PRODUCTION OF RESONANCES IN THE T+U REGION

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(Presented by J. Duboc)

Preliminary results about $K\pi\pi$ and $K\bar{K}\pi$ production of resonances in $\bar{p}p$ annihilations are presented. The $\bar{p}$ momentum covers the range 1.28-2.04 GeV/c and spans the T+U region. The sample of about 26,000 events at present on DST corresponds roughly to 90% of the total statistics and has been limited to events with at least one observed V^0. Neither Monte Carlo nor fit calculations have yet been done.

1. $K\pi\pi$ SPECTRUM

i) Two bumps at masses 1250 MeV/c^2 (C) and 1320 MeV/c^2 (C′) are observed in the Q-region, in various channels and charged states (Fig. 1).

ii) The C meson is enhanced by a selection of the two-body C-K^* reaction (Fig. 2a) and the requirement of a K^* among the decay products of the observed $K\pi\pi$ system (Fig. 2b).

iii) Similarly, the requirement of a two-step decay process $K\rho$ enhances the C′ bump and lessens the C, whose mass is close to the $K\rho$ threshold (Fig. 3a, b). These results seem to confirm the fact that C and C′ are two resonances rather than a diffraction mechanism effect or a single resonance.

iv) Observation of both C and C′ in the reaction

$$\bar{p}p \to K_1^0 K^{\pm}\pi^{\mp}(MM)$$

may induce remarks concerning the quantum numbers of the two resonances. The missing-mass spectrum (MM) clearly exhibits the two bumps corresponding to η and ω resonances. One may reasonably think that outside these two restricted regions the (MM) is mainly $\pi^0\pi^0$.
The K MM spectra (with MM = $\pi^0\pi^0$ or MM = ω) exhibit respectively the two C and C′ bumps, whereas the system K MM (MM = η) presents no structure at all (Fig. 4). This observation is consistent with $J^P = 1^+$ for C and C′ mesons, since such a 1^+ state may easily be built from $K\pi^0\pi^0$ and $K\omega$ systems, while it is impossible in the case of the $K\eta$.

2. $K\bar{K}\pi$ SPECTRUM

i) The $K\bar{K}\pi$ neutral spectrum exhibits clearly the triplet $D^0(1280)$, $E^0(1420)$, $F_1(1540)$ in the various channels $(K\bar{K}\pi)\pi$, $(K\bar{K}\pi)3\pi$, or $(K\bar{K}\pi)$MM (Fig. 5).

ii) Peaks are enhanced through selection of two-body reactions:

- $(K\bar{K}\pi)\eta$ in $(K\bar{K}\pi)MM$ enhances F_1 spectrum (production $F_1\eta$),
- $(K\bar{K}\pi)\rho$ in $K\bar{K}3\pi$ enhances E^0, F_1 (production $E\rho$, $F_1\rho$),
- $(K\bar{K}\pi)\omega$ in $K\bar{K}4\pi$ enhances D^0, E^0 (production $D\omega$, $E\omega$) (Fig. 6).

iii) Similarly, through selection of possible sequential decays, the above-mentioned resonances may be enhanced or reduced.

a) The requirement of K^*K as decay products of the $(K\bar{K}\pi)$ system enhances the E^0 and F_1 resonances, and at the same time kills the D^0 which is below the K^*K threshold (Figs. 7a, 7b).

b) In the same way, the presence of the charged $(K\bar{K})$ system at threshold with $M_{K\bar{K}} < 1.08$ GeV/c^2 leads to enhancements of D^0 and E^0 resonances and vanishing of the F_1 (Fig. 8a).

Conversely, $(K\bar{K})$ threshold antiselection (i.e. $M_{K\bar{K}} > 1.08$ GeV/c^2) increases the F_1 signal (Fig. 8b). This observation is confirmed by Fig. 9 and seems to rule out the presence of a $(K\bar{K})$ structure at threshold in F_1 decay.

3. QUANTUM NUMBERS OF THE F_1

As is well known, the quantum numbers $I^G J^P$ of the $D^0(0^+1^+)$ and $E^0(0^+0^-)$ have been determined from previous experiments on antiprotons. These experiments also lead to preliminary results regarding the F_1.

- A first experiment $\bar{p}p$ at 0.7 GeV/c led to the discovery of this resonance and assigned it to the abnormal series $J^P = 0^-, 1^+, 2^-$ [1].

- A second experiment at 1.2 GeV/c excluded the 0^- possibility. It also gave some restriction about charge conjugation and limited the ambiguity to $J^{PC} = 1^{+-}, 2^{-+}$ [2].

- In the T+U experiment, the results presented here do not allow definite conclusions at this time. However, one can point out:

1) The confirmation and new evidence of I = 1 (Fig. 10).

2) The presence of a small F_1 signal in the $K_1^0K_1^0\pi^0$ spectrum and its absence in the $K_1^0K_2^0\pi^0$ spectrum (Fig. 11), which seem to indicate the value C = +1 for charge conjugation. The argument is strengthened by the enhancement of the $F_1(= K_1^0K_1^0\pi^0)$ bump through $M(K_1^0K_1^0) > 1.08$ GeV/c^2 and K^*K selection among the decay products of the resonance.

3) One can tentatively draw preliminary remarks about the G parity of the same system. As said above, it seems from Fig. 9 that the decay $F_1 \to (\bar{K}K)_{th}\pi$ is forbidden.

If it were allowed, the following *a contrario* argument might be made

$$(\bar{K}K)_{th} \text{ is a } I^G J^P = 1^- 0^+ \text{ system} .$$

Consequently,

$$G_{F_1} = G_{K\bar{K}} G_\pi = +$$

and

$$C_{F_1} = G_{F_1} (-)^I = - .$$

As the starting hypothesis is false and the $F_1 \to (\bar{K}K)_{th}\pi$ unobserved, it might tentatively be concluded that the result is also false and that

$$G_{F_1} = - \quad \text{and} \quad C_{F_1} = +$$

which is in agreement with the above observation 3(2).

4) One should not consider the preceding argument to be free of pitfalls. But if it is carried forward with the result $J^{PC} = 1^{+-}$ or 2^{-+} of the former experiment and the above conclusion that C = +, we arrive at $J^P = 2^-$ and thus $I^G J^{PC} = 1^- 2^{-+}$ for the F_1.

* * *

REFERENCES

1) M. Aguilar-Benitez et al., Phys. Letters 29 B, 379 (1969), and Nuclear Phys. B14, 195 (1969).

2) J. Duboc et al., Phys. Letters 34 B, 343 (1971), and Nuclear Phys. B46, 429 (1972).

Figure captions

Fig. 1 : Distribution of ($K^{\pm}$ MM) mass from $\bar{p}p \rightarrow K_1^0K^{\pm}\pi^{\mp}$MM when MM is outside the η-region (0.48-0.58 GeV/c^2).

Fig. 2a : Effective mass distribution for $K_1^0\pi^{\pm}\pi^0$ opposite to K^* in $\bar{p}p \rightarrow K_1^0K_1^0\pi^+\pi^-\pi^0$. Presence of bump at C position (two-body CK^* reaction).

Fig. 2b : Effective mass distribution for $K^*\pi$ in the same reaction. Presence of C (selection of a two-step K^* decay).

Figs. 3a and 3b : Histograms of mass distributions $(K_1^0\rho)^0$, $(K_1^0\rho)^{\pm}$ in the same reaction. Presence of C′ (selection of a two-body decay).

Fig. 4 : Distribution of (K_1^0MM) mass from $\bar{p}p \rightarrow K_1^0K^{\pm}\pi^{\mp}$MM, when MM is inside the η-region. No structure.

Fig. 5 : Effective mass distributions for $K_1^0K^{\pm}\pi^{\mp}$ in $\bar{p}p \rightarrow K_1^0K^{\pm}\pi^{\mp}$(MM). Presence of D, E, F_1.

Fig. 6 : Selection of ω opposite to ($K_1^0K^{\pm}\pi^{\mp}$) mass in $\bar{p}p \rightarrow K_1^0K^{\pm}\pi^{\mp}\pi^+\pi^-\pi^0$ enhances D^0 and E bump.

Fig. 7a : Effective mass distribution for (K^*K^0) opposite to ω in $\bar{p}p \rightarrow K_1^0K^{\pm}\pi^{\mp}\pi^+\pi^-\pi^0$ enhances E and F_1 bump.

Fig. 7b : Same distribution as Fig. 7a without any restriction for MM. Same observation.

Fig. 8 : Effective mass distribution $K^0K^{\pm}\pi^{\mp}$ in $\bar{p}p \rightarrow K_1^0K^{\pm}\pi^{\mp}$MM:

a) with selection M($K\bar{K}$) < 1.08 GeV/c^2,
b) with antiselection on M($K\bar{K}$).

Fig. 9 : Distributions of ($K\bar{K}$) mass:

a) with ($K\bar{K}\pi$) inside D^0 region,
b) with ($K\bar{K}\pi$) inside E^0 region,
c) with ($K\bar{K}\pi$) inside F_1 region.

No $K\bar{K}$ signal at threshold in case (c).

Fig. 10 : Evidence for isospin I = 1 for the F_1.

Fig. 11a : Effective mass distribution for $(K_1^0K_1^0\pi^0)$ in $\bar{p}p \to K_1^0K_1^0\pi^+\pi^-\pi^0$. Small signal at F_1 position.

Fig. 11b : Mass distribution for $(K_1^0K_2^0\pi^0)$ in $\bar{p}p \to K_1^0\pi^+\pi^-(K_2^0\pi^0)$ reaction. Signal at F_1 seems to disappear.

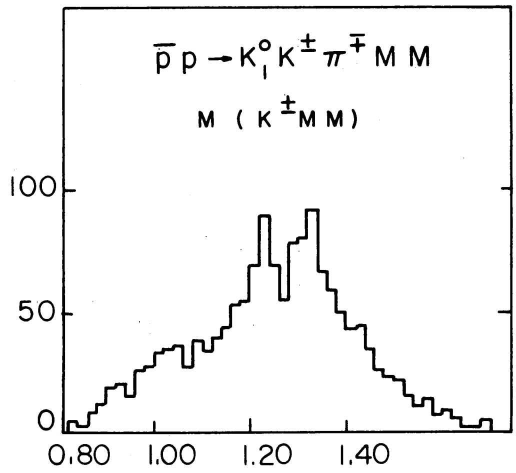
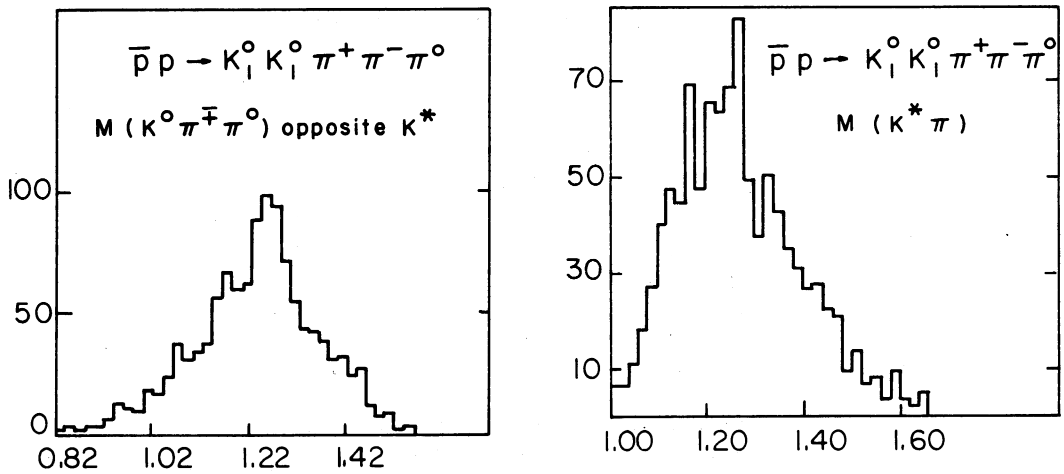
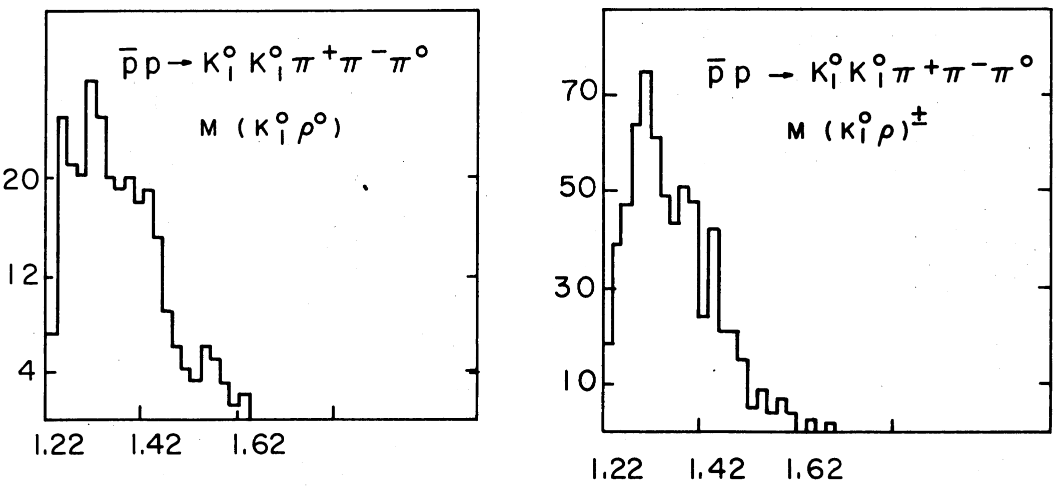


Fig. 1



a) b)

Fig. 2



a) b)

Fig. 3

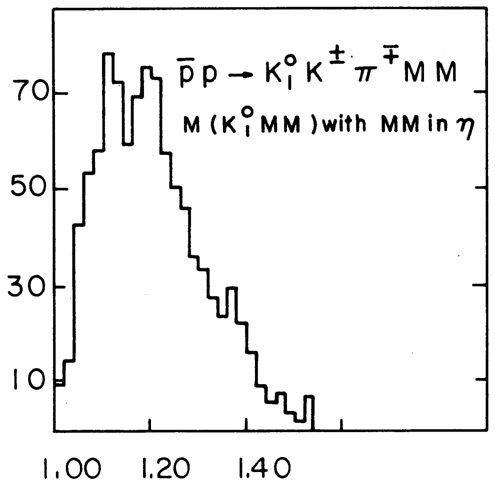


Fig. 4

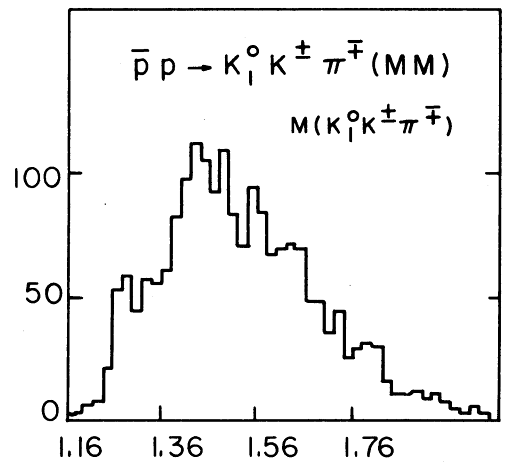


Fig. 5

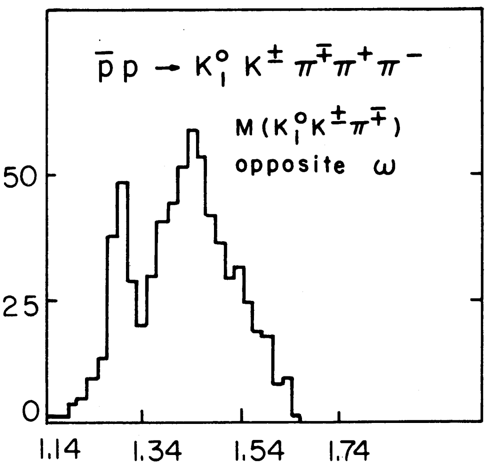
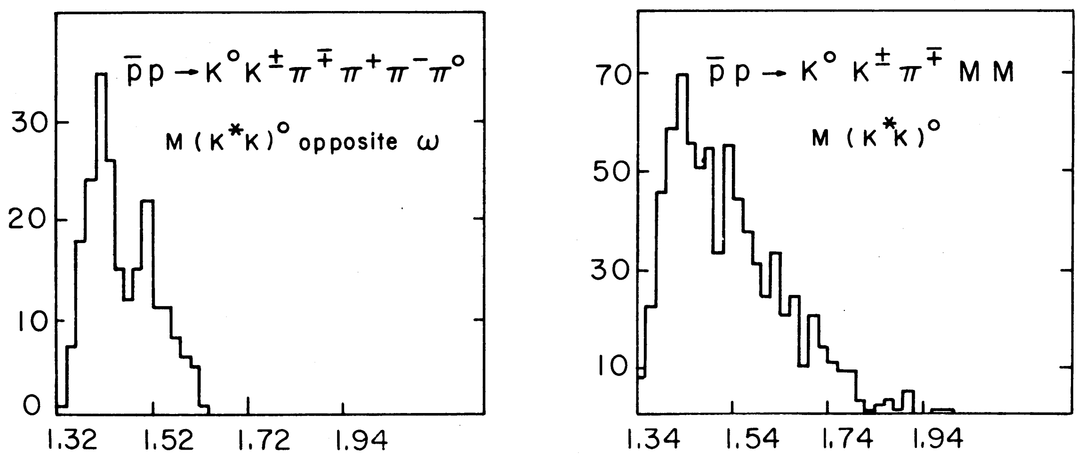
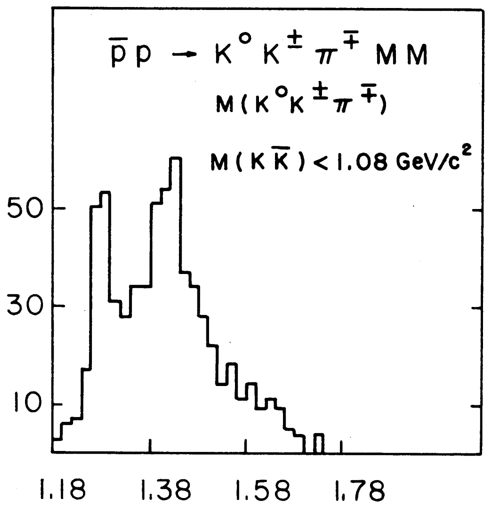


Fig. 6

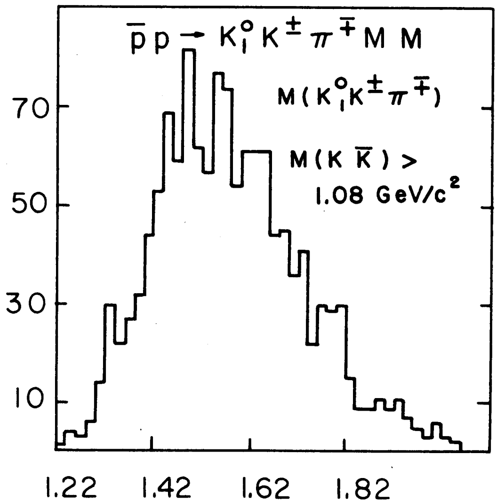


a) b)

Fig. 7


$\bar{p}p \to K^0 K^\pm \pi^\mp$ MM
$M(K^0 K^\pm \pi^\mp)$
$M(K\bar{K}) < 1.08$ GeV/c^2
50
30
10
1.18
1.38
1.58
1.78

a)


$\bar{p}p \to K_1^0 K^\pm \pi^\mp$ M M
$M(K_1^0 K^\pm \pi^\mp)$
$M(K\bar{K}) >$
1.08 GeV/c^2
70
50
30
10
1.22
1.42
1.62
1.82

b)

Fig. 8

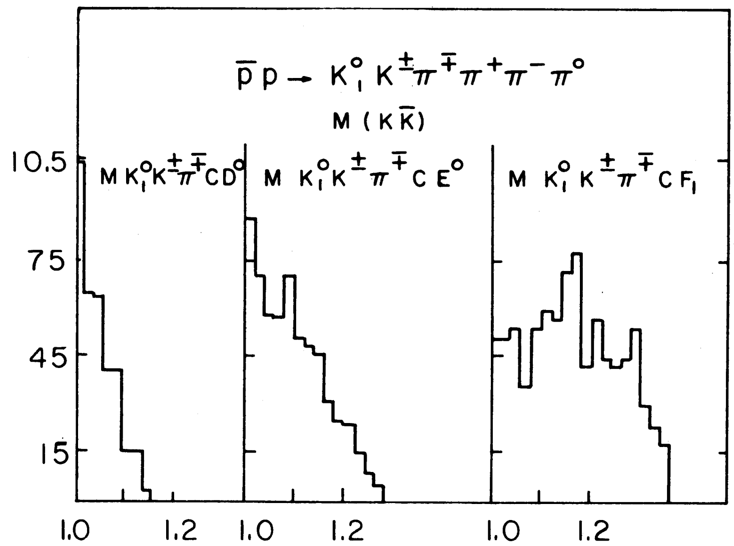

$\bar{p}p \to K_1^0 K^\pm \pi^\mp \pi^+ \pi^- \pi^0$
M (K$\bar{K}$)
10.5
75
45
15
M $K_1^0 K^\pm \pi^\mp$ C D^0
M $K_1^0 K^\pm \pi^\mp$ C E^0
M $K_1^0 K^\pm \pi^\mp$ C F$_1$
1.0
1.2
1.0
1.2
1.0
1.2

Fig. 9

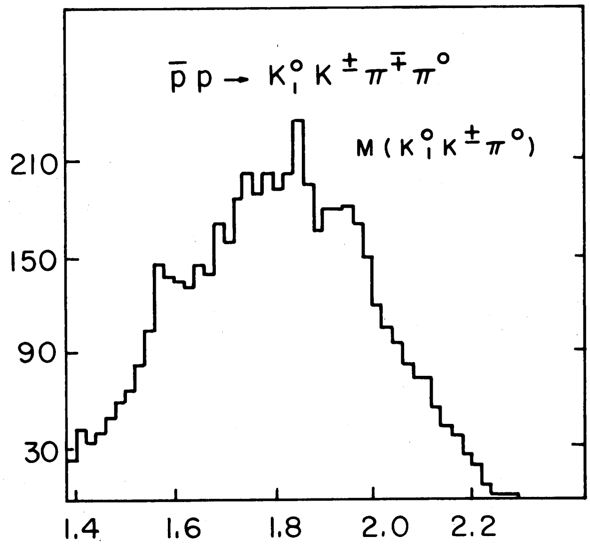
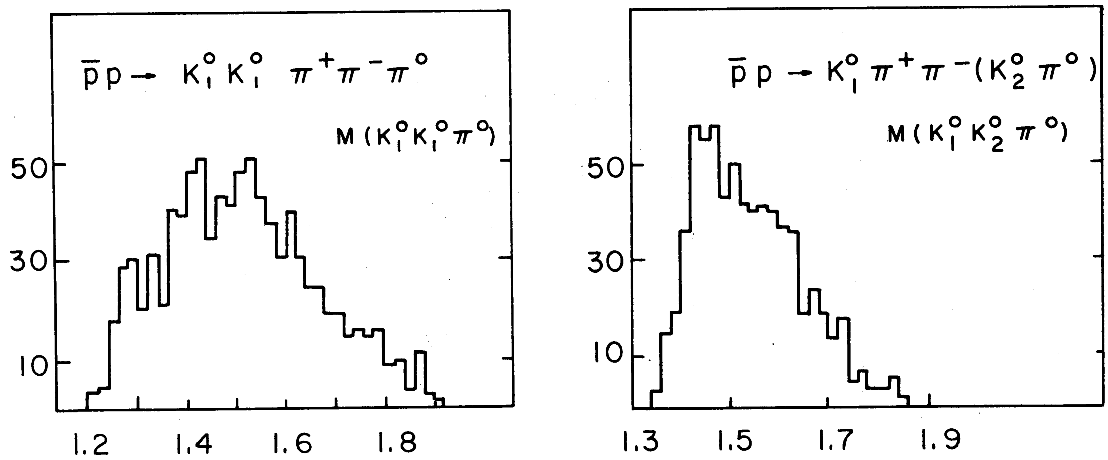


Fig. 10



a) b)

Fig. 11

D I S C U S S I O N

- *Kittel:*

Your Q does not seem to be the same as the diffractively produced one, because there the partial wave analysis gives Kρ for the lower part and $K^*\pi$ for the upper one.

- *Duboc:*

Yes, our result is the opposite.

- *Kittel:*

Do you know the relative phase between these two components?

- *Duboc:*

Not yet.

- *Montanet:*

In the annihilations at rest, the ratio for Kρ and $K^*\pi$ is in agreement with SU(3). Do you not expect that both the C and C′ resonances should decay in both Kρ and $K^*\pi$?

- *Duboc:*

The mass of C is near the threshold for Kρ and, therefore, we excluded it.