially designed mechanical device called Valine and plastic card for glue wiping were used for submodule PRAG 3.

Valine is a vessel of triangular cross-section on 2 rollers, movement of which defines the speed of volume shrinking. The volume of the vessel fully filled with glue was 680 cm^3. The glue was applied on the spacers in the frame in continuous lines separated by 10 mm gaps, by rolling the valine over the frame filled with spacers.

b) Use of special templates for submodules PRAG 1 and PRAG 2.
Three brass templates of thickness 0.2 mm, with holes diameter 6.7 mm and the distance of hole centers 15 mm were used for the glue application. The templates covered the spacers in the special frame and the glue was applied with plastic wiper over the templates (Fig. 4). After templates removal the glue stayed in regular droplets. The glue was very well distributed and the amount of the glue was 7.8 10^{-3} g/drop and approximately 500 g of glue/submodule.

After glueing the templates were cleaned by xylene, while Valine vessel was thrown away. The glue was applied by the two methods in different geometrical patterns. The reproducibility of the amount of glue supplied on spacer no. 2 was found 1.00 ± 0.05 g, during glue tests using both methods.
The method b) was found to be very low-cost solution. The templates made out of brass plates are robust. The glue application was done by one technician and the glue was always applied faster than the stacking of one period. Possible scheme to reduce manpower is to use more templates and apply glue to several periods in one time. Than the technician(s) can help with the stacking.
Advantages (+) and drawbacks (−) of tested methods:

a)
- + Faster applications.
- + Adjustable dose of the glue.
- − Constant viscosity is very critical. The glue starts to polymerize after 30 min. When viscosity is changed, the method is not applicable any more.
- − The trapezoidal geometry of spacers and masters is not very well suited for application of equidistant lines.

b)
- + Ideal geometry pattern is achievable (Fig. 5).
- + Simple application.
- − As the thickness of the templates and its geometry is fixed, the glue amount applied can not be varied easily.

5 Welding

Next day after glueing, the submodules were welded using the tungsten electrode with setting of 90 − 120 Amperes in Argon protection atmosphere at gas flow

10 l/min. The welding wire diameters were 2.4 mm for the narrow and 3.1 mm for the wide side of the submodule respectively. The welding interrupts were always kept as large as possible (more than 30 min) to avoid shrinking of the submodule. The position of height measurement points of the submodules after welding is shown in Fig. 2.

6 Conclusions

The heights measurements after the final welding of the submodules PRAG 1, PRAG 2 and PRAG 3 are summarised in Tab. 6 and Fig. 6. The mean value over all three submodules is 293.16 ± 0.08 mm, which is in a good agreement with the target value 293.20 mm. All three PRAG submodules were used for the construction of the Module 0.

References

[1] *Experience with Stacking the First Four ATLAS Submodules at Argonne*, ANL-HEP-TR-96-14, 1996

[2] *ATLAS Internal Note*, TILECAL-NO-028, CERN, 1994

[3] *ATLAS Internal Note*, TILECAL-NO-030, CERN, 1994

[4] *ATLAS Internal Note*, TILECAL-NO-51, CERN, 1995

Spacer no.	Mean [mm]	RMS [mm]
1	4.114	0.024
2	4.117	0.019
3	4.114	0.023
4	4.116	0.020
5	4.114	0.023
6	4.117	0.029
7	4.140	0.019
8	4.112	0.018
9	4.120	0.013
10	4.103	0.026
11	4.102	0.022
12	4.114	0.024
average	4.115	0.025

Table 1: Thickness of the spacers.

Position	PRAG 1	PRAG 2	PRAG 3	Position
1	290.72	291.06	290.86	1
2	290.22	290.60	290.16	2
3	290.37	290.48	290.22	3
4	290.50	290.44	290.19	4
5	290.56	290.52	290.18	5
6	290.58	290.48	290.40	6
7	*290.80*	*290.78*	*290.77*	*7*
8	*291.20*	*290.98*	*291.03*	*8*
9	291.20	290.90	290.89	9
10	291.13	290.83	290.72	10
11	291.14	290.72	290.65	11
12	291.15	290.72	290.66	12
13	291.18	290.79	290.73	13
14	291.32	291.16	291.06	14
average	290.86	290.75	290.61	average

Table 2: Submodules heights measured of dry stack for moment 100 Nm. The small flags are at the points *7* and *8*.

Position	PRAG 1	PRAG 2	PRAG 3	Position
1	290.72	291.06	290.86	1
2	290.22	290.60	290.16	2
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7	*290.80*	*290.78*	*290.77*	*7*
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9	291.20	290.90	290.89	9
10	291.13	290.83	290.72	10
11	291.14	290.72	290.65	11
12	291.15	290.72	290.66	12
13	291.18	290.79	290.73	13
14	291.32	291.16	291.06	14
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Table 3: Submodules heights measured of dry stack for moment 100 Nm. The small flags are at the points *7* and *8*.

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5	290.56	290.52	290.18	5
6	290.58	290.48	290.40	6
7	*290.80*	*290.78*	*290.77*	*7*
8	*291.20*	*290.98*	*291.03*	*8*
9	291.20	290.90	290.89	9
10	291.13	290.83	290.72	10
11	291.14	290.72	290.65	11
12	291.15	290.72	290.66	12
13	291.18	290.79	290.73	13
14	291.32	291.16	291.06	14
average	290.86	290.75	290.61	average

Table 4: Submodules heights measured of dry stack for moment 100 Nm. The small flags are at the points *7* and *8*.

Position	PRAG 1	PRAG 2	PRAG 3	Position
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2	290.22	290.60	290.16	2
3	290.37	290.48	290.22	3
4	290.50	290.44	290.19	4
5	290.56	290.52	290.18	5
6	290.58	290.48	290.40	6
7	*290.80*	*290.78*	*290.77*	*7*
8	*291.20*	*290.98*	*291.03*	*8*
9	291.20	290.90	290.89	9
10	291.13	290.83	290.72	10
11	291.14	290.72	290.65	11
12	291.15	290.72	290.66	12
13	291.18	290.79	290.73	13
14	291.32	291.16	291.06	14
average	290.86	290.75	290.61	average

Table 5: Submodules heights measured of dry stack for moment 100 Nm. The small flags are at the points *7* and *8*.

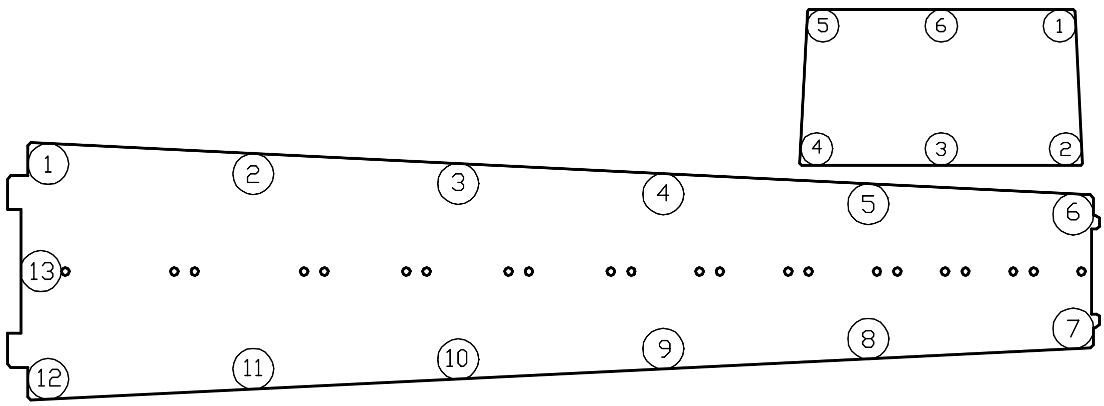

Figure 1: Master and spacer thickness measurement points.

Position	PRAG 1		PRAG 2		PRAG 3		Position
	a	b	a	b	a	b	
1	293.01	293.05	293.19	293.10	293.13	293.18	1
2	293.15	293.22	293.20	293.22	293.15	293.21	2
3	293.15	293.23	293.24	293.26	293.22	293.25	3
4	293.22	293.22	293.29	293.26	293.22	293.25	4
5	293.15	293.14	293.29	293.29	293.14	293.22	5
6	293.16	293.10	293.27	293.18	293.18	293.20	6
7	*293.00*	*293.07*	*293.28*	*292.90*	*293.16*	*292.70*	*7*
8	*292.95*	*292.79*	*293.15*	*292.91*	*293.06*	*292.47*	*8*
9	293.13	293.03	293.15	293.10	293.18	293.18	9
10	293.13	293.05	293.18	293.14	293.05	293.08	10
11	293.22	293.20	293.20	293.20	293.15	293.16	11
12	293.20	293.20	293.17	293.18	293.22	293.28	12
13	293.22	293.22	293.19	293.22	293.18	293.28	13
14	293.13	293.11	293.10	293.11	293.08	293.18	14
15	293.11	293.08	293.16	293.13	293.13	293.20	15
16	293.15	293.19	293.05	293.03	293.20	293.28	16
17	293.16	293.17	293.19	293.17	293.19	293.21	17
18	293.14	293.14	293.15	293.14	293.18	293.21	18
19	293.00	293.00	293.03	293.03	293.04	293.08	19
20	293.04	293.00	293.17	293.06	293.06	293.14	20
average	293.12	293.11	293.18	293.13	293.15	293.14	average
max + error	+ 0.02	+ 0.03	+ 0.09	+ 0.09	+ 0.03	+ 0.08	max + error
max − error	− 0.25	− 0.41	− 0.17	− 0.30	− 0.16	− 0.73	max − error

Table 6: Submodules heights measured in 20 points. Column a) corresponds to values measured just after the top plate release, column b) contains values measured after final welding. The maximum positive and negative errors are taken with respect to the target value 293.20 mm.

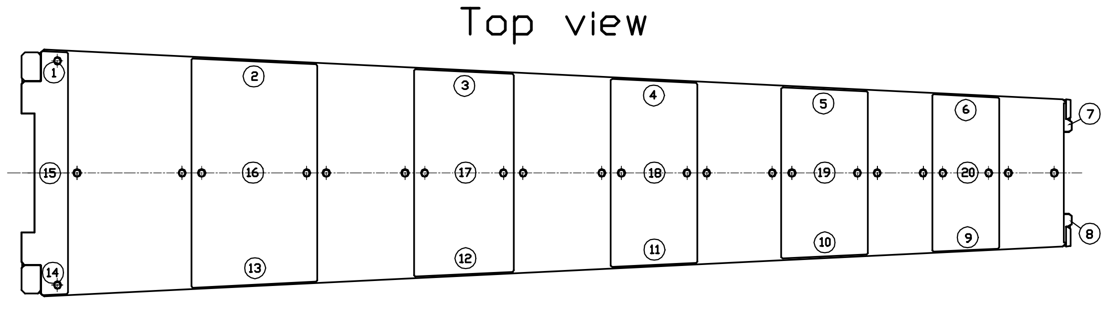

Figure 2: Position of points, where the heights were measured.

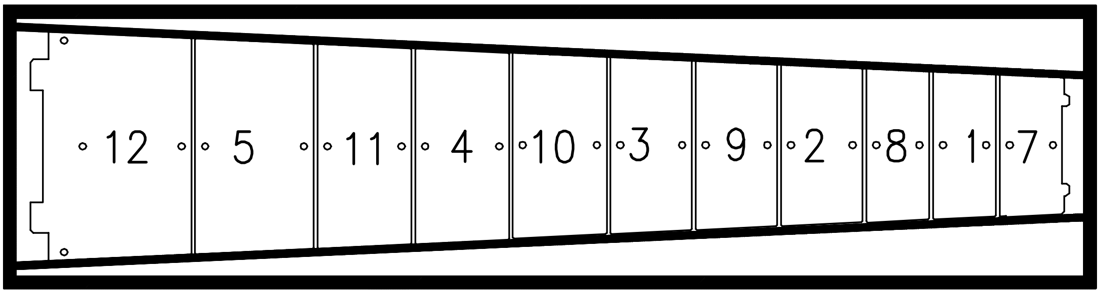

Figure 3: The special frame for treatment of 11 spacers. Spacer no. 6 was treated separately.

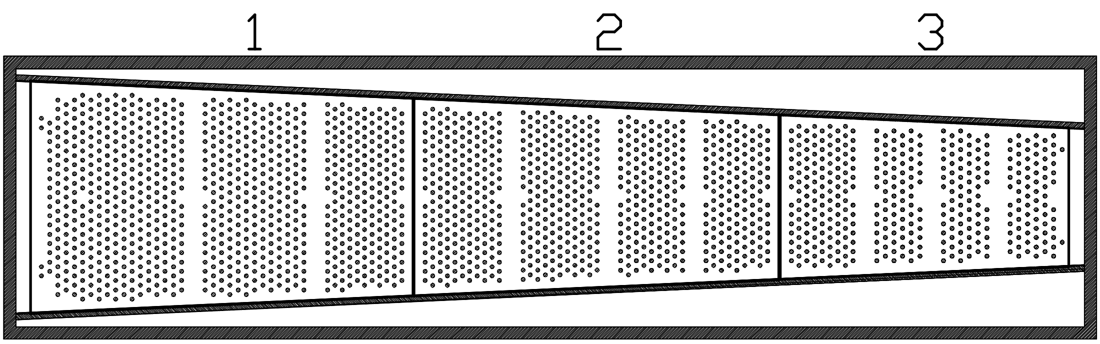

Figure 4: Three templates with hole pattern.

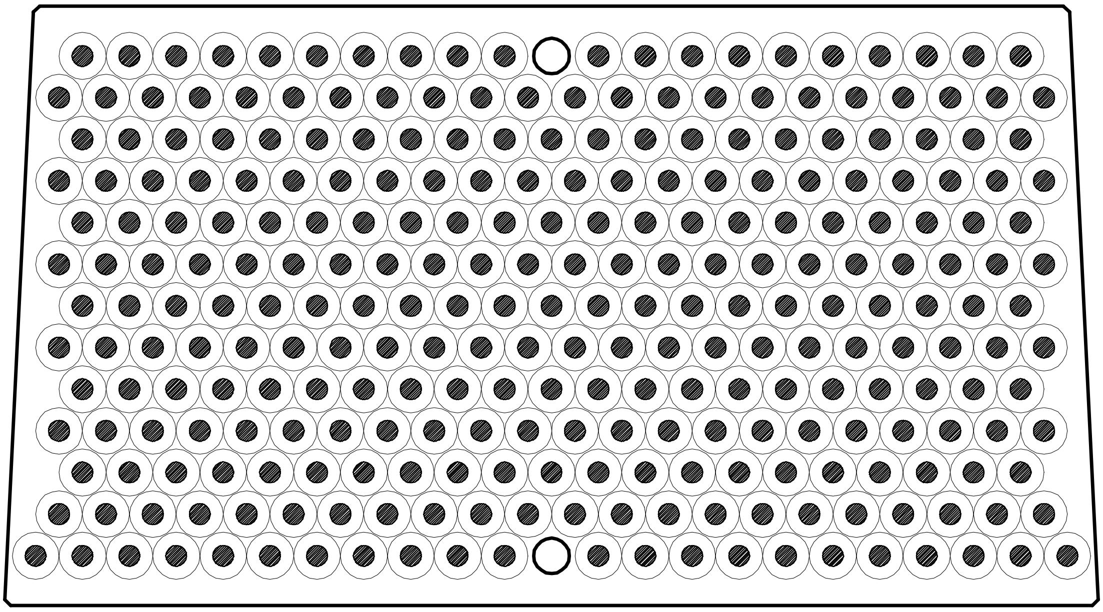

Figure 5: Glue application on the spacer no. 5. The black spots correspond to template holes (the places where the glue is applied), height of each glue drop is 200 μm. The thin open circles indicates the area which the glue possessed after the pressing procedure (calculated for medium glue layer thickness of 40 μm). Finally the glue covered from 75 % to almost 100 % of the total spacer area for glue layer thickness 40 μm and 30 μm respectively. The two bold open circles indicate the fixing holes in the spacer.

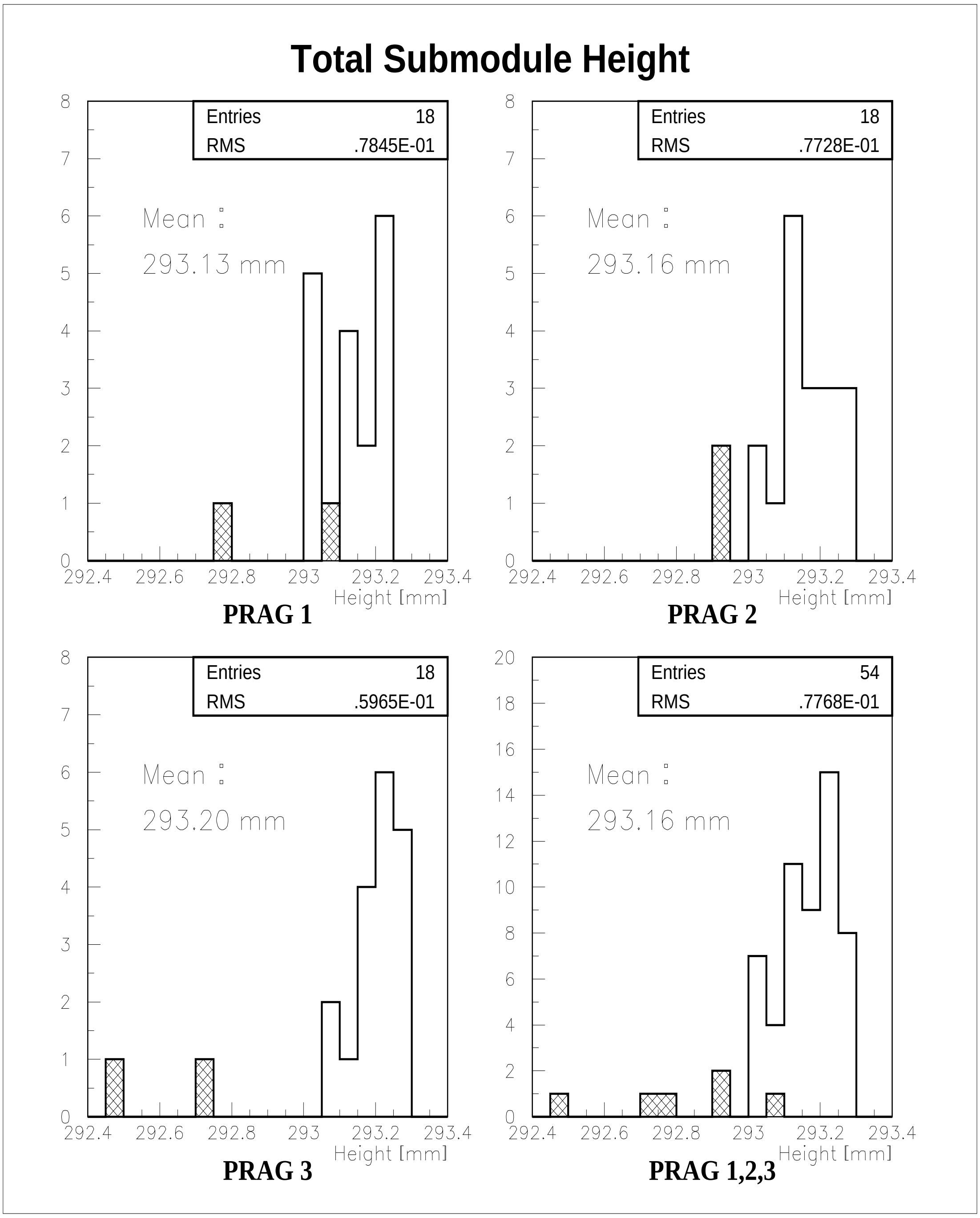

Figure 6: Submodules heights after final welding. The heights measured in the small flag points (hatched area) were not including in the plot statistics, unlike the values in Tab. 6.