Progress with the Double B-quark Fragmentation Function

SLD Collaboration Meeting 2000

by

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Talk Outline

- Motivation
- Analysis Milestones
- Selection Criteria
- Current Best Double-B energy plot
- Summary
- Future Timetable
Motivation of the Double B Hadron Fragmentation Function

- What is it?
The correlated leading B hadron energy:
\[ \frac{1}{\sigma} \cdot \frac{d^2\sigma}{dx_B dx_{\overline{B}}} \]

- Dan measured the single inclusive B hadron energy

- Perhaps the only current experiment that can
  \[ \text{Another World's First} \]

- Tests of Theory
  There are many single B-hadron predictions that ought to be adaptable to the double B case; the correlation between hemispheres needs be calculated.

- We can test against various functional forms

- Catch up with, and prompt further theoretical work
written by *Burrows, Del Duca, Hoyer*
explicitly predicts the energy correlations between the B hadrons

- In general, $b \bar{b}$ events described by 3 independent variables:
  $X_b = E_b/E_{\text{beam}}$,
  $X_{\bar{b}}$,
  $\Psi =$ angle between the two

- The probability density $P(X_b, X_{\bar{b}}; \Psi)$ is calculable in pQCD

- If fragmentation is scale invariant, then the double moments of $P(X_b, X_{\bar{b}})$ are related to the single B hadron moments, $P(X_b)$:

\[
D_{kl} = M_k M_l P_{kl}
\]

\[
D_{kl} = x_B^k x_{\bar{b}}^l P(X_B, X_{\bar{b}}; Y) dx_B dx_{\bar{b}}
\]

\[
M_k = x^k P(X_B) dx
\]

\[
P_{kl}(\Psi) = x_b^{k-1} x_{\bar{b}}^{l-1} P(X_b, X_{\bar{b}}; \Psi) dx_b dx_{\bar{b}}
\]
Of course, $X_b$ is unmeasurable, but I am able to use $X_B$ by virtue of Dan’s analysis:

- The single moment: $M_k = A_{NP}^k P^k_{QCD}$
- The double moment: $D_{kl} = A_{NP}^k A_{NP}^l P^{kl}_{QCD}$

The non-perturbative effects are explicitly measured in the single inclusive analysis, thereby leading to an *absolute prediction* for the double B hadron energy correlations.
The plots show the expected behavior of the double moments $P_{kl}$:

- progressive decrease with increasing $k,l$
- small mass dependence
Figure 1
Further Relevance of the Double-B Analysis

- B-fragmentation is among the largest systematics in heavy flavor analysis
- Correlation not varied: Don’t know how
- Potentially large systematic in the measurement of $R_b$

$$N_b = 2N(R_b \varepsilon_b + R_c \varepsilon_c + R_s \varepsilon_s + ...)$$

$$N_{bb} = N(R_b \varepsilon_b^2 \lambda_b + ...)$$

The Double-B analysis will resolve the problem
Milestones

- Reproduce single inclusive $B$ energy distribution, using the full data set and compare with Dan.
- Selection of event with a measurable $B$ and $\bar{B}$
- Obtain the raw double-$B$ energy distribution
- Compare with:
  - $\rightarrow$ correlations inferred from single $B$ analysis
  - $\rightarrow$ ad hoc functional forms
  - $\rightarrow$ prediction of the explicit correlations between the $B$’s
Selection Details

- The cuts used for the single B analysis gave a final selection efficiency of 4%. \((4\%)^2 = 0.16\%\) for the \(B\bar{B}\) selection!

- Standard point of reference are the Mpt plots, and cuts imposed on this variable.

- **NO CUT ON MPT** \(\rightarrow 90\%\) percent pure
  \(\rightarrow 50\%\) efficient

150481 \(b\bar{b}\) passed hadronic selection
ZVTOP finds 83548 events with a vtx in each hemi
75205 \(b\bar{b}\)
8253 \(c\bar{c}\)
90 u/d/s

- Not yet tried to implement the neural net selection

- \(M_0^2\) cut crucial for resolution but destroys efficiency
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<th>-1 &lt; m0 &lt; X</th>
<th>Tot. BB</th>
<th>Non BB</th>
<th>BB sel. Efficiency</th>
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*I am not trading off efficiency-vs-purity, but rather efficiency-vs-resolution*
Distribution of the Scaled B Hadron Energies

97/98 all Flavor MC
Distribution of the Scaled B Hadron Energies

\[ \sqrt{17} \ 96+97+98 \]

Data: 1338 events
Summary

- Repeated Dan’s single inclusive analysis: we agree
- Taken a first look at reconstructing $B\bar{B}$ events
  -> tighter cuts yield 76 events in the data
  -> looser cuts yield 1338 event
  -> A factor 18 increase in data
  -> degraded resolution by a factor 1.5

- Detailed exploration of the parameter space
  -> try to recover the resolution
Planned Timetable

There will not be a result for the summer or winter conferences.

I will present the results of the updated 1D analysis at DPF in August.

Preliminary result of the 2D analysis ready for Moriond.

Final result and any corresponding publication should be signed and sealed by Fall 2001.