

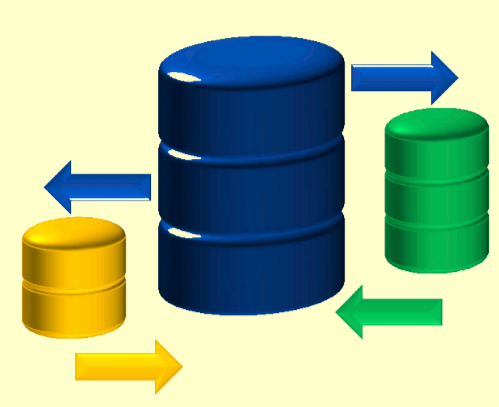
# Common Partial Wave Analysis Framework

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## CompPWA

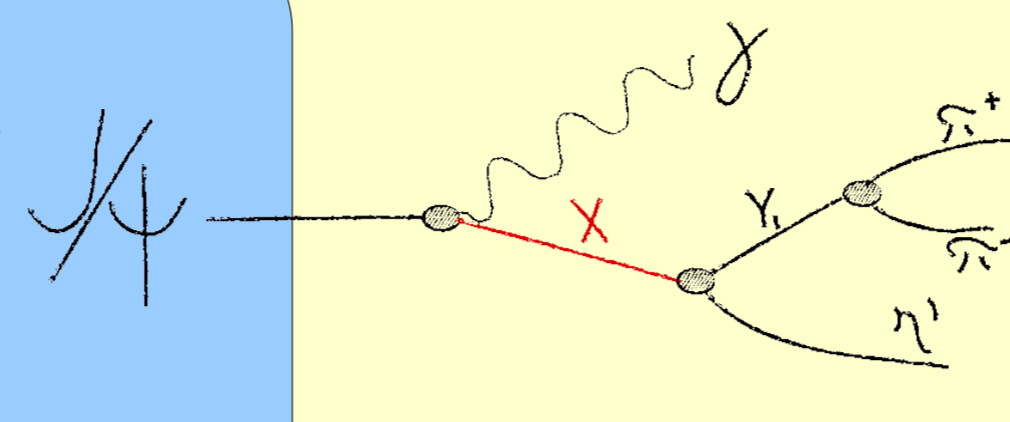


## Data

represents measurements  
local and global values  
multiple experiments  
caching

## Physics

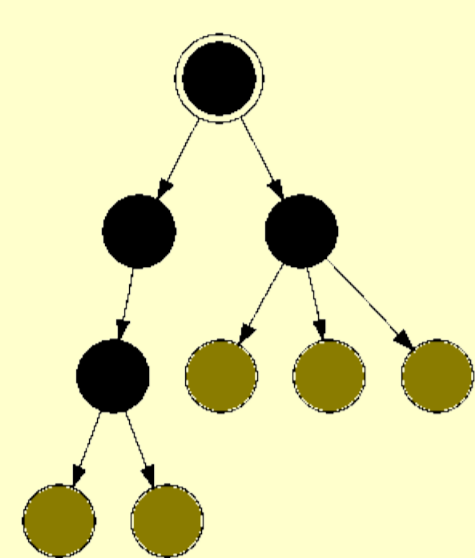
calculates amplitudes  
various formalisms  
various models  
simple ways to add modules



event weight amplitude

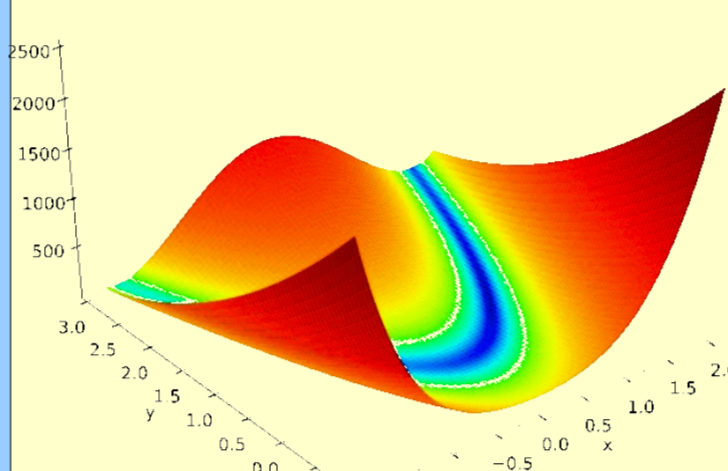
## Estimator

calculates discrepancy from model to data  
Function Tree  
combined fits and re-fits  
documentation of procedure



## Optimizer

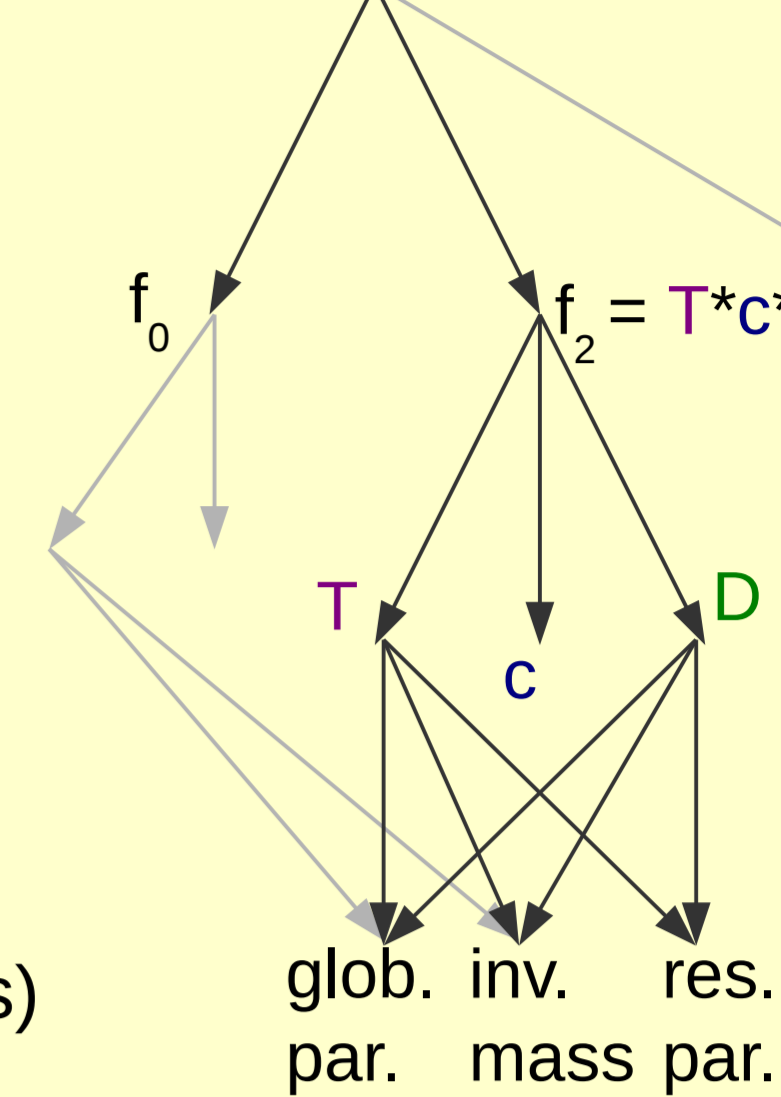
varies model parameter  
interface to external libraries  
various algorithms  
flexible strategies



## Function Tree

- Caching of calculated amplitude independent from model
- Speedup depends on amplitude, parameters and optimizer
- Complex decay  $\Rightarrow$  large tree  $\Rightarrow$  increased speedup by caching

$$A = \sum (T^* c^* D)$$



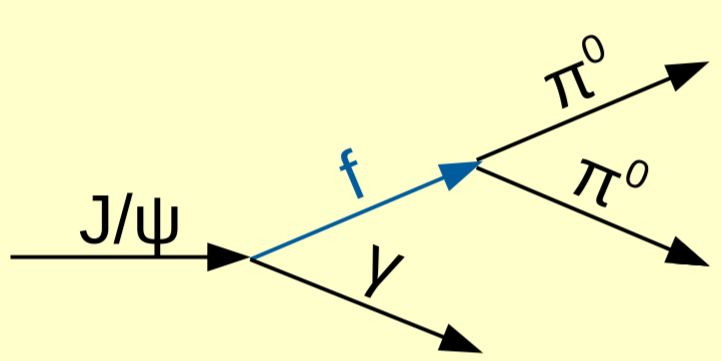
Test Case:

- 100 000  $J/\psi \rightarrow \gamma \pi^0 \pi^0$  Events
- 7 resonances (Breit-Wigner amplitudes)
- Average of several Dalitz plot fits

Scenario (optimized parameter)	CPU time per iteration without tree	CPU time per iteration with tree	Speedup
1 Intensity	29.96 s	0.57 s	>50
5 Intensities	47.74 s	1.65 s	>25
5 BW-Widths	44.19 s	5.01 s	>8

## Model Independent Extraction of Scalar Wave in $J/\psi \rightarrow \gamma \pi^0 \pi^0$

### $J/\psi \rightarrow \gamma \pi^0 \pi^0$ Generator



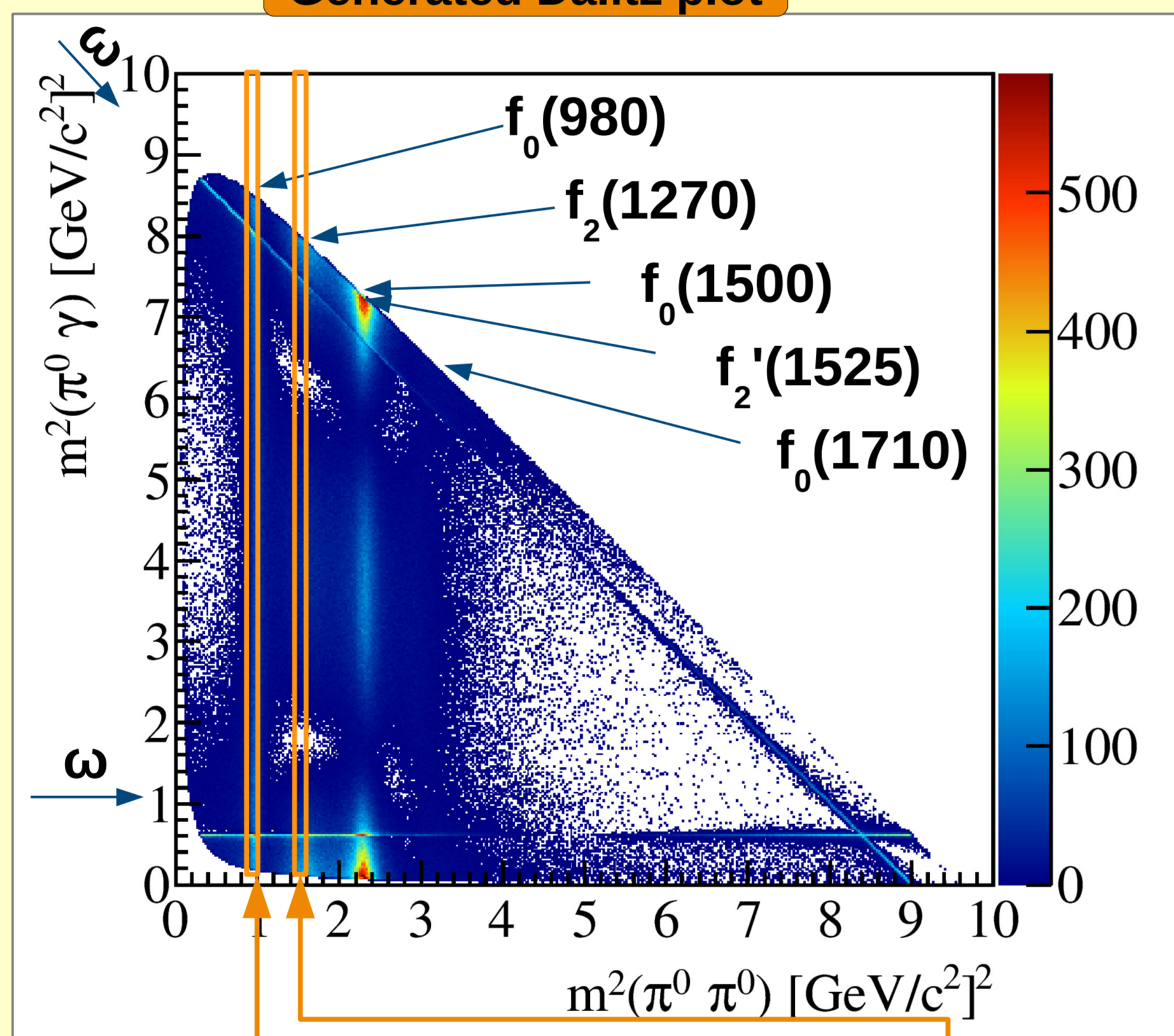
Simple Breit-Wigner sum model

$$I = \left| \sum_n T_n r_n e^{i\phi_n} D_n \right|^2$$

T = Breit-Wigner function  
D = D-Wigner function  
r = strength of resonance  
 $\phi$  = phase of resonance

Generated via hit & miss Monte Carlo sampling

### Generated Dalitz plot



### Fit to Slices

Angular distribution of  $\pi^0 \pi^0$ -resonances visible in conjugate invariant mass

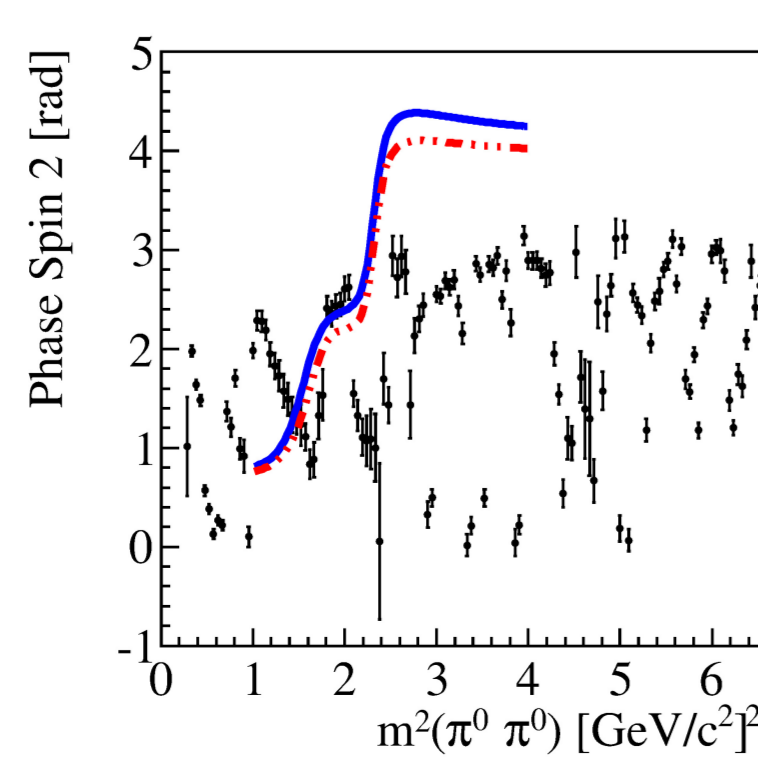
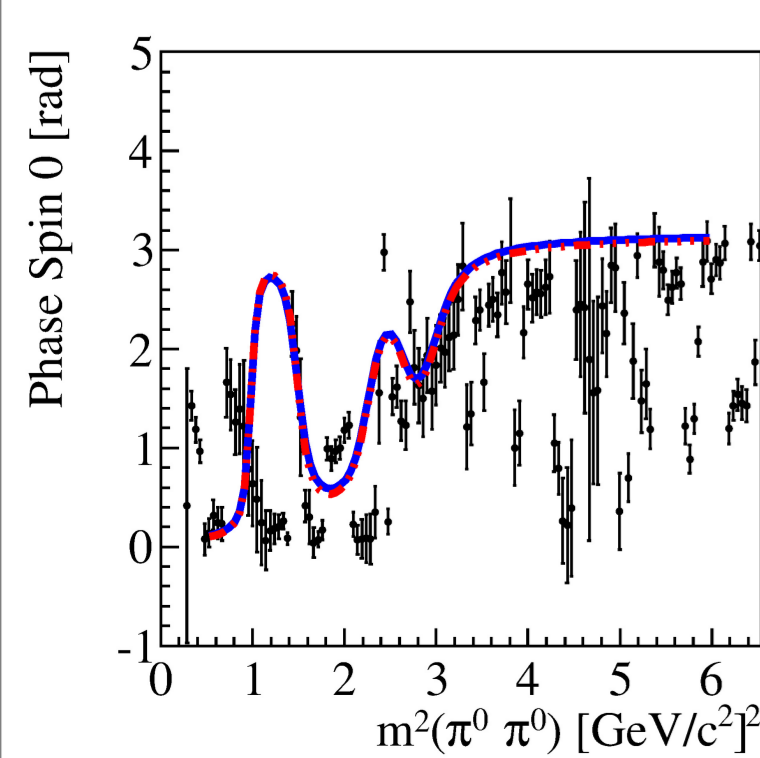
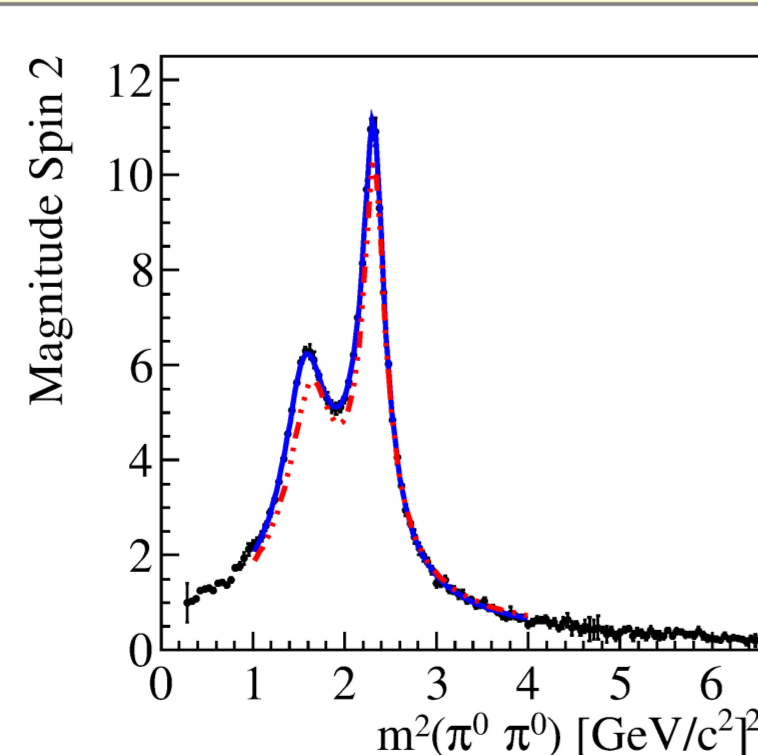
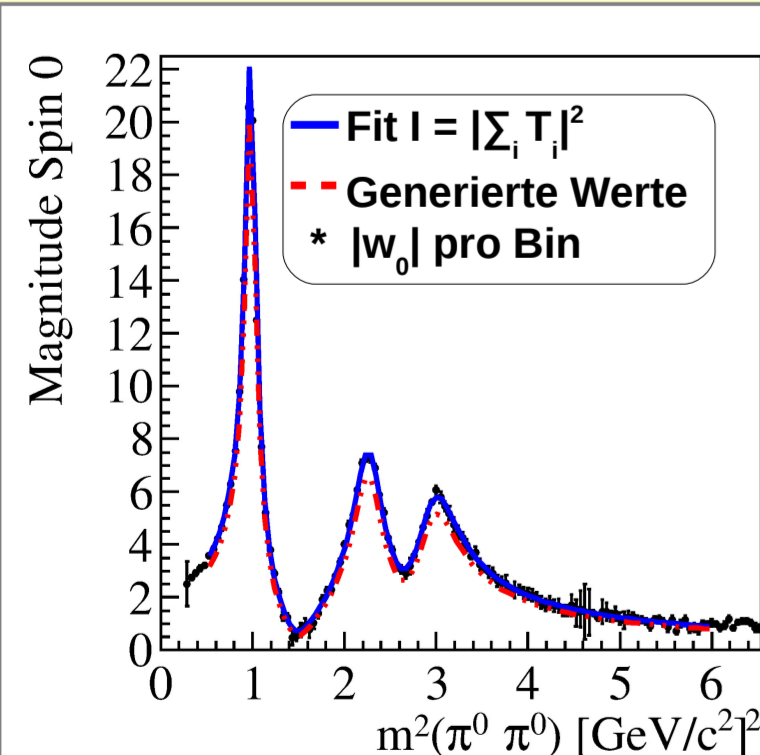
$\Rightarrow$  1D model to extract dynamics of resonances in  $\pi^0 \pi^0$ -channel

$$I = \left| T_\omega w_\omega D_\omega + w_0 D_0 + w_2 D_2 \right|^2$$

$\omega$  model  
0<sup>++</sup> wave  
2<sup>++</sup> wave

Independent fit of complex  $w_0$  &  $w_2$  to all slices

### Extracted Waves



- $\Rightarrow$  Clearly separated by spin
- $\Rightarrow$  Phasemotion visible
- $\Rightarrow$  Easy to identify resonances

### Results

- Parameter extracted with high accuracy
- Binned and unbinned fit in slices tested
- Systematic effects understood
- Interference with  $\omega$  resonance not suitable as reference phase

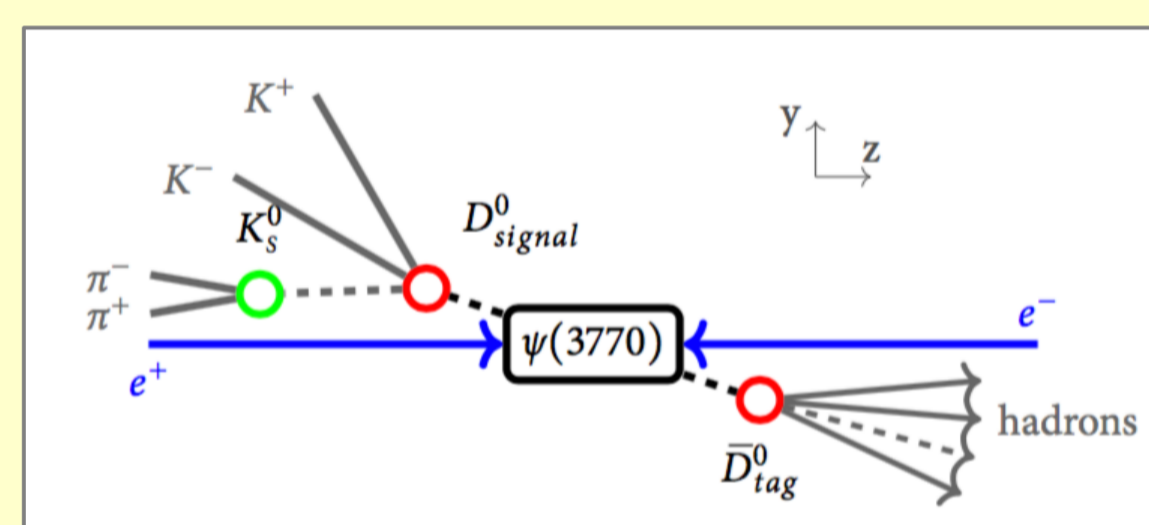
### Outlook

- Analysis of experimental data
- Survey of other suitable channels

## $D^0 \rightarrow K_s^0 K^+ K^-$ Dalitz Plot Fit

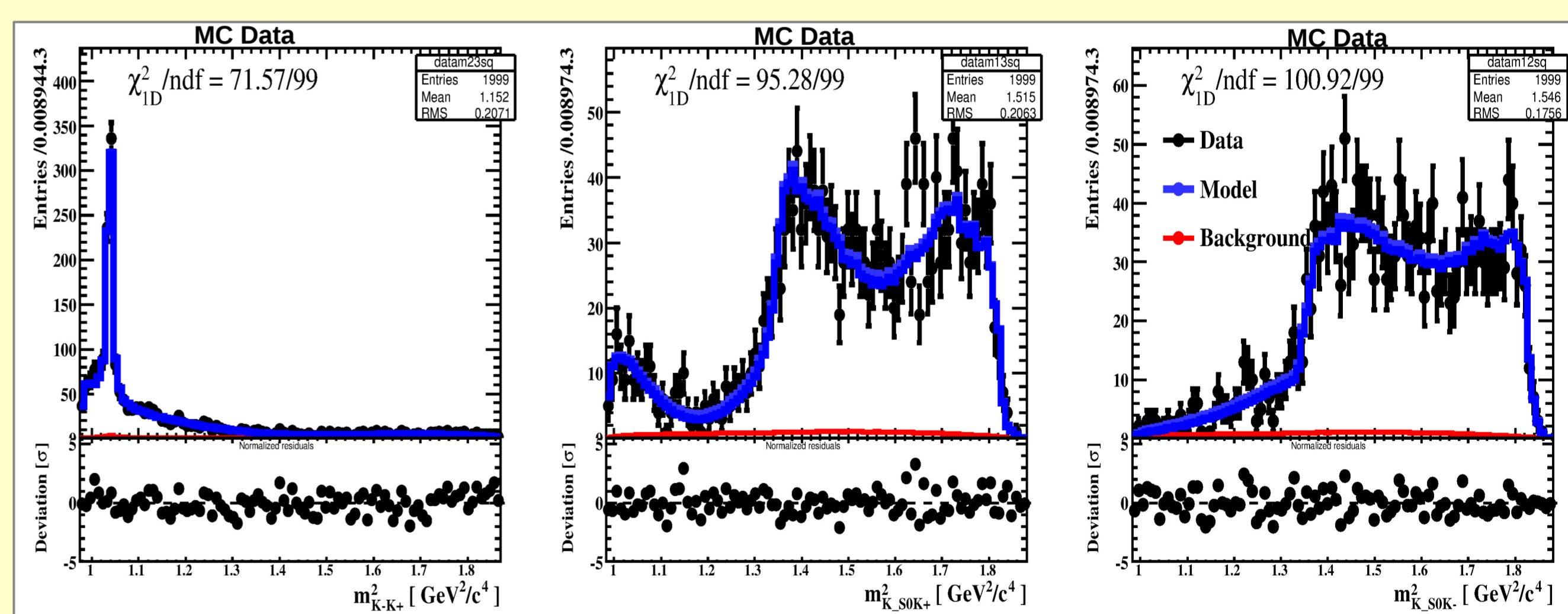
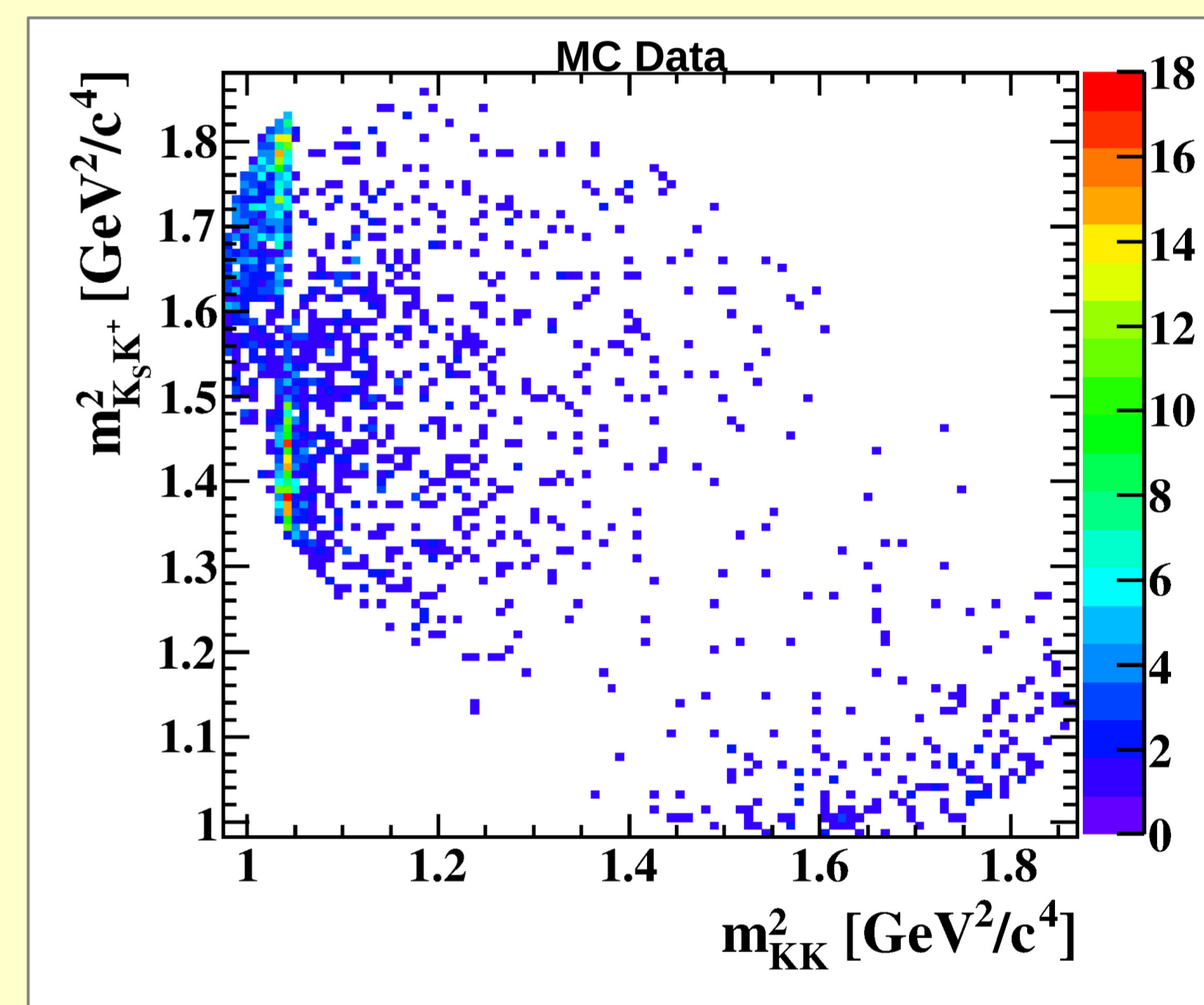
PhD thesis by Peter Weidenkaff for the BESIII collaboration

- Isobar amplitude model using Breit-Wigner and Flatté description
- Unbinned efficiency correction
- Background modeled and fitted



$\Rightarrow$  Fit fraction of four resonances and  $a_0(980)$  coupling to  $K^+ K^-$  determined

$\Rightarrow$  First real-world application for CompPWA successfully completed with great input for further CompPWA developments



## Summary

CompPWA is a multi-purpose amplitude analysis framework including general tools for efficient fitting and parallelization

Core functionality ready, user interface and fit documentation need further development

Used already for BESIII analyses

Modular design allows special analysis methods

Helicity formalism amplitude-generator in preparation by Stefan Pflüger (with configuration via Clips expert systems)

The next analyses and more physics modules will enliven the further development of the framework

<https://github.com/CompPWA/CompPWA>

