W Mass Measurement in CEPC

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EW Meeting

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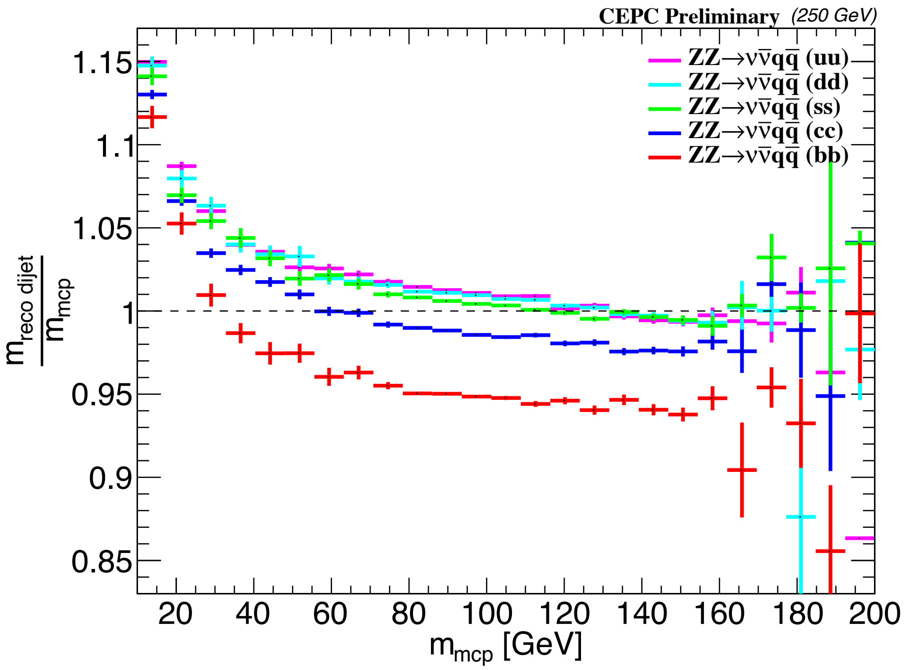
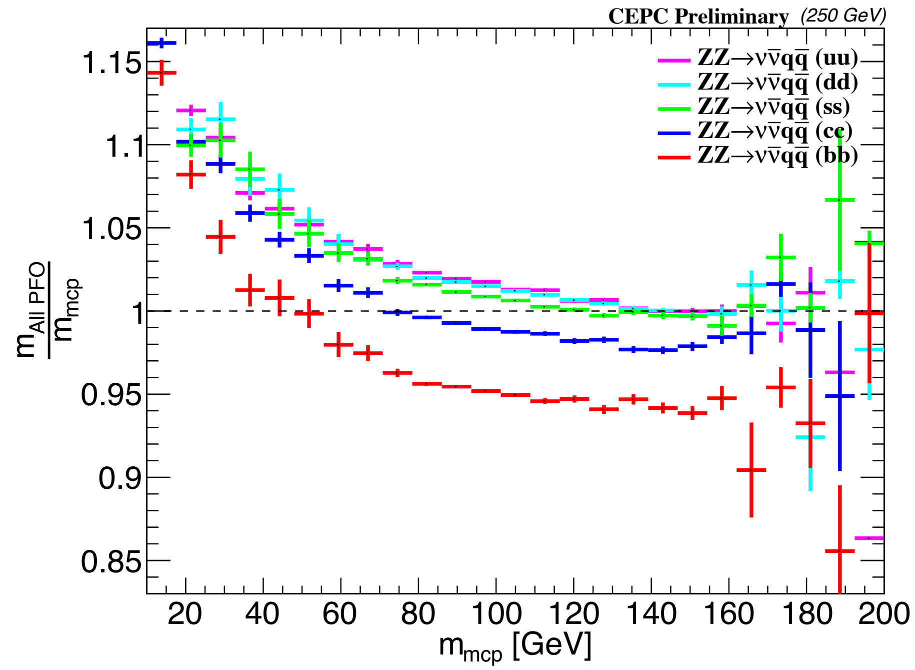
Outline

- **Check the m_{reco} / m_{true} along the m_{true} (m_{qq}) by TProfile. Two approaches are used to reconstruct mass; one method is to use two jets, and another one is to use all particle flow objects (PFO).**
- **Fixed the wrong categorization problems.**
- **Compare the m_{jj} /m_{true} after two different calibration approaches to find the best one. One way is to calibrate using the energy and flavor dependent JES. Another way is to calibrate by each flavor dijet's invariant mass in ZZ process.**
- **The last mission in the Maarten's to do list. Study the ROC of b-/c- tagging.**

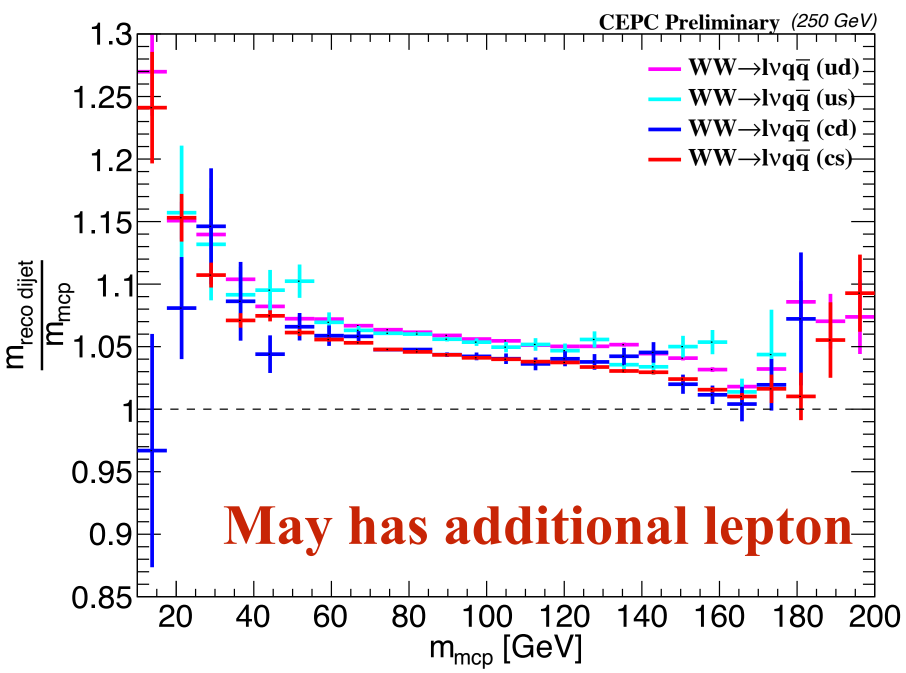
$m_{reoc\ jj}/m_{mcp}$ OR $m_{All\ PFO}/m_{mcp}$ VS. m_{mcp}

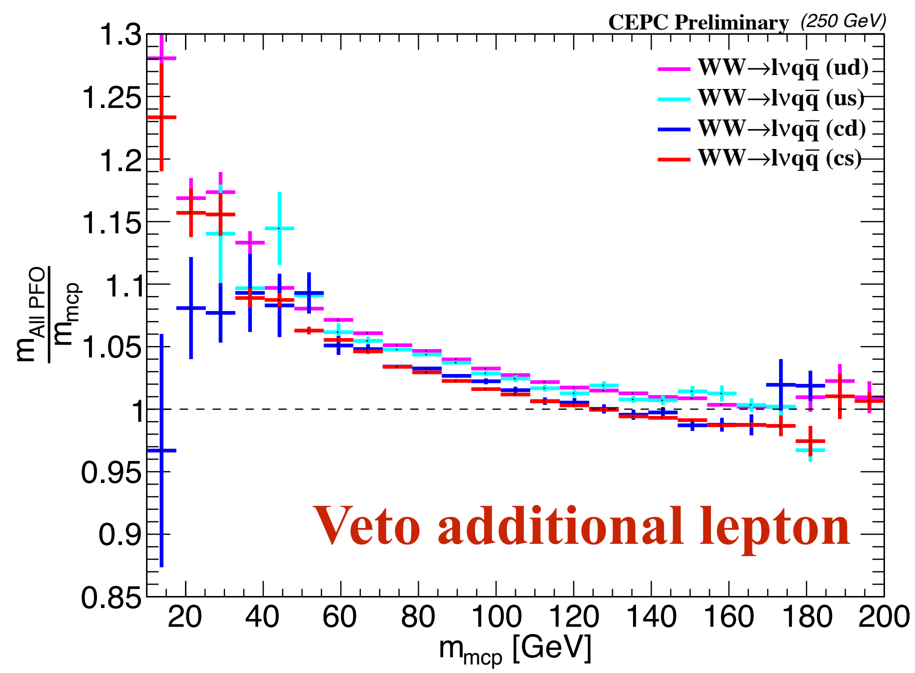
Z





W





- **The mean of m_{reco} / m_{mcp} is shown as a function of m_{mcp}.**
- **The deviation is large in low mass region.**
- **The best one is s-quark around the Z mass region. No significant difference is seen in the case of W.**
- **All PFO has better performance in the high mass region.**
- **The ratio of m_{reco} / m_{mcp} for Z is within 1.15~0.85, and for W is within 1.3~1.**

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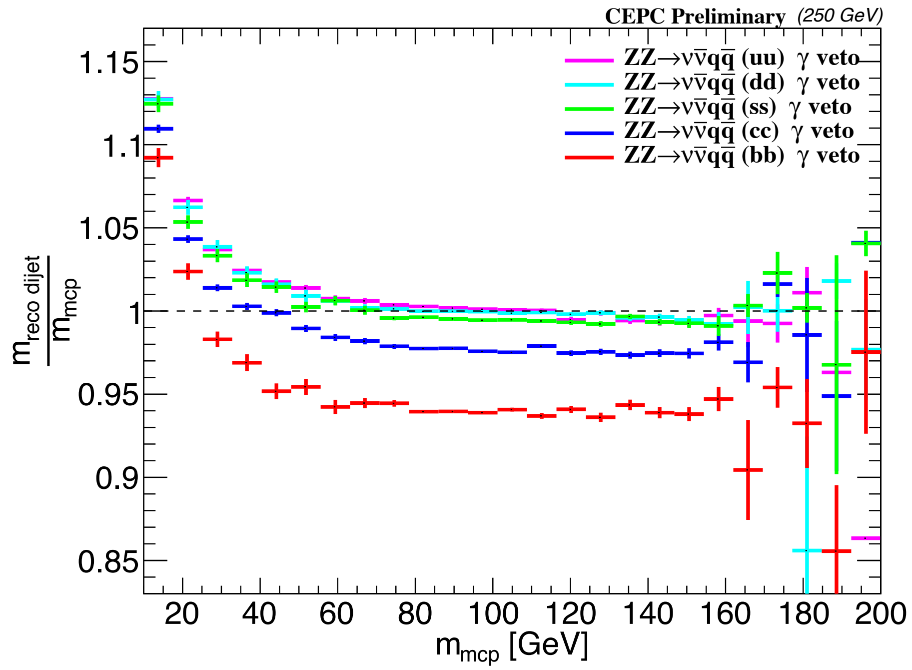
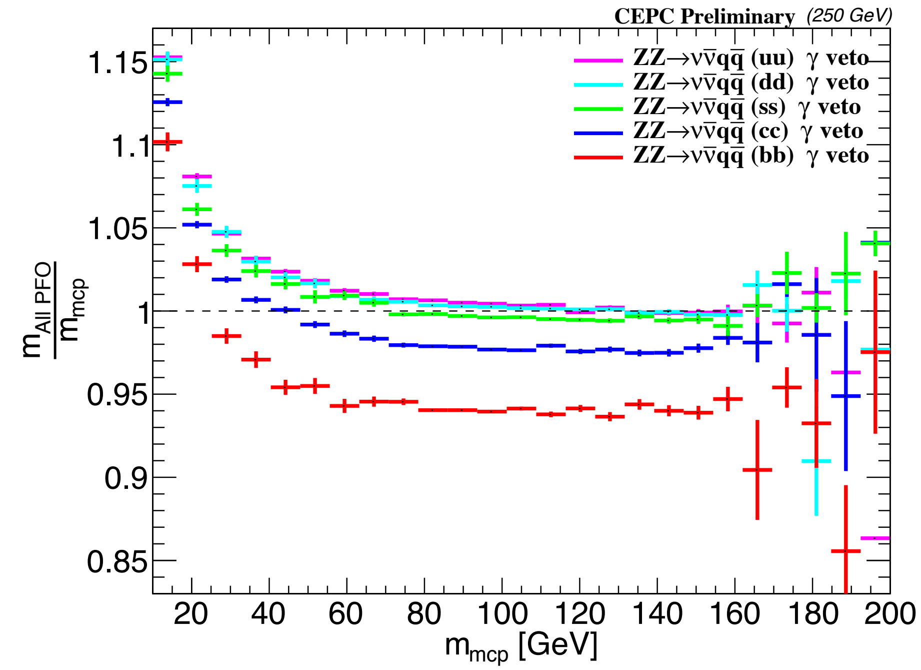
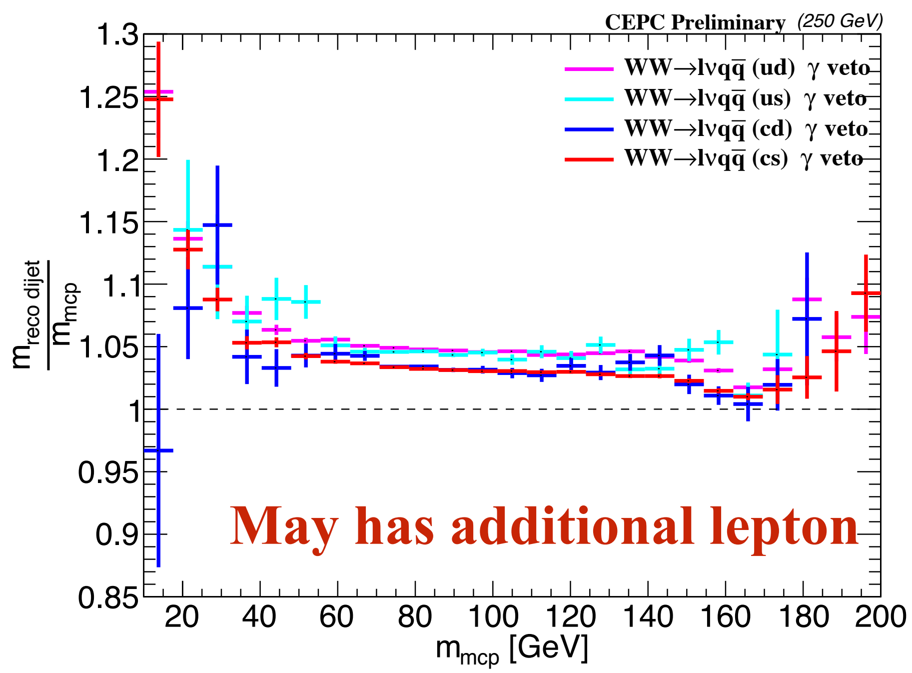
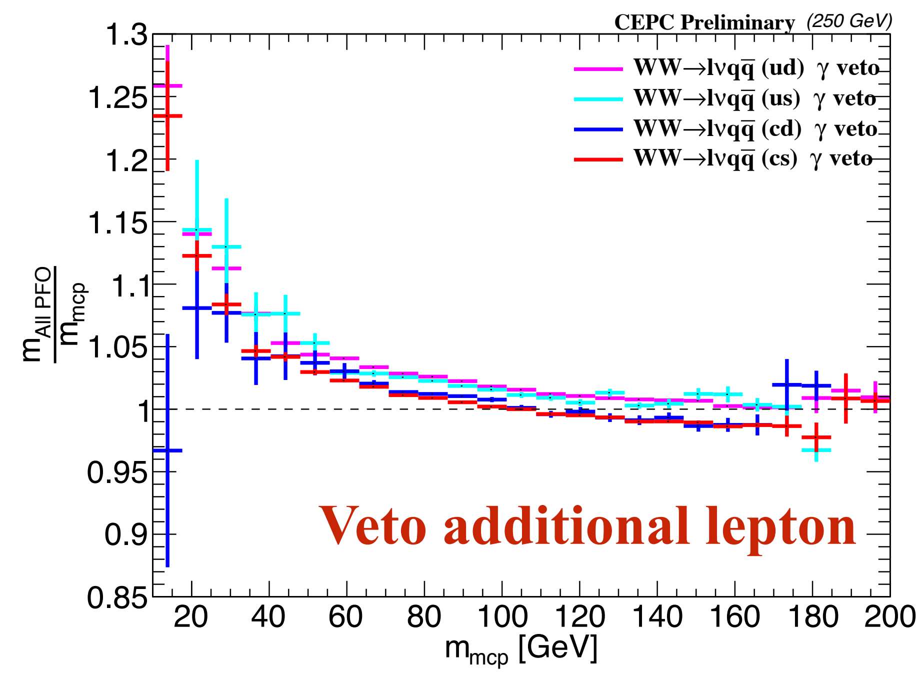
Z





W





- **ISR veto improves the performance a lot, and the light quark invariant mass is ok.**

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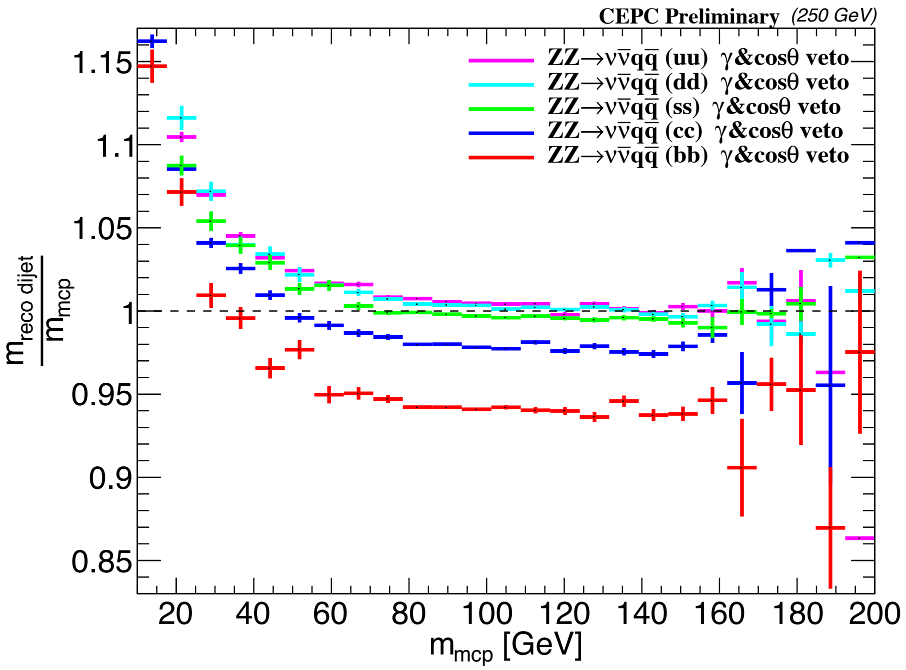
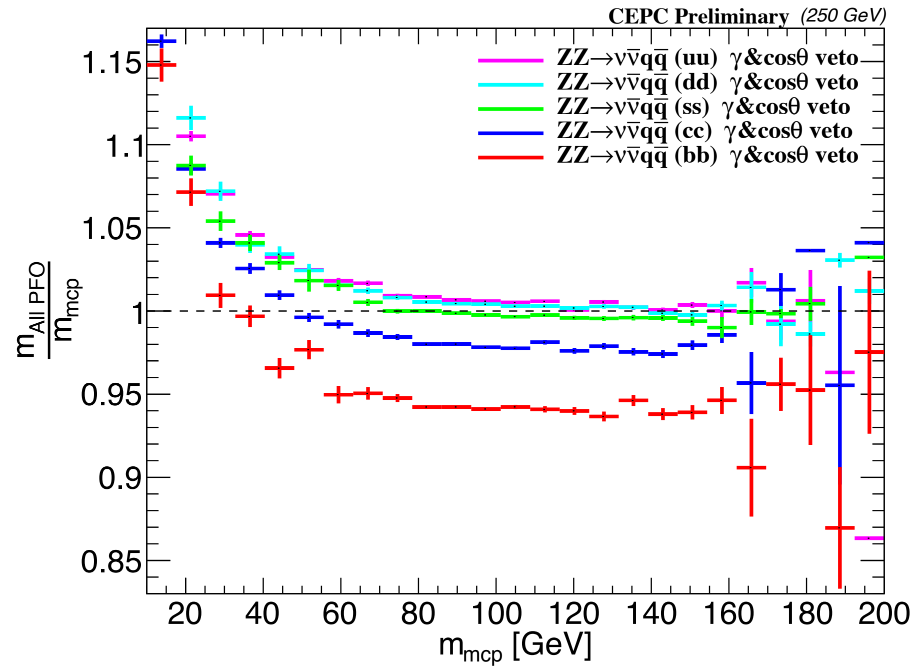
Z





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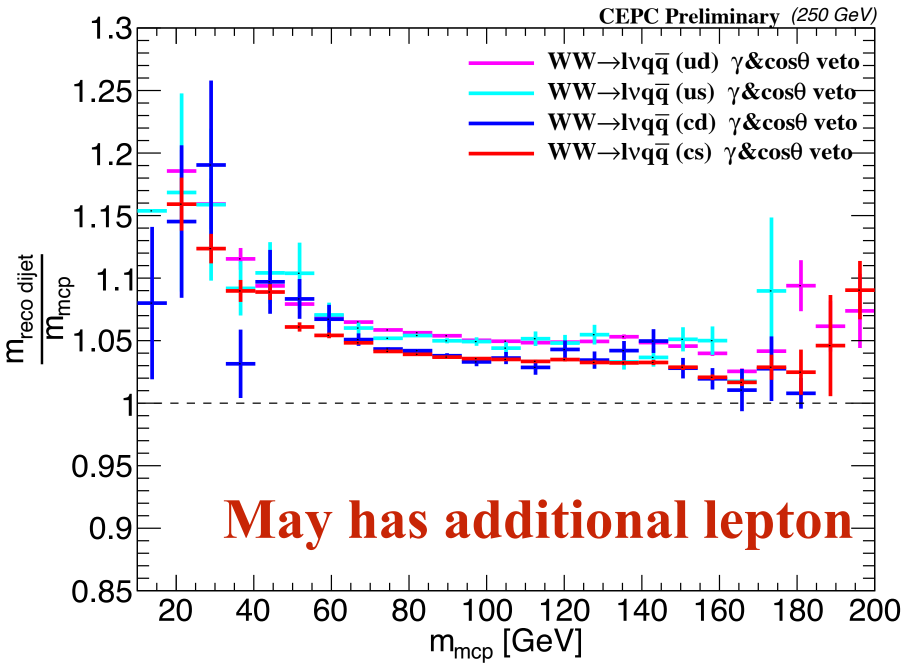
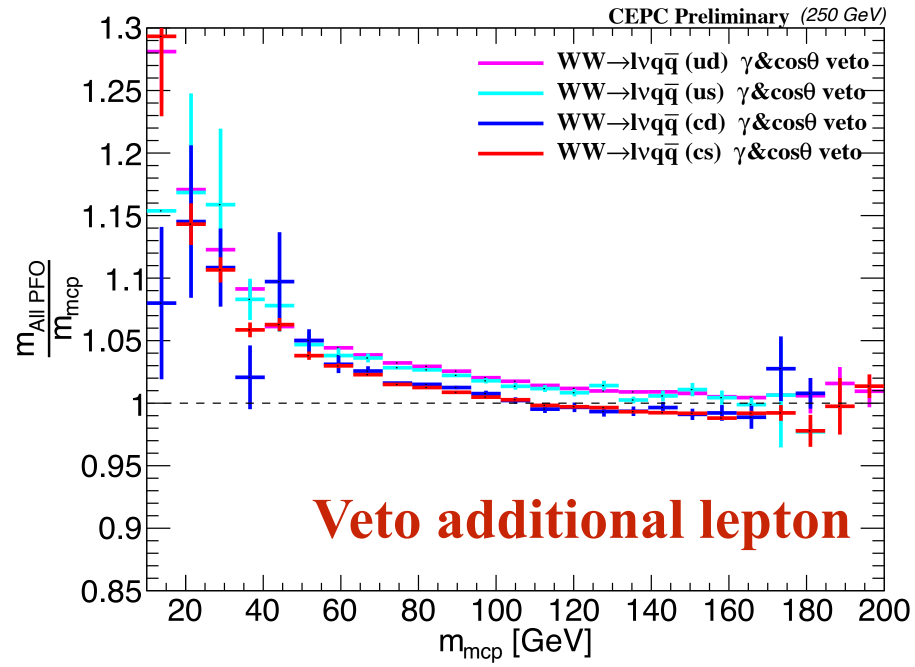


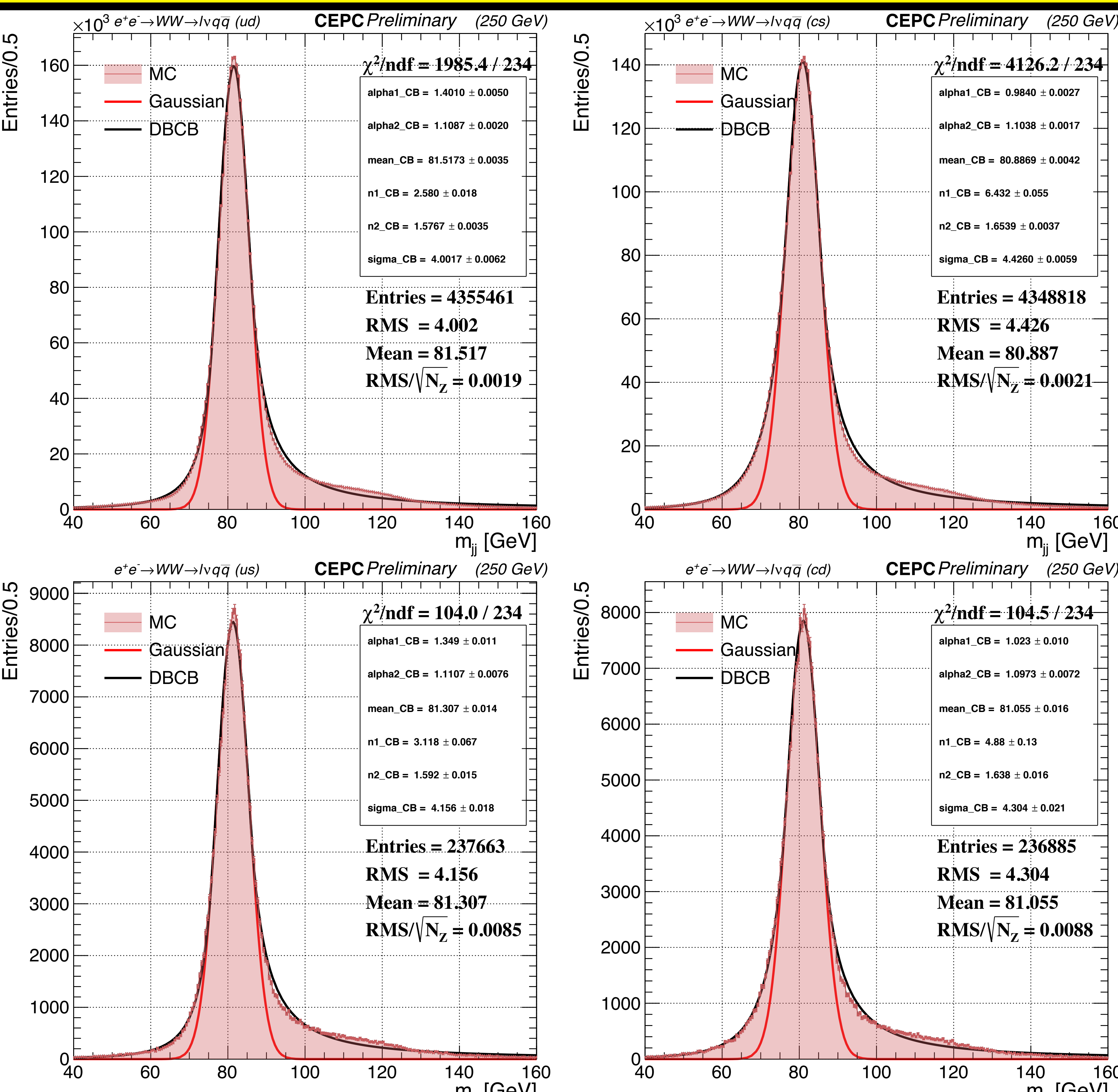


- **Veto the low energy events. Therefore, the low mass region becomes worse.**

Outline

- Check the m_{reco} / m_{true} along the m_{true} (m_{qq}) by TProfile. Two approaches are used to reconstruct mass; one method is to use two jets, and another one is to use all particle flow objects (PFO).
- **Fixed the wrong categorization problems.**
- Compare the m_{jj} /m_{true} after two different calibration approaches to find the best one. One way is to calibrate using the energy and flavor dependent JES. Another way is to calibrate by each flavor dijet's invariant mass in ZZ process.
- The last mission in the Maarten's to do list. Study the ROC of b-/c- tagging.

W->(ud, cs, us, cd) (40<m_W<160)



- **Calculate the value from the fitting results.**
- **The number of cross generations decay is less than the same generation decay.**

W->(ud, cs, us, cd) (40<m_W<160)

	W→ud	W→cs	W→us	W→cd
Entries	4355461	4348818	237663	236885
RMS	4.002	4.426	4,156	4.304
Mean	81.517	80.887	81.307	81.055
RMS/$\sqrt{N_W}$	0.0019	0.0021	0.0085	0.0088

m_W = 80.385

m_u = 2.2 MeV	m_c = 1.27 GeV	m_t = 173 GeV
m_d = 4.7 MeV	m_s = 96 MeV	m_b = 4.6 GeV

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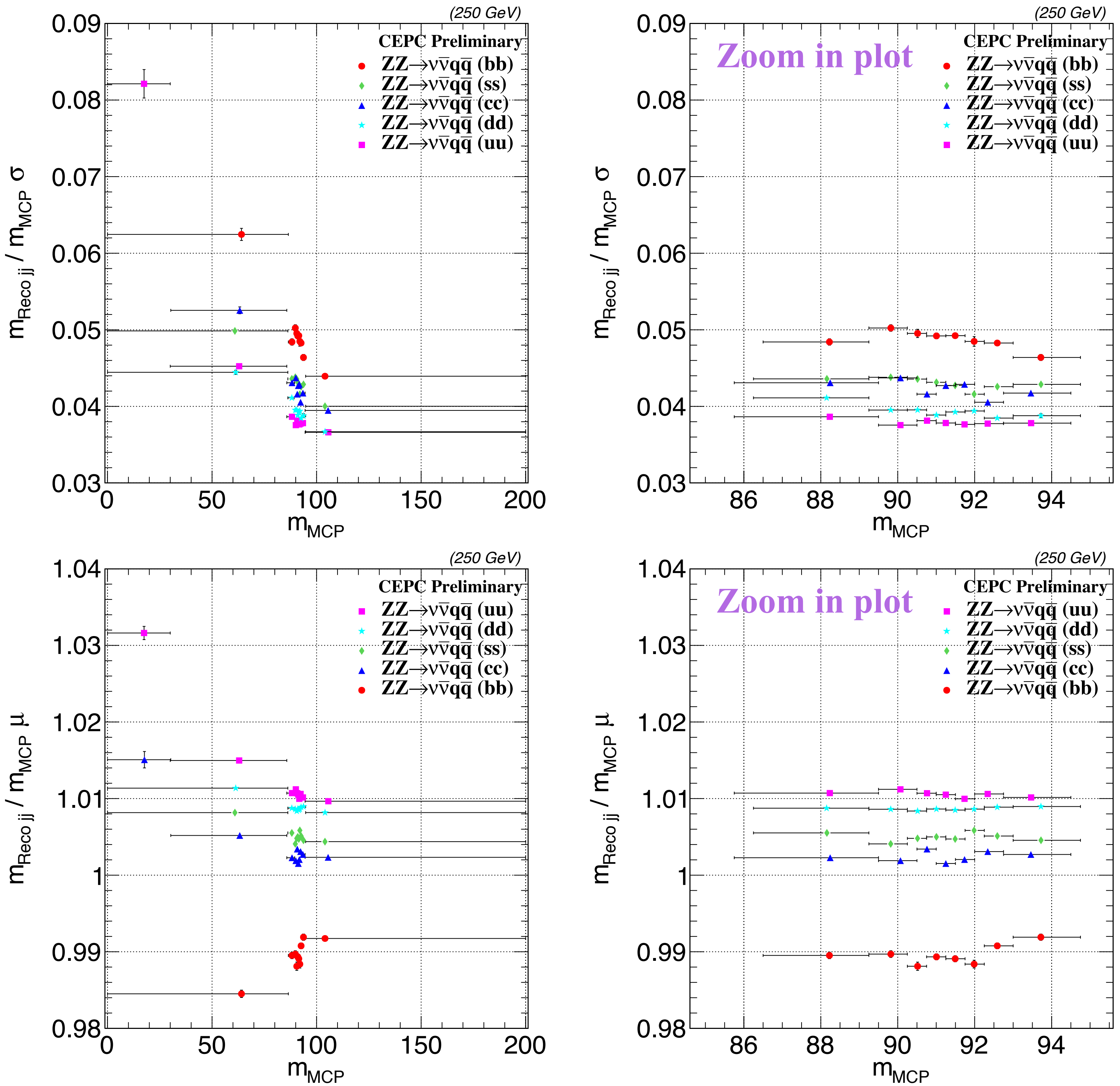
Z || $m_{reoc\ jj} / m_{mcp}$ VS. m_{mcp}



- The boson mass resolution follows the decay product mass. The order is from b to u.
- The boson mass scale follows the neutrino productivity of quark.

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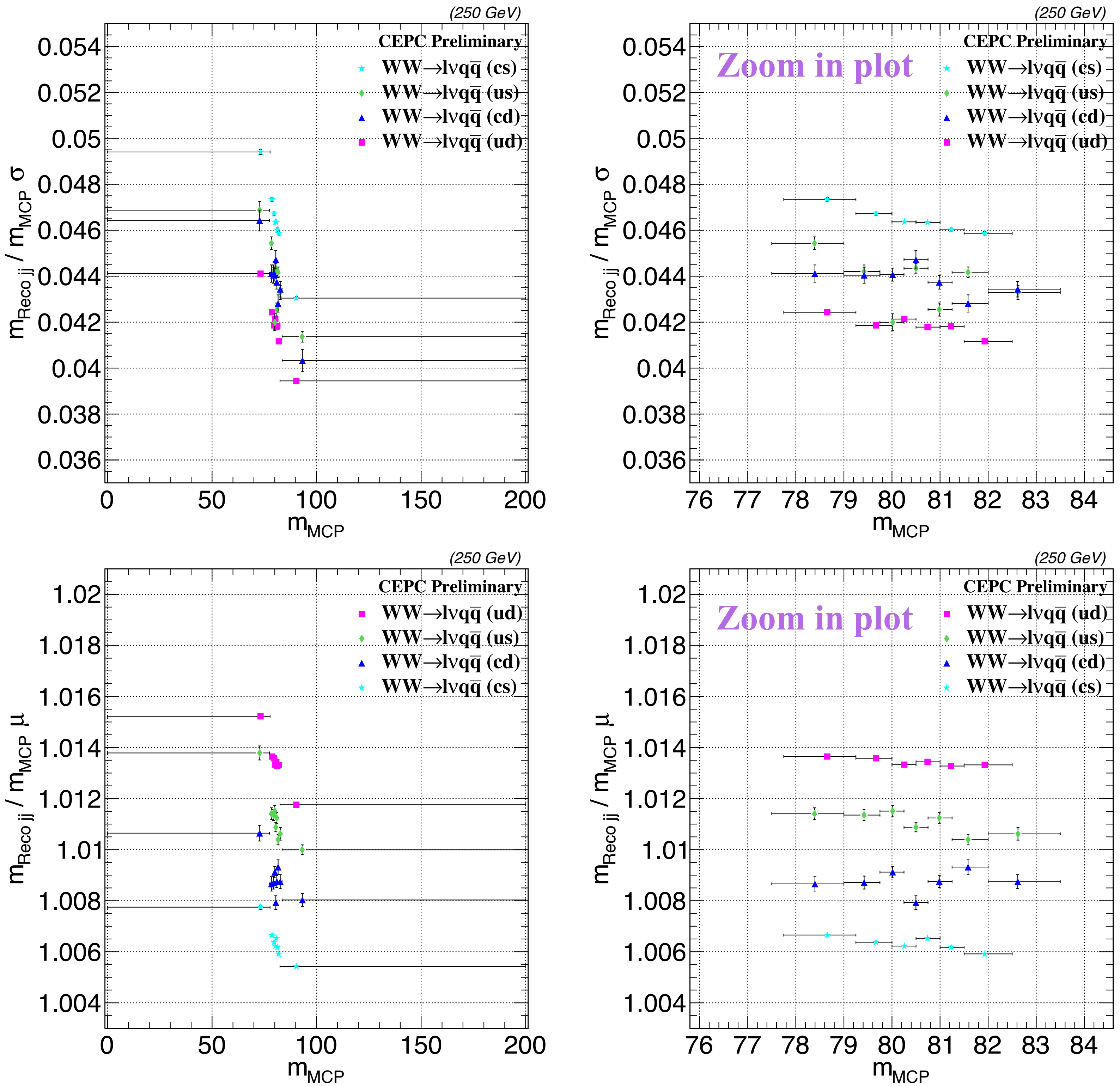

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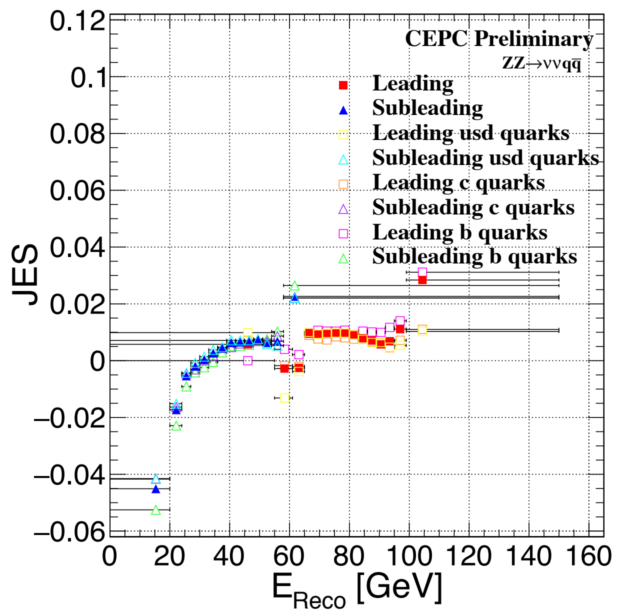
Calibration Workflow

Approach 1

Study the JES (enery, flavor) → Identified individual jet's energy and flavor → Applied on individual jet $E_{reco\ jet}$ / (1+JES)

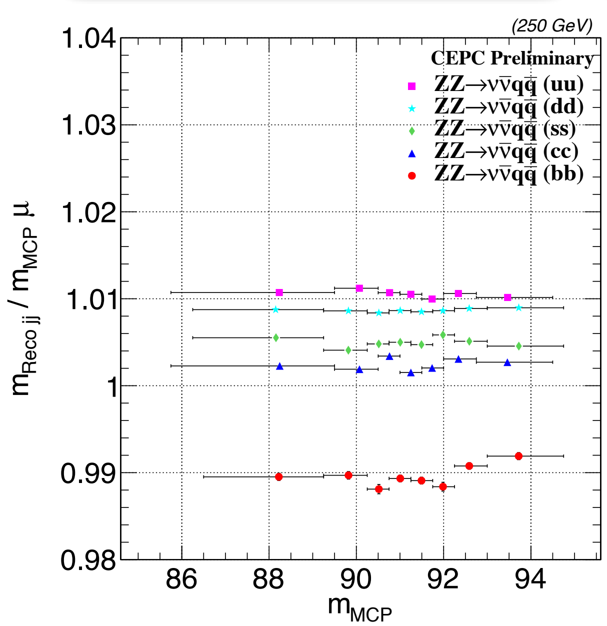
$$\frac{E_{RecoJet} - E_{GenJet}}{E_{GenJet}}$$



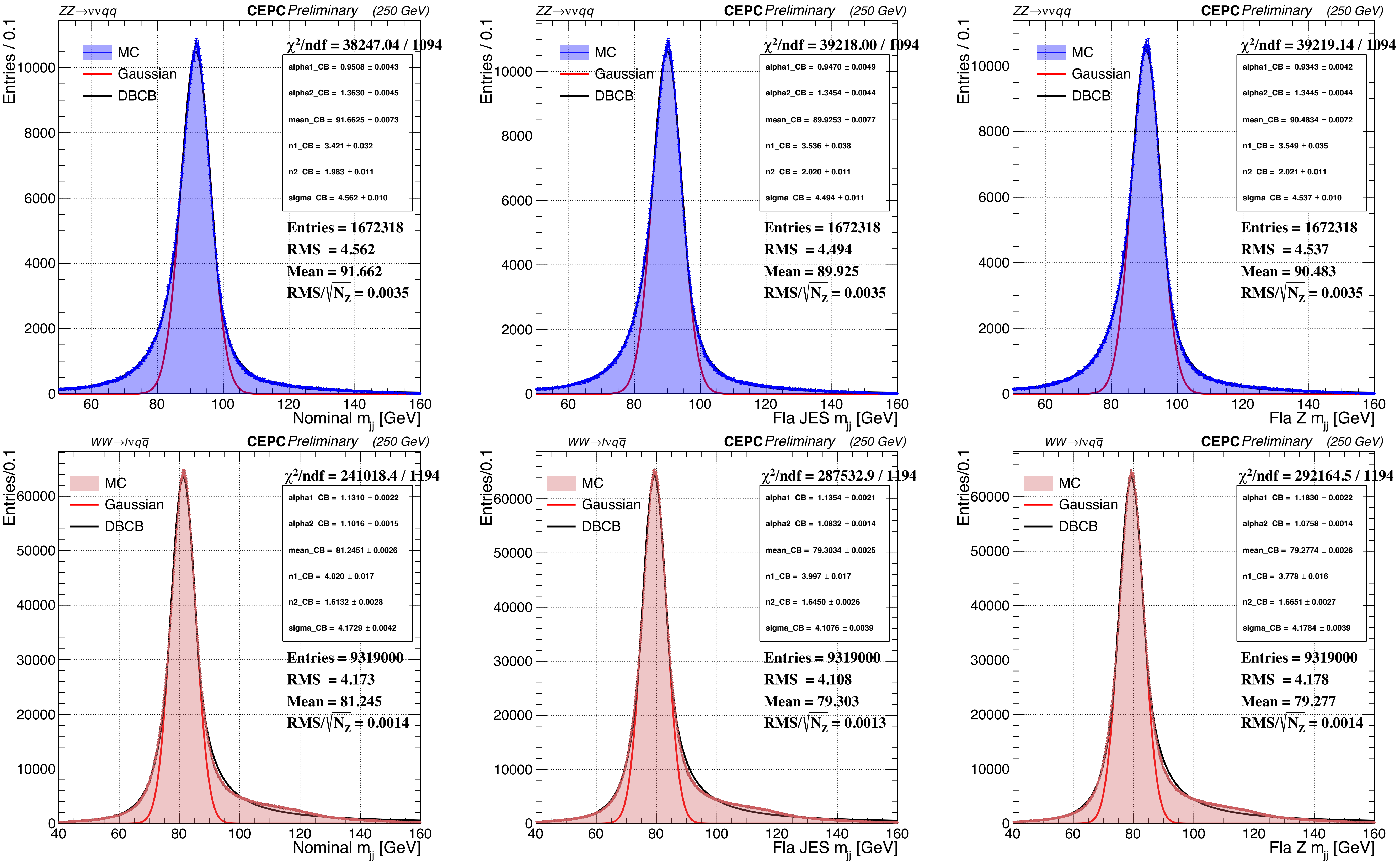
Approach 2

Study the BMS (m_{MCP} , flavor) → Identified dijet m_{MCP} and flavor of jet → Applied on individual jet $E_{reco\ jet}$ / (BES)

$$\frac{m_{RecodiJet}}{m_{MCP}}$$



Apply calibration to $m_{reoc\ jj}$



Apply calibration to $m_{reoc\ jj}$

	Nominal Z→qq	Applied JES Z→qq	Applied BMS Z→qq
Entries	1672318	1672318	1672318
RMS	4.562	4.494	4.537
Mean	91.662	89.925	90.483
Mean/m_Z	1.00520	0.98615	0.99227

	Nominal W→qq	Applied JES W→qq	Applied BMS W→qq
Entries	9319000	9319000	9319000
RMS	4.173	4.108	4.178
Mean	81.245	79.303	79.277
Mean/m_W	1.01069	0.98653	0.98621

- **Nominal one is the best. ……………………**
- **Go back to check the JES calibration first. I want to know where is the reason. First, I will divide the energy and flavor to reconstruct mass.**

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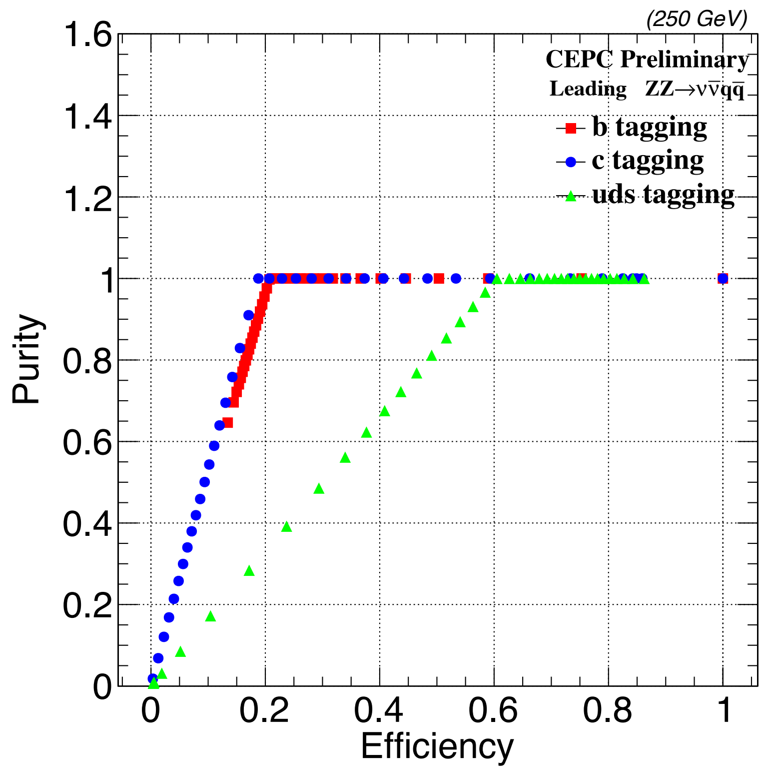
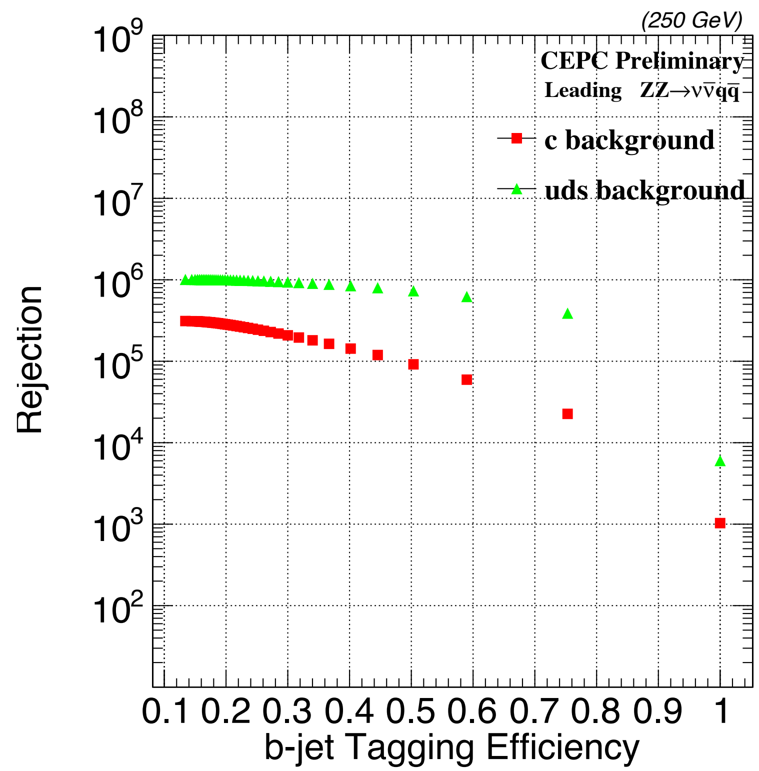
b-/c- quark Tagging



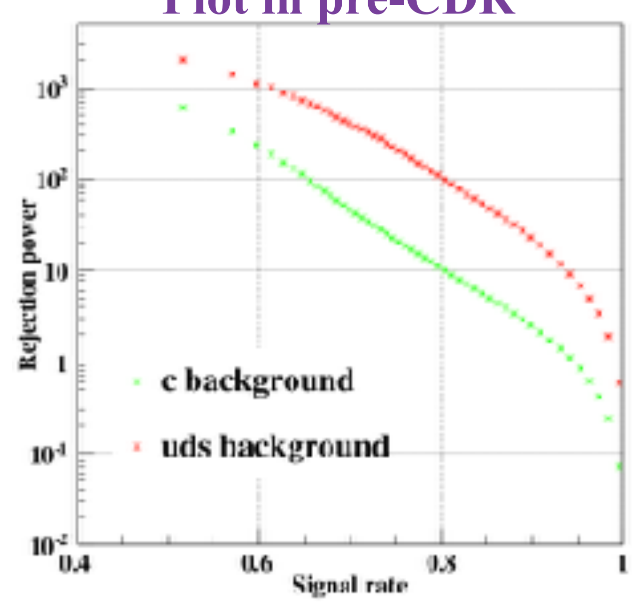


$$purity = \frac{\#\ of\ \ pass\ b\ tagging}{\#\ of\ \ MC\ b}$$

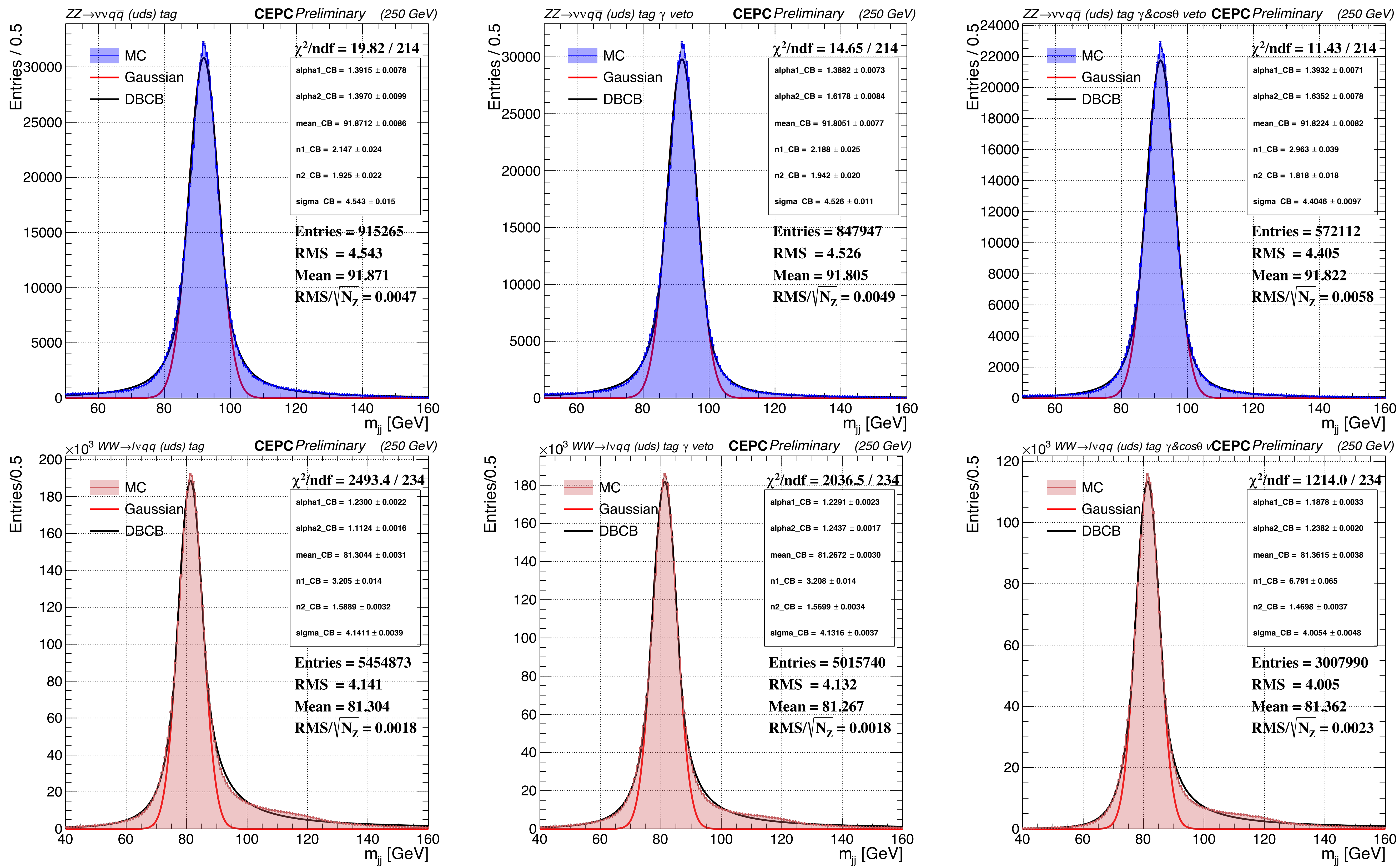
$$efficiency = \frac{\#\ of\ \ pass\ b\ tagging}{\#\ of\ all\ \ jet}$$

- I want to do a plot like the pre-CDR, but the plot is strange. How to study the plot like pre-CDR?
- Thus, I applied the number from the Dr. Gang Li. B-tagging < 0.9 and efficiency is 95%. C-tagging < 0.5 and efficiency is 60%.

Plot in pre-CDR



Apply typical b-/c- tagging $m_{reoc\ jj}$



- **Both jets are required b-jet tagging score < 0.9 and c-jet tagging score < 0.5.**

Apply typical b-/c- tagging $m_{reoc\ jj}$

	Z→qq(uds)	Z→qq(uds) γ veto	Z→qq(uds) γ & cosθ veto
Entries 54.7%	915265 92.6%	847947 67.4%	572112
RMS	4.543	4.526	4.405
Mean	91.871	91.805	91.822
$RMS/\sqrt{N_Z}$	0.0047	0.0049	0.0058

	W→qq(uds)	W→qq(uds) γ veto	W→qq(uds) γ & cosθ veto
Entries 59.4%	5454873 91.9%	5015740 59.9%	3007990
RMS	4.141	4.132	4.005
Mean	81.304	81.267	81.362
$RMS/\sqrt{N_W}$	0.0018	0.0018	0.0023

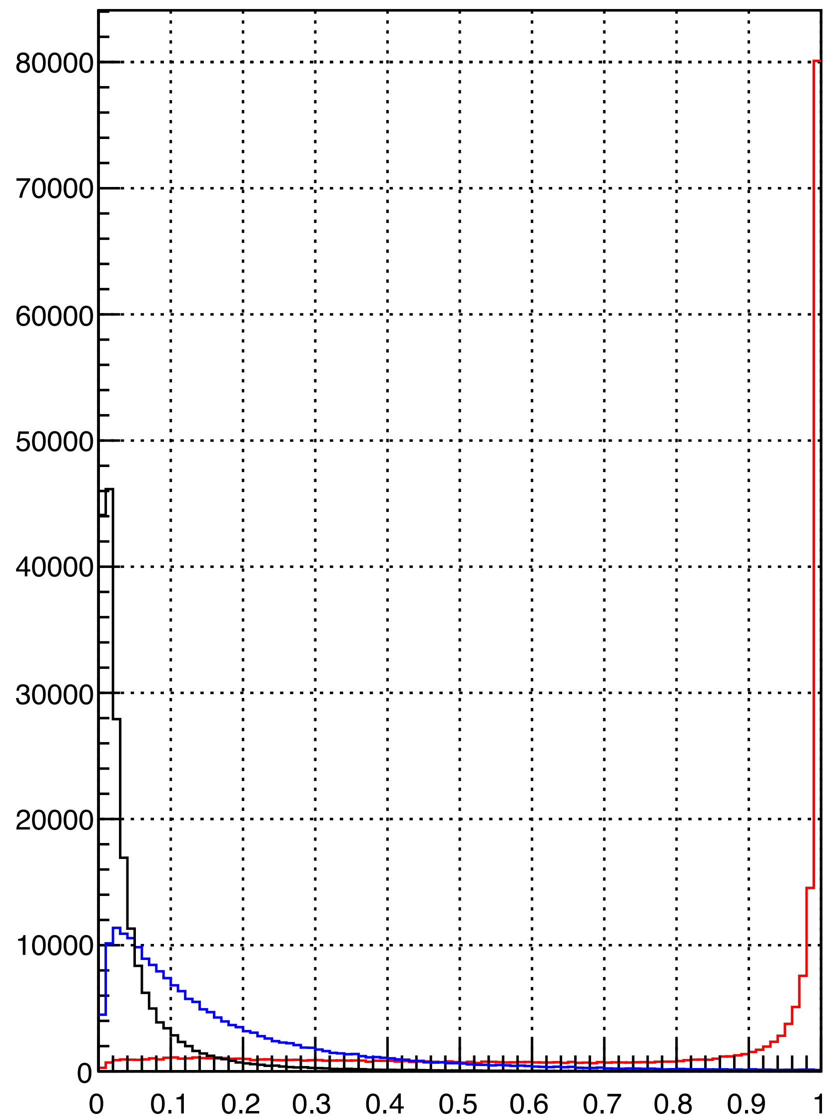
- These plots present the state of the boson mass resolution at CEPC because these approach can be reality.

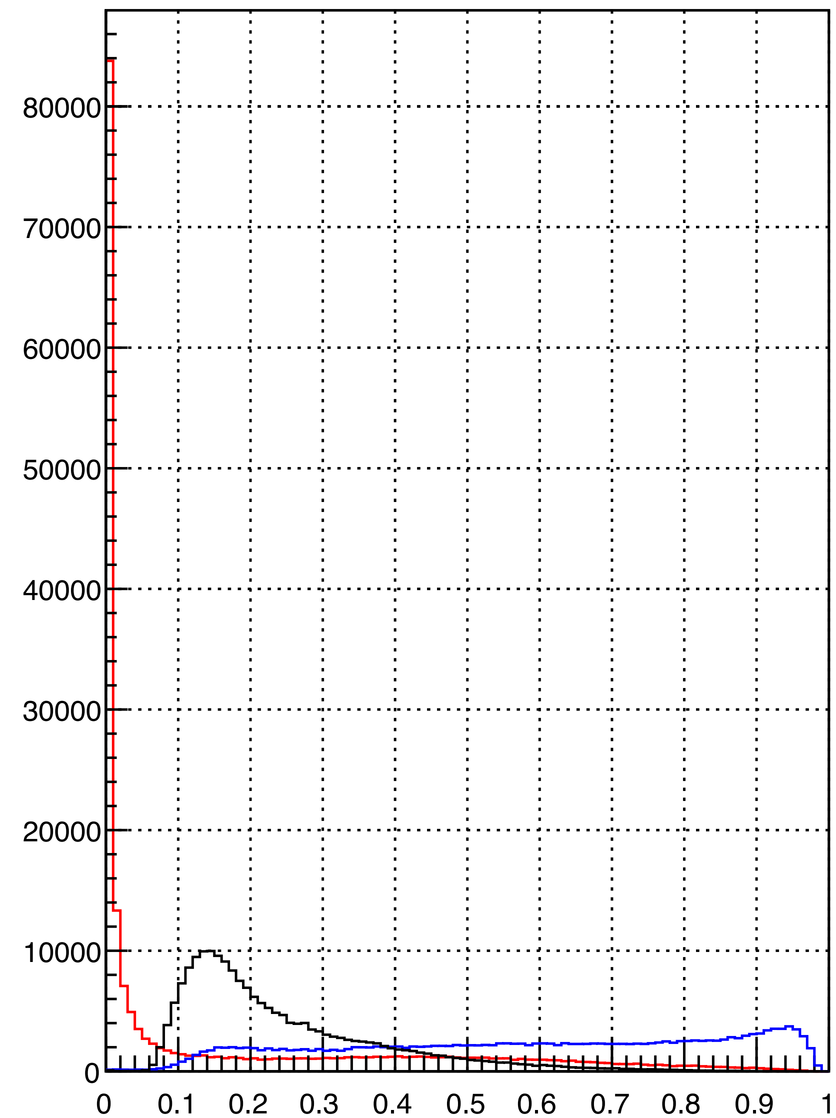
Summary

- The linearity of m_{jj} /m_{mcp} as a function of m_{mcp} in the case of Z and W are different. The linearity performance of Z is changing with flavor, and the less flavor dependence for W.
- From the Z plots, the heavy jet is our major target to calibrate and try to calibrate the W boson scale.
- The number of cross generations decay is less than the same generation decay in the W decay.
- I need to check the JES calibration to figure out the problems.
- The Z and W mass distribution are present in the reality way. The selection can be applied in the future.

Back up

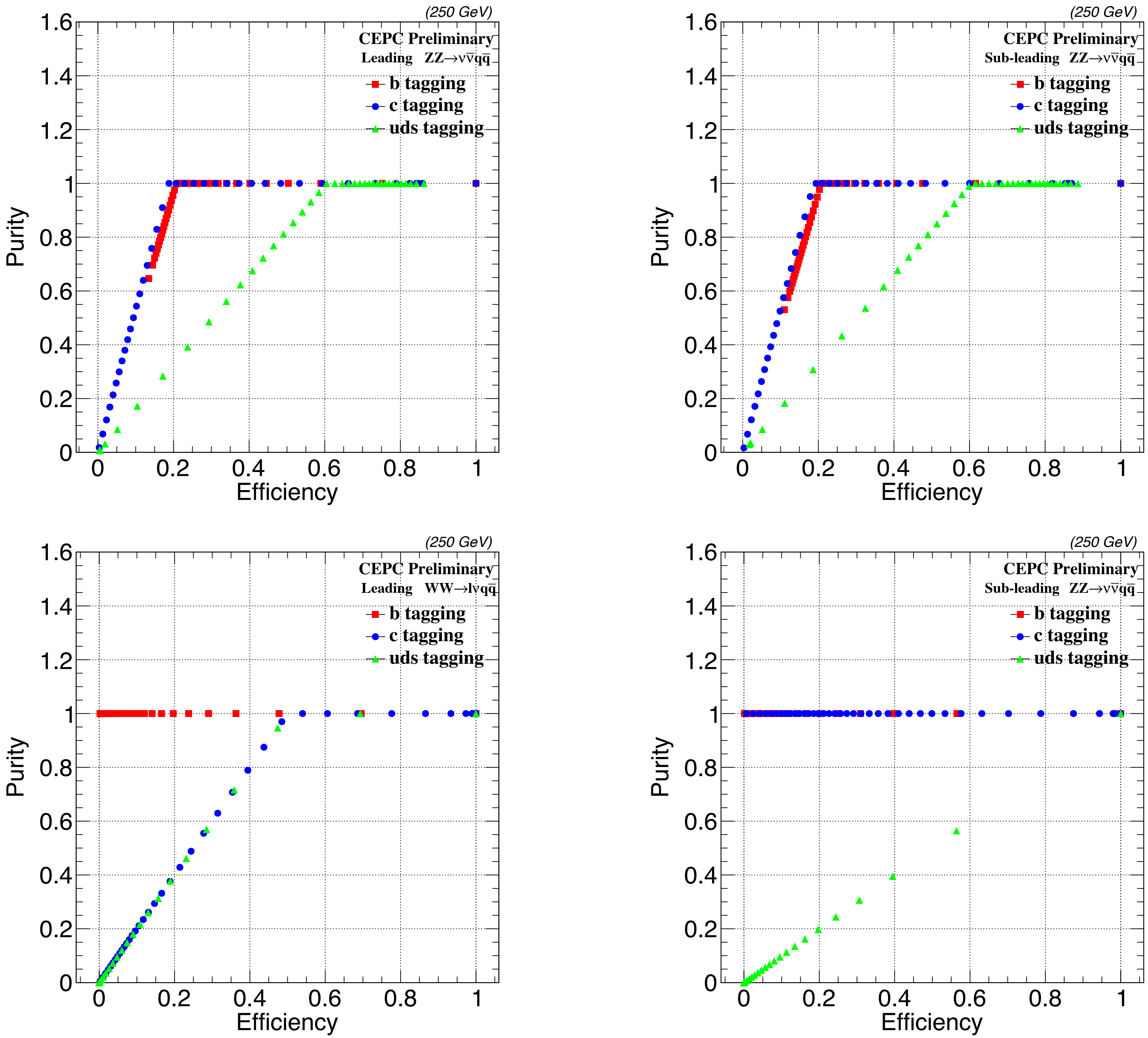
b-/c- tagging plots



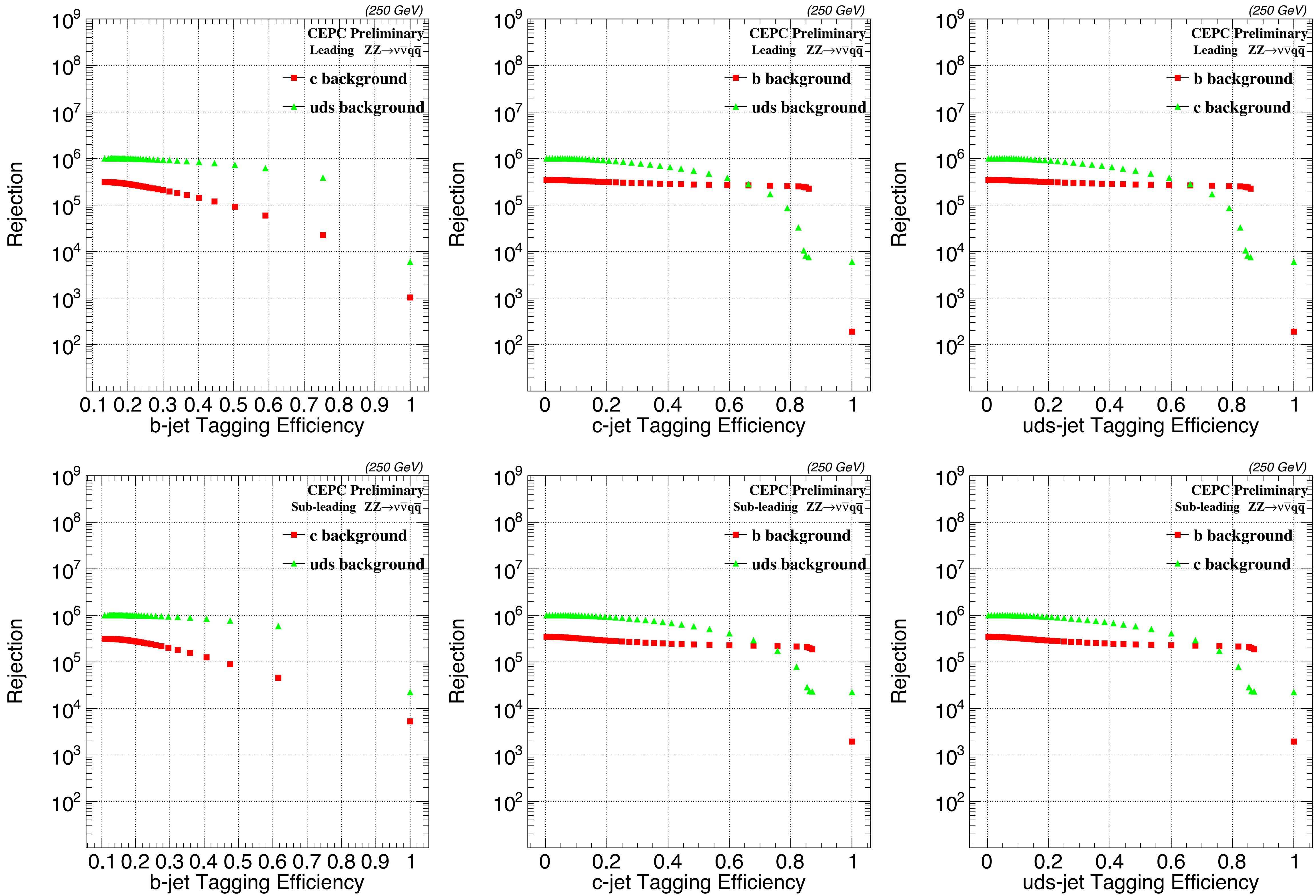


- **Red line is for b-jet, blue line is for c-jet, and black line is for light-jet.**
- **According to left plot, if want to reject b-jet, the score is recommended less than 0.9; if want to select b-jet, the score is recommended greater than 0.8.**
- **According to right plot, if want to reject c-jet, the score is recommended less than 0.6; if want to select c-jet, the score is recommended greater than 0.4.**

b-/c- tagging plots



b-/c- tagging plots



b-/c- tagging plots