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A Study of the VDET Laser Alignment Data taken during the 1994 ALEPH run

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Abstract

The VDET Laser Alignment System, designed to monitor the relative movements between the VDET and the ITC, is described. Results from this system taken during the 1994 run were used to investigate a deterioration of tracking quality around run 26600 since a movement of the VDET was suggested as a possible explanation for this deterioration. The laser data showed no evidence for a movement at this time but a significant shift was observed around run 29500. No satisfactory explanation has been found to account for this latter shift.

1 Introduction

The present VDET Laser Alignment System was installed in 1992. Its main purpose is to help maintain the tracking quality by monitoring relative movements between the VDET and the ITC. The performance of the laser system is independent of the performance of the ITC or TPC tracking. In this paper the system is briefly described, the data analysis procedure is outlined and results are presented. The work was motivated when a deterioration of the tracking quality was discovered after the ALEPH June '94 opening around run 26600. One possible suggestion for the cause of this deterioration was that the VDET had moved [1]. A total of 650 runs were analysed from June to November and the results are presented.

2 Outline of Laser Alignment System

The present VDET Laser Alignment System became operational in 1992 after the previous system, which was suspended from strings, was shown to be mechanically unstable [2]. In addition, changes were made in the DAQ such that the laser events were written to DST and online code was developed so that the laser data could be monitored using the ALEPH presenter program.

A diagram of the laser alignment system is shown in figure 1. Two kapton foils are glued onto the inner tube of the ITC with water soluble glue, each foil covering a half cylinder. Six sets of pairs of prisms are mounted on each foil, three sets at each end. In each set, one of the prisms delivers light perpendicular to the wafer and the other is orientated to deliver light at a 30^0 angle of incidence. Thus, for example, any radial motion of the wafers would cause changes in the distance between the two spots. There are two semiconductor infrared lasers, one at each end of the detector, and light is transmitted to the prism sets via optical fibres. The lasers are fired by an oscillator which sends an independent signal to the ALEPH trigger at the same time. Bit 21 of the level 3 trigger mask is set if there is a VDET laser trigger. There are approximately 100 laser events per run. Light is pulsed onto the end wafers, 1 and 4, of faces 1, 4, 6, 9, 11 and 13 of the outer layer. The numbering of VDET faces is shown in figure 2 and more detailed information on the VDET geometry can be found elsewhere [3]. Each wafer should have two spots making 24 in total, and each spot has a Z view and an XY view which are treated separately giving 48 'spots' in total. The spots are numbered such that spots 1-24 correspond to the Z view and 25-48 correspond to the XY view. Plots of pulse height versus strip number are shown in figure 3 for the Z view and figure 4 for the XY view. It can be seen that some of the spots are missing or are very weak. Modules B001, B006 and A009 are the only ones which have two good spots in both views. Most of the other modules have one good spot seen in both views, except module A006 which has no spots at all. Figure 5 shows the XY distribution of hits for laser events during runs 29130, 29131 and 29132. The laser spots can be seen along with some noise hits.

3 Analysis

The following analysis was performed on around 650 PERF or MAYB runs. DST's were used when available, otherwise the analysis was done on POT's. The hit positions determined by JULIA were found to be unreliable for the laser spots. This can be understood by looking at the plots of raw pulse height against strip number, figures 3 and 4. JULIA appeared to make false clusters from the background 'halo' surrounding certain spots, giving wrong spot positions and large errors. To overcome this problem, a threshold was set for each module in order to eliminate the halo. For some modules this threshold was set equal to zero. Clusters were then formed using only the strips with pulse height above threshold and the hit positions were re-calculated using a centre of gravity technique. The hit position distributions for spots 4 and 28, before and after re-clustering, are shown in figure 6. After re-clustering the resolution for a single laser shot is around 2-3 μm for most spots. This gives a spot position error of around 0.3 μm for a 100 event run.

For each spot, a nominal position was determined. This was taken as being the mean hit position found using 200 laser events. Windows centred on each spot were then set to allow each hit to be associated with a certain spot number. For most spots the width of this window was set at 600 μm (ie. 6 readout strips), to allow for movements of that size. In the case of two very close spots, (for example spots 13 and 14 in figure 3), a smaller window was chosen. Deviations from the nominal positions were then calculated on an event by event basis and history plots were produced showing the run-averaged deviation as a function of run number.

4 Results

Figures 7 and 8 show the average spot deviation as a function of run number for representative spots. It can be seen that until around run 29400 the spots are stable within approximately 3 μm. Around run 29400 however, all the spots show a significant shift. The size of the shift varies between spots and is summarized in table 1. The shift occurs gradually, starting on the 4th October and taking 4 days for the spots to reach their maximum deviation on the 7th. The spots then return to their previous positions on the

13th October around run 29700. From run 29700 onwards the spots are less stable than before. The following observations were made concerning the nature of the shift:

- The spots are stable around run 26600 indicating that a VDET/ITC relative movement was not a possible explanation for the tracking distortions seen at that time.
- The start of the shift does not coincide with ALEPH being closed on the 22nd September but starts 12 days afterwards.
- The fact that the shift occurred relatively slowly and the spots returned to their normal positions suggests that the movement is related to a gradual change of temperature or pressure, for example.
- The average cluster pulse heights were studied as a function of time because if some of the strips were to saturate, the pulse height information would no longer be accurate for these strips[1] and this could cause an apparent shift in the cluster position. Graphs of average pulse height against run number for selected spots are shown in figure 9. Figure 10 shows the fraction of time that these spot clusters contain at least one saturated strip as a function of run number. The pulse heights are stable for all spots. Spots 9, 12, 13, 14, 33 and 36 contain saturated strips but no correlation is seen between the saturation and the spot deviation. The rest of the spots do not saturate at all. Furthermore, the spot profiles shown in figure 11 for two runs (one before the shift and one at the maximum displacement) clearly show that the shift is genuine.

4.1 Possible Explanations for the Shift

Three possible explanations suggest themselves to account for the observed spot shifts.

a. The laser system moved relative to the ITC inner wall.

b. The ITC inner wall moved and the laser system moved with it.

c. The VDET moved.

It is unlikely that (a) is an explanation since this would require that both kapton foils detached themselves from the inner wall of the ITC and then re-attached themselves in such a way that the laser spots returned to their normal positions.

[1] If a strip saturates then the strip pulse height is measured to be smaller than it really is.

Module No.	Z side			XY side	
	Spot no.	Max. shift (μm)	Approx. ϕ pos.	Spot no.	Max. shift (μm)
B013	1	+2	290^0	*	
	2	+4		26	−12
A013	*		290^0	*	
	4	+9		28	+70
B001	5	+17	0^0	29	+7
	6	+20		30	+12
A001	7	+12	0^0	*	
	*			32	−40
B004	9	+20	70^0	33	−85
	*			34	−50
A004	*		70^0	35	−10
	12	+14		36	+45
B006	13	+15	120^0	37	+3
	14	+16		38	+10
A006	*			*	
	*			*	
B009	17	+8	195^0	*	
	*			42	+17
A009	19	+5	195^0	43	−7
	20	+5		44	+4
B011	21	−11	245^0	45	+65
	*			46	+85
A011	*		245^0	47	−5
	24	+12		*	

Table 1: Summary table of spot shifts. A positive shift indicates that the spot moved in the direction of increasing strip number (see figs. 12,13). A * indicates an absent spot.

Explanation (b) appears to be slightly more feasible. It is interesting to note that the ITC started to DUCK runs on October 4th, coincident with the start of the shift. This was due to a gas composition problem however and should not have caused any movements. It also was noticed that atmospheric pressure rose from 970 mbar on October 4th to 990 mbar on October 7th. The latter pressure was the highest recorded around this time and coincides with the time of the maximum spot displacement. However since the gas pressure inside the ITC chamber follows the pressure outside, this pressure change should not have resulted in a movement of the walls.

The third explanation (c) is that the VDET itself moved. If this was the case then a deterioration in tracking quality would be expected for runs between 29400 and 29700. In order to check this, the DQUAL tracking quality code was used [4]. During the 1994 data taking period the DQUAL code used di-muon events and analysed the residuals between the actual VDET hit and the expected hit position found by extrapolating a track back from the TPC and ITC. This analysis should have been able to detect VDET movements of greater than 30 μm. Runs 29400-29700 were analysed and also a set of runs taken when the spots were stable. No significant differences were seen between the two sets of results. However, many of the spot shifts are less than 30 μm and therefore it is possible that the DQUAL analysis is not sensitive to them.

4.2 Global Interpretation of Spot Movements.

Adopting the assumption that it was the VDET which shifted it is worthwhile trying to interpret the individual spot movements in terms of a global movement of the VDET. The first point to notice from table 1 is that all the spots, except spot 21, move in the direction of increasing strip number in Z. Figure 12 shows the way the strips are numbered and so the Z movements can be considered as suggestive of the VDET contracting along its length[2]. However, problems arise when trying to interpret the movements more accurately. This is because there is a two-fold ambiguity when matching the Z view of a spot with its corresponding XY view. For example, on module B006 spot 13 (Z) could be paired with either spot 37 or 38 (XY) (see table 1). An attempt was made to resolve this ambiguity by looking for correlations between the pulse heights of the Z and XY spots but this did not prove very successful since, for example, spot 20 was equally correlated with spots 43 and 44. Another way to resolve this problem is by obtaining a more detailed knowledge of the geometry of the system.

Despite these limitations, we can still obtain an idea of the sort of movement that

[2]Note that the movement of a spot in one direction implies that the VDET module moved in the opposite direction.

took place. One possible movement is pictured in figure 13, where each face is drawn individually. It can be seen that the motion cannot be easily accounted for in terms of a simple rotation or translation. However, this strange combination of contractions and expansions would perhaps be expected if temperature fluctuations were the cause. The VDET temperatures were investigated in the period from the 4th to 14th of October and were found to be stable to within 2^0C. Figure 14 shows temperature plots obtained from the ALEPH presenter program for this period. The temperature plots from the earlier period from 22nd September to 4th October, however, show a spike occurring on the 25th September, figure 15. This spike represents a rise in temperature of 8-10^0C but only corresponds to a single reading and so is more likely to be simply a spurious reading rather that a real temperature change.

5 Improvements for the Future

If the laser alignment system is to be used to its full potential it is necessary to resolve the ambiguity in spot matching. A detailed study of the geometry of the system should perhaps be made when the VDET is next removed. However, even if the XY and Z view spots are correctly matched up, there are still too few spots on each module to be able to constrain the problem and hence determine the exact movement (assuming each module moves independently).

A new light spot system is planned for the 1996 running with the upgraded VDET. It will be particularly useful for high energy running as the monitoring of the VDET alignment using just data will be difficult due to the small event rates[3]. To solve some of the problems mentioned above, the new system will incorporate additional spots and be better matched to the increased length of the new VDET. In addition an effort will be made to improve the uniformity of their intensity.

5.1 The Addition of Laser Spot Analysis into DQUAL

It was mentioned above that the 1994 DQUAL analysis program was perhaps not sensitive to VDET movements of less than 30 μm. In view of this it was decided to include some code in DQUAL to analyse the VDET laser events. The new DQUAL laser code produces the following histograms :

- XY view spot deviation against ϕ. (Side A)
- XY view spot deviation against ϕ. (Side B)

[3]At LEP–II the number of di-muon events will be reduced by a factor of the order of 100.

- Z view spot deviation against ϕ. (Side A)
- Z view spot deviation against ϕ. (Side B)
- Distribution of XY deviations for all spots.
- Distribution of Z deviations for all spots.

Examples of these histograms are shown in figures 16 and 17. The solid triangles correspond to data taken between runs 28496 and 28608 (before the shift) and the open triangles correspond to data taken between runs 29508 and 29540 (during the shift). The distributions in figure 17 should be gaussian and the extent to which they are not gaussian is an indication that movement has taken place. Clearly these histograms are sensitive to the movements which took place.

6 Conclusions

The performance of the VDET Laser Alignment System has been studied using data from the 1994 ALEPH run. The original motivation for this work came when a deterioration of the tracking quality after the June '94 opening suggested that the VDET had perhaps moved. The results show that the VDET did not move at this time. In general the stability of the system was better than 3 μm until 4th October. All the laser spots were then seen to move - the largest shift being 85 μm. This movement can be attributed to either a movement of the VDET or of the laser system or of its support (ITC inner wall). The spots returned to their nominal positions around October 13th suggesting that a pressure or temperature change had been the cause. This was investigated and no satisfactory explanation was found. The DQUAL tracking quality program did not show any differences in the results from di-muon events which occurred before and during the shift. In view of this, code has been added to DQUAL to analyse the VDET laser events. It is hoped that this new code will be sensitive to relative movements between the ITC and VDET of less than 10 μm.

Acknowledgments

We would like to thank Ian Tomalin for analysing the di-muon events for runs taken before, during and after the period when the shift was observed.

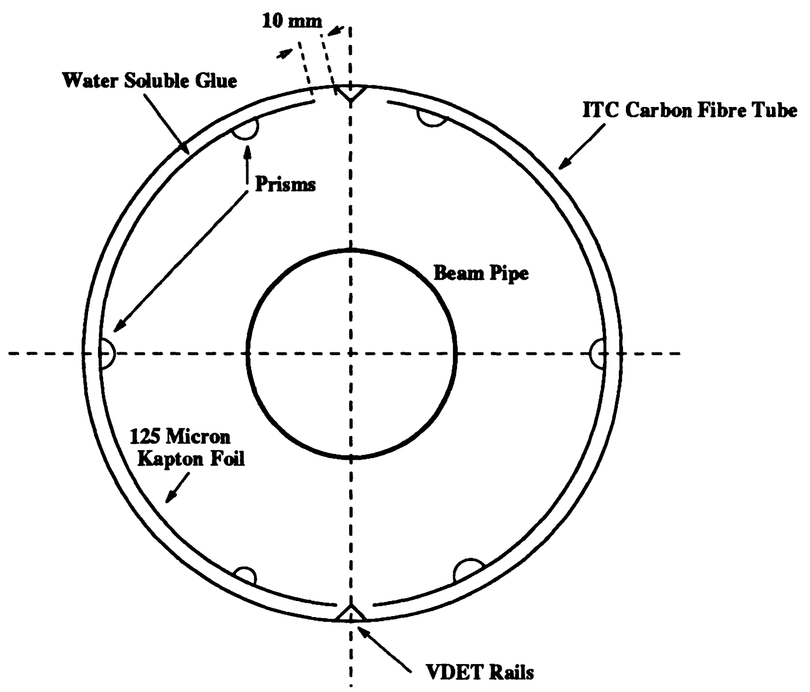
References

[1] I. R. Tomalin *Minutes of the Tracking Meeting of 22/9/94.*

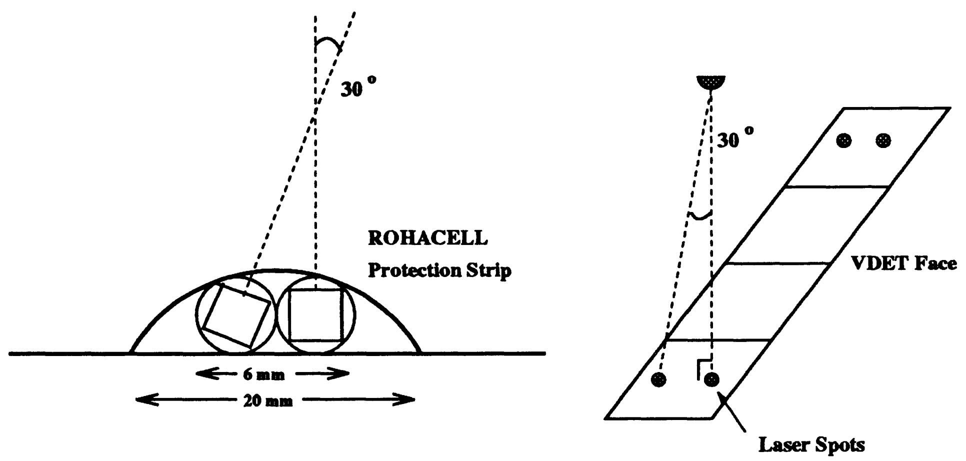
[2] P. Coyle and L. Roos *Performance of the 1991 VDET Laser Alignment System.* ALEPH 91-166, MINIV 91-007

[3] J. Rothberg et al. *VDET Geometry Package.* ALEPH 94-174, SOFTWR 94-012

[4] I. R. Tomalin *Improvements in Offline Checks of Tracking Quality.* ALEPH 94-159, SOFTWR 94-014



(a) Cross section of foil and prism arrangement.



(b) Close-up of one of the prism cells and a view of one of the VDET faces showing the angles of the two beams.

Figure 1: The Laser System

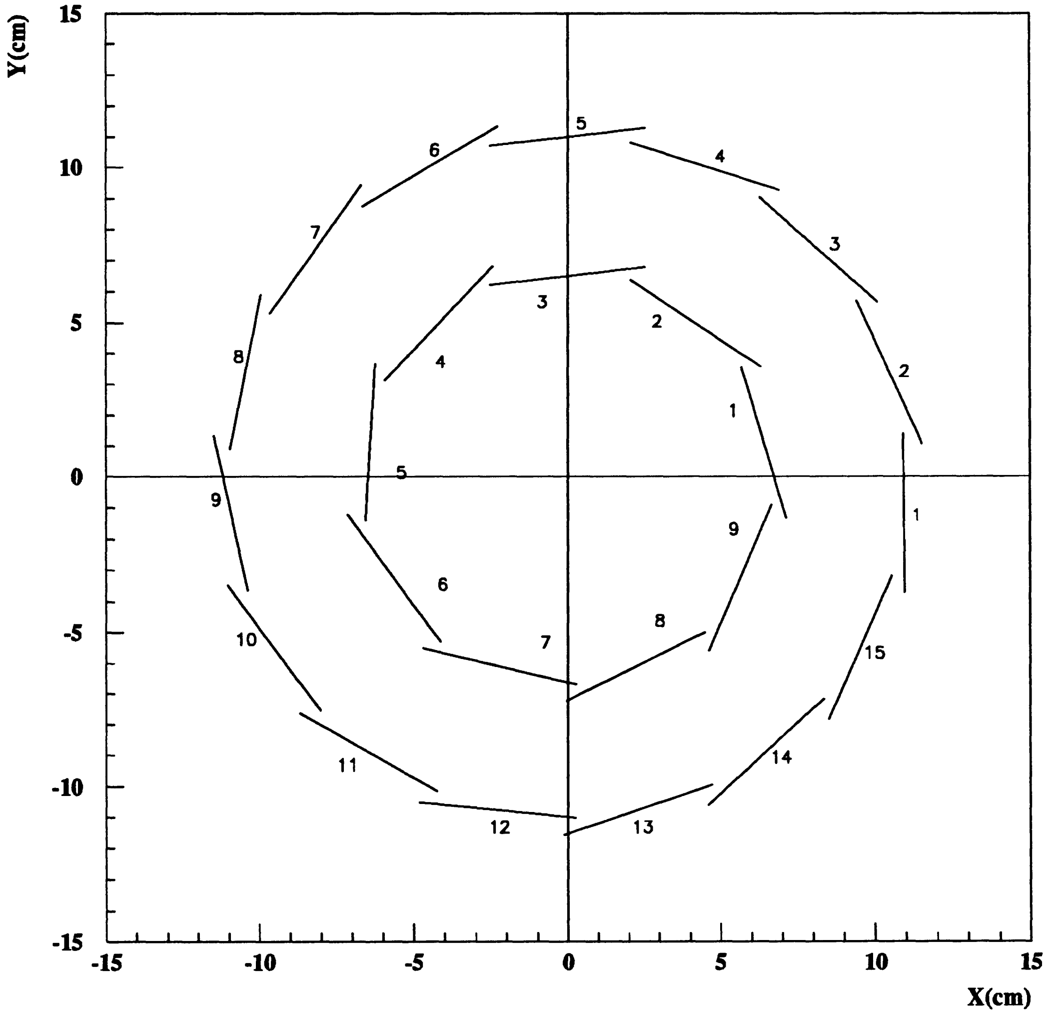


Figure 2: VDET faces projected onto the ALEPH XY plane, as viewed from side A. The face numbers are shown. Laser light is incident on the end wafers of faces 1, 4, 6, 9, 11 and 13 of the outer layer.

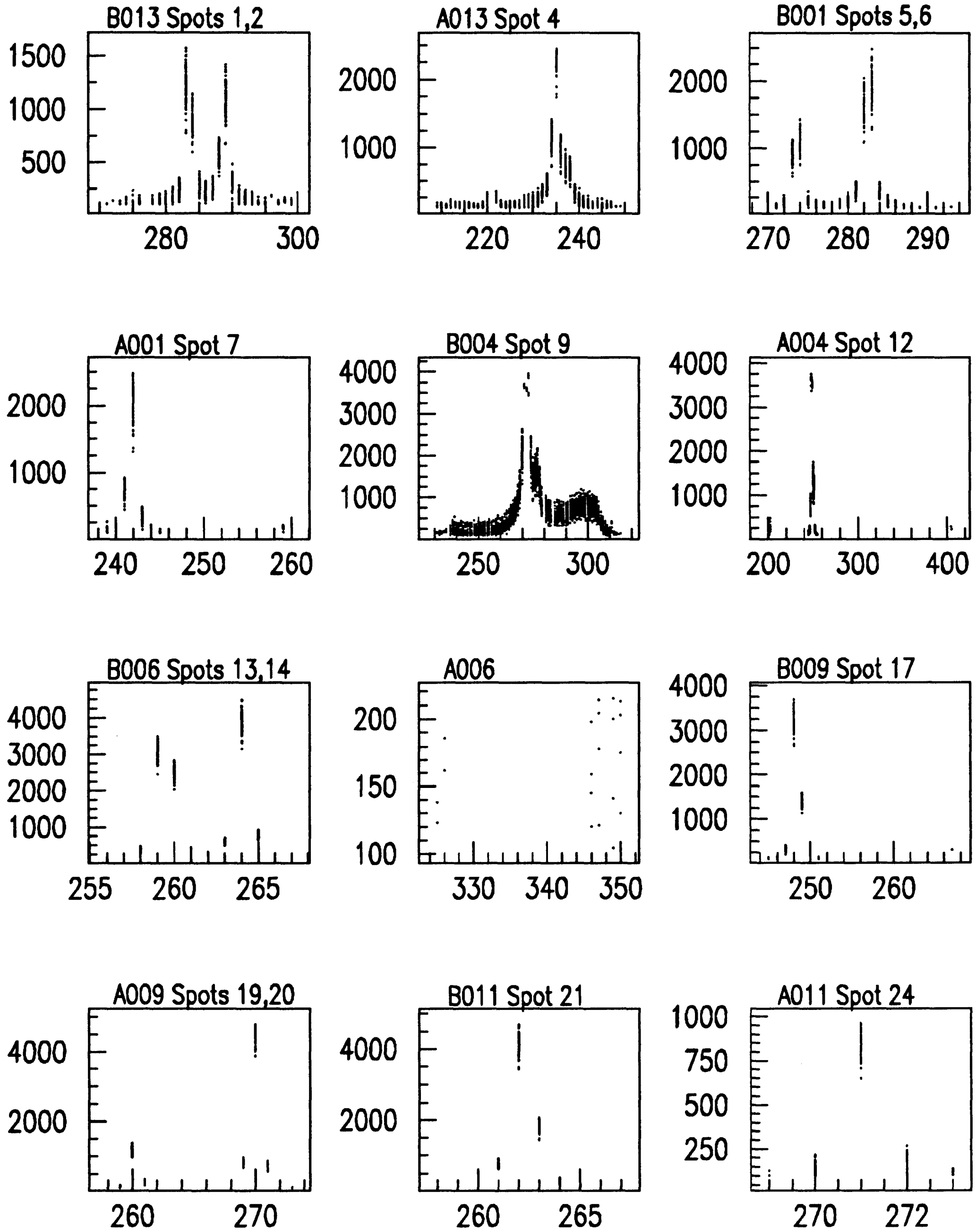


Figure 3: Pulse height against strip number for Z view spots. Note some spots are not seen, for example spot 8 on module A001

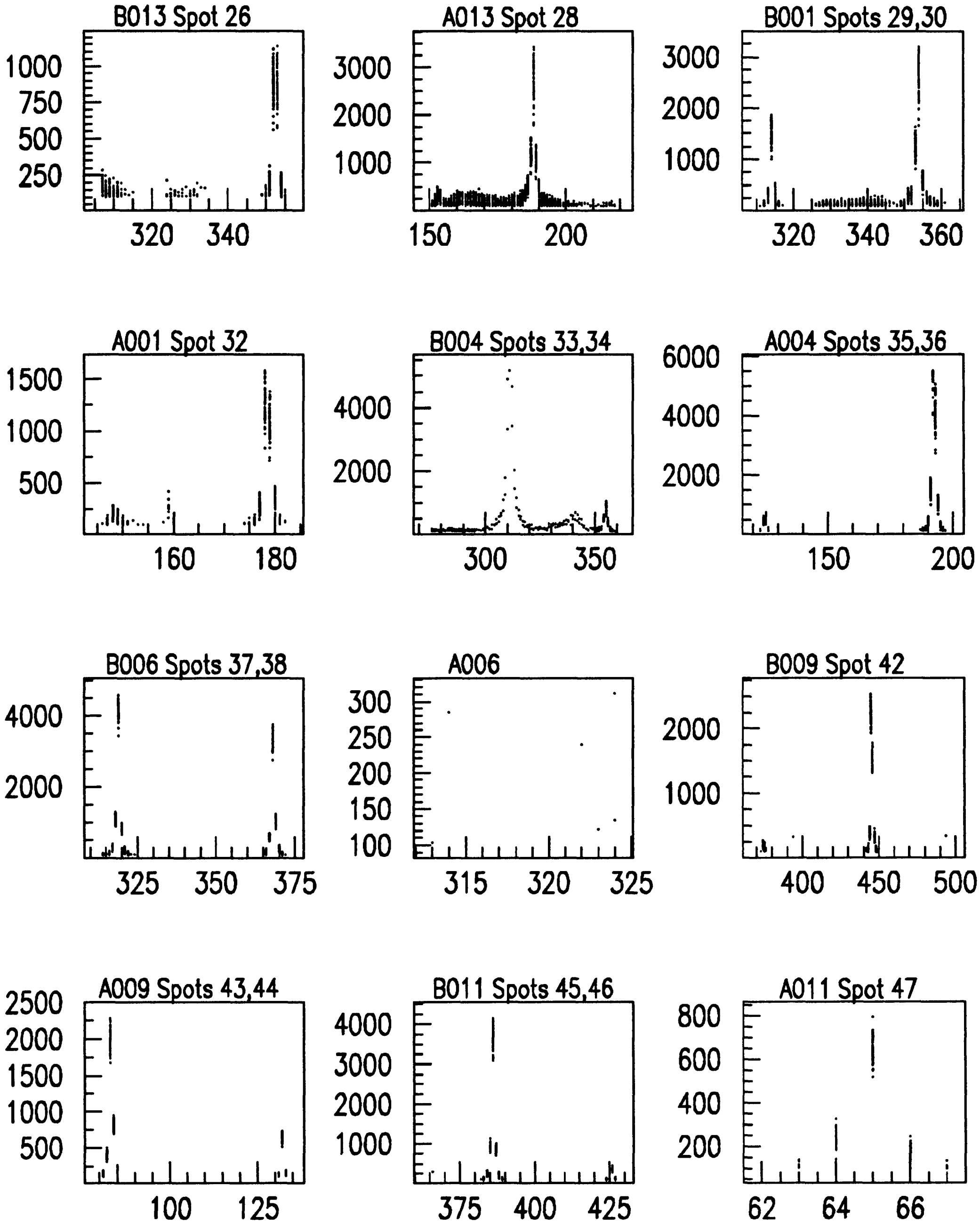
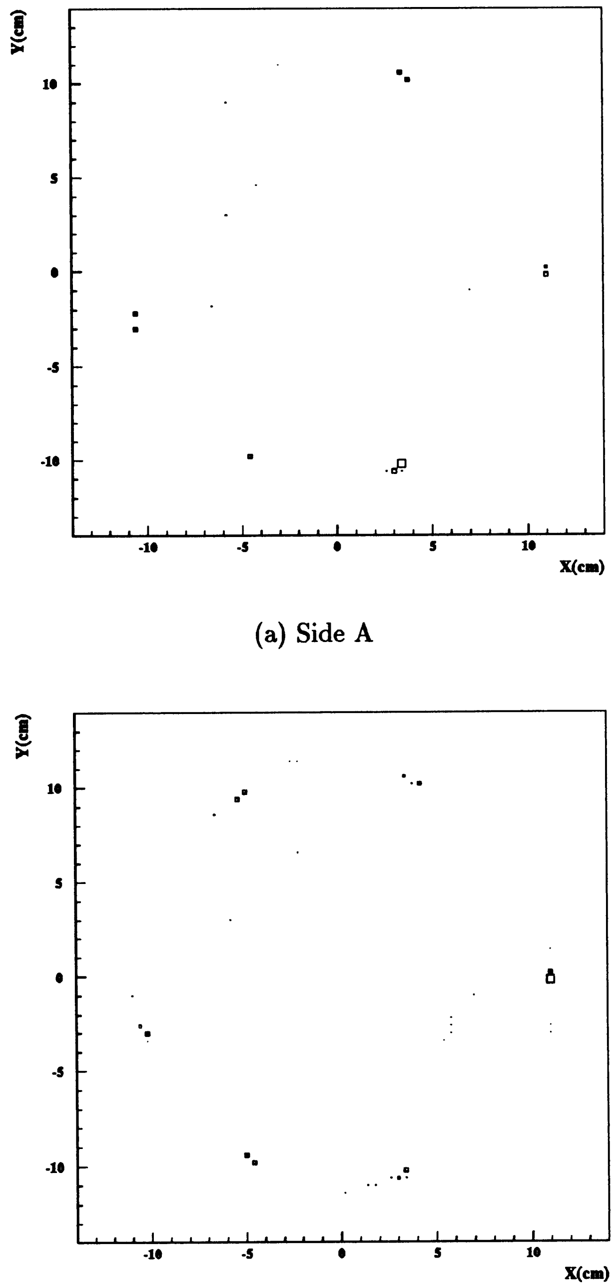


Figure 4: Pulse height against strip number for XY view spots. Again note that some spots are not seen.



(a) Side A

(b) Side B

Figure 5: XY distribution of laser hits.

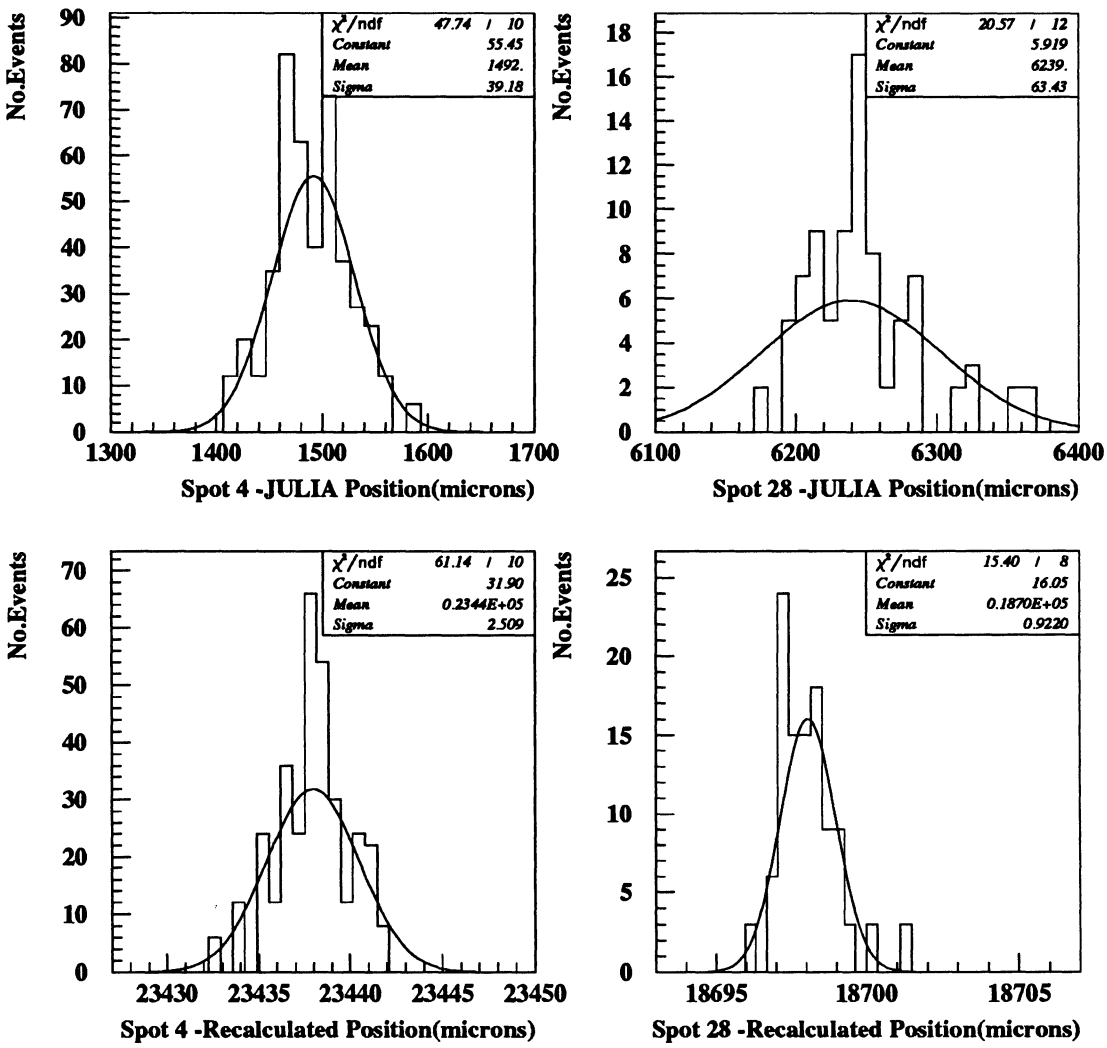
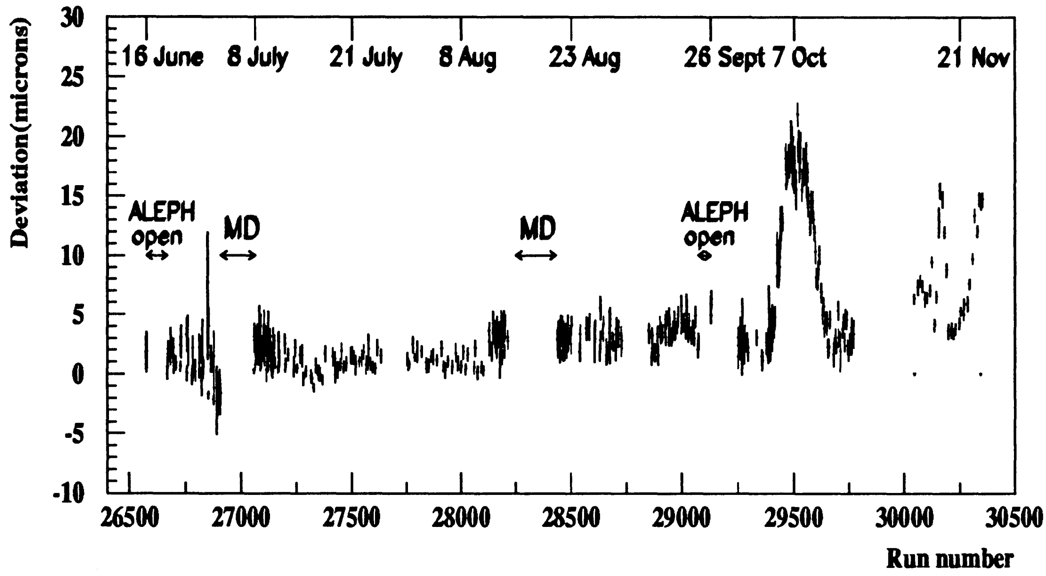
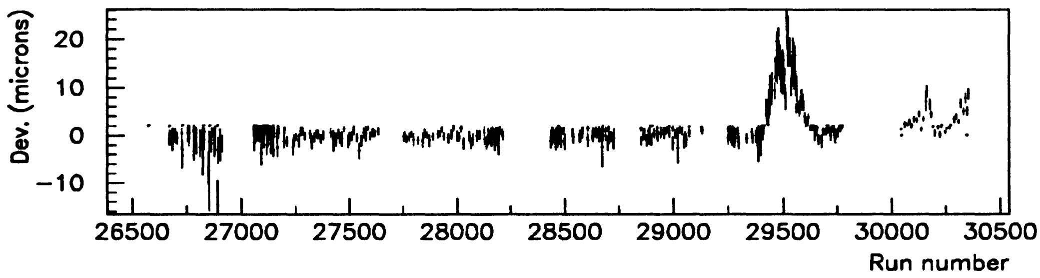


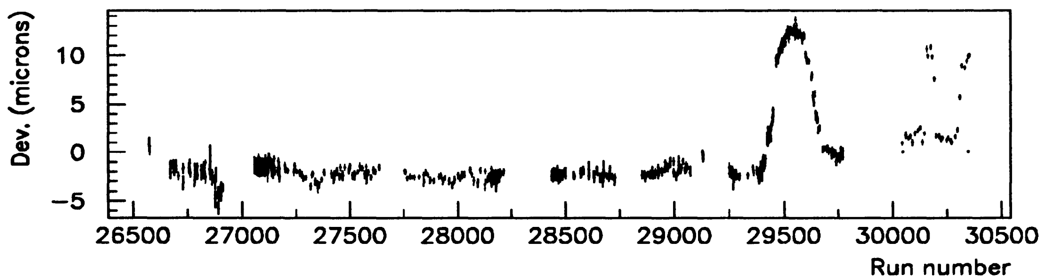
Figure 6: Comparison of JULIA hit positions and re-calculated hit positions. Note that due to a different choice of origin by JULIA compared to the reclustering algorithm the two scales are offset by 22000 and 12500.



(a) B001 Spot 5

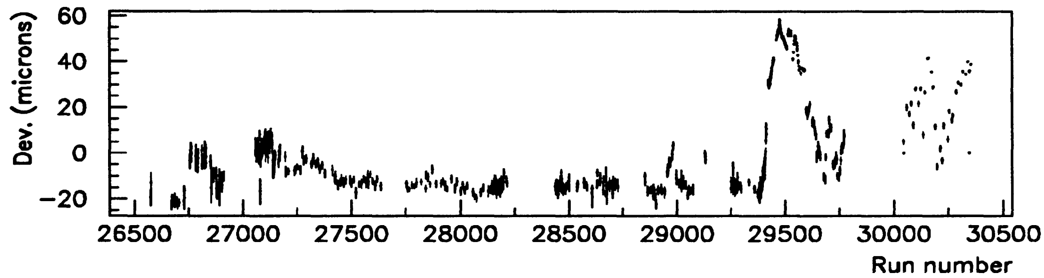


(b) B004 Spot 9

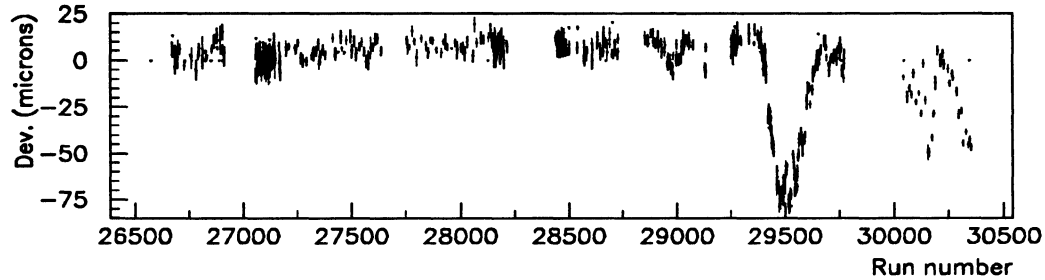


(c) B006 Spot 13

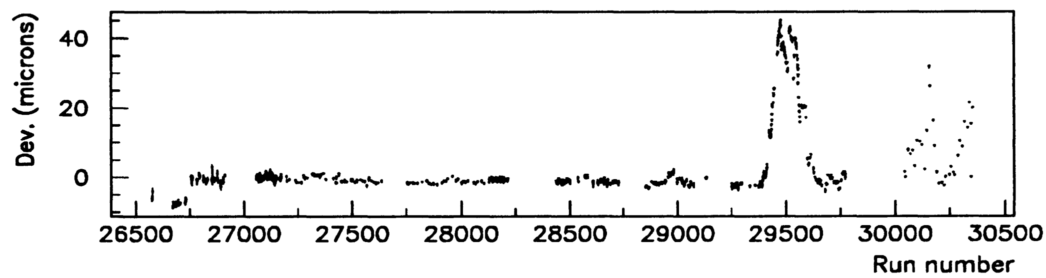
Figure 7: Deviation against run number for the Z view of representative spots.



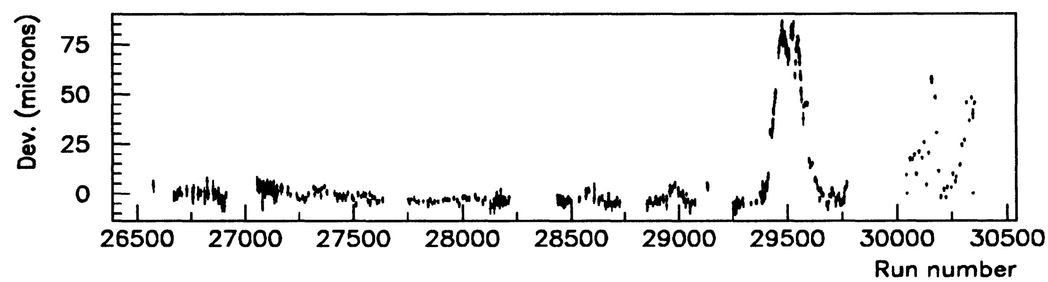
(a) A013 Spot 28



(b) B004 Spot 33

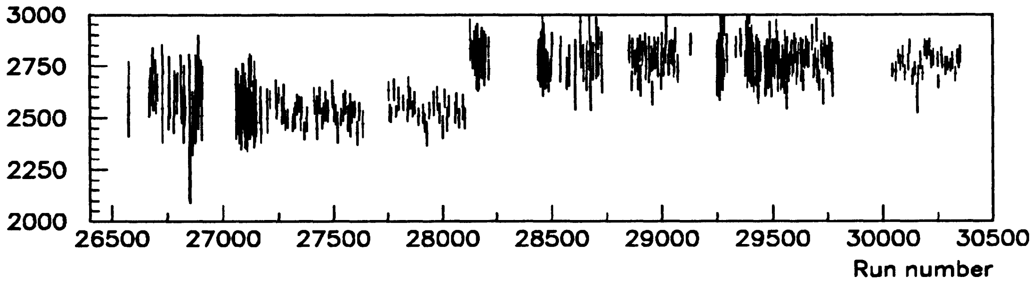


(c) A004 Spot 36

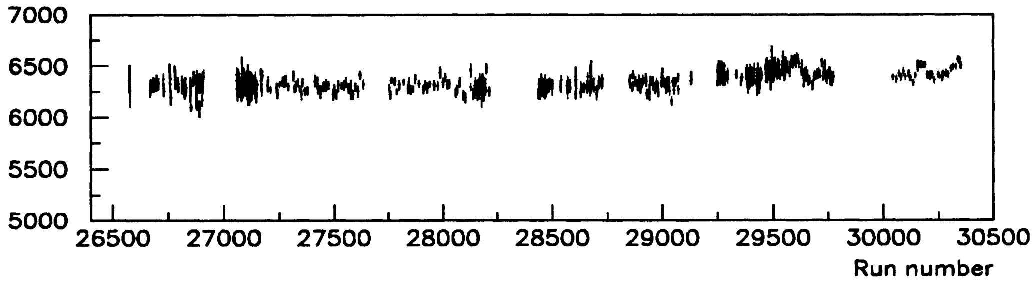


(d) B011 Spot 46

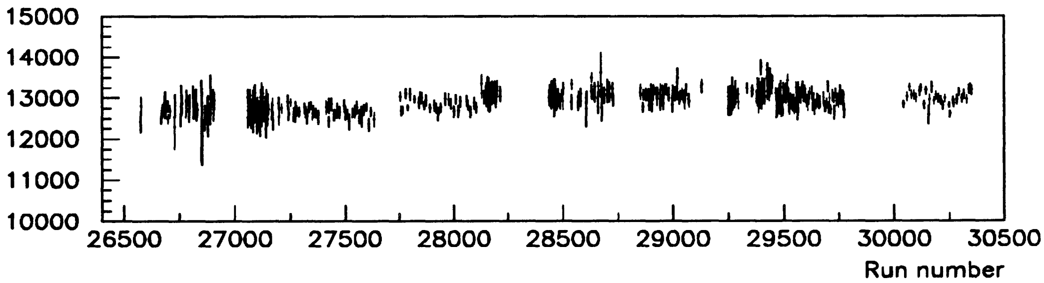
Figure 8: Deviation against run number for the XY view of representative spots.



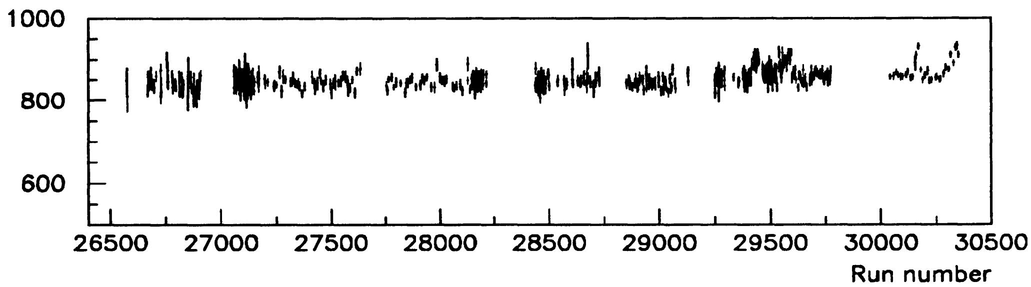
(a) B001 Spot 5



(b) B006 Spot 13

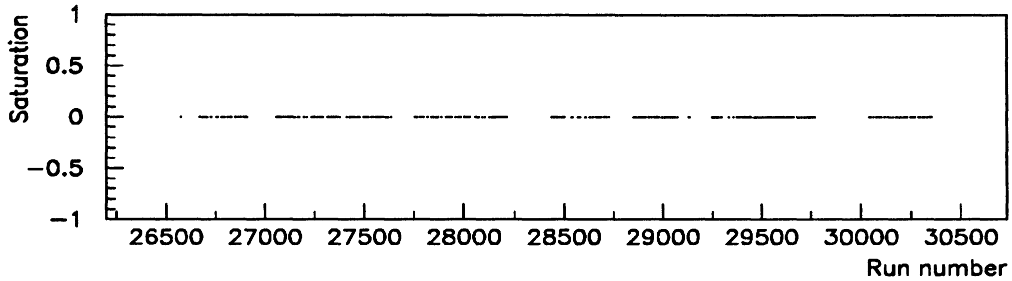


(c) A004 Spot 36

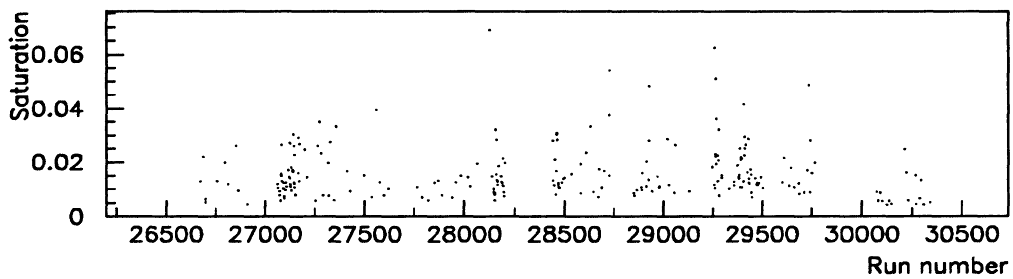


(d) B011 Spot 46

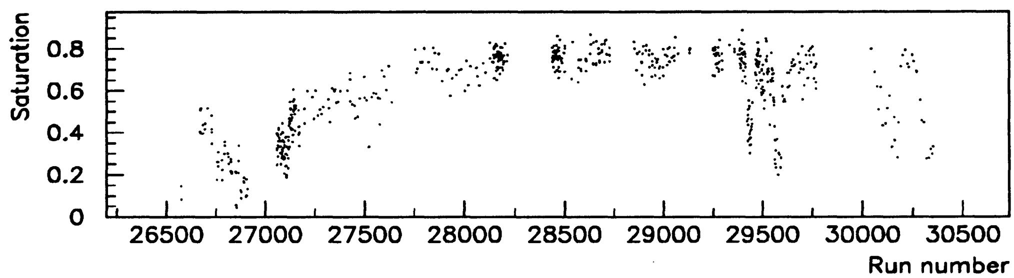
Figure 9: Cluster pulse height (ADC counts) against run number for representative spots.



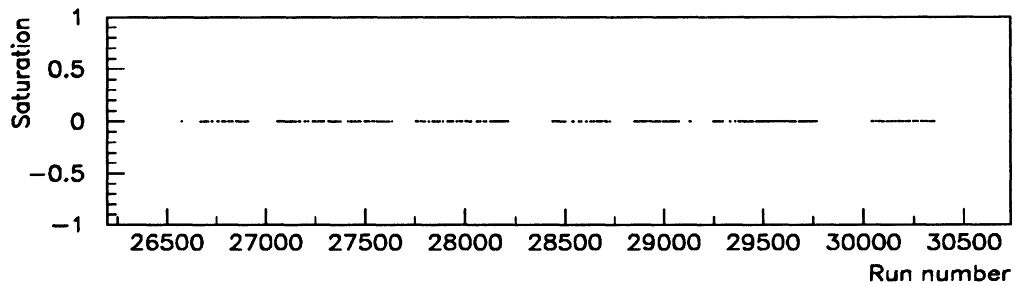
(a) B001 Spot 5



(b) B006 Spot 13



(c) A004 Spot 36



(d) B011 Spot 46

Figure 10: Fraction of time that a spot contained at least one saturated strip, against run number.

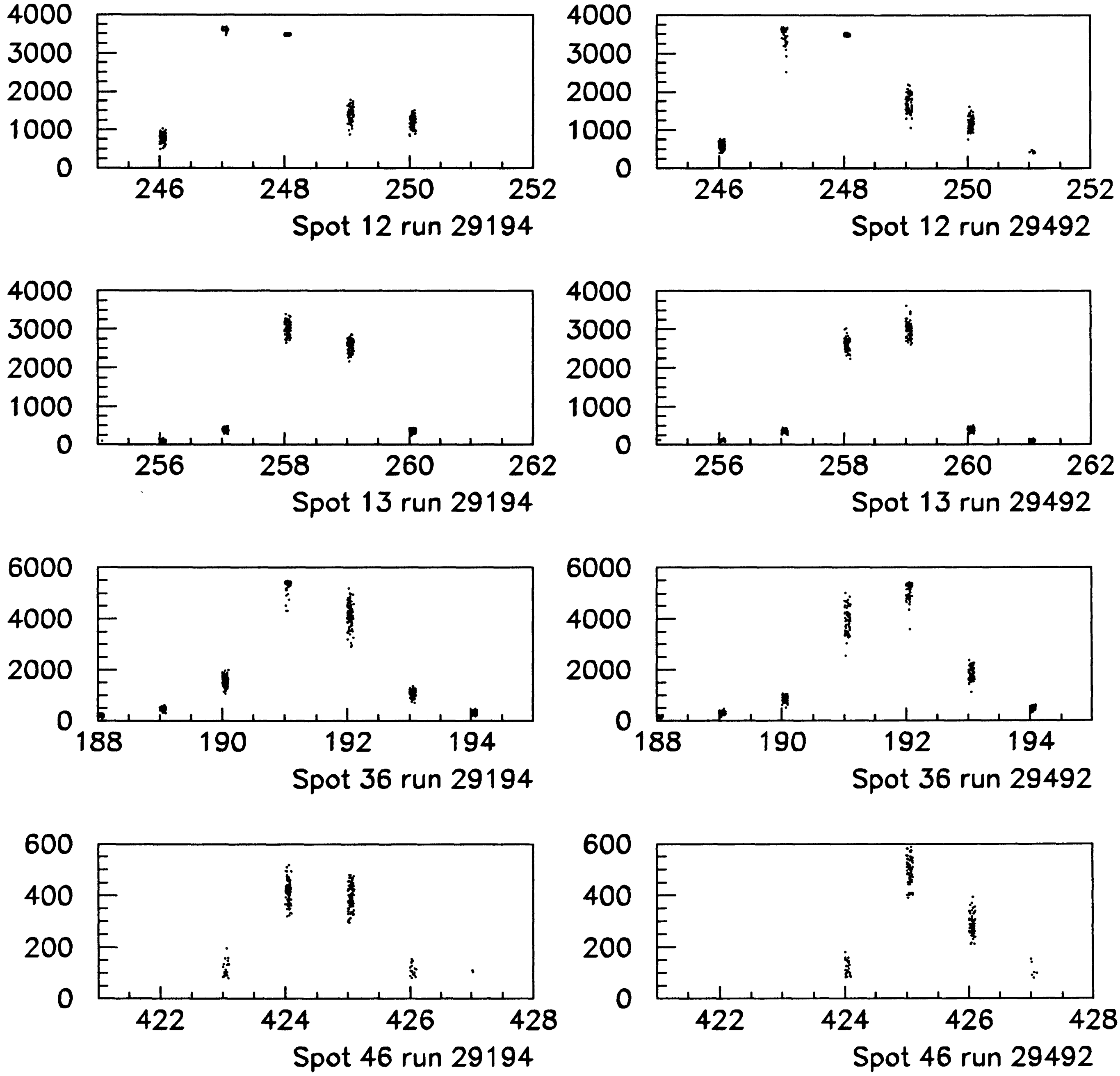


Figure 11: Pulse height against strip number for representative spots for run 29194 (before shift) and run 29492 (during shift).

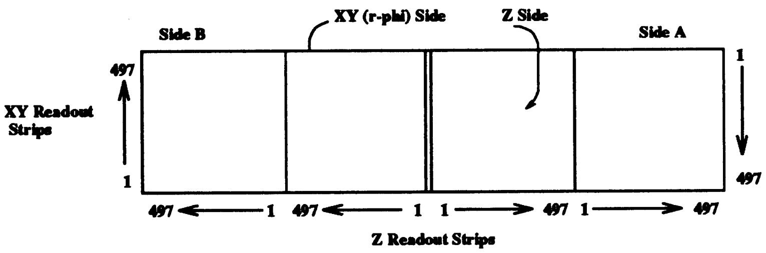


Figure 12: Numbering of VDET strips.

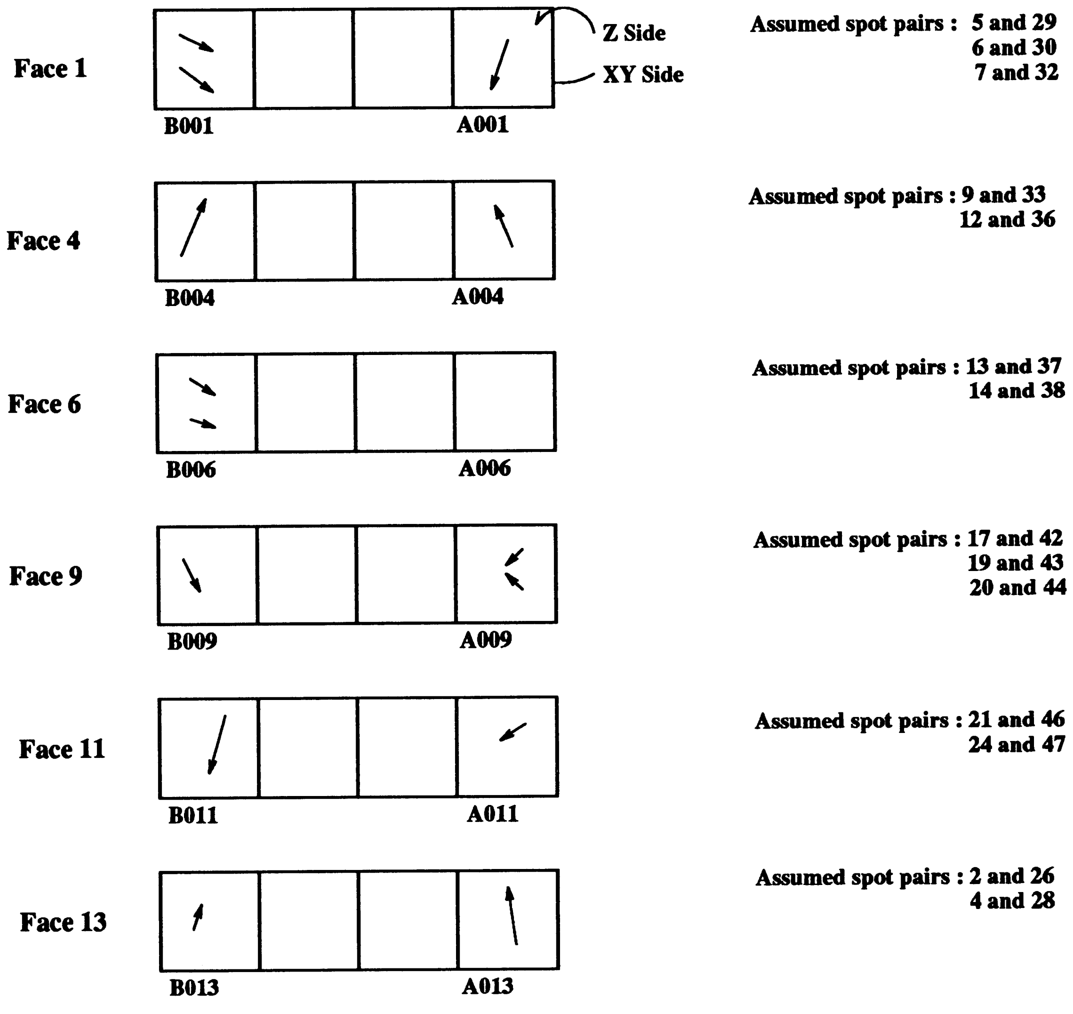


Figure 13: Possible movements of VDET faces.

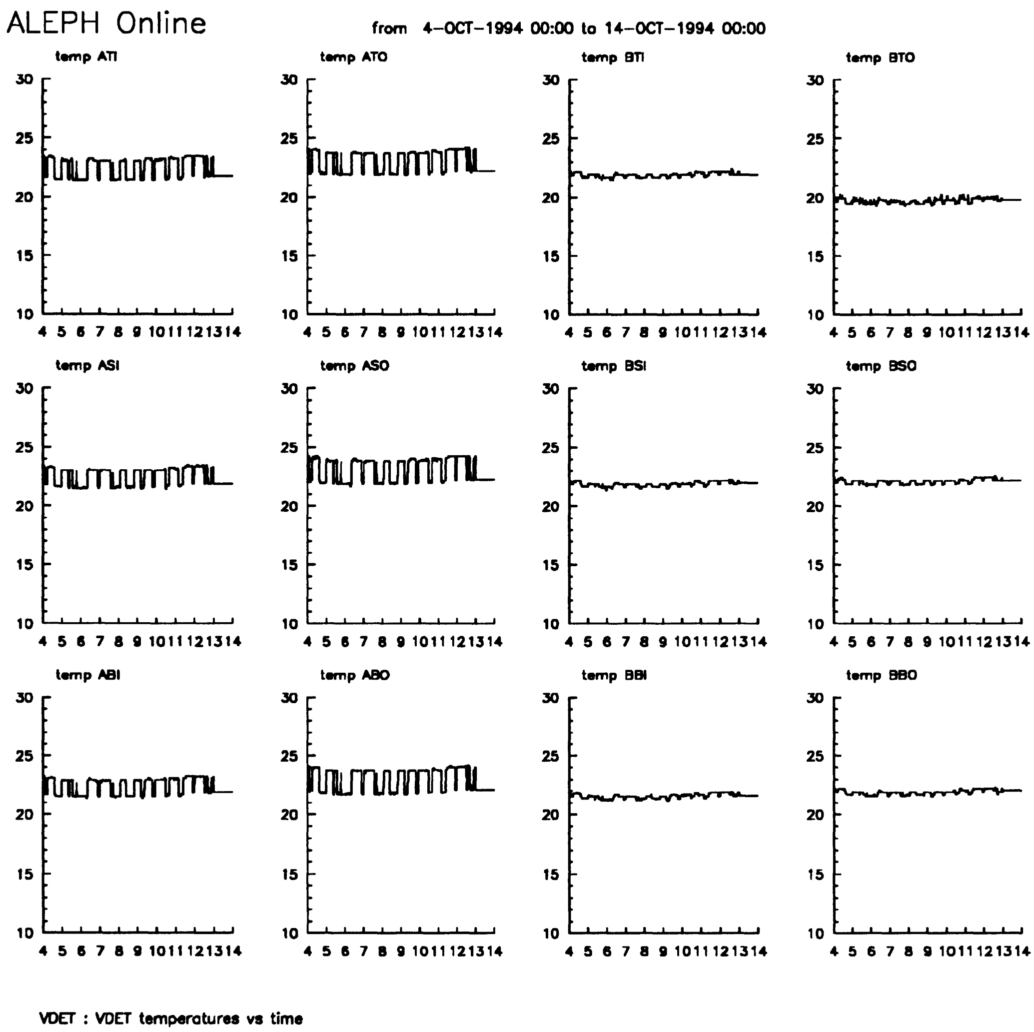


Figure 14: ALEPH presenter plots of VDET temperatures from 4th to 14th October.

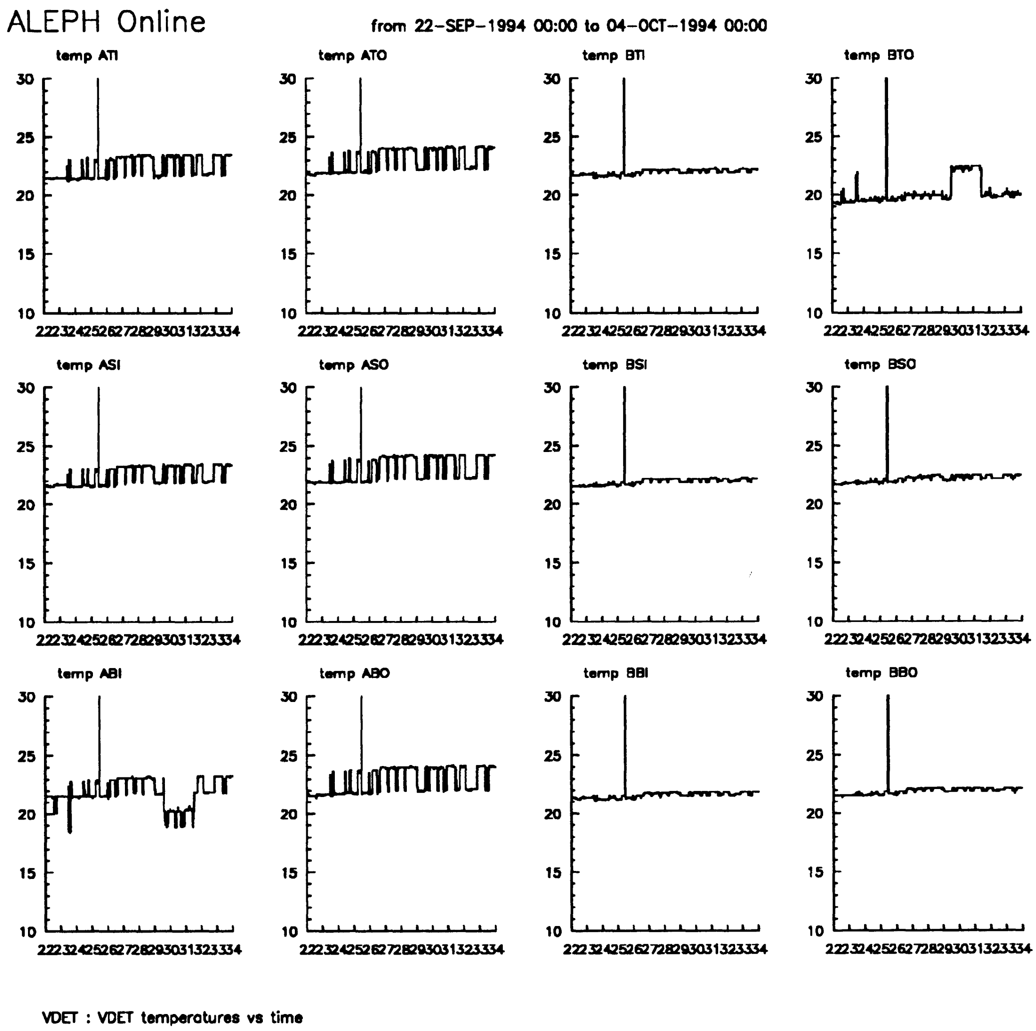
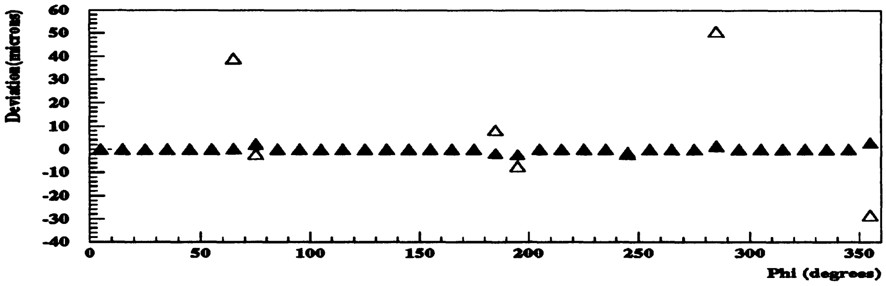
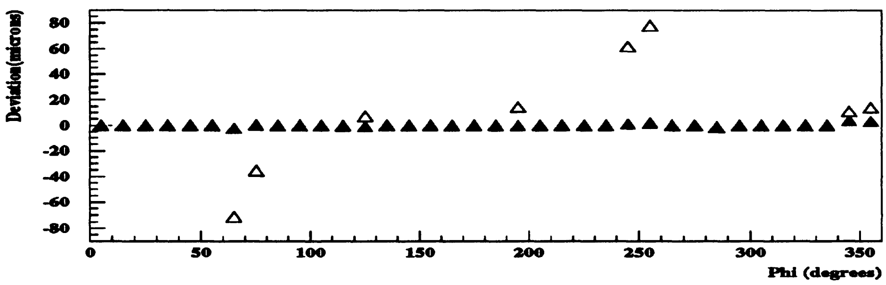


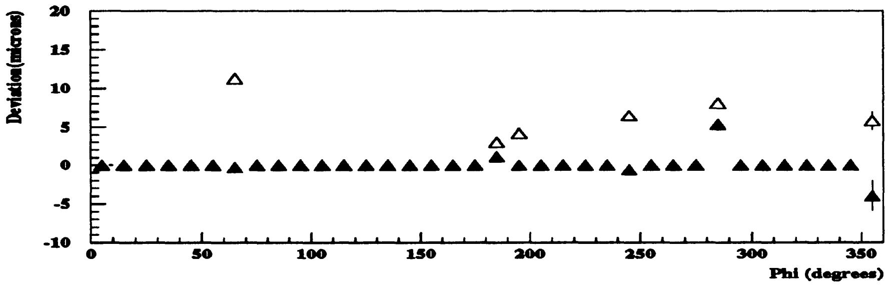
Figure 15: ALEPH presenter plots of VDET temperatures from 22nd September to 4th October.



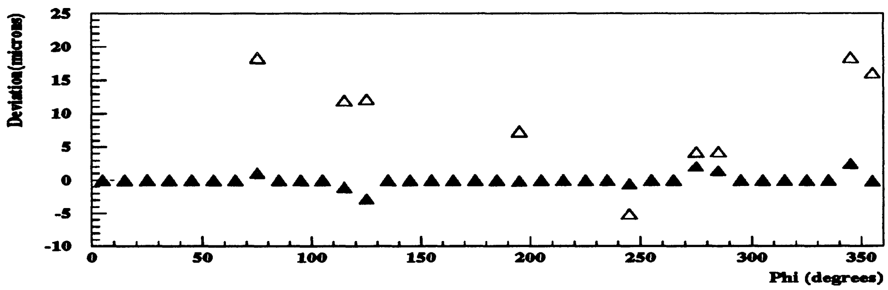
(a) XY deviation vs ϕ, side A



(b) XY deviation vs ϕ, side B

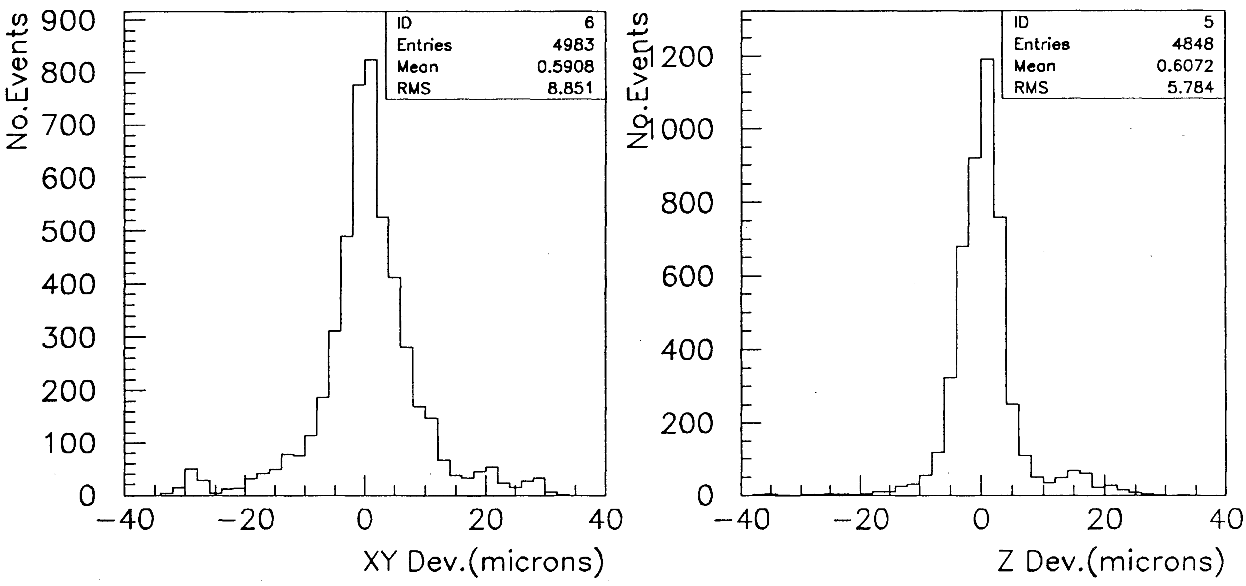


(c) Z deviation vs ϕ, side A

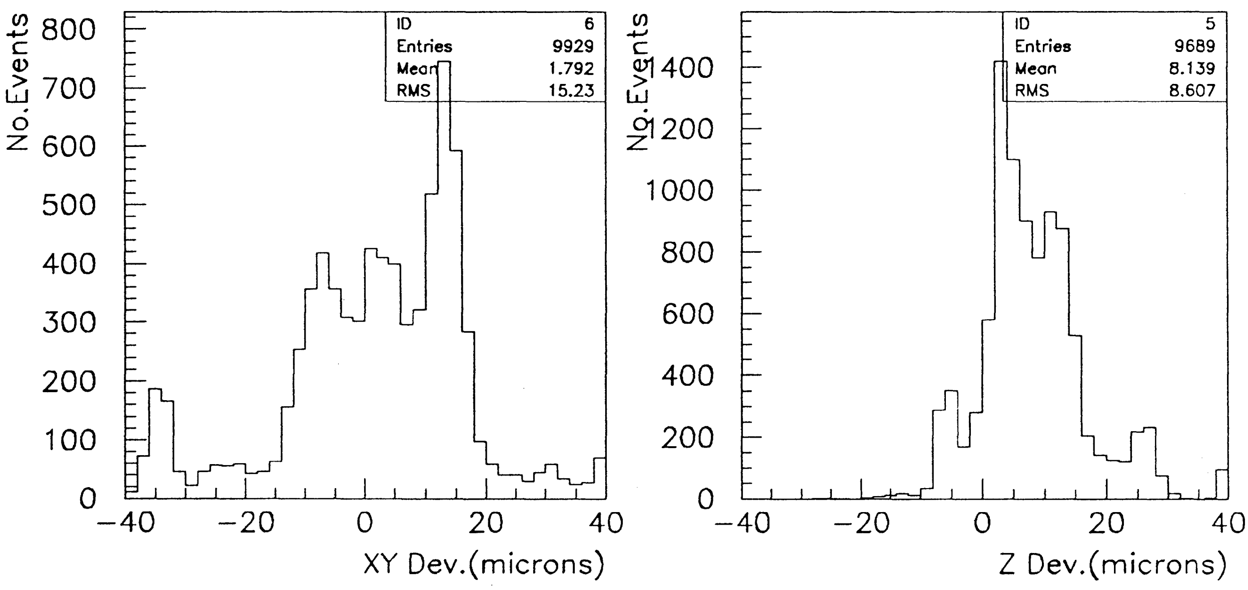


(d) Z deviation vs ϕ, side B

Figure 16: DQUAL Laser Plots of Deviation vs. ϕ(spot). (Solid triangles - runs 28496—28608, open triangles - runs 29508—29540)



(a) Distribution of deviations, runs 28496–28608



(b) Distribution of deviations, runs 29508–29540

Figure 17: DQUAL Laser Plots of Deviation Distributions.