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Evidence for a $B_s^0\pi^\pm$ state

(The D0 Collaboration)

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Auxiliary material

In this document we provide supplemental information on the evidence for a narrow structure, $X(5568)$, based on 10.4 fb^{-1} of $p\bar{p}$ collision data at $\sqrt{s} = 1.96$ TeV. The decay sequence $X(5568) \to B_s^0\pi^\pm$, $B_s^0 \to J/\psi\phi$, $J/\psi \to \mu^+\mu^-$, $\phi \to K^+K^-$ is shown in Fig. 1. The dotted lines for $X(5568)$, J/ψ, and ϕ represent the unmeasurably short decay lengths for these particles.

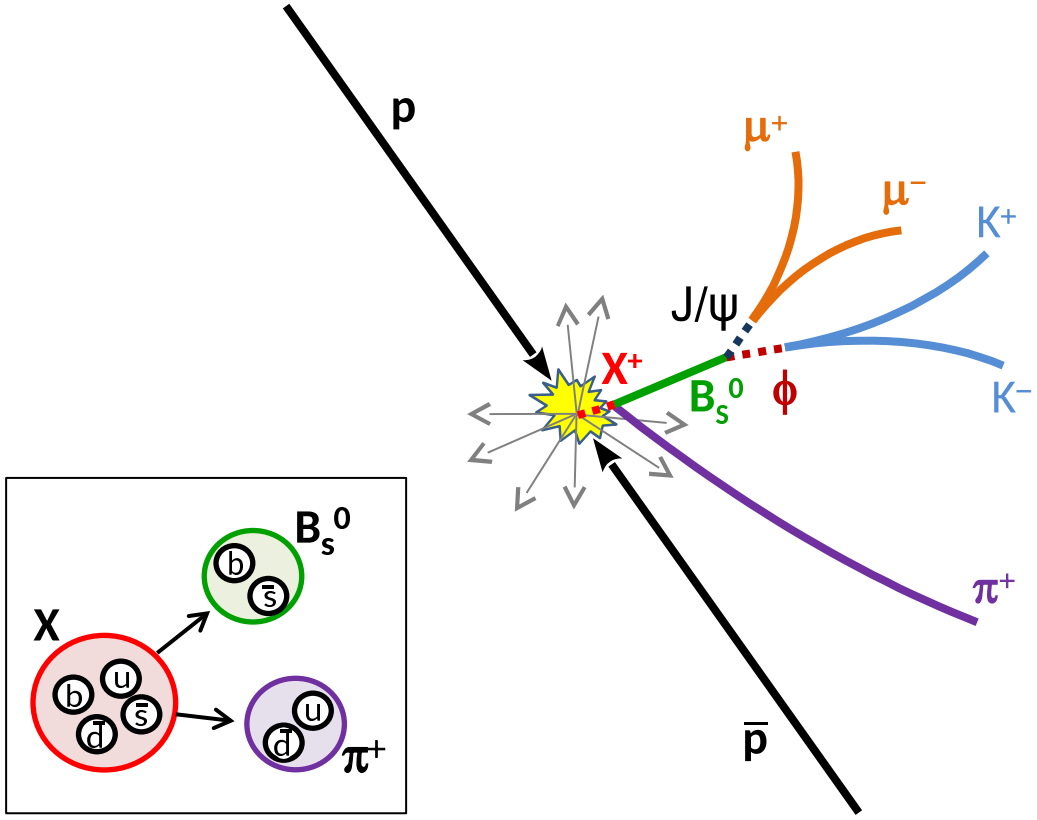

FIG. 1: Schematic representation of the production of $X(5568)$ with prompt decay to B_s^0 and $\pi^\pm$ and subsequent decays $B_s^0 \to J/\psi\phi$, $J/\psi \to \mu^+\mu^-$ and $\phi \to K^+K^-$.

The two components of our background model are shown in Fig. 2 with no cut on ΔR between the B_s^0 and π. The mass distributions for these two components are nearly identical.

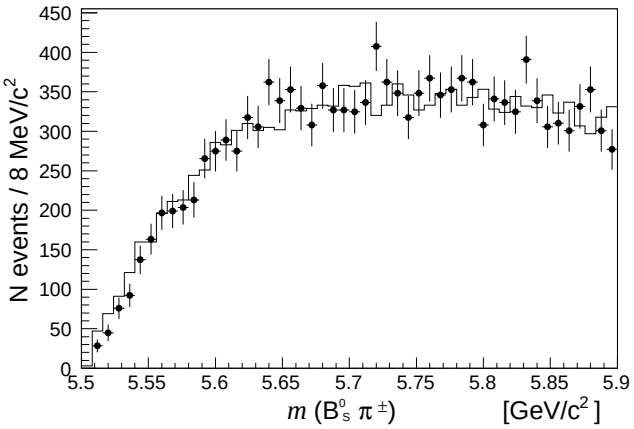

FIG. 2: Comparison of the shapes of the two components of background without the cone cut. Points with error bars: sidebands in data, histogram: simulated sample of events containing a B_s^0 meson.

Figure 3 shows the $B_s^0\pi^\pm$ selection efficiency vs $m(B_s^0\pi^\pm)$ for three values of the ΔR cone cut and the corresponding mass distributions with fit results superimposed. The fitted mass as a function of the value of the cone cut is shown at the bottom. The mass is stable within the fit uncertainties of a few MeV/c^2, whereas the knee of the efficiency curves has shifted by about 120 MeV/c^2 going from $\Delta R < 0.2$ to $\Delta R < 0.5$.

Figure 4 compares the data and the background model for the $B_s^0\pi^\pm$ mass region above the $X(5568)$ signal, $5.6 \leq m(B_s^0\pi^\pm) \leq 5.9$ GeV/c^2 both with and without the $\Delta R < 0.3$ cone cut. The background model gives a good representation of the data with the cone cut (Kolmogorov Smirnov probability of the compatibility in shape is about 99%) but for the data without the cone cut this probability is 0.3%. The relatively poor match between data and background model is due in part to the tendency of the model to overestimate the data in the region $5.6 \leq m(B_s^0\pi^\pm) \leq 5.75$ GeV/c^2 and to underestimate it above 5.75 GeV/c^2.

The $B_s^0\pi^\pm$ mass distribution and fitted signal is shown in Fig. 5 for subsamples of the data with $10 < p_T(B_s^0) < 15$ GeV/c and $15 < p_T(B_s^0) < 30$ GeV/c. The fitted mass, width, and number of events are shown in Table I.

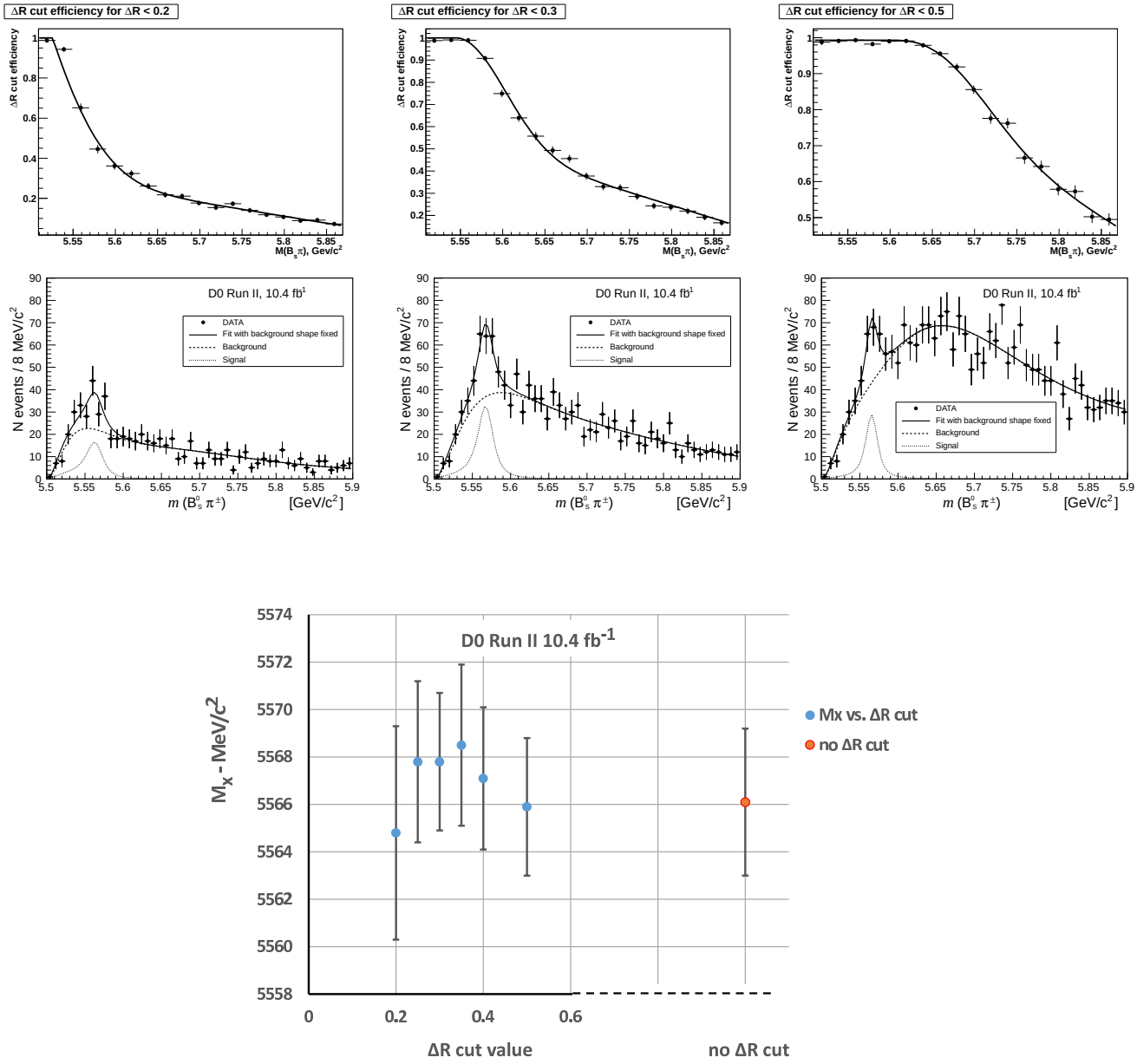

FIG. 3: Top: The $B_s^0\pi^\pm$ selection efficiency vs. $m(B_s^0\pi^\pm)$ for $\Delta R < 0.2$, $\Delta R < 0.3$, and $\Delta R < 0.5$, obtained as a ratio of the MC background distributions with and without the cut. Middle: The corresponding mass distributions together with the background distributions and the fit results. Bottom: Fit results for the $X(5568)$ mass vs. ΔR cone cut.

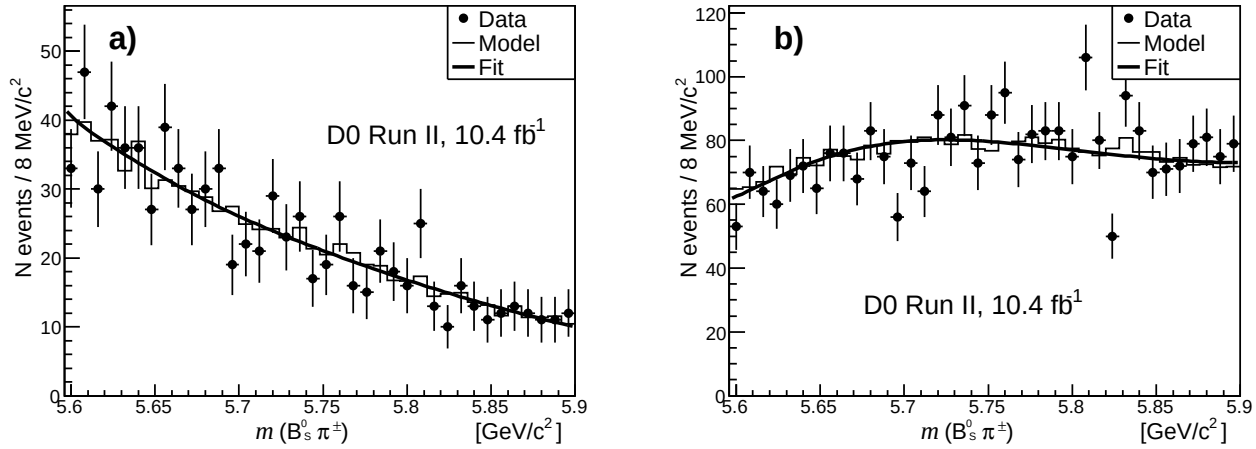

FIG. 4: Comparison of the shapes of the $m(B_s^0\pi^\pm)$ distributions of data and the background model in the range 5.6 – 5.9 GeV/c^2 above the $X(5568)$ (a) after applying the cone cut and (b) without the cone cut.

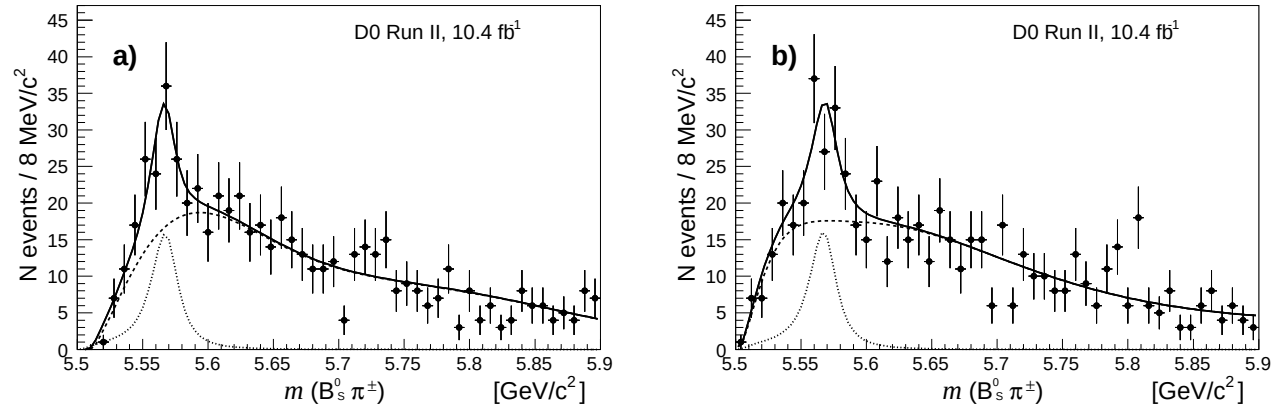

FIG. 5: The $m(B_s^0\pi^\pm)$ distribution with the cone cut together with the background distribution and the fit results for (a) $10 < p_T(B_s^0) < 15$ GeV/c and (b) $15 < p_T(B_s^0) < 30$ GeV/c.

TABLE I: The $X(5568)$ number of events, mass, and natural width, the number of reconstructed B_s^0 mesons, the reconstruction efficiency of the soft pion $\epsilon(\pi^{\pm})$, and the production ratio R $(X(5568)/B_s^0)$ for two $p_T(B_s^0)$ ranges.

Parameter	$10 < p_T(B_s^0) < 15$ GeV/c	$15 < p_T(B_s^0) < 30$ GeV/c
N $(X(5568))$, events	58.6 ± 16.7	67.5 ± 21.8
M $(X(5568))$, MeV/c^2	5566.3 ± 3.3	5568.9 ± 4.4
Γ $(X(5568))$, MeV/c^2	18.4 ± 7.0	21.7 ± 8.4
N (B_s^0), events	2463 ± 63	1961 ± 56
$\epsilon(\pi^{\pm})$	(26.1 ± 3.2)%	(42.1 ± 6.5)%
R $(X(5568)$ / $B_s^0)$	(9.1 ± 2.6 ± 1.6)%	(8.2 ± 2.7 ± 1.6)%