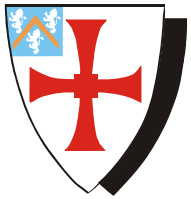

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Particle Data for Herwig++

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Particle Data

- Some people think that the particle data in event generators is simply inputted from the PDG.
- However there is a lot more to it.
- For any but the leptons, lowest lying light mesons and baryons the data in the PDG is far from complete.
- In particular the branching ratios rarely sum to one and are sometimes useless.

Particle Data

$f_0(980)$ [l]

$I^G(J^{PC}) = 0^+(0^{++})$

Mass $m = 980 \pm 10$ MeV
Full width $\Gamma = 40$ to 100 MeV

$f_0(980)$ DECAY MODES	Fraction (Γ_i/Γ)
$\pi\pi$	dominant
$K\overline{K}$	seen
$\gamma\gamma$	seen

$a_0(980)$ [l]

$I^G(J^{PC}) = 1^-(0^{++})$

Mass $m = 984.7 \pm 1.2$ MeV (S = 1.5)
Full width $\Gamma = 50$ to 100 MeV

$a_0(980)$ DECAY MODES	Fraction (Γ_i/Γ)
$\eta\pi$	dominant
$K\overline{K}$	seen
$\gamma\gamma$	seen

$a_1(1260)$ [m]

$I^G(J^{PC}) = 1^-(1^{++})$

Mass $m = 1230 \pm 40$ MeV [n]
Full width $\Gamma = 250$ to 600 MeV

$a_1(1260)$ DECAY MODES	Fraction (Γ_i/Γ)
$(\rho\pi)_{S-\text{wave}}$	seen
$(\rho\pi)_{D-\text{wave}}$	seen
$(\rho(1450)\pi)_{S-\text{wave}}$	seen
$(\rho(1450)\pi)_{D-\text{wave}}$	seen
$\sigma\pi$	seen
$f_0(980)\pi$	not seen
$f_0(1370)\pi$	seen
$f_2(1270)\pi$	seen
$K\overline{K}^*(892)+$ c.c.	seen
$\pi\gamma$	seen

Particle Data

- Also what decay modes are included depends on how you simulate the decay.
- If you look at the papers used by the PDG most of the modes for the a_1 come from a CLEO study of three pion tau decays.
- The main observed a_1 decay modes are

$$a_1^+ \to \pi^+\pi^+\pi^- \qquad\qquad a_1^+ \to \pi^+\pi^0\pi^0$$

  which occur with equal rate if isospin is conserved.
- The $\rho\pi$ mode is dominant.

Particle Data

- So if you don't have any special modelling the best thing to do is have the modes.

$$a_1^+ \to \rho^+ \pi^0 \qquad\qquad a_1^+ \to \rho^0 \pi^+$$

- However for example Herwig++ implements the matrix element from the CLEO fit including all the intermediates in the PDG entry and therefore has three pion modes.
- So the entries in the data tables are generator specific.

Particle Data

- Often we have to make up decay modes to ensure that branching ratios sum to one.
- We even invent particles to ensure that there are complete SU(3,4,5) multiplets of mesons and baryons.
- These choices are made with some physical insight but are arbitrary.

Particle Data

- The PDG tends to be conservative in choices they make.
- For example they do not give branching ratios for the recently discovered D_s states, or for their production in B decays.
- We are forced to interpret the data ourselves to obtain these numbers.

Particle Data

- In the change from FORTRAN to C++ we realised the particle data tables in Herwig had not be updated in some time.
- Also as the last changes were made by a collaborator who has left we didn't understand some of the choices he had made.
- We are also making major improvements to the simulation of the decays.

Particle Data

- Until now the particle data was stored in a text file, or COMMON block, and was hard to edit and read.
- We envisage the C++ being used for a long time and therefore we needed a solution which was easier to maintain.
- In particular we want to be able to store information about why choices were made.

Herwig++ Particle Data Base

- We have adopted a new solution based on a MySQL database to store the information and comments.
- This allows us to
  - Include comments and other additional information
  - Generate the data files for event generation automatically
  - Allows the data to be viewed and edited more easily via a web interface.

Herwig++ Particle Data Base

- It also has the advantage that the users will be able to
  - view the particle data in a way they can understand.
  - know what came from the PDG or experimental data and what logic was used to make up the rest.
- Should allow the discussion of different choices.

Herwig++ Particle Data Base

- The data base is available at
- http://www.ippp.dur.ac.uk/~richardn/particles
- It is currently password protected and as it is in development running on my laptop.
- I have added a temporary account so those people here can look at the information
  - Username - guest
  - Password – hera-lhc

Herwig++ Particle Data Base

- Our current plan is that the information in the database will be publicly accessible when the next version of Herwig++ which uses it is released.
- Depending on demand we would be willing to run private copies for the experiments which could be modified or supply the source code.

Event Generation

- There is also a very dangerous trend in particle decays which is to rely solely on EvtGEN.
- We don’t think this is wise for other aspects of event generation so why is it for decays?
- We need alternatives with good physics modelling but different choices for the undetermined things.

Event Generation

- Herwig++ includes spin correlations for the hadronic decays in the same way as the FORTRAN had for the shower and perturbative decays, this is the same algorithm as EvtGEN.
- We have made different choices for some things and used data where possible.
- Some of the modelling, i.e. decays of the B^0 and B^+ is less sophisticated.
- Other things, for example taus and baryons, is more sophisticated.

Conclusion

- We have made changes to both the storage and simulation of particle decays.
- This should allow both better simulation of the decays and make clear what choices we have made.
- This is an important aspect of event generation and we should get it right now so we are not left with a bad solution for the next generation of event generators.