1 Distribution of flattened MLP response

The MLP response distributions for the signal, background and same-sign samples, after being transformed to make the signal candidates distributed evenly between zero and unity, are shown in Fig. 1.

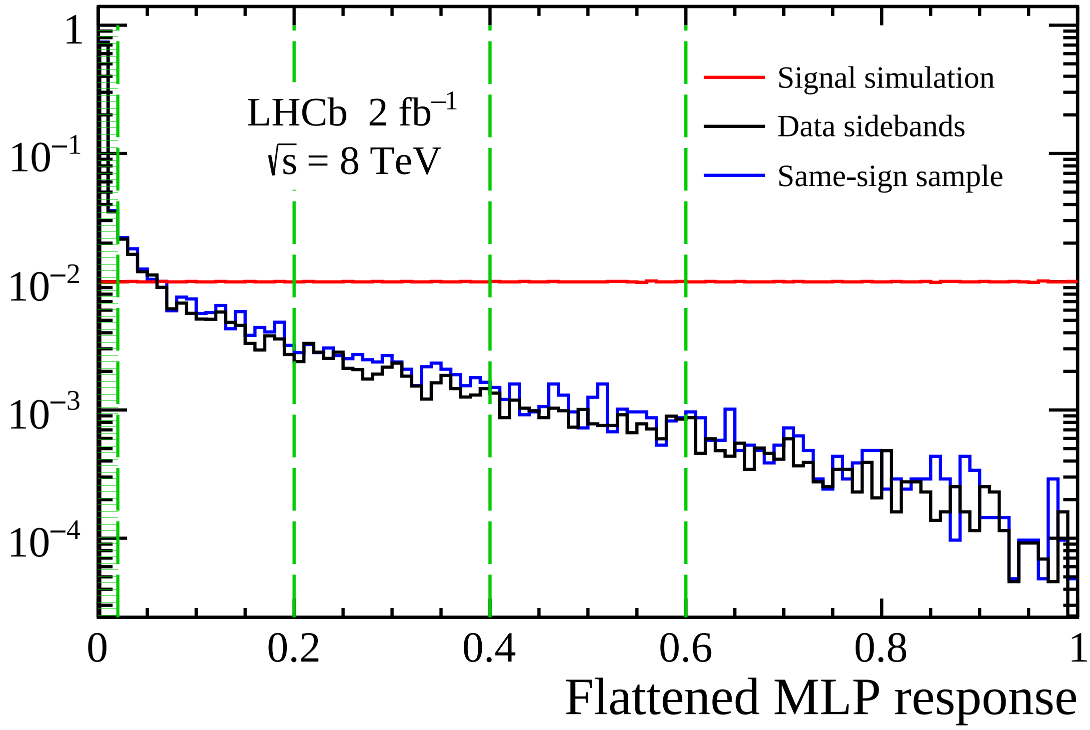

Figure 1: Flattened distribution of the MLP response for the signal sample from simulation, together with the distributions for the background from the sidebands and same-sign samples. The red line stands for the signal simulation, the black line the data sidebands, and the the blue line the same-sign sample. The vertical green lines indicate the boundaries of the MLP categories.

2 Theoretical predictions of $\mathcal{R}$

The ratio $\mathcal{R}$ can be predicted using BCVEGPY [1]. The wave function at the origin, $R(0)$, is taken to be $1.241\,\mathrm{GeV}^{3/2}$ for $B_c(1S)$ states, and $0.991\,\mathrm{GeV}^{3/2}$ for $B_c(2S)$ states [2]. The masses of b and c quarks are set to $m(b) = 5400\,\mathrm{MeV}/c^2$ and $m(c) = 1458\,\mathrm{MeV}/c^2$ for $B_c(2S)^+$, and $m(b) = 5400\,\mathrm{MeV}/c^2$ and $m(c) = 1490\,\mathrm{MeV}/c^2$ for $B_c^*(2S)^+$, respectively. The production cross-sections of the B_c mesons are calculated using several theoretical models [3,4]. Under the assumption that 15% of the B_c^+ mesons come from the P-wave states [3], the BCVEGPY generator predicts

$$\frac{\sigma_{B_c(2S)^+}}{\sigma_{B_c^+}} = 0.04 \tag{1}$$

and

$$\frac{\sigma_{B_c^*(2S)^+}}{\sigma_{B_c^+}} = 0.10, \tag{2}$$

which are consistent with the predictions given in Ref. [5], while according to Ref. [6], the production cross-section ratios are

$$\frac{\sigma_{B_c(2S)^+}}{\sigma_{B_c^+}} = 0.09 \tag{3}$$

and

$$\frac{\sigma_{B_c^*(2S)^+}}{\sigma_{B_c^+}} = 0.23. \tag{4}$$

Considering the branching fractions $\mathcal{B}(B_c^{(*)}(2S)^+ \to B_c^{(*)+}\pi^+\pi^-)$, Ref. [5] predicts $\mathcal{B}(B_c(2S)^+ \to B_c^+\pi^+\pi^-) = 49\%$ and $\mathcal{B}(B_c^*(2S)^+ \to B_c^{*+}(\to B_c^+\gamma)\pi^+\pi^-) = 39\%$, and Ref. [7] predicts $\mathcal{B}(B_c(2S)^+ \to B_c^+\pi^+\pi^-) = 59\%$ and $\mathcal{B}(B_c^*(2S)^+ \to B_c^{*+}(\to B_c^+\gamma)\pi^+\pi^-) = 53\%$. The predicted values of $\mathcal{R}$ are summarised in Table 1.

Table 1: Summary of the predictions for the $\mathcal{R}$ values.

	Ref. for $\mathcal{B}$ prediction	$\mathcal{R}_{B_c(2S)^+}$	$\mathcal{R}_{B_c^*(2S)^+}$
BCVEGPY with listed settings	[5]	0.02	0.04
	[7]	0.02	0.05
Production according to Ref. [5]	[5]	0.02	0.04
Production according to Ref. [6]	[5]	0.04	0.09
	[7]	0.05	0.12

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