e1-6 Proton Identification

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Abstract

This chapter describes the proton identification for the e1-6 data. The candidate protons are all the events containing at least one positive time-based track, after the electron identification. The cuts are based on the candidate's reconstructed momentum and its signals on the Time of Flight (TOF)[2]. The cuts are sector-dependent.

Contents

1 Proton identification

The purpose of this study is the proper identification of the scattered protons. The CLAS timing resolution decreases as the particles momentum increases. It is problematic to properly identify charged particles with the timing information alone at very large (greater than $3, 4$ GeV) momentum. The goal of this analysis is to make the best possible selection of protons, while keeping in mind that further refinements based on individual reactions kinematics will be necessary.

1.1 CLAS Timing

During the event reconstruction the momentum of a track is calculated with the tracking procedure [1]. To determine its speed β, the start time T_0 is calculated as

$$T_0 = T_{el} - \frac{\ell}{c} - \frac{z - z_0}{c} \tag{1}$$

where T_{el} is the electron time from TOF measurement, ℓ is the path length of the electron track from the vertex to its TOF hit, c is the speed of light, z is the z-component of the event vertex and z_0 is the z position of the center of the target[1]. T_0 is then used as the reference for all the remaining tracks in the event. The track speed β is calculated as:

$$\beta = \frac{v}{c} = \frac{1}{c}\frac{\ell}{T - T_0} \tag{2}$$

where ℓ is the track path length from the target and T its TOF time. In Fig.1 is plotted β versus momentum for the all the particles after the electron particle ID. One can clearly see bands corresponding to pions, kaons, protons, deuterons.

[1]For this experiment $z_0 = -4$ cm.

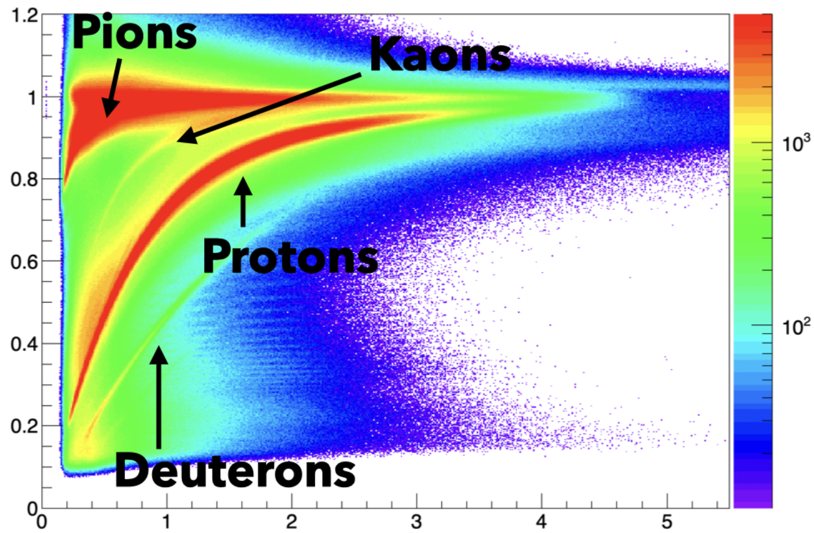

Figure 1: β versus momentum for positive particles in e1-6 running period. Bands corresponding to pions, kaons, protons and deuterons are visible.

1.2 ΔT cut

For this analysis every positive track (determined by its curvature in the torus field) is a *proton candidate*.

The difference ΔT between the time calculated using the candidates's momentum (assuming it is a proton) and its actual TOF time T should peak at zero for protons:

$$\Delta T = \frac{\ell}{\beta'} + T_0 - T (\sim 0) \tag{3}$$

where $\beta' = \sqrt{p^2/(M_P^2 + p^2)}$ is the speed of the track calculated from its momentum and M_P is the proton mass. A plot of ΔT versus momentum for Sector 1 is shown in Fig.2. The distribution is sliced along ΔT and each slide is fitted with 2 Gaussians + 2^{nd} order polynomial function to calculate the mean positions μ and sigmas σ of the proton and pions/kaons signals. The proton's μ and σ are then fitted with a 5^{th}-order polynomial. An example of μ fit is also shown in Figures 2 and 3.

At low momentum the protons are well separated. The pions distribution start to contaminate the protons when $\mu_P + 3\sigma_P < \mu_\pi - 3\sigma_\pi$; in that case $(\mu_\pi - 3\sigma_\pi - \mu_P)/3$ is used as the signal σ instead of σ_P. In Fig.3 the cuts for all sectors are shown.

Two quantities normally used to monitor the quality of the charged particles selection are β and the TOF Mass M^2_{TOF}:

$$M^2_{TOF} = \frac{p^2(1-\beta^2)}{\beta^2}$$

Both β and M^2_{TOF} versus momentum are shown for sector 5 in Fig.4. The M^2_{TOF} was initially considered to perform this identification. However, when sliced, the corresponding 1-dimensional plots could not resolve the protons and kaons/pions signal as well as ΔT can.

The value of the μ and σ parameters used are listed in sec1.2.1.

1.2.1 Cut parameters

$$f(p) = a + bp + cp^2 + dp^3 + ep^4 + fp^5$$

	S1	S2	S3	S4	S5	S6
mean:						
a:	-0.9113	-0.655048	-0.904261	-0.709094	-0.724329	-0.418643
b:	2.98931	1.38425	1.76954	0.591925	4.06097	0.781139
c:	-4.09545	-2.10418	-1.9409	0.272274	-5.8547	-0.943656
d:	2.19893	1.2356	0.948967	-0.454383	3.18819	0.501819
e:	-0.495131	-0.290715	-0.194741	0.158209	-0.720678	-0.117491
f:	0.0389196	0.0232255	0.0136907	-0.0165409	0.0568144	0.00959472
sigma						
a:	6.16714	6.60215	5.87269	5.90242	5.96331	5.99657
b:	-12.1628	-14.4183	-10.6575	-11.7175	-12.2304	-12.4064
c:	9.86015	12.6391	8.00035	9.75136	10.391	10.69
d:	-3.74511	-5.02972	-2.86622	-3.90726	-4.04935	-4.35567
e:	0.679294	0.926557	0.497855	0.750446	0.737621	0.835659
f:	-0.0470408	-0.0639353	-0.033369	-0.0545215	-0.0505353	-0.0600134

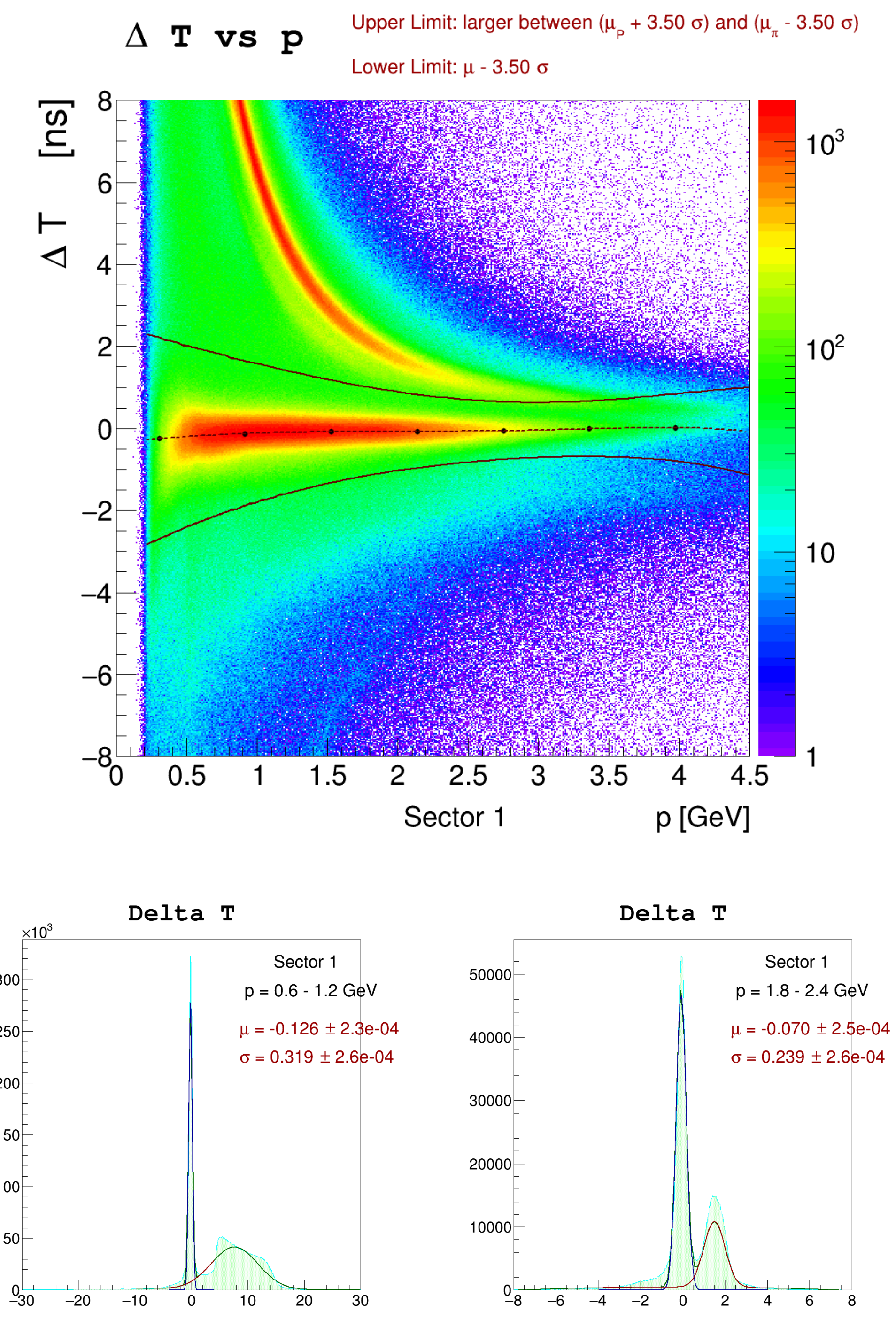

Figure 2: ΔT versus momentum and slices at different momentum. At low momentum the proton signal is well separated from kaons and pions, so we include everything up to 3σ from the pion/kaons signal. At high momentum kinematic constrains for exclusive channels will be necessary. The colors are as follows: blue: proton signal (gaussian). Red: pion signal (gaussian) + background (2^{nd} order polynomial). Dark green: total fit function.

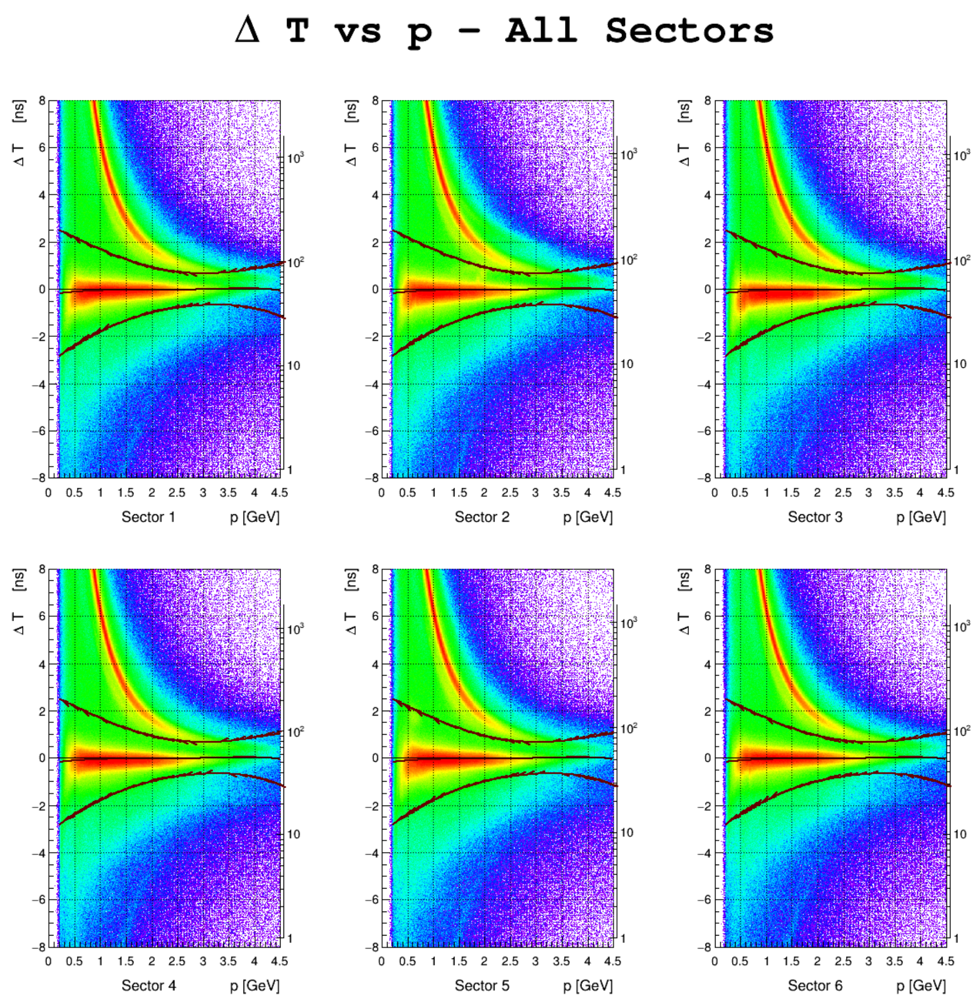

Figure 3: ΔT versus momentum cuts in all sectors. Plot grids emphasize the differences between sectors.

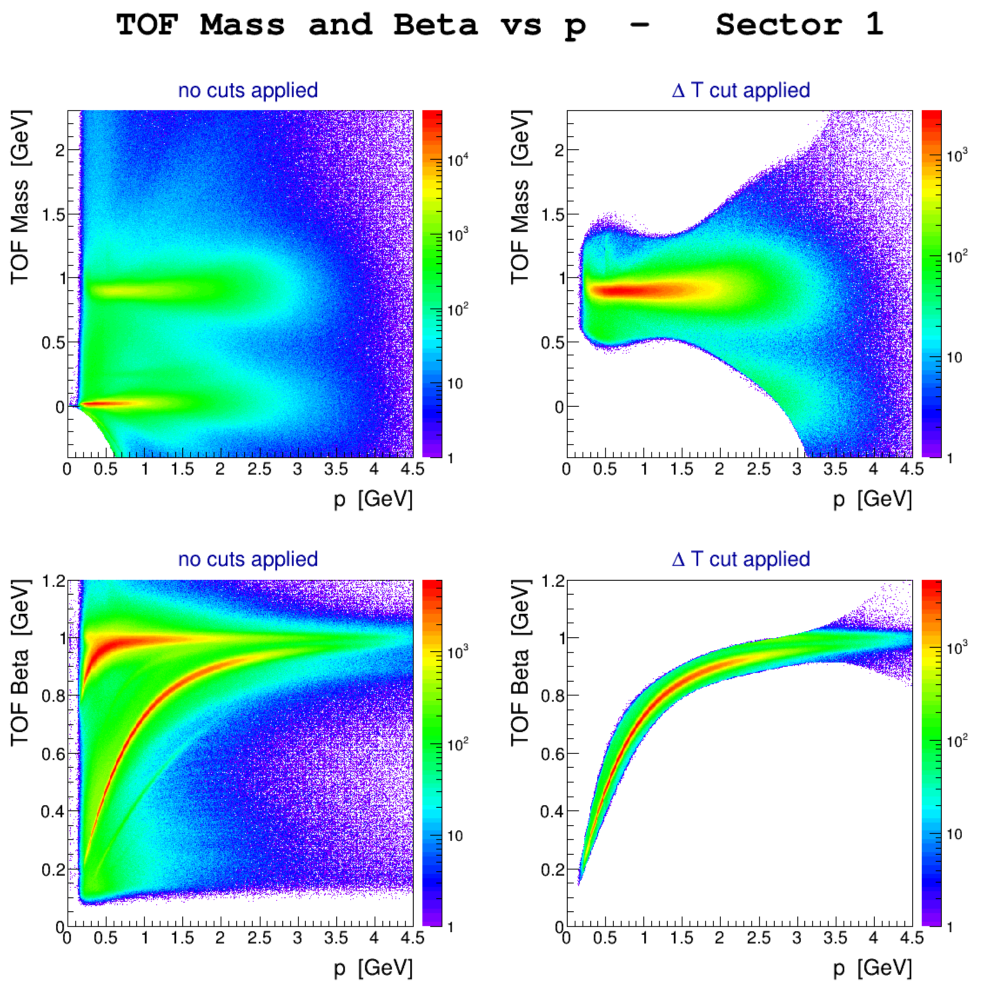

Figure 4: Left: β and M^2_{TOF} versus momentum for positive tracks with no cut applied. Right: the same quantities with the ΔT cut applied.

References

[1] B. Niczyporuk, *CLAS NOTE 91 - 001*

[2] E.S. Smith et al., The Time-of-Flight System for CLAS, *Nucl. Inst. and Meth. A 432, 265 (1999)*