TAUOLA – hadronic currents: systematic errors and fits

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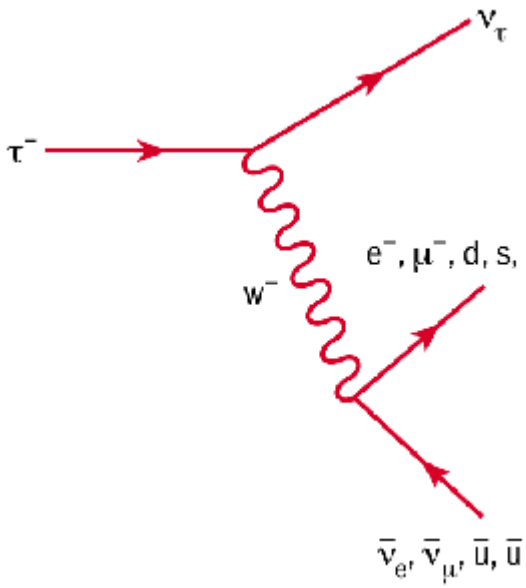
Outline

1. About TAUOLA
2. Tauola-bbb – „BaBar” initialization of TAUOLA currents developed by collaboration
   a) Code validation
   b) Comparison of some available currents for $\tau \rightarrow 3\pi\nu$
3. Discussions of systematics
4. Fitting freamework prototype
5. Few words on „projection operators”

About TAUOLA

- TAUOLA is a Monte Carlo generator for τ lepton decays
- Event generation in TAUOLA is split into two independent parts - phase space and matrix element
- Matrix element is model dependent, but can be replaced easily



Tauola-bbb

- Recently we have prepared new version of TAUOLA recreating BaBar setup of their basic simulations
- We believe, it is beneficial for user to have setup of TAUOLA replicating what was used by renoved experiment
- Our new version provides also more user flexibility to modify the generator physics initialization.
  - Most notably we added option to add/replace currents with pointers to user functions
  - To account for such modification we also gave possibility to change parameters of phase space generation (to improve efficiency of presamplers).
  - Core of TAUOLA code remain in FORTRAN but new verion is a step towards C++, or another higher level programing language. Mixed language for models possible.

Tauola-bbb - Code validation

- We have compared results of our new initialization of TAUOLA with BaBar collaboration production files
- Agreement was checked with MC-TESTER with samples of 1 617 945 000 decays
- The MC-TESTER-based tests accounted for over 133 decay channels (including those with multiple photons in final state generated by PHOTOS) as used by BaBar collaboration
- All invariant masses constructed from stable decay products were monitored

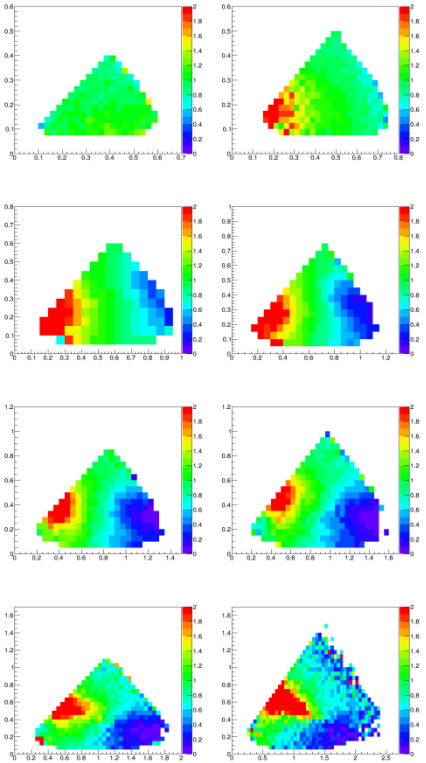
Tauola-bbb - Comparison of some available currents for three pions

- By default new version uses BaBar currents for three pions but available in earlier versions models are accessible (mostly by internal flags).
- For three pions we have model made by CLEO collaboration [1], and RChL model [2]
- Both of them are substantially more complex than BaBar model but data sample used by BaBar was larger

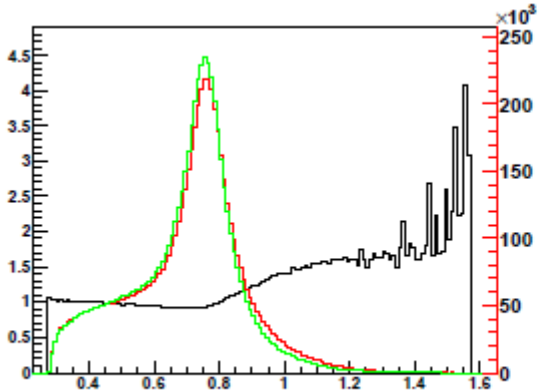
1. CLEO Collaboration Collaboration, D. Asner et al., Phys.Rev. D61 (2000) 012002
2. O. Shekhovtsova, T. Przedzinski, P. Roig, and Z. Was, Phys.Rev. D86 (2012) 113008

Numerical comparison

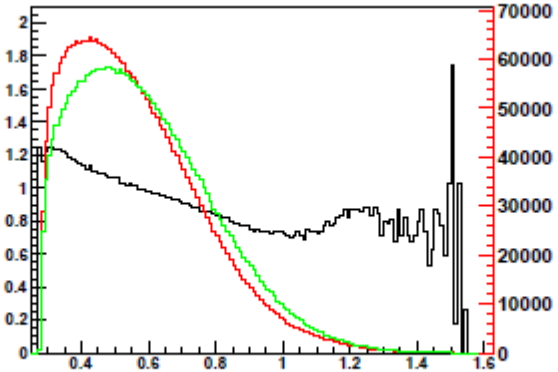
On the right, plots of ratios of Dalitz plots in S1, S2 variables in BaBar model to CLEO modeling. Consecutive plots correspond to slices in Q2; respectively for 0.36-0.81, 0.81-1.0,1.0-1.21, 1.21-1.44, 1.44-1.69, 1.69-1.96, 1.96-2.25, 2.25-3.24 GeV2. Scale: red: ratio over 2, blue: ratio below 0.5



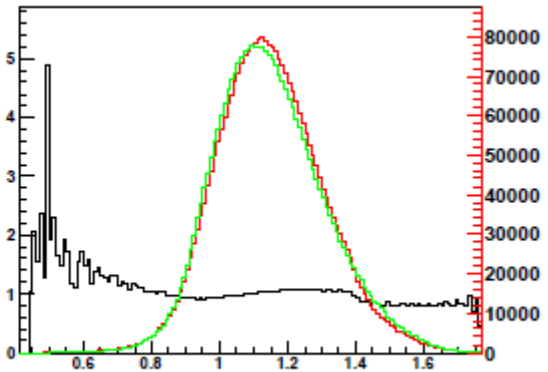
Example of comparison of BaBar (red) and CLEO (green) collaborations models for $\tau \to \pi\pi\pi\nu$ decay. Black line is the ratio of red plot to green



Mass of π -π+



Mass of π -π -



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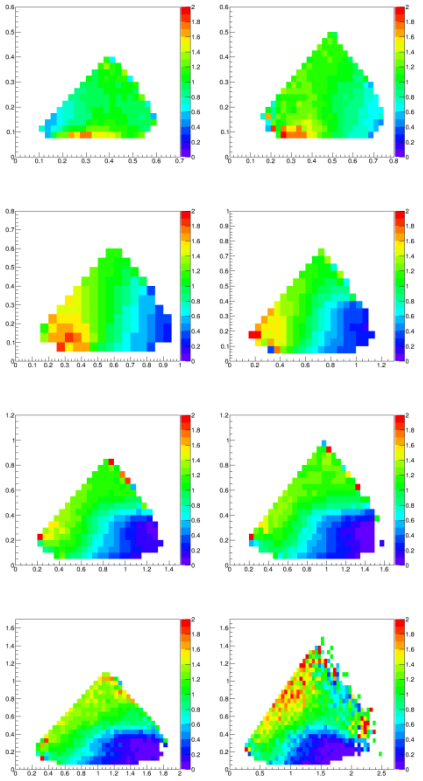
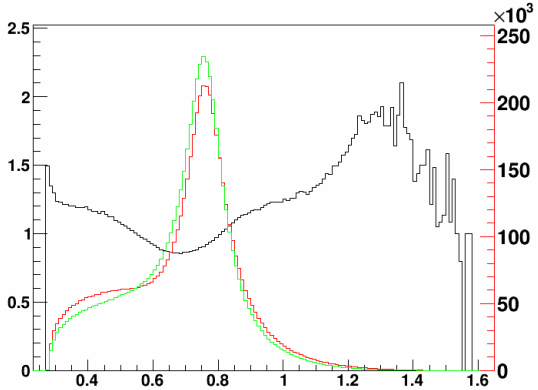
Numerical comparison

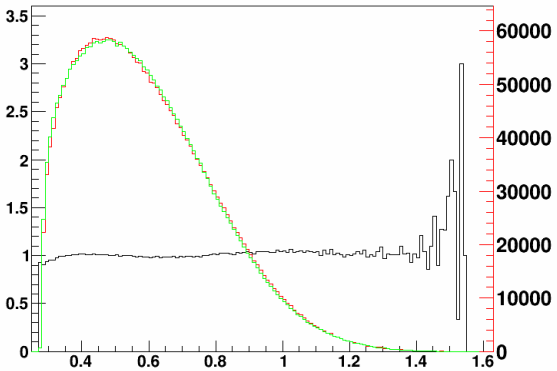
On the right, plots of ratios of Dalitz plots in S1, S2 variables in BaBar model to RChL modeling. Consecutive plots correspond to slices in Q2; respectively for 0.36-0.81, 0.81-1.0,1.0-1.21, 1.21-1.44, 1.44-1.69, 1.69-1.96, 1.96-2.25, 2.25-3.24 GeV2. Scale: red: ratio over 2, blue: ratio below 0.5



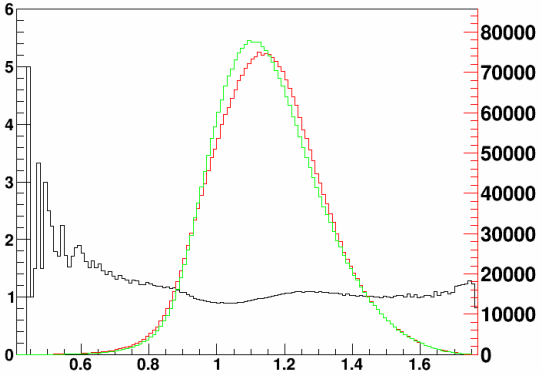
Example of comparison of RChL (red) and BaBar (green) collaborations models for $\tau \to \pi\pi\pi\nu$ decay. Black line is the ratio of red plot to green



Mass of π -π+



Mass of π -π -



Mass of π -π -π+

Discussion of systematics

- In any analysis based on MC simulation systematic error plays an important role
- On previous slides we can see that models results can differ by a factor of two in some areas of phase space
- Usually systematic error of modeling is estimated as difference between two well regarded models
- Previous slides show importance of using multidimensional plots for analysis whenever it is possible, as one dimensional plots can be misleading

Fitting freamework prototype

- We are working on fitting freamework for three pion currents that could work in semi analitical freamework but would enable easy switch between models that you can plug into TAUOLA later
- In its core, freamework uses for fitting minuit2 library
- Use of multiple cores is supported
- Main target of this freamework is to allow simple way of fitting multidimensional distributions and calculate errors, correlation matrices etc.

Projection operators

- We are also working on „projection operators” to acces fully differential distributions of 3 scalar τ decay modes
- Once finished they should be easily to pluged into prepared fitting freamowork
- This is by far more complex that when it was used for the first time at CLEO collaboration
- Recent „low-energy” (Belle, BaBar) have energies much higher than CLEO, where taus were produced at rest
- Neutrino momentum needs to be reconstructed now and it is very complex, see talk of Brian Lee for similar difficulties and modern (ML) solutions
- Gate to full dynamic of medium energy QCD at ~0.2% precision level

Thank you for your attention !