Study of the $\Lambda_b^0 \to D^0 p K^-$ decay for a future measurement of the CKM angle γ at the LHCb experiment

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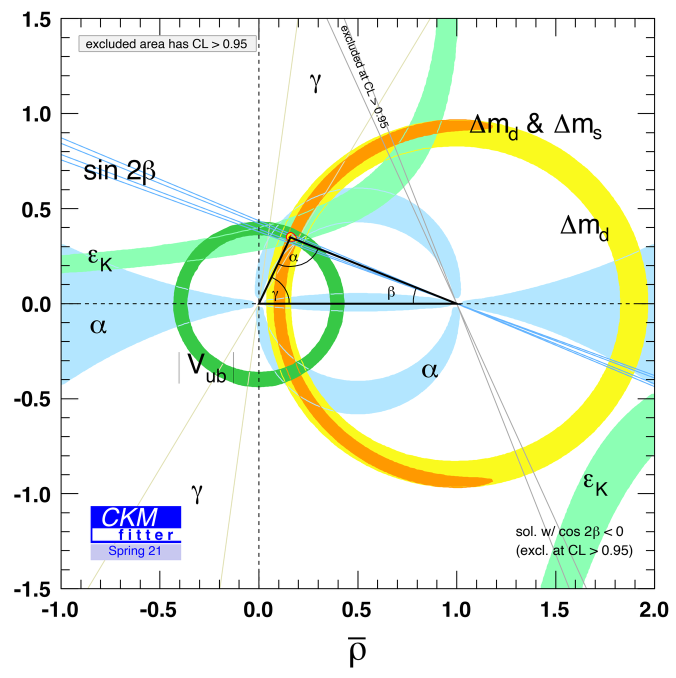
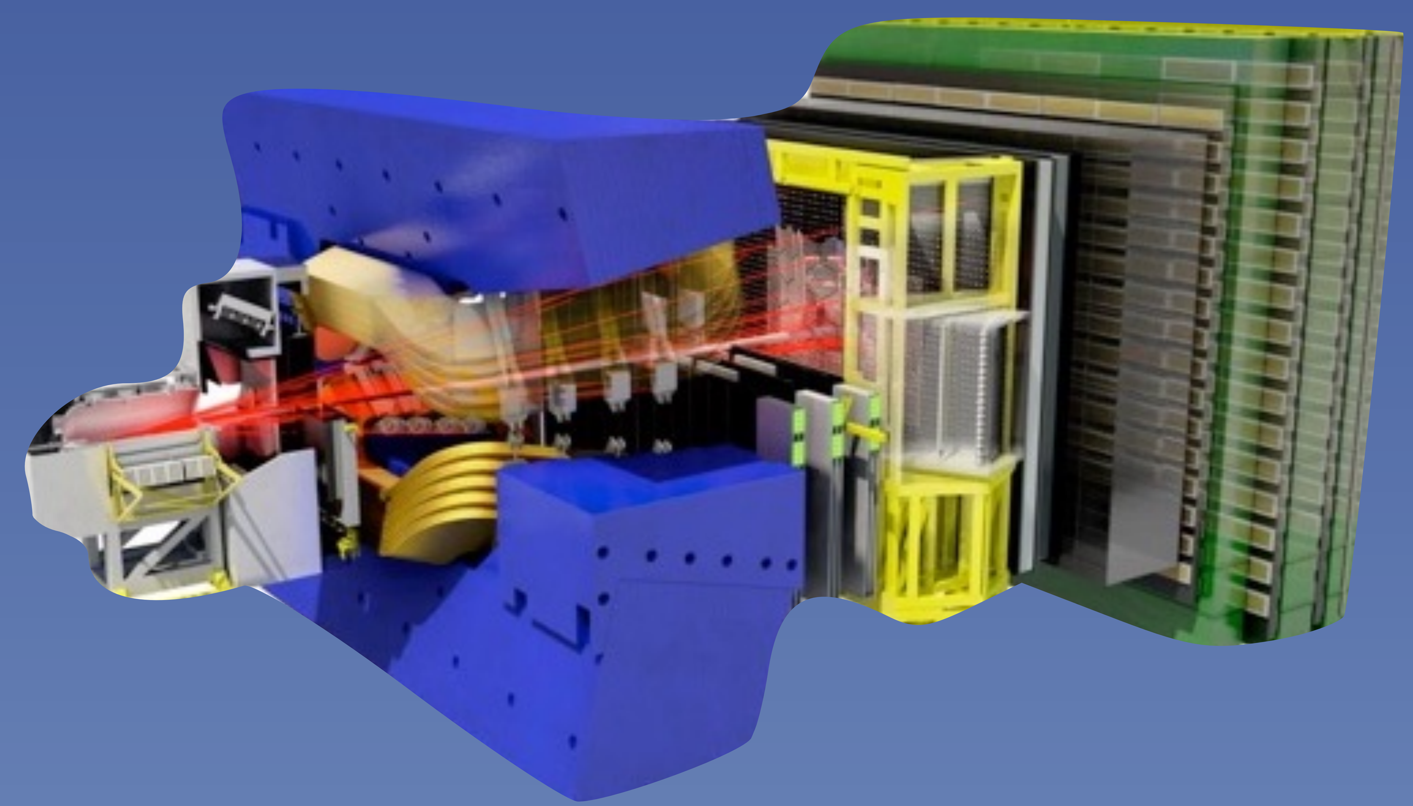
1 Motivation

- The CKM angle γ is, within the unitarity triangle, the angle known with the worst experimental uncertainty

Indirect measurement
$\gamma = (65.6^{+1.1}_{-2.7})^\circ$
[http://ckmfitter.in2p3.fr]
Direct measurement
$\gamma = (63.8^{+3.5}_{-3.7})^\circ$
[LHCb-CONF-2022-002]

$$\gamma = \arg\left[\frac{-V_{ud}V_{ub}^*}{V_{cd}V_{cb}^*}\right]$$





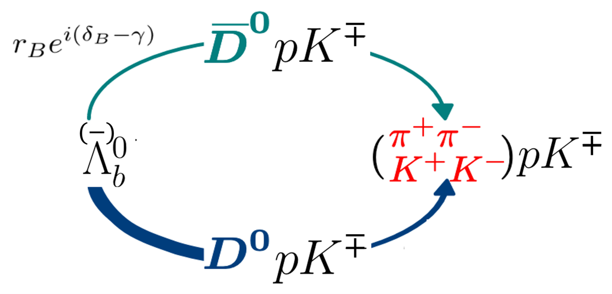
- Theoretically clean measurement
- CP violation never measured in baryons

2 Technique

[Phys. Lett. B265 (1991), pp. 172–176]

Gronau, London, Wyler (GLW) method → D^0 decays into **CP eigenstates**

- CP-even eigenstates: $K^-K^+, \pi^-\pi^+$
- CP-odd eigenstates: $K_S\pi^0, K_S\rho^0, \ldots$



$$A_{CP} = \frac{\Gamma(\Lambda_b^0 \to D_{CP} p K^-) - \Gamma(\bar{\Lambda}_b^0 \to D_{CP} \bar{p} K^+)}{\Gamma(\Lambda_b^0 \to D_{CP} p K^-) + \Gamma(\bar{\Lambda}_b^0 \to D_{CP} \bar{p} K^+)} = \frac{2 r_B \sin\delta_B \sin\gamma}{1 + r_B^2 + 2 r_B \cos\delta_B \cos\gamma}$$

$$R_{CP} = \frac{\Gamma(\Lambda_b^0 \to D_{CP} p K^-) - \Gamma(\bar{\Lambda}_b^0 \to D_{CP} \bar{p} K^+)}{\Gamma(\Lambda_b^0 \to D^0 p K^-) + \Gamma(\bar{\Lambda}_b^0 \to \bar{D}^0 \bar{p} K^+)} = 1 + r_B^2 + 2 r_B r_D \cos\delta_B \cos\gamma$$

3 Analysis strategy

- Analysis performed on **RunI** and **RunII** (2011 - 2018) data sample collected by LHCb (9 fb^{-1} of integrated luminosity of pp collisions)
- Wide use of control channel $\Lambda_b^0 \to D^0 p \pi^-$

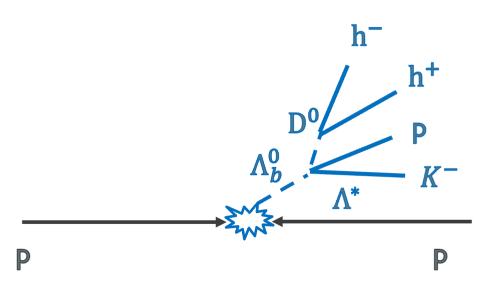
$$B(\Lambda_b^0 \to D^0 p \pi^-) = (6.3 \pm 0.7) \times 10^{-4}$$
$$B(\Lambda_b^0 \to D^0 p K^-) = (4.6 \pm 0.8) \times 10^{-5}$$

- Preselection on PID of $p, h^\pm_{D^0}$

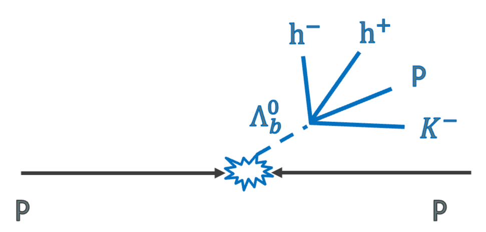
$$S_{FoM} = \frac{S}{\sqrt{S+B}} = \frac{\epsilon_S S_0}{\sqrt{\epsilon_S S_0 + \epsilon_B B_0}}$$

4 The challenge

- Highly contaminating background → **charmless decays**, i.e. $\Lambda_b^0 \to p h^- h^+ h^-$ which reduces the sensitivity to γ
- Previously eliminated with rectangular cuts
  → New tool: **Boosted Decision Tree** (BDT) able to discriminate three typologies of events

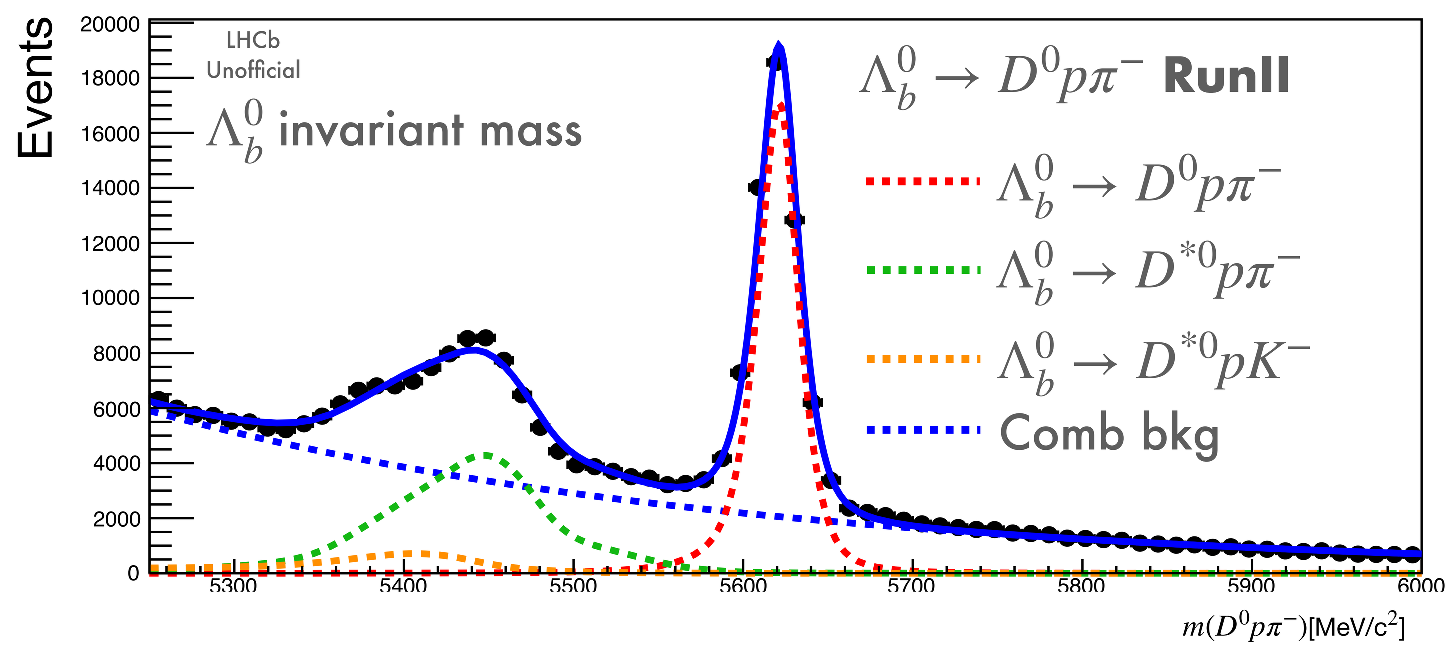


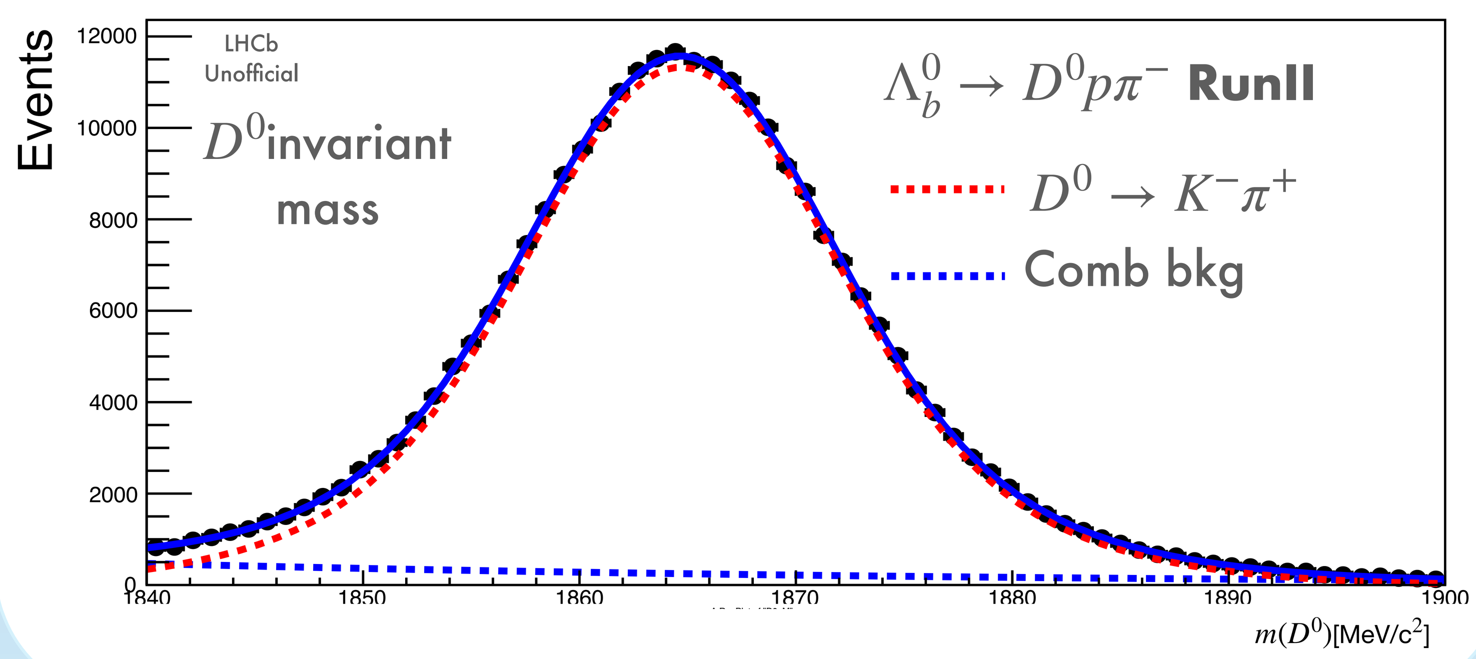
- Trained with kinematic variables of mother and daughter particles, key to remove the charmless background is the **distance** between Λ_b^0 and D^0 **vertices**



5 The fit

To further constrain the possible charmless contribution, a **simultaneous fit** is realised between the Λ_b^0 and D^0 invariant mass distributions





6 Prospects and next steps

- Expected sensitivity on γ = 10°
- Angular analysis of $\Lambda_b^0 \to D^0 p K^-$ foreseen
- Joint measurement of γ with $\Lambda_b^0 \to D^0 p K^-$, where D^0 is decaying to 4-body
- Analysis on RunIII data

Stay tuned!

12th LHC students poster session