MC-TESTER and TAUOLA Interface Update

http://mc-tester.web.cern.ch/MC-TESTER

http://www.ph.unimelb.edu.au/~ndavidson/tauola/doxygen/index.html

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MC-Tester (Reminder)

- The tool allows semi-automated comparisions of decays of particles or resonances between Monte-Carlo programs.
- Very useful for the validation of monte-carlo from eg. TAUOLA.
  - Compare different athena releases.
  - Compare stand-alone version of generator with ATLAS monte-carlo.
  - Can compare different generators.
- Works for a variety of generators:
  - Can be Fortran or C++
  - Events types: HEPEVT, LUJETS, PYJETS and HepMC
  - For any particle (tau, B, Z, W, H..)
- Written by P. Golonka, T. Pierzchala, Z. Was
  - Version 1.1 documented in Comput. Phys. Commun. In 2004
- Extended last year to HepMC.

Example Output – Title Page (Reminder)

MC-TESTER results for decays of particle τ^- (PDG code 15).

Piotr Golonka Tomasz Pierzchala Zbigniew Was

March 27, 2008

Results from generator 1.

Pythia 8.1 demo; e-e at 92GeV, Z^0 single production
Z^0 decay to $\tau^{\pm}$ exclusively.
No π decays.

- From directory:
  /afs/cern.ch/user/n/ndavidso/MC-TESTER-1.2/examples-C++/pythia
- Total number of analyzed decays: 1000008
- Number of decay channels found: 45 + 25

Results from generator 2.

Pythia 6.4.14 demo; e-e at 92GeV, Z^0 single production
Z^0 decay to $\tau^{\pm}$ exclusively. No π decays.
Multi-body tau decay switched on.

- From directory:
  /afs/cern.ch/user/n/ndavidso/MC-TESTER-1.2/examples-F77/pythia
- Code version (from version file): PYTHIA 6.4.14
- Total number of analyzed decays: 1000000
- Number of decay channels found: 45 + 17

User Analysis: MCTest01

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Particle decays being tested

Description as set by user for generator #1

Number of channels found (channel in common for #1 and #2 + channels unique in #1)

Total decays found in MC sample

Algorithm used for shape difference calculation

Example Output – Channel List (Reminder) - usually a few pages long

Found decay modes:

Decay channel	Branching Ratio ± Rough Errors Generator #1	Generator #2	Max. shape dif. param.
$\tau^- \to \nu_\tau \pi^0 \pi^-$	25.3085 ± 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%	0.30340
$\tau^- \to \nu_\tau \pi^0 \pi^0 \pi^0 \pi^-$	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”

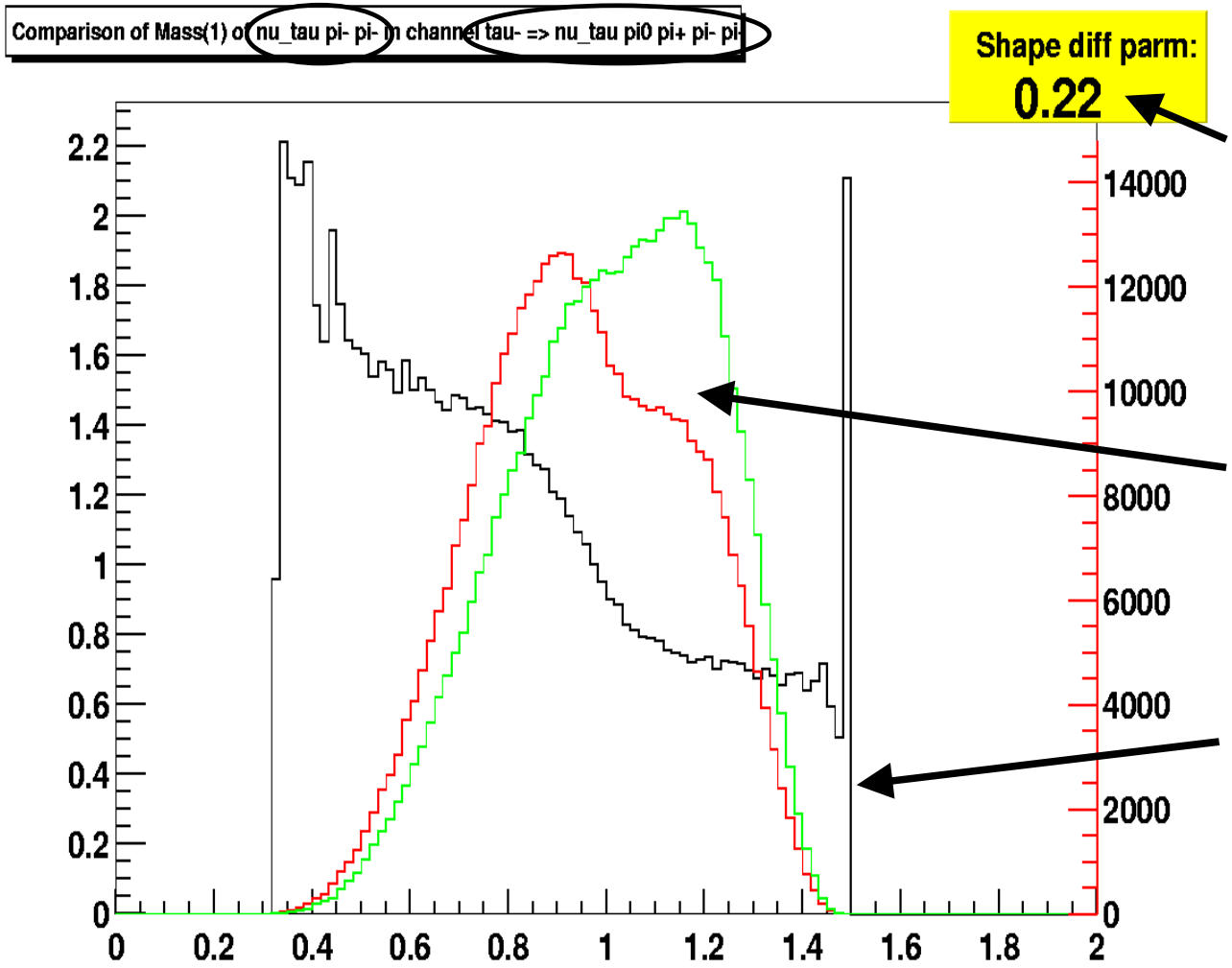
Similarity Coefficients (combined: for all decay modes)

Slide from Piotr Golonka

Example Output – Histogram of Invariant Mass - 100s of these histograms are produced

This shows the invariant mass of

nu_tau pi- pi- in mode tau -> nu_tau pi0 pi+ pi- pi-



Shape Difference Parameter value

Histograms of invariant mass from generator #1 and #2

Ratio of the two histograms (after normalisation)

What's new since the last tau workshop? (1)

- Installed by GENSER on afs at /afs/cern.ch/sw/lcg/external/MCGenerators/mctester
- Interfaced into Athena from release 14.2.0 (MC-TESTER - 1.211)
- Has been used for validation of monte-carlo samples:
  - Zhonghua Qin tested tau decays for Herwig++, Herwig, Herwig+Tauola+ Photos, Pythia, Pythia+Tauola+Photos, and Sherpa.
    - http://indico.cern.ch/materialDisplay.py?contribId=23&materialId=slides&confId=36
  - Aldo Saavedra has begun using MC-TESTER on new tau samples on the grid. Results should be ready soon.

What's new since the last tau workshop? (2)

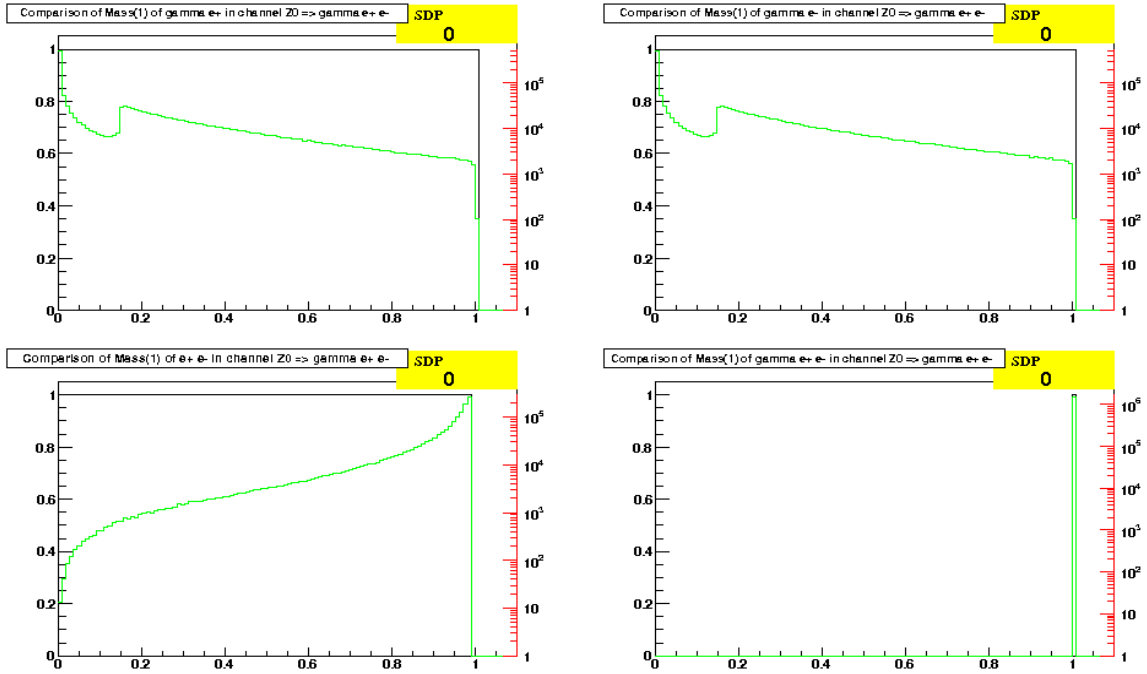
- Latest version 1.23.1 (from Athena r15.0.0) has the following new features:
  - Plots of invariant mass squared may be used instead of invariant mass + options for logarithmic scale and normalisation to the mother particles mass.
  - UserTreeAnalysis – ROOT macro which allows:
    - Filtering of the daughter particles. eg. based on energy.
      - Allows tests with IR sensitive quantities (see next slide).
    - Allows the user to define extra plots. eg. pt, eta, phi spectra.
  - Ready for SLC5
  - In athena from release 15.0.0.
- Paper on arXiv: http://arxiv.org/abs/0812.3215

Example Output with MC-TESTER 1.23.1

- Benchmark distributions for PHOTOS:
  - Photons have E > 1 GeV in Z rest frame.
  - Logarithm scale.

1 Decay Channel: $Z^0 \to \gamma e^+ e^-$

Number of events from generator 1: 1541292
Number of events from generator 2: 1541292

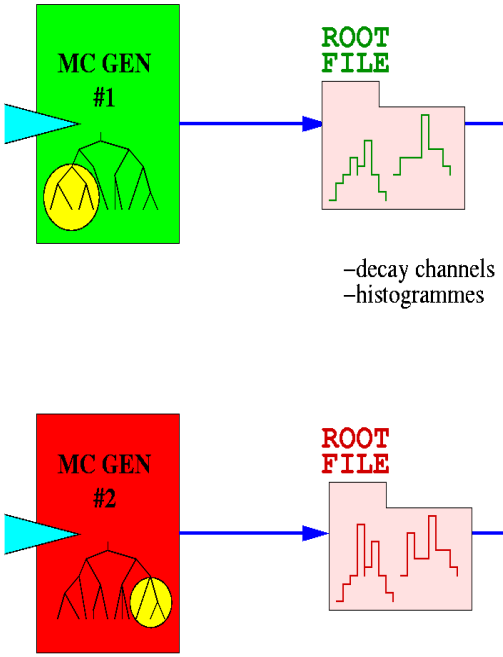


How to run MC-TESTER in Athena

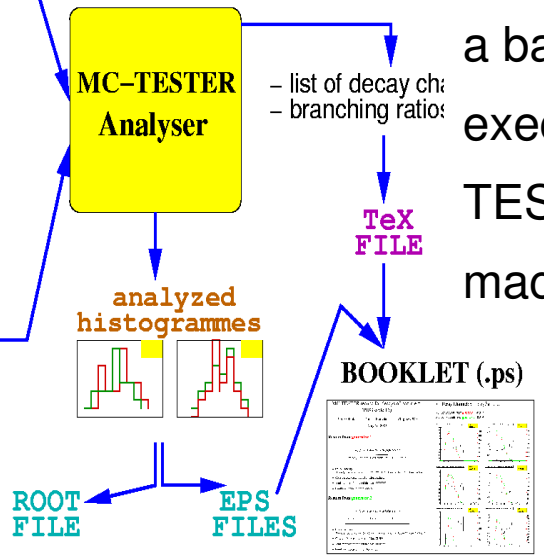
- MC-Tester is connected as an external package to Athena (via packages Generators/MCTester_i and External/MCTester) .
- Running instructions can be found in MCTester_i doxygen mainpage.

Generation Step

HepMC events are read from the McEventCollection in Athena.



Analysis Step



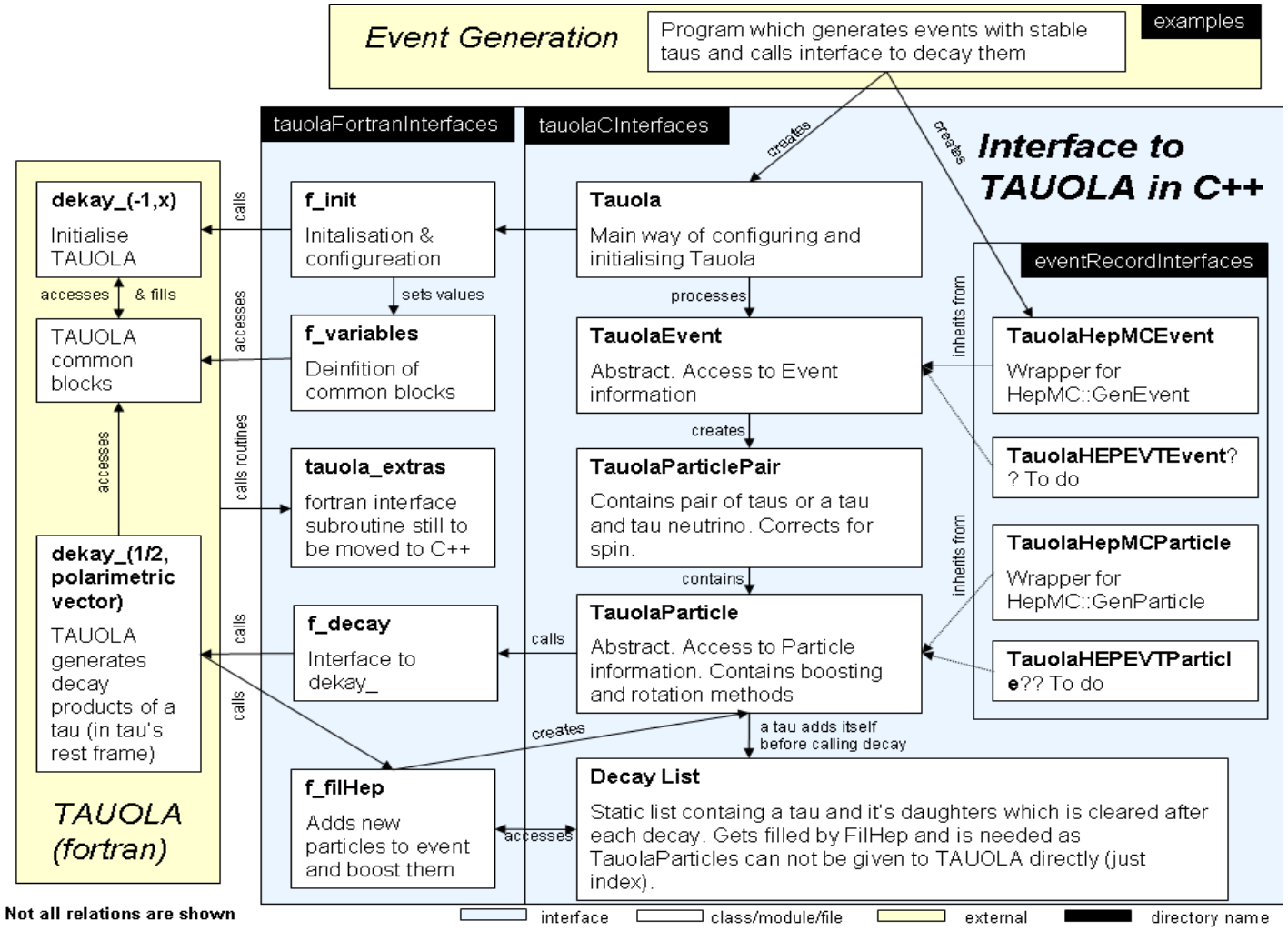
Independent from Athena (run using a bash script to execute MC-TESTER root macros).

TAULOLA Universal Interface

- The TAUOLA Universal Interface is responsible for:
  - Requesting tau decays from TAUOLA.
  - Boosting and writing the decay into the event record.
  - Calculating tau spin states based on the processes which created the tau.
- Currently written in FORTRAN and interfaces with the HEPEVT event record common block.
- Efforts have begun to develop a C++ version which interfaces with HepMC (as these are standard for LHC experiments)
  - Nadia Davidson, Tomasz Przedzinski, Elzbieta Richter-Was, Zbigniew Was
- TAUOLA will remain in FORTRAN for the moment for compatibility and input from the low energy community.
  - A version compatible with SLC5 (with gfortran) will be produced by April (in communication with Alberto Ribbon from the LCG group)

Info on C++ Interface to TAUOLA

- Design, doxygen doc. and download from:
  - http://www.ph.unimelb.edu.au/~ndavidson/tauola/doxygen/index.html

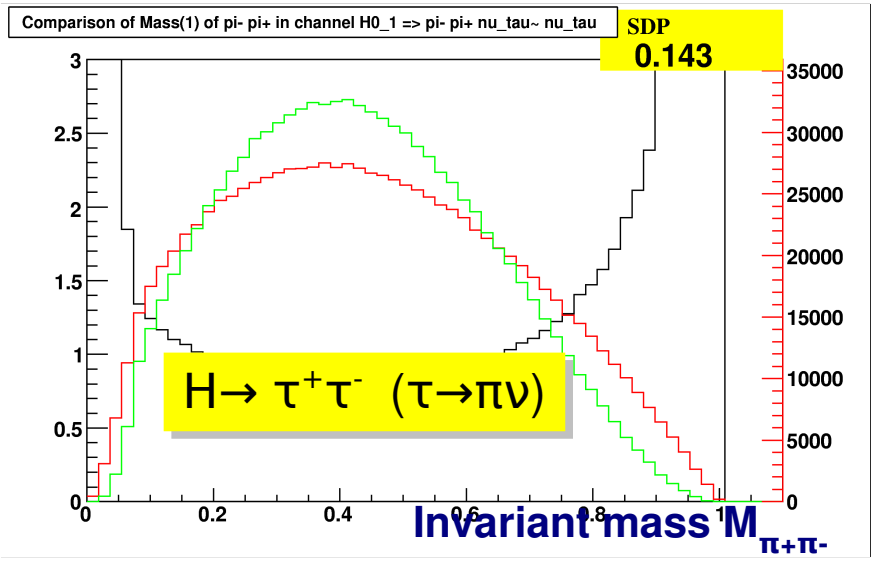


Status of TAUOLA C++ Interface

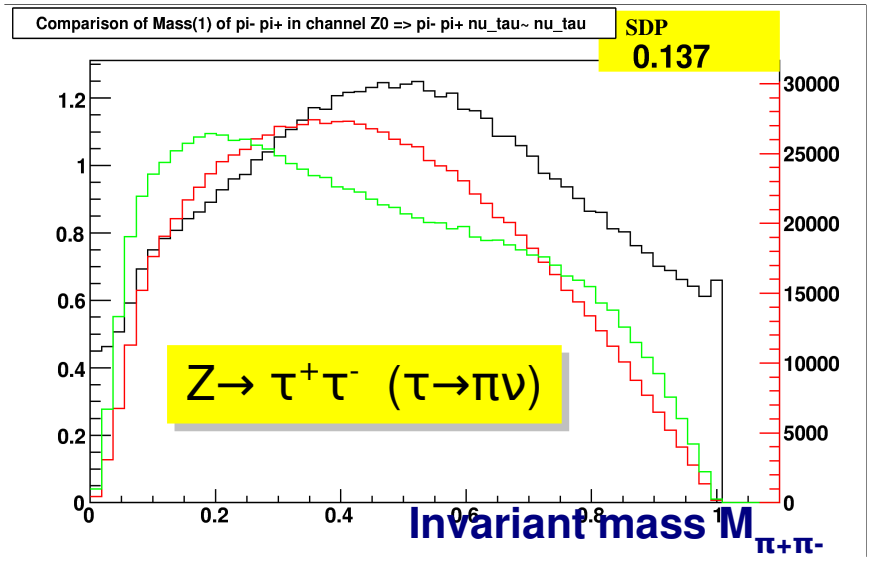
- What has been implemented:
  - Interface to HepMC event record
  - Test environment has been set-up for validation
  - Longitudinal spin correlations for Z,H,$W^{\pm}$,$H^{\pm}$ for simple cases only
- What has not been implemented:
  - Complicated cases eg . with more than one mother producing the tau as in e+ e- -> tau+ tau- or extra final state particles. eg. Z -> tau+ tau- gamma.
  - Transverse spin correlations
  - Many components are left in FORTRAN. eg. Z polarisation calculation.
  - Has not been interfaced with PHOTOS
    - Migration of PHOTOS to C++ is the next goal.

Spin observables with new interface

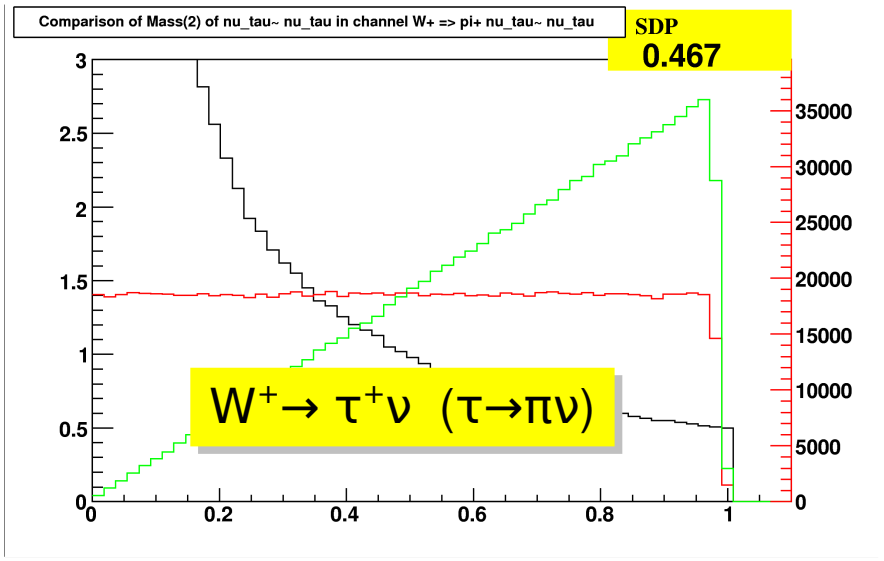
red - spin ignored green – spin on black- ratio of spin on/off



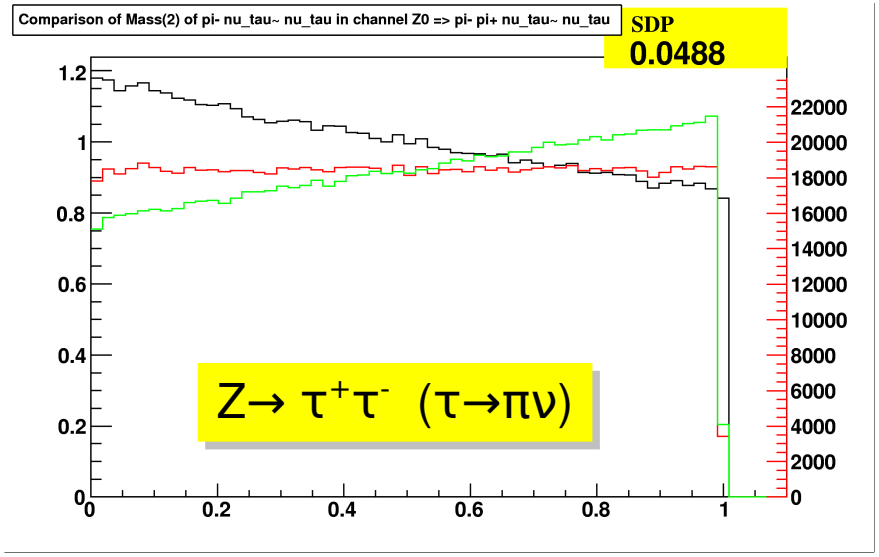
Invariant mass $M_{\pi+\pi-}$



Invariant mass $M_{\pi+\pi-}$



Pion energy: $1-2E_{\pi+}/M_W$



Pion energy: $1-2E_{\pi+}/M_Z$

Summary/Conclusions

- MC-TESTER is a validation tool which allows comparisons of decays from Monte-Carlo generators, for HepMC and HEPEVT, (complementary to existing tools)
  - It has been in Athena since r14.2.0 and being used for validation.
- The TAUOLA Universal Interface is being rewritten in C++
  - Allows TAUOLA to be run directly on HepMC events. (without conversion to HEPEVT)
  - Simple spin correlations have be implemented
  - More complicated cases still need to be added
  - Work on PHOTOS has started with production of benchmark plots.

Extra Slides

MC-TESTER Configurables:

- Configured by:
  - ROOT/C++ macro file **SETUP.C** (interpreted at runtime) or
  - Using “Setup” Class in Monte-Carlo generator code
- Some important configurables:
  - Event Record type
  - Decay particle PDG code
  - Particles considered “stable” (eg. pi0)
  - Histogram binning
  - MC Description on booklet title page
  - Algorithm to calculate shape difference
    - MCTest01 (exclusive surface)
    - MCTest02 (Non-uniformity of Histograms ratio)
    - MCTest03 (Kolmogorov compatibility)
    - User Defined

List of References

- MC-TESTER Documentation:
  - Website: http://mc-tester.web.cern.ch/MC-TESTER
  - P.Golonka, T.Pierzchala, and Z.Was, Comput. Phys. Commun. 157(2004)1, pp 39-62 doi: http://dx.doi.org/10.1016/S0010-4655(03)00466-1
  - Doxygen: http://mc-tester.web.cern.ch/MC-TESTER/doxygen_html/index.html
  - Savannah Bug Tracking: https://savannah.cern.ch/projects/mc-tester/

MC-TESTER Examples of Use

- Tests of PHOTOS Hard Brem. with KKMC, KoralZ, TAUOLA and PYTHIA (By Piotr Golonka)
  http://mc-tester.web.cern.ch/MC-TESTER/PHOTOS-MCTESTER/
- The tool has been used by members of the ATLAS collaboration:
  - In particular, Zhonghua Qin tested tau decays for Herwig++, Herwig, Herwig+Tauola+ Photos, Pythia, Pythia+Tauola+Photos, and Sherpa.
    - http://indico.cern.ch/materialDisplay.py?contribId=23&materialId=slides&confId=36346
    - A precision problem was identified with Sherpa interface read event mode.
  - Used to quickly rule-out a problem with the TAUOLA interface when discrepancies were seen between MC samples of W-> tau nu.
- A matrix of comparisons (eg. pythia 6.4 vs 8) can be found at:
  http://mc-tester.web.cern.ch/MC-TESTER/mc-tester_results/results.html