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Systematic Measurements of tilecal module 0 Grooves Width

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Abstract

Measurements of the grooves width in the non instrumented with optic part of the module 0 were done. The measurements were made along a line corresponding to the center of tile # 7. Tests were made in submodules built by 6 institutes. The mean value for all measurements was 4.21±0.23mm, a value close to the nominal value of the profiles width, 4.25±0.05mm, but with a large RMS. The mean value for measurements on scintillator plates region was 4.10±0.24mm and for measurements on spacer plates region was 4.31±0.17mm. The smallest mean value for the grooves width in one submodule on scintillator tiles region was 4.00±0.14mm and the biggest one was 4.24±0.35mm.

A detailed measurement of the grooves width for a submodule construted at CERN in 1996 was also done. On the scintillator tiles region, a mean value of 4.20±0.13mm was found. On the spacer plates region, the mean value was 4.34±0.12mm.

The master plates present some ondulation: the gaps on scintillator tiles region present almost always a concave shape and the gaps on spacer plates region almost always a convex shape.

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1 Introduction

The module constructed in 1996 is made of 19 submodules all of the same size except one. Each submodule is formed by layers of master plates, that are large trapezoidal steel plates, alternating with layers of spacer plates and scintillator tiles. The spacer plates and the scintillator tiles alternate along the lines of the submodule. Each line is formed by 11 different sizes of plates. See figure 1. Each scintillator tile is read out on the two sides by optical fibres.

To allow the optical coupling between the fibre and the tile, profiles made of high impact white polystyrene (HIPS) doped with TiO_2 to provide a good diffusor reflectivity have been designed and prototypes have been constructed. The elasticity of the plastic material allows an easy insertion of the profiles into the grooves of the submodules. See figure 2. The profiles box into the grooves of the module by a simple pressure action. The nominal value of the profiles width is 4.25 ± 0.05mm.

Each profile gives support to four fibers: the longest fiber read out only the 10cm closer to the inner face of the module, an other fiber read out the following 13cm, an other the following 15cm and the smallest one read out the last 19cm. The profiles have holes to allow the changing of the fibers position in contact with the tile to provide the longitudinal segmentation. There are profiles with two sizes: one for the sub-periods that begins with a tile with size # 1 and the other for sub-periods that begins with a tile with size # 2. The position of the holes allow to move the fiber that is in contact with the tile to inside the profile. Only one of the fibres in the profiles is in optical contact with the tile, collecting the light that is produced in the tile. To provide the maximal collection of light is necessary that the grooves width in the module is inside the limits 4.10 and 4.25mm. Inside these limits the greatest loss of light is 10% since only 90% of the scintillator tile is read. Below or above these limits the collection of light will be deficient because the contact area can be smaller or the coupling between the fiber and the tile can not be adquated, respectively.

2 The measurements

In order to study the uniformity of the grooves size, measurements in the non instrumented with optic part of the barrel module were done. The measurements were made along a central line corresponding to the center of tile # 7. The 9 submodules measured were constructed by 6 different institutes (Argonne, Prague, Barcelona, Protvino, Dubna, Pisa).

A detailed measurement of the grooves width on scintillator tiles and on spacer plates regions in a submodule constructed at CERN in 1996 was also done. For this submodule two series of measurements were made. The measurements were done along lines (see fig. 1) beginning at 25mm from the inner face of the sub-

module. In the first serie, the space between two consecutive measurements was 5cm. In the second serie two lines (6 and 14) were chosen among the 31 measured and a more detailed measurement along each one of these two lines was done. The step between two consecutive measurements was 1cm.

As a consequence of the cutting method, the master plates have curved edges on one side, see figure 3. The measurements on the submodule built at CERN were done inside the grooves, on the flat region. Depending on the way the master plates are mounted, we can find grooves with two curved edges, grooves with only one curved edge and grooves with no curved edges. This is an additional uncerntainty factor on the grooves width.

3 Results

3.1 Measurements of the grooves width for 9 different submodules constructed by 6 institutes

A central measurement (tile # 7) of the grooves width for the 9 submodules of the non instrumented part of the module 0 was done.

The mean value for all measurements is 4.21mm with RMS=0.23mm, a value close to the nominal value of the profiles width, 4.25$\pm$0.05mm, but with a large RMS. The mean value for measurements on scintillator tiles region is 4.10$\pm$0.24mm and for measurements on spacer plates region is 4.31$\pm$0.17mm (see fig. 4 and table 1).

The submodule 8 (see table 1) present de smallest mean value for the grooves width on scintillator tiles region, 4.00$\pm$0.14mm, and the submodule 6 the largest one, 4.27$\pm$0.35mm.

The difference between the mean values on scintillator tiles and spacer plates regions is smaller for Barcelona submodule than for Prague submodule (0.05mm for Barcelona submodule and 0.14mm for Prague submodule), but the dispersion of the measurements on scintillator tiles region is bigger for Barcelona than for Prague (0.35mm for Barcelona and 0.14mm for Prague). The mean values for the other submodules are inside the two limits presented by those two submodules.

3.2 The detailed measurement of the grooves width for the submodule constructed at CERN

Two series of detailed measurements of the grooves width in scintillator tiles and spacer plates regions for a submodule constructed at CERN were made. In the first serie all submodule was measured. In the second serie a more detailed measurement of lines 6 and 14 was done.

In the first serie, the mean value for all measurements is 4.27mm with RMS=0.15mm. The mean value for measurements on scintillator tiles region is

smaller than the mean value for measurements on spacer plates region, 4.20mm with RMS=0.13 and 4.34mm with RMS=0.12mm, respectively (see fig. 5).

In 21.4% of the measurements done on scintillator tiles region, the width of grooves is below 4.10mm and in 30% of those measurements is above 4.25mm.

The mean value for the size of grooves changes from one line to the other line: the largest value is 4.52 ± 0.17mm for line 22; the smallest value is 4.14 ± 0.12mm for line 10 (see table 2).

Fig. 6 shows the oscillation on the grooves width along each line for the first 8 lines of the submodule. This means that the thickness of the master plates present an analogous undulation: they are not completely flat plates.

For each line the deviation on the mean value for the grooves width is larger at the center than at the ends of the submodule (see fig. 7).

The mean value increases from the first row to the last one on spacer plates region, approximately 2.4%, and decreases slightly, only 0.7%, on scintillator tiles region (see fig. 8 and table 3).

Table 2 shows that the mean value for the grooves width for lines 6 and 14 on scintillator tiles region is 4.11mm, below the mean value for all measurements on scintillator tiles region which is 4.20mm.

Table 4 shows that for line 6, there are 0.5% of difference between the first and the second series of measurements on scintillator tiles region gaps; there are 1.2% of difference between the first and the second series of measurements on spacer plates region. For line 14, there are 0.5% of difference between the first and the second series of measurements in scintillator tiles region gaps; there is no difference between the first and the second series of measurements for the mean value of the grooves width on spacer plates region. The results for the two series of measurements are compatible inside the RMS values.

Figures 9 and 10 show a clear separation between the grooves width on scintillator tiles and spacer plates region. The grooves on scintillator tiles region have almost always a concave shape while on spacer plates region have almost always a convex shape (see fig. 11).

3.3 Consequence for the profile dimensions

The dimensions of the profiles should cope with the grooves dimensions and tolerances (see fig. 2). Measurements on profiles in laboratory show a light loss of 10-15% when compared with the situation in which the fiber is surrounded by aluminized mylar in the coupling region. This is essentialy explained by the fact that only 90% of the scintillator tile is seen by the fiber. Preliminary results from the test beam show that when profiles are used there is a loss of about 20% of the light. 10% of this loss is most probably due to deficient mechanical contact. Further developments are in progress in order to get sharper corners, better mechanical coupling (more efficience in the light collection) while keep the reflectivity at the same level as it is now.

4 Summary

A central measurement of the grooves width on the 9 submodules (built by 6 institutes) of the non-instrumented with optic part of the module 0, showed a mean value for all measurements of 4.21$\pm$0.23mm, a value close to the nominal value of the profiles width (2.25$\pm$0.05) but with a large RMS. The mean value on scintillator tiles region is 4.10$\pm$0.24mm and on spacer plates region is 4.31$\pm$0.17mm.

The detailed measurement of the grooves width on a submodule constructed at CERN in 1996 showed a mean value of 4.20$\pm$0.13mm, on the scintillator tiles region. On the spacer plates region, the mean value was 4.34$\pm$0.12mm.

The master plates present some undulation: the grooves on scintillator tiles region have almost always a concave shape and on spacer plates region almost always a convex shape.

A total of 21.4% of the measured grooves on scintillator tiles region have a width below 4.10mm. In these grooves the loss in the light collection is larger than 10%. The 30% of measured points that have a width larger than 4.25mm require a supplementary fixation.

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Table 1: Measurements of the grooves width for 9 different submodules

	all measurements		only scintillator tiles		only spacer plates	
Submodules	MEAN	RMS	MEAN	RMS	MEAN	RMS
1	4.21	0.24	4.11	0.24	4.32	0.18
2	4.18	0.19	4.06	0.15	4.30	0.14
3	4.23	0.17	4.15	0.16	4.30	0.14
4	4.20	0.20	4.09	0.17	4.31	0.16
5	4.23	0.30	4.16	0.38	4.29	0.16
6	4.26	0.26	4.24	0.35	4.29	0.10
7	4.21	0.24	4.10	0.21	4.32	0.21
8	4.18	0.23	4.00	0.14	4.36	0.14
9	4.21	0.25	4.06	0.19	4.36	0.20
All measur.	4.21	0.23	4.10	0.24	4.32	0.17

Table 2: Mean value for the grooves width along each LINE

	all measurements		only scintilator tiles		only spacer plates	
# of line	MEAN VALUE	RMS	MEAN VALUE	RMS	MEAN VALUE	RMS
1	4.32	0.11	4.26	0.10	4.40	0.06
2	4.20	0.12	4.10	0.08	4.31	0.09
3	4.36	0.13	4.27	0.05	4.45	0.12
4	4.15	0.10	4.09	0.08	4.24	0.05
5	4.22	0.11	4.14	0.07	4.31	0.10
6	4.18	0.12	4.11	0.10	4.25	0.11
7	4.35	0.10	4.27	0.06	4.41	0.08
8	4.21	0.14	4.10	0.10	4.32	0.07
9	4.35	0.14	4.25	0.08	4.44	0.12
10	4.14	0.12	4.05	0.07	4.25	0.07
11	4.44	0.11	4.36	0.05	4.54	0.08
12	4.21	0.11	4.12	0.06	4.29	0.09
13	4.26	0.10	4.19	0.10	4.32	0.06
14	4.20	0.10	4.11	0.06	4.29	0.06
15	4.50	0.10	4.46	0.06	4.56	0.10
16	4.16	0.11	4.09	0.08	4.24	0.08
17	4.24	0.12	4.16	0.13	4.33	0.07
18	4.18	0.12	4.10	0.07	4.28	0.07
19	4.24	0.11	4.16	0.08	4.32	0.04
20	4.38	0.11	4.31	0.07	4.45	0.11
21	4.23	0.08	4.18	0.07	4.27	0.05
22	4.52	0.17	4.46	0.17	4.58	0.18
23	4.34	0.10	4.28	0.06	4.40	0.11
24	4.16	0.10	4.10	0.08	4.25	0.05
25	4.27	0.09	4.21	0.06	4.34	0.05
26	4.25	0.12	4.18	0.10	4.34	0.09
27	4.46	0.16	4.38	0.11	4.54	0.18
28	4.28	0.10	4.25	0.10	4.32	0.10
29	4.24	0.12	4.20	0.08	4.29	0.13
30	4.23	0.09	4.18	0.05	4.30	0.09
31	4.22	0.08	4.16	0.04	4.28	0.05

Table 3: Mean value for the grooves width along each ROW

	all measurements		only scintilator tiles		only spacer plates	
# of row	MEAN VALUE	RMS	MEAN VALUE	RMS	MEAN VALUE	RMS
1	4.09	0.12	4.09	0.12	-[1]	-
2	4.10	0.15	4.10	0.15	-	-
3	4.29	0.08	4.28	0.09	4.30	0.08
4	4.29	0.11	4.26	0.09	4.31	0.12
5	4.23	0.13	4.15	0.09	4.32	0.10
6	4.26	0.14	4.15	0.08	4.35	0.10
7	4.24	0.09	4.22	0.09	4.26	0.09
8	4.27	0.14	4.20	0.10	4.34	0.15
9	4.29	0.09	4.29	0.10	4.29	0.09
10	4.27	0.16	4.14	0.09	4.40	0.10
11	4.28	0.15	4.16	0.09	4.39	0.11
12	4.28	0.09	4.28	0.11	4.27	0.06
13	4.26	0.11	4.22	0.12	4.31	0.09
14	4.26	0.10	4.25	0.11	4.28	0.09
15	4.28	0.15	4.18	0.12	4.37	0.12
16	4.27	0.19	4.14	0.15	4.40	0.13
17	4.24	0.18	4.14	0.14	4.34	0.16
18	4.26	0.12	4.24	0.12	4.28	0.12
19	4.26	0.14	4.22	0.16	4.31	0.11
20	4.27	0.12	4.27	0.11	4.27	0.13
21	4.30	0.14	4.21	0.13	4.38	0.08
22	4.30	0.17	4.17	0.14	4.42	0.10
23	4.27	0.14	4.20	0.16	4.35	0.07
24	4.32	0.12	4.28	0.07	4.36	0.14
25	4.28	0.19	4.16	0.12	4.41	0.16
26	4.29	0.16	4.19	0.12	4.39	0.14
27	4.30	0.14	4.29	0.12	4.31	0.15
28	4.29	0.20	4.18	0.18	4.40	0.15
29	4.30	0.26	4.10	0.19	4.49	0.18
30	4.30	0.22	4.13	0.15	4.47	0.16
31	4.31	0.14	4.21	0.08	4.40	0.12
32	4.30	0.12	4.24	0.06	4.37	0.12

Table 4: Comparison between the first and second series of measurements

		all		scintillator tiles		spacer plates	
	measurements	MEAN	RMS	MEAN	RMS	MEAN	RMS
line 6	First	4.18	0.12	4.11	0.10	4.25	0.11
	Second	4.19	0.12	4.09	0.07	4.30	0.05
line 14	First	4.20	0.10	4.11	0.06	4.29	0.06
	Second	4.19	0.12	4.09	0.06	4.29	0.05

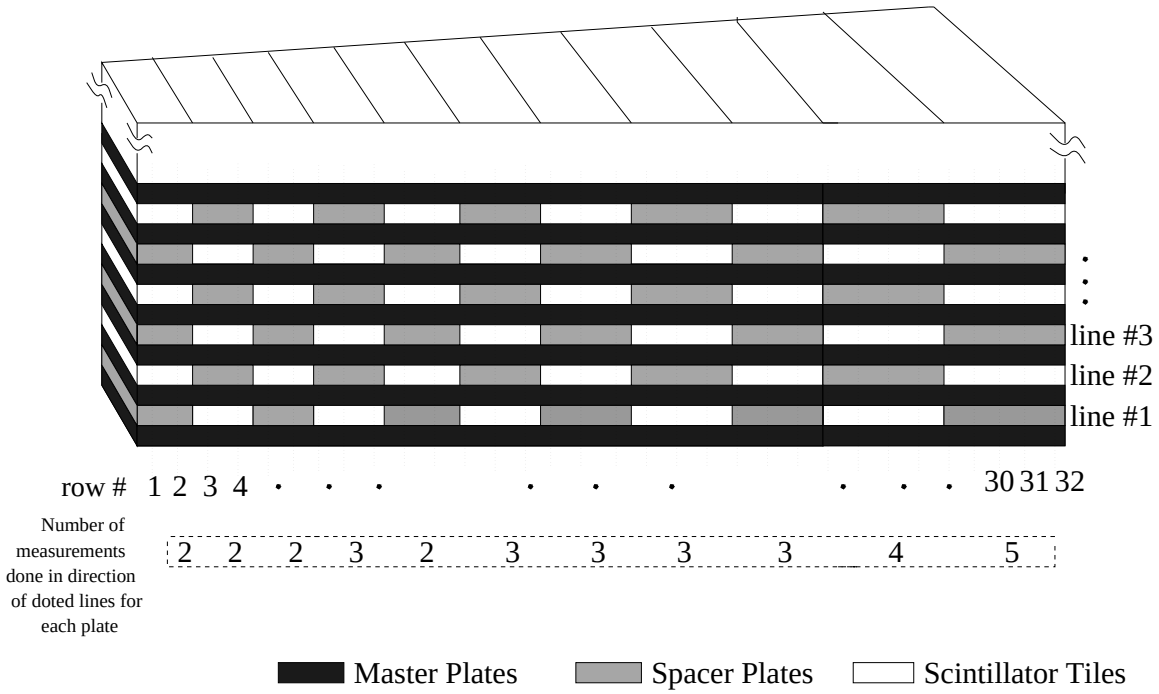

Figure 1: Tridimensional view of a submodule

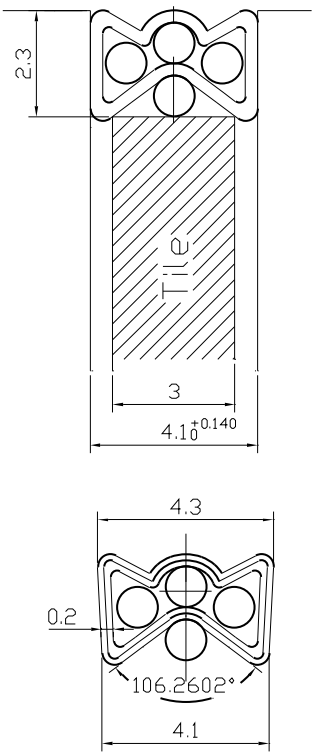

Figure 2: Boxing of the profiles into the grooves of the module.

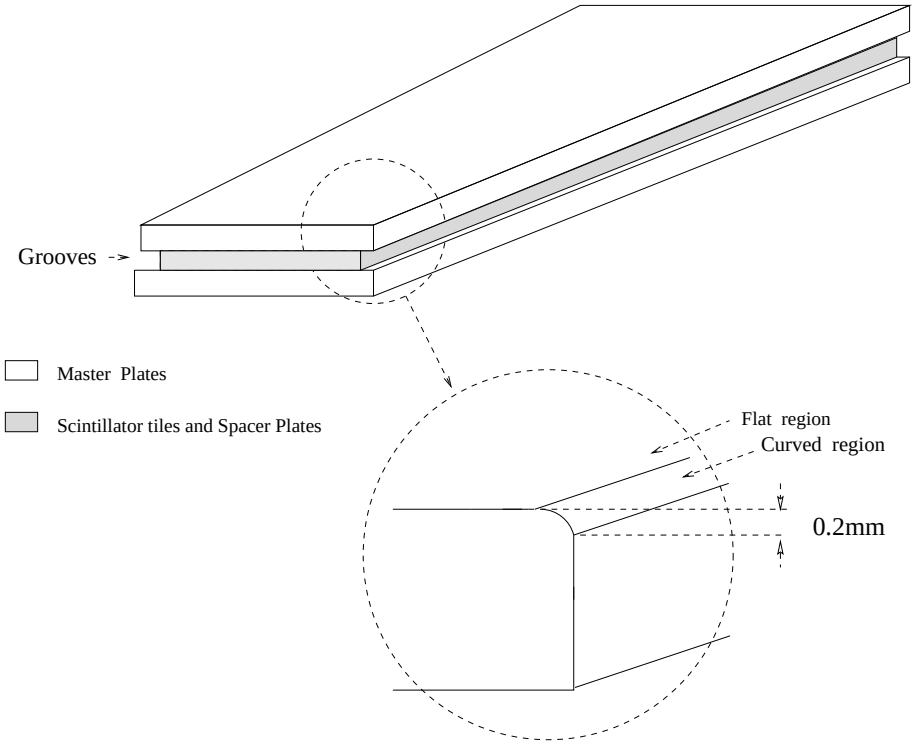

Figure 3: Simplified schematic view of the master plates curved edges

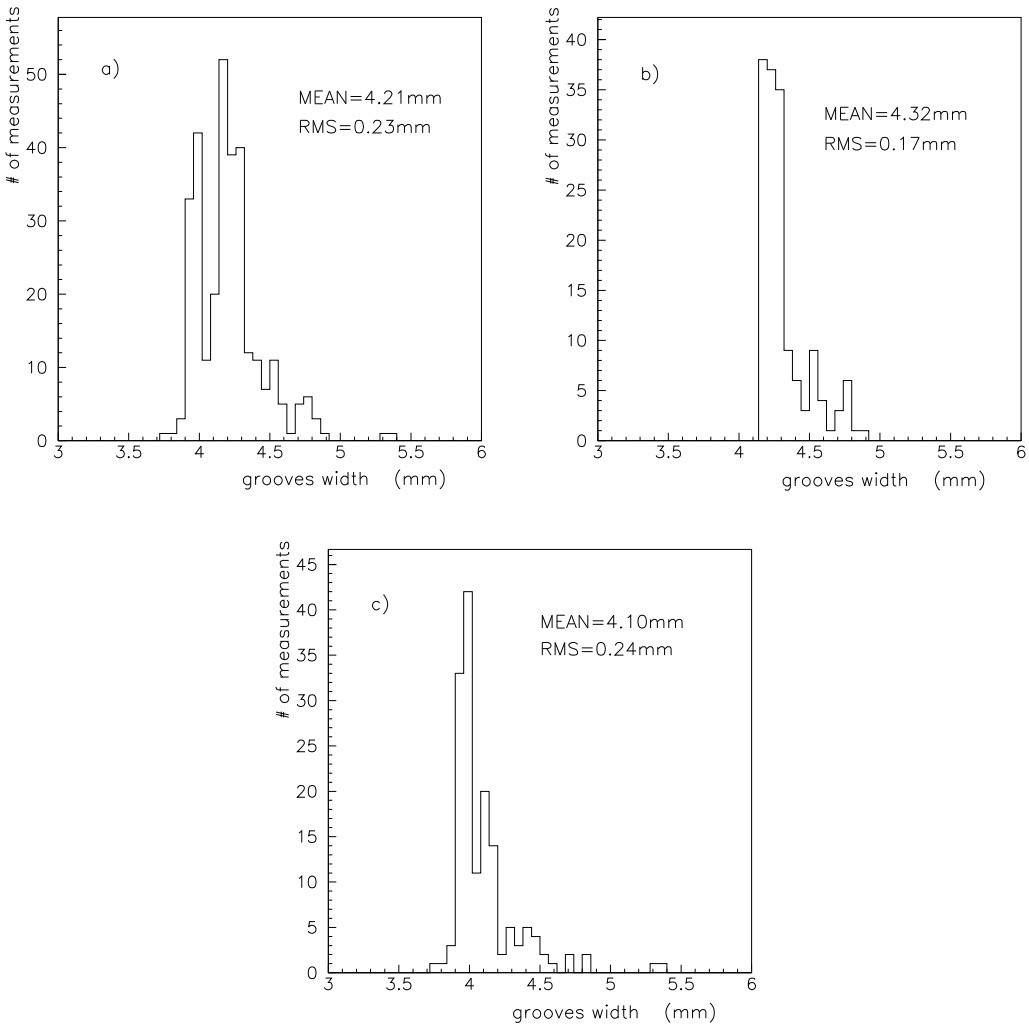

Figure 4: Grooves width in the non instrumented with optic part of the module 0. (a)All measurements; (b)Measurements on spacer plates region; (c)Measurements on scintillator tiles region

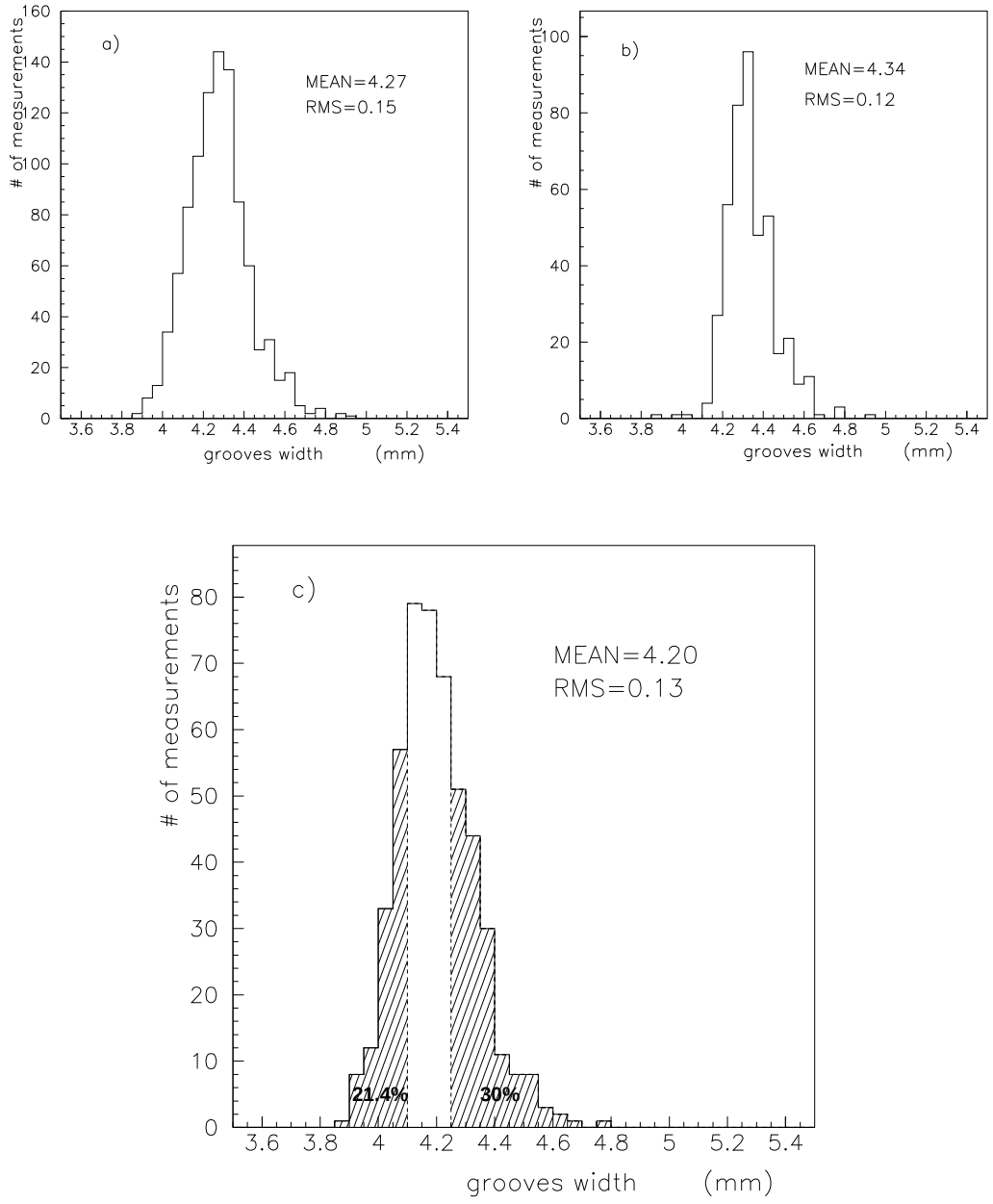

Figure 5: Spread in the grooves width versus number of measurements. (a) Include all measurements; (b) Include only the measurements of the grooves on spacer plates region; (c) Include only the measurements of the grooves on scintilator tiles region

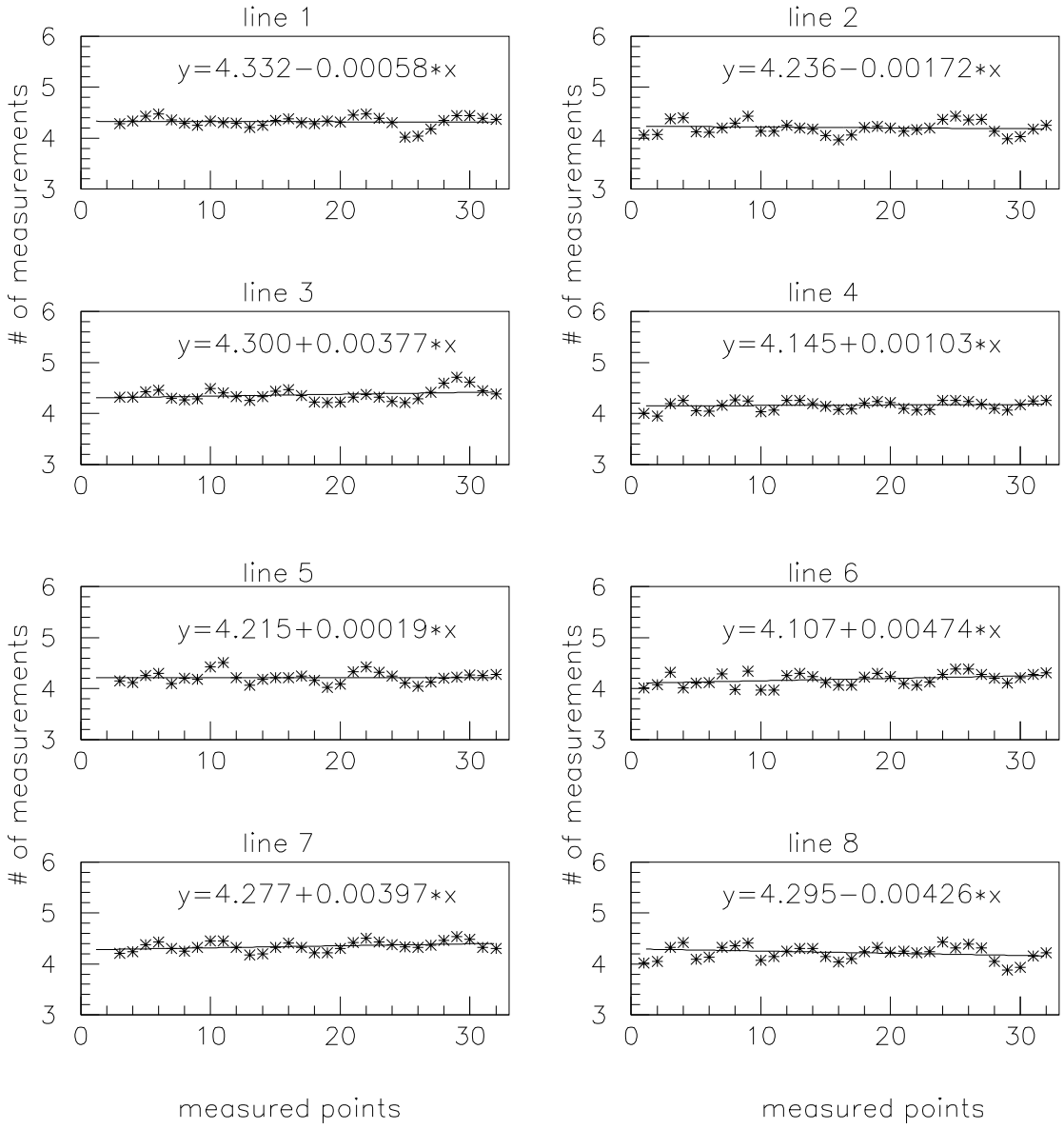

Figure 6: Grooves width versus measured point along each line: first 8 lines

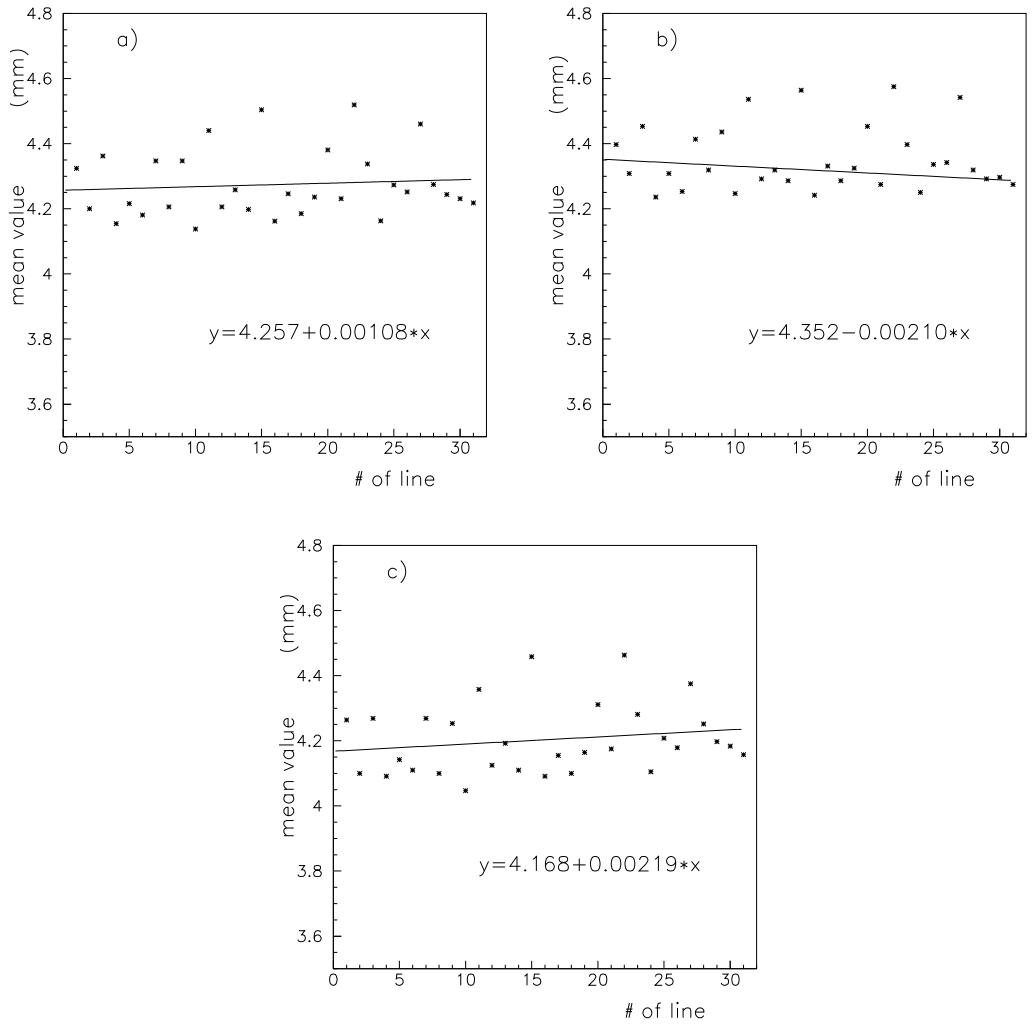

Figure 7: Mean value for the grooves width for each line. (a) Mean value for all measurements; (b) Mean value only for measurements on spacer plates region; (c) Mean value only for measurements on scintillator tiles region

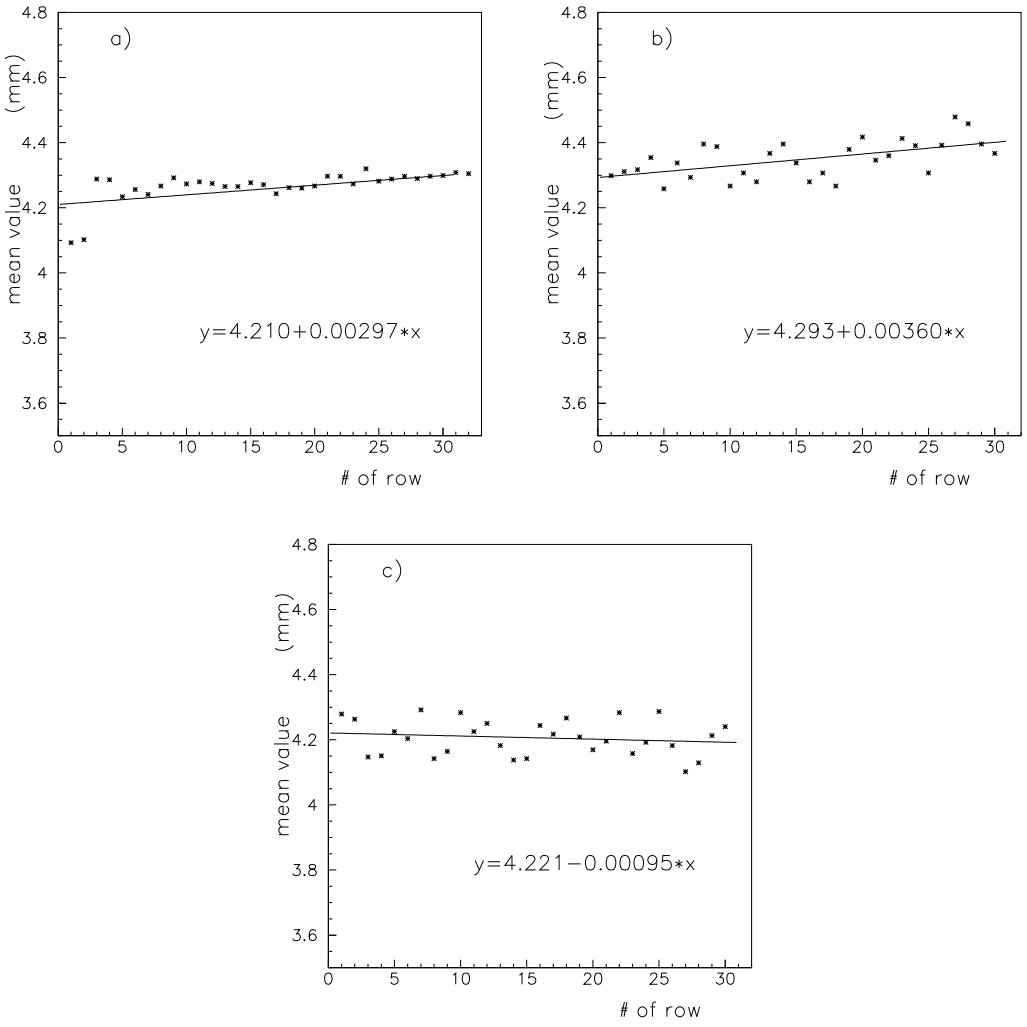

Figure 8: Mean value for the grooves width for each row. (a) Mean value for all measurements; (b) Mean value only for measurements on spacer plates region; (c) Mean value for measurements on scintillator tiles region

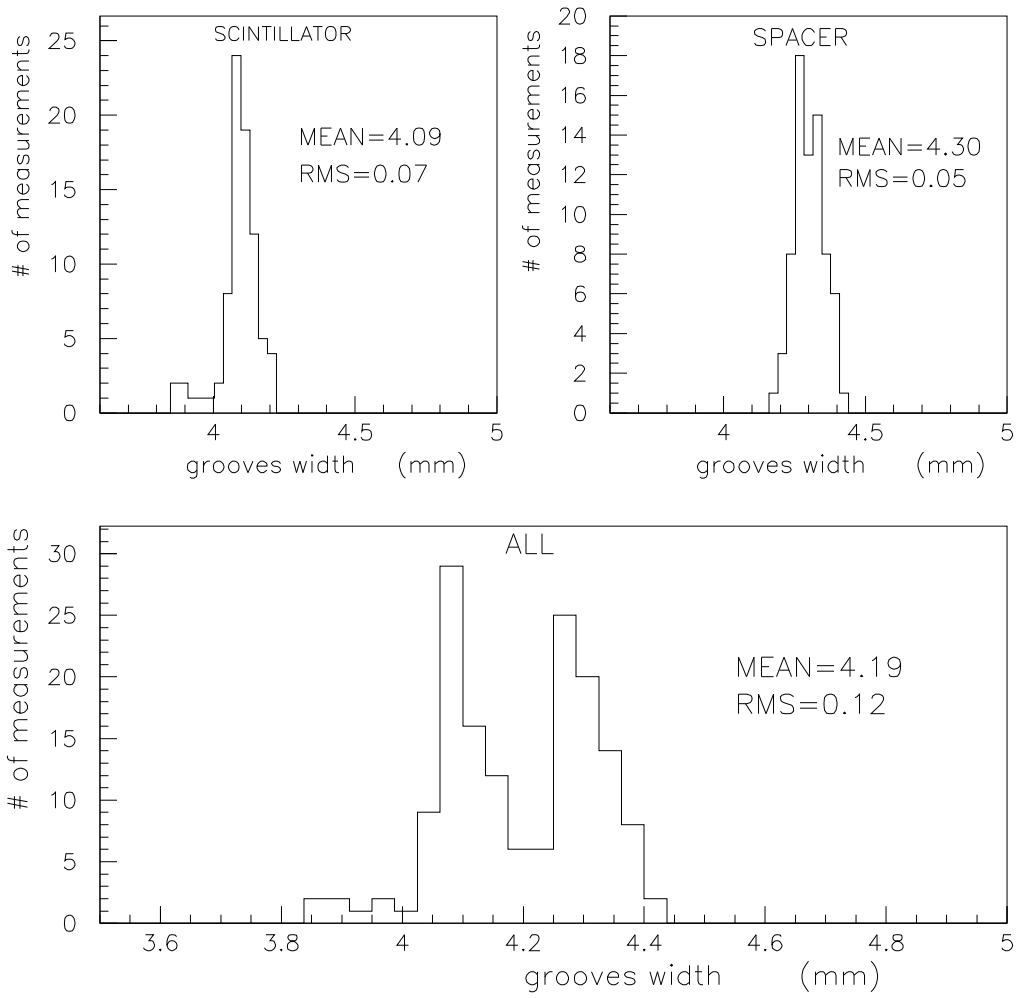

Figure 9: Detailed measurement of the grooves size for line 6. For all measurements; only for measurements on spacer plates region; and only for measurements on scintillator tiles region

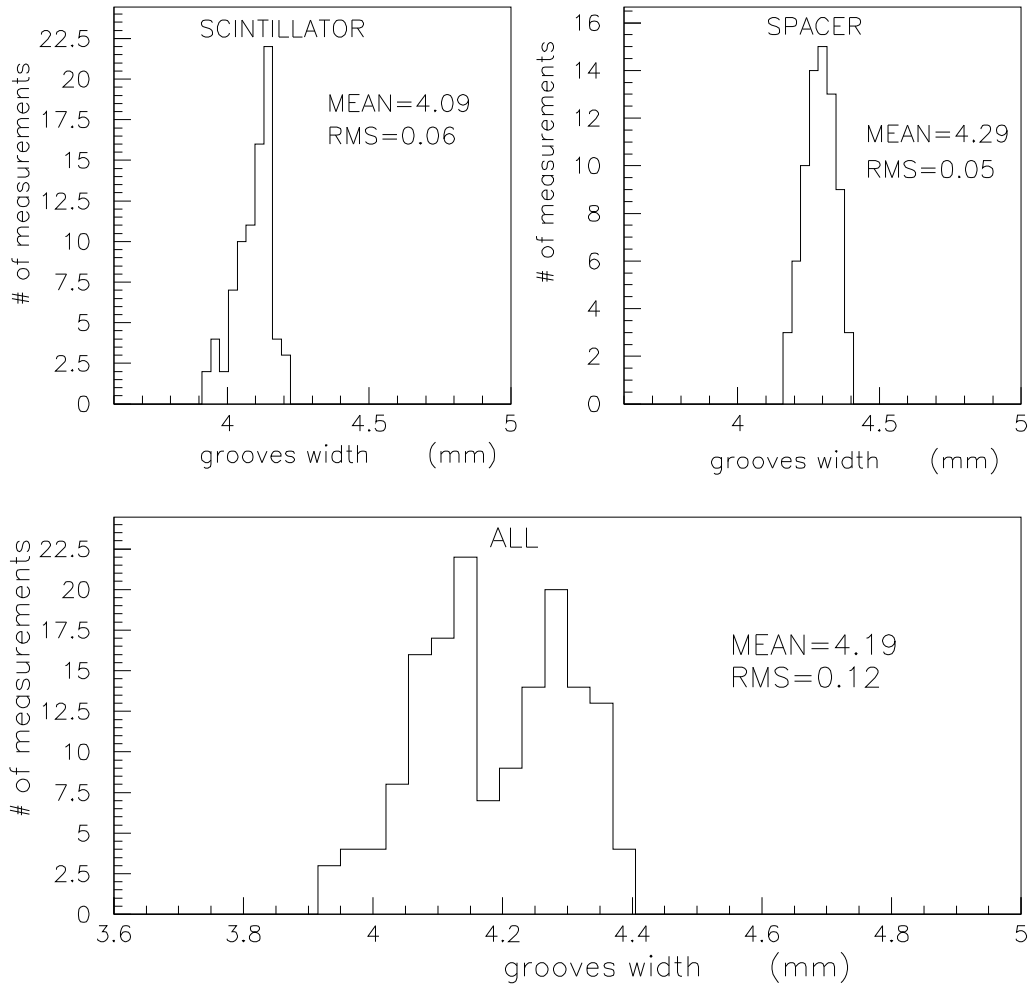

Figure 10: Detailed measurement of the grooves size for line 14. For all measurements; only for measurements on spacer plates region and only for measurements on scintillator tiles region

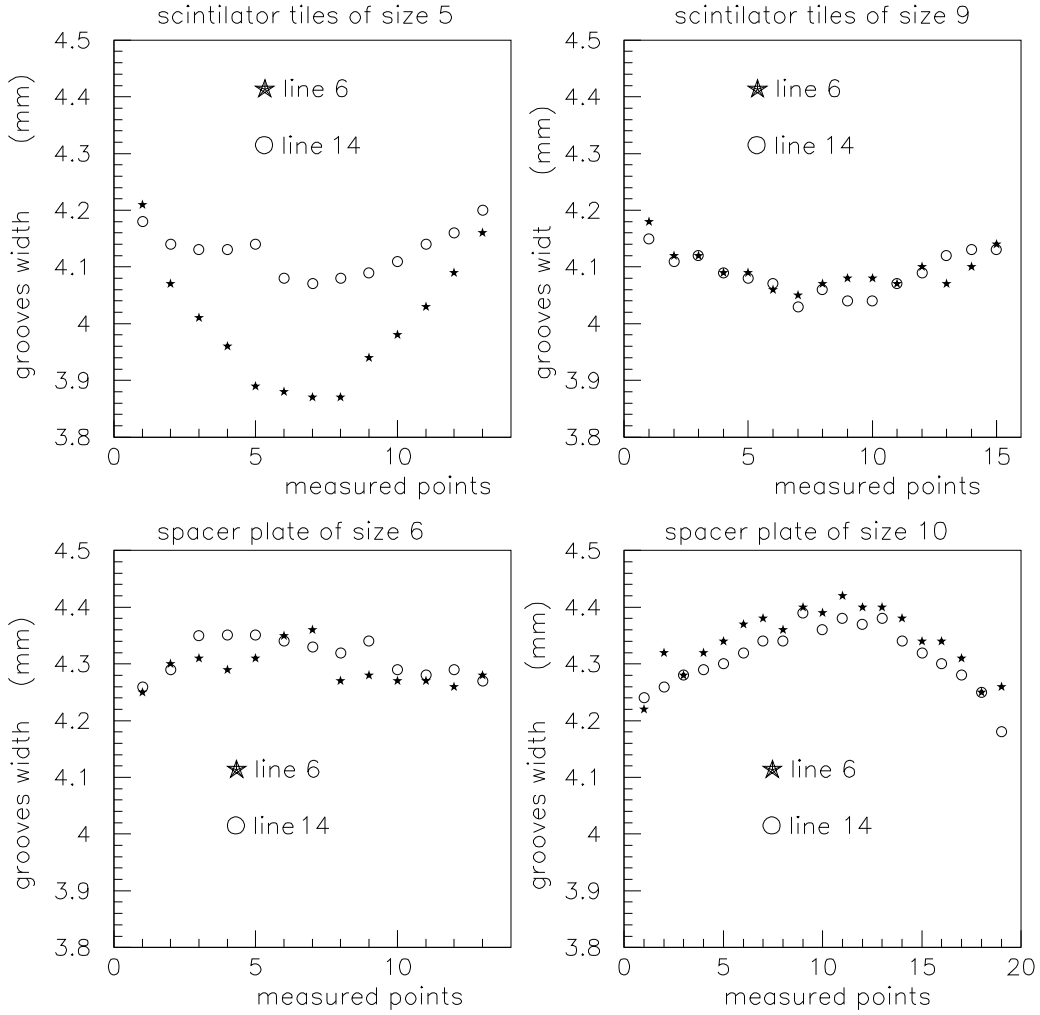

Figure 11: Measurement of the grooves size on plates regions of different sizes (5, 6, 9 and 10) for lines 6 and 14. The first two figures include measurements taken on two scintillator tiles regions, the last two include measurements taken on two spacer plates regions