Studies of ttH events in the semileptonic final states

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Exploring Meeting, 17 Jun 2016, 12h00

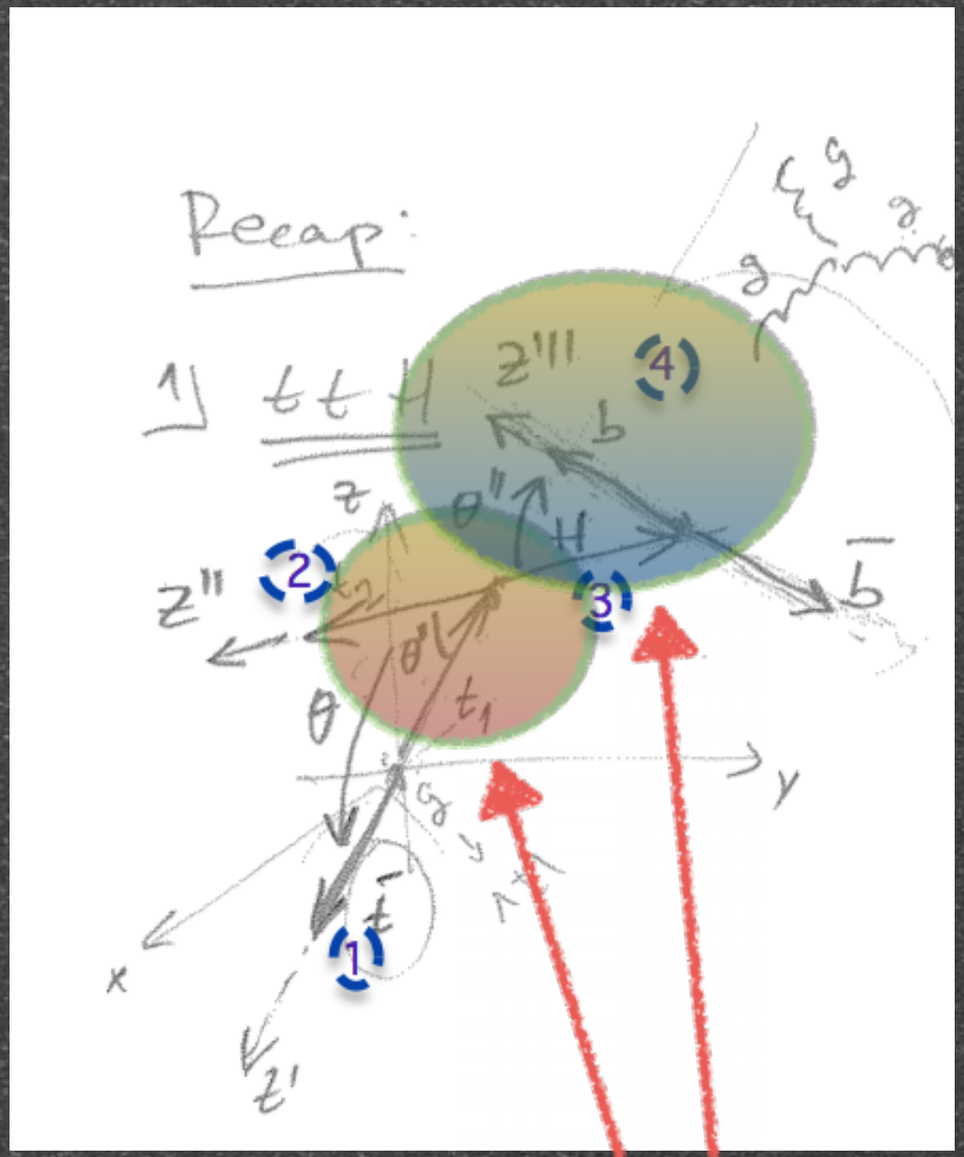
POPH
QUADRO DE REFERÊNCIA ESTRATÉGICO NACIONAL PORTUGAL 2007.2013
UNIÃO EUROPEIA Fundo Social Europeu
FCT Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA EDUCAÇÃO E CIÊNCIA

Angular Distributions

semileptonic events

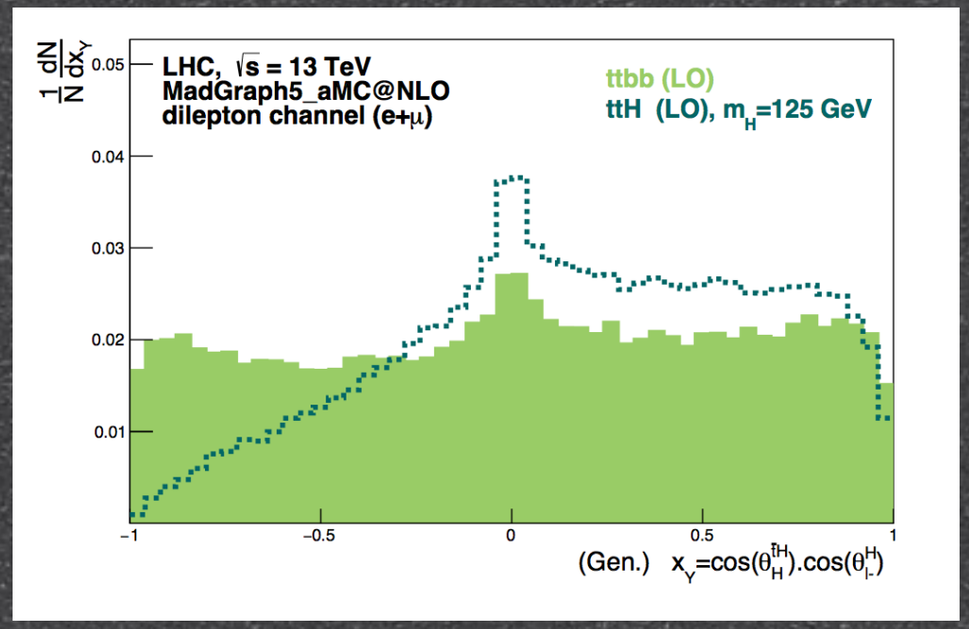
ttH, ttbb and ttZ

Dileptonic Signal

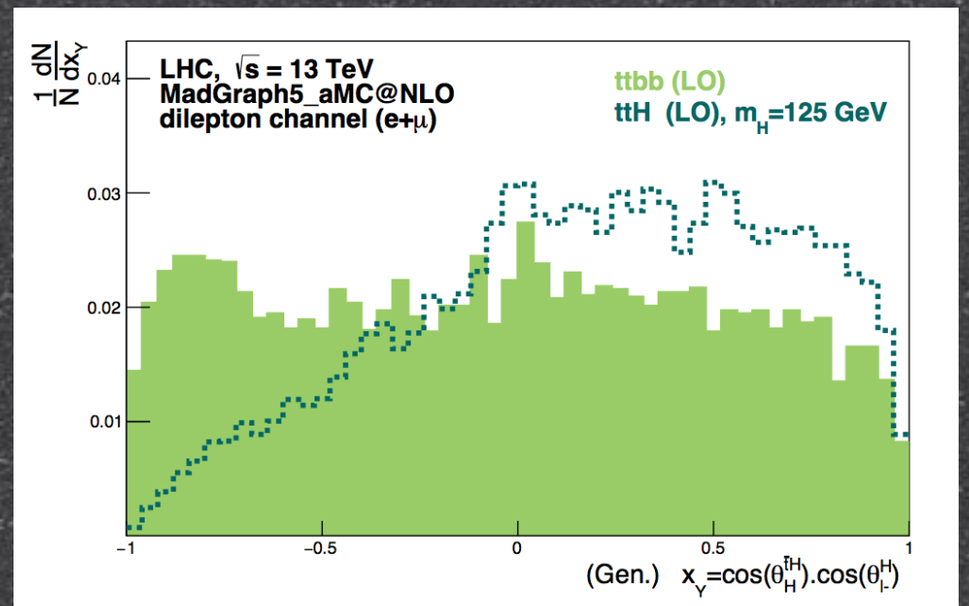


Angles Used

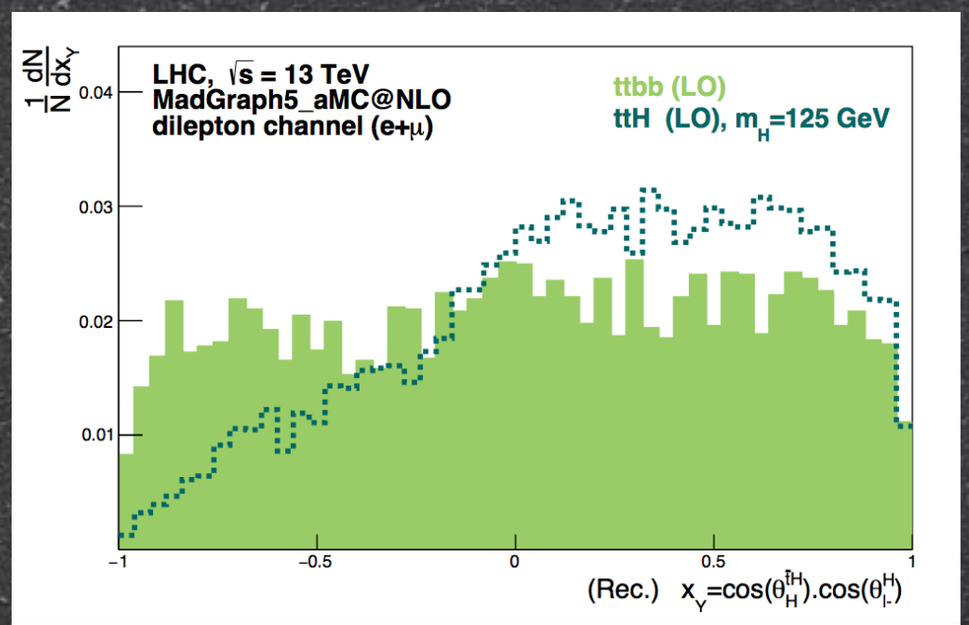
Parton Level



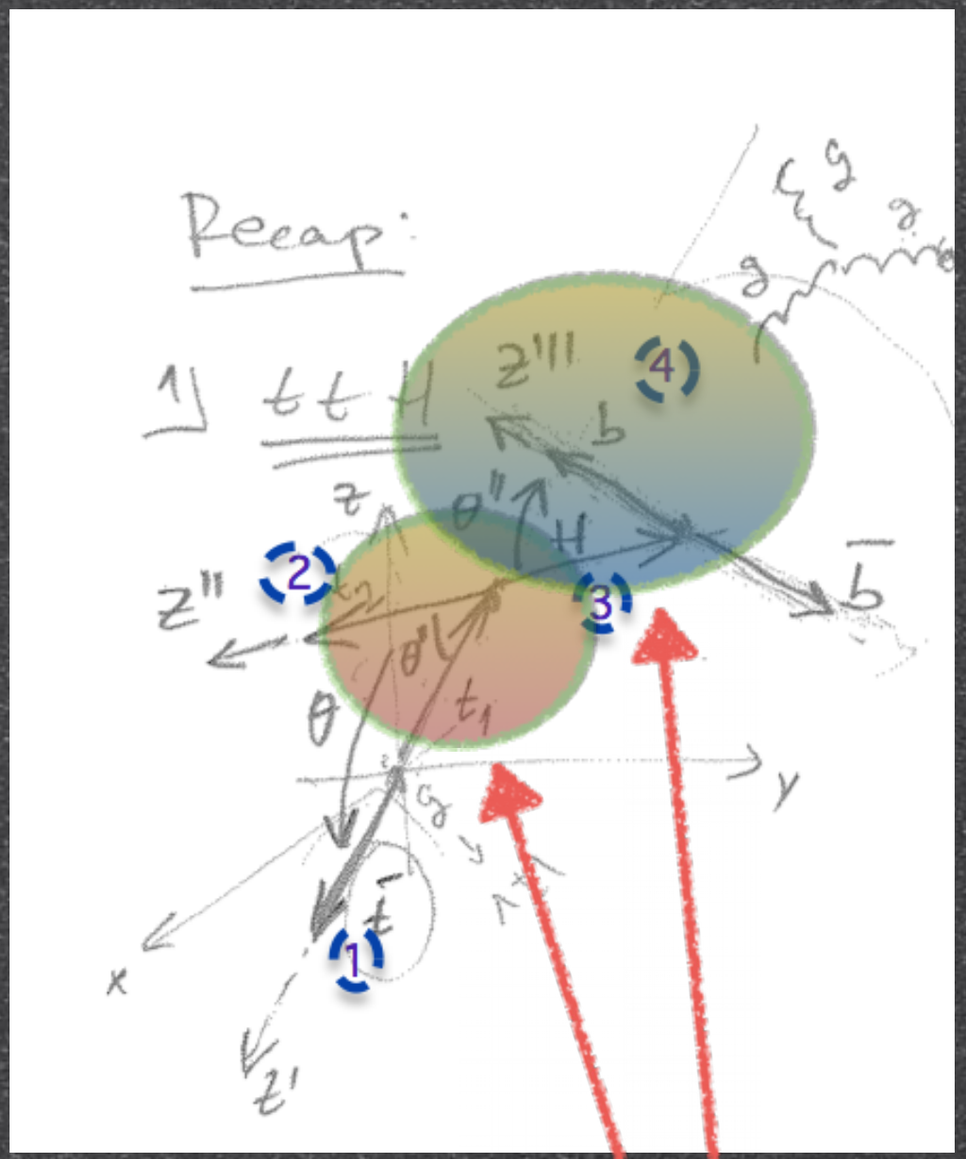
Part. Level w/Cuts



Rec. Level

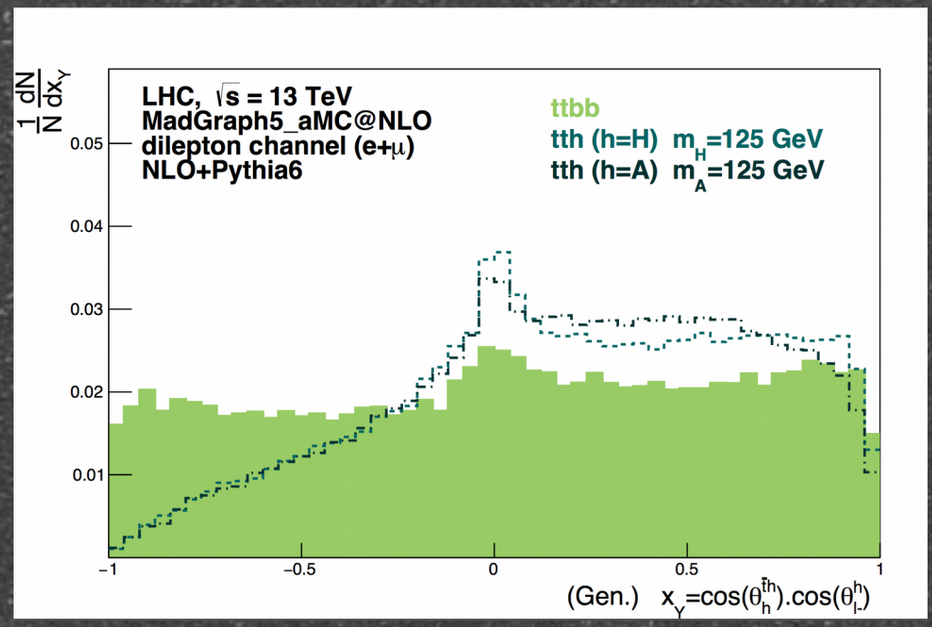


Semileptonic Signal

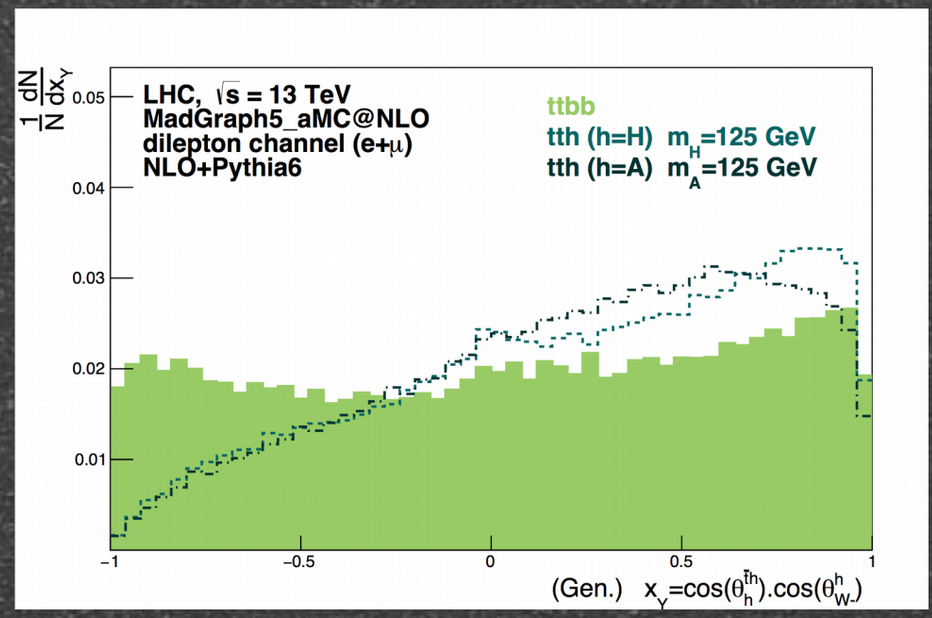


Angles Used

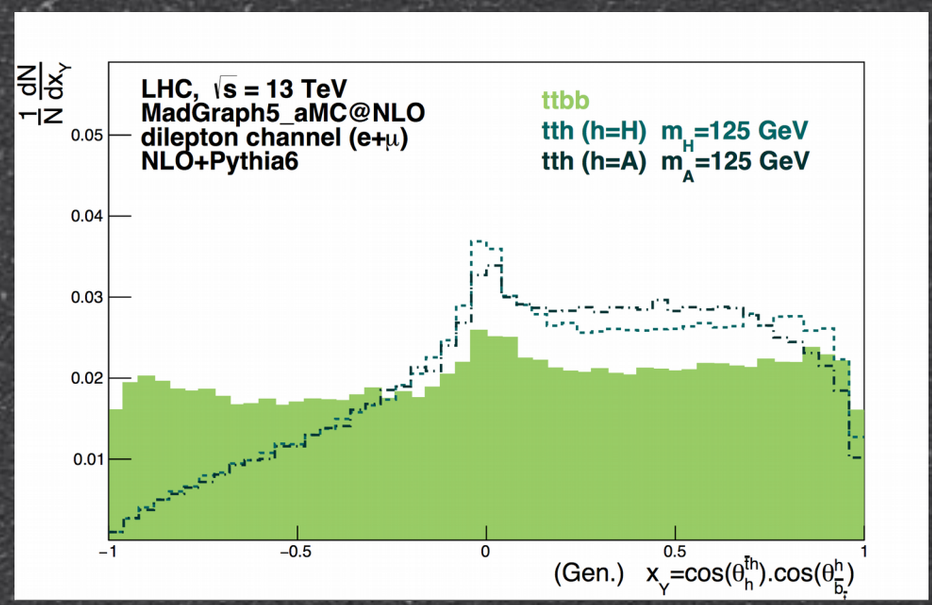
Parton Level l-



Parton Level W-

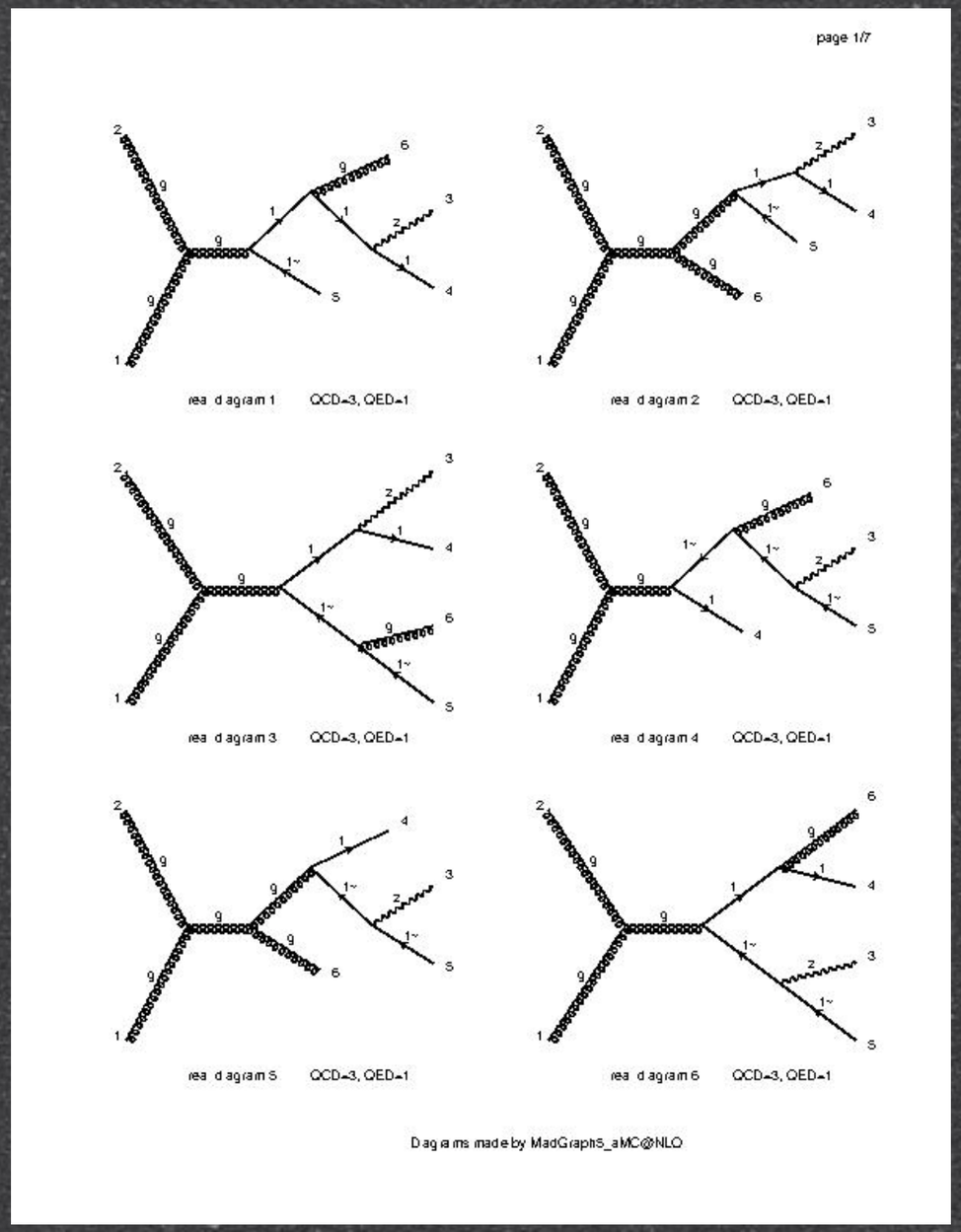


Parton Level $\bar{b}_{\bar{t}}$



Generation Code Example of ttZ at MG5_aMC@NLO

- set group_subprocesses Auto
- set ignore_six_quark_processes False
- set loop_optimized_output True
- set complex_mass_scheme False
- import model sm
- define p = g u c d s u~ c~ d~ s~
- define j = g u c d s u~ c~ d~ s~
- define l+ = e+ mu+
- define l- = e- mu-
- import model loop_sm
- define vl = ve vm
- define vl~ = ve~ vm~
- generate p p > t t~ z [QCD]



MadSpin Code Example at MG5_aMC@NLO

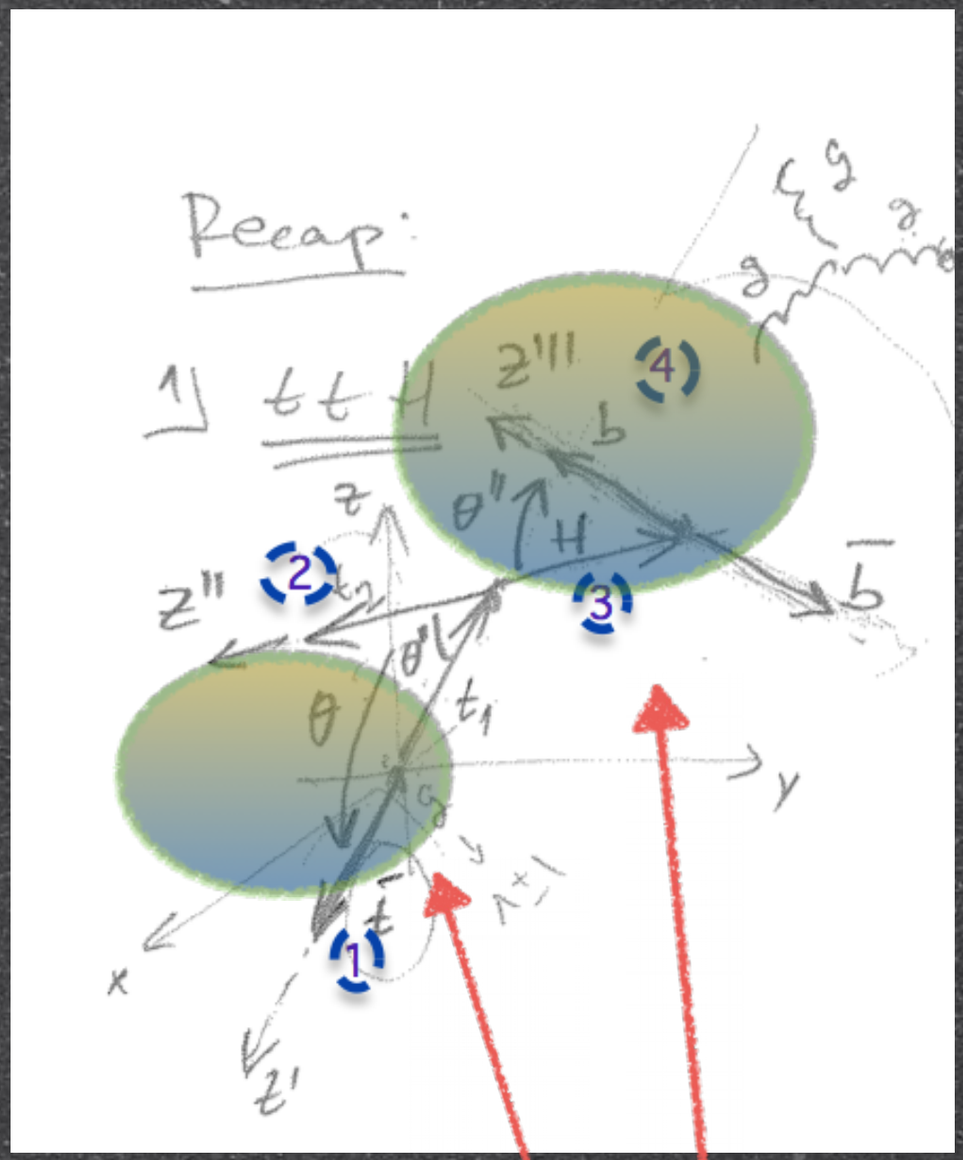
Positive Semileptonic decay

- decay t > w+ b, w+ > l+ vl
- decay t~ > w- b~, w- > j j
- decay w+ > all all
- decay w- > all all
- decay z > all all

Negative Semileptonic decay

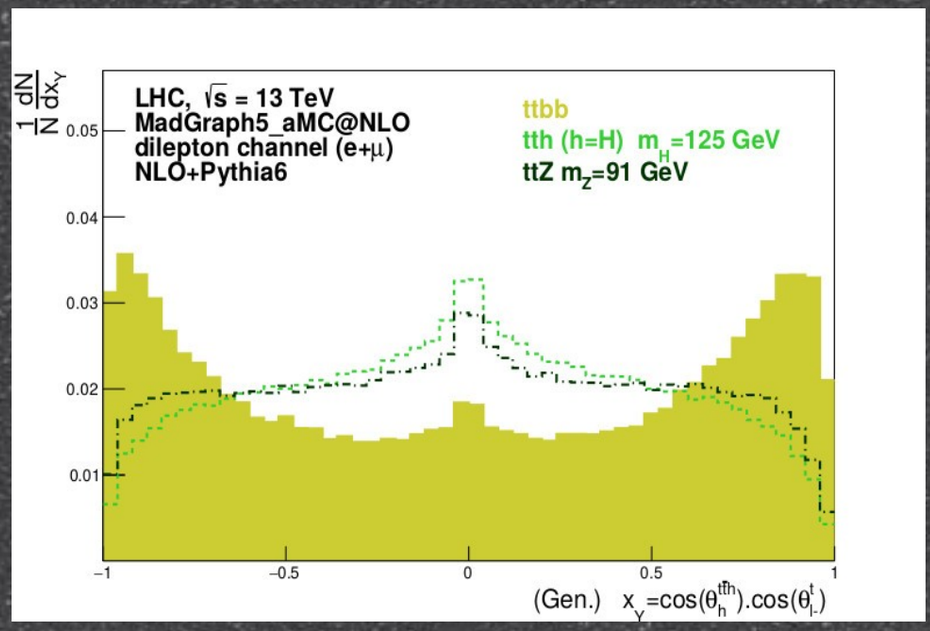
- decay t > w+ b, w+ > j j
- decay t~ > w- b~, w- > l- vl~
- decay w+ > all all
- decay w- > all all
- decay z > all all

Semileptonic ttZ Signal
ttZ vs ttbb

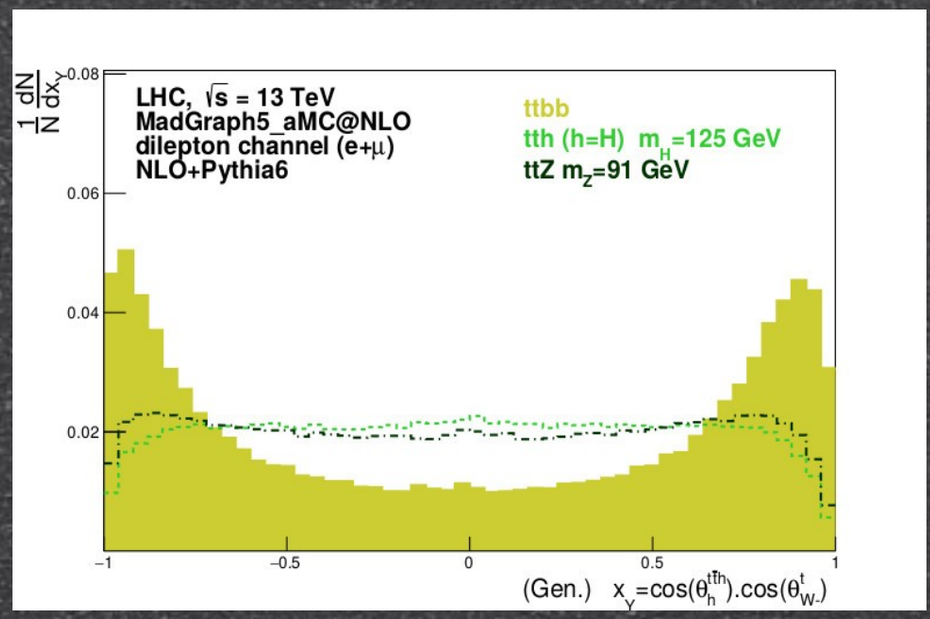


Angles Used

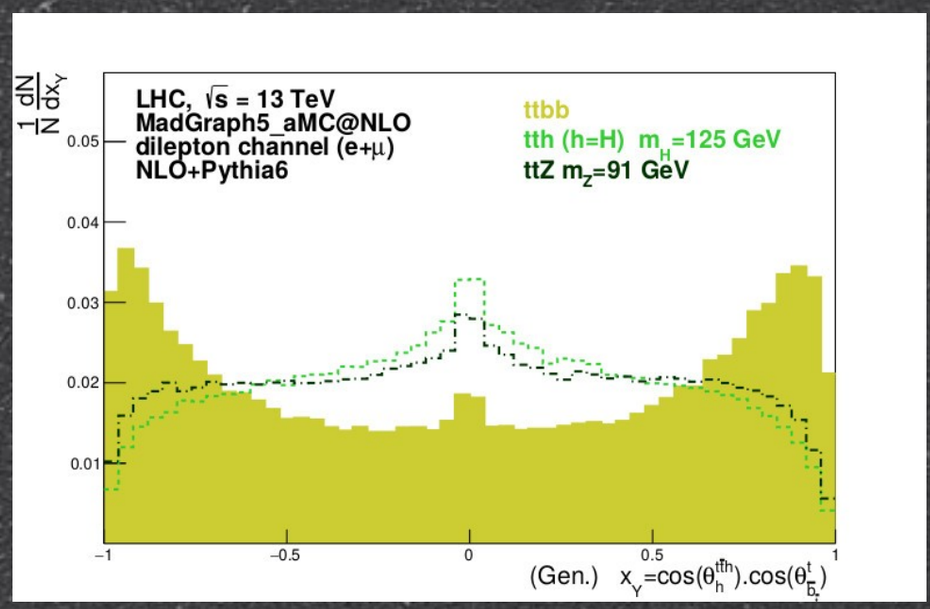
Parton Level l^-



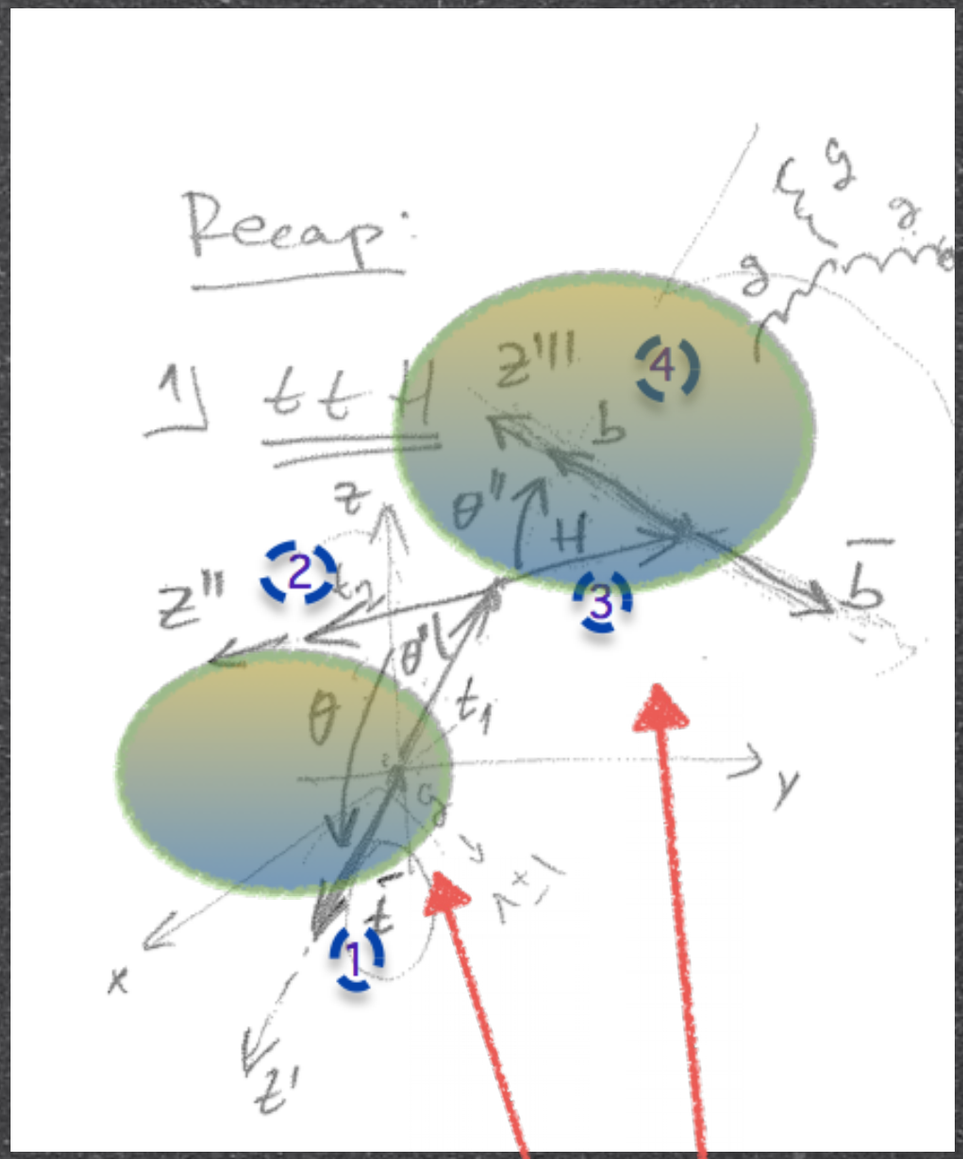
Parton Level W^-



Parton Level $\bar{b}_{t^-}$



Semileptonic ttZ Signal
ttZ vs ttH

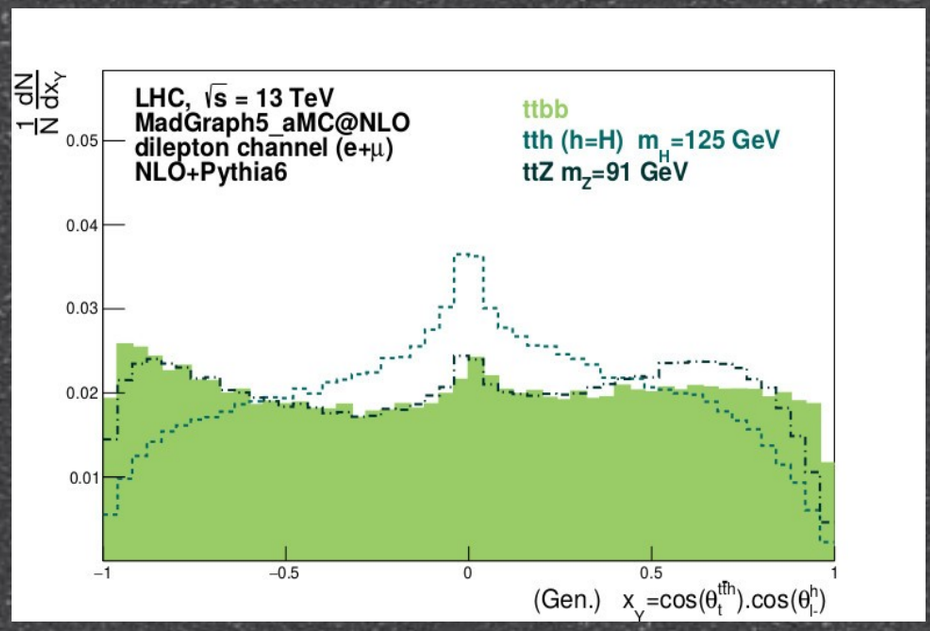


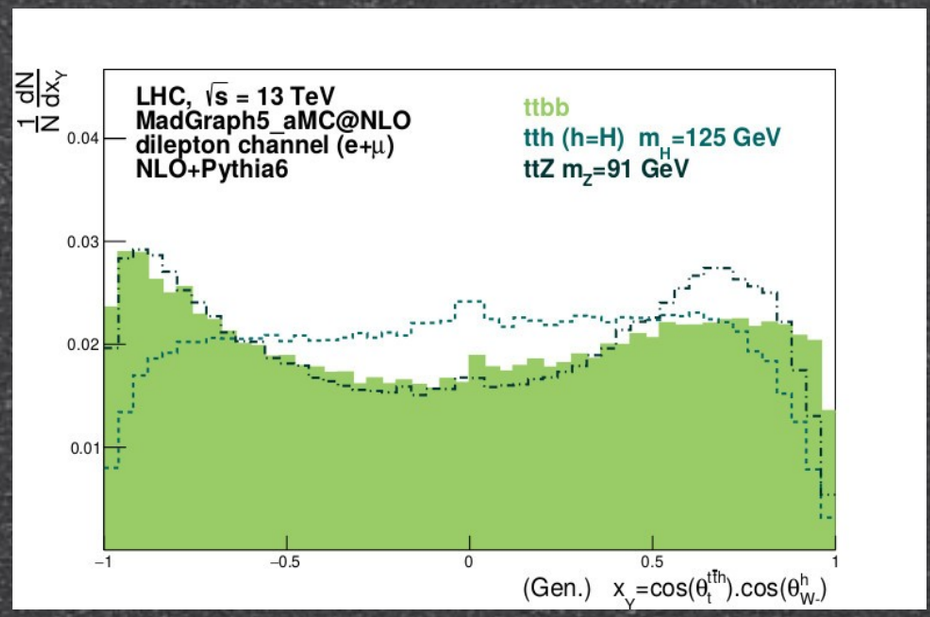
Angles Used

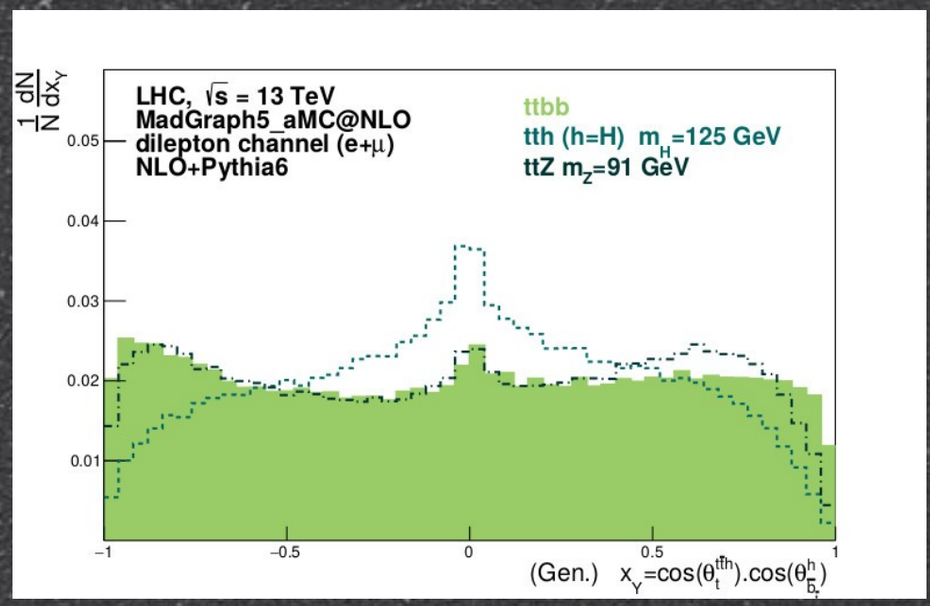
Parton Level l-

Parton Level W-

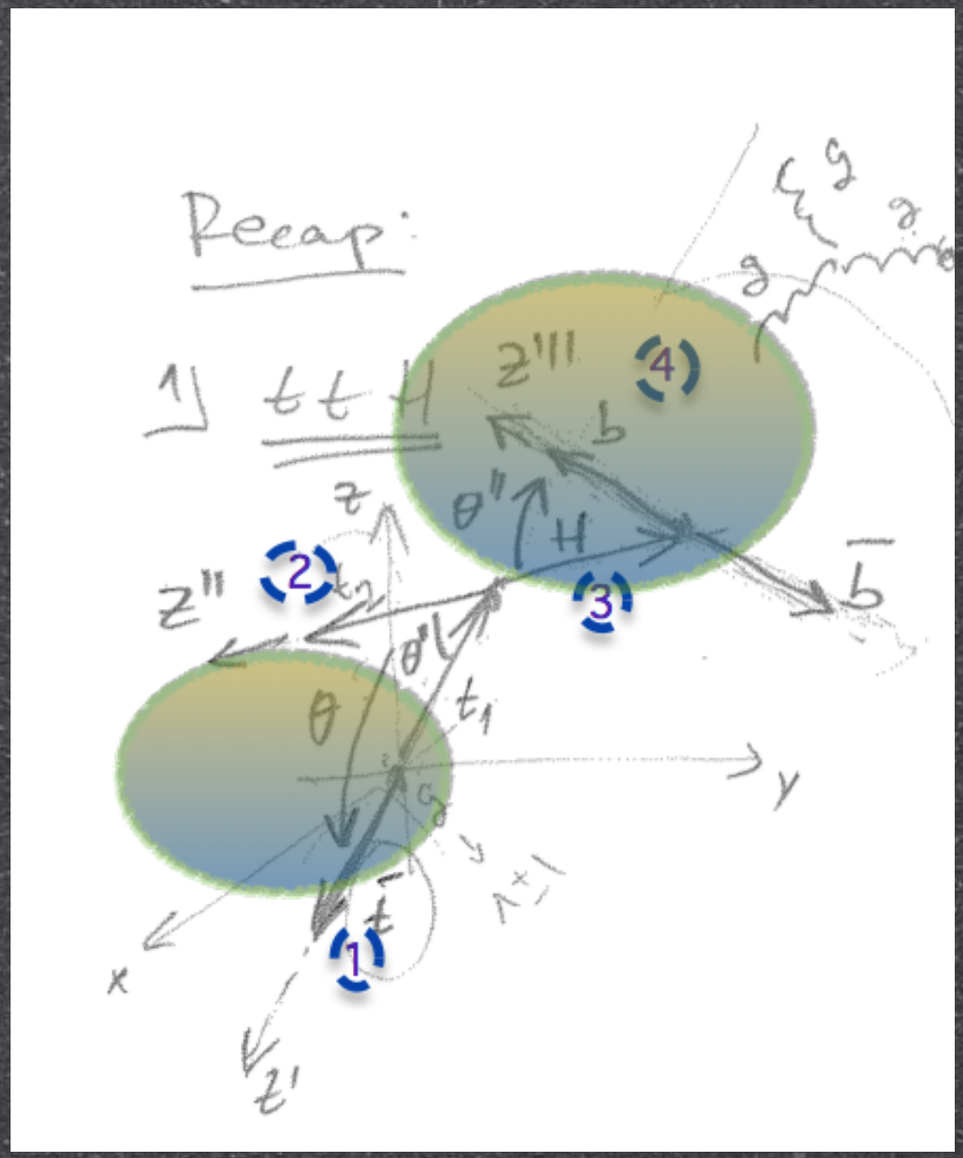
Parton Level $\bar{b}_{\bar{t}}$



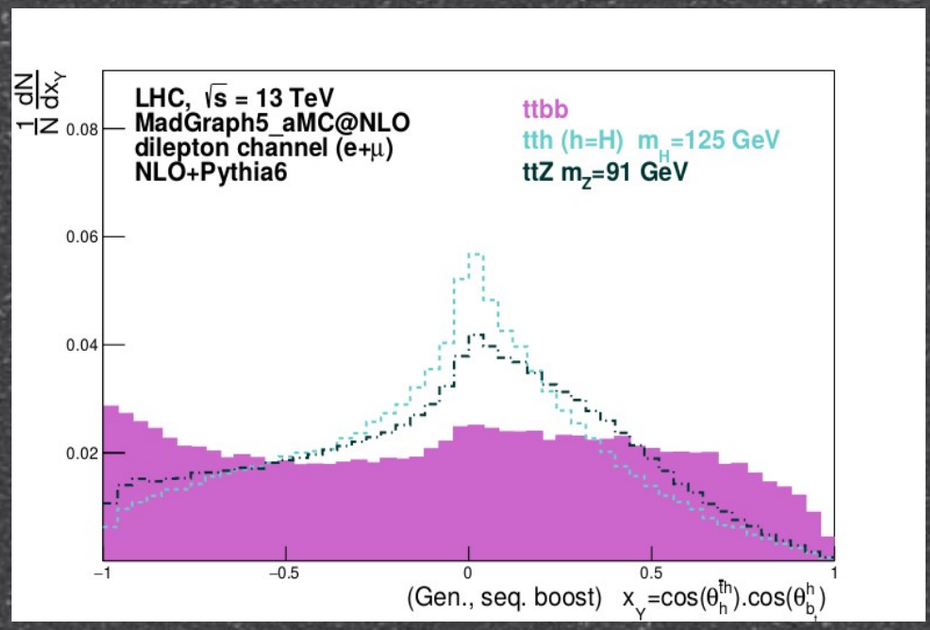


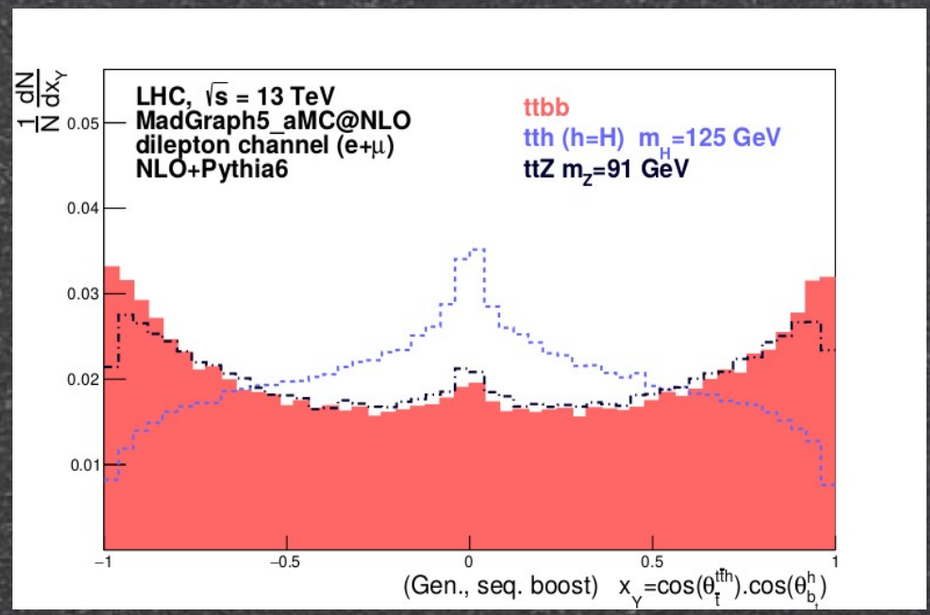


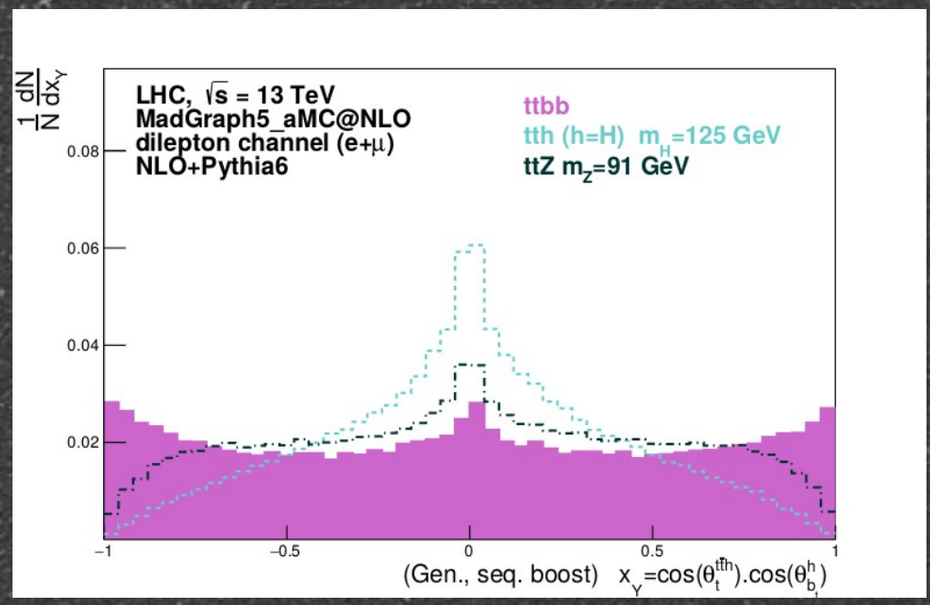
Semileptonic ttZ Signal (seq. boost)



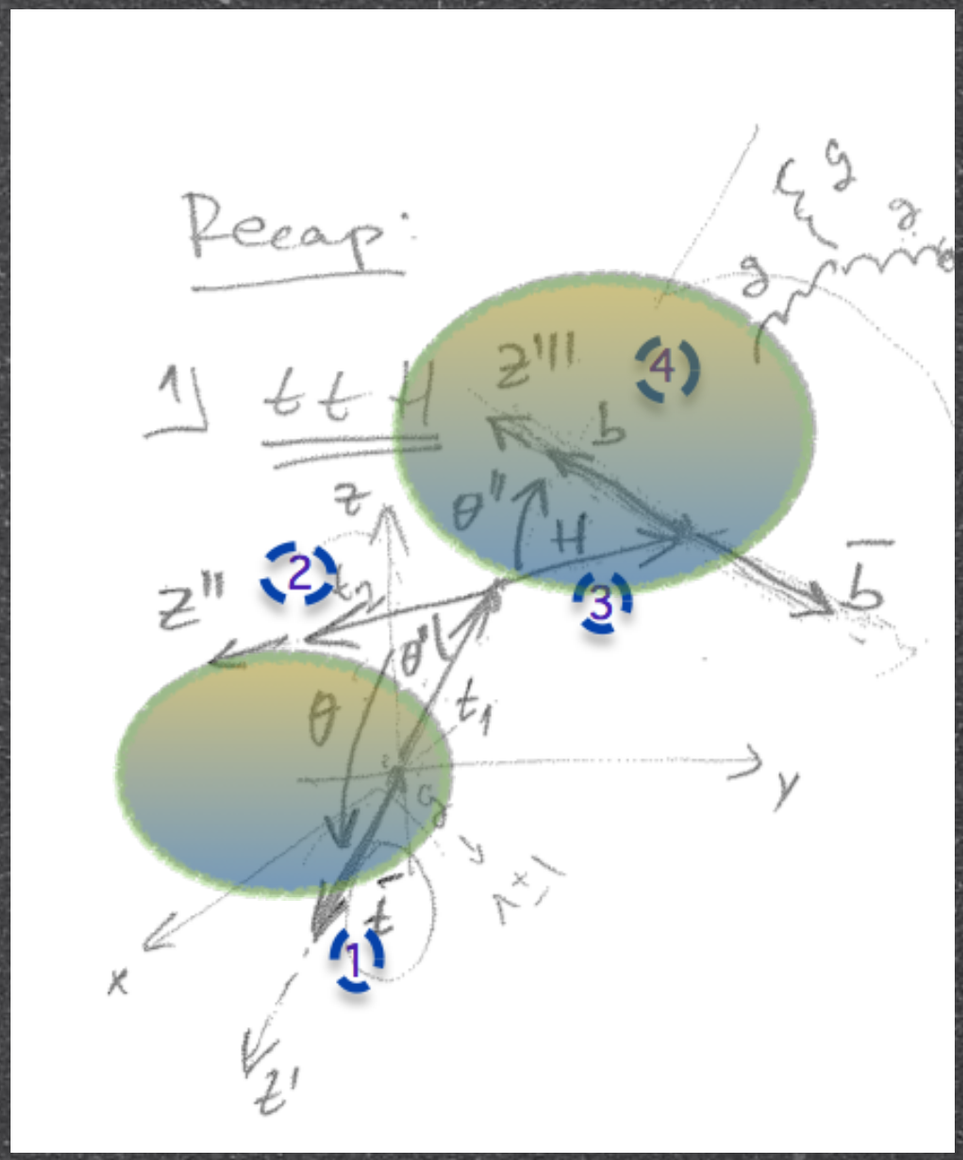
Parton Level



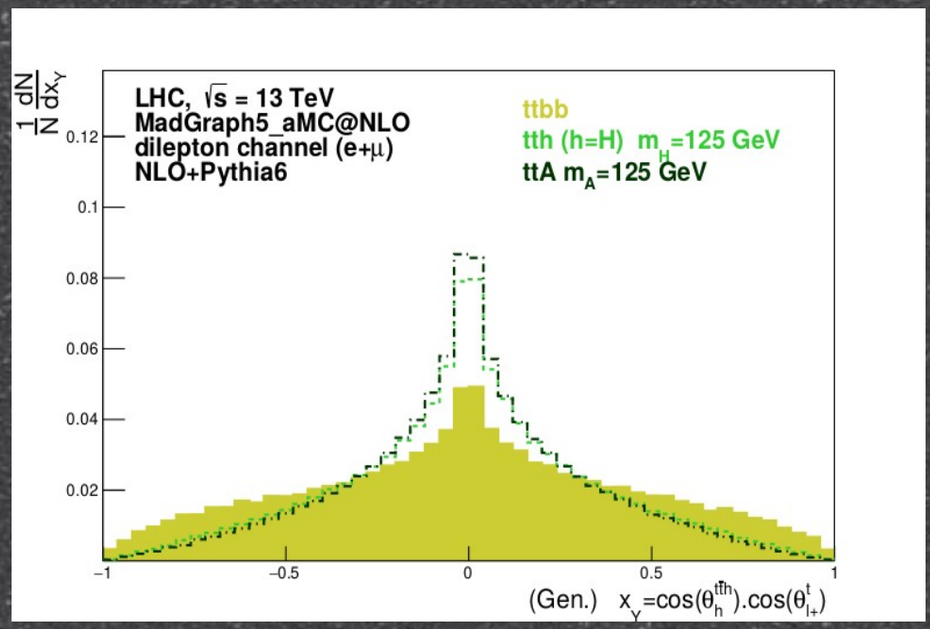


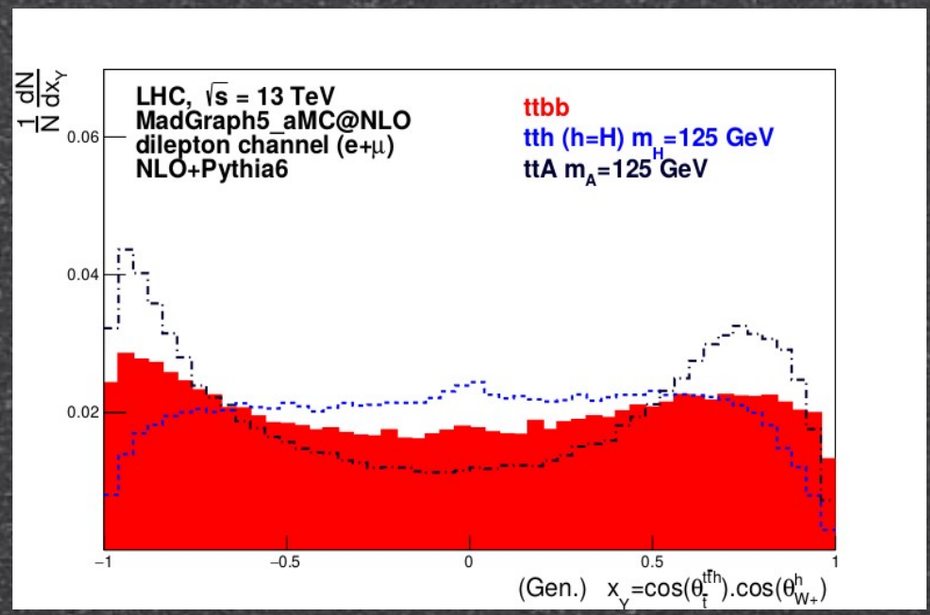


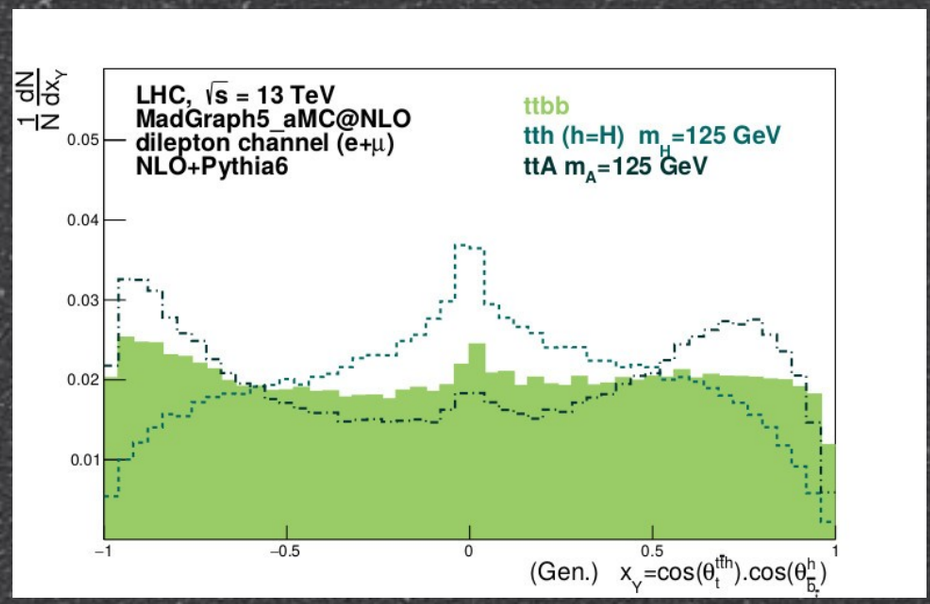
Semileptonic ttA Signal



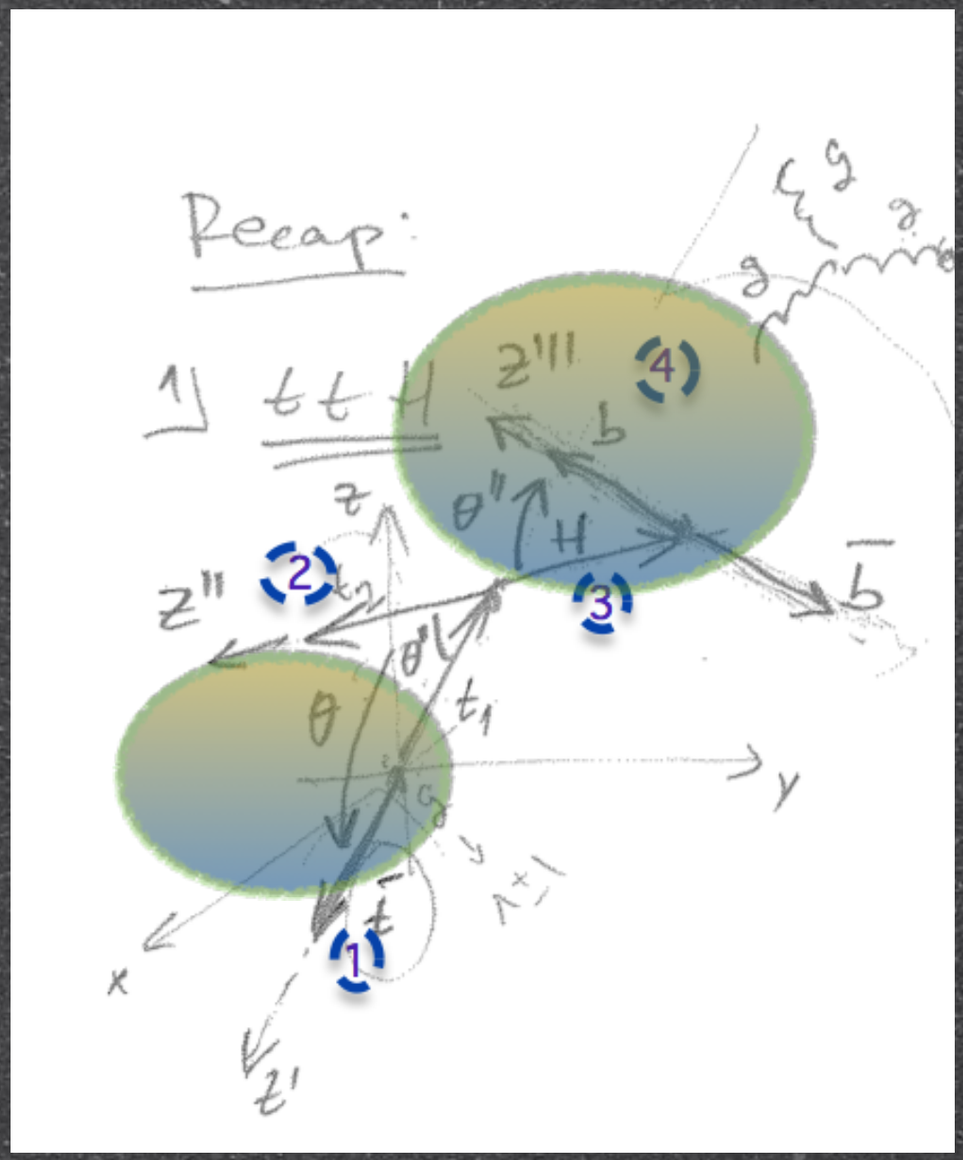
Parton Level





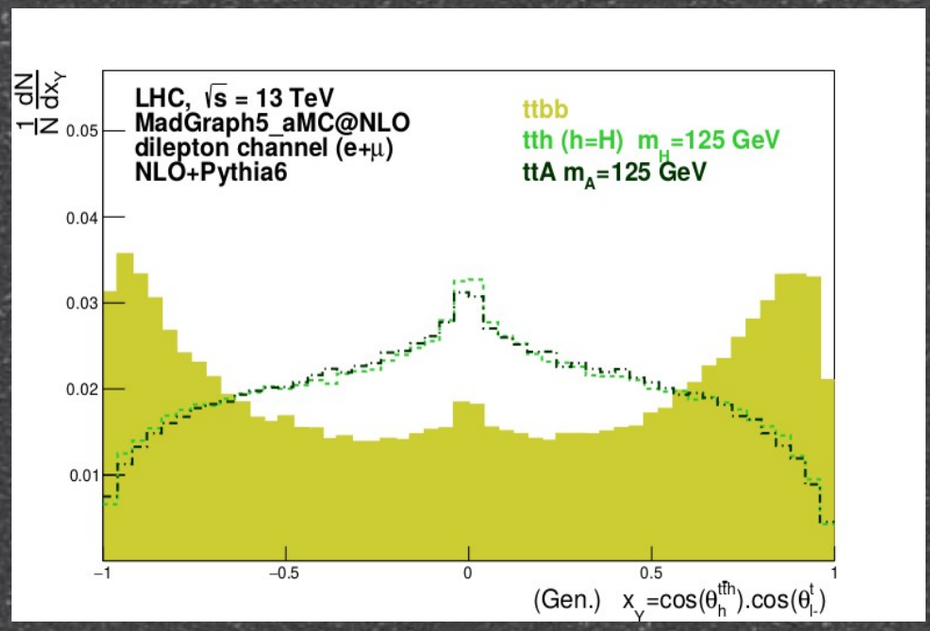


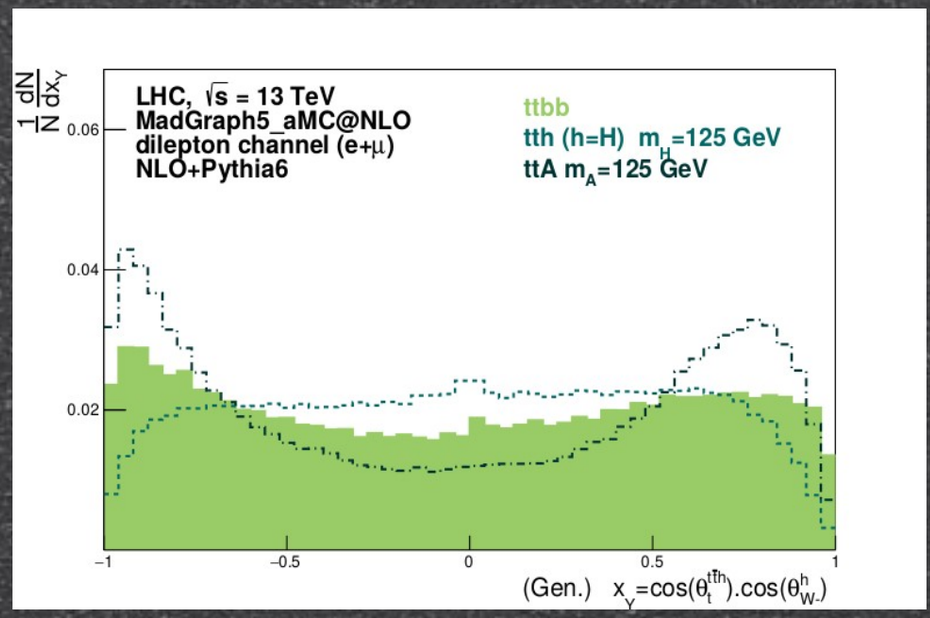
Semileptonic ttA Signal (CP)



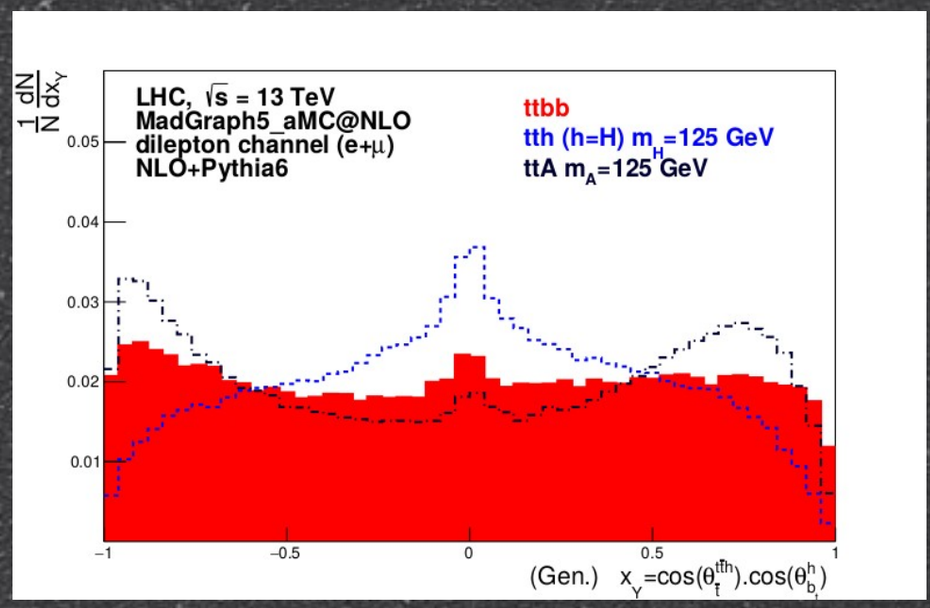
Parton Level

CP





CP



CP

Reconstruction based on Likelihood Method

ChiSquared ->

$$
\begin{aligned}
\chi^2 &= 8 \cdot \ln 2 \cdot \frac{(m_{q_1 q_2 q_3} - m_{\mathrm{top}})^2}{\Gamma_{\mathrm{top}}^2} + 8 \cdot \ln 2 \cdot \frac{(m_{q_1 q_2} - m_{\mathrm{W}})^2}{\Gamma_{\mathrm{W}}^2} \\
&+ 8 \cdot \ln 2 \cdot \frac{(m_{q_4 \ell \nu} - m_{\mathrm{top}})^2}{\Gamma_{\mathrm{top}}^2} + 8 \cdot \ln 2 \cdot \frac{(m_{\ell \nu} - m_{\mathrm{W}})^2}{\Gamma_{\mathrm{W}}^2} \\
&- 2 \cdot \sum_{i=1}^{4} \ln W_{\mathrm{jet}}(E_{\mathrm{jet},i}^{\mathrm{meas}} | E_{\mathrm{jet},i}) - 2 \cdot \ln W_{\ell}(E_{\ell}^{\mathrm{meas}} | E_{\ell}) \\
&- 2 \cdot \ln W_{\mathrm{miss}}(E_x^{\mathrm{miss}} | p_x^{\nu}) - 2 \cdot \ln W_{\mathrm{miss}}(E_y^{\mathrm{miss}} | p_y^{\nu}) \,,
\end{aligned}
$$

Likelihood ->

$$
\begin{aligned}
L &= B(m_{q_1 q_2 q_3} | m_{\mathrm{top}}, \Gamma_{\mathrm{top}}) \cdot \exp\left(-4 \cdot \ln 2 \cdot \frac{(m_{q_1 q_2} - m_{\mathrm{W}})^2}{\Gamma_{\mathrm{W}}^2} \right) \\
&\times B(m_{q_4 \ell \nu} | m_{\mathrm{top}}, \Gamma_{\mathrm{top}}) \cdot B(m_{\ell \nu} | m_{\mathrm{W}}, \Gamma_{\mathrm{W}}) \\
&\times \prod_{i=1}^{4} W_{\mathrm{jet}}(E_{\mathrm{jet},i}^{\mathrm{meas}} | E_{\mathrm{jet},i}) \cdot W_{\ell}(E_{\ell}^{\mathrm{meas}} | E_{\ell}) \\
&\times W_{\mathrm{miss}}(E_x^{\mathrm{miss}} | p_x^{\nu}) \cdot W_{\mathrm{miss}}(E_y^{\mathrm{miss}} | p_y^{\nu}) \,,
\end{aligned}
$$

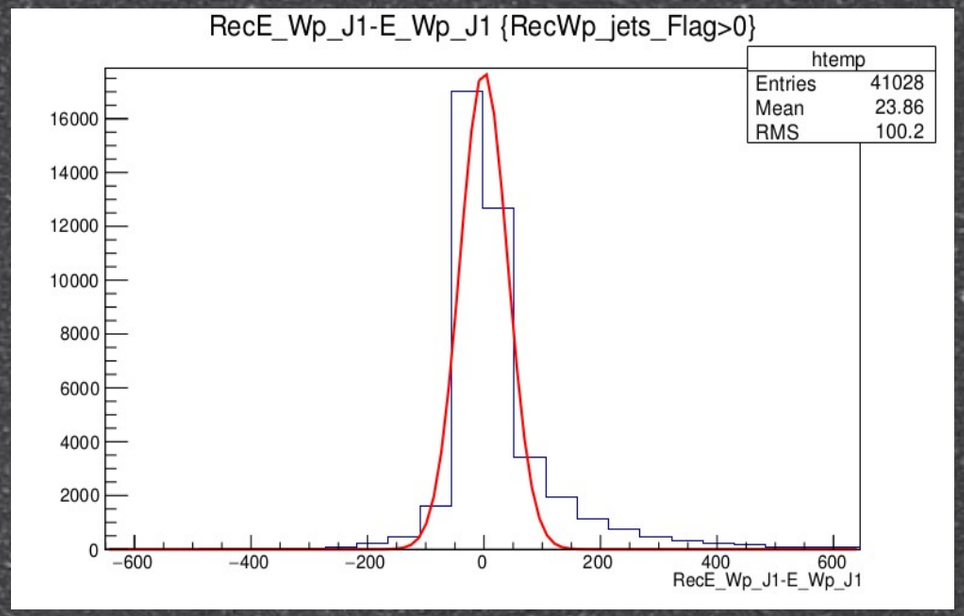
Reconstruction based on Likelihood Method

KLFitter (Arxiv 1312.5595)

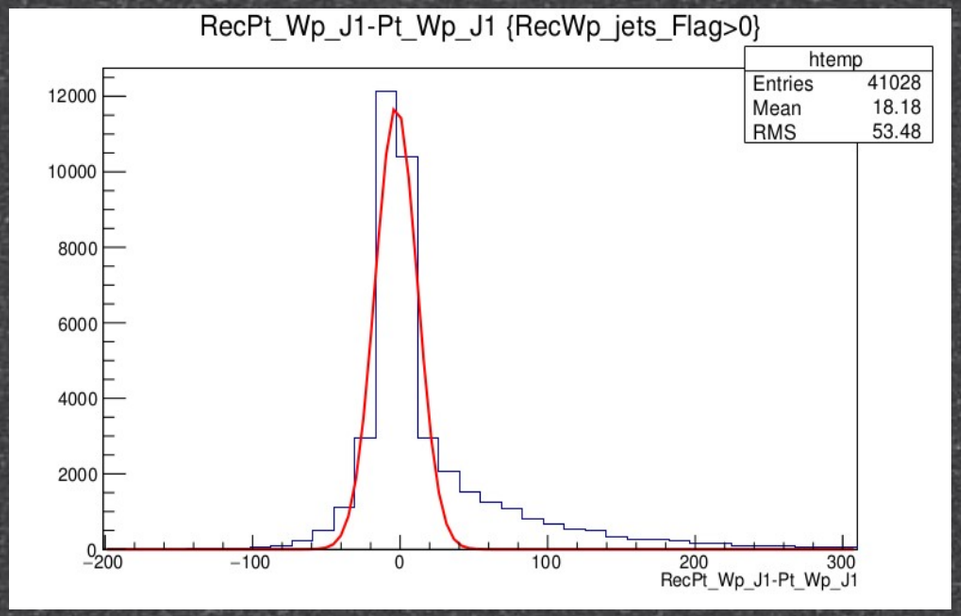
Method	Reconstruction efficiency [%]					
	Overall	W_{had}	b_{had}	b_{lep}	$p(b\text{-id})$	$p(b\text{-mis-id})$
Comb. 0-tag	8.3	16.7	25.0	25.0	50.0	50.0
Comb. 1-tag	16.7	33.3	33.3	33.3	66.7	33.3
Comb. 2-tag	50.0	100.0	50.0	50.0	100.0	0.0
$p_{\text{T}}^{\text{max}}$	21.5 ± 0.1	28.2 ± 0.2	30.7 ± 0.2	47.7 ± 0.2	57.6 ± 0.2	42.4 ± 0.2
χ^2 (m_W con.)	46.1 ± 0.2	59.1 ± 0.3	51.8 ± 0.3	62.4 ± 0.3	77.0 ± 0.3	23.0 ± 0.2
χ^2	48.4 ± 0.2	60.8 ± 0.2	53.8 ± 0.2	64.8 ± 0.2	78.0 ± 0.3	22.0 ± 0.1
Likelihood	51.9 ± 0.2	60.6 ± 0.2	56.8 ± 0.2	70.9 ± 0.2	78.2 ± 0.3	21.8 ± 0.1
χ^2 +b-veto	70.7 ± 0.2	89.1 ± 0.3	72.7 ± 0.2	75.5 ± 0.3	94.6 ± 0.3	5.4 ± 0.1
LH+b-veto	74.3 ± 0.3	88.8 ± 0.3	76.4 ± 0.3	79.5 ± 0.3	94.4 ± 0.3	5.6 ± 0.1
+fix mass	83.3 ± 0.3	91.1 ± 0.3	84.9 ± 0.3	88.0 ± 0.3	95.5 ± 0.3	4.5 ± 0.1
+angles	83.8 ± 0.3	91.2 ± 0.3	85.3 ± 0.3	88.4 ± 0.3	95.6 ± 0.3	4.4 ± 0.1
+0 b-tag	62 ± 12	66 ± 12	62 ± 12	77 ± 13	81 ± 13	19 ± 7
+1 b-tag	75.9 ± 0.4	81.7 ± 0.4	79.1 ± 0.4	85.8 ± 0.4	90.8 ± 0.4	9.2 ± 0.1
+2 b-tag	90.3 ± 0.4	99.2 ± 0.4	90.5 ± 0.4	90.6 ± 0.4	99.6 ± 0.4	0.4 ± 0.1

B-Tagging Efficiency 70% / B-Mismatching 5%

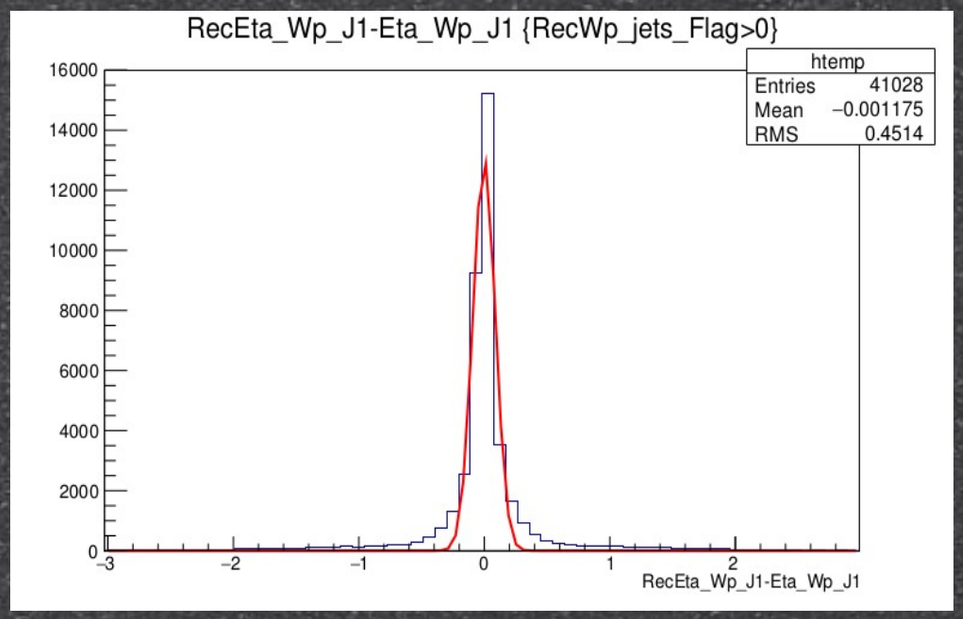
First Glimpse
Transfer Functions (J1 from W+)



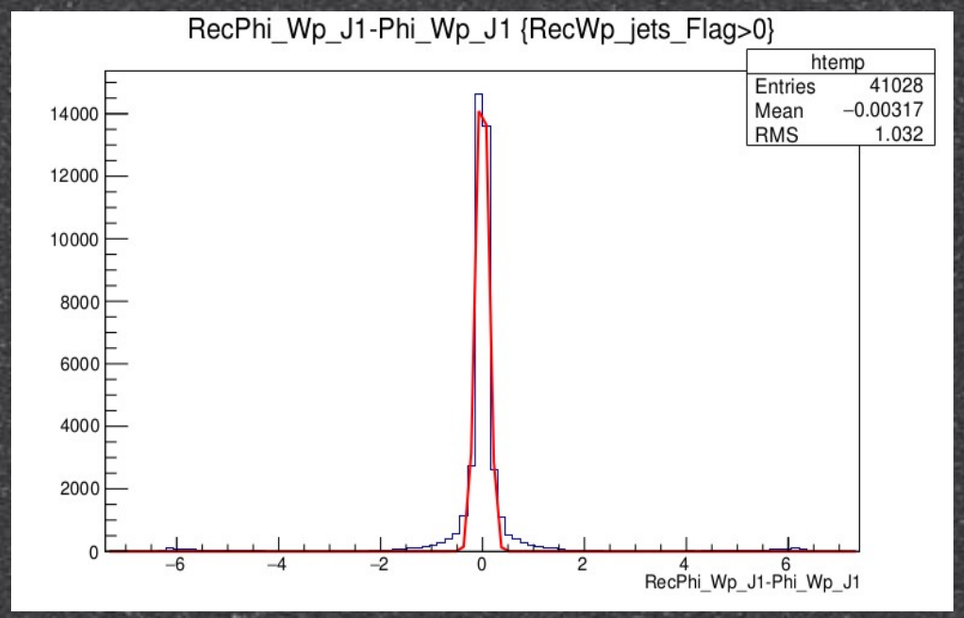
Energy



Transverse Momentum

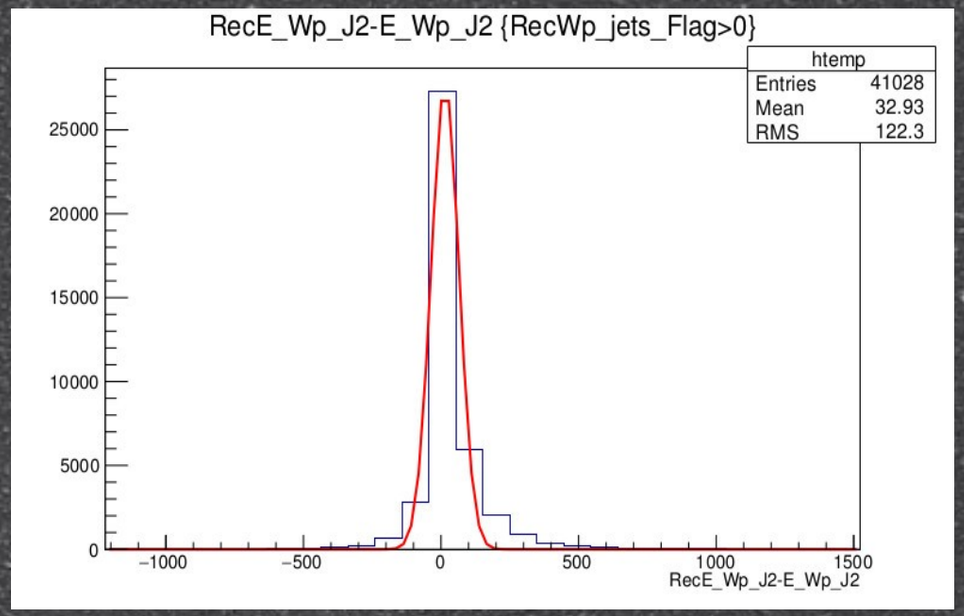


PseudoRapidity

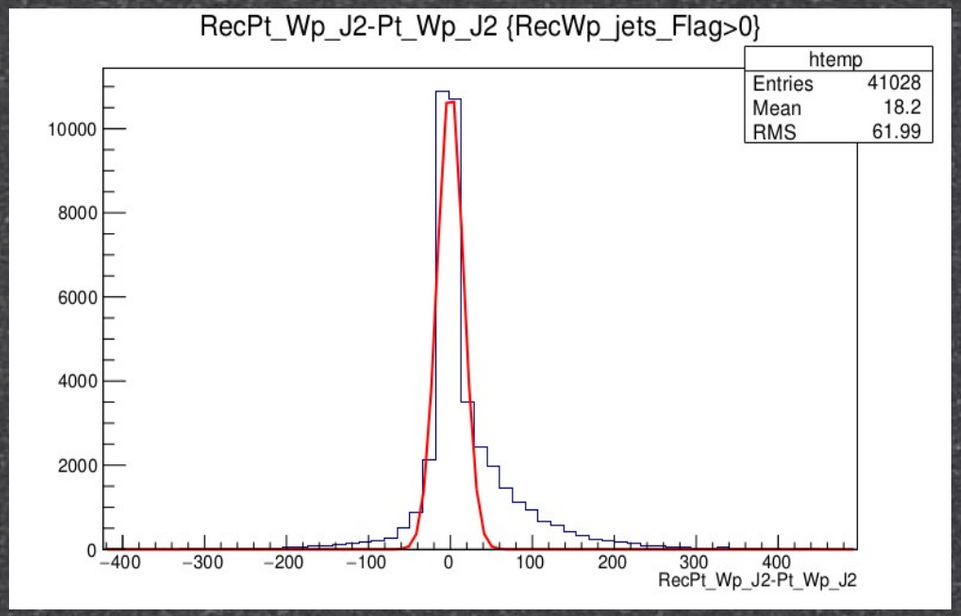


Phi

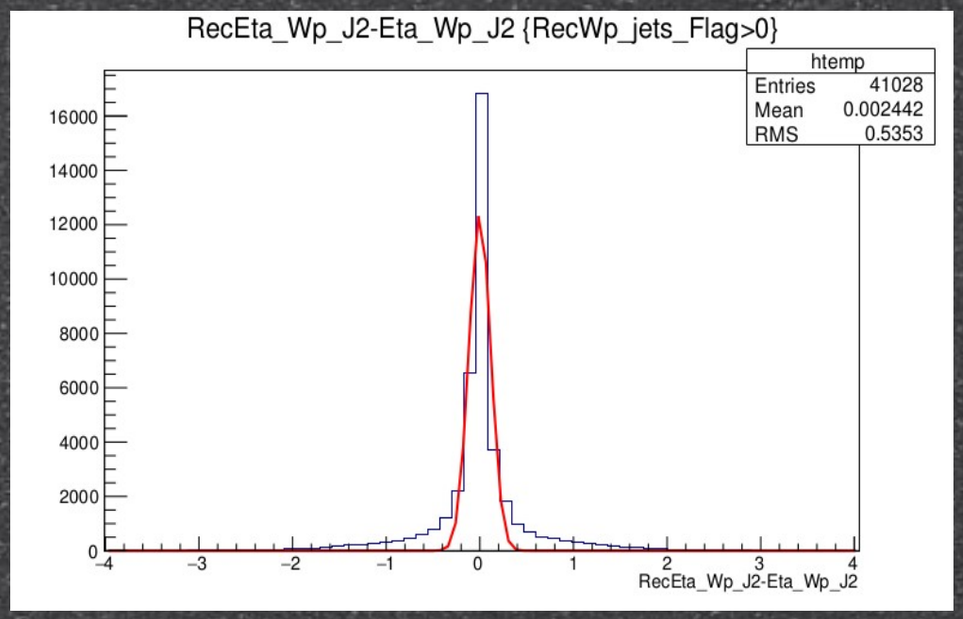
First Glimpse
Transfer Functions (J2 from W+)



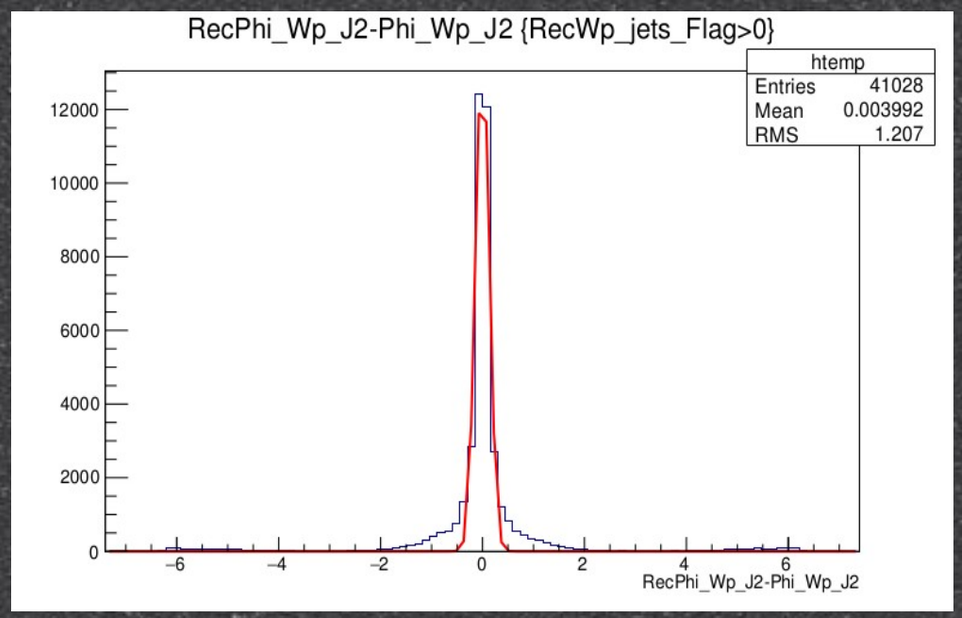
Energy



Transverse Momentum



PseudoRapidity

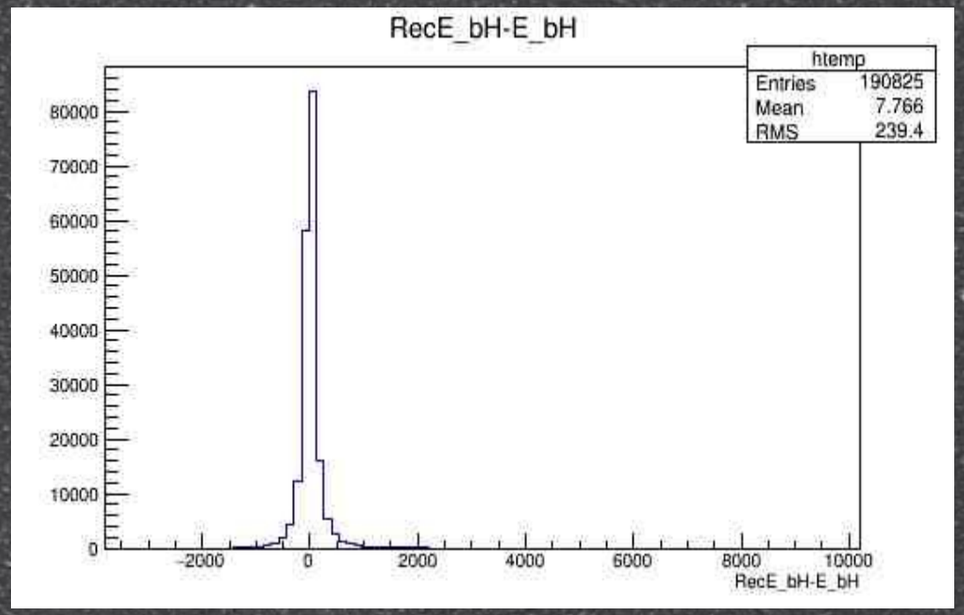


Phi

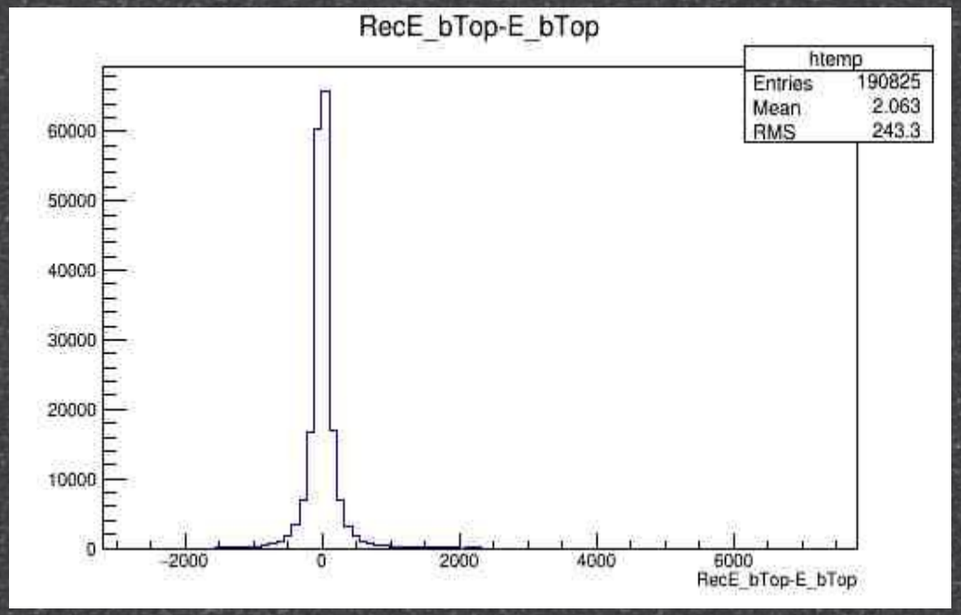
Semilep Code

Transfer Functions (bH and bT)

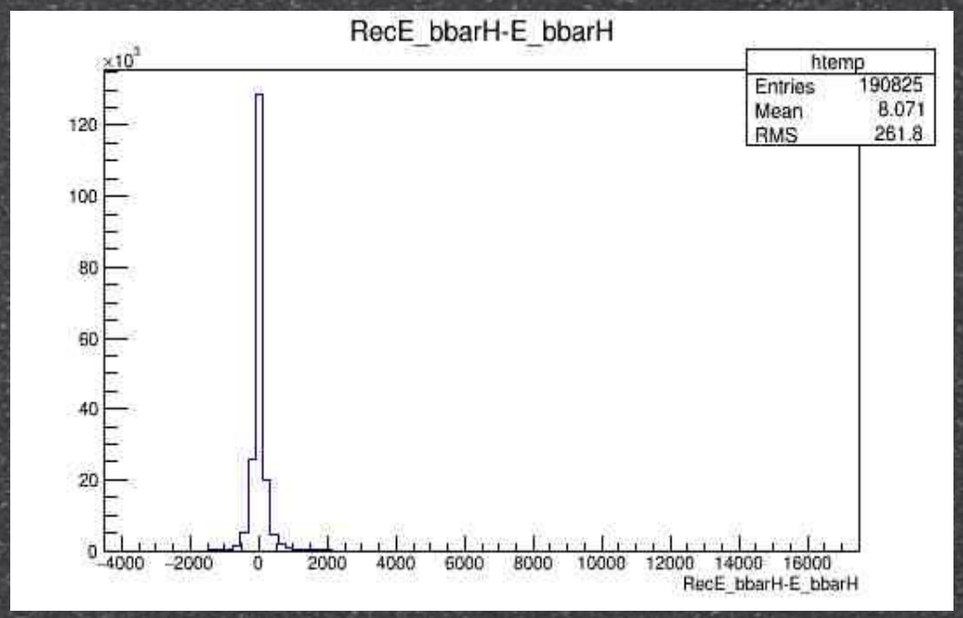
Jet Cone 0.7



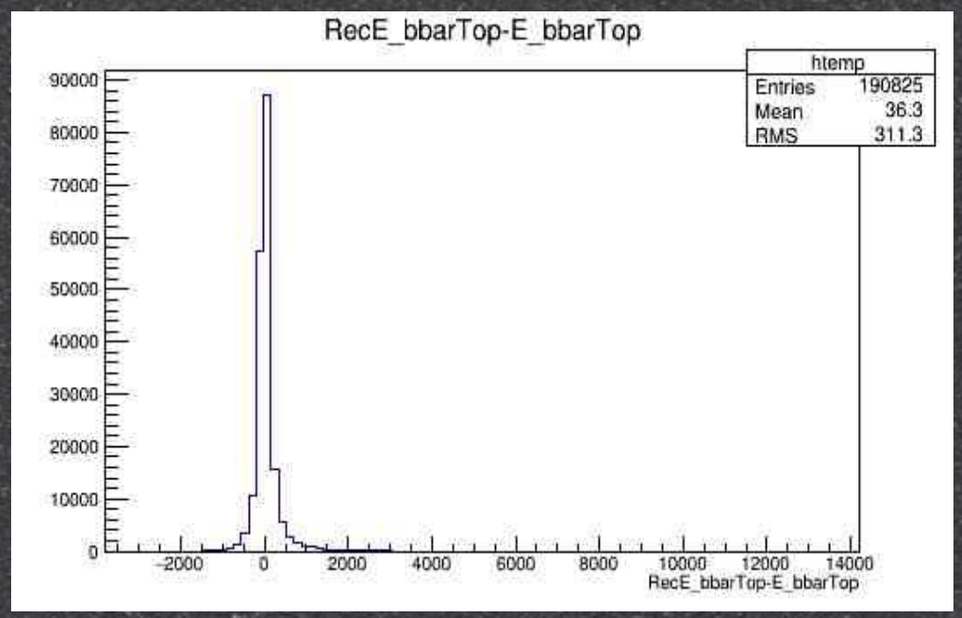
B from Higgs



B from T



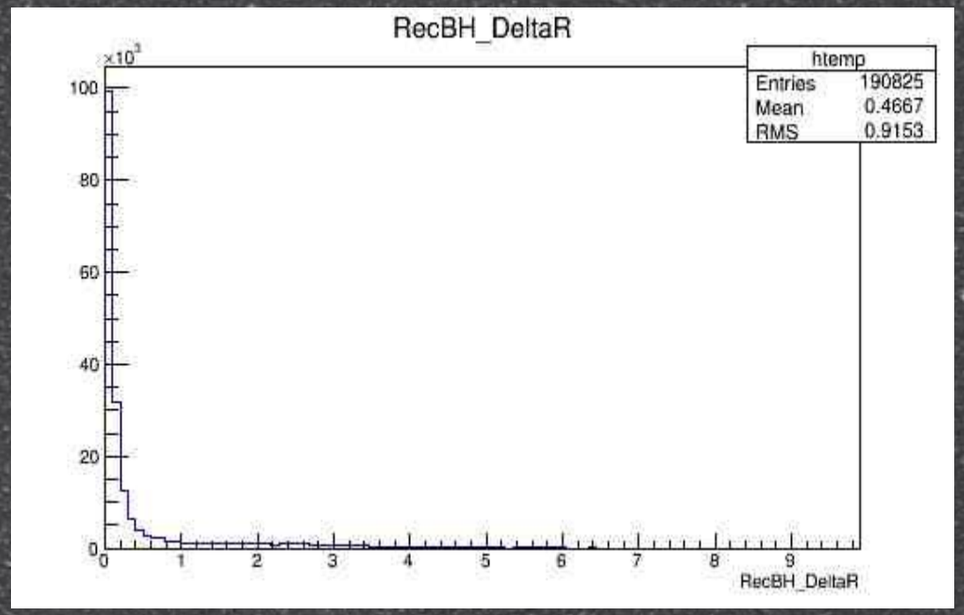
Bbar from Higgs



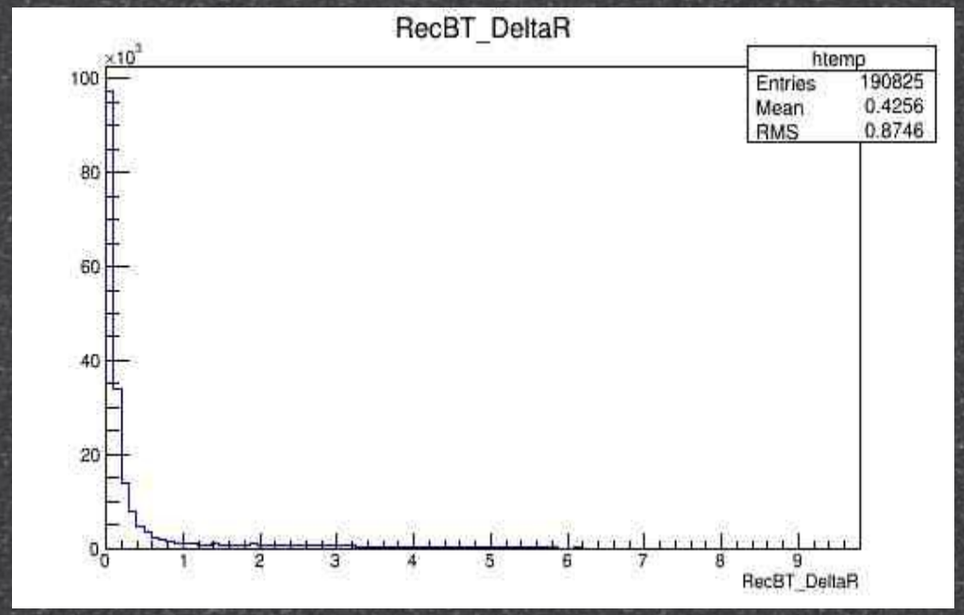
Bbar from Tbar

Delta R (bH and bT)

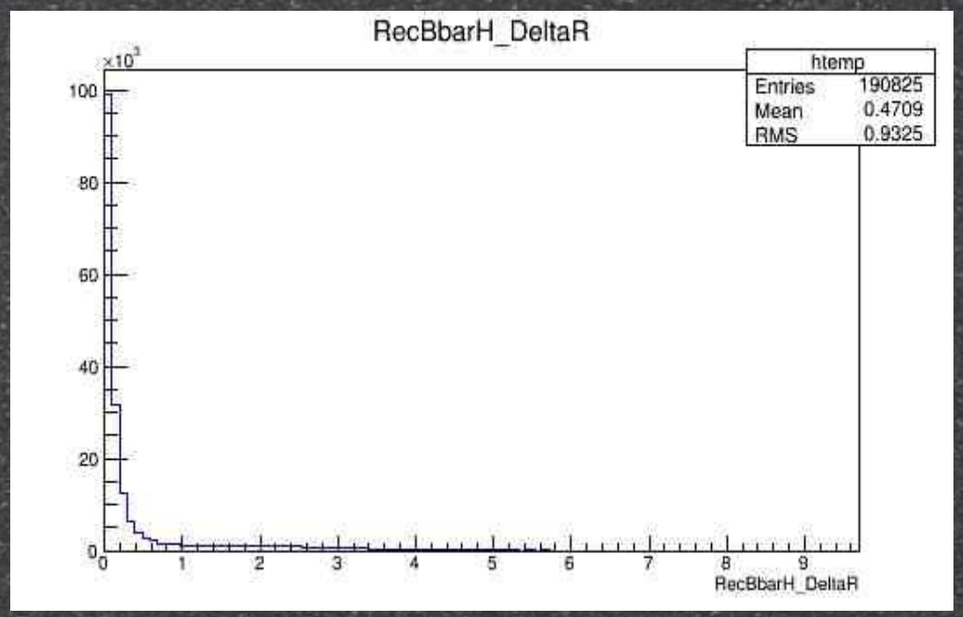
Jet Cone 0.7



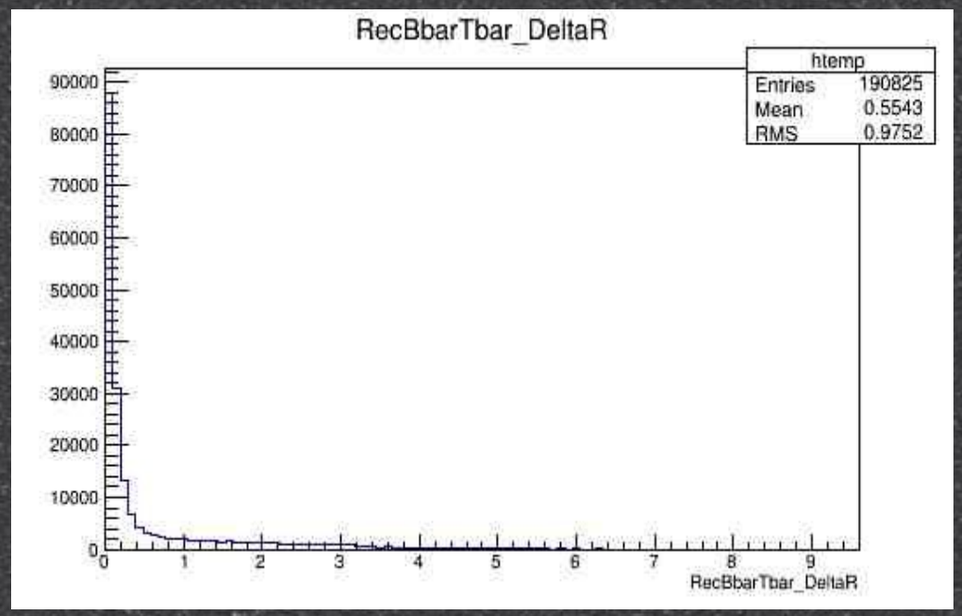
B from Higgs



B from T



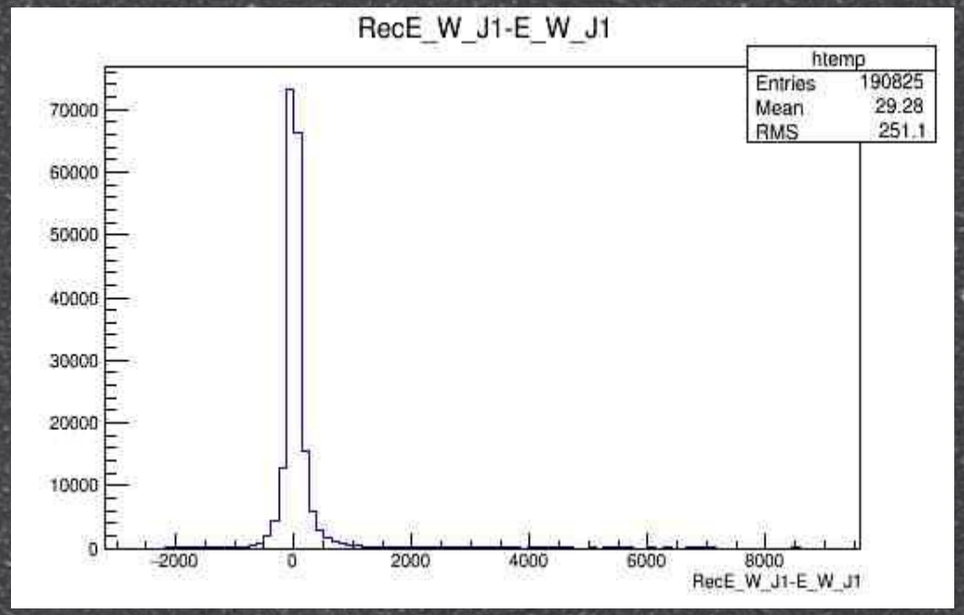
Bbar from Higgs



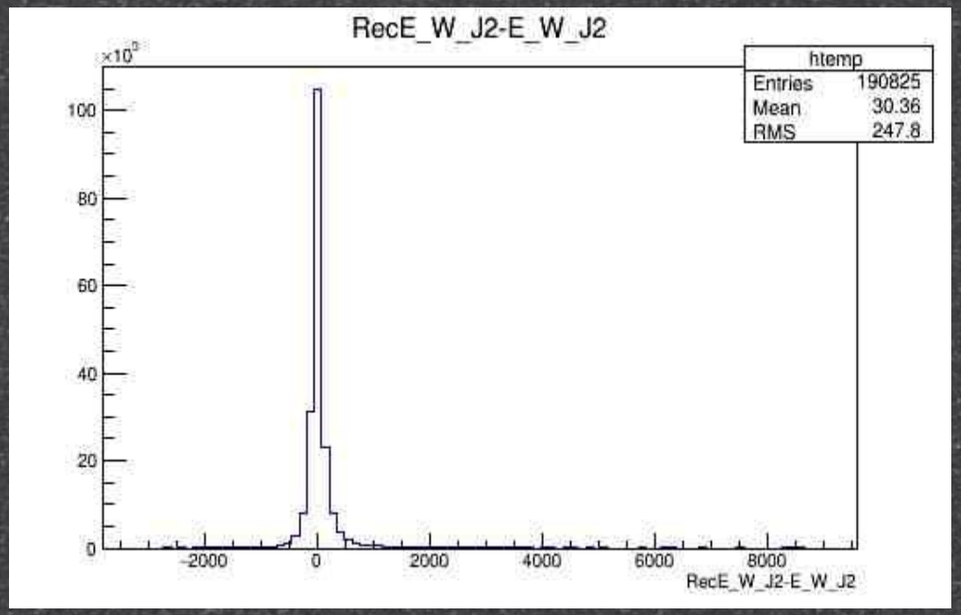
Bbar from Tbar

Transfer Functions (J1 and J2)

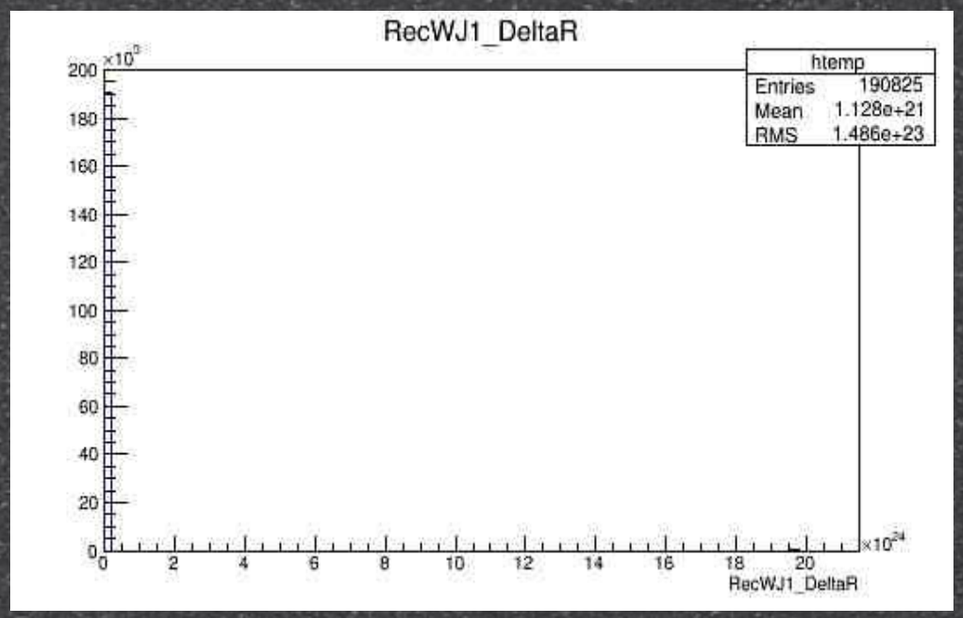
Jet Cone 0.7



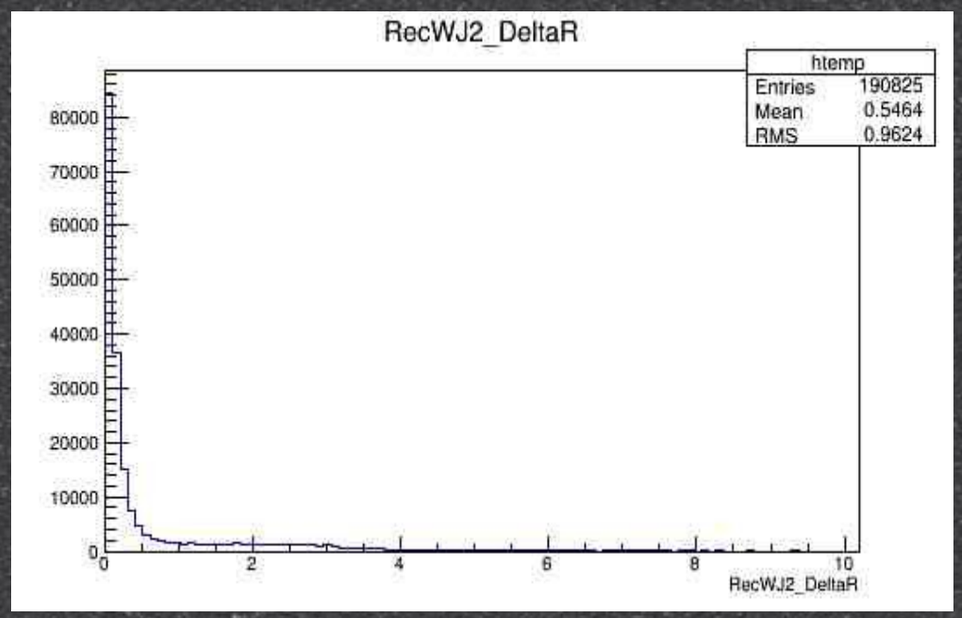
J1 TransferFunction



J2 TransferFunction



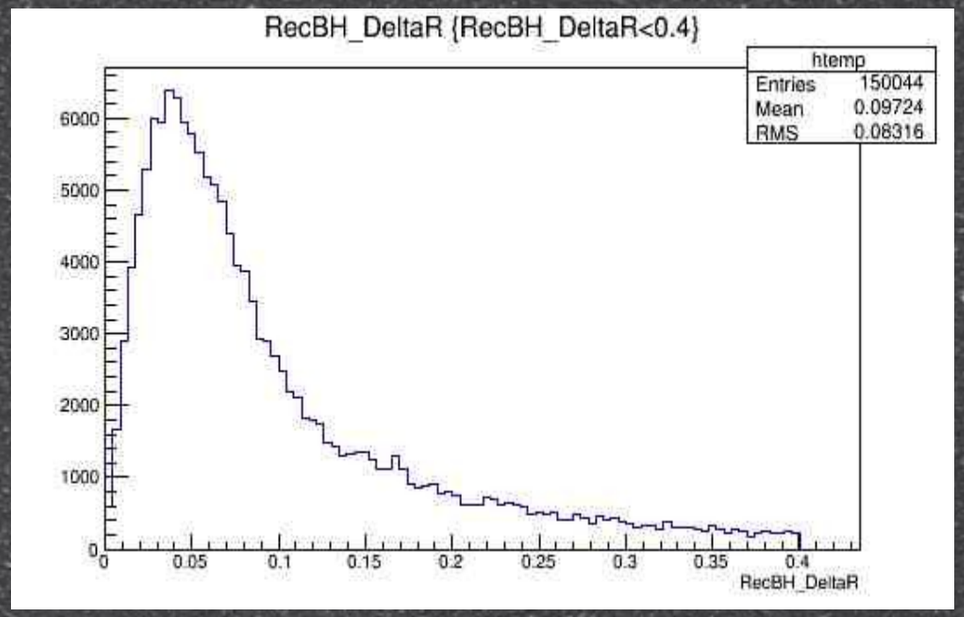
J1 DeltaR



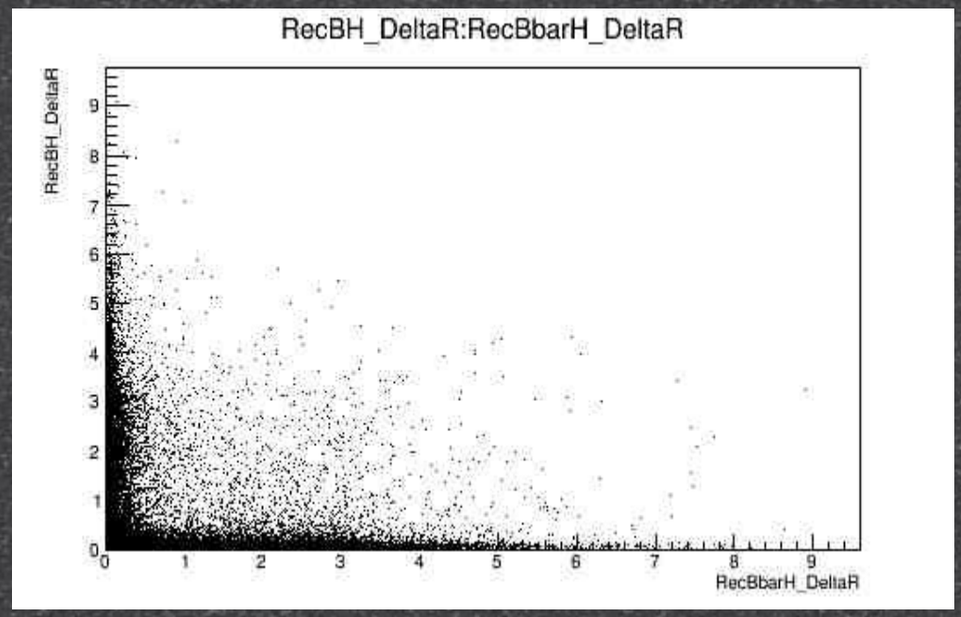
J2 DeltaR

Delta R < 0.4 (bH)

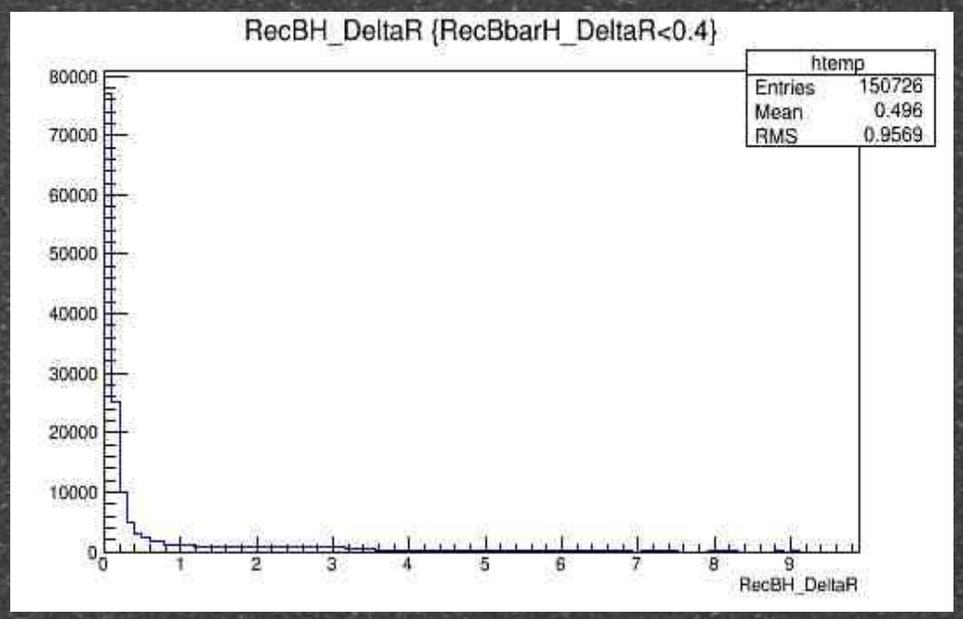
Jet Cone 0.7



BH (BH_DeltaR<0.4)



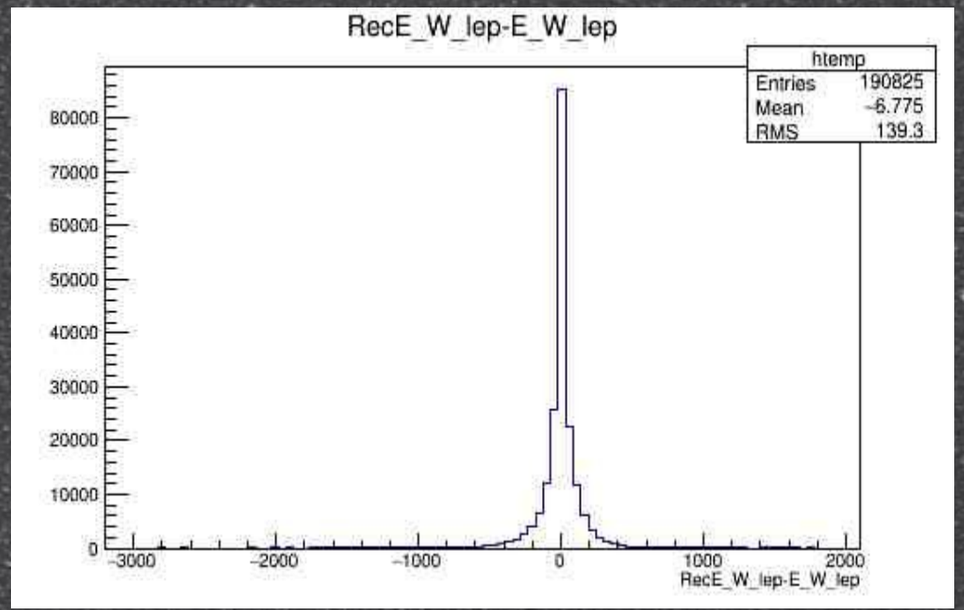
BH vs BbarH (DeltaR)



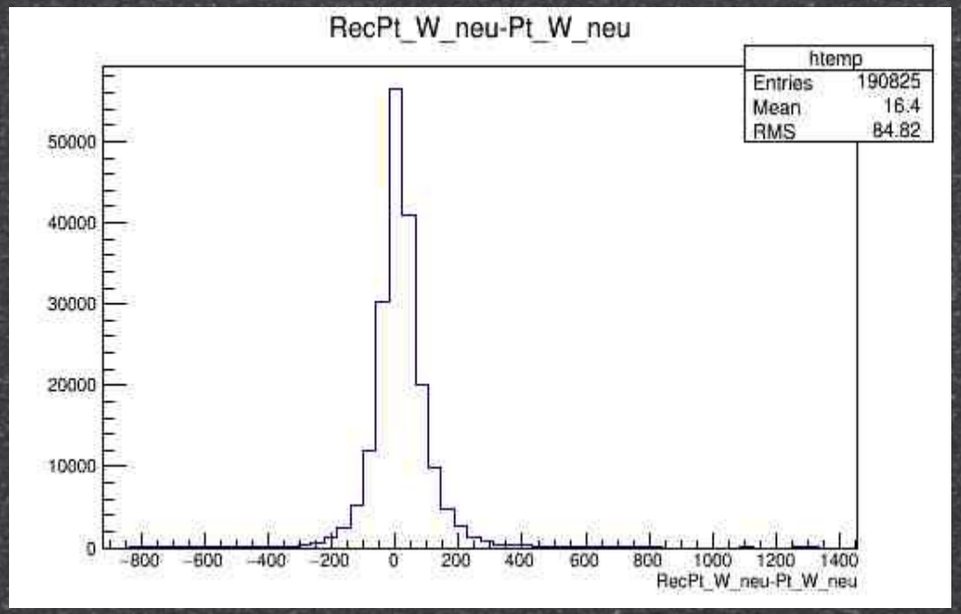
BH (BbarH_DeltaR<0.4)

DeltaR < 0.4 ---> Efficiency = 0.79

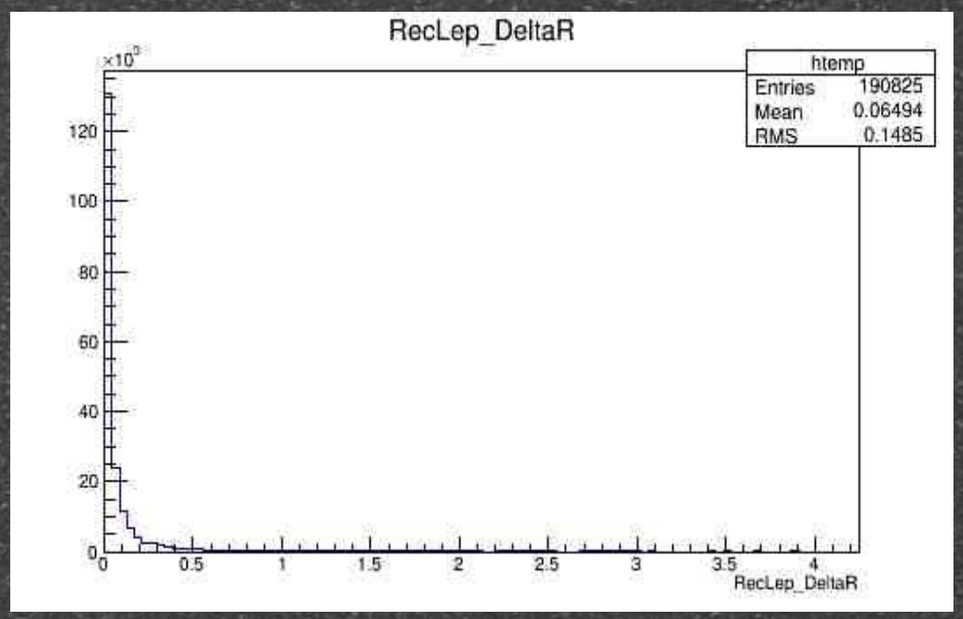
Transfer Functions (Lep and Neu)



Transfer Function Lepton



Missing Pt

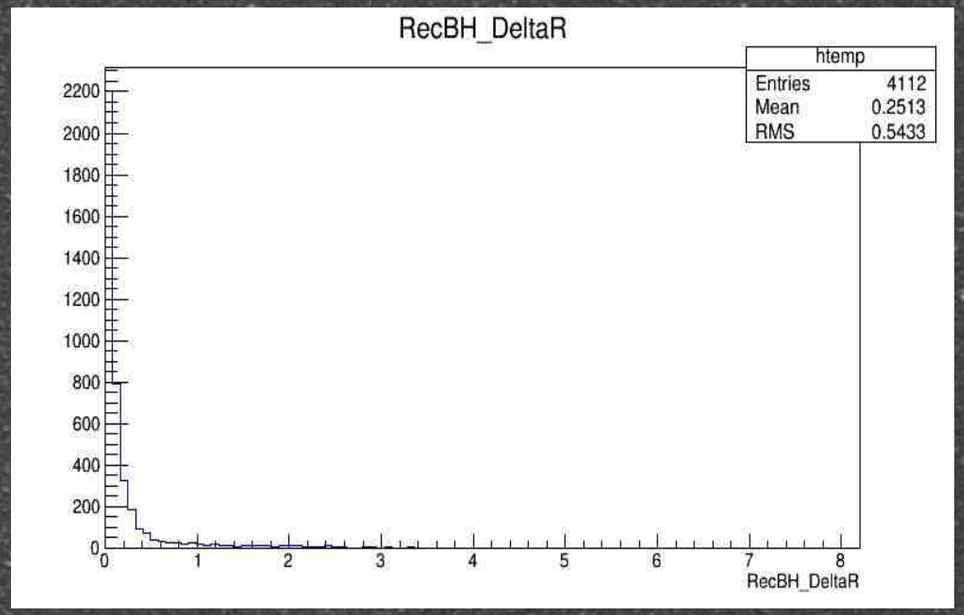


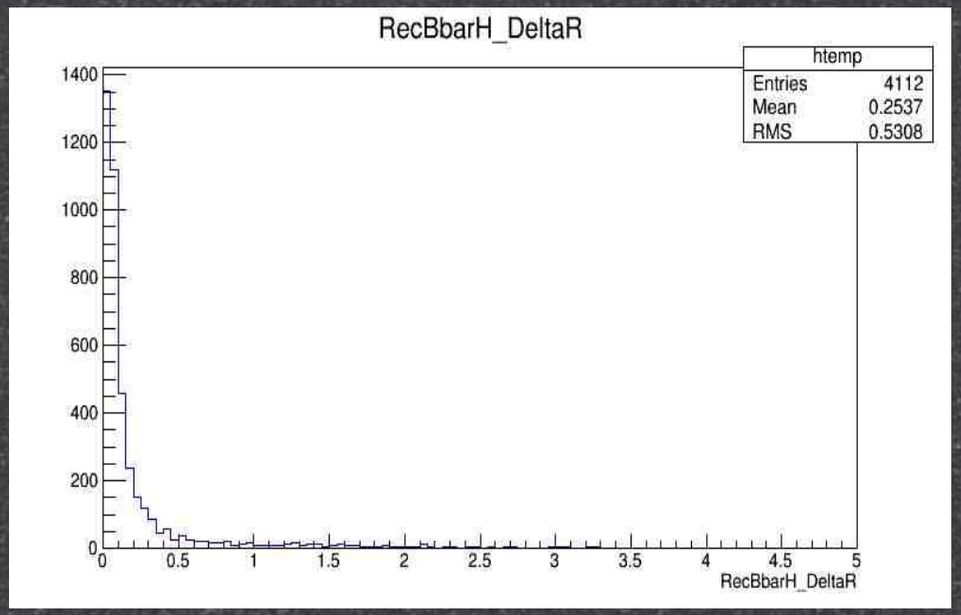
DeltaR Lepton

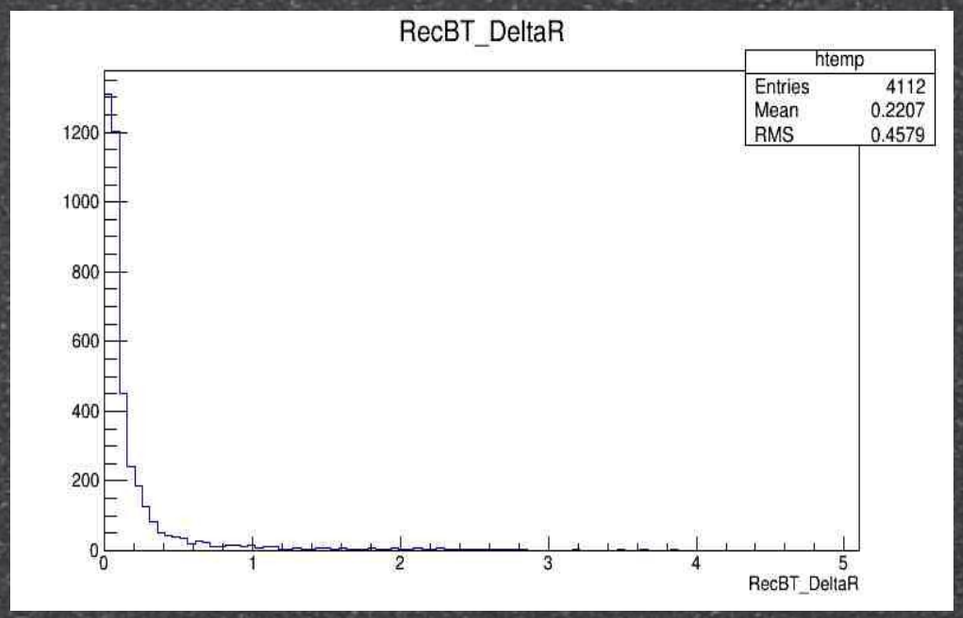
New Rec Method

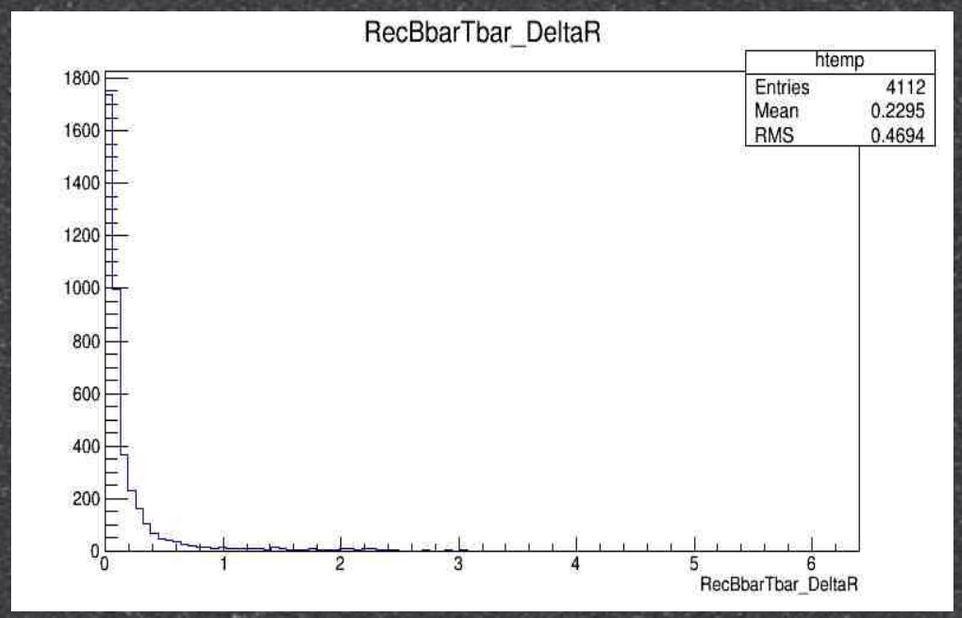
- Minumum Sum of DeltaR
- RecJet Radius 0.4
- New Values for flavour tagging

DeltaR B tagged Jets

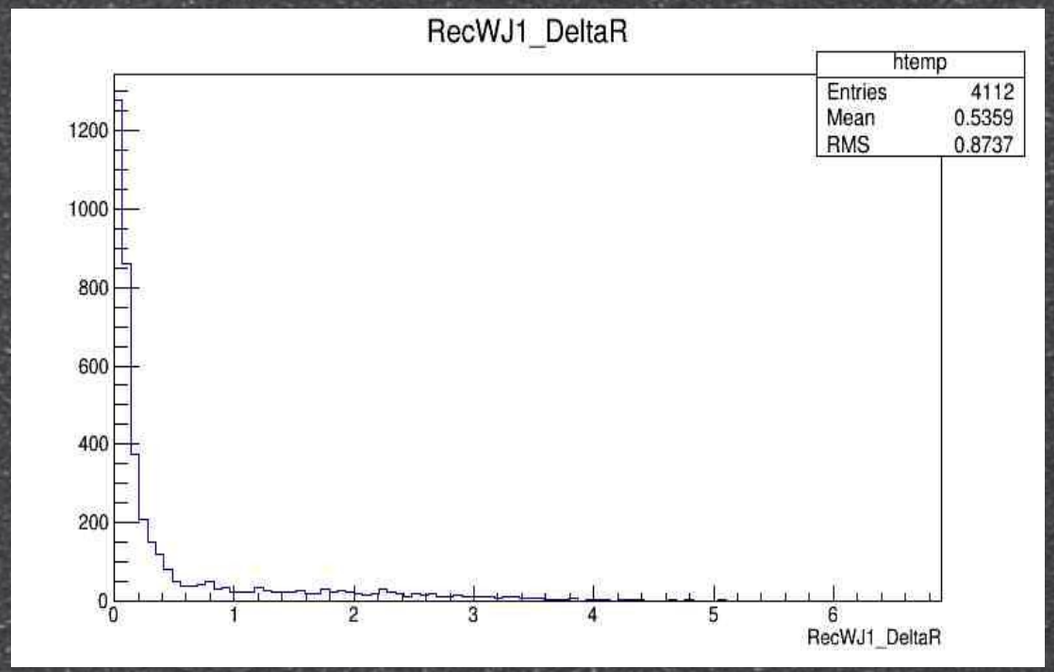


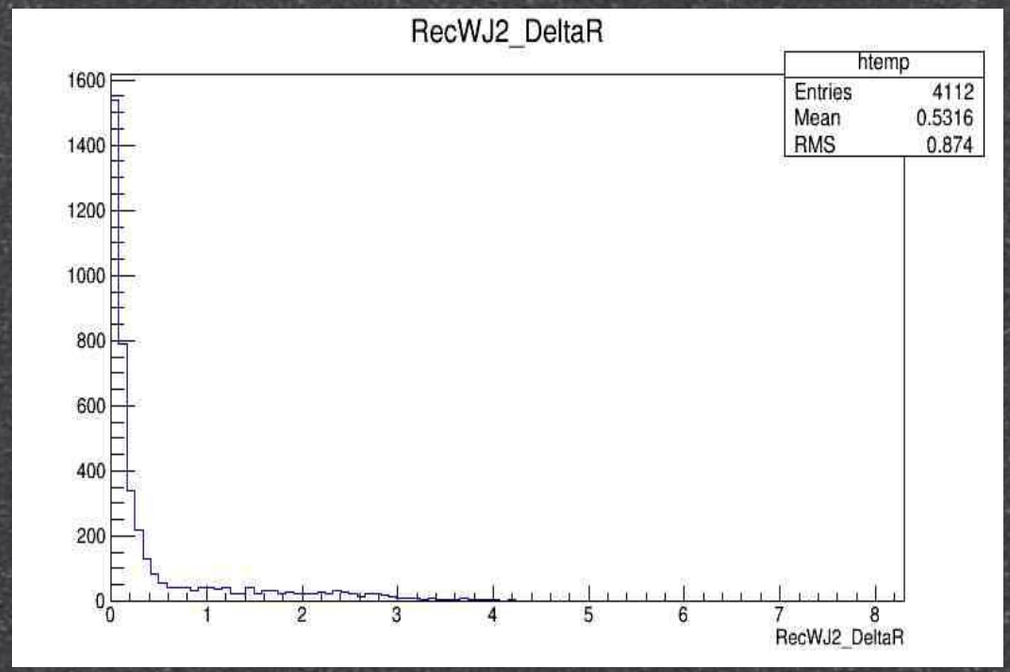




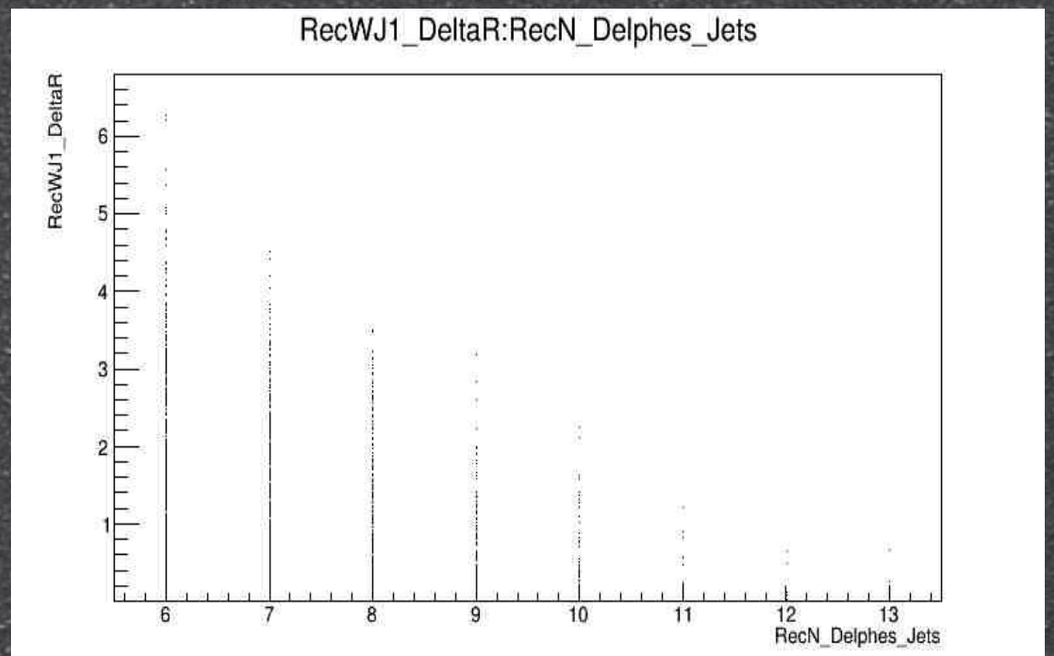


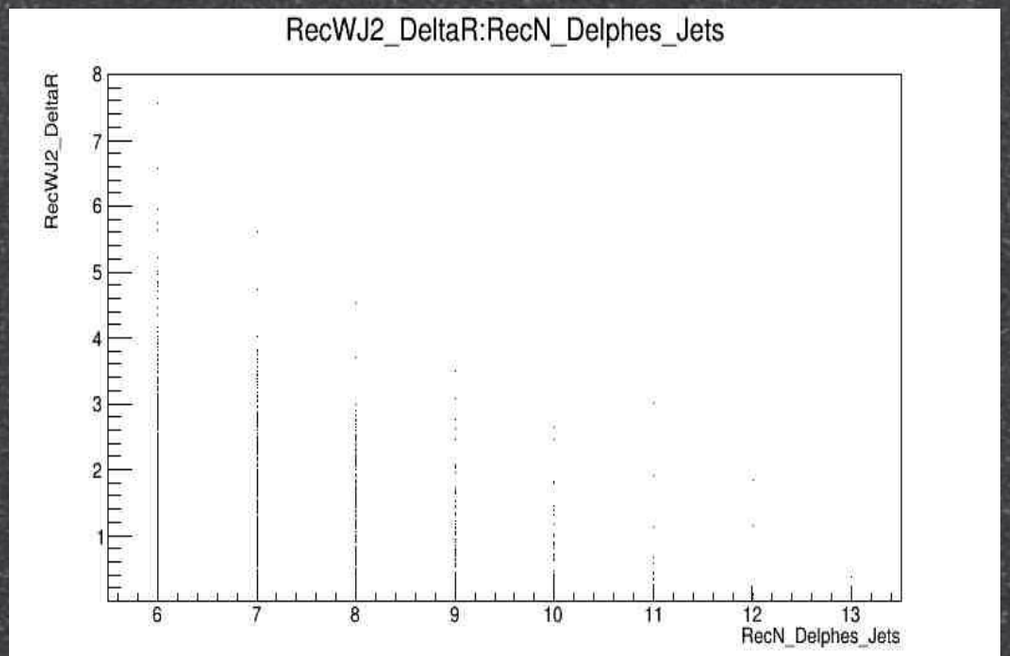
DeltaR Light jets



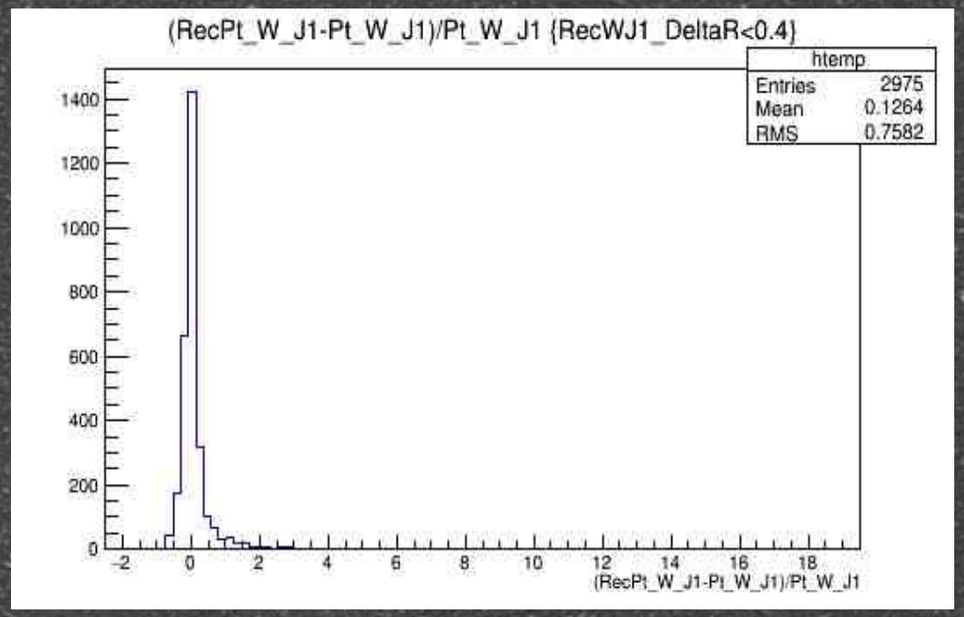


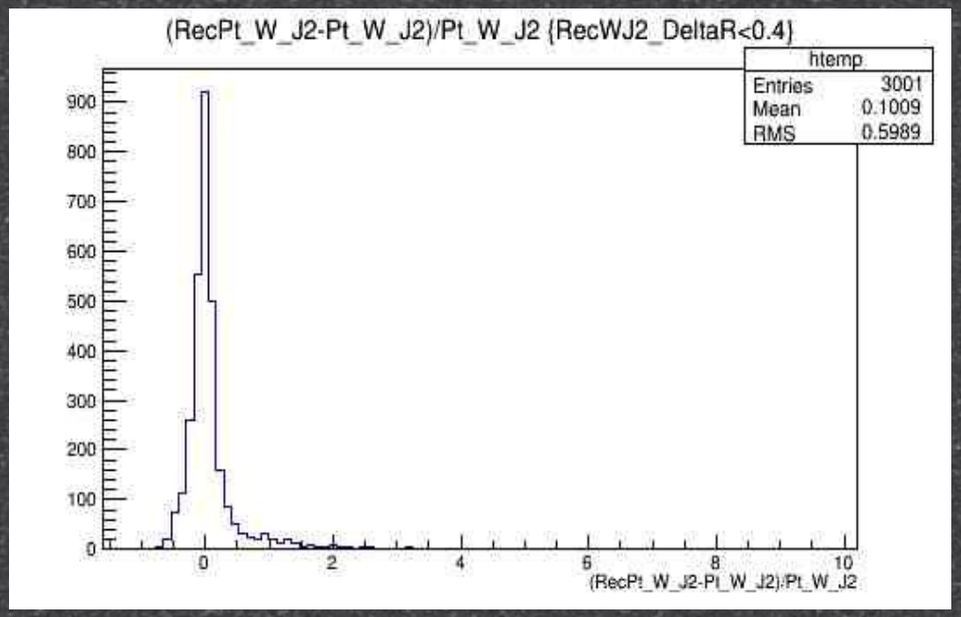
Comparissons with Jet Counters

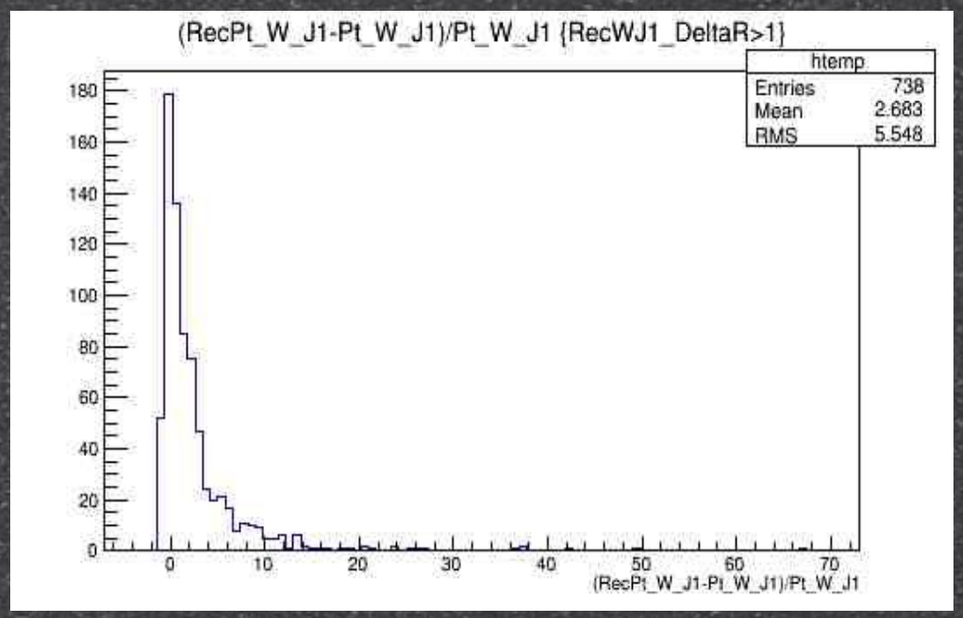


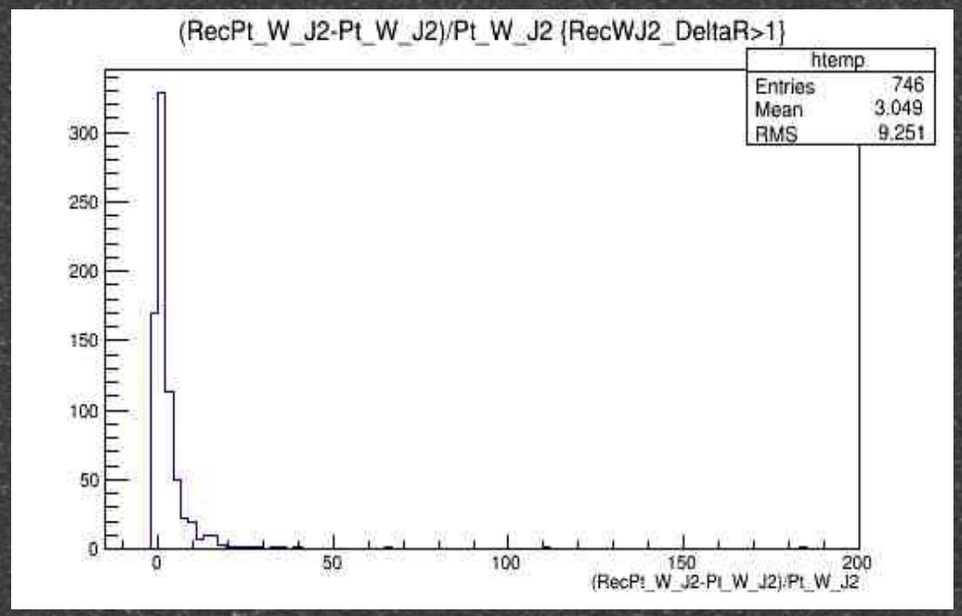


Pt Resolutions





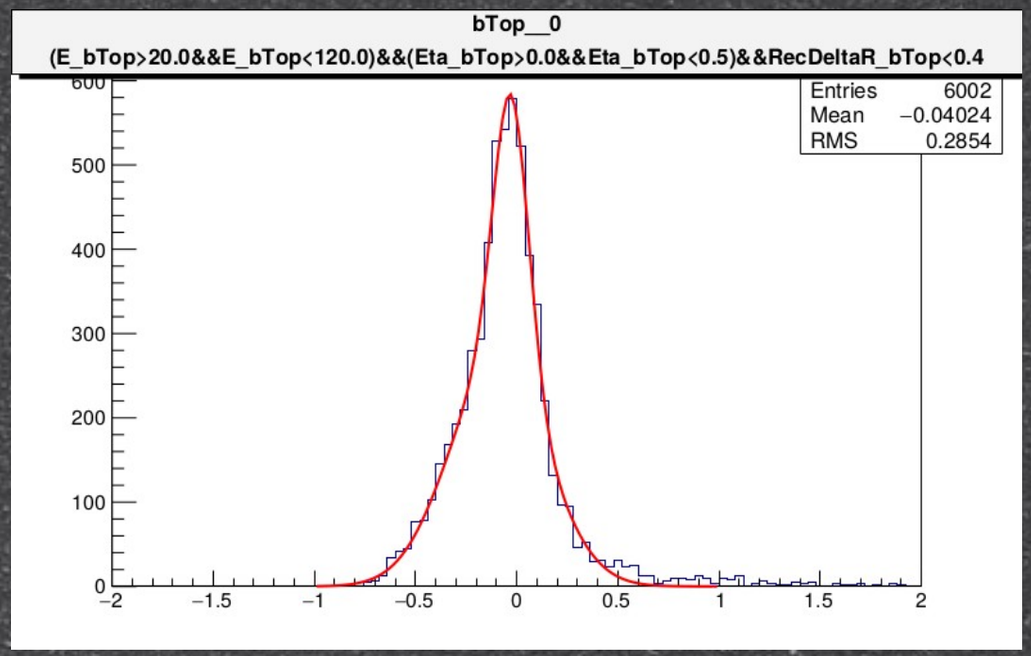


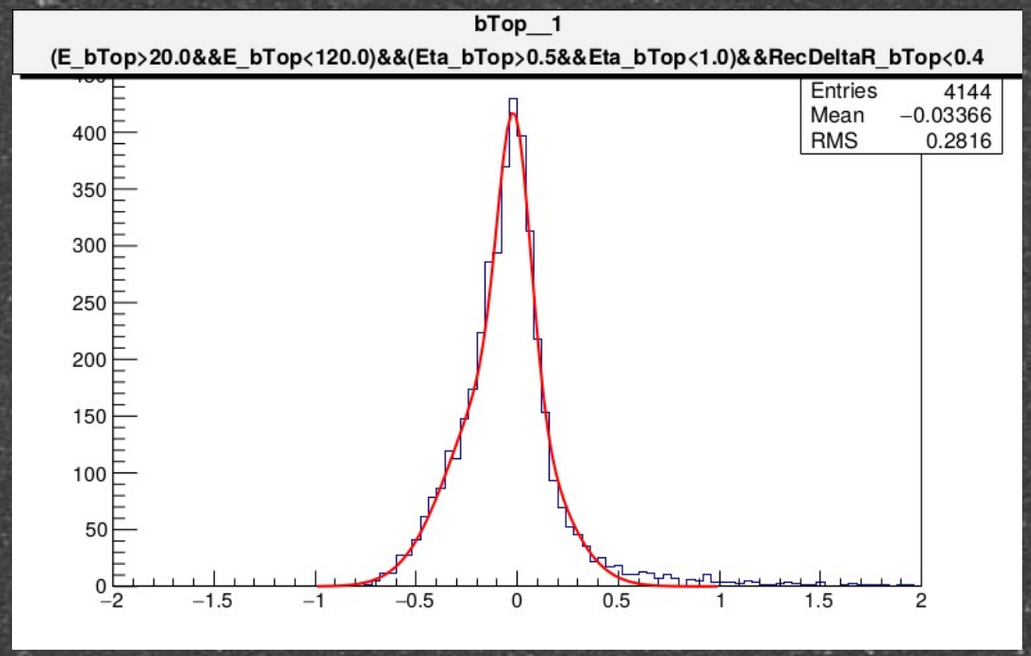


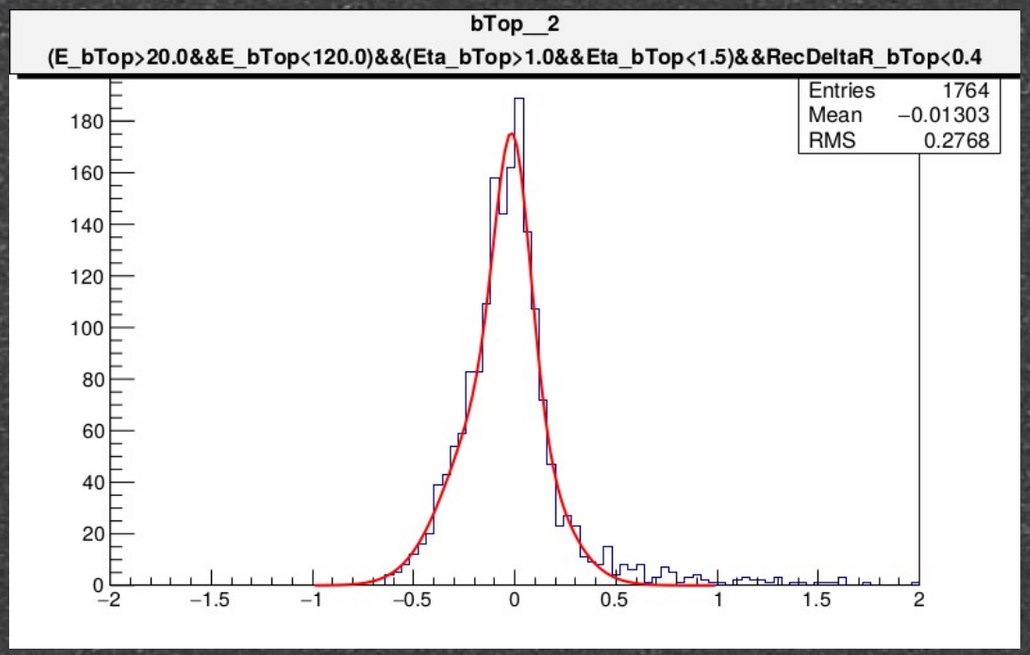
Fitting the Resolution Functions

- Binning: dEta=0.5, dEnergy=100;
- >500 Events Acceptance Condition
- ~3000000 Generated Events
- ~2000000 acceptences from Event Selection
- ~60000 Events Survived after Cuts

Btop - Energy Range 20-120







Btop - Energy Range 20-120

bTop__0 0<Eta<0.5

NO.	NAME	VALUE	ERROR	SIZE	DERIVATIVE
1	p0	7.17372e+01	4.75262e+00	-1.96687e-06	-2.17301e-02
2	p1	-2.79846e-02	4.20506e-03	-2.15496e-06	-3.12308e-02
3	p2	8.66464e-02	3.88052e-03	9.20525e-06	-1.47676e-02
4	p3	1.57294e+02	5.39933e+00	4.11911e-06	-2.92727e-02
5	p4	-9.59294e-02	4.31457e-03	-5.00089e-06	-4.03516e-02
6	p5	2.38349e-01	4.17812e-03	3.93224e-06	-1.45381e-02

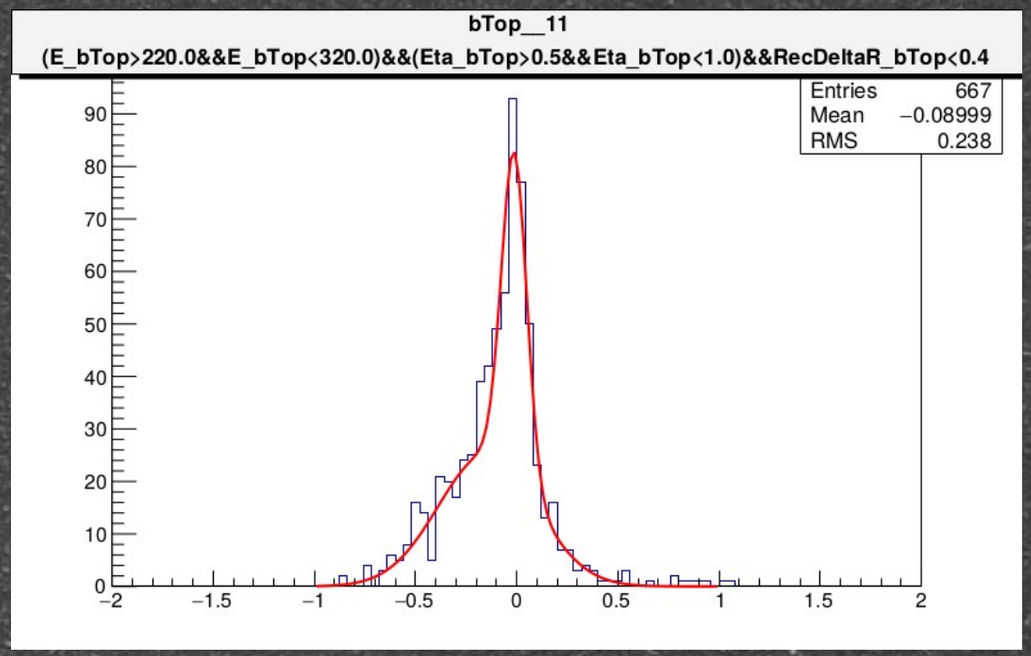
bTop__1 0.5<Eta<1.0

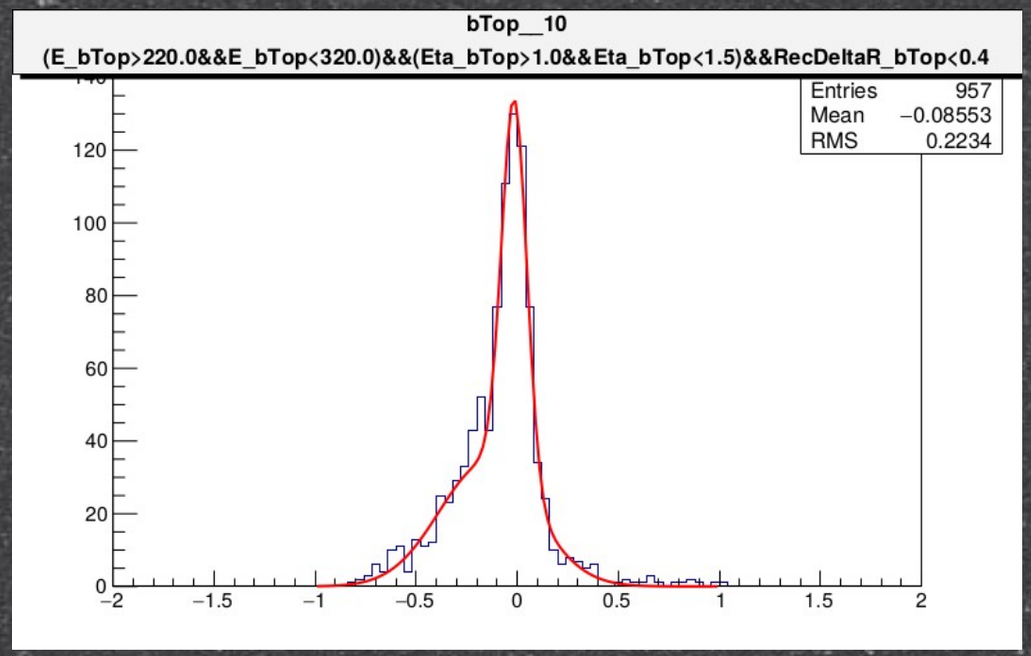
NO.	NAME	VALUE	ERROR	SIZE	DERIVATIVE
1	p0	4.77122e+01	4.21152e+00	2.93493e-05	6.08262e-02
2	p1	-1.50535e-02	5.12110e-03	5.34997e-05	-7.02784e-02
3	p2	7.95675e-02	5.33060e-03	7.35422e-05	-1.51634e-02
4	p3	1.10285e+02	4.47819e+00	2.31918e-05	8.21072e-02
5	p4	-8.98375e-02	5.15302e-03	6.09061e-05	2.45121e-02
6	p5	2.34494e-01	5.03464e-03	4.97117e-05	-3.38874e-02

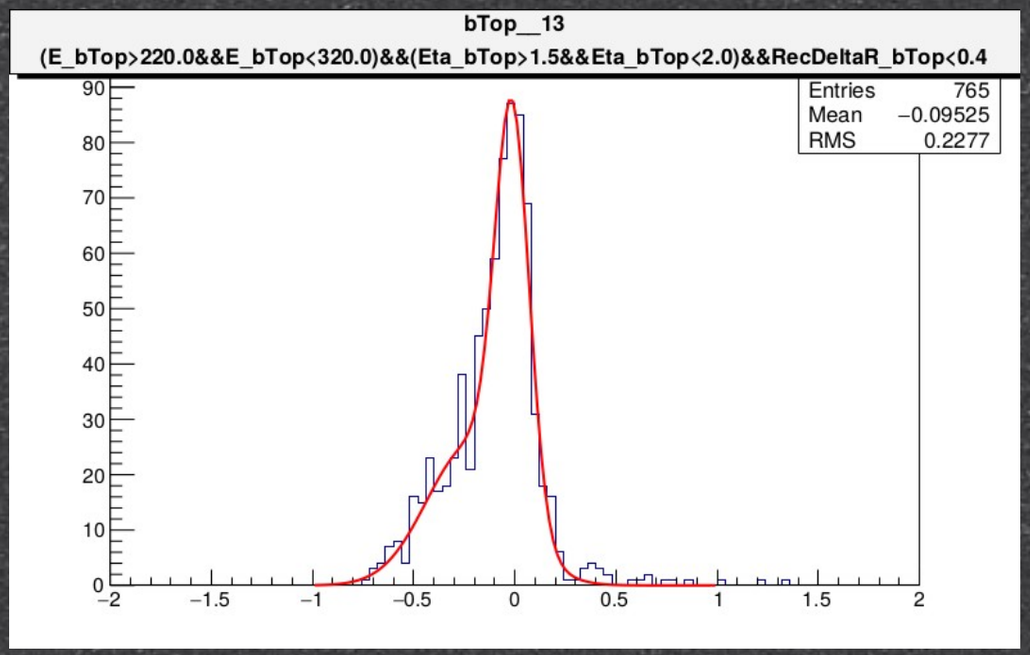
BTop__2 1.0<Eta<1.5

NO.	NAME	VALUE	ERROR	SIZE	DERIVATIVE
1	p0	2.16130e+01	4.01372e+00	3.40840e-05	7.27989e-03
2	p1	-1.03515e-02	9.87395e-03	6.54421e-05	-7.28036e-03
3	p2	8.65589e-02	9.58945e-03	8.00914e-05	-3.75547e-03
4	p3	4.44915e+01	4.06627e+00	2.74499e-05	1.32535e-02
5	p4	-7.79194e-02	8.08890e-03	7.04528e-05	-2.81568e-03
6	p5	2.23953e-01	1.17848e-02	6.74332e-05	-5.98125e-04

Btop - Energy Range 220-320







Btop - Energy Range 220-320

Btop__11 0.5<Eta<1.0

NO.	NAME	VALUE	ERROR	SIZE	DERIVATIVE
1	p0	9.50640e+00	1.75921e+00	3.43538e-05	1.61458e-03
2	p1	-1.26898e-02	9.47468e-03	4.16114e-05	-2.50333e-03
3	p2	6.18784e-02	1.29153e-02	7.74176e-05	-5.15469e-03
4	p3	1.53087e+01	1.75537e+00	3.15201e-05	-1.04550e-02
5	p4	-1.46192e-01	2.23452e-02	9.98144e-05	1.39146e-03
6	p5	2.42538e-01	2.16318e-02	9.25139e-05	-2.12047e-03

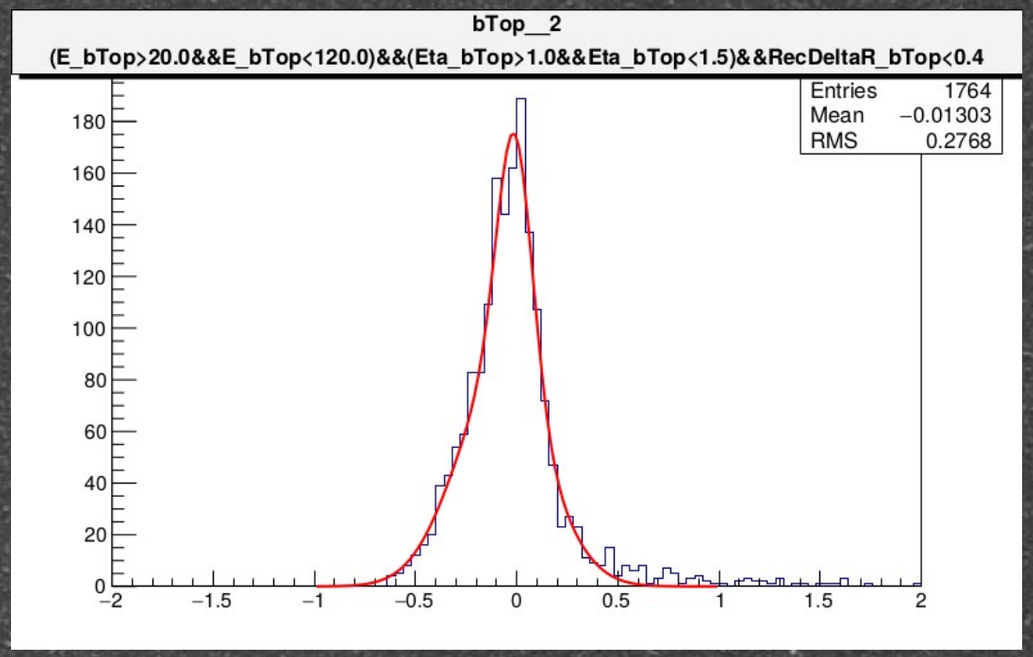
Btop__12 1<Eta<1.5

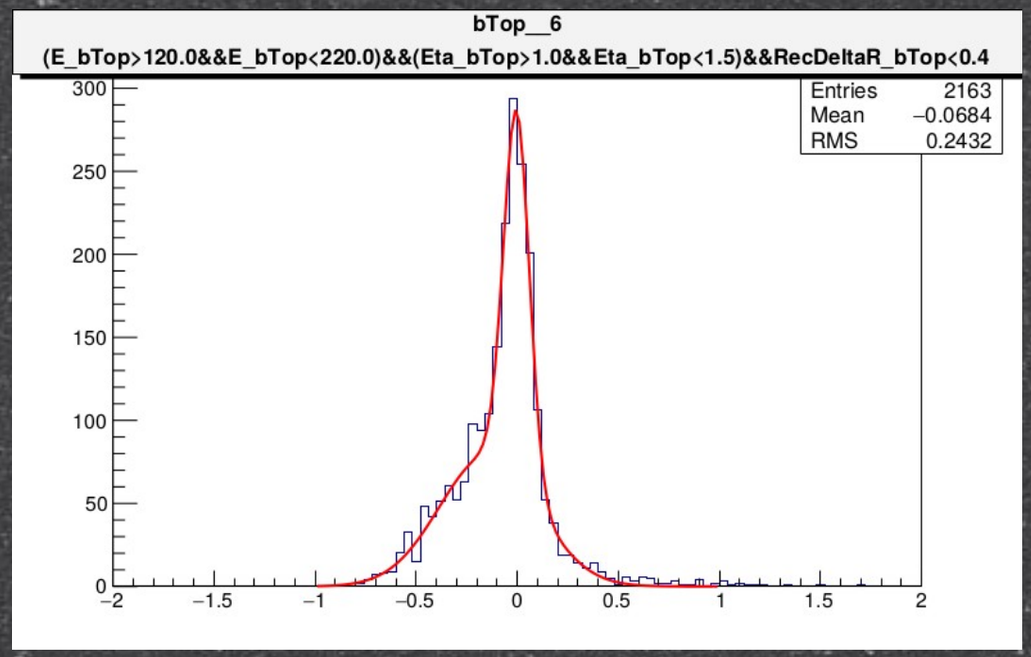
NO.	NAME	VALUE	ERROR	SIZE	DERIVATIVE
1	p0	1.63656e+01	1.48596e+00	2.66466e-05	-3.25918e-02
2	p1	-1.49106e-02	4.86256e-03	2.98207e-05	2.29793e-03
3	p2	6.19398e-02	4.85644e-03	4.63675e-05	6.35057e-03
4	p3	2.01867e+01	1.52205e+00	2.57662e-05	6.56958e-03
5	p4	-1.49670e-01	1.35279e-02	8.18534e-05	-7.82882e-03
6	p5	2.37071e-01	1.51957e-02	8.86880e-05	2.51291e-03

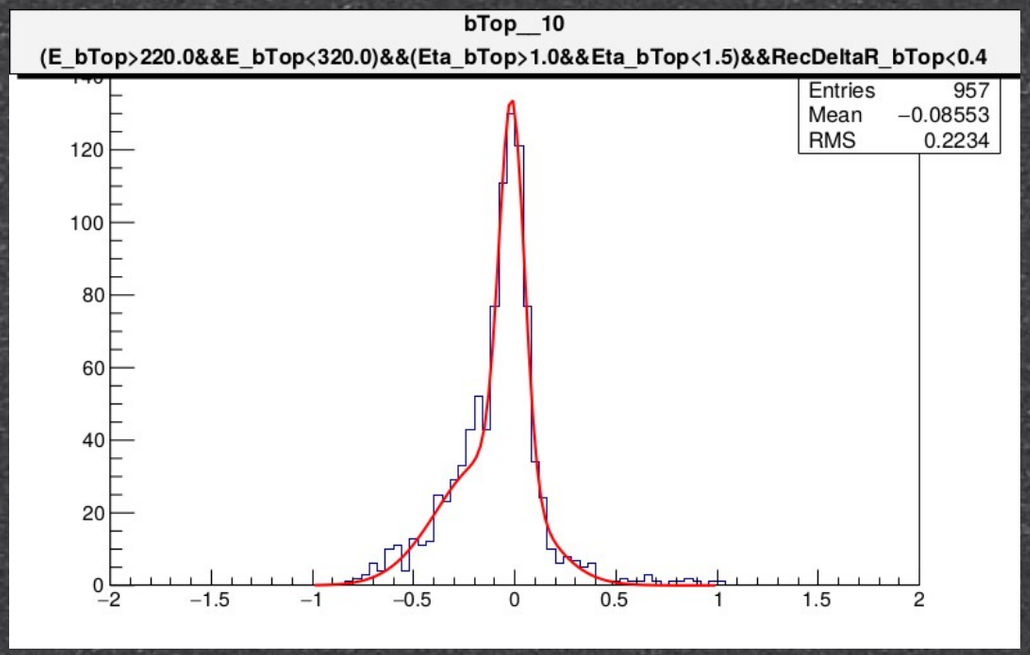
Btop__13 1.5<Eta<2

NO.	NAME	VALUE	ERROR	SIZE	DERIVATIVE
1	p0	1.52699e+01	1.57768e+00	2.89894e-05	1.72818e-02
2	p1	-1.29838e-02	6.94241e-03	3.88558e-05	5.15247e-02
3	p2	8.43356e-02	7.07460e-03	5.28103e-05	6.58447e-02
4	p3	1.35025e+01	1.54982e+00	2.97727e-05	1.09280e-02
5	p4	-2.22545e-01	2.33195e-02	1.10375e-04	1.69183e-02
6	p5	2.15528e-01	1.22288e-02	8.23085e-05	1.39868e-02

Btop - Eta Range 1-1.5







Btop - Eta Range 1-1.5

Btop__2 20<E<120

NO.	NAME	VALUE	ERROR	SIZE	DERIVATIVE
1	p0	2.16130e+01	4.01372e+00	3.40840e-05	7.27989e-03
2	p1	-1.03515e-02	9.87395e-03	6.54421e-05	-7.28036e-03
3	p2	8.65589e-02	9.58945e-03	8.00914e-05	-3.75547e-03
4	p3	4.44915e+01	4.06627e+00	2.74499e-05	1.32535e-02
5	p4	-7.79194e-02	8.08890e-03	7.04528e-05	-2.81568e-03
6	p5	2.23953e-01	1.17848e-02	6.74332e-05	-5.98125e-04

Btop__7 120<E<220

NO.	NAME	VALUE	ERROR	SIZE	DERIVATIVE
1	p0	4.81111e+01	2.17256e+00	2.24180e-05	6.51170e-04
2	p1	-1.42756e-01	8.49330e-03	6.72189e-05	8.75598e-05
3	p2	2.43280e-01	6.66834e-03	5.58398e-05	-1.88758e-03
4	p3	3.50624e+01	2.05859e+00	2.37745e-05	-2.39745e-03
5	p4	-3.85330e-03	3.30715e-03	2.78587e-05	-1.23914e-03
6	p5	6.36011e-02	3.30743e-03	4.36225e-05	2.81711e-03

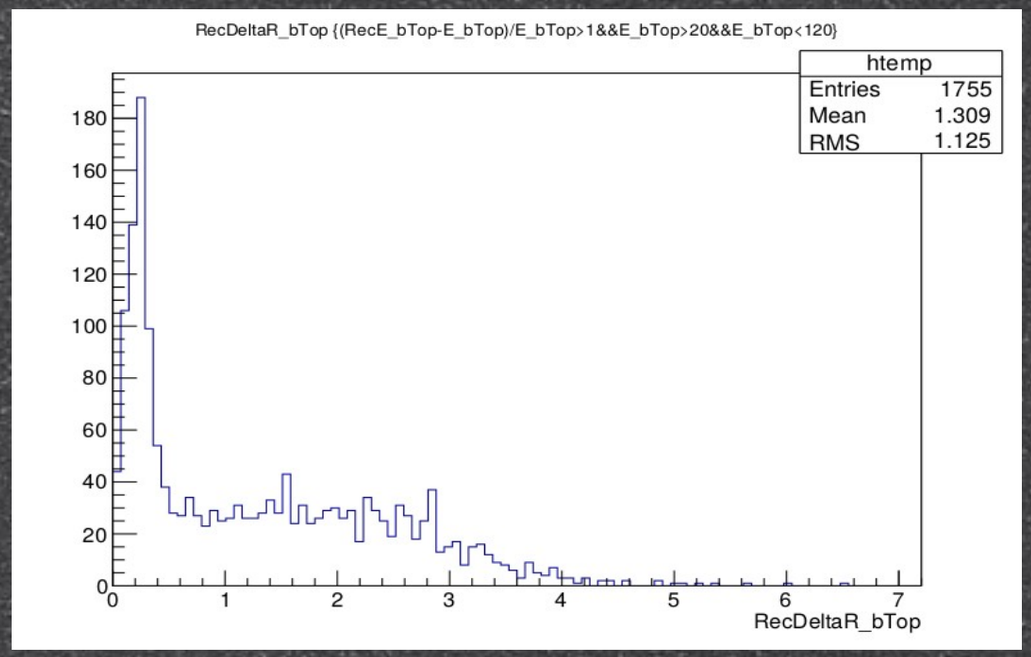
Btop__12 220<E<320

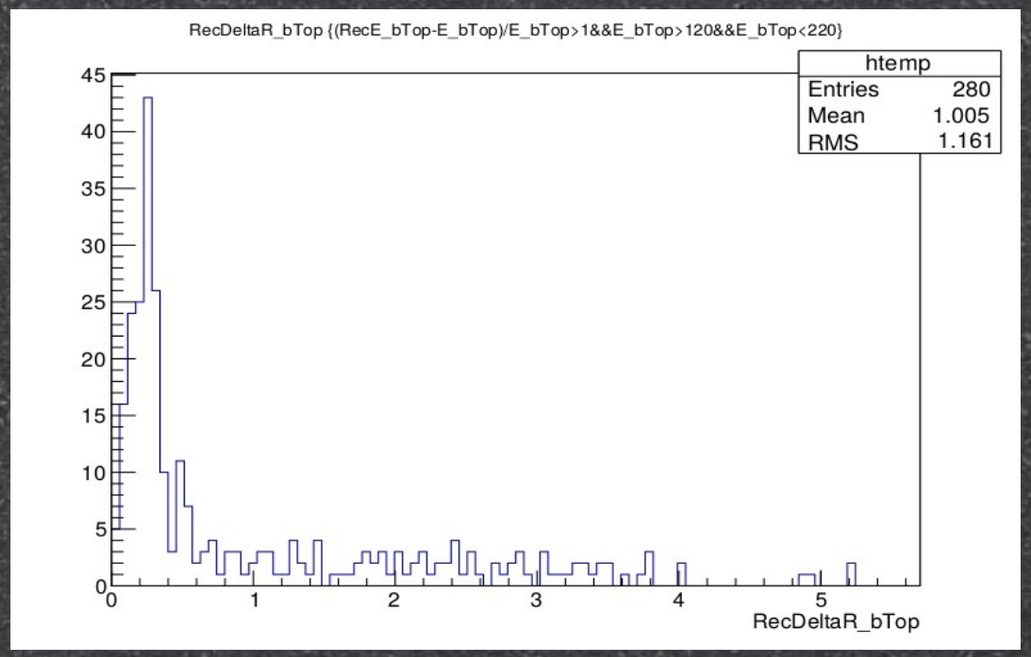
NO.	NAME	VALUE	ERROR	SIZE	DERIVATIVE
1	p0	1.63656e+01	1.48596e+00	2.66466e-05	-3.25918e-02
2	p1	-1.49106e-02	4.86256e-03	2.98207e-05	2.29793e-03
3	p2	6.19398e-02	4.85644e-03	4.63675e-05	6.35057e-03
4	p3	2.01867e+01	1.52205e+00	2.57662e-05	6.56958e-03
5	p4	-1.49670e-01	1.35279e-02	8.18534e-05	-7.82882e-03
6	p5	2.37071e-01	1.51957e-02	8.86880e-05	2.51291e-03

Eta Dependence

- Values of the Mean, RMS change <1% in most of the cases, with a maximum of <5% change in sporadic ones.
- Relative form remains constant.
- One Resolution Function for b quarks
- One Resolution Function for light quarks

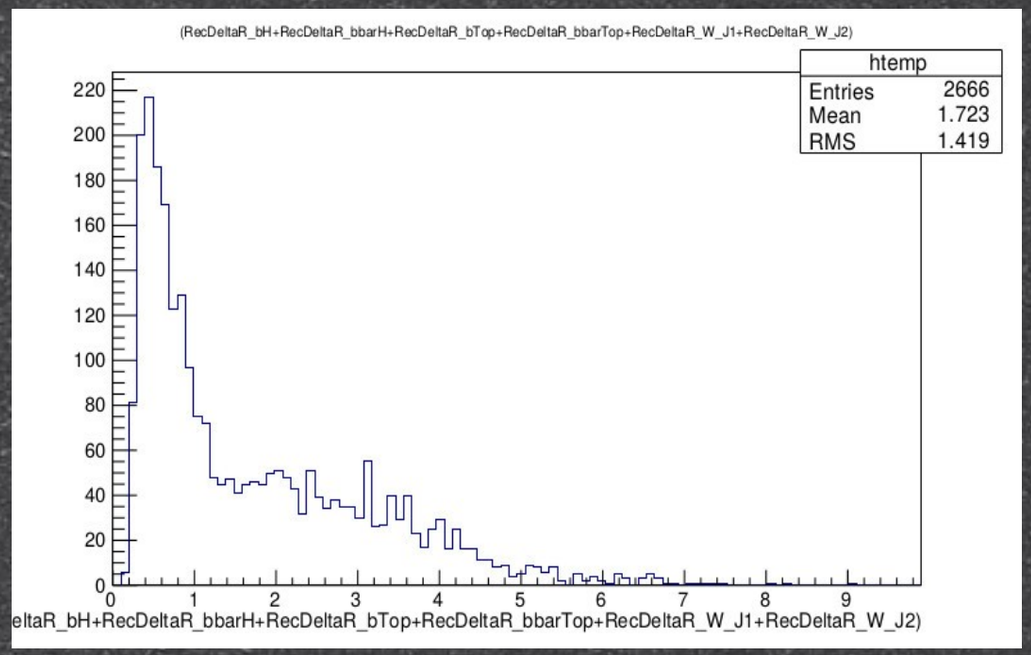
Tails

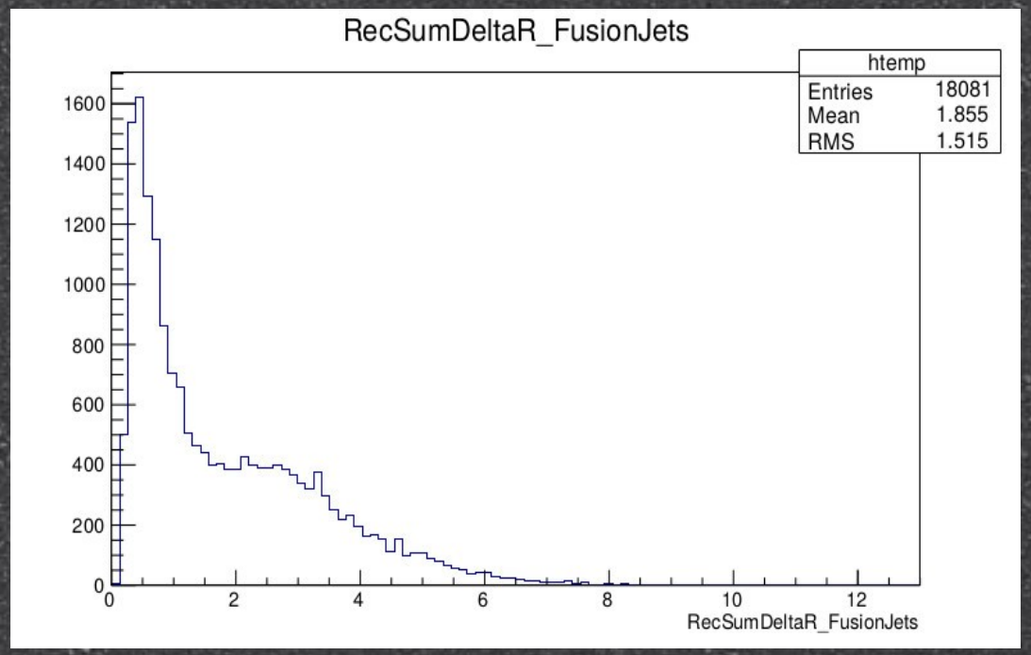




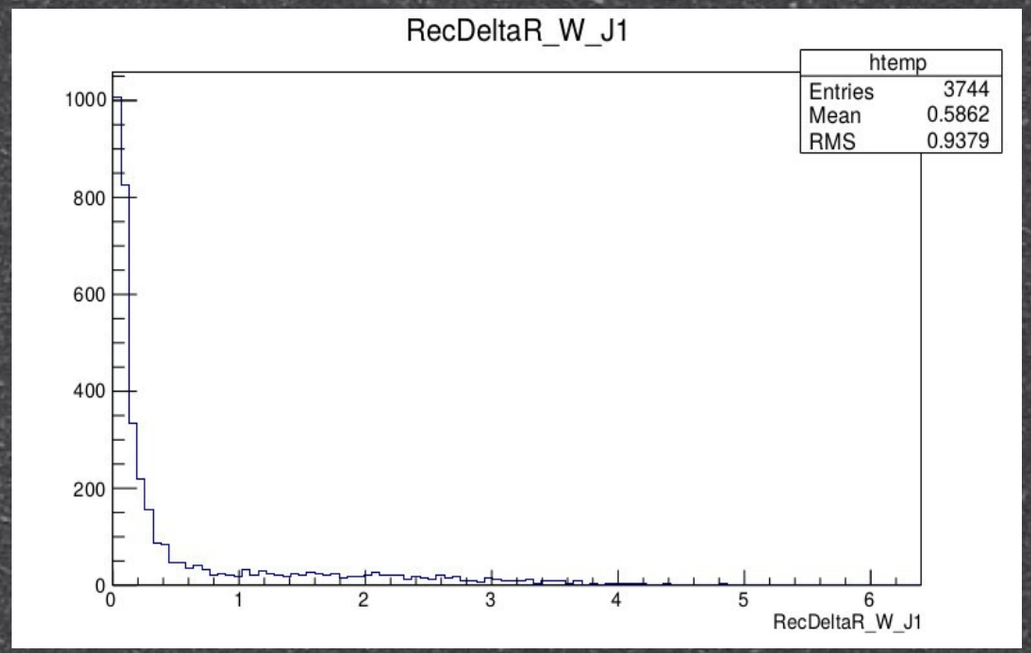
Jet Fusion (NRecJets=5)

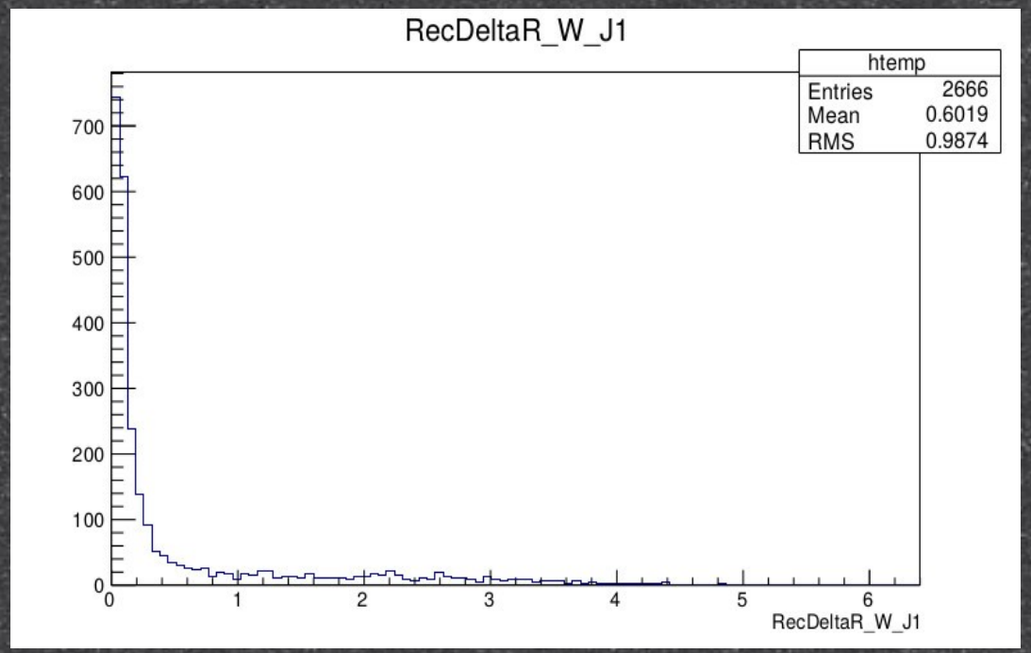
- Analysis of events with low Sum DeltaR where jet fusion occurs.

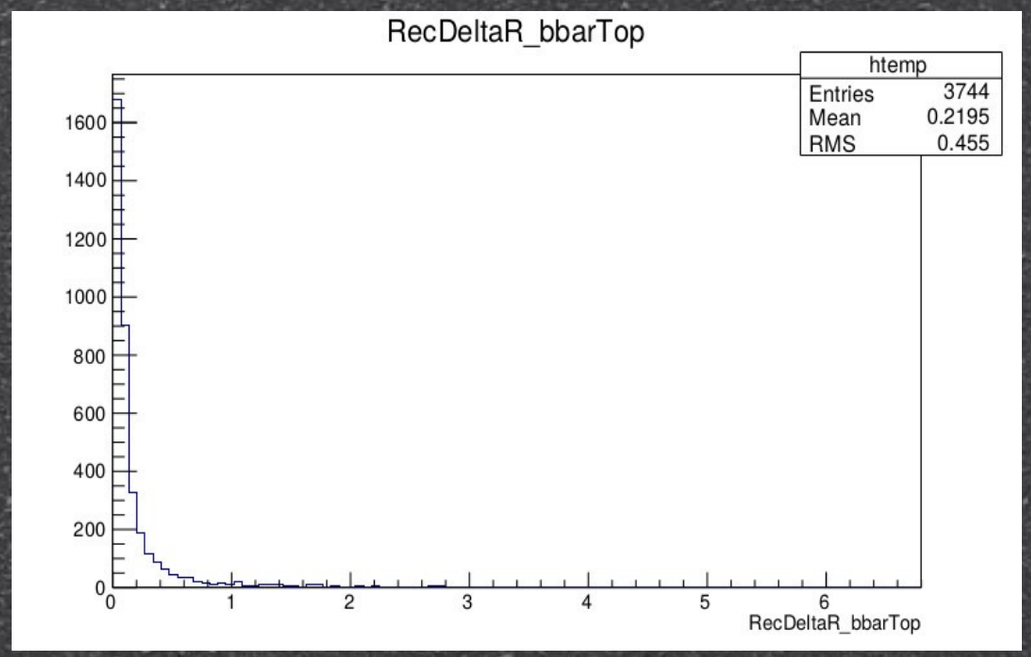


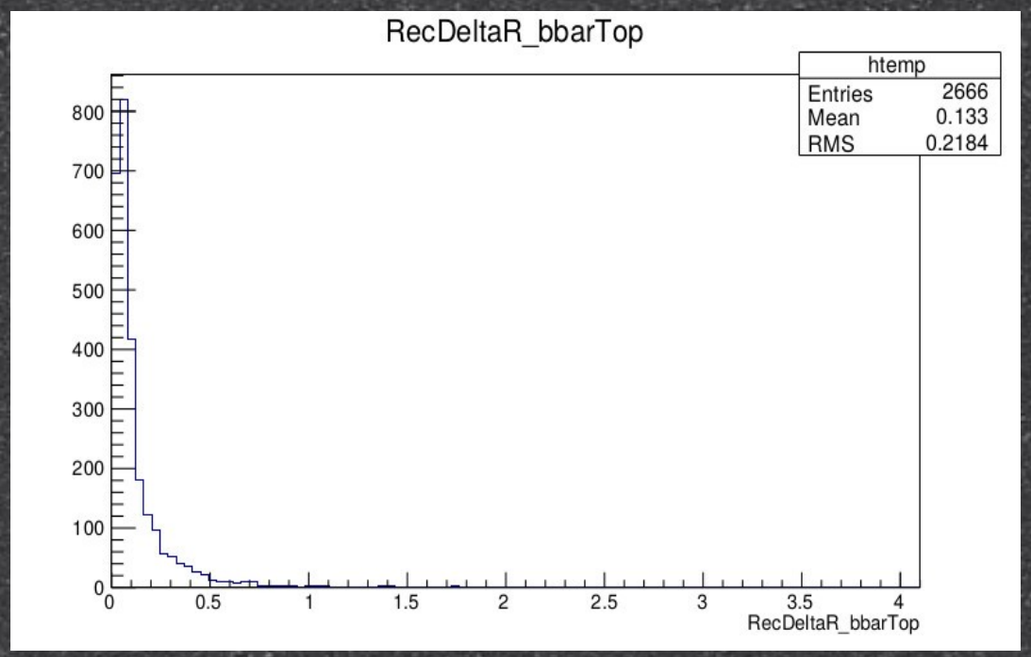


DeltaR


RecDeltaR_W_J1
htemp
Entries 3744
Mean 0.5862
RMS 0.9379
RecDeltaR_W_J1


RecDeltaR_W_J1
htemp
Entries 2666
Mean 0.6019
RMS 0.9874
RecDeltaR_W_J1


RecDeltaR_bbarTop
htemp
Entries 3744
Mean 0.2195
RMS 0.455
RecDeltaR_bbarTop

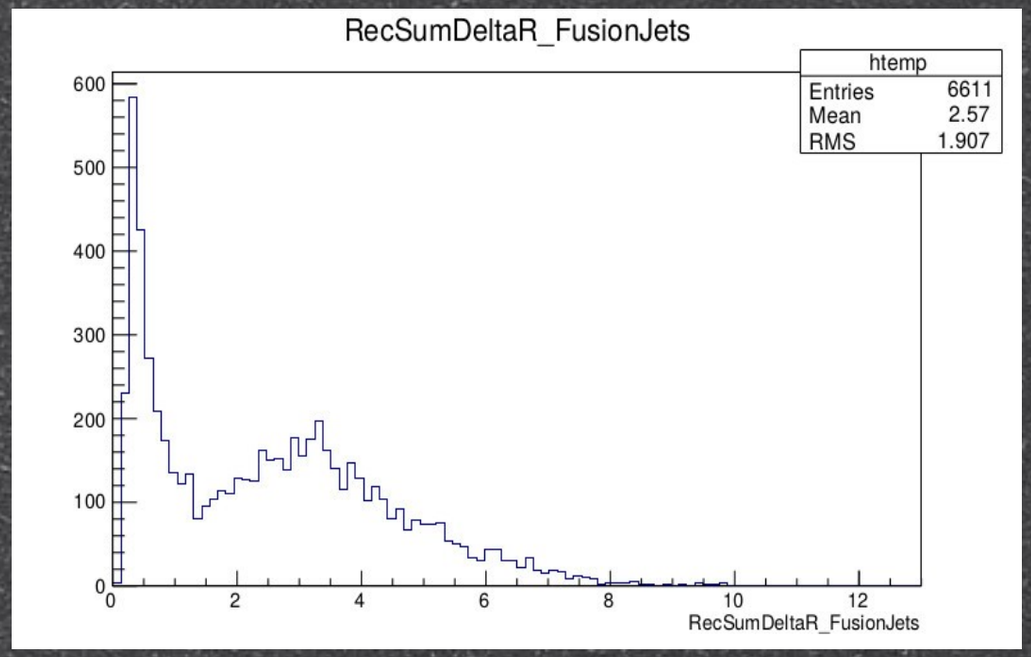

RecDeltaR_bbarTop
htemp
Entries 2666
Mean 0.133
RMS 0.2184
RecDeltaR_bbarTop

Event Drop

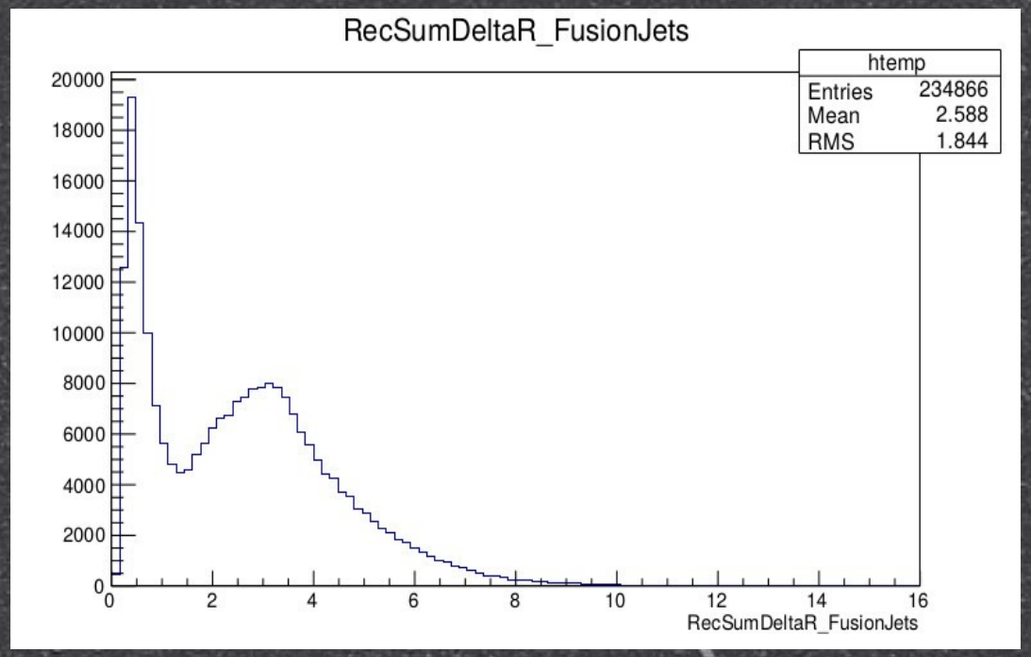
- Initial Number of MadEvents ~ 3*10^6
- Survival Percentage of Gen Events with currect topology ~ 70%
- Survival Percentage of Pre Rec Events ~ 17%
- Survival Percentage of Matched RecEvents ~ 14%
- Percentage of 5 Rec Jets with accepted cuts ~ 7%

Jet Fusion (NRecJets=5)

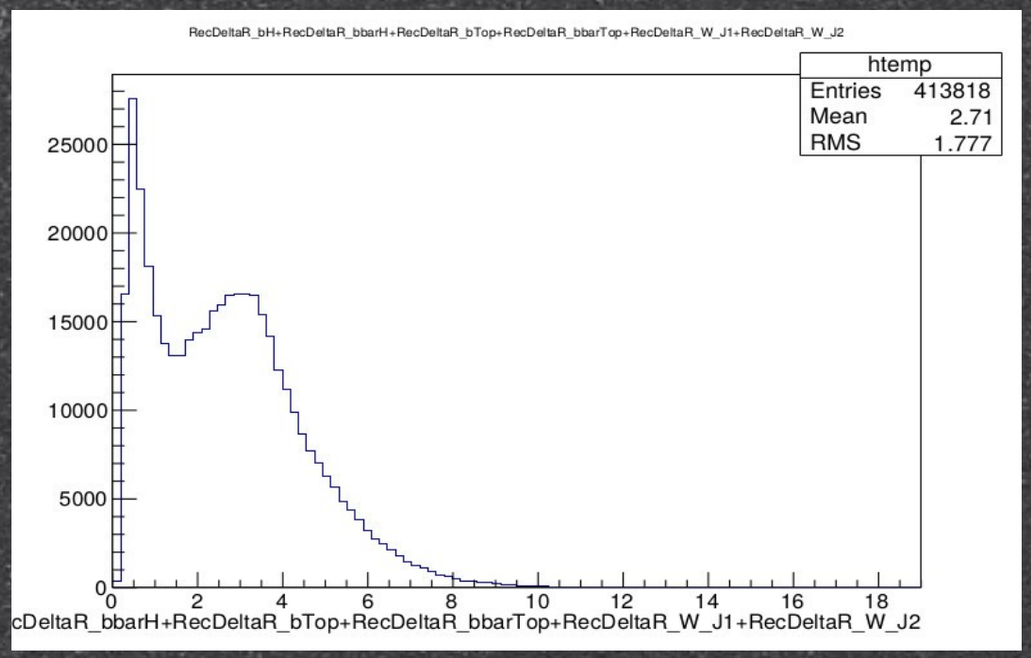
- Analysis of events with low Sum DeltaR where jet fusion occurs.



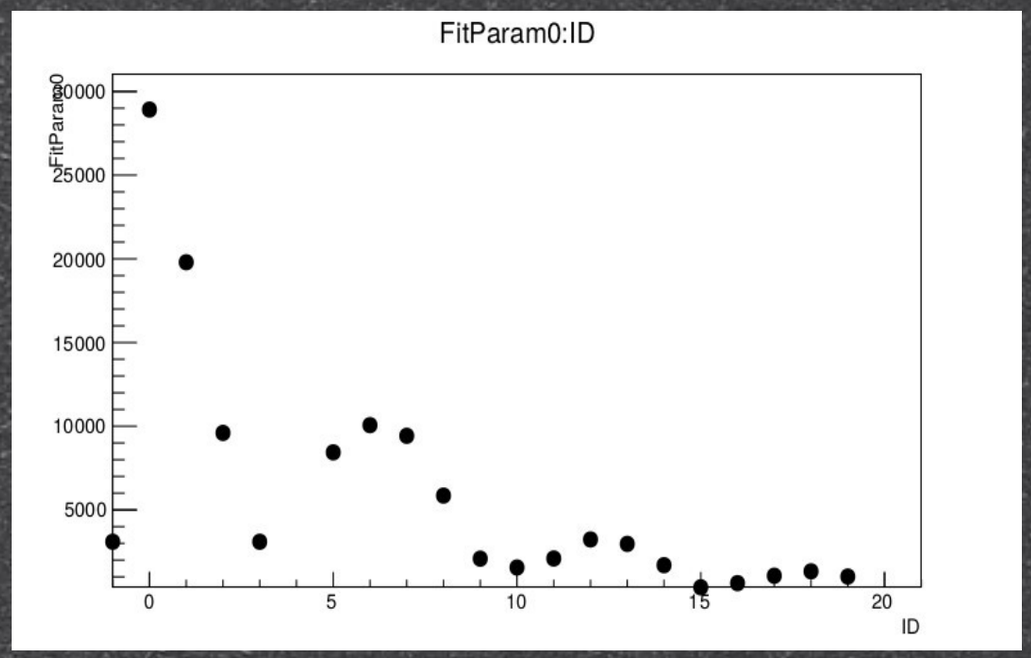
Jet Fusion Cone <= 0.5



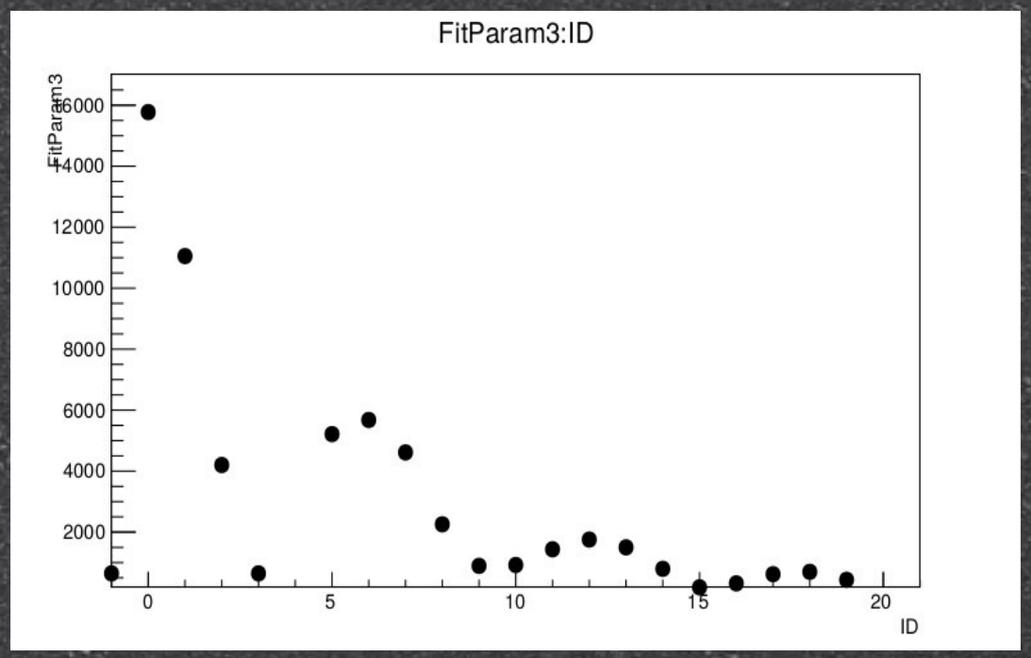
Jet Fusion Cone <= 1



Fitting Parameters
B's from H

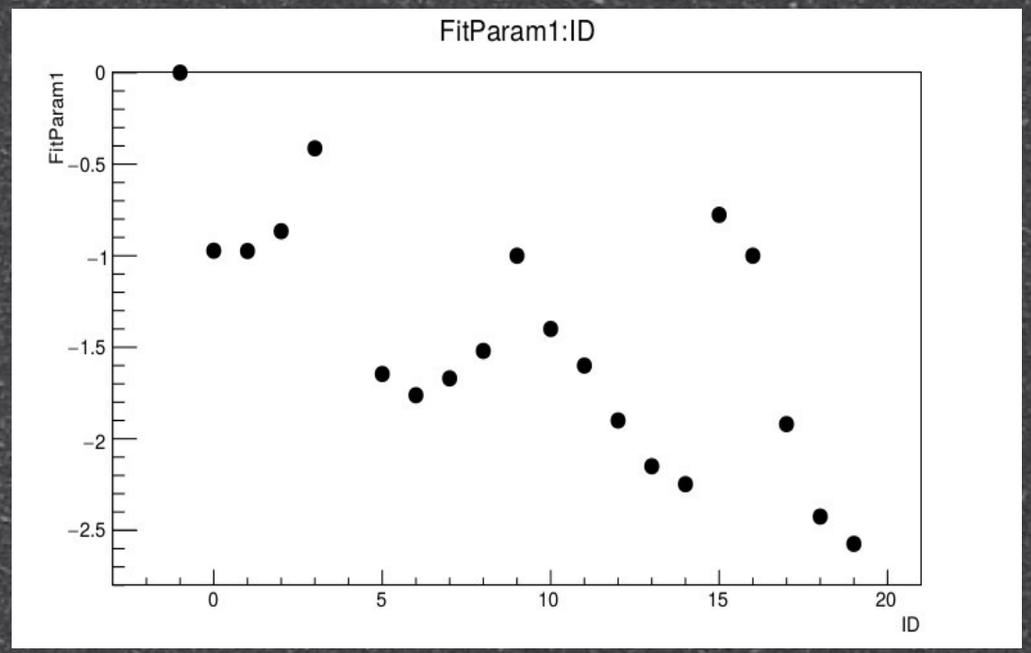


Integral 1

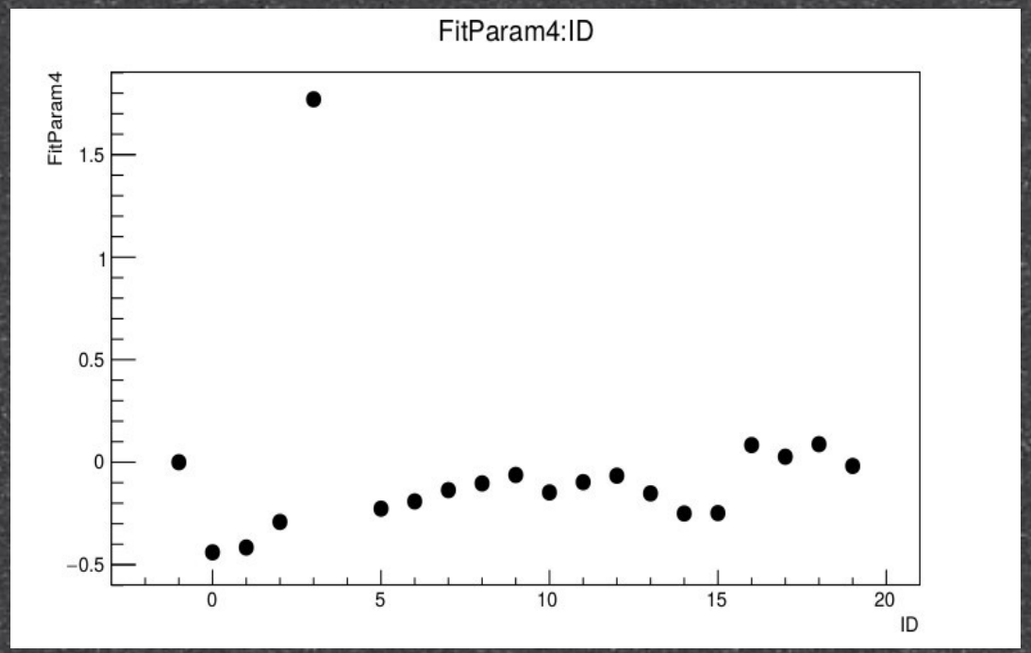


Integral 2

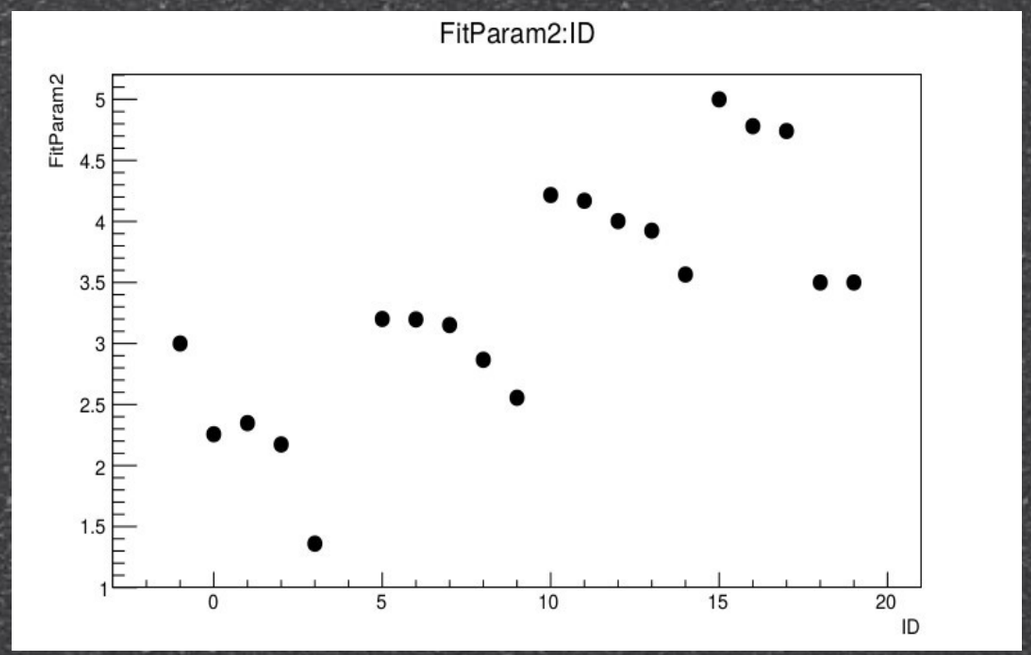
Fitting Parameters
B's from H



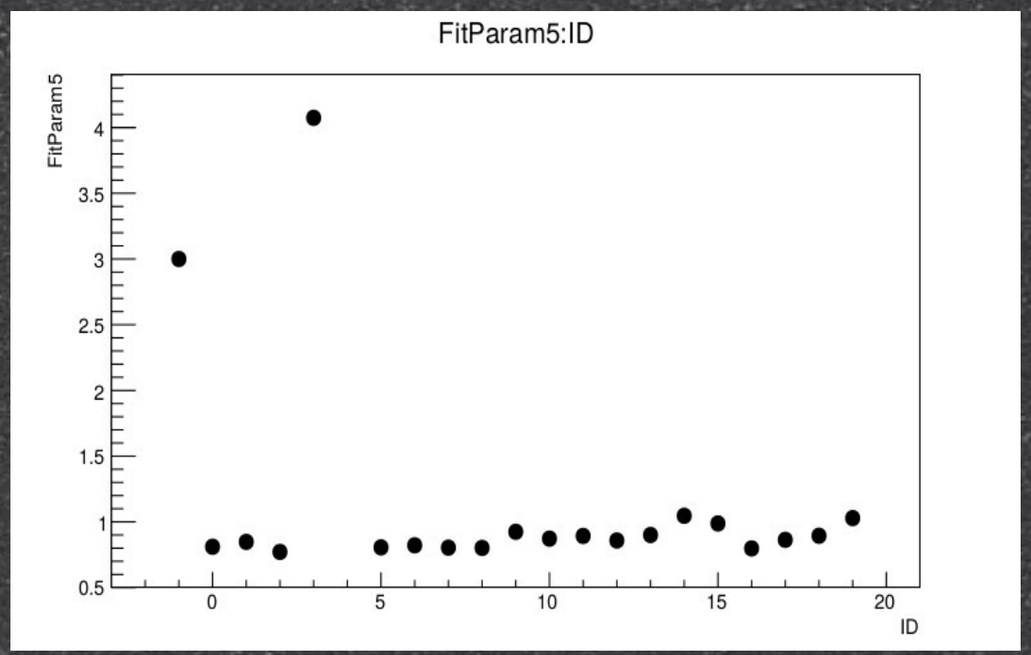
Mean 1



Mean 2



Sigma 1



Mean 2

KLFitter Analysis

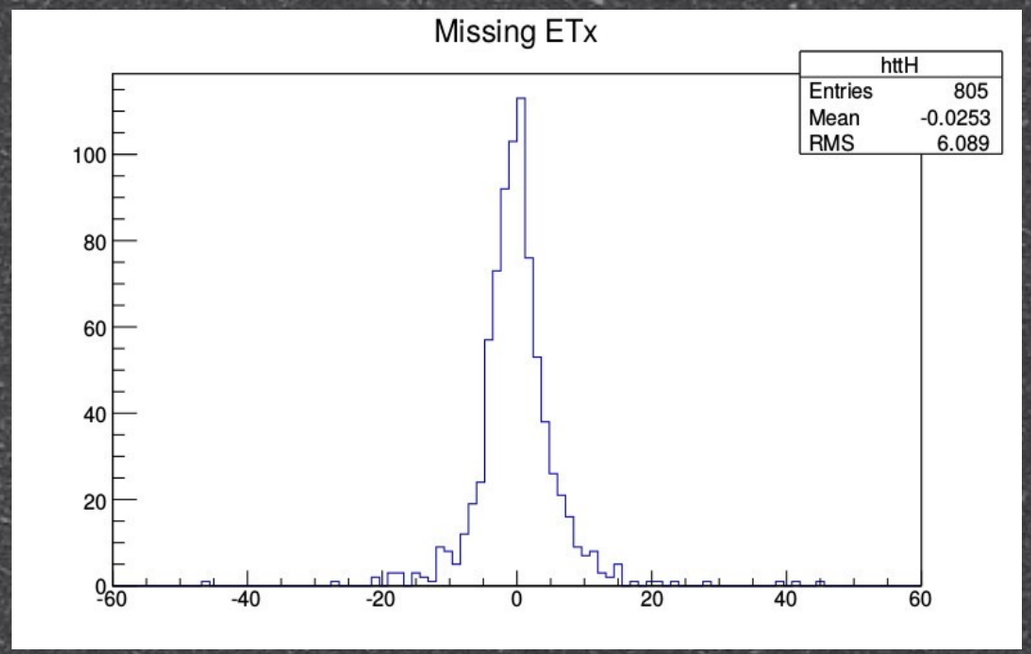
Missing ET components

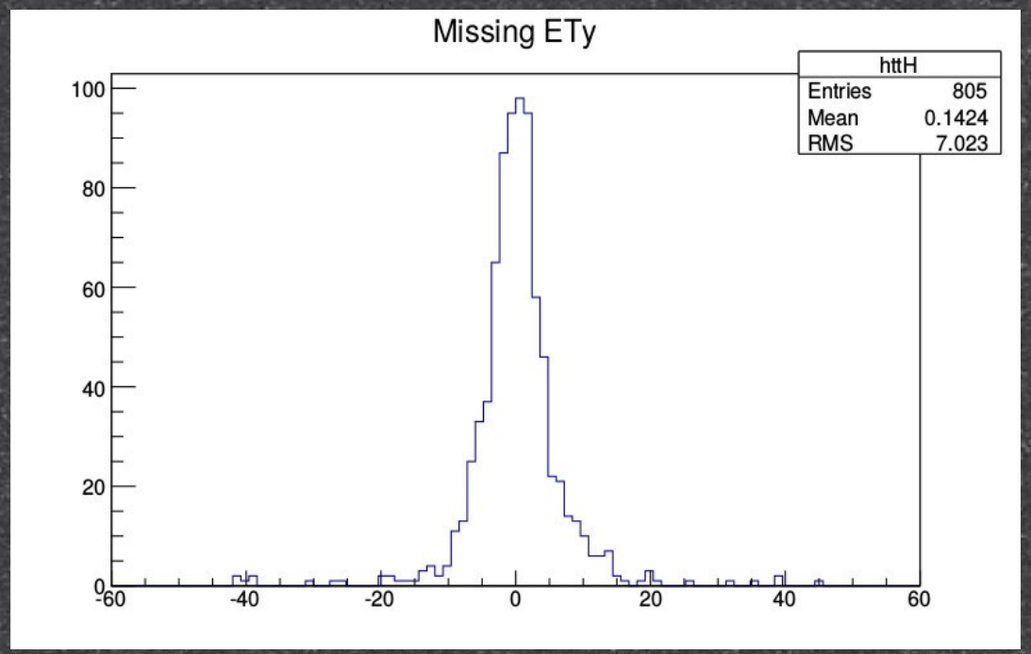
- Only selected 6 Jets
- No applied cuts
- Only accepted objects with DeltaR<0.4
- SumET = Sum (Objects.Pt()) /except neutrino

Missing ET components

METx = -Sum(Objects.px())

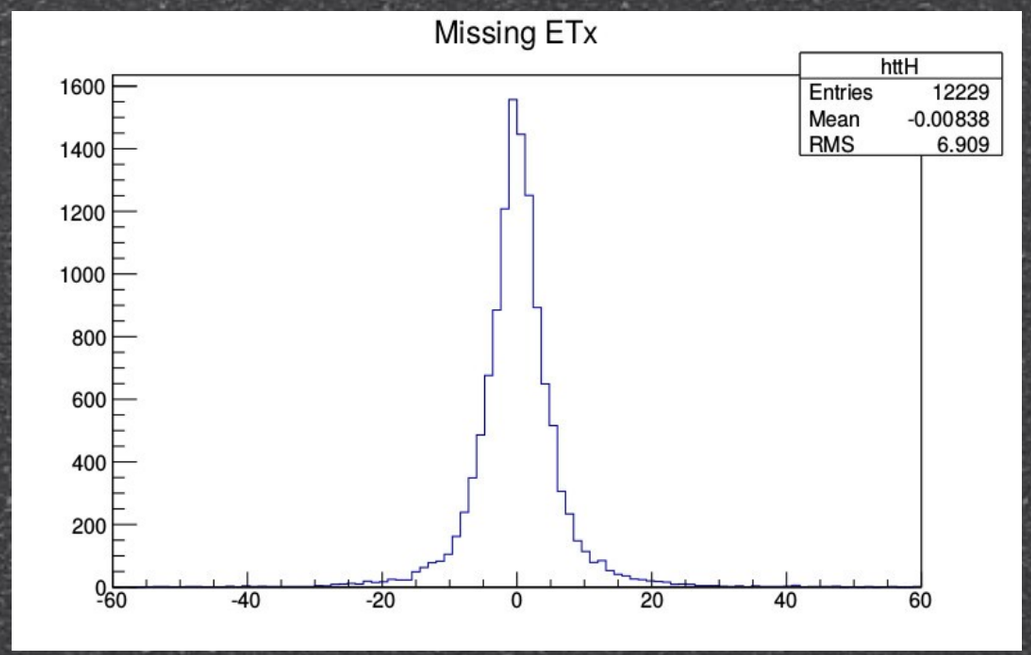
METy = -Sum(Objects.py())

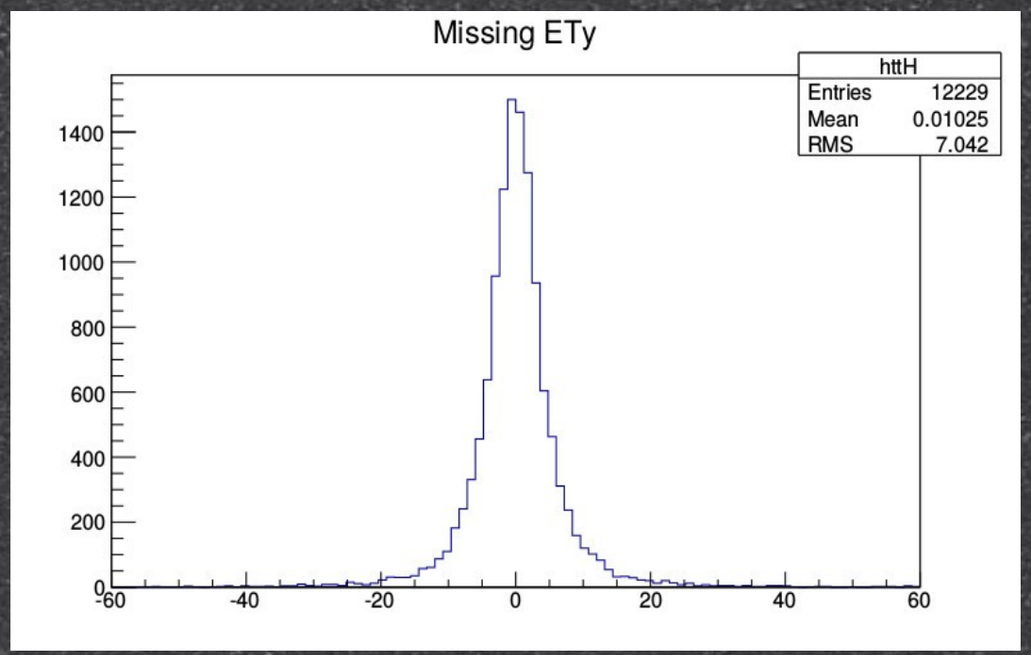




200<SumEt<300

200<SumEt<300



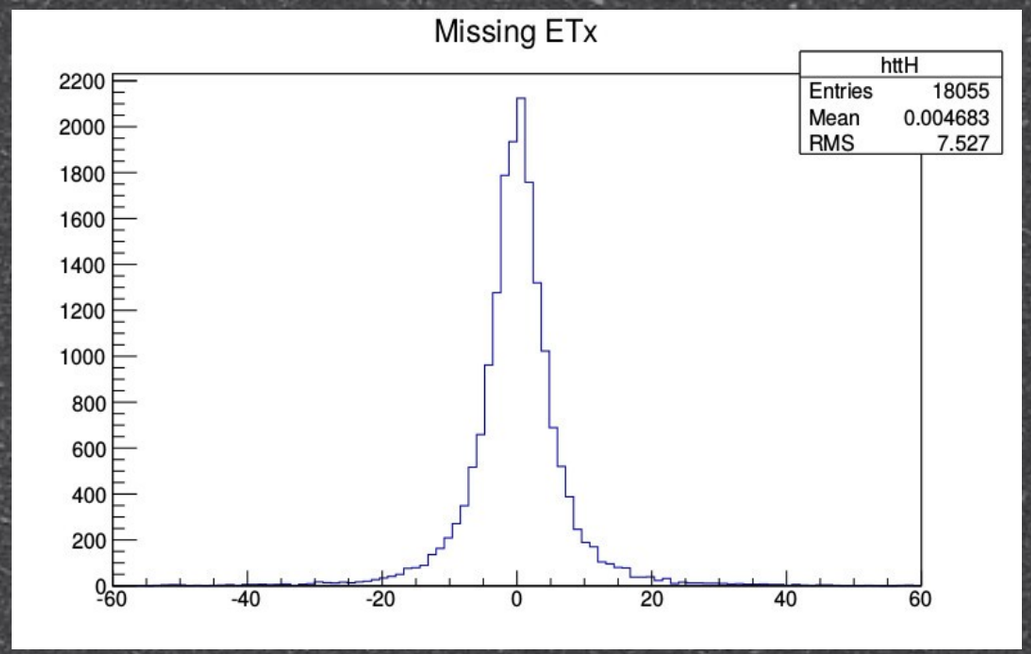


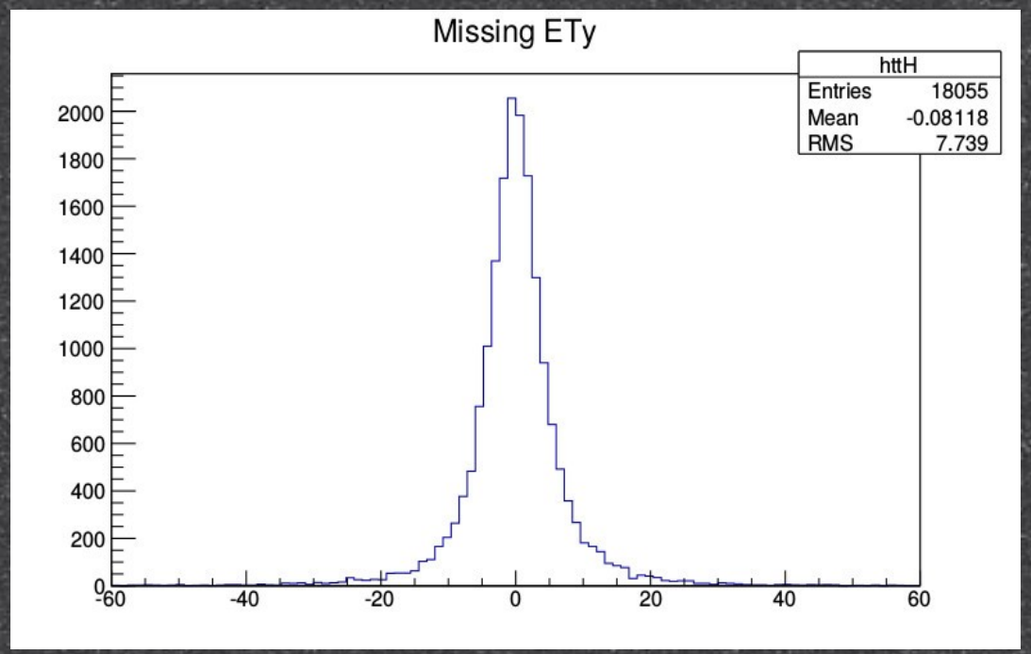
300<SumEt<400

300<SumEt<400

METx = -Sum(Objects.px())

METy = -Sum(Objects.py())





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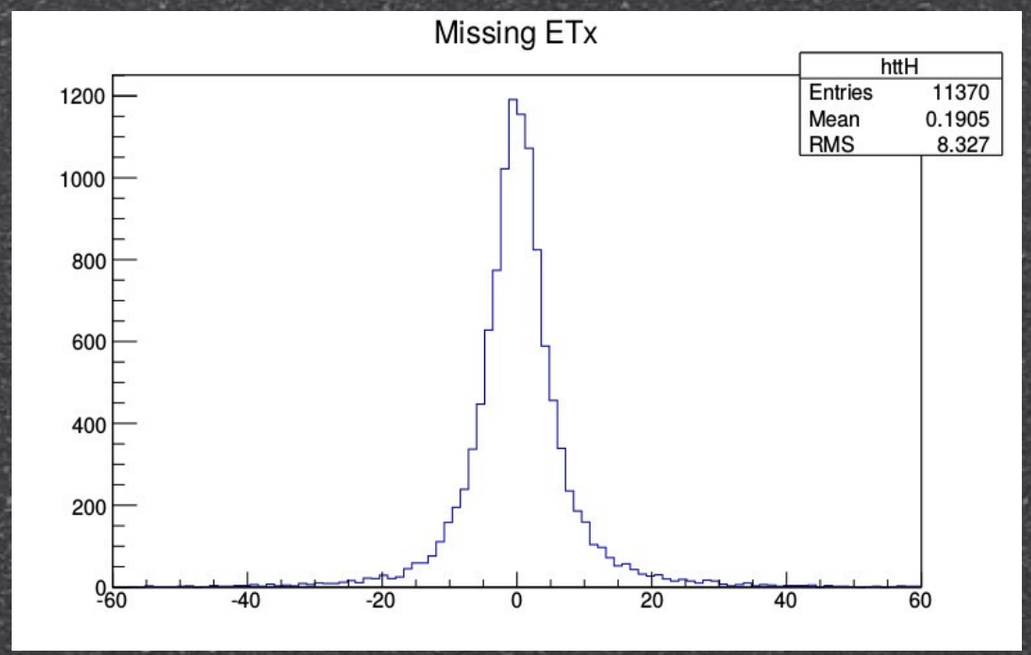
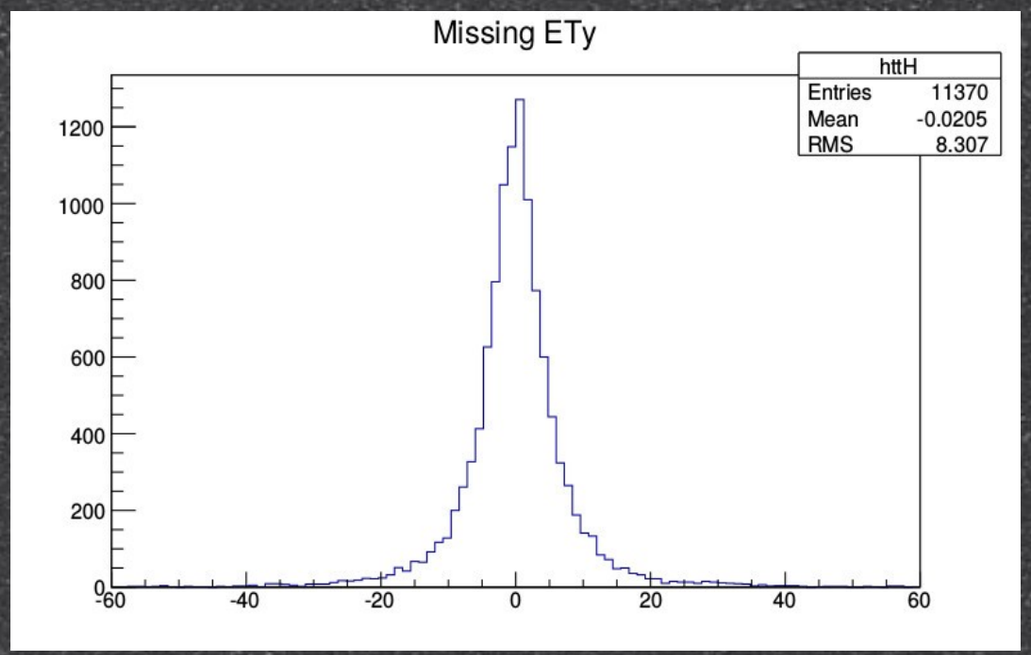




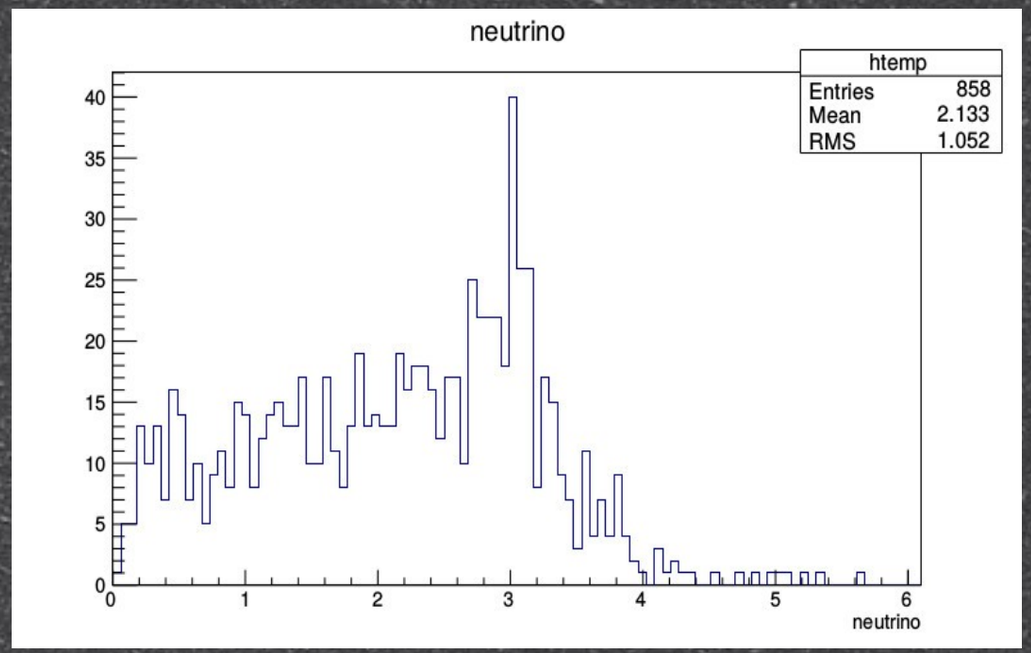
400<SumEt<500

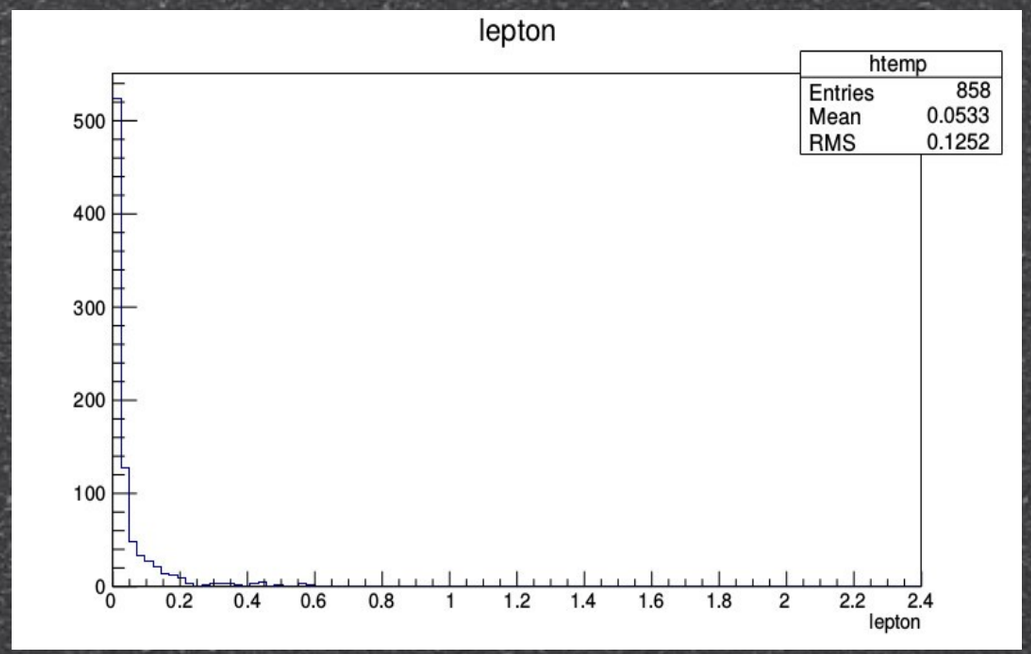
400<SumEt<500

Non-Truth Match Reconstruction

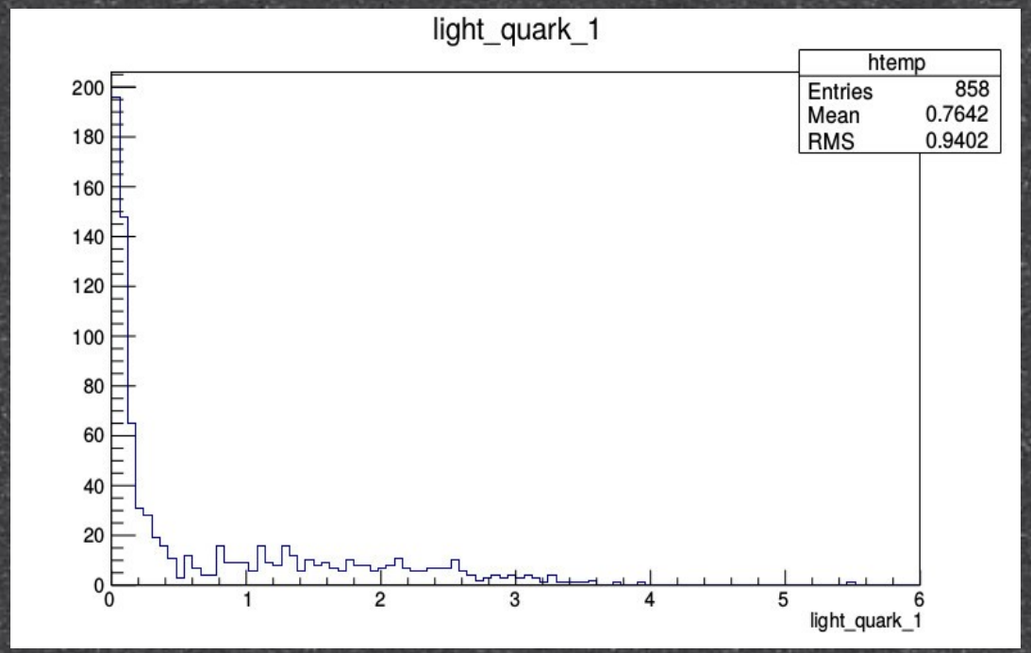
- Only Electrons considered
- Only Perfect Final Topology Considered

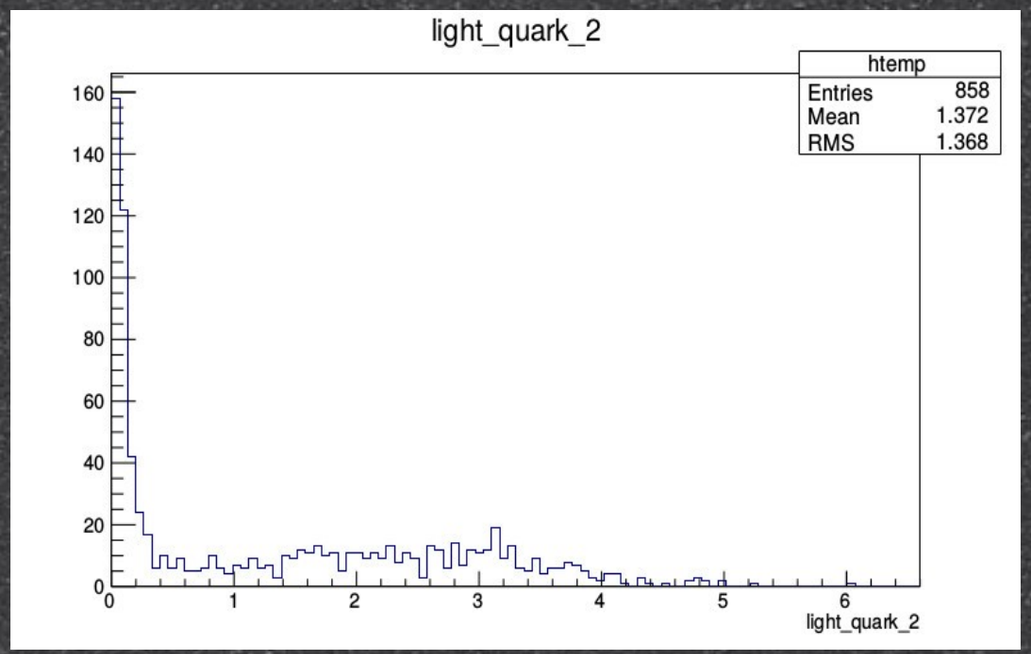
Lepton/Neutrino



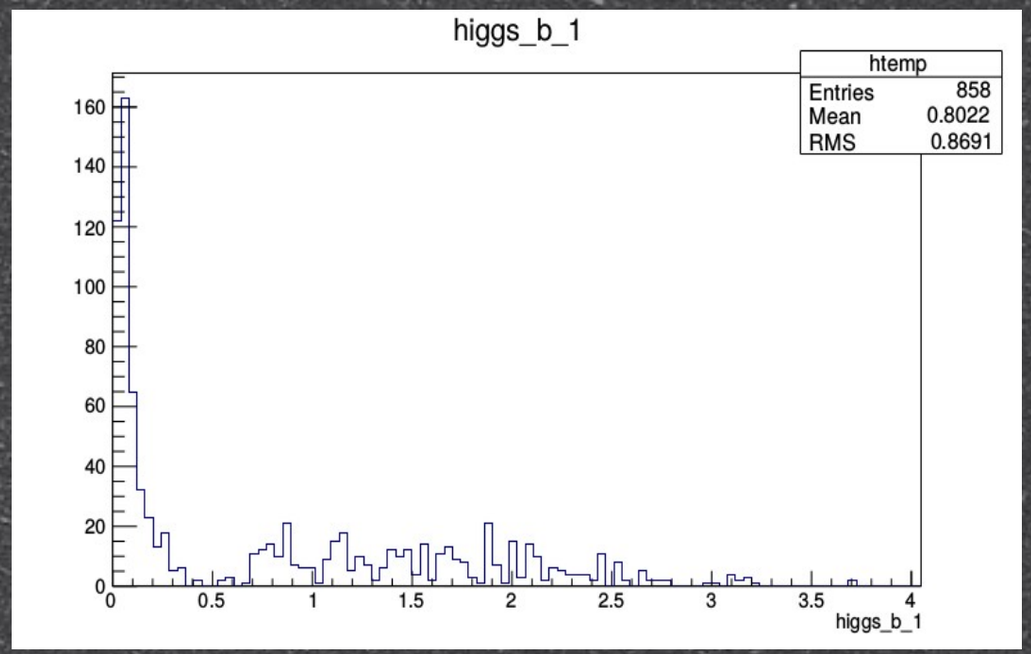


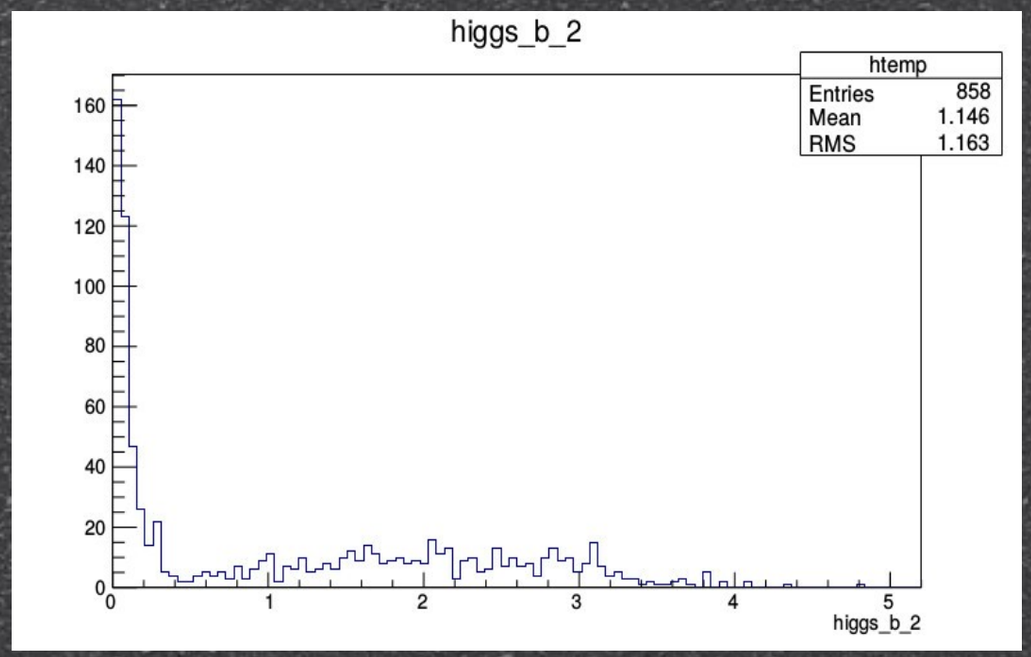
Light Quarks



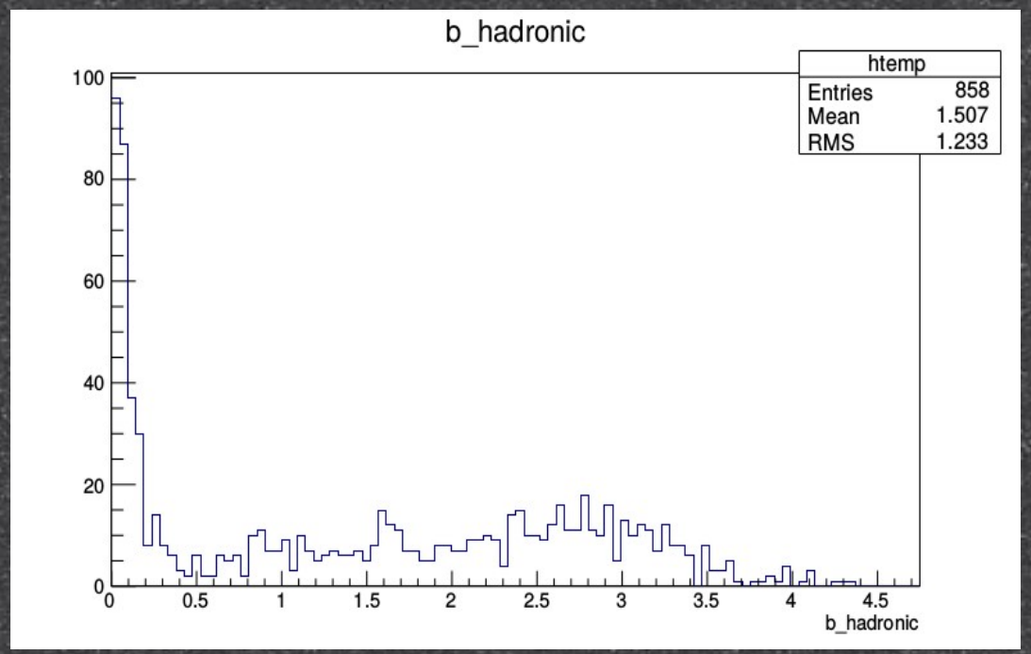


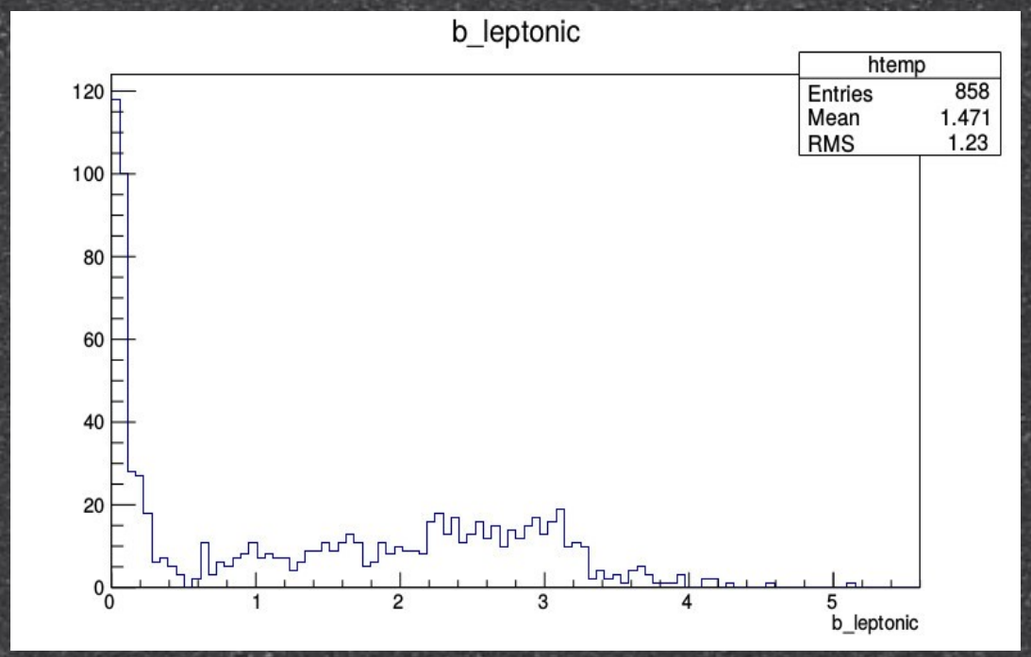
b's from Higgs





Lep_b/Had_b

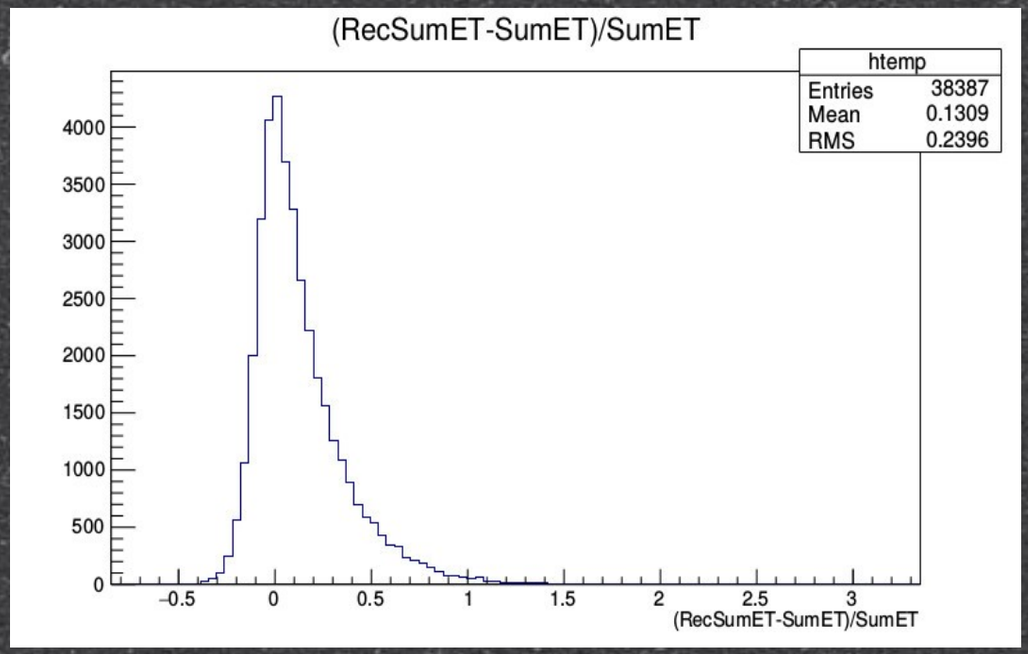




Parametrization of MET

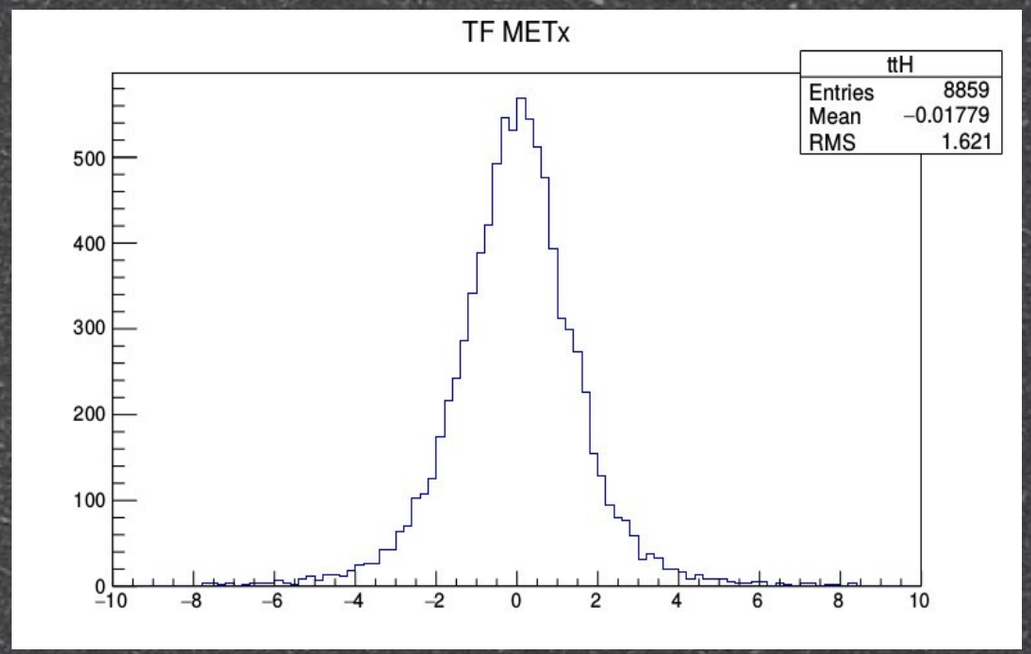
(New Method)

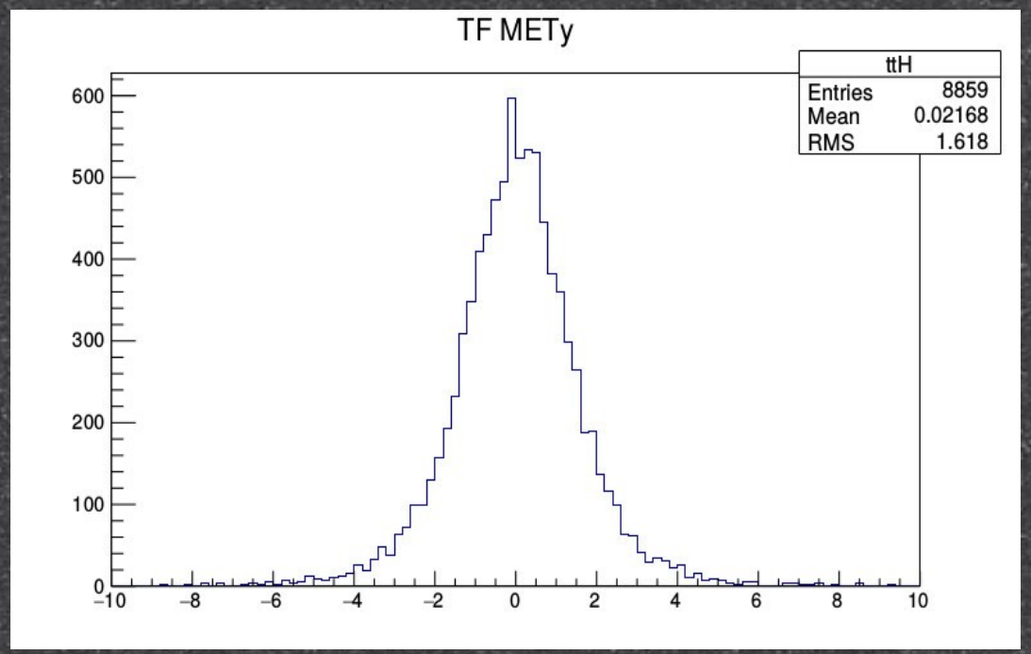
- TF(x_true,x_meas)=(x_meas-x_true)/sqrt(SumET)
- Parametrization of the Total Missing Px (METx)
- Parametrization of the Total Missing Py (METy)



METx

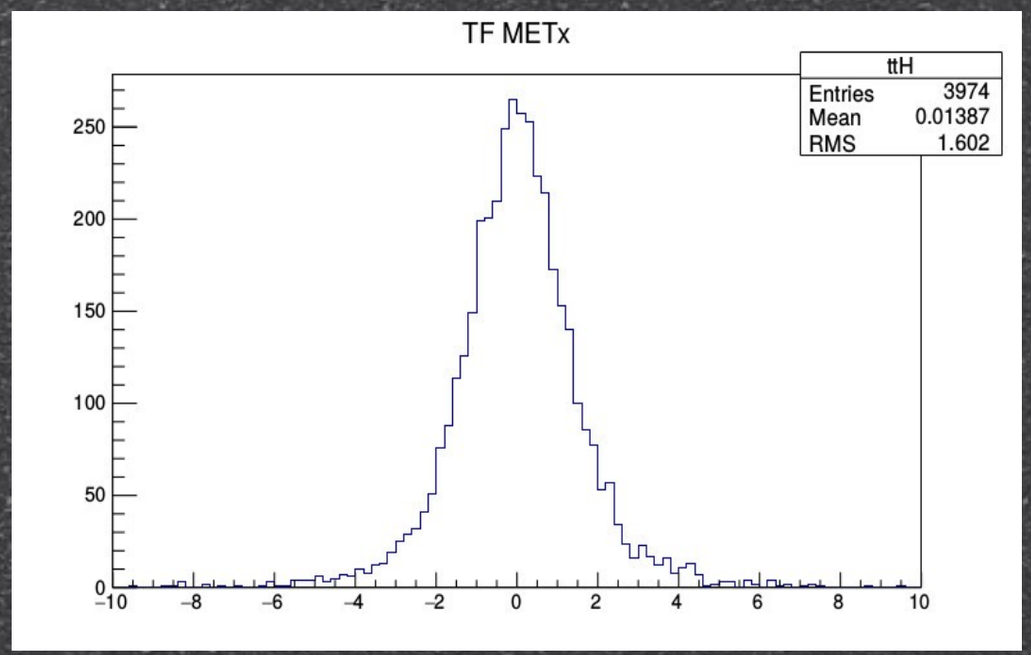
METy

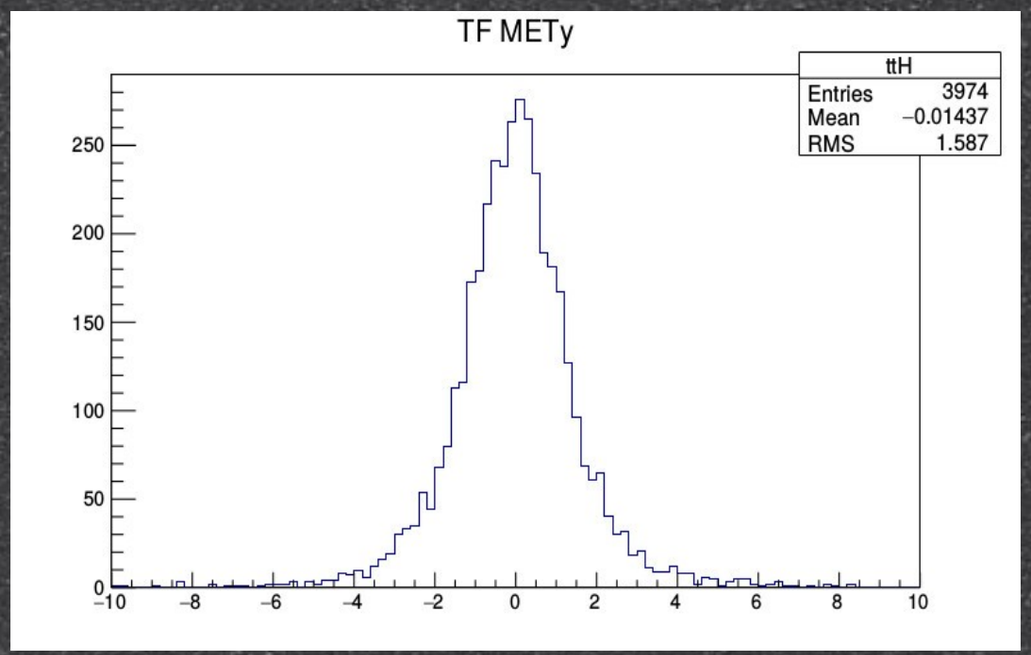




400<SumEt<500

400<SumEt<500

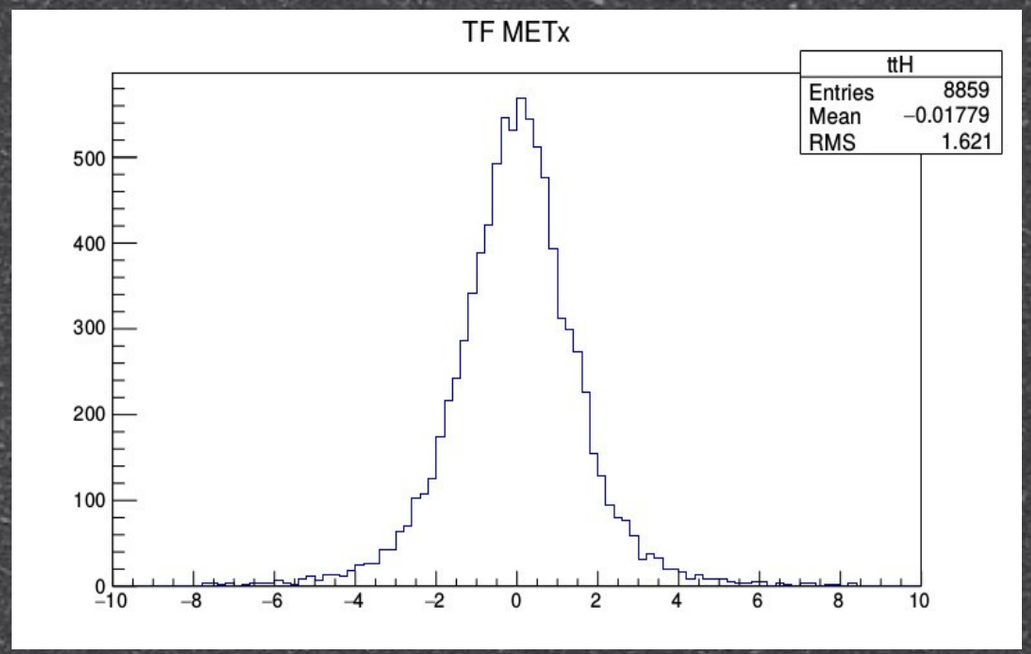




700<SumEt<800

700<SumEt<800

METx



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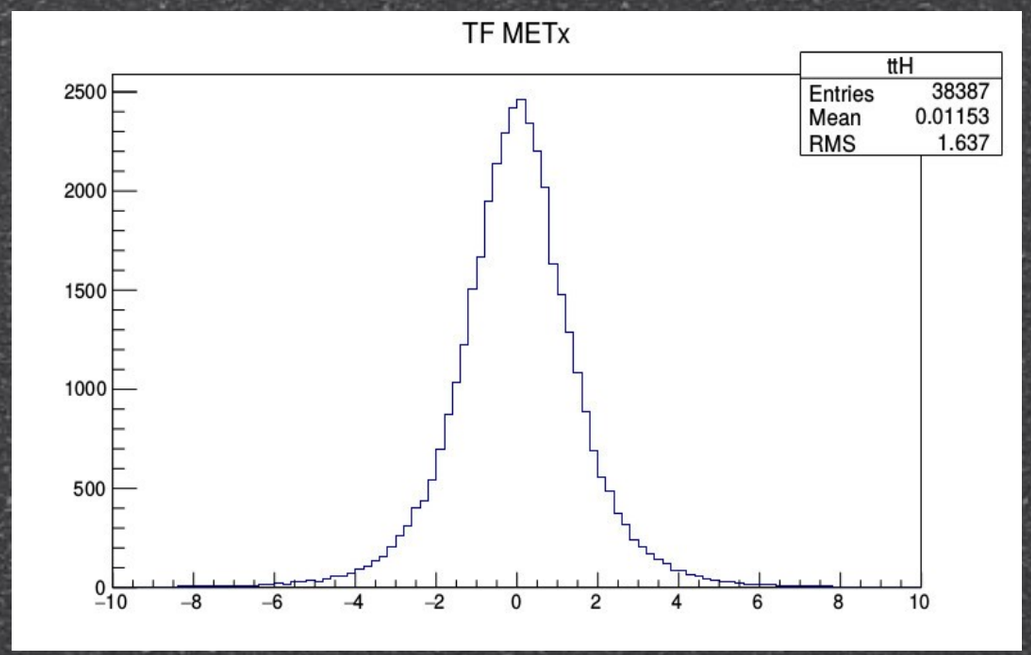
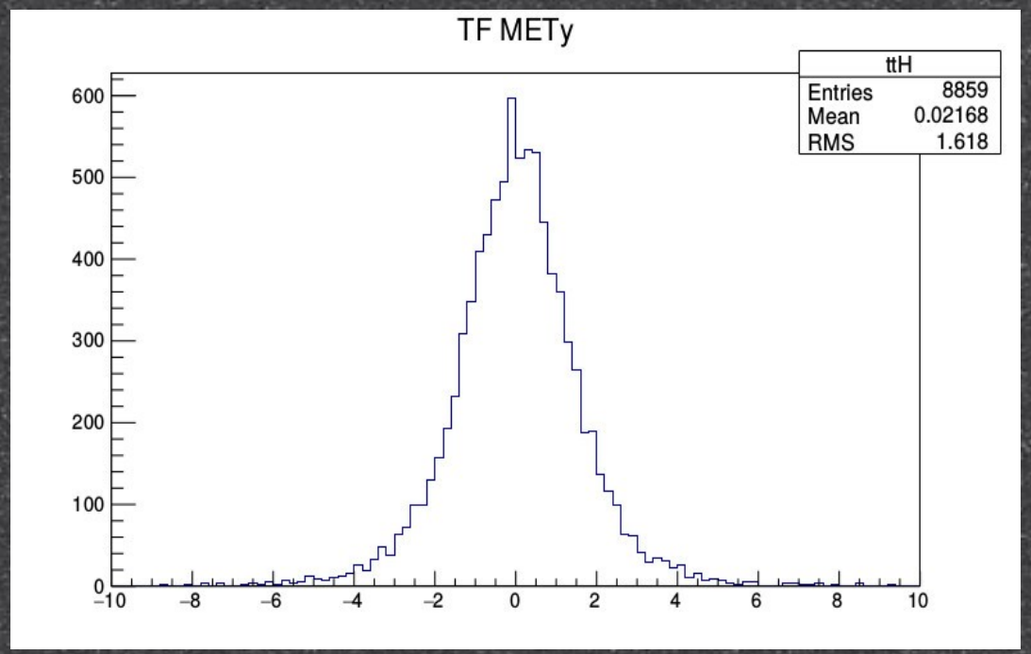


All SumET

METy



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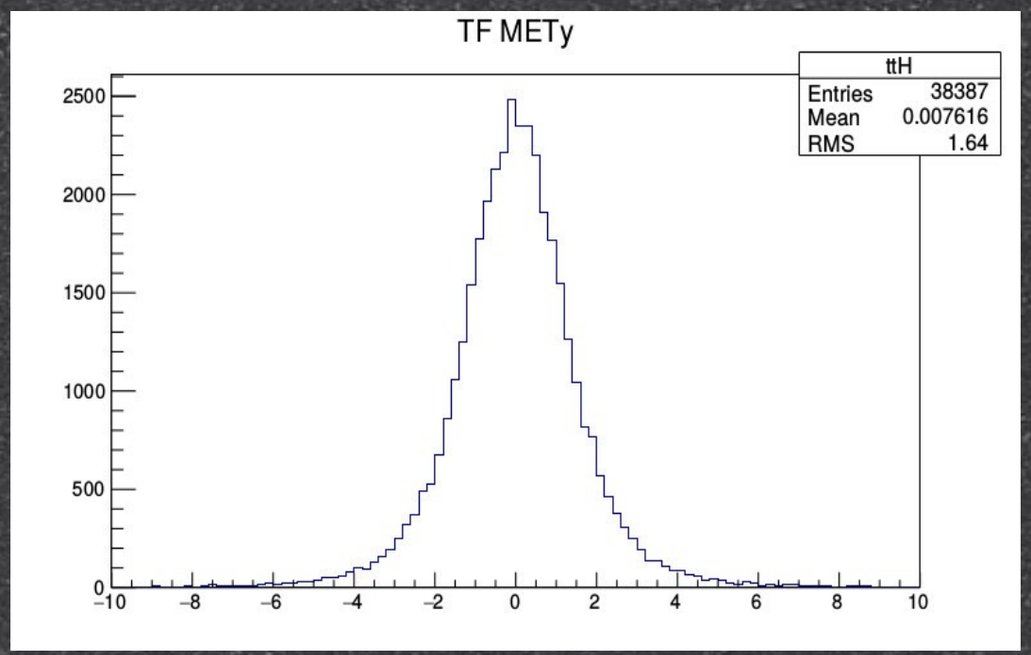
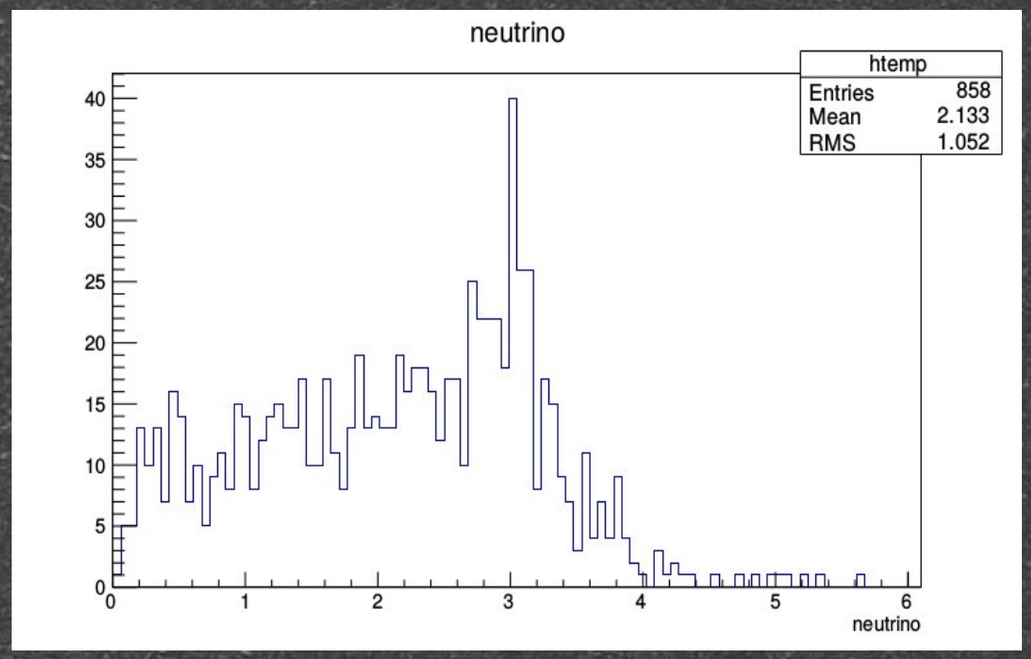


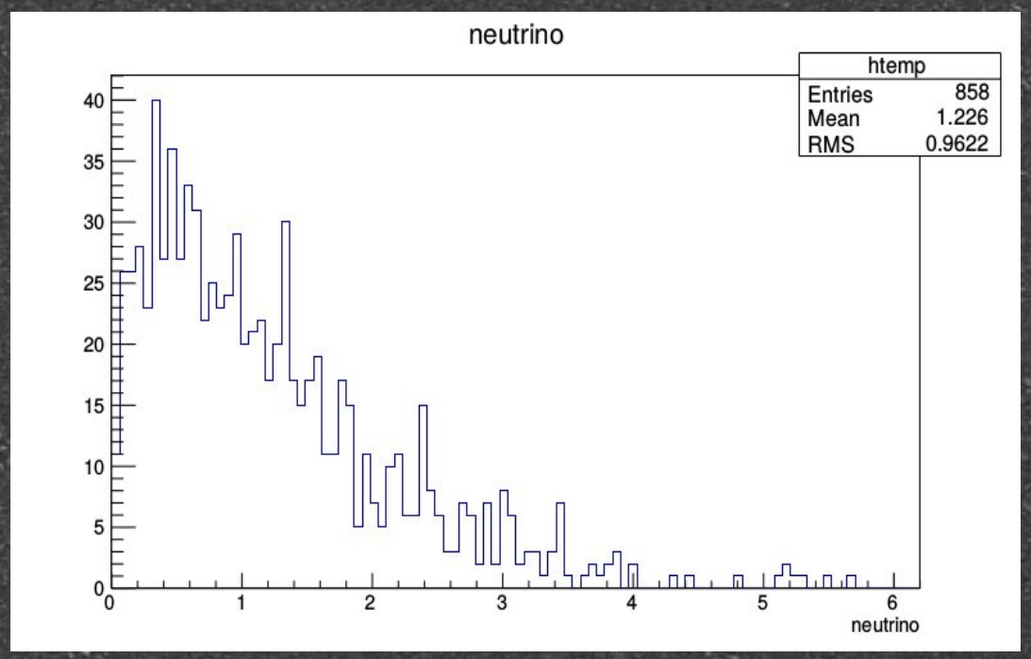
All SumET

MET Parametrization

Neutrino Reconstruction



Before



After