Rb measurement at CEPC MC Level

Bo Li

Btagging correlation factor

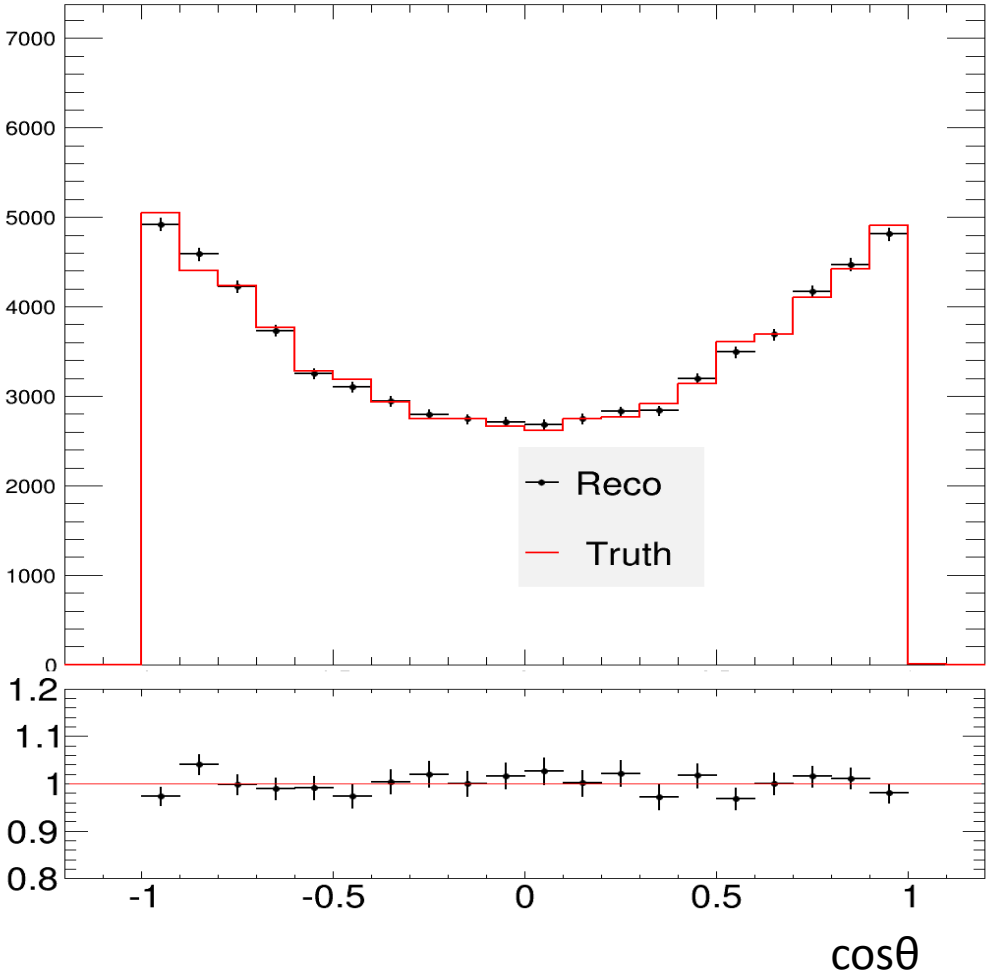
$$C_b = \frac{\varepsilon_{2jet-tagged}}{(\varepsilon_{1jet-tagged})^2}$$

Cut: 180 ° -Δθ(jet1, jet2) <5 °

	Prob >0.6	>0.7	>0.8	>0.9	>0.95	>0.99
Zbb	1.015+-0.009	1.021+-0.009	1.026+-0.009	1.033+-0.010	1.036+0.010	1.062+-0.012
	1.013+-0.009	1.018+-0.010	1.024+-0.010	1.030+-0.010	1.032+-0.011	1.055+-0.013

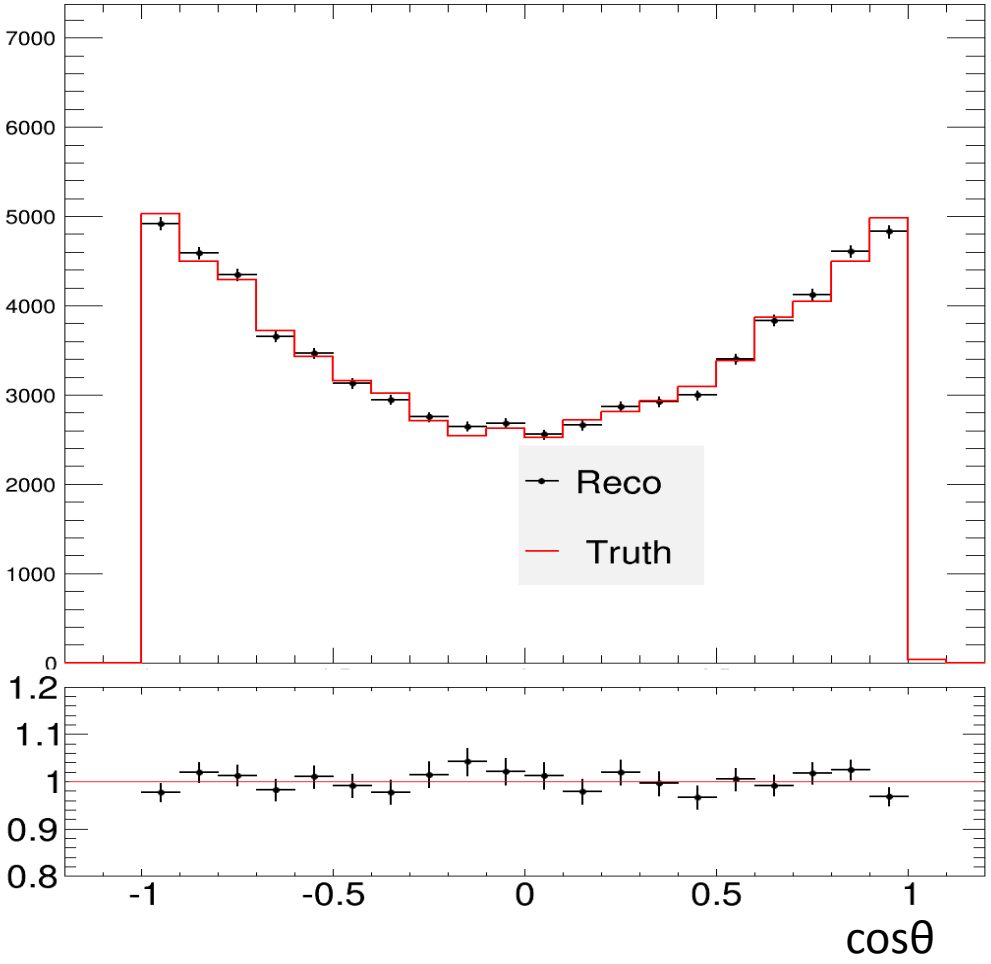
Zbb cosθ

Reco VS Truth



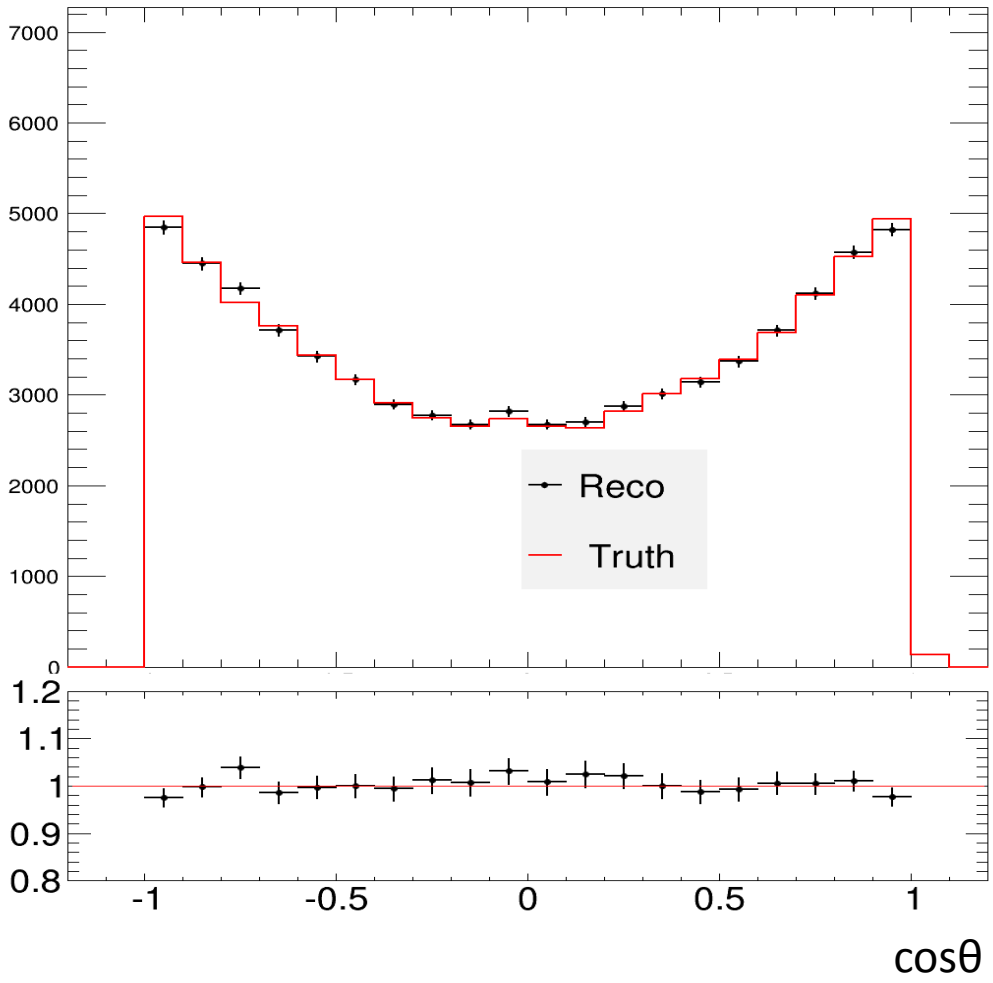
Zcc cosθ

Reco VS Truth



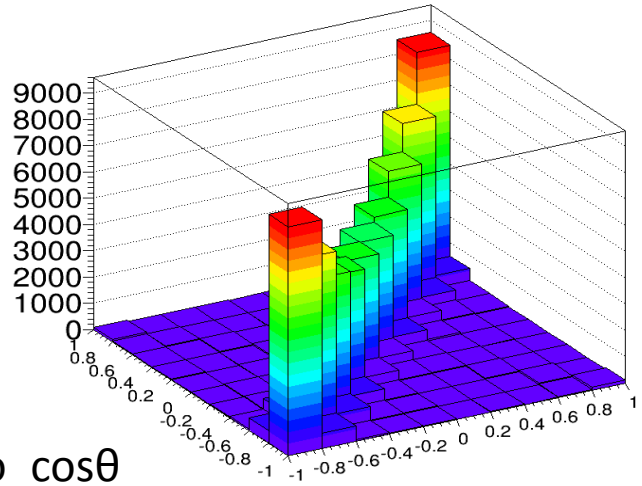
Zuds cosθ

Reco VS Truth



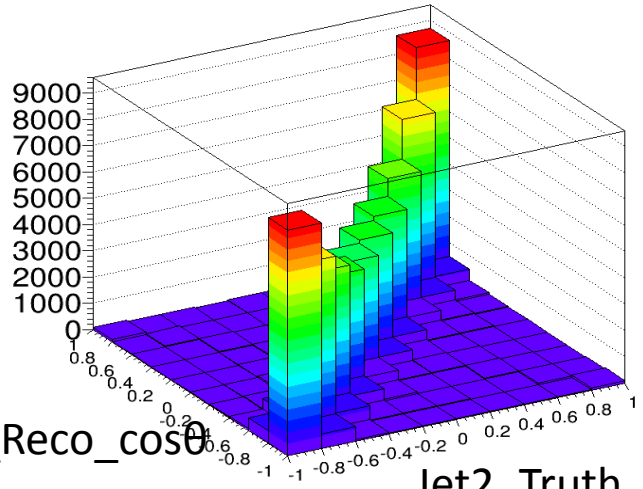
Zbb cosθ

Reco VS Truth Event by Event



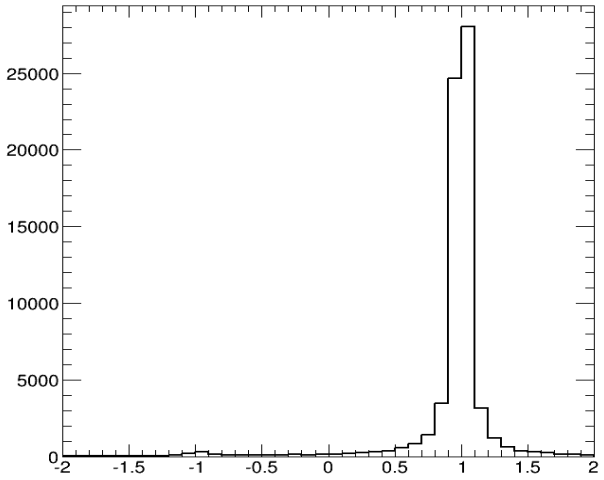
Jet1_Reco_cosθ

Jet1_Truth_cosθ

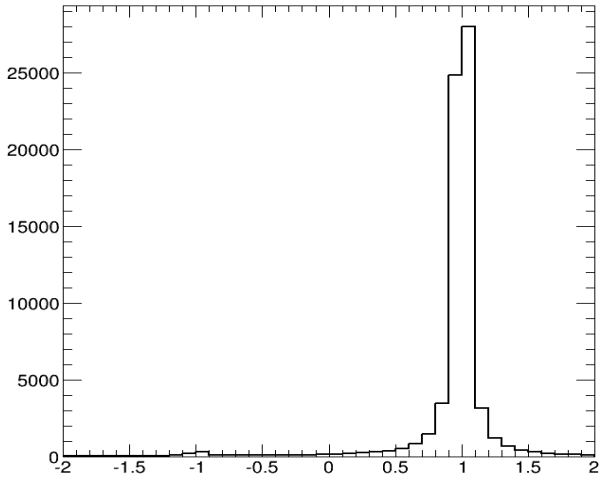


Jet2_Reco_cosθ

Jet2_Truth_cosθ



Reco/Truth

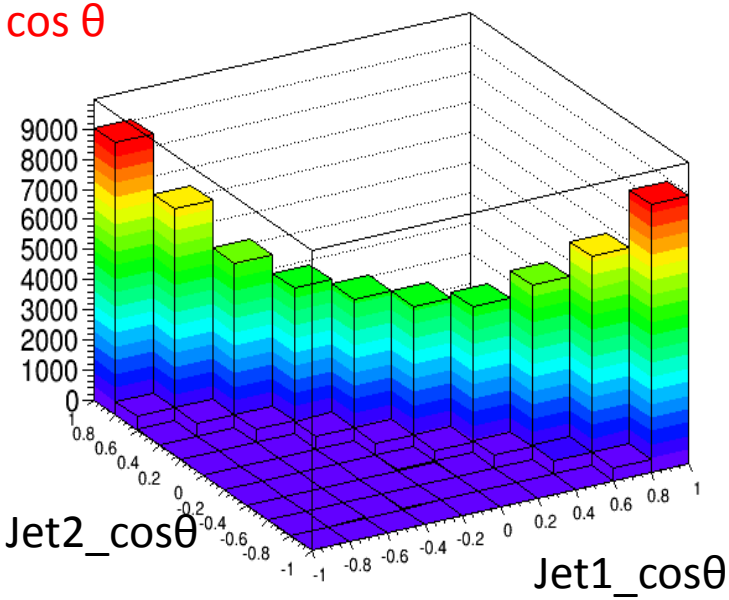


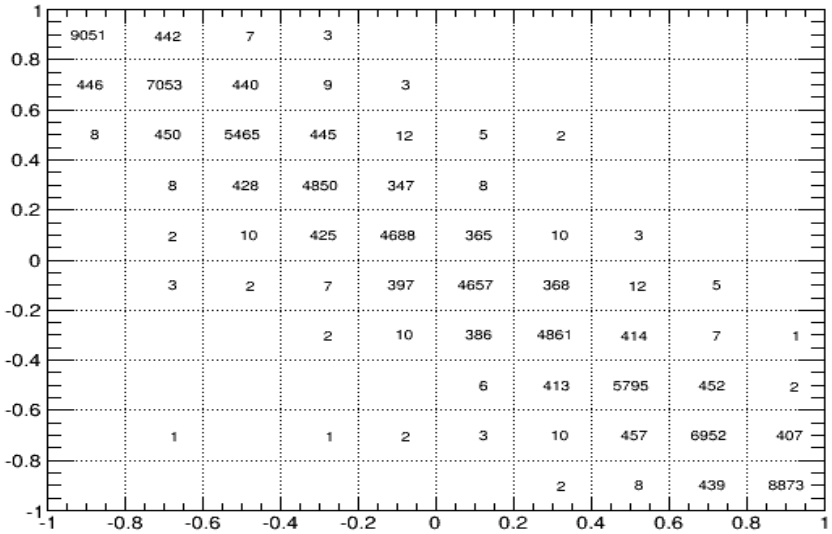
Reco/Truth

2D Correlation Factor

zbb

cos θ





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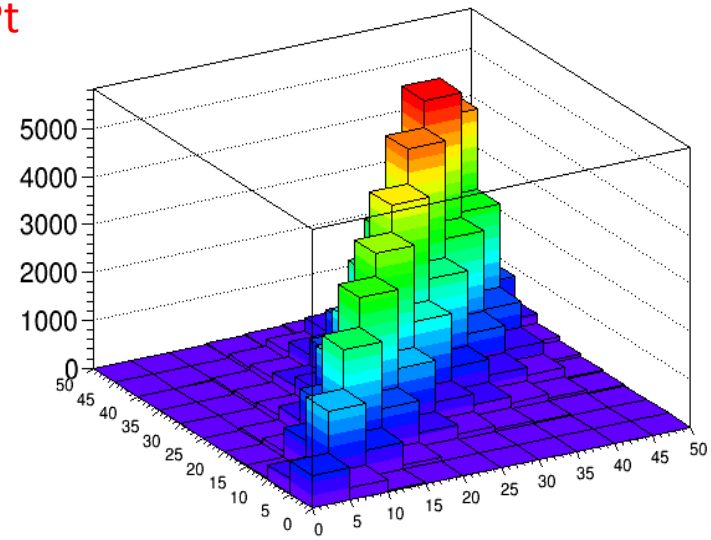
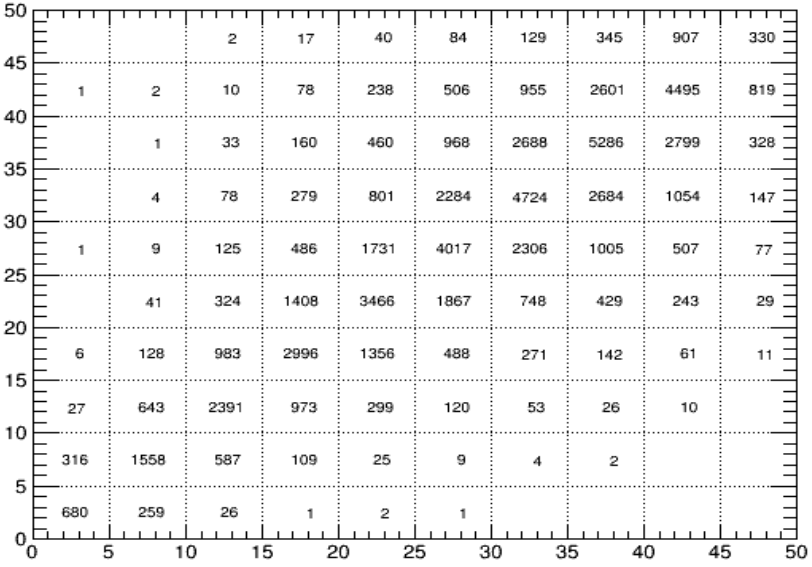
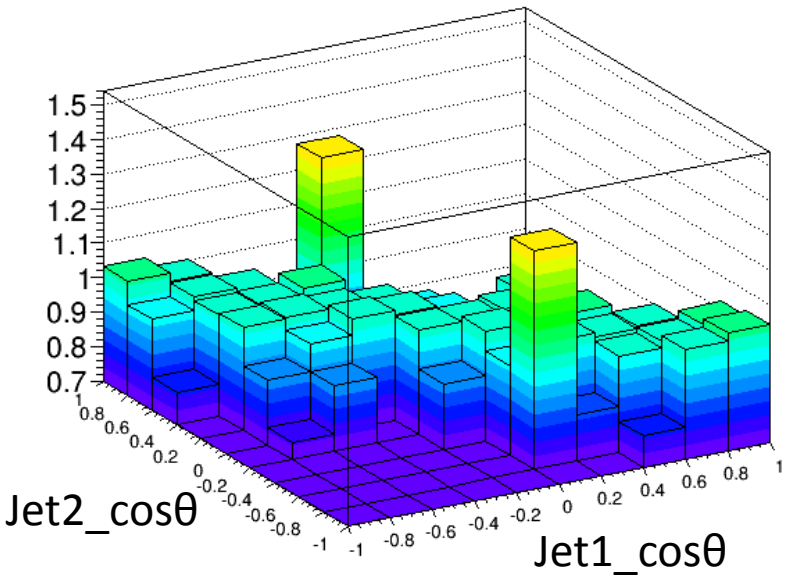
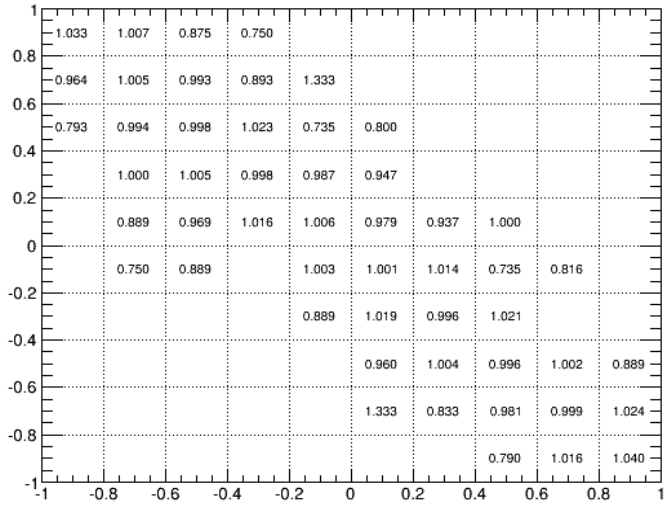




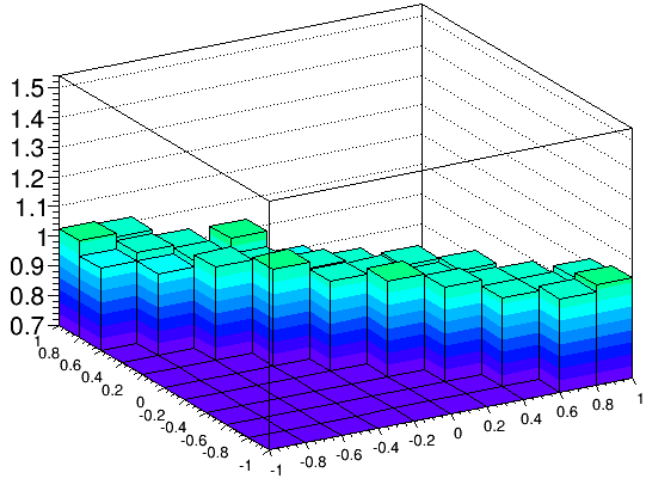
2D Correlation Factor

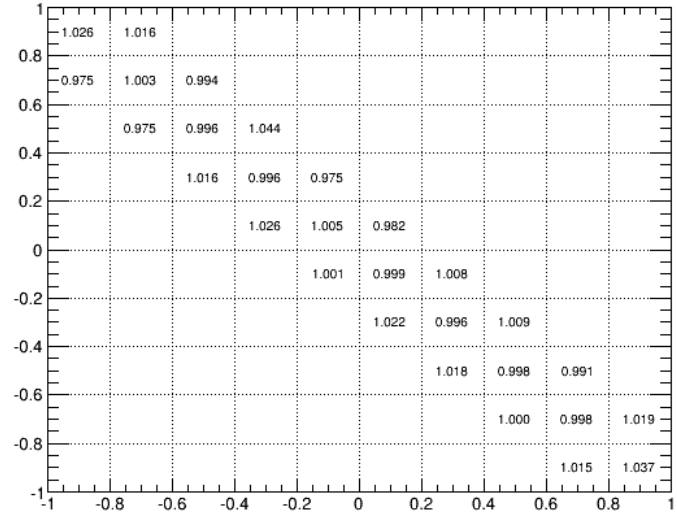
Zbb Prob>0.6





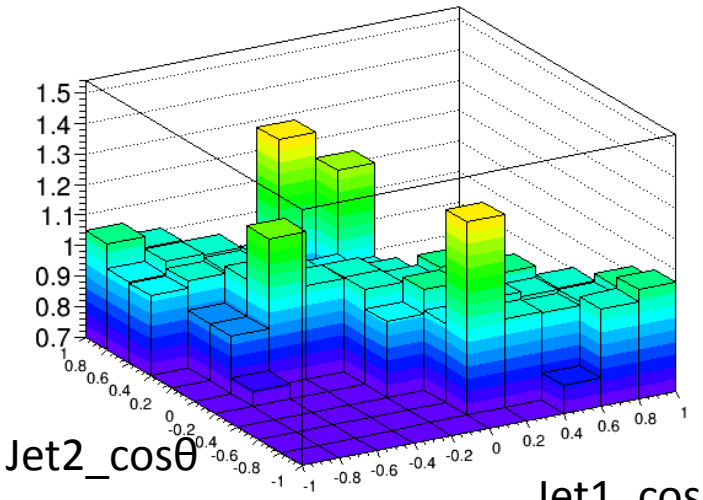
Cut: 180° -Δθ(jet1, jet2) <5°

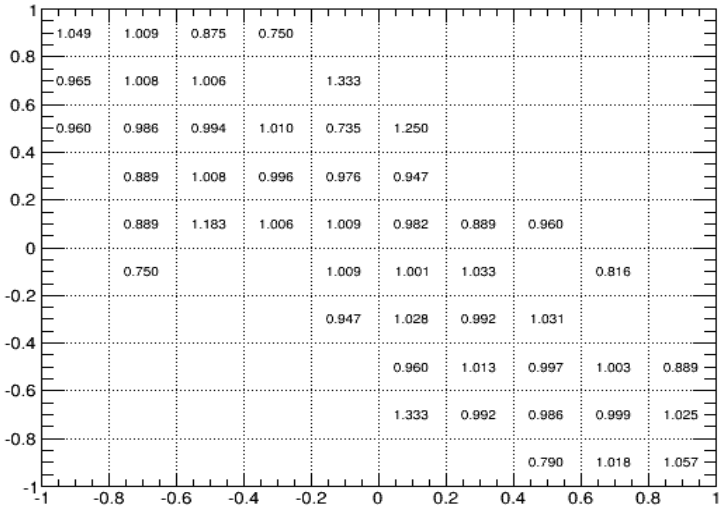




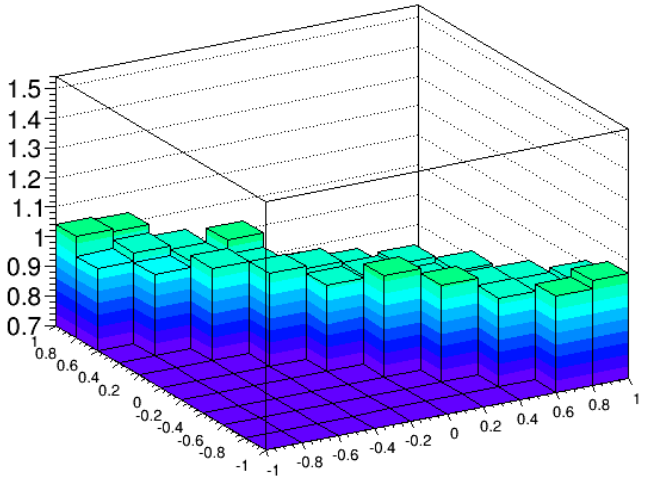
2D Correlation Factor

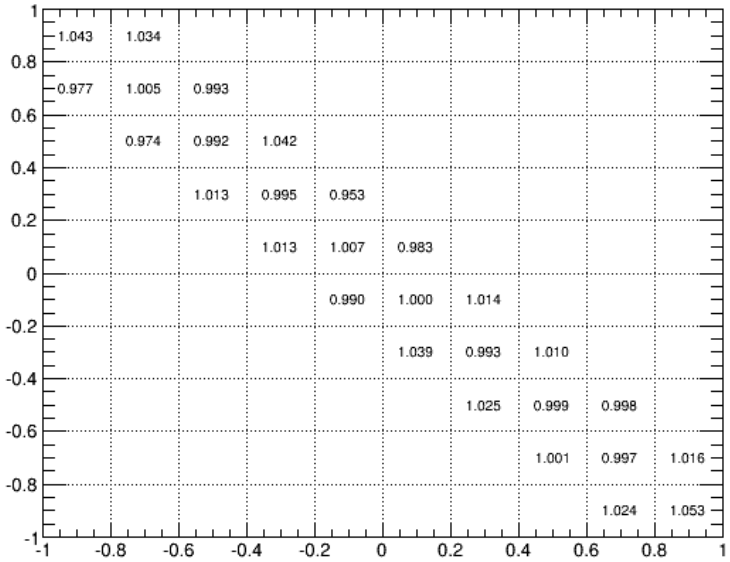
Zbb Prob>0.7





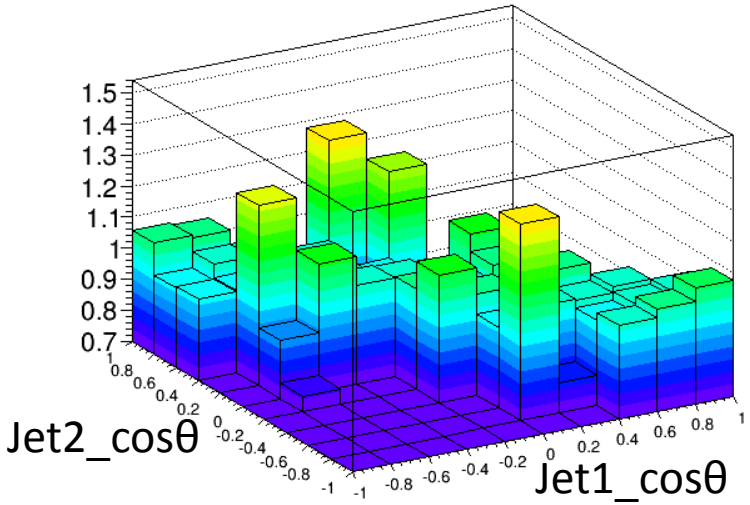
Cut: 180° -Δθ(jet1, jet2) <5°

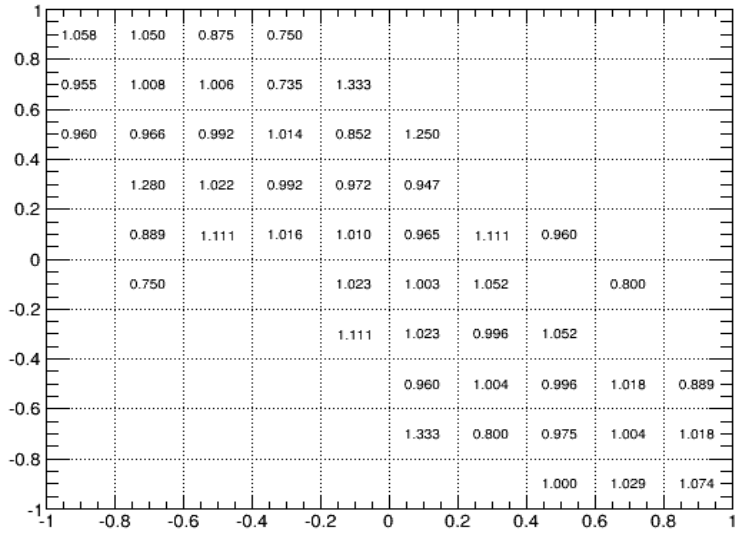




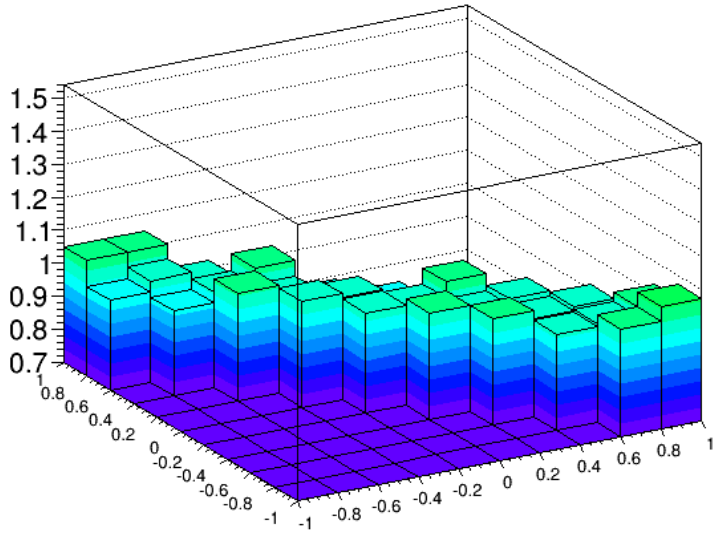
2D Correlation Factor

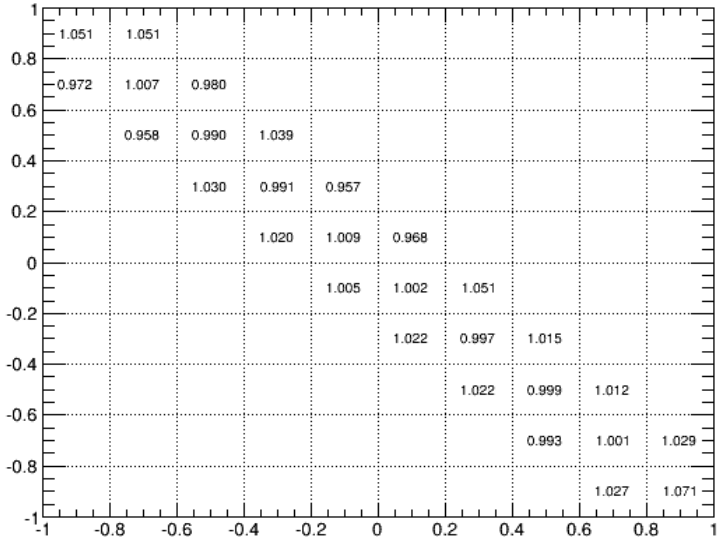
Zbb Prob>0.8





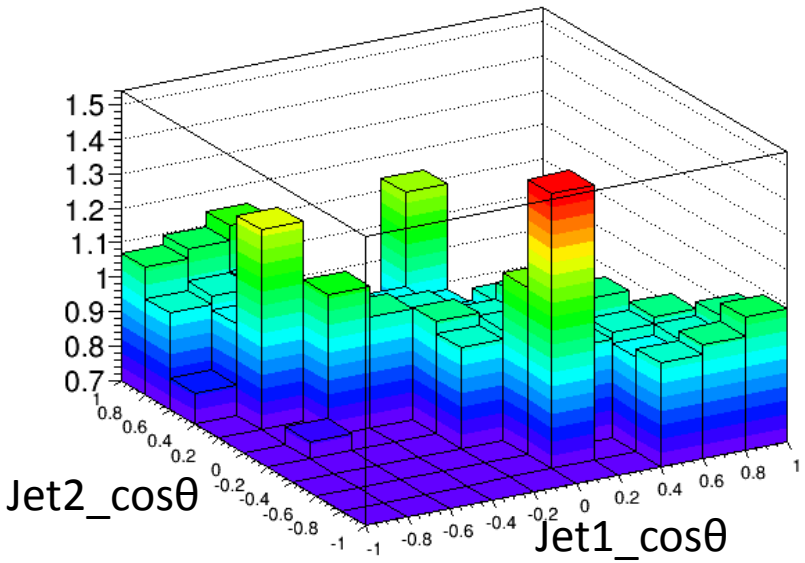
Cut: 180° -Δθ(jet1, jet2) <5°

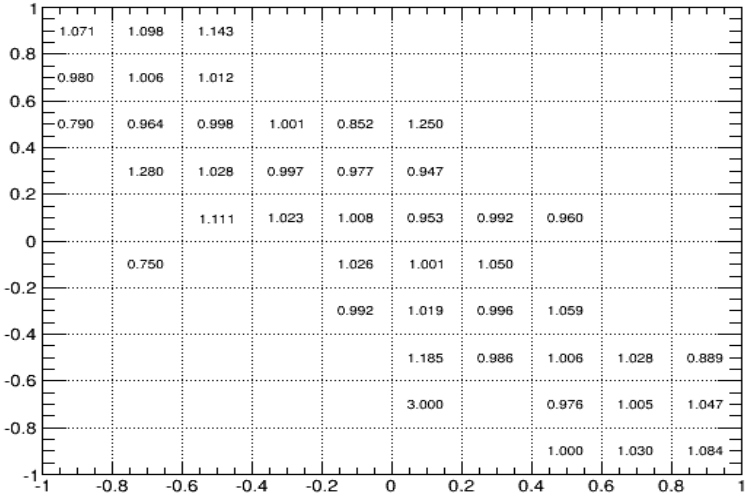




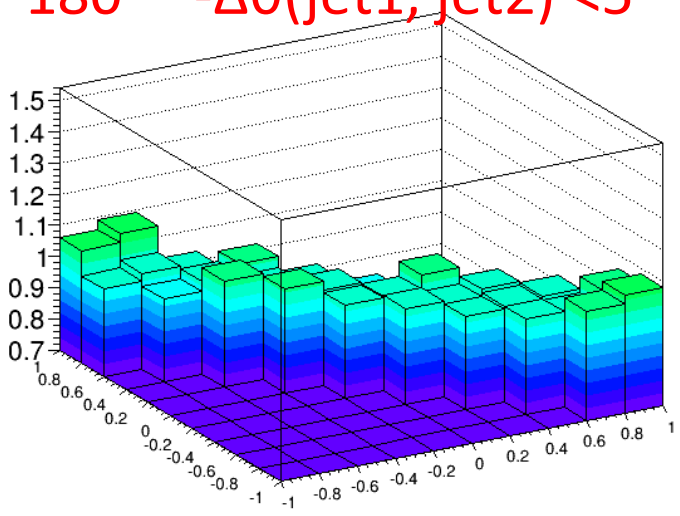
2D Correlation Factor

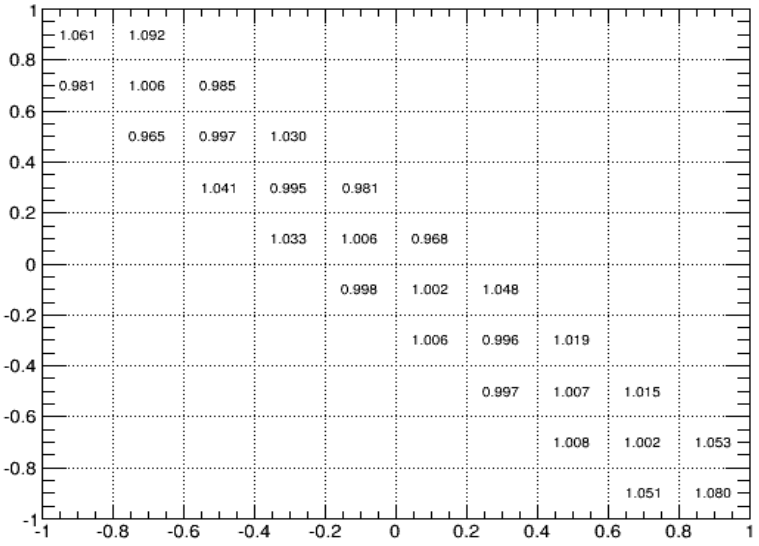
Zbb Prob>0.9





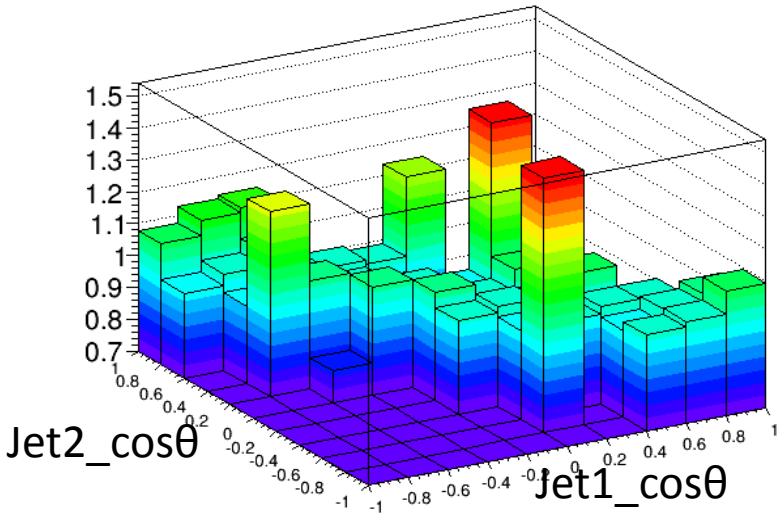
Cut: 180° -Δθ(jet1, jet2) <5°

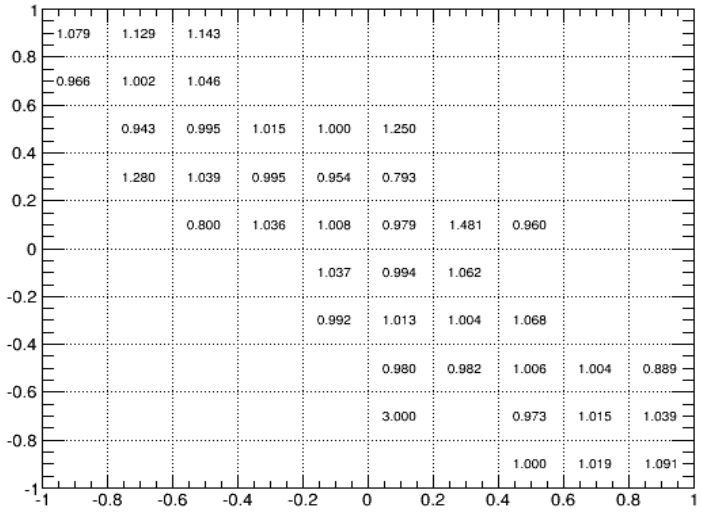




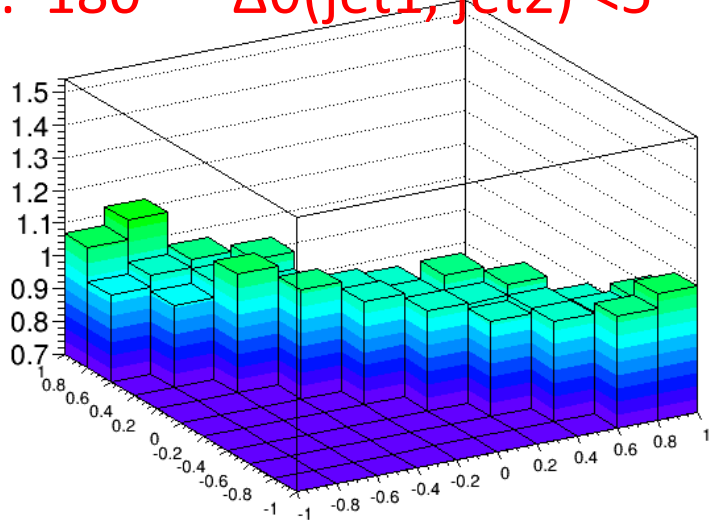
2D Correlation Factor

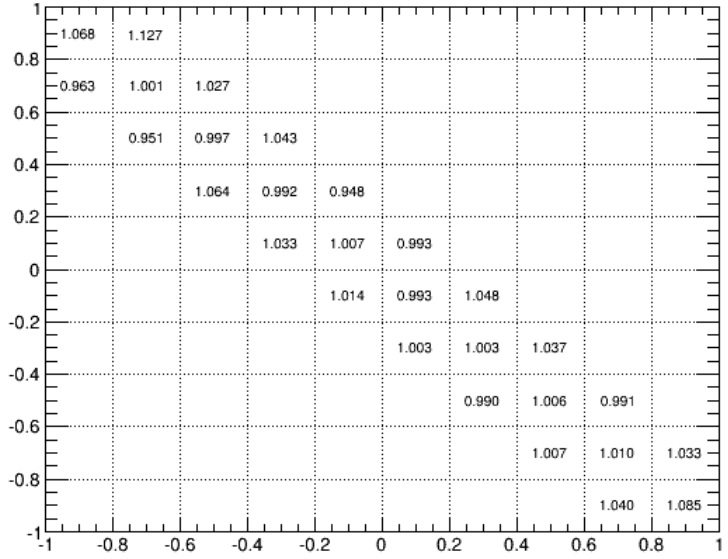
Zbb Prob>0.95





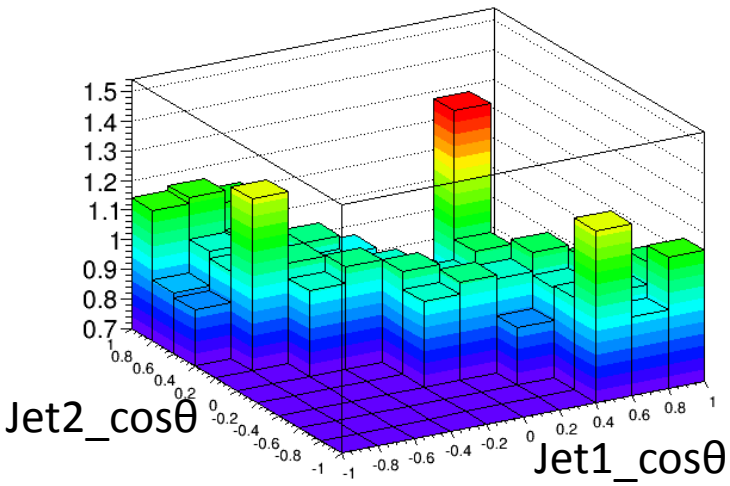
Cut: 180° -Δθ(jet1, jet2) <5°

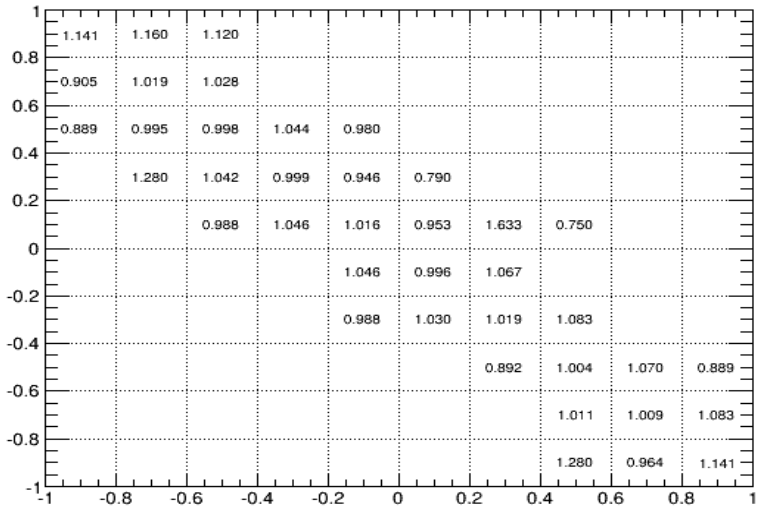




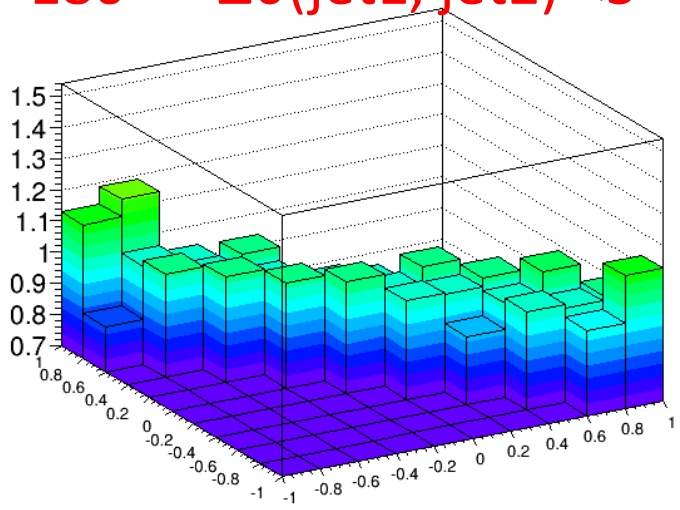
2D Correlation Factor

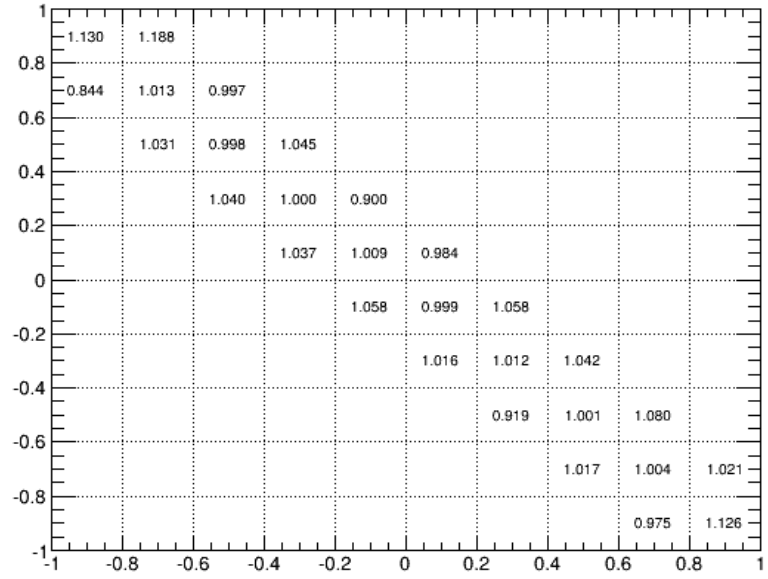
Zbb Prob>0.99





Cut: 180° -Δθ(jet1, jet2) <5°

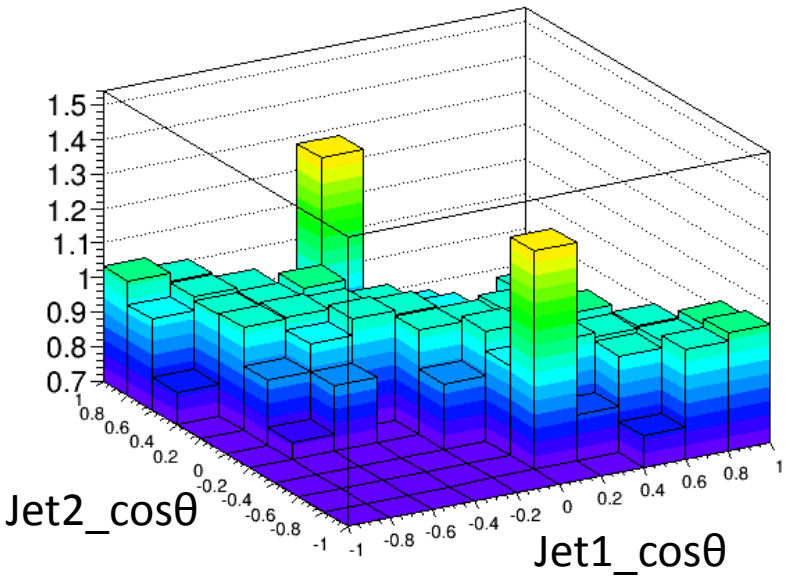


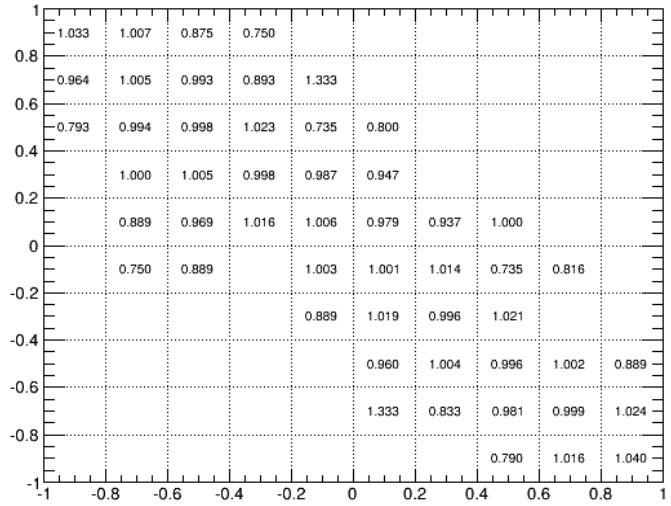


backup

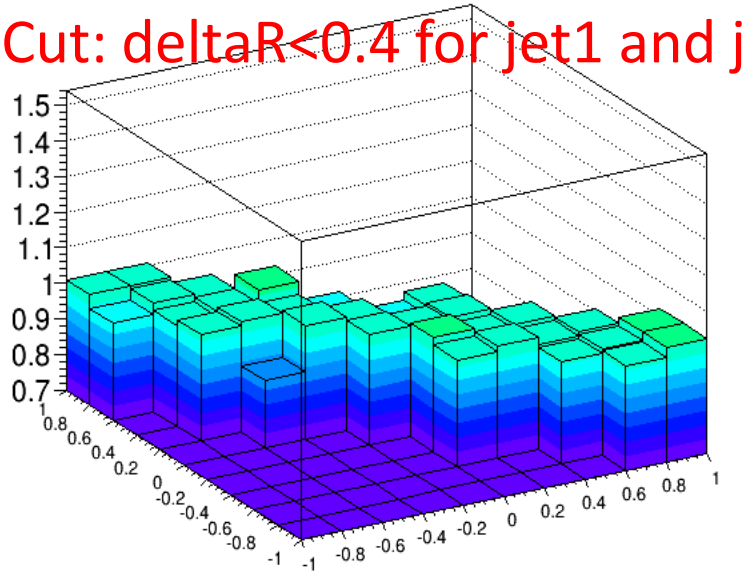
2D Correlation Factor

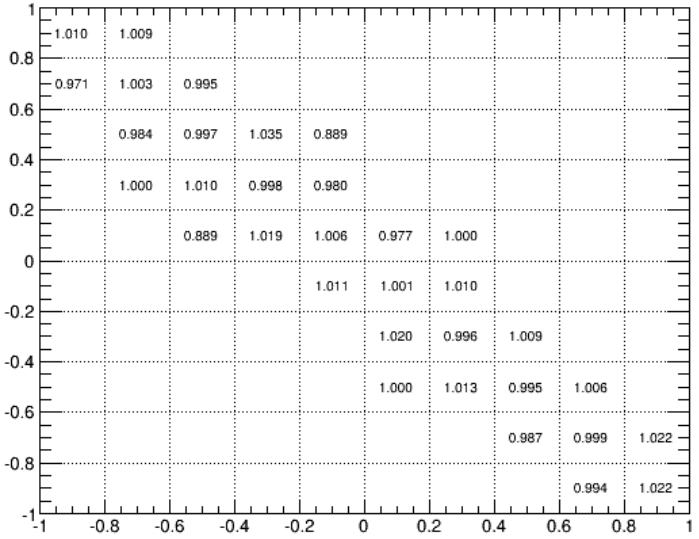
Zbb Prob>0.6





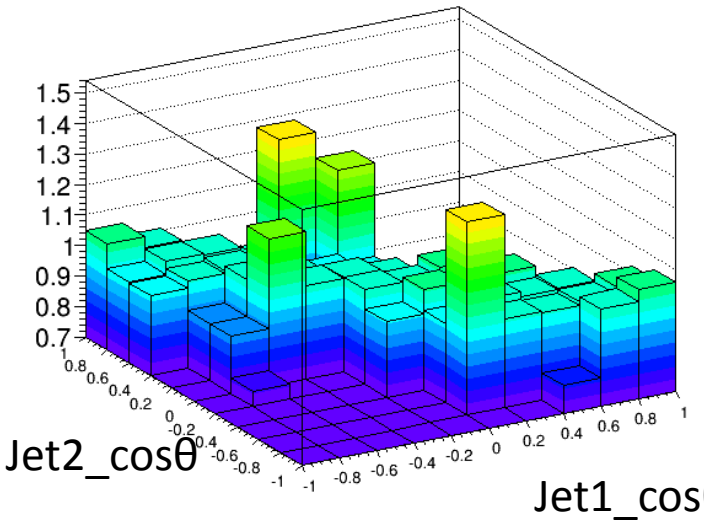
Cut: deltaR<0.4 for jet1 and jet2

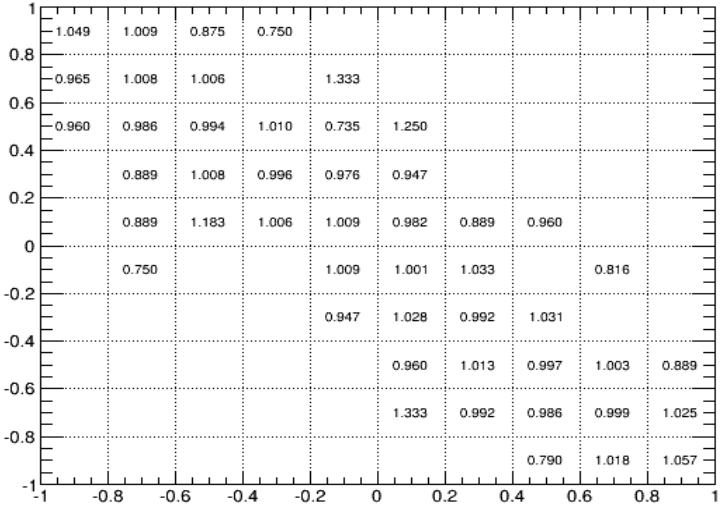




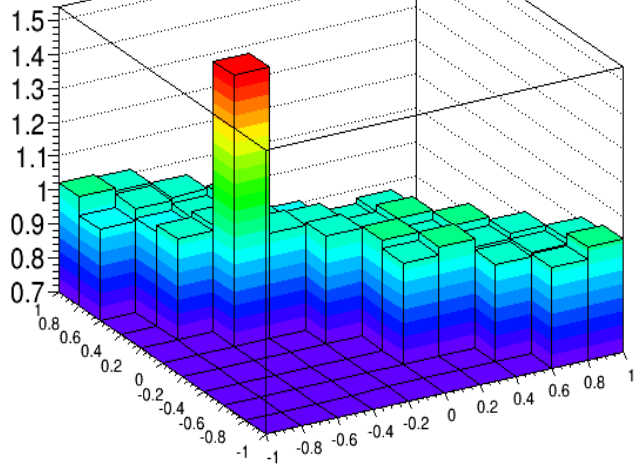
2D Correlation Factor

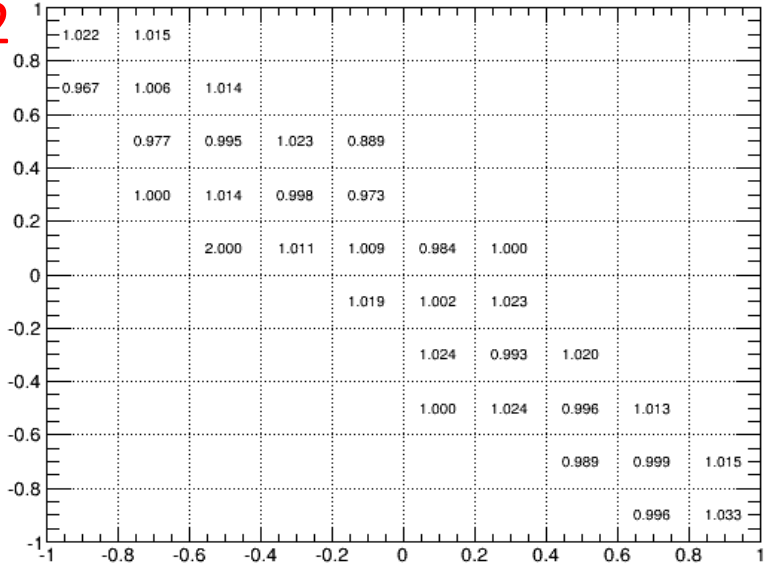
Zbb Prob>0.7





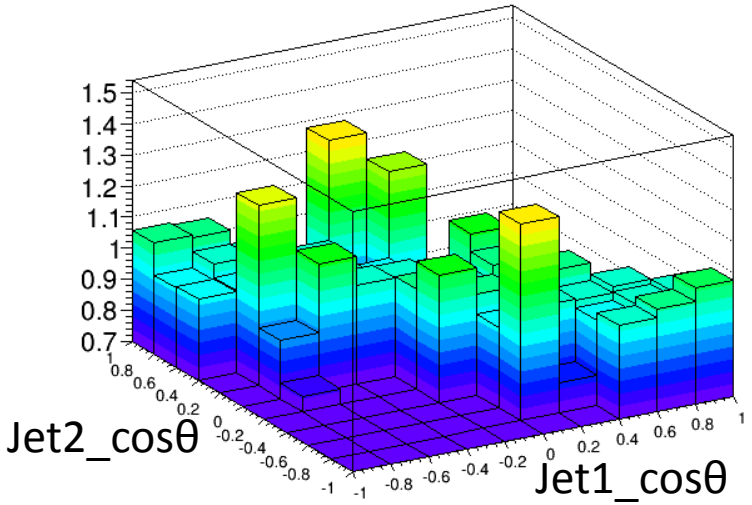
Cut: deltaR<0.4 for jet1 and jet2

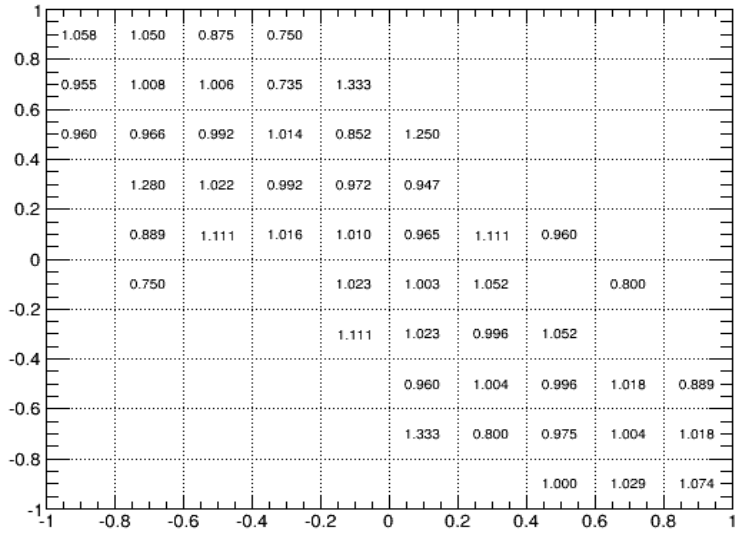




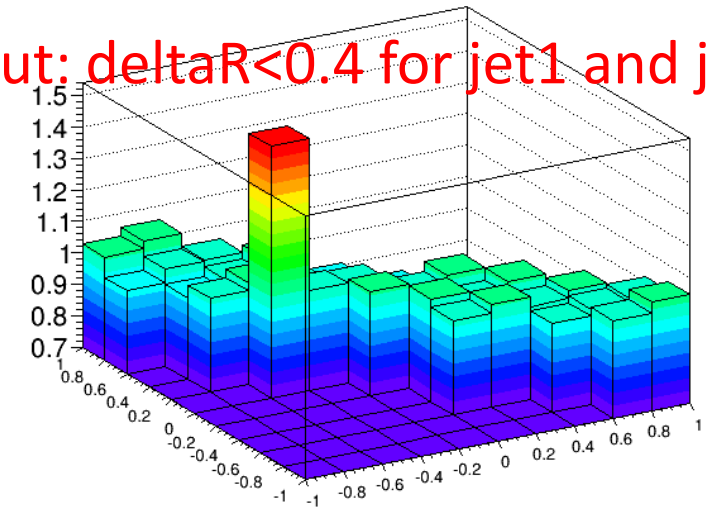
2D Correlation Factor

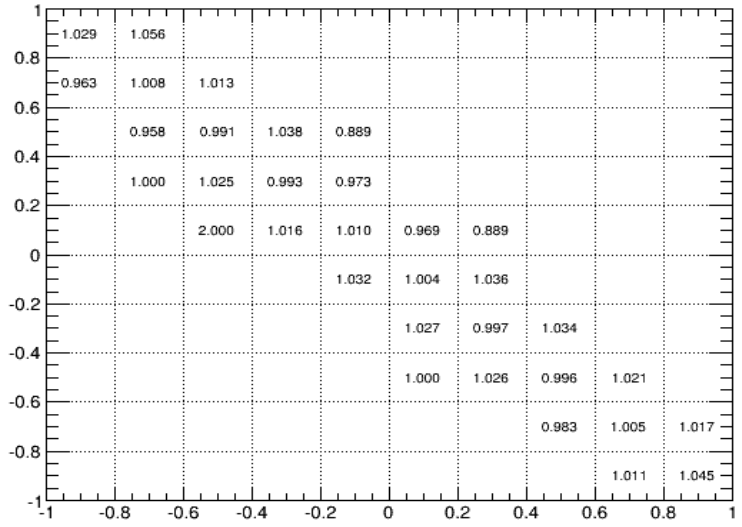
Zbb Prob>0.8





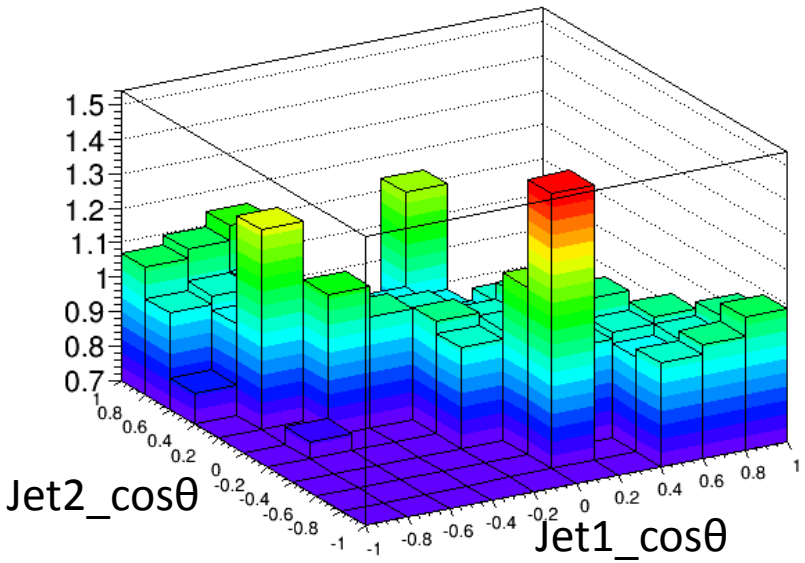
Cut: deltaR<0.4 for jet1 and jet2

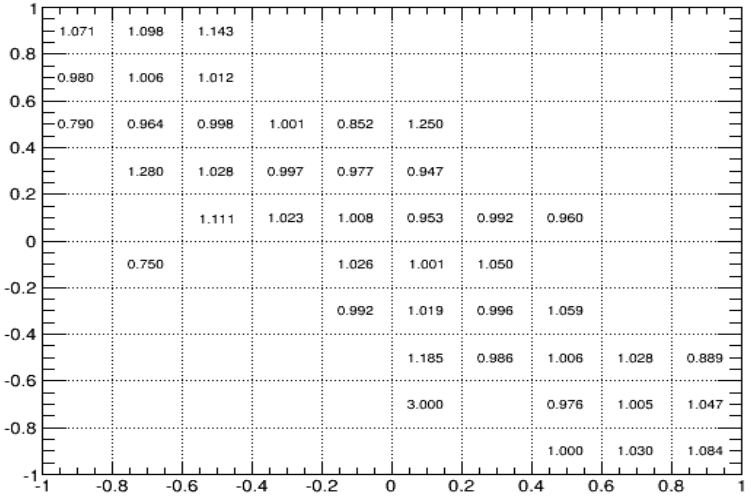




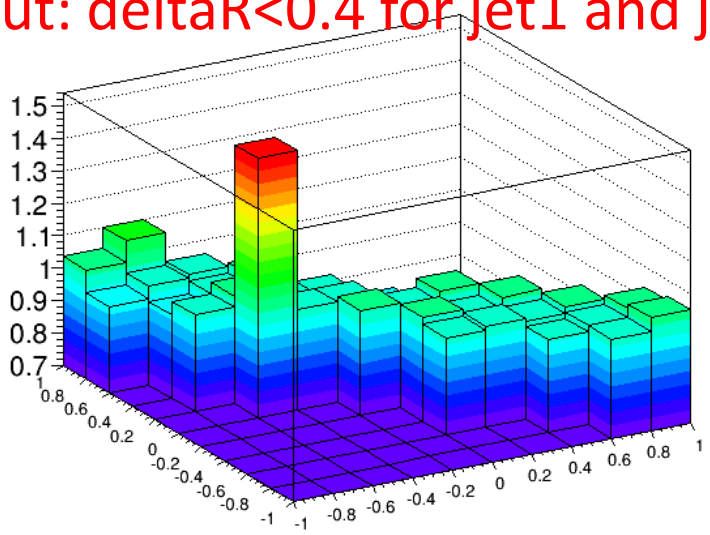
2D Correlation Factor

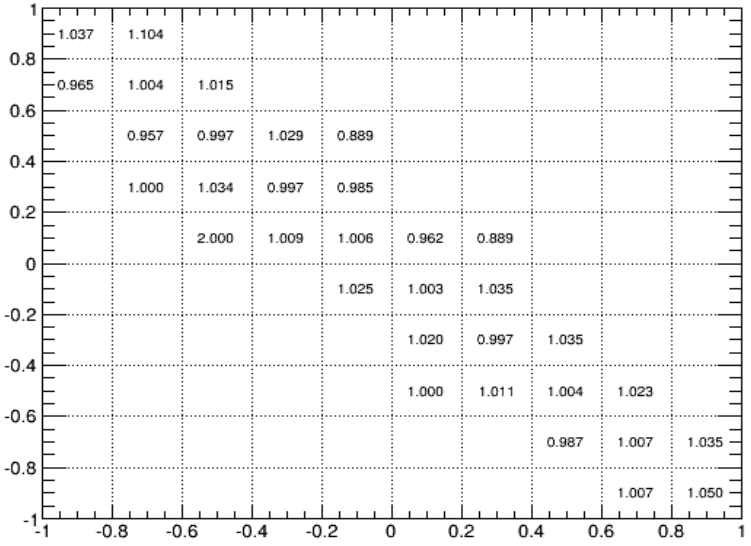
Zbb Prob>0.9





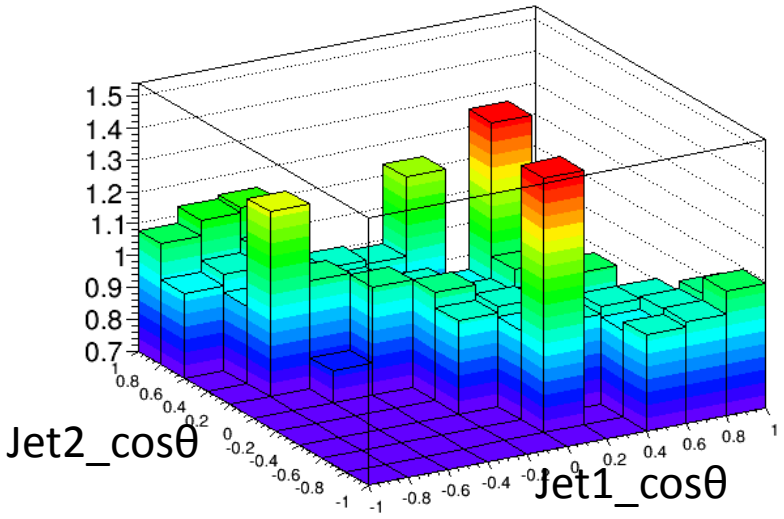
Cut: deltaR<0.4 for jet1 and jet2

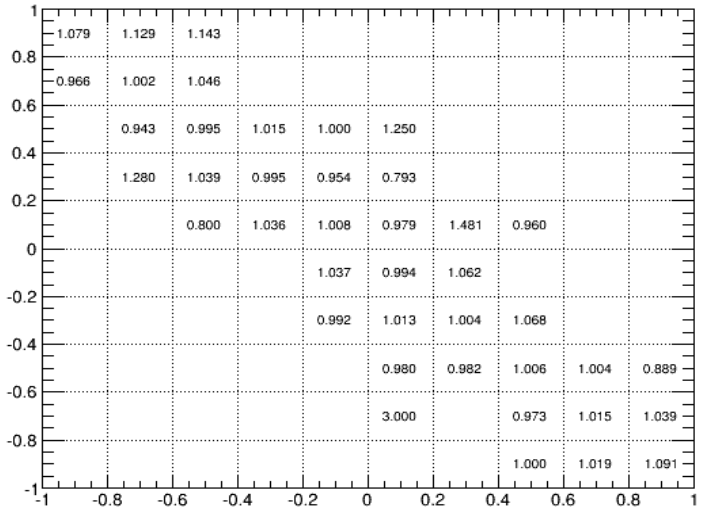




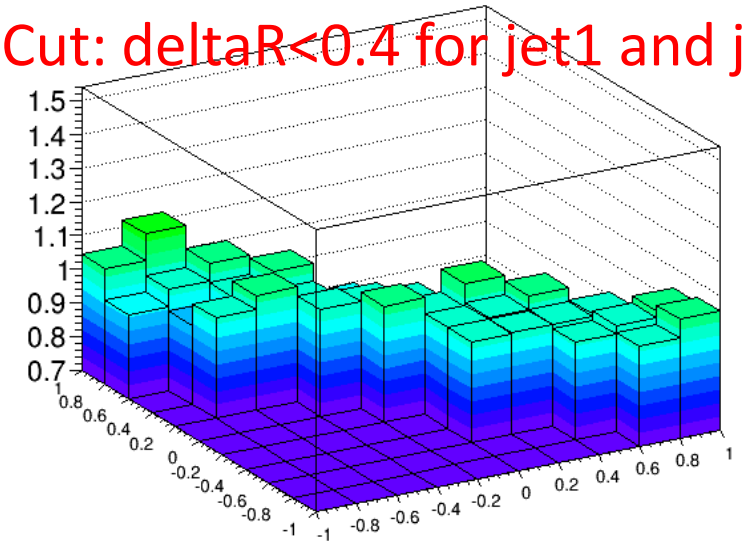
2D Correlation Factor

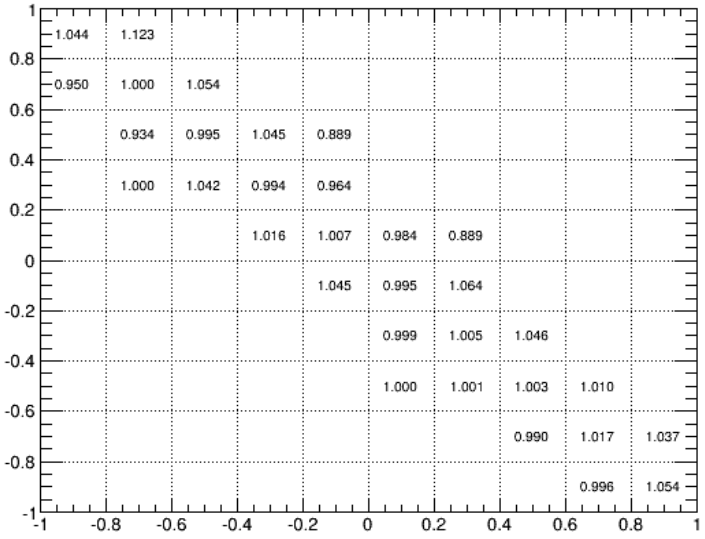
Zbb Prob>0.95





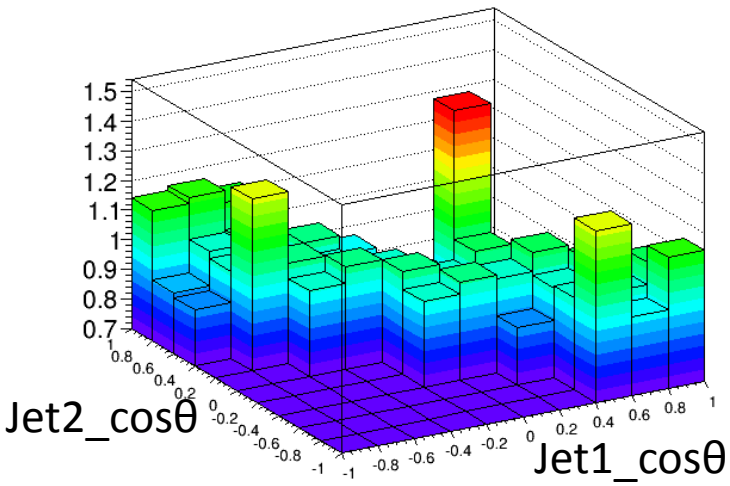
Cut: deltaR<0.4 for jet1 and jet2

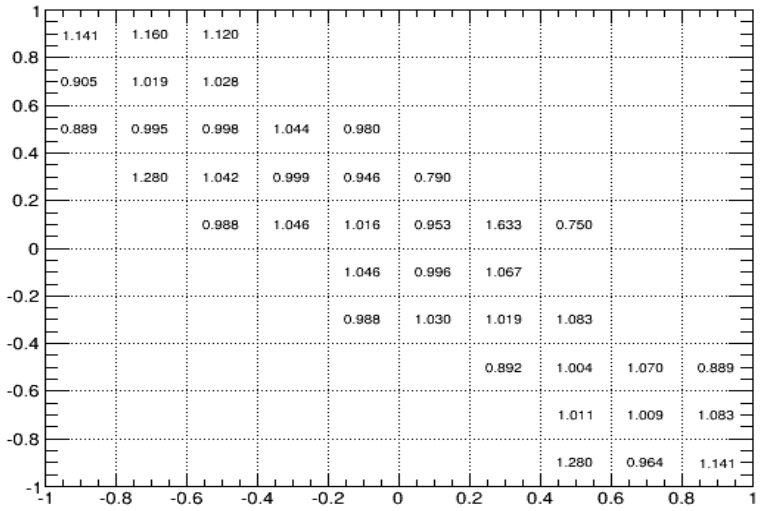




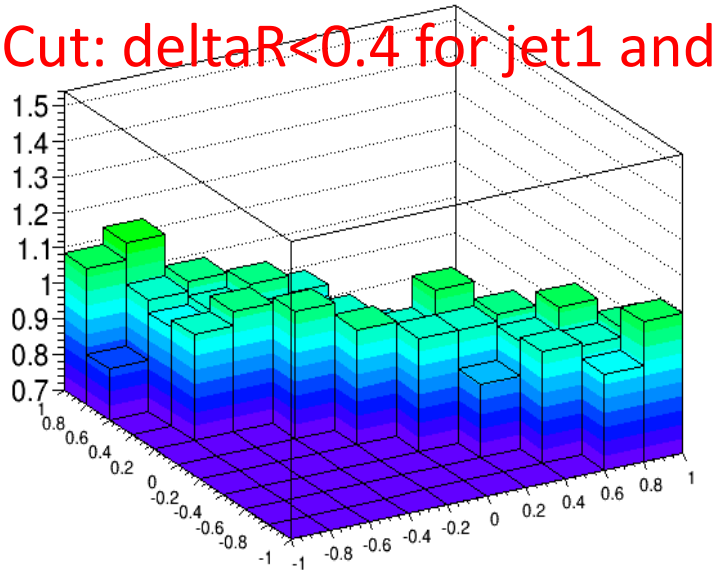
2D Correlation Factor

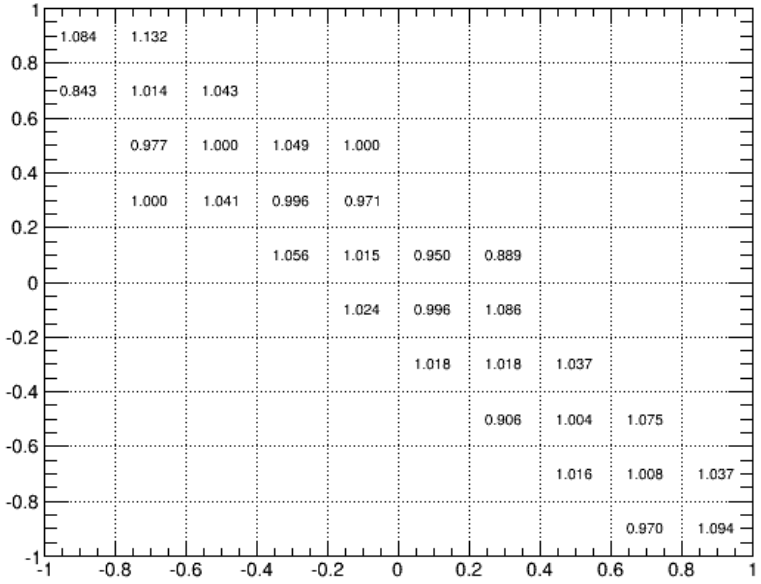
Zbb Prob>0.99





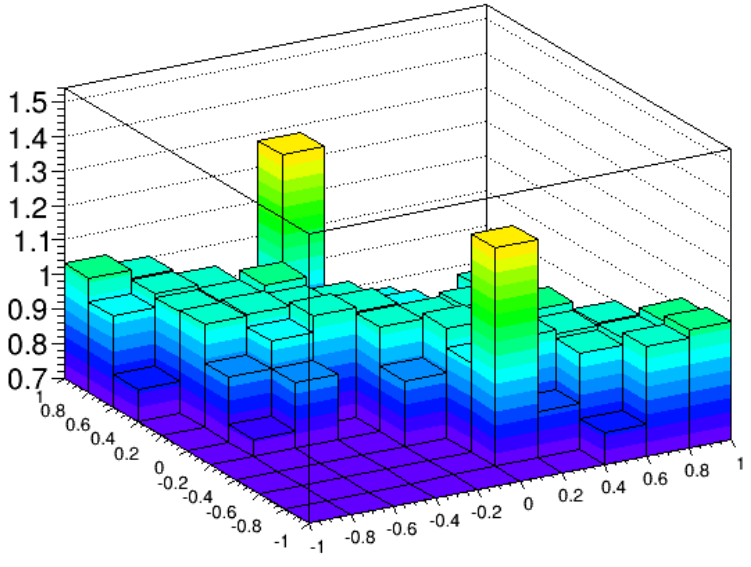
Cut: deltaR<0.4 for jet1 and jet2

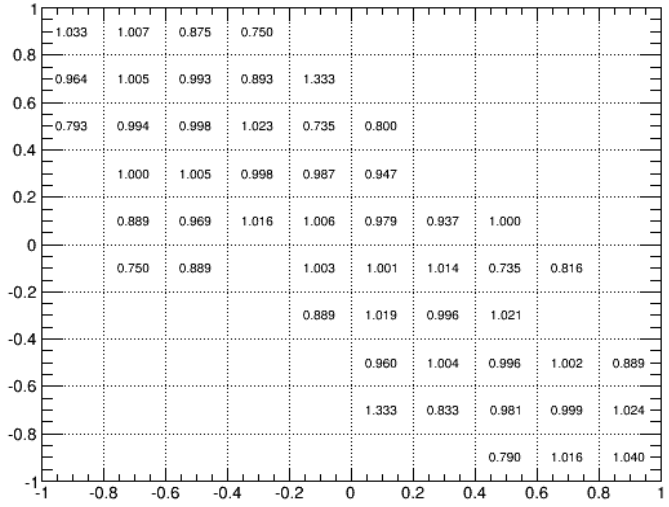


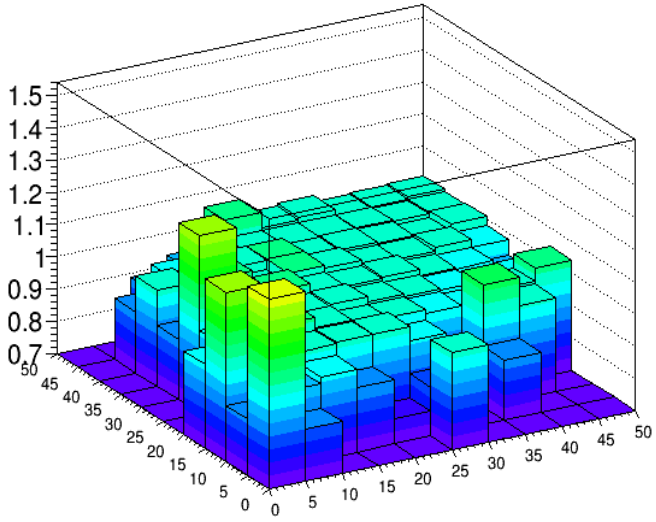


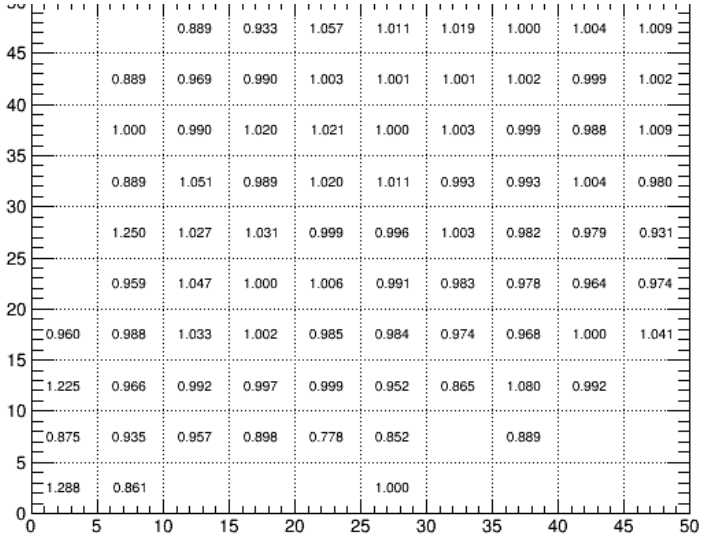
2D Correlation Factor

Zbb Prob>0.6



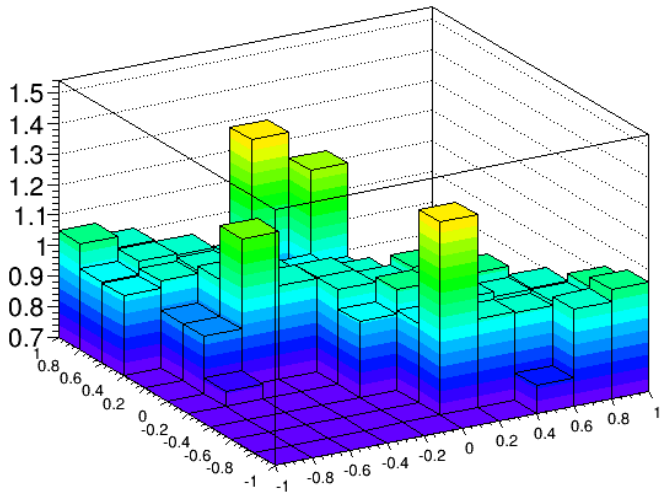


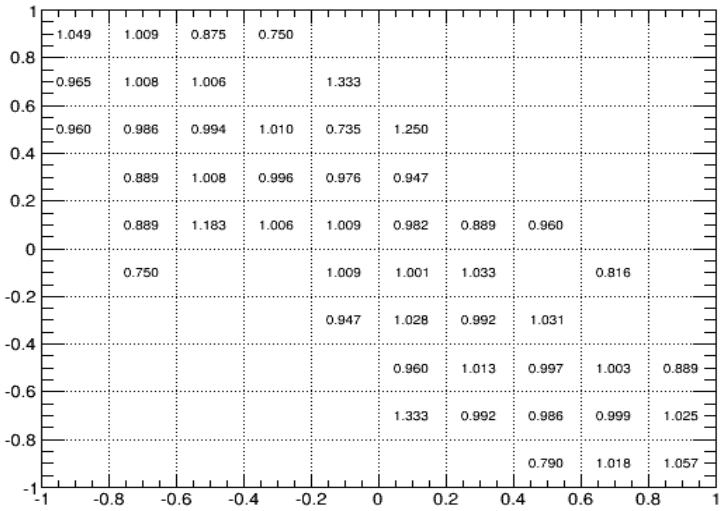


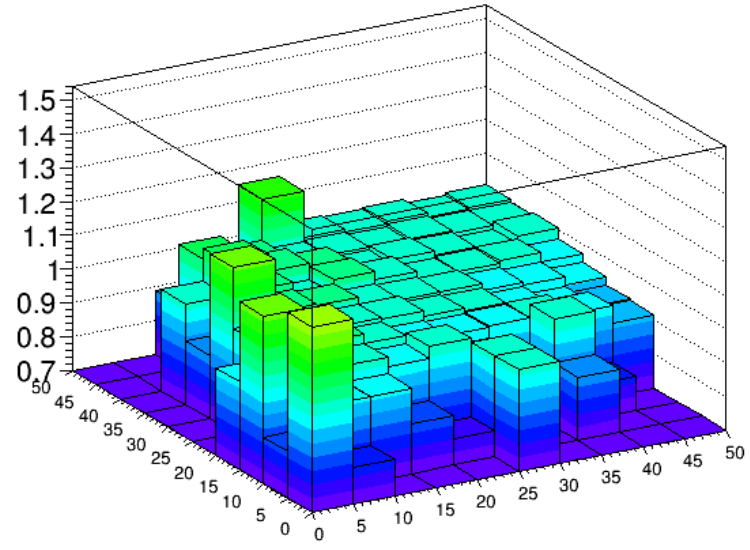


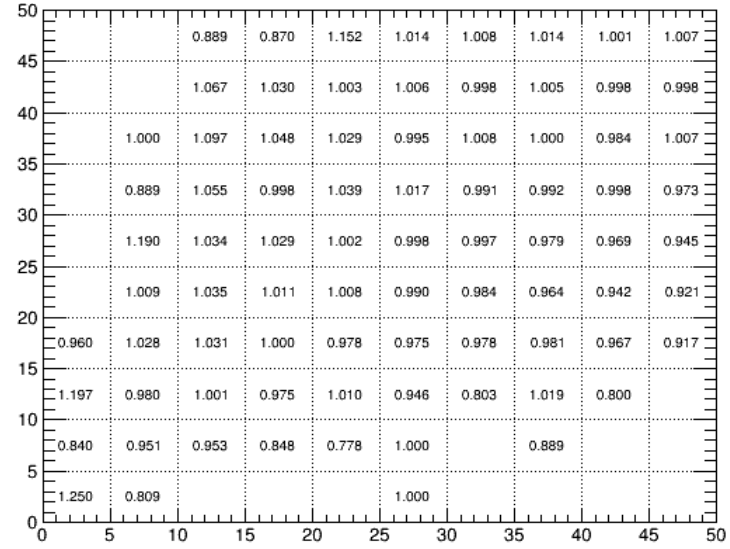
2D Correlation Factor

Zbb Prob>0.7



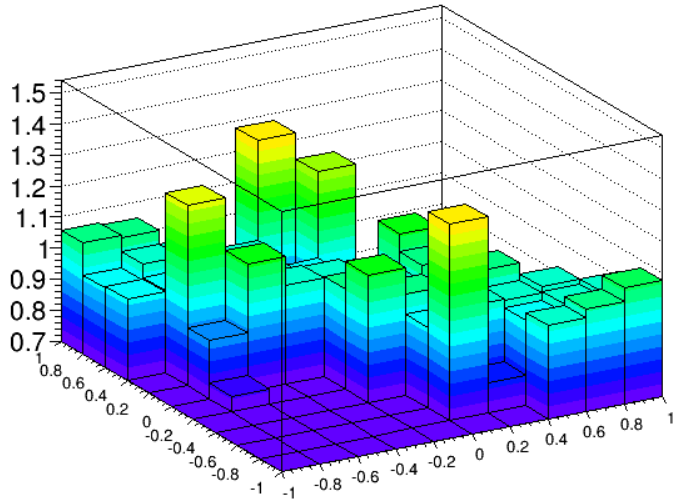


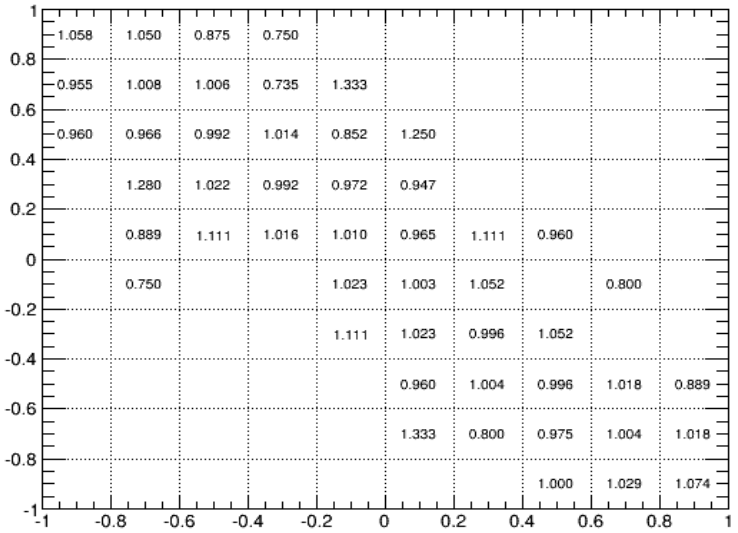


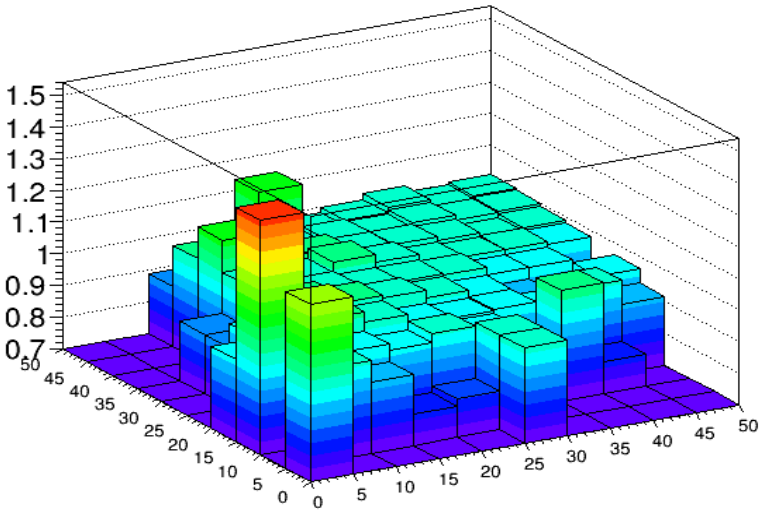


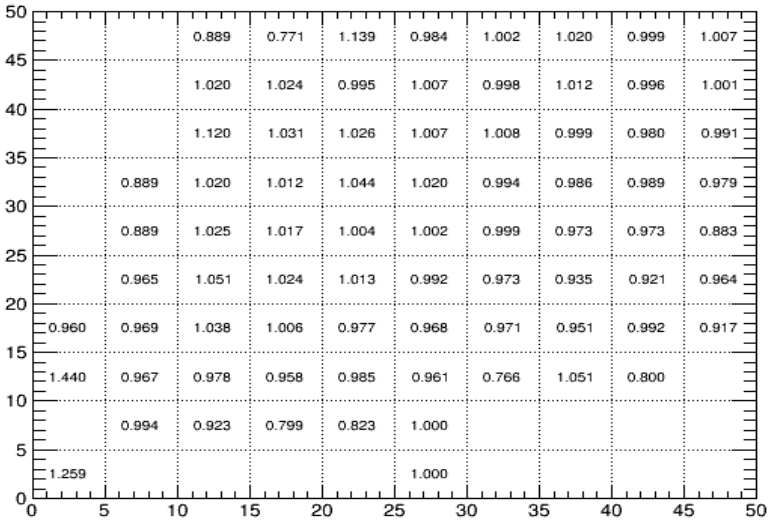
2D Correlation Factor

Zbb Prob>0.8



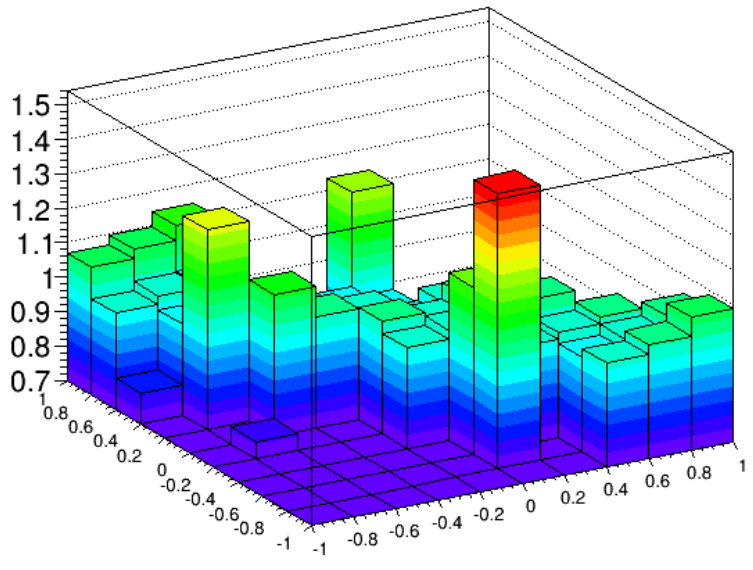


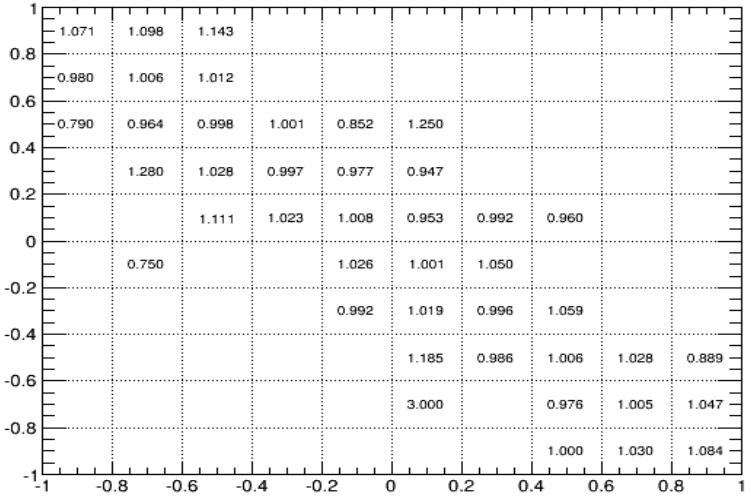


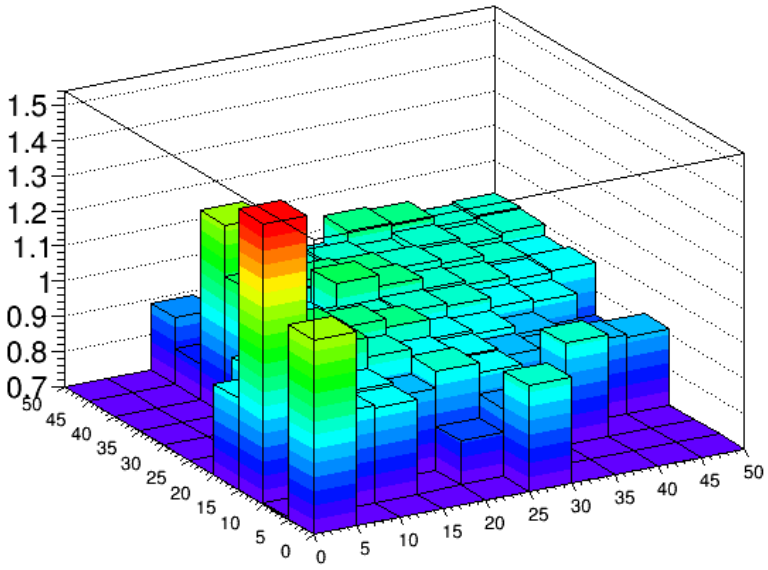


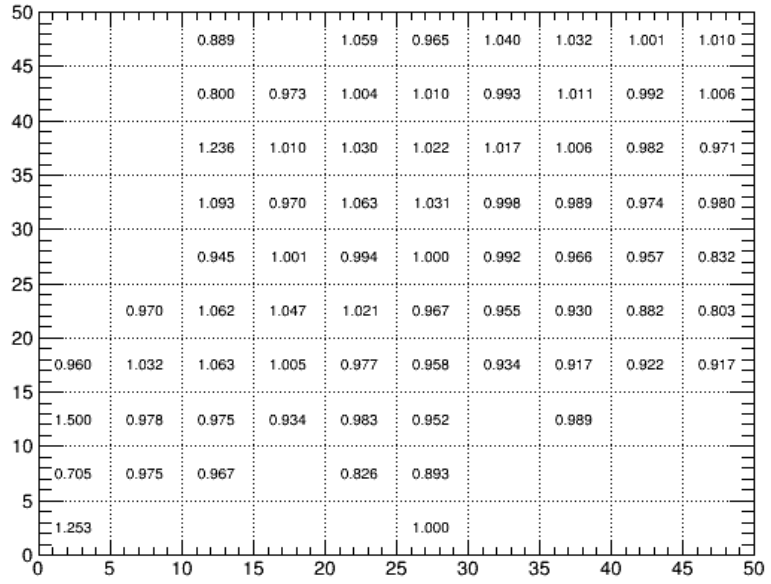
2D Correlation Factor

Zbb Prob>0.9



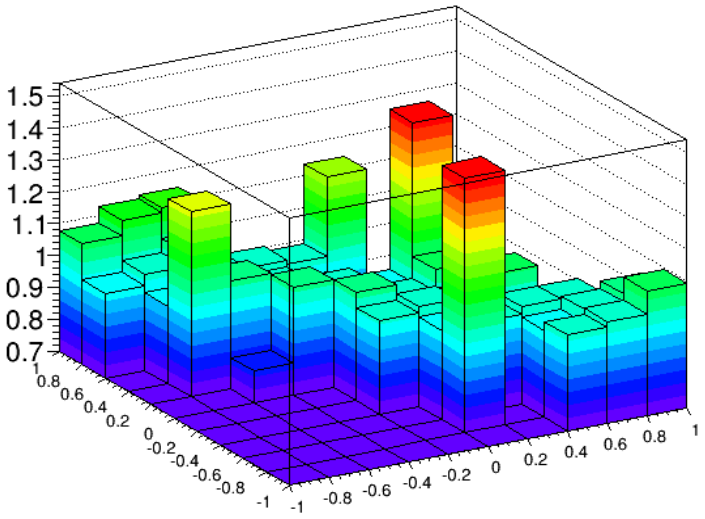


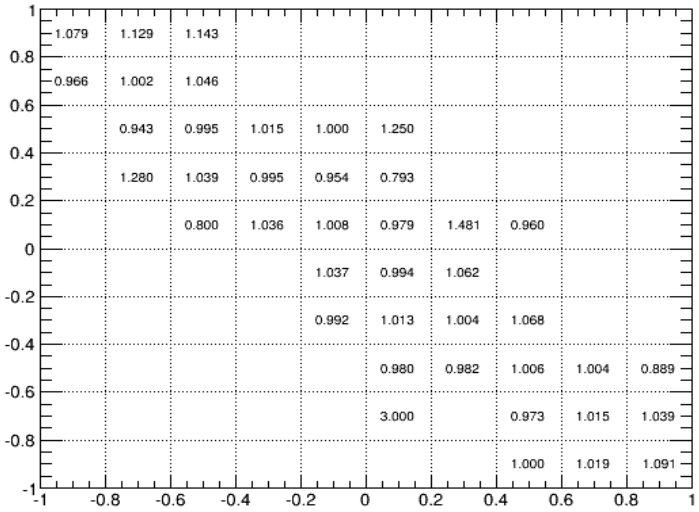


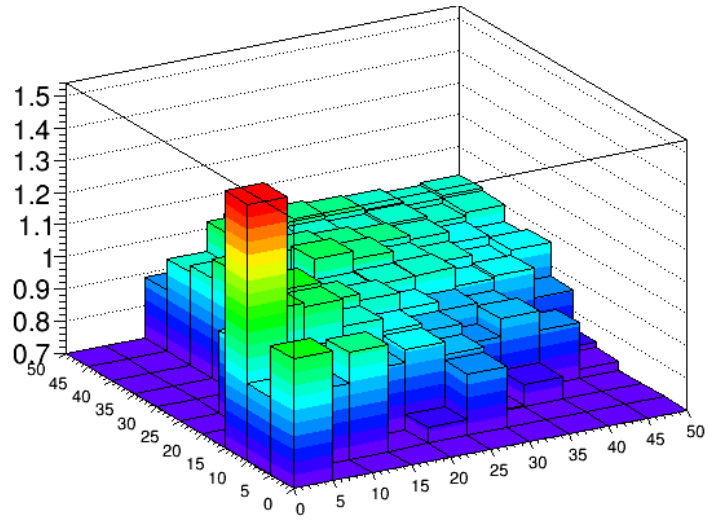


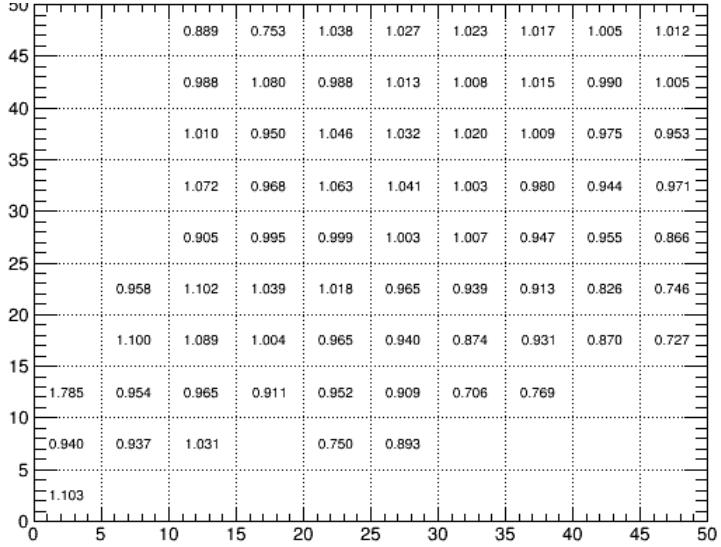
2D Correlation Factor

Zbb Prob>0.95



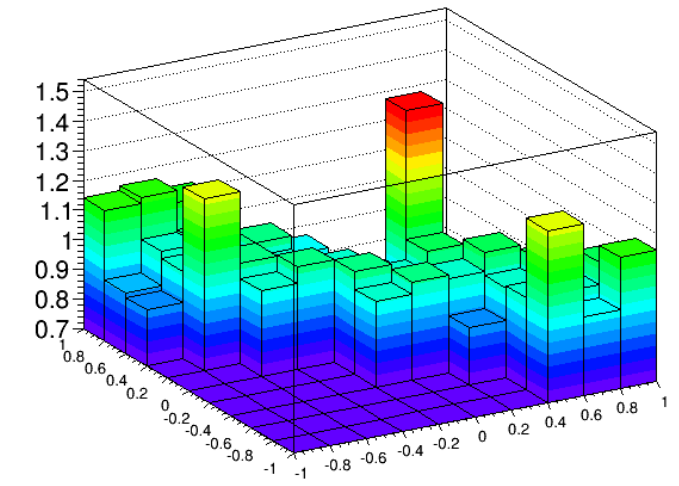


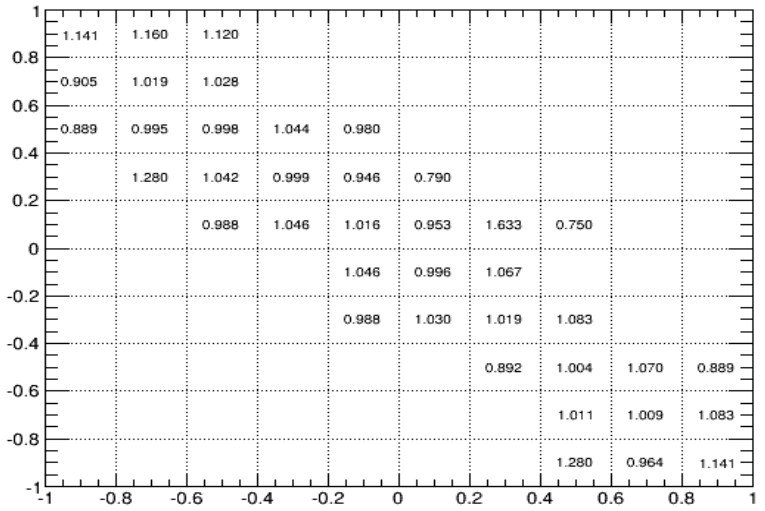


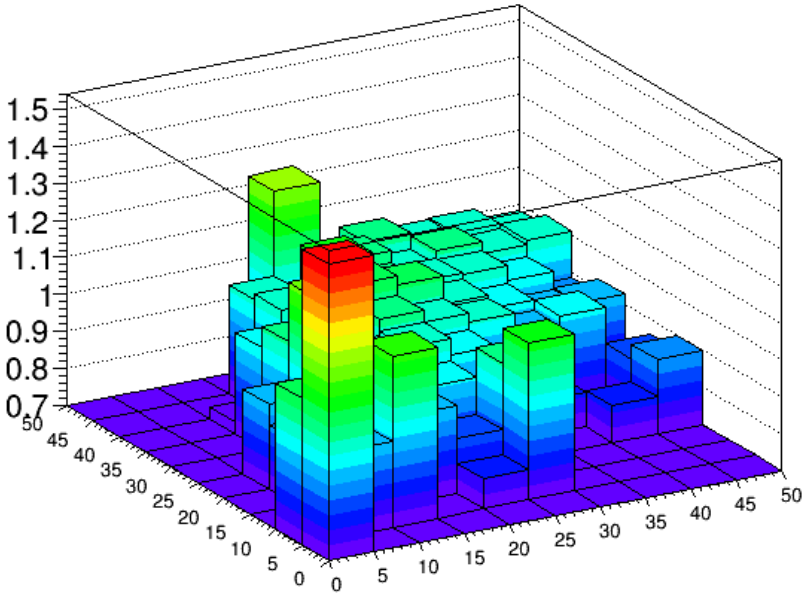


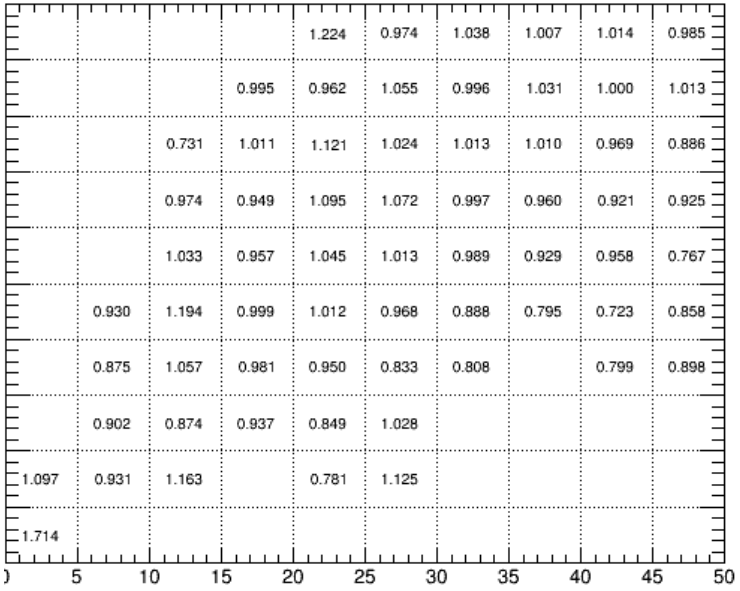
2D Correlation Factor

Zbb Prob>0.99



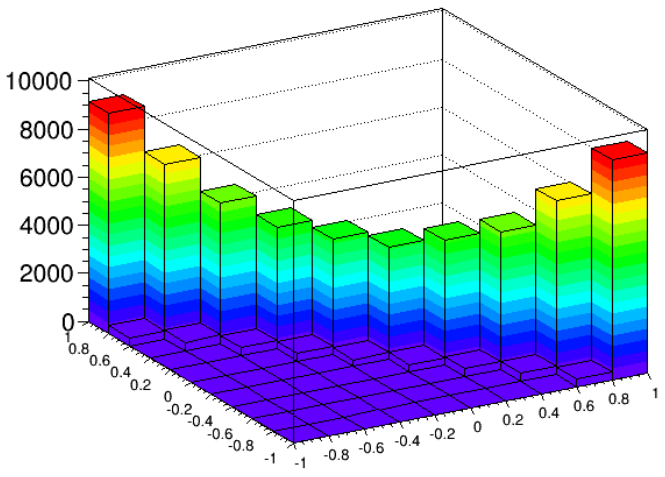


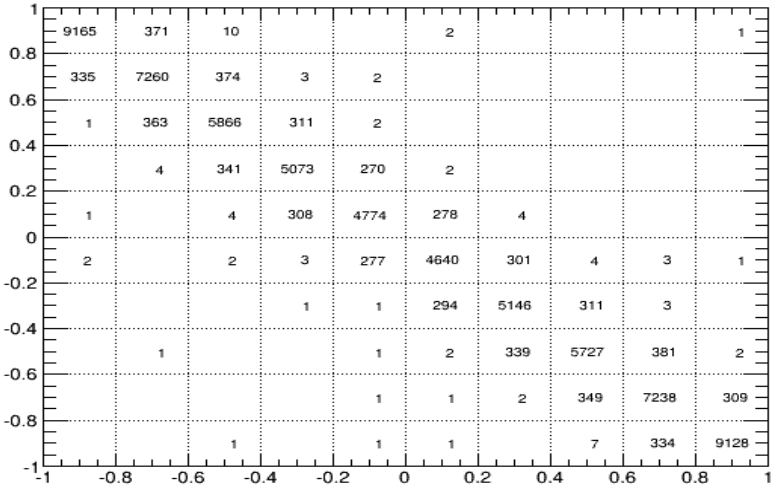


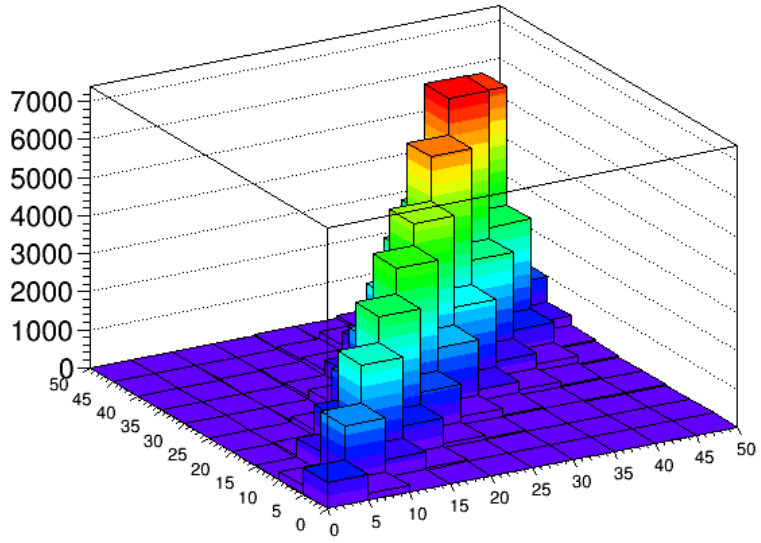


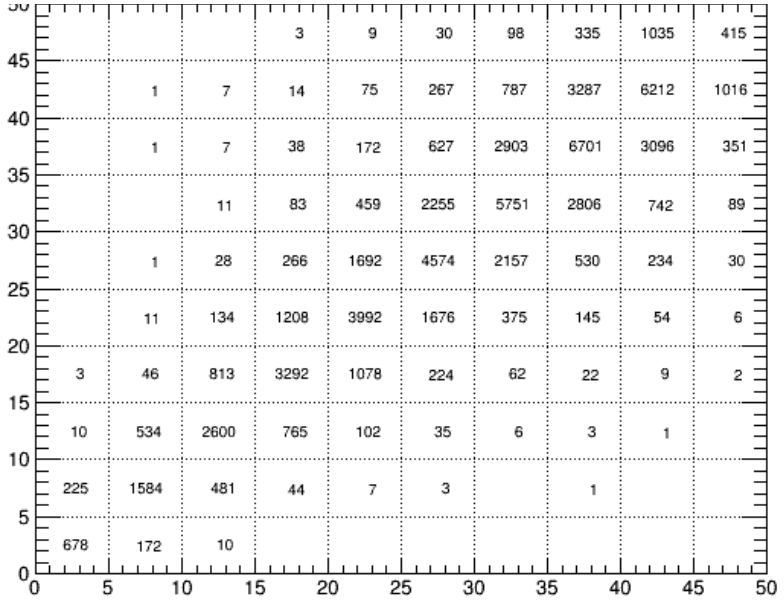
2D Correlation Factor

ZCC



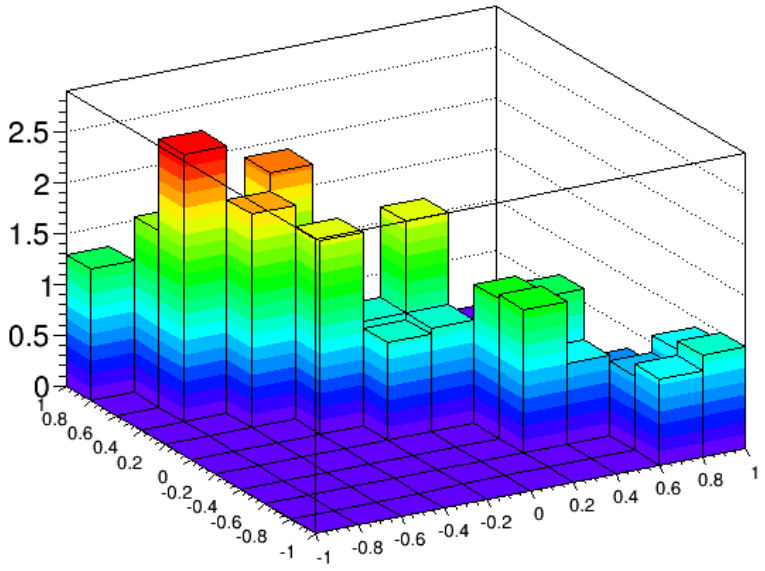


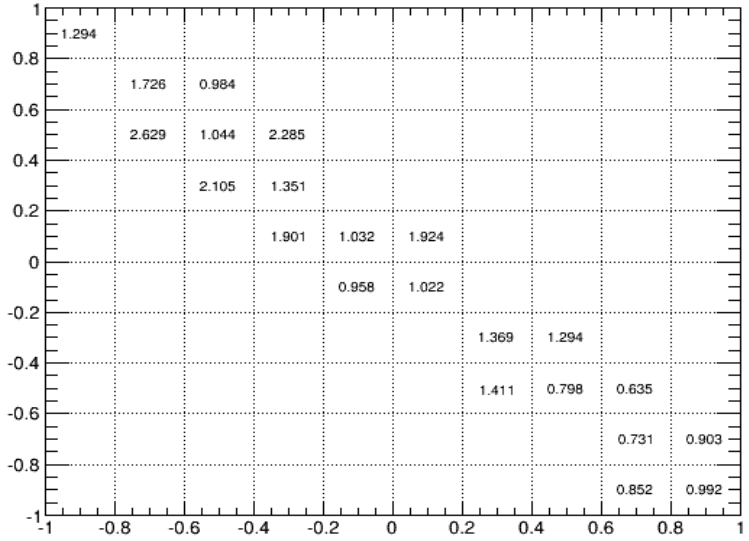


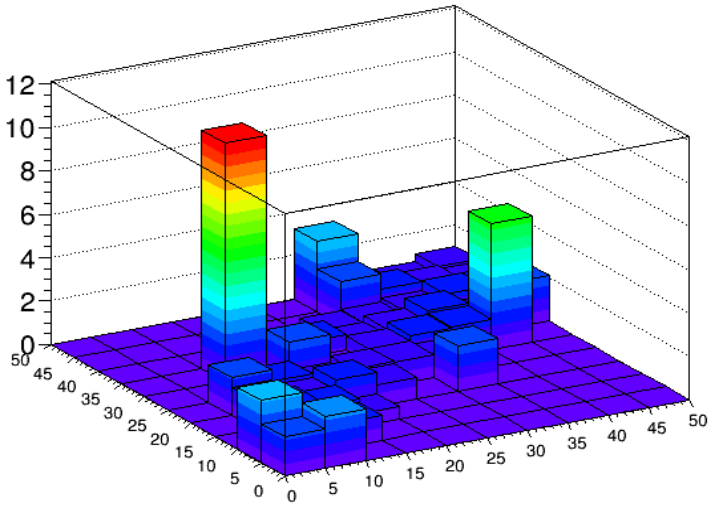


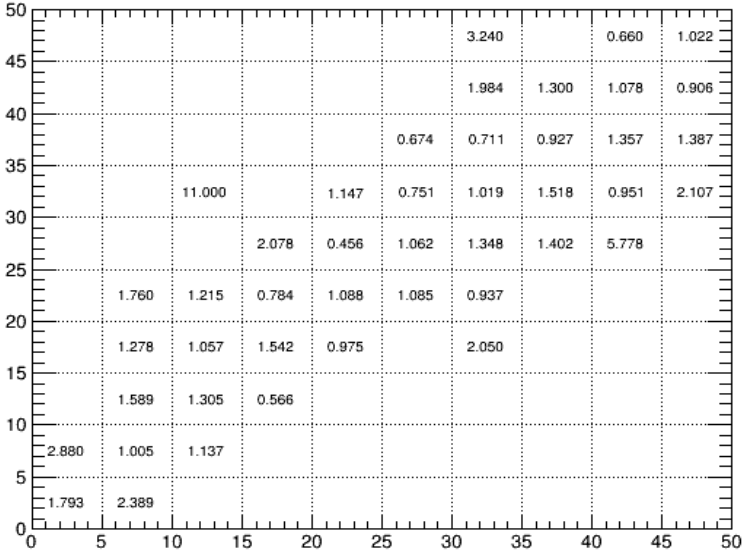
2D Correlation Factor

Zcc Prob>0.6



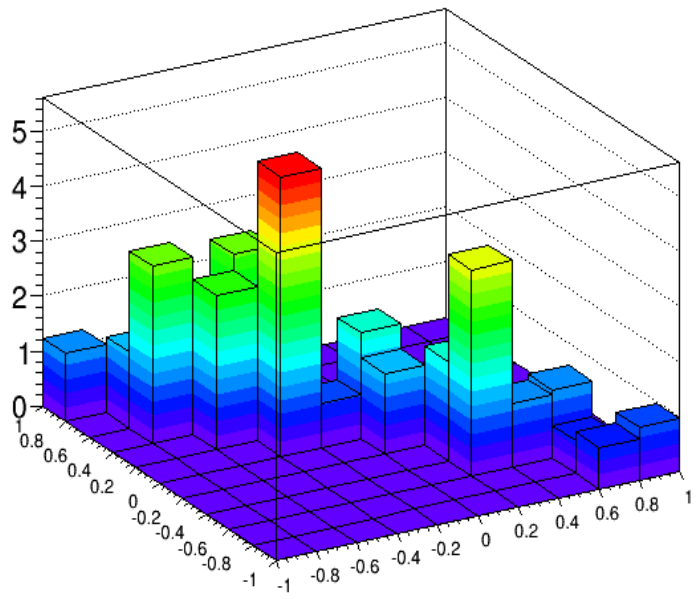


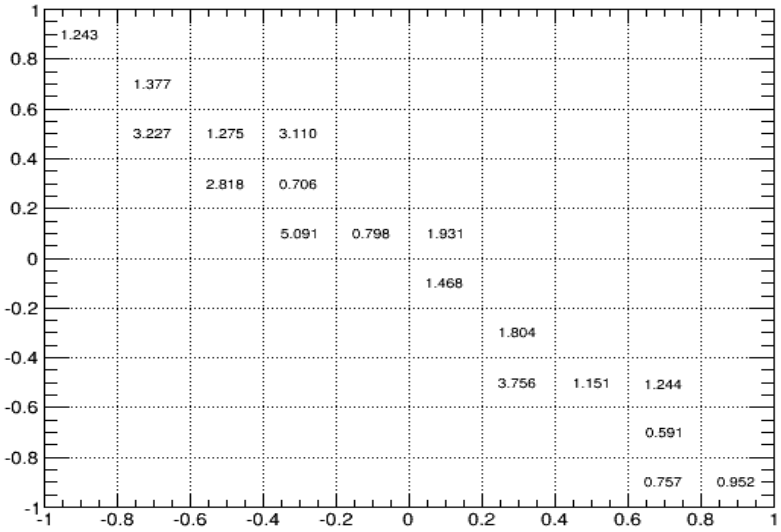


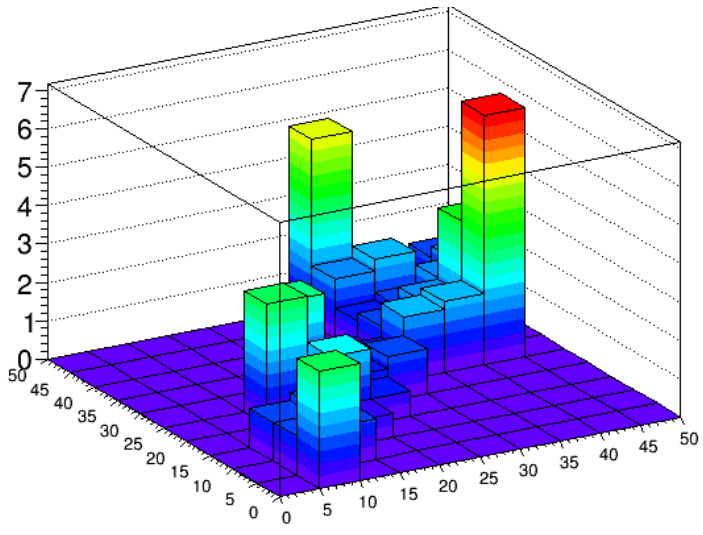


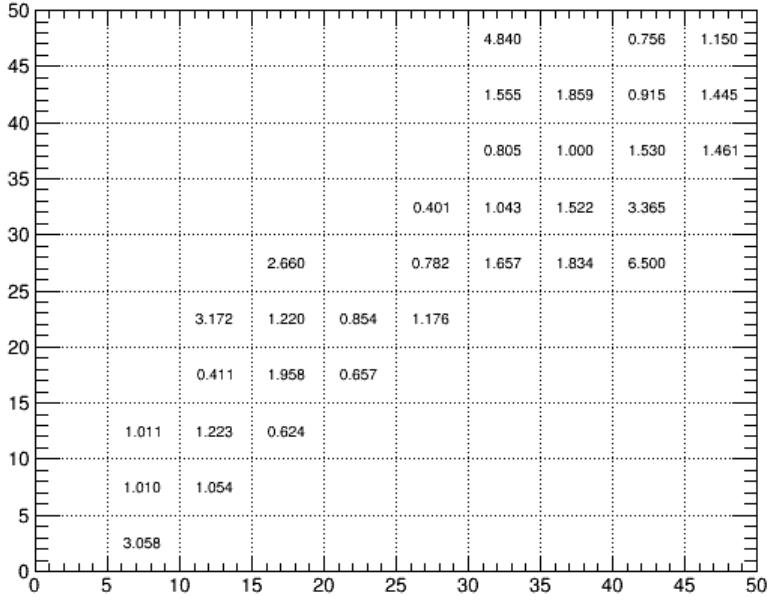
2D Correlation Factor

Zcc Prob>0.7



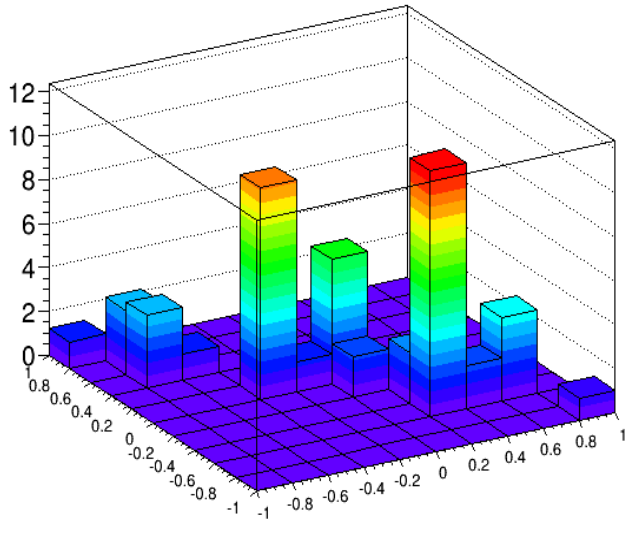


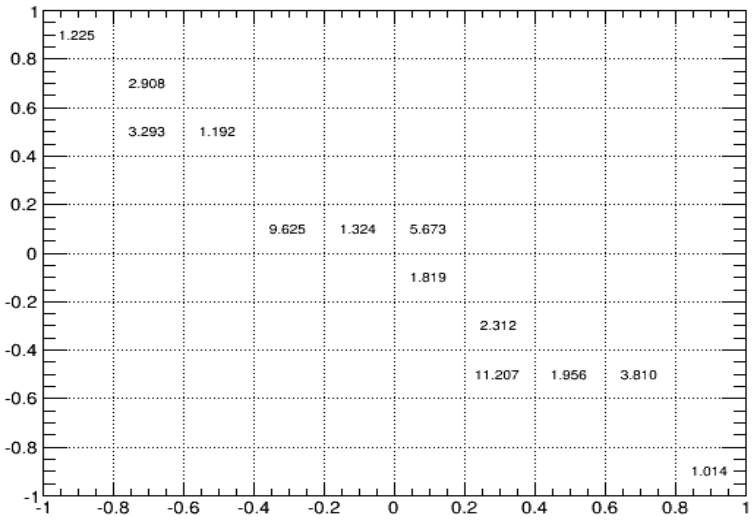


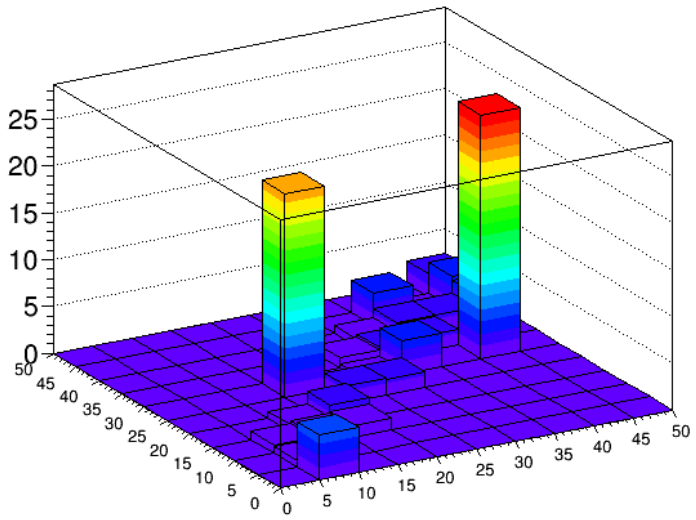


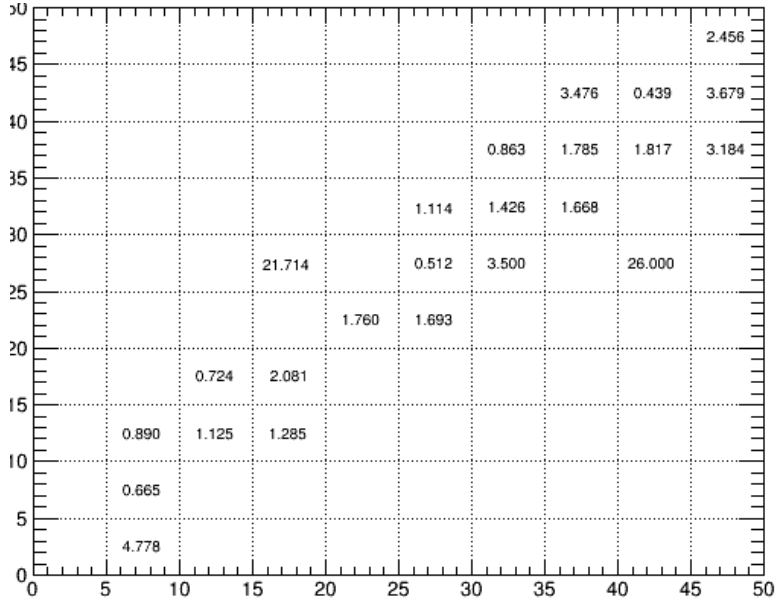
2D Correlation Factor

Zcc Prob>0.8



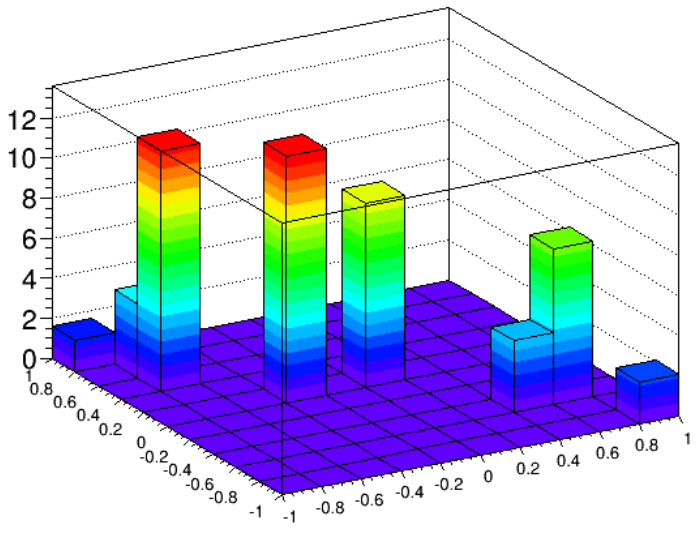


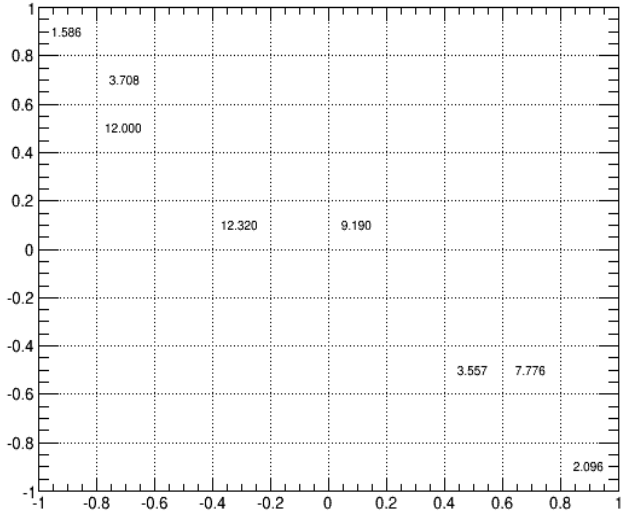


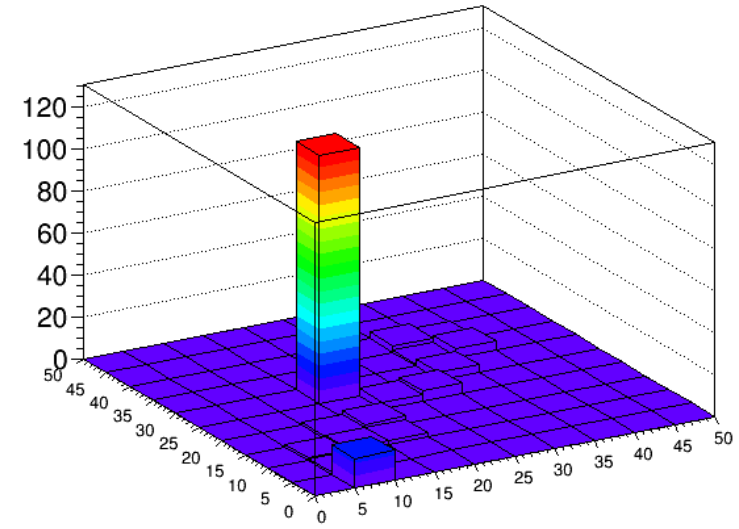


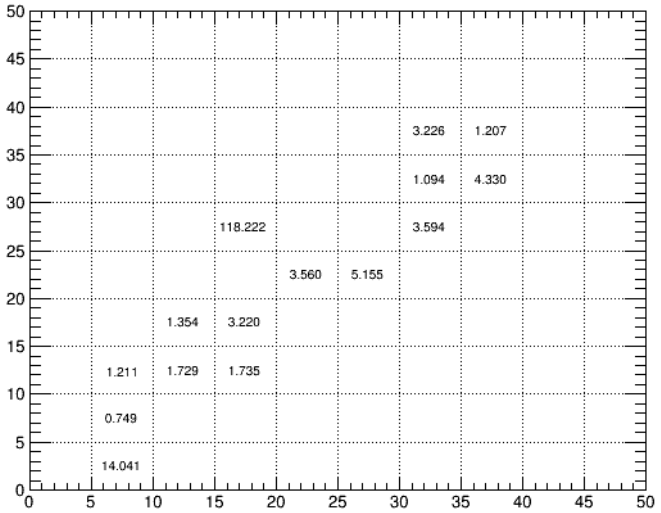
2D Correlation Factor

Zcc Prob>0.9



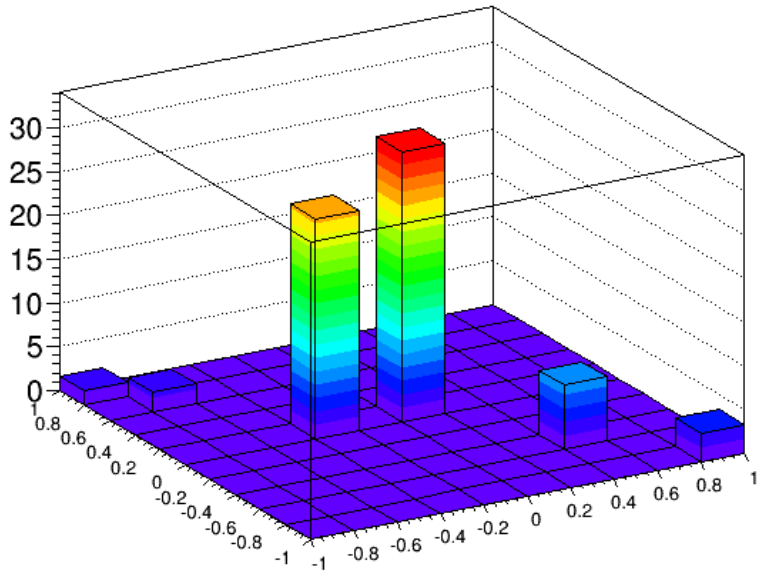


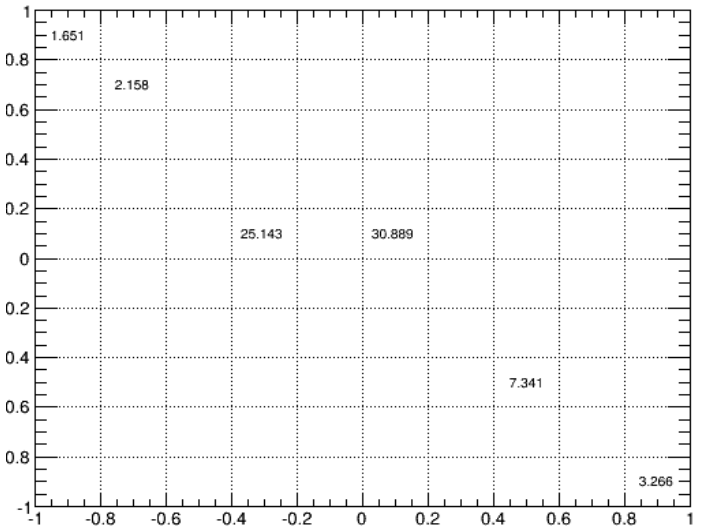


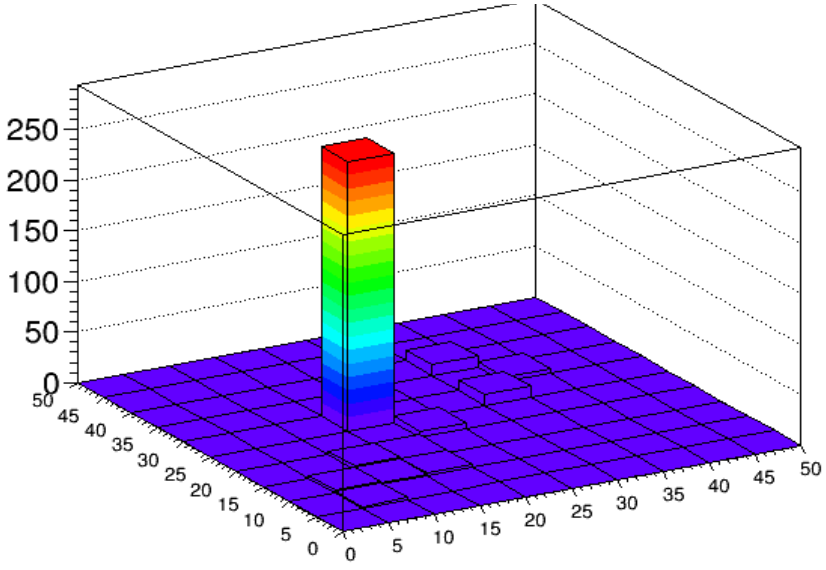


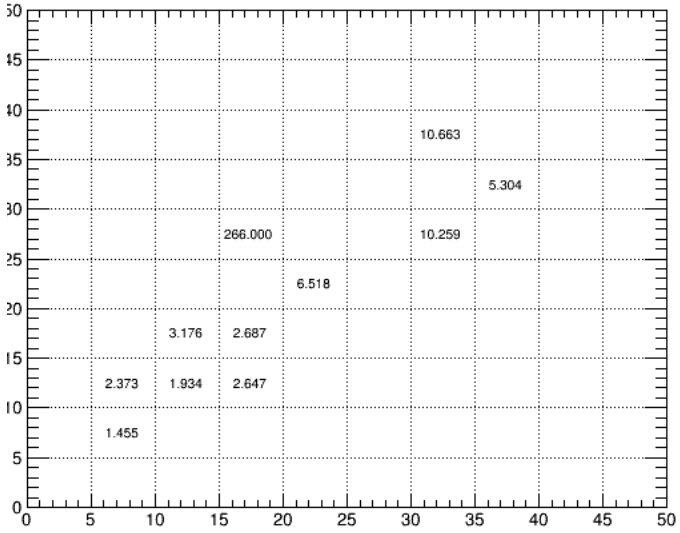
2D Correlation Factor

Zcc Prob>0.95



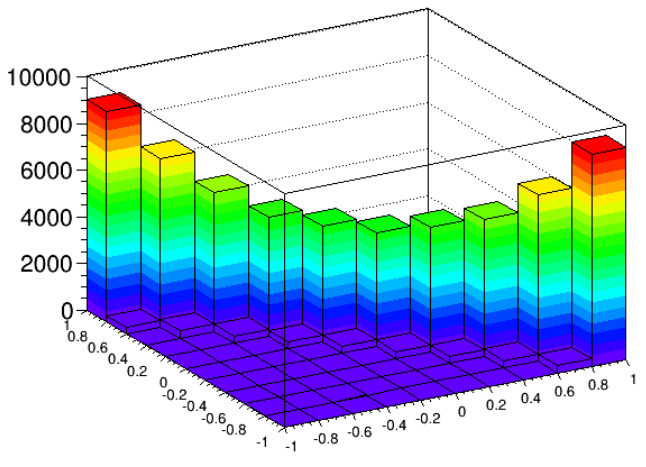


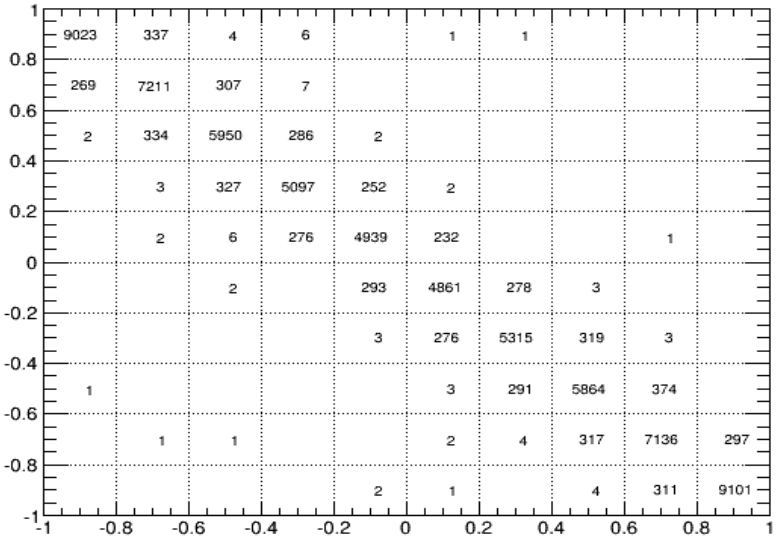


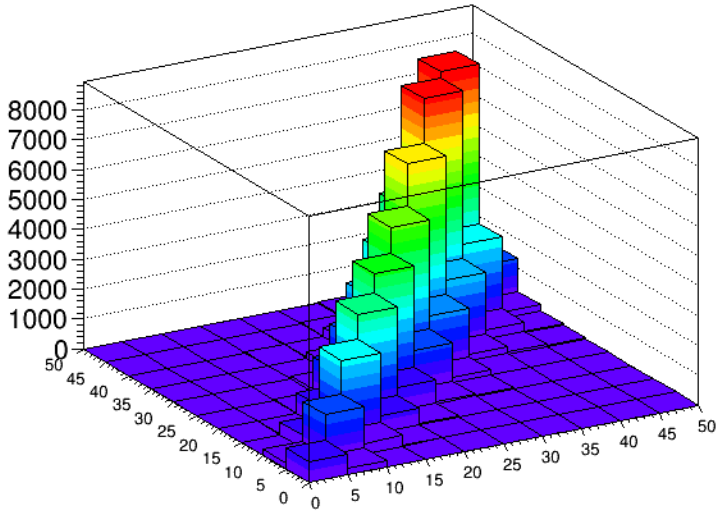


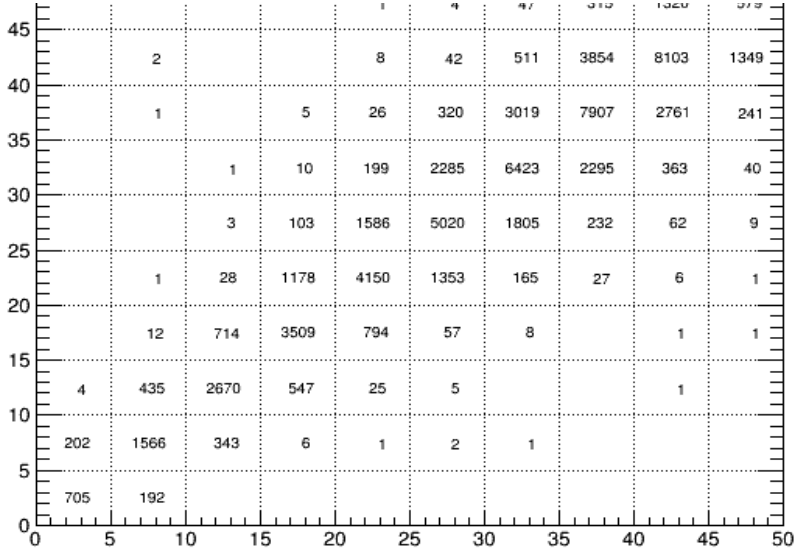
2D Correlation Factor

Zuds



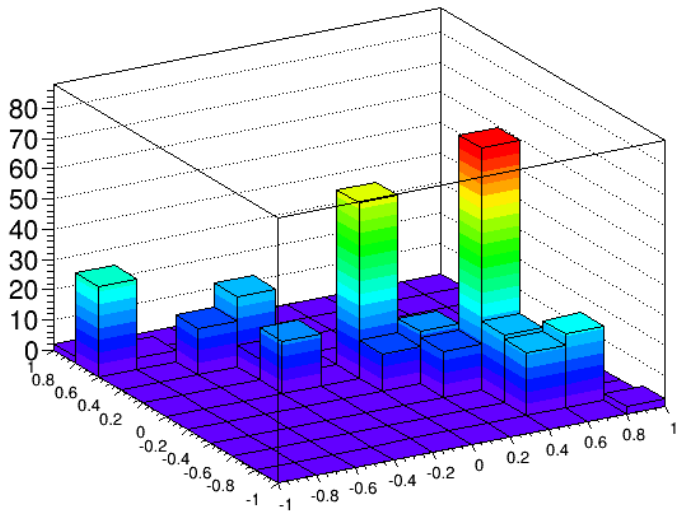


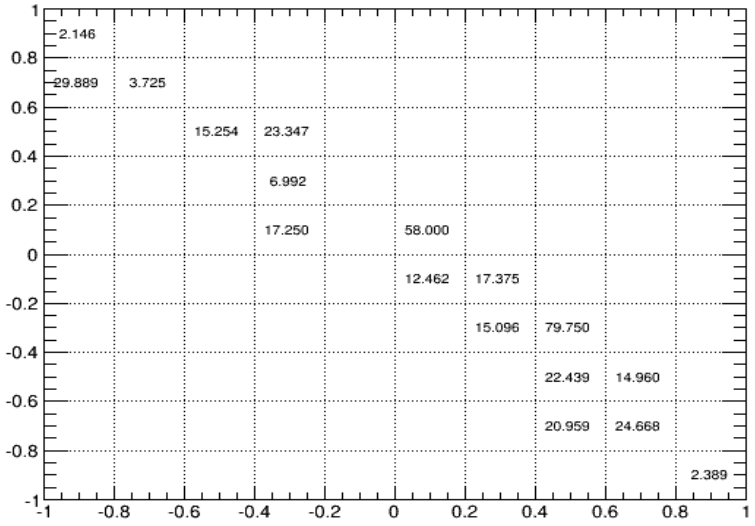


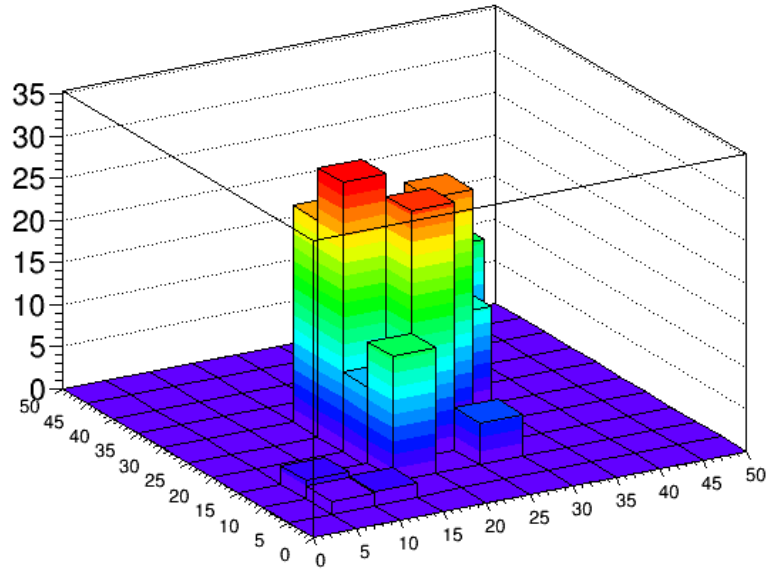


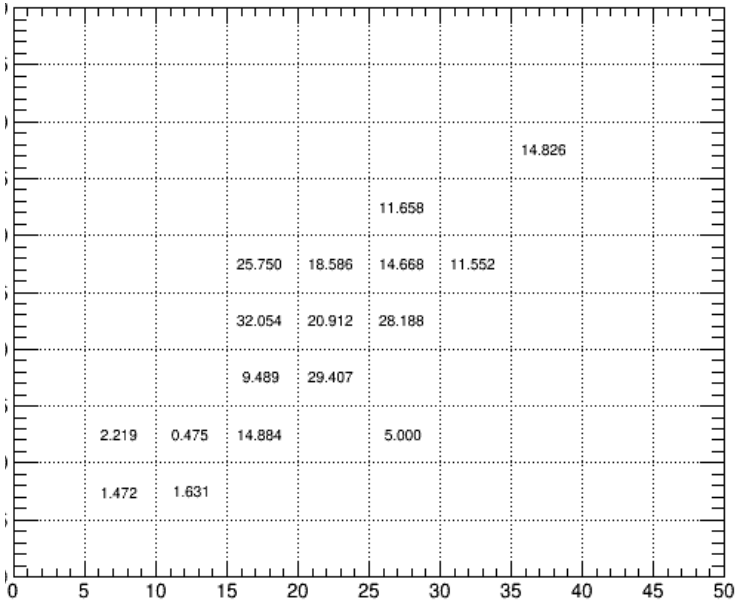
2D Correlation Factor

Zuds Prob>0.6



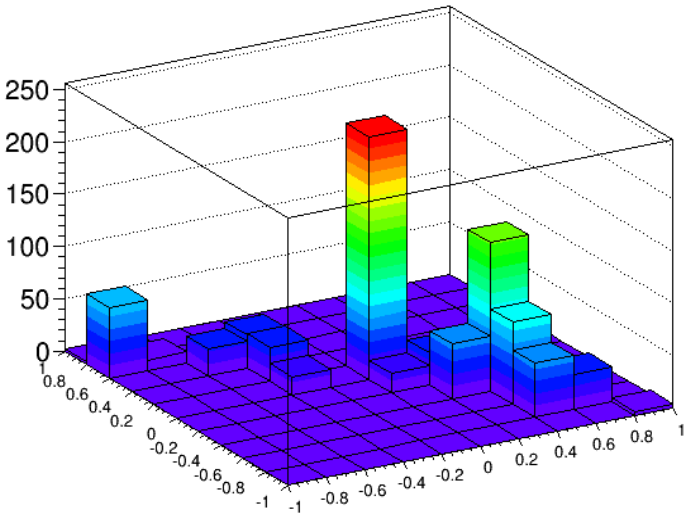


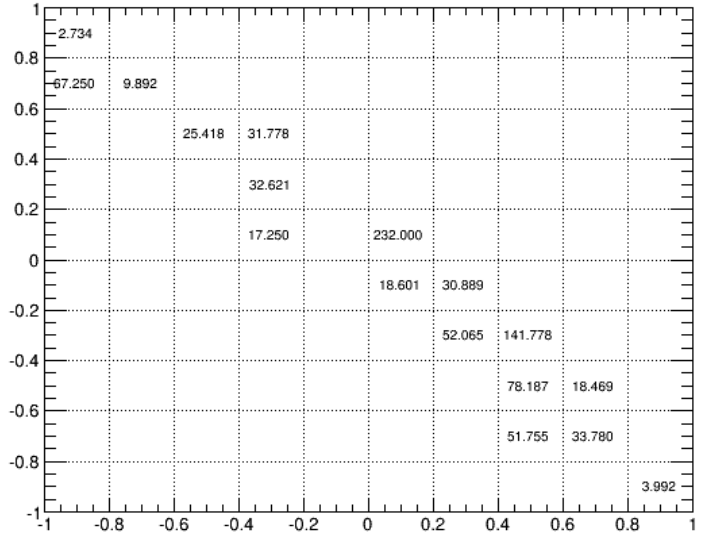


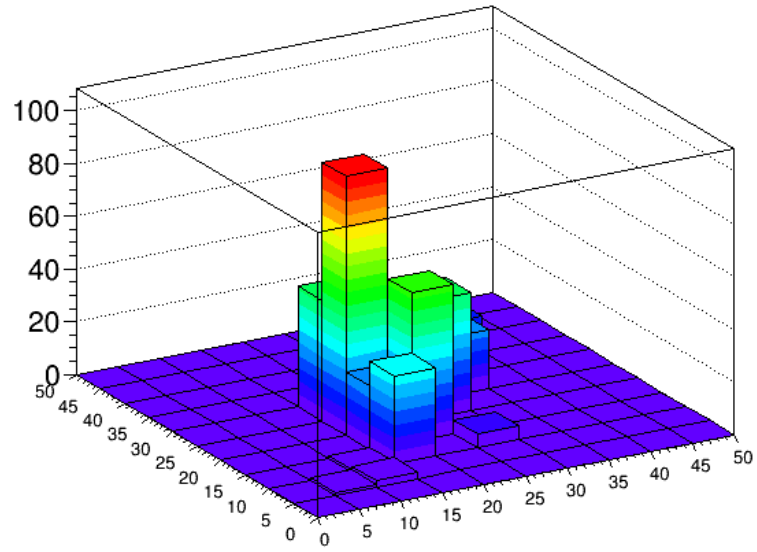


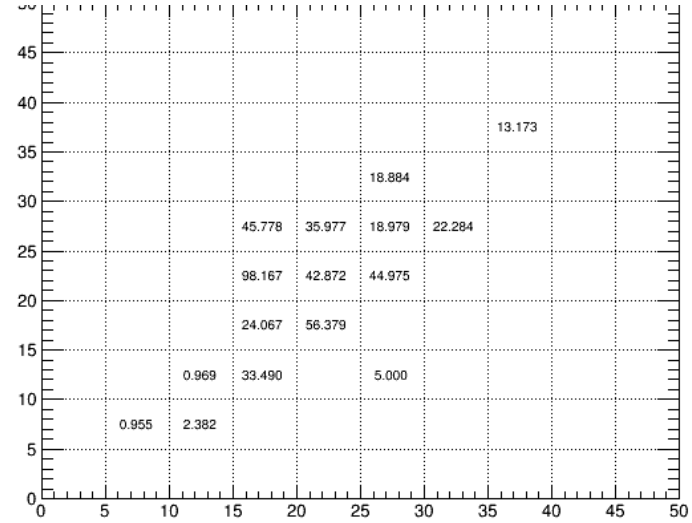
2D Correlation Factor

Zuds Prob>0.7



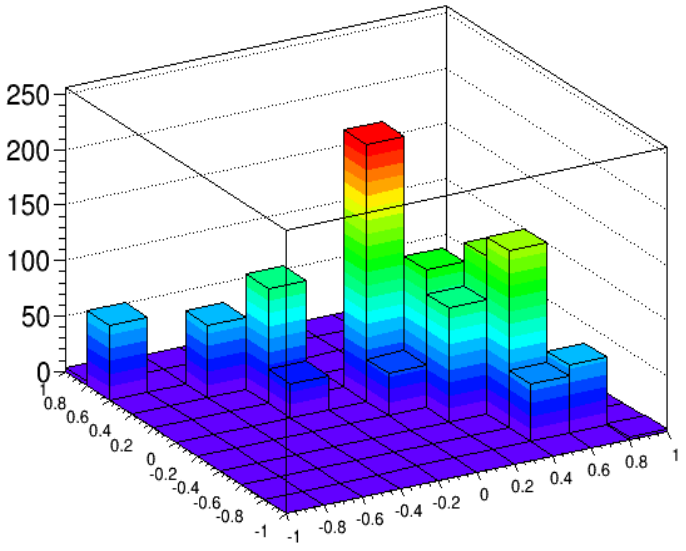


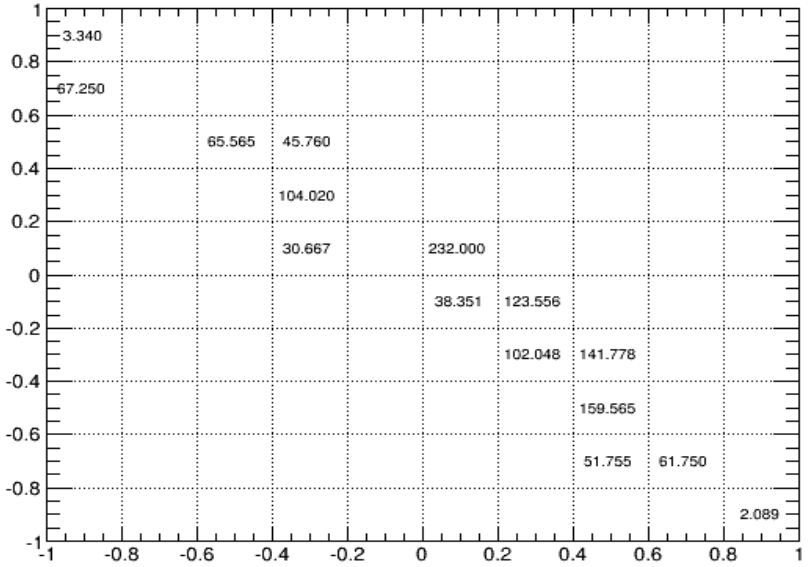


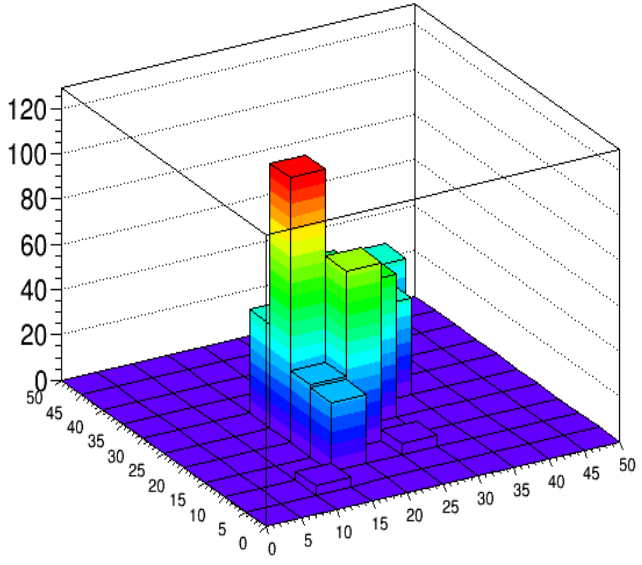


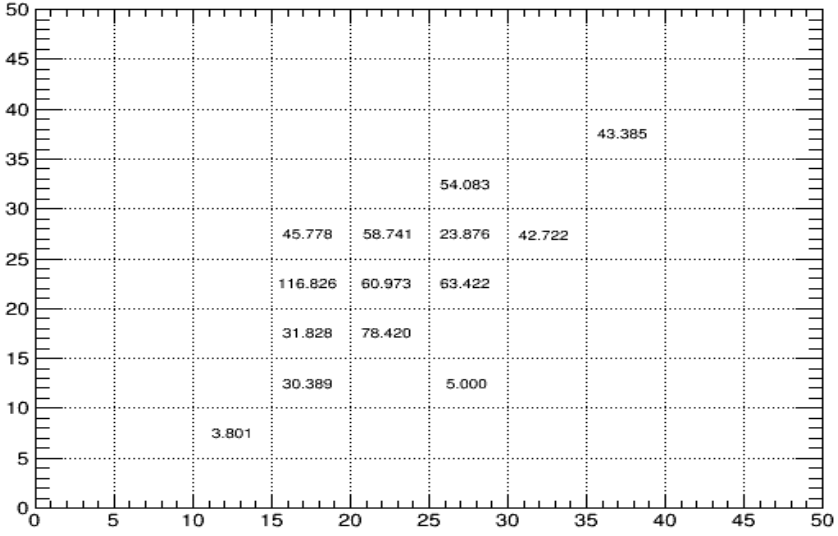
2D Correlation Factor

Zuds Prob>0.8



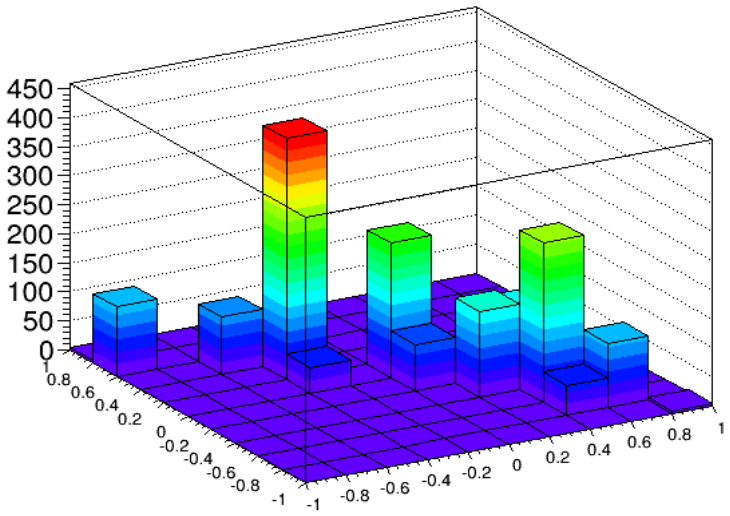


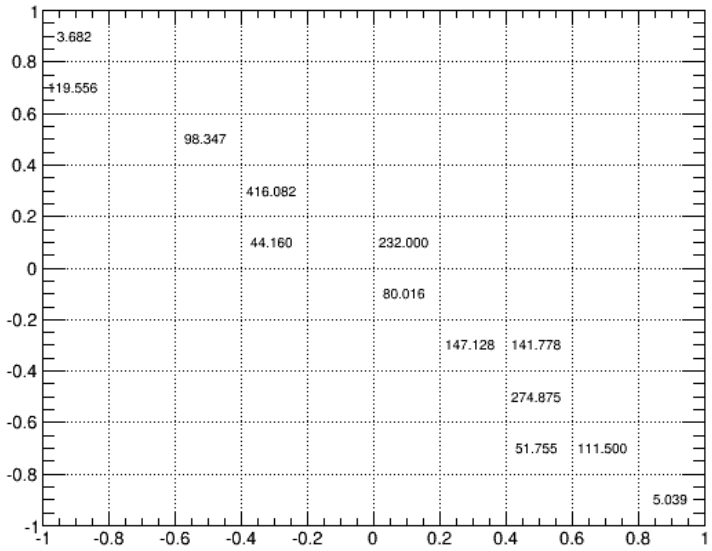


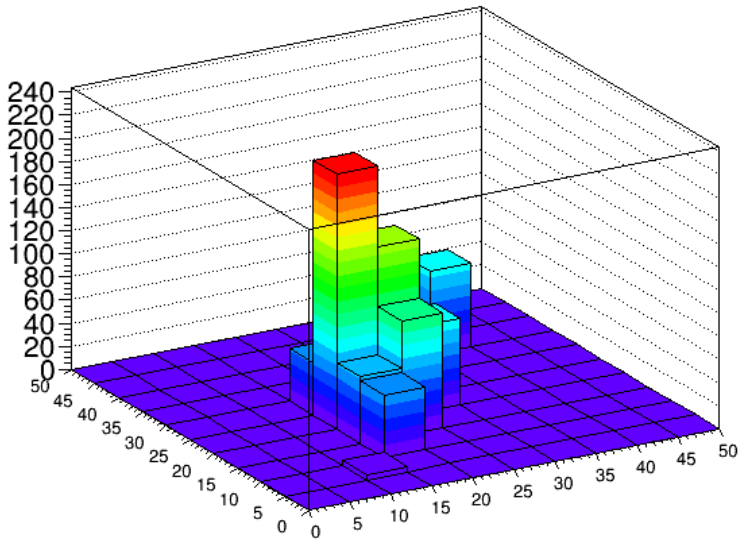


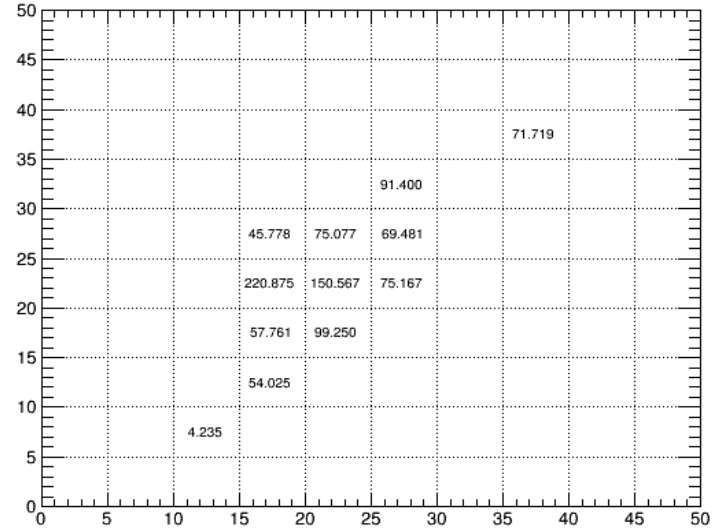
2D Correlation Factor

Zuds Prob>0.9



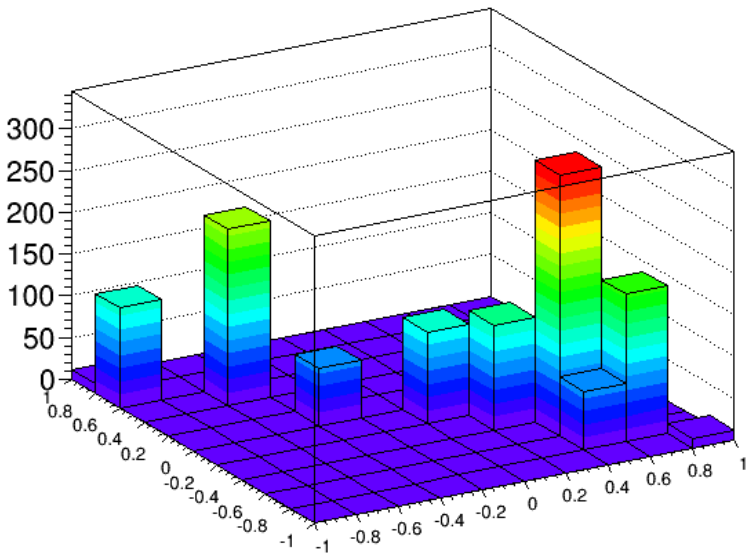


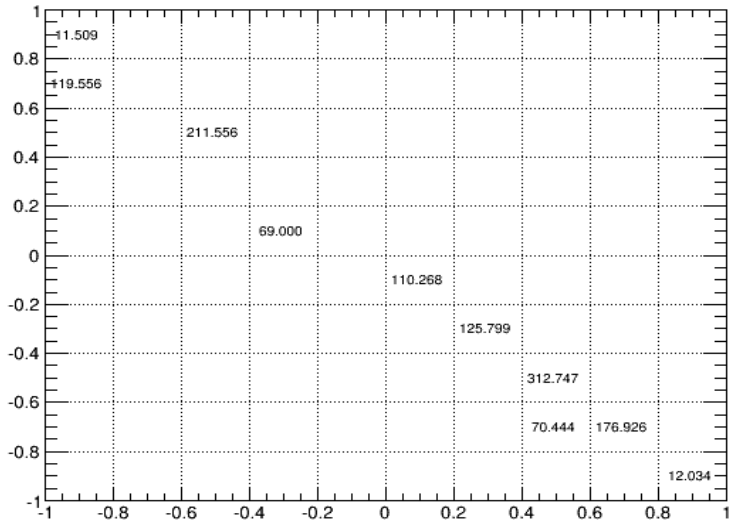


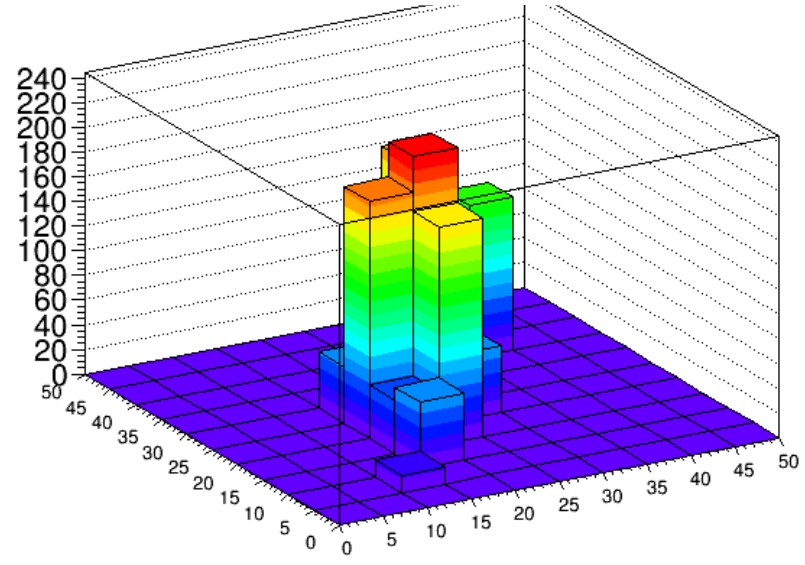


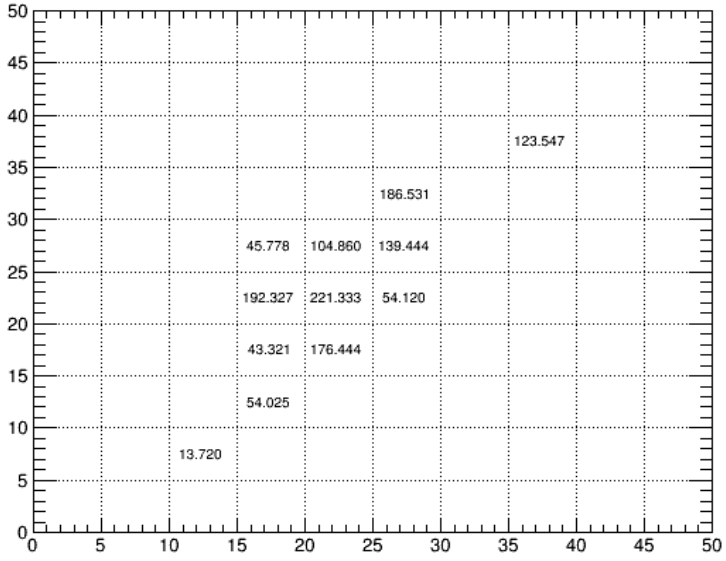
2D Correlation Factor

Zuds Prob>0.95



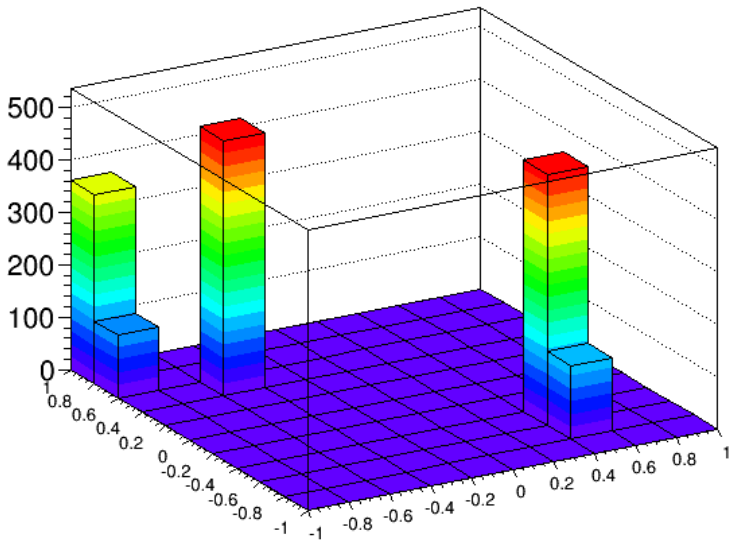


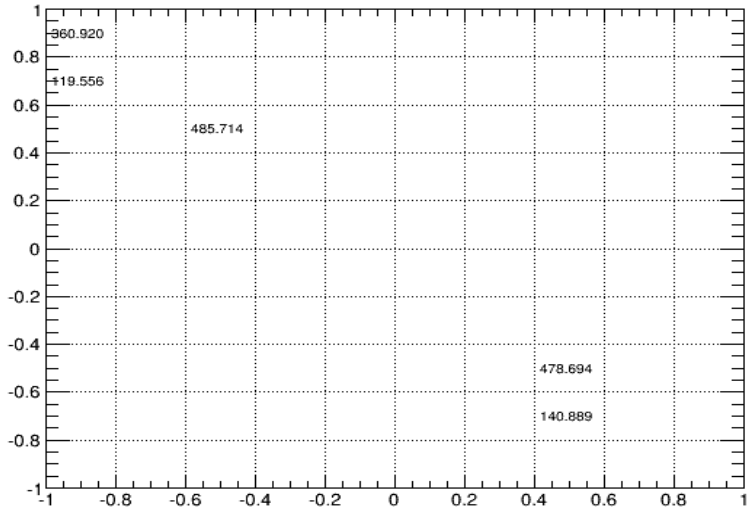


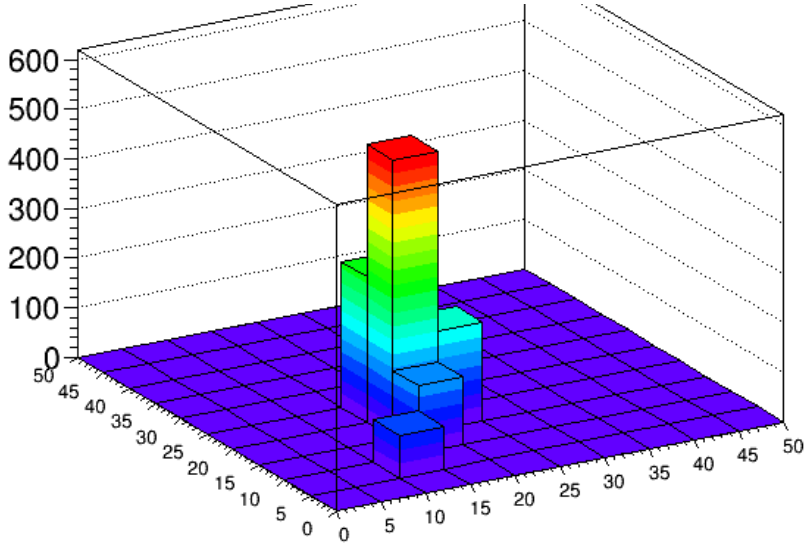


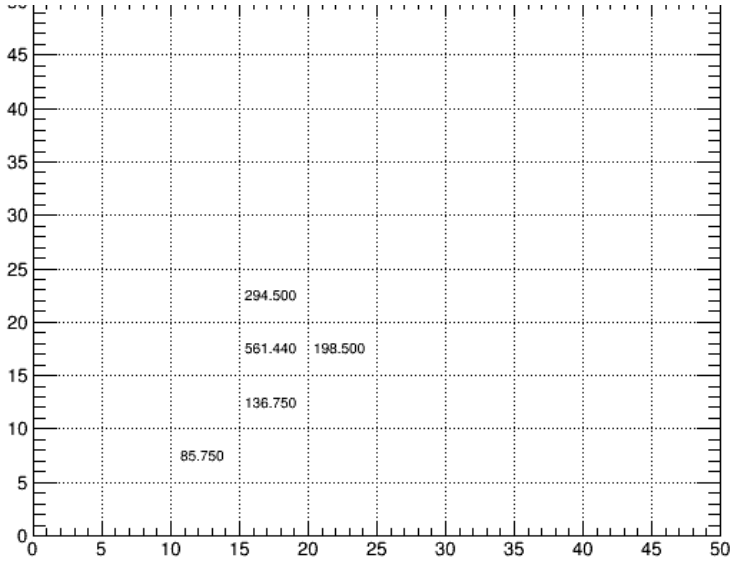
2D Correlation Factor

Zuds Prob>0.99









Btagging correlation factor

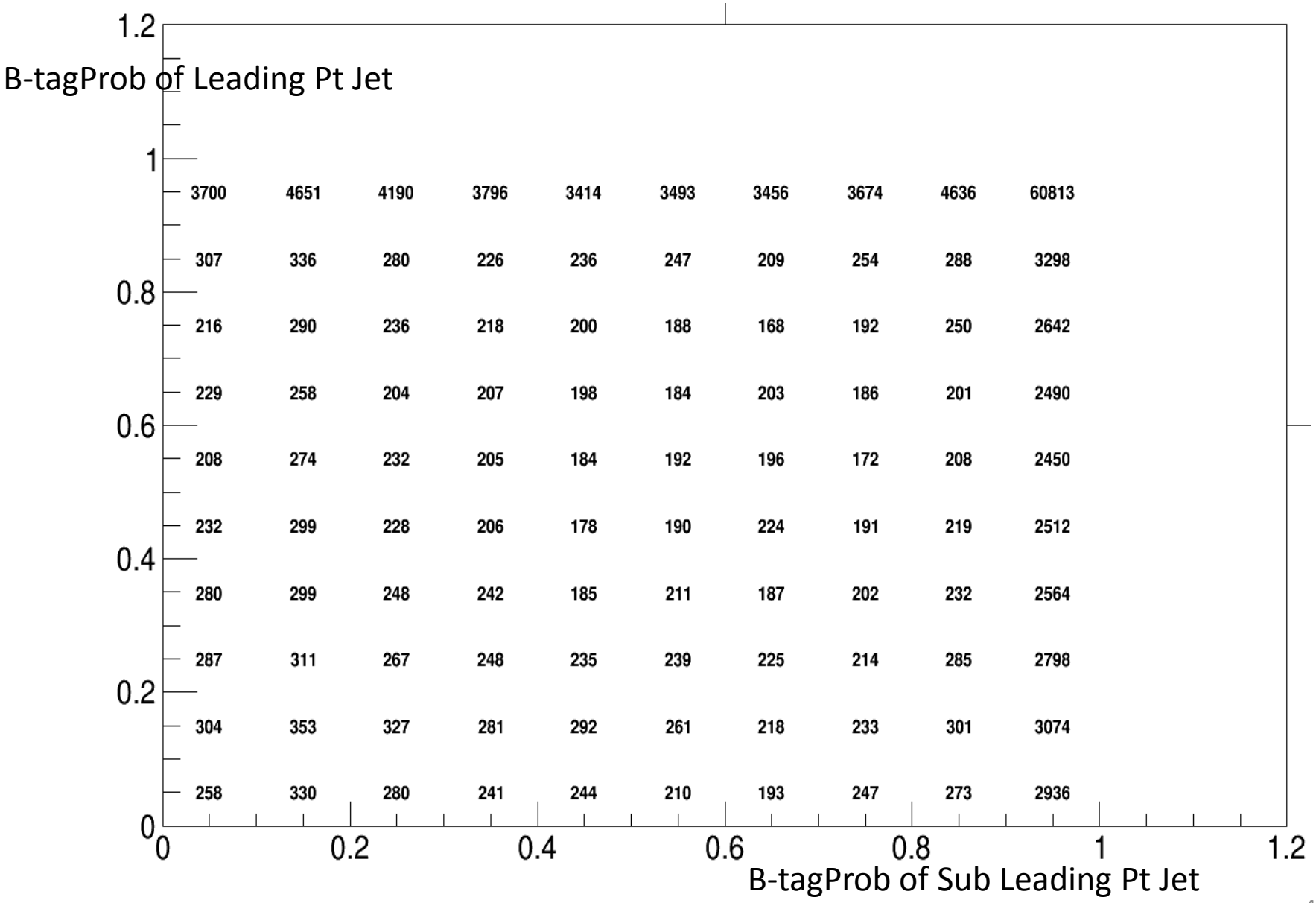
$$C_b = \frac{\varepsilon_{2jet-tagged}}{(\varepsilon_{1jet-tagged})^2}$$

Cut: deltaR<0.4 for jet1 and jet2

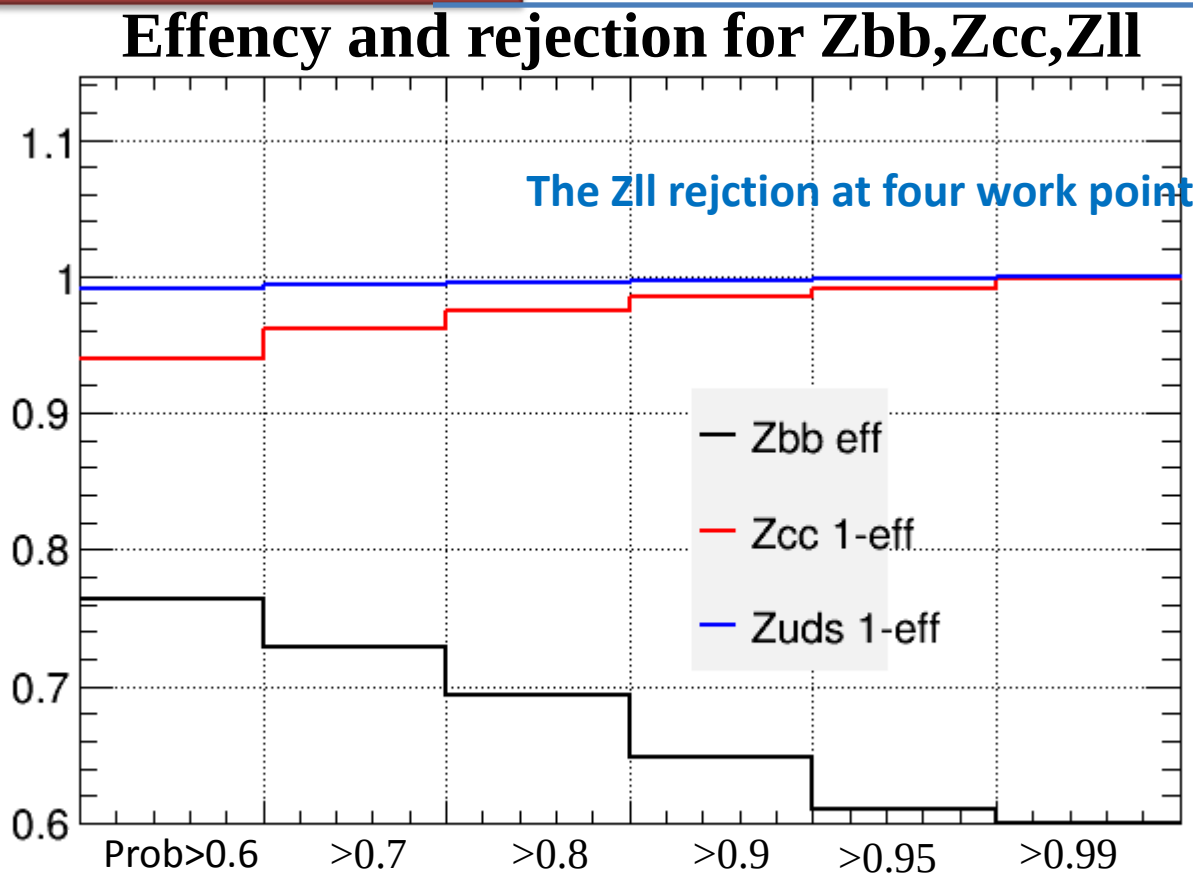
	Prob >0.6	>0.7	>0.8	>0.9	>0.95	>0.99
Zbb	1.015+-0.014	1.021+-0.014	1.026+-0.015	1.033+-0.016	1.036+-0.016	1.062+-0.019
	1.008+-0.014	1.012+-0.015	1.017+-0.015	1.021+-0.016	1.024+-0.017	1.044+-0.019
zcc	1.159+-0.085	1.173+-0.123	1.452+-0.212	1.980+-0.416	2.686+-0.760	0.000
	1.109+-0.090	1.176+-0.134	1.379+-0.222	1.743+-0.417	2.155+-0.733	0.000
zuds	7.568+-1.477	14.35+-3.210	23.86+-6.182	45.76+-13.97	73.92+-26.31	203.0+-132.2
	4.467+-1.278	6.078+-2.285	11.43+-4.698	15.09+-8.571	34.21+-20.49	0.000

backup

2D B_likelihood



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

Btagging correlation factor

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

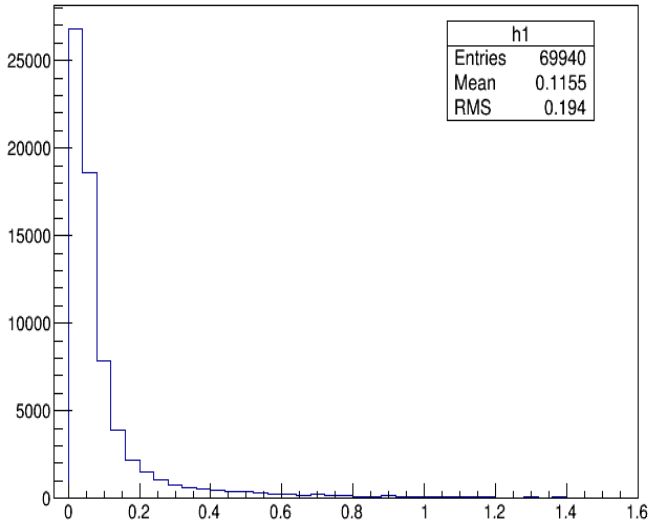
	Prob >0.6	>0.7	>0.8	>0.9	>0.95	>0.99
C_{zbb}	1.015+-0.014	1.021+-0.014	1.026+-0.015	1.033+-0.016	1.036+-0.016	1.062+-0.019
C_{zcc}	1.159+-0.085	1.173+-0.123	1.452+-0.212	1.980+-0.416	2.686+-0.760	0.000
C_{zuds}	7.568+-1.477	14.35+-3.210	23.86+-6.182	45.76+-13.97	73.92+-26.31	203.0+-132.2

2jet-tagged eff in Zcc and Zuds

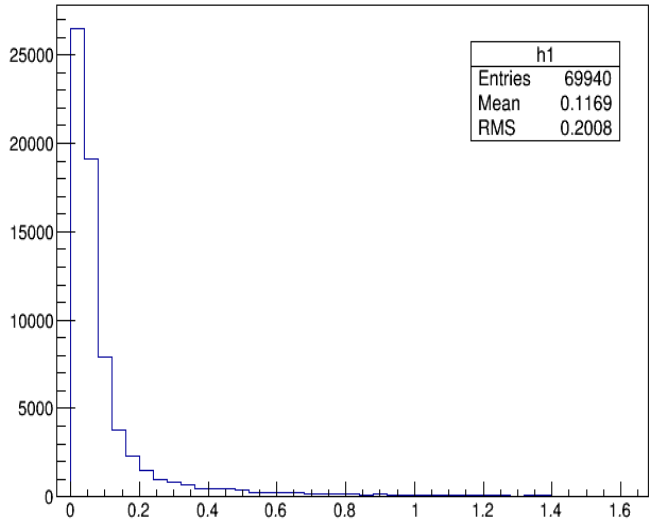
	Prob >0.6	>0.7	>0.8	>0.9	>0.95	>0.99
Zcc_2beff:	0.004146	0.001787	0.0008722	0.0004003	0.0002145	0.000
Zll_2beff:	0.0006005	0.0005004	0.0004003	0.0003289	0.0002574	7.149e-05

Btagging correlation factor

- Check the deltaR of jet vs truejet
  - TLorentzVector::DletaR



jet1



jet2

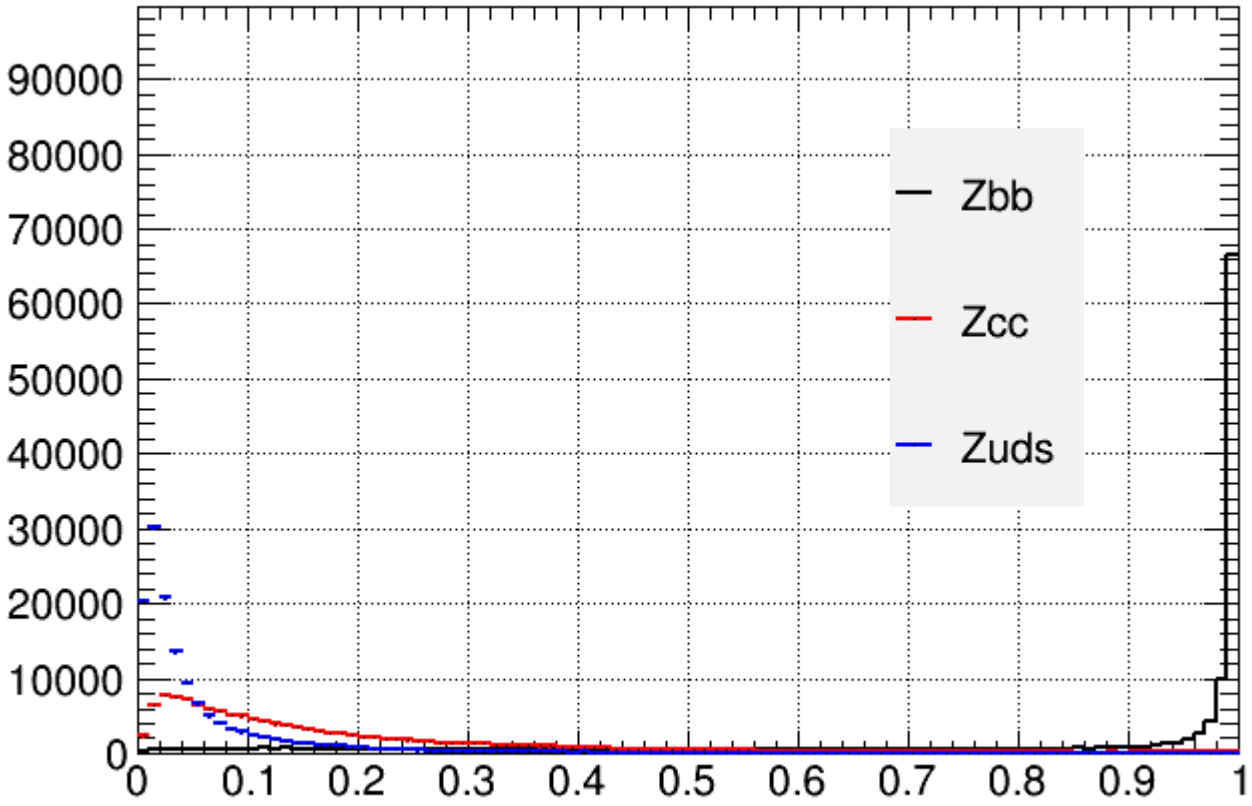
Btagging correlation factor

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

Cut: deltaR<0.4 for jet1 and jet2

	Prob >0.6	>0.7	>0.8	>0.9	>0.95	>0.99
Zbb	1.015+-0.014	1.021+-0.014	1.026+-0.015	1.033+-0.016	1.036+-0.016	1.062+-0.019
	1.008+-0.014	1.012+-0.015	1.017+-0.015	1.021+-0.016	1.024+-0.017	1.044+-0.019
zcc	1.159+-0.085	1.173+-0.123	1.452+-0.212	1.980+-0.416	2.686+-0.760	0.000
	1.109+-0.090	1.176+-0.134	1.379+-0.222	1.743+-0.417	2.155+-0.733	0.000
zuds	7.568+-1.477	14.35+-3.210	23.86+-6.182	45.76+-13.97	73.92+-26.31	203.0+-132.2
	4.467+-1.278	6.078+-2.285	11.43+-4.698	15.09+-8.571	34.21+-20.49	0.000

Btagging correlation factor



Btagging correlation factor

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

	Prob >0.01	>0.02	>0.03	>0.04	>0.05	>0.06
C_{zcc}	0.9999+-0.008	0.9995+--0.008	0.9994+-0.008	0.9998+-0.008	1.001+-0.009	0.9997+-0.009
C_{zuds}	1.006+-0.008	1.034+-0.010	1.067+-0.012	1.097+-0.014	1.132+-0.017	1.162+-0.019

	Prob >0.01	>0.02	>0.03	>0.04	>0.05	>0.06
Eff_Zcc_1tag:	0.9835	0.9380	0.8827	0.8289	0.7777	0.7313
Eff_Zcc_2tag:	0.9671	0.8794	0.7786	0.6870	0.6051	0.5346
Eff_Zuds_1tag:	0.8544	0.6394	0.4911	0.3940	0.3270	0.2801
Eff_Zuds_2tag:	0.7342	0.4225	0.2574	0.1704	0.1210	0.09116

Rb method

Get From Mixed MC Sample

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

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

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

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

1.015 1.021 1.026 1.033

Following this procedure, we can measured the R_b , ε_b

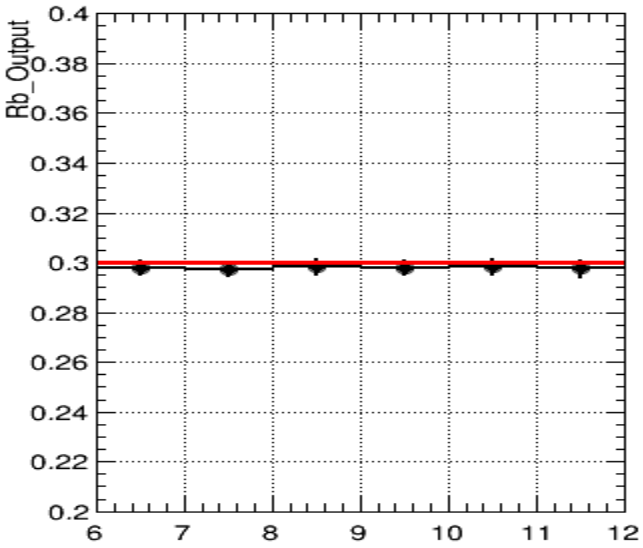
The Z hadronic '**DATA**' is mixed by MC samples: Zbb **sample1**, Zcc **sample1**, Zll sample1
We set Rb=0.3, Rb=0.5, Rb=0.7 as the Input Rb to mix the 'DATA'

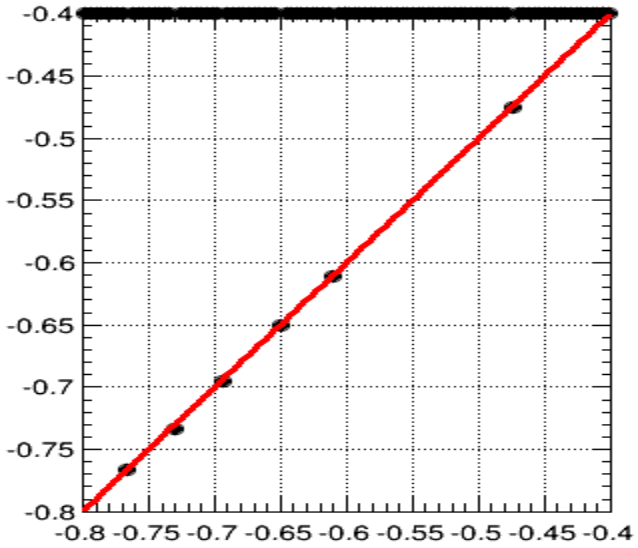
The R_c, ε_c, C_b, C_c, C_{uds} is gotten by MC samples: Zbb sample2, Zcc sample2, Zllsample2
So if **sample1≠** sample2, which means the MC R_c, ε_c, C_b, C_c, C_{uds} are different from the Truth in 'DATA'

Btagging performance

IO test

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



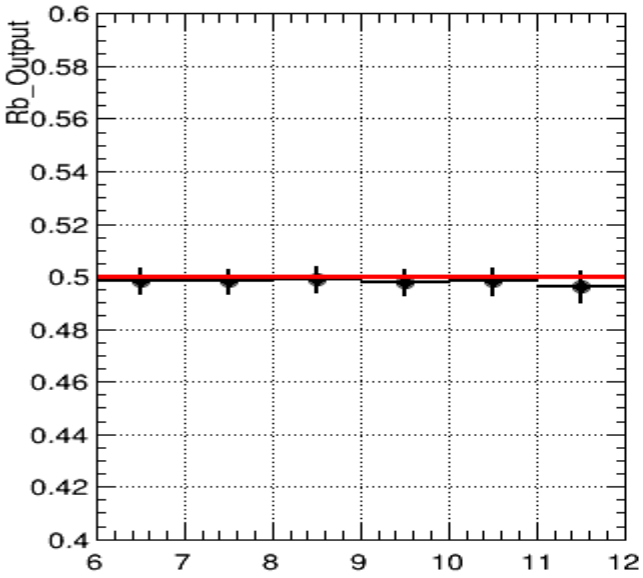


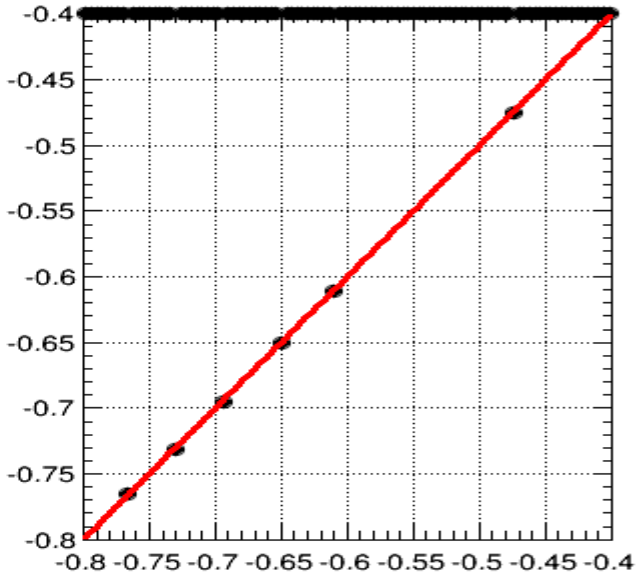
Input Rb: 0.3000					
Output Rb: 0.2981	0.2975	0.2984	0.2980	0.2985	0.2977
Input eff: 0.7643	0.7300	0.6936	0.6480	0.6087	0.4721
Output eff: 0.7668	0.7333	0.6956	0.6508	0.6109	0.4756

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.

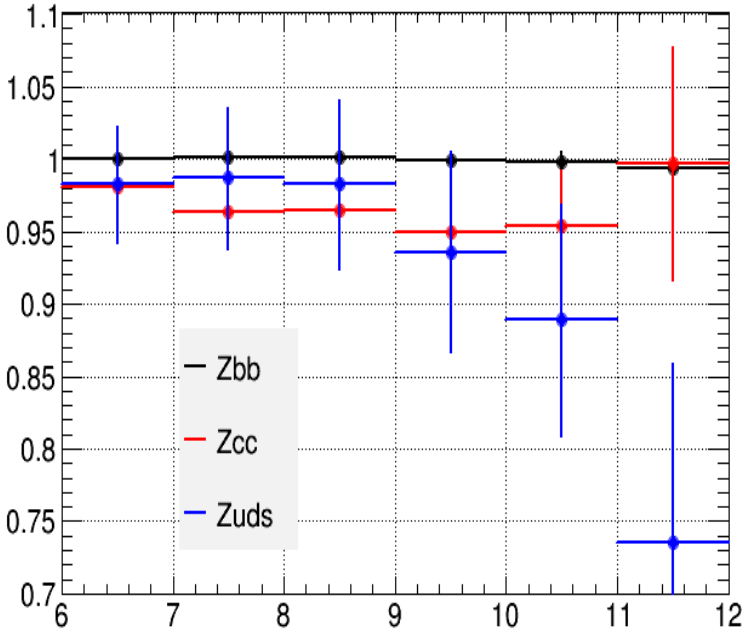
- Increase the statistics of ‘DATA’ and MC.
- Study the FSClasser: know well about the procedure at event reconstruction level.

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'

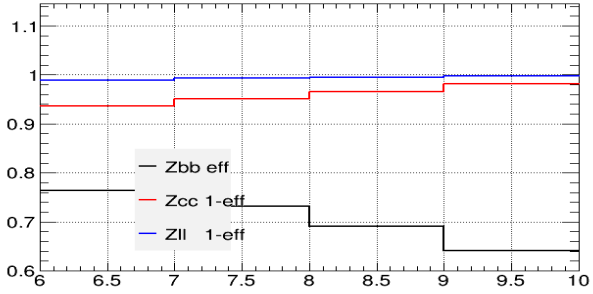
The difference as a Ratio: Eff in 'DATA'/ Eff in MC



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%**



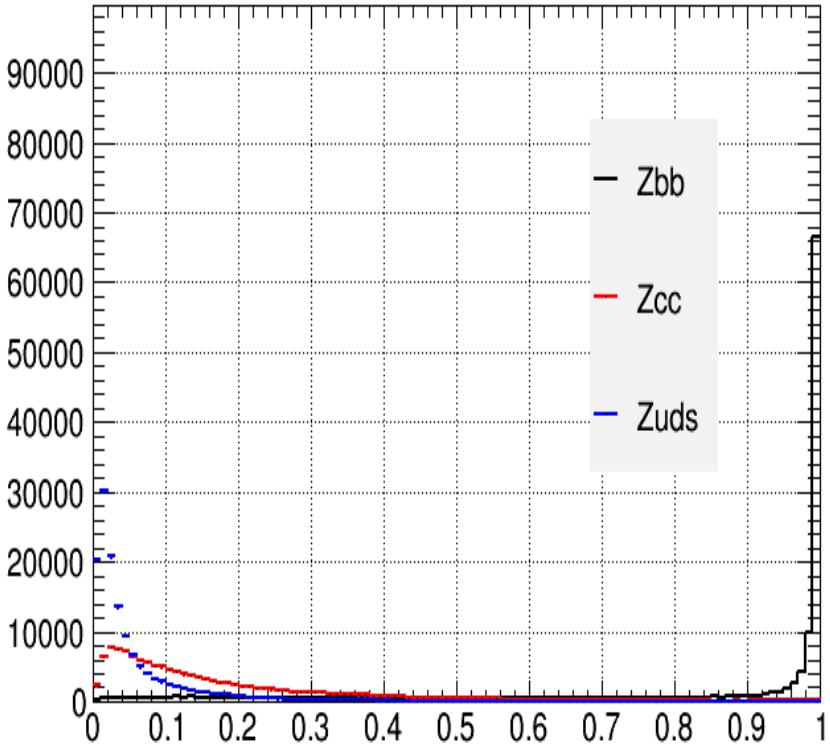
Outline

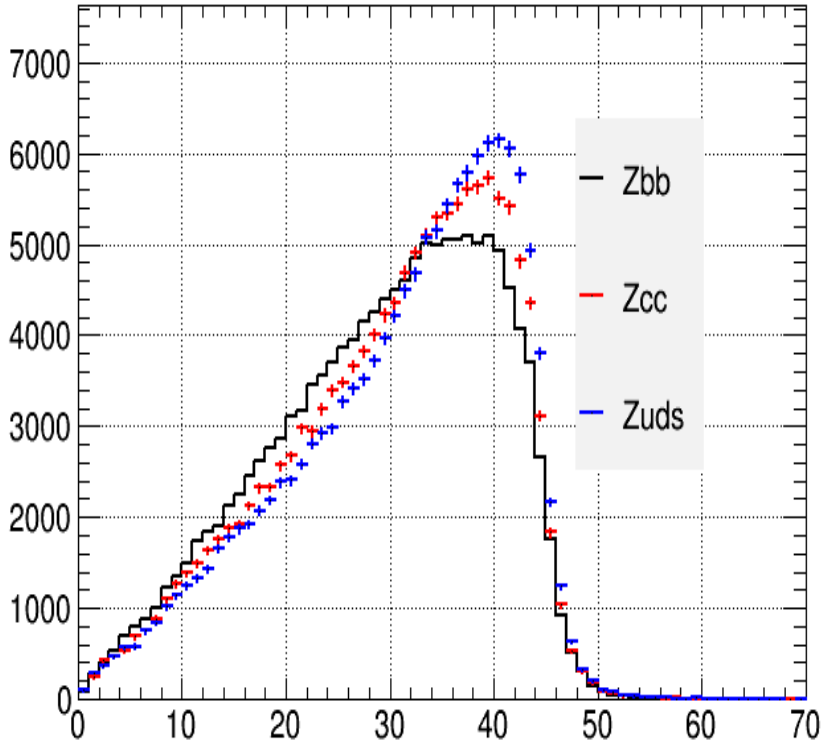
- Basic information
- Btag performance
- Method

Btagging performance

Variable in Zbb,Zcc,Zll

JetBtag Prob all the 2jets **JetPt**



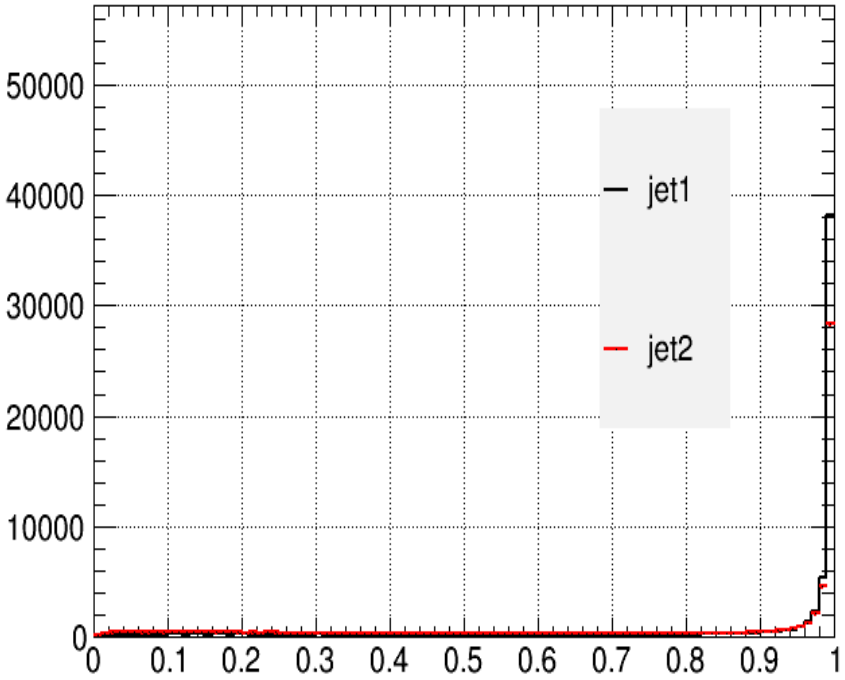


- The BtagProb are different for Zbb, Zcc and Zll
- Four BtagProb Work Point are used :
  - The BtagProb>0.6 , BtagProb>0.7, BtagProb>0.8, BtagProb>0.9

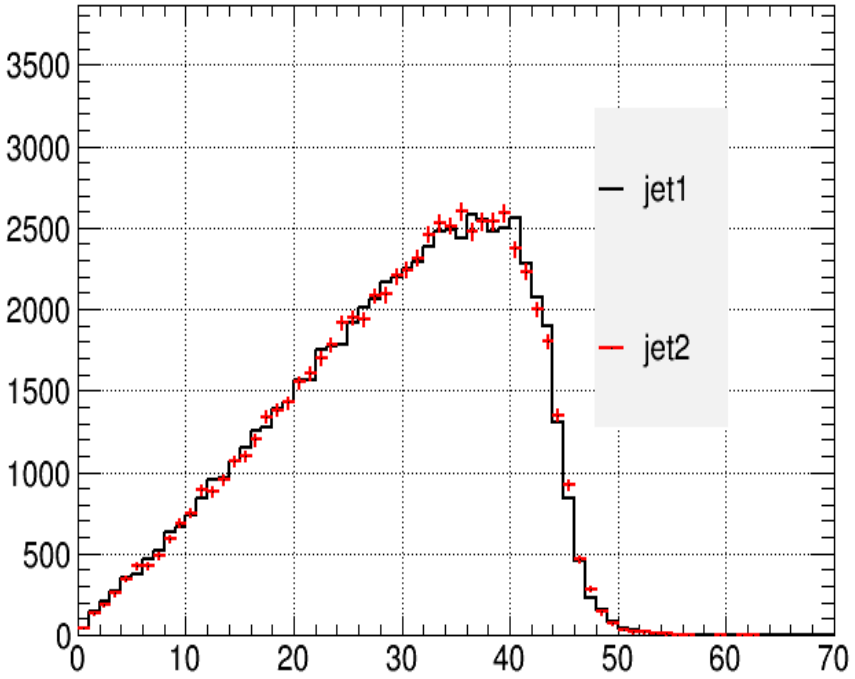
Btagging performance

Variable of jet1, jet2 in Zbb

JetBtag Prob



JetPt

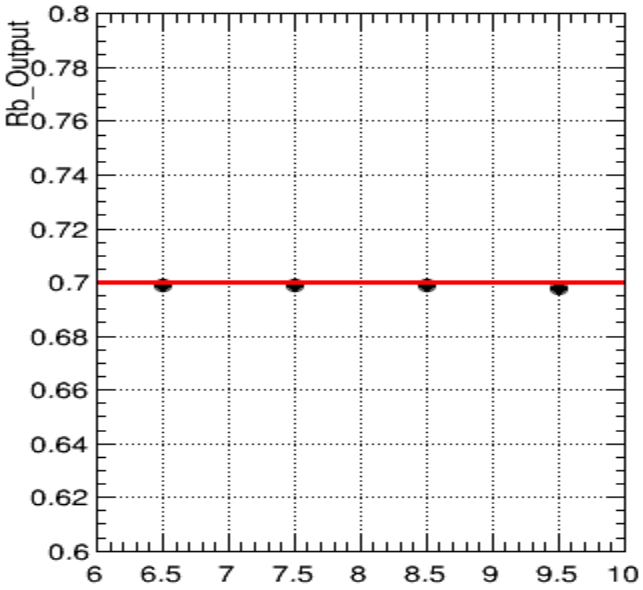


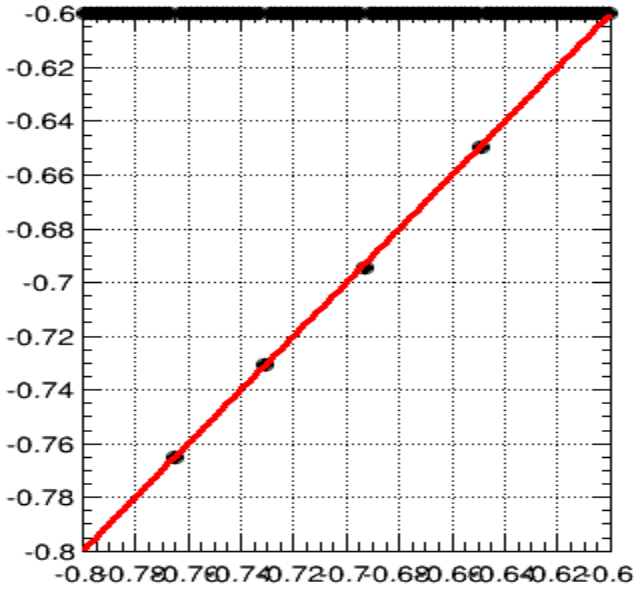
Jet1 vs jet2

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

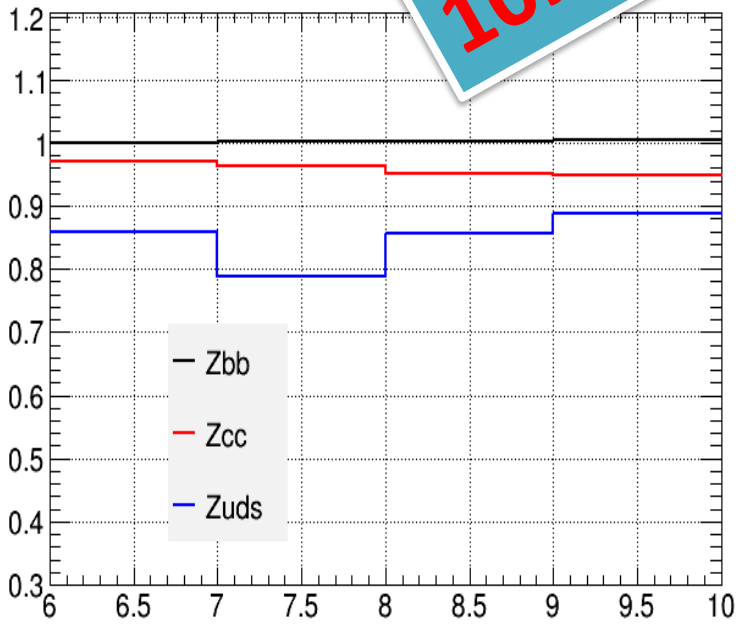
Result

We can see the measured Rb and effb in DATA are different [illegible] Truth Rb and effb

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

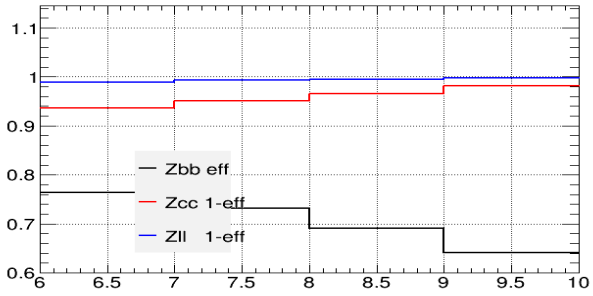
10k events in the past

The difference as a Ratio: Eff in 'DATA' / Eff in 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%**

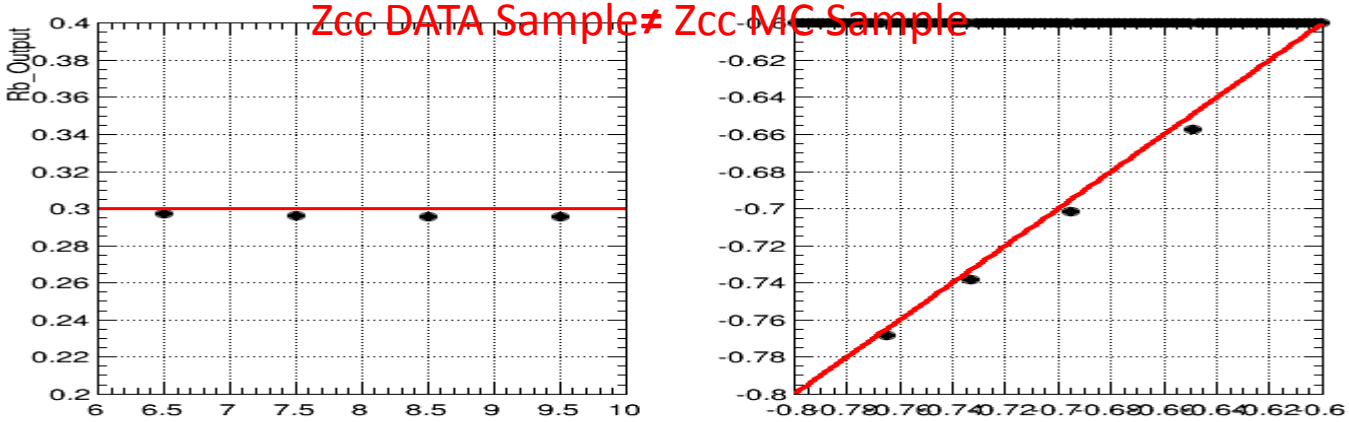


Check

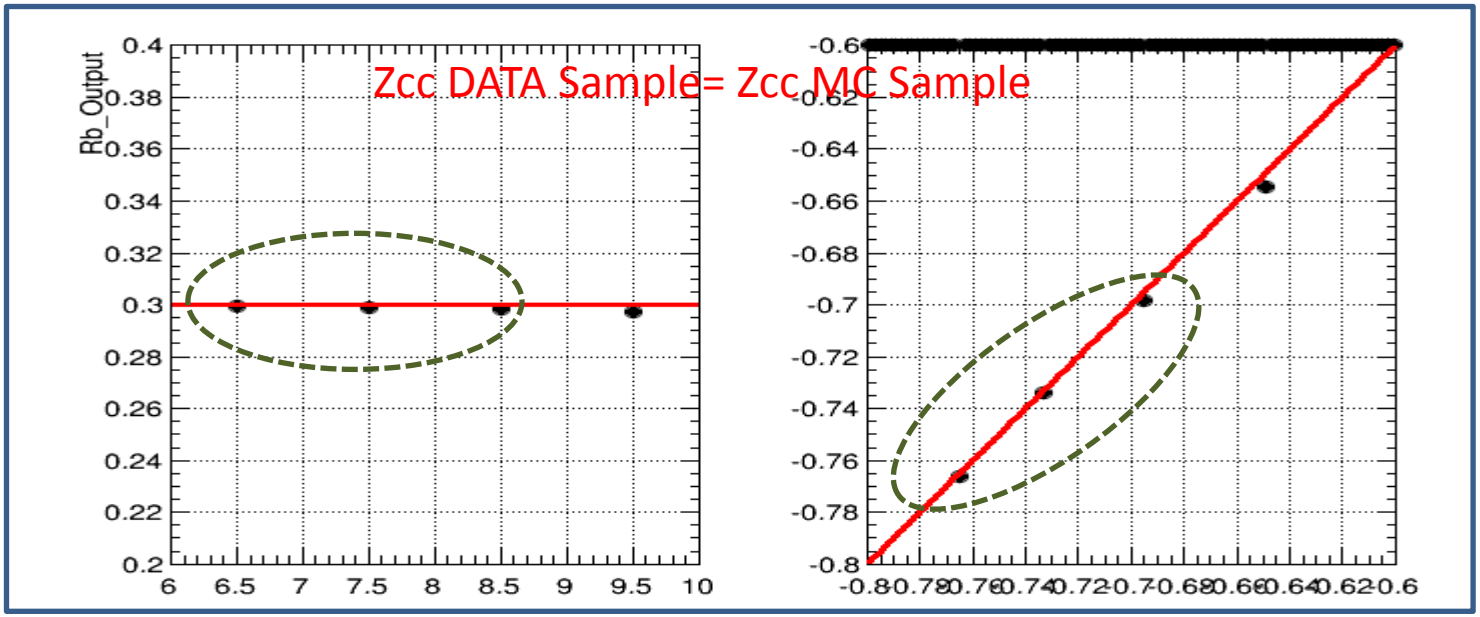
Input Rb=0.3

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

Zcc DATA Sample≠ Zcc MC Sample



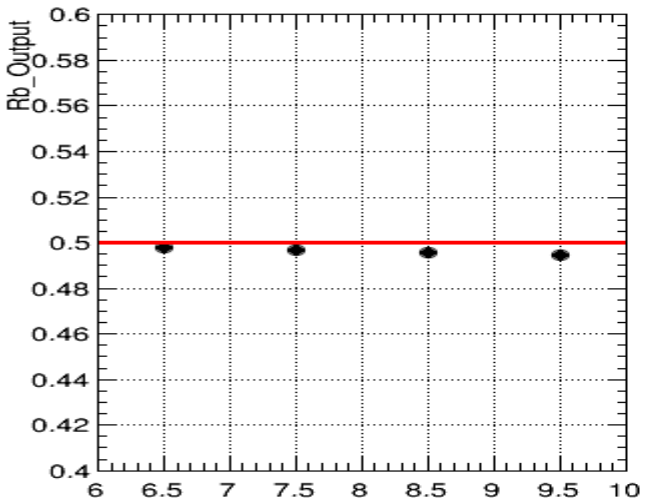
Zcc DATA Sample= Zcc MC Sample

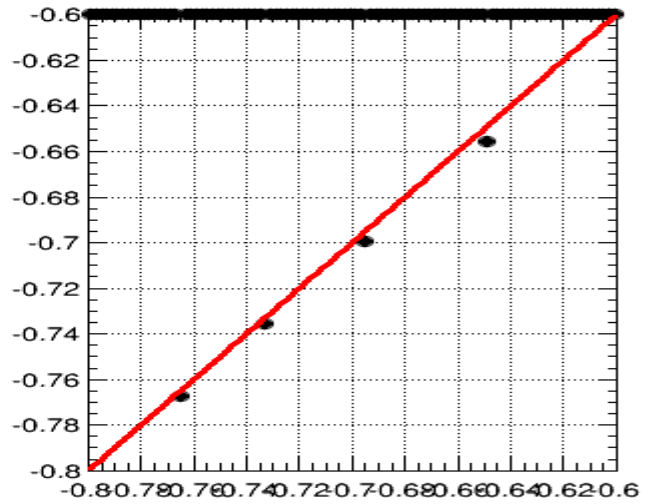


We can see the differences of measured Rb and effb between DATA and MC are smaller

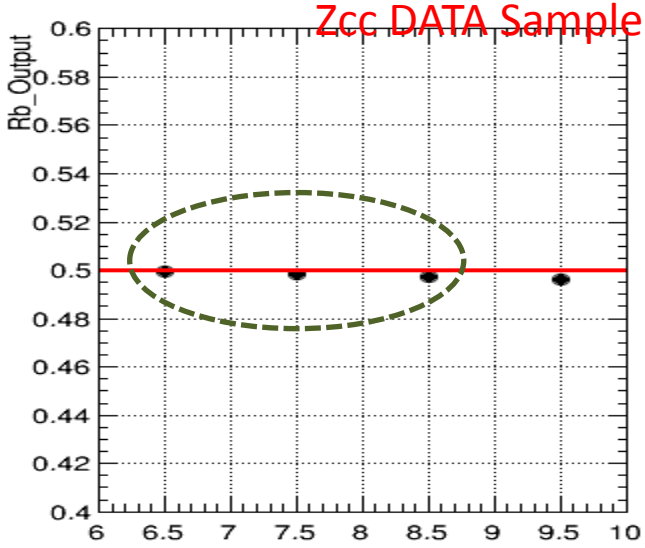
Check

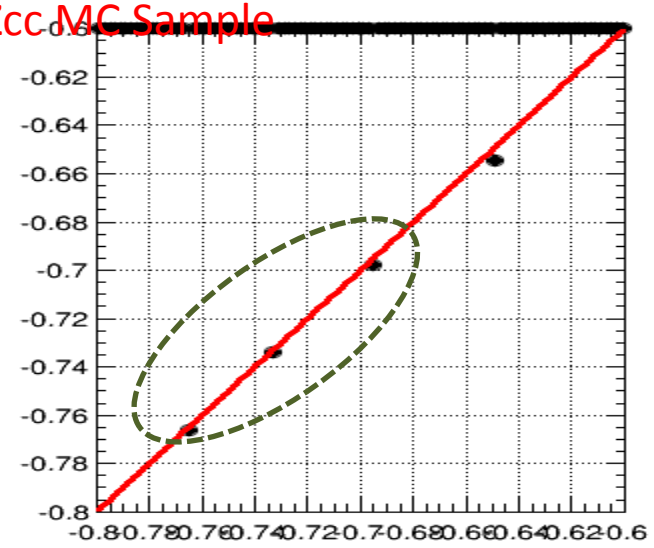
Input Rb=0.5





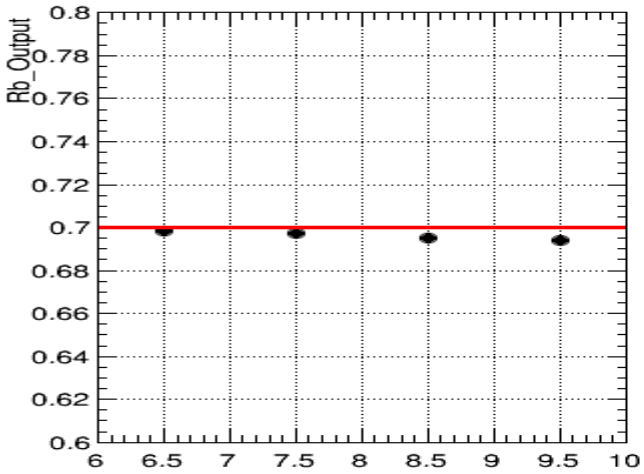
Zcc DATA Sample= Zcc MC Sample

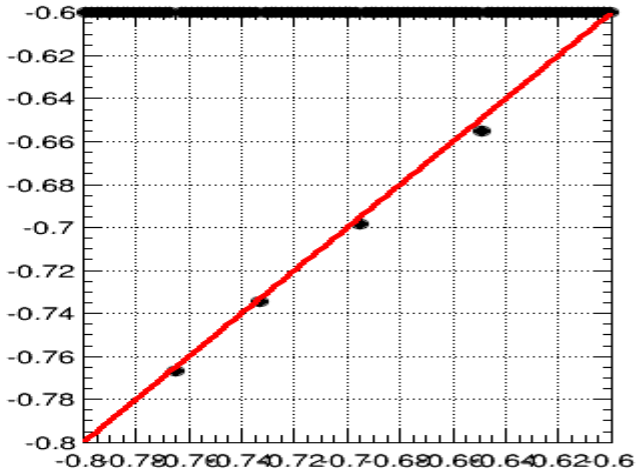




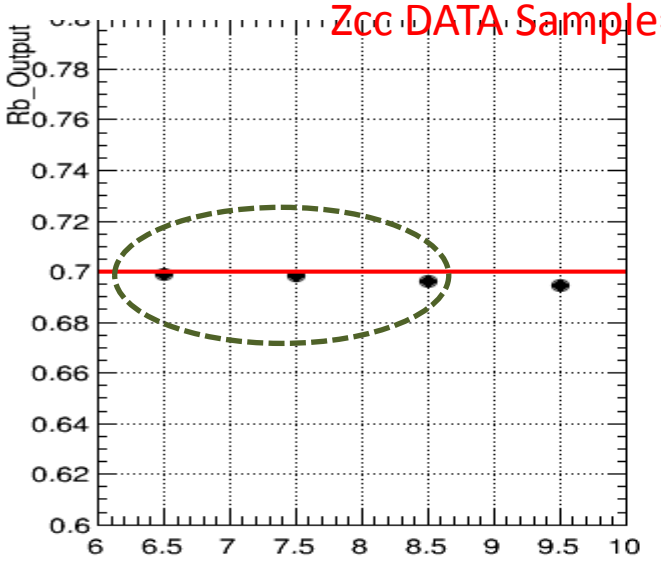
Check

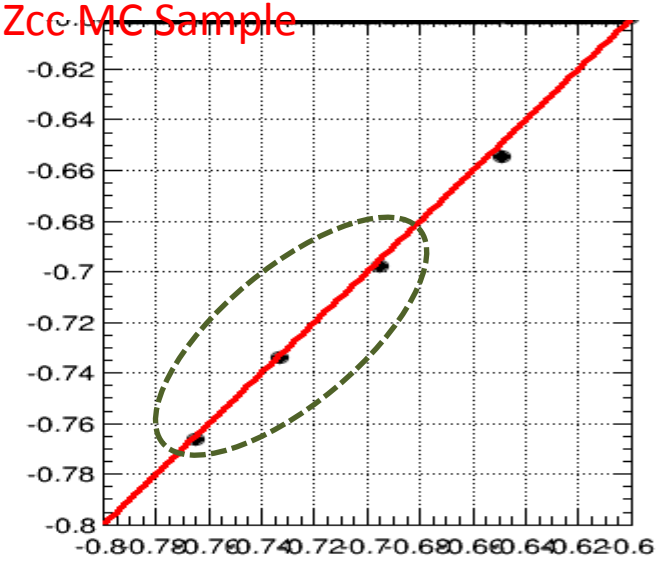
Input Rb=0.7





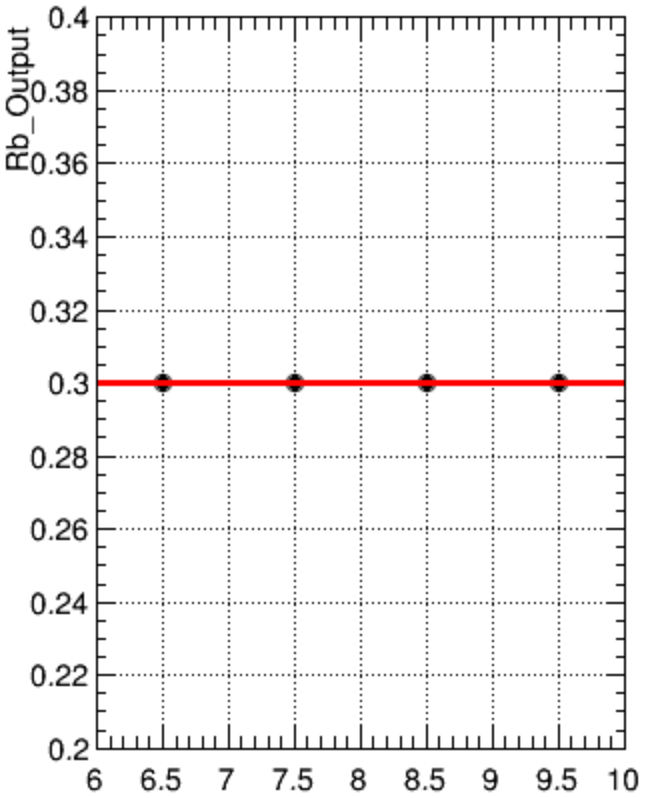
Zcc DATA Sample= Zcc MC Sample

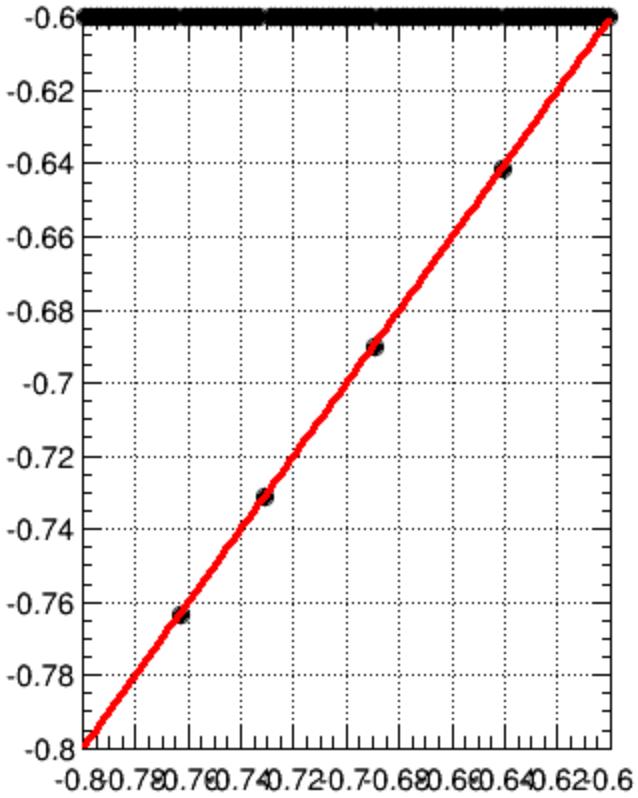


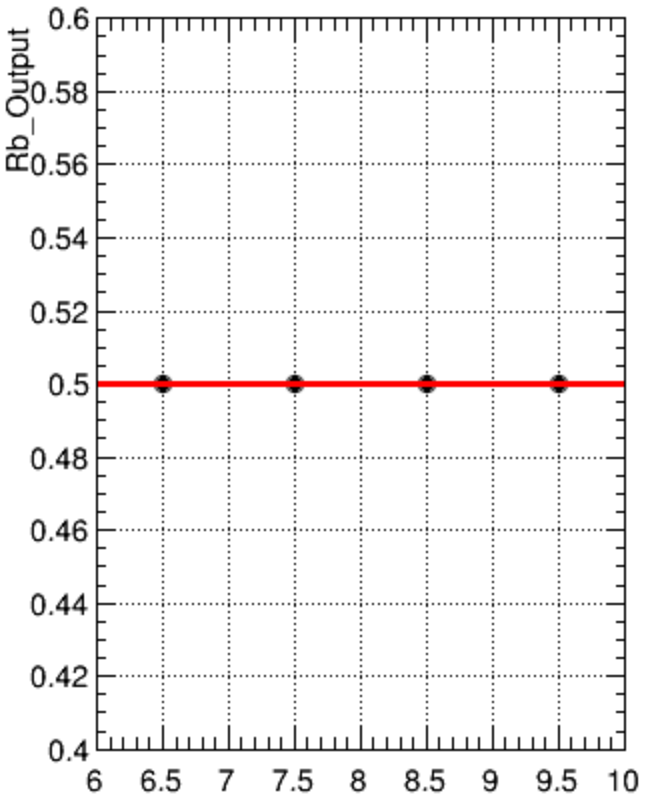


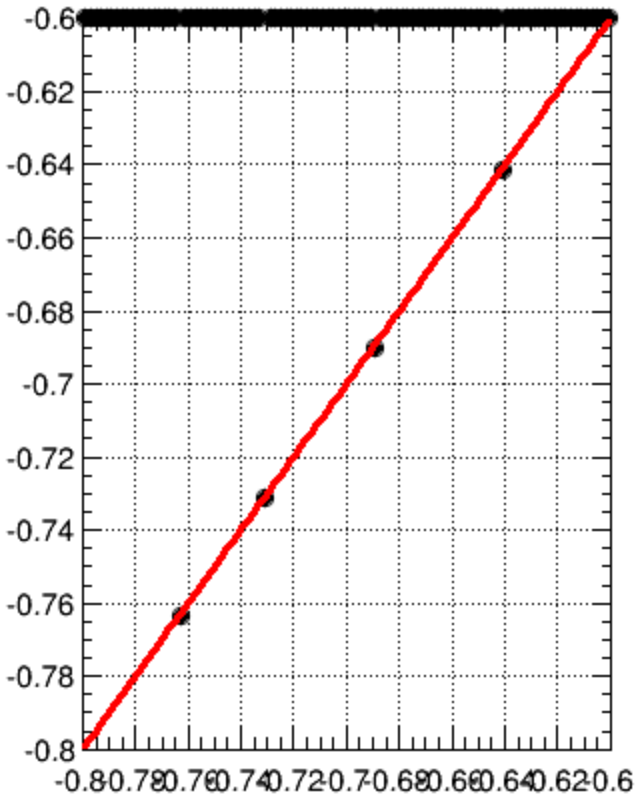
backup

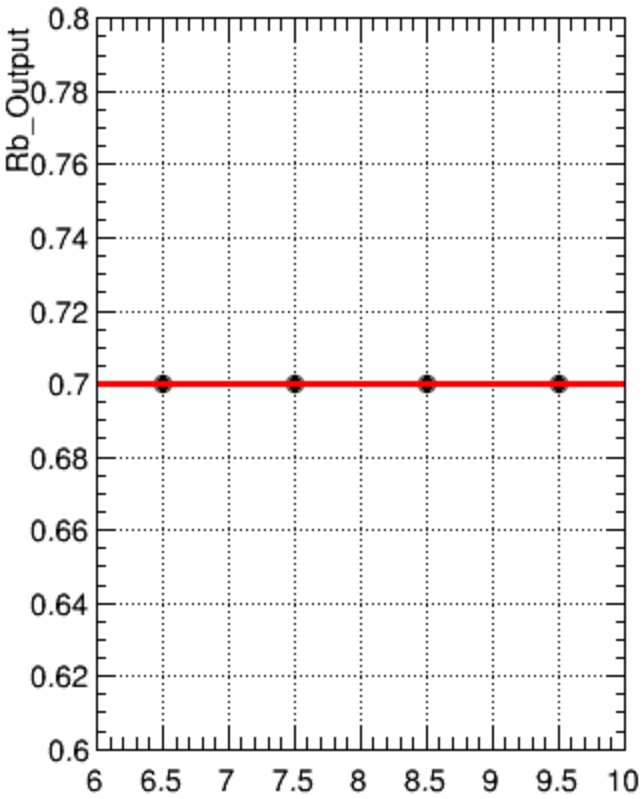
'DATA' and MC all are used the same sample

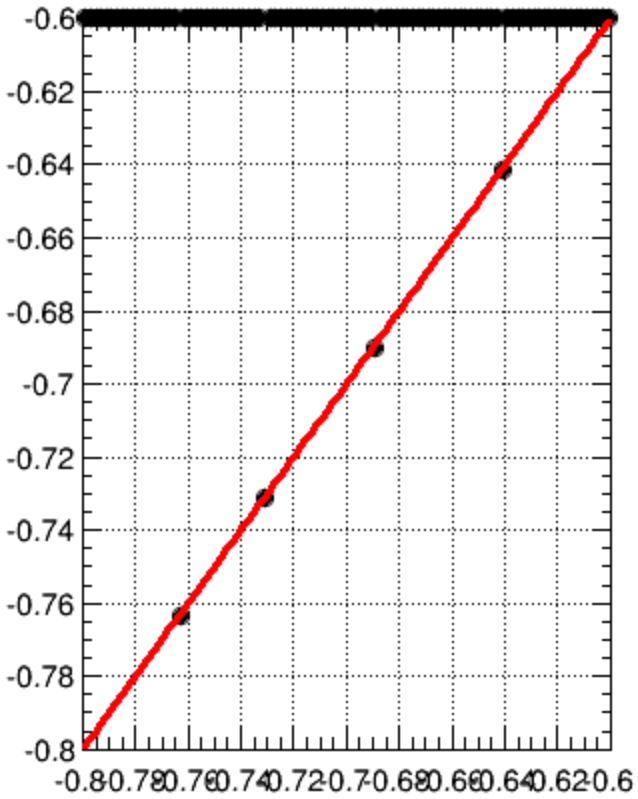





Rb_Output
0.6
0.58
0.56
0.54
0.52
0.5
0.48
0.46
0.44
0.42
0.4
6
6.5
7
7.5
8
8.5
9
9.5
10


-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
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-0.62
-0.6