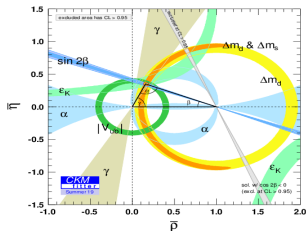


# $\gamma$ analysis update in $B^\pm \rightarrow (K^+ K^- \pi^+ \pi^-)_D K^\pm$ decays

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# Summary of last time

- $\gamma$  from  $B^\pm \rightarrow DK^\pm$ ,  $D \rightarrow K^+K^-\pi^+\pi^-$ , [arXiv:hep-ph/0611272](https://arxiv.org/abs/hep-ph/0611272)
- Model independent measurement with BESIII strong phase input
- Expected precision from signal-only study:  $\Delta\gamma = 12^\circ$
- $B$  candidate selection with BDT
- Initial mass fits

# Summary of analysis procedure

- 1 Perform global fit to fix yields and shapes
- 2 Separate  $B^\pm$  candidates by charge and into bins
- 3 Extract  $x_\pm$  and  $y_\pm$  with a simultaneous fit
- 4 Interpret  $x_\pm$  and  $y_\pm$  in terms of  $\gamma$
- 5 Currently only Run 2

## 1 Backgrounds

- Mis-ID from  $D \rightarrow K\pi\pi\pi$
- Charmless backgrounds

## 2 Global mass fit

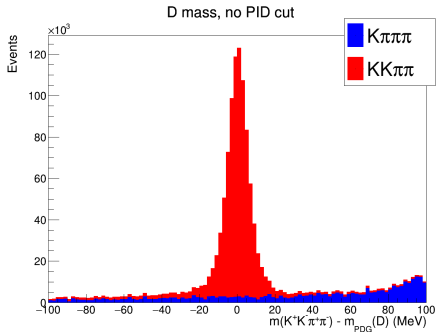
## 3 Toy studies

- Standard fits with 4 and 8 bins
- Biases in CP observables
- Systematics from  $c_i, s_i$

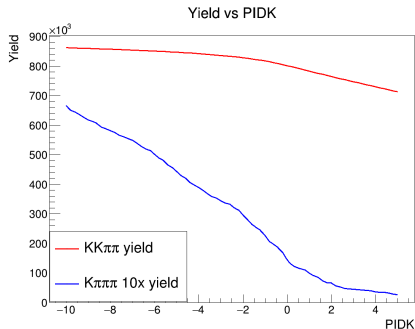
## 4 Summary and future work

# Mis-ID from $D \rightarrow K\pi\pi\pi$

- Mis-ID of  $D$  daughter  $\pi \rightarrow K$
- Peaks a much higher  $D$  mass
- Much higher branching ratio
- Similar background from  $D \rightarrow \pi\pi\pi\pi$  is negligible



(a)  $D$  invariant mass for  $KK\pi\pi$  and  $K\pi\pi\pi$

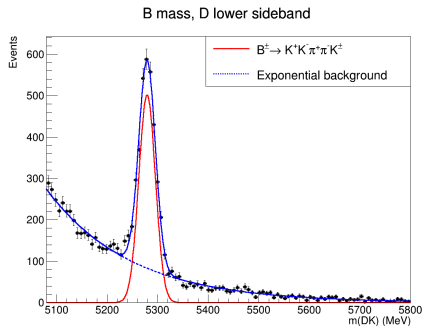


(b) Yield of  $KK\pi\pi$  and  $K\pi\pi\pi$  vs PIDK

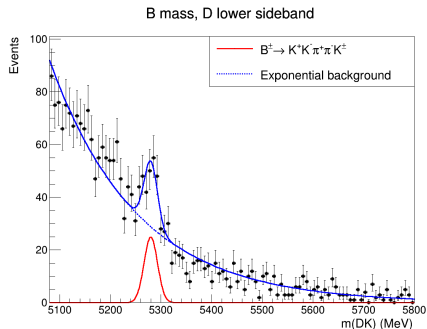
# Charmless backgrounds

- Background from  $B^\pm \rightarrow KK\pi\pi h^\pm$
- Flight significance (FS) cut at 2
- Look in the lower  $D$  mass sideband  $m(D) = [1770 \text{ MeV}, 1820 \text{ MeV}]$
- Upper sideband contaminated with  $K\pi\pi\pi$
- Train a separate BDT without  $\chi_{\text{D TF}}^2$  to preserve  $D$  sidebands
- Overlap between samples without FS cut: 0.0%
- Overlap between samples with FS cut: 0.0%

# Total charmless background yield



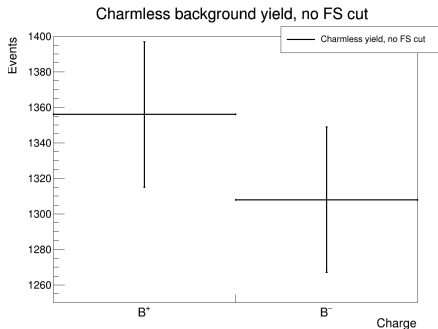
(a) Without flight significance cut



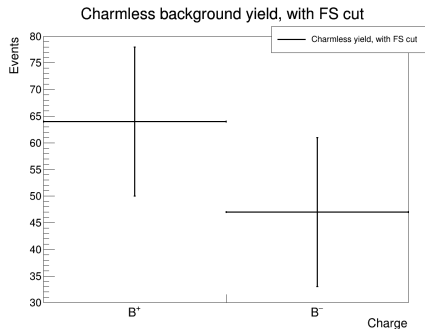
(b) With flight significance cut

**Figure 2:** Charmless background in the  $D$  sideband

# Charmless backgrounds by charge



(a) Without flight significance cut

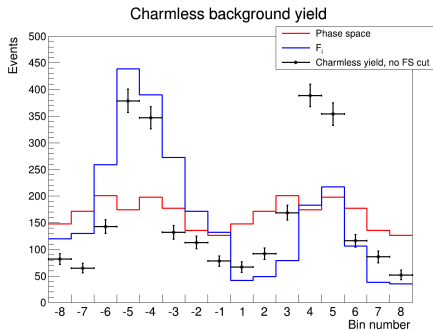


(b) With flight significance cut

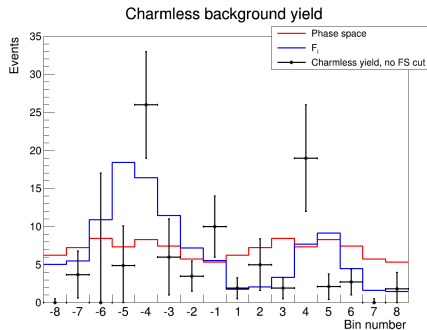
**Figure 3:** Charmless background split by charge



# Charmless backgrounds by bins



(a) Without flight significance cut



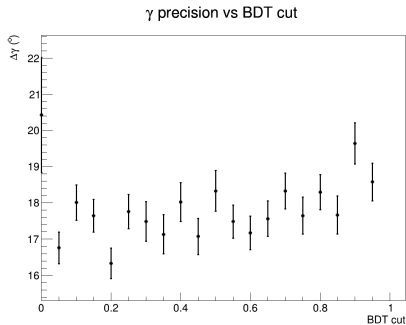
(b) With flight significance cut

**Figure 4:** Charmless background split by bins

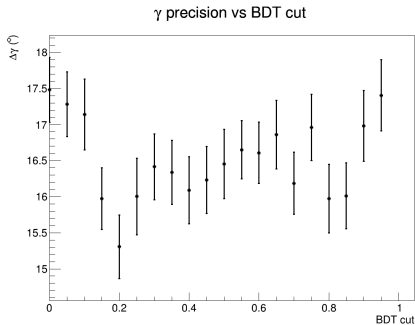
# BDT cut optimization

- Current BDT cut: 0.75
- Minimize statistical  $\gamma$  error
- Procedure:
  - 1 Perform global fit to fix signal and background yields and PDF shapes
  - 2 Generate 1000 toy datasets using the global fit parameters
  - 3 Fit for  $\gamma$
  - 4 Extract expected  $\gamma$  precision from  $\gamma$  distribution of toy datasets
- Only Run 2 for now

# BDT cut optimization



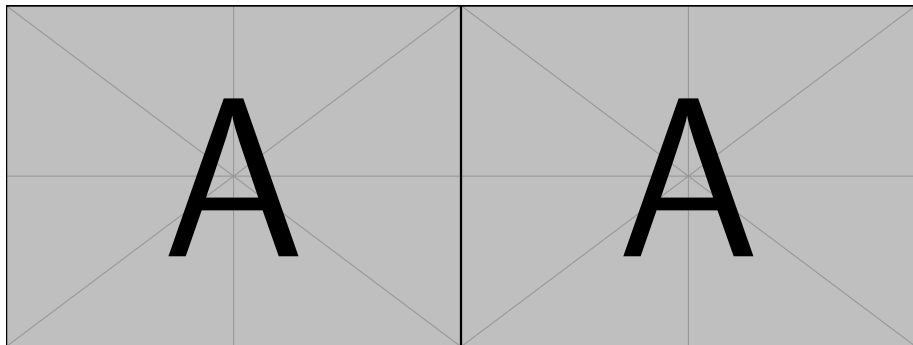
**(a)**  $\gamma$  precision vs BDT cut for 4 bins



**(b)**  $\gamma$  precision vs BDT cut for 8 bins

A large, bold, black letter 'A' is centered on a gray background. The background features a white grid consisting of a horizontal line, a vertical line, and two diagonal lines forming an 'X' shape. The letter 'A' is positioned such that its vertical stem aligns with the vertical grid line and its base sits on the horizontal grid line.

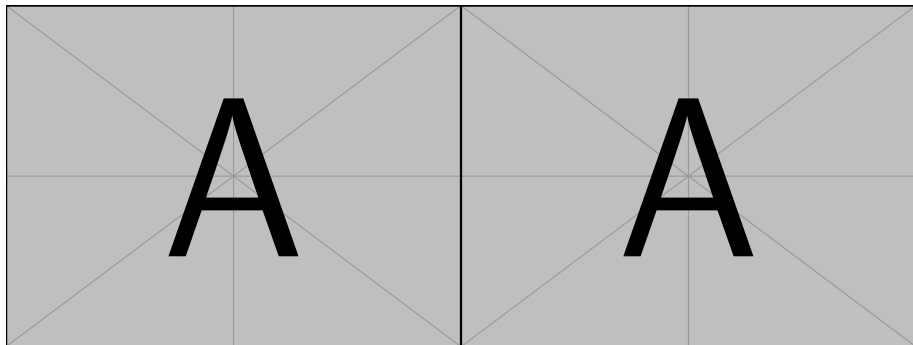
# Standard toy studies with 4 and 8 bins



(a) 4 bins

(b) 8 bins

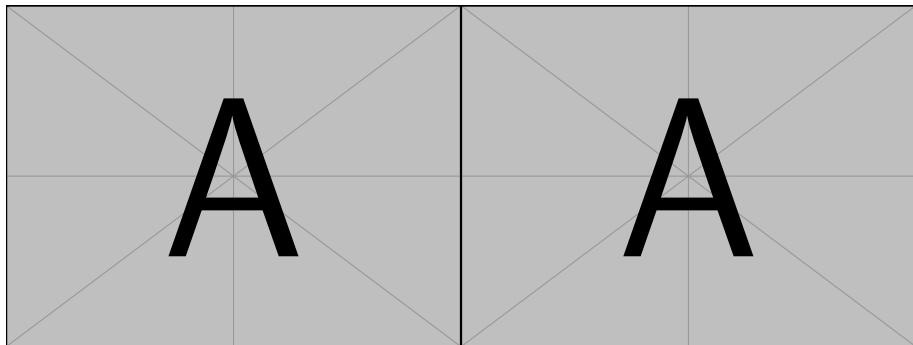
**Figure 7:**  $\gamma$  precision in toy studies



(a) 4 bins

(b) 8 bins

**Figure 8:** CP observable that has bias

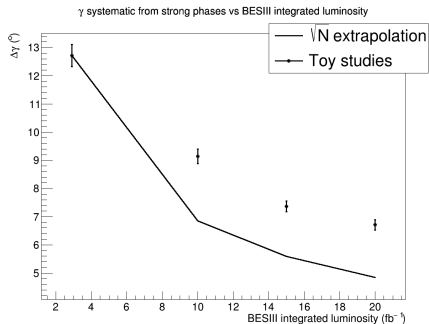


(a) 4 bins

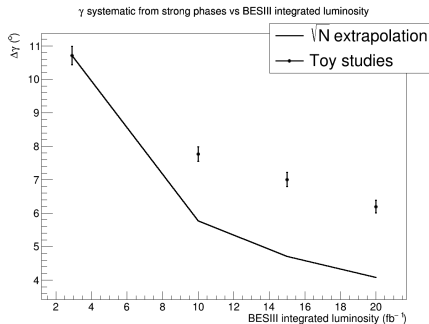
(b) 8 bins

**Figure 9:** CP observable bias with increased statistics

# Systematics from $c_i$ , $s_i$



(a) 4 bins



(b) 8 bins

**Figure 10:** Systematic uncertainty from  $c_i$  and  $s_i$  with extrapolated BESIII statistics



# Summary and future work

- Summary:

- ① Global mass fit looks promising
- ②  $D \rightarrow K\pi\pi\pi$  and charmless backgrounds under control
- ③ Toy studies show no suspicious behaviour
- ④ Expected  $c_i$  and  $s_i$  systematics are not too large

- Next steps:

- ① Study semileptonic backgrounds in RapidSim
- ② Recalculate PID efficiencies with PIDCalib
- ③ Refit MC signal shapes
- ④ Rerun everything with Run 1 (finally!)