Event generation with whizard update

- informations about : Luminosity Spectrum, Beam Energy Spread, Beamstrahlung

- Study of Generate distributions : Correction

  ⟶ deeph problem in Energy distribution

- Next step : W decay in dileptonic channel

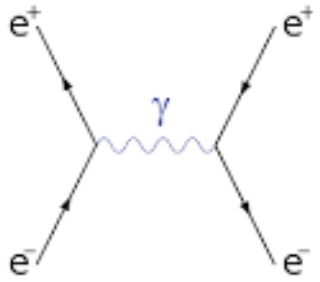
Luminosity : nanometre-sized beams, High energy, pinch effect

➡ Particle deflection : γ emission

➡ Collision below $\sqrt{s}$

LS : Convolution : BES and beamstrahlung

Determined by beam parameters ➡ Unmeasurable



Well known, great precision, large cross-section

Bhabha scattering

Link: https://link.springer.com/content/pdf/10.1140/epjc/s10052-014-2833-3.pdf

BES :

Particle energy depends on longitudinal position

➡ Wakefield intra-bunch : Forward particles gain more energy from RF cavities

➡ Different accelerating gradients

➡ Introduce spread in energy

Beamstrahlung : Energy loss mechanism

➡ Strong E.M field surrounds each bunch

➡ bunch experiences the opposing bunches' EM field

➡ Radiate photons

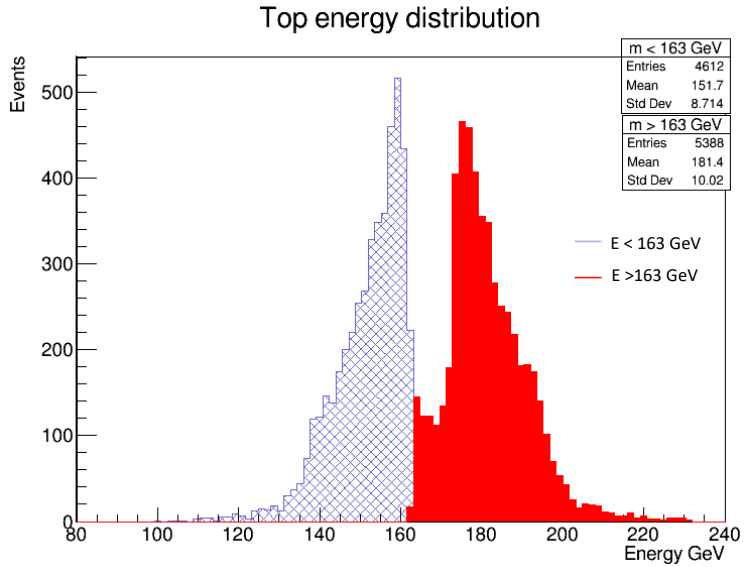
➡ **LS seems to cover BES effects**

Link: https://link.springer.com/content/pdf/10.1140/epjc/s10052-014-2833-3.pdf

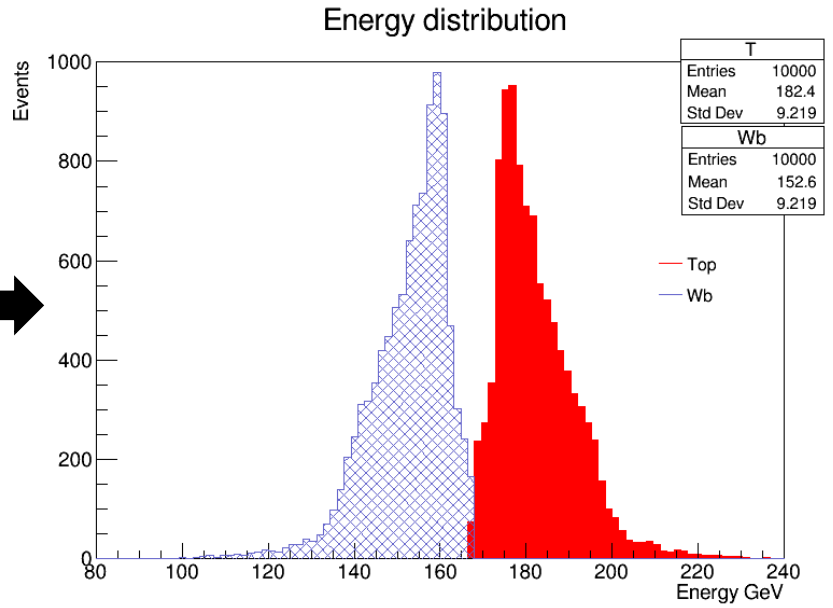
Link: https://www.researchgate.net/publication/240625261_Top_Quark_Physics_Luminosity_Spectrum_and_the_Beam_Energy_Spectrometer_at_the_International_Linear_Collider

SM_tt_threshold

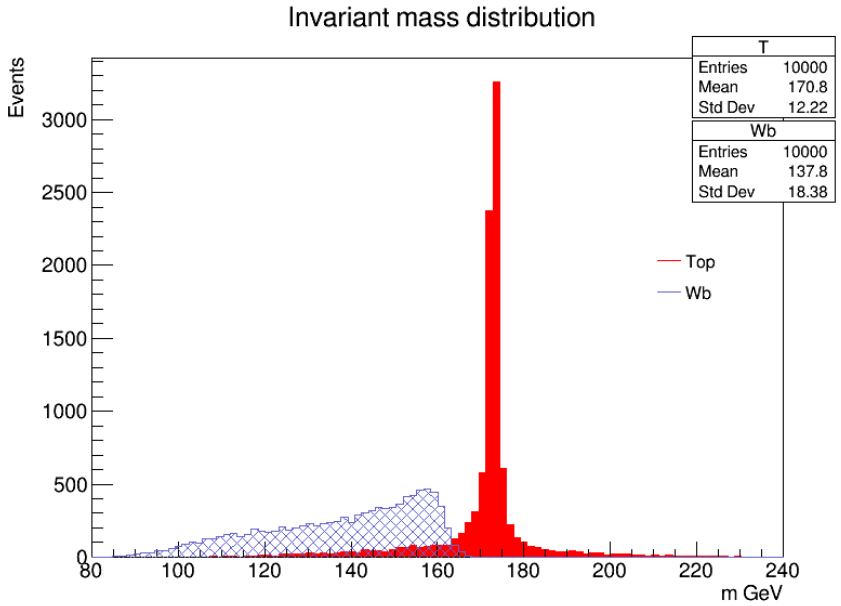
Top and Wb distributions



$\sqrt{s} = 335\ GeV$ **Before threshold**



$\sqrt{s} = 335\ GeV$ **Before threshold**



$\sqrt{s} = 335\ GeV$ **Before threshold**

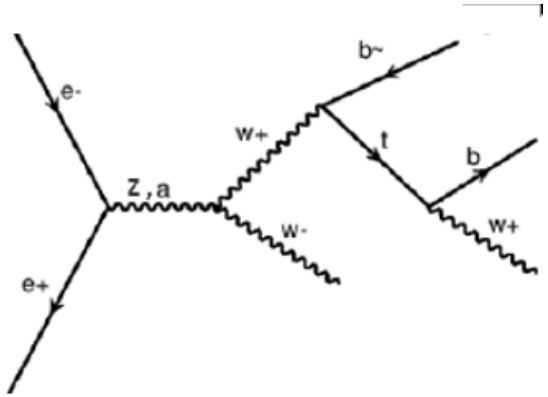
previous histogram

t -> W⁺ b
$\bar{t}$ -> W⁻ $\bar{b}$

➡ Separate contributions

Top { **t -> W⁺ b** ; **$\bar{t}$ -> W⁻ $\bar{b}$** }

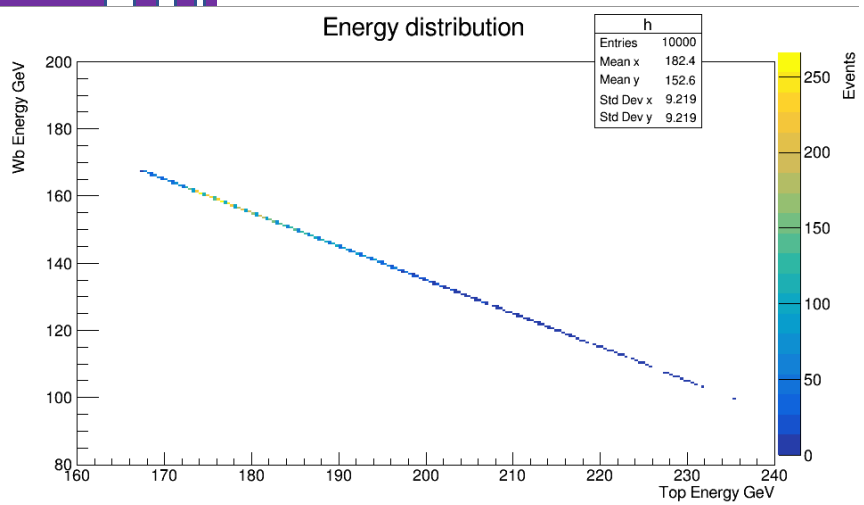
Wb { **-> W⁺ b** ; **-> W⁻ $\bar{b}$** }



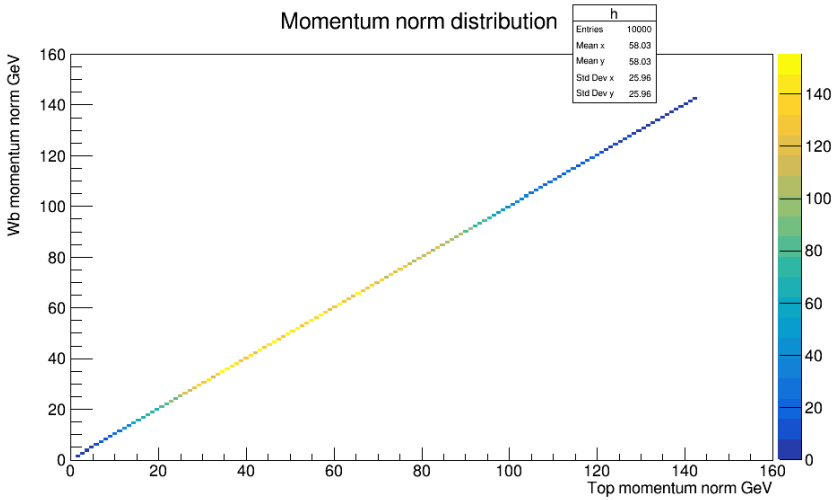
➡ 2 distributions :

- Top
- Wb system

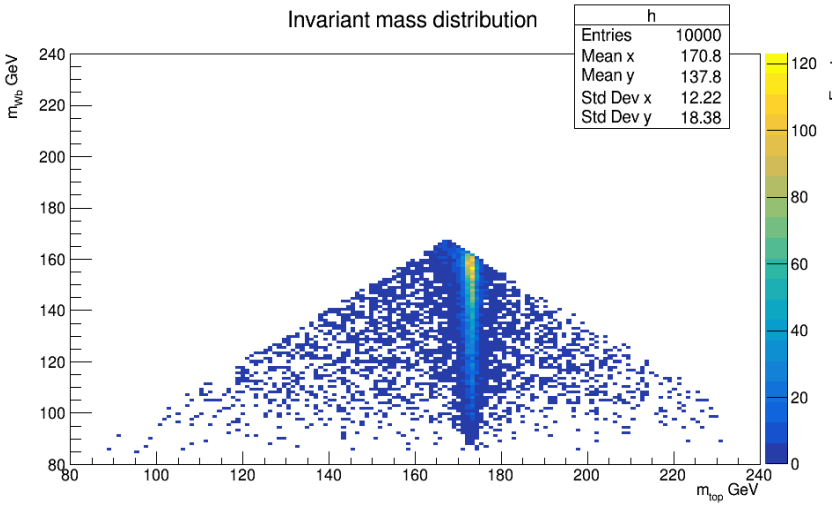
2D distributions



$\sqrt{s} = 335\ GeV$ **Before threshold**



$\sqrt{s} = 335\ GeV$ **Before threshold**



$\sqrt{s} = 335\ GeV$ **Before threshold**

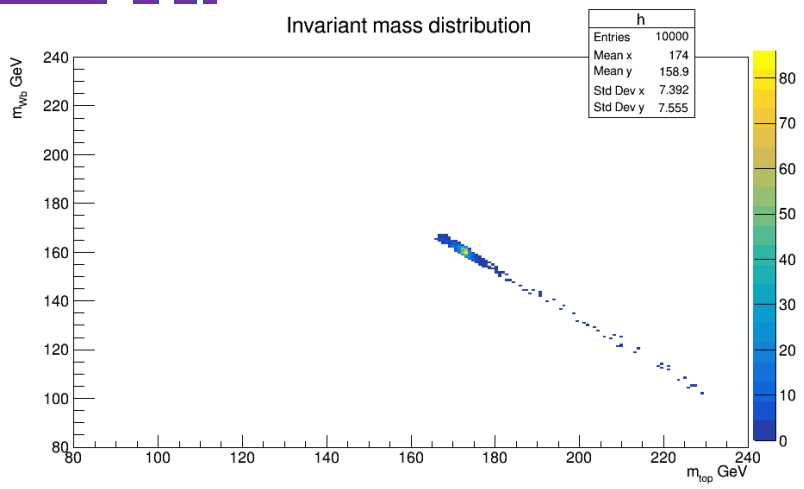
$$\sqrt{s} = E_t + E_{wb}$$

➡ Distribution is anti-correlated

$$|\vec{p_t}| = |\vec{P_{wb}}|$$

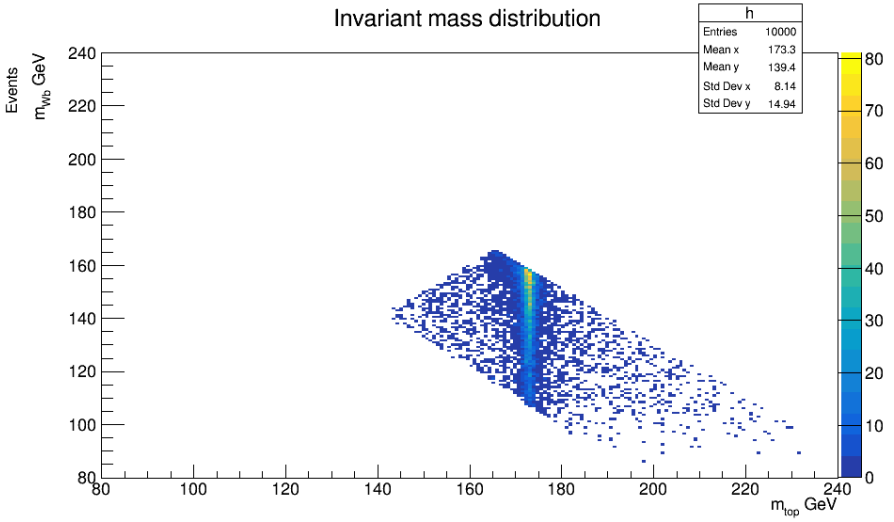
➡ Momentum norm conservation

Invariant mass distribution



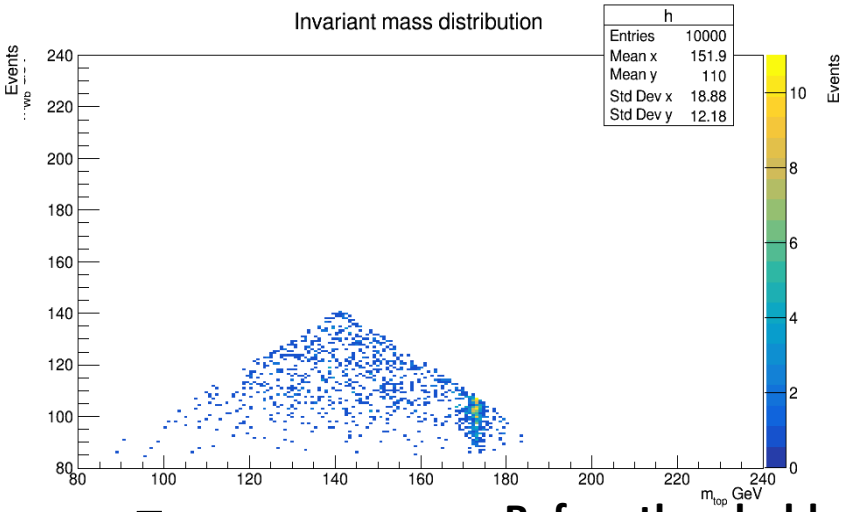
$\sqrt{s} = 335\ GeV$ **Before threshold**

$0 \leq |\vec{p}| \leq 25$ GeV



$\sqrt{s} = 335\ GeV$ **Before threshold**

$25 < |\vec{p}| \leq 90$ GeV



$\sqrt{s} = 335\ GeV$ **Before threshold**

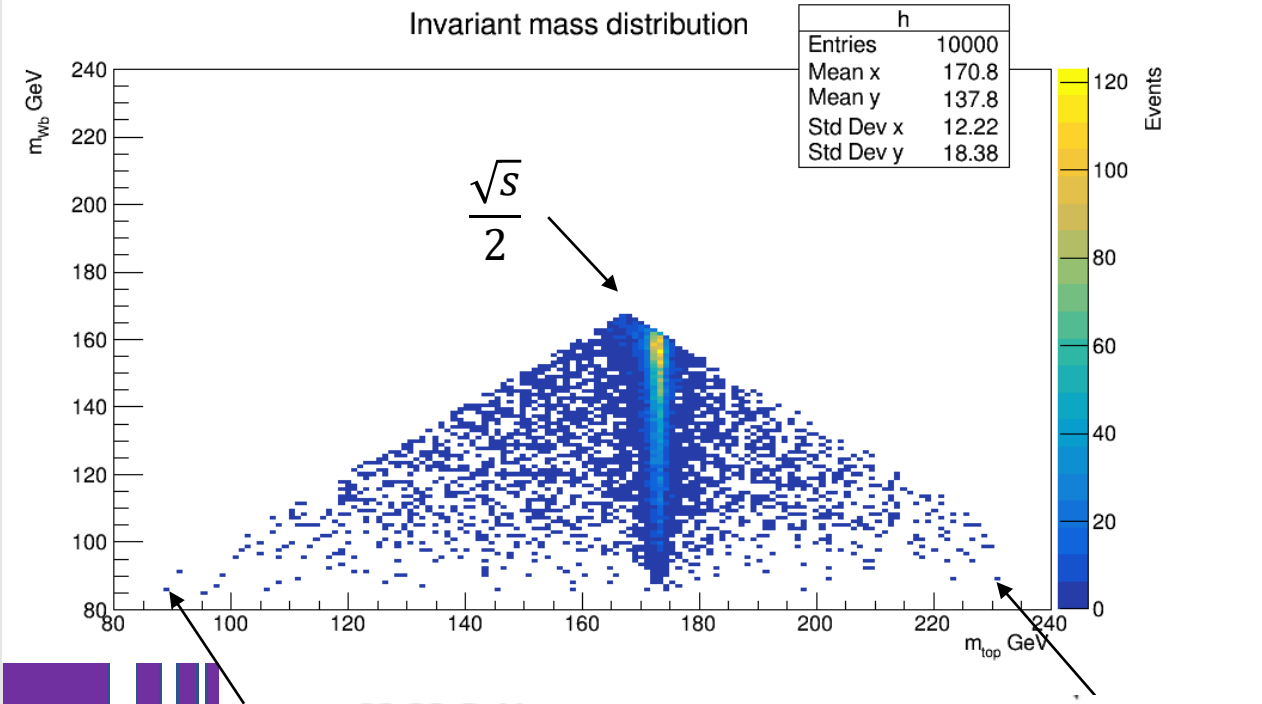
$90 < |\vec{p}| \leq 145$ GeV

$\Rightarrow$ $E = \sqrt{P^2 + m^2}$

if P^2 small then m^2 higher

if m^2 small then P^2 higher

Invariant mass/Energy distribution



m_{Top}=88,98 GeV

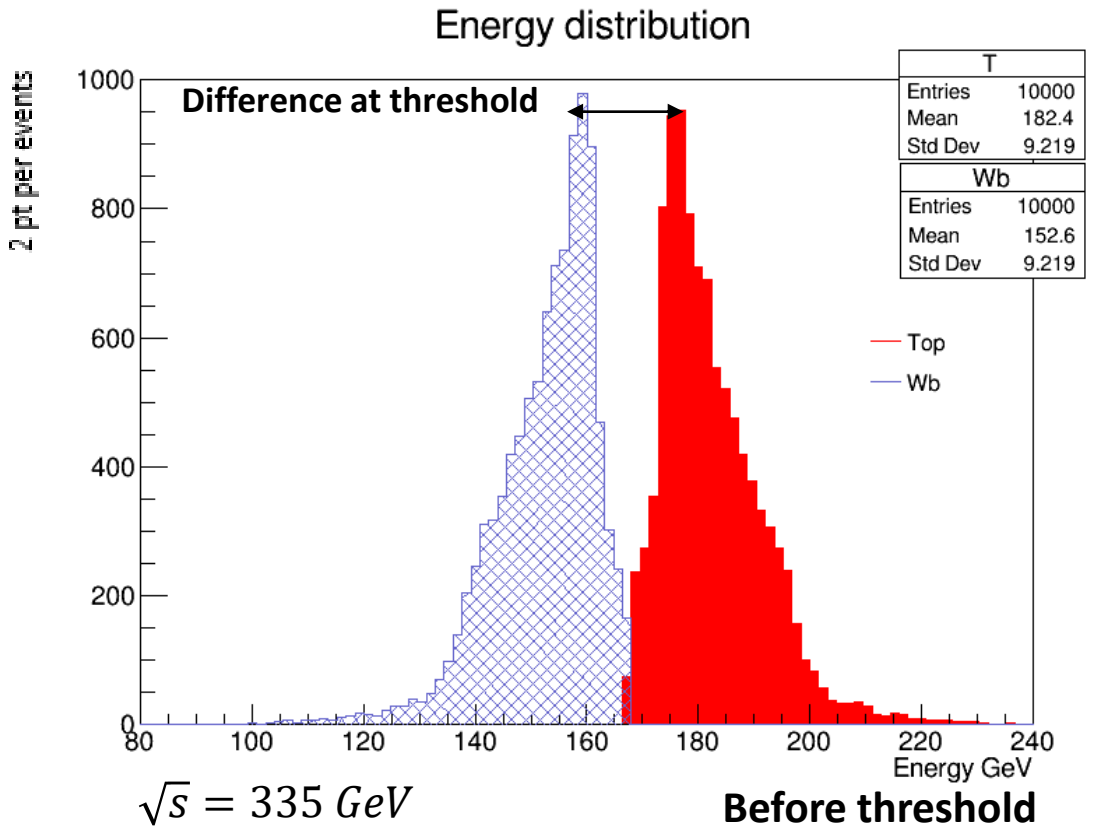
$|\vec{p_t}|$ = 142,75 GeV

Et=168,21 GeV

m_{Top}=231,21 GeV

$|\vec{p_t}|$ = 44,03 GeV

Et=235,36 GeV



$\sqrt{s} = 335\ GeV$

Before threshold

$$\sigma \propto \int_{\phi} |M|^2 \, d\phi$$

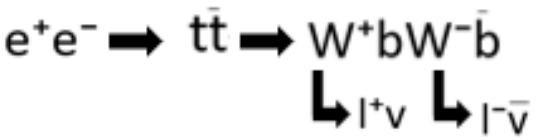
1) Low mTop, high $|\vec{p}|$ ➡ Space phase dominant

2) high mTop, low $|\vec{p}|$ ➡ Matrix element dominant

(A) $2P^2 + m_t^2 + m_{\bar{t}}^2 + 2\sqrt{P^2 + m_t^2}\sqrt{P^2 + m_{\bar{t}}^2} = s$

Next step : W decay in dileptonic channel

After threshold : $\sqrt{s} = 400$ GeV



l = electron, muon

➡ Try to implement Chi2 minimization

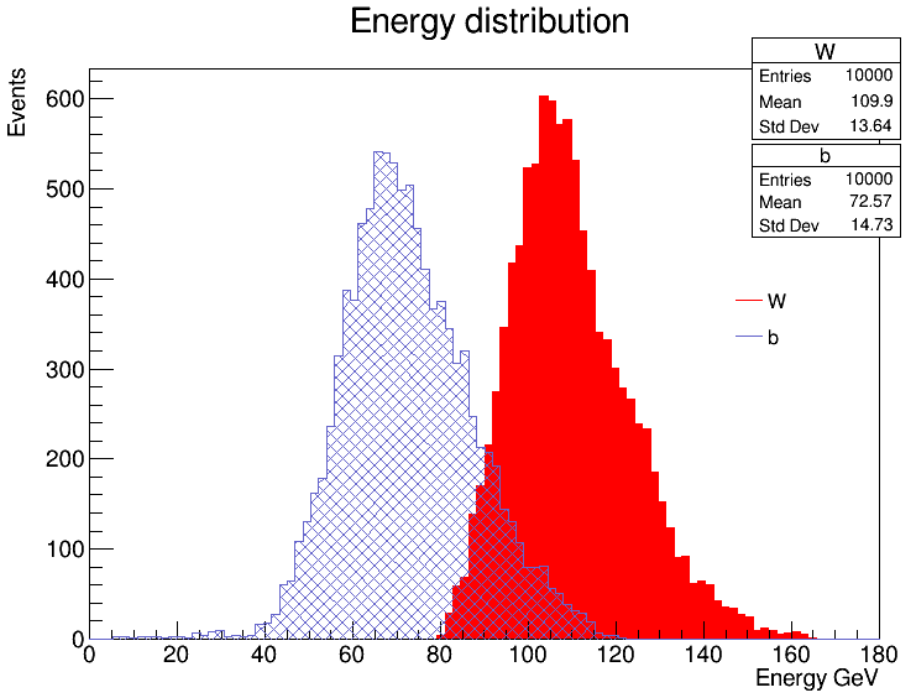
Conclusion

- Try to understand BES/LS : seems to be related
- Solve the deeph problem in energy distribution
  - Understand 2D plot Invariant mass
- W decay dileptonic channel

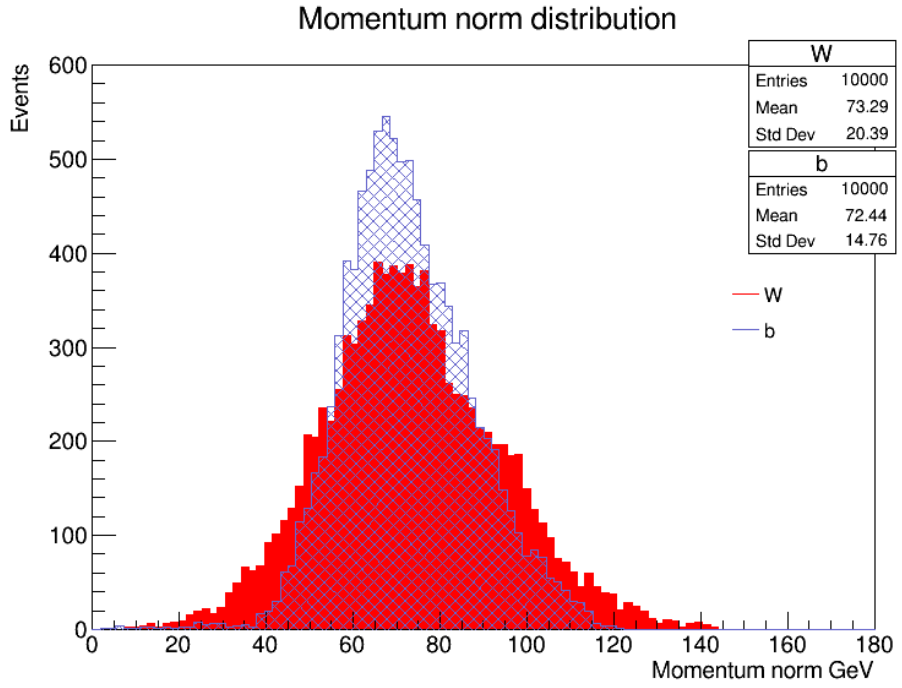
Backup

W and b distribution

SM_tt_threshold



$\sqrt{s} = 335\ GeV$ **Before threshold**



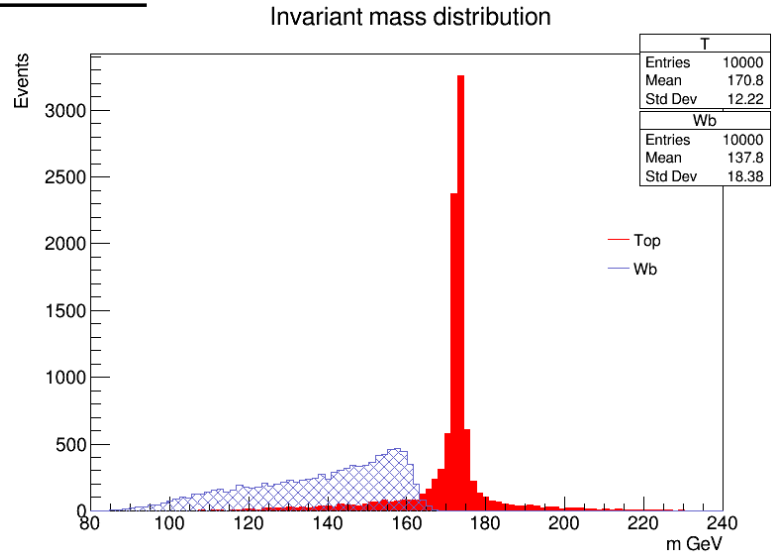
$\sqrt{s} = 335\ GeV$ **Before threshold**

$$E = \sqrt{P^2 + m^2}$$

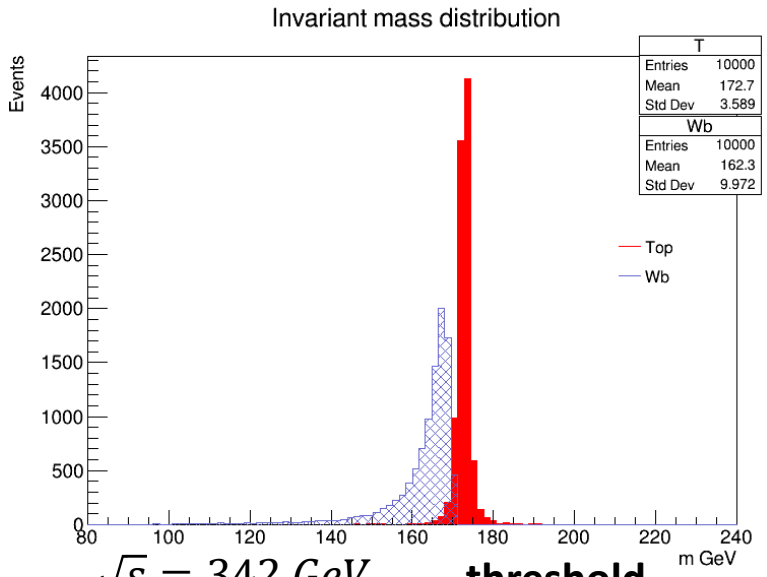
→ Energy not distributed symmetrically between W and b **$M_W > M_b$**

Invariant mass

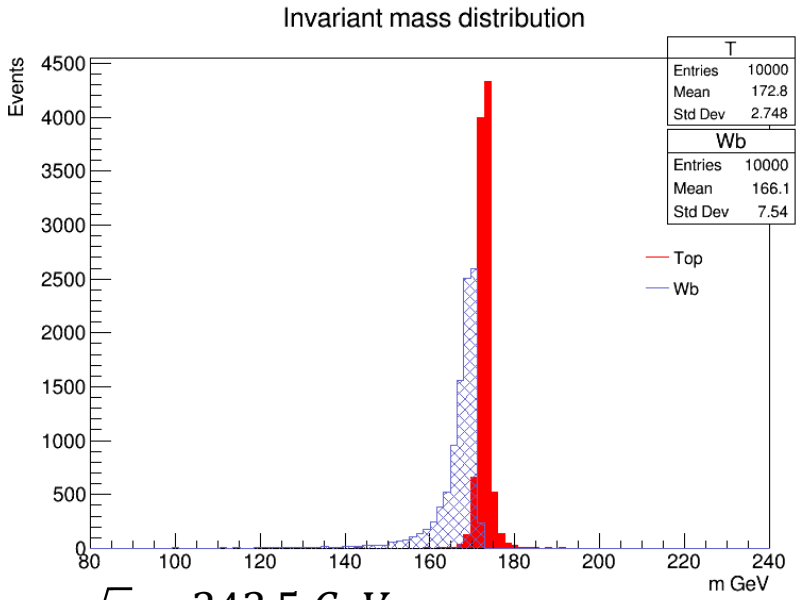
SM_tt_threshold



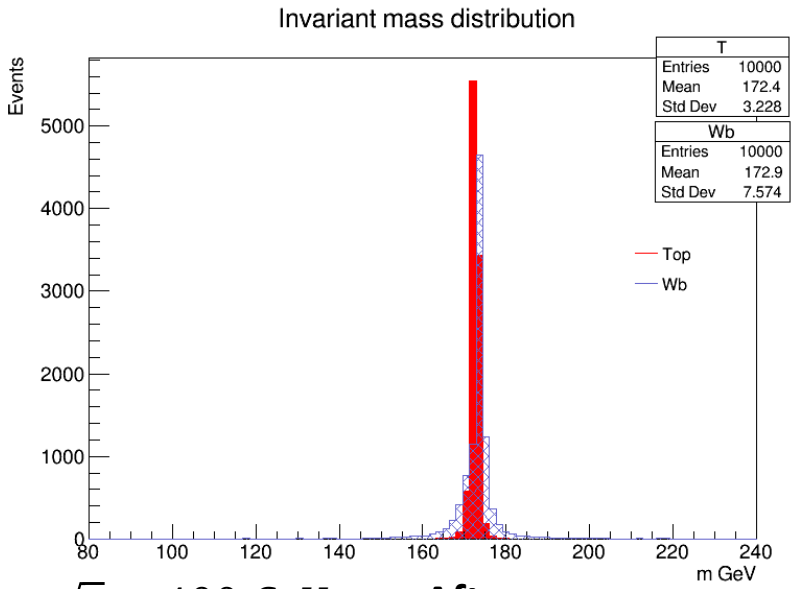
$\sqrt{s} = 335\ GeV$ **Before threshold**



$\sqrt{s} = 342\ GeV$ **threshold**



$\sqrt{s} = 343{,}5\ GeV$ **near resonance**

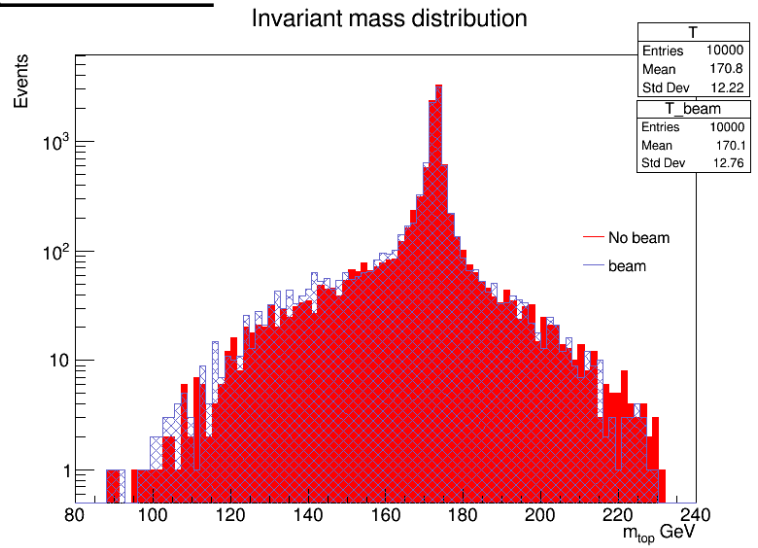


$\sqrt{s} = 400\ GeV$ **After resonance**

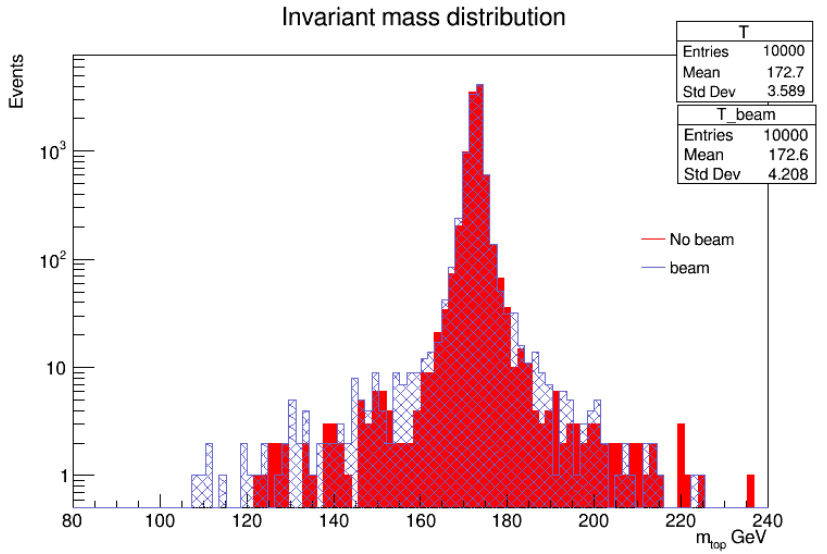
➡ After resonance : dominant Z° contribution, Wb came from Top decay

Top Invariant mass – beam/no beam comparison

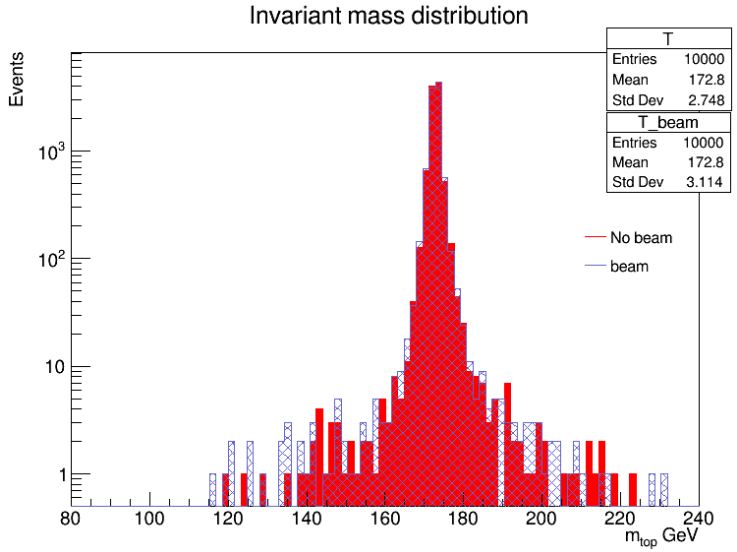
SM_tt_threshold



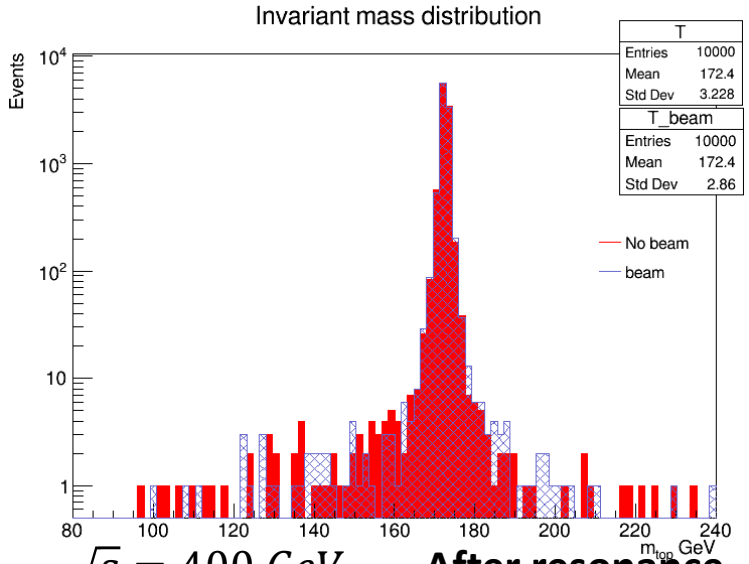
$\sqrt{s} = 335\ GeV$ **before threshold**



$\sqrt{s} = 342\ GeV$ **threshold**



$\sqrt{s} = 343{,}5\ GeV$ **near resonance**

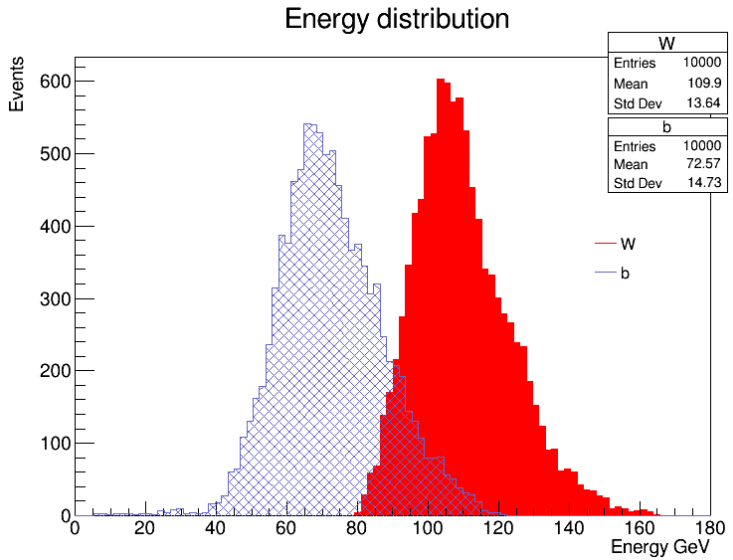


$\sqrt{s} = 400\ GeV$ **After resonance**

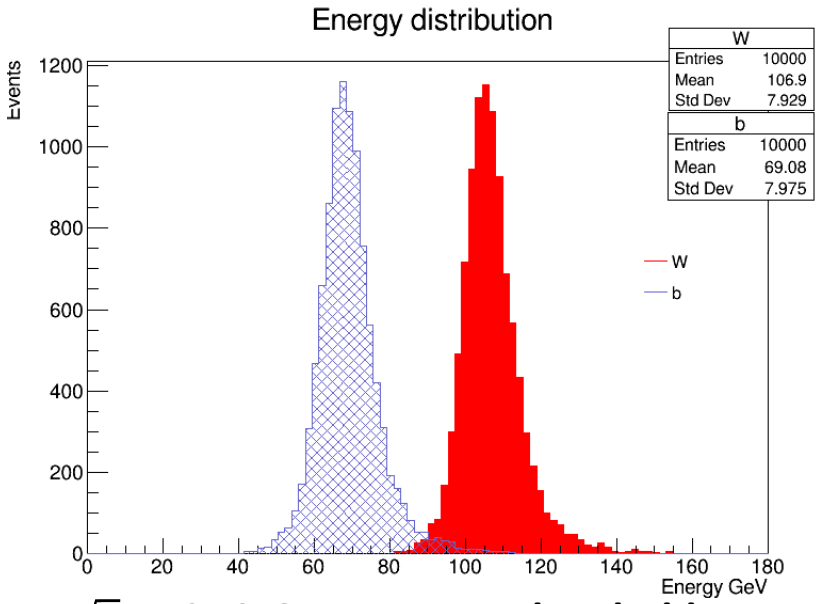
➡ Beam effect more important in the distribution tails

W and b Energy distribution

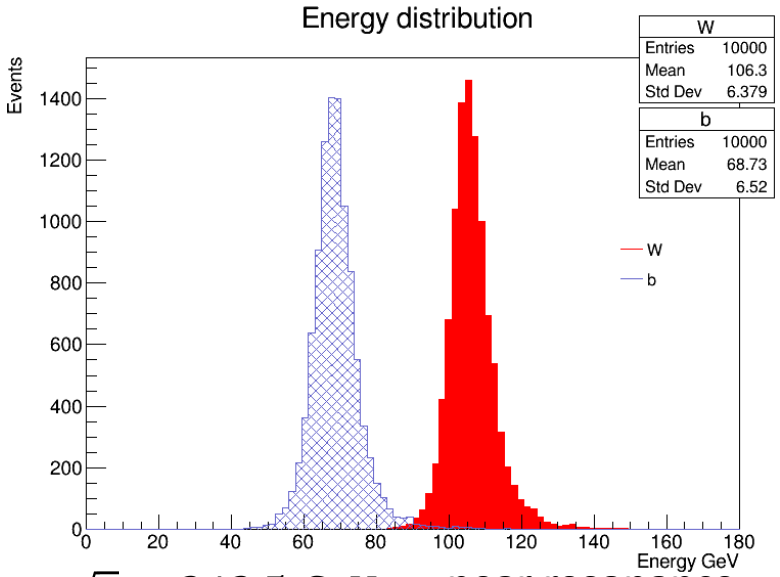
SM_tt_threshold



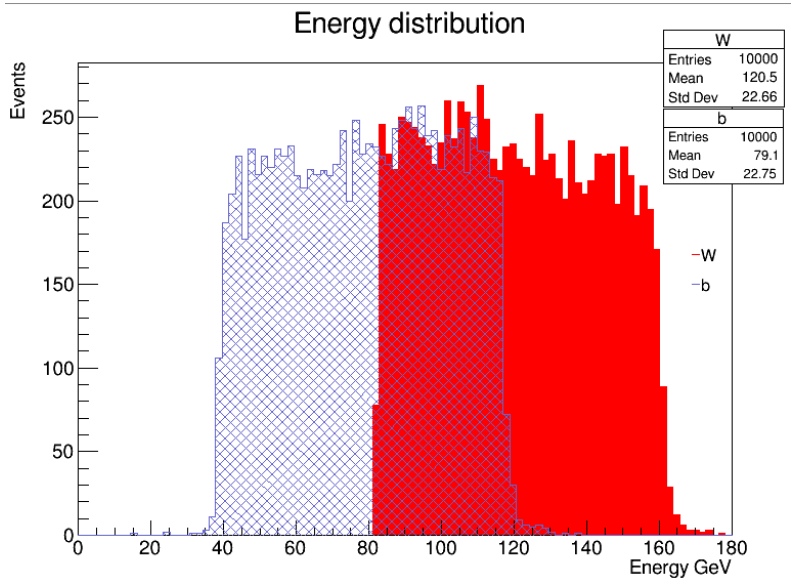
$\sqrt{s} = 335\ GeV$ **Before threshold**



$\sqrt{s} = 342\ GeV$ **threshold**



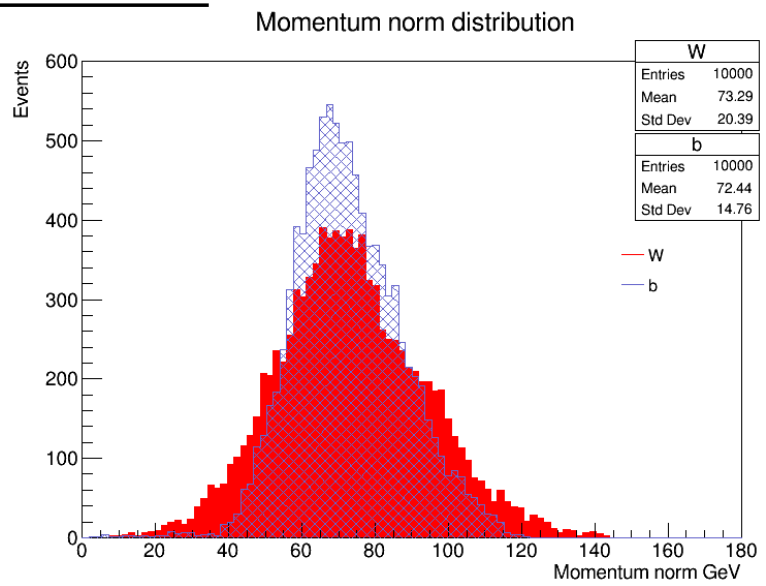
$\sqrt{s} = 343{,}5\ GeV$ **near resonance**



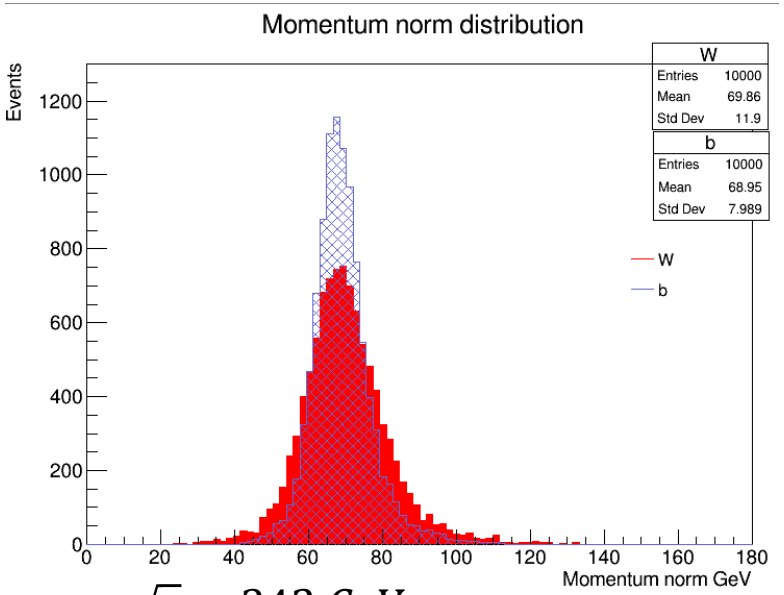
$\sqrt{s} = 400\ GeV$ **After resonance**

W and b momentum norm distribution

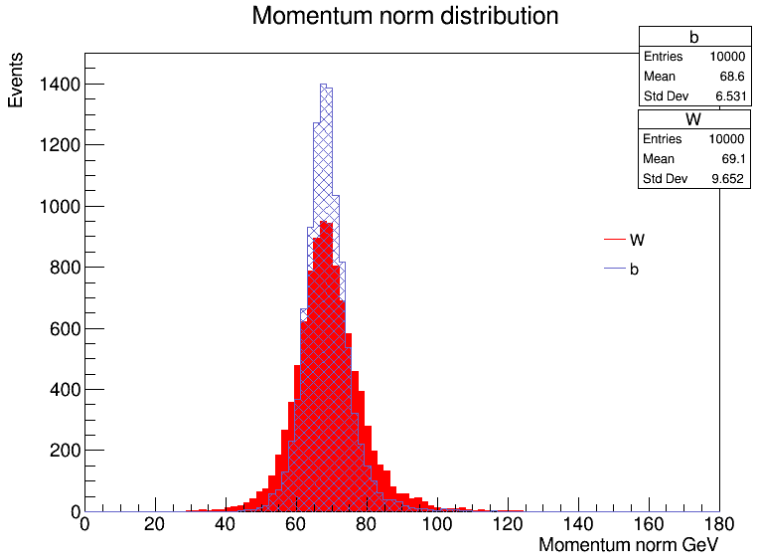
SM_tt_threshold



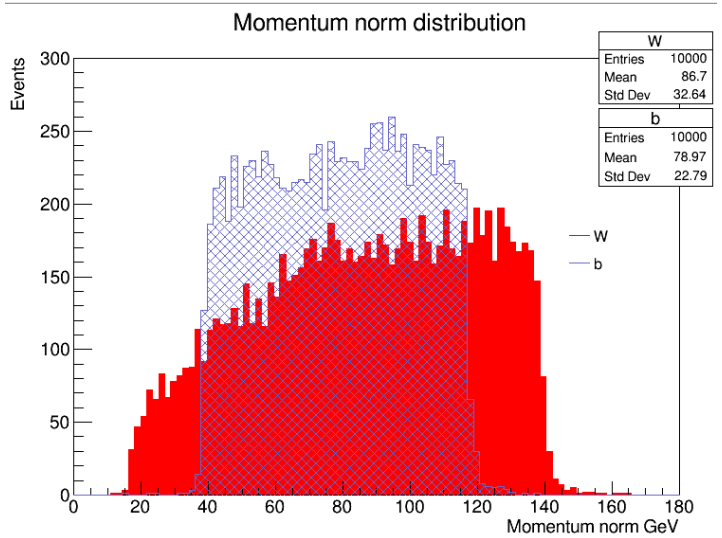
$\sqrt{s} = 335\ GeV$ **Before threshold**



$\sqrt{s} = 342\ GeV$ **threshold**



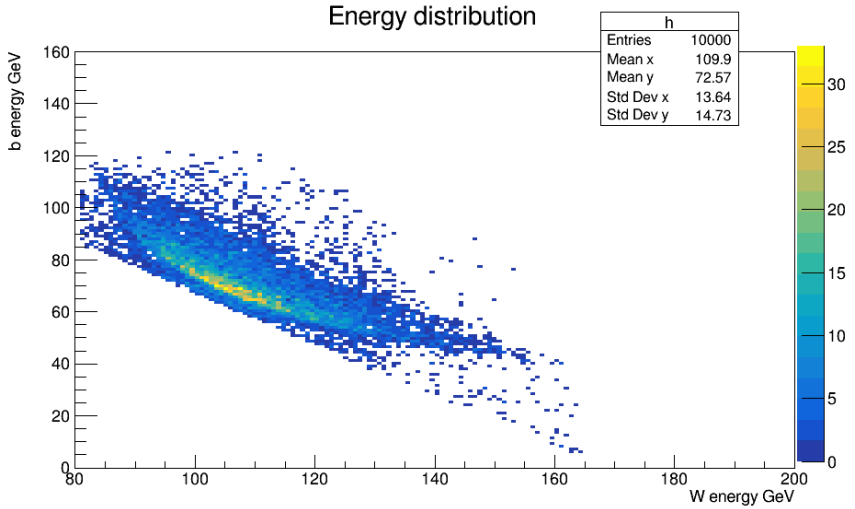
$\sqrt{s} = 343{,}5\ GeV$ **near resonance**



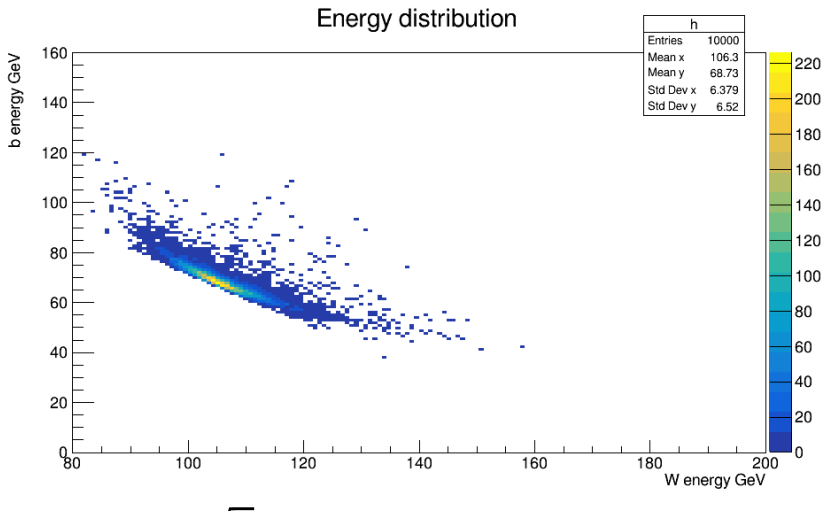
$\sqrt{s} = 400\ GeV$ **After resonance**

➡ Similar shape except at 400 GeV

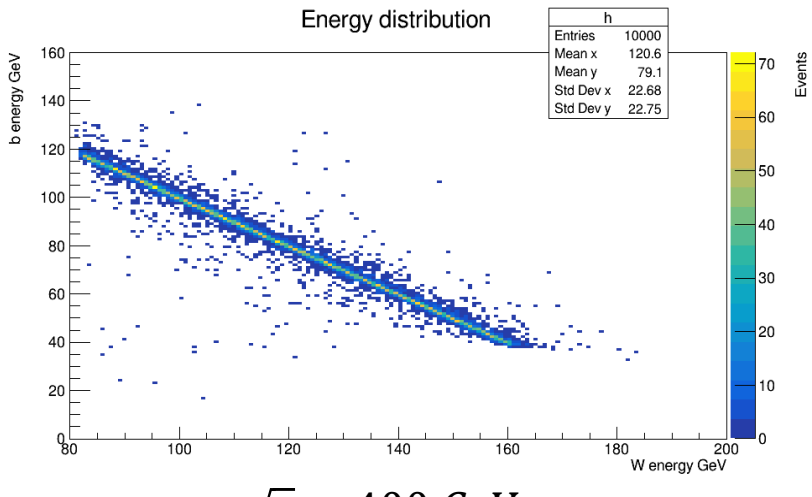
W and b Energy distribution



$\sqrt{s} = 335\ GeV$

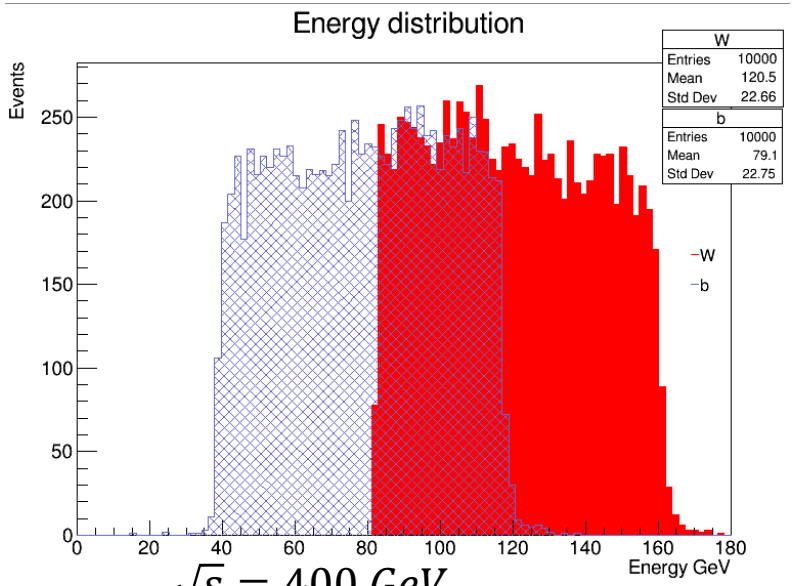


$\sqrt{s} = 343{,}5\ GeV$



$\sqrt{s} = 400\ GeV$

➡ W and b anti-correlation apparition with the center of mass energy rise



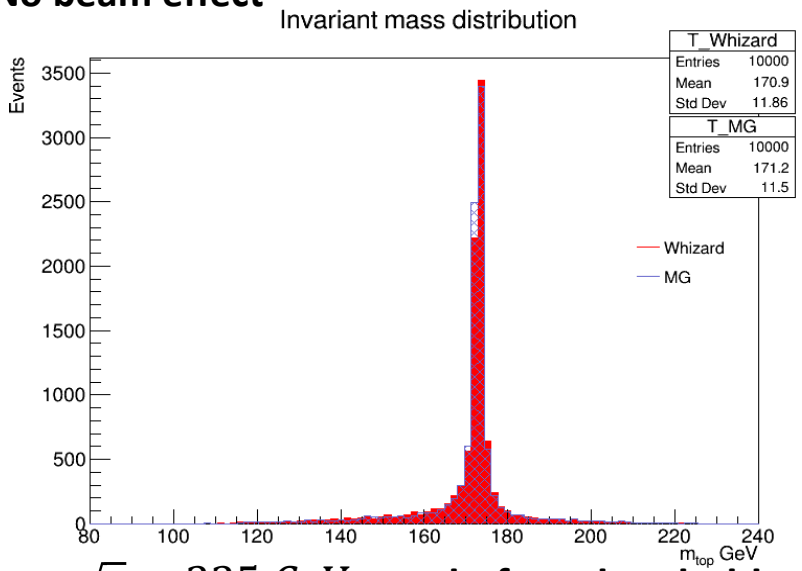
$\sqrt{s} = 400\ GeV$

➡ W and b energy anti-correlated

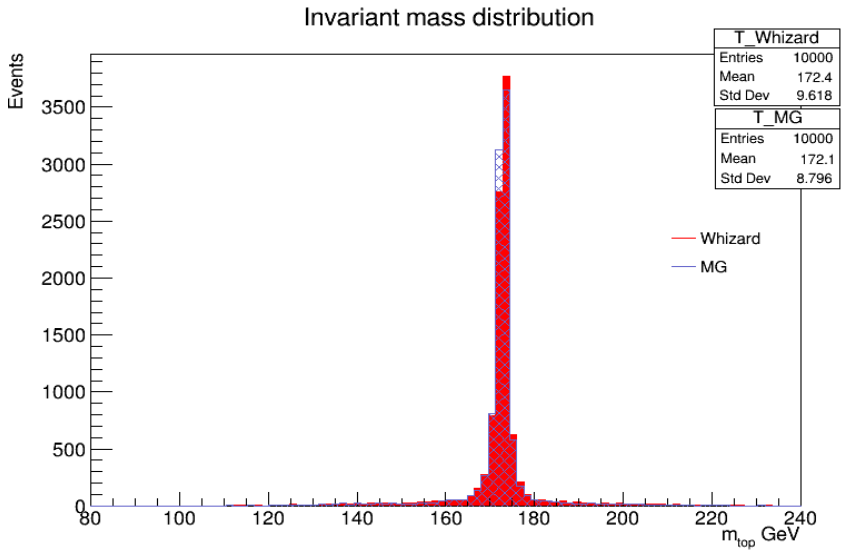
➡ Enough energy to have flat disribution

Top quark invariant mass

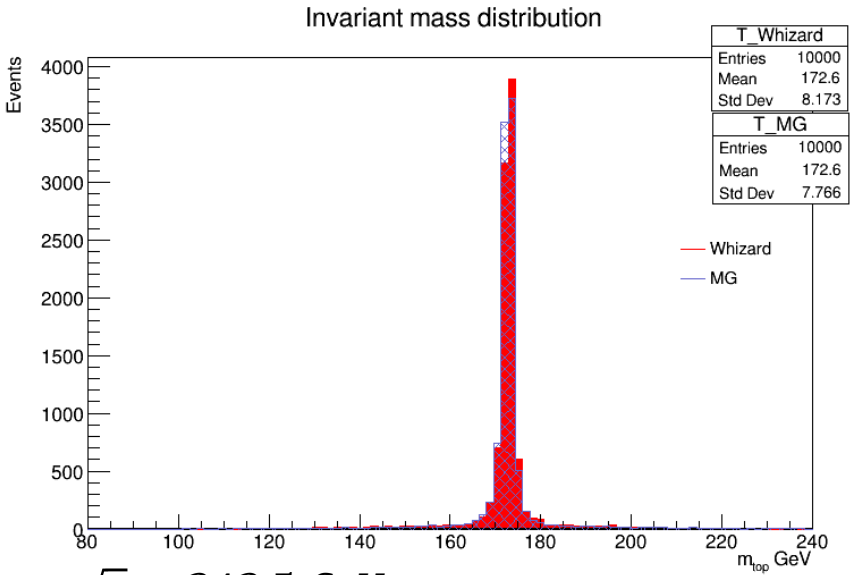
SM：No beam effect



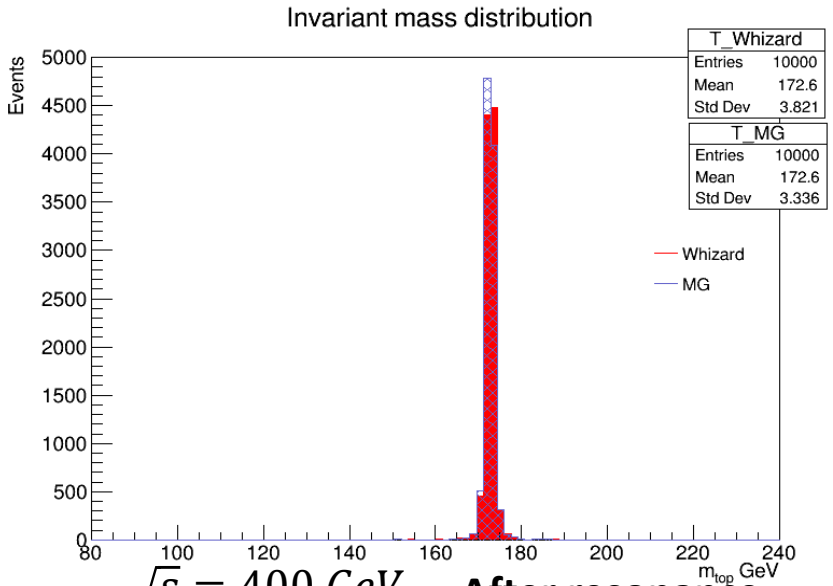
$\sqrt{s} = 335\ GeV$ **before threshold**



$\sqrt{s} = 342\ GeV$ **threshold**



$\sqrt{s} = 343{,}5\ GeV$ **near resonance**



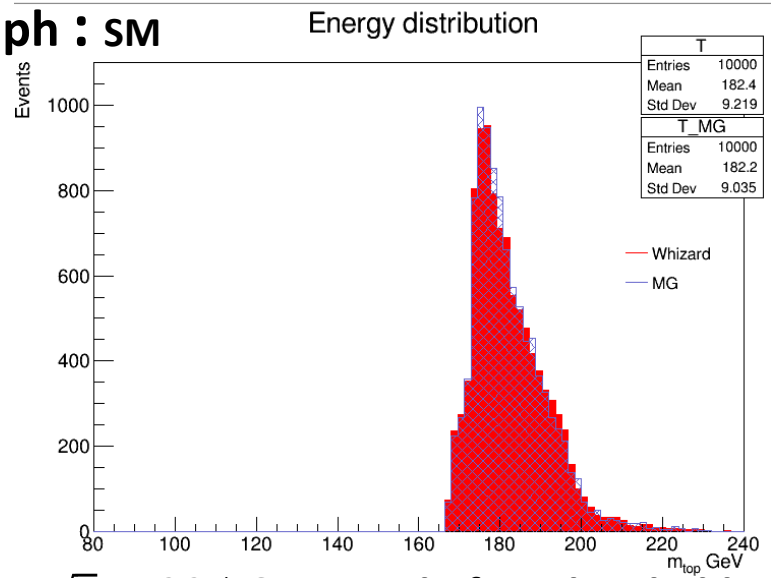
$\sqrt{s} = 400\ GeV$ **After resonance**

➡ Great agreement between Whizard and MadGraph distributions

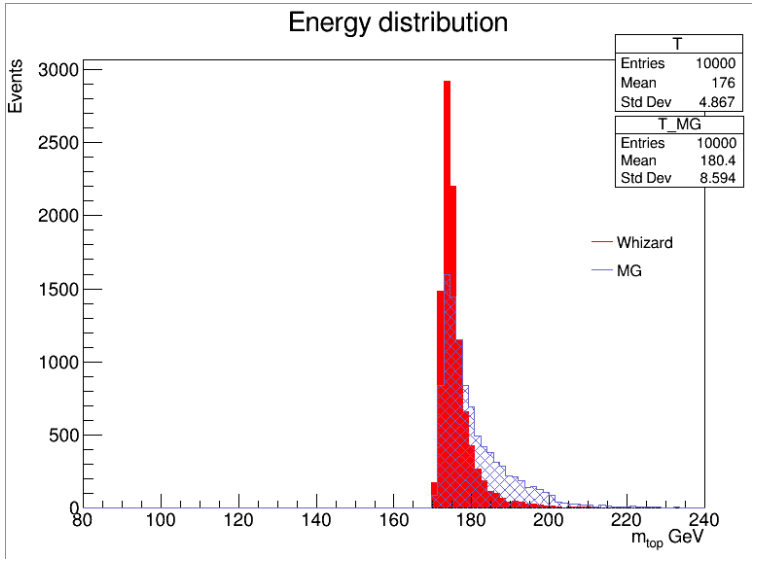
Top energy distribution-Comparison

Whizard：SM_tt_threshold

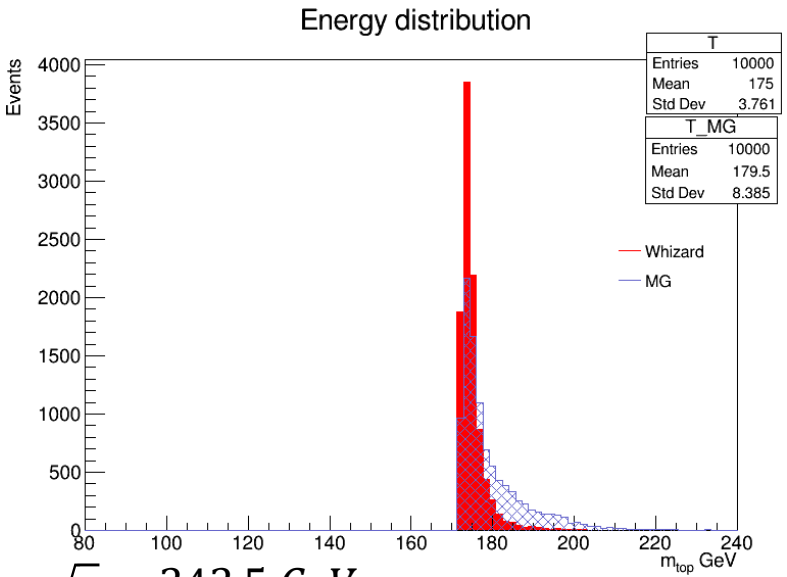
MadGraph：SM



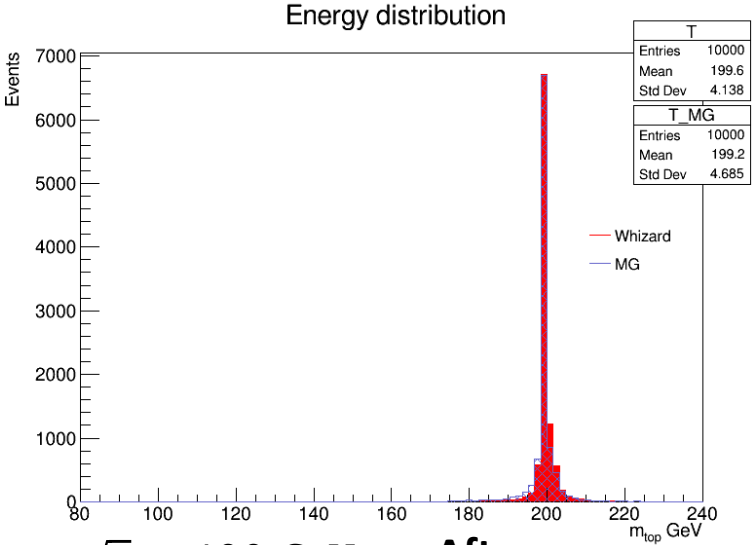
$\sqrt{s} = 335\ GeV$ **before threshold**



$\sqrt{s} = 342\ GeV$ **threshold**



$\sqrt{s} = 343{,}5\ GeV$ **near resonance**



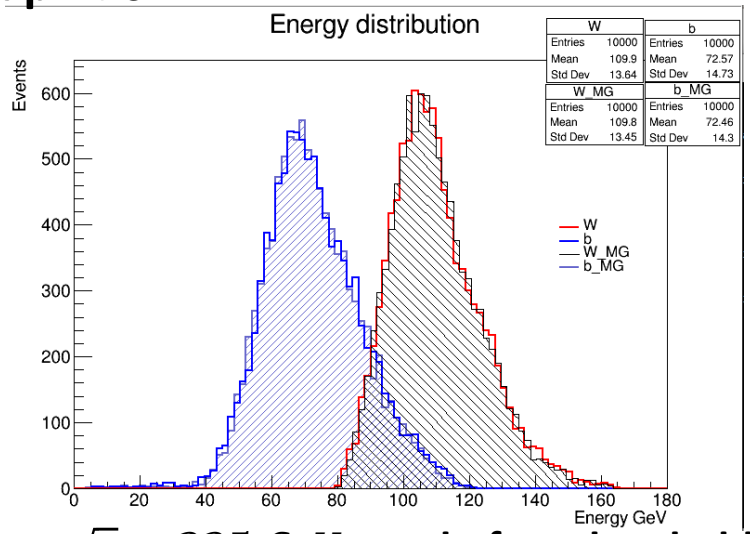
$\sqrt{s} = 400\ GeV$ **After resonance**

➡ <u>At threshold and near resonance :</u> larger r.m.s come from the model used

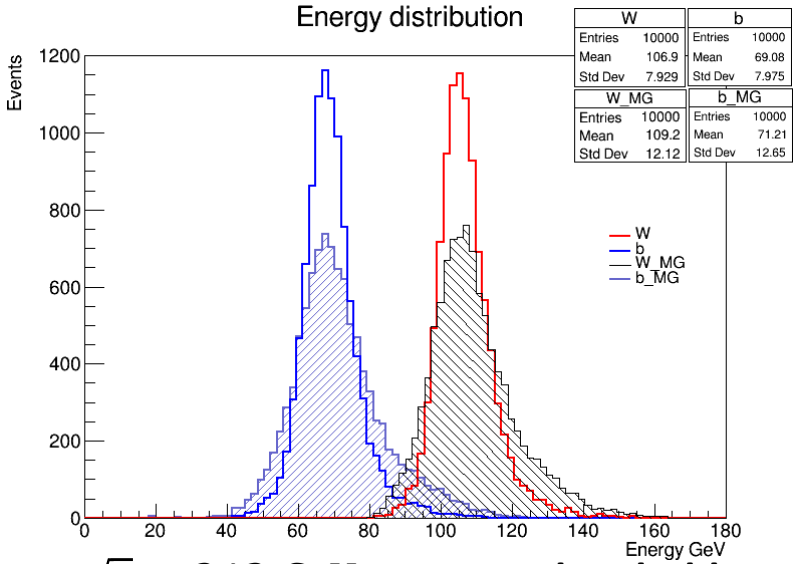
W and b distribution-Comparison

Whizard : SM_tt_threshold

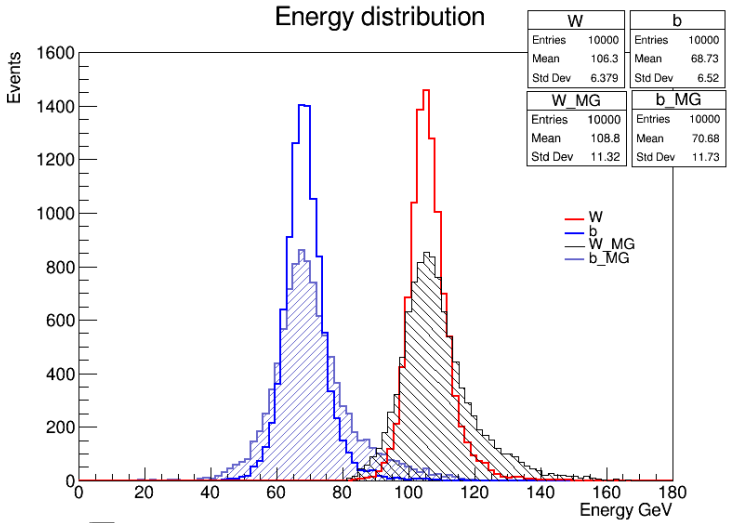
MadGraph : SM



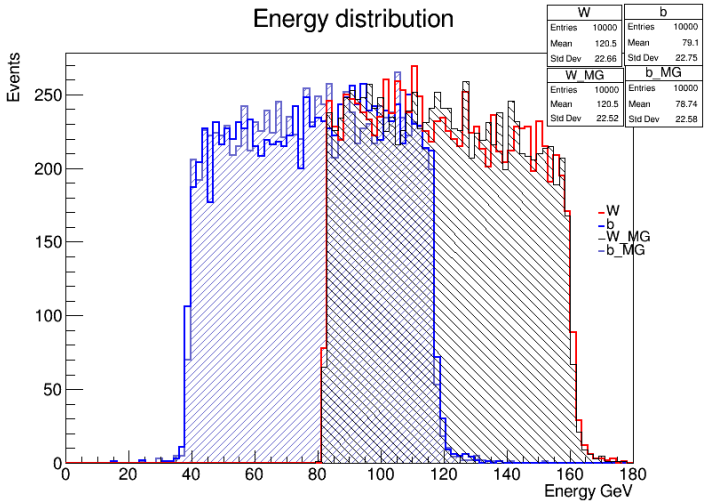
$\sqrt{s} = 335\ GeV$ **before threshold**



$\sqrt{s} = 342\ GeV$ **threshold**



$\sqrt{s} = 343{,}5\ GeV$ **near resonance**



$\sqrt{s} = 400\ GeV$ **After resonance**

➡ <u>At threshold and near resonance</u> : differences come from the model used