Backward EMC for $B \to \tau\nu_\tau$ Decay

A. Chivukula, A. Rakitin

Caltech

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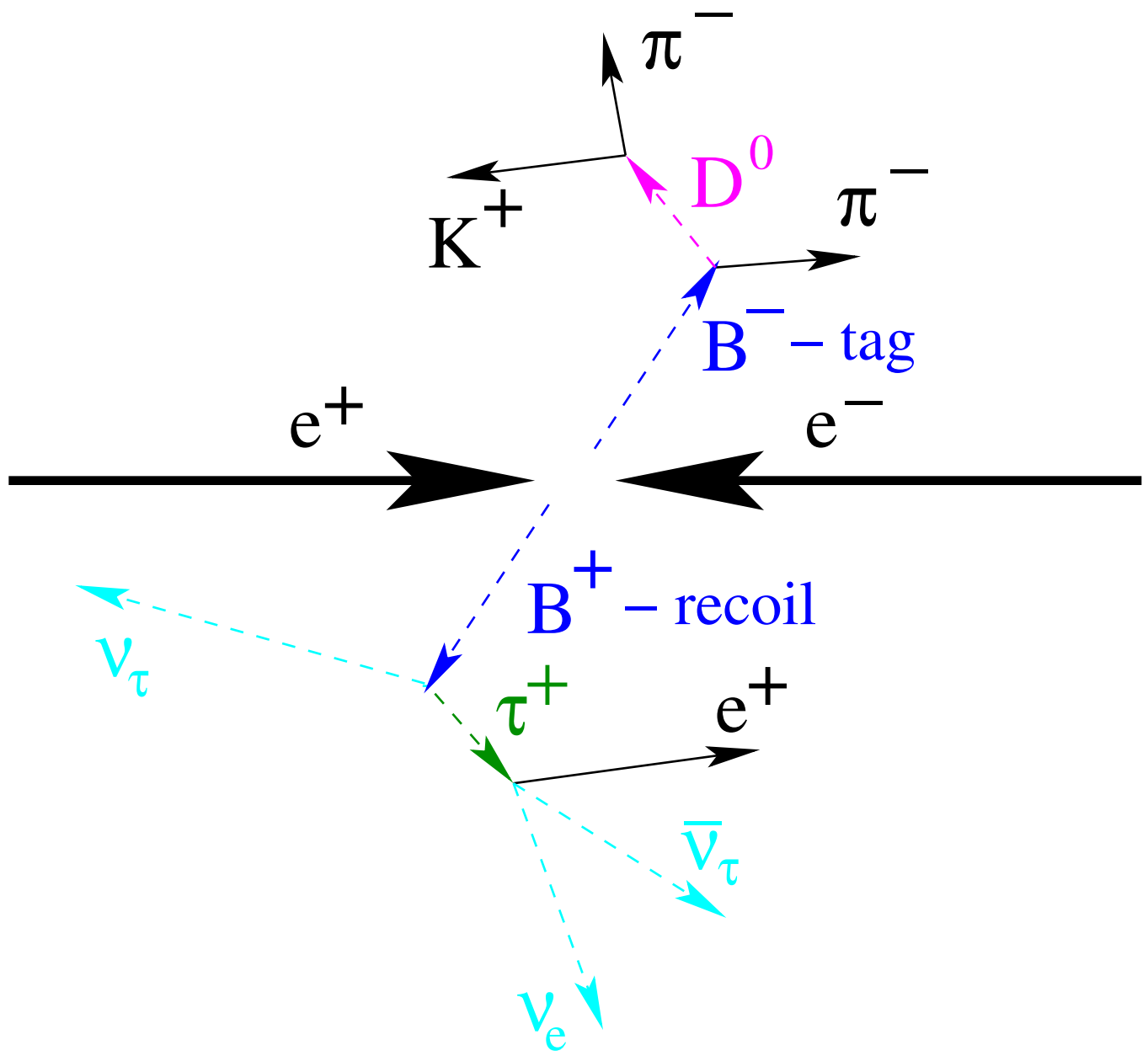
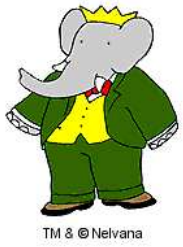
DGWG Meeting

http://www.hep.caltech.edu/~arakitin/tex/2009.Nov.24.DGWG/talk.pdf

$B \to \tau\nu_\tau$ event



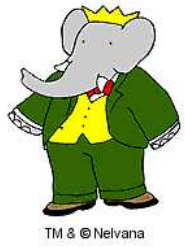
Decays of recoil B with large branching



	$B \to \tau^+\nu_\tau$ and then...	BF(τ) from PDG
1-prong	$\tau^+ \to e^+\nu_e\overline{\nu_\tau}$	17.85%
	$\tau^+ \to \mu^+\nu_\mu\overline{\nu_\tau}$	17.36%
	$\tau^+ \to \pi^+\overline{\nu_\tau}$	10.91%
	$\tau^+ \to \pi^+\pi^0\overline{\nu_\tau}$	25.51%
	$\tau^+ \to \pi^+\pi^0\pi^0\overline{\nu_\tau}$	9.29%
	Total 1-prong	80.92%
3-prong	$\tau^+ \to \pi^+\pi^-\pi^+\overline{\nu_\tau}$	9.32%
	$\tau^+ \to \pi^+\pi^-\pi^+\pi^0\overline{\nu_\tau}$	4.61%
	Total 3-prong	13.93%
	Grand total	94.85%

- These decays cover almost all τ width
- In our analysis presented last time we've covered first three lines (BF = 46.12%)
- Now we are concentrating mostly on the fourth line

Goals

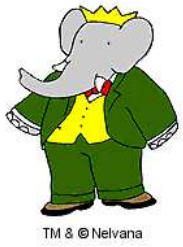


- Reconstruct $B \to \tau\nu, \tau \to \rho\nu, \rho \to \pi\pi^0$ decay
- Separate from background direct decays $B \to \rho + X_{miss}$
- Separate from background indirect decays $B \to$ stuff, stuff $\to \rho + X_{miss}$
- Separate from background decays $B \to \pi^0 +$ random track $+ X_{miss}$ (both direct and indirect)

Once good ρ's from τ's are isolated:

- Obtain E_{extra}^{corr} by subtracting the corresponding photons from E_{extra}
- Plot sig and bkg yields vs. cut on E_{extra}^{corr} and compare the $S/\sqrt{S+B}$ curves for regular SuperB and SuperB-no-Bwd-EMC architectures

Possible direct ρ backgrounds



Decay	BF	BF ratio
Signal $B^+ \to \tau^+\nu_\tau, \tau^+ \to \rho^+\overline{\nu_\tau}, \rho^+ \to \pi^+\pi^0$	$(3.6 \pm 0.1) \times 10^{-5}$	1.00
$B^+ \to \overline{D^0}\rho^+$	$(1.34 \pm 0.18)\%$	372
$B^+ \to \overline{D^{*0}}\rho^+$	$(9.8 \pm 1.7) \times 10^{-3}$	272
$B^+ \to$ other charm $+ \rho^+$	$< \mathcal{O}(10^{-3})$	$\mathcal{O}$(0-10^2)
$B^+ \to J/\psi\rho^+$	$(5.0 \pm 0.8) \times 10^{-5}$	1.39
$B^+ \to K^0\rho^+$	$(8.0 \pm 1.5) \times 10^{-6}$	0.22
$B^+ \to K^{*0}(892)\rho^+$	$(9.2 \pm 1.5) \times 10^{-6}$	0.26
$B^+ \to \rho^+\gamma$	$(8.8^{+2.9}_{-2.5}) \times 10^{-7}$	0.02
$B^+ \to \pi^0\rho^+$	$(1.09 \pm 0.14) \times 10^{-5}$	0.30
$B^+ \to \rho^0\rho^+$	$(1.8 \pm 0.4) \times 10^{-5}$	0.50
$B^+ \to \omega\rho^+$	$(1.06^{+0.26}_{-0.23}) \times 10^{-5}$	0.29
$B^+ \to \eta'\rho^+$	$(8.7^{+3.9}_{-3.1}) \times 10^{-6}$	0.24
$B^+ \to \phi\rho^+$	$< 1.6 \times 10^{-5}$	< 0.44
$B^0 \to \rho + X_{miss}$	negligible for had. tag	small

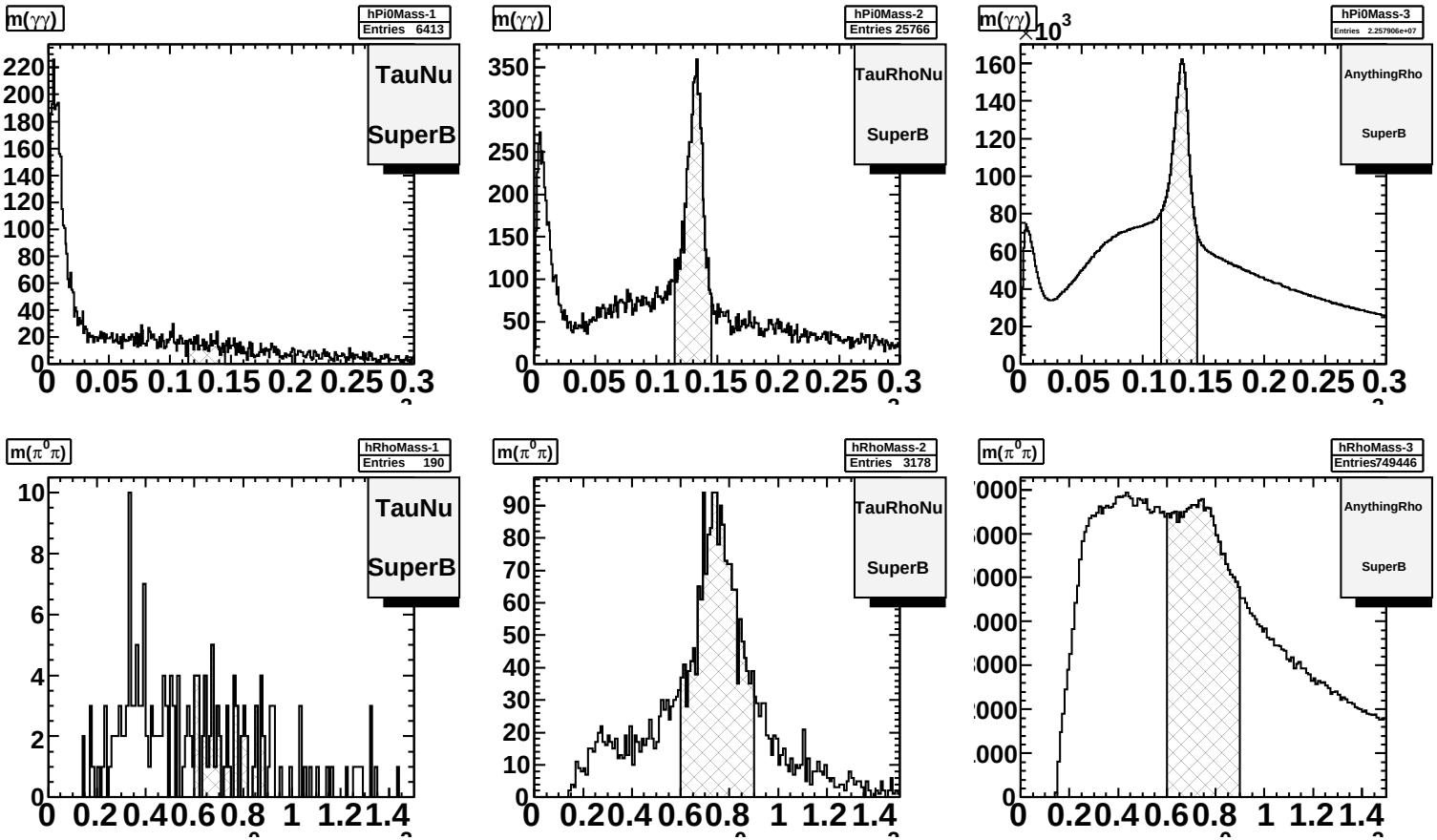
Generated bkg MC sample: RhoAnything ❶

π^0 and ρ mass

$B \to \tau\nu, \tau \to 1\text{-}prong$ (TauNu)

$B \to \tau\nu, \tau \to \rho\nu$ (TauRhoNu)

$B \to \rho + X_{miss}$ (RhoAnything)

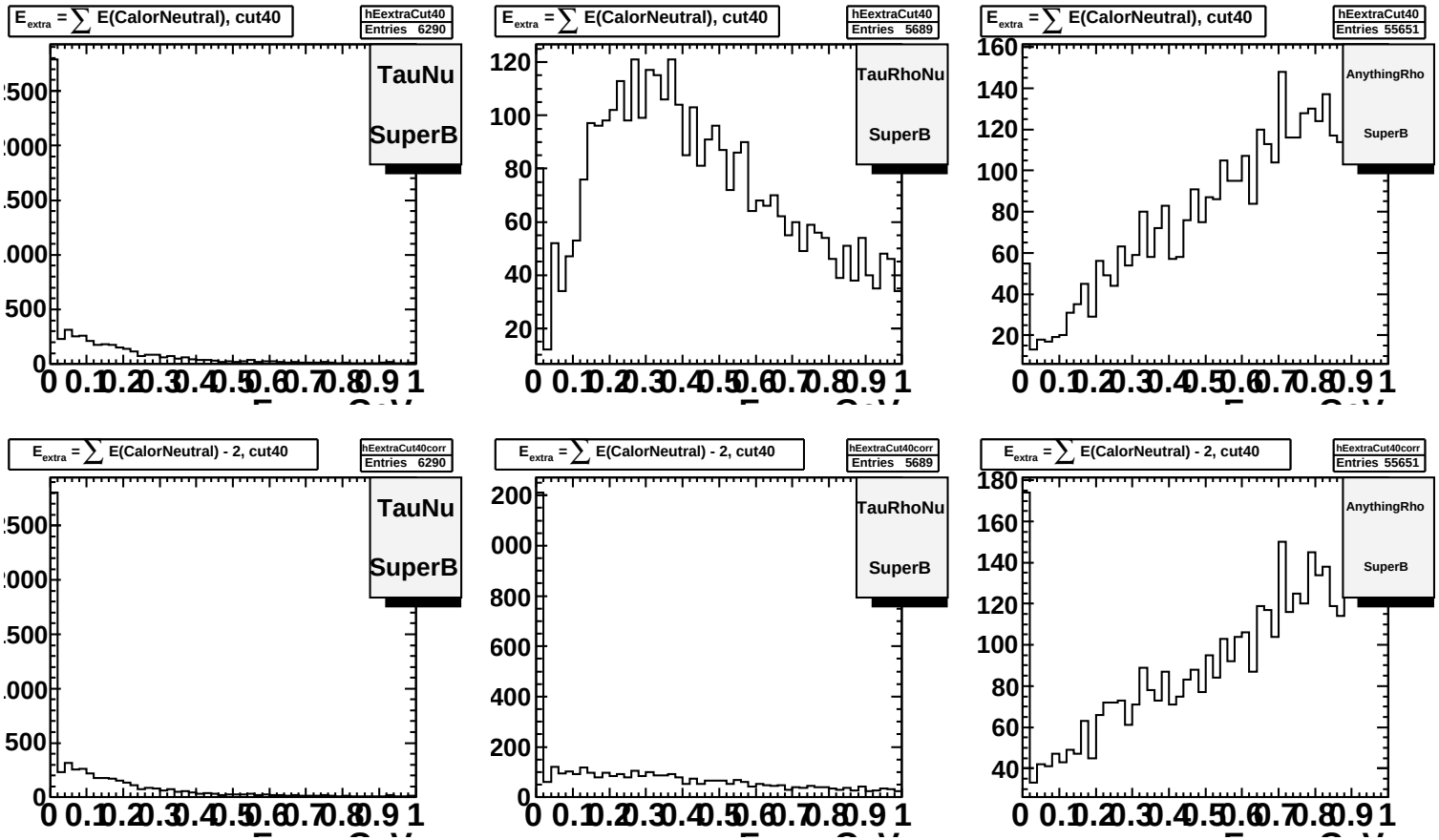


E_{extra}

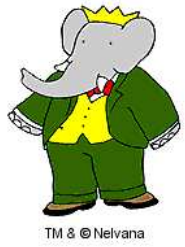
$B \to \tau\nu, \tau \to 1\text{-}prong$ (TauNu)

$B \to \tau\nu, \tau \to \rho\nu$ (TauRhoNu)

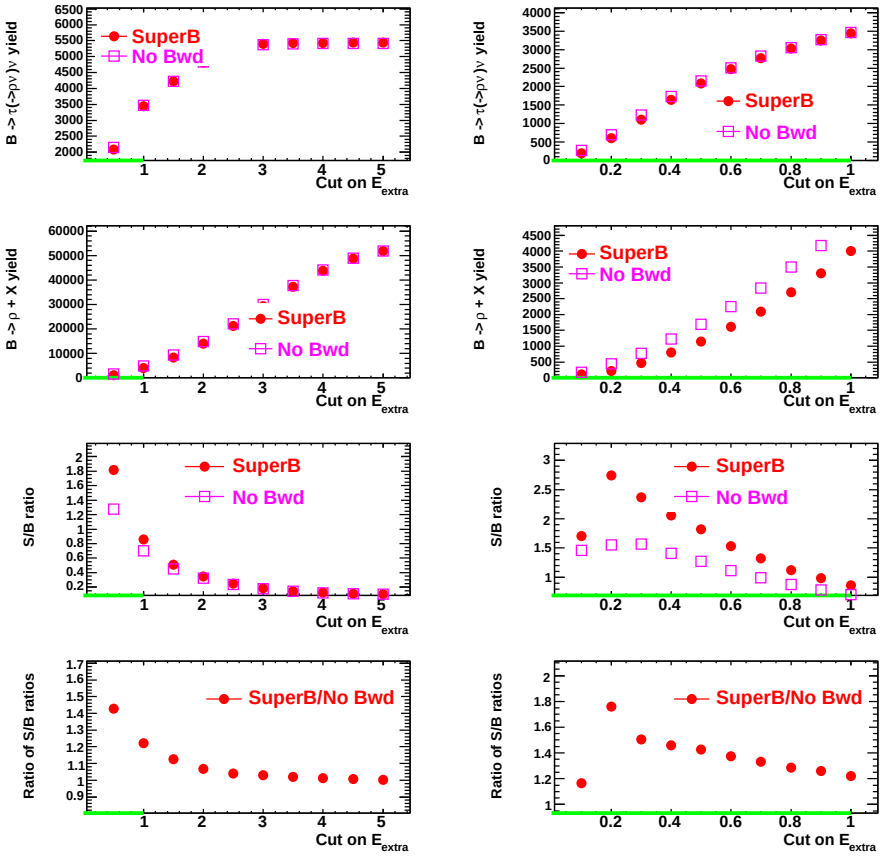
$B \to \rho + X_{miss}$ (RhoAnything)



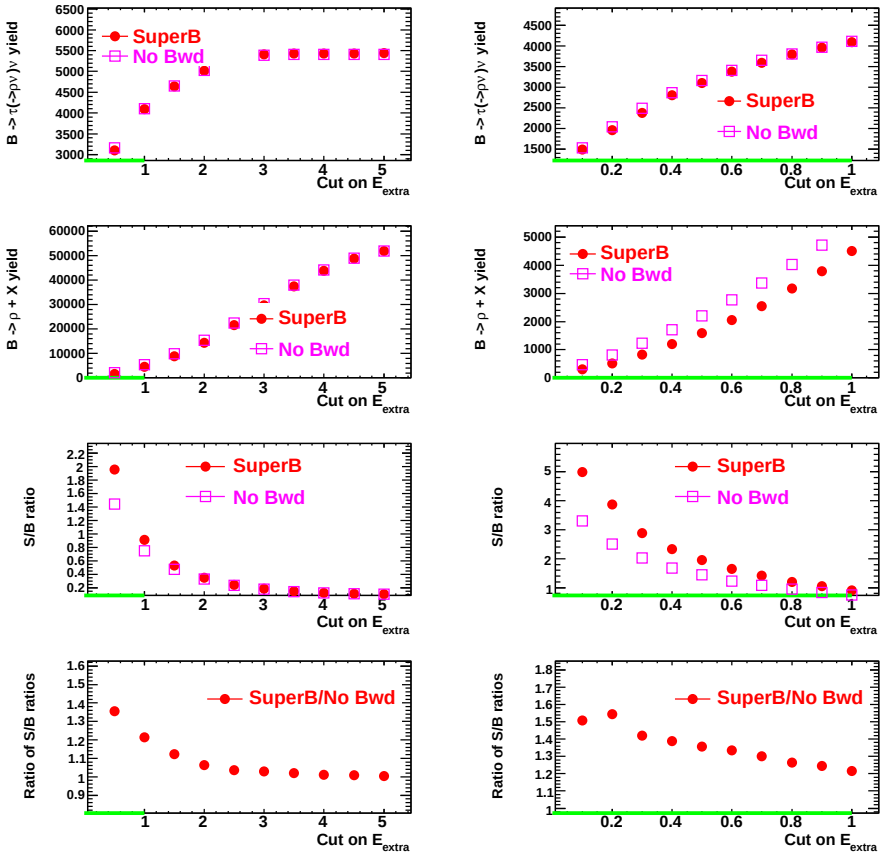
S/B ratios



Cut on E_{extra}

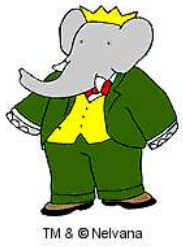


Cut on E_{extra}^{corr}

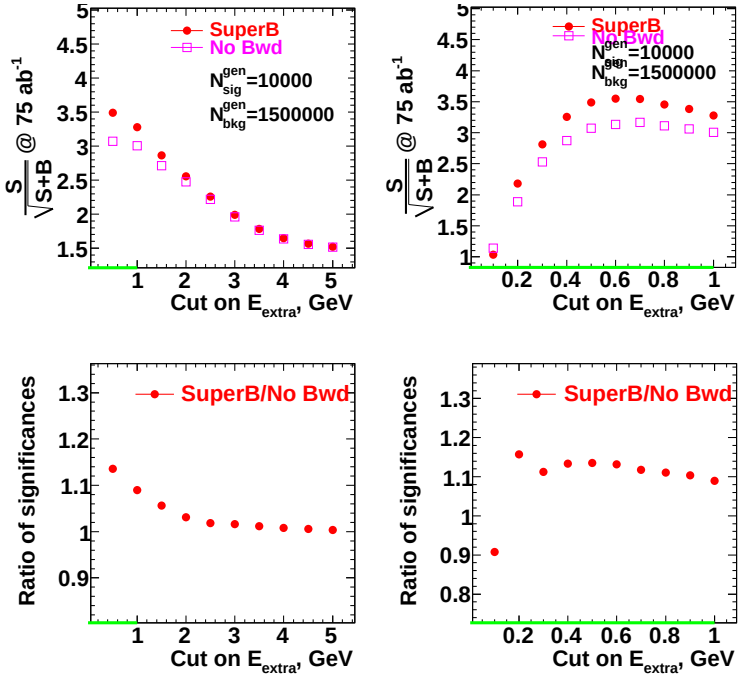


- Cut on E_{extra}^{corr} increases S/B ratio compared to cut on E_{extra}
- In terms of bwd EMC presence, S/B ratio is about 40%-50% better with it

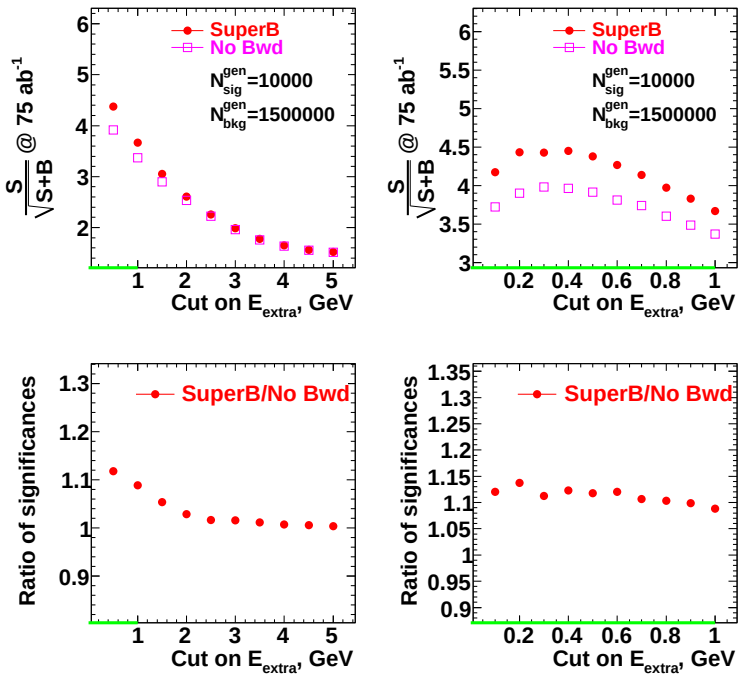
$S/\sqrt{S+B}$



Cut on E_{extra}

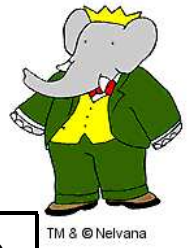


Cut on E^{corr}_{extra}



- $S/\sqrt{S+B}$ ratio is about 10% better with bwd EMC

Possible indirect ρ backgrounds



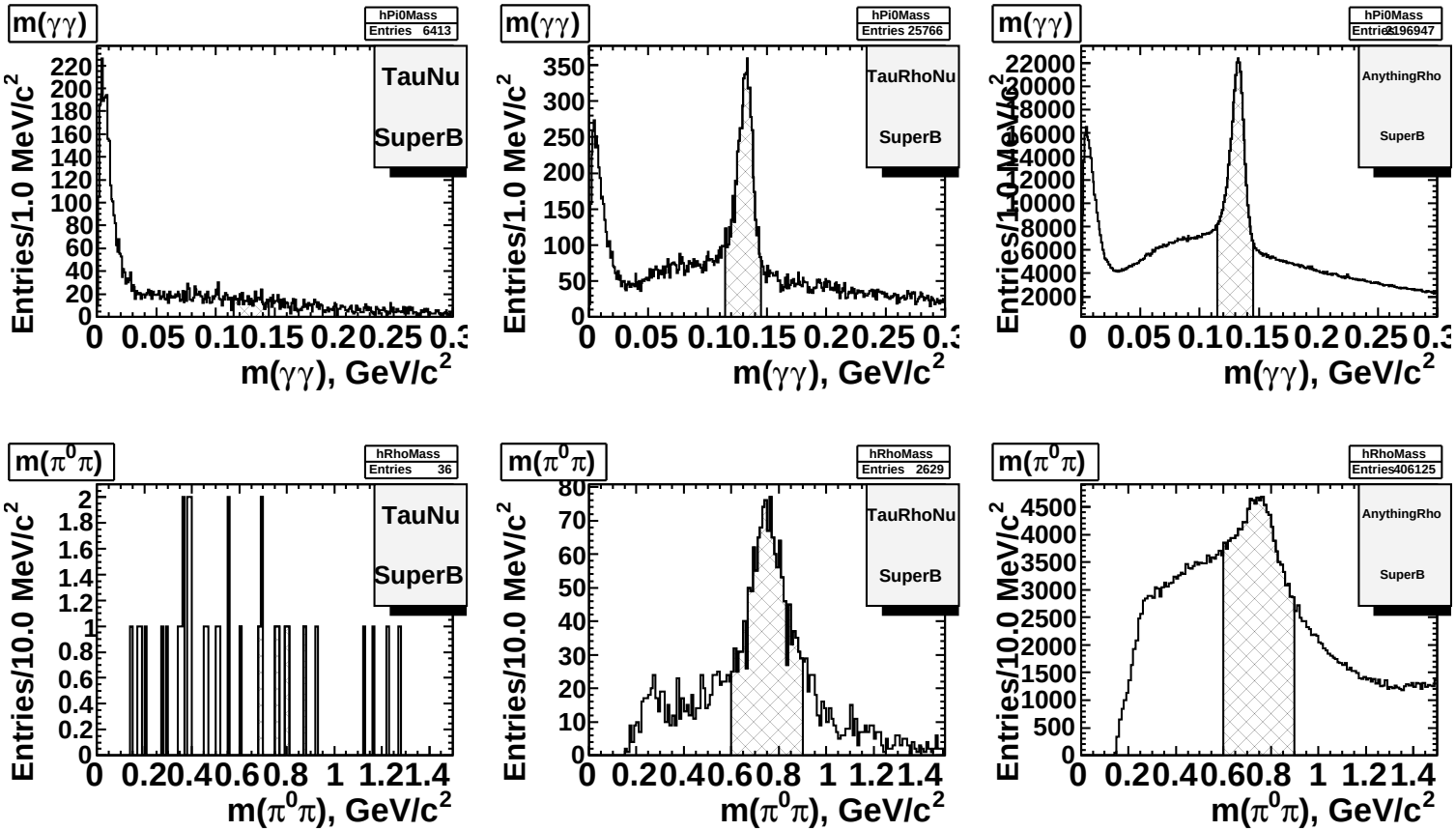
	Decay	BF	BF ratio
	Signal $B^+ \to \tau^+\nu_\tau, \tau^+ \to \rho^+\overline{\nu_\tau}, \rho^+ \to \pi^+\pi^0$	$(3.6 \pm 0.1) \times 10^{-5}$	1.00
semileptonic	$B^+ \to D^{(*(*))0}\ell\nu_\ell, D^{(*(*))0} \to \rho^+ + X$	2.1%	583
	$B^+ \to D^{(*)-}\pi^+\ell\nu_\ell, D^{(*)-} \not\to \rho^+ + X$	0.0	0.0
	$B^+ \to$ non-charm $+ \ell\nu_\ell$, non-charm $\not\to \rho^+ +$ X	0.0	0.0
hadronic	$B^+ \to$ hadrons, hadrons $\to \rho^- +$ X	???	large?
	$B^0 \to$ stuff, stuff $\to \rho^- +$ X	negligible for had. tag	small

Needed bkg MC samples:

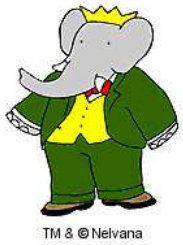
- $B^- \to$ charm $+ \ell^- + \nu_\ell$, charm $\to \rho^- + X$ (CharmRhoLepNu ❷) – done
- $B^- \to$ hadrons, hadrons $\to \rho^- + X$ (HadRho ❸) – to be done

π^0 and ρ mass

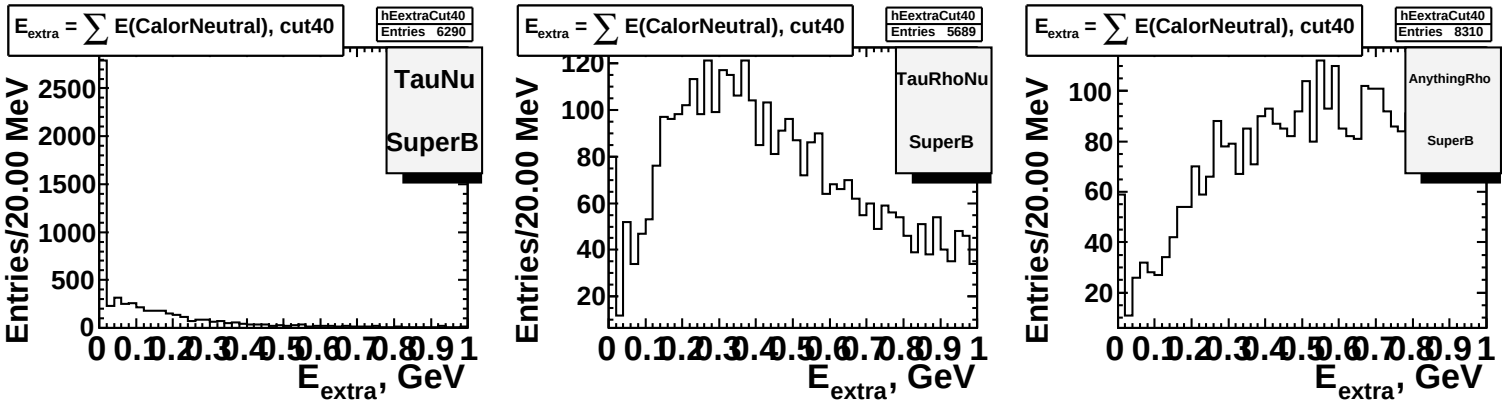
$B \to \tau\nu, \tau \to 1\text{-}prong$	$B \to \tau\nu, \tau \to \rho\nu$	$B \to D\ell\nu_\ell, D \to \rho + X$
(TauNu)	(TauRhoNu)	(CharmRhoLepNu)

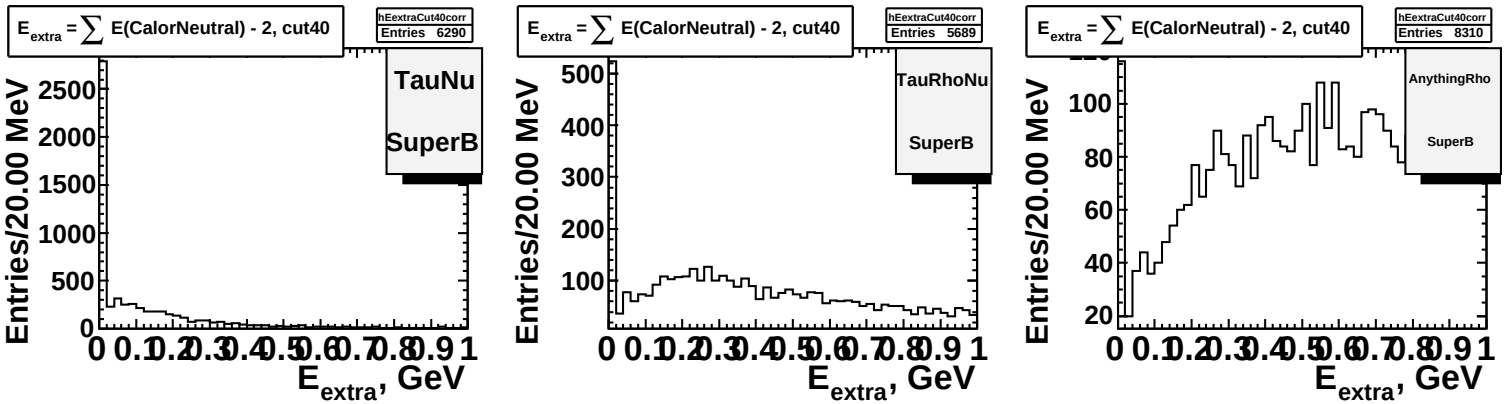


E_{extra}

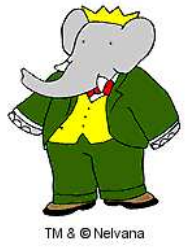


$B \to \tau\nu, \tau \to 1\text{-}prong$	$B \to \tau\nu, \tau \to \rho\nu$	$B \to D\ell\nu_\ell, D \to \rho + X$
(TauNu)	(TauRhoNu)	(CharmRhoLepNu)

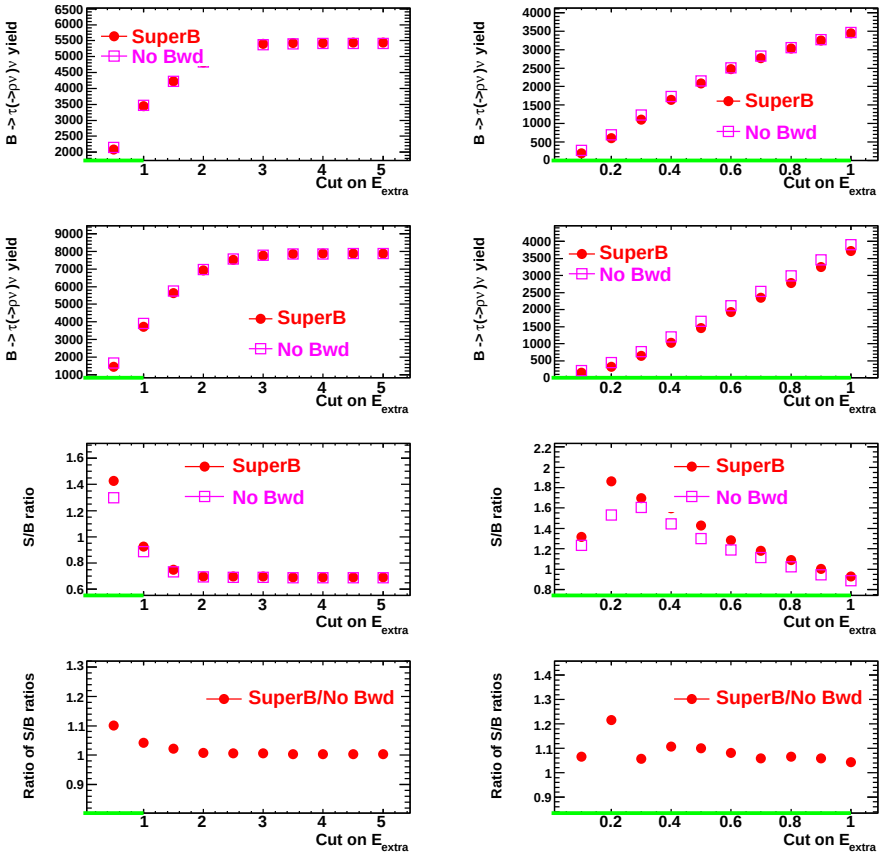




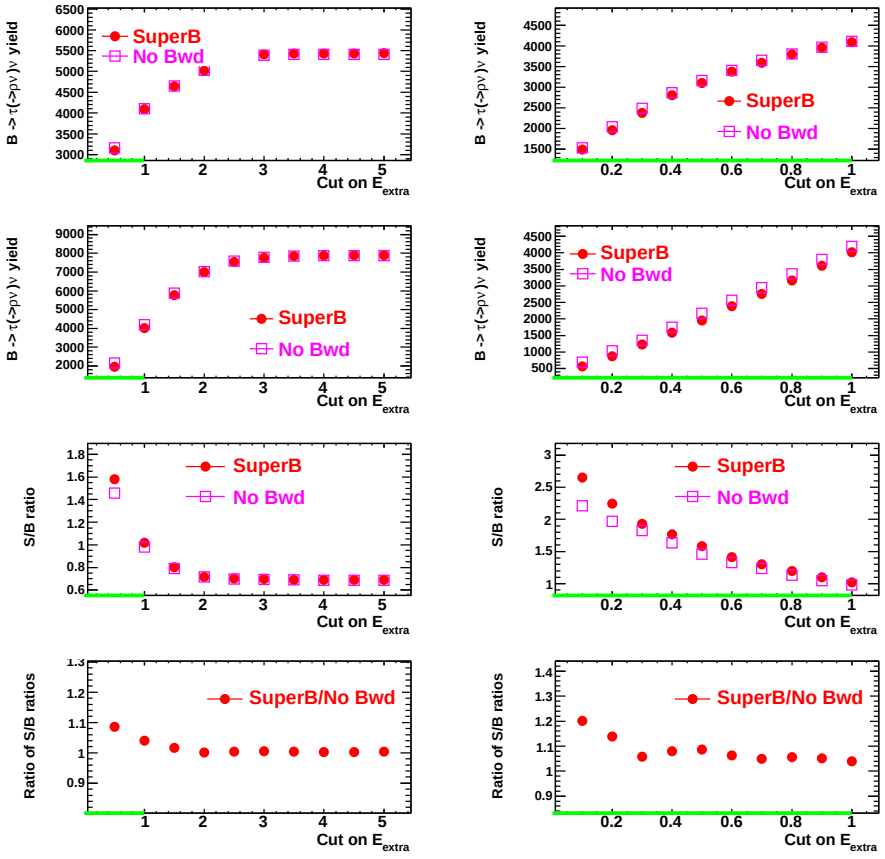
S/B ratio



Cut on E_{extra}

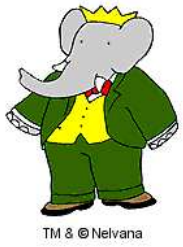


Cut on E_{extra}^{corr}

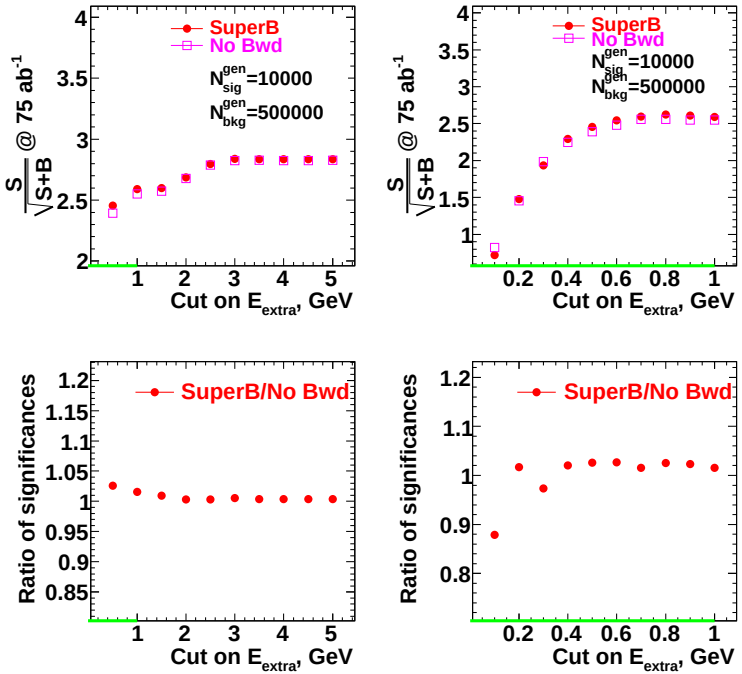


- Again, cut on E_{extra}^{corr} increases S/B ratio compared to cut on E_{extra}
- In terms of bwd EMC presence, S/B ratio is about 10% better with it

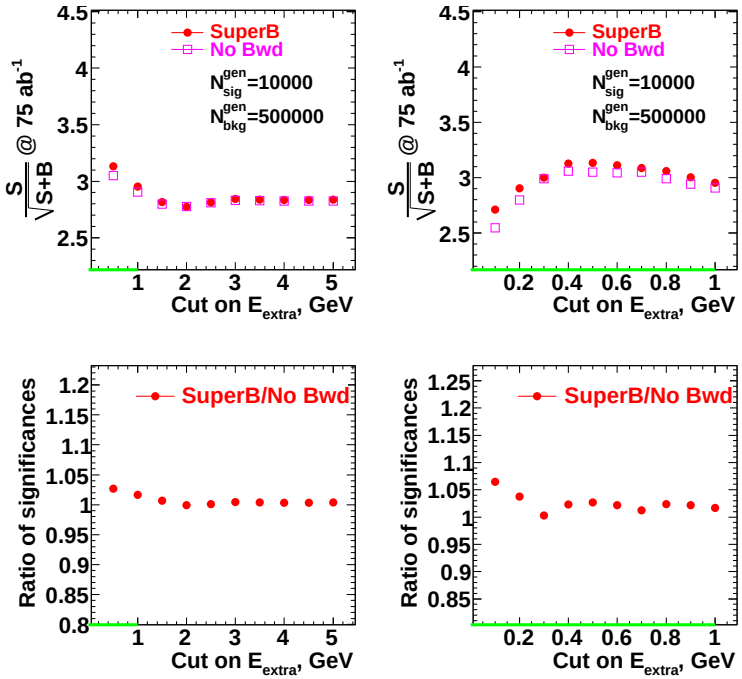
$S/\sqrt{S+B}$



Cut on E_{extra}

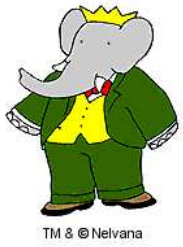


Cut on E^{corr}_{extra}



- $S/\sqrt{S+B}$ ratio is about 2%-3% better with bwd EMC

Hadronic indirect ρ backgrounds

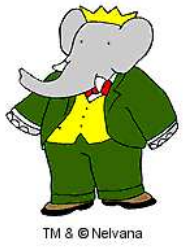


Will be done later

Needed bkg MC sample:

- $B^- \to$ charm $+ X_1$, charm $\to \rho^- + X_2$ (CharmRho ❹)
- $B^- \to$ non-charm $+ X_1$, non-charm $\to \rho^- + X_2$ (NonCharmRho ❺)

Possible π^0 backgrounds



Decay	BF	BF ratio
Signal $B^+ \to \tau^+\nu_\tau, \tau^+ \to \rho^+\overline{\nu_\tau}, \rho^+ \to \pi^+\pi^0$	$(3.6 \pm 0.1) \times 10^{-5}$	1.00
$B^+ \to \pi^0\ell^+\nu_\ell$ (nothing is lost)	7.7×10^{-5}	2.16
$B^+ \to D^{(*(*))0}\ell^+\nu_\ell, D^{(*(*))0} \to \pi^0 + X$	a few %	large
$B^+ \to D^{(*)-}\pi^+\ell^+\nu_\ell, D^{(*)-} \to \pi^0 + X$	a few %	large
$B^+ \to \eta\ell^+\nu_\ell, \eta \to 3\pi^0 + X$		$\mathcal{O}(1)$
$B^+ \to \eta'\ell^+\nu_\ell, \eta' \to \pi^0 + X$	$\sim 2 \times 10^{-5}$	$\mathcal{O}(1)$
$B^+ \to \omega\ell^+\nu_\ell, \omega \to \pi^0 + X$	1.3×10^{-4}	3.54
$B^+ \to \pi^0 + X_{miss}$	???	large?
$B^+ \to$ hadrons, hadrons $\to \pi^0 + X_{miss}$	???	large?

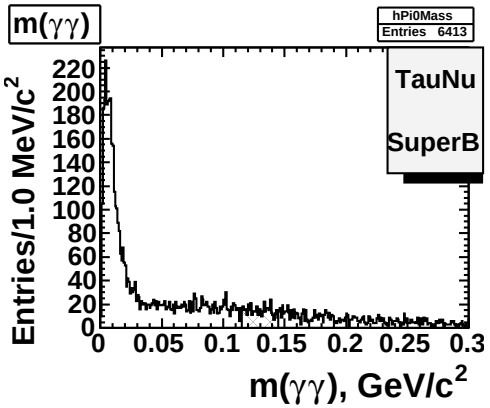
Any π^0 from this table, being combined with a random track, may give a good ρ candidate which will be counted as coming from τ (provided that other tracks and photons are lost)

Needed bkg MC samples:

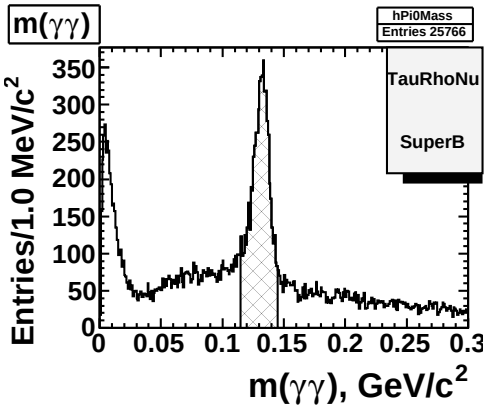
- $B^- \to \pi^0\ell^-\nu$ (Pi0LepNu ❻) – done
- $B^- \to X_1 + \ell^- + \nu, X_1 \to \pi^0 + X_2$ (StuffPi0LepNu ❼) – to be done
- $B^- \to \pi^0 +$ hadrons (Pi0Had ❽) – to be done
- $B^- \to$ hadrons, hadrons $\to \pi^0 + X$ (HadPi0 ❾) – to be done

π^0 and ρ mass

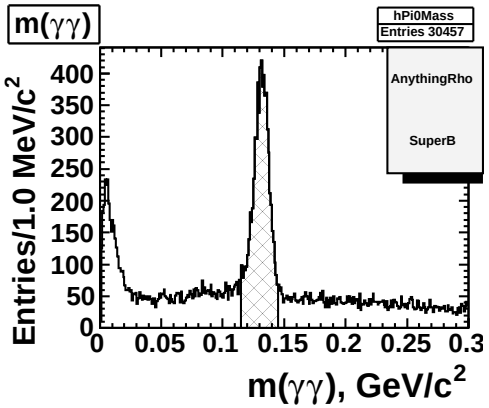
$B \to \tau\nu, \tau \to 1\text{-}prong$ (TauNu)

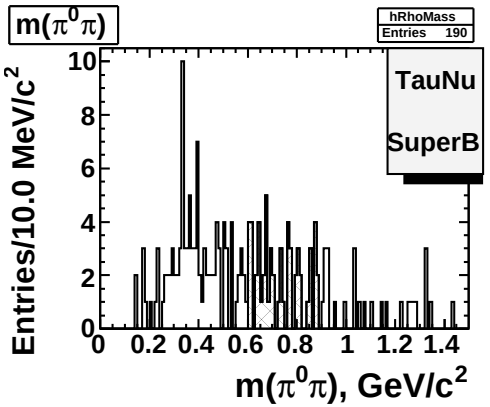


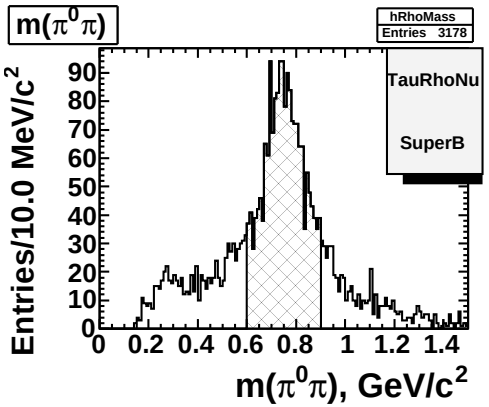
$B \to \tau\nu, \tau \to \rho\nu$ (TauRhoNu)

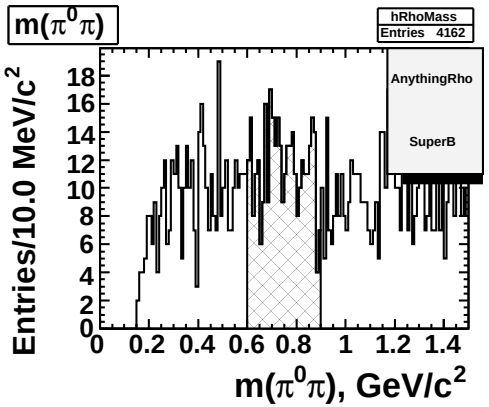


$B \to \pi^0 \ell\nu$ (Pi0LepNu)



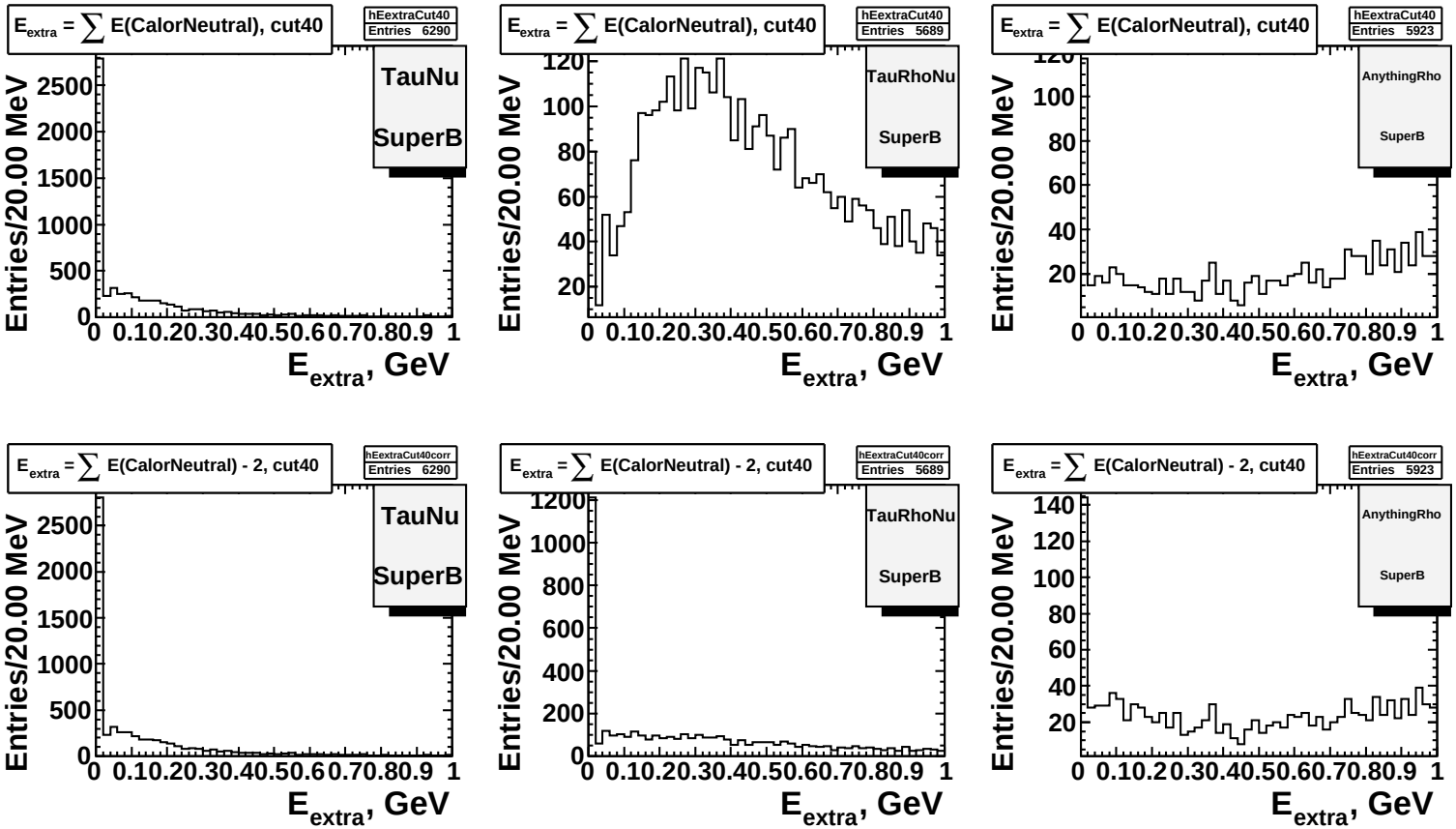




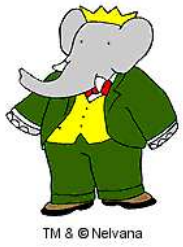


E_{extra}

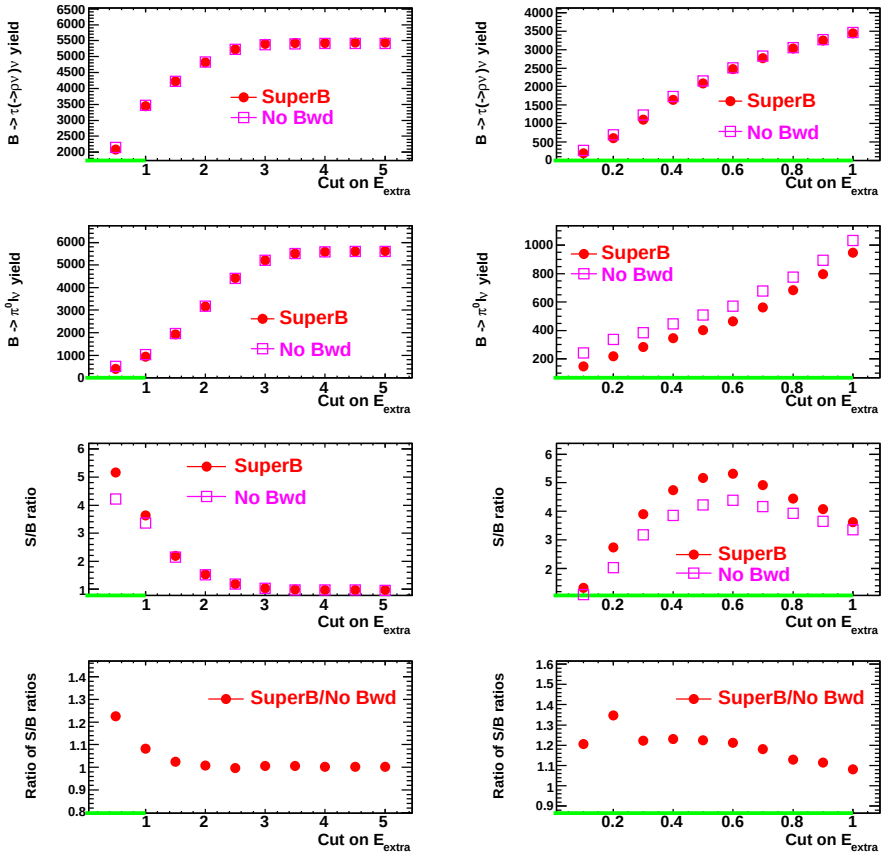
$B \to \tau\nu, \tau \to 1\text{-}prong$	$B \to \tau\nu, \tau \to \rho\nu$	$B \to \pi^0 \ell\nu$
(TauNu)	(TauRhoNu)	(Pi0LepNu)



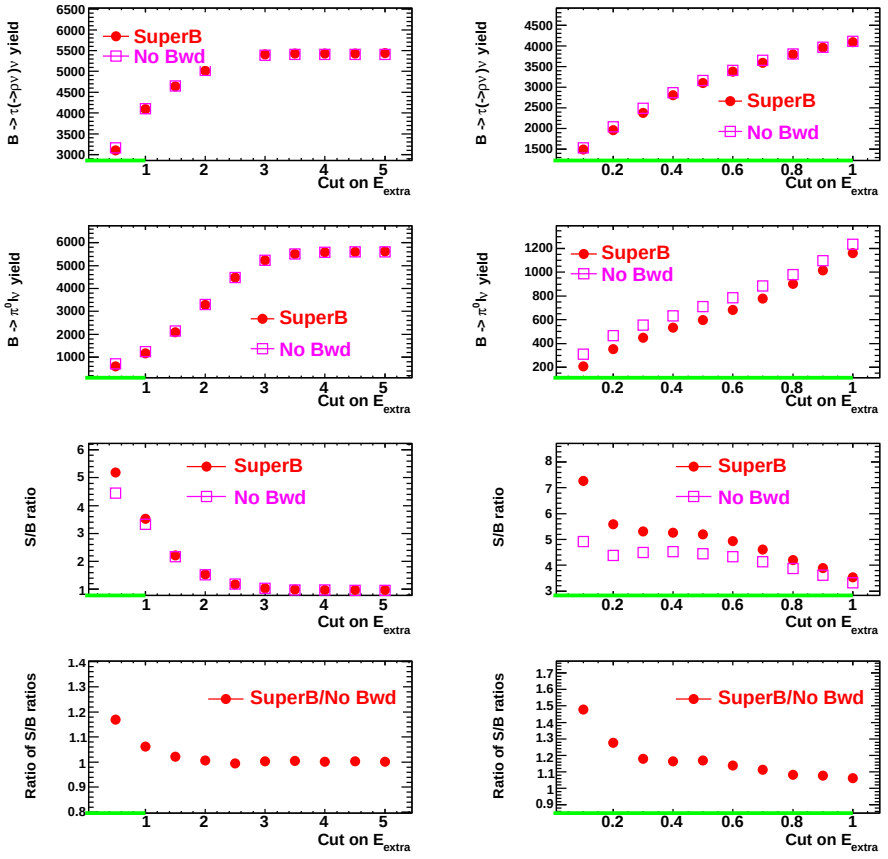
S/B ratio



Cut on E_{extra}

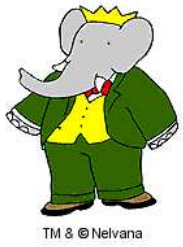


Cut on E_{extra}^{corr}

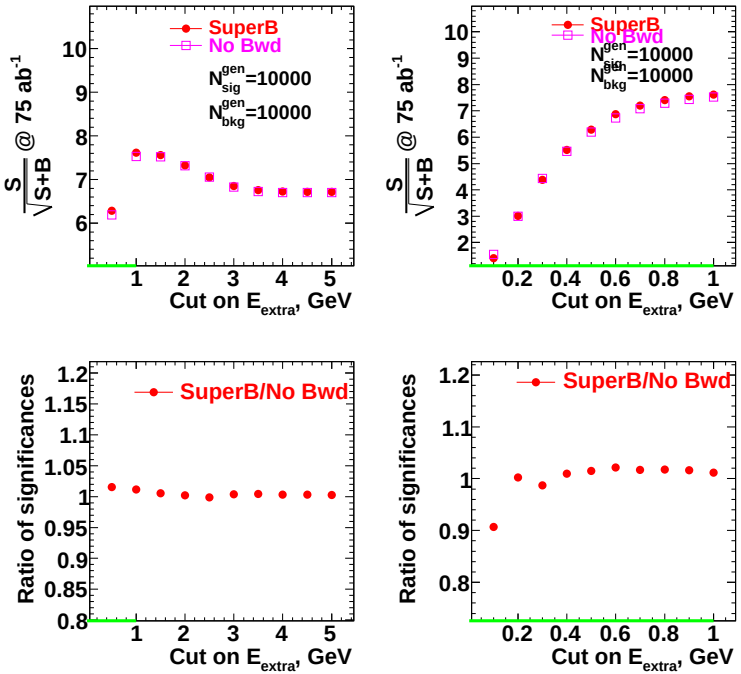


- Again, cut on E_{extra}^{corr} increases S/B ratio compared to cut on E_{extra}
- In terms of bwd EMC presence, S/B ratio is about 20% better with it

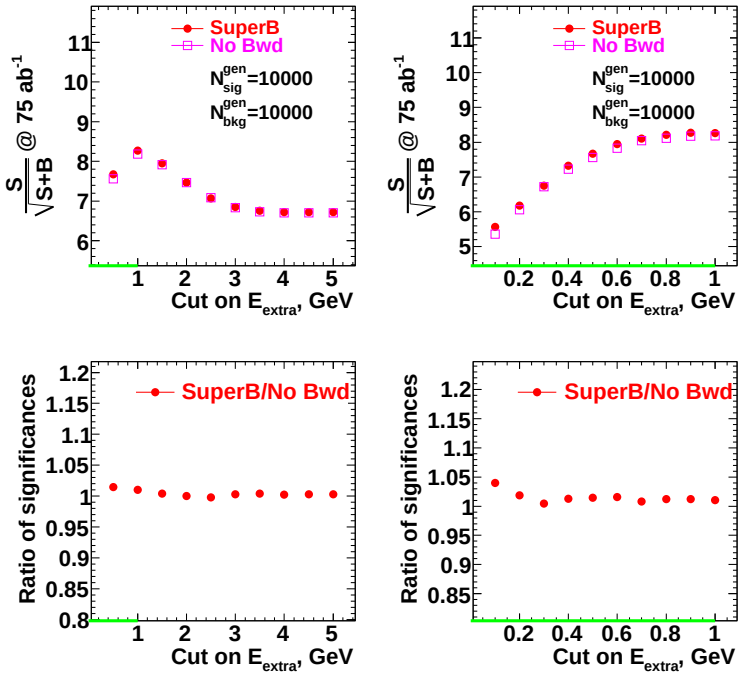
$S/\sqrt{S+B}$



Cut on E_{extra}

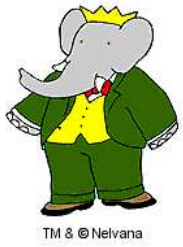


Cut on E^{corr}_{extra}



- $S/\sqrt{S+B}$ ratio is about 2%-3% better with bwd EMC

Conclusion



- We developed cuts for separating signal and background π^0's and ρ's are
- We generated 4 bkg MC samples (5 to go)
- In these 4 samples we saw that bwd EMC improves S/B ratio by 10%-50%
- $S/\sqrt{S+B}$ ratio improved by 2%-10%, depending on the decay generated