B_{reco} studies in FastSim: status report

Elisa Manoni
Università di Perugia and INFN Sez. Perugia

Francesco Renga
Università Roma "La Sapienza" and INFN Sez. Roma

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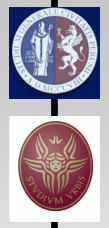
Outline

* Code:
  - Implementation of dedicated packages for B_{reco} reconstruction in FastSim
  - some pending problems:

    HAD: creating and accessing skim UsrData, efficiency loss between V3 and V9

    SL: unexpected gain in efficiency in V9 wrt BaBar FullSim (and previous FastSim versions)

* Physics:
  - BR sensitivity
  - angular analysis



Code

B_{reco} in FastSim

Reconstruction of SL and HAD B_{reco} modes implemented in FastSim

SL

$B \to D l \nu X \quad (X = \gamma, \pi)$

$D^0 \to K^- \pi^+$

$D^0 \to K^- \pi^+ \pi^0 (\gamma\gamma)$

$D^0 \to K^- \pi^+ \pi^+ \pi^-$

$D^+ \to K^- \pi^+ \pi^+$

$D^{*+} \to D^0 \pi^+$

$D^{*+} \to D^+ \pi^0$

$D^{*0} \to D^0 \gamma$

HAD

$B \to D X$

$D^0 \to K^- \pi^+$

$D^0 \to K^- \pi^+ \pi^0 (\gamma\gamma)$

$D^0 \to K^- \pi^+ \pi^+ \pi^-$

$D^0 \to K^0_S \pi^+ \pi^-$

$D^+ \to K^- \pi^+ \pi^-$

$D^+ \to K^- \pi^+ \pi^- \pi^0$

$D^+ \to K^0_S \pi^+$

$D^+ \to K^0_S \pi^+ \pi^- \pi^+$

$D^+ \to K^0_S \pi^+ \pi^0$

$D^{*+} \to D^0 \pi^+$

$D^{*0} \to D^0 \pi^0$

$D^{*0} \to D^0 \gamma$

$X = n\pi + mK + r K^0_S + q\pi^0$

$n + m + r + q < 6$

our AIM: Provide two packages to perform recoil analysis in semileptonic and hadronic B_{reco} samples

Skim emulation

* Two tcl's inspired to FilterTools code
  - BToDlnuSequence.tcl → FilterTools/BToDlnuPath.tcl
  - BSemiExclSequence.tcl → FilterTools/BSemiExclPath.tcl

* Main changes wrt BaBar code:
  - need to include by hand CompositionSequences and SimpleComposition sequences to remove PID requirements in some standard lists not supported in FastSim

* As the BaBar skims, select SL and HAD B_{reco} samples using proper hadron and lepton lists (without dumping collections)

PacSemiLepRecoilUser and PacSemiExclRecoilUser

* Implemented two packages inspired to BaBar code
  - PacSemiLepRecoilUser → BTauNuSemiLepUser
  - PacSemiExclRecoilUser → BTauNuSemiExclUser

* They contain:
  - main analysis tcl on which run the executable
  - tcl for skim emulation
  - tcl for PID selection: Truth-based PID currently used, three different lists for barrel, fw and bw to make PID studies
  - tcl and .cc / .hh for signal and tag side reconstruction and selection
  - tcl for BtaTupleMaker settings
  - README

Known Problems

* HAD Recoil, PacSemiExclRecoilUser:
  - UsrData problem: not able to create and access UsrData implemented at skim level
    - can not make mode-by-mode studies
    - can not apply a mode-based selection on ΔE
  - B_{reco} reconstruction efficiency loss: starting from frozen FastSim V3, -60% in B_{reco} reconstruction efficiency wrt previous FastSim versions and FullSim

* SL Recoil, PacSemiLepUser
  - efficiency "gain": starting from FastSim V4 the B_{reco} reconstruction efficiency is +25-30% wrt BaBar Full simulation

HAD: UsrData problem

* need to access a UsrData created at skim-level in BaBar which contains important info on B_{reco} (i.e decayMode, purity,....)

* Not feasible due to incompatibility between BetaMiniSequence and FastSim

* Trying to fix this (thanks Dave!) → the problem may be related to some lower level code issue....

HAD: Breco reconstruction efficiency loss (I)

* Results presented at Warwick:

- quite good agreement between FastSim and FullSim efficiencies (discrepancy due to difficulties in reproducing BaBar - UsrData problem)
- using FastSim V3 (NOT THE FROZEN VERSION) →V3'

	FastSim	FullSim		FastSim
neutral B_{reco}	4.46×10^{-3}	3.3×10^{-3}		4.89×10^{-3}
charged B_{reco}	4.29×10^{-3}	4.5×10^{-3}		4.86×10^{-3}

BaBar config SuperB config

* since FastSim V3 (FROZEN VERSION) : ~60% drop in Breco reconstr. eff. (same in V4 and V9)

	FastSim		FastSim
neutral B_{reco}	1.87×10^{-3}		2.16×10^{-3}
charged B_{reco}	1.97×10^{-3}		2.33×10^{-3}

BaBar config SuperB config

HAD: Breco reconstruction efficiency loss (II)

In FastSim V9:

* generated 10^9 events both for neutral and charged B_{reco}

* signal side reconstruction in $B_{sig} \rightarrow K^* \nu\nu$
  - selection efficiency:

  0 events with $K^{*0} \rightarrow K^+ \pi^-$ (in FullSim: $\varepsilon = 3.52 \times 10^{-4}$)

  0 events with $K^{*+} \rightarrow K^+ \pi^0$ (in FullSim: $\varepsilon = 2.02 \times 10^{-4}$)

  $K^{*+} \rightarrow K_s \pi^+$ $\varepsilon = 7.03 \times 10^{-6}$ (in FullSim: $\varepsilon = 2.04 \times 10^{-4}$)

* Tests on $B^0 \rightarrow D^{*-} K^+$, $D^{*-} \rightarrow D^0 \pi^-$, $D^0 \rightarrow K^- \pi^+$:
  - one of the Breco mode
  - consistency between FastSim V3' and FastSim V9

* Proposed tests:
  - update the PID selector: from truth-based to table-based
  - check length of particle lists
  - make B_{reco} mode-by-mode study (when UsrData will work)

SL: efficiency "gain" (I)

all the numbers in BaBar config

* Results presented at Warwick:

  good agreement between Fast and Full Simulation (BaBar config)

	FastSim	FullSim
neutral B_{reco}	19.3×10^{-3}	20.0×10^{-3}
charged B_{reco}	19.4×10^{-3}	19.3×10^{-3}

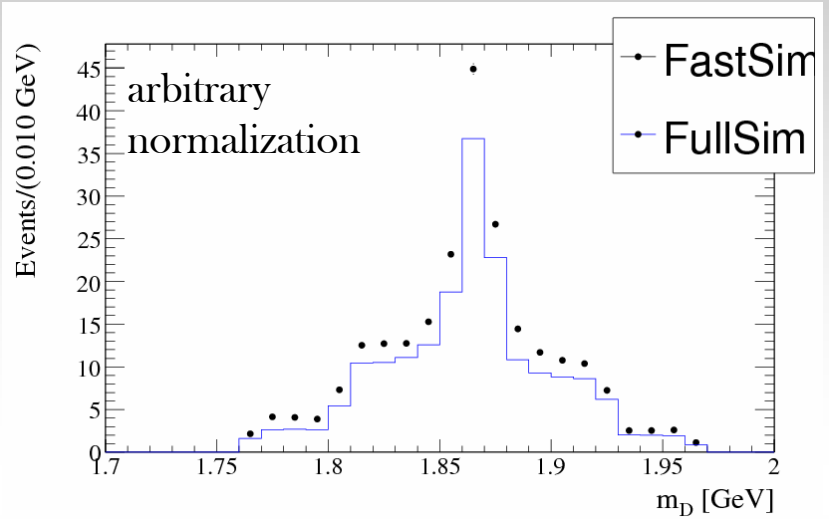
* unexpected gain in B_{reco} reconstruction efficiency when moving to FastSim V4 and V9

* also $B \to K^* \nu\nu$ signal selection efficiency increase wrt full Sim:
  - +40% $K^{*0}\nu\nu$
  - +50% $K^{*+}\nu\nu$

	FastSim
neutral B_{reco}	24.9×10^{-3}
charged B_{reco}	25.6×10^{-3}

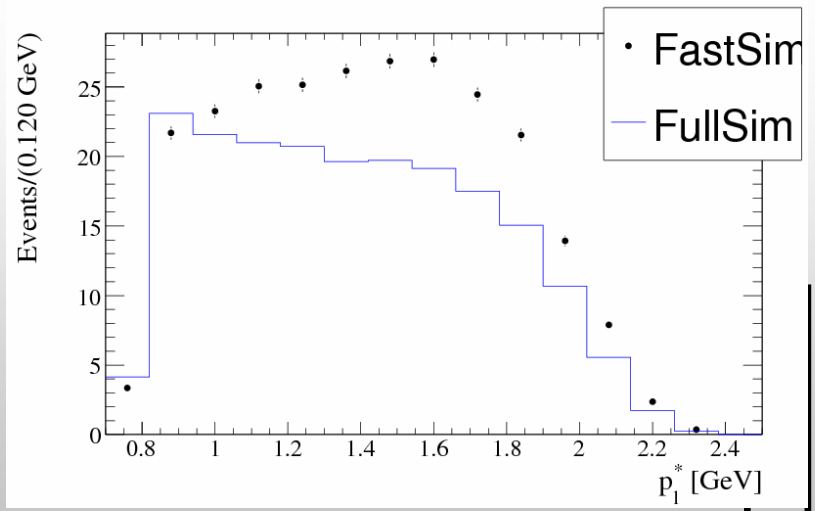
SL: efficiency "gain" (II)

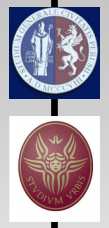
Plots for two tag side variables, no selection on the signal side applied:



* D mass: apart from normalization , good agreement in the shape between fast and full

* lepton spectrum: big discrepancy both in shape and in normalization; shape similar to what obtained when applying a selection in the signal side





Physics

Startegy for SuperB sensitivity estimate

* compare BaBar and SuperB beam and detector configurations
* Super-B configuration: $\beta\gamma = 0.28$, no FWD/BWD PID devices, no BWD calorimeter

* Analysis starting point
  - BaBar efficiencies & Backgrounds
  - BaBar analysis technique

Signal extraction:
- SL: fit to Eextra distribution
- HAD: fit to Neurat Network output

* Systematic uncertainties

BaBar :

- large systematics on signal yield N_s from PDF modeling in the fit ($\sigma_{syst} \sim \sigma_{stat}$);
- systematics largely dominated by MC statistics;
- Syst. error expected to go down with:

  1/sqrt(MC stat) ~ 1/sqrt(Luminosity)

SuperB:

- assume a syst. error equal to the stat. error;

Results

* Comparison between BaBar and SuperB as presented at Warwick
  - SL: 25% improvement in S/sqrt(B) for neutral B;
    35% improvement in S/sqrt(B) for charged B;
  - HAD: 10% improvement in S/sqrt(B) for neutral B;
    20% improvement in S/sqrt(B) for charged B;

* Updates in FastSim_V9
  - SL: background reduction same as showed in Warwick

    smaller gain in signal efficiency (BaBar vs SuperB) affected by fast-sim vs full-sim inconsistency

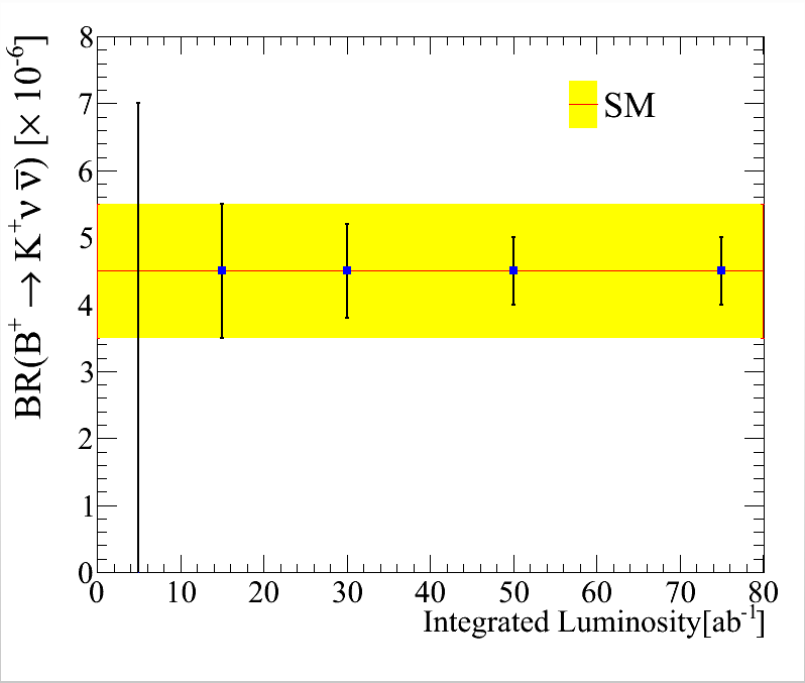
    $B^0 \to K^{*0} \nu\nu$ as in Warwick: S +14% B - 10%

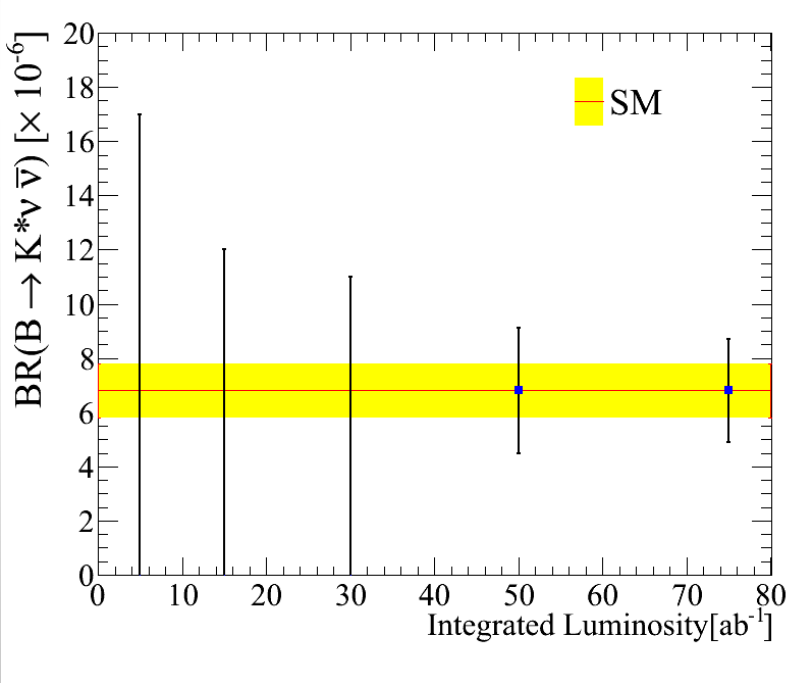
    now : S + 5% e B - 11%
  - HAD: meaningless efficiency estimate in fastsim_V9

BR Expected sensitivity

* Toy MC (fit to Eextra in SL – fit to a NN in HAD);
* PDF parameters from BaBar full simulation;
* Improvements from FastSim (as presented at Warwick).

Preliminary





Angular Analysis: motivation

* Good sensitivity to NP through angular distribution:

θ = angle between K^* direction in B rest frame and K direction in K^* rest frame

F_L = fraction of longitudinally polarized K^*

$$\frac{d\Gamma}{d\cos\theta} \propto \frac{3}{4}(1- < F_L >)\sin^2\theta + \frac{3}{2} < F_L > \cos^2\theta$$

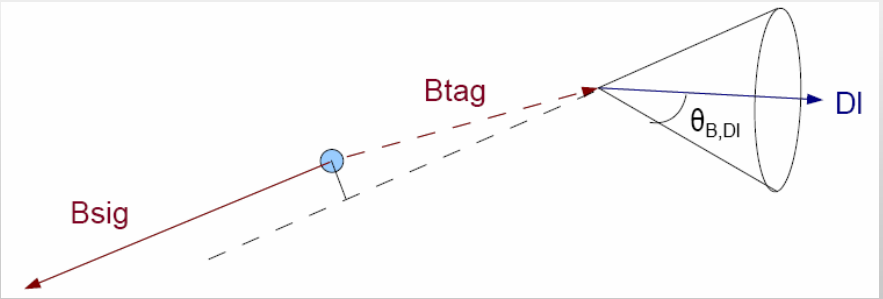
* Experimentally, simultaneous extraction of BR and F_L with a 2D fit (E_{extra} or NN vs. cosθ)

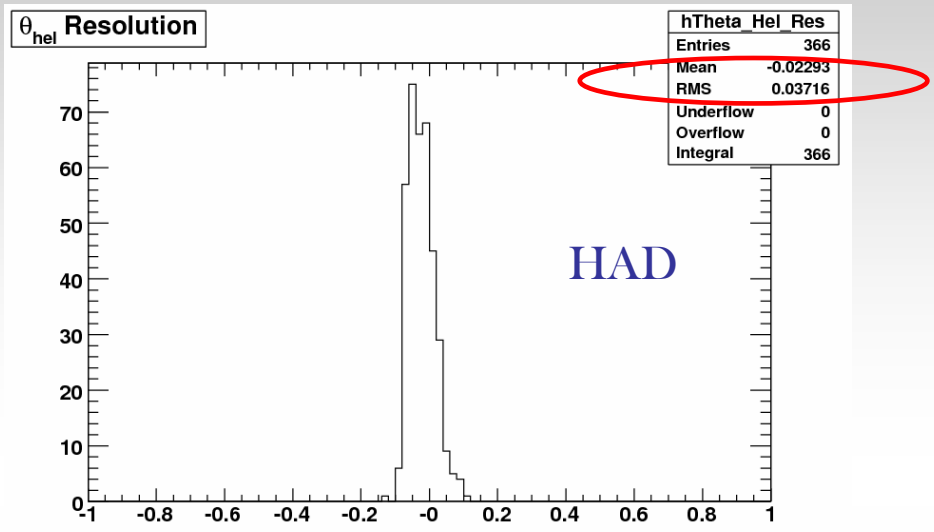
  - Knowledge of B rest frame needed: problems in SL recoil analysis where kinematics is not close
  - HAD alone could be not enough for observing the decay.

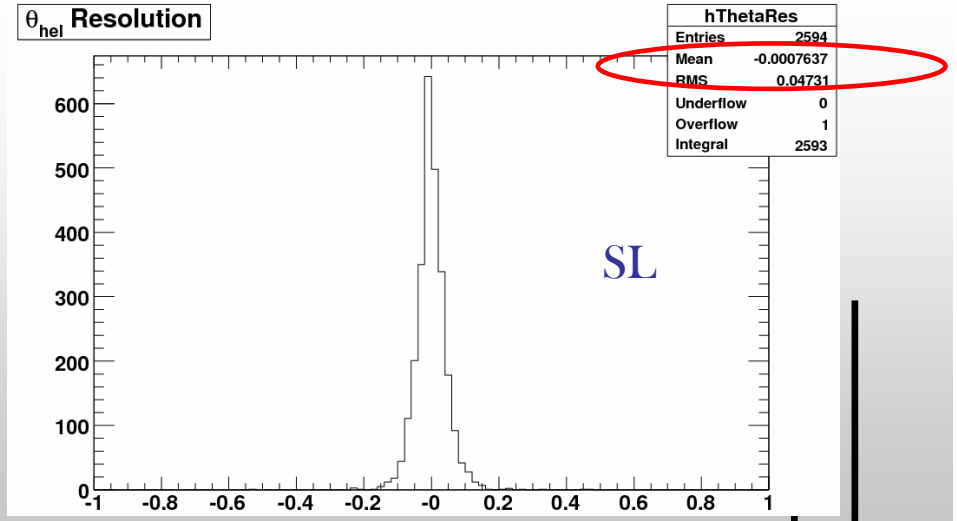
θ_{hel} reconstruction

* HAD: closed kinematics allow to compute the K* helicity angle

* SL: kinematics is not close due to ν strategy: use the Dl pair direction to determine $\cos_{B,Dl}$ and define a cone; chose as Bsig direction the one, inside the cone, which minimize the distance from the interaction point







Analysis strategy and Constraints

* Preliminary study:
* Toy MC
* Neutral channel only
* No cosθ resolution effects
* Background flat in cos θ
* No systematics
* 75 ab^{-1}

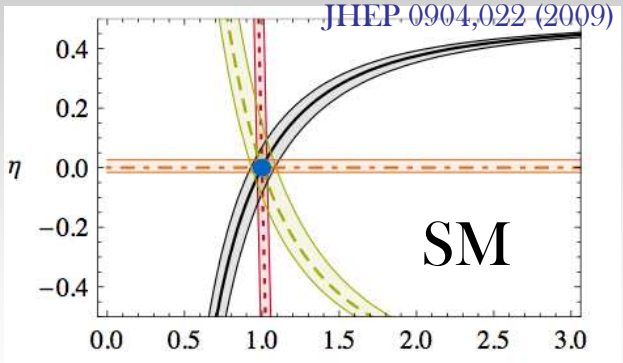
$$\mathrm{BR}(B \to K^* \nu\bar{\nu}) = 6.8 \times 10^{-6}\,(1 + 1.31\,\eta)\epsilon^2\,,$$

$$\mathrm{BR}(B \to K \nu\bar{\nu}) = 4.5 \times 10^{-6}\,(1 - 2\,\eta)\epsilon^2\,,$$

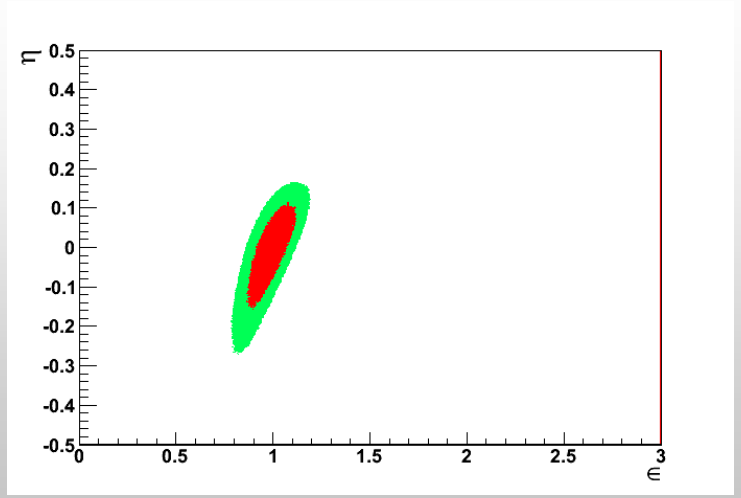
~~$\mathrm{BR}(B \to X_s \nu\bar{\nu}) = 2.7 \times 10^{-5}\,(1 + 0.69\,\eta)\epsilon^2\,,$~~

$$\langle F_L \rangle = 0.54\,\frac{(1 + 2\,\eta)}{(1 + 1.31\,\eta)}\,.$$

Altmannshofer et al. JHEP 0904,022 (2009)



$$\epsilon = \frac{\sqrt{|C_L^\nu|^2 + |C_R^\nu|^2}}{|(C_L^\nu)^{\mathrm{SM}}|} \qquad \eta = \frac{-\mathrm{Re}\,(C_L^\nu C_R^{\nu *})}{|C_L^\nu|^2 + |C_R^\nu|^2}$$

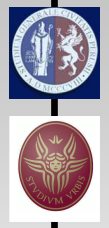


* Toy results:
  - BR(B→K^{*0}νν)$_{HAD}$ = (6.8 ± 3) x 10^{-6}
  - BR(B→K^{*0}νν)$_{SL}$ = (6.8 ± 3) x 10^{-6}
  - $F_{L,HAD}$ = 0.54 ± 0.27
  - $F_{L,SL}$ = 0.54 ± 0.24
  - correlations BR-F_L
    HAD: -0.36
    SL: -0.25

Conclusion

* FastSim Packages for SL and HAD B_{reco} reconstruction set up and almost ready to be committed
  - some pending issue related both to the code (UsrData) and Simulation/Reconstruction (efficiency)
  - PID studies can help on fixing the efficiency problems

* Physics studies
  - angular analysis feasible also in the SL recoil
  - BR sensitivity estimates not updated to V9 results due to efficiency inconsistency
  - Using updated SM predictions, taking into account dominant systematics and considering the results in FastSim_V3', $B \rightarrow K^{*}\nu\nu$ is expected to be observed with about 50 ab^{-1}



Back-up slides

Skim emulation

Changes in some CompositionSequences and SimpleComposition sequences to remove PID requirements in some standard lists not supported in FastSim.

HAD : CompositionSequences/CompSemiExclAddSequence.tcl
CompositionSequences/CompSemiExclSequence.tcl
SimpleComposition/SmpD0ProdSequence.tcl
SimpleComposition/SmpDcProdSequence.tcl
SimpleComposition/SmpJPsiProdSequence.tcl

SL : CompositionSequences/CompBToDlnuProdSequence.tcl
CompositionSequences/CompBToDlnuSequence.cc
CompositionSequences/CompBToDlnuSequence.tcl
CompositionSequences/CompPi0Sequence.cc
CompositionSequences/CompPi0Sequence.tcl
SimpleComposition/SmpCharmlessProdSequence.tcl
SimpleComposition/SmpDcProdSequence.tcl