

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

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Analysis meeting

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Recap

- Suitable control channels for $B^+ \rightarrow K^+ \tau^+ \tau^-$ analysis that give same final state particles:

Channel	BF	FSR
$B^+ \rightarrow [J/\psi \rightarrow l^+ l^-] K^+$	1.22×10^{-4}	$K \ell \ell$
$B^+ \rightarrow [\bar{D}^0 \rightarrow K^+ \pi^-] l^+ \bar{\nu}_l$	9.08×10^{-4}	$K \pi \ell$
$B^+ \rightarrow [\bar{D}^0 \rightarrow K^+ \pi^-] \pi^+$	1.70×10^{-4}	$K \pi \pi$

- Studied $B^+ \rightarrow J/\psi K^+$ and checked that its branching fractions (with 13 % relative uncertainty) agree with PDG values.

$$B^+ \rightarrow [\bar{D}^0 \rightarrow K^+ \pi^-] l^+ \bar{\nu}_l$$

Sample and selection

- Used hadronic FEI skimmed samples: 11180500
- release-06-00-03

Data

- Proc 13 + bucket (26, 28-33, 35-36)
- Luminosity: 361.59 fb^{-1}

MC

- MC15ri_b ($\mathcal{L} = 1 \text{ ab}^{-1}$)

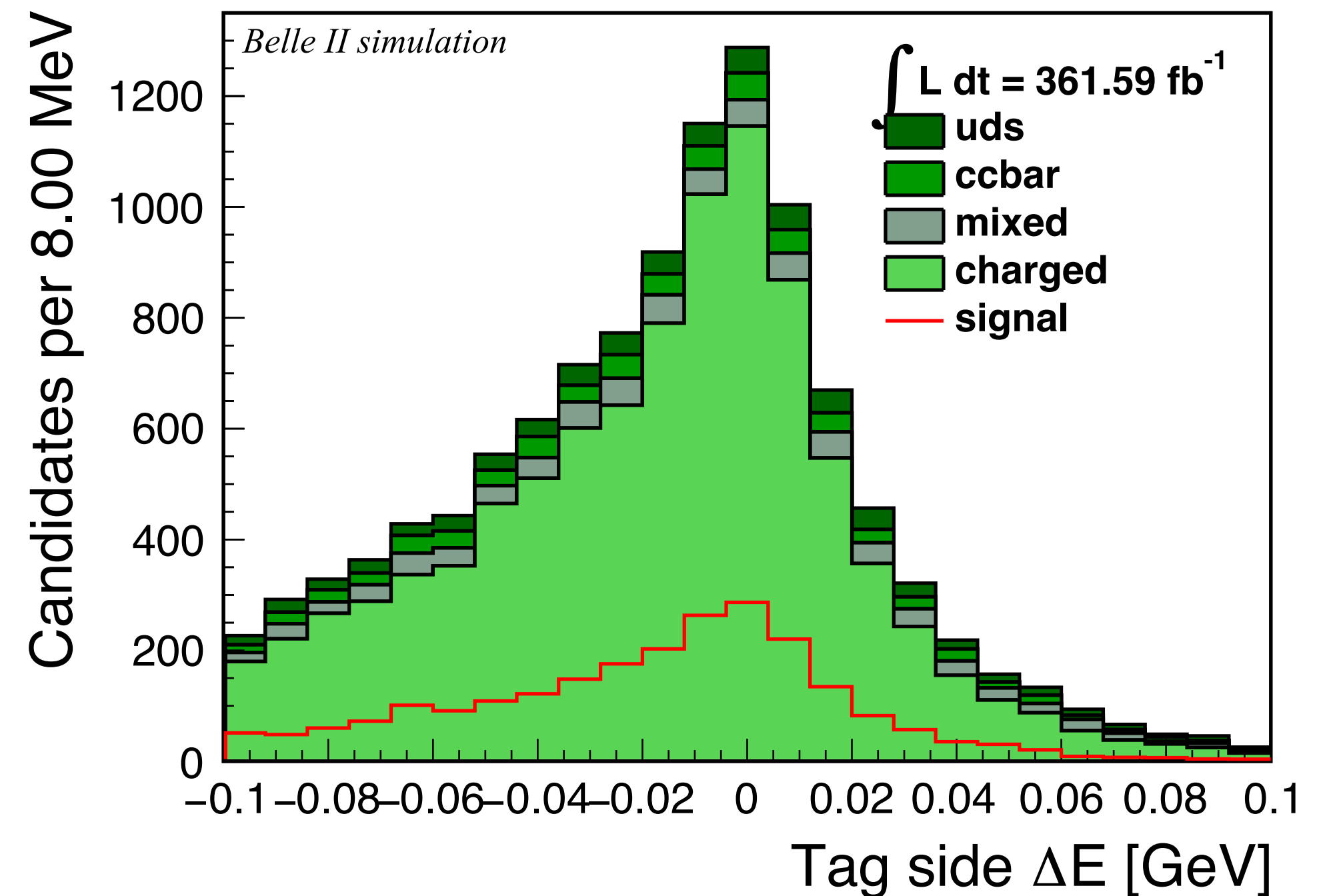
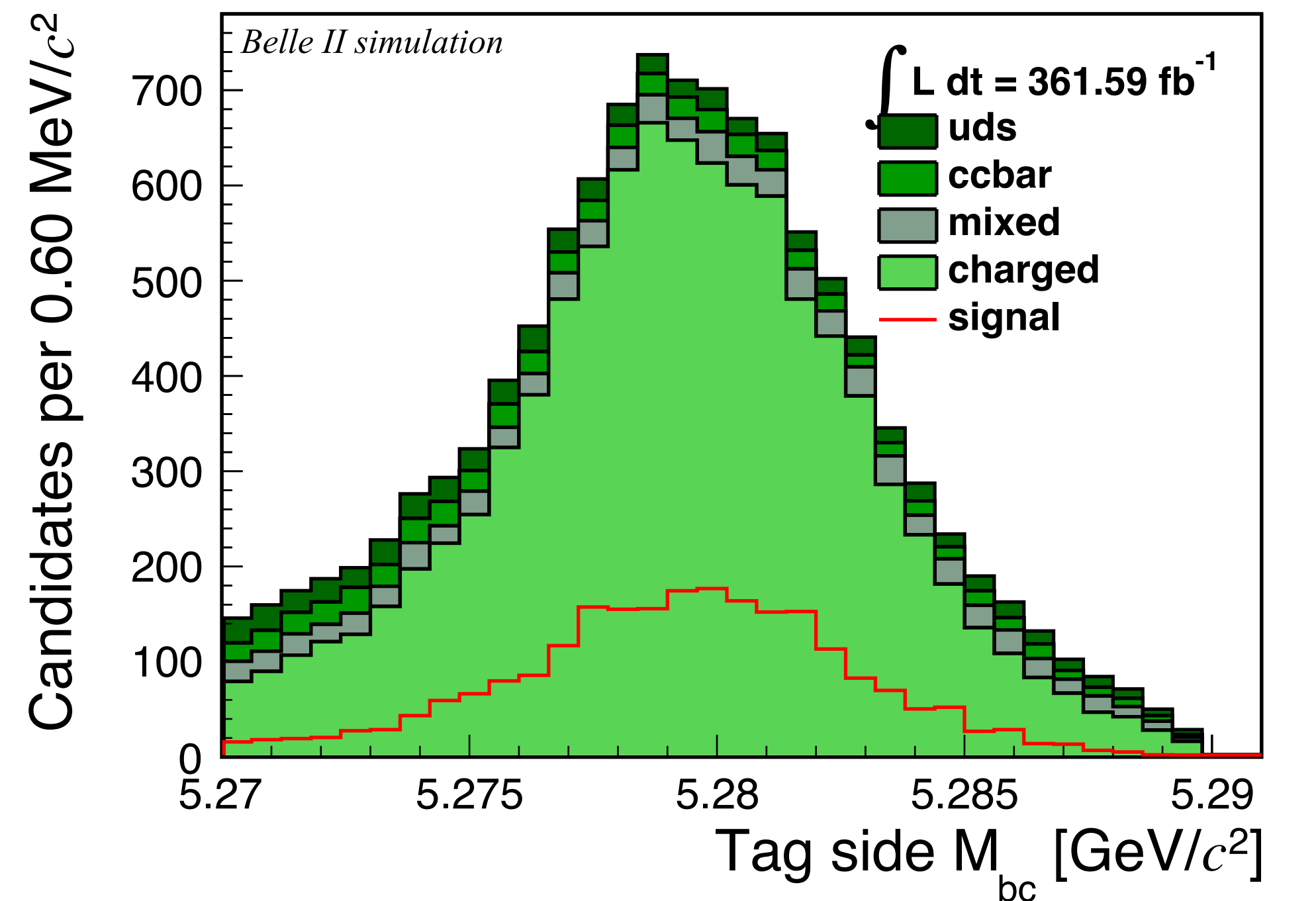
- Reconstruct with same pre-selections as in case of $B^+ \rightarrow K^+ \tau^+ \tau^-$, except the invariant mass of kaon and pion pair cut: $1.80 < m(K^+ \pi^-) < 1.93 \text{ GeV}/c^2$

Global tag: analysis_tools_light-2205-abys

B_{tag} selections

Reconstruct hadronic B_{tag} using FEI:

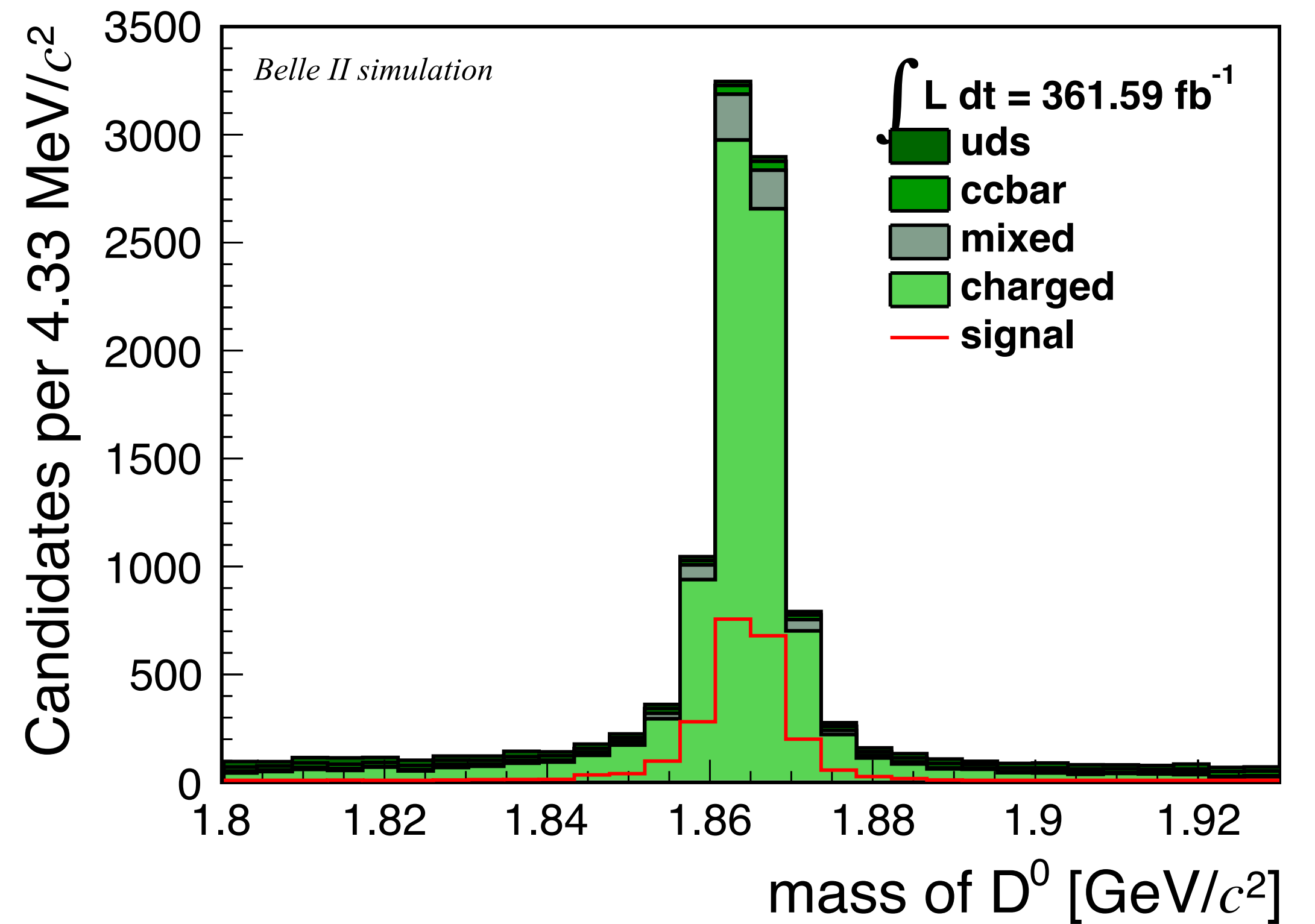
- Database prefix used for all weight files - 'FEIv4_2022_MC15_light-2205-abys'
 - $M_{bc} > 5.27 \text{ GeV}/c^2$
 - $|\Delta E| < 0.1 \text{ GeV}$
 - FEI signal probability > 0.001
 - Two most probable B_{tag} candidates are accepted.
 - In the rest of event (ROE) of B_{tag} , only 3 tracks should remain to reconstruct B_{sig} .
- B_{tag} should be reconstructed properly



B_{sig} selections

Tracks selections to reconstruct B_{sig} :

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



D^0 meson mass selection:

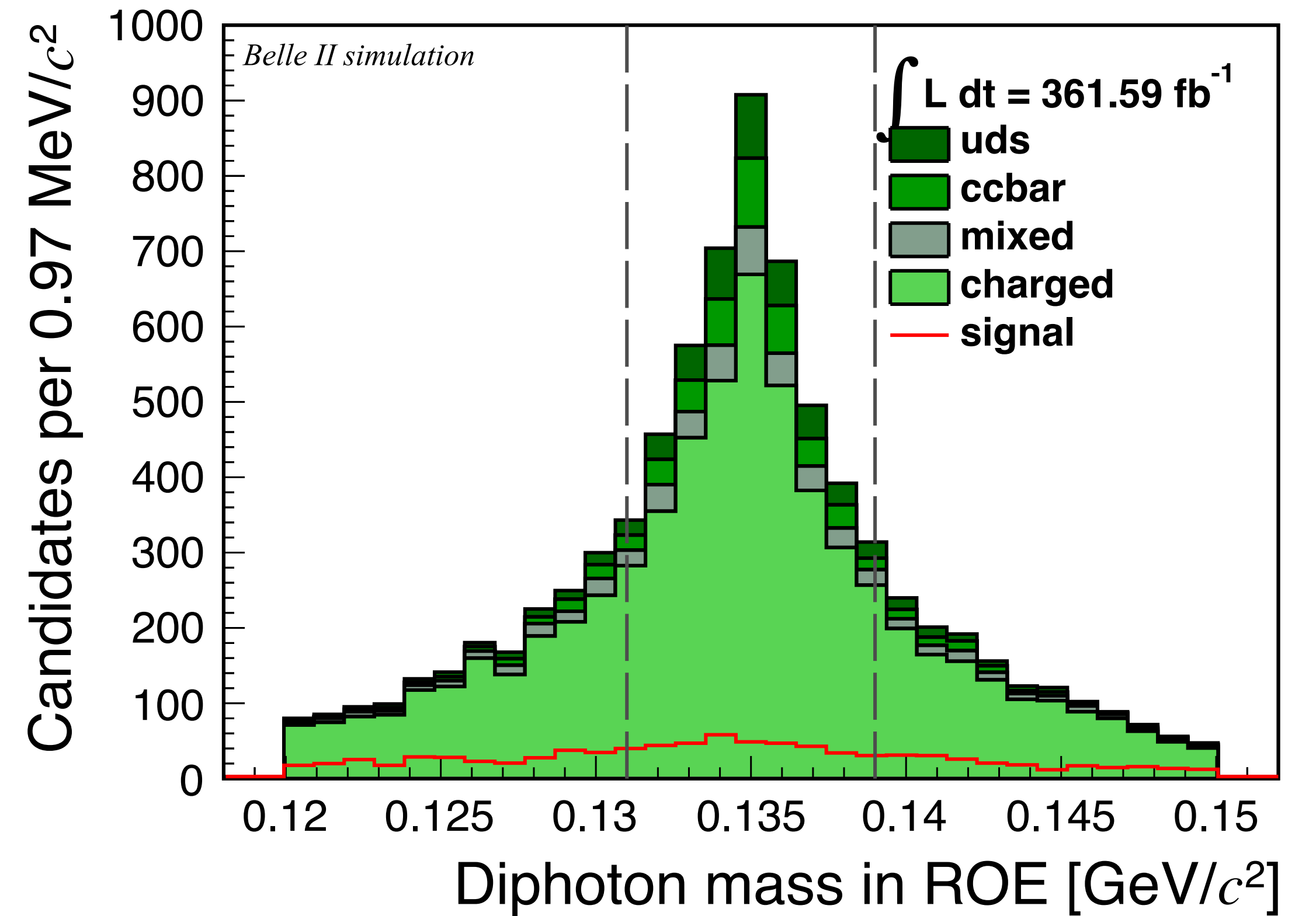
$$1.80 < m(K^+\pi^-) < 1.93 \text{ GeV}/c^2$$

π^0 veto

Cluster selections to reconstruct π^0 from photons in the ROE of B_{tag}

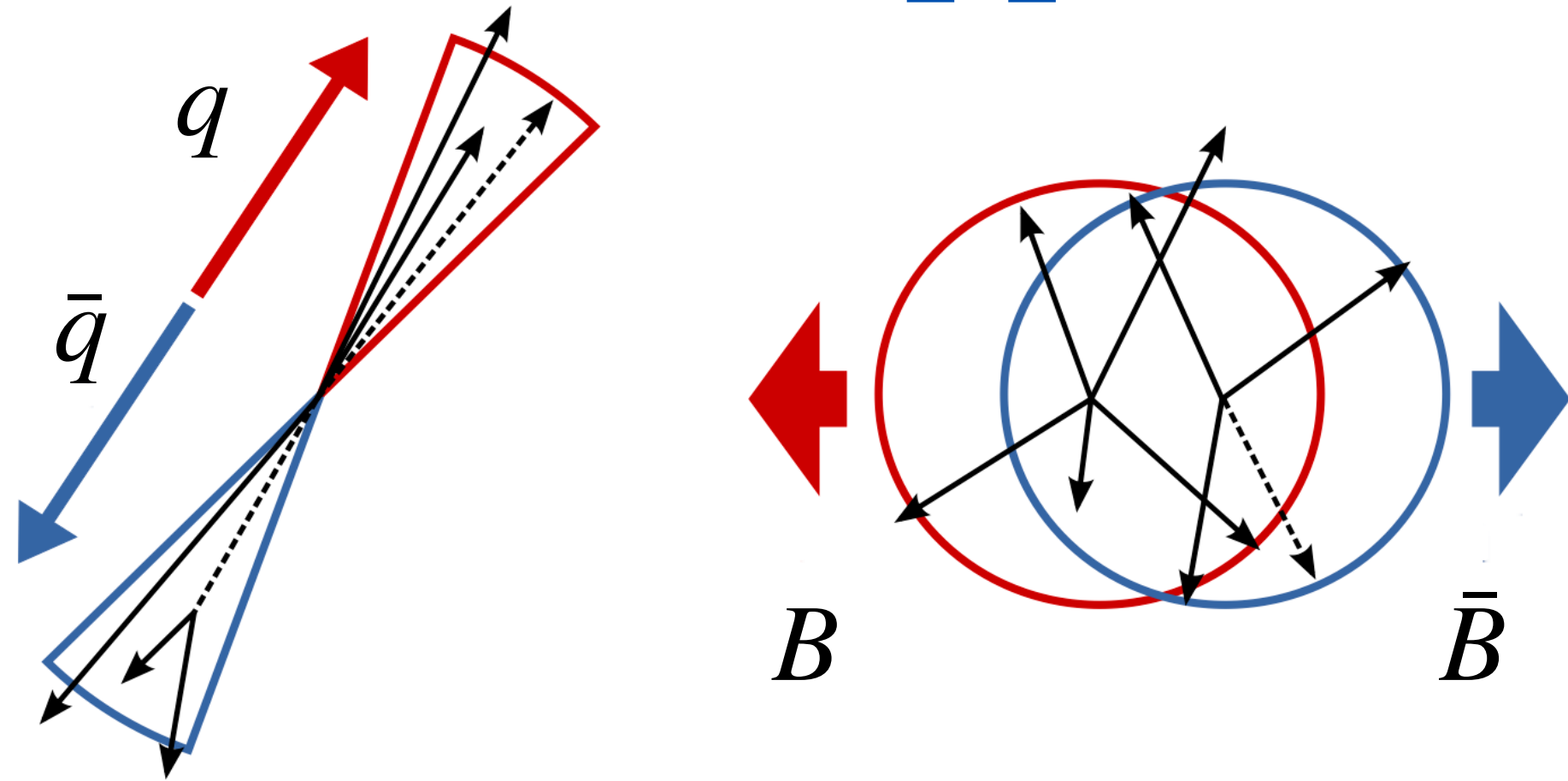
- clusterNHits > 1.5
- $E > 80 \text{ MeV}$ (forward), $E > 30 \text{ MeV}$ (barrel),
 $E > 60 \text{ MeV}$ (backward)
- distance between ECL cluster and nearest track hitting the ECL, minC2TDist > 20 cm
- $|\text{cluster time}| < 200 \text{ ns}$
- $\left| \frac{\text{cluster time}}{\text{cluster error timing}} \right| < 2.0$
- Mass window of π^0 : $120 < m(\gamma\gamma) < 150 \text{ MeV}/c^2$
- Select one π^0 per event that has the nearest invariant mass to the PDG mass.

recommended
by neutral group



- π^0 veto: remove the events that have the invariant mass of diphoton in the ROE of B_{tag} close to the true π^0 mass:
 $131 < m(\gamma\gamma) < 139 \text{ MeV}/c^2$

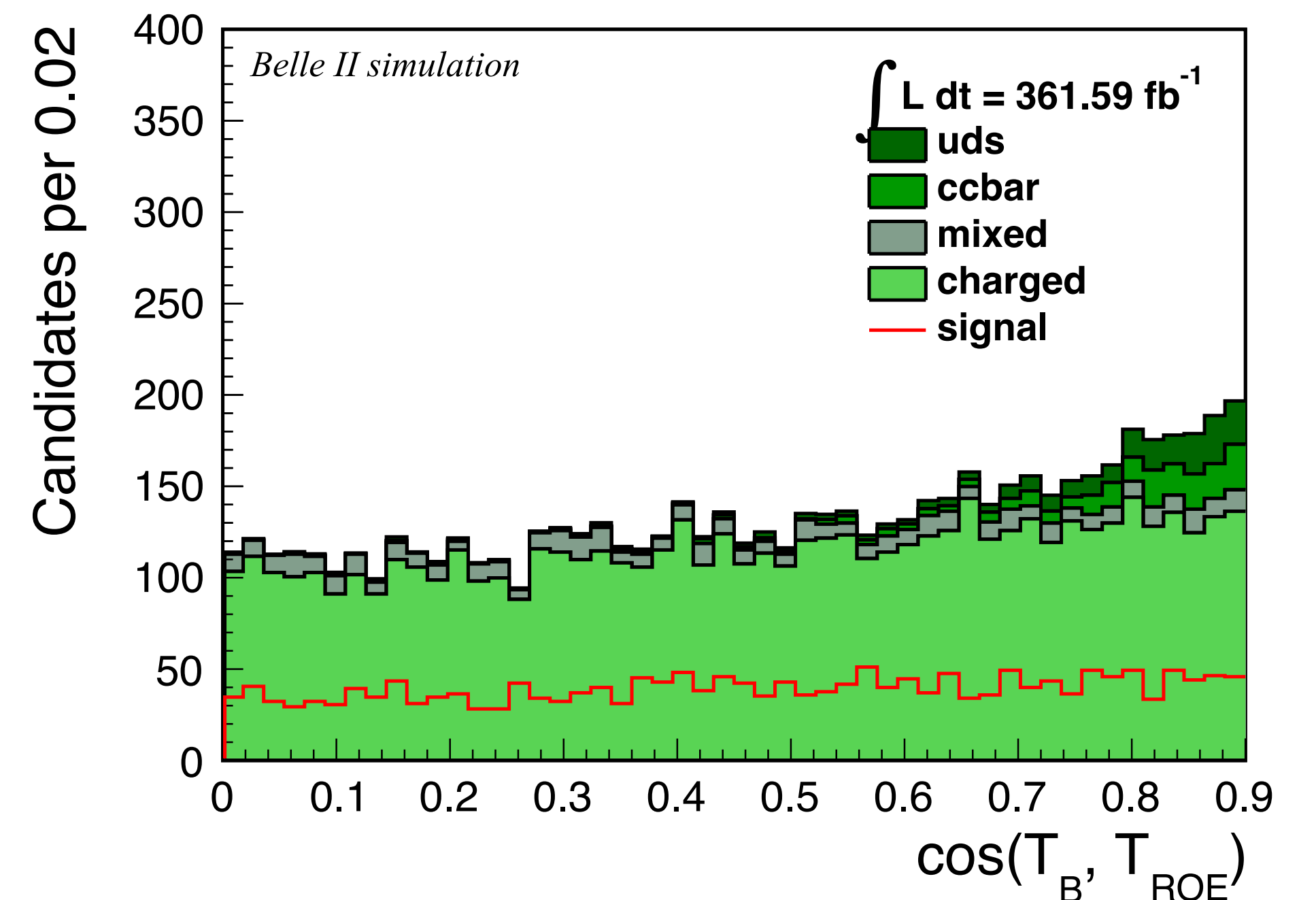
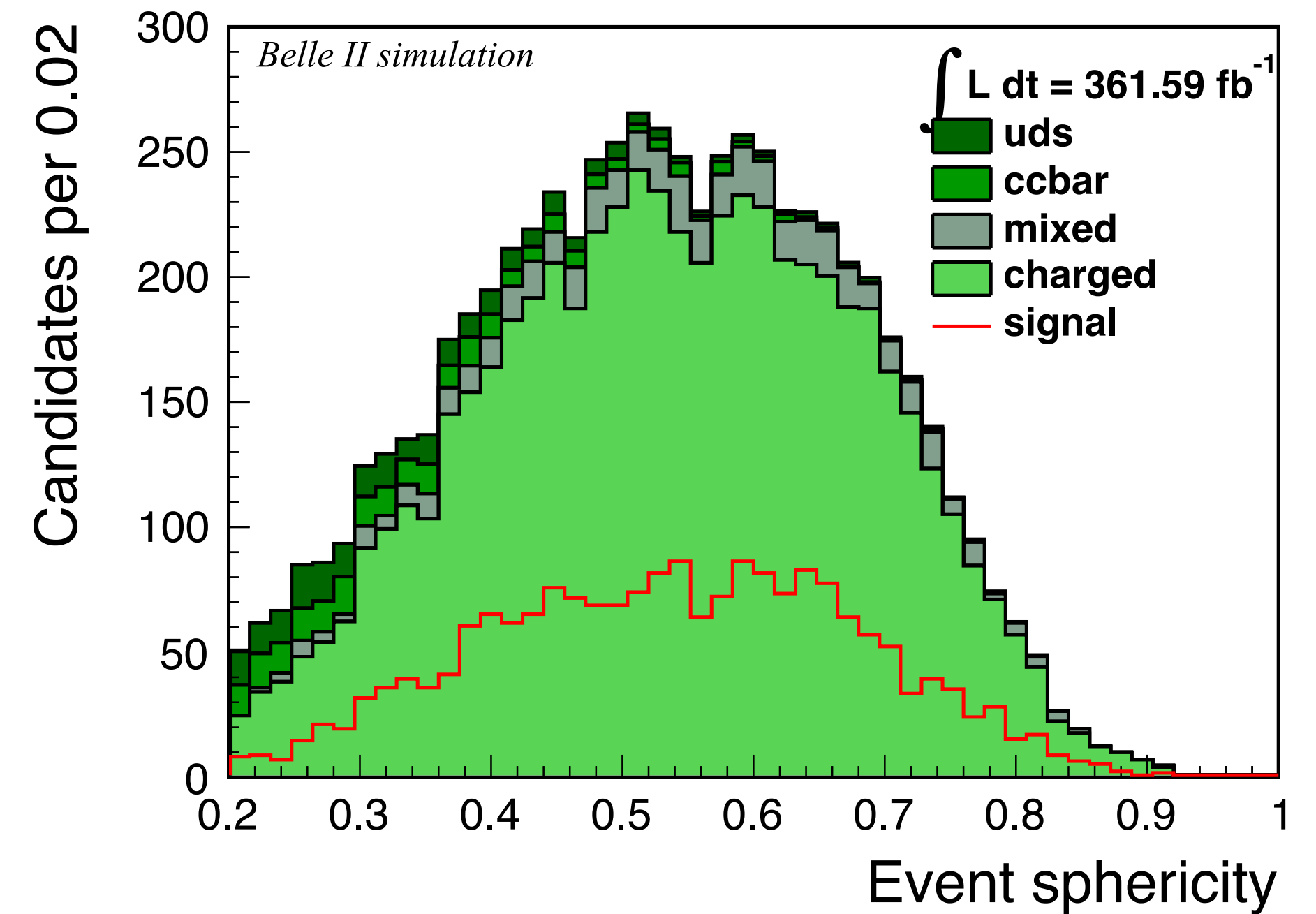
Continuum suppression



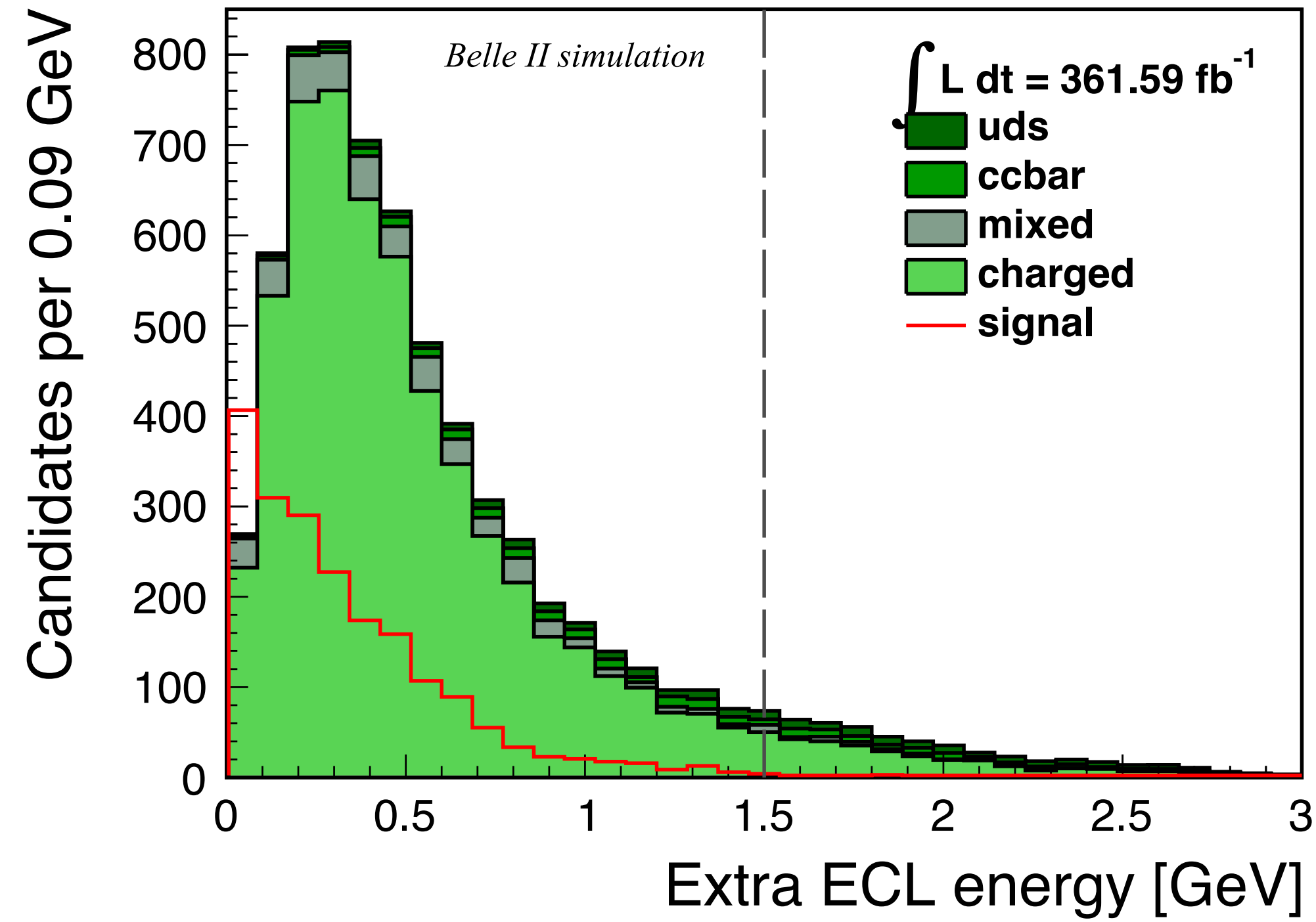
- event sphericity > 0.2
- Cosine of angle between thrust axis of B_{tag} and thrust axis of its ROE, $\cos(T_B, T_{\text{ROE}}) < 0.9$

Best candidate selection

- Select B_{tag} candidate with the highest FEI signal probability.
- Pick one candidate at random if there still exists multiple events.



Selections on E_{ECL}



- Residual energy of ECL clusters which are neither used in B_{tag} or B_{sig} reconstructions should ideally be zero for the signal
- Cut: $E_{\text{ECL}} < 1.5 \text{ GeV}$

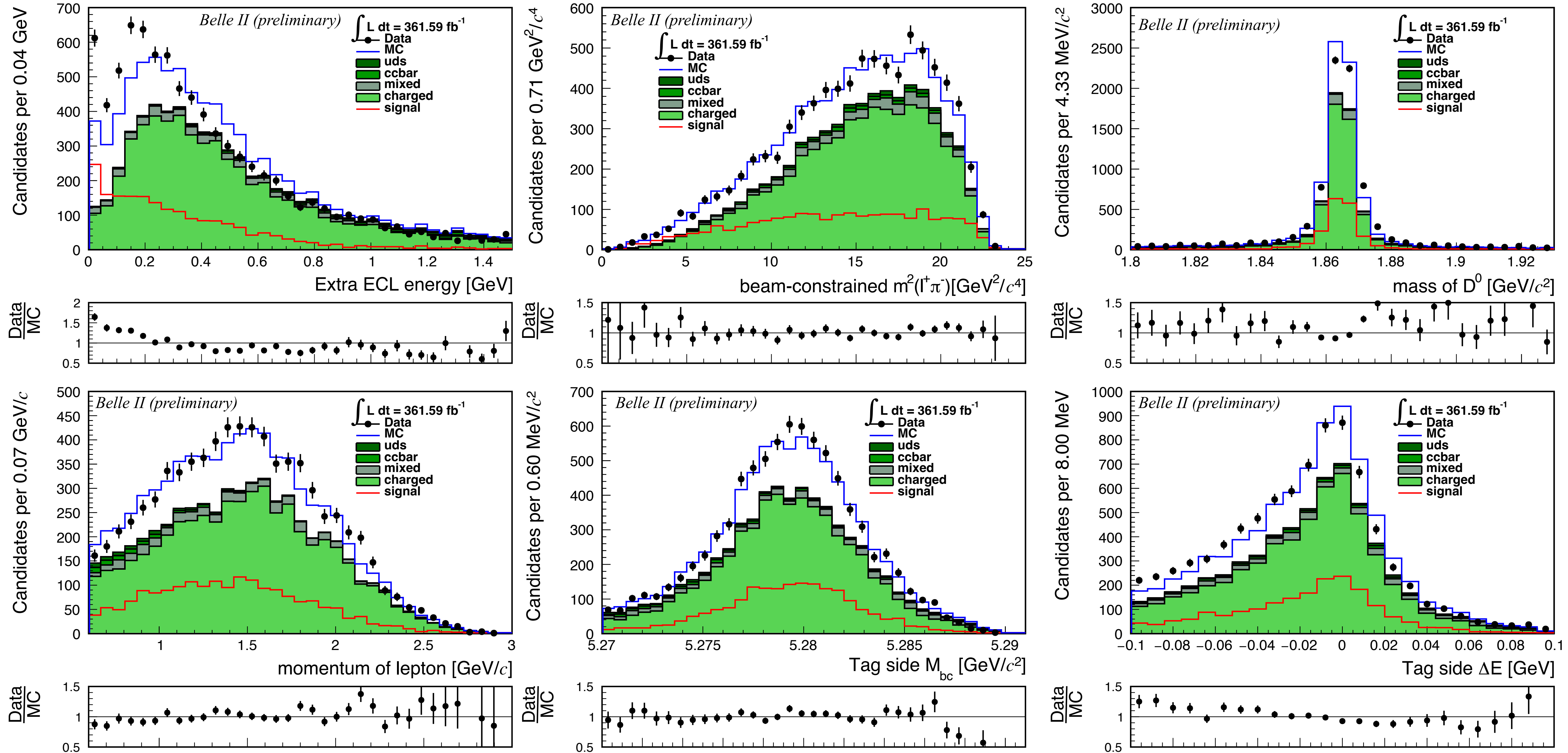
- After applying these selections and scaling with FEI correction factor (0.65), number of TM signal events in MC ($\mathcal{L} = 361.59 \text{ fb}^{-1}$) is 1960.

- Total number of events in data ($\mathcal{L} = 361.59 \text{ fb}^{-1}$) is 8201.
- Total number of events in MC ($\mathcal{L} = 361.59 \text{ fb}^{-1}$) scaled by FEI corr. is 8131.

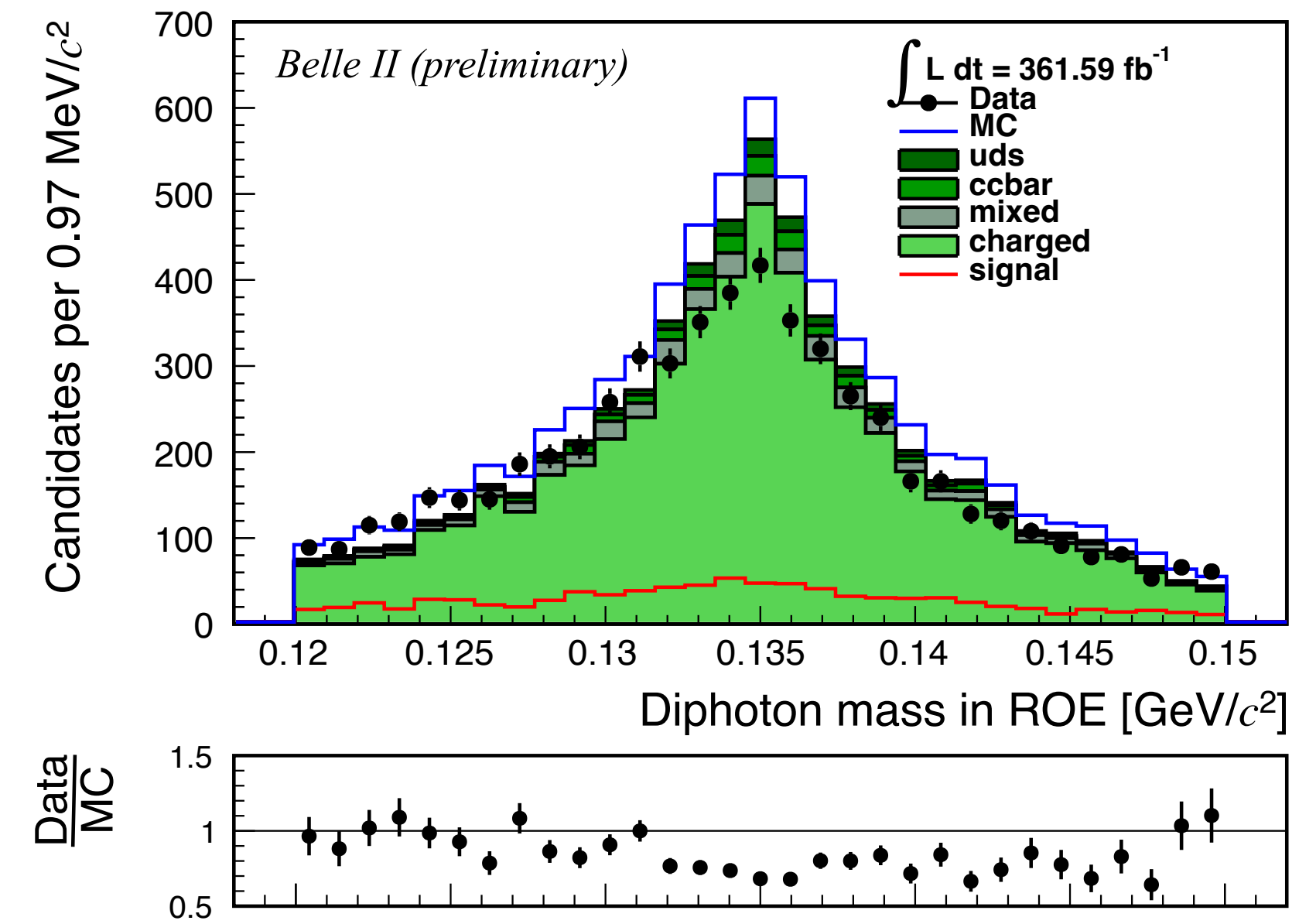
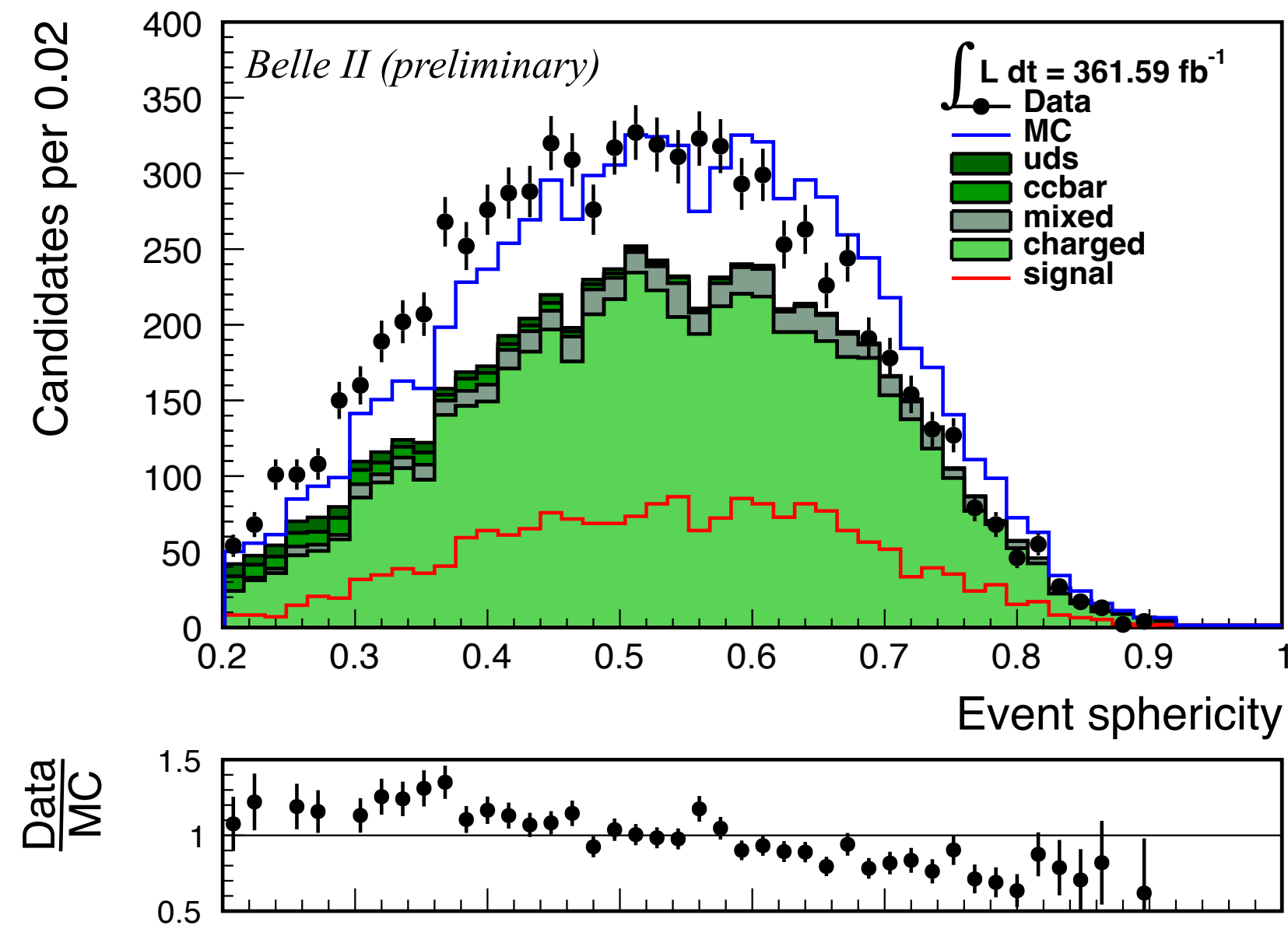
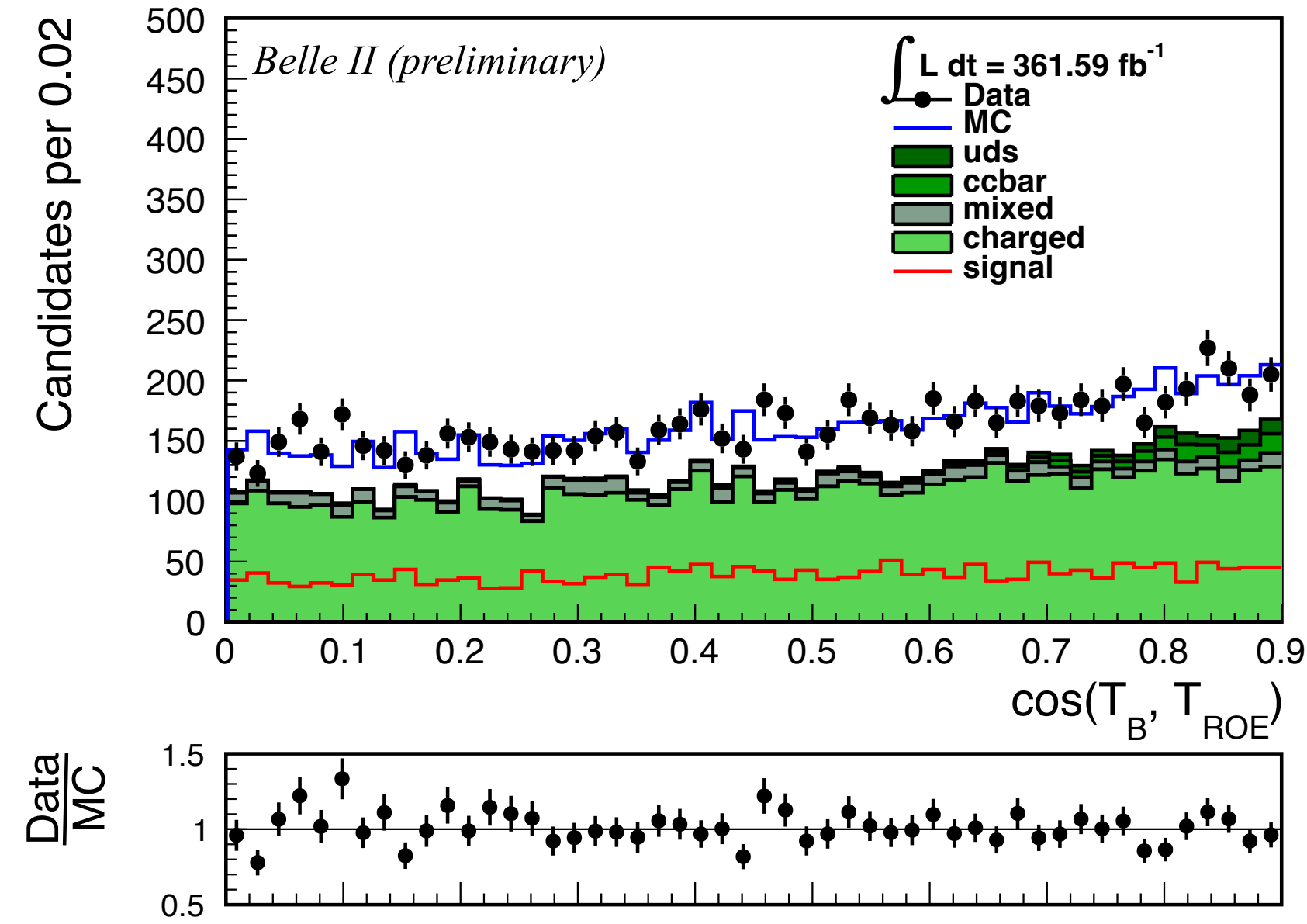
$$\frac{\text{data}}{\text{MC}} = 1.01$$

Data/MC comparison

E_{ECL} is badly modelled



Data/MC comparison



$$B^+ \rightarrow [\bar{D}^0 \rightarrow K^+ \pi^-] \pi^+$$

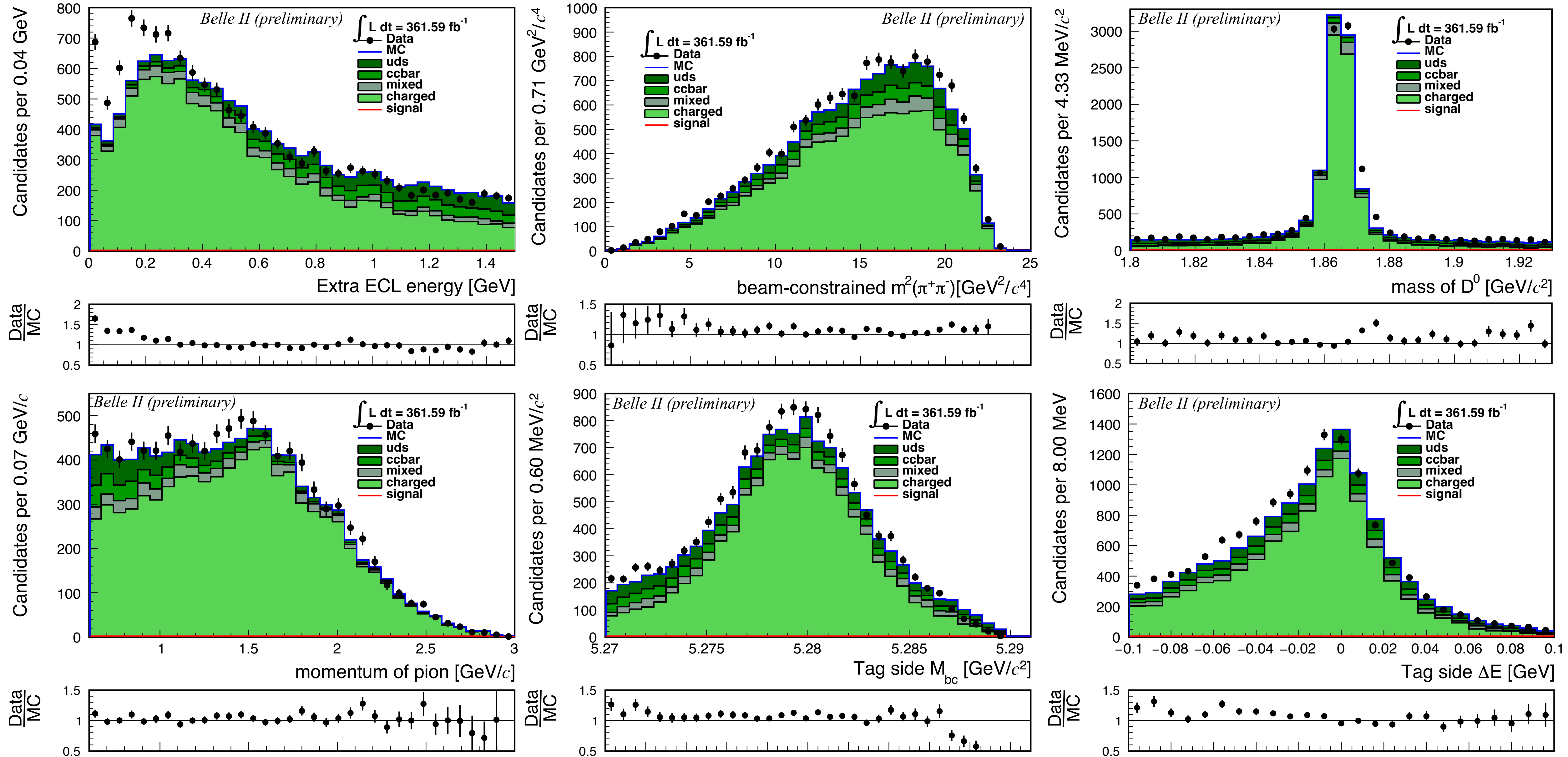
$$B^+ \rightarrow [\bar{D}^0 \rightarrow K^+ \pi^-] \pi^+$$

- Used same samples and selections as of $B^+ \rightarrow [\bar{D}^0 \rightarrow K^+ \pi^-] l^+ \bar{\nu}_l$ channel.
- After applying these selections and scaling with FEI correction factor (0.65), number of TM signal events in MC ($\mathcal{L} = 361.59 \text{ fb}^{-1}$) is 3.

- Total number of events in data ($\mathcal{L} = 361.59 \text{ fb}^{-1}$) is 13366. $\frac{\text{data}}{\text{MC}} = 1.06$

- Total number of events in MC ($\mathcal{L} = 361.59 \text{ fb}^{-1}$) scaled by FEI corr. is 12570.

Data/MC comparison



Data/MC comparison

