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A Measurement of the Position of the Fiducials on Bubble Chamber Film

Introduction

Using the measurements of HPD 1 on pictures of stopping anti-protons in the 81 cm Saclay bubble chamber (taken about February 1965), a study was made of the relative coordinates of the fiducials in the frames of a roll. The deviation of each fiducial from a mean position was plotted, both for the X and for the Y direction. The result is thought to be a test for the quality of the roll.

The method

Initially, following a suggestion of Peter Villemoes, a comparison was made between the measured fiducials and a fixed system of fiducial coordinates, allowing a translation for the whole, in the X and the Y directions. These translations are found by calculating the translation of each fiducial of a certain frame and taking the mean value. The individual translations are compared with this mean value and then deviations from the mean of more than 3 least counts, (one least count is equal to 2.54 microns), are excluded from the sample which determines the next approximation of the mean translation. In fact this is done step by step by excluding the worst value in each step. After the determination of the mean translation in X and Y directions, the difference between this mean value and the translation for each fiducial is calculated. These values are plotted for each roll using the SUMX program (applied to the SMOG output tape).

The result of the first run is in general not particularly good, because the fixed system of fiducial coordinates is itself different for each roll. If a wrong set of given positions is chosen, the translation of the different fiducials are different and the method of finding the mean translation does not work very well. But from the first run a better approximation is obtained for the coordinates of the fixed frame. These values are in general accurate enough so that the second run gives the final result.

Output of the program

For each roll a set of histograms was produced giving the position for each fiducial with respect to the mean position. This was done for each view, for X and Y directions. Moreover a set of cards was punched with the X and Y coordinates of each fiducial and the root mean square value of the distribution. For stable fiducials this value is 1 or 2 least counts (Fig. 1), for moving fiducials much higher values can be obtained, of more than 10 least counts, as shown in Fig. 2. A complication arises by the fact that in some cases (in about 0.2 % of all measurements) the HAZE program finds completely wrong fiducials. This is perhaps caused by crossing tracks or scratches or dust on the film or something like that. To exclude these values from the sample, all deviations from the mean translation, bigger than 30 least counts, are excluded from the histograms and from all calculations.

The punched cards are used as input for the program LIST which makes a list of the coordinates of the fiducials for each roll with respect to one of them, which is taken as origin of the system. Also the root mean square values of the distributions are printed in the list. A comparison is made with the THRESH titles. Because the result is also written on tape, the SUMX program can again be applied to give an overall picture. In this way the histogram of Fig. 3 has been obtained in which all root mean square values from 30 rolls are plotted.

Conclusions for the quality of the rolls

To say something about the result for 30 rolls, we will use the units used in the THRESH titles, obtained from the program PYTHON. The translation from least counts (on the film) into these units (on a virtual front glass) is done by a multiplication factor. The THRESH program accepts deviations of the position of the fiducials from a given value up to 0.4 mm. We call a fiducial "bad" when the root mean square value of the histogram for X or Y coordinates exceeds 0.2 mm, and this has given the following bad fiducials (Table 1):

Table 1

Fiducial	View	Number of rolls (out of 30)
4	1	1
4	3	2
6	2	1
7	1	1

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The numbers of the fiducials on front and backward glass are given in Fig. 4. Also the positions on view 2 of the film are given there. The most important region of the film is between fiducials 7, 8 and 9. Since the interactions which occured in this region are those which are being measured.

The result for fiducial 7 is the worst because this is a central fiducial. Fiducial 6 will not influence the results by a significant amount as was proved by an investigation of Philippe Gavillet (appendix 1). Fiducial 4 is presumably more important, so we can conclude that out of a sample of 30 rolls, 4 have low quality and should be considered seperately in the study of the final results.

Cause for the movement of the fiducials

Ten frames of roll 5261, which has the worst fiducial movement of this experiment (fiducial 6 in view 2), were also measured on the IEP, to look if the effect of moving was caused by the HPD itself. The distance in X and Y coordinates between fiducials 6 and 7 and between 5 and 7, were compared in these 10 frames for HPD and IEP measurements. To make the comparison (in Table 2) easier, the deviations are given relative to the distance observed in one of the frames.

Table 2

Frame	Fid 6 - Fid 7		Fid 5 - Fid 7	
	HPD (2.54μm)	IEP (2.54μm)	HPD (2.54μm)	IEP (2.54μm)
96	65	67	0	0
97	4	5	3	1
102	6	6	1	3
103	8	9	2	2
106	13	14	1	-1
107	4	8	3	1
108	24	17	2	6
109	27	20	1	4
111	0	0	3	3
112	25	19	1	9

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We drew the conclusion that the effect of the moving of fiducial 6 was found in the same way on HPD and IEP. It is thought that it might be caused by a bad functionning of the camera film gate.

Systematics in the moving of the fiducials

For roll 5201 a plot was made of the deviation of the position of the moving fiducial 4 from the mean position, as a function of the frame number. No correlation between the motion and frame number was found, the fiducial movements being completely irregular. (Fig. 5)

Further the direction of the motion in the XY plane was studied. As shown in Fig. 6 there is a special direction for the moving of the fiducials in one roll, but for different rolls the directions are often different. Sometimes there is a clear kink in the distribution (Roll 5225, view 3). One gets the impression that the moving of fiducials 4 and 0 are caused by a wrong functionning of the film gate of the camera. If the pressure on the end part of the film comes to early, the film will be shifted a bit, which will have a bigger effect for fiducial 4 than for fiducial 0 (see Fig. 4) but goes along the same line.

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APPENDIX 1

Some details concerning the investigation of fiducial 6, roll 5261, by Philippe Gavillet.

A comparison was made of the values of the momentum (p) and of the two angles in space (λ and φ) obtained both with fiducial 6 and without fiducial 6 in view 2. Also a comparison was made between the original values and the values obtained after suppressing view 2. Because deviations are only important if they are of the same order of magnitude as (or bigger than) the (external) errors of measurements, a plot was made of the differences observed, divided by the error of measurements. The root mean square values (σ) were calculated. Also the occurrence of a systematic shift of the mean value (Δ) of any one of the quantities was studied. The percentage of the frames (%) where the difference caused by suppressing a fiducial (or a view) is more than one root mean square value, is also given. In Table 3 all those values are given as a function of the value of the fiducial residue (Res) found by THRESH.

Table 3

Res (mm)	Number of frames	p σ	p Δ	p %	λ σ	λ Δ	λ %	φ σ	φ Δ	φ %
0 - .8	3175	.45	-.09		.89	-.01		.15	.65	
0 - .2	1013	.10	-.01	.2	.15	-.01	.3	.12	-.02	.3
.2 - .4	1532	.44	-.12	4.8	.80	-.03	19.0	.80	.22	4.2
.4 - .6	561	.68	-.13	12.5	1.53	.04	28.7	.69	.25	11.4
.6 - .8	69	1.04	-.21	24.6	1.85	-.04	49.3	.83	.37	18.4
			suppressing view 2							
0 - .2	824	1.24	.02	15.7	1.38	.03	15.3	1.76	-.14	20.4

No difference was found between the deviations of positive and of negative tracks with RES .4 mm.

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In Table 4 the differences ($\Delta_1 - \Delta_2$) of the mean values for positive (Δ_1) and negative tracks (Δ_2), are compared with the calculated errors (σ).

Table 4

Res. (min.)	P		λ		φ	
	$\lvert\Delta_1-\Delta_2\rvert$	σ	$\lvert\Delta_1-\Delta_2\rvert$	σ	$\lvert\Delta_1-\Delta_2\rvert$	σ
0 - 0.2	0.006	0.0058	0.01	0.012	0.04	0.080
0.2- 0.4	0.02	0.025	0.02	0.055	0.02	0.040

This roll will not be used for the measurement of the invariance of strong interaction for charge conjugation, but it will be used for investigations of invariant mass plots and so on.

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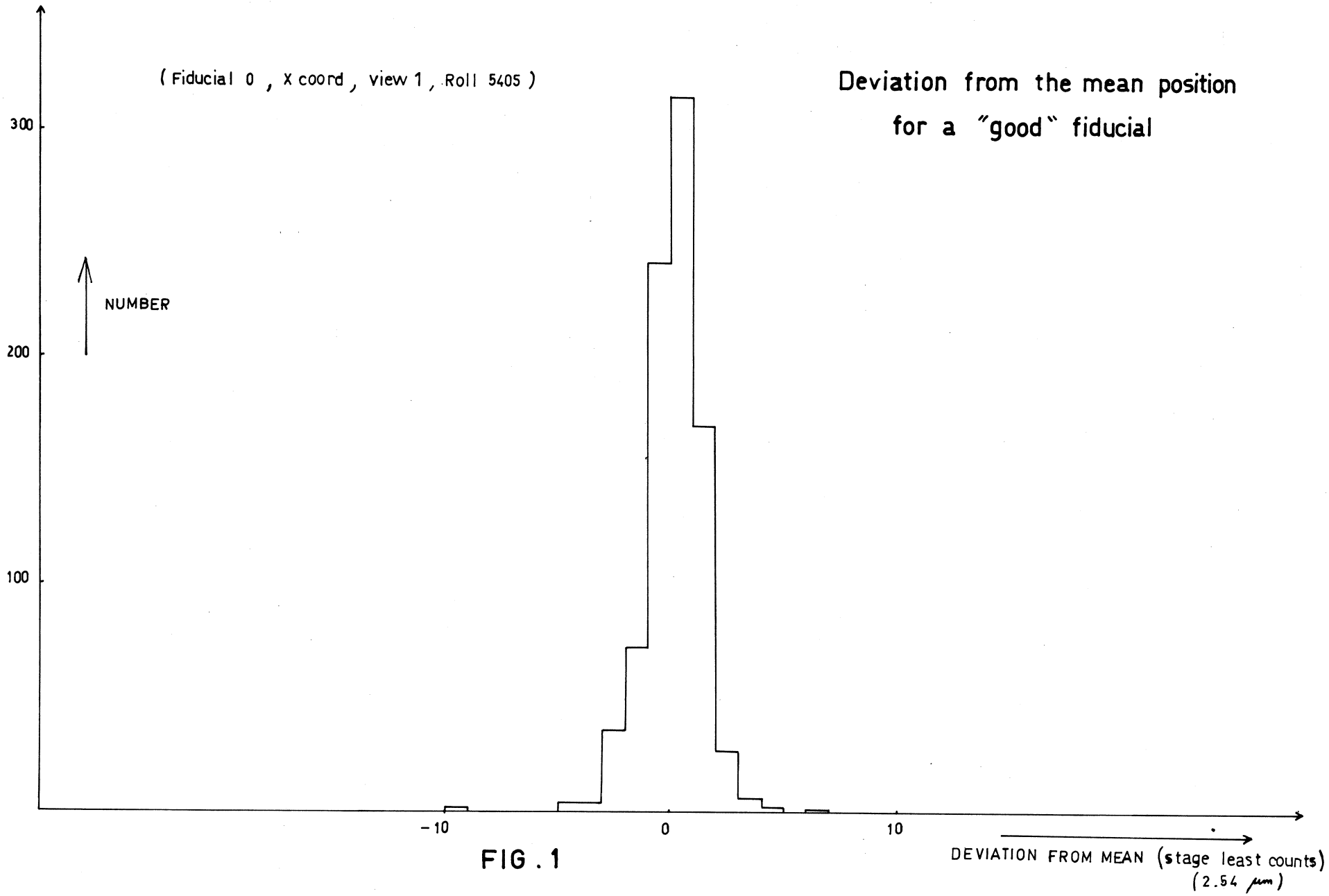


FIG . 1

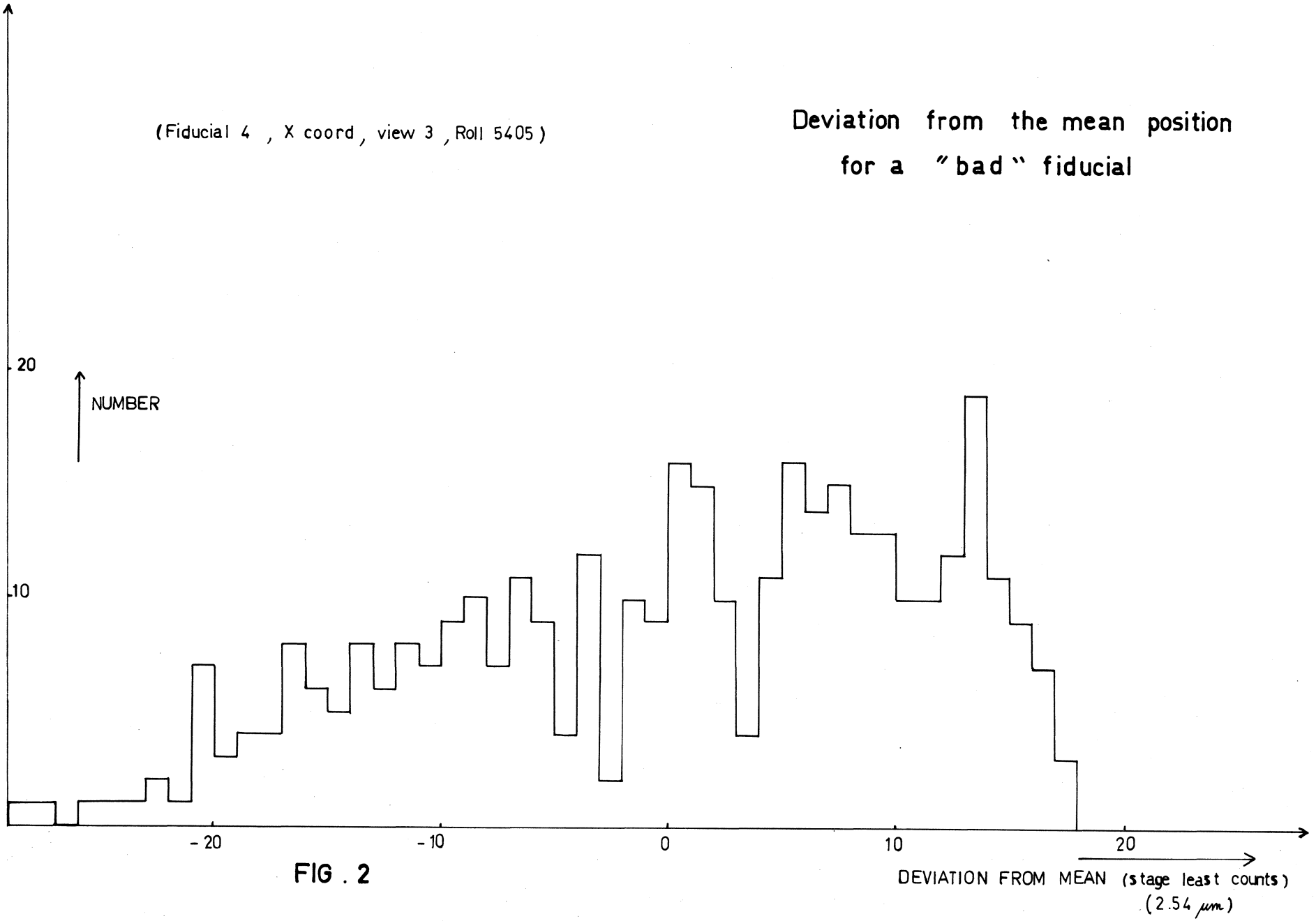

(Fiducial 4 , X coord , view 3 , Roll 5405)
Deviation from the mean position
for a "bad" fiducial
20
NUMBER
10
-20
-10
0
10
20
DEVIATION FROM MEAN (stage least counts)
(2.54 μm)

FIG . 2

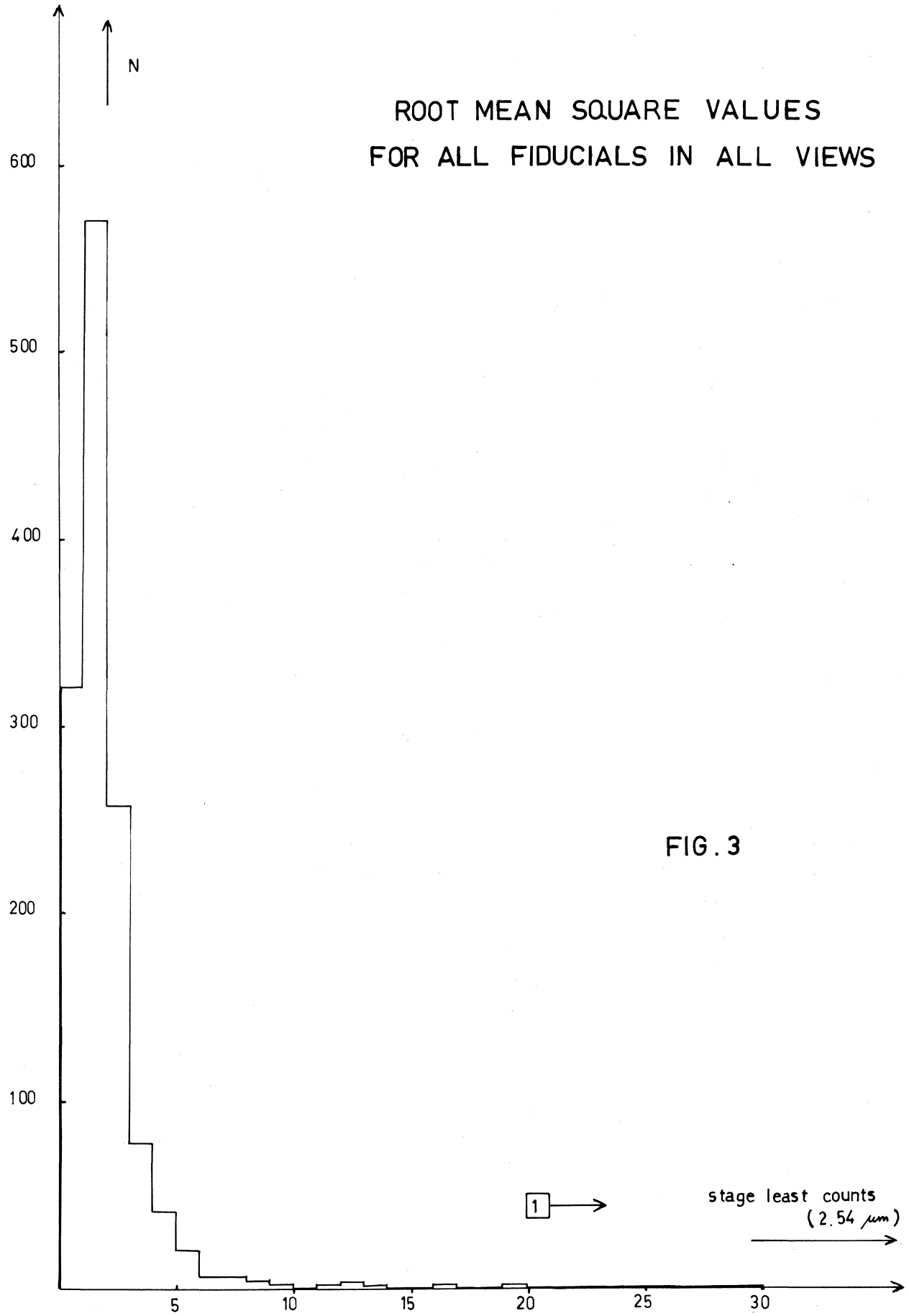
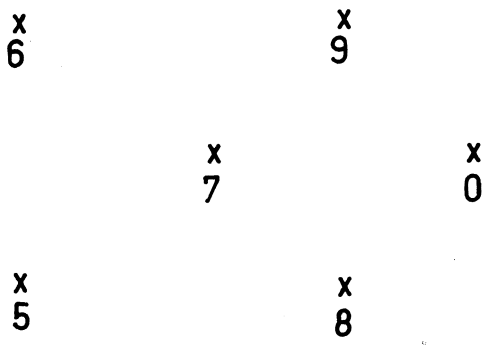
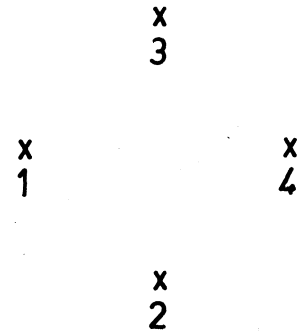

ROOT MEAN SQUARE VALUES
FOR ALL FIDUCIALS IN ALL VIEWS
N
600
500
400
300
200
100
1
stage least counts
(2.54 μm)
5
10
15
20
25
30

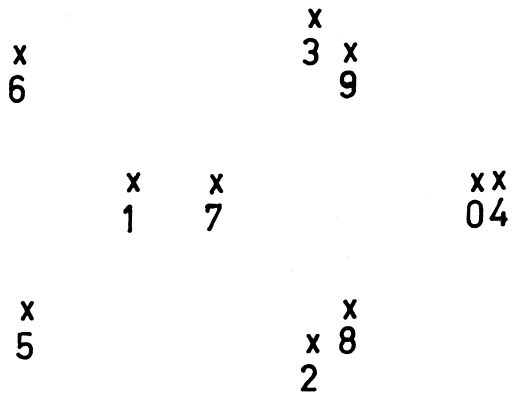
FIG. 3



Backward glass plate



Forward glass plate

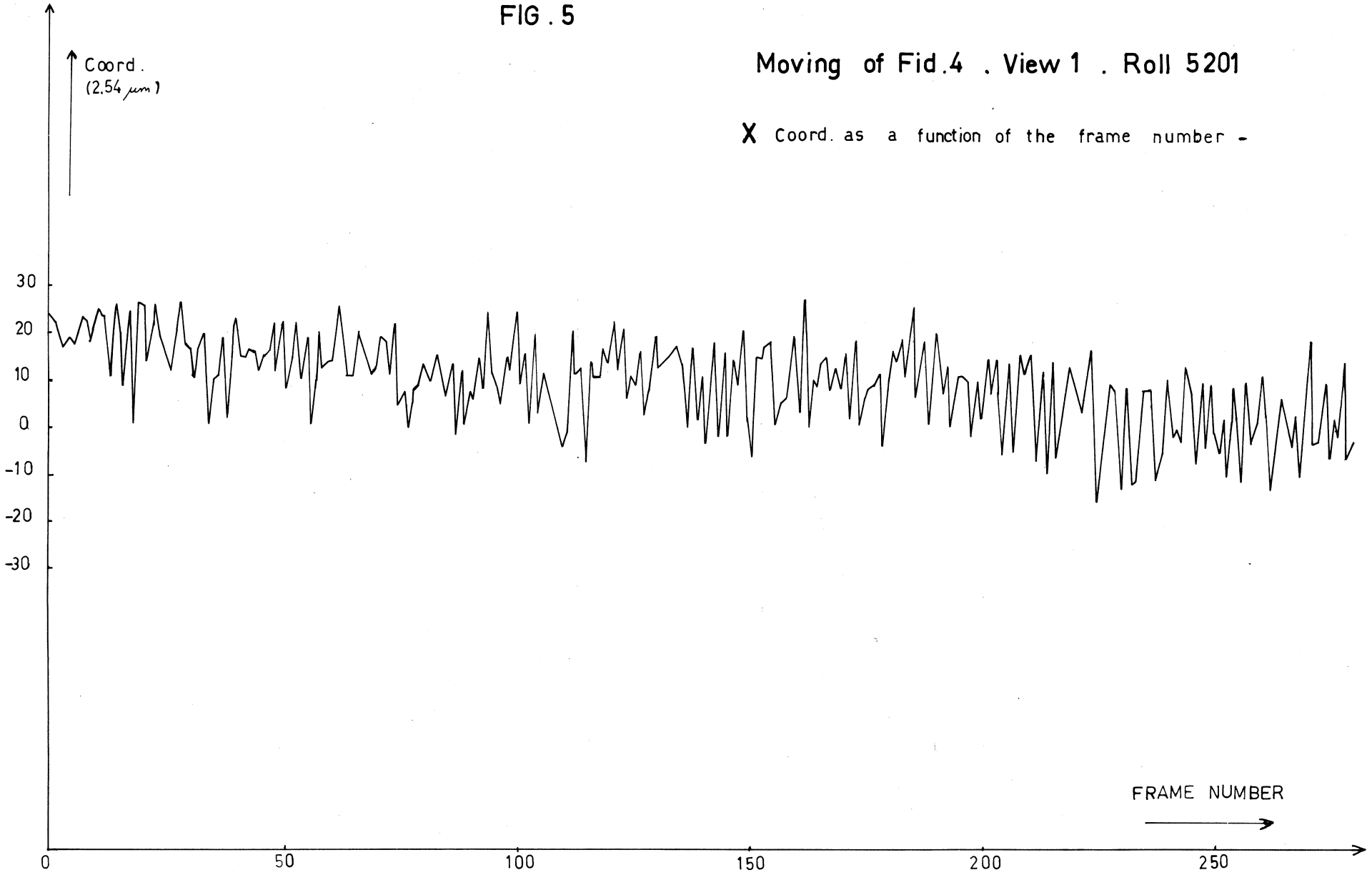


Fiducials in view 2

FIG 4

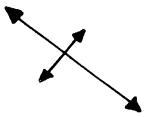
Position of the fiducials

FIG . 5

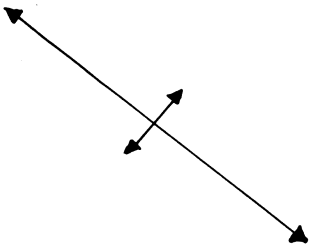

Moving of Fid.4 . View 1 . Roll 5201
X Coord. as a function of the frame number -
Coord.
(2.54 μm)
30
20
10
0
-10
-20
-30
0
50
100
150
200
250
FRAME NUMBER

Roll 5201

view 1



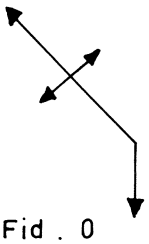
Fid . 0



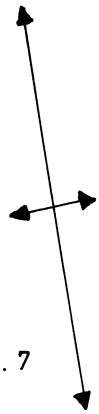
Fid . 4

Roll 5237

view 1



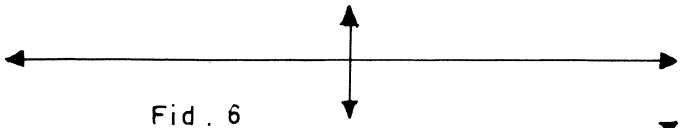
Fid . 0



Fid . 7

Roll 5261

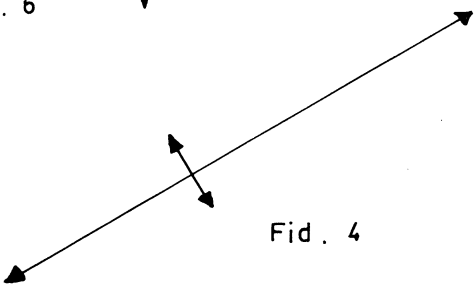
view 2



Fid . 6

Roll 5405

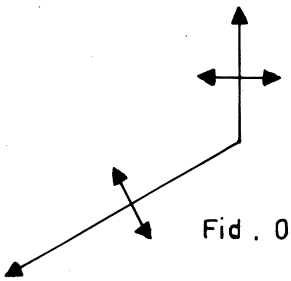
view 3



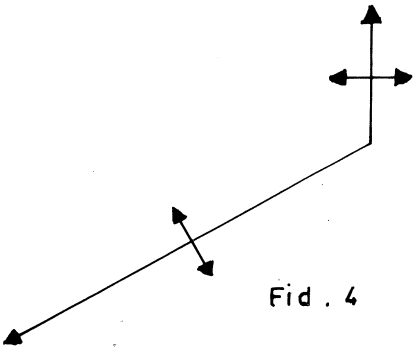
Fid . 4

Roll 5225

view 3

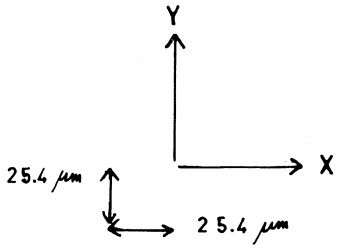


Fid . 0



Fid . 4

FIG . 6



DIRECTION OF MOVING IN THE XY PLANE