Background (rad.) Bhabha on EMC (fastsim)

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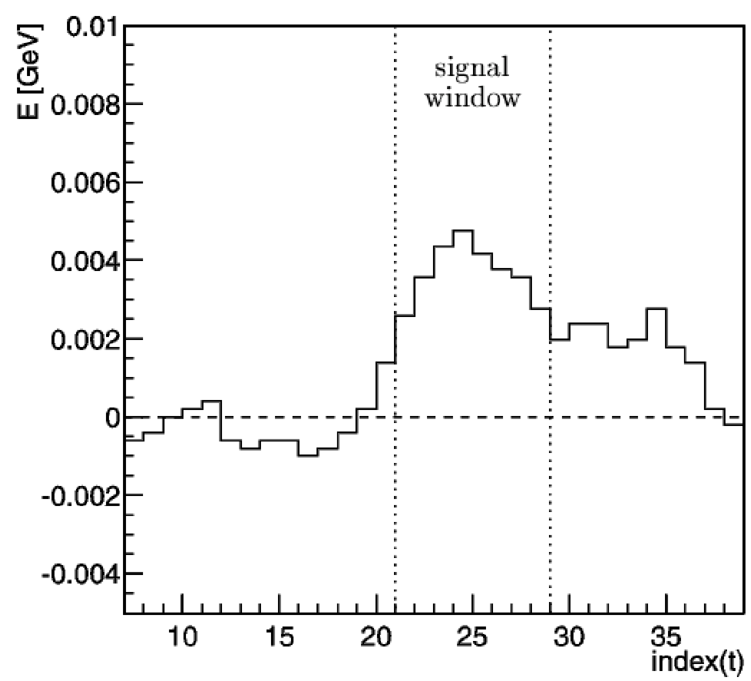
SuperB General Meeting
2010/03/16

EMC waveform

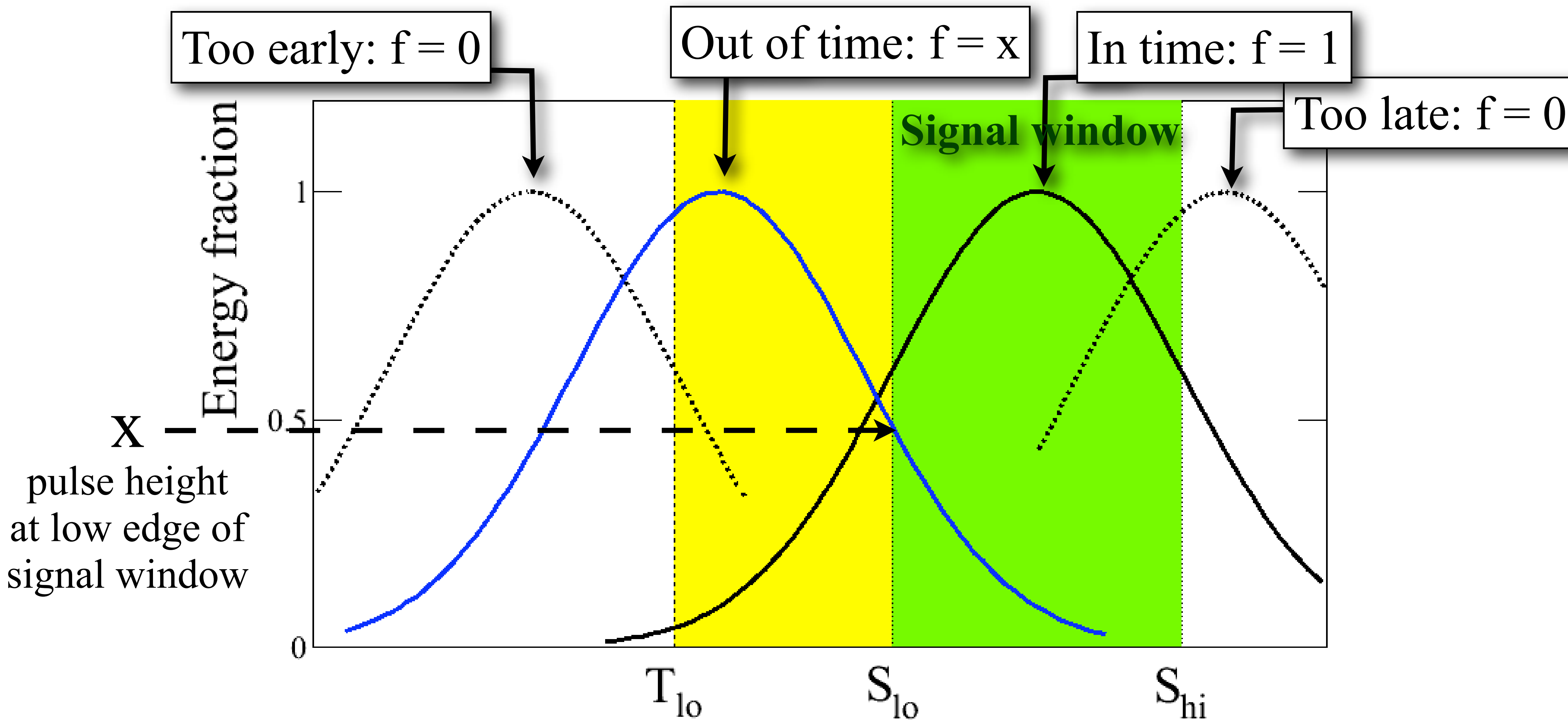
- What does BaBar do?
  - "*Upon receipt of the L1 Accept signal, data samples within a time window of ±1μs are selected for the feature extraction*" [Babar NIM sec.9.3.2].
  - After the peak in the signal window is found, a parabola is fitted using the maximum bin and its two neighbors to obtain the energy (height) and the signal time.
  - One could also search for peak before the signal window and correct for the contribution from out-of-time background. (not implemented)



Babar note 572 Figure 1: *Example waveform. The energy-time signal is digitized every 270ns. Upon trigger accept the waveform is analyzed in the signal window between sample 21 and 29.*

Fastsim model

- Waveform is modeled by a gaussian of mean t0 (simhit time) and σ.
  - physics events have t0 ~ few ns.
- The energy fraction used to create fastsim cluster depends on the time.



Parameters used in recent production

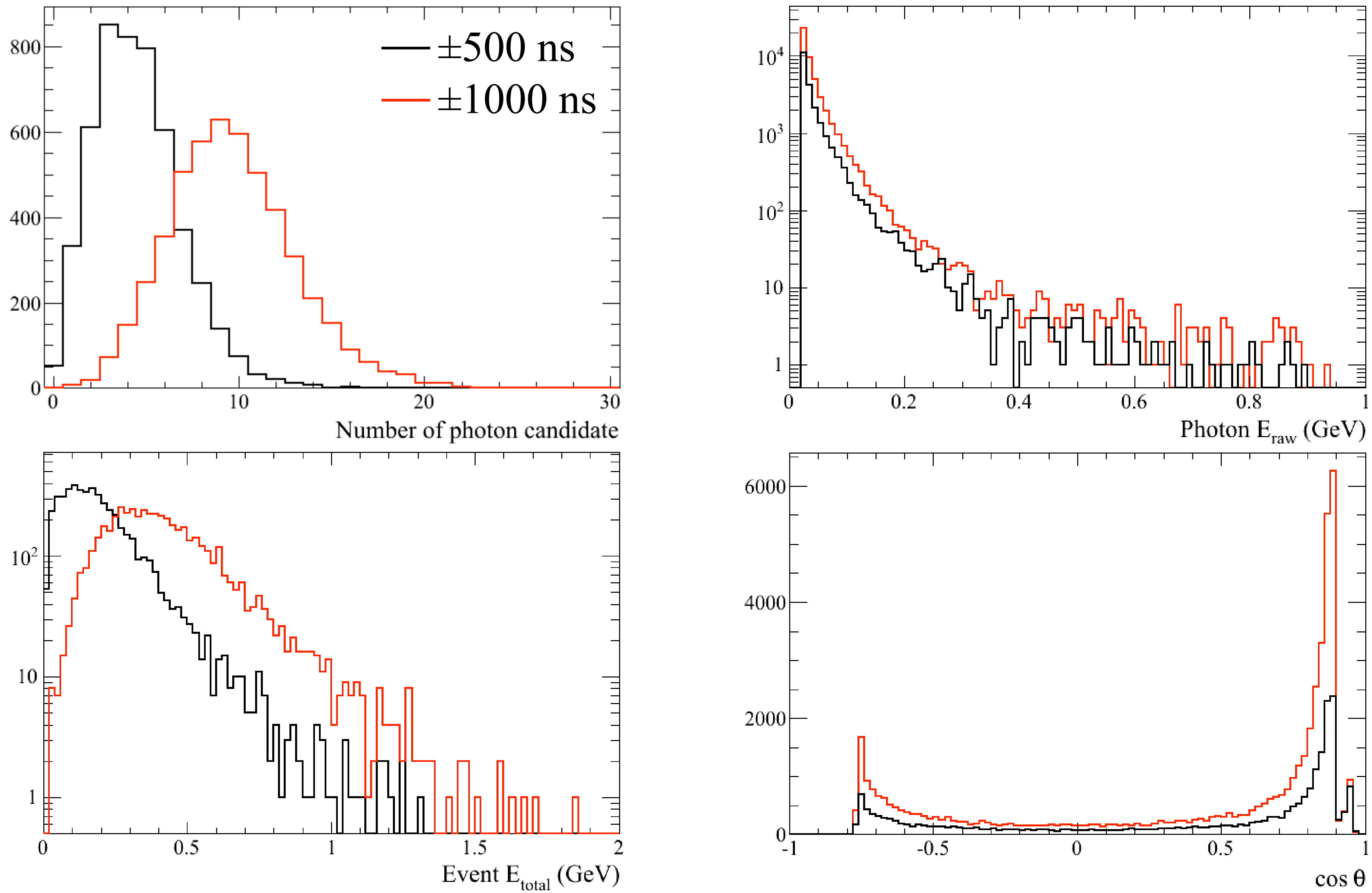
- Assume we cannot remove background if it is within1.5σ below the signal window, but can remove it completely if it happens ealier than that.
  - Reality is probably somewhat in between.
  - These parameters are used in February production.

unit = ns	Fwd	Barrel	Bwd	
σ	100	500	10	
S_hi	100	500	10	+1σ
S_lo	−100	−500	−10	−1σ
T_lo	−250	−1250	−25	−2.5σ

Rad. Bhabha generated by Geant4

- Running fast sim using *neutrino* generator with rad. Bhabha mixed in. This background is dominated by very small angle rad. Bhabhas that interact with materials.
- Assuming 200MHz (5ns) bunch crossing frequency. Number of bunches = time_window/5ns.
- Each bunch is mixed in and its time is randomized within the window.
- To simplify (and easy comparison with full sim study [Stefano]), we set T_lo = S_lo, ie., only use signal window and not scaling the energy, *for the next slide only*.
  - ±500 ns or ±1000 ns for barrel; ±100 ns for forward. Ignore backward for now
- Select: cluster raw E > 20 MeV; crystal E > 1 MeV.

Photon candidate distributions

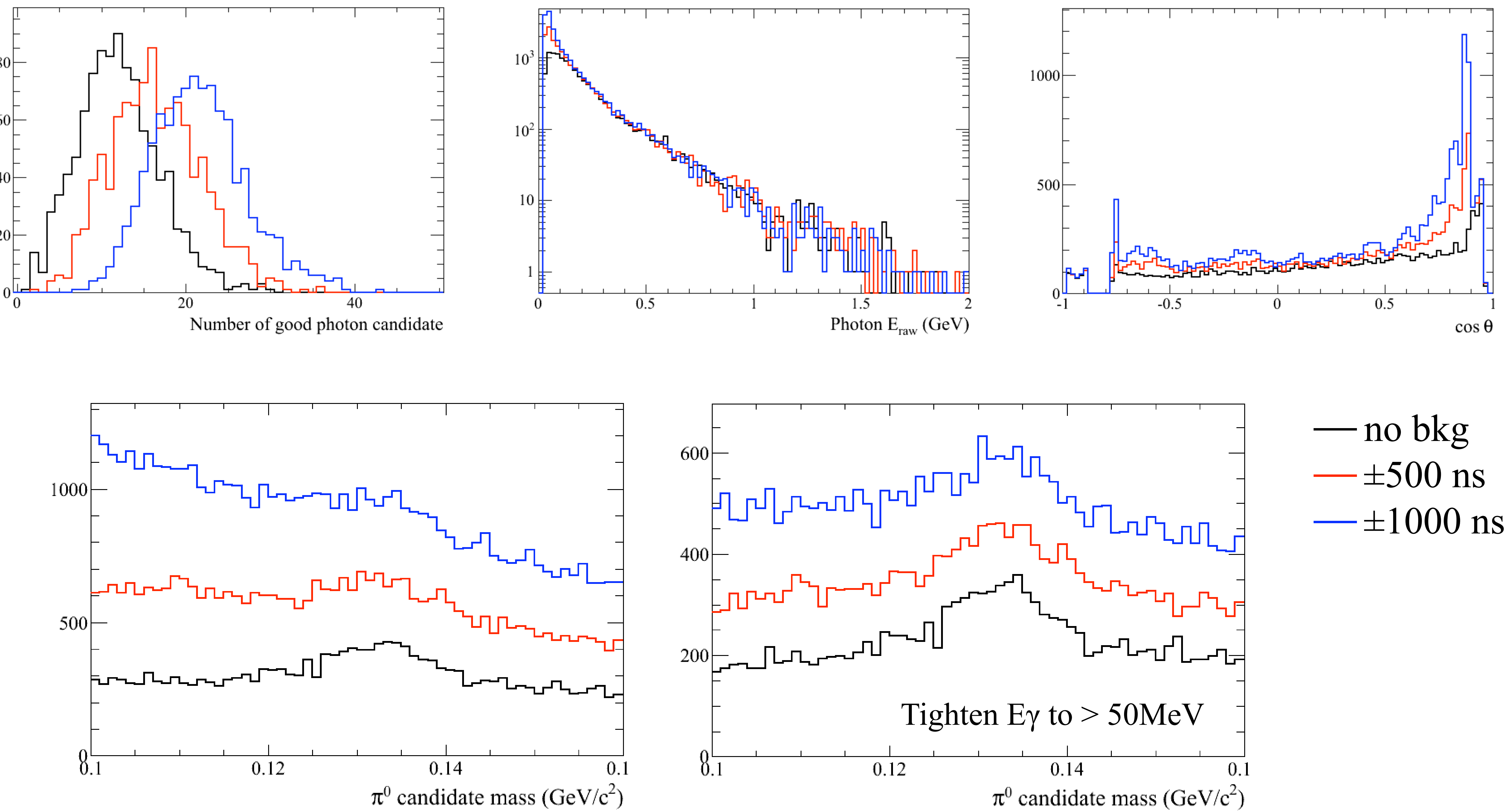


- Background photon is doubled if the window is doubled (no surprise).

Generic B0B0bar

- Generate 1000 B0B0bar generic with three configurations
  - no background
  - low-angle rad. Bhabha with barrel signal window ±500ns
  - low-angle rad. Bhabha with barrel signal window ±1000ns
- Now also include the out-of-time as used in the production.
- Good photon: E>30 MeV, 0.01 < Lat < 0.8
- Compare gamma distributions and $\pi^0 \to \gamma\gamma$ mass.

Background much worse for π^0

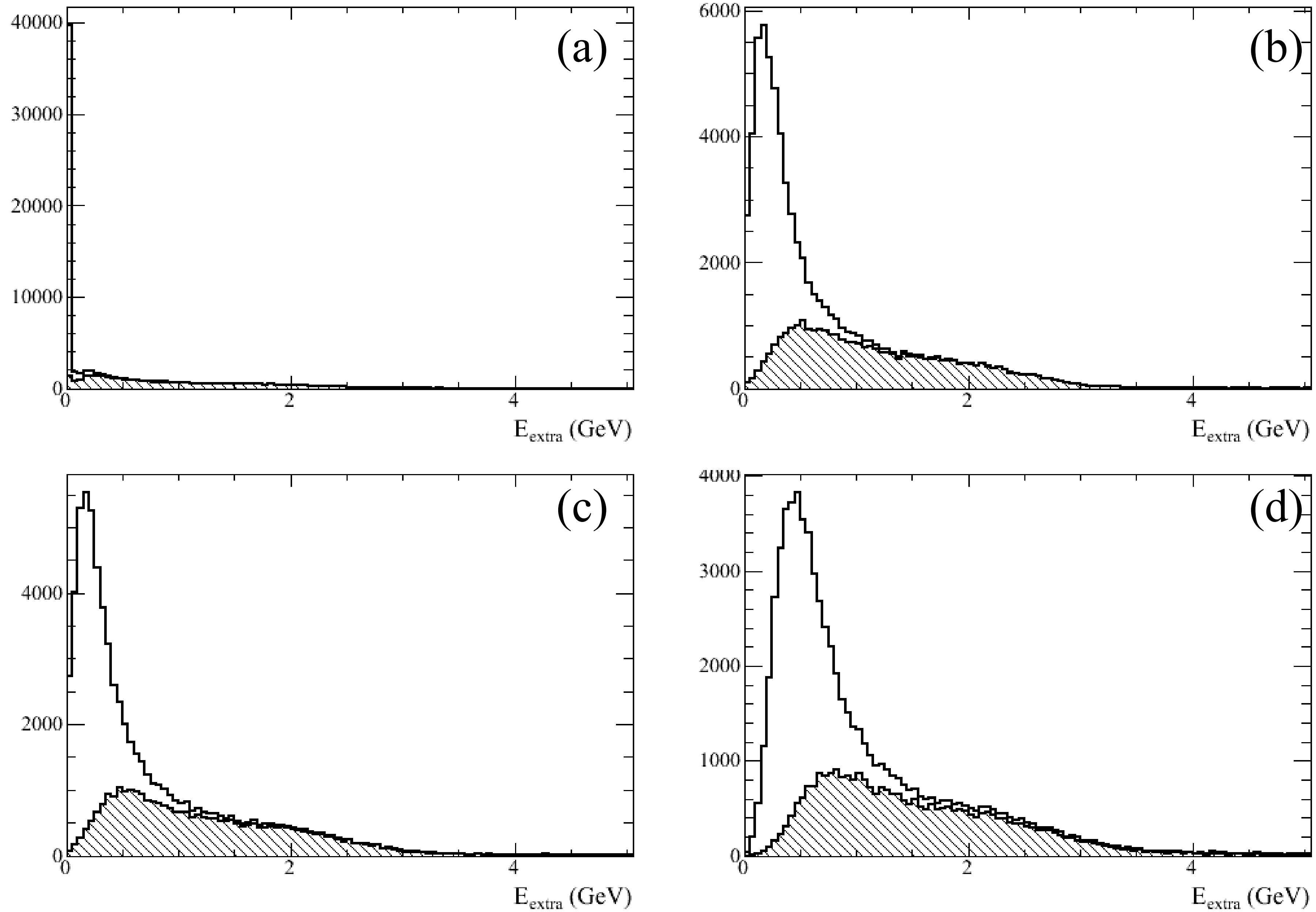


Impact on $B \to \tau\nu$

- Use truth match to tag one B: Start from GoodTracksLoose and GoodPhotonLoose.
  - GoodTracksLoose: pt>0.1 GeV; p<10 GeV; nDch≥12; doca<1.5 cm; |z|<10 cm
  - GoodPhotonLoose: e_raw>0.030 GeV;LAT<0.8
  - Ignore photons with E>2.6 GeV at CM frame.
- Remove candidates associated with one B using MC truth matching. Remaining candidates should be from the other B and background.
- Keep the event if the recoil-side pass the cuts:
  - Only one track remaining; its charge = −tagged B charge
- Signal MC: $B \to \tau\nu$, τ decays genericly; the other B decays genericly.
- Running four configurations: (a) no background; (b) mix fullsim rad. Bhabha; (c) add fastsim large-angle Bhabha; (d) double barrel time window from (c).

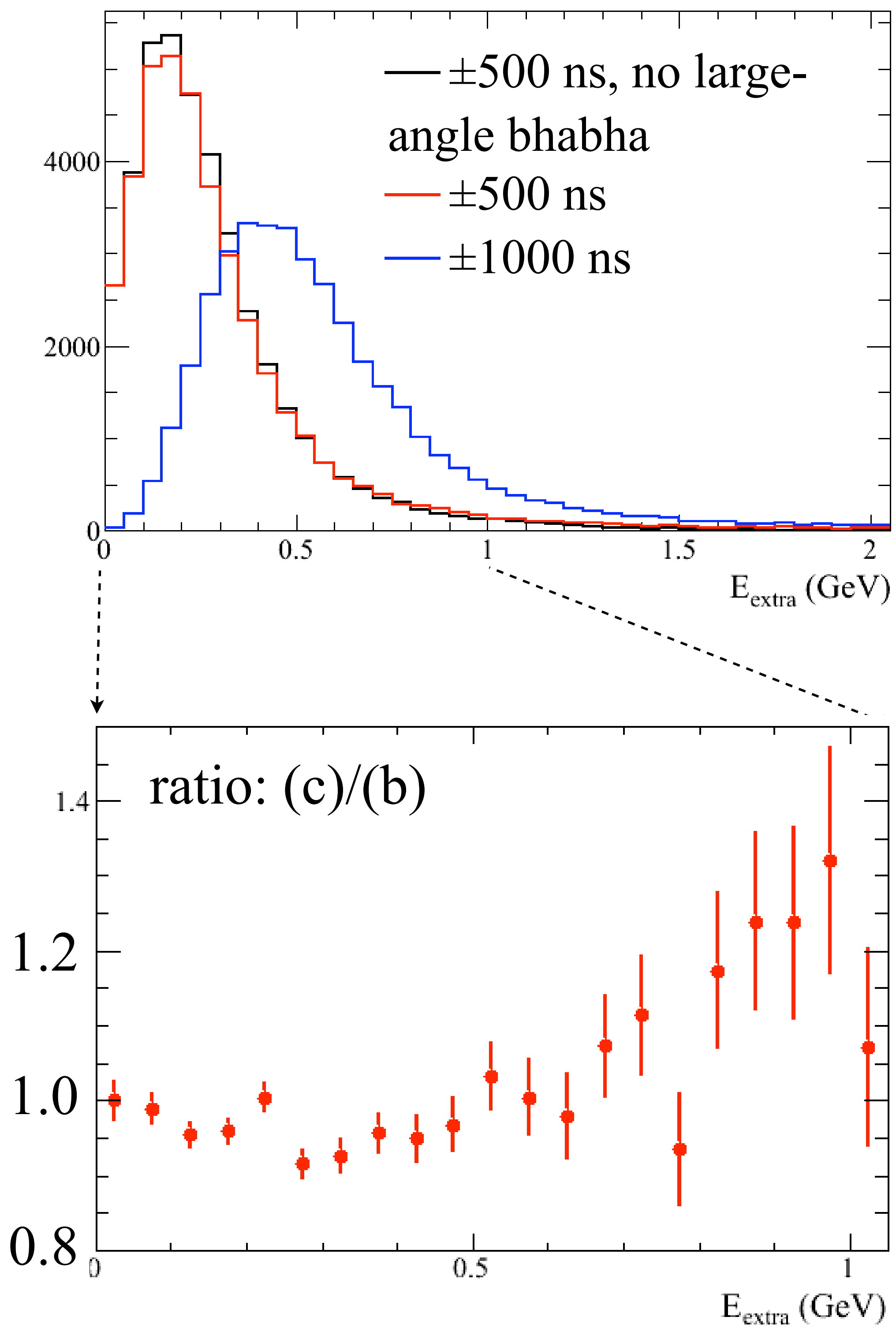
E_{extra}: one prong

- (Regardless whether a π^0 exists or not.)

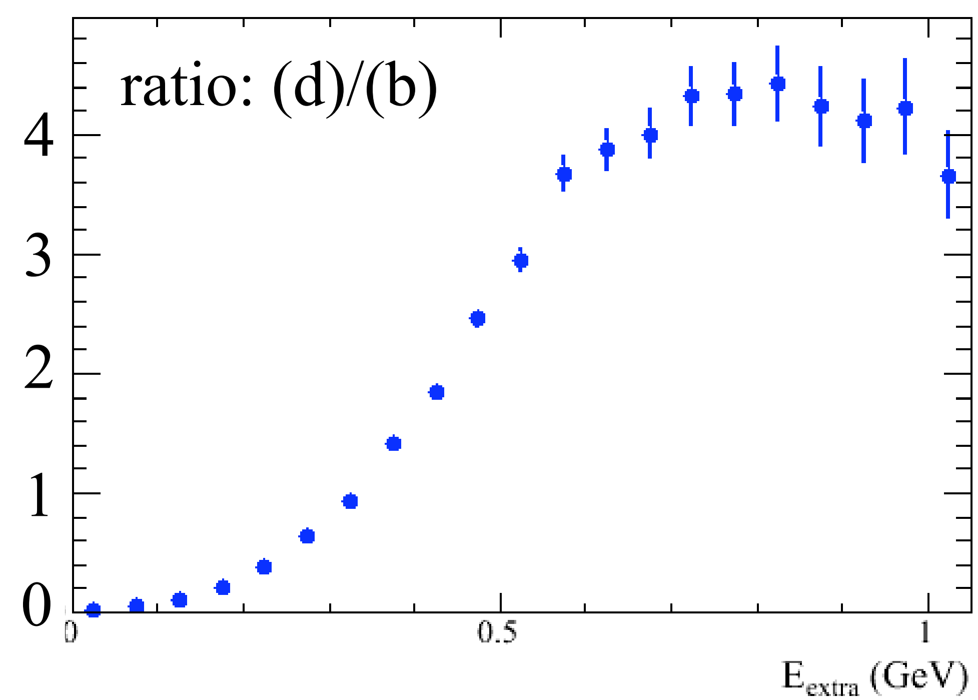


hatched: background events determined by mc truch match.

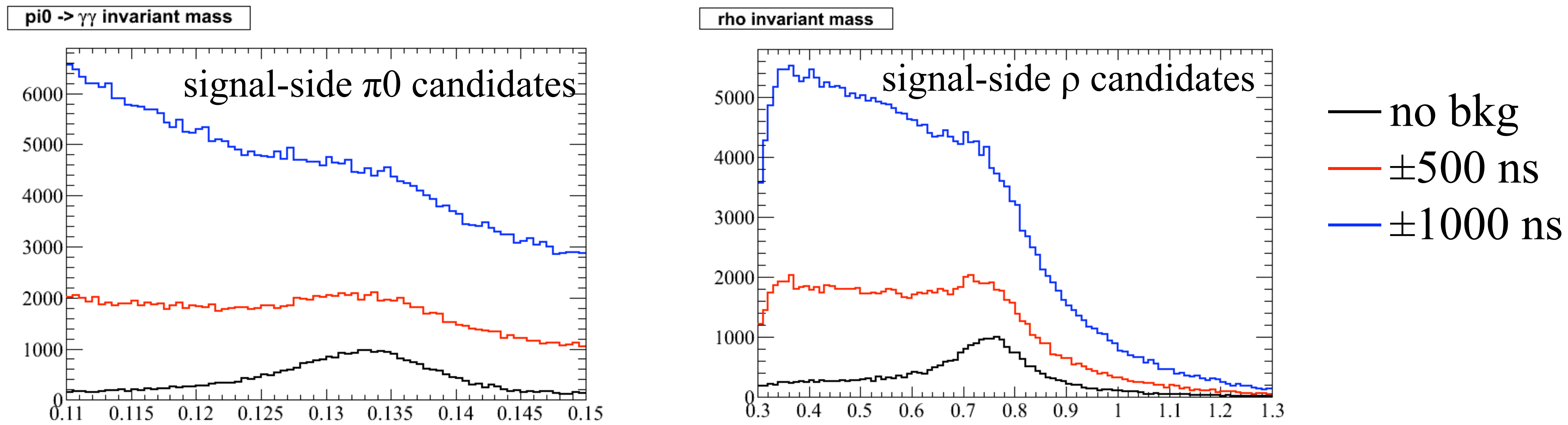
Compare truth-matched signal



- Adding large-angle Bhabhas has a small effect (black to red).
- Doubling barrel time window has a very large effect (red to blue).
- However it is not easy to quantify the significance without the complete background.



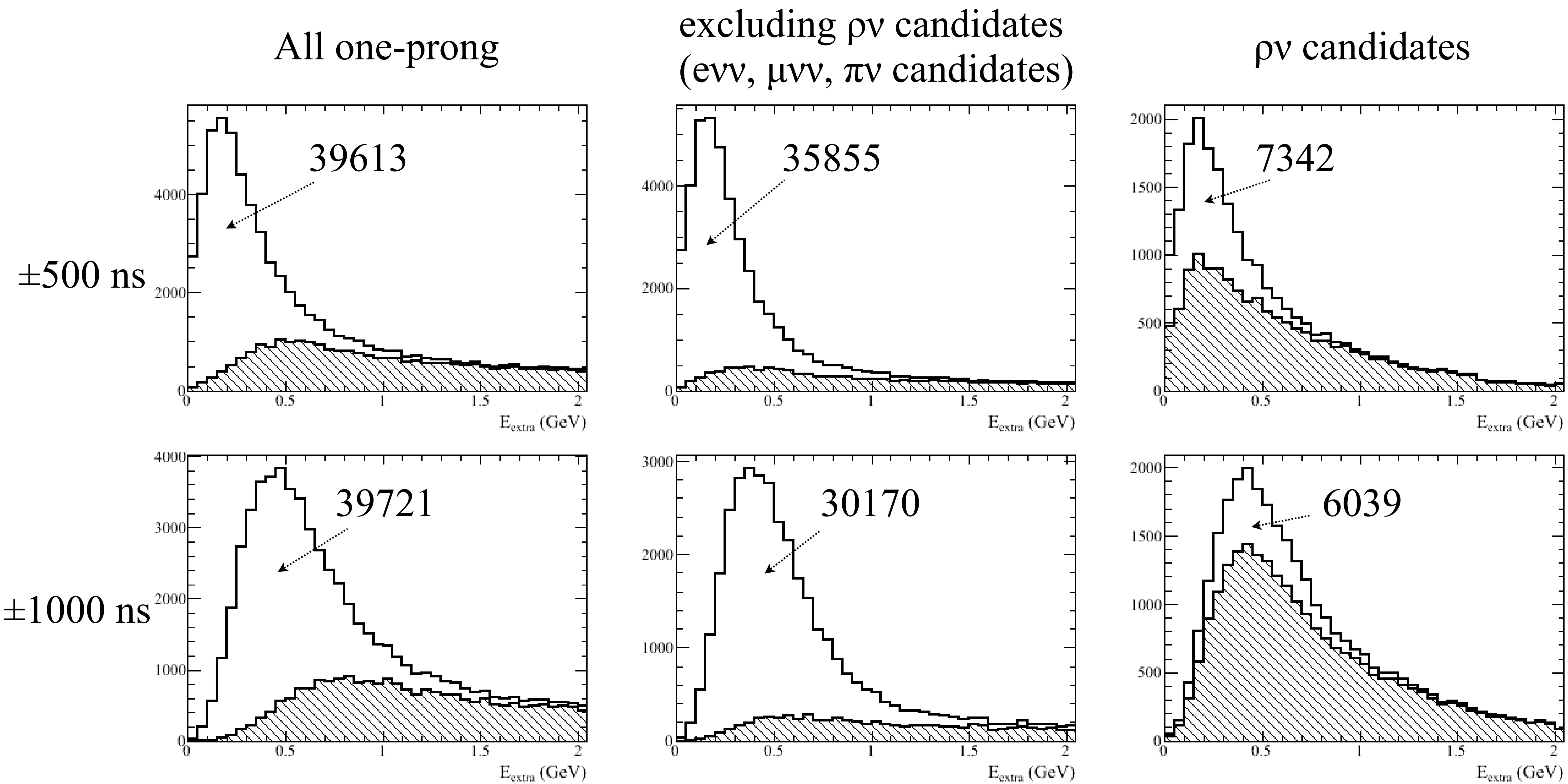
Considering $B \to \tau\nu$, $\tau \to \rho\nu$, $\rho^- \to \pi^-\pi^0$



- $\pi^0 \to \gamma\gamma$ reconstructed from barrel and forward endcap only ($0.11 < m_{\gamma\gamma} < 0.15$ GeV)
- $\rho^+ \to \pi^+\pi^0$: $|m - m_{PDG}| < 0.15$ GeV (and select the ρ closest to PDG mean).

- Background significantly increases combinatorials in π0 and ρ reconstruction.

Efficiencies suffer

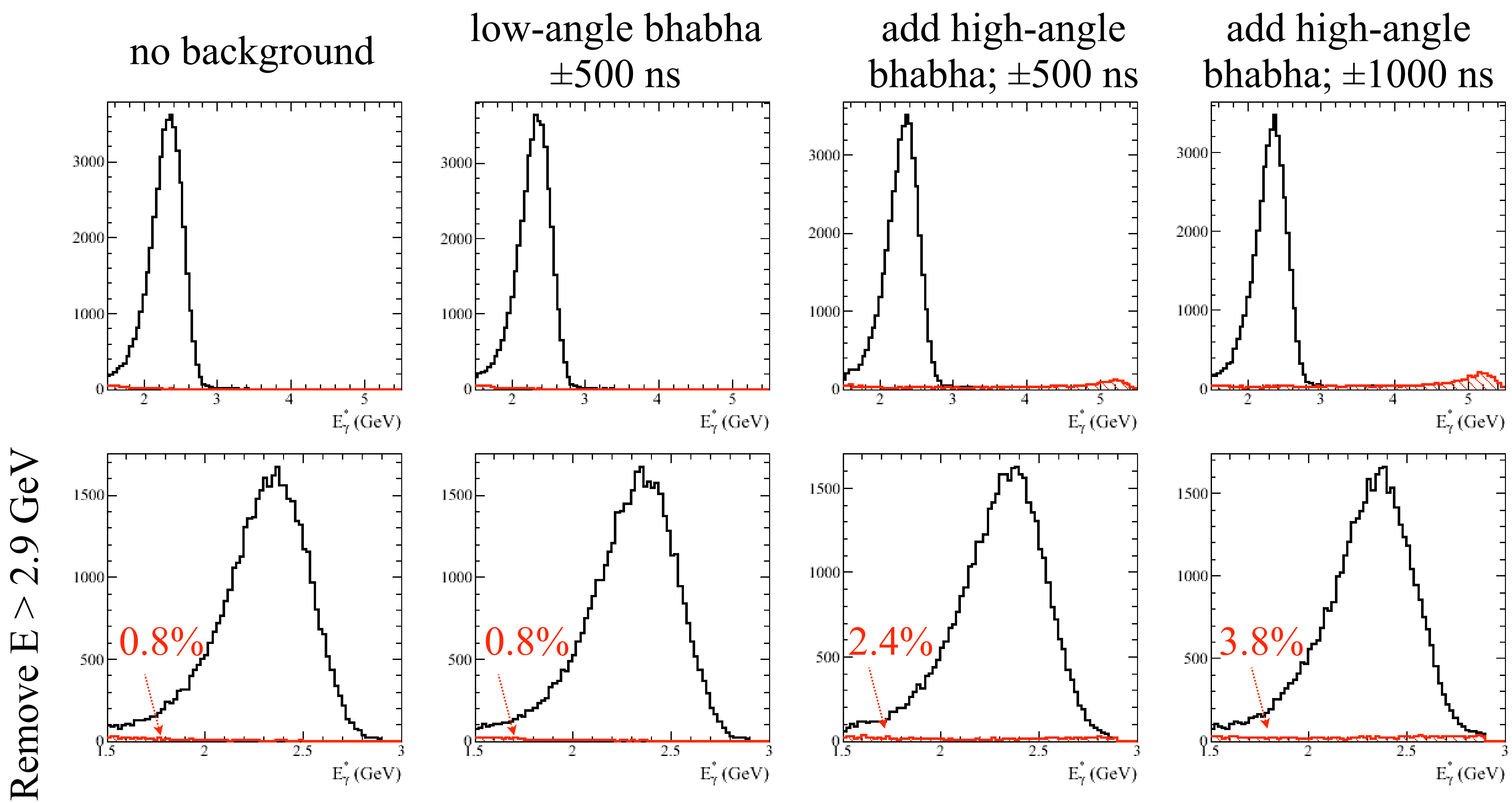


- eνν, μνν, and πν efficiency drops significantly if vetoing ρν, going from ±500ns to ±1000ns.

Impact on $b \to s\gamma$ inclusive

- Generate $b \to s\gamma$ signal MC.
- Again, tag one B^0 using truth match.
- Record events with $E^*_\gamma > 1.5$GeV at Y(4S) frame (I know we can boost it to the B frame, but for now, just for simplicity.).
- Four configurations: (a) no background; (b) low-angle rad. Bhabha from full sim; (c) high-angle Bhabha from fast sim plus (b) with barrel signal window ±500ns; (d) increase signal time windoe to ±1000ns.

Background fraction



- Low angle Bhabhas have negligible contributions to background.
- Background increases 50% from ±500ns to ±1000ns.

Summary

- A simple waveform and timing window for the EMC have been implemented in the fastsim.
- The impact from low-angle rad. Bhabhas (generated by G4) and high-angle rad. Bhabhas (generated by fastsim) are studied:
  - photon distributions, π^0 combinatorials, etc.
- From recoiled analysis $B \to \tau\nu$, low-angle Bhabhas significanly worsen the E_{extra} resolution, especially for wider timing window.
- From recoiled analysis $B \to s\gamma$, high-angle Bhabhas contribute to a few percent background to pure signal MC. But this may be quite sensitive to how the out-of-time Bhabhas are treated.