Hadronic Breco studies

Elisa Manoni
(University and INFN Perugia)

Francesco Renga
Universita' La Sapienza
INFN – Sez Roma I

Alejandro Perez
LAL- Orsay

SuperB workshop – DGWG parallel session
SLAC Oct 7 2009

Outline

- ✓ Hadronic Breco reconstruction
  - philosophy
  - implementation in FastSim
- ✓ September production and detector geometries
- ✓ Detector performances: comparison between geometries
  - Breco selection efficiency
  - Breco kinematics variable
  - purity and multiplicity studies
- ✓ Conclusions and to do list

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→ 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

Hadronic Breco reconstruction in FastSim (I)

- ✓ SemiExclusive reconstruction implemented in FastSim: PacHadRecoilUserPackage
- ✓ Package based on BaBar BtnSemiExclUser code

- ✓ It contains:
  - main analysis tcl on which run the executable
  - tcl for skim emulation (based on FilterTools/BSemiExclPath.tcl)
  - tcl for PID selection (TableBasedXXXSelection selectors based on BaBar run6-r24c PID tables)
  - tcl and .cc / .hh for signal and tag side reconstruction and selection (at the moment only $B_{sig} \rightarrow K^* \nu\nu$ available)
  - tcl for BTupleMaker settings
  - README

- ✓ Code status:
  - used in the September production
  - need to make some clean up and to update the README in order to make any user able to modify the package according to the B_{sig} mode

September production

- ✓ Generic MC samples produced by Dave using PacProduction package
  - machine background included: turn on 50X beamstrahlung (nominal 400X) with neutrons enabled

- ✓ Samples:
  - two detector configurations: DG_1, DG_4 (see next slides)
  - DG_1 sample: 69.15 x 10^6 B^0B^0bar events
    46.1 x 10^6 B^+B^- events
  - DG_4 sample: 46.3 x 10^6 B^0B^0bar events
    36.7 x 10^6 B^+B^- events

		Selection rate				
Analysis	KByte/event	B0 DG1	B+ DG1	B0 DG4	B+ DG4	total size MBytes
Hadronic K*nunu	5.4	5.60%	7.10%	6%	7.70%	40000

  - no uds, cc, tautau samples available

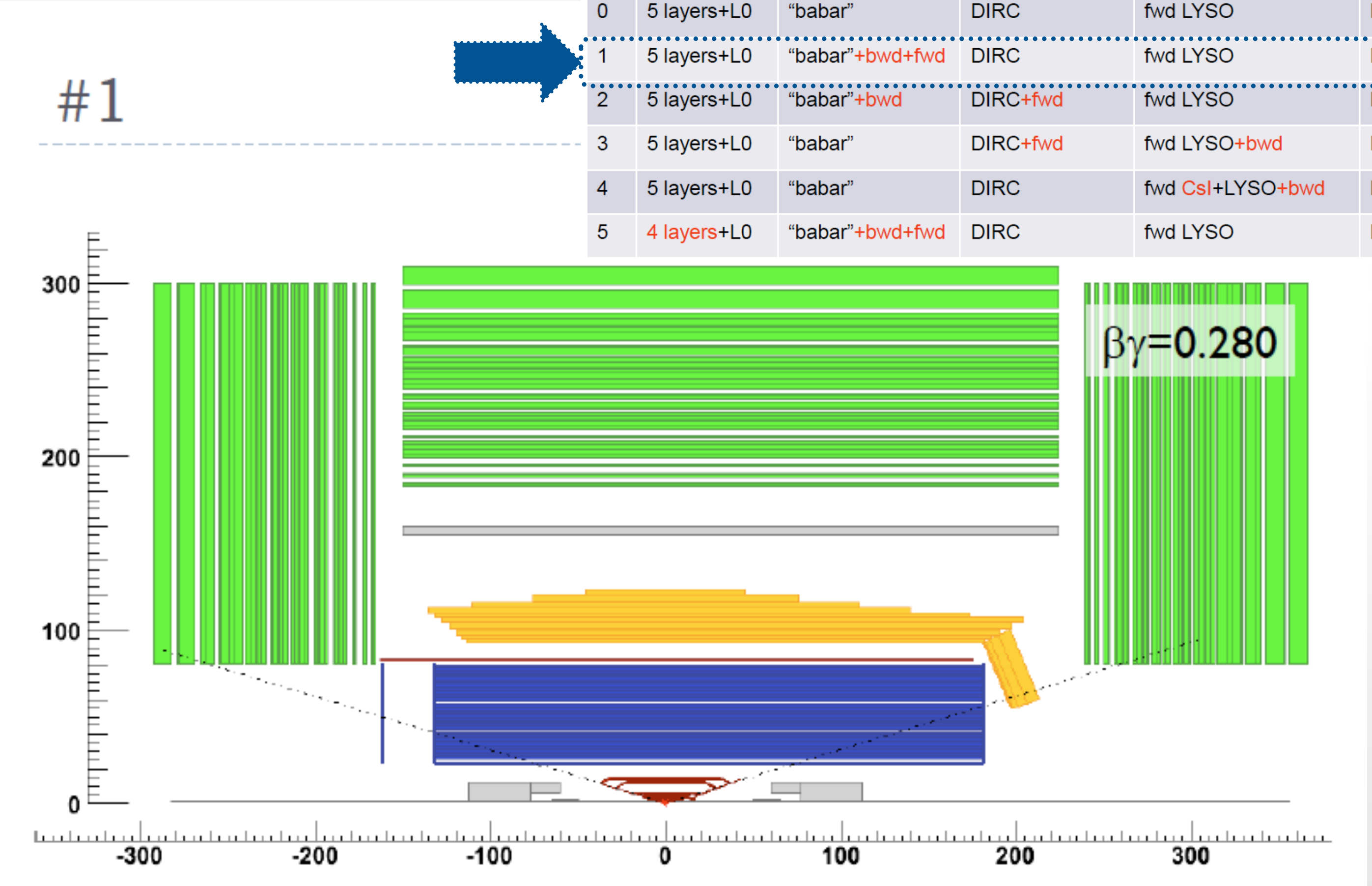
→ study combinatorial contamination only

Detector geometry (I)

✓ DetectorGeometry_1

– SVT_L0 + bwd and fwd DCH: gain in tracking and Breco reconstruction efficiencies

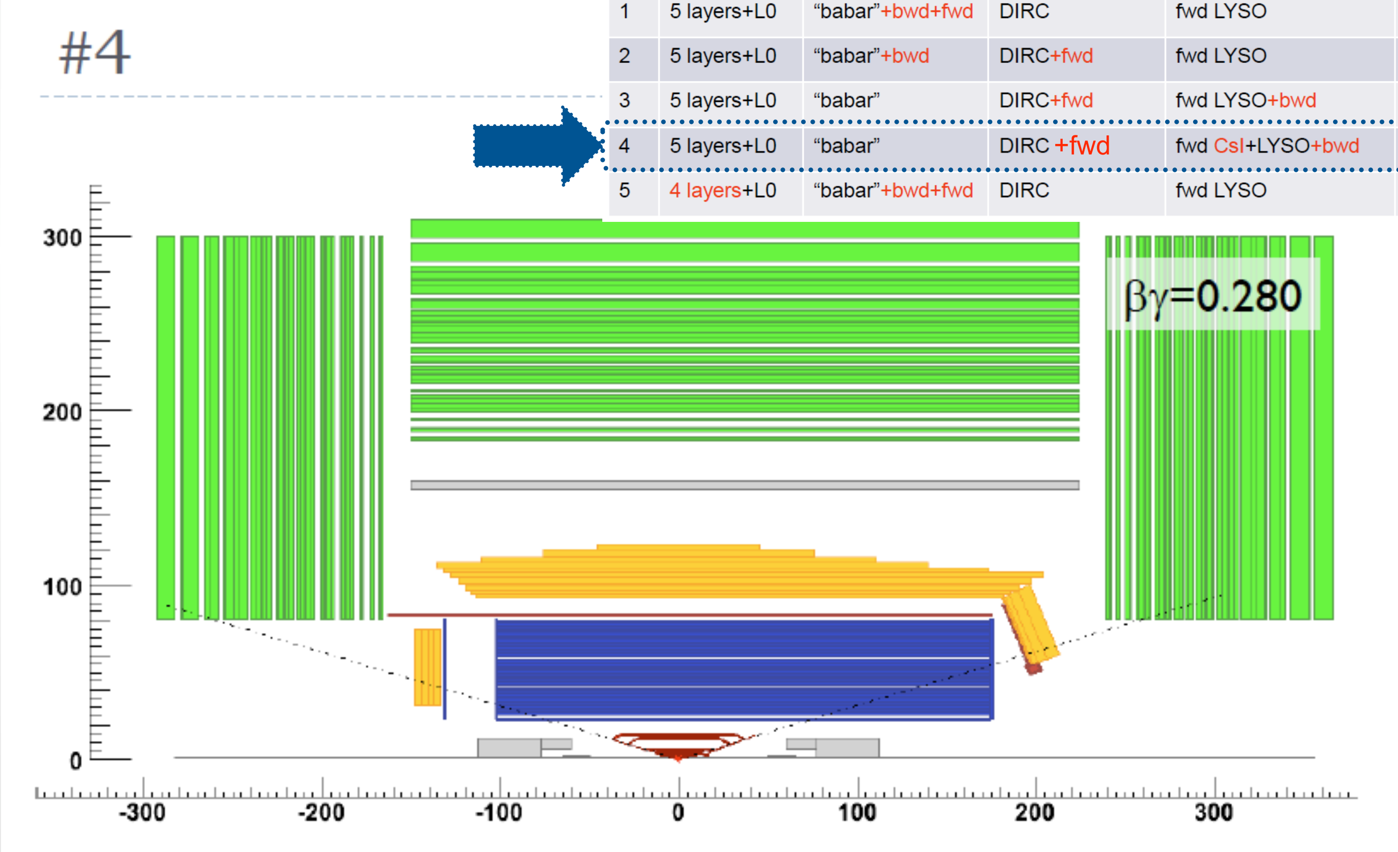
	SVT	DCH	PID	EMC	IFR
0	5 layers+L0	"babar"	DIRC	fwd LYSO	baseline
1	5 layers+L0	"babar"+bwd+fwd	DIRC	fwd LYSO	baseline
2	5 layers+L0	"babar"+bwd	DIRC+fwd	fwd LYSO	baseline
3	5 layers+L0	"babar"	DIRC+fwd	fwd LYSO+bwd	baseline
4	5 layers+L0	"babar"	DIRC	fwd CsI+LYSO+bwd	baseline
5	4 layers+L0	"babar"+bwd+fwd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



Detector geometry (II)

- ✓ DetectorConfiguraztion_4
  - SVT_L0 + fwd DIRC + bwd EMC: higher angular coverage and better K-π discrimination

	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



A remark on PID usage

- ✓ PID selectors used in the D and B lists
  - no PID on π
  - K PID:

    D→ KY lists use GoodTracksLoose or KLHNotPion depending on the D mode

    B→ $D^{(*)}$KY lists use KNNTight depending on the B mode

- ✓ select events in which the K pass the proper PID selector (accounting also for the DG configuration) by using BitMaps
  - require a K from a B to pass the KNNTight selector according to DIRC only (DG_1) or DIRC+FWD PID (DG_4) infos

    → no events found with Breco→ B→ $D^{(*)}$KY, investigation ongoing
  - require ALL the K from a D to pass the KLHNotPion according to DIRC only (DG_1) or DIRC+FWD PID (DG_4) infos

    (→ not considering the GoodTrackLoose option)

Breco study: startegy

- ✓ separate reconstructed neutral and charged Breco
  - "signal" = B0 in B0B0bar_generic sample / B± in B+B-_generic sample
  - "combinatorial background" = B0 in B+B-_generic sample / B± in B0B0bar_geeneric sample

- ✓ Breco selection:

PID requirements on K candidates → best candidate selection: $|\Delta E|_{min}$ → selection on Breco kinematics

$5.27 < m_{ES} < 5.288$ GeV

$-0.09 < \Delta E < 0.5$ GeV

$|\cos\theta_{Breco,Thrust}| < 0.95$

- ✓ Mode by mode study
  - high vs low PURITY modes (integrated purity threshold: 80%)
  - high vs low vs verylow MULTIPLICITY modes

  verylow = $B \to DK/D\pi$ && $D^0 \to K\pi$; D^*, $D^0 \to K\pi$; $D^+ \to K_s\pi$; $D^{*0} \to D^0 pi^0$, $D^0 \to K\pi$; $D^{*0} \to D^0\gamma$, $D^0 \to K\pi$

  low = $B \to DK/D\pi$ && all $D^{(*)}$ modes

  high = !(low)

Cut flow tables: B0B0bar_generic

✓ cumulative efficiencies

	DG_1		DG_4	
	neutral B_{reco}	charged B_{reco}	neutral B_{reco}	charged B_{reco}
reconstructed	1.91×10^{-2}	3.48×10^{-2}	1.97×10^{-2}	3.68×10^{-2}
ΔE cut	1.62×10^{-2}	2.87×10^{-2}	1.68×10^{-2}	3.06×10^{-2}
m_{ES} cut	3.72×10^{-3}	3.86×10^{-3}	3.82×10^{-3}	4.09×10^{-3}
$\cos\theta_{Breco,Thrust}$ cut	3.68×10^{-3}	3.80×10^{-3}	3.78×10^{-3}	4.03×10^{-3}
$\varepsilon_{neutral}/\varepsilon_{charged}$	0.97		0.94	

BaBar Full-Sim:

- $\varepsilon_{neutral}/\varepsilon_{charged} = 2.24$

Cut flow tables: B+B-_generic

- ✓ cumulative efficiencies

	DG_1		DG_4	
	neutral B_{reco}	charged B_{reco}	neutral B_{reco}	charged B_{reco}
reconstructed	1.34×10^{-2}	5.65×10^{-2}	1.36×10^{-2}	5.93×10^{-2}
ΔE cut	1.10×10^{-2}	4.76×10^{-2}	1.12×10^{-2}	5.02×10^{-2}
m_{ES} cut	1.41×10^{-3}	1.02×10^{-2}	1.45×10^{-3}	1.06×10^{-2}
$\cos\theta_{Breco,Thrust}$ cut	1.39×10^{-3}	1.01×10^{-2}	1.43×10^{-3}	1.05×10^{-2}
$\varepsilon_{charged}/\varepsilon_{neutral}$	7.26		7.34	

BaBar Full-Sim:
- $\varepsilon_{charged}/\varepsilon_{neutral} = 5.14$

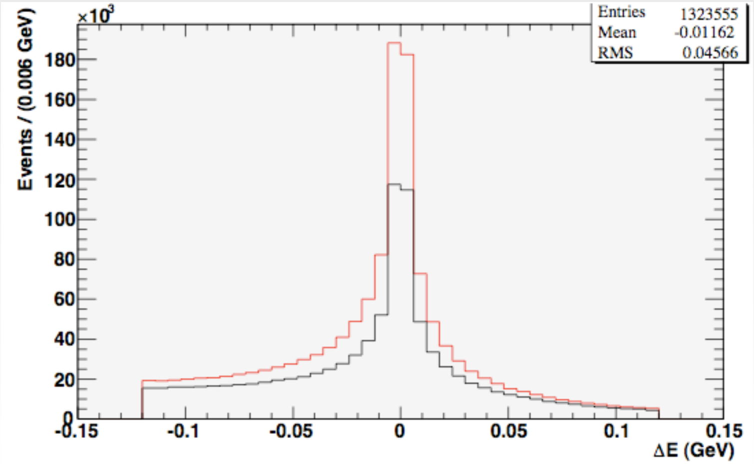
ΔE distributions before any cuts

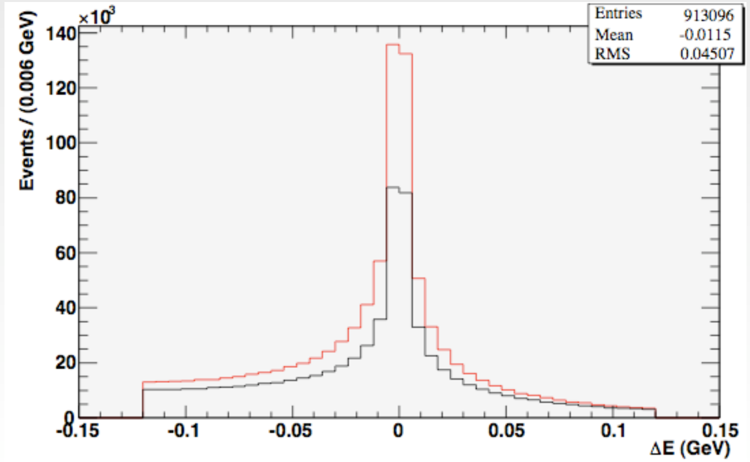
B0B0bar generic

B+B- generic

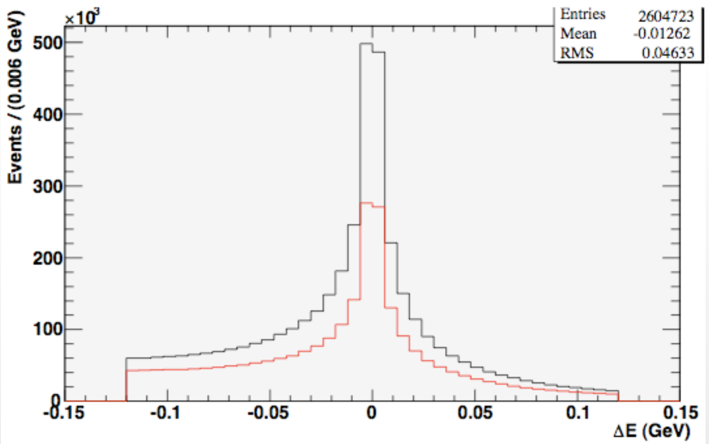
DG_1 DG_4

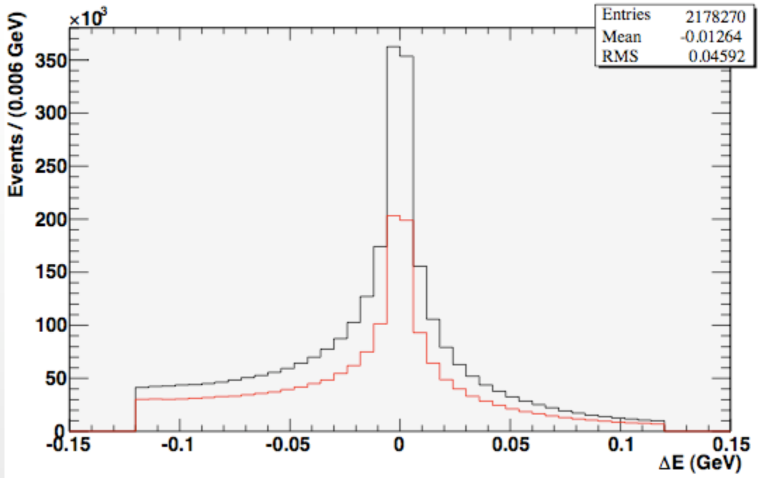
neutral B_{reco}





charged B_{reco}





- distribution normalized to relative # of generated events
- no cuts applied

mES distributions, ΔE cut applied

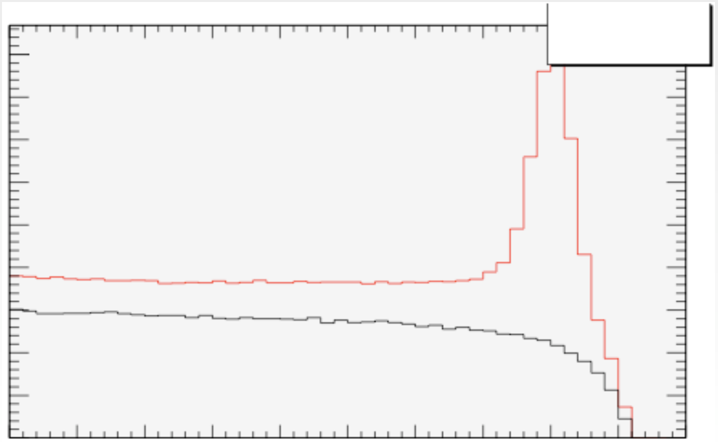
B0B0bar generic

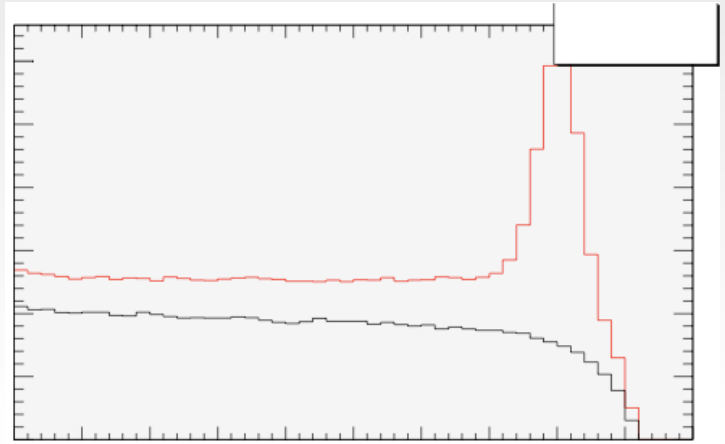
B+B- generic

DG_1

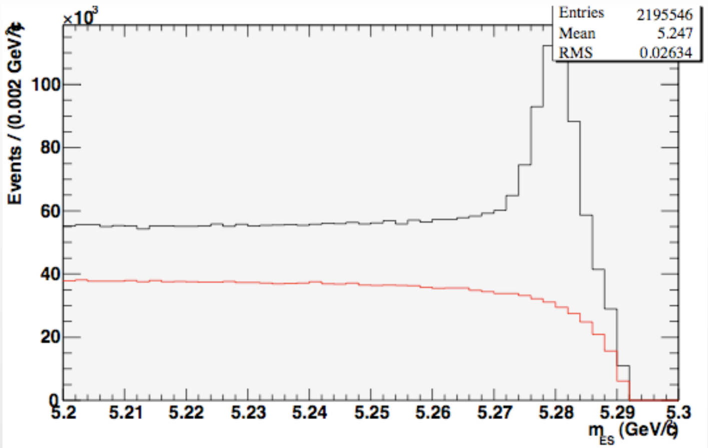
DG_4

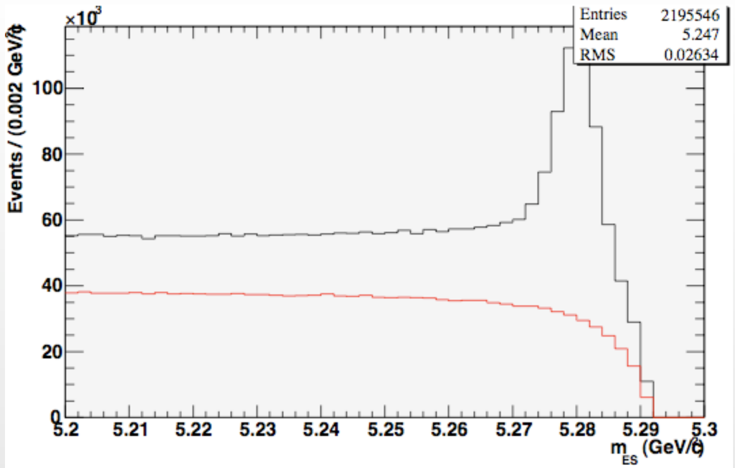
neutral B_{reco}





charged B_{reco}





- distribution normalized to relative # of generated events

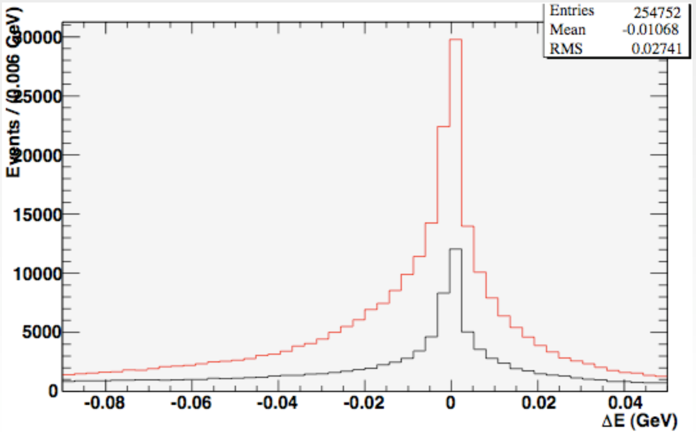
ΔE distributions, all cuts applied

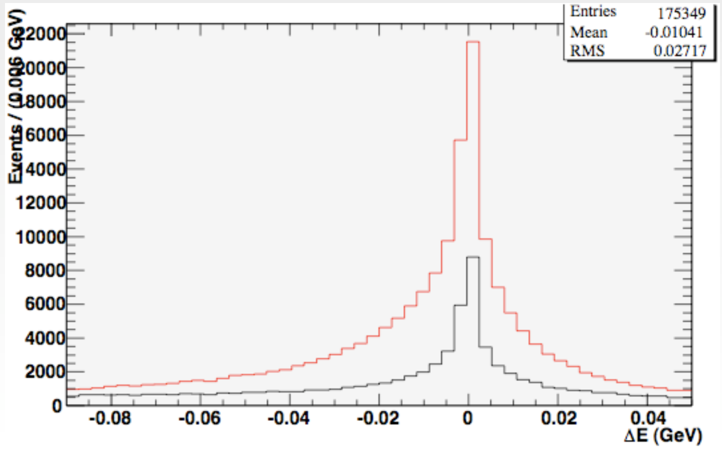
B0B0bar generic

B+B- generic

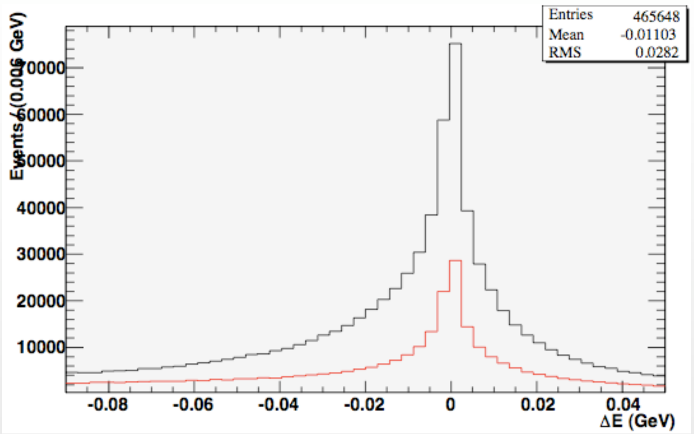
DG_1 DG_4

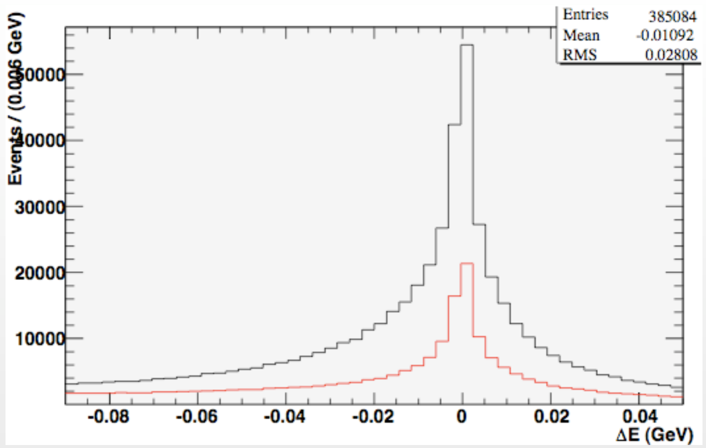
neutral B_{reco}





charged B_{reco}





- distribution normalized to relative # of generated events
- cuts on DE, mES, $\cos\theta_{Breco,Thrust}$ applied

mES distributions, all cuts applied

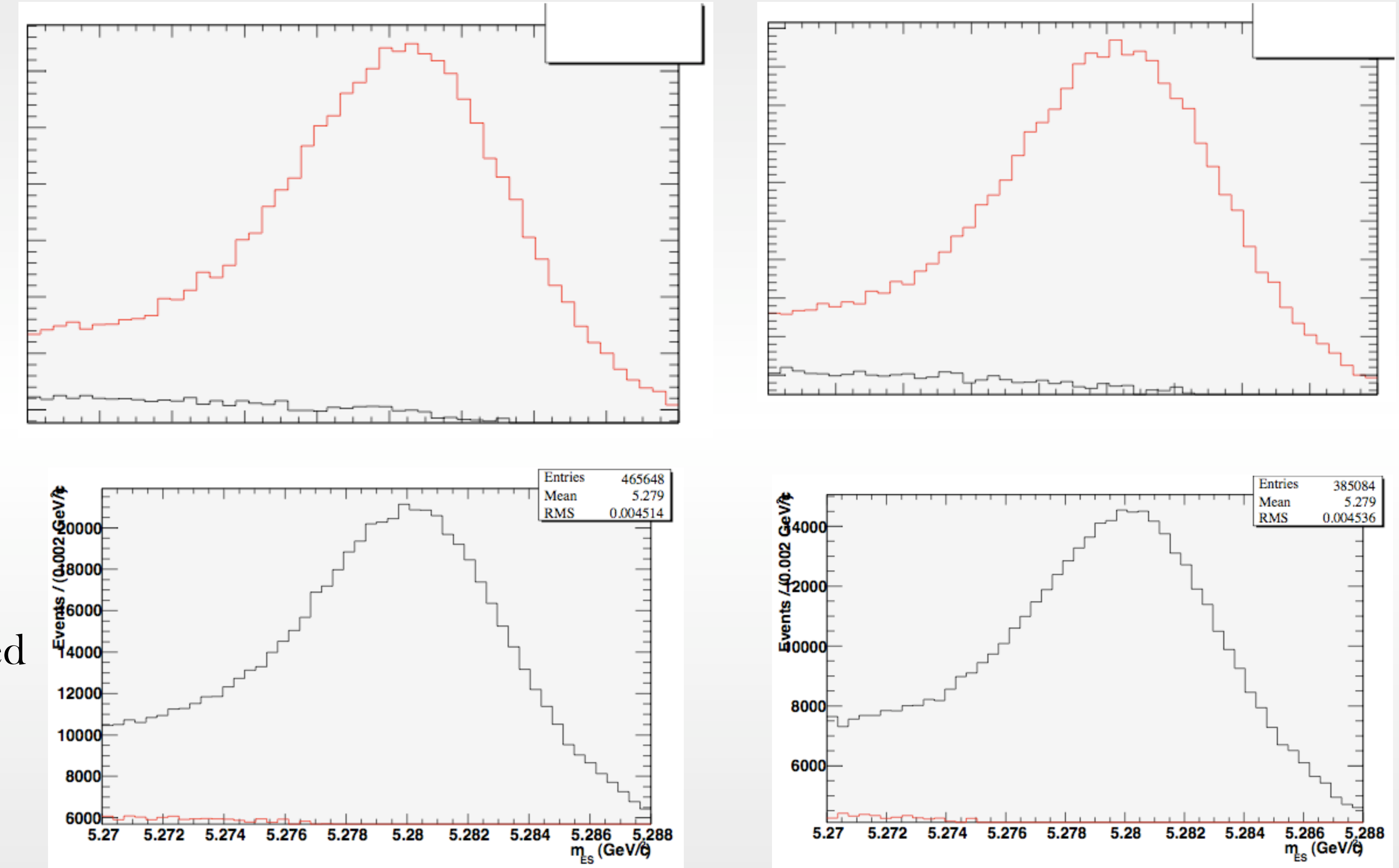
B0B0bar generic

B+B- generic

DG_1 DG_4

neutral B_{reco}

charged B_{reco}



- distribution normalized to relative # of generated events
- cuts on DE, mES, $\cos\theta_{Breco,Thrust}$ applied

Purity studies

✓ B0B0bar_generic

	DG_1		DG_4	
	neutral B_{reco}	charged B_{reco}	neutral B_{reco}	charged B_{reco}
int_purity < 80%	96.1%	99.9%	95.9%	99.9%
int_purity > 80%	3.9%	0.1%	4.1%	0.1%

✓ B+B-_generic

	DG_1		DG_4	
	neutral B_{reco}	charged B_{reco}	neutral B_{reco}	charged B_{reco}
int_purity < 80%	99.7%	97.4%	99.7%	97.5%
int_purity > 80%	0.03%	2.6%	0.03%	2.5%

- fractions computed on the number of events that pass the selection

Multiplicity studies

✓ B0B0bar_generic

	DG_1		DG_4	
	neutral B_{reco}	charged B_{reco}	neutral B_{reco}	charged B_{reco}
high mult	82.2%	98.4%	82.4%	98.4%
low mult (very low mult)	17.8% (1.3%)	1.6% (0.07%)	17.6% (1.3%)	1.6% (0.07%)

✓ B+B-_generic

	DG_1		DG_4	
	neutral B_{reco}	charged B_{reco}	neutral B_{reco}	charged B_{reco}
high mult	85.6%	88.7%	85.7%	89%
low mult (very low mult)	14.4% (0.1%)	11.3% (2.5%)	15.3% (0.1%)	11% (2.4%)

- fractions computed on the number of events that pass the selection

Conclusion and to-do-list

- ✓ PacHadRecoilUser run during September production to test DG_1 and DG_4
- ✓ On charged Breco, DG_4 gives higher efficiency and but also higher background contamination (continuum MC would be needed to confirm this)
- ✓ On neutral Breco, DG_1 and DG_4 gives compatible results

- ✓ Results may be "biased" by
  - low tracking efficiency for low momentum tracks (see Dave posting on FastSim-ml)
  - non correct implementation of B lists/or PID related problems for which B modes with a K as a daughter are never reconstructed

- ✓ To do list:
  - investigate the previous issues
  - implement a Filter to reduce the event rate
  - clean up the package and write documentation to implement other B_{sig} reconstruction

Extra slides

B decay modes

```
bmode = 1    "B->Dpi"
bmode = 2    "B->Dk"
bmode = 3    "B->Dpipi0_<1.5GeV"
bmode = 4    "B->Dkpi0_<1.5GeV"
bmode = 5    "B->Dpiks"
bmode = 6    "B->Dkks"
bmode = 7    "B->Dpi2pi0_<1.5GeV"
bmode = 8    "B->Dk2pi0_<1.5GeV"
bmode = 9    "B->D3pi_<1.5GeV"
bmode = 10   "B->Dk2pi_<1.5GeV"
bmode = 11   "B->D2kpi_Ds"
bmode = 12   "B->Domegah"
bmode = 13   "B->Dk2pipi0_<2.2GeV"
bmode = 14   "B->D2kpipi0_Ds*"
bmode = 15   "B->Dpipi0ks"
bmode = 16   "B->Dkpi0ks_<1.8GeV"
bmode = 17   "B->Dk2pi0ks_1.8-2.2GeV"
bmode = 18   "B->D2ksX"
bmode = 19   "B->D3pi2pi0_<2.2GeV"
bmode = 20   "B->Dk2pi2pi0_<2.2GeV"
bmode = 21   "B->D2kpi2pi0_Ds*"
bmode = 22   "B->D5pi_<2.3GeV"
bmode = 23   "B->Dk4p_<2.7GeV"
bmode = 24   "B->D2K3pi_<2.7GeV"
bmode = 25   "B->D5pipi0_<2.2GeV"
bmode = 26   "B->Dk4pipi0_<2.2GeV"
bmode = 27   "B->D2k3pipi0_<2.5GeV"
```

```
bmode = 28   "B->D3piks_D*"
bmode = 29   "B->D3pikspi0_D*"
bmode = 30   "B->Dk2piks_D*"
bmode = 31   "B->DD*_Dpi0"
bmode = 32   "B->Dpipi0_>1.5GeV"
bmode = 33   "B->Dkpi0_>1.5GeV"
bmode = 34   "B->Dpi2pi0_1.5-2GeV"
bmode = 35   "B->Dk2pi0_>1.5GeV"
bmode = 36   "B->D3pi_1.5-2GeV"
bmode = 37   "B->Dk2pi_>1.5GeV"
bmode = 38   "B->D2kpi_K*"
bmode = 39   "B->D2kpi_other"
bmode = 40   "B->D3pipi0_<1.6GeV"
bmode = 41   "B->D3pipi0_1.6-2.2GeV"
bmode = 42   "B->Dk2pipi0_>2.2GeV"
bmode = 43   "B->D2kpipi0_other"
bmode = 44   "B->Dkpi0ks_>1.8GeV"
bmode = 45   "B->D3pi2pi0_>2.2GeV"
bmode = 46   "B->Dk2pi2pi0_>2.2GeV"
bmode = 47   "B->D2kpi2pi0_other"
bmode = 48   "B->D5pi_>2.3GeV"
bmode = 49   "B->Dk4p_>2.7GeV"
bmode = 50   "B->D2K3pi_>2.7GeV"
bmode = 51   "B->D5pipi0_>2.2GeV"
bmode = 52   "B->D3piks_noD*"
bmode = 53   "B->D3pikspi0_noD*"
```

D decay modes

```
dmode = 110   "D0->kpi"
dmode = 111   "D0->kpipi0"
dmode = 112   "D0->k3pi"
dmode = 113   "D0->kspipi"
dmode = 130   "D*,D0->kpi"
dmode = 131   "D*,D0->kpipi0"
dmode = 132   "D*,D0->k3pi"
dmode = 133   "D*,D0->kspipi"
dmode = 120   "Dc->kspi"
dmode = 121   "Dc->kpipi"
dmode = 122   "Dc->kspipi0"
dmode = 123   "Dc->kpipipi0"
dmode = 124   "Dc->kspipipi"
dmode = 140   "D*0->D0pi0,D0->kpi"
dmode = 141   "D*0->D0pi0,D0->kpipi0"
dmode = 142   "D*0->D0pi0,D0->k3pi"
dmode = 143   "D*0->D0pi0,D0->kspipi"
dmode = 150   "D*0->D0gamma,D0->kpi"
dmode = 151   "D*0->D0gamma,D0->kpipi0"
dmode = 152   "D*0->D0gamma,D0->k3pi"
dmode = 153   "D*0->D0gamma,D0->kspipi"
```