CHAPTER IV
J/ψ TRIGGERS

1993 was the first year for the J/ψ measurement at HERA. The first challenge for the measurement of elastic $J/\psi \rightarrow e^+e^-$ was to trigger on these events.[†] In the 1993 trigger configuration, the GFLT was a multi-branch acceptance trigger, the GSLT was a veto trigger, and the TLT was a veto trigger followed by a multi-branch acceptance trigger. It was found in Monte Carlo studies that the existing triggers accepted less than 15% of the elastic J/ψ events. Therefore, special acceptance subtriggers for J/ψ were required at the GFLT and TLT. A GFLT subtrigger for elastic $J/\psi \rightarrow e^+e^-$, a TLT filter for elastic $J/\psi \rightarrow e^+e^-$, and a TLT filter for general l^+l^- pairs were added to the existing triggers soon after the data taking started.[‡]

4.1 J/ψ subtrigger strategy

The high event rate($10kHz \sim 100kHz$) at the first level trigger is due to proton beam halo and beam-gas background. At the third level trigger, soft photoproduction is a major source of background. A GFLT J/ψ subtrigger must be able to distinguish J/ψ and proton beam background. A TLT J/ψ subtrigger should reject photoproduction background. Since elastic J/ψ study is only one of the many topics, its contribution to the trigger rate should be kept below 10% of the total trigger rate. This means the GFLT rate due to the J/ψ subtrigger had to

[†] Measurement of $J/\psi \rightarrow \mu^+\mu^-$ was done successfully at ZEUS in parallel to this work.

[‡] The author realized the necessity and possibility, and undertook the task of design and test of special GFLT and TLT subtriggers dedicated to $J/\psi \rightarrow e^+e^-$ acceptance in coorperation with the ZEUS trigger group.

be below $10Hz$, and the TLT J/ψ filter rate had to be below $0.25Hz$ for the 1993 running period.

There are 4 final state particles in an elastic $J/\psi \rightarrow e^+e^-$ event: e^+e^-, the beam electron and the beam proton. The beam electron and the beam proton remain inside the beampipes. Particles in the forward(proton beam direction) beampipe could not be detected by the 1993 ZEUS detector. In the rear beampipe, the EDET(electron detector of the luminosity monitor) could detect beam electrons in a limited energy range corresponding to $\sqrt{s_{\gamma p}}$ between 167-194 GeV. In order that J/ψ can be reconstructed, the e^+e^- pair had to lie in the CTD coverage. This requirement limits the acceptance range of $\sqrt{s_{\gamma p}}$ to 40-140 GeV for the 1993 CTD conditions. There was almost no overlap between the CTD and the EDET acceptance ranges.[†] Therefore, only the e^+e^- pair could be detected.

Particle identification, cluster and track momentum were not available to the GFLT. Even at the TLT, track momentum measurement was not of the offline quality, and track-cluster matching capability had not been tested as this was actually the first year of the CTD operation. Therefore the triggers should better not depend on explicit particle identification and accurate track momnetum reconstruction. Since background events usually contain hadrons which deposit energy in both the HAC and EMC sections, the elastic criteria that no particles other than the e^+e^- pair are detected can be substituted by the requirement of no HAC energy deposit. Note that the EMC and HAC separation was available at the TLT and partially available at the GFLT. Kinematically, energy of the e^+e^- pair must be no less than 3.1GeV, which is the mass of J/ψ meson. To the GFLT and TLT, the signature of an elastic $J/\psi \rightarrow e^+e^-$ event would hence be two tracks in the CTD with unspecified charge and a significant energy deposit in the calorimeter's EMC section only. Allowing tolerance for fluctuations, noises and energy loss due to zero suppression of the calorimeter cell energy, the energy deposit in the EMC section of the calorimeter is required to be greater than 2GeV, and the energy

[†] There is a large overlap between the RTD(rear tracking detector) and the EDET, but the RTD was not available until the 1994 running period.

deposit in the HAC section is required to be less than 1GeV, as determined by studies on Monte Carlo and real data.

In summary, the trigger signature of elastic $J/\psi \to e^+e^-$ was two tracks in the CTD, at least 2GeV energy deposit in the EMC section and less than 1GeV energy deposit in the HAC section. In the actual implementation, modifications were made to accommodate energy resolution, errors in track counting, and the peculiar scheme of the EMC and HAC segmentation in the CAL-FLT readout electronics.

Since track-cluster matching as well as track and cluster data were available at the TLT, albeit not well-tested, a more sophisticated TLT subtrigger based on lepton identification was also developed for J/ψ acceptance.

4.2 Global first level trigger

For $J/\psi \to e^+e^-$, the relevant component FLT data were from the CAL-FLT, CTD-FLT, the Veto Wall and C5. The Veto Wall and C5 FLT data were used to reject the proton beam halo and beam-gas background. The CTD-FLT provided the number of tracks in the first superlayer and a track quality indicator. The CAL-FLT provided regional energy sums. In the CAL-FLT, the CAL was divided into 16 regions, each containing 56 trigger towers. The CTD-FLT was designed to be segmented into 32 stereo angle regions. The matching between the CAL and the CTD subregions was implemented in design but was not available in 1993.

The EMC and HAC segmentation was partially implemented in the CAL-FLT readout electronics. Available energy sums(relevant to the J/ψ subtrigger) from the CAL-FLT were:[55,56]

- CAL_EEMC: energy in the EMC section of the CAL excluding the towers adjacent to the rear beampipe and the towers in the first three square rings around the forward beampipe. Digitization step $\Delta E =$ 0.196GeV.