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First observation of charm resonant decay modes in the $\Lambda_b^0 \to \Lambda_c^+\pi^+\pi^-\pi^-$ channel at CDF

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Summary. — We present the first observation of the $\Lambda_b^0 \to \Lambda_c^+\pi^+\pi^-\pi^-$ decay using data from an integrated luminosity of approximately $2.4\,\text{fb}^{-1}$ of $p\overline{p}$ collisions at $\sqrt{1.96}\,\text{TeV}$ collected by the CDF II detector at the Fermilab Tevatron. We also present the first observation of the resonant decays $\Lambda_b^0 \to \Lambda_c(2595)^+\pi^- \to \Lambda_c^+\pi^-\pi^+\pi^-$, $\Lambda_b^0 \to \Lambda_c(2625)^+\pi^- \to \Lambda_c^+\pi^-\pi^+\pi^-$, $\Lambda_b^0 \to \Sigma_c(2455)^{++}\pi^-\pi^- \to \Lambda_c^+\pi^-\pi^+\pi^-$, $\Lambda_b^0 \to \Sigma_c(2455)^0\pi^+\pi^- \to \Lambda_c^+\pi^-\pi^+\pi^-$ reconstructed in the $\Lambda_b^0 \to \Lambda_c^+\pi^+\pi^-\pi^-$ sample, and measure their relative branching ratios.

PACS `14.20.Lq` – Charmed baryons ($|C| > 0, B = 0$).
PACS `14.20.Mr` – Bottom baryons ($|B| > 0$).
PACS `13.30.-a` – Decays of baryons.

1. – Introduction

Presented here is the observation of the $\Lambda_b^0 \to \Lambda_c^+\pi^+\pi^-\pi^-$ decay and resonant structure in analogy to the decay structure observed in the $\Lambda_b^0 \to \Lambda_c^+\pi^+\pi^-\mu^-\nu_\mu$ channel [1]. All new measurements of the Λ_b^0 branching ratios can be compared to theoretical predictions in the heavy quark effective theory (HQET) approximation [2]. b-hadrons are abundantly produced at the Tevatron Collider, and among these the Λ_b baryon. The challenge in this analysis is to extract signals from a background which is orders of magnitude higher at production. This is achieved thanks the to the Silicon Vertex Trigger (SVT) [3] able to reconstruct and identify online the secondary vertices typical of b-hadron decays.

2. – Observation of the resonant structure in the $\Lambda_b^0 \to \Lambda_c^+\pi^+\pi^-\pi^-$ decay mode

CDF reconstructed a signal of 848 ± 93 $\Lambda_b^0 \to \Lambda_c^+\pi^+\pi^-\pi^-$ candidates with $\Lambda_c^+ \to pK^-\pi^+$ in $2.4\,\text{fb}^{-1}$ of data (fig. 1). In the $\Lambda_b^0 \to \Lambda_c^+\pi^+\pi^-\pi^-$ sample we reconstructed the resonant decay modes: $\Lambda_b^0 \to \Lambda_c(2595)^+\pi^-$ (46.6 ± 9.7 candidates), $\Lambda_b^0 \to \Lambda_c(2625)^+\pi^-$ (114 ± 13 candidates) (fig. 1), $\Lambda_b^0 \to \Sigma_c^{++}\pi^-\pi^-$ (81 ± 15 candidates), and $\Lambda_b^0 \to \Sigma_c^0\pi^-\pi^+$

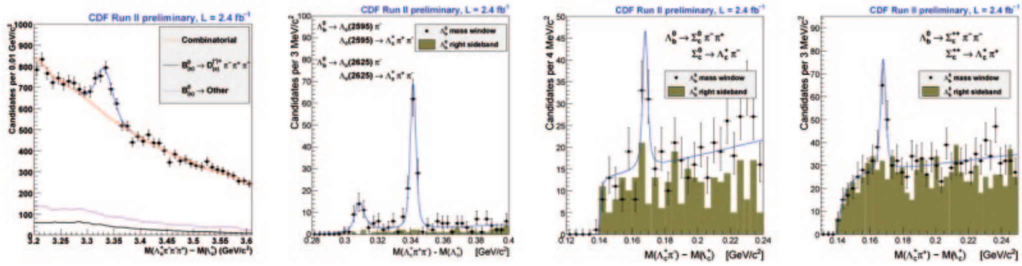

Fig. 1. – $\Lambda_b^0 \to \Lambda_c^+\pi^+\pi^-\pi^-$ mass distribution, $\Lambda_b^0 \to \Lambda_c(2595)^+\pi^-$ and $\Lambda_b^0 \to \Lambda_c(2625)^+\pi^-$ candidates in a $\pm 3\sigma\Lambda_b^0$ mass window, $\Lambda_b^0 \to \Sigma_c^{++}\pi^-\pi^-$ candidates in a $\pm 3\sigma$ Λ_b^0 mass window and $\Lambda_b^0 \to \Sigma_c^0\pi^-\pi^+$ candidates in a $\pm 3\sigma$ Λ_b^0 mass window, from left to right.

Table I. – *Measured relative branching fractions of the resonant* $\Lambda_b^0 \to \Lambda_c^+\pi^+\pi^-\pi^-$ *decay modes.*

$\frac{\mathcal{B}(\Lambda_b^0\to\Lambda_c(2595)^+\pi^-\to\Lambda_c^+\pi^-\pi^+\pi^-)}{\mathcal{B}(\Lambda_b^0\to\Lambda_c^+\pi^-\pi^+\pi^-(all))}$	$(2.5 \pm 0.6(\text{stat.}) \pm 0.5(\text{syst.})) \times 10^{-2}$
$\frac{\mathcal{B}(\Lambda_b^0\to\Lambda_c(2625)^+\pi^-\to\Lambda_c^+\pi^-\pi^+\pi^-)}{\mathcal{B}(\Lambda_b^0\to\Lambda_c^+\pi^-\pi^+\pi^-(all))}$	$(6.2 \pm 1.0(\text{stat.})^{+1.0}_{-0.9}(\text{syst.})) \times 10^{-2}$
$\frac{\mathcal{B}(\Lambda_b^0\to\Sigma_c(2455)^{++}\pi^-\pi^-\to\Lambda_c^+\pi^-\pi^+\pi^-)}{\mathcal{B}(\Lambda_b^0\to\Lambda_c^+\pi^-\pi^+\pi^-(all))}$	$(5.2 \pm 1.1(\text{stat.}) \pm 0.8(\text{syst.})) \times 10^{-2}$
$\frac{\mathcal{B}(\Lambda_b^0\to\Sigma_c(2455)^0\pi^+\pi^-\to\Lambda_c^+\pi^-\pi^+\pi^-)}{\mathcal{B}(\Lambda_b^0\to\Lambda_c^+\pi^-\pi^+\pi^-(all))}$	$(8.9 \pm 2.1(\text{stat.})^{+1.2}_{-1.0}(\text{syst.})) \times 10^{-2}$
$\frac{\mathcal{B}(\Lambda_b^0\to\Lambda_c^+\rho^0\pi^-+\Lambda_c^+3\pi(nr)\to\Lambda_c^+\pi^-\pi^+\pi^-)}{\mathcal{B}(\Lambda_b^0\to\Lambda_c^+\pi^-\pi^+\pi^-(all))}$	$(77.3 \pm 3.1(\text{stat.})^{+3.0}_{-3.3}(\text{syst.})) \times 10^{-2}$

(41.5 ± 9.3 candidates). We measured the relative branching fractions of the resonant Λ_b^0 decay modes (table I), by using the signal yields estimated by perfoming fits of the mass distributions (fig. 1) and relative efficiency factors estimated with Monte Carlo. The main sources of systematic errors derive from the uncertainties on fits of the data and from the uncertainties on estimated relative efficiencies. More details on systematics and in general about this analysis can be found in ref. [4].

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