Amplitude Analysis of $B^0 \longrightarrow K^+\pi^-\pi^0$ Decays

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Introduction

- Our goal: to extract branching ratios of the virtual particles and CP asymmetry
- Our method: Dalitz Plot analysis

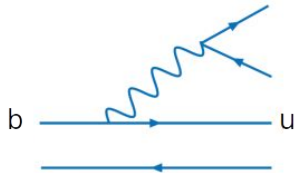
- Why charmless B-decays:
  - CKM suppressed on tree level
  - loop transitions are the dominating contributions
  - New Physics particles could appear as virtual particles in loops
  - small effects visible, because SM physics suppressed

- We study simulation generated data from Belle II

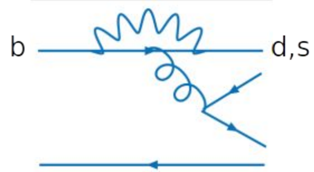
$$B^0 \longrightarrow K^+\pi^-\pi^0$$

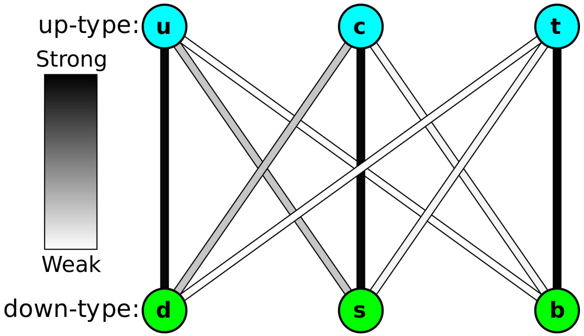
- need to transform: b→u, d, s

b→u tree transition



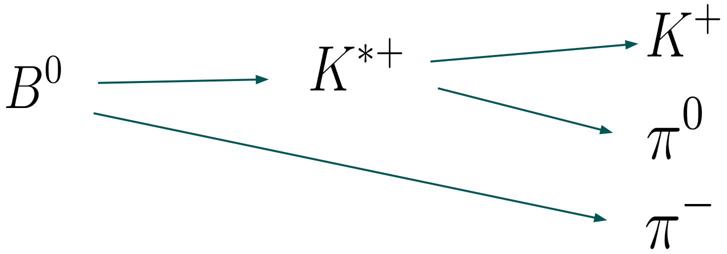
b→d, s loop transition





The Decay and the Resonances

- We use the isobar model to describe the 3 body decay
  - Isobar Model: within the Isobar Model one assumes that the B decay proceeds via an intermediate two-body resonance
  - i.e. we treat the system as two subsequent two-body decays
- Resonance: pull in the decay amplitude, describes particles with very short lifetimes or virtual particles



Resonances
$K^*(892)^0$ and $K^*(892)^+$
$\rho(770)^-$, $\rho(1450)^-$ and $\rho(1700)^-$
$(K\pi)_0^{*0}$ and $(K\pi)_0^{*+}$
non-resonant

The Dalitz Plot and How to Model It

The Amplitude for one resonance is given by:

$$A_i = L_i(J,x) \cdot T_i(J,x,y) \cdot B_i(J,x)$$

Line shape

Angular dependence

Angular momentum Barrier factor

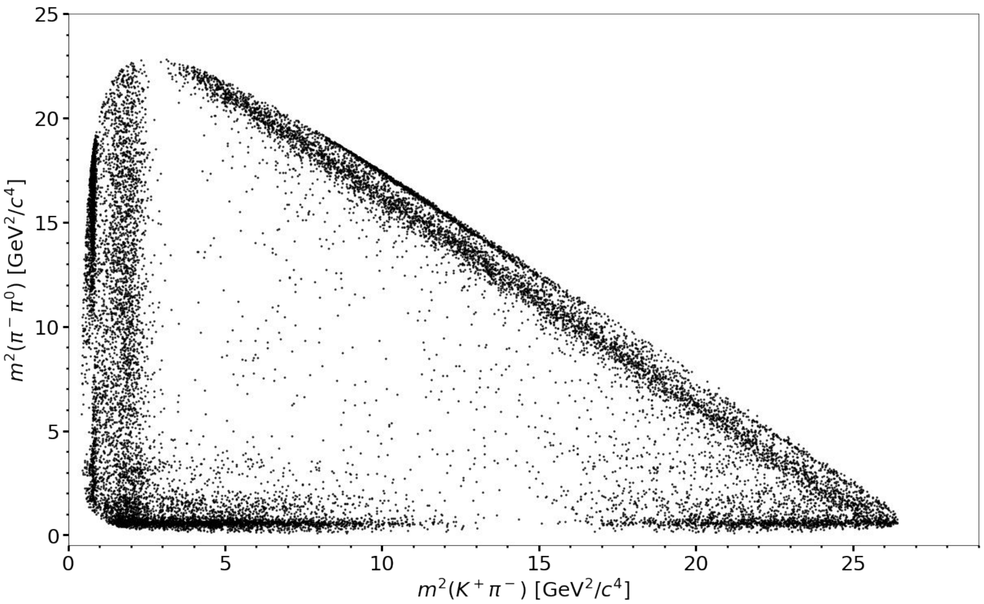
J: Angular momentum   x, y: invariant masses of the two body systems

The full Amplitude is then given by :

$$A = \sum_i c_i \cdot A_i$$

complex coefficient (amplitude and phase)
(This is what we want to determine!)
from the fit

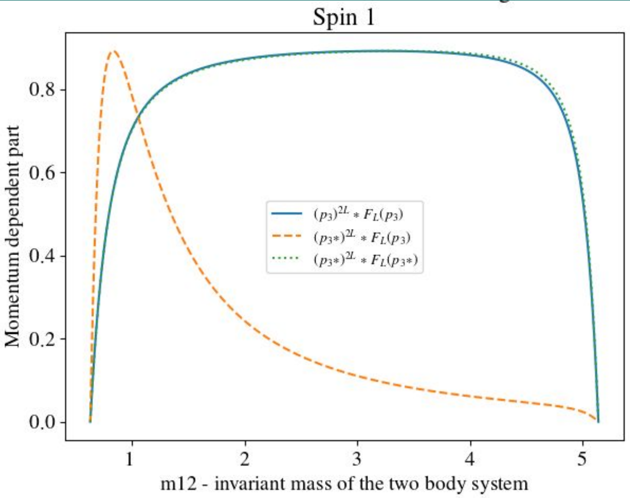
We fit the model to the data distributions

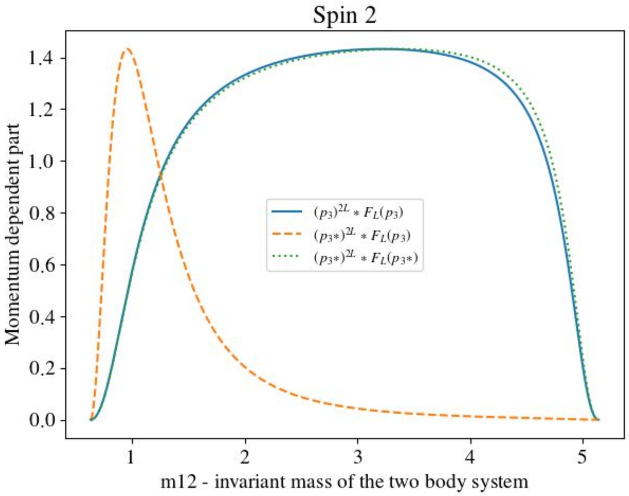


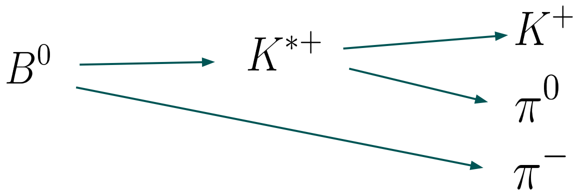
Example Dalitz plot with data from Belle II simulation

Model Parameters

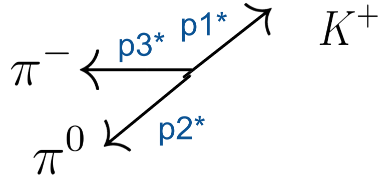
- Angular Momentum Barrier Factor:
  - $B_{iR} = |p_1^*|^L\sqrt{F_L(p_1^*)}$ $B_{iB} = |p_3|^L\sqrt{F_L(p_3)} or |p_3^*|^L\sqrt{F_L(p_3^?)}$
- $F_L(p)$: Blatt-Weisskopf compensation factors
  - compensate the high-energy behavior of the $|p^L|$ term
- Different formalisms suggest different momenta
- How to continue with the compensation factors?
  - $B_R^2 = |p_1^*|^{2L}F_L(p_1^*)$
  - $B_B^2 = |p_3|^{2L}F_L(p_3)$ $|p_3^*|^{2L}F_L(p_3)$ or $|p_3^*|^{2L}F_L(p_3^*)$
  - $B = B_R B_B$



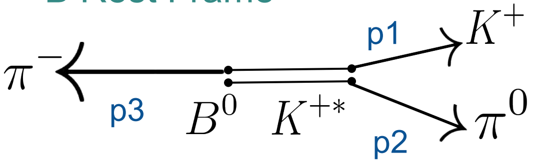




Isobar(e.g.K*+) Rest Frame



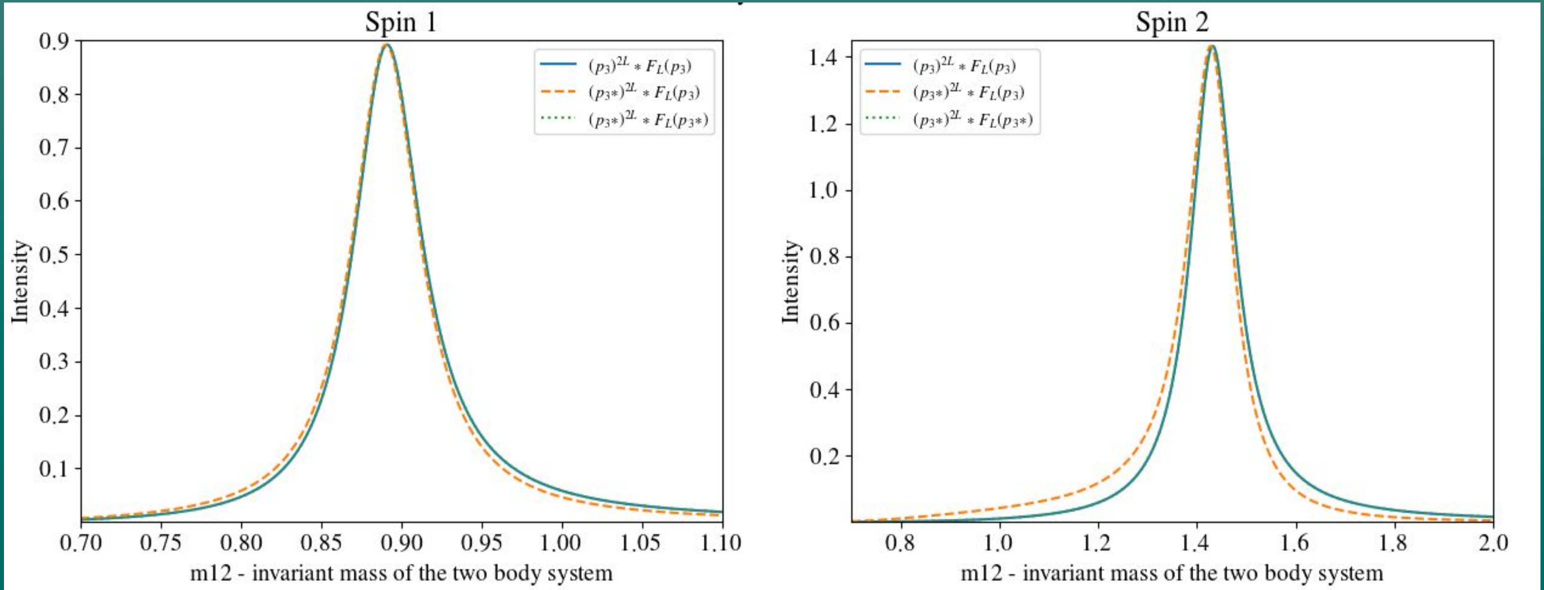
B Rest Frame



Intensity

- Does this difference in modelling affect the full amplitude?
- What we can measure are the intensities -> $I = |A|^2 = B^2 |L_i|^2 (p_1 p_3)$

Line Shape: here Breit Wigner as an example



- Using the same momentum for both factors gives similar shape
- Slight shift when using different momentums
- We need to be careful when writing the compensation factors
- If the resonance was broader, we could observe a larger effect.

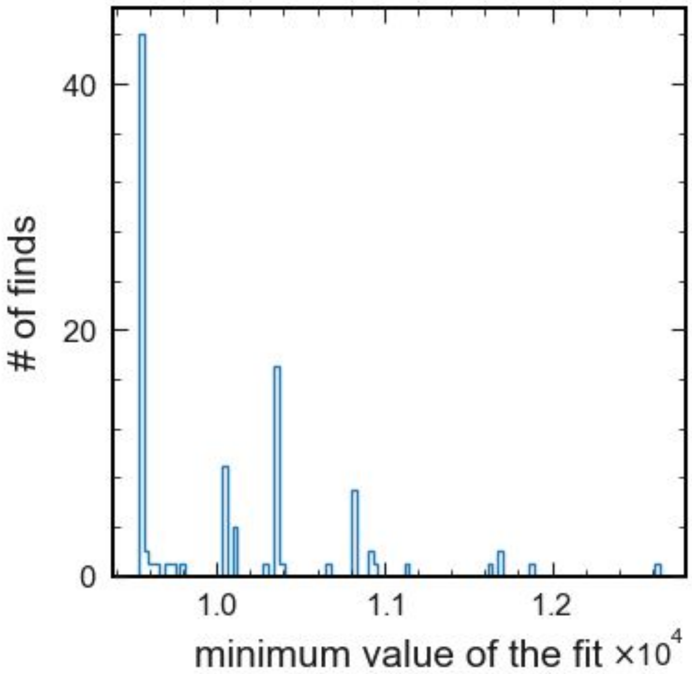
The Fit

- We fit the c_i to the data using an unbinned maximum-likelihood fit.
- We fit to signal-MC only (no background)

- Given how fitting works, we need to define the set of start parameters
- To study the dependence on the choice of start parameters, we perform multiple fits with random start parameters.

- The fitter seems to find the same minimum ~45% of the time

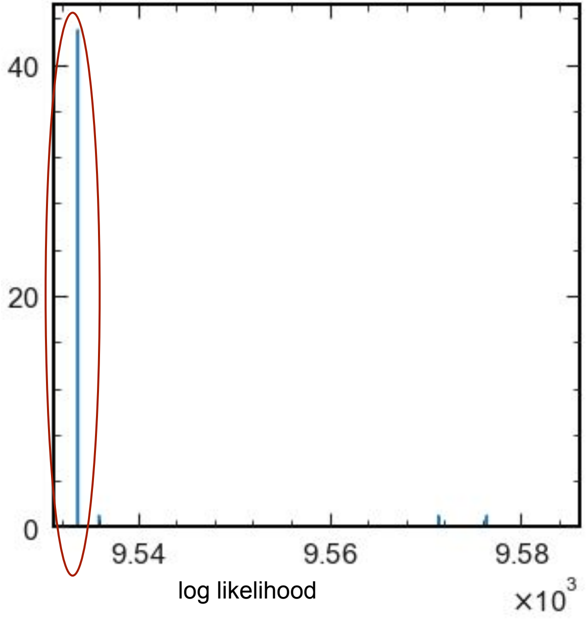
Histogram of the minimum value of the fit

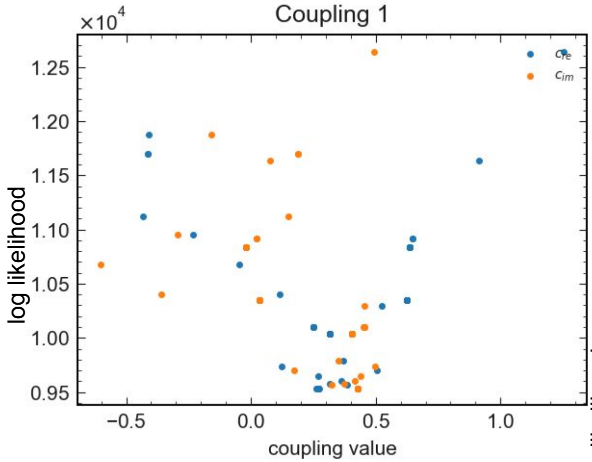


showing 100 fit attempts

Dependence on start values

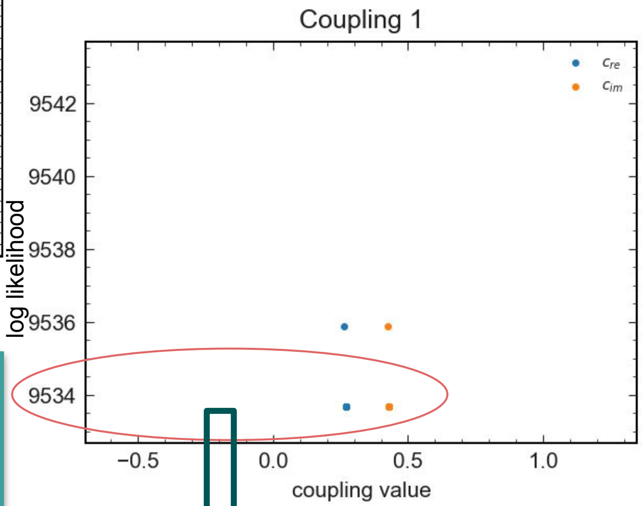
- We also investigate if the value of the couplings fitted are consistent





While the values seems to be scattered for the general fit, we see that they are indeed consistent for the lowest minima!

log likelihood



There are around 40 couplings at this value

Summary

- ❖ Studied barrier factors in different reference frames
- ❖ Investigated which reference frames to choose for the parameters of the Blatt-Weisskopf factors
- ❖ Studied dependence on start values:
  - ➢ the fit yields the same minimum in a reasonable amount of fit attempts
  - ➢ the couplings the fit gives are the same for the lowest minima

Outlook

- ➢ Testing parametrization for different partial wave models
- ➢ Inclusion of background
- ➢ Fitting model to real data
- ➢ Calculating branching ratios and CP asymmetry

Thanks for listening!