# BESIII Charm Meeting
# Measurement of $\delta_D^{K\pi}$ with $D \to K_{S,L}\pi^+\pi^-$ tags

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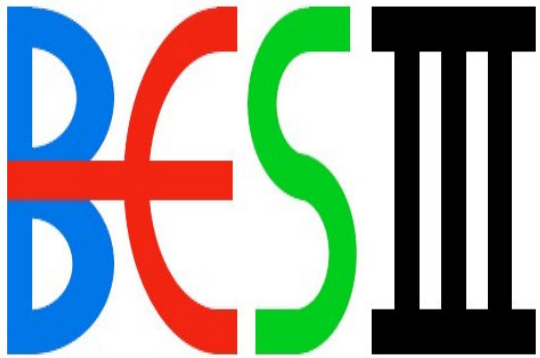
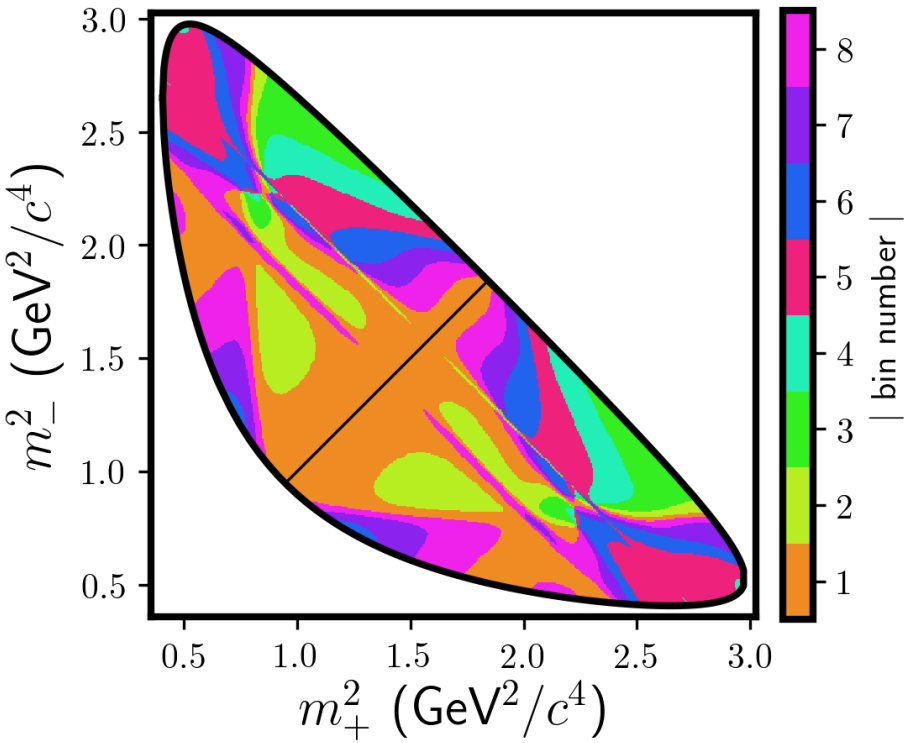


# Measurement of $\delta_D^{K\pi}$ with $D \to K_{S,L}\pi^+\pi^-$ tags

- Measurement of <u>both</u> $r_D^{K\pi}\cos\delta_D^{K\pi}$ and $r_D^{K\pi}\sin\delta_D^{K\pi}$
- Equal-$\Delta\delta_D$ phase space binning
- Double tag yields taken from Phys. Rev. D **101** (2020)
- $K_i$, $c_i$, $s_i$ re-determined without $D \to K^-\pi^+$ inputs (by Lei Li)



# $D \to K^0_{S,L}\pi^+\pi^-$ inputs

## $K^-\pi^+$ vs $K^0_{S,L}\pi^+\pi^-$ double tag yield prediction

$$Y(K^-\pi^+|K^0_{S,L}\pi^+\pi^-)_i =$$
$$H^{(\prime)}\left(K_i^{(\prime)} + \left(r_D^{K\pi}\right)^2 K_{-i}^{(\prime)} \mp 2r_D^{K\pi}\sqrt{K_i^{(\prime)}K_{-i}^{(\prime)}}\left[c_i^{(\prime)}\cos\delta_D^{K\pi} - s_i^{(\prime)}\sin\delta_D^{K\pi}\right]\right)$$

- $K_i$: Flavour tag yields
  - $D \to K^0_{S,L}\pi^+\pi^-$ vs $D \to K^-\pi^+\pi^0$
  - $D \to K^0_{S,L}\pi^+\pi^-$ vs $D \to K^-\pi^+\pi^-\pi^+$
  - $D \to K^0_S\pi^+\pi^-$ vs $D \to K^-e^+\nu_e$
  - Updated coherence factors from J. High Energ. Phys. **2021**, 164
- $c_i$ and $s_i$: Amplitude-averaged strong phases
  - Updated with no $D \to K^-\pi^+$ inputs

# Fit setup and results

- Minimize $\chi^2 = \sum \left( \frac{Y_{\text{obs}} - Y_{\text{exp}}}{\Delta Y_{\text{obs}}} \right)^2$
  - $\Delta Y_{\text{obs}}$ statistical uncertainty only
- Systematic uncertainties: Run $10^5$ fits with smearing
  - $K_i$: Independent Gaussian smearing according to uncertainties
  - $c_i$, $s_i$: Gaussian smearing according to correlations and uncertainties

## Final results

$$r_D^{K\pi} \cos \delta_D^{K\pi} = -0.0547 \pm 0.0084 \pm 0.0049 \pm 0.0010$$

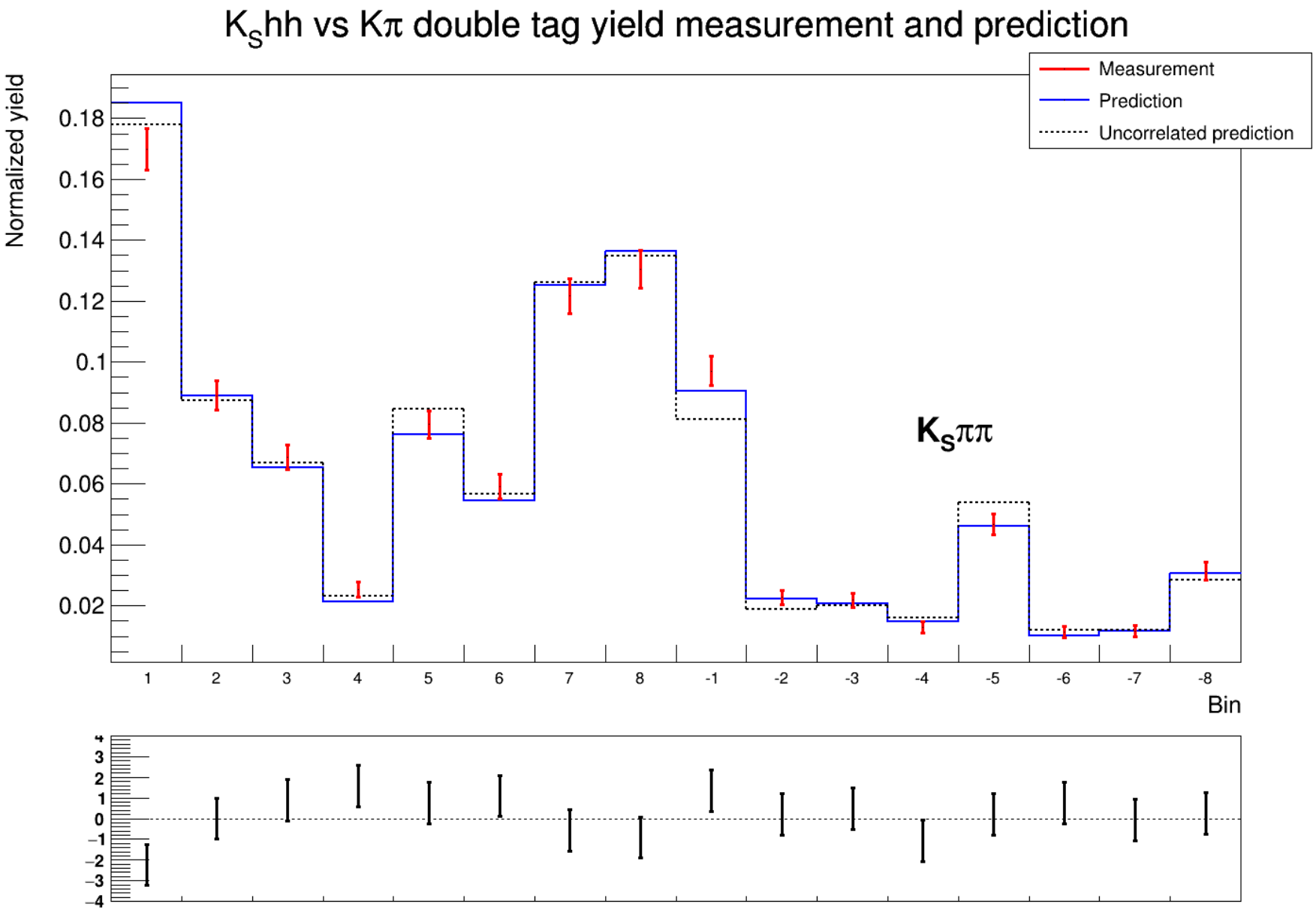
$$r_D^{K\pi} \sin \delta_D^{K\pi} = -0.010 \pm 0.012 \pm 0.007 \pm 0.003$$

Uncertainties: Statistical $\pm$ $K_i$ systematics $\pm$ $c_i/s_i$ systematics

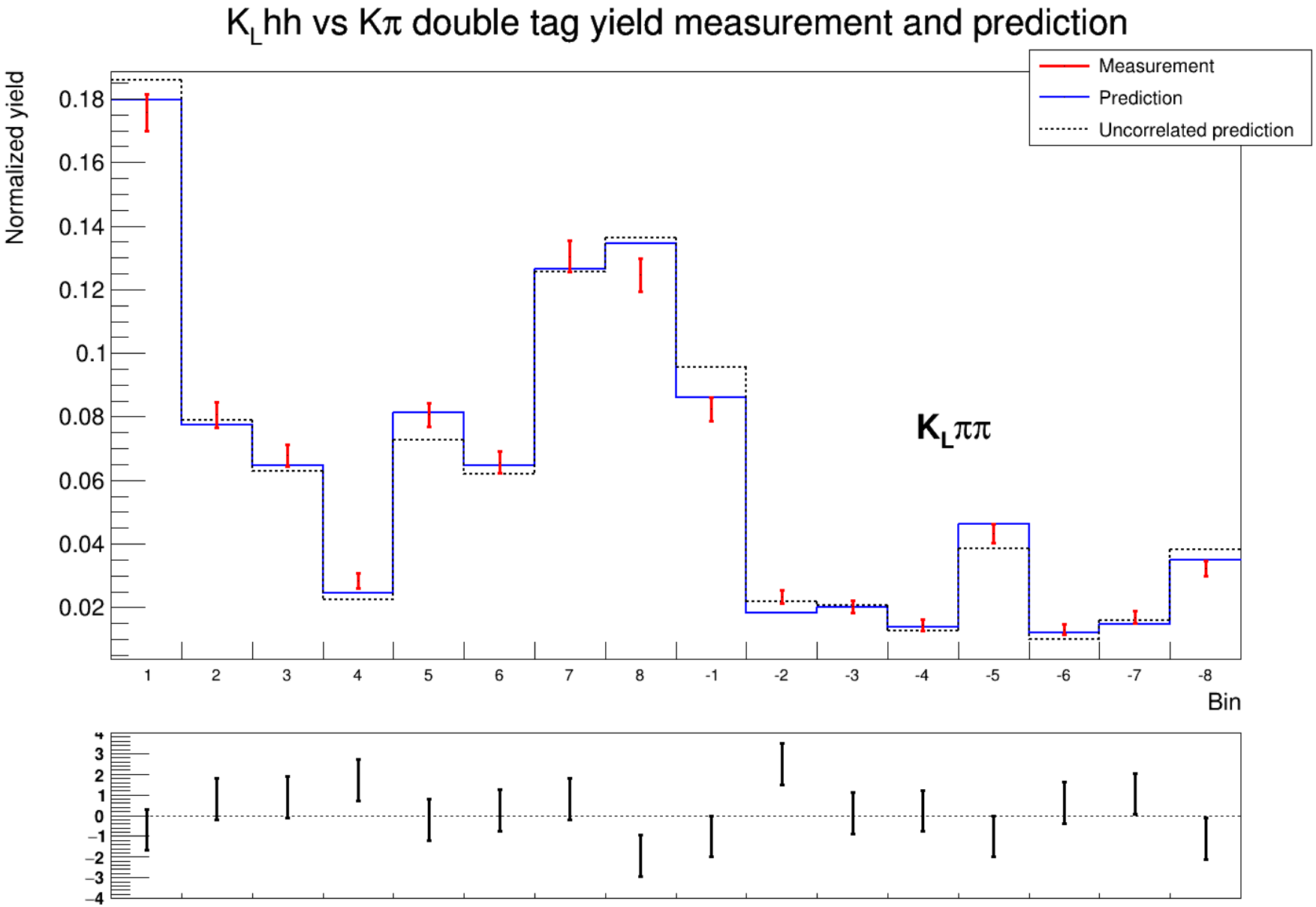
- $r_D^{K\pi} \cos \delta_D^{K\pi} / r_D^{K\pi} \sin \delta_D^{K\pi}$ correlations are small:

| $K^-\pi^+$ | $K_i^{(\prime)}$ | $c_i^{(\prime)}, s_i^{(\prime)}$ |
|---|---|---|
| 0.035 | -0.005 | 0.021 |

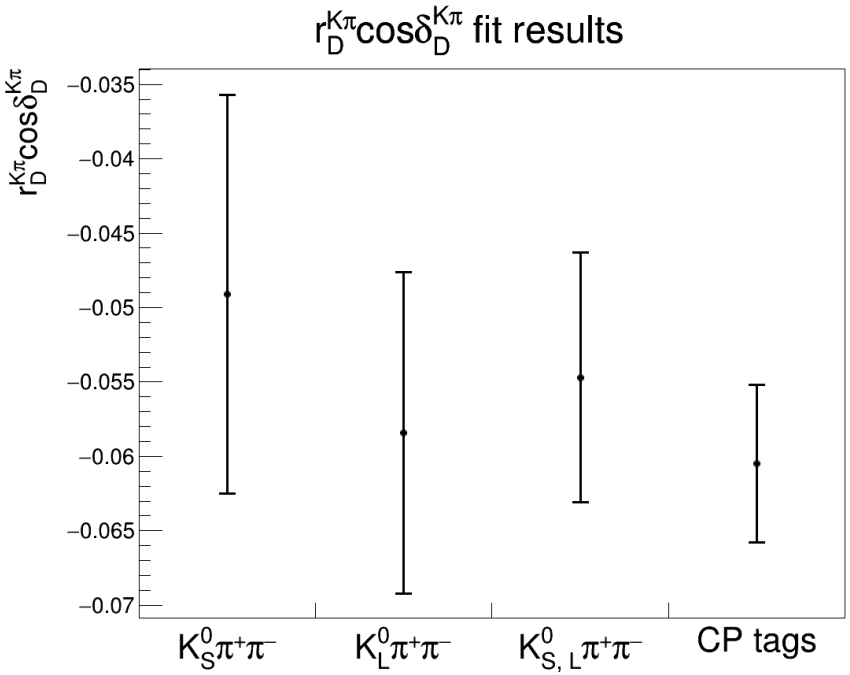
# Bin yield yield vs fit prediction

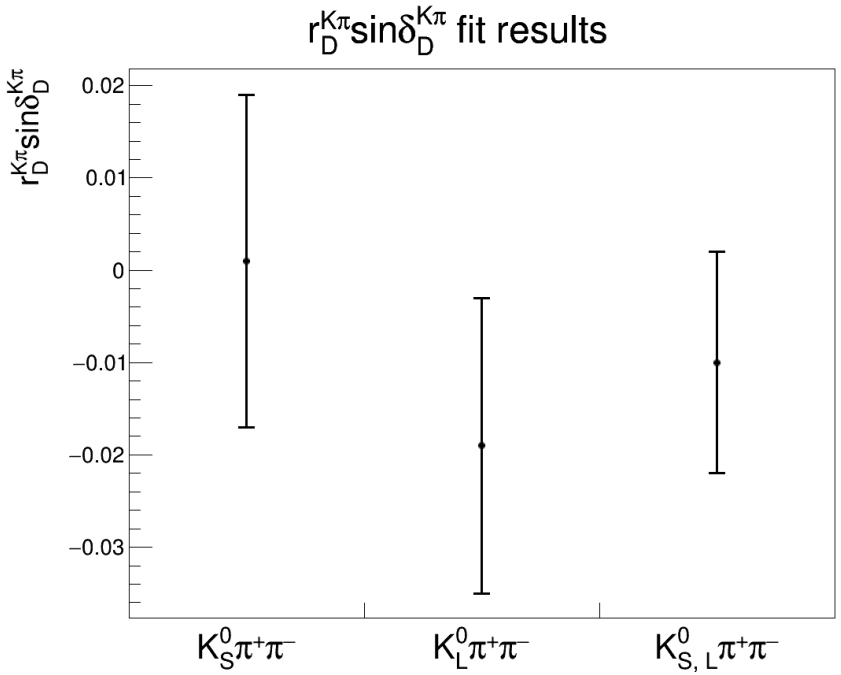


# Bin yield yield vs fit prediction



# Separate $K^0_S\pi^+\pi^-$ and $K^0_L\pi^+\pi^-$ fits



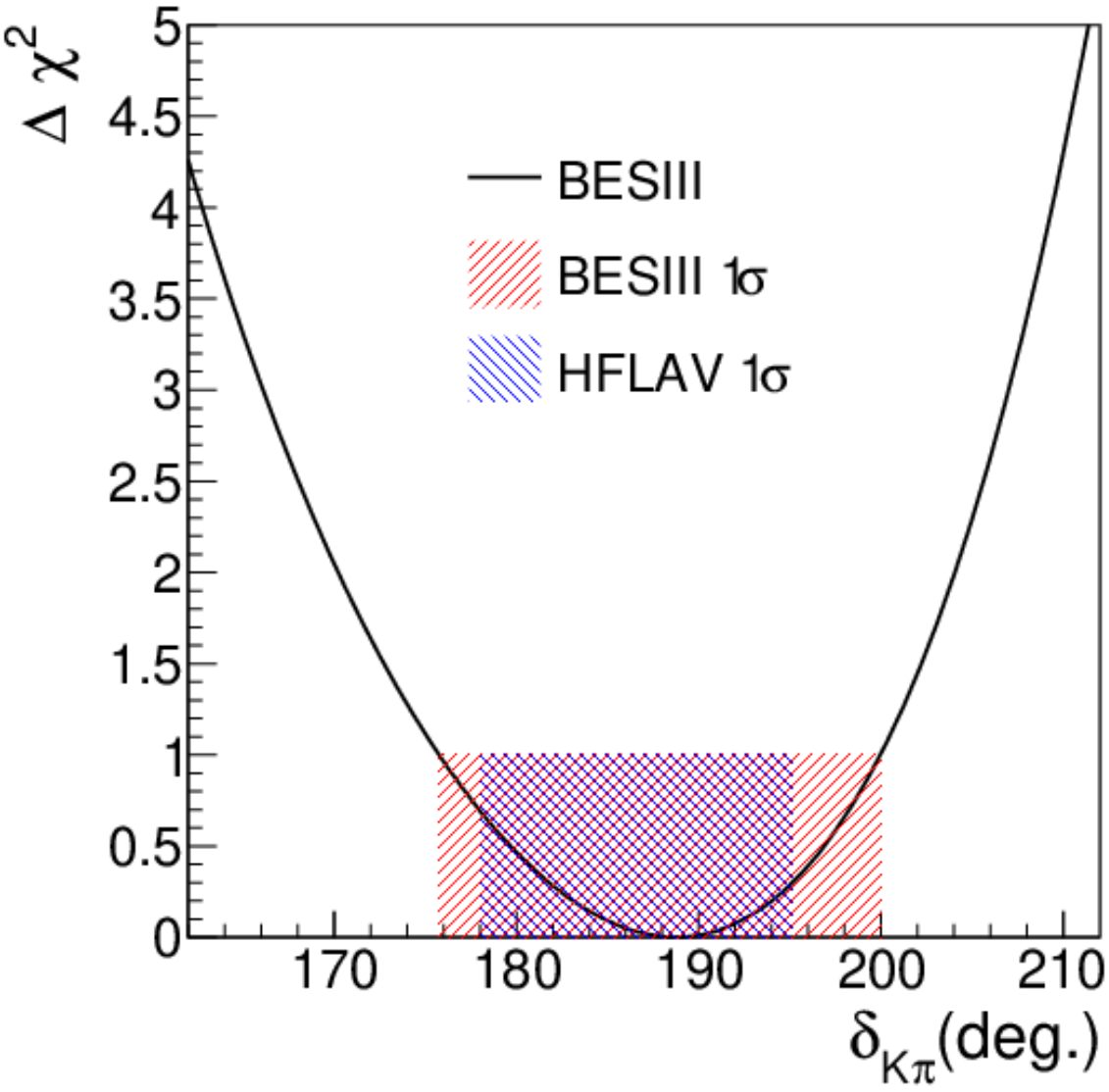

| Sample | $r_D^{K\pi}\cos\delta_D^{K\pi}$ | $r_D^{K\pi}\sin\delta_D^{K\pi}$ | $\chi^2/ndf$ |
|---|---|---|---|
| $K^0_S\pi^+\pi^-$ | -0.0491 $\pm$ 0.0134 | 0.001 $\pm$ 0.018 | 14.4/14 |
| $K^0_L\pi^+\pi^-$ | -0.0584 $\pm$ 0.0108 | -0.019 $\pm$ 0.016 | 20.1/14 |
| $K^0_{S,L}\pi^+\pi^-$ | -0.0547 $\pm$ 0.0084 | -0.010 $\pm$ 0.012 | 35.4/30 |
| CP tags | -0.0605 $\pm$ 0.0053 | - | |

# Combination of measurements

Inputs to combination:

- $r_D^{K\pi} \cos \delta_D^{K\pi} = -0.0588 \pm 0.0052$
  - $K^2_{S,L}\pi^+\pi^-$
  - CP tags

- $r_D^{K\pi} \sin \delta_D^{K\pi} = -0.010 \pm 0.014$
  - $K^0_{S,L}\pi^+\pi^-$



# Summary

- Have performed an updated measurement of $\mathcal{A}_{K\pi} = 0.127 \pm 0.012$
- As part of this analysis, BR of three $K_L X$ modes in a manner independent of flavour-tag input were determined
  - These will be valuable inputs for future strong-phase studies
- Have fitted $K^-\pi^+$ vs $K_{S,L}\pi^+\pi^-$ in bins of phase space
  - Gain sensitivity to both $r_D^{K\pi}\cos\delta_D^{K\pi}$ and $r_D^{K\pi}\sin\delta_D^{K\pi}$
- Final result: $\delta_D^{K\pi} = \left(188.7^{+11.2}_{-13.0}\right)^\circ$
- Precision compares favourably with that from ensemble of charm-mixing data, will improve significantly with increase in data set foreseen at $\psi(3770)$
- MEMO in preparation, and will be circulated in coming week

# Thank you!