accepted by the TLT $J/\psi \to ee$ and l^+l^- as well. At the pre-selection stage, there was no strong argument to exclude this filter. It is advantageous to have independent triggers to cross check the detector acceptance correction.

5.2 Pre-selection based on event history

The goal of pre-selection is to select a sample of moderate size using a set of fundamental cuts so that further selection and analysis can be performed on this sample instead of going through the whole 1993 ZEUS data repetitively.

Hereafter we refer the data taken *after* the implementation of the previously described GFLT triggers and TLT filters as *the 1993 ZEUS data*, which contains 488nb^{-1}(from run6494 to run7549) of the total 543nb^{-1} luminosity(excluding runs with severe problems in the detector) taken by ZEUS during the 1993 runs(from run5677 to run7549). In this sample, 255(233)nb^{-1} of luminosity were taken before(after) the modification of the TLT l^+l^- filter.

Among the 5.1×10^6 triggers in the 1993 ZEUS data(from run6494 to run7549), 3.9×10^6 were physics triggers(the rest were special triggers for the environmental and trigger efficiency studies). Physics triggers were composed of logical OR of all TLT physics filters. In the 1993 data, TLT $J/\psi \to ee$ accepted 2.8×10^4 events, TLT l^+l^- accepted 2.6×10^5 events, and TLT *charm* accepted 1.0×10^6 events.

All the 1993 data were reprocessed offline, and were further screened by physics filters(DST filter) provided by various physics analysis groups. 1.5×10^6 events on disk passed the screening and were written into reduced data structure which contains only the essential trigger information and reconstructed event data, and stored on common disks for further analysis. These 1.5×10^6 events on disk are hereafter referred to as the 1993 MINIDST data. The J/ψ DST filter unconditionally passed all events accepted by TLT $J/\psi \to ee$, and for all other events required at least one pair of loosely defined e^+e^- or $\mu^+\mu^-$ with an invariant mass greater than 2 GeV. Acceptance of J/ψ DST filter to analyzable diffractive $J/\psi \to e^+e^-$ events that have already passed the online J/ψ triggers is nearly 100%. Thus the event loss due to the J/ψ DST filter was negligible.

Starting with these 1.5×10^6 MINIDST events on ZARAH disk, 13,612 events were pre-selected by applying the requirement that an event:

(1) passed J/ψ DST filter.

(2) was accepted by the GFLT $J/\psi \to ee$ or ρ trigger.

(3) was accepted by the TLT $J/\psi \to ee$ or l^+l^- or *charm* trigger.

(4) contains one to ten good tracks.

(5) had BCAL HAC energy less than 2.5 GeV and CAL EMC energy greater than 1.5 GeV, in order to reject muons.

(6) contains at least one pair of e^+e^-, where the definition of electron is the same loose definition used by the J/ψ DST filter.

Table 15: 1993 data pre-selection

selection criteria	remaining events
all triggers	5,103,450
physics triggers	3,860,618
MINIDST	1,518,903
J/ψ DST tagged	215,649
GFLT $J/\psi \to ee,\rho$ accepted	48,696
TLT $J/\psi \to ee,l^+l^-,charm$ accepted	42,111
$1 <$ good tracks < 11	34,490
BHAC,EMC energy	33,046
e^+e^- pair found	13,612

Table 15 lists the effects of each pre-selection requirement on data reduction.

Instead of saving the complete event data, only key information of each pre-selected event was stored in a user defined ntuple file. This ntuple contains all the information that may be inquired in further processing and analysis. The most interesting information is the parameters of the *signal* e^+e^- *pair*. If more than one pair of e^+e^- were found in an event, the pair with invariant mass closest to 3.1 GeV (in most cases this is also the pair with the largest invariant mass) is defined as the *signal pair*(not to be confused with signal events). The only pair of

e^+e^- in a two-track event is by definition the *signal pair*. Eventually, only two-track events enter the final sample. Data of other tracks were irrelevant to the analysis of two-particle events and were therefore not saved. Basic information of event history, (run number, event number, trigger decisions) was also saved. Reconstructed kinematic variables of the signal e^+e^- pair, quantities that are closely related to the selection criteria, such as partial sums of the calorimeter energy, reconstructed vertex parameters, reconstructed track parameters of e^+ and e^- of the *signal pair*, shower shape of the cluster energy and so on can be retrieved from the pre-selection ntuple.

Figure 29 shows profiles of the signal e^+e^- pairs. Figure (a) shows the invariant mass histograms. The edge at invariant mass of 2 GeV is caused by J/ψ DST filter's invariant mass cut at 2GeV. The TLT $J/\psi \rightarrow ee$ accepted events were not subjected to this cut(the dot shaded area). A small number of events in the invariant mass less than 2 GeV region were not accounted for using this explanation. These events contain $\mu^+\mu^-$ pairs of large invariant mass($>$ 2GeV) in addition to e^+e^- pair of small invariant mass. J/ψ mass peak is not visible even in this biased sample(the *signal pairs* were selected in favor of a J/ψ mass peak). 1450 events fall in the region of the J/ψ mass peak (2.85 GeV to 3.25 GeV region as used in this study), as compared with 76 elastic candidates(inelastic J/ψ candidates are negligible since the pre-selection is in favor of elastic events) in the same region after the final selection. Figure (b) shows that most of these 1450 events contain more than two tracks (only 145 events are exactly two track events). In multi-track events, genuine electrons are extremely rare and most "e^+e^-" pairs are misidentified pions. A requirement that track multiplicity be exactly two would reject most background. Figure (c) shows $|t| = p_t^2$ distribution. The exponential decrease with $|t|$ is a general feature of the soft scattering. It is clear $|t|$ does not help in separating signal and background. Figure (d) shows distribution of the true rapidity of the pair defined by $y_{\rm rap} = -\frac{1}{2}\log\frac{E+p_z}{E-p_z}$, with proton direction as z-axis. $y_{\rm rap} = -\log(\frac{s_{\gamma p}-m_p^2}{2MassE_p})$, as shown in Chapter II. For J/ψ, 40GeV $< \sqrt{s_{\gamma p}} <$ 140GeV corresponds to $-1.35 < y_{\rm rap} < 1.15$. Figure (e)

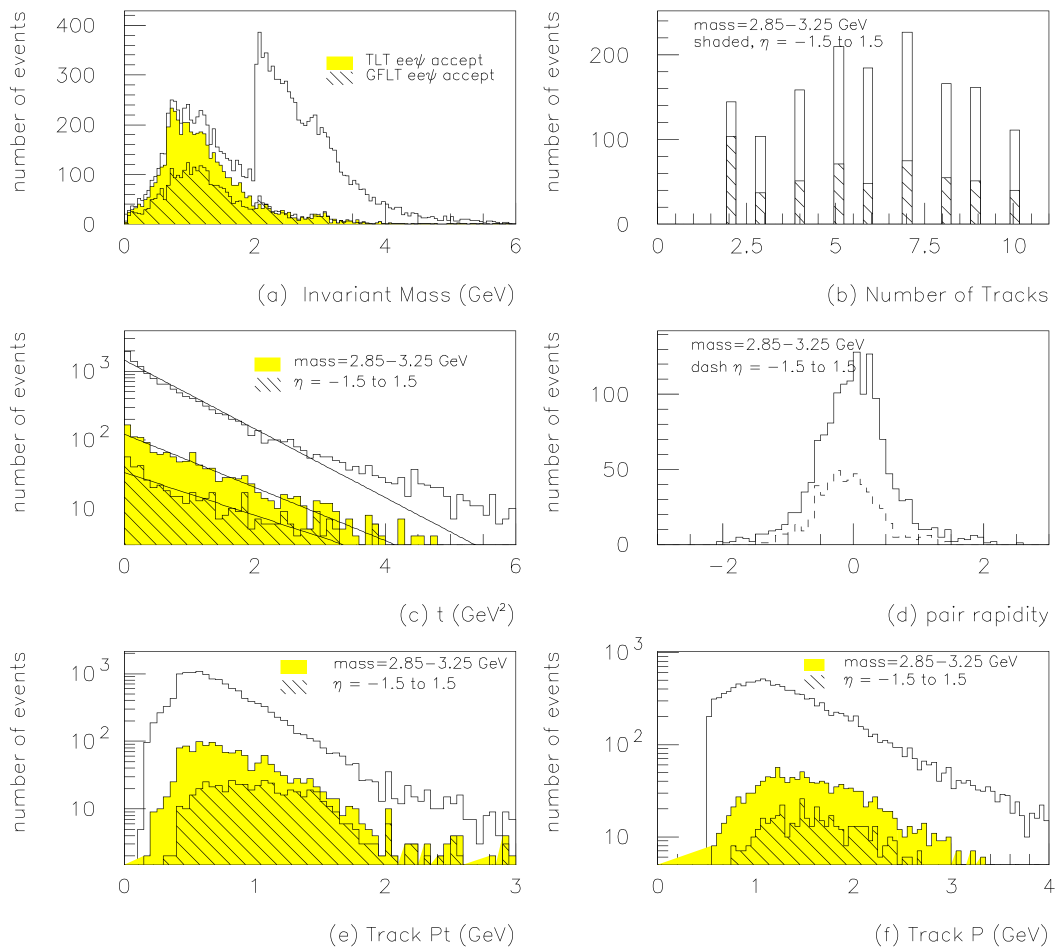

Figure 29: Profile of the pre-selected events. (a) The invariant mass of the *signal* e^+e^- *pair*. The background dominates in all regions. The sharp edge at 2 GeV is due to an invariant mass cut in the J/ψ DST filter. Histograms of events accepted by the GFLT and TLT $J/\psi \to ee$ triggers are shaded. (b) Track multiplicity for events with invariant mass in the J/ψ mass peak region. The histogram of events with $|\eta| < 1.5$ for both signal tracks is shaded. Most of the background can be excluded by two-track-only requirement. (c) $|t|$ dependence. Straight lines are the exponential fitting curves. Exponential decrease is a general feature of soft scattering. Signal and background are not separated. (d) Pair rapidity of the *signal pair* under the J/ψ mass peak. (e) Transverse momenta of e^+ track. (f) Momenta of e^+ track. Histograms of events under the J/ψ mass peak and with track η requirement are shaded. Low energy and transverse momentum are characteristic of both signal and background.

and Figure (f) show the track p_t and p distributions. The signal and background all fall in the low energy range where it is difficult to separate electrons and pions.

5.3 Final selection based on event topology

The signature of diffractive $J/\psi \rightarrow e^+e^-$ is very clear: nothing but a pair of e^+e^- of invariant mass 3.1 GeV is detected in the main detector. However, the identification of an electron and an accurate measurement of its momentum vector are challenging tasks for a new detector. Measurement difficulties were exacerbated by a lack of forward and rear tracking chambers. Track momentum uncertainty is large if the track has a large dip angle and penetrates fewer superlayers of the CTD.

The final selection criteria of diffractive $J/\psi \rightarrow e^+e^-$ consisted of following requirements:

(1) Topological feature:

  a. only one pair of oppositely charged tracks with two clusters matched.

  b. energy in CAL not related to e^+e^- be less than 1 GeV.

(2) Kinematic region: $40\text{GeV} < \sqrt{s_{\gamma p}} < 140\text{GeV}$

(3) Accuracy in momentum measurement: track rapidity $|\eta| < 1.5$

(4) Track $p_t > 0.5$GeV (to reject pions).

(5) Electron identification.

Not all of these cuts can be applied with same confidence. For example, requirement(5) is a big challenge. The ZEUS calorimeter was designed for detection of the ep scatterings at very short distances(very hard scatterings). Separation of low energy(about 1.5 GeV) electrons and pions is not relevant to very hard scatterings. While low energy electrons can be well identified by dE/dx measurement along the tracks, it requires special efforts to reduce the 12% error in dE/dx measurement in the 1993 data. Therefore, requirement(5) is reserved only as a last resort. It is clear a two step event selection is advantageous.