Performance of Backward EMC at SuperB

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SuperB Workshop

http://www.slac.stanford.edu/~arakitin/tex/2009.Oct.06.SuperB/talk.pdf

Short Reminder

- Many interesting B-decays have neutrinos in final state, e.g. $B \to (D)\tau\nu$, $B \to K/\pi\nu\nu$, $B \to \nu\nu(\gamma)$, $B \to \tau\tau$, $B \to \ell\nu(\gamma)$...
- Analysis of such decays is possible via reconstruction of *the other* B in the event (called *the tag* B)
- Usually these analyses are dominated by backgrounds, typically by similar decays with lost particles (e.g. $B \to \tau\nu$ is dominated by $B \to D^0\tau\nu$ with lost D^0 decay products)
- Backward EM calorimeter helps catch as many decay products as possible, thus diminishing these backgrounds

$B \to \tau\nu_\tau$ Decay

- The tag B can decay either hadronically (fully-reconstructed hadronic tag) or semileptonically (only-neutrino-missing semileptonic tag)
- The recoil $B \to \tau\nu_\tau$, then either $\tau \to e\nu_e\nu_\tau$ or $\tau \to \mu\nu_\mu\nu_\tau$ or $\tau \to \pi\nu_\tau$: 1-prong decay (other decays also possible and we will consider them in the future)
- Signature: the reconstructed tag B + one track + nothing else in the detector
- Background: any process that may resemble this signature due to lost decay products

Possible backgrounds:

Recoil B decay:	Lost particles	BF (from PDG)	BF ratio
Signal $B^+ \to \tau^+\nu_\tau$	–	$(1.4 \pm 0.4) \times 10^{-4}$	1.00
$B^+ \to \overline{D^0}\ell^+\nu_\ell$	$\overline{D^0}$ decay product(s)	$(2.24 \pm 0.11)\%$	160
$B^+ \to \overline{D^{*0}}\ell^+\nu_\ell$	$\overline{D^{*0}}$ decay product(s)	$(5.68 \pm 0.19)\%$	406
$B^+ \to D^-\pi^+\ell^+\nu_\ell$	D^- decay product(s) and π^+	$(4.2 \pm 0.5) \times 10^{-3}$	30
$B^+ \to D^{*-}\pi^+\ell^+\nu_\ell$	D^{*-} decay product(s) and π^+	$(6.1 \pm 0.6) \times 10^{-3}$	44
$B^+ \to \overline{D^{**0}}\ell^+\nu_\ell$	$\overline{D^{**0}}$ decay product(s)	a few %	$\mathcal{O}(10^2)$
$B^+ \to \pi^0\ell^+\nu_\ell$	π^0 photon(s)	$(7.7 \pm 1.2) \times 10^{-5}$	0.55
$B^+ \to \eta\ell^+\nu_\ell$	η photon(s)	$(6 \pm 4) \times 10^{-5}$	0.43
$B^+ \to \eta'\ell^+\nu_\ell$	η' decay product(s)	$(1.7 \pm 2.2) \times 10^{-5}$	0.12
$B^+ \to \omega\ell^+\nu_\ell$	ω pion(s)	$(1.3 \pm 0.6) \times 10^{-4}$	0.93
$B^+ \to \rho^0\ell^+\nu_\ell$	ρ^0 pion(s)	$(1.28 \pm 0.18) \times 10^{-4}$	0.91
$B^0 \to D^-\ell^+\nu_\ell$	D^- decay product(s)	$(2.17 \pm 0.12)\%$	155
$B^0 \to D^{*-}\ell^+\nu_\ell$	D^{*-} decay product(s)	$(5.16 \pm 0.11)\%$	369
$B^0 \to \overline{D^0}\pi^-\ell^+\nu_\ell$	$\overline{D^0}$ decay product(s) and π^-	$(4.3 \pm 0.6) \times 10^{-3}$	31
$B^0 \to D^{**-}\ell^+\nu_\ell$	D^{**-} decay product(s)	a few %	$\mathcal{O}(10^2)$
$B^0 \to \rho^-\ell\nu$	ρ^- pion(s)	$(2.47 \pm 0.33) \times 10^{-4}$	1.76
$B^0 \to \pi^-\ell\nu$	π^-	$(1.34 \pm 0.08) \times 10^{-4}$	0.96

Analysis Strategy

- Generate signal MC (50K events):
  - Tag $B^+ \to \overline{D^0}\pi, \overline{D^0} \to K^+\pi^-$ (simplest hadronic tag for the moment)
  - Recoil $B^- \to \tau^-\overline{\nu_\tau}$
    - ☞ $\tau^- \to e\overline{\nu_e}\nu_\tau$
    - ☞ $\tau^- \to \mu\overline{\nu_\mu}\nu_\tau$
    - ☞ $\tau^- \to \pi^-\nu_\tau$
- Reconstruct the tag B
- Make sure there is exactly one extra track (from 1-prong recoil B)
- Obtain signal B yield
- Generate background MC:
  - Same tag $B^+ \to \overline{D^0}\pi, \overline{D^0} \to K^+\pi^-$
  - Different recoil B^-
- Apply the same tag B reconstruction procedure
- Obtain background B yield and $S/\sqrt{S+B}$
- Repeat for different detector configurations (xml files) to see the effect:
  - "SuperB with backward EMC"
  - "SuperB without backward EMC"
  - "BaBar (no backward EMC)"

B^+ Reconstruction

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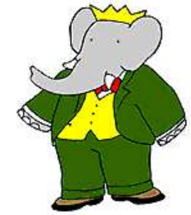
- Use BtaTupleMaker to make $D^0 \to K\pi$ out of two tracks (GoodTracksLoose list) with the aid of Cascade fitter with Geo constraints
- Add one more track (GoodTrackLoose list, Cascade fitter, Geo constraints, $5.2 < m_{ES} < 5.3$ GeV, $-0.1 < \Delta E < 0.1$ GeV)
- Ntuple level:
  - ☞ Require $1.84 < m(D) < 1.89$ GeV
  - ☞ Require $nTracks = 4$
  - ☞ Check if there is only one B candidate per event
- Compute extra (not associated with any track) energy $E_{extra} = \sum E(\gamma_i)$, where γ_i - photons from CalorNeutral list, $E(\gamma_i) > 30$ MeV
- Obtain B yield as a function of the cut on E_{extra}

Background MC

- Over the summer we were working with different background decays
- Results for the separate decay modes were presented earlier (see Abhiram's talk on Sep 22nd)
- Now we amalgamated all the background decay modes into one decay file
- Generated 10M background events
- Apply the same tag B reconstruction procedure
- Apply the same requirement of exactly one extra track ($nTracks = 4$)
- Again, obtain B yield as a function of the cut on E_{extra}
- Obtain $S/\sqrt{S+B}$ as a function of cut on E_{extra}

D^0 mass and number of tracks



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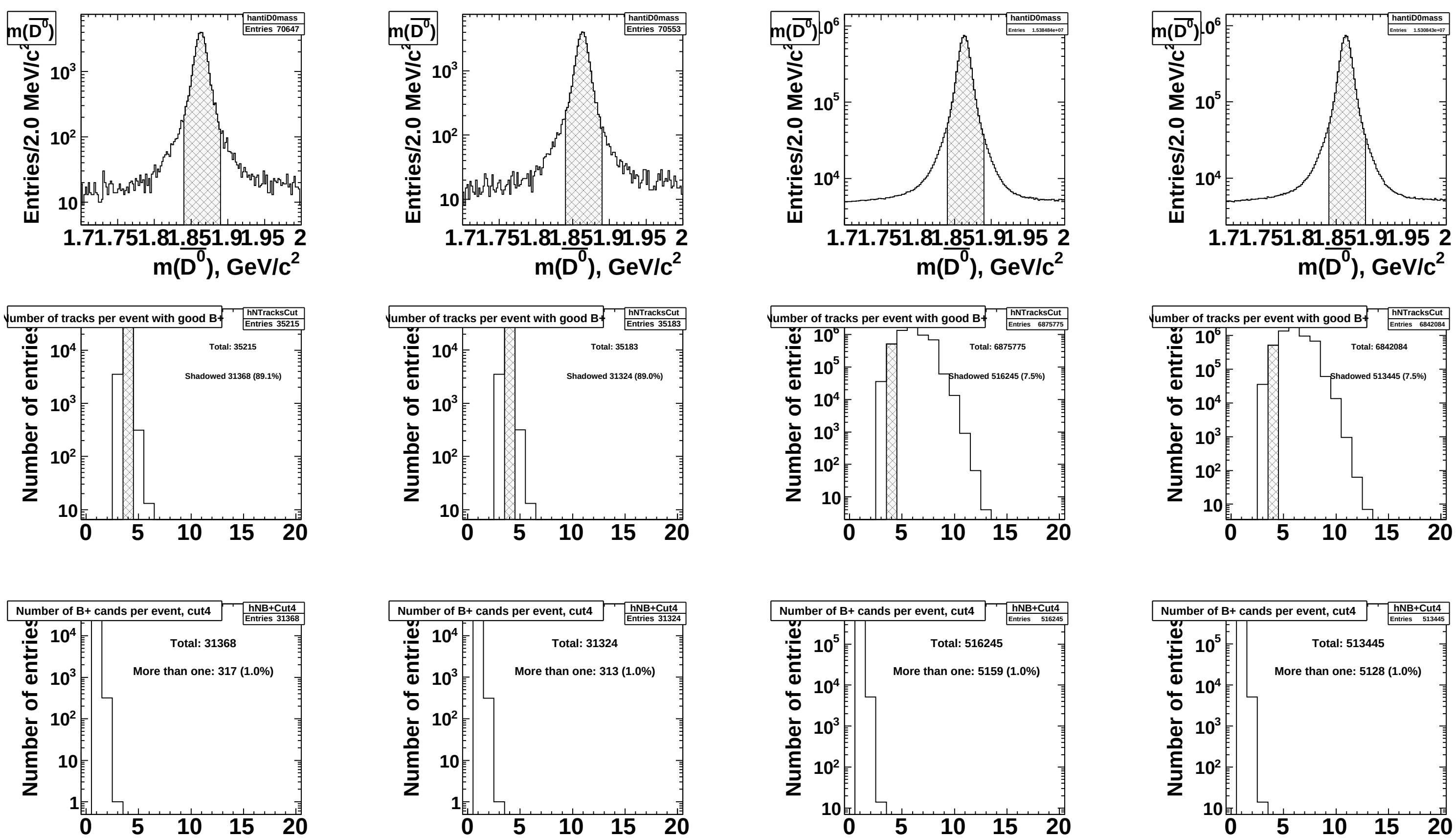
Signal MC — Background MC

w/bwd EMC — no bwd EMC — w/bwd EMC — no bwd EMC

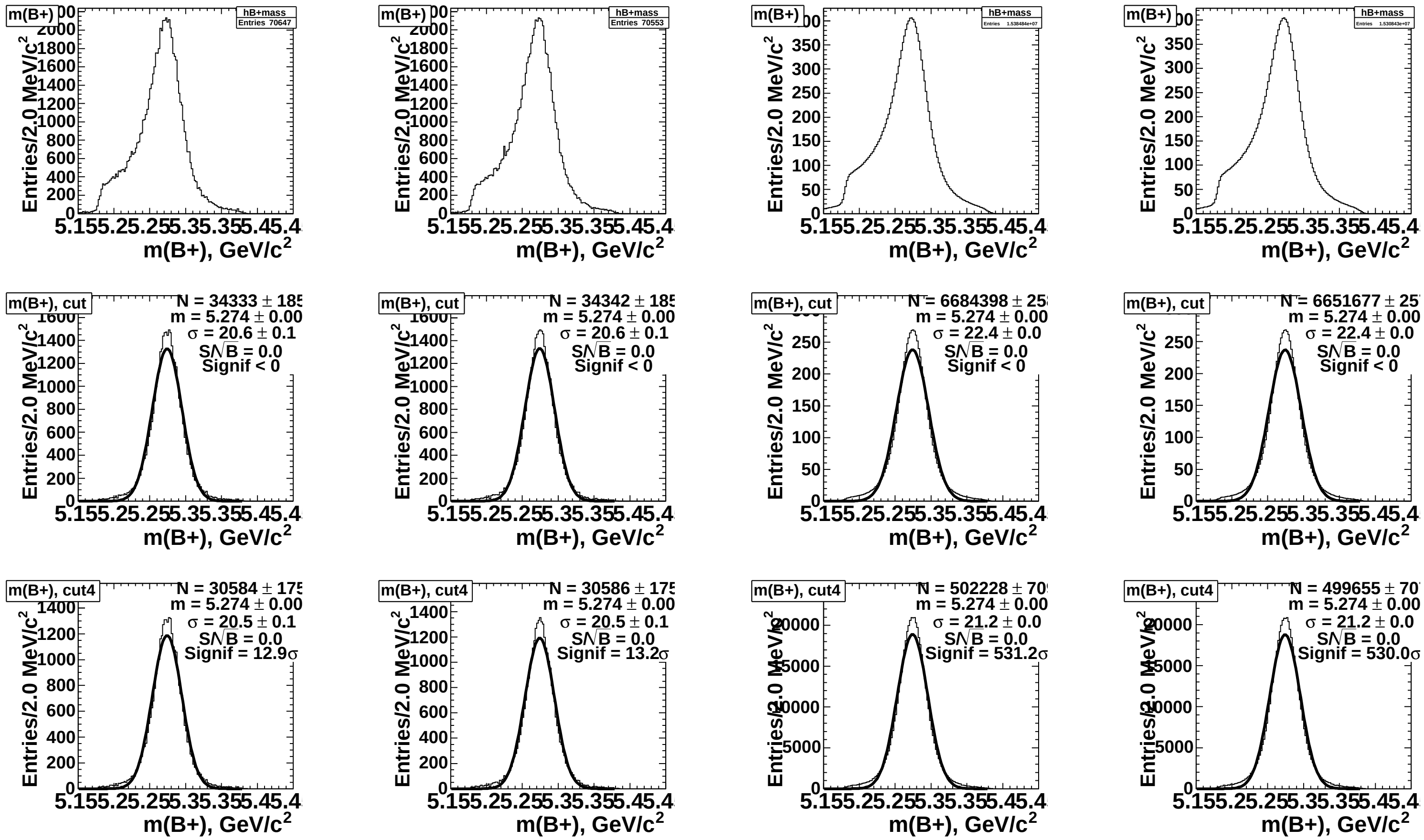


- Top row: D mass, log scale, cut: $1.84 < m(D^0) < 1.89$ GeV$/c^2$
- Middle row: 89% of sig and 7.5% of bkg have exactly 4 tracks
- Bottom row: only 1% of the events has more than 1 B candidate

B mass

Signal MC | Background MC

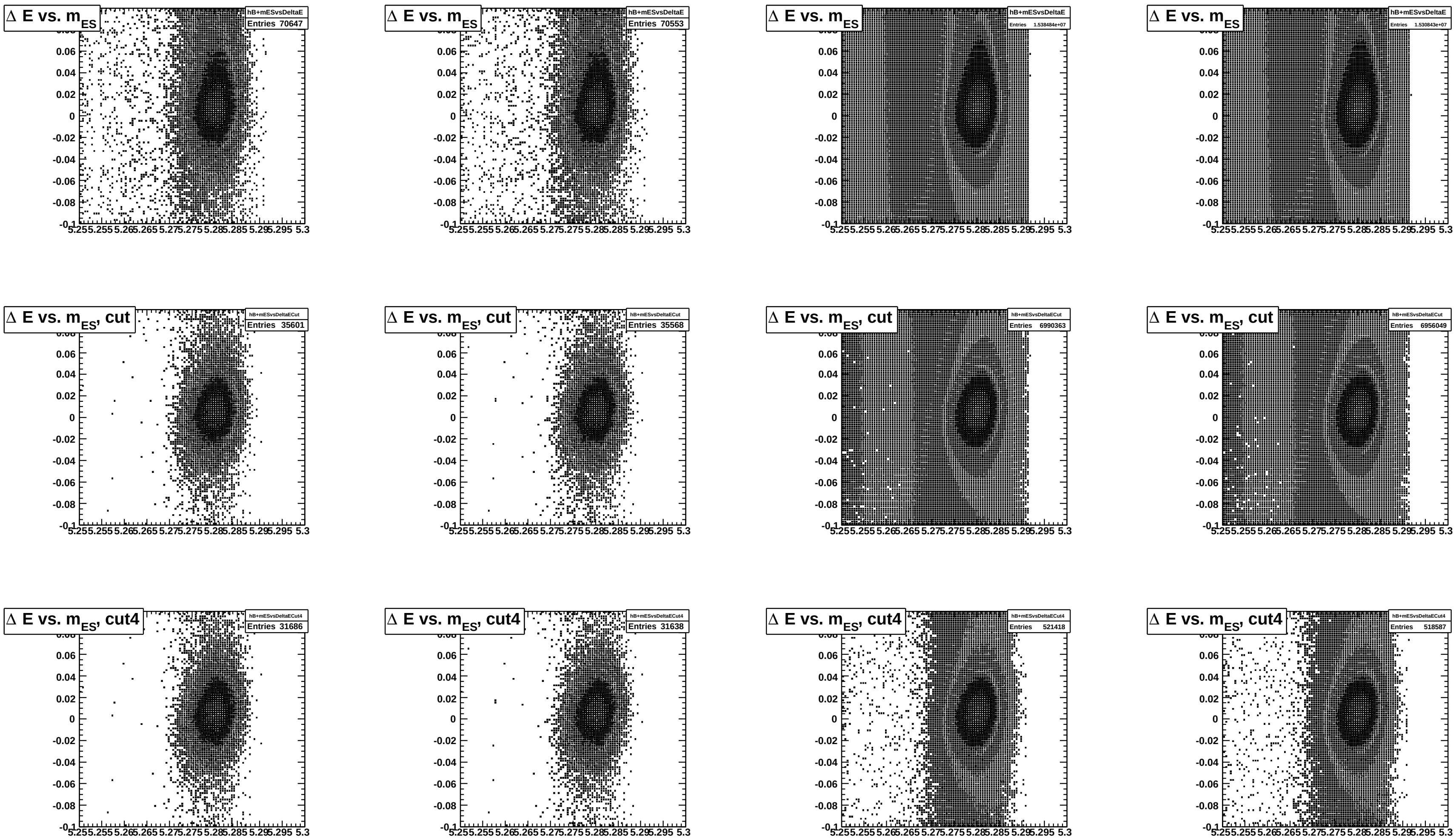
w/bwd EMC | no bwd EMC | w/bwd EMC | no bwd EMC



- Top row: uncut B mass
- Middle row: cut on $m(D^0)$ keeps $\sim$67-68% of the events
- Bottom row: cut $nTracks = 4$ reduces this number to $\sim$50-60%

m_{ES} vs ΔE

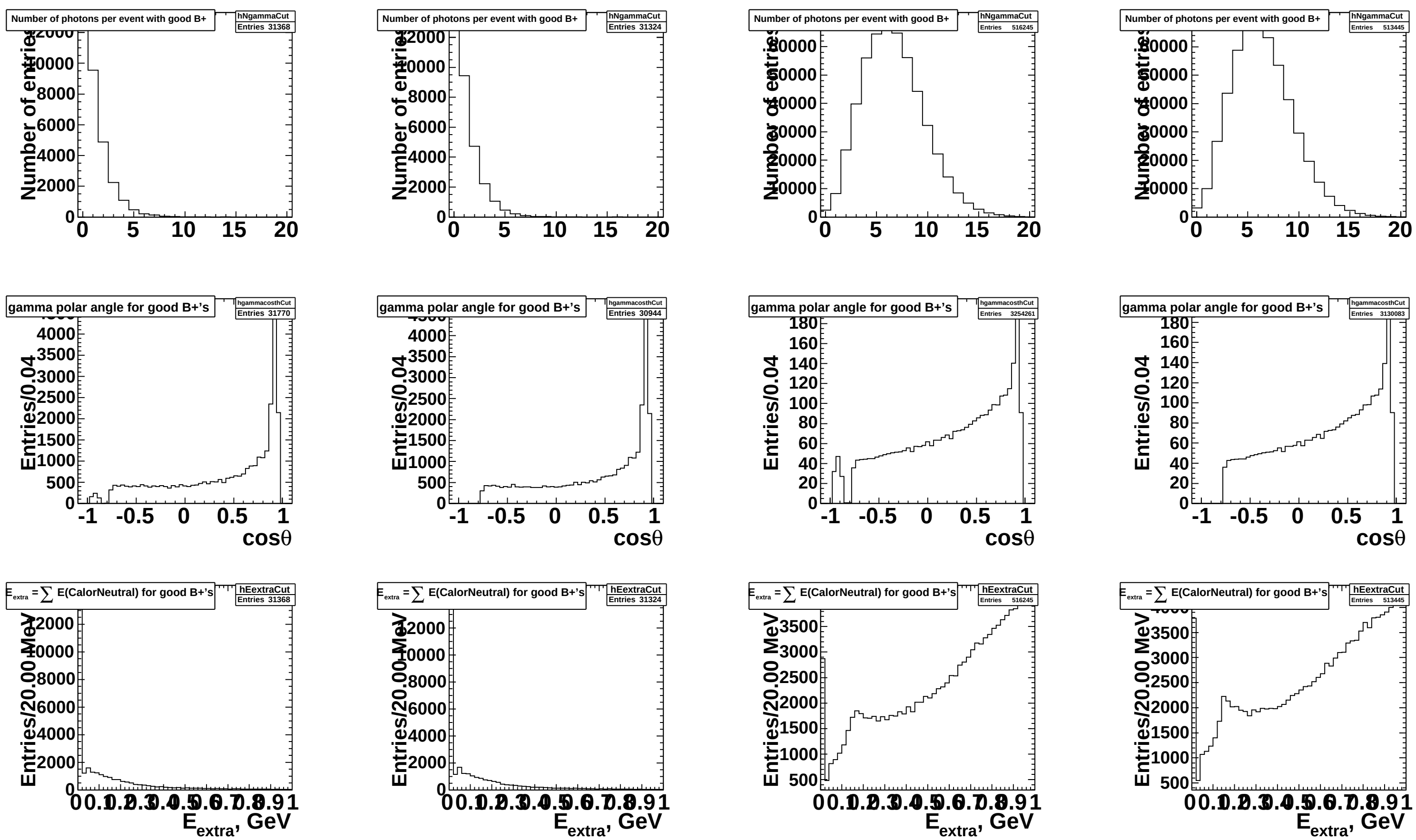
Signal MC		Background MC	
w/bwd EMC	no bwd EMC	w/bwd EMC	no bwd EMC



Photons

Signal MC | Background MC

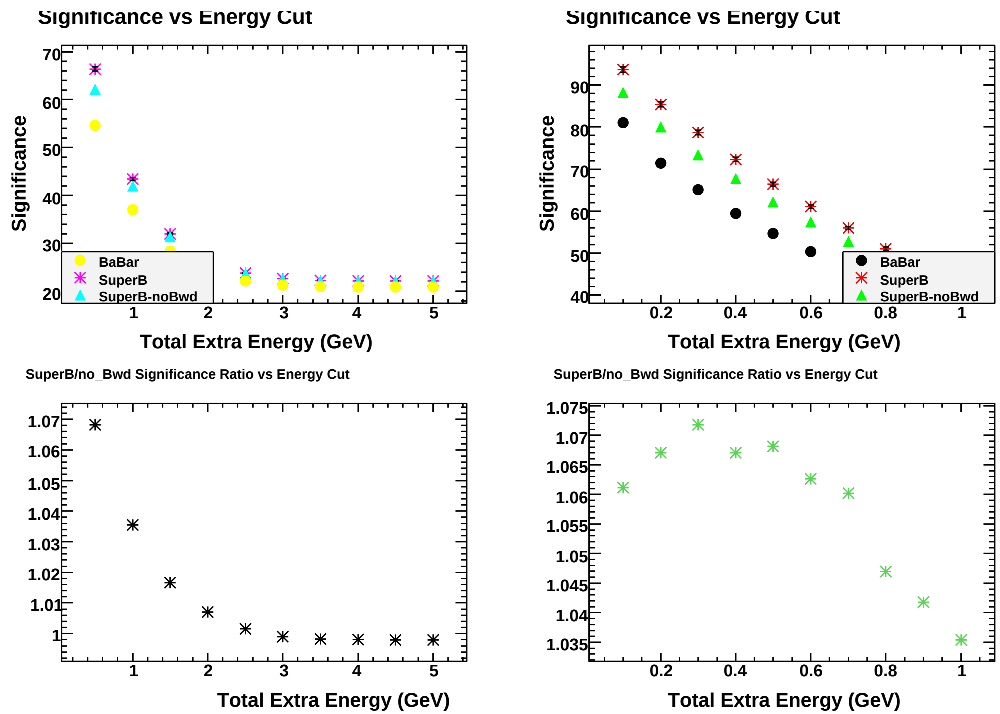
w/bwd EMC | no bwd EMC | w/bwd EMC | no bwd EMC



- Top row: Number of photons tends to be larger for bkg, as it should be
- Middle row: Photon polar angle distribution shows presense/absense of EMC
- Bottom row: E_{extra} distribution

SuperB with/out bwd EMC

Now let's plot $S/\sqrt{S+B}$ as a function of cut on E_{extra}:



SuperB seems to work about 7% better (in terms of $S/\sqrt{S+B}$) with the backward EMC than without (for the cleanest tag $B^- \to \overline{D^0}\pi, \overline{D^0} \to K^+\pi^-$)

Plans

- Include all the background decays of recoil B
  - ☞ Done for B^+, to be done for B^0 as well
- Include other hadronic decays of tag B
- Include other (non 1-prong) signal decays of recoil B
- Include semileptonic decays of tag B