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HEAVY FLAVOUR RESULTS FROM THE TEVATRON*

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Given the large number of heavy flavour results from the Tevatron this document can only be a subjective overview. The main selection criterion was to only present results obtained from the analysis of Tevatron Run II data. There is also a preference for cross section measurements, owing to the scope of the conference. The Tevatron and detector upgrades are only discussed briefly. All results are preliminary unless otherwise stated.

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1. The Tevatron and detector upgrades for Run II

The two major goals of the Tevatron upgrade for Collider Run II at Fermilab were higher center of mass energy and higher instantaneous luminosity. While the latter does not yet reach the Run II design value of $8.60 \times 10^{31}\mathrm{cm}^{-2}\mathrm{s}^{-1}$, it already exceeds the peak values for Run I. The following table compares the major Tevatron Run I and Run II features.

	Run I	Run II
Bunch Crossing Time	3.5 μs	369 ns
Number of Bunches	6×6	36×36
$\sqrt{s}$ [TeV]	1.8	1.96
Peak Luminosity	2.4×10^{31}	4.7×10^{31}

The CDF and DØ Detectors both are general purpose collider detectors. The Run II upgrades where necessary to handle the increased bunch crossing rate and luminosity and to fully exploit the physics potential of Run II. They are described in detail elsewhere [1,2].

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With respect to the results presented here the most significant upgrades are the new tracking systems including a superconduction solenoid magnet for DØ and better triggers. Among the latter the most remarkable are the displaced track triggers. While DØ is about to commission the track trigger, CDF has already taken data using its Secondary Vertex Trigger (SVT).

2. Charm results

All Charm results presented here are based on CDF data collected with the SVT in 'two-track' mode. This setup allows to trigger on fully hadronic final states which were previously inaccessible. Figure 1 illustrates the trigger cuts and the clean signals available from this trigger.

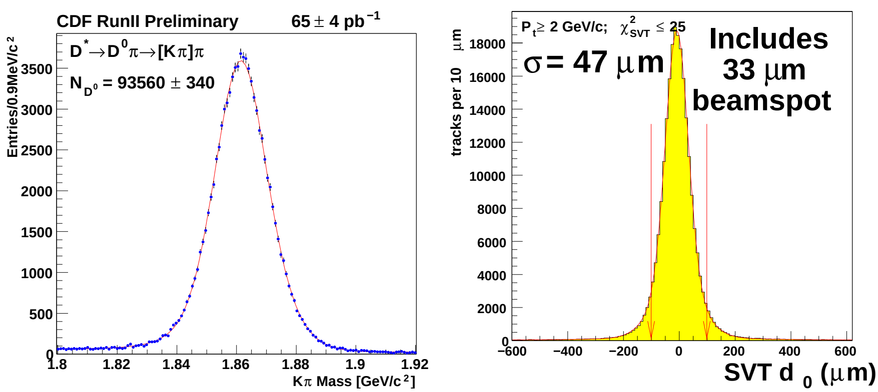

Fig. 1. $D^* \to D^0\pi_s \to [K\pi]\pi_s$ signal and SVT impact parameter resolution.

CDF has measured the differential Charm cross section $d\sigma/dp_{\mathrm{T}}(|y| \leq 1)$ in the channels $D^0 \to K^-\pi^+$, $D^{*+} \to D^0\pi^+$, $D^+ \to K^-\pi^+\pi^+$, and $D_s^+ \to (\phi \to K^+K^-)\pi^+$. In order to avoid folding in the $b\bar{b}$-cross section it is necessary to separate prompt Charm from Charm from B decays. This is achieved by utilising differences in the D impact parameter distributions for the two cases. Figure 2 illustrates this technique. The results from 5.8 pb^{-1} of data are shown in the following table and the comparison with theory predictions [3] is given in figure 3.

p_{T} range	$d\sigma/dp_{\mathrm{T}}(\lvert y\rvert \leq 1)$ [nb/(GeV/c)]			
[GeV/c]	D^0	D^{*+}	D^+	D_s^+
5.5–6	7837±220±884	—	—	—
6–7	4056±93 ±441	2421±108±424	1961±69 ±332	—
7–8	2052±58 ±227	1147±48 ±145	986 ±28 ±156	—
8–10	890 ±25 ±107	427 ±16 ±54	375 ±9 ±62	236±20 ±67
10–12	327 ±15 ±41	148 ±8 ±18	136 ±4 ±24	64 ±9 ±19
12–20	39.9 ±2.3 ±5.3	23.8 ±1.3 ±3.2	19.0 ±0.6 ±3.2	9.0 ±1.2 ±2.7

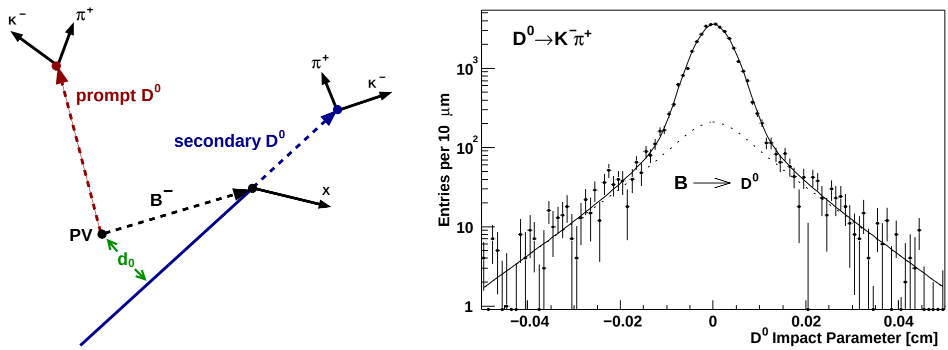

Fig. 2. Impact parameters (d_0) of prompt *vs* secondary D mesons.

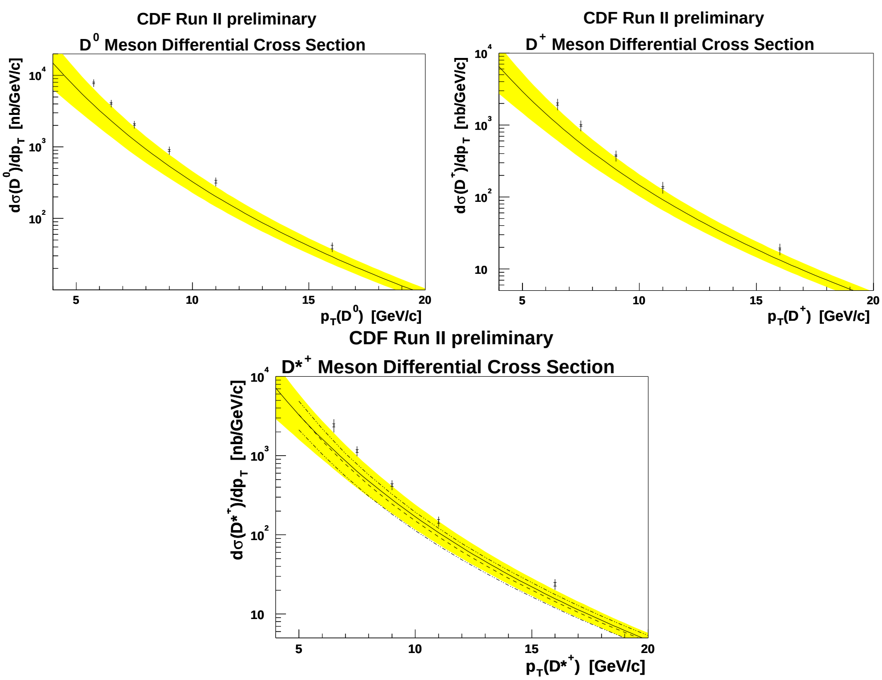

Fig. 3. Differential Charm cross section comparison with theory. There is no prediction for D_s available.

Using a clean D^0 sample from the decay $D^* \to D^0\pi_s \to [K\pi]\pi_s$, the branching fractions $\Gamma(D^0 \to f^+f^-)/\Gamma(D^0 \to K\pi)$ with $f = K, \pi$ were measured on 65 pb^{-1} of data: $\Gamma(D^0 \to K^+K^-)/\Gamma(D^0 \to K\pi) = 9.38 \pm 0.18 \pm 0.1\%$, $\Gamma(D^0 \to \pi^+\pi^-)/\Gamma(D^0 \to K\pi) = 3.686 \pm 0.076 \pm 0.036\%$. In contrast to a measurement of absolute branching ratios, most systematics cancel in this measurement of branching ratio ratios.

By using the slow pion, π_s, for flavour tagging the direct CP asymmetry $\mathcal{A}_{\rm CP} = \frac{\Gamma(D^0\to f)-\Gamma(\bar{D}^0\to f)}{\Gamma(D^0\to f)+\Gamma(\bar{D}^0\to f)}$ with $f = K^+K^-, \pi^+\pi^-$ was measured to be compatible with zero: $\mathcal{A}(D^0 \to K^+K^-) = 2.1\pm1.9\pm0.5$, $\mathcal{A}(D^0 \to \pi^+\pi^-) = 2.1 \pm 2.1 \pm 0.5$

The first CDF publication from Run II was a measurement of the mass difference $m(D_s^+) - m(D^+)$ [4] using $11.6\,\mathrm{pb}^{-1}$ of data from the two-track trigger. The masses were measured using fully reconstructed $D_s, D^+ \to \phi\pi$, $\phi \to K^+K^-$ decays. The sensivity of the published results is similar to that of the current PDG average: $m(D_s^+) - m(D^+) = 99.41 \pm 0.38(\mathrm{stat}) \pm 0.21(\mathrm{syst})\,\mathrm{MeV}/c^2$.

3. Beauty results

The mass and lifetime measurements presented below all use decays of the form $B \to J/\psi X$, $J/\psi \to \mu^+\mu^-$ collected with a dimuon trigger. It is noteworthy that the Tevatron is currently the only machine capable of producing the heavy b-hadrons B_s, B_c and Λ_b. The B_s samples collected by CDF and DØ are the largest worldwide and their measurements of the B_s properties are the most accurate available today.

Using $80\,\mathrm{pb}^{-1}$ of integrated luminosity, CDF II has measured various b-hadron masses:

Mode	m [GeV/c^2]
$B^\pm \to J/\psi\, K^\pm$	5279.32±0.65±0.94
$B^0 \to J/\psi\, K^{0*}$	5280.30±0.92±0.96
$B^0 \to J/\psi\, K_S$	5281.54±0.8 ±1.2
$B_s \to J/\psi\, \phi$	5365.50±1.29±0.94
$\Lambda_b \to J/\psi\, \Lambda$	5620.4 ±1.6 ±1.2

Both experiments have measured exclusive lifetimes of b-hadrons:

Mode	CDF τ[ps]	DØ τ[ps]
$B_s \to J/\psi\, \phi$	1.33± 0.14 ± 0.02	$1.19^{+0.19}_{-0.16}$ ± 0.14
$B^+ \to J/\psi\, K^+$	1.63± 0.05 ± 0.04	1.65± $0.083^{+0.096}_{-0.1233}$
$B^0 \to J/\psi\, K^*$	1.51± 0.06 ± 0.02	$1.51^{+0.19}_{-0.17}$ ± 0.2
$\Lambda_b \to J/\psi\, \Lambda, \Lambda \to p\,\pi^-$	1.25± 0.26 ± 0.1	$1.05^{+0.21}_{-0.18}$ ±0.12

DØ has also measured the inclusive lifetime:

Mode	DØ τ[ps]
$B, \Lambda_b \to J/\psi\, X, J/\psi \to \mu^+\mu^-$	$1.561 \pm 0.024 \pm 0.074$

4. Top cross section results

As opposed to $c\bar{c}$- and $b\bar{b}$-production, $t\bar{t}$-production is dominated by strong interaction-mediated $q\bar{q}$-annihilation. Since $|V_{tb}| \simeq 1$, t-quarks almost exclusively decay into b-quarks by radiating off a W-boson. This leads to three classes of signatures for $t\bar{t}$-events: dilepton events where both Ws decay leptonically, events with one W decaying leptonically ('lepton + jets') and all-jets events. In all cases the two b-jets from the top decay are present. Different backgrounds are present for the different modes and numerous methods exist to suppress them. It is beyond the scope of this document to explain the details. A detailed description of the analyses can be found in [5]. Dilepton events are the cleanest but provide the lowest statistics (Br $\sim$ 5%). The 'lepton + jets' mode is the best compromise between background and statistics (Br $\sim$ 30%). All-jets events (Br $\sim$ 44%) have not yet been used for measurements. The table below summarises the $t\bar{t}$-cross section results from CDF II and DØ, figure 4 gives a comparison between theory and Tevatron results.

Exp.	Mode	$\sigma_{t\bar{t}}$ ±stat±sys ±lum[pb]
DØ	ll	$8.7\ ^{+6.4}_{-4.7}\ ^{+2.7}_{-2.0} \pm 0.9$
CDF	ll	$7.6\ ^{+3.8}_{-3.1}\ ^{+1.5}_{-1.9}$
CDF	l + track	$7.3 \pm 3.4 \pm 1.7$
DØ	$l+j$, CSIP	$7.4\ ^{+4.4}_{-3.6}\ ^{+2.1}_{-1.8} \pm 0.7$
DØ	$l+j$, SVT	$10.8\ ^{+4.9}_{-4.0}\ ^{+2.1}_{-2.0} \pm 1.1$
DØ	$l+j$, topo	$4.6\ ^{+3.1}_{-2.7}\ ^{+2.1}_{-2.0} \pm 0.5$
DØ	$l+j$, soft μ	$11.4\ ^{+4.1}_{-3.5}\ ^{+2.0}_{-1.8} \pm 1.1$
DØ	$l+j$, comb.	$8.0\ ^{+2.4}_{-2.1}\ ^{+1.7}_{-1.5} \pm 0.8$
CDF	$l+j$, SVX	$5.3 \pm 1.9 \pm 0.9$
CDF	$l+j$, H_{T}	$5.1 \pm 1.8 \pm 2.1$
DØ	combined	$8.1\ ^{+2.2}_{-2.0}\ ^{+1.6}_{-1.4} \pm 0.8$

CDF II has also put an upper limit on the electroweak top production (single top) cross section: σ (t-Channel) + σ (s-Channel) < 17.5 pb @ 95% C.L. This is comparable to the equivalent Run I results of CDF and DØ. The diagrams for single top production are shown in figure 5.

5. Conclusions

Both CDF II and DØ already provide competitive heavy flavour results based on Tevatron Run II data. The top quark signal in $t\bar{t}$-production has been 're-established', and will form the basis for upcoming studies on top quark properties and production with improved precision. We are looking forward to the even more exciting results (*e.g.* B_s mixing) that will be available with more statistics and better detector understanding.

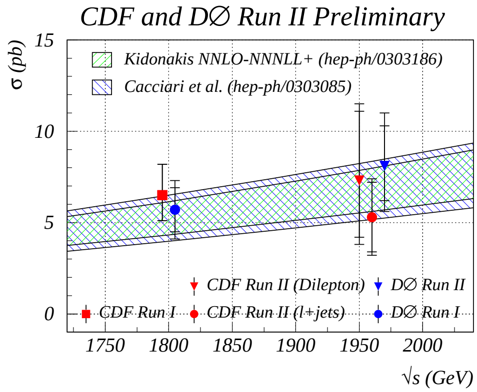

Fig. 4. $t\bar{t}$-cross section comparison with theory.

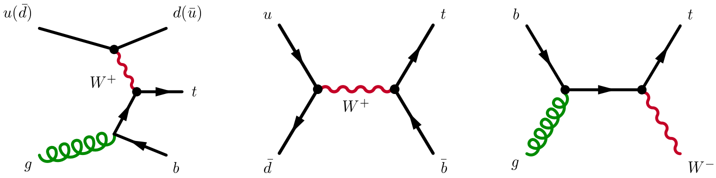

Fig. 5. t-channel W-gluon fusion, s-channel and associated single top production.

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