



7th ComHEP: Colombian Meeting on
High Energy Physics

Search for $B_c^+ \rightarrow \phi K^+$ using LHCb experiment Run 2 data

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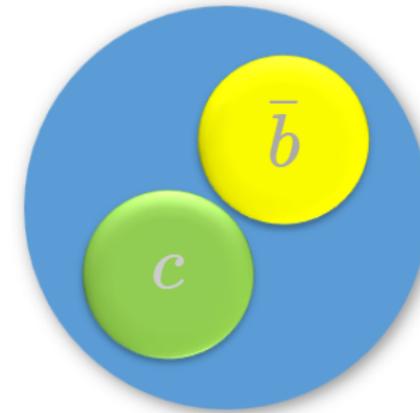
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The decay channel

Introducing B_c^+

- Only pseudoscalar meson formed by two heavy quarks of different flavor
- Has no strong or electromagnetic decay channels
- There can be \bar{b} and c competing decays, or annihilation of both into a virtual W

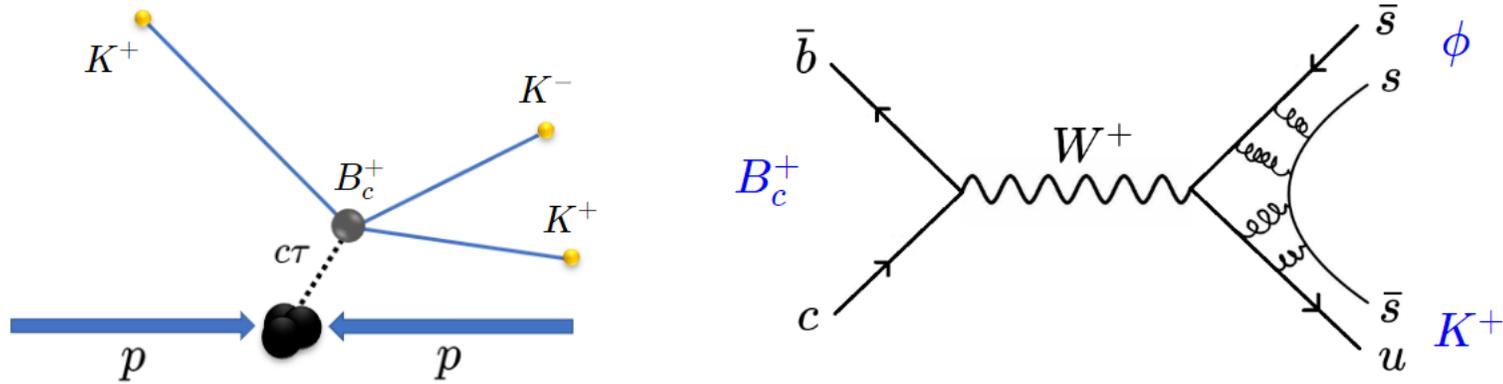


Meson	Mean life τ (s)
$B^+ = u\bar{b}$	$(1.641 \pm 0.008) \times 10^{-12}$
$B^0 = d\bar{b}$	$(1.519 \pm 0.007) \times 10^{-12}$
$B_s^0 = s\bar{b}$	$(1.509 \pm 0.004) \times 10^{-12}$
$B_c^+ = c\bar{b}$	$(0.507 \pm 0.009) \times 10^{-12}$

Annihilation contributions are significant. Certain B_c^+ decay modes are excellent annihilation labs!

The decay channel

$B_c^+ \rightarrow \phi K^+$ is one of the possible non-leptonic and charmless decay channels of B_c^+ to two light mesons

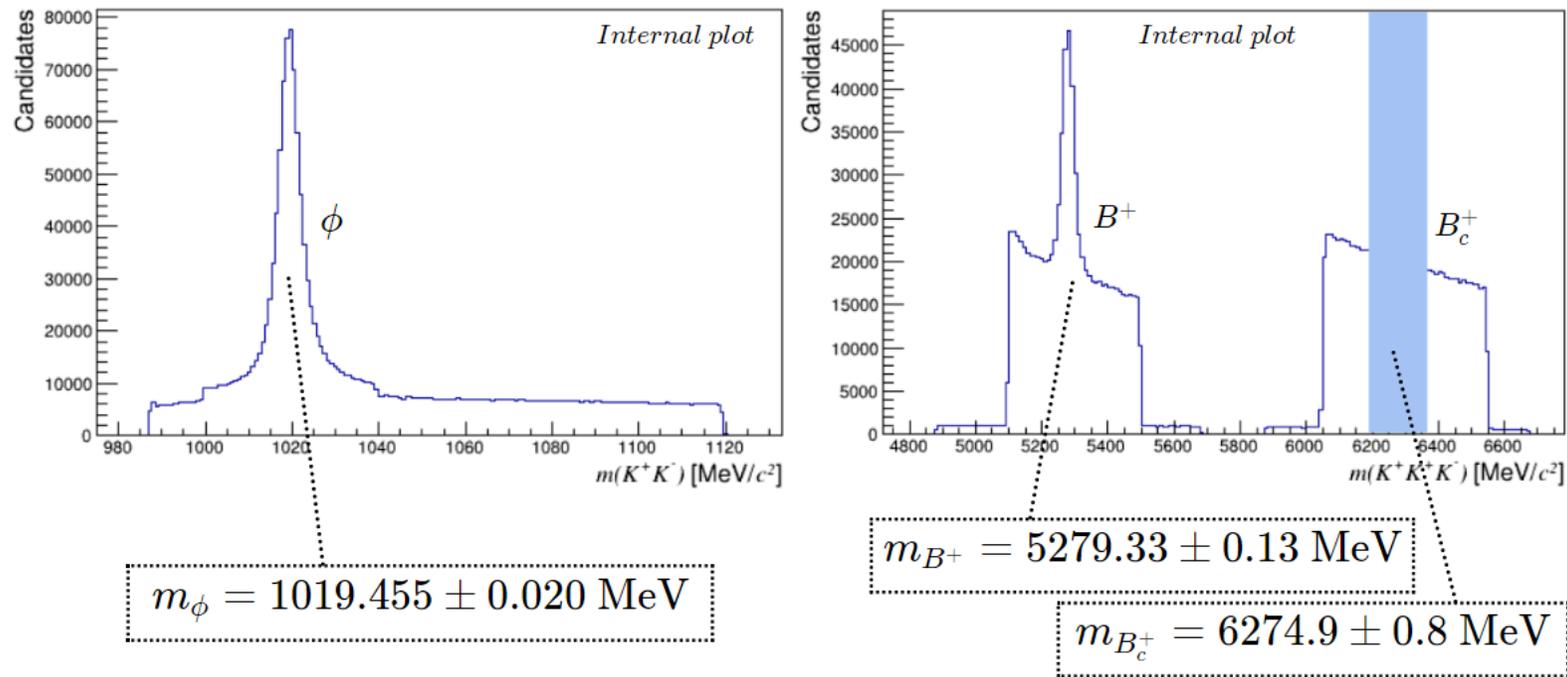


Successful measurement of this decay will:

- Be the first for the B_c^+ meson annihilation
- Reveal more properties of the B_c^+ meson
- Lead to a new independent determination of V_{cb}

Dataset and selection

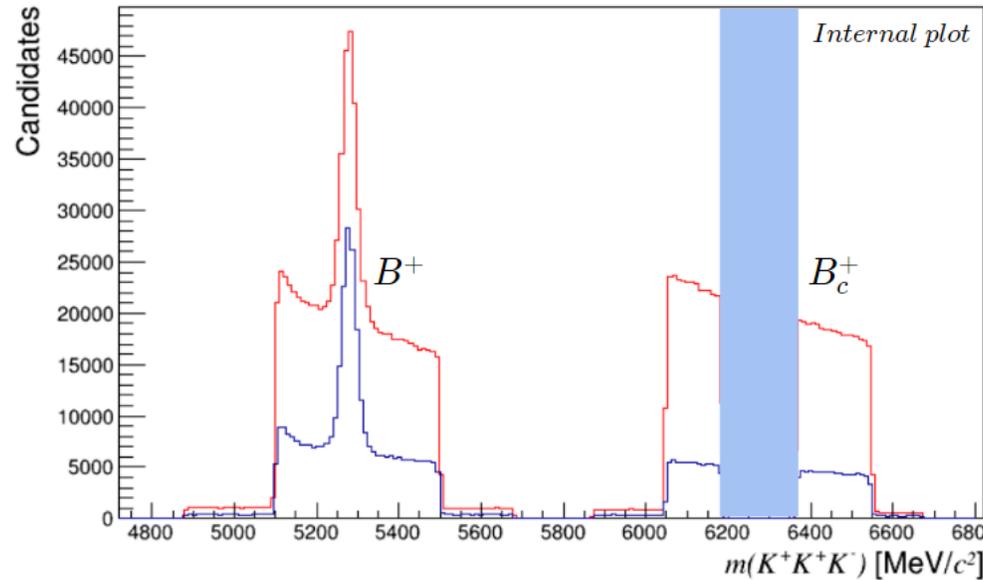
LHCb Run 2 data from proton-proton collisions, at $\sqrt{s} = 13$ TeV and 5.9 fb^{-1} integrated luminosity



(PDG mass values)

Dataset and selection

A set of selection requirements is initially applied, which consists on track quality, p_T and identification for the kaons, vertex quality for the mother and ϕ , and flying distance for the mother

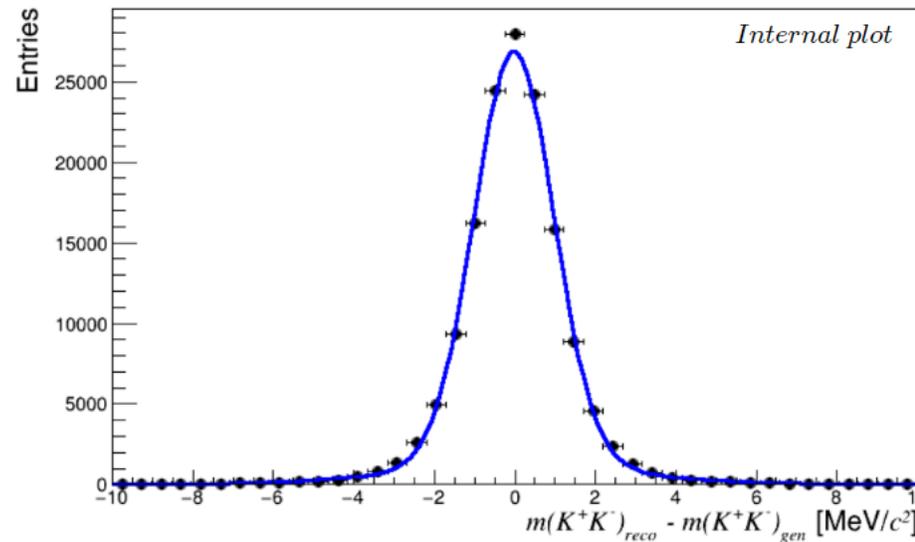


All results are to be studied
around the B^+ mass

$$\frac{\mathcal{B}(B_c^+ \rightarrow \phi K^+)}{\mathcal{B}(B^+ \rightarrow \phi K^+)} \frac{f_c}{f_u} = \frac{N(B_c^+ \rightarrow \phi K^+)}{N(B^+ \rightarrow \phi K^+)} \frac{\epsilon_{B^+}}{\epsilon_{B_c^+}}$$

Fit models

As a resolution model, a double Gaussian fit was made using the generated and reconstructed ϕ mass distributions of simulated sample, to obtain resolution parameters



$$R = fG(x; \mu, \sigma_1) + (1 - f)G(x; \mu, \sigma_2)$$

Fit models

A model for the ϕ resonance in data

$$F = \underbrace{\sqrt{x - 2m_K}}_{\text{threshold}} \left[\underbrace{N_b F_b(x; \alpha)}_{\text{background}} + \underbrace{N_s F_s(x; x_0, \Gamma, \sigma, f, \beta)}_{\text{signal}} \right]$$

Specifically, the background and signal functions

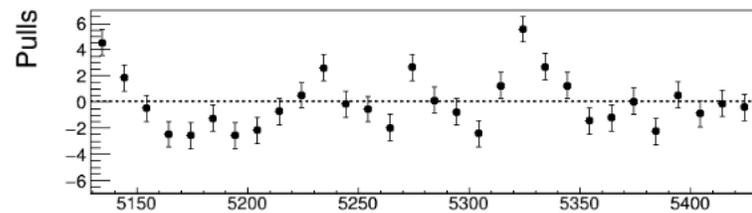
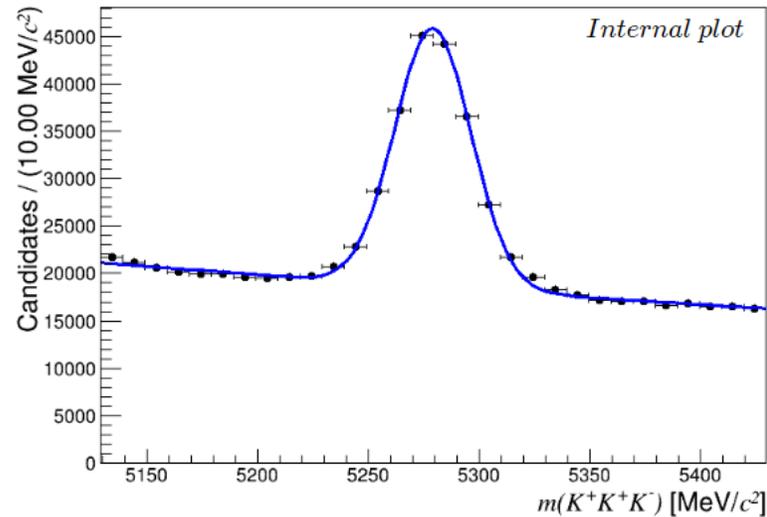
$$F_b(x; \alpha) = e^{-\alpha x}$$

$$F_s = f(G \otimes BW)(x; x_0, \Gamma, \sigma) + (1 - f)(G \otimes BW)(x; x_0, \Gamma, \beta\sigma)$$

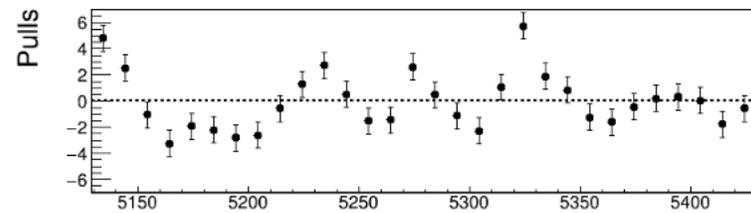
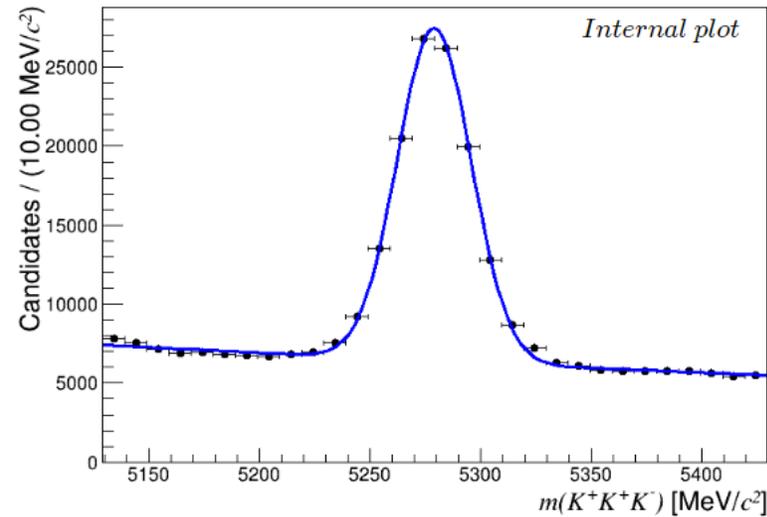
Where f and β come from the two-Gaussian fit of the resolution model. $\beta = \sigma_2/\sigma_1$

Fit models

Simple model on B^+ , before and after applying the selection



Purity = 0.39

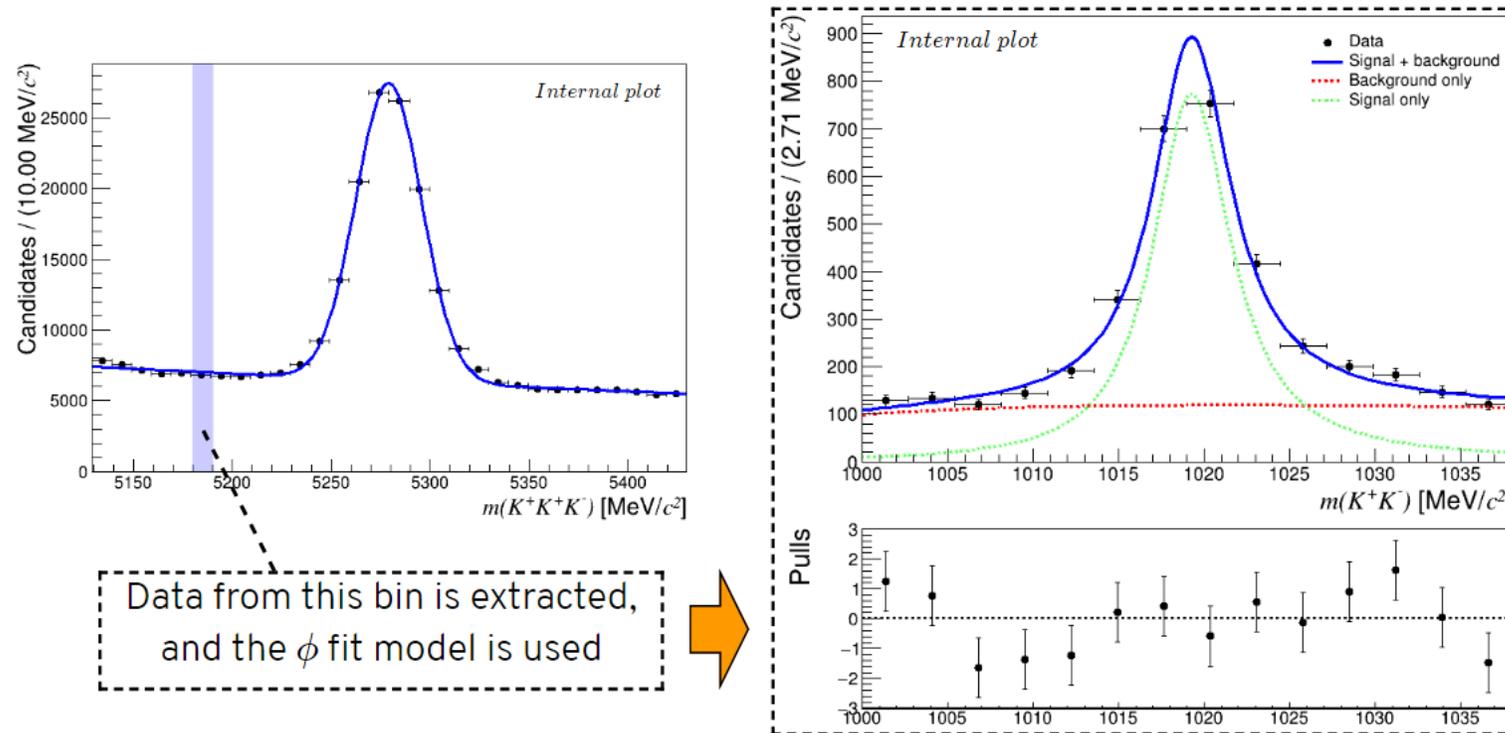


Purity = 0.58

Where Purity = $S/(S + B)$ within the signal region

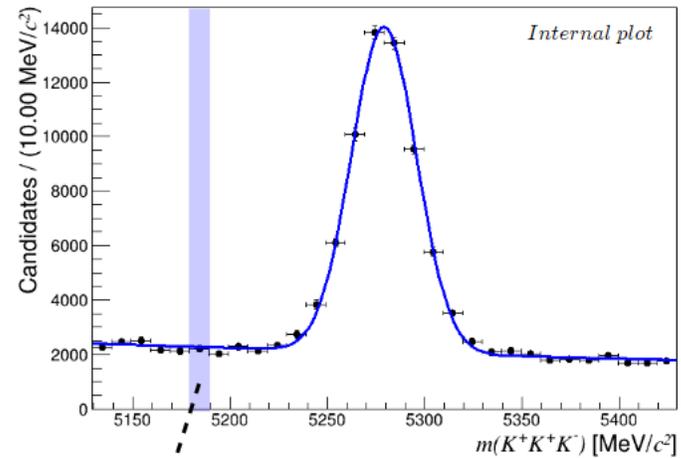
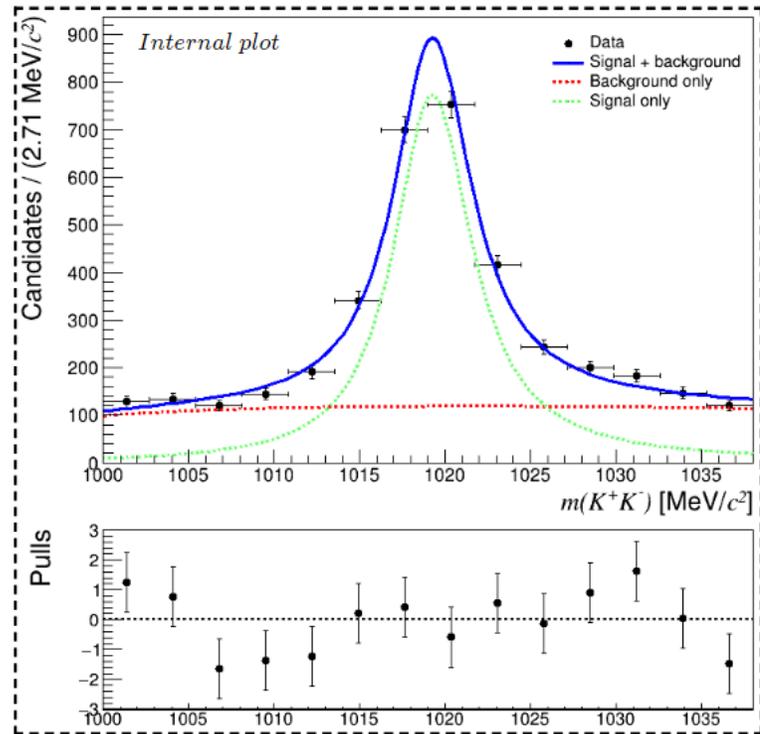
Fit models

Working out fits of ϕ in bins of B^+



Fit models

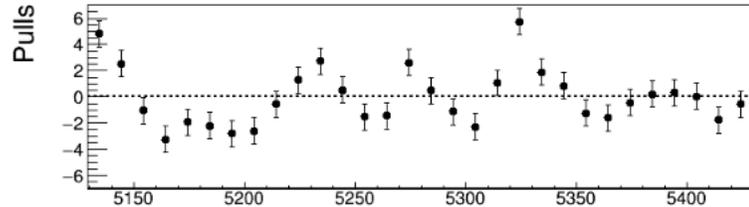
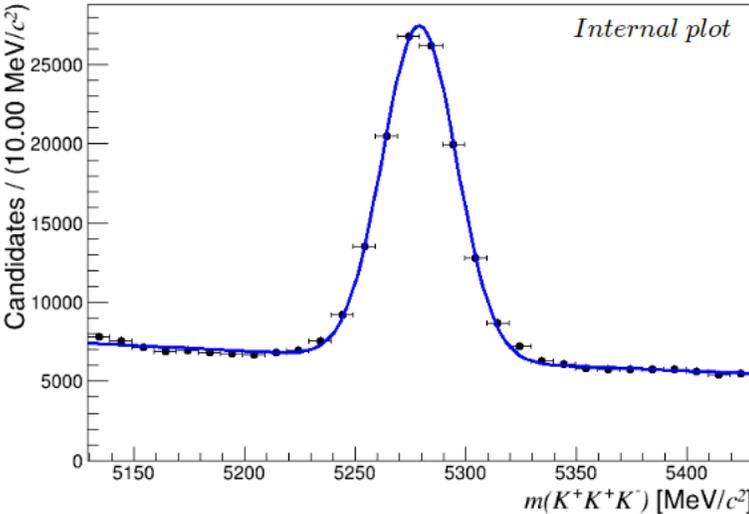
Working out fits of ϕ in bins of B^+



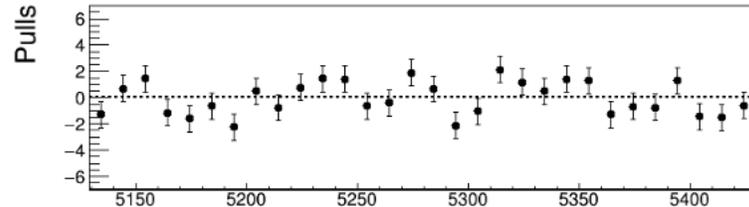
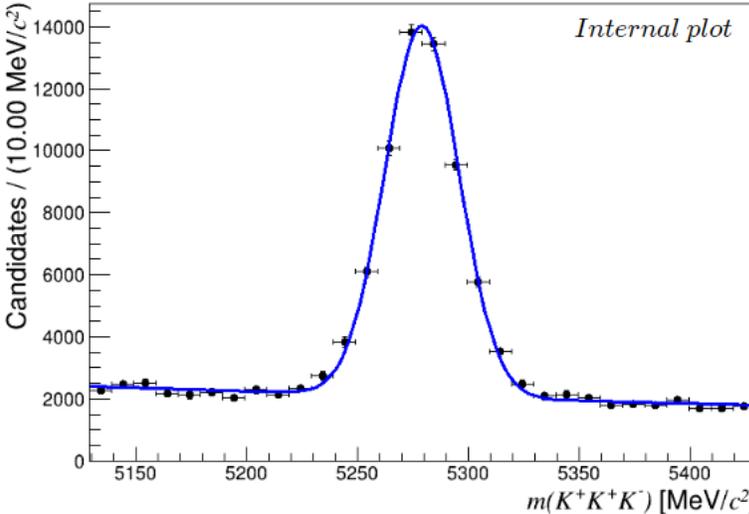
The signal yield is 2206.67 ± 117.28

Fit models

Simple model on B^+ with base selection, before and after fitting ϕ in bins of B^+



Purity = 0.58



Purity = 0.71

Summary and final comments

Thus far in the analysis:

- Extracted data from the LHCb database
- Applied selection requirements
- Performed fits on the simulation sample and experiment data
- Obtained numbers of $B^+ \rightarrow \phi K^+$ decays in data

Currently working on:

- Identification of discriminating variables
- Optimization of selection requirements, using data sidebands and simulation
- Determination of efficiency from simulation

Backup slides

Cuts

Kaons

- Track quality: $\chi^2/\text{ndf} < 3$
- Impact parameter to primary vertex: $\chi_{IP}^2 > 4$
- Transverse momentum: $p_T > 0.5 \text{ GeV}/c$
- Identification: $\text{ProbNNk} > 0.2$ (> 0.6 for the bachelor)

Phi

- Vertex quality: $\chi^2 < 25$

Mother

- Vertex quality: $\chi^2/\text{ndf} < 9$
- Distance between the decay vertex and the primary vertex: $\chi^2 > 100$

Selection optimization

Two examples of discriminating variables for the bachelor kaon

