

Correlations between D and \bar{D} Mesons in High Energy Photoproduction



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Introduction

Correlations between D and \bar{D} mesons in charm-pair events are important for studies of heavy quark production. Charm-pair correlations are used as probes of perturbative QCD, and are used to study non-perturbative effects.

Overview:

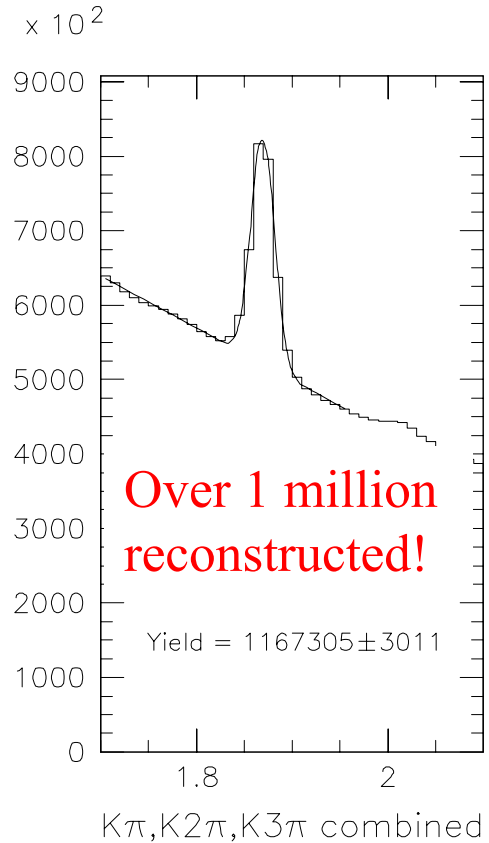
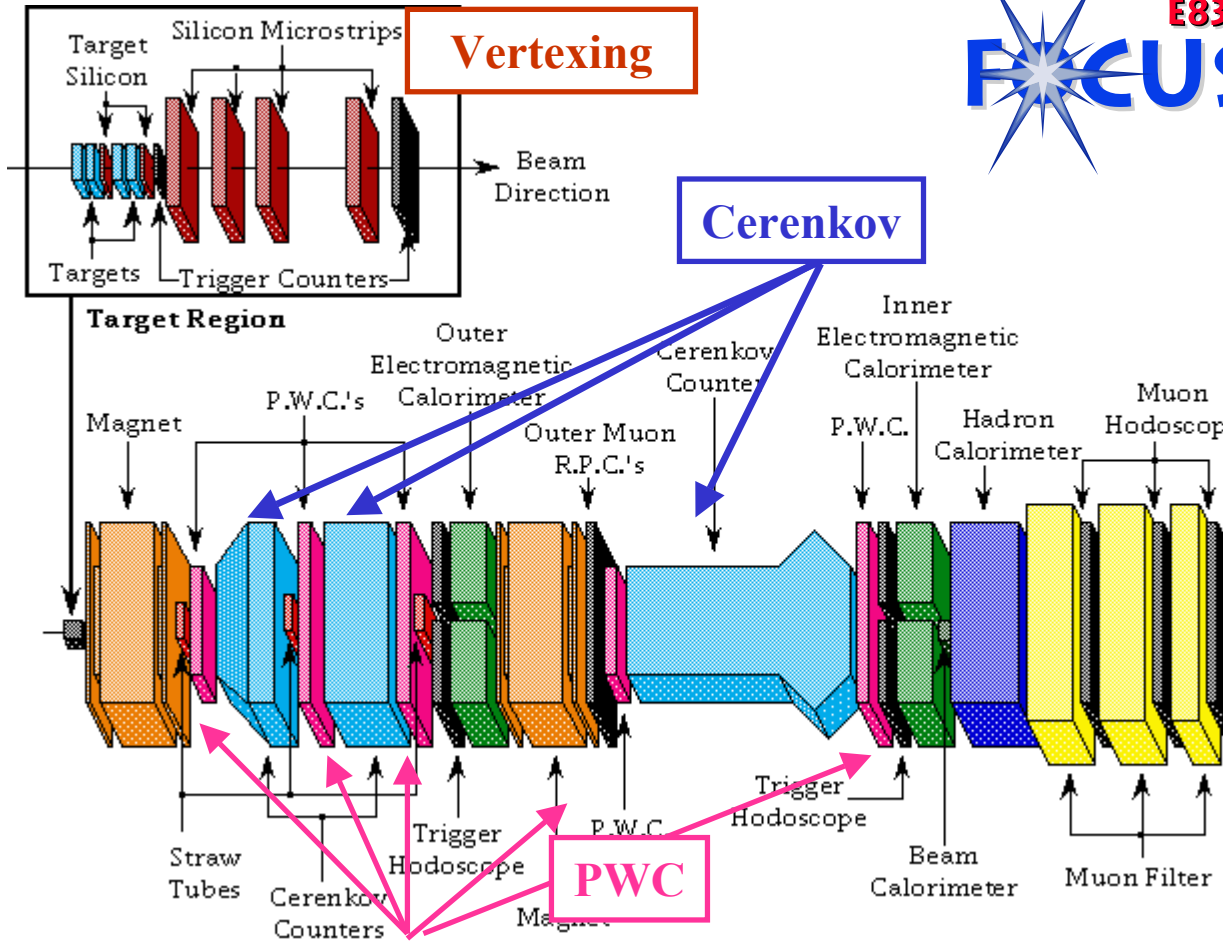
- describe the FOCUS sample of charm-pair events
- mention an interesting “discovery” in our data
- compare preliminary FOCUS results to published E687 results
- compare results to PYTHIA predictions

Key concepts:

- primary vertex multiplicity (**NPRIM**)
- invariant mass of the $D\bar{D}$ pair
- $p_t^2(D\bar{D})$ - transverse momentum squared \Rightarrow **LO QCD: $p_t^2(D\bar{D}) = 0$**
- $\Delta\phi$ - angle between D and \bar{D} in the plane transverse to the beam \Rightarrow **LO QCD: $\Delta\phi = \pi$**
- k_T kick - intrinsic momentum of the incoming partons (**intrinsic k_T**)

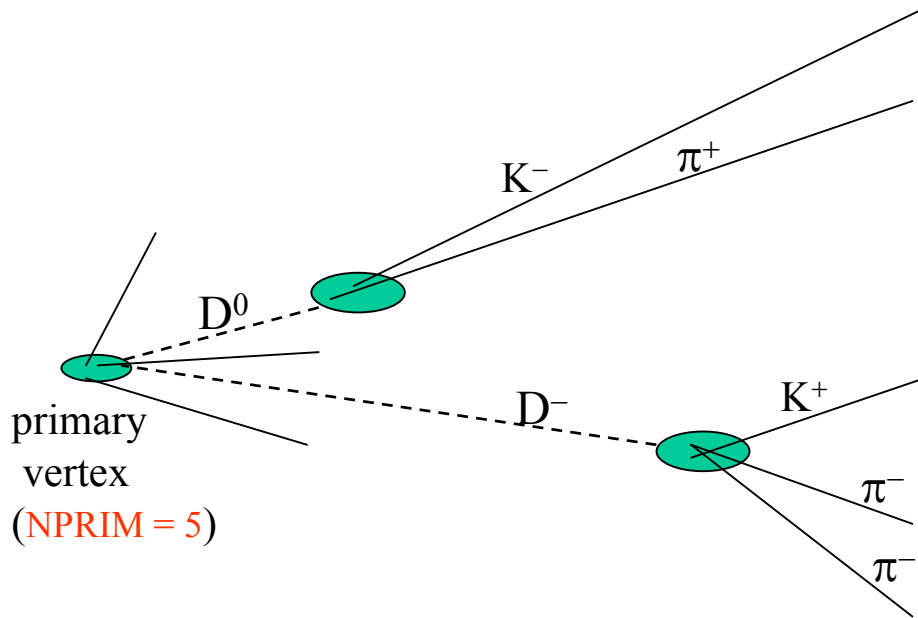


Spectrometer



Successor to E687. Designed to study charm particles produced by **~ 180 GeV photons** using a fixed target spectrometer with updated **Vertexing**, **Cerenkov**, **EM Calorimeters**, and **Muon id** capabilities. Member groups from USA, Italy, Brazil, Mexico, Korea.

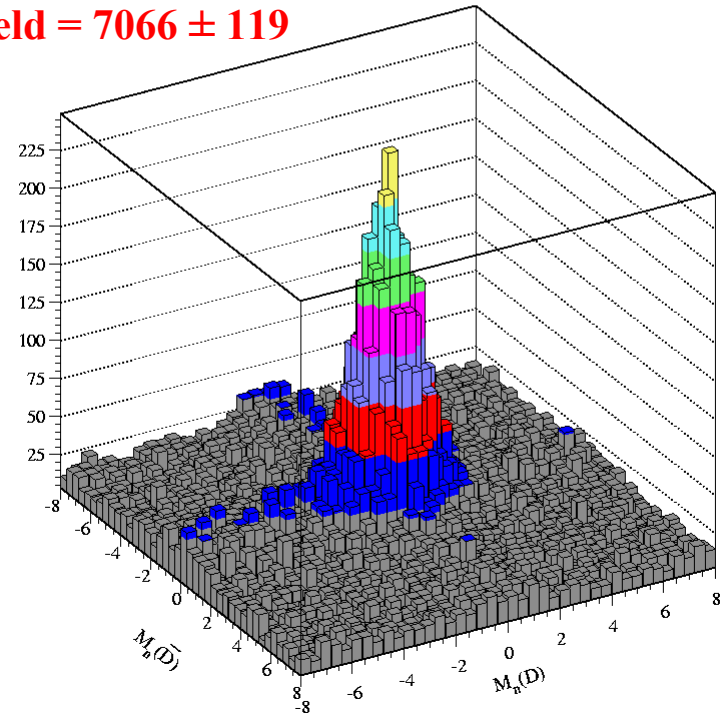
Charm-pair events in FOCUS



The FOCUS sample of $D\bar{D}$ events was reconstructed using the decay modes $D^0 \rightarrow K^-\pi^+$, $D^+ \rightarrow K^-\pi^+\pi^+$, $D^0 \rightarrow K^-\pi^+\pi^+\pi^-$, and charge conjugate modes. Each event has two D candidates. A new candidate-driven algorithm was used to obtain this sample of events.

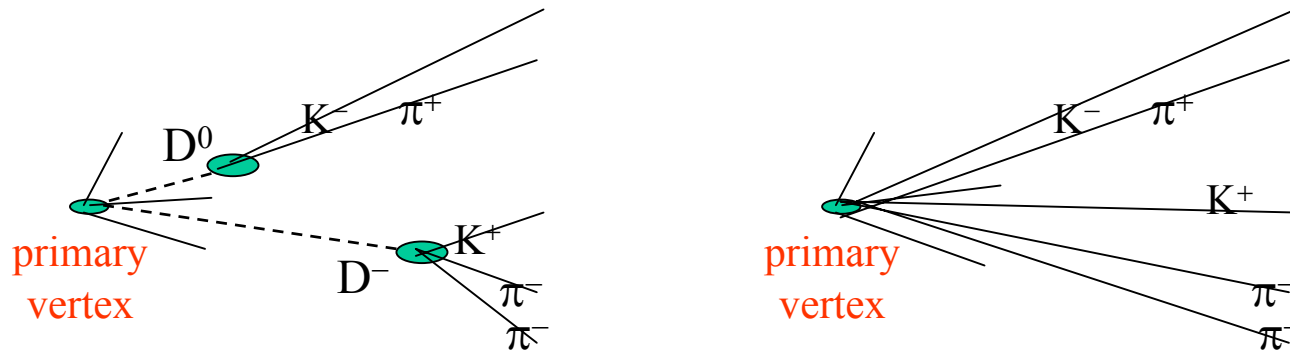
Normalized D mass vs. normalized \bar{D} mass

Yield = 7066 ± 119



Charm-pair selection (candidate-driven algorithm)

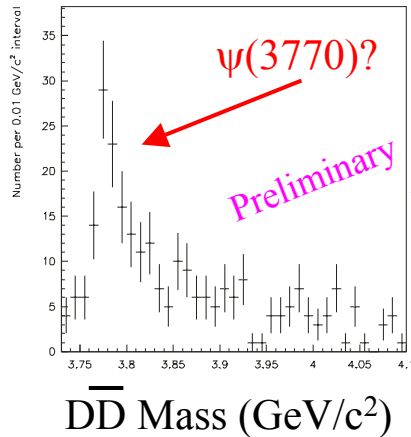
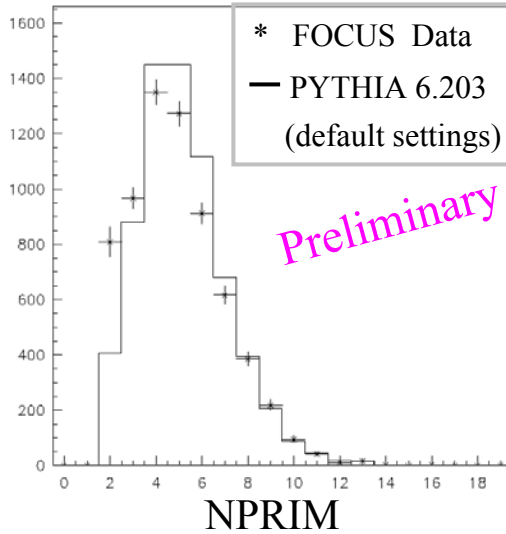
- Consider all **pairs** of 2, 3 and 4 track combinations ($K\pi$, $K\pi\pi$, $K\pi\pi\pi$) \Rightarrow **2 D candidates**
- Require opposite charge for the *kaon* in each D candidate \Rightarrow **D & \bar{D} candidate**
- Each candidate is required to have a vertex with $CL > 1\%$ \Rightarrow **2 secondary vertices**
- Both candidates are required to form a vertex with $CL > 1\%$ \Rightarrow **primary vertex**
- Take all tracks for both candidates and require $CL < 0.1\%$ (background rejection)



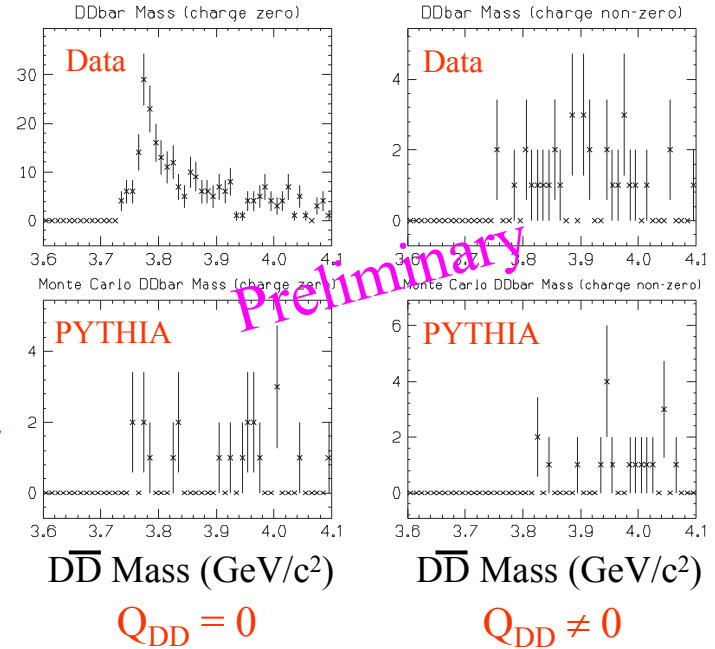
- Cherenkov particle identification for *kaons* and *pions*
- Require normalized mass ($\Delta M/\sigma$) in the range $[-10, 10]$
- Require that the primary vertex is located in the target material
- Require detachment between primary and secondary vertices $> 1\sigma$ ($L/\sigma > 1$)
- For $K\pi\pi$ vertices require $L/\sigma > 5$ if the vertex is located in material
- For $K\pi\pi\pi$ require $L/\sigma > 5$ if the vertex is in material AND not associated with a D^* tag

Primary vertex multiplicity (NPRIM) and comparisons to PYTHIA

NPRIM = # of charged particles assigned to the primary vertex + 2 D mesons



Invariant mass of the DDbar pair for data and PYTHIA 6.203

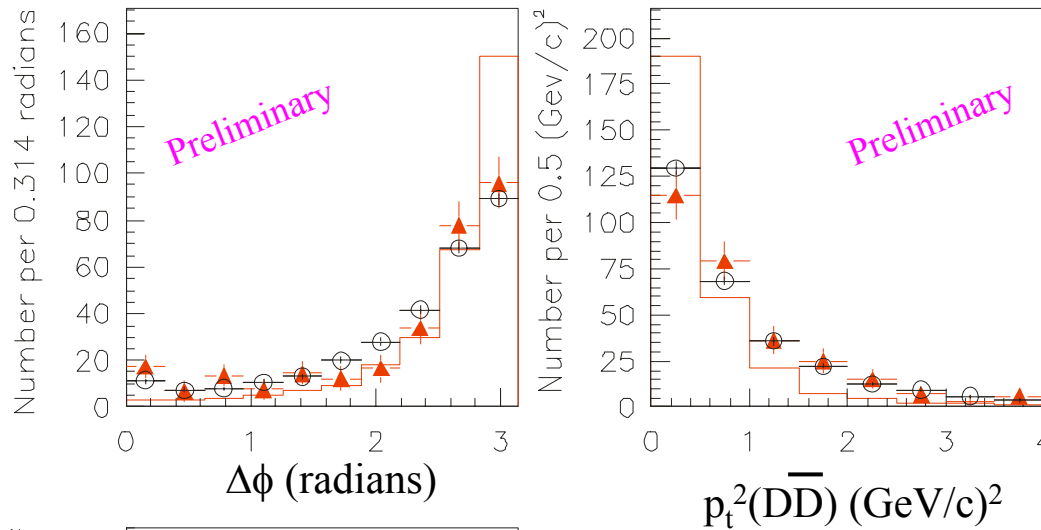


Cuts:

- NPRIM = 2
- $\Delta M/\sigma$ in the range [-2, 2]
- zero energy in calorimetry
- charge(D \bar{D}) = 0 ($Q_{DD} = 0$)
- $p_t^2(\text{D}\bar{\text{D}}) < 0.2 \text{ (GeV/c)}^2$

$D\bar{D}$ correlations for FOCUS & E687 compared to PYTHIA 5.6

For studies of $D\bar{D}$ correlations, an $NPRIM > 2$ cut is used to remove “ $\psi(3770)$ ” events.



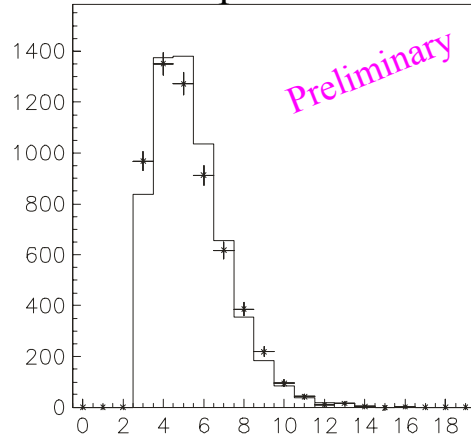
- PYTHIA 5.6
- Δ E687 data (published)
PL B308(1993) 193
- \oplus FOCUS data
($NPRIM > 2$ cut)

Comparisons of E687 data with FOCUS data show good agreement.

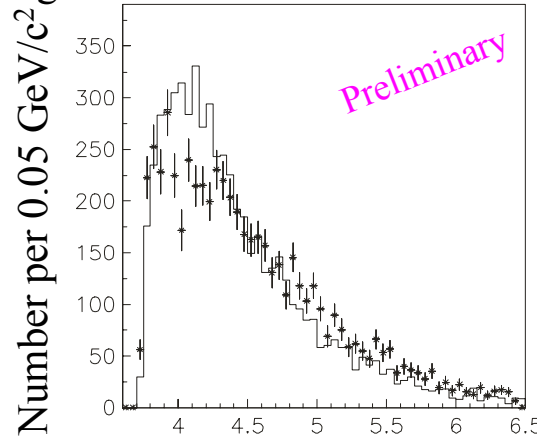
E687 and FOCUS data are not in agreement with PYTHIA 5.6.

$D\bar{D}$ correlations for FOCUS compared to PYTHIA 6.203

However, comparisons of FOCUS data with PYTHIA 6.203 show much better agreement. Part of the improvement is due to larger transverse momentum for initial partons (intrinsic k_T).

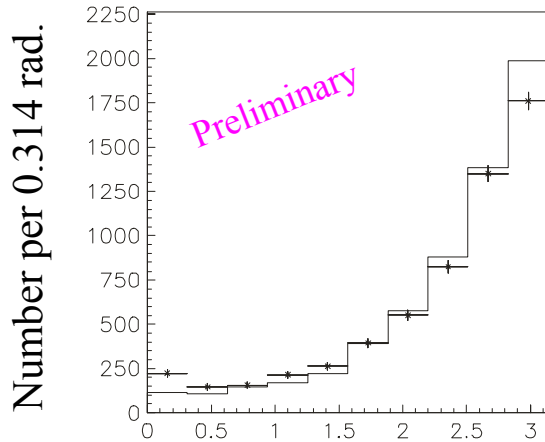


NPRIM

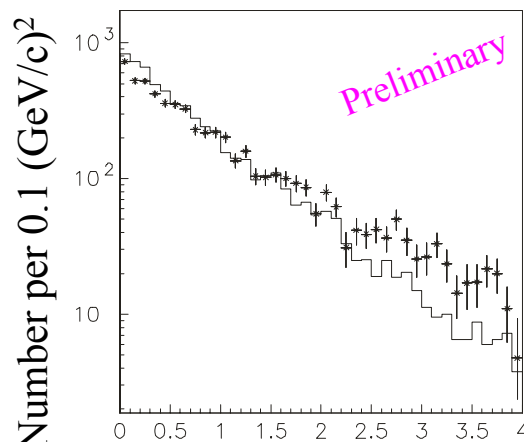


$\bar{D}\bar{D}$ Mass (GeV/c²)

* FOCUS Data
— PYTHIA 6.203
(default settings)
 $\langle k_T^2 \rangle = 1 \text{ GeV}^2$



$\Delta\phi$ (radians)



$p_t^2(\bar{D}\bar{D})$ (GeV/c)²

Summary

- FOCUS has a large sample of charm-pair events for studies of QCD
- FOCUS sees a possible signal for diffractive $\psi(3770)$ production
- comparisons of FOCUS data with PYTHIA 6.203 show improved agreement compared to earlier versions (part of the improvement is due to larger intrinsic k_T in PYTHIA)
- results are being prepared for publication