II.C LEPTON TRIGERS FOR HEAVY QUARKS

R. Lipton, Northwestern University

Introduction

The use of lepton triggers in experiments searching for charm production is by now a well-established technique. Lepton triggers which take advantage of the associated production of charmed particles and their high semi-leptonic branching ratios can increase the signal/background ratio by factors of several hundred over simple interaction triggers. Such experiments are now in progress both at Fermilab (E-515) and at CERN (ABCCORC Collaboration). The Tevatron makes the extension of these experiments to B meson production feasible. The need for high-B acceptance will dictate detector geometries. Constraints on the selection of the trigger and the forward spectrometer will also be imposed by the needs of specific vertex detectors.

Muon and Electron Triggers

A figure of merit for lepton triggers is the fraction of candidate hadrons which simulate leptons in the trigger. For prompt muon triggers this background is supplied by charged pion decay. Direct electrons are simulated by π^0 Dalitz decay, photon conversions, and hadrons which are misidentified as electrons.

We can calculate an approximate trigger rejection per produced charged pion for a muon trigger with an absorber a few inches from the target. One obtains for an average 0.5 GeV/c pion

$$\frac{\text{decays}}{\text{pion}} \sim \frac{\text{decay length}}{\gamma c\tau} \sim \frac{20\ \text{cm}}{6\times10^4} \sim 3\times10^{-4}/\text{pion}.$$

The hadron rejection for an electron trigger is more difficult to estimate. Backgrounds from $\gamma \to e^+e^-$ and $\pi^0 \to e^+e^-\gamma$ are copious but concentrated at low P_t. The CERN electron-trigger experiment uses sophisticated on-line filtering to obtain a hadron rejection of a few $\times10^{-3}$ per candidate track. They also impose a p_t cut on the electron candidates to reduce the trigger rate. To achieve the appropriate hadron rejection in an electron triggered B experiment, the stiff p_t spectrum for leptons from B decay must be exploited.

Transverse Momentum of the Trigger Lepton

An experiment which triggers on single leptons has the choice of a moderate "charm" lepton trigger some of which originate from the cascade $b \to c \to \mu$ or a high $P_\perp$ (~1.5 GeV) trigger which utilizes leptons directly from B decay.

Extrapolating the μ trigger results of E-515 one can expect the moderate $P_\perp$ trigger to contain a 20% contribution from charm. We can then expect for the moderate p_T sample

$$\frac{\mu \text{ from B}}{\text{trigger}} \approx \frac{\sigma(b\bar{b})}{\sigma(c\bar{c})} \frac{BR(b\to\mu)}{BR(c\to\mu)} (0.2 \text{ charm/trigger})$$

$$\sim (\frac{1}{1000}) \; (2) \; (0.2) \quad H \times 10^{-3}$$

for a high p_T electron sample we estimate

$$\frac{\text{leptons from B}}{\text{leptons from } \pi} = \frac{\sigma(b\bar{b})}{\sigma(\pi > 1.5 \text{ GeV/c } P_\perp)} (\frac{\text{lepton accept.}}{\text{hadron reject.}}) \; [2\times BR(B\to\ell)]$$

$$\approx (1.5 \times 10^{-4}) \; (0.5) \; (0.4)$$

$$\approx 6 \times 10^{-3} \text{ (within an order of magnitude).}$$

Such a trigger would have a very low rate. The low p_T lepton trigger is well matched in rate to a 10^6 interaction second experiment. A high $P_\perp$ trigger would register at a rate perhaps an order of magnitude lower. It should be pointed out that the two triggers are not mutually exclusive. A low p_T muon trigger can be executed in a geometry similar to E-515 with a high p_T electron trigger in the forward arm.

Geometry for the Muon Trigger

To achieve a pion rejection of a few $\times 10^{-4}$ a moderate p_T (0.5 GeV/c) muon trigger requires that the hadron absorber begin within inches of the target. This then dictates a separated function spectrometer with both muon and hadron arms (Fig. 1). Good pion rejection in this scheme requires a tight vertical beam focus. In such a system the μ trigger acceptance is sacrificed for hadron-arm acceptance. This is the cleanest method of triggering on a low p_T lepton retaining the forward multiparticle spectrometer. Attempts to avoid the compromised acceptance include compression of the forward spectrometer to ~2 meters. This is at the sacrifice of particle identification and an order of magnitude increase in pion decays.

Spectrometer

The forward spectrometer associated with a high resolution vertex detector will be entrusted with a few hundred (thousand?)

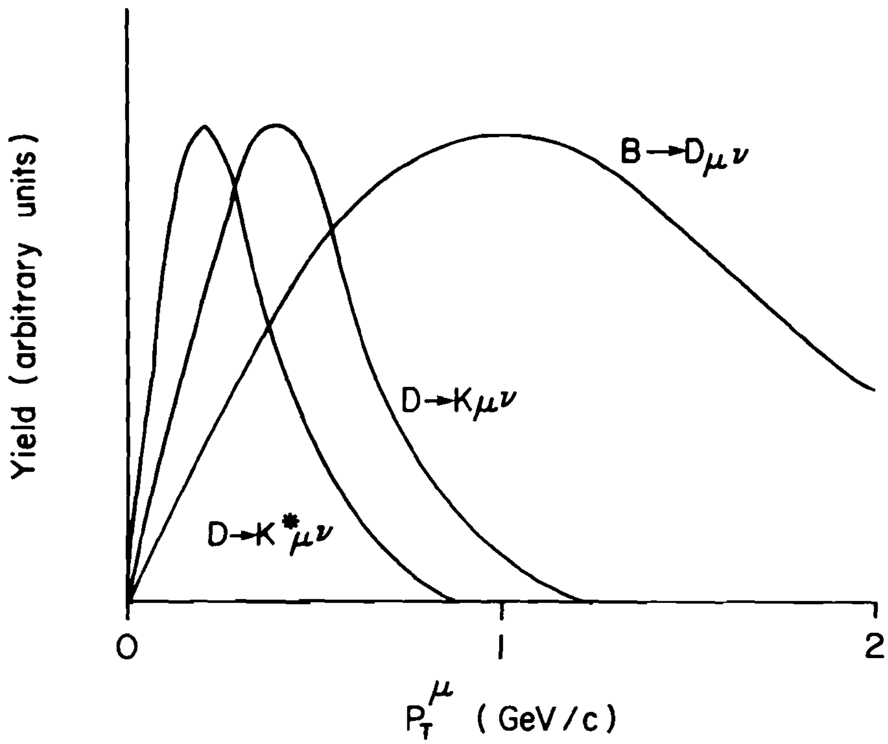

Fig. 1. Phase space decay of the parent particle is assumed.

for D decays	$\langle p_\perp \rangle$	≈ 0.2	$D \to K^* \mu\nu$
		≈ 0.4	$D \to K\mu\nu$
for B decay	$\langle p_\perp{}^\mu \rangle$	≈ 1.0	$B \to D\mu\nu$

detectable B decays. It is clearly important to obtain all the information possible about each event. This means good acceptance for both the trigger particle and the associated state. There must also be an emphasis on particle identification. This might include Cherenkov ring imaging, ionization measurements, high quality shower detectors and V^0 tagging. Such a system will challenge the state of the art.

Acceptances for B meson decay have been calculated for two different μ-triggered spectrometers. The acceptances are listed for both the trigger muons and the associated states. They are assumed to be independent. The calculation was performed for a 100-GeV incident beam. One expects these numbers to improve (20%?) at Tevatron energies.

Table I. B Decay Acceptances.

<u>Spectrometer A</u>

Trigger Arm:	40 mr	$< \theta\mu <$ 150 mr vertically
	150	$< \theta\mu <$ 150 mr horizontally
Hadron Arm:	80 mr	$< \theta h <$ 40 mr vertically
	150 mr	$< \theta h <$ 150 mr horizontally

<u>Spectrometer B</u>

Trigger Arm:	60 mr	$< \theta\mu <$ 200 mr vertically
	-200 mr	$< \theta\mu <$ 200 mr horizontally
Hadron Arm:	-130 mr	$< \theta h <$ 60 mr vertically
	-250 mr	$< \theta h <$ 250 mr horizontally

Decay	E(Spectrometer A)	E(Spectrometer B)
$B \rightarrow 4K\pi$ $\rightarrow \mu^+\mu^-$	0.04	0.15
$B \rightarrow D\mu(e)\nu$	0.35	0.60
$B \rightarrow D\bar{D}K$ $\rightarrow K\pi$ $\rightarrow \bar{K}\pi$	0.045	0.08
$B \rightarrow D\pi$ $\rightarrow \bar{K}\pi$	0.10	0.18
$B \rightarrow D\bar{D}K$ $\rightarrow K$ $\rightarrow K$	0.10	0.14

(observe and identify kaons)