1 Identification of short track particles by use of TOF

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Introduction Collisions in Hermes target produce some low momenta particles. These particles don't make it all the way to the detectors placed after Hermes' magnet, as it bends their paths too much. Their momenta can be determined by the magnet chamber, but they can't be identified, since they do not go through RICH, which is main PID detector for Hermes.

The goal of this summer project is to make a preliminary study of this low energy particles in order to know where should new scintillators be placed to measure the time of flight (TOF) of these short tracks and thus to reduce background for Lambda decay. Other applications of such additional PID will be considered.

Modeling and Setups

In order to achieve our goal, we studied to possible scintillator setups, explained in detail below, and calculated the times of flight of low energy particles arriving at the "scintillator" in each setup.

Setup 1 The first setup studied is illustrated in Fig 1. The two inclined lines show the planes of particle incidence in which times of flight were calculated. For simplicity, we assumed that magnetic induction field was uniform inside the strip $-63 < z < 63$ in the z direction andaero everywhere else. Even if it's an oversimplification of the actual way the magnet is, our assumption can't change the qualitative behavior of particles in the given planes, and it allowed us to make a simple calculation for the short tracks since outside the magnet the particle's paths are straight lines, and inside the magnet are circles with a radii given by:

$$\rho = \tfrac{p}{0.003B},$$

where p is the particle's momentum in GeV, B is the magnetic induction field in Tesla, and ρ is the circle's radius in cms (Grebenyuk, 1995). Hence a particle's path, like the one in Fig 2, will be described, after entering the magnetic induction field by:

$$\begin{aligned} x &= x_{in} + \rho\cos(m)(\cos(\theta)-1) + \rho\sin(m)\sin(\theta), \\ y &= y_{in} - \rho\sin(m)(\cos(\theta)-1) + \rho\cos(m)\sin(\theta). \end{aligned}$$

θ stands for the angle subtended by the particle's travel, and m is the initial slope the particle has when it reaches the magnet's acceptance. Since we are interested in calculating the track's total length the next step is to calculate the angle θ in which the track crosses the given planes. If the particle's charge is positive, then it will hit the left plane. Since such plane is given by

$$y = -3.9907(x + 60.5).$$

the point in wich both the circular path and the plane will cross can be calculated by direct substitution of the circular path's coordinates into the plane's equation

$$\begin{gathered} y_{in} - \rho\sin(m)(\cos(\theta)-1) + \rho\cos(m)\sin(\theta) = \\ -3.9907(x_{in} + \rho\cos(m)(\cos(\theta)-1) + \rho\sin(m)\sin(\theta) + 60.5). \end{gathered}$$

And so we will obtain the θ value of the angle swept by the particle (the complete expression for θ can be seen in the FORTRAN code delivered with this report). The same procedure holds for particles with negative charge, using the proper equation for the right plane:

$$y = 3.9907(x - 60.5).$$

Once we know this, it's straightforward to calculate the total length for the particle's travel:

$$l = \rho\theta + 212\sqrt{1 + S_x}.$$

Since we know the particle's momentum, we can calculate it's energy:

$$E = \sqrt{m^2 + p^2}.$$

Then it's velocity is

$$v = \frac{p}{E}$$

And once we have the velocity, we can calculate the time of flight

$$t = \frac{l}{v}.$$

Setup 2 The second setup is shown in Fig 2, and it is much more simple. All calculations are performed for particles going through the line (in Fig 2) placed just in magnet's acceptance, which is the suggested place in this setup to place scintillators. We followed the same procedure (except for the circular paths which become, in this case, unnecessary) for calculating the times of flight.

Results and Conclusions Time of flight distributions are shown in Fig 3 for setup 1 and in Fig 4 for setup 2, in both cases for different momentum intevals.

For setup one, it can be seen right away that times of flight for pions and kaons overlap for momentum values greater than 0.4 GeV, and the same thing happens for protons and kaons for momentum values greater than 0.5 GeV. For set up two, on the other hand, we see that distributions do not overlap at all, and even feature big gaps between distributions for different particles in the same momentum interval. If time of flight techniques are to be used to reduce noise in Hermes' detector then setup 2 will render the best results because of the lack of overlapping in its distributions, and also because it will be able to work with every momenta available in the experiment but on the other hand it will suffer from large particles multiplicity, and will reduce the overall detector performance in momentum resolution.

Setup 1 has some advantages of its own: times of flight are shorter as tracks are shorter, and that means that the time resolution needed is not as high as in setup 2. The place in which scintillators are to be placed in setup 1, also, allows the experiment's momentum resolution go unchanged and introduces no multiplicity.

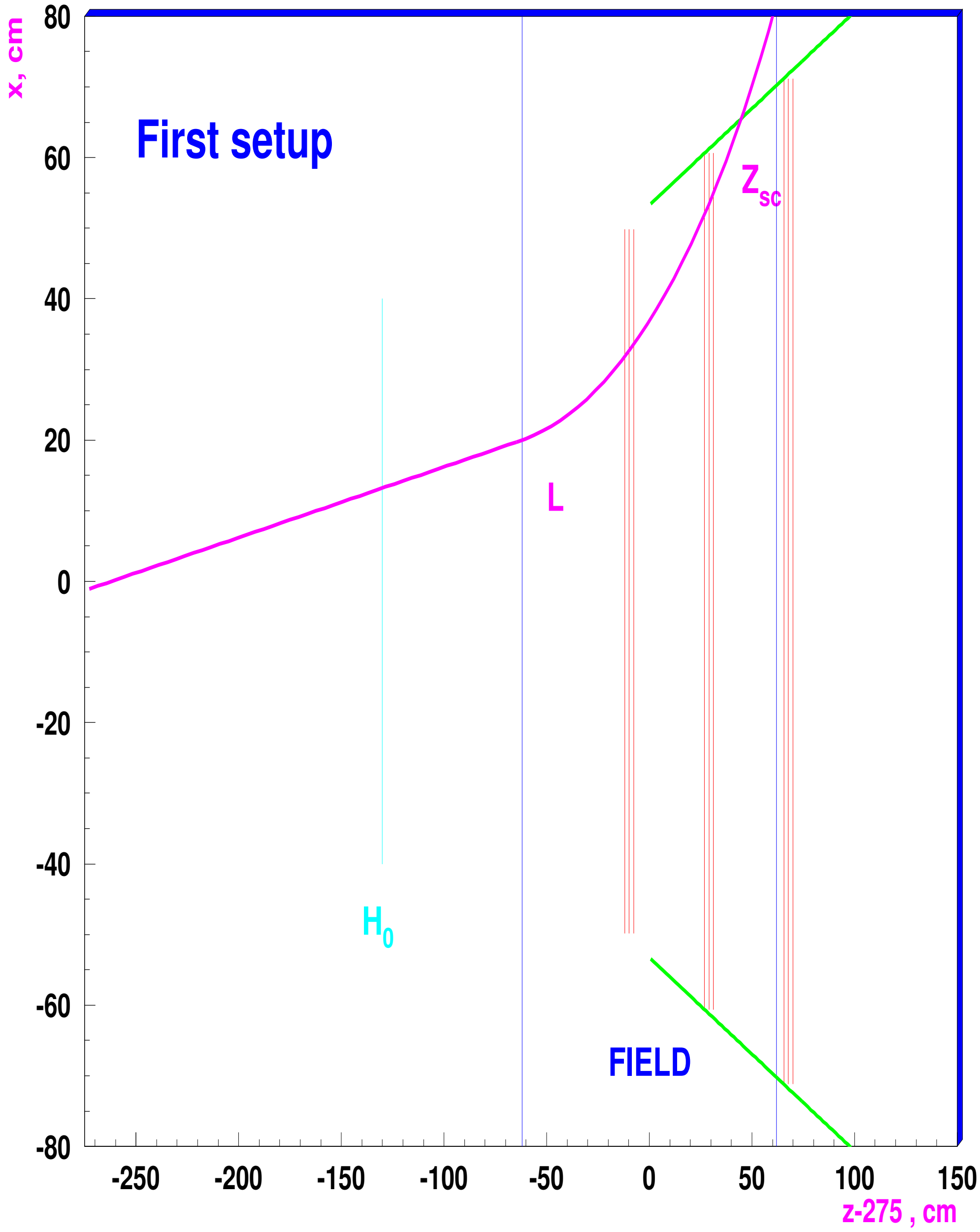

Figure 1: Setup One's Scheme.

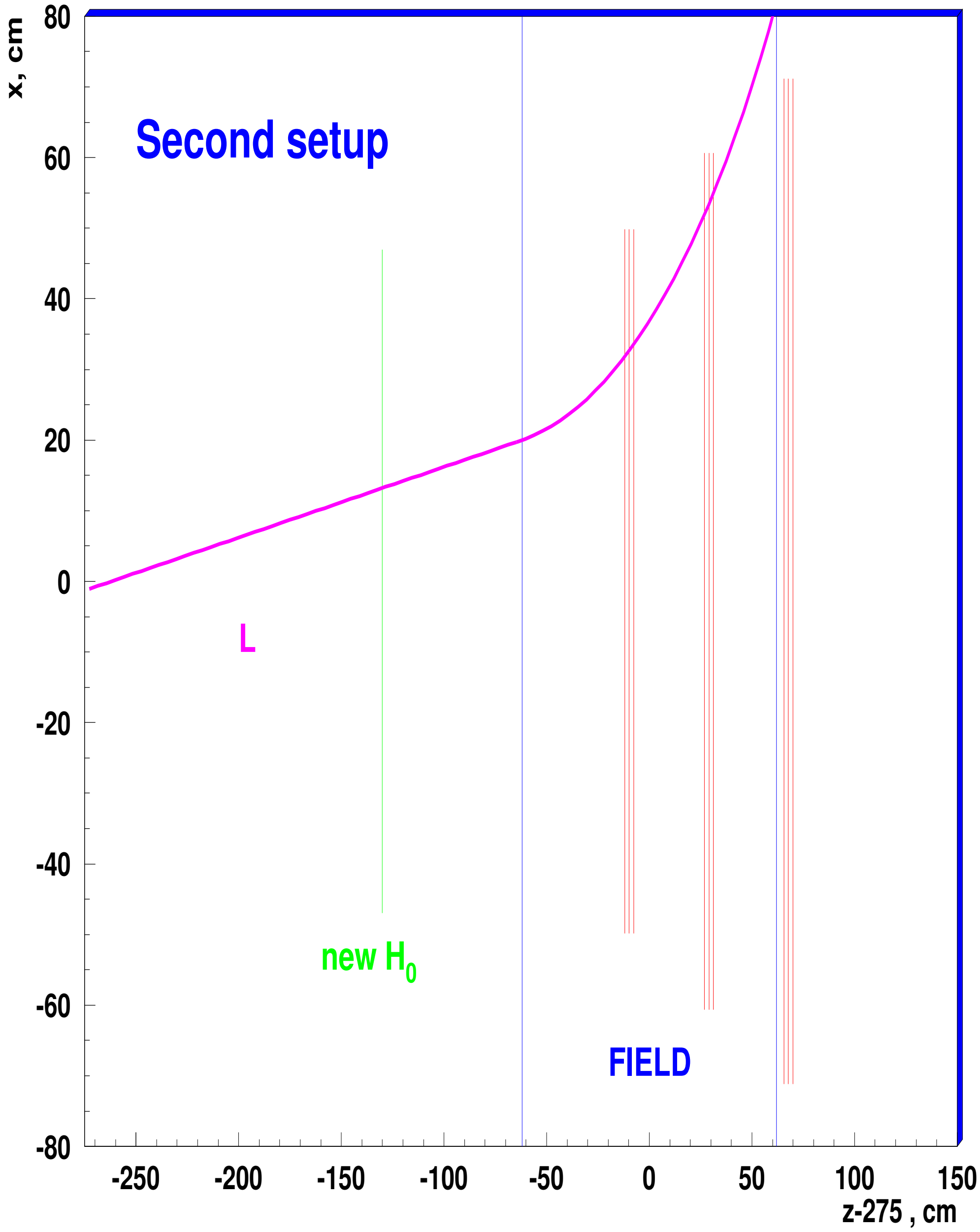

Figure 2: Setup two's Scheme

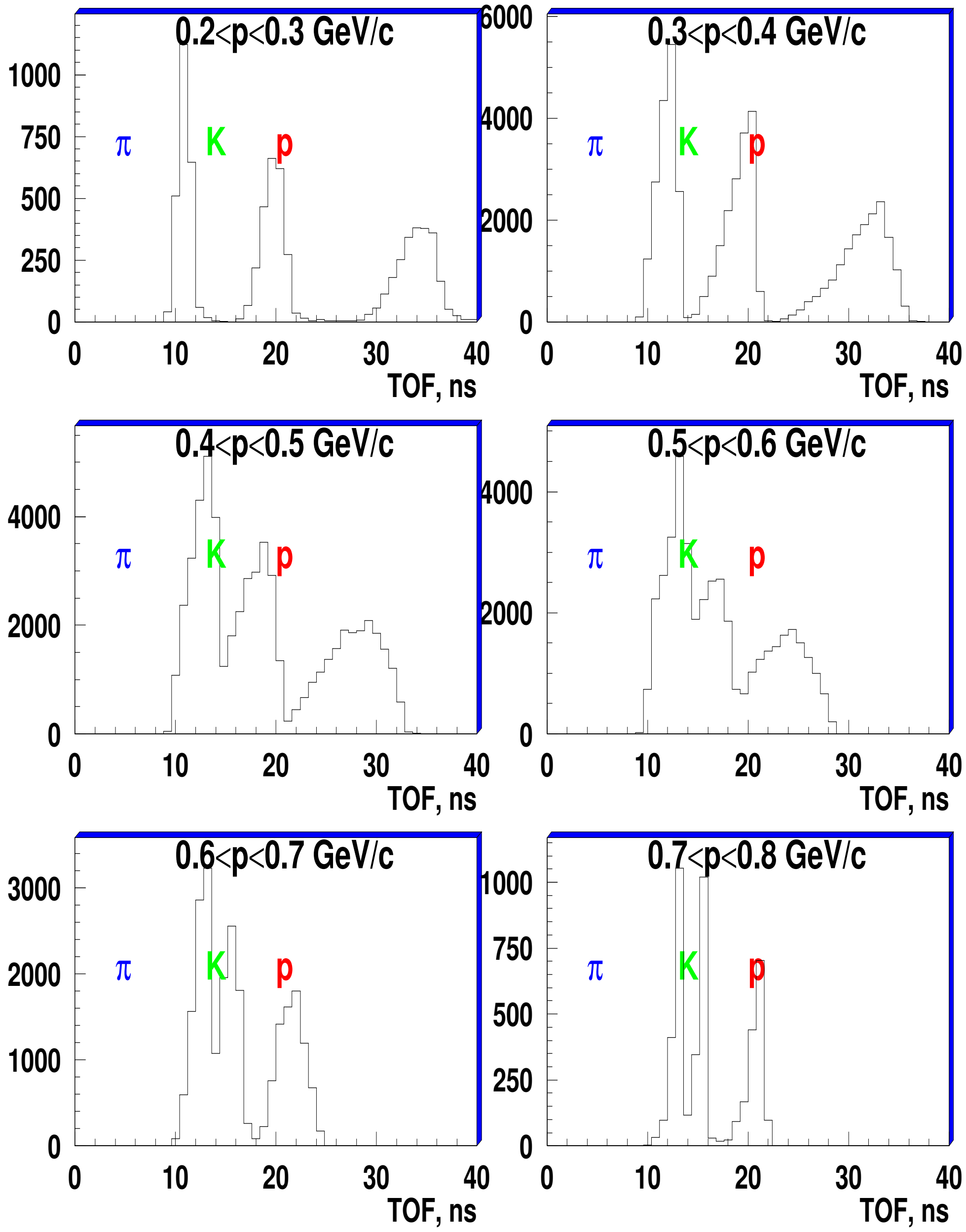

Figure 3: Time of flight distributions for setup one

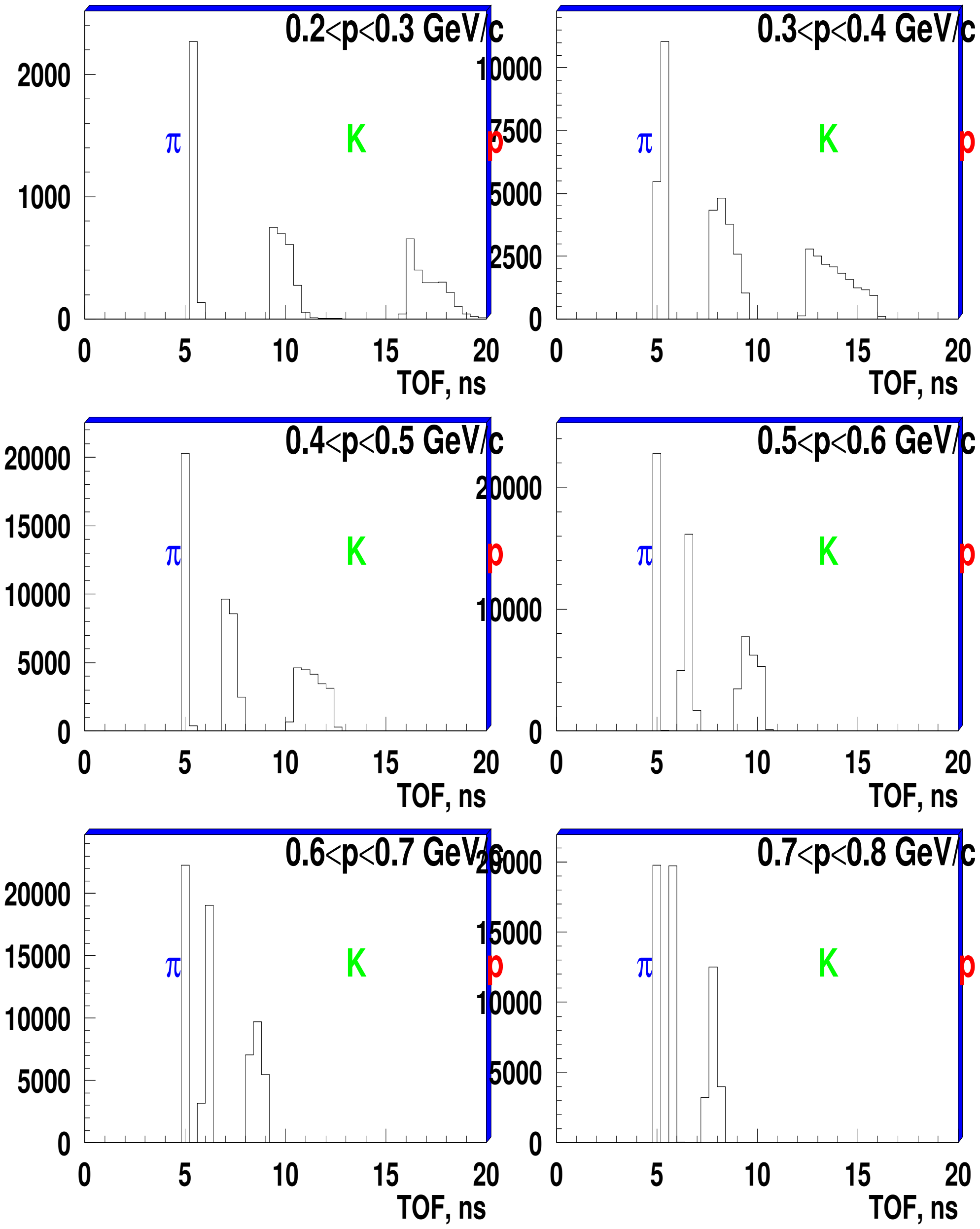

Figure 4: Time of flight distributions for setup two