Rb measurement at CEPC MC Level

Bo Li

Basic information

- MC samples:Zbb,Zcc,Zll

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

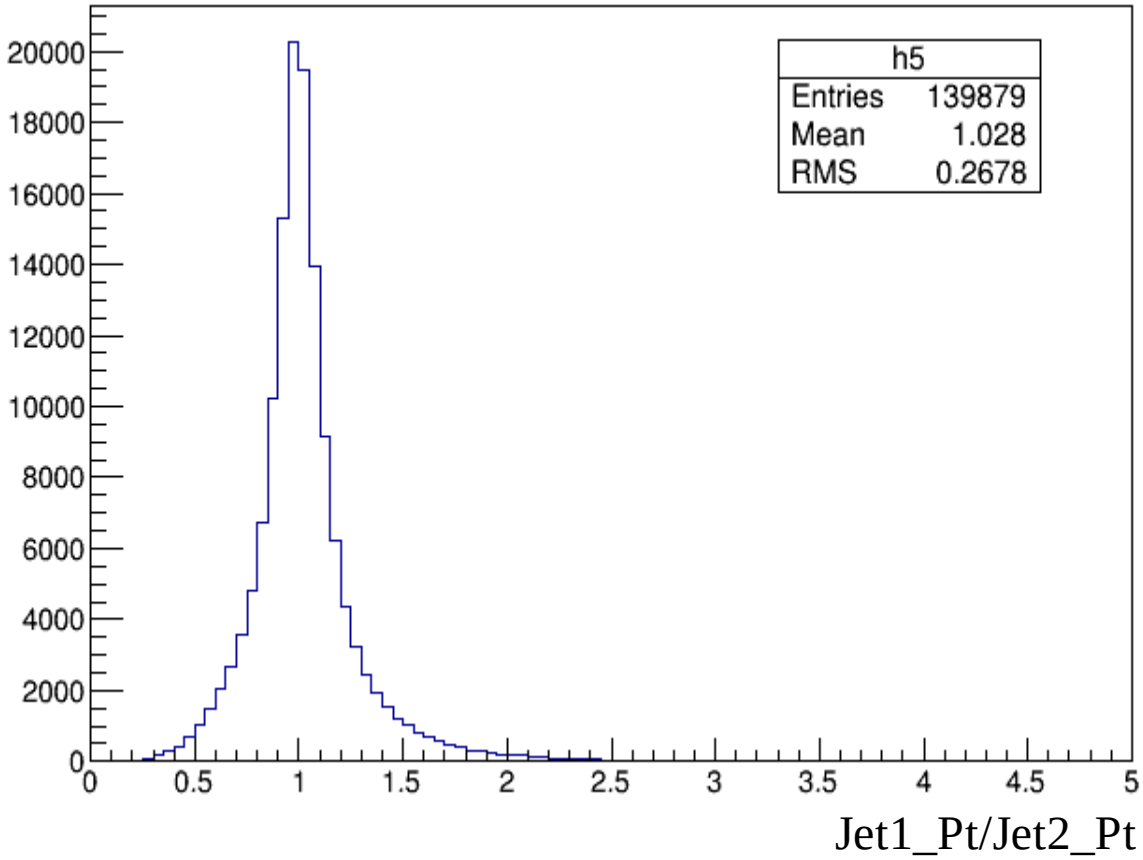
```
Double_t        JetMcPxP1;
Double_t        JetMcPyP1;
Double_t        JetMcPzP1;
Double_t        JetMcEnP1;
Double_t        JetAngleRecMcP1;
Double_t        JetVtxRP2;
Double_t        JetVtxZP2;
Double_t        JetVtxSigRP2;
Double_t        JetVtxSigZP2;
Double_t        JetBtagP2;
Double_t      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

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

~140,000 events are produced

Btagging correlation

- Two jet named: Jet1 Jet2

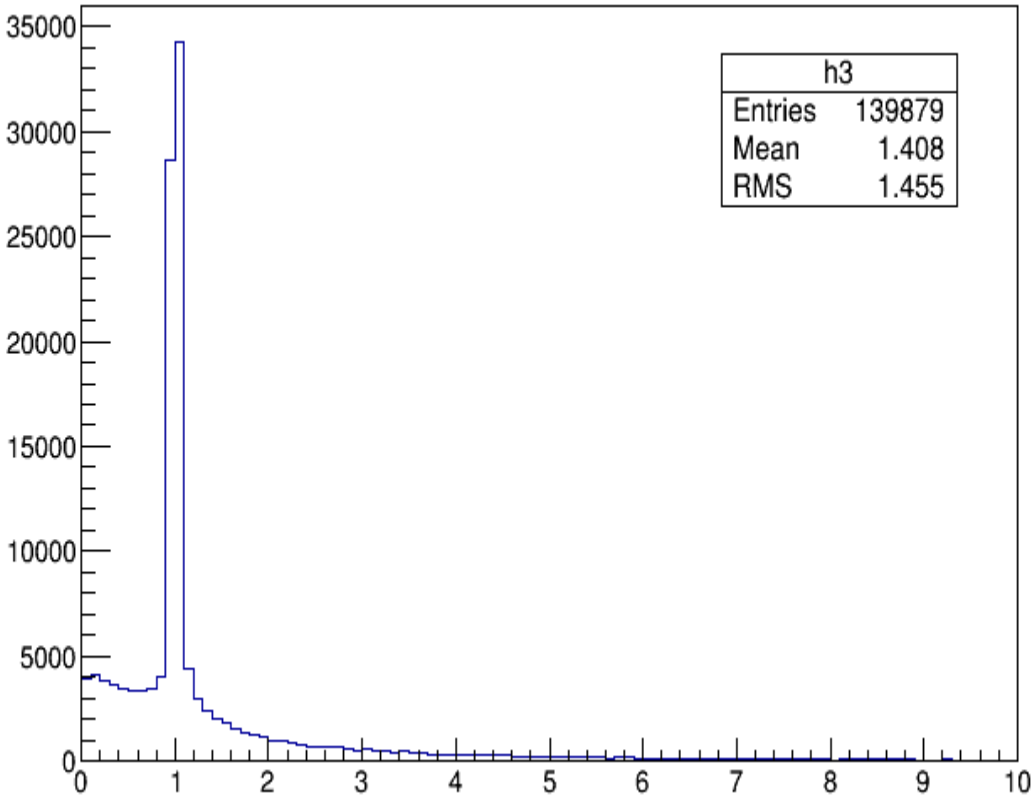


Total event: ~**139879**

70057 events with jet1 Pt >jet2 Pt

69822 events with jet2 Pt >jet1 Pt

- B-tag prob ratio:
  - Leading Pt Jet/Sub leading pt Jet

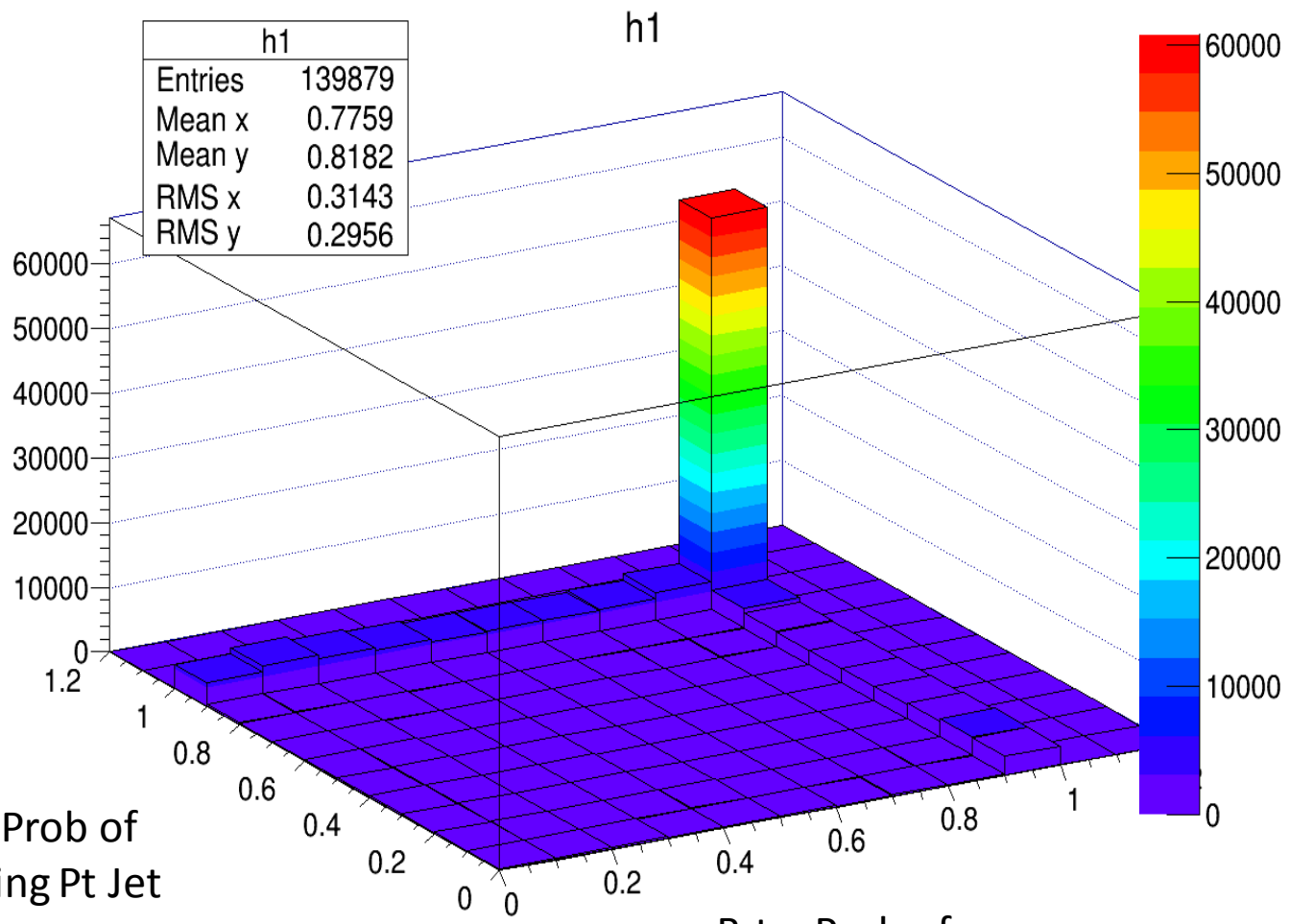


Total event: ~ **139879**

78119 events with B-tag prob ratio >1

61760 events with B-tag prob ratio<1

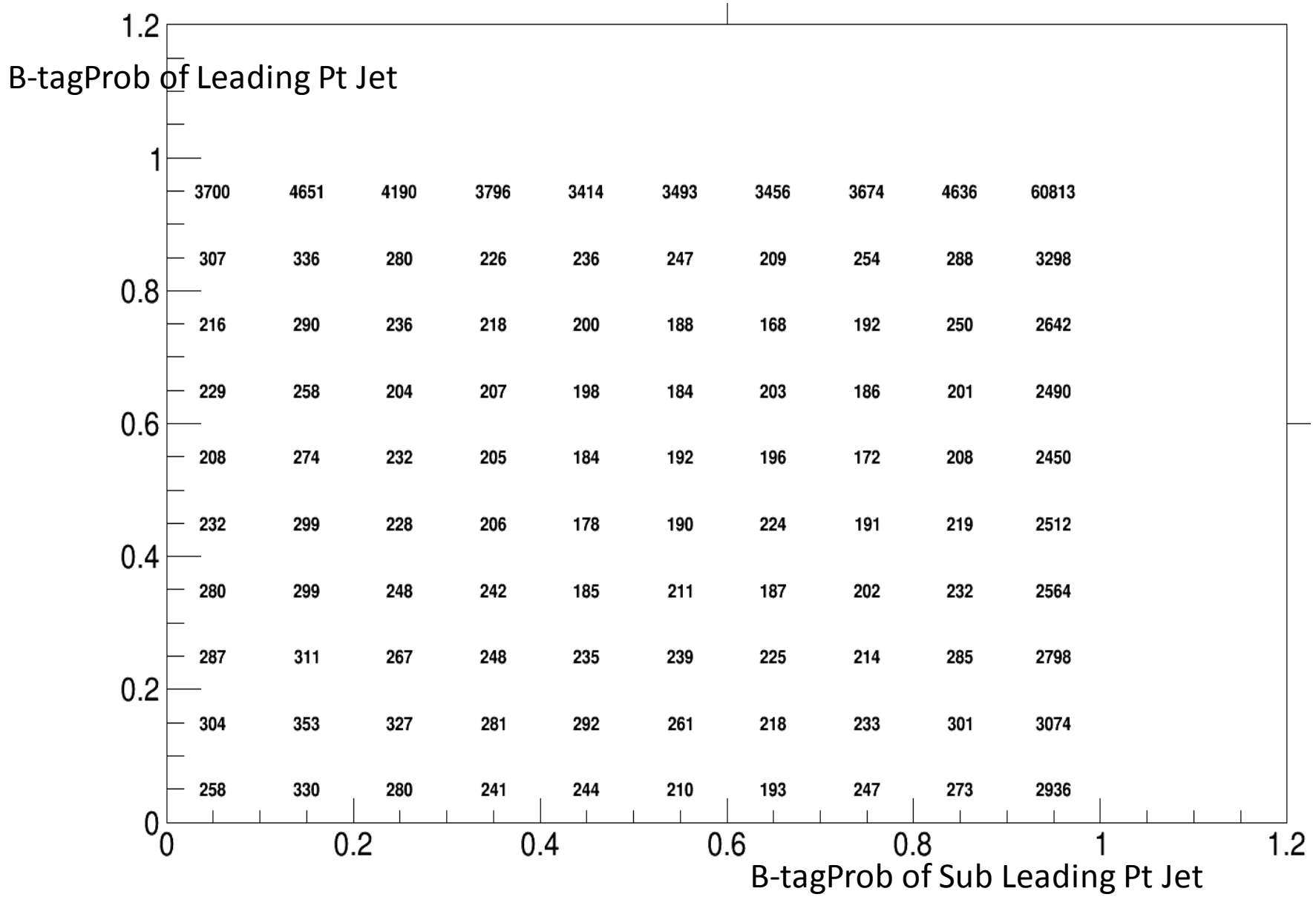
139879 events



B-tagProb of Leading Pt Jet

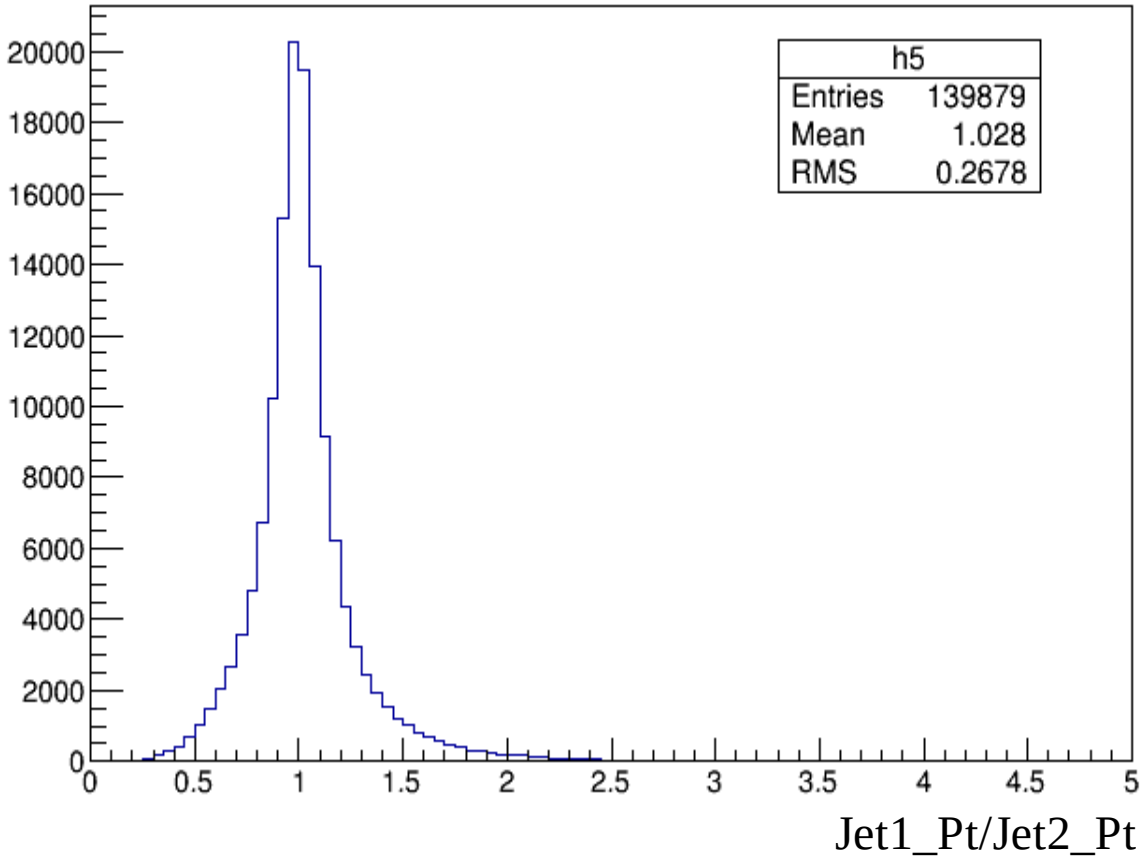
B-tagProb of Sub Leading Pt Jet

139879 events



Btagging correlation

- Two jet named: Jet1 Jet2



Total event: ~**139879**

70057 events with jet1 Pt >jet2 Pt

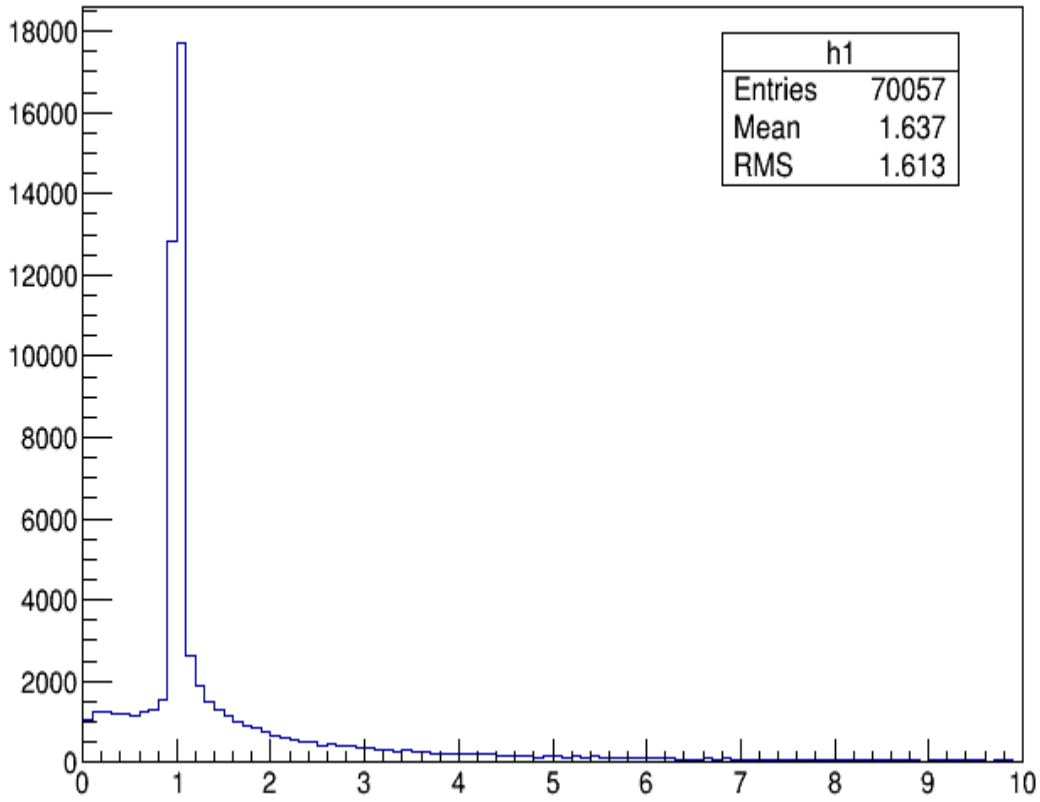
69822 events with jet2 Pt >jet1 Pt

70057 events with jet1 Pt >jet2 Pt

- Btagprob Jet1/Jet2

Jet1: leading Pt jet

Jet2: sub leading Pt jet



Jet1_Btag/Jet2_Btag

Total event: ~ **70057**

46118 events with jet1_Btag> jet2_Btag

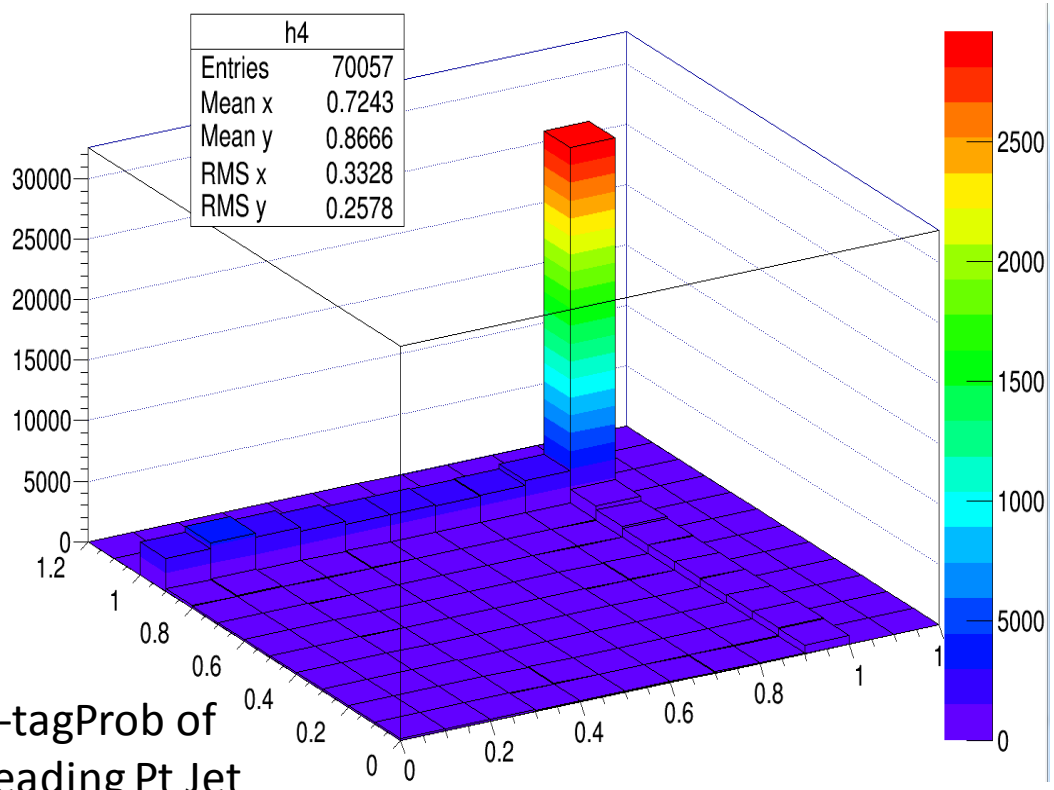
23939 events with jet1_Btag< jet2_Btag

70057 events with jet1 Pt >jet2 Pt

- Btagprob Jet1/Jet2

Jet1: leading Pt jet

Jet2: sub leading Pt jet



B-tagProb of Leading Pt Jet

B-tagProb of Sub Leading Pt Jet

Total event: ~ **70057**

46118 events with jet1_Btag> jet2_Btag

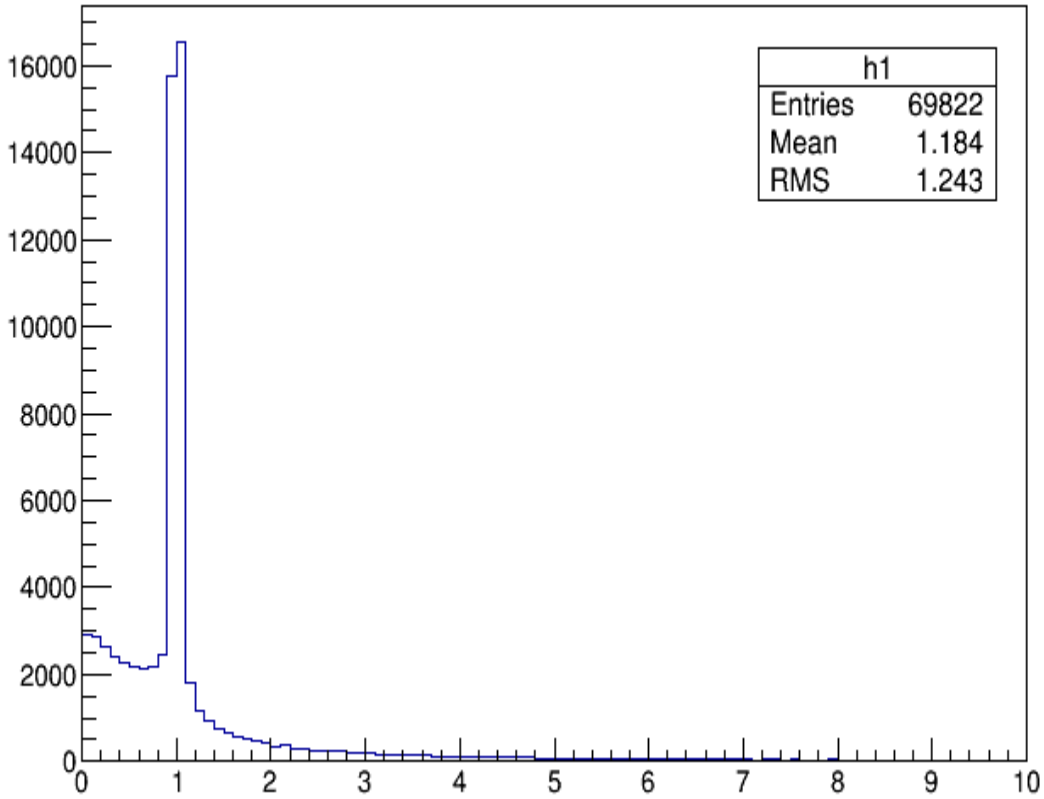
23939 events with jet1_Btag< jet2_Btag

69822 events with jet2 Pt >jet1 Pt

- Btagprob Jet2/Jet1

Jet2: leading Pt jet

Jet1: sub leading Pt jet



Jet2_Btag/Jet1_Btag

Total event: ~ **69822**

32001 events with jet2_Btag> jet1_Btag

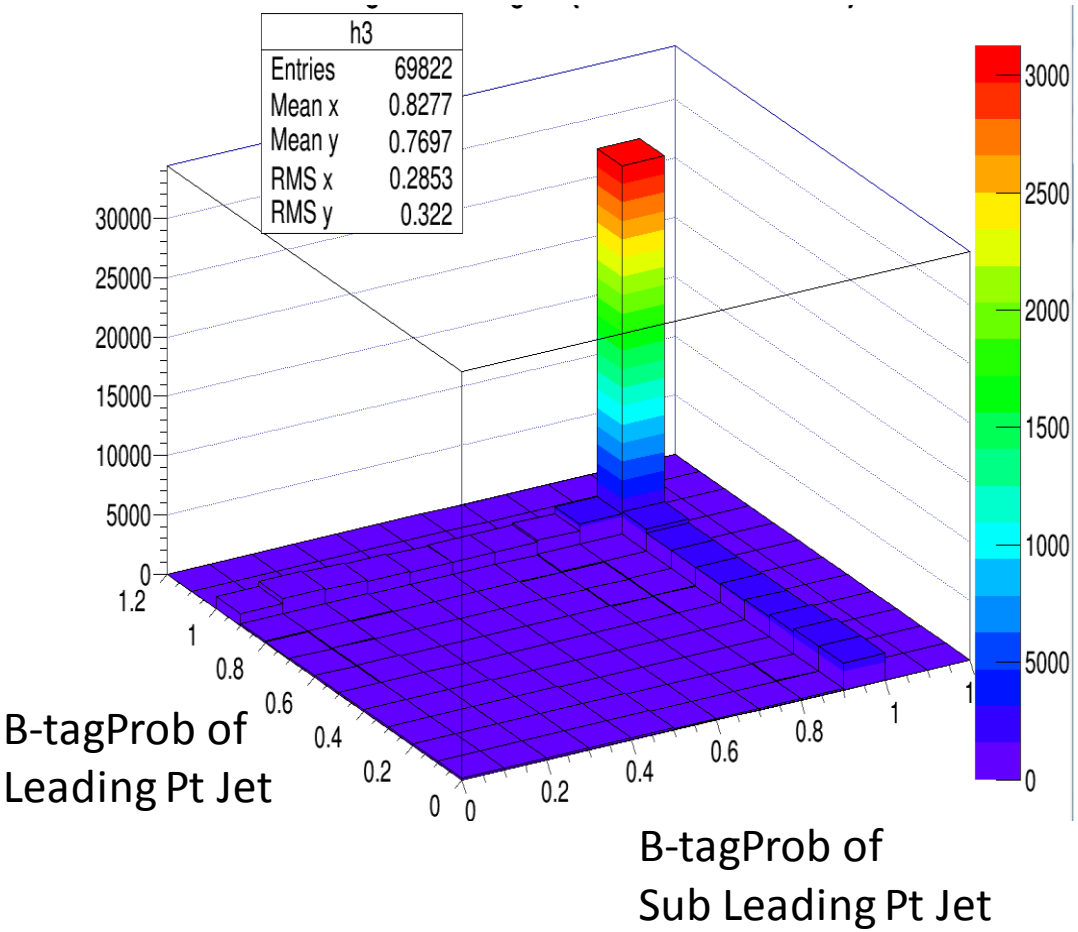
37821 events with jet2_Btag< jet1_Btag

69822 events with jet2 Pt >jet1 Pt

- Btagprob Jet2/Jet1

Jet2: leading Pt jet

Jet1: sub leading Pt jet

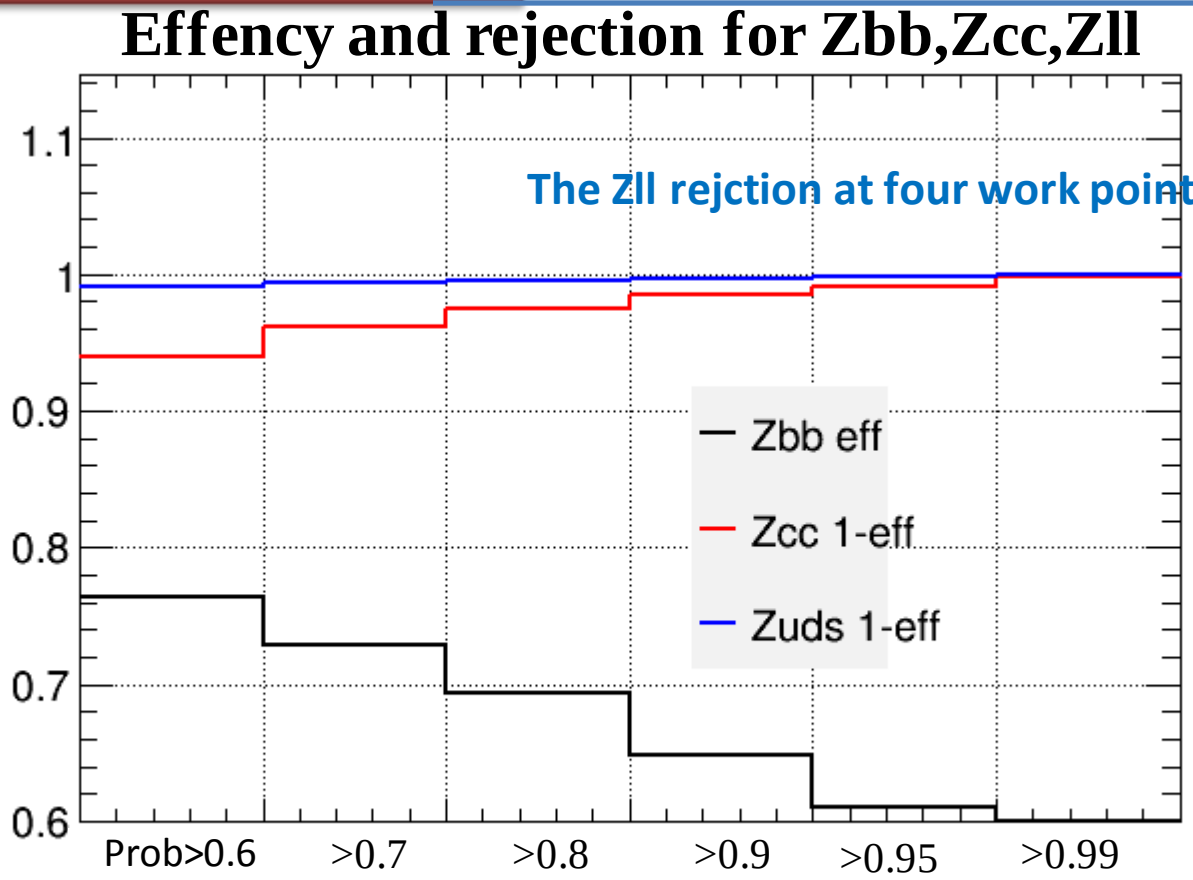


Total event: ~ **69822**

32001 events with jet2_Btag> jet1_Btag

37821 events with jet2_Btag< jet1_Btag

Btagging performance



	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

Rb method

Get From Mixed MC Sample

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

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

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

$$C_b = \frac{\varepsilon_{2\,jet-tagged}}{(\varepsilon_{1\,jet-tagged})^2}$$

1.015 1.021 1.026 1.033

Following this procedure, we can measured the R_b , ε_b

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'

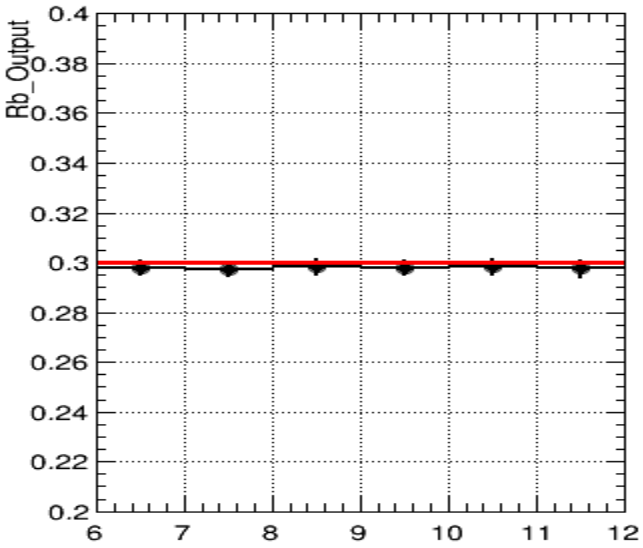
The R_c, ε_c, C_b, C_c, C_{uds} is gotten by MC samples: Zbb sample2, Zcc sample2, Zllsample2

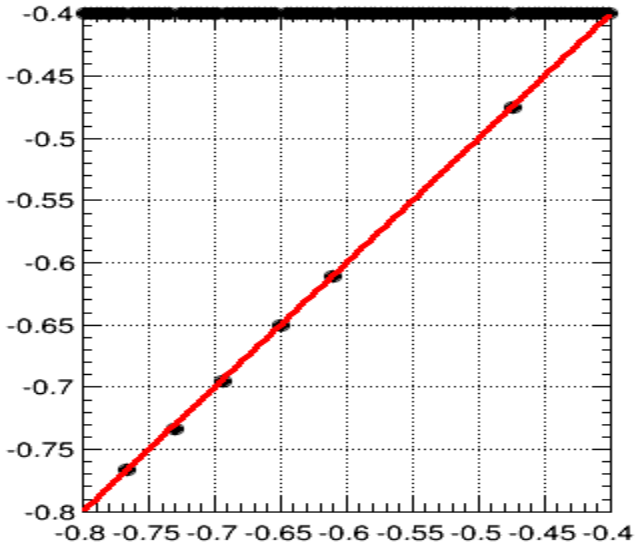
So if **sample1≠** sample2, which means the MC R_c, ε_c, C_b, C_c, C_{uds} are different from the Truth in 'DATA'

Btagging performance

IO test

Input Rb=0.3, Four BtagProb work point: Prob>0.6, >0.7, >0.8, >0.9



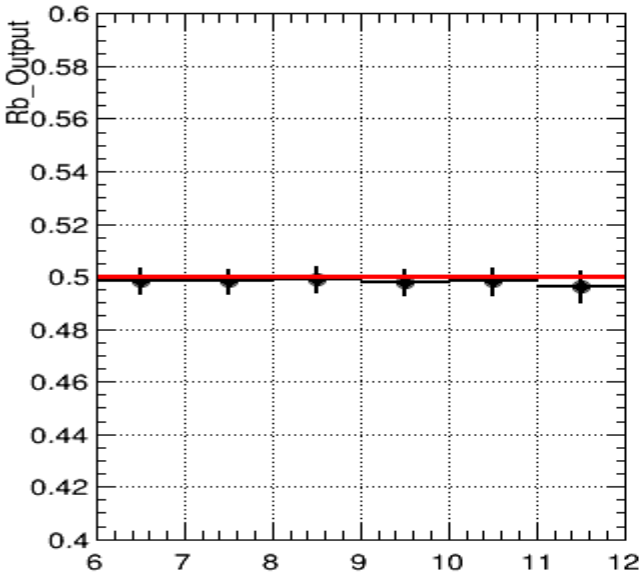


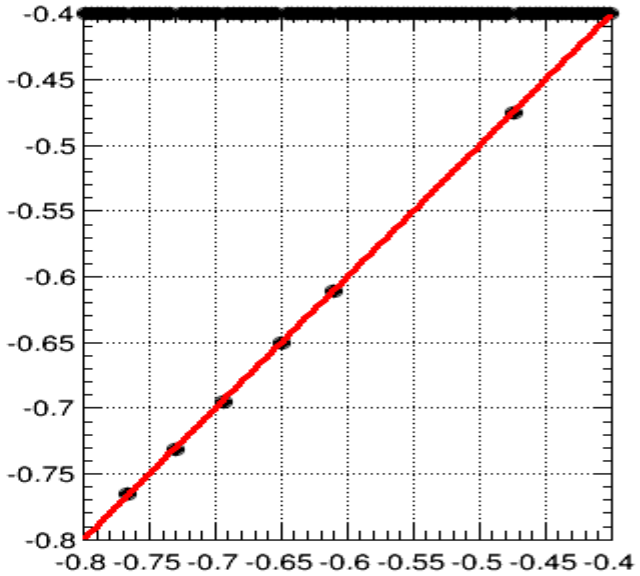
Input Rb:	0.3000					
Output Rb:	0.2981	0.2975	0.2984	0.2980	0.2985	0.2977
Input eff:	0.7643	0.7300	0.6936	0.6480	0.6087	0.4721
Output eff:	0.7668	0.7333	0.6956	0.6508	0.6109	0.4756

Btagging performance

IO test

Input Rb=0.5, Four BtagProb work point: Prob>0.6, >0.7, >0.8, >0.9





Input Rb:	0.5000					
Output Rb:	0.4985	0.4981	0.4988	0.4980	0.4982	0.4962
Input eff:	0.7643	0.7300	0.6936	0.6480	0.6087	0.4721
Output eff:	0.7657	0.7316	0.6946	0.6501	0.6105	0.4756

Summary

- The IO test shows Analysis code worked as expected.

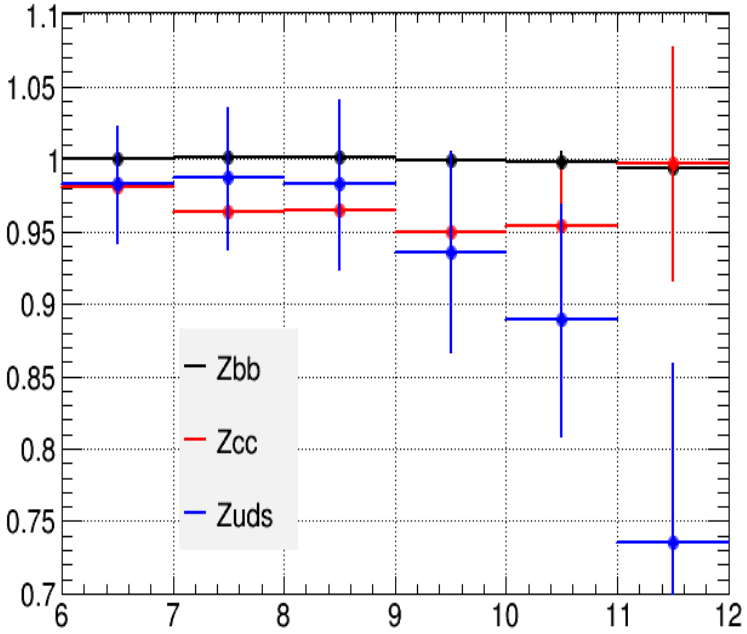
- Increase the statistics of ‘DATA’ and MC.
- Study the FSClasser: know well about the procedure at event reconstruction level.

Result

the measured Rb and effb in DATA are different from the Input Truth Rb and effb at Prob>0.9

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

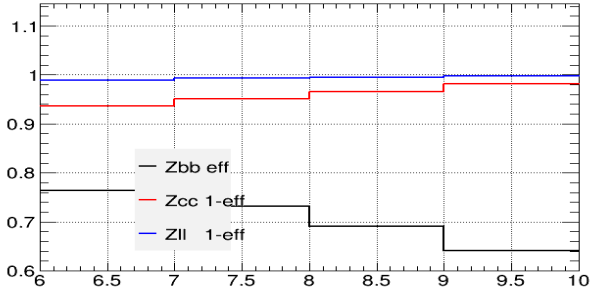
The difference as a Ratio: Eff in 'DATA'/ Eff in MC



1. ε_b difference between DATA and MC are very small

2. ε_c and ε_{uds} differences are big at Prob>0.9 :
   - which may come from the very low statistics after Btagging
   - which will lead to the difference in the IO test

3. ε_{uds} effect is very small, as **The Zll rejction at four work point are ~100%**



backup

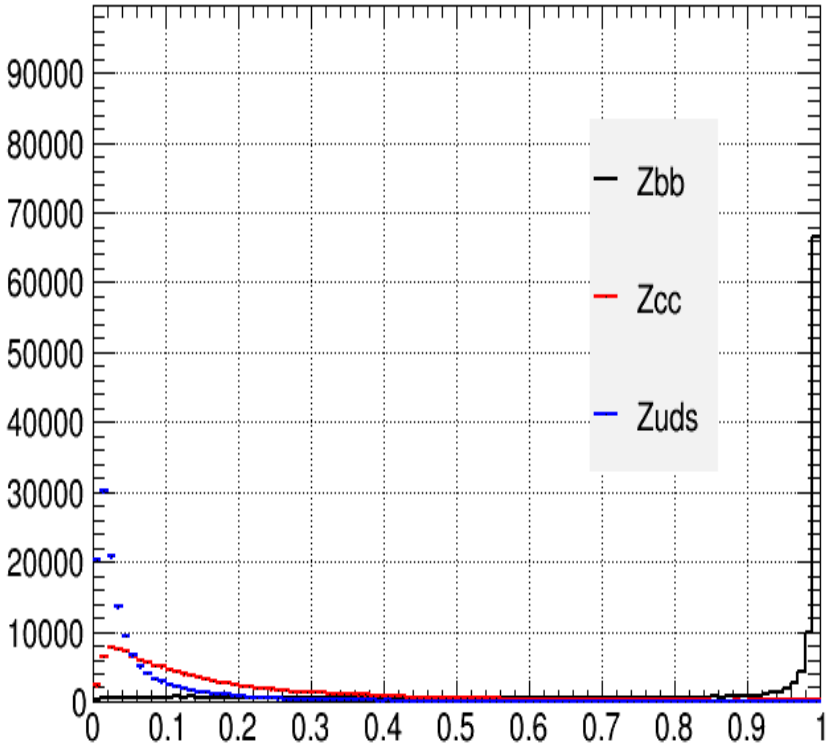
Outline

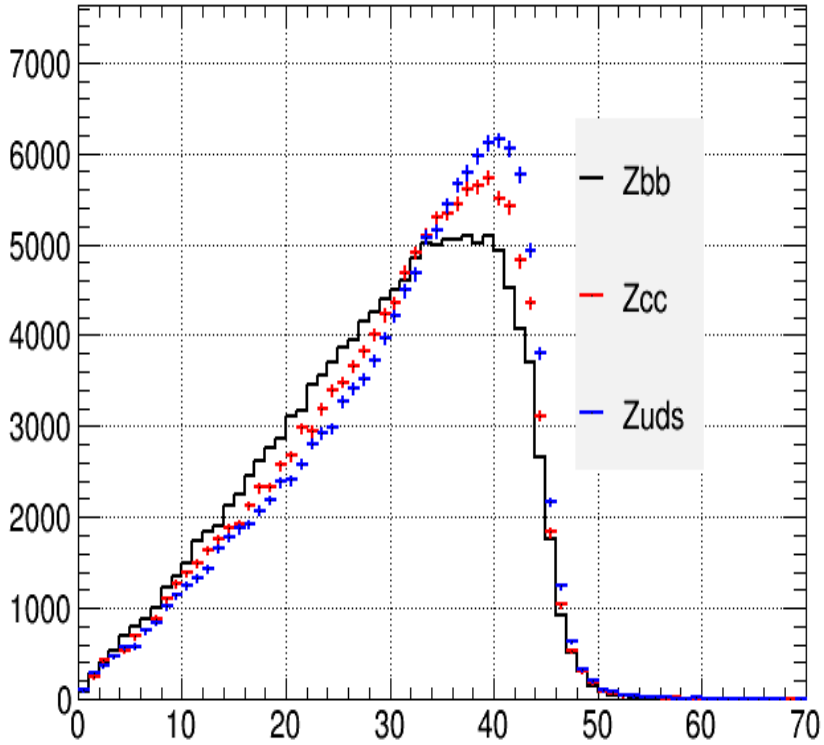
- Basic information
- Btag performance
- Method

Btagging performance

Variable in Zbb,Zcc,Zll

JetBtag Prob all the 2jets **JetPt**



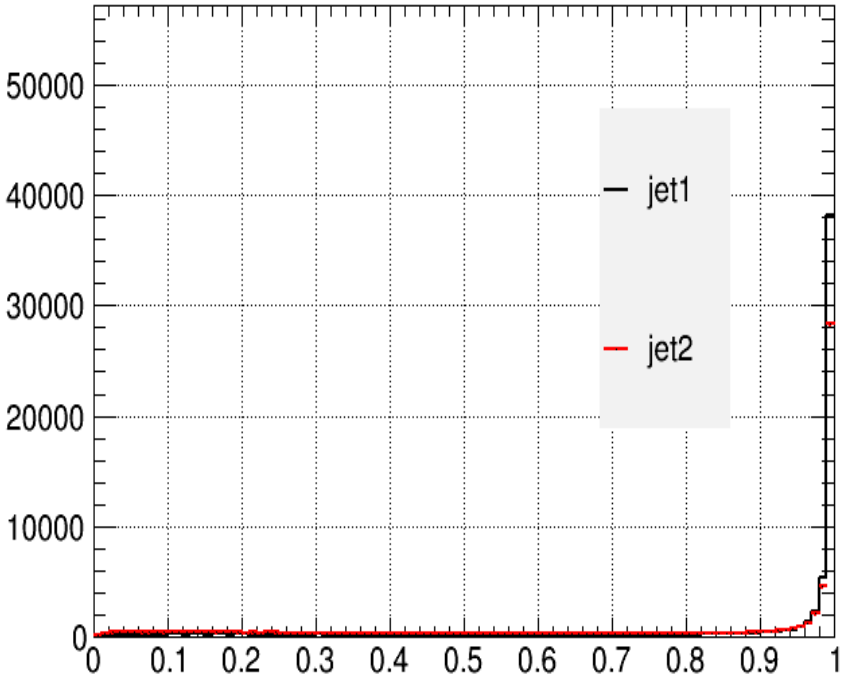


- The BtagProb are different for Zbb, Zcc and Zll
- Four BtagProb Work Point are used :
  - The BtagProb>0.6 , BtagProb>0.7, BtagProb>0.8, BtagProb>0.9

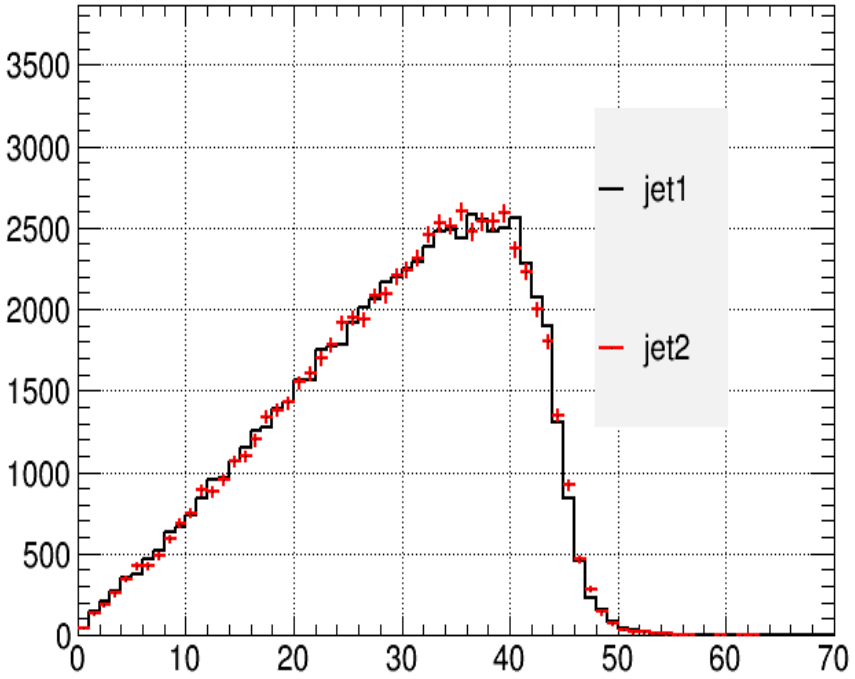
Btagging performance

Variable of jet1, jet2 in Zbb

JetBtag Prob



JetPt

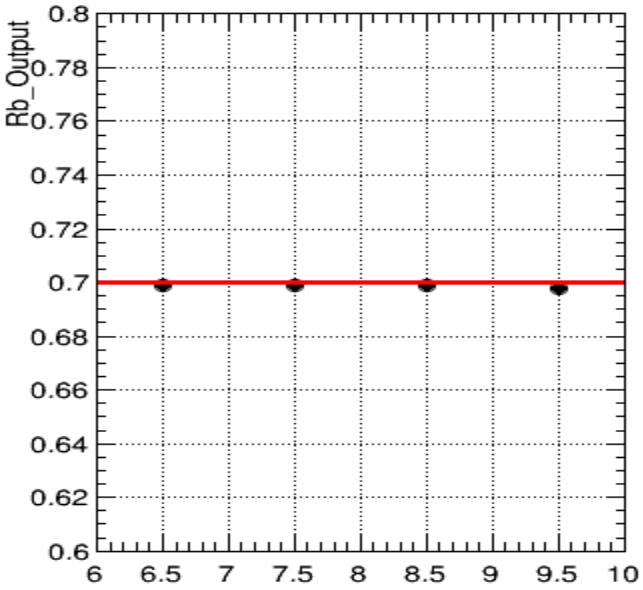


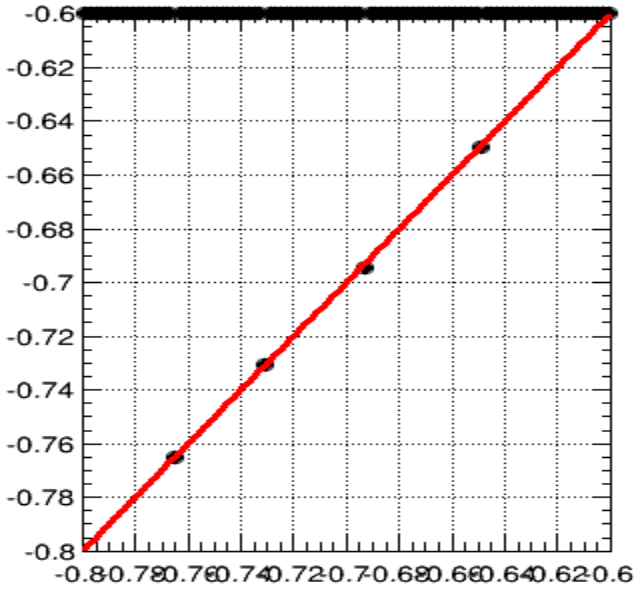
Jet1 vs jet2

Btagging performance

IO test

Input Rb=0.7, Four BtagProb work point: Prob>0.6, >0.7, >0.8, >0.9





Input Rb:	0.7000			
Output Rb:	0.6988	0.6988	0.6991	0.6979
Input eff:	0.7643	0.7300	0.6936	0.6480
Output eff:	0.7652	0.7308	0.6942	0.6498

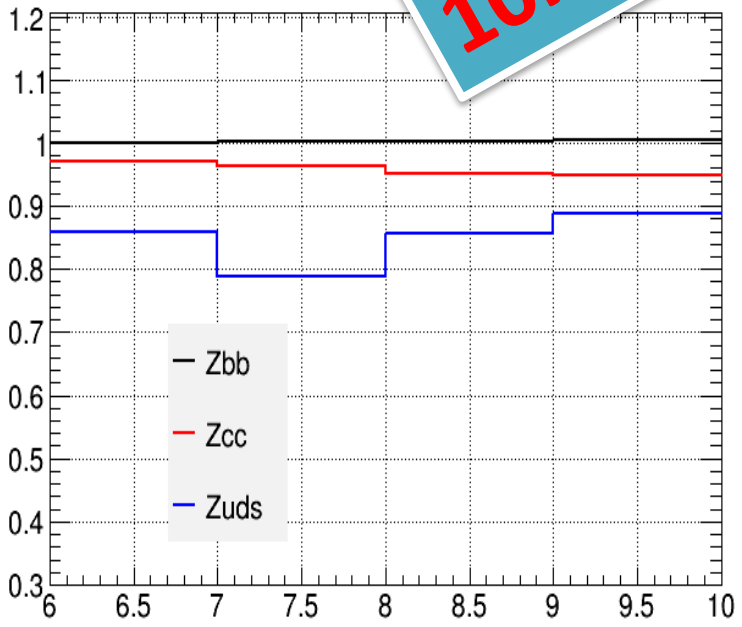
Result

We can see the measured Rb and effb in DATA are different… …t Truth Rb and effb

The R_c, ε_c, C_b, C_c, C_{uds} is got by MC sample… …2, Zcc sample2, Zllsample2
So if **sample1≠** sample2, which means the M… …b, C_c, C_{uds} is different from the 'DATA'

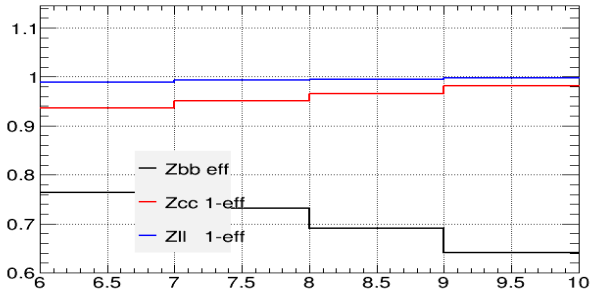
10k events in the past

The difference as a Ratio: Eff in 'D… MC



ε_b difference between DATA and MC are very small

2. ε_c and ε_{uds} difference are very big:
   - which may come from the very low statistics after Btagging
   - which will lead to the difference in the IO test
3. ε_{uds} effect is very small, as **The Zll rejction at four work point are ~100%**

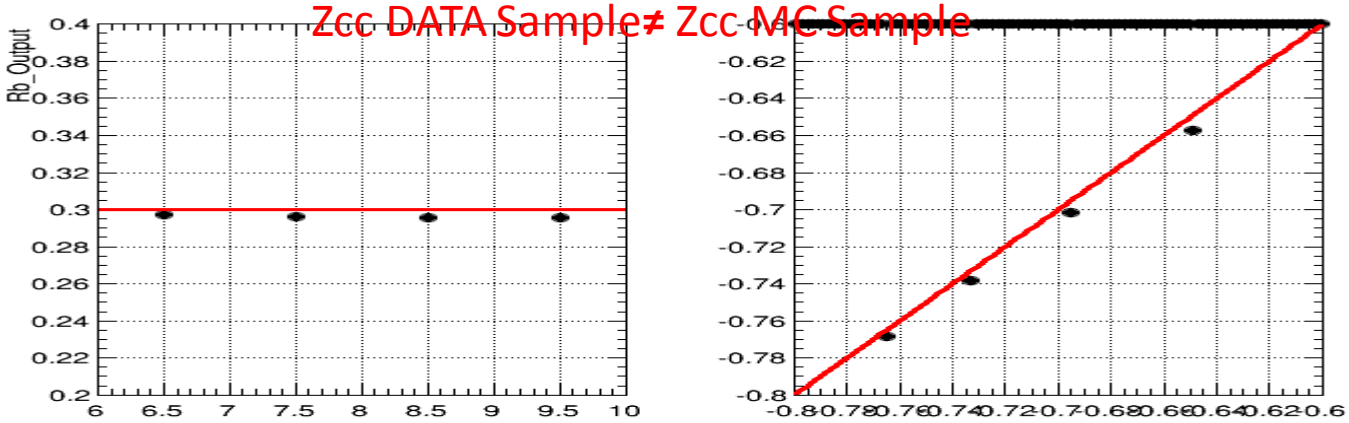


Check

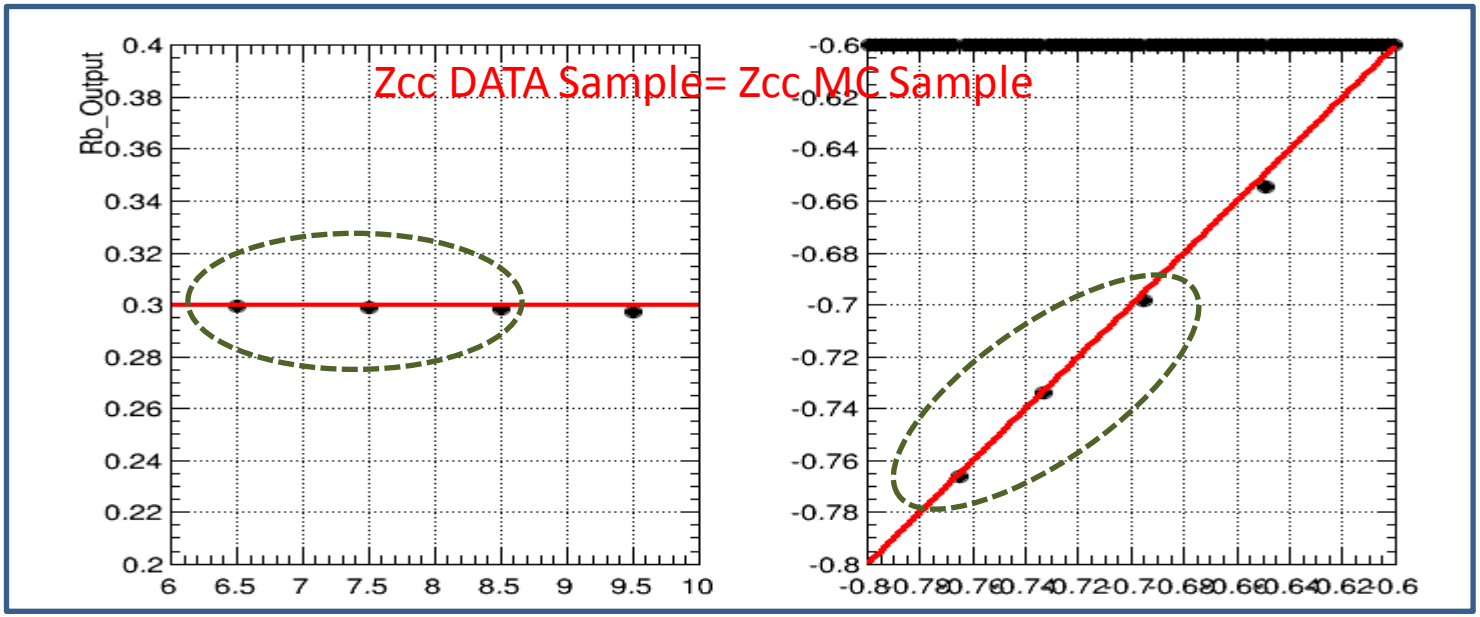
Input Rb=0.3

We redo the IO test by 'DATA' and MC with same Zcc sample

Zcc DATA Sample≠ Zcc MC Sample



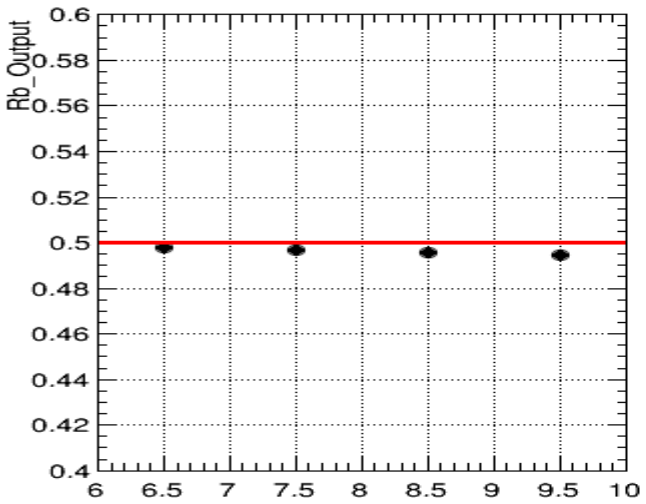
Zcc DATA Sample= Zcc MC Sample

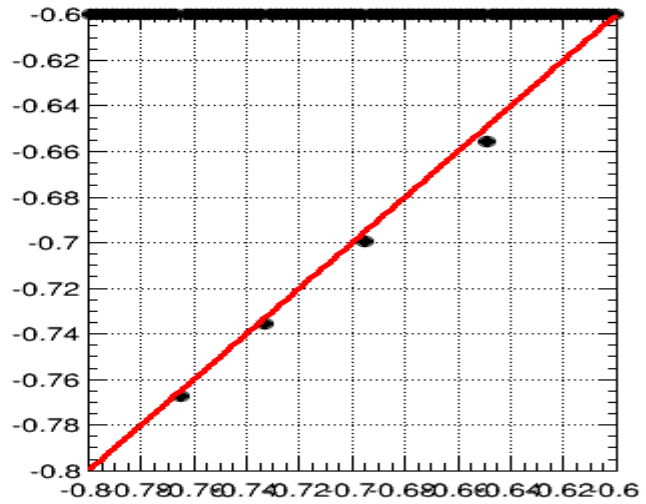


We can see the differences of measured Rb and effb between DATA and MC are smaller

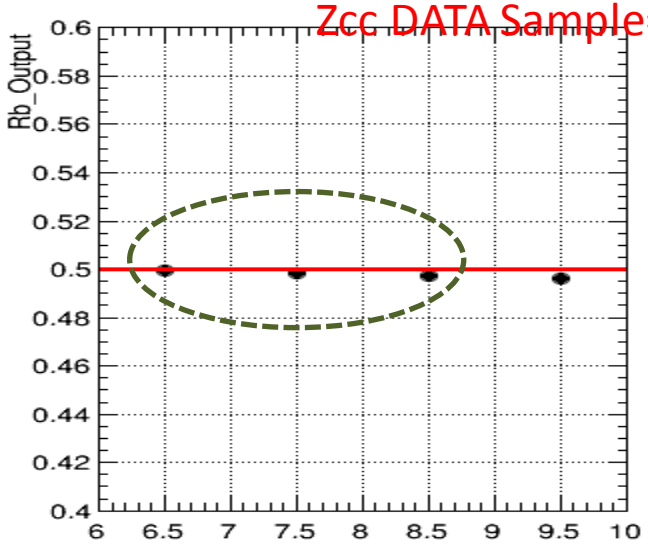
Check

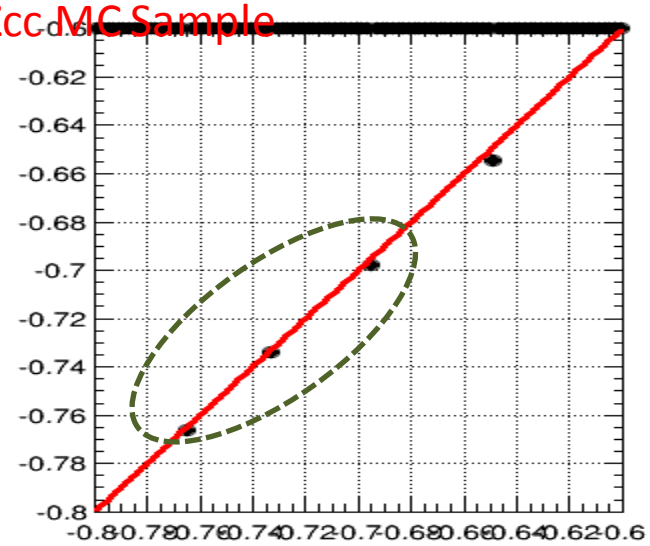
Input Rb=0.5





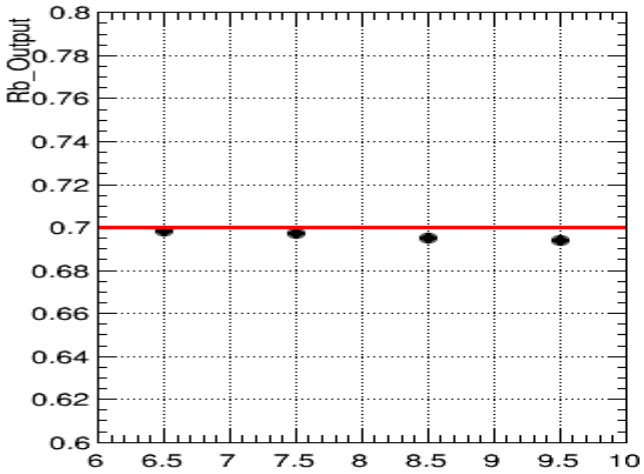
Zcc DATA Sample= Zcc MC Sample

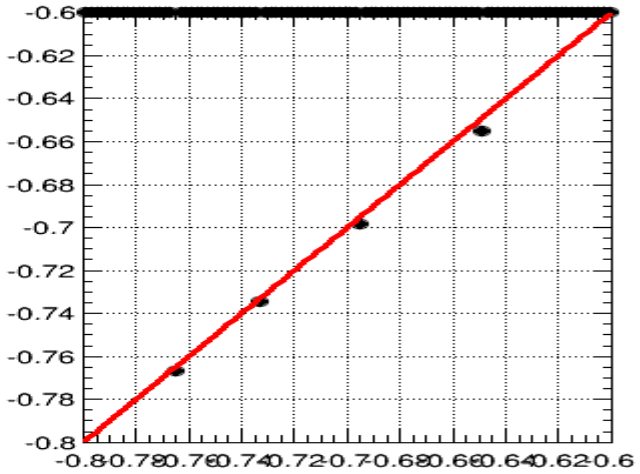




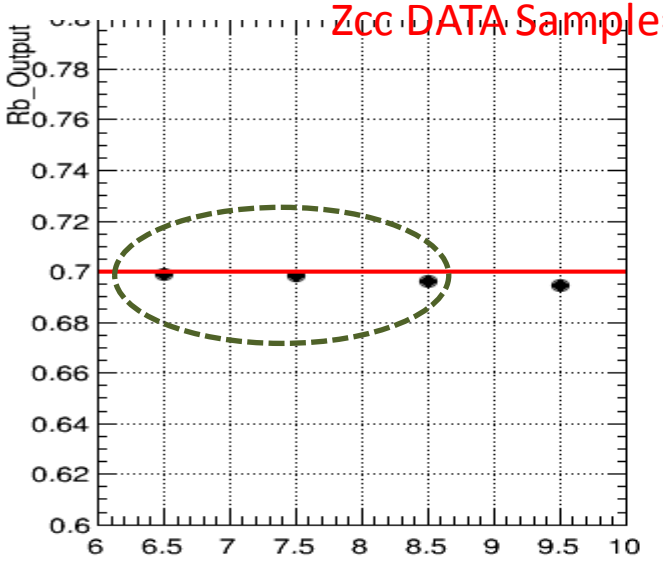
Check

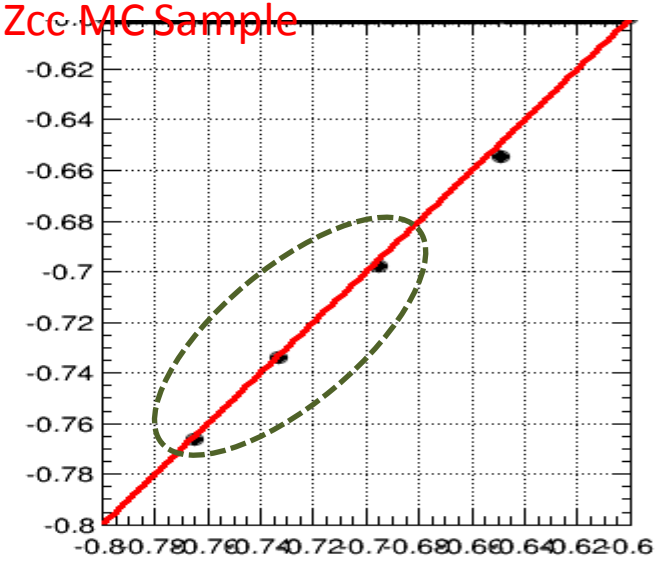
Input Rb=0.7





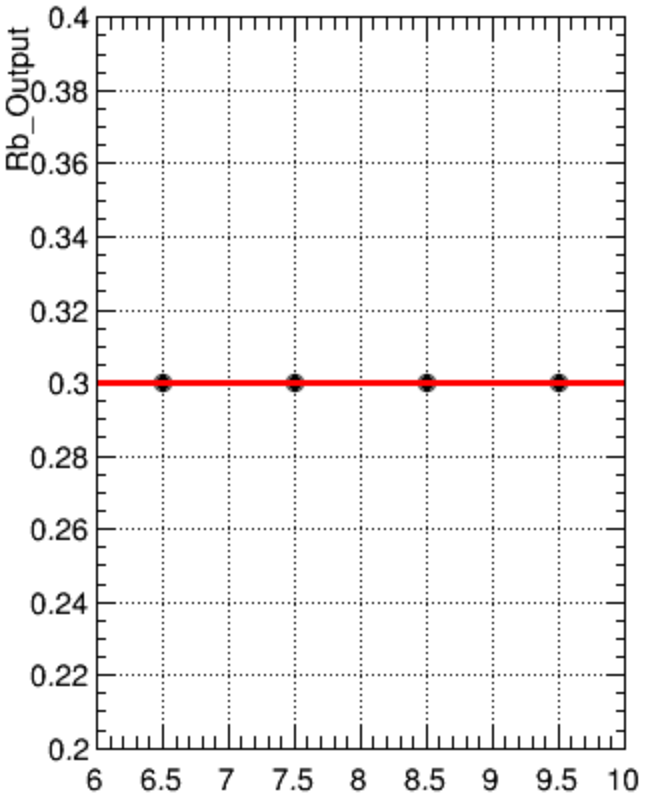
Zcc DATA Sample= Zcc MC Sample

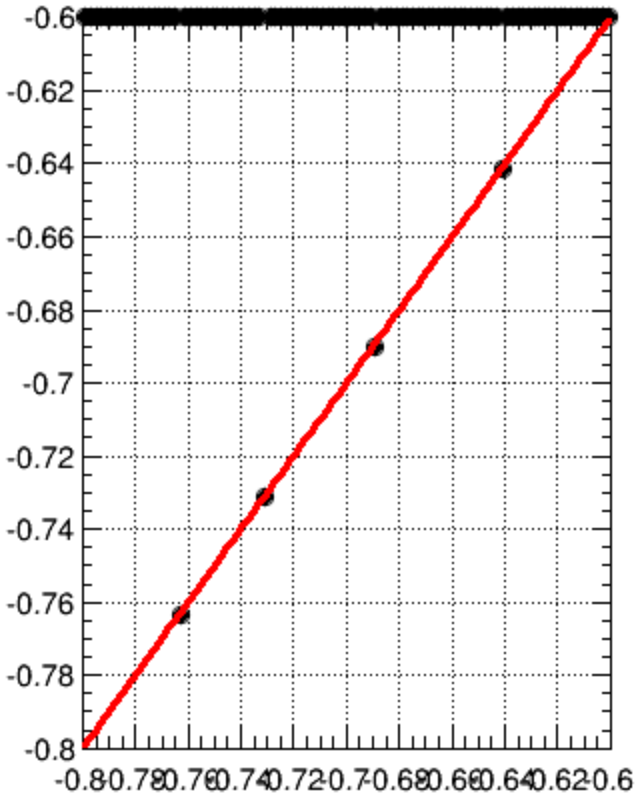


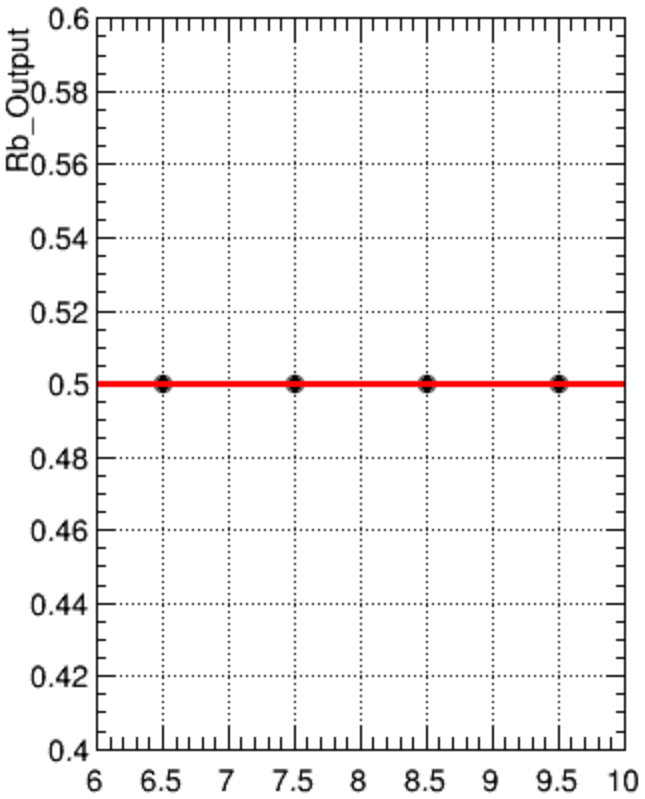


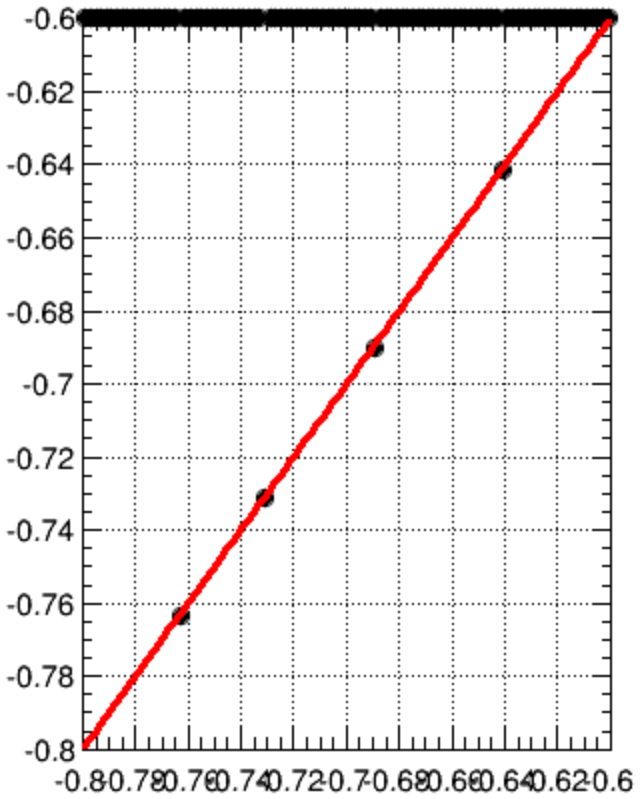
backup

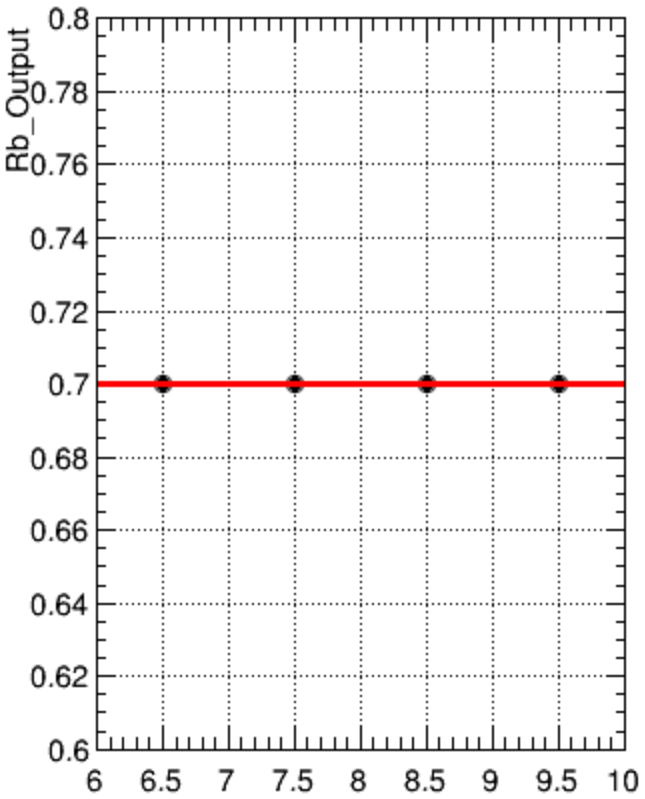
'DATA' and MC all are used the same sample

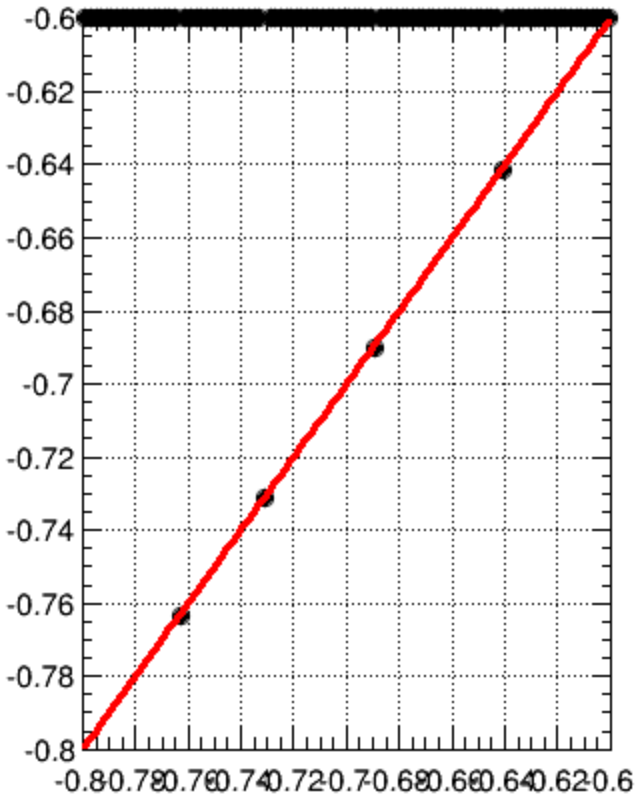





Rb_Output
0.6
0.58
0.56
0.54
0.52
0.5
0.48
0.46
0.44
0.42
0.4
6
6.5
7
7.5
8
8.5
9
9.5
10


-0.6
-0.62
-0.64
-0.66
-0.68
-0.7
-0.72
-0.74
-0.76
-0.78
-0.8
-0.8
-0.78
-0.76
-0.74
-0.72
-0.7
-0.68
-0.66
-0.64
-0.62
-0.6


Rb_Output
0.8
0.78
0.76
0.74
0.72
0.7
0.68
0.66
0.64
0.62
0.6
6
6.5
7
7.5
8
8.5
9
9.5
10


-0.6
-0.62
-0.64
-0.66
-0.68
-0.7
-0.72
-0.74
-0.76
-0.78
-0.8
-0.8
-0.78
-0.76
-0.74
-0.72
-0.7
-0.68
-0.66
-0.64
-0.62
-0.6