BaBar Fast/Full Simulation comparison using B$^+$→K$^+$νν

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LAPP SuperB Workshop

Outline

- **Reminder on February 2010 production**

- **Validation strategy**

- **Some results and plots**

- **Summary and outlook**

February 2010 Production: DG_BaBar

- **Signal samples:**
  - $B^+ \to K^+ \nu\nu$:   1M events
  - $B^0 \to K^0 \nu\nu$:   1M events
  - $B^+ \to K^{*+} \nu\nu$:   1M events
  - $B^0 \to K^{*0}(\to K^+\pi^-)\nu\nu$:   1M events

- **Background Samples:**
  - B^+B^- Generic: 10.25M events
  - B^+B^- double SL: 11M events
  - B^0B^0 Generic: 10.075M events
  - B^0B^0 double SL: 11M events
 - cc: 10.75M events
  - uds: 19.49M events

- **All samples generated with bkg mixing (Bhabha/Rad-Bhabha)**

Validation

- **Start with B$\to$K$\nu\nu$(K$^+$,K^0_S) and B$\to$K$^{*(+/0)}\nu\nu$ analyses**

- **The goal is to compare Fast-Sim with the BaBar full-sim analyses:**
  - Try to use the same selection
  - Compare signal and background relative/absolute efficiencies
  - Compare the shapes of the main discriminant variables

- **B$\to$K$\nu\nu$:**
  - Use n-tuples from the latest BaBar analysis (BAD-2123).
  - Will try to perform a simple cut-and-count analysis as done in BAD-293.

- **B$\to$K$^*\nu\nu$:**
  - Use n-tuples from the latest BaBar analysis (Fracesco Renga's BAD-1845).
  - Will try to perform a simple cut-and-count analysis as done in BAD-293.

- **Will only show results for BaBar Full/Fast Sim comparison for:**
  - B$^+\to$K$^+\nu\nu$ signal
  - Try to compare B$^+$B$^-$ Generic (full sim) with B$^+$B$^-$ double SL (fast sim) when possible
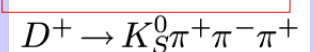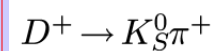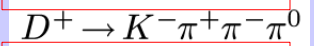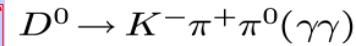 - Similar results are obtained for the other samples/modes

Reminder: SL technique

- **Search for $B \to D^{(*)} l \nu$**
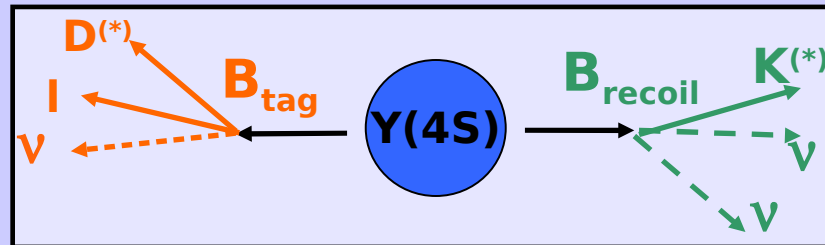
- **Reconstruction steps:**

  - **Reconstruct $D^{(*)} \to$ hadrons**

$$D^{*+} \to D^0 \pi^+$$
$$D^{*0} \to D^0 \pi^0$$ (crossed out)
$$D^{*0} \to D^0 \gamma$$

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

$$D^+ \to K^- \pi^+ \pi^-$$
$$D^+ \to K^- \pi^+ \pi^- \pi^0$$
$$D^+ \to K^0_S \pi^+$$
$$D^+ \to K^0_S \pi^+ \pi^- \pi^+$$
$$D^+ \to K^0_S \pi^+ \pi^0$$
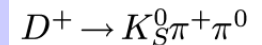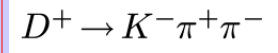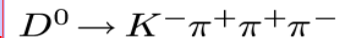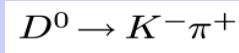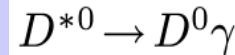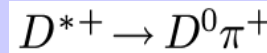
  - **Use $D^{(*)}$ and add lepton ($e^\pm, \mu^\pm$) to form a $D^{(*)} l$ candidate**

- **Sample of 14 decay modes (charged + neutrals)**

- **Kinematics is unconstrained due to neutrinos** ☹

- **Relatively high reconstruction efficiency ~2%** ☺

# Reminder: $B^+ \to K^+ \nu\nu$ Analysis

- **Btag candidate:** K^+ (π^+) from D reconstruction is LHKaonTight (is not LHKaonNotAPion)

- **Bsig candidate:** look in ROE for a K^+ in LHKaonTight list with opposite charged as Btag

- **<u>Do a cut and count analysis</u>** with the following selection cuts:

  - ➜ Number of Charged tracks in event < 12

  - ➜ Number of Neutrals in event < 15

  - ➜ R2 < 0.84

  - ➜ $-2.5 < Cos(\theta_{BDl}) < 1.1$

  - ➜ $|M_D(rec) - M_D(PDG)| < 3\sigma$ (mass resolution)

  - ➜ $M_{Dl} > 3.0$ GeV/c^2

  - ➜ $p^*_D(CM) > 0.5$ GeV/c

  - ➜ $p^*_{lep}(CM) > 1.35$ GeV/c

  - ➜ $M_{miss} > 1.0$ GeV/c^2

  - ➜ $p^*_{signalK}(CM) > 1.25$ GeV/c

  - ➜ $|Cos(\theta[K,Dl])(CM)| < 0.8$

  - ➜ $E_{extra} < 250$MeV (**see later slide**)

Validation: $B^+ \rightarrow K^+ \nu\nu$

Variable: R2

Full Sim
Fast Sim

Signal
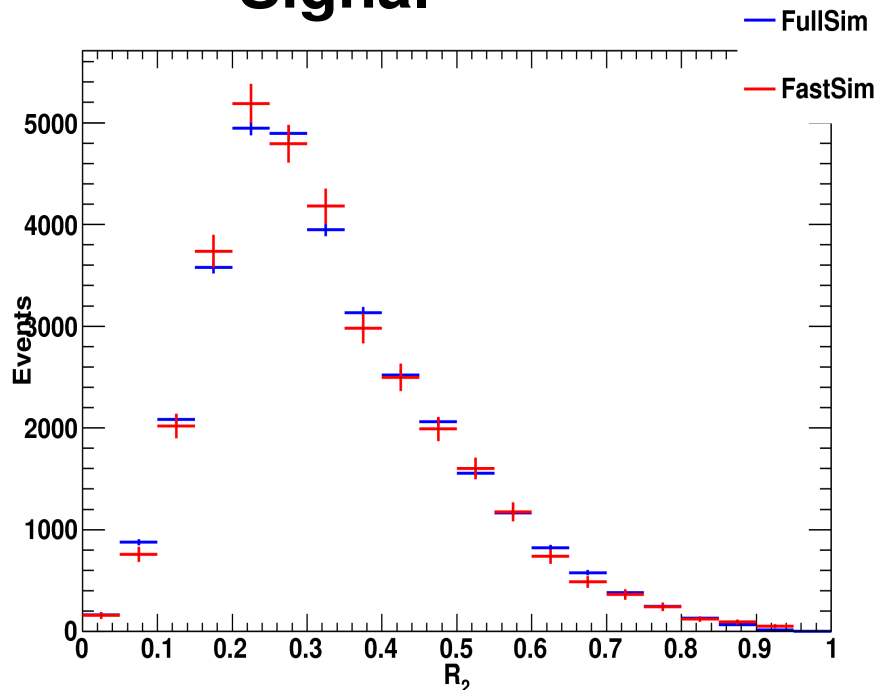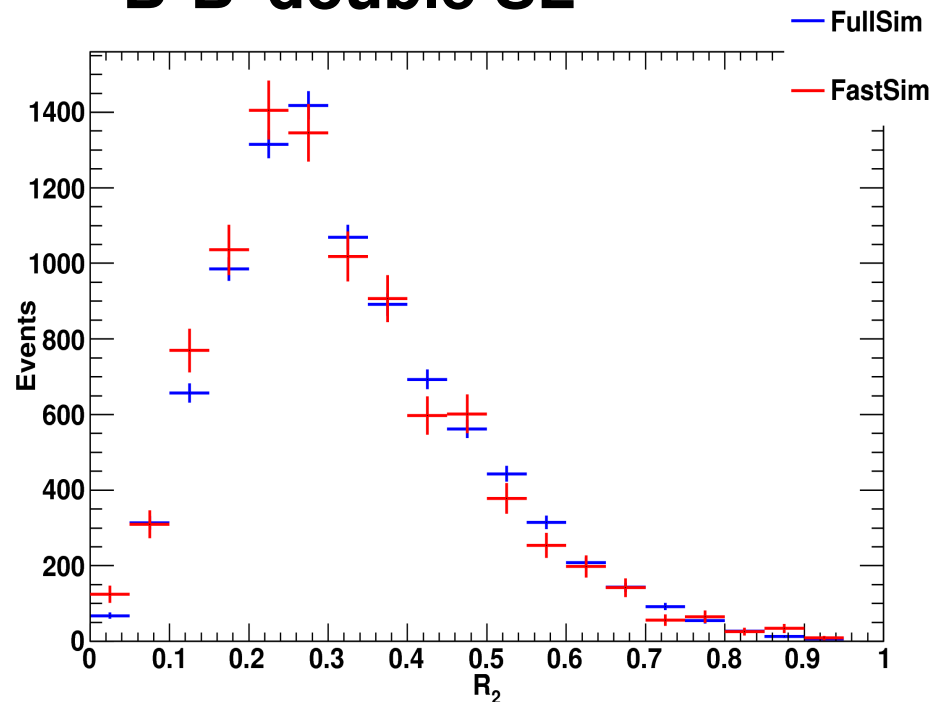
B⁺B⁻ double SL

Fast-sim distributions normalized to BaBar full-sim
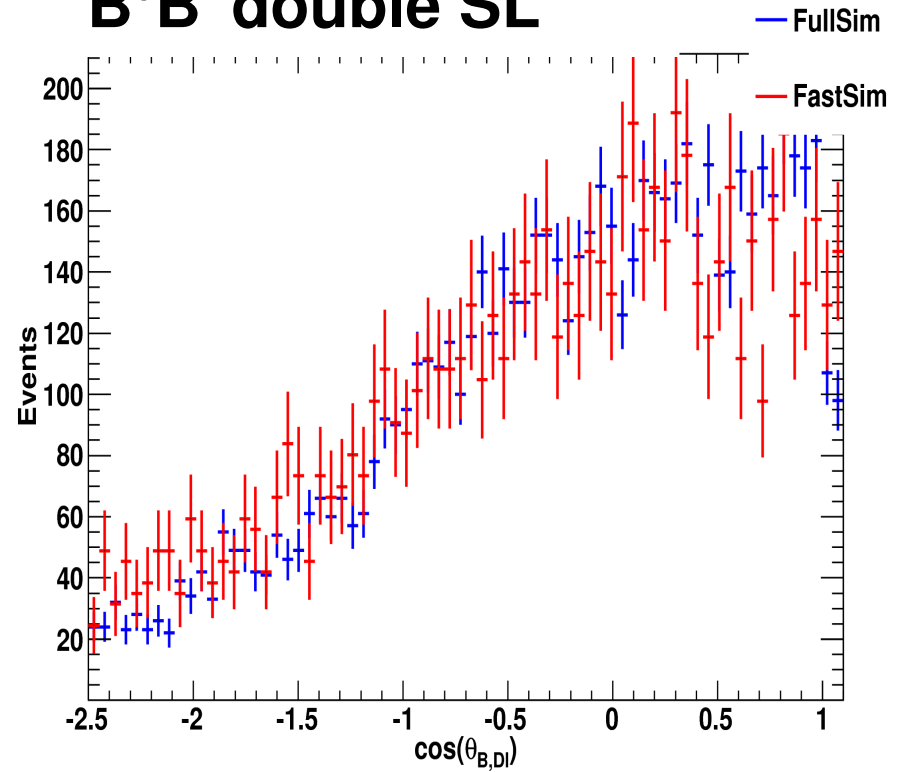
Validation: $B^+ \rightarrow K^+ \nu\nu$

Variable: cos(θ(BDl))

Full Sim
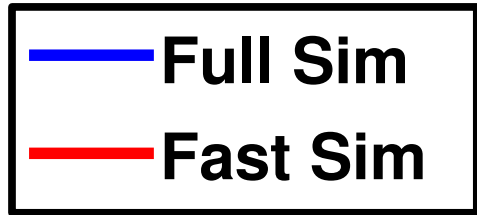**Fast Sim**

Signal

B⁺B⁻ double SL

Validation: $B^+ \to K^+ \nu\nu$

Variable: D mass

Full Sim	
Fast Sim	

Signal

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

— FullS[im]
— Fast[Sim]

B^+B^- double SL

— FullSim
— FastSim

Validation: $B^+ \to K^+ \nu\nu$

Variable: D mass

Full Sim (blue)
Fast Sim (red)

Signal

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

FullSim
FastSim

B^+B^- double SL

FullSim
FastSim

Validation: $B^+ \to K^+ \nu\nu$

Full Sim
Fast Sim
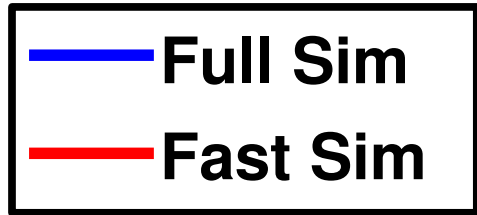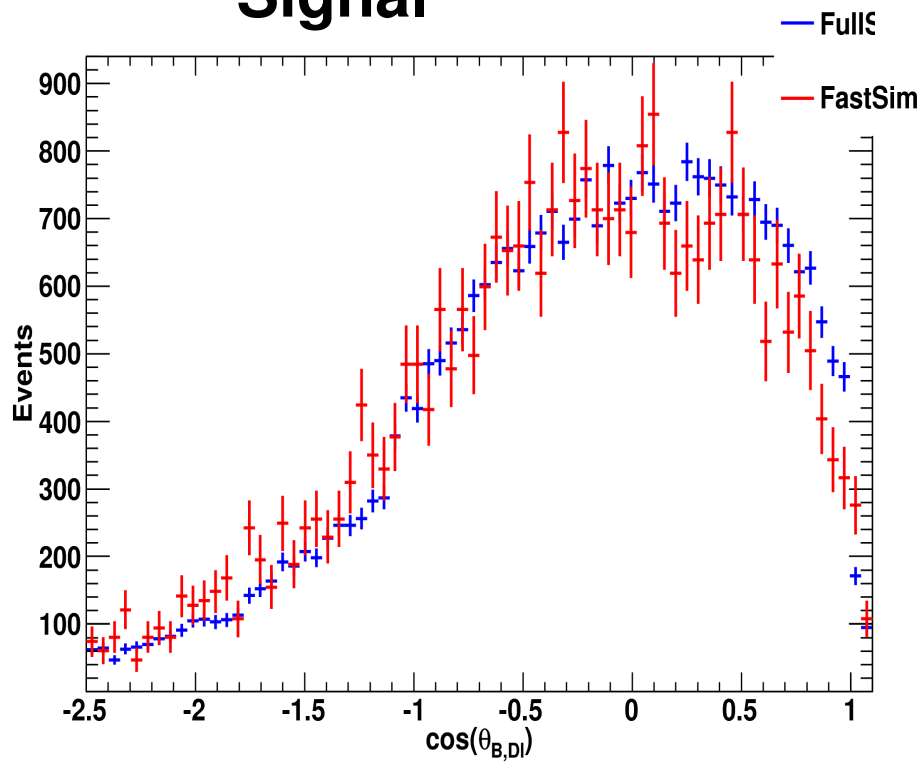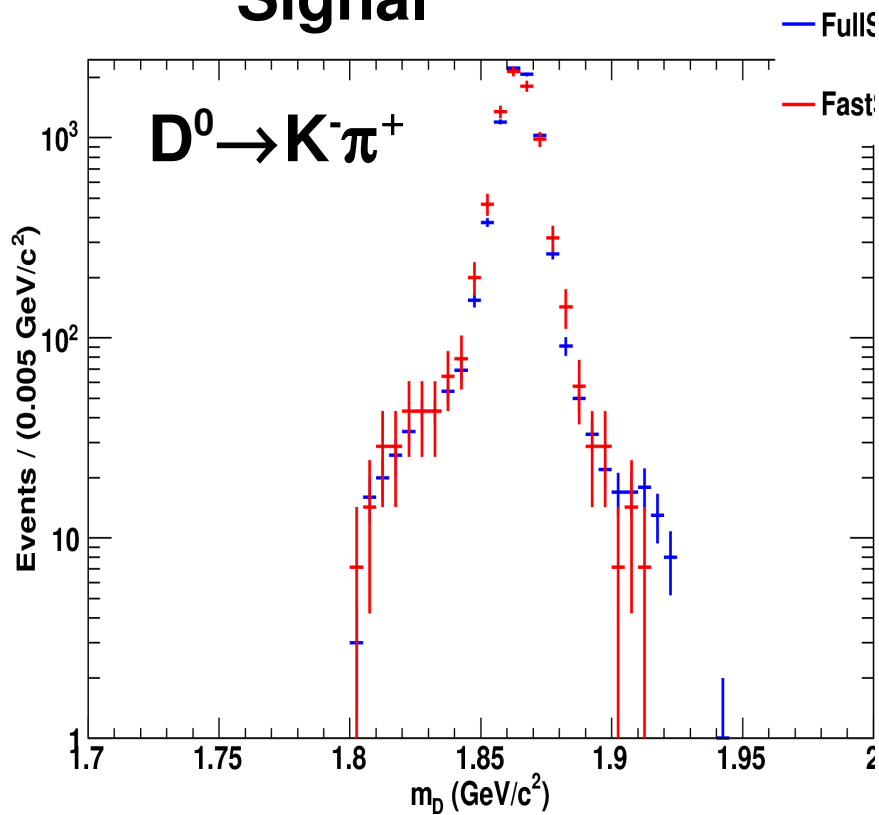
Variable: D mass

Signal

B^+B^- double SL

BaBar analysis do a π^0 mass constraint fit to reconstruct D

Validation: $B^+ \to K^+ \nu\nu$

Variable: D mass

Full Sim (blue)
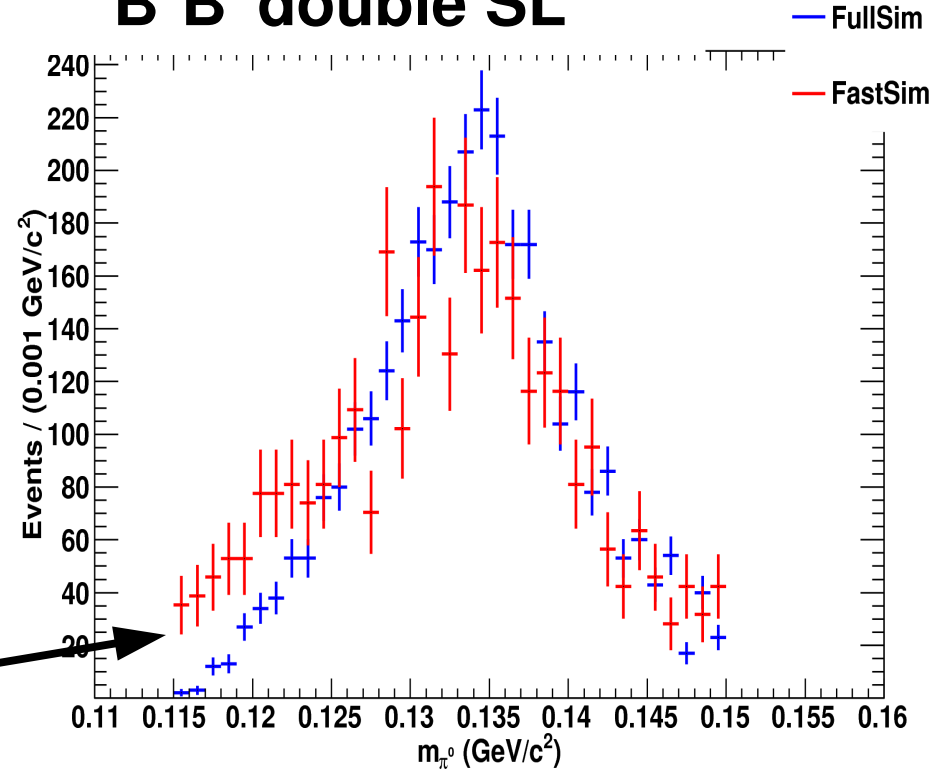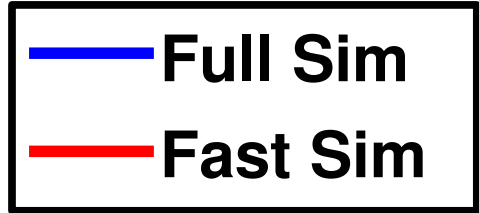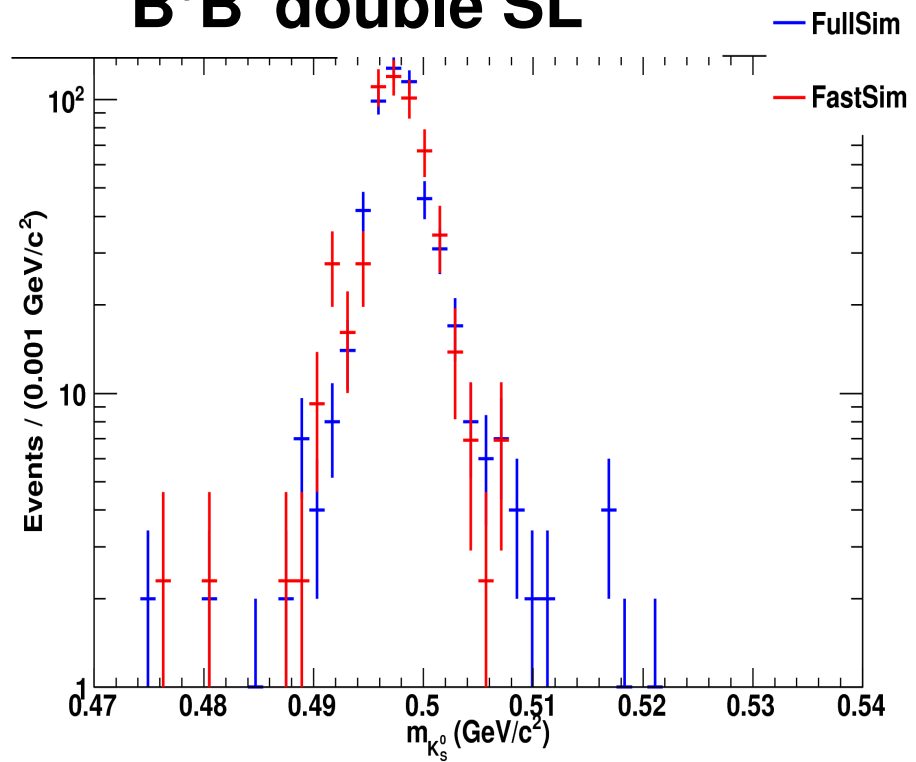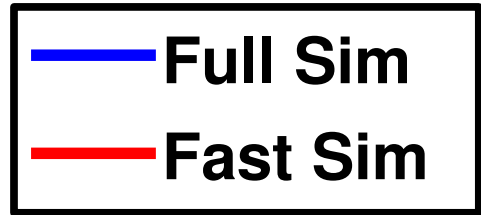**Fast Sim** (red)

Signal

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

B^+B^- double SL

Validation: $B^+ \to K^+ \nu\nu$

Variable: π^0 mass

Full Sim	(blue)
Fast Sim	(red)

Signal

from $D^0 \to K^- \pi^+ \pi^0$
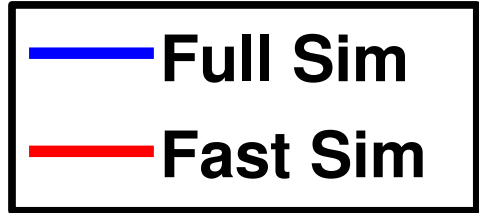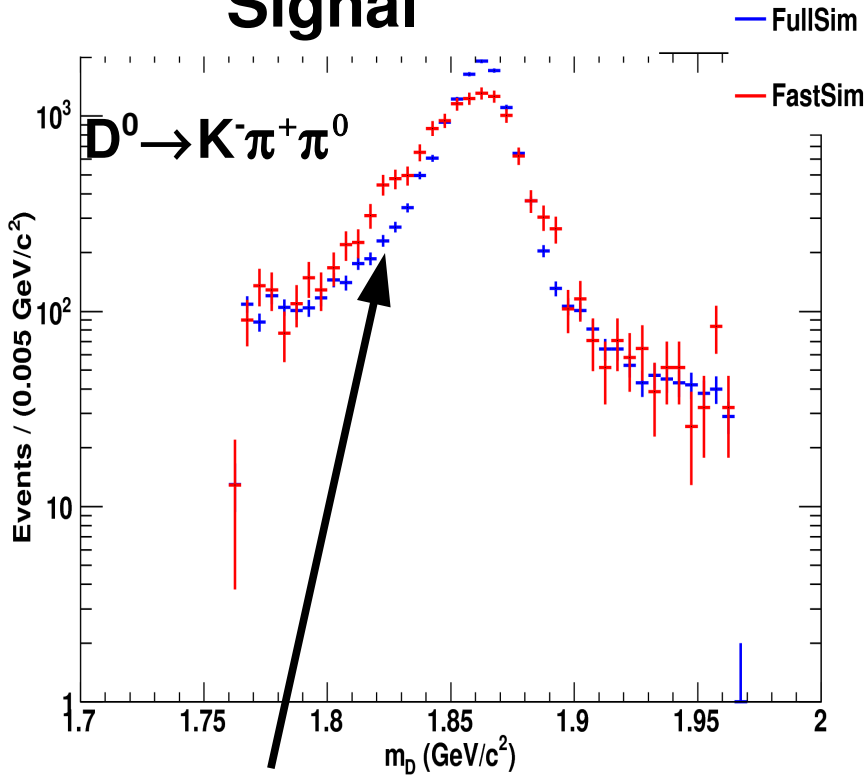
BaBar analysis do a π^0 mass constraint fit to reconstruct D

B^+B^- double SL

Validation: $B^+ \to K^+ \nu \nu$

Variable: K_S^0 mass

Full Sim (blue)
Fast Sim (red)

Signal

from $D^0 \to K_S^0 \pi^+ \pi^-$
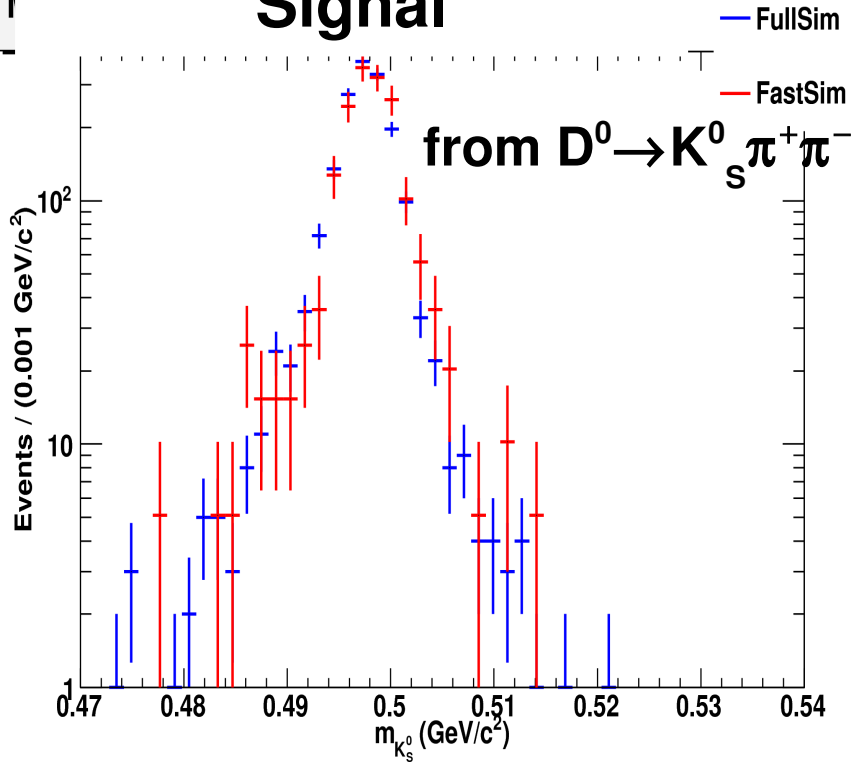
$B^+ B^-$ double SL

Validation: $B^+ \rightarrow K^+ \nu\nu$

Full Sim
Fast Sim

Variable: p*(D)
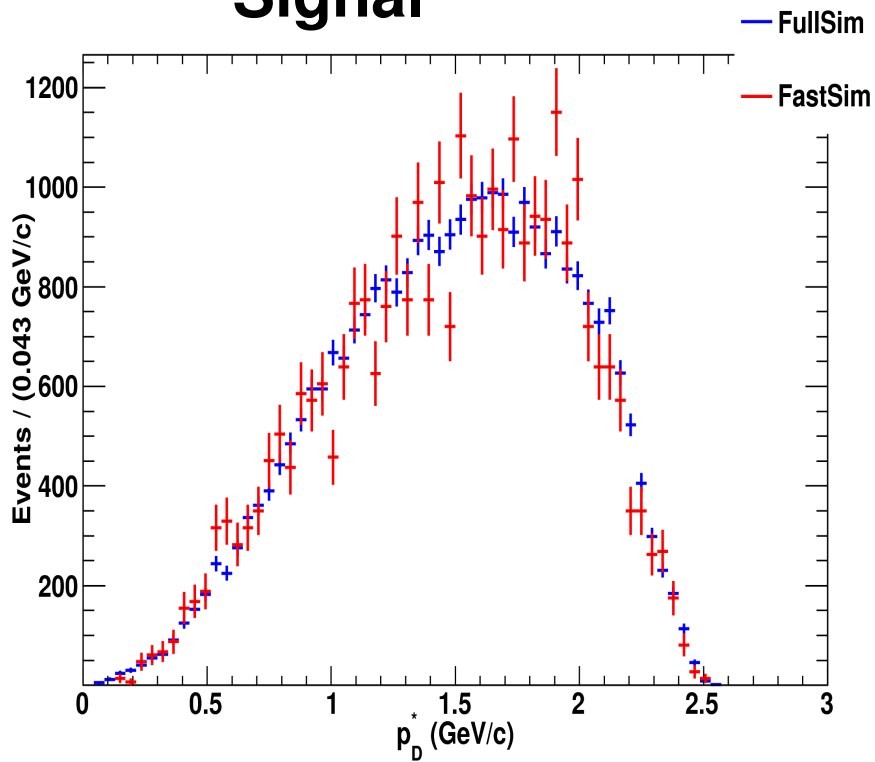
Signal

B^+B^- double SL
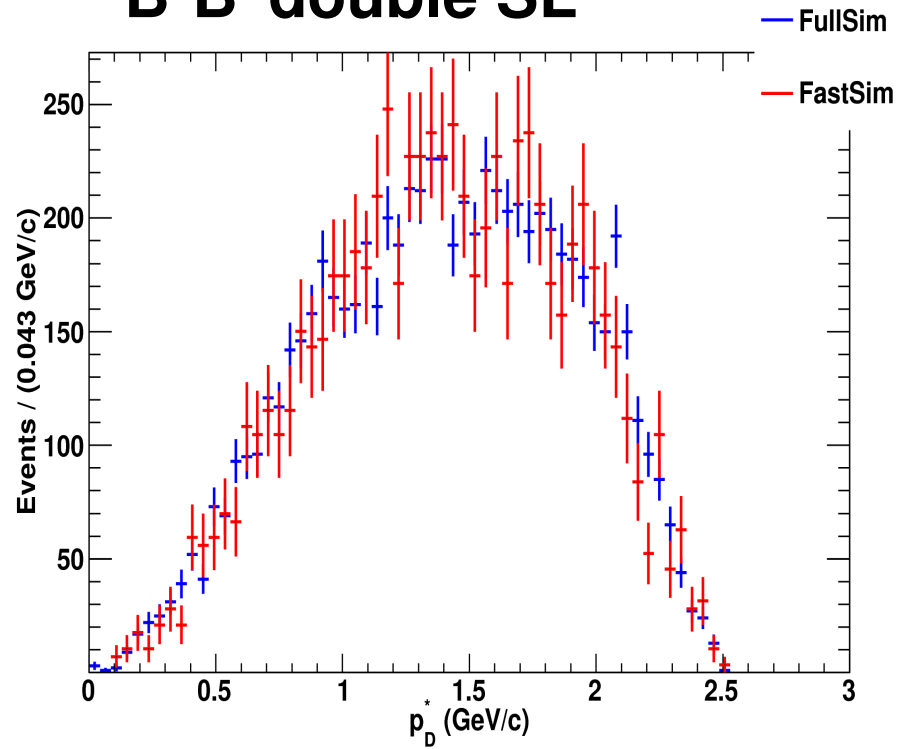
Validation: B⁺→K⁺νν

Variable: p*(lep)

Full Sim

Fast Sim

Signal

B⁺B⁻ double SL

Validation: $B^+ \rightarrow K^+ \nu\nu$

Full Sim
Fast Sim

Variable: p*(Sig-K)

Signal

FullSim
FastSim

B$^+$B$^-$ double SL

FullSim
FastSim
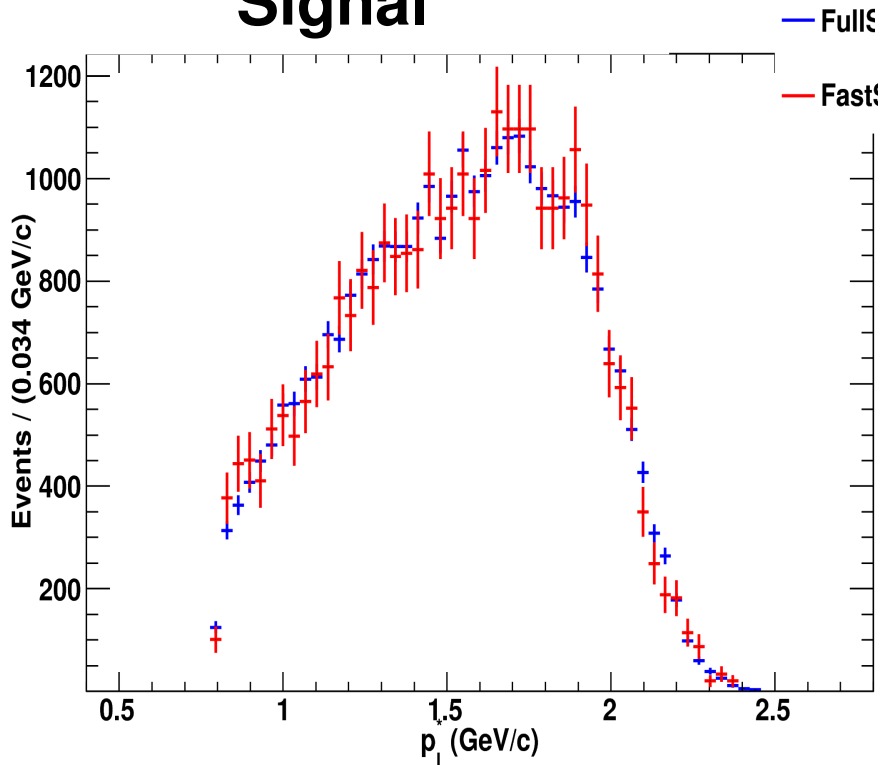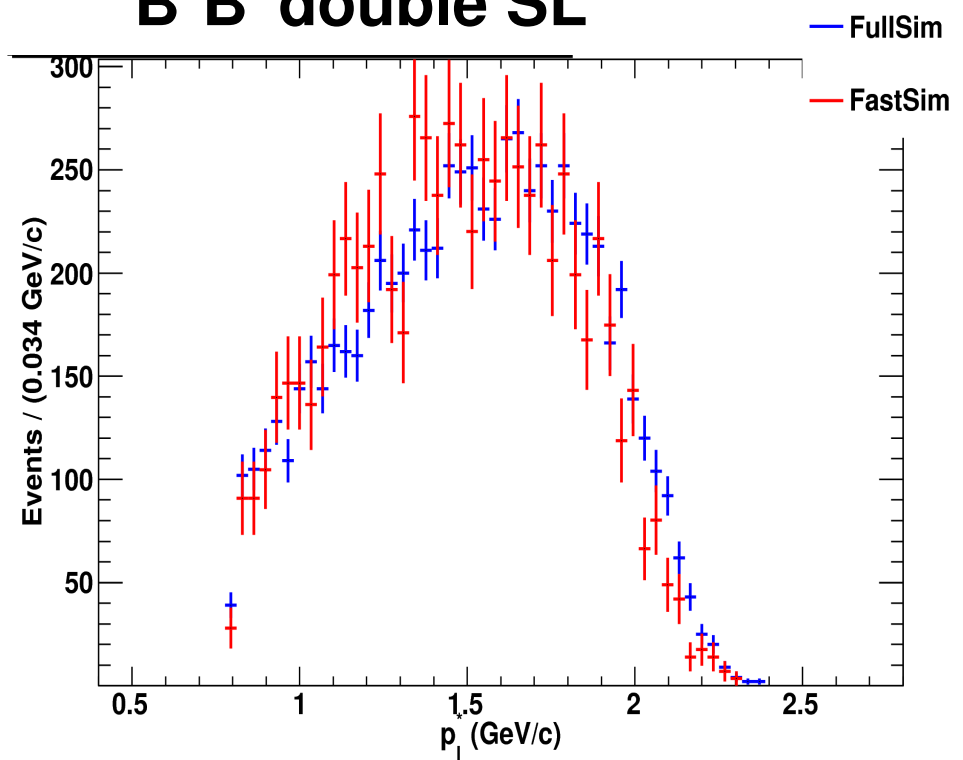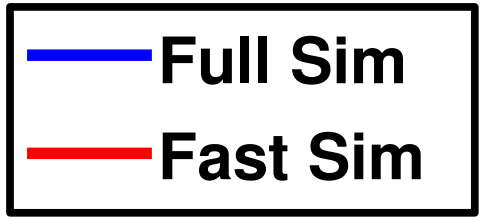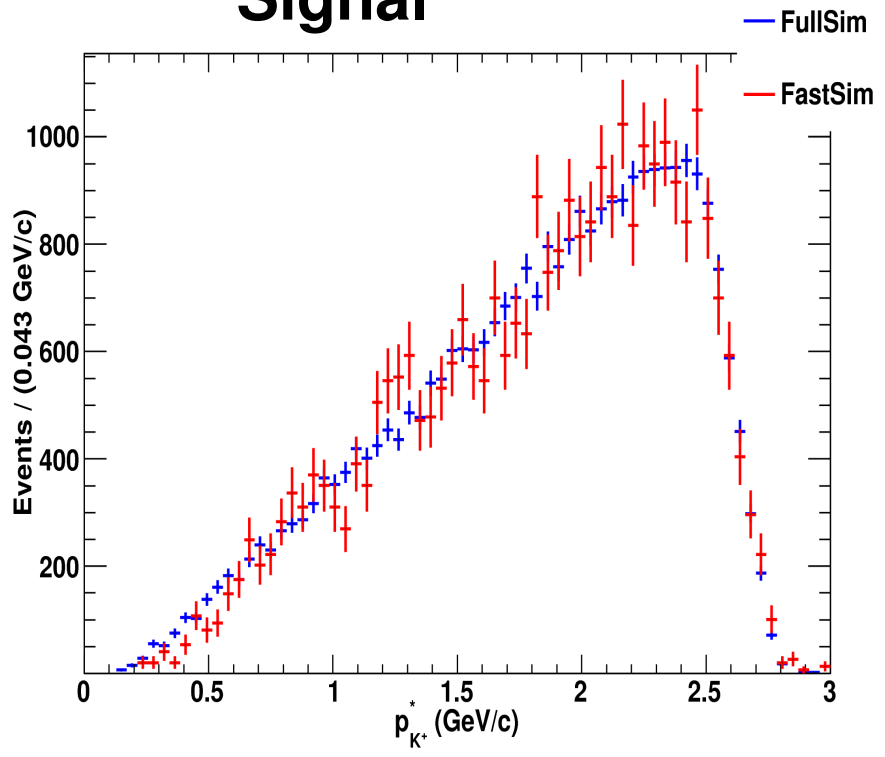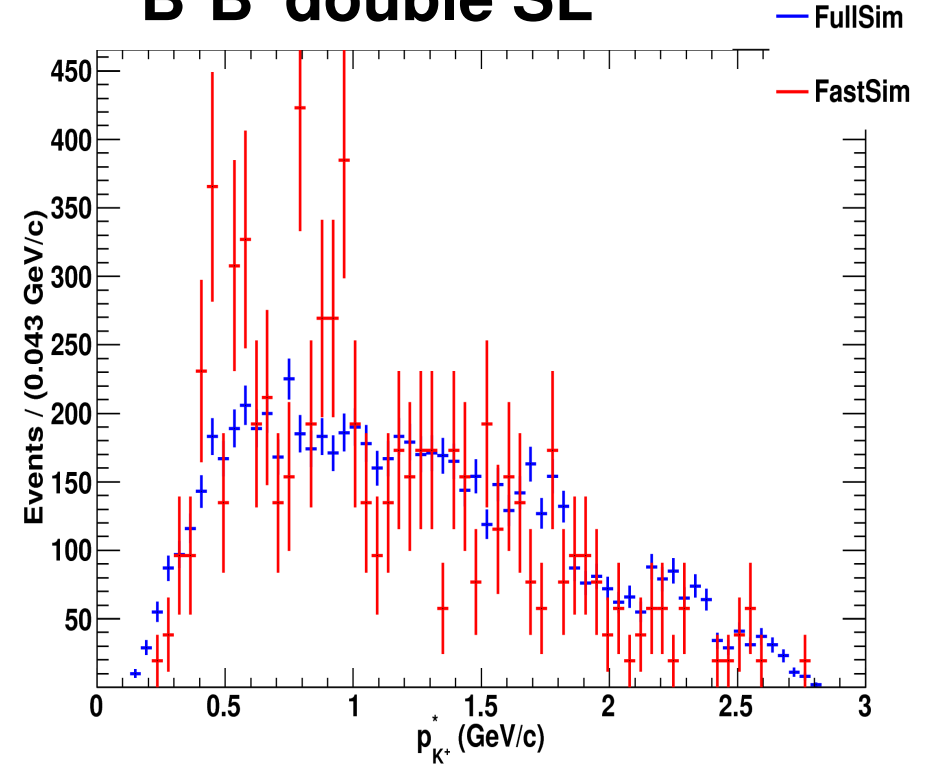
Validation: $B^+ \to K^+ \nu\nu$

Variable: E_{extra}

Full Sim (blue)
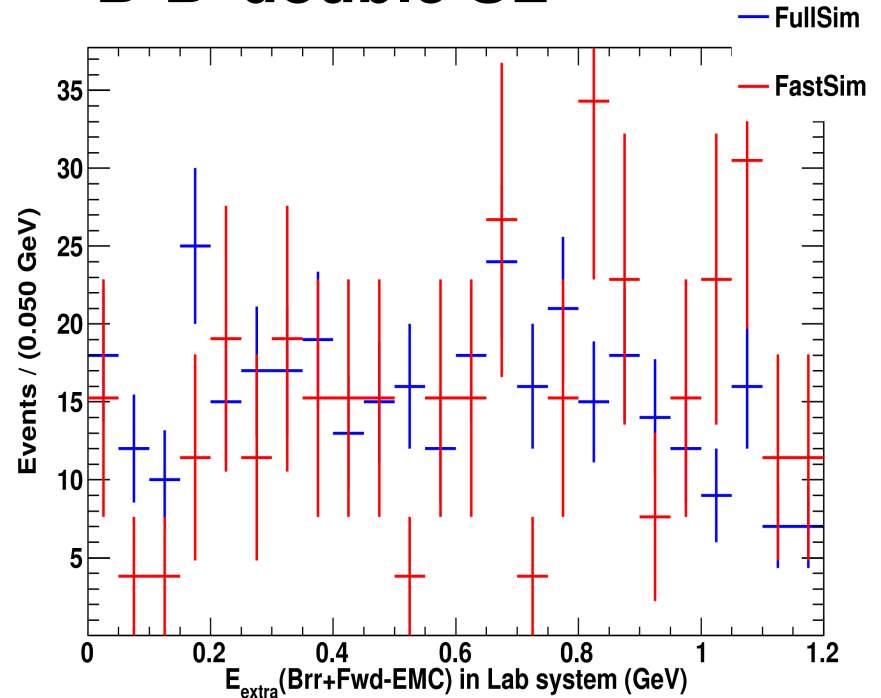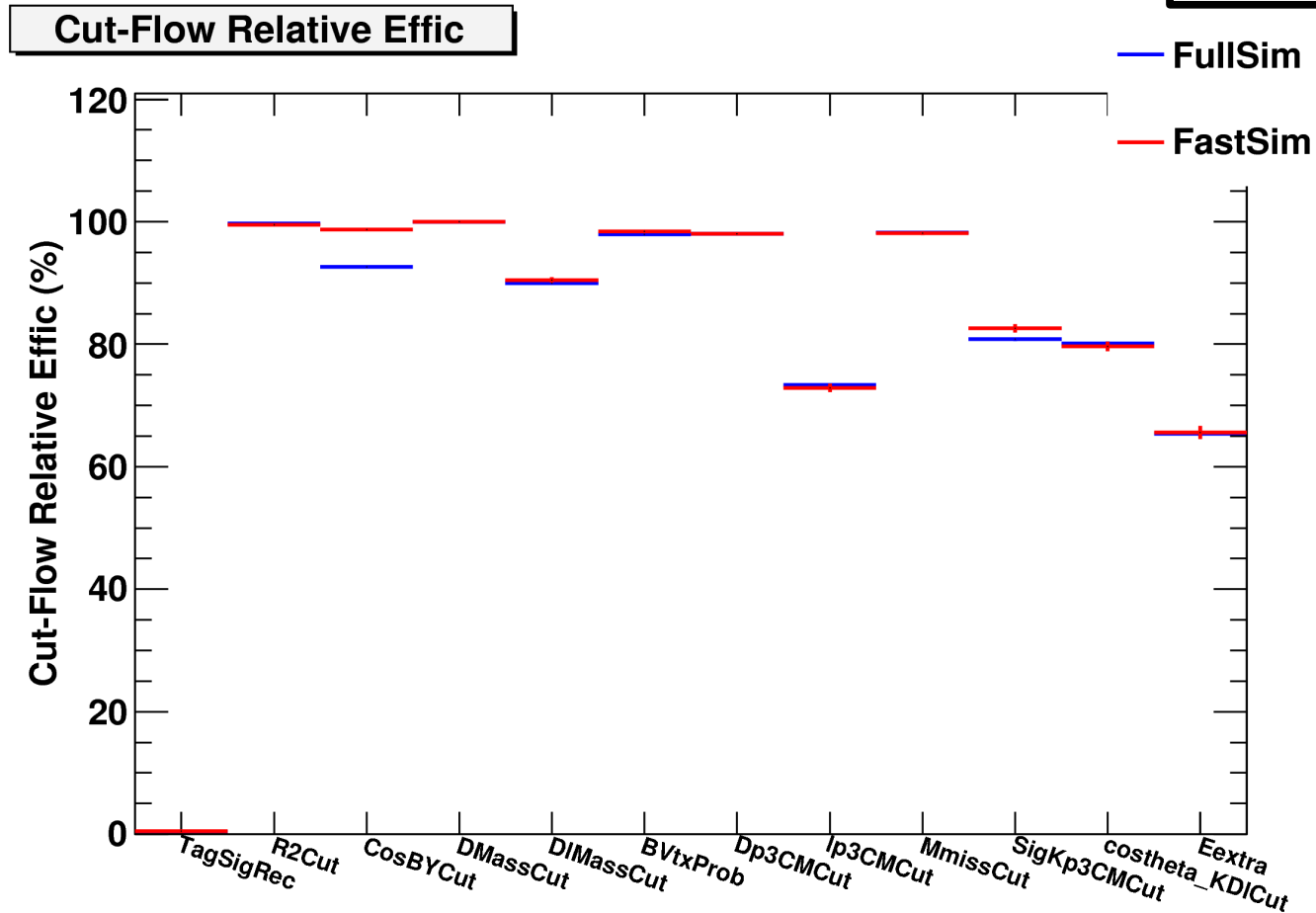**Fast Sim** (red)
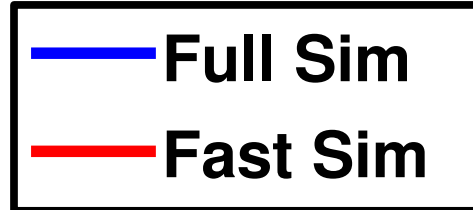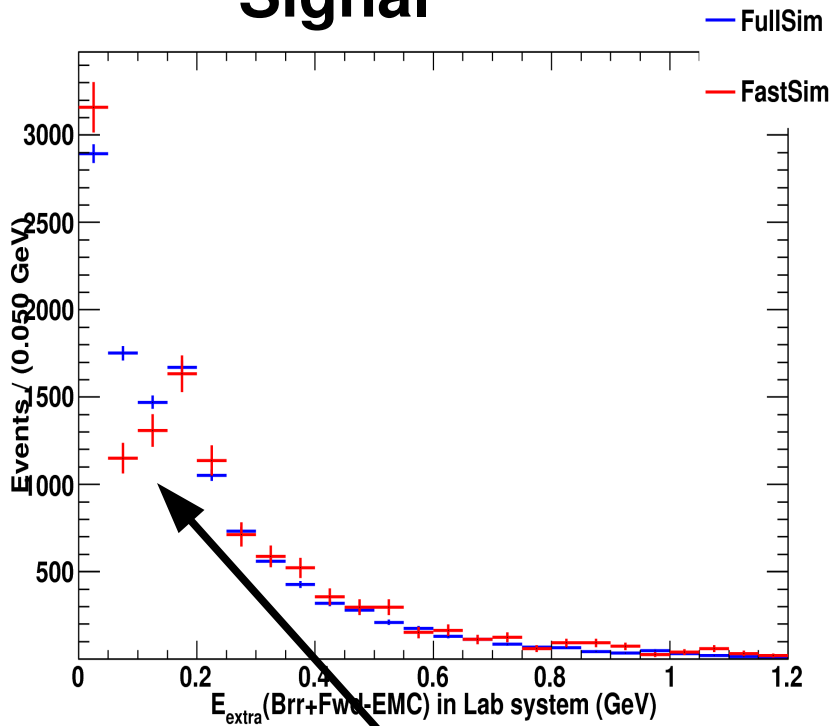
Signal

B^+B^- double SL

Lack of other sources of machine backgrounds

different from Bhabhas/Rad-Bhabhas

Validation: B⁺→K⁺νν

Cut flow relative efficiency: Signal

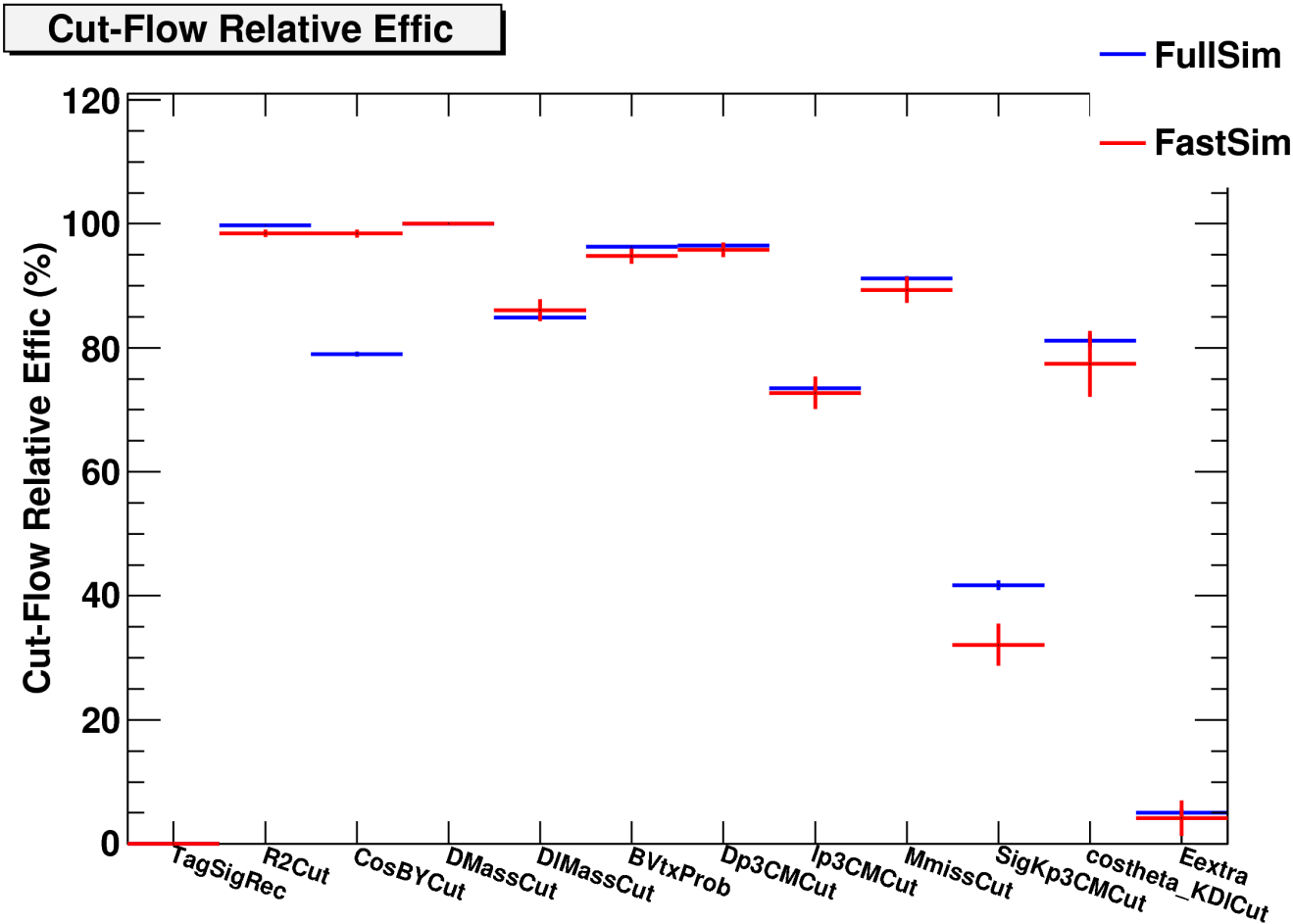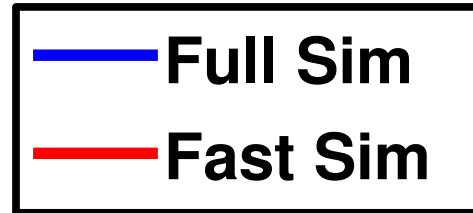# Validation: B$^+\to$K$^+\nu\nu$

Cut flow absolute efficiency: Signal
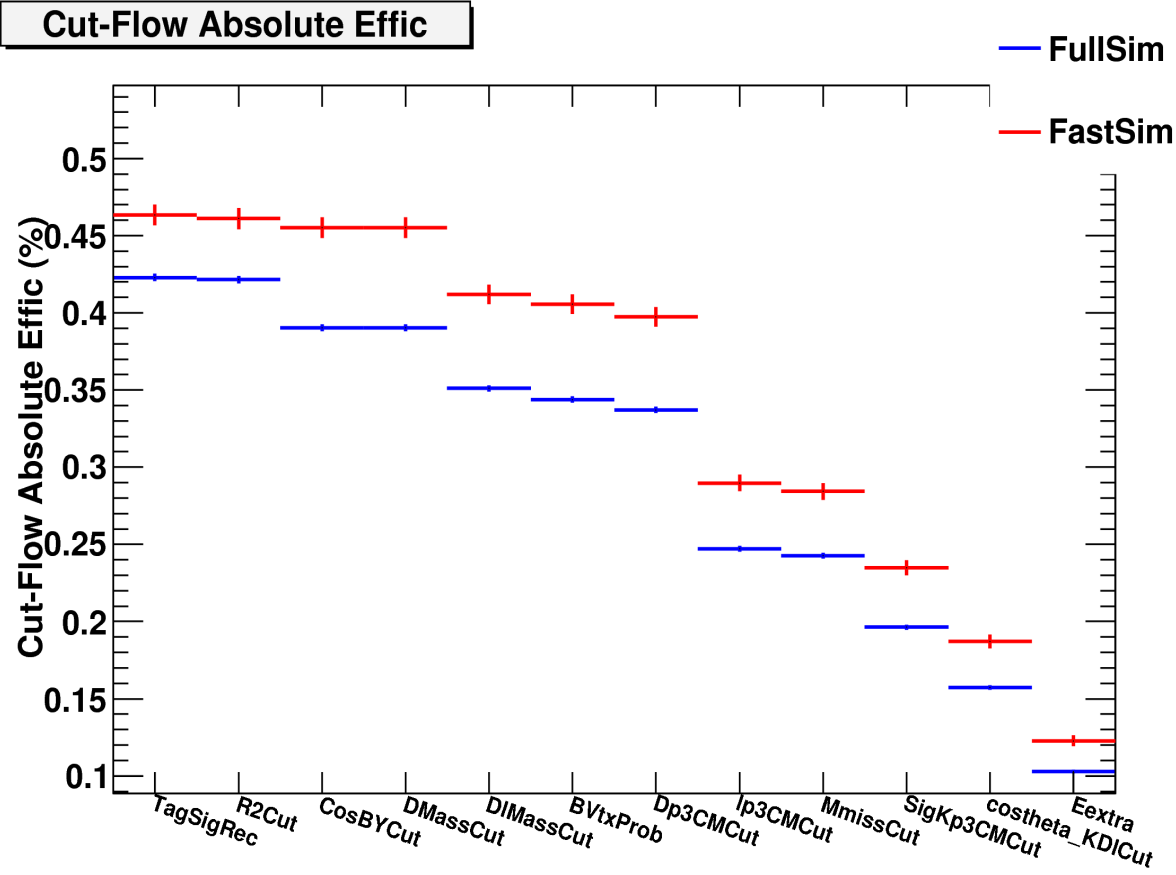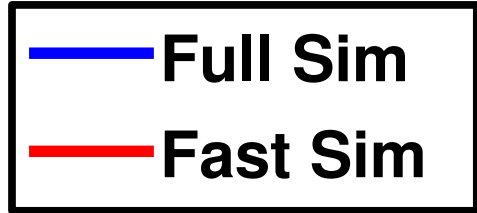
- **Main differences due to reconstruction**
- **Need to understand the source of the difference**

Validation: B⁺→K⁺νν

Full Sim (blue)
Fast Sim (red)

Cut flow relative efficiency: B⁺B⁻ SLSL

Summary and outlook

- **PacSemiLepRecoilUser package reproduce reasonably well BaBar full simulation**

- **Almost all shapes are well reproduced**

- **Shapes with contributions from background photons differ slightly**

- **Obtain almost the same cut flow relative efficiencies in Fast and Full simulation**

- **Absolute efficiencies in Fast-sim are higher than in Full sim**
  - Main source of difference is tag-side reconstruction
  - Principal suspect: B→Dlnu skim

- **Obtain similar results for other decay modes ($B^{(0/+)} \to K^{*(0/+)} \nu \nu$ and $B^0 \to K^0 \nu \nu$)**

- **Once this difference understood will commit validation code**

Backup