How Many Completely Reconstructed B Mesons Can We Expect Per Year ?

Much of what follows is based on: G. London, "What Can We Do With The First 100k Multi-Hadron Events ?", a contribution to the discussion within the Hadronic Bottom/Charm Physics Group.

Basic Assumptions

One year: 30 fb^{-1} [$\simeq$ 30 million $B/\overline{B}$-pairs, that is, 15 million mesons of each of the following types: B^+, B^-, B^0 and $\overline{B^0}$]

Assumed efficiencies: charged track: 0.85
π^0: 0.45

J/Ψ are assumed to be recontructed in the channel $J/\Psi \to \mu^+ \mu^-$ only (Br=0.06). Assumed efficiency: 0.7, including the effects of tracking and lepton PID.

K^0_S are assumed to be recontructed in the channel $K^0_S \to \pi^+ \pi^-$ only (Br=0.6).

$Br(\rho^+ \to \pi^+ \pi^0)$=100%.

Charmonium Modes

Reconstruction of $K^*(892)^+$:

mode	branching ratio	br. ratio $\times$ eff.
$K^*(892)^+ \to K^0\ \pi^+$	50%	9.2%
$K^*(892)^+ \to K^+\ \pi^0$	50%	19.1%
Σ	100%	**28.3%**

Reconstruction of $\Psi(2S)$:
Only in the channel $\Psi(2S) \to J/\Psi\ \pi^+\ \pi^-$ (Br=30.2%). Branching ratio $\times$ efficiencies = **0.9%**.

Reconstruction of the B mesons:

	mode	branching ratio	br. ratio $\times$ eff.	reconstr. events / year
$\mathbf{B^0/\overline{B^0}}$	$B^0 \to J/\Psi\ K^0_S$	4.4×10^{-4}	8.1×10^{-6}	255
	$B^0 \to J/\Psi\ K^+\ \pi^-$	1.1×10^{-3}	3.3×10^{-5}	1051
				Σ = 1306
$\mathbf{B^+/B^-}$	$B^+ \to J/\Psi\ K^+$	9.9×10^{-4}	3.5×10^{-5}	1113
	$B^+ \to J/\Psi\ K^+\ \pi^+\ \pi^-$	1.4×10^{-3}	3.6×10^{-5}	1137
	$B^+ \to J/\Psi\ \pi^+$	5.0×10^{-5}	1.8×10^{-6}	56
	$B^+ \to J/\Psi\ K^{*+}$	1.47×10^{-3}	1.7×10^{-5}	550
	$B^+ \to \Psi(2S)\ K^+$	6.9×10^{-4}	5.3×10^{-6}	166
	$B^+ \to \Psi(2S)\ K^+\ \pi^+\ \pi^-$	1.9×10^{-3}	1.1×10^{-5}	331
				Σ = 3353

D Modes

Reconstruction of the D mesons:

	mode	branching ratio	br. ratio × eff.
$\mathbf{D^+/D^-}$	$D^+ \to K^0_S\ \pi^+$	0.014	0.0051
	$D^+ \to K^0_S\ \pi^+\ \pi^0$	0.049	0.0073
	$D^+ \to K^-\ \pi^+\ \pi^+$	0.09	0.0553
	$D^+ \to K^-\ \pi^+\ \pi^+\ \pi^0$	0.064	0.0177
	$D^+ \to K^0_S\ \pi^+\ \pi^+\ \pi^-$	0.035	0.0085
	$D^+ \to K^0_S\ \pi^+\ \pi^+\ \pi^-\ \pi^0$	0.027	0.0030
		$\Sigma = 0.237$	$\mathbf{\Sigma = 9.7\%}$
$\mathbf{D^0/\overline{D^0}}$	$D^0 \to K^-\ \pi^+$	0.0385	0.0278
	$D^0 \to K^-\ \pi^+\ \pi^0$	0.139	0.0452
	$D^0 \to K^0_S\ \pi^+\ \pi^-$	0.027	0.0078
	$D^0 \to K^0_S\ \pi^+\ \pi^-\ \pi^0$	0.050	0.0064
	$D^0 \to K^-\ \pi^+\ \pi^-\ \pi^+$	0.076	0.0397
	$D^0 \to K^-\ \pi^+\ \pi^-\ \pi^+\ \pi^0$	0.041	0.0096
		$\Sigma = 0.3455$	$\mathbf{\Sigma = 13.6\%}$

Reconstruction of the D_s^+ mesons:

mode	branching ratio	br. ratio × eff.
$D_s^+ \to K^+\ K^-\ \pi^+$	4.4%	2.7%
$D_s^+ \to K^+\ K^0_S$	1.8%	0.7%
$D_s^+ \to K^0_S\ K^-\ \pi^+\ \pi^+$	2.2%	0.6%
$D_s^+ \to \pi^+\ \pi^+\ \pi^-$	1%	0.6%
$D_s^+ \to K^+\ \pi^+\ \pi^-$	1%	0.6%
Σ	10.4%	**5.2%**

Reconstruction of the B mesons:

	mode	branching ratio	br. ratio × eff.	reconstr. events / year
$\mathbf{B^0/\overline{B^0}}$	$B^0 \to D^- \pi^+$	3.0×10^{-3}	2.5×10^{-4}	7.8k
	$B^0 \to D^- \pi^+ \pi^+ \pi^-$	8.0×10^{-3}	4.7×10^{-4}	15.0k
	$B^0 \to D^- \rho^+$	7.9×10^{-3}	2.9×10^{-4}	9.2k
	$B^0 \to D^- D_s^+$	8.0×10^{-3}	4.0×10^{-5}	1.3k
				$\mathbf{\Sigma = 33.3}$k
$\mathbf{B^+/B^-}$	$B^+ \to \overline{D^0} \pi^+$	5.3×10^{-3}	6.1×10^{-4}	19.3k
	$B^+ \to \overline{D^0} \pi^+ \pi^+ \pi^-$	1.1%	9.2×10^{-4}	28.9k
	$B^+ \to \overline{D^0} \rho^+$	1.34%	7.0×10^{-4}	22.0k
	$B^+ \to \overline{D^0} D_s^+$	1.3%	9.2×10^{-5}	2.9k
				$\mathbf{\Sigma = 73.1}$k

D^* Modes

Reconstruction of the D^* mesons:

	mode	branching ratio	br. ratio × eff.
$\mathbf{D^{*+}/D^{*-}}$	$D^{*+} \to D^0(\to \text{no } \pi^0)\ \pi^+$	0.683	0.0437
	$D^{*+} \to D^0(\to \text{one } \pi^0)\ \pi^+$	0.683	0.0356
	$D^{*+} \to D^+(\to \text{no } \pi^0)\ \pi^0$	0.306	0.0095
			$\mathbf{\Sigma = 8.9\%}$
$\mathbf{D^{*0}/\overline{D^{*0}}}$	$D^{*0} \to D^0(\to \text{no } \pi^0)\ \pi^0$	0.619	0.0210
			$\mathbf{\Sigma = 2.1\%}$

Reconstruction of the B mesons:

	mode	branching ratio	br. ratio × eff.	reconstr. events / year
$\mathbf{B^0/\overline{B^0}}$	$B^0 \to D^{*-}\ \pi^+$	2.8×10^{-3}	2.1×10^{-4}	6.7k
	$B^0 \to D^{*-}\ \pi^+\ \pi^0$	1.5%	5.1×10^{-4}	16.1k
	$B^0 \to D^{*-}\ \pi^+\ \pi^+\ \pi^-$	7.6×10^{-3}	4.2×10^{-4}	13.1k
	$B^0 \to D^{*-}\ \pi^+\ \pi^+\ \pi^-\ \pi^0$	3.4%	8.4×10^{-4}	26.3k
	$B^0 \to D^{*-}\ D_s^+$	9.6×10^{-3}	4.4×10^{-5}	1.4k
				$\mathbf{\Sigma = 63.6}$k
$\mathbf{B^+/B^-}$	$B^+ \to \overline{D^{*0}}\ \pi^+$	4.6×10^{-3}	8.2×10^{-5}	2.6k
	$B^+ \to \overline{D^{*0}}\ \rho^+$	1.55%	1.2×10^{-4}	3.9k
	$B^+ \to \overline{D^{*0}}\ \pi^+\ \pi^+\ \pi^-$	9.4×10^{-3}	1.2×10^{-4}	3.8k
	$B^+ \to \overline{D^{*0}}\ D_s^+$	1.2%	1.3×10^{-5}	0.4k
				$\mathbf{\Sigma = 10.7}$k

The Potential of Semileptonic Modes

One could try to reconstruct decays of B mesons with one single neutrino in the final state. This neutrino can either stem from the decay of the B meson itself or from the subsequent charm decay.
Assumed lepton PID efficiency: 70%.

Semileptonic B decay:

	mode	branching ratio	br. ratio $\times$ eff.	reconstr. events / year
$\mathbf{B^0/\overline{B^0}}$	$B^0 \to D^- \; l^+ \; \nu_l$	2.0%	1.6×10^{-3}	36k
	$B^0 \to D^{*-} \; l^+ \; \nu_l$	4.6%	3.5×10^{-3}	77k

An l indicates an e or a μ mode, not a sum over these modes. The total number of reconstructed events is thus $2 \cdot (36\text{k} + 77\text{k}) =$**226**k.

	mode	branching ratio	br. ratio $\times$ eff.	reconstr. events / year
$\mathbf{B^+/B^-}$	$B^+ \to \overline{D^0} \; l^+ \; \nu_l$	1.86 %	2.2×10^{-3}	48k
	$B^+ \to \overline{D^{*0}} \; l^+ \; \nu_l$	5.3%	9.5×10^{-4}	21k

An l indicates an e or a μ mode, not a sum over these modes. The total number of reconstructed events is thus $2 \cdot (48\text{k} + 21\text{k}) =$**138**k.

Semileptonic D decay:

Try to reconstruct the $D^0/\overline{D^0}$ in the additional mode $D^0 \to K^- \; l^+ \; \nu_l$ (Br=3.5%)
$\Rightarrow$ overall $D^0/\overline{D^0}$ efficiency: 13.6% $\to$ **17.1%**.

Try to reconstruct the D^+/D^- in the additional mode $D^+ \to K^0_S \; l^+ \; \nu_l$ (Br=3.4%)
$\Rightarrow$ overall D^+/D^- efficiency: 9.7% $\to$ **11.5%**.

$\Rightarrow$ overall $D^{*0}/\overline{D^{*0}}$ efficiency: 2.1% $\to$ **2.6%**
overall D^{*+}/D^{*-} efficiency: 8.9% $\to$ **11.1%**

Effect on the number of reconstructed $B^0/\overline{B^0}$ mesons:

$B^0 \to D^- \pi^+$	7.8k	$\to$	9.2k
$B^0 \to D^- \pi^+ \pi^+ \pi^-$	15.0k	$\to$	17.8k
$B^0 \to D^- \rho^+$	9.2k	$\to$	10.9k
$B^0 \to D^{*-} \pi^+$	6.7k	$\to$	8.3k
$B^0 \to D^{*-} \pi^+ \pi^0$	16.1k	$\to$	20.1k
$B^0 \to D^{*-} \pi^+ \pi^+ \pi^-$	13.1k	$\to$	16.3k
$B^0 \to D^{*-} \pi^+ \pi^+ \pi^- \pi^0$	26.3k	$\to$	32.8k
Σ	94.2k	$\to$	**115.4k**

Effect on the number of reconstructed B^+/B^- mesons:

$B^+ \to \overline{D^0} \pi^+$	19.3k	$\to$	24.3k
$B^+ \to \overline{D^0} \pi^+ \pi^+ \pi^-$	28.9k	$\to$	36.3k
$B^+ \to \overline{D^0} \rho^+$	22.0k	$\to$	27.7k
$B^+ \to \overline{D^{*0}} \pi^+$	2.6k	$\to$	3.2k
$B^+ \to \overline{D^{*0}} \rho^+$	3.9k	$\to$	4.8k
$B^+ \to \overline{D^{*0}} \pi^+ \pi^+ \pi^-$	3.8k	$\to$	4.7k
Σ	80.5k	$\to$	**101.0k**

Summary

	$B^0/\overline{B^0}$	B^+/B^-
Charmonium	1,306	3,353
D	33,300	73,100
D^*	63,600	10,700
Σ	**98,200**	**87,200**
Semileptonic	**226,000**	**138,000**