## 4.3 Third level trigger

The TLT was organized into a veto trigger followed by a multi-branch acceptance trigger. The physics branches were SPP(soft photoproduction), DIS, BGF(boson gluon fusion), EXO(exotic physics beyond the standard model), and MUON. The BGF branch consists of a common veto followed by 5 sub-branches which were: BGF01(for high Et), BGF02(for LUMI tagged), BGF03(for charm), BGF04(for elastic $J/\psi \rightarrow e^+e^-$) and BGF05(for $l^+l^-$ pair).

The common veto in the BGF05 filter rejected an event if $(P_z/E)_{CAL} \geq 0.94$). Here $E$ and $P_z$ are the total energy and $z$ component of the momentum as measured by the CAL. Assuming all energy deposits in the CAL were due to decay of a parent particle, this common cut was then equivalent to a cut on the rapidity of the parent particle to reject $y_{\rm rap} \geq 1.74$. Since the CTD covers $-1.7 < y_{\rm rap} < 1.7$, this common cut did not affect $l^+l^-$ acceptance.

The quantities used in the TLT $J/\psi \rightarrow e^+e^-$ were:[58]

- Tnum: number of tracks with track $p_t > 0.2$GeV.
- PosTrk: number of positively charged tracks with track $p_t > 0.4$GeV.
- NegTrk: number of negatively charged tracks with track $p_t > 0.4$GeV.
- FEMC: EMC energy in the FCAL.
- BEMC: EMC energy in the BCAL.
- REMC: EMC energy in the RCAL.
- EMC: total EMC energy in the CAL.
- FHAC: HAC energy in the FCAL.
- BHAC: HAC energy in the BCAL.
- RHAC: HAC energy in the RCAL.
- HAC: total HAC energy in the CAL.

The logic of the TLT $J/\psi \rightarrow e^+e^-$ is listed in Table 8.[58]

MC elastic $J/\psi \rightarrow e^+e^-$ events and real data from an $ep$ physics run taken before implementation of the $J/\psi$ triggers were passed through the TLT trigger simulation to check the performance of the TLT $J/\psi \rightarrow e^+e^-$ filter. The MC $J/\psi$

**Table 8:** TLT $J/\psi \rightarrow e^+e^-$ filter logic

| TLT $J/\psi \rightarrow e^+e^-$ filter(BGF04) |
|---|
| Tnum $<$ 5 .AND. PosTrk $>$ 0 .AND. NegTrk $>$ 0 |
| EMC $>$ 1.5 GeV .AND. HAC $<$ 1.0 GeV |
| BHAC $<$ 0.1BEMC .OR. BHAC $<$ 0.2 GeV |
| RHAC $<$ 0.1REMC .OR. RHAC $<$ 0.2 GeV |

events were required to be within the CTD coverage and have been accepted by the GFLT. Effects of the TLT $J/\psi \rightarrow e^+e^-$ filter cuts are shown in Figure 25 and Figure 26.

The TLT $l^+l^-$ filter accepts an event if it contains at least a pair of $e^+e^-$ or $\mu^+\mu^-$. This requires track-cluster matching. Since reconstruction of tracks and clusters is time consuming, the TLT provides the standard TLT tracks and TLT clusters. A 1993 TLT track was a fitted helix trajectory based on the partially digitized CTD hit data("z-by-timing" information available from the first three axial superlayers).

At the TLT, clusters in the calorimeter were defined by "islands" of energy. Calorimeter towers with nonzero energy deposits† were grouped into islands using the "island algorithm".[59] The "island algorithm" is illustrated in Figure 27. A tower was connected to its most energetic nearest neighbor tower unless the tower itself was a local maxima. Towers were also joined across the BCAL/FCAL and BCAL/RCAL boundaries.

Track-cluster matching was attempted only for "good" TLT tracks. A "good" TLT track passed following requirements:

(1) $\chi^2$ per degree of freedom $< 3$.

(2) $|z_h| < 80cm$ and $d_h < 10cm$. $z_h$ and $d_h$ measure the longitudinal and transverse distances between the helix and the interaction point.

(3) Track momentum $> 0.5$GeV

† Zero suppression thresholds at the 1993 TLT were 0.060 GeV for an EMC cell, 0.100 GeV for a HAC0 cell, and 0.110 GeV for a HAC1 or HAC2 cell.

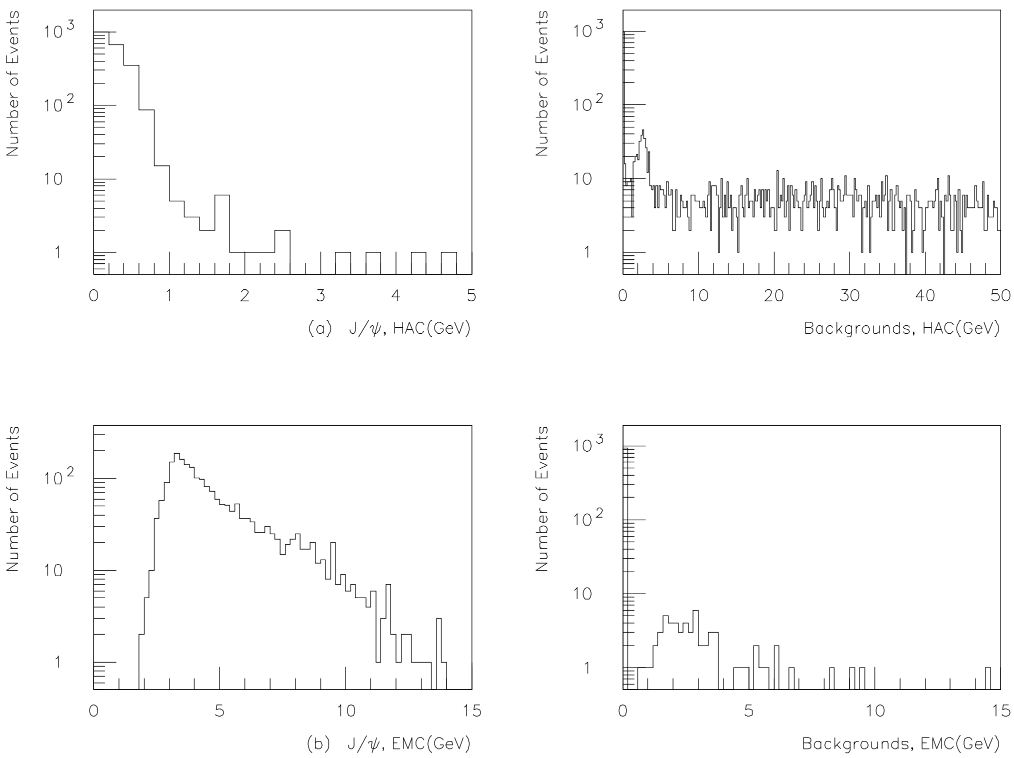


**Figure 25:** Comparison of $J/\psi$ signal and background at the TLT. Leftside: MC $J/\psi$ signals that have passed GFLT. Rightside: background from an $ep$ physics run. (a) Most of the $J/\psi$ deposit less than 1 GeV energy in the HAC section. Trigger cut: HAC $<$ 1GeV. (b) EMC energy for events with HAC energy less than 1 GeV. Trigger cut: EMC $>$ 1.5GeV.

For a good track, the momentum vector was calculated at the point $P$ at which the track intercepted the surface of the CTD outer cylinder or endcap. Another vector is defined by the direction of the straight line joining the point $P$ with the center of cluster $i$. The "match quality factor", defined as the angle cosine between these two vectors, measures how well cluster $i$ matches the track. Looping over all clusters finds the best matched cluster.

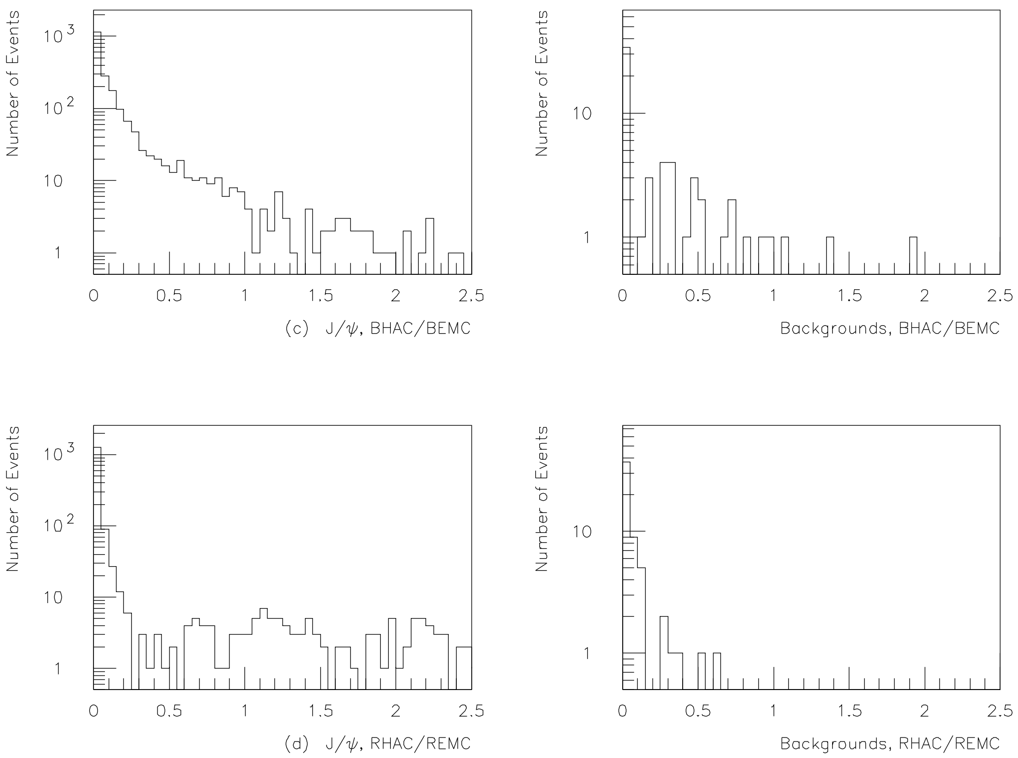


**Figure 26:** Comparison of $J/\psi$ signal and background at the TLT.
(c) BHAC/BEMC ratio for events having passed above cuts and have nonzero energy deposit in the BCAL.
Trigger cut: BHAC$\leq$ 0.1BEMC.
(d) same as (c) but for RCAL.

Definitions of electron and muon candidates are listed in Table 9 and Table 10.[58]

Since the momentum reconstruction at the TLT was crude, track-cluster matching was also crude. In order to keep high acceptance for $J/\psi$ events, there was

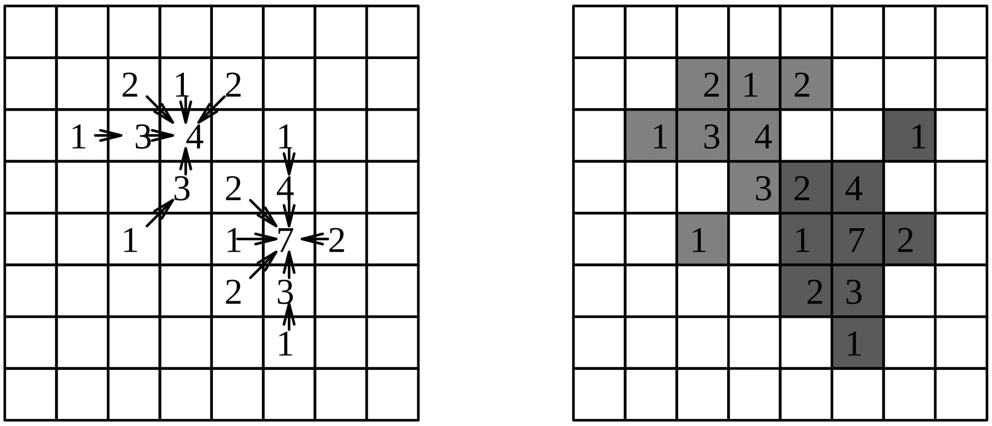


**Figure 27:** Illustration of the "Island algorithm".

**Table 9:** Electron definition in TLT $l^+l^-$ filter

| Electron definition in TLT $l^+l^-$ filter(BGF05) |
|---|
| Track-cluster match quality $> 0.9$ |
| Number of EMC cells $\leq 8$ .AND. Number of HAC cells $\leq 3$ |
| EMC energy $> 0.9$(EMC+HAC) .AND. EMC energy $\geq 0.5$GeV |
| Track $p_t > 0.4$GeV |

**Table 10:** Muon definition in TLT $l^+l^-$ filter

| Muon definition in TLT $l^+l^-$ filter(BGF05) |
|---|
| Track-cluster match quality $> 0.9$ |
| Number of EMC cells $\leq 4$ .AND. Number of HAC cells $\leq 6$ |
| EMC energy $< 0.9$(EMC+HAC) .AND. EMC energy $< 3.0$GeV |
| 0.5GeV $<$ HAC energy $<$ 8GeV |
| Track $p_t > 0.4$GeV |

no cut on the invariant mass. With experience from the 1993 data taking and improved TLT track reconstruction in the future, this trigger can be tuned to yield a very clean trigger.