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Space and momentum distributions of pions and kaons from $A_{\pi^+K^-}$

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Abstract

Pions and kaons from $A_{\pi^+K^-}$ breakup were simulated in the DIRAC setup. Events were selected if π^+ and K^- were detected by all drift chambers. Space distributions and correlation plots were obtained in dounstream detector planes. Pions and kaons were also traced through the spectrometer magnet and downstream detectors with AutoCAD. Simulated space distributions were transformed to AutoCAD and compared with the tracing results. It is a good cross-check of simulation and tracing. The results obtained are useful for estimation of detector dimensions (especially new Cherenkov counters) in the modified DIRAC setup.

Contents

1 Simulation and AutoCAD tracing

Pions and kaons from $A_{\pi^+K^-}$ breakup simulated in the DIRAC setup. Events were selected if π^+ and K^- were detected by all drift chambers. Then different distributions were obtained in DC2, DC3, DC4 planes, in front of CH, in a plane 1 m downstream of the front plane of CH, in back side of CH and in PR. If pions and kaons decay or interact before a plane they are excluded from distributions.

Pions and kaons from $A_{\pi K}$ breakup were also traced with AutoCAD through the spectrometer magnet and downstream detectors. Momentum ranges of π and K detected by DC were determined.

Simulated π^+ and K^- space distributions were transformed to AutoCAD format and were attached to the downstream detectors (DC2, DC3, DC4, front of CH (CH1), 1 m downstream of the front of CH (CH2), back of CH (CH3), and PR). It is a good cross-check of simulation and tracing.

In simulated hystograms CH2 is marked as CH3 and CH3 is marked as CH2.

It was convenient to put in AutoCAD π^+ to the right arm and K^- to the left arm. So in AutoCAD π^- and K^+ space distributions are drawn.

Coordinate systems in simulation:
z – along the detector centres of the positive and negative arms,
x – along the detector planes from positive to negative arm,
y – verical coordinate from down to up.

Coordinate systems in AutoCAD:
y – along the detector centres of the positive and negative arms,
x – along the detector planes from left to right,
z – verical coordinate from down to up.

2 Pion x-distributions

Table 1 is extraction of boundaries, ranges, mean values and numbers of events from histograms 1, 2, 3, 4, 5, 6 and 7.

Table 1: *Pion x-boundaries, ranges, mean values, number of events and ratios.*

plane	x_1 cm	x_2 cm	Δx cm	mv cm	N	R
DC2	-32	+40	72	+14.96	2392421	1.000
DC3	-37	+52	89	+20.94	2392421	1.000
DC4	-42	+64	106	+27.23	2392421	1.000
CH1	-50	+82	132	+35.70	2245956	0.939
CH2	-60	+110	170	+47.65	2174851	0.909
CH3	-75	+160	235	+67.46	1935698	0.809
PR	-80	+175	255	+73.44	1916720	0.801

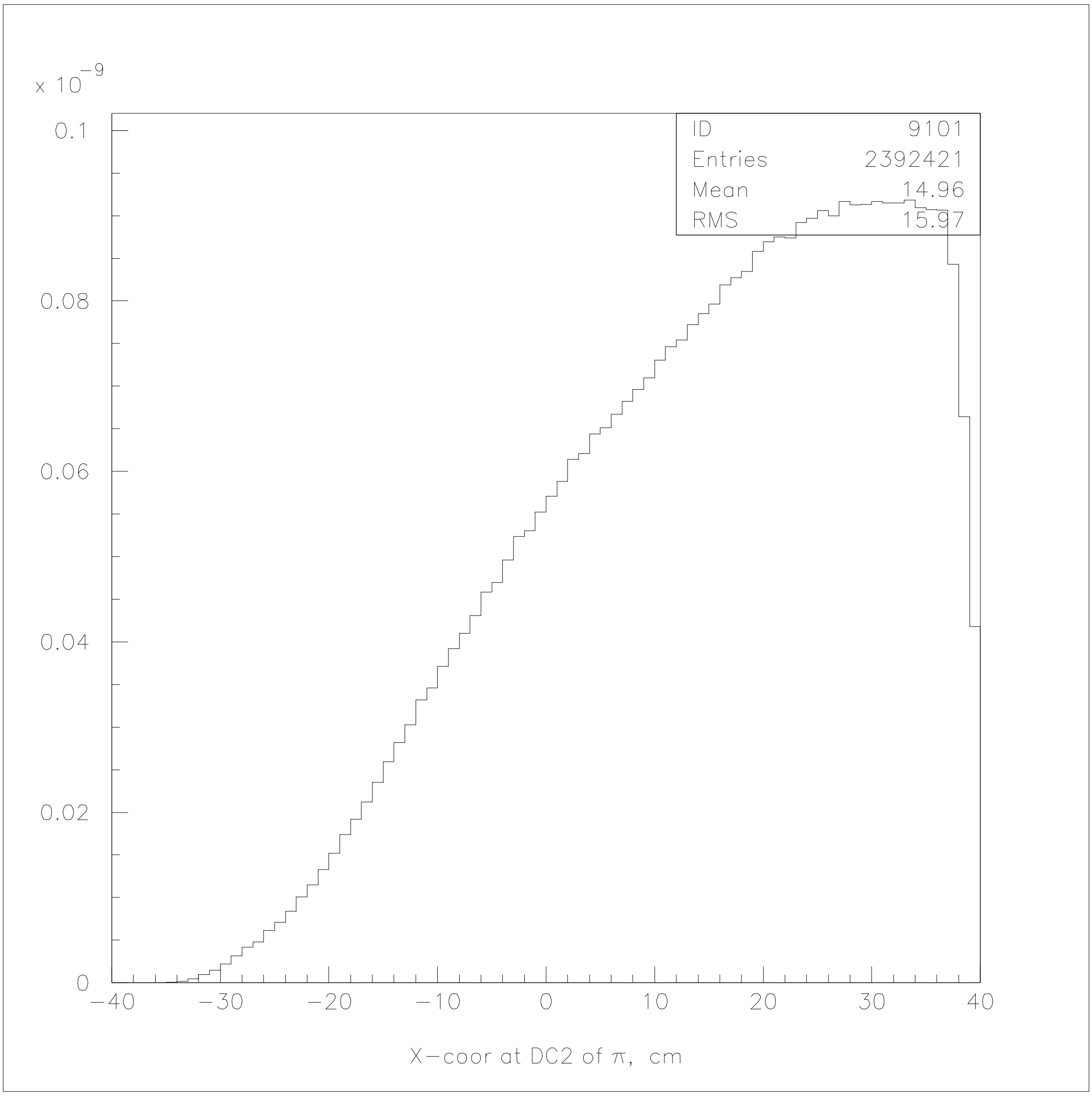

Figure 1: *Pion x-distribution in DC2.*

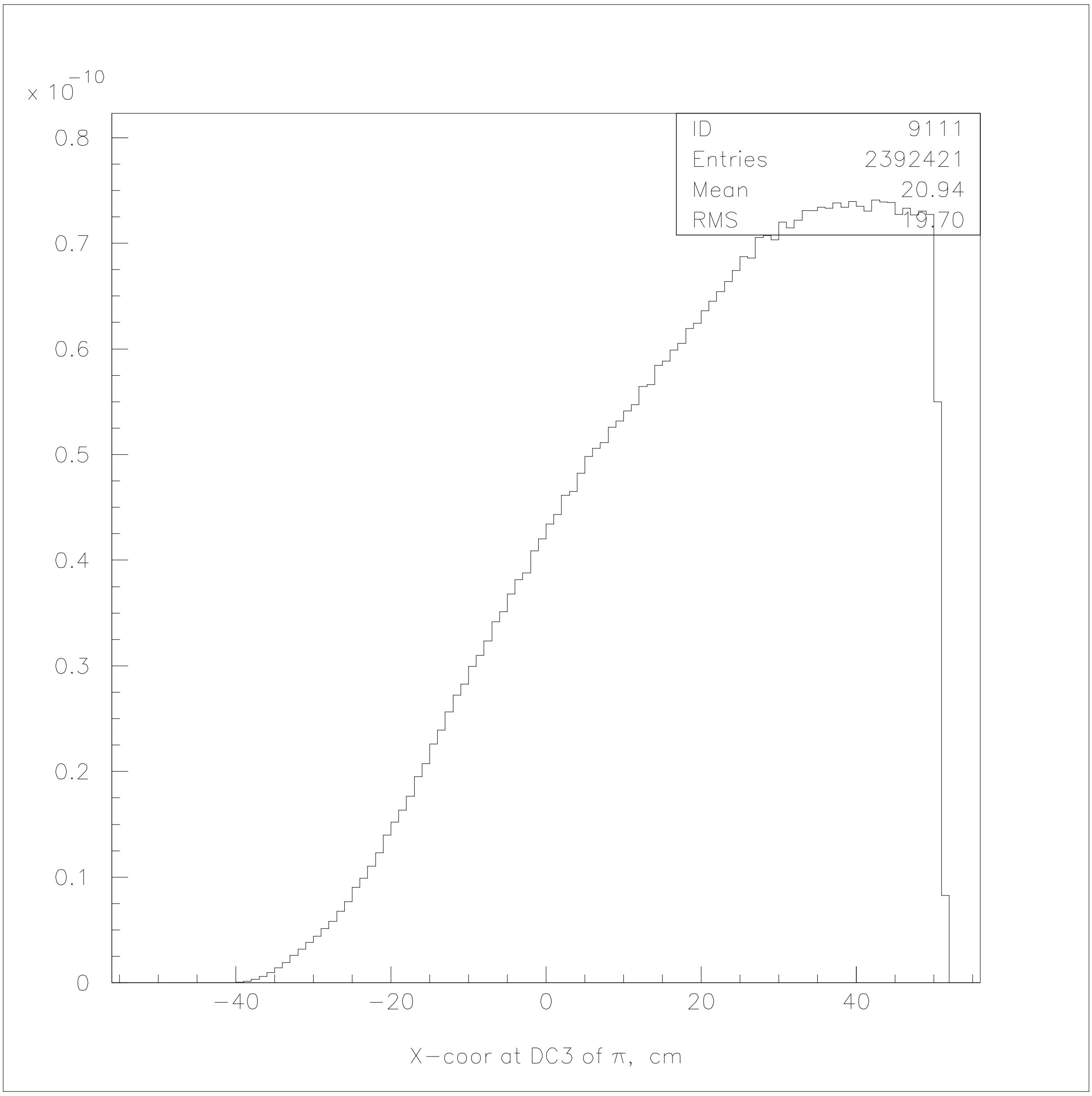

Figure 2: *Pion x-distribution in DC3.*

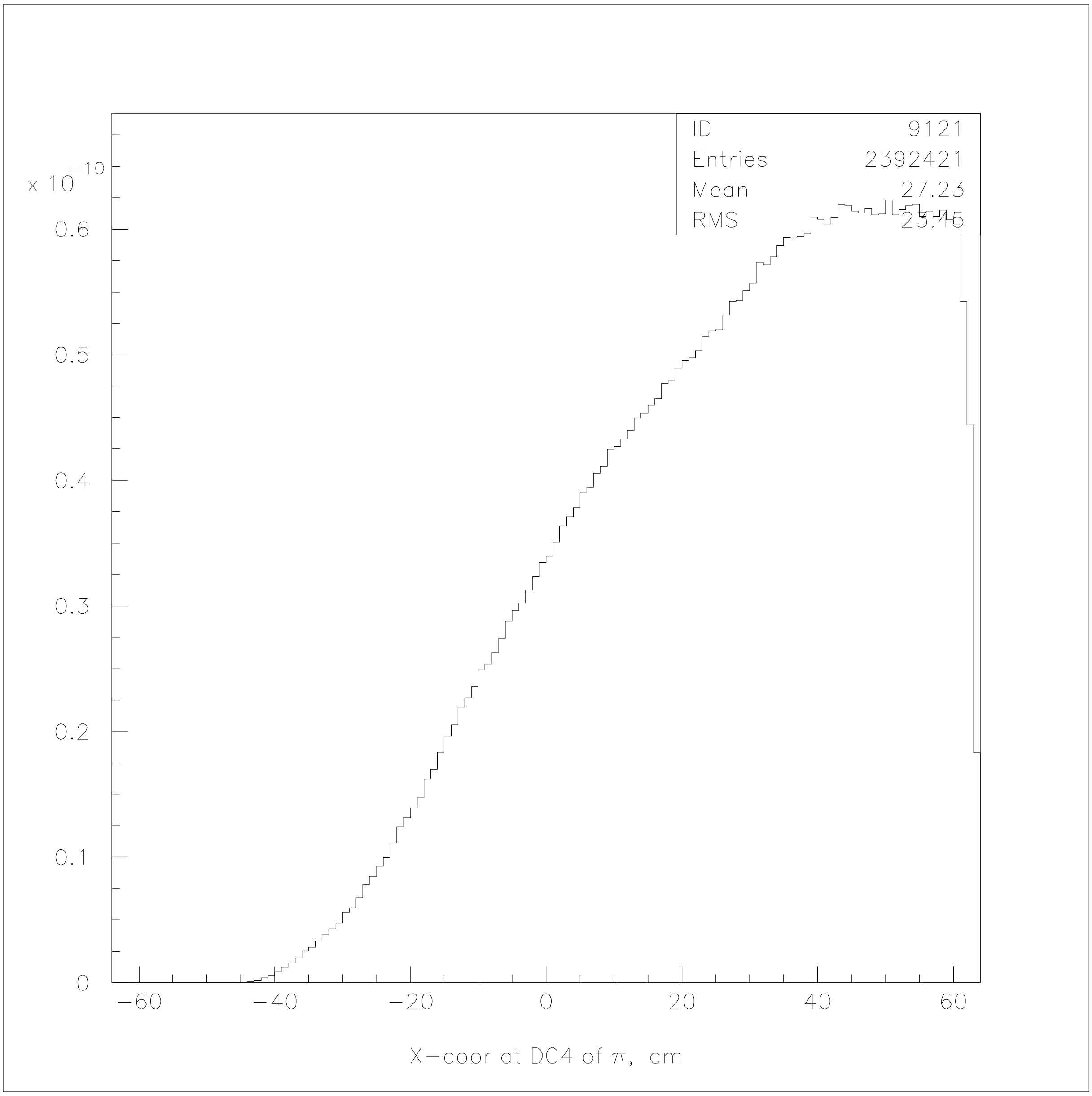

Figure 3: *Pion x-distribution in DC4.*

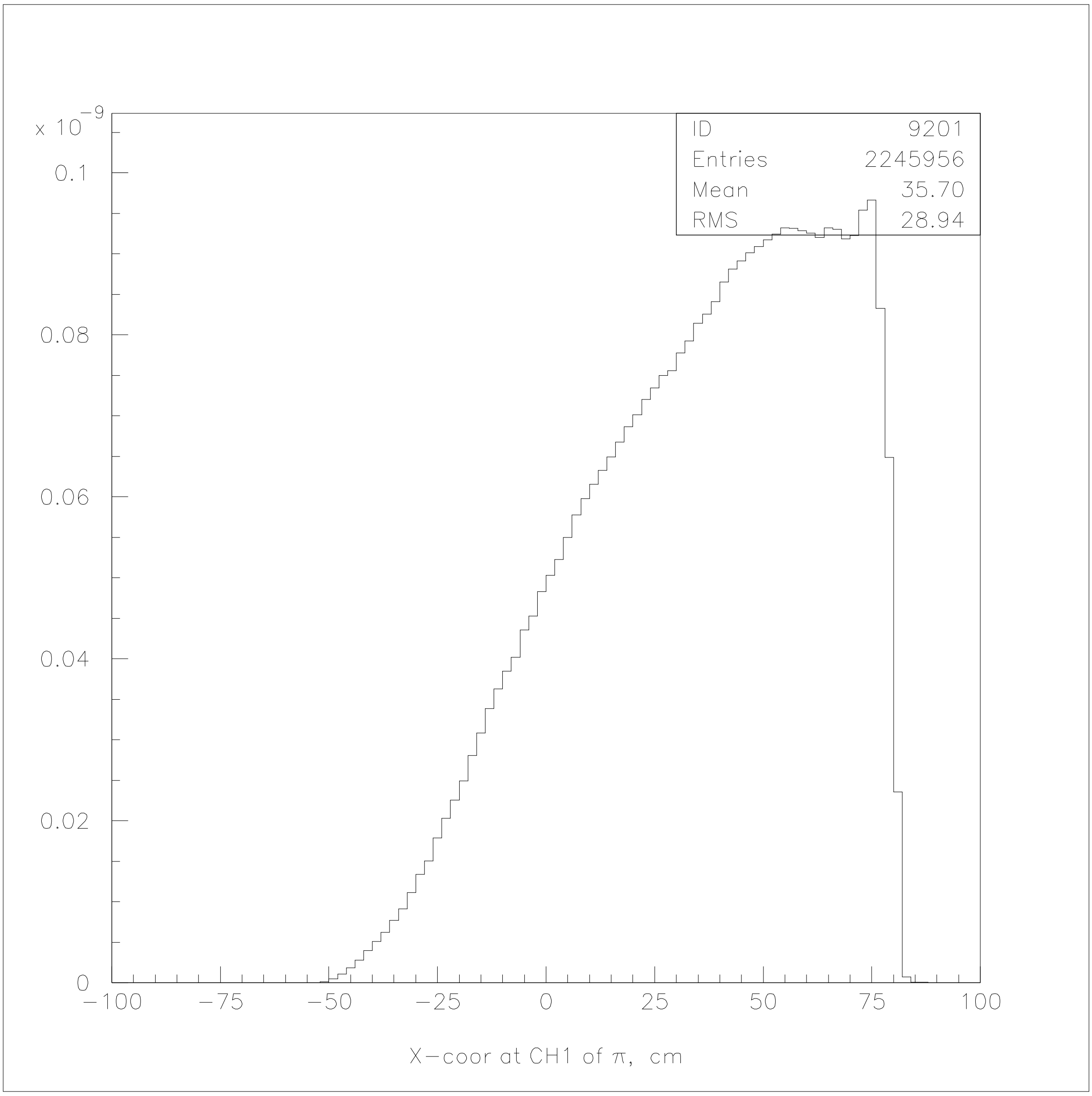

Figure 4: *Pion x-distribution in the front of CH (CH1).*

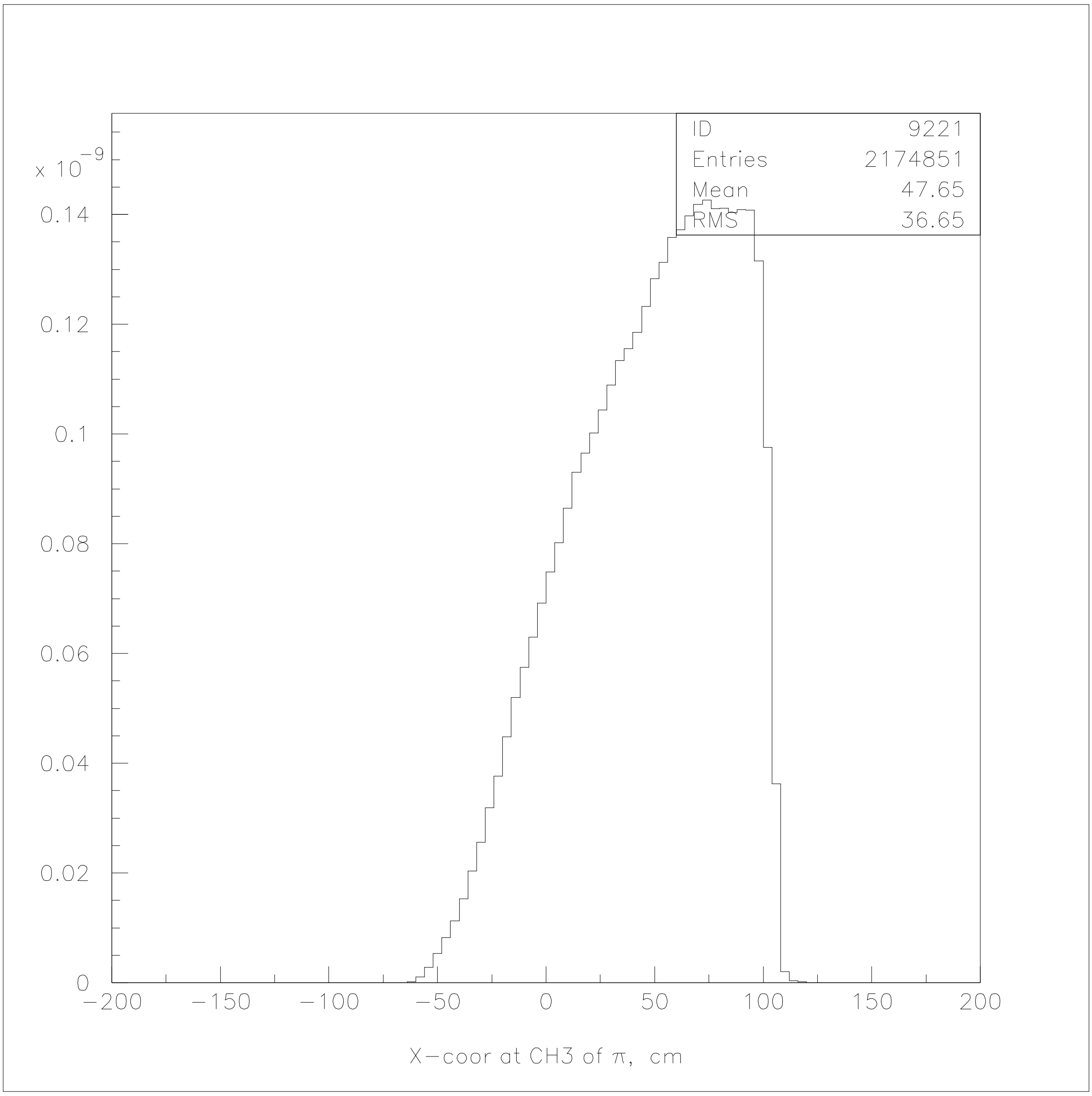

Figure 5: *Pion x-distribution in 1 m from the front of CH (CH2).*

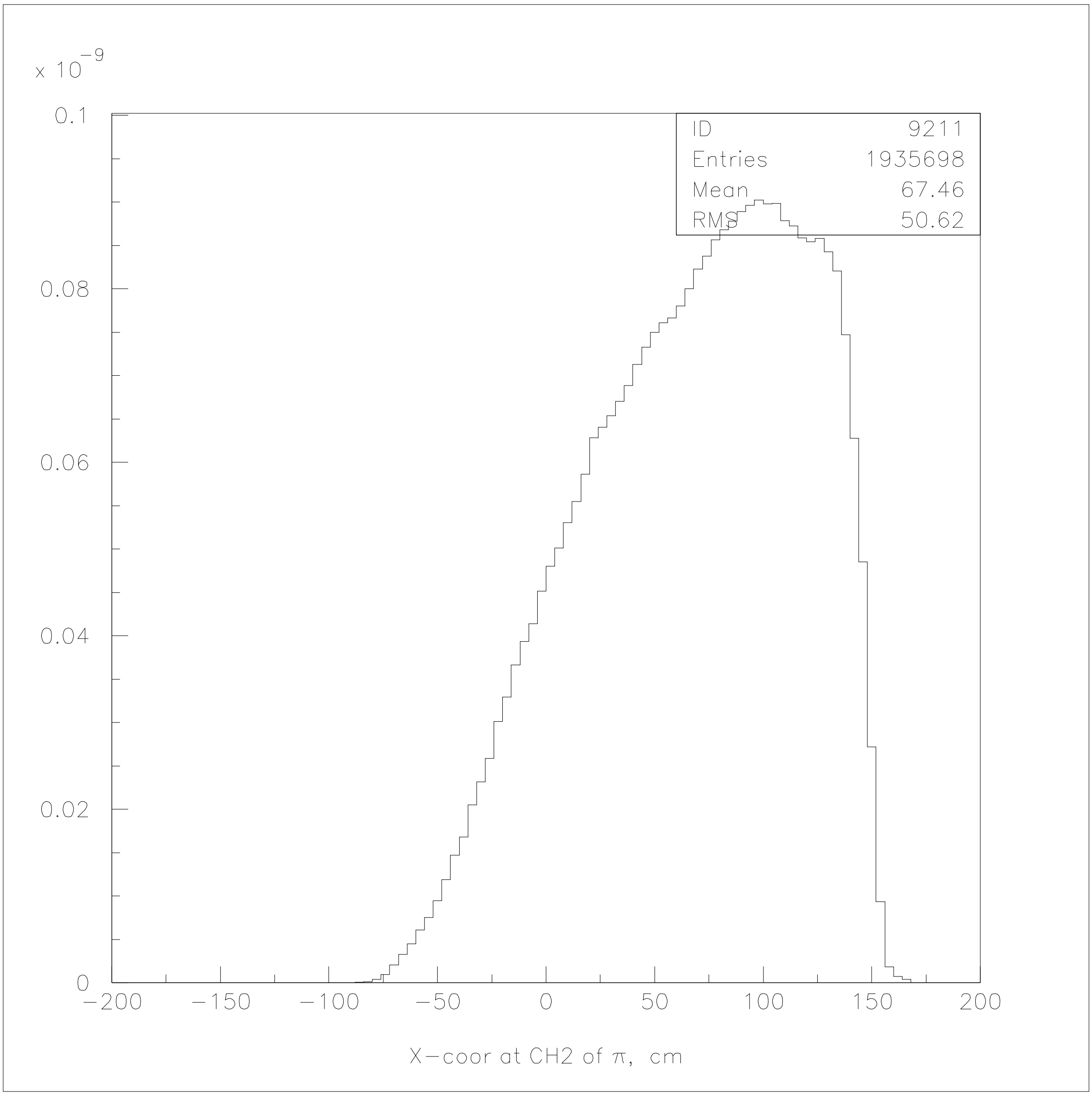

Figure 6: *Pion x-distribution in the back of CH (CH3).*

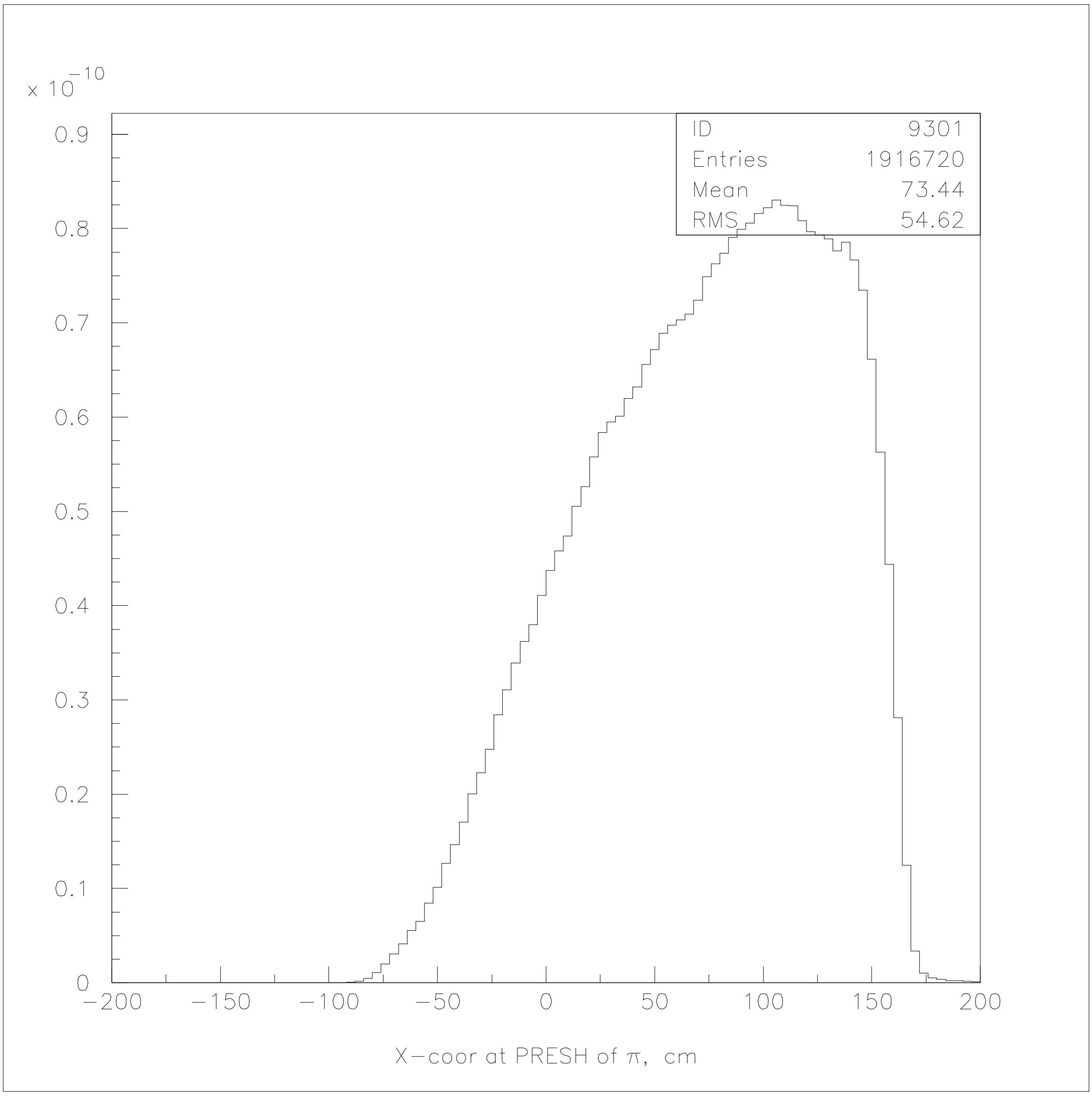

Figure 7: *Pion x-distribution in PR.*

3 Kaon x-distributions

Table 2 is extraction of boundaries, ranges, mean values and numbers of events from histograms 8, 9, 10, 11, 12, 13 and 14.

Table 2: *Kaon x-boundaries, ranges, mean values, number of events and ratios.*

plane	x_1 cm	x_2 cm	Δx cm	mv cm	N	R
DC2	+19	+40	21	+32.56	2392421	1.000
DC3	+26	+52	26	+42.57	2392421	1.000
DC4	+34	+64	30	+52.29	2392421	1.000
CH1	+46	+82	36	+66.89	2268528	0.948
CH2	+62	+107	45	+87.07	2172724	0.908
CH3	+88	+152	64	+123.50	1978202	0.827
PR	+95	+175	80	+133.80	1950366	0.815

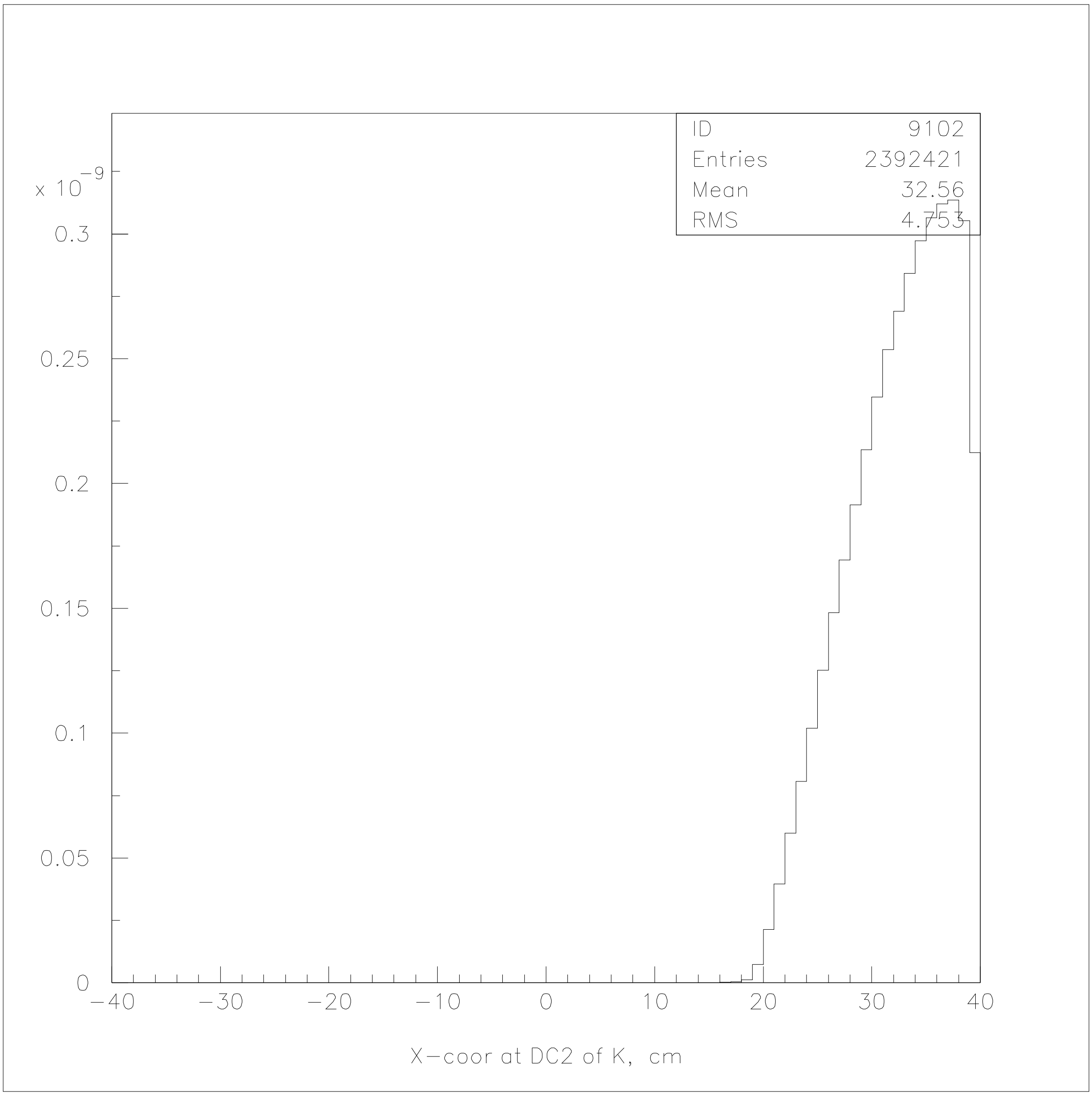

Figure 8: *Kaon x-distribution in DC2.*

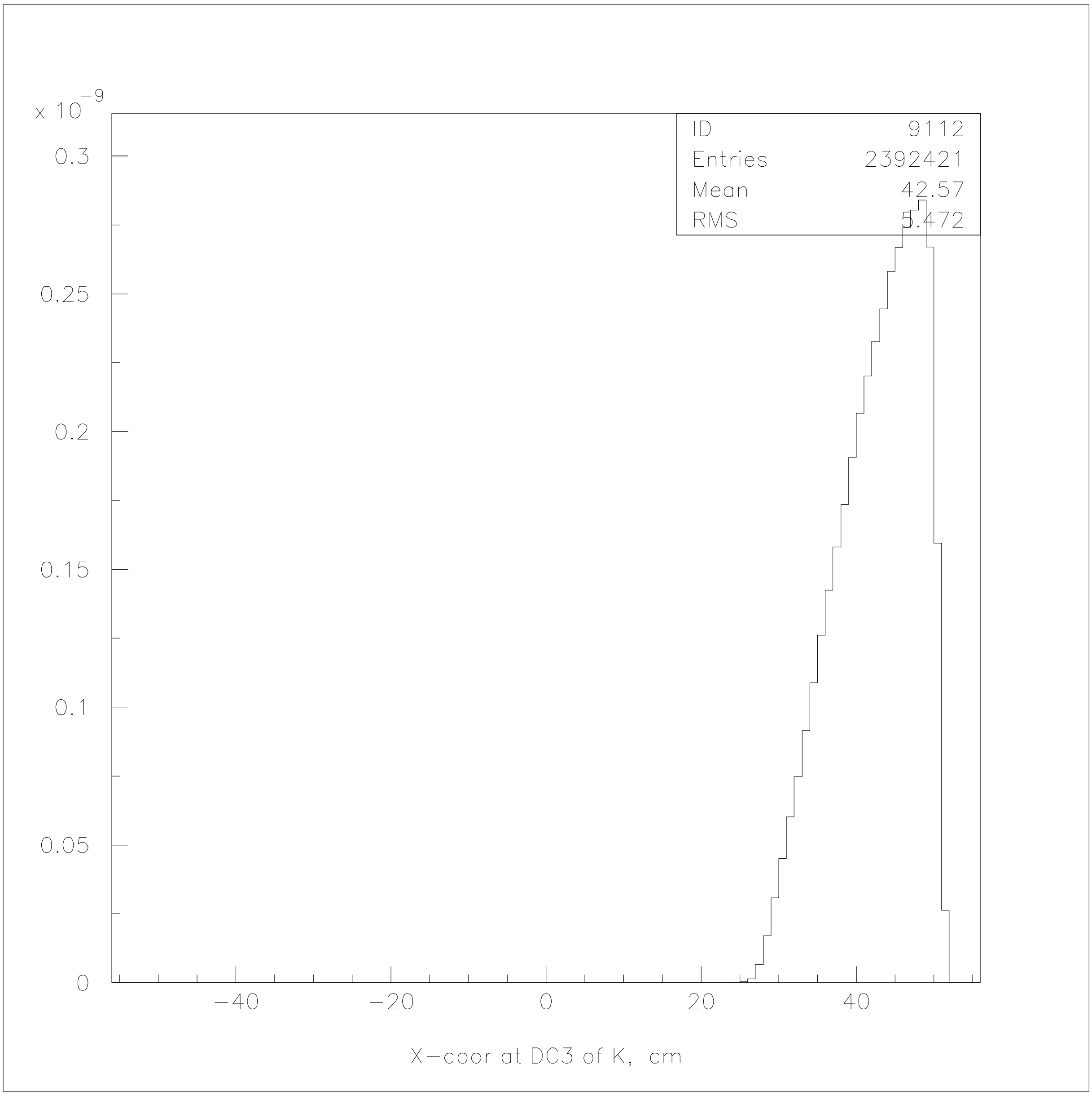

Figure 9: *Kaon x-distribution in DC3.*

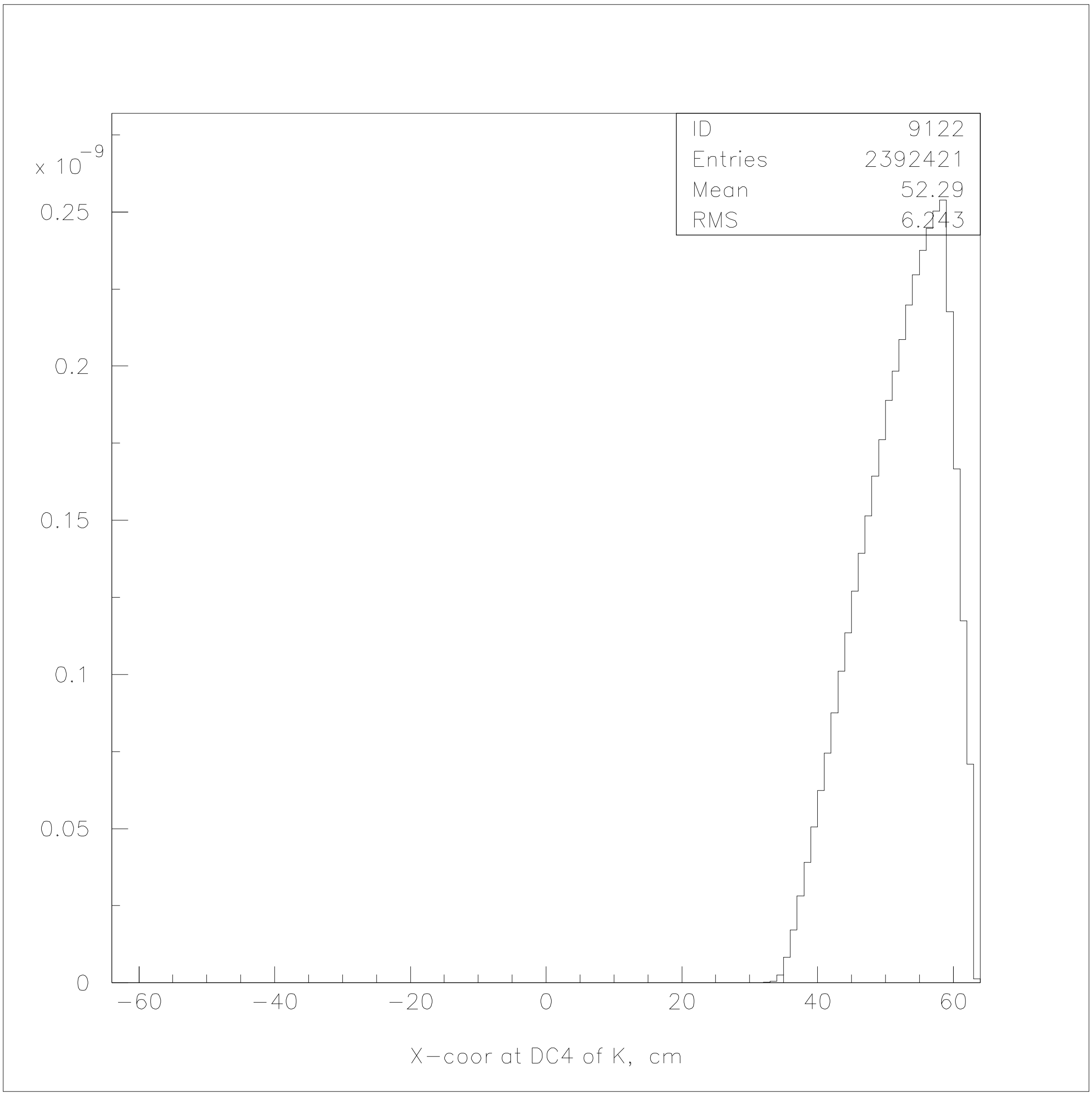

Figure 10: *Kaon x-distribution in DC4.*

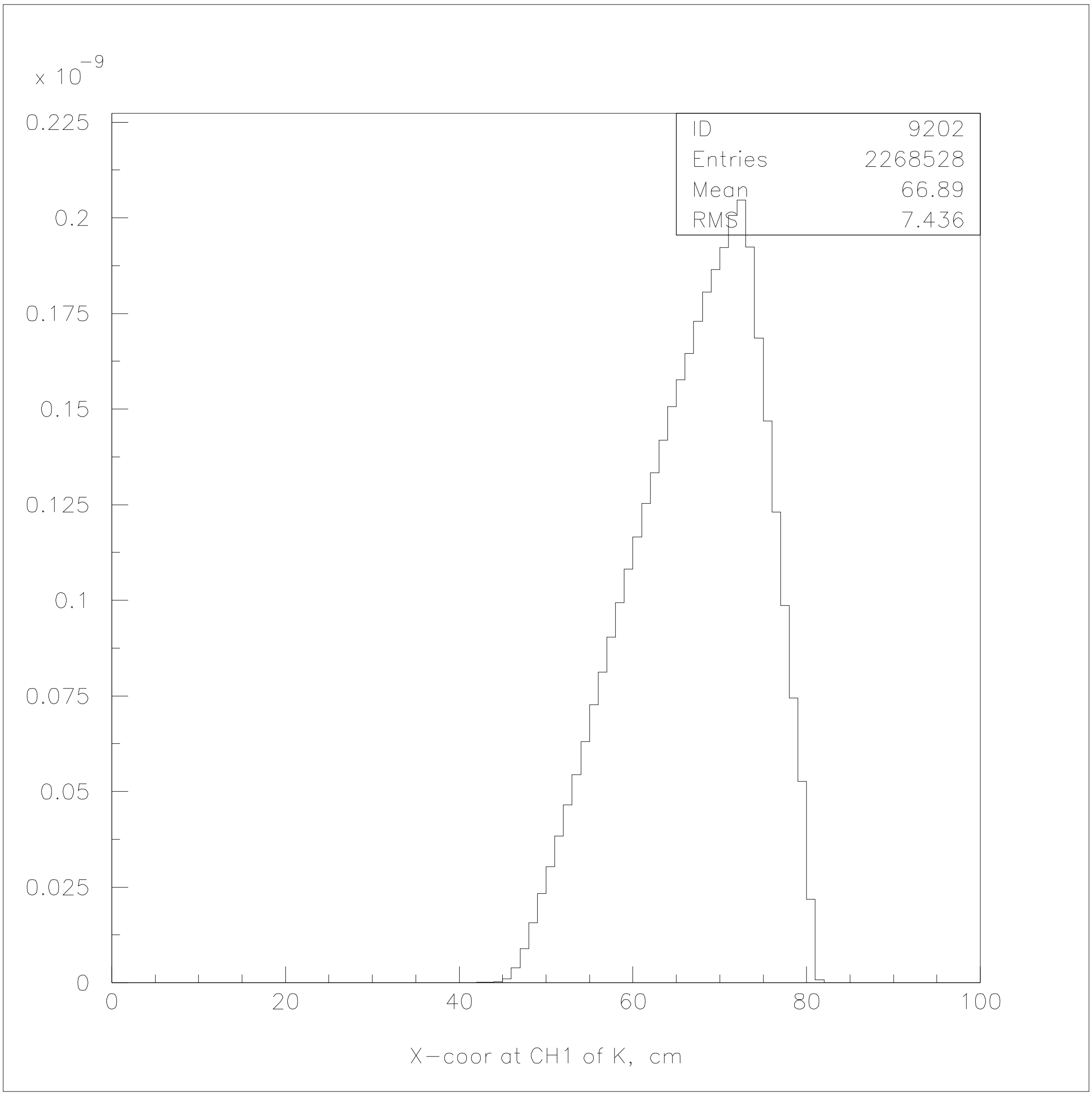

Figure 11: *Kaon x-distribution in the front of CH (CH1).*

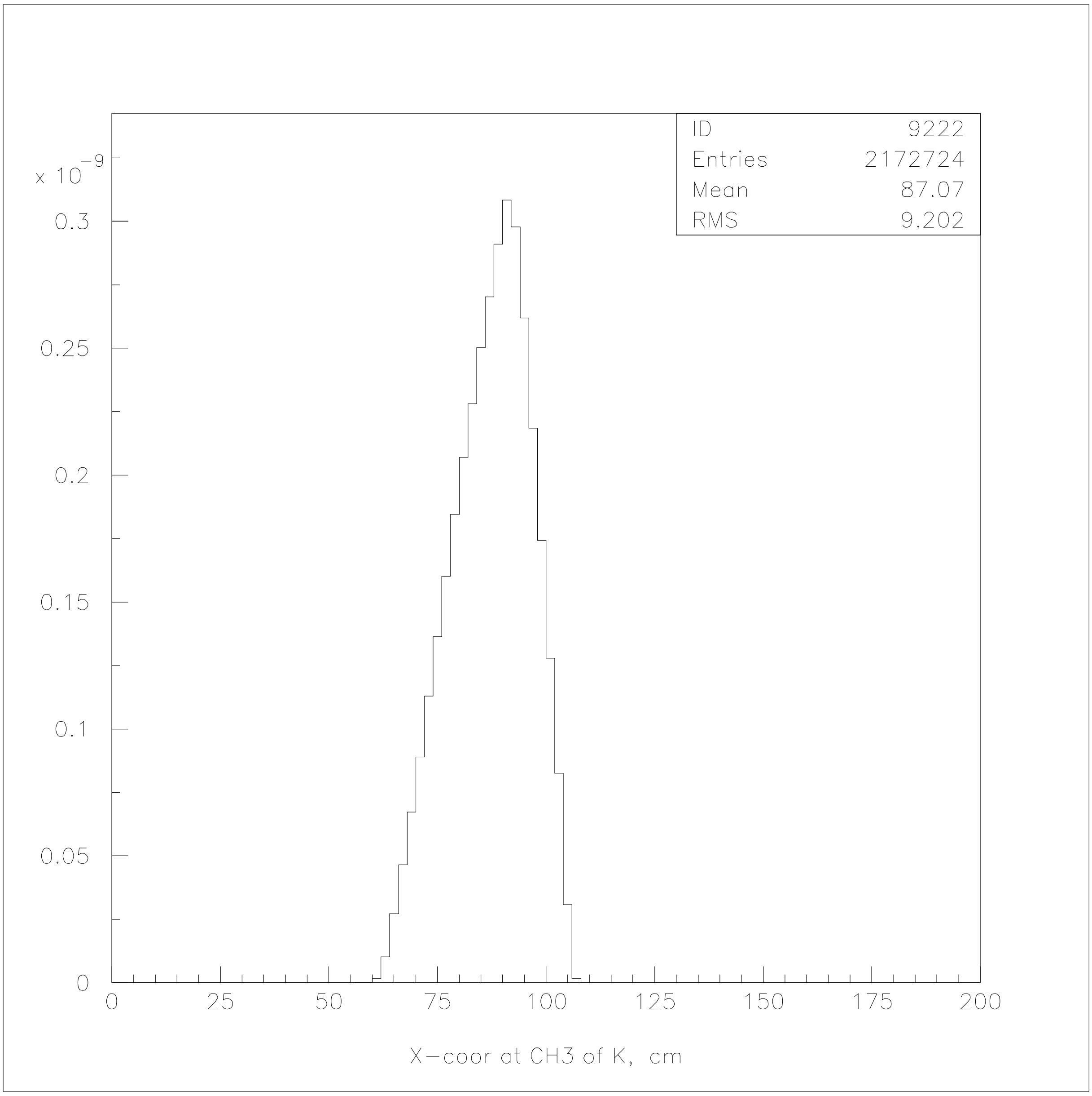

Figure 12: *Kaon x-distribution in 1 m from the front of CH (CH2).*

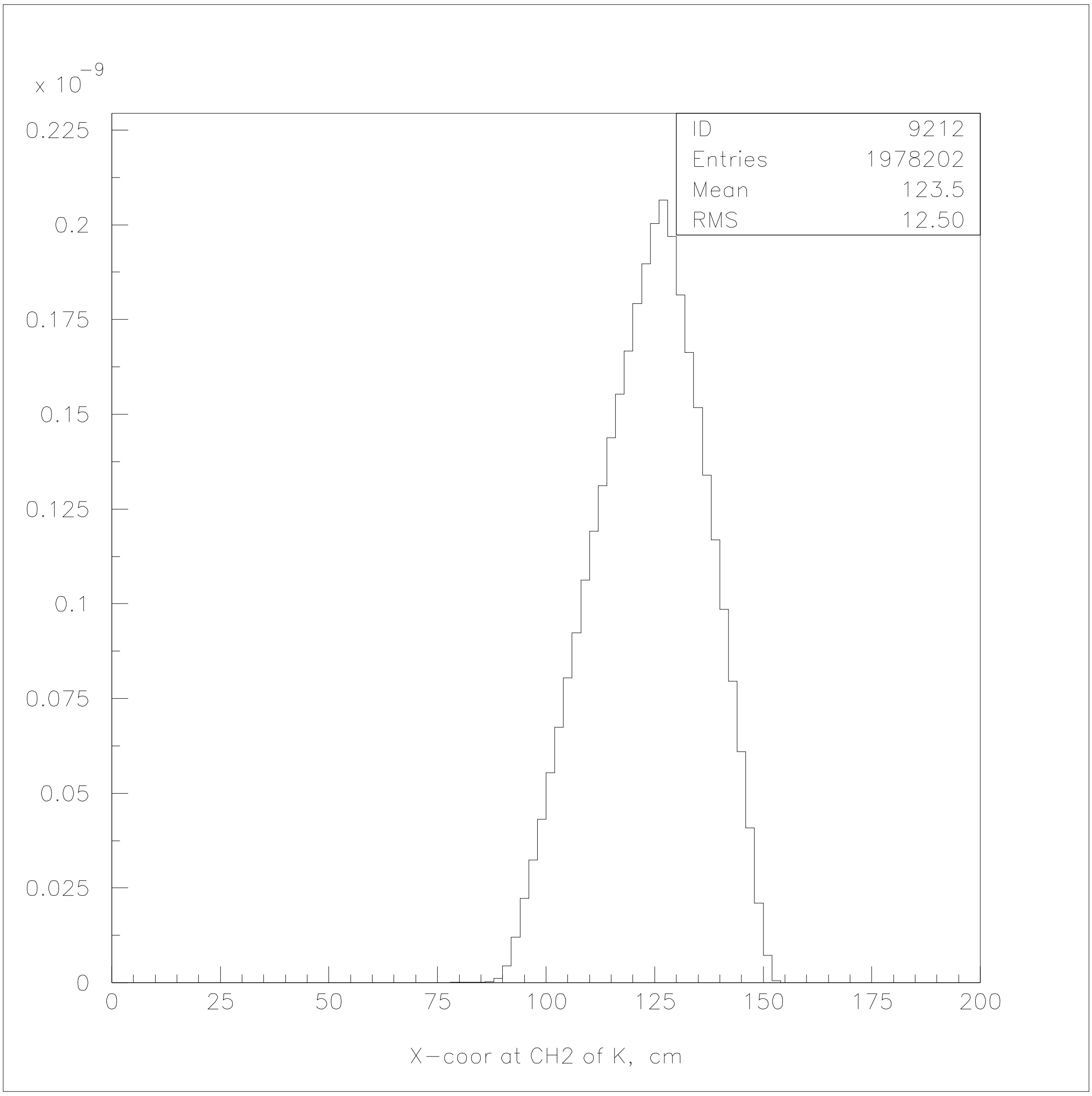

Figure 13: *Kaon x-distribution in the back of CH (CH3).*

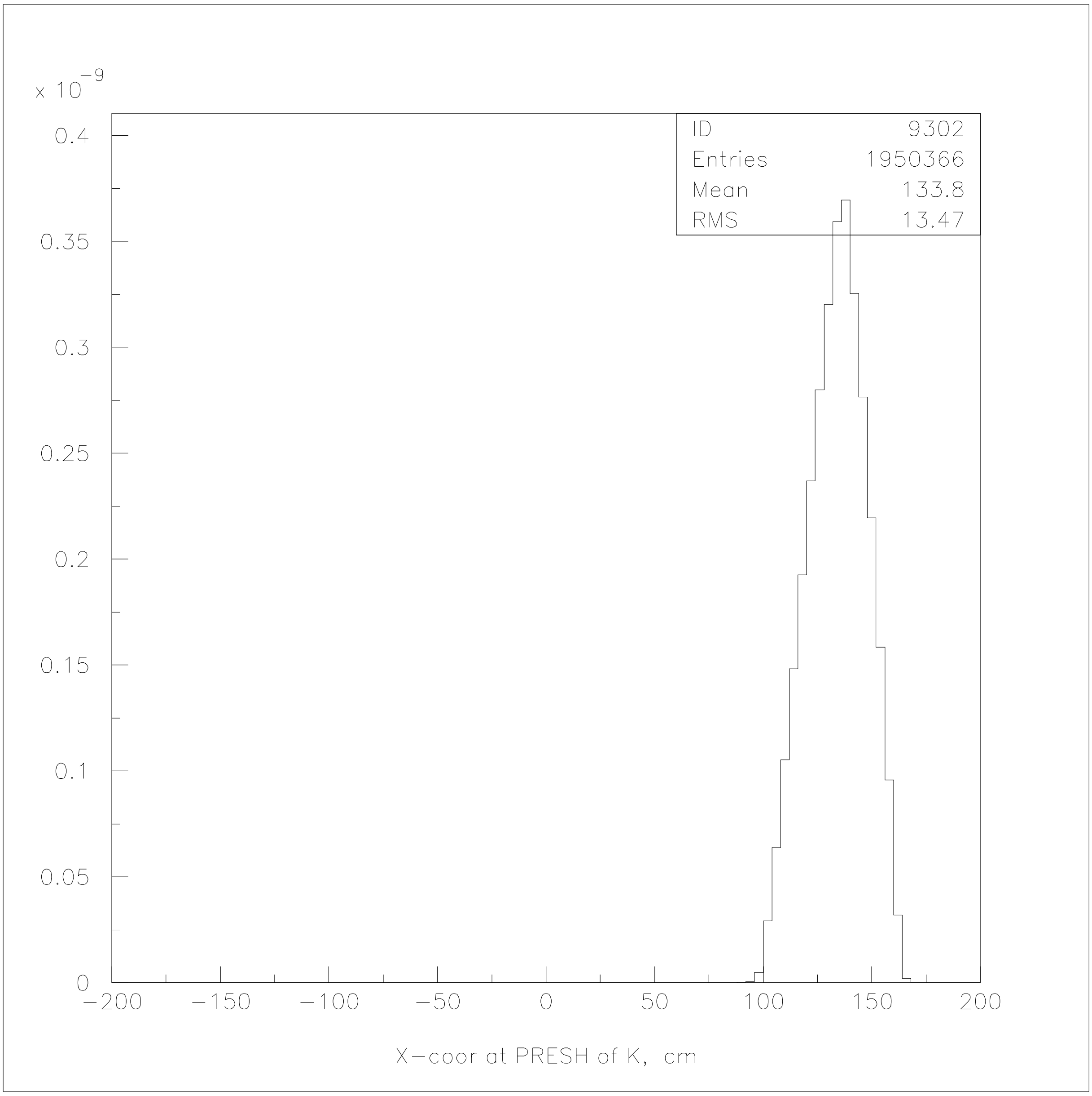

Figure 14: *Kaon x-distribution in PR.*

4 Pion y-distributions

Table 3 is extraction of boundaries and mean values from histograms 15, 16, 17, 18, 19, 20 and 21.

Deep cavity in the hystograms 20 and 21 is determined by the Al plate in the Cherenkov counter.

Table 3: *Pion y-boundaries and mean values.*

plane	y_1 cm	y_2 cm	Δy cm	mv cm
DC2	-18	+18	36	-1.363
DC3	-18	+18	36	-1.062
DC4	-18	+18	36	-0.482
CH1	-19	+19	38	-0.106
CH2	-20	+20	40	+0.445
CH3	-26	+26	52	+1.551
PR	-25	+25	50	+1.825

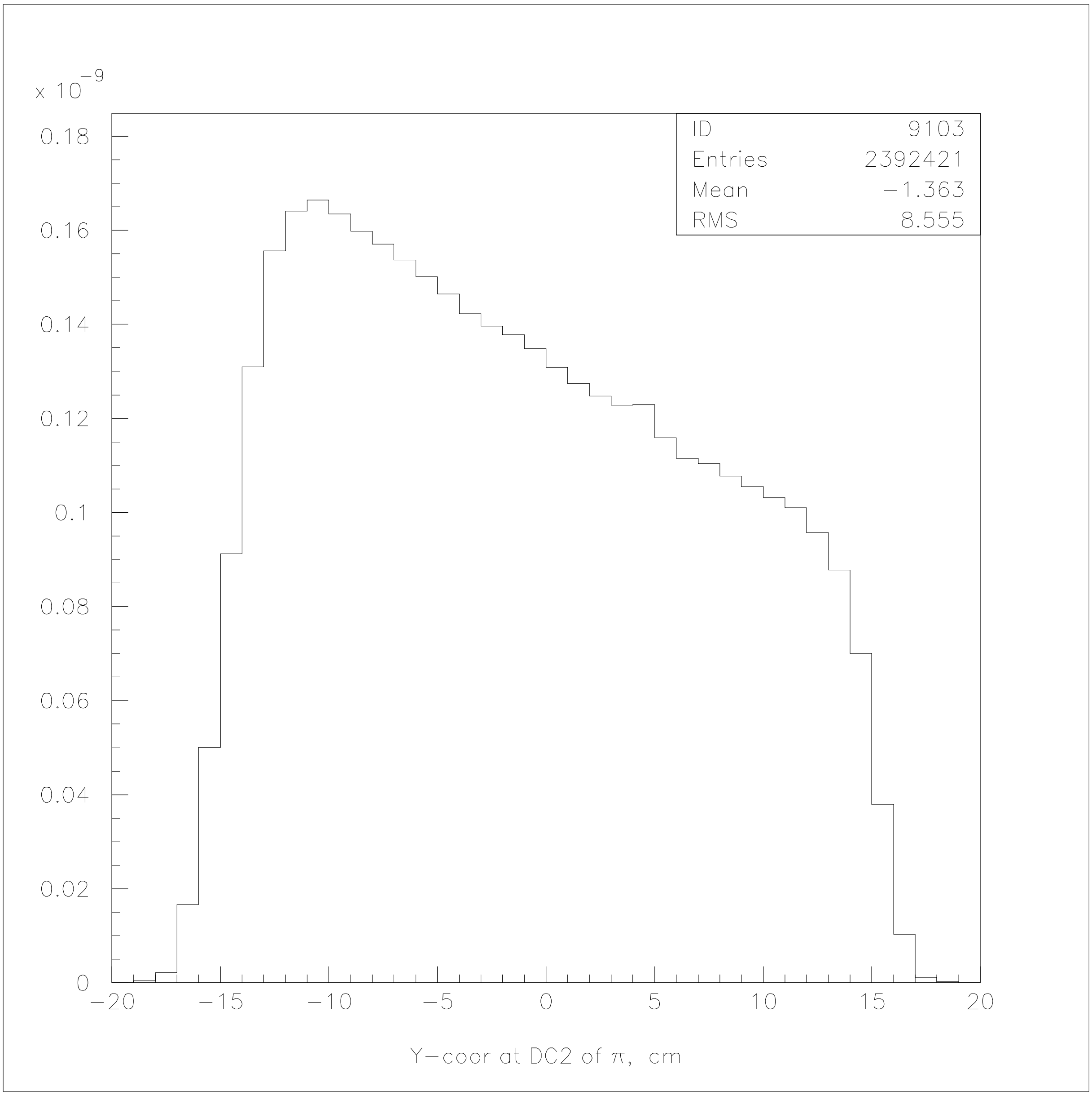

Figure 15: *Pion y-distribution in DC2.*

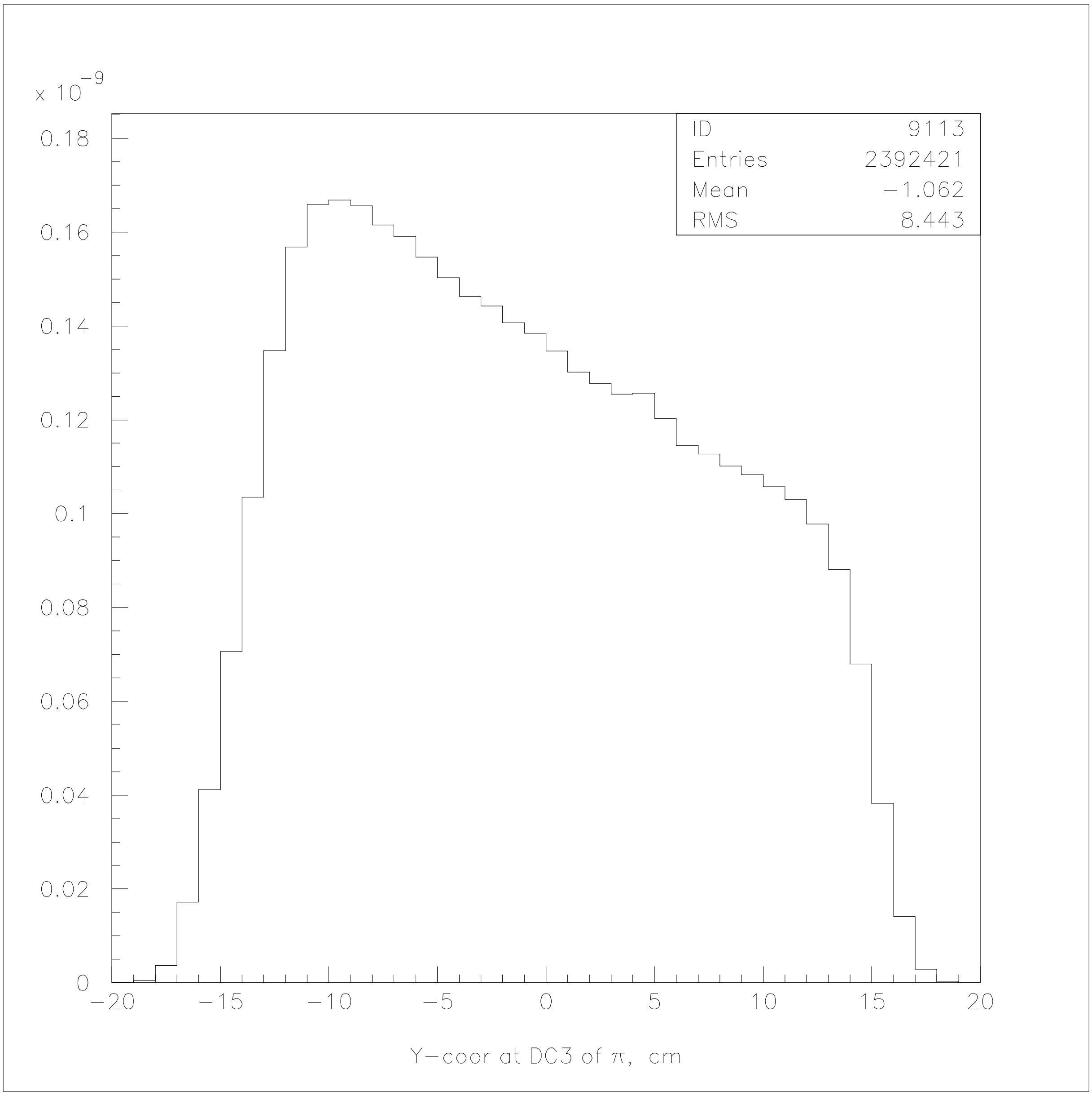

Figure 16: *Pion y-distribution in DC3.*

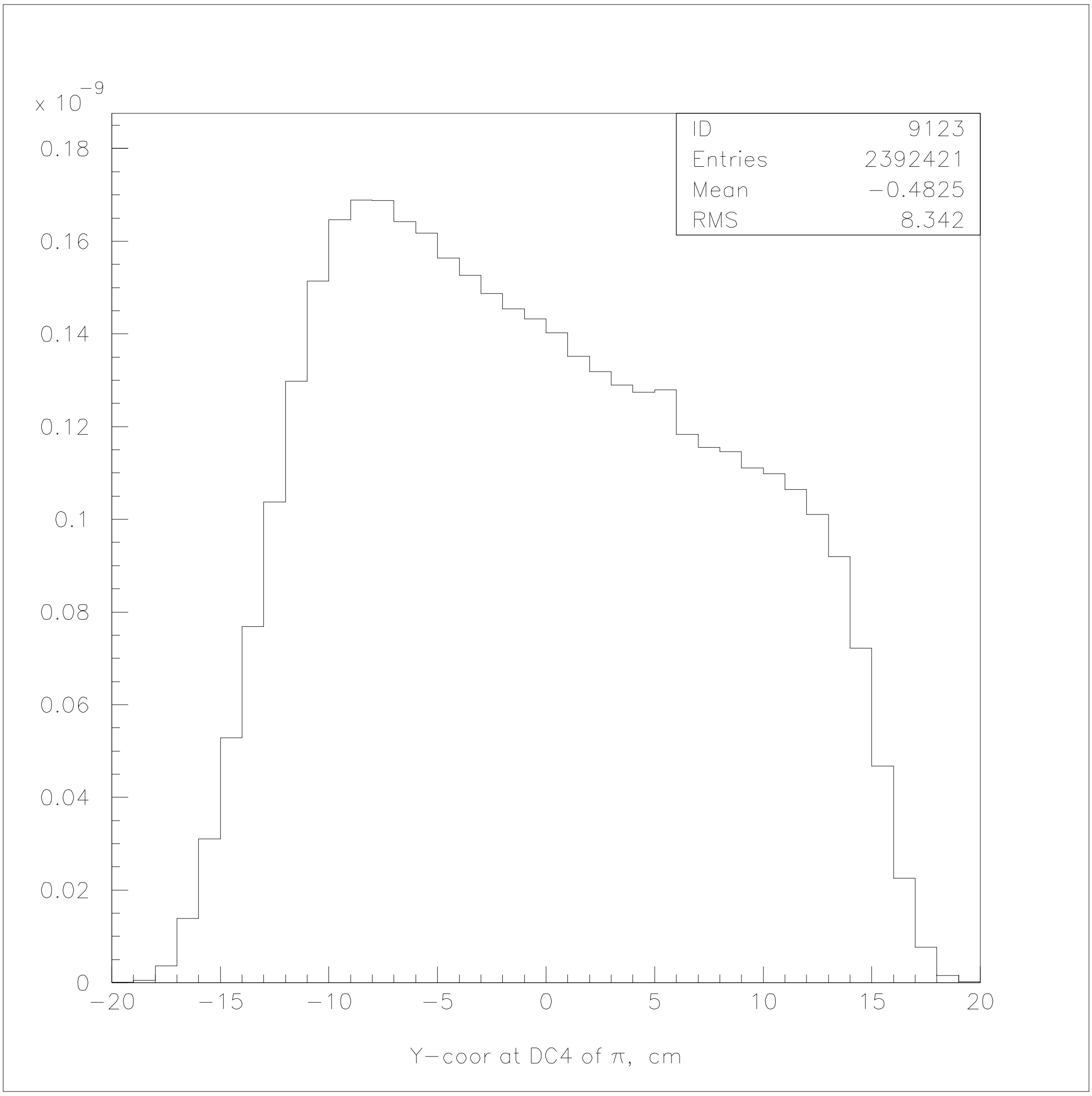

Figure 17: *Pion y-distribution in DC4.*

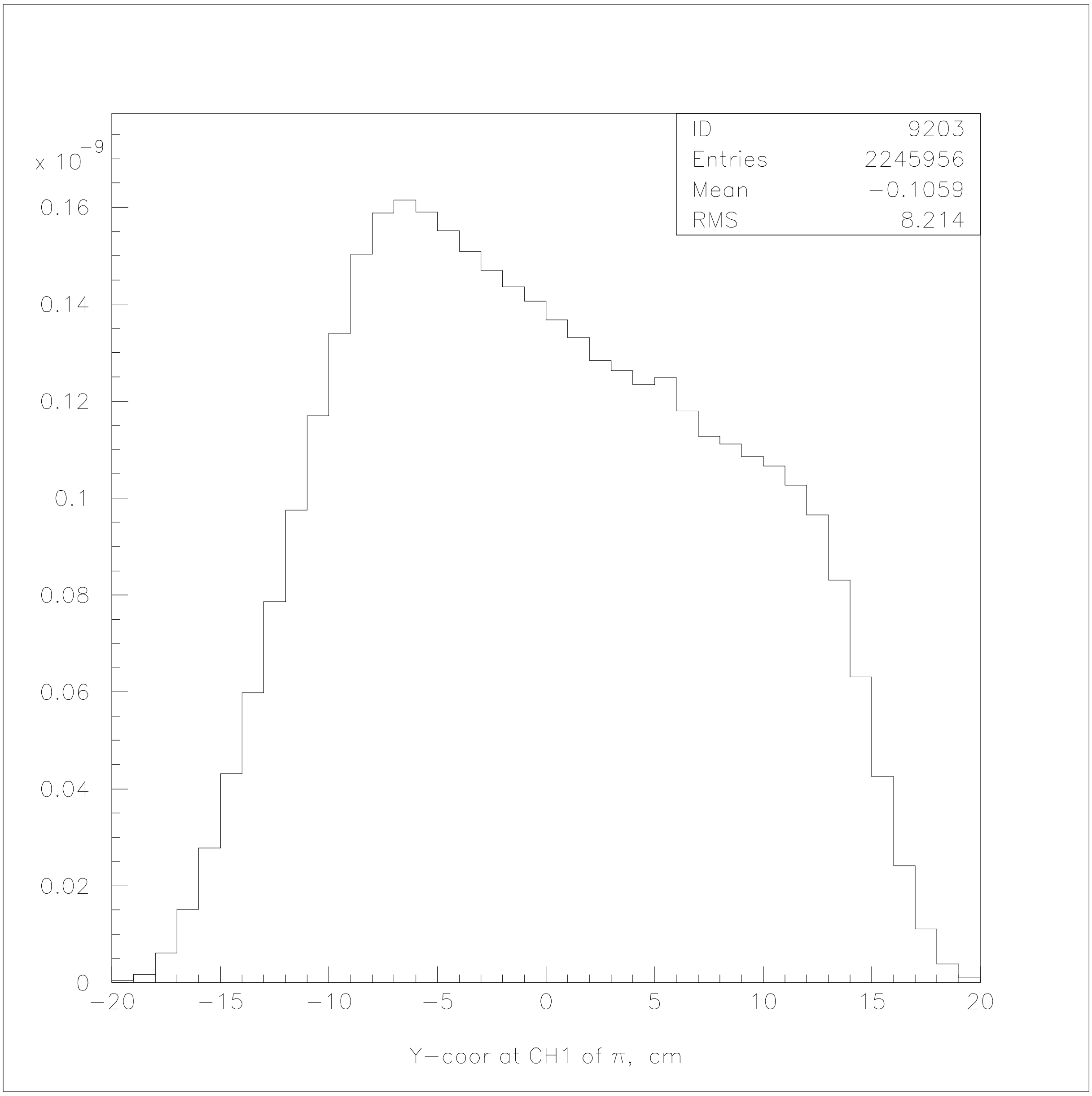

Figure 18: *Pion y-distribution in the front of CH (CH1).*

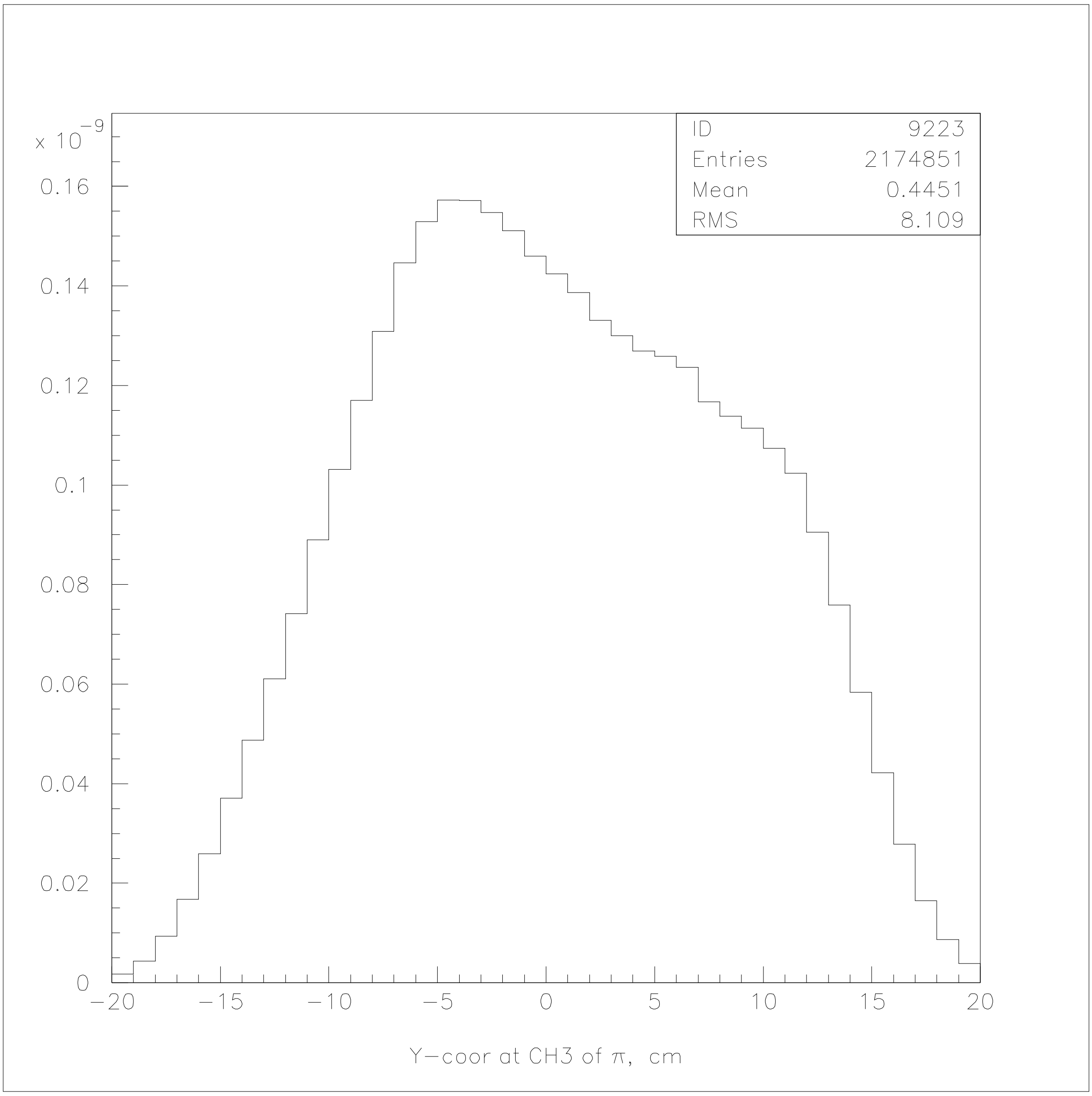

Figure 19: *Pion y-distribution in 1 m from the front of CH (CH2).*

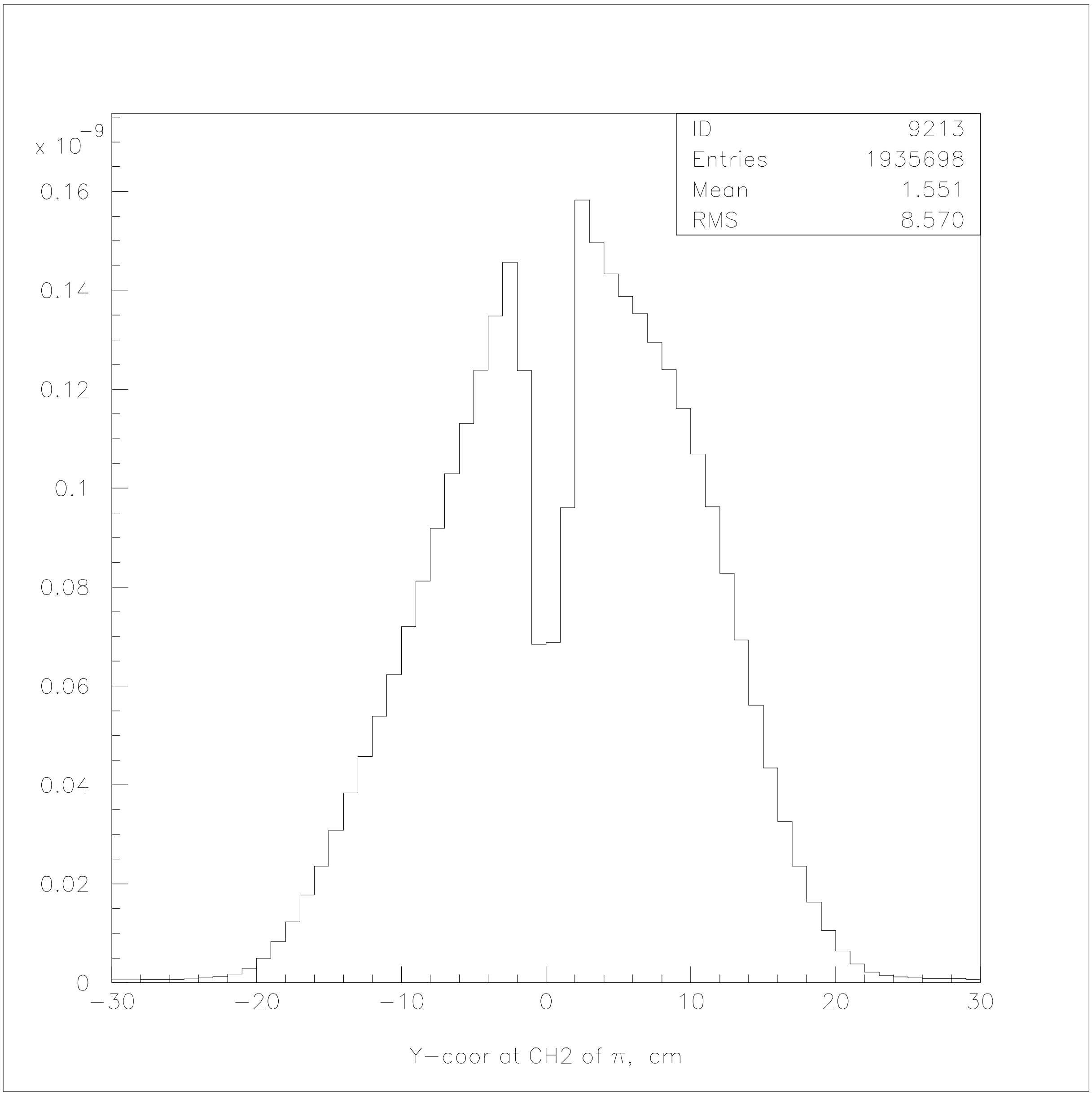

Figure 20: *Pion y-distribution in the back of CH (CH3).*

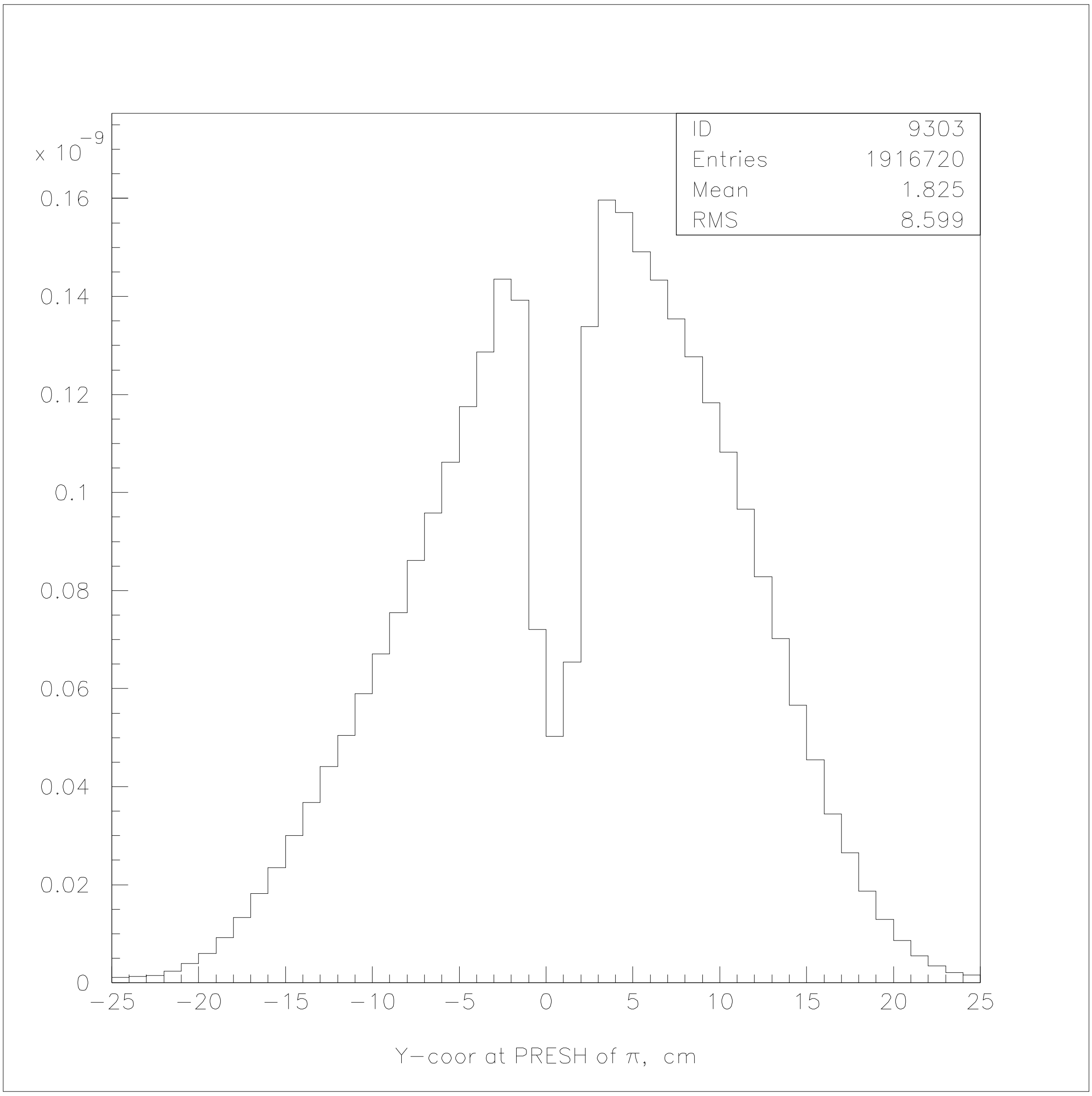

Figure 21: *Pion y-distribution in PR.*

5 Kaon y-distributions

Table 4 is extraction of boundaries and mean values from histograms 22, 23, 24, 25, 26, 27 and 28.

Deep cavity in the hystograms 27 and 28 is determined by the Al plate in the Cherenkov counter.

Table 4: *Kaon y-boundaries and mean values.*

plane	y_1 cm	y_2 cm	Δy cm	mv cm
DC2	-19	+19	38	-2.209
DC3	-19	+19	38	-2.224
DC4	-20	+20	40	-2.121
CH1	-21	+21	42	-2.153
CH2	-23	+23	46	-2.286
CH3	-26	+26	52	-2.607
PR	-27	+27	54	-2.639

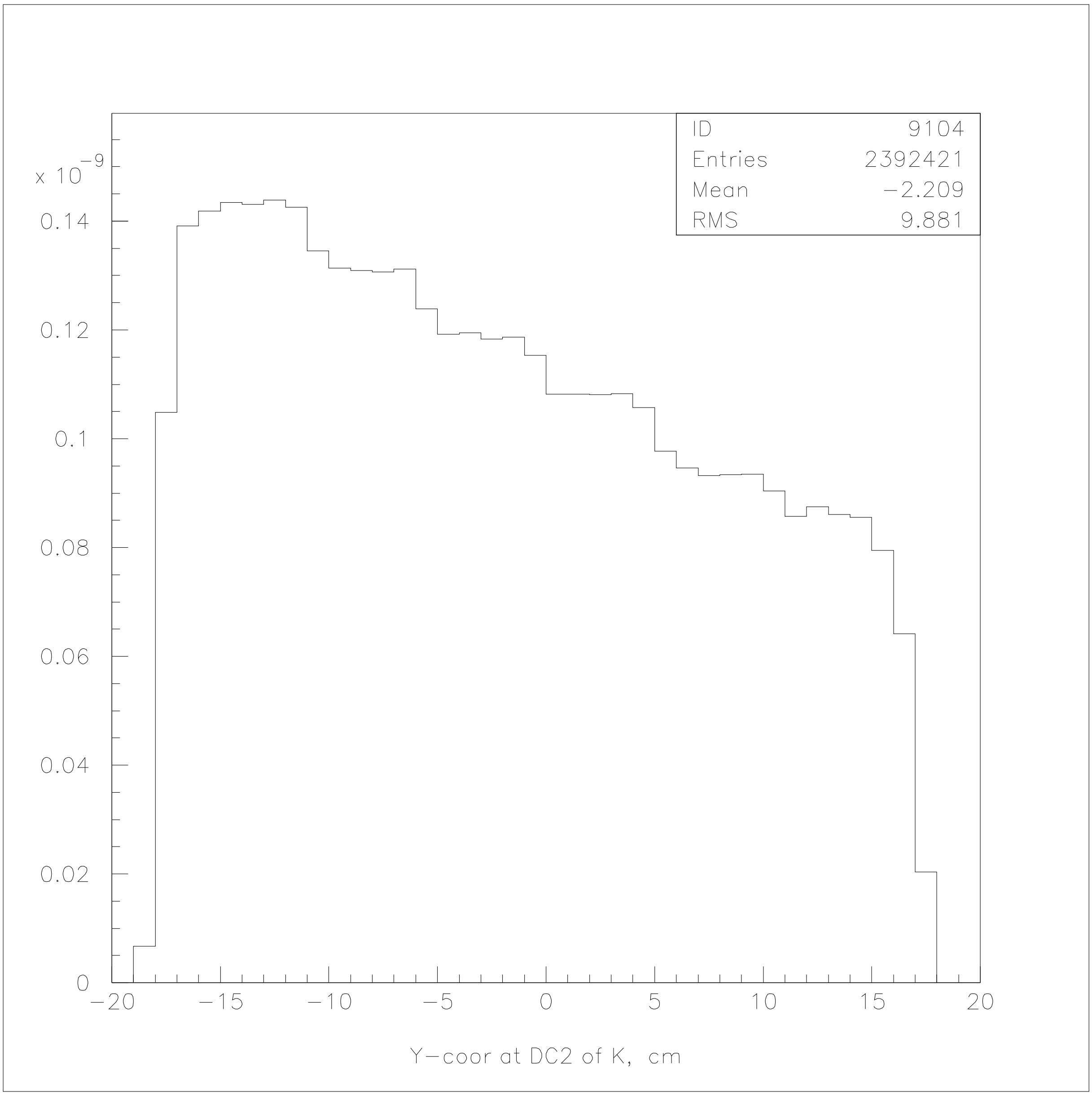

Figure 22: *Kaon y-distribution in DC2.*

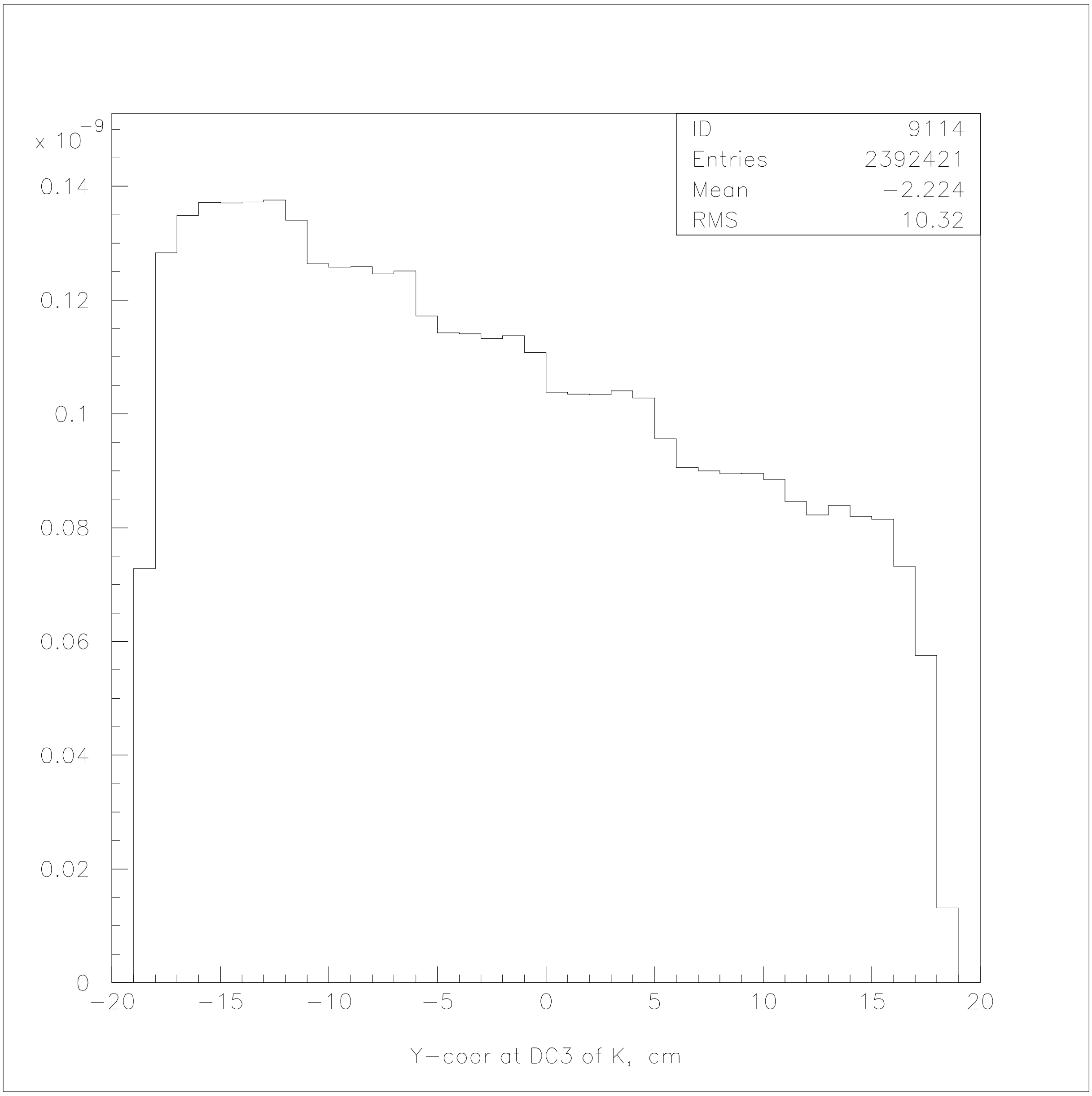

Figure 23: *Kaon y-distribution in DC3.*

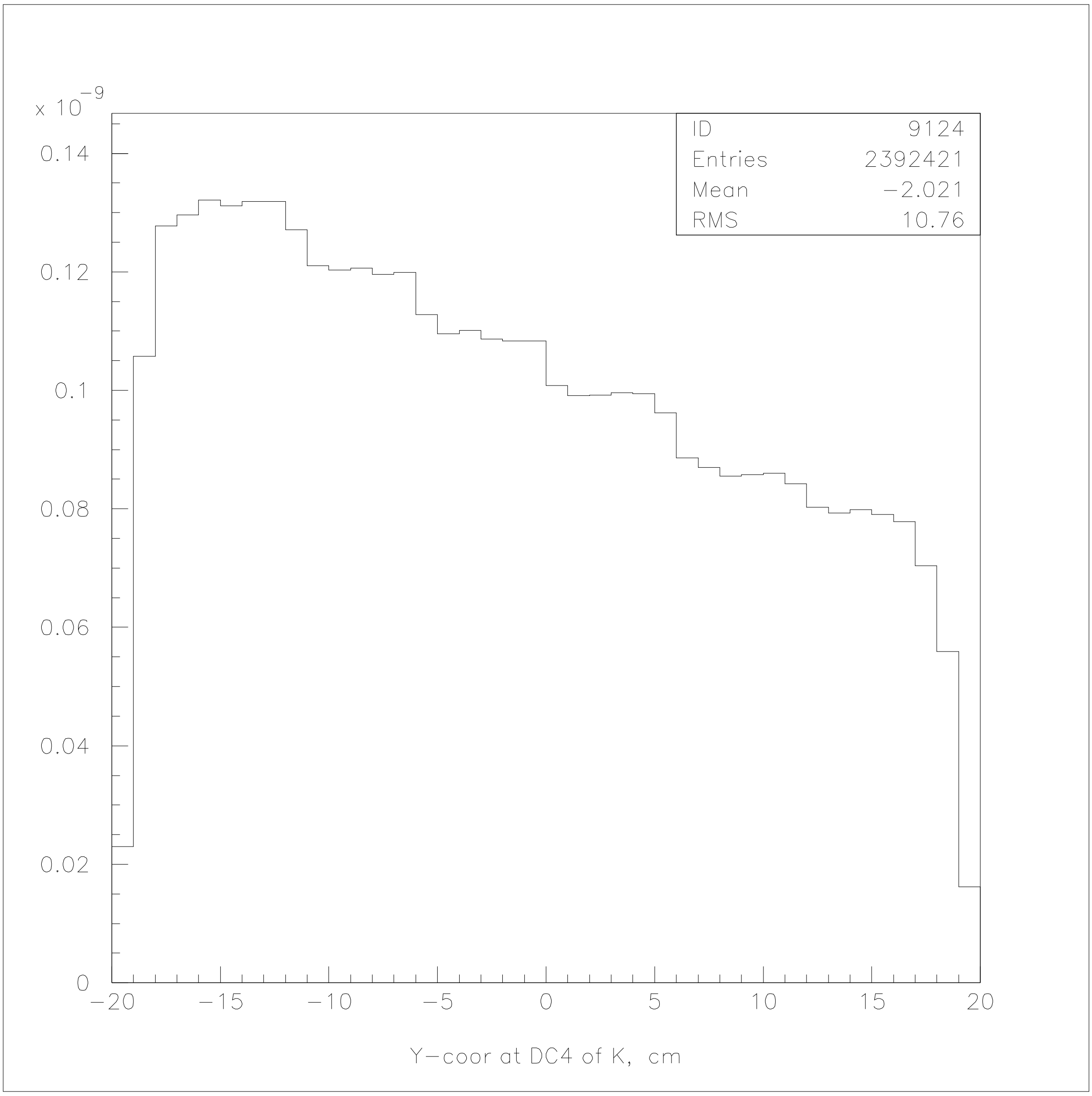

Figure 24: *Kaon y-distribution in DC4.*

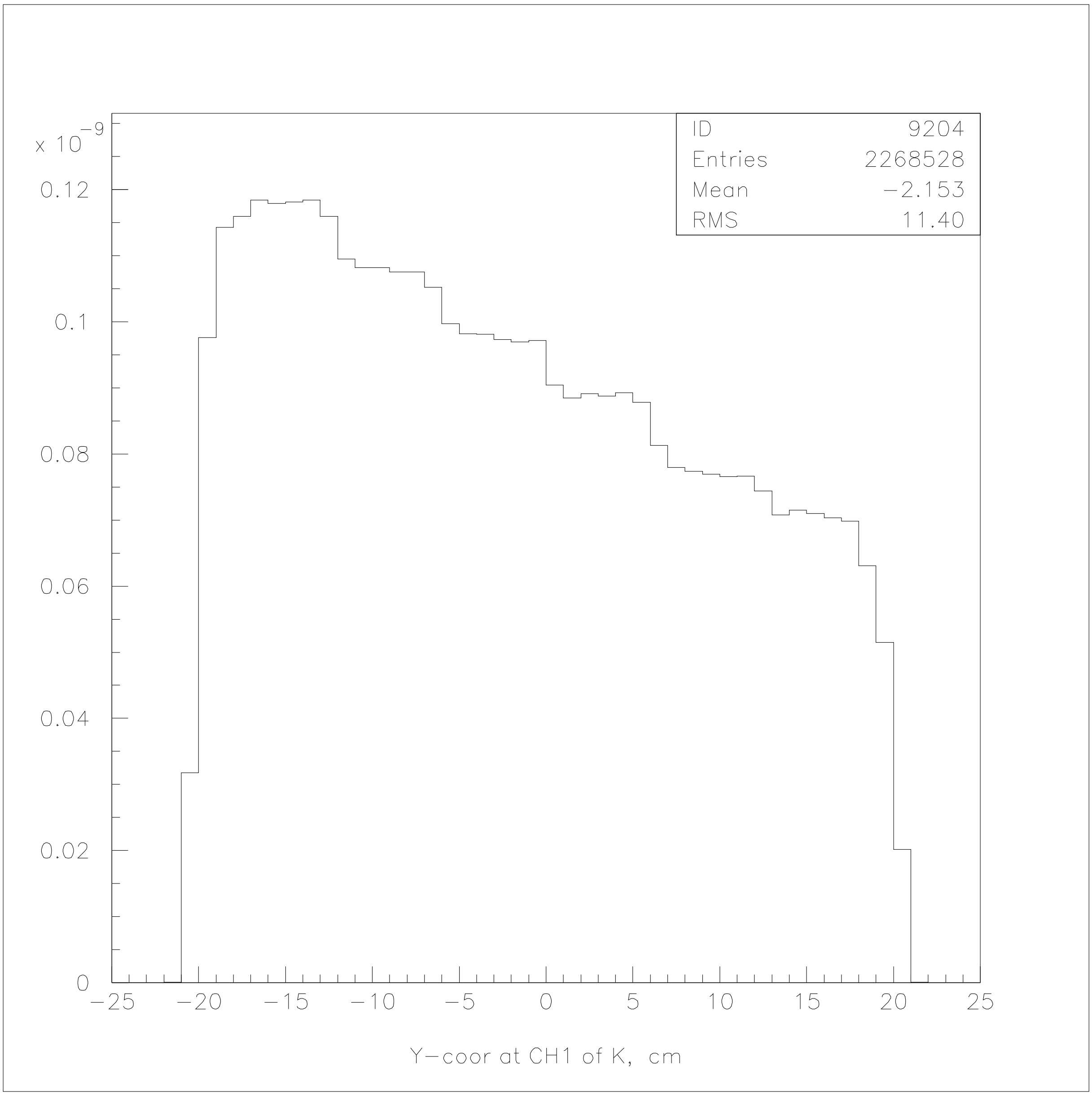

Figure 25: *Kaon y-distribution in the front of CH (CH1).*

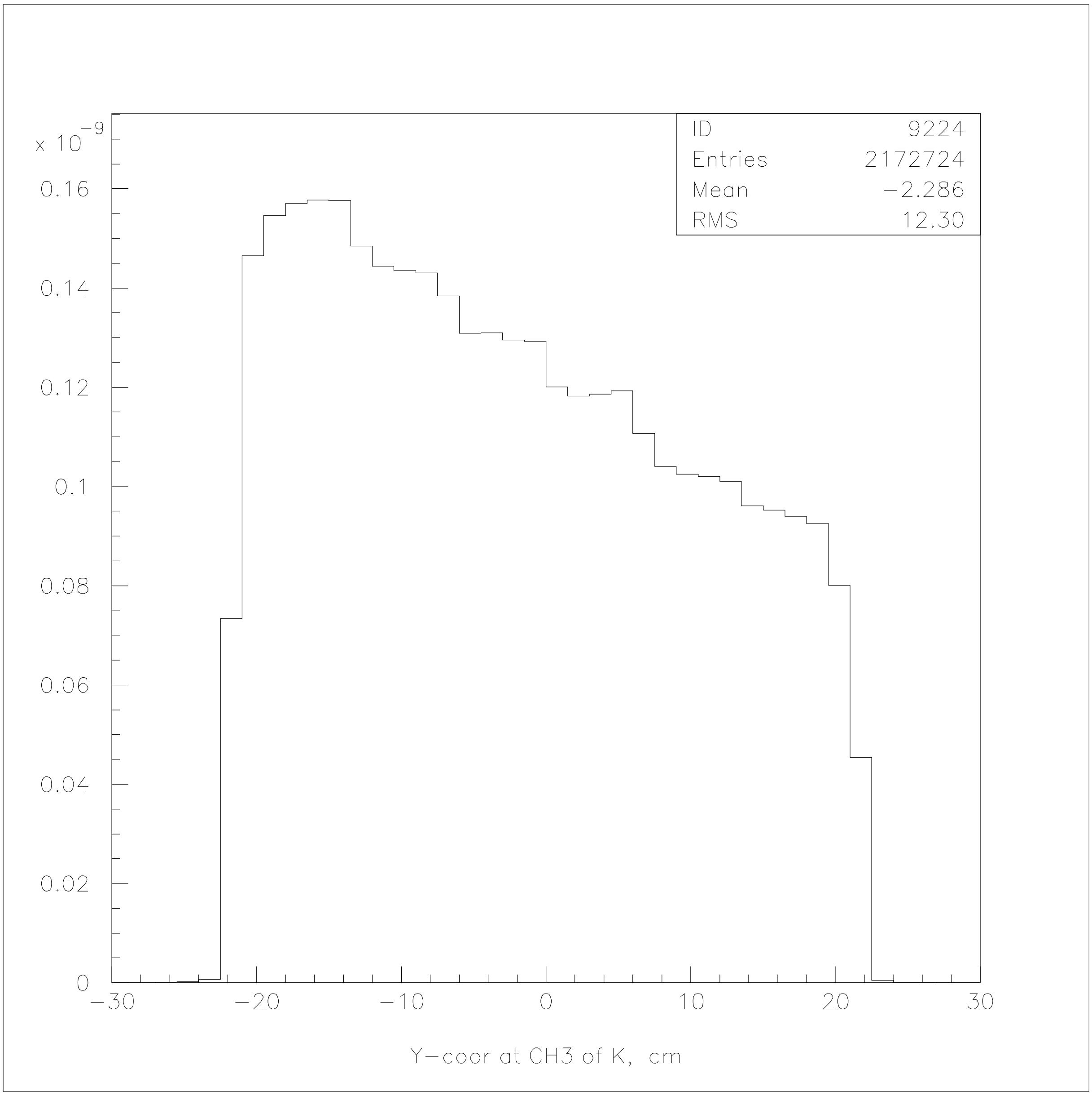

Figure 26: *Kaon y-distribution in 1 m from the front of CH (CH2).*

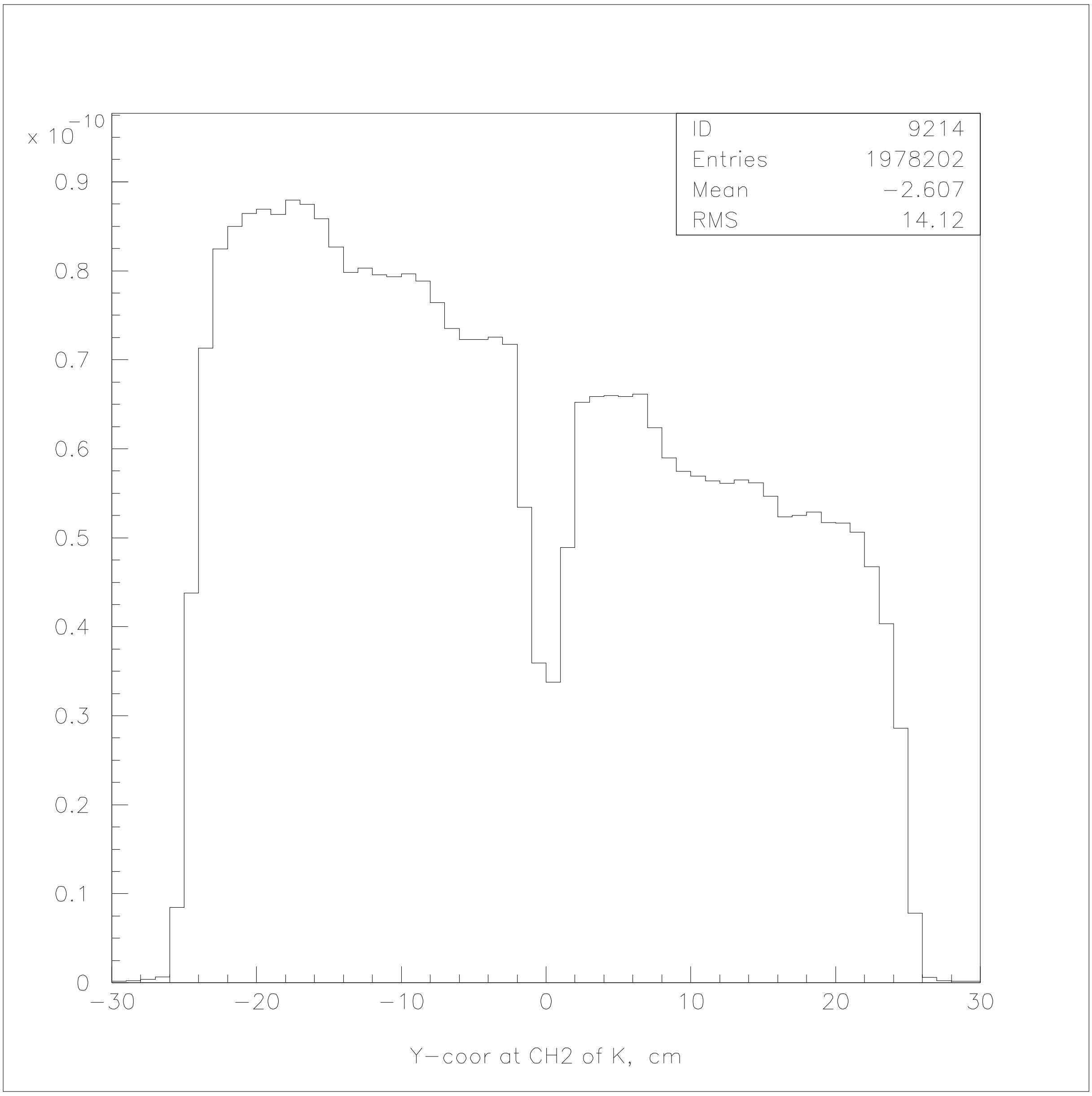

Figure 27: *Kaon y-distribution in the back of CH (CH3).*

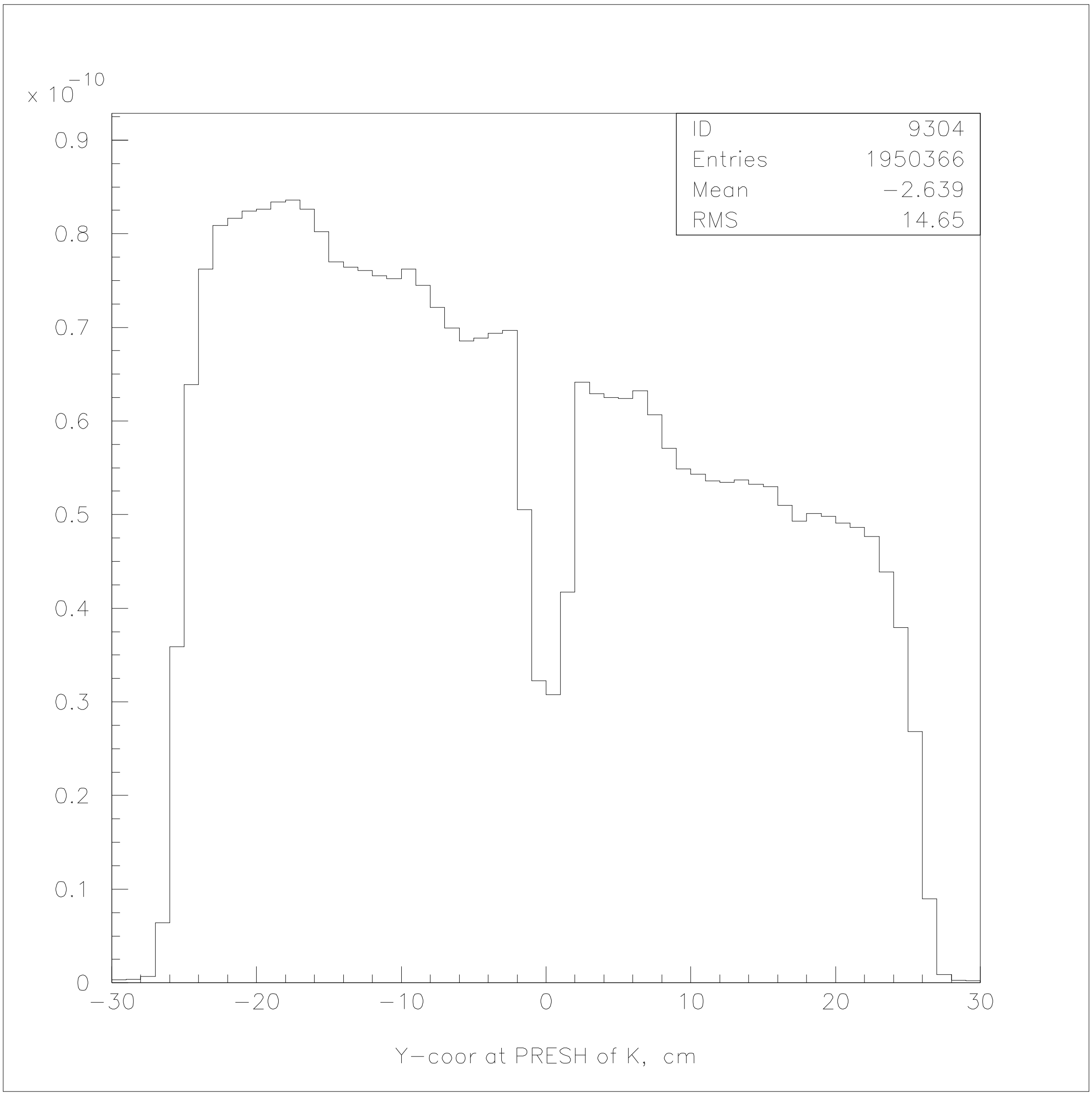

Figure 28: *Kaon y-distribution in PR.*

6 Pion momentum distributions

Table 5 is extraction of boundaries and mean values from histograms 29, 30, 31, 32, 33, 34 and 35.

Table 5: *Pion p-boundaries and mean values, (GeV/c).*

plane	p_{min}	p_{max}	Δp	$\frac{p_{max}}{p_{min}}$	mv
DC2	1.0	2.6	1.6	2.6	1.519
DC3	1.0	2.6	1.6	2.6	1.519
DC4	1.0	2.6	1.6	2.6	1.519
CH1	1.0	2.6	1.6	2.6	1.510
CH2	1.0	2.6	1.6	2.6	1.508
CH3	1.0	2.6	1.6	2.6	1.503
PR	1.0	2.6	1.6	2.6	1.503

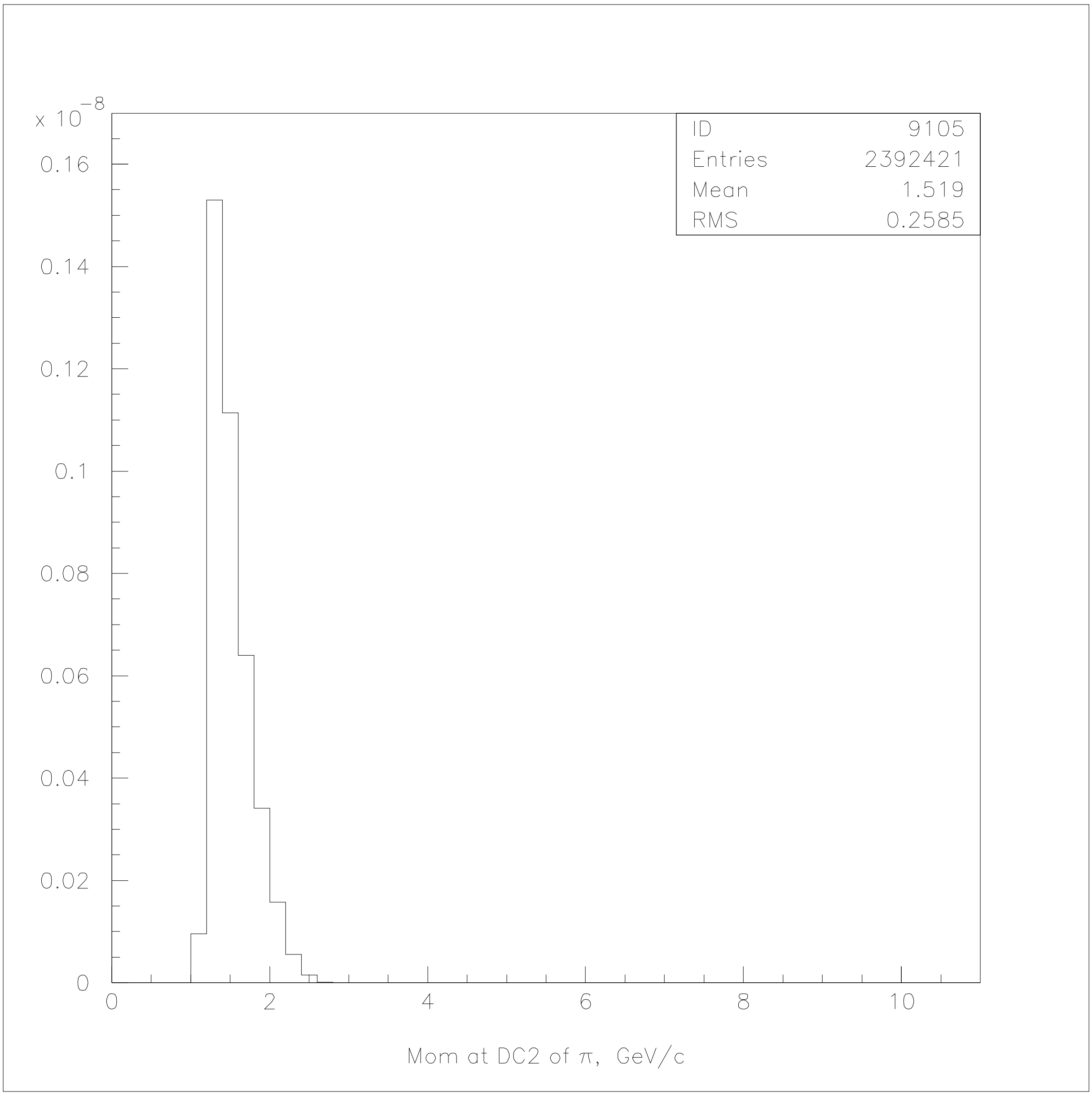

Figure 29: *Pion p-distribution in DC2.*

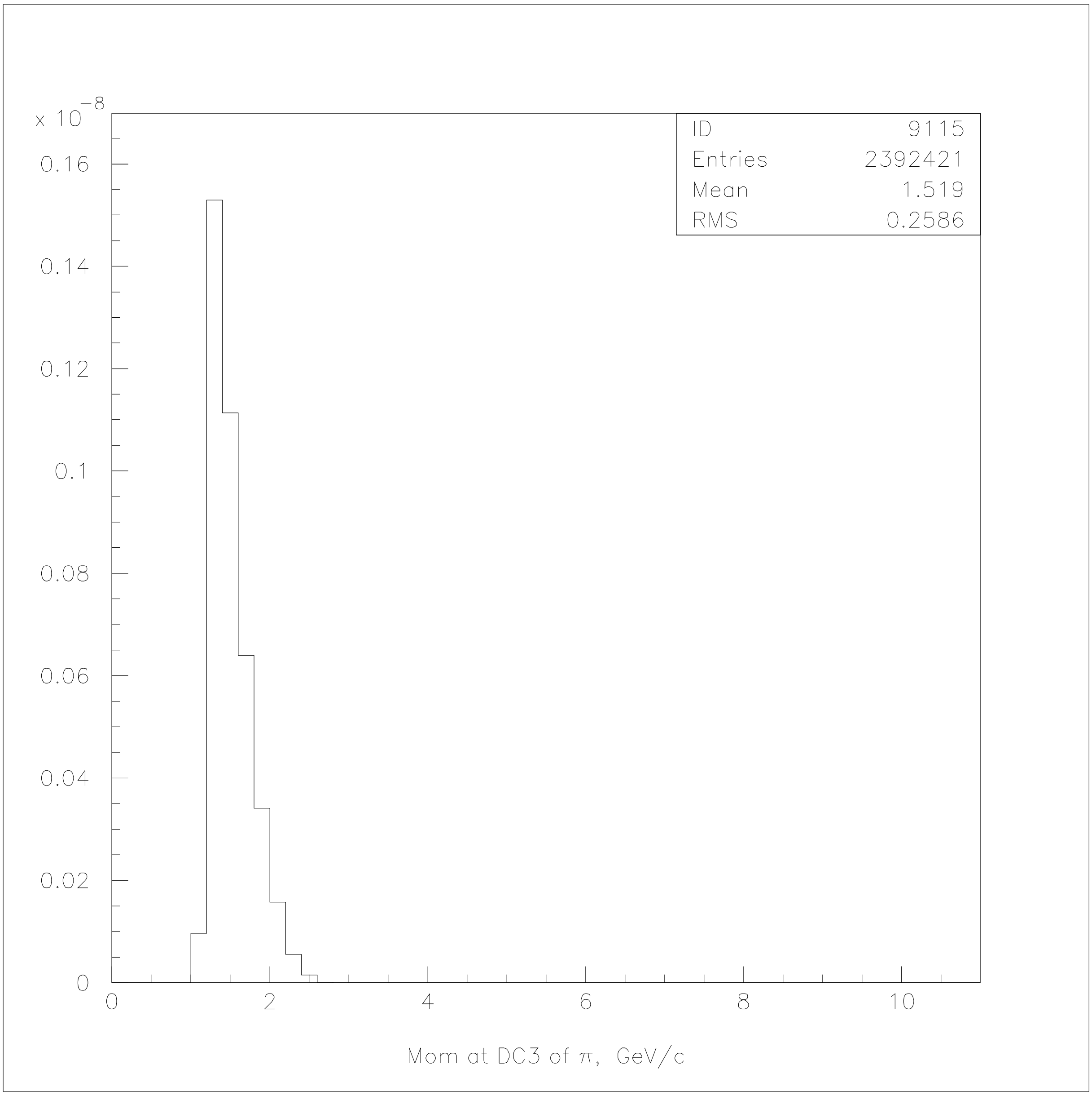

Figure 30: *Pion p-distribution in DC3.*

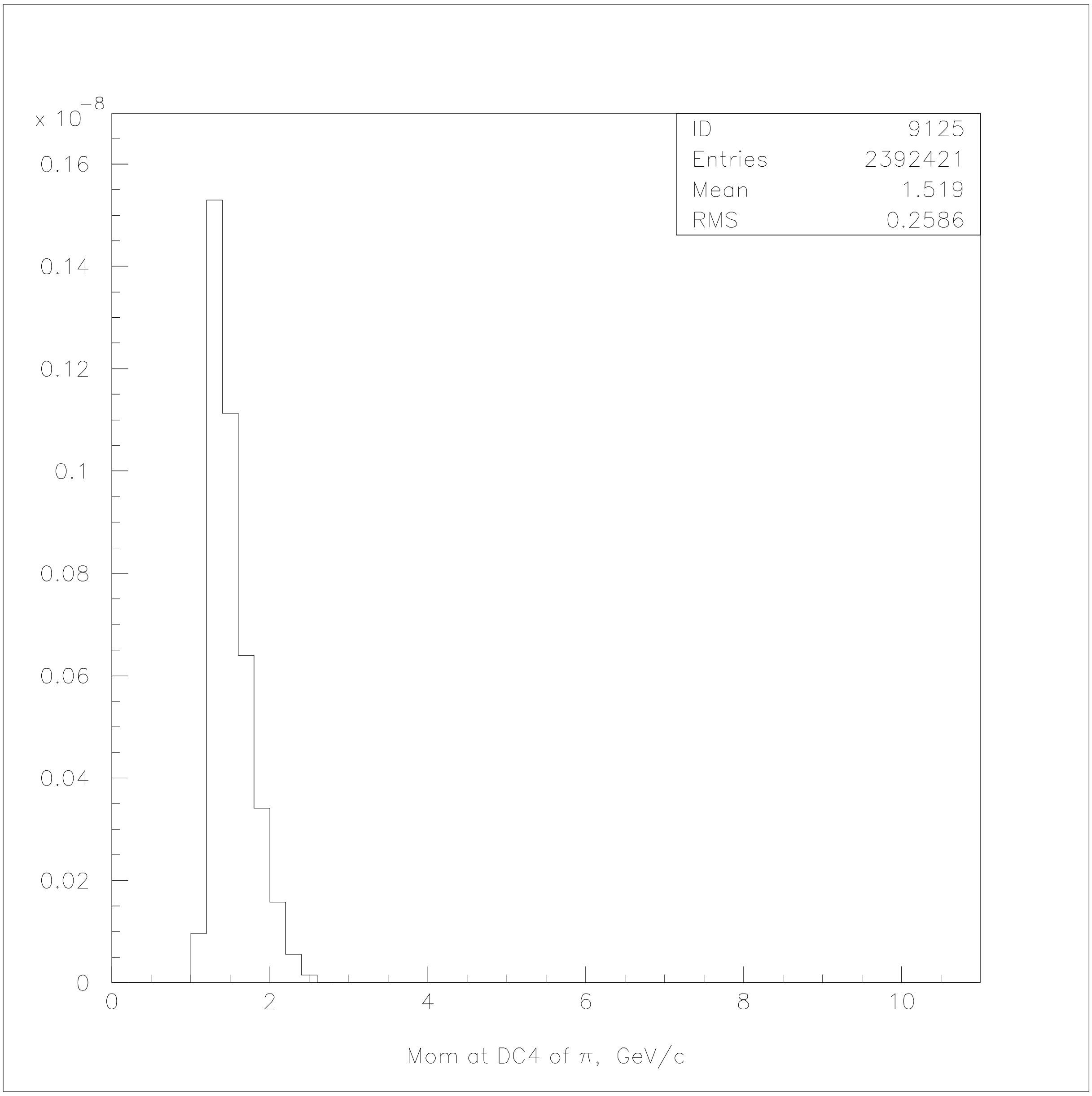

Figure 31: *Pion p-distribution in DC4.*

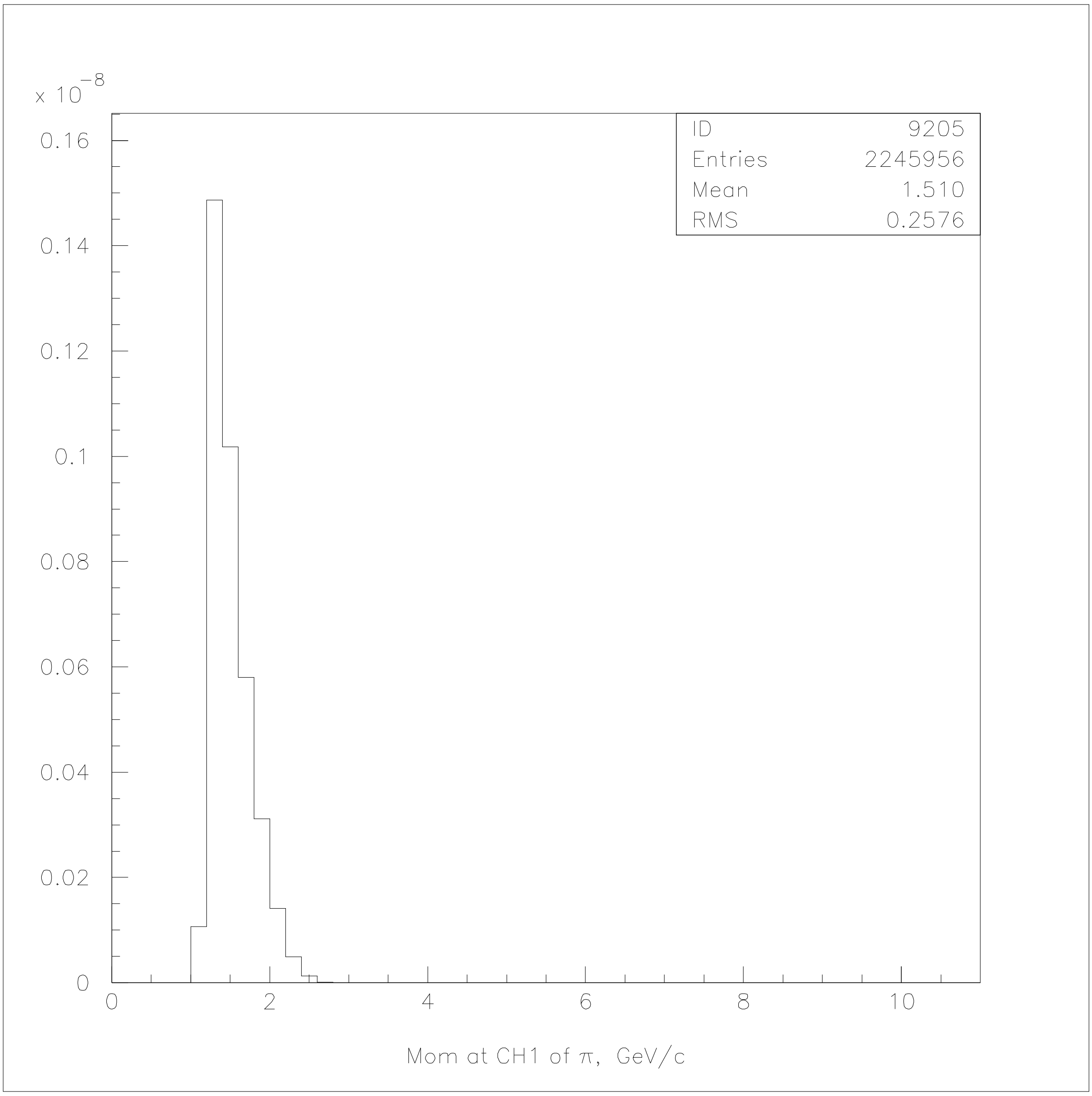

Figure 32: *Pion p-distribution in the front of CH (CH1).*

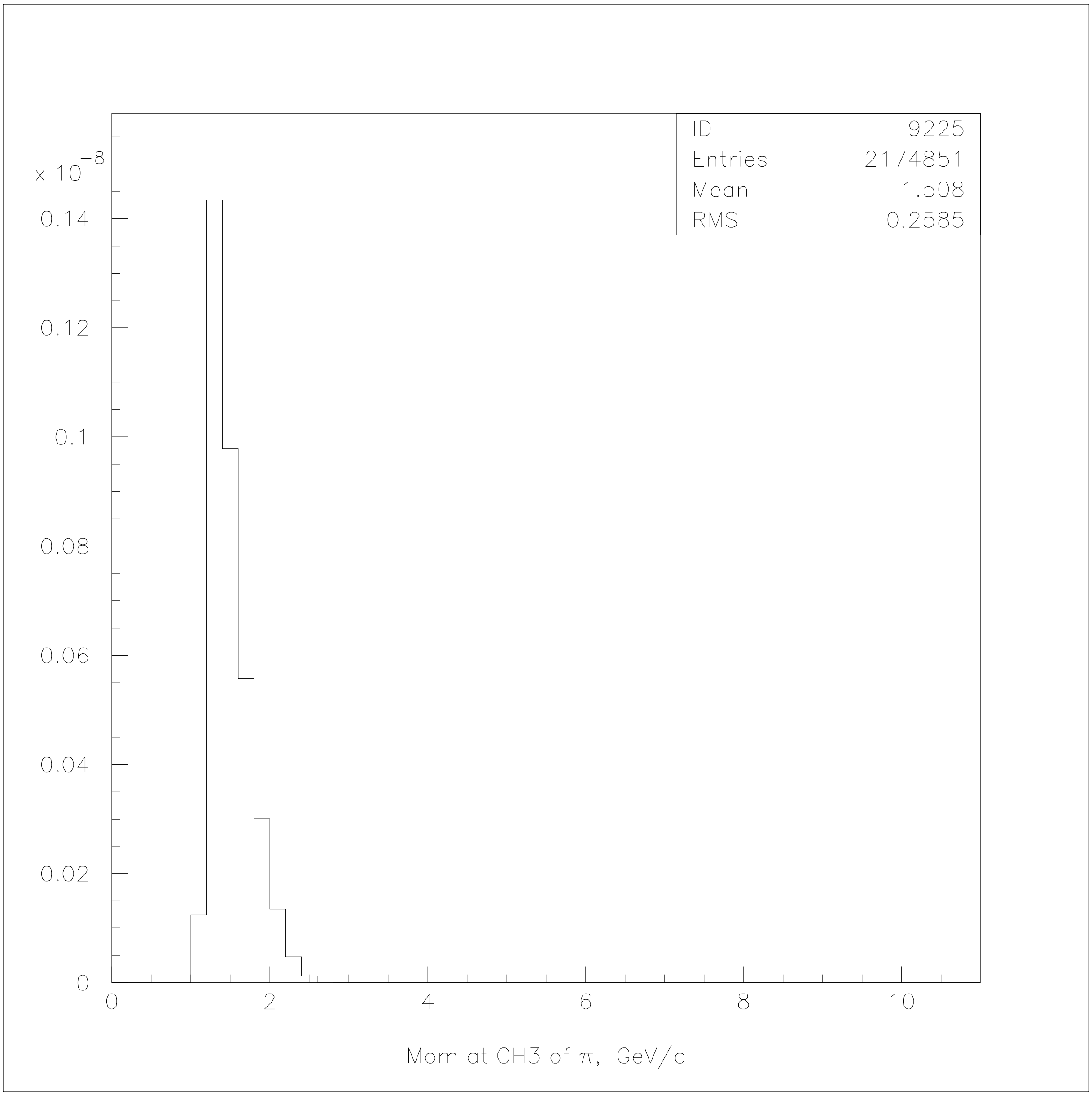

Figure 33: *Pion p-distribution in 1 m from the front of CH (CH2).*

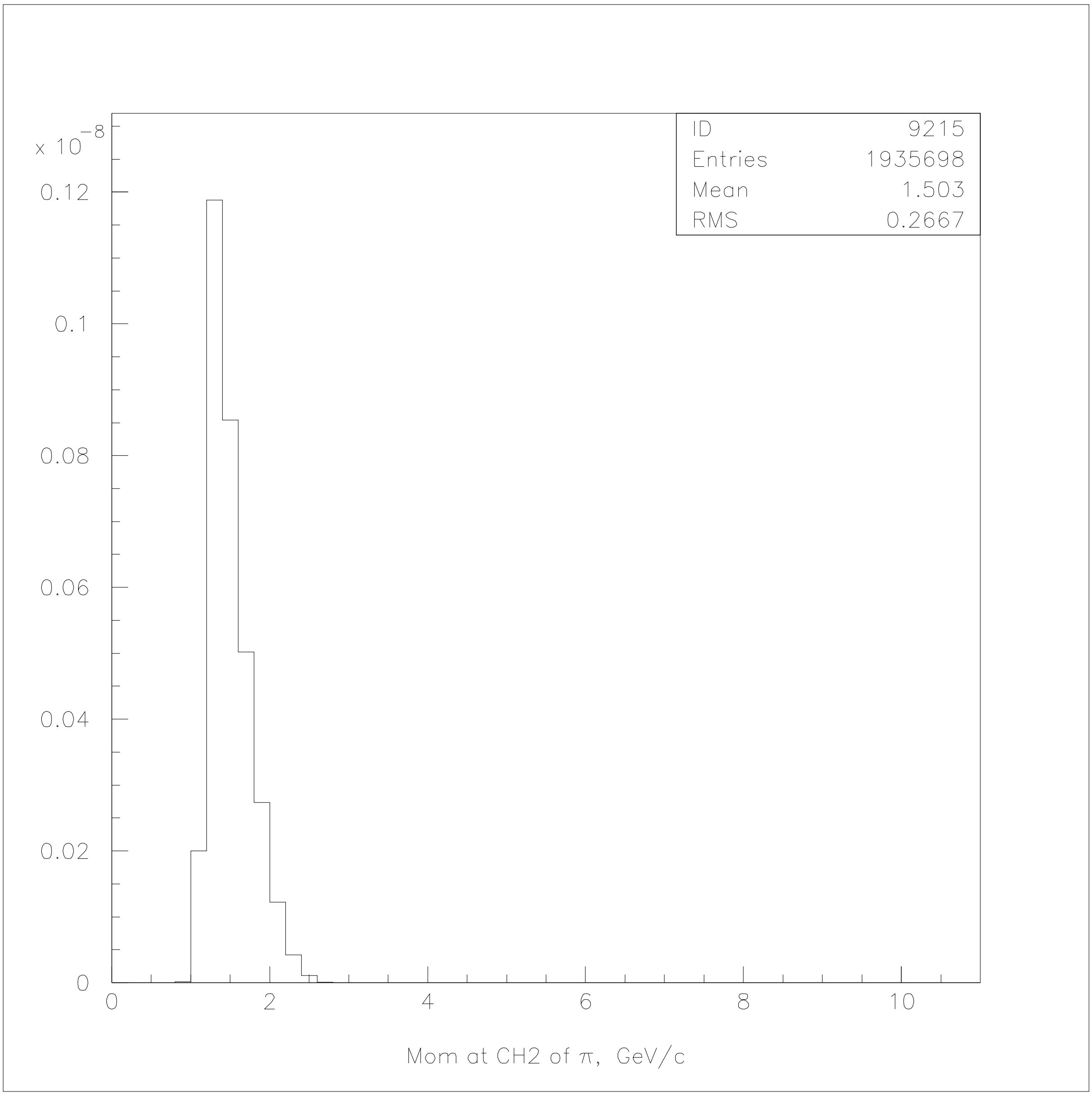

Figure 34: *Pion p-distribution in the back of CH (CH3).*

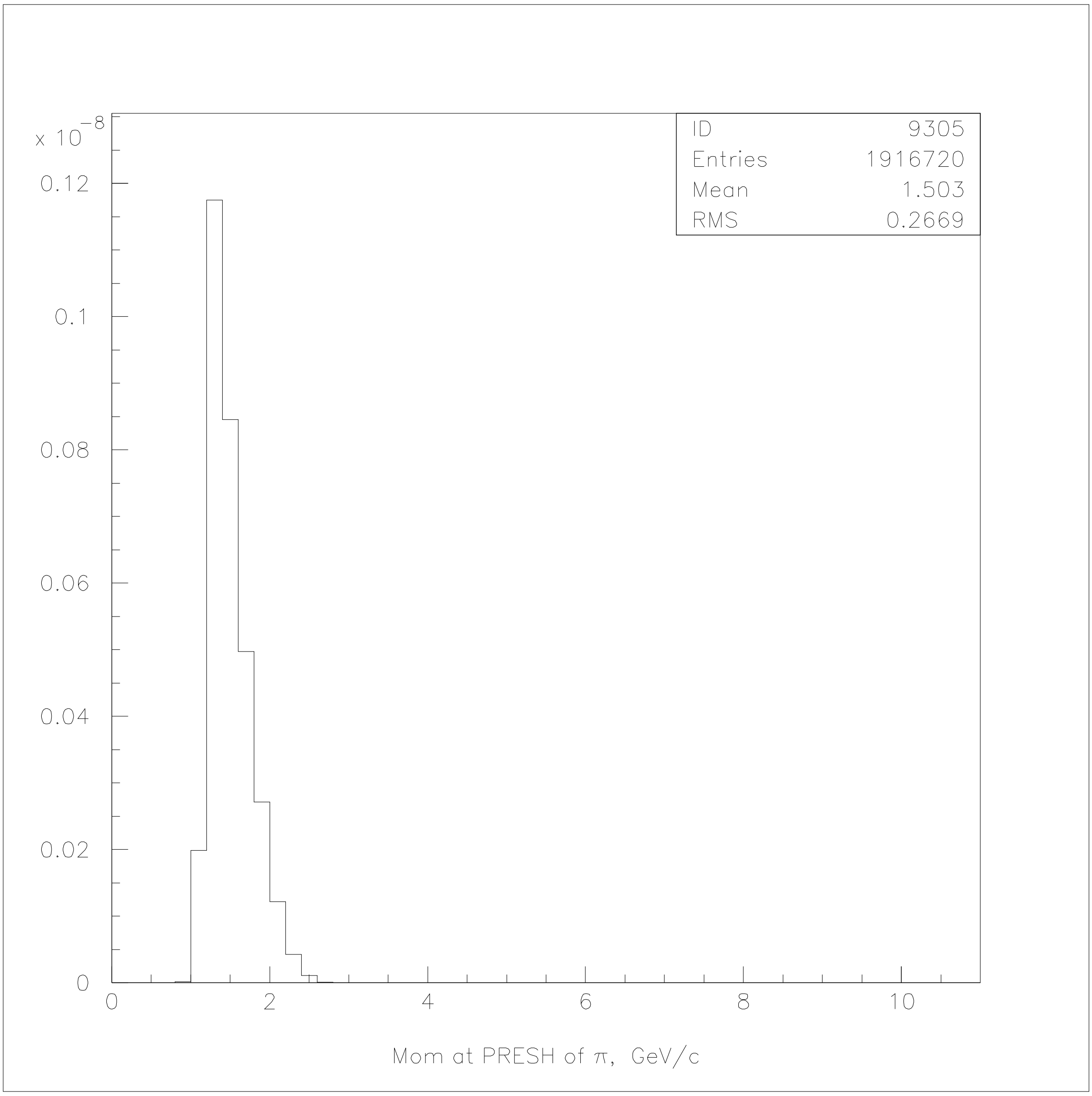

Figure 35: *Pion p-distribution in PR.*

7 Kaon momentum distributions

Table 6 is extraction of boundaries and mean values from histograms 36, 37, 38, 39, 40, 41 and 42.

Table 6: *Kaon p-boundaries and mean values (GeV/c).*

plane	p_{min}	p_{max}	Δp	$\frac{p_{max}}{p_{min}}$	mv
DC2	4.0	9.2	5.2	2.3	5.377
DC3	4.0	9.2	5.2	2.3	5.377
DC4	4.0	9.2	5.2	2.3	5.377
CH1	4.0	9.2	5.2	2.3	5.382
CH2	4.0	9.2	5.2	2.3	5.380
CH3	4.0	9.2	5.2	2.3	5.379
PR	4.0	9.2	5.2	2.3	5.381

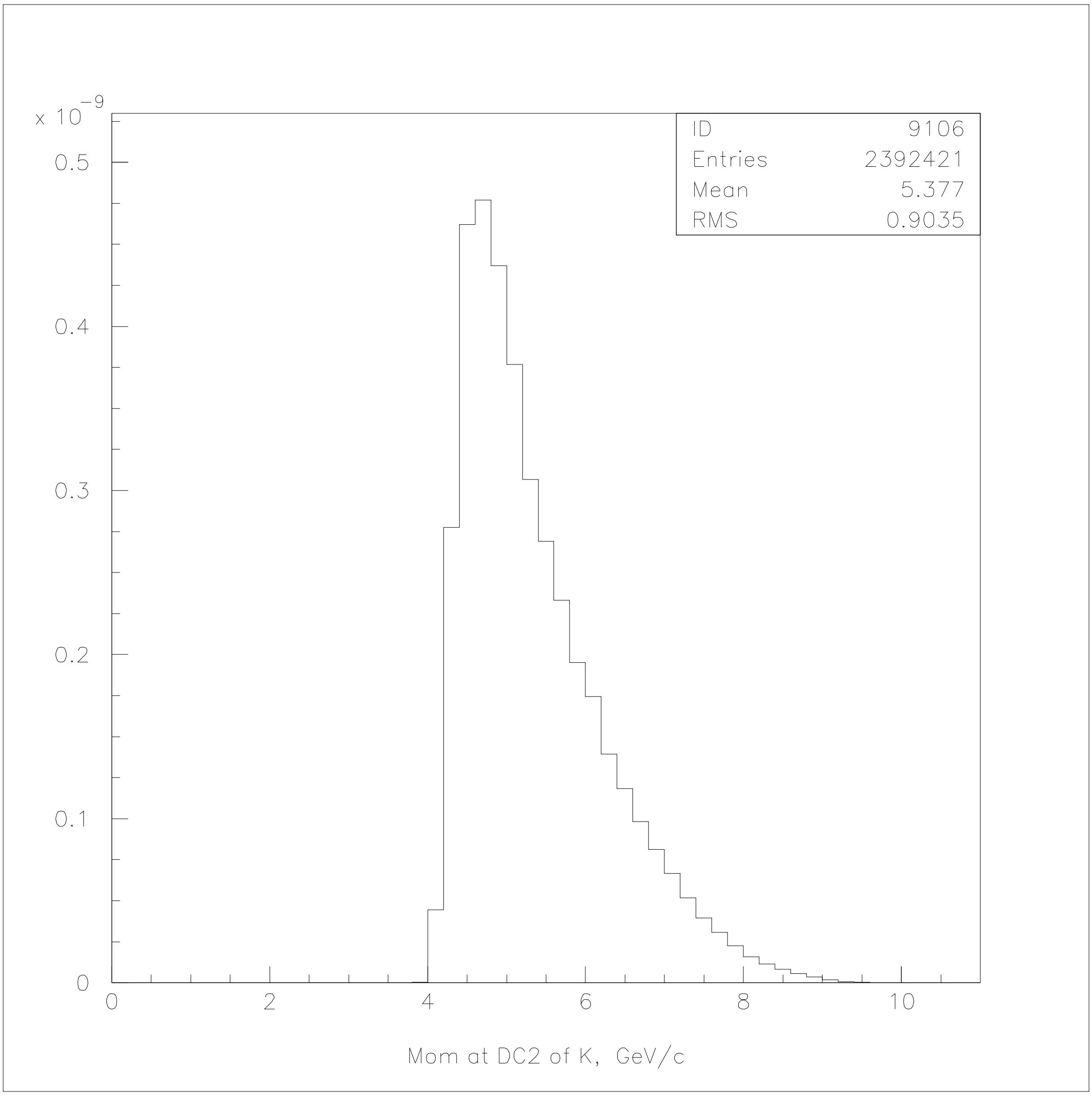

Figure 36: *Kaon p-distribution in DC2.*

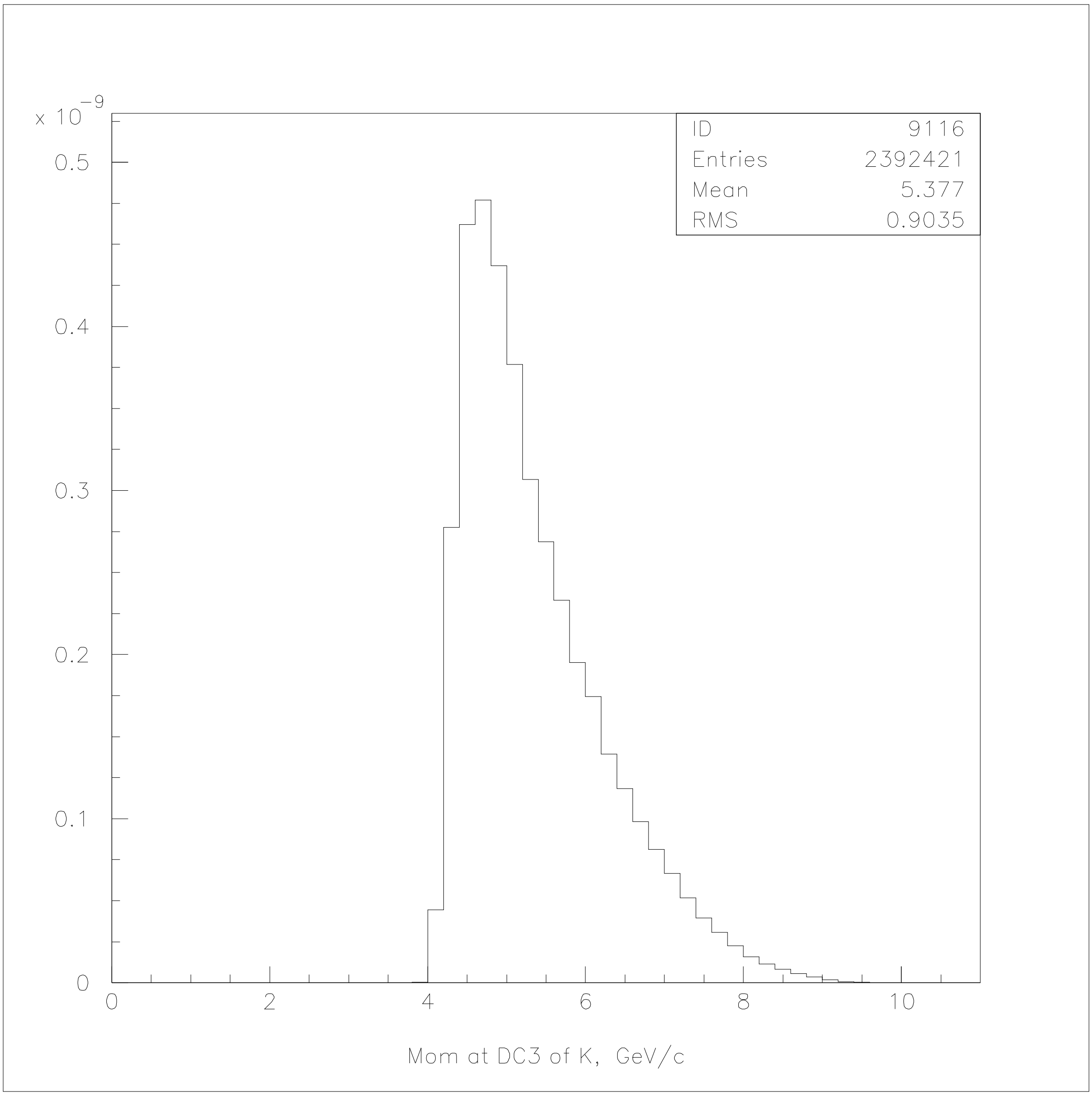

Figure 37: *Kaon p-distribution in DC3.*

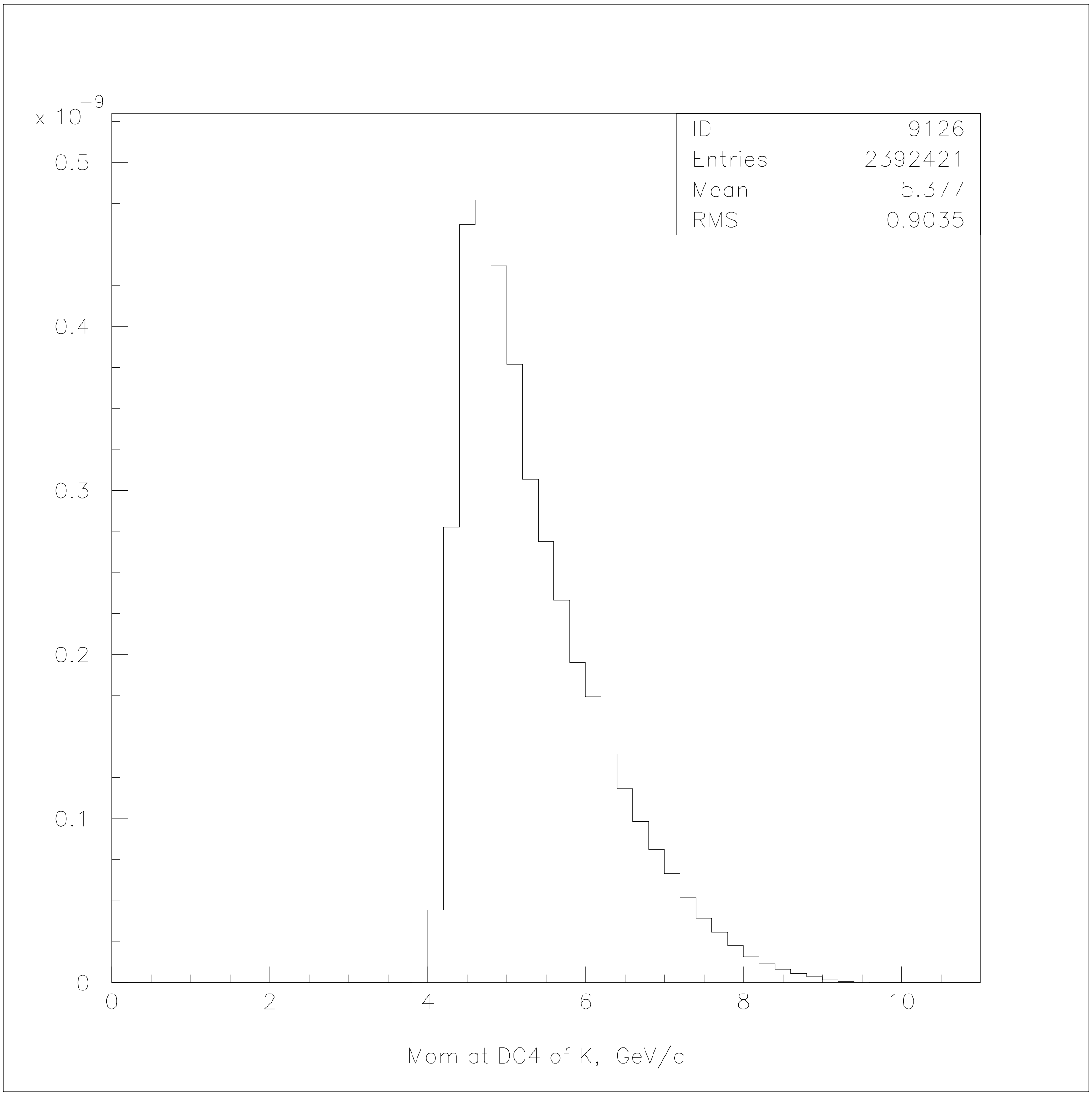

Figure 38: *Kaon p-distribution in DC4.*

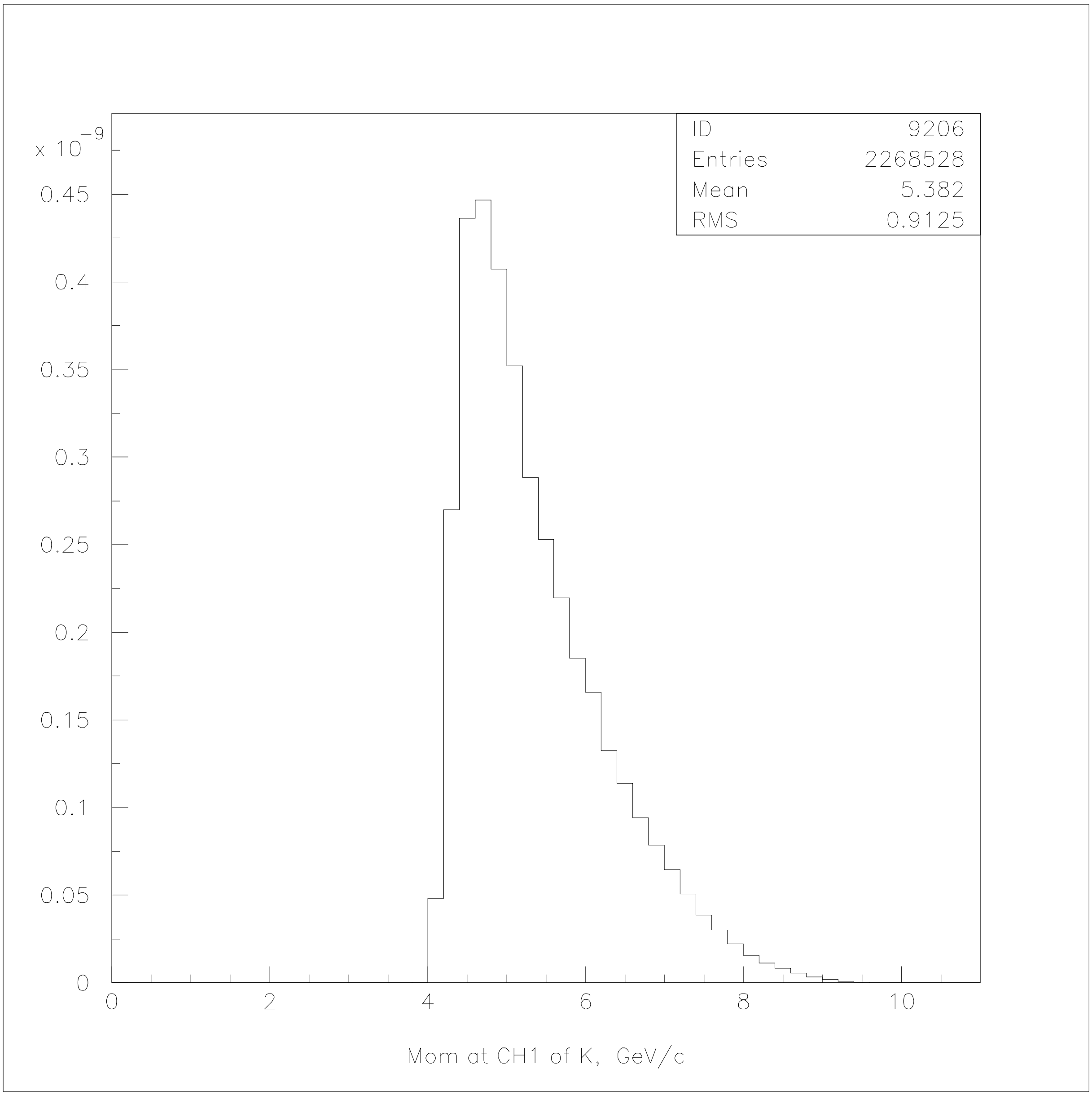

Figure 39: *Kaon p-distribution in the front of CH (CH1).*

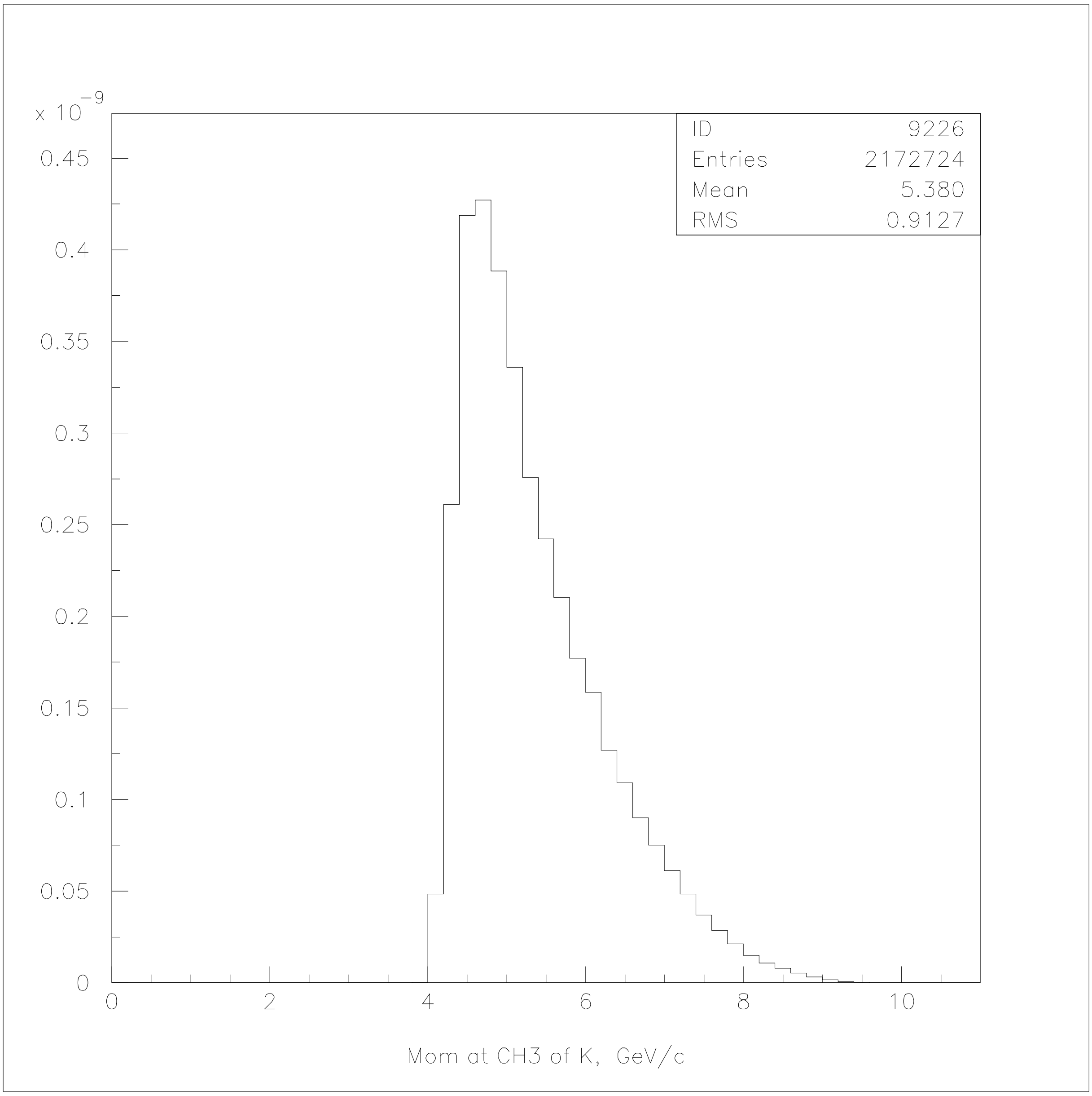

Figure 40: *Kaon p-distribution in 1 m from the front of CH (CH2).*

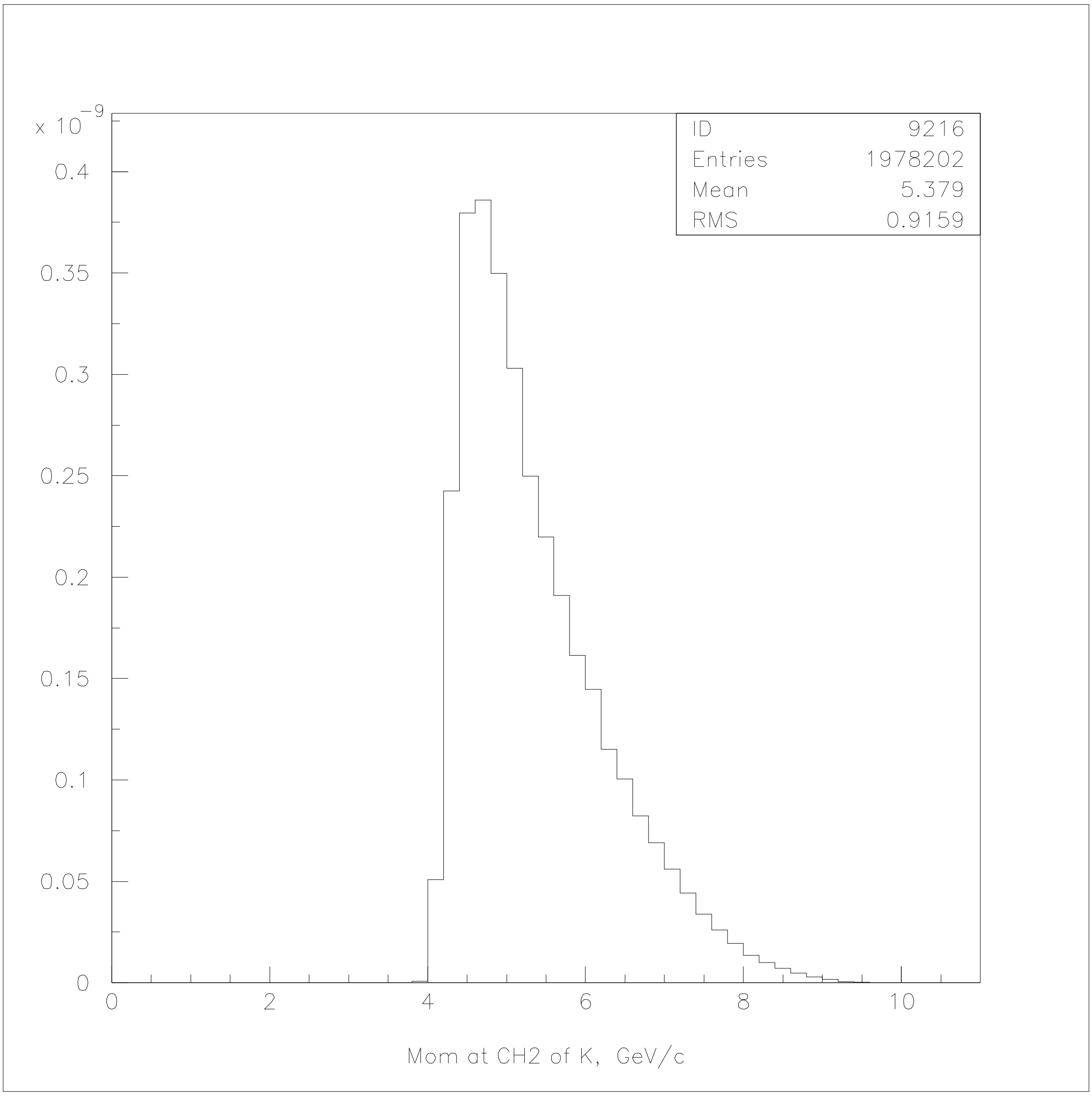

Figure 41: *Kaon p-distribution in the back of CH (CH3).*

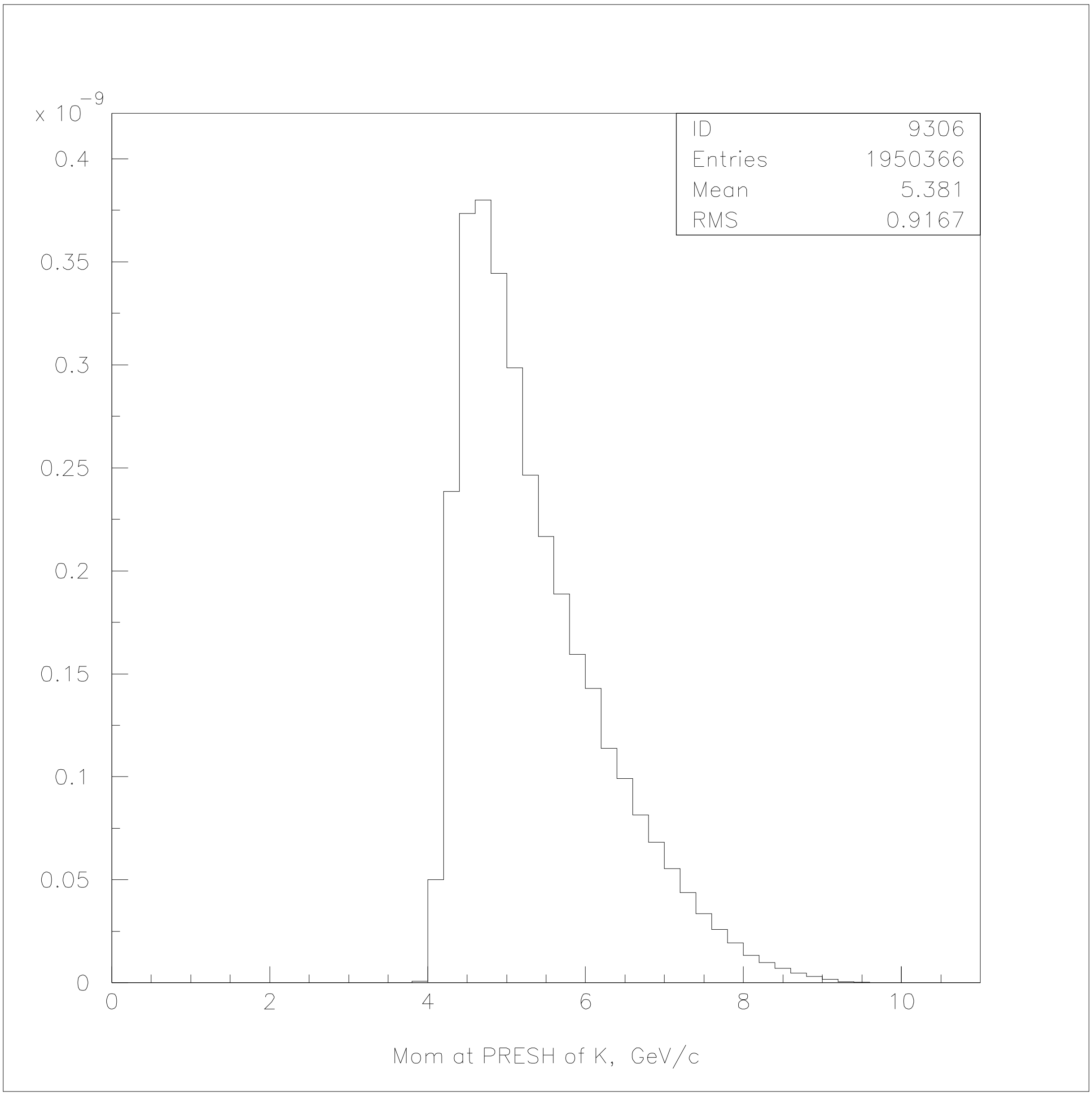

Figure 42: *Kaon p-distribution in PR.*

8 Pion xy-plots

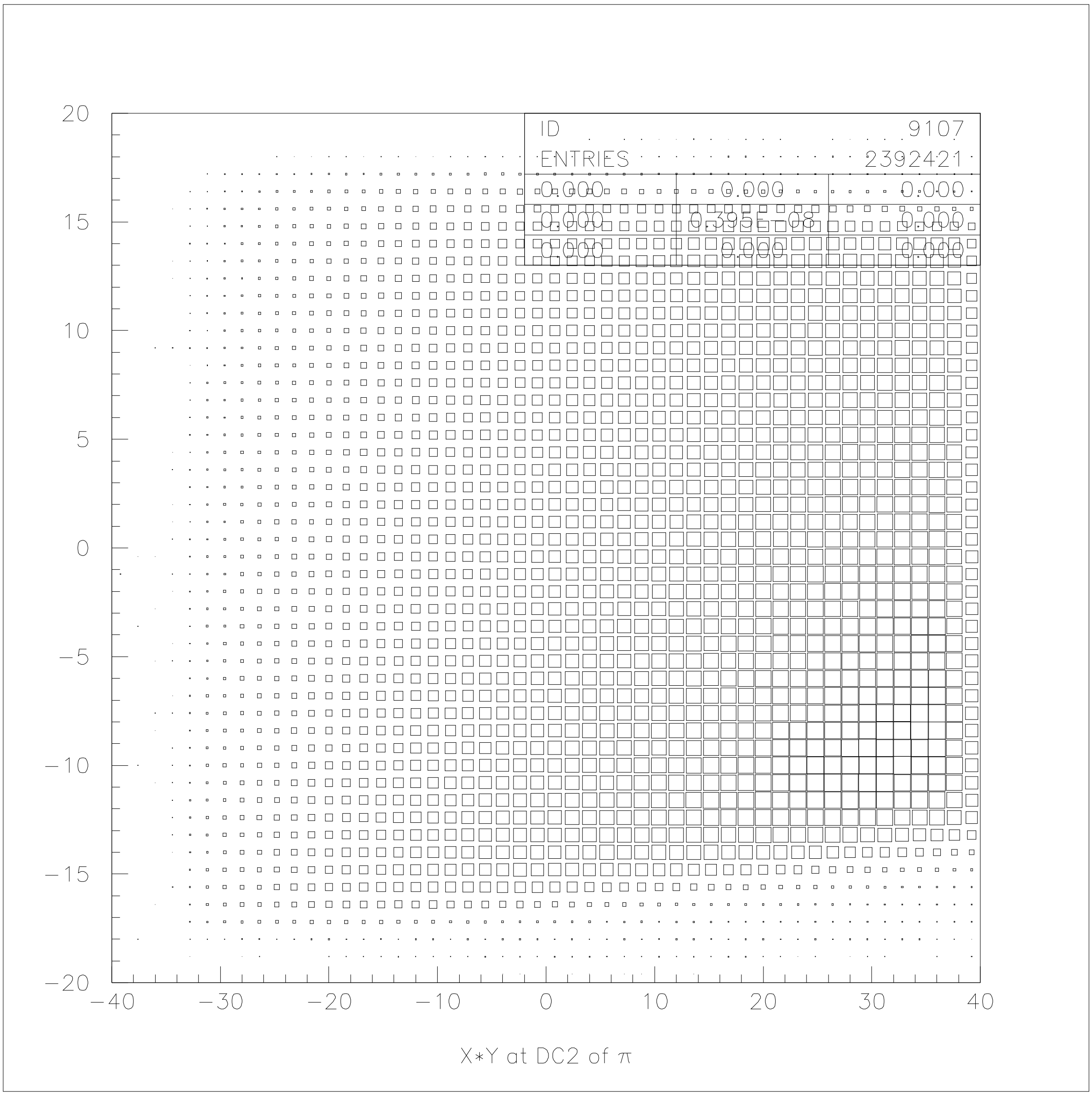

Figure 43: *Pion xy-plot in DC2.*

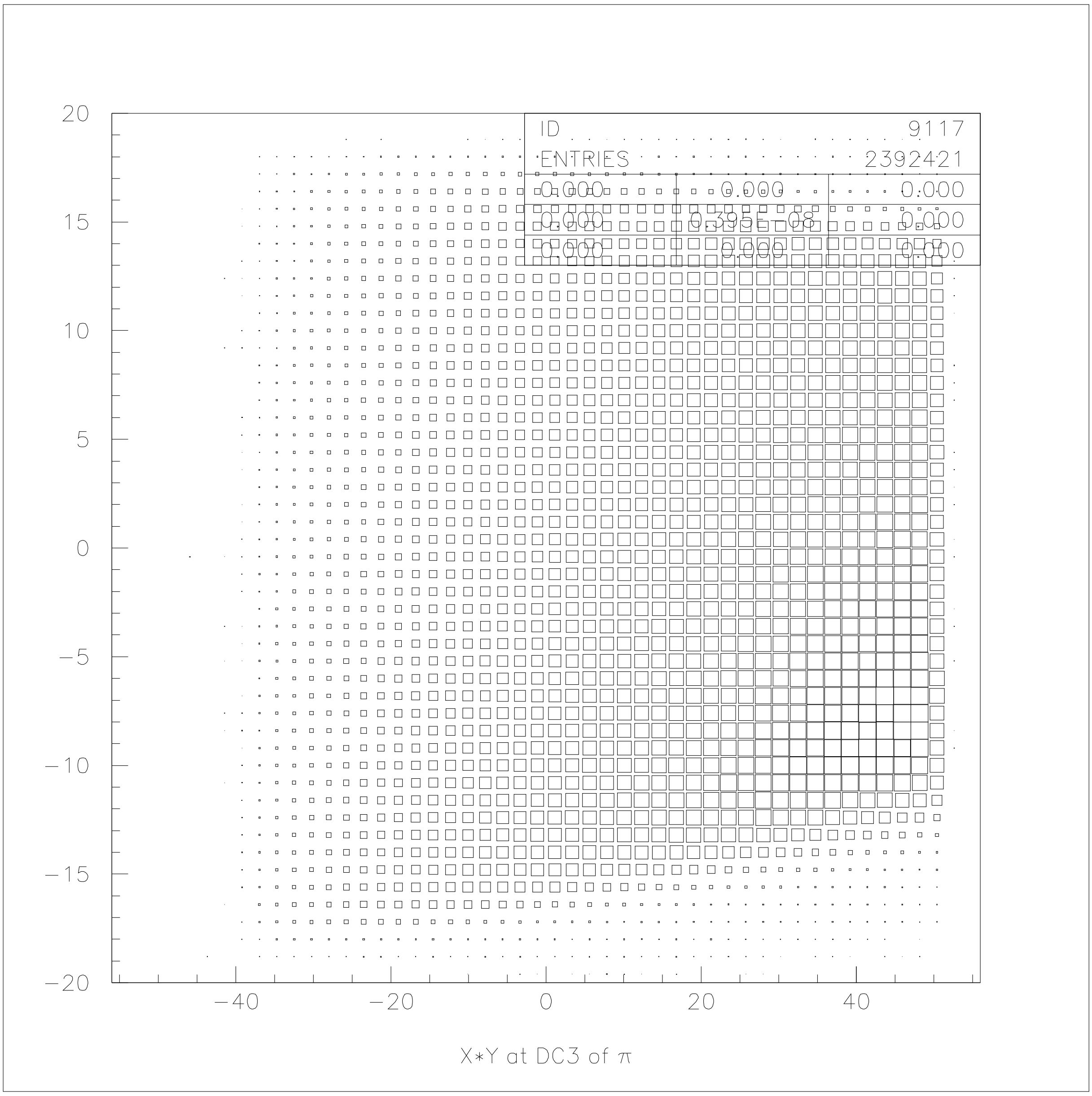

Figure 44: *Pion xy-plot in DC3.*

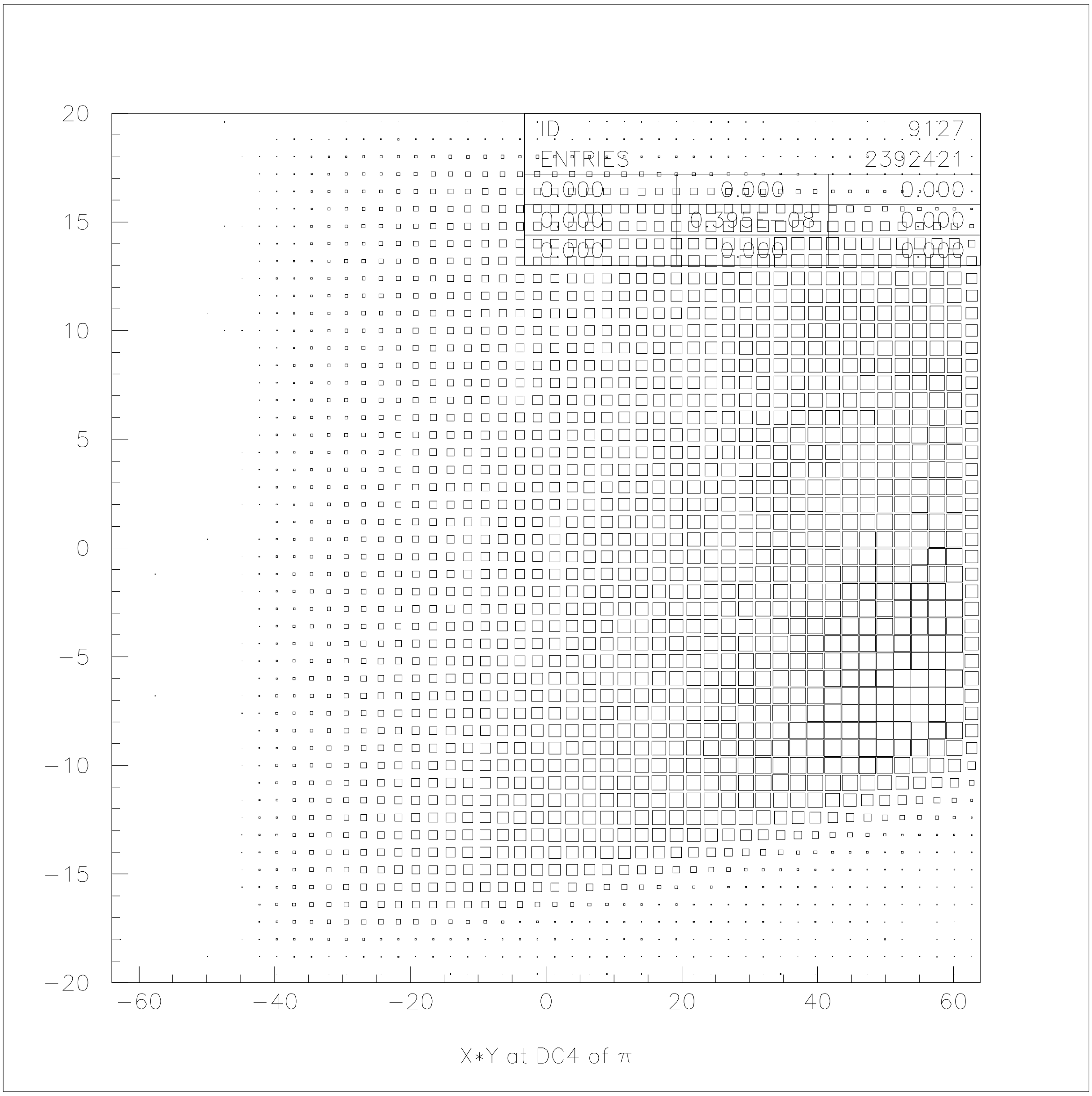

Figure 45: *Pion xy-plot in DC4.*

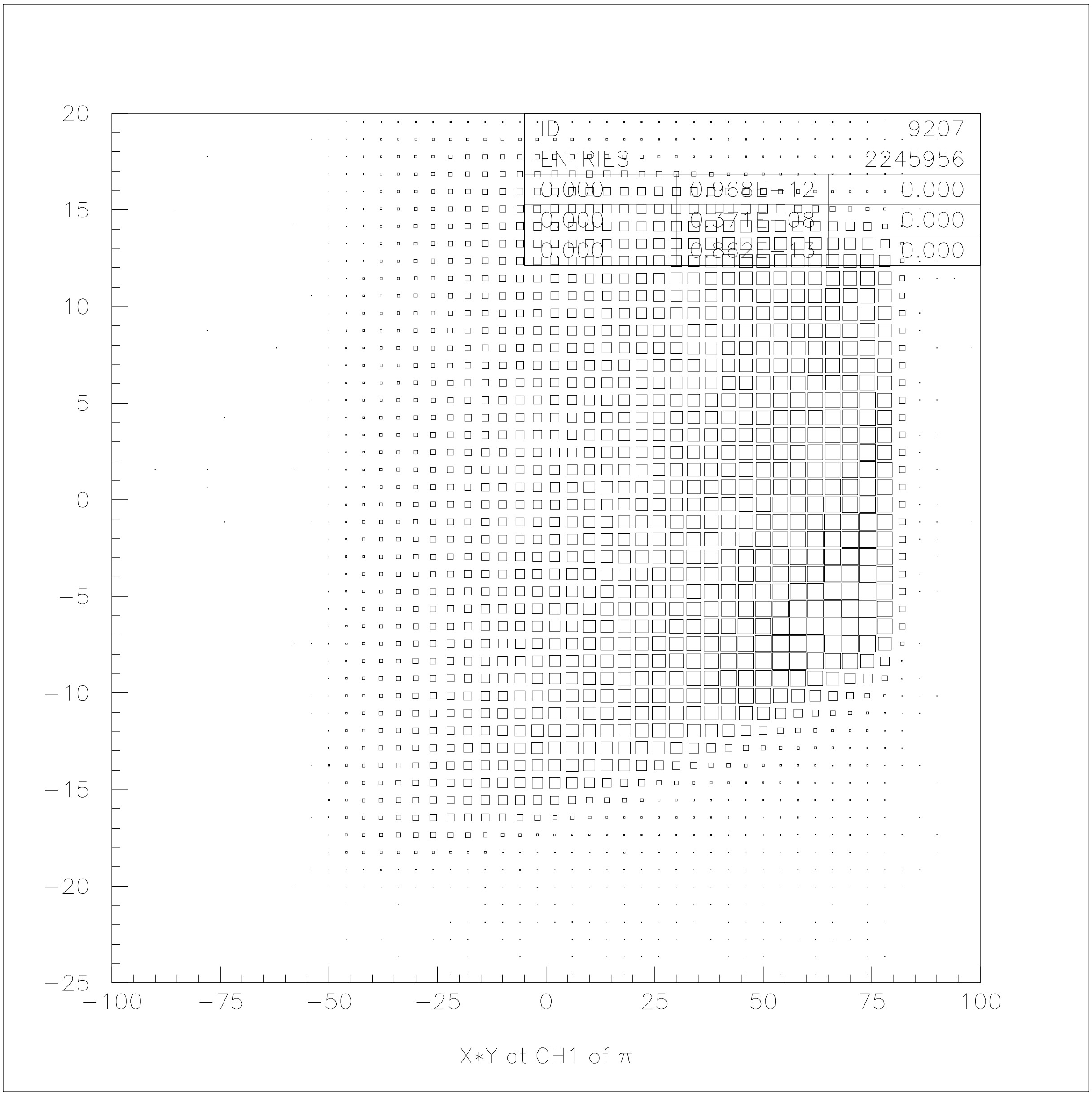

Figure 46: *Pion xy-plot in the front of CH (CH1).*

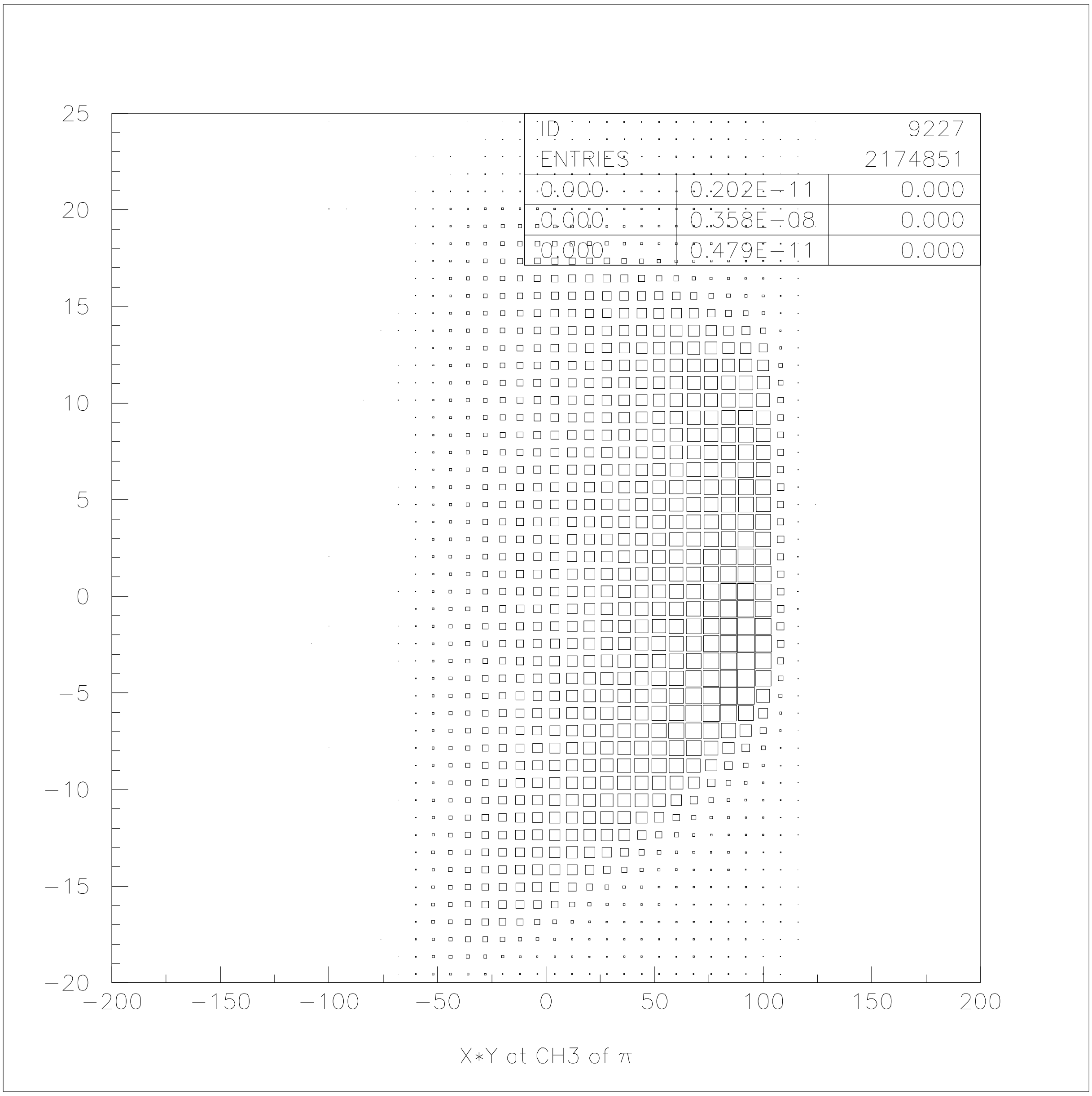

Figure 47: *Pion xy-plot in 1 m from the front of CH (CH2).*

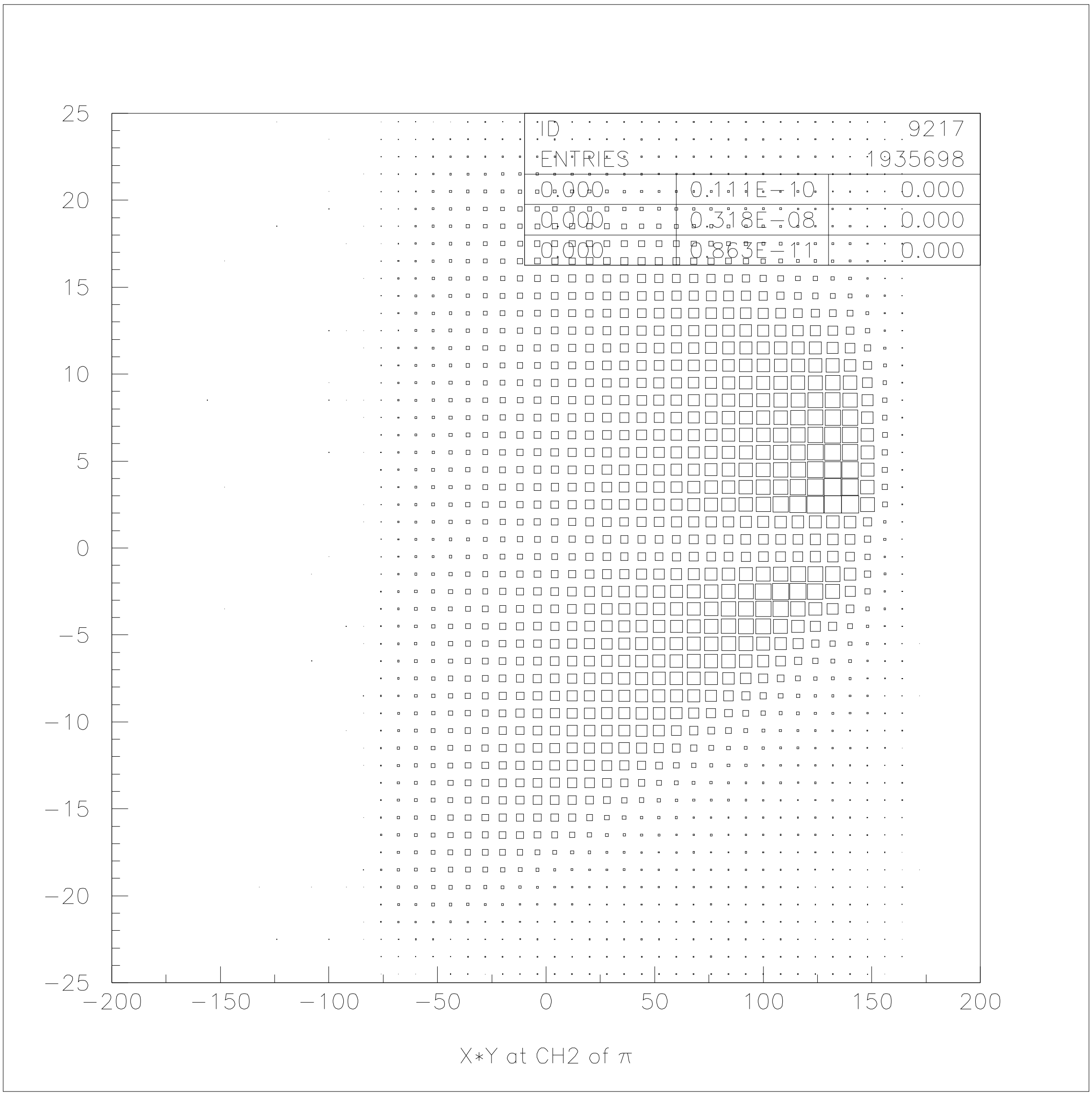

Figure 48: *Pion xy-plot in the back of CH (CH3).*

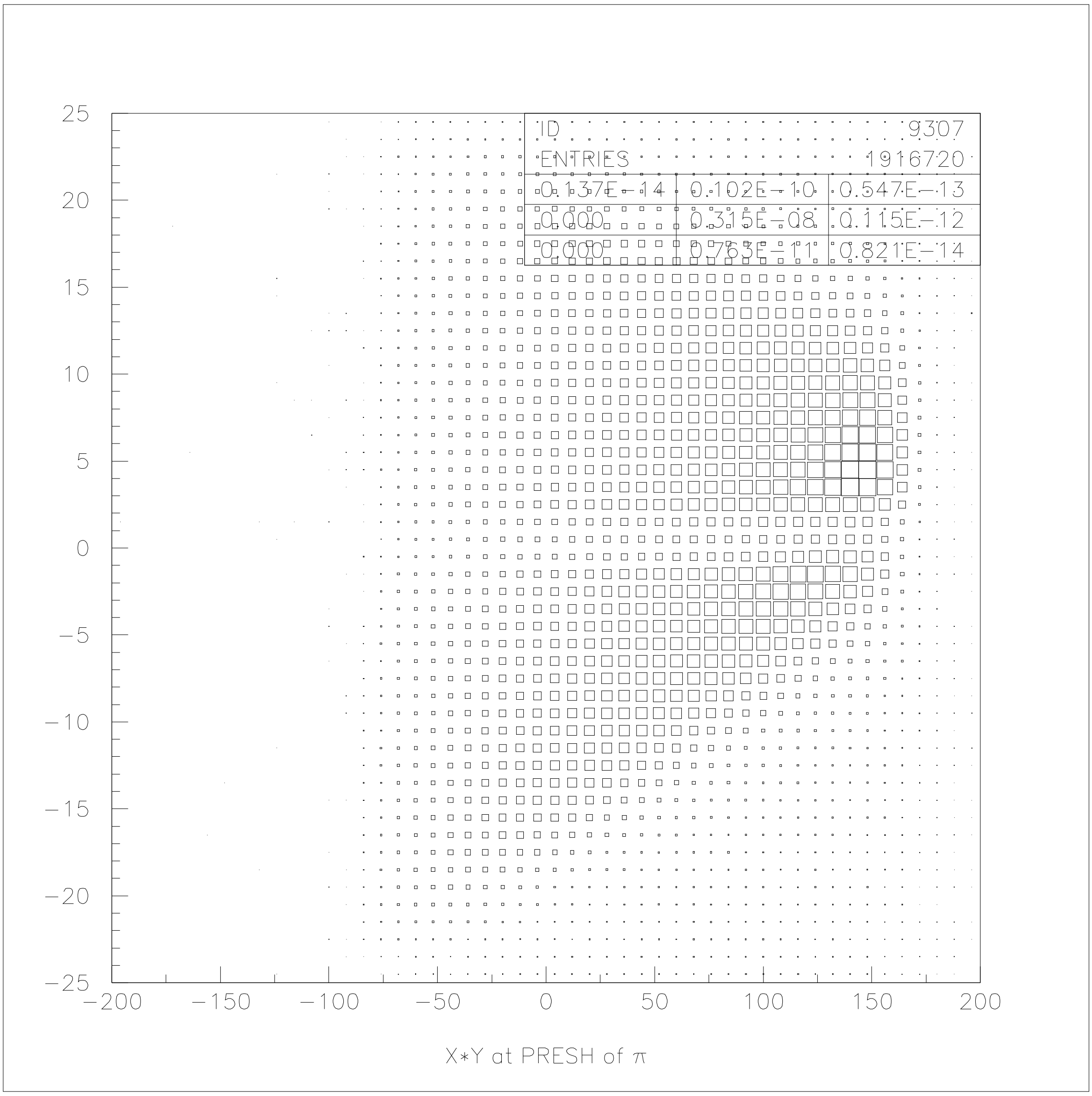

Figure 49: *Pion xy-plot in PR.*

9 Kaon xy-plots

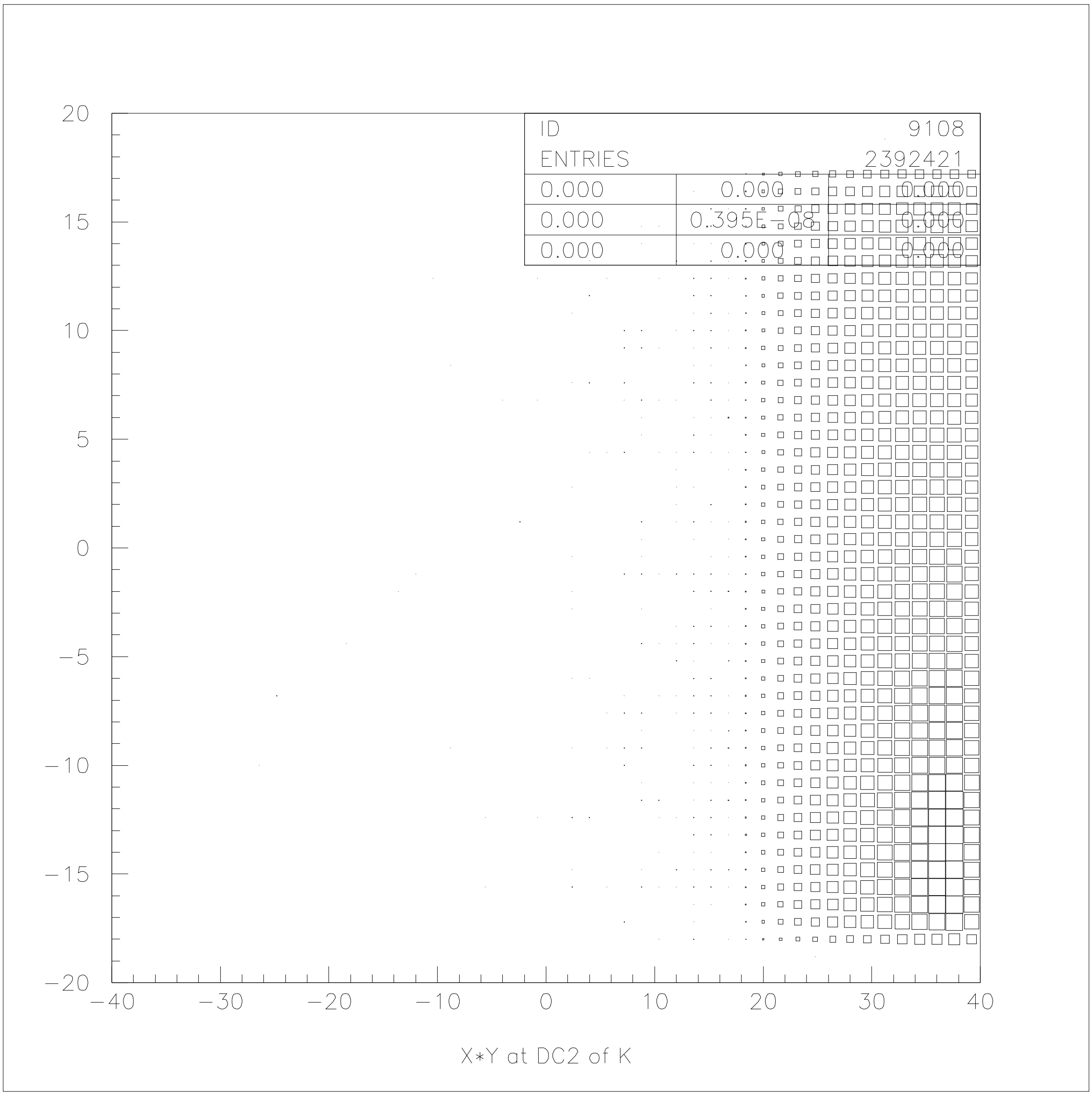

Figure 50: *Kaon xy-plot in DC2.*

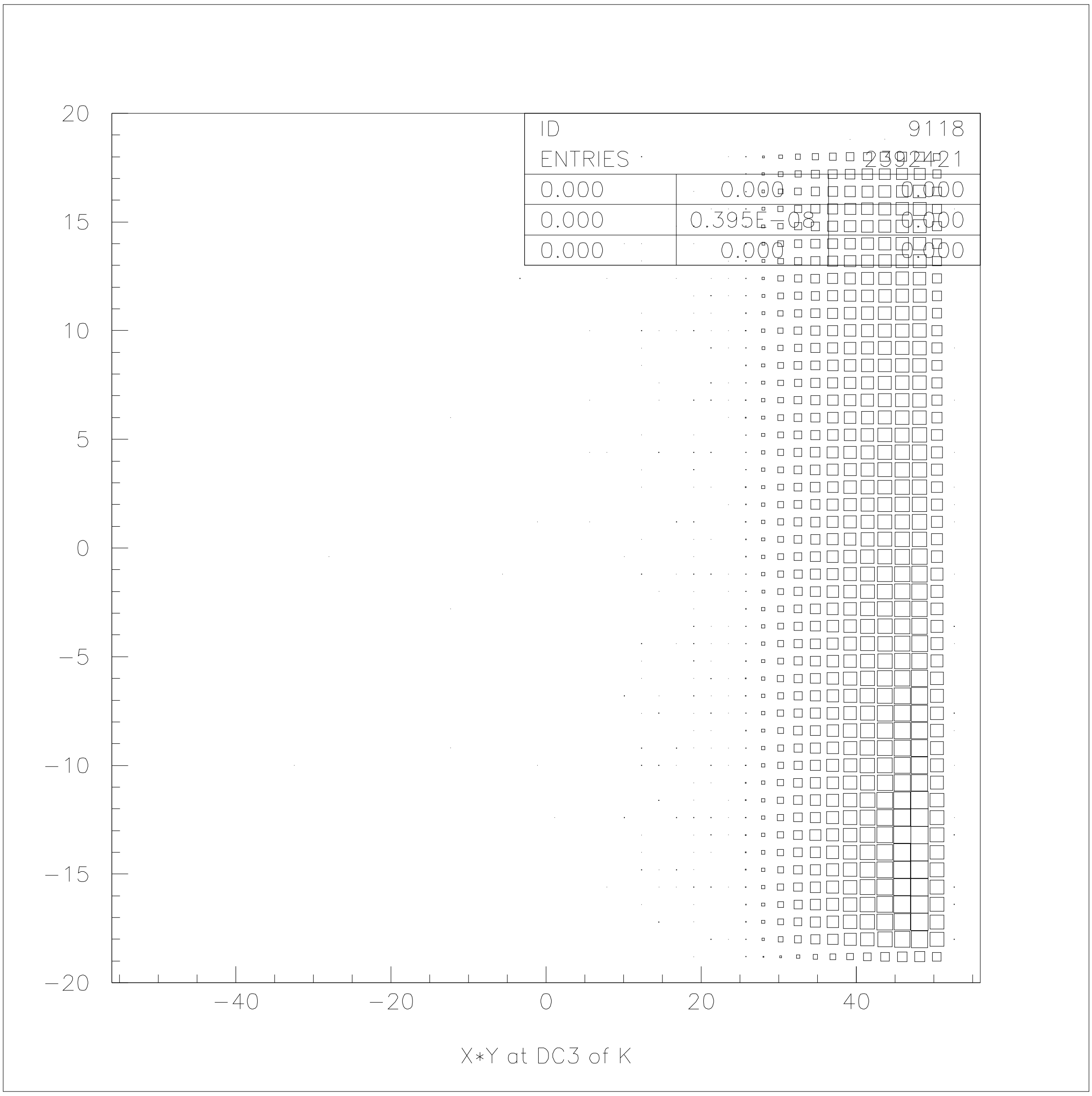

Figure 51: *Kaon xy-plot in DC3.*

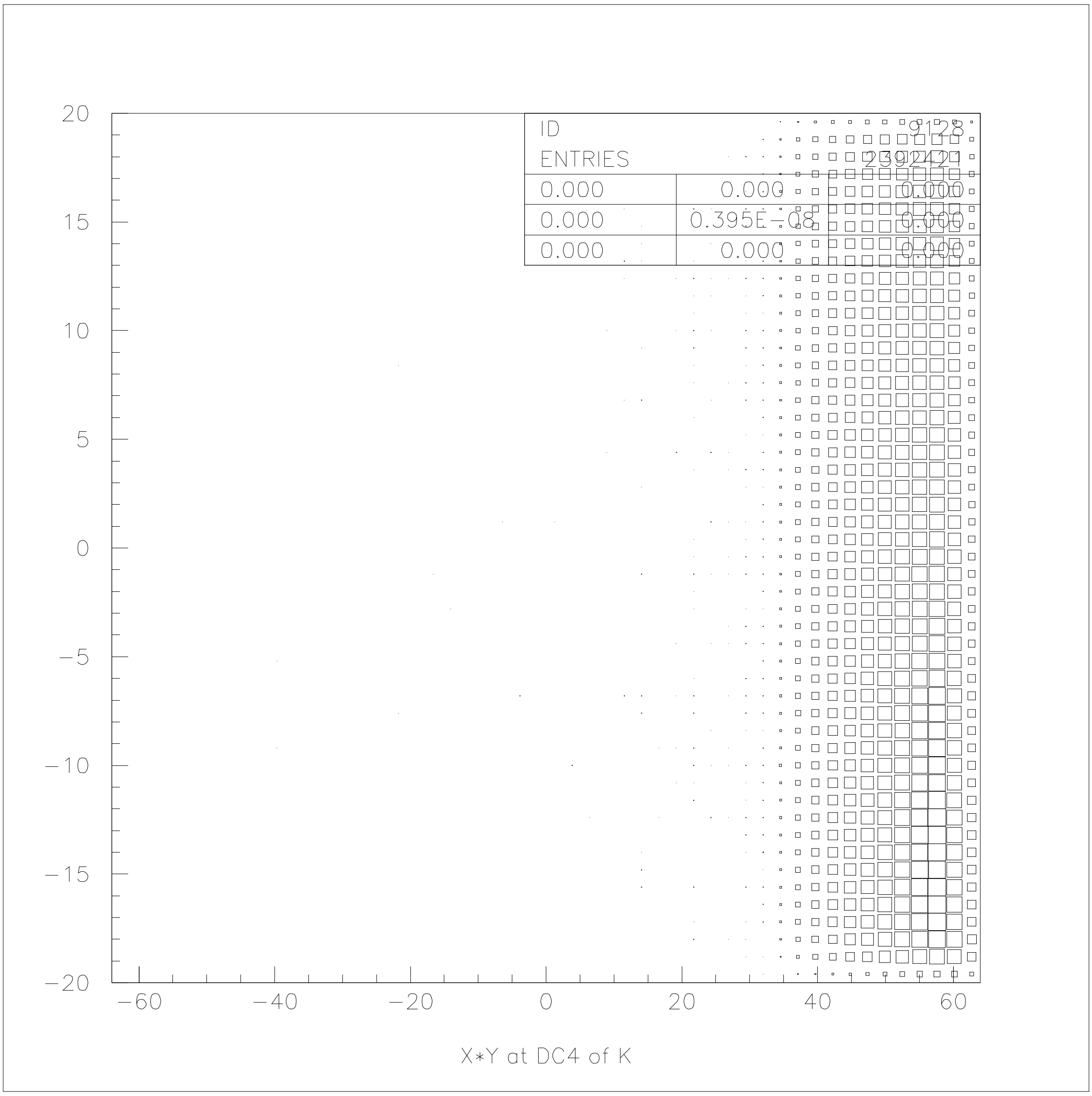

Figure 52: *Kaon xy-plot in DC4.*

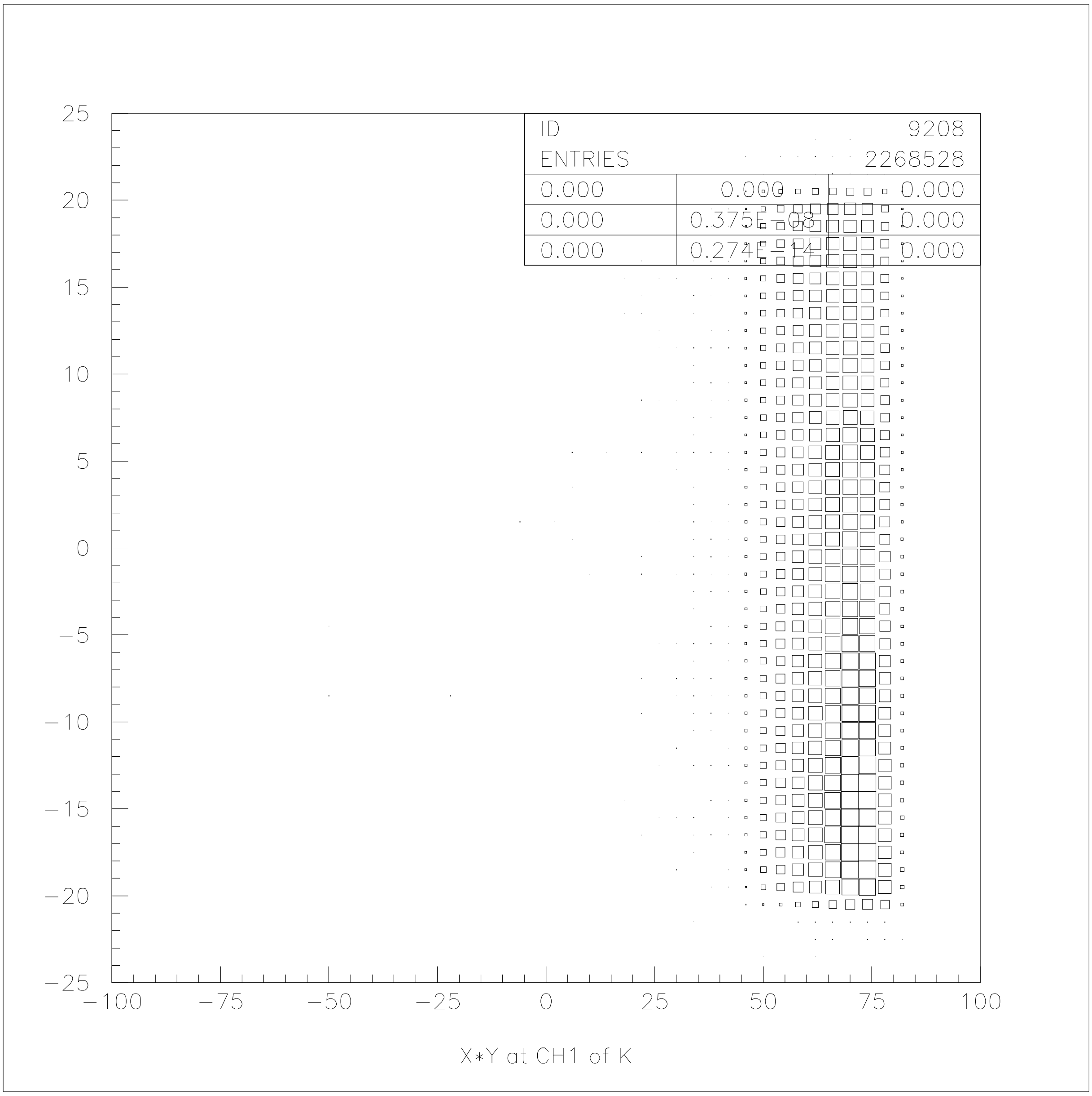

Figure 53: *Kaon xy-plot in the front of CH (CH1).*

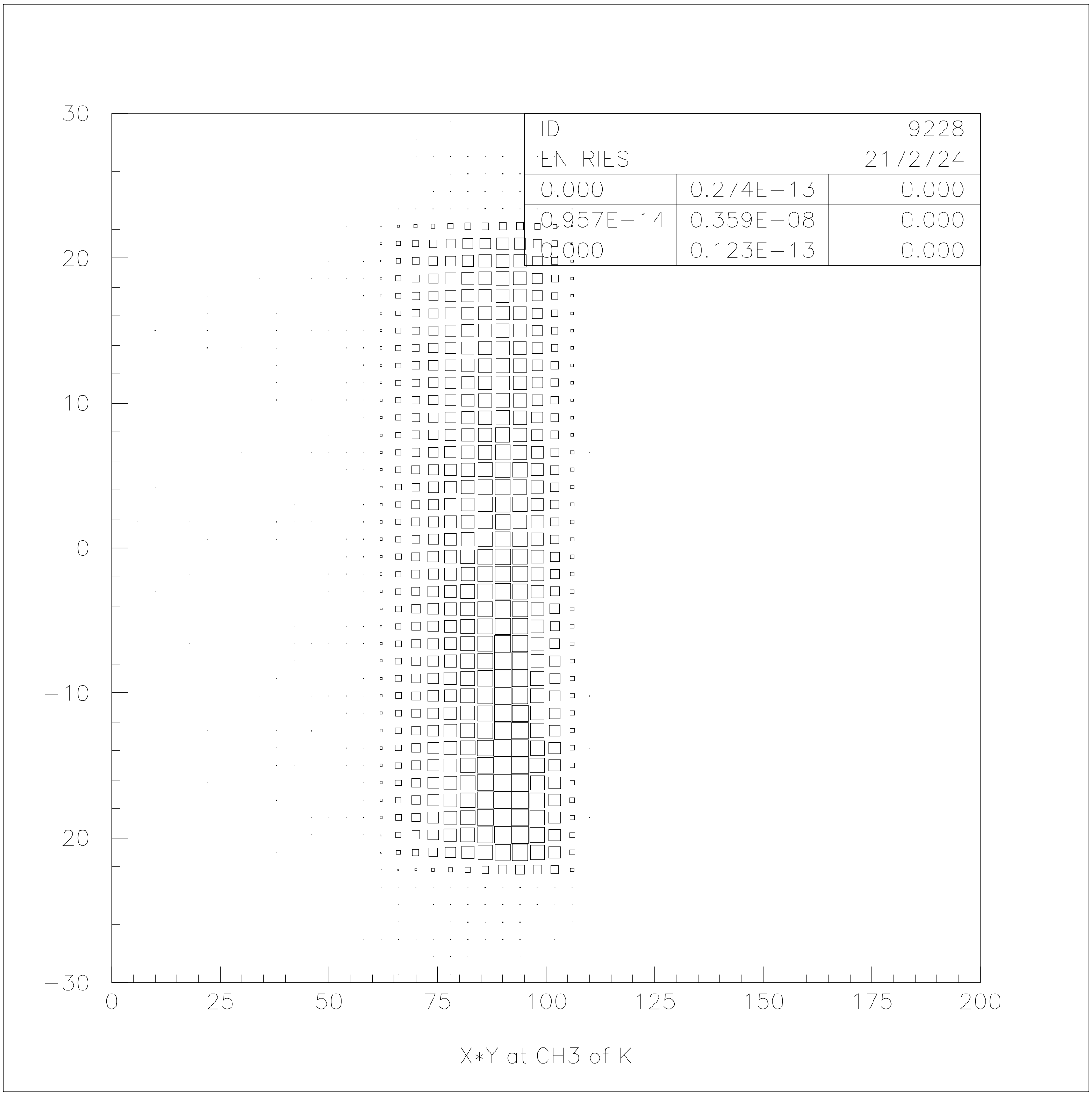

Figure 54: *Kaon xy-plot in 1 m from the front of CH (CH2).*

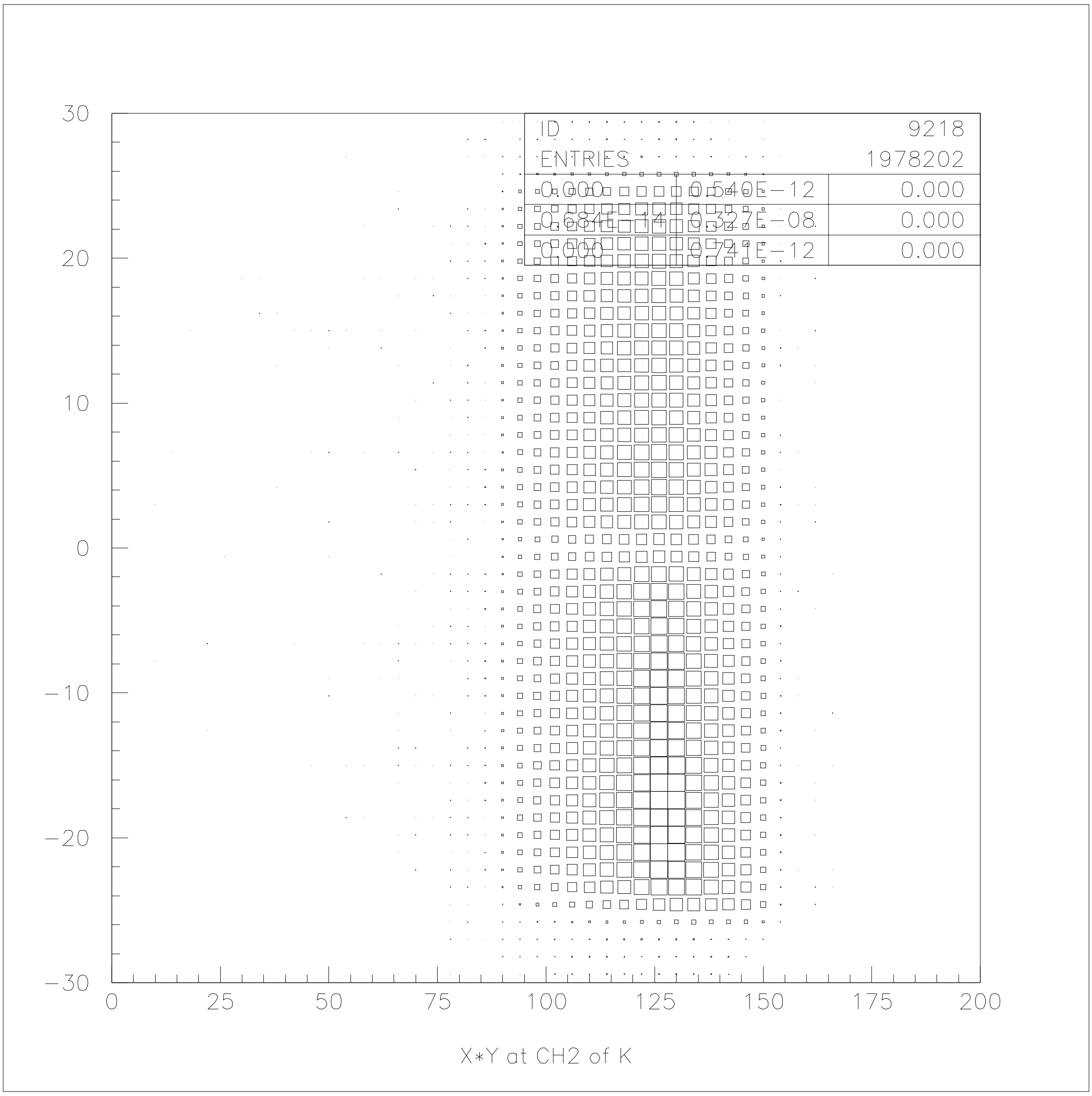

Figure 55: *Kaon xy-plot in the back of CH (CH3).*

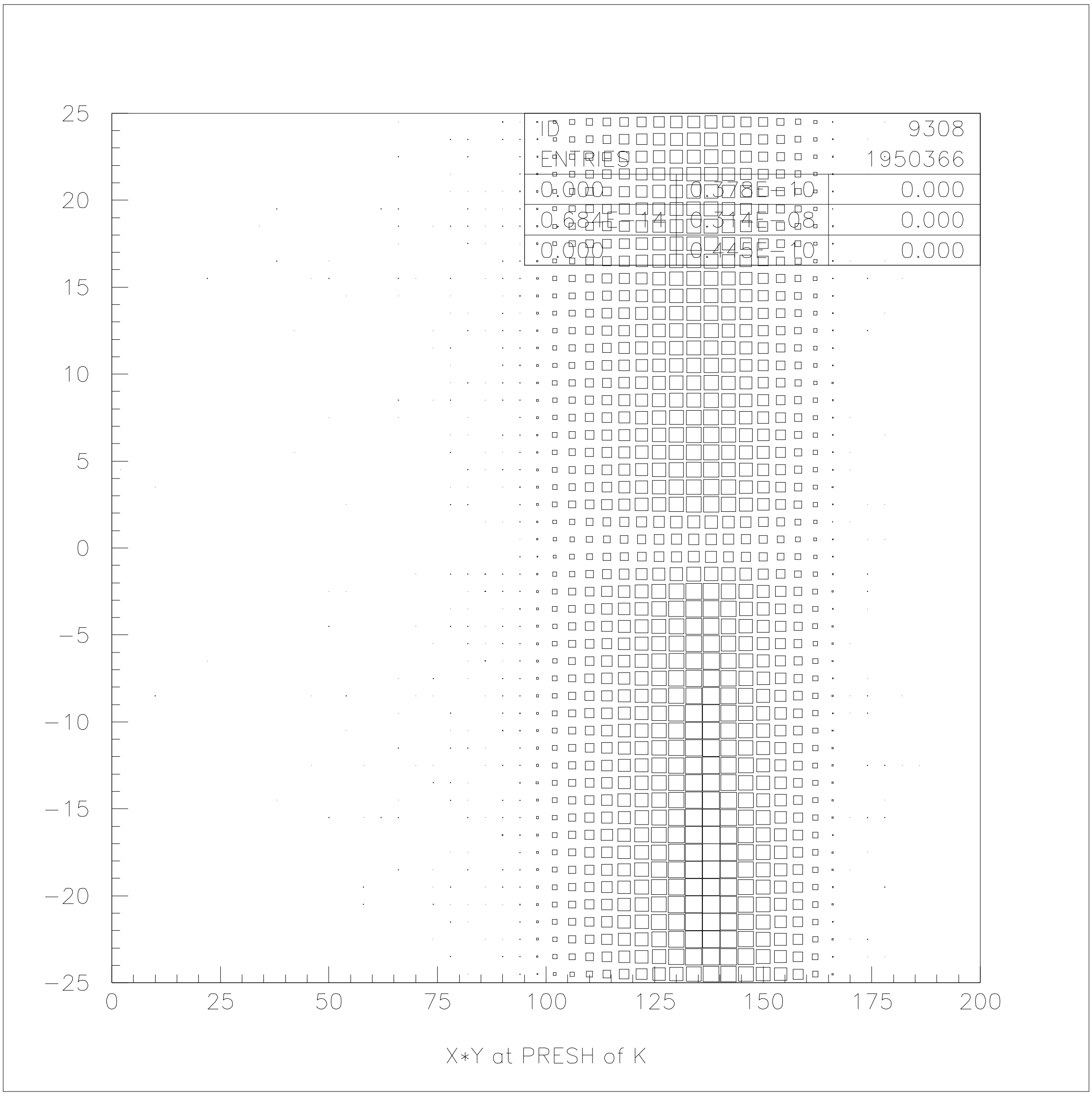

Figure 56: *Kaon xy-plot in PR.*

10 Pion xp-correlations

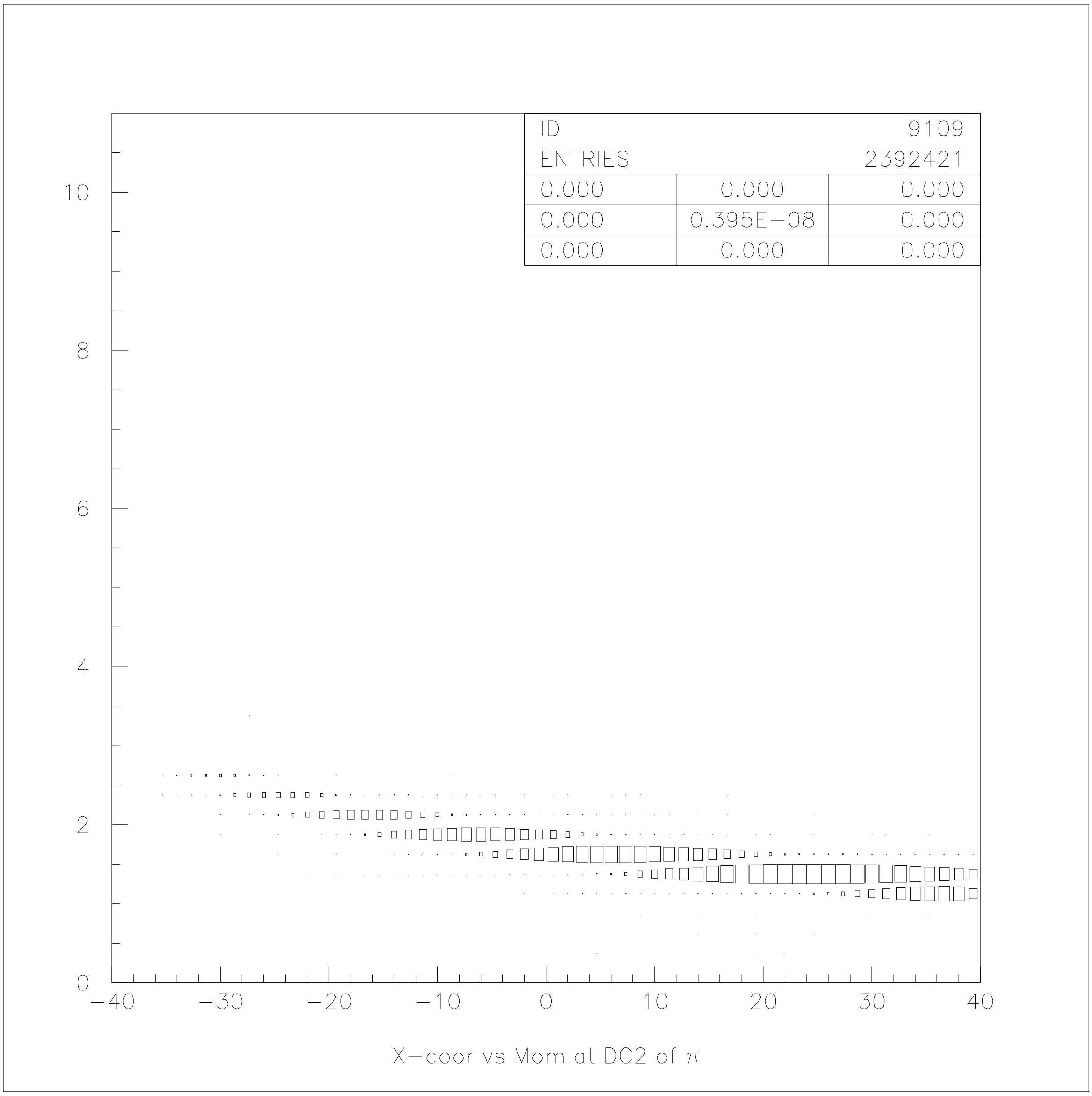

Figure 57: *Pion xp-plot in DC2.*

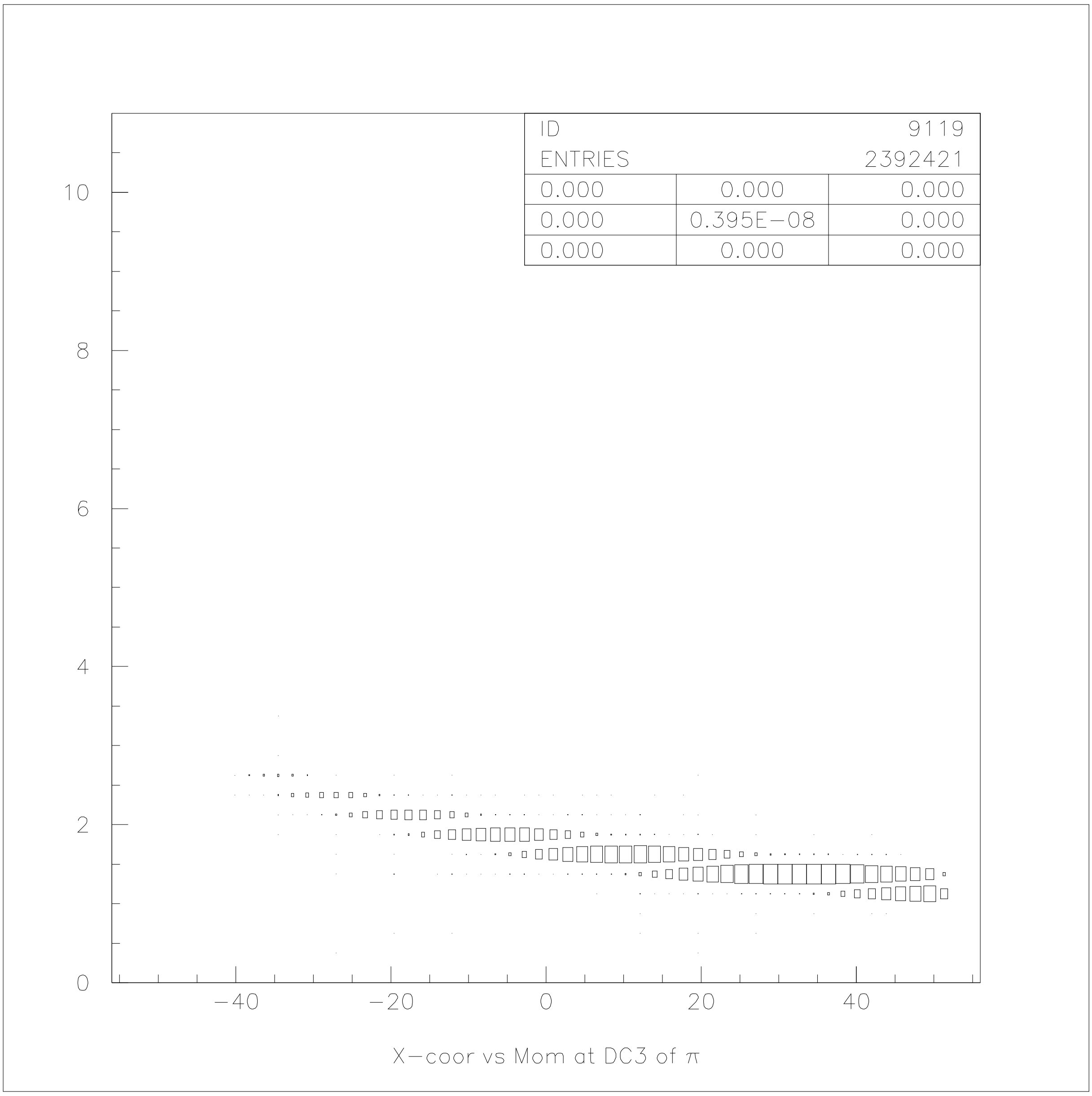

Figure 58: *Pion xp-plot in DC3.*

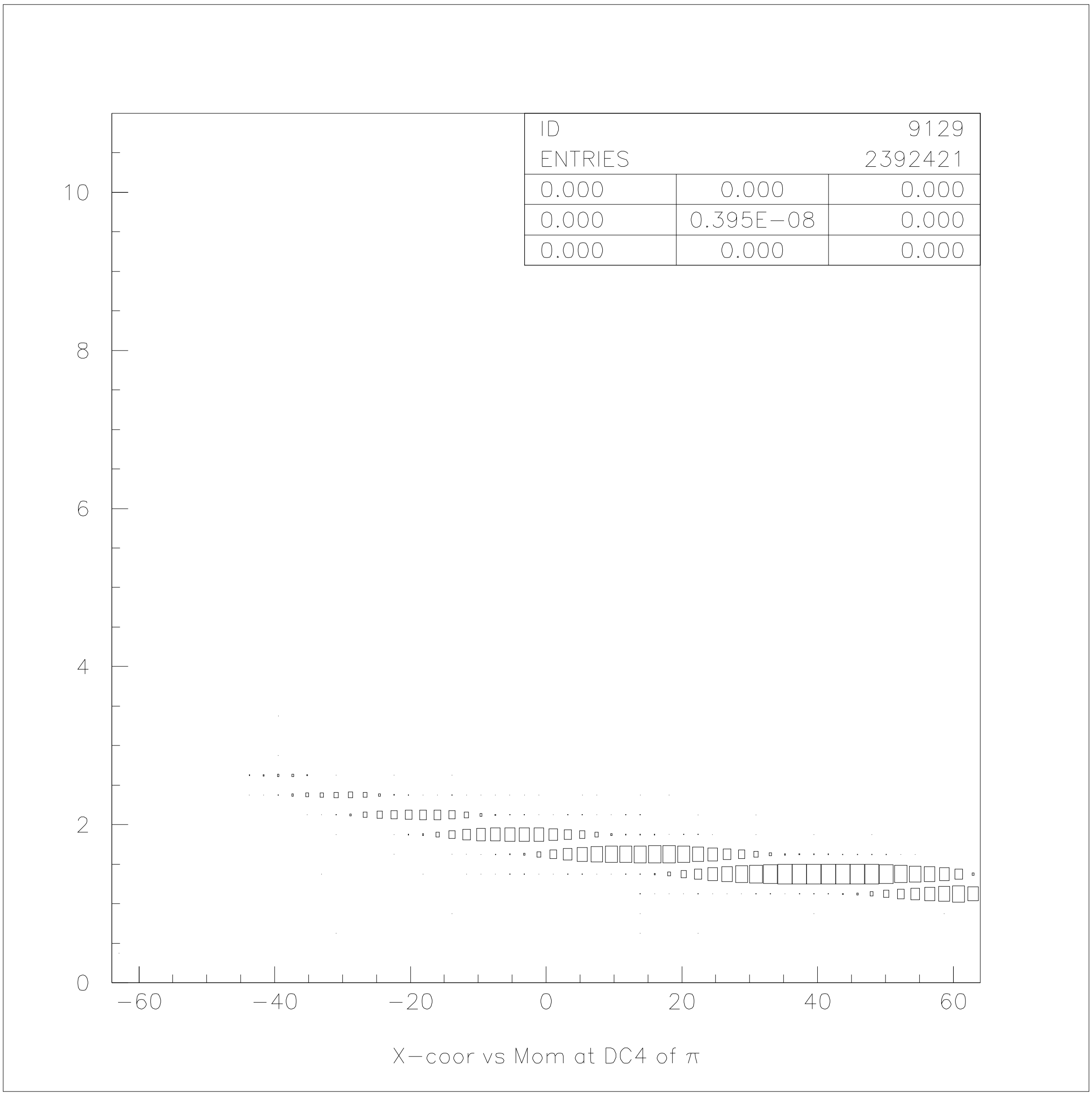

Figure 59: *Pion xp-plot in DC4.*

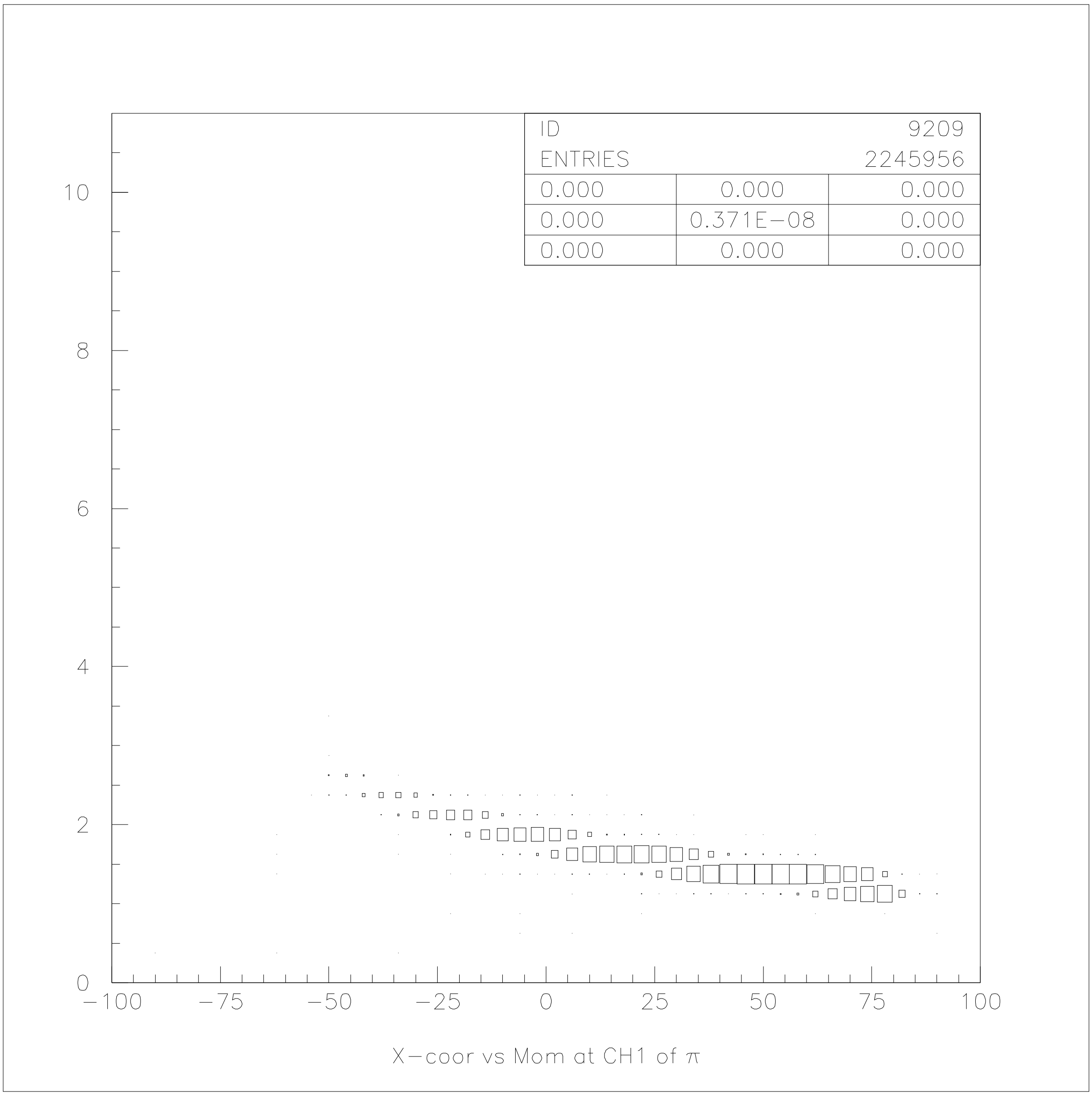

Figure 60: *Pion xp-plot in the front of CH (CH1).*

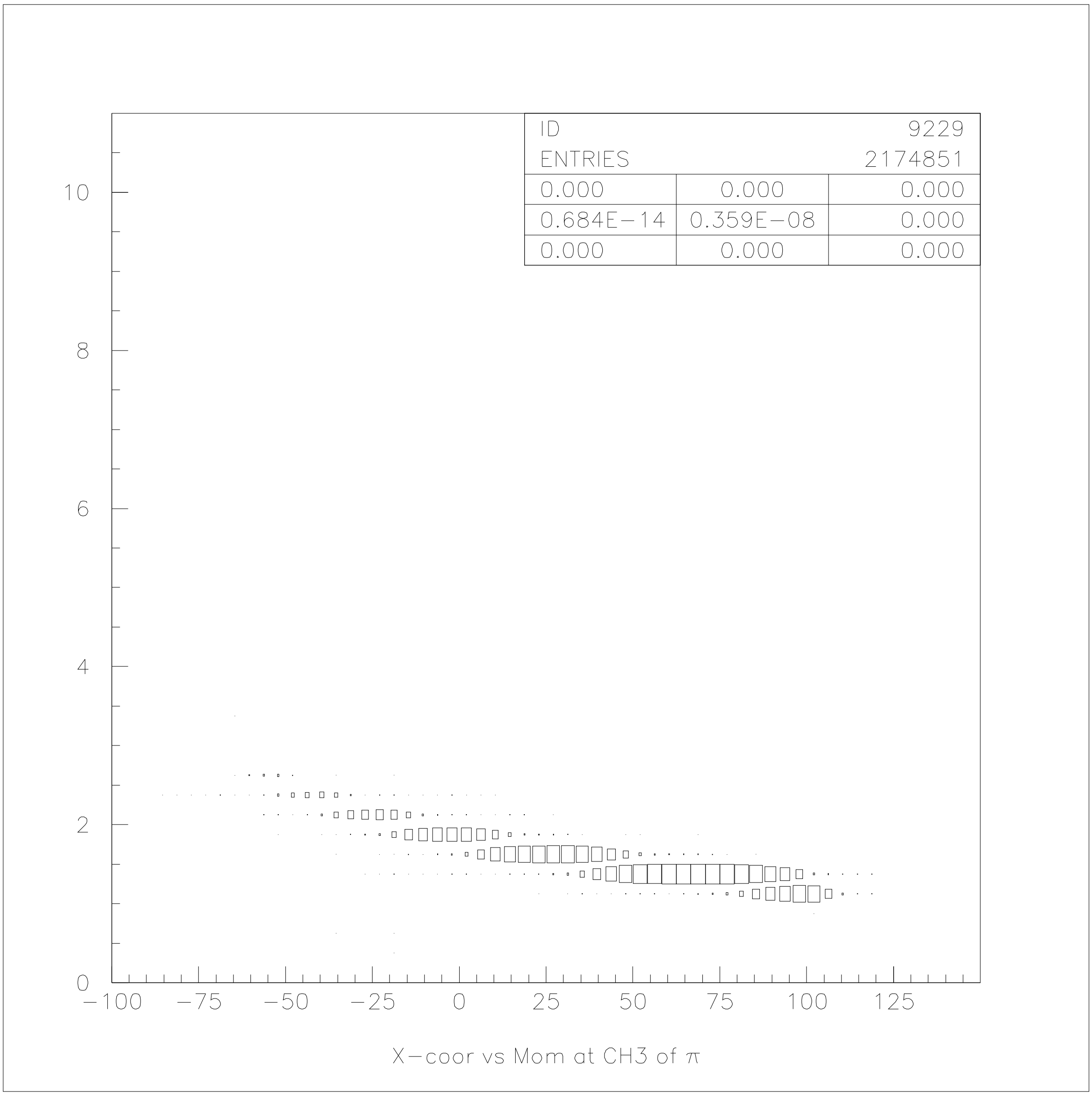

Figure 61: *Pion xp-plot in 1 m from the front of CH (CH2).*

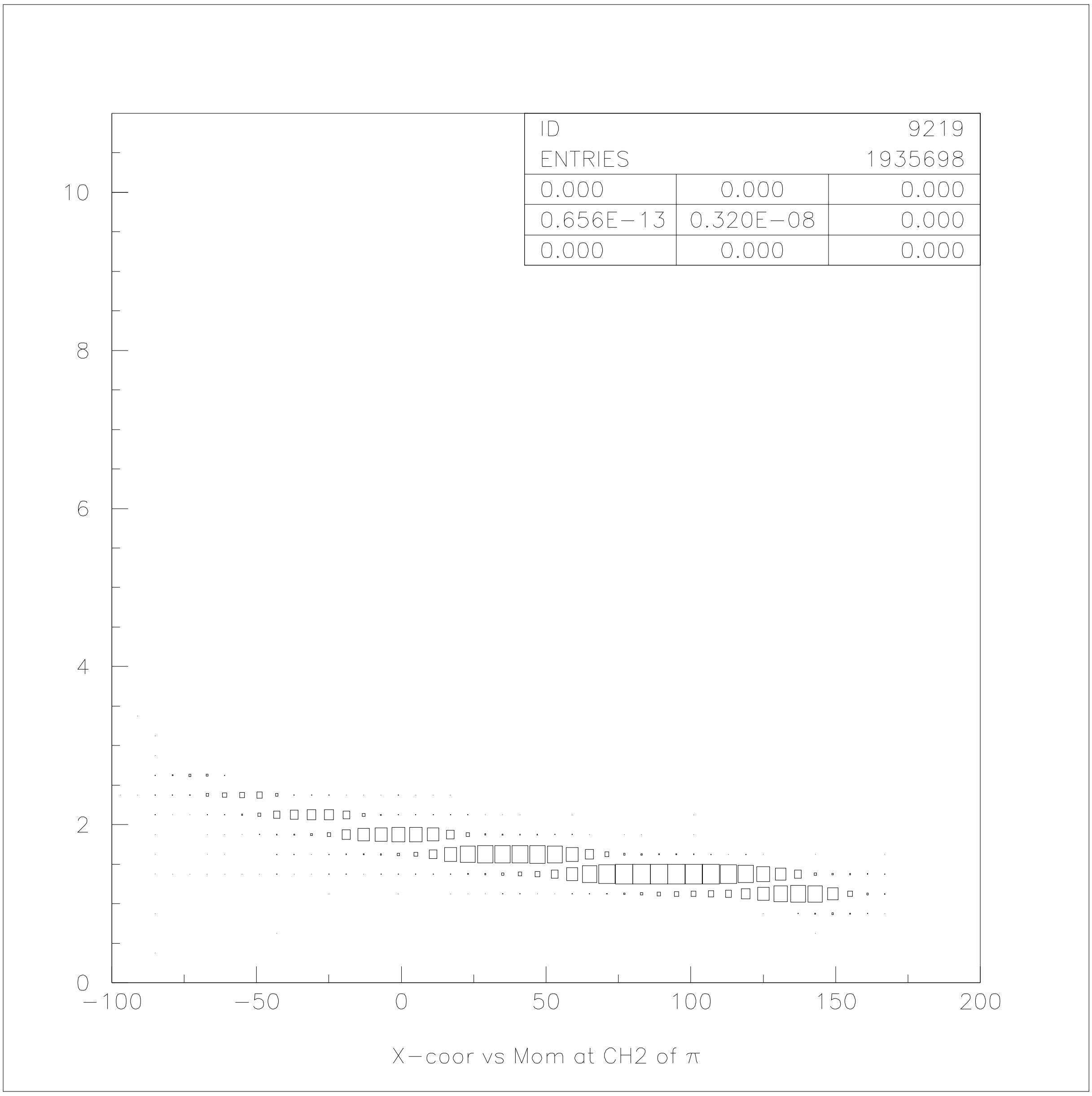

Figure 62: *Pion xp-plot in the back of CH (CH3).*

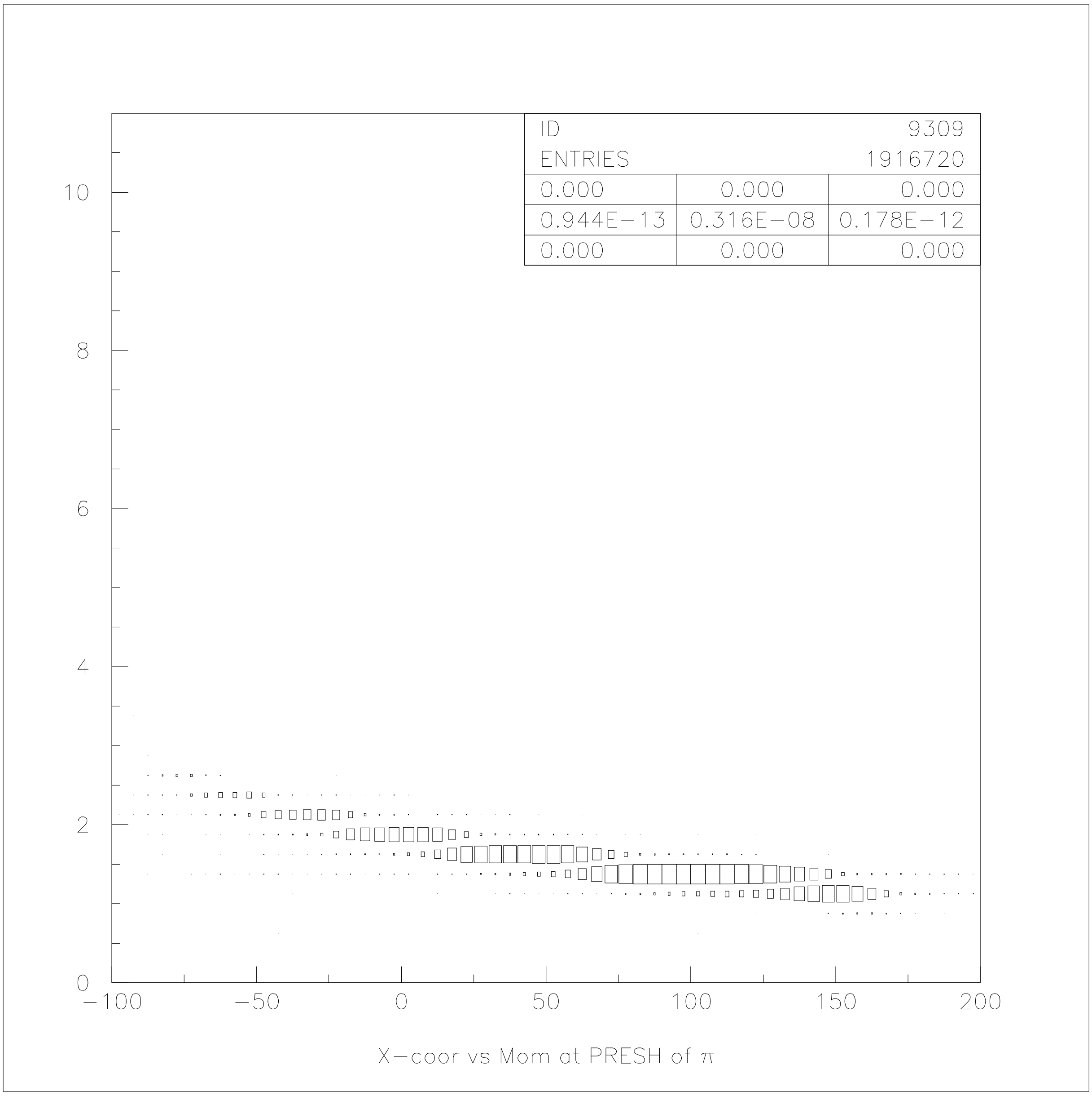

Figure 63: *Pion xp-plot in PR.*

11 Kaon xp-correlations

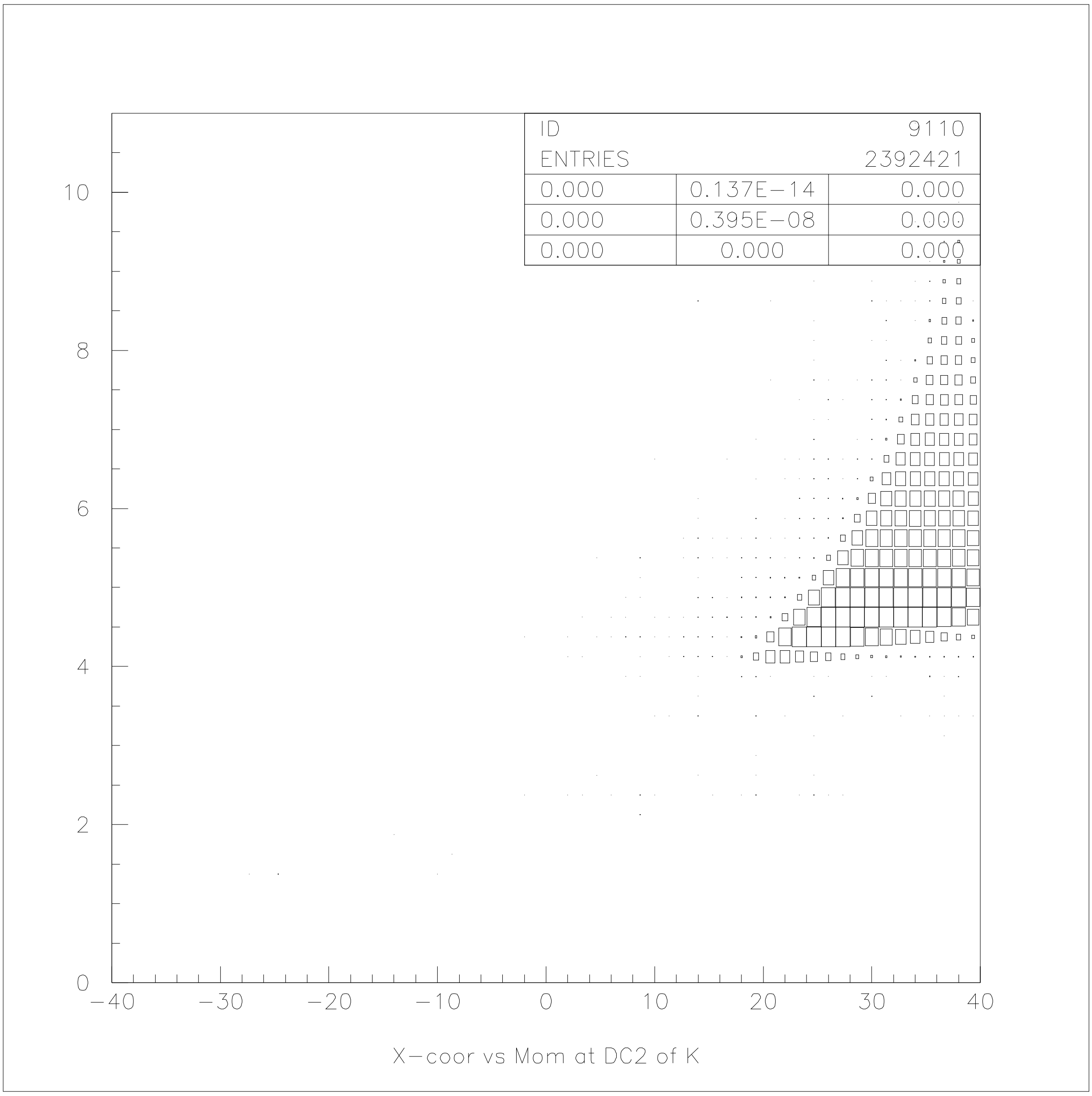

Figure 64: *Kaon xp-plot in DC2.*

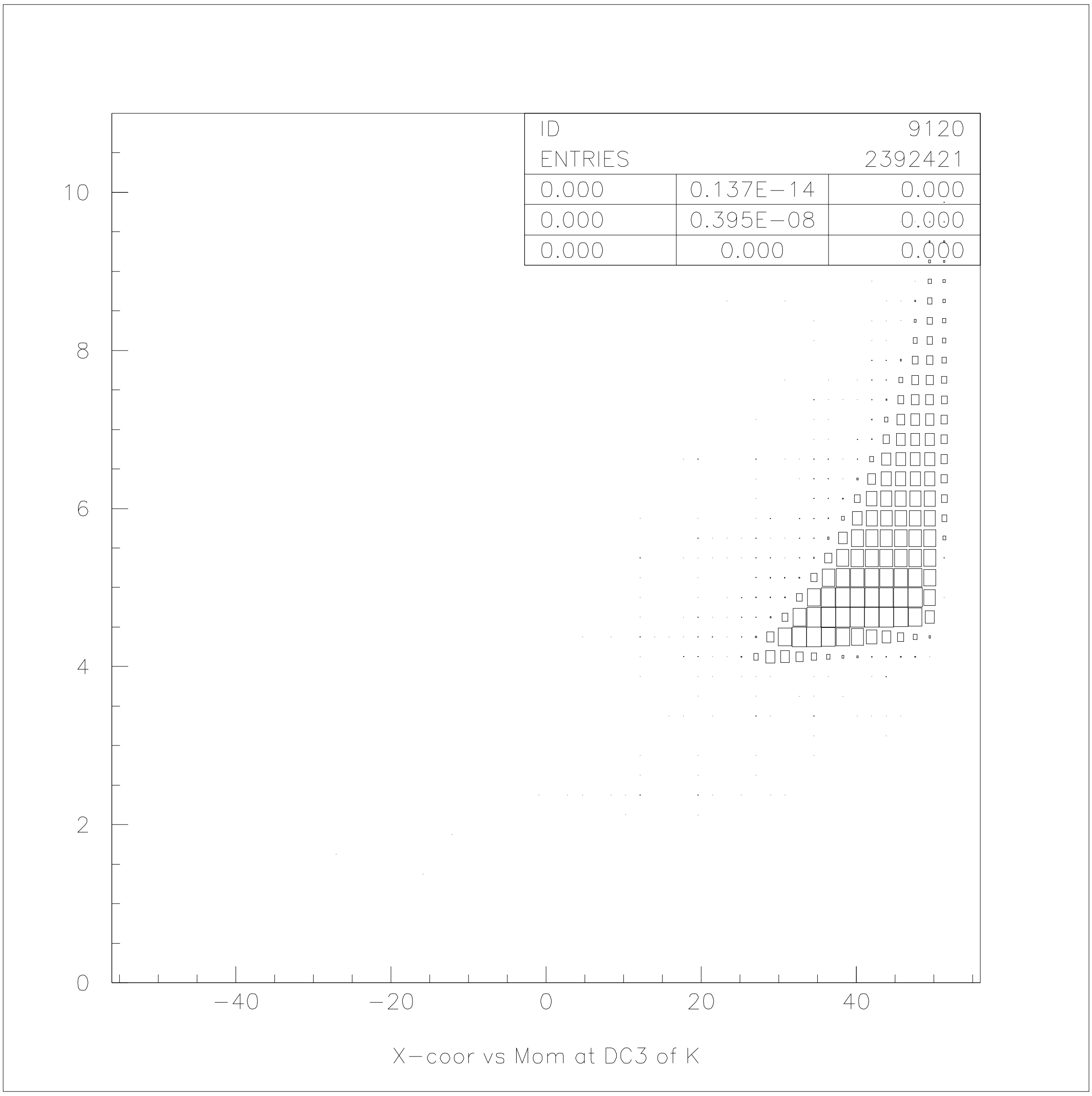

Figure 65: *Kaon xp-plot in DC3.*

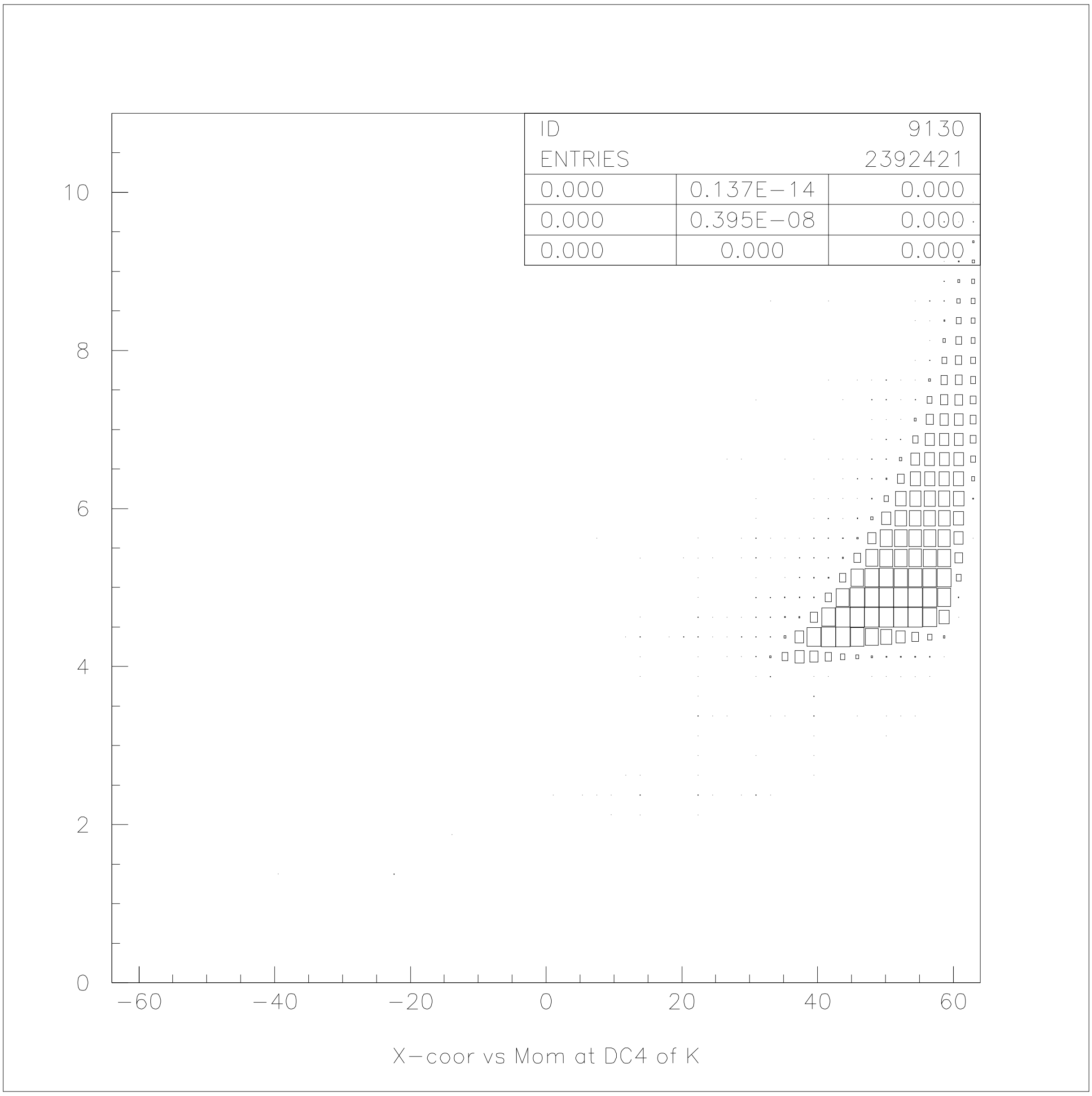

Figure 66: *Kaon xp-plot in DC4.*

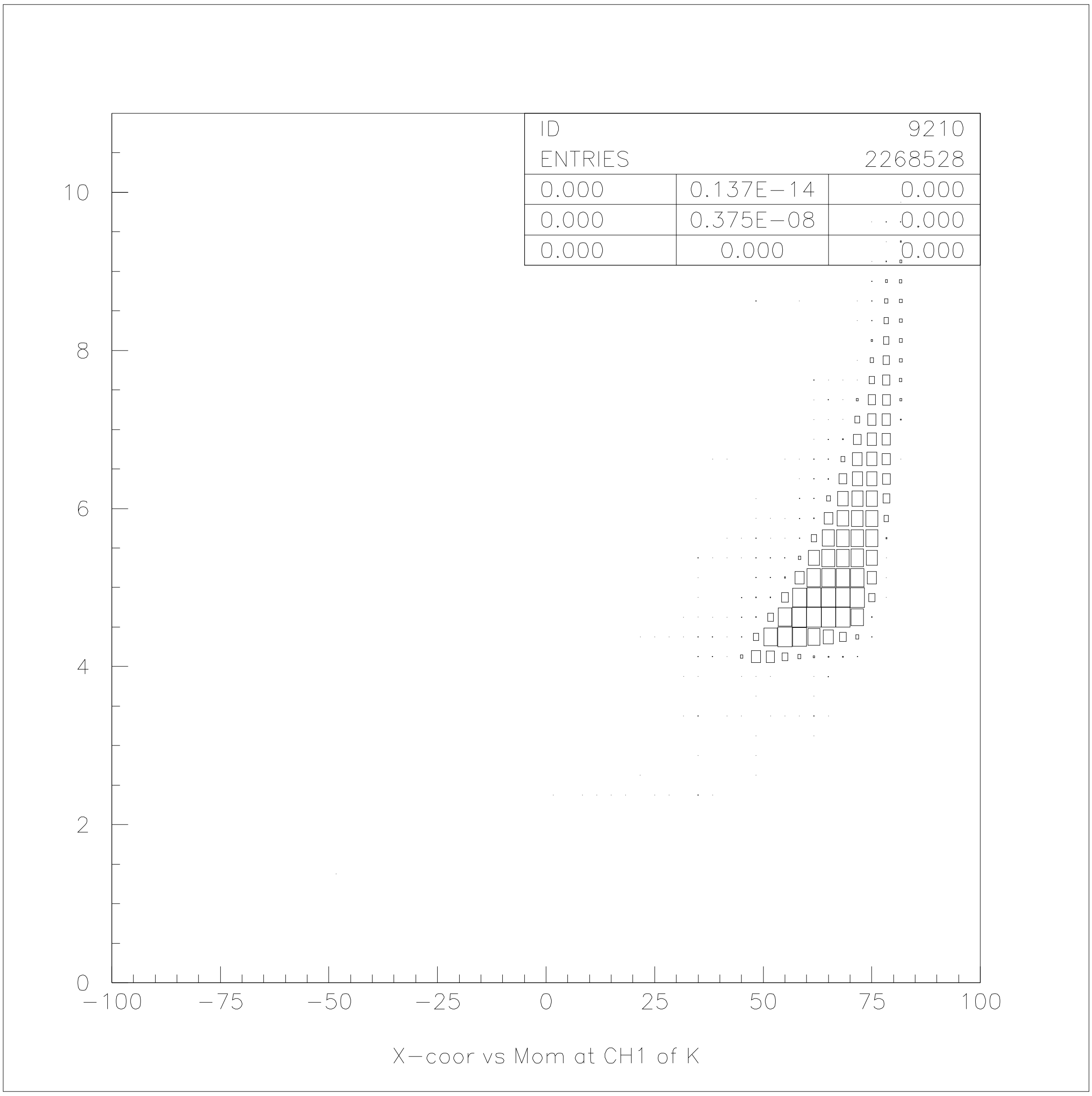

Figure 67: *Kaon xp-plot in the front of CH (CH1).*

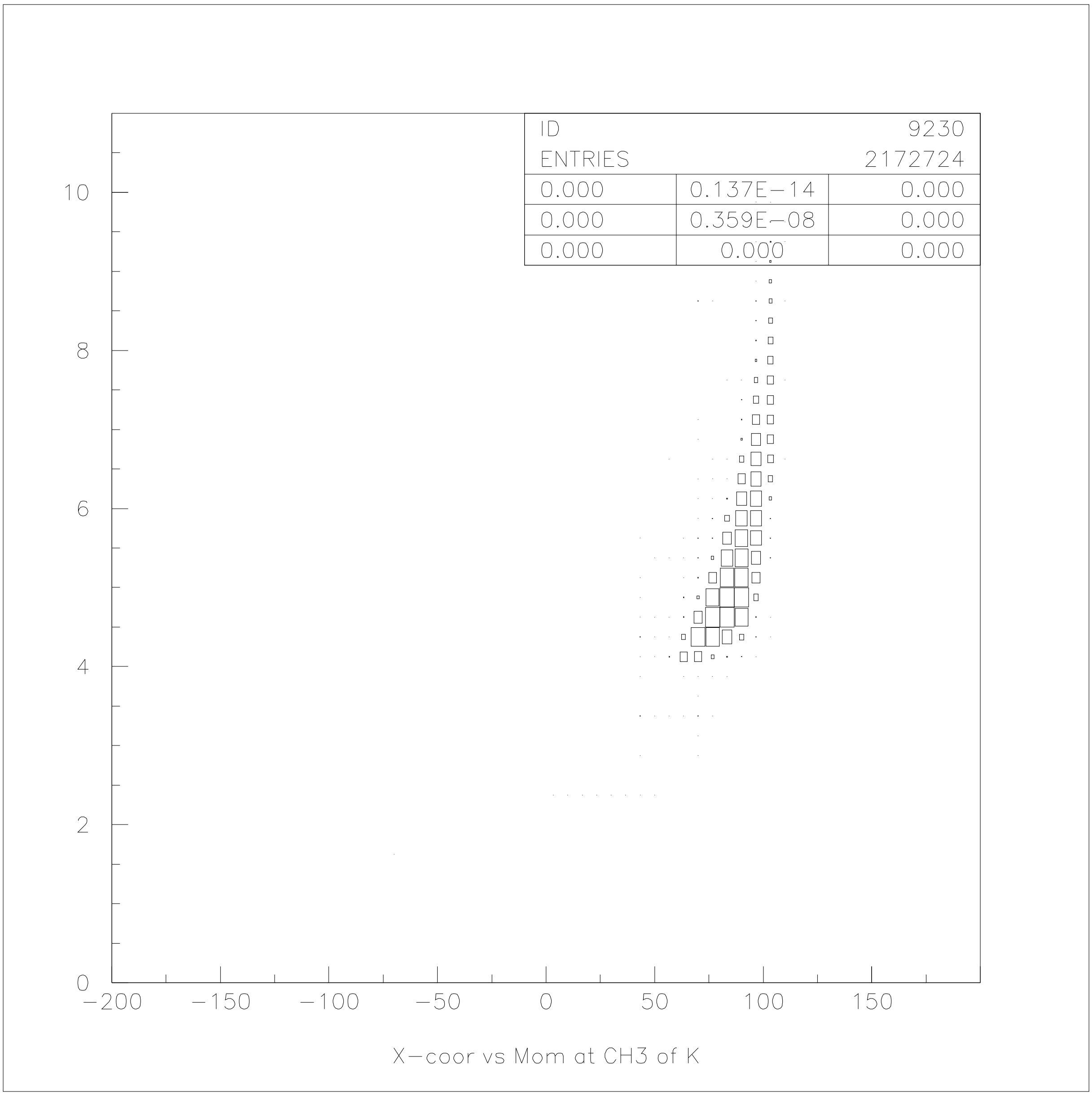

Figure 68: *Kaon xp-plot in 1 m from the front of CH (CH2).*

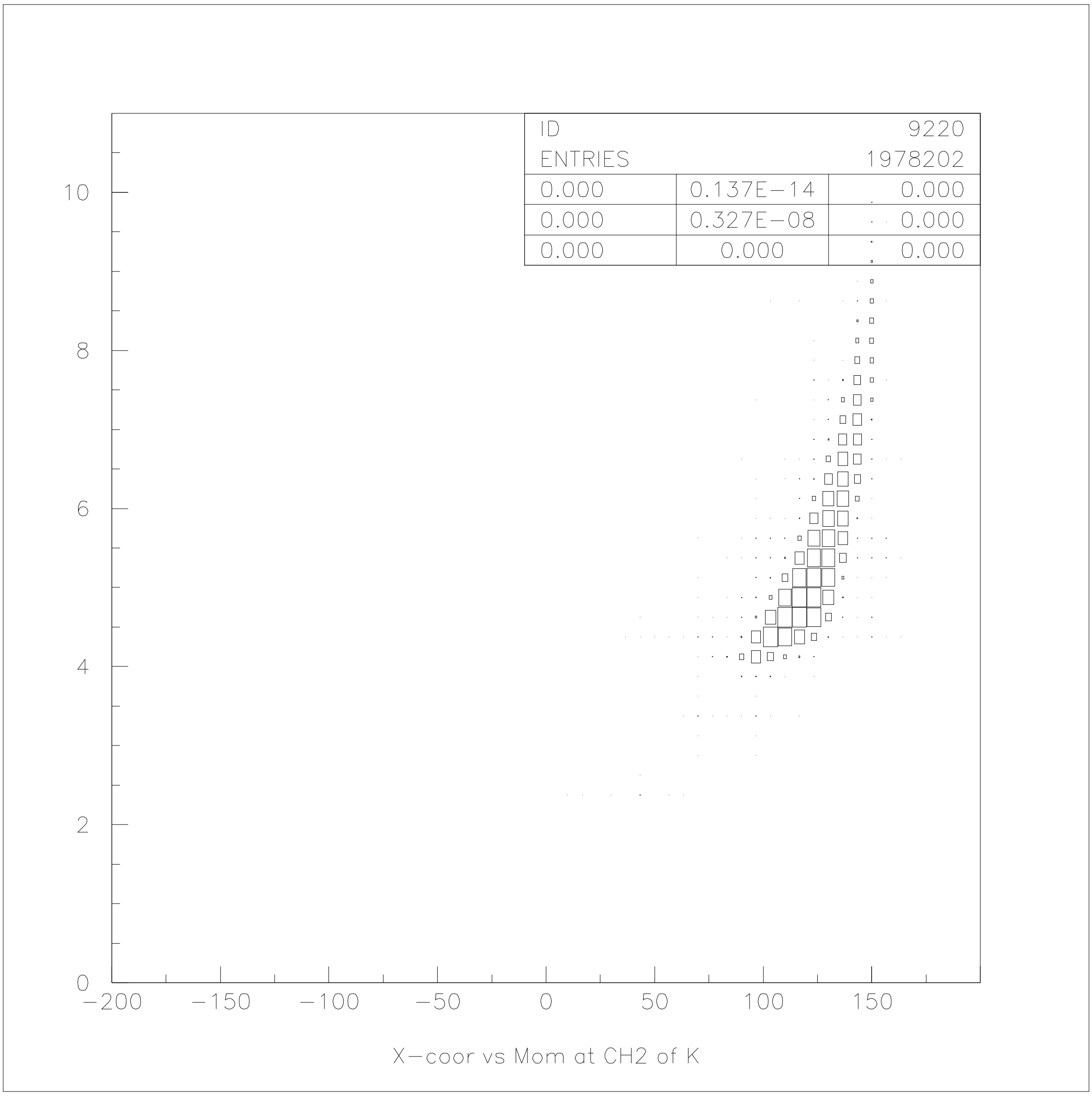

Figure 69: *Kaon xp-plot in the back of CH (CH3).*

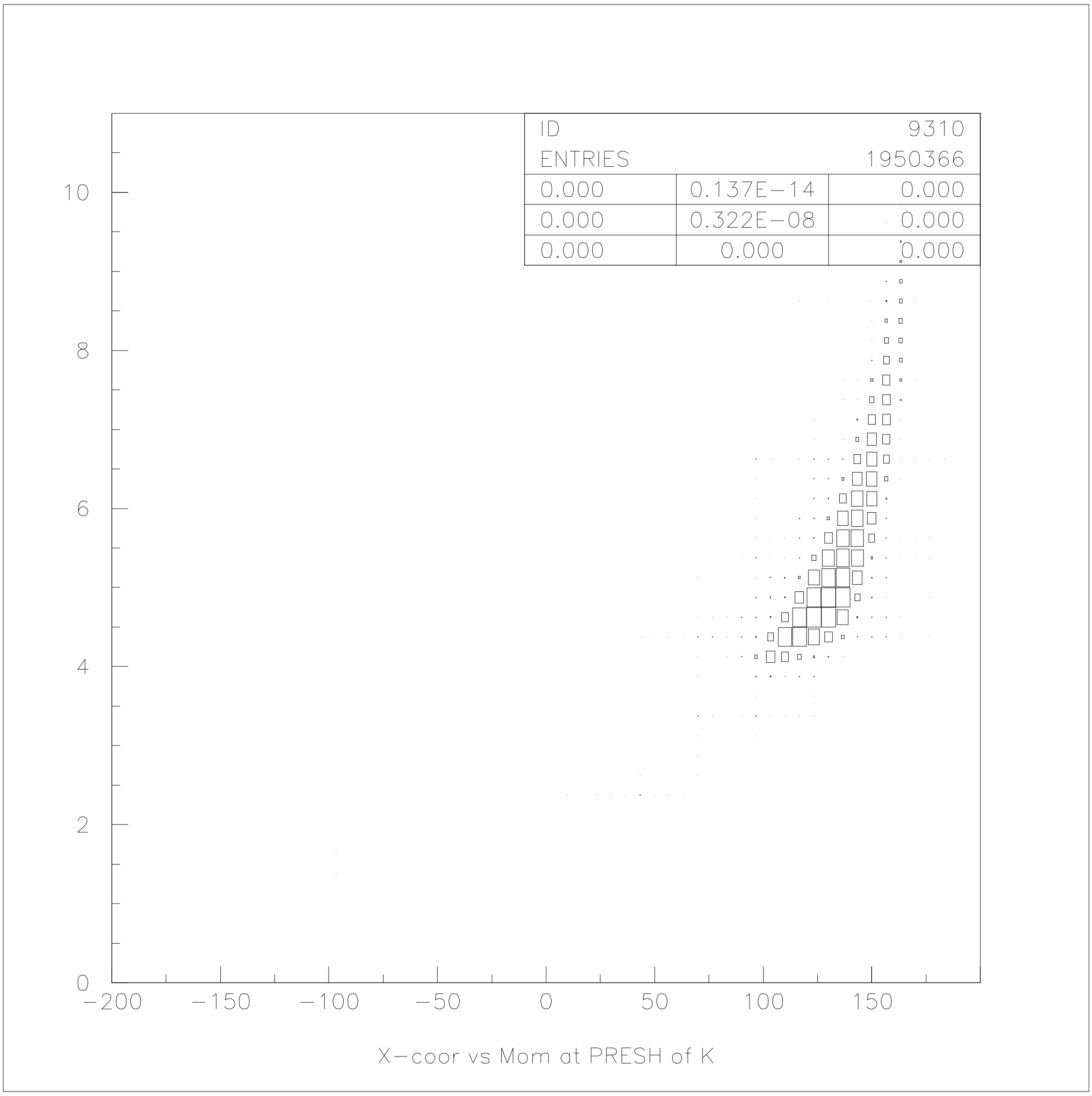

Figure 70: *Kaon xp-plot in PR.*

12 Pion and kaon hit plots in SFD

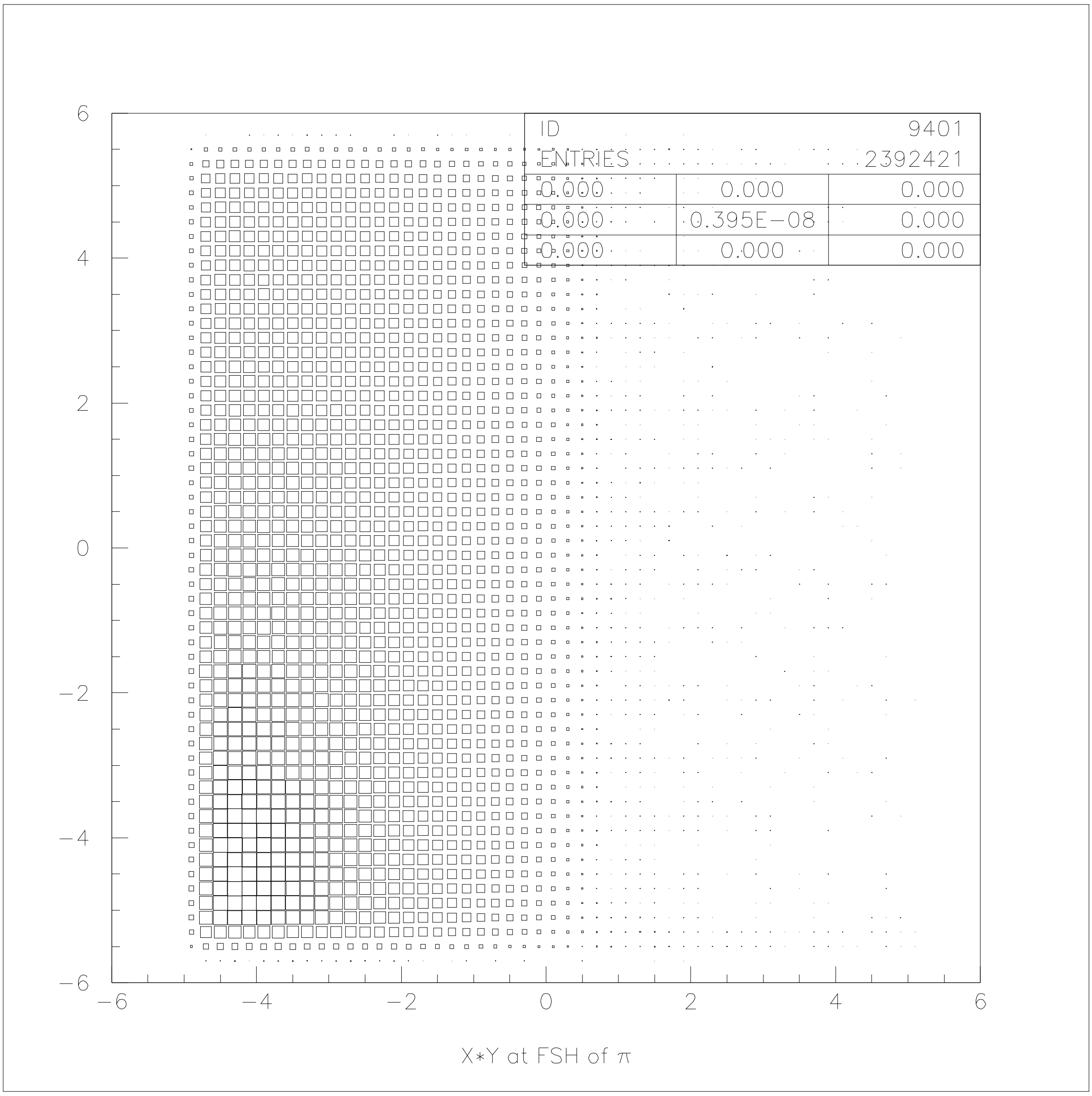

Figure 71: *Pion xy-plot SFD.*

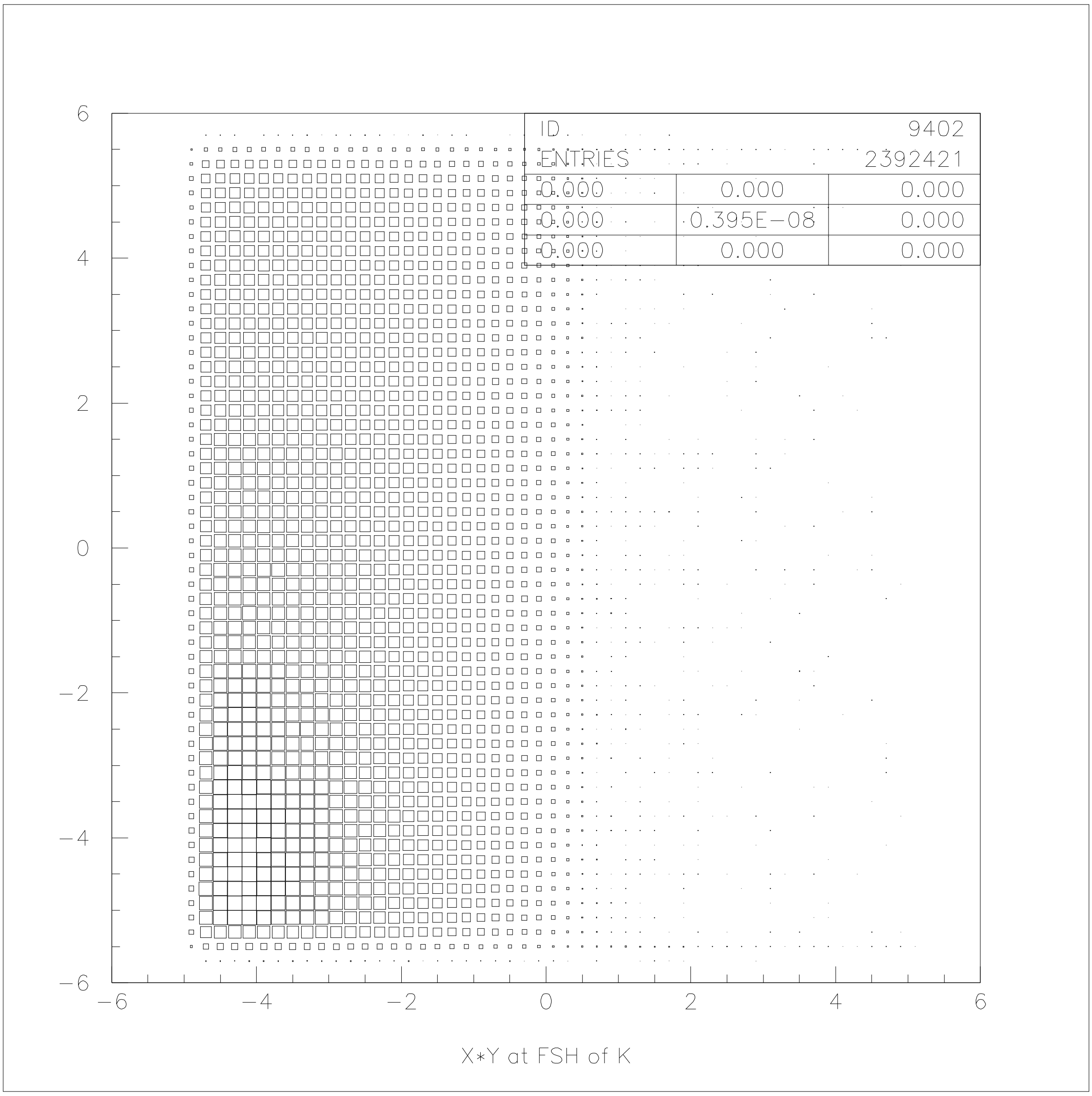

Figure 72: *Kaon xy-plot in SFD.*

13 Transformation of distributions to AutoCAD

Simulated pion and kaon x-distributions in tabular form were transformed to AutoCAD format: coordinates and number of events were transformed to metres. Then splines were drawn through these points. For convenience the pion and kaon signes were changed to opposite ones. In figs. 73 and 74 the pion and kaon distributions are shown in DC2, DC3, DC4, CH1, CH2, CH3 and PR positions. There is no normalization.

14 Comparison of simulation and tracing

Distributions in figs. 73, 74 and the DIRAC downstream detectors with pion and kaon tracing were combined together (fig.75).

From tracing:
When $A_{\pi K}$ beam passes through the setup axis (0°):
Pions are detectable by DC in the momentum interval from 1.27 to 1.41 GeV/c,
Kaons are detectable by DC in the momentum interval from 4.5 to 5.0 GeV/c.
When $A_{\pi K}$ beam passes along the collimator left wall (1°):
Pions are detectable by DC in the momentum interval from 1.13 to 3.11 GeV/c,
Kaons are detectable by DC in the momentum interval from 4.0 to 11.0 GeV/c.

From simulation:
Pions are detectable by DC in the momentum interval from 1.0 to 2.6 GeV/c,
Kaons are detectable by DC in the momentum interval from 4.0 to 9.2 GeV/c.

From tracing and simulation:
In fig. 76 pions in the DC area are shown.
In fig. 77 pions in the CH and PR area are shown.
In fig. 78 kaons in the DC area are shown.
In fig. 79 kaons in the CH1 and CH2 area are shown.
In fig. 80 kaons in the CH3 and PR area are shown.

Conclusions:
Tracing and simulaion agree well.
Lack of pions and kaons with high momenta in simulation can be explained by small production cross section.

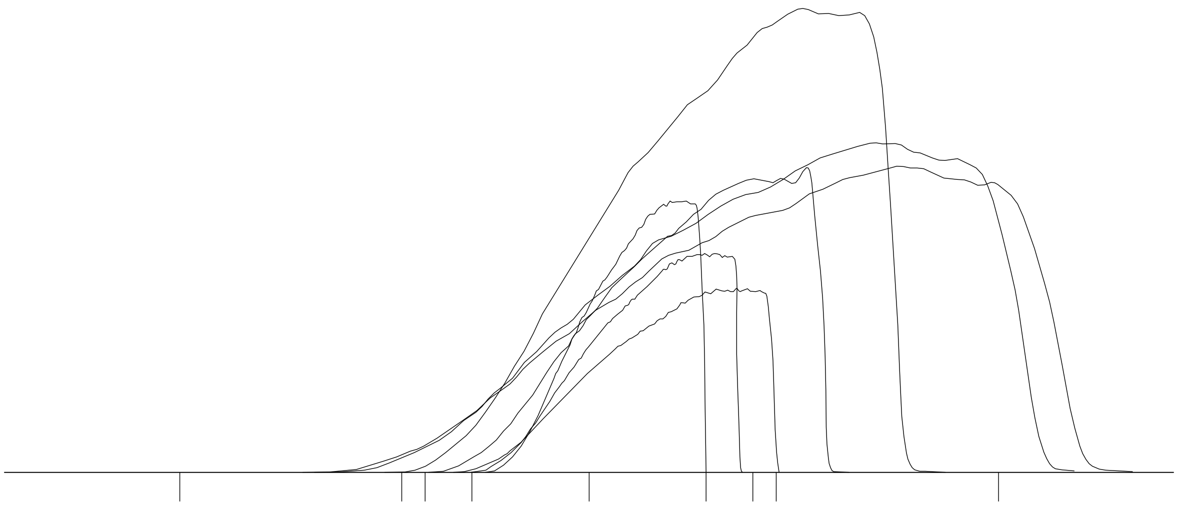

Figure 73: *Pion x-distributions in DC2, DC3, DC4, CH1, CH2, CH3 and PR. Lines mark y=0 coordinate and boundaries of DC2, DC3, DC4 and PR.*

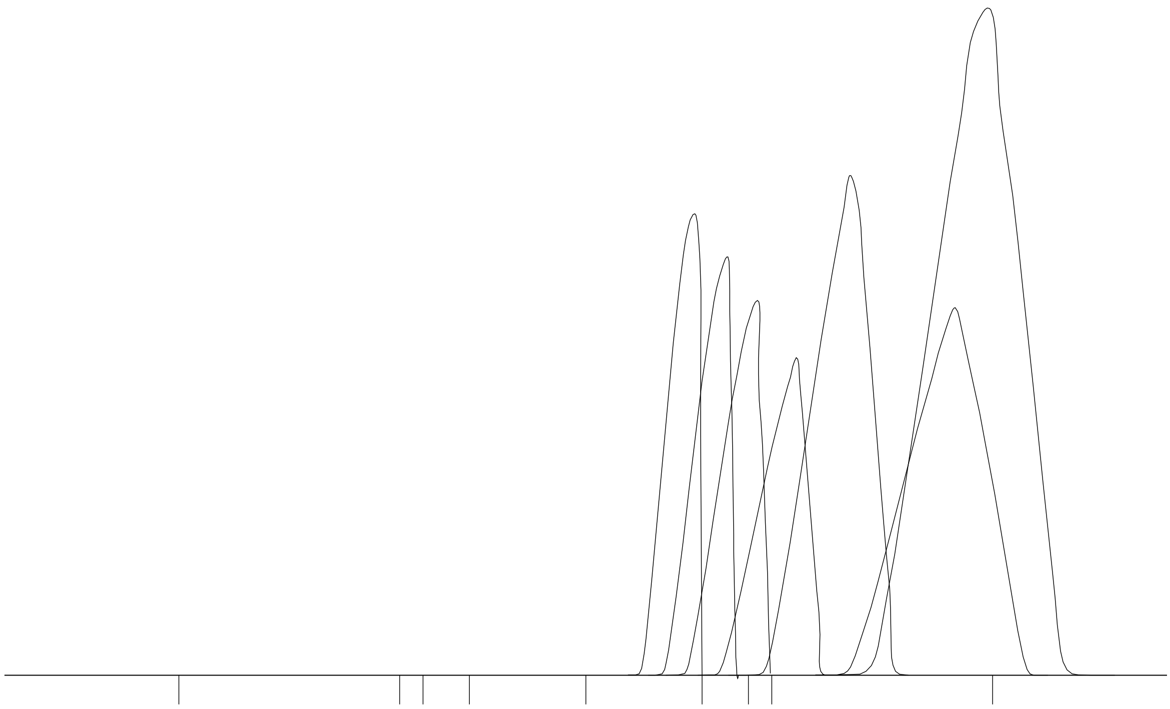

Figure 74: *Kaon x-distributions in DC2, DC3, DC4, CH1, CH2, CH3 and PR. Lines mark y=0 coordinate and boundaries of DC2, DC3, DC4 and PR.*

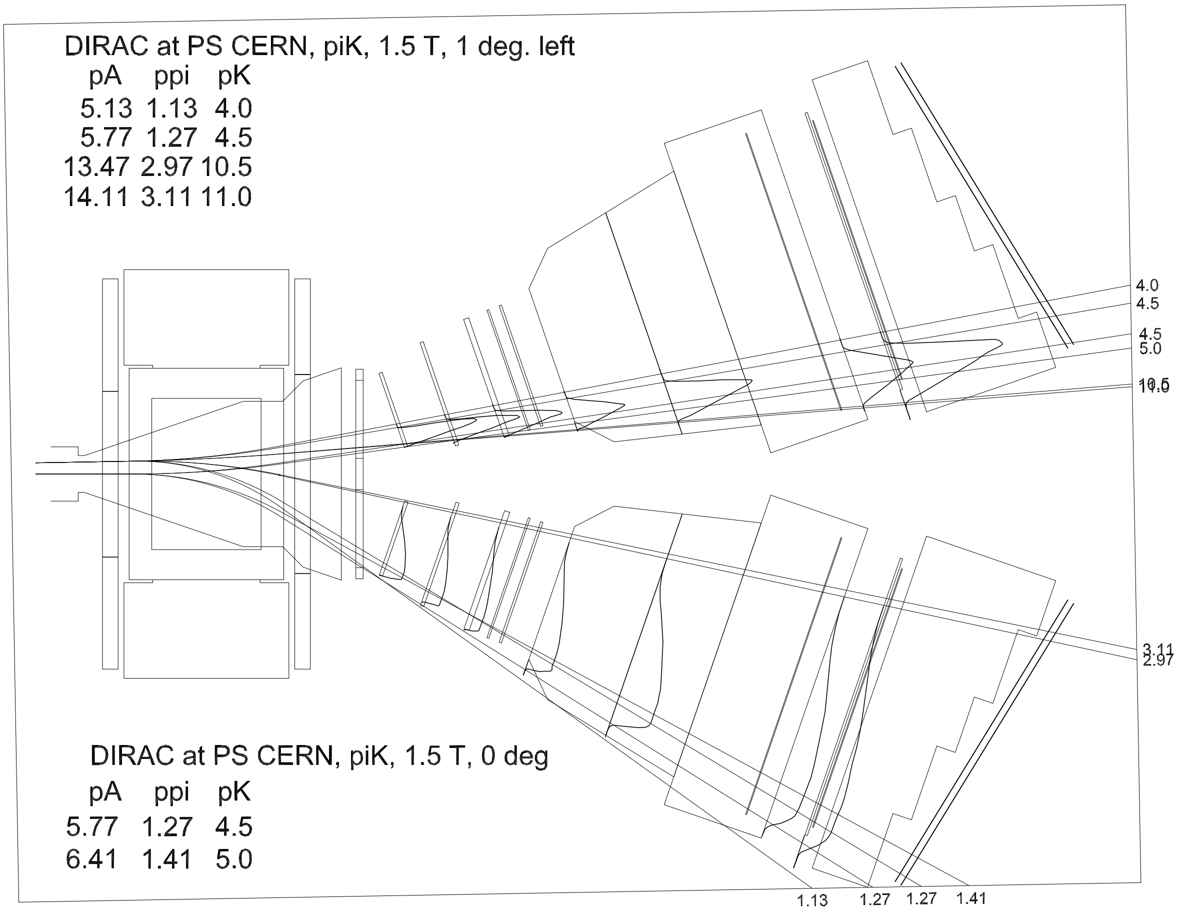

Figure 75: *Setup, tracing and simulated distributions.*

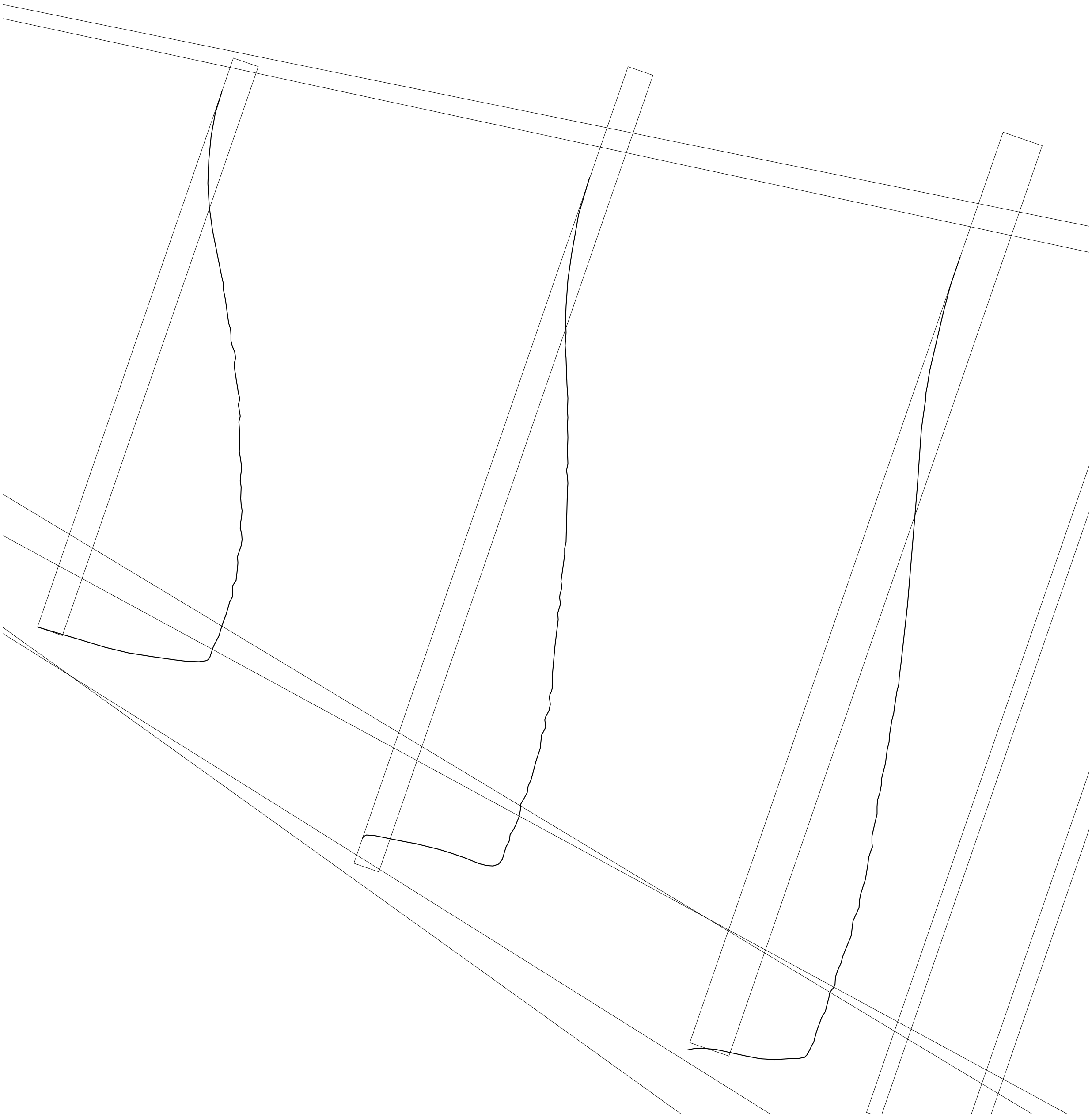

Figure 76: *Pion tracing and simulated distributions, DC area.*

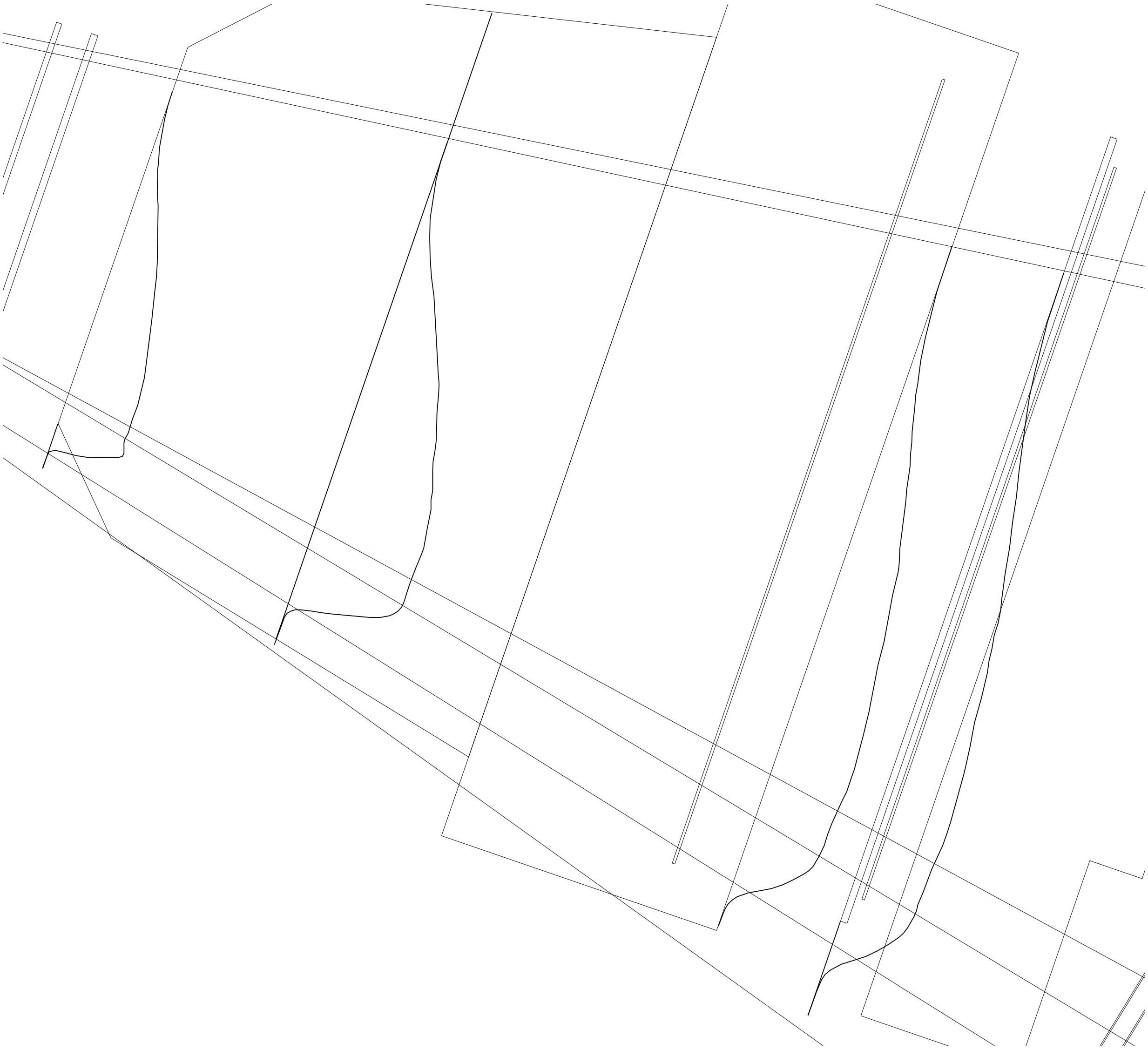

Figure 77: *Pion tracing and simulated distributions, CH and PR area.*

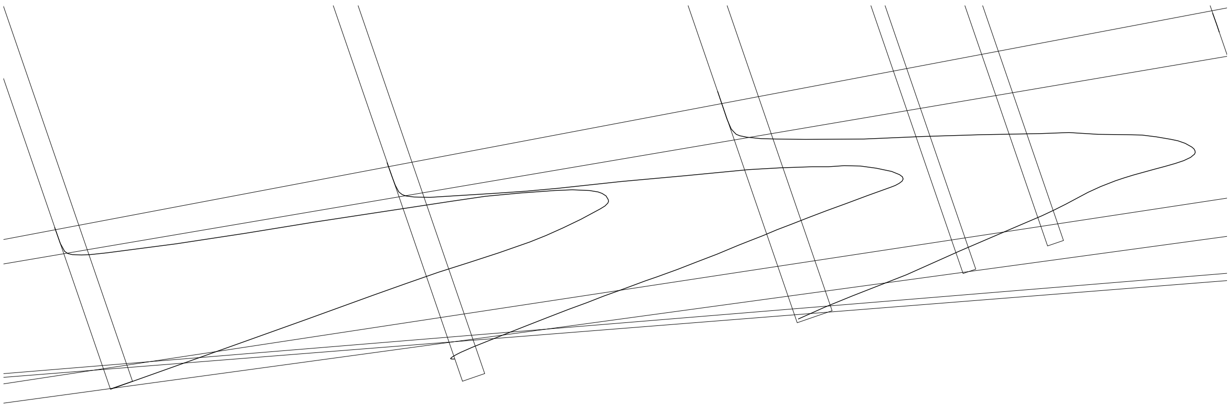

Figure 78: *Kaon tracing and simulated distributions, DC area.*

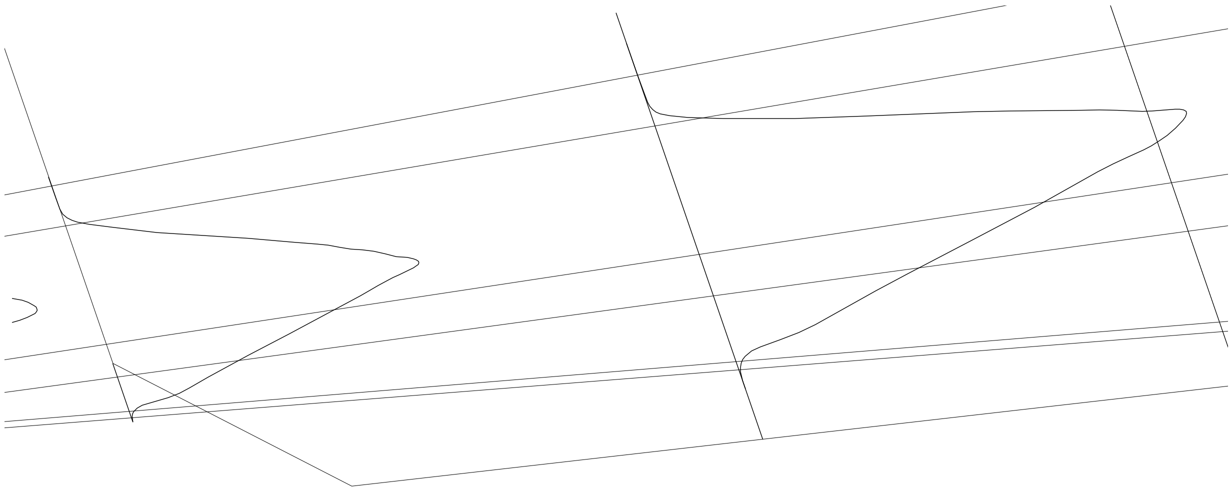

Figure 79: *Kaon tracing and simulated distributions, CH1 and CH2 area.*

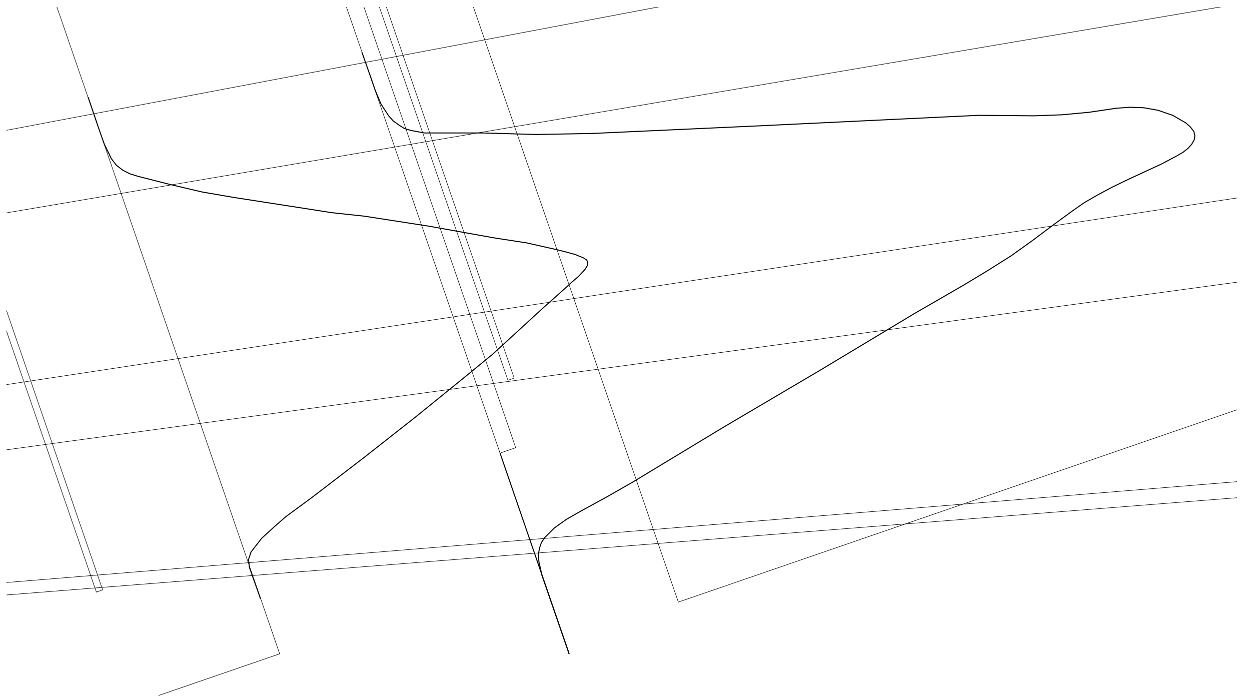

Figure 80: *Kaon tracing and simulated distributions, CH3 and PR area.*