Measurement of the branching ratio of $D^+ \to K^-K^+K^+$ decays in LHCb

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Introduction

Some of the particles created in LHCb colisions are D^+ mesons. We want to know how many of these mesons decays in three charged kaons. This is the branching ratio of $D^+ \to K^-K^+K^+$, a double Cabibbo-supressed decay – a very rare one. In order to avoid many systematic effects, the measure of the ratio of two branching fractions can be done – $D^+ \to K^-K^+K^+$ and $D^+ \to K^-\pi^+\pi^+$, a much more abundant and well measured decay.

The relative Branching Ratio will be given by the

$$BR = \frac{\Gamma(D^+ \to K^-K^+K^+)}{\Gamma(D^+ \to K^-\pi^+\pi^+)} = \frac{N_{Obs(D^+ \to K^-K^+K^+)}}{N_{Obs(D^+ \to K^-\pi^+\pi^+)}} \frac{\varepsilon_{Obs(D^+ \to K^-\pi^+\pi^+)}}{\varepsilon_{Obs(D^+ \to K^-K^+K^+)}}$$

To measure this ratio, we need to determine:

- How many $D^+ \to K^-K^+K^+$ and $D^+ \to K^-\pi^+\pi^+$ events are seen by the detectors
- The total efficiency of the detectors and selection criteria

How do we get these informations? Through the LHCb detection system. As the particles travel across the detectors, they give us many physical data:

- Particles momenta, velocity, time of flight, distance of flight, charge, …
- With those informations we can identify particles and reconstruct the desired events

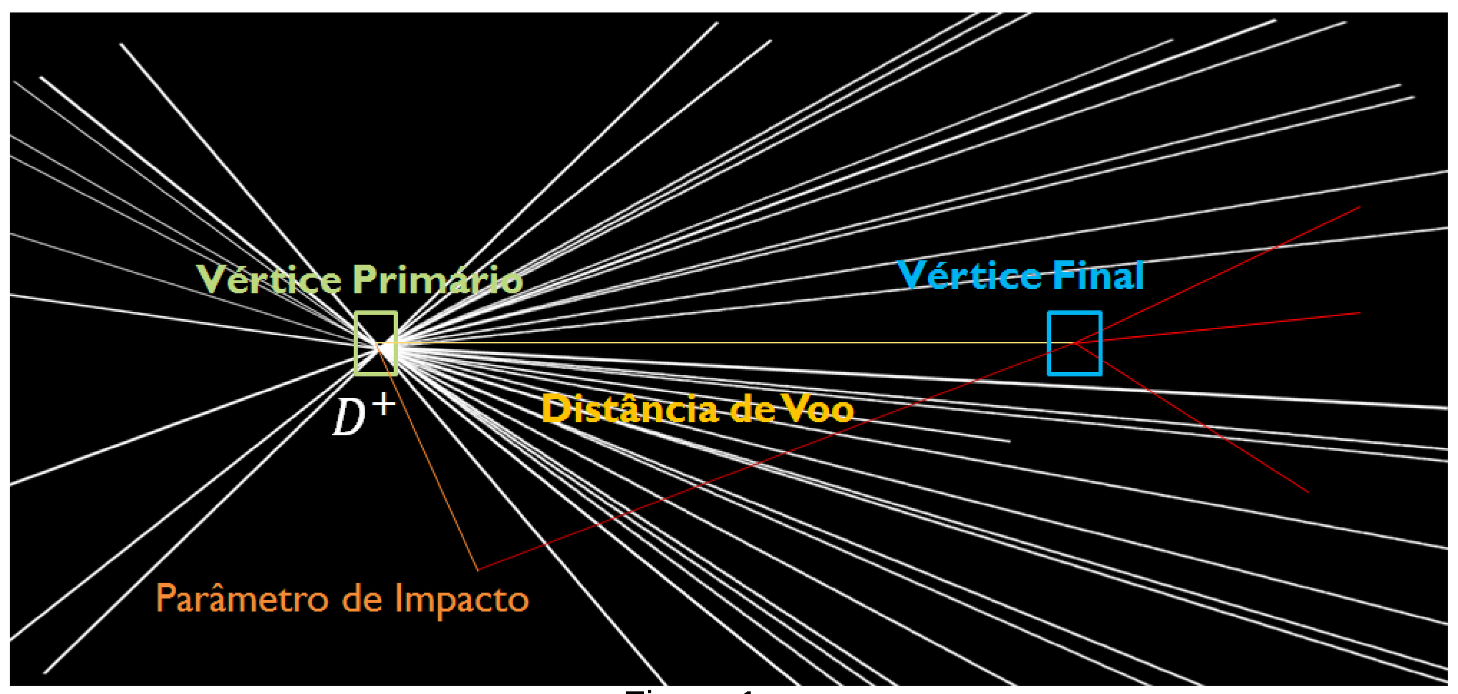

Figure 1

Selection of events

With the informations gathered, we can identify the particles and reconstruct the $D^+ \to K^-K^+K^+$ and $D^+ \to K^-\pi^+\pi^+$ events. However, many background events remain in our data. To reduce this contamination, we search for every physical information that we have (eg. Momenta) and see if there is a cut value for this variable that maximizes the signal over background events ratio.

With the reduced background, we then perform a fit over the data, with different models for signal and background.

Efficiency

After all the procedures are done, what is left to determine is the total efficiency of the proceedings. So we have to account for every step:

- Geometric acceptance of the detector
- The reconstruction process
- The online and offline selections
- The particle identification process

As we don't have access to how many D+ mesons we had beforehand, to determine these efficiencies we make use of Monte Carlo simulation samples.

Results

With the signal yields resulting from the fits, and the efficiencies determined, we have a measure for the branching ratio:

$$BR = (6.853 \pm 0.025) \times 10^{-4}$$

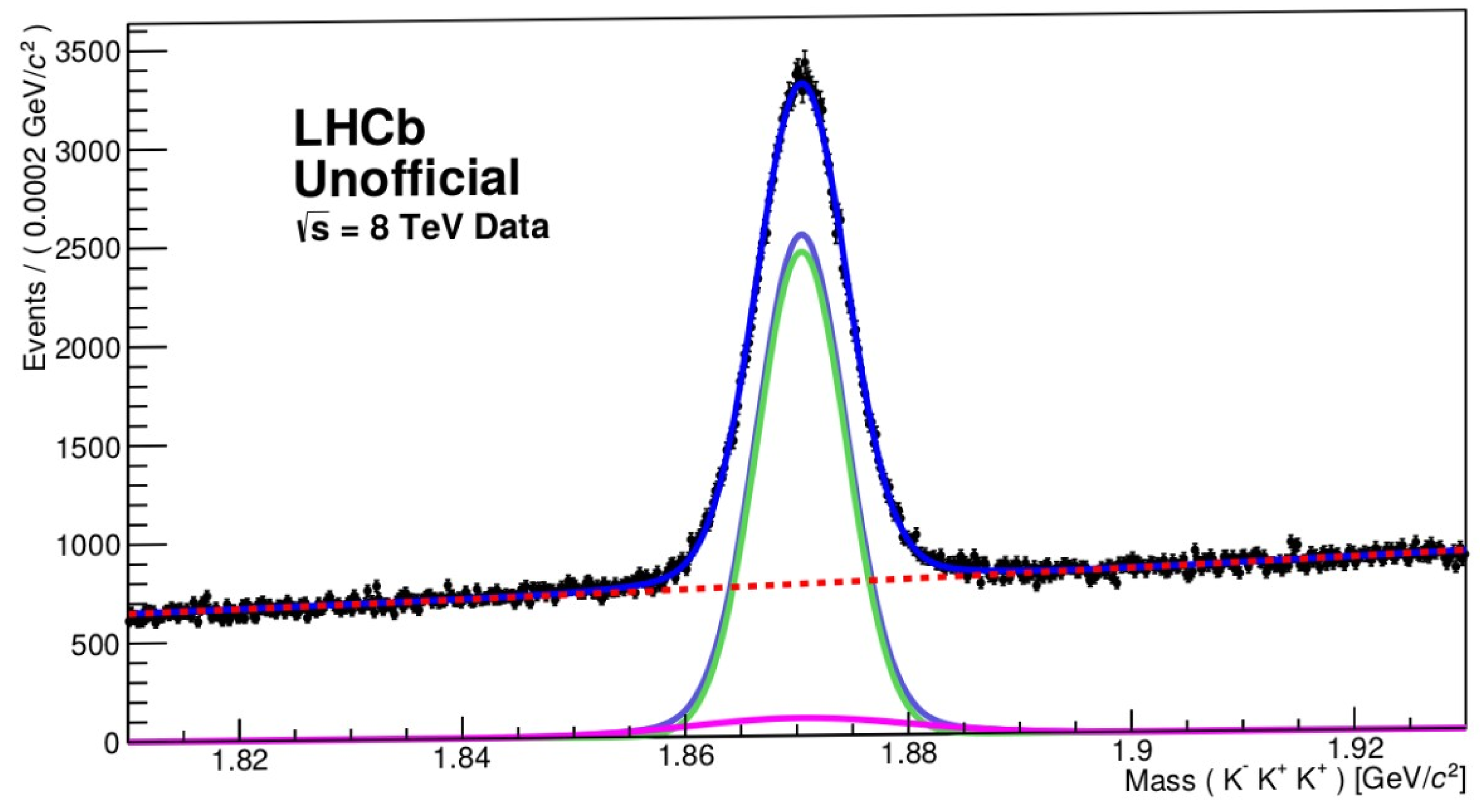

Figure 2

Which is **60 times more precise** than the current world average (FOCUS, Fermilab, 2002), which is on PDG (Particle Data Group), at only **1.2σ**.

Present and future work

The efficiency may vary in the phase-space of the decay, so we want, as a next step, to **determine the signal yields and efficiency over the phase-space**.

Also, the **systematic errors** due to the fit model, to the binning over the phase-space etc must yet be determined.

References

[1] Particle Data Group, C. Patrignani et al., Review of Particle Physics, Chin. Phys. C 40 (2016) 100001
[2] FOCUS collaboration, J. M. Link et al., Measurement of the D+ and Ds+ decays into K + K − K + , Phys. Lett. B 541 (2002) 227, arXiv:0206049.

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