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 interpretion of the states, it is important to fully explore all possibilities

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

- CDF EM Calorimeter not appropriate for searches involving π^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 know $D^{**} \to D\pi$ 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 $D_s^{**} \to DK$ in progress

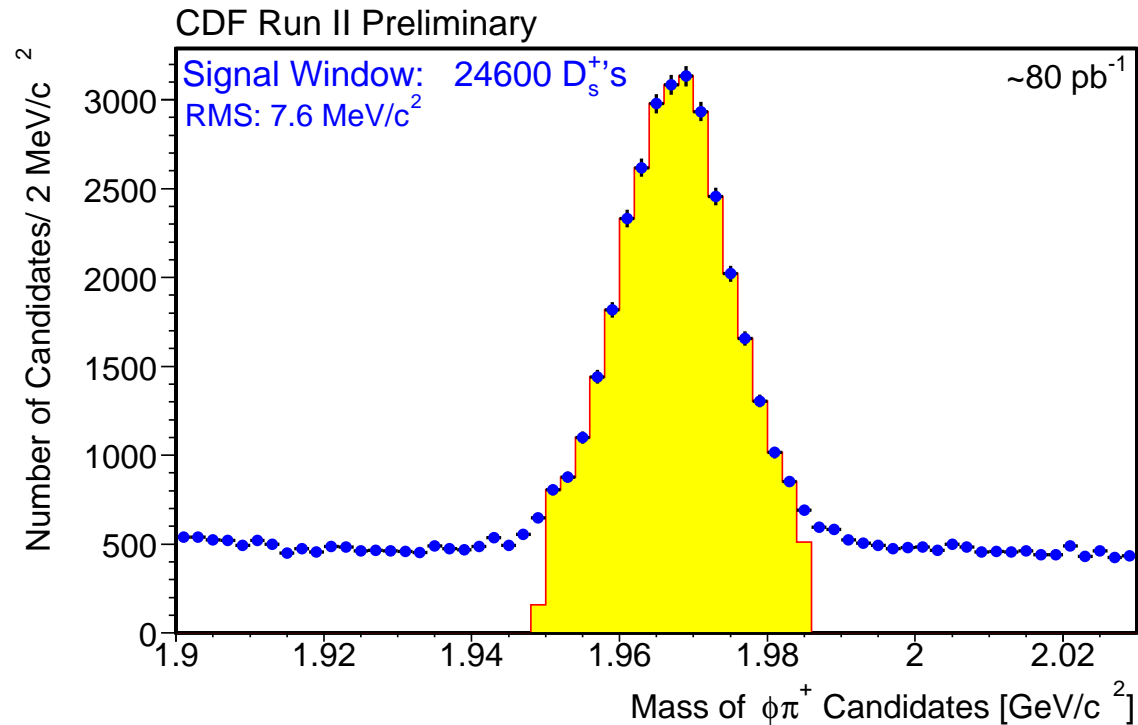# Charm Reconstruction at CDF
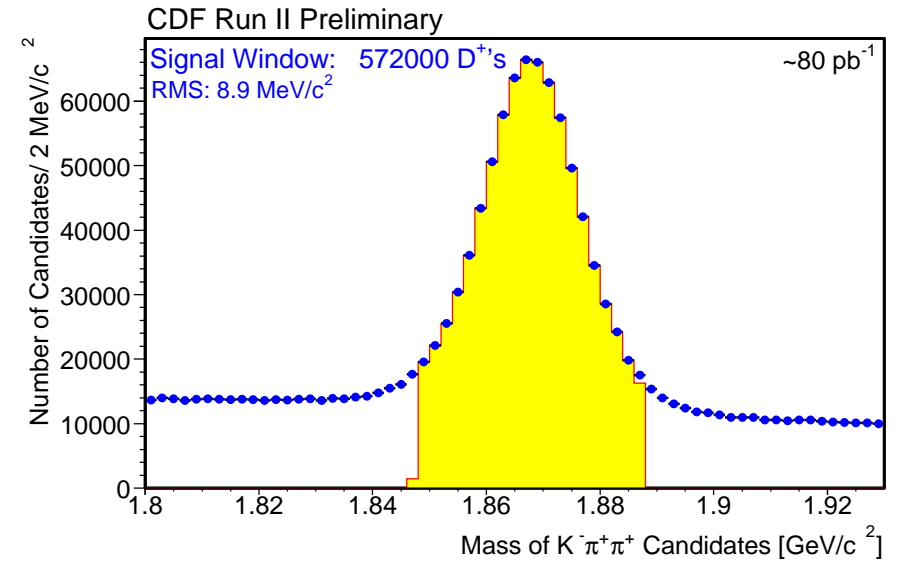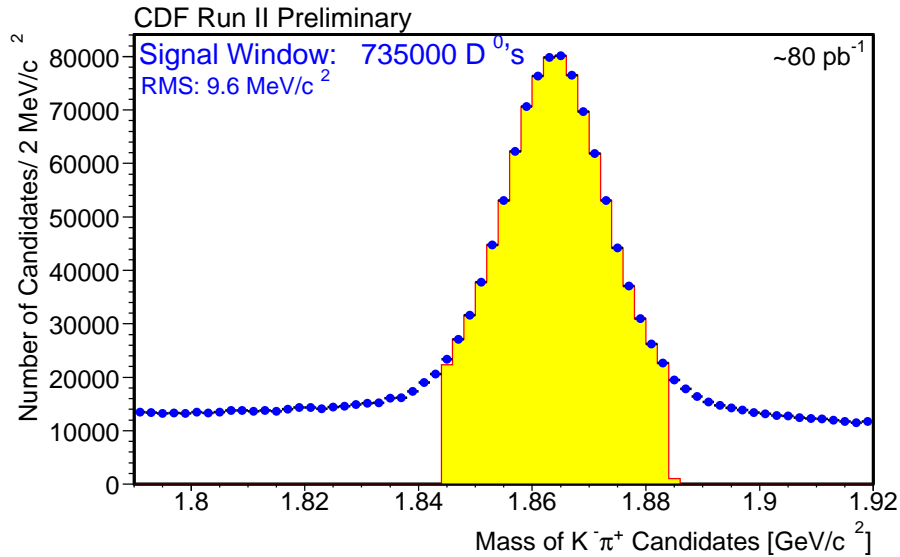
- D Events collected using CDF Silicon Vertex Trigger

- 735K $D^0 \to K\pi$, 572K $D^+ \to K\pi\pi$ with good mass resolution and good S:B

- $\sim 88\%$ direct charm, remainder from B decays

$$D_s \rightarrow D_s \pi$$

Number of Candidates/ 2 MeV/c^2

Signal Window: 24600 $D_s^{+\prime}$'s

RMS: 7.6 MeV/c^2

~80 pb^{-1}

3000
2500
2000
1500
1000
500
0

1.9   1.92   1.94   1.96   1.98   2   2.02

Mass of $\phi\pi^+$ Candidates [GeV/c^2]

- Use $\left|\cos\theta_{helicity}\right| > 0.4$ to improve S:B

- 24,600 $D_s \rightarrow \phi\pi$ remain

- About $\frac{1}{3}$ size of Babar D_s sample

  $\rightarrow$ Adequate sample size for meaningful search
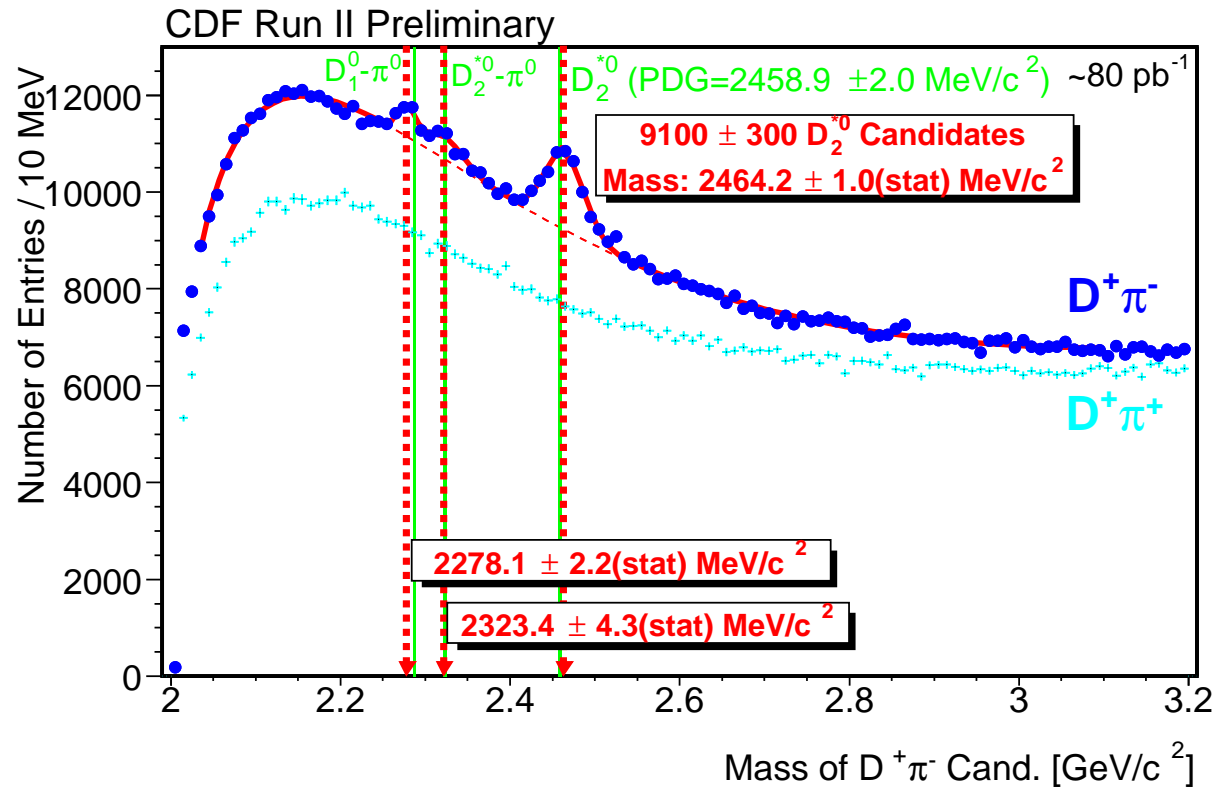
- $\sim 77\%$ direct charm, remainder from B decays

$D\pi$ Reconstruction

- No attempt to remove $B \to DX$ component

- Vertex constrain D track combination

- Mass constrain D candidate tracks

- Procedure gives slightly better resolution than plotting ΔM
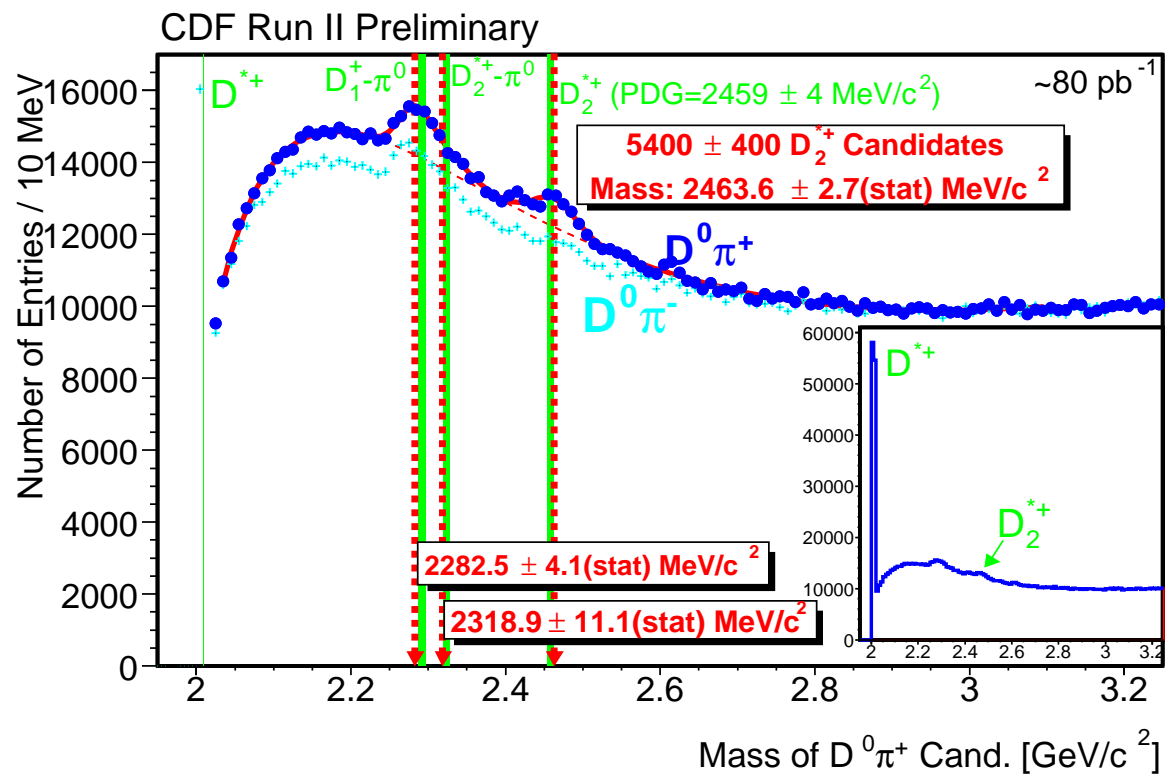
- But no qualitative change over using ΔM

Benchmark I: $D_2^{*0} \to D^+\pi^-$

CDF Run II Preliminary

D_1^0-π^0 D_2^{*0}-π^0 D_2^{*0} (PDG=2458.9 ±2.0 MeV/c^2)   ~80 pb^{-1}

9100 ± 300 D_2^{*0} Candidates

Mass: 2464.2 ± 1.0(stat) MeV/c^2

$D^+\pi^-$

$D^+\pi^+$

2278.1 ± 2.2(stat) MeV/c^2

2323.4 ± 4.3(stat) MeV/c^2

Number of Entries / 10 MeV

Mass of D$^+\pi^-$ Cand. [GeV/c^2]

- 9100 ± 300 D_2^{*0} events

- Reflections from D_1^0 and D_2^{*0} with lost π^0

- No Structure in $D^+\pi^+$
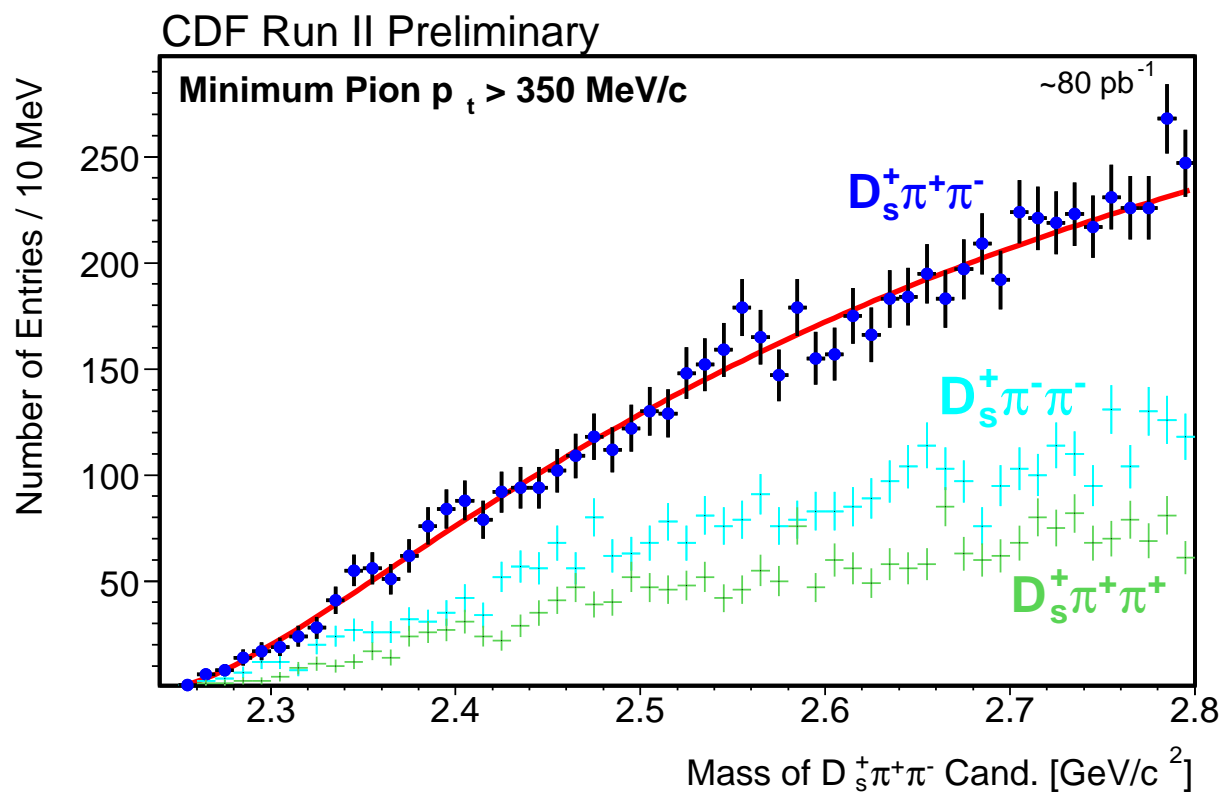
Benchmark II: $D_2^{*+} \rightarrow D^0\pi^+$

- Dominant Structure: D^{*+} (see inset)

- 5400 ± 400 D_2^{*+} events

- Reflections from D_1^+ and D_2^+ with lost π^0

- Some Reflection Structure in $D^0\pi^-$
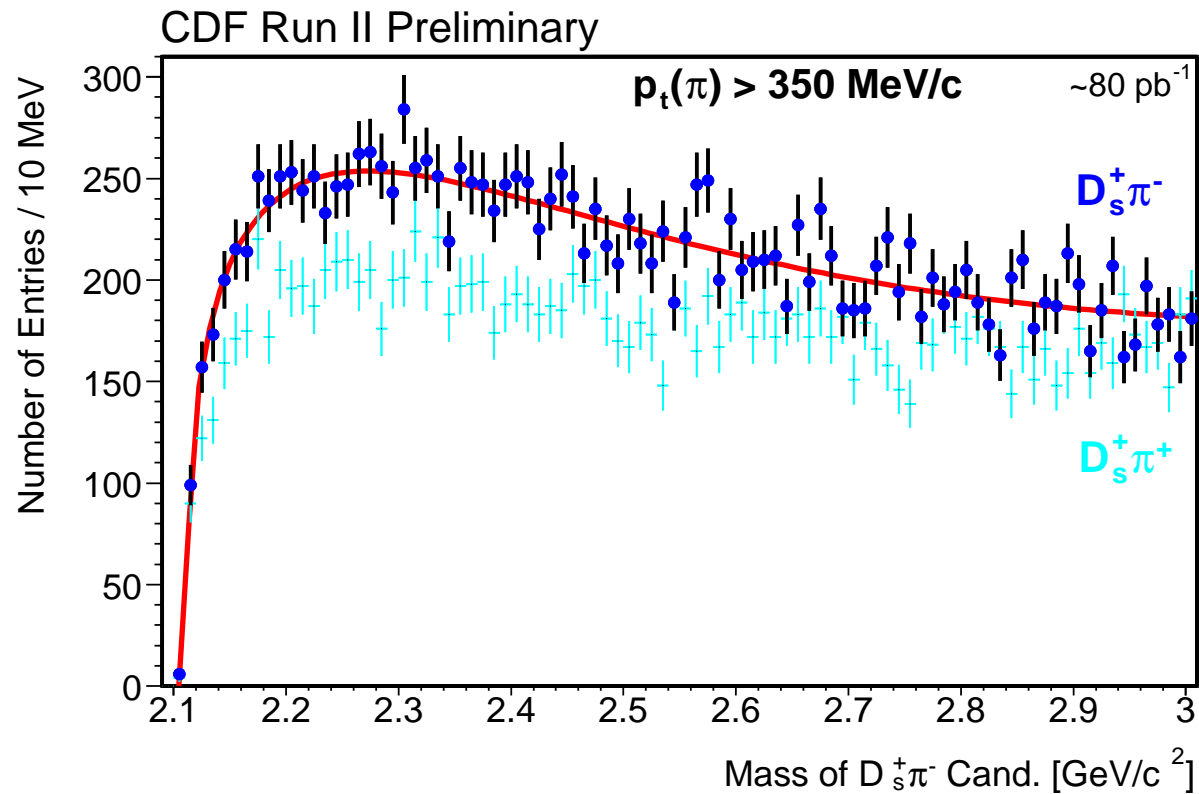
Search Mode I: $D_s\pi\pi$ Mass Distribution

CDF Run II Preliminary

Minimum Pion p$_t$ > 350 MeV/c

~80 pb^{-1}

$D_s^+\pi^+\pi^-$

$D_s^+\pi^-\pi^-$

$D_s^+\pi^+\pi^+$

Number of Entries / 10 MeV

Mass of $D_s^+\pi^+\pi^-$ Cand. [GeV/c^2]

- No Evidence of Resonant Structure at either 2317 or 2463

$\longrightarrow$ 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

$p_t(\pi) > 350$ MeV/c   ~80 pb^{-1}

$D_s^+\pi^-$

$D_s^+\pi^+$

Number of Entries / 10 MeV

Mass of D$_s^+\pi^-$ Cand. [GeV/c^2]

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

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

Conclusions

- CDF has searched for the decays $D_{sJ} \to D_s \pi^+ \pi^-$ and $D_{sJ} \to D_s \pi^\pm$

- Sensitivity is estimated using benchmark D^{**} modes:

Mode	# D Candidates	# D^{**} Candidates
$D_2^{*0} \to D^+ \pi^-$	735K	9.1K
$D_2^{*+} \to D^0 \pi^+$	572K	5.4K

- In sample of 24.6K D_s Candidates, no evidence for D_{sJ} states is seen

  – $D_{sJ} \to D_s \pi^+ \pi^-$ results consistent with Cleo

  – This is first $D_{sJ} \to D_s \pi^\pm$ search presented

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