A MORE PRECISE MASS MEASUREMENT OF THE Λ_c BARYON

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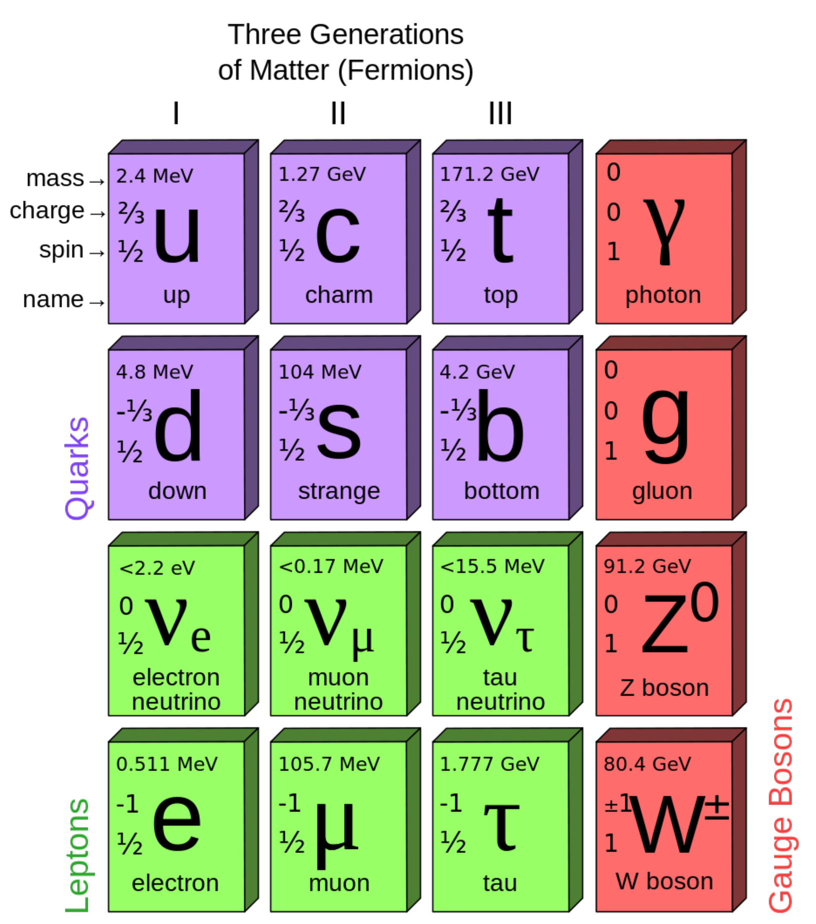
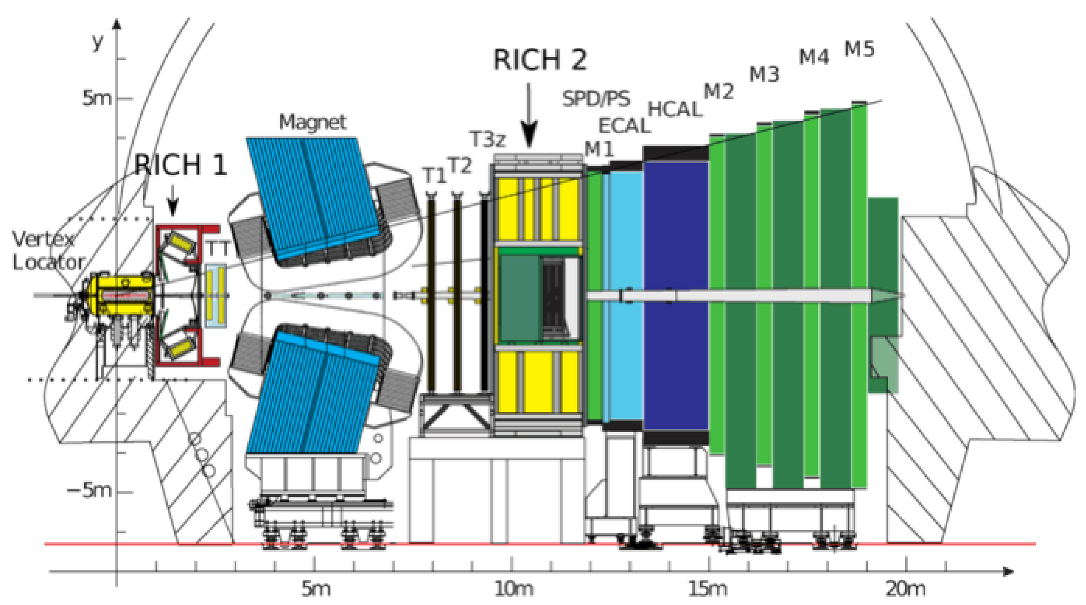
The Standard Model



The most rigorous theory to describe the interactions of elementary particles is the Standard Model. The Standard Model classifies particles into distinct groups. Fermions are the building blocks of matter and bosons are the mediators of interaction. Quarks are fermions that must exist in pairs. The particles that consist of quarks are known as hadrons. Baryons are hadrons composed of three quarks or anti-quarks and mesons are hadrons composed of a quark/anti-quark pair. The Λ_c baryon is a hadron composed of an up, down, and strange quark.

The LHCb Detector

This analysis utilizes data collected from the LHCb in 2017.



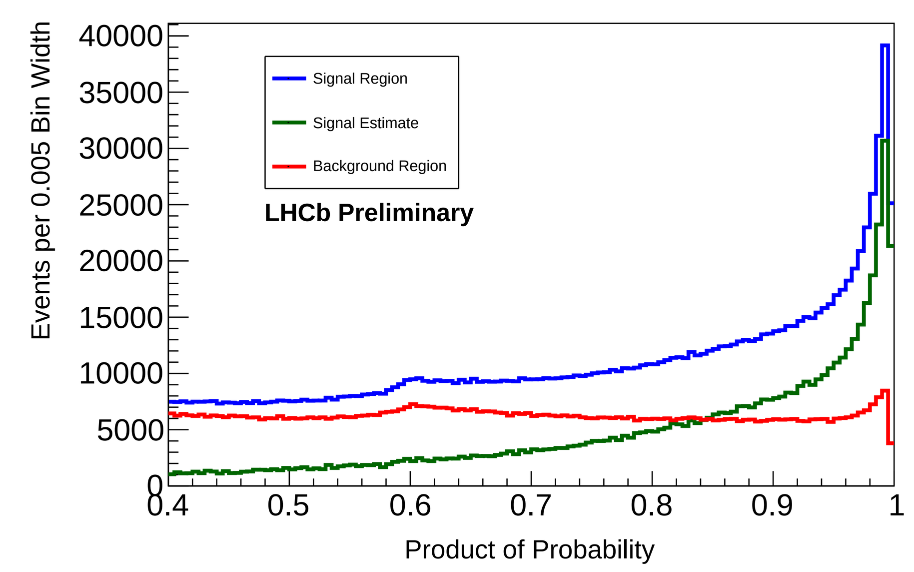
The LHCb detector is one of four primary experiments that receives particles from the collisions of high-energy protons inside the Large Hadron Collider. The detector is a single-arm forward spectrometer dedicated to observing bottom, also called beauty, and charm hadron decays. Beauty and charm hadron decays are of primary interest to the collaboration because asymmetries between quark and anti-quark decays could help explain CP violation.

Motivation

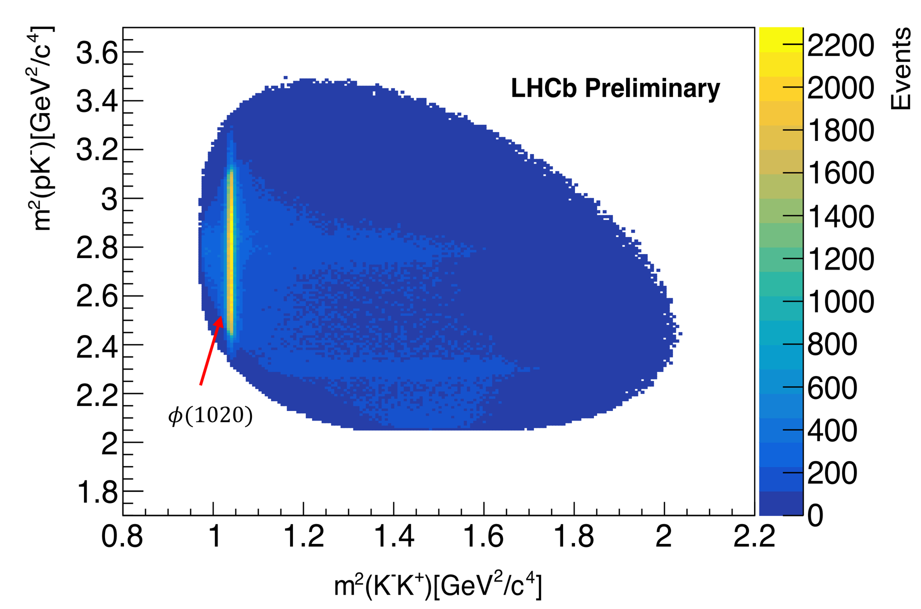
The LHC produces both charm and anti-charm hadrons. Therefore, a precision measurement of the Λ_c baryon and its anti-particle will provide essential details for CP violation studies. Furthermore, the LHCb collaboration has recently discovered that doubly charmed baryons can decay into Λ_c baryons. Precision measurements of the Λ_c baryon can help with determining constraints for the doubly charmed baryon decay kinematics. This analysis was conducted using the decay channel $\Lambda_c^+ \to pK^+K^-$.

Analysis of $\Lambda_c^+ \to pK^+K^-$

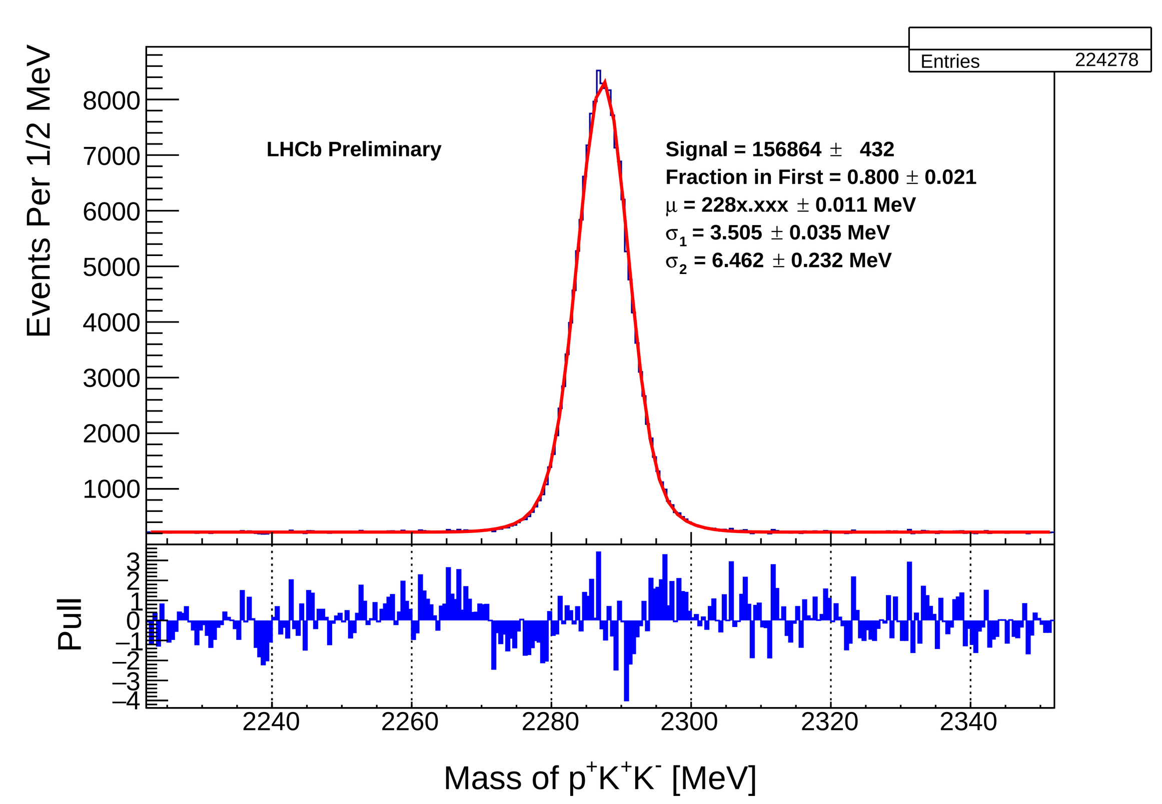
The goal of this project is to increase statistical precision by determining selection criteria on particle identification and decay kinematics through studies of background subtracted distributions. Charged tracks in the LHCb are given probability variables called ProbNNx. Optimal requirements for the ProbNNx variables are determined from their background subtracted distributions.



A potential intermediate resonance exists between the K^+ and K^- mesons known as the $\phi(1020)$ meson. Most of the signal events have the $\phi(1020)$ intermediate resonance. Therefore, statistical precision can be improved by requiring an intermediate $\phi(1020)$ decay.

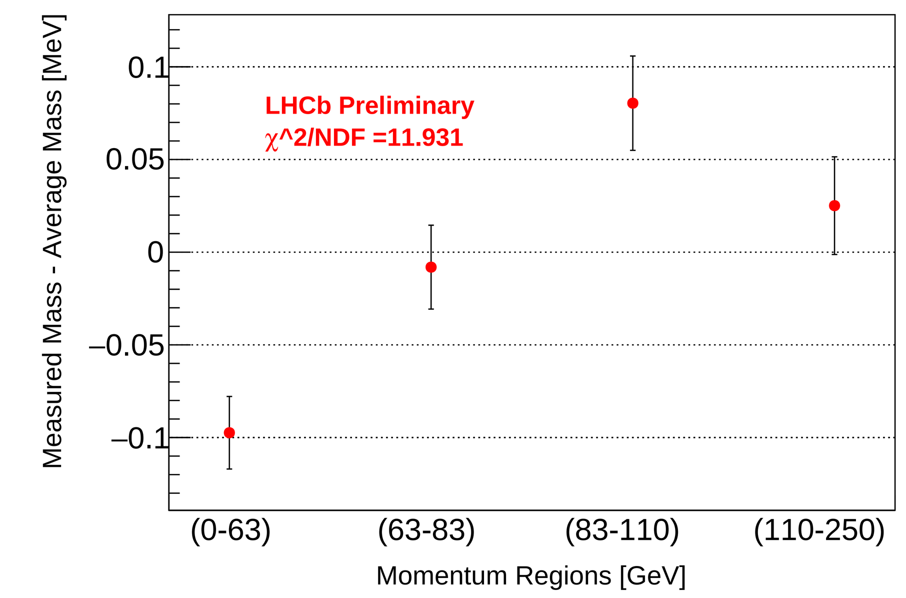


Fit Results



Resulting Λ_c mass histogram fit with a double Gaussian function.

Systematic Uncertainty



Systematic errors are evaluated by studying the resulting Λ_c mass of disjoint data samples. A χ^2/NDF was determined for each subset by studying how the Λ_c mass deviates from an average mass. Systematic errors due to the magnetic field orientation and particle charges were consistent with random fluctuation. However, the systematic error from four disjoint momentum regions resulted in a systematic error of 0.0364 MeV.

Conclusion

Λ_c Mass from 2017 LHCb data:
$(228x.xx \pm 0.05)$MeV$/c^2$

Λ_c Mass recorded by PDG:
(2286.46 ± 0.14)MeV$/c^2$

The overall precision of the new Λ_c mass measurement is around three times better than the current PDG value. Further studies of momentum correction uncertainties must be conducted to understand systematic variations. Studies of other sources of systematic uncertainty must be conducted to more accurately determine the systematic error.

References

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[2] LHCb collaboration, A.A Alves Jr. *et al., The LHCb detector at the LHC,* JINST **3** (2008) S08005

[3] LHCb collaboration, A. Powell, *Particle Identification at LHCb,* LHCb-PROC-2011-008 `https://cds.cern.ch/record/1322666`

[4] Standard Model of Elementary Particles. Courtesy to Wikipedia: 'Standard Model of Elementary Particles' by MissMJ

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