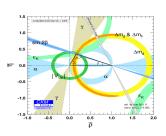
# $\gamma$ analysis update in $B^\pm o (K^+K^-\pi^+\pi^-)_D K^\pm$ decays

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# Summary of last time

- $\gamma$  from  $B^{\pm} \to DK^{\pm}$ ,  $D \to K^+K^-\pi^+\pi^-$ , arXiv:hep-ph/0611272
- Model independent measurement with BESIII strong phase input
- ullet Expected precision from signal-only study:  $\Delta \gamma = 12^{\circ}$
- B candidate selection with BDT
- Currently only Run 2
- Inital mass fits

# Summary of analysis procedure

- 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
- Interpret  $x_{\pm}$  and  $y_{\pm}$  in terms of  $\gamma$

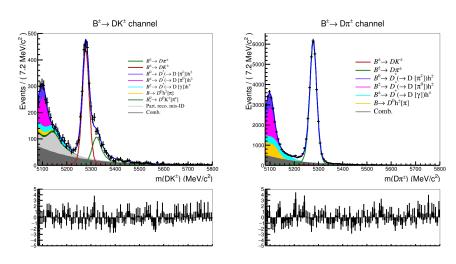
#### CP observables

$$\begin{aligned} x_{\pm} &= r_B^{DK} \cos \left(\delta_B^{DK} \pm \gamma\right), \quad y_{\pm} &= r_B^{DK} \sin \left(\delta_B^{DK} \pm \gamma\right) \\ x_{\xi}^{D\pi} &= \text{Re}(\xi^{D\pi}), \quad y_{\xi}^{D\pi} &= \text{Im}(\xi^{D\pi}), \quad \xi^{D\pi} &= \frac{r_B^{D\pi}}{r_B^{DK}} e^{i(\delta_B^{D\pi} - \delta_B^{DK})} \end{aligned}$$

#### Outline

- Global mass fit
- 2 Backgrounds
  - Mis-ID from  $D \to K\pi\pi\pi$
  - Charmless backgrounds
- 3 BDT cut optimization
- Toy studies
  - Standard fits with 4 and 8 bins
  - Biases in CP observables
  - Systematics from c<sub>i</sub>, s<sub>i</sub>
- Summary and future work

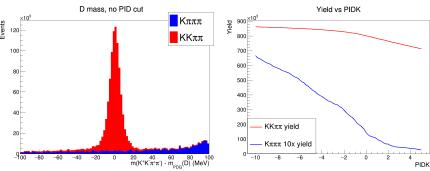
#### Global mass fit



**Figure 1:** Global mass fit (left)  $B \to DK$  and (right)  $B \to D\pi$ 

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

- Mis-ID of *D* daughter  $\pi \to K$
- Peaks a much higher D mass
- Much higher branching ratio
- Similar background from  $D \to \pi\pi\pi\pi$  is negligible
- Pick cut at 0 for now



(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

- ullet  $B^\pm o KK\pi\pi h^\pm$  background
- Flight significance (FS) cut at 2
- Use D mass sideband  $m(D) = [1770 \,\mathrm{MeV}, 1820 \,\mathrm{MeV}]$
- $\bullet$  Train a separate BDT without  $\chi^2_{\rm DTF}$
- $\bullet$  Overlap between samples with (without) FS cut: 93.1% (90.7%)

#### Total charmless background yield

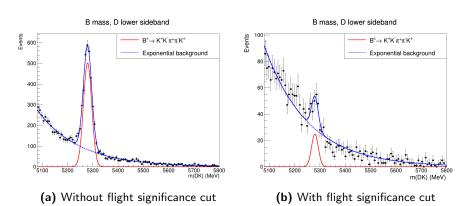


Figure 3: Charmless background in the D sideband

# Charmless backgrounds by charge

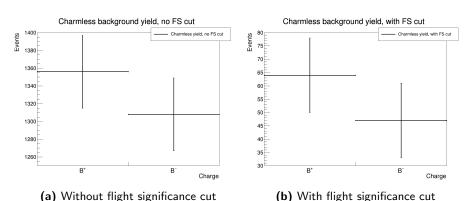


Figure 4: Charmless background split by charge

## Charmless backgrounds by bins

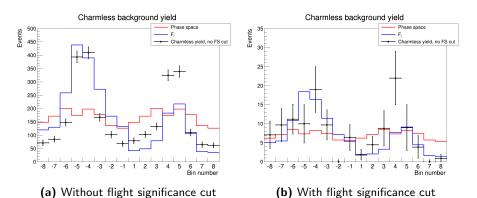
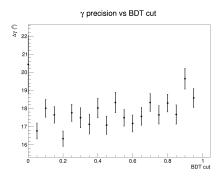


Figure 5: Charmless background split by bins

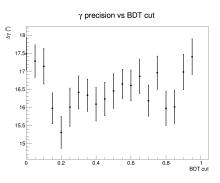
#### BDT cut optimization

- Current BDT cut: 0.75
- ullet Minimize statistical  $\gamma$  error
- Procedure:
  - Perform global fit to fix signal and background yields and PDF shapes
  - Generate 1000 toy datasets using the global fit parameters
  - $\odot$  Fit for  $\gamma$
  - lacktriangledown Extract expected  $\gamma$  precision from  $\gamma$  distribution of toy datasets

#### BDT cut optimization

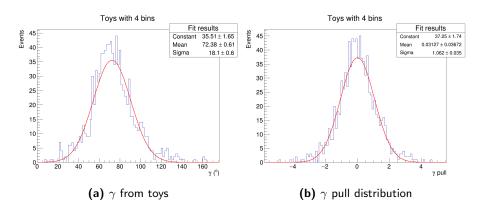


(a)  $\gamma$  precision vs BDT cut for 4 bins

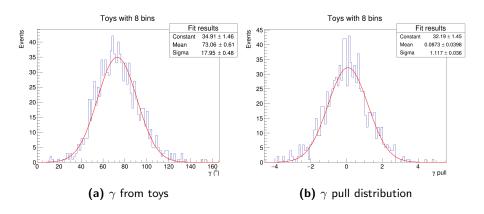


**(b)**  $\gamma$  precision vs BDT cut for 8 bins

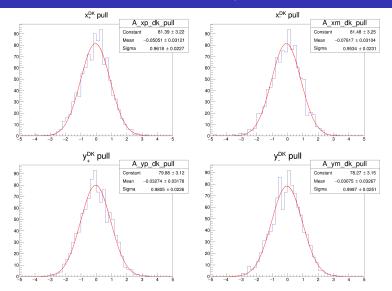
## Standard toy studies with 4 bins



# Standard toy studies with 8 bins

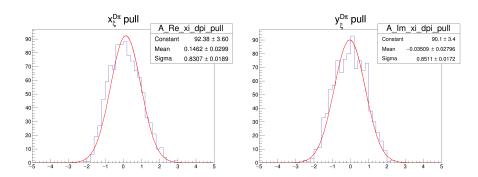


#### Biases in $B \rightarrow DK$ CP observables, 4 bins



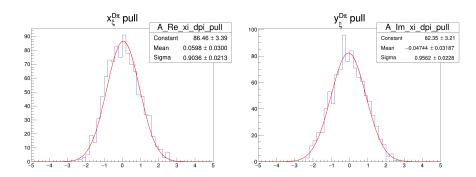
**Figure 9:**  $B \rightarrow DK$  CP observable pull distributions

#### Biases in $B \to D\pi$ CP observables, 4 bins



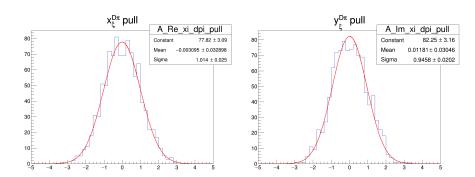
**Figure 10:**  $B \rightarrow D\pi$  CP observable pull distributions

#### Biases in $B \to D\pi$ CP observables, 4 bins, 2x statistics



**Figure 11:**  $B \rightarrow D\pi$  CP observable pull distributions

#### Biases in $B \to D\pi$ CP observables, 4 bins, 10x statistics



**Figure 12:**  $B \rightarrow D\pi$  CP observable pull distributions

## Systematics from $c_i$ , $s_i$

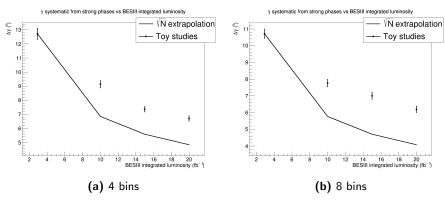
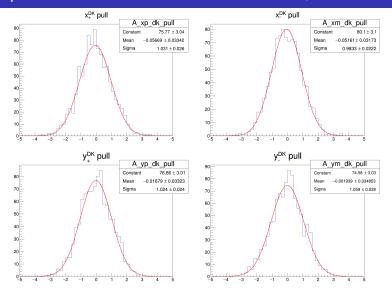


Figure 13:  $c_i$ ,  $s_i$  systematic uncertainty with extrapolated BESIII statistics

# Summary and future work

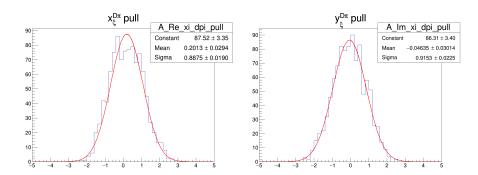
- Summary:
  - 1 Global mass fit looks promising
  - 2  $D o K\pi\pi\pi$  and charmless backgrounds under control
  - 3 Toy studies show no suspicious behaviour
  - **4** Expected  $c_i$  and  $s_i$  systematics are not too large
- Next steps:
  - Study semileptonic backgrounds in RapidSim
  - Recalculate PID efficiencies with PIDCalib
  - Refit MC signal shapes
  - Rerun everything with Run 1 (finally!)

#### Backup: Biases in $B \rightarrow DK$ CP observables, 8 bins



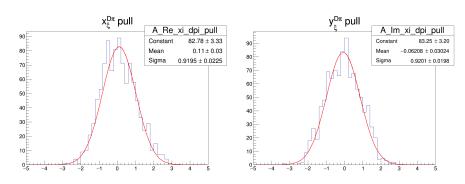
**Figure 14:**  $B \rightarrow DK$  CP observable pull distributions

#### Backup: Biases in $B \to D\pi$ CP observables, 8 bins



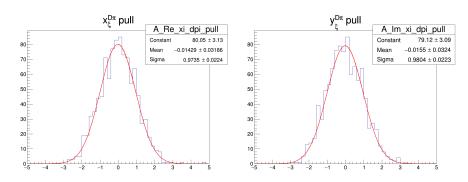
**Figure 15:**  $B \rightarrow D\pi$  CP observable pull distributions

# Backup: Biases in $B \to D\pi$ CP observables, 8 bins, 2x statistics



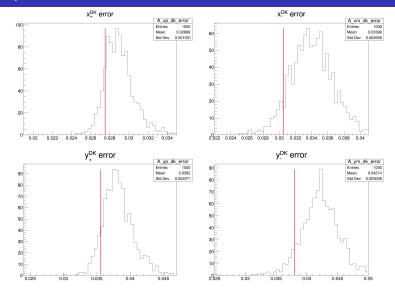
**Figure 16:**  $B \rightarrow D\pi$  CP observable pull distributions

# Backup: Biases in $B \to D\pi$ CP observables, 8 bins, 10x statistics



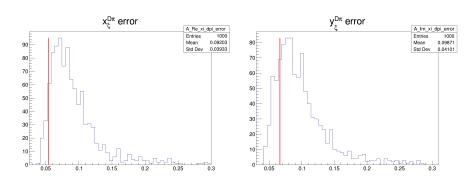
**Figure 17:**  $B \rightarrow D\pi$  CP observable pull distributions

#### Backup: Errors in $B \rightarrow DK$ CP observables, 4 bins



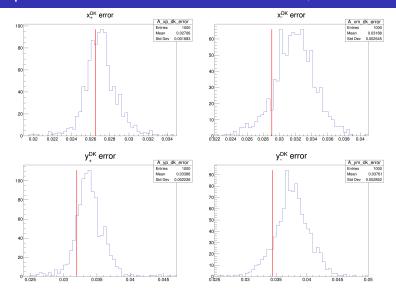
**Figure 18:**  $B \rightarrow DK$  CP observable error distributions, red line is data

## Backup: Errors in $B \to D\pi$ CP observables, 4 bins



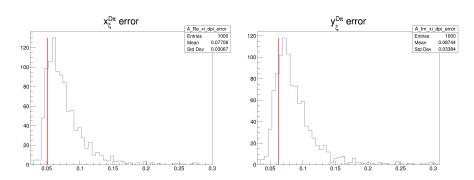
**Figure 19:**  $B \rightarrow D\pi$  CP observable error distributions, red line is data

#### Backup: Errors in $B \rightarrow DK$ CP observables, 8 bins



**Figure 20:**  $B \rightarrow DK$  CP observable error distributions, red line is data

## Backup: Errors in $B \to D\pi$ CP observables, 8 bins



**Figure 21:**  $B \rightarrow D\pi$  CP observable error distributions, red line is data

## Backup: Errors in $\gamma$

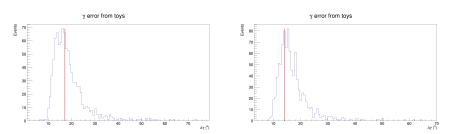


Figure 22:  $\gamma$  error distributions, red line is data