Evaluation of systematic errors in TAUOLA

Jakub Zaremba

IFJ Kraków

Kraków, 9 January 2015

Outline

1. Tauola is the Monte Carlo program for Tau lepton decays. Interfaces for productions will be discused in talk by Cosimo Sanitate
2. **In my talk:**
    1. motivation
    2. Tauola physics contexts
    3. code validation
    4. preliminary example of numerical comparison

Motivation

Why do we need to evaluate systematical errors?

- To get most from experimental data and theory assumptions at the same time, while not getting biased.
- Results including systematic errors may provide input for studies of intermediate energy QCD, Lattice QCD, effective Lagrangian's etc.
- To get most from LHC data - τ decays are commonly used to measure properties of hard processes.
- All this need good control of experimental and theoretical results including systematic errors and at the same time.
- Technically correct comparisons of different options may provide hint on systematic errors both for theoretical and experimental sides.

Physics contexts

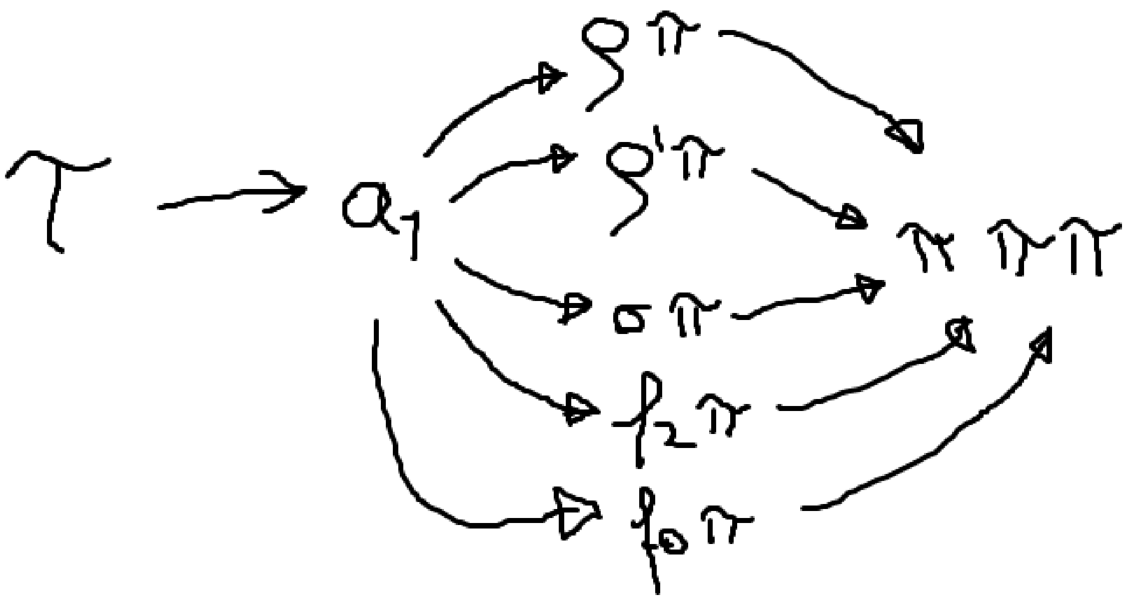
- For purpose of Monte Carlo generation one has to model physics processes.
- Models often are built on field theory predictions and experimental results. Sometimes they are only semi empirical.
- It is important that model is approved by experimental collaboration.
- In Tauola modeling of τ decay channels is done by calculation of matrix element out of hadronic current. On practical side hadronic currents are built on Breit-Wigner functions visible/predicted in the decay. Usually this is done with theoretically sophisticated way (unitarity constraint, approach of Resonance Chiral Lagrangians). But it is not always easy to avoid temptation of quick work to add new resonances in ad hoc way.
- Improvement in one distribution may destroy agreement in other one.

Physics contexts

- My work is at this moment technically oriented. I am not yet competent in all theoretical aspects of current construction. I am analyzing existing programs and physics (theory/experiment) used for their preparation.
- I analyze existing code and I treat hadronic currents as combination of constants and Breit-Wigner enhanced propagators. I do not look for original motivations why they were introduced, I will not discuss principles of unitarity, origin of Resonance Chiral Lagrangian approach etc. I just want to be sure what is in the code and compare the available versions of currents. Discussion of physics options and possible improvements is for the future. Also I will not present long equations, I'm concentrating on what do they mean and how they effect end result of Monte Carlo simulation.

Physics contexts

Example of hadronic current contributions for $\tau \to \pi\pi\pi\nu$ decay



Code validation

- In search for technical errors in Monte Carlo simulation one may try extracting physical equations and numerical constants investigating strictly the code and only afterwards checking if they coincide with the model supposedly used.
- Such extraction was performed for Tauola for $\tau \to \pi\pi\pi\nu$ then followed by comparison with current discription given in published papers.
- Several options were studied this way (see slide 10).

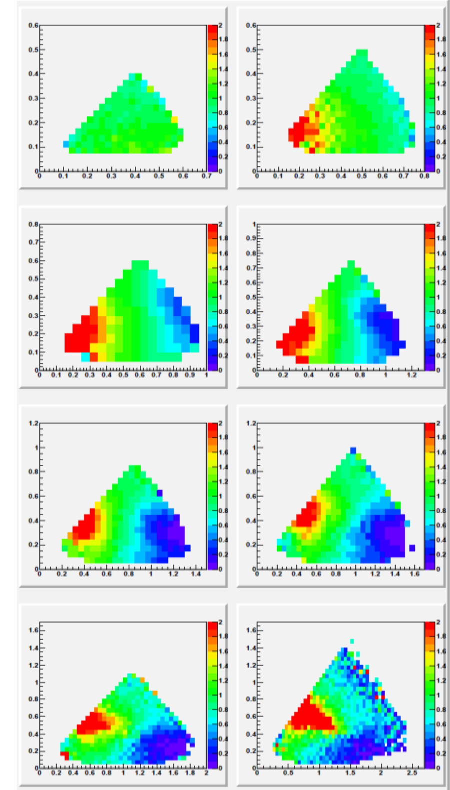
Numerical comparison

- For numerical comparisons of different models I used Tauola Monte Carlo generator and construct distributions as in CLEO collaboration work[1]. This is in principle 3-dimensional data representation. Dalitz plots in S_1, S_2 variables in slices in Q^2. $S_1=(P_2+P_3)^2$, $S_2=(P_1+P_3)^2$, $Q^2=(P_1+P_2+P_3)^2$, where P_1, P_2, P_3, are final state pion momenta. This type of plots is show on next slide.
- Until now the CLEO paper is the most sophisticated comparison of experimental data with τ decay predictions. We use this paper as starting point of our work.

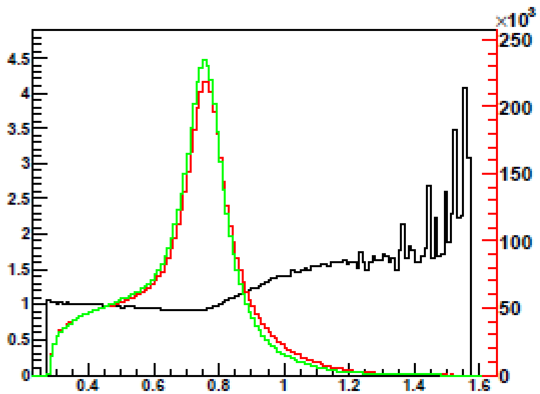
1. Structure functions in the decay tau-+ ---> pi-+ pi0 pi0 neutrino(tau), CLEO Collaboration (Browder, T.E. et al.) Phys.Rev. D61 (2000) 052004 hep-ex/9908030

Numerical comparison

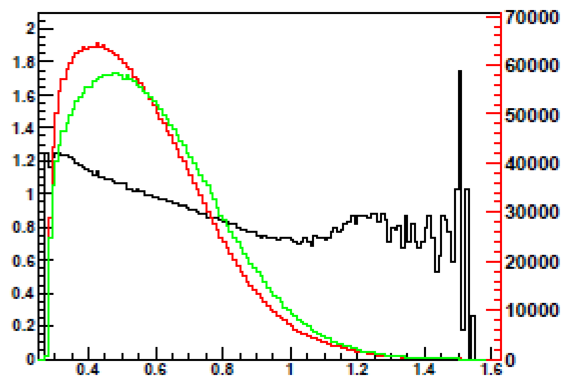
Example of comparison of BaBar (red) and CLEO (green) collaborations models for $\tau \to \pi\pi\pi\nu$ decay



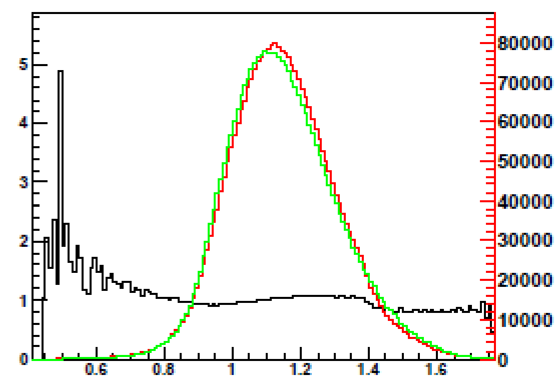
Ratio of Dalitz plots in slices in Q^2



Mass of π -π+



Mass of π -π -



Mass of π -π -π+

Lesson from previous comparison

- Agreement for $\pi+\pi-$ mass is reasonable
- Agreement for $\pi+\pi-\ \pi-$ mass is reasonable
- Agreement for $\pi-\pi-$ mass is **not** reasonable
- Probably as is our first paper on RChL[1], the first two invariant masses were used as input and the third one was prediction.
- This shows that developing models is difficult task. Input from measurements is important help.
- I am planning to devote time for this kind of practically oriented studies of properties for different models and experimental data.
- *Different assumptions → similar deformations of distributions.*
- For the previously presented plots this were missing contributions from sigma resonance. This was the case of BaBar and early RChL models.

1. Resonance chiral Lagrangian currents and τ decay Monte Carlo,
O. Shekhovtsova et all, Published in Phys.Rev. D86 (2012) 113008

Numerical comparison

I have prepared such comparisons for:

- CLEO model
- BaBar model
- RChL model
- Not published CLEO model

This multidimensional representation is preliminary step to multidimensional fitting including projection operators.
But already now one can see advantages and disadvantages of different approaches. There is a big challenge to evaluate importance of theoretical conjectures or importance of data distributions when systematic errors are still at work.

Thank you for your attention !