Studying the Sensitivity of the Upgrade Phase II LHCb Calorimeter for the rare decay $B^0 \to \pi^0\pi^0$, where one π^0 decays to the Dalitz $e^+e^-\gamma$ channel

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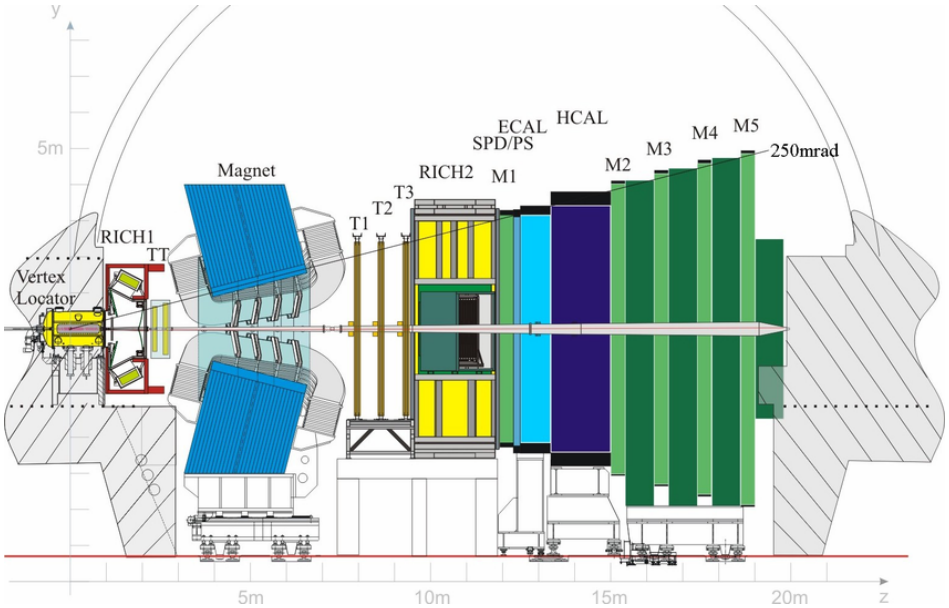
Overview

- Goal: study the feasibility of the observation of this decay with upgrade phase II of LHCb calorimeter.
  A full Geant 4 based simulation of the decay will be performed.
- LHCb experiment is dedicated to flavor physics.
- Collides protons together at high energies and detects the particles produced from those collisions.

LHCb Detector



- Vertex Locator
- warm magnet, 4 Tm
- tracker stations
- two RICH detectors
- electromagnetic calorimeter with preshower
- hadron calorimeter
- muon identification system

Upagrade Phase II

- RUN 5 (2030): $14\,TeV$ pp colisions.
- Increase of the luminosity to $\approx 300 fb^{-1}$ corresponding to more than 50 pp collisions at a frequency of $40\,MHz$.
- To be able to cope with such a high rate, the LHCb calorimeter must be upgraded.The proposed upgraded II calorimeter design will be described in a future TDR due to the LHCC by September 2024.

Charmless B-meson decay $B^0 \to \pi^0\pi^0$

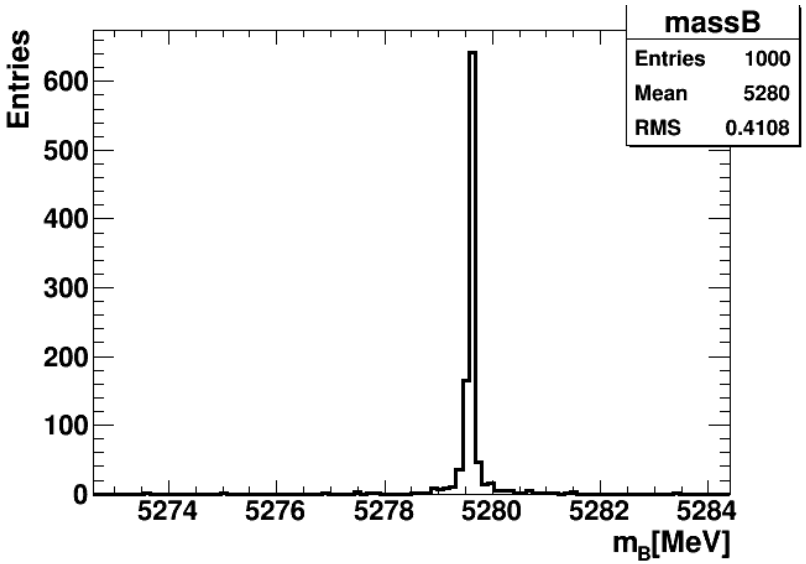
$$\mathcal{B}(B^0 \to \pi^0\pi^0) = 1.59 * 10^{-6}$$

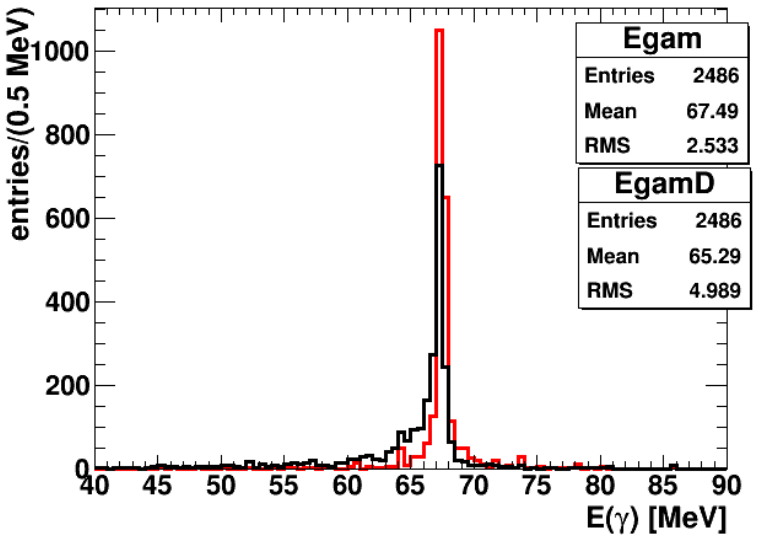
$$\Gamma(\pi^0 \to \gamma\gamma) = 98.823\%$$

$$\Gamma(\pi^0 \to \gamma e^+ e^-) = 1.174\%$$

The reconstruction of the rare decay $B^0 \to \pi^0\pi^0$, where one π decays to the Dalitz e^+e^- channel, offers a clean signature to perform a time-dependent CP violation measurement. The precise study of this decay is important because it allows for strong constraints on the CKM angle because with $B \to \pi\pi$ system, we can measure angle α of the Unitary triangle.

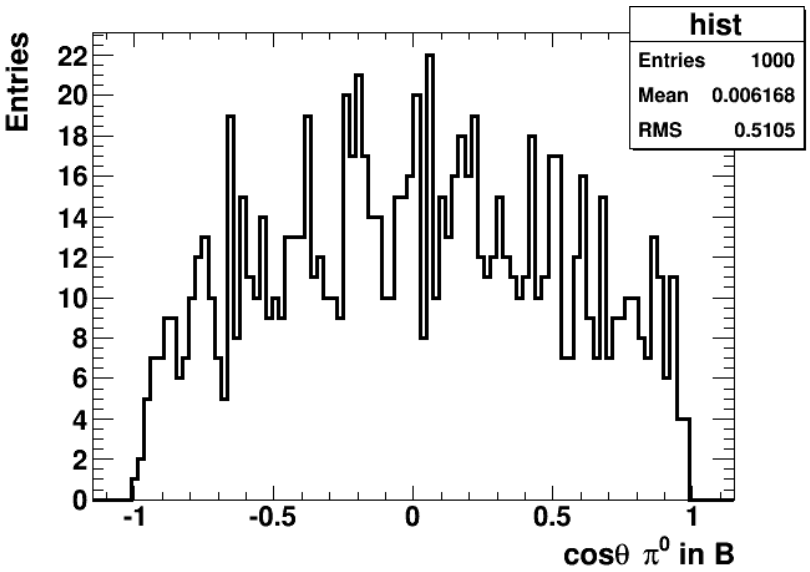
$B^0 \to \pi^0\pi^0$ Analysis

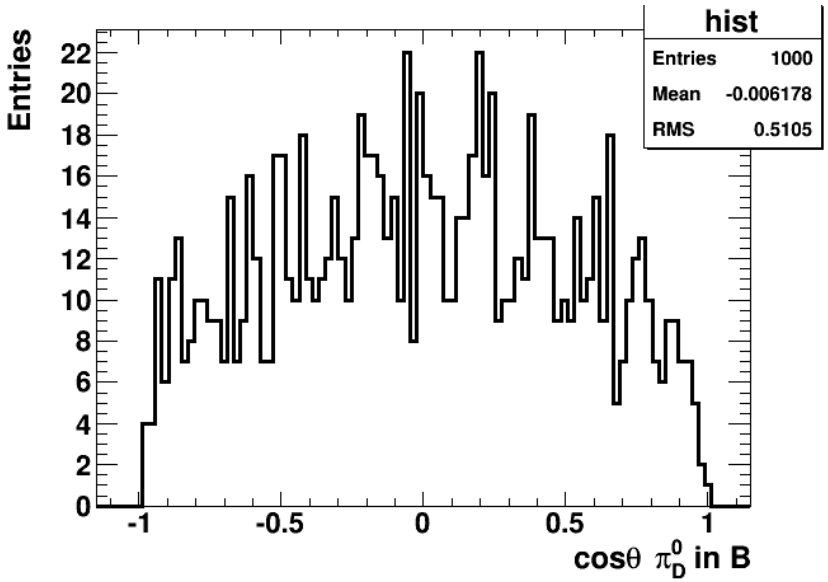




Mass of the B^0 reconstructed with final particules. We have the energy of one photon for the π^0Dalitz case (black 3 Body decay) and the π^0 (red 2-body decay). The energy corresponds to half the mass of the neutrals pions.

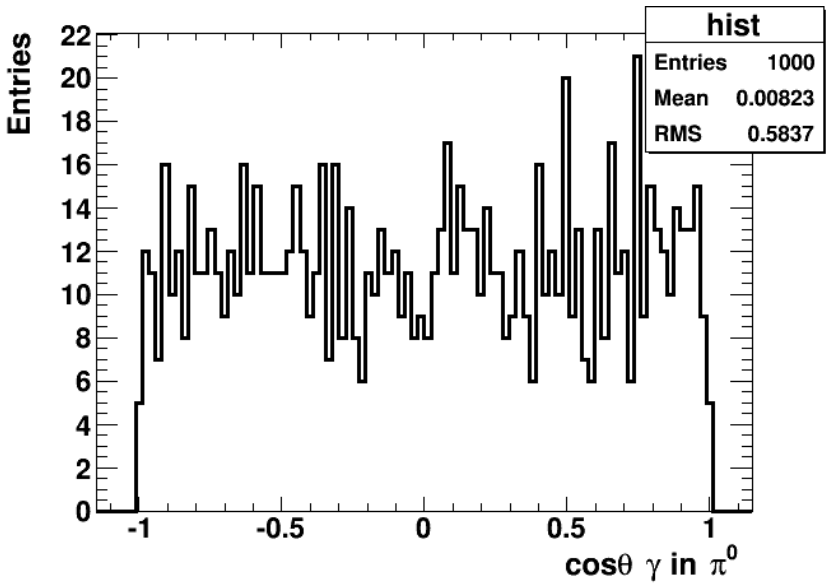
$B^0 \to \pi^0\pi^0$ Analysis

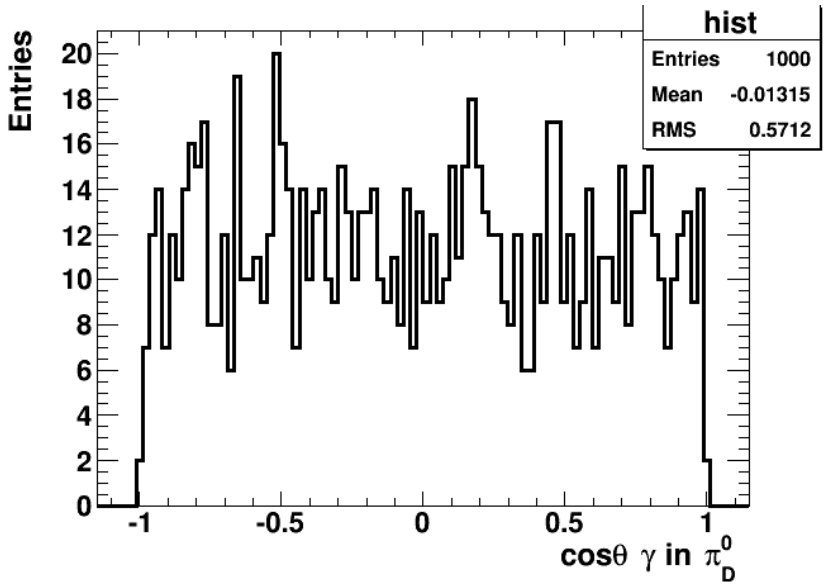




Angle of the pion in the rest frame of the B. They have a similar shape and must be flat because no direction are priviligied.

$B^0 \to \pi^0\pi^0$ Analysis





In this case, the angular distribution is very flat.