Tau Decay validation for Herwig++ using MC-Tester

Zhonghua qin

Desy Atlas Group

About MC-Tester

- Originally created to compare tau decays in different versions of tauola
- Written by: P. Golonka, T. Pierzchala, Z. Was
- The tool allows comparisons of decays for any particle or resonance between different Monte-Carlo Programs.
- The Monte-Carlo Generators can be Fortran or C++
- The event record formats can be HEPEVT, LUJETS, PYJETS and recently HepMC
- Interest from the GENSER group for their validation needs
- Recently also interfaced to Athena by Nadia Davidson
- More see : http://mc-tester.web.cern.ch/MC-TESTER and the talk given by Nadia on Atlas MC meeting

Example of output: Table of decay modes

Found decay modes:

Decay channel	Branching Ratio ± Rough Errors Generator #1	Generator #2	Max. shape dif. param.
$\tau^- \to \nu_\tau \pi^0 \pi^-$	25.3683 ± 0.0159%	25.3085 ± 0.0159%	0.04375
$\tau^- \to e^- \widetilde{\nu}_e \nu_\tau$	17.8479 ± 0.0134%	18.1093 ± 0.0135%	0.00000
$\tau^- \to \mu^- \widetilde{\nu}_\mu \nu_\tau$	17.3866 ± 0.0132%	17.6326 ± 0.0133%	0.00000
$\tau^- \to \nu_\tau \pi^-$	11.0768 ± 0.0105%	11.1765 ± 0.0106%	0.00000
$\tau^- \to \nu_\tau \pi^0 \pi^0 \pi^-$	9.1865 ± 0.0096%	9.1171 ± 0.0095%	0.09413
$\tau^- \to \nu_\tau \pi^+ \pi^- \pi^-$	8.9837 ± 0.0095%	8.8828 ± 0.0094%	0.09368
$\tau^- \to \nu_\tau \pi^0 \pi^+ \pi^- \pi^-$	4.2973 ± 0.0066%	4.5319 ± 0.0067%	0.30310
$\tau^- \to \nu_\tau \pi^0 \pi^0 \pi^0 \pi^-$	1.0765 ± 0.0033%	1.0090 ± 0.0032%	0.00724
$\tau^- \to \nu_\tau K^-$	0.7202 ± 0.0027%	0.7138 ± 0.0027%	0.00000
$\tau^- \to \nu_\tau \pi^0 \pi^0 \pi^+ \pi^- \pi^-$	0.4990 ± 0.0022%	0.0897 ± 0.0009%	0.00000
$\tau^- \to \nu_\tau \pi^0 K^-$	0.4785 ± 0.0022%	0.4617 ± 0.0021%	0.00000
$\tau^- \to \nu_\tau K_L^0 \pi^-$	0.4624 ± 0.0022%	0.4444 ± 0.0021%	0.00000
$\tau^- \to \nu_\tau \pi^- K_S^0$	0.4610 ± 0.0021%	0.4449 ± 0.0021%	0.00000
$\tau^- \to \nu_\tau \pi^+ \pi^- K^-$	0.3902 ± 0.0020%	0.5051 ± 0.0022%	0.52330
$\tau^- \to \nu_\tau \pi^0 \pi^- \eta$	0.1707 ± 0.0013%	0.1696 ± 0.0013%	0.00000
$\tau^- \to \nu_\tau \pi^- K^+ K^-$	0.1704 ± 0.0013%	0.1509 ± 0.0012%	0.07360
$\tau^- \to \nu_\tau \pi^0 K_L^0 \pi^-$	0.1605 ± 0.0013%	0.2745 ± 0.0017%	0.92850
$\tau^- \to \nu_\tau \pi^0 \pi^- K_S^0$	0.1592 ± 0.0013%	0.2734 ± 0.0017%	0.93657
$\tau^- \to \nu_\tau \gamma \pi^0 \pi^-$	0.1559 ± 0.0012%	0.1303 ± 0.0011%	0.00000
$\tau^- \to \nu_\tau K_L^0 \pi^- K_S^0$	0.1510 ± 0.0012%	0.0763 ± 0.0009%	0.00270
$\tau^- \to \nu_\tau K_L^0 K^-$	0.1289 ± 0.0011%	0.0508 ± 0.0007%	0.00000
$\tau^- \to \nu_\tau K_S^0 K^-$	0.1287 ± 0.0011%	0.0507 ± 0.0007%	0.00000
$\tau^- \to \nu_\tau \pi^0 \pi^0 \pi^0 \pi^+ \pi^- \pi^-$	0.1094 ± 0.0010%	0.0506 ± 0.0007%	0.00000
$\tau^- \to \nu_\tau \pi^+ \pi^+ \pi^- \pi^- \pi^-$	0.0803 ± 0.0009%	0.0401 ± 0.0006%	0.00000
$\tau^- \to \nu_\tau \pi^0 \pi^0 K^-$	0.0792 ± 0.0009%	0.0504 ± 0.0007%	0.29190
$\tau^- \to \nu_\tau K_L^0 K_L^0 \pi^-$	0.0760 ± 0.0009%	0.0372 ± 0.0006%	0.00854
$\tau^- \to \nu_\tau \pi^- K_S^0 K_S^0$	0.0756 ± 0.0009%	0.0378 ± 0.0006%	0.01189
$\tau^- \to \nu_\tau \pi^0 K_L^0 K^-$	0.0507 ± 0.0007%	0.0763 ± 0.0009%	0.85321
$\tau^- \to \nu_\tau \pi^0 K_S^0 K^-$	0.0498 ± 0.0007%	0.0746 ± 0.0009%	0.87506
$\tau^- \to \nu_\tau \pi^0 \pi^+ \pi^+ \pi^- \pi^- \pi^-$	0.0186 ± 0.0004%	0.0293 ± 0.0005%	0.00000

Similarity coefficients: T1=1.881148 , T2=4.510389

Decay channel

Branching ratio for generator #1 and #2

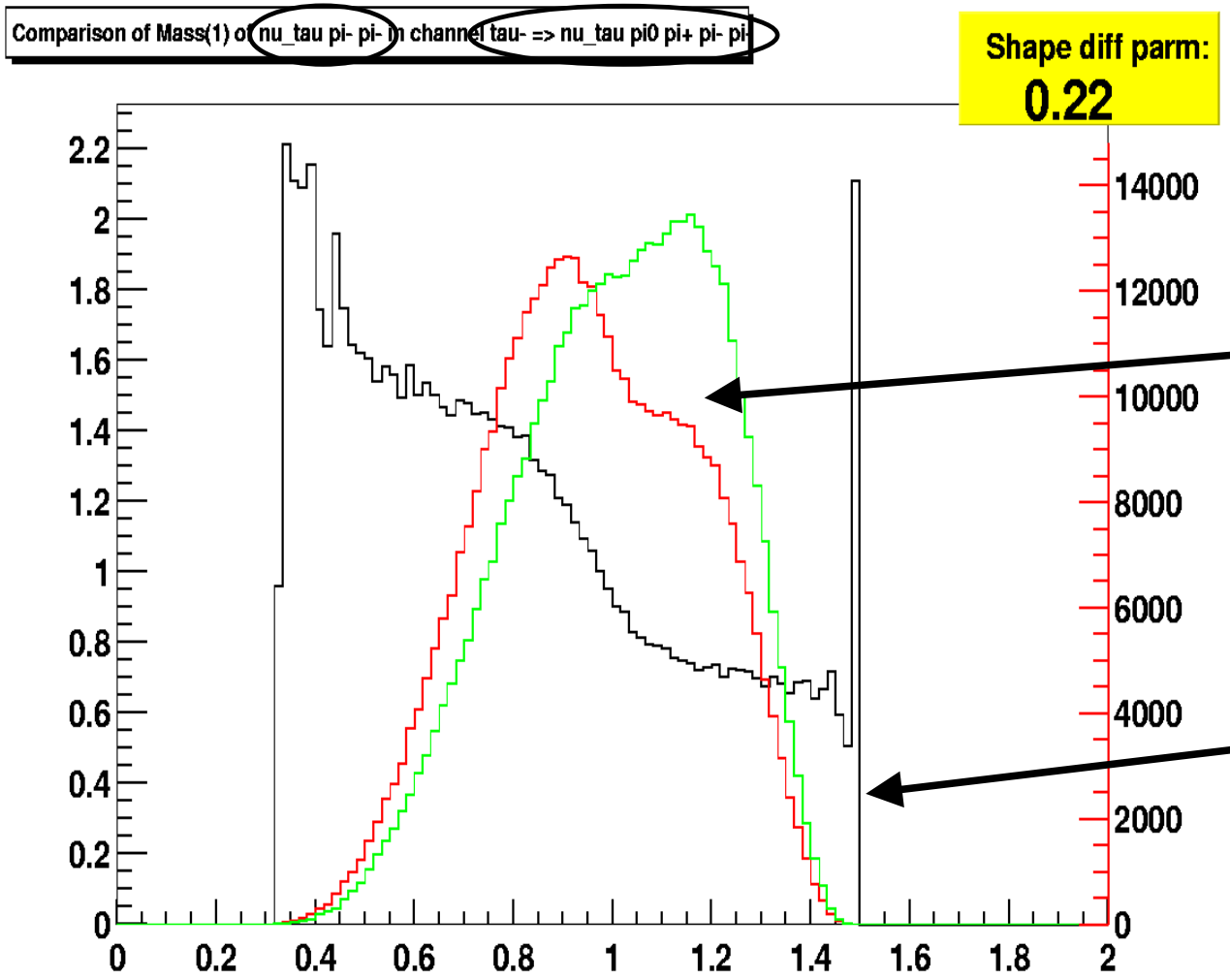
Rough statistical errors of branching ratios

Maximal “Shape Difference Parameter”

Slide from Nadia Davidson

Example of output: histograms

This shows the invariant mass of
nu_tau pi- pi- in mode tau -> nu_tau pi0 pi+ pi- pi-



Histograms of invariant mass from generator

#1 and #2

Ratio of the two histogrammes(normalized)

Tau Decays validation for Herwig++

- Compare Tau decay between Herwig++, Herwig and Pythia
- Using the same physics process for the different generators

  qqbar -> W -> Tau nu_Tau
- Tau decays with different package

  For Herwig++ and Pythia, tau decayed by the generators themselves,

  and for Herwig, decayed by Tauola.
- 60000 events produced in Athena

- First results for the validation

1) see the .pdf output files
2) and some branching ratios of decay channel obtained from the three generators listed

Decay Channel	Branching Ratio ± errors			
	PDG(06)	Herwig++	Pythia	Herwig
$\tau^- \to \pi^- \nu_\tau$	10.90 ±0.07%	11.0090 ± 0.2053%	11.0606 ±0.2081%	10.4920 ±0.2037%
$\tau^- \to \pi^- \pi^0 \nu_\tau$	25.50 ±0.10%	25.3254 ±0.3114%	25.2076 ±0.3142%	24.8675 ±0.3136%
$\tau^- \to \pi^- \pi^0 \pi^0 \nu_\tau$	9.25 ±0.12%	9.4626 ±0.1903%	8.8516 ±0.1862%	8.8231 ±0.1868%
$\tau^- \to \pi^- \pi^- \pi^+ \nu_\tau$	9.33 ±0.08%	9.2329 ±0.1880%	9.2276 ±0.1901%	8.3762 ±0.1820%
$\tau^- \to \pi^- \pi^- \pi^+ \pi^0 \nu_\tau$	4.46 ±0.06%	4.4557 ±0.1306%	4.3397 ±0.1304%	4.4056 ±0.1320%
$\tau^- \to \pi^- \pi^0 \pi^0 \pi^0 \nu_\tau$	1.04 ±0.08%	1.1790 ±0.0672%	1.1750 ±0.0678%	0.7554 ±0.0547%
$\tau^- \to \nu_\tau \tilde{\nu}_\mu \mu^-$	17.36 ±0.05%	17.8380 ±0.2613%	17.6563 ±0.2630%	16.9422 ±0.2588%
$\tau^- \to \nu_\tau \tilde{\nu}_e e^-$	17.84 ±0.05%	17.9758 ±0.2623%	17.9069 ±0.2648%	15.2495 ±0.2456%
$\tau^- \to K^- \nu_\tau$	(6.91 ±0.23) ×10-3	0.5206 ±0.0446%	0.7520 ±0.0543%	0.7119 ±0.0531%
$\tau^- \to \pi^- K_L^0 \nu_\tau$		0.3981 ±0.0390%	0.4700 ±0.0429%	0.3203 ±0.0356%
$\tau^- \to \pi^- \pi^- \pi^+ \pi^0 \pi^0 \nu_\tau$		0.3828 ±0.0383%	0.5483 ±0.0463%	0.0989 ±0.0198%
$\tau^- \to K^- \pi^0 \nu_\tau$	(4.52 ± 0.27)×10-3	0.3215 ±0.0351%	0.4700 ±0.0429%	0.3401 ±0.0367%
$\tau^- \to K^- K^+ \pi^- \nu_\tau$	(1.53 ±0.10))×10-3	0.1378 ±0.0230%	0.2350 ±0.0303%	0.0989 ±0.0198%
$\tau^- \to \pi^- \pi^0 \gamma \nu_\tau$		0.1378 ±0.0230%	0.1723 ±0.0260%	0.8938 ±0.0595%
$\tau^- \to K^- K_L^0 \nu_\tau$		0.1225 ±0.0217%	0.0313 ±0.0111%	0.0356 ±0.0119%
$\tau^- \to \pi^- K_L^0 \pi^0 \nu_\tau$		0.1072 ±0.0203%	0.1723 ±0.0260%	0.2017 ±0.0282%
$\tau^- \to K^- \pi^0 \pi^0 \nu_\tau$	(5.8 ±2.3)×10-4	0.0766 ±0.0171%	0.0313 ±0.0111%	0.0356 ±0.0119%
$\tau^- \to K^- K_L^0 \pi^0 \nu_\tau$		0.0459 ±0.0133%	0.0627 ±0.0157%	0.0672 ±0.0163%

Conclusions of validation

- Altogether, the branching ratios of tau decay from Herwig++ are more consistent with PDG ,Pythia than Herwig
- For Herwig, there are some channels with the ratios lower than the other generators and PDG, need to investigate further for that.

Sumary

- Using MC-tester correctly in Athena and many useful feedback given to the authors
- the first results of tau decay validation for Herwig looks reasonable
- The tool can be used for other particles decay so try it out if interested .