ComPWA
A Common Partial Wave Analysis Framework for PANDA

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On behalf of the ComPWA group

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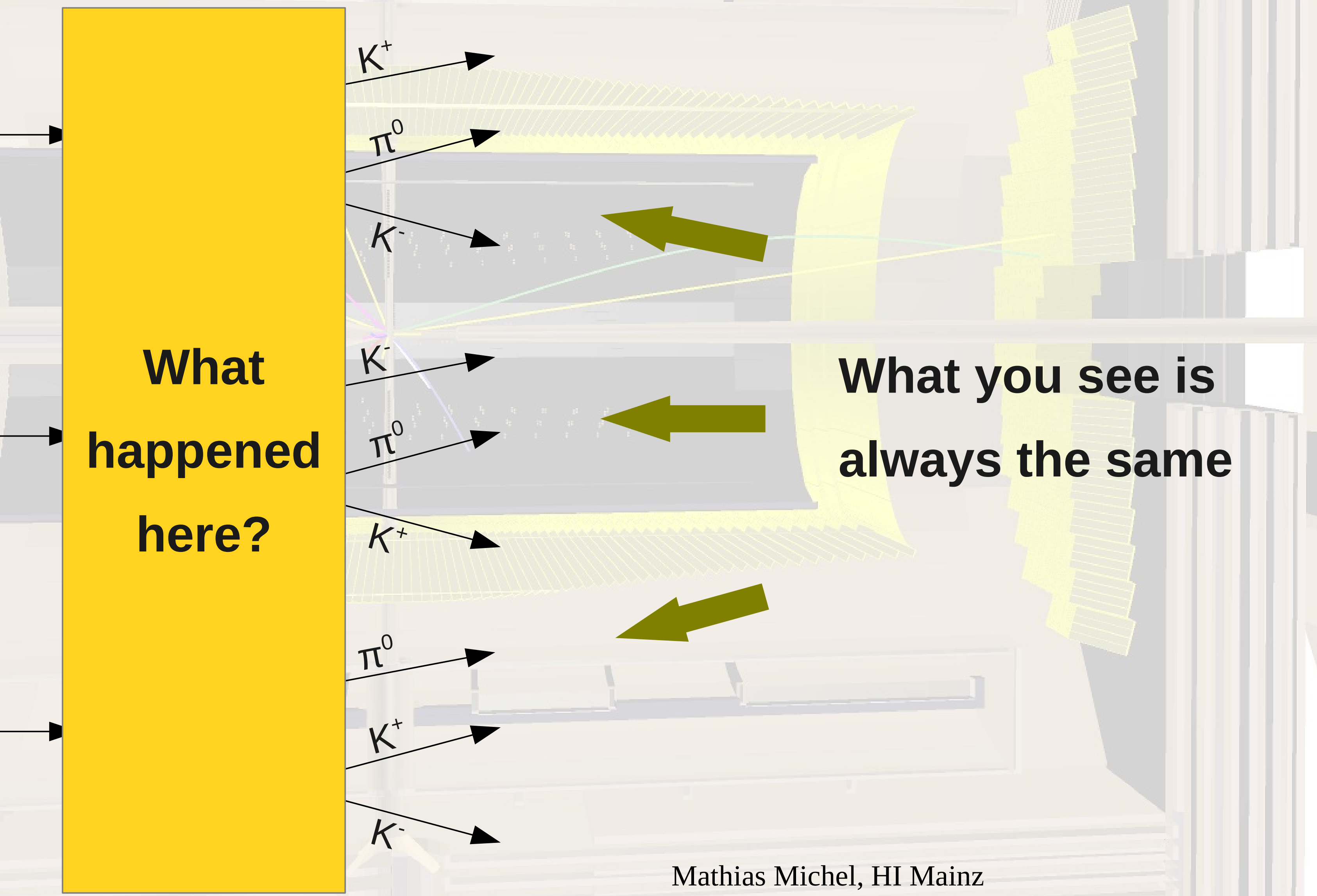
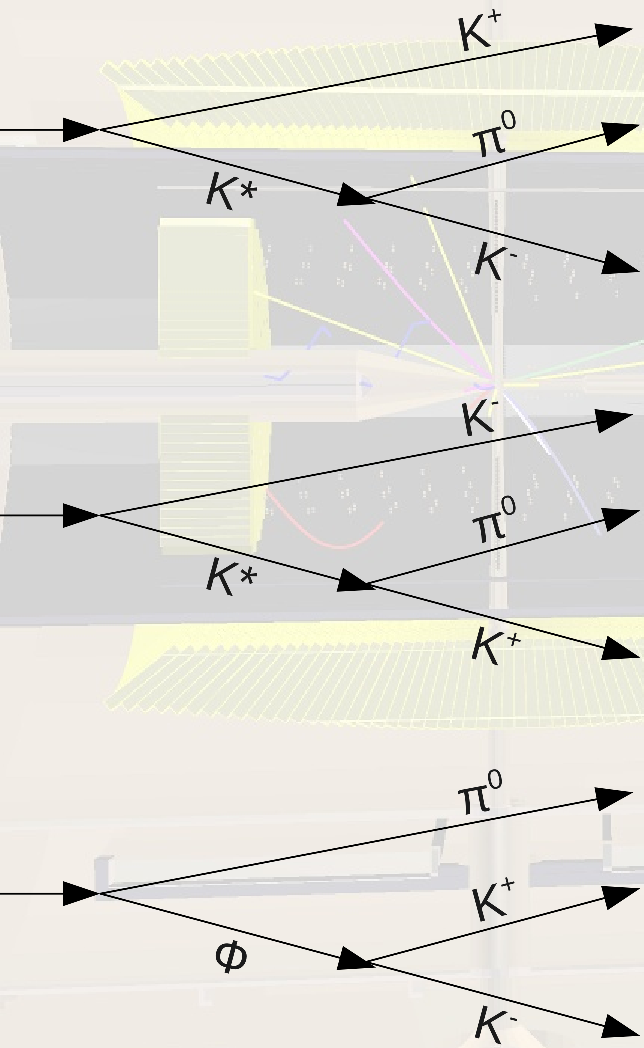
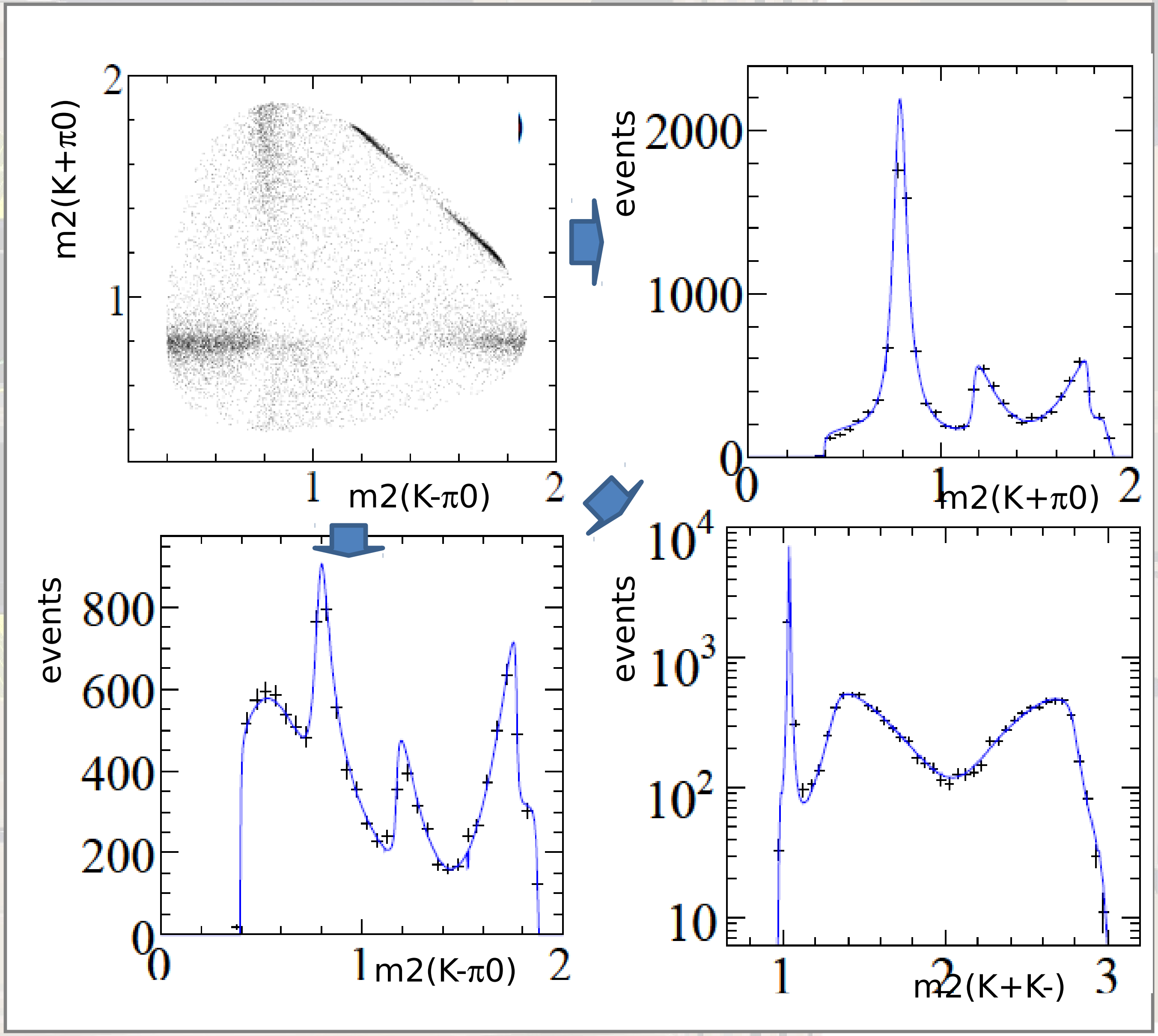
Hadron Spectroscopy

understanding how hadrons are built

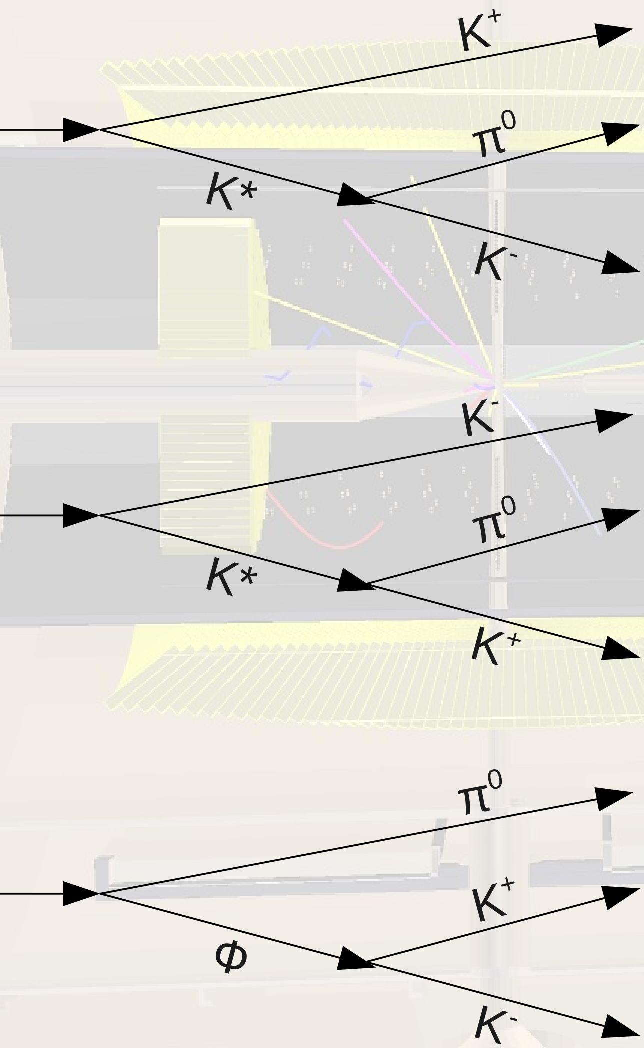


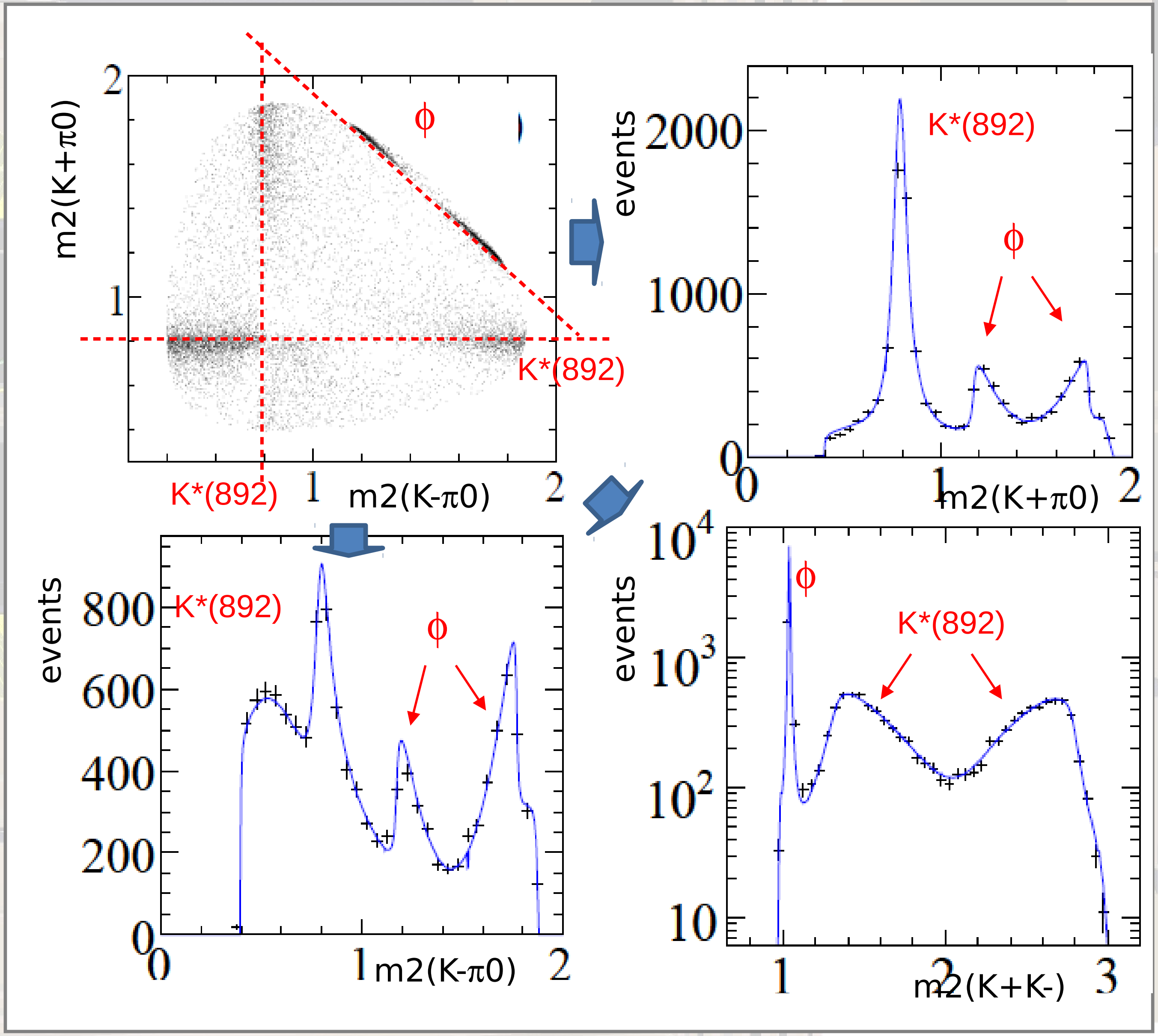
Resonances


K+
π0
K*
K-
K-
π0
K*
K+
π0
K+
φ
K-

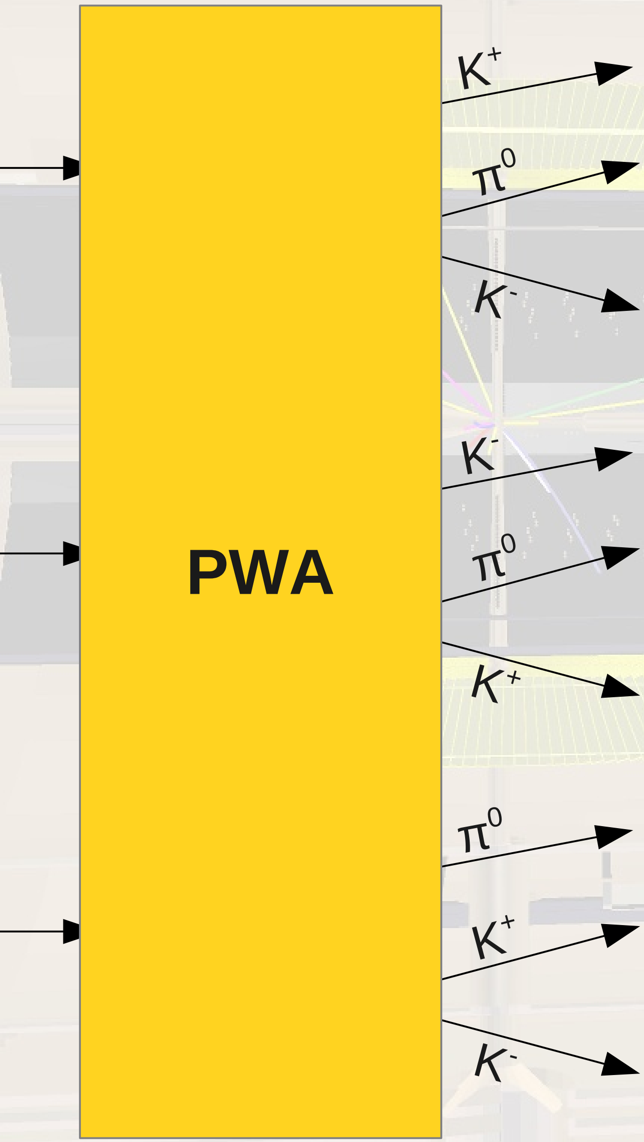

m2(K+π0)
m2(K-π0)
events
m2(K+π0)
events
m2(K-π0)
events
m2(K+K-)

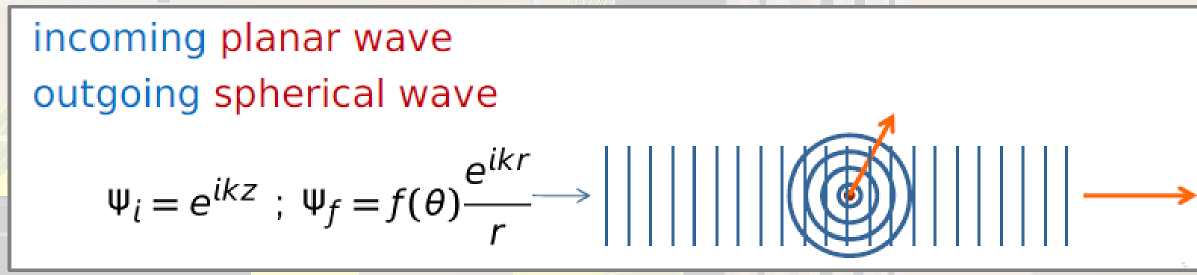
Resonances


K+
π0
K*
K-
K-
π0
K*
K+
π0
K+
ϕ
K-


m2(K+π0)
m2(K-π0)
ϕ
K*(892)
K*(892)
events
K*(892)
ϕ
m2(K+π0)
events
K*(892)
ϕ
m2(K-π0)
events
ϕ
K*(892)
m2(K+K-)

Amplitude Analysis





Example: partial waves for inelastic scattering

The measured cross-section relates to the scattering matrix

$$\frac{d\Omega}{d\theta} = \left|(f(\theta))^2\right|$$

Compose planar wave in terms of partial waves with given l

$$e^{ikr\cos(\theta)} = \sum_l (2l+1)\, i^l\, j_l(kr)\, P_l(\cos\theta)$$

Calculating the scattered wave (outgoing - incoming)

$$f(\theta) = \frac{1}{k}\sum_l (2l+1)\frac{\eta_l e^{2i\delta_l} - 1}{2l} P_l(\cos\theta)$$

ComPWA Challenges

$\bar{P}$ANDA physics program
→ various models needed

$\bar{p}p$ initial state at 1.5 – 15 GeV/c
→ high initial spin (≈ up to 6-7)
→ many possible waves
→ many parameters

High statistics
→ parallelization needed

Detector effects
→ distorted phasespace

Coupled channels
→ different efficiencies

Quality assurance

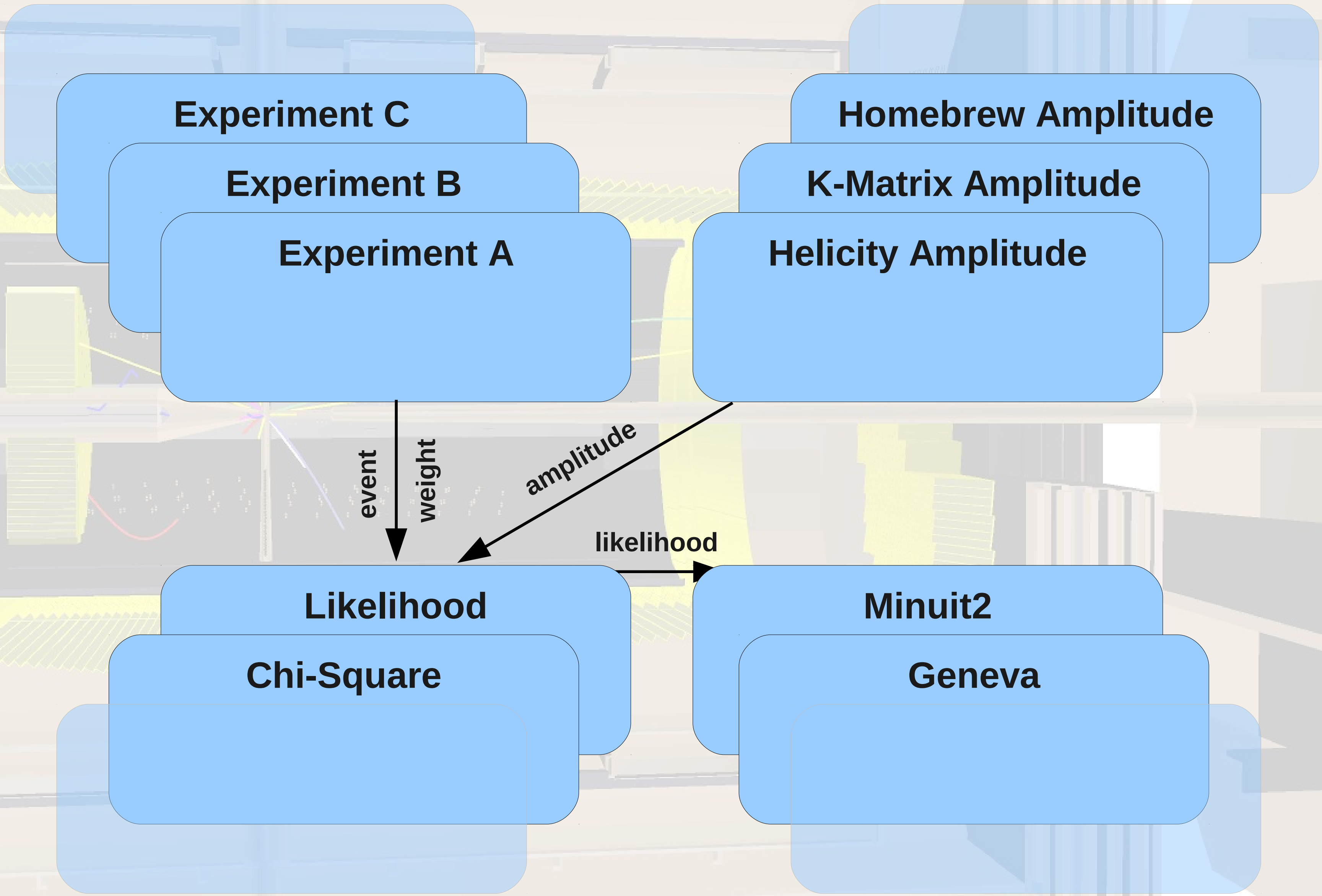
Why a *common* framework?

PWA tools on the market are specialised
→ not extendible to PANDA

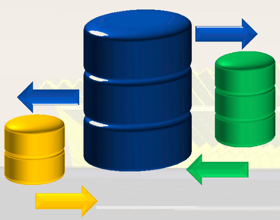
PANDA is still years from data taking
→ start now and we could have a well tested and reliable software ready

comparison of results from different experiments possible

ComPWA Framework



ComPWA Framework



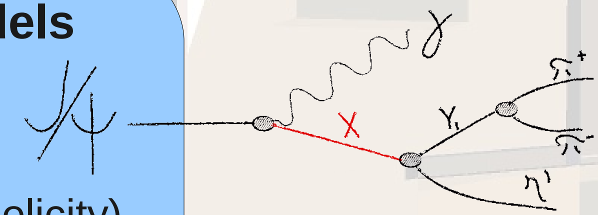
Data & MC

represents measurements

- local and global values
- multiple experiments (at once)
- **caching**

Physics & Models

calculates amplitudes



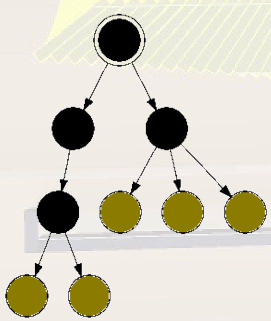
- various formalisms (helicity)
- various models (isobar)
- simple ways to add new modules (wrapper)

event

weight

amplitude

likelihood



Estimators

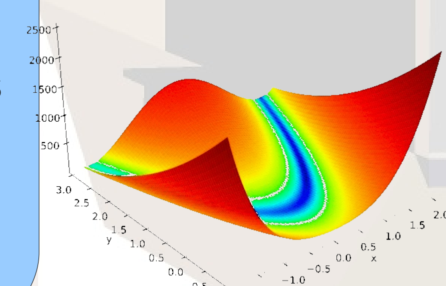
calculates discrepancy from model to data

- **functiontree**
- combined fits and re-fits
- documentation of procedure

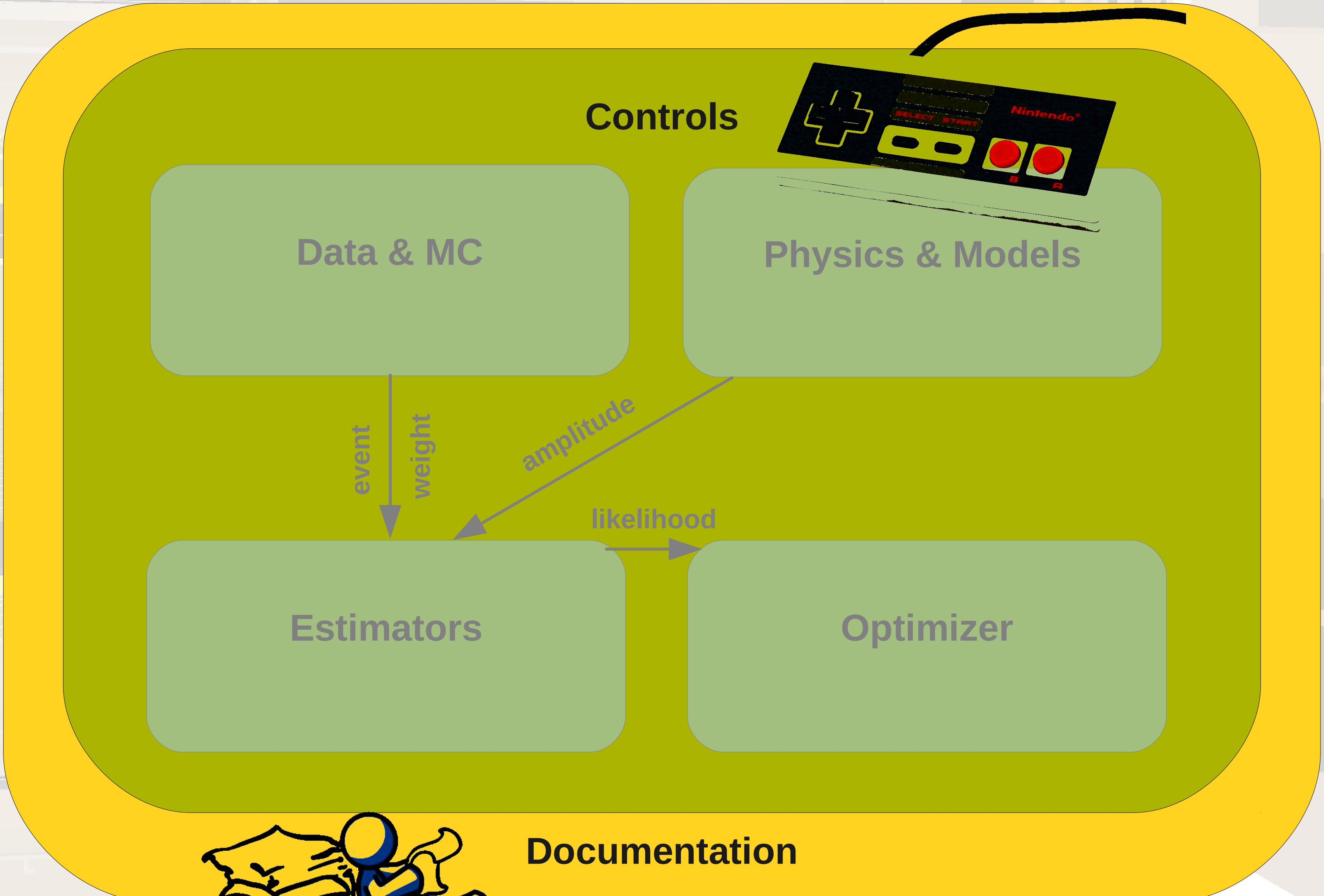
Optimizer

varies model parameter

- interface to **external** libraries
- various algorithms (gradient decent, genetic, swarm)
- flexible strategies



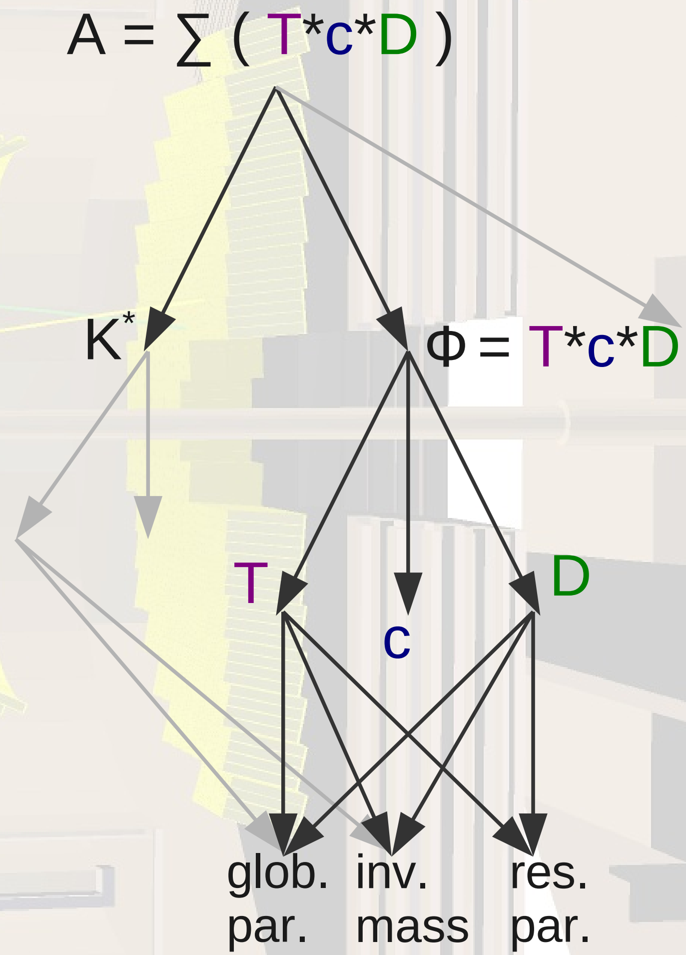
ComPWA Framework



FunctionTree

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

T = Breit-Wigner Function
D = D-Wigner Function
r = Strength of Resonance
φ = Phase of Resonance



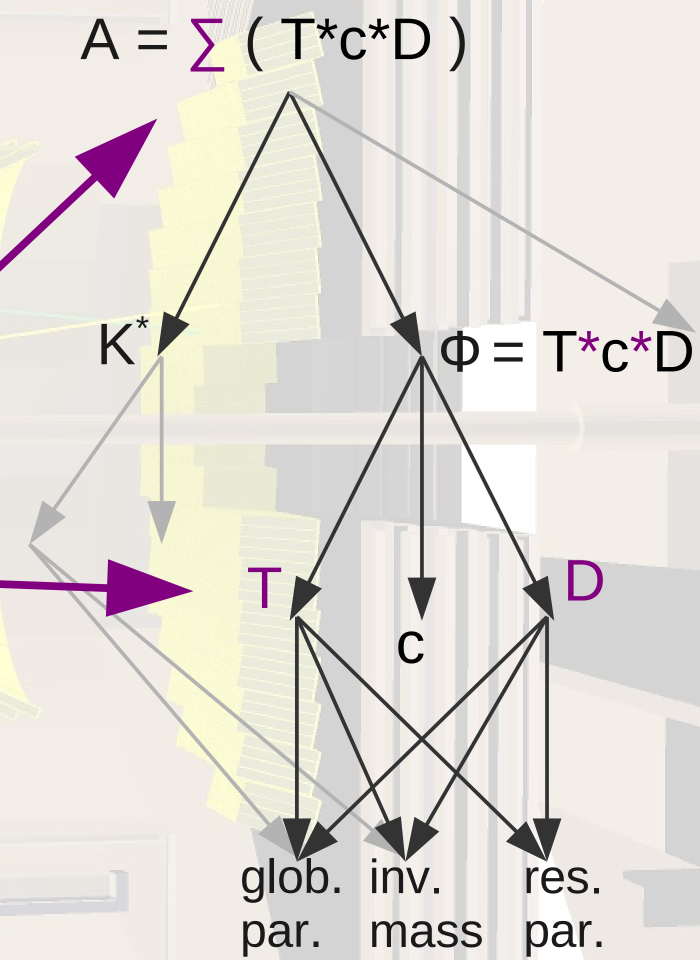
FunctionTree: **Strategies**

Node

List of parents
List of children
My parameter
Strategy

Strategy pattern

execute function
input:
parameter list (children)
output:
calculated parameter

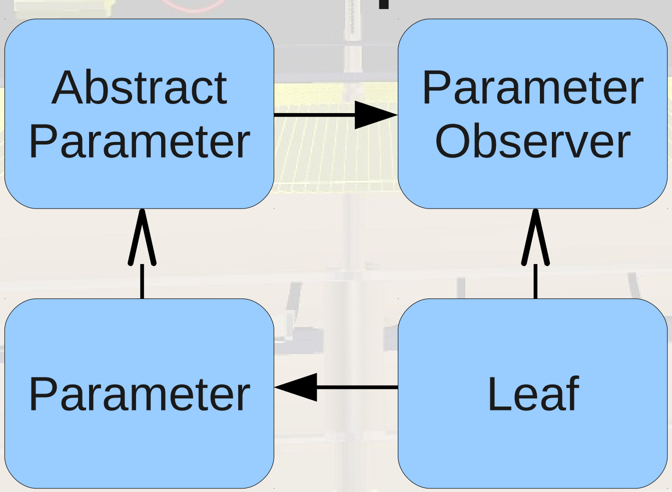


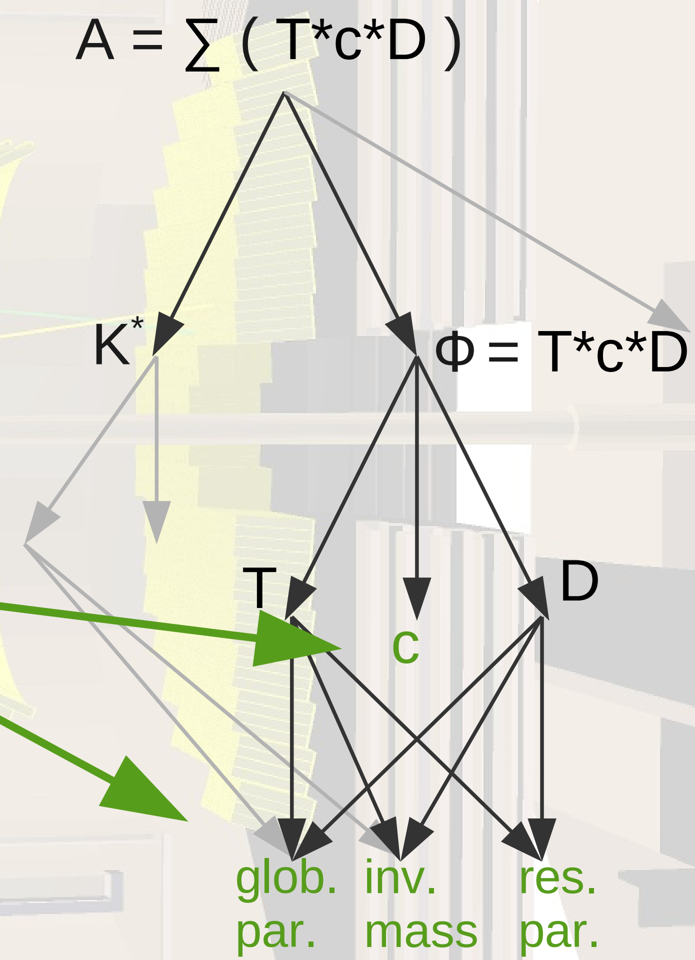
FunctionTree: Parameters

Leaf

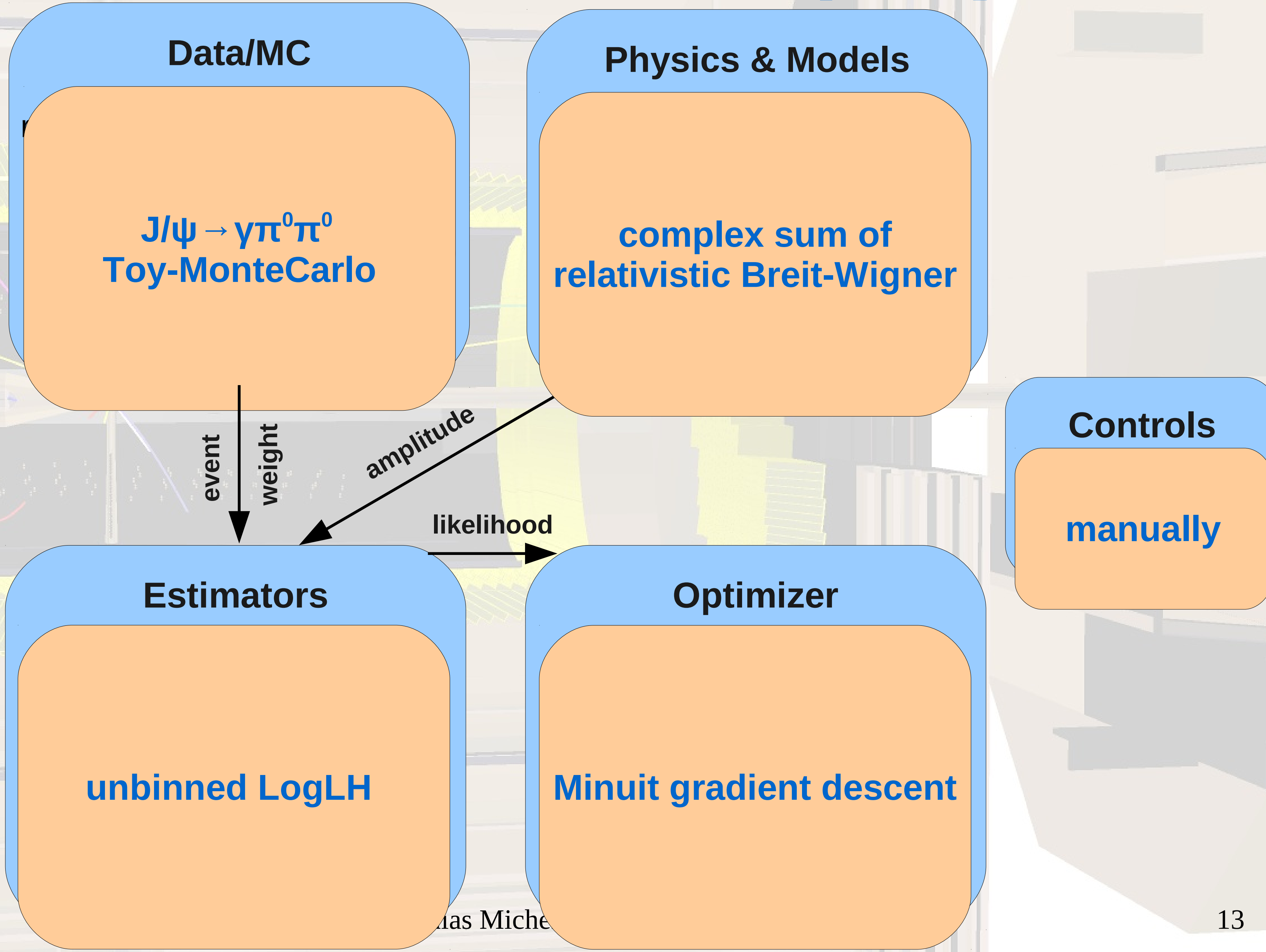
- List of parents
- ~~List of children~~
- **My Parameter**
- ~~Strategy~~

Observer pattern

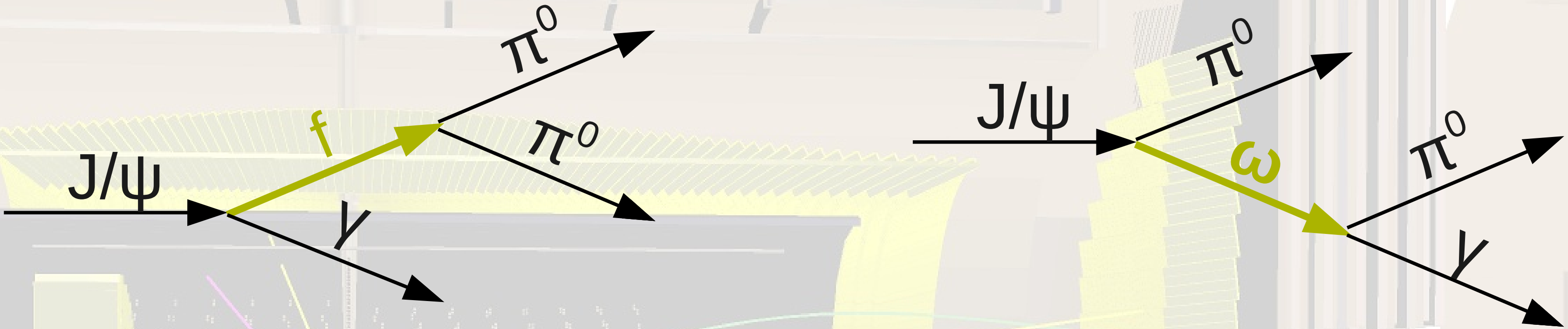




Test Environment: $J/\psi \rightarrow \gamma\pi^0\pi^0$



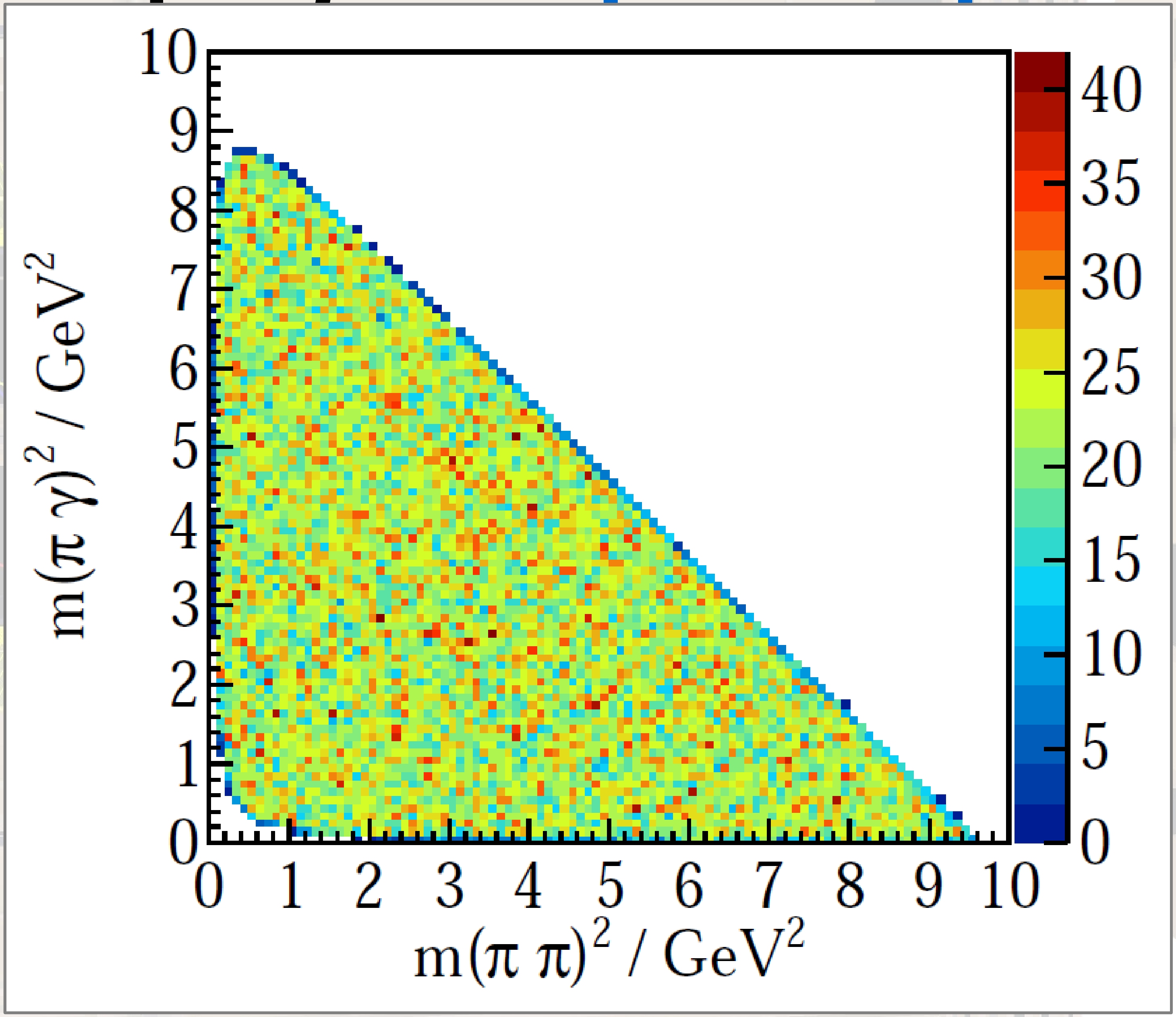
$J/\psi \rightarrow \gamma\pi^0\pi^0$ Model



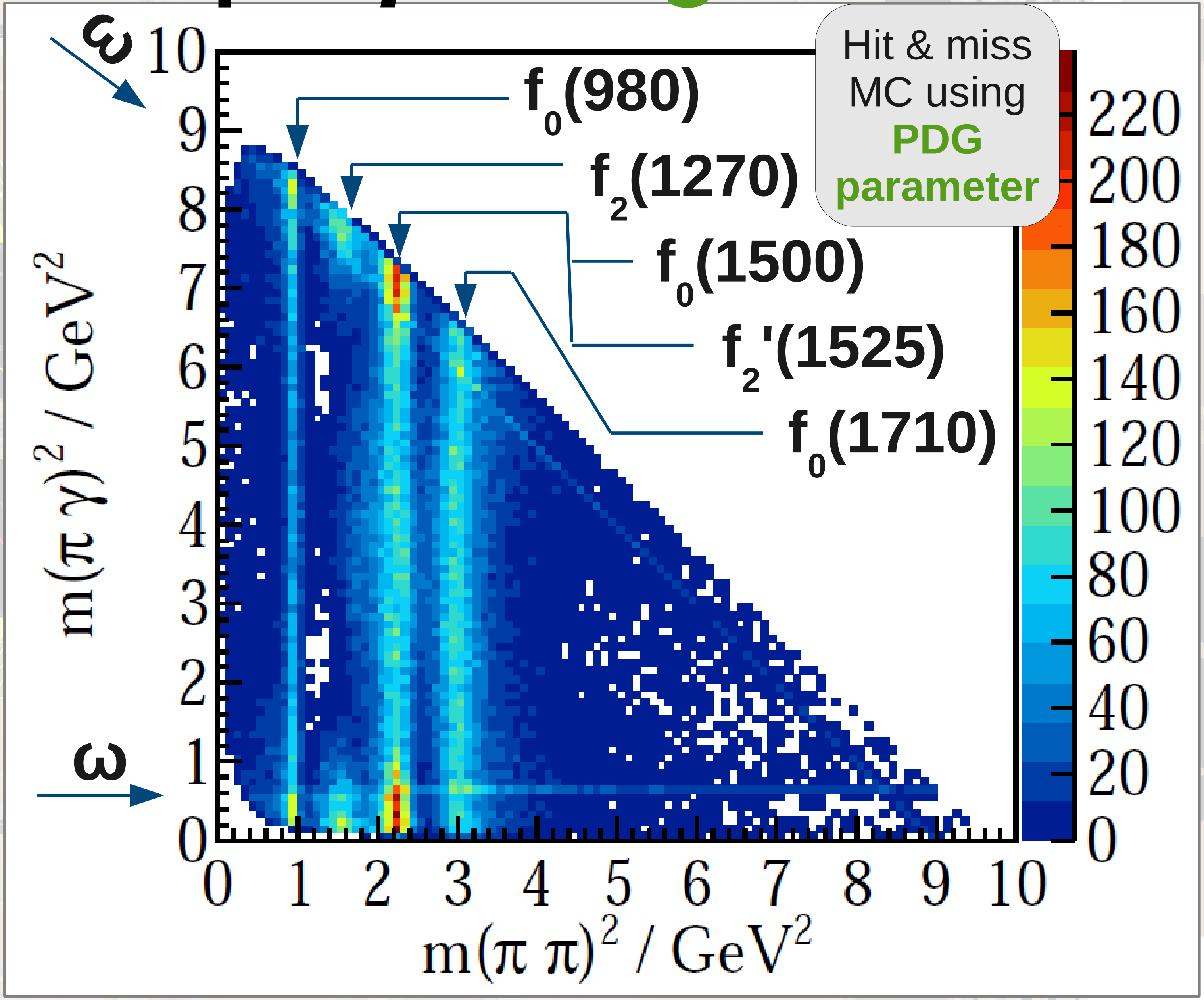
$$I = \left| \sum_n T_n r_n \mathrm{e}^{i\varphi_n} D_n \right|^2$$

T = Breit-Wigner Function
D = D-Wigner Function
r = Strength of Resonance
φ = Phase of Resonance

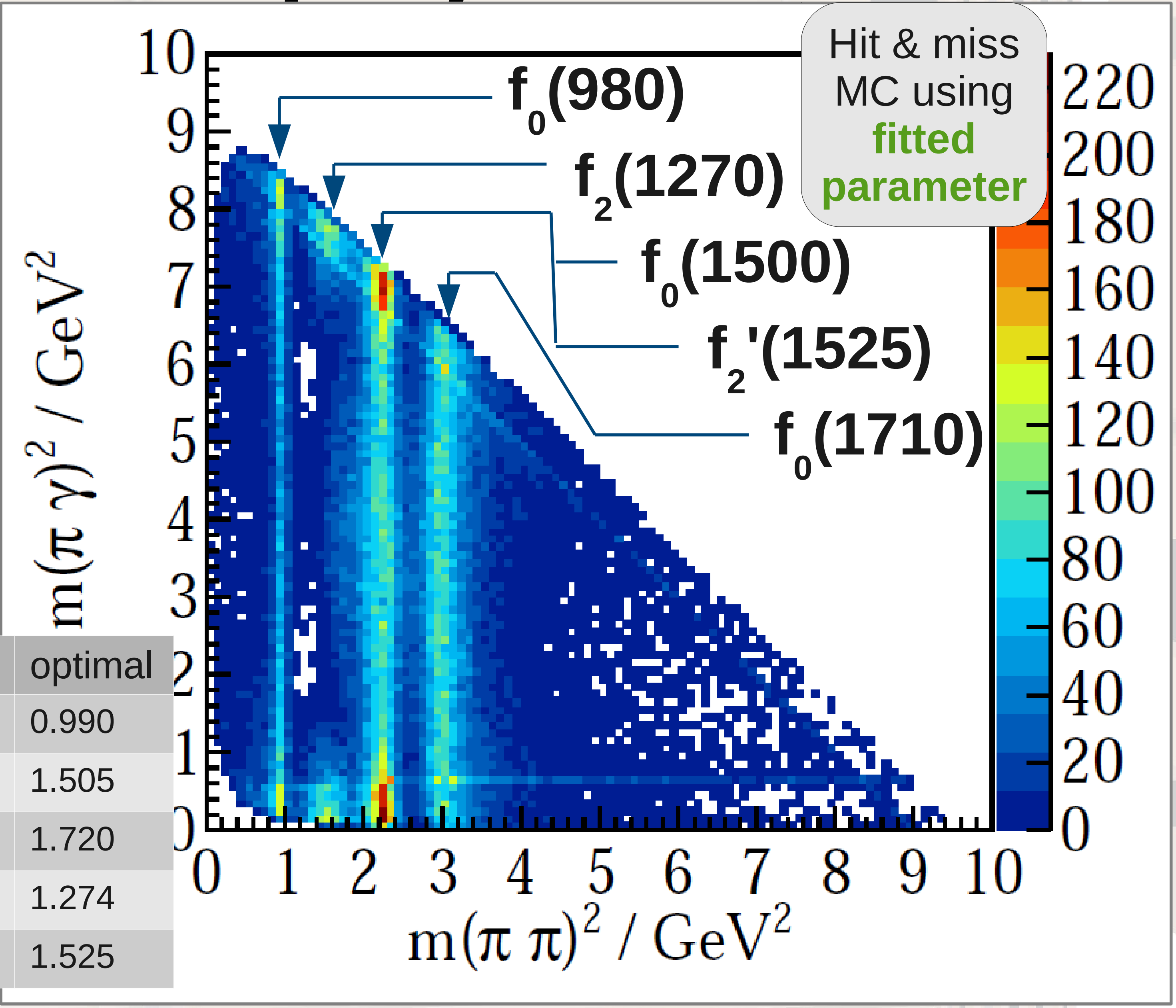
$J/\psi \rightarrow \gamma\pi^0\pi^0$ phasespace



$J/\psi \rightarrow \gamma\pi^0\pi^0$ generated



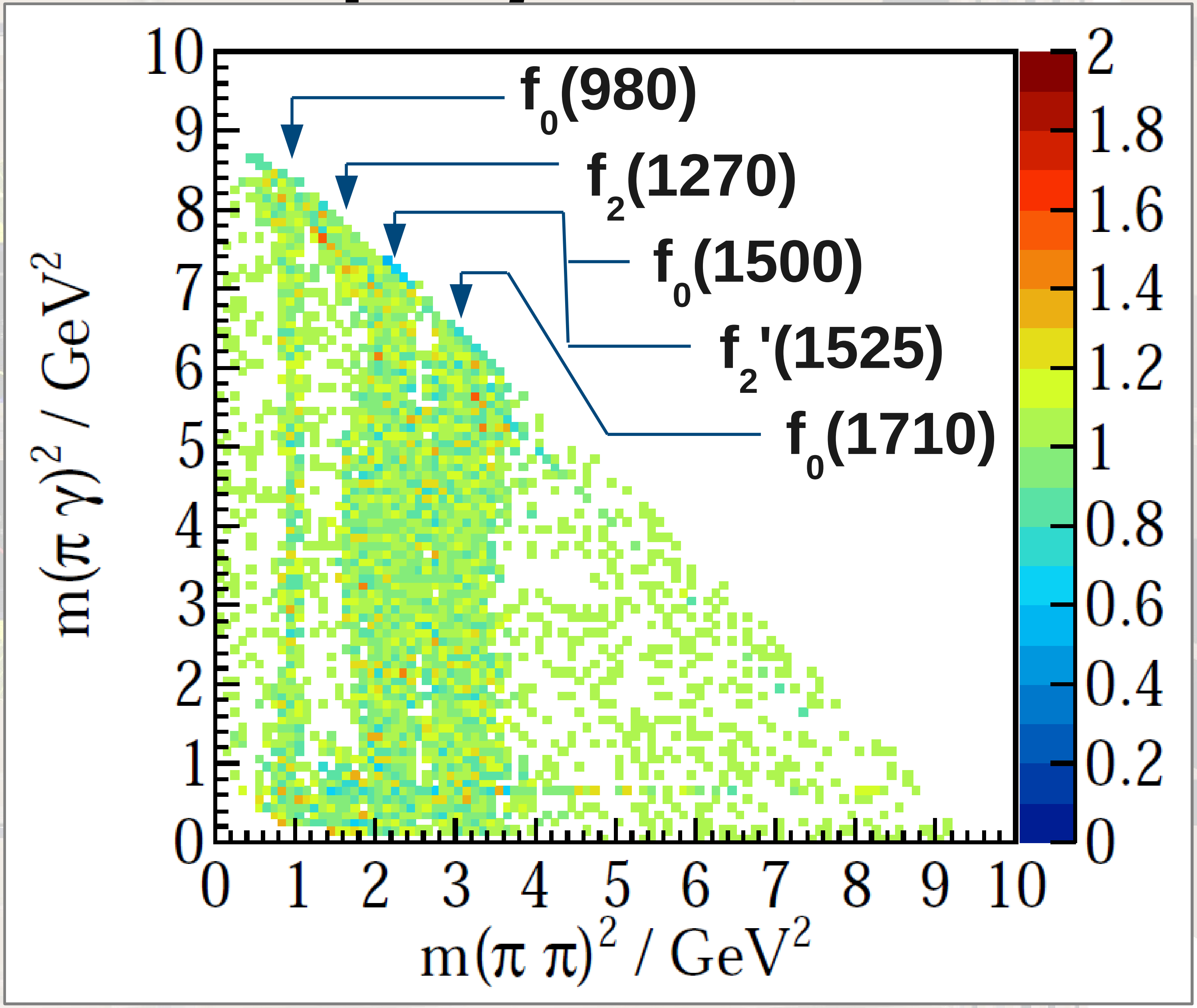
$J/\psi \rightarrow \gamma\pi^0\pi^0$ first fit



	result	optimal
p0	0.99004	0.990
p1	1.50483	1.505
p2	1.72052	1.720
p3	1.27245	1.274
p4	1.52454	1.525

startvalues: 0.95*optimal

$J/\psi \rightarrow \gamma\pi^0\pi^0$ ratio



Status & Outlook

Language and Dependencies
- C++11
- Boost
- Boost.Build

Optional External Packages Used
- Root
- qft++
- Minuit2
- Geneva

Documentation
- Doxygen
- Doku Wiki

Version-Control
- Git

About Geneva

Geneva is available as Open Source software (AGPL v3) from **http://www.launchpad.net/geneva,** and is also supported commercially by Gemfony scientific **http://www.gemfony.eu**

This is work in progress!

Biggest ToDo's
- go public
- controls and configuration
- documentation module
- more physics cases

Contact

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