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

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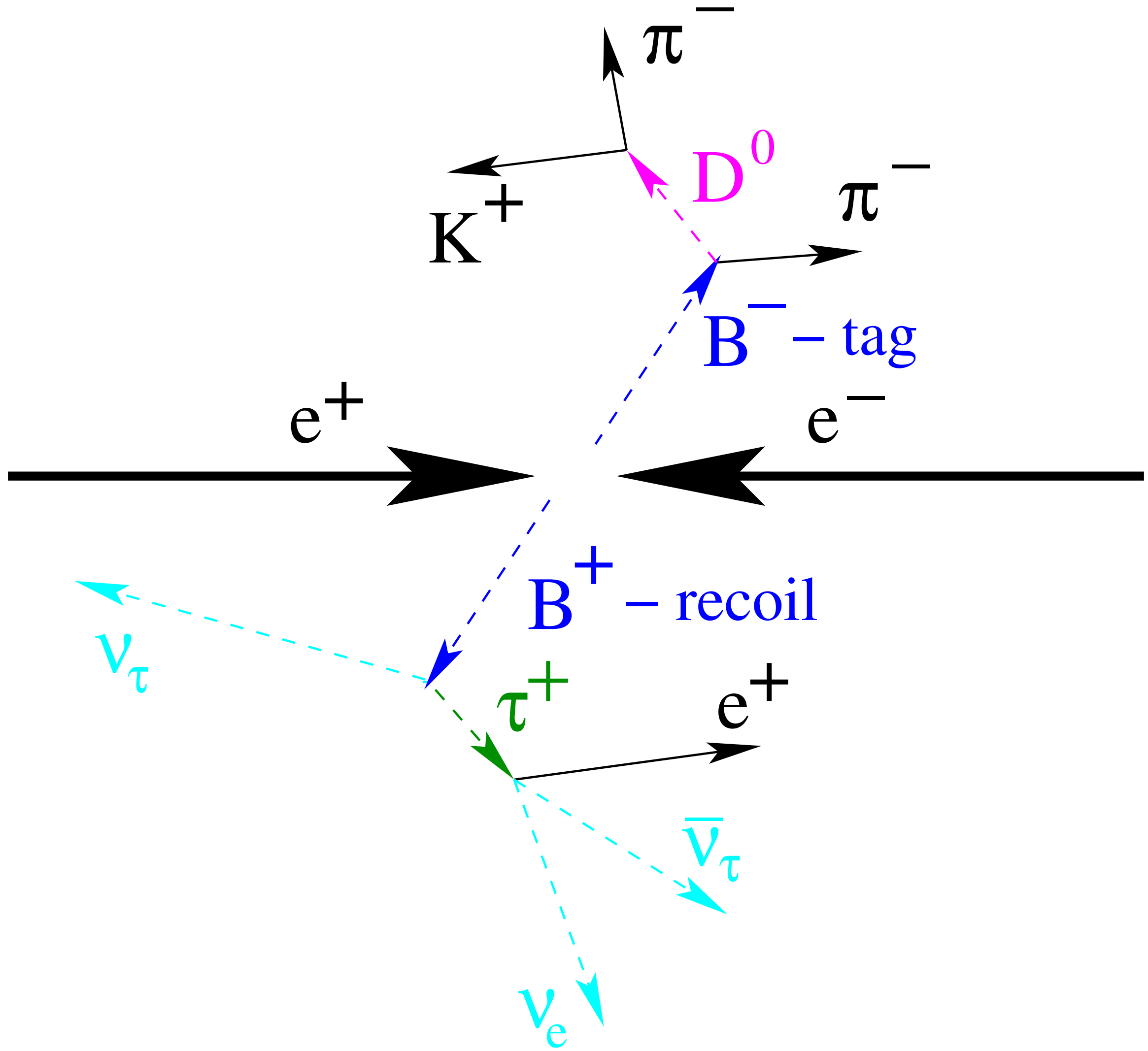
http://www.hep.caltech.edu/~arakitin/tex/2009.Dec.01.SuperB/talk.pdf

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



We use the cleanest tag $B_{tag} \to D^0\pi, D^0 \to K\pi$ for the moment

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%
	$\tau^+ \to \rho(\pi^+ \pi^0) \overline{\nu_\tau}$	25.51%
	$\tau^+ \to \pi^+ \pi^0 \pi^0 \overline{\nu_\tau}$	9.29%
	Total 1-prong	80.92%
3-prong	$\tau^+ \to a_1(\pi^+ \pi^- \pi^+) \overline{\nu_\tau}$	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%)
- Since then we were concentrating mostly on the fourth line (BF = 25.51%)
- Other lines are still to be done

Background

Background: any decay resembling $B \to \tau\nu_\tau$ decay due to lost and/or misreconstructed decay products

Let's split possible backgrounds into types of τ decay:

$\tau \to \ell\nu\nu, \pi\nu$		$\tau \to \rho(\pi\pi^0)\nu$			$\tau \to \pi 2\pi^0\nu, a_1(3\pi)\nu, 3\pi\pi^0\nu$	
Mimicking decay	Rel. BF		Mimicking decay	Rel. BF	Mimicking decay	Rel. BF
$B \to D^{(*(*))0}\ell\nu$ $B \to D^{(*)}\pi\ell\nu$ $B \to$ non-charm $\ell\nu$	$\mathcal{O}(10^2\text{-}10^3)$ $\mathcal{O}(10^2)$ $\mathcal{O}(1)$	direct ρ	$B \to D^{(*(*))0}\rho$ $B \to J/\psi\rho$ $B \to$ non-charm ρ	$\mathcal{O}(10^2\text{-}10^3)$ 1.39 $\mathcal{O}(1)$	Anything with final state $\pi 2\pi^0, 3\pi$ or $3\pi\pi^0$	???
		indirect ρ	$B \to$ stuff, stuff $\to \rho + X_{missed}$	???		
		π^0 + track	Anything with final state π^0 + track + X_{missed}	???		
			Special case: $B \to \pi^0\ell\nu$ (nothing is missed)	0.55		
Done, ~ 8% improvement in $S/\sqrt{S+B}$ due to bwd EMC		Partially done, ~ 10% imp. for direct ρ, need generic MC for the rest			Definitely need generic MC	

- Overwhelming background contributions are balanced by low probability to loose the decay products
- Backward EMC diminishes this probability even further

Now, after seeing the final results, let's look at the details...

Analysis strategy

☞ Reconstruct B_{tag}:

- Start with $D^0 \to K\pi$ (both are from `GoodTracksLoose` list) fitted with `Cascade` + `Geo` constraints
- 1.833 GeV$/c^2 < m(D^0) < 1.893$ GeV$/c^2$
- Add π track from `GoodTracksLoose` list
- 5.2 GeV$/c^2 < m_{ES} < 5.3$ GeV$/c^2$, -0.1 GeV $< \Delta E < 0.1$ GeV

☞ Require only one additional track (1-prong τ decay) and $Q_{tot} = 0$

- In the future we will add 3-track requirement for 3-prong τ decays

☞ Calculate E_{extra} as a sum of all clusters in EMC, not associated with tracks

- Use this E_{extra} as main discriminator between signal and background

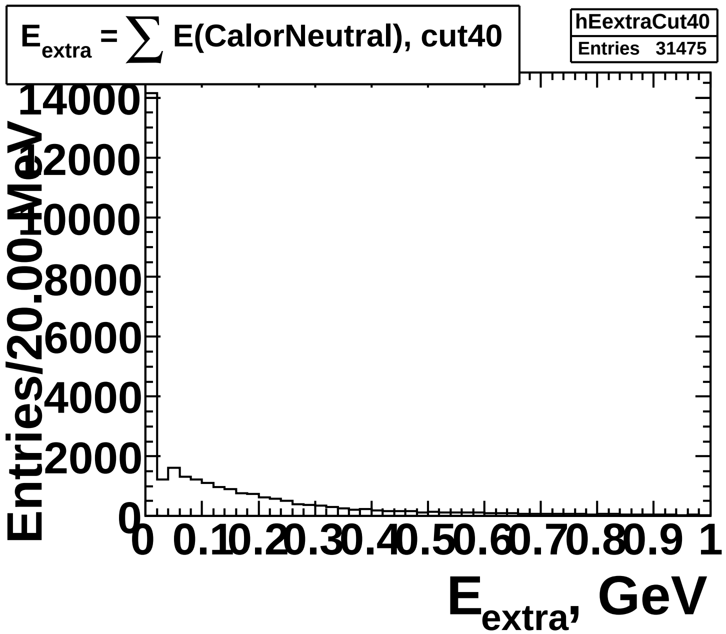
☞ $\tau \to \rho\nu_\tau$ decay: if good $\pi^0 \to \gamma\gamma$ and good $\rho \to \pi\pi^0$ candidate found then remove these photons from $E_{extra} \Longrightarrow$ obtain E_{extra}^{corr}

- In the future we will extend this correction onto $\pi 2\pi^0$, 3π and $3\pi\pi^0$

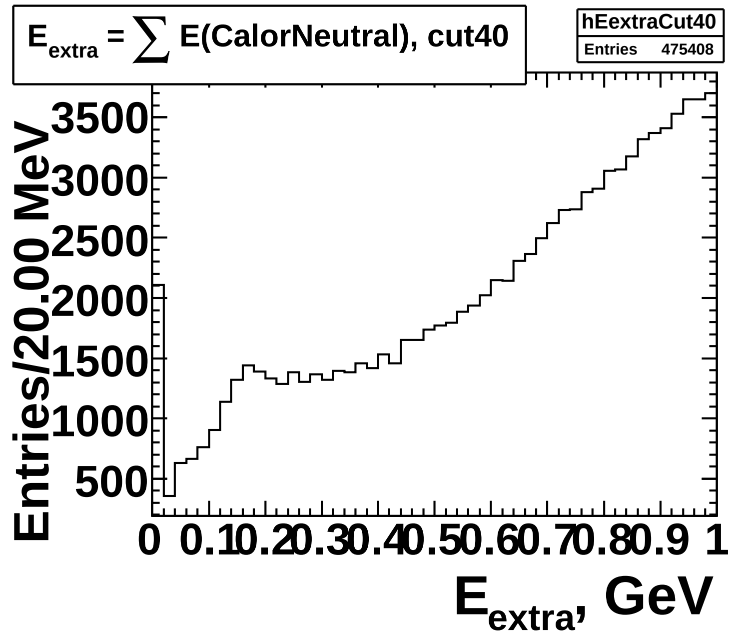
$\boldsymbol{\tau \longrightarrow 1\text{-}prong}$

E_{extra} for $\tau \to \ell\nu_\ell\nu_\tau$ and $\tau \to \pi\nu_\tau$

Sig $: B \to \tau\nu_\tau, \tau \to 1\text{-}prong$

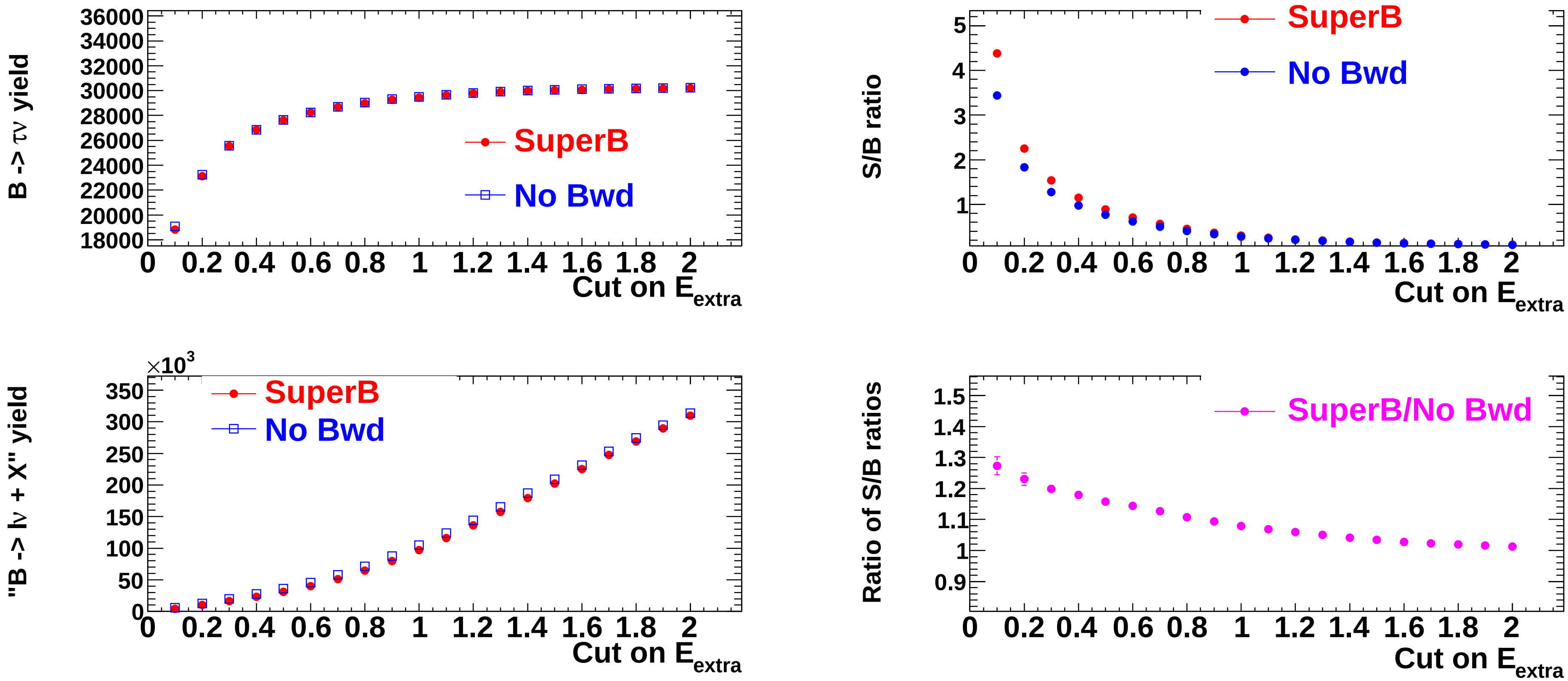


Bkg $: B \to \ell\nu_\ell X_{missed}$



By cutting on E_{extra} we can improve S/B ratio

S/B for $\tau \to \ell\nu_\ell\nu_\tau$ and $\tau \to \pi\nu_\tau$



Backward EMC improves S/B ratio by about 20%

$\frac{S}{\sqrt{S+B}}$ for $\tau \to \ell\nu_\ell\nu_\tau$ and $\tau \to \pi\nu_\tau$

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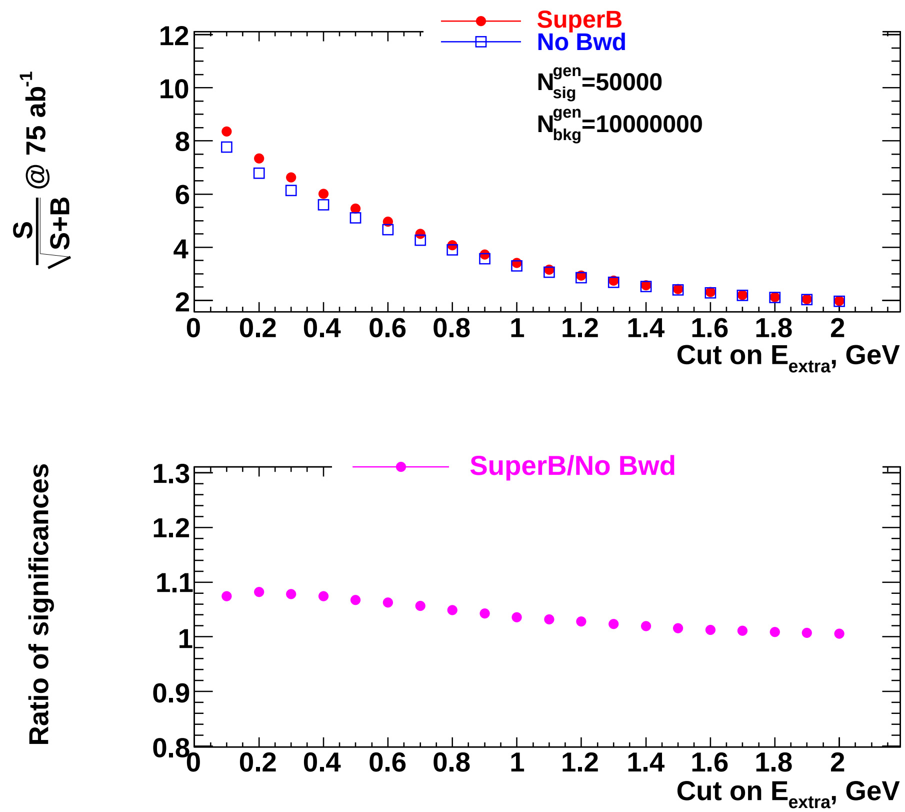
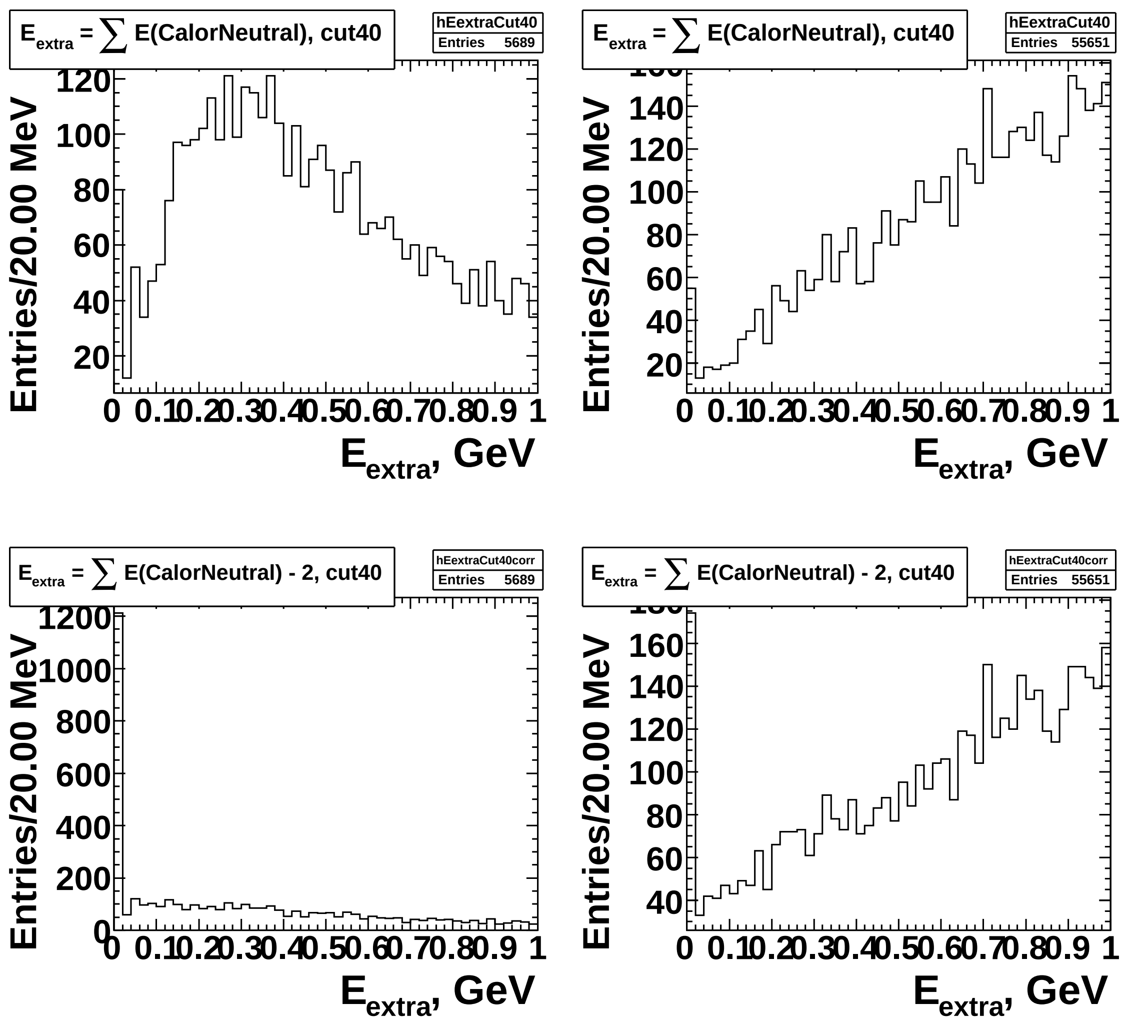


Backward EMC improves $\frac{S}{\sqrt{S+B}}$ by about 7-8%

$$\tau \longrightarrow \rho\nu_\tau$$

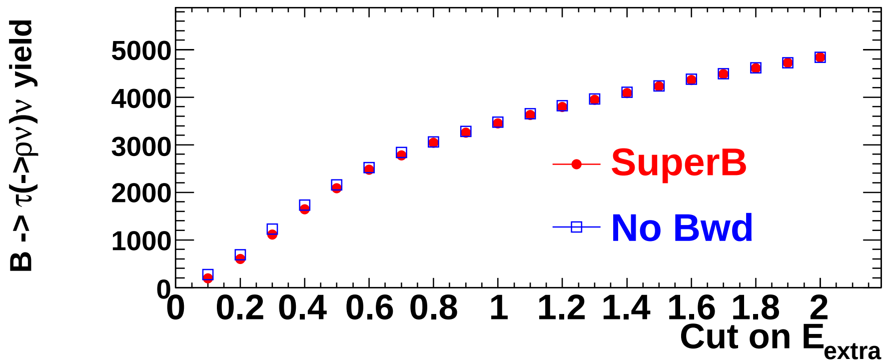
E_{extra} for $\tau \rightarrow \rho\nu_\tau$

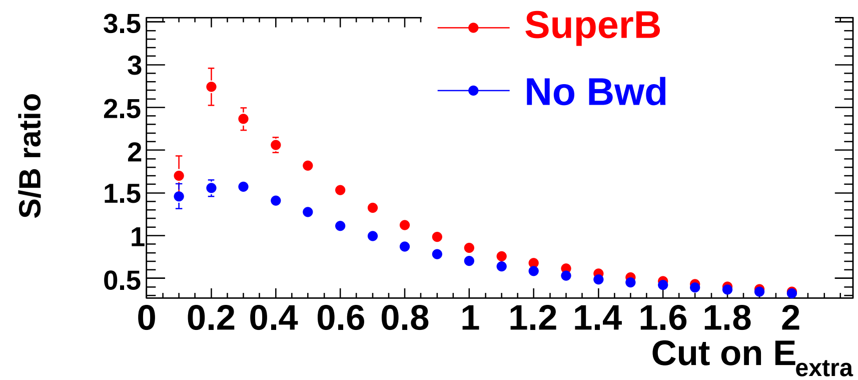
Sig $: B \rightarrow \tau\nu_\tau, \tau \rightarrow \rho\nu_\tau$ Bkg $: B \rightarrow \rho + X_{missed}$

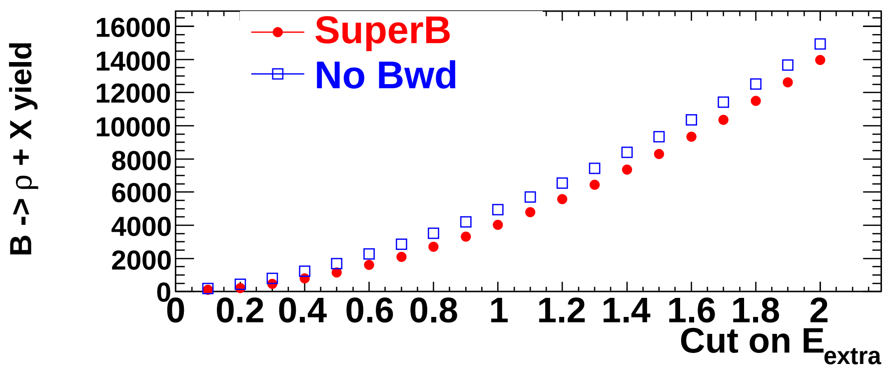


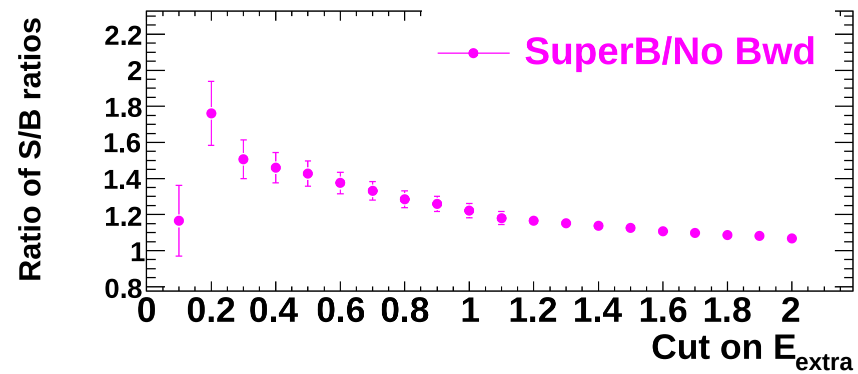
By correcting E_{extra} we can improve the discrimination power

S/B for $\tau \to \rho\nu_\tau$



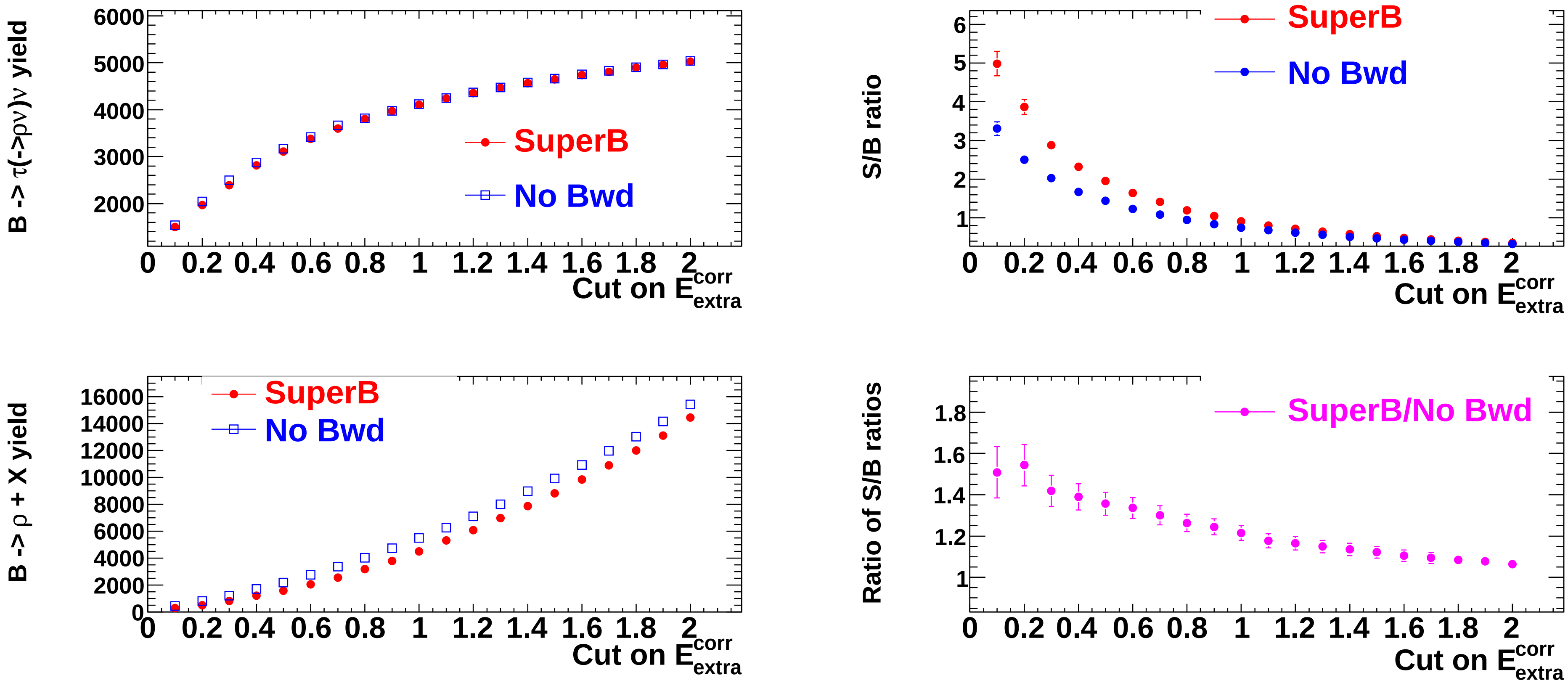






Cut on E_{extra} means "photons coming from ρ **are not** subtracted"

S/B for $\tau \to \rho\nu_\tau$

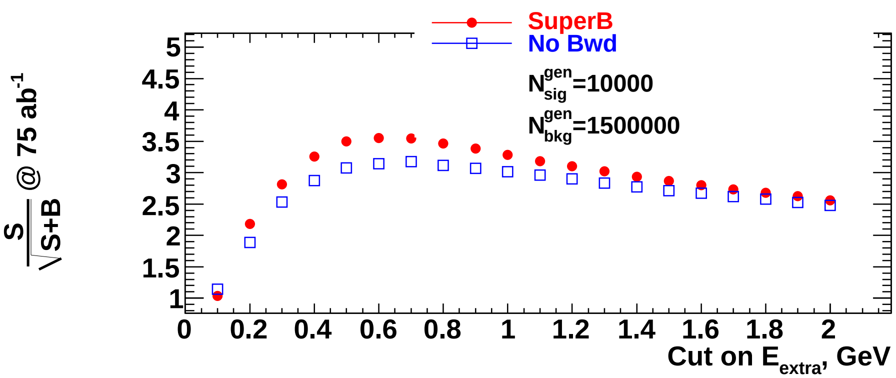


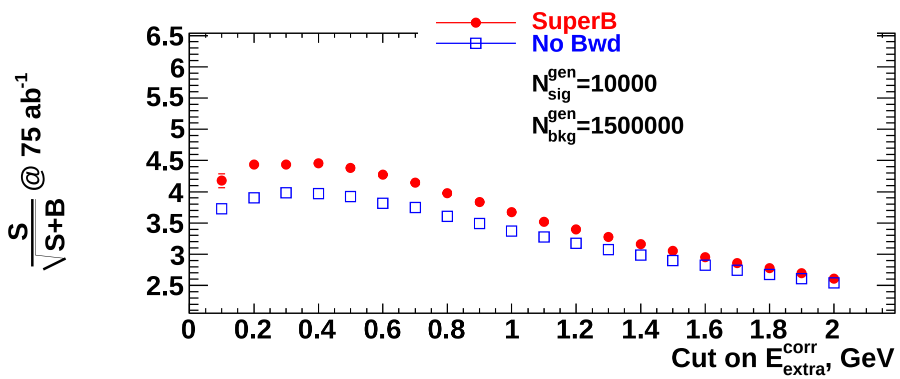
Cut on E_{extra}^{corr} means "photons coming from ρ **are** subtracted"

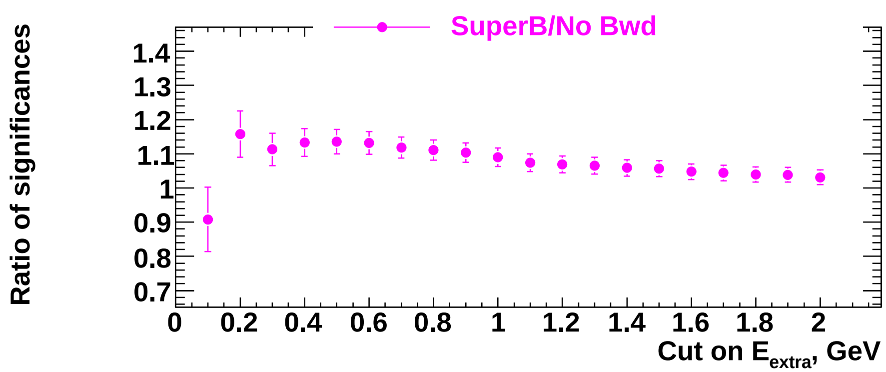
Backward EMC improves S/B ratio by about 40-50%

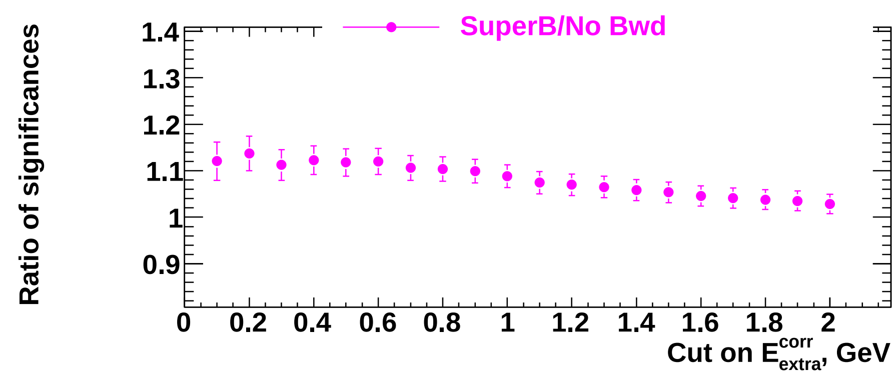
$S/\sqrt{S+B}$ for $\tau \to \rho\nu_\tau$

Before correction | After correction







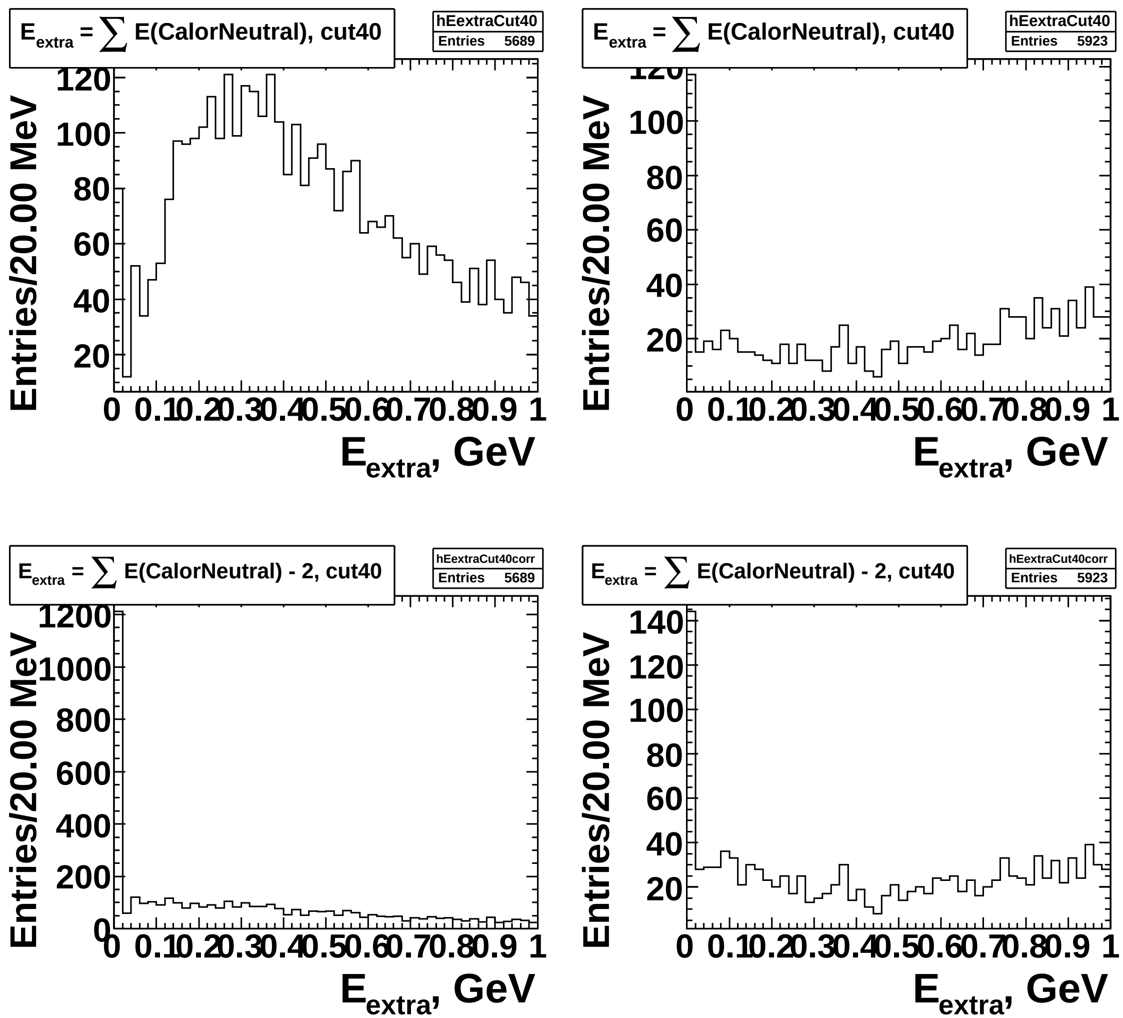


Backward EMC improves $\frac{S}{\sqrt{S+B}}$ by about 12%

Special bkg: $B \to \pi^0 \ell \nu_\ell$

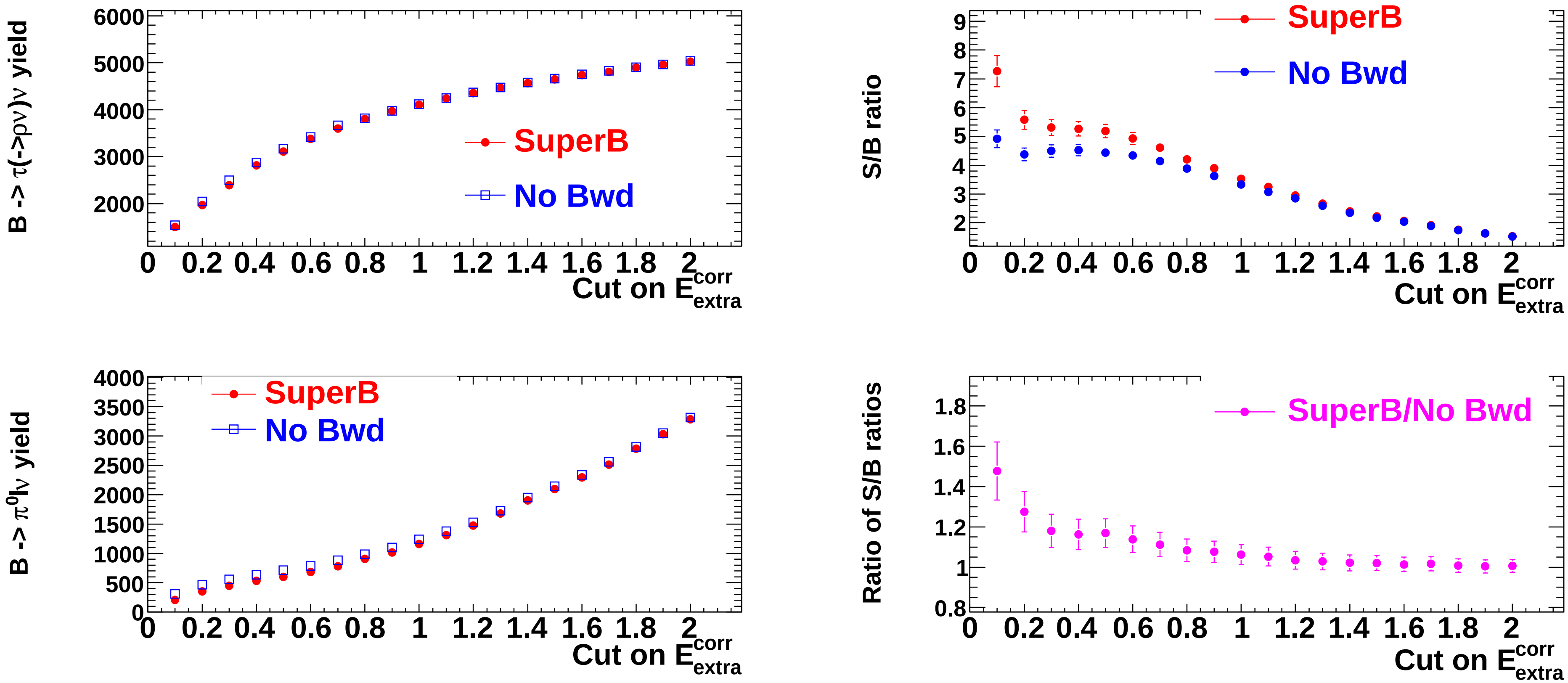
E_{extra}

Sig: $B \to \tau\nu_\tau, \tau \to \rho\nu_\tau$ Bkg: $B \to \pi^0 \ell \nu_\ell$



Large effect on signal, small effect on background

S/B for $\tau \to \rho\nu_\tau$ and $B \to \pi^0\ell\nu_\ell$



20% improvement in S/B ratio

$\frac{S}{\sqrt{S+B}}$ for $\tau \to \rho\nu_\tau$ and $B \to \pi^0\ell\nu_\ell$

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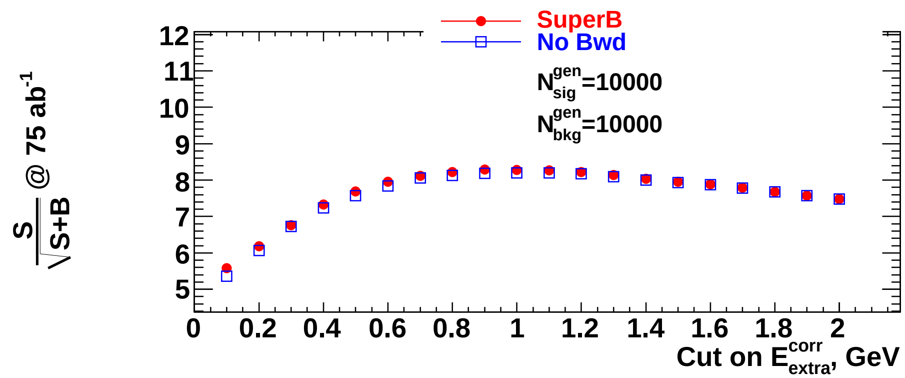

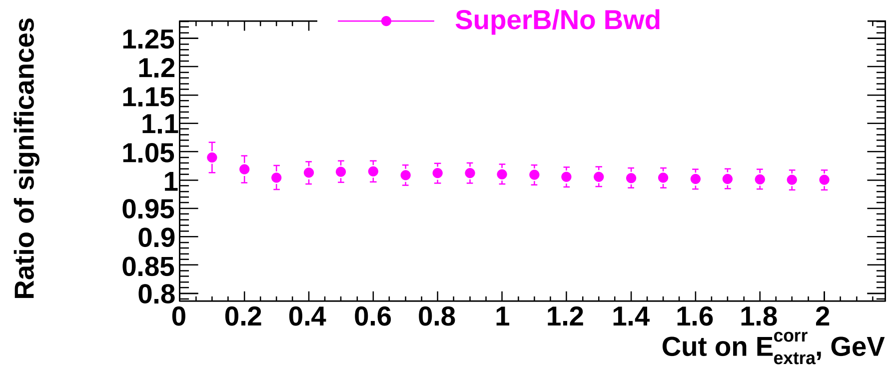

Very small improvement in $\frac{S}{\sqrt{S+B}}$

Conclusion

☞ We looked at $B \to \tau\nu_\tau$ with $\tau \to 1\text{-}prong$

- Backward EMC improves S/B ratio by about 20%
- $S/\sqrt{S+B}$ is improved by about 8%

☞ We also looked at $B \to \tau\nu_\tau$ with $\tau \to \rho\nu$

- Backward EMC improves S/B ratio by about 40-50%
- $S/\sqrt{S+B}$ is improved by about 12%

☞ We also looked at special background $B \to \pi^0\ell\nu_\ell$ where nothing is missing

- S/B ratio improves by about 20%
- $S/\sqrt{S+B}$ almost not improved

☞ Need generic MC to look at other cases