Study of $B^+ \to K^+\tau^+\tau^-$ using hadronic tagging

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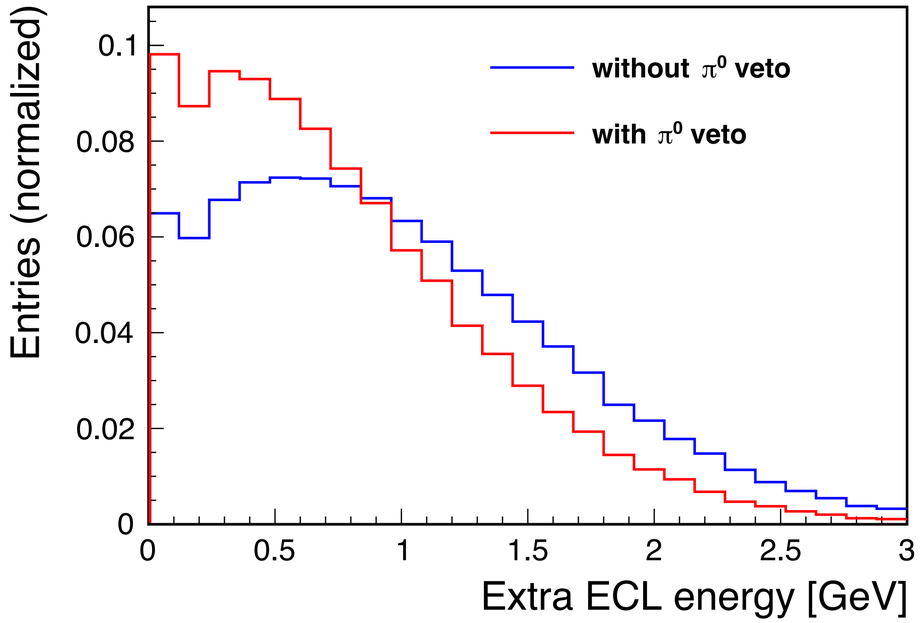
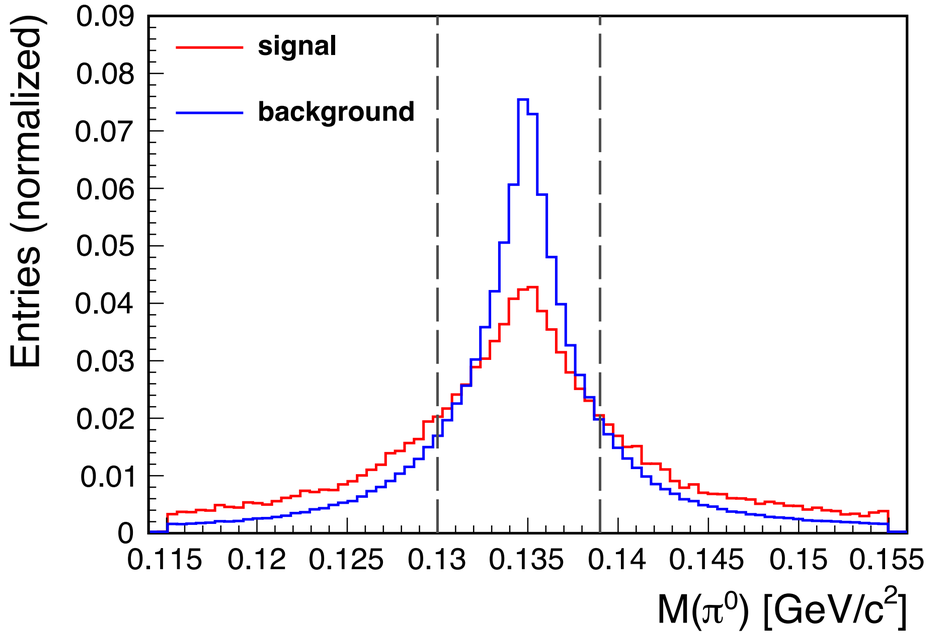
Effect of π^0 veto

- Little improvement in signal E_{ECL}
- Removes lot of backgrounds

after applying π^0 veto:

- 29.04 % drop in signal events
- 57.07 % drop in background events

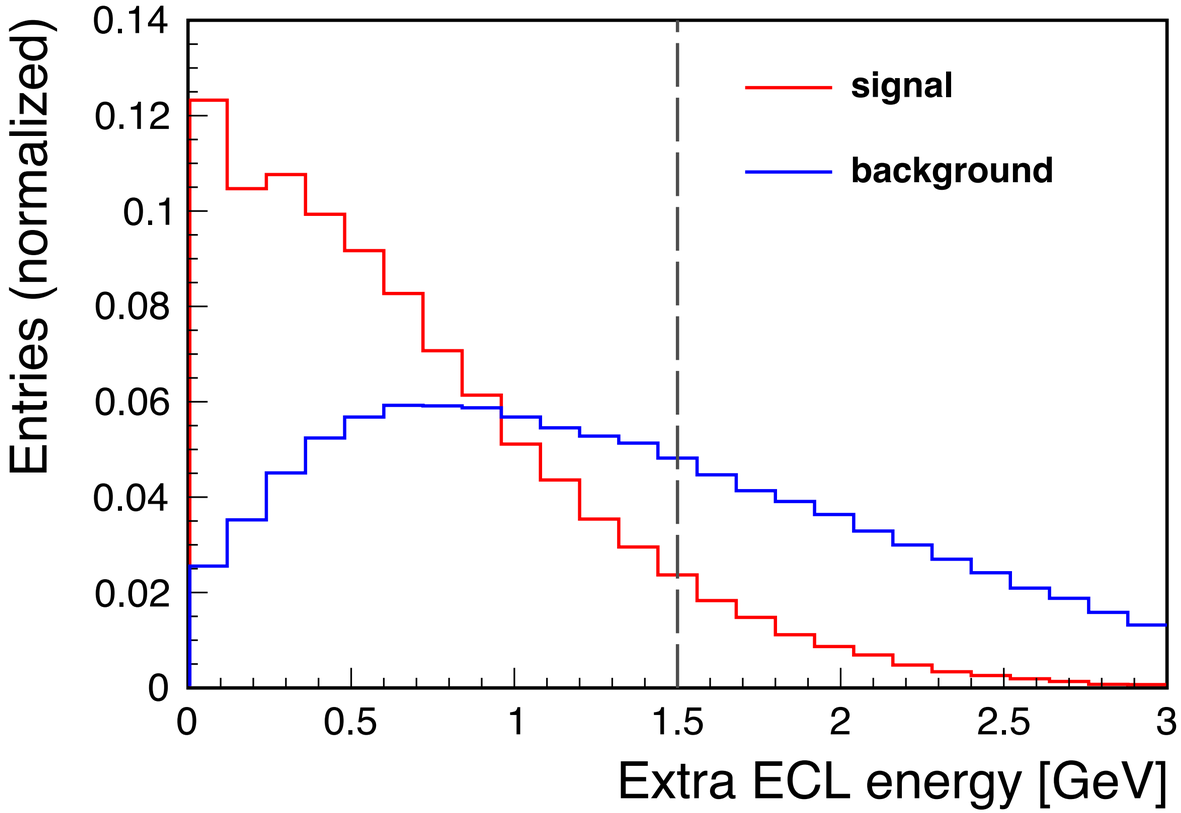




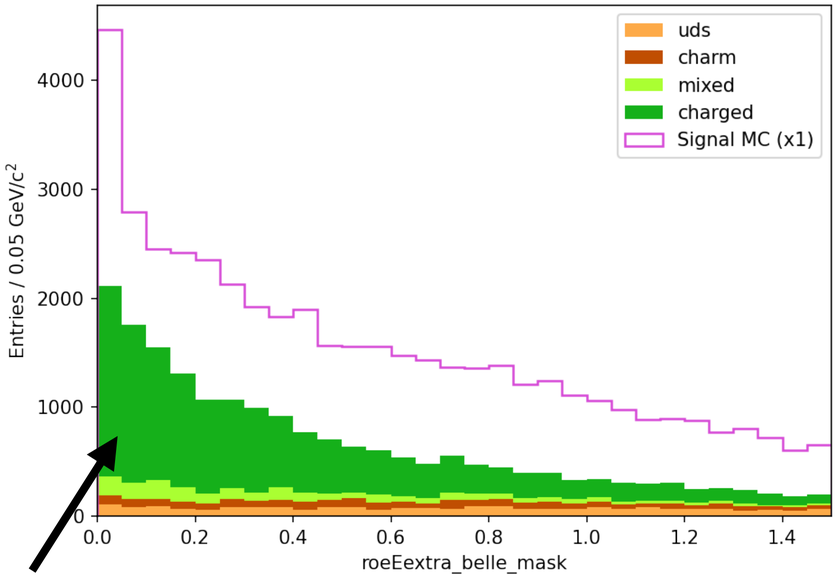
E_{ECL}

signal=> signalMC

background=> genericMC (MC15rib, $400\,fb^{-1}$)

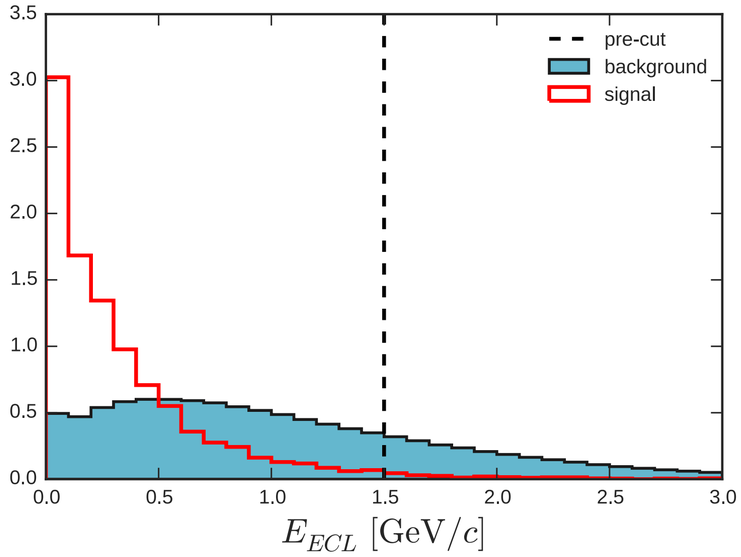


cut	Loss in signal	Loss in bkg
$E_{\mathrm{ECL}} < 1.5$	8.90%	39.71%



Vidya

background plot don't match



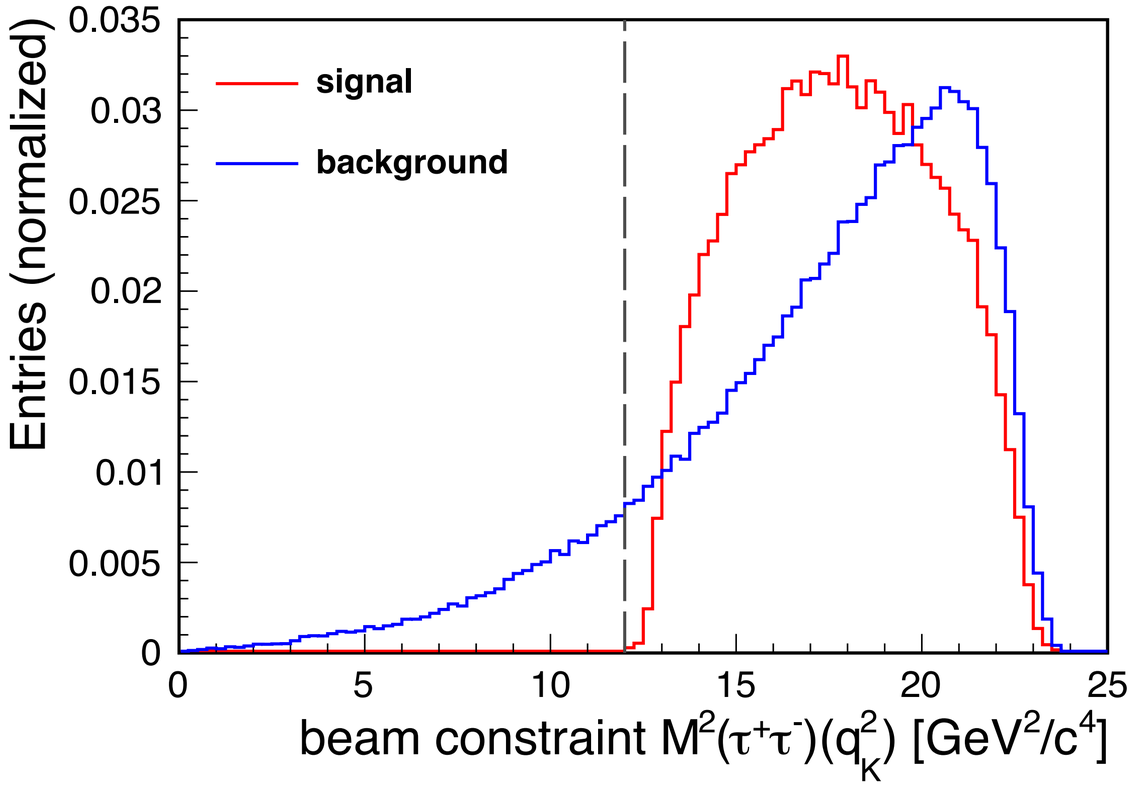
Simon

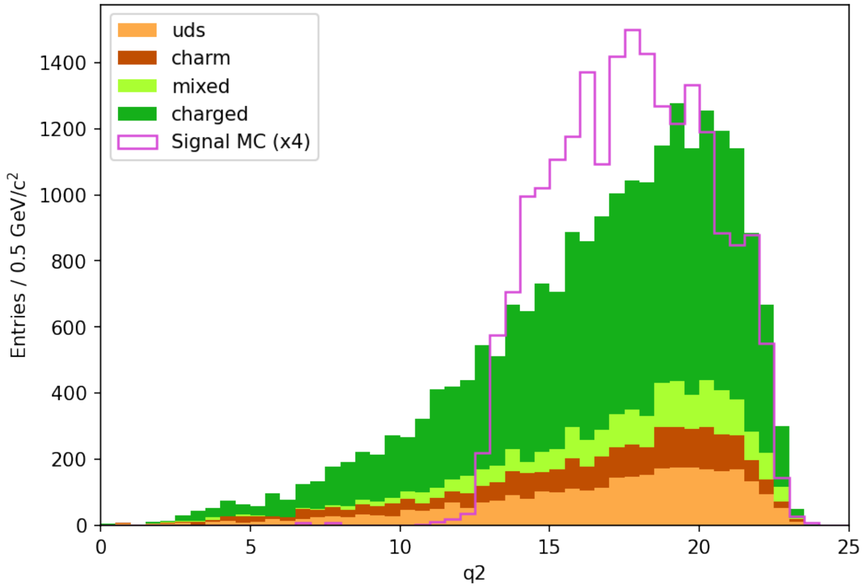
q_K^2

$$q_K^2 \equiv (p_{\Upsilon(4S)} - p_{B_{tag}} - p_K)^2$$

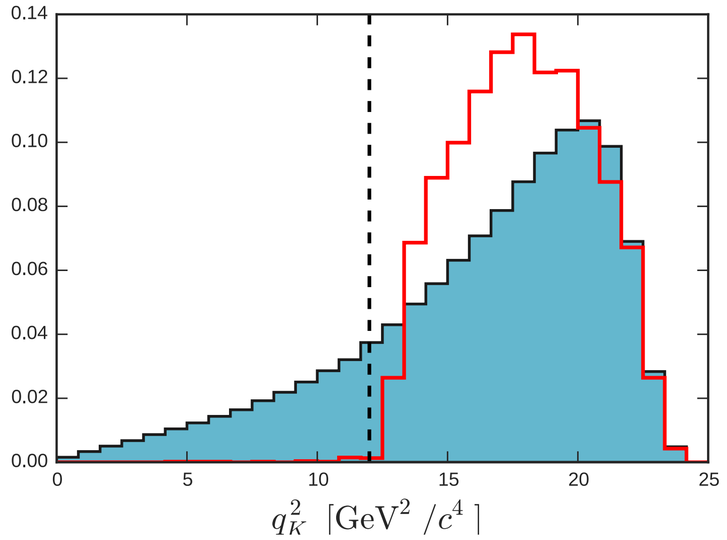
signal=> signalMC

background=> genericMC (MC15rib, $400\,fb^{-1}$)





Vidya



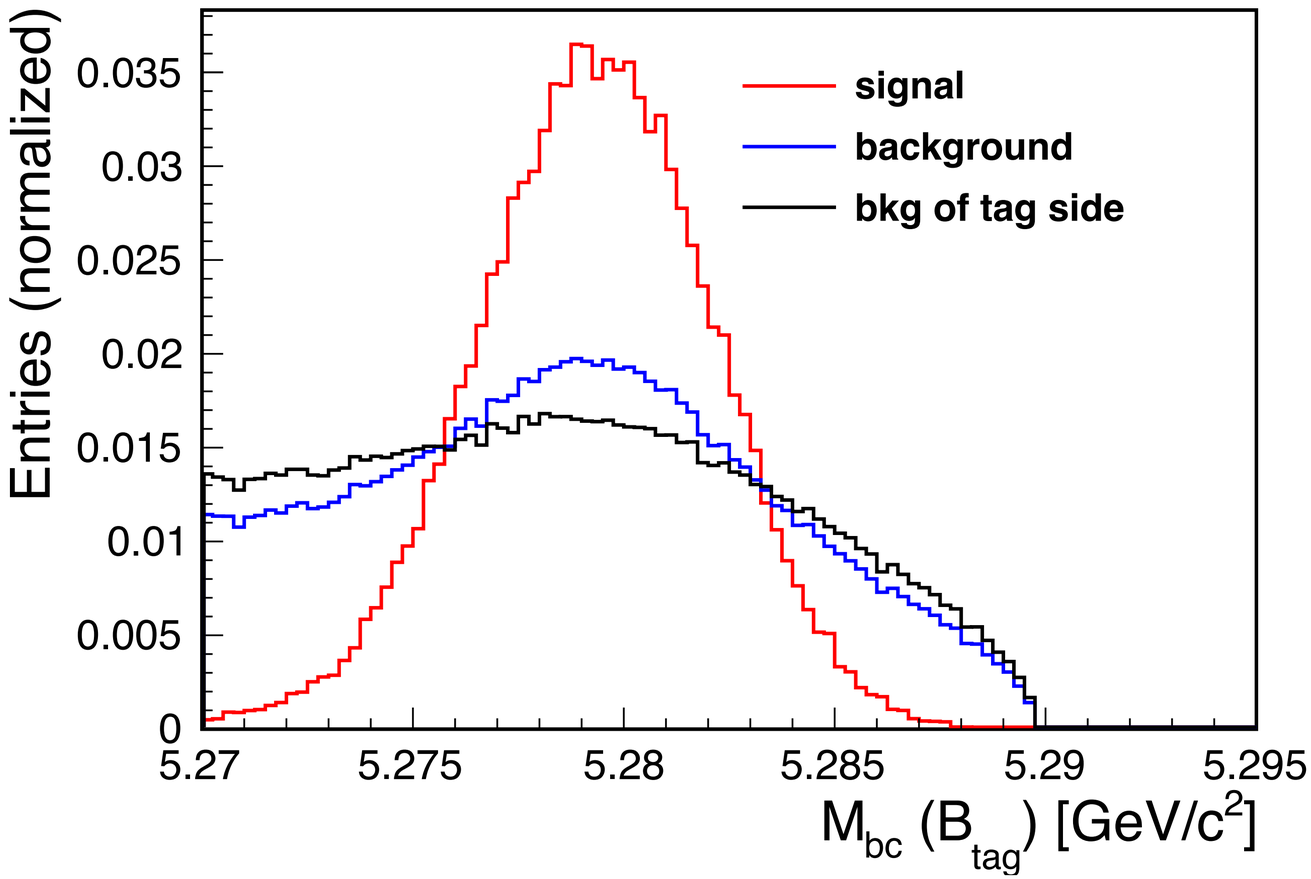
Simon

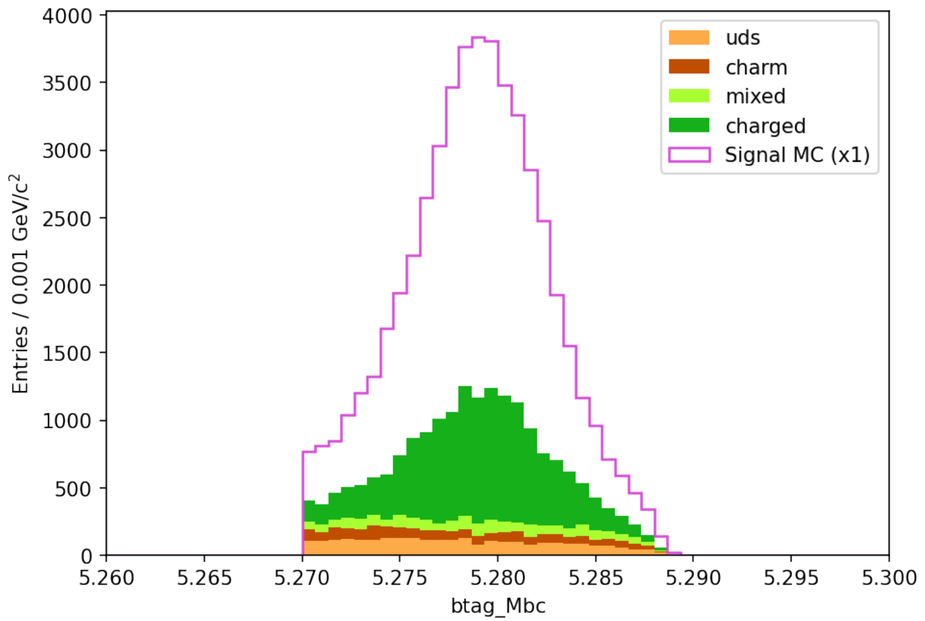
cut	Loss in signal	Loss in bkg
$q_K^2 > 12$	0%	12.09%

Tag side M_{bc}

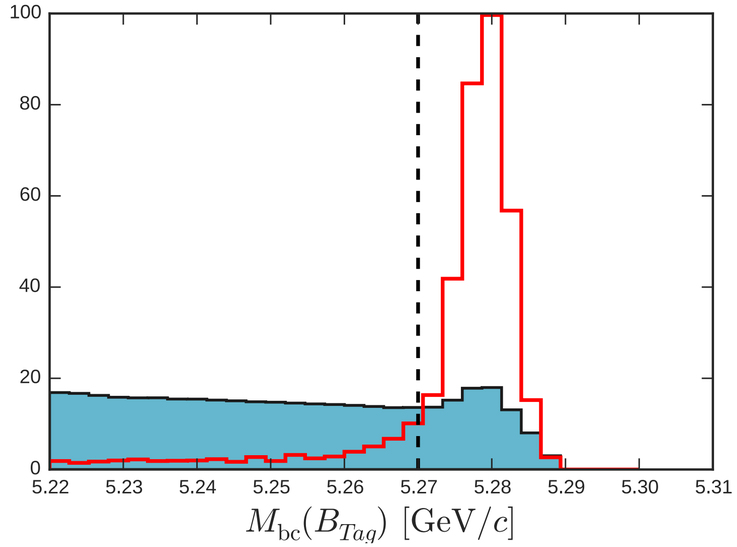
signal=> signalMC

background=> genericMC (MC15rib, $400\,fb^{-1}$)





Vidya



Simon

Signal efficiency

with some additional cuts same as Vidya's,

- $q_K^2 > 12$
- $E_{\mathrm{ECL}} < 0.2$
- $p(l_1) < 1.5$
- $M(K^+\tau^-) < 1.8$ or $\mathrm{M}(\mathrm{K}^+\tau^-) > 1.9$

Truth-match:

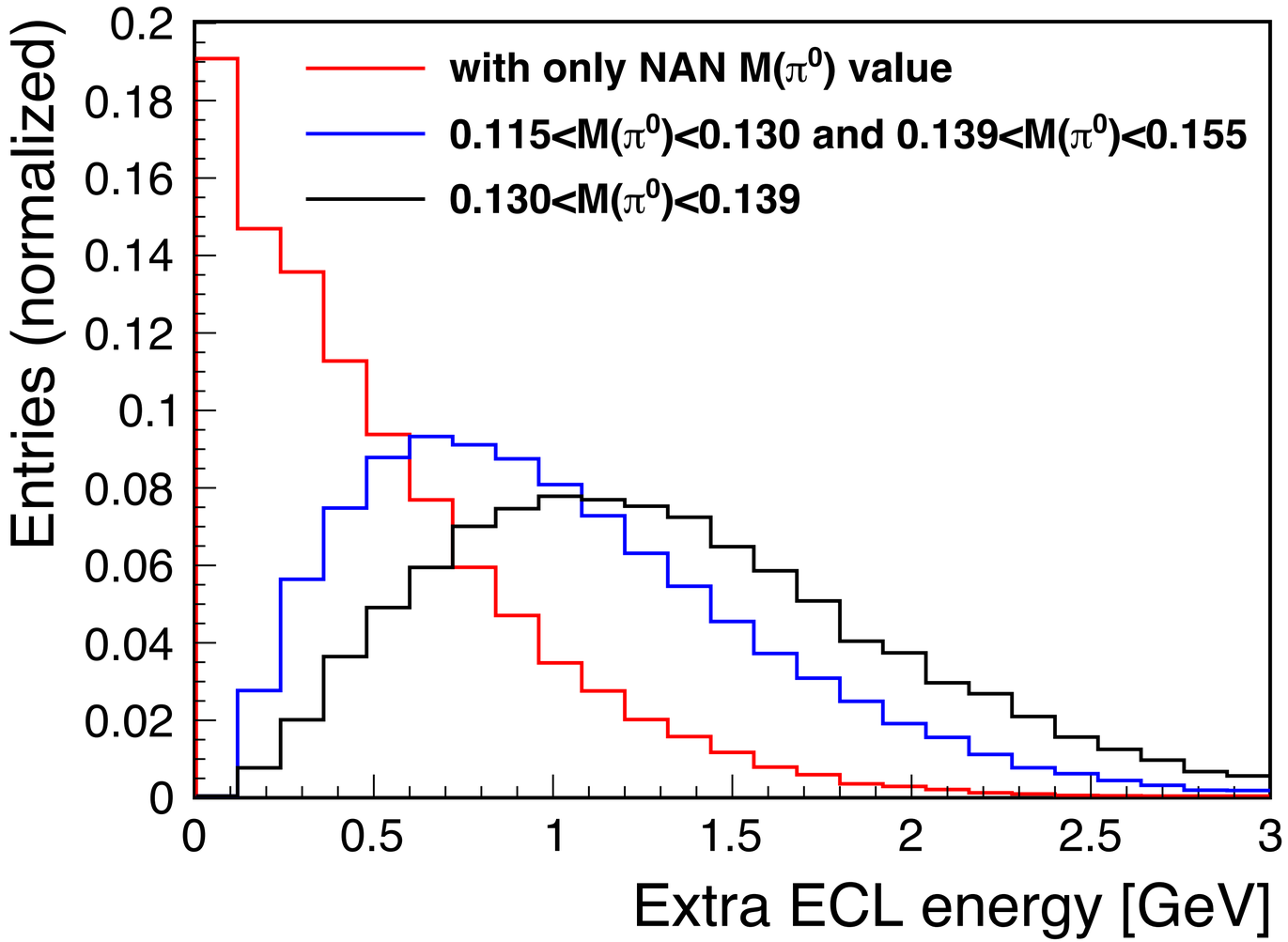
signal efficiency $= 5.03 \times 10^{-4}$

Signal + self-cross feed:

Efficiency $= 8.30 \times 10^{-4}$

Efficiency $= 6.96 \times 10^{-4}$ Vidya's

Next



- Signal events has pi0 mass with NAN value
- signal events reduce by 90% on removing them
- we need to understand why it has "NAN" values

Understand NAN π^0 mass value

Backup

SignalMC generator

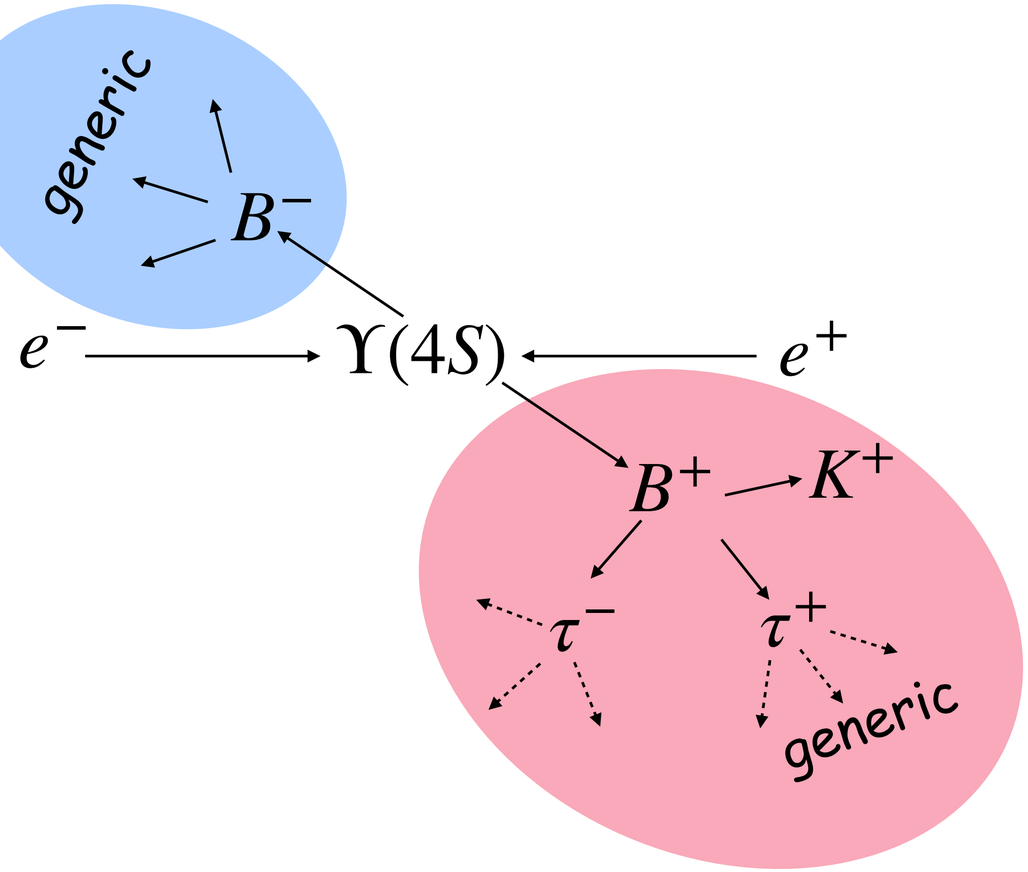
#simulated sample size: 50 million

generator model: BTOSLLBALL

release-06-00-10

globalTag: mc_production_MC15ri_a

bkg: early phase III (release-06-00-05), BGx1



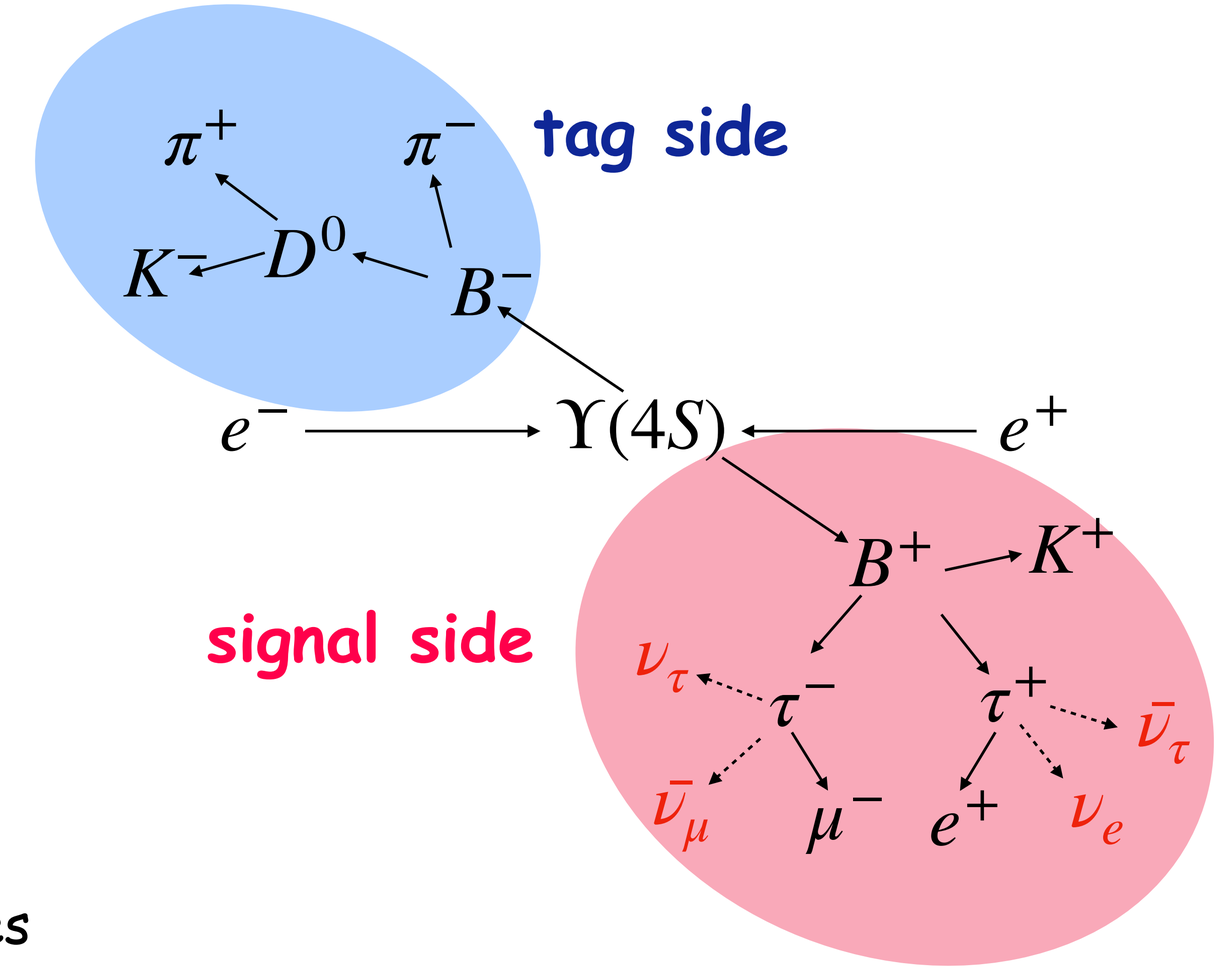
later: only τ decays to

$e^-\nu\nu, \mu^-\nu\nu, \pi^-\nu$

Reconstruction

B^+_{sig} is composed of K^+, h^+, and h'^-:

$K^+e^+e^-, K^+e^+\mu^-, K^+e^-\mu^+$
$K^+e^+\pi^-, K^+e^-\pi^+, K^+\mu^+\mu^-$
$K^+\mu^+\pi^-, K^+\mu^-\pi^+, K^+\pi^+\pi^-$



"tauSignalMissing" flag is built by combining:

1. matching mother, grandmother,..., PDG codes
2. btag_isSignal

Selection

Charged tracks (e, μ, K, π) cuts:

- transverse distance from IP, $dr < 0.5$
- distance in beam direction from IP, $|dz| < 2$
- polar angle is with in CDC acceptance (thetaInCDCAcceptance)
- Kaon binary PID, $\mathscr{L}(K/\pi) > 0.6$
- Pion binary PID, $\mathscr{L}(\pi/K) > 0.6$
- Electron PID, $\mathscr{L}(e) > 0.9$
- Muon PID, $\mathscr{L}(\mu) > 0.9$

Continuum suppression:

- event sphericity > 0.2
- cosTBTO < 0.9

Reconstruct FEI hadronic B_{tag}:

- weight file prefix - 'FEIv4_2021_MC14_release_05_01_12'
- most probable B_{tag} candidates is accepted
- $M_{bc} > 5.27$
- $|\Delta E| < 0.1$
- FEI signal probability > 0.001
- ROE of B_{tag} has 3 charged tracks

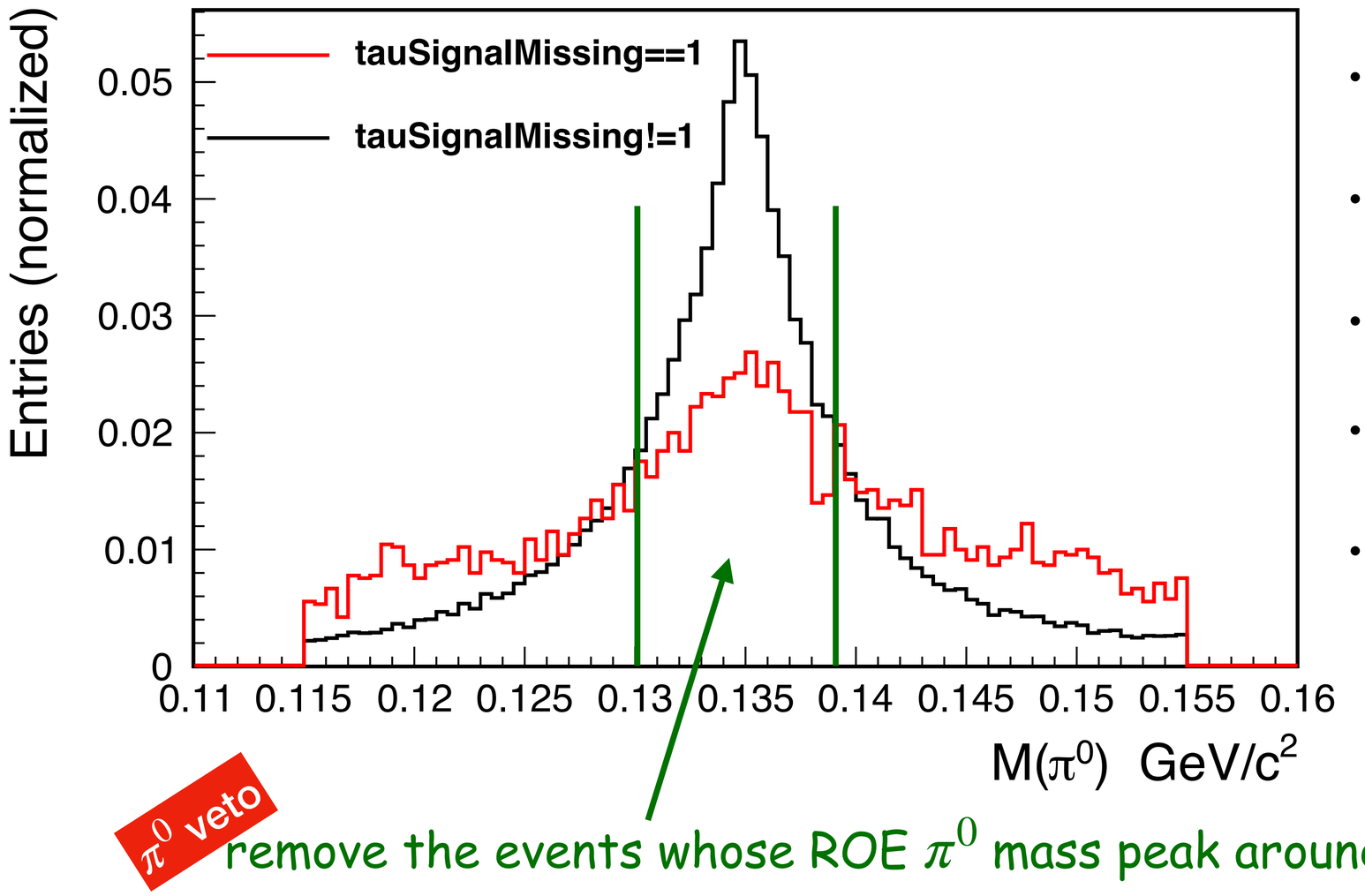
ROE mask:

- $dr < 0.5, |dz| < 2$, thetaInCDCAcceptance
- $E > 0.06$ and |cluster time| < 20

Analysis globalTag: 'analysis_tools_light-2203-zeus'

π^0 in ROE of $\Upsilon(4S)$

signalMC



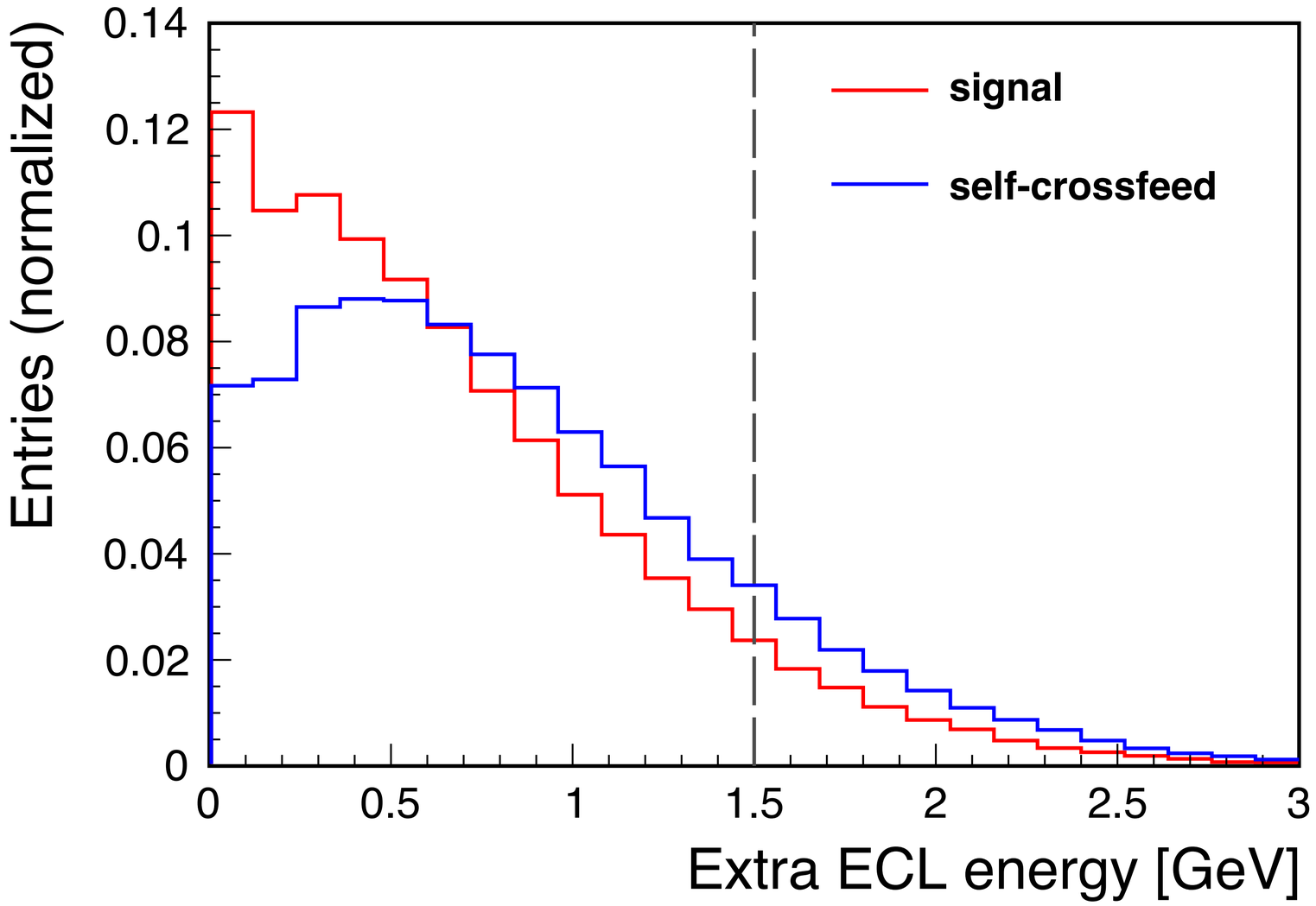
- π^0 is built from ROE photons
- Cut on photons: $E > 60\,\mathrm{MeV}$
- Cut on π^0: $115 < \mathrm{M} < 155\,\mathrm{MeV/c^2}$
- Apply mass constraint
- Select one π^0 per event that has the nearest mass to the PDG mass

π^0 veto

remove the events whose ROE π^0 mass peak around π^0 actual mass: $0.130 < \mathrm{M}(\pi^0) < 0.139\,\mathrm{GeV/c^2}$

Extra ECL energy

signalMC



τ decay modes in π^0 mass window

$0.130 < \mathrm{M}(\pi^0) < 0.139\,\mathrm{GeV/c^2}$

without isSignalMissingNeutrino flag

Modes	% of signal in pi0 region
$\tau \to Kee$	7.95
$\tau \to Ke\mu$	16.23
$\tau \to Ke\pi$	5.9
$\tau \to K\mu\mu$	8.3
$\tau \to K\mu\pi$	6.09
$\tau \to K\pi\pi$	1.1

$\sim 46\,\%$

with isSignalMissingNeutrino flag

Modes	% of signal in pi0 region
$\tau \to Kee$	12.51
$\tau \to Ke\mu$	27.06
$\tau \to Ke\pi$	17.80
$\tau \to K\mu\mu$	15.06
$\tau \to K\mu\pi$	20.78
$\tau \to K\pi\pi$	6.80

$\sim 100\,\%$