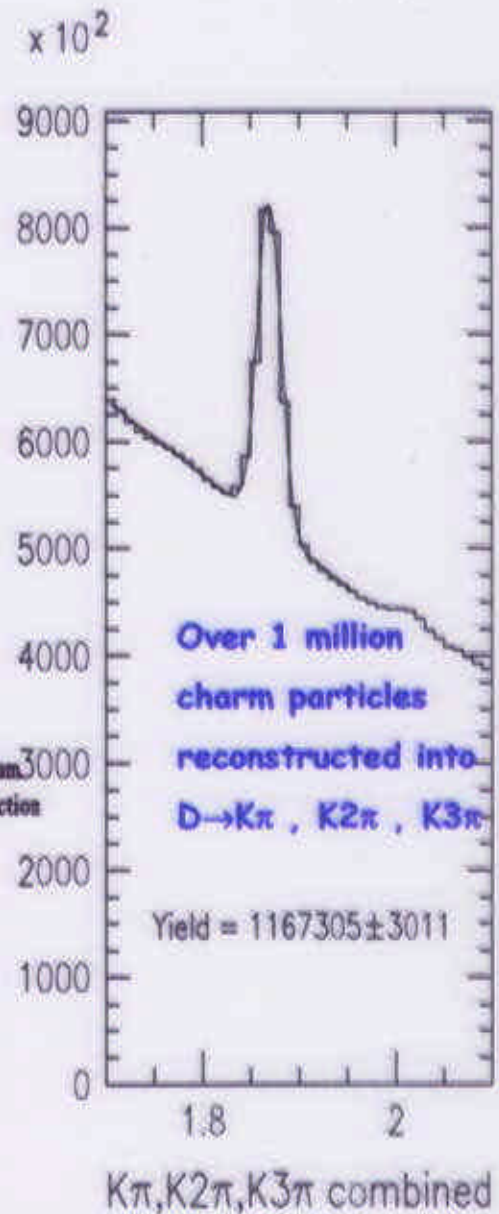
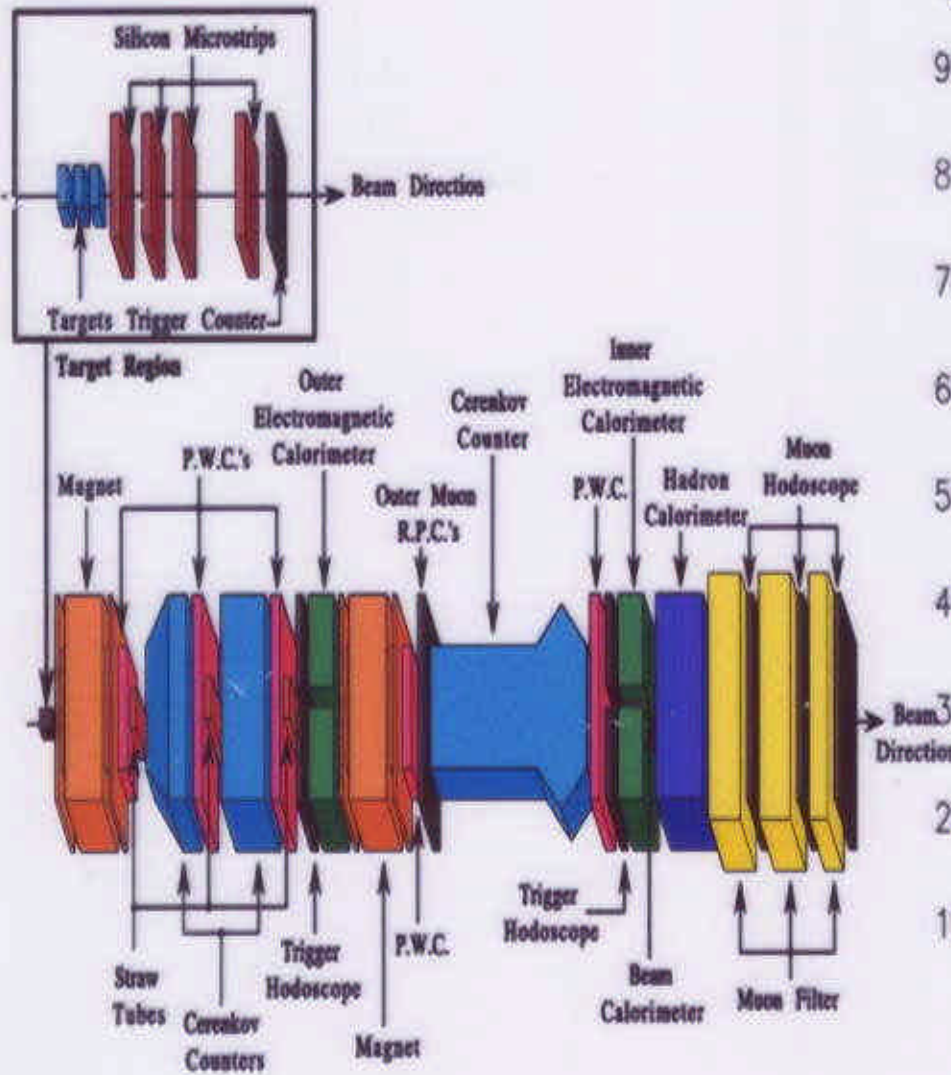


# Charmed mesons Spectroscopy from Focus

F.L. Fabbri  
Laboratori Nazionali di Frascati INFN -Italy

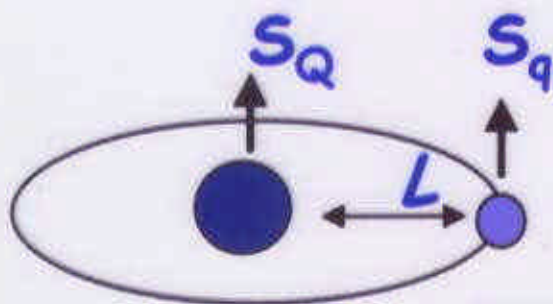
ICHEP2000, Osaka July 2000

# The searcher for charm



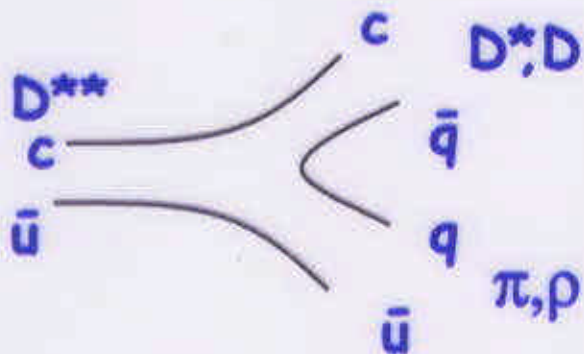
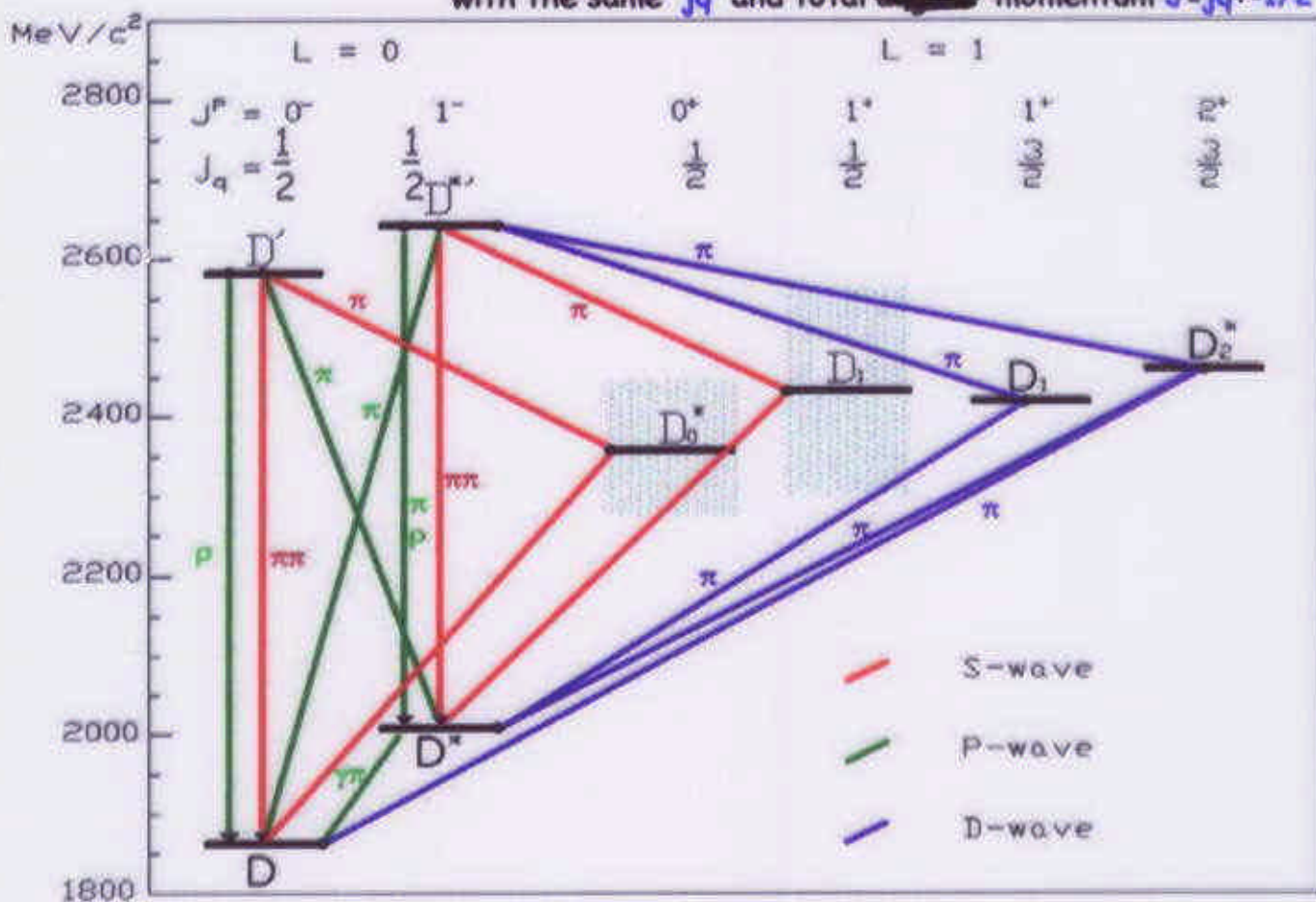
Successor to E687. Includes groups from USA, Italy, Brazil, Mexico, Korea  
 Designed to study charm particles produced by ~200 GeV photons using a fixed target spectrometer with upgraded Vertex, Cerenkov, E+M Calorimetry, and Muon id capabilities.

# Charmed mesons spectroscopy chart (HQS)



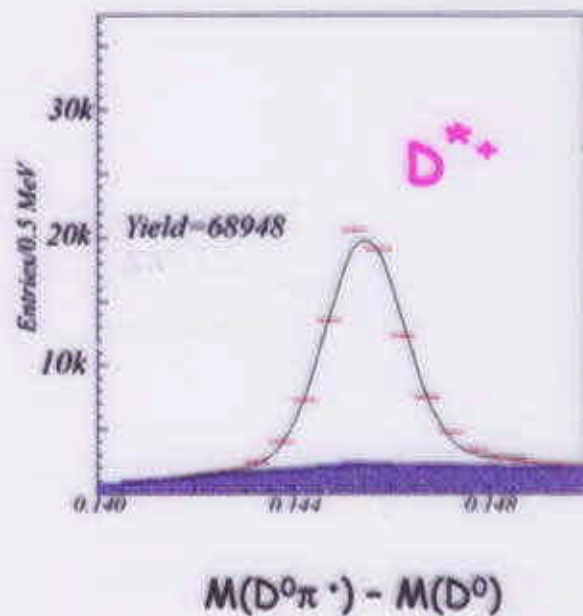
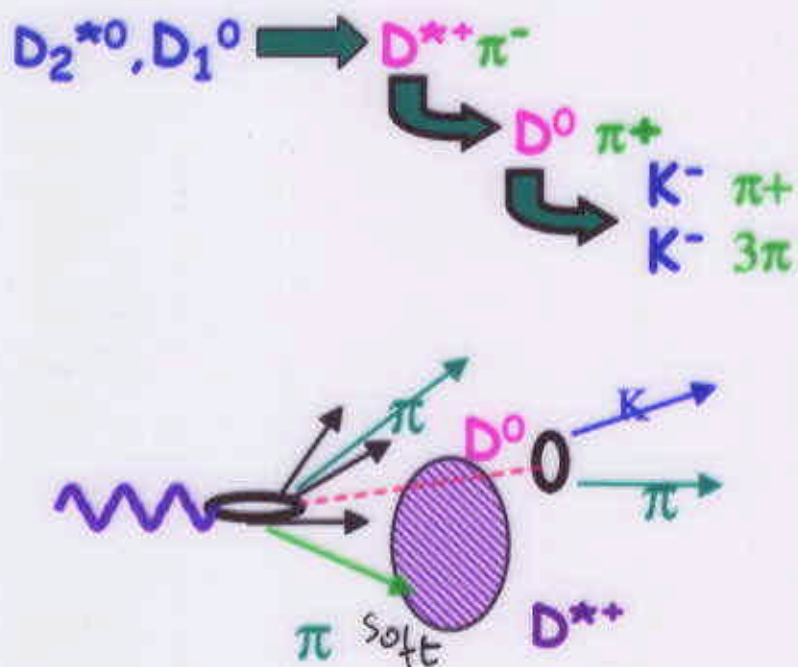
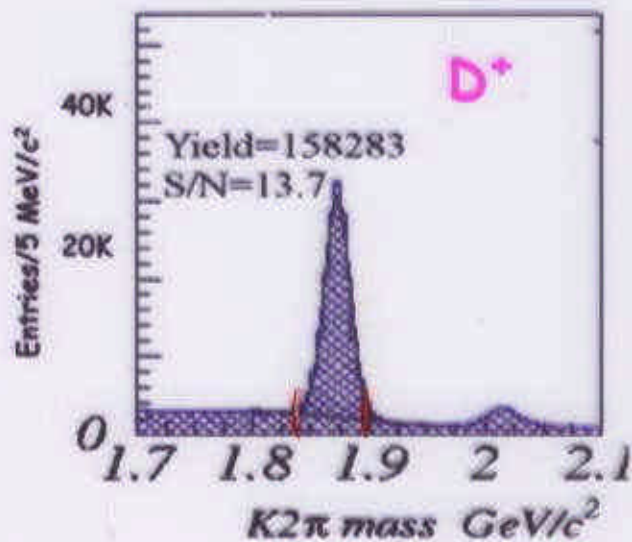
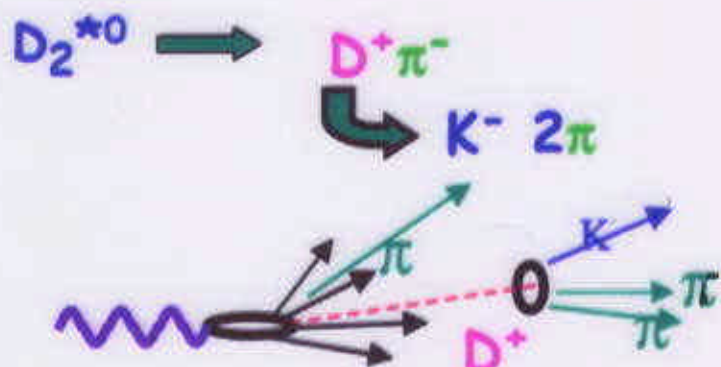
In the heavy-quark limit the heavy-quark spin  $S_Q$  and the total angular momentum of the light-quark  $j_q = L + S_q$  are conserved

Each level is composed of a degenerate pair of states with the same  $j_q$  and total momentum  $J = j_q + 1/2$

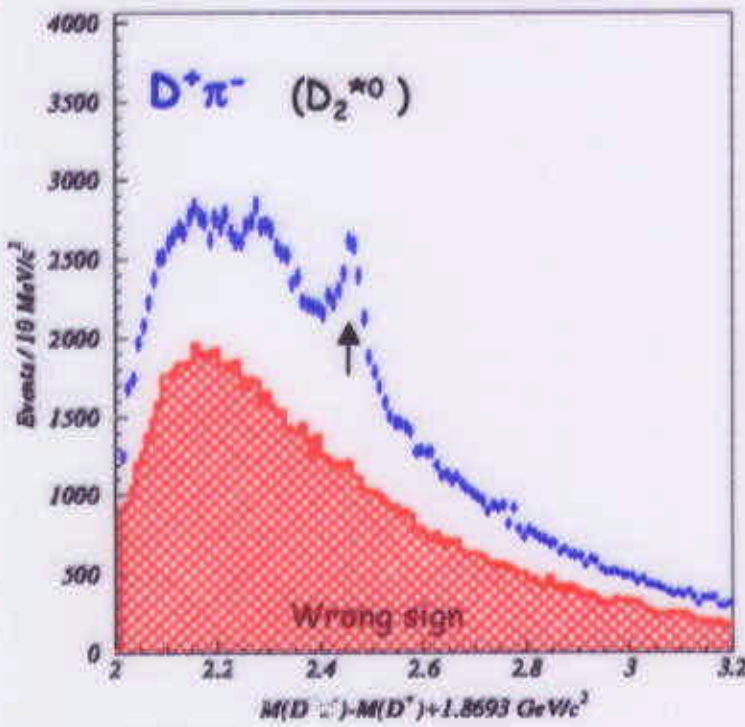


| $j_q$ | $J^P$ | Mode         | PW | Width  |
|-------|-------|--------------|----|--------|
| 3/2   | $2^+$ | $D \pi$      | D  | narrow |
|       |       | $D^* \pi$    | D  | narrow |
|       | $1^+$ | $D^* \pi$    | D  | narrow |
| 1/2   | $1^+$ | $D^{**} \pi$ | S  | broad  |
|       | $0^+$ | $D \pi$      | S  | broad  |

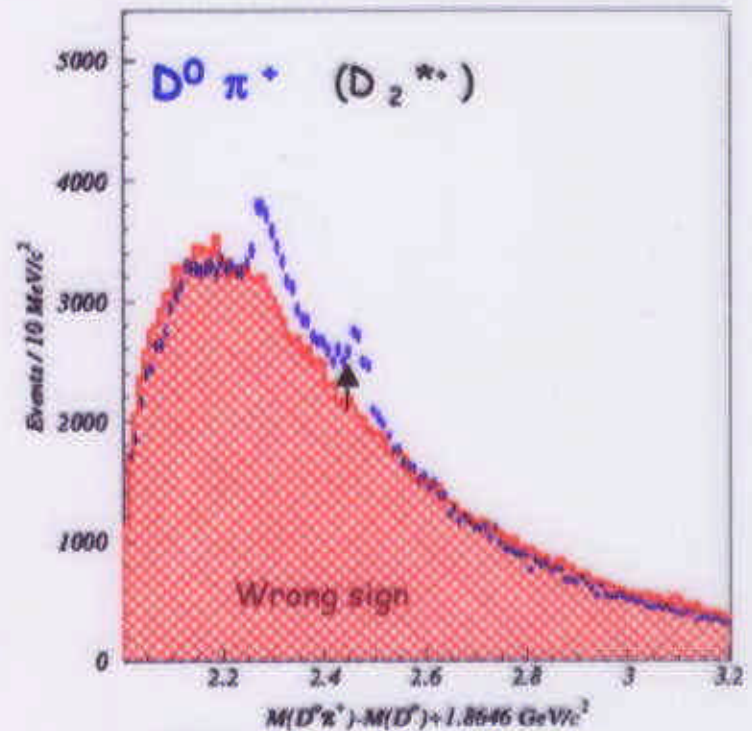
# Event selection for D-wave decays of L=1 D<sup>\*\*</sup>



# The $D\pi$ mass spectrum

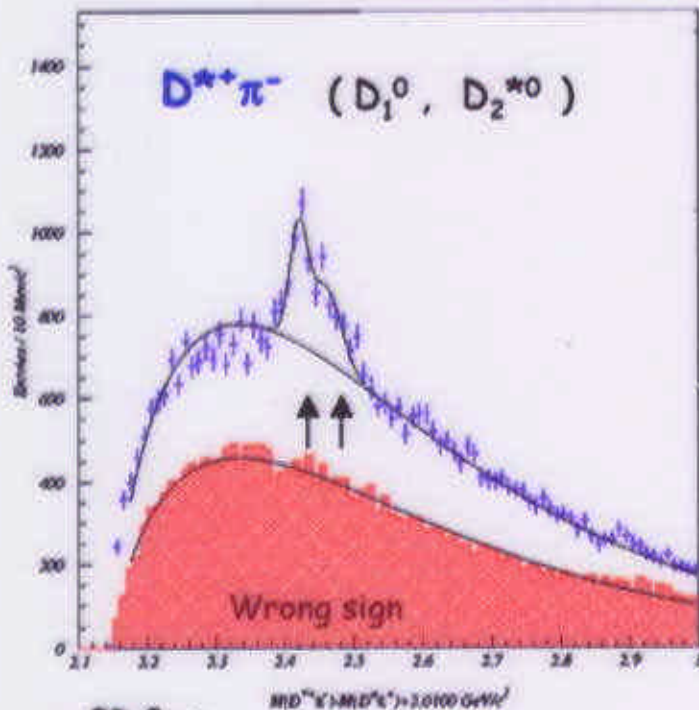


PDG →  
 $D_2^{*0}$  Mass =  $2458.9 \pm 2.0 \text{ MeV}/c^2$



PDG →  
 $D_2^{*+}$  Mass =  $2459 \pm 4 \text{ MeV}/c^2$

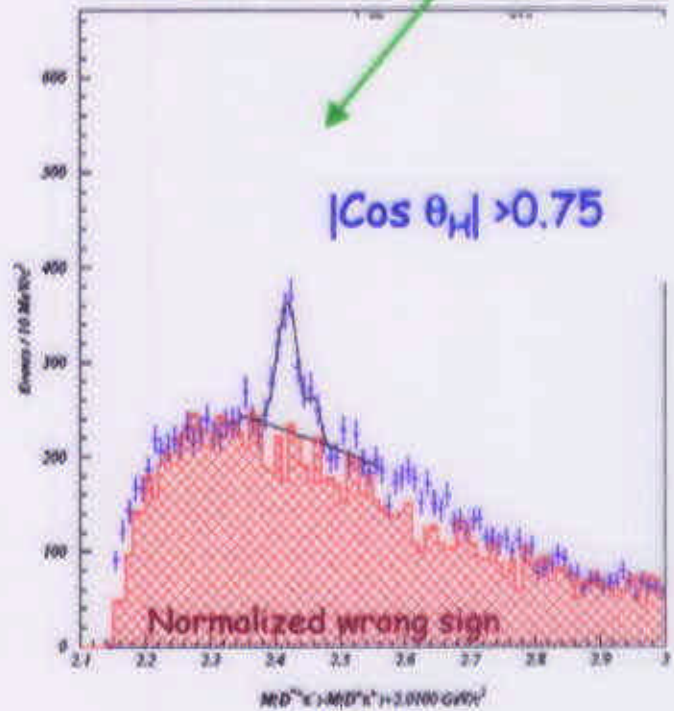
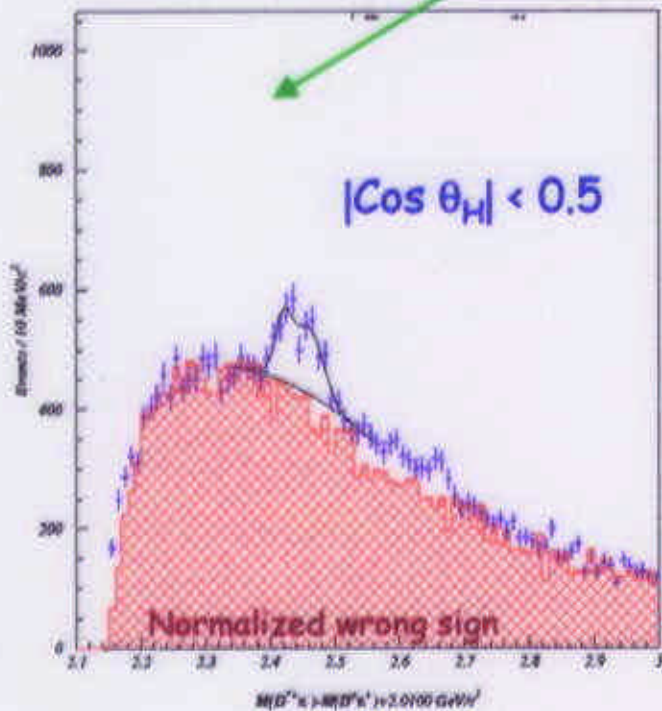
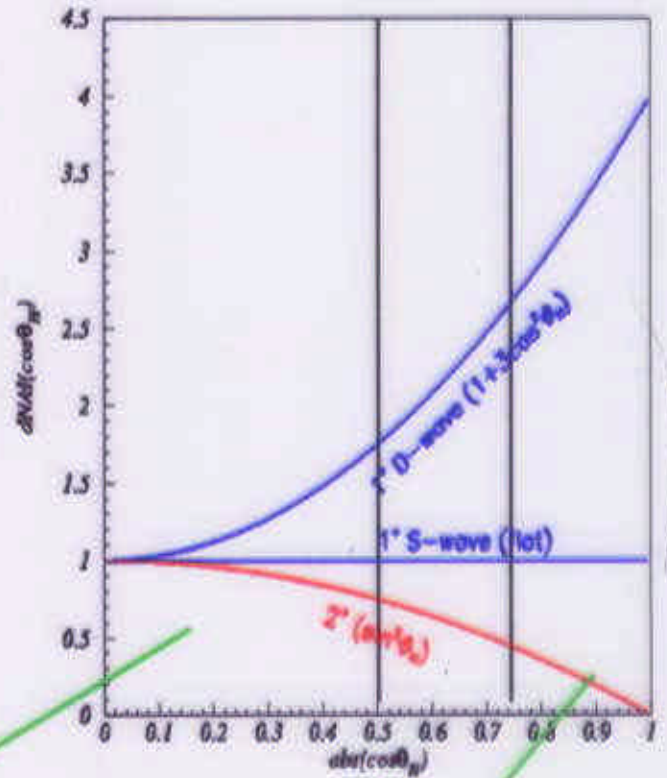
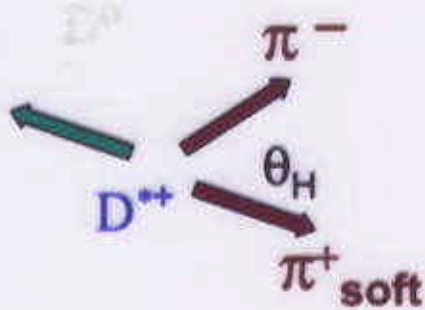
# The $D^*\pi$ mass spectrum



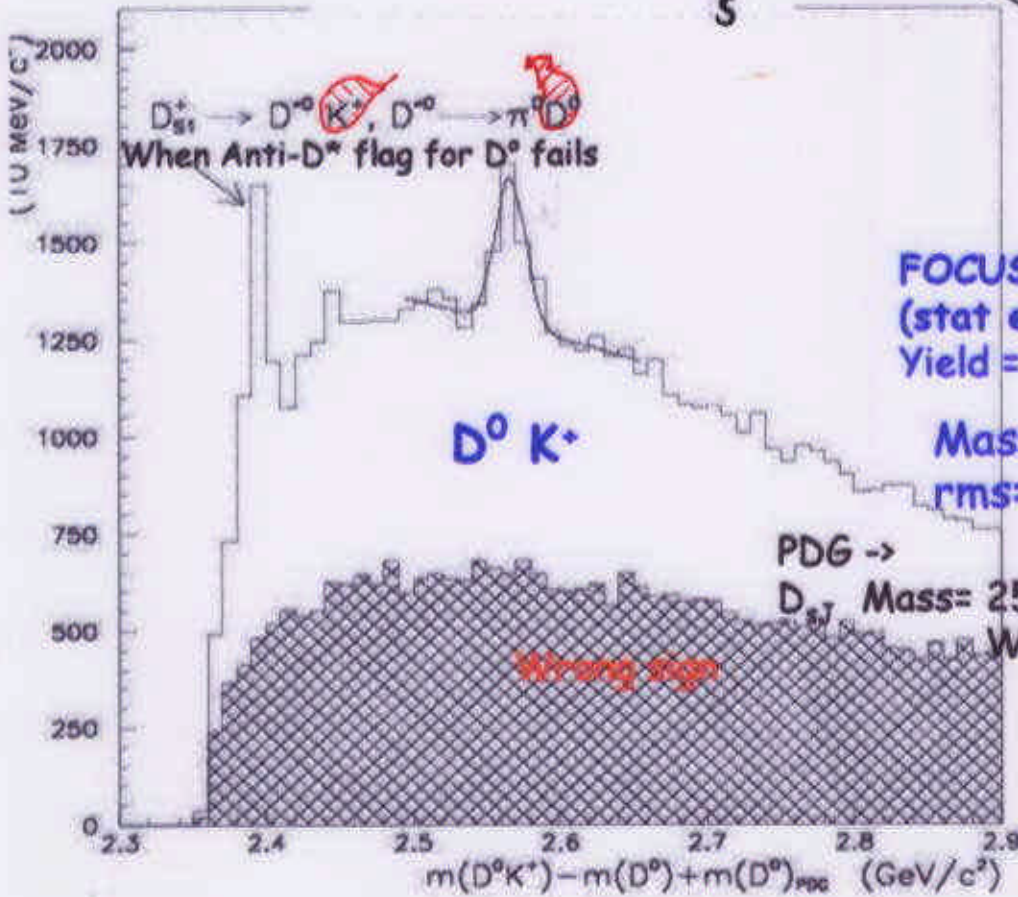
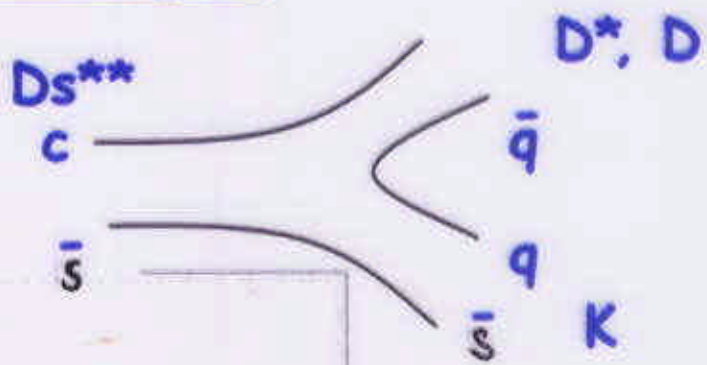
PDG →  
 $D_1^0$  Mass =  $2422.2 \pm 1.8 \text{ MeV}/c^2$   
 $D_2^{*0}$  Mass =  $2458.9 \pm 2.0 \text{ MeV}/c^2$

# Disentangling the $D_1$ e $D_2^*$ signals in $D^*\pi$

$D^*$  Helicity angle distribution for different  $D^{**}$  Spin-Parity

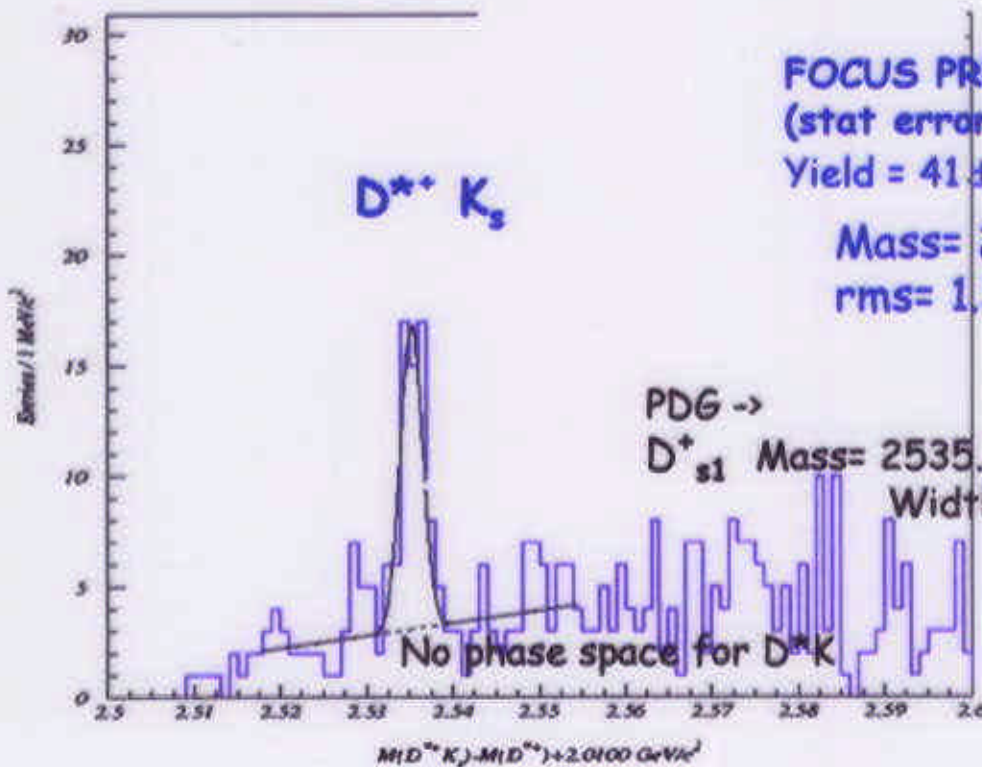


# Focus excited $c\bar{s}$ mesons samples



**FOCUS PRELIMINARY**  
 (stat errors only)  
 Yield =  $744 \pm 99$

Mass =  $2568.1 \pm 1.6 \text{ MeV}/c^2$   
 rms =  $10 \pm 1 \text{ MeV}/c^2$



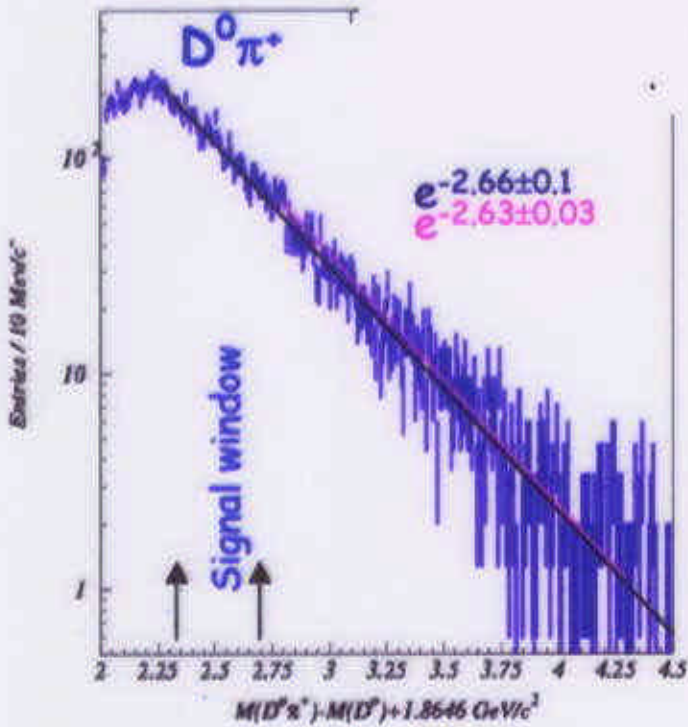
**FOCUS PRELIMINARY**  
 (stat errors only)  
 Yield =  $41 \pm 6$

Mass =  $2535.2 \pm 0.4 \text{ MeV}/c^2$   
 rms =  $1.3 \pm 0.1 \text{ MeV}/c^2$

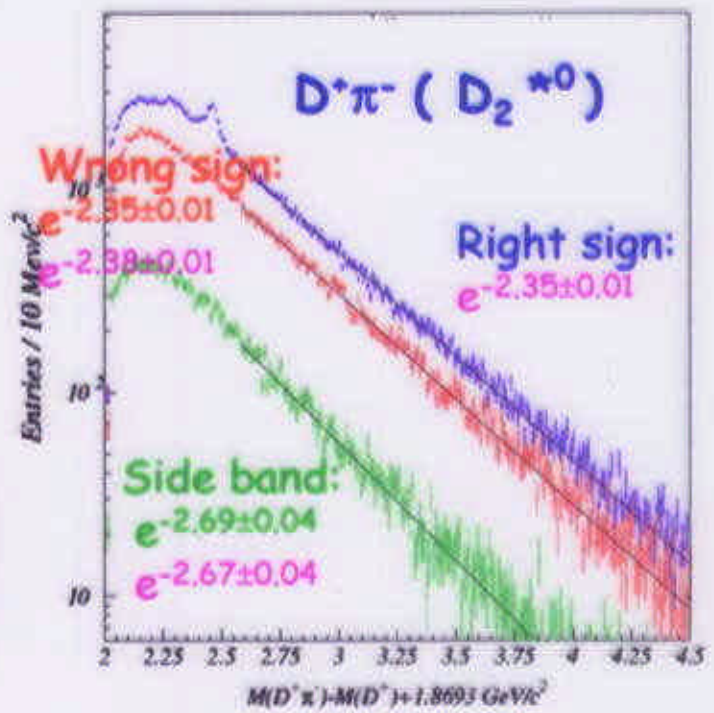
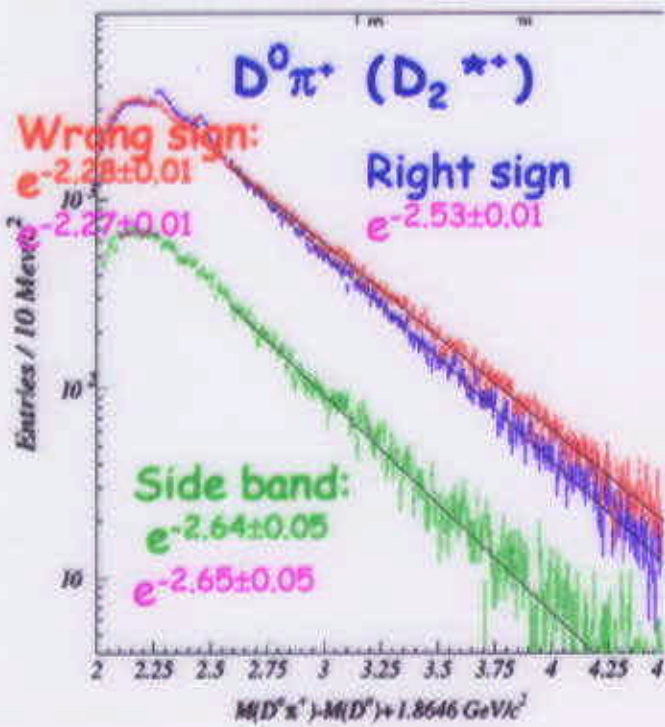
# Modeling the background in $D\pi$ spectrum

McFOCUS simulation code

$D^0\pi^+$  Mass spectrum from  $c\bar{c}$  production with No  $D^{**}$  generated

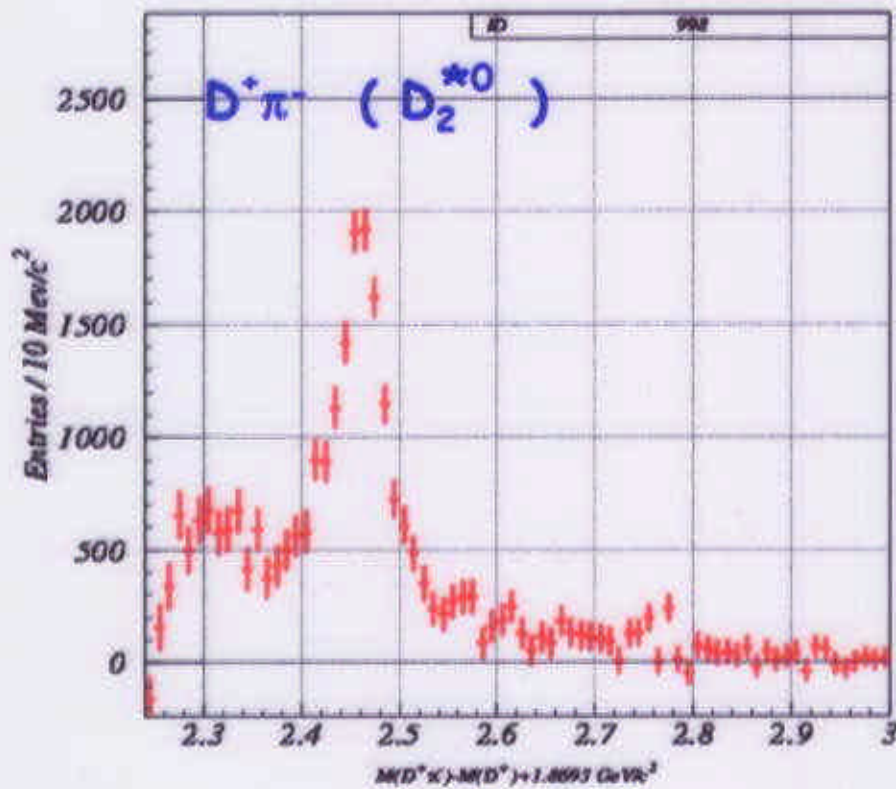
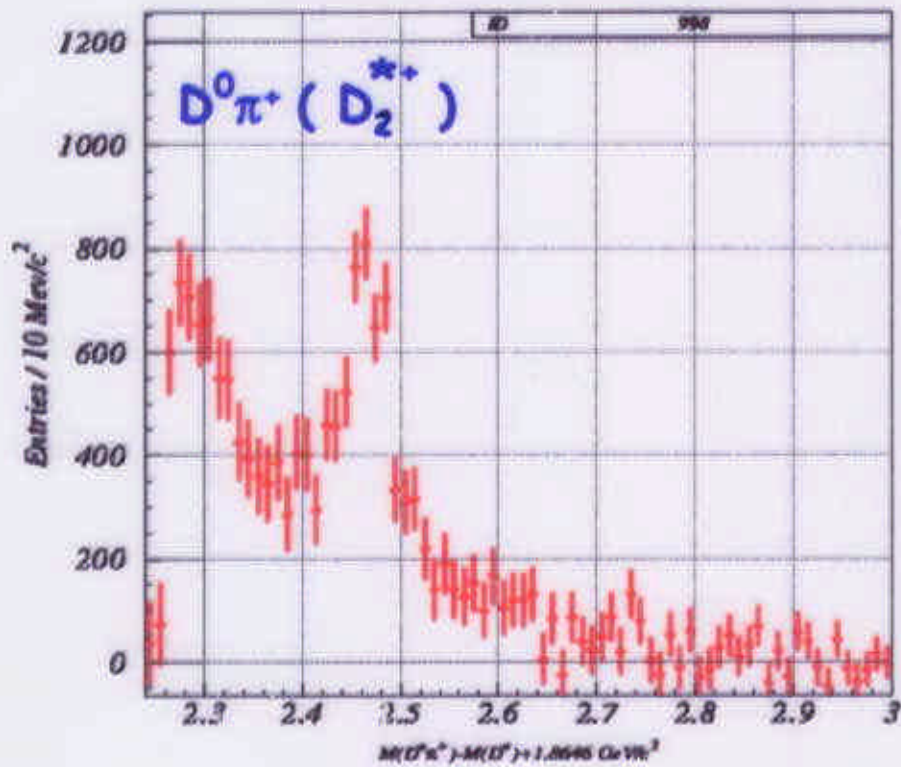


exponential behavior in the range 2.2-4.5  $GeV/c^2$  confirmed by the wrong sign and by the side band spectra



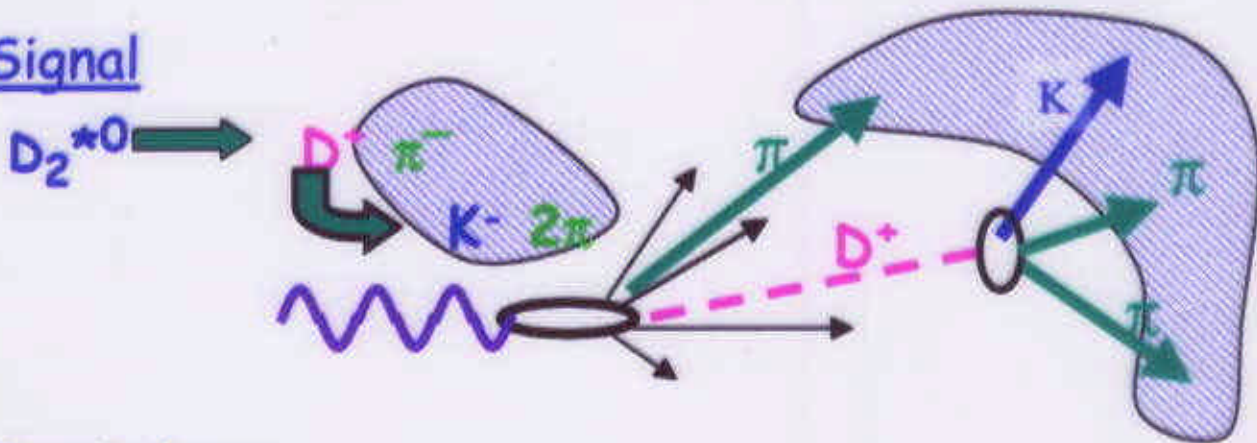


# Excess of mass once the background is subtracted

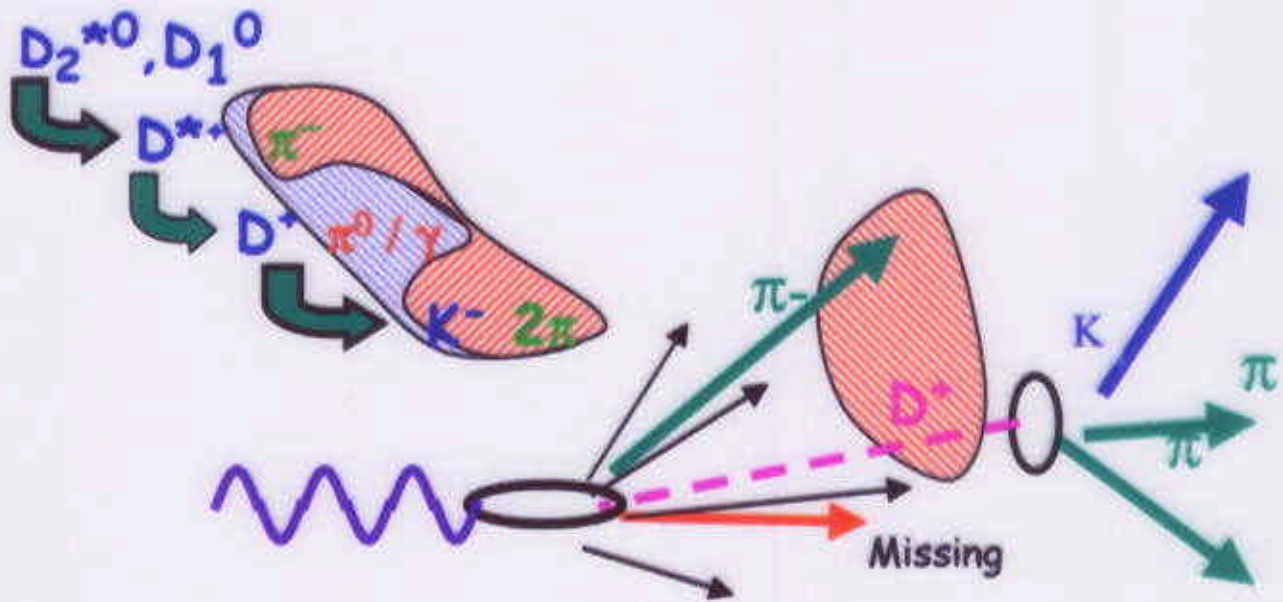


# Feed-down contribution for $D\pi$ spectrum

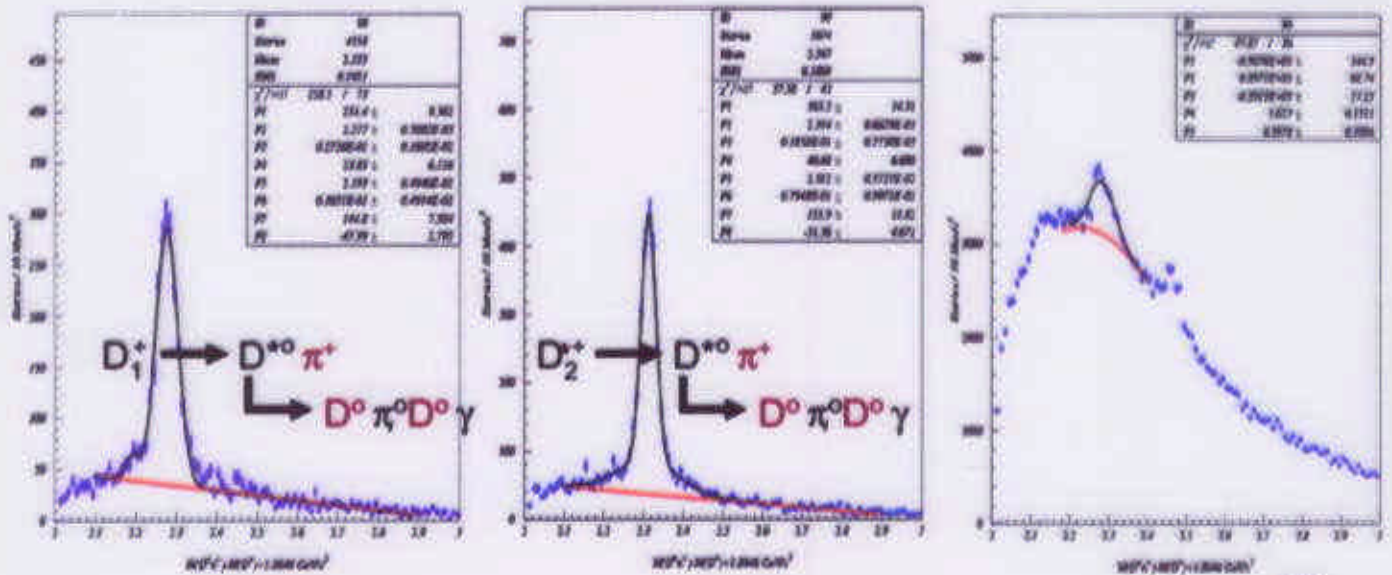
## Signal



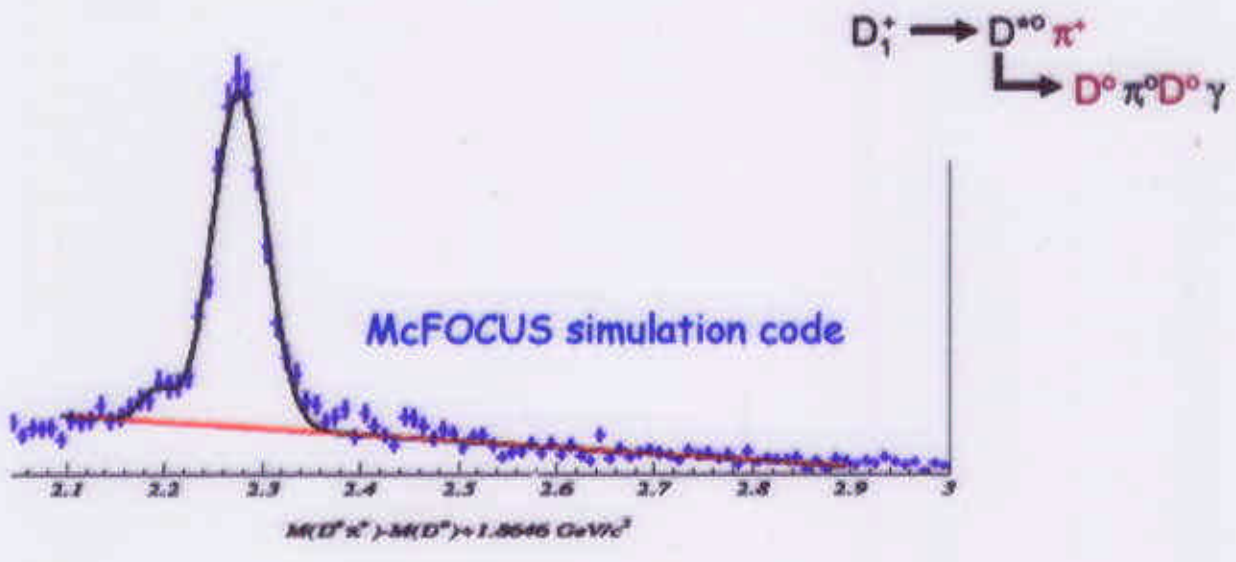
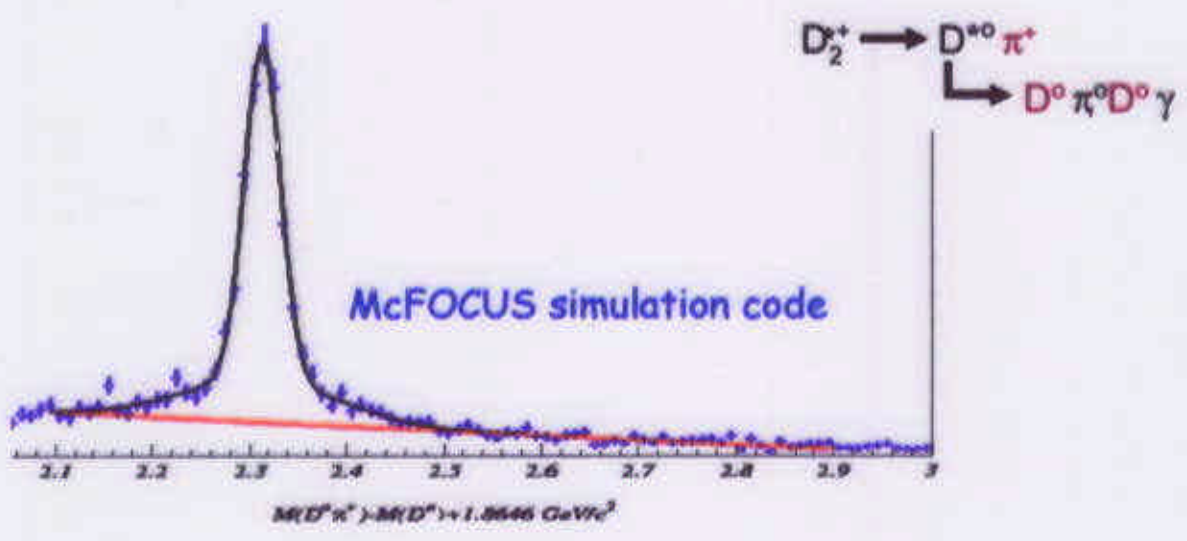
## Feed-down

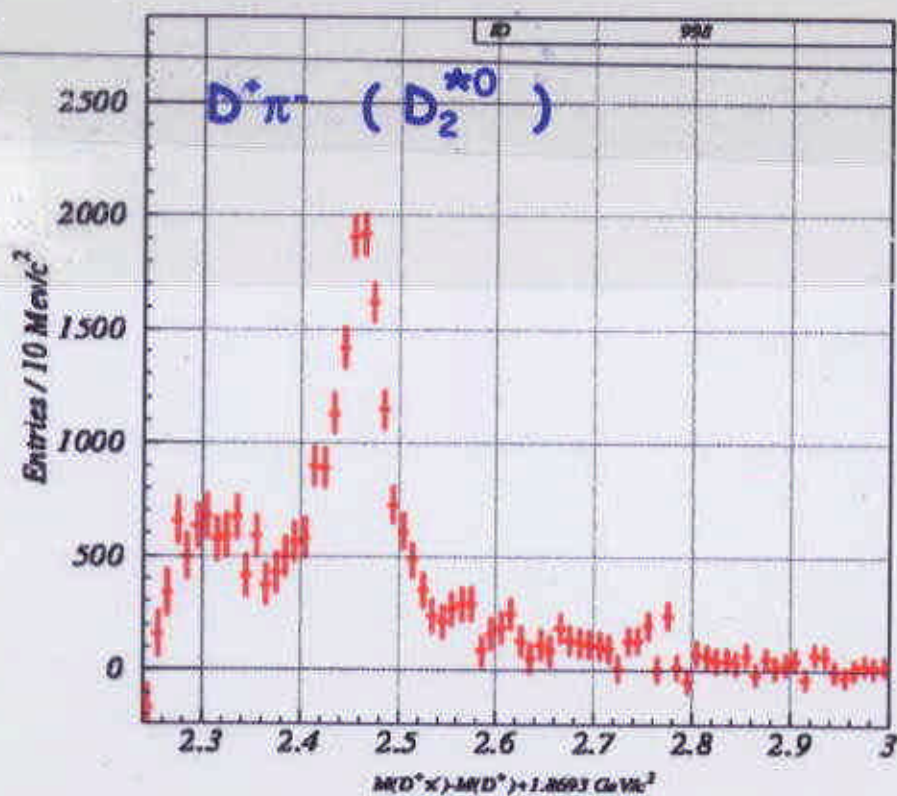
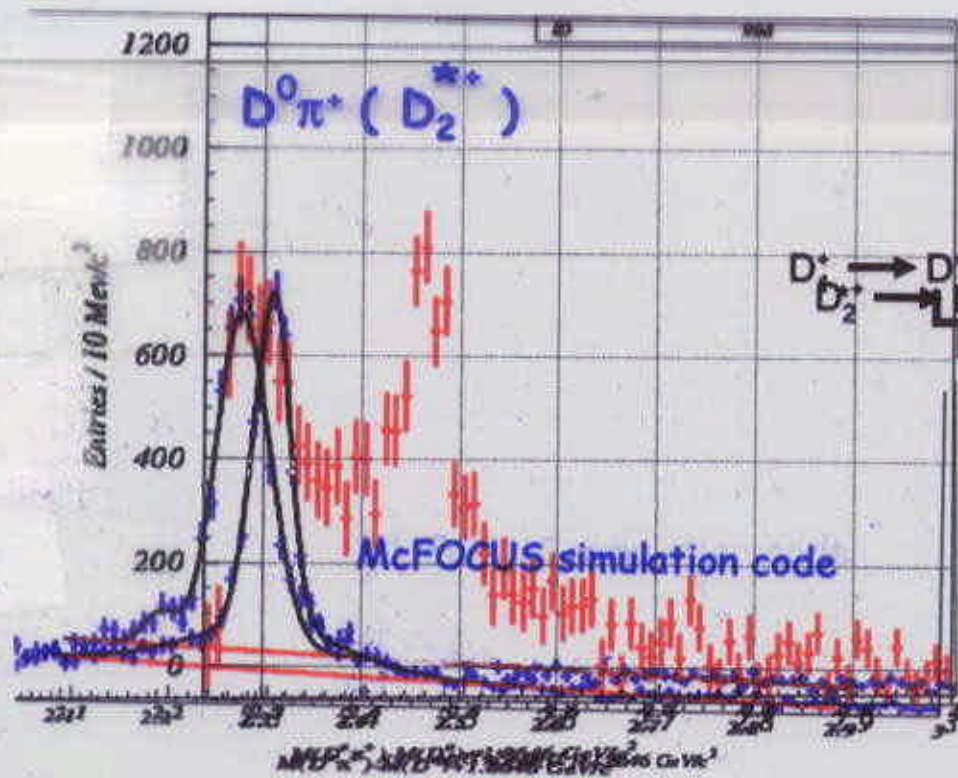


## Feed-down from MCFocus simulation (PDG masses and widths assumed)

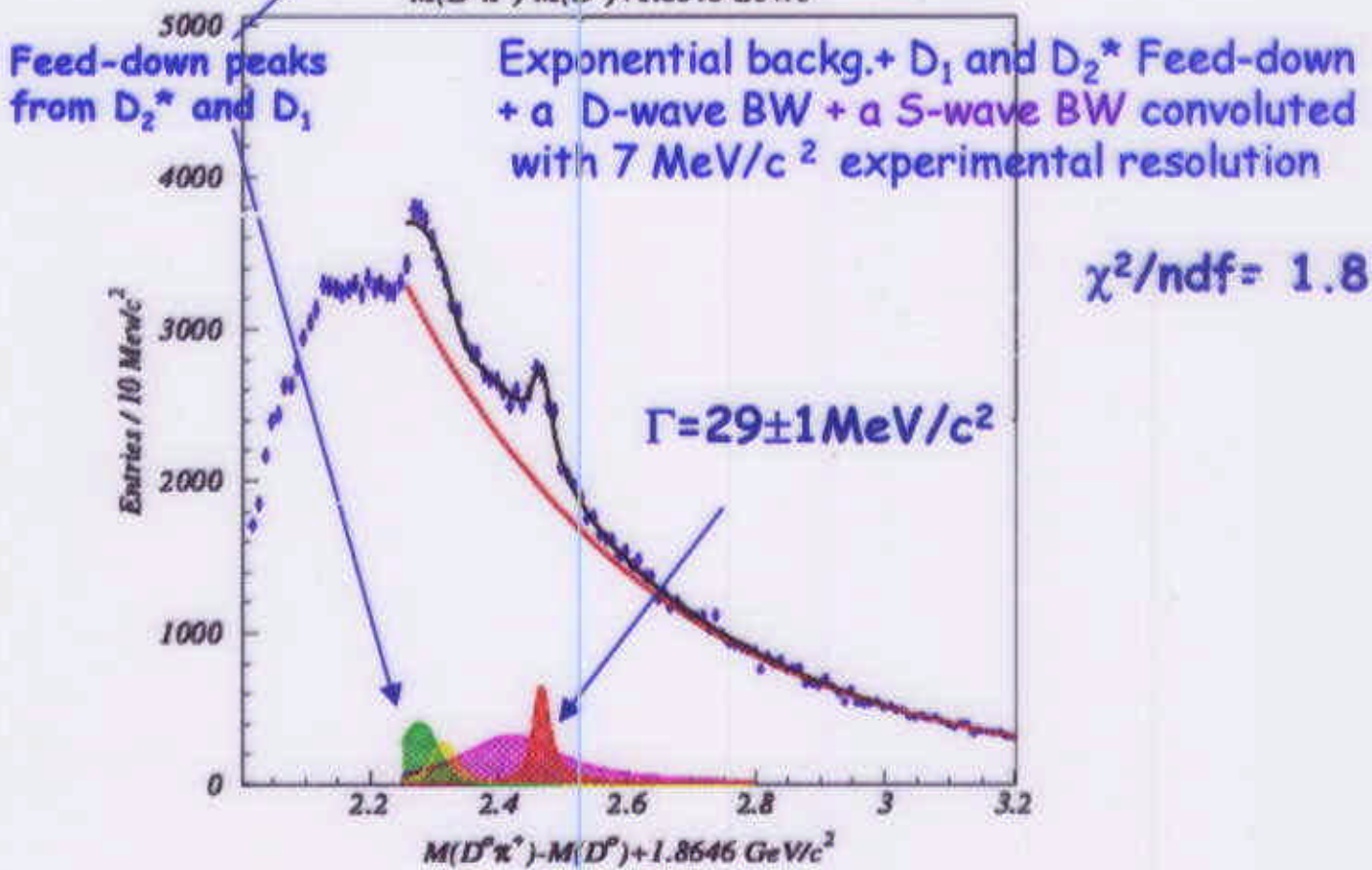
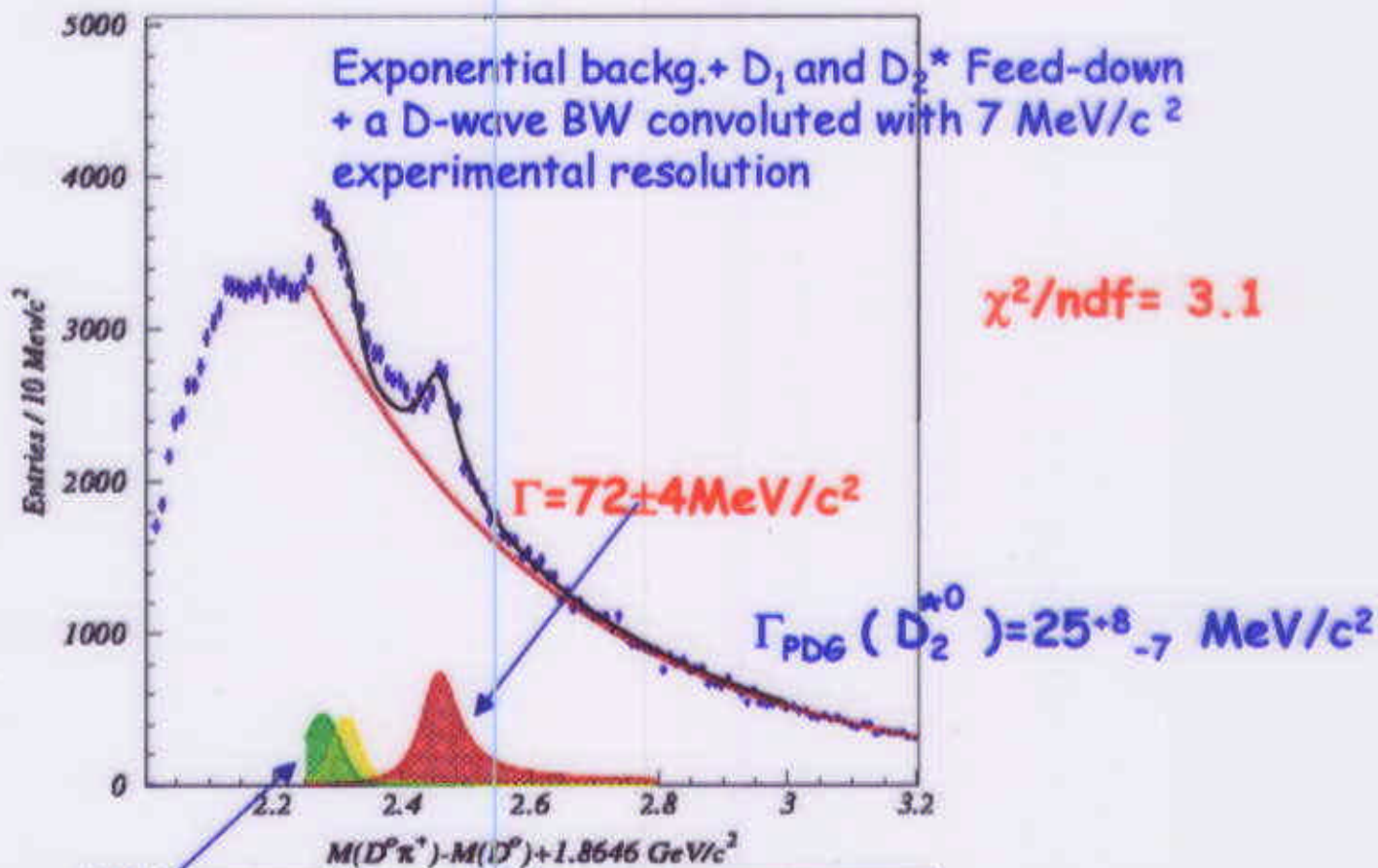


# Feed-down from $D_2^*$ $D_1$ via $D^*$ to $D\pi$ final channel

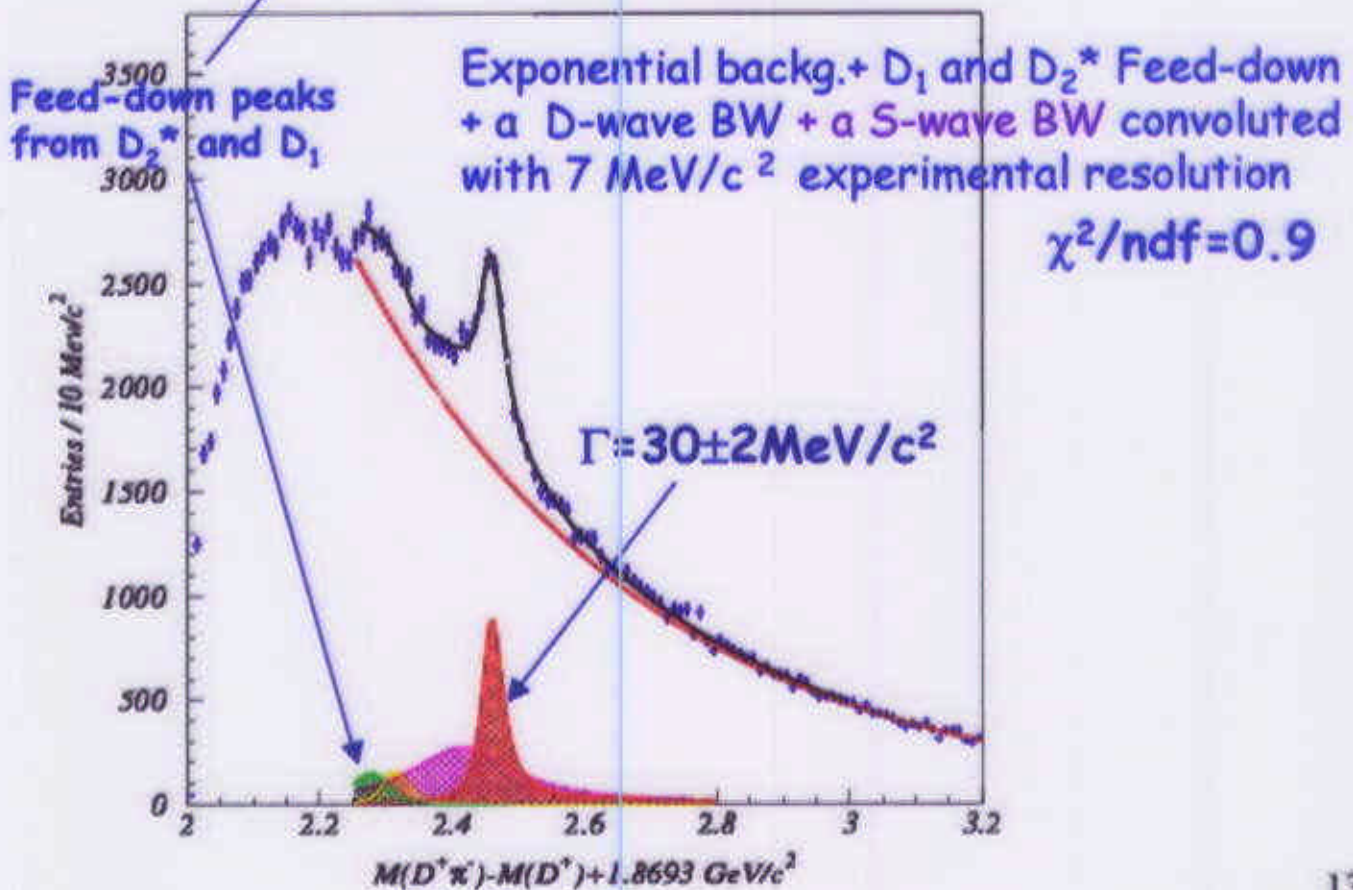
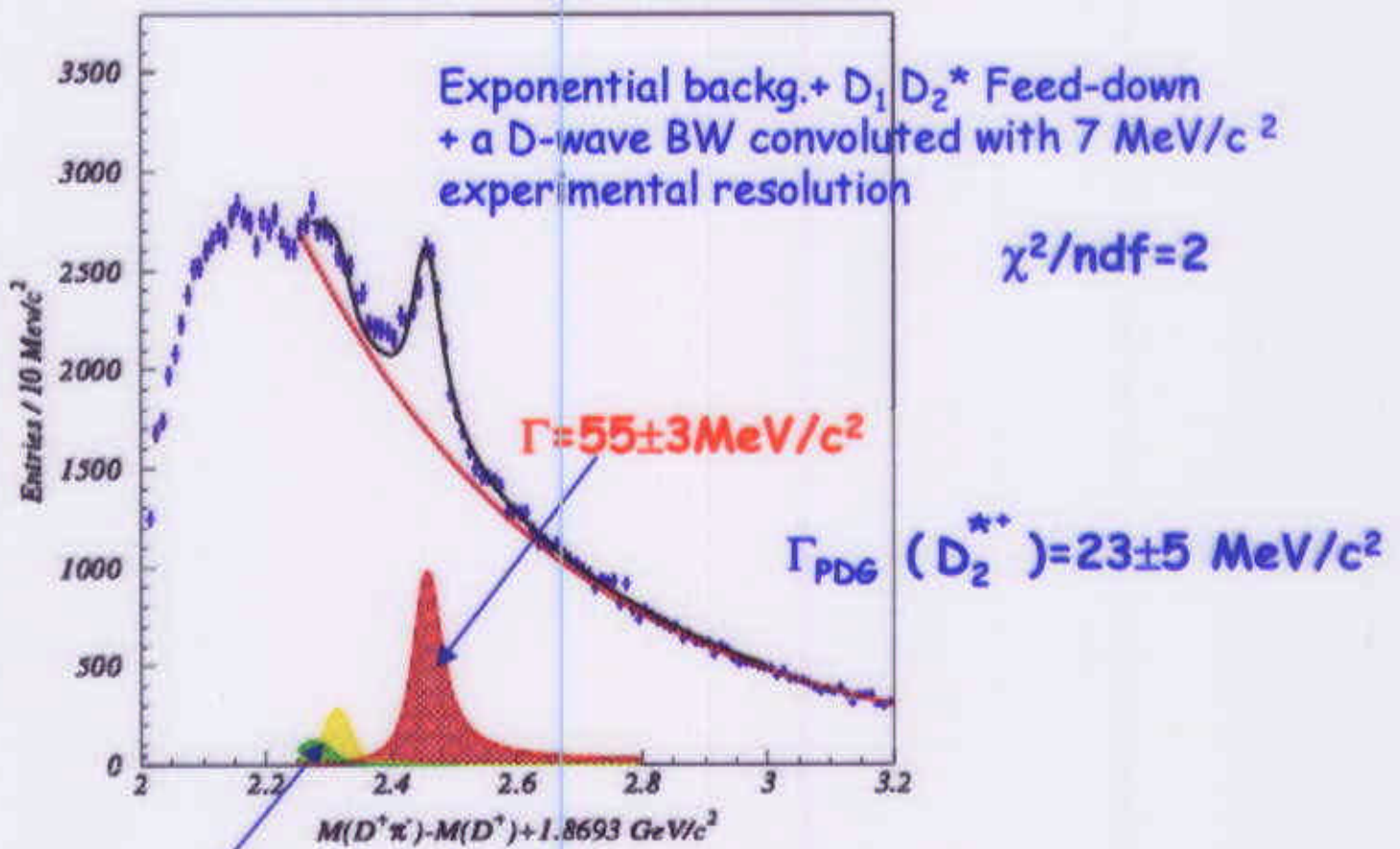




# Fitting the mass excess in the $D^0 \pi^+$ spectrum

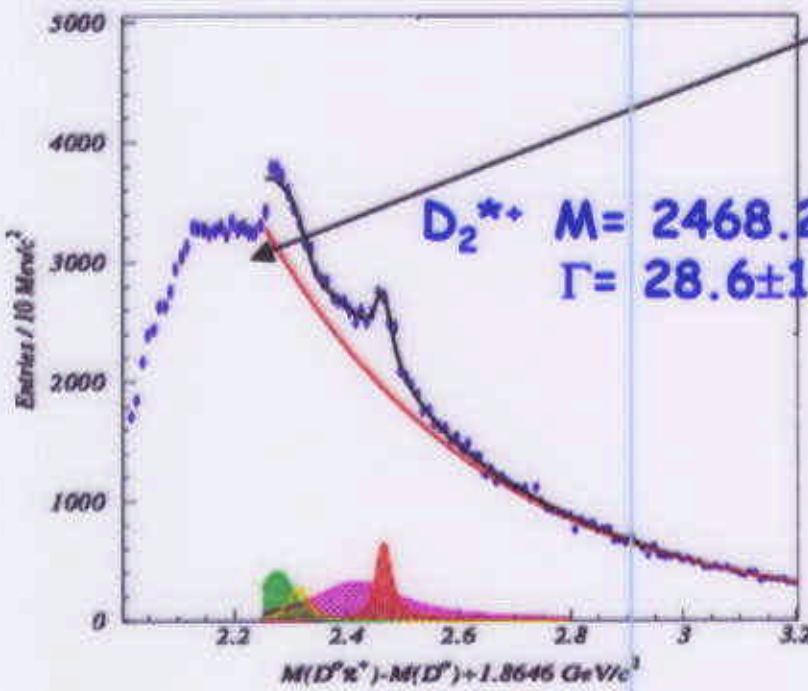


# Fitting the mass excess in the $D^+ \pi^-$ spectrum

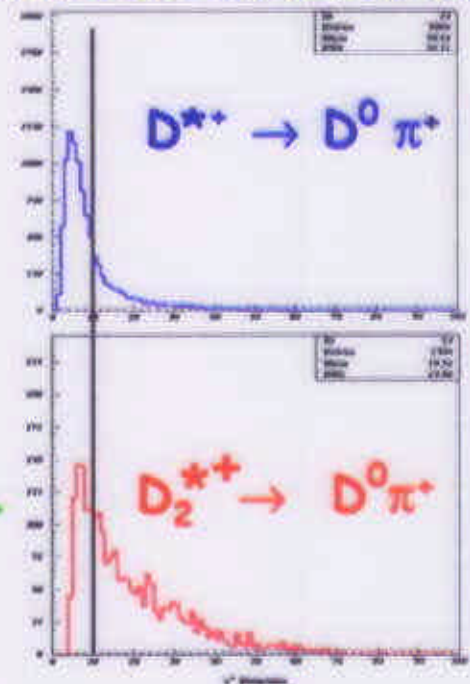


# Soft pion contribution to the combinatorial backg.

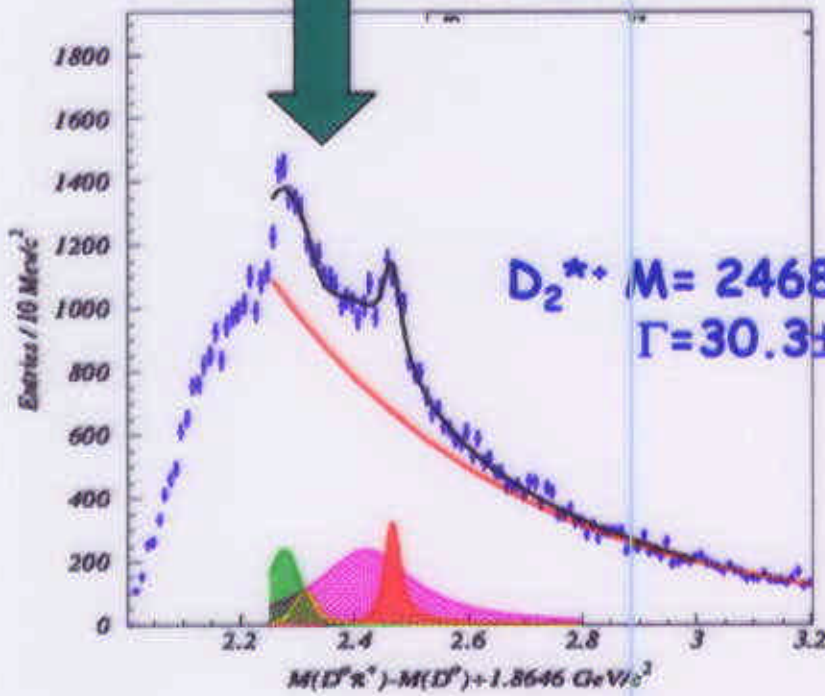
Shoulder probably due to soft pions from missed  $D^*$



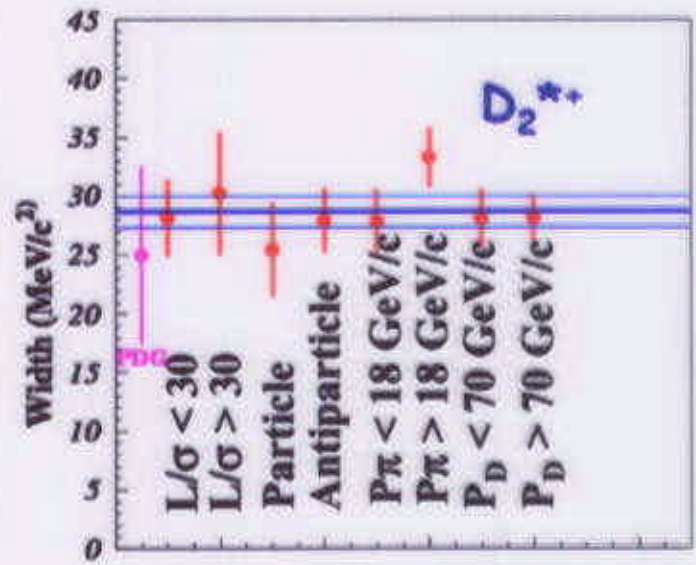
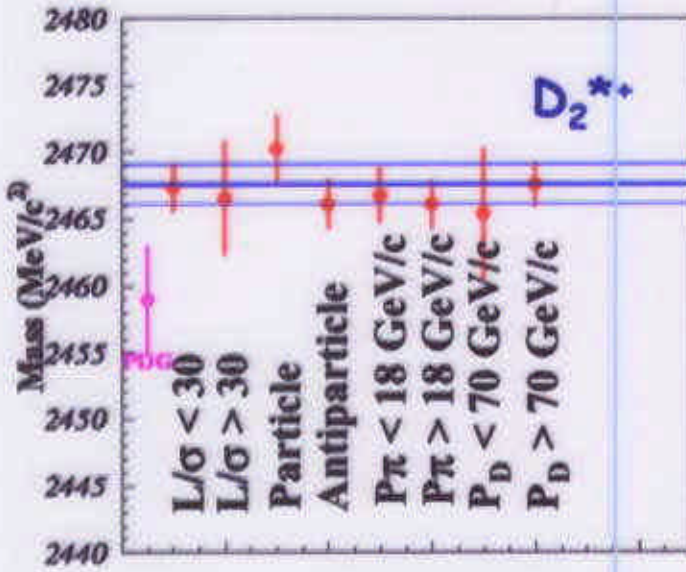
McFOCUS simulation code



If  $P_\pi > 10 \text{ GeV}$



# $D_2^*$ Mass and width systematic studies



## $D_2^*$ FOCUS new measurements PRELIMINARY

Mass

Width

$$D_2^{*+} \quad 2468.2 \pm 1.5 \pm 1.4 \text{ MeV}/c^2 \quad 28.6 \pm 1.3 \pm 3.8 \text{ MeV}/c^2$$

$$D_2^{*0} \quad 2463.5 \pm 1.5 \pm 1.5 \text{ MeV}/c^2 \quad 30.5 \pm 1.9 \pm 3.8 \text{ MeV}/c^2$$



## Conclusions

✧ Focus has collected about

**10<sup>6</sup>** charm meson states  
**0.5 10<sup>4</sup>** excited charm decays

✧ The study of  $D\pi$  mass spectrum gives new **preliminary** values of the masses and widths for the  $D_2^*$  meson

|            | Mass                                    | Width                |                          |
|------------|---|----------------------|--------------------------|
| $D_2^{*+}$ |   |                      |                          |
| FOCUS:     | <b>2468.2±1.5±1.4 MeV/c<sup>2</sup></b> | <b>28.6±1.3±3.8</b>  | <b>MeV/c<sup>2</sup></b> |
| PDG:       | 2459±4 MeV/c <sup>2</sup>               | 25 <sup>+8</sup> -.7 | MeV/c <sup>2</sup>       |
| $D_2^{*0}$ |   |                      |                          |
| FOCUS:     | <b>2463.5±1.5±1.5 MeV/c<sup>2</sup></b> | <b>30.5±1.9±3.8</b>  | <b>MeV/c<sup>2</sup></b> |
| PDG:       | 2458.9±2.0 MeV/c <sup>2</sup>           | 23±5                 | MeV/c <sup>2</sup>       |

✧ The  $D\pi$  mass spectrum (once subtracted the background, the  $D_2^*$  signal, and the expected feed-down) shows an excess of events centered around 2420 MeV/c<sup>2</sup> and about 185 MeV/c<sup>2</sup> wide.

✧ A broad (~100-200 MeV/c<sup>2</sup>) state (the  $D_0^*$ ) is predicted by Heavy Quark Symmetry at about 2350 MeV/c<sup>2</sup>. The observed excess could be reminiscent of this state, or of a feed down from another broad state, such as the  $D_1(j_1=1/2)$ . Work is in progress to verify such hypothesis.

✧ More FOCUS results to come.