FOCUS Preliminary Results on D^0 decays into multi K_S^0 final states

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Motivations:

Non leptonic charmed mesons decays:

- The theoretical predictions are limited mainly to two - body decay modes.
- Difficult calculations due to poor knowledge of charm hadronic wavefunctions; QCD short – distance effects and final state interactions (FSI).

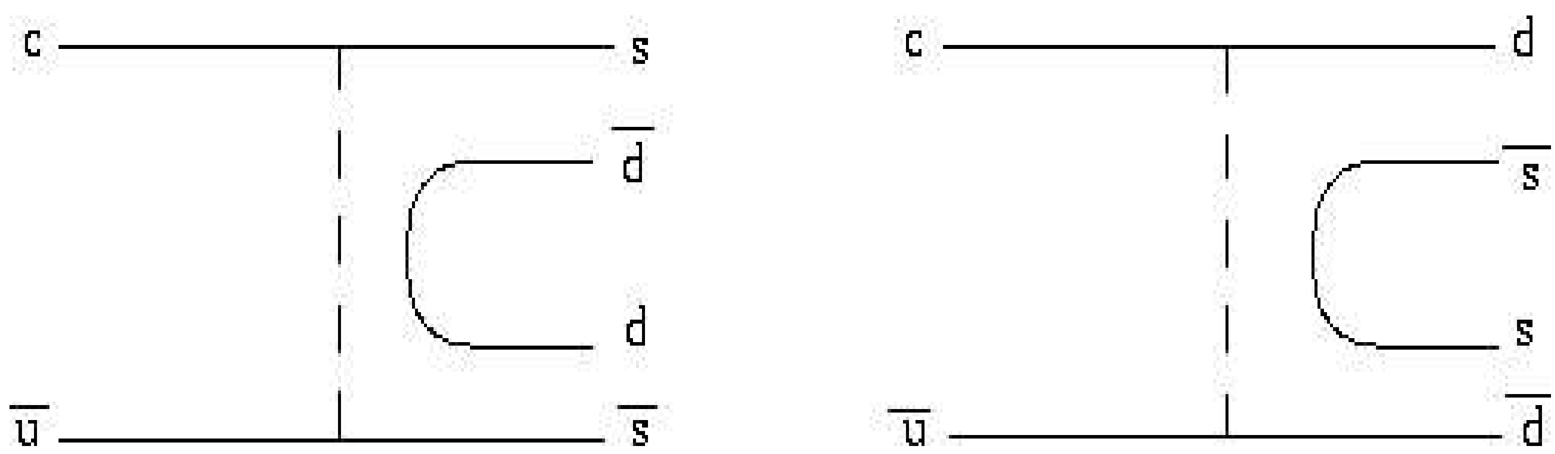
→ Previous Measurements of D^0 decays into multi K_s final states still have large uncertainties:

Decay Mode:	*Branching Fraction:*
$D^0 \to K^0\bar{K}^0$	$(7.1 \pm 1.9) \cdot 10^{-4}$
$D^0 \to K^0\bar{K}^0K^-\pi^+$	–
$D^0 \to \bar{K}^0\bar{K}^0K^+\pi^-$	–
$D^0 \to K^0\bar{K}^0\pi^+\pi^-$	$(7.5 \pm 2.9) \cdot 10^{-3}$

Theoretical Predictions:

All modes, except for $D^0 \to K^0\bar{K}^0K\pi$ and $D^0 \to \bar{K}^0\bar{K}^0K\pi$, are Cabibbo suppressed.

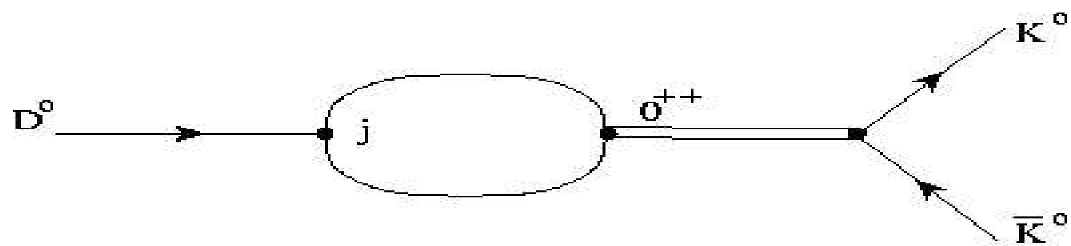
The two - body decay is described by two exchange-type Feynman diagrams, which interfer destructively (due to CKM matrix element's signs).



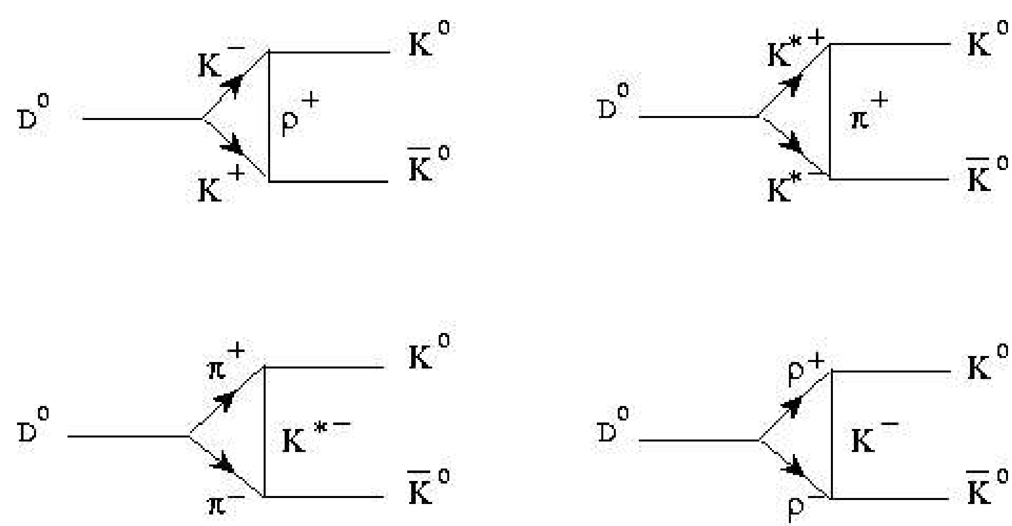
Feynman diagrams for $D^0 \to K^0\bar{K}^0$

Different models have been applied to the study of this decay mode:

- Non factorizable contributions: factorization models estimate a null amplitude for $D^0 \to K^0\bar{K}^0$ decay mode. Non factorizable contributions, as final state soft gluon exchange, produce non zero amplitude
- Final State Interactions (FSI): intermediate resonant states (i.e. f^0 (1710)..)

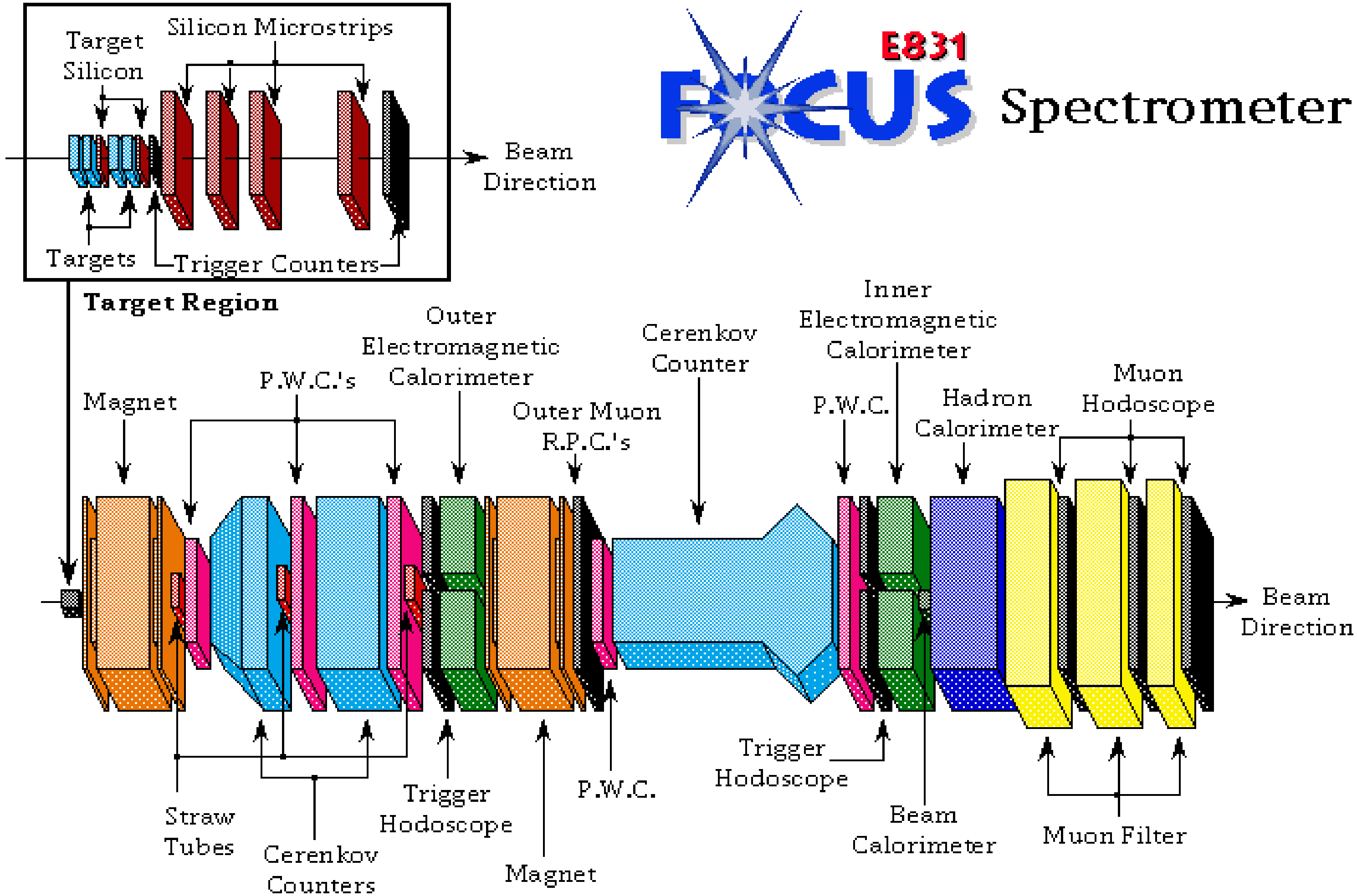


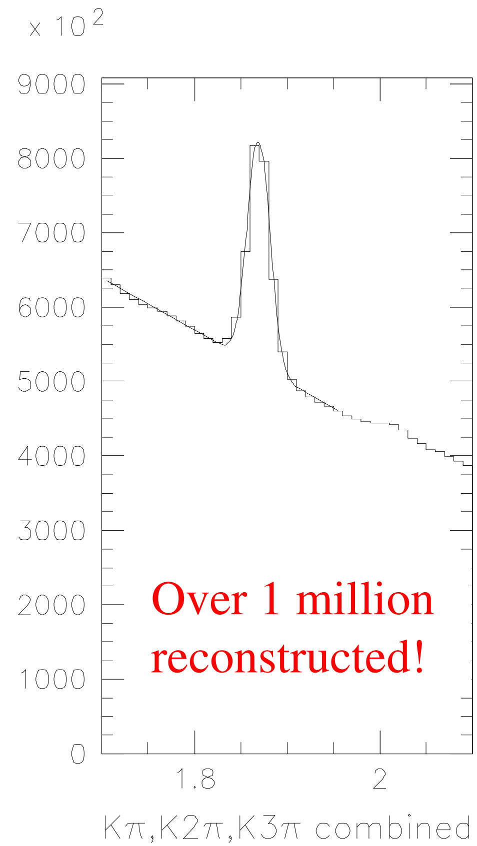
or final state rescattering (OPE: One Particle Exchange)



Branching Ratio $\Gamma(D^0 \to K^0\bar{K}^0)/\,\Gamma(D^0 \to \bar{K}^0\pi^+\pi^-)$ previsions range from 0. to 5.08%.

E831 FOCUS Spectrometer



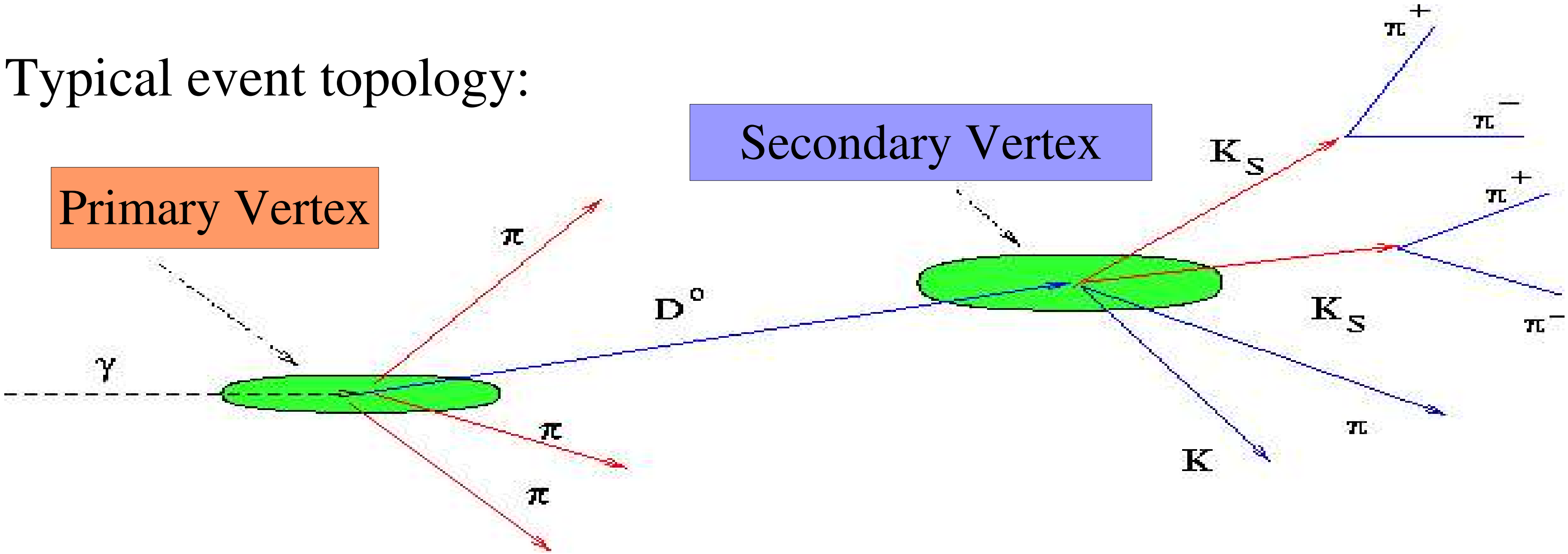


Successor to E687. Designed to study charm particles produced by ~180 GeV photons using a fixed target spectrometer with updated Vertexing, Cerenkov, EM Calorimeters, Hadron Calorimeter and Muon id capabilities.

Member groups from USA, Italy, Brazil, Mexico, Korea.

Events Reconstruction

Typical event topology:



$D^0 \to K^0\bar{K}^0$ (+ K,π) decay mode is reconstructed through $D^0 \to K_sK_s$(+ K,π)

Secondary vertex is obtained combining K_s candidates and charged tracks (if any).

For $D^0 \to K_sK_s$, a stand-alone Algorithm is used to reconstruct primary vertex.

All the SSD tracks in the event (excluding those already associated with K_sK_s reconstruction) are used to construct all the possible vertices.

Among these, we choose the highest multiplicity vertex (ties are resolved choosing the more upstream vertex).

For $D^0 \to K_sK_sK\pi$ $(\pi\pi)$, D^0 candidate is used as seed track to intersect the other tracks in the event to reconstruct primary vertex.

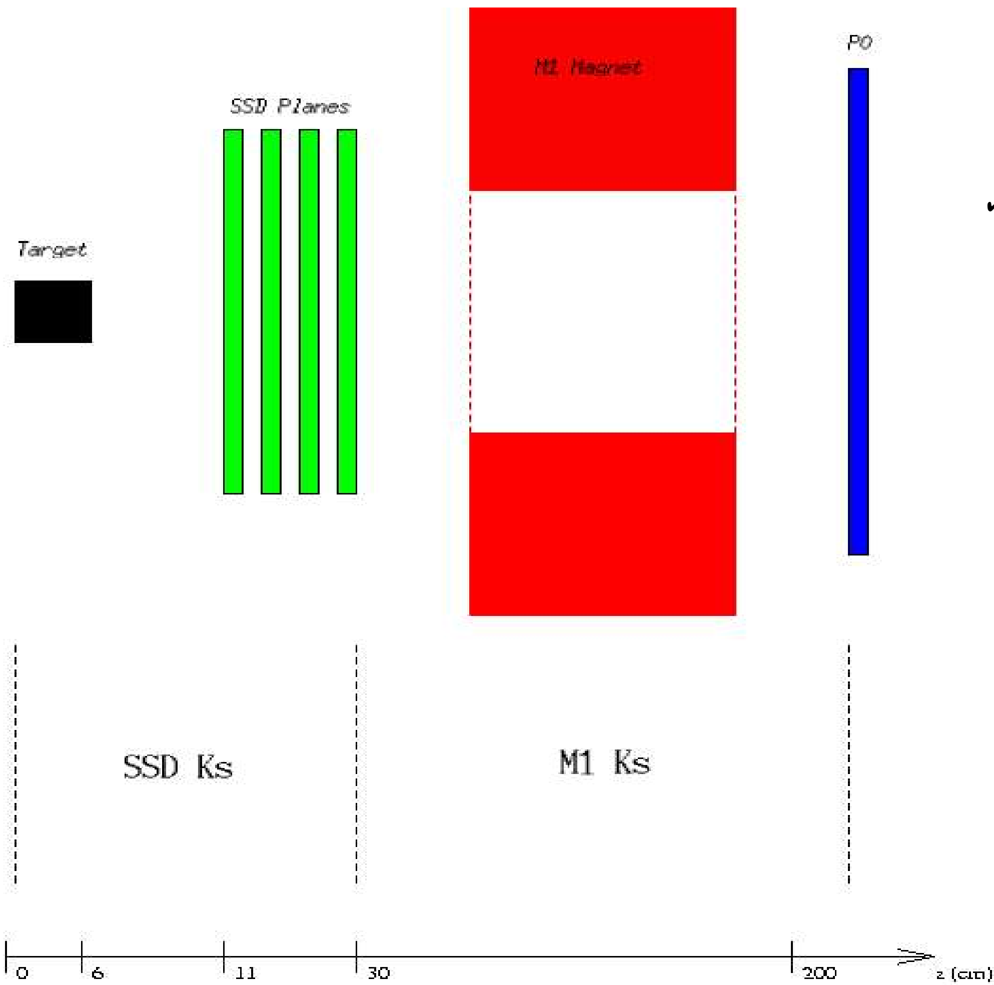
K_s Reconstruction

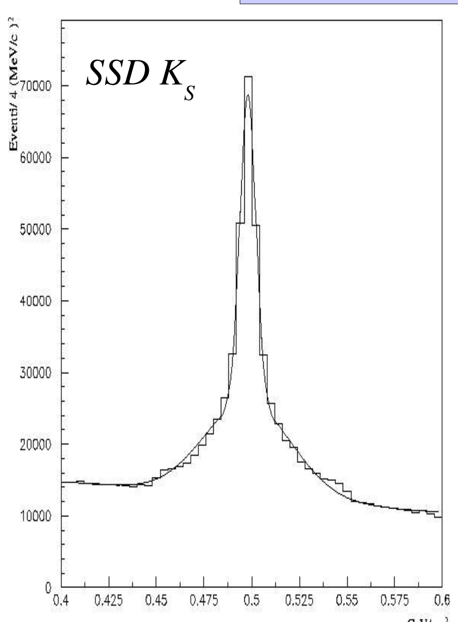
K_s Candidates are identified by the decay mode:

$K_s \to \pi^+\pi^-$ (B.R.= 68.3 %)

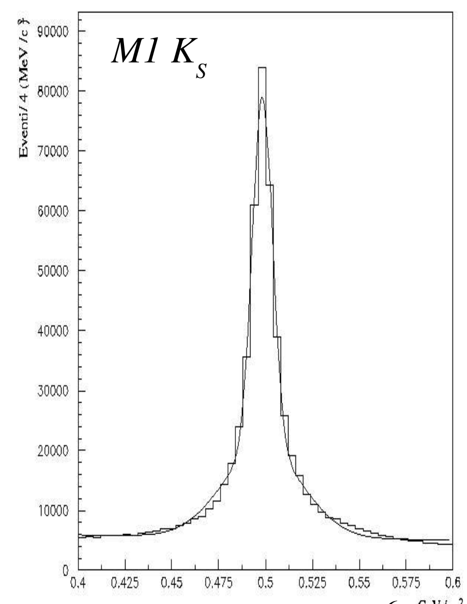
- SSD K_s: decaying upstream of SSD and composed of two linked SSD – PWC tracks;
- M1 K_s: two unlinked 3 or 5-chambers tracks;

2K_s sample used in the analysis





Yield= 2.7 x 10^5
σ=*3.4 MeV/c^2*



Yield= 1.15 x 10^6
σ=*6.2 MeV/c^2*

Events Selection (1)

- K_s Selection

  A cut on $\pi^+\pi^-$ invariant mass around K_s nominal value

  Cerenkov Cuts to remove possible misidentification with Λ ($\Lambda \rightarrow p\pi^-$)

  M1 K_s : a cut on distance of closest approach of π tracks

  M1 K_s : a cut on error on longitudinal coordinate of K_s decay vertex

- Charm decay selection

  Selection Criteria for the two - body decay are different than for multi - body decays, due to poorer resolution on vertices.

- $D^0 \rightarrow K_s K_s$

- A momentum cut on D^0 candidates
- A cut on the angle between the D^0 flight direction and the K_s direction in D^0 rest frame
- D* signature:

  Events signature through decay chain $D^{*\pm} \rightarrow D^0(K_s\, K_s)\, \pi^{\pm}$ is used to substantially reject the background. A cut is applied on the $D^* - D^0$ mass difference -> $|M(D^* - D^0) - 0.14542| < 0.002$ GeV/c^2

Events Selection (2)

- $D^0 \to K_S K_S K\pi\ (\pi\pi)$

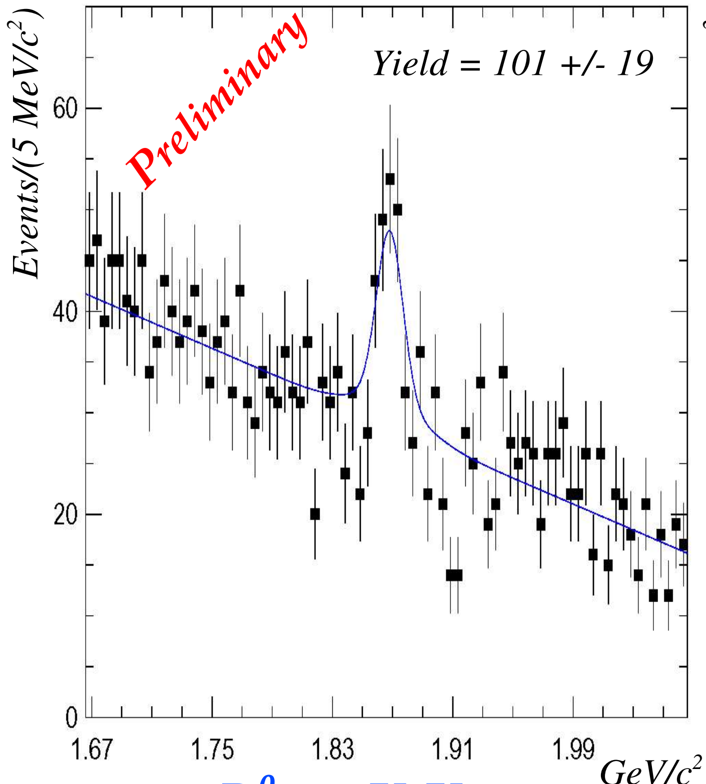
- ✓ Cerenkov cuts for charged tracks
- ✓ Vertex quality cuts: Secondary and Primary vtx CL > 1%, isolation of secondary vtx
- ✓ A cut on charm decay length significance (L/σ)
- ✓ No D* signature requested to isolate a signal

➨ Charm Background rejection

Contaminations from different charm meson decay modes, which could produce reflections in D^0 mass region, have been studied.

- ✓ SSD K_s : a cut on decay length significance (L/σ) removes misidentification with a $\pi^+\pi^-$ pair coming from the decay vertex. In particular, for the two – body decay, this cut removes possible contamination from $D^0 \to K_s\pi^+\pi^-$ decay mode, for which K_s misidentification with a $\pi^+\pi^-$ pair yields a reflection in D^0 mass region.

D^0 Mass Plots



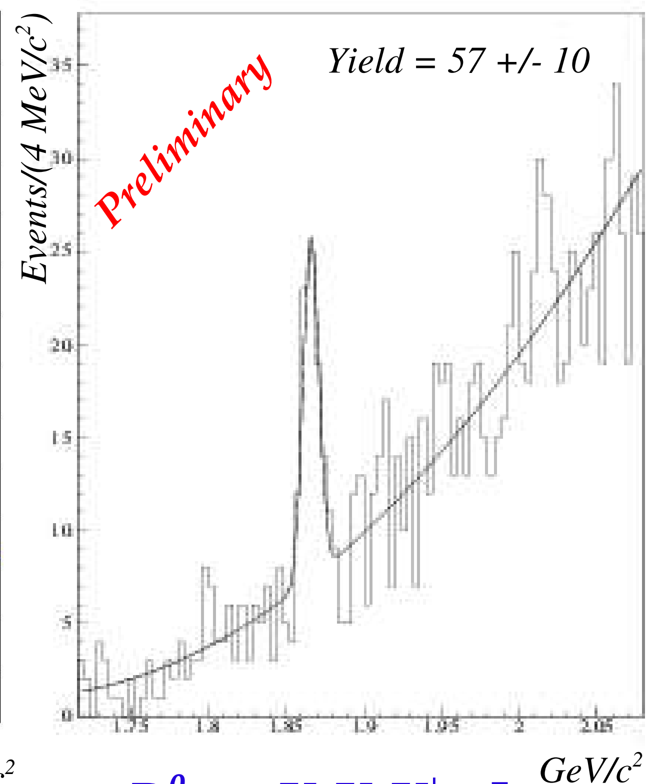
$D^0 \rightarrow K_s K_s$

σ = 12.72 MeV/c^2

Mass=1.868 +/- 0.002 GeV/c^2

- Two gaussian for the signal, plus a Chebychev first order for the background
- shape fixed to MC

Efficiency = 0.65 %



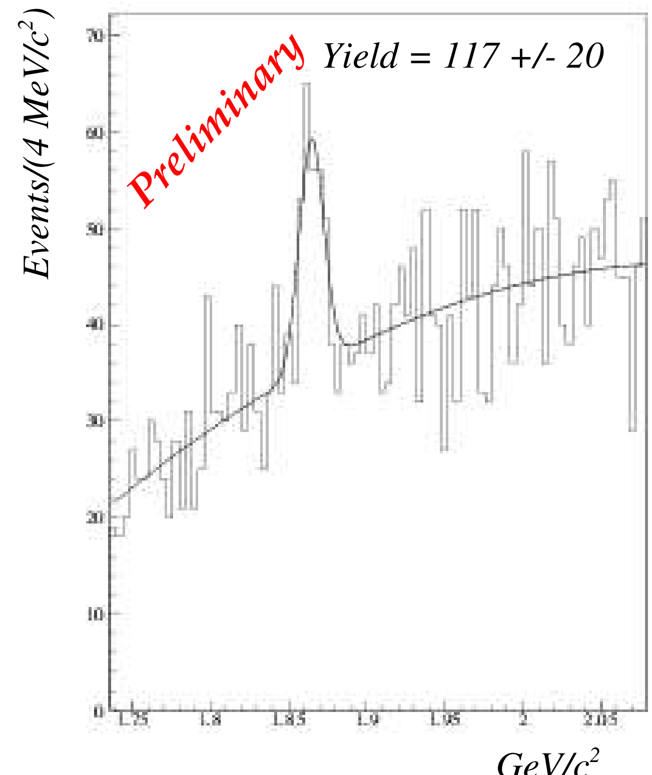
$D^0 \rightarrow K_s K_s K^{\pm} \pi^{\mp}$

σ = 5. MeV/c^2

Mass=1.8660 +/- 0.0011 GeV/c^2

- One gaussian for the signal, plus a polynomial second order for the background
- shape fixed to MC

Efficiency = 0.154 %



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

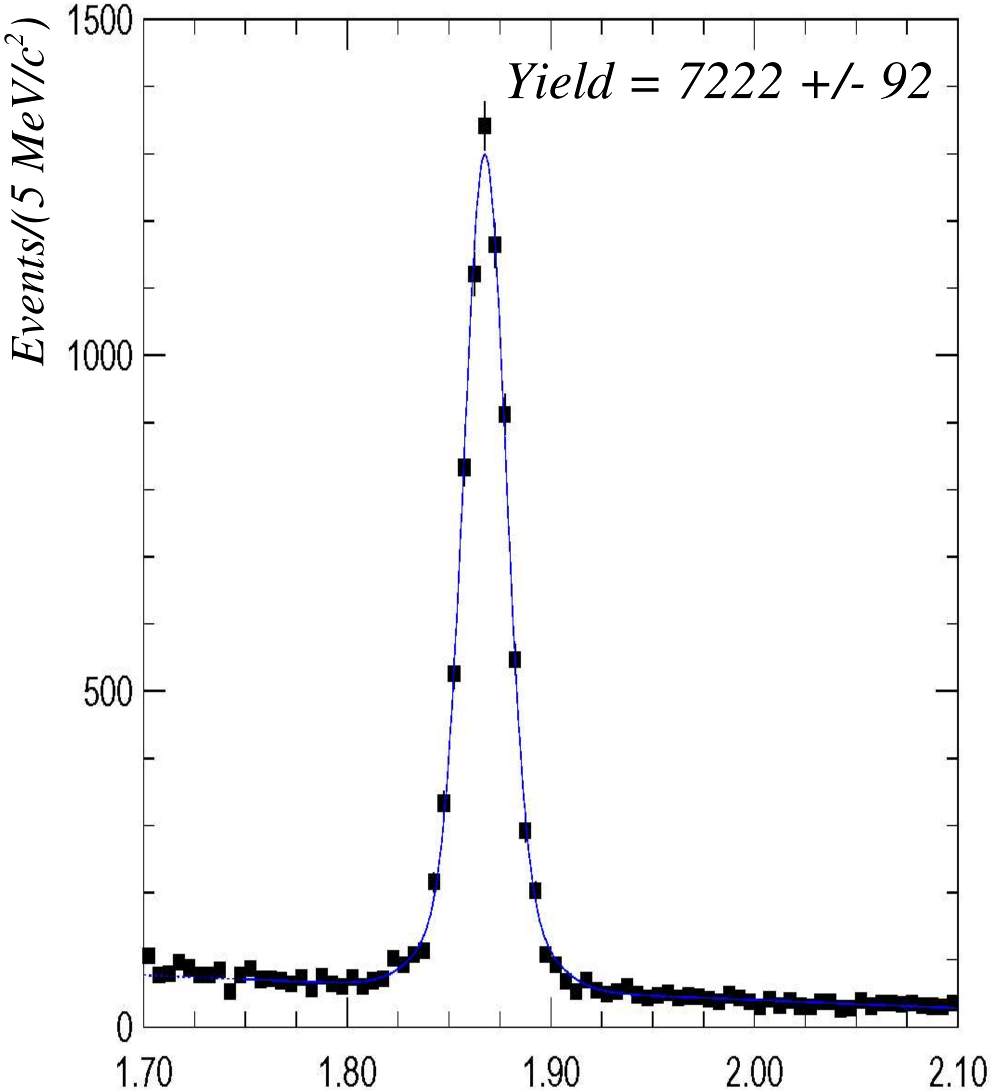
σ = 6.5 MeV/c^2

Mass=1.8648 +/- 0.0011 GeV/c^2

- One gaussian for the signal, plus a polynomial second order for the background

Efficiency = 0.16 %

Normalization channel: $D^0 \to K_S\pi^+\pi^-$



$D^0 \to K_S\pi^+\pi^-$ mass plot for $\Gamma(D^0 \to K^0\bar{K}^0)/\Gamma(D^0 \to \bar{K}^0\pi^+\pi^-)$ measurement

$D^0 \to K_S\pi^+\pi^-$ decay mode has been used as normalization for B.R. measurement to minimize systematic errors connected with K_s reconstruction

- Selection Criteria as much as possible equal to $D^0 \to K_SK_S$ ($K\pi$, $\pi\pi$)
- Cerenkov cuts on charged tracks
- Charm decay length significance
  - Same Parameterization as for $2K_S$ decay mode

σ_1=12.4 MeV/c^2

Mass=1.868 +/- 0.002 GeV/c^2

Systematic Studies under investigation

The variable used for events selection have been studied:

- Different K_s type and different selection criteria
- Angular and momentum distribution
- Charm background
- Possible Resonant Contributions

The systematic uncertainty is found by splitting the data in statistically independent samples, as

- Different run period conditions
- Particle/Antiparticle
- High /Low Charm momentum

Other Systematic sources:

- Different fitting conditions
- Limited Montecarlo statistics
- Different K_s type and reconstruction

Preliminary Branching Ratio

$$\frac{\Gamma(D^0 \to K^0\bar{K}^0)}{\Gamma(D^0 \to \bar{K}^0 \pi^+\pi^-)} = 1.62 \pm 0.30\ \%$$

$$\frac{\Gamma(D^0 \to K_S K_S K^\pm \pi^\mp)}{\Gamma(D^0 \to \bar{K}^0 \pi^+\pi^-)} = 1.13 \pm 0.20\ \%$$

$$\frac{\Gamma(D^0 \to K_S K_S \pi^+\pi^-)}{\Gamma(D^0 \to \bar{K}^0 \pi^+\pi^-)} = 2.23 \pm 0.38\ \%$$

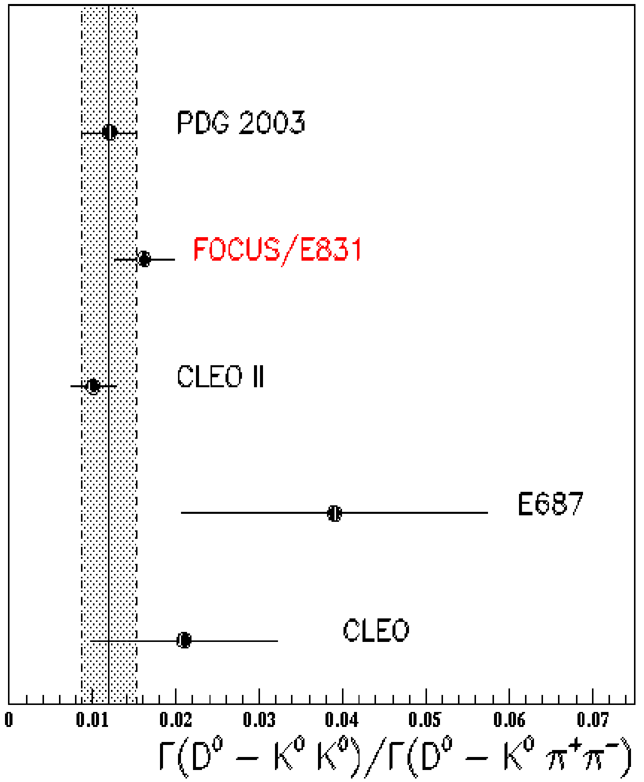
The errors reported are only Statistical.

Previous Measurements for $D^0 \to K^0\bar{K}^0$:

CLEO II (26 ev)	$(1.01 \pm 0.22 \pm 0.16)\ 10^{-2}$
E687 (20 ev)	$(3.9 \pm 1.3 \pm 1.3)\ 10^{-2}$
CLEO (5 ev)	$(2.1\ ^{+0.11}_{-0.08} \pm 0.2)\ 10^{-2}$

Previous Measurements for $D^0 \to K^0\bar{K}^0\pi^+\pi^-$:

ARGUS (25 ev)	$(12.6 \pm 3.8 \pm 3.)\ 10^{-2}$



Conclusions

- Improved Measurements on D^0 decays into multi K_s final states and first evidence for $D^0 \to K_s K_s K\pi$ modes.
- For $D^0 \to K^0\bar{K}^0$ decay mode, FOCUS result useful for a comparison with theoretical previsions.

Model	$\Gamma(D^0 \to K^0\bar{K}^0)/\Gamma(all)$ (%)
BSW model	0
Resonant Intermediate State	0.00032
OPE	0.025 - 0.063
Non factorizable contribution [1]	0.13
Non factorizable contribution [2]	0.043 +/ 0.014
PDG (2003)	0.071 +/- 0.019
FOCUS Preliminary	0.096 +/- 0.018

[1] K.Terasaki, Phys. Rev. D59 114001(99)
[2] J.O. Eeg, Phys. Rev. D64 034010(01)