Analysis of $B \rightarrow K^{(*)}\nu\nu$ against Hadronic Breco

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Outline

* Hadronic Breco and February production

* BaBar Full Simulation vs Fast Simulation in the BaBar configuration

* Comparison between SuperB Detector geometry # 3 (DG_3) and SuperB Detector geometry # 4 (DG_4), w/o BWD EMC
  - Breco side
  - $B \rightarrow K^{(*)}\nu\nu$ signal side analysis

Hadronic Breco reconstruction in FastSim

* SemiExclusive reconstruction implemented in FastSim: PacHadRecoilUserPackage (based on BaBar BTauSemiExclUser code)
* Breco side: limit the number of reconstructed modes according to their purity
  - Breco mode classification: neat : purity > 80% , $\varepsilon_{neat} \approx O(10^{-4})$
    clean : 50% < purity < 80% , $\varepsilon_{clean} \approx O(10^{-3}\text{-}10^{-2})$
    dirty : 8%<purity<50% , $\varepsilon_{dirty} \approx O(10^{-2})$

→ reconstruct only neat+clean modes

* Bsig side:
  - $K^+\nu\nu$
  - $K_s(\pi^+\pi^-)\nu\nu$
  - $K^{*+}(K_s\pi^+, K^+\pi^0)\nu\nu$
  - $K^{*0}(K^+\pi^-)\nu\nu$
  - $\tau^+\nu$, with $\tau^+ \to e^+\nu\nu, \mu^+\nu\nu, \pi^+\nu, \rho^+(\pi^+\pi^0)\nu, a_1^+(\rho^0\pi^+)\nu$

discussed in this talk (referring to $K^+\nu\nu$, K^{*+} and K^{*0} modes)

February production

* two SuperB Detector Geometry used (seen next slides) + BaBar geometry (and beams) to compare Fast Sim with BaBar Full Sim
* Generic samples (B+B-_generics, B0B0bar_generics, uds, ccbar)
  - DG_BaBar: w background, 50million evts
  - DG_3: w background (25M evts) + w/o background on (530M evts)
  - D_4: w background on (28million evts) + background on (830M evts)
* Signal Samples:

done JOBS

Geometry	Generator	tcl	Total Number of Jobs	Total Number of Events
DG_BaBar	B+B-_Kstar+nunu	MixBaBarBkg_NoPair.tcl	10	1 000 000
DG_BaBar	B0B0bar_Kstar0nunu_Kpi	MixBaBarBkg_NoPair.tcl	10	1 000 000
DG_3	B+B-_Kstar+nunu	MixSuperbBkg_NoPair.tcl	10	1 000 000
DG_3	B0B0bar_Kstar0nunu_Kpi	MixSuperbBkg_NoPair.tcl	10	1 000 000
DG_4	B+B-_Kstar+nunu	MixSuperbBkg_NoPair.tcl	10	1 000 000
DG_4	B0B0bar_Kstar0nunu_Kpi	MixSuperbBkg_NoPair.tcl	10	1 000 000
Total			60	6 000 000

done JOBS

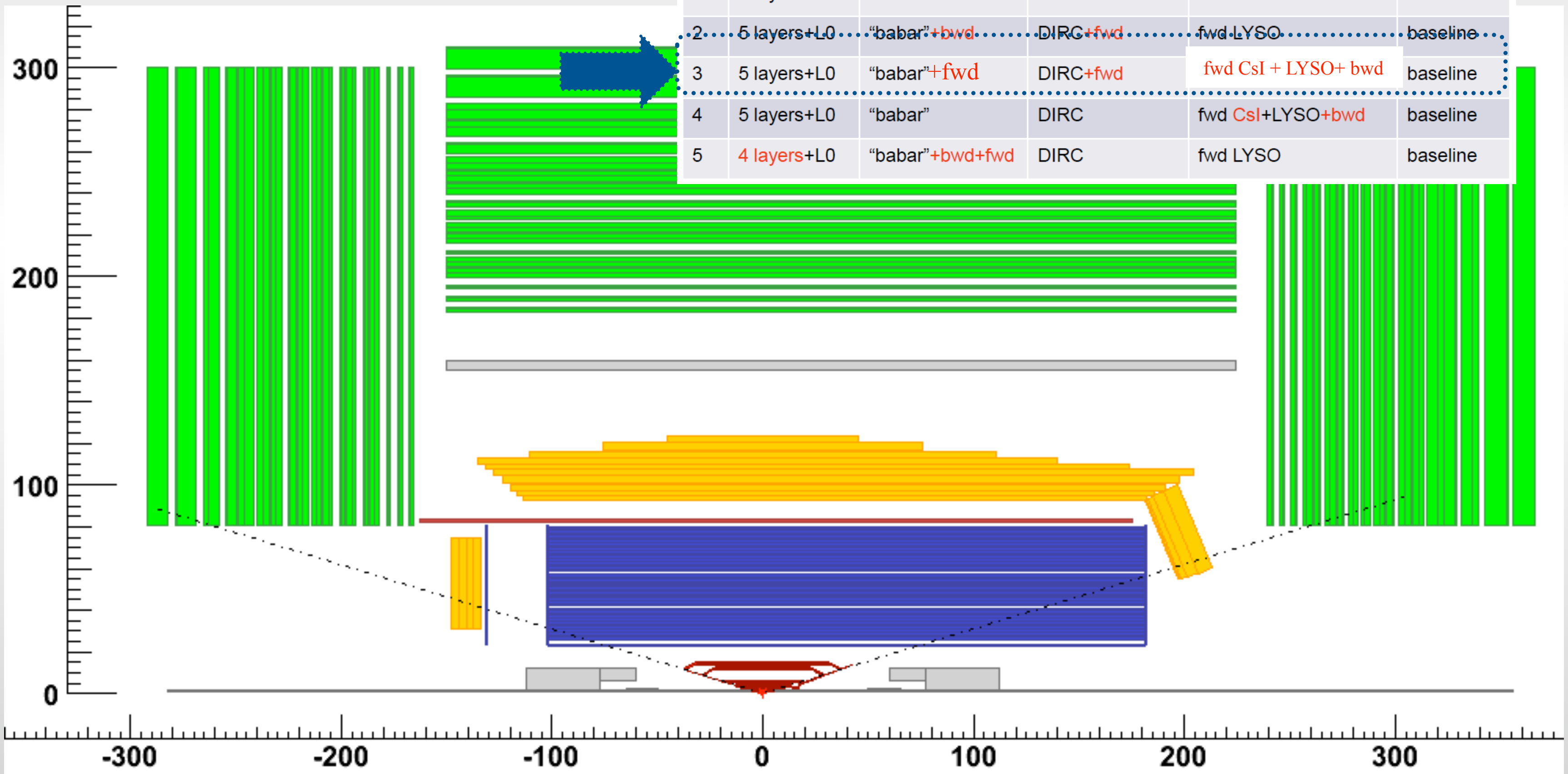
Geometry	Generator	tcl	Total Number of Jobs	Total Number of Events
DG_BaBar	B+B-_K+nunu	MixBaBarBkg_NoPair.tcl	10	1 000 000
DG_BaBar	B0B0bar_K0nunu	MixBaBarBkg_NoPair.tcl	10	1 000 000
DG_3	B+B-_K+nunu	MixSuperbBkg_NoPair.tcl	10	1 000 000
DG_3	B0B0bar_K0nunu	MixSuperbBkg_NoPair.tcl	10	1 000 000
DG_4	B+B-_K+nunu	MixSuperbBkg_NoPair.tcl	10	1 000 000
DG_4	B0B0bar_K0nunu	MixSuperbBkg_NoPair.tcl	10	1 000 000
Total			60	6 000 000

in this talk:
- signal MC samples w bkg
- generic MC samples w/o bkg

Detector geometries (I)

* DetectorConfiguraztion_3
  - SVT_L0 + fwd DCH+ bwd EMC

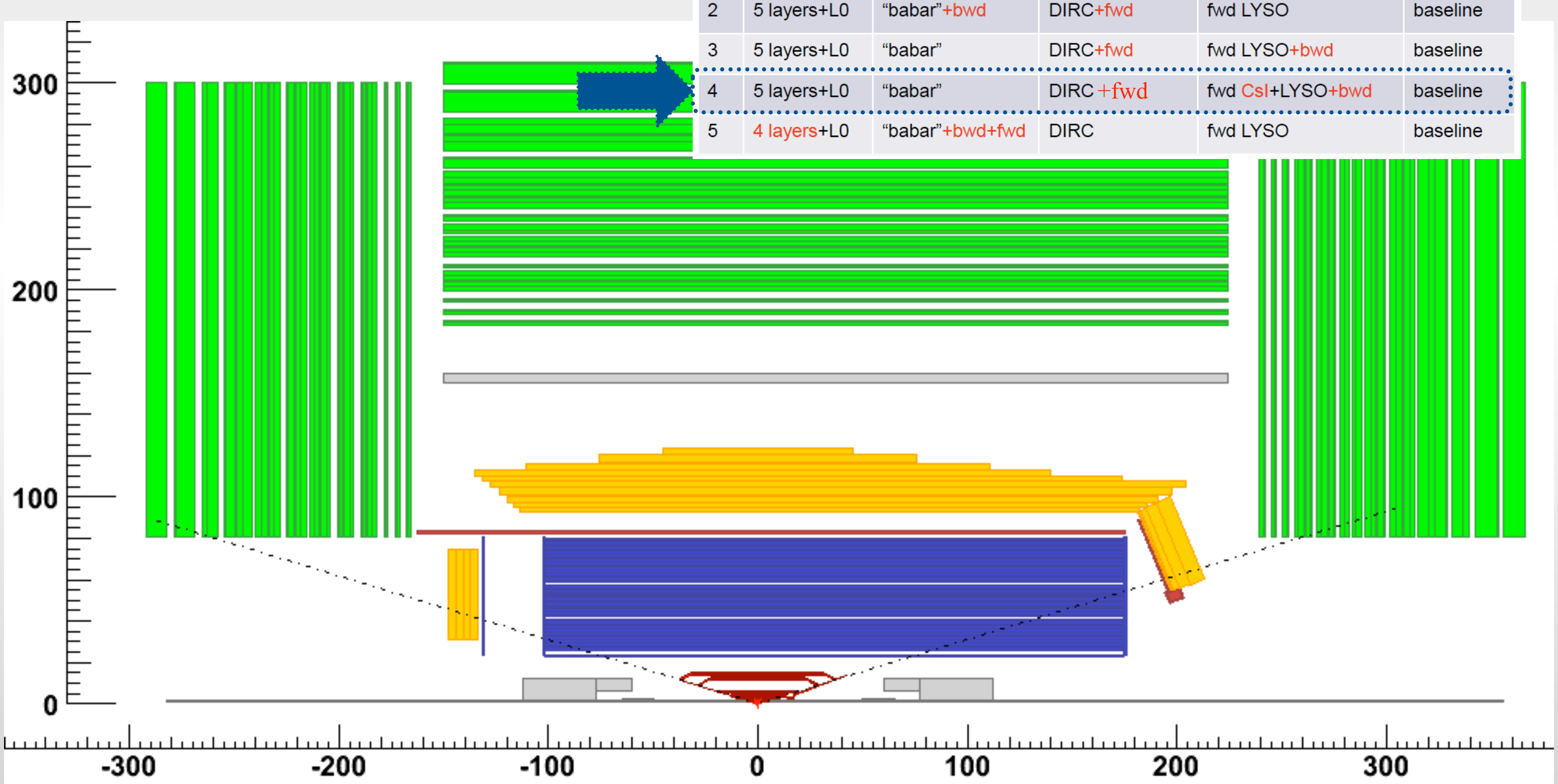
	SVT	DCH	PID	EMC	IFR
0	5 layers+L0	"babar"	DIRC	fwd LYSO	baseline
1	5 layers+L0	"babar"+bwd+fwd	DIRC	fwd LYSO	baseline
2	5 layers+L0	"babar"+bwd	DIRC+fwd	fwd LYSO	baseline
3	5 layers+L0	"babar"+fwd	DIRC+fwd	fwd CsI + LYSO+ bwd	baseline
4	5 layers+L0	"babar"	DIRC	fwd CsI+LYSO+bwd	baseline
5	4 layers+L0	"babar"+bwd+fwd	DIRC	fwd LYSO	baseline



Detector geometries (II)

* DetectorConfiguraztion_4
  - SVT_L0 + fwd PID + bwd EMC

	SVT	DCH	PID	EMC	IFR
0	5 layers+L0	"babar"	DIRC	fwd LYSO	baseline
1	5 layers+L0	"babar"+bwd+fwd	DIRC	fwd LYSO	baseline
2	5 layers+L0	"babar"+bwd	DIRC+fwd	fwd LYSO	baseline
3	5 layers+L0	"babar"	DIRC+fwd	fwd LYSO+bwd	baseline
4	5 layers+L0	"babar"	DIRC +fwd	fwd CsI+LYSO+bwd	baseline
5	4 layers+L0	"babar"+bwd+fwd	DIRC	fwd LYSO	baseline



Analysis strategy

* Compare DG_3 vs DG_4
  - PID in the fwd region weaker in DG_3 (dE/dx) then in DG_4 (dE/dx+TOF)
  - in DG_3, smaller amount of material in front of fwd EMC

* Use bwd EMC as VETO device:
  - reject candidates with neutrals reconstructed in bwd EMC
  - apply BaBar selection
  - require "zero" EExtraNeutralBwd

* pid device angular acceptance: 20°(tracking)$<\theta_{lab}<$ 144.4 (DIRC)

* Apply BaBar Analysis cuts for $B^+\rightarrow K^+\nu\nu$, $B^+\rightarrow K^{*+}\nu\nu$, $B^0\rightarrow K^{*0}\nu\nu$ and compare efficiencies for Breco and Bsig selection

A remark on PID usage

* PID selectors used in the D and B lists
  - π from GoodTracksVeryLoose
  - K PID:
    * Breco side, DIRC region: D→ KY lists use GoodTracksLoose or KLHNotPion depending on the D mode, B→ $D^{(*)}$KY lists use KNNTight depending on the B mode
    * Breco side, Fwd region: KLHNotPion
    * Bsig side: KNNTight

* select events in which the K pass the proper PID selector
  - kaons in the DIRC region: TableBased selectors (performances form BaBar)
  - kaons in the fwd region:
    * TableBased selectors with performances from TOF FullSim studies (DG_4)
    * TableBased selectors with performances from BaBar (DG_BaBar, DG_3)

BaBaf Full Simulation

vs

SuperB Fast Simulation

Fast Sim DG_BaBar vs BaBar Full Sim (I)

- SuperB FastSim:
  - B+B-, B0B0bar, ccbar, uds MC samples
  - $B^+\to K^+\nu\nu$, $B^+\to K^{*+}\nu\nu$, $B^0\to K^{*0}\nu\nu$ signal MC samples
  - BaBar beams and detector geometry

- BaBar FullSim, Run3 (same code and same “skim” as in FastSim):
  - B+B- : 49,766x10^3 gen. evts
  - B0B0bar : 50,556x10^3 gen. evts
  - ccbar : 83,974x10^3 gen. evts
  - uds : 66,892x10^3 gen evts
  - $B^+\to K^+\nu\nu/B^+\to K^{*+}\nu\nu/B^0\to K^{*0}\nu\nu$: 7,845/7,8510/6,282 x 10^3 gen evts

- Selection applied:
  - at least one reconstructed Breco; if #Breco > 1, best candidate ↔ $|\Delta E|$min
  - $-0.09<\Delta E<0.05$ GeV
  - $5.270<m_{ES}<5.288$ GeV/c^2

Breco efficiencies, generic samples (I)

ε= nsel/nbreco(purity >0.5, abs(charge)==0/1, pid requirements)
(see back up for stat errors on efficiencies)

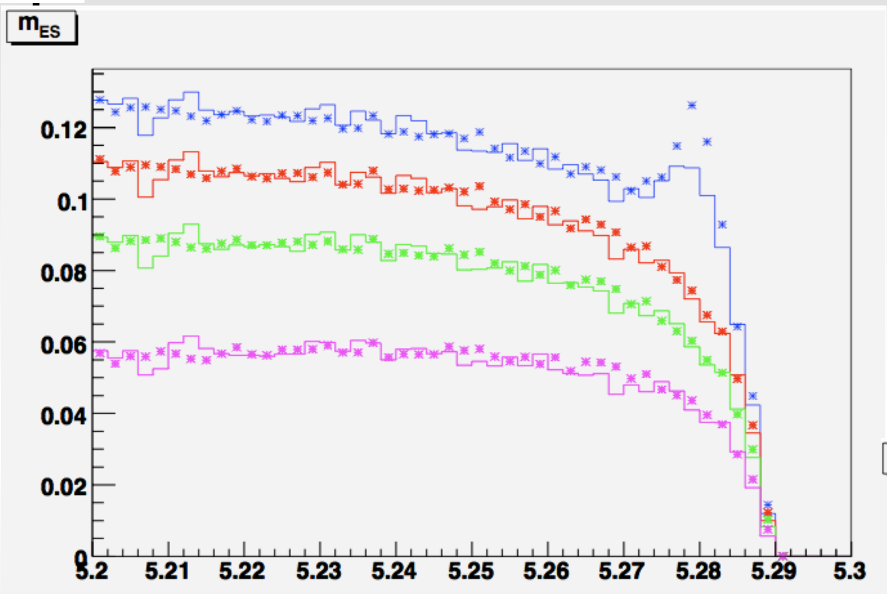
neutral Breco	B0B0bar		BpBm		ccbar		uds	
	FullSim	FastSim	FullSim	FastSim	FullSim	FastSim	FullSim	FastSim
mES cut	0.254	0.209	0.116	0.111	0.125	0.101	0.125	0.121
deltaE cut	0.223	0.184	0.093	0.091	0.088	0.081	0.088	0.087
$\varepsilon_{Fast}/\varepsilon_{Full}$	0.85		0.98		0.92		0.99	

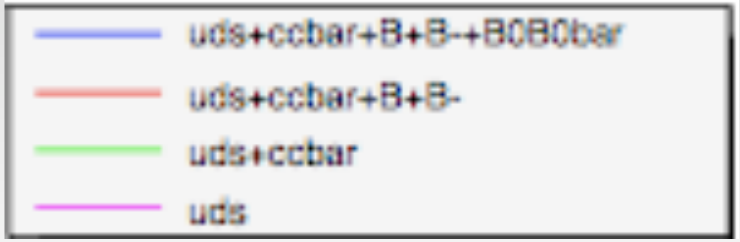
charged Breco	B0B0bar		BpBm		ccbar			
	FullSim	FastSim	FullSim	FastSim	FullSim	FastSim	FullSim	FastSim
mES cut	0.152	0.140	0.336	0.289	0.126	0.128	0.139	0.137
deltaE cut	0.118	0.110	0.309	0.241	0.089	0.090	0.096	0.094
$\varepsilon_{Fast}/\varepsilon_{Full}$	0.93		0.78		1.01		0.98	

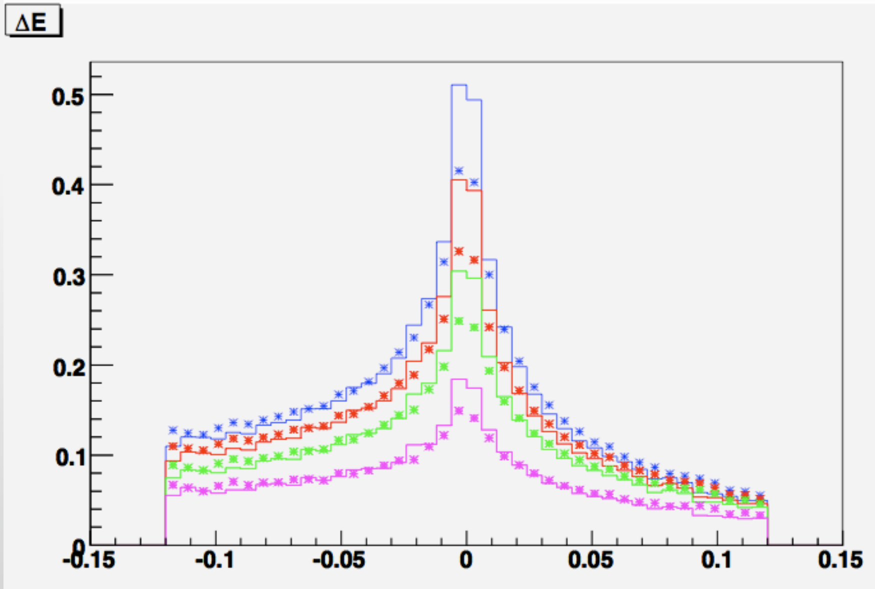
loosing efficiency in the "signal sample": B0B0bar for neutral Breco and B+B- for charged Breco

neutral Breco shapes, generic samples

* m_{ES} and ΔE before the selection





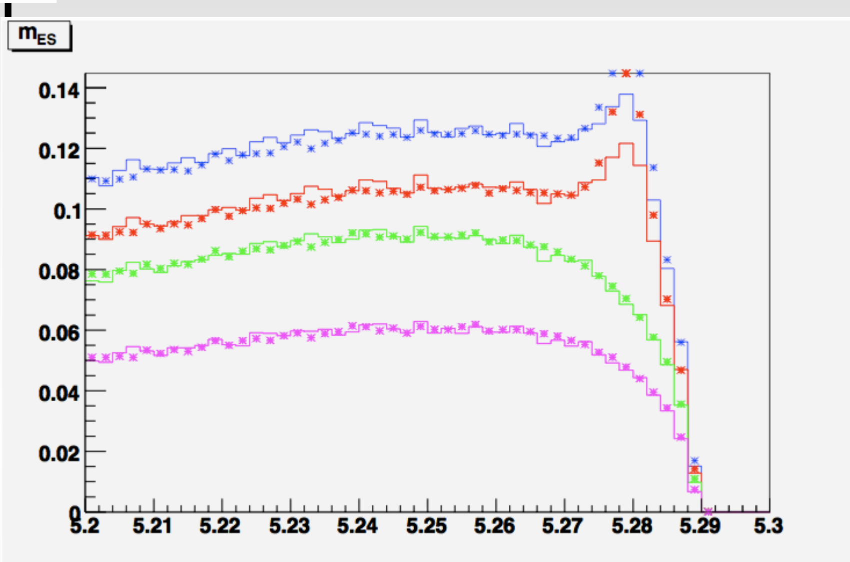


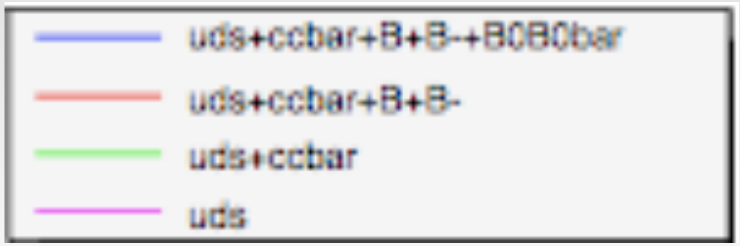
* FullSim

__ FastSim

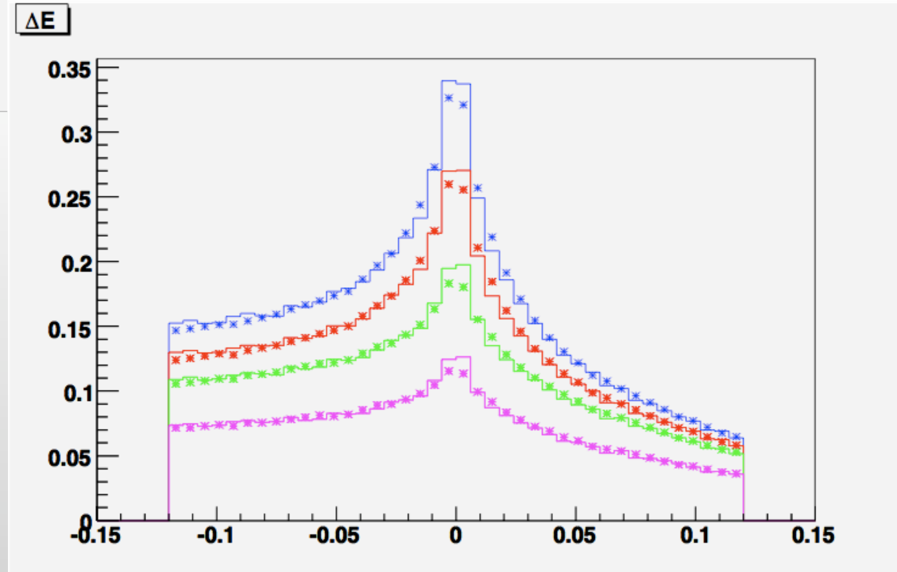
charged Breco shapes, generic samples

* m_{ES} and ΔE before the selection

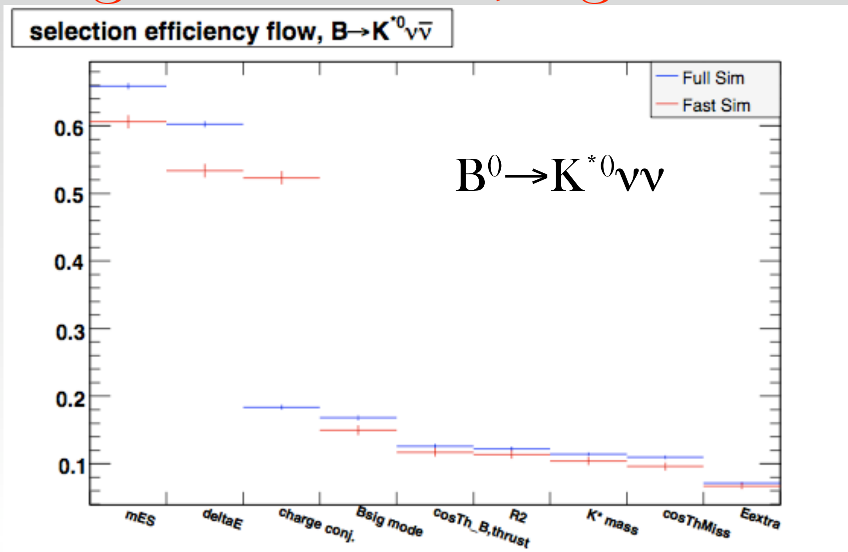


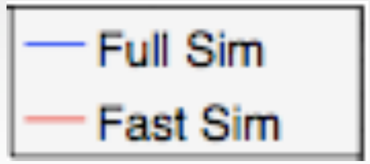


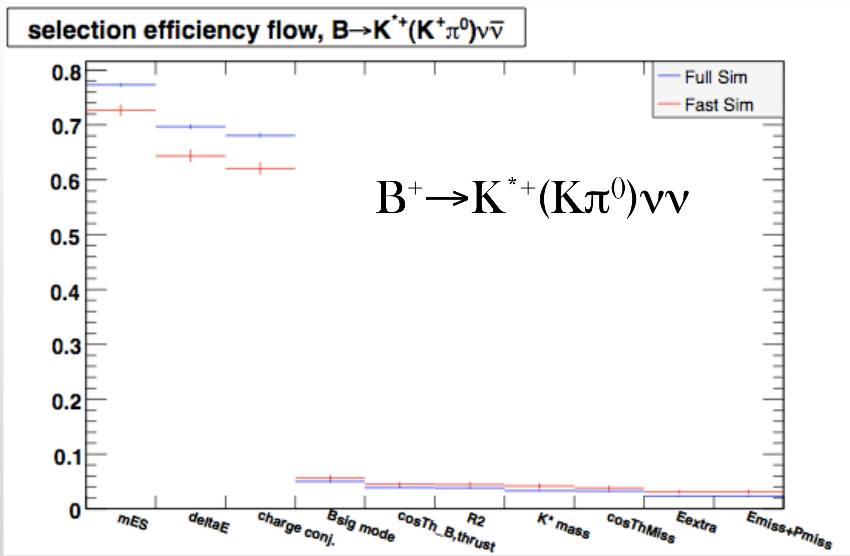
* FullSim
__ FastSim

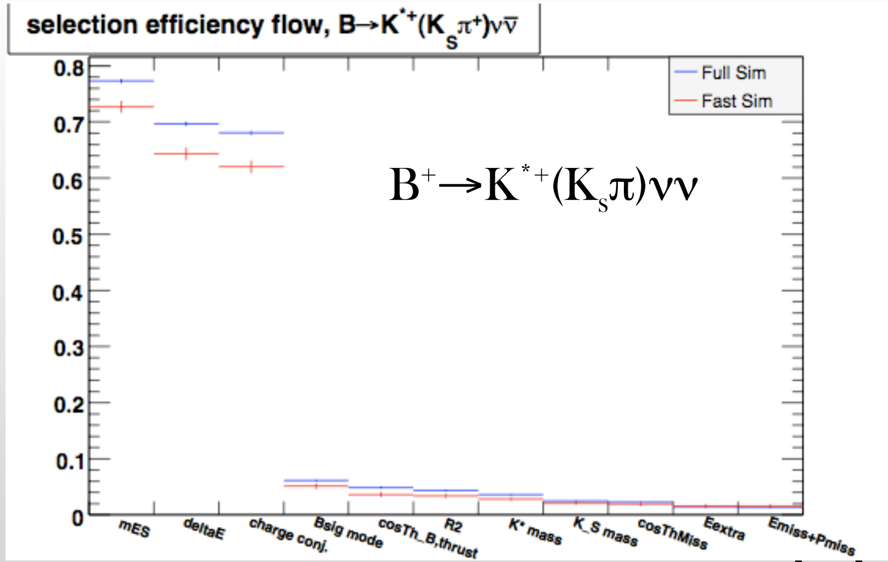


Bsig efficiencies, signal samples









SuperB Fast Simulation: DG_3 vs DG_4

neutral Breco efficiencies, generic samples

ε= nsel/ngen

(see back up for stat errors on efficiencies)

neutral Breco	B0B0bar		BpBm		ccbar		uds	
	DG_3	DG_4	DG_3	DG_4	DG_3	DG_4	DG_3	DG_4
nBreco>=1	0.0197	0.0199	0.0098	0.0098	0.0080	0.0085	0.0017	0.0017
mES cut	0.0040	0.0040	0.0011	0.0010	0.0008	0.0008	0.0002	0.0002
delatE cut	0.0036	0.0036	0.0009	0.0009	0.0006	0.0007	0.0001	0.0001
	DG_BaBar		DG_BaBar		DG_BaBar		DG_BaBar	
	0.0029		0.0007		0.0005		0.0001	
$(\varepsilon_{DG3}-\varepsilon_{DGbbr})/\varepsilon_{DGbbr}$	+0.24		+0.28		+0.20		--	

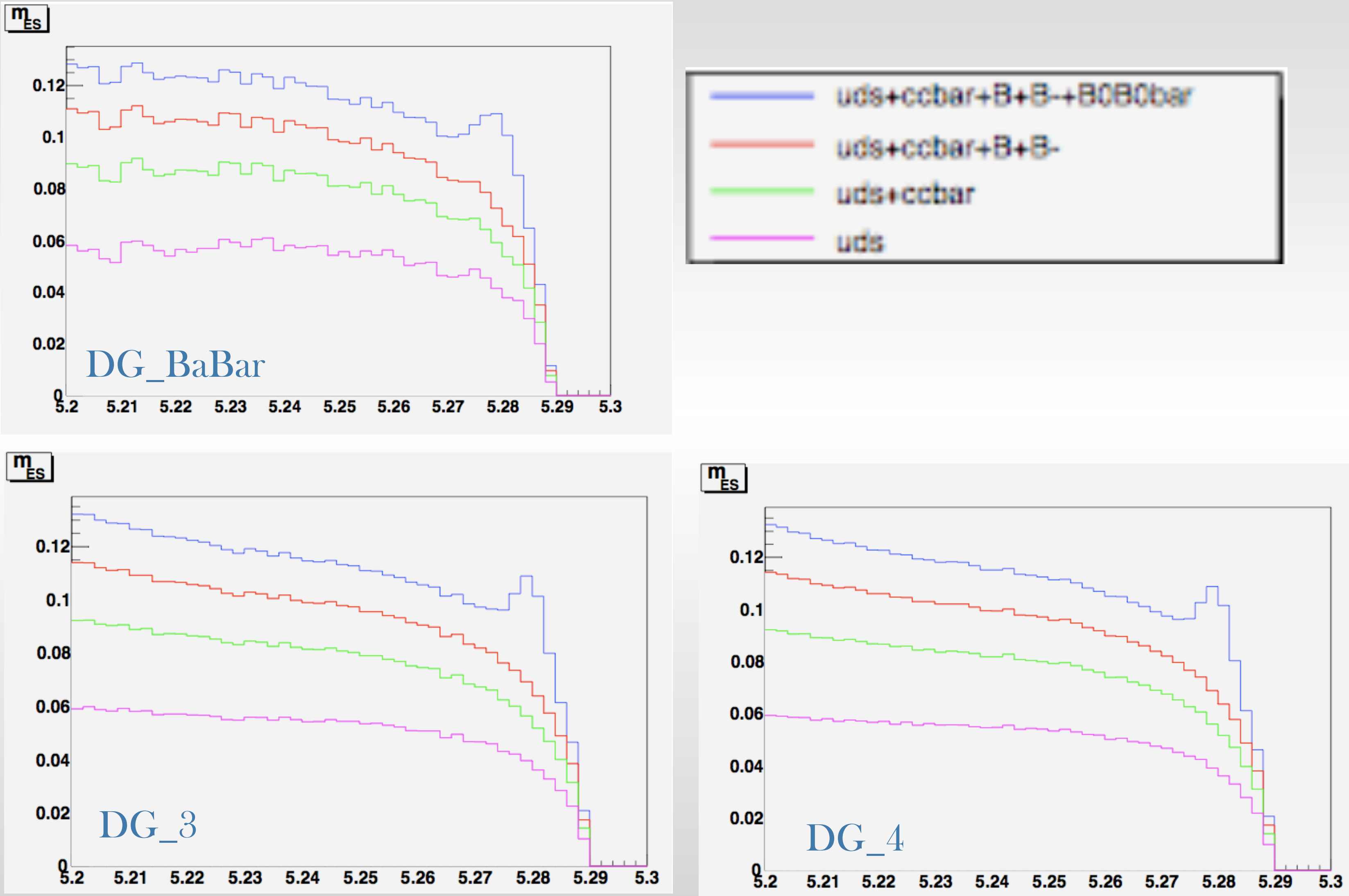
charged Breco efficiencies, generic samples

ε= nsel/ngen

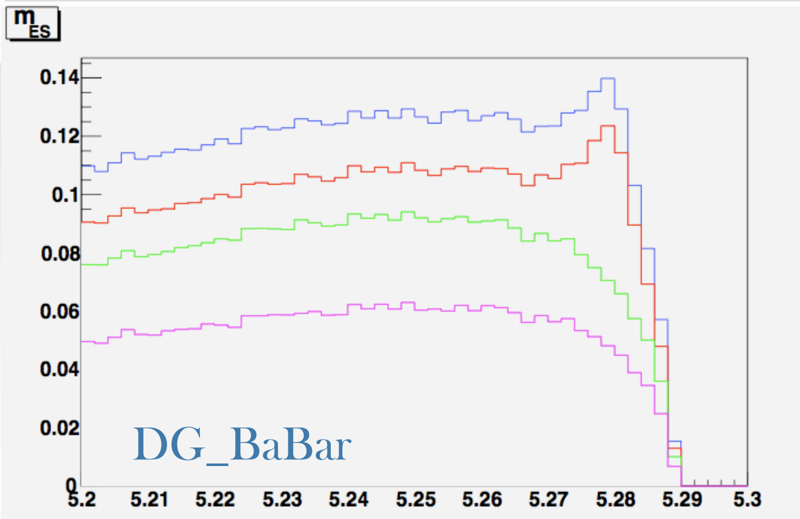
(see back up for stat errors on efficiencies)

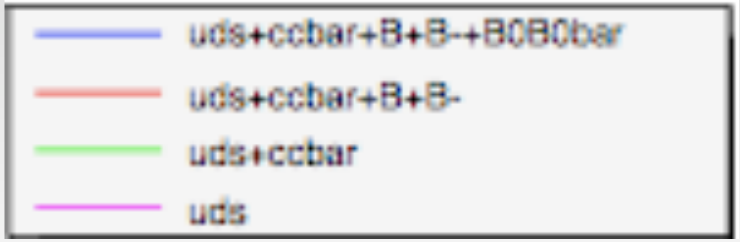
charged Breco	B0B0bar		BpBm		ccbar		uds	
	DG_3	DG_4	DG_3	DG_4	DG_3	DG_4	DG_3	DG_4
nBreco>=1	0.0087	0.0086	0.0171	0.0170	0.0118	0.126	0.0075	0.0074
mES cut	0.0012	0.0012	0.0048	0.0048	0.0015	0.0016	0.0010	0.0010
delatE cut	0.0010	0.0010	0.0042	0.0041	0.0011	0.0012	0.0007	0.0007
	DG_BaBar		DG_BaBar		DG_BaBar		DG_BaBar	
	0.0008		0.0035		0.0009		0.0006	
$(\varepsilon_{DG3}-\varepsilon_{DGbbr})/\varepsilon_{DGbbr}$	+0.25		+0.20		+0.22		+0.17	

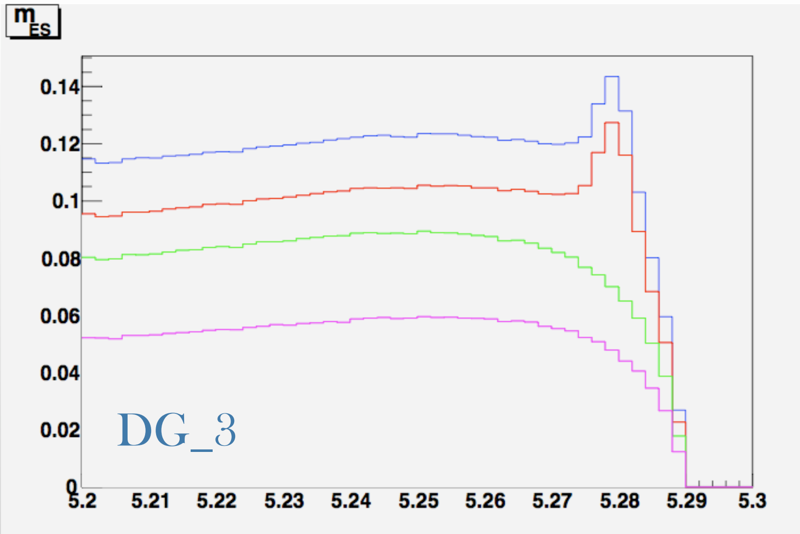
neutral Breco distributions, generic samples

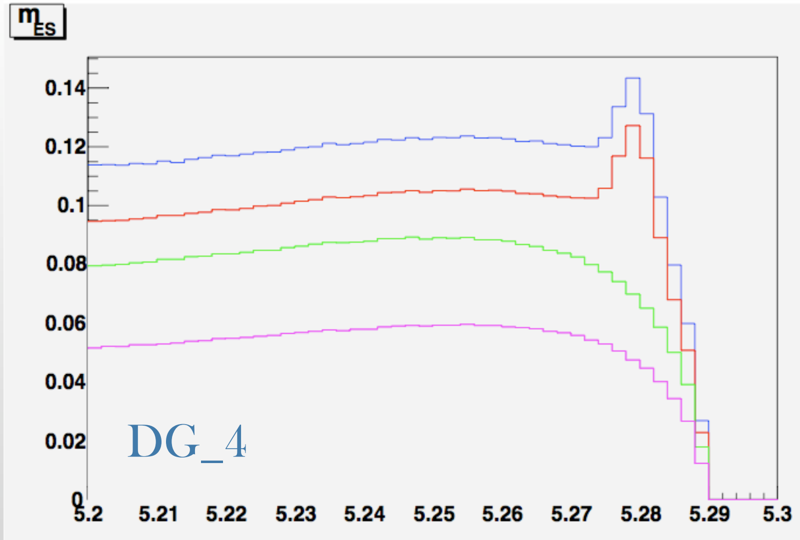


charged Breco distributions, generic samples (II)









$B^+ \to K^+ \nu\nu$: selection efficiency (I)

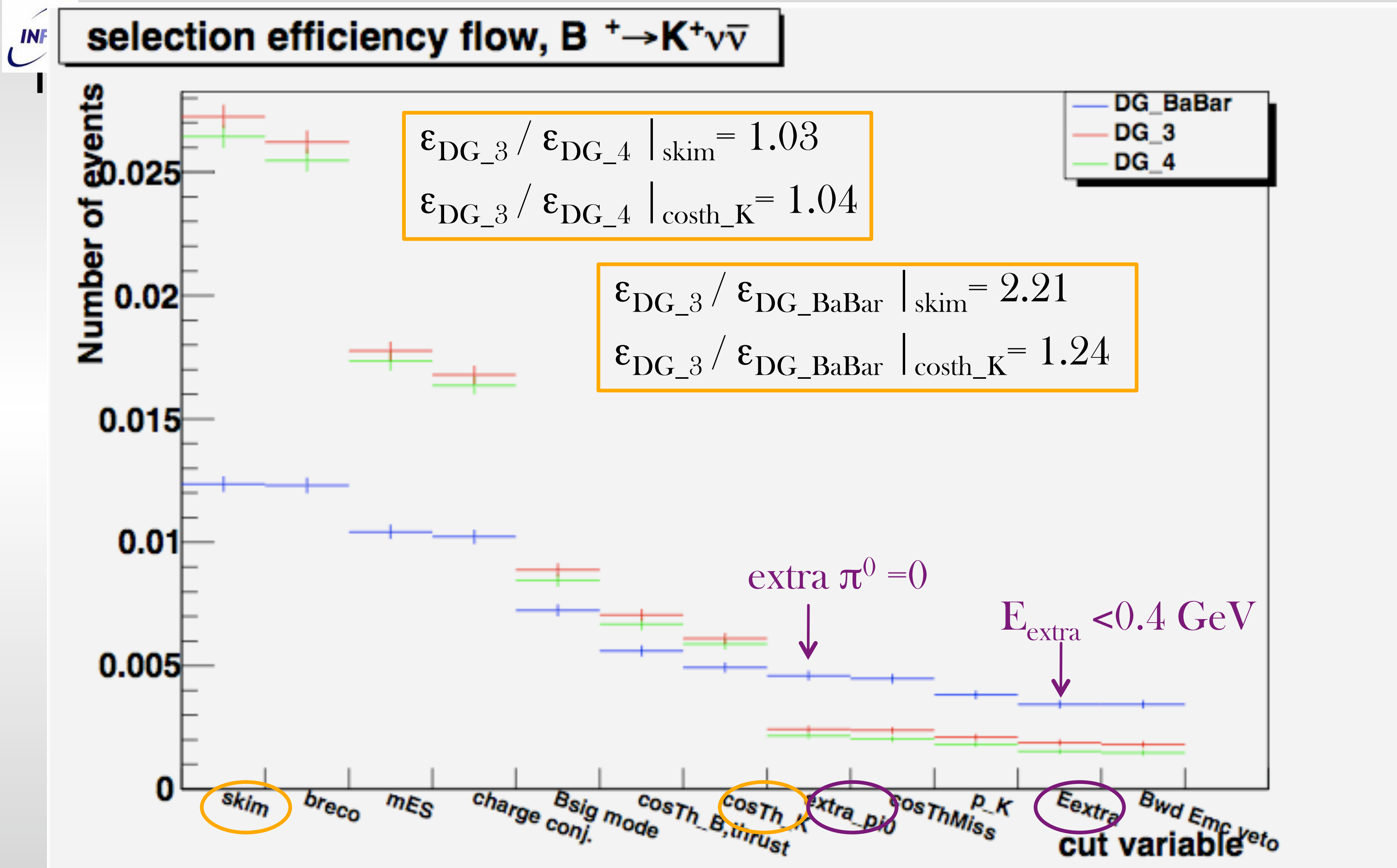
* BaBar-like cut and count analysis

$Q_{tag} = \pm 1$
$5.270 < m_{ES} < 5.288$ GeV/c^2
$|\cos\theta_{Breco,Thrust}| < 0.85$

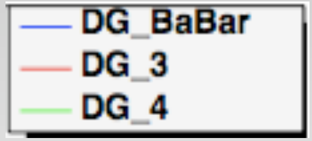
K candidate from Bsig
$|\cos\theta^*_{trk}| < 0.85$
$N_{extraTrk} < 3$
$E_{extra} < 0.4$ GeV
$N_{\pi 0} = 0$
$p_K^B > 1.1$Gev/c
$-0.85 < \cos\theta_{pmiss} < 0.9$

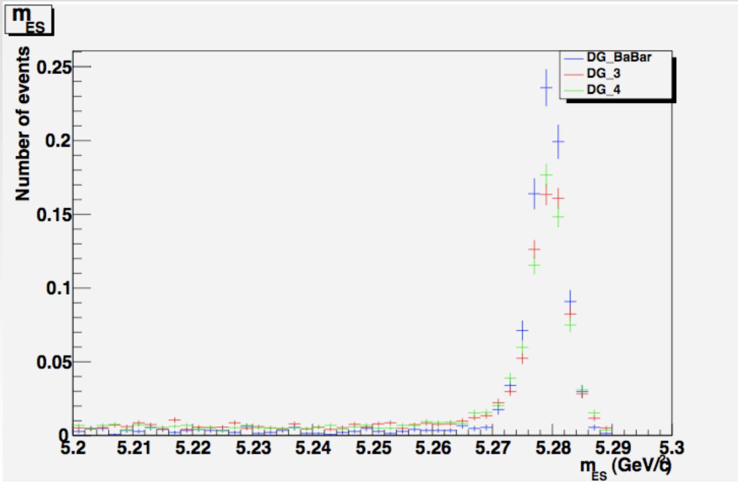
in the following,
ε = n_selected/n_generated

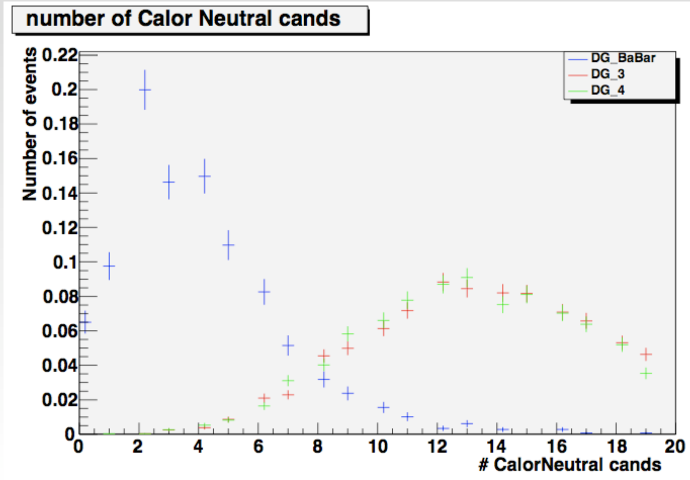
$B^+ \to K^+ \nu\nu$: selection efficiency(II)

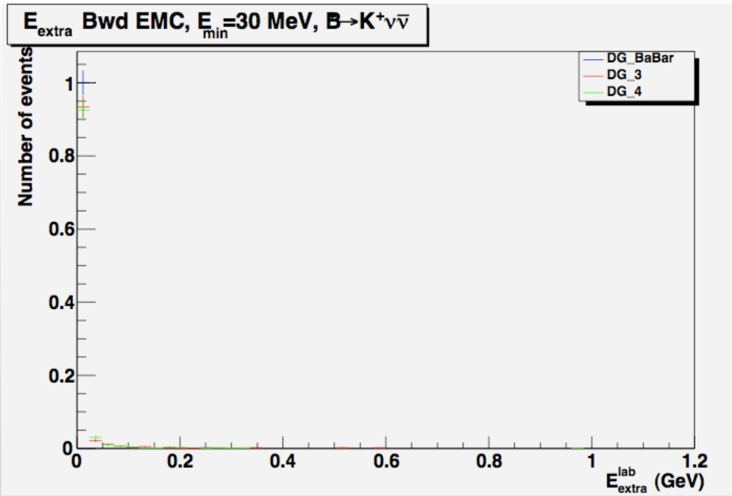


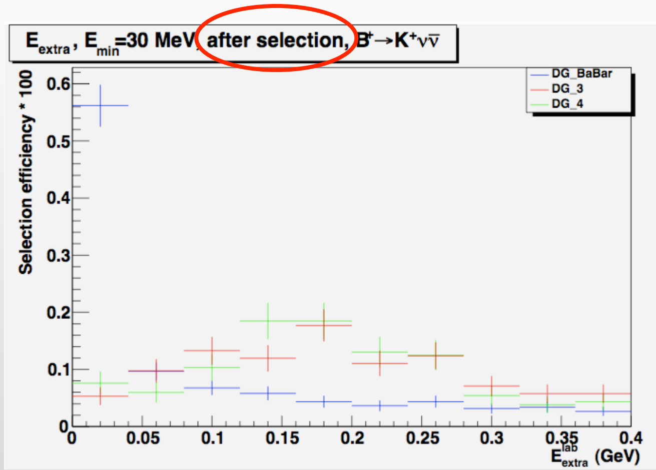
$B^+ \to K^+ \nu\nu$: some distributions











B→K*νν: selection efficiency (I)

* BaBar-like cut and count analysis

B_{sig}-B_{reco} charge correlation
$5.270<m_{ES}<5.288$ GeV/c^2
$-0.09<\Delta E<0.05$ GeV
$|\cos\theta_{Breco,Thrust}|<0.9$

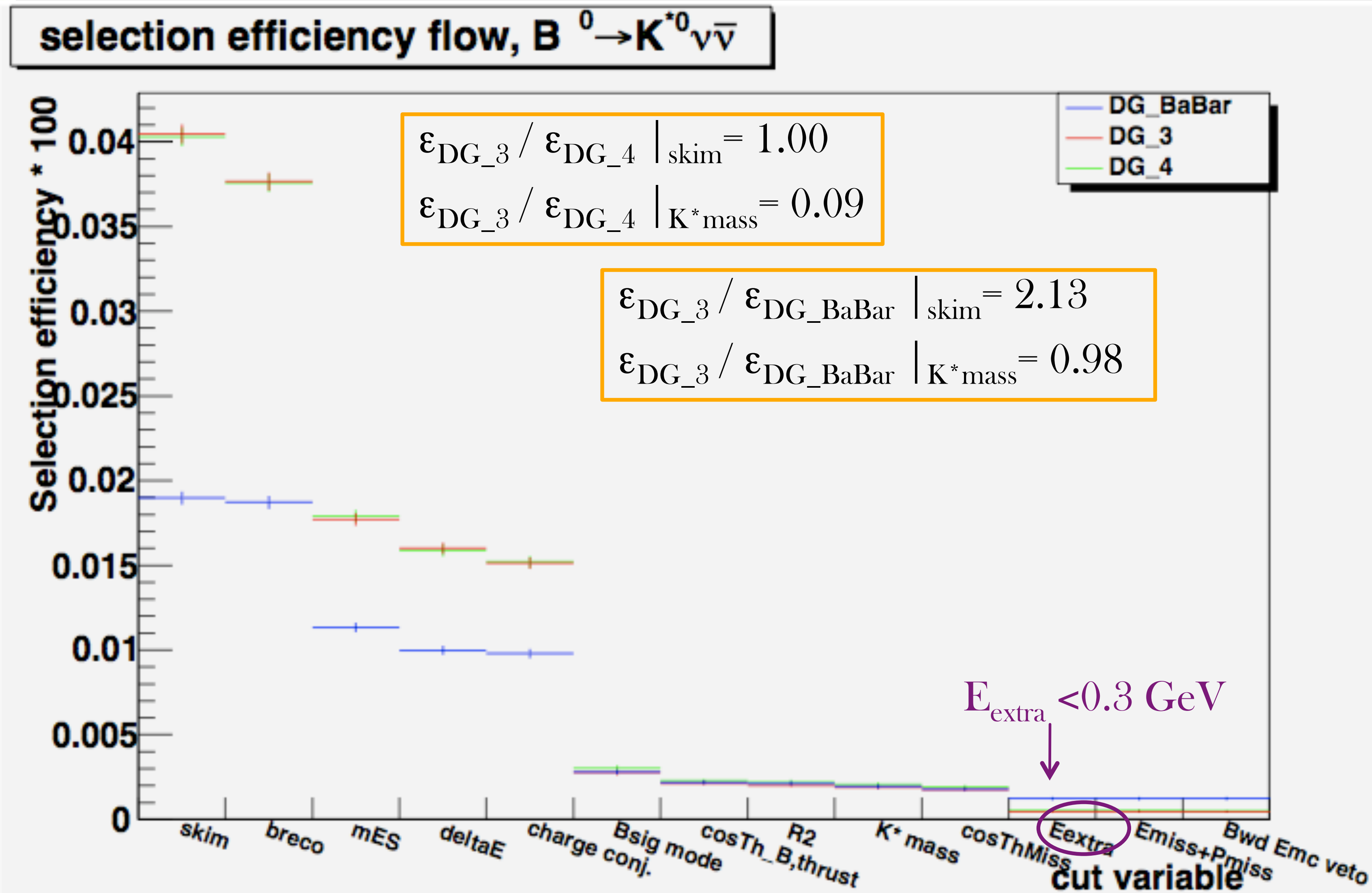
channel	selection criteria
$K^{*\pm} \to K^{\pm}\,\pi^0$	$0.03 < \mathrm{R}_2 < 0.70$ $0.004 < \lvert\cos\theta^*_{\mathrm{thrust}}\rvert < 0.84$ $0.84 < \mathrm{m}_{K^*} < 0.95$ GeV/c^2 $-0.78 < \cos\theta^*_{\mathrm{miss}} < 0.93$
$K^{*\pm} \to K^0_s\,(\pi^+\,\pi^-)\,\pi^{\pm}$	$0.0 < \mathrm{R}_2 < 0.49$ $0.0 < \lvert\cos\theta^*_{\mathrm{thrust}}\rvert < 0.85$ $0.86 < \mathrm{m}_{K^*} < 0.95$ GeV/c^2 $0.49 < \mathrm{m}_{K^0_S} < 0.50$ GeV/c^2 $-0.82 < \cos\theta^*_{\mathrm{miss}} < 0.82$
$K^{*0} \to K^-\,\pi^+$	$0.06 < \mathrm{R}_2 < 0.53$ $0.002 < \lvert\cos\theta^*_{\mathrm{thrust}}\rvert < 0.85$ $0.85 < \mathrm{m}_{K^*} < 0.97$ GeV/c^2 $-0.86 < \cos\theta^*_{\mathrm{miss}} < 0.90$

E*miss+cp*miss>4.5GeV
Eextra<0.3GeV

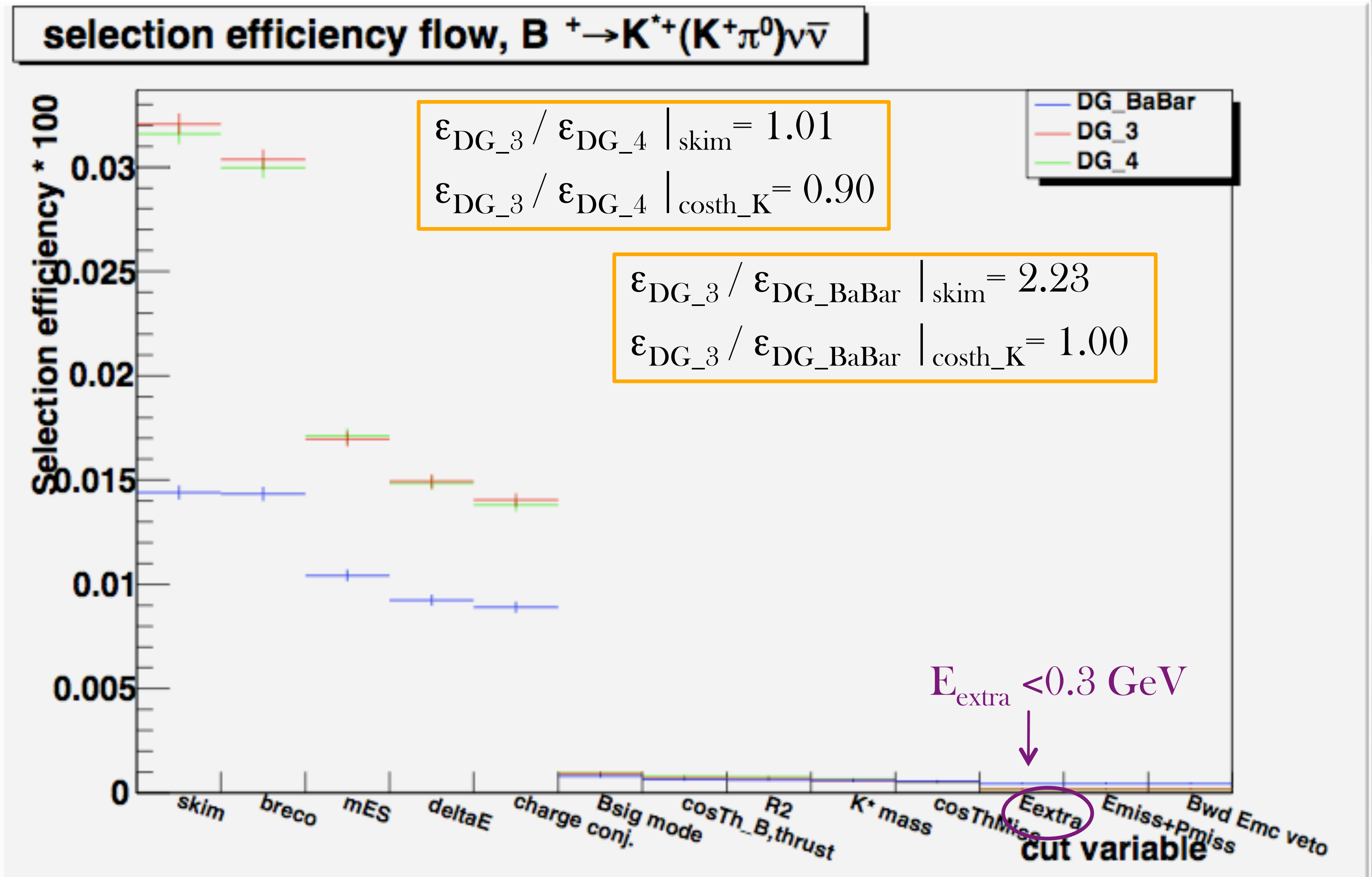
in the following,
ε= n_selected/n_generated

n.b.: very small stat, ε (after K*mass cut)
compared in next pages consistent within stat errors

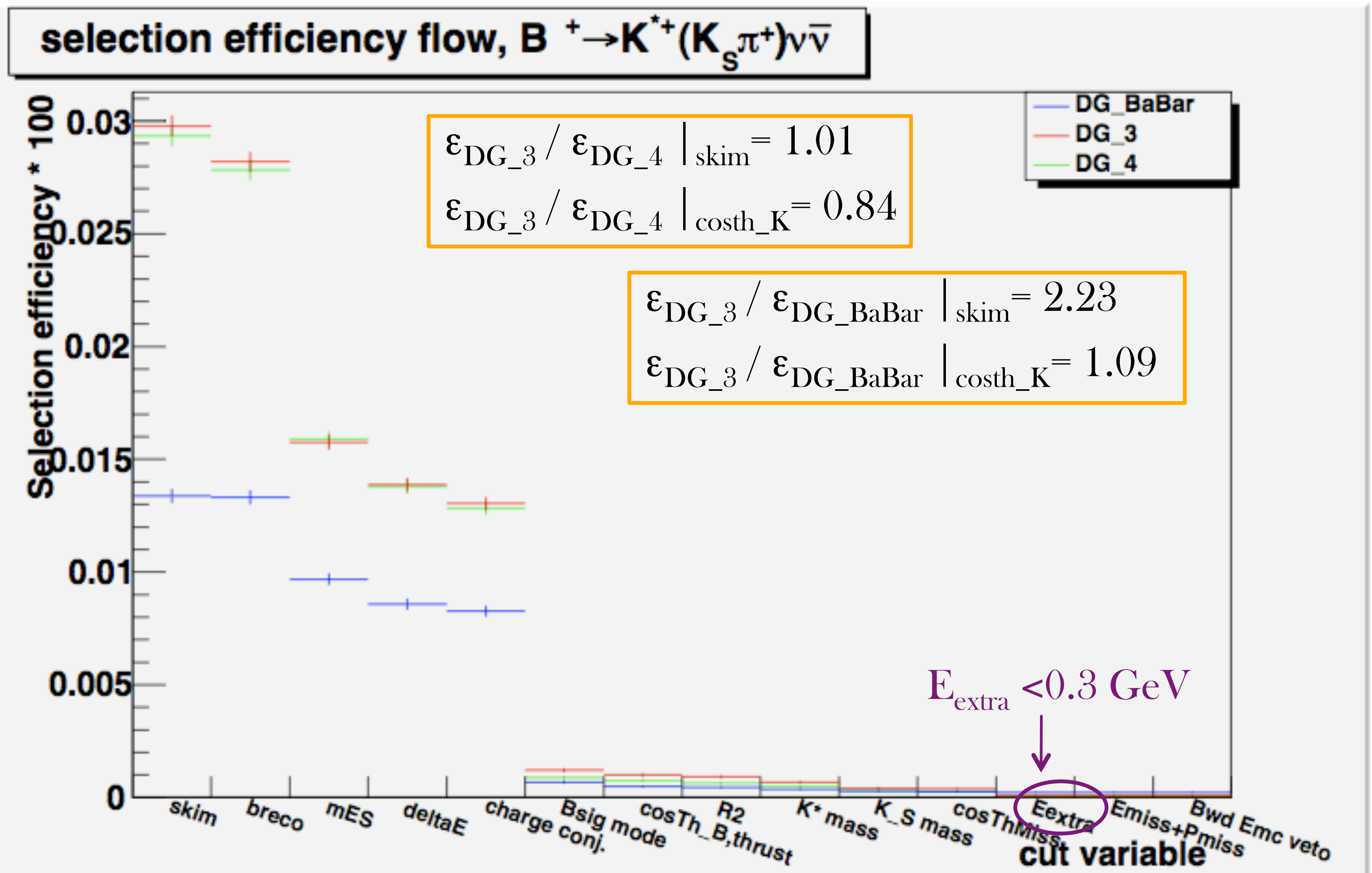
$B^0 \rightarrow K^{*0}(K\pi)\nu\nu$: selection efficiency (II)



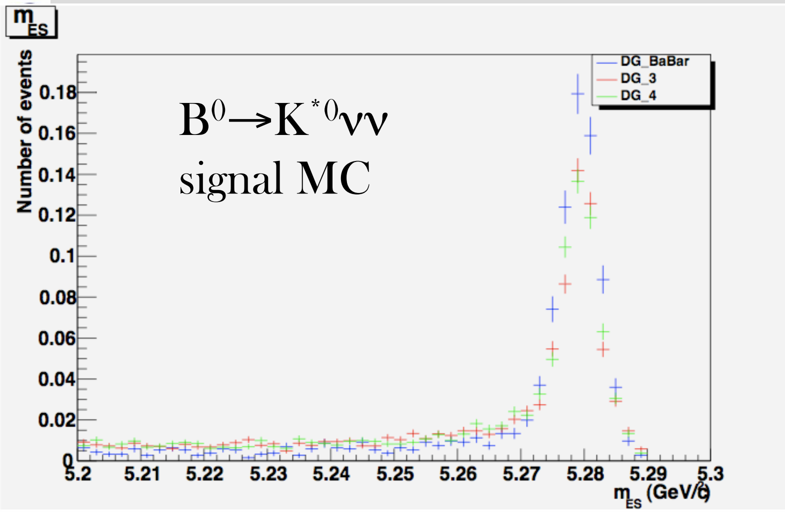
$B^+ \to K^{*+}(K\pi^0)\nu\nu$: selection efficiency (II)

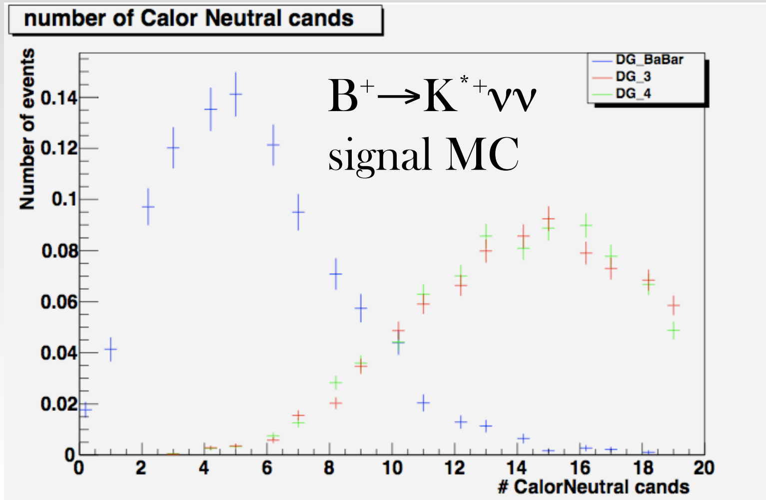


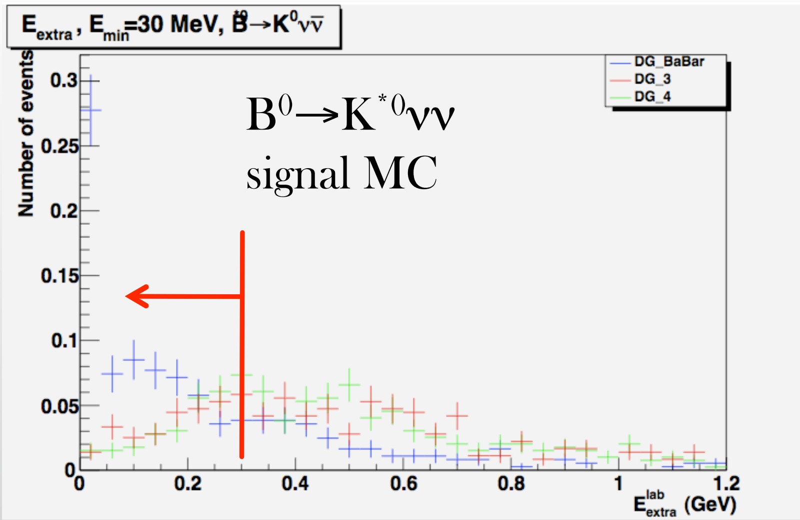
$B^+ \to K^{*+}(K_s\pi)\nu\nu$: selection efficiency (II)

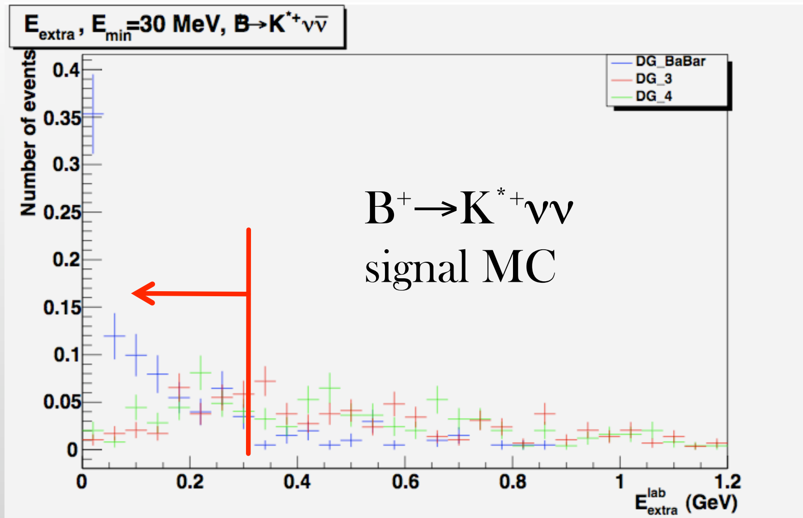


B→K*νν: some distributions









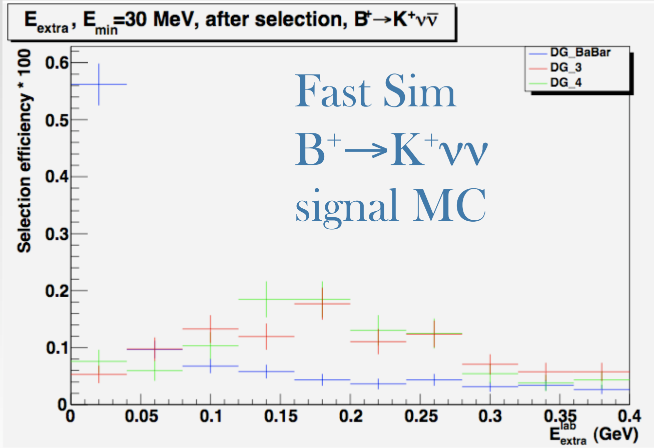
Remarks on Eextra shape

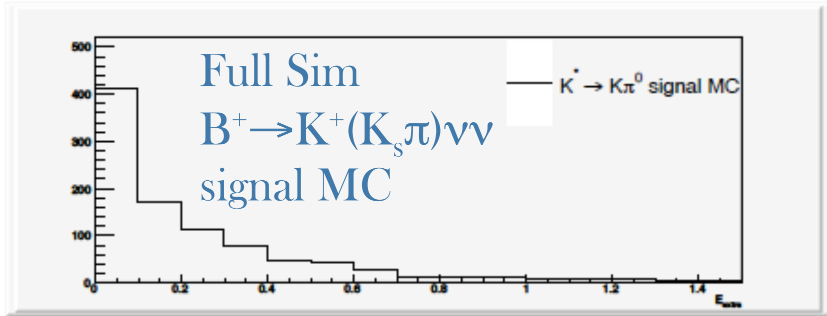
* background (radiative BhaBha) dramatically increase the number of reconstructed neutrals → Eextra shifts at high values, loosing the bin 0 discriminating power
(apply a cut on the maximum gamma energy?)

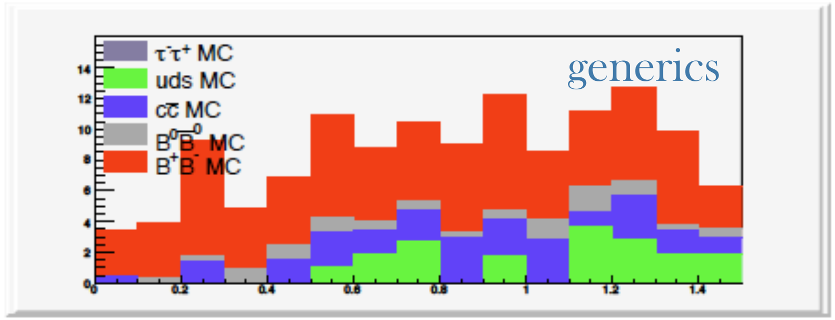
* in this production, not enough generic statistics with machine in, to study the bkg Eextra shape (probably shifted → need to enlarge the signal region to be more discriminant)

* not enough signal statistics to quantify the benefits from the Bwd EMC veto

- bkg studies to find minimum photon energy for the bwd
- optimize Eextra_bwd cut







Conclusions

* PacHadRecoilUser used in February production, in this talk
  - generic Mc samples w/o background
  - signal MC samples : $B \rightarrow K^{+}\nu\nu$, $B \rightarrow K^{*0}\nu\nu$, $B \rightarrow K^{*+}\nu\nu$ with background

* comparison with BaBar FullSim:
  - agreement in shapes and efficiency is improving (more details at the fast sim session)

* test SuperB detector geometry configuration
  - DG_4 and DG_3 seems to be equivalent
  - adding radiative bhabha, the Eextra shape in signal-MC is less signal-like
  - need a high statistic generic sample, mixed with bkg, to evaluate generic Eextra shape
  - some attempts to improve this ($E_{max,\gamma}$?), issue discussed also within the EMC group
  - not enough statistics to test the impact of bwd EMC

Back-up slides

Hadronic Breco reconstruction philosophy

- Aim: collect as many as possible fully reconstructed B mesons in order to study the property of the recoil
- SemiExclusive reconstruction: search for $B \to D(^*)X$, with $X = n\pi\ mK\ pK_s\ q\pi^0$ and $n+m+r+q<6$, without making requirements on intermediate resonances
- Reoconstruction steps:
  - reconstruct $D \to$ hadrons

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

  - use D as a seed and add X to have a system compatible with the B hypotesys
- Signal box defined by using:

$$m_{ES} = \sqrt{E^{*2}_{beam} - p^{*2}_B}$$

$$\Delta E = E^*_B - E^*_{beam}$$

- Sample of 1100 B decay modes, ordered by purity.
- In events with multiple candidates, the best one is selected according to the smallest ΔE

neutral Breco efficiencies, generic samples

*** fast sim:

B0B0Bar : mES cut = 0.2095+/-0.0010
de cut = 0.1840+/-0.0010

B+B- : mES cut = 0.1110+/-0.0011
de cut = 0.0909+/-0.0010

cc : mES cut = 0.1013+/-0.0012
de cut = 0.0812+/-0.0011

uds : mES cut = 0.1213+/-0.0021
de cut = 0.0879+/-0.0006

*** full sim:

B0B0Bar : mES cut = 0.2548+/-0.0009
de cut = 0.2279+/-0.0008

B+B- : mES cut = 0.1156+/-0.0009
de cut = 0.0929+/-0.0008

cc : mES cut = 0.0967+/-0.0006
de cut = 0.0740+/-0.0005

uds : mES cut = 0.1246+/-0.0015
de cut = 0.0877+/-0.0004

charged Breco efficiencies, generic samples

*** fast sim:

B0B0Bar : mES cut = 0.1403+/-0.0013
de cut = 0.1096+/-0.0012

B+B- : mES cut = 0.2895+/-0.0012
de cut = 0.2416+/-0.0012

cc : mES cut = 0.1284+/-0.0011
de cut = 0.0902+/-0.0009

uds : mES cut = 0.1370+/-0.0011
de cut = 0.09387+/-0.0003

*** full sim:

B0B0Bar : mES cut = 0.15187+/-0.0010
de cut = 0.1183+/-0.0009

B+B- : mES cut = 0.3557+/-0.0003
de cut = 0.3094+/-0.0003

cc : mES cut = 0.1263+/-0.0005
de cut = 0.0889+/-0.0004

uds : mES cut = 0.1395+/-0.0006
de cut = 0.0961+/-0.0002

B→Kνν: selection efficiency

* BaBar cut and count analysis
  - Selection:

$Q_{tag} = \pm 1$
$5.270 < m_{ES} < 5.288$ GeV/c^2
$|\cos\theta_{Breco,Thrust}| < 0.85$

K candidate from Bsig
$|\cos\theta^*_{trk}| < 0.85$
$N_{extraTrk} < 3$
$E_{extra} < 0.4$ GeV
$N_{\pi 0} = 0$
$p_K^B > 1.1$ Gev/c
$-0.85 < \cos\theta_{pmiss} < 0.9$

ε = n_selected/n_generated

with pK,B and Eextra cuts

	DG_BaBar	DG_3		DG_4	
		w/o BWD EMC	w BWD EMC	w/o BWD EMC	w BWD EMC
$\varepsilon_{tot,\,K}$ ($/10^{-4}$)	4.13±0.20	2.26±0.15	2.17±0.15	1.84±0.13	1.77±0.13
ε gain wrt DG_BaBar		-45%	-47%	-55%	-57%

$(\varepsilon_{DG4} - \varepsilon_{DG3})/\varepsilon_{DG3} \approx -19\%$

$B \rightarrow K^* \nu\nu$: selection efficiency (I)

	DG_BaBar	DG_3		DG_4	
		w/o BWD	w BWD	w/o BWD	w BWD
$\varepsilon_{tot,\ K^*0(K+\pi-)}$ (10^{-4})	1.61±0.13	0.60±0.08	0.58±0.08	0.68±0.08	0.65±0.08
ε gain wrt DG_BaBar		-63%	-63%	-58%	-59%
$\varepsilon_{tot,\ K^*+(K+\pi0)}$ (10^{-4})	0.50±0.07	0.23±0.05	0.23±0.05	0.24±0.07	0.24±0.07
ε gain wrt DG_BaBar		-54%		-52%	
$\varepsilon_{tot,\ K^*+(Ks\pi+)}$ (10^{-4})	0.30±0.05	0.14±0.03	0.14±0.03	0.12±0.03	0.10±0.03
ε gain wrt DG_BaBar		-53%	-53%	-60%	-66%

with Eextra cut