EvtGen - Pythia Integration @ CDF for Run II

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Status:

- Know how to do it: "copy" what's done for QQ.
- actual work to be done "summer 2000".

QQ - Pythia Interface in a Nutshell:

- Pythia 6.1 generates $p \leftrightarrow \bar{p}$ collision and saves event in **Fortran COMMON** HEPEVT (i.e. stdhep).
- Loop over HEPEVT common to find particles to decay with QQ
  - delete their Pythia generated decay tree.
  - decay them via QQ and add descendents to HEPEVT

Drawback:

- Available Info per particle:
  - parents and daughters
  - particle codes
  - 4-momentum
  - 4-vertex
- Missing Info:
  - polarization at production
  - polarization of stable final state particle

Technical Details

- COMMON block clashes between Pythia 6.1 and Jetset 7.4

  → add Jetset 7.4 to EvtGen

  → excised Pythia out of LULOGO + LUGIVE

- EvtGen clobbers HEPEVT via use of Photos

  → add Photos to EvtGen

  → rename HEPEVT in Photos

Issues in B_s Physics

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- decay list: (done for QQ using spectator $d \to s$ replacement)
- Implementation of $\Delta\Gamma$:
  - for CP viol. in decays like $B \to VV$

    $\to$ model specific solution in EvtGen.
  - for flavor-tagging B_s decays

    $\to$ done correctly in EvtGen (?)
  - for common final states of B_s and $\bar{B}_s$

    $\to$ ignored in EvtGen.

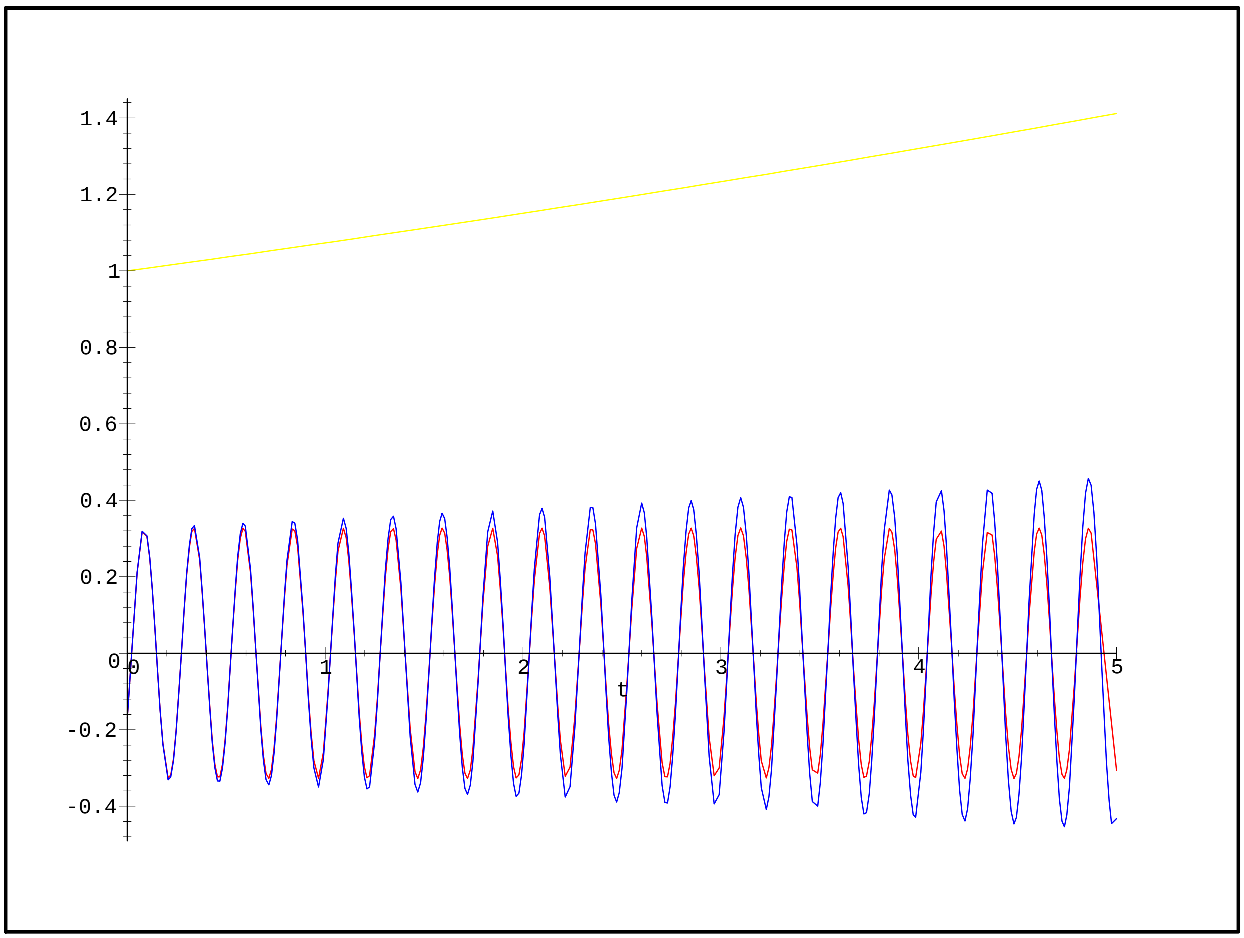
Example: CP Violation in $B_s \to K^+K^-$

$$\frac{B_s\to K^+K^- - \bar{B}_s\to K^+K^-}{B_s\to K^+K^- + \bar{B}_s\to K^+K^-} = \frac{2e^{-\langle\Gamma\rangle t}}{e^{-\Gamma_H t}+e^{-\Gamma_L t}+A_{\Delta\Gamma}(e^{-\Gamma_H t}-e^{-\Gamma_L t})}\times (A_{cp}^{dir}\times\cos\Delta m_s t + A_{cp}^{mix}\sin\Delta m_s t)$$

$$1 = (A_{cp}^{dir})^2 + (A_{cp}^{mix})^2 + (A_{\Delta\Gamma})^2$$

from untagged lifetime fit :

$$A_{\Delta\Gamma} = (R_H - R_L)/(R_H + R_L)$$



Common Final States of B_s, $\bar{B}_s$

Work at amplitude level:

Implement Mixing:

$$
\begin{aligned}
|B^0_{phys}(t)\rangle &= e^{-i\bar{\mu}t}(\cos(\Delta\mu t/2)|B^0\rangle + i\tfrac{q}{p}\sin(\Delta\mu t/2)|\bar{B}^0\rangle) \\
|\bar{B}^0_{phys}(t)\rangle &= e^{-i\bar{\mu}t}(\cos(\Delta\mu t/2)|\bar{B}^0\rangle + i\tfrac{p}{q}\sin(\Delta\mu t/2)|B^0\rangle)
\end{aligned}
$$

Implement Decay:

$$
\begin{array}{ccc}
\langle f|\bar{B}^0\rangle & \text{and} & \langle f|B^0\rangle \\
\langle \bar{f}|\bar{B}^0\rangle & \text{and} & \langle \bar{f}|B^0\rangle
\end{array}
$$

Decay file then defines:

- $Arg(q/p), Im(q/p)$ for B_s and B_d
- $\Delta\mu = \Delta m - \frac{i}{2}\Delta\Gamma$ for B_s and B_d
- $\bar{\mu} = m - i\Gamma/2$ for B_s and B_d
- and for each final state $f, \bar{f}$:
  - Arg and Im of $\langle f|B^0\rangle$ and $\langle f|\bar{B}^0\rangle$
  - Arg and Im of $\langle \bar{f}|B^0\rangle$ and $\langle \bar{f}|\bar{B}^0\rangle$

Some Comments on this Suggestion

- All the Fortran models for time dependent Dalitz plot become obsolete. Implement them in a few lines of code as Dalitz decay amplitudes.
- Mixing and decay factorize as product of two complex amplitudes.
- All the relationships between various CP violating quantities are automatic.
- Decays where $b \to c\bar{u}d$ interfere with $\bar{b} \to \bar{u}c\bar{d}$ are handled correctly automatically. No need for seperate models in "modes that measure γ".

Conclusion:

- 3 different types of decays — 3 different implementations
  - flavor-tagging decays
  - Decays that aren't flavor-tagging
  - Decays into superpositions of CP eigenstates

Outstanding Issue

What to do about final state polarization ?

E.g. $B \to K^* \gamma$ followed by $\gamma \to e^+ e^-$

See Y. Grossman, D. Pirjol hep-ph/0005069

Same solution as polarization at production !

Issues in Generator Tuning

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- Sample of things that work well in QQ
- Sample of things that don't work well in QQ