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**FAST ASYNCHRONOUS LEVEL 1 PRE-TRIGGER
FOR ELECTRONS AT $L = 10^{33} \text{ cm}^{-2} \text{ sec}^{-1}$**

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Asynchronous Triggers have long been used at fixed-target accelerators and the CW High Luminosity CERN ISR. Bunched beam colliders have tended to use triggers which were synchronized with the time of the beam crossing. The CDF trigger scheme¹ has 3.5 μsec between such crossings to decide whether to further process any events which occurred during the crossing. The level 1 trigger can accept a rate of 50 KHz without appreciable dead time.¹ The level 2 trigger uses fast bit-slice processors to select event topologies in 10 μsec and thus can accept a trigger rate of 5 KHz¹. Readout of the system which takes 1/2 msec is required for level 3, thus limiting the triggering rate at level 3 to $\sim 100 \text{ Hz}$.¹ The purpose of this note is to show that this same trigger scheme would work at a CW luminosity of $10^{33} \text{ cm}^{-2} \text{ sec}^{-1}$ by the addition of a conventional hard-wired asynchronous pre-trigger.

A pre-trigger for relatively low p_T electrons is discussed, since electrons have long been used as a signature for interesting hadron interactions. Low p_T is emphasized, since such interesting particles like J/ψ and T tend to produce electrons with $p_T \sim 1 \text{ GeV}/c$ and $\sim 4 \text{ GeV}/c$ respectively. If these electrons are lost at the trigger level there is no hope of getting them back afterwards.

One imagines² a typical central region detector as covering the full azimuth, a rapidity range $-2 < y < +2$ and being segmented into $40 \times 40 = 1600$ calorimeter towers each covering $\Delta\phi = .16$, $\Delta y = 0.10$. The calorimeter will be divided into electromagnetic and hadronic compartments. For the purpose of the low p_T electrons discussed here, a 17 radiation length counter is superior in charged pion rejection to the 26 radiation lengths used in UA1,³ so it is assumed that the electron compartment will be subdivided into at least 2 compartments, with the first ~ 17 radiation lengths being used in this trigger.

It is important to distinguish the time resolution required to obtain analog information with precision suitable for triggering from the time required to integrate the signal for the ultimate energy resolution. For the R-807 calorimeter⁴, the pulses could have been clipped to $\sim 20 \text{ nsec}$ for triggering, although a 125 nsec integration time was required at the ADC. A high impedance fanout near the photomultiplier would tap-off, clip and distribute the fast signals for the hard-wired trigger while the main signal would proceed to the precision ADC through a delay of $\sim 500 \text{ nsec}$. During this time the main signal would have its rise time degraded by the long delay but this predominantly dispersive process would have little effect on the pulse area.

The tower size of the calorimeter discussed above² is well matched to single particle detection for $p_T < 15 \text{ GeV}/c$. CCON⁵ used a tower size of $\Delta\phi = 0.10$, $\Delta y = .10$ for single particle studies at the ISR. Furthermore, the jets at these low p_T values are much wider than those at higher p_T . It is expected that the background conditions for single particle triggers with $p_T < 15 \text{ GeV}/c$ will be very similar to conditions at the ISR where extensive data exist on single particles and jets with $p_T < 15 \text{ GeV}/c$.

The pre-trigger is made as follows: A single particle solid angle cell is defined by linearly fanning-in (100) independent groups of 4×4 towers in the 40×40 array. The output of each fan-in goes to a discriminator with several thresholds and also to the next level linear fan-in (3×3 cells of the 4×4 towers, for a total coverage $\Delta\phi = 0.6\pi$, $\Delta y = 1.2$ which is suitable for a jet trigger, etc.). Each of the cells of 4×4 towers is fully efficient for single particles in the central 2×2 towers, and less efficient in the outer 12 towers. Thus for full efficiency over the whole array, four sets of cells of 4×4 towers can be formed, each centered on the intersections of the edges of alternate rows and columns.

The trigger will have a time slewing of 20 nsec due to the dynamic range so that it will have to be retimed with a zero-crossing or constant fraction discriminator to a precision of $\sim 2 \text{ nsec}$. At this point other fast trigger information like Transition Radiator Electron Identification¹ or a nearby track¹ with $p_T > 2 \text{ GeV}/c$ can be added. Leading edge timing from the calorimeter¹ can be used to determine which towers were struck in-time (5 to 20 nsec) to avoid pile-up during the longer ADC gate.

The triggering cell size is sufficiently small that triggering rates can be estimated by integrating the measured⁶ single τ^0 cross section at $\sqrt{s} = 540 \text{ GeV}$.

$$E \frac{d^3\sigma}{dp^3} = \frac{4.9 \times 10^{-25} \text{ cm}^2}{(p_T + 1)^{8.31}}$$

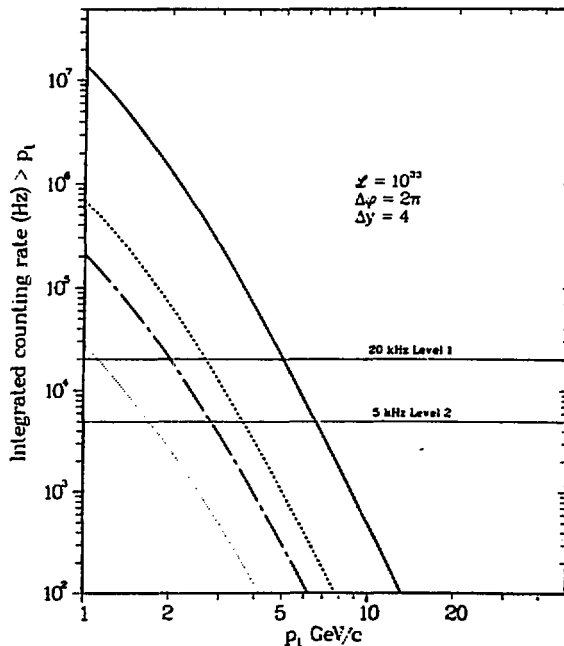


Figure 1. Trigger Rates for Low p_T electron triggers.

1. M. Shochet, Trigger Summary, These Proceedings.
2. H. Gordon, et al., "Reasons Experiments can be Performed at $L = 10^{33}$," DPF Snowmass Proceedings.

For a detector covering $\Delta\theta = 2\pi$, $\Delta\eta = 4$ and for $L = 10^{31} \text{ cm}^{-2} \text{ sec}^{-1}$, the τ^0 production rate is shown as the solid curve in Figure 1. If there were no tracking or particle I.D. information, this would be the trigger rate. The threshold is determined by either the 20 KHz maximum trigger rate at level 1 or the 5 KHz of level 2. With tracking, or particle I.D., the threshold can be reduced.

The principal background is due to charged hadrons, π^+ , which deposit most of their energy in the electromagnetic calorimeter. For a fixed energy deposition, this background is down by a factor of 20 from τ^0 (dashed line). This would be the limit of the trigger improvement with fast tracking.¹ A similar but smaller background is a τ^0 which deposits its energy accompanied by a charged track with $p_T > 2 \text{ GeV}/c$ coming from the same jet and landing on the same 4×4 cell. This is at the level⁵ of $\sim 1.5\%$ and is less of a problem (long-short dashed curve). The dotted curve shows the real electron background⁷ due to Dalitz and external conversions ($1.5\% X_0$) which is down a factor of 500 from the τ^0 rate. If the electron energy is not measured independently of the parent τ^0 , then the relevant rejection factor is only 5% which is the probability that the energy of a τ^0 includes any conversion electrons. With a magnetic field to sweep away soft electrons, a Segmented Transition Radiator² could provide a trigger level rejection of 1% (long-short dashed curve). This would allow a threshold of $\sim 4 \text{ GeV}/c$ for single electrons at 5KHz triggering rate. Level 2 can then be used to find interesting event topologies like 2 or more electrons, electron + jet, electron + missing E_T etc.

3. C. Rubbia, These Proceedings.
4. B. Pope, Calorimeter Summary, These Proceedings, quoting R.B. Palmer.
5. A.L.S. Angelis, et al., Physics Letters 79B, 505 (1978); Physics Scripta 19, 116 (1979).
6. UA2, J.P. Repellin, Paris Conference 1982, as quoted by R. Cahn, These Proceedings.
7. G. Bunce, et al., Z^0 Production, DPF Snowmass 1982
8. N.B. the threshold of $3 \text{ GeV}/c$ from Figure 1 was multiplied by a factor of 1.3 to allow for systematics. This factor will be refined with further investigation.