Summary of Heavy Flavour Working Group (Experimental)

Paul Thompson, Uri Karshon, Ingo Schienbein

- Experimental techniques
- $B_s$ mixing at Tevatron
- open b production
- open c production
- Heavy flavour at RHIC
- B-Factories
- Future

Sorry, not all talks could be fitted in

20 Experimental talks
2 joint HFS sessions
1 joint SF session
Heavy flavour tagging

E.g. explicit secondary vertex reconstruction

Fit secondary vertex mass distribution
Heavy flavour tagging

Component of $\mu$ momentum transverse to jet axis, $p_{\perp}^{\text{rel}}$
- Large for B decays because of large B mass

Signed $\mu$ impact parameter, $\delta$
- Symmetrically distributed around zero for light flavours
- Positive tail for beauty and charm due to life-time

Fit most sensitive variables with MC templates

$D^*-$\mu and $\mu-$\mu correlations

Correlations between hemispheres provide info on c + b

Employ wide range complementary methods
**B_s Mixing**

Thorsten Kuhl(D0)

**B_s mixing measurement only at Tevatron due to COM of B-factories**

Frequency of oscillations between mass eigenstates

\[ \Delta m_s = M_H - M_L \] higher than for \( \Delta m_d \)

Measure the CKM matrix element \( V_{ts} \)
Technique

\[ D_S \rightarrow \Phi \pi \rightarrow K^+ K^- \pi \]

- Final state reconstruction:
  - b-flavor at decay
  - b momentum (missing: \( p_\nu \))

- Proper lifetime
  \[ c\tau = m_B \frac{L_{xy}}{P_T(B)} \]

- Initial state (opposite side):
  - lepton charge
  - sec. vtx/lepton jet charge

Asymmetry(t) = \[ \frac{N(t)_{unmixed} - N(t)_{mixed}}{N(t)_{unmixed} + N(t)_{mixed}} \]

Asymmetry(t) = A \cdot D \cdot \cos(\Delta m \cdot t) \]
DØ Result

(a) $M_{(KK)\pi}$ [GeV]

(b) $-\Delta \log(L)$ vs. $\Delta m_s$ [ps$^{-1}$]

17 ps$^{-1} < \Delta m_s < 21$ ps$^{-1}$
(90% CL assuming Gaussian error)

Reconstruction of explicit hadronic decay channels

Impact parameter trigger

$17 < \Delta m_S < 21 \text{ ps}^{-1}$ at 90% CL (DØ)

$\Delta m_S = 17.33^{+0.42}_{-0.26}(stat) \pm 0.07(syst)\text{ ps}^{-1}$,

$17.00 < \Delta m_S < 17.91 \text{ ps}^{-1}$ at 90% CL,

$16.94 < \Delta m_S < 17.97 \text{ ps}^{-1}$ at 95% CL (CDF)

$V_{td}/V_{ts} = 0.208^{+0.008}_{-0.007}$
b production at Tevatron

Run I

Tuned fragmentation

Data often higher but description within scale uncertainties

Run II
b jets at Tevatron

Daniel Jeans (CDF)

Agreement with (massive) NLO QCD within uncertainties

Large data and theory uncertainties -> improved by measuring b fraction?
Z+b-jets at Tevatron

Sensitive to different QCD processes

Statistics limit precision

Agreement with (massless) NLO QCD

<table>
<thead>
<tr>
<th></th>
<th>CDF RunII measurement</th>
<th>NLO (MCFM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma(Z^0 + b-jet)/\sigma(Z^0 + jet)$</td>
<td>0.0237 ± 0.0078 ± 0.0033</td>
<td>0.0185</td>
</tr>
<tr>
<td>$\sigma(Z^0 + b-jet)/\sigma(Z^0)$</td>
<td>0.0038 ± 0.0012 ± 0.0005</td>
<td>0.0021</td>
</tr>
<tr>
<td>$\sigma(Z^0 + b-jet)$</td>
<td>0.96 ± 0.32 ± 0.14 pb</td>
<td>0.52 pb</td>
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</table>
## Compatibility of Tevatron data

**Fabio Happacher (INFN), Frascati**

hep-ph/0509348

Single b quark data. Ratio to same theory (MC).

<table>
<thead>
<tr>
<th>channel (ex.)</th>
<th>$R$ for $p_T^{mn}$ (GeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6</td>
</tr>
<tr>
<td>$J/\Psi K^+$ (CDF)</td>
<td>4.0±15%</td>
</tr>
<tr>
<td>$J/\Psi K^+$ (CDF)</td>
<td>2.9±23%</td>
</tr>
<tr>
<td>$\mu X$ (CDF)</td>
<td>2.5±26%</td>
</tr>
<tr>
<td>$e X$ (CDF)</td>
<td>2.4±23%</td>
</tr>
<tr>
<td>$e D^0$ (CDF)</td>
<td>2.1±34%</td>
</tr>
<tr>
<td>$J/\Psi X$ (CDF)</td>
<td>4.0±10%</td>
</tr>
<tr>
<td>$J/\Psi X$ (CDF2)</td>
<td>3.1±9%</td>
</tr>
<tr>
<td>$\mu X$ (DØ)</td>
<td>2.1±27%</td>
</tr>
<tr>
<td>$\mu X$ (DØ)</td>
<td>2.5±25%</td>
</tr>
<tr>
<td>b jets($\mu$) (DØ)</td>
<td>2.4±20%</td>
</tr>
</tbody>
</table>

Consistent picture between processes?

Run II final data…
b jets at HERA

Lars Finke(H1) Using impact parameter of tracks in jets (Final data)

- Measurement to high $p_T$
- Compatibility with theory although data are higher
- $b$ fraction consistent with (massless) charge counting limit
Final HERA-I low $Q^2$ data

Displaced tracks method allows access to lower $p_T$ reducing extrapolation

Large uncertainty in QCD

Data consistent with all predictions

Require HERA-II data to improve precision and constrain schemes/PDFs
b from $D^*-\mu$ and $\mu-\mu$ correlations

Adriana E. Nuncio-Quiroz (ZEUS)

New interface of NLO QCD program to PYTHIA

Consistent with although higher than NLO QCD

Consistent with H1 published data when interpolated to same phase space
HERA-II (only small fraction of data) consistent with HERA-I and QCD

Use of ZEUS silicon detector, looking forward to precise HERA-II results
Open charm production

NLO consistent with data

Not all details described at low $x_\gamma$ (consistent picture with ZEUS $D^*+\text{jets}$)
Consistent results between displaced tracks (VTX) and D* methods

Similar overall statistical plus systematic errors for 2 methods

Aim to measure over wide range as possible to constrain PDF
charm fragmentation at HERA-I

William Dunne (ZEUS)

Large data sets allow for high statistics studies of c mesons/baryons

Consistent with fragmentation universality

Combine final data for improved precision?

(Final ZEUS $\gamma p$ data)

Fragmentation ratios

Can be measured at Tevatron
charm production at HERA-II

Falk Karstens (ZEUS)

Apply cut on secondary vertex decay length
Substantial reduction in background
Much more charm data to come from HERA
Measure $e, \mu, D^0$ in Au+Au collisions for central rapidity

Study suppression w.r.t. p+p depends on “hot” medium and probe mass

Suppression not expected for HF although difficult without tagging b (future->upgrades)
Rare charmless $B$ decays

Wolfgang Gradl (BaBar/Belle)

Joint HF+ HFS Session

- Many new and updated results from both $B$ factories
- Rare charmless $B$ decays help to improve understanding of Standard Model amplitudes
- More interesting results to come with more data
Charm at B-Factories

M. Saleem (BaBar)

Also, D_{SJ}, D mixing and lepton decay. Plus, talks on charm at Belle (Kichimi), Quarkonium at BaBar (Vitale), HF at HERA-B (Spighi), B resonances at D0 (Gele),..
Towards the LHC

Claudia Ciocca (CMS)

Studies of top pair production in hadronic channels

Plus Matthew Wing on relevance of HERA for LHC (HERA-LHC Workshop)
Summary

- Wealth of heavy flavour information from HERA, Tevatron, B-factories, RHIC,…

- Heavy flavours provide direct access to gluon measured indirectly from fits to inclusive data.

- QCD is a success! Differences only in corners of phase space.

- HF sensitive to weak processes and new physics

- HF is a low cross section process and will benefit from machine upgrades E.g. $B_s$ at Tevatron Run-II, HERA-II

- Much more to come…