$K\tau\tau$ status

17/06/2024

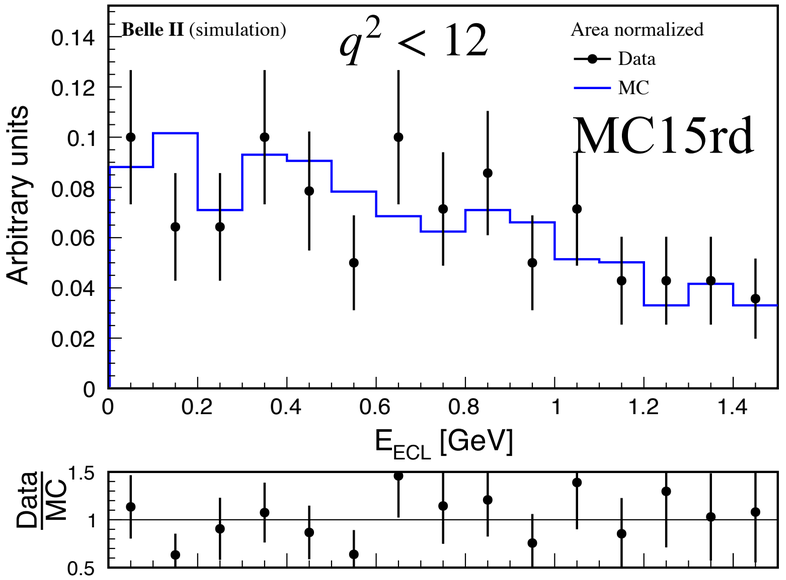
Re-do E_{ECL} validation

Old configuration: good E_{ECL} data/MC consistency

Changes in last two months:

- re-order tag side selections
- q^2 selection from > 12.5 to $> 14.18\ \mathrm{GeV}^2/c^4$
- run-independent with updated decay table (MC15ri-up)
- latest FEI training (trained on MC15ri-up)

Old configuration

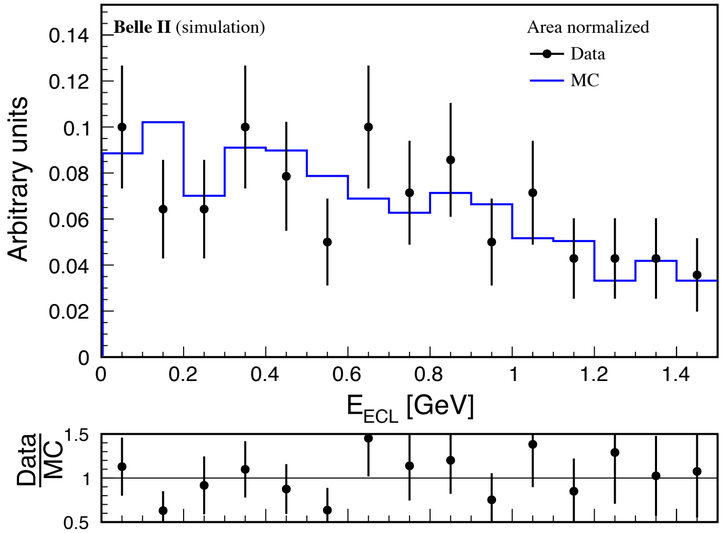


Thorough comparison with new configuration in reliable data sidebands

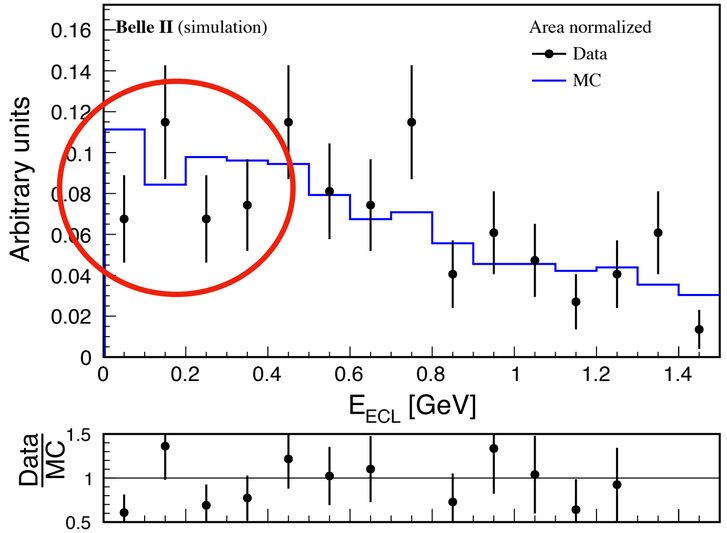
E_{ECL} validation for MC15-rd (old FEI)

no M^2_{miss}, $p^*_{\ell+}$ cut due to low statistics

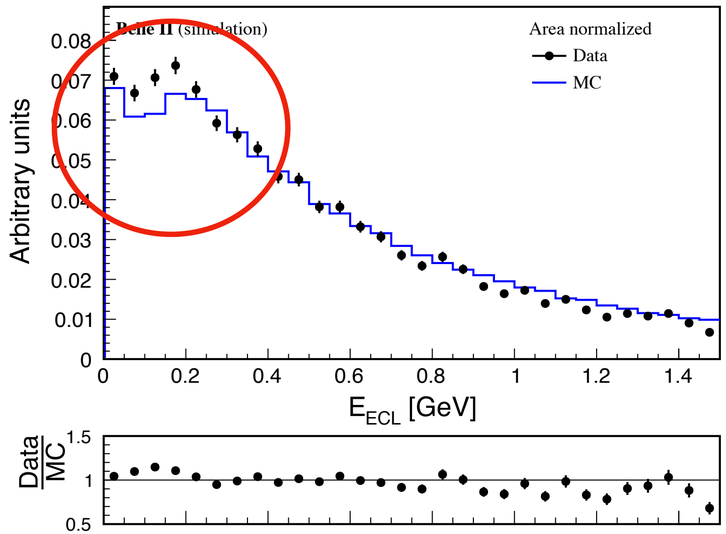
$q^2 < 14.18\ \mathrm{GeV}^2/c^4$



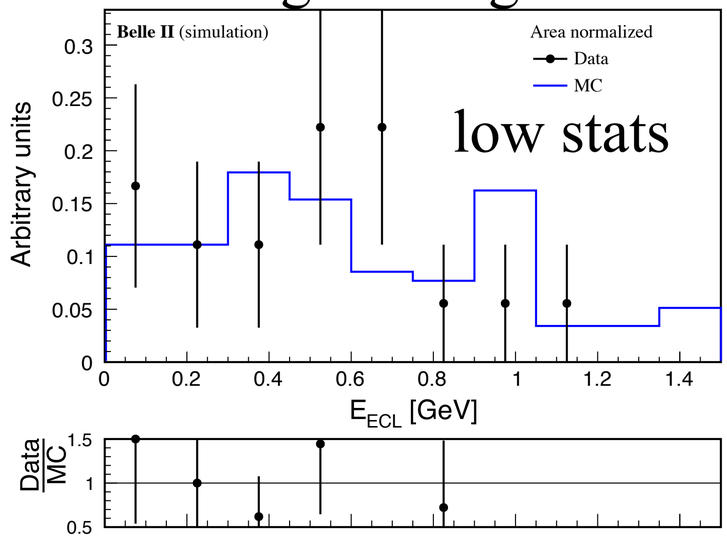
wrong tau charge sb



$m(K^+\ell^-) < 1.8\ \mathrm{GeV}/c^2$



wrong B charge sb



Small disagreement; hard to correct as there is no pattern

Background composition — MC15-rd (old FEI)

Focus in the signal region: $E_{ECL} < 300$ MeV; no M^2_{miss}, $p^*_{\ell^+}$ cut due to low statistics

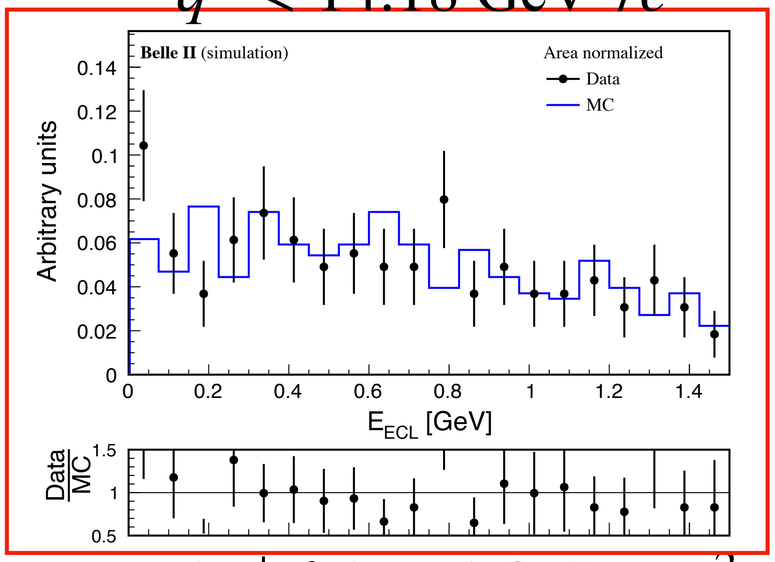
$K\tau\tau$ bkg	q^2 SB	$m(K^+\ell^-)$ SB	Wrong τ charge SB	Wrong B charge SB
B^+B^-: 64 (65%)	B^+B^-: 169 (79%)	B^+B^-: 30397 (95%)	B^+B^-: 152 (87%)	B^+B^-: 22 (85%)
$B\bar{B}^0$: 23%	$B\bar{B}^0$: 7%	$B\bar{B}^0$: 4%	$B\bar{B}^0$: 5%	$B\bar{B}^0$: 12%
$q\bar{q}$: 11%	$q\bar{q}$: 14%	$q\bar{q}$: 1%	$q\bar{q}$: 8%	$q\bar{q}$: 3%
Charged %				
$D^{*0}\ell^+\nu$: 28%	$J/\psi K^+$: 36%	$D^{*0}\ell^+\nu$: 60%	$D^{*0}\ell^+\nu$: 40%	$D^{*0}\ell^+\nu$: 36%
$D^0\ell^+\nu$: 20%	$D^{*0}\ell^+\nu$: 13%	$D^0\ell^+\nu$: 36%	$D^0\ell^+\nu$: 26%	$D^0\ell^+\nu$: 32%
$D_S^{(*)-}K^+\ell^+\nu$: 13%	$D^0\ell^+\nu$: 9%	$J/\psi K^+$: 1%	$X_u^0\mu^+\nu$: 12%	$D_0^{*0}e^+\nu$: 15
$J/\psi K^{*+}$: 3%	$D_S^{(*)-}K^+\ell^+\nu$: 7%		$D_1^0e^+\nu$: 3%	
	$J/\psi K^{*+}$: 2%		$D_0^{*0}e^+\nu$: 3%	

$m(K^+\ell^-)$ SB has a different bkg composition than $K\tau\tau$ bkg and other SBs

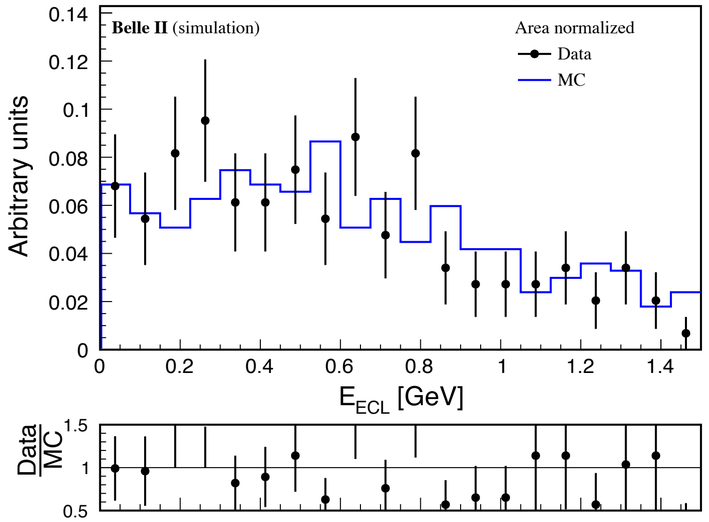
E_{ECL} validation for MC15-ri-up (new FEI)

no M^2_{miss}, $p^*_{\ell+}$ cut due to low statistics

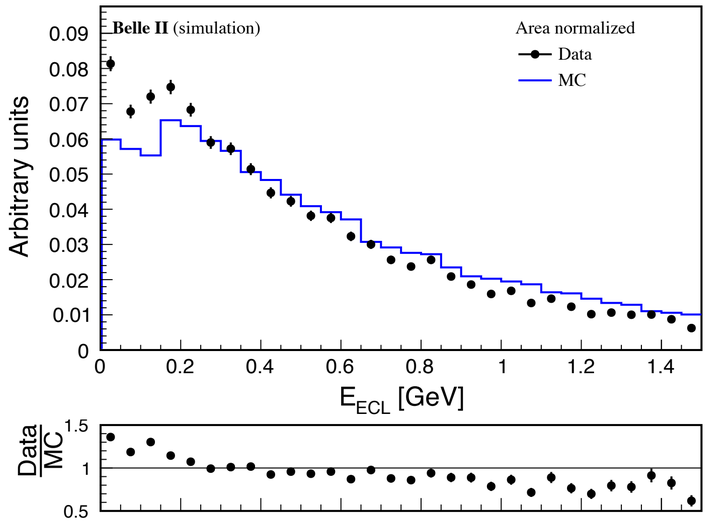
$q^2 < 14.18\ \mathrm{GeV}^2/c^4$



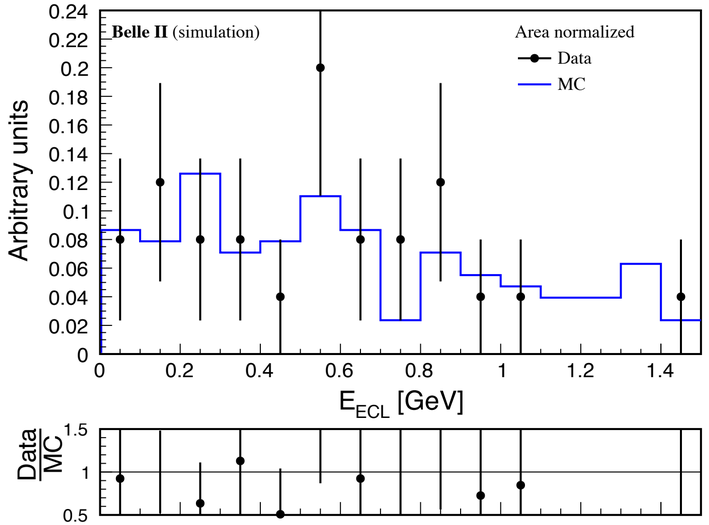
wrong tau charge sb



$m(K^+\ell^-) < 1.8\ \mathrm{GeV}/c^2$



wrong B charge sb



Unlike run-dependent, q^2 SB shows slight disagreement in signal bin

Background composition — MC15-ri-up (new FEI)

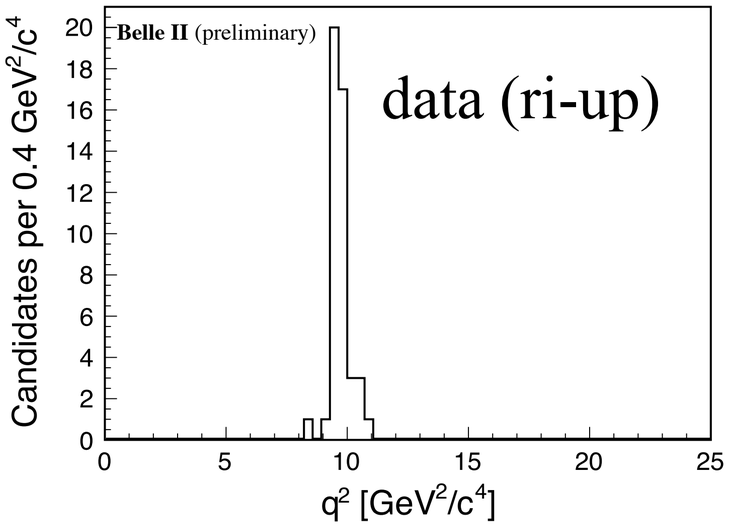
Focus in the signal region: $E_{ECL} < 300$ MeV; no M^2_{miss}, $p^*_{\ell^+}$ cut due to low statistics

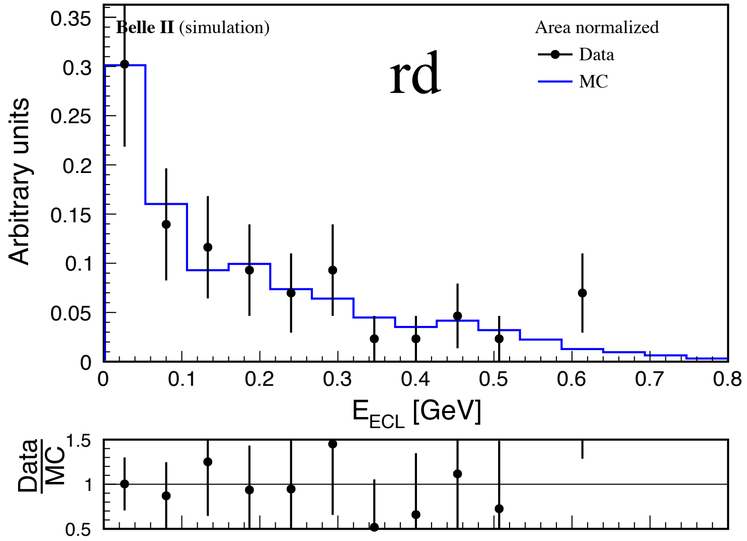
$K\tau\tau$ bkg	q^2 SB	$m(K^+\ell^-)$ SB	Wrong τ charge SB	Wrong B charge SB
B^+B^-: 24 (57%)	B^+B^-: 76 (76%)	B^+B^-: 14487 (95%)	B^+B^-: 63 (79%)	B^+B^-: 24 (67%)
$B\bar{B}^0$: 14%	$B\bar{B}^0$: 10%	$B\bar{B}^0$: 5%	$B\bar{B}^0$: 9%	$B\bar{B}^0$: 24%
$q\bar{q}$: 29%	$q\bar{q}$: 14%	$q\bar{q}$: <1%	$q\bar{q}$: 12%	$q\bar{q}$: 9%
Charged %				
$D^{*0}\ell^+\nu$: 42%	$J/\psi K^+$: 27%	$D^{*0}\ell^+\nu$: 60%	$D^{*0}\ell^+\nu$: 41%	$D^{*0}\ell^+\nu$: 46%
$D^0\mu^+\nu$: 8%	$D^{*0}\ell^+\nu$: 19%	$D^0\ell^+\nu$: 37%	$D^0\ell^+\nu$: 27%	$D^0\ell^+\nu$: 21%
$D_S^{(*)-}K^+\mu^+\nu$: 8%	$D^0\ell^+\nu$: 16%	$J/\psi K^+$: 1%	$X_u^0\mu^+\nu$: 6%	
$J/\psi K_1^+$: 8%	$D_S^{(*)-}K^+\ell^+\nu$: 7%		$D_1^0 e^+\nu$: 5%	
			$D_0^{*0} e^+\nu$: 3%	

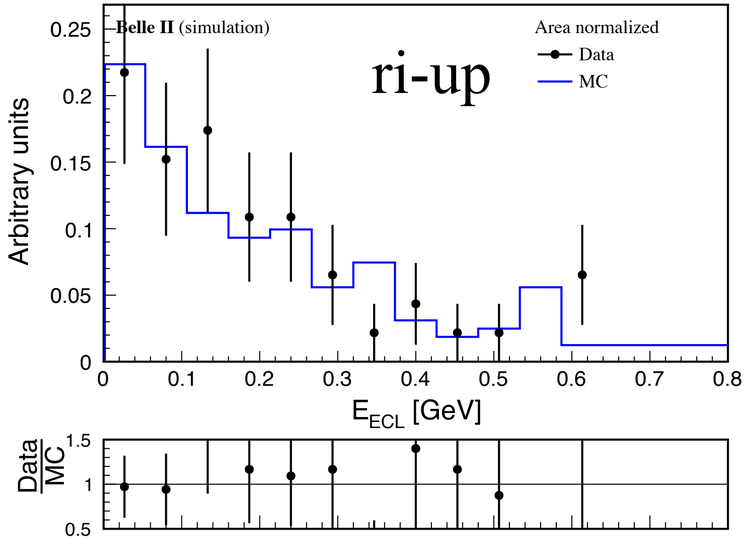
Two probable reasons for q^2 SB disagreement:
1. increase of $D^{(*)0}\ell\nu$ proportion wrt 'rd'; 2. if there is mismodelling in $J/\psi K^+$

J/ψ signal validation

Pure signal with no background: clear peak in q^2







J/ψ signal shape is well modelled. So the increase of $D^{(*)0}\ell\nu$ proportion in q^2 SB may be the reason of disagreement in "ri-up"

Current big picture

$D^{(*)0}\ell\nu$ channels has well known E_{ECL} mismodelling. E_{ECL} mismodelling in data sidebands depends on $D^{(*)0}\ell\nu$ proportion

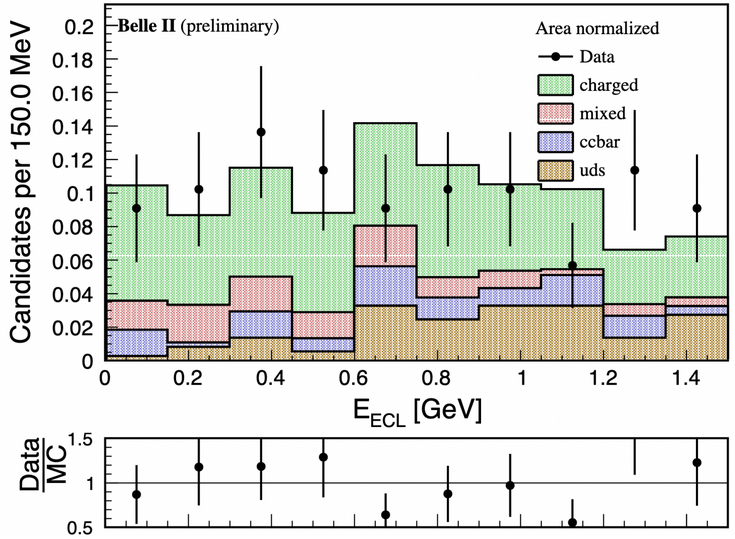
q^2 sideband is the most reliable data sideband.

	MC15 rd	**MC15 ri-up**
q2 sb	consistent	inconsistent in 1st bin
wrong tau charge sb	inconsistent in signal bins	consistent
wrong B charge sb	consistent; low stat	consistent; low stat
m(kl2) sb	inconsistent	inconsistent

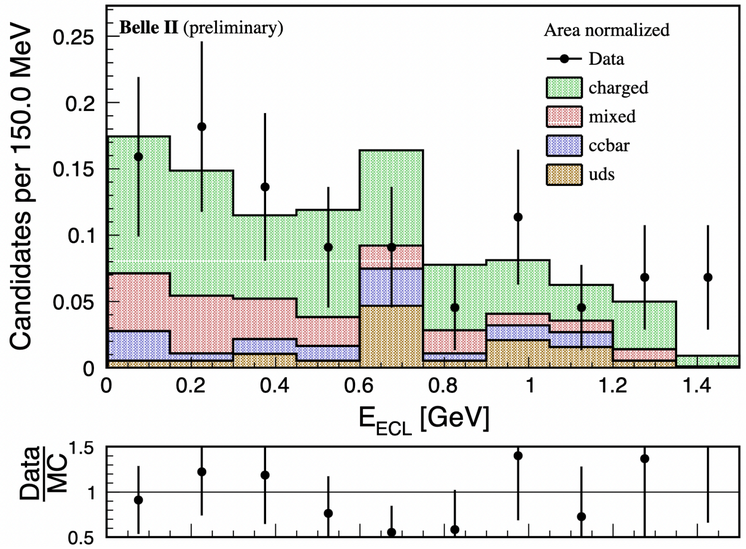
Any inconsistency is hard to correct as there is uniform pattern across sidebands

Signal region of $K\tau\tau$ — MC15 rd

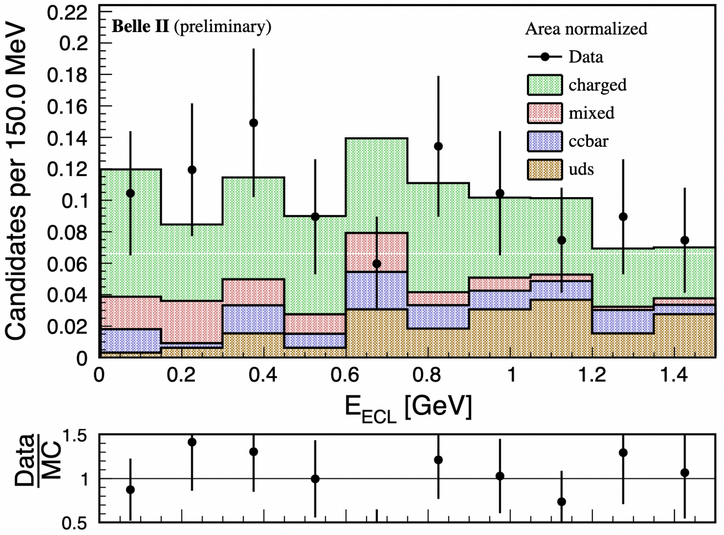
No M^2_{miss}; no $p^*_{\ell+}$ cuts



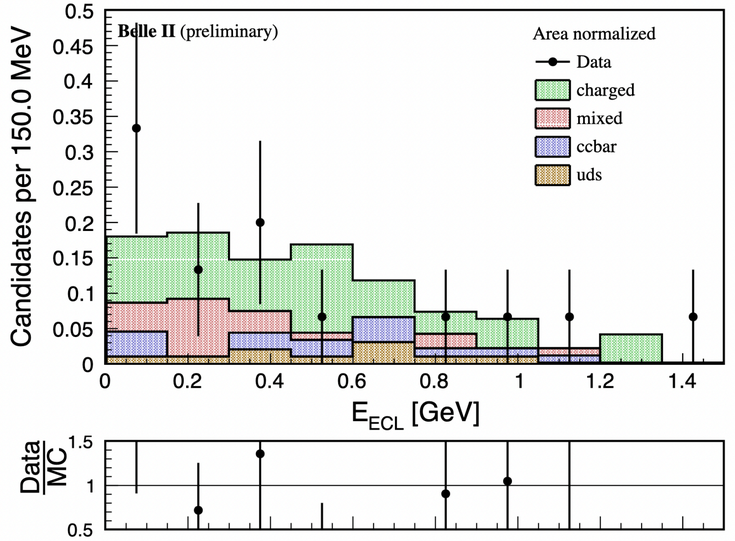
with M^2_{miss} cut; no $p^*_{\ell+}$ cuts



no M^2_{miss} cut; with $p^*_{\ell+}$ cut



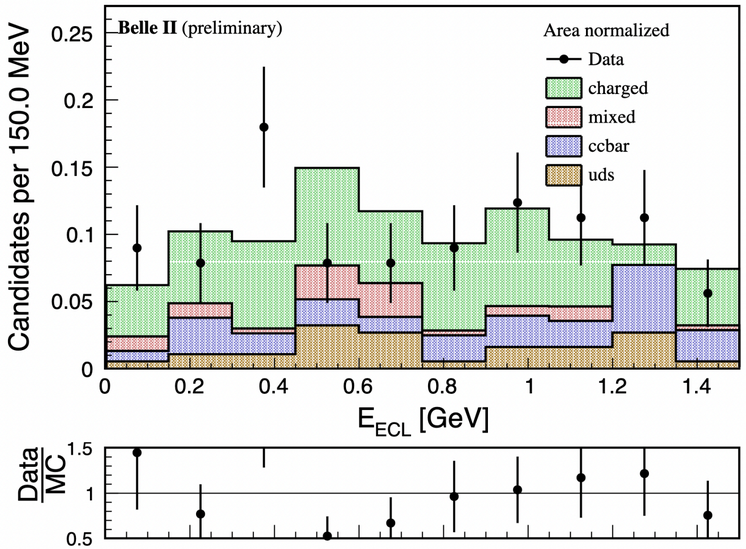
with M^2_{miss} cut; with $p^*_{\ell+}$ cut



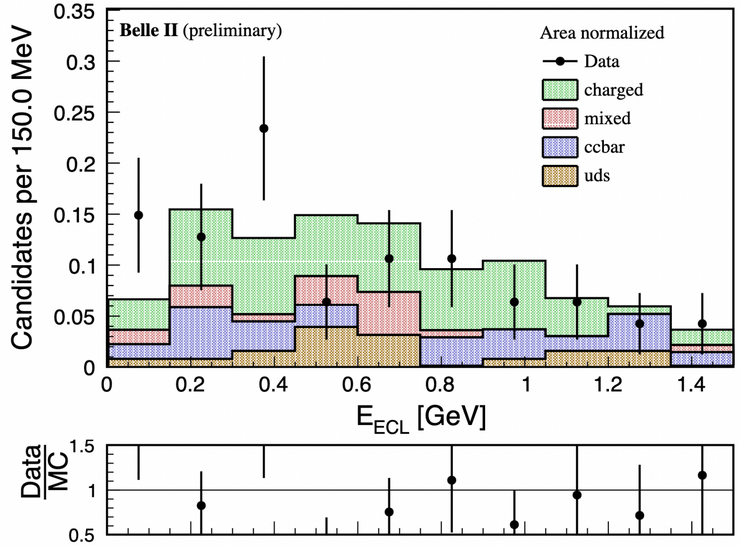
All looks good except 0.6 to 0.8 GeV bin

Signal region of $K\tau\tau$ — MC15 ri-up

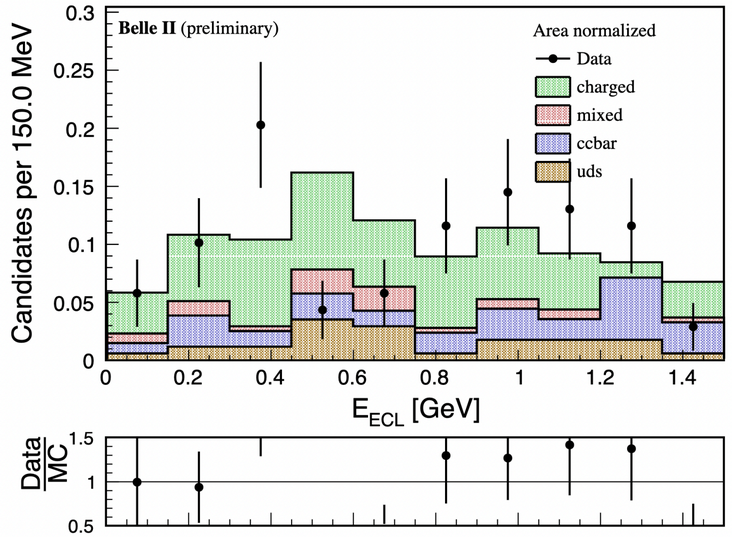
No M^2_{miss}; no $p^*_{\ell+}$ cuts



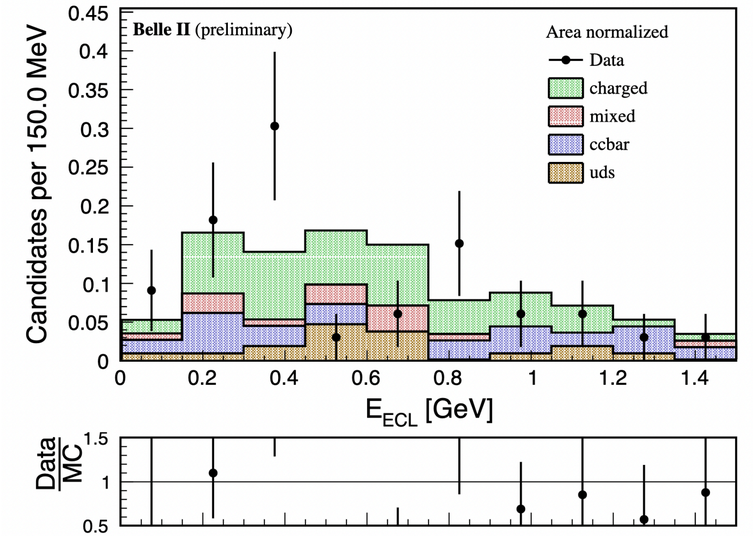
with M^2_{miss} cut; no $p^*_{\ell+}$ cuts



no M^2_{miss} cut; with $p^*_{\ell+}$ cut



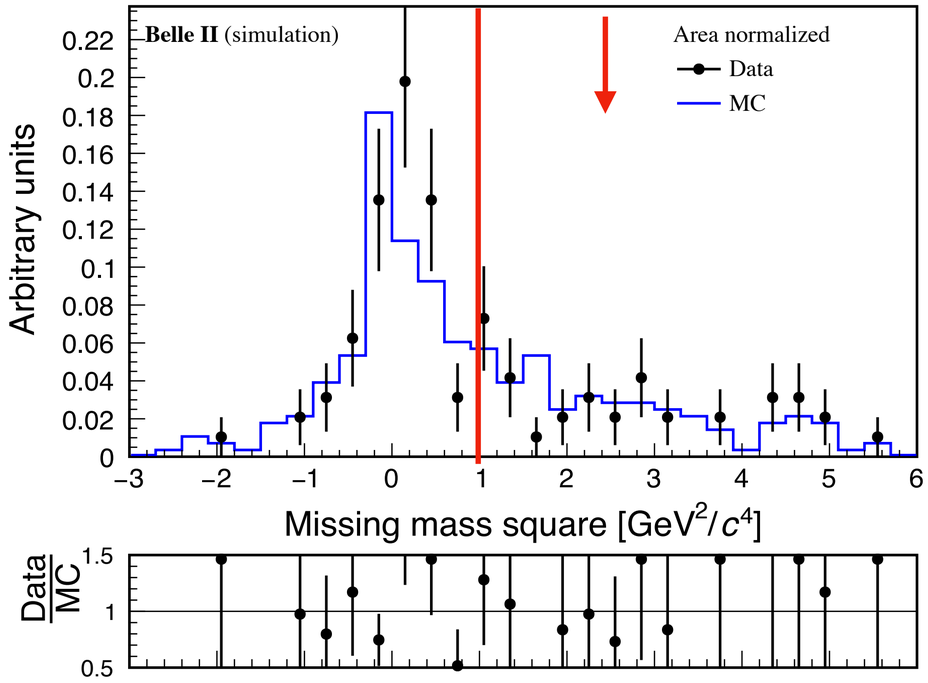
with M^2_{miss} cut; with $p^*_{\ell+}$ cut



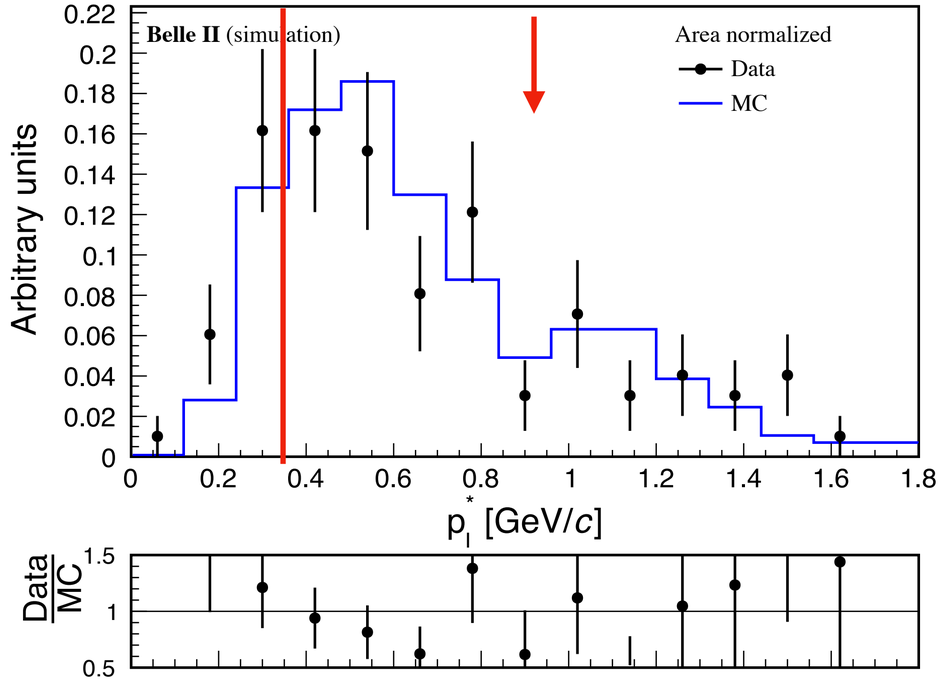
M^2_{miss} introduces slight inconsistency in signal bin; however, in all cases large disagreement shows in E_{ECL} sideband 300 - 700 MeV

E_{ECL} SB — MC15 ri-up

M^2_{miss}



$p^*_{\ell+}$



Disagreement is outside the signal region

Less data than MC after $p^*_{\ell+} > 0.4$ GeV/c

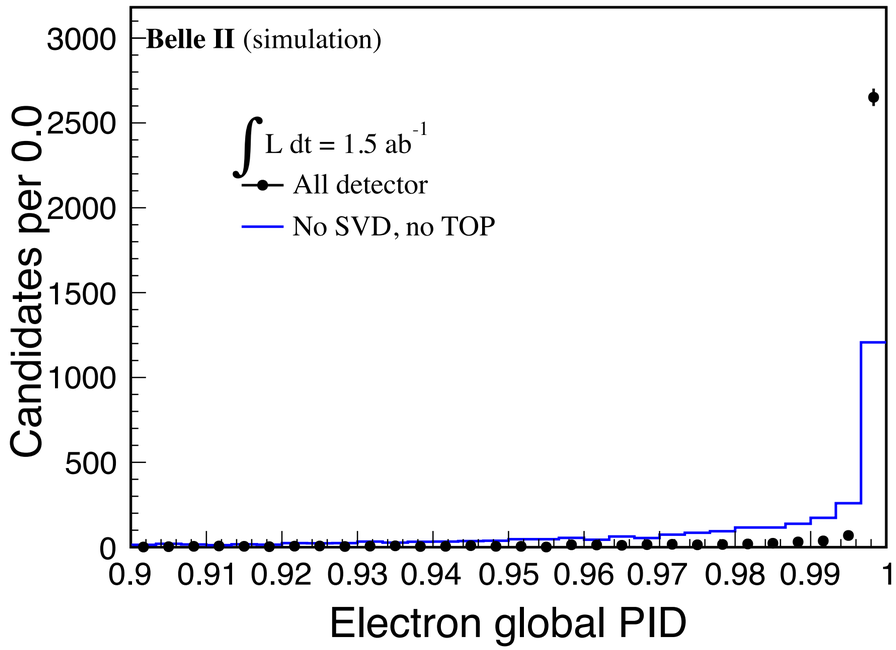
New e, μ PID

- No PID correction available with our PID for e, μ

Changes:

electron global PID (all detector) to global PID (without SVD and TOP)

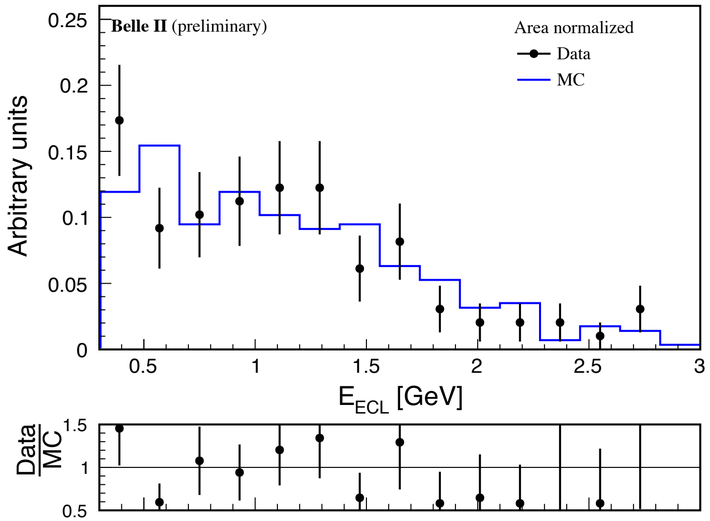
muon global PID (all detector) to global PID (without SVD)



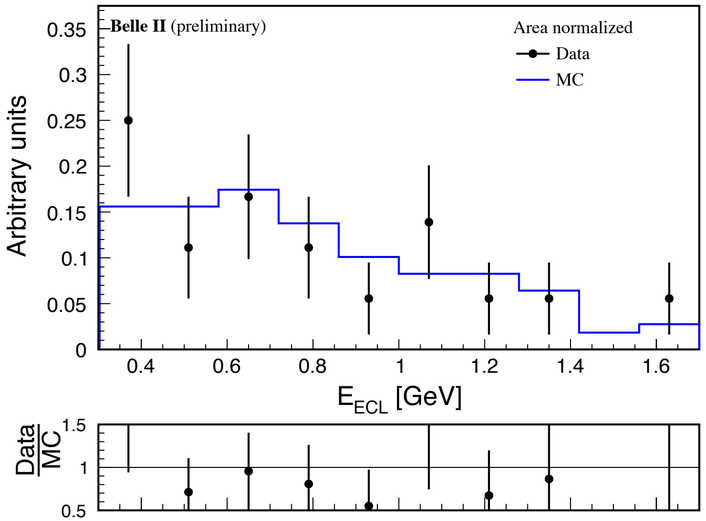
- Negative effect in sensitivity (20%) due to low electron efficiency. Next: BDT e PID

E_{ECL} SB — MC15 ri-up

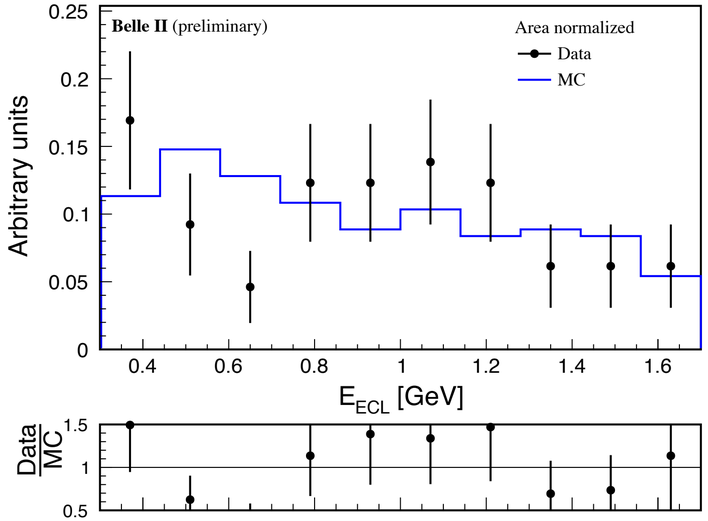
No M^2_{miss}; no $p^*_{\ell+}$ cuts



with M^2_{miss} cut; no $p^*_{\ell+}$ cuts



no M^2_{miss} cut; with $p^*_{\ell+}$ cut



with M^2_{miss} cut; with $p^*_{\ell+}$ cut