ATLAS Internal Note
TILE-CAL-NO-124
October 1, 1997

Measurements of Some Optical Properties of the Tiles for the Extended Barrel Modules 0

M. Cobal[(1)], E. Mazzoni[(2)]

(1) CERN, Geneva, Switzerland , (2) University and INFN of Pisa, Italy

Abstract

We report on several measurements performed on the new scintillating tiles produced for the Extended Barrel Modules 0. We measured the light yield, the response uniformity, the attenuation length and the tiles thickness. The results are compared with those obtained with the old tiles used to equip the Barrel Module 0 in 1996. The performance of the new Tyvek sleeves were also examined.

1 Introduction

The equipment of the two extended Barrel Modules 0 with a new set of tiles has been completed recently. The new tiles, as the ones used for the Barrel Module 0 in 1996, were make by IHEP at Protvino. A sample of these new production scintillators, already wrapped with Tyvek, arrived at CERN. The Tyvek sleeves were produce by the Irrigro Company, in Ontario, and were also black-painted on the side where the Mylar had to be applied, in order to smooth the light yield near the edges.

At CERN, on the two lateral sides where the fibres have to be connected, a small piece of aluminized Mylar was put (fixed with adhesive tape in the two sides) to keep the fibres in place.

In addition, we tested a rectangular tile produced by Bicron using the injection molding technique. The tile is made of PolyVinylToluene (PVT). The claim is that the use of PVT as base plastic should lead to an intrinsic light yield 15-20% higher than the one obtained with tiles made of polystyrene (which is used for the tiles produced in Protvino). Table 1 lists the geometrical dimension of the tiles.

Tile nr.	length$_1$ (mm)	length$_2$ (mm)	Width (mm)	Area (cm^2)	Width/Area (cm^{-1})
1	221	231	97	219.2	0.04425
2	231	241	97	228.9	0.04327
3	241	251	97	238.6	0.04065
4	251	262	128	328.3	0.03899
5	262	274	128	343.0	0.03731
6	274	287	128	359.0	0.03565
7	287	301	147	432.2	0.03401
8	301	316	147	453.5	0.03241
9	316	331	147	475.6	0.03091
10	331	351	188	641.1	0.02933
11	351	367	188	674.9	0.02786
Bicron	202	202	152	307.0	0.04951

Table 1: *List of the geometrical dimensions of the 11 Protvino tile sizes used for the two Extended Barrel Module 0 equipment. The dimensions of the injection molded Bicron tile are also shown.*

2 Experimental Setup

The measurements were done using the setup shown in Figure 1. To excite the scintillating material of the tiles we used a ^{90}Sr β source (the black point

in Figure 1). Green WLS Y11 fibres of Kuraray, about 1 meter long with a diameter of 1 mm, and with one end mirrored, were inserted at the two sides of the tile, into the Mylar guides. The non-mirrored end was sent to a photomultiplier (PM). The PM cathodic current was then sent to a multimeter which measured the light yield in mV. All the system was light tight.

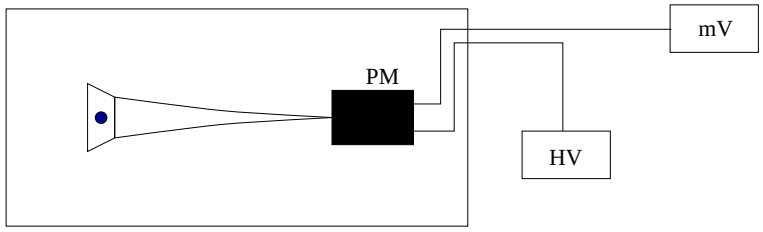

Figure 1: *Setup of the measurements.*

3 Effect of Tyvek on light yield

Differently to the last year only the internal side of the tile envelopes were blackned, in the previous production the envelopes were dippened in the black paint so both sides were masked.

To give an idea of the different masking areas, we measured the small and large sides (side a and side b as shown in Figure 2) for one envelope of each

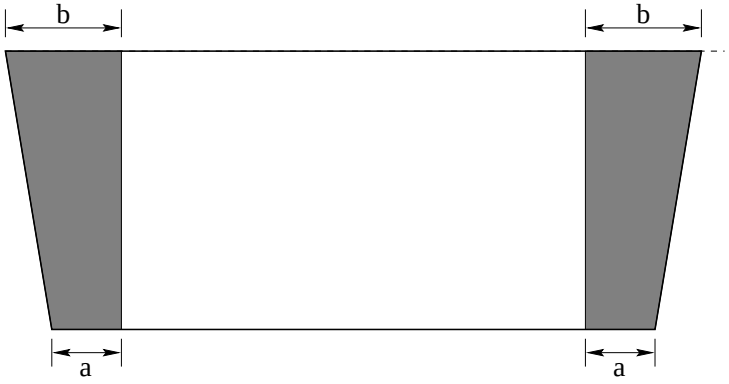

Figure 2: *Scheme of the tile masking.*

size of the old and new production. The results (in mm) are summarized in table 2. As a first step the performance of the new Tyvek envelopes was

Tile nr.	Mod0 max (mm)	Mod0 min (mm)	EB Mod0 max (mm)	EB Mod0 min (mm)
1	-	-	10	6
2	-	-	7	4
3	-	-	15	11
4	-	-	13	8
5	-		20	14
6	22	16	20	15
7	20	11	18	13
8	22	13	26	18
9	27	21	32	24
10	39	29	40	32
11	35	25	51	43

Table 2: *Dimensions of the masking for the 6 larger envelopes of the production for Module0 (first two columns) and for the 11 sizes of the production for the Extended Barrel Module0 (last two columns).*

measured. Tiles of the new production were excited with the source located in their centre. One tile for each size was first wrapped in the old sleeves and after in one of the new sleeves. The results are shown in Figure 3. It seems that in general for the old Tyvek a higher light yield was obtained. Differences are within 10%–15%. This result can be due to the masking, since the old small sleeves (from #1 to #5) were unmasked, and for the large sleeves (from #6 to #11) the new masking area is larger than the old one. Moreover the new masking looks darker than the old one.

4 Light Yield

The light yield was measured by exciting the tiles with the source in their centre. The results (average the measurements of 2-3 tiles at each size) are shown in Figure 4, where the light yield vs the ratio of the the width over the tile area is shown [1].

The results are compared with those relative to the 1996 production tiles, and show that the 1997 light yield is larger (despite of what previously seen for the new Tyvek envelopes). This can be a consequence of the increased tile thickness (see Section 5). In addition, the linear dependence on w/A

[1] We remind that this parametrisation, in the case of trapezoidal tile is equal to the half-sum of the trapezoidal bases

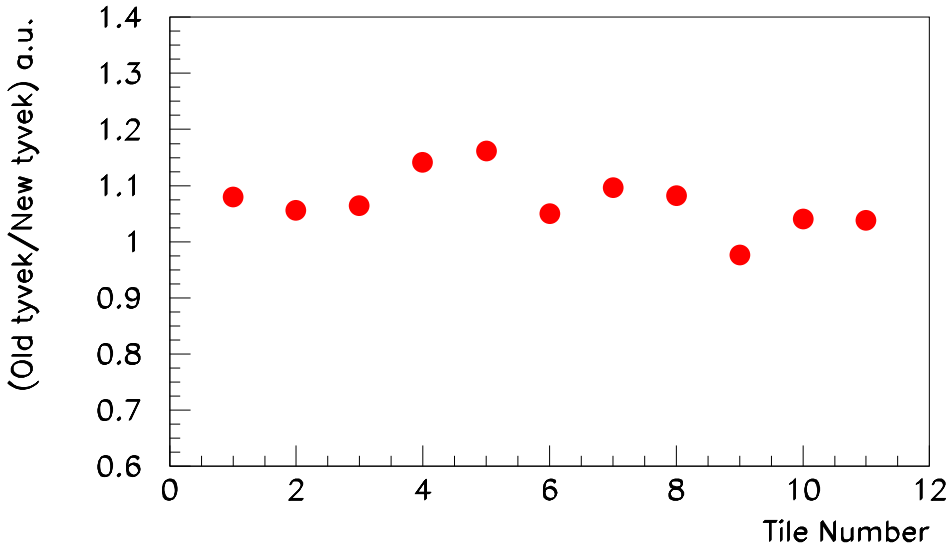

Figure 3: *Ratio of the light yield for the 11 new tiles wrapped with the old and the new Tyvek envelopes.*

in the 1996 production is replaced by a rater flatter dependence. The tiles we measured were chosen randomly from a batch of tiles, left over from the Extended Barrel Modules 0 assembly, Figure 4 shows also the light yield for the Bicron tile [2], which is lower than that obtained with our tiles.

5 Thickness

After removing the envelopes, the old and new tiles thickness was measured in 8 different points according to the scheme shown in Figure 5. The points are at a distance of about 2 cm from the tile sides. To perform these measurements we used a micrometer (with an accuracy of 0.01 mm).

Figures 6 and 7 show the thickness in mm for the old and new tiles. For

[2]The Bicron tile was inserted in one of the new envelope.

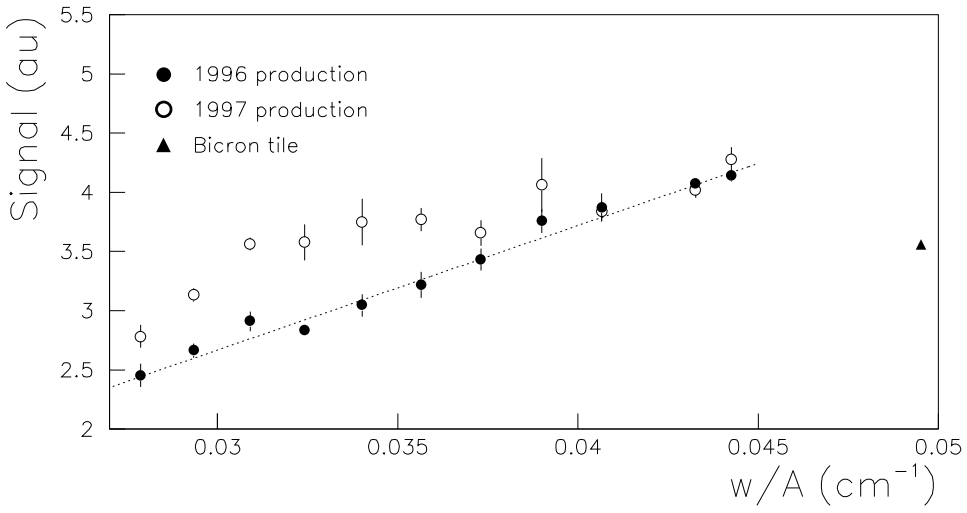

Figure 4: *Light yield as a function of the w/a dimension.*

each of the 11 sizes 4 different tiles have been measured, and the plot shows the mean value.

The same exercise was repeated for the Bicron tile, which is characterised by a larger thickness (around 4.9 mm) with respect to our standard tiles. The results are shown in Table 3. In this case the thickness is very uniform over the tile surface. Finally, Figure 8, 9 shows the ratio between new and old thicknesses for the Protvino tiles. From these data the following observations can be made:

- The 1997 tiles are thicker than the 1996 ones;
- This increase in thickness is different for different tile sizes: for the largest tiles (#9, #10 and #11) it is much larger then for the small tiles;
- For all the tiles, the axial region (points P5 and P7) shows the larger increase ($\simeq$ 10%); In particular, point P7 (in the injection side) is thicker than the rest of the tile;

Similar measurements have been recently performed in Barcelona [2] (on a larger sample of tiles), and confirm our results.

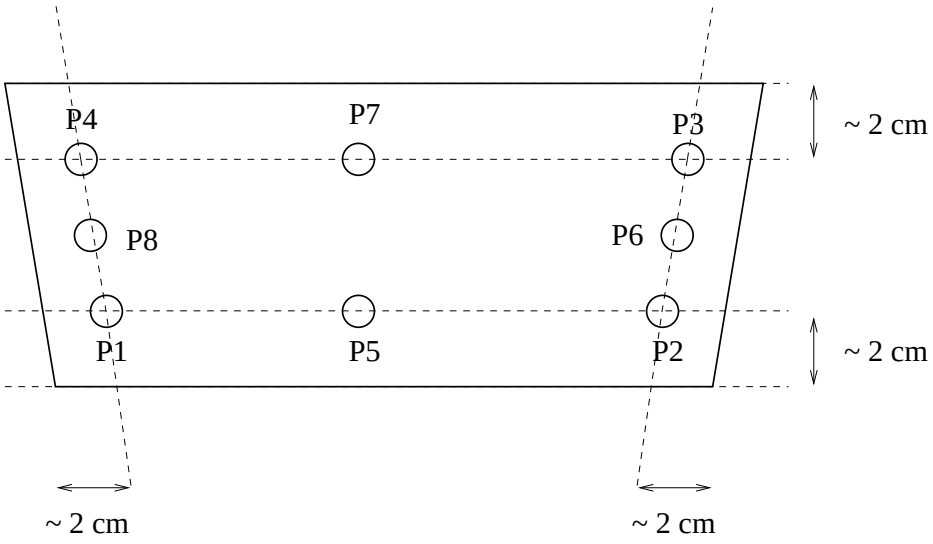

Figure 5: *Scheme of the 8 different points were the tiles thickness was measured.*

Figures 10 shows in more detail the profile along the long and short bases of the tile, where measurements have been taken every 2 cm.

6 Uniformity and attenuation length

We measured the light yield uniformity in the new tiles and the new Tyvek envelopes. Only one tile for each size was measured. The results are shown in Figure 11 and Figure 12. Table 4 summarizes the rms (%) obtained for the 11 tiles (new production) [3]

Point	Thickness(mm)
P1	4.87
P2	4.87
P3	4.91
P4	4.91
P5	4.87
P6	4.85
P7	4.89
P8	4.86

Table 3: *Thickness for the Bicron tile, measured in the 8 points.*

Tile	rms(%)
1	1.9
2	1.7
3	1.3
4	1.9
5	2.0
6	2.2
7	2.6
8	1.8
9	2.5
10	2.5
11	2.6

Table 4: *Rms from the uniformity study of the 11 tile sizes (new production).*

We also measured the Bicron tile which looks rather uniform (the rms is around 1.6%). For this tile the attenuation length was also measured (see Figure 13, lower plot). To make this measure, we read the tile with only one fibres, while blackening the other side. If the result is fitted with an exponential function, a value for the attenuation length equal to about 23 cm is obtained, compatible with the value measured for our tiles [3] [4]. We have repeated this exercise for the 1996 production tiles, in Figure 14 are reported the results for the smallest and the largest tiles.

7 Conclusions

The new tiles perform better than those of the previous (1996) production in terms of light yield, at least for the biggest tiles. A factor contributing to this improvement can be the larger thickness. For what concern the Tyvek sleeves, the measurements have been performed only on one set of 11 new and old envelopes, but the results indicate that the new sleeves worsen the light yield with respect to the old ones (most probably due to the new masking). The tiles uniformity is in the range 1.3-2.6%. From the geometrical point of view, the 1997 tiles present a rather pronounced non-uniformity in their thickness. This problem is particularly evident for the larger size tiles and caused some troubles during the tile insertion in the Extended Barrel Module0's [4].

[3]Note that the values reported here are higher than those presented by G. Grandes at the Tile general meeting, during the May 97 Atlas Week.

[4]J. Proudfoot, private communications

We also tested the performance of a Bicron tile produced by injection molding and using a different base. The light yield seems to be worse than that of the Protvino tiles, and the measured attenuation length is about 20 cm. For the light response and geometry, the Bicron tile is more uniform than ours.

References

[1] M. Cobal et al., ATLAS internal note, TILECAL-NO-081 (1996)

[2] S. Bravo, J. Ferrer, L. Miralles, IFAE internal note (1997)

[3] B. Di Girolamo, E. Mazzoni, ATLAS internal note, TILECAL-NO-065 (1995)

[4] A. Karyukhin et al., ATLAS internal note, TILECAL-NO-086 (1996)

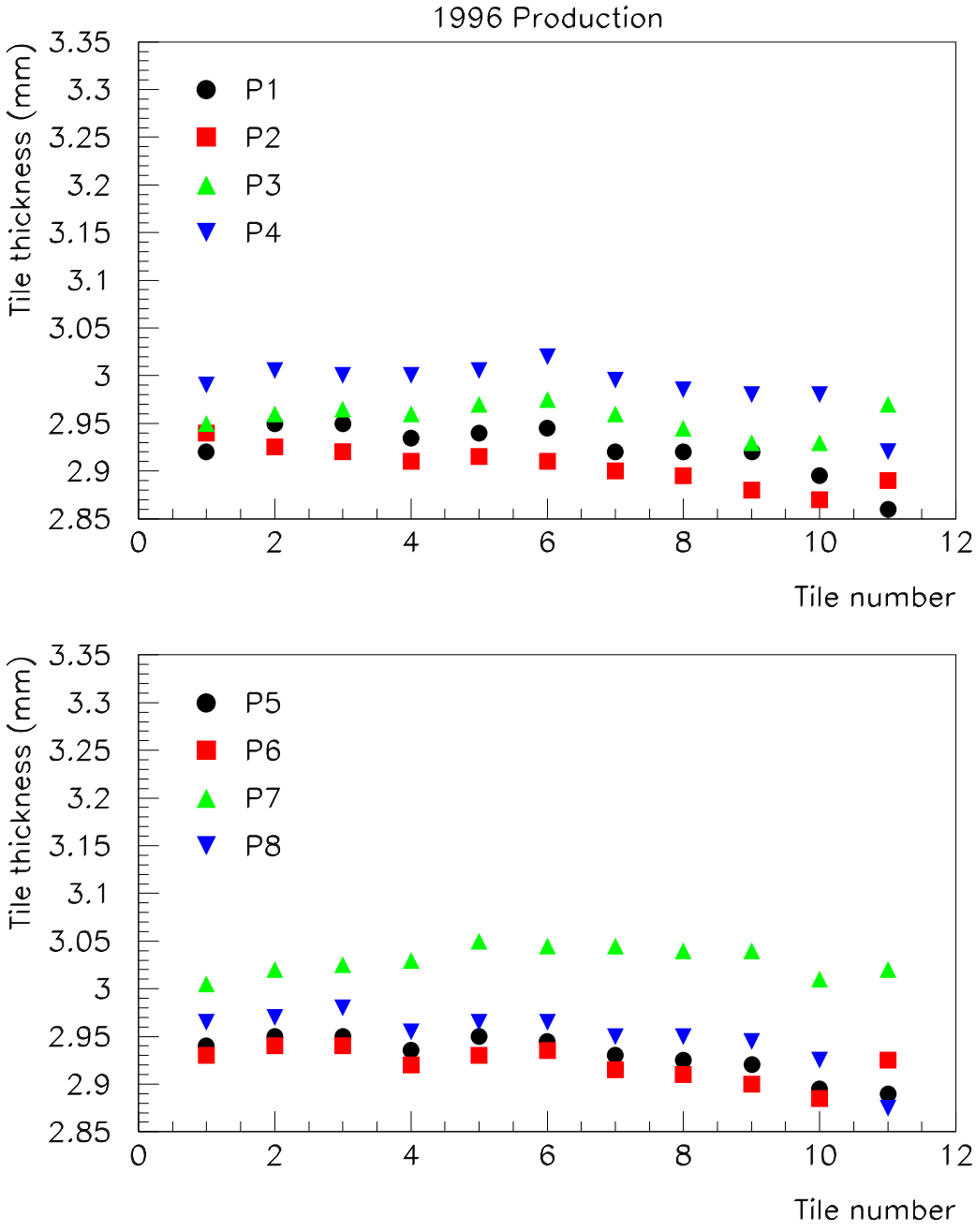

Figure 6: *Thickness for the 11 sizes of the old tiles.*

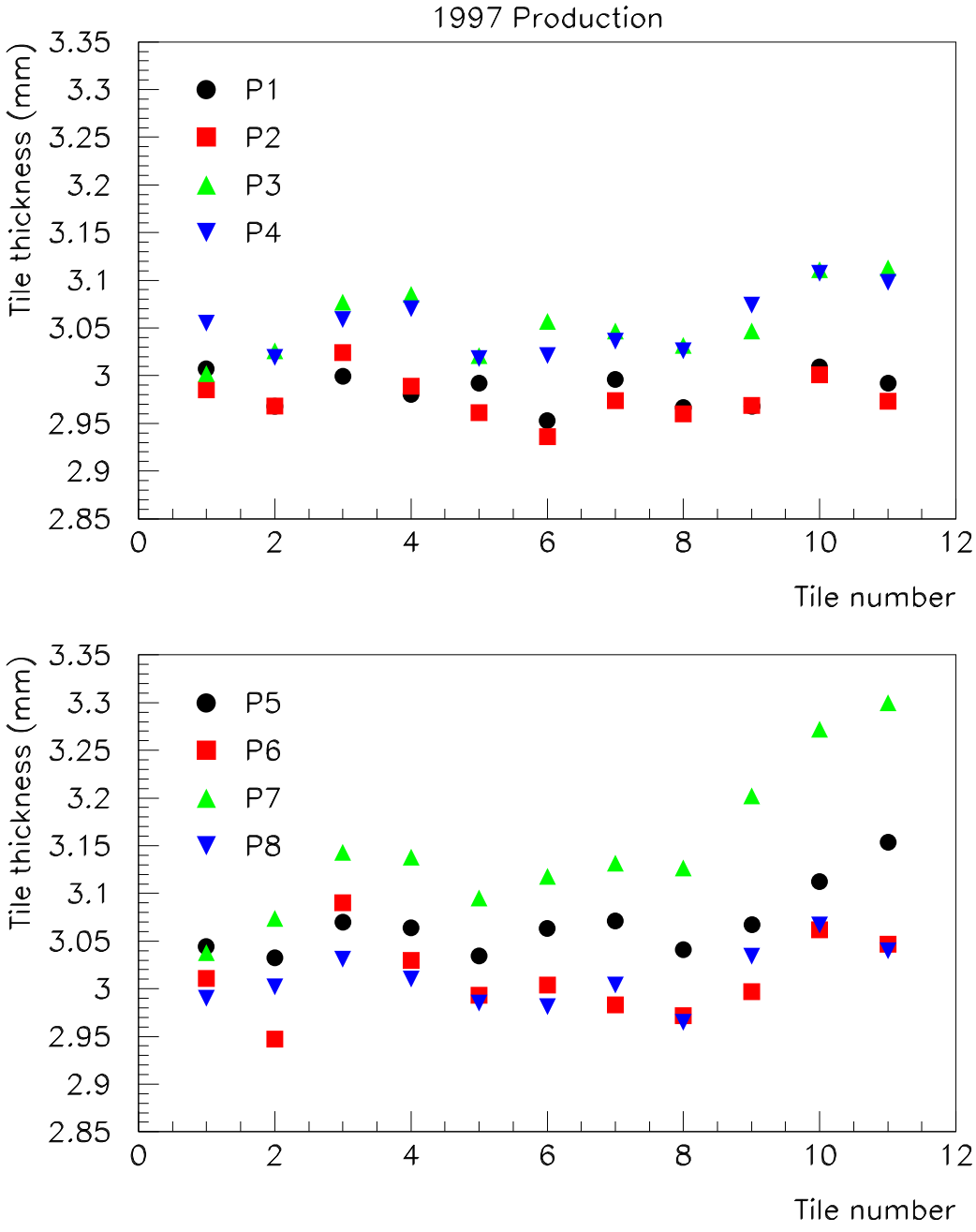

Figure 7: *Thickness for the 11 sizes of the new tiles.*

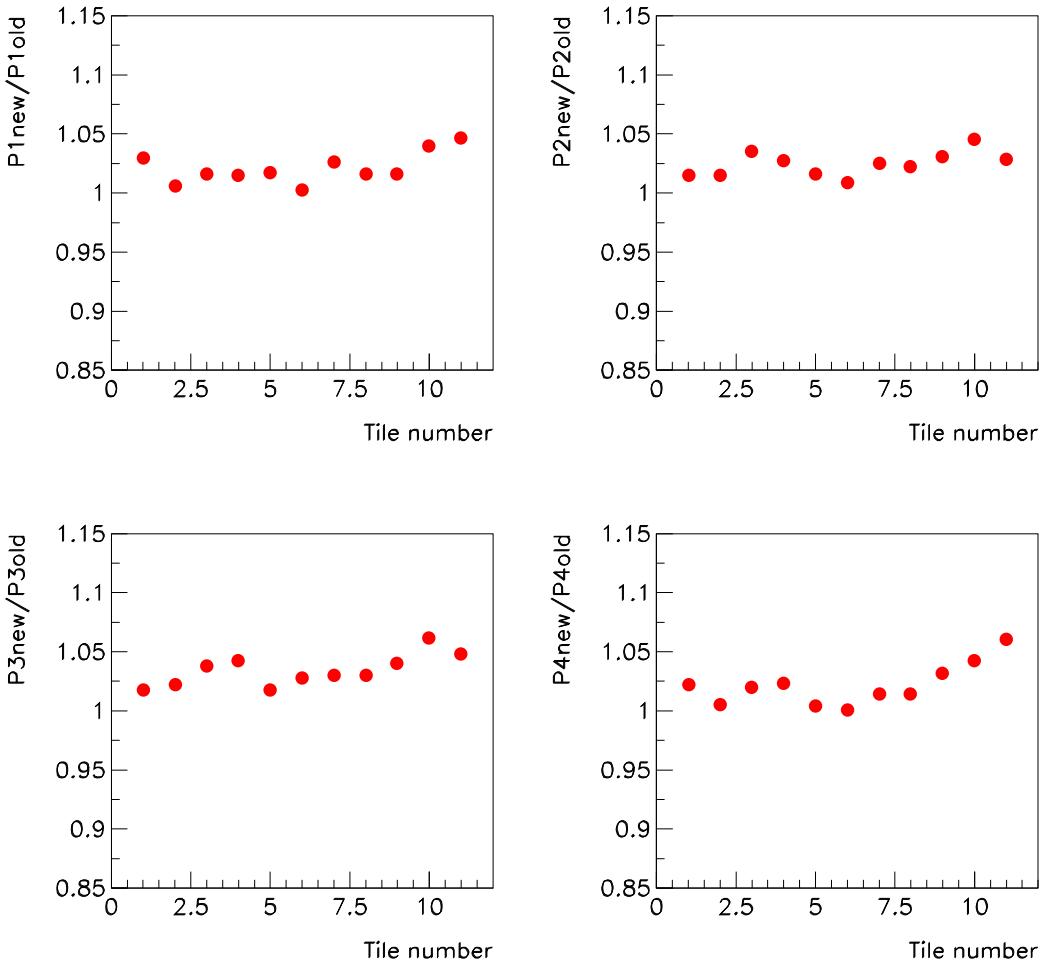

Figure 8: *Ratio of the new/old tile thicknesses for the points P1, P2, P3, P4, see figure 5.*

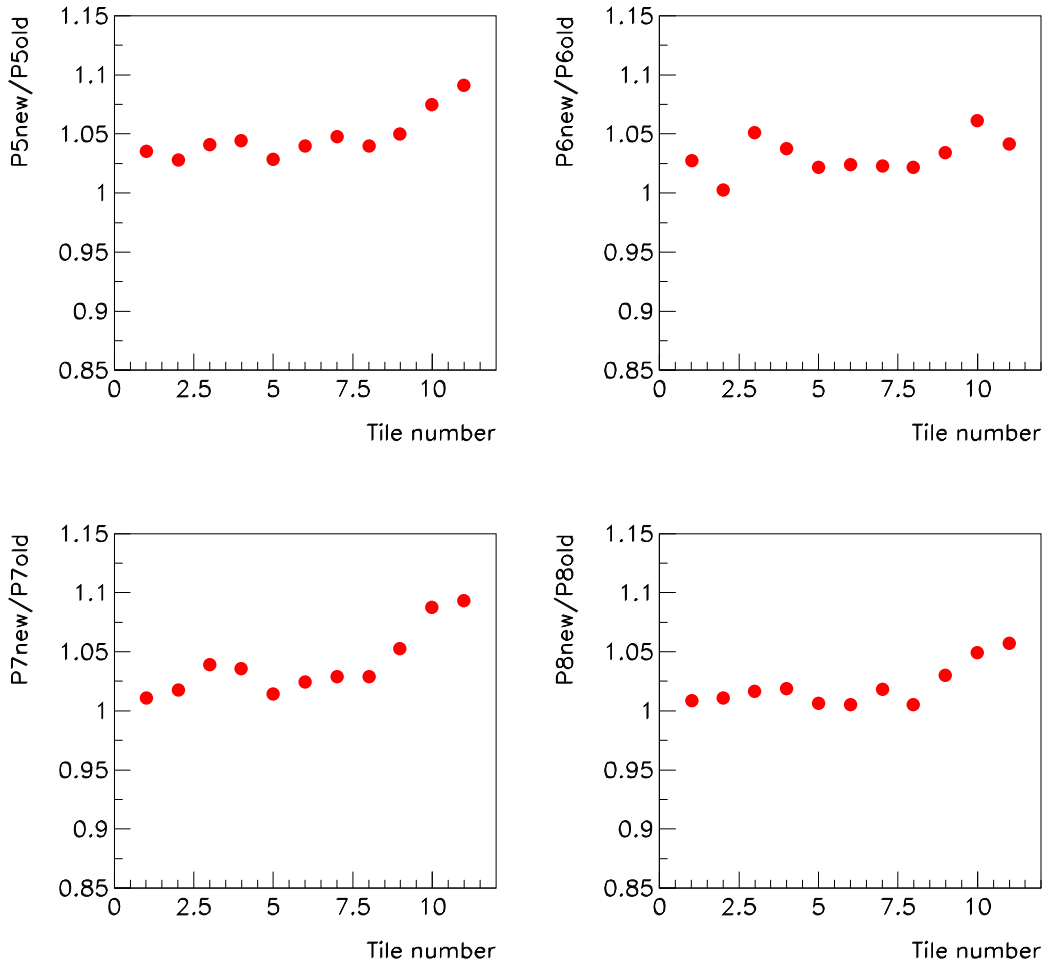

Figure 9: *Ratio of the new/old tile thicknesses for the points P5, P6, P7, P8, see figure 5.*

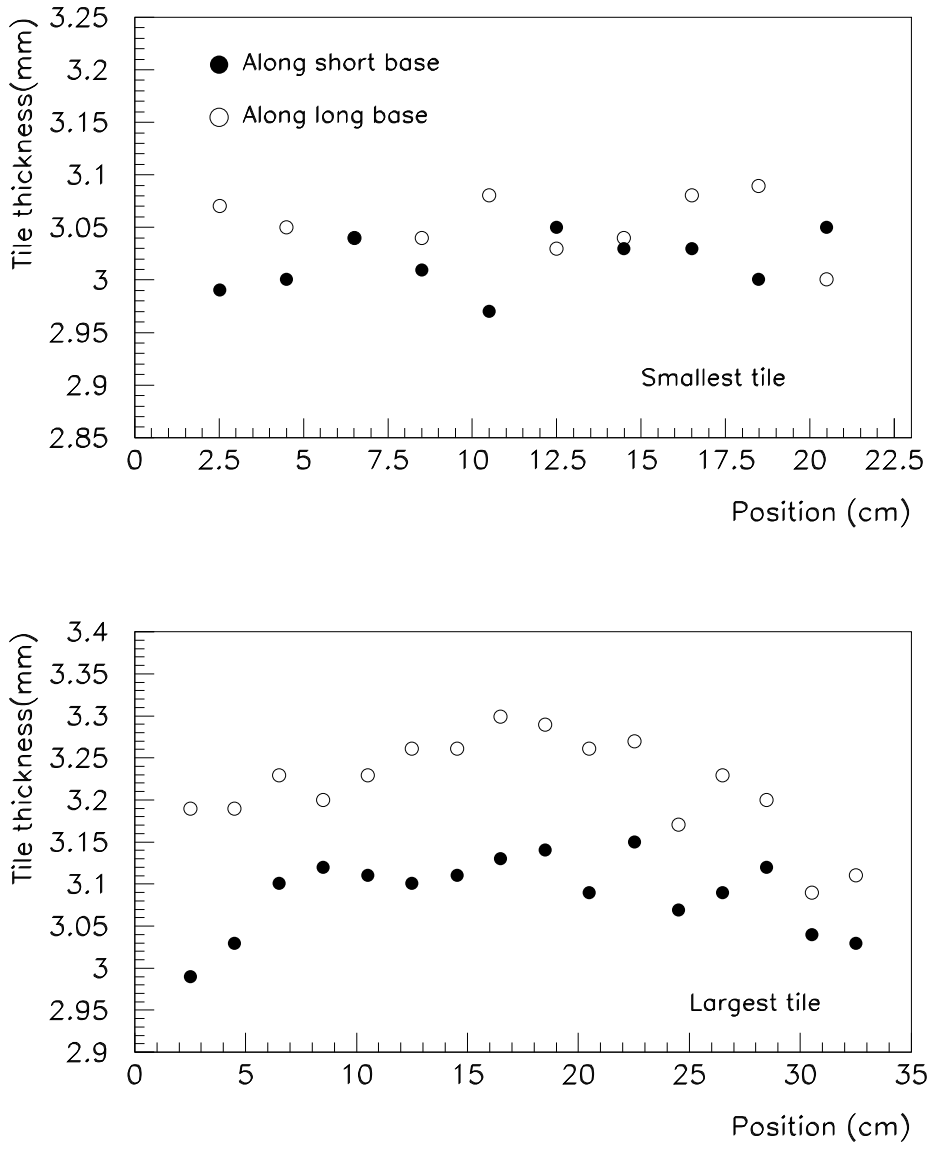

Figure 10: *Thickness profile along the bigger and smaller tile bases (see figure 5) for the new tiles. The upper plot refers to the tile of smallest dimensions (#1), while the lower one is for the biggest tile (#11).*

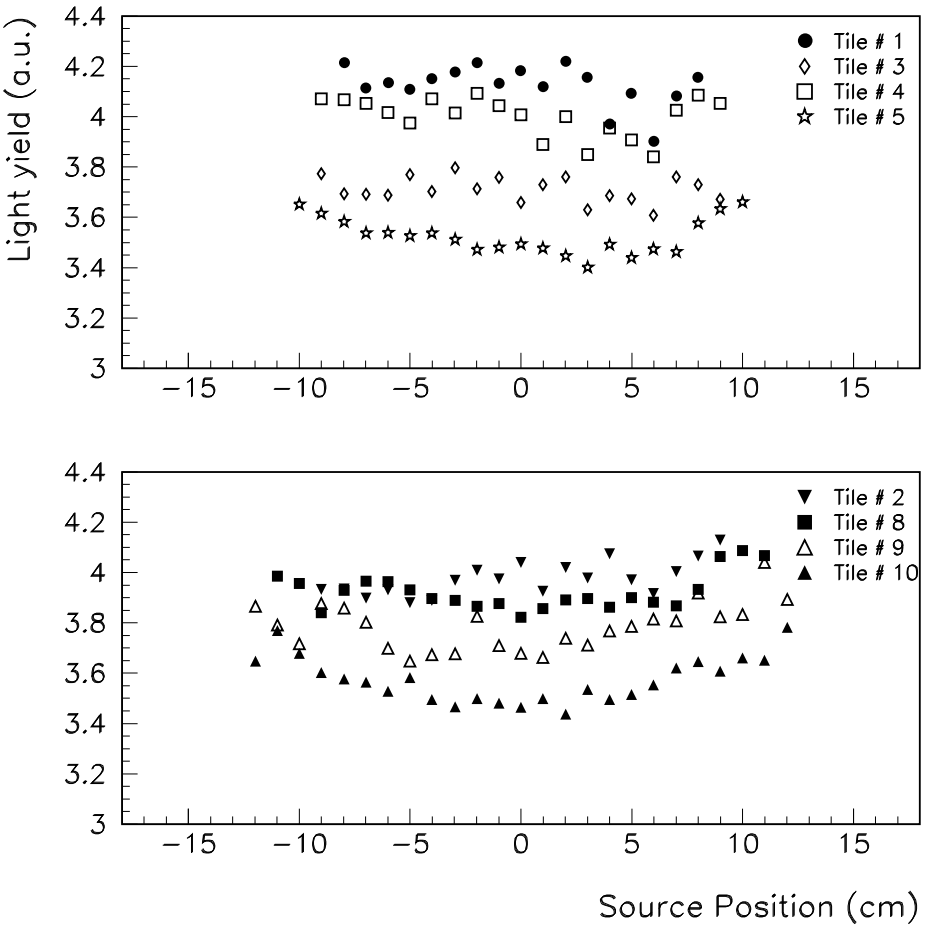

Figure 11: *Uniformity for the new tiles. The two plots shows a scan for the 5 smallest size tiles.*

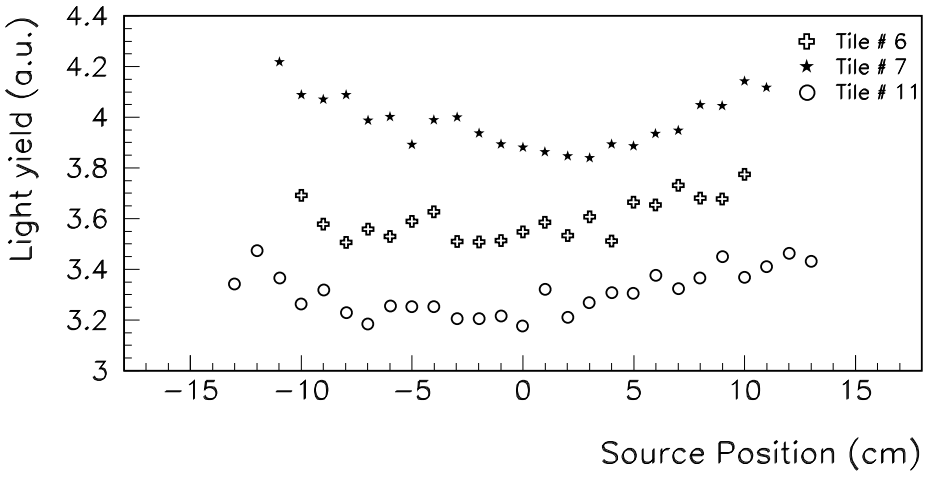

Figure 12: *Uniformity for the new tiles. The two plots shows a scan for the 6 largest size tiles.*

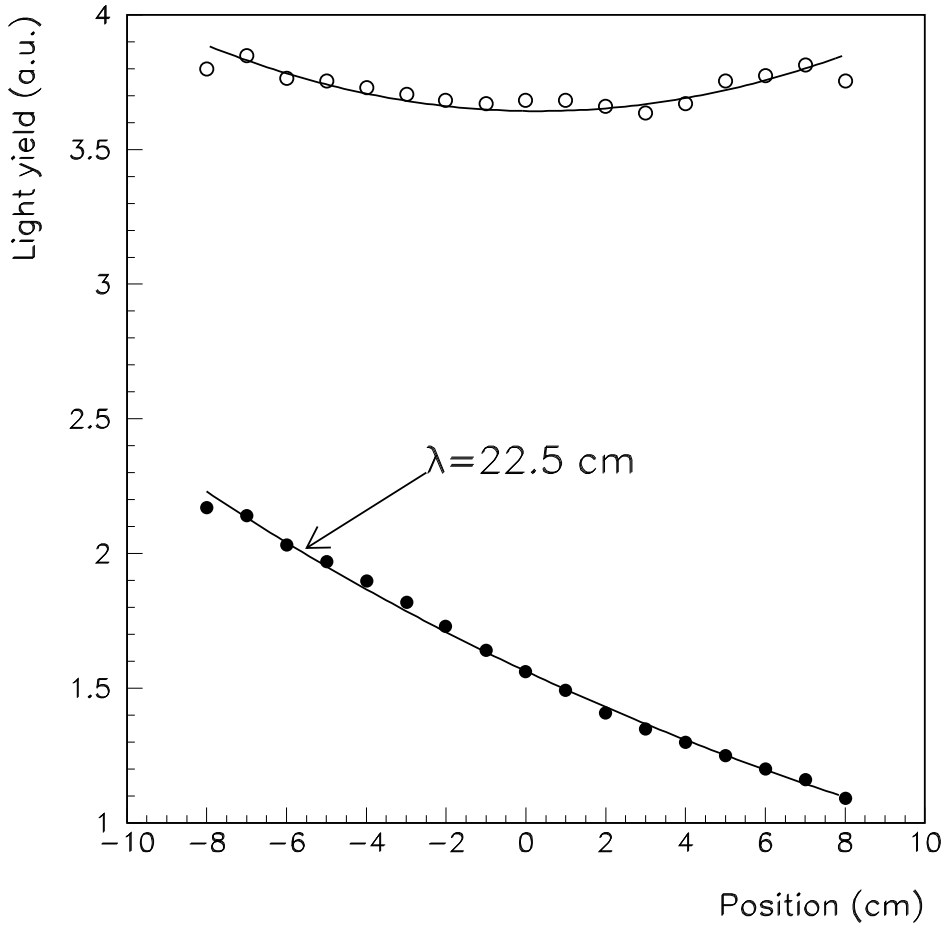

Figure 13: *Uniformity and light attenuation for the Bicron tile.*

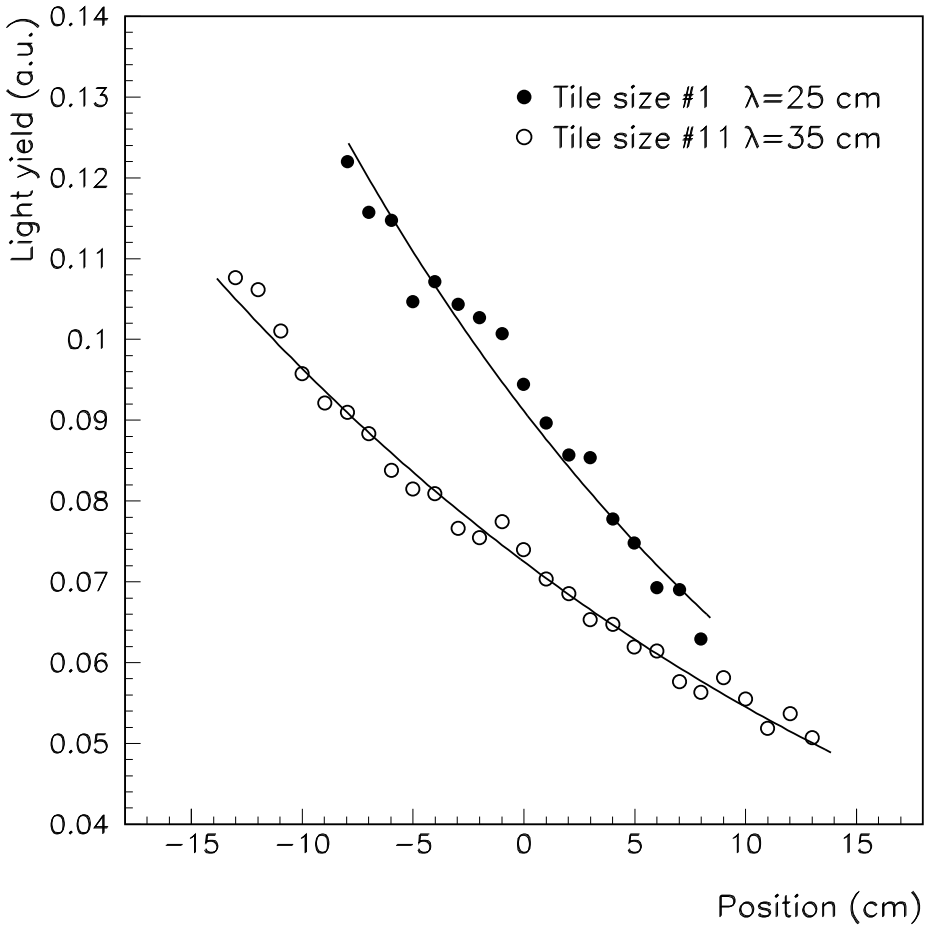

Figure 14: *Measurement of the attenuation length for the smallest and the largest of our tiles.*