



# ILD Top/HF group meeting

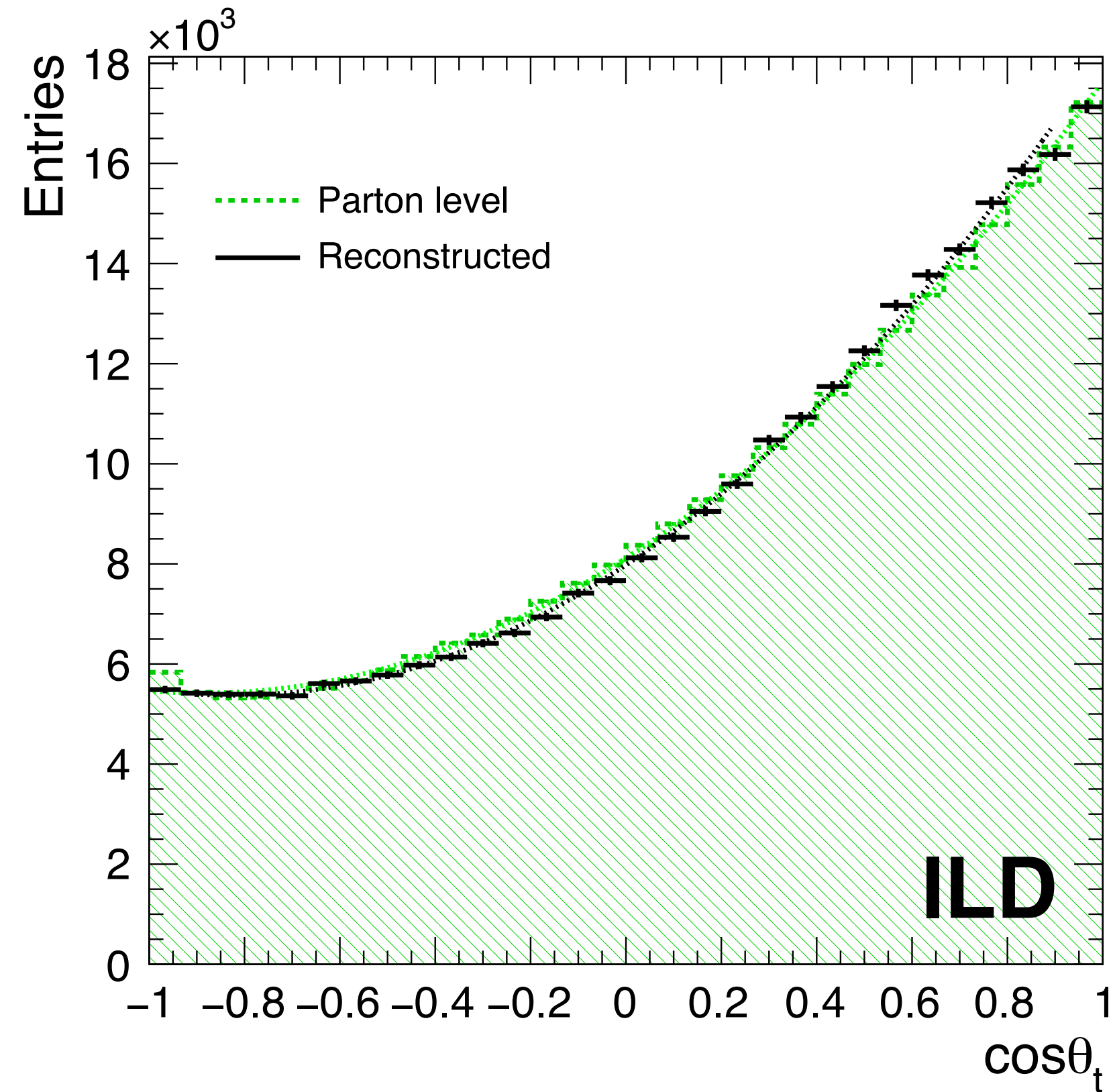
11/13/20

Yuichi Okugawa

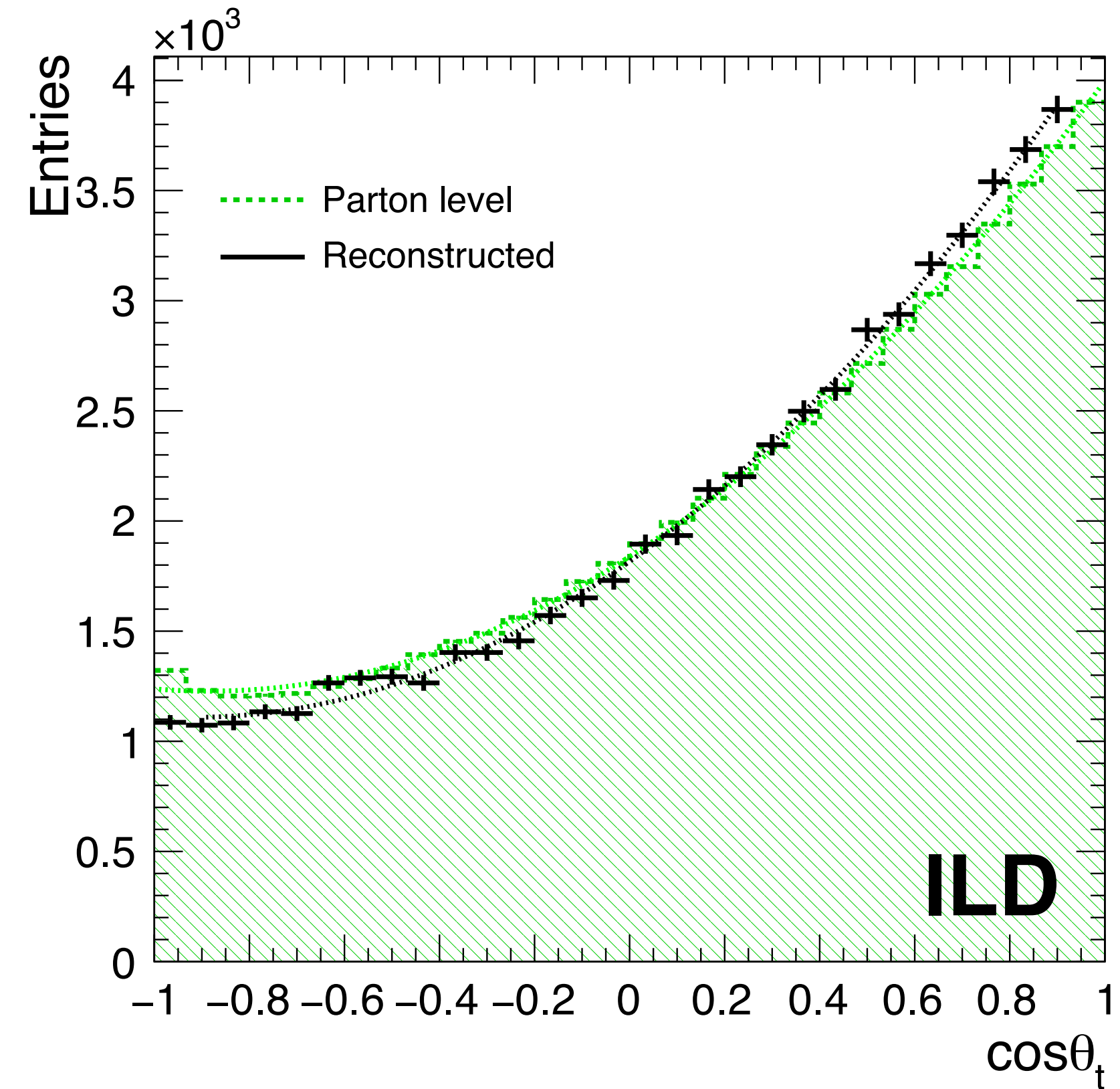
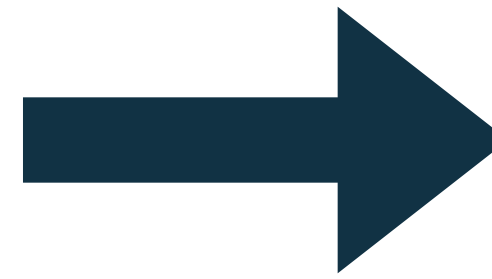
# 0. Outline

- 1. Brief introduction to single top analysis.**
- 2. Single Top Analysis**
- 3. Selection**
- 4. Conclusion**

# 1. Introduction

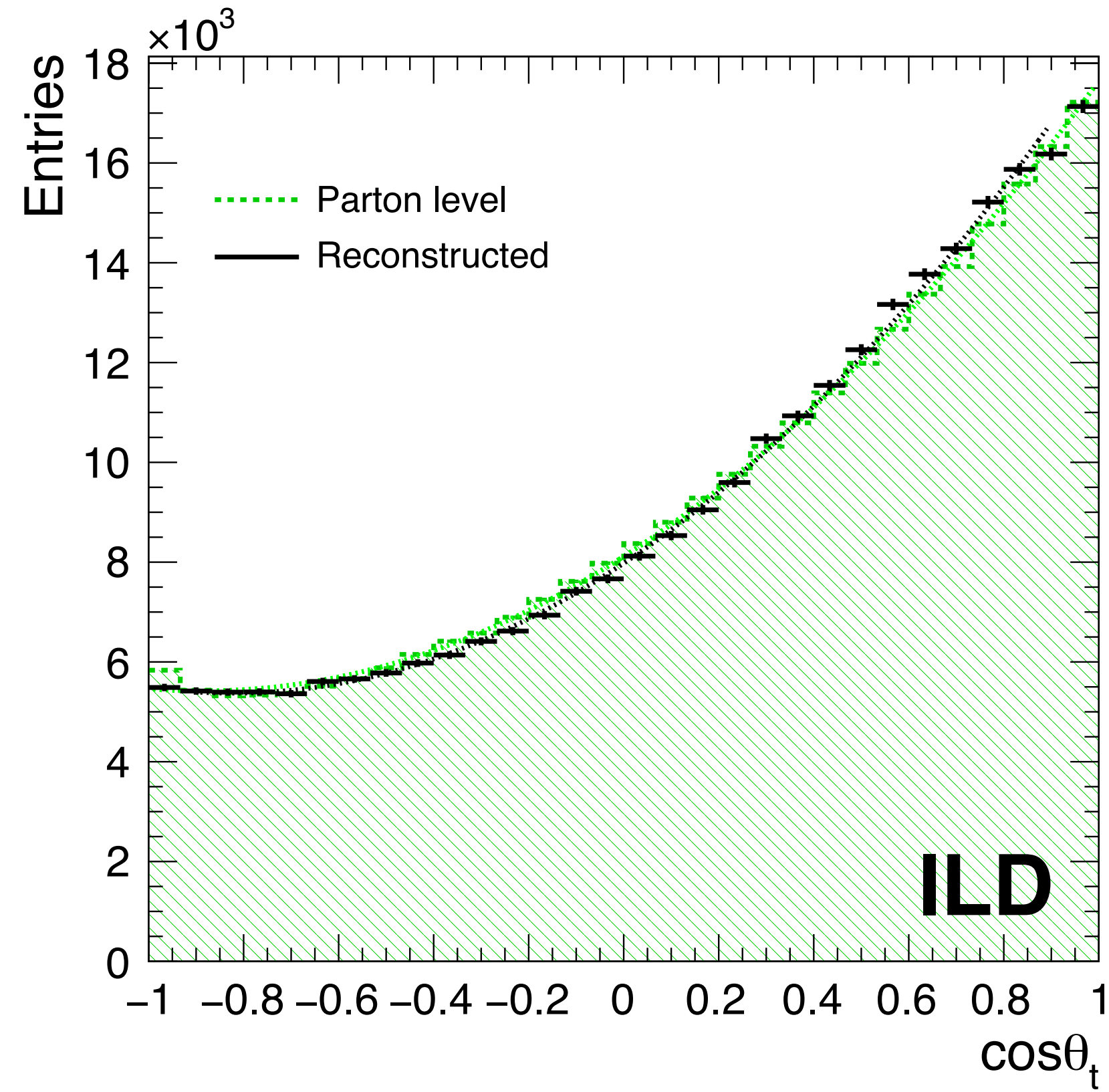


- ▶ Polar angle distribution of top quark for all reconstructed events

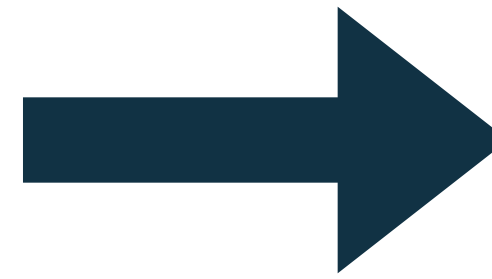


- ▶ Polar angle distribution of top quark only using vtx x vtx comparison.

# 1. Introduction

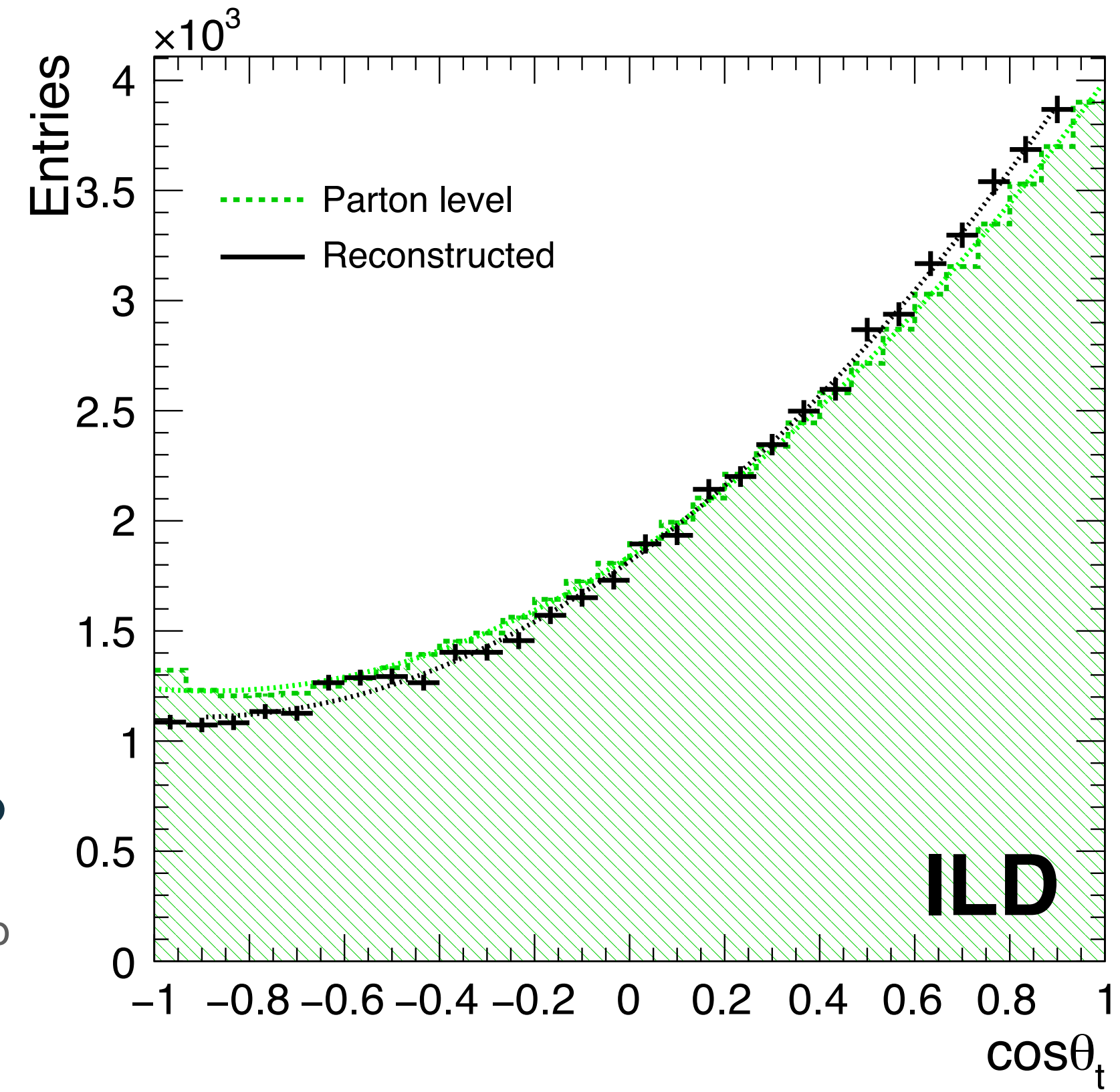


- ▶ Polar angle distribution of top quark for all reconstructed events



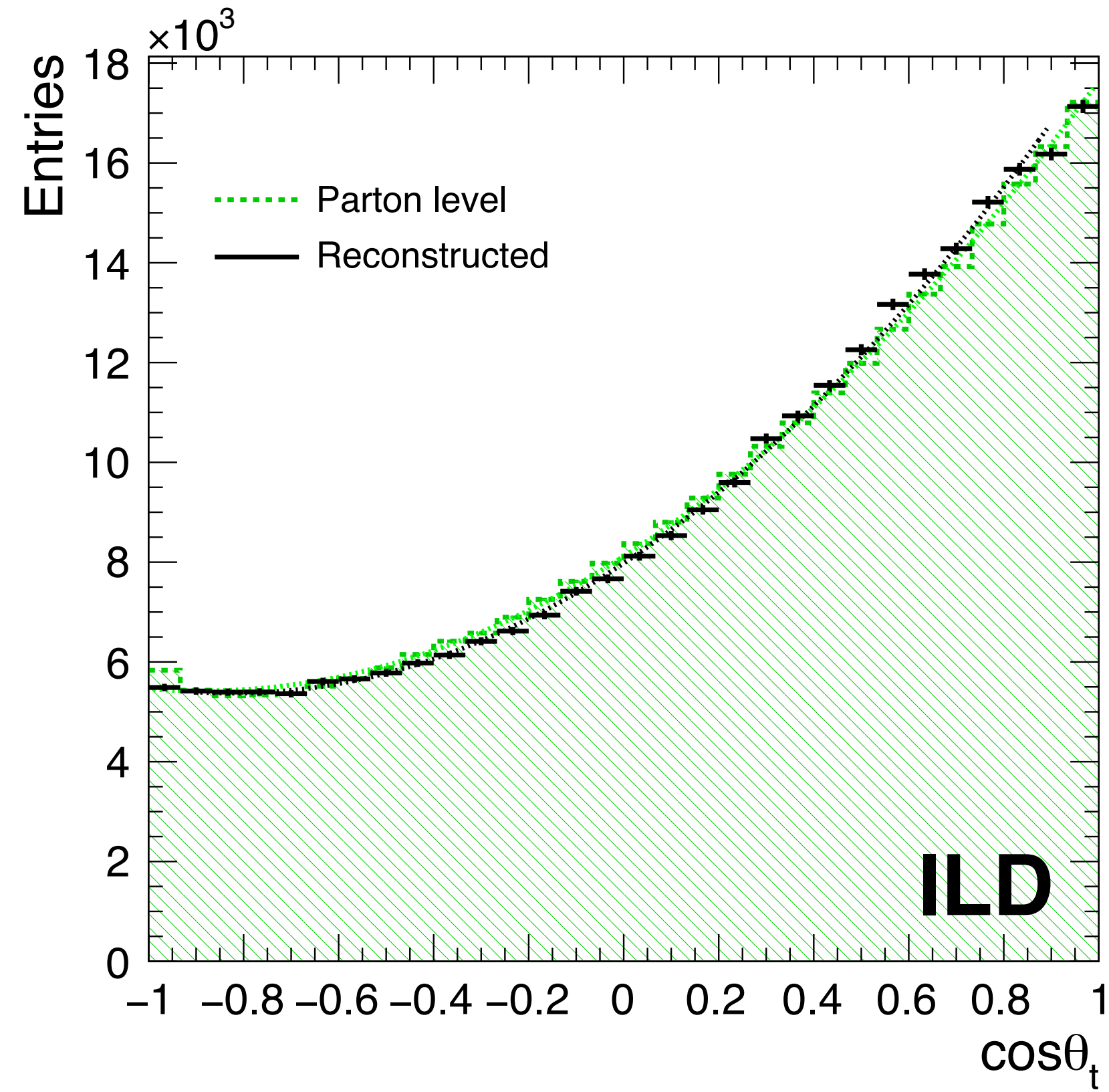
## Background?

- Mis-combination of b and W?
- Single Top Background?

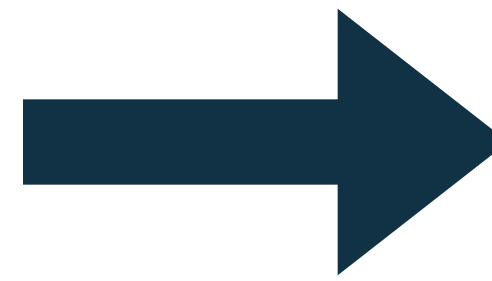


- ▶ Polar angle distribution of top quark only using vtx x vtx comparison.

# 1. Introduction



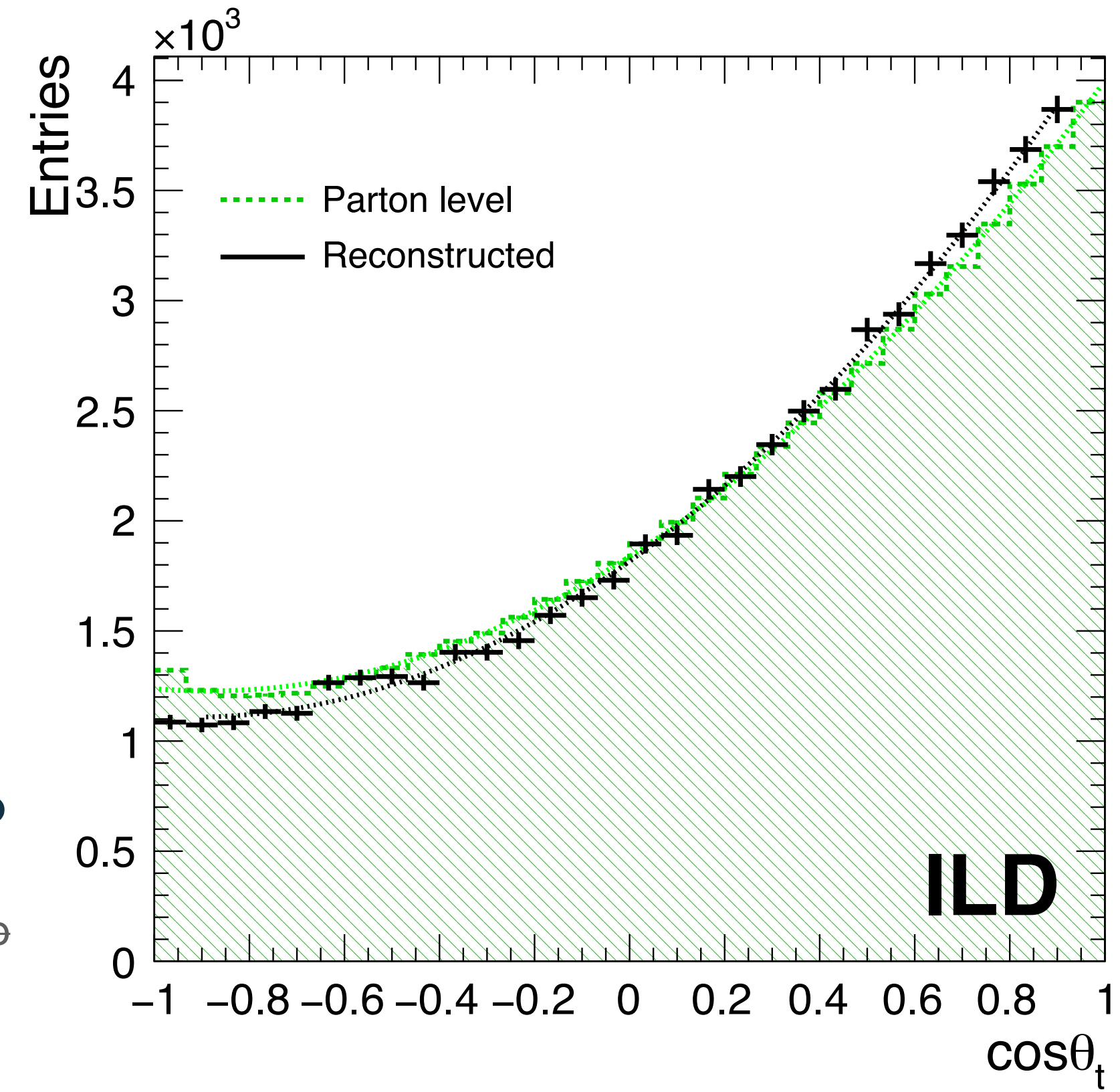
► Polar angle distribution of top quark for all reconstructed events



## Background?

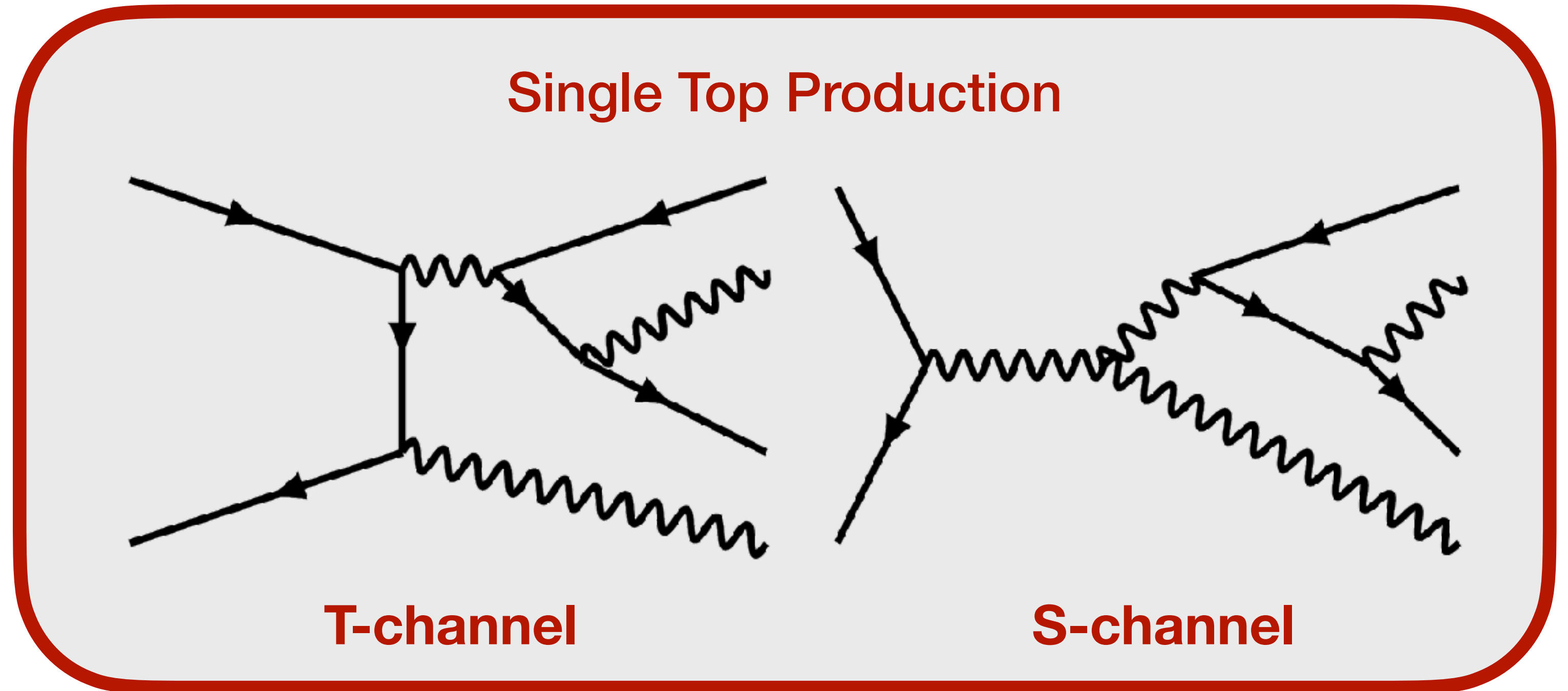
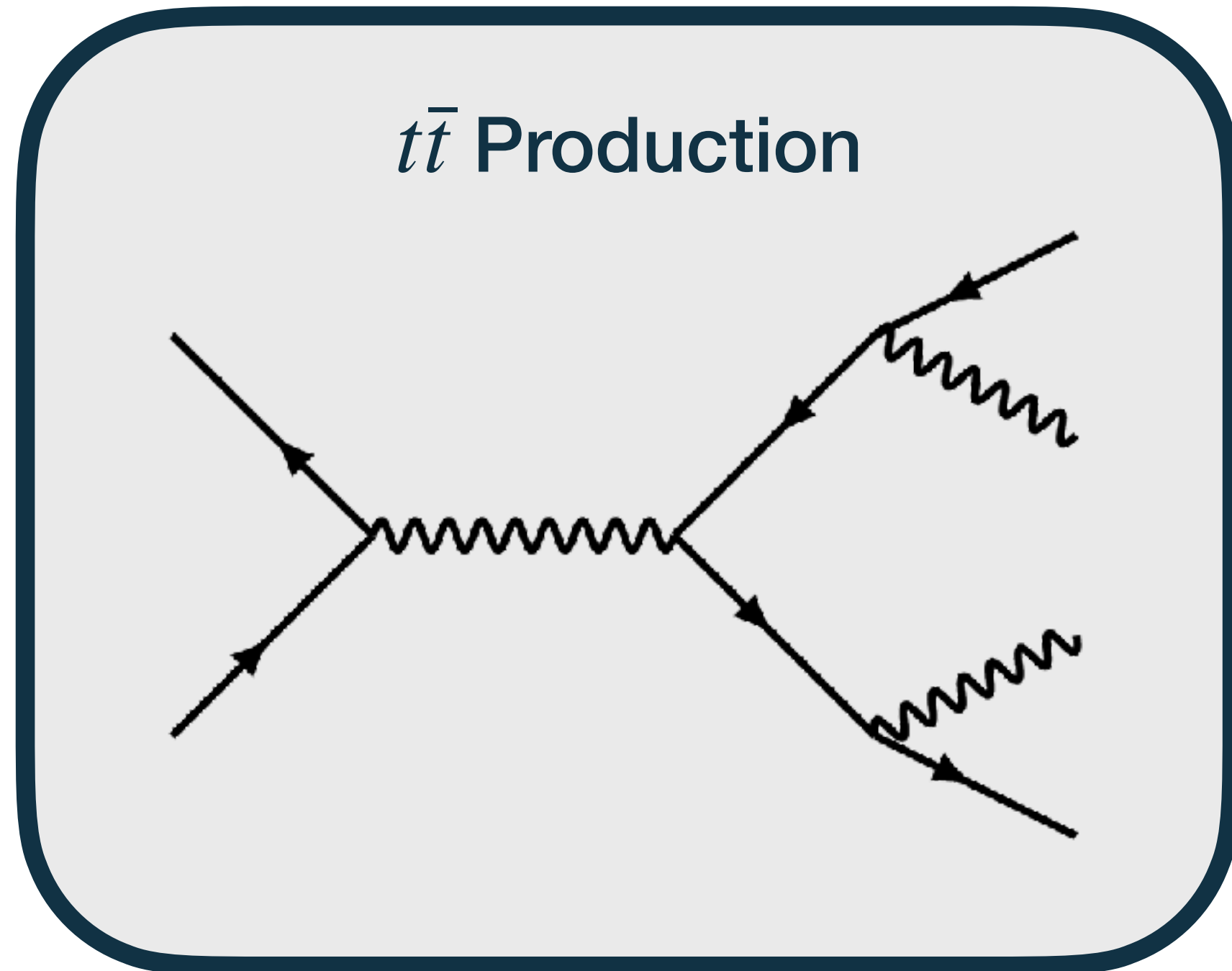
- Mis-combination of b and W?
- Single Top Background?

Source of systemic error



► Polar angle distribution of top quark only using vtx x vtx comparison.

# 1. Introduction

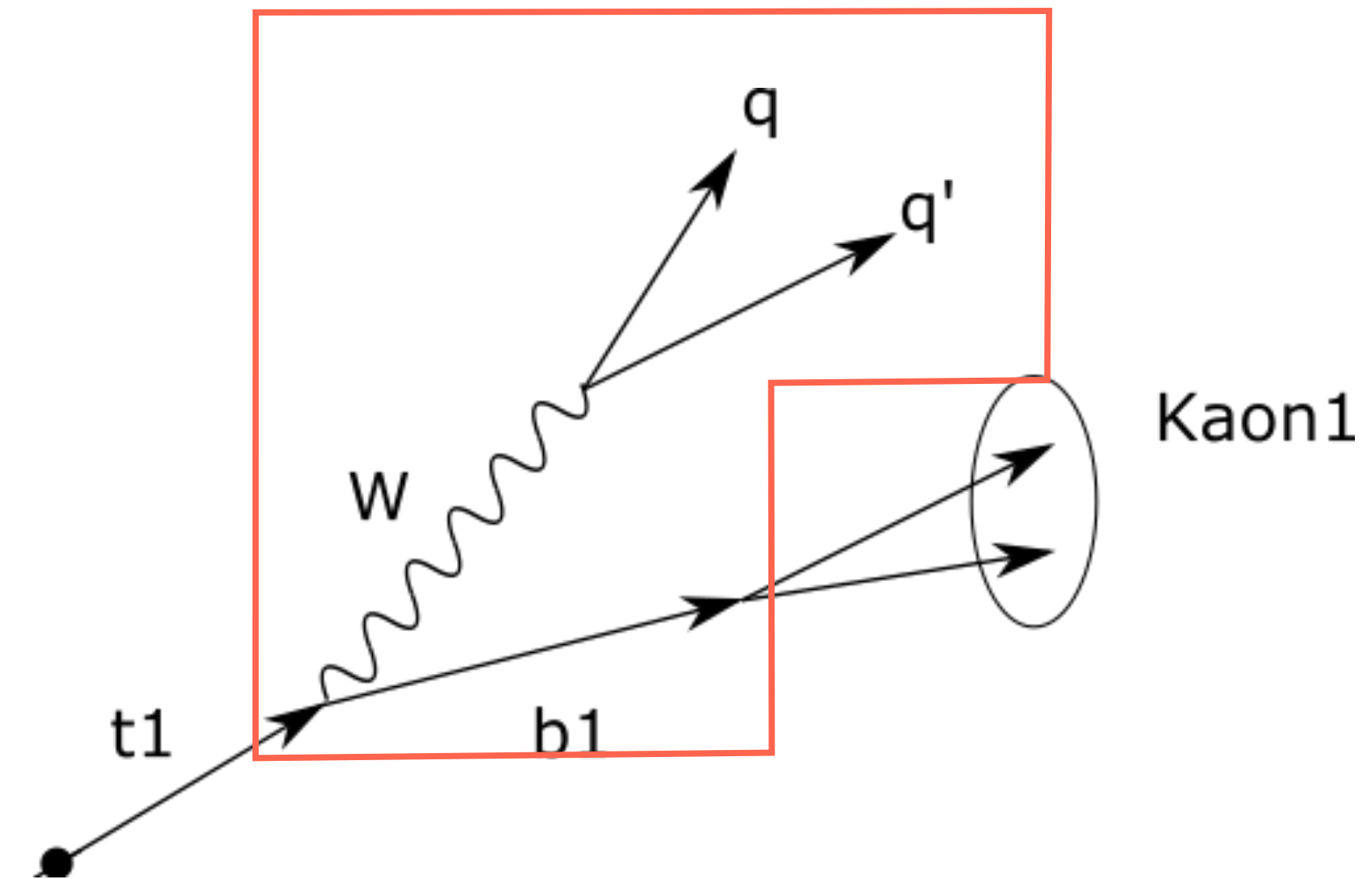


- Two processes are difficult to be distinguished.
  - Share the same final states. ( $b\bar{b}q\bar{q}'\ell\bar{\nu}$ )
  - Events are mixed in the parton level.

## 2. Single Top Analysis

### MC Generated Process

- MC generates events  $e^+e^- \rightarrow b\bar{b}q\bar{q}'\ell\nu$ 
  - $b\bar{b}$  comes from  $e^+e^-$  before hadronization thus FSR would not be included.
  - Processor would then look for  $W^+W^-$ . Sometimes these already decay in 2 fermion pairs ( $q\bar{q}'\ell\nu$ ). In this case, it'll find combination that fit W charges.
    - If there's FSR, there should be extra particle in this list. ( $\gamma$  or  $g$ )



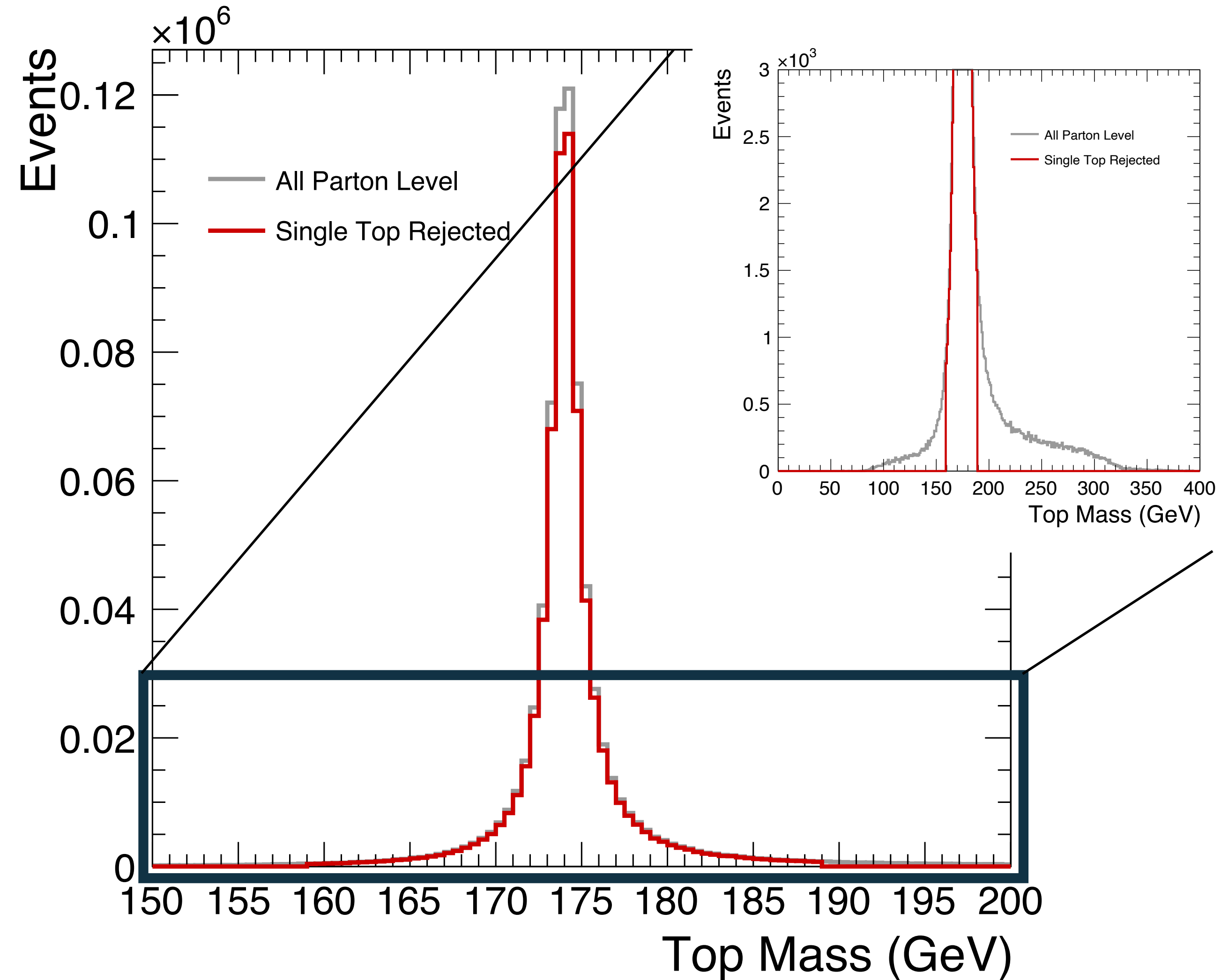
## 2. Single Top Analysis

- This analysis considered events to correspond to top quark pair production when the following criteria is satisfied for both of  $W$  and  $b$  pairs.

$$|m_{Wb} - m_t^{MC}| < 15 \text{ GeV}$$

If only one of these pair meet this criterium, the events are labeled as single top quark event.

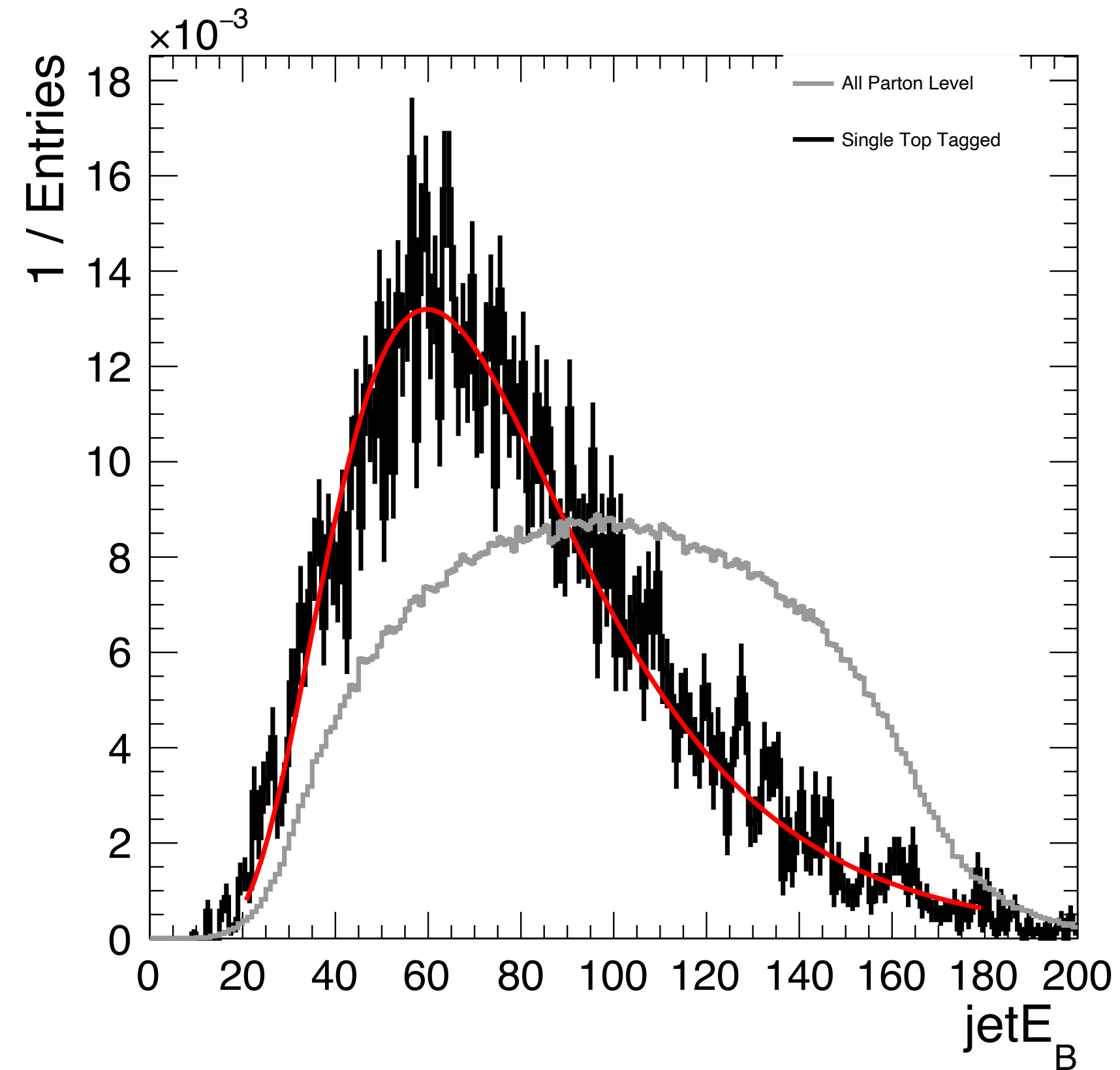
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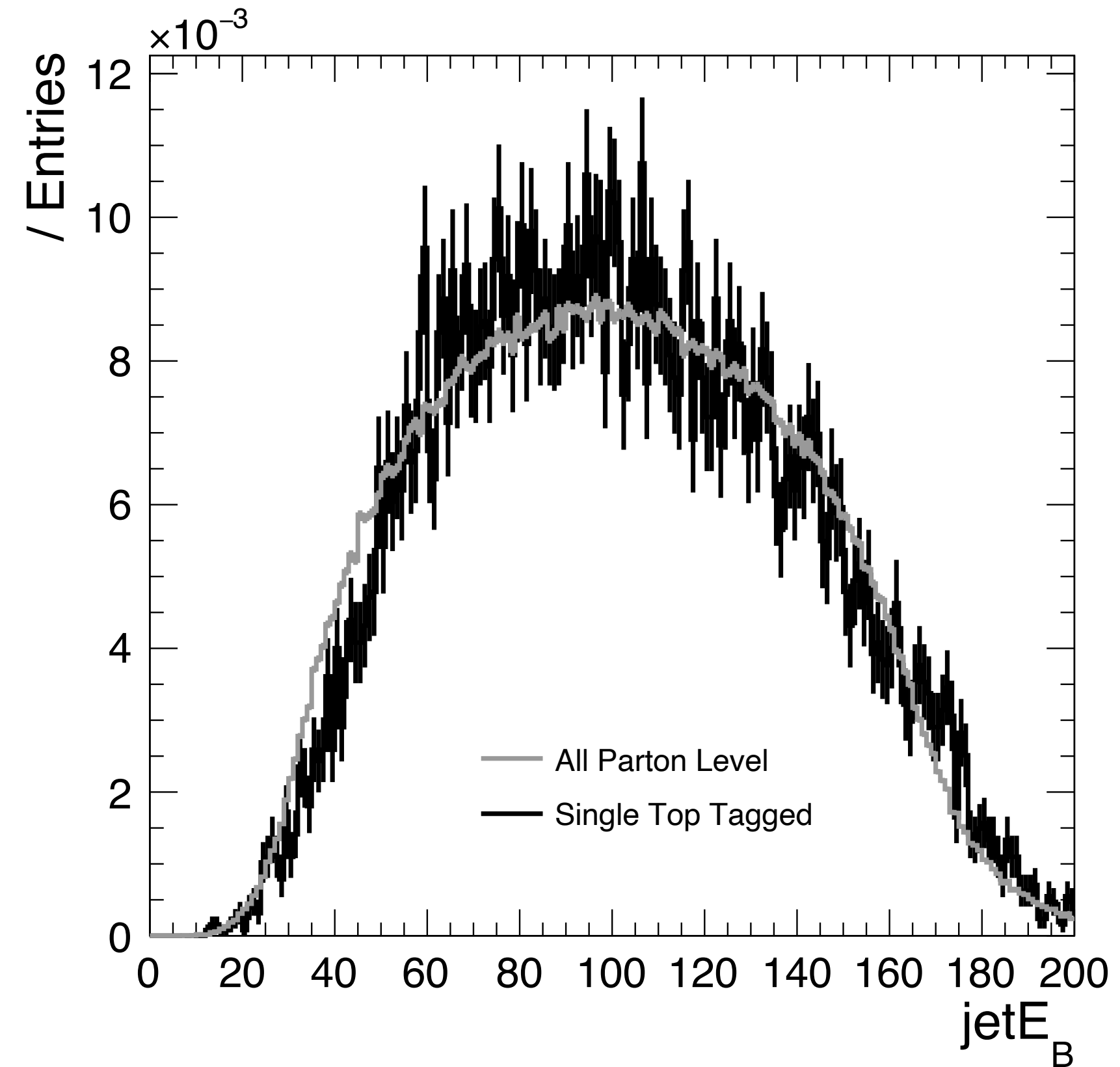


# 2. Single Top Analysis (ILD 10/02)

## $b$ -jet Energy Distribution



- ▶  $b$ -jet energy distribution of hadronic top for all reconstructed events.
- ▶ black:  $\cos \theta < -0.9$  && singleTop tag



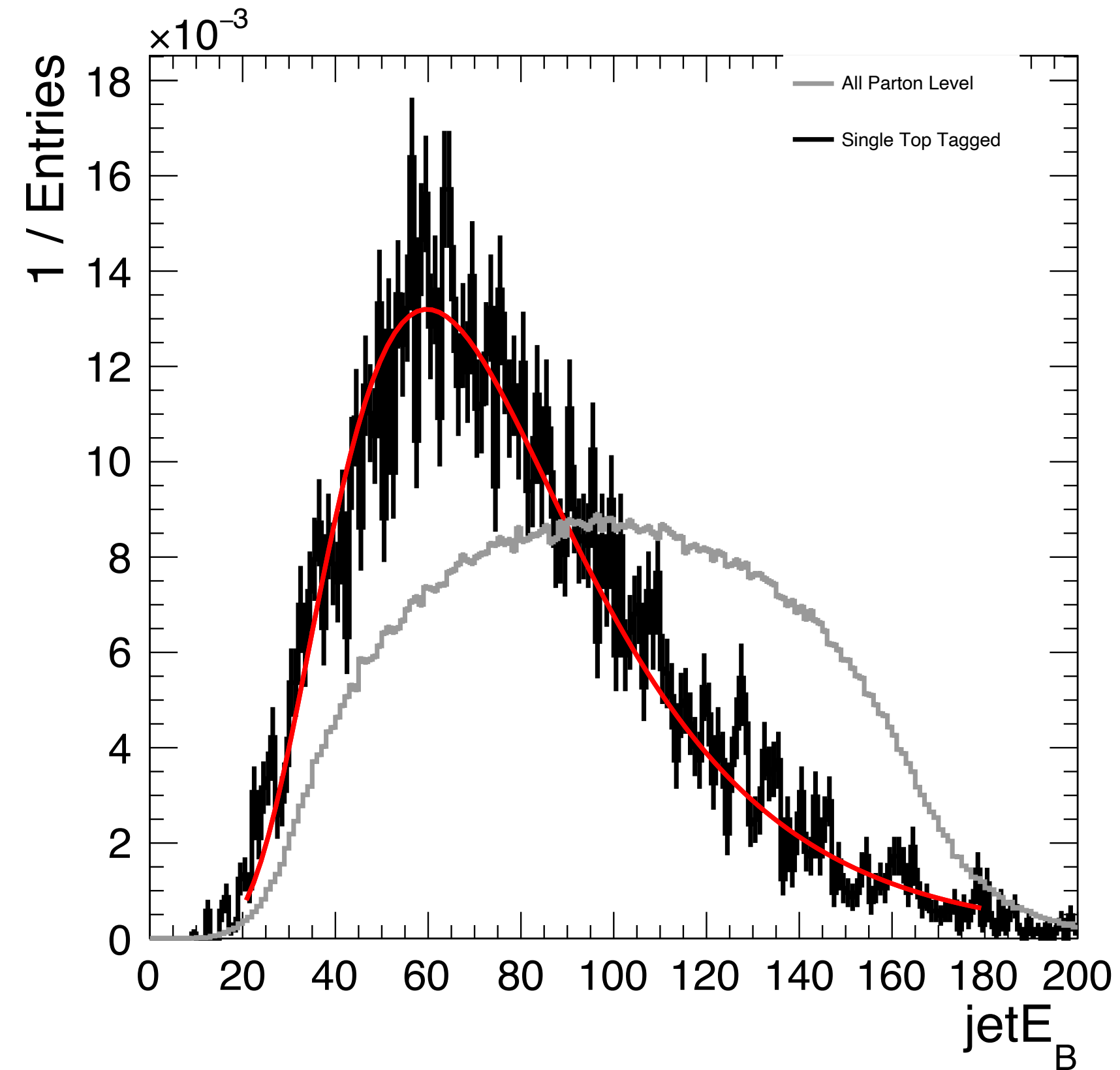
- ▶  $b$ -jet energy distribution of hadronic top only using  $vtx \times vtx$  comparison.

- ▶ black: method1 && singleTop tag

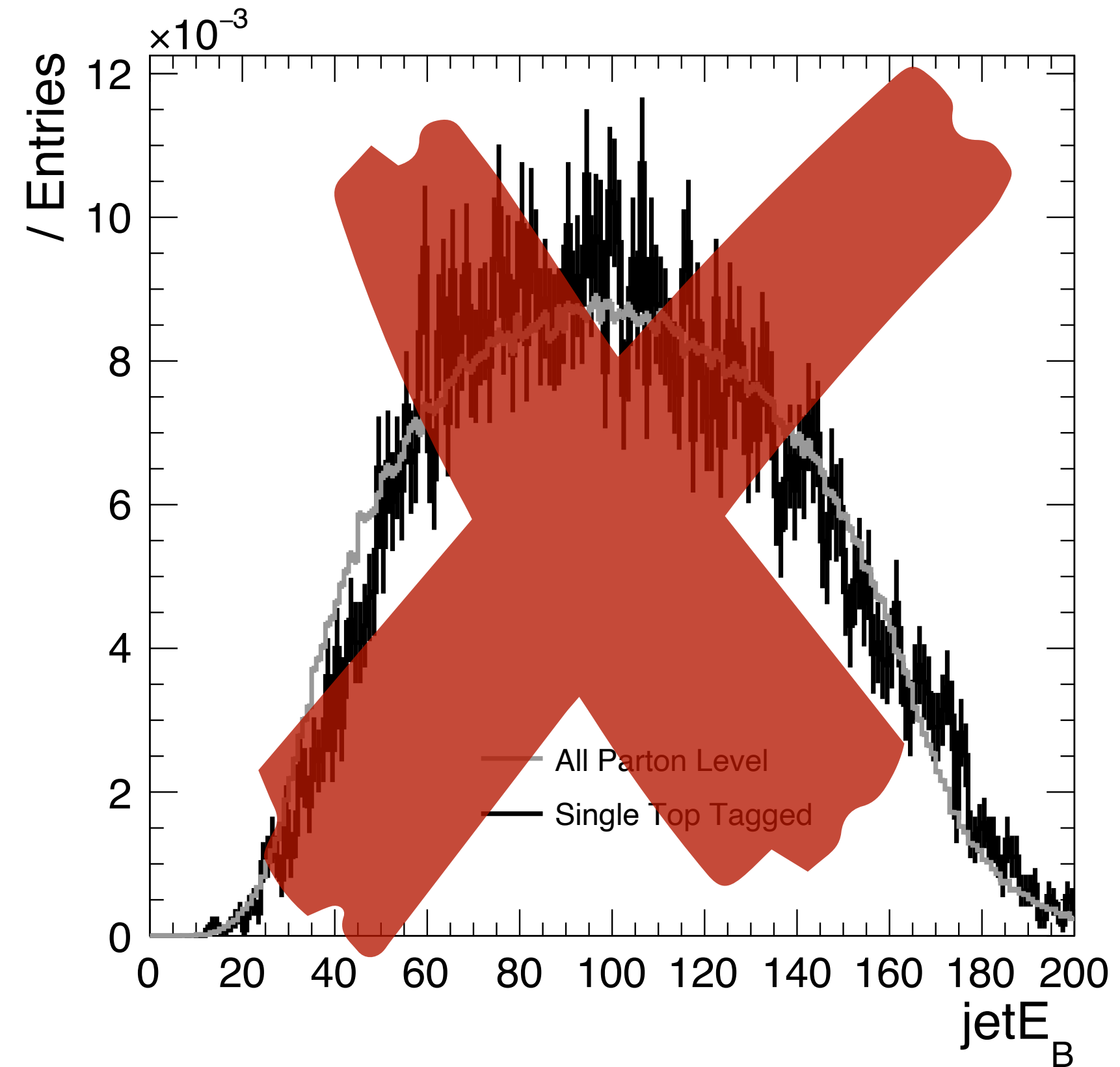
↑  
no  $\cos \theta < -0.9$

# 2. Single Top Analysis (ILD 10/02)

## b-jet Energy Distribution



- b-jet energy distribution of hadronic top for all reconstructed events.
- black:  $\cos \theta < -0.9$  && singleTop tag



- b-jet energy distribution of hadronic top only using vtx x vtx comparison.

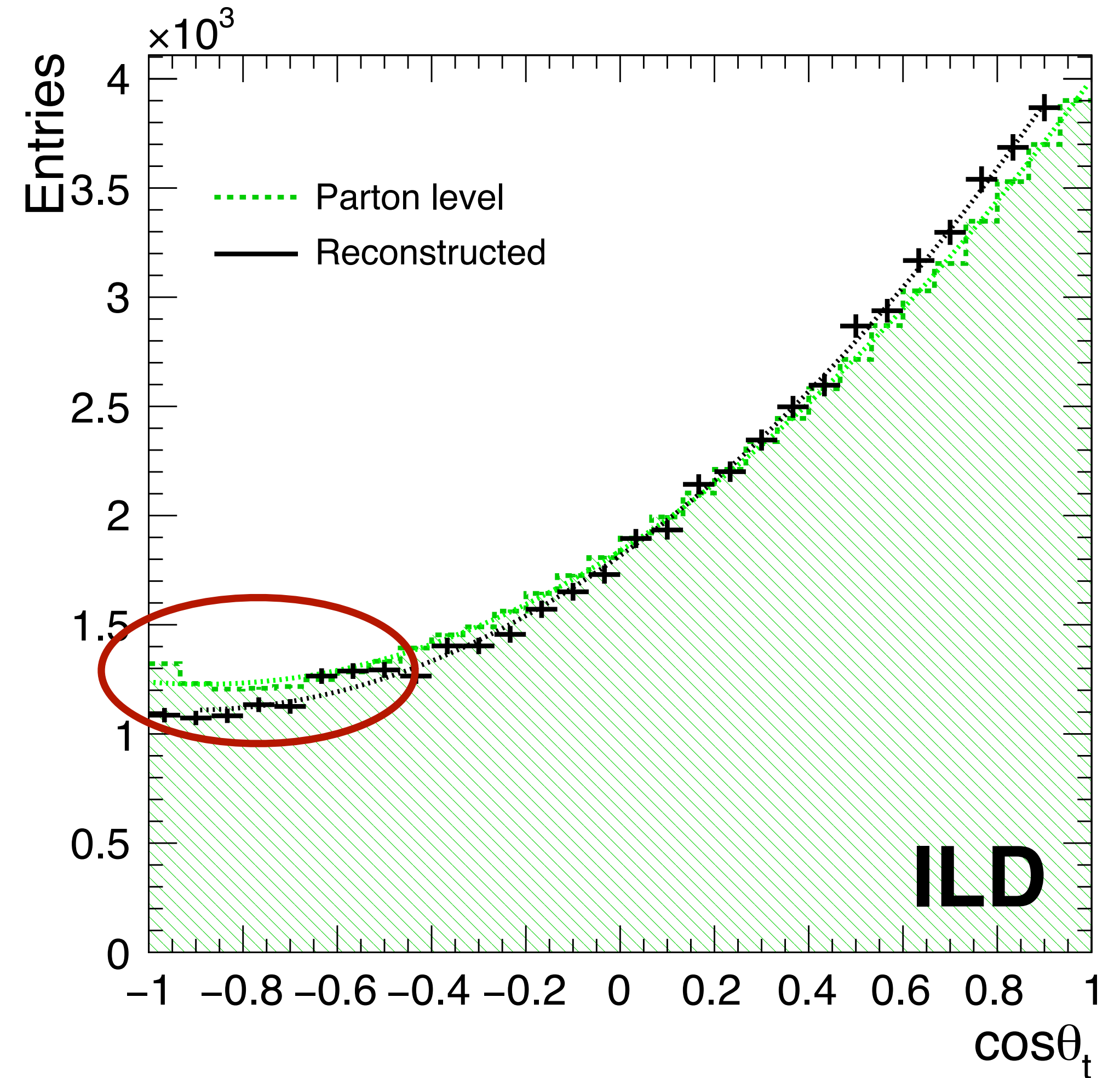
- black: method1 && singleTop tag

↑  
no  $\cos \theta < -0.9$

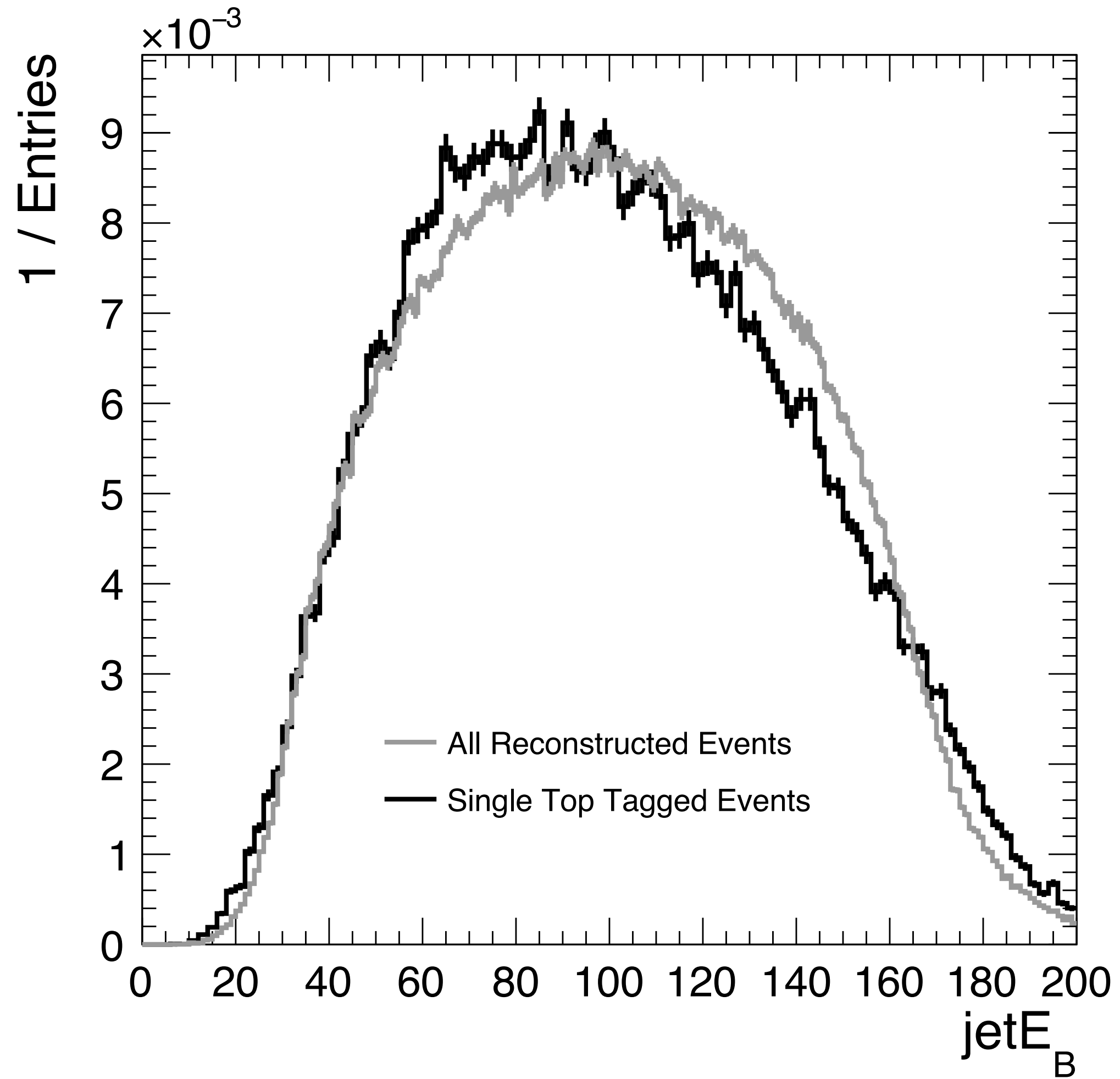
## 2. Single Top Analysis

### What are we interested?

- Key parameters
  - $\cos \theta < -0.9$
  - Single Top Tag (based on Gen info)
  - Usage of Method1 (vtx x vtx)



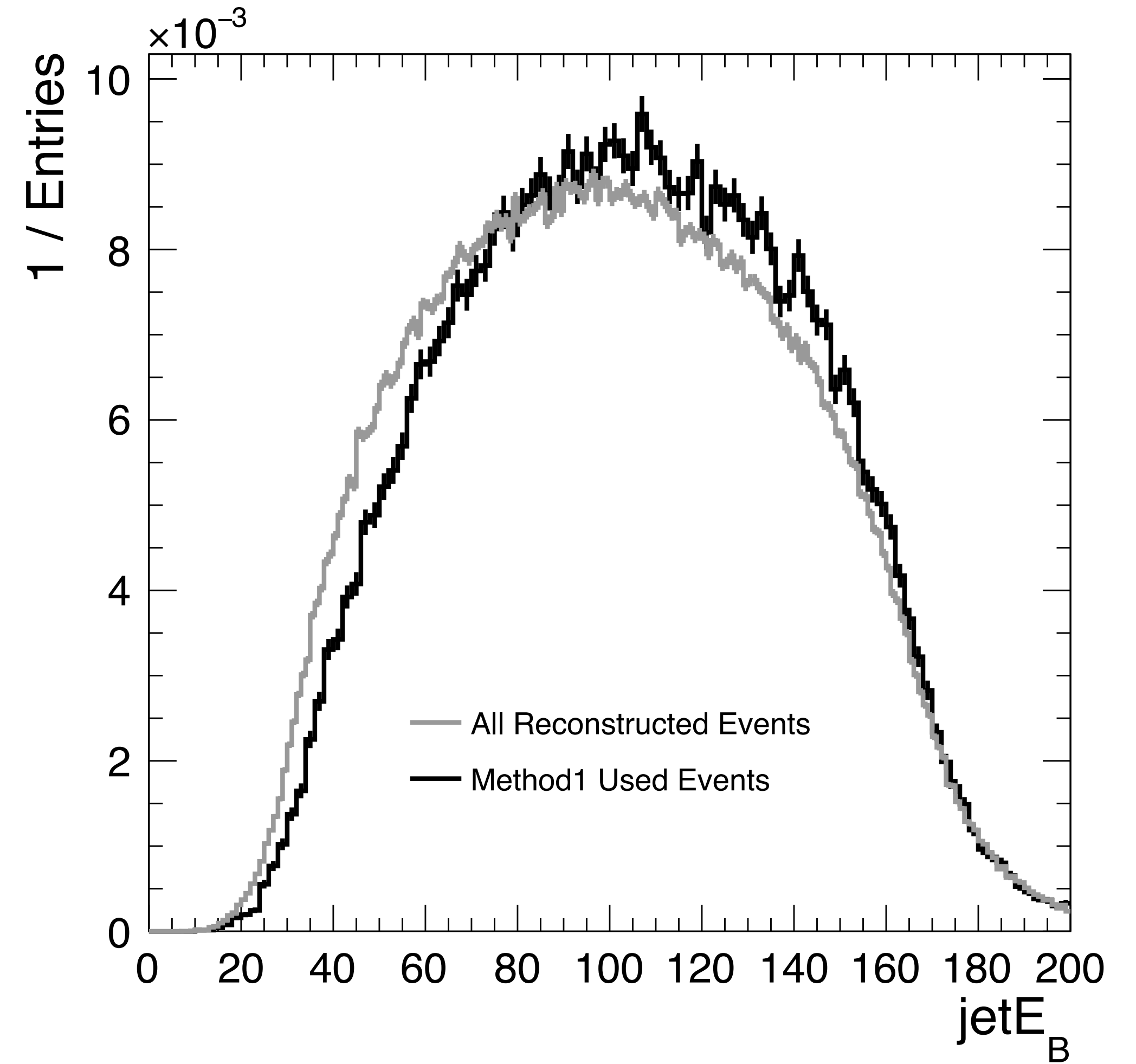
# 3. Selection



**Number of Events:**

All Reco Events: 1.51585e+06

Single Top Tagged Events: 183956

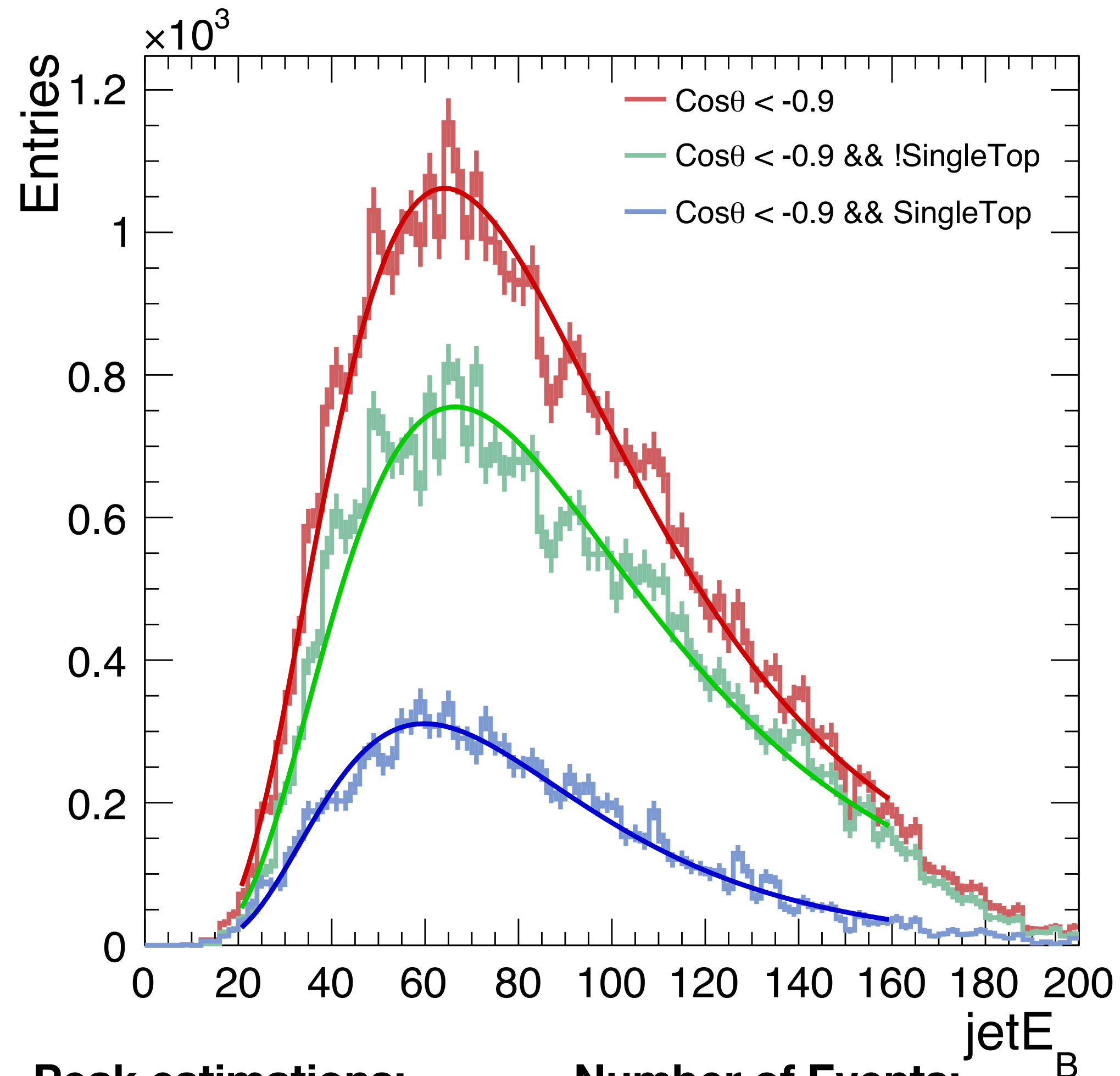


**Number of Events:**

All Reco Events: 1.51585e+06

Method1 Used Events: 107715

# 3. Selection



Peak estimations:

Number of Events:

maxRed = 64.2 GeV

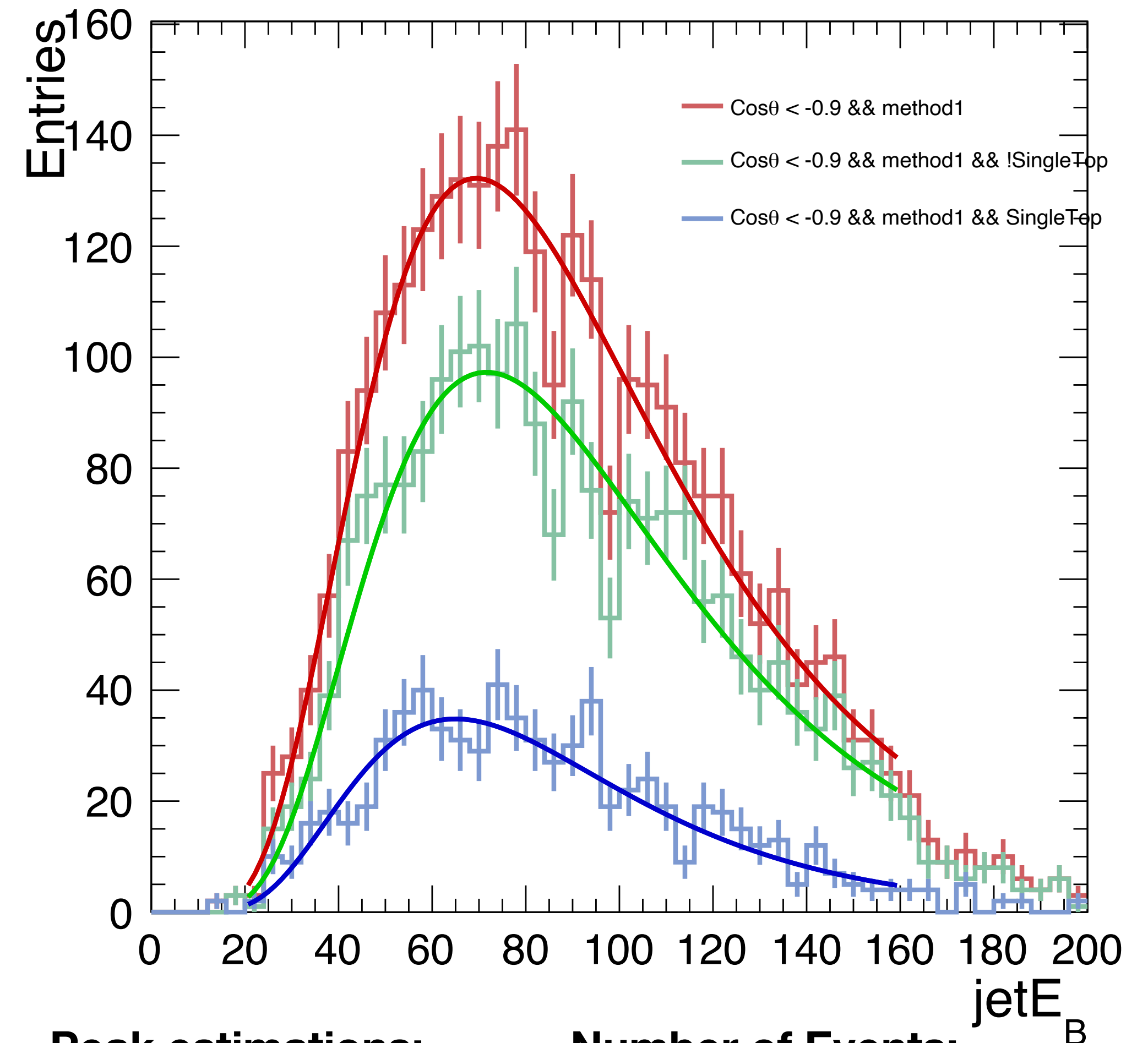
Red Events: 45868

maxGreen = 66.4 GeV

Green Events: 12185

maxBlue = 59.8 GeV

Blue Events: 33683



Peak estimations:

Number of Events:

maxRed = 68.9 GeV

Red Events: 2876

maxGreen = 70.8 GeV

Green Events: 721

maxBlue = 64.5 GeV

Blue Events: 2155

# 4. Conclusion

- **$t\bar{t}$  Pair Production**

- ▶  $t\bar{t}$  production at the ILC at  $\sqrt{s} = 500$  GeV for fully-left handed beam polarization using 900,000 events was processed.

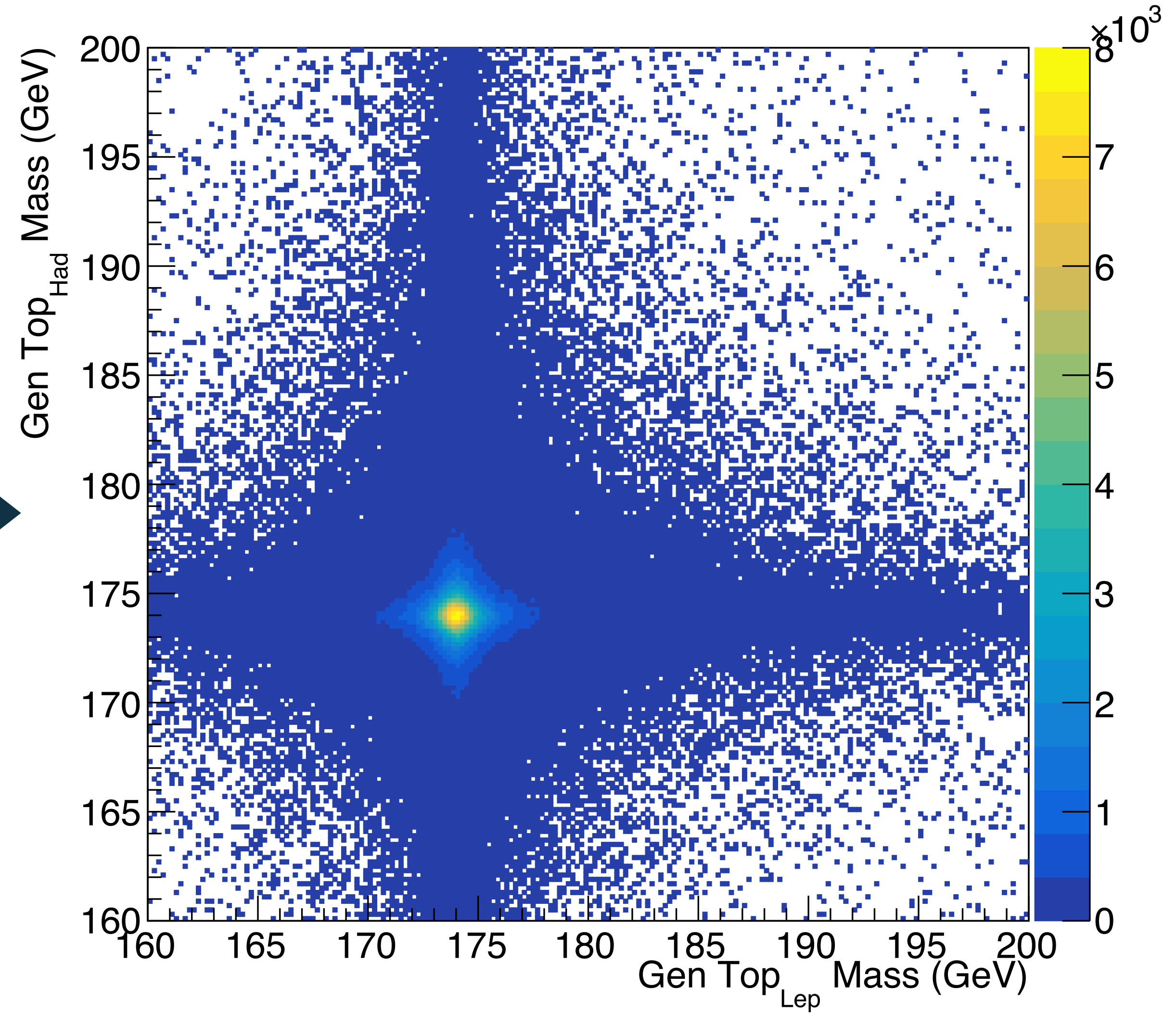
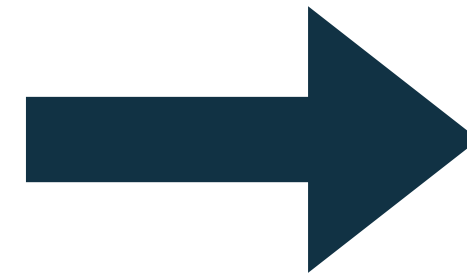
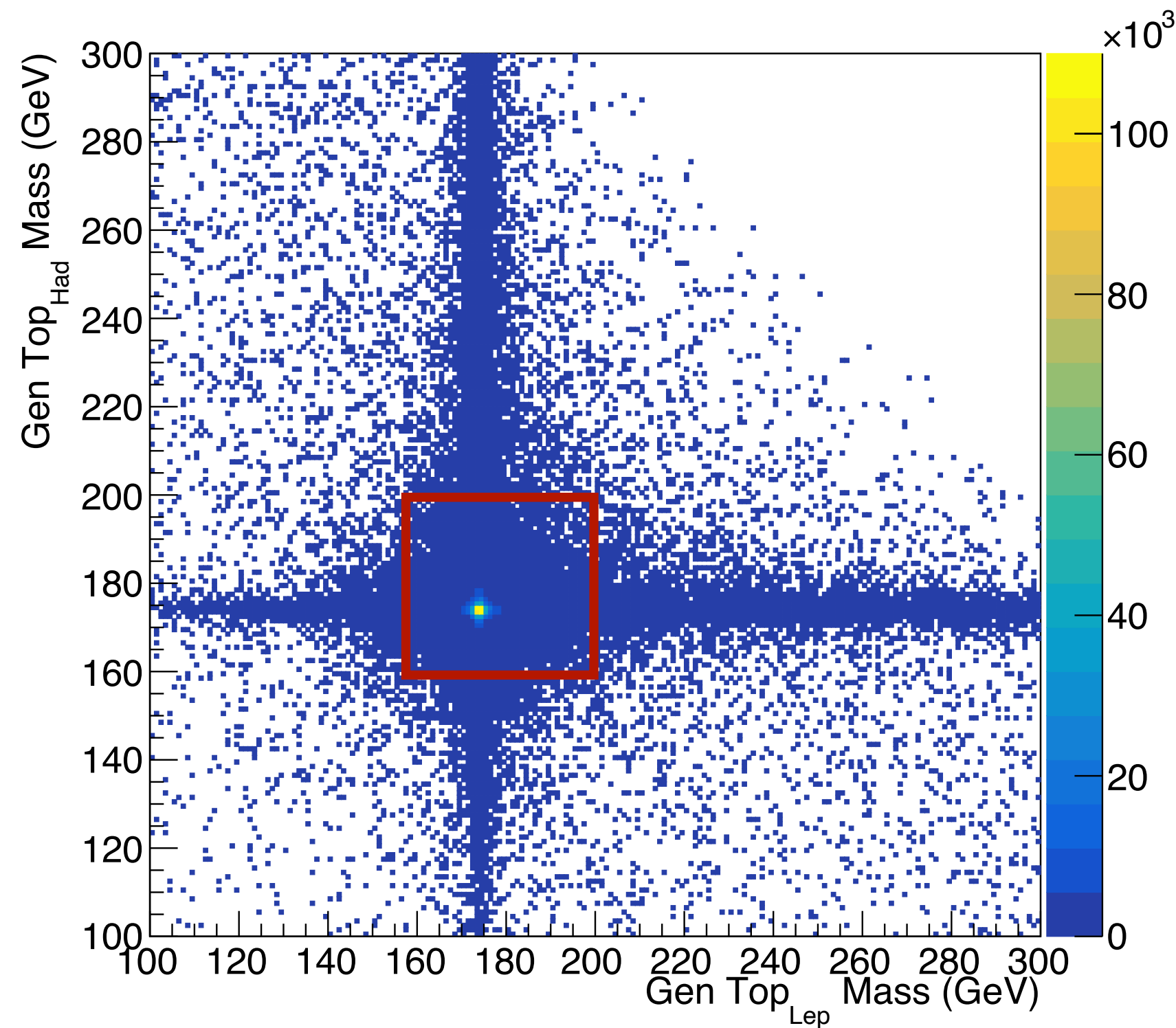
- **Single Top Analysis**

- ▶ Single top problem emerged as a source of systematic error, thus applied a selection for single top generated events on combined generated mass of  $b$  and  $W$ .
- ▶ Generated single top events consist 12.5% of overall events.
- ▶ Vtx x Vtx comparison scheme seems to eliminate such events by filtering out the soft b-jets.
  - ▶ It is possible that at the detector level, vertex detector fail to reconstruct tracks associated to b-jets, which results in this 'filtering' effect.
  - ▶ Differentiating single top process is perplexing when it comes down to reconstruction level, yet vertex charge measurement could be an identifier to estimate such events.

# Backup

# 4. Single Top Analysis

- Generated Lep/Had Top Mass

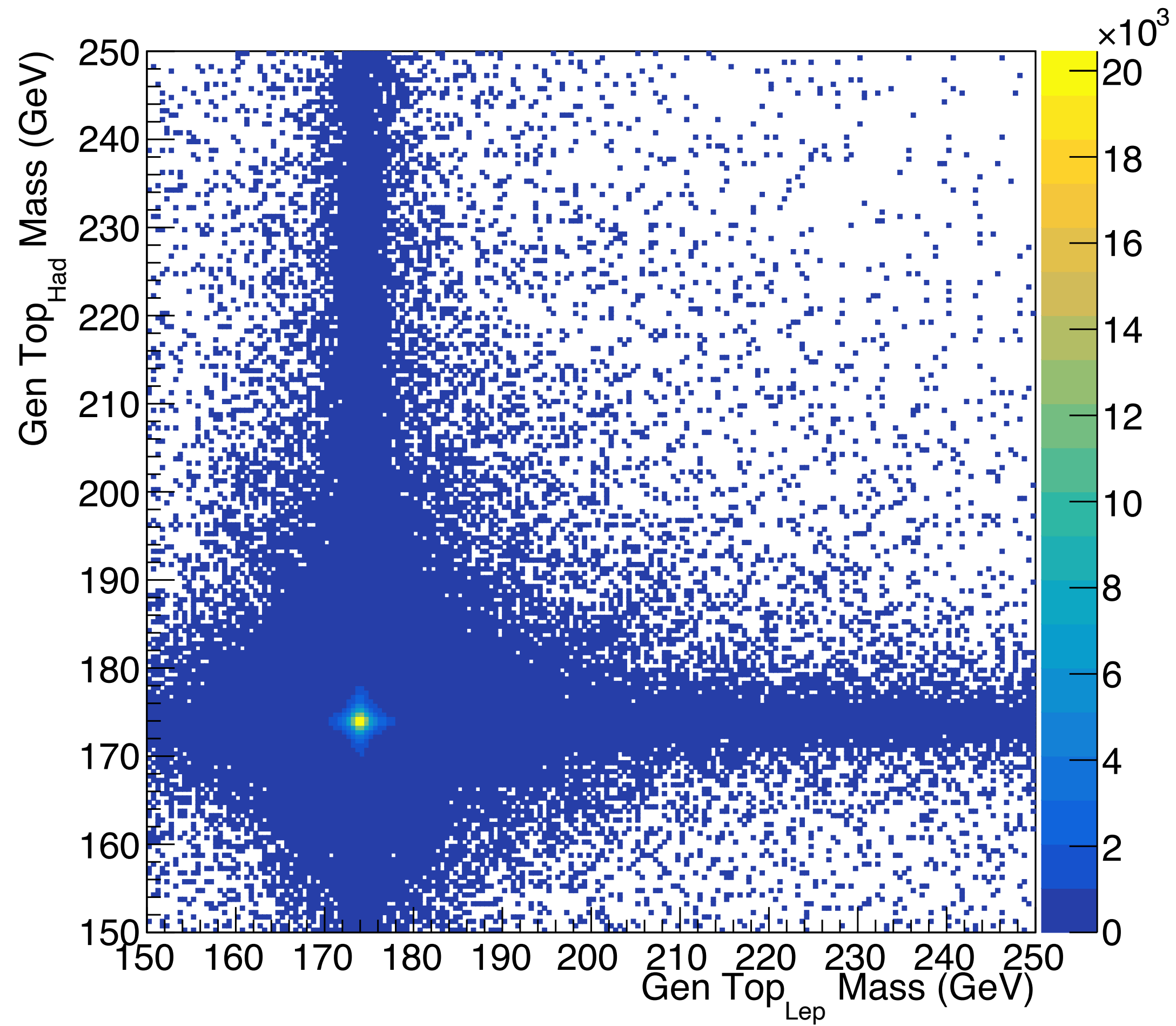


- ▶ Events clusters around 174 GeV region yet still huge amount of off-shell events.

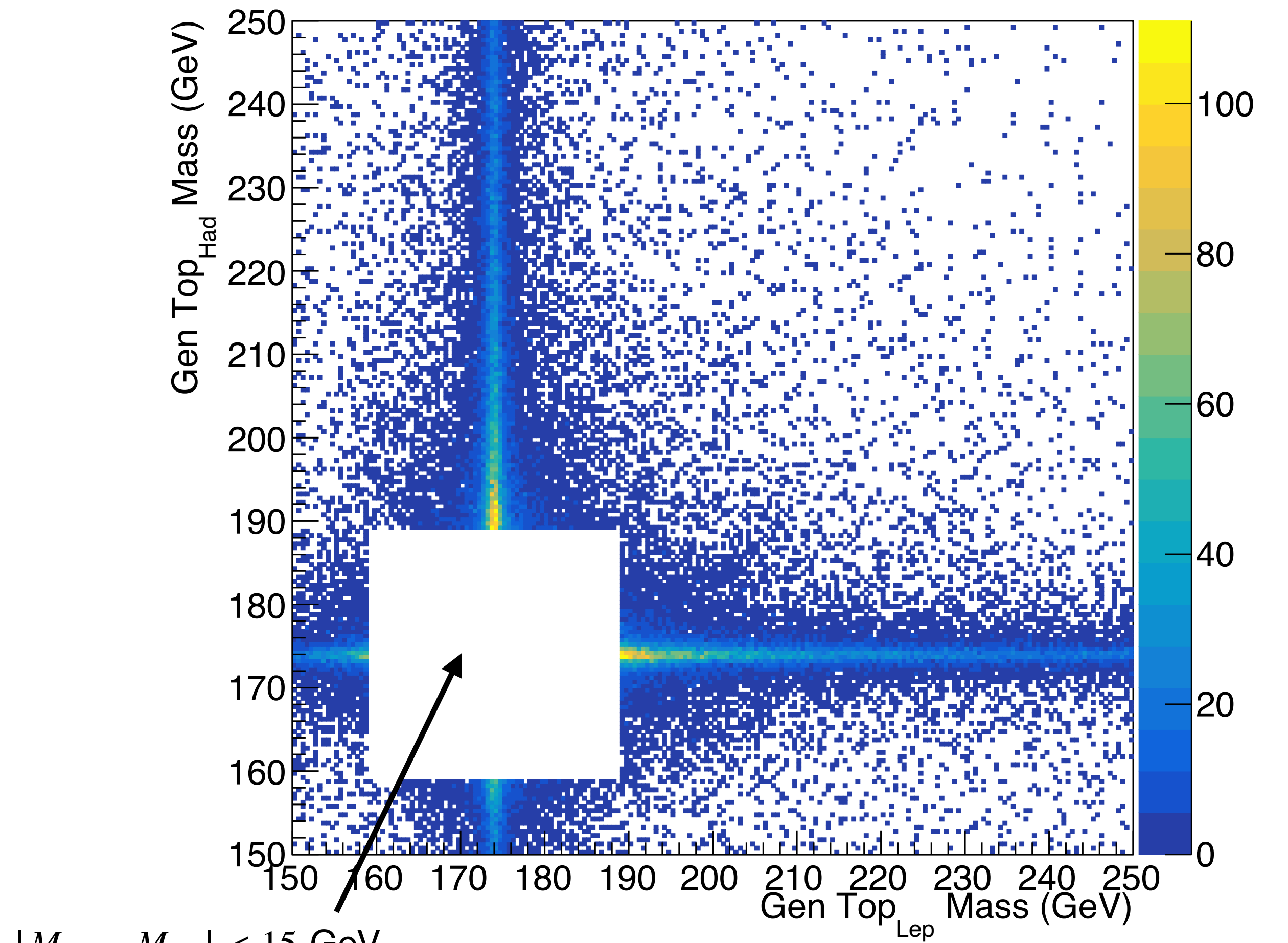


# 3. Single Top Analysis

## MC Top mass



▸ Gen Top mass for the entire events

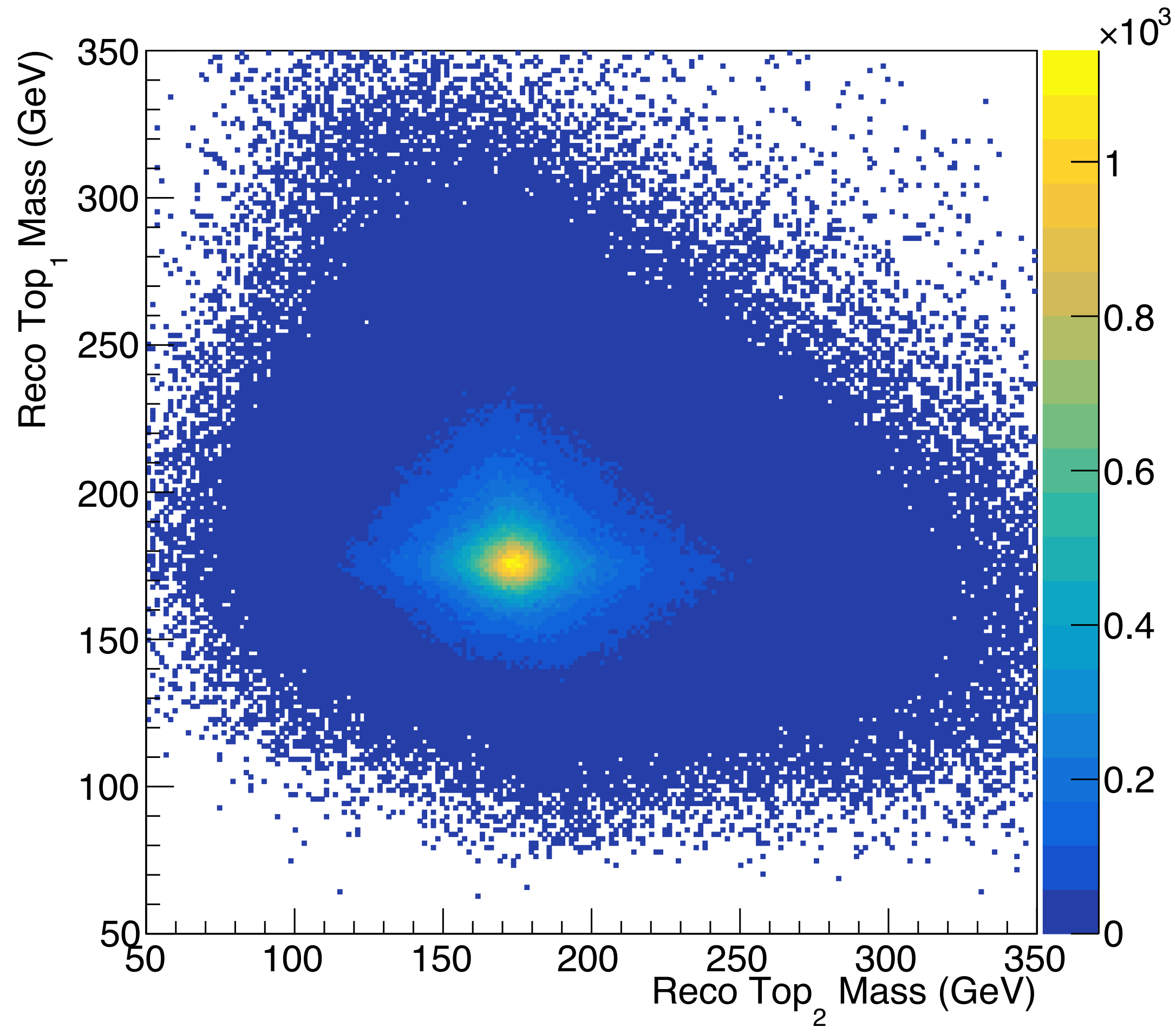


$|M_{bW} - M_{top}| < 15 \text{ GeV}$

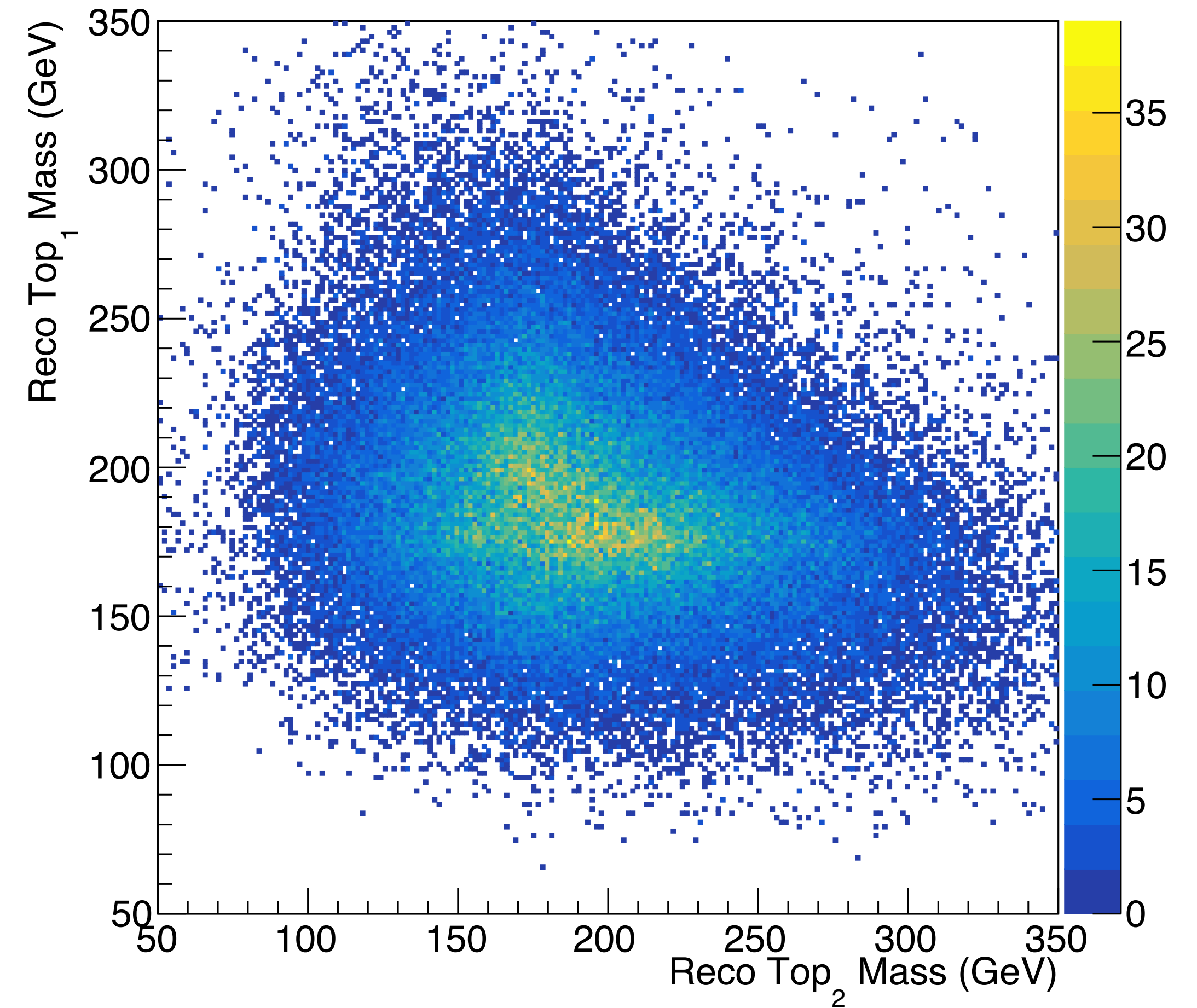
▸ Gen Top mass after single Top ID

# 3. Single Top Analysis

## Reco Top mass



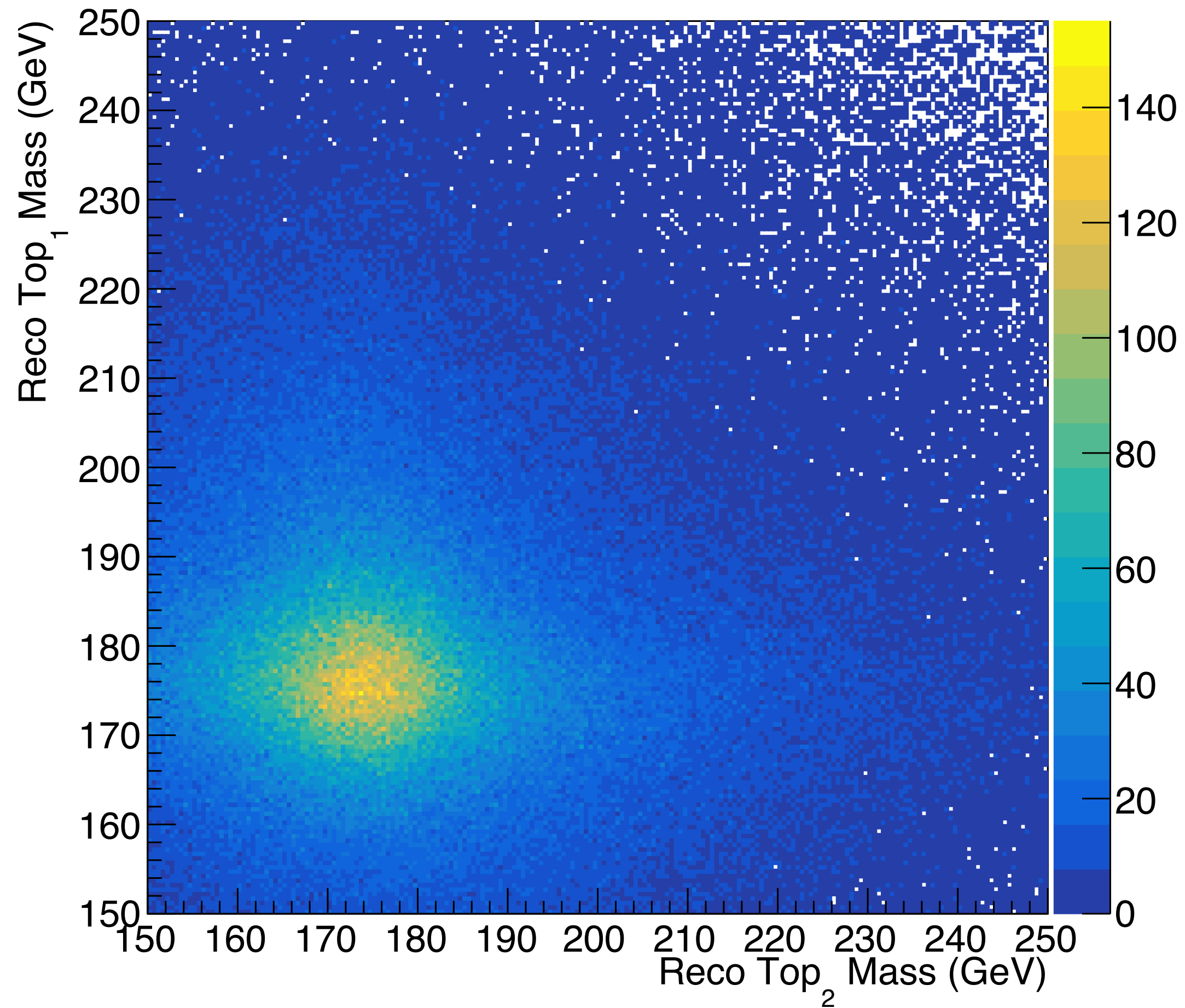
▸ Reco Top mass for the entire events (Top1=Had, Top2=Lep)



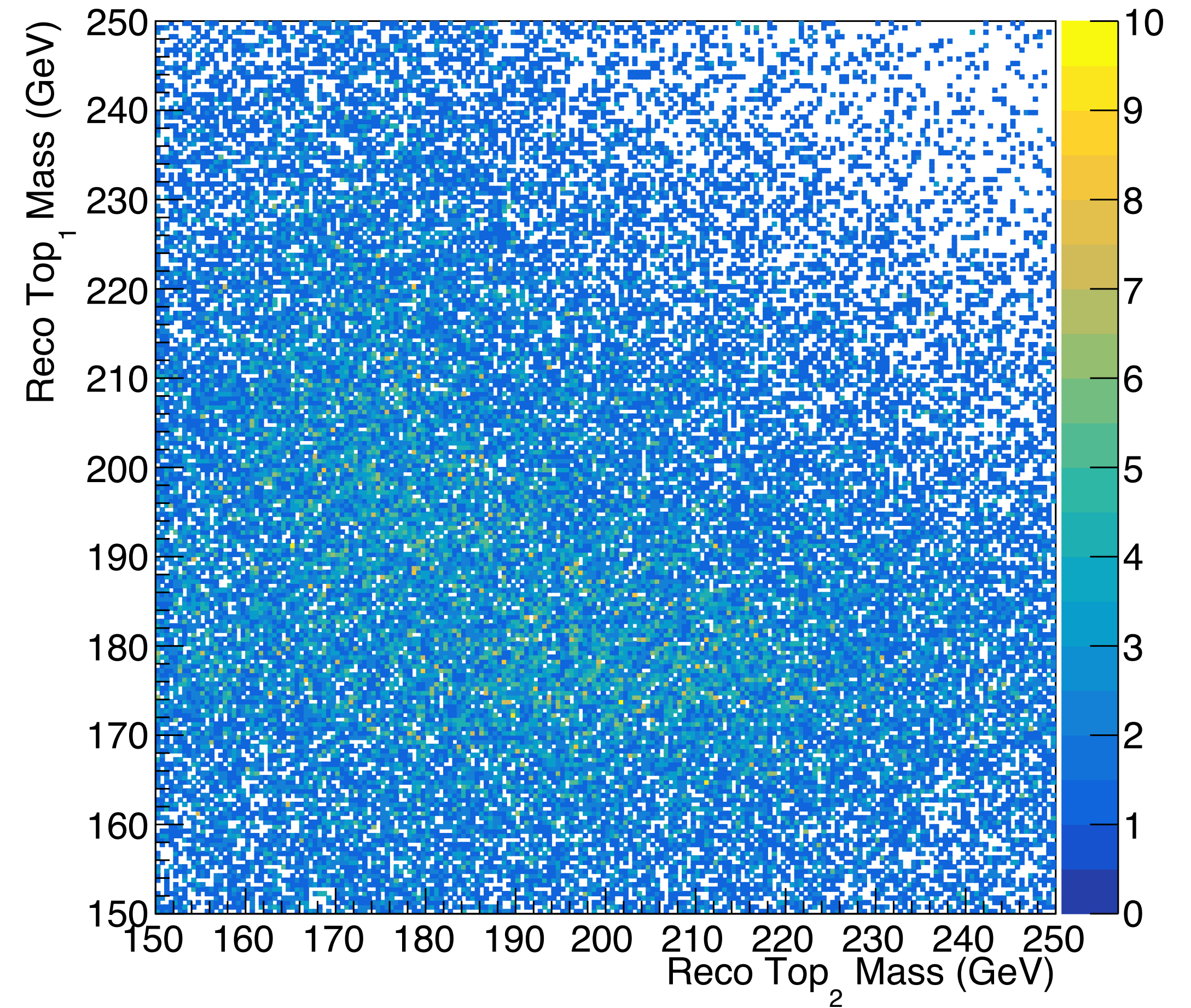
▸ Reco Top mass after single Top ID

# 3. Single Top Analysis

## Reco Top mass (zoomed)



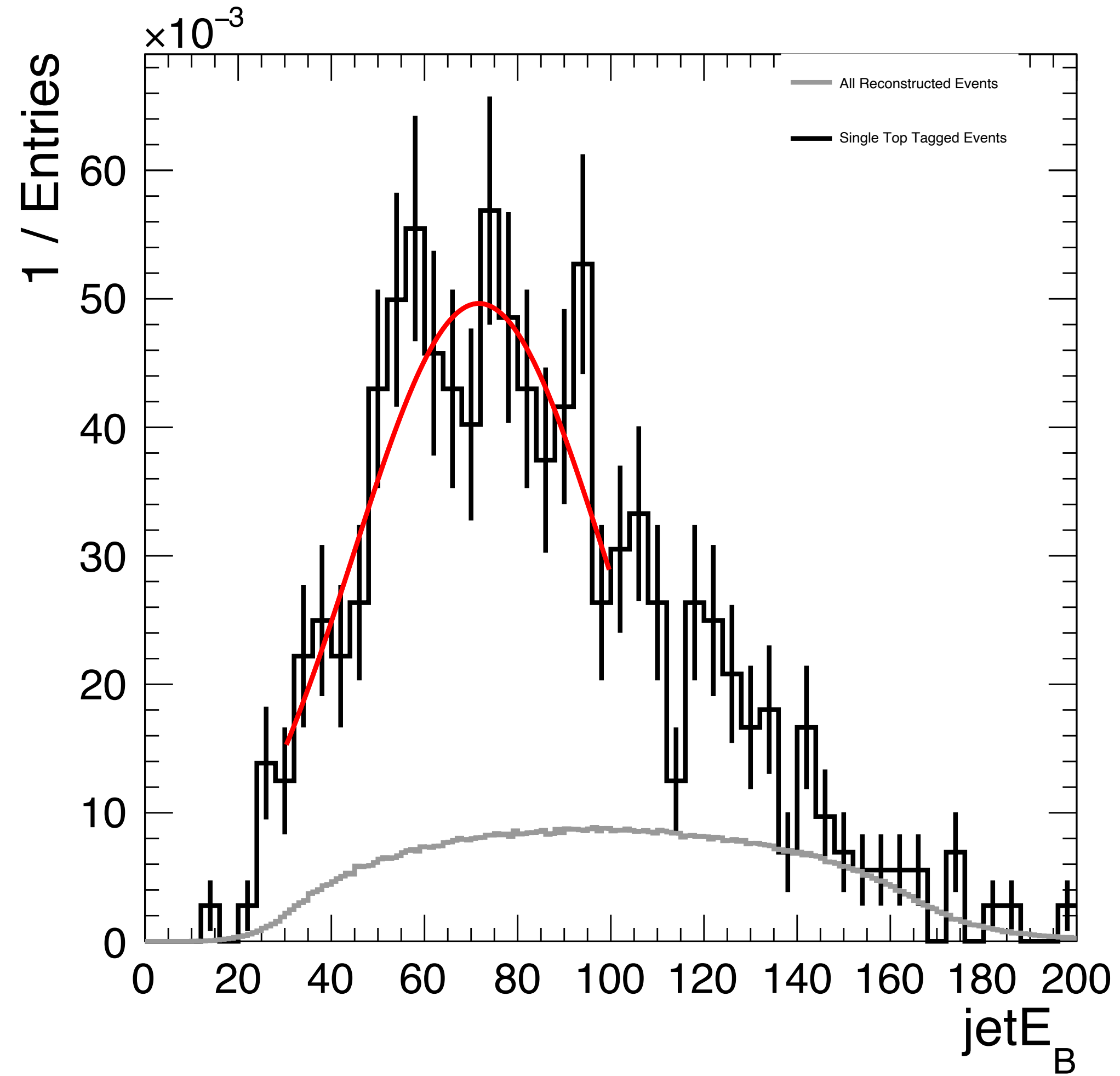
▸ Reco Top mass for the entire events (Top1=Had, Top2=Lep)



▸ Reco Top mass after single Top ID

# 4. Selection

## SingleTop & Cos0.9 & Method1



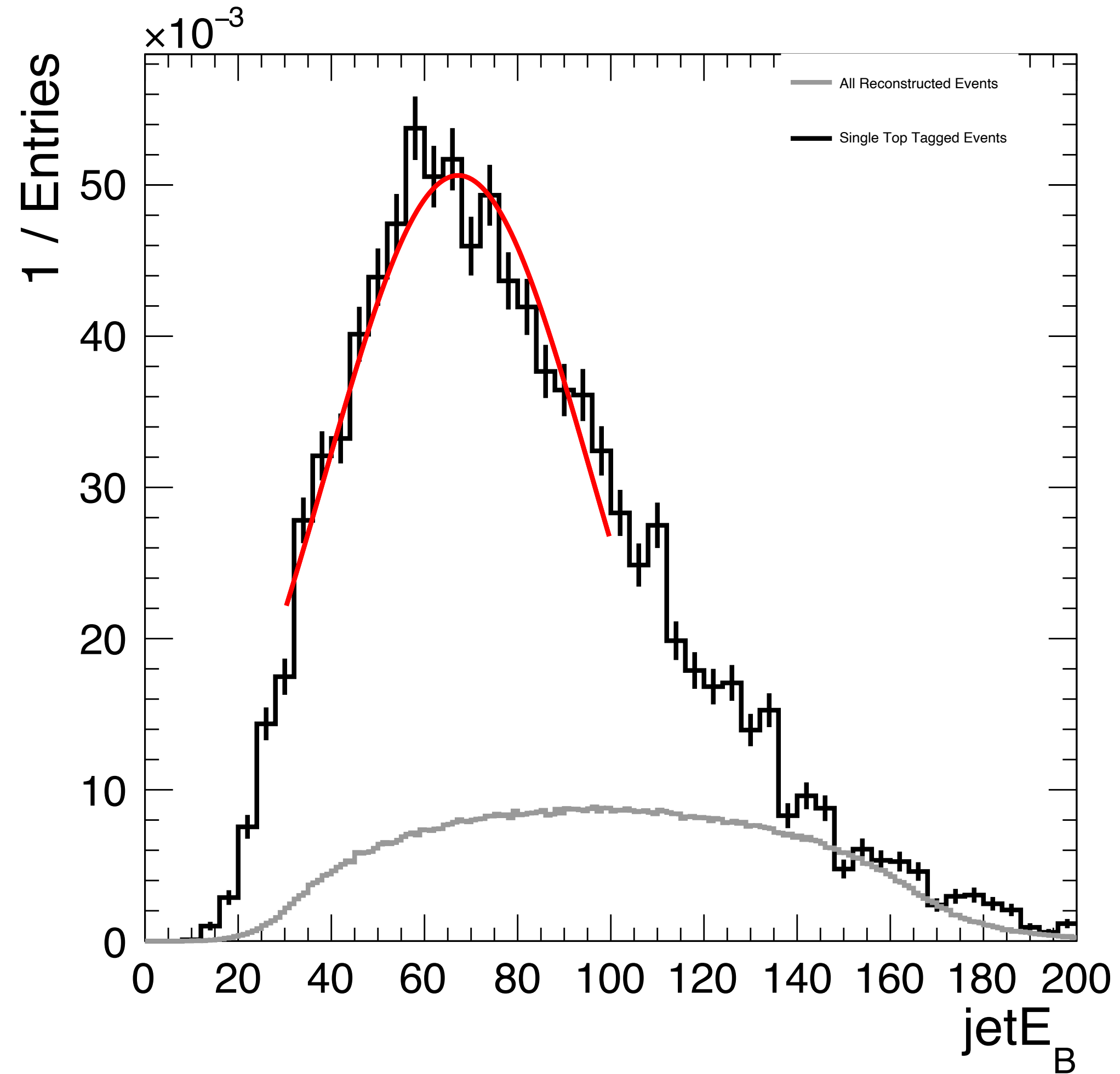
### Fit Parameters (Crystalball)

NAME	VALUE	ERROR
Constant	4.96431E-02	2.25619E-03
Mean	7.16641E+01	1.76326E+00
Sigma	2.6926E+01	1.62229E+00
Alpha	1.54754E+00	7.3487E-01
N	-1.12659E+05	4.24264E-01

Total Events: 1.51585e+06  
Selected: 721

# 4. Selection

## SingleTop & Cos0.9



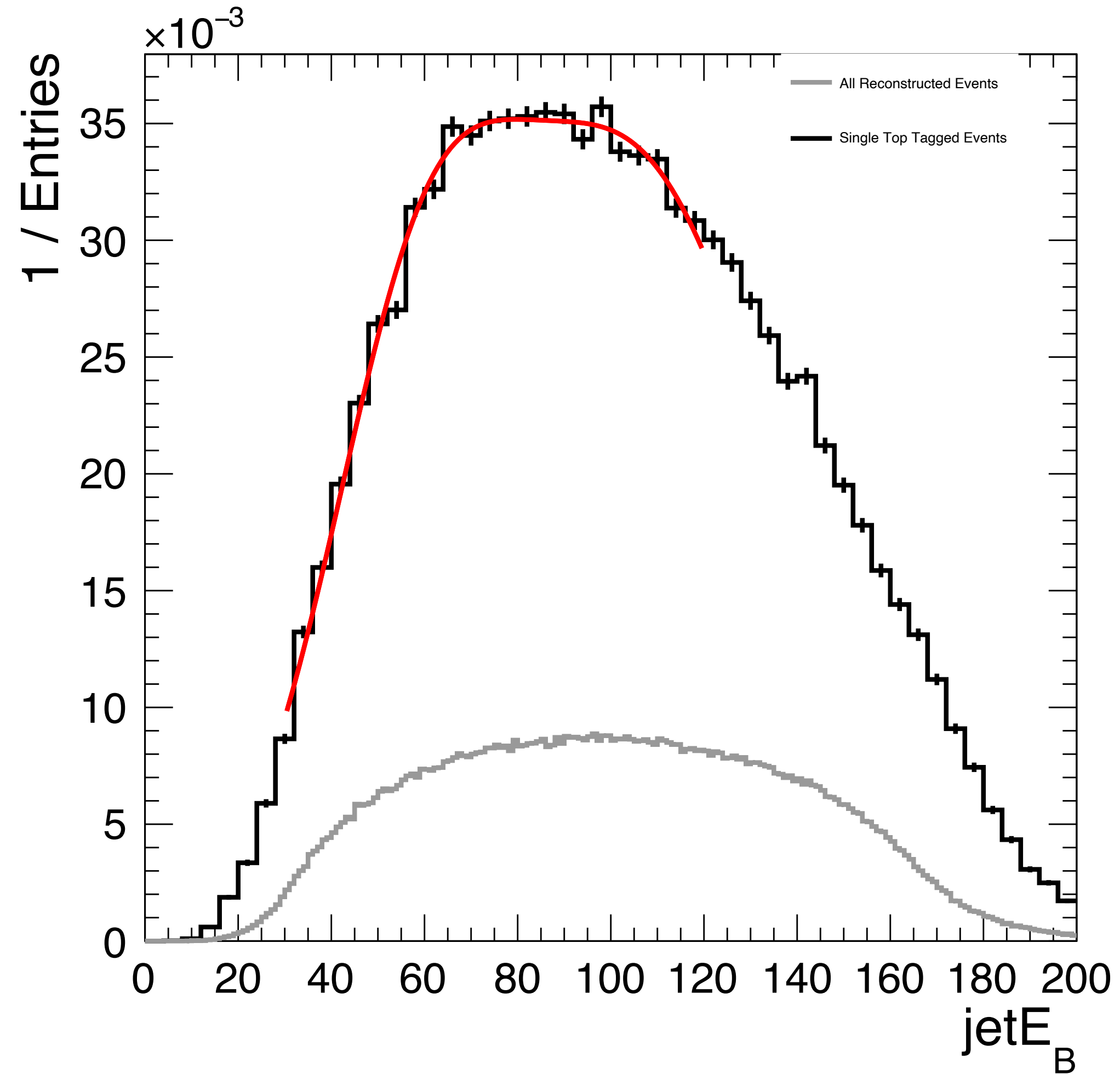
### Fit Parameters (Crystalball)

NAME	VALUE	ERROR
Constant	5.06353E-02	5.50782E-04
Mean	6.7238E+01	5.53692E-01
Sigma	2.87102E+01	5.70428E-01
Alpha	1.51941E+00	3.31116E-03
N	1.53473E+00	4.24264E-01

Total Events: 1.51585e+06  
Selected: 12185

# 4. Selection

## SingleTop



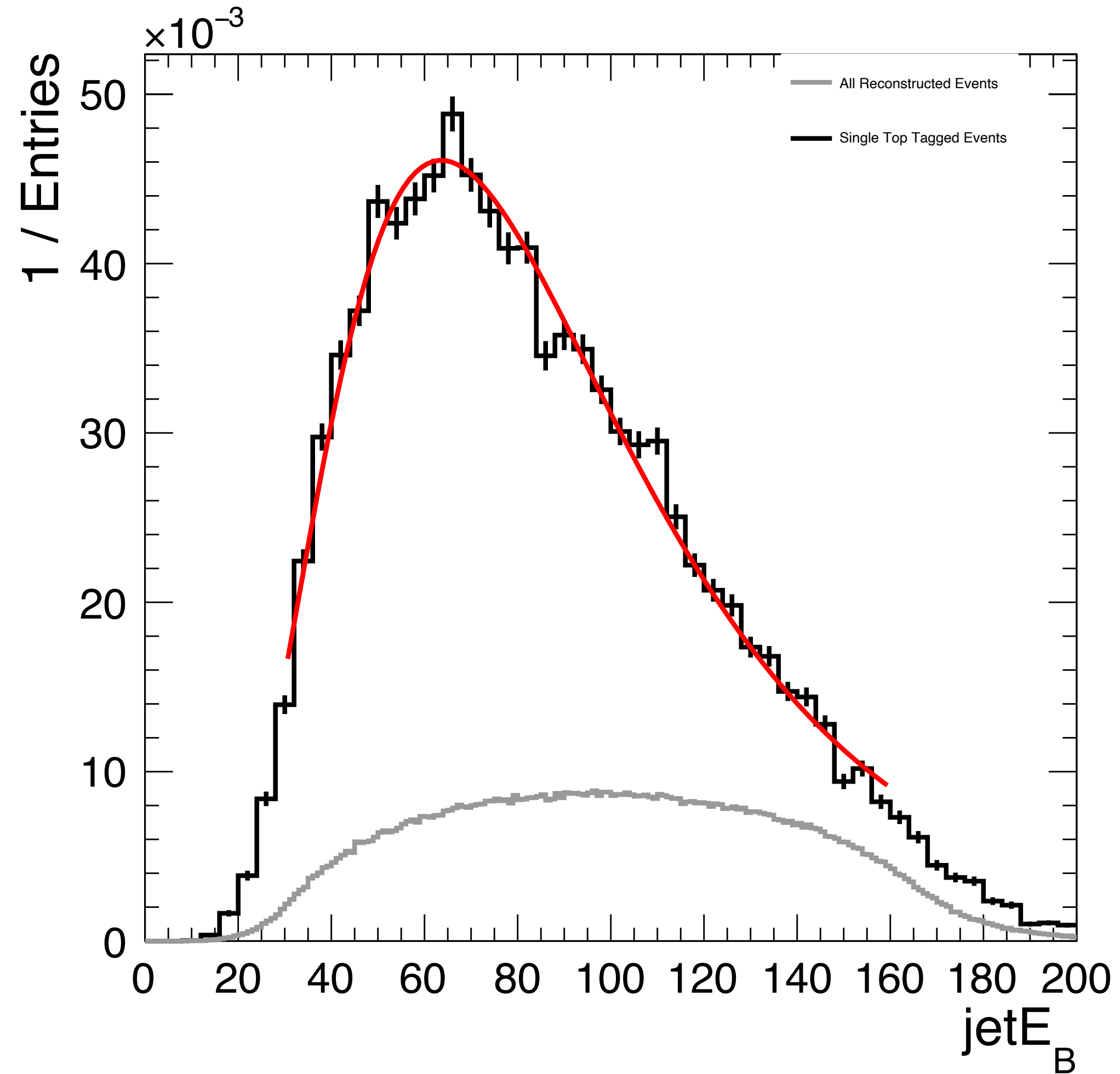
### Fit Parameters (Double Gaus)

NAME	VALUE	ERROR
Const1	3.30635E-02	6.16687E-04
Mean1	1.0408E+02	1.98225E+00
Sigma1	3.24949E+01	2.1929E+00
Const2	1.89943E-02	2.70058E-03
Mean2	5.7729E+01	8.85771E-01
Sigma2	1.97371E+01	8.33313E-01

Total Events: 1.51585e+06  
Selected: 183956

# 4. Selection

Cos0.9



## Fit Parameters (Log Normal)

NAME	VALUE	ERROR
p0	4.132E+00	6.76613E-02
p1	8.08274E+01	8.50019E-01
p2	1.65201E+00	1.15857E-02

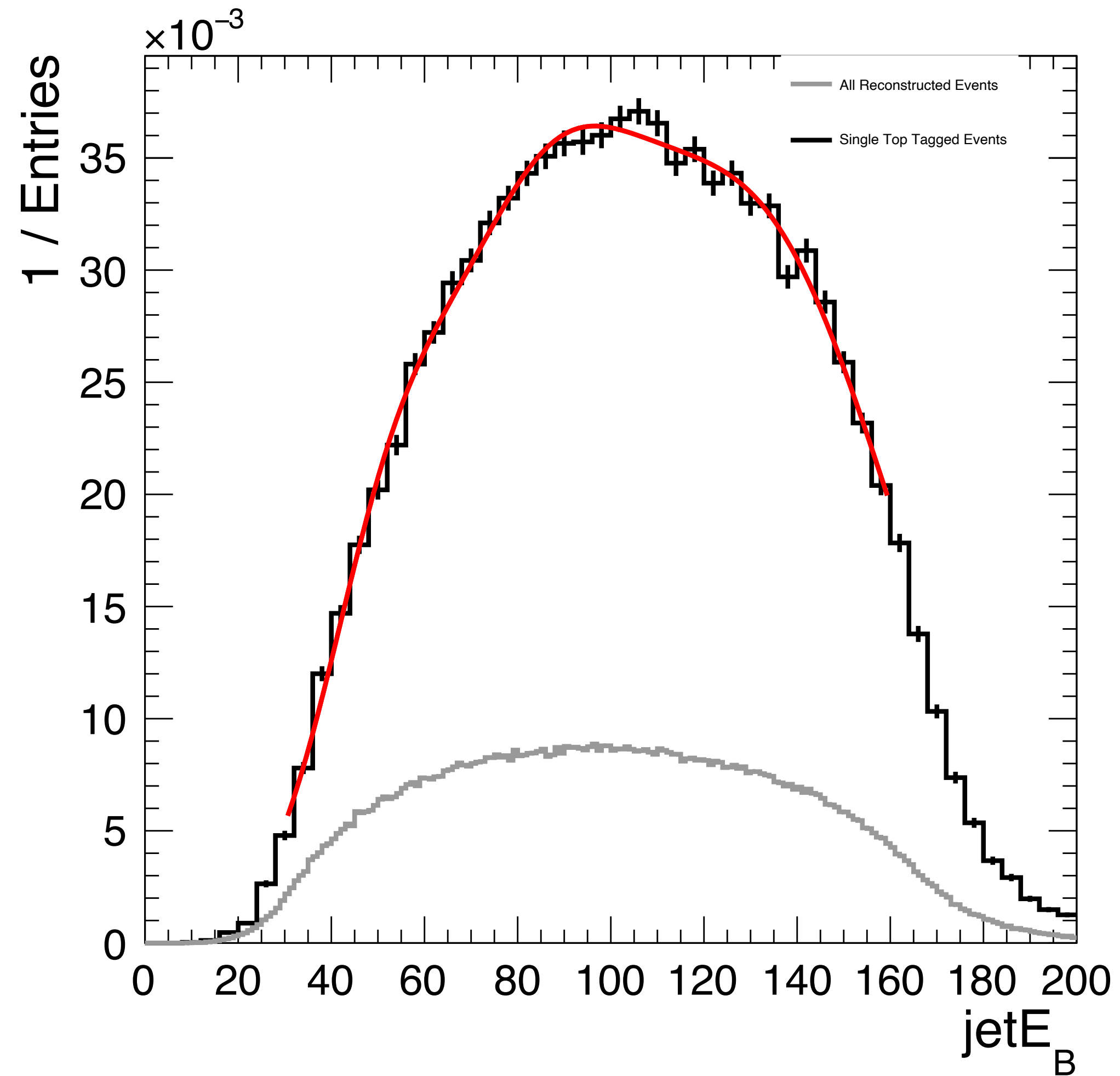
Total Events: 1.51585e+06

Selected: 45868

Max = 62.823 GeV

# 4. Selection

## Method1



## Fit Parameters (Triple Gaus)

NAME	VALUE	ERROR
Const1	1.01315E-02	2.57171E-03
Mean1	5.08603E+01	1.94586E+00
Sigma1	1.37695E+01	1.40127E+00
Const2	2.56534E-02	5.36272E-03
Mean2	8.14914E+01	5.19481E+00
Sigma2	2.27535E+01	1.87701E+00
Const3	3.08501E-02	2.37975E-03
Mean3	1.31256E+02	5.68089E+00
Sigma3	2.99661E+01	4.16266E+00

Total Events: 1.51585e+06

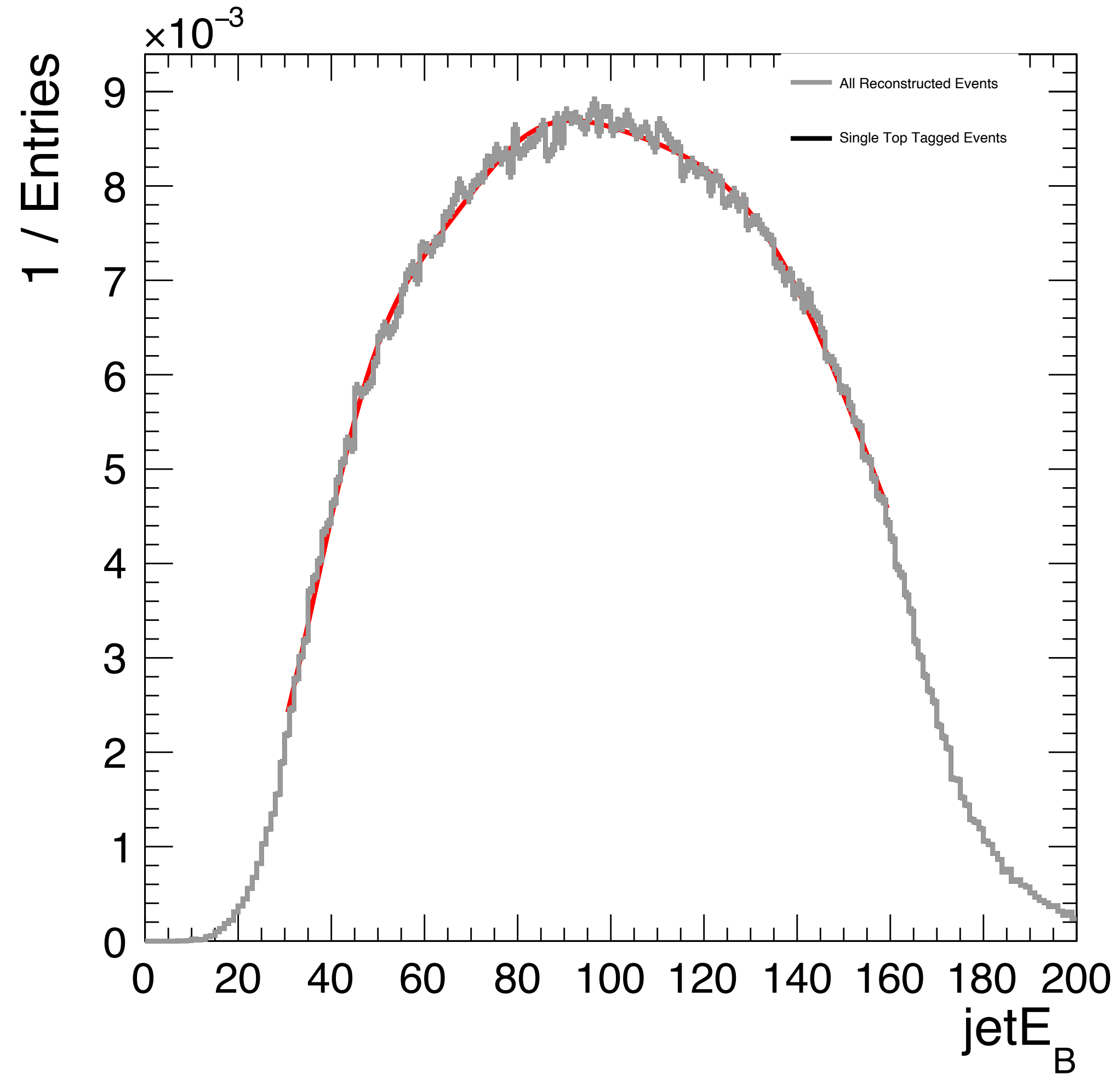
Selected: 107715

Max = 96.5769 GeV



# 4. Selection

All



Fit Parameters (Triple Gaus)

NAME	VALUE	ERROR
Const1	2.32525E-03	2.55238E-04
Mean1	4.6308E+01	4.37737E-01
Sigma1	1.31458E+01	6.46767E-01
Const2	5.20107E-03	3.89298E-04
Mean2	7.28125E+01	1.6434E+00
Sigma2	2.36618E+01	6.96797E-01
Const3	7.52981E-03	1.56847E-04
Mean3	1.24267E+02	1.85224E+00
Sigma3	3.5185E+01	1.28613E+00

Total Events: 1.51585e+06

Max = 91.6638 GeV