CHAPTER V
EVENT SELECTION

During the 1993 runs, ZEUS wrote 7 million events to tape, of which 5 millions were physics triggers. The number of elastic $J/\psi \to e^+e^-$ in this sample is expected to be only about 100. Thus sophisticated analysis is required to isolate this rare data sample.

The goal of offline event selection is to

(1) obtain a sample of high purity

(2) define a well determined acceptance

(3) maintain high efficiency

The following equation heuristically illustrates how each of the above items contributes to the accuracy of a measurement,

$$n_{\rm sig} = \frac{\rho n}{\epsilon}\left(1 \pm \frac{1}{\rho\sqrt{n}}\right) / \left(1 \pm \frac{\Delta\epsilon}{\epsilon}\right) \tag{49}$$

where n is the number of data events in a bin(a volume of phase space), ρ is the estimated purity, ϵ is the bin acceptance to the signal, $\Delta\epsilon$ is the error in ϵ, and $n_{\rm sig}$ is the measurement of the number of signal events in this bin, taking into account statistical fluctuations and detector acceptance correction.

Since the error of detector acceptance comes mainly from uncertainty in the online triggers, the online triggers must be understood in detail. Section 5.1 describes the major contributing online triggers for J/ψ.

The event selection procedure is illustrated in Figure 28. Pre-selection and final selection will be explained in Sections 5.2 and 5.3.

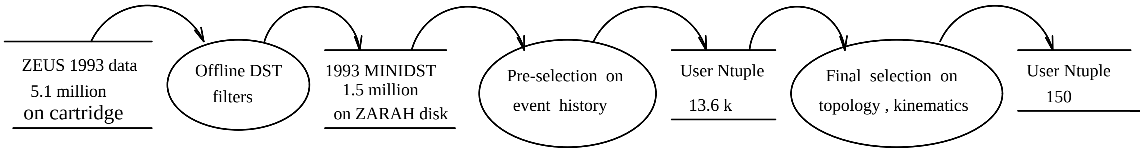

Figure 28: Chart of event selection procedure

5.1 Major triggers

For diffractive $J/\psi \to e^+e^-$ events, the major uncertainty in the detector acceptance comes from the online calorimeter first level trigger(CFLT), and track finding efficiency at the third level trigger(TLT).

Soon after the end of the 1993 runs, a quick selection of diffractive $J/\psi \to e^+e^-$ candidates was made based solely on the event signature, irrespective of the online triggers. Studies of these candidates showed that: (1) almost all(97%) of the candidates were accepted by either or both of the GFLT $J/\psi \to ee$ trigger and the ρ trigger (2) most(84%) of the candidates were accepted by either or both of the TLT $J/\psi \to ee$ filter and the l^+l^- filter. The TLT *charm* filter contributes a small amount(another 4%) of events to the final event sample. Here we briefly describe the major features of these online triggers as regards to event selection(the GFLT $J/\psi \to ee$ trigger, TLT $J/\psi \to ee$ filter and l^+l^- filter have been discussed in more detail in the previous chapter).

The GFLT $J/\psi \to ee$ trigger was designed for accepting diffractive $J/\psi \to e^+e^-$ in the area covered by the central tracking detector(CTD). It requires, in addition to a beam-gas veto, that one to three tracks be found in the first superlayer of the CTD. To exclude overwhelming nondiffractive background, the energy deposit in the calorimeter towers adjacent to the forward beampipe was required to be less than 3.75 GeV. Additionally, a significant amount of energy deposited in the calorimeter was required, at least 660 MeV of which was deposited in EMC section to exclude cosmic muons and empty events. While this trigger is the most efficient GFLT subtrigger for diffractive $J/\psi \to e^+e^-$, the calorimeter energy was not calibrated at the CFLT[†] and this effect was not simulated in the Monte Carlo version of the CFLT and therefore lead to about 10% uncertainty in the trigger acceptance.

The GFLT ρ trigger was designed to collect diffractive $\rho \rightarrow \pi^+\pi^-$ in the rear calorimeter(RCAL). It requires, in addition to a beam-gas veto, that at least one track be found in the first superlayer of CTD. Additionally, the energy deposit in the calorimeter towers adjacent to the forward beampipe was required to be less than 3.75 GeV to exclude overwhelming nondiffractive background, and at least 464 MeV energy be deposited in EMC section of RCAL. This trigger contributes to $J/\psi \rightarrow e^+e^-$ acceptance only in the rear hemisphere, corresponding to $y_{\mathrm{rap}} < 0$. However, this trigger has an advantage in that its RCAL EMC threshold is far below the energy of the $J/\psi \rightarrow e^+e^-$ signal and therefore any error in energy scales had negligible consequence in determination of acceptance for the $J/\psi \rightarrow e^+e^-$ signal.

All of the three TLT filters are subjected to a common kinematic cut $(P_z/E)_{\mathrm{CAL}} < 0.94$, where E is the total energy and P_z the total momentum along the proton beam direction as measured by the calorimeter. This cut was designed to reject p beam-gas background. Since for two particle events this cut is equivalent to a rapidity cut $y_{\mathrm{rap}} > 1.74$, and therefore does not affect the acceptance of diffractive $J/\psi \rightarrow e^+e^-$, which fall almost entirely in $-1.7 < y_{\mathrm{rap}} < 1.7$ region due to the limited geometrical coverage of the CTD.

The TLT $J/\psi \rightarrow ee$ filter is basically the TLT version of the GFLT $J/\psi \rightarrow ee$ trigger. It requires that number of CTD tracks, excluding tracks with p_t (transverse momentum of the track) less than 0.2 GeV, be less than five, and at least one pair of oppositely charged CTD tracks with p_t of each track greater than 0.4 GeV be found. Additionally, the energy deposit in the HAC section of CAL is required to be less than 1 GeV in order to exclude nondiffractive background, and the energy deposit in the EMC section of CAL greater than 1.5 GeV to exclude muons. For BCAL and RCAL it is required that the EMC section contains more

[†] See section 3.2.5 of Chapter III.

than 90 percent of the total energy. A few comments are in order. Although a requirement on the invariant mass greater than 2 GeV removes a large portion of the background in the offline selection, no invariant mass cut was applied online at the TLT. This is because the quality of the online track momentum reconstruction at the TLT is far below that of the offline reconstruction. The complete set of the digitized data for the CTD was used only in the offline reconstruction, as explained in Chapter III. Therefore the thresholds of the track momentum related cuts were loose. Track p_t cut was also kept very loose due to the large uncertainty in its p_t measurement at the TLT. Additionally, p_t is correlated to the decay angle, θ, in the center of mass frame of the e^+e^- pair. If J/ψ moves along the beam axis, p_t of either track is simply $m_{J/\psi}\sin\theta/2$ since the boost along the beam axis does not change p_t. If a measurement of the polarization of J/ψ is intended, p_t threshold should be as low as possible. This is not a problem for the 1993 data, since a detailed study of the polarization of J/ψ requires much higher statistics than are presently available. Although the TLT $J/\psi \to ee$ filter can in principle accept all of the diffractive $J/\psi \to e^+e^-$ which are accepted by the TLT l^+l^- and *charm* filters, in reality this was not quite true. The requirement that the HAC energy be less than 1 GeV rejected some signal events due to calorimeter noise.

The TLT l^+l^- filter was designed to accept J/ψ, irrespective of its production mechanism. This filter required at least a pair of leptons, either e^+e^- or $\mu^+\mu^-$, be found, where the lepton identity is loosely defined by the shower profile in the calorimeter. This filter was crucial in accepting inelastic J/ψ events. However, this filter underwent a modification(in track-cluster matching) at the middle of the 1993 runs. Its acceptance to elastic $J/\psi \to e^+e^-$ increased about 45% after the modification(since run7135). Presently, Monte Carlo only simulates the latter version of this filter.

The TLT *charm* filter was designed to accept heavy quark events. It has much more stringent cuts on the TLT track momentum and depends weakly on the calorimeter performance. This filter accepts diffractive $J/\psi \to e^+e^-$ events only in the rear hemisphere. Signals accepted by this filter were mostly(77%)

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.