Validation of the CMS EvtGen interface

R.Covarelli
University of Rochester

Outline

- Brief introduction:
  - CMS interface to EvtGen
- CMS validation plots
- Status of validation
- Conclusions

The CMS framework (CMSSW)

- Code compilation/linking (C++):
  - Automatic generation of MakeFile and compilation (scram)
  - Library linking (in order):
    - User-defined libraries in local areas
    - Standard CMSSW packages (a set of compatible package versions is altogether referred to as a release)
    - "External" (non-CMSSW) libraries, e.g. MC generators
  - Single executable application as output (cmsRun)
- Configuration and running (Python):
  - cmsRun driven by a configuration file
    - It contains a schedule of modules to be run in the specified order
  - Output information stored in ROOT file format

EvtGenLHC in CMSSW

- Event generation flow:
  1) Run e.g. Pythia6 as the event source
     - Particle types known from EvtGen tables artificially made stable
  2) Run EvtGenLHC as an "external decay driver"
     - Decay "undecayed" particles that are in EvtGen tables
     - Inclusive B decays (i.e. those whose BR's are not specified) are generated via external interface to Pythia6
     - Radiative corrections calculated via interface to PHOTOS
  3) Output stored as CMS HepMCProducts
     - Decay products are translated from standard HEP to HepMC format

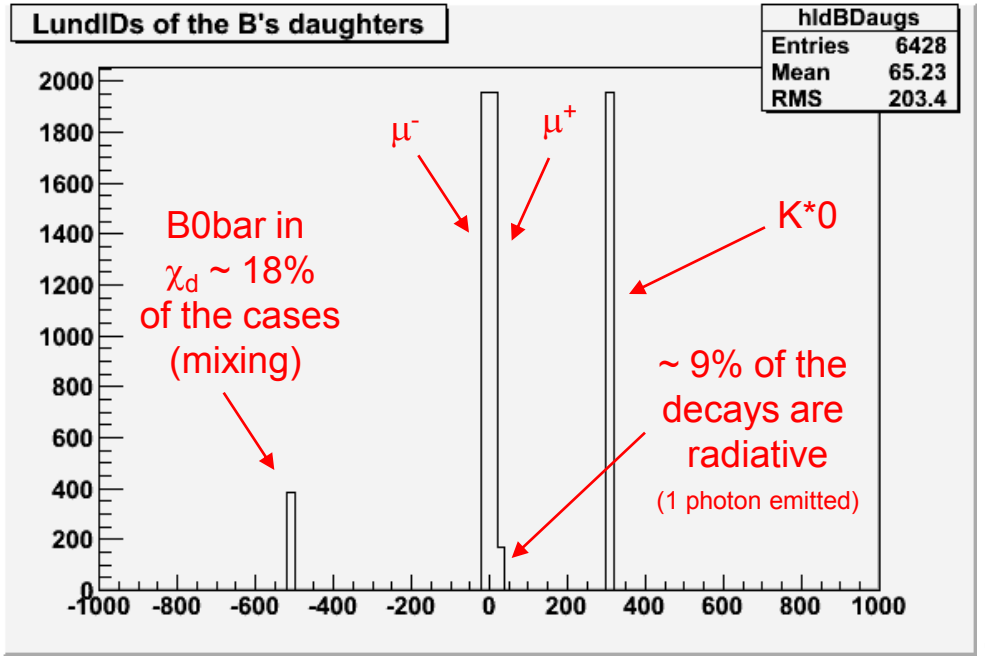
Steps of validation

- A simple analyzer of the HepMC event is being coded → can be easily expanded
- In the following some validation plots will be shown
  - The standard MC validation recipe from the CMS generator group is difficult to apply to our case ← e.g. includes comparison with the standalone version output which is impossible for a combined generator (Pythia + EvtGen)
- Tests are done for:
  1. The standard CMS EvtGen version (EvtGenLHC 9.1)
  2. Some "intermediate" version taken from LHCb already based on Anders' merging (thanks to P. Robbe)
  - Not possible to test yet Warwick versions → lack of manpower

1) Testing decays / decay models

- Example: forced signal mode
  - $B^0 \rightarrow K^{*0}\mu\mu$ (non resonant)
- In the user file decay model is BTOSLLBALL (b → sll according to Ali and Ball's parameterization)

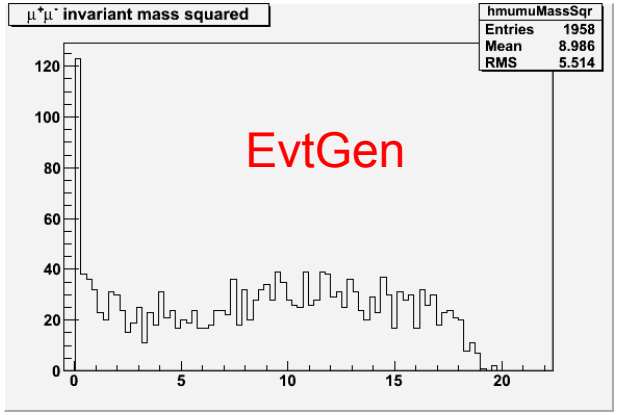
Simple check of decay products



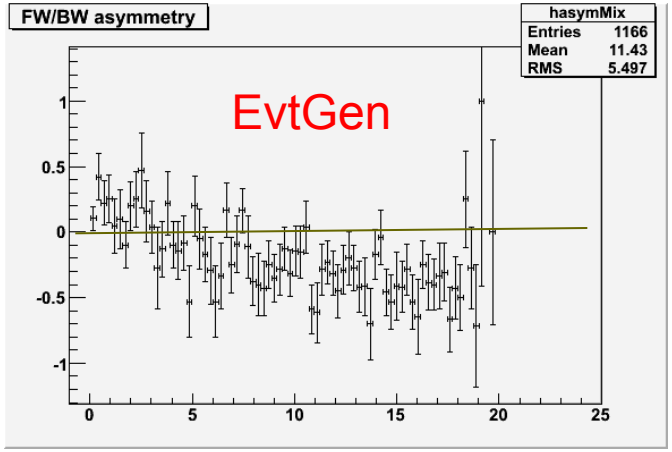
Standard √
LHCb √

1) Testing decays / decay models

- Di-muon invariant mass squared

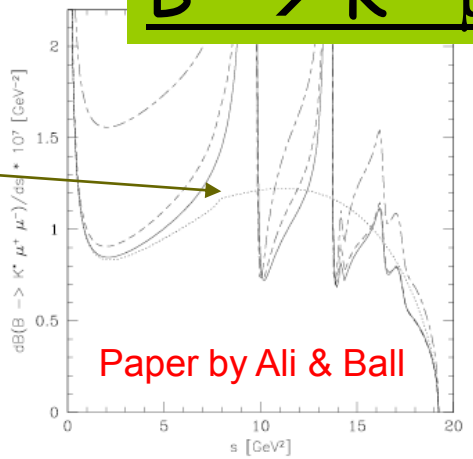


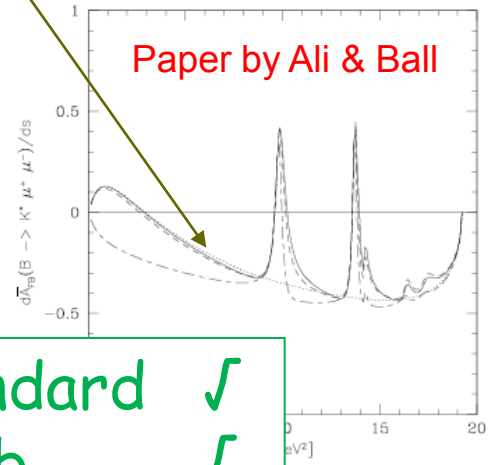
- Forward-backward asymmetry



$B^0 \rightarrow K^{*0}\mu\mu$

Look at dashed lines (if you can…), meaning no ψ resonances

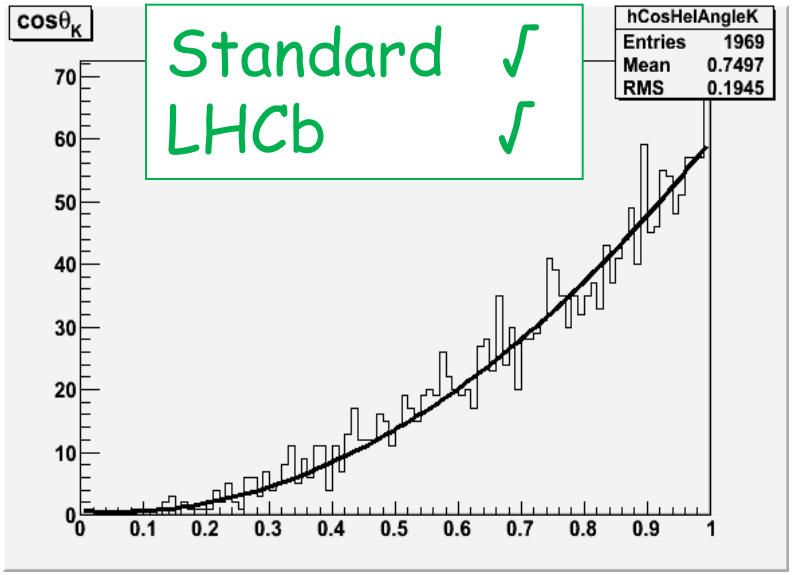




Standard √
LHCb √

2) Angular correlations

- To test angular correlations we need decay chains with well-defined spin structure (e.g. $D_s \rightarrow \phi\pi$, $\phi \rightarrow KK$)
  - For all-hadronic two-body decays the helicity angle has peculiar distributions.
  - The helicity angle in a $A \rightarrow BX \rightarrow CX$ decay is the angle between the C direction in the B rest frame and the B direction in the A rest frame.
  - If the first decay is a $P \rightarrow VP$ and the second is a $V \rightarrow PP$, then the θ_H distribution is proportional to $|Y_1^0(\theta,\phi)|^2 \sim \cos^2\theta_H$

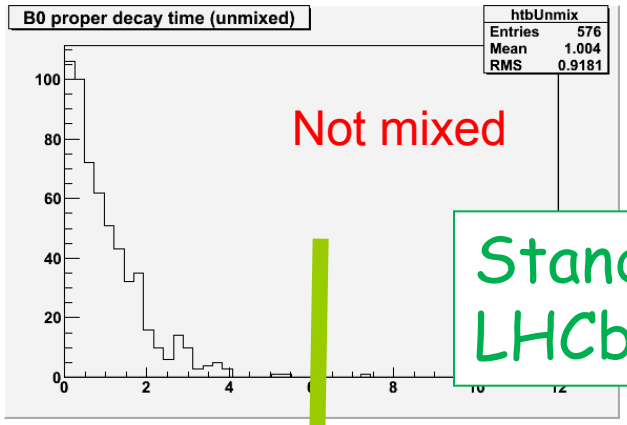


Distribution of $|\cos\theta_H|$ for the positive kaon in $D_s \rightarrow \phi\pi$ ($\phi \rightarrow KK$)

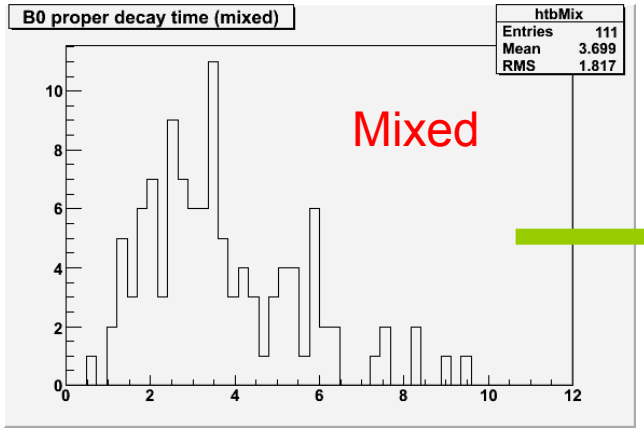
3) Mixing Asymmetry

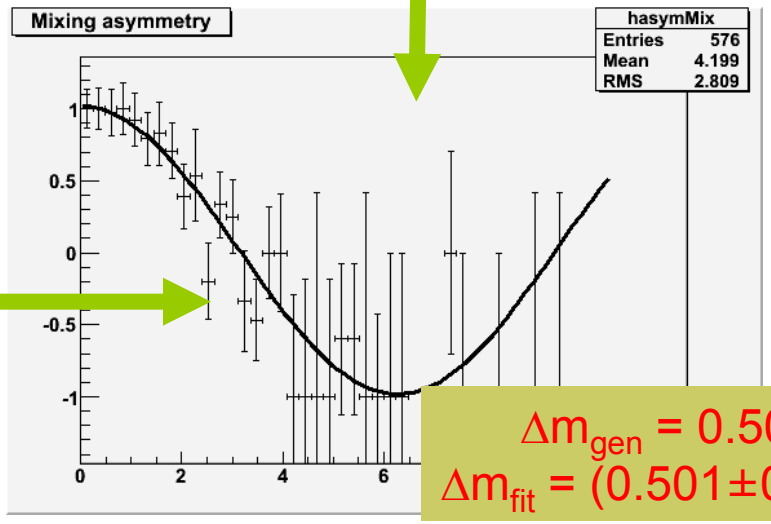
- No forced decays
- $B^0 \rightarrow l^{\pm}X$ sorted out of generic B decays: for these processes

$$A_{\text{mix-unmix}} = \cos(\Delta m t)$$



Standard √
LHCb √



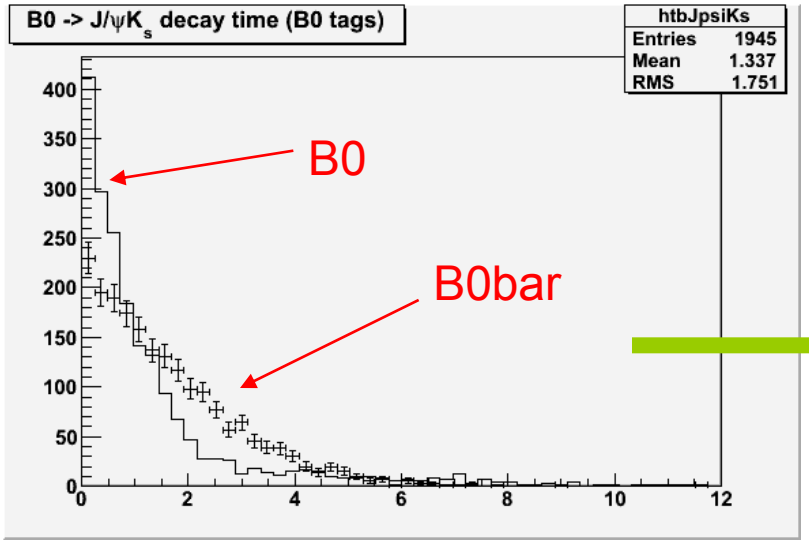


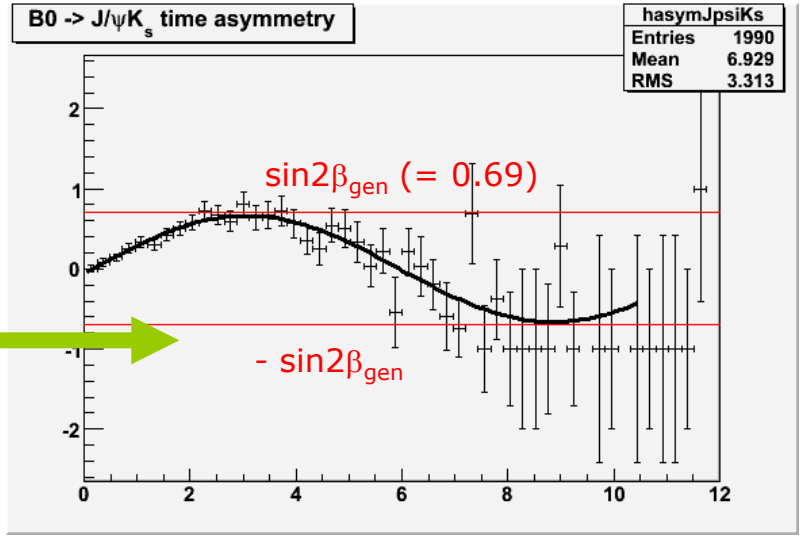
$\Delta m_{gen} = 0.502\ ps^{-1}$
$\Delta m_{fit} = (0.501 \pm 0.003)\ ps^{-1}$

4) CP violation

Standard √
LHCb x
(asymmetry distribution is flat)

- Forced decay:
  - $B^0 \rightarrow J/\psi K_S$
- Decay mode is SSD_CP (CP eigenstate with weak phase = -2β in this case)





5) CPV in mixing

- No forced decays
- $B^0 \rightarrow l^{\pm}X$, with one of the B mixed (i.e. same-sign leptons) sorted out of generic B decays: for these processes

$$A_{++/--} \sim 2(1- |q/p|)$$

Standard x
LHCb x
(asymmetry distribution is flat at 0 for any value of |q/p|)

- Important due to recent D0 measurement (3σ from SM)...
- ... but very easy to obtain with event reweighting

Conclusions

- Validation of EvtGen in CMS is based on a few key plots that show proper behaviour of quantities that other generators are not able to model
  - Done every few releases → OK with EvtGen 9.1
- Few discrepancies found in most recent EvtGen versions
  - Probably due simply to different implementation of inchoerent mixing and CPV
- Too small manpower to ensure staying always up-to-date
  - Hopefully, first results from Warwick EvtGen very soon…