Search for $h^+ \to cb$ at $\sqrt{s} = 13\text{TeV}$

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Contents

Introduction : importance of $H^+ \rightarrow c\bar{b}$ channel

SM-like Higgs particle (h) was found at the LHC (2012).

SM : one Higgs doublet.

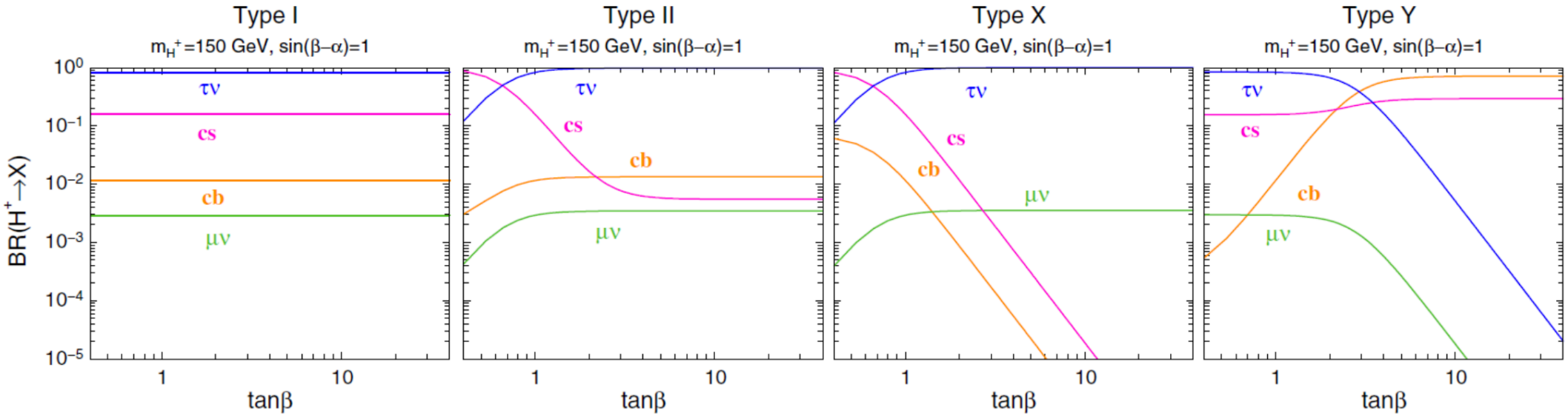
2HDM : two Higgs doublet ($h^0, H^0, A^0, h^+, and\ h^-$).

It is useful to distinguish two cases; $M_{H^\pm} < M_{top}$ or $M_{H^\pm} > M_{top}$.

In the search of light $H^\pm$, $h^+ \rightarrow c\bar{b}$ channel is being studied.

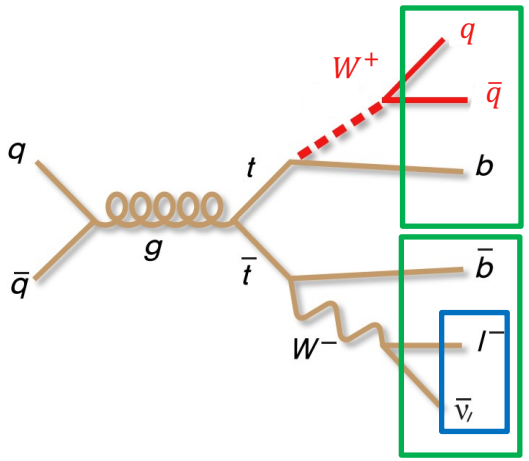
The channel is remaining major channel especially in Type Y model.

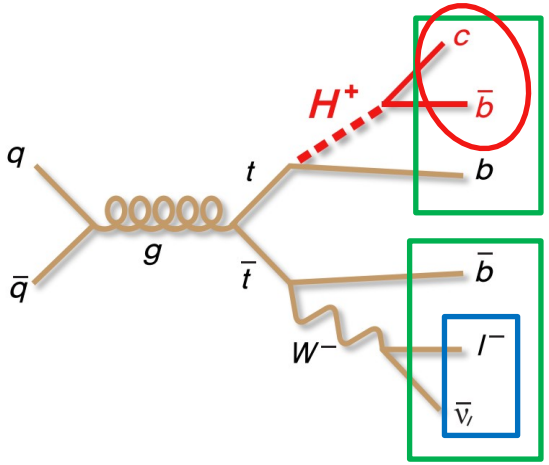
Phys. Rev. D 80, 015017



Introduction : $H^+ \rightarrow c\bar{b}$ search strategy

We investigate 2b tag and 3b tag region in $t\bar{t}$ channel.





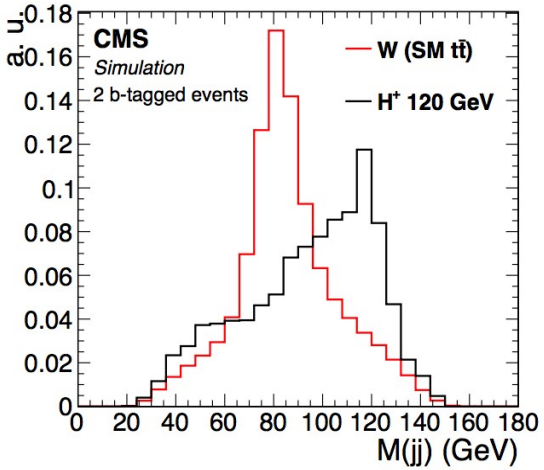
m_{top} = 172.5 GeV constraint

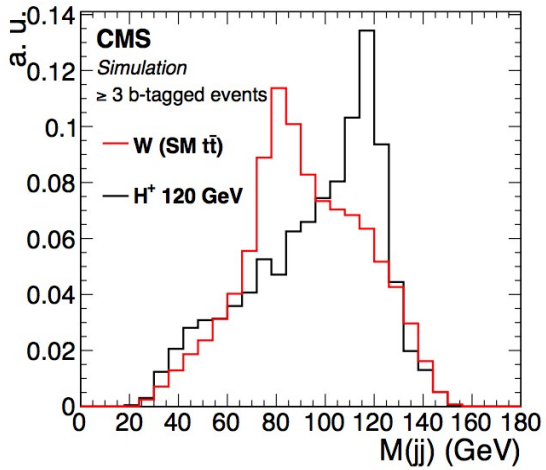
$m_{W^+(H^+)}$: no constraint

m_W = 80.398 GeV constraint

There are three mass constraint: hadronic top mass, leptonic top mass, leptonic W mass.
Only one that moves freely without constraint is a boson mass from top side.

A boson from top side can be a SM W^+ or a charged Higgs boson.

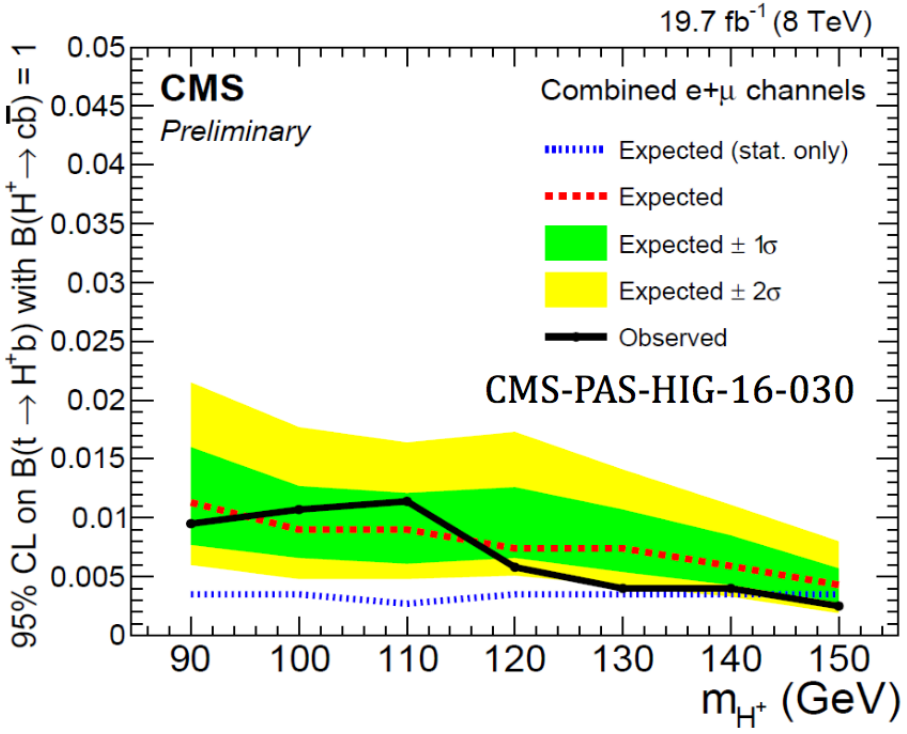




Dijet mass distribution for W from SM $t\bar{t}$ and H^+ from signal $t\bar{t}$.

To improve mass distribution, the parton level correction is necessary.
⇒ TS(top specific) correction

Introduction : 8 TeV results and advantage of $\sqrt{s} = 13$ TeV data



Search for $h^+ \to c\bar{b}$ at $\sqrt{s} = 8$ TeV by SNU group.

Publication is being prepared. (CMS-PAS-HIG-16-030)

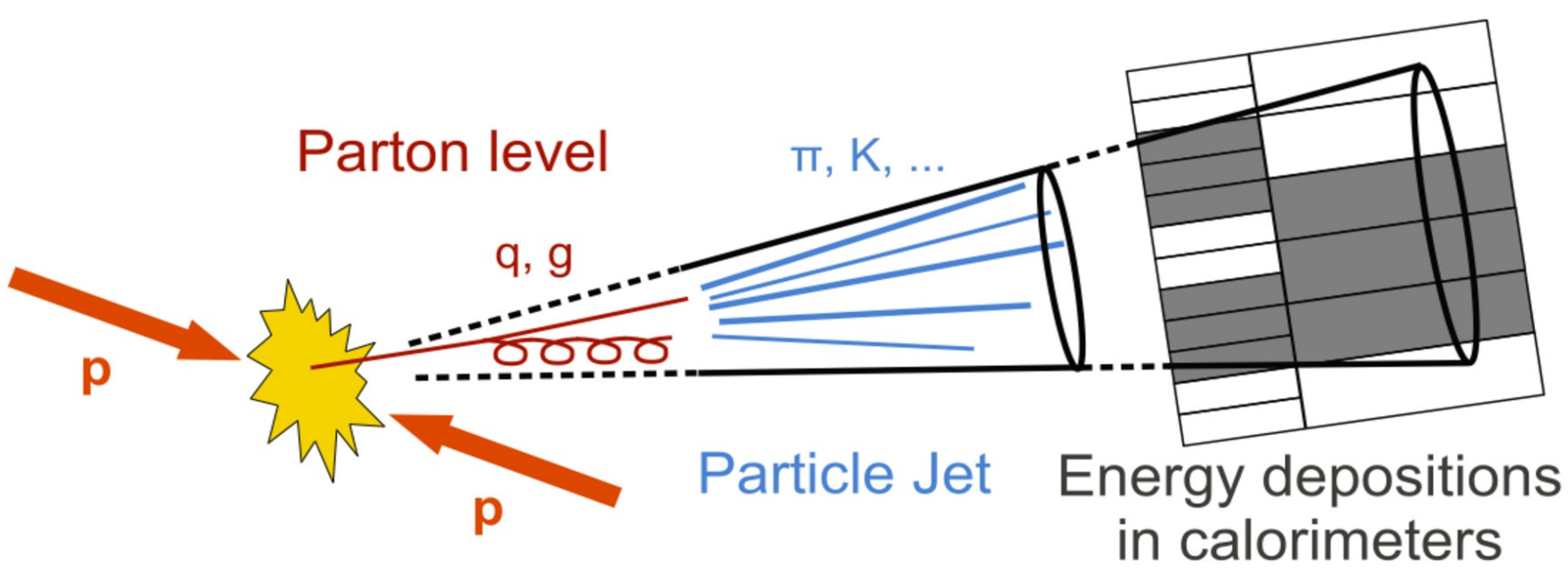
SNU group is analyzing 13 TeV data to search $h^+ \to c\bar{b}$.

2 times more data available in 13TeV

$t\bar{t}$ cross-section increases 3 times due to increased $\sqrt{s}$.

$\Rightarrow$ statistically 2.5 times precise result with 13 TeV data

TS(top specific) Correction



To reconstruct a particle mass from jets, the parton level correction is applied.

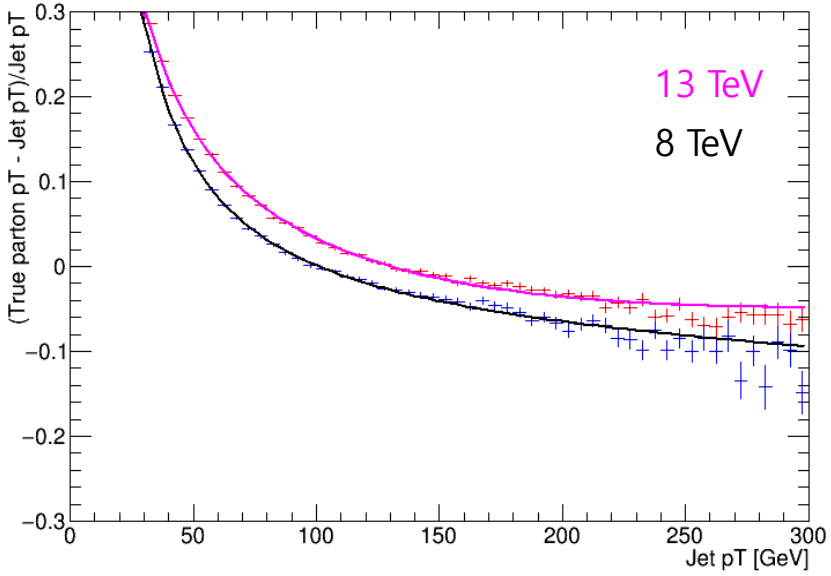
The $(True\ parton\ p_T - Jet\ p_T)/Jet\ p_T$ response and its sigma are parameterized as a function of p_T and η.

(Note: $True\ parton\ p_T$ means parton level p_T, $Jet\ p_T$ means particle level p_T)

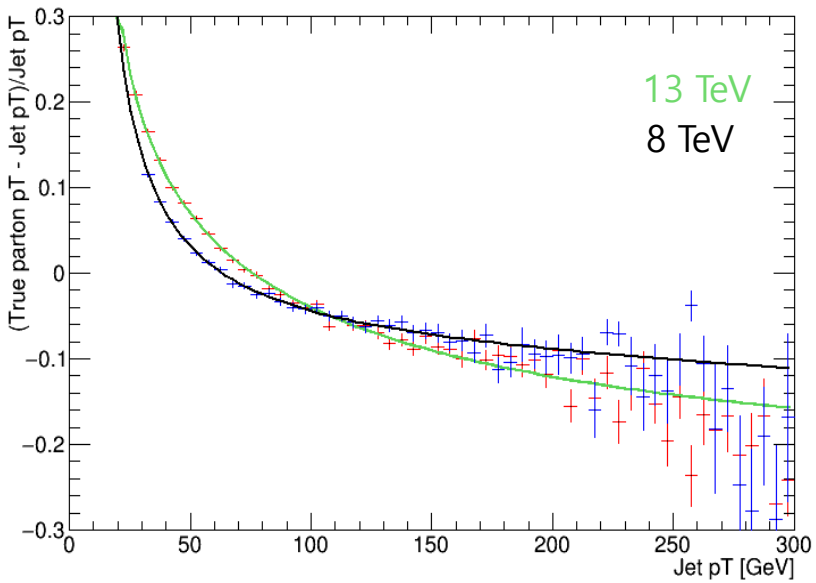
After the $Jet\ p_T$ correction, a mass reconstructed from jets get closer to its true value.

p_T Response Function at 8TeV and 13TeV

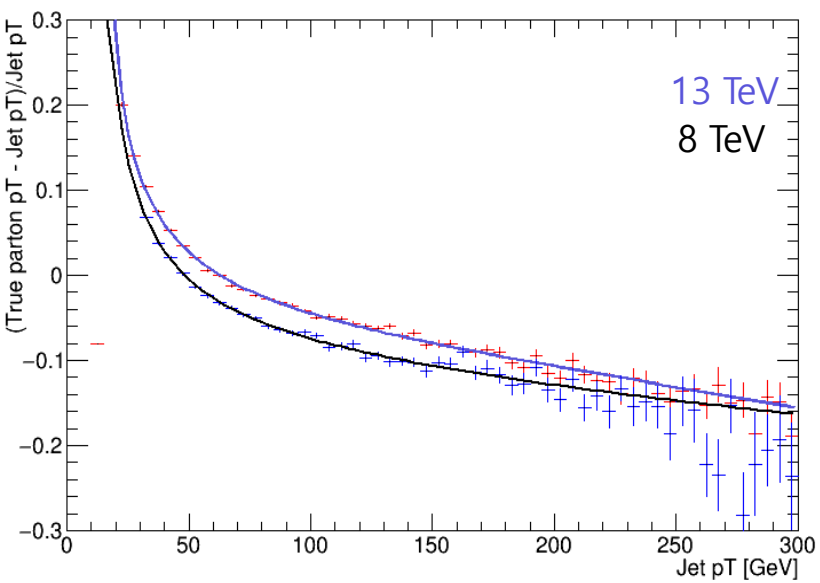
η<0.176, no cut, $(True\ parton\ p_T - Jet\ p_T)/Jet\ p_T$ response plot



b jets



c jets

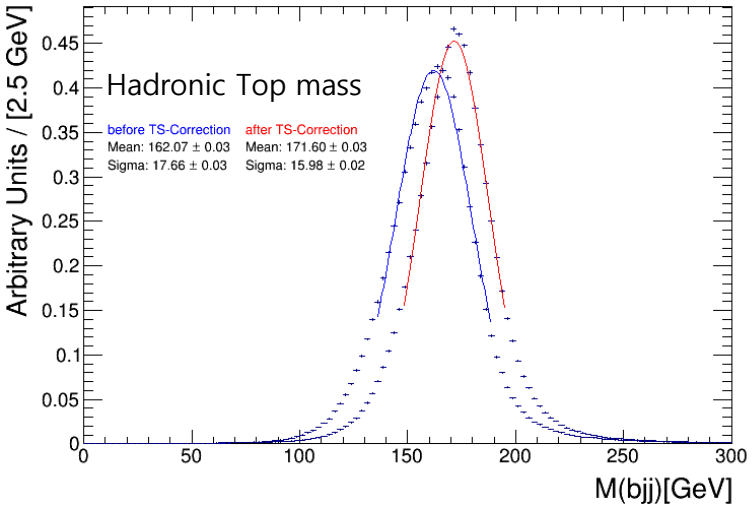


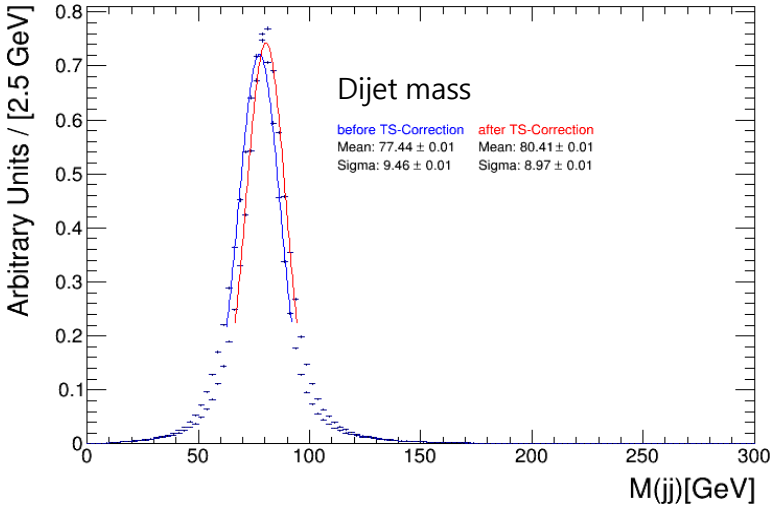
light jets

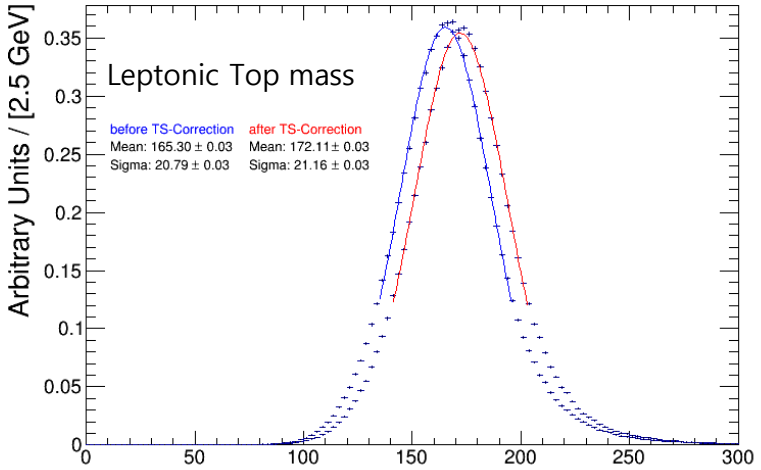
Fit function $f(p_T) = a + b\times\sqrt{p_T} + c/p_T + d\times p_T$

Mass before/after the TS correction

Correction Set #3

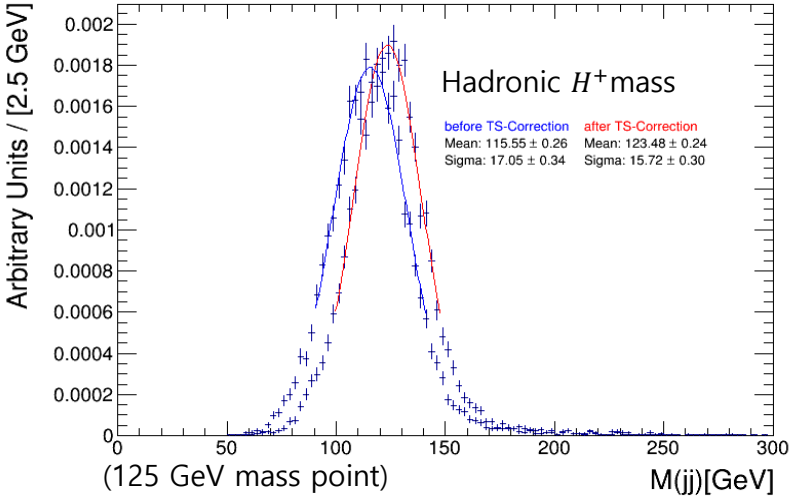






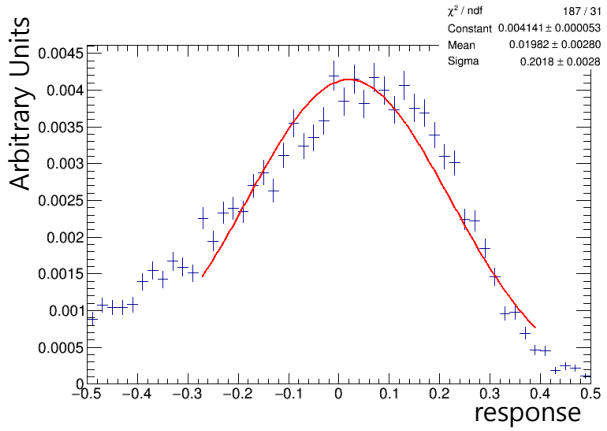
After the correction, all reconstructed masses get closer to the true value.

Its resolution improved by 5~9% except leptonic top mass.

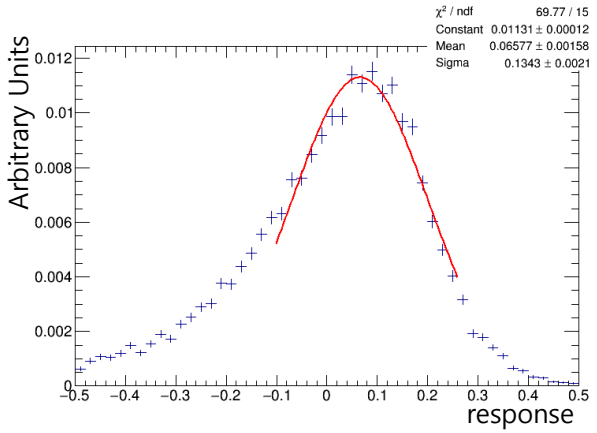


Sigma of TS(top specific) Correction

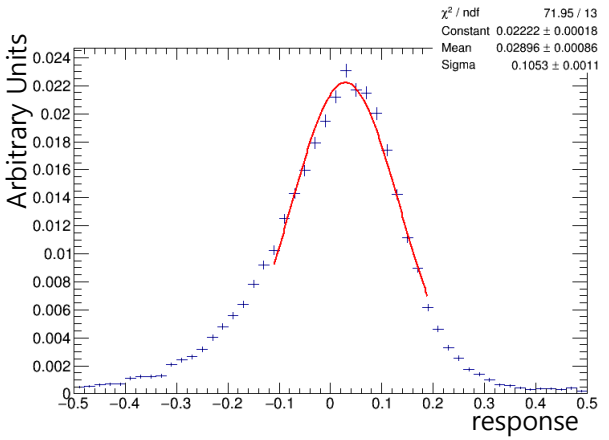
b jet, η < 0.174, No-cut Correction



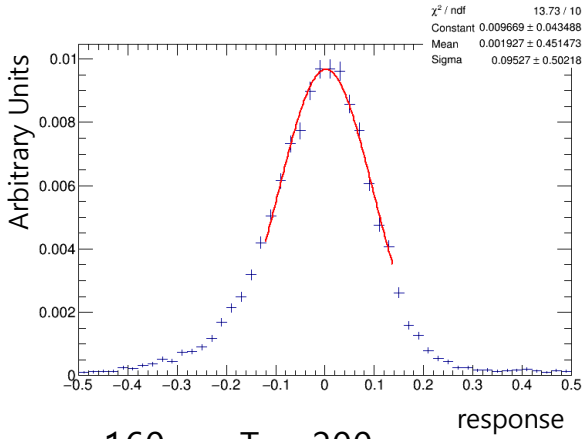
20 < pT < 25



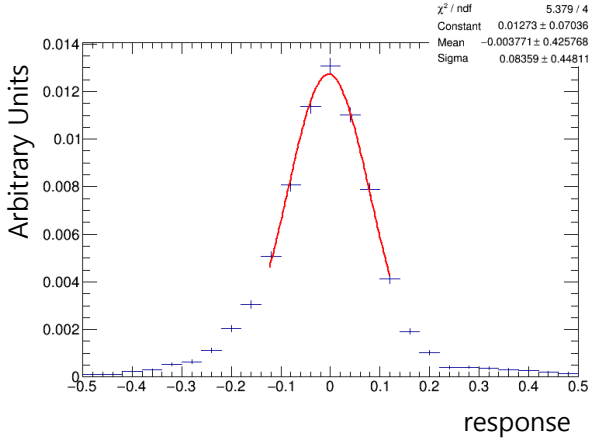
50 < pT < 55



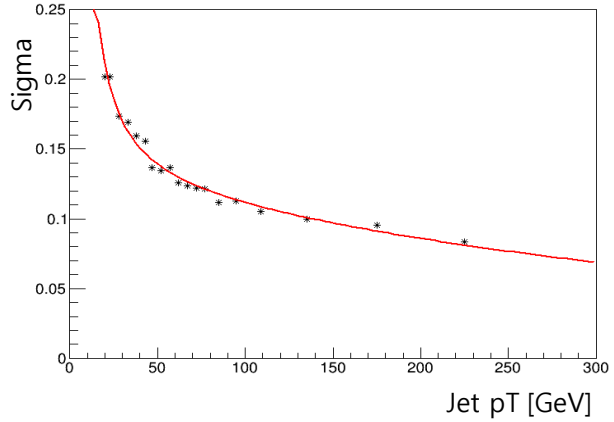
100 < pT < 120



160 < pT < 200



200 < pT < 300



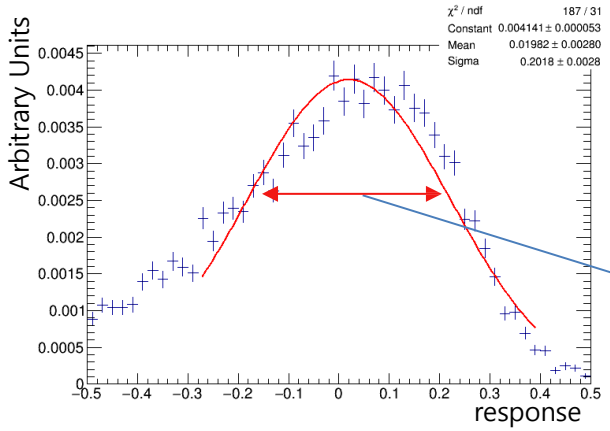
with fitting function

$(Response) = (True\ parton\ P_T - Jet\ P_T)/Jet\ P_T$

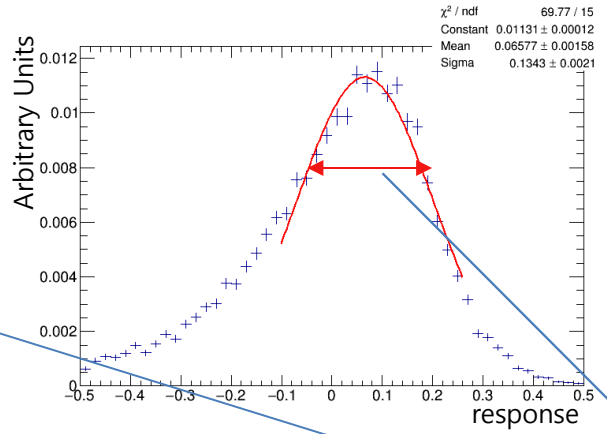
$\exp(a + b \times p_T + c/p_T)$

Sigma of TS(top specific) Correction

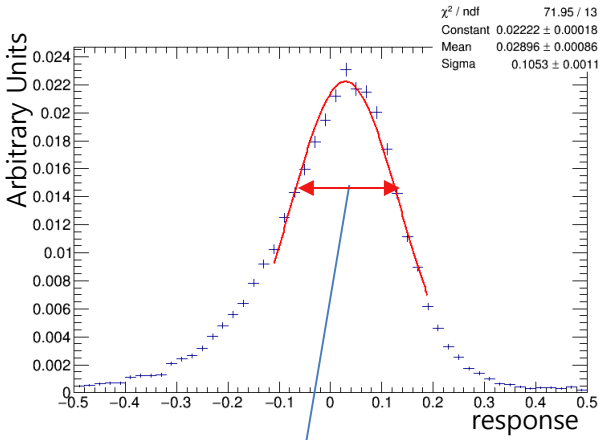
b jet, η < 0.174, No-cut Correction



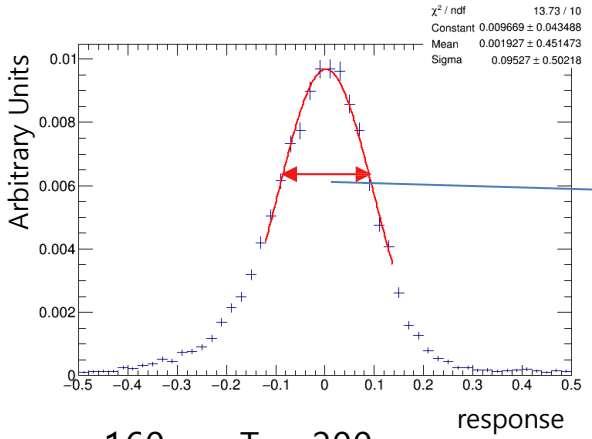
20 < pT < 25



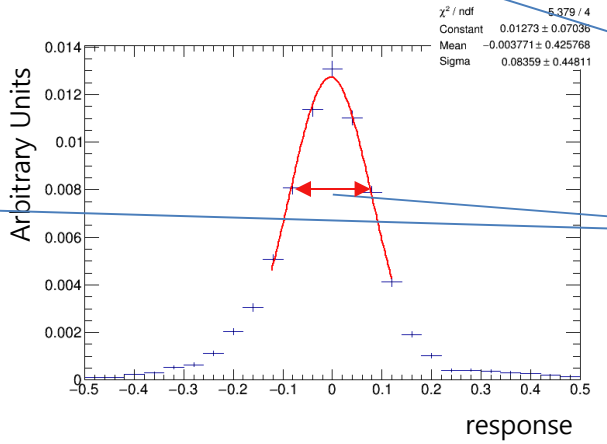
50 < pT < 55



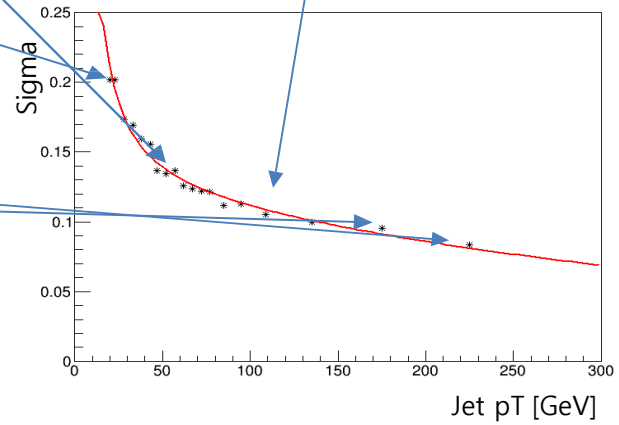
100 < pT < 120



160 < pT < 200



200 < pT < 300

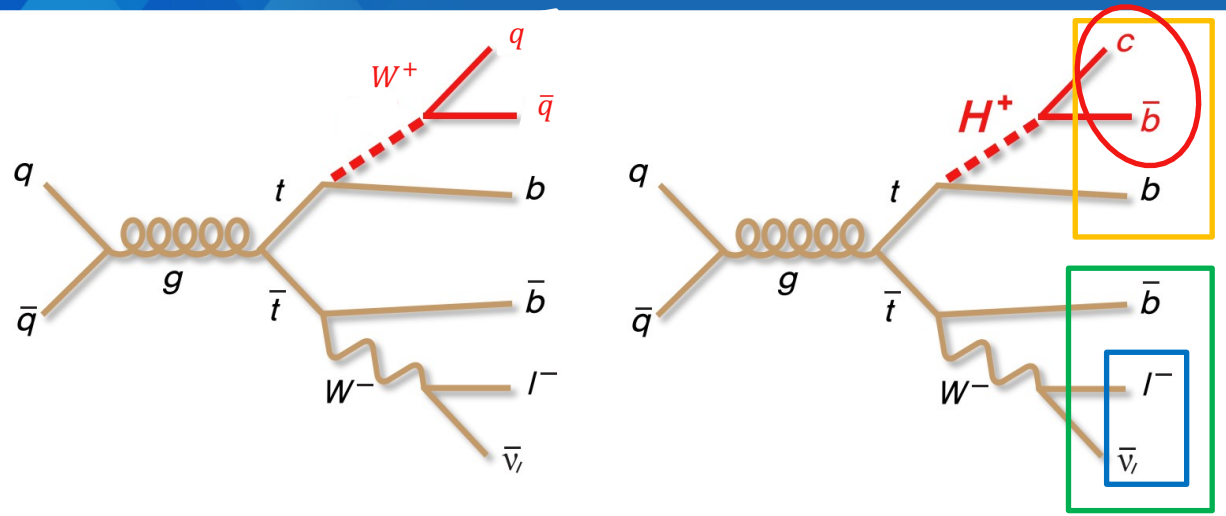


with fitting function

$(Response) = (True\ parton\ P_T - Jet\ P_T)/Jet\ P_T$

$\exp(a + b \times p_T + c/p_T)$

Kinematic Fitter



TS Corrected p_T

$$\chi^2 = \sum_{i=l,4jets} \frac{\left(p_T^{i,fit} - p_T^{i,measured}\right)^2}{\sigma_i^2} + \sum_{j=x,y} \frac{\left(p_j^{UE,fit} - p_j^{UE,measured}\right)^2}{\sigma_{UE}^2} + \frac{(M_{l\nu} - M_W)^2}{\Gamma_W^2} + \frac{(M_{bl\nu} - M_t)^2}{\Gamma_t^2} + \frac{\left(M_{bjj} - M_t\right)^2}{\Gamma_t^2}$$

Sigma of TS Correction

Kinematic fitter has three mass constraint: hadronic top mass, leptonic top mass, leptonic W mass.

A boson mass from top side is a sole free parameter.

Kinematic fitter finds minimum χ^2 on each permutation of four jets and neutrino p_z^ν solution.

Then, the combination with lowest χ^2 is selected to make the dijet mass template.

Summary

To improve dijet mass distribution, the parton level correction is necessary.

TS correction parton-jet matching study was performed and we tested 3 best selections.

Sigma of TS correction is parameterized as a function of p_T and η.
This sigma is used in the kinematic fitter.

$H^+ \rightarrow c\bar{b}$ search in 13TeV is under progress.

THANK YOU

BACK UP

Introduction : general information of 2HDM

Motivation of 2HDM

Supersymmetric theories need 2HDM,
Single Higgs doublet can't give mass simultaneously to u-type and d-type quark because different chirality multiplet can't couple together.

Axion model needs 2HDM.
Global U(1) symmetry imposed in Axion model is only possible if there are two Higgs doublets.

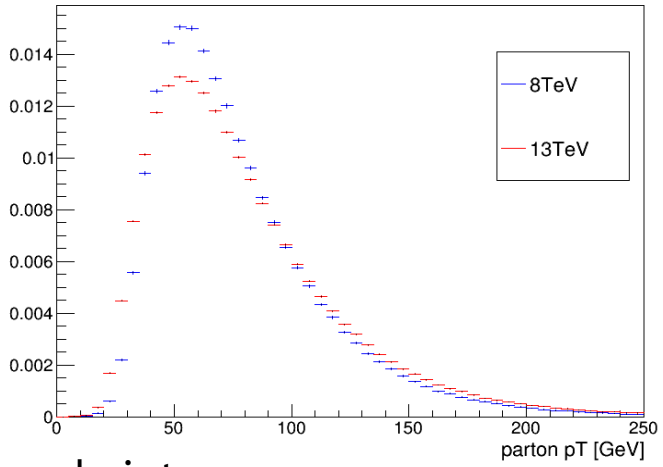
Clue to the baryon asymmetry
The flexibility of Higgs mass spectrum in 2HDM can be additional source of CP violation

Ref) Physics Reports 516 (2012) 1–102

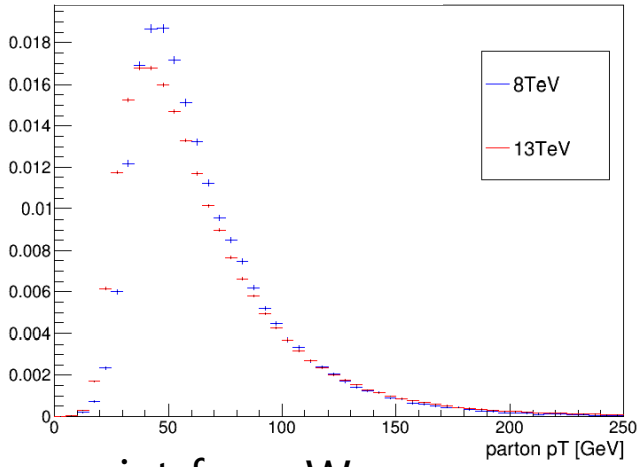
Jet Transverse Momentum ($t\bar{t}$ events)

8TeV : Medgraph, 13TeV: Powheg

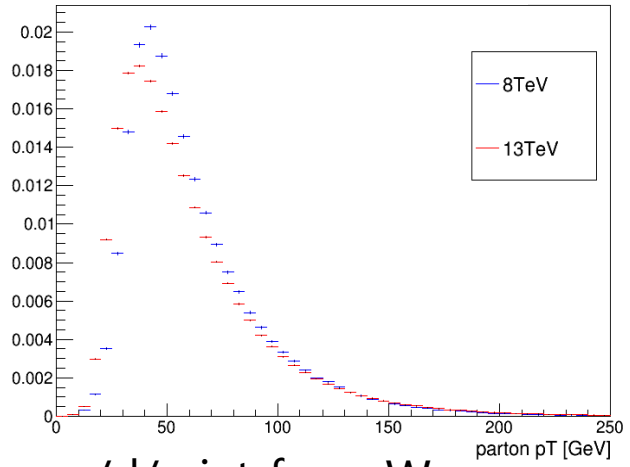
b quark



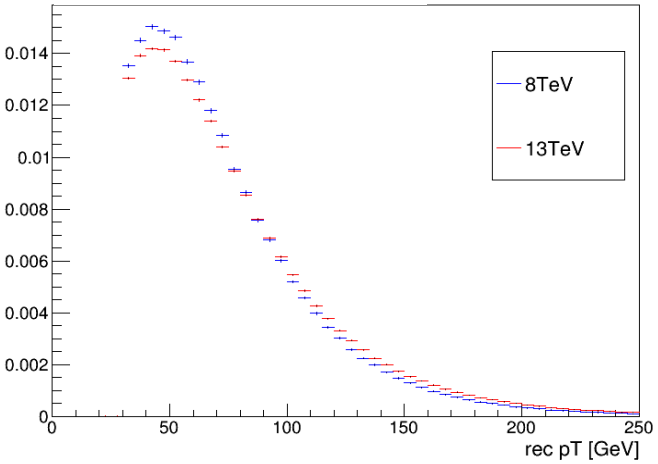
c quark from W



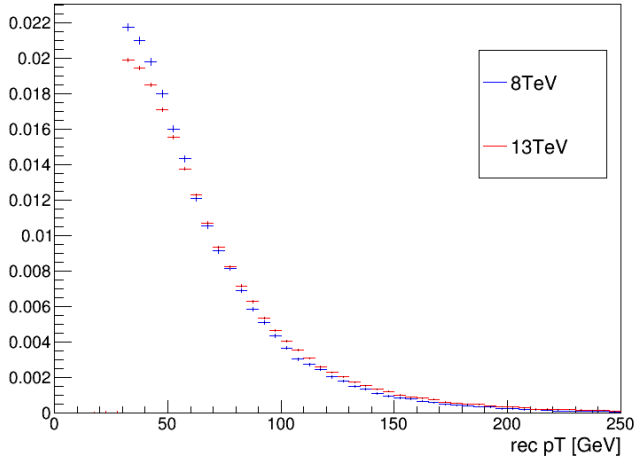
u/d/s quark from W



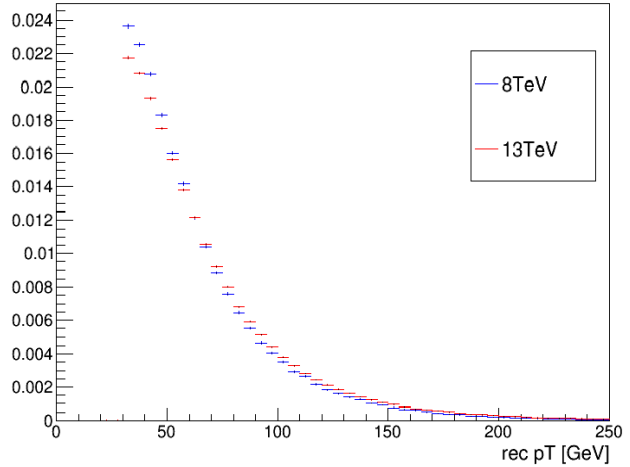
b-jet



c-jet from W



u/d/s-jet from W



Jet-parton Matching Study at 13TeV

3 Best Cut

1.

No-cut Correction

2.

$|parton\ p_T - Jet\ p_T| < 40 + 0.05 \times Jet\ p_T$ b jet
$|parton\ p_T - Jet\ p_T| < 25 + 0.20 \times Jet\ p_T$ c jet
$|parton\ p_T - Jet\ p_T| < 20 + 0.30 \times Jet\ p_T$ light jet

3.

$|parton\ p_T - Jet\ p_T| < 30 + 0.10 \times Jet\ p_T$ b jet
$|parton\ p_T - Jet\ p_T| < 25 + 0.20 \times Jet\ p_T$ c jet
$|parton\ p_T - Jet\ p_T| < 20 + 0.30 \times Jet\ p_T$ light jet

	Leptonic top mass		Hadronic top mass		Hadronic W mass		W mass from light jets		W mass from 1 c jet & 1 light jet	
	Mean	Resloution	Mean	Resloution	Mean	Resloution	Mean	Resloution	Mean	Resloution
No-cut Correction	165.3	20.79	162.1	17.66	77.44	9.46	78.29	9.00	76.67	9.61
1 cut	172.9	21.31	172.18	16.15	80.40	9.03	80.16	9.09	80.45	9.40
2 cut	172.6	21.21	171.93	16.03	80.40	8.97	80.32	8.86	80.37	9.37
3 cut	172.1	21.16	171.59	15.98	80.40	8.97	80.32	8.86	80.37	9.37

Event Selection / Parton Jet Matching condition

	pT	eta	
Muon	POG_TIGHT	POG_TIGHT	
Electron	POG_TIGHT	POG_TIGHT	
Jets	< 20	< 2.5	

4 jet matched efficiency : ~ 3%

Sigma of Top Specific Correction

variable pT bin size for b jets

20 ~ 80 : 5GeV
80 ~ 100 : 10GeV
100 ~ 120 : 20GeV
120 ~ 200 : 40GeV
200 ~ 300 : 100GeV

variable pT bin size for c & light jets

20 ~ 60 : 5GeV
60 ~ 80 : 10GeV
80 ~ 120 : 20GeV
120 ~ 200 : 40GeV
200 ~ 300 : 100GeV

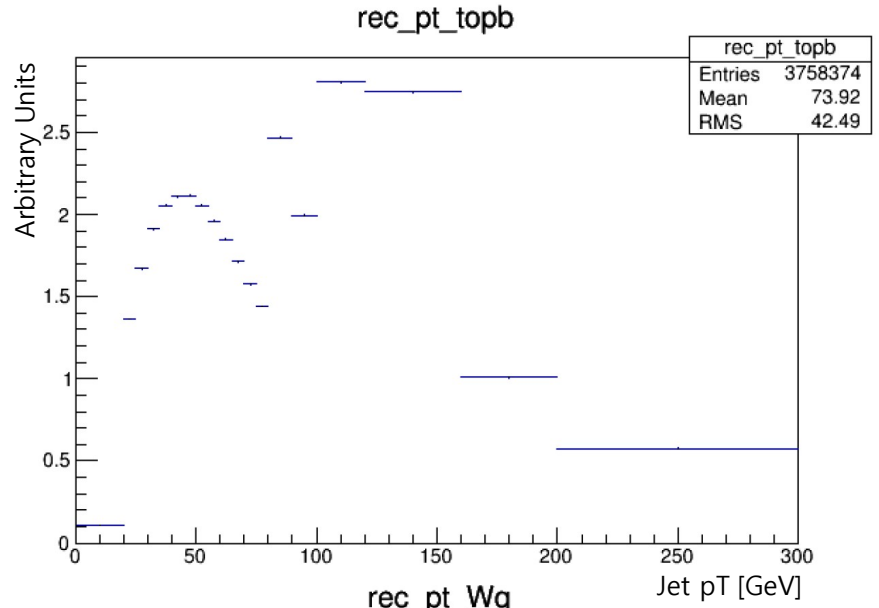
9 eta bin × 18 pT bin for b jets = 162 histograms

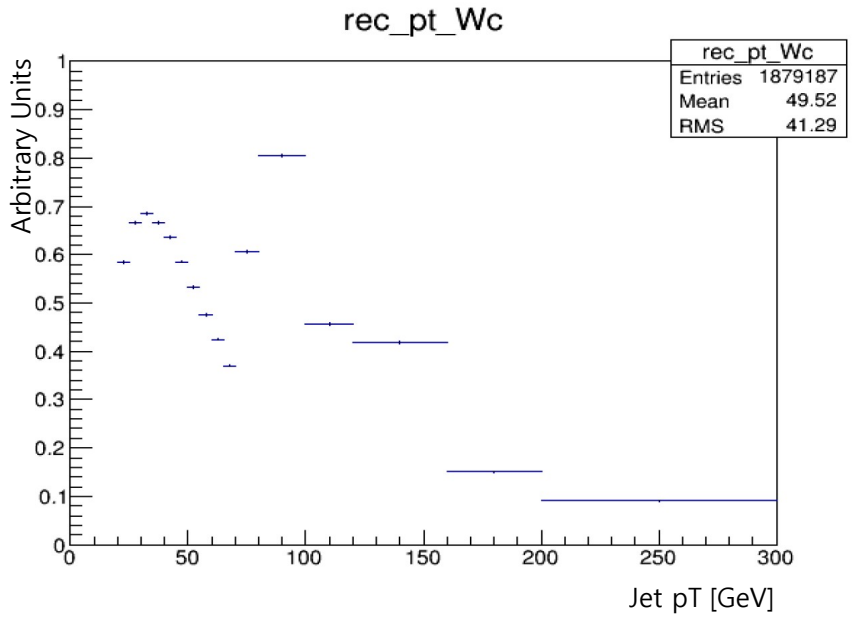
9 eta bin × 16 pT bin for c & light jets = 288 histograms

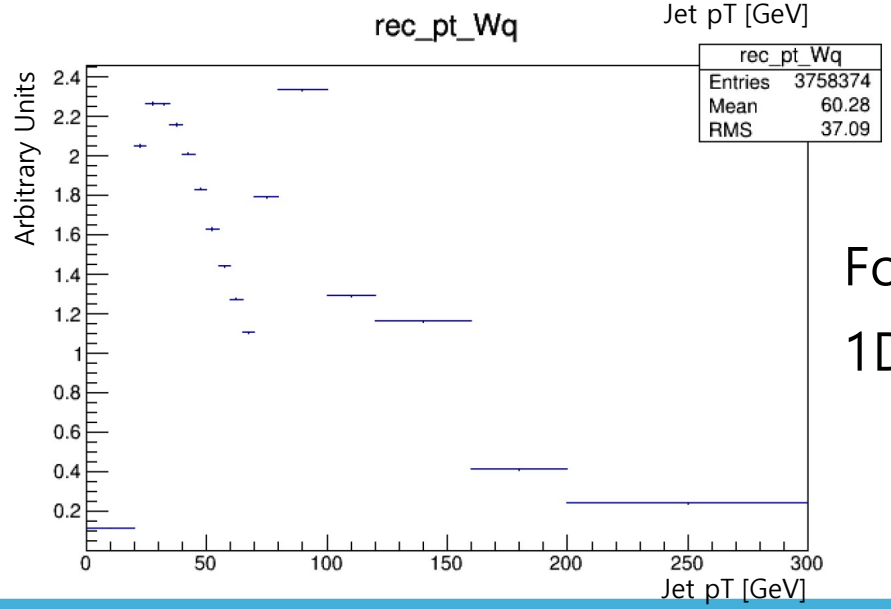
=> Total 450 bin

For each bin, 1D histogram about a response is drawed.

Sigma of Top Specific Correction



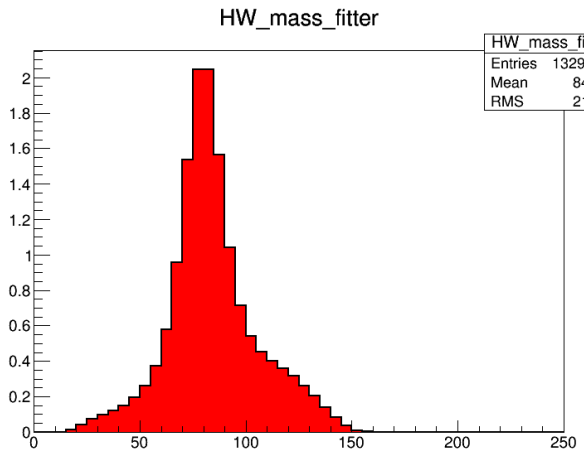


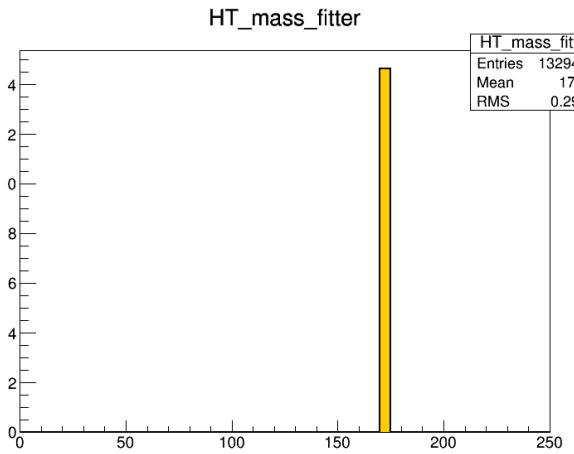


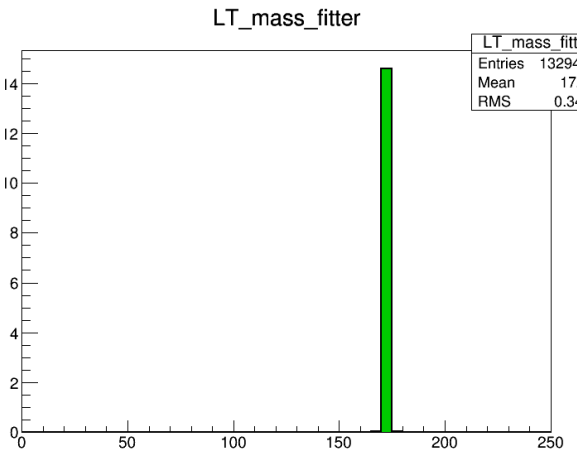
For each bin,

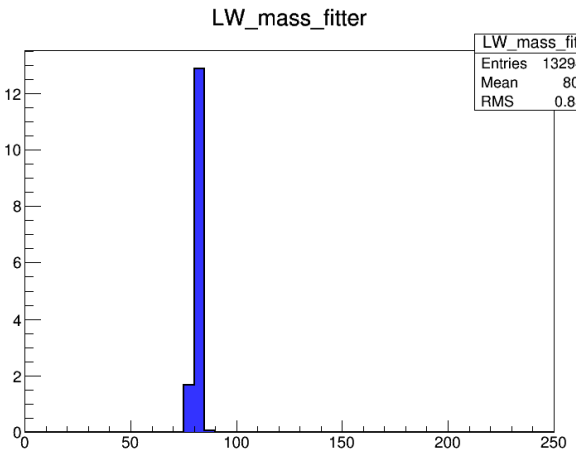
1D histogram for response is drawed.

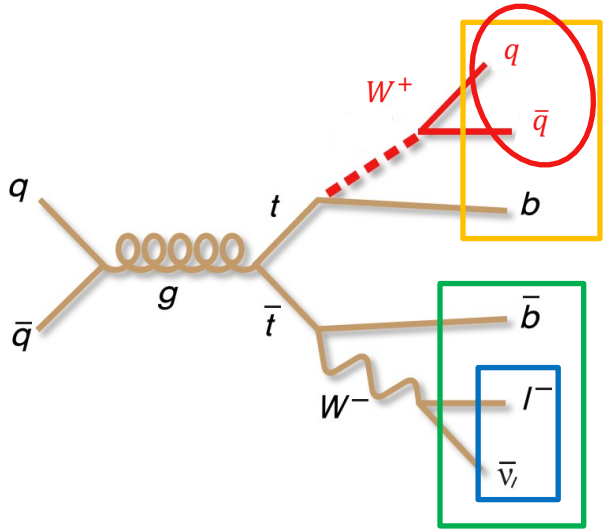
Kinematic Fitter











Above histograms show the fitting results of the 4 jets matched with partons.

Hadronic top mass, leptonic top mass, leptonic W mass are well constraint.

Hadronic W mass has a peak around 80GeV.