STAR-Note # 126
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September 1993

dE/dx information with the SVT

1 Introduction

In this document we present the first results of a feasibility study concerning the dE/dx capabilities of the Silicon Vertex Tracker (SVT) in the $1/\beta^2$ region. Only the SVT information is considered in this report, i.e. we did not use the TPC dE/dx information at all. Only tracks which crossed an active area in each layer were considered and a simple truncated mean result was extracted.

First results show that the SVT would be able to separate two particle species (e.g. *p/K)* up to a momentum close to the mass of the heavier particle (in this case $\approx$ 1 GeV).

2 Description of the method

A knowledge of the mean energy deposited in the SVT could provide particle identification and help tracking in the SVT (for low momentum tracks). Also during track matching between the SVT and TPC one could use the SVT together with the TPC dE/dx information to form an extra constraint. The work presented here is a follow up to the analytical calculations done by J.G. Cramer [1].

In order to suppress the Landau tail, which gives rise to an asymmetric energy loss distribution, one takes the average of a certain fraction of samples, the ones with the lower energy loss values. This improves the determination of the most probable energy loss and, thus, the energy resolution. The maximum number of samples per track is limited to three in the SVT (a maximum of 3 samples), but this should be sufficient since the total energy deposited in Silicon is almost two orders of magnitude greater than in gas of comparable thickness.

Some departures from the Landau distribution have been observed when highly energetic particles ($\approx$2 GeV) pass through thin Si layers. So the question of how good is the GEANT dE/dx for 300 microns Si wafers was raised [4]. This departure becomes very small for thicker detectors [2]. In our case we have 300 microns of Si and particles in the few hundred MeV range. The possibility for departure from the Landau distribution is big only when the most probable energy loss is of the order of the inner shell's binding energy $\mathbf{E_k}$ (for the K-shell E_k = 2 keV). To estimate the importance of this effect in the SVT we checked the inequality $E_k < x_i < E_{max}$ where x_i = 17.8 [keV/mm] · (x/β^2) for Silicon (x is the thickness of the detector) and $E_{max} = 2mc^2\beta^2\gamma^2$ is the maximum energy transfer. We choose pions (the effect is bigger for lighter particles) with p = 300 MeV which gives for x= 300 microns: $E_{max} \approx 5$ MeV and $x_i = 5.343/\beta^2$keV. The result immediately shows that the GEANT Landau energy loss can be applied safely.

Our investigation made the following assumptions:

- perfect tracking, i.e. GEANT information was used in order to associate hits belonging to the same track in the different SVT layers.
- the particle track length traversed inside the Silicon wafer was calculated by GEANT.
- perfect reconstruction of the particle momentum, as returned by GEANT.
- negligible loss of signal due to the long electron drift distances in Si.

The SVT configuration in the simulation comprises **3** non-tiled layers of 300 micron Si allowing almost no extra material for cooling and support structures (fig. 1).

We used a simple truncated mean method, which in this case is to take the average of the two (out of three) lower samples, although a more sophisticated maximum likelihood technique has been shown to give slightly better results [1],

The programs are integrated into a TAS module and executed within the framework of the prototype STAR analysis shell. The TAS table mhits_svt contains all the input information. The module:

- reads in the mhits_svt table and finds the hits belonging to the same track number.
- sorts the hits per track and keeps only the first three hits associated with the three Silicon layers, thus taking care of spiraling tracks.
- rejects the hit with the largest dE/dx and calculates the < dE > and the < dE/dx > by dividing with the corresponding length traversed.

3 Results and discussion

We generated 1200 pions and the same number of kaons and protons covering the momenta range p_X = 50 - 450 MeV/c. The results are presented in fig. 2 and fig. 3. We found that the < dE/dx > values are in close agreement with the Bethe-Bloch values [3] (although the dE/dx axis is labeled as arbitrary the units are in fact GeV per 300 microns of Si). To demonstrate this the Bethe-Bloch normalized predictions are plotted together with the simulation in fig. 2. A very good mass separation is obtained for π/K up to about 450 MeV/c (fig. 3), and *p/K* up to about 1 GeV/c.

We also ran three central Fritiof RHIC Au+Au events to test the real performance of the dE/dx module. The particle separation is shown in figs. 4 and 5. In fig. 5 the particle population is shown for two different momentum ranges. The qualitative features of the previous figures are also seen here. As expected the number of pions is much higher than the other species. Given the anticipated momentum distribution of the different particle species (from Fritiof), the *π/p* separation is good over the whole pion momentum range (up to about 1 GeV). The *π/K* and *p/K* resolution is consistent with the earlier result. We also calculated the anticipated dE/dx resolution by taking a slice in momentum $(350 < p < 450 \text{ MeV}/c)$ and evaluate the ratio RMS/< dE/dx >. It is 14% which is in very good agreement with the calculations done in [1]. Further analysis is in progress.

4 Acknowledgement

The authors would like to thank W.K. Wilson, M. Bloomer, G. Odyniec and C. Byrd for their comments and suggestions.

References

[1] J.G. Cramer, SVT Note, STAR CDR PUB-5347
[2] J.F.Bak et al., Nuclear Physics B288 (1987) 681.
[3] Particle Properties Data Booklet, AIP (1992).
[4] C. Byrd, private communication.

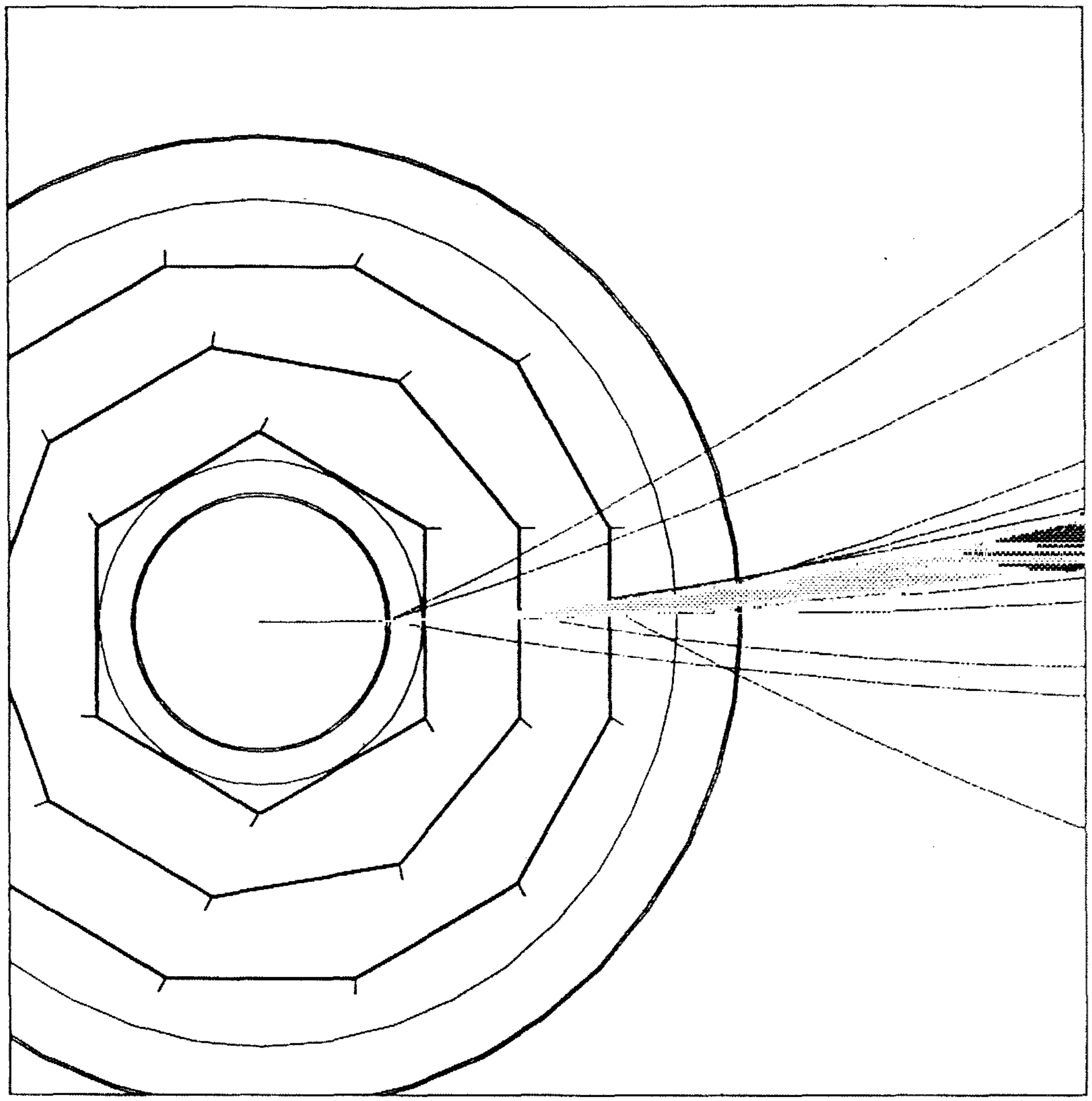

Figure 1: kaons at normal incidence to the SVT modules with momenta in the 200-250 MeV range. The inner is the beam pipe. Hard scattering lead to larger deflection.

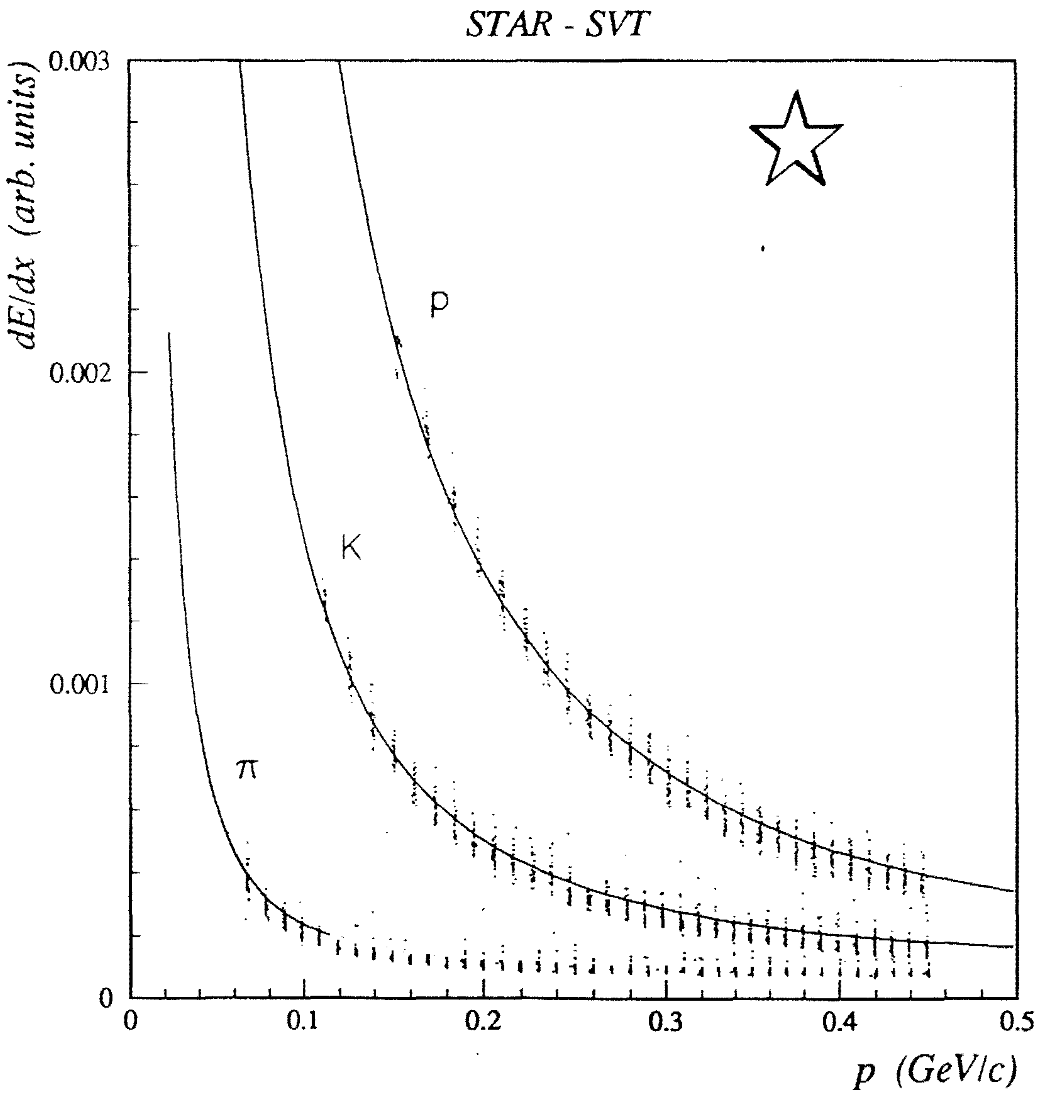

Figure 2: Energy loss distributions for protons, kaons and pions. Equal numbers of each species were taken. The solid lines are the Bethe-Bloch curves taken from [3].

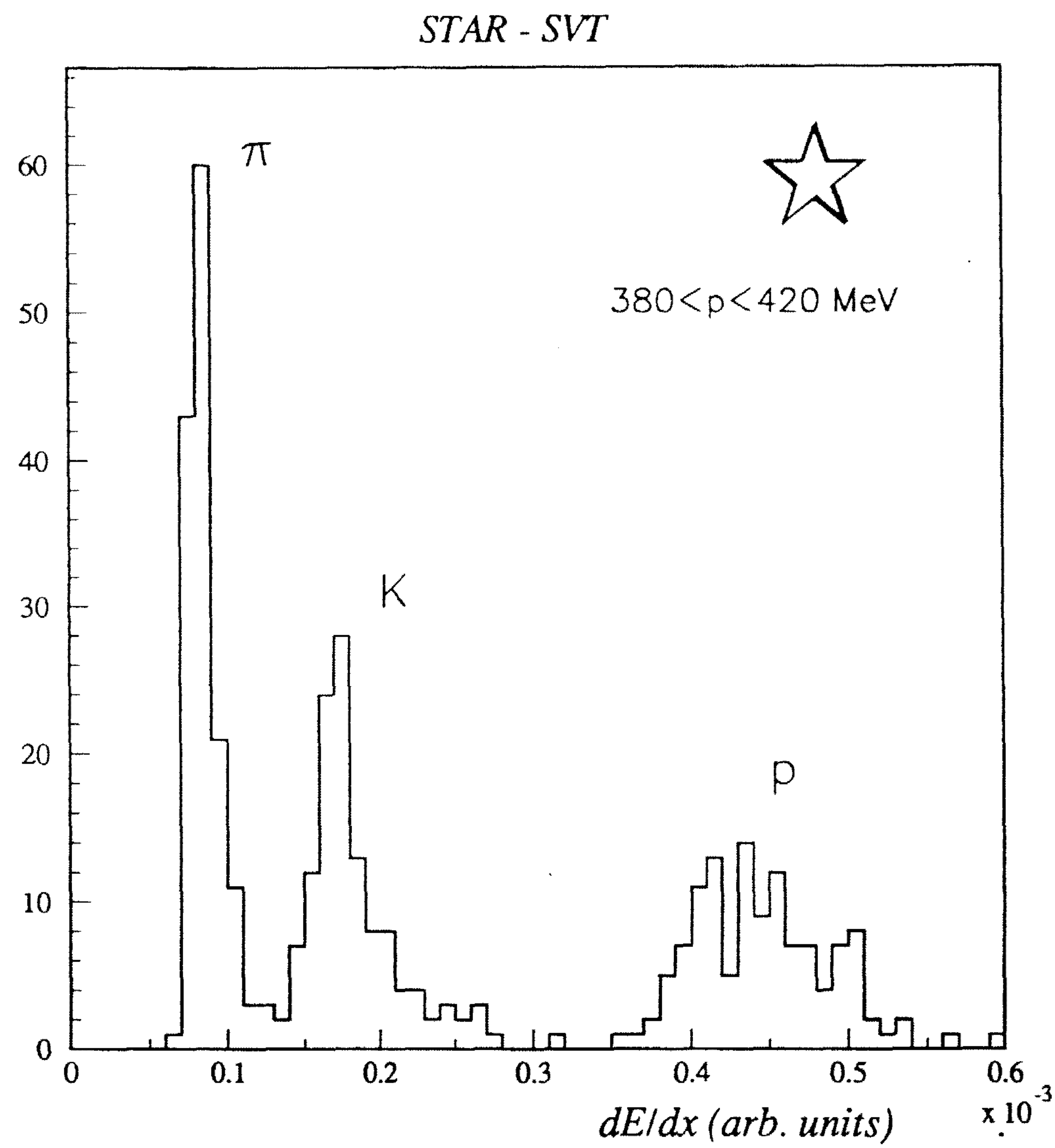

Figure 3: Projection onto the dE/dx axis of particles with momentum in the range 380-420 MeV illustrating the good particle separation achieved.

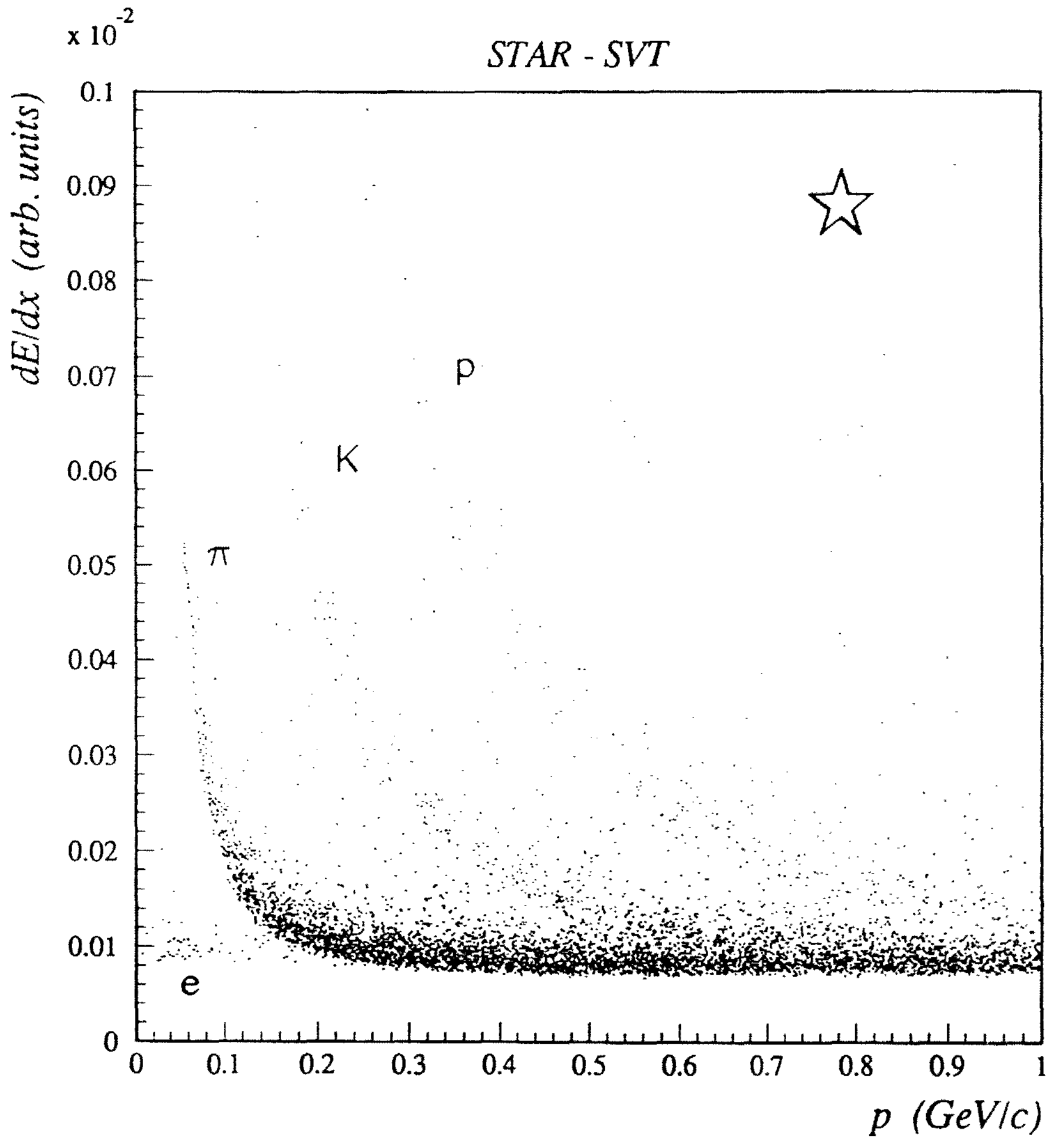

Figure 4: Energy loss spectrum for three Fritiof Au+Au events. Despite the very

Figure 4: Energy loss spectrum for three Fritiof Au+Au events. Despite the very limited statistics, one can distinguish the dE/dx bands for the different particles. The particles at the lower left corner of the plot are δ-electrons.

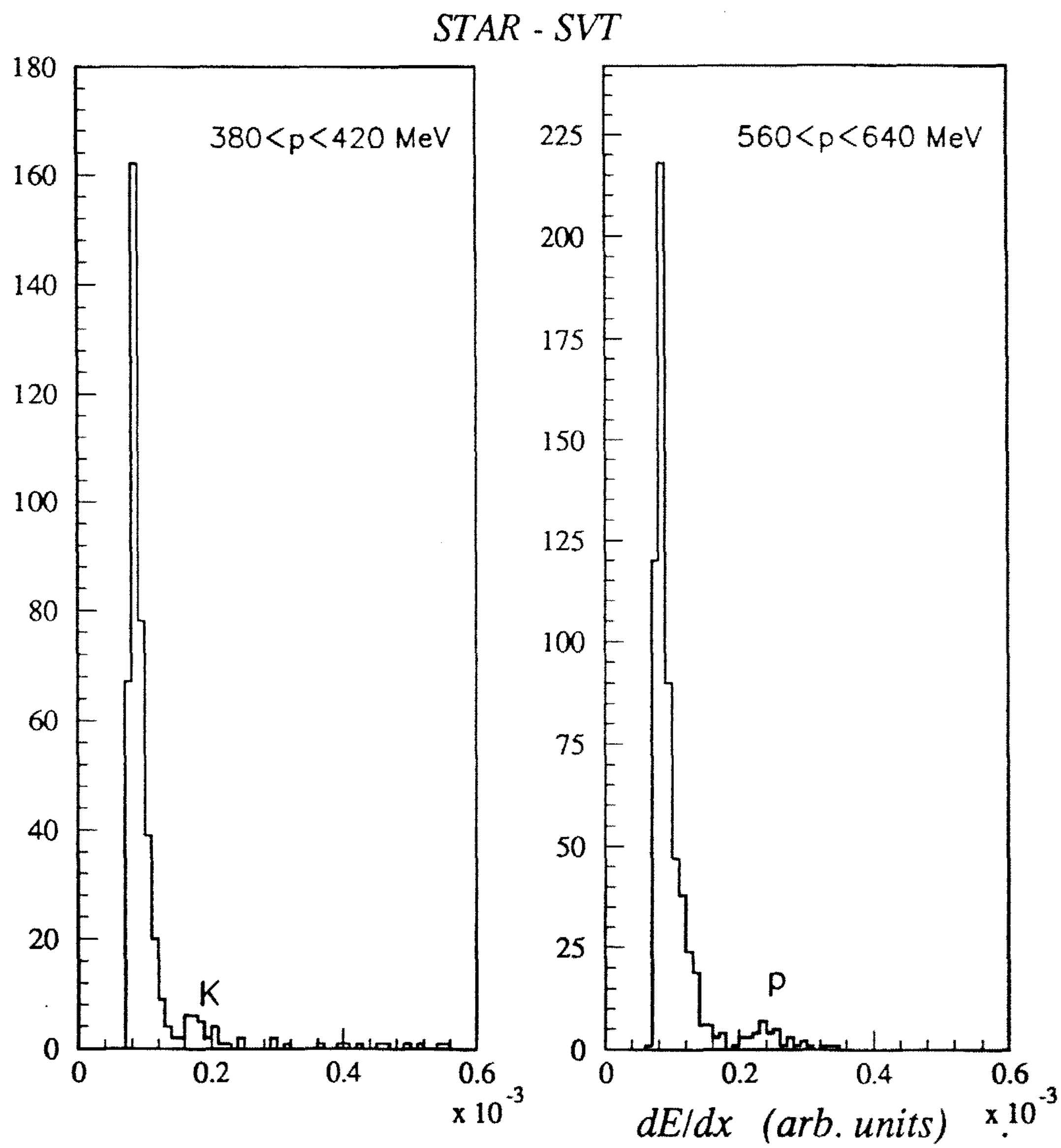

Figure 5: Energy loss spectrum for two slices in momentum taken from the previous figure.