MAX-PLANCK-INSTITUT FÜR PHYSIK

Dalitz Analysis of $B^+ \to K_S \pi^+ \pi^0$ Decays

OSKAR TITTEL, MARKUS REIF, STEFAN WALLNER, HANS-GÜNTHER MOSER

Max Planck Institut für Physik, Technische Universität München

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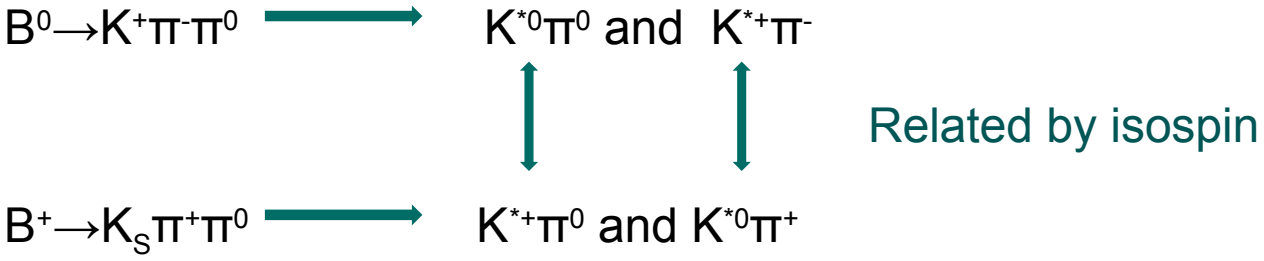
Belle II

Motivation

B meson decays via meson resonances in two-body subsystems



$$\sqrt{2}\mathcal{A}_{K^{*0}\pi^0} + \mathcal{A}_{K^{*+}\pi^-} = \sqrt{2}\mathcal{A}_{K^{*+}\pi^0} + \mathcal{A}_{K^{*0}\pi^+}$$

Motivation

$$I_{K^*\pi} = A_{CP}^{K^{*+}\pi^-} + A_{CP}^{K^{*0}\pi^+} \frac{\mathcal{B}_{K^{*0}\pi^+}}{\mathcal{B}_{K^{*+}\pi^-}} \frac{\tau_{B^0}}{\tau_{B^+}} - 2A_{CP}^{K^{*+}\pi^0} \frac{\mathcal{B}_{K^{*+}\pi^0}}{\mathcal{B}_{K^{*+}\pi^-}} \frac{\tau_{B^0}}{\tau_{B^+}} - 2A_{CP}^{K^{*0}\pi^0} \frac{\mathcal{B}_{K^{*0}\pi^0}}{\mathcal{B}_{K^{*+}\pi^-}}$$

Extract all asymmetries and BF's from Dalitz analyses of $B^0 \to K^+\pi^-\pi^0$ and $B^+ \to K_S\pi^+\pi^0$

Perform both analyses using the same framework to allow for a self-consistent extraction of $I_{K^*\pi}$

Compare extracted value with SM prediction of $I_{K^*\pi} = \mathcal{O}(1\%)$

Fit Recap

Amplitude of one resonance: $\mathcal{A}_i = L_i(J,x)T_i(J,x,y)B_i(J,x)$

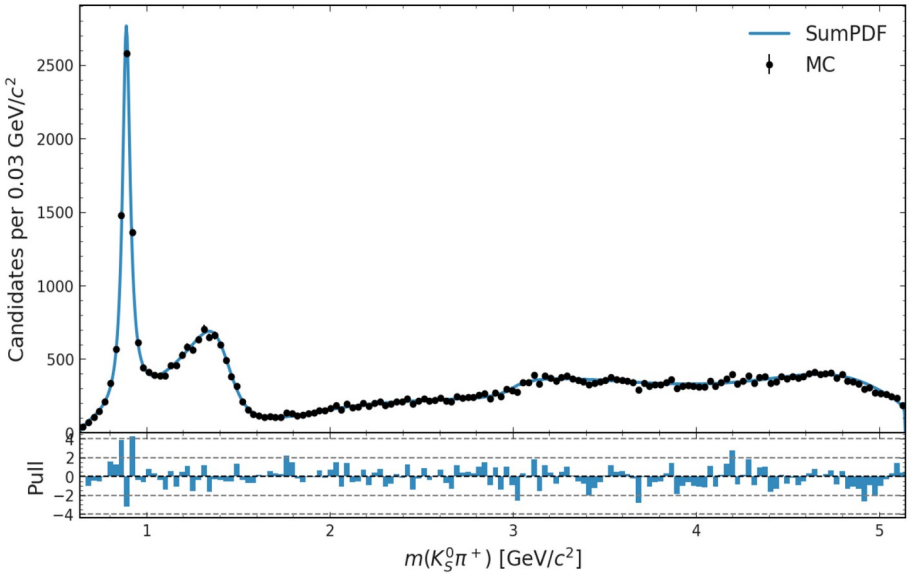
Set of resonances: $K^{*0}(892)$, $\rho(770)$, ...

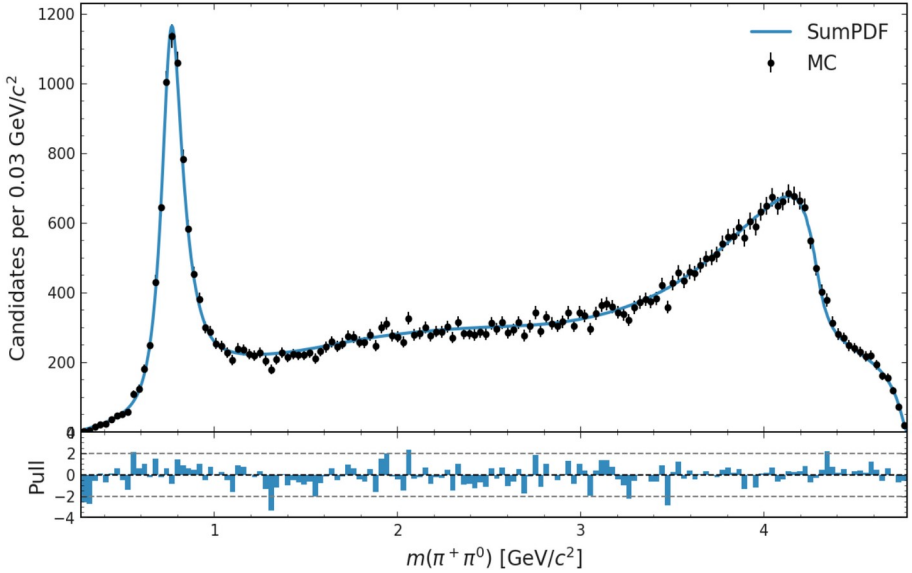
Total amplitude: $\mathcal{A} = \sum_i c_i \mathcal{A}_i$

→ Perform fit to extract c_i

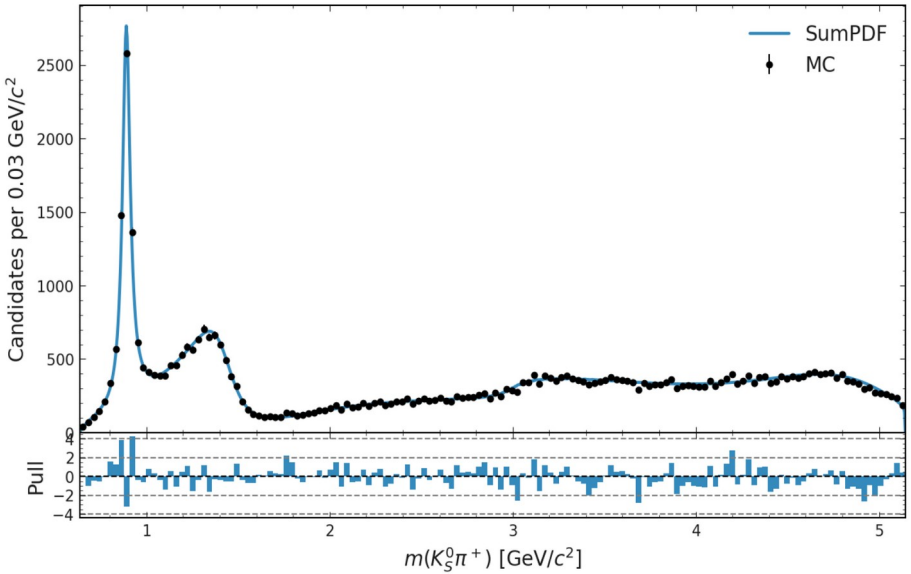
Currently: Performing MC input-output studies with a fixed set of resonances

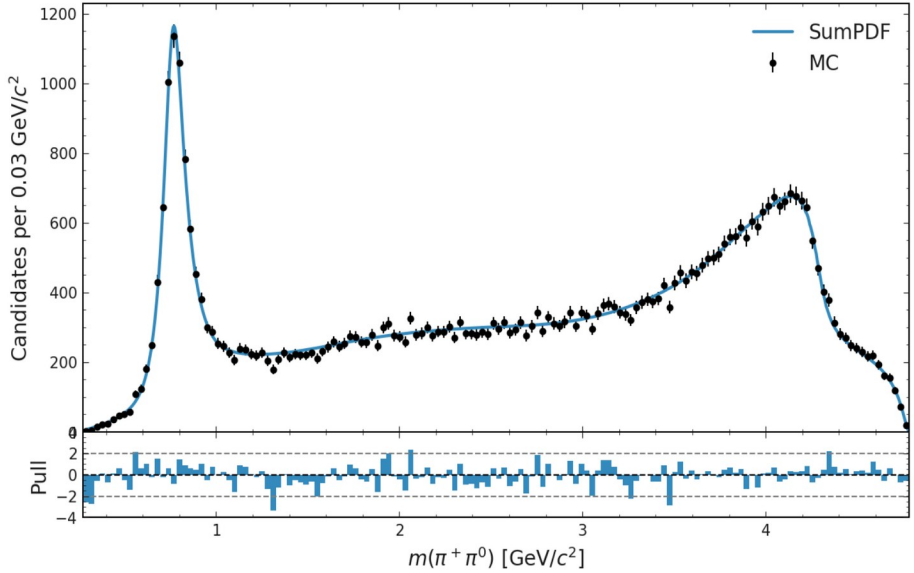
Signal MC Fit





Signal MC Fit





But: Resonances are not known a priori

Selection of Resonances

Goal: Find set of waves, which are significantly contributing to the data

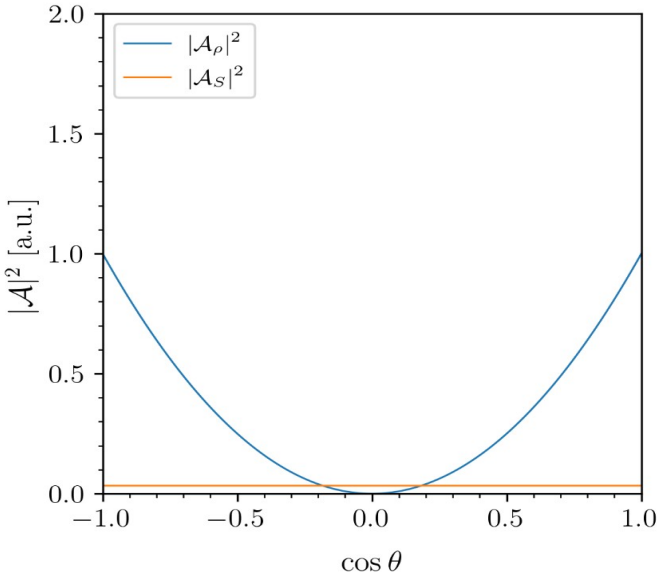
Using wrong resonances can cause dramatic shifts in the results due to interference

Two amplitudes
- $\rho(770)$: $\mathcal{A}_\rho$
- S-wave: $\mathcal{A}_S$

$|\mathcal{A}_S|^2/|\mathcal{A}_\rho|^2 = 0.1$

$\pi\pi$ helicity angle θ

Relative phase: ϕ



[Plots S. Wallner]

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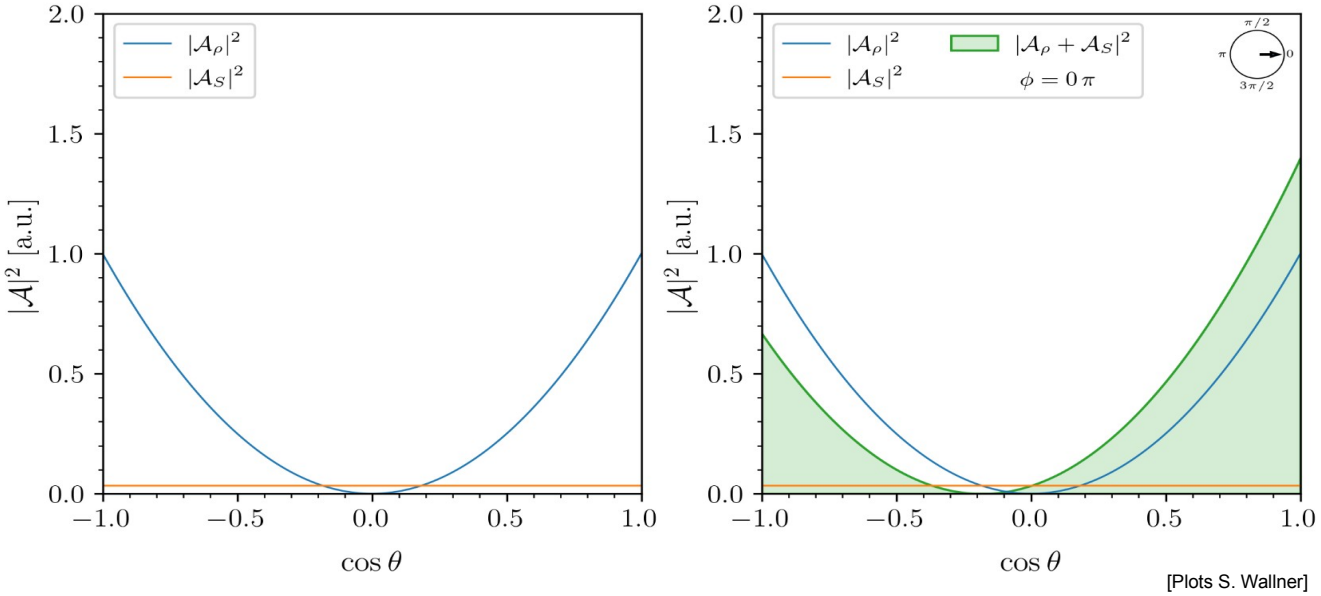


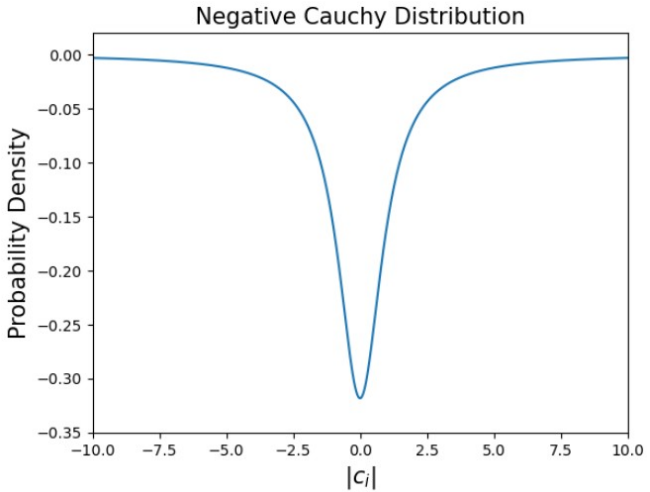
[Plots S. Wallner]

Strategy

1. Define pool of resonances:
   Select considered resonances using objective rule (depending on angular momentum or energies)
2. Suppress non-significant resonances:
   Add suppressing (Cauchy-) term for each resonance to the neg. likelihood

$$\mathcal{L}' = \mathcal{L} - \sum_i \left[1 + \frac{|c_i|^2}{\Gamma^2}\right]^{-1}$$

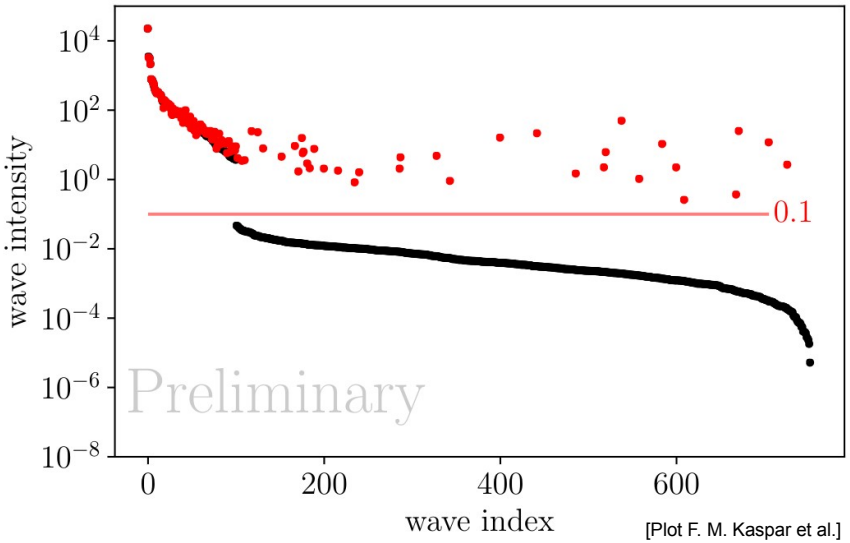
Low gradient for high resonance strength



Strategy

3. Select final resonance set:
   Define cut-off value based on distribution of resulting resonance-strengths

4. Perform final fit:
   Repeat fit with selected resonances but without Cauchy-term and extract final parameters



[Plot F. M. Kaspar et al.]

Summary and Conclusion

The Dalitz analysis of $B^+ \to K_S \pi^+ \pi^0$ complements the analysis on $B^0 \to K^+ \pi^- \pi^0$ and allows for a coherent measurement of $I_{K^*\pi}$ (direct test of the SM)

Currently, the full selection in this analysis is done and the fit framework is under development

Selection of used resonances is crucial for reliability of fit results and calculation of related uncertainties

→ The ongoing development of the analysis shows promising progress, and upon completion, it will mark a significant milestone for Belle II's transition to amplitude analyses.