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Extract of information on TAUOLA PHOTOS and MC-TESTER
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ABSTRACT

TAUOLA and PHOTOS Monte Carlo still remain very conservative in software arrangements all changes introduced in recent years should not change the mode of operation as explained in published documentation of the programs. Comfort of the users from the on-giong experiments is high priority.

Of course physics content was in many respect improved. Such changes are monitored, for example in materials from the Tau-lepton conferences.

Migration of the programs to C++ or better say to HepMC was delayed until now, because of users in low energy collaborations such as Belle, BaBar, Na49 etc. The tool necessary for such migration MC-TESTER is ready.

Program Info for TAUOLA, MC-TESTER

TAUOLA main references: [1–3]
MC-TESTER main reference: [4]
TAUOLA universal interface (based on HEPEVT) main references: [5–7]
web page: http://wasm.home.cern.ch/wasm/goodies.html

TAUOLA is a Fortran 77 package used for generation of tau lepton decays including spin polarization. For each decay mode in consist of:

- an individual phase space generator (with no approximation used);
- part describing weak current: including first order QED corrections for leptonic decays and the possibility to include some non standard interactions due to: tau neutrino mass and, free choice of vector and axial-vector couplings of tau to virtual W;
- part describing hadronic current; several choices are available, some of them are supported/distributed from TAUOLA web page, but in every case require individual referencing (available from the program printout); options represent significant effort of experimental collaborations
- part responsable for: choice of the decay mode, overall administration, and for writing the generated decay into HEPEVT record, it is common for all decay modes.

For more details see program references. Talk, of the last tau conference Ref. [8], may be useful as well. Relatively recent improvements in the generation of decays into five scalars, are described in ref. [9]. Up to date, and also older versions of the proram, are available from the web-page.

A universal interface for TAUOLA to the HEPEVT event record is provided in the TAUOLA Interface program, see refs. [5–7]. Technical documentation is included in [7]. Discussion of all improvements of years 2001-2005, in particular TAUOLA universal interface, is documented in that reference as well.

A program called MC-Tester [4] (Authors P. Golonka, T. Pierzchala, Z. Was, `http://cern.ch/MC-TESTER`) is expected to be useful for TAUOLA users. This package, written in C++ and interfaced to Fortran 77/90, is developed for tests of decay packages, in particular for the tests of future C++ TAUOLA versions. The idea is to have a quick way of comparing two packages for the decay, say of a particle 'X'. The algorithm searches over the input event records (HEPEVT, PYJETS, LUJETS, some C++ records may be used as input as well) for occurence(s) of decay of 'X'. Whenever new decay of 'X' is found, a list of the decay modes is extended (classified on the basis of the decay products) and histograms of all invariant masses are initialized; at further occurences the hstograms filled in.

The data from two distinct runs of MC-Tester with two decay packages (or just two tunings) for the same particle 'X' can be later compared within a MC-Tester analysis run, independently of the programming language or event records used by the compared generators.

Program Info for PHOTOS

Main references: [10, 11]
Web page: http://wasm.home.cern.ch/wasm/goodies.html

In the cascade decays of resonances, effects of QED bremsstrahlung corrections need to be simulated. Because of a multitude of decay channels, taylored solution for every case is not practical. and it is also not necessary. In general case PHOTOS can be used for bremsstrahlung corrections. The precision of the generation is under full control only for decay channels where tests, comparisons/implementations of exact matrix element calculations, were performed. Some properties of the generated distributions are nonetheless granted in every case: (i) complete, multiphoton phase space is covered in every case (ii) in the soft photon regions of the phase space shapes and normalization of the distributions are correctly simulated, if decays into stable particles are considered, this is true starting from the program version of January 2005, (iii) distributions of the Leading Logarithm sense are also correctly covered by the PHOTOS simulation; precision is not worse than the complete multiple bremsstrahlung of LL approximation.

The action of the algorithm consists of generating, with internally calculated probability, bremsstrahlung photon(s), which are later added to the event (typically HEPEVT) record. Kinematic configurations and event trees are appropriately modified at the same time. Energy-momentum conservation is not compromised, mass effects are taken into account.

Precision of PHOTOS simulation depend on the event record prepared for its operation; degrading technical difficulties may arise. Sometimes remedies are possible at the PHOTOS level, they are explained in the program technical documentation [7]. This documentation, valid for all versions of the program until now, explain installation and how use the program. Note, that demonstration program of the distribution, is initialized with the backward compatible setting. To activate, for example, multiphoton radiation, initializations need to be modified.

Since 1999, the C++ version of the algorithm exist [12]. So far, it is not in wide use, that is why, until now, it was not regularily updated.

Relatively recent improvements and also numerical tests for two-body decays of W, Z and B mesons are covered in references [13–15]. In [15], detailed description of the exact multiphoton phase-space parametrization as used in the program is given.

In case of Z and B meson decays, exact first order matrix element became available as internal weight within PHOTOS. As a consequence complete NLO corrections can be simulated. Benchmarks – coparisons with second order Monte Carlo program results – were completed, precision level better than 0.1 % was verified. Because of explicit separation of the program internal weight into part corresponding to phase-space and matrix element, electromagnetic hadronic form-factors can be, if necessary, introduced for each decay channel. These encouraging results, demonstrating that missing in older versions of PHOTOS non-leading matrix element effects contribute below 0.1 % precision tag, can not be used as a general proof of the program precison.

References

[1] S. Jadach, Z. Was, R. Decker and J. H. Kuhn, Comput. Phys. Commun. **76** (1993) 361.

[2] M. Jezabek, Z. Was, S. Jadach and J. H. Kuhn, Comput. Phys. Commun. **70** (1992) 69.

[3] S. Jadach, J. H. Kuhn and Z. Was, Comput. Phys. Commun. **64** (1990) 275.

[4] P. Golonka, T. Pierzchala and Z. Was, Comput. Phys. Commun. **157** (2004) 39 [arXiv:hep-ph/0210252].

[5] Z. Was and M. Worek, Acta Phys. Polon. B **33** (2002) 1875 [arXiv:hep-ph/0202007].

[6] T. Pierzchala, E. Richter-Was, Z. Was and M. Worek, Acta Phys. Polon. B **32** (2001) 1277 [arXiv:hep-ph/0101311].

[7] P. Golonka, B. Kersevan, T. Pierzchala, E. Richter-Was, Z. Was and M. Worek, Comput. Phys. Commun. **174**, 818 (2006) [arXiv:hep-ph/0312240].

[8] Z. Was, Nucl. Phys. Proc. Suppl. **169** (2007) 16 [arXiv:hep-ph/0610386].

[9] J. H. Kuhn and Z. Was, arXiv:hep-ph/0602162.

[10] E. Barberio and Z. Was, Comput. Phys. Commun. **79** (1994) 291.

[11] E. Barberio, B. van Eijk and Z. Was, Comput. Phys. Commun. **66** (1991) 115.

[12] P. Golonka, "Photos+ : C++ implementation of the PHOTOS algorithm", http://piters.web.cern.ch/piters/

[13] G. Nanava and Z. Was, Acta Phys. Polon. B **34** (2003) 4561 [arXiv:hep-ph/0303260].

[14] P. Golonka and Z. Was, Eur. Phys. J. C **50** (2007) 53 [arXiv:hep-ph/0604232].

[15] G. Nanava and Z. Was, Eur. Phys. J. C **51** (2007) 569 [arXiv:hep-ph/0607019].