$D \to K^+K^-\pi^+\pi^-$ strong phase analysis and γ measurement at LHCb and BESIII

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Brief introduction to my PhD analysis

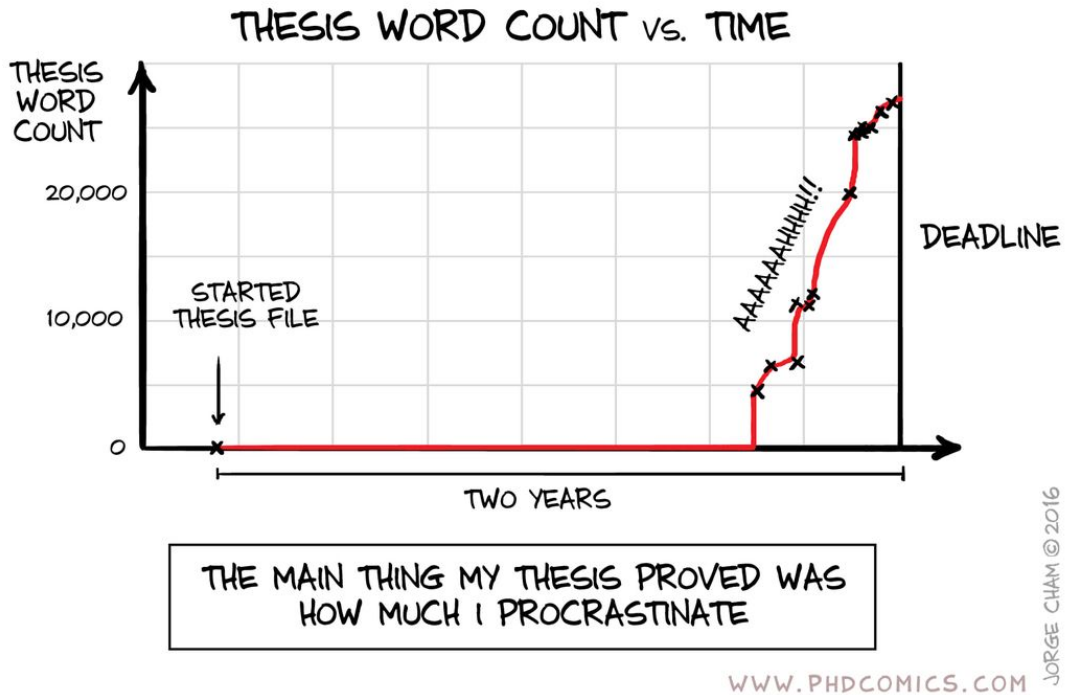
What's happened since my last update in June?

- Very busy summer! Many presentations, holiday, some analysis...
- Analysis: First strong-phase measurement of $D^0 \to K^+K^-\pi^+\pi^-$ in phase-space bins complete!
- Today: The combination of LHCb and BESIII, resulting in the first model-independent measurement of γ in this channel

Brief introduction to my PhD analysis

Status after 3 years:

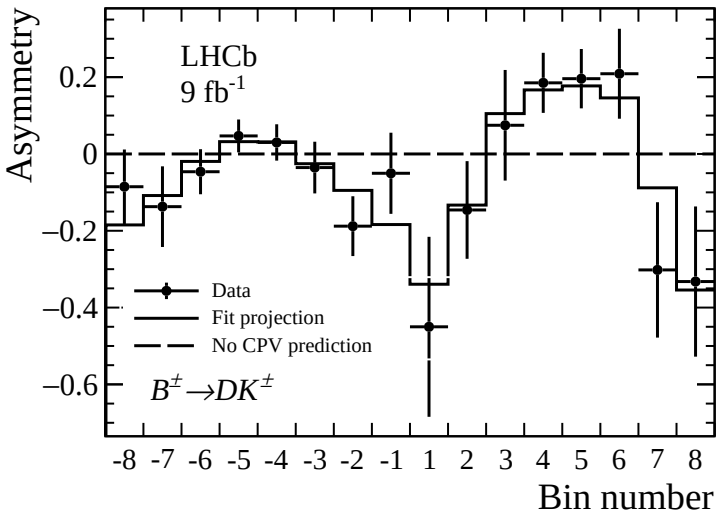
1. Final piece of my PhD analysis is coming together
2. Just started on analysis of November 2022 TORCH testbeam data
3. Will probably start writing PhD thesis next term



Recap of LHCb analysis of $B^{\pm} \to [K^+K^-\pi^+\pi^-]_D h^{\pm}$

LHCb paper: A study of CP violation in the decays
$B^{\pm} \to [K^+K^-\pi^+\pi^-]_D h^{\pm}$ $(h = K, \pi)$ and $B^{\pm} \to [\pi^+\pi^-\pi^+\pi^-]_D h^{\pm}$

- Binned model-dependent GGSZ analysis of $B^{\pm} \to [K^+K^-\pi^+\pi^-]_D h^{\pm}$
- A 3σ tension: $\gamma = (116^{+12}_{-14})^{\circ}$



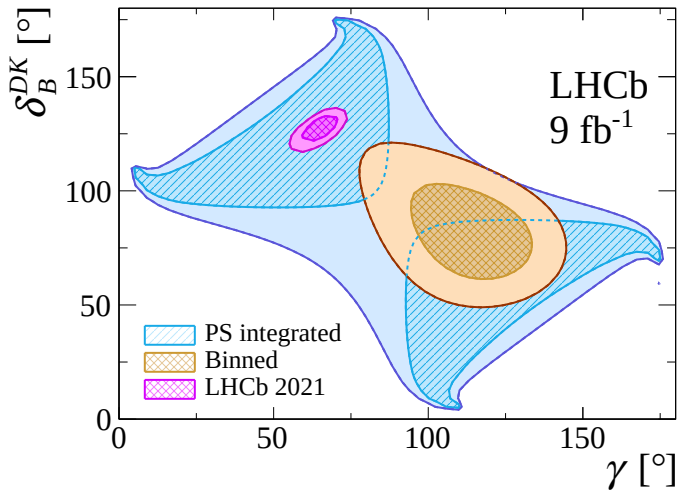


Figure 1: Left: $B^{\pm} \to DK^{\pm}$ bin asymmetries. Right: Interpretation of γ

Recap of LHCb analysis of $B^{\pm} \to [K^+K^-\pi^+\pi^-]_D h^{\pm}$

Why is there a 3σ tension?

- $D^0 \to K^+K^-\pi^+\pi^-$ strong phases are from a model
- Model-independent inputs from BESIII are necessary
- It's been challenge to convince reviewers that γ is model dependent:

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"*A general comment is that in (7 !!) different places [Abstract, Introduction (page 1)...] it is mentioned the same message: that the analysis is model-dependent...*" - EPJC referee 2

Brief summary of formalism

- Identical formalism to BPGGSZ analyses with $D^0 \to K^0_S h^+ h^-$
- Split events into bins of phase space
- LHCb: Measure CP asymmetries in each bin
- BESIII: Measure the cosine (sine) of the strong-phase difference c_i (s_i)

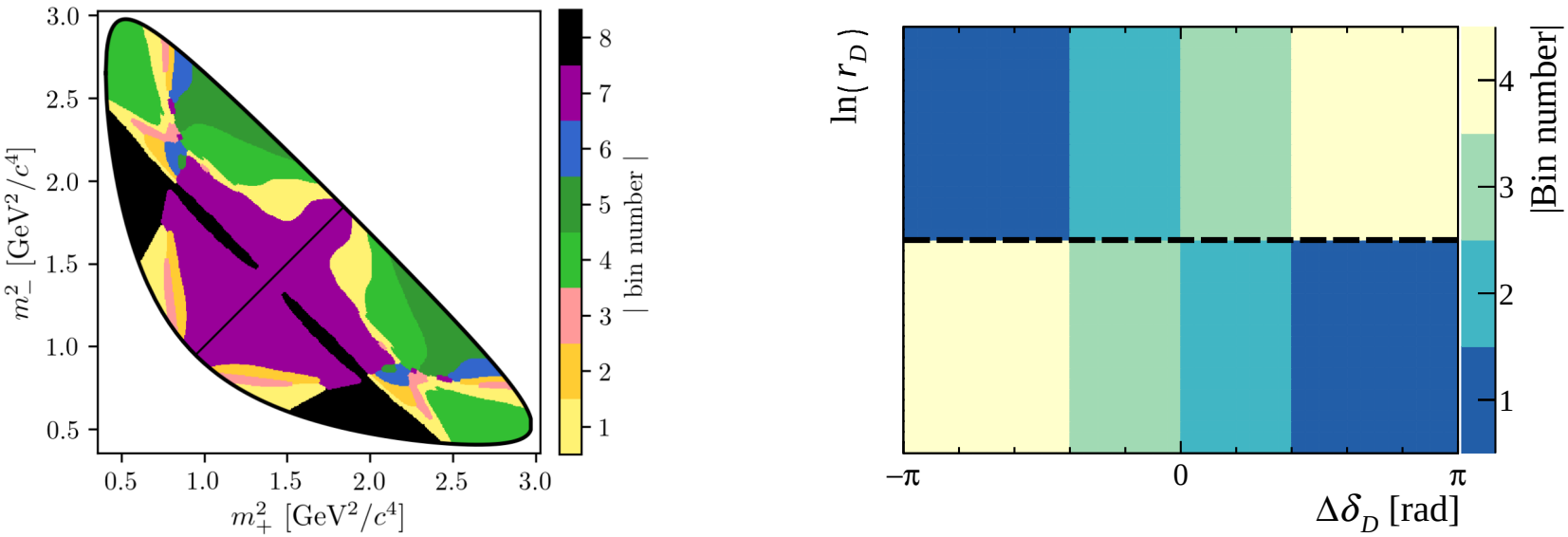
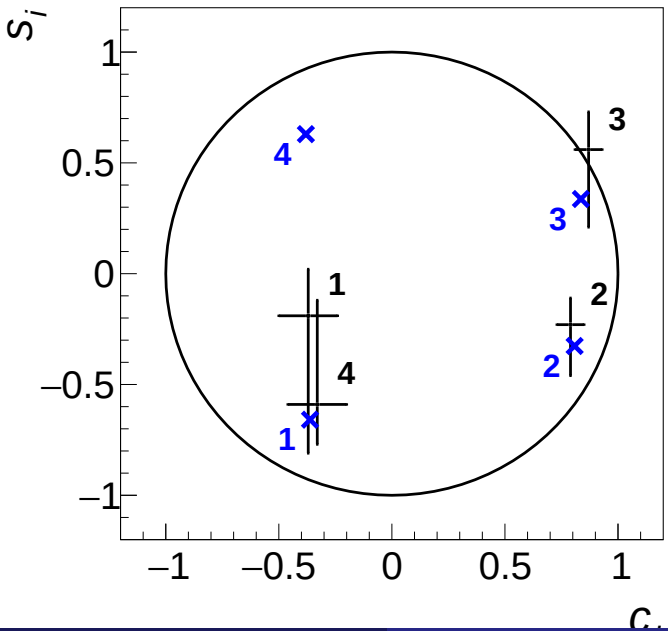


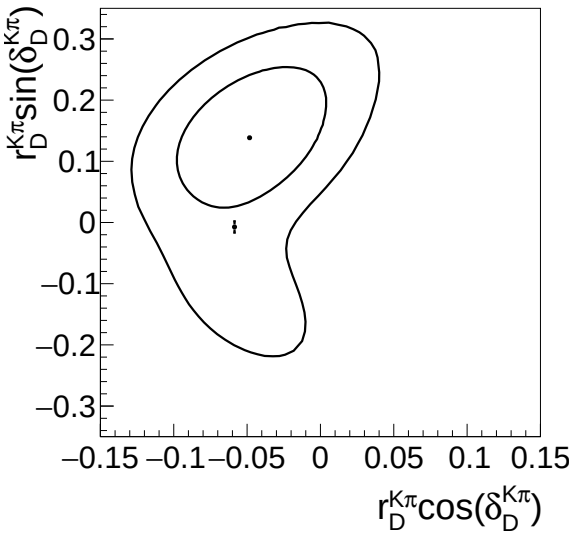
Figure 2: Left: Binning scheme of $D^0 \to K^0_S \pi^+ \pi^-$, visualised on a Dalitz plot. Right: Analogous binning scheme for $D^0 \to K^+ K^- \pi^+ \pi^-$, where the 5D phase space is projected onto the model-predicted δ_D and r_D.

BESII c_i and s_i results

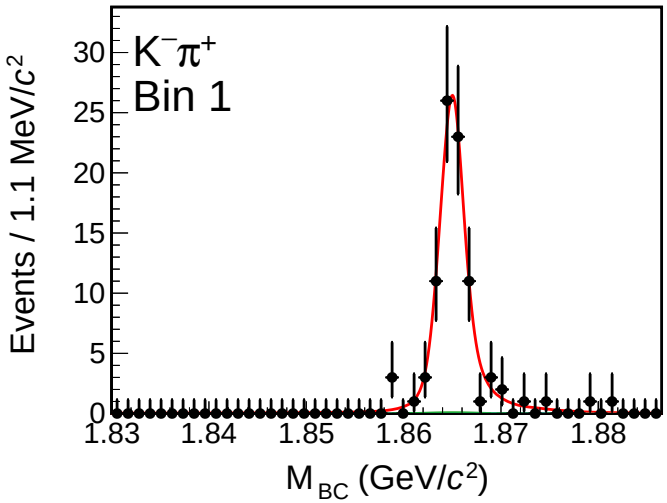
How to measure c_i and s_i? Sneha already introduced BESIII in last week's seminar!

1. Measure the double-tag yields
2. Tags with different CP content can enhance/suppress yields
3. Infer c_i and s_i in a large simultaneous fit of all tags

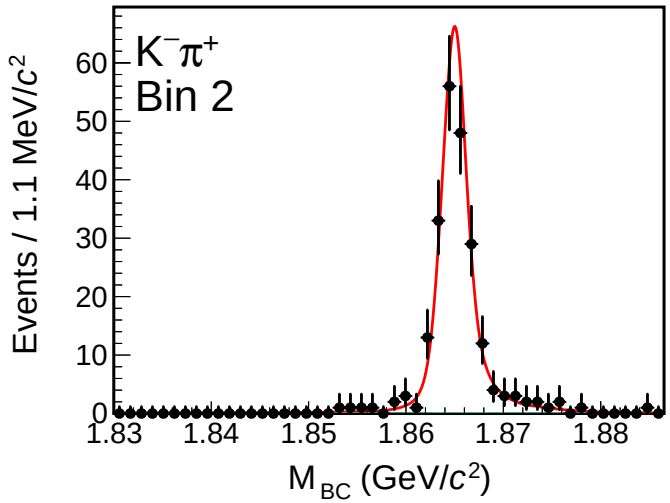




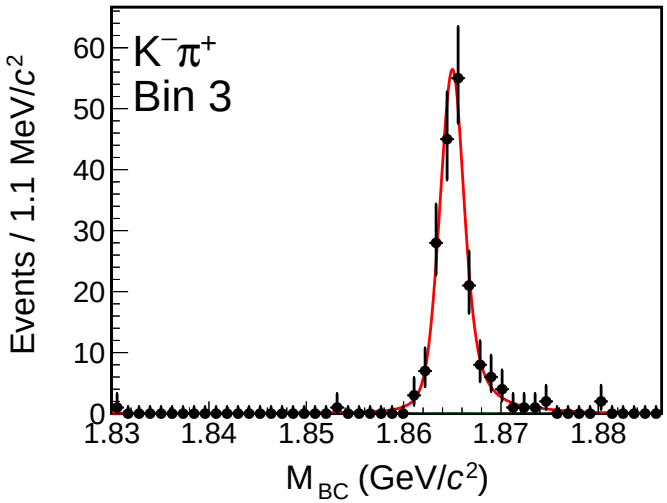
Double tag fit of $KK\pi\pi$ vs $K\pi$



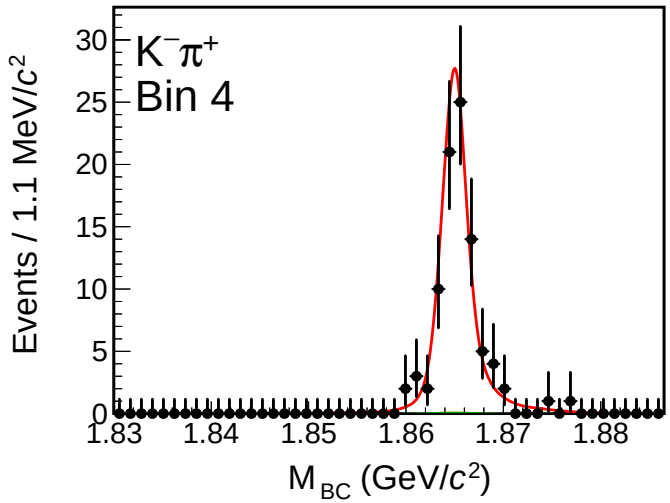
(a) Bin 1 yield: $84.5^{+9.8}_{-9.1}$



(b) Bin 2 yield: $211.2^{+15.4}_{-14.8}$

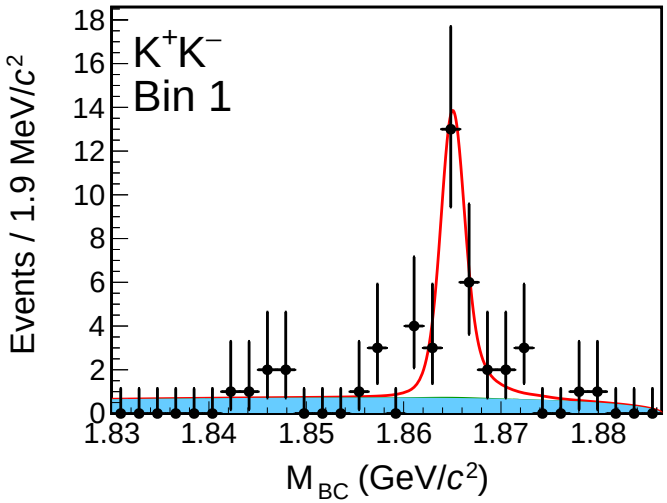


(c) Bin 3 yield: $181.0^{+14.0}_{-13.3}$

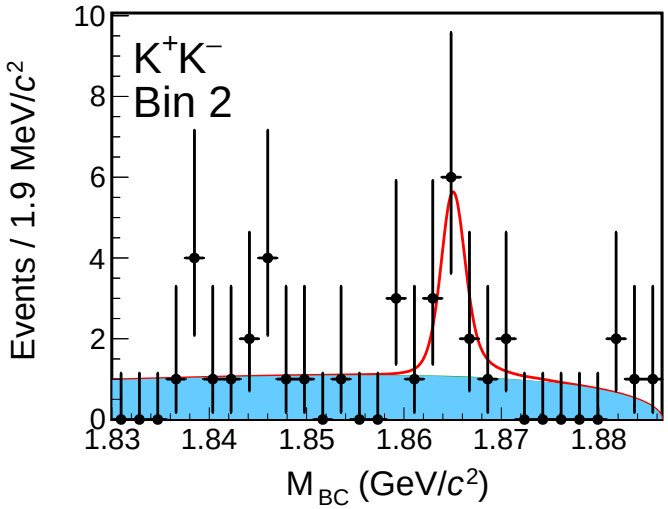


(d) Bin 4 yield: $88.6^{+9.7}_{-9.0}$

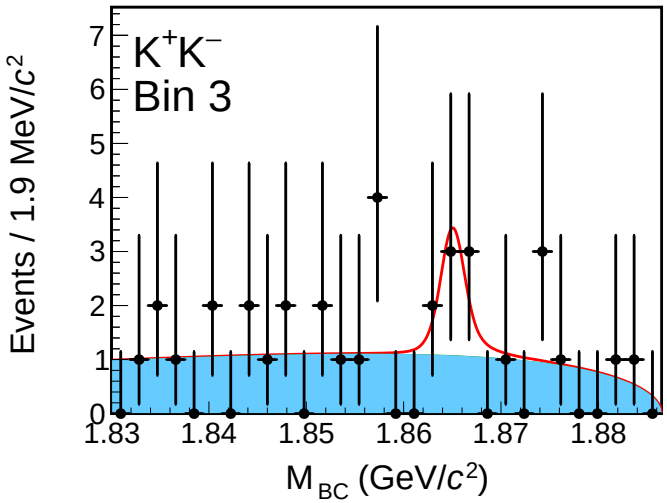
Double tag fit of $KK\pi\pi$ vs KK



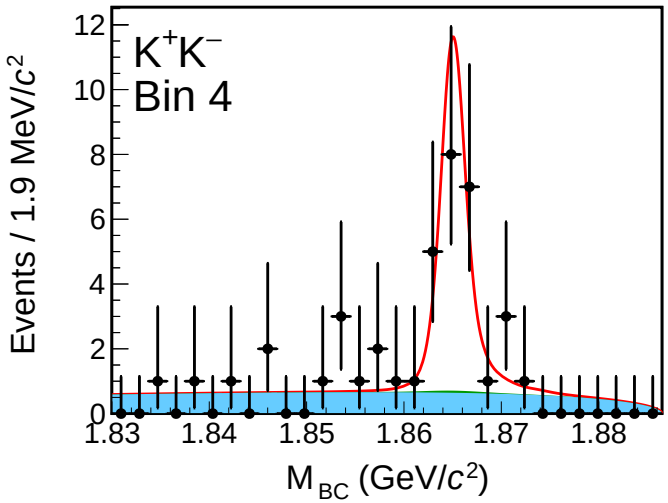
(a) Bin 1 yield: $25.3^{+6.2}_{-5.5}$



(b) Bin 2 yield: $8.8^{+4.0}_{-3.3}$

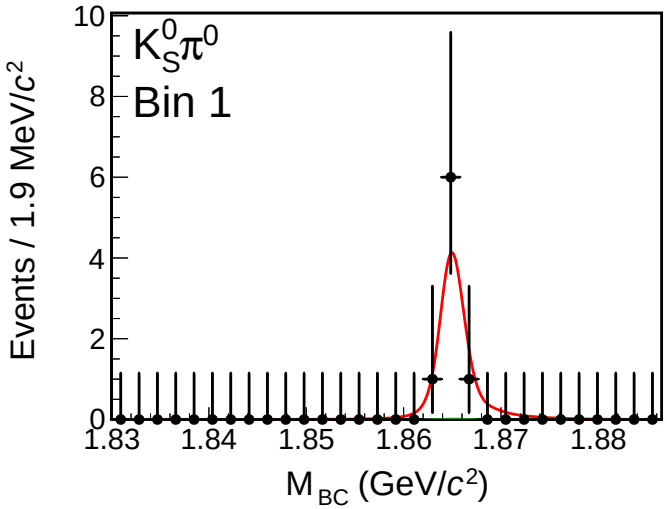


(c) Bin 3 yield: $4.5^{+3.3}_{-2.6}$

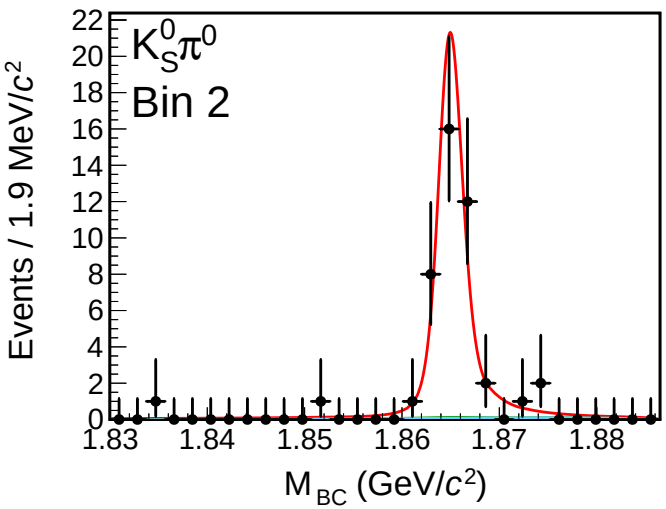


(d) Bin 4 yield: $21.1^{+5.5}_{-4.8}$

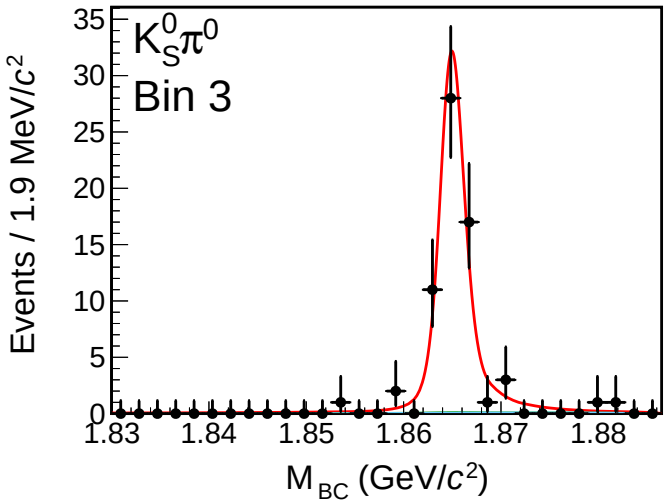
Double tag fit of $KK\pi\pi$ vs $K_S\pi^0$



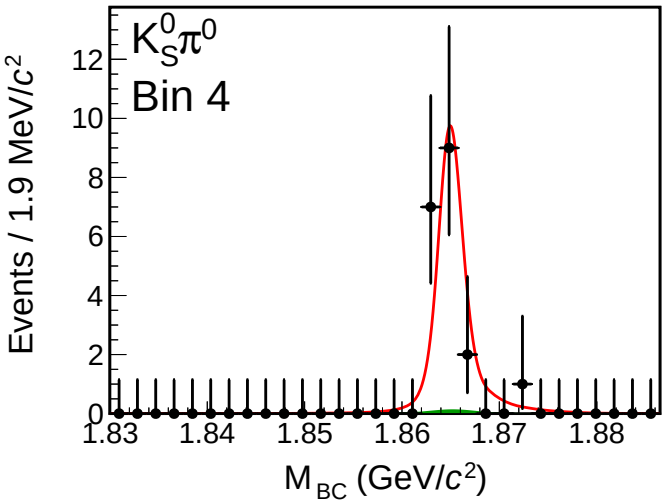
(a) Bin 1 yield: $7.9^{+3.1}_{-2.5}$



(b) Bin 2 yield: $40.4^{+6.8}_{-6.3}$

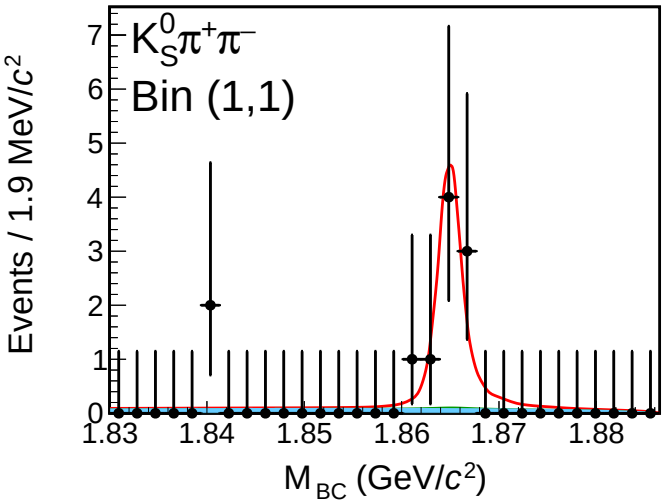


(c) Bin 3 yield: $61.1^{+8.3}_{-7.8}$

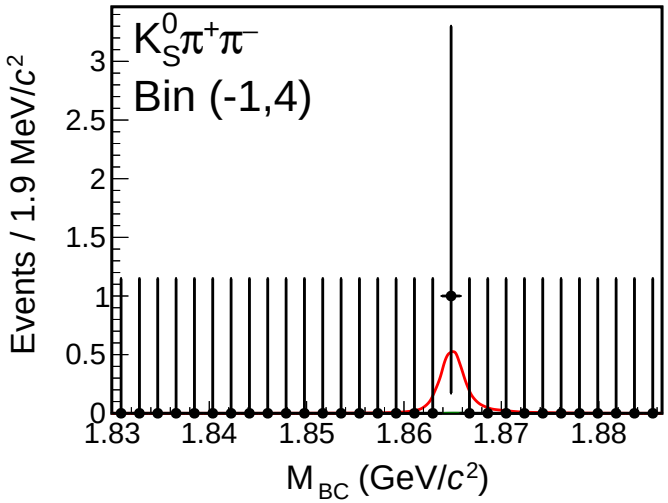


(d) Bin 4 yield: $18.3^{+4.5}_{-3.9}$

Double tag fit of $KK\pi\pi$ vs $K_S\pi^+\pi^-$

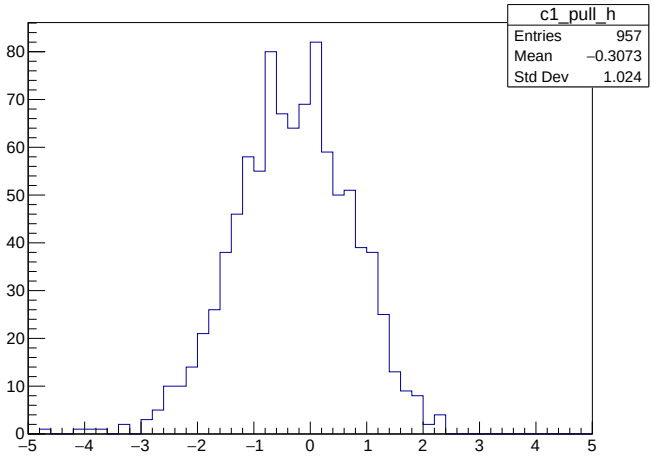


(a) Bin $(1,1)$ yield: $8.2^{+3.3}_{-2.7}$

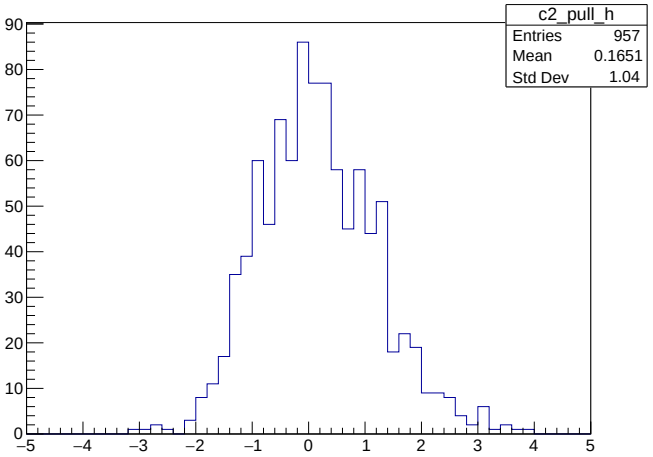


(b) Bin $(-1,4)$ yield: $0.9^{+1.3}_{-0.7}$

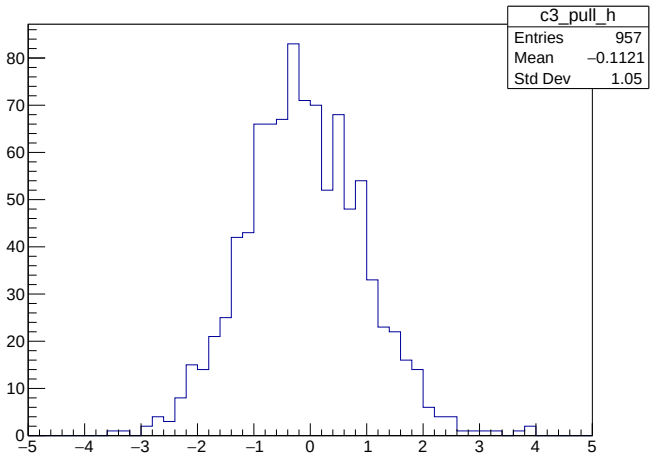
Toy studies



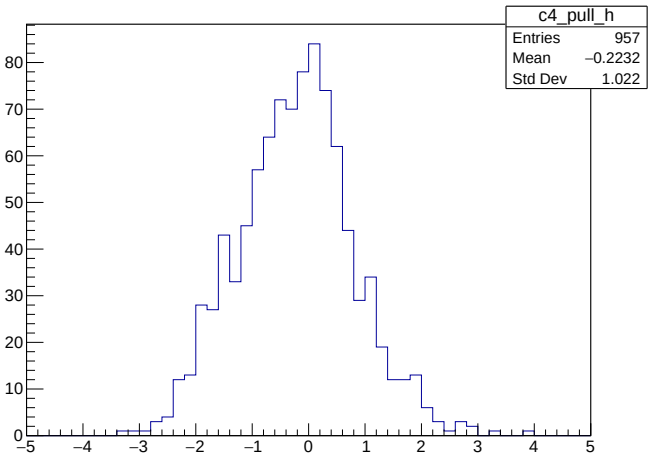
(a) c_1 pulls



(b) c_2 pulls

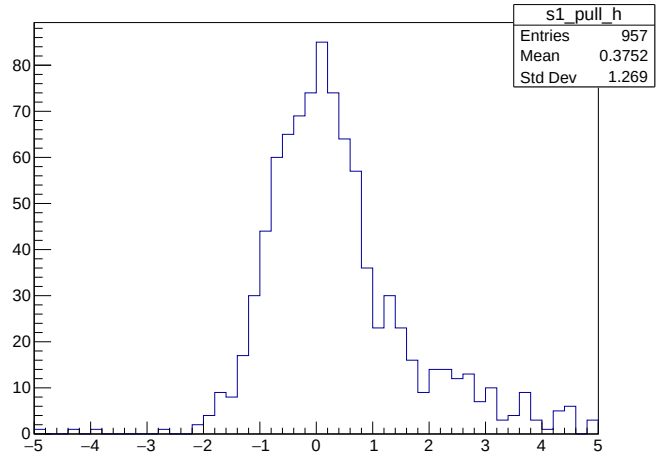


(c) c_3 pulls

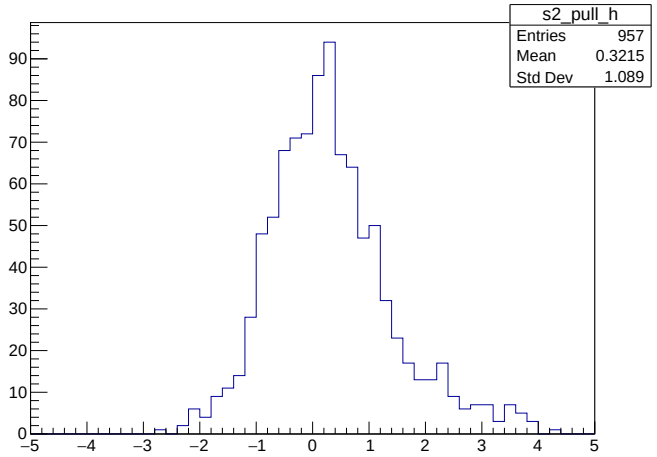


(d) c_4 pulls

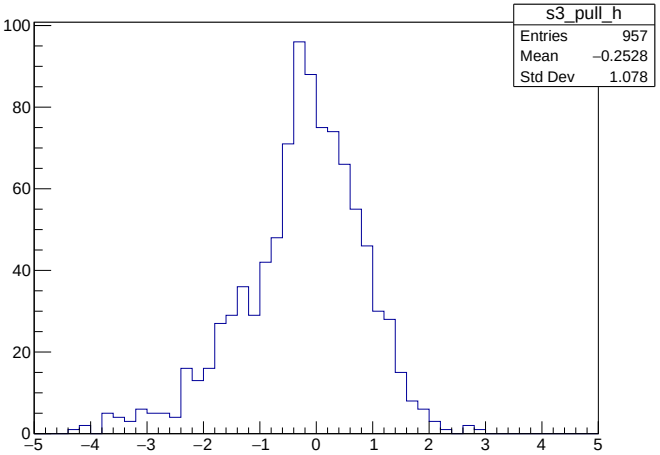
Toy studies



(a) s_1 pulls



(b) s_2 pulls



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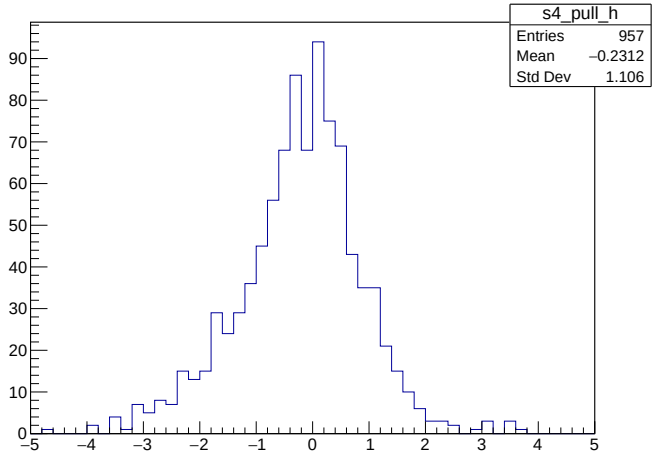

(d) s_4 pulls

Toy studies

What do the toy fits tell us?

1. Small bias in c_i which can be corrected
2. s_i pulls are very asymmetric, and uncertainties are not very reliable