Search for Additional Decay Modes of and Partners to the $D_{sJ}^{*}(2317)^+$

- CDF Search Strategy
- Reconstructed Charm Samples
- Benchmark $D^{**}$ Modes
- Search Modes
- Conclusions

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CDF Search Strategy:

- Discovery of $D_{sJ}^*(2317)^+$ by Babar sparked a flurry of theory papers
- While Cleo’s discovery of $D_{sJ}^*(2463)^+$ favors a conventional interpretation of the states, it is important to fully explore all possibilities

  → Can CDF make a contribution to the study of $D_{sJ}$ states?

- CDF EM Calorimeter not appropriate for searches involving $\pi^0$
- Concentrate on all-charged modes:
  - $D_{sJ} \rightarrow D_s \pi^+ \pi^-$
    - $J^P = 0^+$ assignment forbids this mode for $D_{sJ}^*(2317)^+$
    - $J^P = 1^+$ assignment permits this mode for $D_{sJ}^*(2463)^+$, but no evidence of this mode from Cleo
  - $D_{sJ} \rightarrow D_s \pi^\pm$
    - Would imply isovector assignment for $D_{sJ}$
    - Four quark or $DK$ molecule interpretations possible
Estimating CDF’s Sensitivity

- No prediction exists for $D_{sJ}$ production cross section
- CDF not sensitive to $D_s \pi^0$ mode
- Can infer sensitivity to search modes by studying well known $D^{**} \rightarrow D \pi$ modes
  - Provides demonstration of CDF’s reconstruction capabilities
  - Provides estimate of $D^{**} : D$ relative production rates in hadron collisions
- $D^{**}$ yields, together with relative $D_s : D$ rates allow approximate estimate of sensitivity
- Alternate normalization using $D^{**} \rightarrow DK$ in progress
**Charm Reconstruction at CDF**

- *D* Events collected using CDF Silicon Vertex Trigger
- $735K \ D^0 \rightarrow K\pi$, $572K \ D^+ \rightarrow K\pi\pi$ with good mass resolution and good S:B
- $\sim 88\%$ direct charm, remainder from $B$ decays
\[ D_s \rightarrow D_s\pi \]

CDF Run II Preliminary

- Signal Window: 24600 \( D_s^+ \)s
- RMS: 7.6 MeV/c^2

\( \pm 19 \) ~80 pb^{-1}

- Use \( |\cos \theta_{helicity}| > 0.4 \) to improve S:B
- 24,600 \( D_s \rightarrow \phi\pi \) remain
- About \( \frac{1}{3} \) size of Babar \( D_s \) sample
  - Adequate sample size for meaningful search
- ~77\% direct charm, remainder from \( B \) decays
$D\pi$ Reconstruction

- No attempt to remove $B \rightarrow DX$ component
- Vertex constrain $D$ track combination
- Mass constrain $D$ candidate tracks
- Procedure gives slightly better resolution than plotting $\Delta M$
- But no qualitative change over using $\Delta M$
Benchmark I: $D_2^{*0} \rightarrow D^+\pi$

- 9100 $\pm$ 300 $D_2^{*0}$ events
- Reflections from $D_1^0$ and $D_2^{*0}$ with lost $\pi^0$
- No Structure in $D^+\pi^+$
Benchmark II: $D^*_2 \rightarrow D^0 \pi^+$

- Dominant Structure: $D^{*+}$ (see inset)
- $5400 \pm 400$ $D^*_2$ events
- Reflections from $D^+_1$ and $D^+_2$ with lost $\pi^0$
- Some Reflection Structure in $D^0 \pi^-$

CDF Run II Preliminary

5400 ± 400 $D^*_2$ Candidates
Mass: 2463.6 ± 2.7(stat) MeV/c$^2$

$2282.5 \pm 4.1$(stat) MeV/c$^2$
$2318.9 \pm 11.1$(stat) MeV/c$^2$

CDF-FPCP/M, Shapiro/June 2003/8
Search Mode I: $D_s \pi \pi$ Mass Distribution

- No Evidence of Resonant Structure at either 2317 or 2463
  - Consistent with Cleo Search
- No Structure in $D_s^+ \pi^+ \pi^+$ and $D_s^+ \pi^- \pi^-$
Search Mode II: $D_s\pi$ Mass Distribution

CDF Run II Preliminary

- No Evidence of Resonant Structure
- First Search in this Mode

Absence of $D_s\pi$ mode → isovector and four-quark interpretations of $D_{sJ}^*(2317)^+$ disfavored
Conclusions

- CDF has searched for the decays $D_{sJ} \rightarrow D_s \pi^+ \pi^-$ and $D_{sJ} \rightarrow D_s \pi^\pm$
- Sensitivity is estimated using benchmark $D^{**}$ modes:

<table>
<thead>
<tr>
<th>Mode</th>
<th># D Candidates</th>
<th># $D^{**}$ Candidates</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D_{2}^{*0} \rightarrow D^+ \pi^-$</td>
<td>735K</td>
<td>9.1K</td>
</tr>
<tr>
<td>$D_{2}^{*+} \rightarrow D^0 \pi^+$</td>
<td>572K</td>
<td>5.4K</td>
</tr>
</tbody>
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- In sample of 24.6K $D_s$ Candidates, no evidence for $D_{sJ}$ states is seen
  - $D_{sJ} \rightarrow D_s \pi^+ \pi^-$ results consistent with Cleo
  - This is first $D_{sJ} \rightarrow D_s \pi^\pm$ search presented

- Work continuing on quantifying limits using $D_s^{**} \rightarrow DK$ for normalization