

EVTGEN: Experience and needs from ATLAS

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(thanks to Marjorie Shapiro for useful additions)

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LHC Heavy Flavour Working Group meeting on EVTGEN

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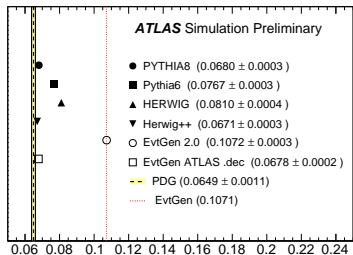
Generators for B-physics in ATLAS

- ▶ Standard generator used for B-physics in ATLAS is PYTHIA 8
 - ▶ Now mostly migrated to 8.210
 - ▶ Use A14 tune with CTEQ6L1 PDF (reference: [ATL-PHYS-PUB-2014-021](#))
- ▶ LCG installation of PYTHIA is used
 - ▶ `/afs/cern.ch/sw/lcg/external/MCGenerators.lcgcm67c/pythia8/210/`
- ▶ Additional interface for HF production:
 - ▶ Generate full set of hard QCD processes (HardQCD:a11)
 - ▶ The events with $b\bar{b}$ pair are selected
 - ▶ Once a $b\bar{b}$ passes user's preselection cuts, hardonise that event a few times
 - ▶ (Ensuring the fraction of events with cloned HQ kinematics is negligible)
- ▶ Substantially speeds up the generation
- ▶ + handy user selection routines

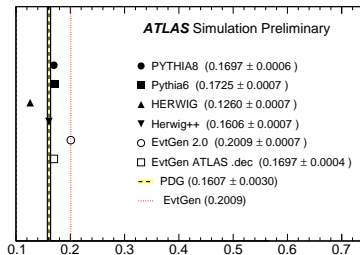
EVTGEN in ATLAS

- ▶ Use LCG installation, version 1.2 (1.6 to be used next – validating the C++ PHOTOS takes long)
 - ▶ `/afs/cern.ch/sw/lcg/external/MCGenerators_lcgcm67b/evtgen/1.2.0/`
 - ▶ Inclusive DEC and PDT files taken from internal ATLAS area
- ▶ Works as an “after-burner”:
 - ▶ Takes full HepMC tree (validated with PYTHIA or HERWIG)
 - ▶ Re-decay particles from a “white list” of heavy flavours (by default)
- ▶ EvtGen is recommended to use in all samples
- ▶ Advantages:
 - ▶ Consistent HF decay treatment across various generators
 - ▶ Improved modelling of the b-jet tagging efficiency
 - ▶ Improved modelling of quantities related to the HF modelling in top events
- ▶ Changes in particle data – *needs better collaboration*
 - ▶ Wrong semileptonic decay fractions – fixed in ATLAS private version
 - ▶ More details in [Jackie Brosamer's talk](#) at [EVTGEN workshop](#)
 - ▶ The most problematic are charm decays – problems with parsing PDG's ASCII files
 - ▶ Is it still the issue?

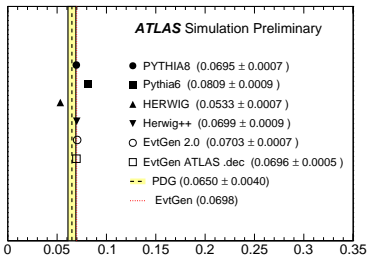
EVTGEN in ATLAS: charm semileptonic fraction (ATL-PHYS-PUB-2014-008)



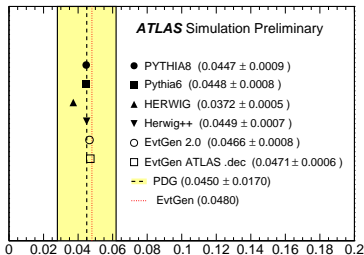
D^0 semileptonic fraction



D^+ semileptonic fraction

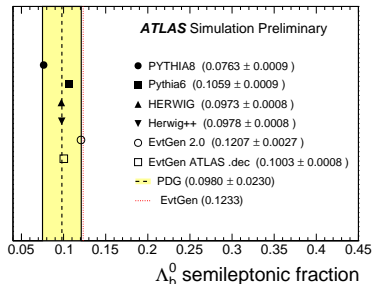
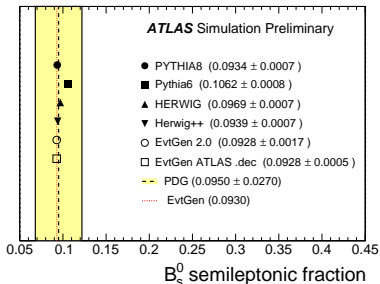
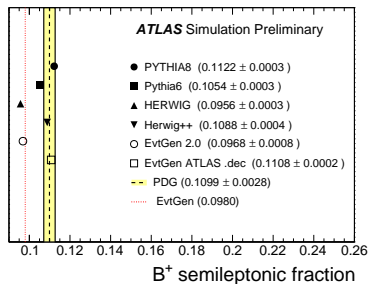
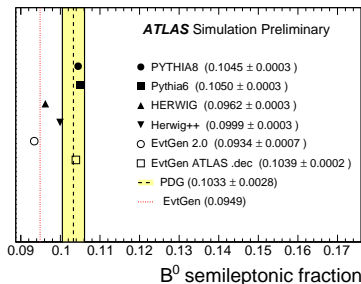


D_s^+ semileptonic fraction

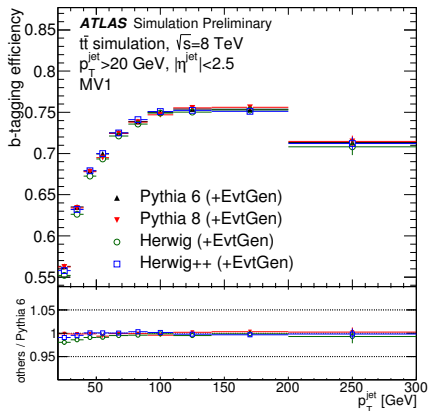
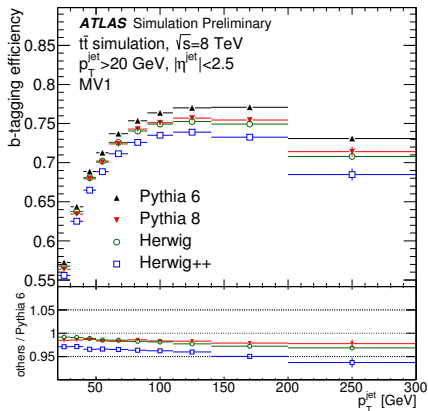


Λ_c^+ semileptonic fraction

EVTGEN in ATLAS: B semileptonic fraction (ATL-PHYS-PUB-2014-008)



EVTGEN in ATLAS: b-tagging efficiency (ATL-PHYS-PUB-2016-004)



- ▶ W/o EVTGEN generator-dependent b-tagging scale factors have to be used
- ▶ EVTGEN harmonizes this efficiency across the generators

EVTGEN for B-physics in ATLAS

- ▶ Particle data is retrieved from different sources across the generators:
 - ▶ PYTHIA uses its own database with masses, lifetimes, decay modes
 - ▶ EVTGEN takes these data from PDT and DEC files
- ▶ It makes problems sometimes:
 - ▶ E.g. B^+ can be produced either by PYTHIA promptly or by EVTGEN having decayed an excited B state
 - ▶ Two different masses in the two cases!
 - ▶ Should manually fix these values for relevant samples
- ▶ Until now, we have not often use EVTGEN for *inclusive* B-physics samples
- ▶ But more often for *exclusive*
 - ▶ Use global ATLAS-wide inclusive DEC file and PDT
 - ▶ Exclusive (user) DEC file prepared individually and generated on-the-fly within generation JobOption
 - ▶ Can tune any properties we need

(Some) EVTGEN use-cases in B-physics studies

- ▶ $B^+ \rightarrow J/\psi(\mu^+\mu^-)K^+$ and similar modes:
 - ▶ SVS and VLL models not requiring parameters
 - ▶ Get proper angular behaviour automatically
 - ▶ $B^+ \rightarrow J/\psi\pi^+$, $B_c^+ \rightarrow J/\psi\pi^+$ are generated similarly
- ▶ Semileptonic decay samples for **dimuon background studies**
 - ▶ $B^0 \rightarrow \pi^-\mu^+\nu_\mu$, $B_s^0 \rightarrow K^-\mu^+\nu_\mu$
 - ▶ ISGW2 model to get proper mass shapes
- ▶ Samples for **semileptonic (e.g. $K^{*0}\mu^+\mu^-$) final state studies**
 - ▶ $B^0 \rightarrow K^{*0}\mu^+\mu^-$ – with flat angles (PHSP) and SM angles (BTOSLLBALL)
 - ▶ $B^0 \rightarrow J/\psi K^{*0}$ – flat angles (PHSP) and SVV_HELAMP (amplitudes from an earlier measurement)
- ▶ Samples for $B_c^+ \rightarrow J/\psi D_s^{(*)+}$ **analysis**
 - ▶ $B_c^+ \rightarrow J/\psi(\mu^+\mu^-)D_s^+$ with $D_s^+ \rightarrow \phi\pi^+$, $\phi \rightarrow K^+K^-$: SVS, VLL, VSS models
 - ▶ $B_c^+ \rightarrow J/\psi D_s^{*+}$: SVV_HELAMP model, 3 individual samples for each helicity component
 - ▶ used for the measurement of their relative contributions

Other desirable features for B-physics

- ▶ Sometimes need to introduce new particles
 - ▶ E.g. for new states search
 - ▶ Now doable only via PDT file, i.e. should replace the whole list
 - ▶ **Why it can't be done via separate user file?**
- ▶ Modification of the existing particle properties (can be alternative to the above)
 - ▶ Possible via user DEC file:
Particle <name> <mass> <width>
e.g.
Particle Upsilon(4S) 10.5794 0.02
 - ▶ **Is it not possible to change lifetime too?**
 - ▶ Needed e.g. to generate high-lifetime enhanced sample (for detector effects studies)

Summary

- ▶ EVTGEN is used ATLAS by default for all HF decays
 - ▶ Very beneficial for HF modelling
- ▶ General point: updating *inclusive decay tables*
 - ▶ Especially charm decays
 - ▶ Also B_s^0 and B_c^+ (+ B_c excited states)
 - ▶ We are also not happy maintaining our own
- ▶ In B-physics, used frequently but still not everywhere
 - ▶ Additional issue of *particle data consistency with PYTHIA*
 - ▶ Somewhat less flexible in on-the-fly configuration

Backup slides