First observation of $\bar{B}_s^0 \to D^0 K^{*0}$ and measurement of the ratio $\frac{\mathcal{B}(\bar{B}_s^0 \to D^0 K^{*0})}{\mathcal{B}(\bar{B}^0 \to D^0 \rho^0)}$ with LHCb at $\sqrt{s} = 7$ TeV

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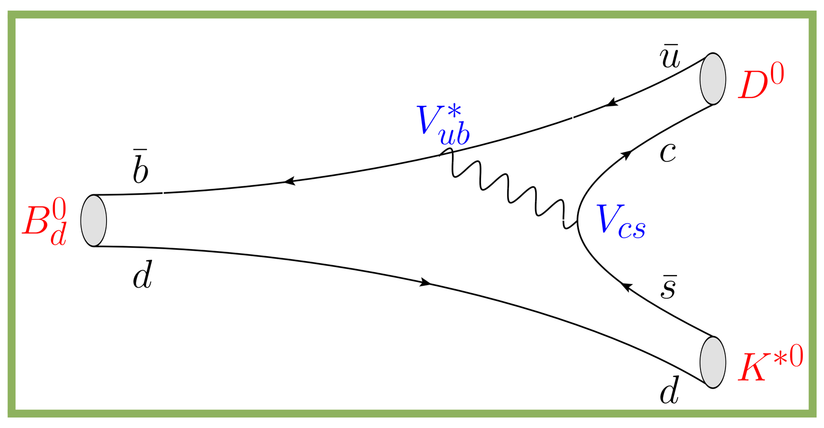
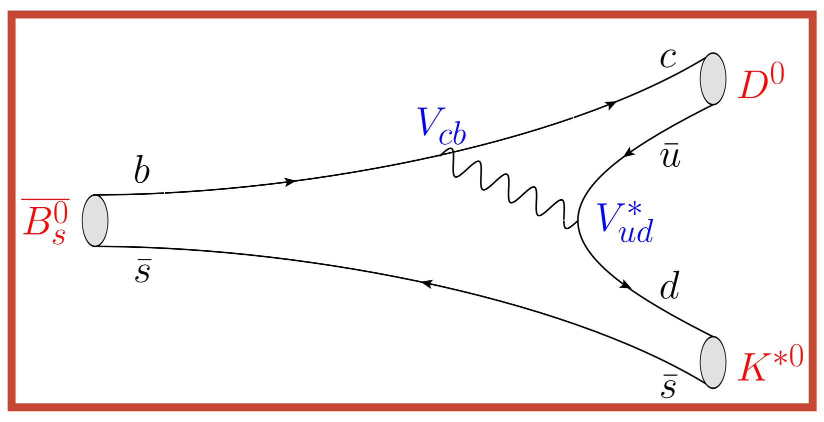
Abstract

In 36 pb^{-1} of pp collisions at a centre-of-mass energy $\sqrt{s} = 7$ TeV, we observe for the first time the decay $\bar{B}_s^0 \to D^0 K^{*0}$. The $\bar{B}_s^0 \to D^0 K^{*0}$ decay mode is a potentially dangerous background for the Cabibbo suppressed decay $B^0 \to \bar{D}^0 K^{*0}$ used in the measurement of the CKM angle γ. A clear signal of 34.5 ± 6.9 events is obtained with a statistical significance over 9 standard deviations and we measure its branching ratio relative to the $\bar{B}^0 \to D^0 \rho^0$ branching ratio: $\frac{\mathcal{B}(\bar{B}_s^0 \to D^0 K^{*0})}{\mathcal{B}(\bar{B}^0 \to D^0 \rho^0)} = 1.39 \pm 0.31\,(\text{stat}) \pm 0.17\,(\text{syst}) \pm 0.18\,(f_d/f_s)$. The $\bar{B}_s^0 \to D^0 K^{*0}$ branching fraction is then $\mathcal{B}(\bar{B}_s^0 \to D^0 K^{*0}) = (4.44 \pm 1.00\,(\text{stat}) \pm 0.55\,(\text{syst}) \pm 0.56\,(f_d/f_s) \pm 0.69\,(\mathcal{B}(\bar{B}^0 \to D^0\rho^0))) .10^{-4}$.

Introduction : context and motivation





Long term plan [2011-201X]

- $B^0 \to \bar{D}^0 K^{*0}$: interference between diagrams involving $b \to u$ and $b \to c$ transitions.
- CKM unitarity triangle angle γ theoretically clean extraction [1,2] : Standard Model benchmark.

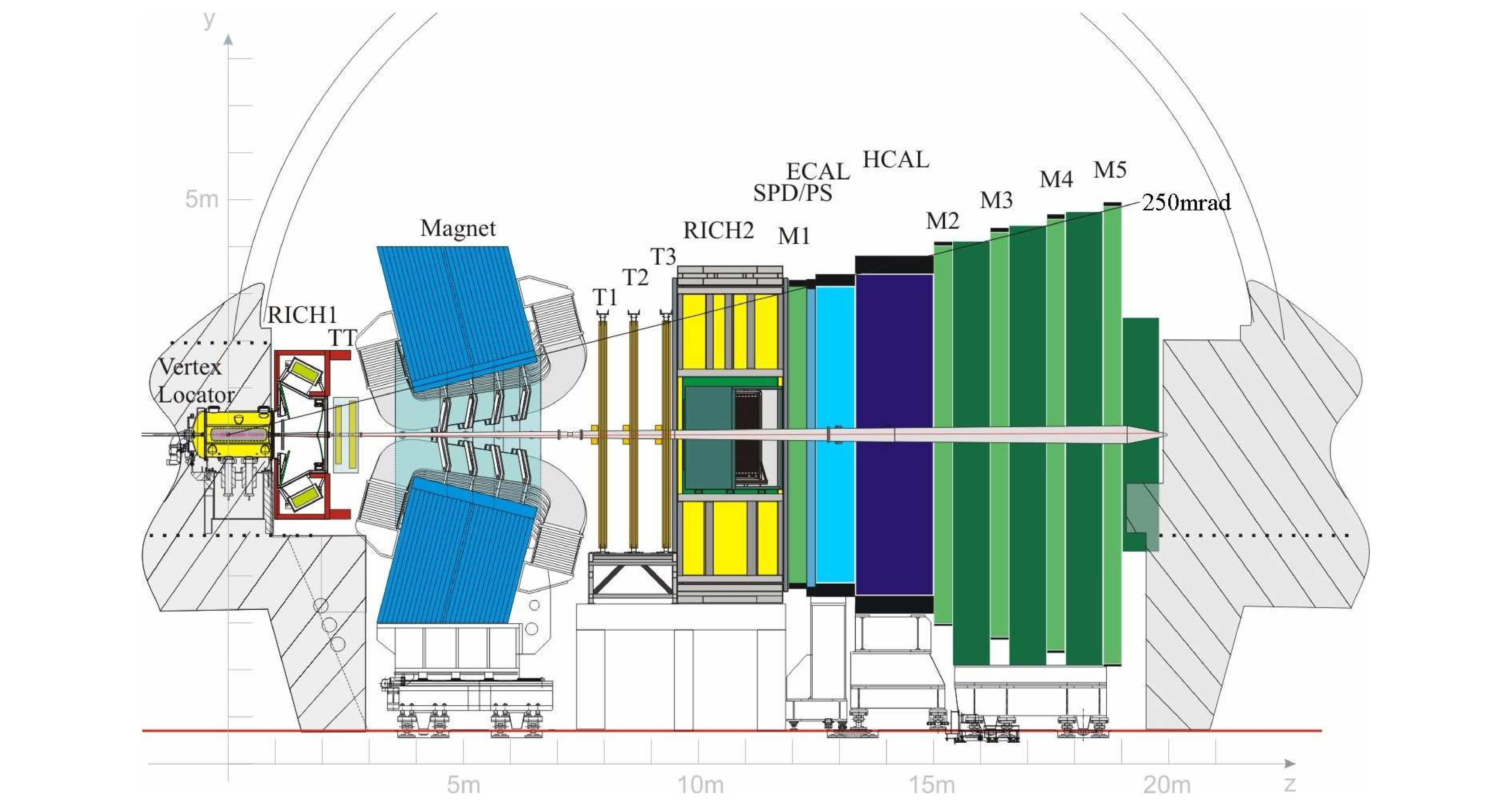
Short term plan [2010-2011]

Understanding background for suppressed $B^0 \to \bar{D}^0 K^{*0}$ decays: favoured $\bar{B}_s^0 \to D^0 K^{*0}$ in the **same final state**.

Additional motivations

- $\bar{B}_s^0 \to D^0 K^{*0}$ **not yet measured**.
- Comparing $\bar{B}_s^0 \to D^0 K^{*0}$ and $B^0 \to \bar{D}^0 K^{*0}$ is a **probe** of SU(3) **breaking** in colour suppressed $B^0 \to D^0 V^0$ decays.

The LHCb detector [3]



- L0 hardware trigger (in 2010, $E_T > 3.6$ GeV/c) and HLT B inclusive software trigger.

Analysis Strategy

channel	B decay $\mathcal{B}$(in 10^{-5})	total $\mathcal{B}$(in 10^{-6})	Events produced in LHCb geo. acceptance
$\bar{B}^0 \to D^0 \rho^0$	32 ± 5	12 ± 2	20000
$B^0 \to \bar{D}^0 K^{*0}$	4.2 ± 0.6	1.1 ± 0.2	1800
$\bar{B}_s^0 \to D^0 K^{*0}$	32 to 87	8 to 23	3000 to 9600
$B^0 \to D^0 K^{*0}$	$\simeq 0.26$	$\simeq 0.07$	110

Selection

- Cancellation of systematics in ratio.
- Selections as similar as possible (p_T, track quality, track impact parameter, B decay topology.
- Mass windows of ρ^0 and K^{*0} equal the Breit-Wigner width (150 MeV/c^2 and 50 MeV/c^2)
- Particle Identification (**PID**) for one V daughter (optimized on data using D^0) **is different**.

Trigger

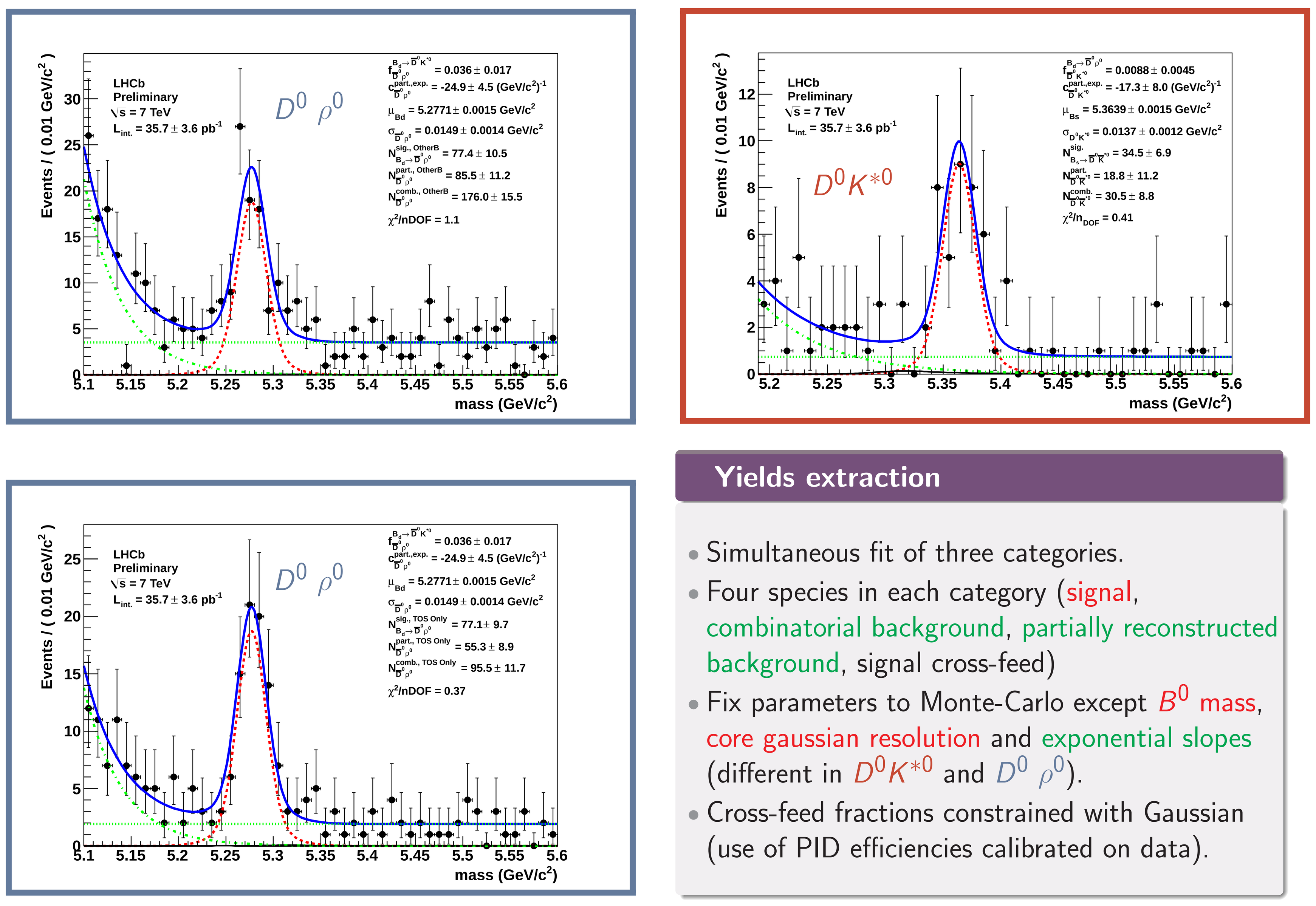
- Similar HLT efficiencies for both channels $\to$ no specific requirement on HLT.
- Difference only at L0 (E_T threshold).
- Events triggered on the rest of the event, independent of the candidate-B (OtherB) or on the signal only (TOSOnly).
- **Do not trust absolute Monte Carlo efficiencies, only ratios.**

Extraction of the ratio of branching fractions

$$\frac{\mathcal{B}(\bar{B}_s^0 \to D^0 K^{*0})}{\mathcal{B}(\bar{B}^0 \to D^0 \rho^0)} = \frac{1}{\mathcal{B}(K^{*0} \to K^+\pi^-)} \frac{f_d}{f_s} r_{\text{acc.}}\, r_{\text{sel}}\, r_V\, r_{\text{PID}} \times \frac{N^{sig.}_{\bar{B}_s^0 \to D^0 K^{*0}}}{r^{-1}_{\text{L0HadronTOSOnly}}(N^{\text{L0HadronTOSOnly}}_{\bar{B}^0 \to D^0\rho^0} - 0.5 N_{\text{non }\rho^0}) + r^{-1}_{\text{OtherB}}(N^{\text{OtherB}}_{\bar{B}^0 \to D^0\rho^0} - 0.5 N_{\text{non }\rho^0})}$$

- Ratio of selection and geometrical acceptance efficiencies from Monte Carlo (except PID).
- PID from data (using D^0 from D^{*0} and reweighting for difference in kinematics).
- Ratio of fragmentation fractions from HFAG [4].
- Relative trigger abundances in OtherB and TOSOnly from data.
- Correction for non-ρ^0 contributions.

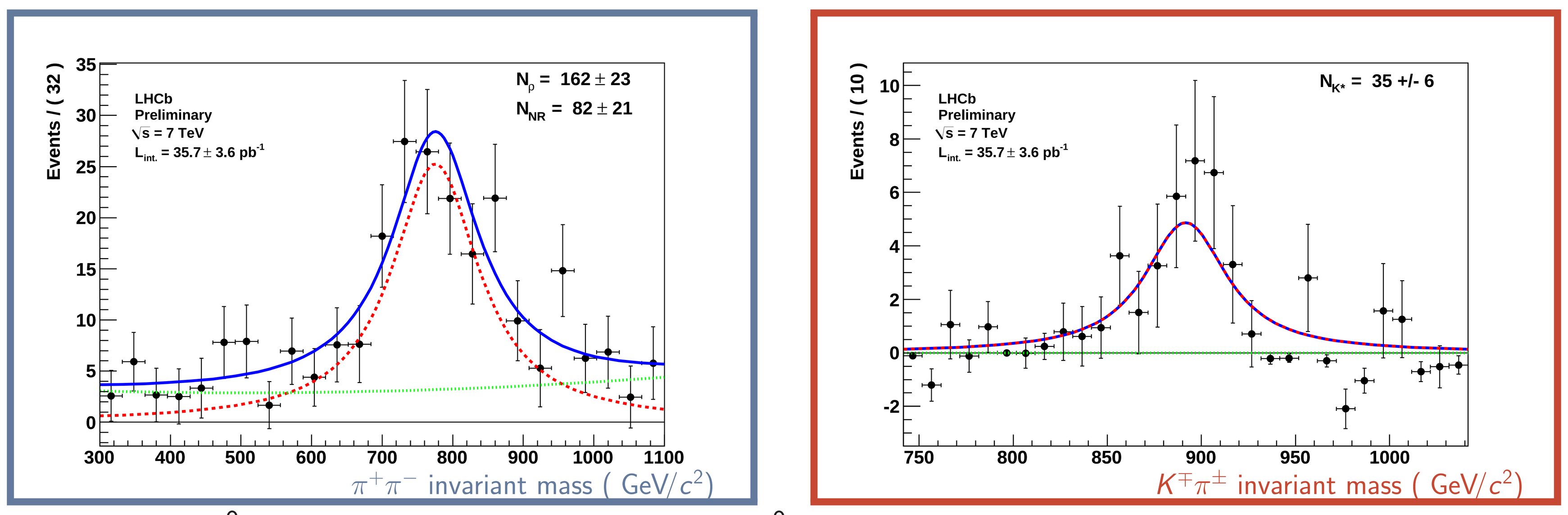
Fit result



Yields extraction

- Simultaneous fit of three categories.
- Four species in each category (signal, combinatorial background, partially reconstructed background, signal cross-feed)
- Fix parameters to Monte-Carlo except B^0 mass, core gaussian resolution and exponential slopes (different in $D^0 K^{*0}$ and $D^0\ \rho^0$).
- Cross-feed fractions constrained with Gaussian (use of PID efficiencies calibrated on data).

"Non-resonant" contributions



- 20 % of non-ρ^0 events in the selection while clean K^{*0} mass (using sPlots [5]) $\to$ corrected for the extraction.

Systematics

Source of the uncertainty	σ_R/R
MC statistics $r_{\text{acceptance}} = 0.955 \pm 0.004$	0.4 %
MC statistics	1.0 %
Change in the central value of the vector mass window $r_V = 1.02 \pm 0.01$	1.0 %
Difference in p_T distributions of tracks between data vs MC $r_{\text{sel.}} = 0.802 \pm 0.020$	2.5 %
Use of the unweighted calibration sample for $r_{\text{PID}} = 1.03 \pm 0.07$	6.8 %
L0 Hadron threshold influence on $r_{\text{TOSOnly}} = 1.20 \pm 0.08$	3.0 %
OtherB triggering efficiency independent on the mode $r_{\text{OtherB}} = 1.03 \pm 0.03$	1.6 %
PDF parameterizations	6.4 %
Statistical uncertainty on the non-ρ^0 component $= 30.1 \pm 7.9$	6.8 %
Overall relative systematical uncertainty	12.3 %
HFAG average $\frac{f_d}{f_s} = 3.71 \pm 0.47$	12.7 %

Results

- First observation of $\bar{B}_s^0 \to D^0 K^{*0}$ with $N = 34.5 \pm 6.9$ ($> 9\sigma$ from change of likelihood with no signal).
- $\frac{\mathcal{B}(\bar{B}_s^0 \to D^0 K^{*0})}{\mathcal{B}(\bar{B}^0 \to D^0 \rho^0)} = 1.39 \pm 0.31\,(\text{stat}) \pm 0.17\,(\text{syst}) \pm 0.18\,(f_d/f_s)$.
- $\mathcal{B}(\bar{B}_s^0 \to D^0 K^{*0}) = (4.44 \pm 1.00\,(\text{stat}) \pm 0.55\,(\text{syst}) \pm 0.56\,(f_d/f_s) \pm 0.69\,(\mathcal{B}(\bar{B}^0 \to D^0\rho^0))) \cdot 10^{-4}$ [6].
- Compatible with predictions [7,8,9].

Selected references

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