Rb measurement at CEPC MC Level

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Outline

- Basic information
- Btag performance
- Method

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;
```

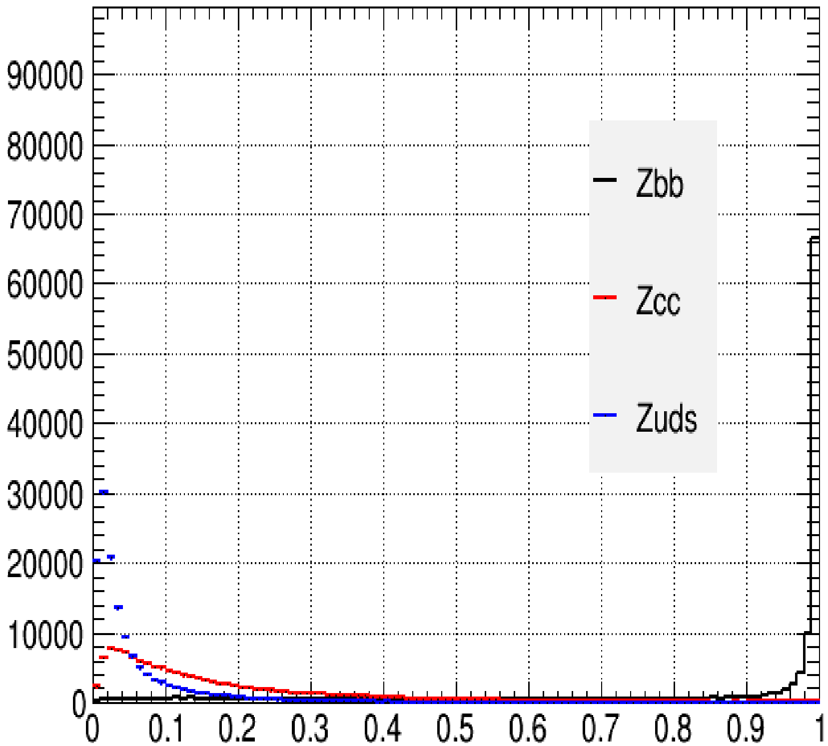
Including the final particle information: Such as the lepton Pt, jet Pt, jet tag prob ..

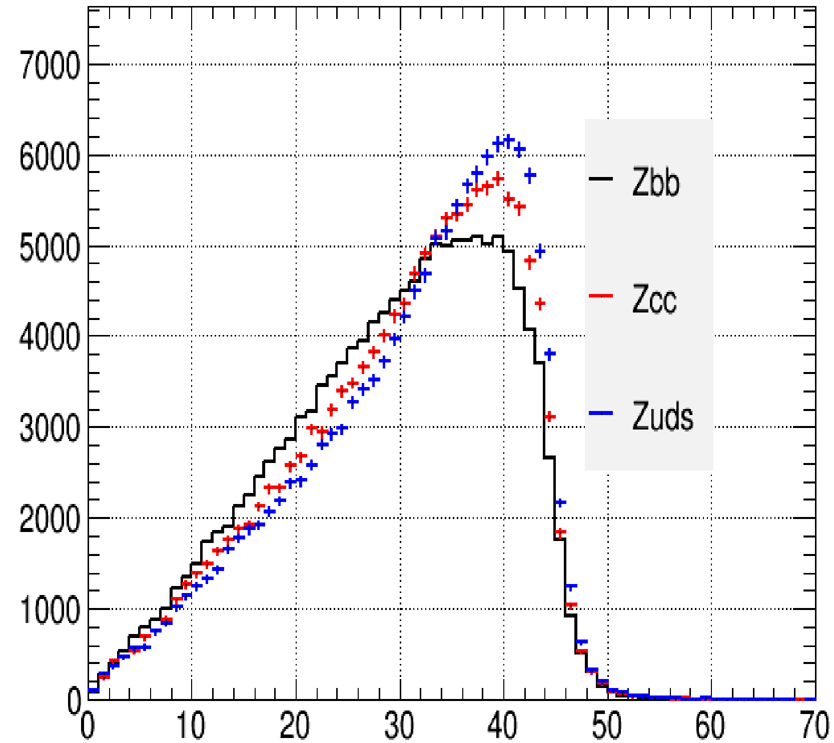
~140,000 events are produced

Btagging performance

Variable in Zbb,Zcc,Zll

JetBtag Prob all the 2jets **JetPt**



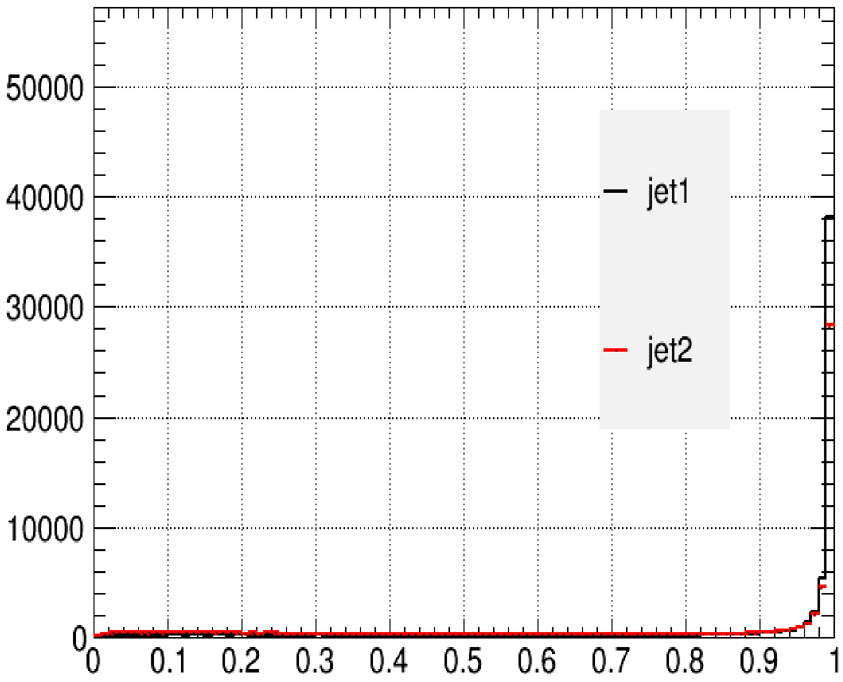


- The BtagProb are different for Zbb, Zcc and Zll
- Four BtagProb Work Point are used :
  - The BtagProb>0.6 , BtagProb>0.7, BtagProb>0.8, BtagProb>0.9

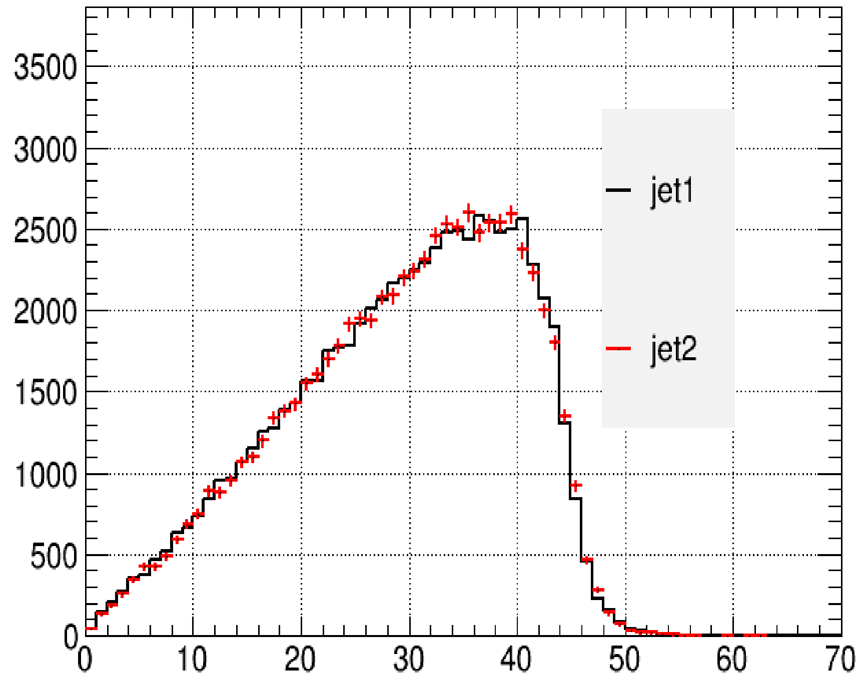
Btagging performance

Variable of jet1, jet2 in Zbb

JetBtag Prob



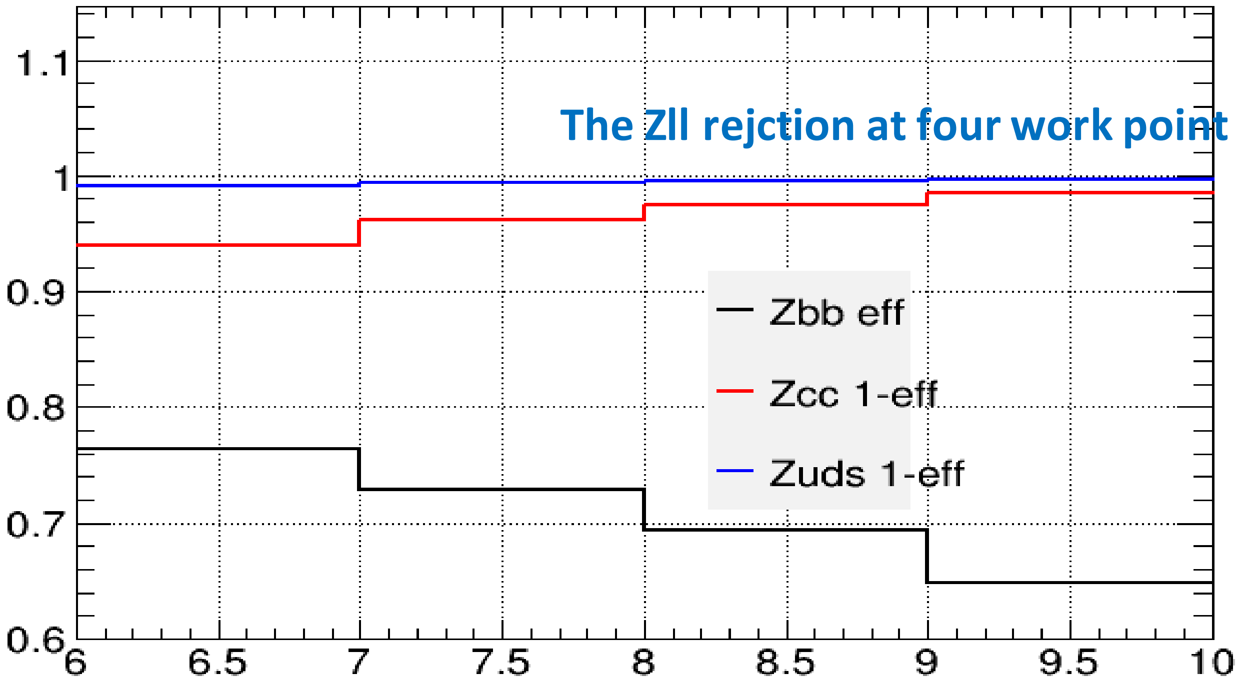
JetPt



Jet1 vs jet2

Btagging performance

Effency and rejection for Zbb,Zcc,Zll



The Zll rejction at four work point are ~100%

	Prob>0.6	Prob>0.7	Prob>0.8	Prob>0.9
Zbb_eff	0.7640	0.7294	0.6931	0.6488
Zcc_Rej:	0.9402	0.9610	0.9755	0.9858
Zll_Rej	0.9911	0.9941	0.9959	0.9973

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

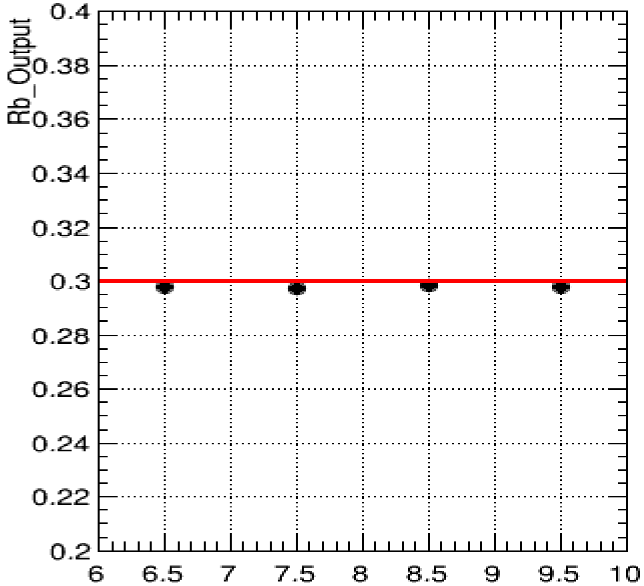
The Z hadronic '**DATA**' is mixed by MC samples: Zbb **sample1**, Zcc **sample1**, Zll sample1
We set Rb=0.3, Rb=0.5, Rb=0.7 as the Input Rb to mix the 'DATA'

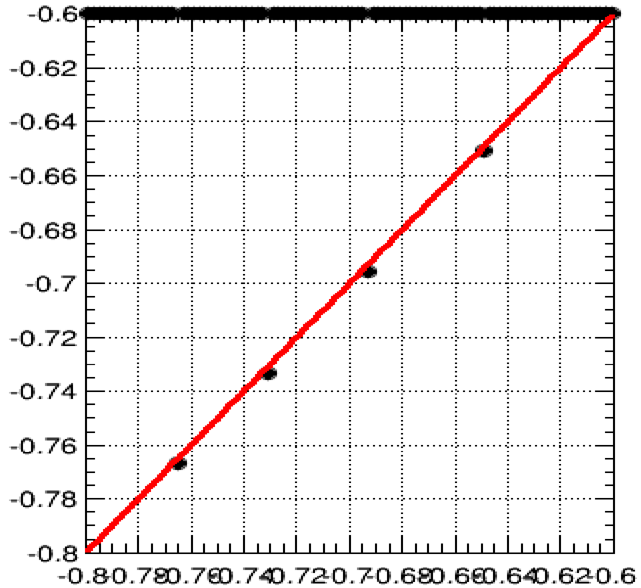
The R_c, ε_c, C_b, C_c, C_{uds} is gotten by MC samples: Zbb sample2, Zcc sample2, Zllsample2
So if **sample1≠** sample2, which means the MC R_c, ε_c, C_b, C_c, C_{uds} are different from the Truth in 'DATA'

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

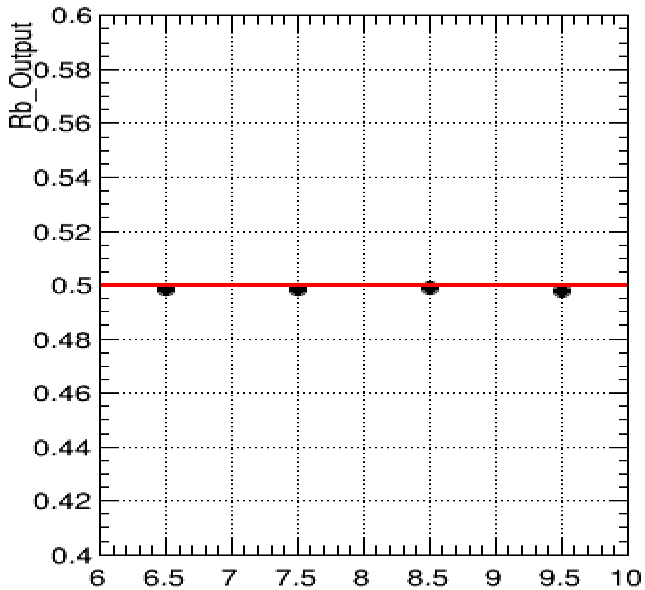
Input eff: 0.7643   0.7300 0.6936 0.6480

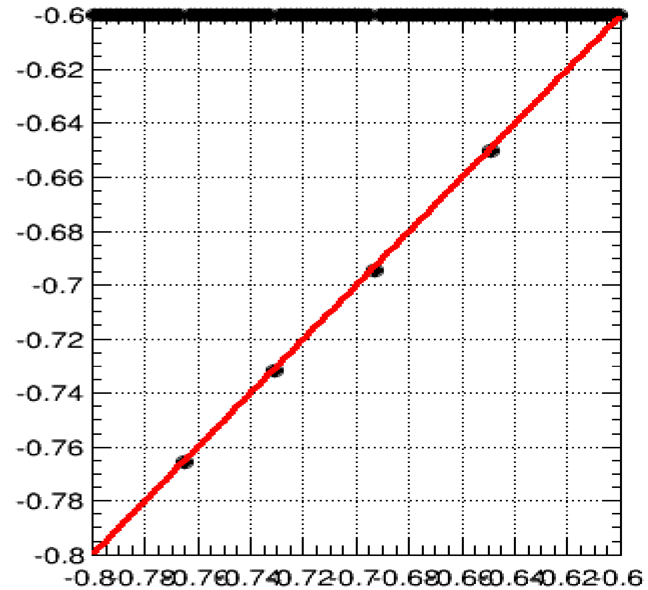
Output eff: 0.7668   0.7333 0.6956 0.6508

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

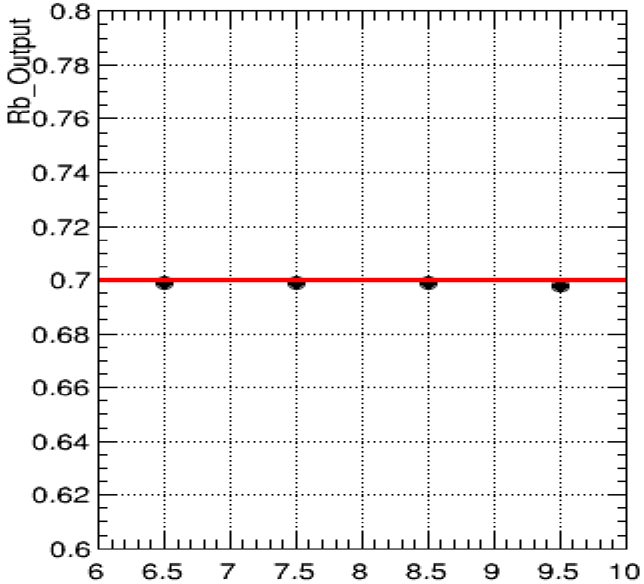
Input eff: 0.7643 0.7300 0.6936 0.6480

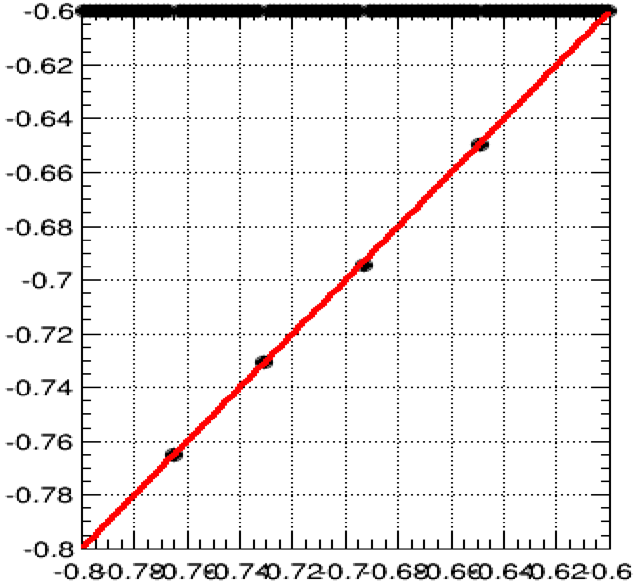
Output eff: 0.7657 0.7316 0.6946 0.6501

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

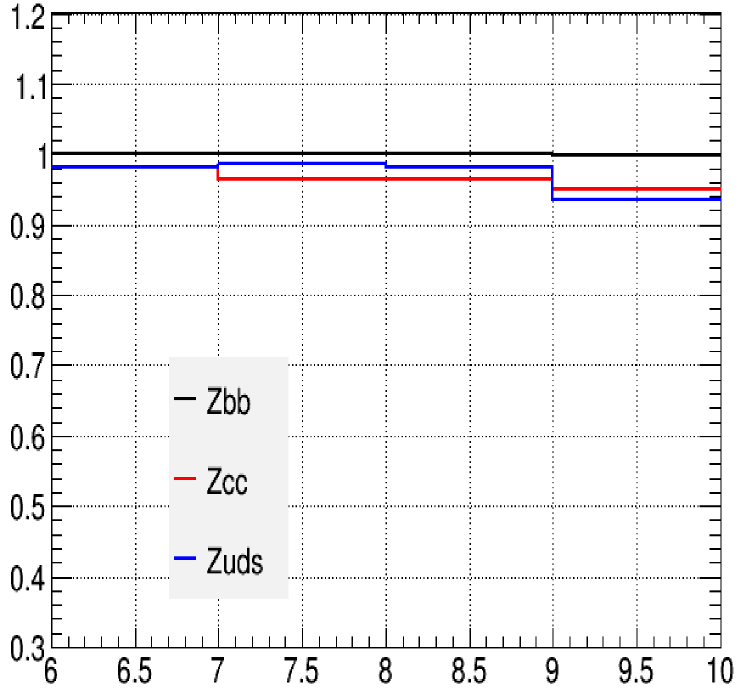
Output eff: 0.7652   0.7308 0.6942   0.6498

Result

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

The $\boldsymbol{R_c}$, $\boldsymbol{\varepsilon_c}$, $\boldsymbol{C_b}$, $\boldsymbol{C_c}$, $\boldsymbol{C_{uds}}$ 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'

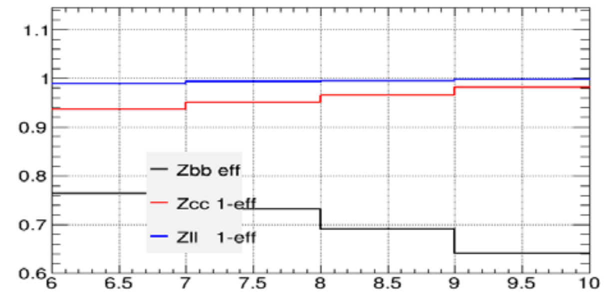
The difference as a Ratio: Eff in 'DATA'/ Eff in MC



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%**



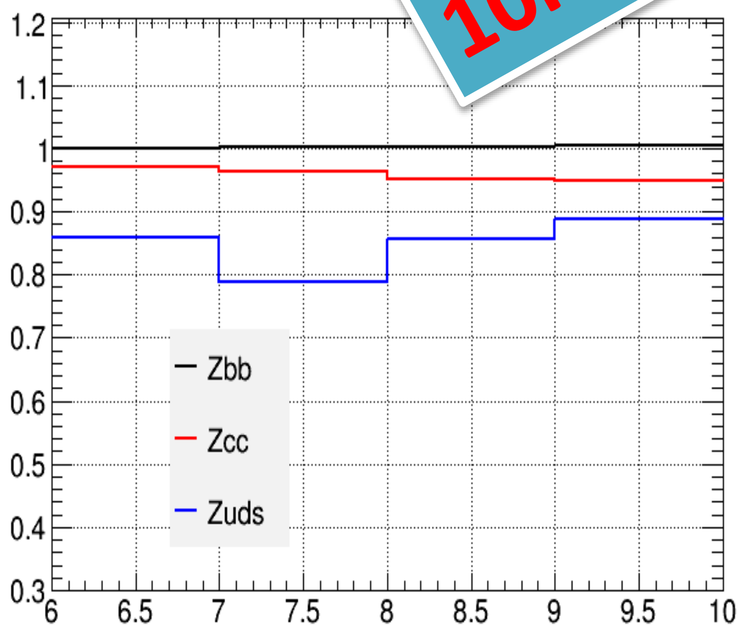
Result

10k events in the past

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

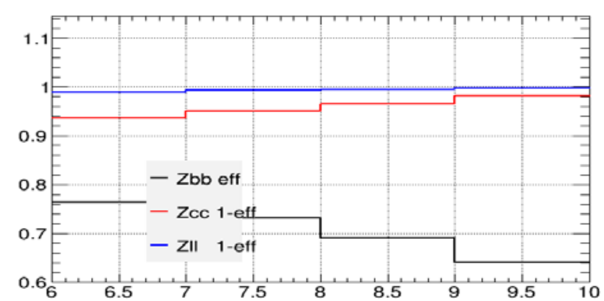
The R_c, ε_c, C_b, C_c, C_{uds} is got by MC sampl... 2, Zcc sample2, Zllsample2
So if **sample1≠** sample2， which means the M... C_c, C_{uds} is different from the 'DATA'

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%**

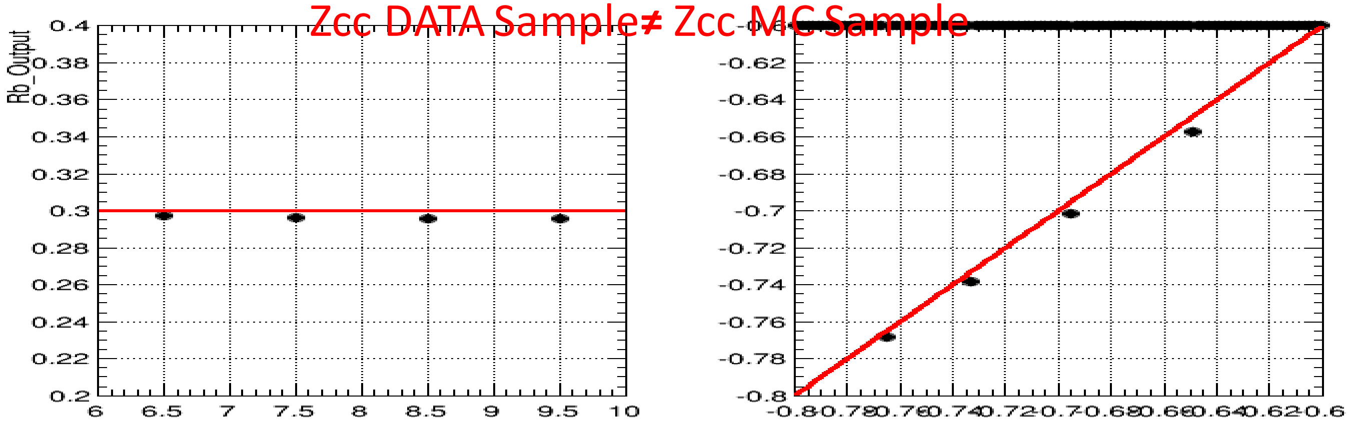


Check

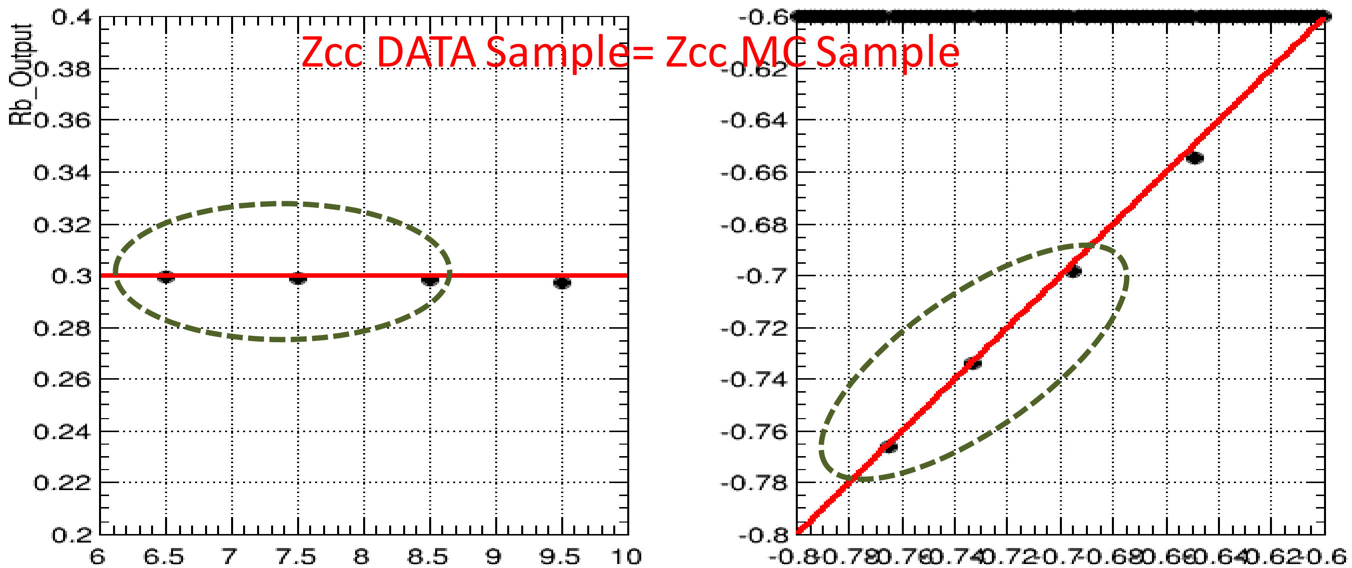
Input Rb=0.3

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

Zcc DATA Sample≠ Zcc MC Sample



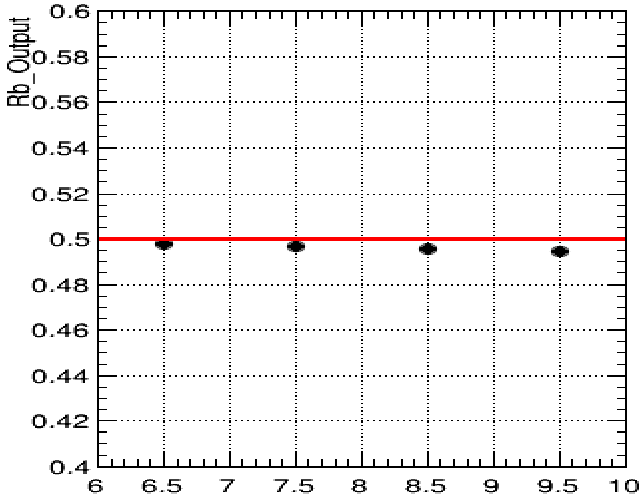
Zcc DATA Sample= Zcc MC Sample

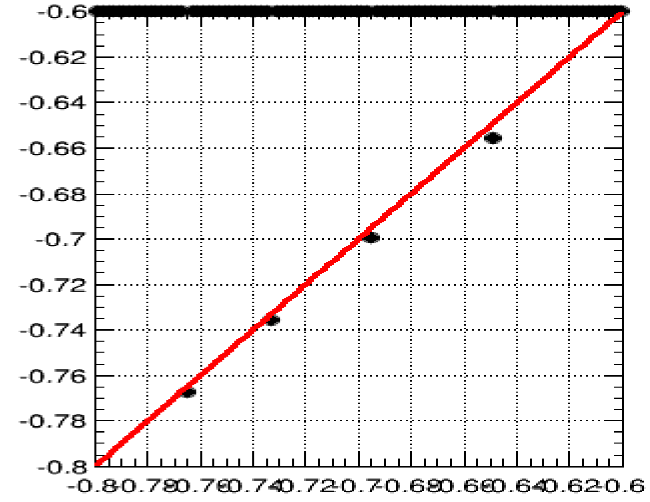


We can see the differences of measured Rb and effb between DATA and MC are smaller

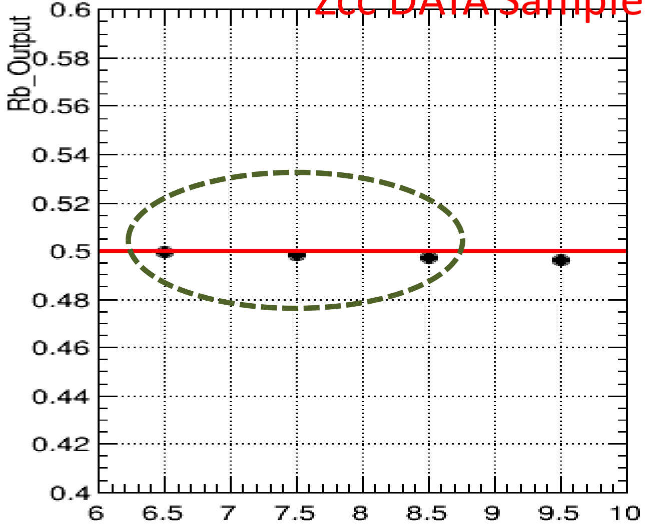
Check

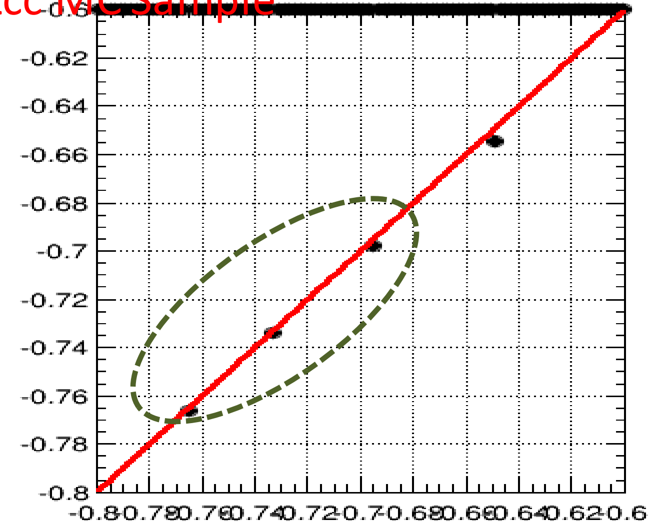
Input Rb=0.5





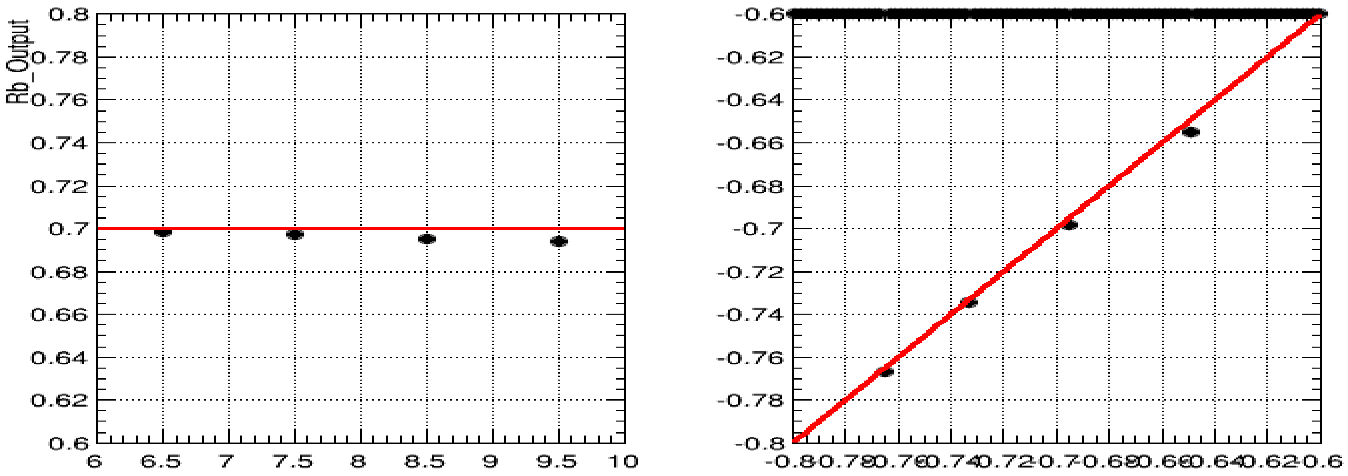
Zcc DATA Sample= Zcc MC Sample

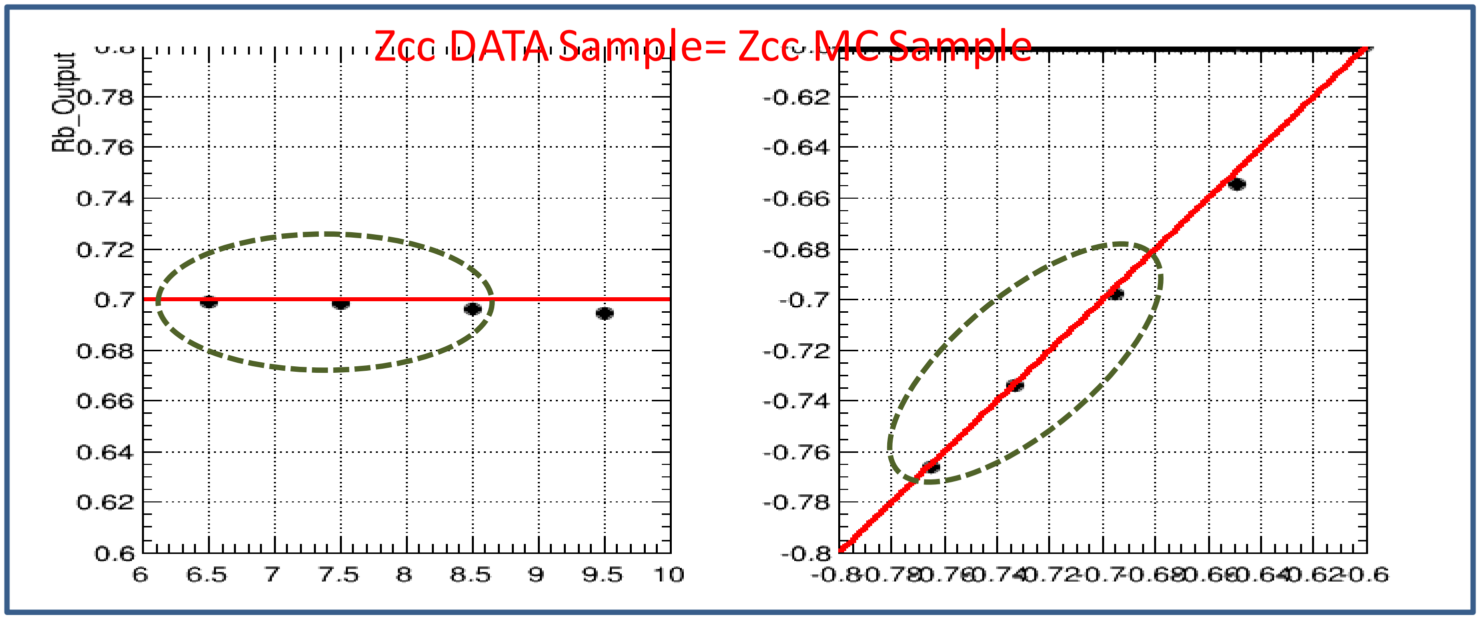




Check

Input Rb=0.7





Summary

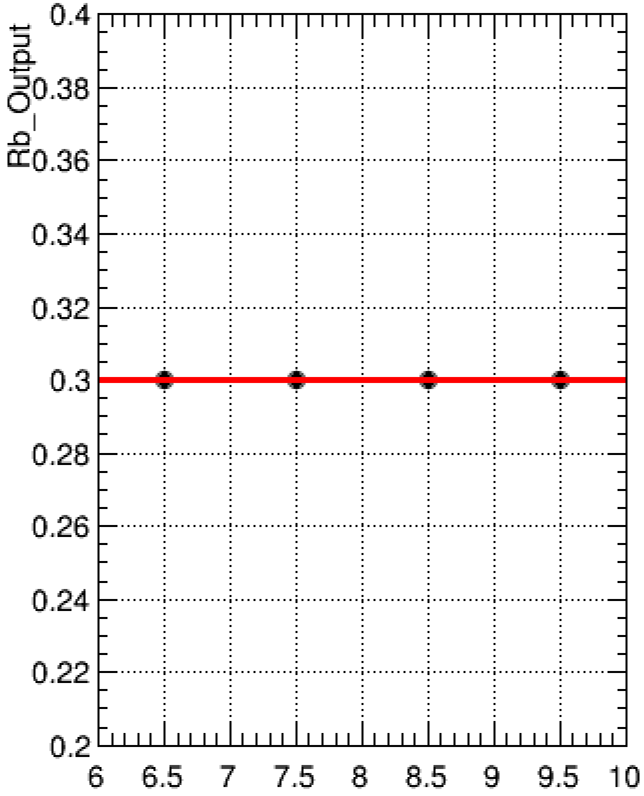
- The IO test shows Analysis code worked as expected.

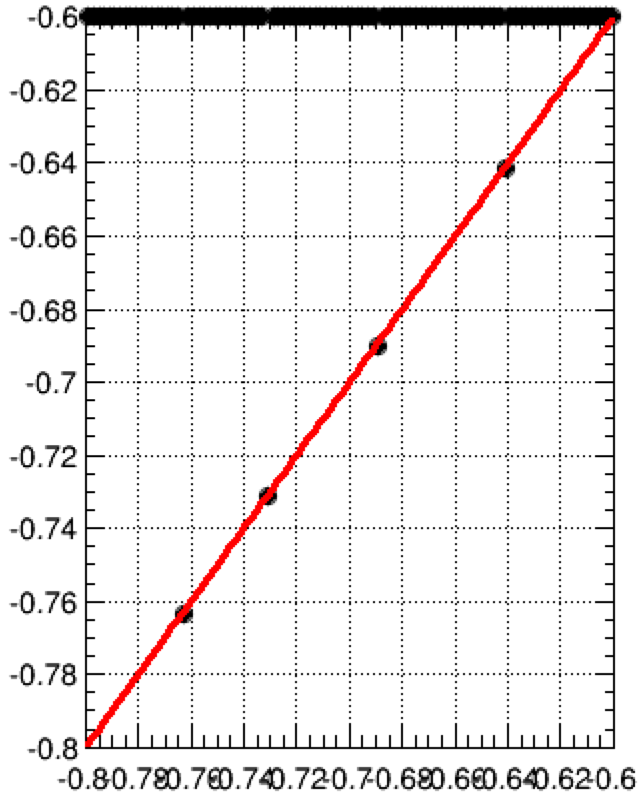
- Increase the statistics of ‘DATA’ and MC.
- Study the FSClasser: know well about the procedure at event reconstruction level.

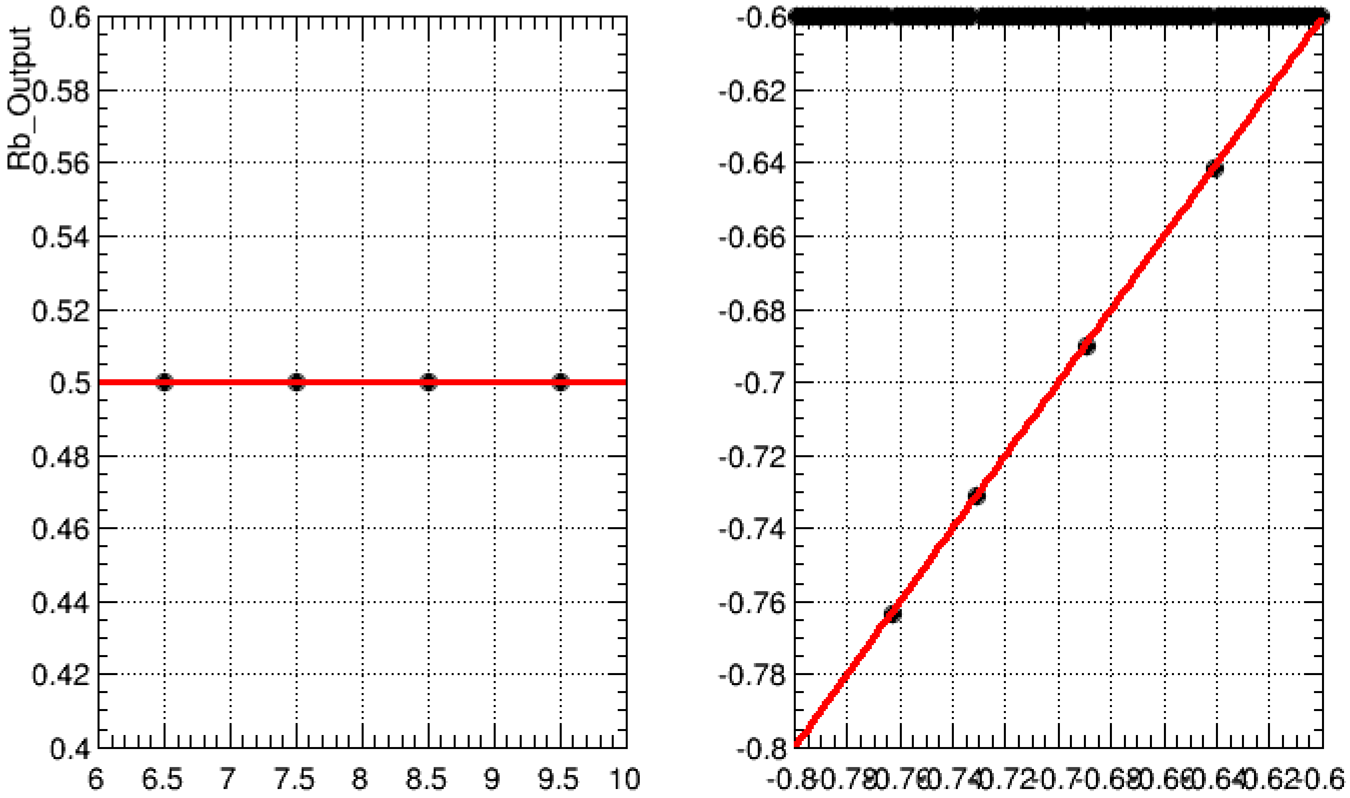
backup

backup

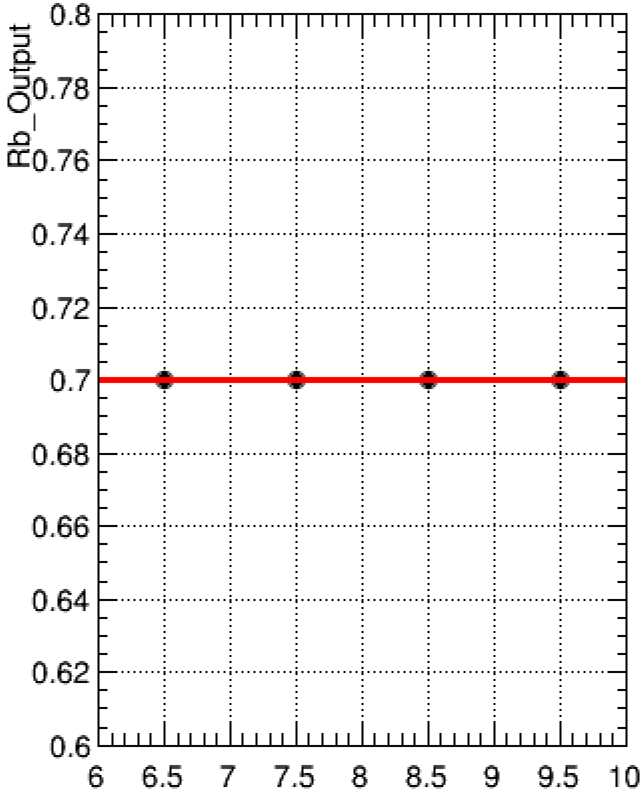
'DATA' and MC all are used the same sample

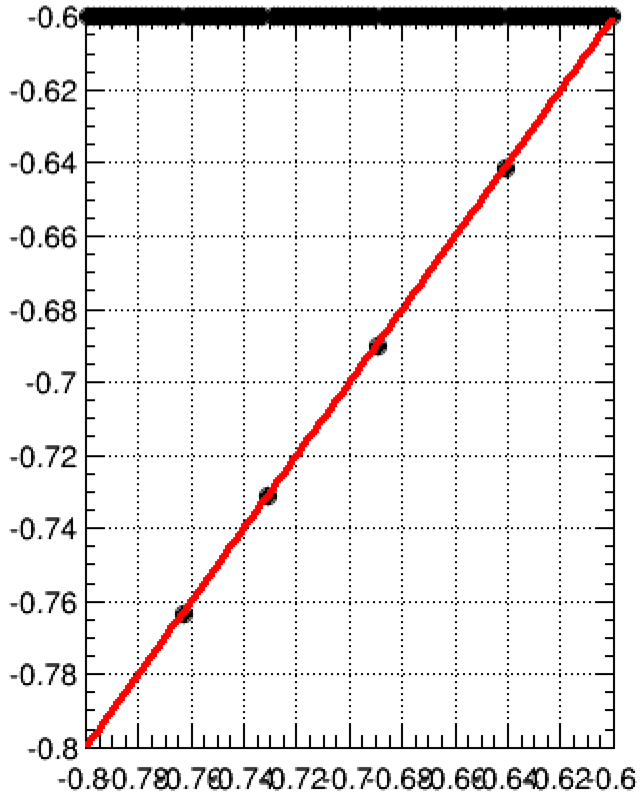






Rb_Output
0.6
0.58
0.56
0.54
0.52
0.5
0.48
0.46
0.44
0.42
0.4
6
6.5
7
7.5
8
8.5
9
9.5
10
-0.6
-0.62
-0.64
-0.66
-0.68
-0.7
-0.72
-0.74
-0.76
-0.78
-0.8


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