Rb measurement at CEPC MC Level

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Introduction

R_b : the relative decay width of Z into b quarks

$$(R_b = \Gamma_{b\bar{b}}/\Gamma_{had})$$

Method: Double tagging method

- function1： The ratio of one jet tagged as b jet
- function2 The ratio of both jets tagged as b jets
- By using these two functions, we can got the two variables R_b and ε_b

Get From Mixed MC Sample

$$\frac{N_t}{2N_{had}} = R_b\varepsilon_b + R_c\varepsilon_c + (1-R_b-R_c)\varepsilon_{uds}$$

$$\frac{N_{tt}}{N_{had}} = C_bR_b\varepsilon_b^2 + C_cR_c\varepsilon_c^2 + C_{uds}(1-R_b-R_c)\varepsilon_{uds}^2 \qquad C_b = \frac{\varepsilon_{2jet-tagged}}{(\varepsilon_{1jet-tagged})^2}$$

R_c, ε_c, ε_{uds}, C_b, C_c, C_{uds} Get from MC

- The R_{uds} , R_c, ε_{uds} , ε_c , C_b, C_c, C_{uds} are gotten from MC samples
- The N_t , N_{tt} , N_{had} are gotten from DATA samples

B-tagging performance

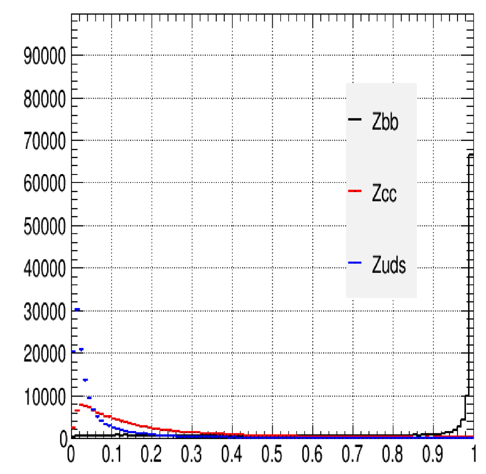
1. **Produced from FSClasser with command : " Marlin *.xml"**
2. **The Z boson hadronic events root file:**

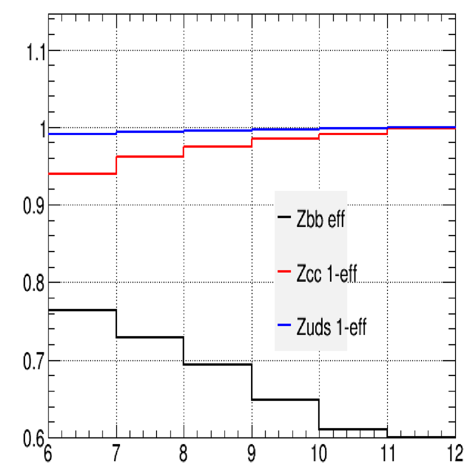
```
Double_t    JetMcPxP1;
Double_t    JetMcPyP1;
Double_t    JetMcPzP1;
Double_t    JetMcEnP1;
Double_t    JetAngleRecMcP1;
Double_t    JetVtxRP2;
Double_t    JetVtxZP2;
Double_t    JetVtxSigRP2;
Double_t    JetVtxSigZP2;
Double_t    JetBtagP2;
Double_t    JetCtagP2;
```

Including the final particle information: Such as the lepton Pt, jet Pt, jet tag prob ..

~140,000 events are produced

Efficiency for Zbb, and rejection for Zcc, Zll



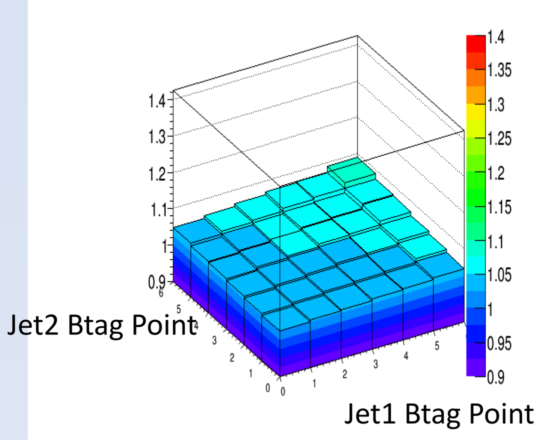


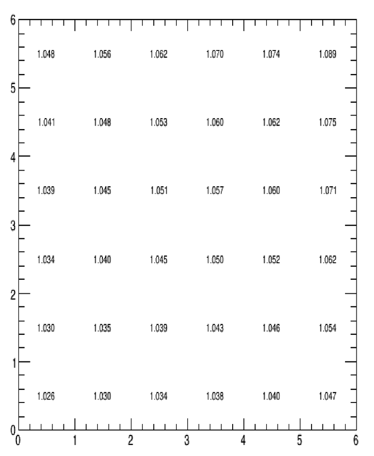
b jet- probability BtagProb Work Points

- The BtagProb distribution are different for Zbb, Zcc and Zll, which can allow us tagging the bjet with high efficiency, as well as high rejection for c and light jets.
- BtagProb Work Points are used :
  - The BtagProb>0.6 , BtagProb>0.7, BtagProb>0.8, BtagProb>0.9, BtagProb>0.95, BtagProb>0.99

	Prob>0.6	Prob>0.7	Prob>0.8	Prob>0.9	0.95	0.99
Zbb_eff	0.7640	0.7294	0.6931	0.6488	0.6097	0.4749
Zcc_Rej:	0.9402	0.9610	0.9755	0.9858	0.9911	0.9978
Zll_Rej	0.9911	0.9941	0.9959	0.9973	0.9981	0.9994

To get the R_b accurately, the correlation factor C_b should be expected to 1





Procedure

Get From Mixed MC Sample

$$\frac{N_t}{2N_{had}} = R_b\varepsilon_b + R_c\varepsilon_c + (1-R_b-R_c)\varepsilon_{uds}$$

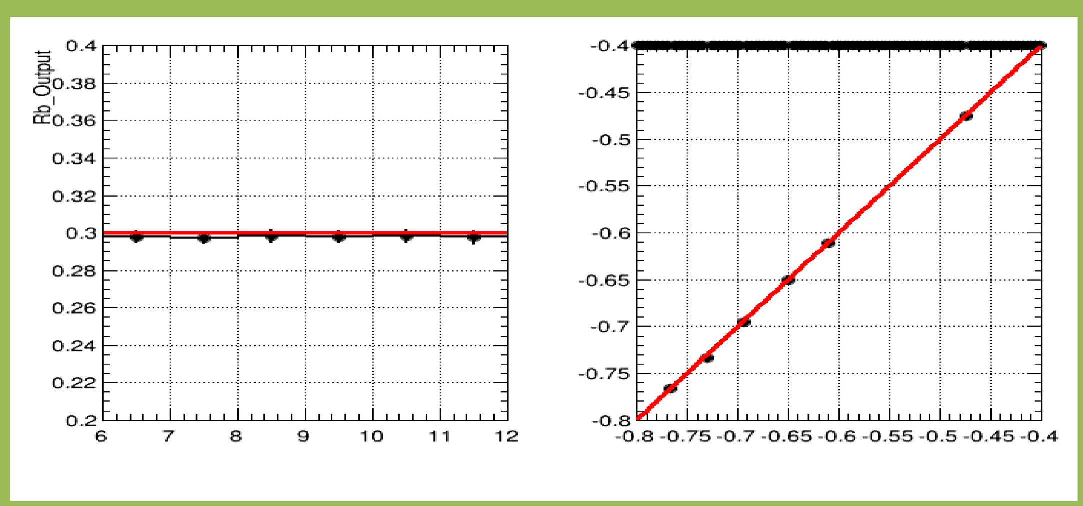
$$\frac{N_{tt}}{N_{had}} = C_bR_b\varepsilon_b^2 + C_cR_c\varepsilon_c^2 + C_{uds}(1-R_b-R_c)\varepsilon_{uds}^2 \qquad C_b = \frac{\varepsilon_{2jet-tagged}}{(\varepsilon_{1jet-tagged})^2}$$

R_c, ε_c, ε_{uds}, C_b, C_c, C_{uds} Get from MC

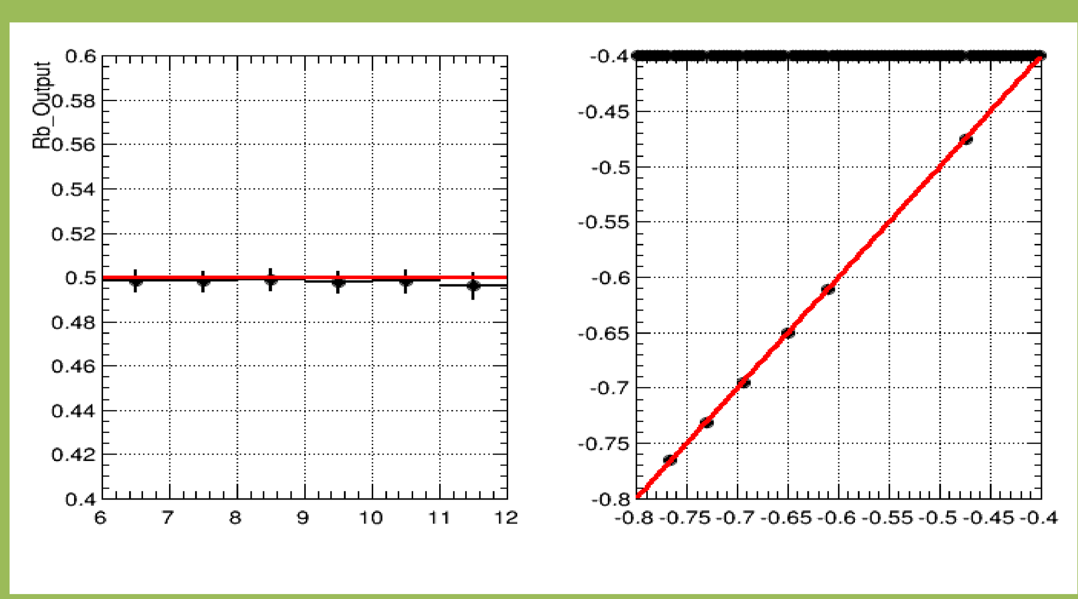
The Z hadronic '**DATA**' is mixed by MC samples: Zbb **sample1**, Zcc **sample1**, Zll sample1
We set Rb=0.3, Rb=0.5, Rb=0.7 as the Input Rb to mix the 'DATA'

The R_c, ε_c, C_b, C_c, C_{uds} is gotten by MC samples: Zbb sample2, Zcc sample2, Zllsample2
So if **sample1≠**sample2, which means the MC R_c, ε_c, C_b, C_c, C_{uds} are different from the Truth in 'DATA'

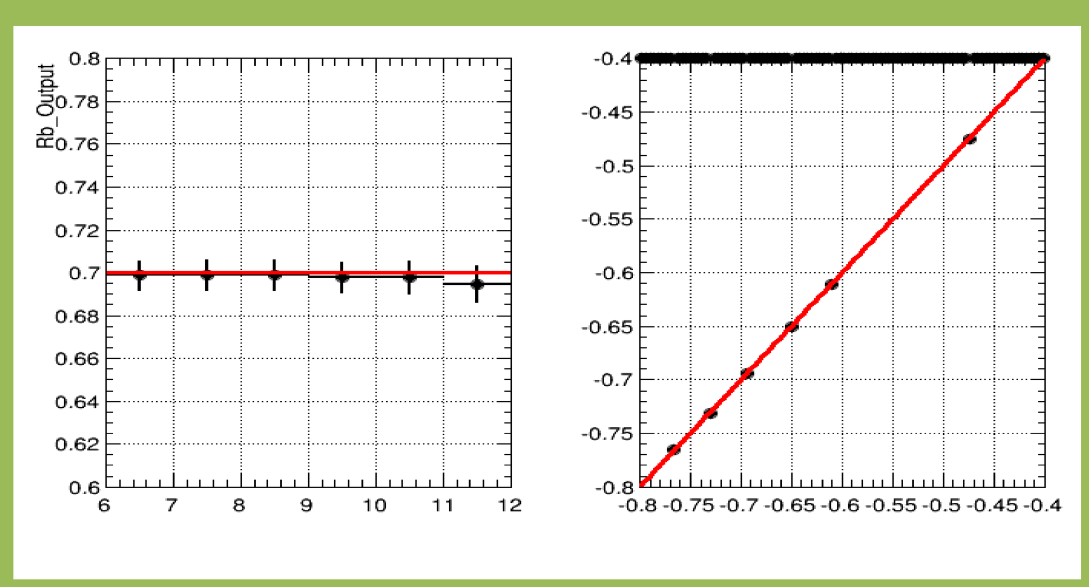
Input Rb=0.3, six BtagProb work point: Prob>0.6, >0.7, >0.8, >0.9, >0.95,>0.99



Input Rb=0.5, six BtagProb work point: Prob>0.6, >0.7, >0.8, >0.9,>0.95,>0.99



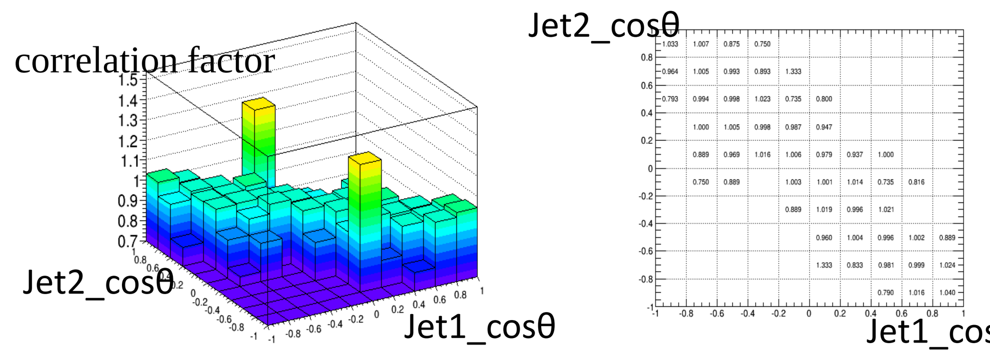
Input Rb=0.7, six BtagProb work point: Prob>0.6, >0.7, >0.8, >0.9,>0.95,>0.99

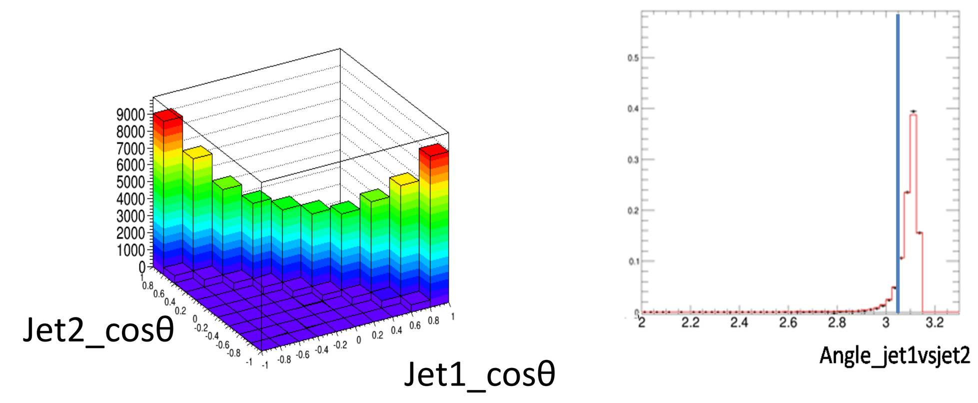


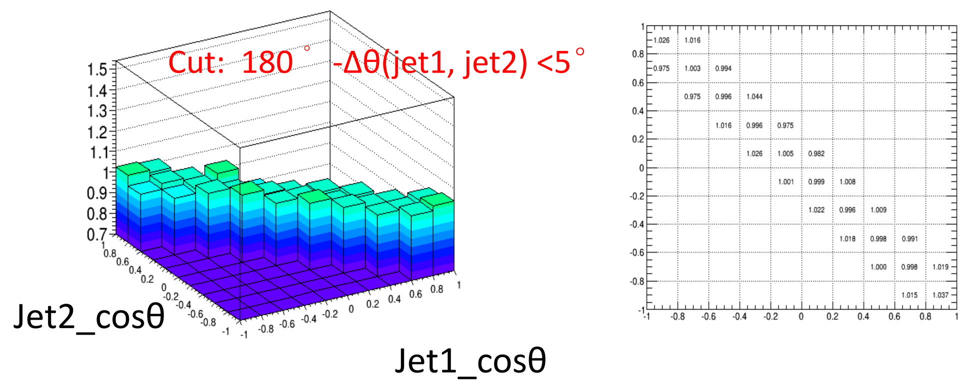
The I/O test shows the procedure works well

Improvement

Make sure the two jets are from Z ->bb







To further improve the b-tagging correlation factor, two different b-tagging method are used instead of two b-tagging work points in one b-tagging method

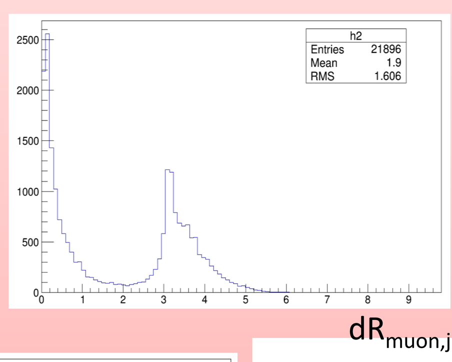
$$\frac{N_t}{N_{had}} = R_b\varepsilon^I_b + R_c\varepsilon^I_c + (1-R_b-R_c)\varepsilon^I_{uds} \quad \text{jet1 Btag work point I}$$

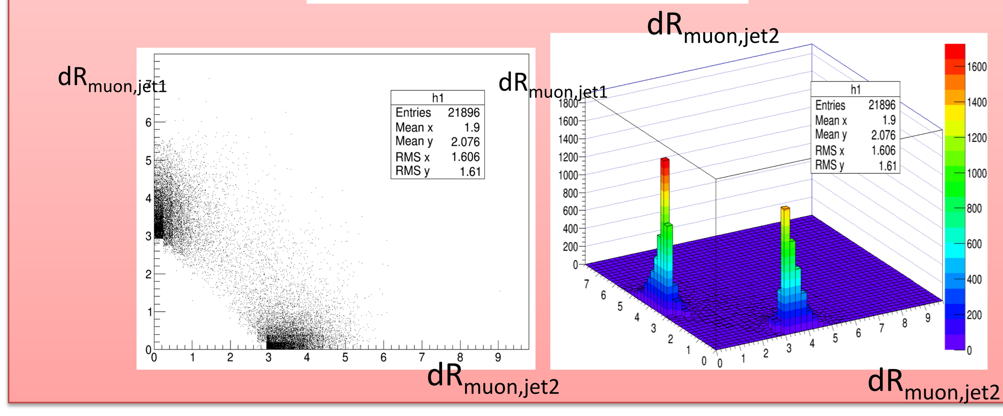
$$\frac{N_t}{N_{had}} = R_b\varepsilon^J_b + R_c\varepsilon^J_c + (1-R_b-R_c)\varepsilon^J_{uds} \quad \text{jet2 Btag work point J}$$

$$\frac{N_{tt}}{N_{had}} = C_bR_b\varepsilon^I_b\varepsilon^J_b + C_cR_c\varepsilon^I_c\varepsilon^J_c + C_{uds}(1-R_b-R_c)\varepsilon^I_{uds}\varepsilon^J_{uds}$$

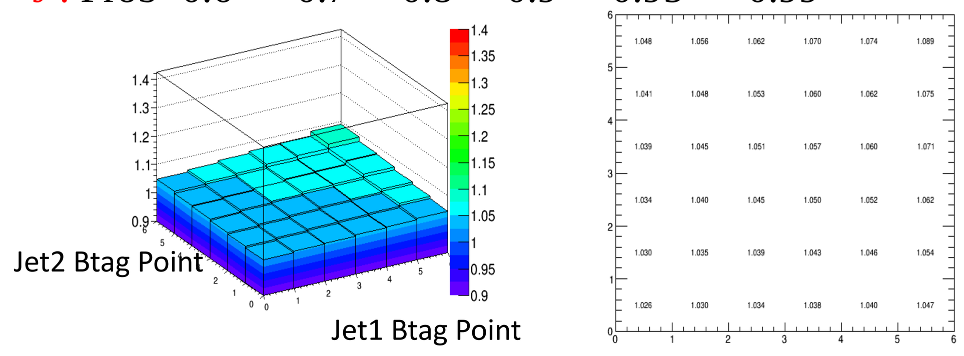
$$C_b = \frac{\varepsilon_{2jet-tagged}}{\varepsilon^I_b\varepsilon^J_b}$$

jet1: the same b-tagging method as before.
jet2: using the deltaR between the muon and jet

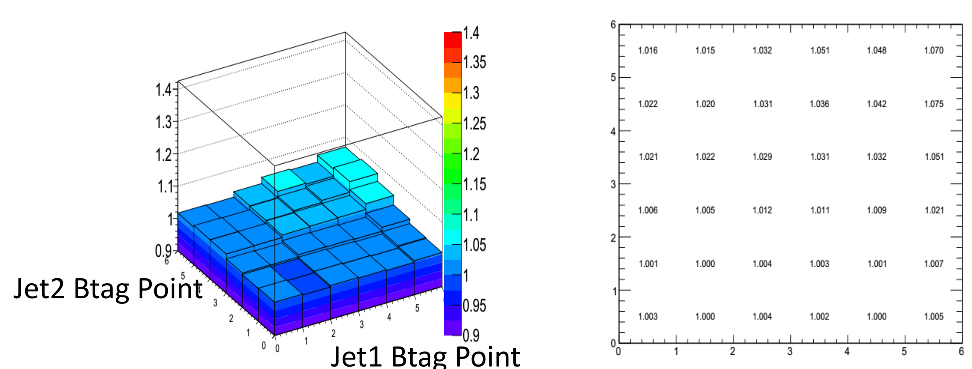




J : Prob>0.6 >0.7 >0.8 >0.9 >0.95 >0.99



J : $dR_{muon,jet2}$ <0.5 <0.4 <0.3 <0.2 <0.1 <0.05



Next step:
More studies need to be done on the correlation factors.
The systematic uncertainties need to be studied accurately