Hadron-Lepton Trigger

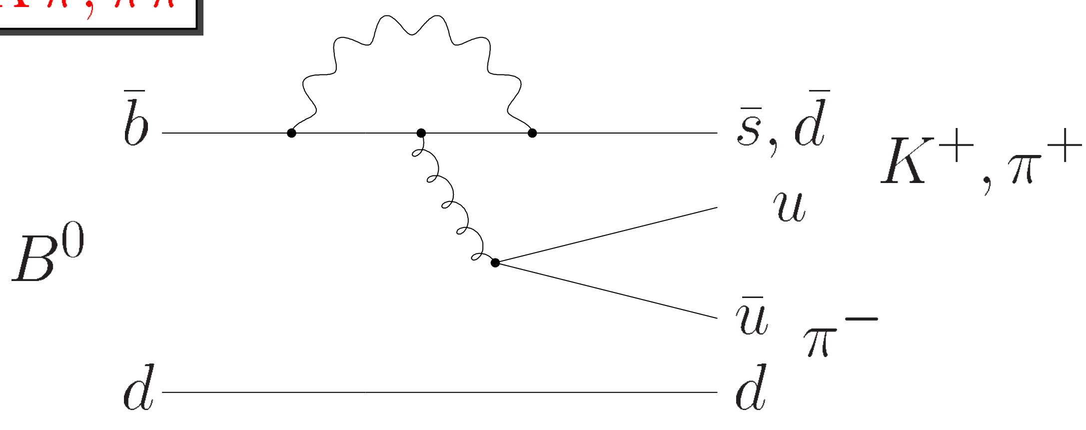
FLT	•$P_T(e,\mu) \quad > 1.4, 1.0,$ •$P_T(track) > 1.8$ GeV/c $\rightarrow 10MHz/500 = 20kHz$
SLT	• tracks refit using vertex detector • hadron, lepton not from main VX $\rightarrow 20kHz/50 = 0.4kHz$

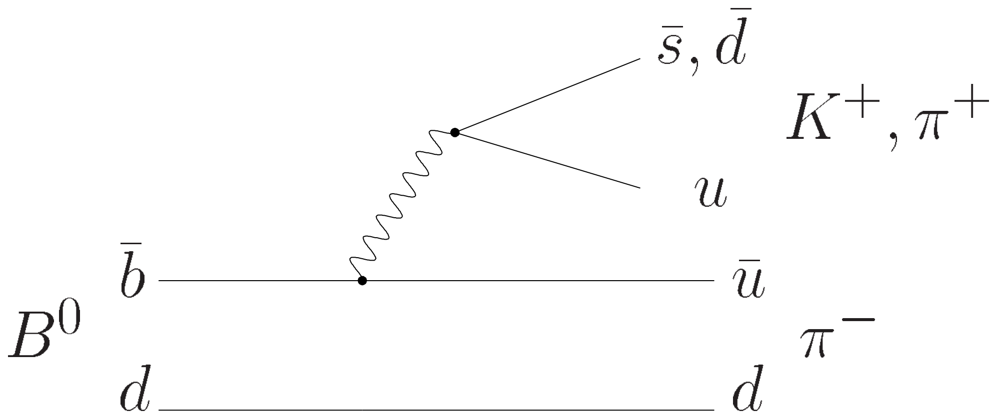
Hadron-Hadron Trigger

FLT	•$P_T^{1,2} > 1.5,\ M_{1,2} > 4.5,$ GeV/c •$\lvert E_1 - E_2\rvert/(E_1 + E_2) < 0.5$ $\rightarrow 10MHz/500 = 20kHz$
SLT	• tracks refit using vertex detector • common vertex of two tracks $\rightarrow 20kHz/50 = 0.4kHz$

If IR will be smaller than 40 MHz one can gain extra statistics using lower pretrigger cuts. (IR = 40 MHz was optimized for J/Ψ trigger).

$B \to K\pi, \pi\pi$





$K\pi$:

$$\mathcal{A}_{CP} \approx -0.40(1 - 0.20 \cos\delta \cos\gamma) \cdot \sin\delta \sin\gamma.$$

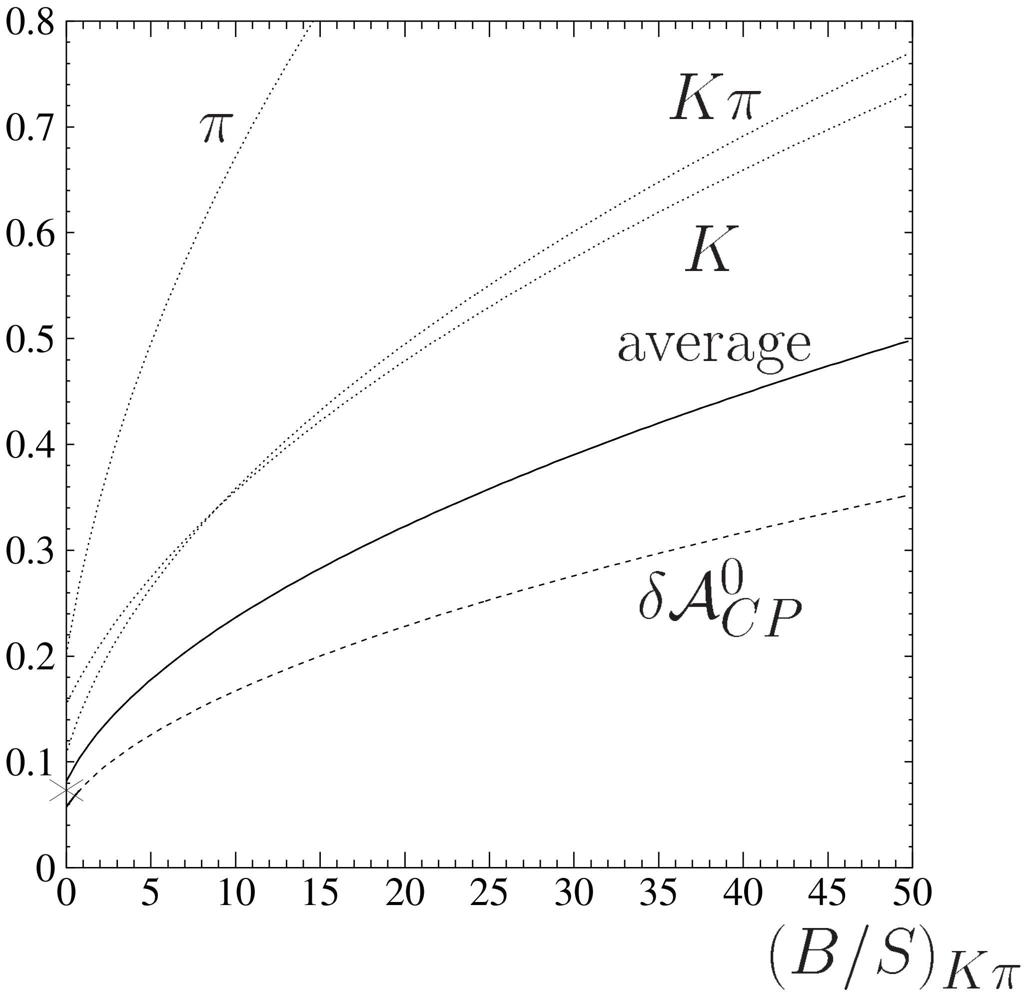
$\pi\pi$:

$$\begin{array}{lrcl} \text{CLEO'99} & Br(\pi^+\pi^-) & < & 0.84 \cdot 10^{-5} \quad @\ 90\%\ \text{CL} \\ & Br(K^+\pi^-) & = & 1.4 \cdot 10^{-5} \end{array}$$

$\to K\pi$, $a_1\pi$ modes look more favorable.

$B \to K\pi$

HERA-B note 98-136:

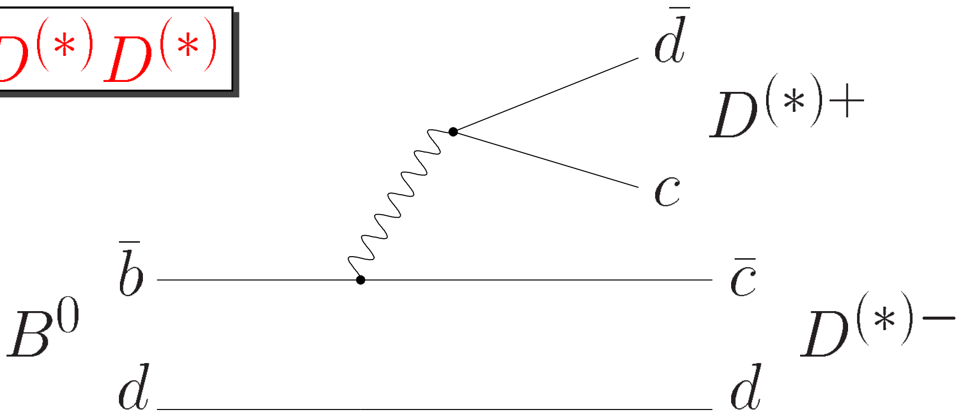


The relative statistical errors in $Br(B \to K^{\pm}\pi^{\mp})$ in one year of HERA-B operation for the separate samples with full, K and π identifications (dotted lines) and after averaging over all three samples (solid line). The cross on the vertical axis shows, for a comparison, the error $\delta Br/Br$ in the ideal case when there are no background contributions from the reflections and minimum bias events. The dashed line shows the corresponding absolute statistical error in the asymmetry $\delta\mathcal{A}^0_{CP} = \frac{1}{\sqrt{2}}\delta Br/Br$.

$\boxed{B \to K\pi}$

Br	$1.4 \cdot 10^{-5}$
$\mathrm{eff}^{\mathrm{trig}} \cdot \mathrm{eff}^{\mathrm{VX}}$	$0.28 \cdot 0.57$
ev/year	720
ID cuts	$0.24 + 2 \cdot 0.14$
ev/year	370
assumed VX, 2d B cuts mb bgr suppression	$4 \cdot 10^5$
B/S	4
CP reach	$\frac{\delta Br}{Br} = 17\%$ $\delta \mathcal{A}_{CP} = 0.12$

$\boxed{B \to D^{(*)} D^{(*)}}$



$D^{*+}D^{*-}, D^{+}D^{-}$:

$$\mathcal{A}_{CP}(t) = \frac{N_{B^0}(t) - N_{\bar{B}^0}}{N_{B^0}(t) + N_{\bar{B}^0}} = 1 + \sin 2\beta \cdot \sin \Delta m t$$

$D^{*+}D^{-} + D^{*-}D^{+}$:

$$P(B^0, \bar{B}^0 \to D^{*+}D^{-}) \propto$$
$$e^{-t}[1 \pm R\cos \Delta m t \pm D \sin(2\alpha + \delta) \sin \Delta m t]$$
$$P(B^0, \bar{B}^0 \to D^{*-}D^{+}) \propto$$
$$e^{-t}[1 \mp R\cos \Delta m t \pm D \sin(2\alpha - \delta) \sin \Delta m t]$$
$$D = \frac{2|A||\bar{A}|}{|A|^2+|\bar{A}|^2}, \qquad R^2 + D^2 = 1.$$

Neglecting strong phase δ for D^*D:

$$\delta(\sin 2\beta) = \frac{1}{M(t_0)(D_M D_T)} \frac{1}{\sqrt{N^{DD}_{B^0} + N^{DD}_{\bar{B}^0}}}$$
$$\approx \frac{1}{0.72 \cdot 0.60} \cdot \frac{1}{\sqrt{N}} = \frac{2.3}{\sqrt{N}}$$

When reconstructing $D^{*\pm}$ partially p_{B^0} and τ_B are known with large uncertainty. However, variation of the cut $\tau_B/\tau_{B^0} > t_0 \approx 0.7$ affects $M(t_0)$ in time-integrated $\mathcal{A}_{CP}$ only slightly:

t_0	0.5	0.7	1.0
$M(t_0)$	0.66	0.72	0.79.

Thus the average value of $< M(t_0) >$ corresponding to the chosen cuts on VX_{B^0} can be reliably predicted by MC.

In case of $D^{*+}D^{*-}$ there can be $S, D(CP = +1)$ and $P(CP = -1)$ waves.
Theoretically prefered value of P-wave contribution is 6%. This value was taken by the BaBar for their simulations.
The dilution and uncertainty in $\sin 2\beta$ extraction caused by P-wave are not considered in the following.

$$N^{tot}_{D^*D^*} = 40MHz\cdot 10^{-6}(b\bar{b})\cdot 10^7 s\cdot 0.8(B^0+\bar{B}^0)\times$$
$$\times 0.97\cdot 10^{-3}(Br) = 310\ 000$$
$$N^{reco}_{D^*D^*} = 310\,000\cdot 0.683^2(Br(D^{*+}\to D^0\pi+))\times$$
$$\times 0.208(Br(B\to lX))\cdot \mathrm{eff}^{\mathrm{reco}} = 30\ 000\cdot \mathrm{eff}^{\mathrm{reco}}$$

- $\delta(\sin 2\beta) = \frac{2.3}{\sqrt{N^{reco}_{D^*D^*}}}$ — given for the ideal case with no backgrounds.
- $\mathrm{eff}^{\mathrm{reco}}$ includes the efficiency of $\tau_B/\tau_{B^0} > 0.7$ requirement (VX_{B^0} cut): $\exp(-0.7) = 0.5$
- it is required that D mesons form secondary VX;

Additional possibilities

- $D^{**+}D^{**-}$ modes
- $(D^{*+}D^{*-}K^0_S(n\pi))_{nonres}$ — Cabibbo-allowed, free of penguins (like $J/\Psi K^S_0$)

Mode	Br	eff	N_{ev}	Backgrounds /		$\delta \sin(2\beta)$
$D^{*+}D^{*-}$ full	$0.97 \cdot 10^{-3}$	0.08%	23	$pt(h) > 1.5$		0.48
		0.04%	13	$pt(h) > 1.8$		0.65
partial (one D^0)		0.71%	210			0.16
		0.39%	120			0.21
partial (none)		2.1%	630	not considered		0.09
		1.2%	350			0.12
min bias (10^9) full				$2\mathrm{VX}_D, \mathrm{VX}_{D^0\bar{D}^0\pi^+\pi^-}, \vec{p_B}\|\|n\vec{V}_X,$ $l, \mathrm{P_T}(h), 2\mathrm{M}_{D^0}, 2\mathrm{M}_{D^*}, \mathrm{M}_{B^0}$	$10^5 \cdot 4 \cdot 10^4 \cdot 10^4 \cdot 40 \cdot 0.04\%$ $2\mathrm{M}_{D^0}, 2\mathrm{M}_{D^*}, \mathrm{M}_{B^0}$	$\ll 10^{-3}$
partial				$2\mathrm{VX}_D, \Delta_{D^0}, \mathrm{VX}_{\pi^+\pi^-}, l, \mathrm{P_T}(h),$ $\mathrm{IP}_{B^0}, \mathrm{M}_{D^0,D^*}, \Delta\mathrm{M}_\pi, \mathrm{M}_{B^0}$	$10^5 \cdot 10 \cdot 20 \cdot 10^4 \cdot 40 \cdot 0.4\%$ $\mathrm{M}_{D^0}, \mathrm{M}_{D^*}, \Delta\mathrm{M}_\pi, \mathrm{IP}_{B^0}$	$\ll 0.03$
$c-\bar{c}$ (10^6) full				$P(D^*D^*), \mathrm{VX}_{D^0\bar{D}^0\pi^+\pi^-},$ $\vec{p_B}\|\|n\vec{V}_X, l, \mathrm{P_T}(h), \mathrm{M}_{B^0}$	$10 \cdot 4 \cdot 10^4 \cdot 10^4 \cdot 40 \cdot 0.04\%,$ M_{B^0}	$\ll 10^{-2}$
partial				$P(D^*D^*), \Delta_{D^0}, \mathrm{VX}_{\pi^+\pi^-},$ $l, \mathrm{P_T}(h), \mathrm{IP}_{B^0}, \mathrm{M}_{B^0}$	$10 \cdot 10 \cdot 20 \cdot 10^4 \cdot 40 \cdot 0.4\%$ IP_{B^0}	0.3
$b-\bar{b}$ (only partial) $D^{*+}D^{*-}K^0(n\pi^0)$				$0.1\%/\mathrm{Br}, \mathrm{M}_{B^0}$		
$D^{*+}D^0\pi^-K^0(n\pi^0)$				$0.1\%/\mathrm{Br}, \mathrm{M}_{B^0}$ soft π, $\Delta\mathrm{M}_\pi, \mathrm{M}_{B^0}$		
$D^{*+}D_s^-(n\pi^0)$				$0.1\%/\mathrm{Br}, \mathrm{M}_{B^0}$ π^+ from VX_{D_s} goes to VX_B		
$D^{*+}D^-$ $D^{*-}D^+$ full	$0.94 \cdot 10^{-3}$	0.08%	24			0.47
		0.05%	14			0.63
partial		0.32%	92			0.24
		0.17%	49			0.33
min bias (10^9) full				$2\mathrm{VX}_D, \mathrm{VX}_{D^0D^-\pi^+}, \vec{p_B}\|\|n\vec{V}_X, l,$ $\mathrm{P_T}(h), \mathrm{M}_{D^0}, \mathrm{M}_{D^-}, \mathrm{M}_{D^*}, \mathrm{M}_{B^0}$	$10^5 \cdot 4 \cdot 10^4 \cdot 10^4 \cdot 40 \cdot 0.05\%,$ $2\mathrm{M}_D, \mathrm{M}_{D^*}, \mathrm{M}_{B^0}$	$\ll 10^{-3}$
partial				$2\mathrm{VX}_D, \mathrm{VX}_{D^+\pi^-}, l, \mathrm{P_T}(h),$ $\mathrm{IP}_{B^0}, \mathrm{M}_{D^-}, \Delta\mathrm{M}_\pi, \mathrm{M}_{B^0}$	$10^5 \cdot 200 \cdot 10^4 \cdot 40 \cdot 0.2\%,$ $\mathrm{M}_{D^-}, \Delta\mathrm{M}_\pi, \mathrm{IP}_{B^0}$	$\ll 0.06$
$c-\bar{c}$ (10^6) full				$P(D^{*\pm}D^\mp), \mathrm{VX}_{D^0D^-\pi^+},$ $\vec{p_B}\|\|n\vec{V}_X, l, \mathrm{M}_{B^0}$	$10 \cdot 4 \cdot 10^4 \cdot 10^4 \cdot 40 \cdot 0.05\%$ M_{B^0}	10^{-2}
parial				$P(D^{*\pm}D^\mp), \mathrm{VX}_{D^+\pi^-},$ $l, \mathrm{P_T}(h), \mathrm{IP}_{B^0}, \mathrm{M}_{B^0}$	$10 \cdot 200 \cdot 10^4 \cdot 40 \cdot 0.2\%$ IP_{B^0}	0.6
$b-\bar{b}$ (only partial) $D^{*+}D^{*-}K^0(n\pi^0)$				$0.1\%/\mathrm{Br}, \mathrm{M}_{B^0}$		
$D^{*+}D^0\pi^-K^0(n\pi^0)$				$0.1\%/\mathrm{Br}, \mathrm{M}_{B^0}$ soft π, $\Delta\mathrm{M}_\pi, \mathrm{M}_{B^0}$		
$D^{*+}D_s^-(n\pi^0)$				$0.1\%/\mathrm{Br}, \mathrm{M}_{B^0}$ π^+ from VX_{D_s} goes to VX_B		
D^+D^- full	$0.39 \cdot 10^{-3}$	0.07%	9			0.79
		0.04%	5			1.00
min bias ($3 \cdot 10^9$) full				$2\mathrm{VX}_D, \mathrm{VX}_{D^+D^-}, \vec{p_B}\|\|n\vec{V}_X,$ $l, \mathrm{P_T}(h), \mathrm{M}_{D^+}, \mathrm{M}_{D^-}, \mathrm{M}_{B^0}$	$10^5 \cdot 4 \cdot 10^4 \cdot 10^4 \cdot 40 \cdot 0.04\%,$ $\mathrm{M}_{D^+}, \mathrm{M}_{D^-}, \mathrm{M}_{B^0}$	$\ll 0.005$
$c-\bar{c}$ ($3 \cdot 10^6$) full				$P(D^\pm D^\mp), \mathrm{VX}_{D^+D^-},$ $\vec{p_B}\|\|n\vec{V}_X, l, \mathrm{P_T}(h), \mathrm{M}_{B^0}$	$25 \cdot 4 \cdot 10^4 \cdot 10^4 \cdot 40 \cdot 0.04\%,$ M_{B^0}	$\ll 0.02$