A Monte-Carlo study of background secondary tracks in the H1 FTD

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Abstract

Using the Monte-Carlo ntuples from Lepto 6.4, as generated for the forward P_t analysis of 1994 data, the distribution and sources of secondary background tracks in the FTD are investigated.

Outline

At the last FTD/upgrade meeting at RAL on 13th May JVM was asked to look at the effects of secondary tracks arising from interactions with material of the trackers, as simulated for the H1 "BFKL P_t" paper[1]. This note is the result.

Procedure

Although the original MoCa data-sets for the "BFKL" P_t studies have been deleted the ntuples still exist at RAL and contain sufficient information to allow a reasonable estimate of the contamination produced by secondaries from interaction in the material of the H1 detector.

For MoCa data, a reconstructed "primary" track is *defined* as one which has the majority of its hits belonging to a generated track originating from a vertex who's true position lies inside a cylinder surrounding the *ep* interaction point[2]. The cylinder has its axis along the proton beam (z) direction, has length 10cm and radius 3cm. Thus, for example, all charged hadrons arising from the *ep* interaction vertex are "primary" as are all charged pions coming from K^0s which have decayed inside the defining cylinder. K^0s decaying outside the defining cylinder produce "secondary" tracks. Photons from the decay of primary π^0s form the main source of secondary tracks by pair-production of e^+e^- in the material of the detector.

Identification of the cause of secondary track production, eg e^+ from conversion of a photon in the dividing wall between Planar orientations 0 and 1, is possible in principle for MoCa data. Unfortunately, in practice, we did not write this level of detailed information to the output ntuples so we have to resort to a model, with some (reasonable)

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[1] C.Adloff et al - *Measurement of charged particle transverse momentum spectra in DIS.* Nucl.Phys.B485(1997)3
[2] D.G.Cussans and J.V.Morris - *Track Selection in H1 DIS Data.* H1-note to be published.

assumptions as input, to estimate the contributions from the different detector material sources.

The ntuples, which were derived from 1994 Lepto 6.4 data, give the lab pseudo-rapidity (η_{lab}) and allow us to tell for each reconstructed track whether it is a secondary or a primary track. Thus we can calculate the ratio of secondary to primary reconstructed tracks as a function of η_{lab} as shown in Figure 1.

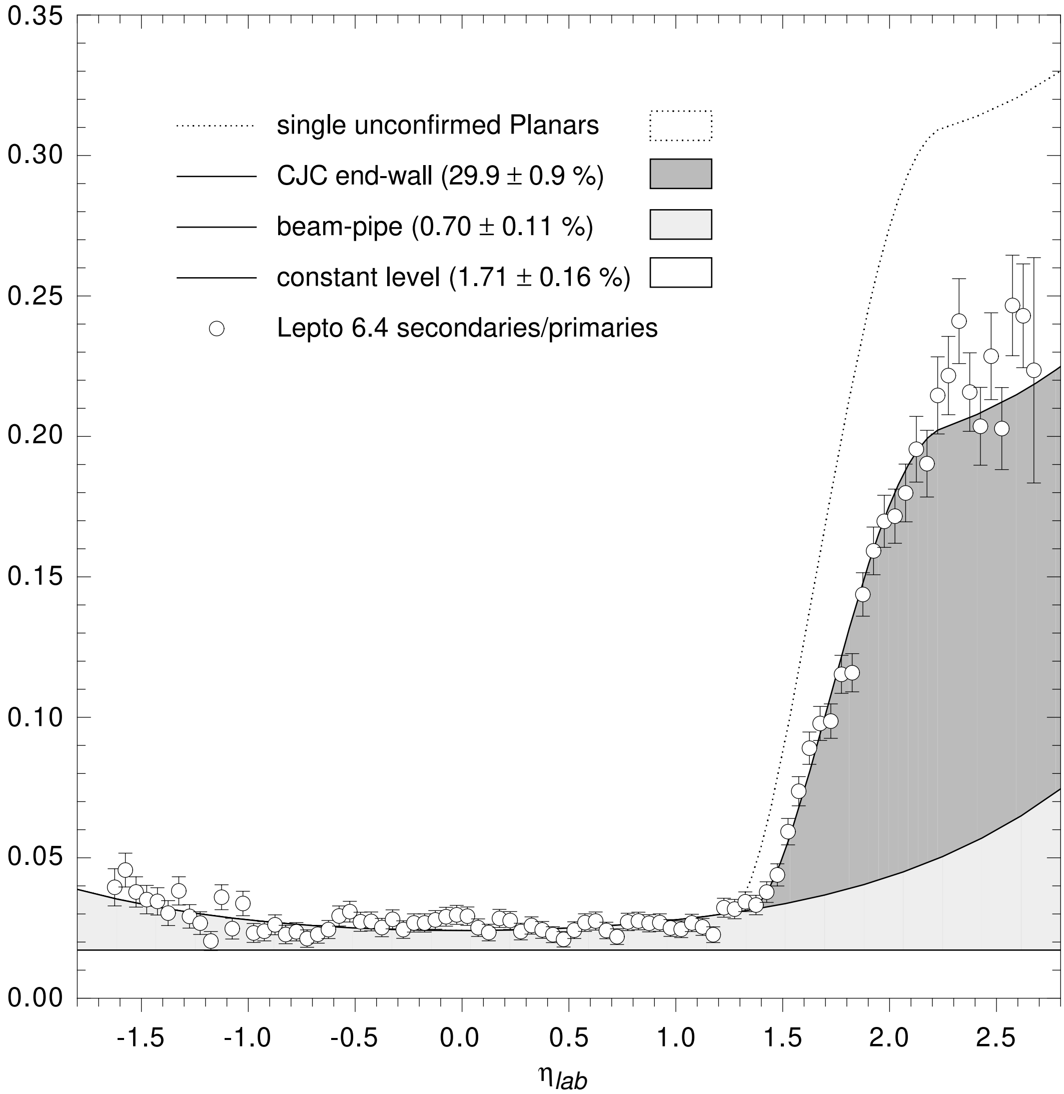

Figure 1: The ratio of secondary to primary reconstructed tracks from Lepto 6.4 as a function of pseudo-rapidity. The model curves are described in the text.

The model used to describe these data has the following components;

- all secondary particles are assumed to originate from either the decay or the interaction of a neutral primary particle.

- the distribution in η_{lab} of these neutral primary particles is assumed to be the same as that of the charged primary particles multiplied by a constant scale factor.

- charged secondaries resulting from the decay or interaction of a neutral primary are assumed to be reconstructed at the same η_{lab} as the primary. It follows that secondaries from K^0 decay contribute a constant level to the above ratio.

- photons from π^0 decay must traverse the beam-pipe, which produces secondaries with a probability proportional to $\alpha/\sin\Theta$ where α is related to the effective thickness of the pipe and Θ is the polar production angle of the photon in the H1 rest frame..

- photons which reach the end-wall of the CJC will produce secondaries with a probability proportional to $\beta/\cos\Theta$ where β is related to the effective thickness of the end-wall.

- the interaction of photons in other material of the trackers (gas, wires and cell boundary walls) is assumed to be independent of η_{lab} contributing a constant level to the above ratio.

The relative positions of the various components referred to above, and the critical angles defining the geometric boundaries of the relevant regions are shown in Figure 2 and are summarised below.

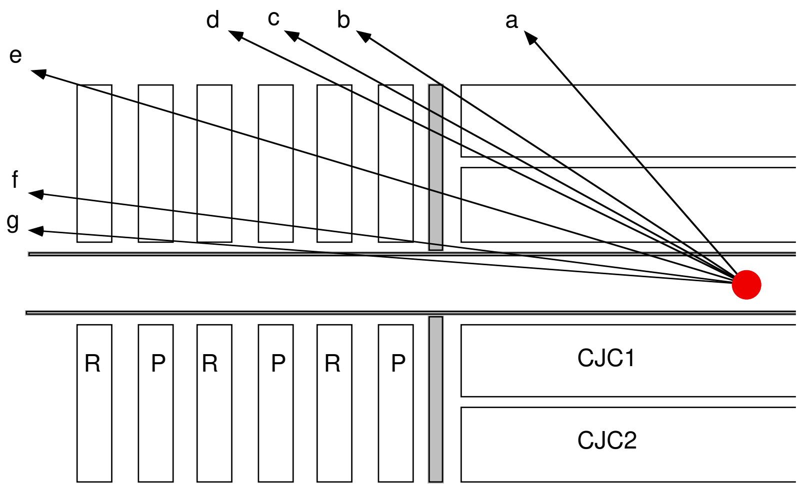

Figure 2: Angles defining the geometric boundaries of the FTD acceptance and the regions sensitive to background secondary production in the material of the beam pipe and CJC end-wall.

(a) $\Theta>32.6$deg $\eta<1.23$ to first order a central primary particle (charged or neutral) sees only the material in the beam-pipe where it may interact producing secondaries in the CJC but not in the FTD.

(b) $\Theta=32.6$deg $\eta=1.23$ the particle also sees the end-wall of the CJC with which it may interact but the products of the interaction are outside the acceptance of the FTD.

(c) Θ=29.2deg η=1.34 the secondaries can be detected as unconfirmed single Planar segments in SM0 of the FTD.

(d) Θ=25.2deg η=1.50 the secondaries can be detected as confirmed (by Radial hits) single Planar segments. This accounts for the sudden rise in the ratio of secondaries to primaries visible in Figure 1, due to photon conversion in the CJC end-wall and the track selection requirement that single Planar segments must be confirmed.

(e) Θ=16.0deg η=1.96 the FTD track-finding acceptance (for primaries and secondaries) reaches its plateau when all FTD modules are traversed by the track

(f) Θ=7.0deg η=2.79 the acceptance starts to decrease as the track moves outside the radial aperture of Planar module 0, reducing the number of possible Planar segments from three to two.

(g) Θ=4.7deg η=3.20 the low angle limit of the acceptance is defined by the point where a single Planar segment can no longer be formed in Planar module 2.

The efficiency for detecting a secondary charged particle in the FTD is the same as that for primary charged particles[3]. If single unconfirmed Planar segments are allowed by the track selection cuts this efficiency rises from zero at η=1.34 (track (c) in Figure 2) to reach a plateau at η=1.84 (track (e) in Figure 2) where the efficiency is about 88% for 1994 Hades selected DIS data. If the track selection cuts require single Planar segments to be confirmed, by connected hits in other Planar or Radial chambers, the plateau efficiency is roughly halved (the single Planar segment finding efficiency was ~51% for 1994 data[4]).

The above assumptions and geometry were used to create a simple computer model to describe the production and detection of secondaries. The model had 3 free parameters which were;

- α, the fraction (%) of secondaries per primary produced at normal incidence through the beam pipe
- β, the fraction (%) of secondaries per primary produced at normal incidence through the CJC end-wall.
- γ, the (assumed) constant fraction (%) of secondaries per primary produced in the remaining material of the H1 detector.

These parameters were allowed to vary in a minimum χ^2 fit to the data of Figure 1 with the following results;

$$\alpha = 0.70 \pm 0.11 \ \%$$

$$\beta = 29.9 \pm 0.9 \ \%$$

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[3] S.Burke et al - *Track Finding and Fitting in the H1 Forward Track Detector*. Nucl.Inst.Meth.A373(1996)227

[4] D.G.Cussans and J.V.Morris - *Track Selection in H1 DIS Data.* H1-note to be published.

$$\gamma = 1.71 \pm 0.16\ \%$$

Of the ~30% secondaries per primary through the CJC end-wall, approximately half are reconstructed and selected in the FTD, accounting for the ~15% contribution visible in Figure 1 (dark shaded area) at high pseudo-rapidity. The distribution of secondaries as a function of P_t is shown in Figure 3.

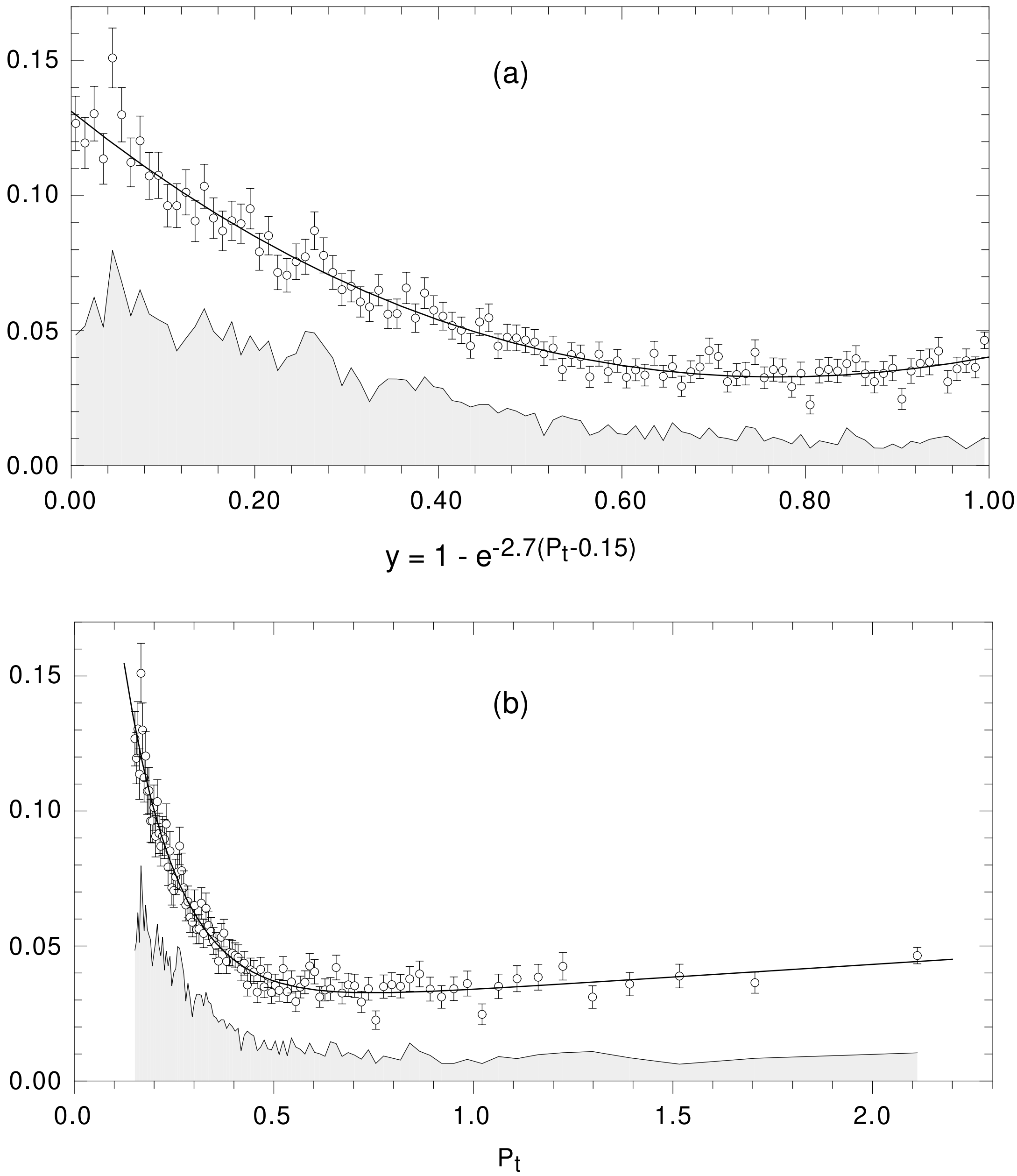

Figure 3: The ratio of secondary to primary tracks as a function of y (a) and transverse momentum (b). The shaded region shows the contribution from Forward secondary tracks.

In order to equalise the statistics per bin we use the variable $y = 1 - e^{-2.7(P_t-0.15)}$ which is equal to 0 when $P_t = 0.15$, the track selection cut of Table 1, and equal to 1 when $P_t = \infty$.

This gives roughly equal statistics per y-bin because the source P_t distribution is approximately exponential with a range of 0.37 GeV/c. Figure 3(a) shows the ratio of secondaries to primaries as a function of y. It is clear that the largest contamination (~13%) occurs at the lowest y reducing to about 3%-5% at the highest y. This effect is even more clearly seen if the same data points are plotted as a function of P_t (computed at the centre of the corresponding y-bin) as shown in Figure 3(b).

Conclusions

The material in the end wall of the CJC increases the number of background secondaries in the forward direction by a factor of three. For any study of forward hadronic multiplicity this constitutes a serious background which should be reduced if it is possible. These secondaries are confined mainly to low P_t. At high P_t, where H1 is sensitive to the differences between DGLAP and BFKL QCD evolution, the secondaries constitute a ~5% contamination which can be removed by the usual MoCa correction, and is, in any case, small compared to the difference between the QCD predictions which we attempt to measure.