Rb measurement at CEPC MC Level

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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;
```

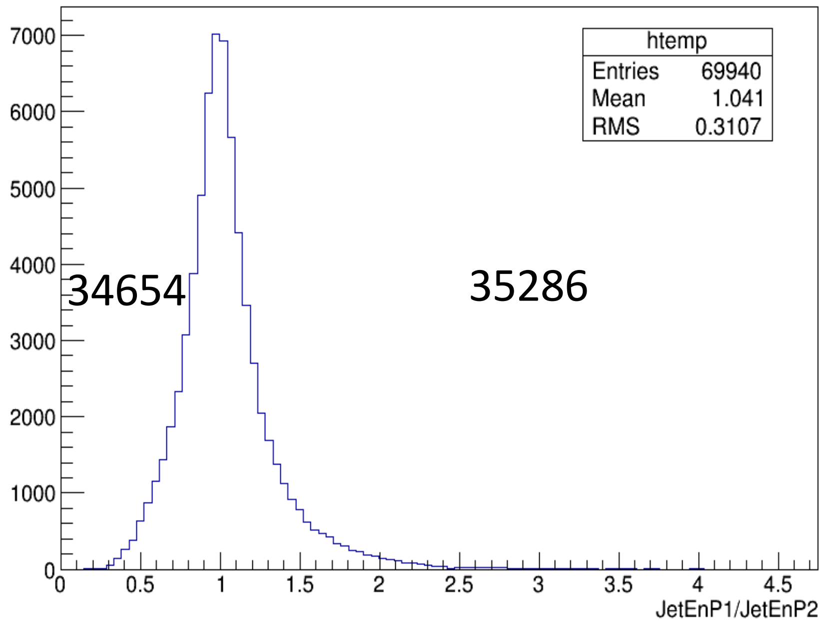
Including the final particle information: Such as the lepton Pt, jet Pt, jet tag prob ..

~140,000 events are produced

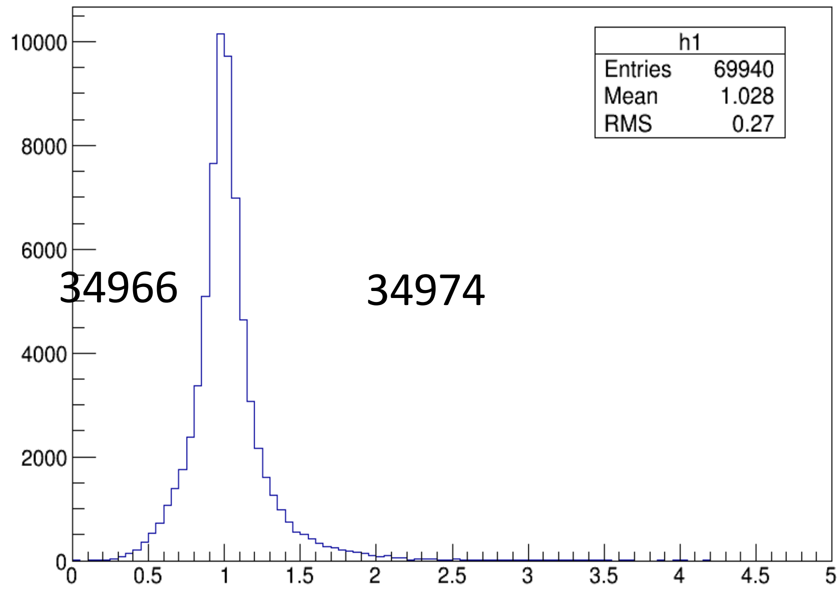
Outline

- Jet1/jet2

Jet Energy



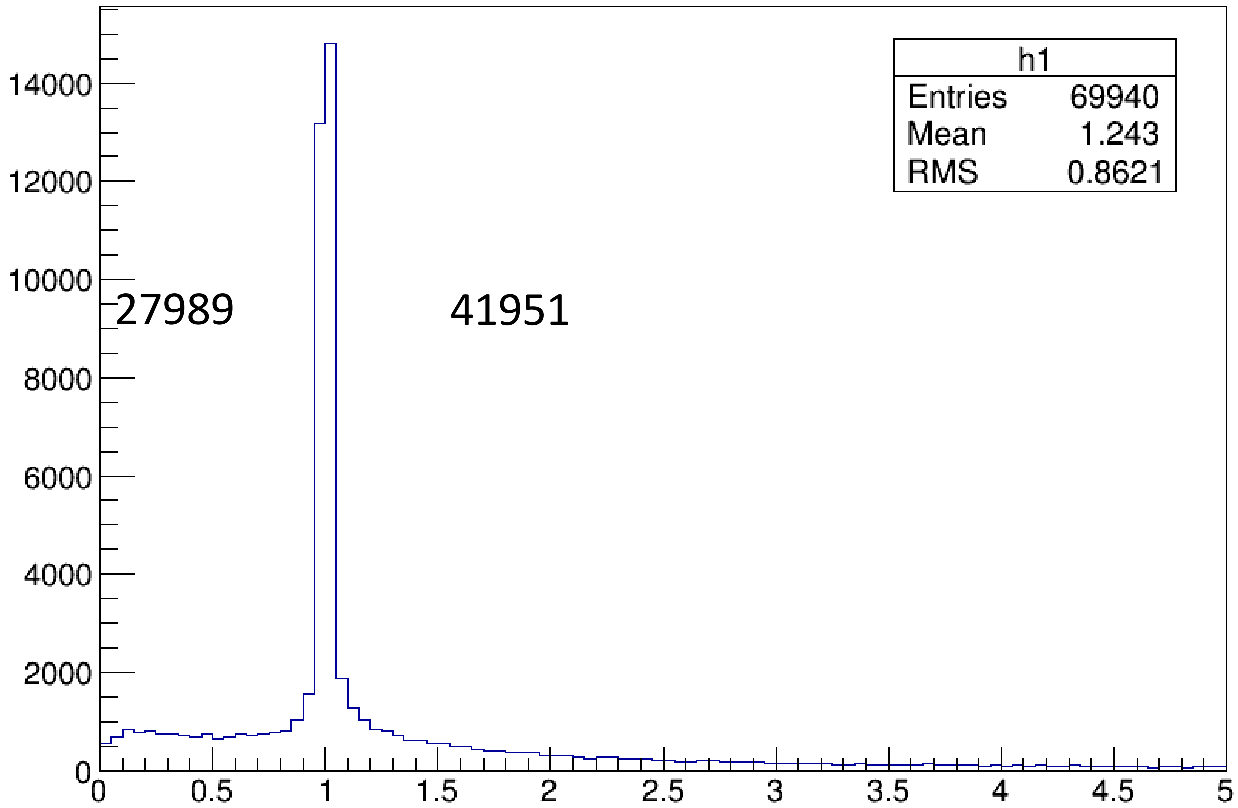
Jet Pt



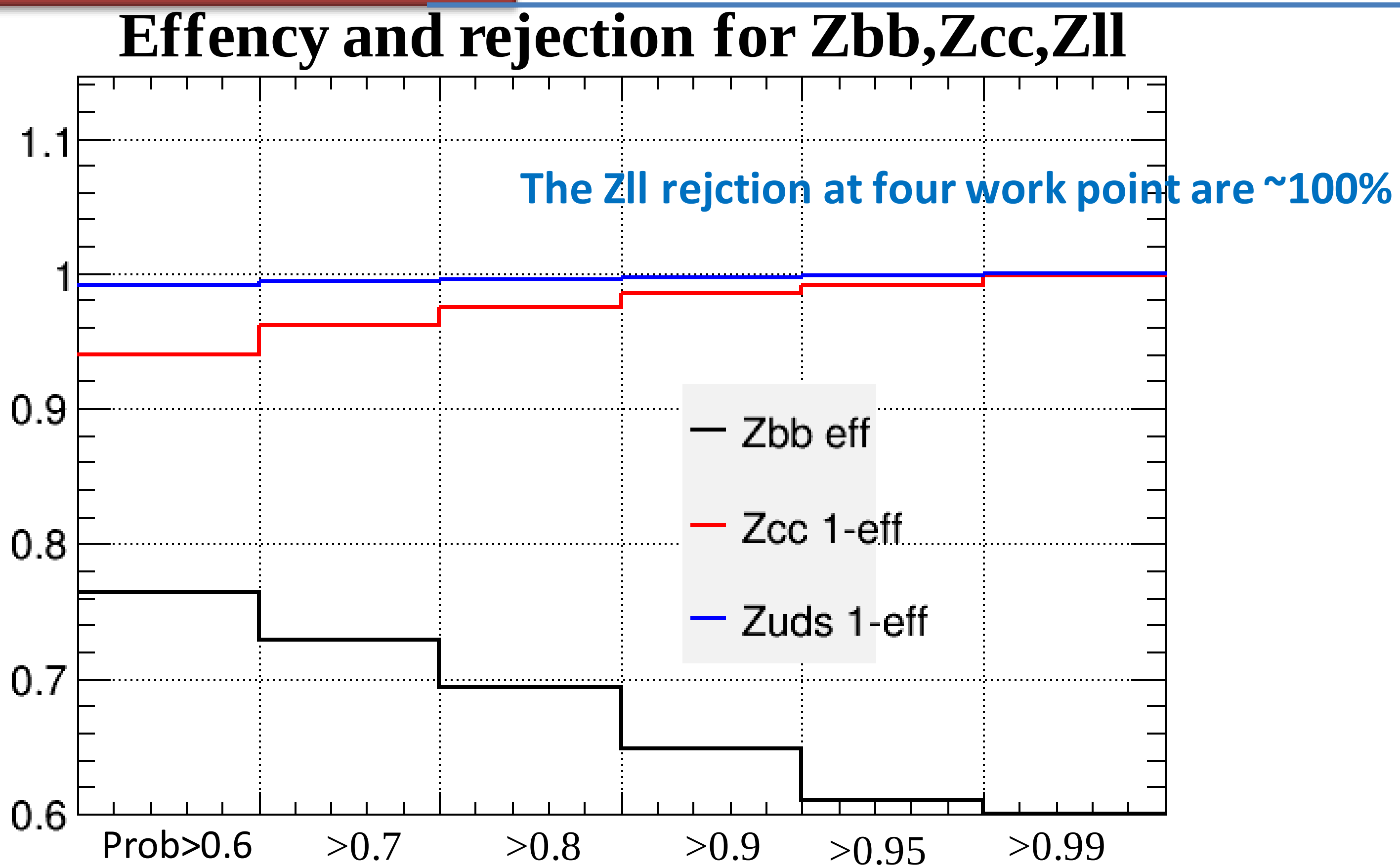
Outline

- Jet1/jet2

Jet BtagProb



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

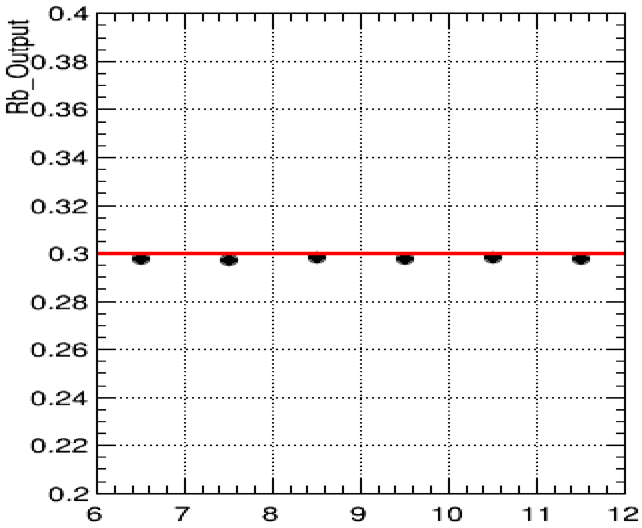
The Z hadronic '**DATA**' is mixed by MC samples: Zbb **sample1**, Zcc **sample1**, Zll sample1
We set Rb=0.3, Rb=0.5, Rb=0.7 as the Input Rb to mix the 'DATA'

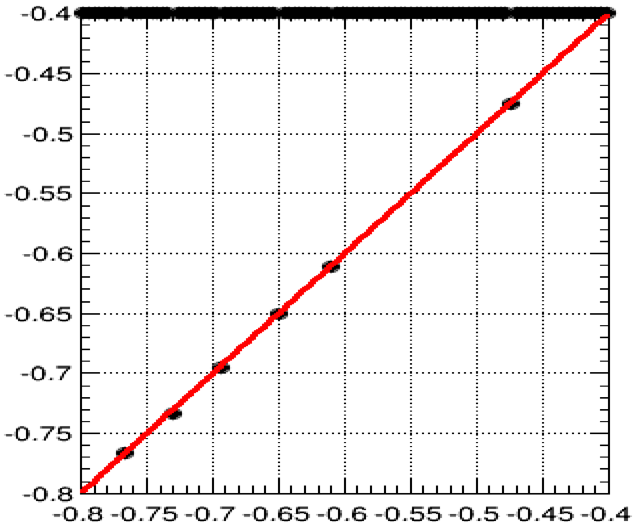
The R_c, ε_c, C_b, C_c, C_{uds} is gotten by MC samples: Zbb sample2, Zcc sample2, Zllsample2
So if **sample1≠** sample2, which means the MC R_c, ε_c, C_b, C_c, C_{uds} are different from the Truth in 'DATA'

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

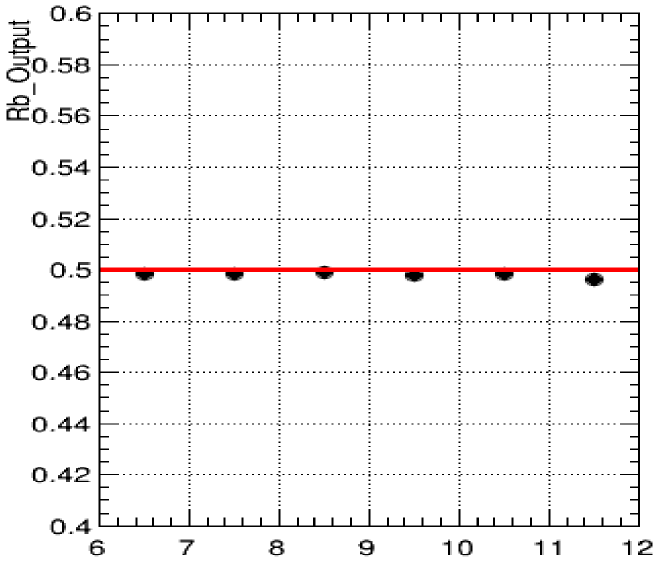
Input eff: 0.7643   0.7300 0.6936 0.6480 0.6087 0.4721

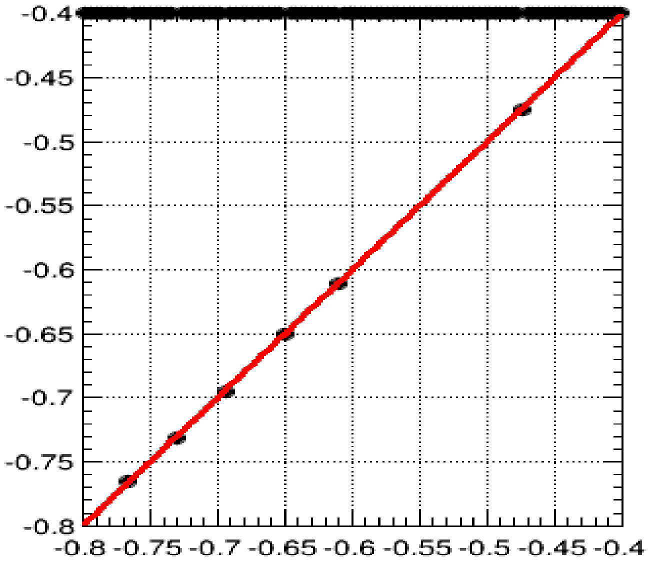
Output eff: 0.7668   0.7333 0.6956 0.6508 0.6109 0.4756

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

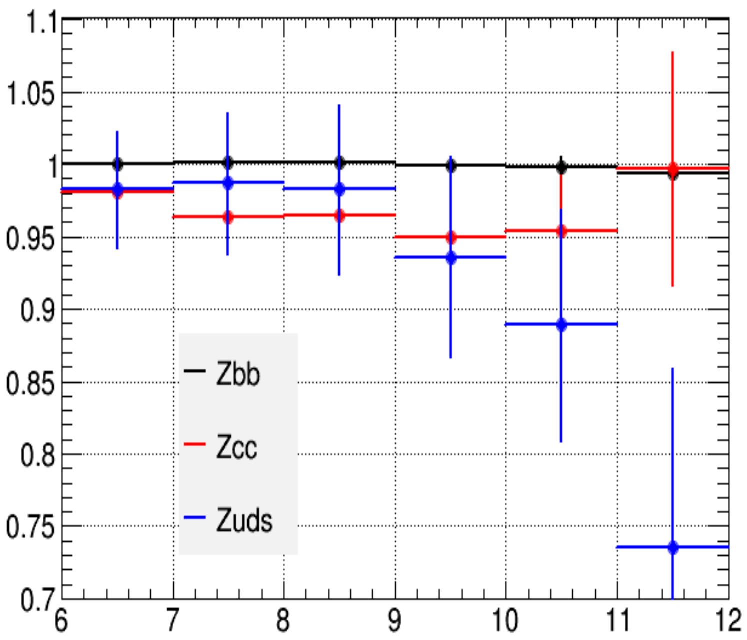
Output eff: 0.7657 0.7316 0.6946 0.6501 0.6105 0.4756

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'

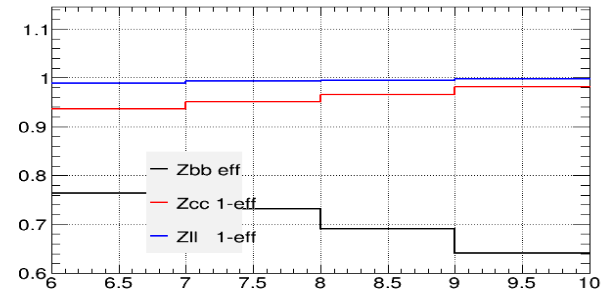
The difference as a Ratio: Eff in 'DATA'/ Eff in MC



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%**



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.

backup

Outline

- Basic information
- Btag performance
- Method

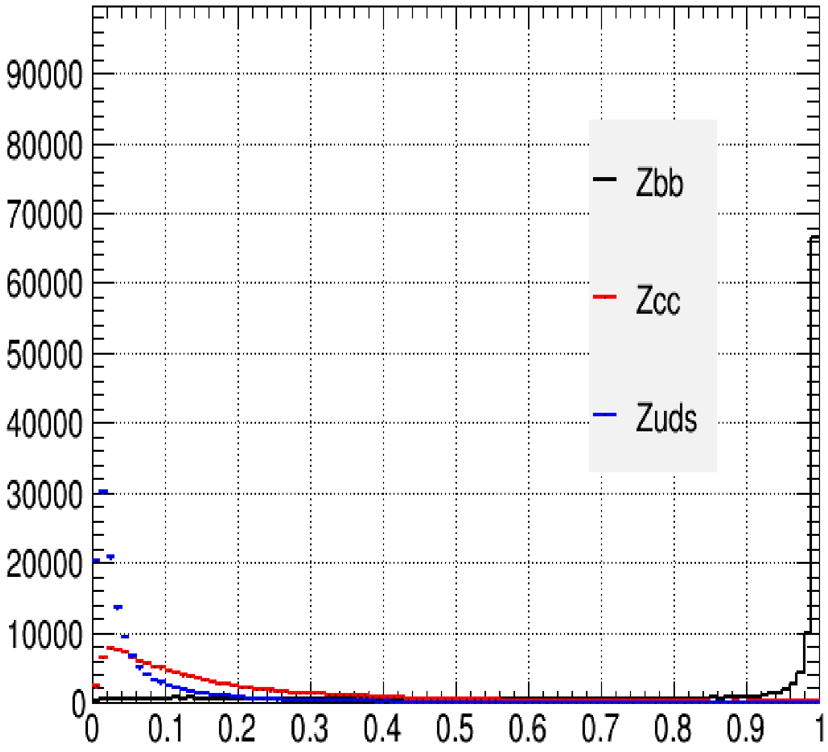
Btagging performance

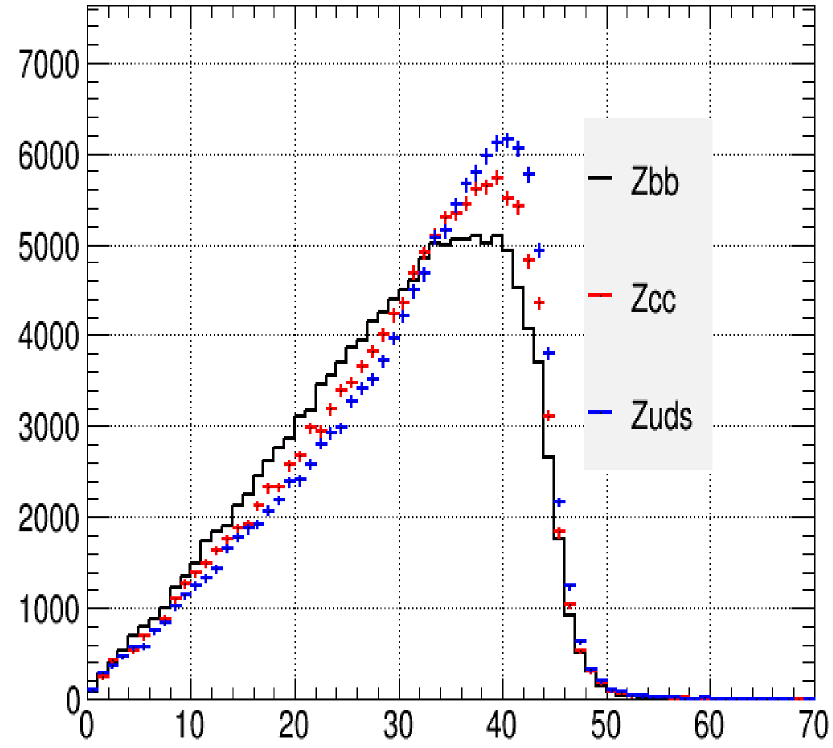
Variable in Zbb,Zcc,Zll

JetBtag Prob

all the 2jets

JetPt



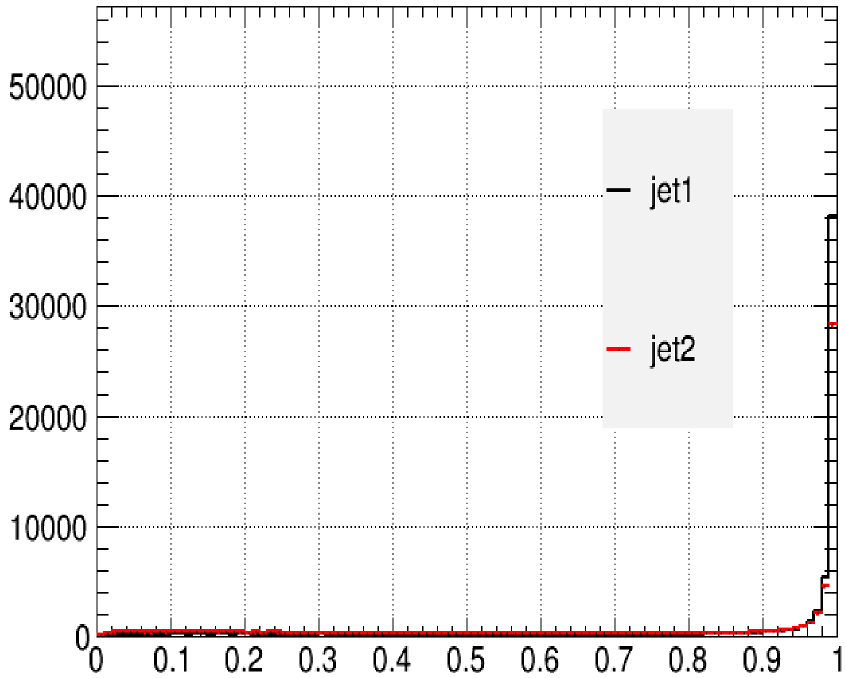


- The BtagProb are different for Zbb, Zcc and Zll
- Four BtagProb Work Point are used :
  - The BtagProb>0.6 , BtagProb>0.7, BtagProb>0.8, BtagProb>0.9

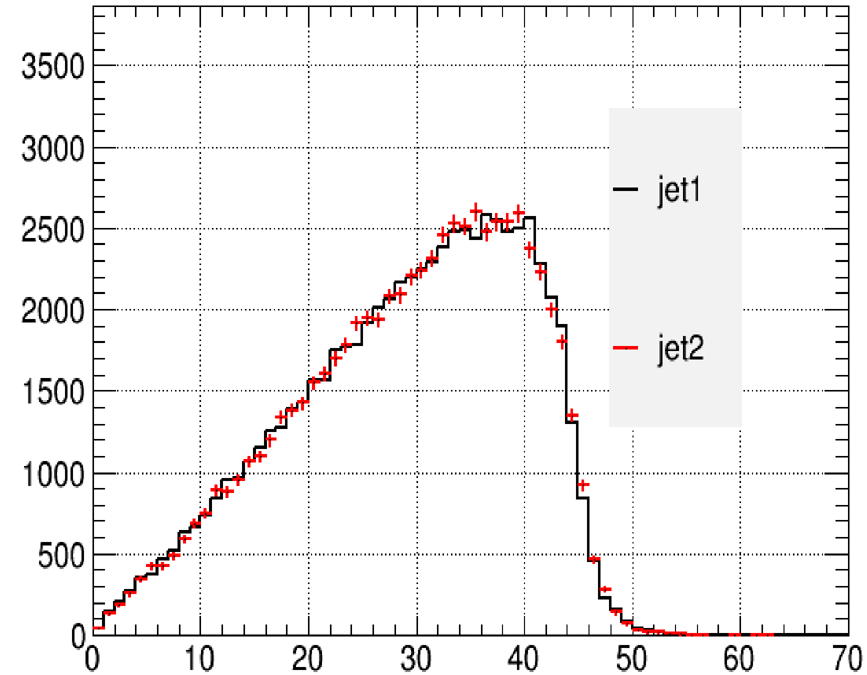
Btagging performance

Variable of jet1, jet2 in Zbb

JetBtag Prob



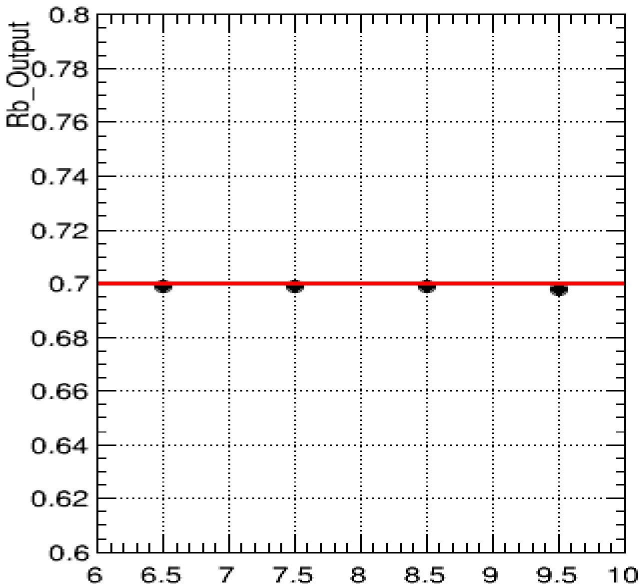
JetPt

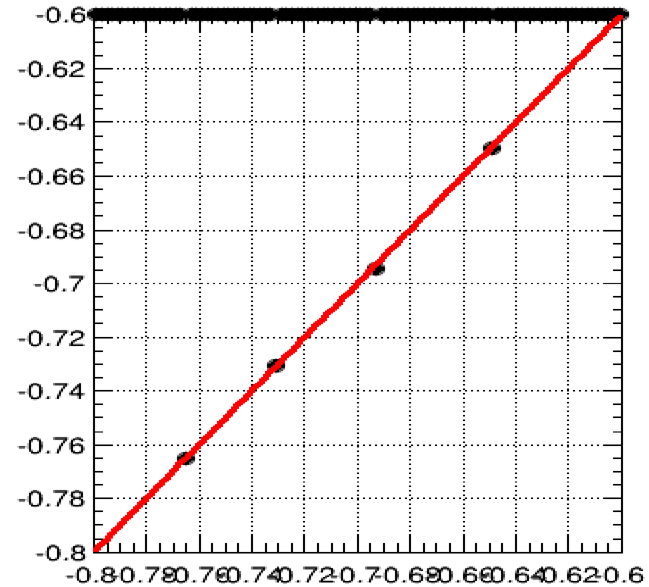


Jet1 vs jet2

Btagging performance

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

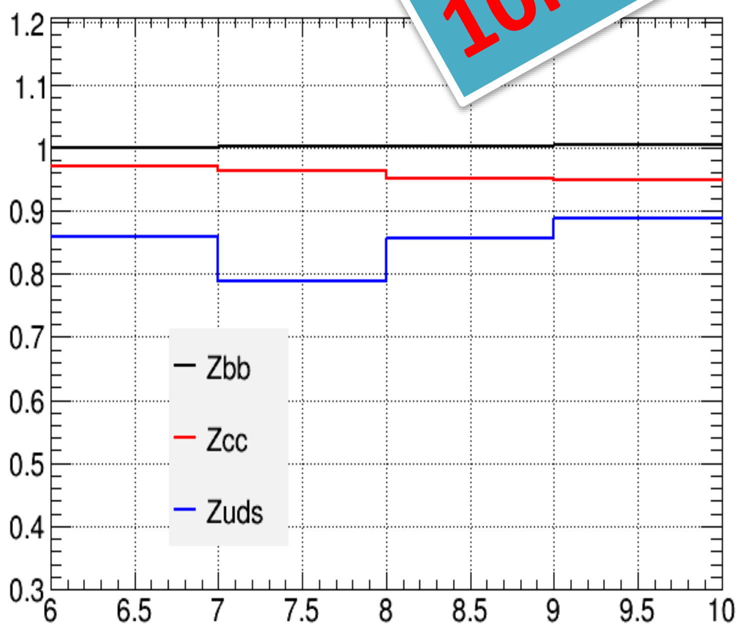
Result

We can see the measured Rb and effb in DATA are differen[…] […]t Truth Rb and effb

The R_c, ε_c, C_b, C_c, C_{uds} is got by MC sampl[…] […]e2, Zcc sample2, Zllsample2
So if **sample1≠** sample2, which means the M[…] […]$_b$, C_c, C_{uds} is different from the 'DATA'

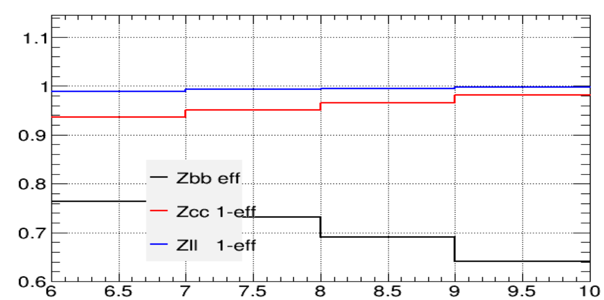
10k events in the past

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



[…] ε_b difference between DATA and MC are very small

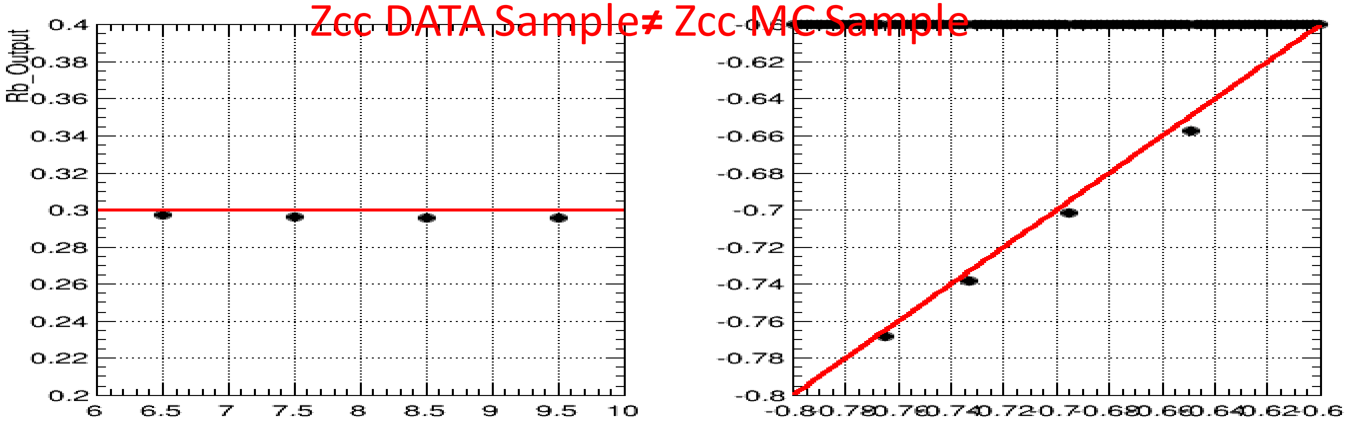
2. ε_c and ε_{uds} difference are very big:
   - which may come from the very low statistics after Btagging
   - which will lead to the difference in the IO test
3. ε_{uds} effect is very small, as **The Zll rejction at four work point are ~100%**

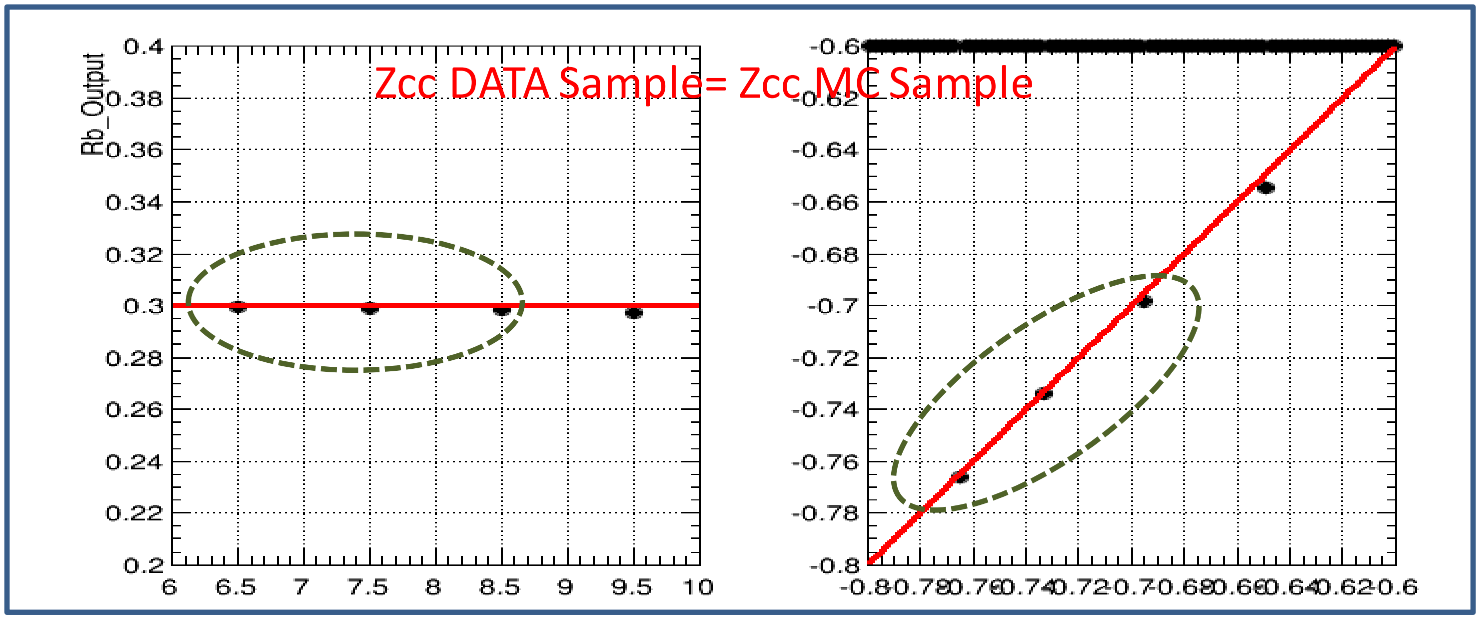


Check

Input Rb=0.3

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

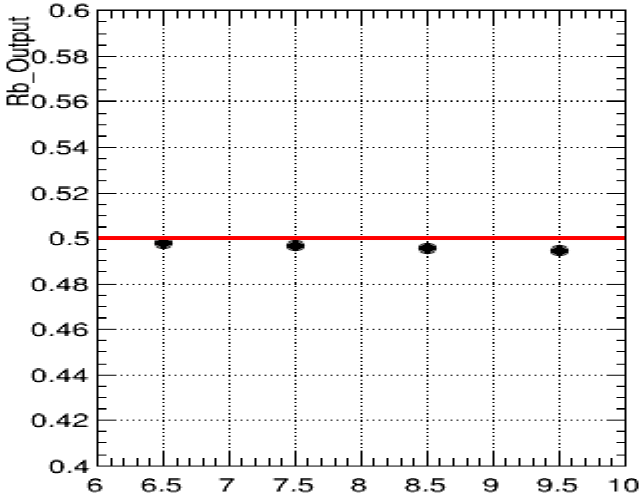


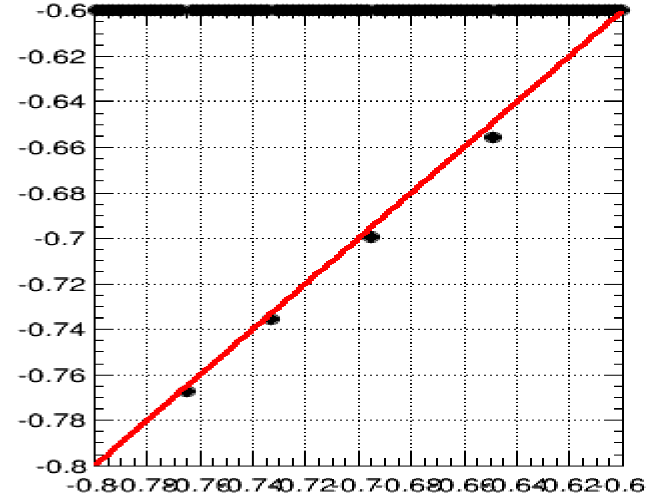


We can see the differences of measured Rb and effb between DATA and MC are smaller

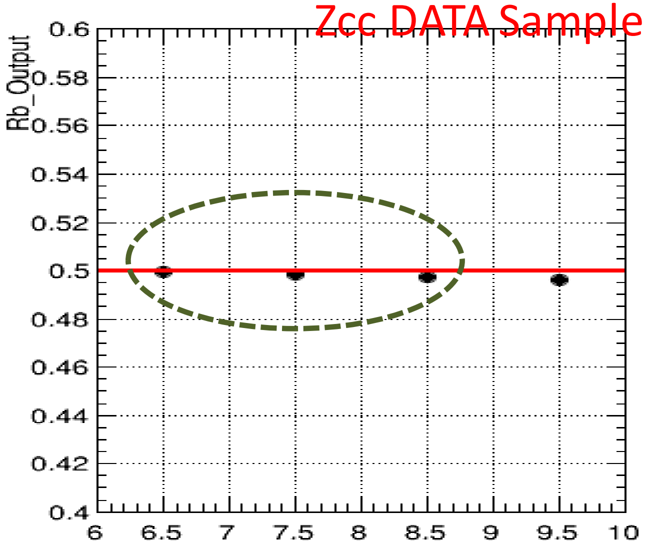
Check

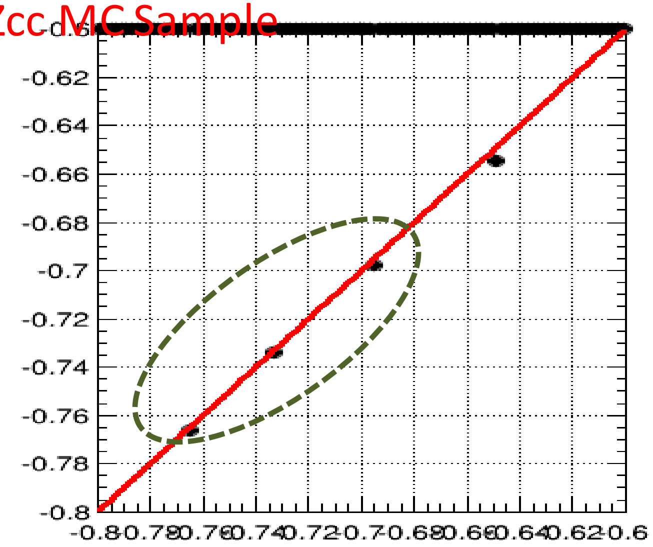
Input Rb=0.5





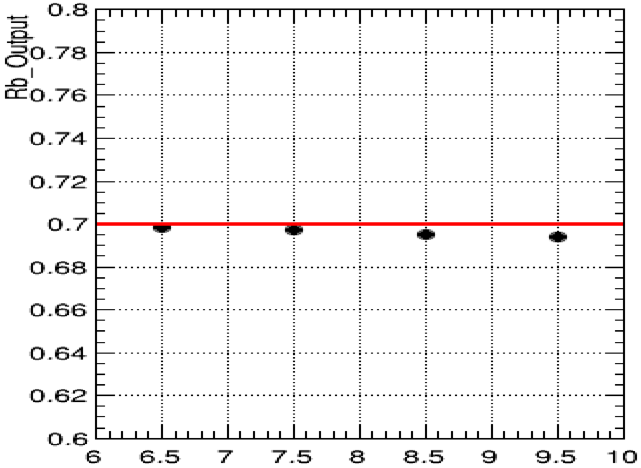
Zcc DATA Sample= Zcc MC Sample

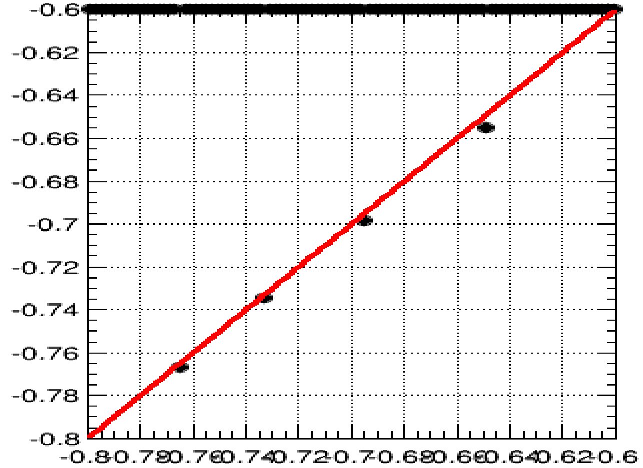




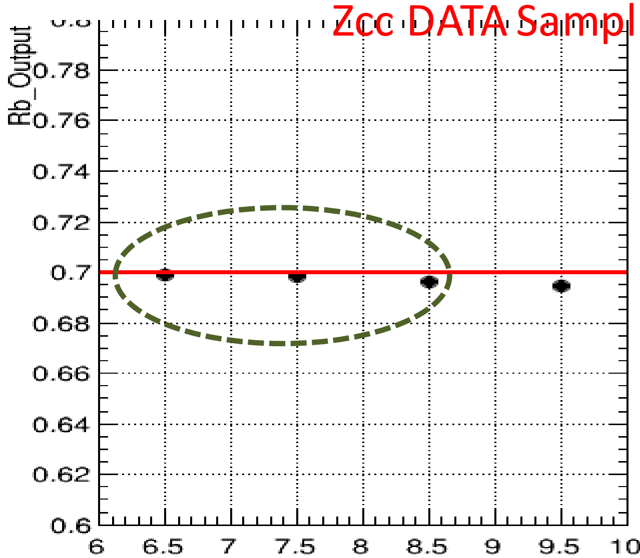
Check

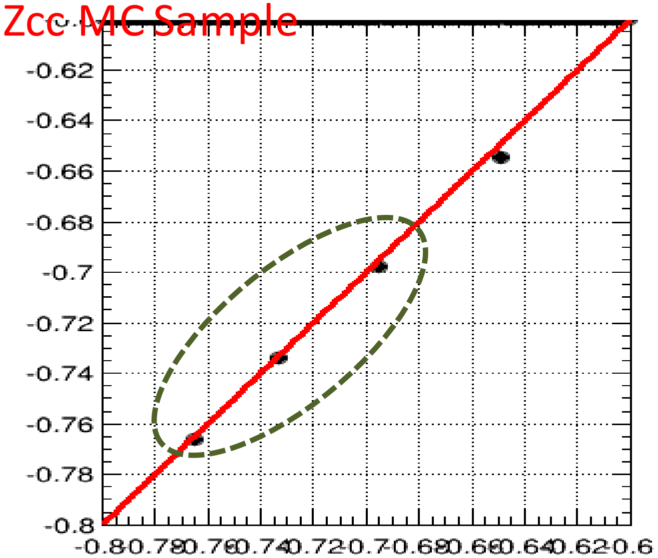
Input Rb=0.7





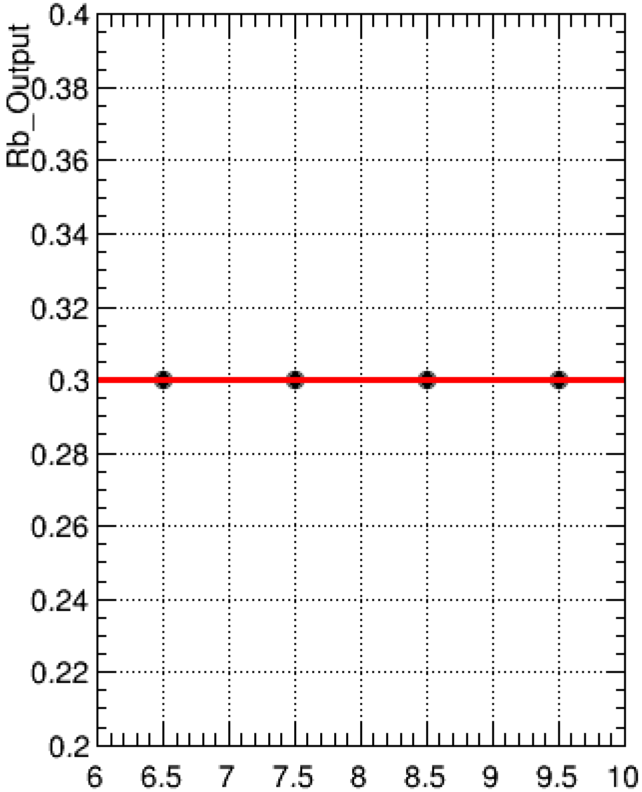
Zcc DATA Sample= Zcc MC Sample

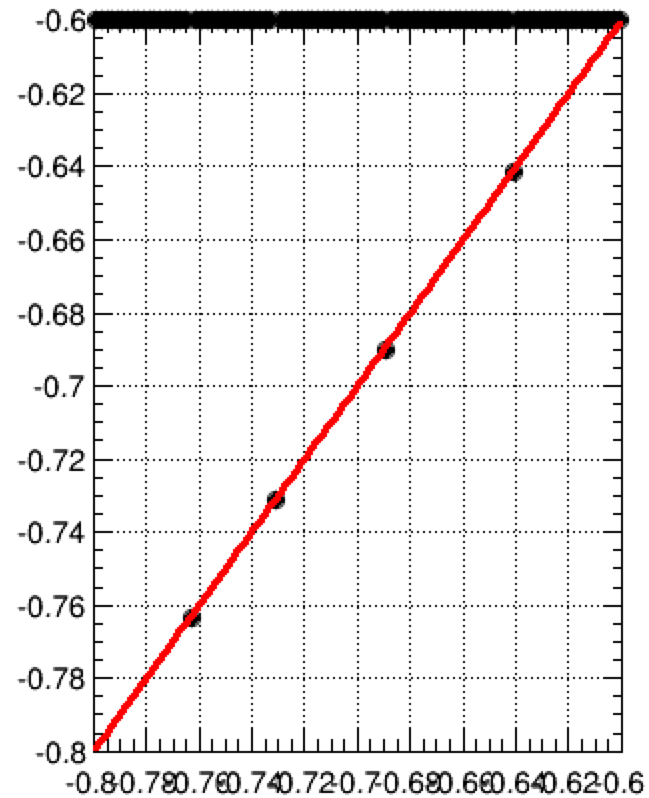


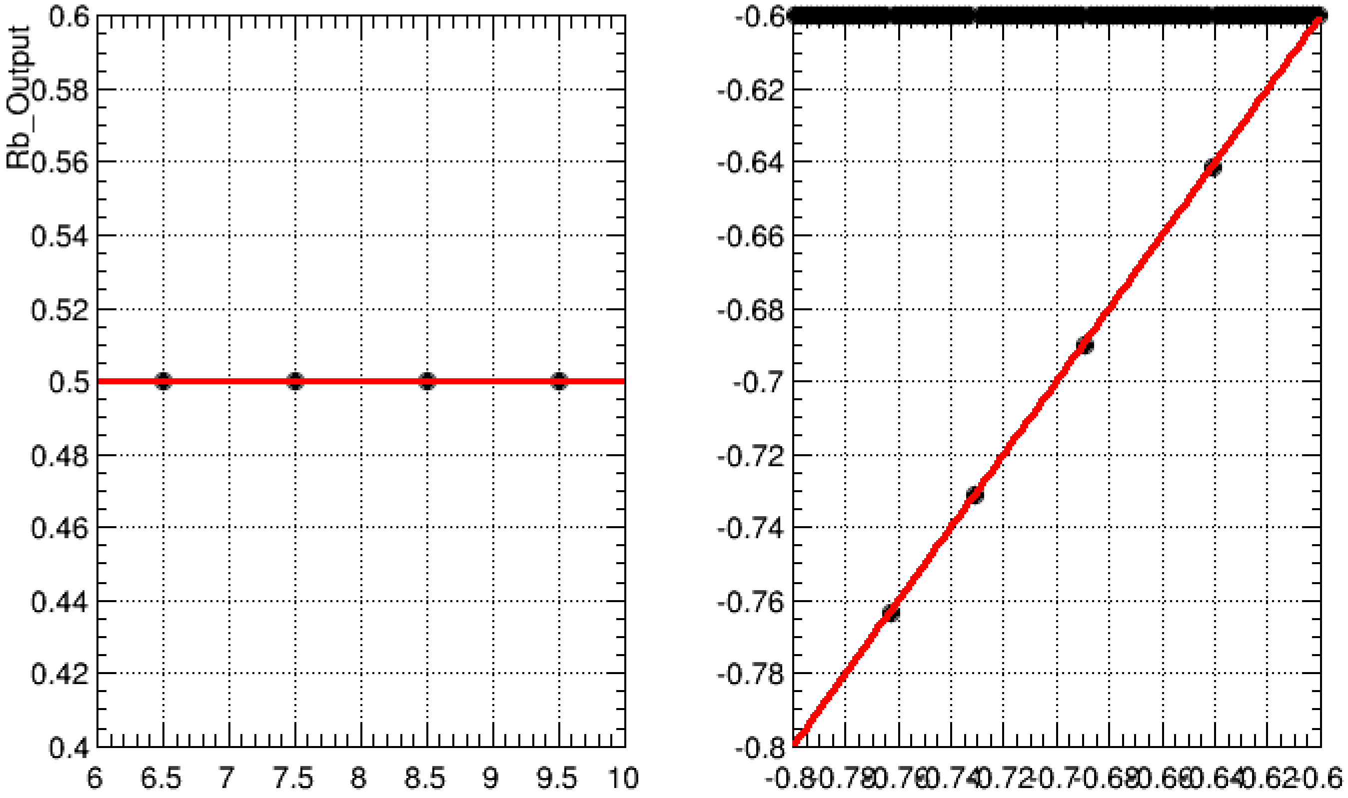


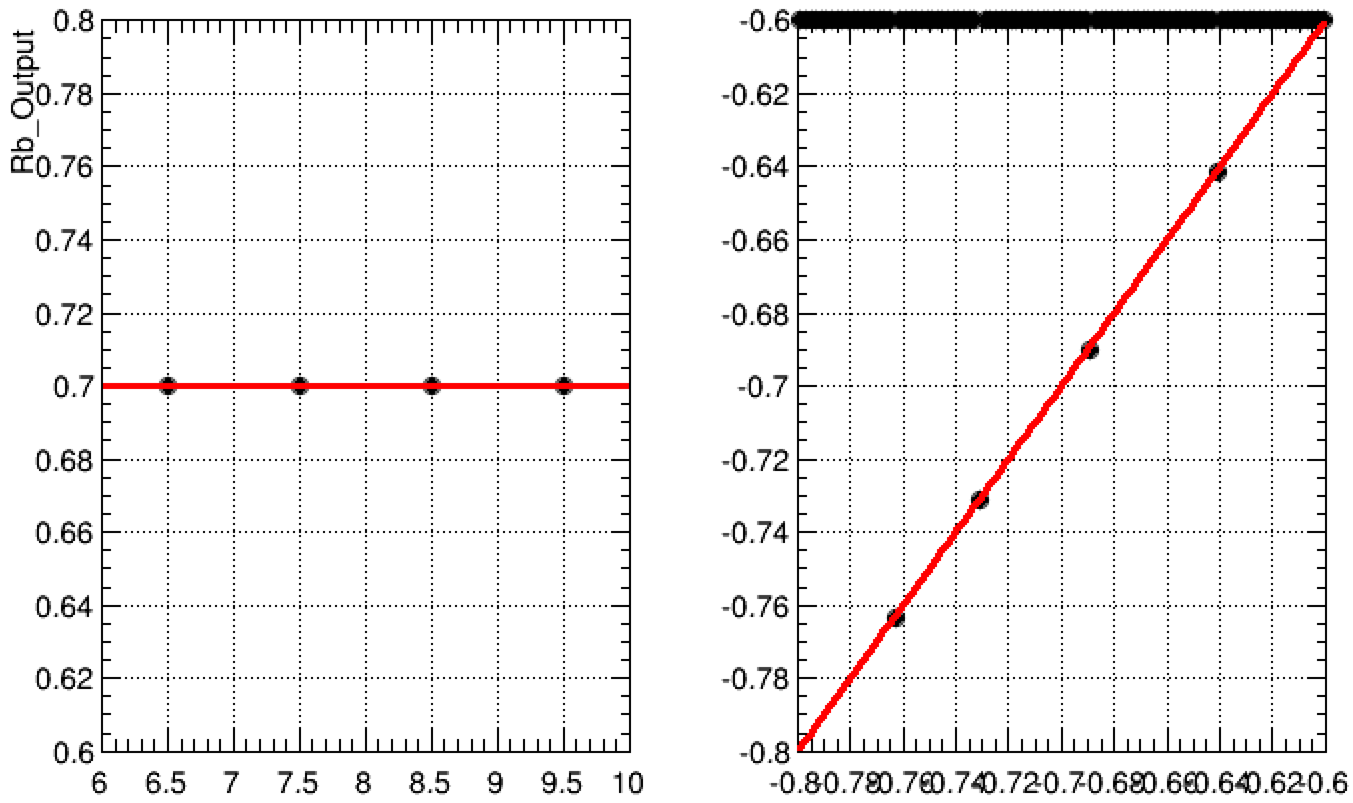
backup

'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


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