TAUOLA Monte Carlo (of τ lepton decays) for Belle-II

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- **(1)** The τ lepton decays: fascinating laboratory for intermediate energy QCD
- **(2)** How to optimize work of inhomogeneous community. From model builders to people managing large experimental data files.
- **(3)** From F77 to C++ and Python. From journal plots to Mashine Learning fits.
- **(4) Main topic:** how to manage work. In particular of systematc errors: experiment, theory, computing **Also:** (i) consequences/limitations of quantities used in TH-exp. comparisons. (ii) consequences/limitations of particular theory assumptions.
- **(5)** Also on what can/should be the role of MC (authors) in this respect.
- **(6)** I will underline different points of views. All of them are important, none to be ignored.
- **(7)** I recall hot (and noisy) discussions in Frascati corridors. As a consequence in our paper DOI: 10.1103/PhysRevD.86.113008, we have even quoted philospoper on what is a theory .... Fortunately Mexico is much calmer place than Roma ;-)

Issues

1. Model building and its numerical implementation

2. Experimental input; (i) rates only, (ii) histogram, (iii) histograms, (iv) multidim histograms, (v) as before, but with errors and correlation matrices and estimates of background contamination, (vi) full datasamples ML.

3. Experimental input: responsabilities, systematic errors.

4. Fitting software is a bridge for comunication between theorists preparing models and experimental physicists.

5. After fitting verification of models. If fit point to resonances at 0.5 σ significance, then one has to revisit question if model principles can be used, e.g. for isospin rotations to other channels.

6. Service to society: Technical correctness of Monte Carlos and of fitting algorithms. Its re-usability and reliability.

7. Benchmarks for everything. Technical precision, statistical precision, physics precision.

Important pre-conditions

1. Precision of models for hadronic τ decays does not match precision of data.
2. In the past there were at most 2-3 experiments collecting precision τ. τ data. Now it will be only 1.
3. Experimental data are multi-dimensional. Fitting represent important issue.
4. For all aspect of the projects we need to take care of:
   (a) Physics precision: we need non interesting effects (QED) to be below experimental precsion which is at permille precision level.
   (b) Statistical precision must be factor of 3 better (10^7 samples)
   (c) Technical precision must be even better. It is challenge and all aspects must be taken into account simultaneously.
   (d) In particular, flexible arrangements for experiments to use new versions of models.
5. All this is challenge and find motivated people for long term projects is not easy. Usually people do not share this point of view: somebody else should take care.

Do not forget: MC+fitting env. is a service to society.

Recall: somebody must take care of

- Benchmarks
- Re-usability
- Orientation toward users
- That is why, we do not prepare new parametrizations of hadronic currents only.
- We must make it easy for the user to replace and/or re-fit.
- That was my strategy in the past
- and that is what I need to persuade people who will (one day) take over.
- It seems not to be easy. Everybody want quick flashy publications.

General formalism for semileptonic decays

- Matrix element used in TAUOLA for semileptonic decay

$$\tau(P,s) \to \nu_\tau(N)X$$
$$\mathcal{M} = \frac{G}{\sqrt{2}}\bar{u}(N)\gamma^\mu(v + a\gamma_5)u(P)J_\mu$$

- J_μ the current depends on the momenta of all hadrons

$$|\mathcal{M}|^2 = G^2\frac{v^2+a^2}{2}(\omega + H_\mu s^\mu)$$
$$\omega = P^\mu(\Pi_\mu - \gamma_{va}\Pi_\mu^5)$$
$$H_\mu = \frac{1}{M}(M^2\delta_\mu^\nu - P_\mu P^\nu)(\Pi_\nu^5 - \gamma_{va}\Pi_\nu)$$
$$\Pi_\mu = 2[(J^*\cdot N)J_\mu + (J\cdot N)J_\mu^* - (J^*\cdot J)N_\mu]$$
$$\Pi^{5\mu} = 2\,\mathrm{Im}\,\epsilon^{\mu\nu\rho\sigma}J_\nu^* J_\rho N_\sigma$$

$$\gamma_{va} = -\frac{2va}{v^2+a^2}$$

$$\hat{\omega} = 2\frac{v^2-a^2}{v^2+a^2}m_\nu M(J^*\cdot J)$$
$$\hat{H}^\mu = -2\frac{v^2-a^2}{v^2+a^2}m_\nu\,\mathrm{Im}\,\epsilon^{\mu\nu\rho\sigma}J_\nu^* J_\rho P_\sigma$$

In Lorentz invariance we trust.

- Independently of model for tau decay, any distributions can be obtained either by semi-analytical or Monte Carlo integrations; then used for fits, cross checks, predictions.
- Currents must preserve Lorentz invariance. **Examples:**
- For 2-scalar channels channel, two indepenent single variable distributions at most. Current: $J^\mu = (p_{\pi^\pm} - p_{\pi^0})^\mu F_V(Q^2) + (p_{\pi^\pm} + p_{\pi^0})^\mu F_S(Q^2)$ ($F_S \simeq 0$).
- Already for 3-scalar channels: 4 complex function of 3 variables to fit. Scalar $J_4^\mu \sim Q^\mu = (p_1 + p_2 + p_3)^\mu$, vector $J_1^\mu \sim (p_1 - p_3)^\mu|_{\perp Q}$ and $J_2^\mu \sim (p_2 - p_3)^\mu|_{\perp Q}$ and pseudovector $J_5^\mu \sim \epsilon(\mu, p_1, p_2, p_3)$.
- Arguments of form factors: Q^2, $s_1 = (p_2 + p_3)^2$, $s_2 = (p_1 + p_3)^2$. Angular asymmetries helpful to separate currents [Kuhn Mirkes]. At least nine 3-dim distributions needed. 1-dim distributions and total rates, do not constrain model.
- Multi dim. methods, were used only in part and only by CLEO. Practical constraints: (i) enough data, (ii) **precision of data for reconstruction of ν_τ directions** (needed for currents orthogonality conditions), (iii) background control.
- Semi-analytical distributions and Monte Carlo techniques helpful. Advantages, respectively: precision/stability versus flexibility Mashine Learning techniques etc.

Semi analytical distributions are better ...

1. Once semi analytical distributions are constructed on the basis of **exact phase space** and **clearly defined** module calculating τ decay matrix elements also. All is then automatic **and available for fits. WE HAVE NOT REACHED THIS LEVEL for activities with RChL currents**.
2. Matrix elements may be technically complicated: unitarity constraints etc. But fit strategy does not depend on that.
3. Fitting software is a bridge for comunication between theorists preparing models and experimental physicists.
4. In principle any distribution can be calulated, including all cuts and precision better than of the exp. data. In practice integration over phase space must be relatively complete, not easy for complicated acceptance.
5. Good numerical stability. Practical for calculating derivatives with respect to model parameters necessary for evaluation of fits errors.
6. Algorithms searching for minima for the sake of fits work well, unless insufficient effort on models; correlated parameters. It is true for some hadronic current, but not always.

Monte Carlo is better ...

1. Once Monte Carlo is constructed on the basis of **exact phase space** and **clearly defined** module calculating τ decay matrix elements is prepared: all is ready **and available for modifications with weights**.
2. Matrix elements may be technically complicated: unitarity constraints etc. Disturbance for somebody concentrating on detector.
3. Monte Carlo as a bridge for comunication between theorists preparing models and experimental physicists.
4. In principle any distribution can be genrated by MC, including all cuts and precision better than of the exp. data.
5. Monte Carlo samples are affected by statistical errors. Not easy for calculating derivatives with respect to model parameters. Thus fits errors.
6. This may be partly overcomed with the weight techniques, correlated samples.
7. Nearly perfect solution, but minima searching algorithms used in fits suffer, CPU constraints, problems due to linearization of dependencies. Jakub Zaremba was studying practical aspects of such work and suffered; for some hadronic currents.

Mashine Learning rule it all ...

1. It is believed to be a breakthrough strategy: just take events consisting of 4-momenta and PDGids...
2. But it is not as straightforward: we have experienced that for LHC applications.
3. Question of how to calculate systematic errors and subtract background for multi-dimensional distribution is serious.
4. Also we need to fit many parameters of models which are correlated.
5. Automated methods are unforgiving for unprepared...

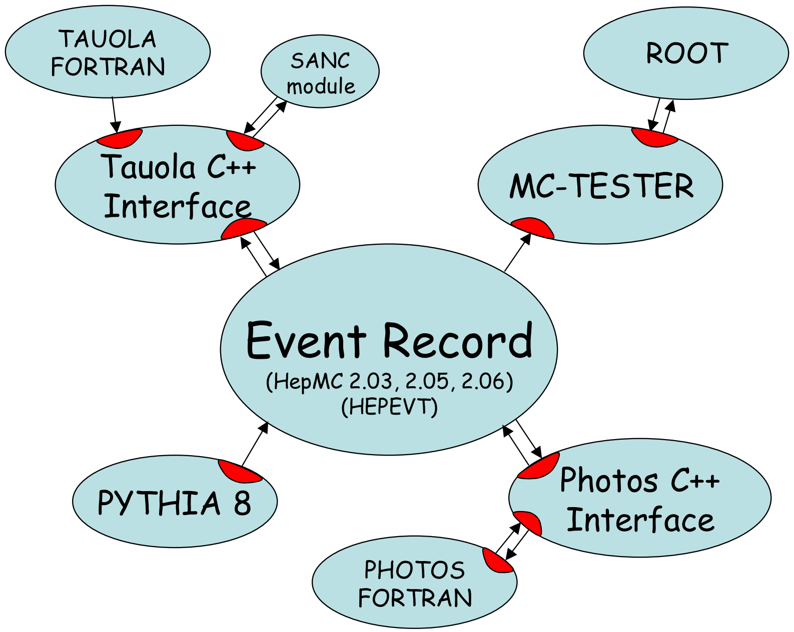
Quality of Models and quality of experimental distributions

1. Basic estimation of uncertainty for Resonance Chiral Lagrangian approach $\frac{1}{N_C} = \frac{1}{3}$. In many cases it can work better, but it can not be granted.
2. Isospin symmetry, precision at the level of 5-10 %. Better, can not be granted.
3. Experimental samples: M-events per τ decay channel, precision of 0.1 % . At least order of magnitude better than behind th. models.
4. We should not expect approach from model building based on theory only.
5. Feed-back from experimental fits may change directions for model building. Keys are in theirs, experimentalists of Belle II hands.
6. Default currents, even if of no high physical precisions are to establish technical precison of the tools.
7. **that is the main role of defaults** like RChL currents now. In the past of not so physical CPC currents.
8. I do not have full support for that aspect of work. **I am essentially alone.**
9. Fitting of RChL can not be re-done without help of Tomasz: out of physics now.

General software organization.

Communication though event record: (for program inerfaces or data files).

Solution for phase space $\times\ |M|^2$ algorithms.



Parts:

- hard process: (Born, weak, new physics),
- parton shower,
- τ decays
- QED bremsstrahlung

- High precision achieved

- Detector studies: acceptance, resolution lepton with or without photon.

Such organization requires:

- Good control of factorization (theory)
- Good understanding of tools on user side.

Weighted events like `TauSpinner`

- Organization of sotware for fits with semi-analytical calculations is simpler.

Software organization, fits with events, also ML.

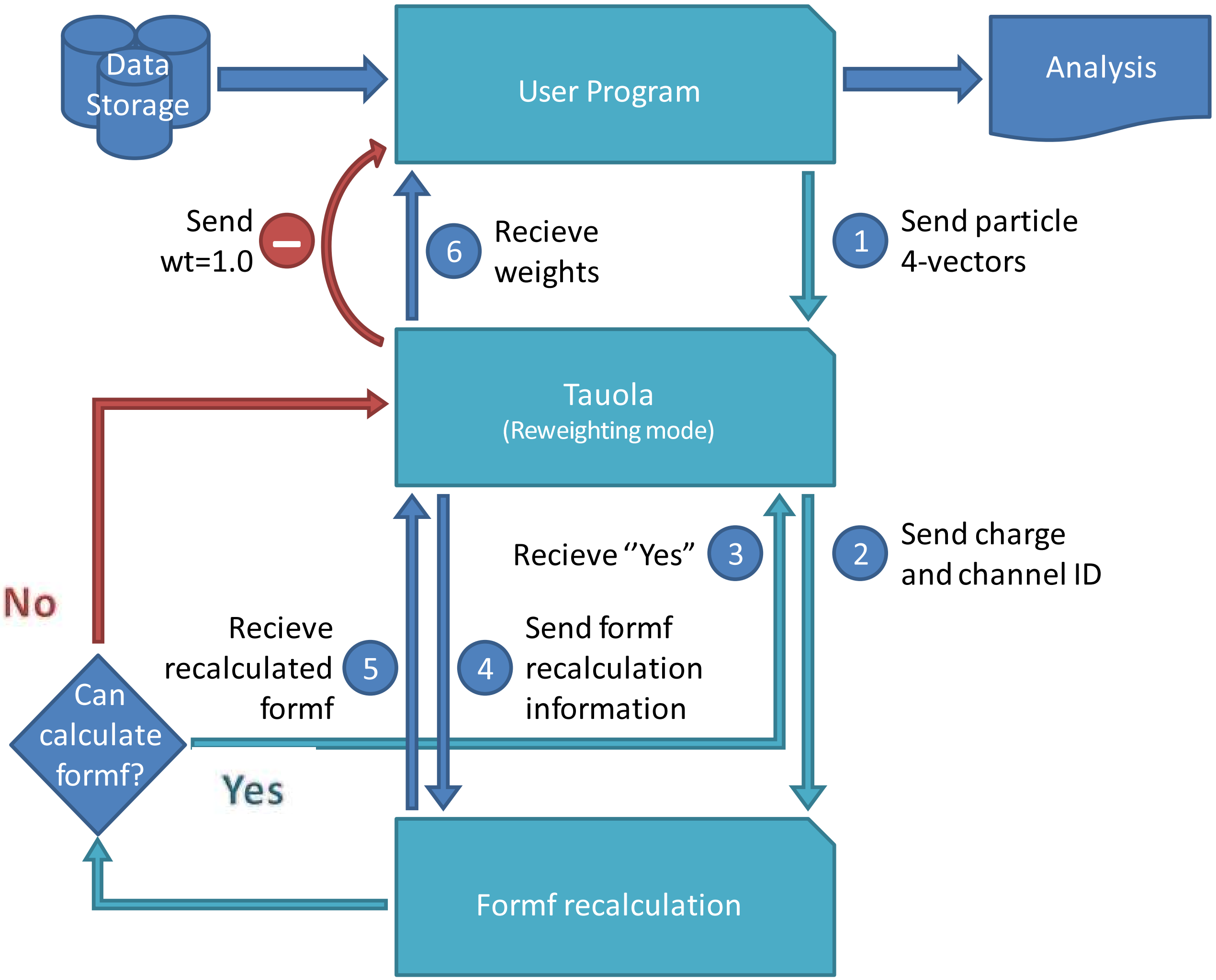


Figure 1: Flow chart for communication when already stored events are modified with the weights.

Useful at LHC also with Mashine Learning application. Surely for τ decay hadronic current applications as well.

Technical tests past.

1. Main technical tests of tauola originate from work a the time of papers J. H. Kuhn and E. Mirkes, “Structure functions in tau decays,” Z. Phys. C **56**, 661 (1992) Erratum: [Z. Phys. C **67**, 364 (1995)]. and S. Jadach, Z. Was, R. Decker and J. H. Kuhn, “The tau decay library TAUOLA: Version 2.4,” Comput. Phys. Commun. **76** (1993) 361.

2. The idea was to keep in the code parametrizations which can be integrated over phase space with semi analytical formula `CPC initialization` of default `Tauola`, see `http://wasm.web.cern.ch/wasm/f77.html` and its set of tests embeded in program: `Tautestroman`

3. Tests were based on semi-analytical calculations and could be **repeated whenever precison requirement reached new level**.

4. Tests were prepared for 2,3,4,5 scalar final states, and leptonic channels also.

Now, with `C++` and other stuctural changes (new people, importance of fitting algorithms) this arrangement is less convenient to use.

Could be a good partial benchmark ...

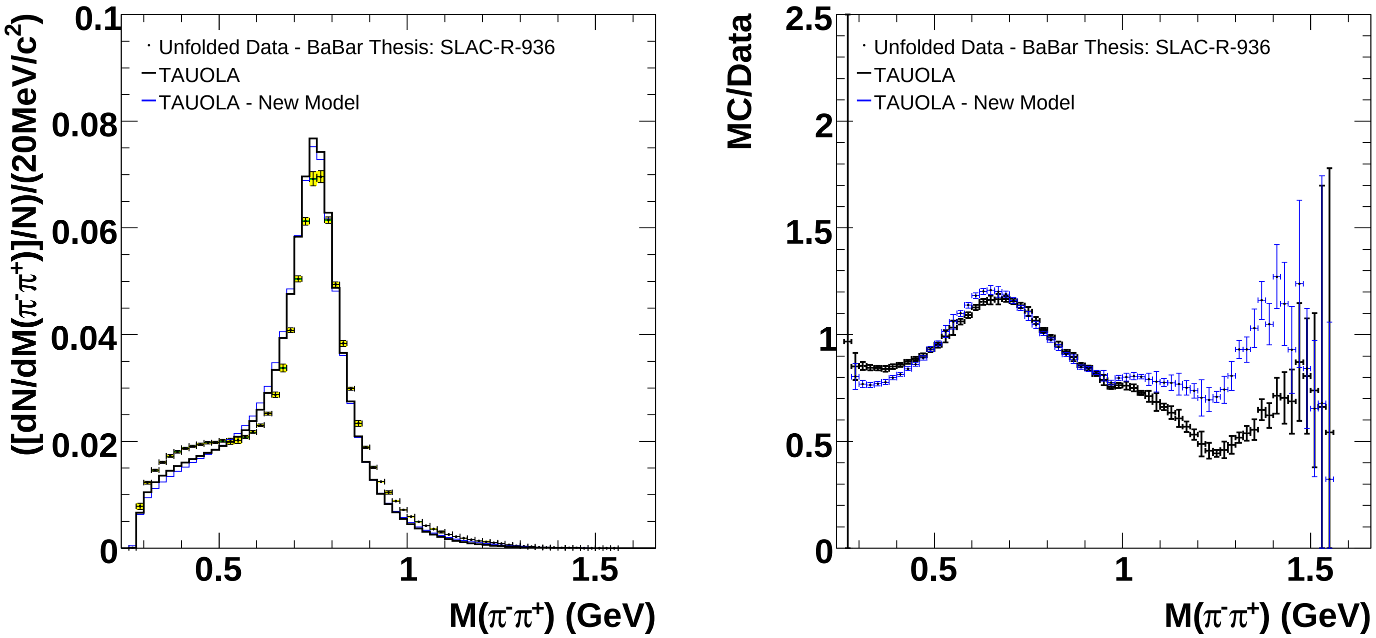
Channel	Width [GeV]	reference	In `tauola/RChL-currents` directory channel's current: `file` $\longrightarrow$ `routine`
$\pi^-\pi^0$	$5.2678 \cdot 10^{-13} \pm 0.01\%$	Subsection 2.4	`frho_pi.f` $\longrightarrow$ `CURR_PIPI0`
$K^-\pi^0$	$5.853 \cdot 10^{-15} \pm 0.02\%$	Subsection 2.4	`fkpipl.f` $\longrightarrow$ `CURR_KPI0`
π^-K^0	$1.1025 \cdot 10^{-14} \pm 0.03\%$	Subsection 2.4	`fkpipl.f` $\longrightarrow$ `CURR_PIK0`
K^-K^0	$2.415 \cdot 10^{-15} \pm 0.02\%$	Subsection 2.4	`fk0k.f` $\longrightarrow$ `CURR_KK0`
$\pi^-\pi^-\pi^+$	$2.08 \cdot 10^{-12} \pm 0.017\%$	Subsection 2.1	`f3pi_rcht.f` $\longrightarrow$ `F3PI_RCHT`*
$\pi^0\pi^0\pi^-$	$2.126 \cdot 10^{-12} \pm 0.017\%$	Subsection 2.1	`f3pi_rcht.f` $\longrightarrow$ `F3PI_RCHT`*
$K^-\pi^-K^+$	$3.8467 \cdot 10^{-15} \pm 0.04\%$	Subsection 2.2	`fkkpi.f` $\longrightarrow$ `FKKPI`*
$K^0\pi^-\bar{K}^0$	$3.5935 \cdot 10^{-15} \pm 0.03\%$	Subsection 2.2	`fkkpi.f` $\longrightarrow$ `FKKPI`*
$K^-\pi^0K^0$	$2.769 \cdot 10^{-15} \pm 0.04\%$	Subsection 2.3	`fkk0pi0.f` $\longrightarrow$ `FKK0PI0`*
			* The F_i of form-factors.

Table 1: Collection of numerical results from paper: O. Shekhovtsovaa, T. Przedzinski, P. Roig and Z. Was *Resonance Chiral Lagrangian currents and τ decay Monte Carlo*, Phys.Rev. D86 **(2012)** 113008. References to subsections of that paper. Last column includes references to routines of the currents code. It looked like mission accomplished. Just fine tuning of some parameters.

Could be a good partial benchmark ...

- Those new hadronic currents (more than 88 % of hadronic τ decay width) version installed with the 0.05 % technical tag:
  O. Shekhovtsovaa, T. Przedzinski, P. Roig and Z. Was *Resonance Chiral Lagrangian currents and τ decay Monte Carlo*, Phys.Rev. D86 (2012) 113008
- **But** physics precision was definitely **NOT** as good as 0.05 %.
- Over the last two years we worked on preparing confrontation env. with the data keeping precision in mind.
- But despite partial success for 3π modes, we are nearly as far from the complete solution as in 2012.
- **Useful for further work:**
- We have investigated technical aspects for fitting using weights.
  It is of interest in case when experimental cuts are present, multidimensional distributions are used and no semi-analytical results can be easily obtained.
- We have returned to the semi-analytical 1-dim distributions for fits. Similar as in 90's.
- Such distributions are essential for technical tests of our code, but also for fits and evaluation how experimental errors propagate to parameters of the models.

Attempt: comparison with experimental distr.



(a) A (b) B

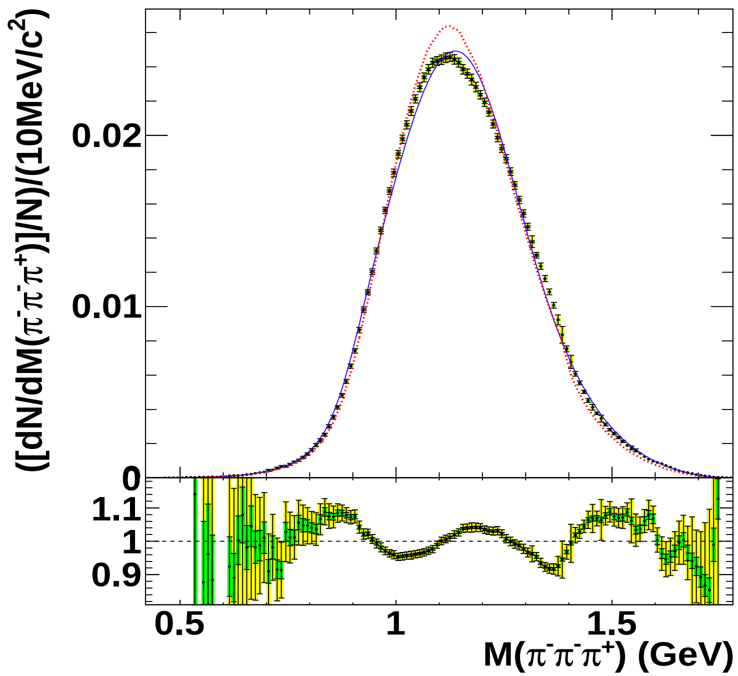
Figure 2: Invariant mass distribution of the $\pi^+\pi^-$ pair in $\tau \to \pi^+\pi^-\pi^-\nu$ decay. Histogram is from our model. Unfolded BaBar data are taken from PhD thesis of Ian Nugent. Left hand side, mass distribution. On the right hand side, ratios of Monte Carlo results and data.

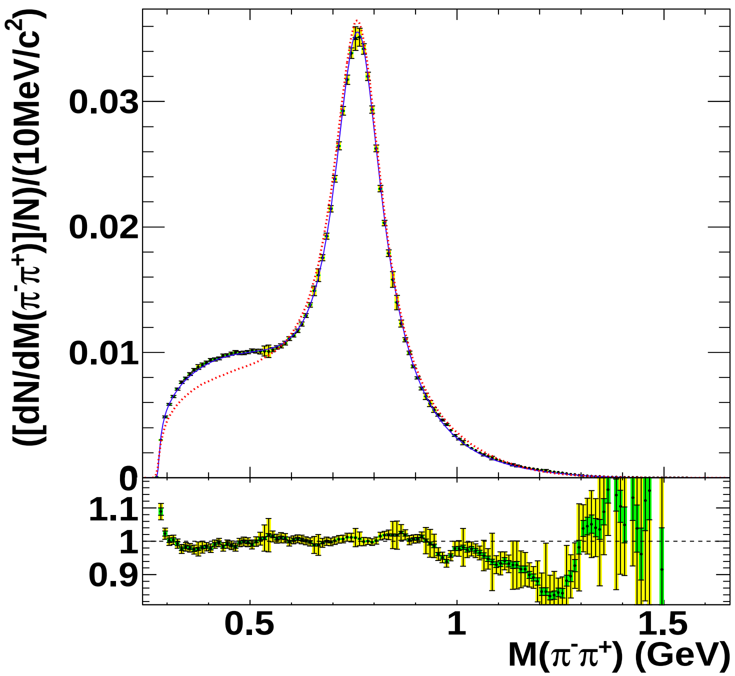
Picture had to change once $\pi^-\pi^-$ invariant mass distribution became available.

Attempt: comparison with experimental distr.

New currents for $\tau \to 3\pi$ and $\tau \to 2\pi$ decays

Currents based on Resonance Chiral Lagrangian approach and fits to BaBar data. Experimental systematic errors considered. Software environment for figs (semianalytical distr.) was prototyped but used in non automated way. From: *Resonance Chiral Lagrangian Currents and Experimental Data for* $\tau^- \to \pi^-\pi^-\pi^+\nu_\tau$, I.M. Nugent, T. Przedzinski, P. Roig, O. Shekhovtsova, Z. Was, Phys. Rev. D 88, 093012 (2013).





Attempt: comparison with experimental distr.

To progress in case of $\tau \to 3\pi\nu_\tau$ we had to:

- Modify the model (contribution of σ)
- Work simultaneously with fits using weights (to cross-check results). We had difficulties with stability: strong correlations of parameters. Template method I have learned from ALEPH requires better understanding if model parameters are strongly correlated if for some - dependencies on parameters is not too weak. Necessity to linearize dependencies because of CPU-time constraints in case when model was not giving perfect predictions complicates things.
- We relied on fitting semi-analytical formulas.
  - We had to assure that derivaties of results are continuous.
  - To speed up calculations methods of pretabulation/interpolation of results for Q-dependent a_1 width (unitarity constraint) were used.
  - We relied on 1-dimensional invariant mass distributions.
  - But before fits of model, distributions were not checked for parameter correlations.

Attempt: comparison with experimental distr.

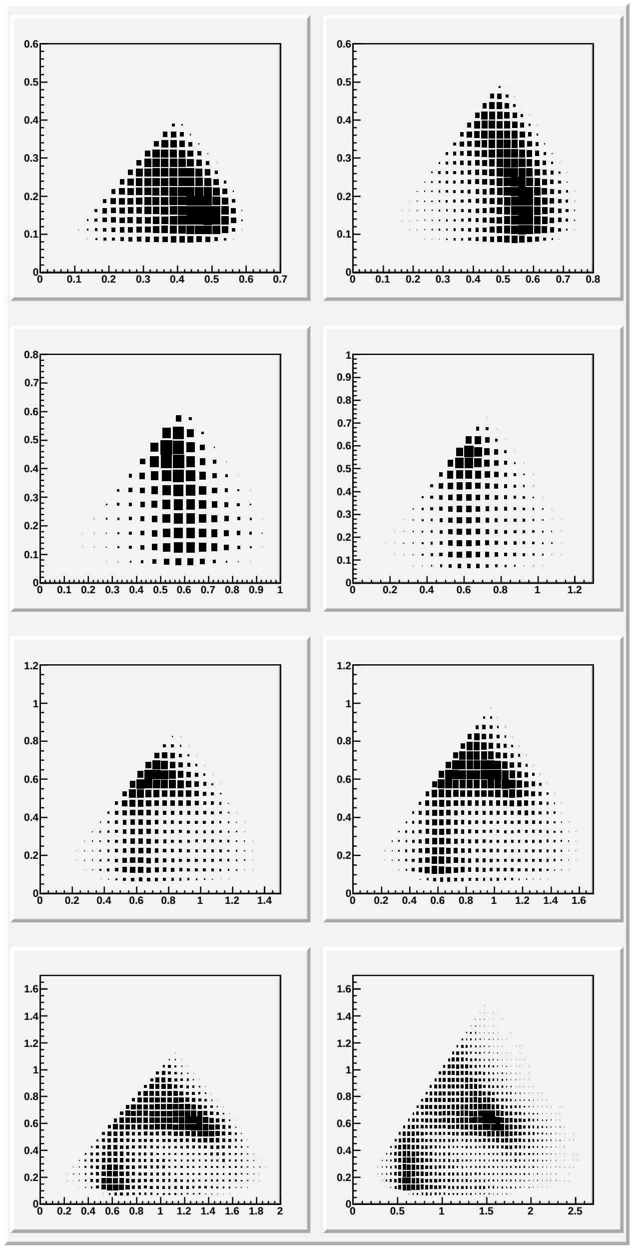
- Not anymore separation into theoretical, experimental and computing aspects. Even for the simple case of 1-dimensional unfolded distribution.
- We got substantial improvement for 3π modes for 1-dim distr.
- **OK, how it with survive comparisons of 3 dim distributions?**
- Control of experimental systematic errors.
- Experience for the future steps, but no organized software solution.
- What is the best input from experimental side? Or how input from theorist should look so experiments can do the hard work on systematics.
- Multidimensional histograms, number of bins comparable with size of measured sample? Moments, bias due to model assumptions?
- How to coordinate work?
- **Not acceptable: theorist/experimentalist have to wait for ...**

Even at CLEO times ...

- Biases in art, Giuseppe Arcimboldo (1572 - 1593).

- Already for 3-scalar final states theoretical predictions and experimental data: distributions over 8-dimensional space. We fit 1- dim. histos. Result depend on model assumptions. Models inspired with results ... Fitting setup $\rightarrow$ biases.
- Our algorithms are far less elaborate than human eye/brain.
- Who in charge? (TH, EXP?)
- How to facilitate dialog, role of MC. Defalut initialization weighting algorithms, semi analytical distributions environment.

Even at CLEO times ...



- **We have not used histograms CLEO style for fits of RChL currents.**
- Note 3-dimensional representation of the data used by CLEO.
- It is good to constrain complexity of models, but also for systematic studies. Each bin of each histogram is constructed from its unique sub- set of events.
- At least in principle.
- It is not fully differential representation of data, CLEO supplemented their work with appropriate cross checks.
- but we are working in this important technical direction as well ...

Interferences and pseudo-resonances

- In preparation of model results for stable fits one has to look at the quality/dimensionality of distributions to be fitted and the possible traps.
- Input for 3-scalar moldels : (i) Just total rate (ii) single 1-dim histogram (iii) two 1-dim histograms (iv) three 1-dim histograms (v) CLEO style 3-dim distr. (vi) fully differential methods.
- To avoid: pseudo-resonance
- To avoid: new resonancec changing shapes through interferences.
- The two classes of topics are of course correlated.
- The more exlusive distributions the easier control of unwanted correlations/biases.
- Let us see some results from: Z. Was and J. Zaremba, “Study of variants for Monte Carlo generators of $\tau \to 3\pi\nu$ decays,” arXiv:1508.06424, EPJC 2016.

Interferences and pseudo-resonances

- Performance of semmingly similar models differ (or not), depending on the way one look at their results.
- case of interference of σ, f_0, f_2 contribution with the rest of the currents in $\tau \to 3\pi\nu$ decay modes.

Current	Absolute width	1D distributions	3D distributions	Absolute width differential
$\pi^0\pi^0\pi^-$ **CLEO**	75.1% 4.4% 20.5%	75.1% 4.4% 20.8%	75.1% 4.4% 22.4%	75.1% 4.4% 22.7%
$\pi^-\pi^-\pi^+$ **CLEO**	75.3% 4.3% 20.4%	75.3% 4.3% 20.7%	75.3% 4.3% 22.3%	75.3% 4.3% 22.6%
$\pi^-\pi^-\pi^+$ **CLEO isospin intricate**	74% 5.8% 20.2%	74% 5.8% 20.2%	74% 5.8% 20.6%	74% 5.8% 20.7%
$\pi^-\pi^-\pi^+$ **RChL**	97.5% 6.5% 4%	97.5% 6.5% 11%	97.5% 6.5% 18.2%	97.5% 6.5% 18.5%
$\pi^0\pi^0\pi^-$ **RChL**	94% 1.3% 4.7%	94% 1.3% 7.4%	94% 1.3% 9.5%	94% 1.3% 10%

Table 2: In each cell, first number is contribution from the spin one intermediate states, second is from isoscalars and the third one is interference. For 1-D (one-dimensional) distributions interference effect of the histogram with largest effect is taken. In the case of "Absolute width differential", average of (module of) interference over all events is shown.

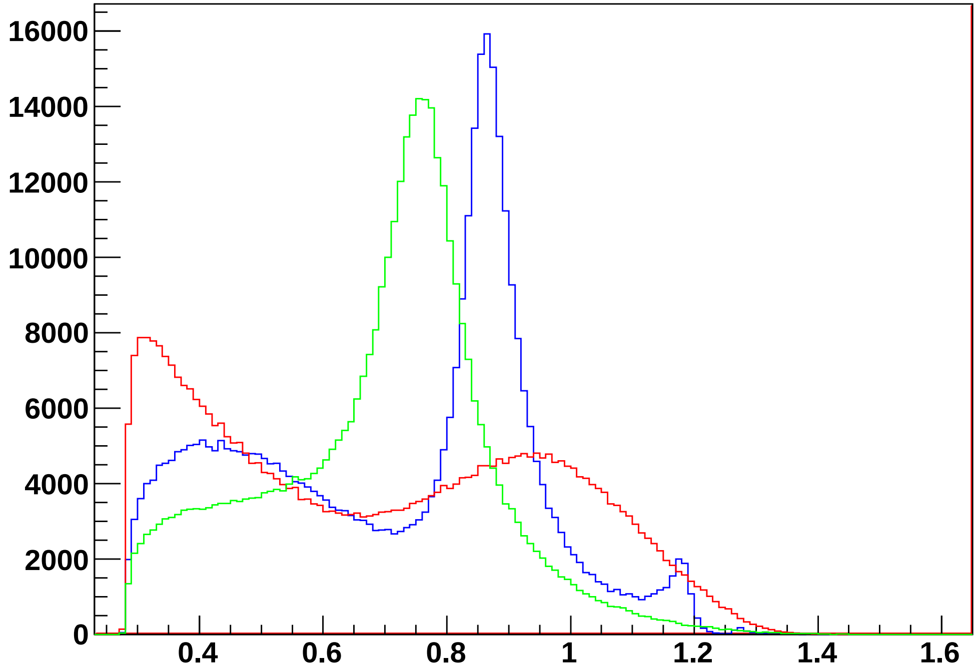


Figure 3: Invariant mass of $\pi^-\pi^+$ system in $\tau \to \pi^-\pi^-\pi^+$ decay using **TAUOLA CLEO isospin intricate** (green), current with multiplied 10 times amplitude from isoscalars (red) and also with width of isoscalars reduced 10 times (blue). Note forming low energy peak. Also at high energy σ peak apper for red line and shift down for blue. All disributions are normalized to the same number of events.

Interferences and pseudo-resonances

- Software for fitting MC, should be prepared in a way, that hadronic currents can be installed/replaced easily. Experimental data are order of magnitude better than theory.
- Theoretical results perepared to match the software. Also: what is the range of parameters, what is the dependence of distributions on these parameters, correlations etc.
- Fitting performed within experiments and results published by them?
- Resulting currents made available to non-tau experiments and theorists.
- Nice picture, but reality was nearly always away from that ...
- Having precisely installed matrix element which is explicitely coded offer gate for solutions, even if matrix element itself is of doubtful physics basis.

Technical tests future.

1. Unfortunately, so far, work on RChL currents did not evolved into set of test-environments.

2. For high precision, fitting is integral part of software construction, data dominate over model building.

3. Reproductability of our major results is not automatic. In fact, it is laborious and require sometimes help of people who are not anymore associated with science (calculation of errors for fits).

4. This translates into problems even with financing.

5. and of course re-use of fitting environment for new currents is not straightforward.

6. Should not be better to spent some time and attention on tools/techniques before new physics? I was asking this few years ago and I repeat now.

New (old) Tauola-bbb.

1. **I want to adress following contexts: fit strategy, experimental, theoretical syst. errors., cooperation between sub-communities.**
2. **All this started at τ conference under inspiration from Swagato, see Z. Was and P. Golonka, "TAUOLA as tau Monte Carlo for future applications," Nucl. Phys. Proc. Suppl. 144, 88 (2005).**
   (a) I am introducing changes into TAUOLA keeping this constraints in mind.
   (b) Location of TAUOLA with new hadronic currents, 200 decay channels, which can be manipulated by user: https://twiki.cern.ch/twiki/bin/view/FCC/Tauola
   (c) It is source of the code as explained in our paper arXiv:1609.04617, finally submitted for publication.
   (d) What should be included in standard initialization(s), it is not so important for Belle. They will change several times the currents anyway. Quality stamps from the side of theory, experiment, technical precision.
   (e) Goal: input for MC the same as input for fits.

New (old) Tauola-bbb.

- **Tests rely on old production files of BaBar**
- **No fitting enrionment prepared and accepted by Belle.**
- **Some features of new currents installations**
- **Fitting env. should follow.**

ChannelForTauola class for C++ main prog.

```
// get information about existing decay channel
ChannelForTauola *demo_modify = GetChannel(87);

demo_modify->setName( demo_modify->getName() + " modified" );
demo_modify->setBr( demo_modify->getBr() * 1234 );

// redefine decay products
vector<int> products = demo_modify->getProducts();
products[0] = -3; //K-
products[1] =  4; //K0
demo_modify->setProducts(products);

// register modified channel
Tauolapp::RegisterChannel( 87, demo_modify );
demo_modify->print();

// set ME type to flat phase space
demo_modify->setMeType(1);

// register into first available free slot
Tauolapp::RegisterChannel( -1, demo_modify );
demo_modify->print();
```

- Use `tauola-bbb/tauola-c/ChannelForTauola.h` to define user channels. No need to link Tauola library.
- New matrix element or current provided by a pointer to user function. Arguments of the function checked at compile time.
- Use `RegisterChannel` for `*demo_modify` object.
- Can be also used to modify existing channels (change name, BR, decay products, etc.)
- New channel can substitute existing one or be added at the end of the list
- All, except ponters to user provided functions of hadronic currents (ME's) re-initialize content of F77 common blocks: minimal changes in old F77 code.

Installation and running the example


```
demo-KK-face:
  README
  KK2f_defaults_adendum.txt
  Tauface.f

demo-tauolapp:
  README
  tauola_extras.f
  tauolapp.patch

demo-standalone:
  README
  iniofc.c
  lfv.c
  makefile
  MEutils.c
  MEutils.h
  pipi0.c
  pipi0.h
  prod
  taumain.f
  tauola-random.h
  TestCommunication.c

tauola-c:
  README
  ChannelForTauola.h
  ChannelForTauolaInterface.c
  ChannelForTauolaInterface.h
  channels_wrappers.c
  TauolaStructs.h
```

- Execute `make` and `make run` in `tauola-bbb/demo-standaone` : a stand-alone ready to use example of new functionality.
- See `tauola-bbb/demo-standalone/iniofc.c` on channel reinitialization.
- See `tauola-bbb/demo-KK-face` on how to install into KKMC.
- See `tauola-bbb/demo-tauolapp` on how to install into Tauola++ and TauSpinner.
- The `tauola-c` include interface to C++. If replaced by dummy Fortran routiones new version of Tauola is reduced to the same style fortran as in the past.

C++ wraper. Prototype.

- **Achieved:**
- TAUOLA MC with 200 decay channels, solution similar as presented on TAU04 and used by BaBar. Neutrinoless channels available.
- **Default BaBar Tauola initialization.**
- Alternatively, for 2 and 3 π's, new currents with comparison with experimental data prepared.
- Theoretically motivated currents, 4 and 5 π's decay modes, also as alternative.
- No fits to global properties such as average charged energy. For alternatives, no experimental quality stamps.
- User can re-initialize TAUOLA with own (C++ coded) currents (or matrix elements).

- **Non completed tasks:**
- Results for 3-scalar modes with K's are not incorporated, need quality fits.
- Many alternative parametrizations, eg. for 2K 2π modes (BaBar) are not incorporated, even though these are missing channels, at present only flat phase space.
- Environments for fits are not well structured for model independent use.

Summary for program as of today

- How should we proceed to get most from experimental data for hadronic interactions?
- (i) Experimental systematic errors (ii) Theoretical systematic errors
- Systematic errors due to cross biasing.
- What are the constraints on organization of Monte Carlo and fitting environments?
- Flexibility for re-definition of dynamic of tau decays and initialization based on work of BaBar/Belle collaborations and some older works was achieved with the help of plug-ins.
- We have collected some experience on requirements for building fitting environments, but we are not at the level of automated and/or systematized approach.
- Context of systematic errors, in case of fits to multi-dimensional representation of data, require further discussion and implementation.
- Question of manpower and training as well as motivation of involved people.
- Present step of the project development is possible, because of previous efforts and development phases. Let us recall some of those. I think this is universal to any large scale effort.

What from that can be of a general interest?

`Lessons and observations from my 30 years.`

- Previous results, which could work as prototypes.
- In particular results/programs of other people.
- Their advice.
- Humiliations as motivation to unnecesary work, very useful later.
- Hints on what to learn and what to avoid.
- Boring unnecessary skills $\longrightarrow$ key to success.
- People wanting results.
- Lucky mistakes.
- Growing with the field.
- Of course there is nothing systematic in that. Every step could have been played differently. No problem if one makes mistakes. Solution: make sufficiently many mistakes, learn from them and stay motivated.