

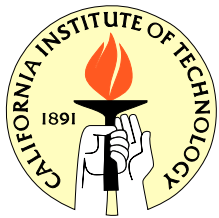
**Backward EMC for  $B \rightarrow \tau \nu_\tau$  Decay  
With Hadronic Tag  $B$**

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Caltech

May 29, 2011

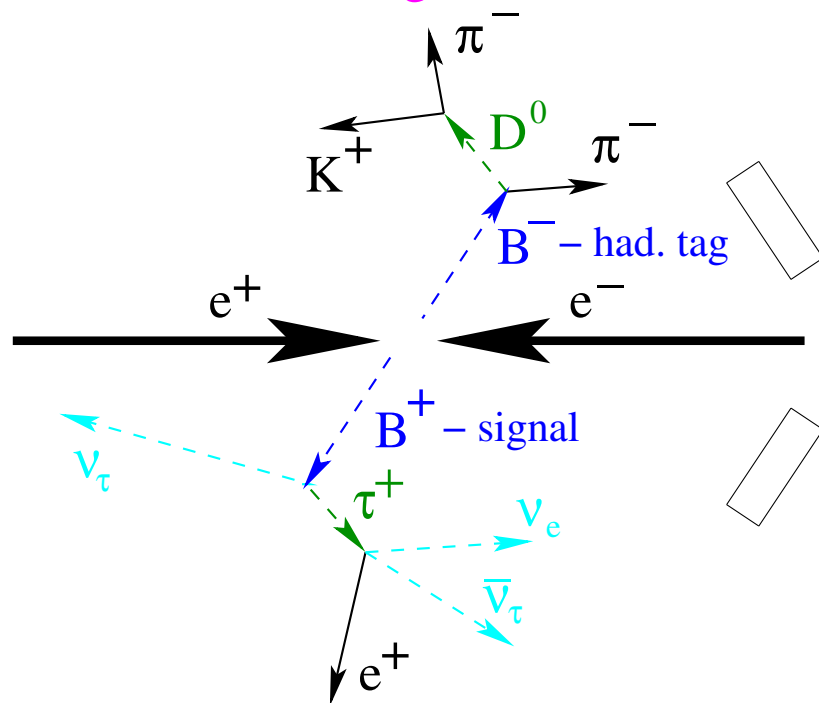
XVII SuperB General Meeting



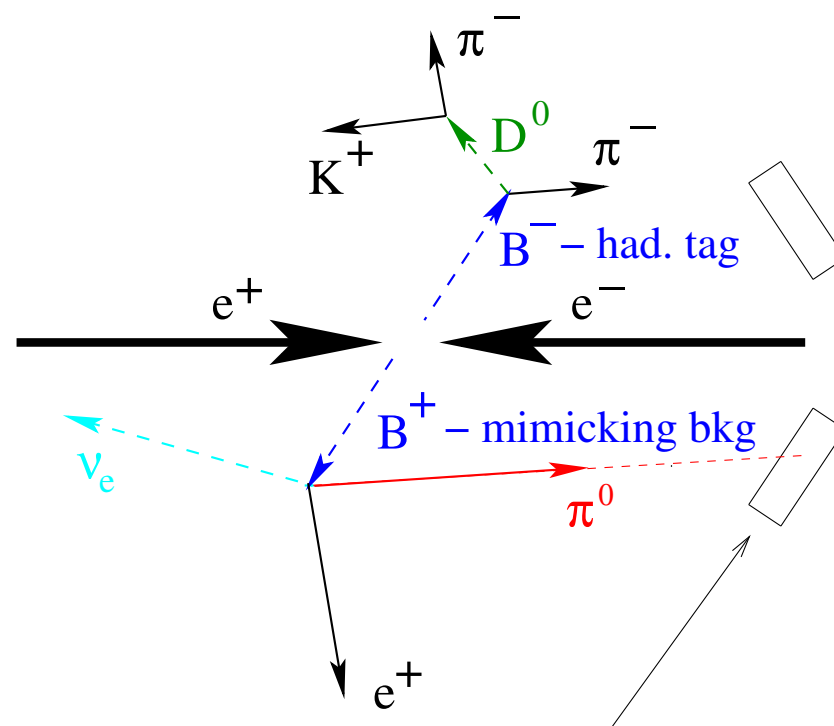
# $B \rightarrow \tau \nu_\tau$ Event



True signal event

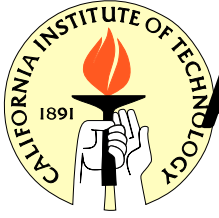


Mimicking bkg event



Without Backward EMC  
 $\pi^0$  may escape detection

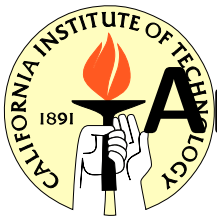
Reminder: The purpose of Backward EMC is to help better distinguish between signal and mimicking background by detecting (otherwise lost) photons



# Analysis Strategy - I (no Bwd EMC)

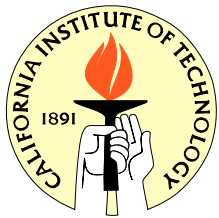


- Generate  $B^+B^-$  Monte Carlo with FastSim V0.2.6 and V0.2.7 pre-compiled executables and V0.2.7 with the latest patches applied (i.e. all(?) bugs fixed) for DG\_4 and MixSuperbBkg\_NoPair for different decays of  $B_{tag}$  and  $B_{recoil}$
- Reconstruct  $B_{tag}$  and  $B_{recoil}$  with PacHadRecoilUser package
- Select only  $B_{tag}$  with minimum  $\Delta E$  (one or more per event)
- Plot  $m_{ES}(B_{tag})$  and fit it with Crystal Ball (sig) + Argus (bkg) to get  $B_{tag}$  yield
- Obtain yields for signal ( $S$ ) and mimicking background ( $B$ ) decays of  $B_{recoil}$
- Calculate  $S/B$  ratio and  $S/\sqrt{S+B}$  at  $75 \text{ ab}^{-1}$  **without using Backward EMC info (reference values)**
- In particular, ensure that  $B_{tag}$  and  $B_{recoil}$  reconstruction does not include bwd photons with  $\cos\theta < -0.8$



# Analysis Strategy - II (with Bwd EMC)

- Calculate changes in  $S/B$  ratio and  $S/\sqrt{S+B}$  at  $75 \text{ ab}^{-1}$  using **Backward EMC info**
- Calculate  $E_{extra}$  in Bwd EMC for 6 different thresholds: none, 20, 30, 50, 70, 100 MeV  
☞ Thus every plot comes in 6 copies
- Obtain reconstruction efficiencies for signal and mimicking background decays of  $B_{recoil}$ , as well as  $S/B$  ratio and  $S/\sqrt{S+B}$  at  $75 \text{ ab}^{-1}$  **as functions of cut on  $E_{extra}$**
- Compare to reference values without Bwd EMC, obtain 6 rel. differences **as functions of cut on  $E_{extra}$**
- Quote **maximum value** of these 6 functions as final result for this combination of signal and mimicking background decays of  $B_{recoil}$
- Repeat for different signal and mimicking background decays of  $B_{recoil}$
- Repeat for FastSim V0.2.6, V0.2.7 pre-compiled executables and V0.2.7 with the latest patches applied, to see the difference
- Check if bwd photons with  $\cos\theta < -0.8$  can be used in in  $B_{tag}$  and  $B_{recoil}$  reconstruction (according to the latest news from Chih-hsiang)



# $\tau$ reconstruction



Sig $B_{sig} \rightarrow \tau\nu$ decay	$\tau$ BF from PDG	Mimicking bkg
$B_{sig} \rightarrow \tau\nu, \tau \rightarrow e\nu\nu$	17.36%	$B \rightarrow e\nu + X$
$B_{sig} \rightarrow \tau\nu, \tau \rightarrow \mu\nu\nu$	17.85%	$B \rightarrow \mu\nu + X$
$B_{sig} \rightarrow \tau\nu, \tau \rightarrow \pi\nu$	10.91%	$B \rightarrow \pi + X$
$B_{sig} \rightarrow \tau\nu, \tau \rightarrow \rho\nu$	25.51%	$B \rightarrow \rho + X$
$B_{sig} \rightarrow \tau\nu, \tau \rightarrow a_1\nu$	9.32%	$B \rightarrow a_1 + X$
$B_{sig} \rightarrow \tau\nu, \tau \rightarrow \pi 2\pi^0\nu$	9.29%	$B \rightarrow \pi 2\pi^0 + X$
$\tau \rightarrow 6$ modes	90.24%	$B \rightarrow$ anything

- $X$  - any lost particle(s). Rare loss of particles compensated by large relative BF of the process involving  $X$  w.r.t. signal decay  $B \rightarrow \tau\nu$

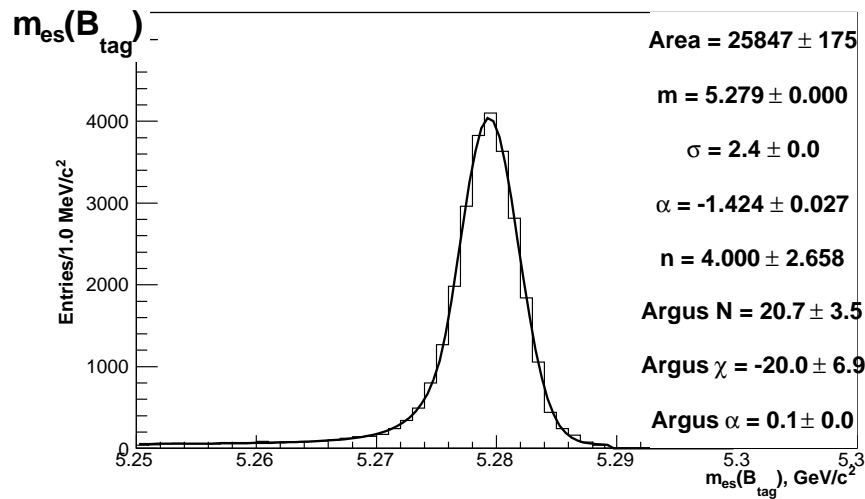


**Sig:**  $B_{recoil} \rightarrow \tau\nu, \tau \rightarrow \mu\nu\nu$

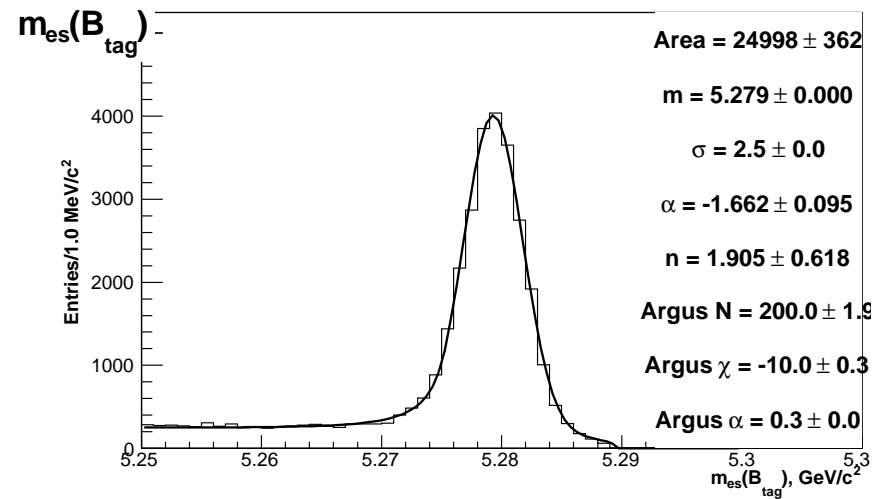
**Bkg:**  $B_{recoil} \rightarrow \pi^0\mu\nu$

Bkg: very special case with almost the same branching and only two extra photons

$m_{ES}$  in signal sample



$m_{ES}$  in bkg sample



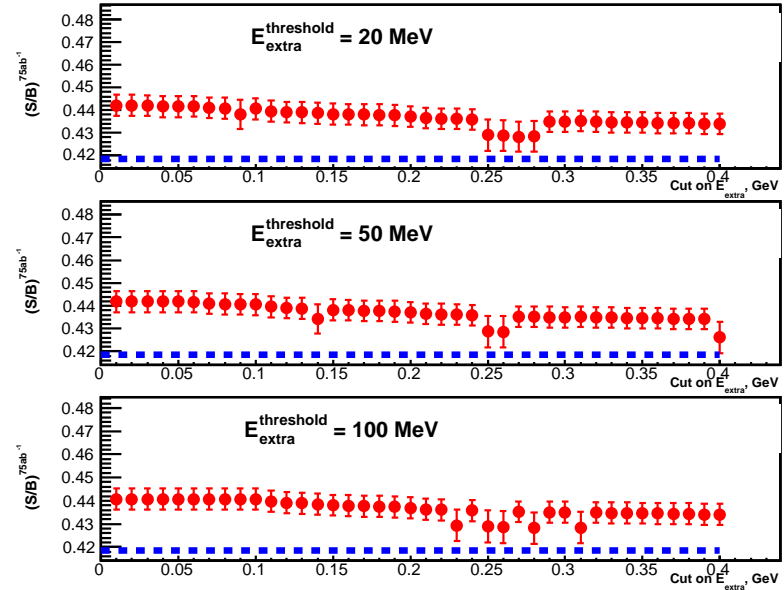
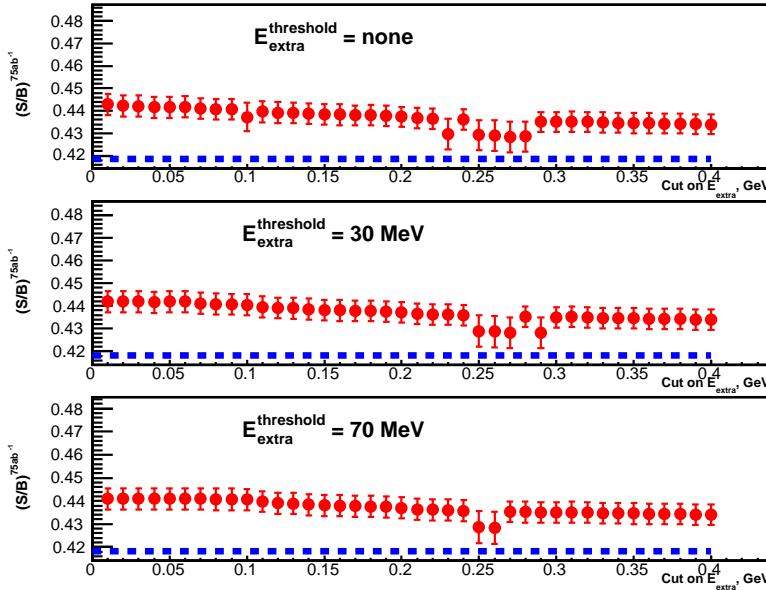
- Cut on different values of  $E_{extra}$  in Backward EMC
- Fit for the peak yield after each cut
- Plot peak yields vs. cut values



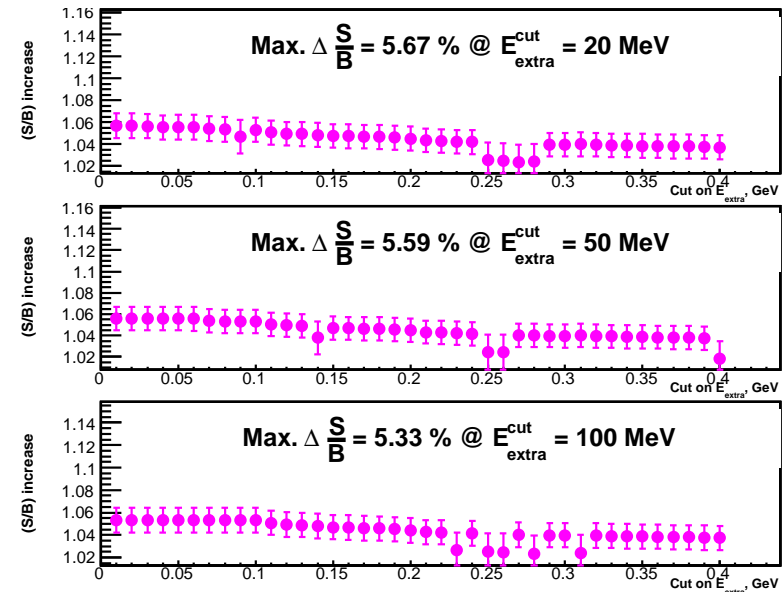
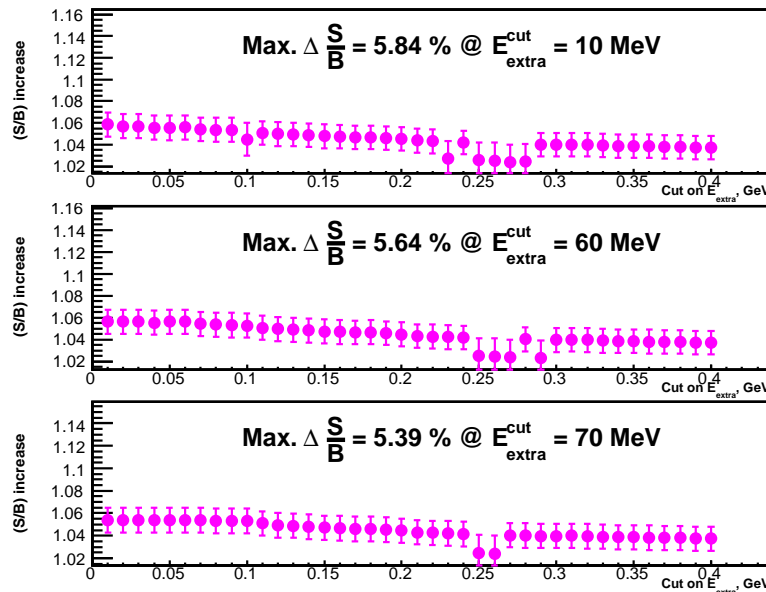
# $S/B$ ratio at $75 \text{ ab}^{-1}$

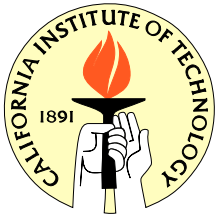


Absolute value



Relative increase

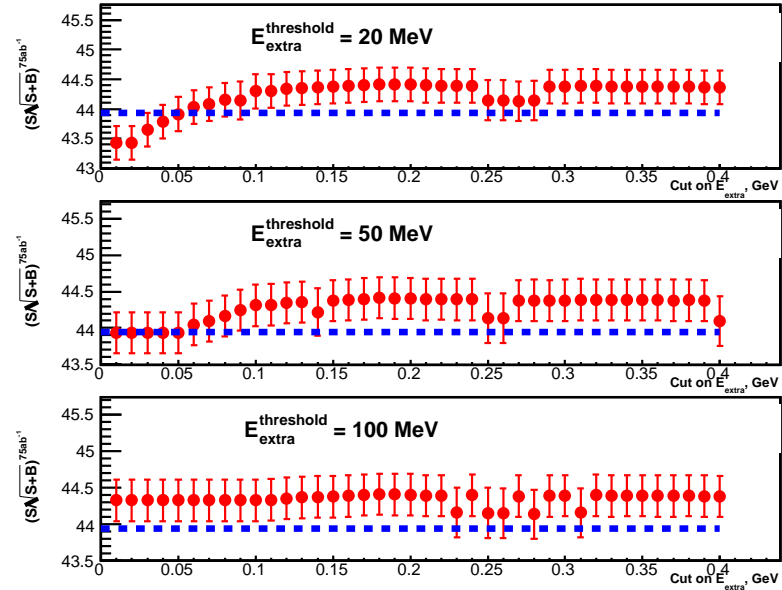
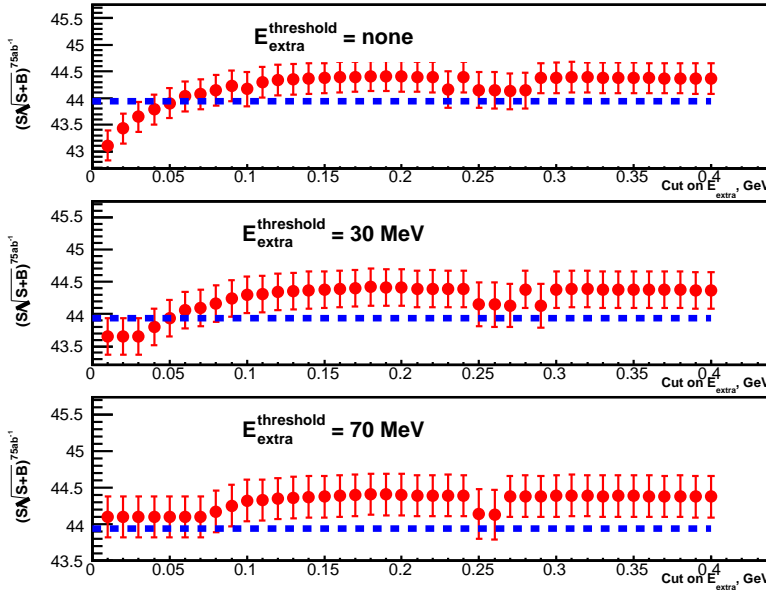




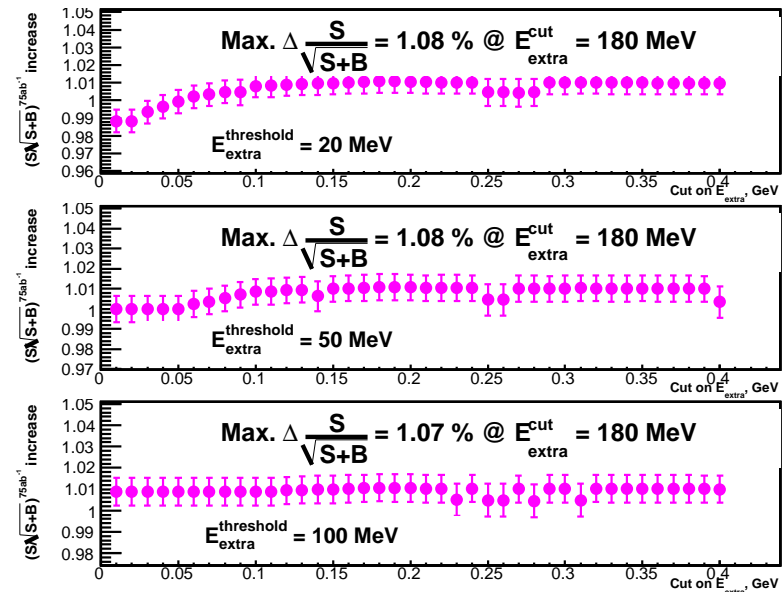
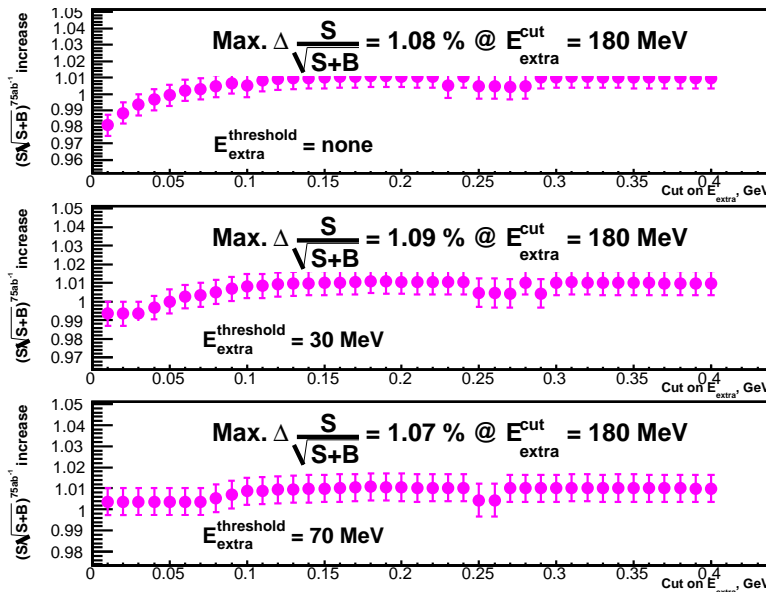
# $S/\sqrt{S+B}$ at $75 \text{ ab}^{-1}$



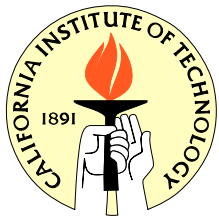
Absolute value



Relative increase







# Bwd EMC influence



Sig	Mimicking background HC = Had. Cocktail (V0.2.4)	Max. $\Delta S/B$ , %		Max. $\Delta S/\sqrt{S+B}$ , %	
		V0.2.6	V0.2.7	V0.2.6	V0.2.7
$\mu\nu$ $\tau$	$B_{recoil} \rightarrow \pi^0 \mu\nu$	$5.84 \pm 1.13$	$4.04 \pm 1.49$	$1.09 \pm 0.65$	$0.62 \pm 0.84$
	$B_{recoil} \rightarrow \mu\nu X$	$15.14 \pm 1.83$	$15.31 \pm 3.15$	$3.97 \pm 1.02$	$4.27 \pm 1.62$
	$B_{recoil} \rightarrow \tau\nu X, \tau \rightarrow \mu\nu$	$12.26 \pm 1.94$	$12.62 \pm 2.14$	$2.34 \pm 1.03$	$3.53 \pm 1.25$
	$B_{recoil} \rightarrow HC$	$16.75 \pm 0.81$	$16.61 \pm 1.05$	$4.76 \pm 0.73$	$5.11 \pm 0.94$
$e\nu$ $\tau$	$B_{recoil} \rightarrow \pi^0 e\nu$	$4.97 \pm 1.35$	$3.79 \pm 1.94$	$0.53 \pm 0.73$	$0.17 \pm 0.93$
	$B_{recoil} \rightarrow e\nu X$	$14.21 \pm 1.88$	$14.16 \pm 2.05$	$3.47 \pm 1.04$	$3.36 \pm 1.22$
	$B_{recoil} \rightarrow \tau\nu X, \tau \rightarrow e\nu$	$12.39 \pm 1.98$	$10.86 \pm 2.36$	$2.47 \pm 1.07$	$1.72 \pm 1.36$
	$B_{recoil} \rightarrow HC$	$16.66 \pm 0.81$	$15.92 \pm 1.06$	$4.68 \pm 0.73$	$4.22 \pm 0.93$
$\pi\nu$ $\tau$	$B_{recoil} \rightarrow X$	$21.71 \pm 0.97$	$21.01 \pm 1.06$	$6.69 \pm 0.77$	$6.61 \pm 0.85$
	$B_{recoil} \rightarrow \tau\nu X, \tau \rightarrow \pi\nu$	$12.08 \pm 1.85$	$11.97 \pm 2.00$	$2.82 \pm 1.04$	$3.02 \pm 1.13$
	$B_{recoil} \rightarrow HC$	$16.95 \pm 0.81$	$16.50 \pm 0.92$	$4.94 \pm 0.73$	$5.10 \pm 0.82$
$\rho\nu$ $\tau$	$B_{recoil} \rightarrow X$	$16.61 \pm 1.26$	$16.96 \pm 1.24$	$2.31 \pm 1.03$	$3.26 \pm 1.07$
	$B_{recoil} \rightarrow \tau\nu X, \tau \rightarrow \rho\nu$	$13.05 \pm 2.18$	$14.60 \pm 2.15$	$0.98 \pm 1.29$	$2.29 \pm 1.29$
	$B_{recoil} \rightarrow HC$	$12.10 \pm 1.12$	$12.60 \pm 1.11$	$0.59 \pm 1.00$	$1.95 \pm 1.03$
$a_1\nu$ $\tau$	$B_{recoil} \rightarrow X$	$21.10 \pm 1.10$	$20.43 \pm 1.48$	$6.10 \pm 0.89$	$6.15 \pm 1.24$
	$B_{recoil} \rightarrow \tau\nu X, \tau \rightarrow a_1\nu$	$15.91 \pm 2.62$		$3.98 \pm 1.37$	
	$B_{recoil} \rightarrow HC$	$16.30 \pm 0.95$	$4.35 \pm 0.86$	$15.95 \pm 1.35$	$4.53 \pm 1.18$
$\pi^0\nu$ $\tau$	$B_{recoil} \rightarrow X$	$12.84 \pm 1.53$	$11.57 \pm 1.81$	$-0.72 \pm 1.20$	$-0.89 \pm 1.50$
	$B_{recoil} \rightarrow \tau\nu X, \tau \rightarrow \pi^0\nu$	$17.19 \pm 2.57$		$1.10 \pm 1.53$	
	$B_{recoil} \rightarrow HC$	$8.67 \pm 1.41$	$7.42 \pm 1.69$	$-1.37 \pm 1.18$	$-1.61 \pm 1.48$



# Bwd EMC influence:

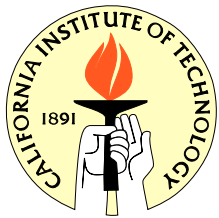


## Via cut on $E_{extra}$ only

Signal	Mimicking background HC = Had. Cocktail (V0.2.4)	Max. $\Delta S/B$ , %			Max. $\Delta S/\sqrt{S+B}$ , %		
		V0.2.6	V0.2.7	Latest	V0.2.6	V0.2.7	Latest
$\downarrow$	$B_{recoil} \rightarrow X$	<b>18.99 <math>\pm</math> 1.01</b>	<b>18.25 <math>\pm</math> 1.04</b>	<b>18.01 <math>\pm</math> 1.18</b>	<b>4.57 <math>\pm</math> 0.81</b>	<b>4.33 <math>\pm</math> 0.84</b>	<b>4.57 <math>\pm</math> 0.95</b>
$\uparrow$	$B_{recoil} \rightarrow \tau\nu X, \tau \rightarrow 6$	12.87 $\pm$ 2.00	12.65 $\pm$ 2.05		1.74 $\pm$ 1.10	2.08 $\pm$ 1.14	
$\tau$	$B_{recoil} \rightarrow HC$	<b>14.63 <math>\pm</math> 0.86</b>	<b>13.85 <math>\pm</math> 0.90</b>	<b>13.85 <math>\pm</math> 1.05</b>	<b>2.86 <math>\pm</math> 0.77</b>	<b>2.81 <math>\pm</math> 0.80</b>	<b>3.07 <math>\pm</math> 0.91</b>

## Including bwd photons into reconstruction

Signal	Mimicking background HC = Had. Cocktail (V0.2.4)	Max. $\Delta S/B$ , %			Max. $\Delta S/\sqrt{S+B}$ , %		
		V0.2.6	V0.2.7	Latest	V0.2.6	V0.2.7	Latest
$\downarrow$	$B_{recoil} \rightarrow X$	<b>19.04 <math>\pm</math> 1.01</b>	<b>18.23 <math>\pm</math> 1.03</b>	<b>18.08 <math>\pm</math> 1.18</b>	<b>4.53 <math>\pm</math> 0.81</b>	<b>4.30 <math>\pm</math> 0.84</b>	<b>4.54 <math>\pm</math> 0.95</b>
$\uparrow$	$B_{recoil} \rightarrow \tau\nu X, \tau \rightarrow 6$	12.97 $\pm$ 2.00	12.82 $\pm$ 1.98		1.73 $\pm$ 1.10	2.08 $\pm$ 1.11	



# Conclusion



- Cutting on  $E_{extra}$  in Backward EMC for V0.2.6 increases:
  - ☞  $S/B$  by  $\sim 15-20\%$  depending on  $\tau$  decay mode
  - ☞  $S/\sqrt{S+B}$  by  $\sim 3-5\%$
- Using a different FastSim version (V0.2.7) with proper energy smearing changes these numbers insignificantly
- Using the latest patches also changes these numbers insignificantly
- Using bwd photons in  $B_{tag}$  and  $B_{recoil}$  reconstruction also changes these numbers insignificantly