Collaboration

Heavy Quarks at
Fixed Target
Fermilab
October 11, 1998

- Collaboration of 19 institutions from:
  - Brazil, Italy, Korea, Mexico, Puerto Rico and U.S.

- Continuation of Fermilab experiment E687.

- Charm photoproduction experiment.

- Took data during Fermilab's 1996/97 fixed target run.

- Goal: $10\times >$ E687 charm sample

Institutions

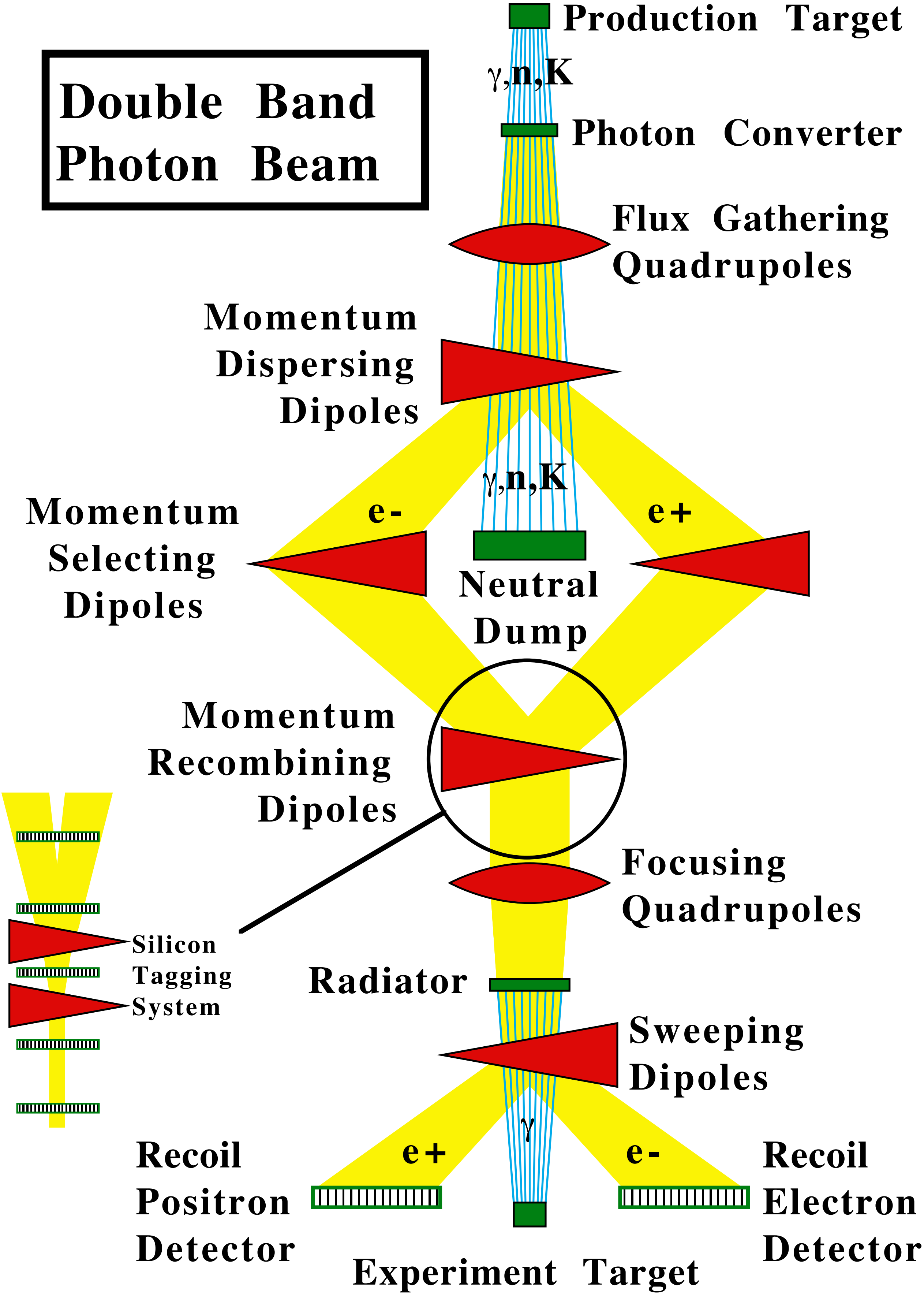
University of California, Davis (USA)
CBPF (Brazil)
CINVESTAV (Mexico)
University of Colorado, Boulder (USA)
Fermi National Accelerator Laboratory (USA)
Laboratori Nazionali di Frascati dell'INFN (Italy)
University of Illinois, Urbana (USA)
Korea University, Seoul (Korea)
Università and INFN - Milano (Italy)
University of North Carolina, Asheville (USA)
Università and INFN - Pavia (Italy)
Universidad Autonoma de Puebla (Mexico)
University of Puerto Rico, Mayaguez (Puerto Rico)
University of South Carolina (USA)
University of Tennessee (USA)
Vanderbilt University (USA)
University of Wisconsin, Madison (USA)
Yeonsei University (Korea)

E687

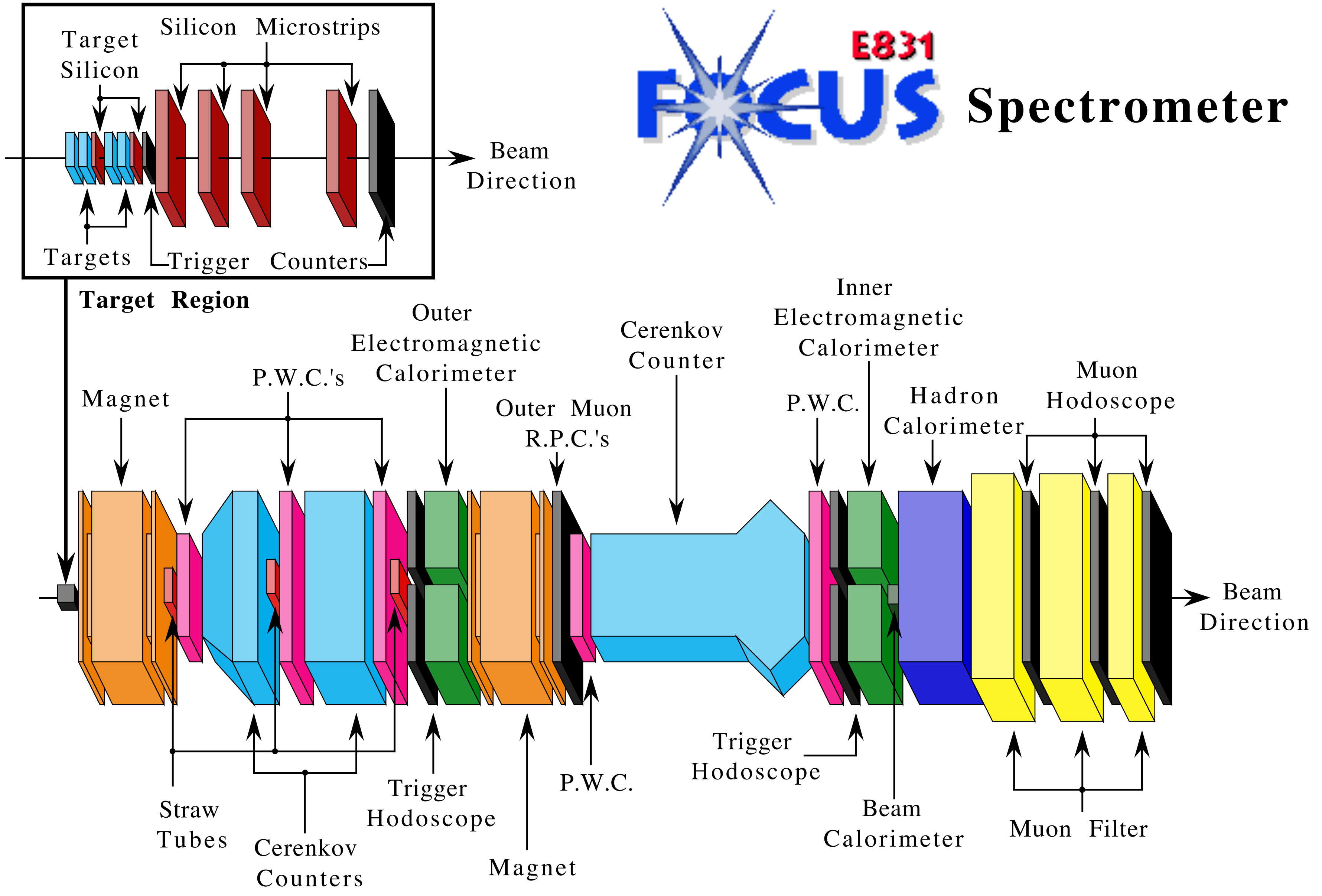
- Over 50 papers on charm physics.
- More than 120 measurements reported in PDG98.
- Only experiment to measure the lifetime of all charm particles.
- Continuing to publish new papers.

How to increase the sample by a factor of 10...

- Increase beam flux on target. (factor $\sim$5)
  - More primary protons. ($\sim$1.8)
  - Lower secondary beam energy. ($\sim$1.7)
  - Add positron arm. ($\sim$1.7)
- Upgrades to the spectrometer.
  - Segment the target.
  - Add SSD's between target segments.
  - Add straw tubes in high rate pair region.
  - New outer muon system - RPC's.
  - New inner EM calorimeter - lead glass.
  - **New hadronic calorimeter.**
  - New inner muon system
- Upgrade DAQ and triggering.
  - New DAQ – reduced deadtime to 20%.
  - Add hadronic energy to the level 1 trigger.


Double Band Photon Beam
Production Target
γ,n,K
Photon Converter
Flux Gathering Quadrupoles
Momentum Dispersing Dipoles
γ,n,K
e-
e+
Momentum Selecting Dipoles
Neutral Dump
Momentum Recombining Dipoles
Focusing Quadrupoles
Silicon Tagging System
Radiator
Sweeping Dipoles
γ
e+
e-
Recoil Positron Detector
Recoil Electron Detector
Experiment Target

Target Region

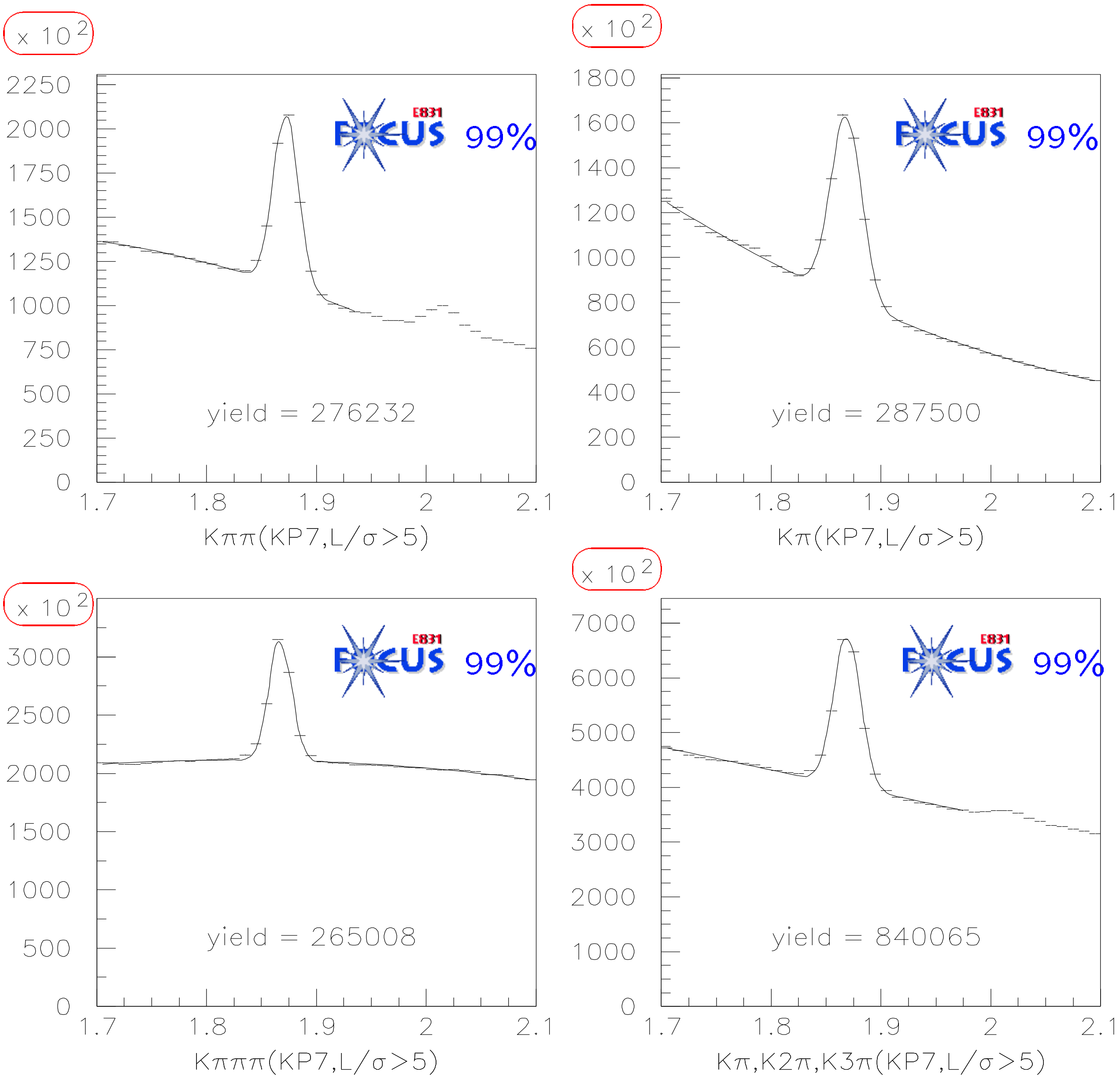

E831
FOCUS Spectrometer
Target Silicon
Silicon Microstrips
Beam Direction
Targets
Trigger Counters
Target Region
Magnet
P.W.C.'s
Outer Electromagnetic Calorimeter
Outer Muon R.P.C.'s
Cerenkov Counter
P.W.C.
Inner Electromagnetic Calorimeter
Hadron Calorimeter
Muon Hodoscope
Beam Direction
Straw Tubes
Cerenkov Counters
Trigger Hodoscope
Magnet
P.W.C.
Trigger Hodoscope
Beam Calorimeter
Muon Filter

We achieved at least $14\times >$ E687!

Golden Mode decays from first level of processing...

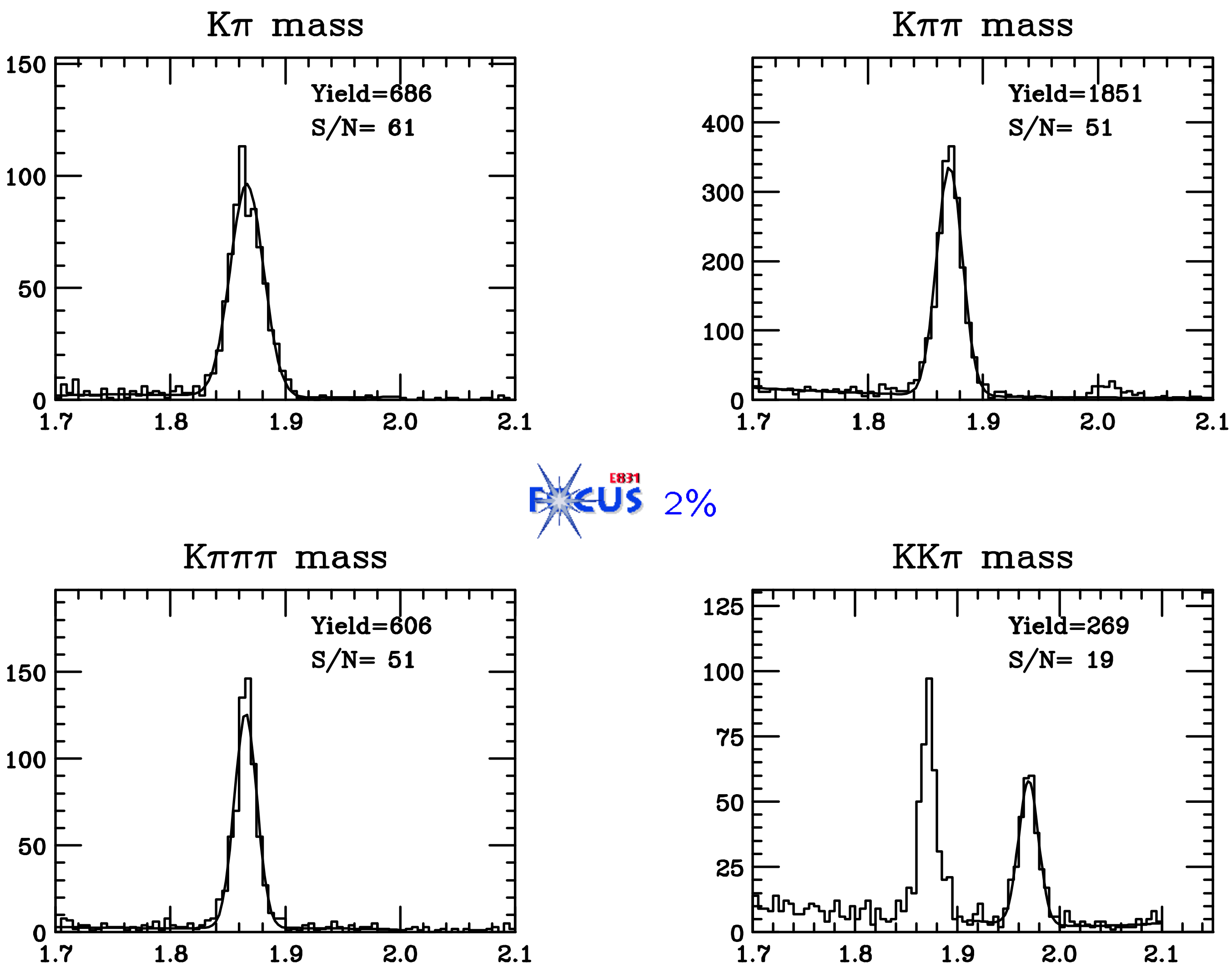
$D^+ \to K^-\pi^+\pi^+$,

$D^0 \to K^-\pi^+$ and $D^0 \to K^-\pi^+\pi^+\pi^-$

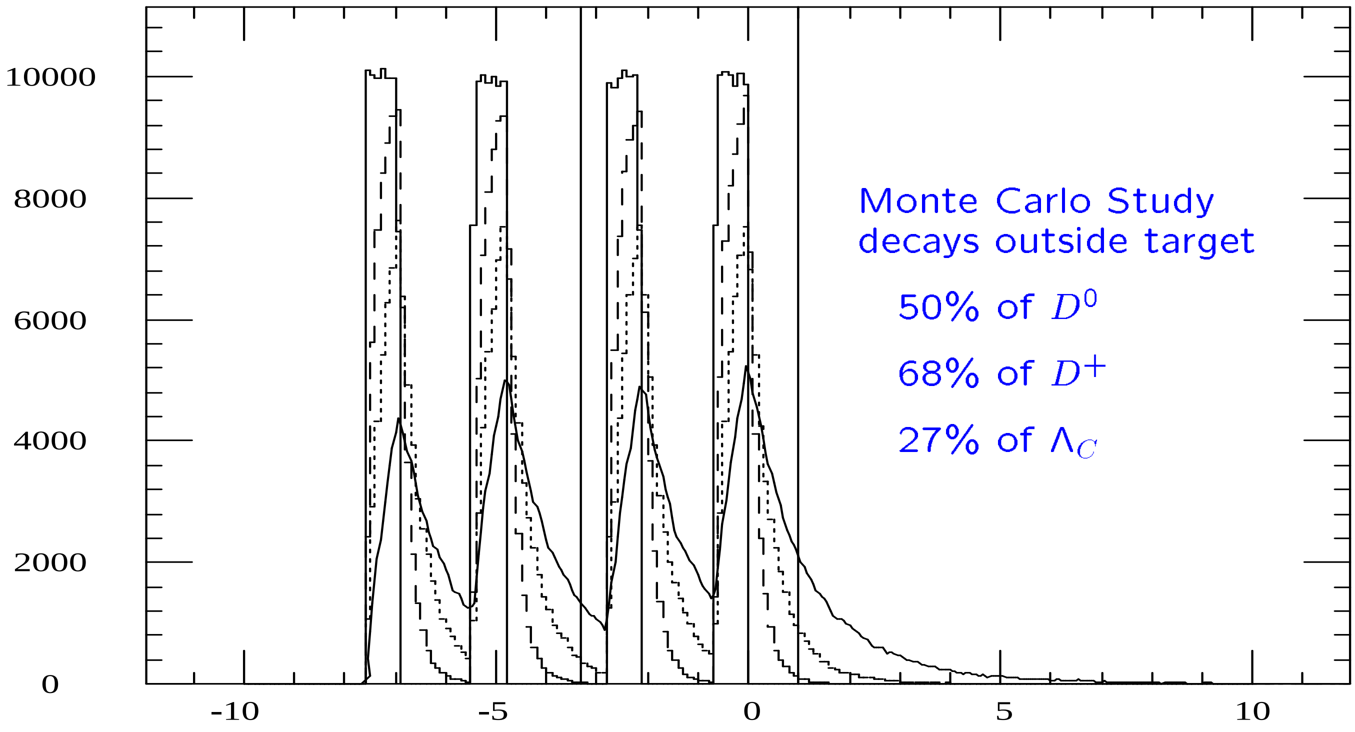


We also have dramatic gains in signal quality and sensitivity, due to the development of several powerful analysis tools.

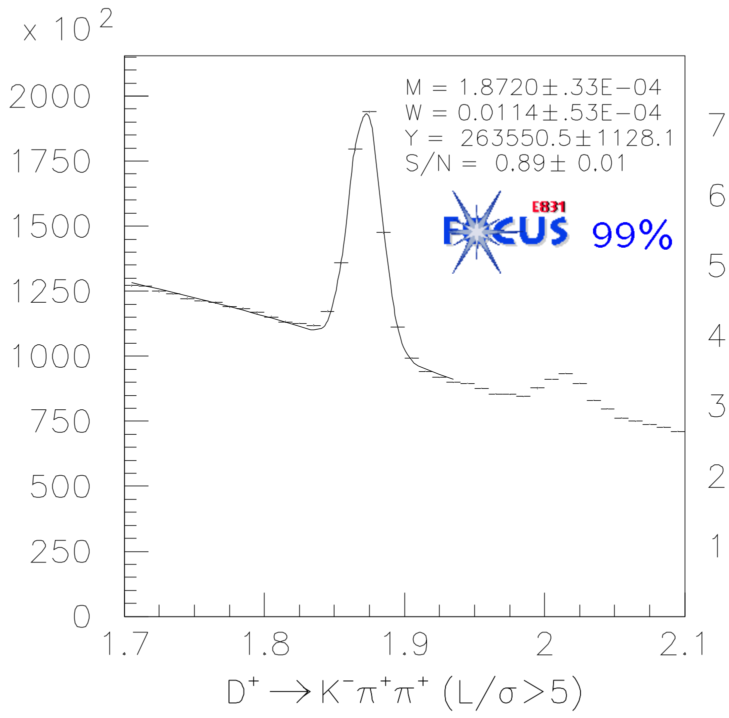
- New and very powerful Čerenkov algorithm.
- Overall improvement to particle ID.
- Improved vertex resolution.
- More decays out of target.

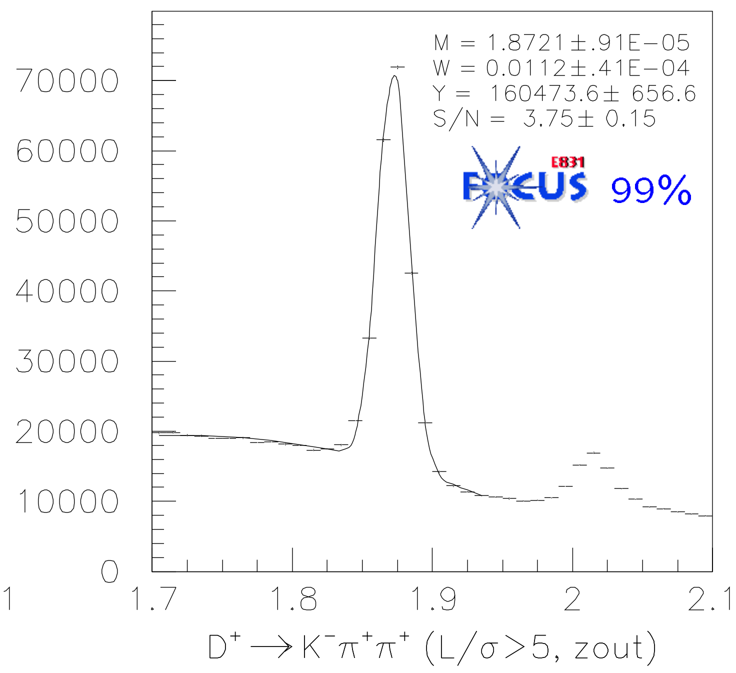


Segmented Target and Out of Target Cut



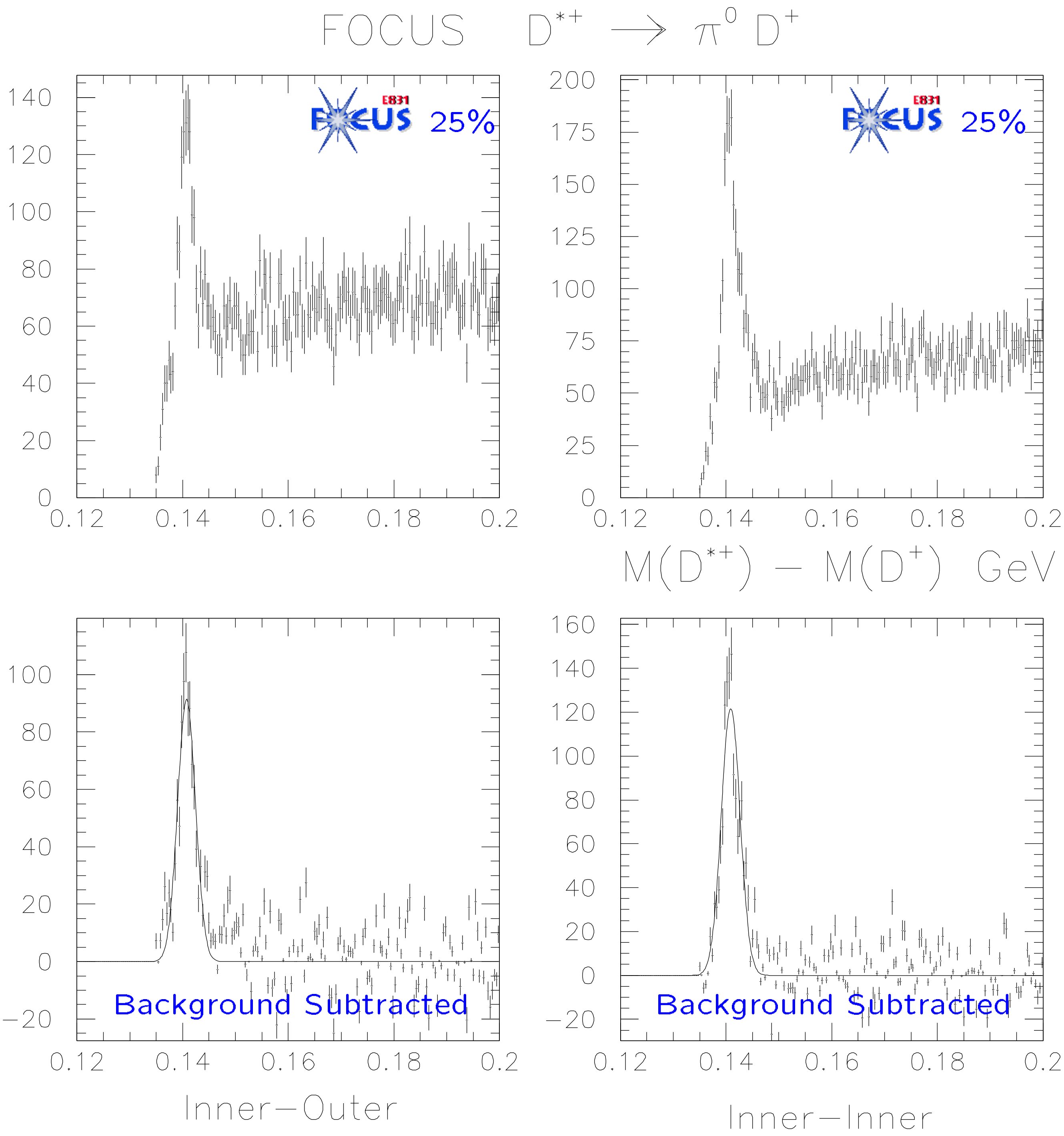
Decay vertex out of the target by $\geq 3\sigma$.





Retain 60% of the signal, and gain a factor of 4 in S/N.

π^0 Reconstruction

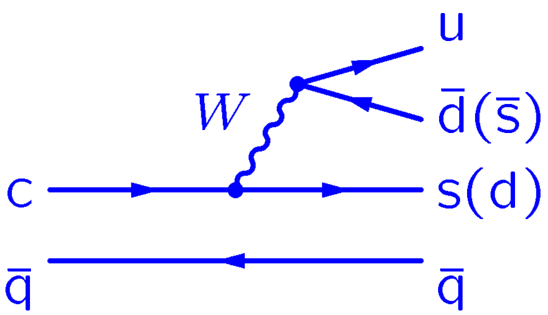


Hadronic Decays of Charm Mesons:

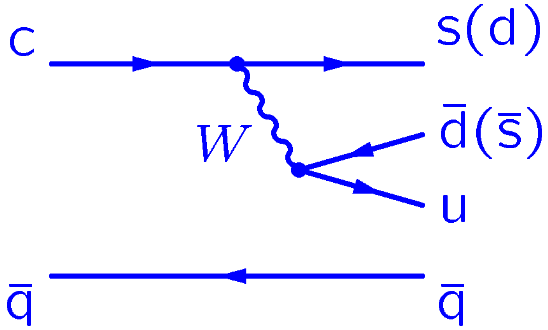
- Why study charm hadronic decays?
  - To understand charm quark decay dynamics.
  - Learn about final state interactions (FSI).
  - Large D sample for studying...
    - ∗ Lifetimes, CP violation, mixing, D^*, etc.

- How do D mesons decay?

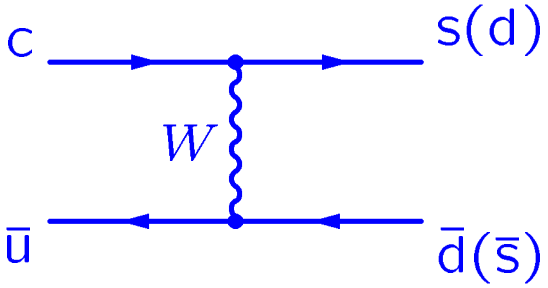
External W Spectator



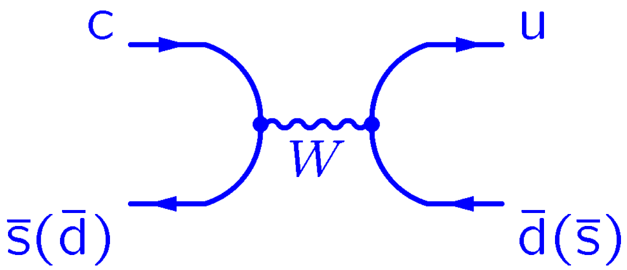
Internal W Spectator



W Exchange (D^0)



Annihilation (D^+, D_S^+)



  - Cabibbo favored (CF).
  - Singly Cabibbo suppressed (SCSD).
  - Doubly Cabibbo suppressed (DCSD).

All Plots are Preliminary!

Further Legal Notice:

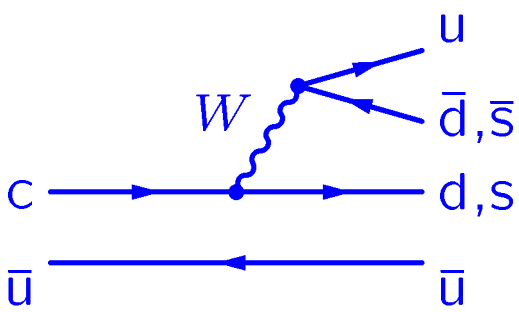
Persons attempting to find a motive in this narrative will be prosecuted; persons attempting to find a moral in it will be banished; persons attempting to find a plot...

Alright, you got me there!

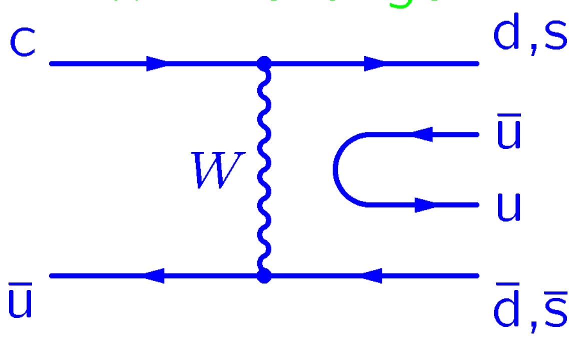
$D^0 \to \pi^+\pi^-$ and $D^0 \to K^+K^-$

Both decay through the same diagrams.

External Spectator



W Exchange



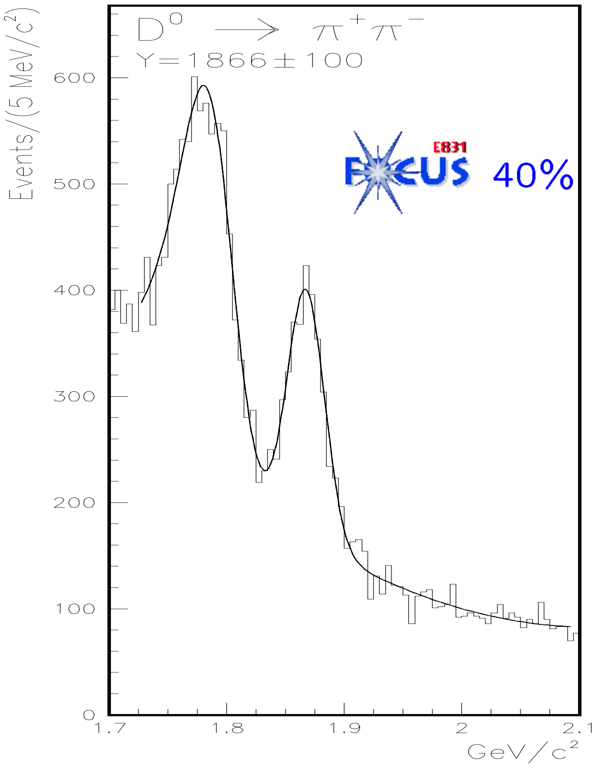
Branching Ratio $\left(\frac{D^0 \to K^+K^-}{D^0 \to \pi^+\pi^-}\right)$

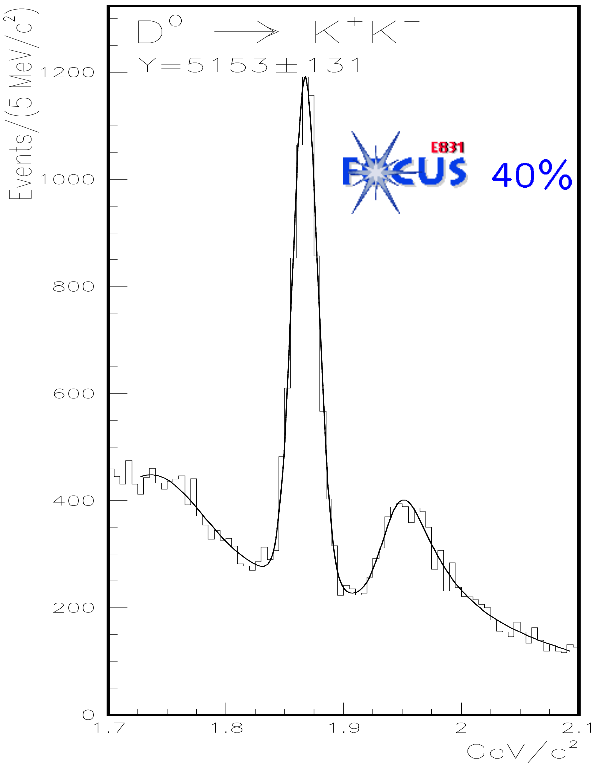
≤ 1.4 Theory (no FSI)

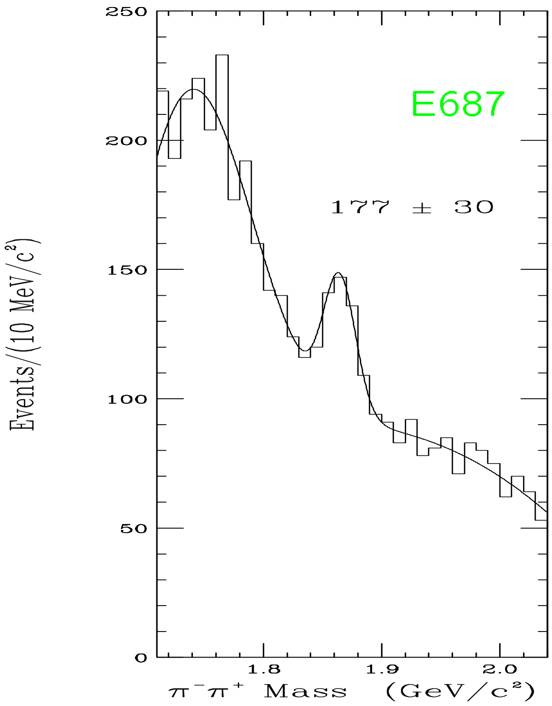
$= 2.54 \pm 0.46 \pm 0.19$ E687

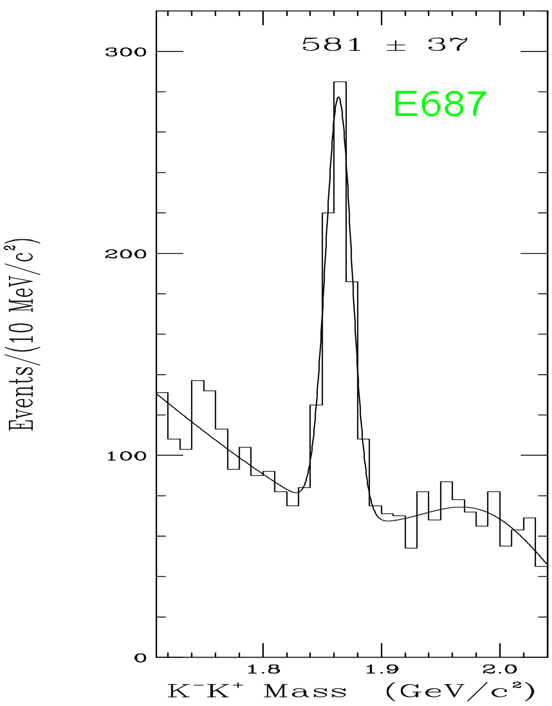
$= 2.79 \pm 0.17$ PDG

$D^0 \to \pi^+\pi^-$ and $D^0 \to K^+K^-$

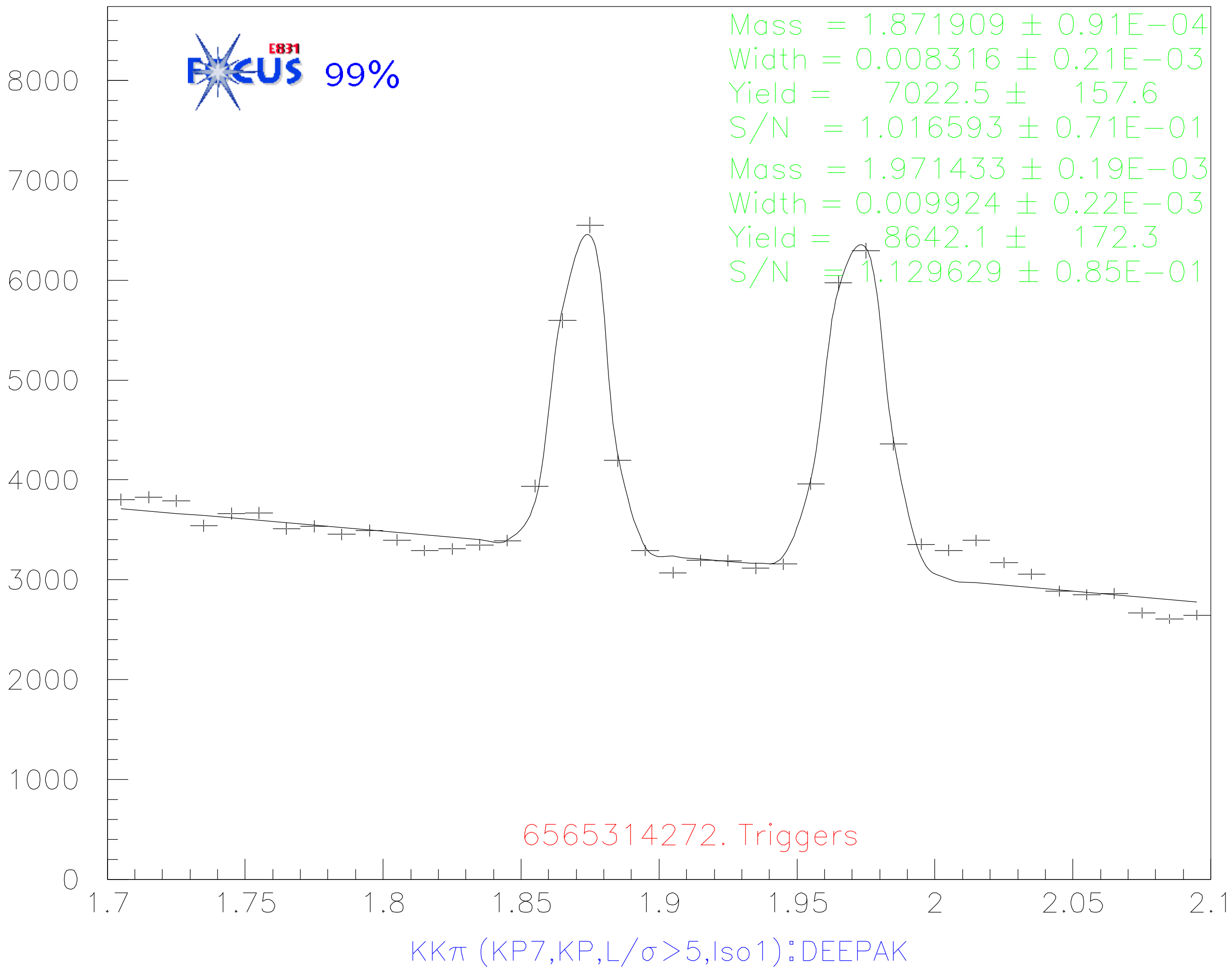








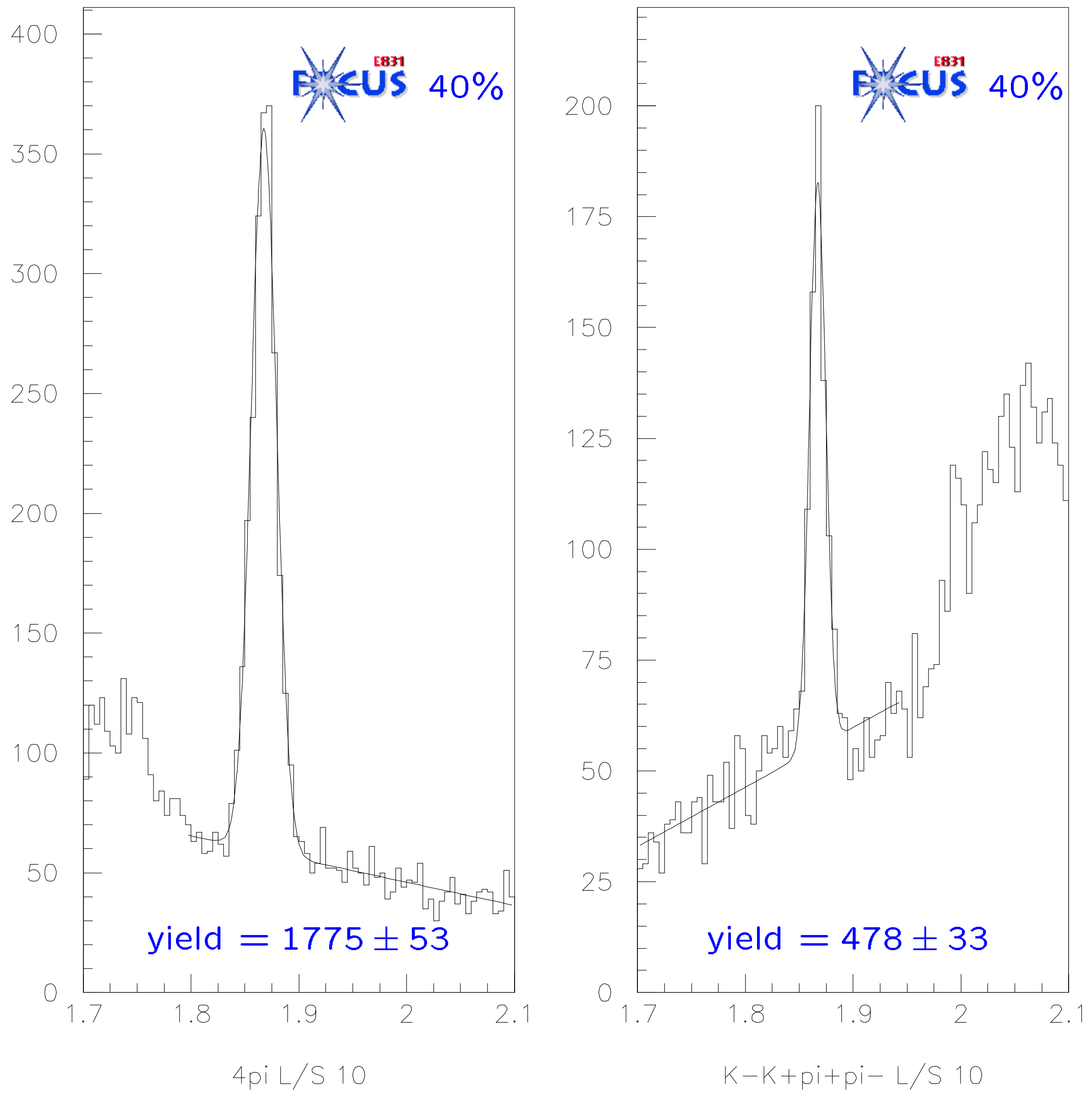
D_S^+ and $D^+ \to K^+K^-\pi^+$



Used as part of our online charm yield monitoring!

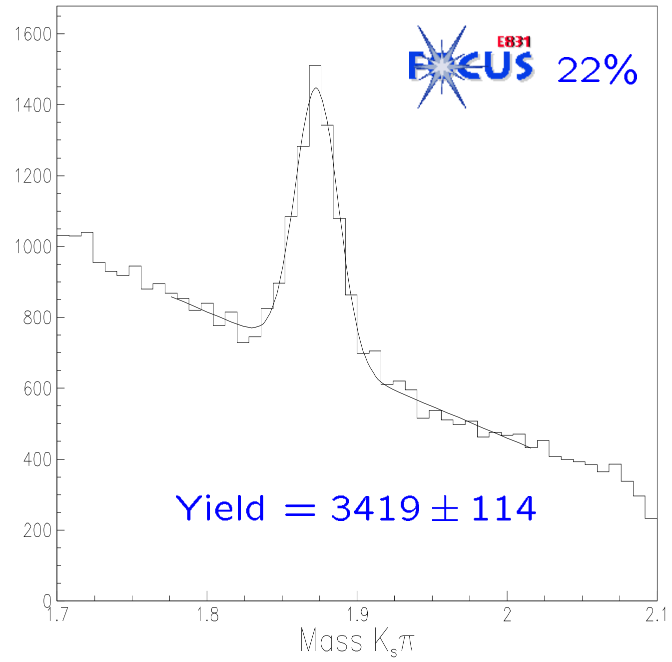
For D_S^+ and $D^+ \to \pi^+\pi^+\pi^-$
See next talk by Eric Vaandering.

$D^0 \to K^+K^-\pi^+\pi^-$ and $D^0 \to \pi^+\pi^-\pi^+\pi^-$

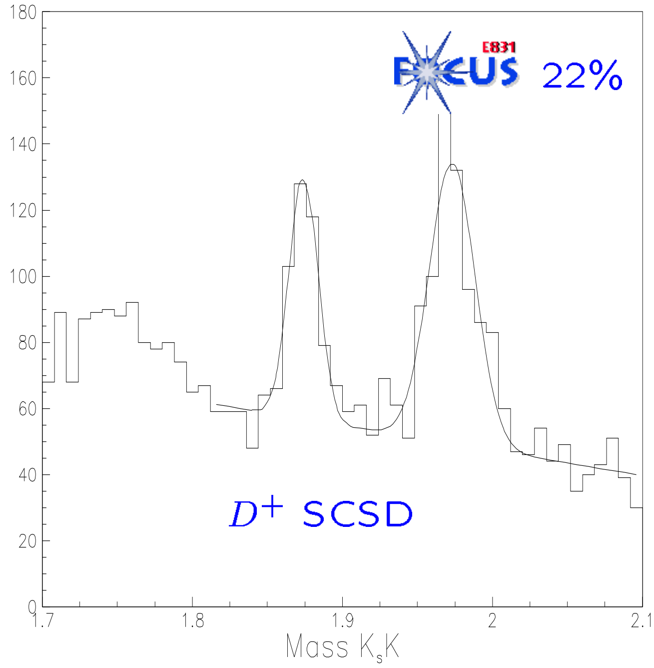


D Signals With K_s's

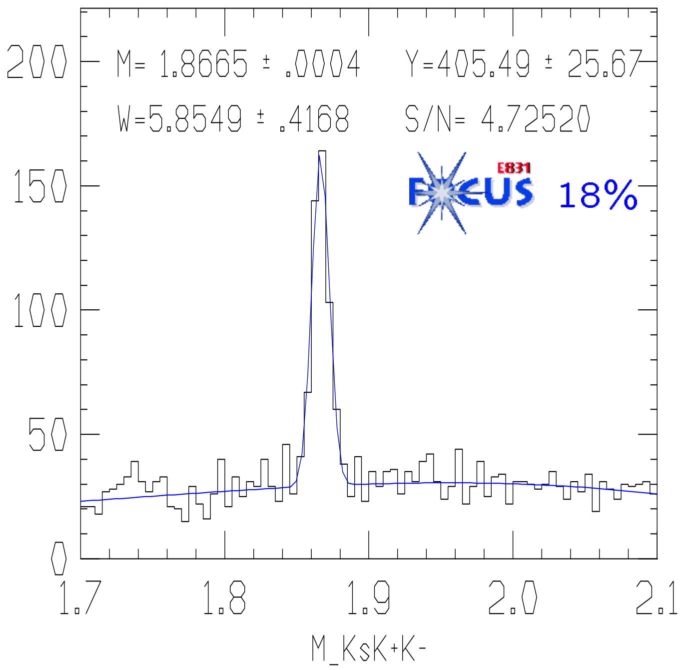
$D^+ \to K_s \pi^+$



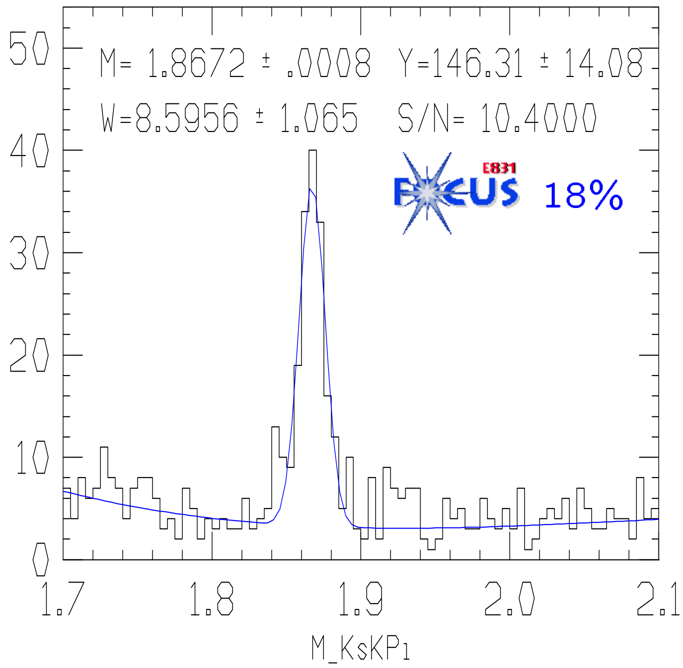
$D^+, D_s^+ \to K_s K^+$



$D^0 \to K_s K^+ K^-$

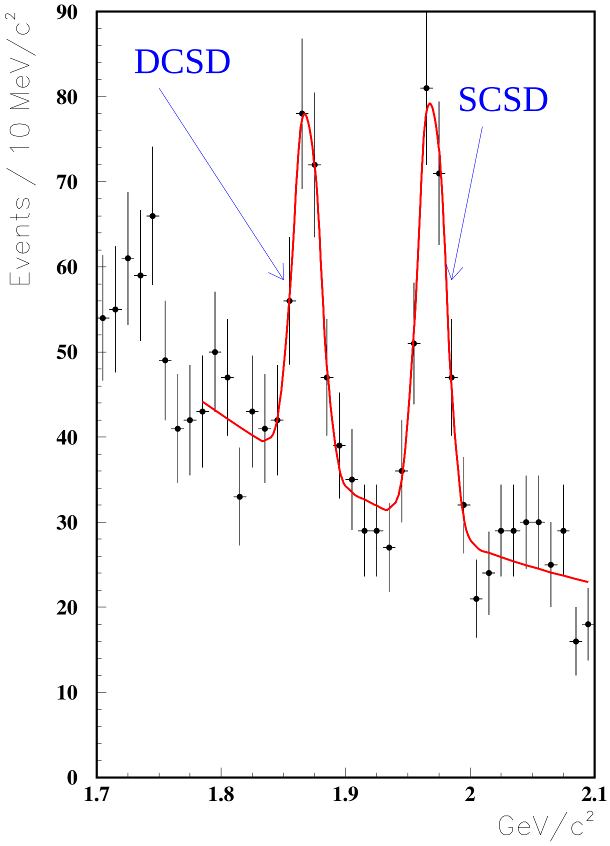


$D^0 \to K_s K^\pm \pi^\mp$



D_S^+ and $D^+ \to K^+\pi^+\pi^-$

$K^+\pi^+\pi^-$ invariant mass plot



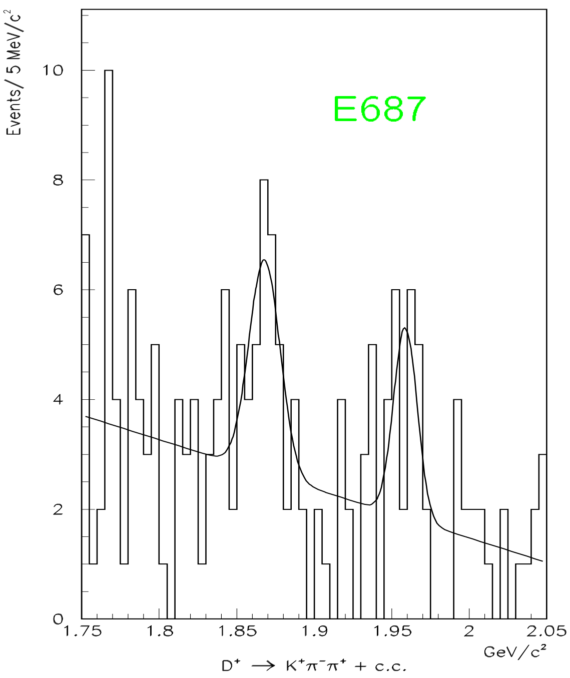
YIELD D^+ = 110.2 ± 20.1

S/N D^+ = 0.7 ± 0.1

YIELD D_s^+ = 136.1 ± 18.2

S/N D_s^+ = 1.1 ± 0.1

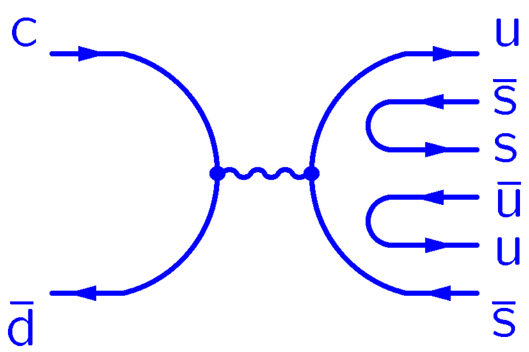
E831 FOCUS 25%



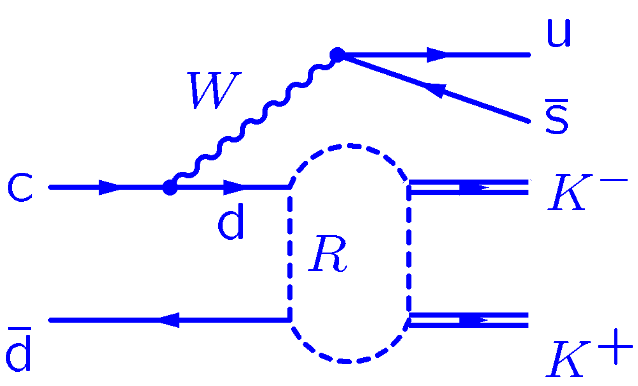
$K^+K^+K^-$ Mode (DCSD for D^+)

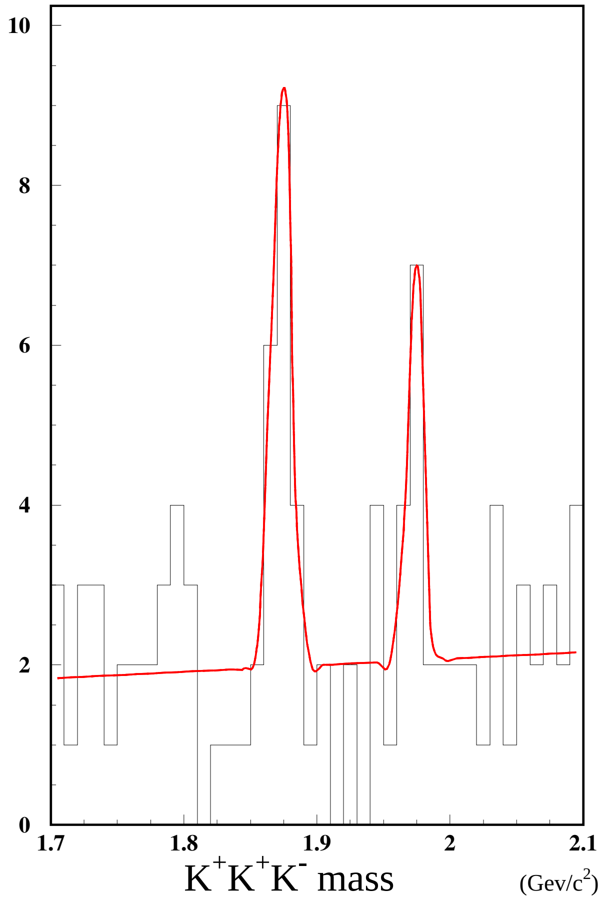
- D^+ does not decay via simple spectator process.

Annihilation



External Spectator





Under investigation

25% of full sample

D^+: 13.2 ± 4.5 events
D_s^+: 7.0 ± 3.5 events

E831 FOCUS 25%

Conclusions

- Large charm decay sample ($> 10^6$)
- Vastly improved signal quality.
- Should greatly improve our understanding of charm hadronic decays.

Upcoming talks by Eric Vaandering and Will Johns.

Stay Tuned!