THE UNIVERSITY OF WARWICK

DECAY.DEC and tuning in EvtGen

Michal Kreps

Physics Department

Update of DECAY.DEC

THE UNIVERSITY OF WARWICK

- We try from time to time update using latest RPP from PDG
- Last time we did this exercise in 2010
- Attempt with 2012 did not work due to limited resources
- Access to data is difficult
- In 2008 update was done by hand by reading pdf files
  - This proved to be unmanageable and too error prone
  - In 2010 we received ASCII dump of summary tables from PDG
  - Spent about half a year to make sure we read it properly and that we handle all special cases properly

Input to update

- Example from B^+

```
...Dbar0 tau+ nu(tau)                                  (  7.7  +-2.5        )\        1911
                                                       E-3
...Dbar*(2007)0 lepton+ nu(lepton)  [q\                (  5.70 +-0.19       )%        2258
                                    qq\
                                    q]
...Dbar*(2007)0 tau+ nu(tau)                           (  2.04 +-0.30       )%        1839
...D- pi+ lepton+ nu(lepton)                           (  4.2  +-0.5        )\        2306
                                                       E-3
......Dbar(0)*(2420)0 lepton+ nu(l\                    (  2.5  +-0.5        )\          --
epton)   x  B(Dbar(0)*0 --> D- pi+)                    E-3
......Dbar(2)*(2460)0 lepton+ nu(l\                    (  1.53 +-0.16       )\        2065
epton)   x  B(Dbar(2)*0 --> D- pi+)                    E-3
...D(*) n pi lepton+ nu(lepton) (n\                    (  1.87 +-0.26       )%          --
>= 1)
......D*- pi+ lepton+ nu(lepton)                       (  6.1  +-0.6        )\        2254
                                                       E-3
D(s)*- K+ lepton+ nu(lepton)                           (  6.1  +-1.2        )\        2185
                                                       E-4
......Dbar(1)(2420)0 lepton+ nu(le\                    (  3.03 +-0.20       )\        2084
pton)   x  B(Dbar(1)0 --> D*- pi+)                     E-3
......Dbar(1)'(2430)0 lepton+ nu(l\                    (  2.7  +-0.6        )\          --
epton)   x  B(Dbar(1)'0 --> D*- pi\                    E-3
+)
```

- Format slightly changes between different particles
- Parsing is not fully trivial

Last update

THE UNIVERSITY OF WARWICK

- In principle, where there is measurement we just update branching fraction in DECAY.DEC
  - Look carefully to all cases where we move by more than 10σ
  - If there is only limit, we check the BF and if it is larger than limit, we move it down to the level of limit
- Difficulty comes from submodes, which are not always well separated (sometimes probably just from historical reason)
- New decays, which do not exist in DECAY.DEC are added with some checks
  - Default decay model is PHSP, no attempt yet to more smarter

Weighting of branching fractions

THE UNIVERSITY OF WARWICK

- In generation we need proper probability
- Sum of all BFs has to be 1
- Code does renormalize automatically, but it is just common scale factor
- We try to be better than that and respect how well we know different branching fractions
- For some particles we use Pythia hadronization to fill in unmeasured (and perhaps unpredicted) final states
- In first step in weighting, we try to adjust how much is filled in by pythia
  - In some cases we can increase or decrease this to get sum equal to 1
  - Sometimes not possible

Weighting of branching fractions

THE UNIVERSITY OF WARWICK

- When “inclusive” modes do not allow to normalize BFs, we turn to decays which are not in PDG and try to weigh those
- If we need to move to next step and include also modes in PDG:
  - Assign unmeasured modes 10% uncertainty
  - Use PDG uncertainty on measured ones
  - Weight according to uncertainties
- Sometimes there are inclusive modes measured, but we do not attempt to constrain sum of exclusives to agree with inclusive one
  - In principle it should be doable, but it needs thinking about exact impementation

Update of B_s and Λ_b

THE UNIVERSITY OF WARWICK

- What I described works reasonably well for B^+ and B^0
- Situation for B_s and Λ_b is worst as there are only handful of decays measured
  - There is bit of improvement, but we are nowhere near of B^+ and B^0
- I believe that original decay table is based on predictions and some flavour symmetries
  - Currently we do not have way to update things based on updated B^+ and B^0
  - We do not have good metadata to do this
  - Most likely will have to wait until much more BF are measured
  - Or somebody has to pay for archeology required to build metadata

Tuning

THE UNIVERSITY OF WARWICK

- Most of the data which are relevant are branching fractions, lifetimes or amplitudes
- They enter directly as parameters, so no need for tuning
- There are few measurements of more inclusive quantities, which one can possibly check
- We will hear about some attempt to look to semileptonic decays
- With updates to DECAY.DEC, BF are taken into account (mostly)
- Missing part is to update amplitudes and form factors in case there is new information
- This is potentially nasty job as many parameters are hardcoded
- Will try to do this in future, but timescale unclear

Word on semileptonic BF

THE UNIVERSITY OF WARWICK

- ATLAS observed that some semileptonic branching fractions do not agree with inclusive measurements in PDG
- I got examples of B^0 and D^0
- For B^0 EvtGen has smaller inclusive semileptonic branching fraction
  - Exclusive modes do not saturate incluse BF and we do not fill it up
  - I did not had time to look into uncertainties to see how much is missing
- For D^0 EvtGen inclusive branching fraction is much higher than in PDG
  - Without all details, there seems to be double counting (see next page)

D^0 inclusive semileptonic BF

THE UNIVERSITY OF WARWICK

Semileptonic modes

Γ_{17}	$D^0 \to K^- \ell^+ \nu_\ell$		
Γ_{18}	$D^0 \to K^- e^+ \nu_e$	$(3.55 \pm 0.04) \%$	S=1.2
Γ_{19}	$D^0 \to K^- \mu^+ \nu_\mu$	$(3.30 \pm 0.13) \%$	
Γ_{20}	$D^0 \to K^*(892)^- e^+ \nu_e$	$(2.16 \pm 0.16) \%$	
Γ_{21}	$D^0 \to K^*(892)^- \mu^+ \nu_\mu$	$(1.90 \pm 0.24) \%$	
Γ_{22}	$D^0 \to K^- \pi^0 e^+ \nu_e$	$(1.6 \, {}^{+\,1.3}_{-\,0.5}) \%$	
Γ_{23}	$D^0 \to \overline{K}^0 \pi^- e^+ \nu_e$	$(2.7 \, {}^{+\,0.9}_{-\,0.7}) \%$	
Γ_{24}	$D^0 \to K^- \pi^+ \pi^- e^+ \nu_e$	$(2.8 \, {}^{+\,1.4}_{-\,1.1}) \times 10^{-4}$	
Γ_{25}	$D^0 \to K_1(1270)^- e^+ \nu_e$	$(7.6 \, {}^{+\,4.0}_{-\,3.1}) \times 10^{-4}$	
Γ_{26}	$D^0 \to K^- \pi^+ \pi^- \mu^+ \nu_\mu$	$< 1.2 \times 10^{-3}$	CL=90%
Γ_{27}	$D^0 \to (\overline{K}^*(892)\pi)^- \mu^+ \nu_\mu$	$< 1.4 \times 10^{-3}$	CL=90%
Γ_{28}	$D^0 \to \pi^- e^+ \nu_e$	$(2.89 \pm 0.08) \times 10^{-3}$	S=1.1
Γ_{29}	$D^0 \to \pi^- \mu^+ \nu_\mu$	$(2.37 \pm 0.24) \times 10^{-3}$	
Γ_{30}	$D^0 \to \rho^- e^+ \nu_e$	$(1.9 \pm 0.4) \times 10^{-3}$	

Only by checking papers one can find out that $K^*(892)$ is included in other BF

Plan

THE UNIVERSITY OF WARWICK

- Planning another update of DECAY.DEC
  - Try to prepare whole chain by summer
  - Once new RPP from PDG is published, will try to create updated file
- Probably later this year I want to start to look into amplitudes and form factors
  - Possibly remove hardcoded parameters
- Check what is available for tuning
- Once data are available, want to significantly improve baryon decays
  - Light quark and charm baryons might already have some data available, needs review
- Consider some additional checks that things do add up properly