Search for Charmed Pentaquark States at CDF

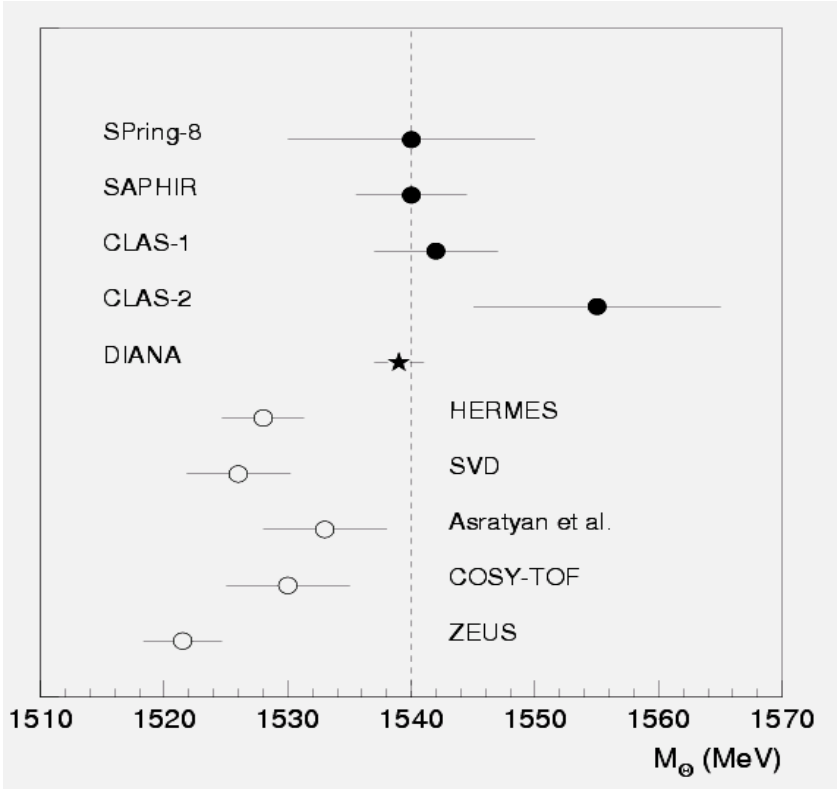
Chicago Flavor Seminar
May 21, 2004

YeonSei Chung
University of Rochester
for the CDF Collaboration

Overview

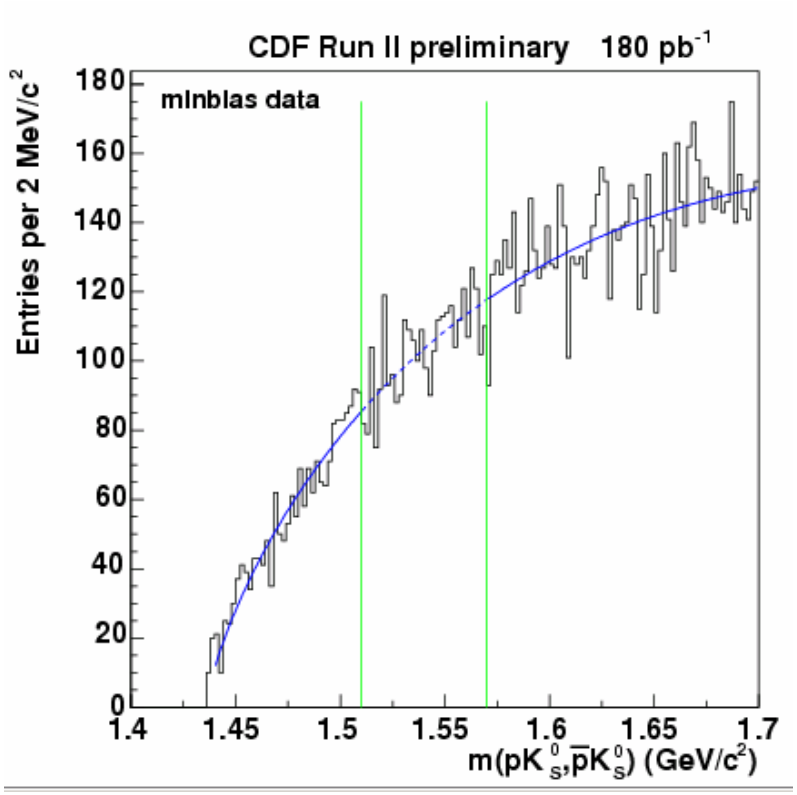
Θ^+ ($uudd\bar{s}$) s=+1
M~1.53 GeV/c²
Γ~15 MeV/c²

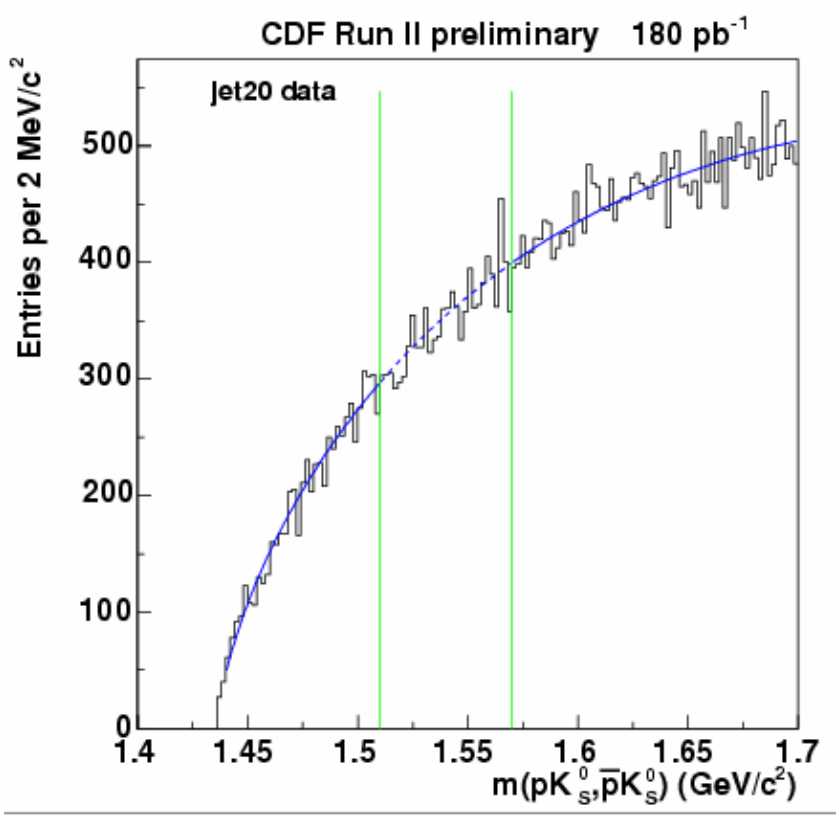
10 experiments report evidence
Many experiments report no observation
(HERA-B, PHENIX, BES, BaBar, CDF, and ….)



$\Xi_{3/2}$ ($qsqs\bar{q}$) : s=−2, M=1.862 GeV/c²
Γ < a detector resolution ~18 MeV/c²
NA49 observed. CDF – Elena's talk

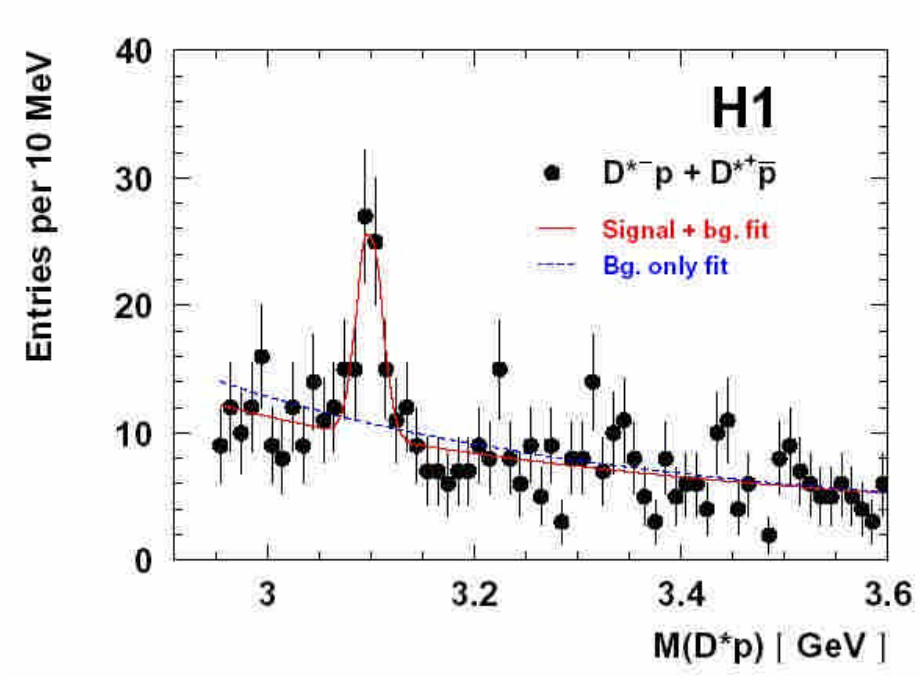
CDF : $\Theta \rightarrow pK^0_s$

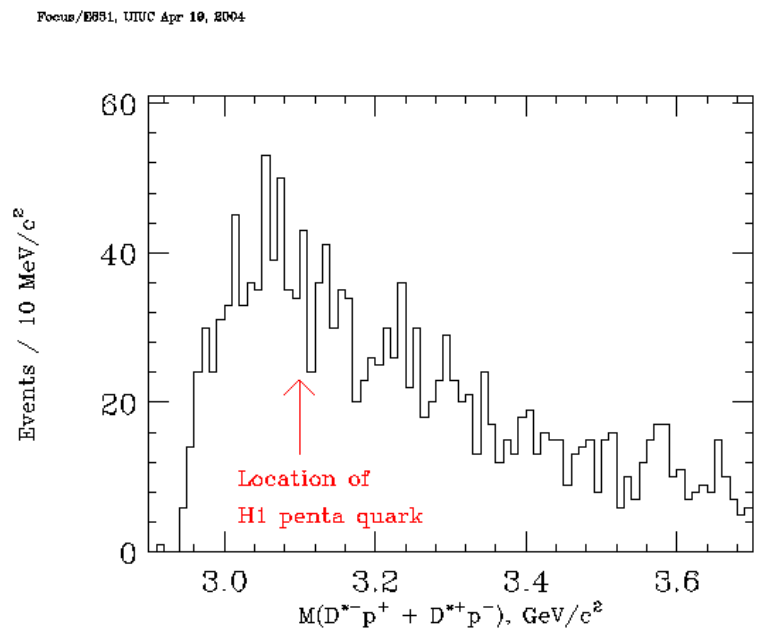




No evidence of narrow resonance

Θ_c^0 (uudd$\bar{c}$) → D*$^{\mp}$p+c.c.





H1 at HERA (hep-ex/0403017)

mass = 3.099 GeV/c²

Γ < an experimental resolution

www-focus.fnal.gov/penta/penta_charm.html

FOCUS(E831) at FNAL

Charm Photoproduction Exp.

No evidence

Data Sample

CDF II Detector at Fermilab

- $p\bar{p}$ collisions, $\sqrt{s}$ = 1.96 TeV
- Integrated Luminosity ~ 240 pb^{-1}
- Use Two Track Trigger sample

✓ 2 oppositely-charged tracks with impact parameter>0.012cm
✓ We have about 3 million of D0->$K^-\pi^+$ reconstructed events

Search Mode

$\Theta_C^0 \rightarrow D^{*+}\bar{p}$+ c.c.

$D^{*+} \rightarrow D^0\pi^+$

$D^0 \rightarrow K^-\pi^+$

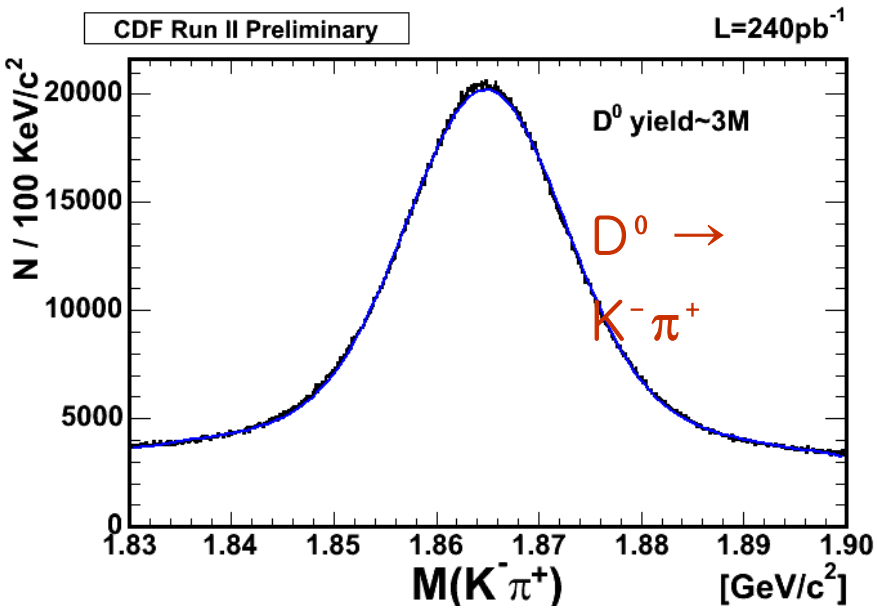
Calibration Mode

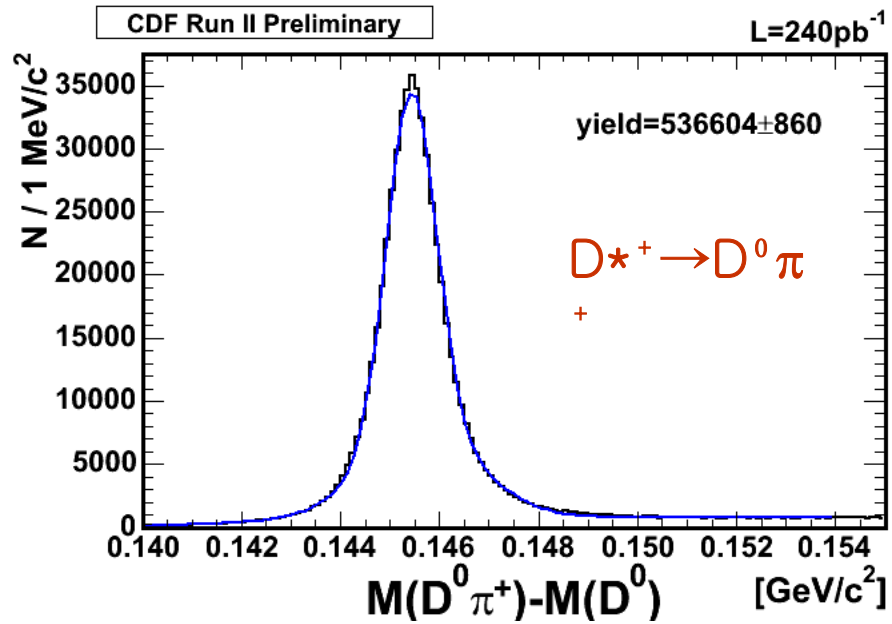
$D_1(2420), D^*_2(2460) \rightarrow D^{*+}\pi^-$+c.c.

$D^{*+} \rightarrow D^0\pi^+$

$D^0 \rightarrow K^-\pi^+$

D^0 & D*





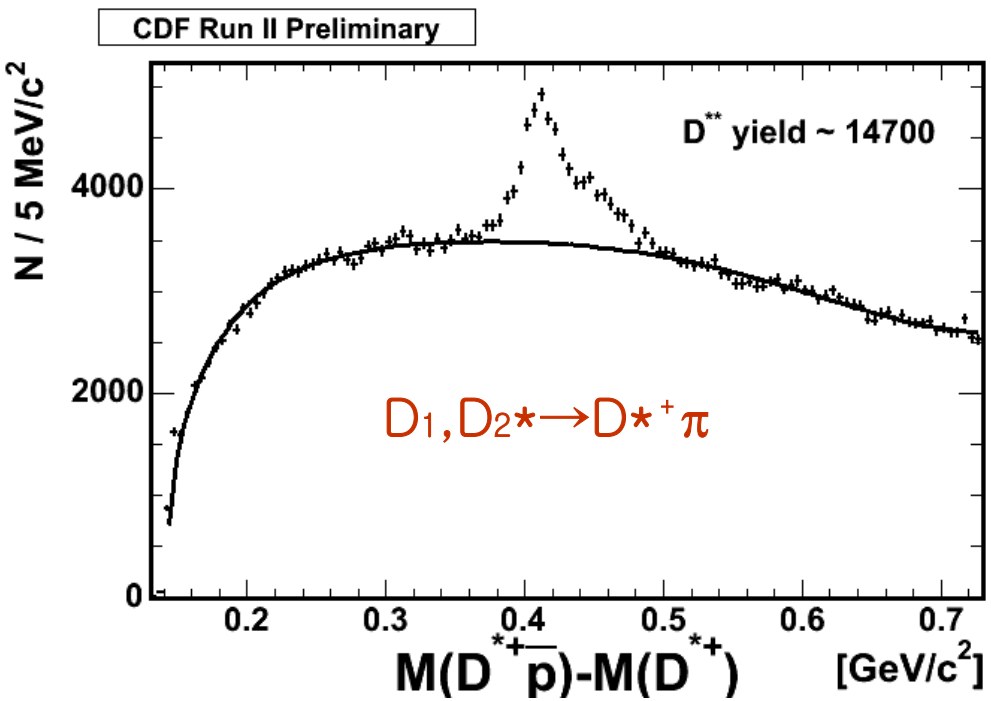
- K and π pass all tracking cuts
- K and π form a good vertex with vertex $\chi^2 < 30$

N(D^0)~ 3 M events
Sigma ~ 8 MeV/c²

- Pion pass all tracking cuts
- Pt(π) > 400 MeV
- D^0 and pion form a good vertex with vertex $\chi^2 < 30$
- 1.845 < M(D^0) < 1.885 GeV/c²

N(D*) ~0.5 M events,
Sigma ~ 1.2 MeV /c²

$D_1(2420)$ & $D_2^*(2460)$



Fit with a threshold factor times polynomial

Reference signal

Pion pass all tracking cuts

$Pt(\pi) > 500$ MeV/c

D* and pion form a good vertex

with vertex $\chi^2 < 30$

$143.6 < M(D^*) - M(D^0) < 147.2$ MeV/c²

N(D_1(2420), D_2^*(2460)) ~ 15k events

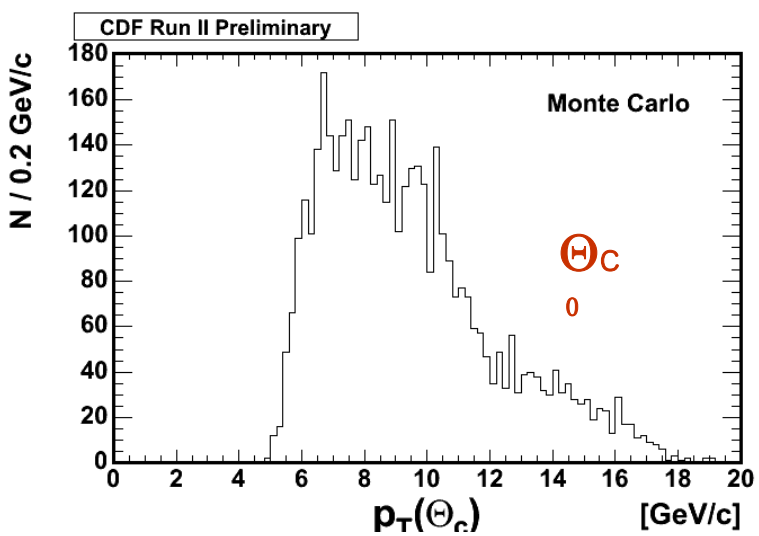
Θ_c^0 Monte Carlo

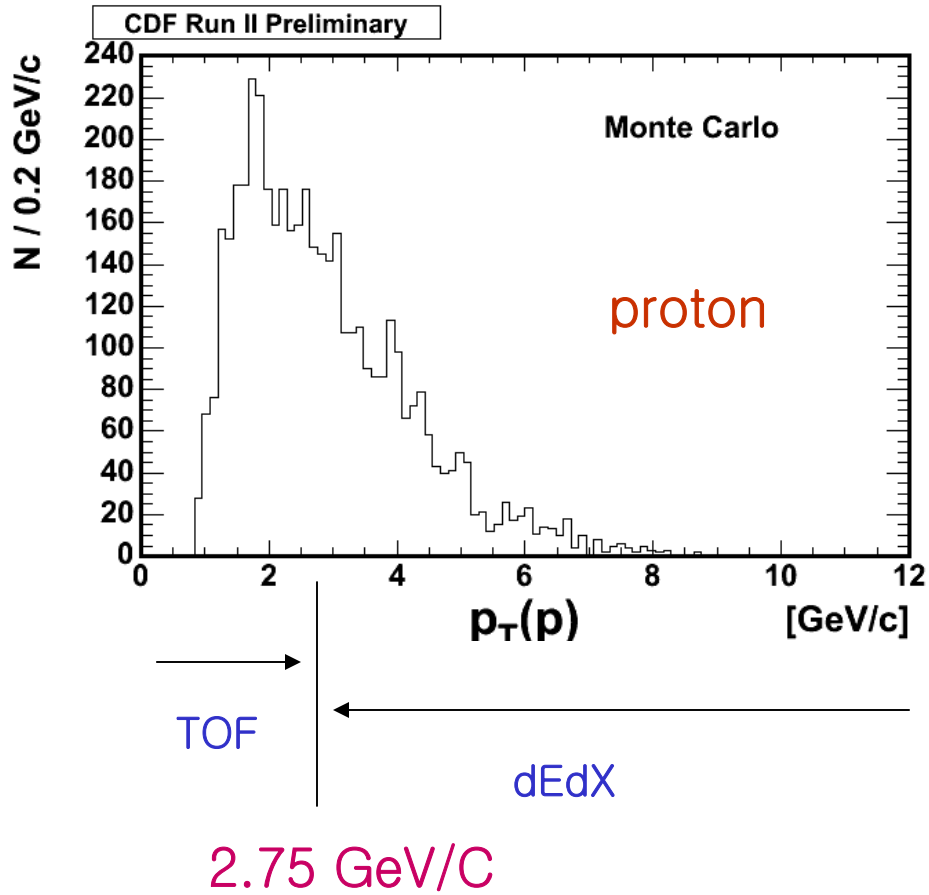
Input Parameters

- M=3.1 GeV/c²
- Γ=0.0 MeV/c²

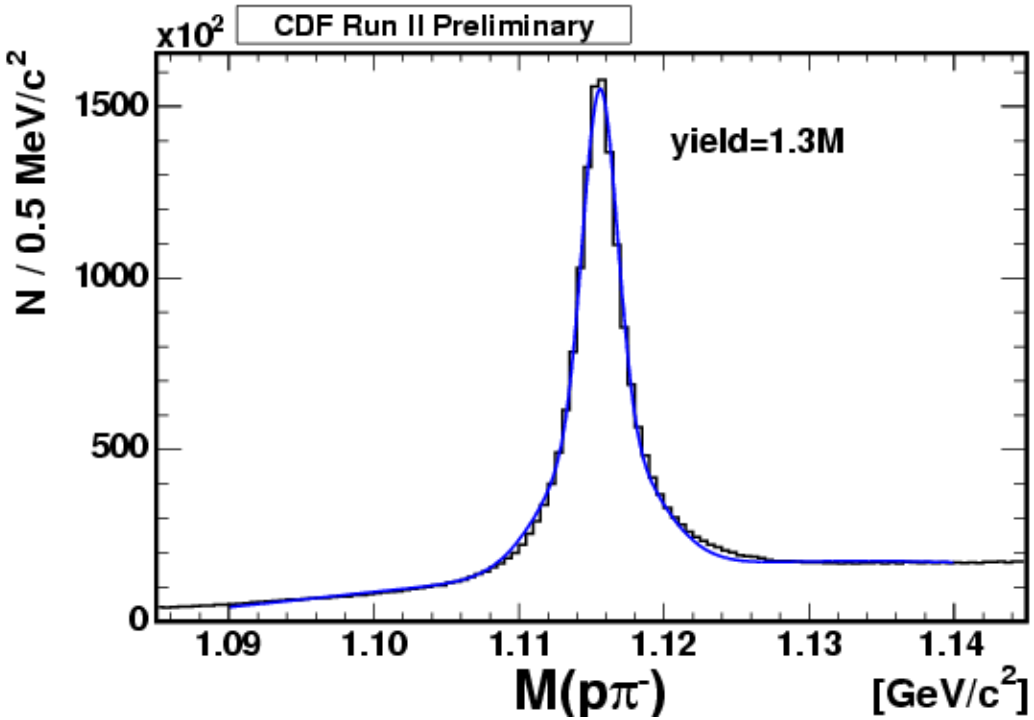
Zero Width MC Mass Resolution ~ 2.5 MeV/c²

→ should be able to resolve Θ_c^0 that H1 claims

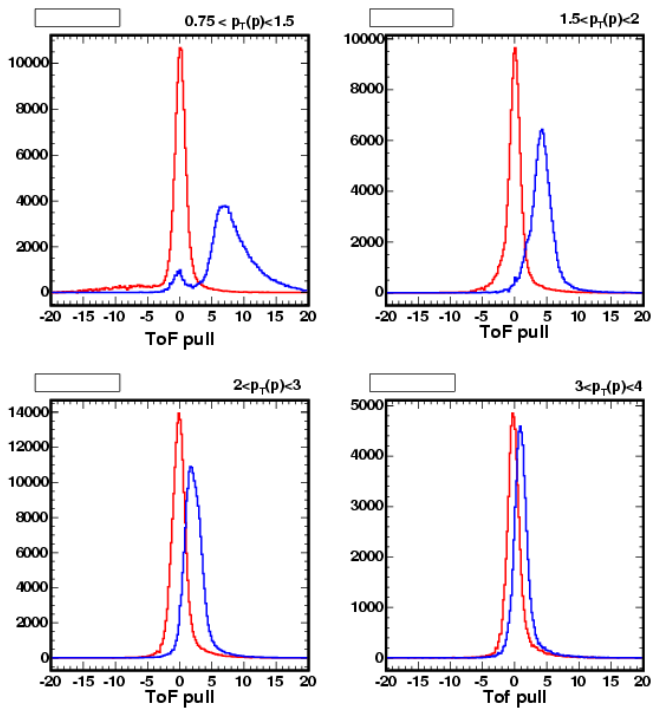




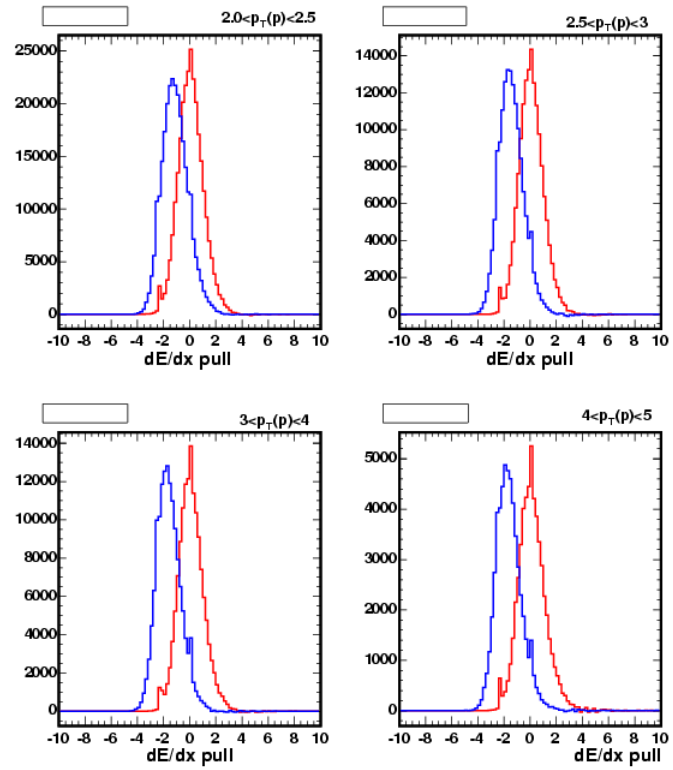
Λ Samples for PID studies



Proton PID – TOF and dEdX



TOF



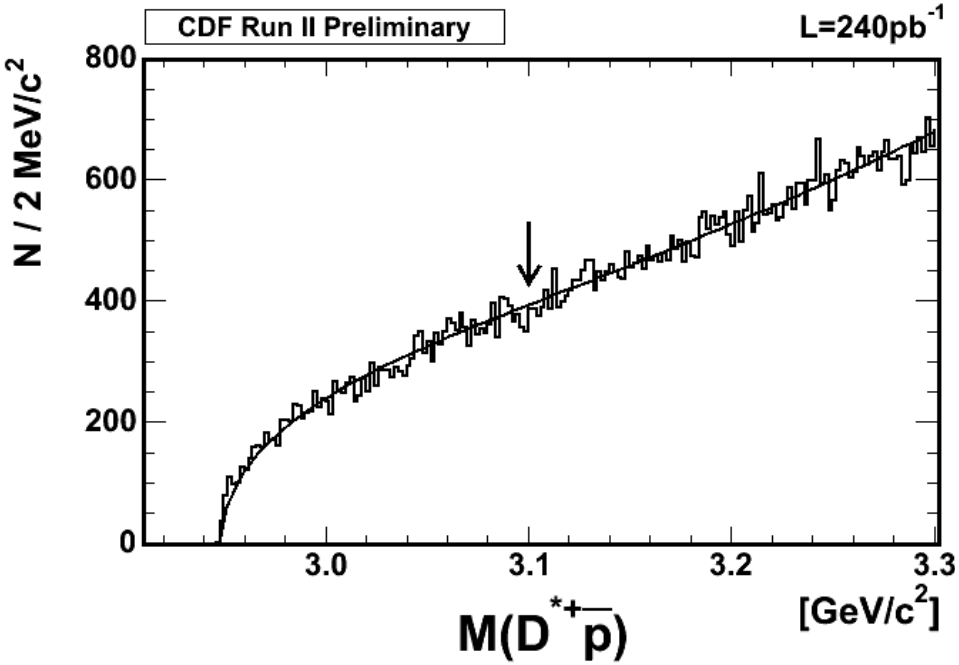
dEdX

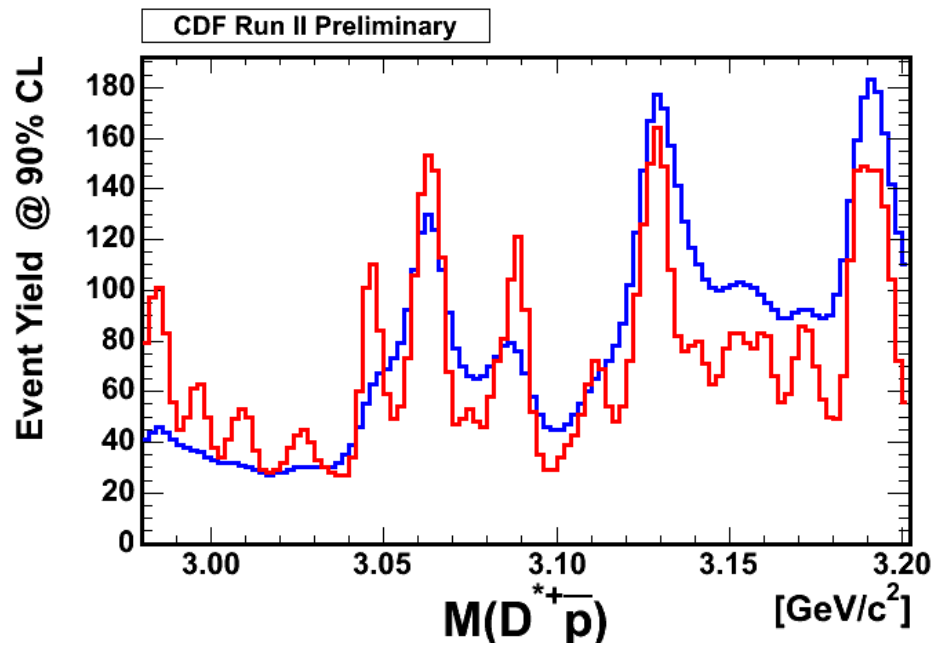
PID studies with D*, Λ, and Ks

TOF : >2σ separation between protons and pions p_T<~2.75 GeV/c

dEdX : >1.3σ separation between protons and pions p_T>~2.75 GeV/c

D*proton mass – No PID





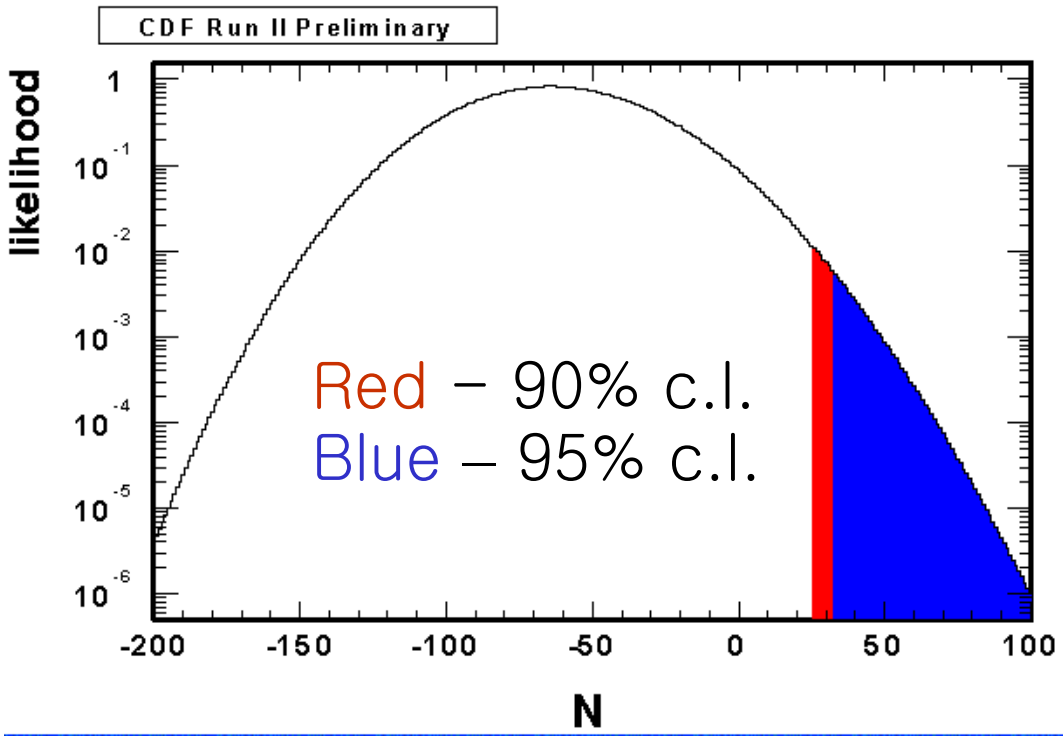
- Proton pass all tracking cuts
- Pt(proton) > 500 MeV/c
- D* and proton form a good vertex with vertex $\chi^2 < 30$
- 142.5 <M(D*)−M(D^0) < 148.5 MeV/c²
- No PID cut

For M=3.099 GeV/c²,

<29 events for Γ=0.0 MeV/c² @90% C.L.

<44 events for Γ=12.0 MeV/c² @90% C.L.

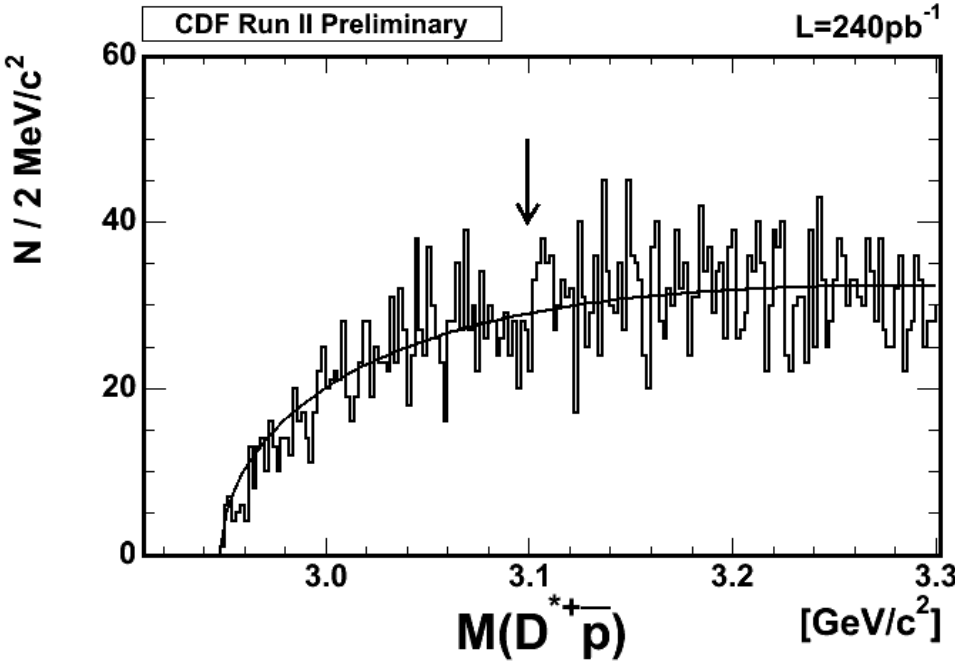
Upper Limit on the event yield

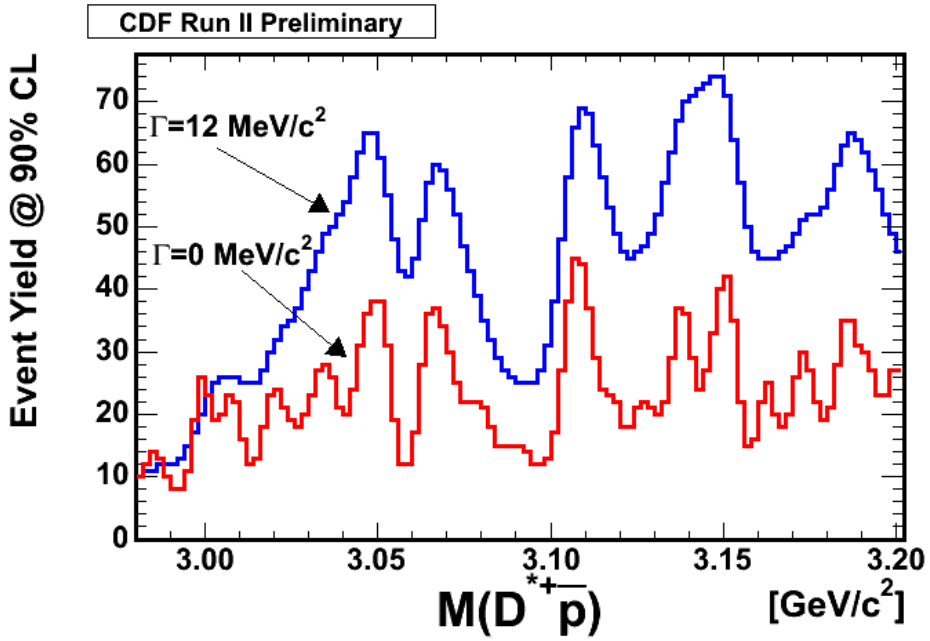


Likelihood profile

- Gaussian⊗BW + Background
- Sigma = 2.5 MeV/c²
  (Monte Carlo simulation)
- Mass = 3.099 GeV/c²
  (H1 measured)
- Width = 0.0 MeV/c²

D*proton mass with TOF





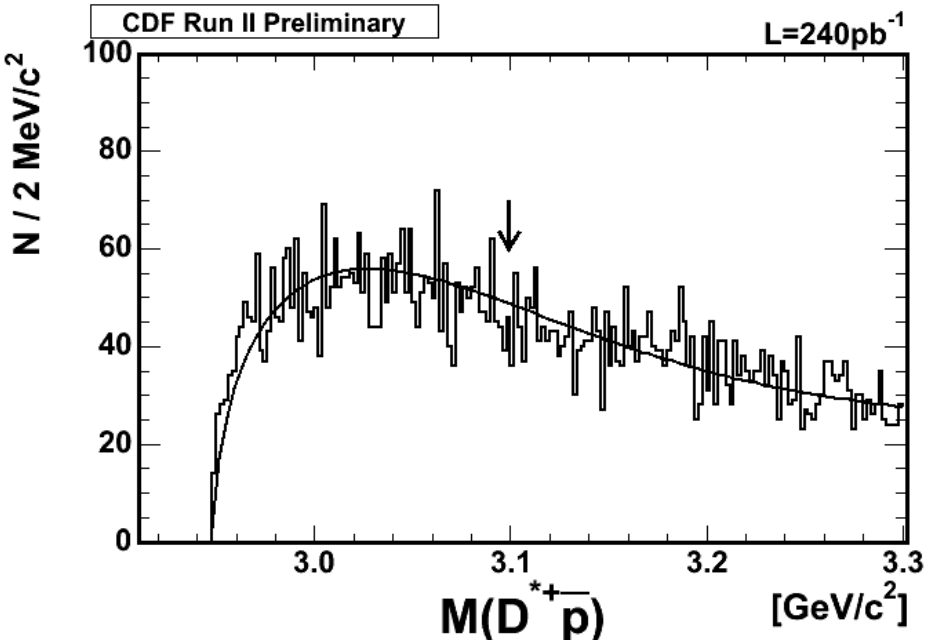
- Proton pass all tracking cuts
- 0.5 GeV/c < Pt(proton) <2.75 GeV/c
- D* and proton form a good vertex with vertex χ^2 < 30
- 142.5 <M(D*)−M(D^0) < 148.5 MeV/c^2
- TOF : (measured−expected)/error <2.0

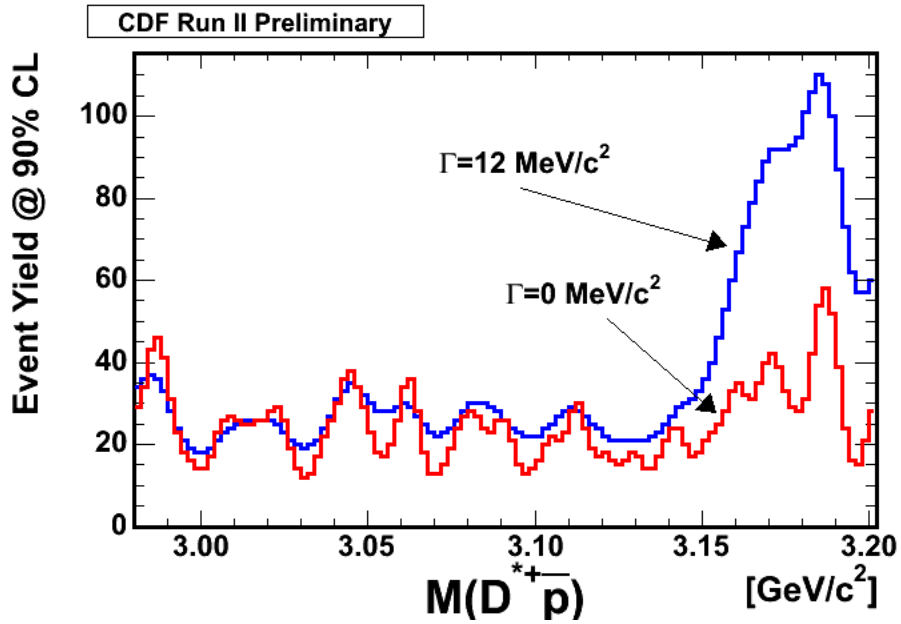
For M=3.099 GeV/c^2,

<12 events for Γ=0.0 MeV/c^2 @90% C.L.

<25 events for Γ=12.0 MeV/c^2 @90% C.L.

D*proton mass with dEdX





- Proton pass all tracking cuts
- 2.75 GeV/c < Pt(proton)
- D* and proton form a good vertex with vertex χ^2 < 30
- 142.5 <M(D*)−M(D^0) < 148.5 MeV/c^2
- dEdX : (measured−expected)/error <1.3

For M=3.099 GeV/c^2,

<19 events for Γ=0.0 MeV/c^2 @90% C.L.

<30 events for Γ=12.0 MeV/c^2 @90% C.L.

Summary & Conclusions

- ✓ CDF collaboration searched for a charmed Pentaquark state, $\Theta_c^0(uudd\bar{c})$ in D^{*-}proton+c.c. decay mode
- ✓ No evidence of the charmed exotic state observed at H1 has been found
- ✓ We are vigorously searching for other possible charmed Pentaquark states