W Mass Measurement in CEPC

Presented by [1]Pei-Zhu Lai（賴培築）

Supervisor: [2]Man-Qi Ruan, [2]Gang Li, [2]Bo Liu, [1]Chia-Ming Kuo

[1]National Central University, Taiwan

[2]Institute of High Energy Physics, China

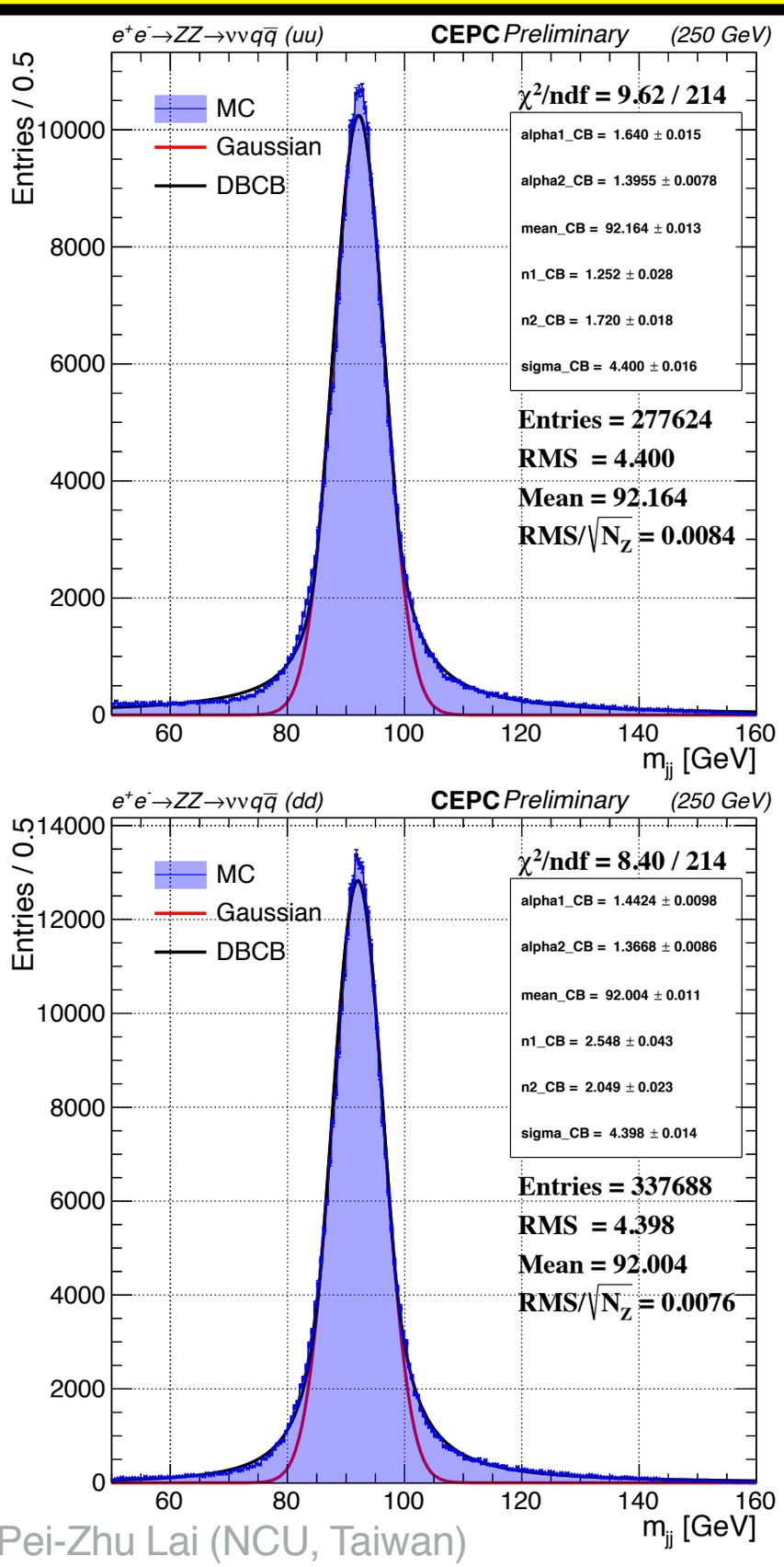
Electroweak Measurement Meeting

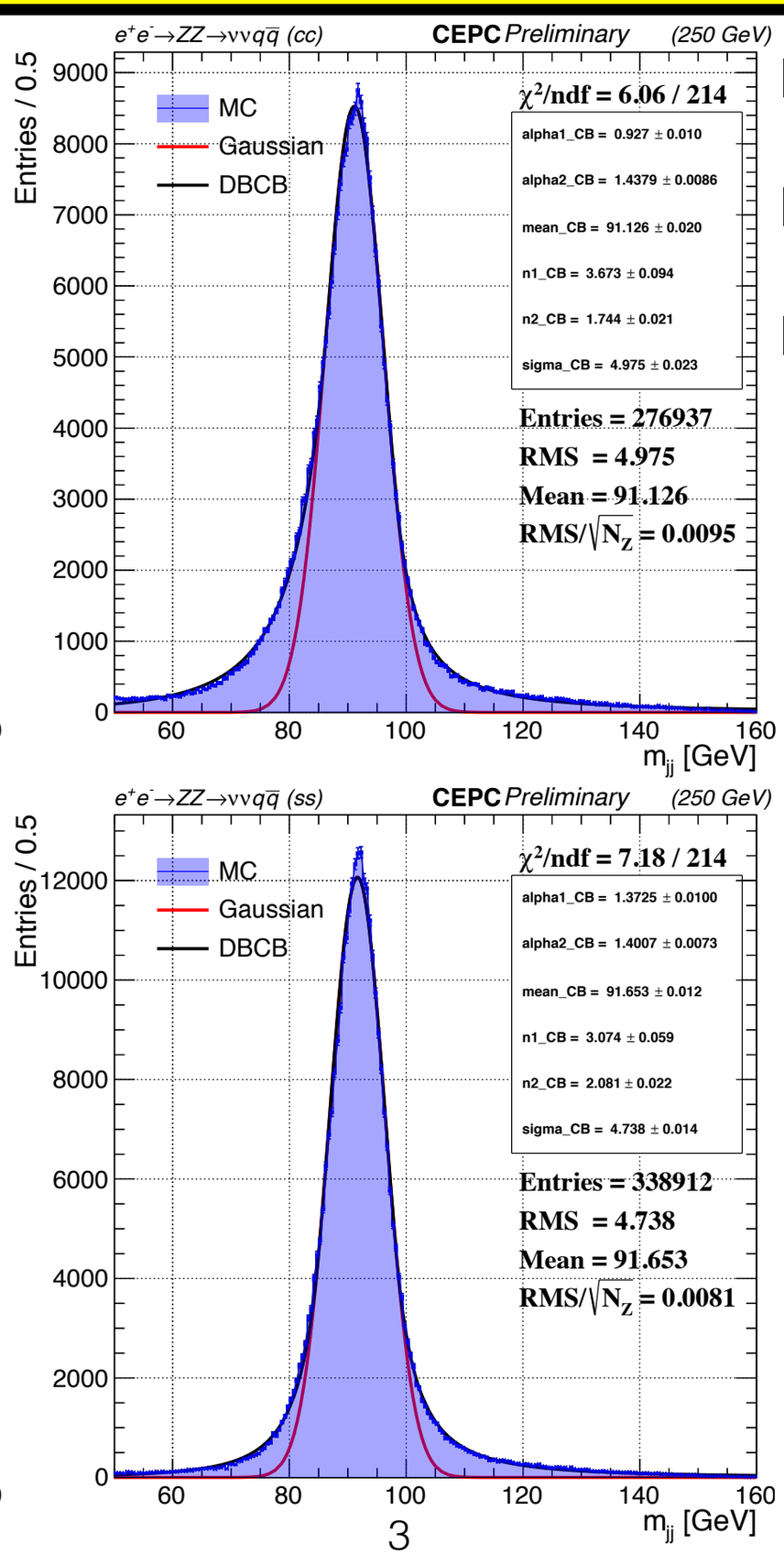
Mar 12, 2018

Last Time to Do List

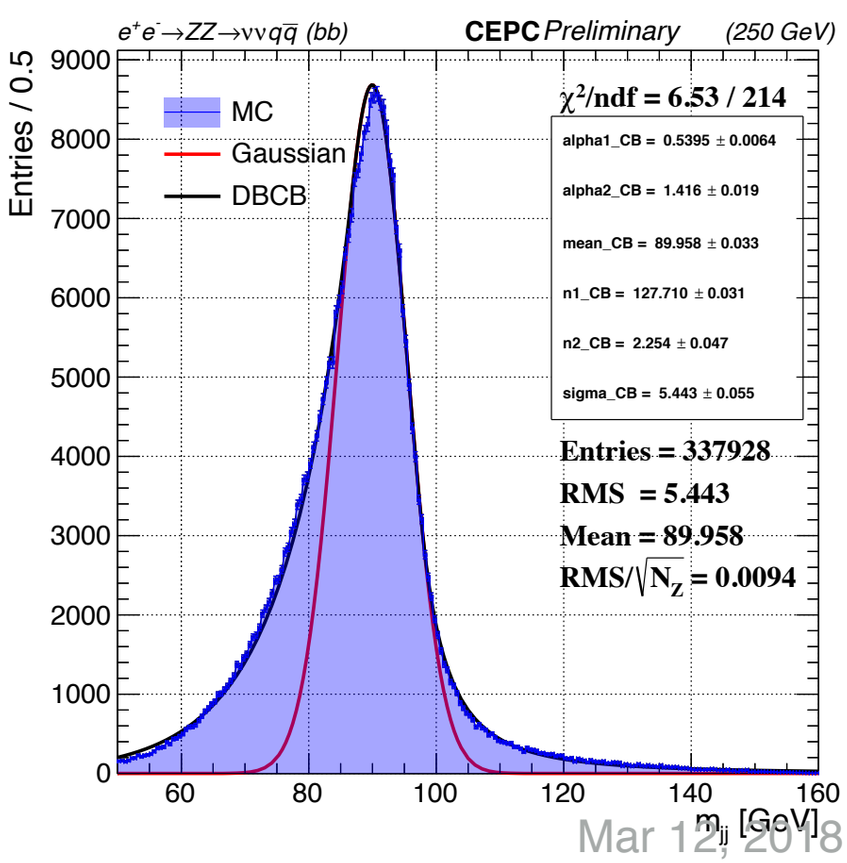
- Assume WW → lν jj events only
- Statistical sensitivity ~ $RMS_{Mvis}/sqrt(N_W)$
- To estimate calibration systematics :
  - Z calibration statistical uncertainty ~ $RMS_{Mvis}/sqrt(N_Z)$
  - Z → W extrapolation:
    - ✓ M_{vis} for W → ud, cs, us, cd (#, mean value, RMS)
    - ✓ M_{vis} for Z → uu, dd, ss, cc, bb
    - ✓ M_{vis} vs M_{true} (to check linearity) in W and Z events
    - Rejection of Z → bb/cc events, and efficiency for Z → uu/dd/ss, or a typical b-tagging working point

Z->(uu, dd, cc, ss, bb) (50<m_Z<160)





- **Calculate the value from the fitting results.**
- **c- and b- quark jet energy resolution is the worst one.**
- **Use these mean value try to calibrate W and itself.**



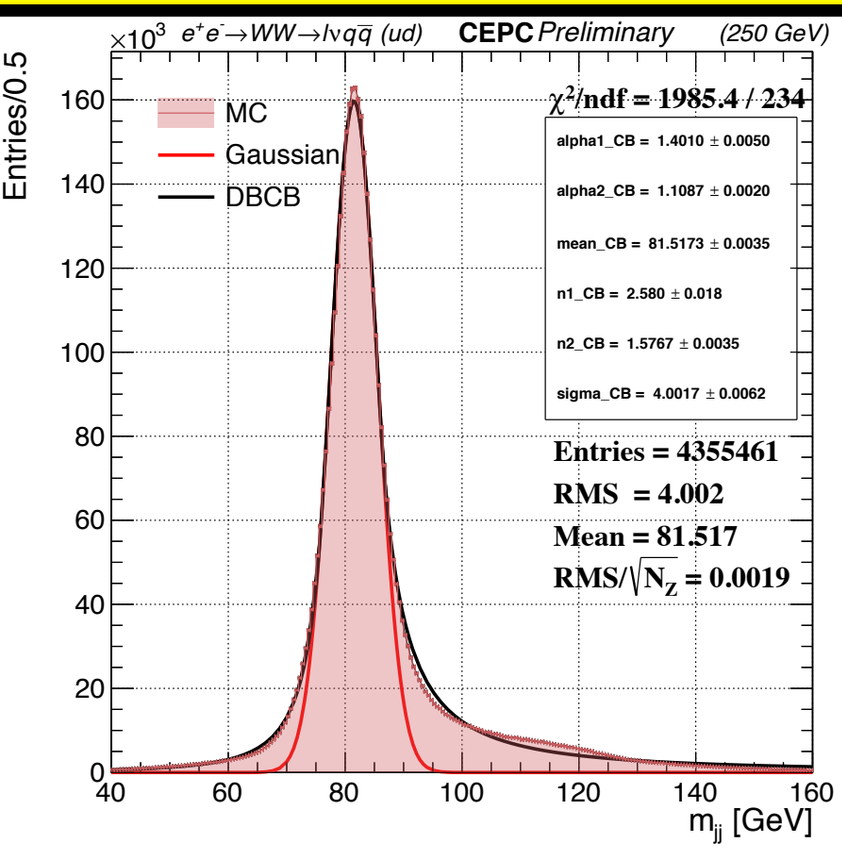
Z->(uu, dd, cc, ss, bb) (50<m_Z<160)

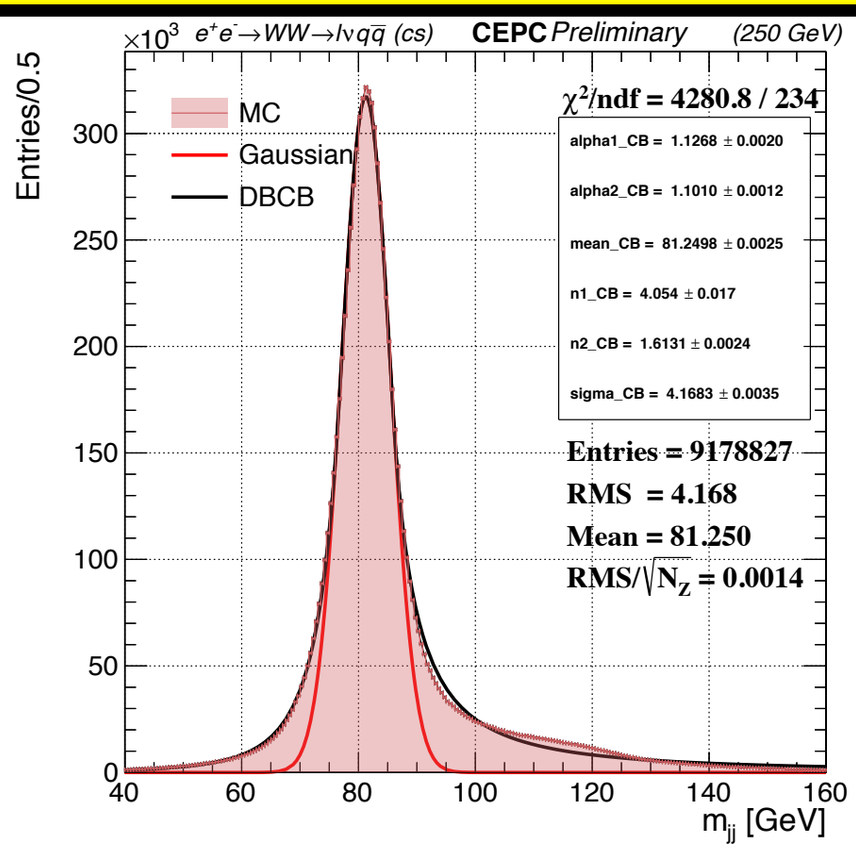
	Z→uu	Z→dd	Z→cc	Z→ss	Z→bb
Entries	277624	337688	276937	338912	337928
RMS	4.400	4.398	4.975	4.738	5.443
Mean	92.164	92.004	91.126	91.653	89.958
RMS/√N_Z	0.0084	0.0076	0.0095	0.0081	0.0094

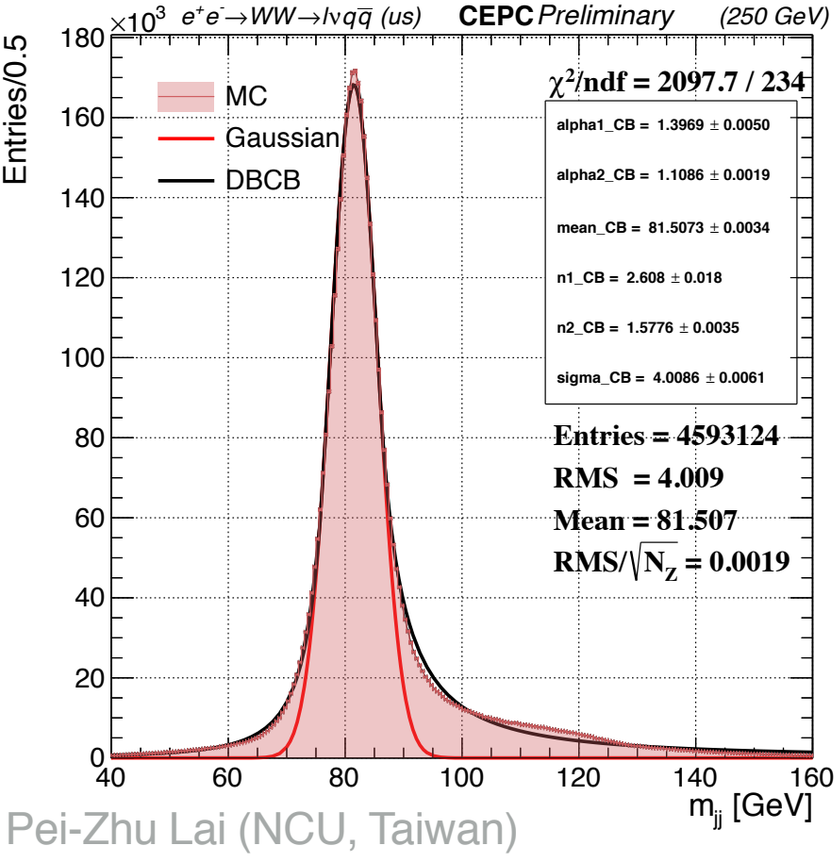
m_z = 91.1876

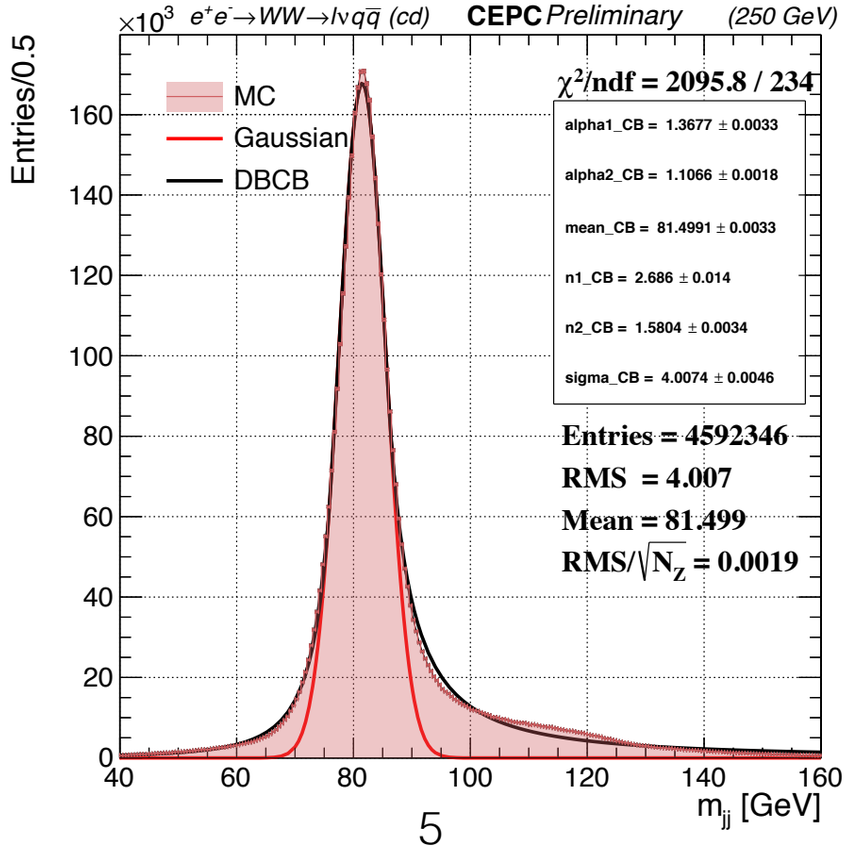
m_u = 2.2 MeV	m_c = 1.27 GeV	m_t = 173 GeV
m_d = 4.7 MeV	m_s = 96 MeV	m_b = 4.6 GeV

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









- **Calculate the value from the fitting results.**
- **Mean value systematically higher than current measurement's value, because the additional lepton.**
- **The performance is quite stable. Right column is poor than left one because c-quark.**

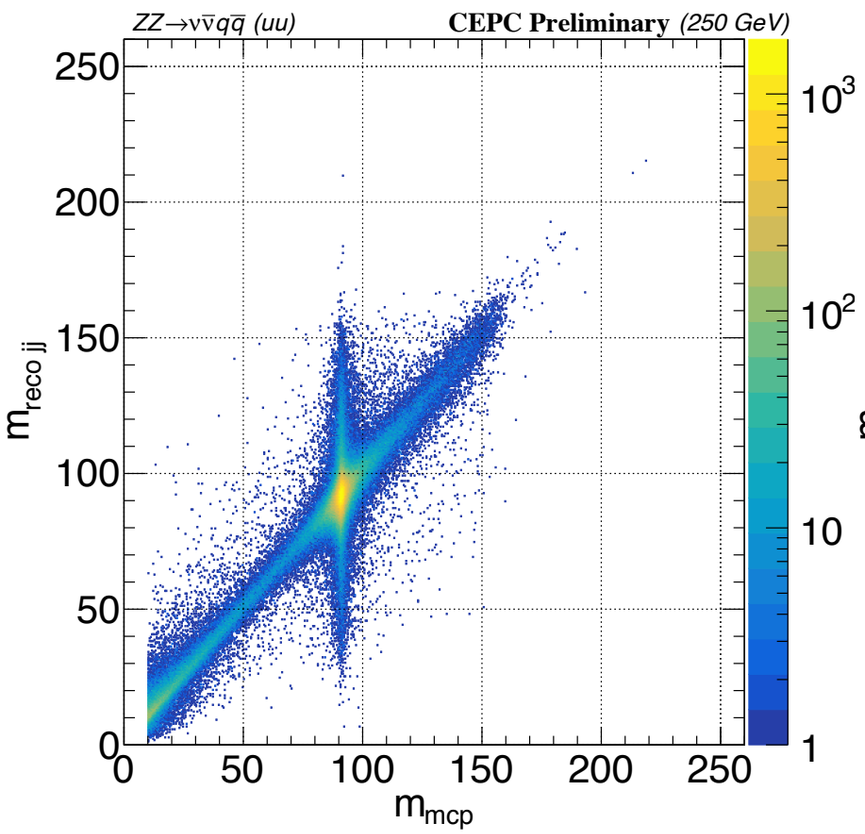
W->(ud, cs, us, cd) (40<m_W<160)

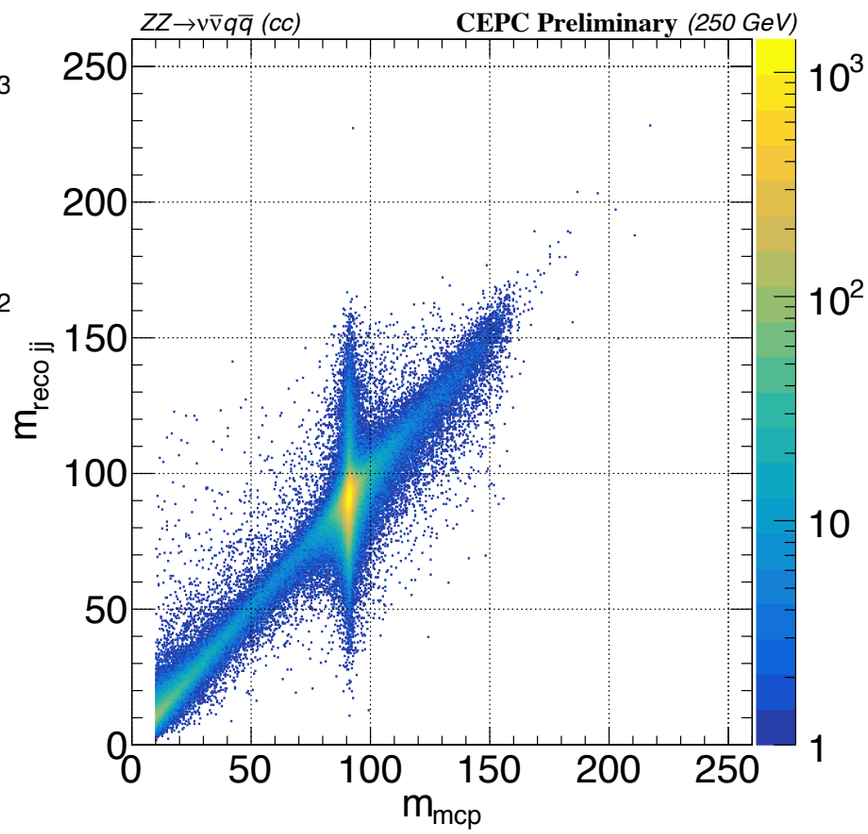
	W→ud	W→cs	W→us	W→cd
Entries	4355461	9178827	4593124	4592346
RMS	4.002	4.168	4.009	4.007
Mean	81.517	81.250	81.507	81.499
RMS/$\sqrt{N_W}$	0.0019	0.0014	0.0019	0.0019

m_W = 80.385

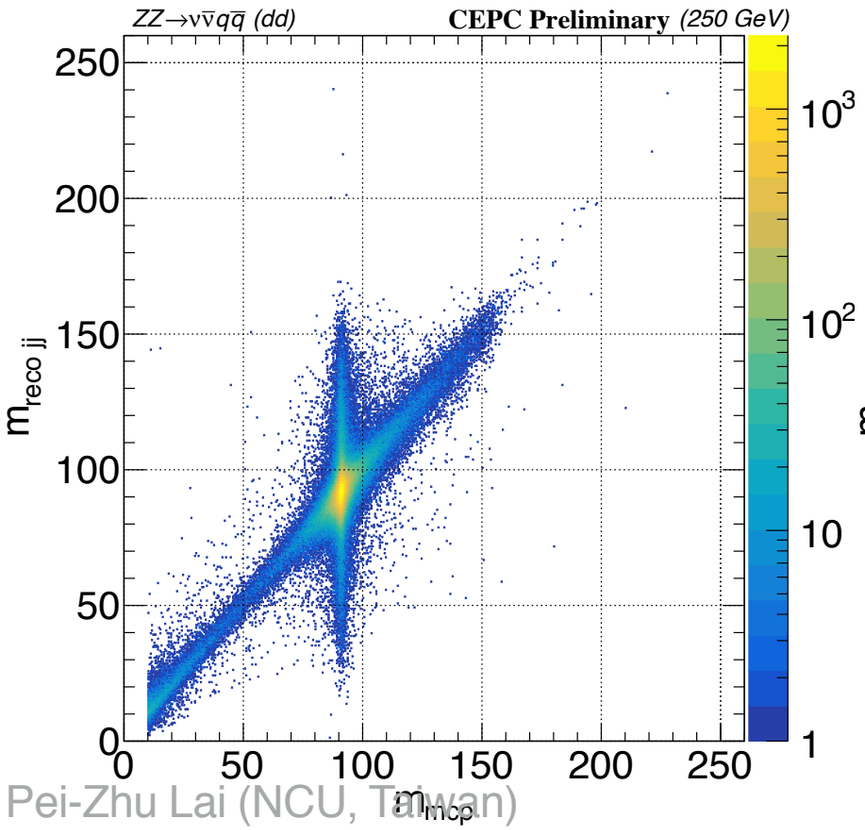
m_u = 2.2 MeV	m_c = 1.27 GeV	m_t = 173 GeV
m_d = 4.7 MeV	m_s = 96 MeV	m_b = 4.6 GeV

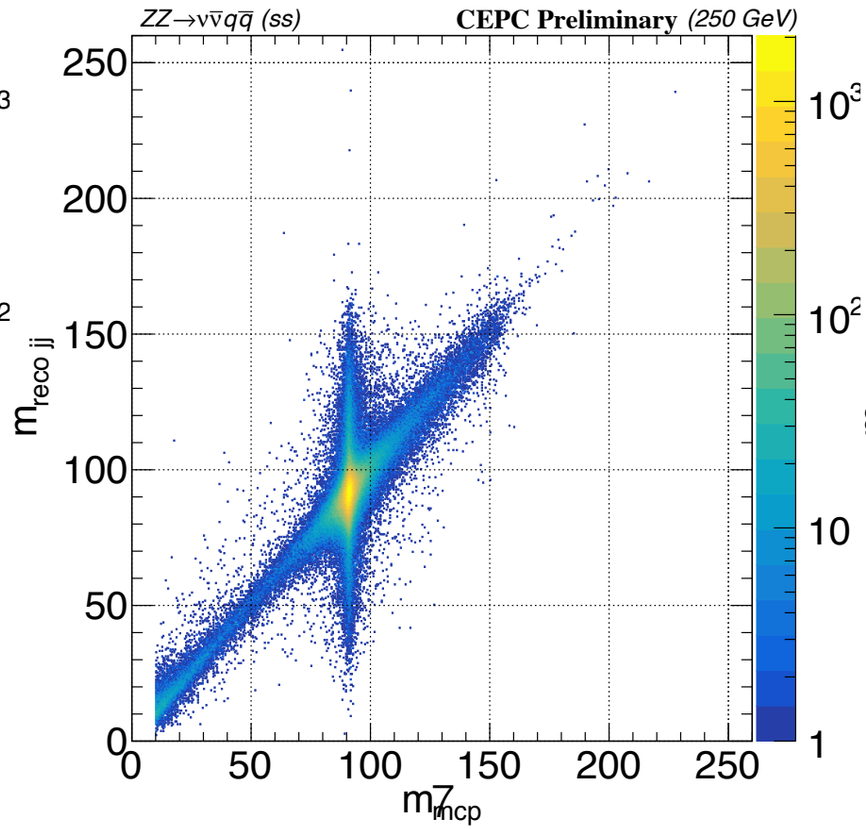
m_{jj} vs. m_{true} | Z->(uu, dd, cc, ss, bb)

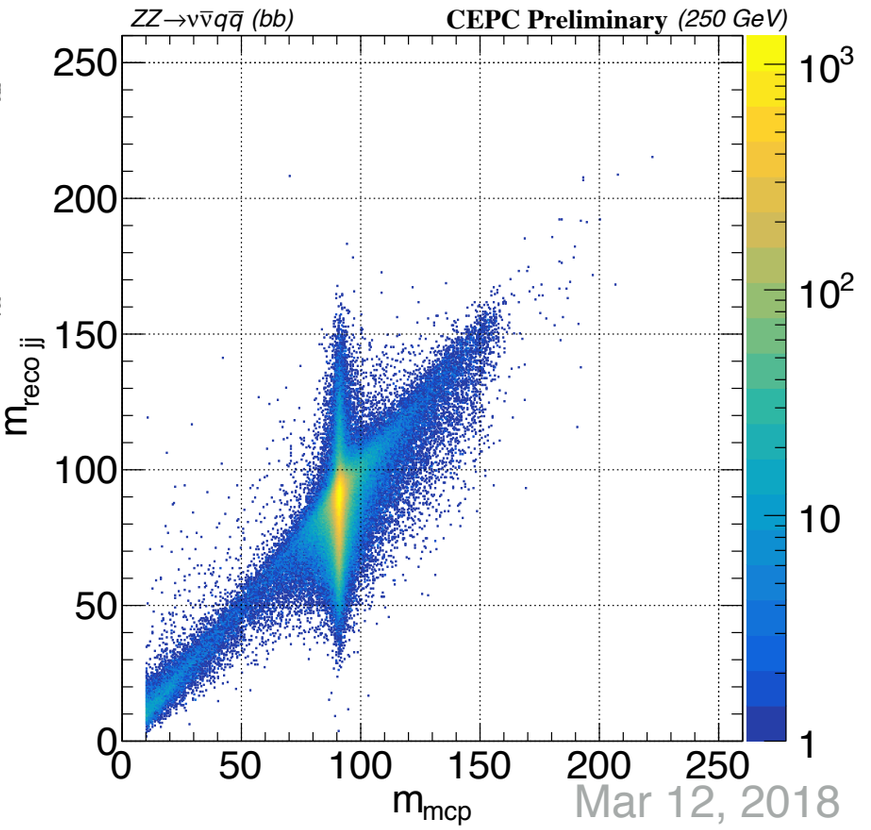




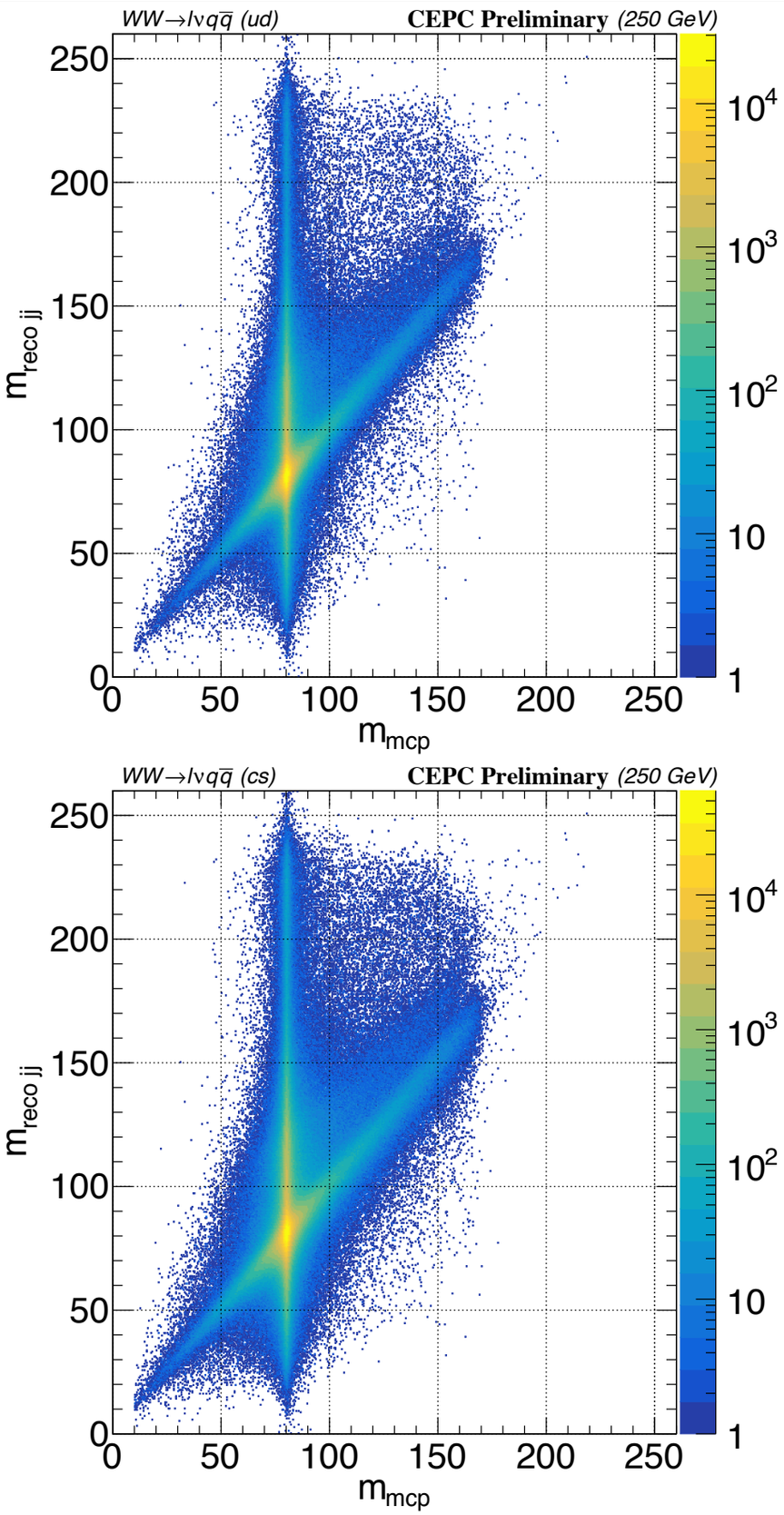
- **The mjj higher part caused by ISR photons, lower part caused by the detector acceptance.**
- **Need to extract the slope.**

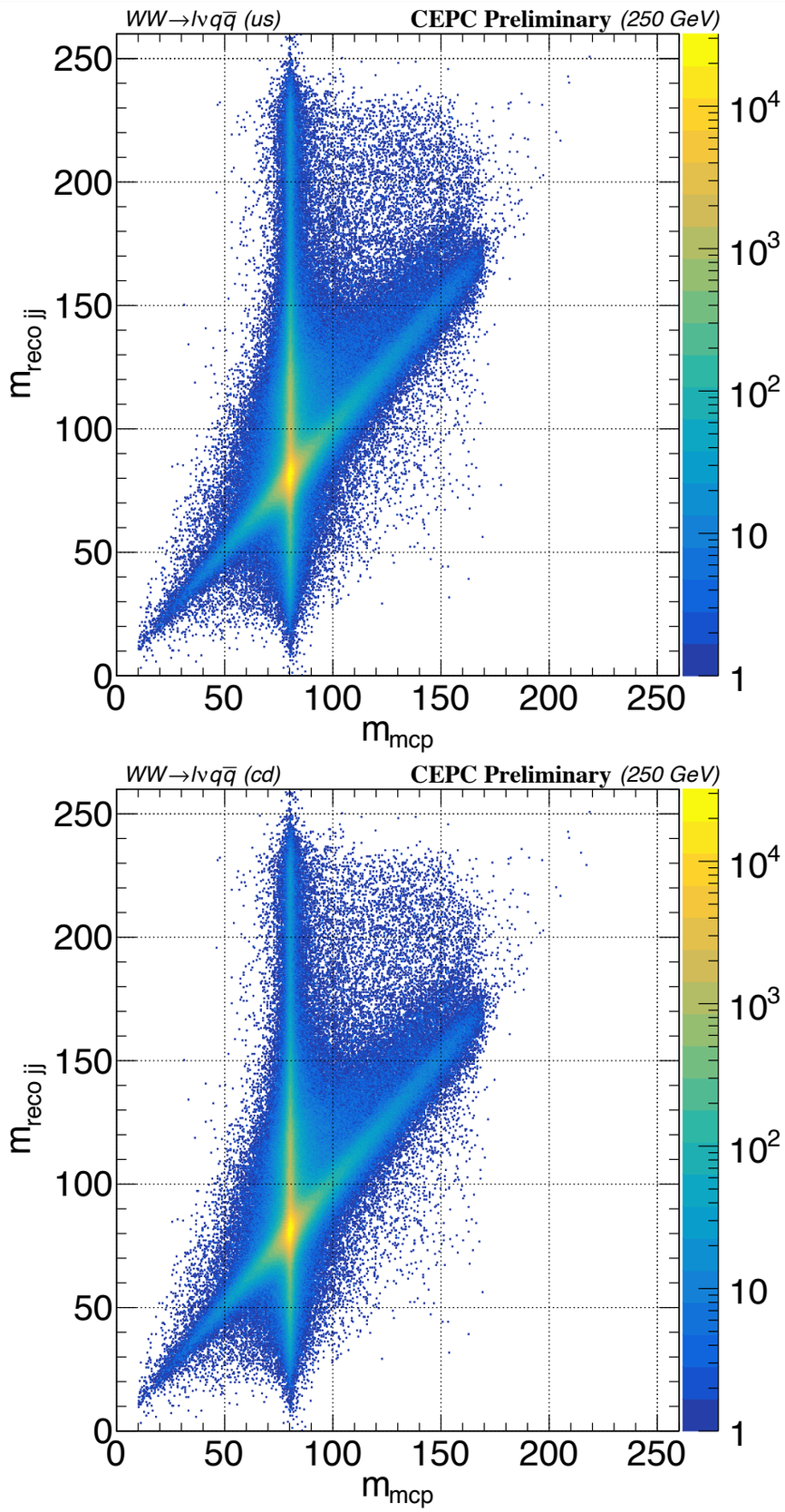






m_{jj} vs. m_{true} | W->(ud, cs, us, cd)

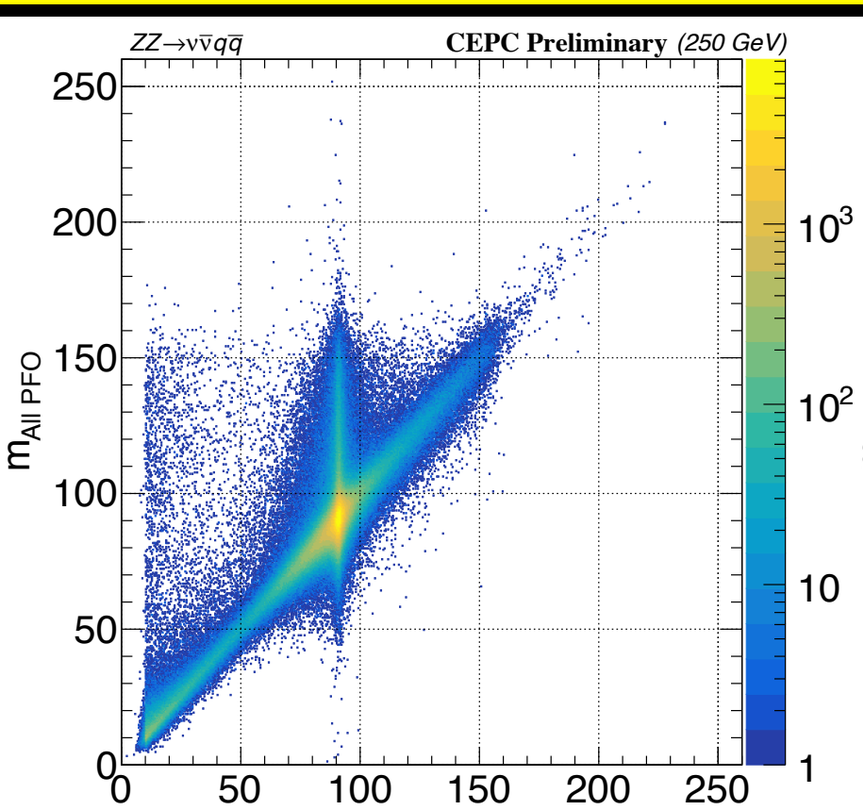


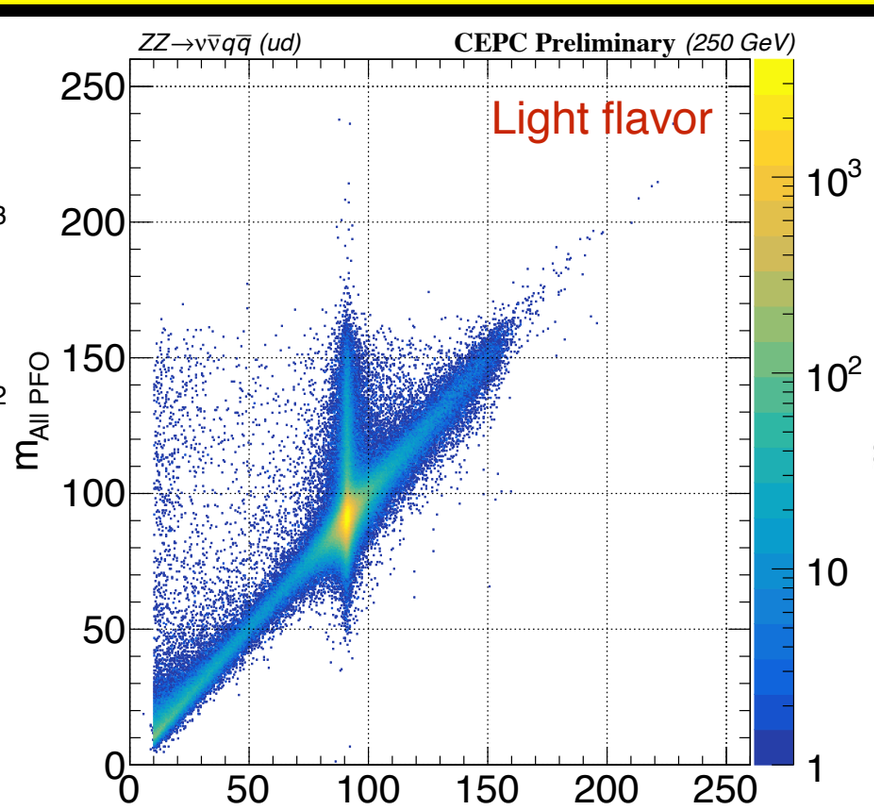


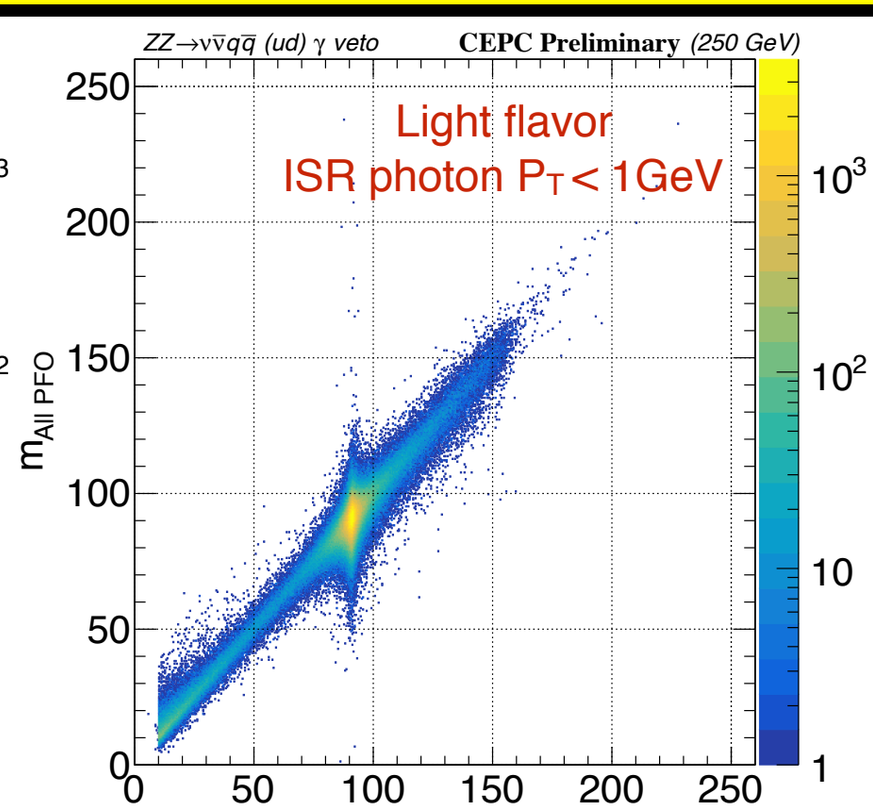
- The mjj higher part mainly caused by additional lepton, lower part caused by the detector acceptance.
- Need to veto the additional lepton and then extract the slope.

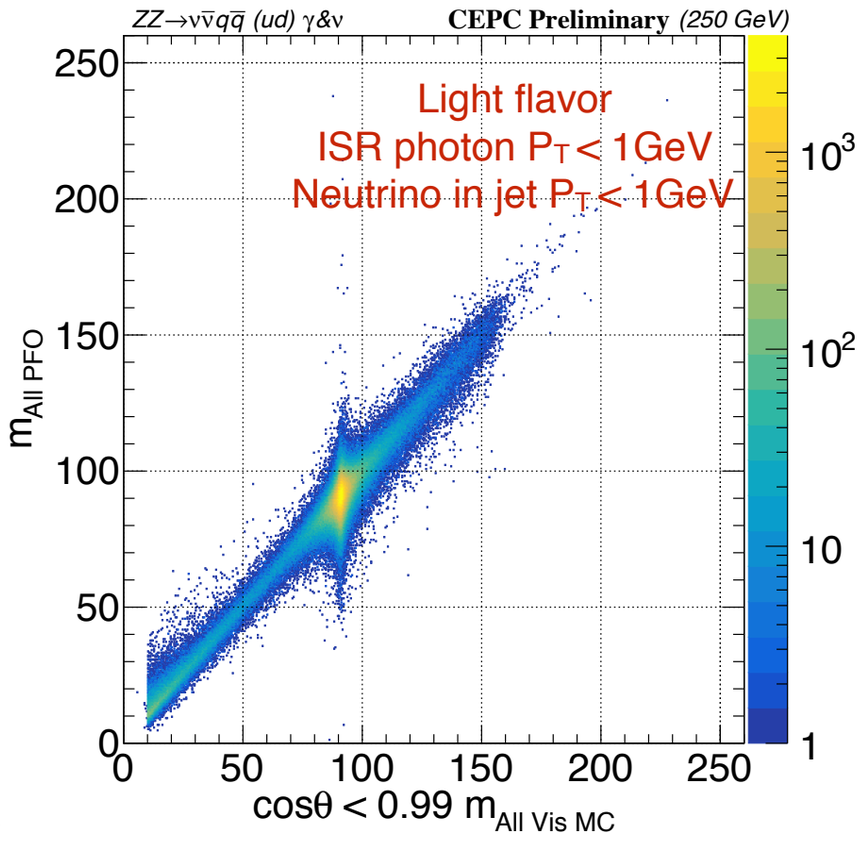
Mar 12, 2018

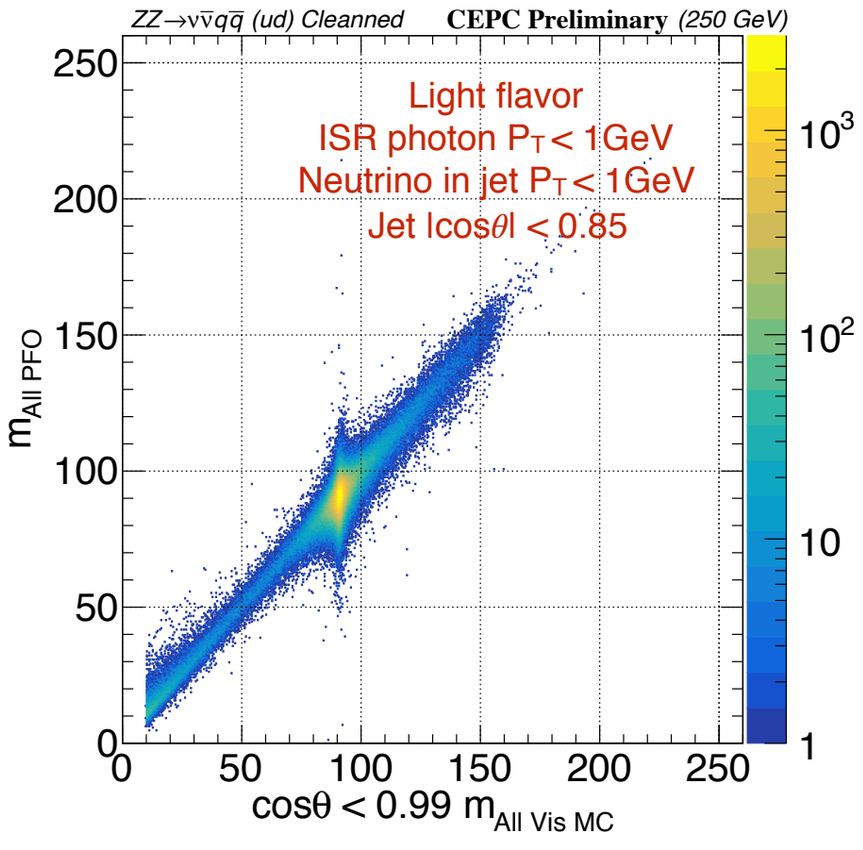
$m_{\text{All PFO}}$ VS. $\cos\theta < 0.99$ $m_{\text{All Vis MC}}$



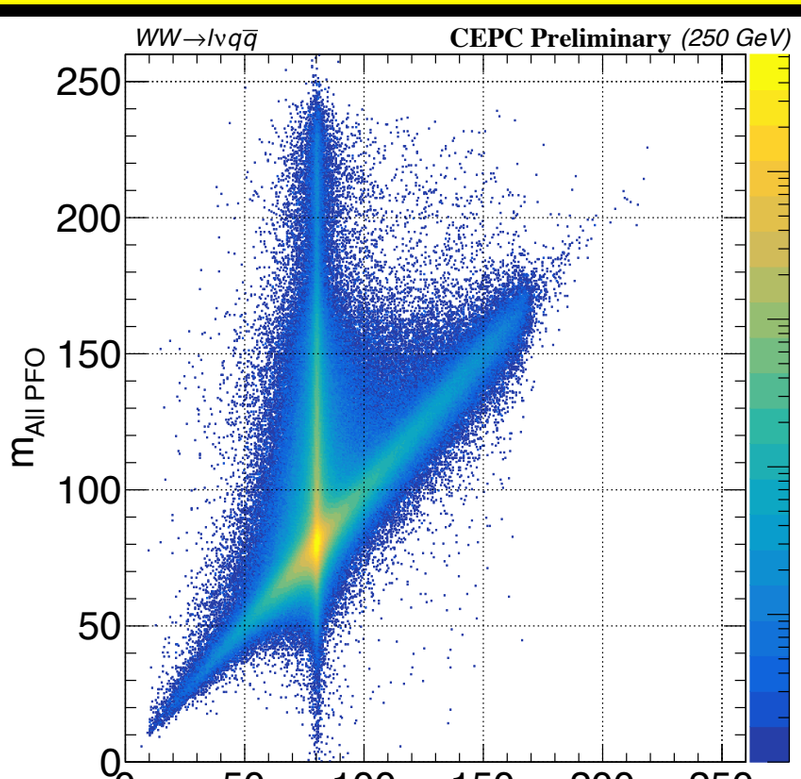


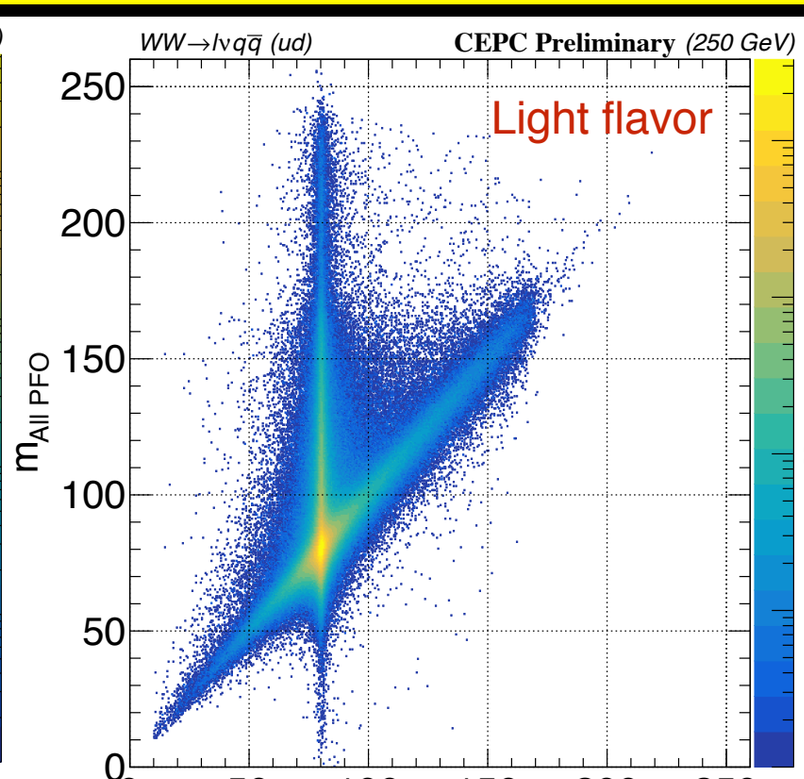


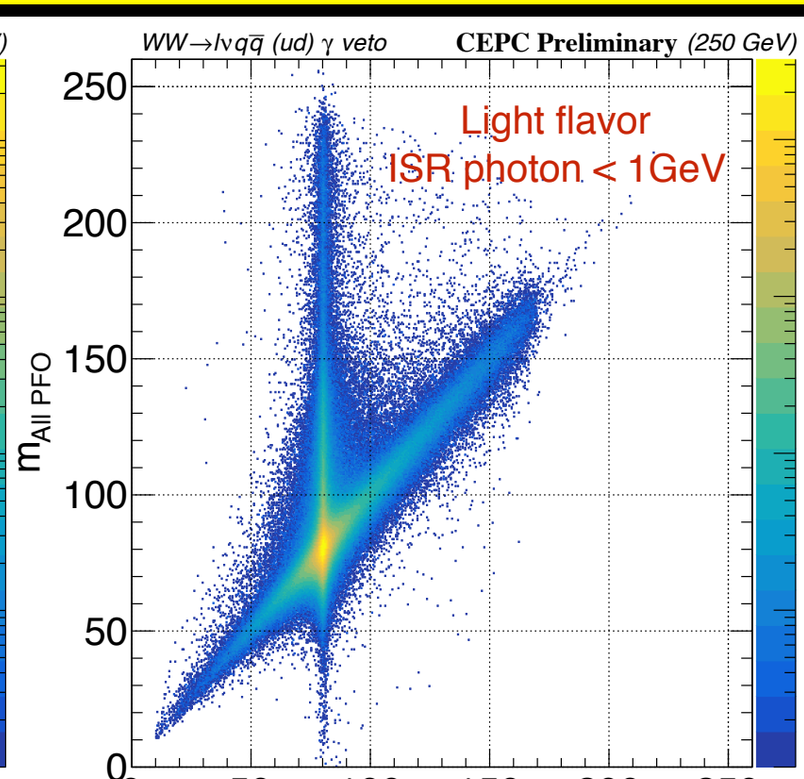


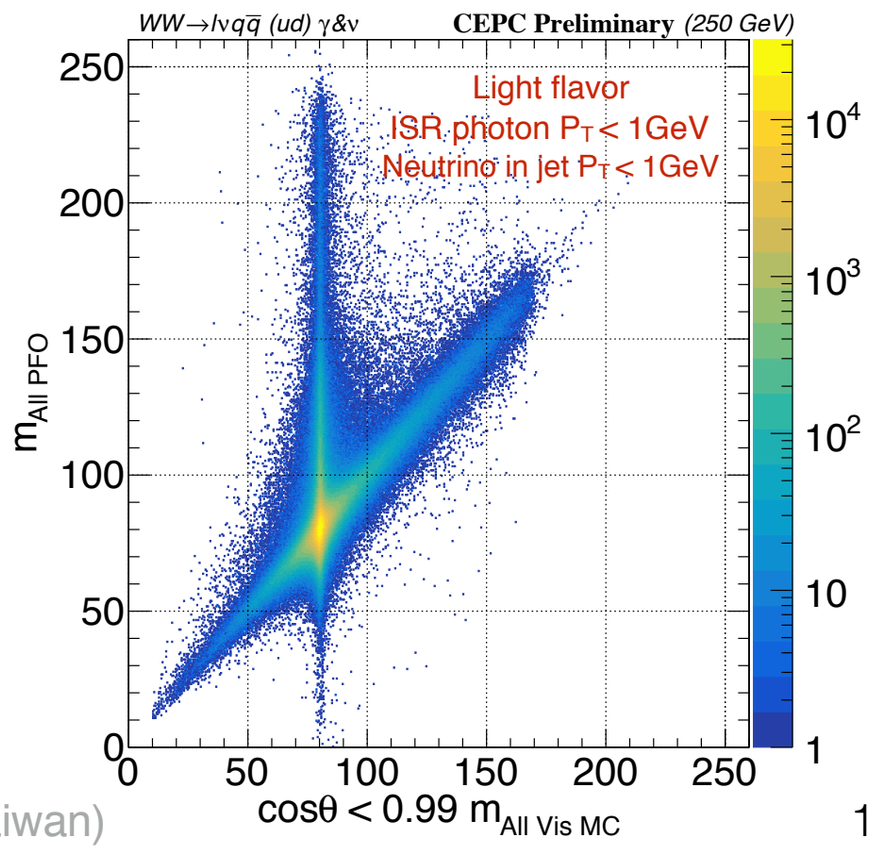


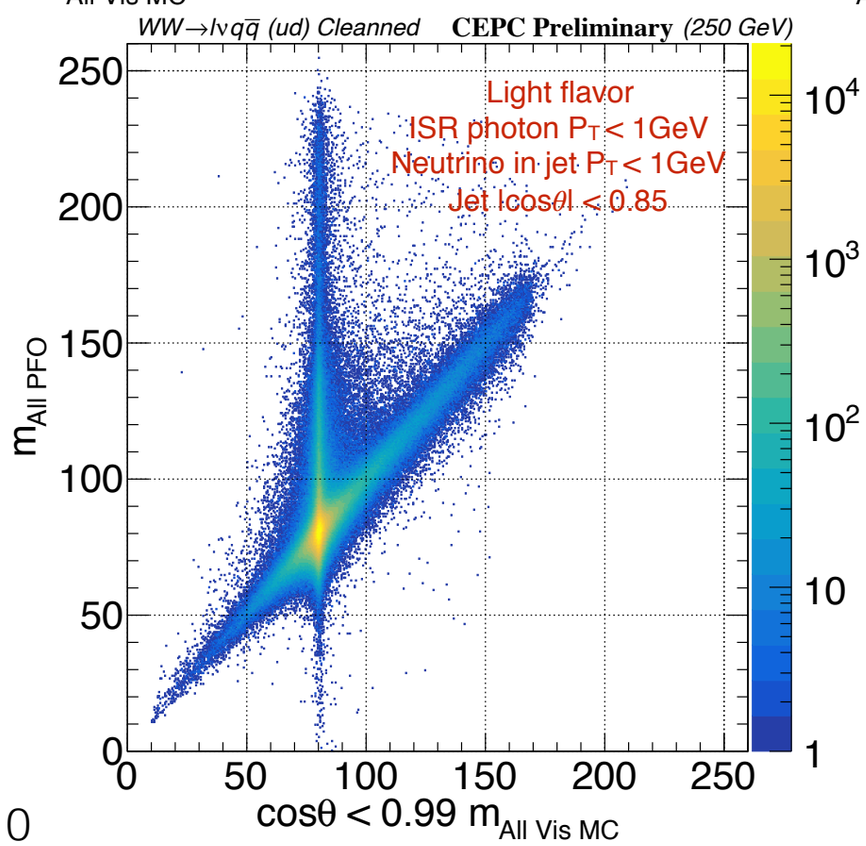
$m_{\text{All PFO}}$ VS. $\cos\theta < 0.99$ $m_{\text{All Vis MC}}$



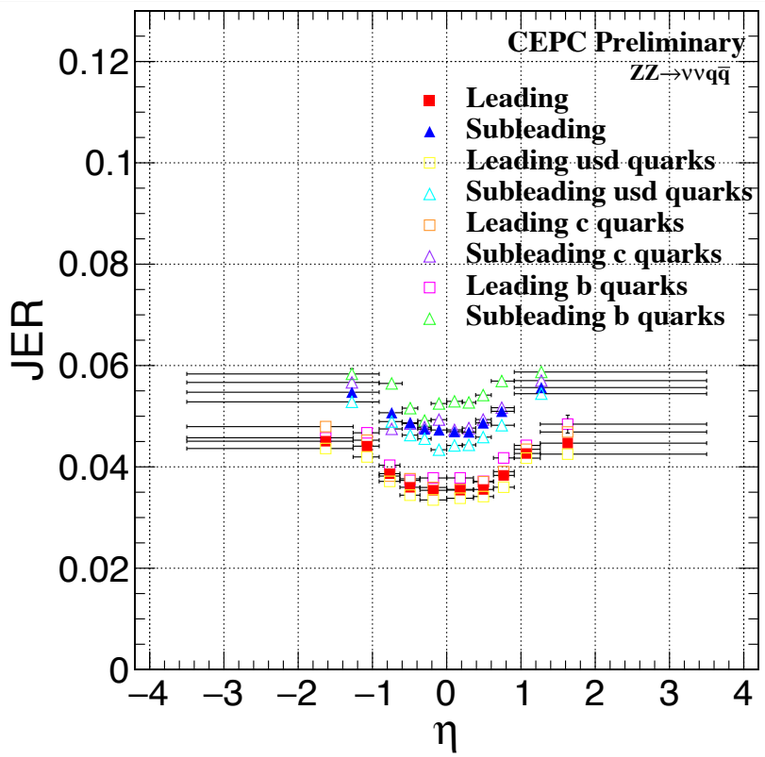


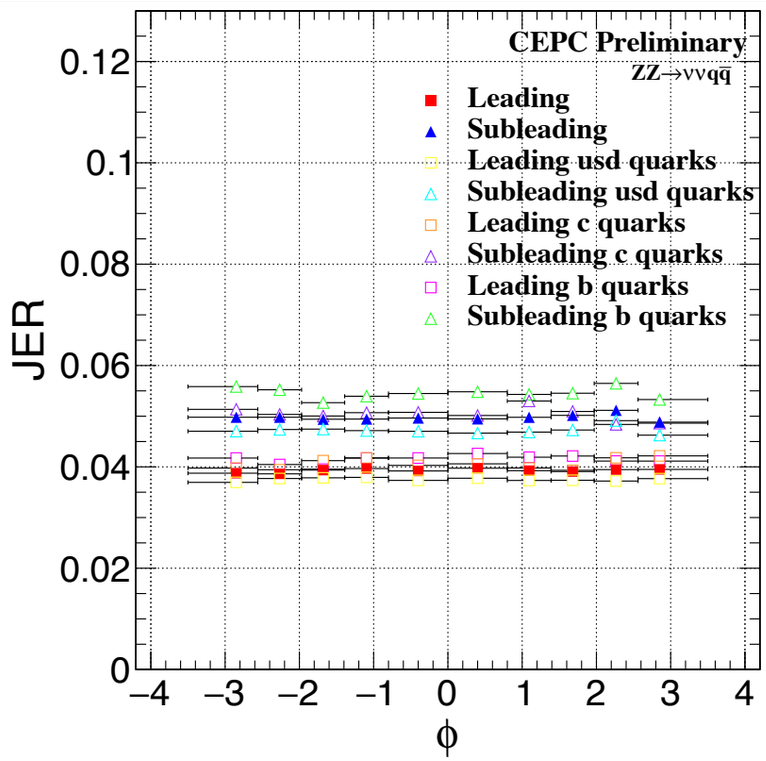


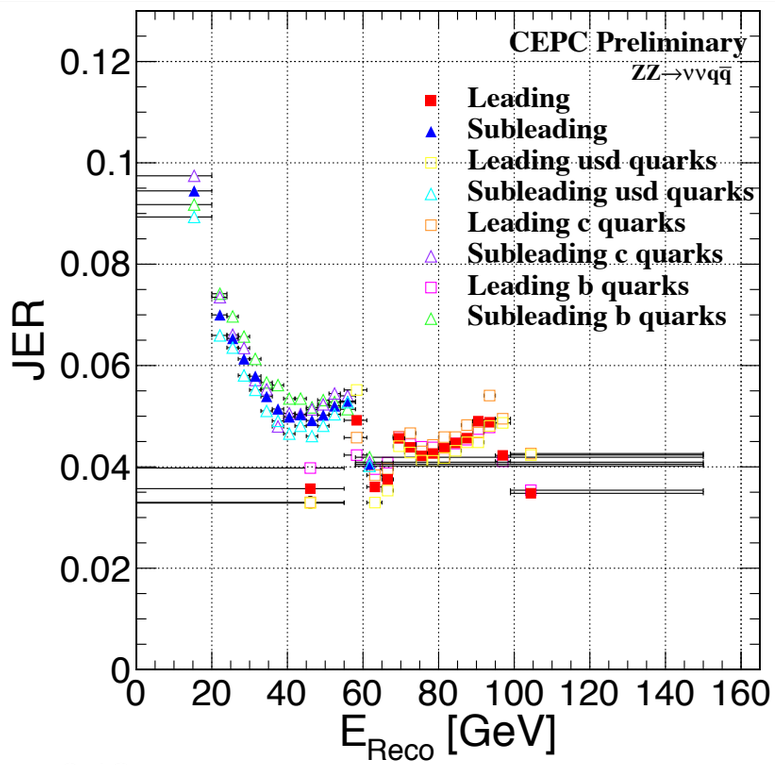


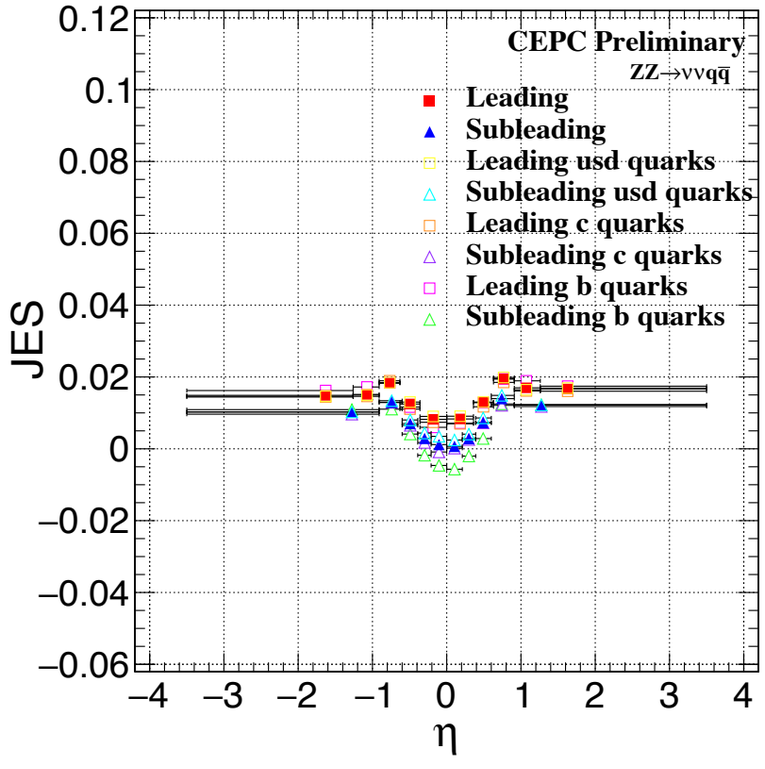


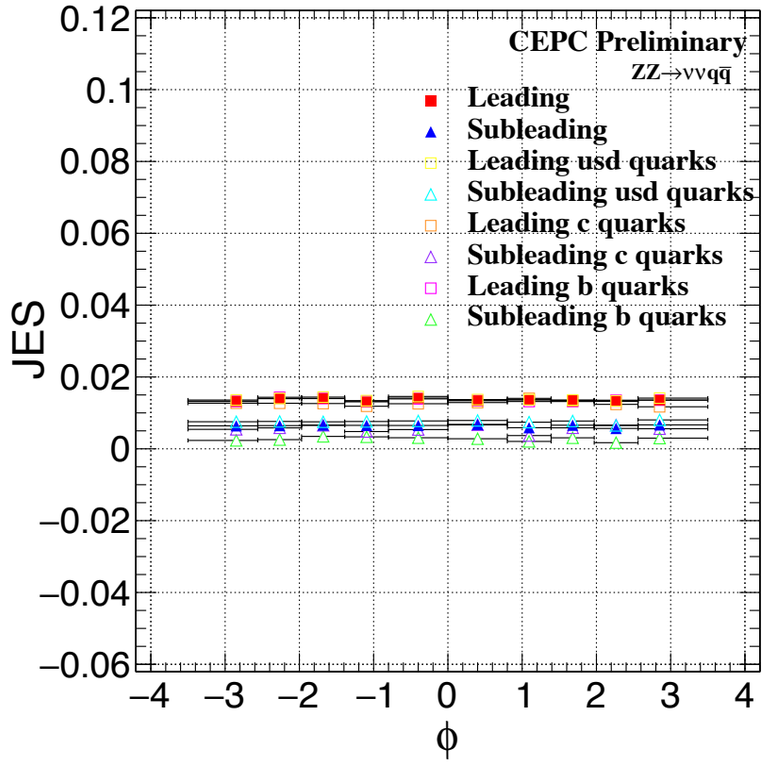
JER & JES(Reco-Gen)

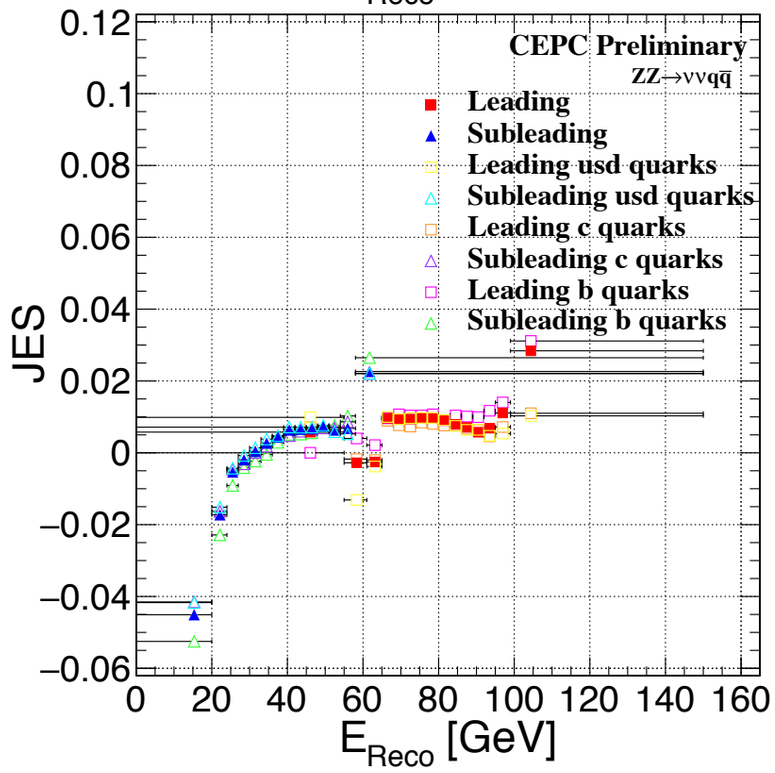






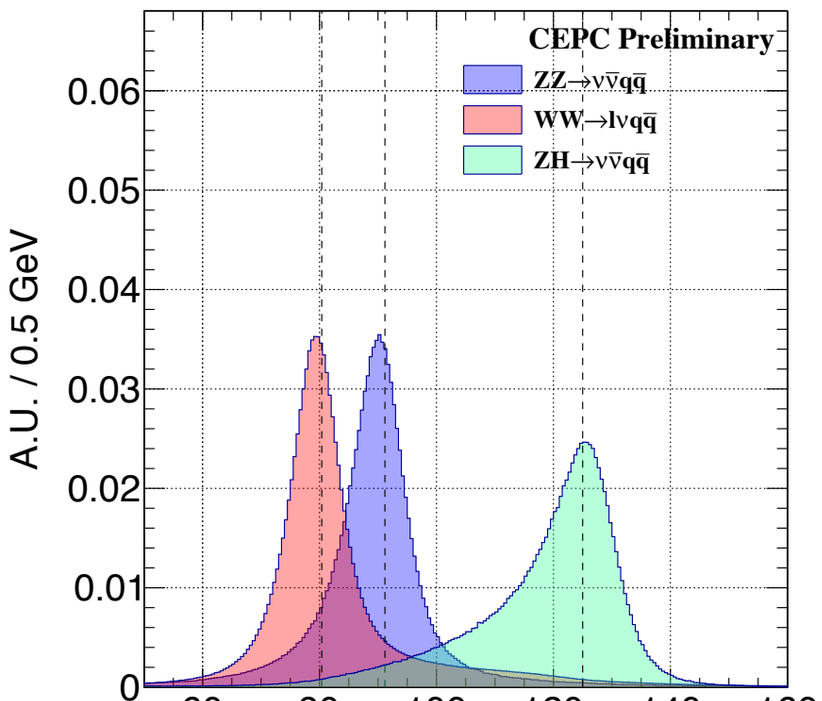


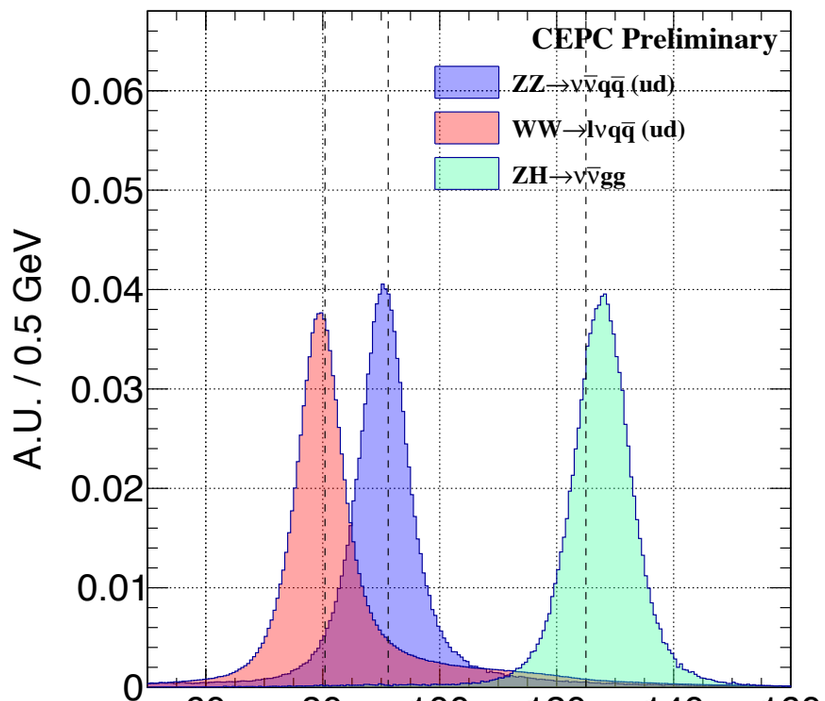


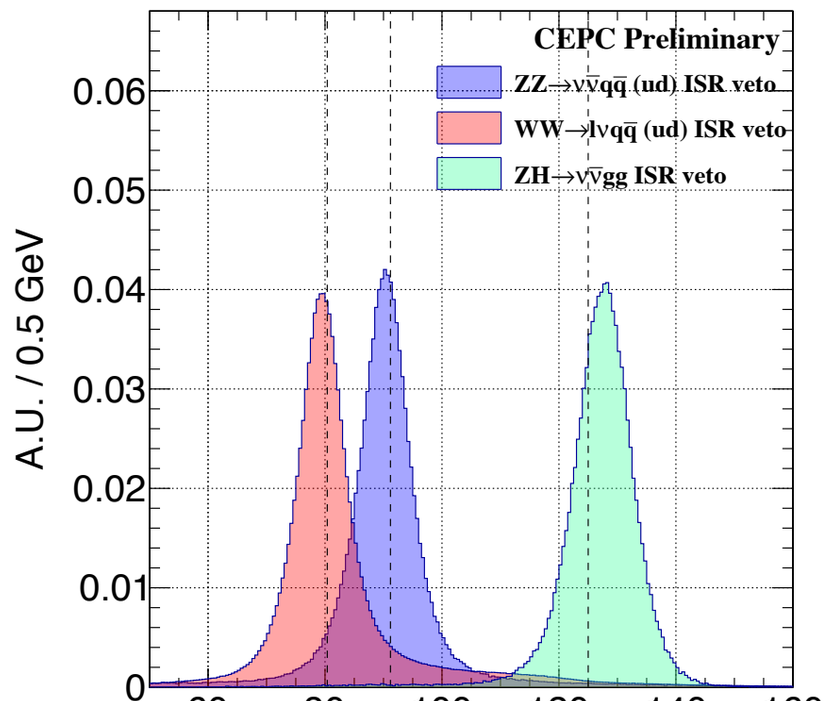


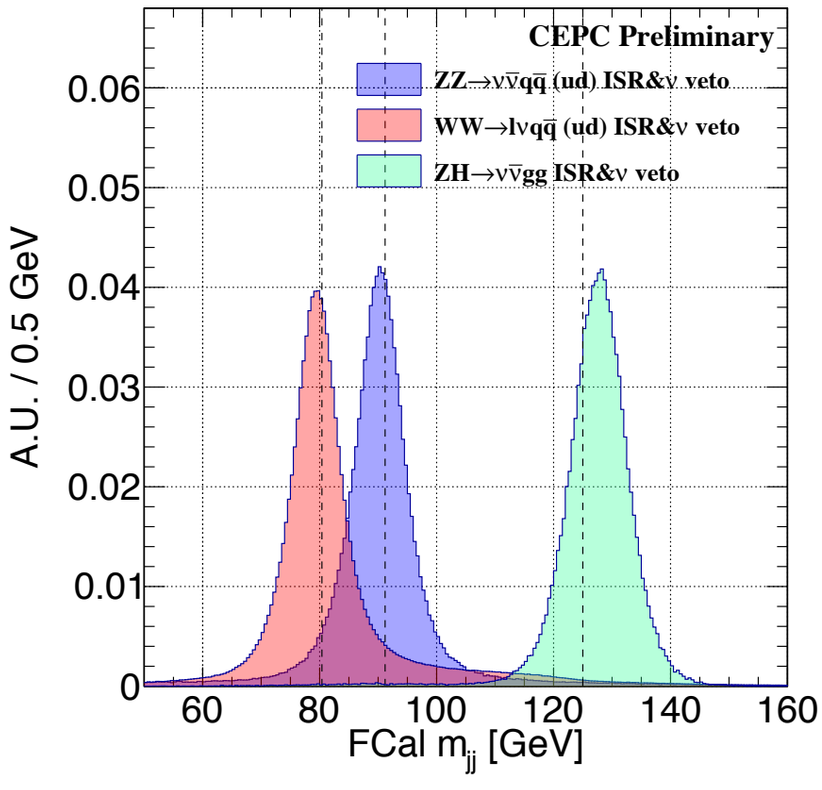
- **JER/JES of heavy flavor quark are worse than light flavor one about 0.5%.**

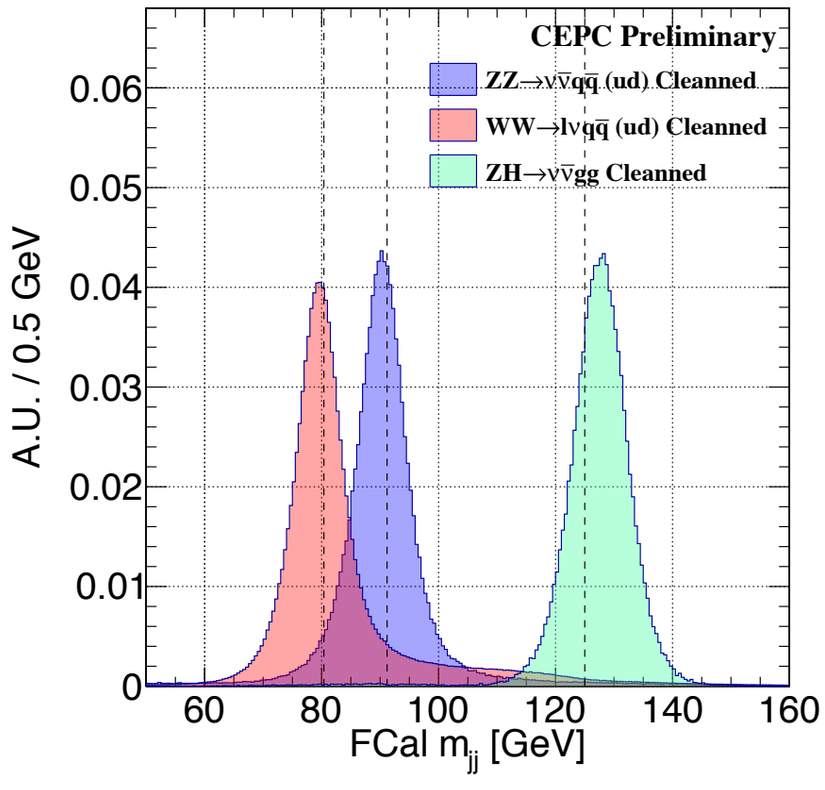
Flavor and En dependent calibration by JES











Summary

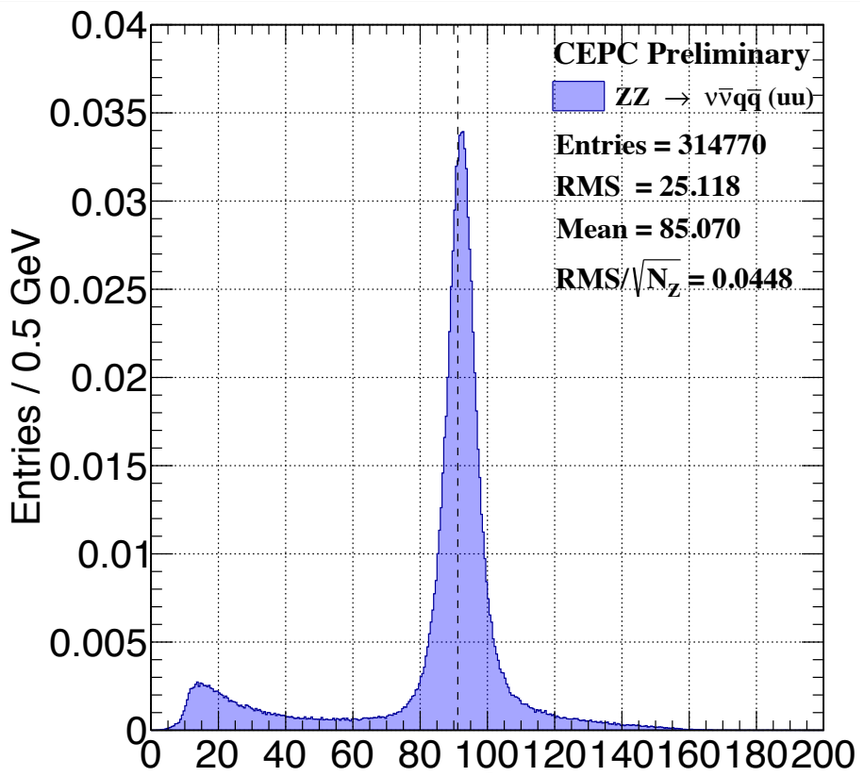
- We have the calibration constants of each flavor from Z.
- RMS of Z and W invariant mass distribution is bigger when the final state is the heavy flavor quark, but the condition of mean is converse.
- The value in each category in WW process is quite stable.
- We know several factors which caused the vertical line in the 2-D histogram, ISR photon, $|\cos\theta|$, and additional lepton.

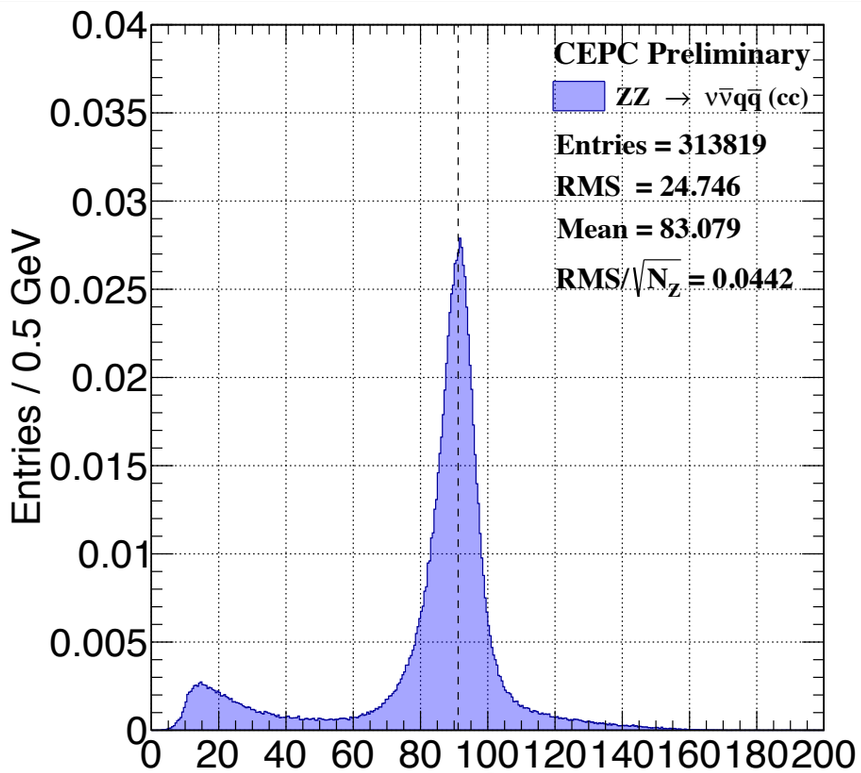
To do

- **The last mission in the Maarten's to do list. What is the b-tagging and c-tagging cut value?**
- **Compare the m_{jj} /m_{true} after two ways calibration to fine the best one. One way is that calibrated by the energy and flavor dependent JES. Another is that calibrated by the each flavor dijet's invariant mass in ZZ process.**
- **Add the requirement to reduce the vertical line in the 2-D histogram, and then try to extract the slope in the m_{jj} vs. m_{true} plots in each category.**

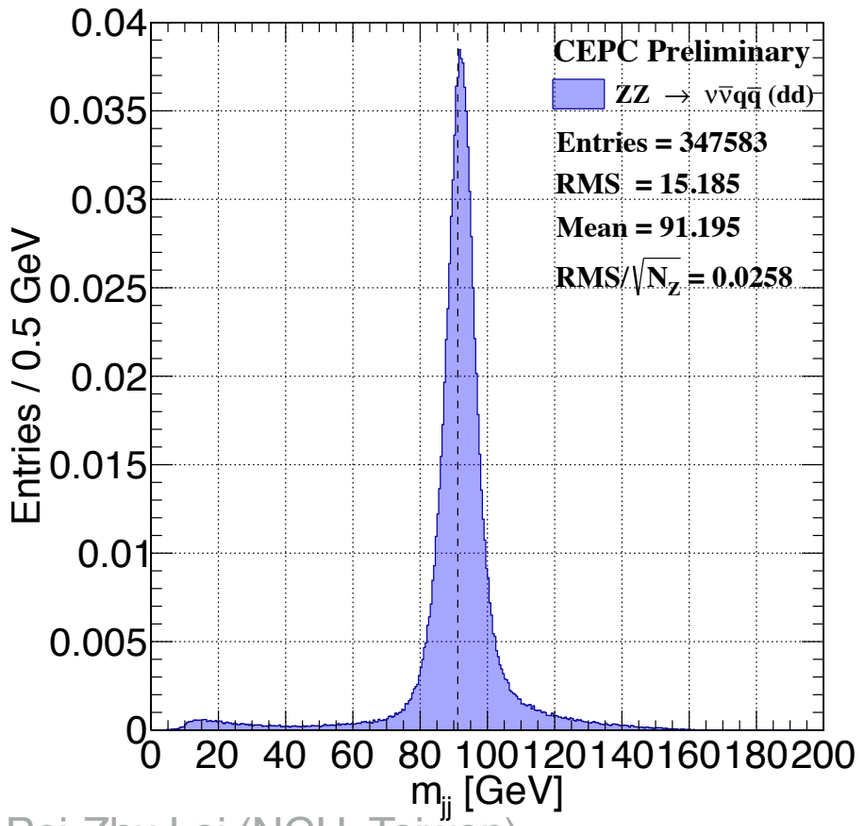
Back up

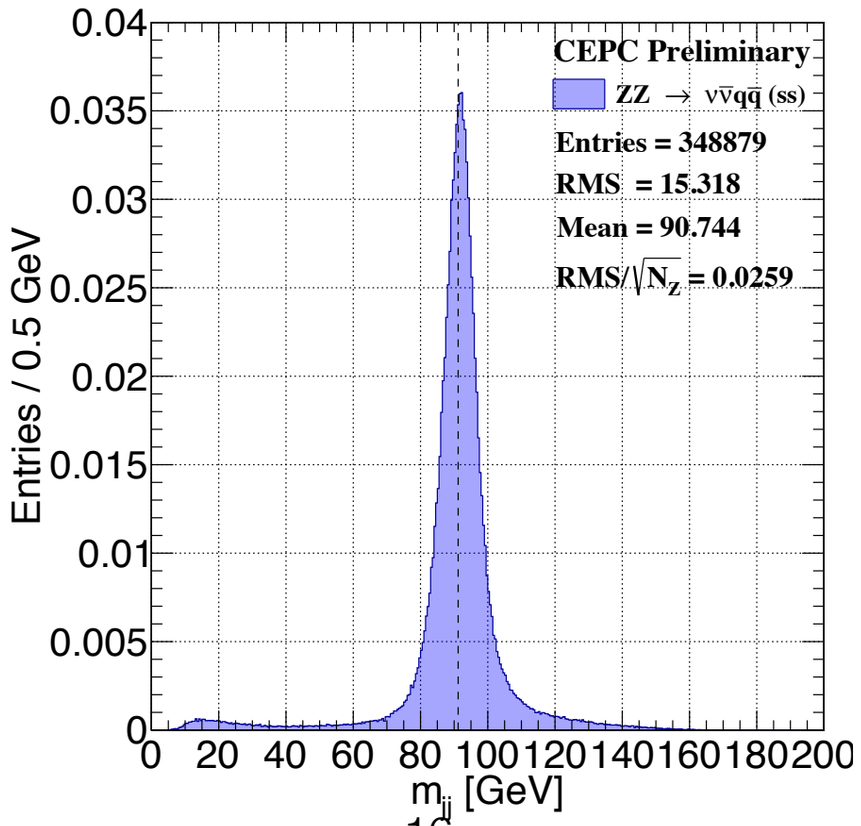
Z->(uu, dd, cc, ss, bb)

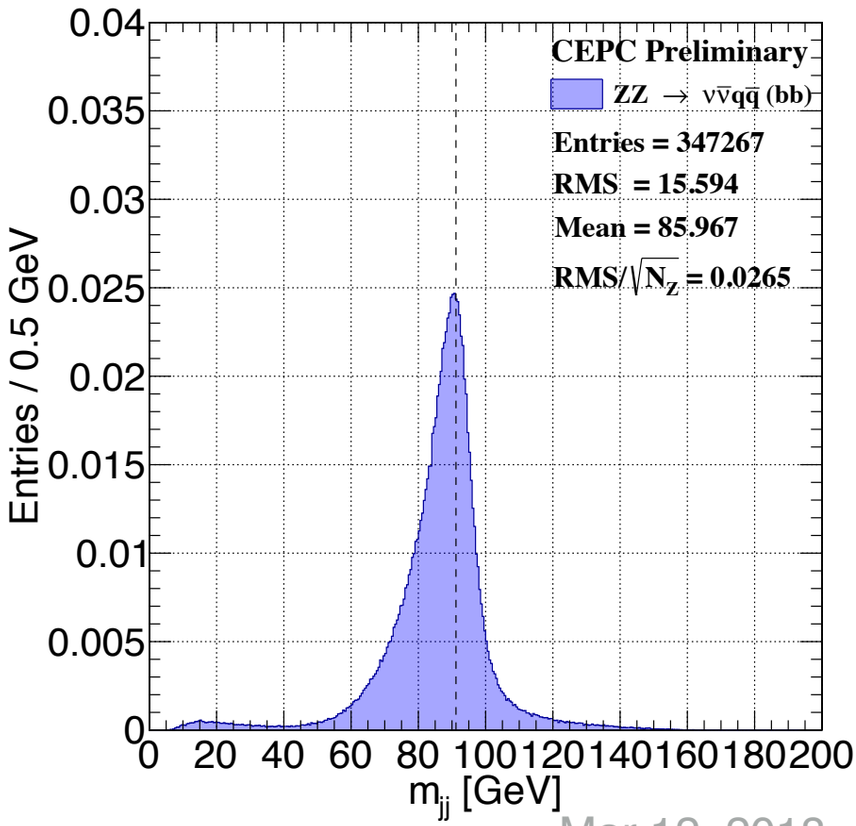




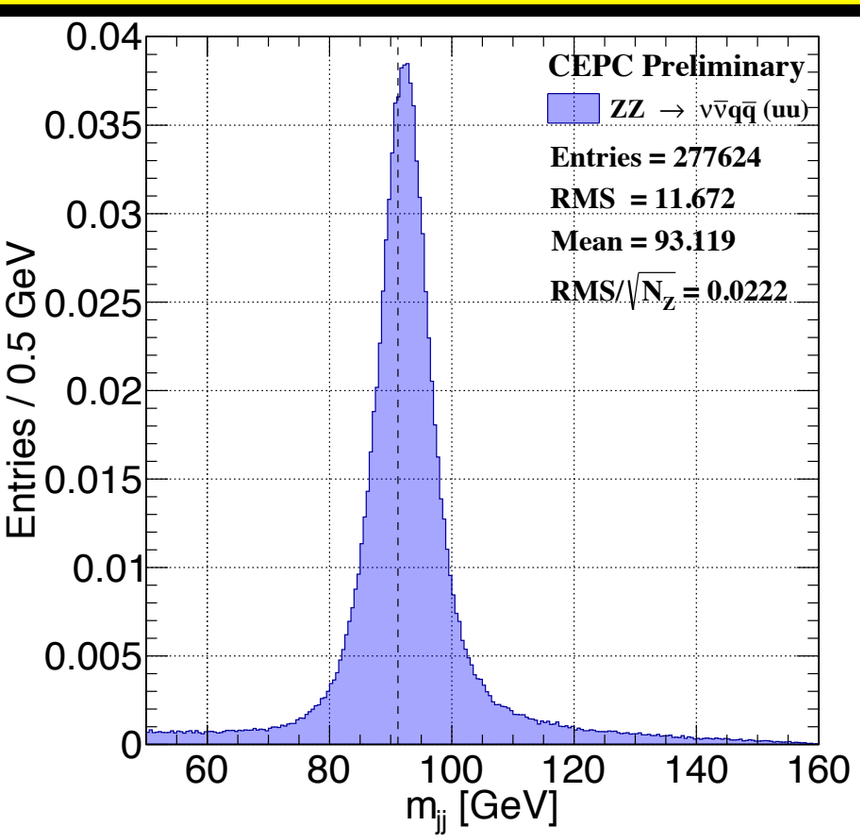
- Calculate the value event-by-event.
- Up-type quarks have higher probability decay from γ^*.
- c- and b- quark have worse resolution.

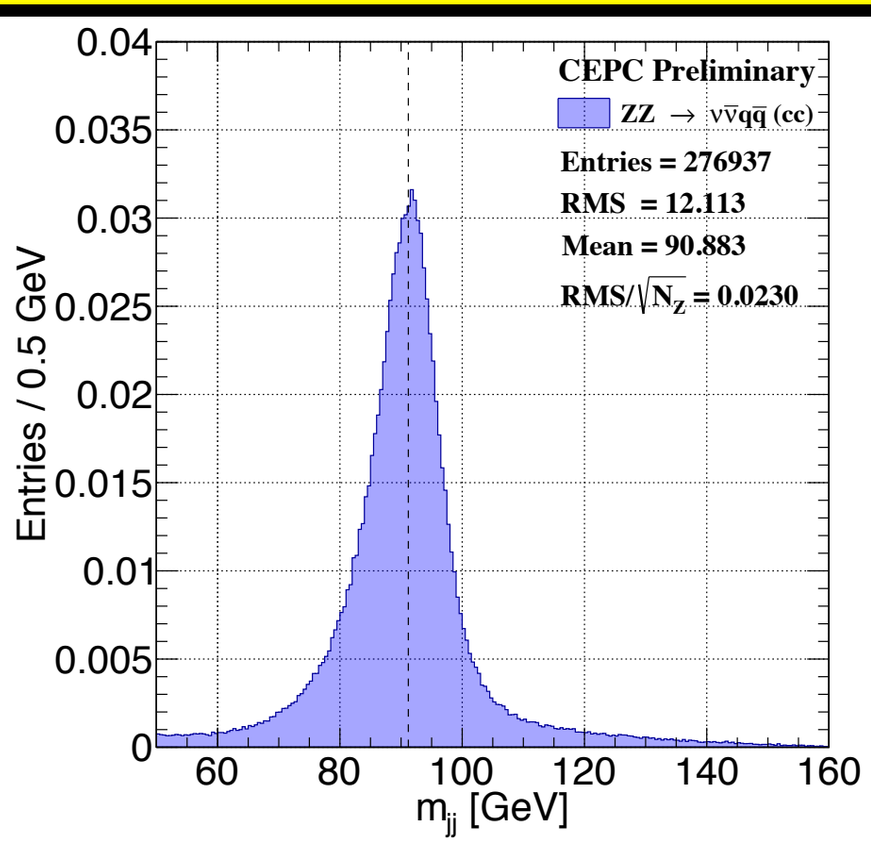




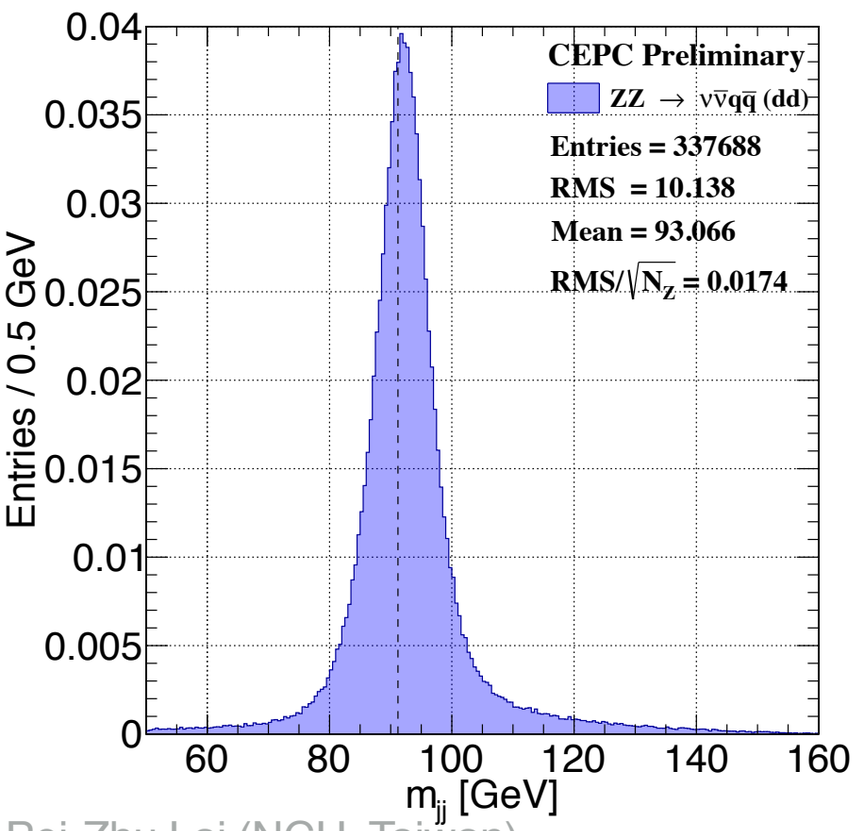


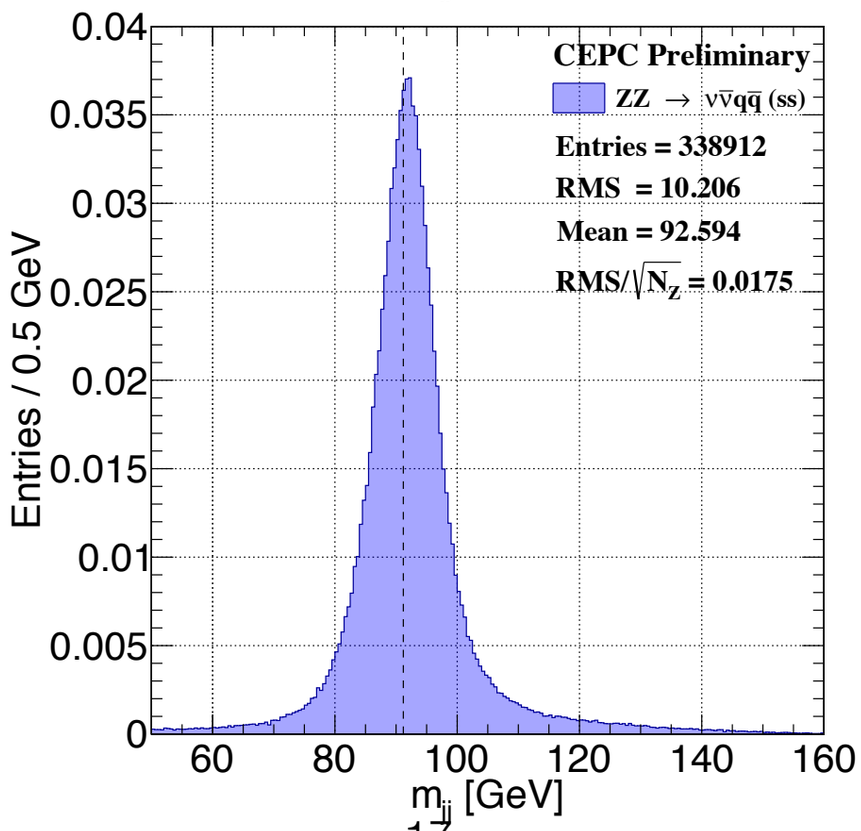
Z->(uu, dd, cc, ss, bb) (50<m_Z<160)

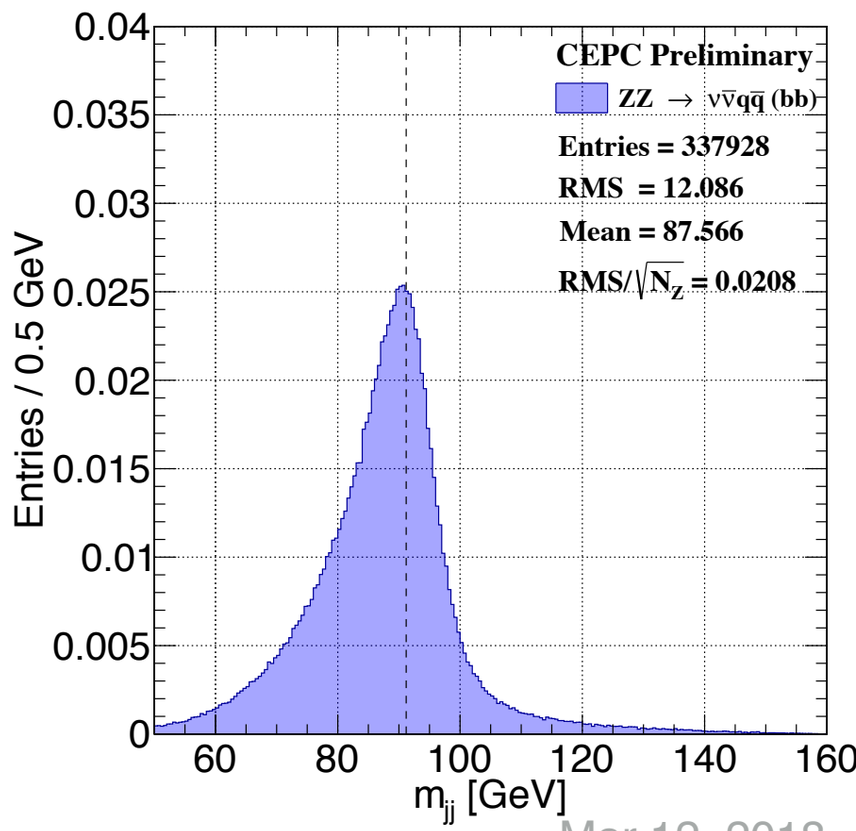




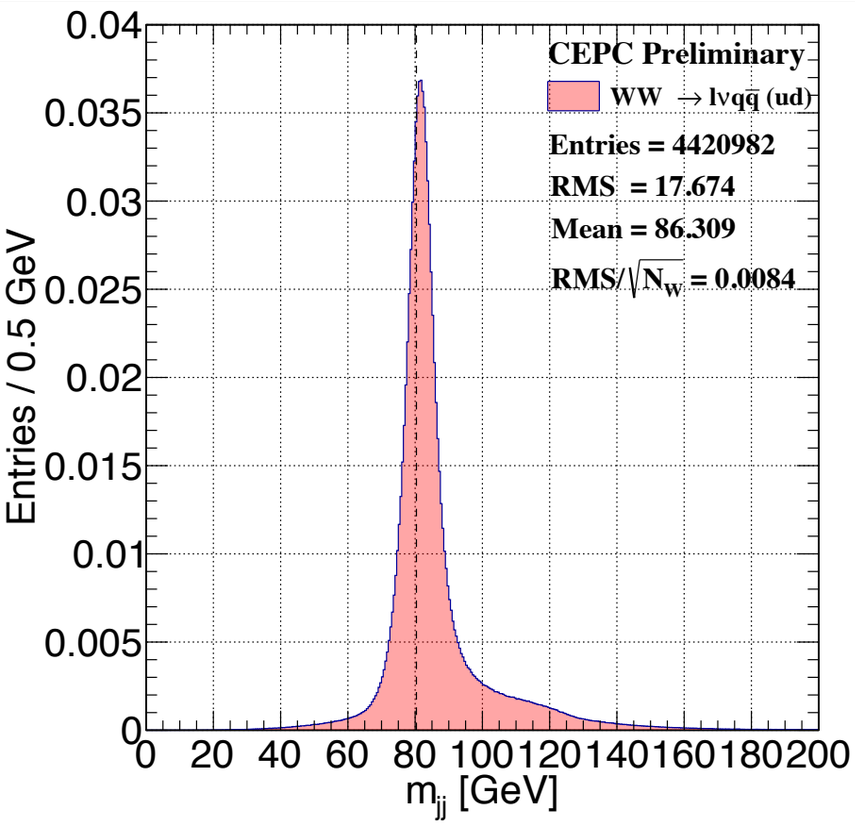
- Suppress the effect from the low mass range. (Calculate the σ, $\bar{x}$ in this range)
- u-, c-, b- statically sensitivity is higher than the others.
- Does mean value has meaning for calibration? We use the peak position to calibrate right?

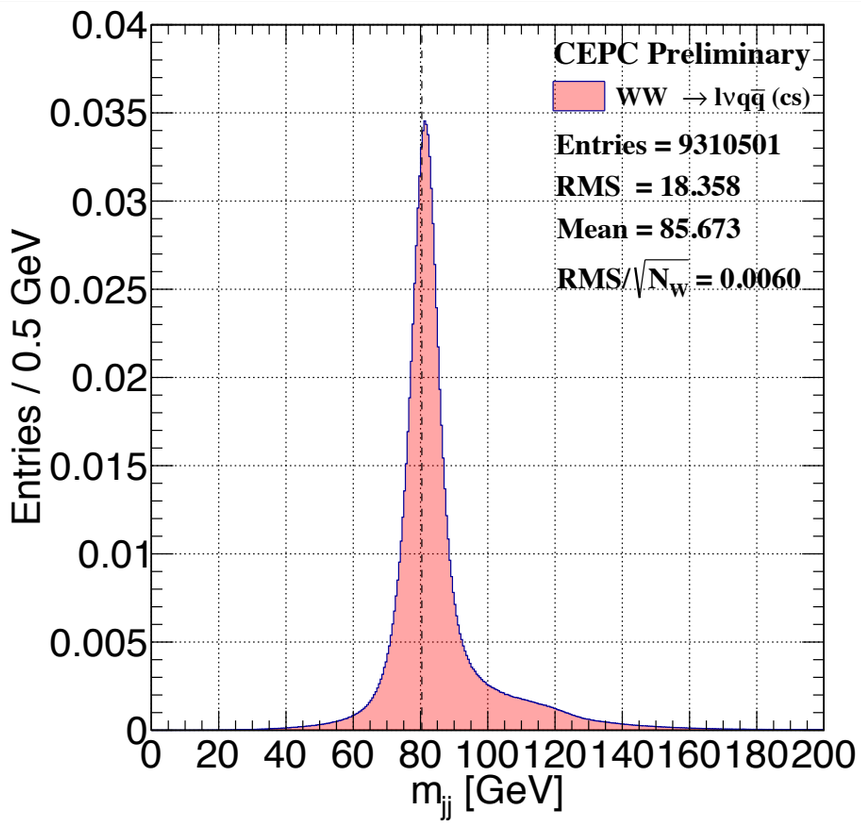


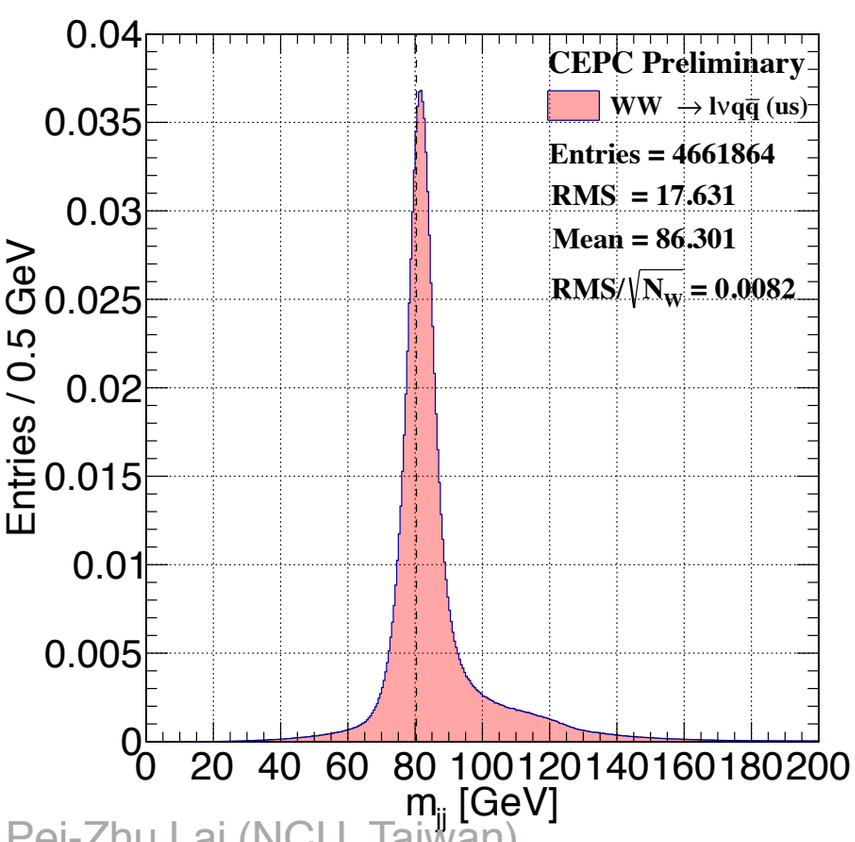


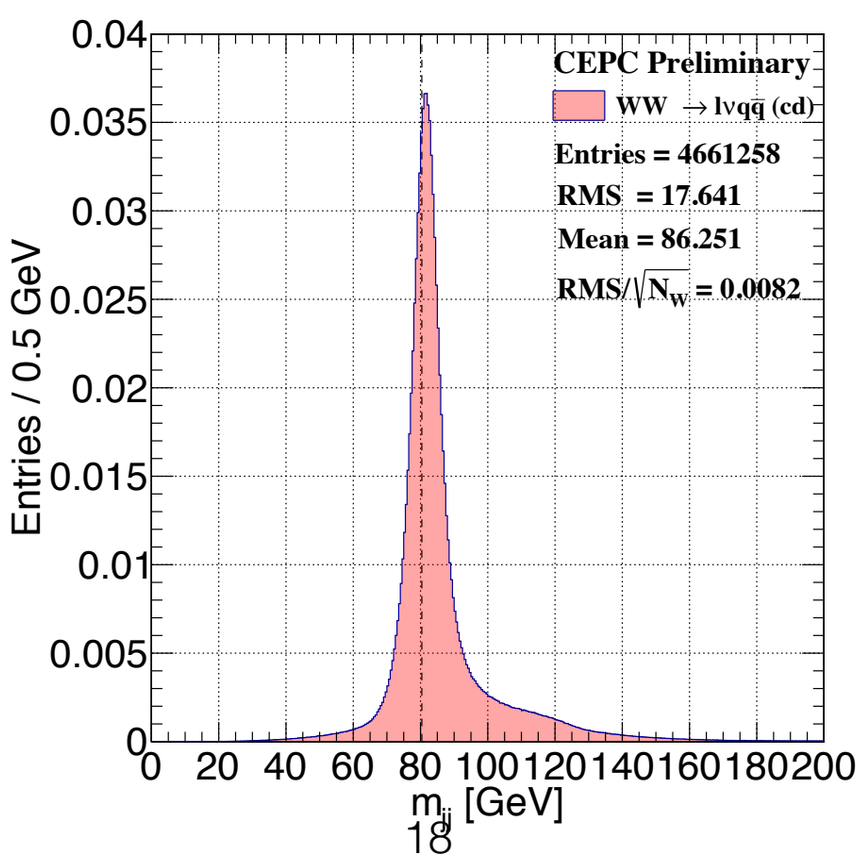


W->(ud, cs, us, cd)



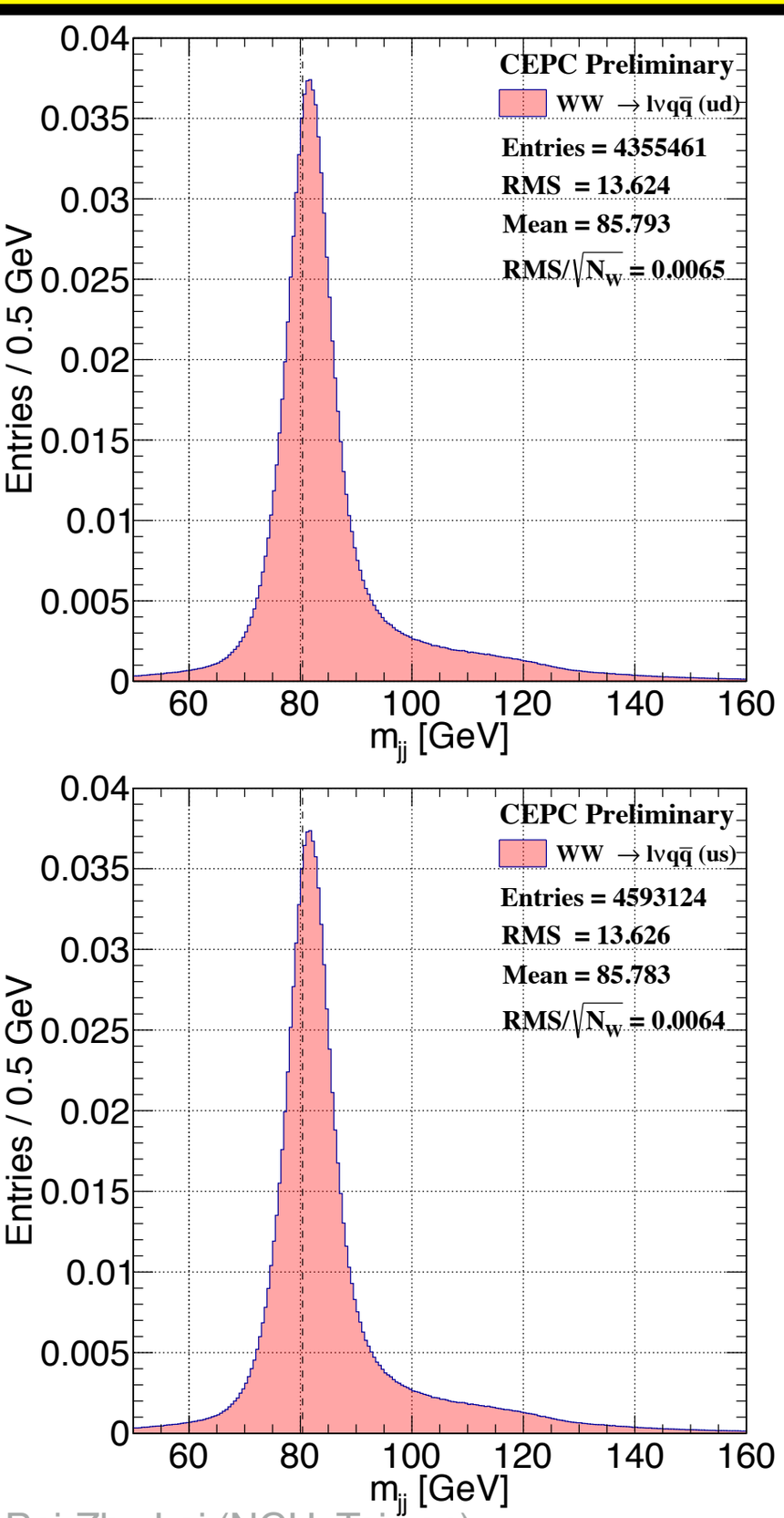


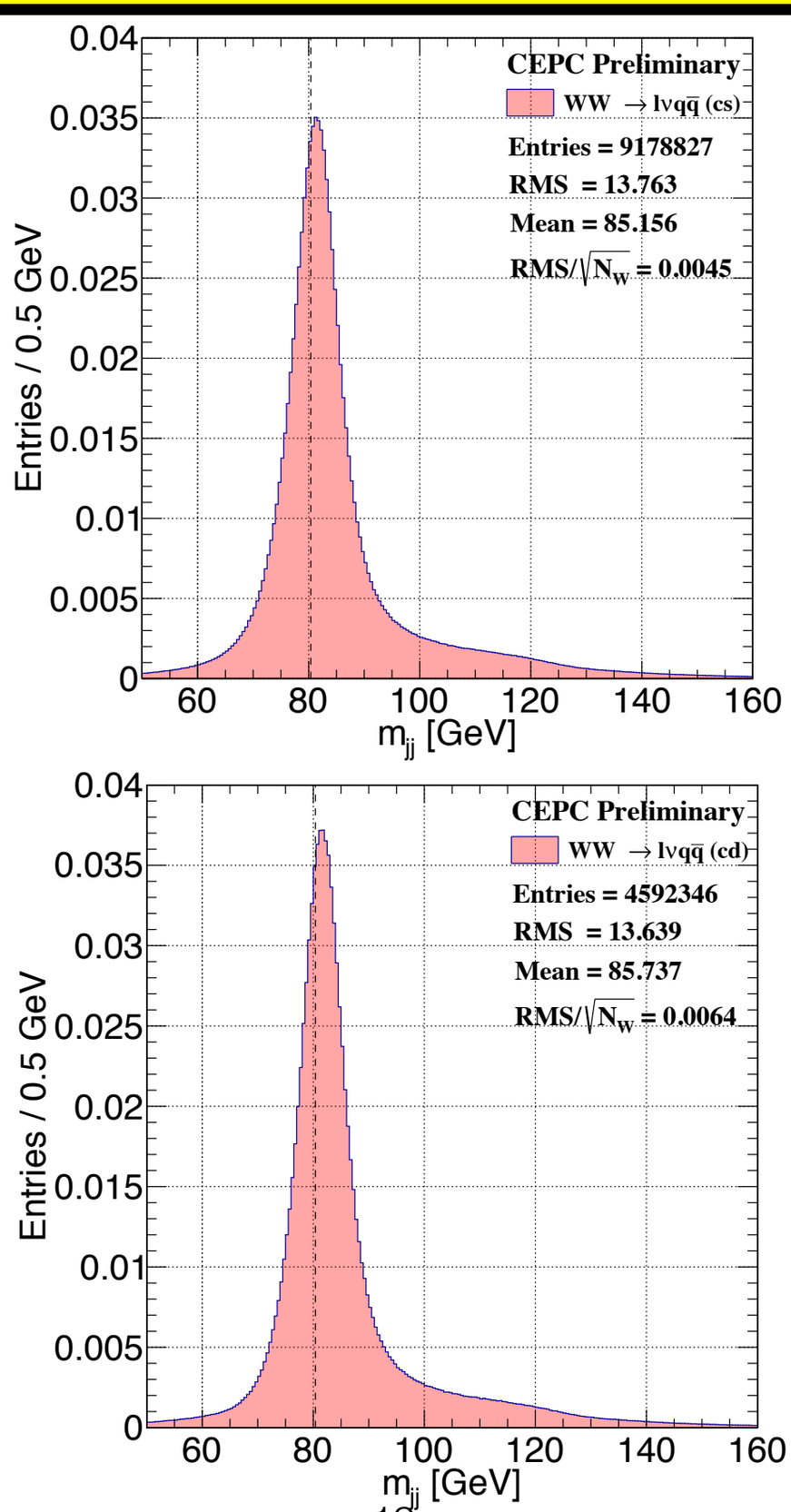




- Calculate the value event-by-event.
- Mean value systematically higher than current measurement's value, because the additional lepton.
- The performance is quite stable. Right column is poor than left because c-quark.

W->(ud, cs, us, cd) (50<m_W<160)





- In this mass range, the value dose not change too much.
- These plot is used to compare with the Z in the same range.