Remaining cross checks and issues before CWR

$B^0 \to K^* \mu\mu$ angular analysis

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Status of the paper

- PAS public since Moriond;
  - `CMS-PAS-BPH-15-008`
- paper has been finalized
  - Language Editor ready to give green light to CWR
- we have a set of cross check that we'd like to perform before going to CWR
  - ✓ BR of $B^0 \to K^* \psi'$ vs $B^0 \to K^* J/\psi$;
  - × comparison of P_1 and P_5' in control regions with F_L fixed vs F_L free;
  - × impact of reduced side bands on M_{B^0} for background determination;

BR of $B^0 \to K^* \psi'$ vs $B^0 \to K^* J/\psi$

Motivation

- The efficiency has been computed for each individual bin $q^2 = 1 - 19$ GeV^2
- ε checked by comparing efficiency-corrected results obtained from the CR with the corresponding world average values.
- We used $B^0 \to K^* J/\psi$ CR (160 kevents vs 10 kevents for ψ')
- compare F_L measured on J/ψ with world average
  - $F_L^{our} = 0.537 \pm 0.002$ (stat) vs $F_L^{PDG} = 0.571 \pm 0.007$ (stat+syst)
  - difference propagated to all other bins
- Cross check
  - check efficiency determination on both CR regions (J/ψ and ψ') by comparing the relative BR

BR of $B^0 \to K^* \psi'$ vs $B^0 \to K^* J/\psi$ (c'ed)

BR ratio

$$\frac{\mathcal{B}(B^0 \to K^* \psi')}{\mathcal{B}(B^0 \to K^* J/\psi)} = \frac{Y_{\psi'}}{\epsilon_{\psi'}} \frac{\epsilon_{J/\psi}}{Y_{J/\psi}} \frac{\mathcal{B}(J/\psi \to \mu^+\mu^-)}{\mathcal{B}(\psi' \to \mu^+\mu^-)} = 0.484 \pm 0.018_{(\text{stat})} \pm 0.011_{(\text{syst})} \pm 0.012_{(R_\psi^{ee})} \text{ PDG}$$

1. Compute the ε-corrected yield with aboslute ε
2. compute taking into account the signal and ε distribution wrt to angular variables $\vec{x} = \cos\theta_\ell, \cos\theta_K, \varphi$
   - $\varepsilon_{J/\psi/\psi'} = \int_{phase\ space} S(\vec{x};\vec{p}) \times \varepsilon(\vec{x}) d\vec{x}$
   - where:
     - $S(\vec{x};\vec{p})$ is the signal PDF (right tag or wrong tag-only)
     - $\vec{p}$ is the set of angular parameter we got from the fit on the data on each CR
     - $\varepsilon(\vec{x})$ is the efficiency (MC) for each CR as a function of angular variables

Results

- took some iteration due to lack of precise documentation (and memory) about how the normalization of the ε was computed (almost two years ago!)
- $R_{\psi}^{\mu\mu} = 7.54$ (PDG)
- With absolute efficiency $\varepsilon = \frac{\text{ev. passing selection}}{\text{all events}}$
  - BR ratio= 0.476
- taking into account signal and ε shape $\int S \times \varepsilon$
  - our result 0.480 using only Right Tag events and efficiency;
  - same if using only Wrong Tag events and corresponding ε.
  - stat error to be computed

✓ Cross check done

comparison of P_1 and P_5' in control regions w/ and w/o F_L fixed

What we did

- Perform same fit as in BPH-13-010 (integrating φ out) and obtain same values of F_L
  - basic cross check, mostly for efficiency
- Perform fit of toys w/ and w/o fixing F_L, F_S, A_S and compare the statistical uncertainties
  - used to obtain the scale factor of the stat uncertainties on P_1 and P_5' to be used as systematics uncertainties $\sqrt{\rho^1 - 1}$

What we want to do

As a cross check of our procedure concerning the fixed value of F_L , we fit the two control regions either fixing F_L or allowing it to vary, and find that the values of P_1 and P_5' are unaffected.

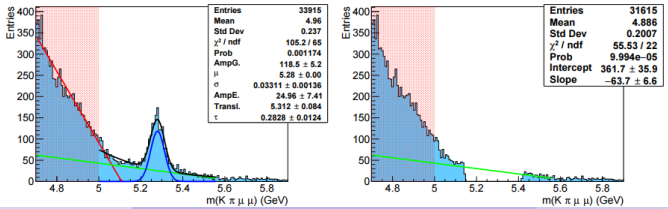
Status

- Tried, but we are having problem with fit convergence
- with the usual 5 parameters works ok: $(Y_s, Y_b, A_5^s, P_1, P_5')$
- with 6 parameters does not $+F_L$;
- # events is large, so that should not be the problem
- We double check that we are using the corrent input parameters, and it should be the case
- error is:
  - `machine accuracy limits further improvement`
  - investigating...

Reduced side bands on M_{B^0} for background determination

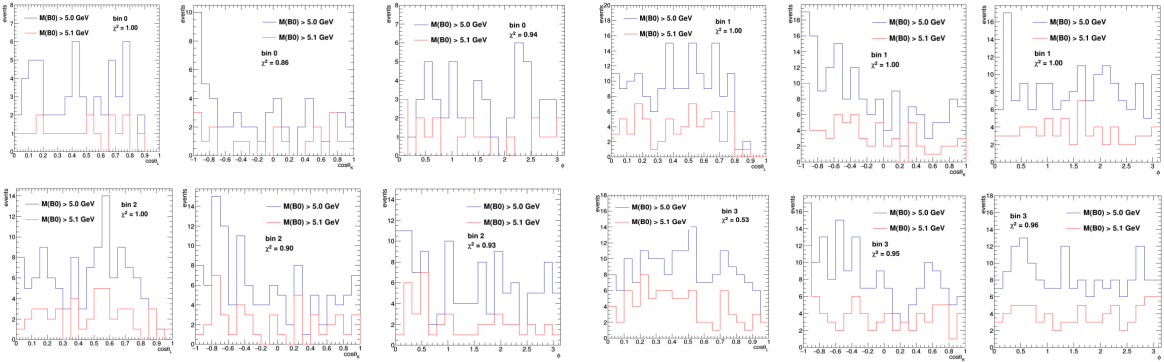
Issue

- reported by Sandra after a discussion with LHCb people at LHCP
- Partially reconstructed B^0 decay (5-body decays reconstructed as 4-body ones) can contribute to the left side-band of M_{B^0} up to 5.15 GeV
- Our side-bands is $5 < M < 5.6$ (excluding the B^0 peak at 3σ)
- our determination of the background under the peak might be affected by these partially reonctructed decays, leading to a bias



Example of backgroung with different side bands range

RED: $5.1 < M_{B^0} < 5.6$ BLUE: $5.0 < M_{B^0} < 5.6$ (excluding B^0 peak 3σ)



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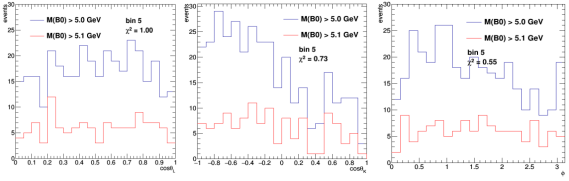

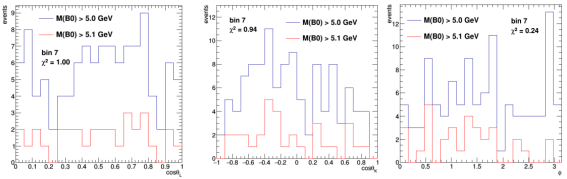

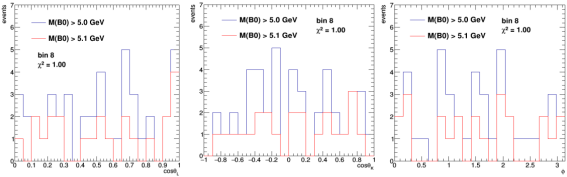

- polynomial fit to reduced/full side-bands background
- compare with full/reduced side-bands background distribution
- $\chi^2 < 1$ for all bins/varaibles.

Cross check in progress

Action items

- ✓ Differences in shape look not so large
- TODO checking quantitatively if it is indeed within the statistical uncertainties of the background determination
  - for which we already have a systmematics
- TODO repeating the fit for some bin with the background from reduced sidebands to spot any bias
  - larger than the stat+syst uncertainties

Work in progress, not yet completed

Summary

Before going to CWR:

We want to complete three additional cross-check

✓ BR of $B^0 \to K^* \psi'$ vs $B^0 \to K^* J/\psi$;
- **DONE**

× comparison of P_1 and P_5' in control regions with F_L fixed vs F_L free;
- Issue with fit convergence

∼ impact of reduced side bands on M_{B^0} for background determination;
- Background from reduced side-bands computed: no major difference
- Quantitative comparison and redo the fit (for some bins) with new background functions

After the huge effort for approval (see "not-so-useful" FC computation of stat uncertainties) we lost momentum. We must stay focused for a little more.

Additional stuff

Additional or backup slides

Bibliography I