A 550 MeV/c kaon beam

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1 Summary

This report describes the design of a 550 MeV/c kaon beam. See figure 1. The optics is described in section 2. The beam envelopes are given in figure 2.

The beam line is 13.74 m long, including a 1.0 m drift after the last quadrupole. The ratio of production of pions and kaons is 23. This ratio increases by a factor 18 due to decay to 400 at the final focus. A 0.1 percent transmission of pions corresponds, therefore, to a pion contamination fraction of 0.40.

There are two crossed field separators, 1.2 m long with an electric gradient of 50 kV/cm, or 600 kV over a 12 cm vertical gap. Separation is done in two stages by two slits MS1 and MS2 which together remove 99 percent of the pions. The remaining 1 percent pions, corresponding to 4 times the kaon rate, is removed by a fixed piece of beam blocker in Q8.

Experiment E949 at BNL was done at LESB3, a 19.6 m long beam, at first at 800 MeV/c, but later at 710 MeV/c. The angle acceptance was 12 msr, and the momentum bite was 4 percent, for a total acceptance of 48 msr.percent. The kaon survival rate was 2.52 percent.

In the present design, the angle acceptance is 20 msr, and the momentum bite is 6 percent, for a total acceptance of 120 msr. percent. This is a factor 2.5 improvement. The kaon survival rate is now 3.58 percent, a factor 1.42 improvement over 710 MeV/c at LESB3.

The length of the production target was 6 cm. It is possible to use a 8 cm target, but MS2 has to be closed further at the expense of some kaon rate. The netto increase in intensity compared to a 6 cm target is estimated to be 12 percent.

An important reason for having two stages is the cloud pion problem. They originate in the decay of other particles produced in the production target, and present a large vertical source to the channel. MS1 redefines this source for the second stage. The two mass slits together succesfully remove most of the cloud pions.

Pions decay into muons. Since MS1 stops 80 percent of the pions, they can no longer decay into muons further downstream. The muon contamination is negligible.

2 Layout and optics

The layout is shown in figure 1. The first order beam envelopes for zero momentum bite are given in figure 2 which also shows the dispersion in cm per percent ΔP/P. The beam line elements are listed in tables 1 and 2.

The beam takes off at zero degrees to the proton beam from a 6 cm long production target. The doublet Q1-Q2 catches the beam and focusses through bending magnet B1. The beam is vertically parallel in the first separator. B1 is a 38 degrees sector magnet which bends 45 degrees. The negative poleface entrance and exit angles of -3.5 degrees enhance the horizontal focussing of B1. Therefore, the strength of Q1 can be reduced. This results in a larger vertical angle acceptance.

After Q3 and Q4 the beam has a vertical focus at the first mass slit MS1. In order to make the beam line short, the distance between Q4 and Q5 is only 29 cm. MS1 is 22 cm from Q4, and 7 cm from Q5. It is not possible to put a variable slit here. It has to be a fixed vertical aperture with a width of 6 mm. The doublet Q5-Q6 steers the beam through the second separator, where the beam is vertically parallel. Q7 focusses the beam vertically at the second mass slit MS2. Q7 and Q8 together also steer the beam through the 45 degree bending magnet B2. This is a parallel faced bending magnet with entrance and exit poleface angles of 22.5 degrees. The short 7 inch diameter doublet Q9-Q10 gives a final horizontal and vertical focus 1.0 m downstream of Q10. The beam is nearly achromatic in both angle and position.

Second order aberrations have been corrected with 3 sextupoles. Third order aberrations have been left uncorrected.

3 Results of Monte Carlo calculations

These calculations were done with the high order raytracing program ZGOUBI. The performance of the kaon beam is given for the case that MS1 is 6 mm wide and MS2 has an aperture of 8 mm. Figure 3 shows the momentum acceptance in the top plot and the beam spots at the bottom. Figure 4 shows the final angle distributions.

Figure 5 shows the vertical pion and kaon beam spots at MS1 and MS2. The pion tails sneak under the kaon spots. About 1 percent of the pions pass through the mass slits. They can be removed by a beam blocker piece in a corner of Q8. This can be seen in figure 6. It shows the x-y distribution of the blue kaons and the red pions that pass through the two mass slits.

Table 1: Beamline elements, and poletip fields

element	length (cm)	pole radius (cm)	design pole field (kG)
Quadrupole			
Q1	45.0	10.16	12.43
Q2	40.0	10.16	-8.58
Q3	40.0	15,24	-7.71
Q4	40.0	15.24	3.35
Q5	40.0	15.24	7.81
Q6	40.0	15.24	-8.36
Q7	40.0	15.24	-8.06
Q8	40.0	15.24	9.16
Q9	30.0	8.89	-10.56
Q10	30.0	8.89	8.56
Sextupole			
S1	15.0	15.24	2.28
S2	15.0	15.24	-3.60
S3	15.0	12.24	-1.91

Table 2: Dipole and separator characteristics.

	entr/exit angle to pole face (deg)	length (cm)	pole gap (cm)	field (kG)	bend angle (deg)
dipole					
B1	-3.5/-3.5	80.0	8.89	18.01	45.0
B2	22.5/22.5	80.0	7.62	18.01	45.0
separator	length (m)	plate width (cm)	plate gap (cm)	plate gap voltage (kV)	magnetic field (kG)
SEP1	1.20	30	12.00	600	0.224
SEP1	1.20	30	12.00	600	0.224

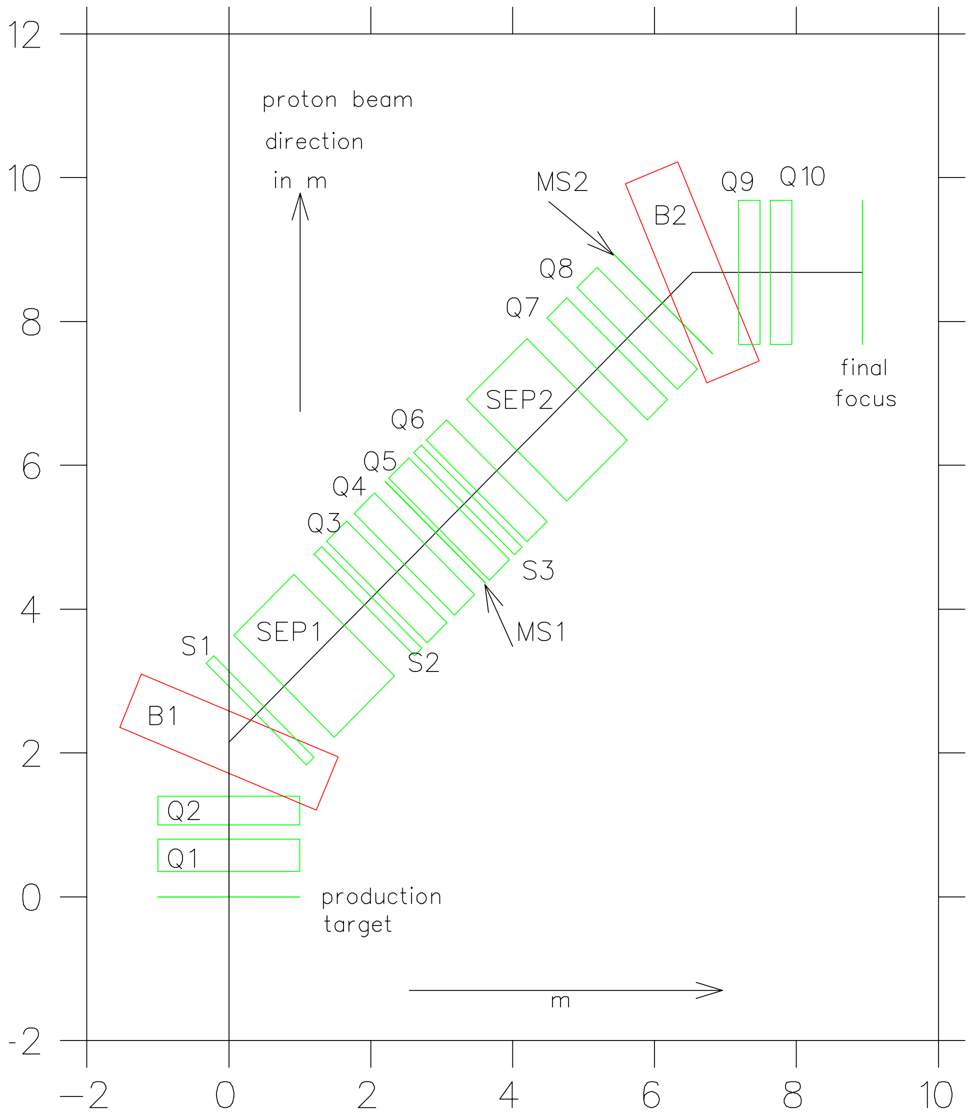

Figure 1: The beam line layout

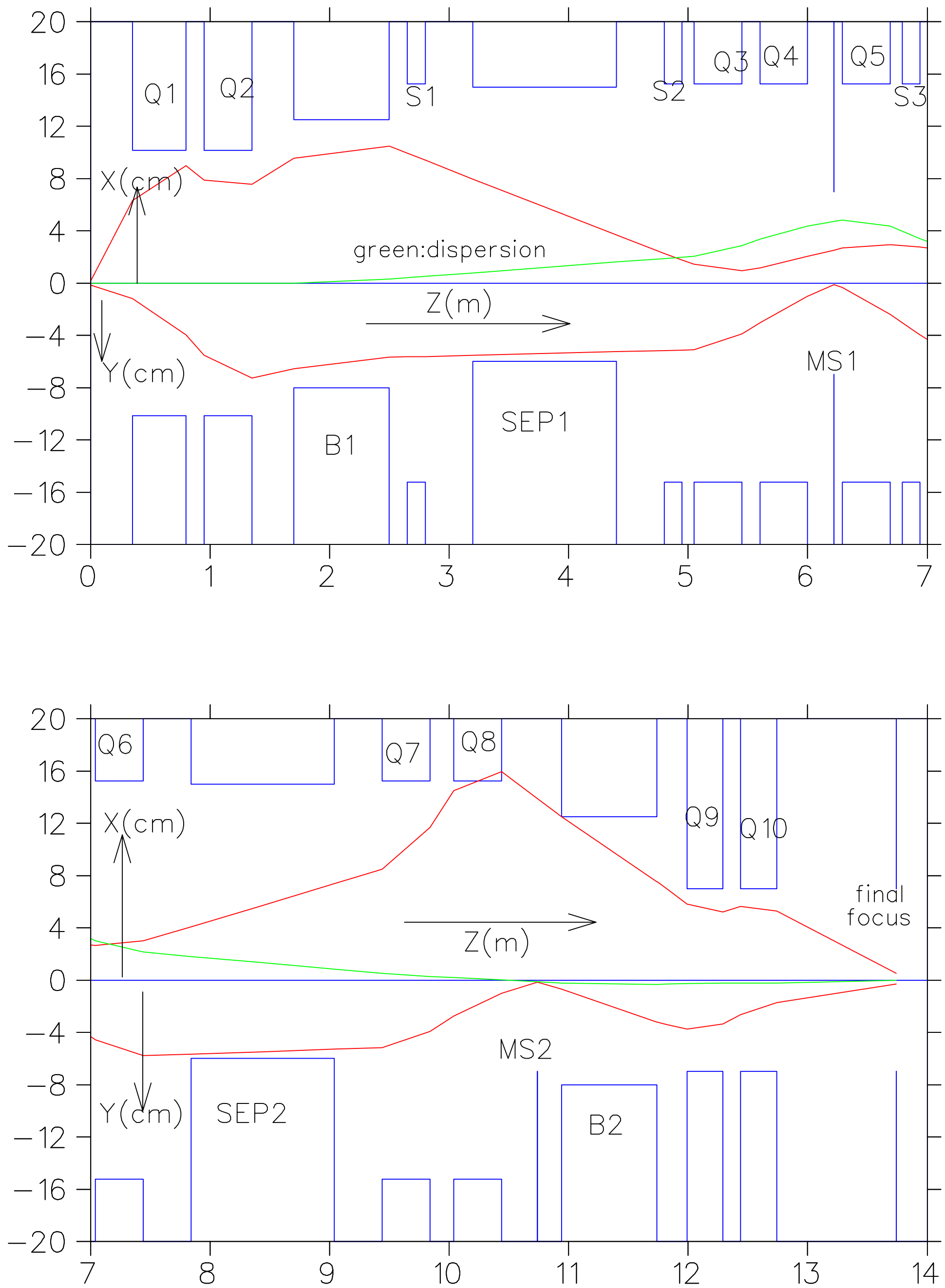

Figure 2: The beam envelopes

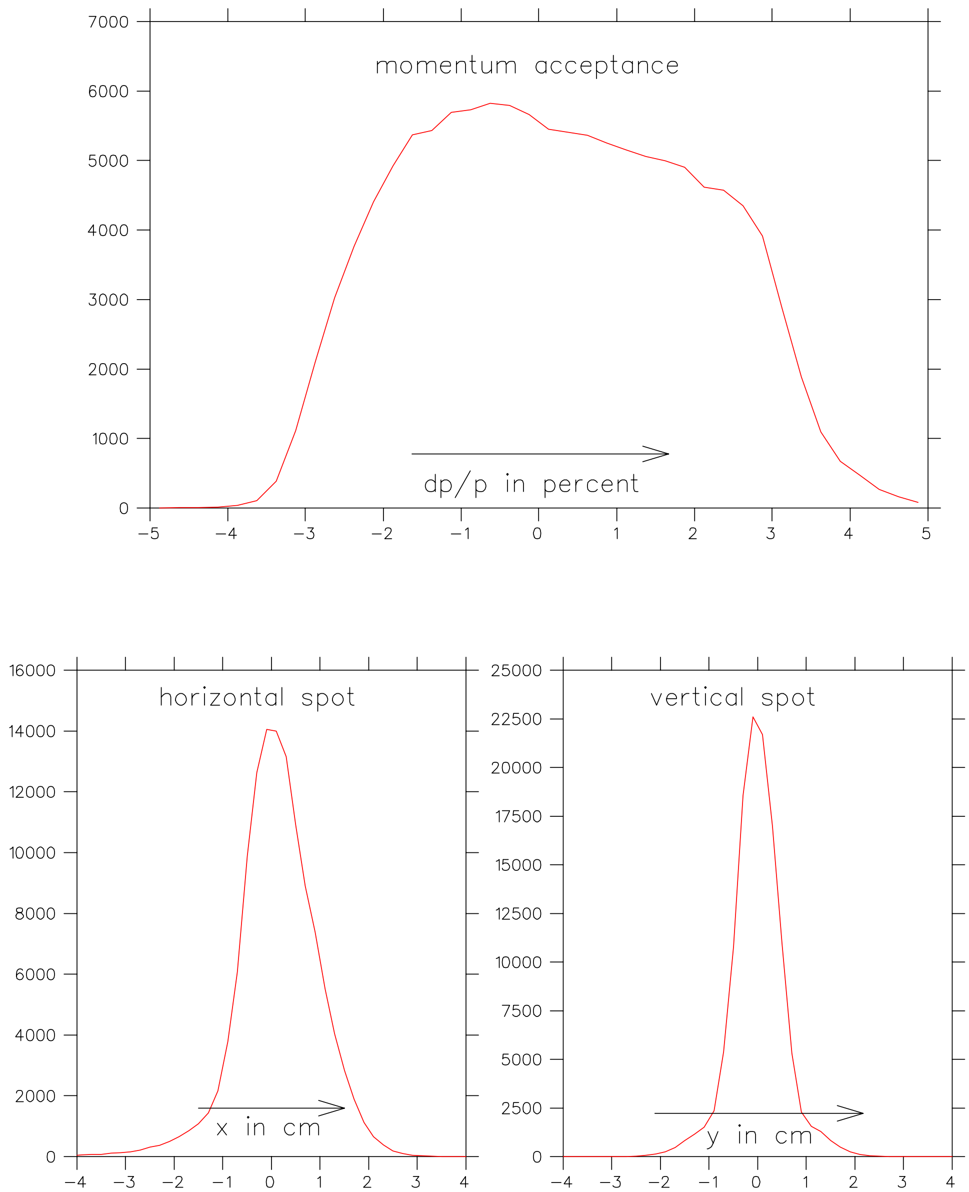

Figure 3: The final spot size and the momentum acceptance.

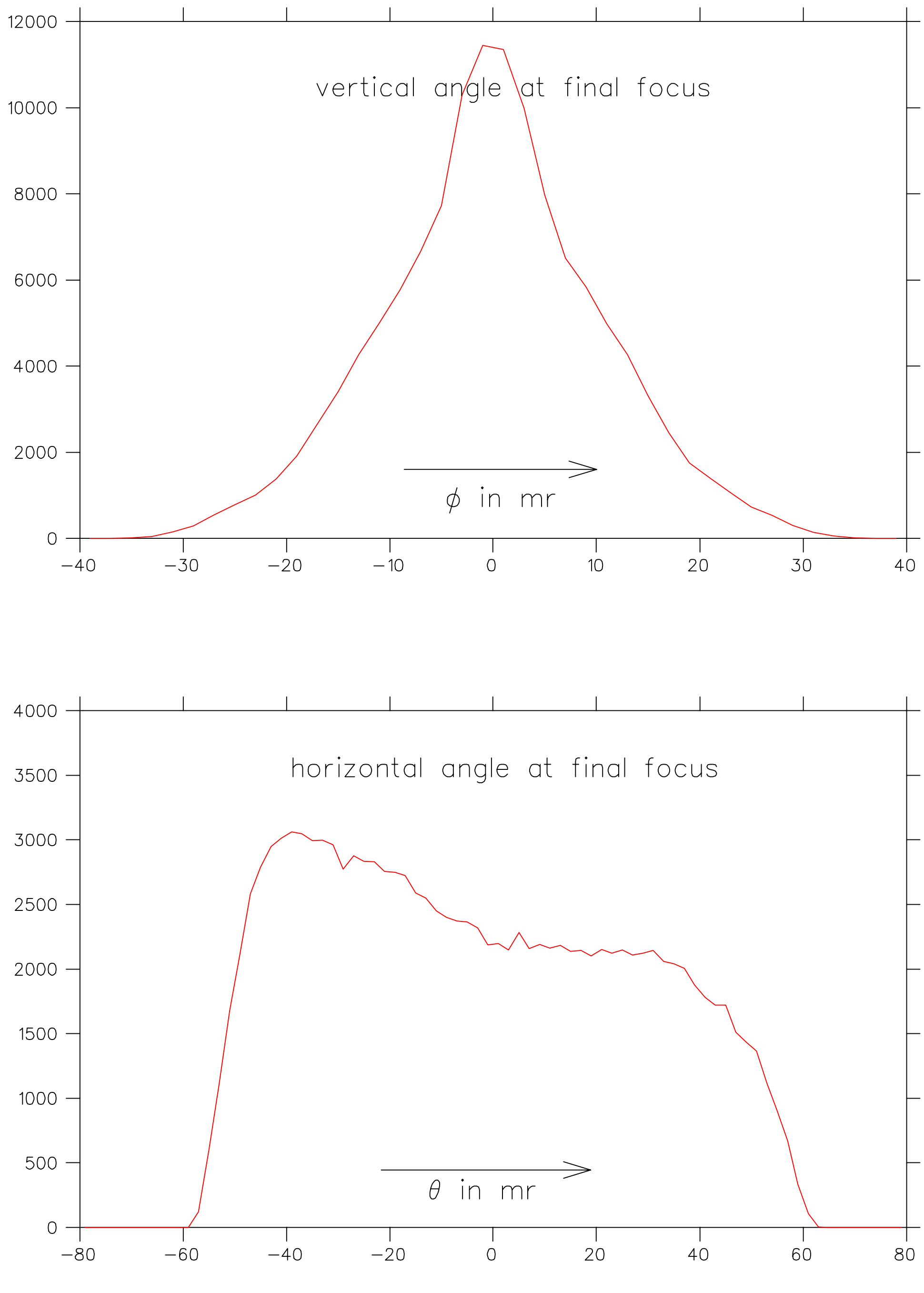

Figure 4: The angle distribitions at the final focus.

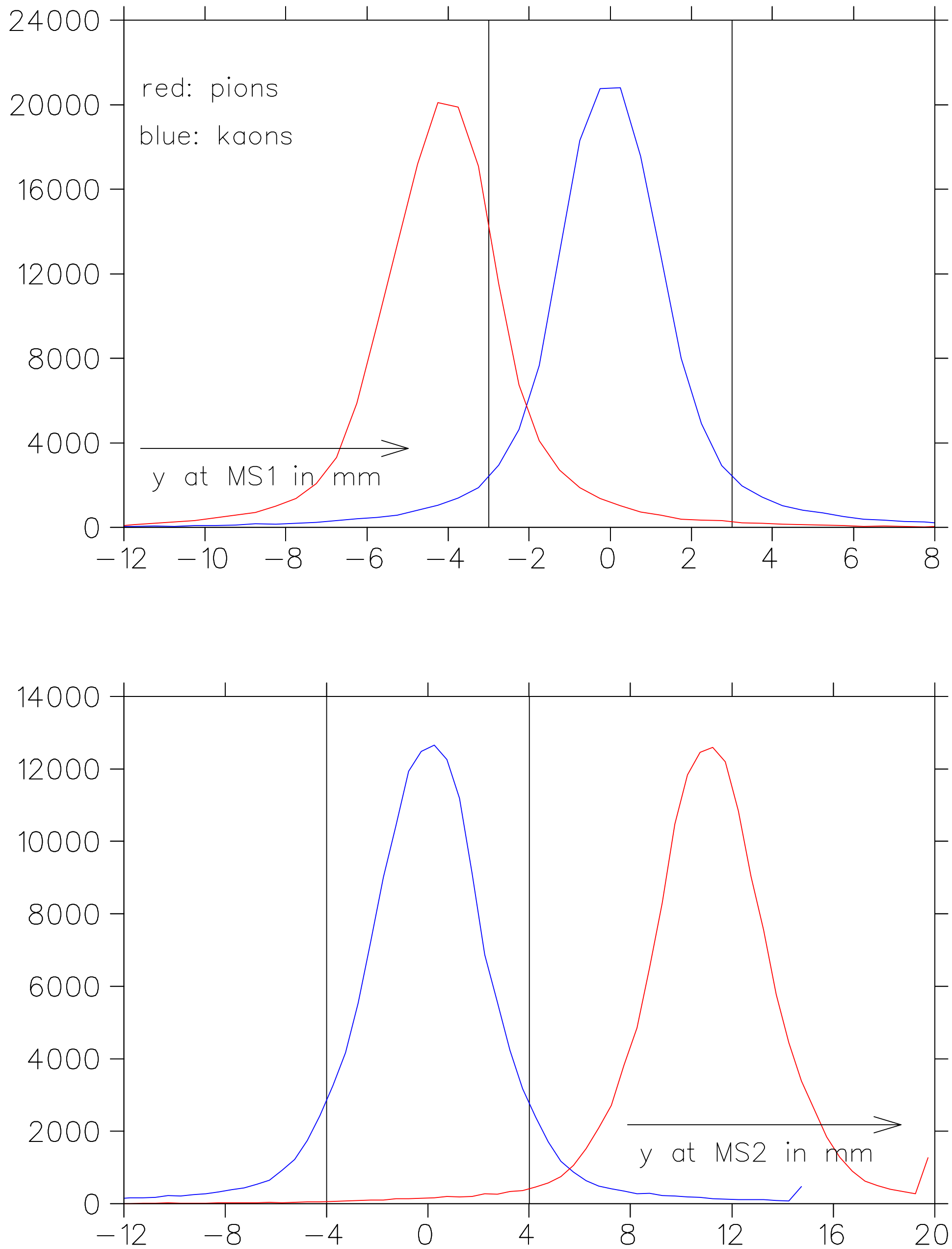

Figure 5: Vertical kaon and pion spots at the mass slits.

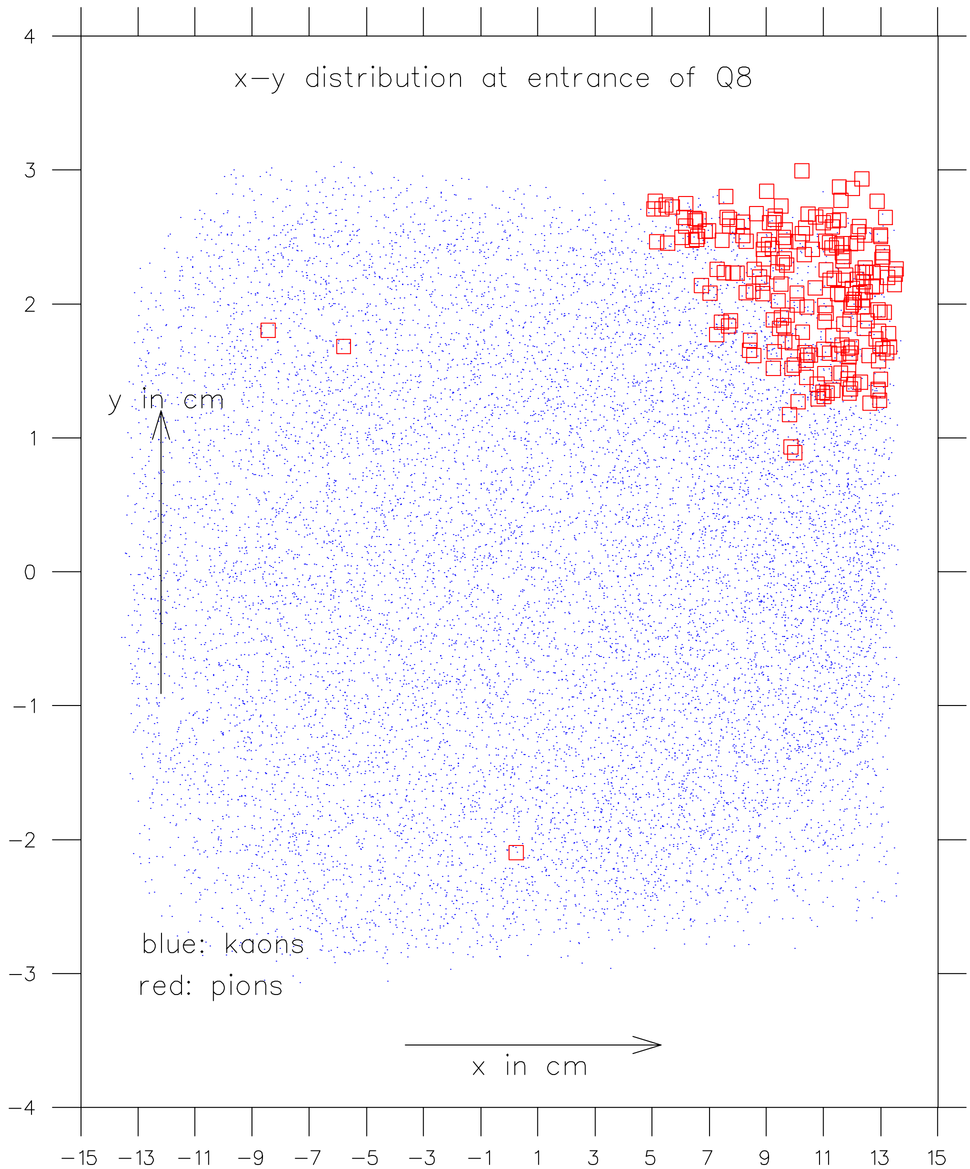

Figure 6: Kaon and pion scatter plot at the entrance of Q8 for those particles transmitted through the mass slits when MS1 is 6 mm wide and MS2 has 8 mm aperture.