γ analysis update in $B^\pm \to (K^+K^-\pi^+\pi^-)_D K^\pm$ decays

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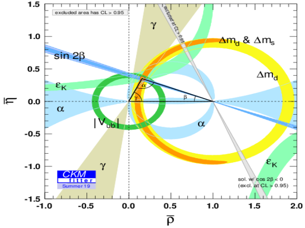


Summary of last time

- γ from $B^\pm \to DK^\pm$, $D \to K^+K^-\pi^+\pi^-$, arXiv: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
- Inital mass fits

Summary of analysis procedure

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

CP observables

$$x_\pm = r_B^{DK}\cos\left(\delta_B^{DK} \pm \gamma\right), \quad y_\pm = r_B^{DK}\sin\left(\delta_B^{DK} \pm \gamma\right)$$

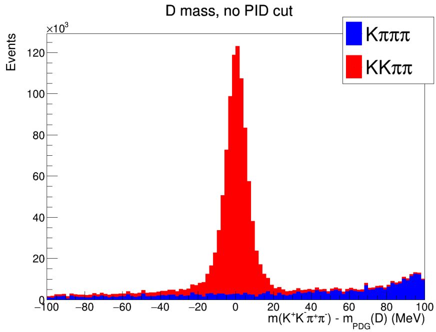
$$x_\xi^{D\pi} = \mathrm{Re}(\xi^{D\pi}), \quad y_\xi^{D\pi} = \mathrm{Im}(\xi^{D\pi}), \quad \xi^{D\pi} = \frac{r_B^{D\pi}}{r_B^{DK}} e^{i(\delta_B^{D\pi} - \delta_B^{DK})}$$

Outline

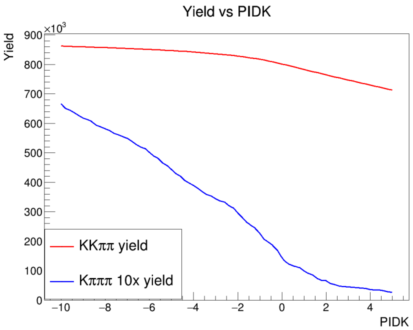
1. Backgrounds
   - Mis-ID from $D \to K\pi\pi\pi$
   - Charmless backgrounds
2. Global mass fit
3. Toy studies
   - Standard fits with 4 and 8 bins
   - Biases in CP observables
   - Systematics from c_i, s_i
4. Summary and future work

Mis-ID from $D \to K\pi\pi\pi$

- 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



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

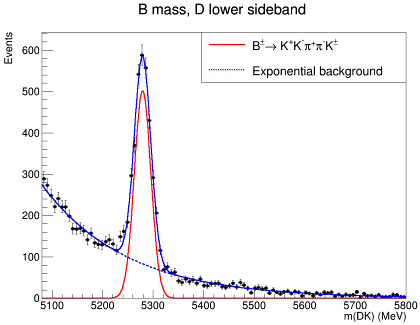


(b) Yield of $KK\pi\pi$ and $K\pi\pi\pi$ vs PIDK

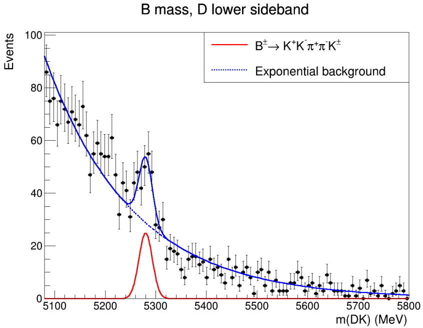
Charmless backgrounds

- Background from $B^{\pm} \to KK\pi\pi h^{\pm}$
- 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 χ^2_{DTF} to preserve D sidebands
- Overlap between samples without FS cut: 90.7%
- Overlap between samples with FS cut: 93.1%

Total charmless background yield



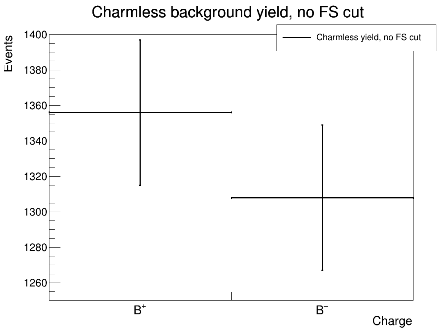
(a) Without flight significance cut



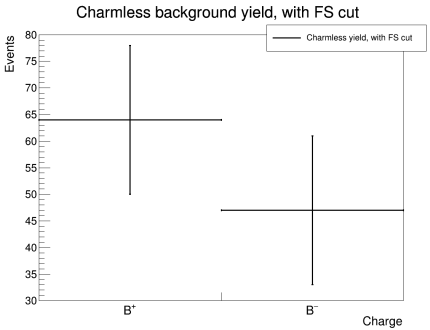
(b) With flight significance cut

Figure 2: Charmless background in the D sideband

Charmless backgrounds by charge



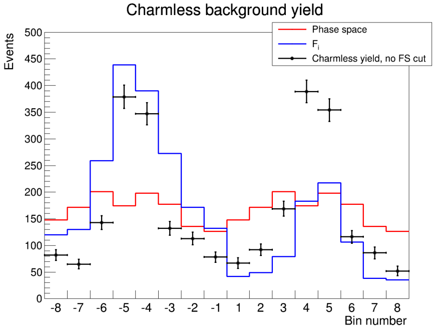
(a) Without flight significance cut



(b) With flight significance cut

Figure 3: Charmless background split by charge

Charmless backgrounds by bins



(a) Without flight significance cut

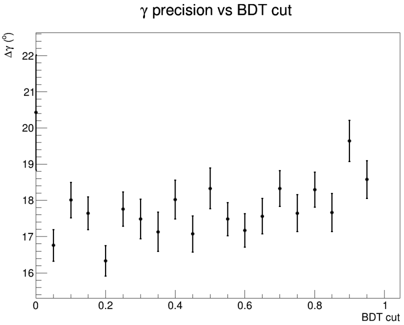
(b) With flight significance cut

Figure 4: Charmless background split by bins

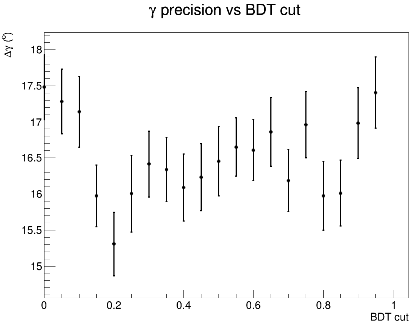
BDT cut optimization

- Current BDT cut: 0.75
- Minimize statistical γ 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 γ
  4. Extract expected γ precision from γ distribution of toy datasets

BDT cut optimization



(a) γ precision vs BDT cut for 4 bins



(b) γ precision vs BDT cut for 8 bins

Global mass fit

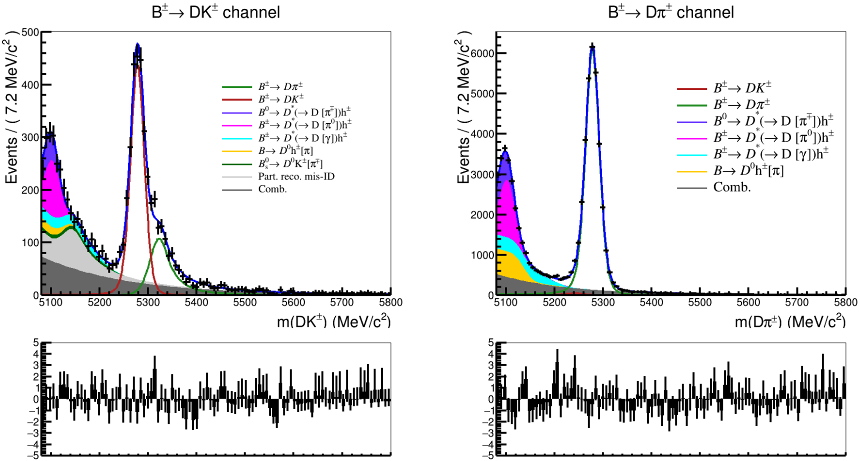
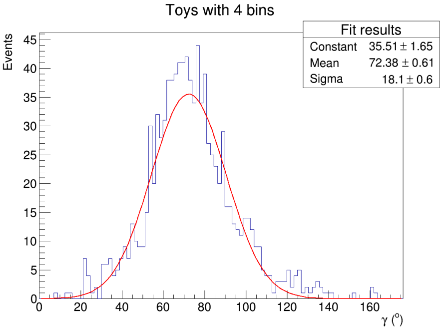
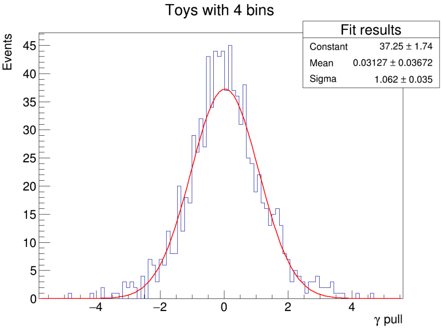


Figure 6: Global mass fit (left) $B \to DK$ and (right) $B \to D\pi$

Standard toy studies with 4 bins

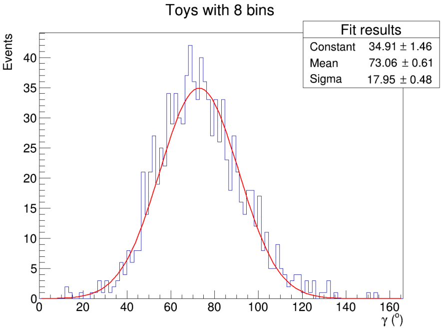


(a) γ from toys

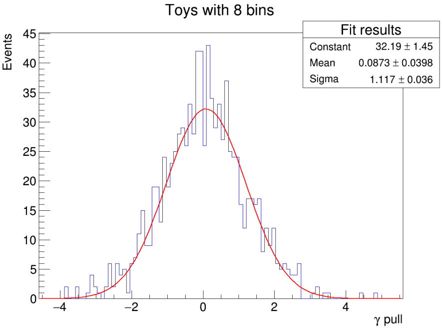


(b) γ pull distribution

Standard toy studies with 8 bins



(a) γ from toys



(b) γ pull distribution

Biases in $B \to DK$ CP observables, 4 bins

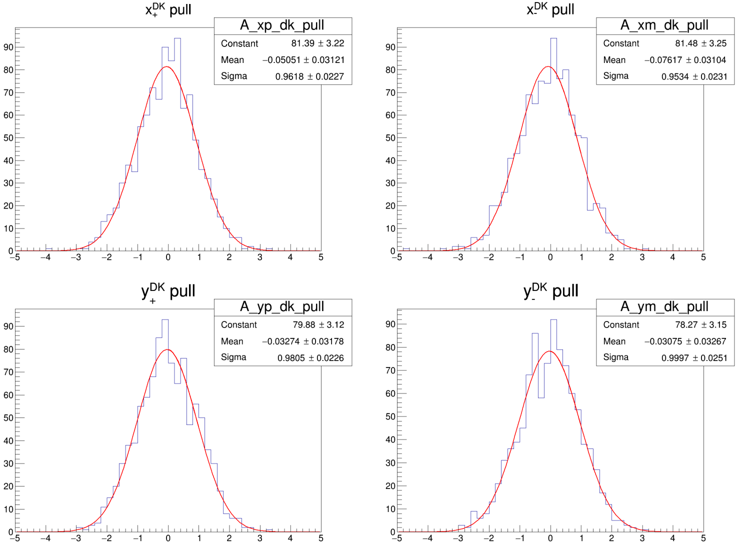


Figure 9: $B \to DK$ CP observable pull distributions

Biases in $B \to DK$ CP observables, 8 bins

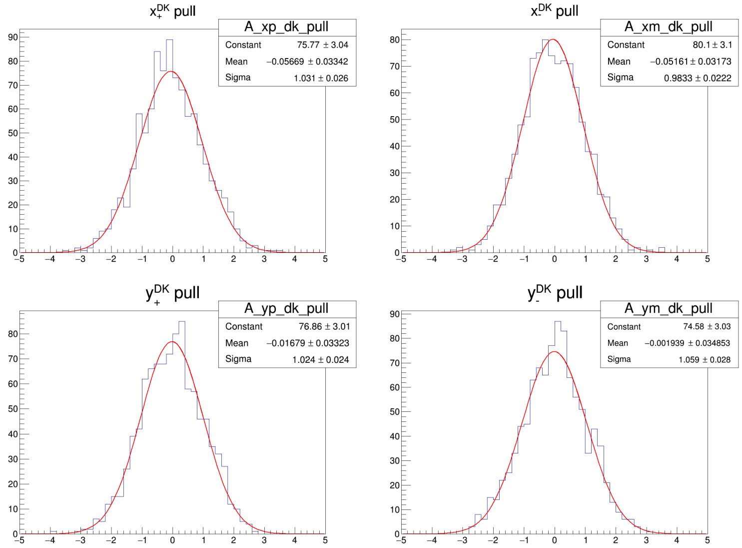


Figure 10: $B \to DK$ CP observable pull distributions

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

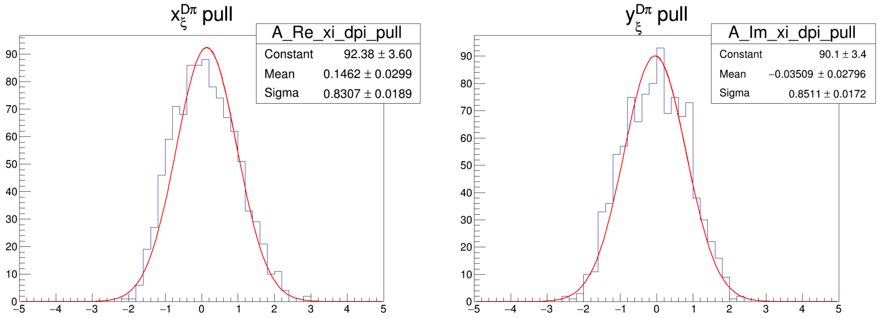


Figure 11: $B \to D\pi$ CP observable pull distributions

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

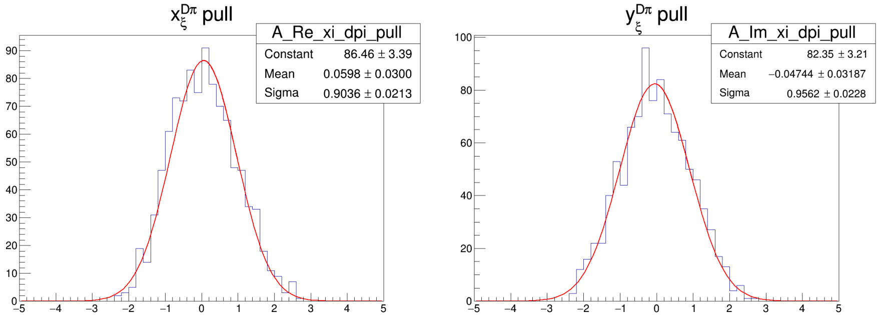


Figure 12: $B \to D\pi$ CP observable pull distributions

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

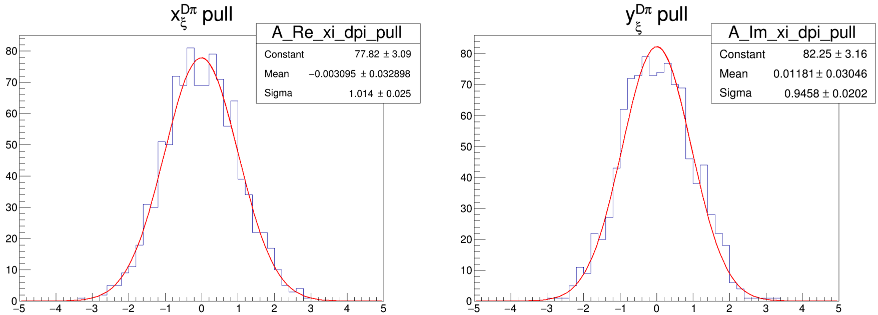


Figure 13: $B \to D\pi$ CP observable pull distributions

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

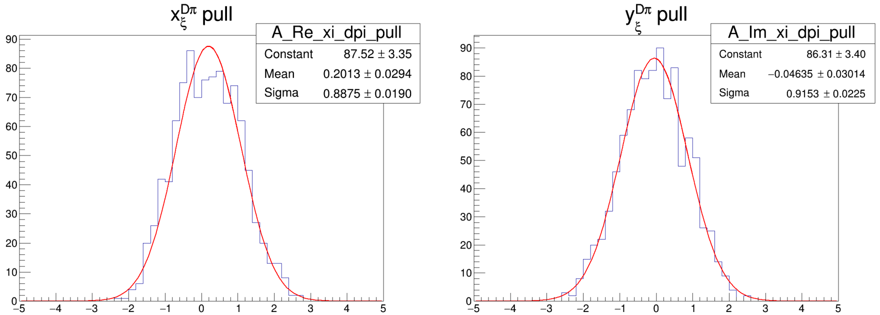


Figure 14: $B \to D\pi$ CP observable pull distributions

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

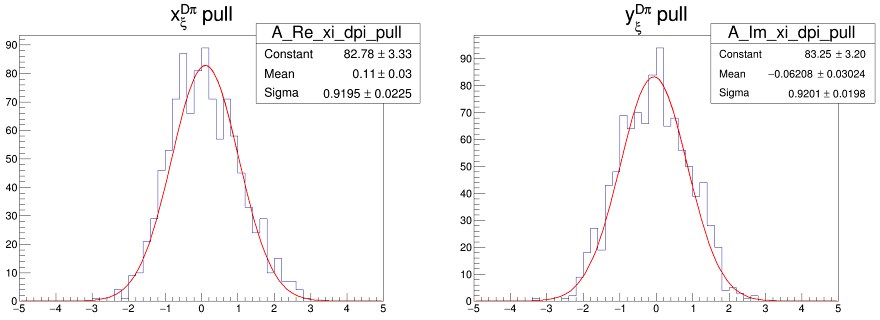


Figure 15: $B \to D\pi$ CP observable pull distributions

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

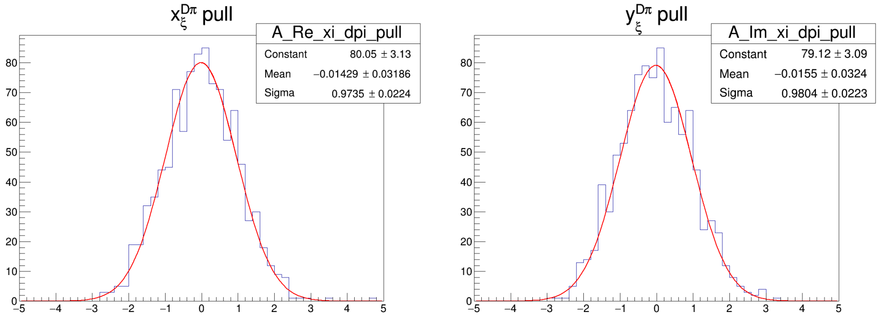
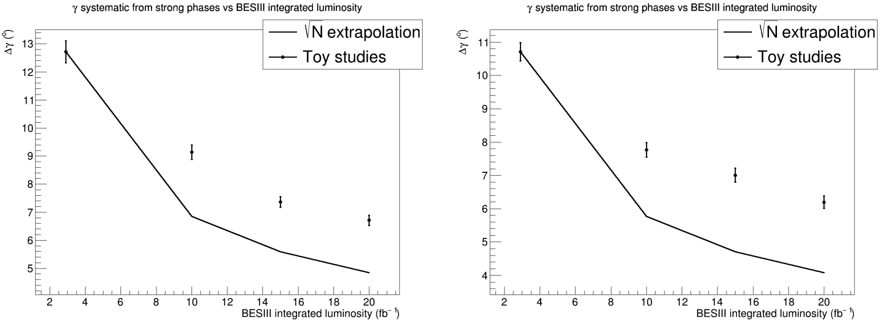


Figure 16: $B \to D\pi$ CP observable pull distributions

Systematics from c_i, s_i



(a) 4 bins **(b)** 8 bins

Figure 17: Systematic uncertainty from c_i and s_i with extrapolated BESIII statistics

Summary and future work

- Summary:
  1. Global mass fit looks promising
  2. $D \to K\pi\pi\pi$ 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!)