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USE OF SYNCHROTRON RADIATION FOR ELECTRON IDENTIFICATION AT HIGH LUMINOSITY

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Introduction

Synchrotron radiation has been used successfully to identify electrons of 10 to 30 GeV traversing a field length of 30 kG-m.[1] Since comparable field lengths are a feature of many proposed collider detectors, and since this is an electron energy range of interest at $\sqrt{s} = 1$ TeV, we consider whether such a device could be useful in the $L = 10^{33}$ environment.[2]

Figure 1 shows the arrangement. The electron track and its "tail" of X-rays are detected in a

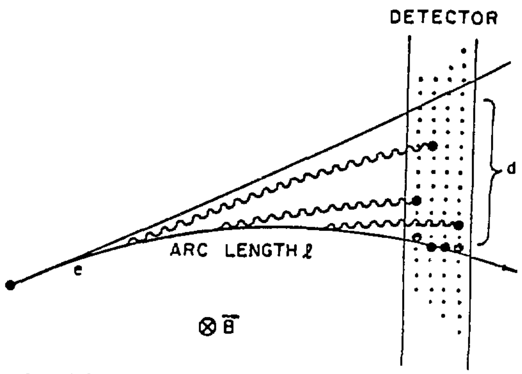

Fig. 1. Schematic depiction of electron identification by synchrotron radiation. The length of the X-ray "tail" is denoted by d. The detector is a multilayer wire chamber, the large dots represent hits.

Xenon-filled MWPC. Figure 2 shows the spectrum of X-rays produced in a 1 meter distance at 30 kG for several electron energies. The total energy emitted in a distance ℓ and field B is given by

$$\Delta E_x = 0.013\, E_e^2 B^2 \ell,$$

where ΔE_x is in keV, E_e is in GeV, ℓ is in meters and B is in kG. Despite the fact that the total energy is proportional to E_e^2, the number of detected photons peaks at $E_e = 5$ GeV (see Fig. 3). This is due to the detection efficiency of Xenon and to the shift of the spectrum with E_e depicted in Fig. 2.

The electron identification depends on the spatial correlation between the electron and X-ray hits; the X-rays lie in the bend plane of the electron, spread over a distance d(mm), where

$$d = 15\, B\ell^2/E_e.$$

For example d is 15mm for a 30 GeV electron with B = 30 kG and ℓ = 1m. The width of the X-ray tail is determined by the spatial resolution of the detector in the direction perpendicular to the bend plane.

Rates and Particle Densities

We assume a detector which covers about 2 units of rapidity (centered at y = 0) and is composed of 4mm mini-drift cells at 1m from the interaction diamond,

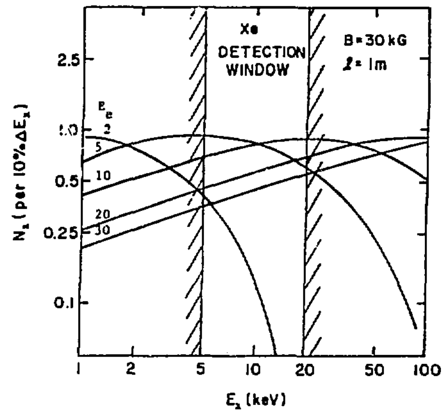

Fig. 2. The number of X-ray photons produced versus photon energy, E_x. The curves are labelled according to electron energy in GeV. The shaded vertical lines delimit the region of good X-ray detection efficiency in Xenon.

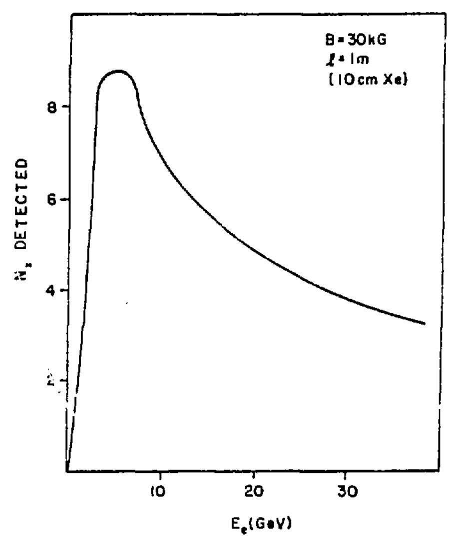

Fig. 3. The number of photons detected in 10 cm of Xe as a function of electron energy.

with 2.4m long wires parallel to the magnetic field. The charged single particle rate at $L = 10^{33}$ (taking into account the p_T cutoff of the field) is about 0.25 MHz/wire (or 4 μsec mean separation). Since one should be able to operate such a chamber with a gate $<$ 100 nsec, rate does not appear to be a problem in this configuration.

A more serious question (albeit independent of luminosity) is that of fake electron triggers or trigger losses due to the spatial overlap of particles within the same event. To investigate this question we use predictions of particle densities within 100

GeV jets from ISAJET.[3] To estimate the resolution perpendicular to the bend plane, we assume this is done with cathode strips which yield 5mm localization of the hits. Taking any spatial coincidence of two charged particles within an area = 5mm x d to be an "electron," we find about 0.1 fake electrons above 10 GeV per 100 GeV jet. This can be suppressed significantly by seeing if the tracking system finds 1 or more than 1 track pointing to the "electron." Further suppression could be based on the fact that a charged track and a collection of X-rays would produce very different energy depositions on the drift wires. With dedicated processors these reduction factors could probably be obtained in the few μsec available. A crude estimate of these factors yields $< 10^{-3}$ fake electron triggers above 10 GeV per event.

Using the same input from ISAJET one can determine the loss of real electrons due to overlaps of other charged tracks. In 100 GeV jets this loss is 1 to 2% for 10 to 30 GeV electrons. (A brief look at 1000 GeV jets reveals that for comparable values of $E_e/E(jet)$ the losses are at most a factor of 2 worse.)

Compatibility with Other Detector Components

Note that $\Delta E_x \propto B^2 \ell$ and $d \propto B\ell^2$. Thus one benefits (at fixed $\int B d\ell$) from larger B and smaller ℓ. This yields more X-rays in a smaller impact area. Tracking systems, on the other hand, prefer large ℓ and smaller B. This gives larger sagittas (also $\propto B\ell^2$) and fewer trapped soft tracks. Thus compromises need be made in a system that includes both. It should be kept in mind that if the tracking chamber is carefully designed to keep the mass low, then it will be transparent to those X-rays which can be detected in the Xenon chamber. Thus tracking and electron identification can coexist in the same field volume.

Research and Development

At E_e = 10 GeV the number of detected X-rays is already falling (albeit slowly) because the X-ray spectrum peak has shifted out of the Xenon detection window. The energy range of identifiable electrons could be expanded (or the B,ℓ requirements lowered) if a detector with good efficiency for $E_x > 100$ keV could be used. Thus development of a practical liquid or solid detector might be very useful.

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References

1. J. Dworkin, Univ. of Michigan Ph.D thesis (unpublished). In this case electrons from Λ-β decay in a neutral hyperon spectrometer were identified with a Xe-filled proportional chamber following the analysis magnet.
2. J. Kirz and H. Walenta, Proceedings of the 1981 ISABELLE Summer Workshop, BNL 51443, p. 1406.
3. F.E. Paige and S.D. Protopopescu, "ISAJET: A Monte Carlo Event Generator for pp and p̄p Interactions, Version 3," BNL 31987 (Sept. 1982).