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D_s inclusive production in $Z^0 \to b\bar{b}$ decays

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Abstract

The inclusive production of D_s meson in $Z^0 \to b\bar{b}$ decays has been measured selecting the decay $D_s^+ \to \phi\pi^+$, with the ϕ decaying into K^-K^+, on a high b purity sample of data collected in the 92-95 period. The $Z^0 \to b\bar{b}$ events have been selected using a new algorithm developed in the R_b group characterized by a very high purity ($\simeq 99\%$). The result obtained is $f(b \to D_s^+) = (19.1 \pm 2.3 \pm 2.7)\%$, where the systematic error is dominated by the uncertainty on the $BR(D_s^+ \to \phi\pi^+)$.

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1 Introduction

The measurement of the D_s production in $Z^0 \rightarrow b\bar{b}$ decays has been performed following the same method used to measure the D^0 and D^+ production [1]. This document has to be considered as an addendum to the D^0 and D^+ note and only the aspects which differ from that note are described in the following.

2 The $D_s^+ \rightarrow K^-K^+\pi^+$ selection

On a selected sample of about 230 thousand b hemispheres, the D_s^+ are reconstructed looking at the decay chain $D_s^+ \rightarrow \phi\pi^+$ followed by $\phi \rightarrow K^-K^+$.

First of all the $\phi \rightarrow K^-K^+$ decay is reconstructed pairing *good* tracks with a dE/dx compatible with the kaon hypothesis. A *good* track is selected requiring a momentum greater than 0.2 GeV/c, a $|d_0| < 2cm$, a $|z_0| < 10cm$ and more than 4 reconstructed TPC points. The invariant mass of the two kaons, with momenta above 1 GeV, is required to be in a 8 MeV mass window around the ϕ mass; the momentum of the ϕ is required to be greater than 4 GeV. In a second step the pion candidate, with a momentum greater than 1 GeV, is added and the three tracks are vertexed. The χ^2/ndf of the vertex is required to be less than 8 and the vertex has to be in the same hemisphere of the D_s direction with respect to the beam position.

The fractional energy of the reconstructed D_s^+ $(E(D_s)/E_{beam})$ is required to be more than 10% (this cut strongly reduces the combinatorial background). The requirement $|cos(\lambda^*)| > 0.5$ is applied, where λ^* is the angle between the kaon and ϕ boost direction evaluated in the ϕ rest frame; this cut exploits the P-wave nature of the decays $D_s^+ \rightarrow \phi\pi^+$ and $\phi \rightarrow K^+K^-$.

The efficiency[1] for reconstructing a D_s^+ in a b selected hemisphere is $(22.3 \pm 1.6_{MCstat})$% with a contamination of D_s^+ from c of 0.3%.

3 The D_s fitting procedure

The mass spectrum obtained with selection is fitted using a function defined as follows:

$$f(m)_{data} = G_{D_s^+} + G_{D^+} + P_{bk}$$

where:

- $G_{D_s^+}$ is the Gaussian parameterizing the signal spectrum;
- P_{bk} is a second order polynomial parameterizing the combinatorial background spectrum;
- G_{D^+} is the Gaussian parameterizing the $D^+ \rightarrow K^-K^+\pi^+$ decay spectrum.

All the parameters of the 3 functions are left free in the fit.

The fit has been performed on the whole 92-95 data sample giving the result: $N(D_s^+ \rightarrow K^+K^-\pi^+) = 168 \pm 20$ events. The plots of the fits are shown in fig. 1 for the Monte Carlo sample and fig. 2 for the data sample.

[1]This efficiency is corrected for the difference between data and MC of the dE/dx information availability.

4 D_s inclusive fraction measurements

In order to extract the D_s inclusive fractions in b events, we have to correct the fit results for two kinds of background: the D_s coming from the c events and the ones coming from gluon splitting.

The D_s from $Z^0 \to c\bar{c}$ contribution to the fitted signal, has been evaluated to be 0.5 events (from MC). The number of D_s coming from the process $g \to c\bar{c}$ (gluon splitting) has been evaluated to be 2.7 events (the value of $g \to c\bar{c}$ has been taken from the OPAL measurement [3]).

The numbers of D_s from $b\bar{b}$ is (165 ± 19), where the error is statistical only (the light quark contribution has been neglected, being much less than 1 event).

The derivation of the fraction of D_s produced in $b\bar{b}$ events is straightforward:

$$f(b \to D_s^+) \times BR(D_s \to \phi\pi) \times BR(\phi \to K^+K^-) = \frac{N(D_s)_b}{\epsilon(D_s)_b \times N_b} = (0.33 \pm 0.04)\%$$

and

$$f(b \to D_s^+) = \frac{N(D_s)_b}{\epsilon(D_s)_b \times N_b \times BR(D_s \to \phi\pi) \times BR(\phi \to K^+K^-)} = (19.1 \pm 2.3)\%$$

where the two branching ratios [2] $BR(\phi \to K^+K^-) = (49.1 \pm 0.9)\%$ and $BR(D_s^+ \to \phi\pi^+) = (3.5 \pm 0.4)\%$ were used.

5 The systematics on the D_s inclusive production

The different sources of systematics taken into account, together with the techniques adopted to determine them, are listed in table 1.

The evaluation of the systematics related to some kinematic cuts has been done in quite a crude and probably redundant way (the momenta of the ϕ, of the π and of the kaons depend on the D_s spectrum which is partially taken into account with the Peterson parameter variation). This crude treatment is justified by the large statistical uncertainty and by the large irreducible systematic sources like the MC statistics and the branching ratio error. In fact the systematic error is largely dominated by these two sources.

Since some of the selection cuts of the $D_s^+ \to K^+K^-\pi^+$ decay are very similar to the ones used for $D^+ \to K\pi\pi$, the corresponding systematics are taken from that analysis. The treatment of the other sources is explained in the following:

- $P(\pi)$ and P(K) cuts: a study of the measurement behavior as a function of these cuts has been performed varying them in the 1-1.5 GeV/c momentum range;

- $P(\phi)$ cut: a study of the measurement behavior as a function of this cut has been performed varyinf the cut in the 4-6 GeV/c momentum range;

Source	Variation	relative error %
Track qual. cut	from D^+	0.5
dE/dx avail. and shape	from D^+	0.6
Cut on $P(\phi)$	(4-6) GeV/c	2.6
Cut on $M(\phi)$	(6-9) MeV/c^2	2.0
Cut on $P(\pi)$ and P(K)	(1-1.5) GeV/c	0.5
$E(D_s)/E_{beam}$ cut	Change in ϵ_b	0.5
Vertex cut	from D^+	3.5
Combinatorial Bkg.	Diff. param.	1.3
Charm contam.	50%	0.4
Gluon split.	50%	0.8
MC stat.	-	6.8
Tot. no BR		8.5
$BR(D_s^+ \to \phi\pi^+)$	PDG error	11.1
$BR(\phi \to K^+K^-)$	PDG error	1.8
Total	-	14.1

Table 1: Systematics errors for the $f(b \to D_s)$ measurement

- $M(\phi)$ cut: a study of the measurement behavior as a function of this cut has been performed varying the mass window range between 6 and 9 MeV/c^2;
- Combinatorial background: Different background parameterization (first, third order polynomial and decreasing exponential) were tried;
- Charm contamination: a 50% error on the charm contamination has been assumed;
- Gluon splitting contribution: an error of 50% has been assumed on the number of D_s coming from the process $g \to c\bar{c}$ subtracted.

6 Conclusions

We have measured the production rate of D_s^+ meson in $Z^0 \to b\bar{b}$ events with a method almost free from systematics coming from the b tag selection. The results obtained are:

$$f(b \to D_s^+) \times BR(D_s \to \phi\pi) \times BR(\phi \to K^+K^-) = (0.33 \pm 0.04 \pm 0.03)\%$$

and

$$f(b \to D_s^+) = (19.1 \pm 2.3 \pm 2.7)\%$$

where the first error is statistical and the second one is systematics.

References

[1] G. Calderini et al., ALEPH PHYSICS 96-07

[2] Particle Data Group, L. Montsnet et al.,Phys. Rev. Lett. D50 (1994) 1173.

[3] The OPAL collaboration, CERN PPE/95-058

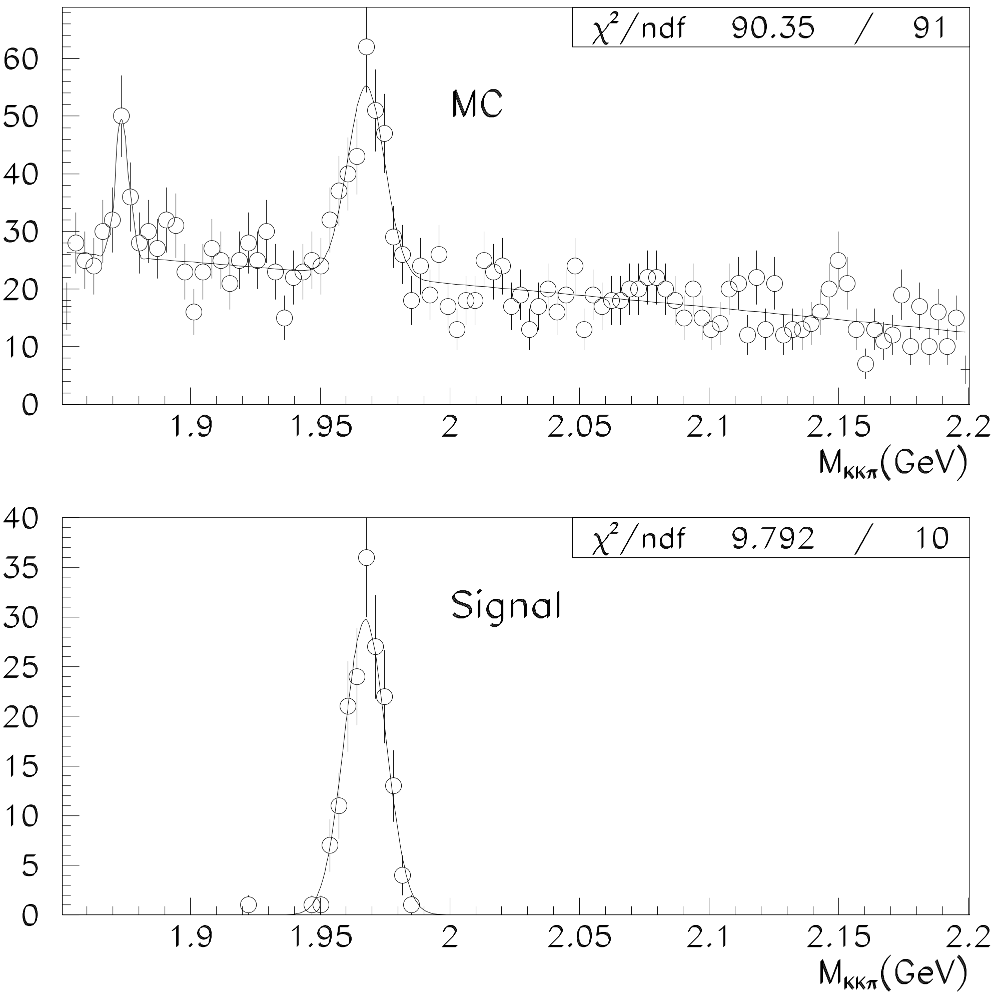

Figure 1: MonteCarlo mass spectrum plus fit, $D_s^+ \rightarrow K^- K^+ \pi^+$ candidates; in the second plot only the signal events are shown.

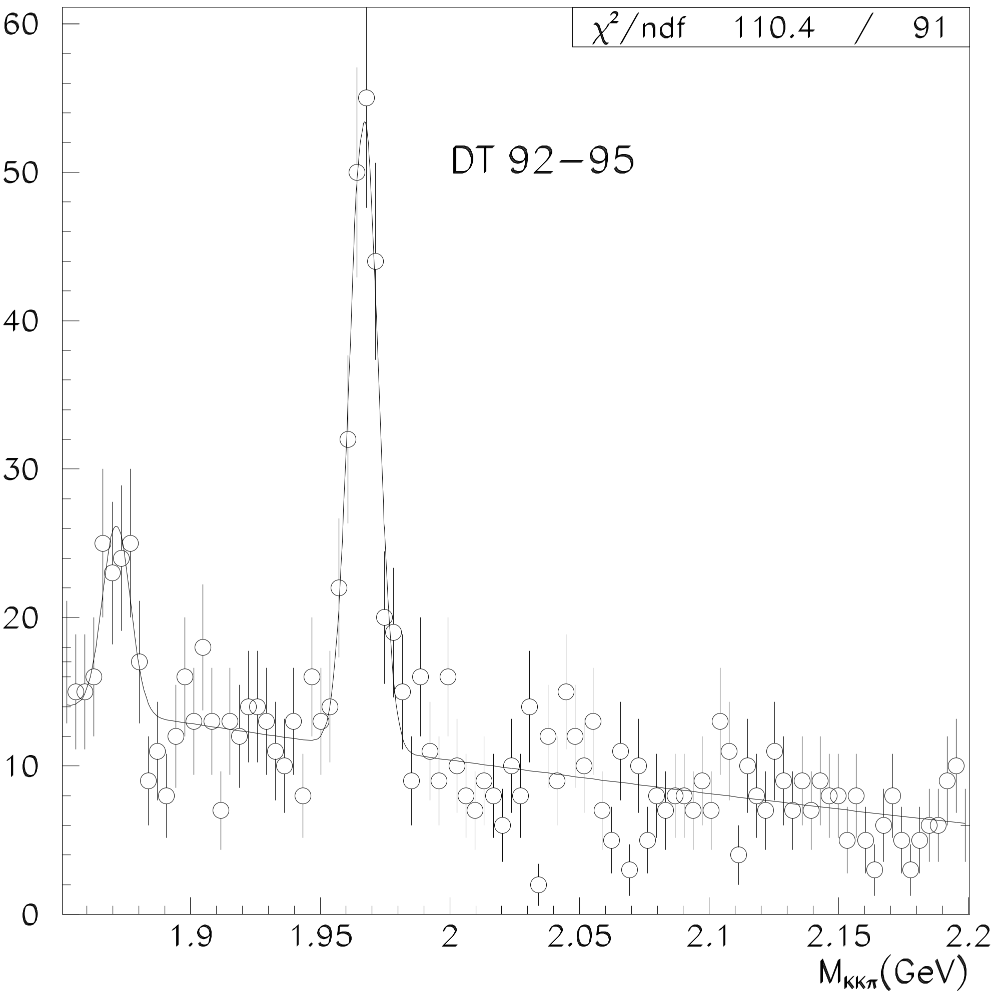

Figure 2: Mass spectrum od the data $D_s^+ \rightarrow K^-K^+\pi^+$ candidates for the 92-95 data sample.