$A_c$, $A_b$ with Vertex/Kaon Charge

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SLD Collaboration Meeting
Kirkwood, June 21-23, 2000
Current Status

Currently have three self-calibrated results using these tags:

- $A_c = 0.588 \pm 0.031 \pm 0.025$, VTX+K tag (96-98 R15)
- $A_b = 0.997 \pm 0.044 \pm 0.065$, K tag (97-98 R16)
- $A_b = 0.926 \pm 0.019 \pm 0.028$, VTX tag (97-98 R17)

Would like to have one analysis for $A_c/A_b$:

- for 96-98 R17
- using both tags, for better calibration statistics
- same ZVTOP/tagging/track settings
- incorporate VXD-only vectors/NN tagging
- new $K$ efficiency corrections from Jodi/Stéphane
Neural-Net Tagging

Similar to BZMASS, but with selection cuts replaced by neural-networks.

- Seed vertex selection uses:
  - \( D \) - distance to IP
  - \( D/\sigma_D \) - normalized by error
  - \( \angle \vec{P} \vec{D} \) - angle between \( \vec{P} \) and \( \vec{D} \)

- Attach remaining tracks to selected vertices using:
  - \( T \) - transverse POCA of track to \( \vec{D} \)
  - \( L \) - length along \( \vec{D} \) at which POCA is found
  - \( L/D \) - normalized by \( D \)
  - \( \angle \vec{p} \vec{D} \) - angle between \( \vec{p} \) and \( \vec{D} \)
  - \( b/\sigma_b \) - normalized 3D impact parameter to IP

- VXN-only vectors attached using same vars as for tracks
Flavor Tagging

charm tag: \[ 0.5 < M_{VTX} < 2 \text{ GeV} \]

\[ P_{VTX} > 5 \text{ GeV} \]

\[ P_{VTX} - 15 \times M_{VTX} > -10 \text{ GeV} \]

bottom tag: \[ M_{VTX} > 2 \text{ GeV} \]

\[ \eta_c = 0.193, \ \epsilon_b = 0.566 \]
Quark Tagging

Two methods: Charge of the vertex or of attached kaons

charm: $\epsilon_{VTX} \sim 0.47$, $\epsilon_K \sim 0.24$
bottom: $\epsilon_{VTX} \sim 0.57$, $\epsilon_K \sim 0.27$
Tag Combination

The two tags make four combinations

<table>
<thead>
<tr>
<th></th>
<th>$p_c$</th>
<th>$P_b$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V = K$</td>
<td>0.988</td>
<td>0.910</td>
</tr>
<tr>
<td>$V, V \neq K$</td>
<td>0.713</td>
<td>0.613</td>
</tr>
<tr>
<td>$V$ only</td>
<td>0.923</td>
<td>0.813</td>
</tr>
<tr>
<td>$K$ only</td>
<td>0.918</td>
<td>0.648</td>
</tr>
</tbody>
</table>

The $P_b$ column includes mixing effects.

Should be possible to use a separate tag for each combination, to maximize statistics.

For now, lump them together taking:

$V$ first if nonzero,
else $K$.

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<th>$P_b$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V \rightarrow K$</td>
<td>0.920</td>
<td>0.788</td>
</tr>
</tbody>
</table>
Calibration

Calibrate using max-\( \mathcal{L} \) fit to numbers of events observed for each combination of tags, for example double-charm-tagged, same sign or charm-tag+bottom-tag, opposite sign, etc.

Fixing \( R_b \) and \( R_c \), can extract:

- charm tag: \( \eta_c, \eta_b, p_c, p_b \)
- bottom tag: \( \epsilon_b, \epsilon_c, P_b \)

Results for 96-98 data:

<table>
<thead>
<tr>
<th></th>
<th>MC</th>
<th>data calib.</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \eta_c )</td>
<td>0.194</td>
<td>0.193±0.002</td>
</tr>
<tr>
<td>( f_c )</td>
<td>0.898</td>
<td>0.886±0.003</td>
</tr>
<tr>
<td>( p_c )</td>
<td>0.923</td>
<td>0.908±0.010</td>
</tr>
<tr>
<td>( p_b )</td>
<td>0.504</td>
<td>0.520±0.031</td>
</tr>
<tr>
<td>( \epsilon_b )</td>
<td>0.576</td>
<td>0.566±0.002</td>
</tr>
<tr>
<td>( F_b )</td>
<td>0.966</td>
<td>0.955±0.005</td>
</tr>
<tr>
<td>( P_b )</td>
<td>0.805</td>
<td>0.805±0.004</td>
</tr>
</tbody>
</table>

For \( f, p, F, P \) the numbers are averages over all events used in the corresponding asymmetry fit.
Results

Events are pretty clearly separated into $c$ and $b$ samples
\[ \implies \text{do separate } A_b \text{ and } A_c \text{ fits} \]

Fits are to usual polarized cross-section, using thrust axis:
\[
\mathcal{L} \sim (1 - A_e P_e)(1 + \cos^2 \theta) + 2(A_e - P_e) A_f \cos \theta
\]

MC shapes are used for the $\cos \theta$ dependences:

Fitting all the 96-98 R17 data gives:

\[
A_c = 0.667 \pm 0.028 \pm 0.020 \\
A_b = 0.928 \pm 0.018 \pm 0.013
\]

Where the second error is due to calibration statistics.

**The good news:**

$A_b$ is in good agreement with the previous results.

**The bad news:**

$A_c$ is quite a bit higher than what was seen before.
What’s up with $A_c$?

Still have old R15 ntuples - analyze with new code
$\implies$ can reproduce old $A_c$ result

Use MC $f_c$, $p_c$ instead of calibrated ones
$\implies$ both sets say $A_c \sim 0.64$

Difference looks to be in calibrated $p_c$

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<tr>
<td>R15</td>
<td>0.921</td>
<td>0.943±0.012</td>
</tr>
<tr>
<td>R17</td>
<td>0.934</td>
<td>0.917±0.011</td>
</tr>
</tbody>
</table>

These numbers don’t include hemis with $V\neq K$, which were discarded for the R15 measurement.

How can it be so different? Check overlap of double-charged events, used for the calibration.

R15: 407 events
R17: 530 events
Overlap: $\sim$180 events

Guess it could just be statistics...
Polar Angle Dependence

Check stability of result versus polar-angle cutoff.

For self-calibrated purity, analyzing power:

For Monte Carlo purity, analyzing power:
**Tracking Efficiency**

VXD3 and CDC are (almost) independent trackers. Start with a good track (or VXD vector) and see how often you get the other piece.

\[
\frac{(L_{MC}/T_{MC})}{(L_{data}/T_{data})}
\]

\[
\frac{(L_{MC}/V_{MC})}{(L_{data}/V_{data})}
\]

\(L=\#\text{linked tracks, } T=\#\text{CDC tracks, } V=\#\text{VXD vectors}\)

Need better simulation of CDC at high \(\cos \theta\)?
**ToDo**

- figure out $A_c$ R15/R17 situation
- find optimal tag setup
- tag consistency checks
- study tracking efficiency for $\cos \theta$ shapes
- new QCD corrections
- study hemisphere correlations
- generate results for ICHEP if all goes well