

# On the possibility of stop mass determination in photon-photon and $e^+e^-$ collisions at ILC

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# The Photon beams at ILC

The option of a photon collider at ILC will be achieved by using backscattered photon beams by Compton scattering of laser beams with electron ones.

*Unlike the situation at  $e^+e^-$  collider, the energy of the backscattered photon beams will vary from event to event.*

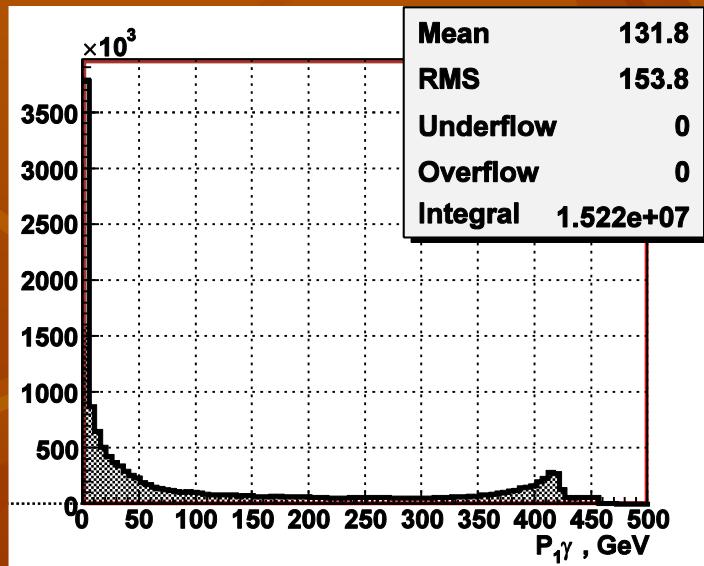
Circe2 program gives the energy spectra of the colliding backscattered photons & the values of photon beam luminosities.

# Energy spectrum from CIRCE 2

shows the degree of monochromaticity of the backscattered photons

We used as a reasonable approximation the CIRCE2 output spectra generated for  $E_{e+e-}^{tot} = 800 \text{ GeV}$  and scaled them (by 1000/800) to the higher beam energy

$$2E_{beam}^e = 1000 \text{ GeV}$$



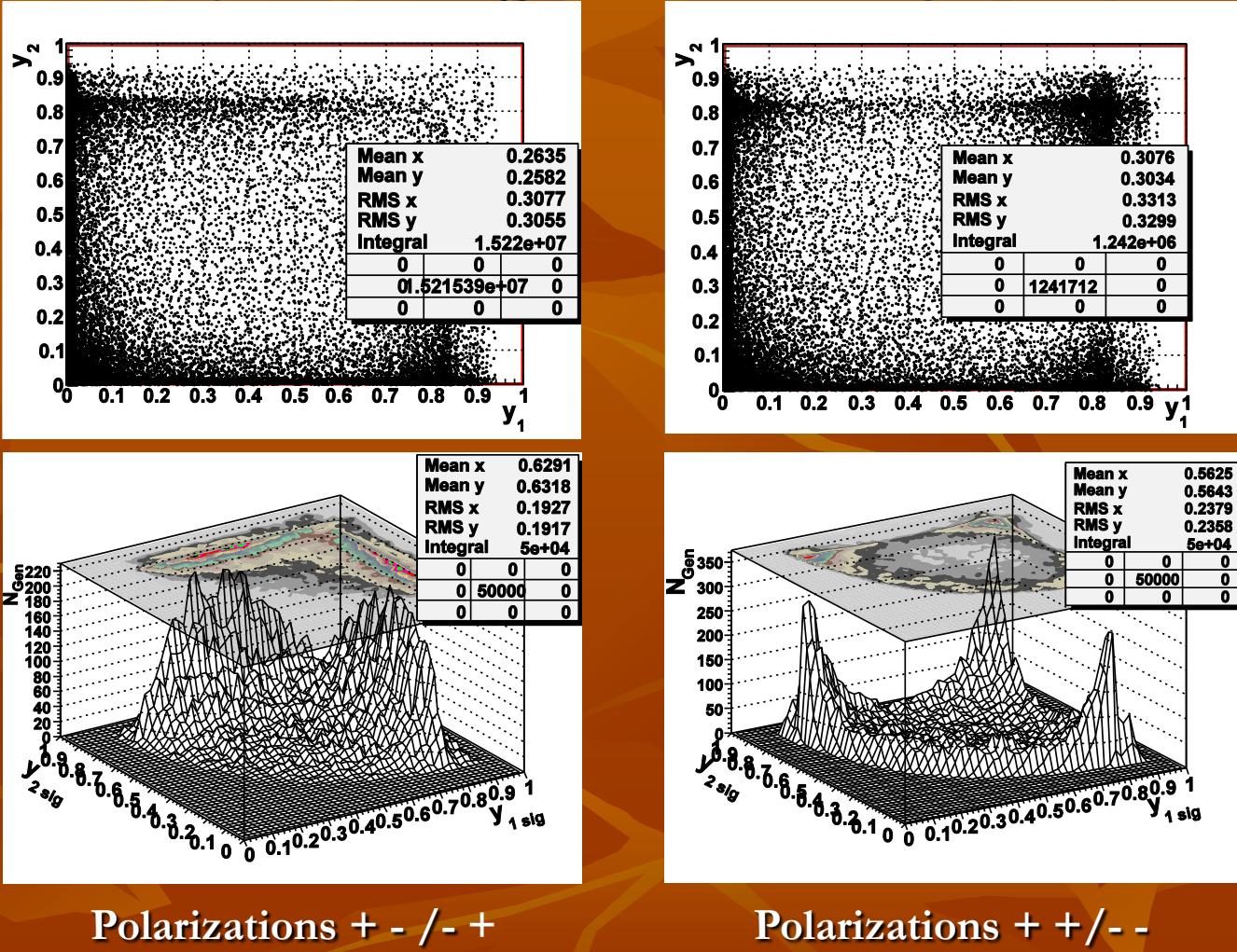
- The left peak is caused by multiple Compton scattering and beamstrahlung photons
- The right one at the energy fraction  $Y = E_i^\gamma / E_{beam}^e \approx 0.83$  ( $i=1,2$ ) is due to the hard photon production

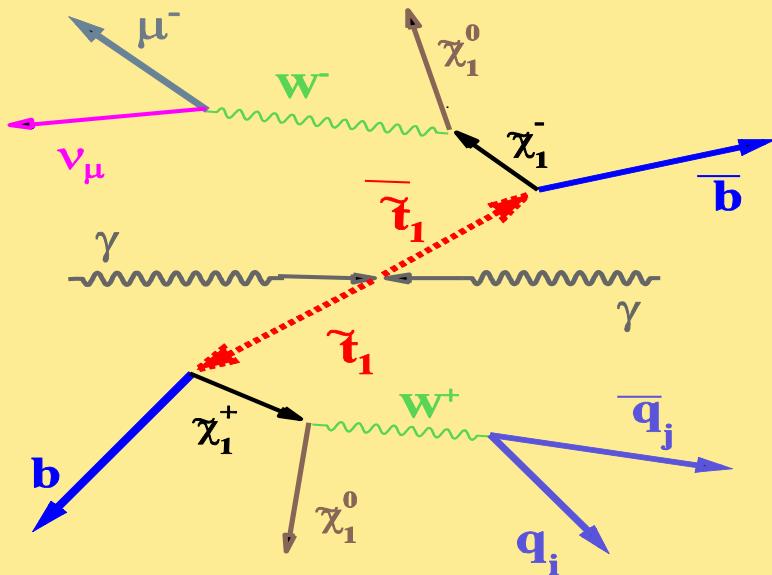
*Only on a 0.3% the  $\gamma\gamma$  energy is high enough for  $\gamma\gamma \rightarrow \text{stop stop bar production}$*

# $\gamma$ -energy correlation $Y_1/Y_2$ spectra for J=0 enhanced

( $J$  – total angular momentum)

Whole  $\gamma$  spectrum





4-6 factor difference

TOP pair production  
cross sections

$$\sigma = \dots \text{fb} \quad "+ -" \& "- +"$$

$$\sigma = \dots \text{fb} \quad "+ +" \& "- -"$$

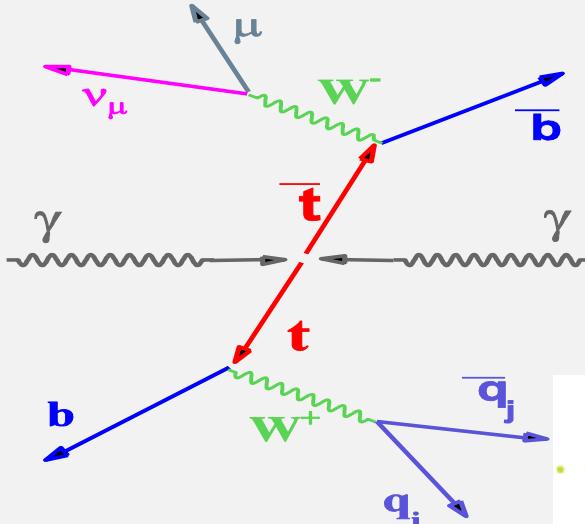
$e^+ e^-$  CM energy = 1000

GeV

STOP pair production cross  
sections

$$\sigma = \dots \text{fb} \quad "+ -" \& "- +"$$

$$\sigma = \dots \text{fb} \quad "+ +" \& "- -"$$



PYTHIA 6.4 + cross section distribution formula taken from S.Berge et al. hep-ph/0008081

The subsequent decay channels have been considered:

- $\text{STOP STOP} \rightarrow b \ \chi_1^+ \ b_{\bar{\text{bar}}} \ \chi_1^- \rightarrow b \ b_{\bar{\text{bar}}} \ q_i \ q_{\bar{j}} \ \mu^- \nu_{\mu} \ \chi_1^0 \ \chi_1^0$
- $t \ t \rightarrow b \ W^+ \ b_{\bar{\text{bar}}} \ W^- \rightarrow b \ b_{\bar{\text{bar}}} \ q_i \ q_{\bar{j}} \ \mu^- \nu_{\mu}$

The only difference of STOP / TOP production is the presence of the two non-detectable neutralinos in the case of stop pair production.

Both the signal and background events have the same experimental signature  
(  $b$  &  $b_{\bar{\text{bar}}}$ - jets, 2 jets from  $W \rightarrow q_i \bar{q}_j$  decay and  $\mu^-$  ).

The quarks hadronize into jets. Jets are determined by use of PYCLUS jetfinder based on “Durham” cluster distance measure algorithm.

# In order to simulate the STOP pair production, we assumed the following scenario for the MSSM model parameters:

- $M_{\tilde{Q}} = M_{\tilde{t}_L} = 270 \text{ GeV}$  (left squark mass)
- $M_{\tilde{U}} = M_{\tilde{t}_R} = 270 \text{ GeV}$  (right squark mass)
- $A_t = -500 \text{ GeV}$  (top and bottom trilinear coupling)
- $\mu = -370 \text{ GeV}$
- $\tan\beta = 5$
- $M_1 = 80 \text{ GeV}$
- $M_2 = 160 \text{ GeV}$

*Our aim is:*

- *To find out physical variables (Energy, PT, angle and invariant mass distributions) most suitable for signal (stop) / background (top) separation*
- *To estimate the corresponding values of cuts on these variables*

Corresponds to

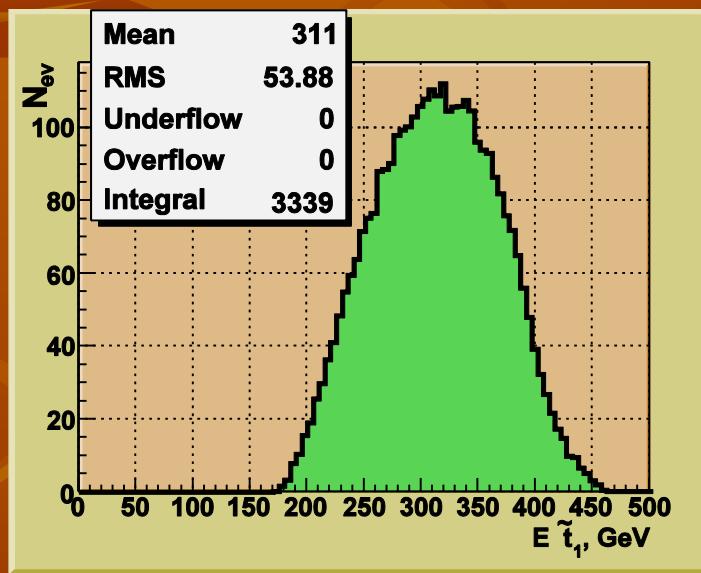
$$M_{\text{stop}} = 167.9 \text{ GeV},$$

$$M_{\chi^0} = 80.9 \text{ GeV}$$

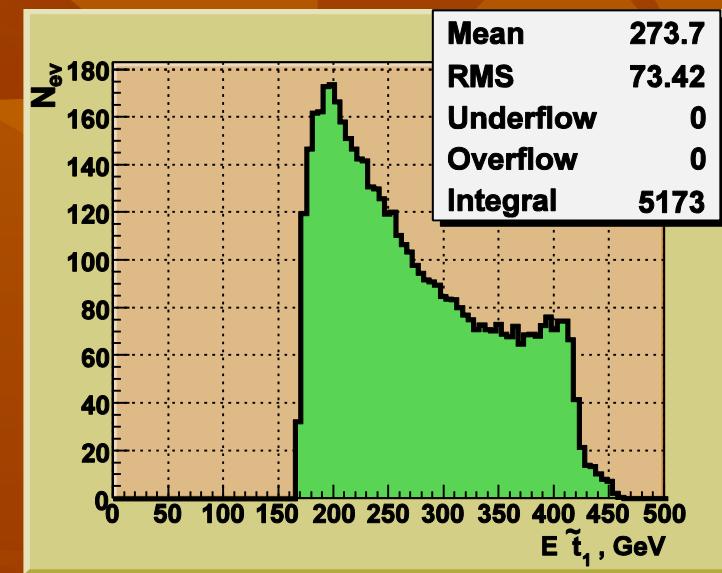
$$M_{\chi^{1+}} = 159.2 \text{ GeV}$$

# STOP Energy distributions

The shapes of these spectra follow backscattered  $\gamma$ -energy distributions

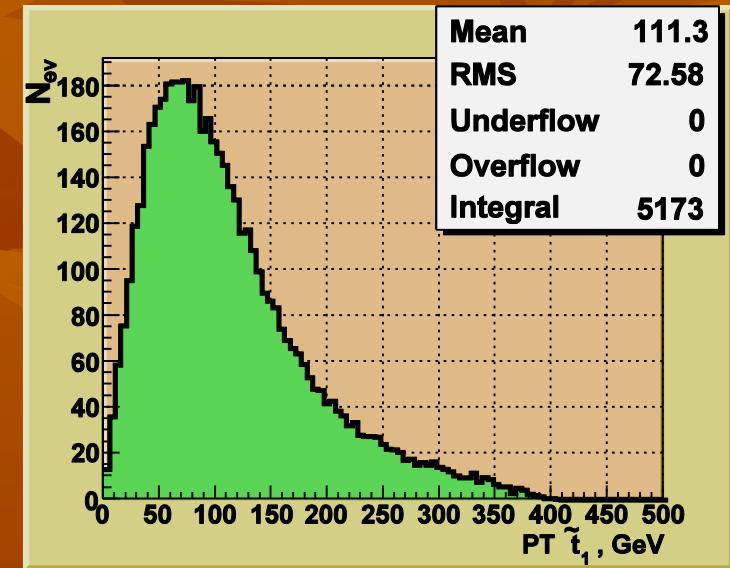
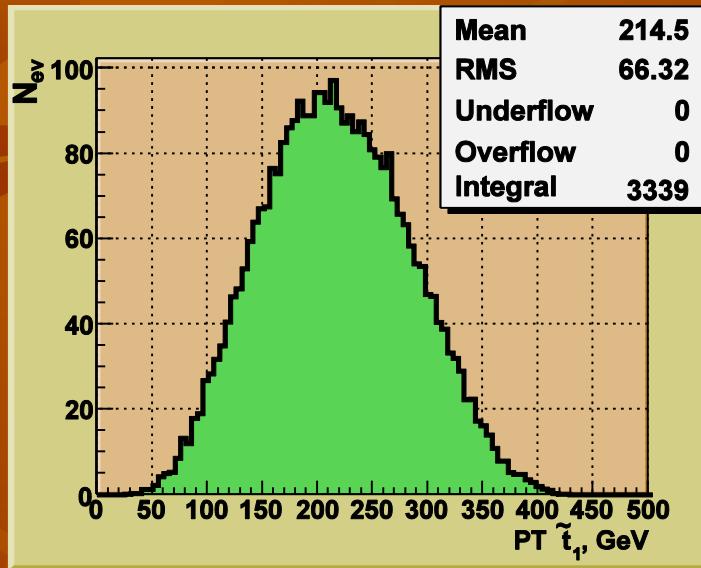


Polarization : +- / -+



Polarization : +++/-

# STOP P<sub>T</sub> distributions

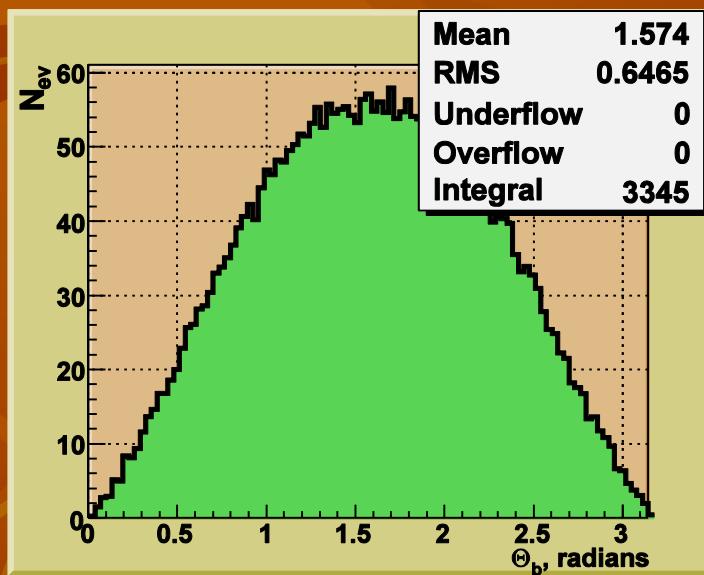


Polarization :  $+-/-+$

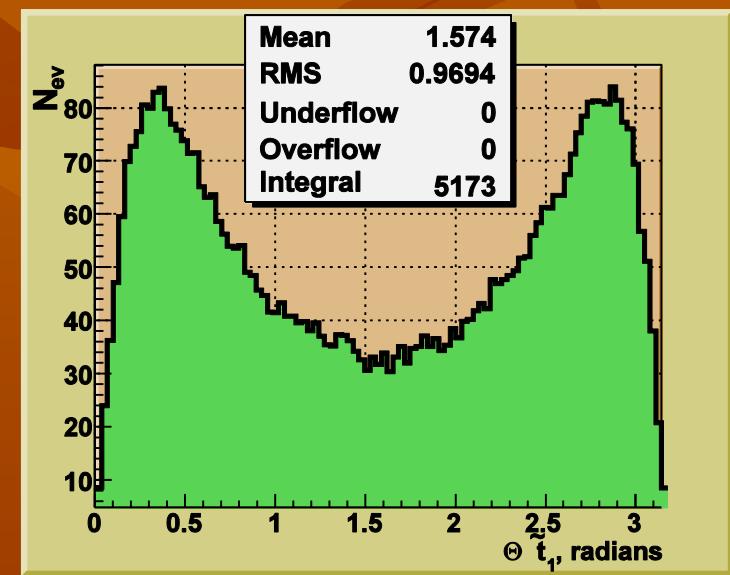
Polarization :  $++--$

The PT-spectrum for “ $++--$ ” polarization is much softer then for “ $+-/-+$ ” polarization

# STOP angle $\Theta$ distributions



Polarization : +- / +-

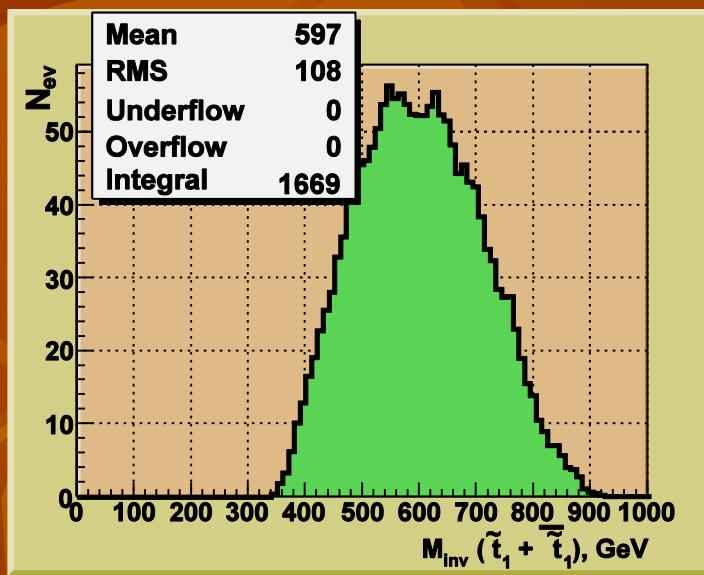


Polarization : ++/ --

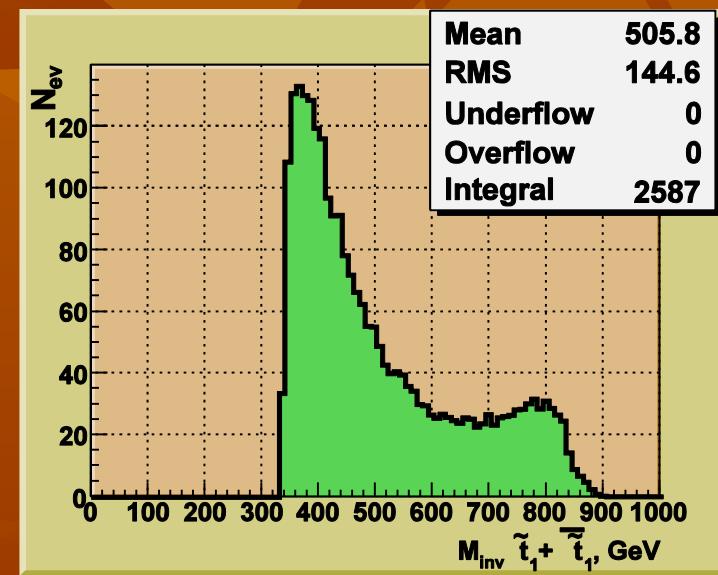
$$M_{inv}(\text{stop} + \text{stop}_{\bar{\text{bar}}}) = M_{inv}(\gamma\gamma) = \sqrt{(P\gamma_1 + P\gamma_2)^2}$$

# distributions

The shapes of these spectra also follow backscattered  $\gamma$ -energy distributions



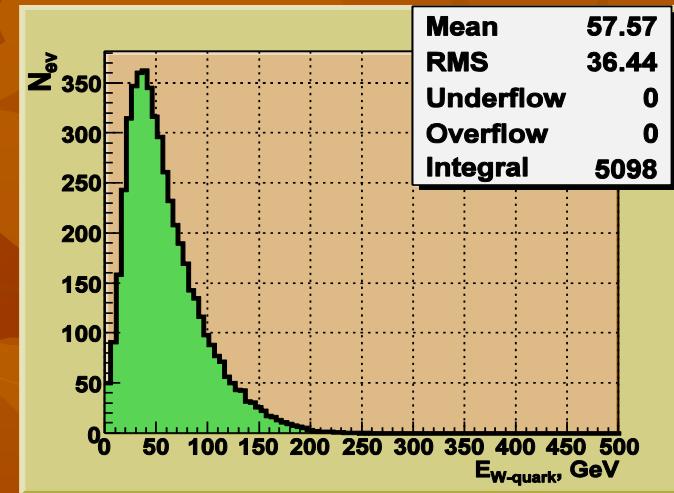
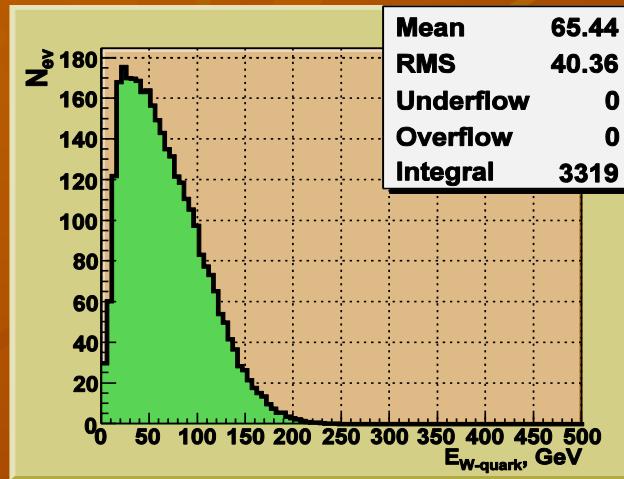
Polarization : +- / -+



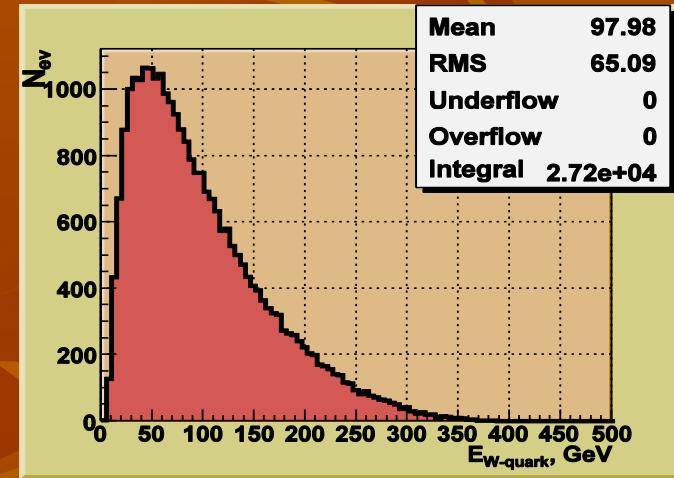
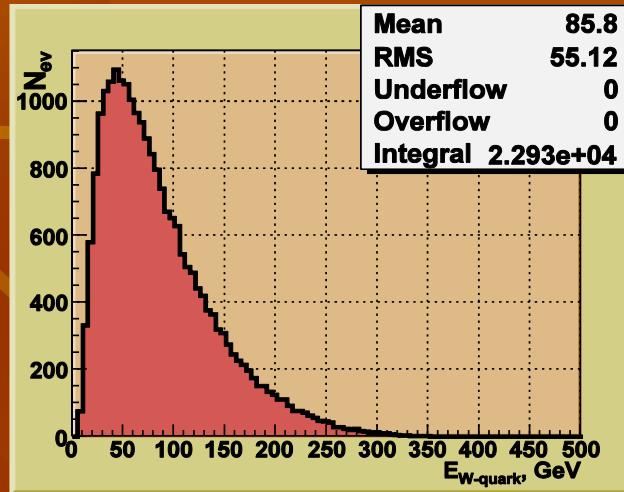
Polarization : +++-

# E- spectra of quarks from W

**STOP**



**TOP**

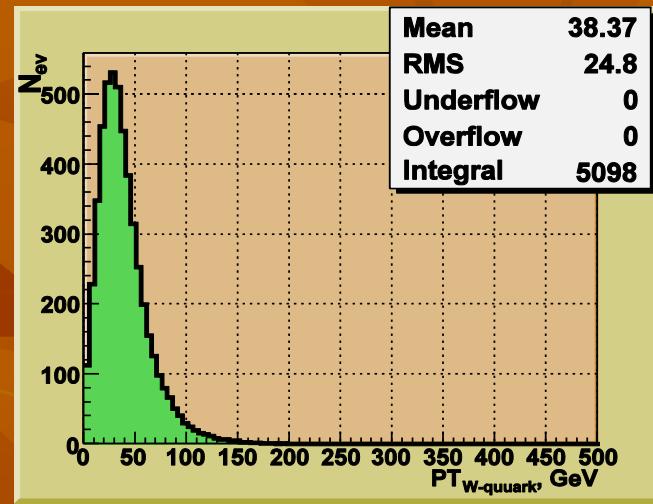
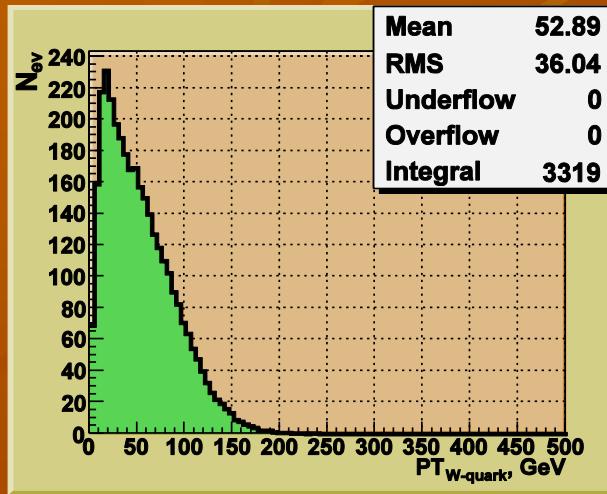


Polarization : +- / -+

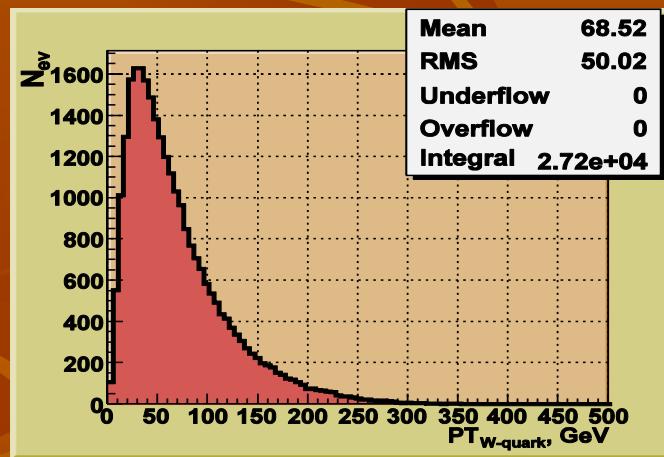
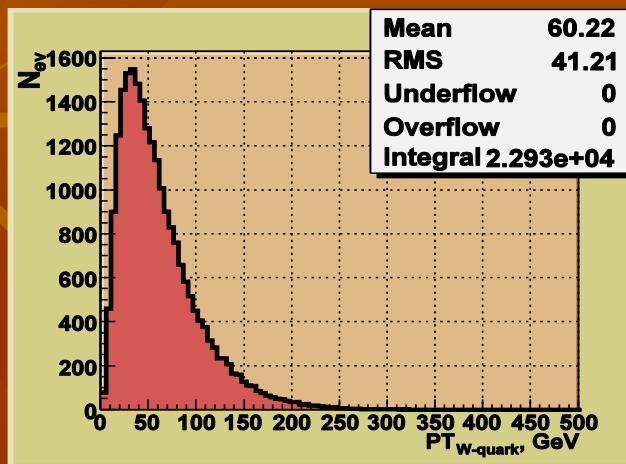
Polarization : ++/ --

# PT- spectra of quarks from W

STOP



TOP

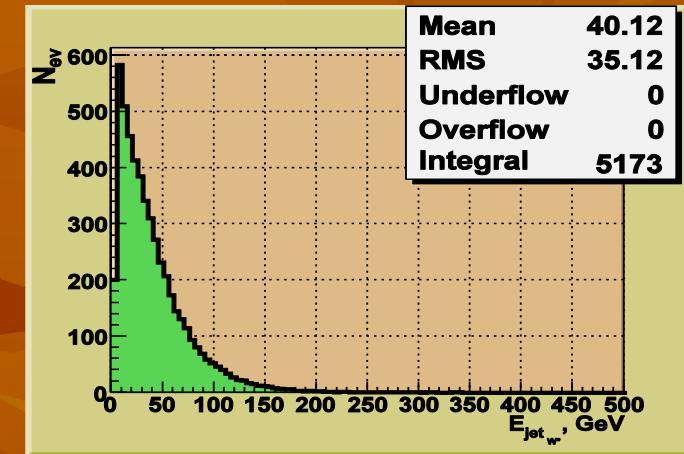
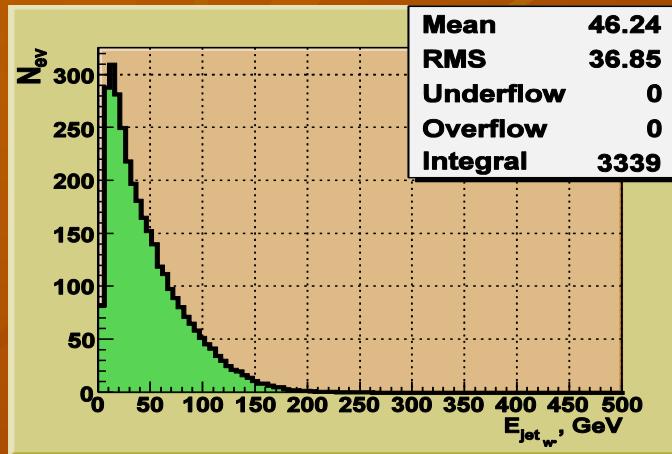


Polarization :  $+- / -+$

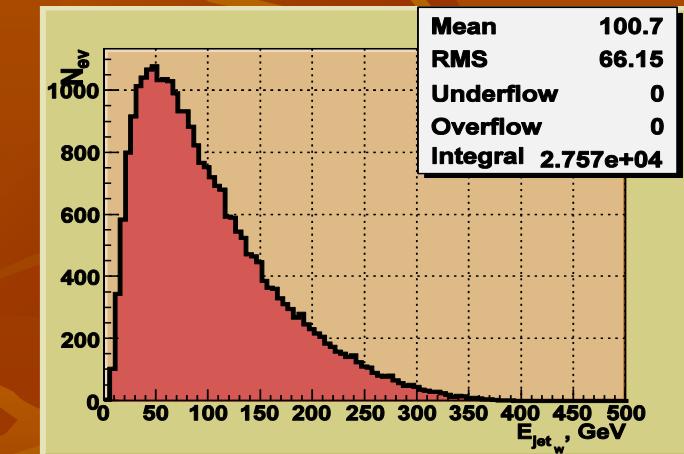
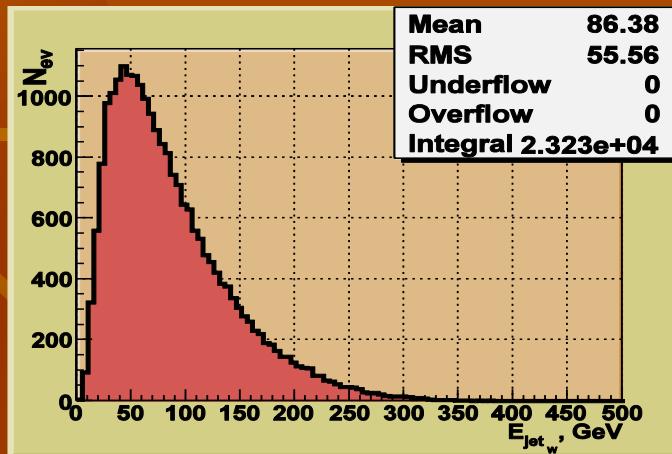
Polarization :  $++ / --$

# E- spectra of jets from W

STOP



TOP

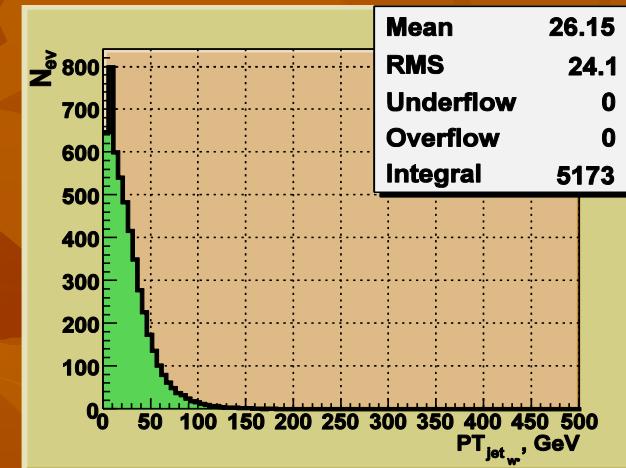
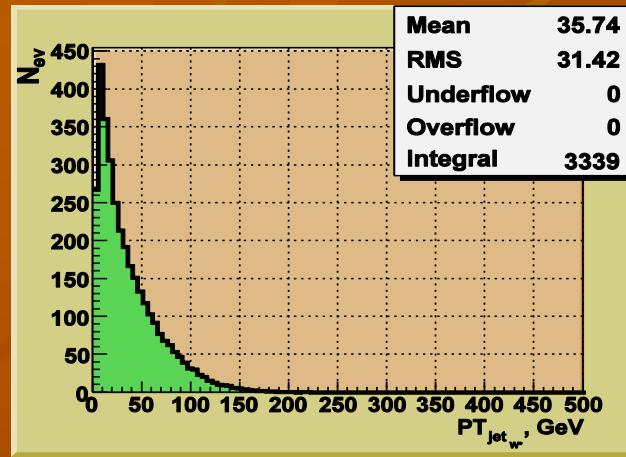


Polarization : +- / -+

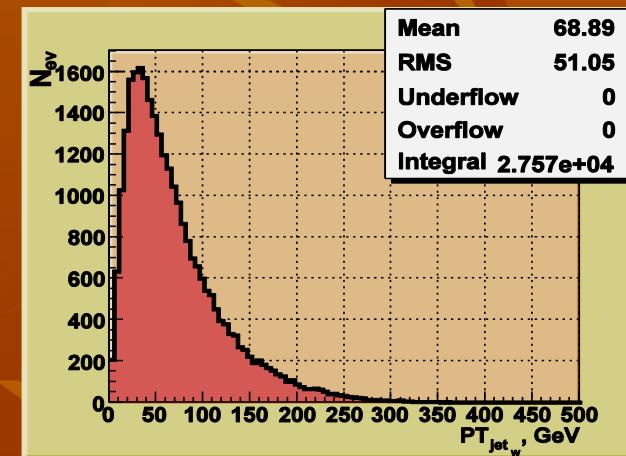
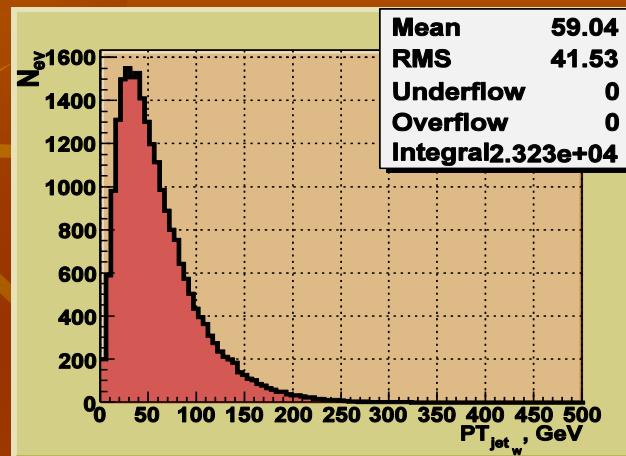
Polarization : ++/ --

# PT- spectra of jets from W

**STOP**



**TOP**

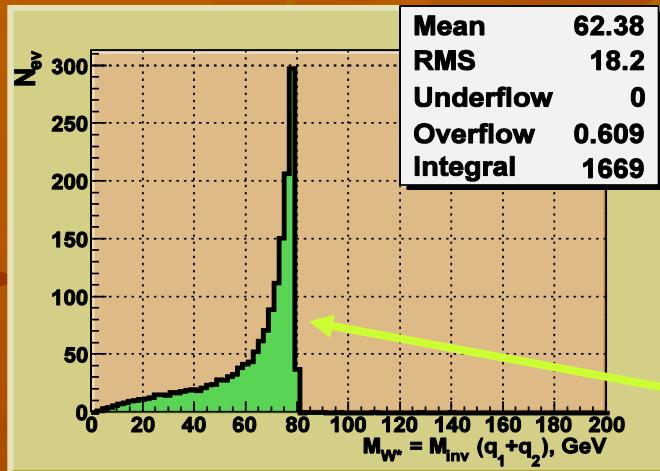


Polarization : +- / +-

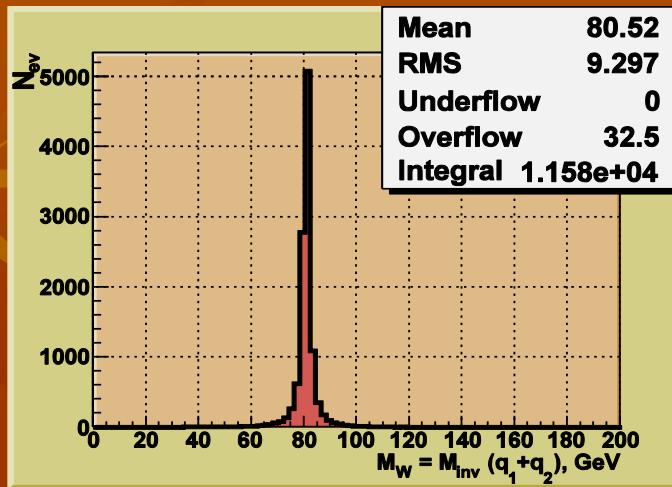
Polarization : +- / +-

# W mass reconstruction as $M_{\text{inv}}$ of 2 W jets

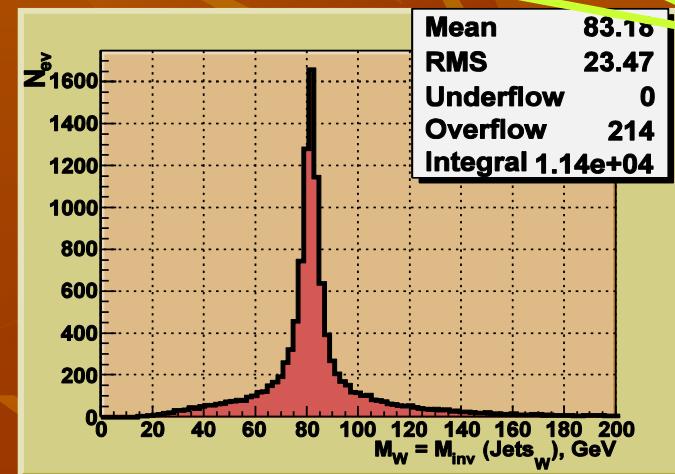
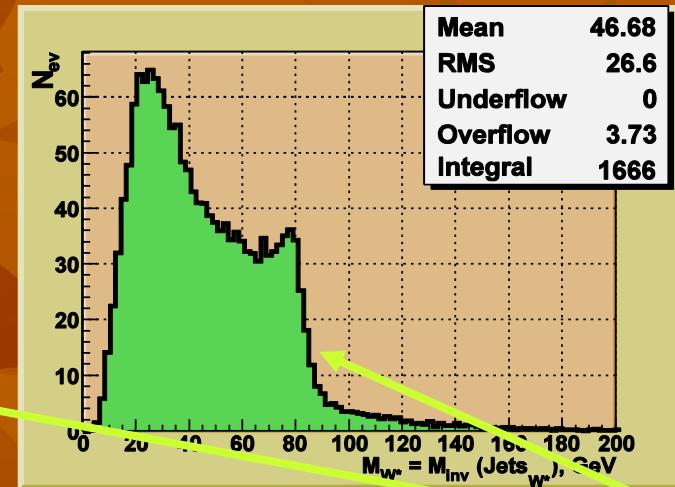
STOP



TOP



Partonic level

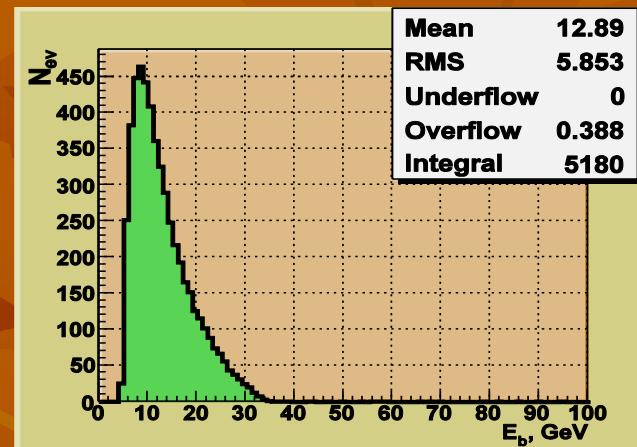
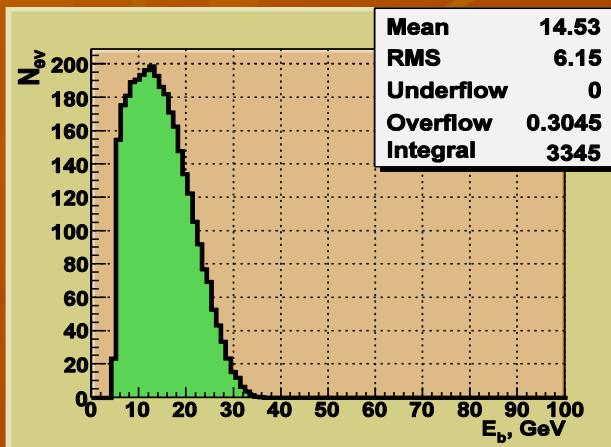


Level of jets

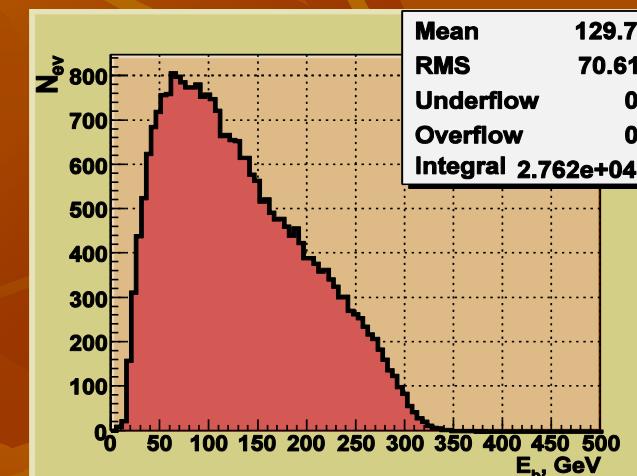
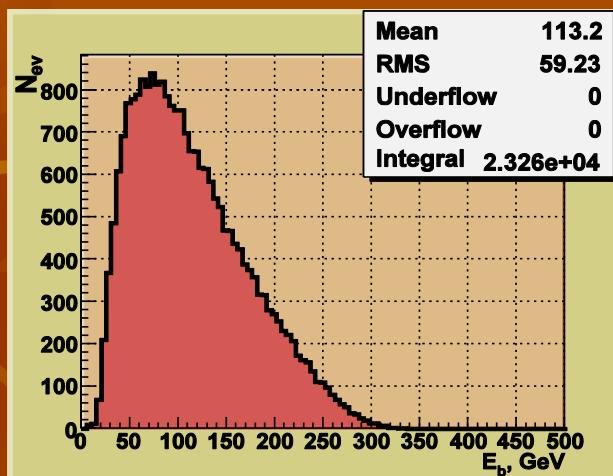
Clear seen visible virtual nature of W boson

# E- spectra of b-quarks

STOP



TOP

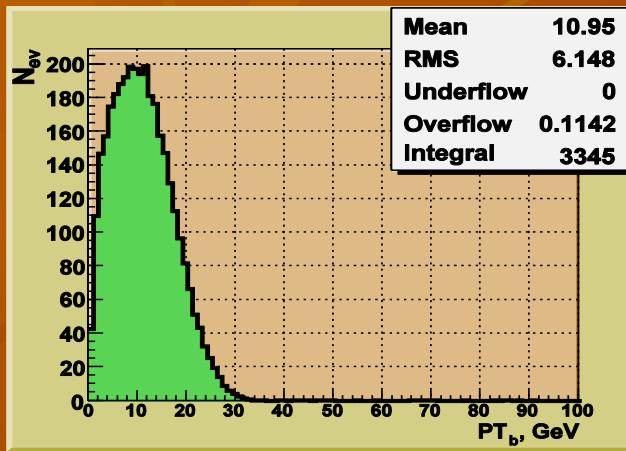


Polarization : +- / -+

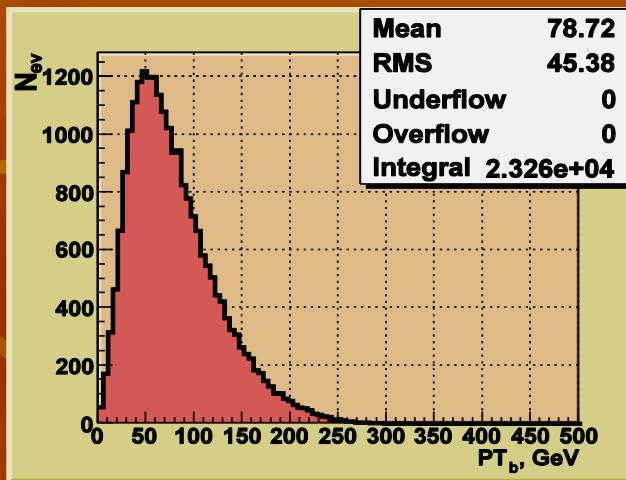
Polarization : ++/ --

# PT- spectra of b-quarks

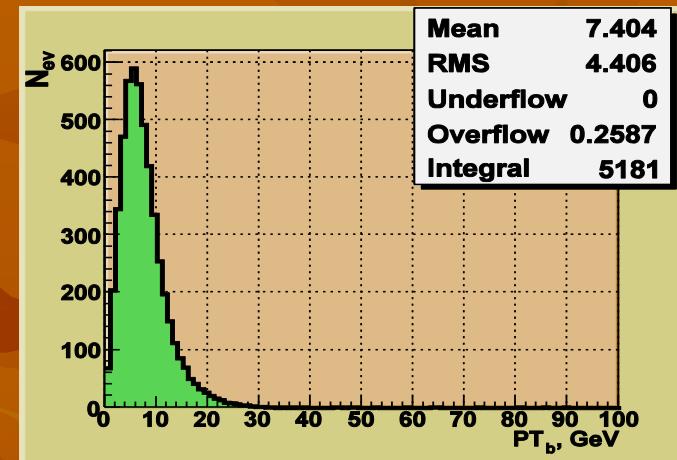
STOP



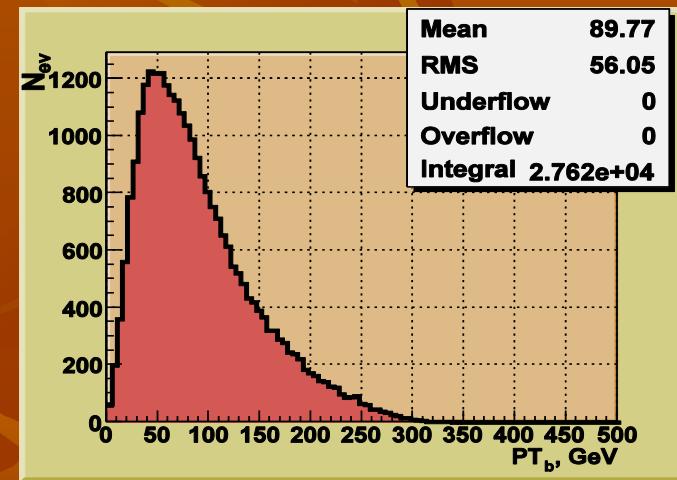
TOP



Polarization :  $+- / -+$



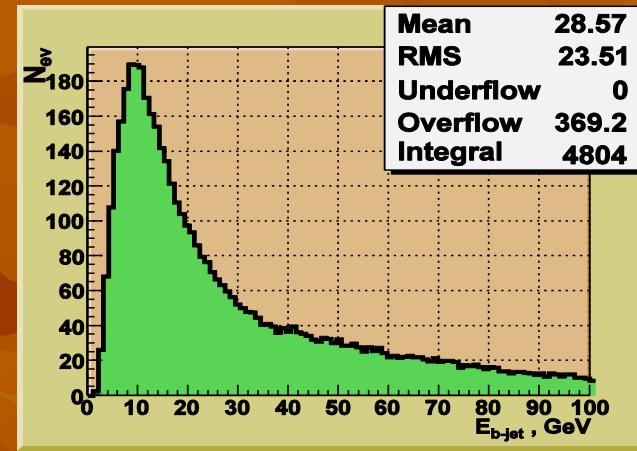
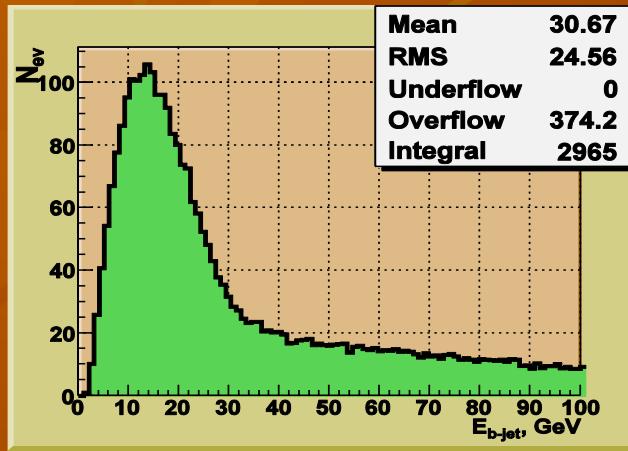
Polarization :  $+++ / --$



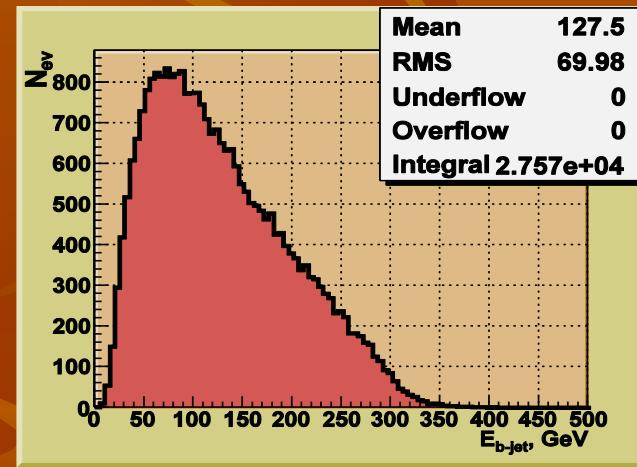
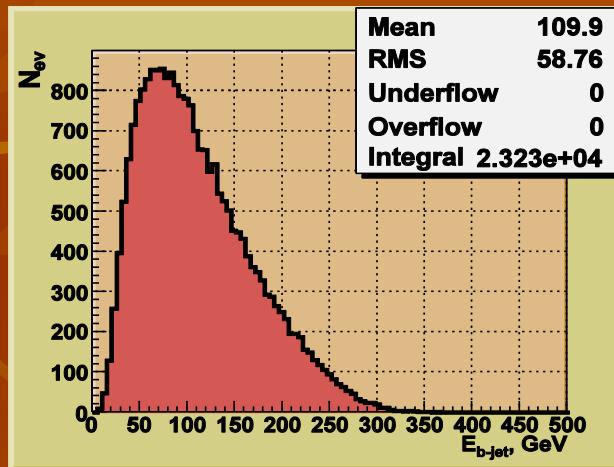
# E- spectra of $b$ -jets

( $B$ -jet is determined as a jet that includes  $b$ -meson)

STOP



TOP

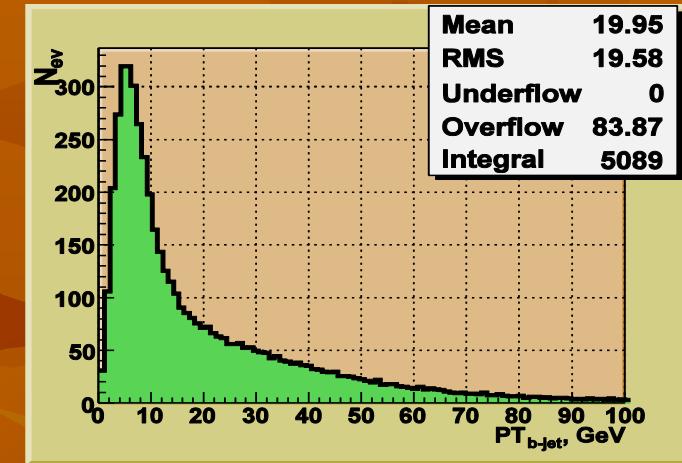
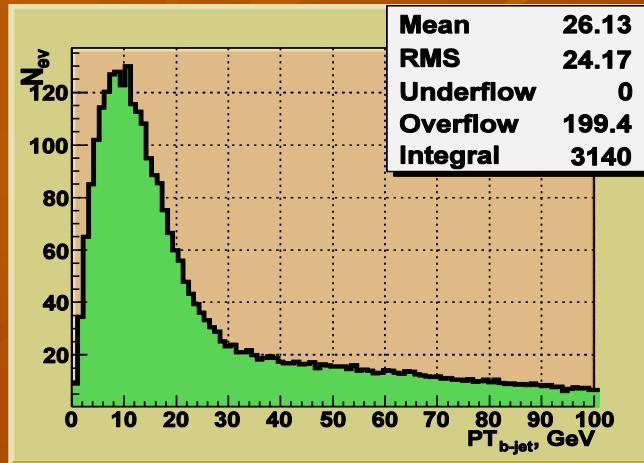


Polarization : +- / -+

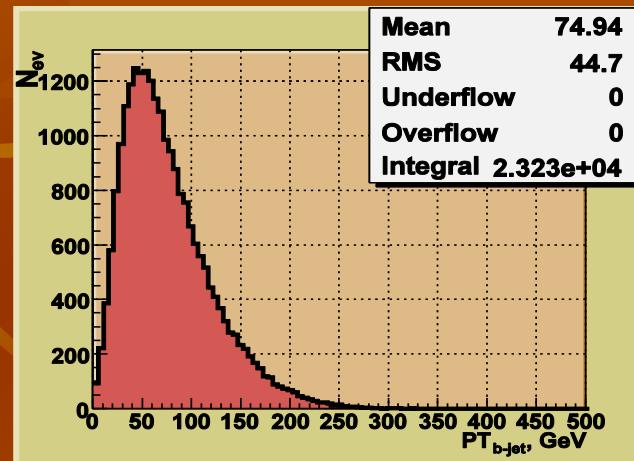
Polarization : ++/ --

# PT- spectra of $b$ -jets

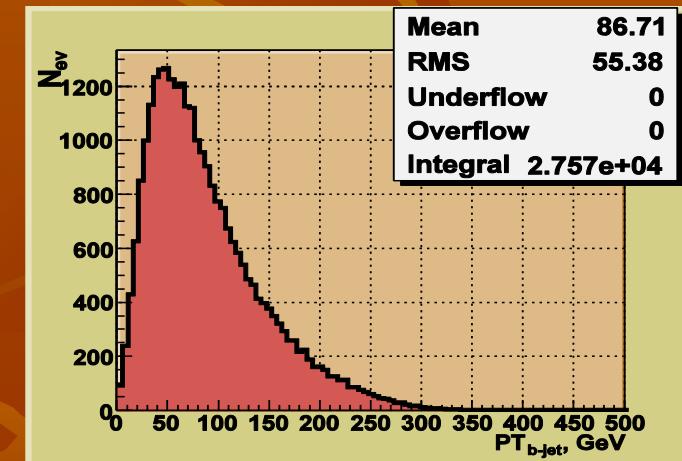
**STOP**



**TOP**

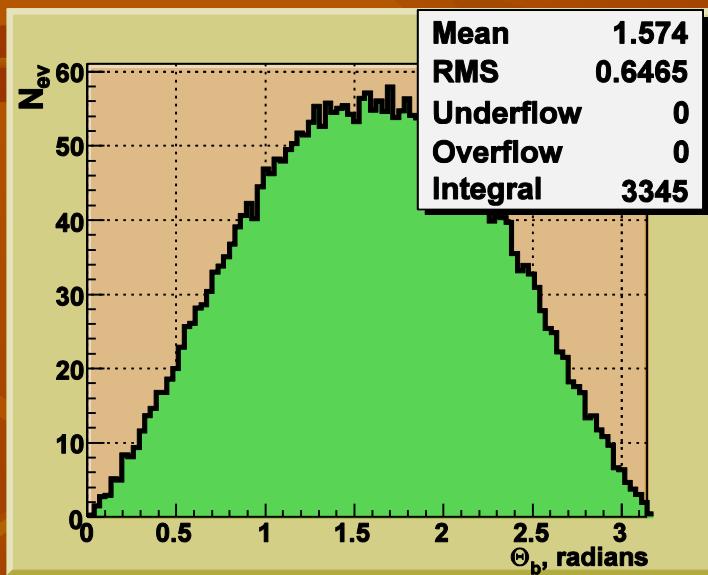


Polarization : +- / -+

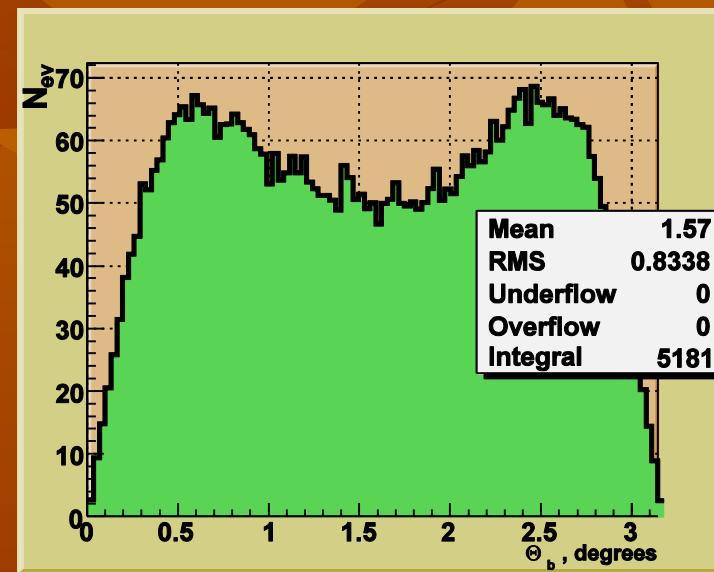


Polarization : ++/ --

# of b-quarks for stop production

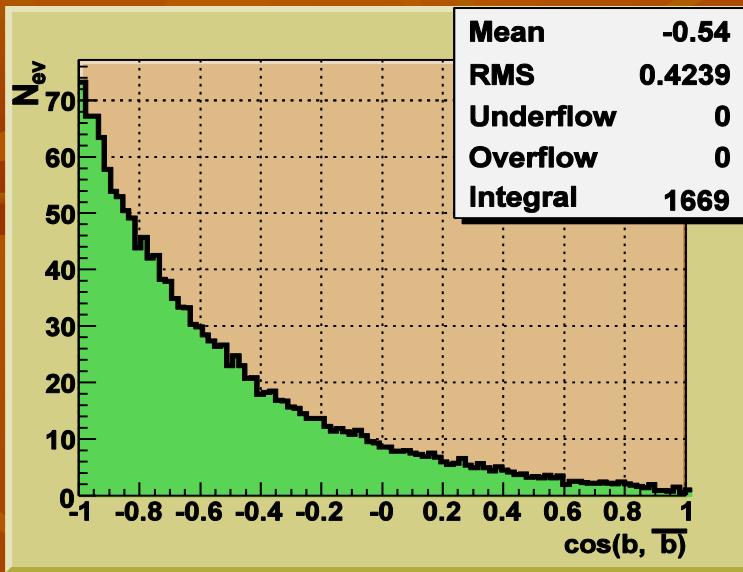


Polarization : +- / -+

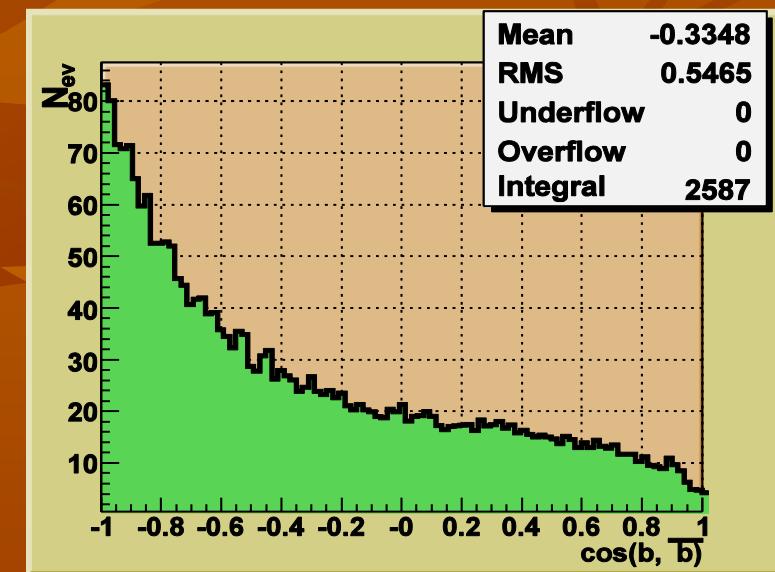


Polarization : ++/ --

# Cos (b, b<sub>bar</sub>) spectra for Stop pairs production



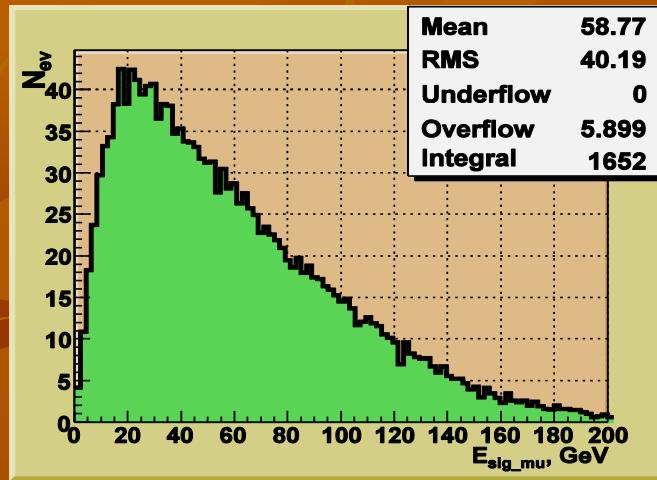
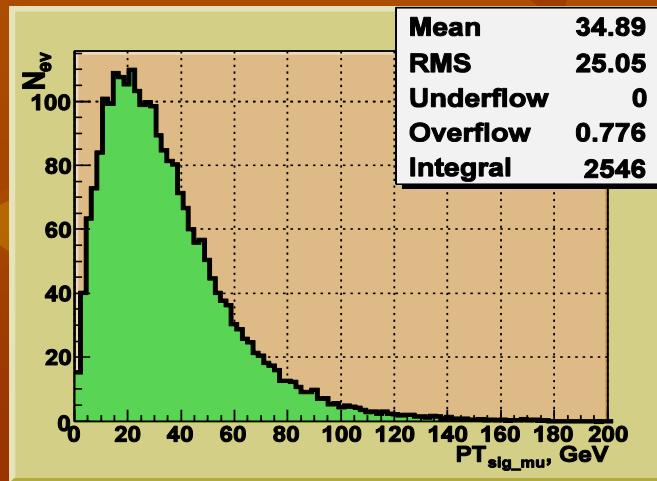
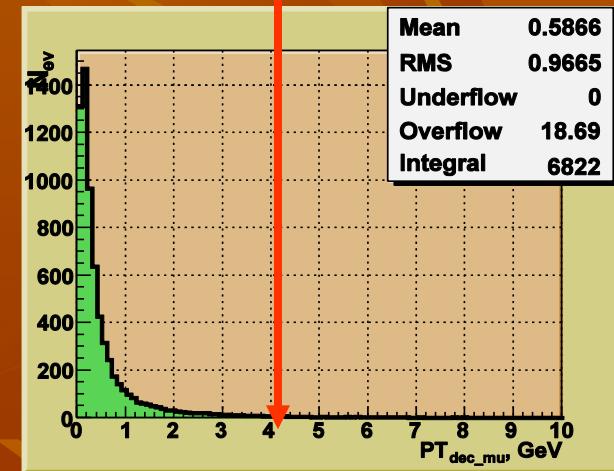
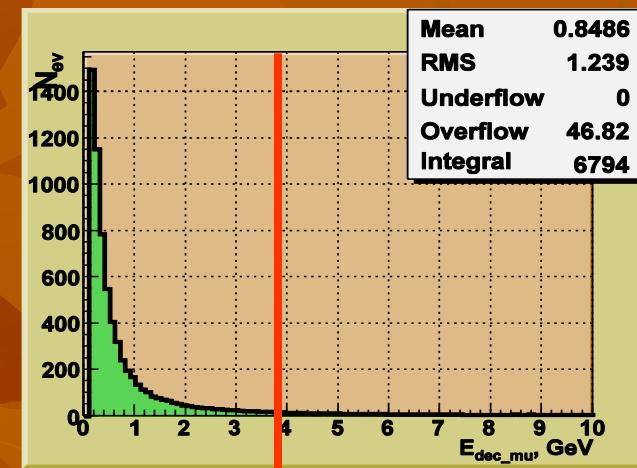
Polarization : +- / -+



Polarization : ++ / --

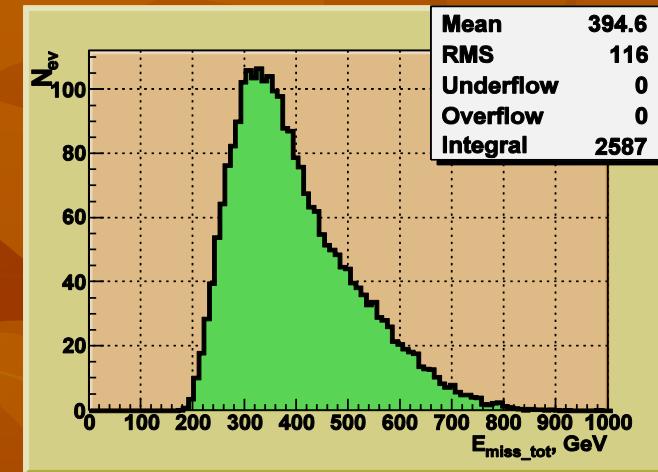
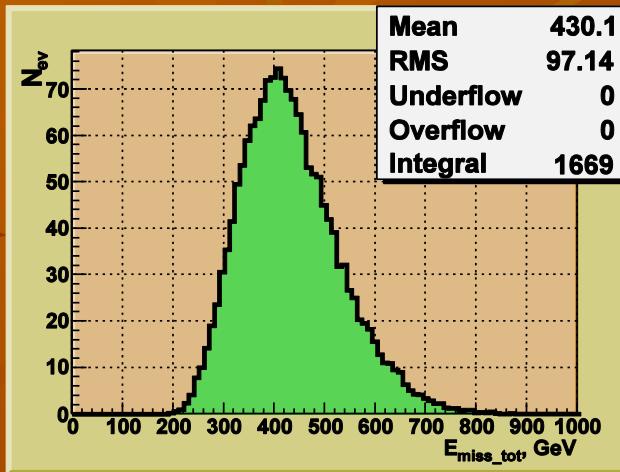
Most of  $b$ - and  $b\ bar$  – jets move approximately in the opposite directions,  
but some are in the same hemisphere

# $\mu$ distributions in the signal events

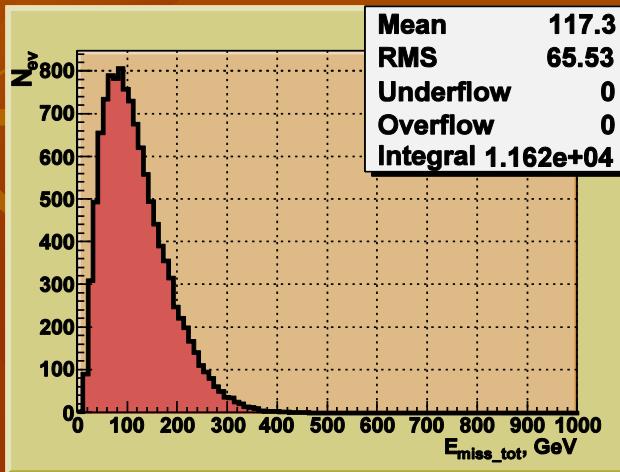
 $E_\mu$  $P_T \mu$ Signal  $\mu$ 'sFake  $\mu$ 's

# Missing energy ( $\nu_\mu$ , $\sim\chi_1^0$ , beam pipe) distributions

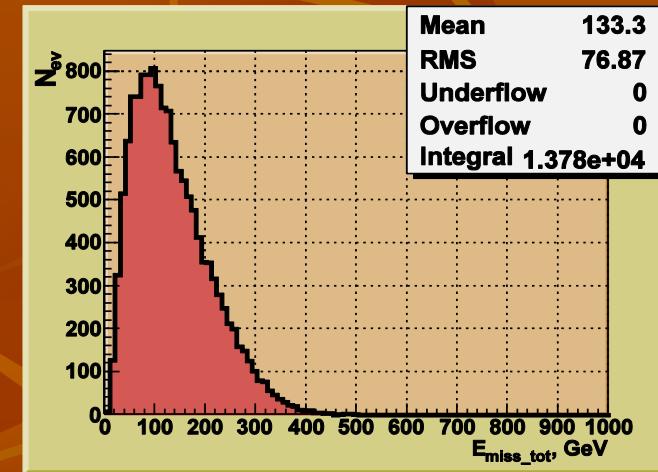
STOP



TOP



Polarization : +- / -+

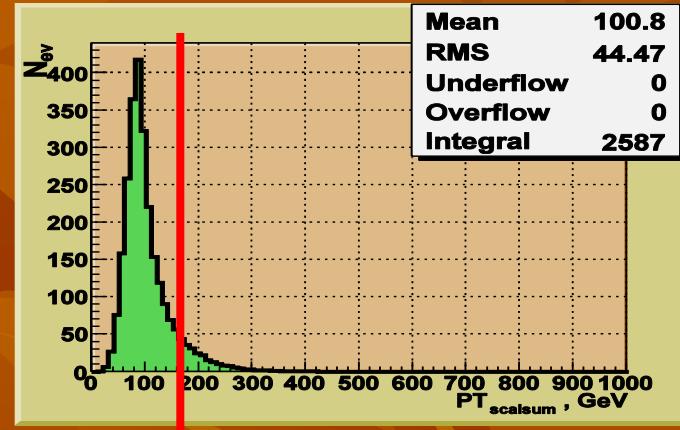
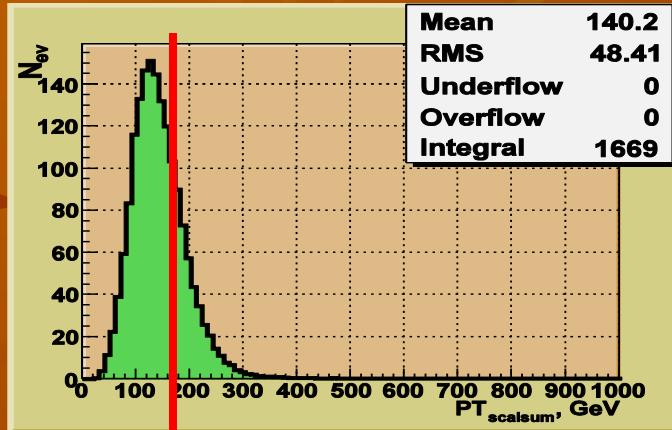


Polarization : ++ / --

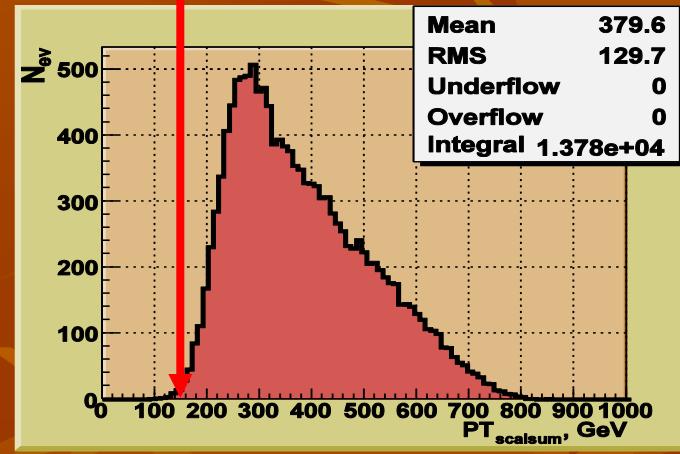
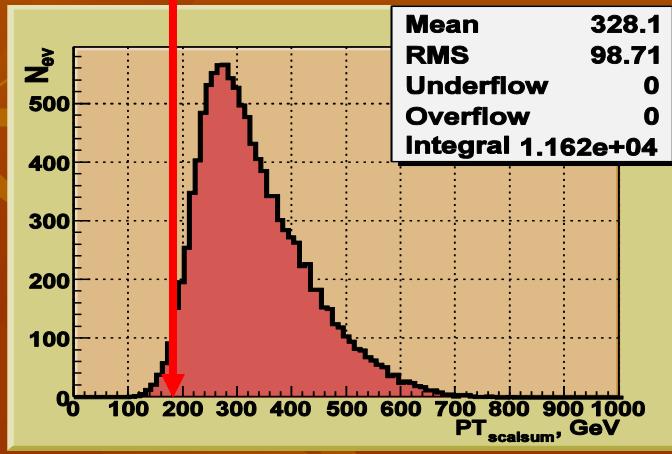
# Total scalar $\sum_{i=1}^n |\text{PT}_i|$ variable

A cut  $\text{PT}_{\text{skalsum}} < 180 \text{ GeV}$  would lead to a good Signal / Background separation

STOP



TOP



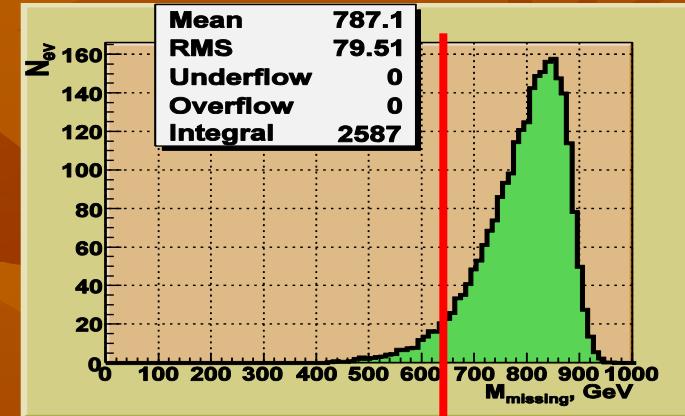
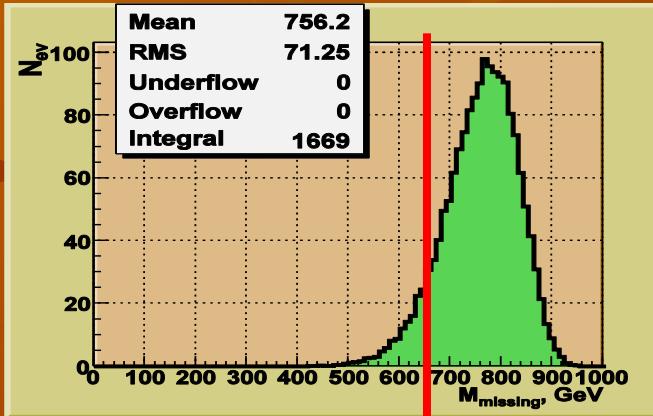
Polarization : +- / -+

Polarization : ++ / --

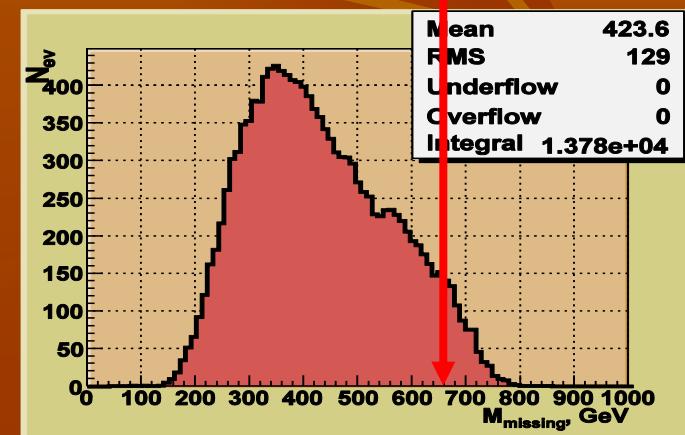
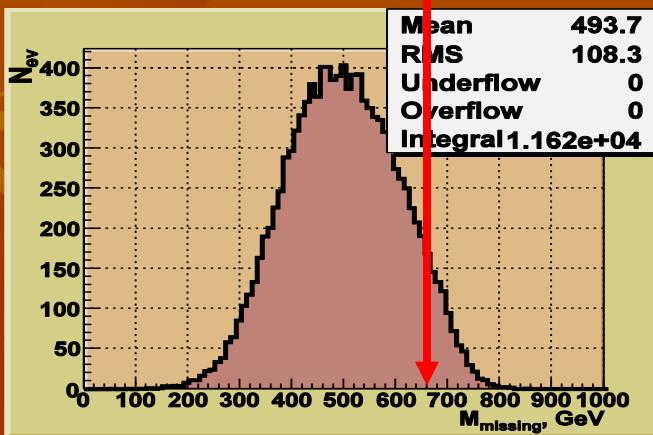
# Missing mass

$$M_{\text{missing}} = \sqrt{(\sqrt{s} - (\sum_{n=1}^{N_{\text{jet}}} E_{\text{jet}}^n + E_{\mu}))^2 - (\sum_{n=1}^{N_{\text{jet}}} P_{\text{jet}}^n + P_{\mu})^2}$$

STOP



TOP



Polarization : +- / -+

Polarization : ++ / --

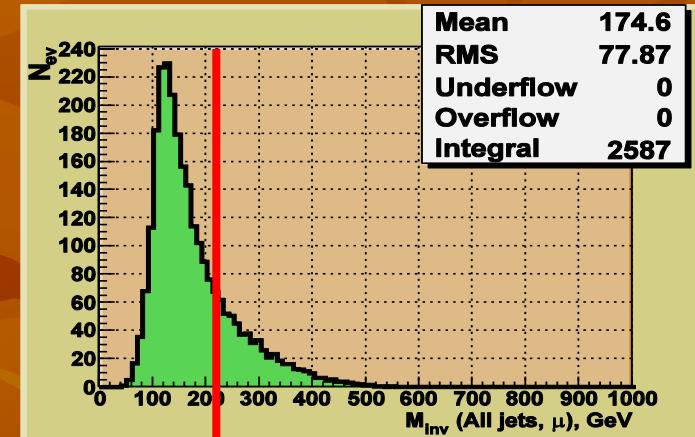
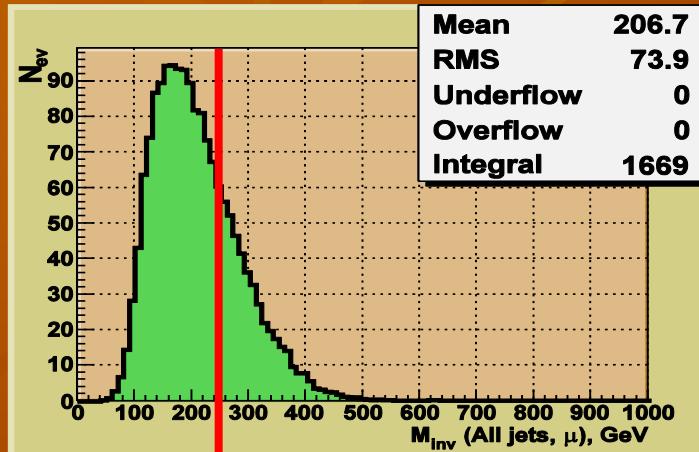
Good for Signal / Background separation !

$M_{\text{missing}} > 650$  GeV

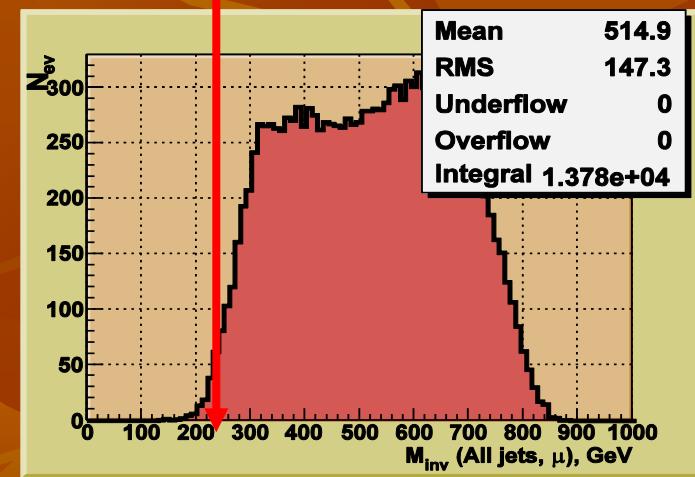
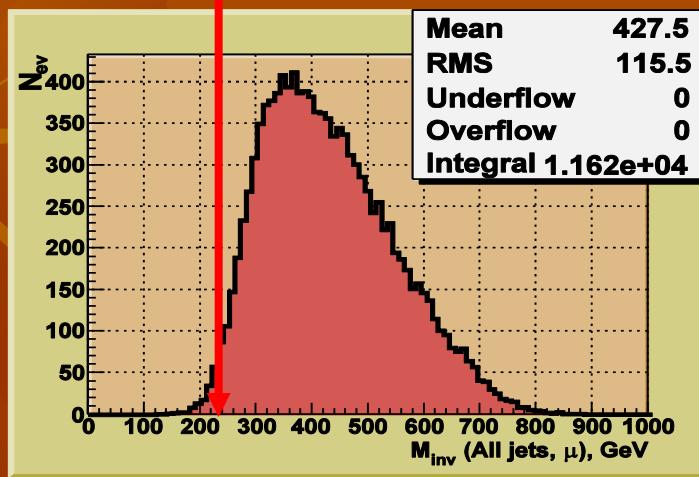
# Invariant mass of 4jets + $\mu$

Good for Signal / Background separation with a cut < 230 GeV!

STOP



TOP



Polarization : +- / -+

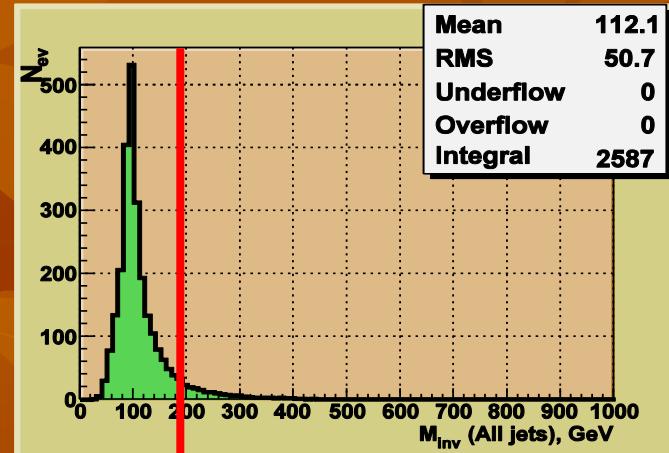
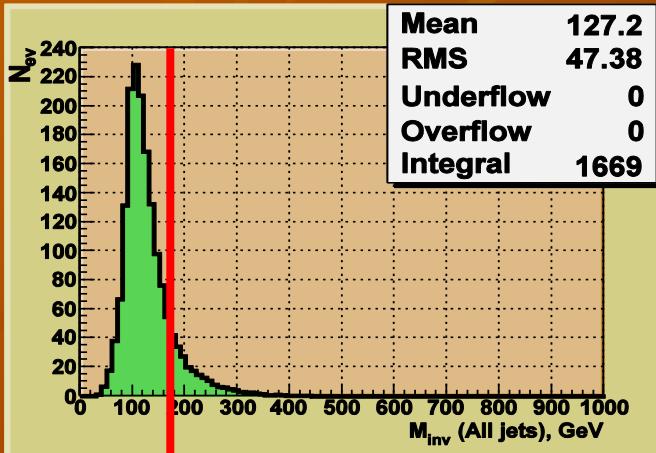
Polarization : ++ / --

# Invariant mass of 4 jets

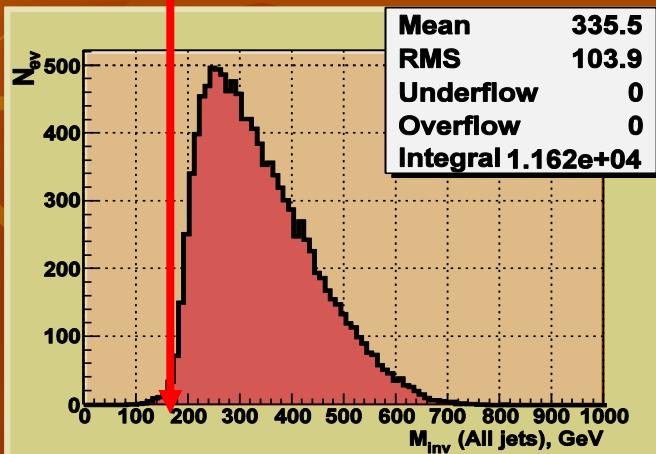
$$M_{inv}(All\ jets) = \sqrt{(\sum_{i=1,2,3,4} P_{jet}^i)^2}$$

Perfect for Signal / Background separation with cut  $M_{inv} < 180$  GeV!

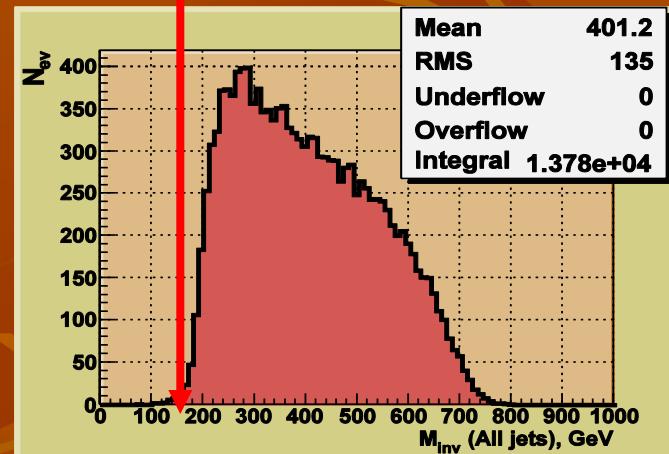
STOP



TOP



Polarization : +- / -+

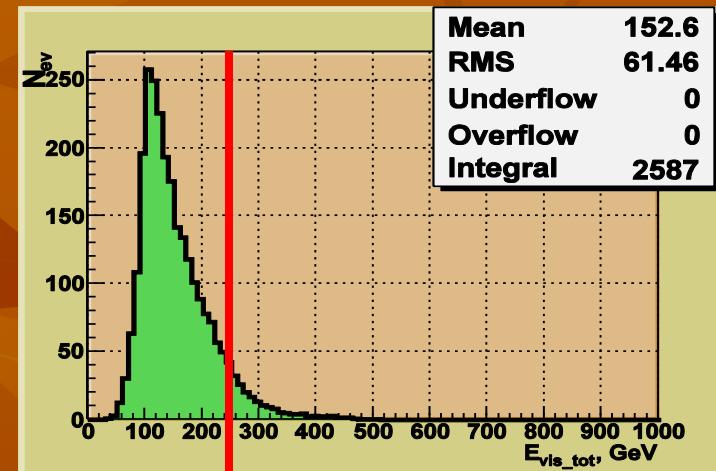
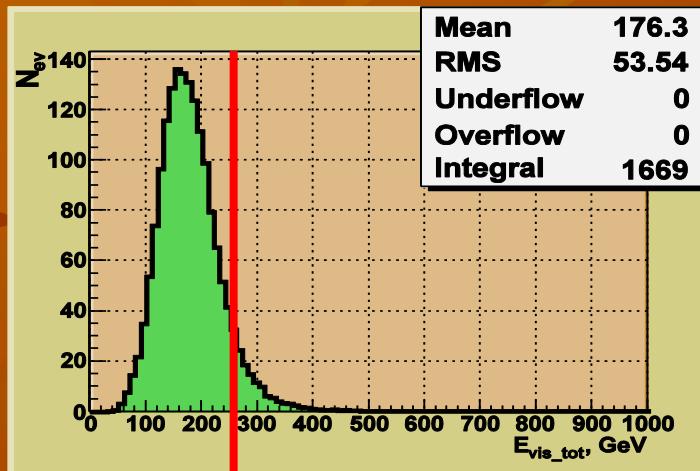


Polarization : ++ / --

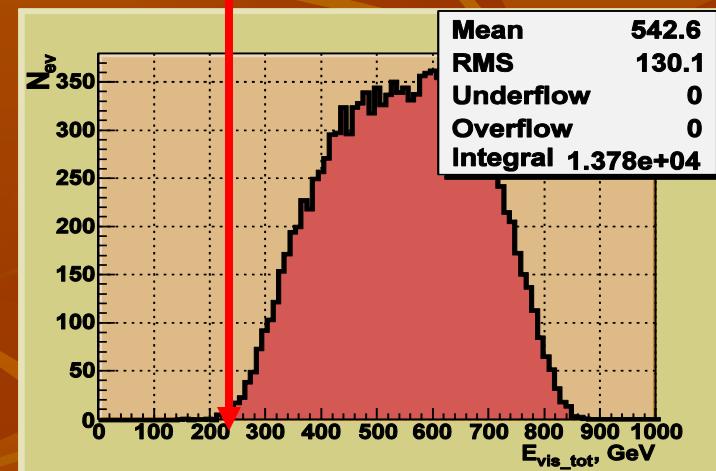
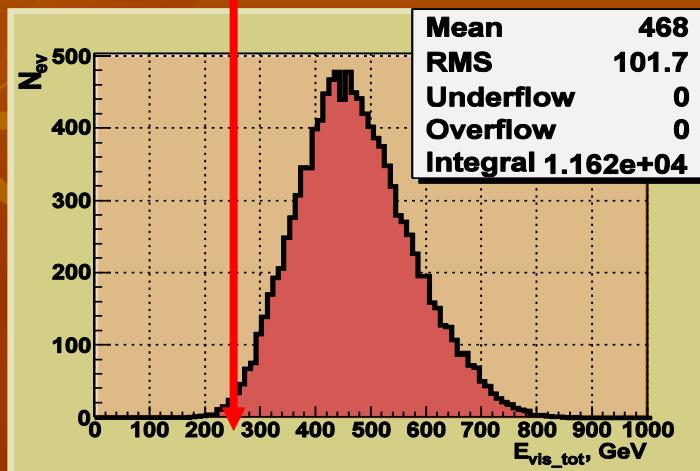
# Detected (visible) energy distributions

Perfect for Signal / Background separation with a cut  $E_{\text{vis\_tot}} < 250 \text{ GeV}$  !

STOP



TOP



Polarization : +- / -+

Polarization : ++ / --

# Used cuts for S/B separation

Polarization : +- / -+

Polarization : ++ / --

## 1.) The events with clear recognized 2 B-jets (according to PYTHIA)

*Stop cut efficiency = 0.88*

*Top cut efficiency = 0.94*

*Stop cut efficiency = 0.80*

*Top cut efficiency = 0.94*

But, in the experiment only 50% efficiency of the B-jets and  $B_{\bar{}}^{}-jets$  separation and the 80% of the corresponding purity is expected

## 2.) Invariant mass of all jets $M_{inv}(All\ jets) < 180\ GeV$

*together with the cut above*

*Stop cut efficiency = 0.89*

*Top cut efficiency = 0.012*

*Stop cut efficiency = 0.92*

*Top cut efficiency = 0.008*

## 3.) Visible energy < 250 GeV

*together with the cut above*

*Stop cut efficiency = 0.98*

*Top cut efficiency = 0.176*

*Stop cut efficiency = 0.98*

*Top cut efficiency = 0.175*

# Final results of S/B separation

Polarization : +- / -+

Polarization : ++ / --

Achieved S/B ratio

**59**

**120**

With a loss of signal events

23 %

28 %

The rest of Background events per year is only

**24**

**19**

while the estimated rate of Signal events per year

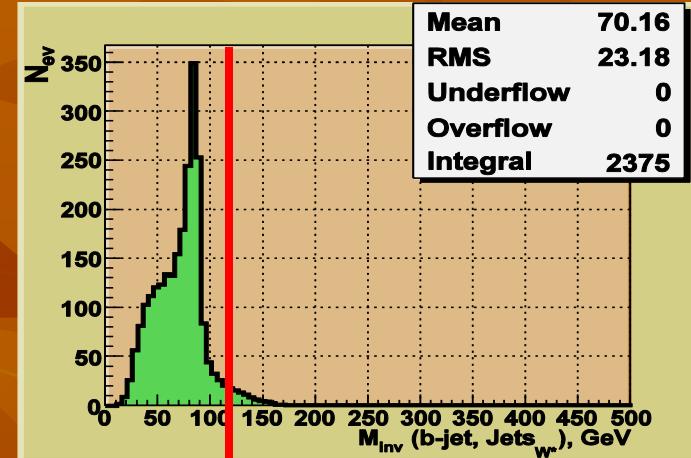
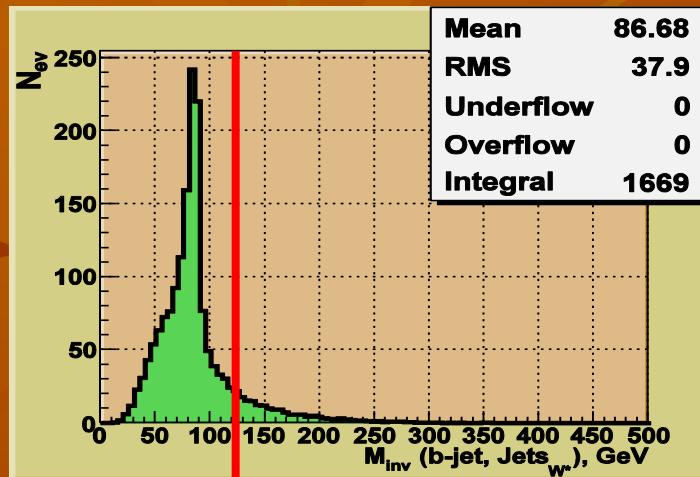
**1484**

**2375**

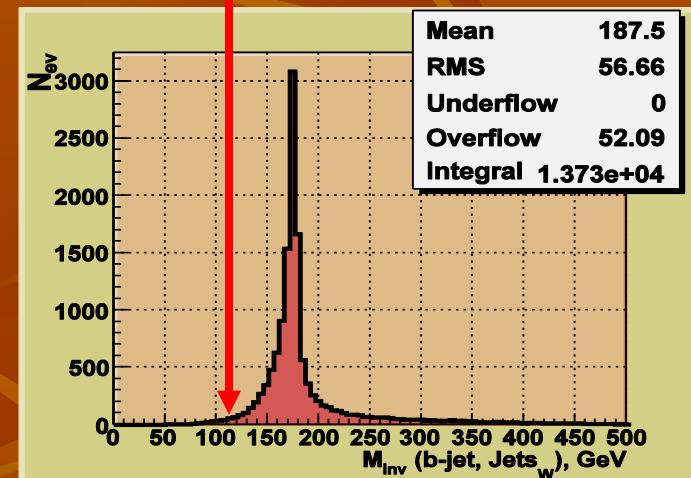
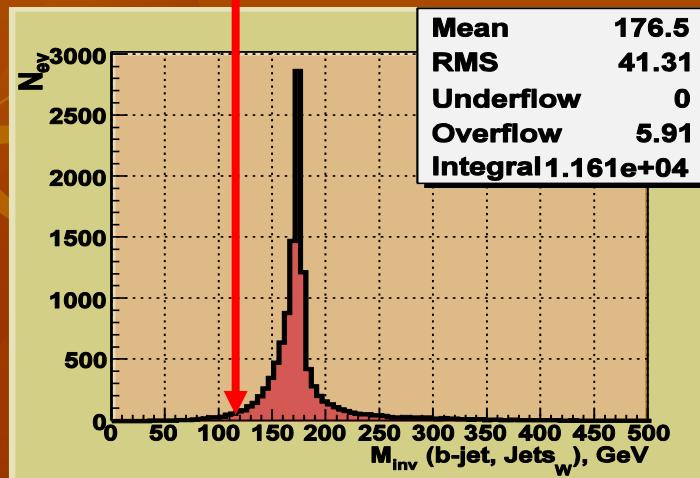
# Invariant mass of $B_{jet}$ & 2jets<sub>W</sub>

Can also be used for Signal / Background separation with a cut < 120 GeV!

STOP



TOP



Polarization : +- / -+

Polarization : ++ / --

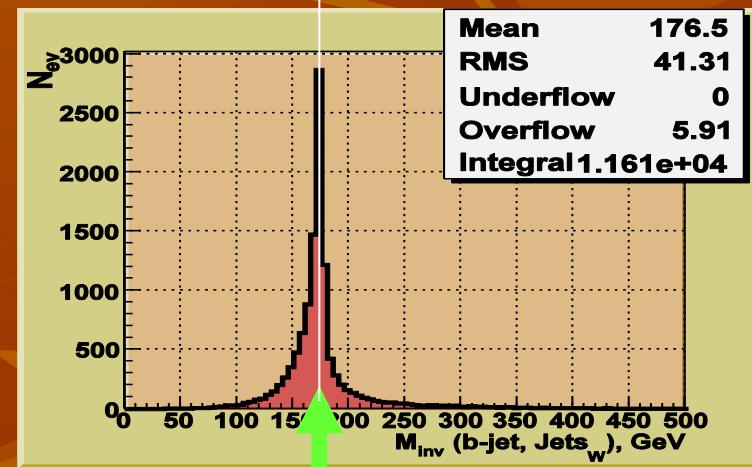
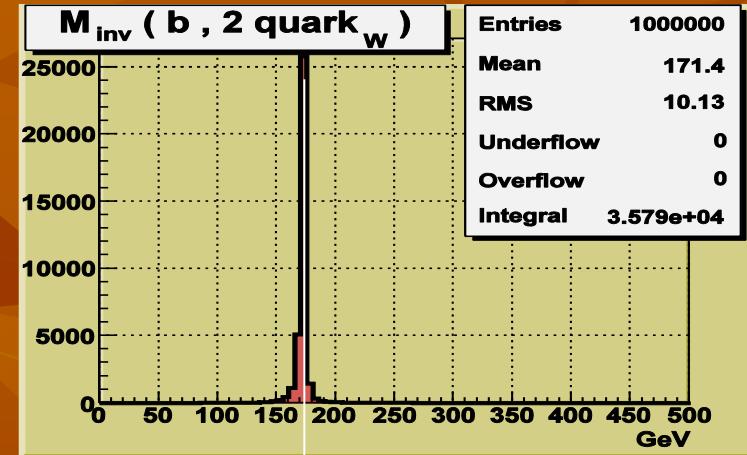
# The most important variable - invariant mass of $B_{jet}$ & $2jets_W$

In the case of *TOP pair* production it gives

The mass reconstruction of the

top-quark  $M_{Top}$  (175 GeV) :

$$M_{inv}(B_{jet} \& 2jets_W) = M_{Top}$$



# Stop invariant mass

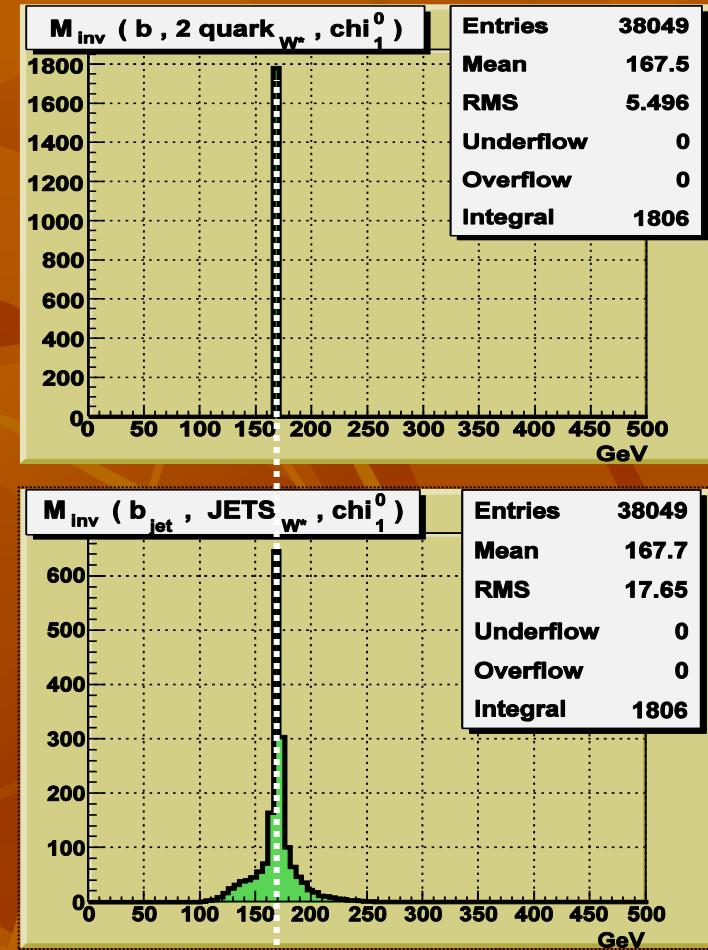
The reconstruction of the STOP invariant mass  $M_{STOP}$  (167.9 GeV):

$$M_{inv}(STOP) =$$

$$M_{\chi_1^0} + M_{inv}(b_{jet}, 2jets_W) =$$

$$= M_{\chi_1^0} + \sqrt{(P_{b_{jet}} + P_{jet1W} + P_{jet2W})^2}$$

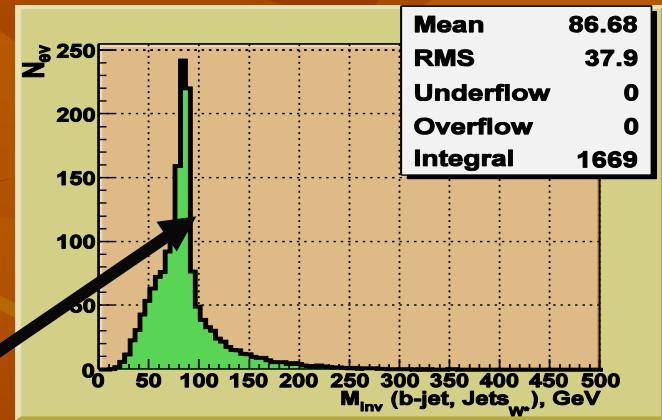
But  $\chi_1^0$  - is not detectable particle



# Invariant mass of $B_{jet}$ & $2jets_W$

For the case of *STOP pair* production gives

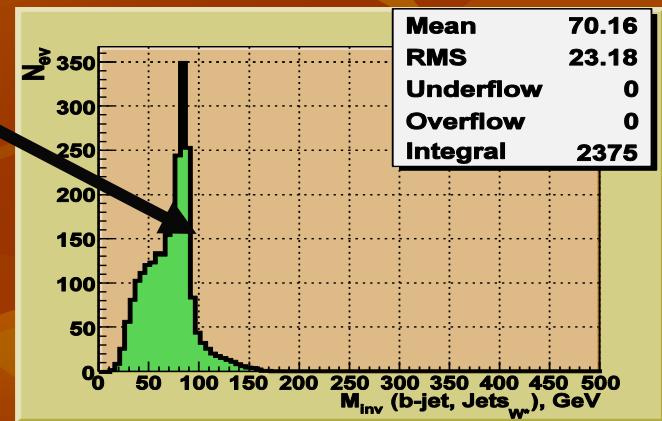
$$M_{inv}(B_{jet}, 2jets_W) = M_{inv}(STOP) - M_{\chi_1^0}$$



Right edge of  $M_{inv}(B_{jet}, 2jetW) \approx 87$  GeV

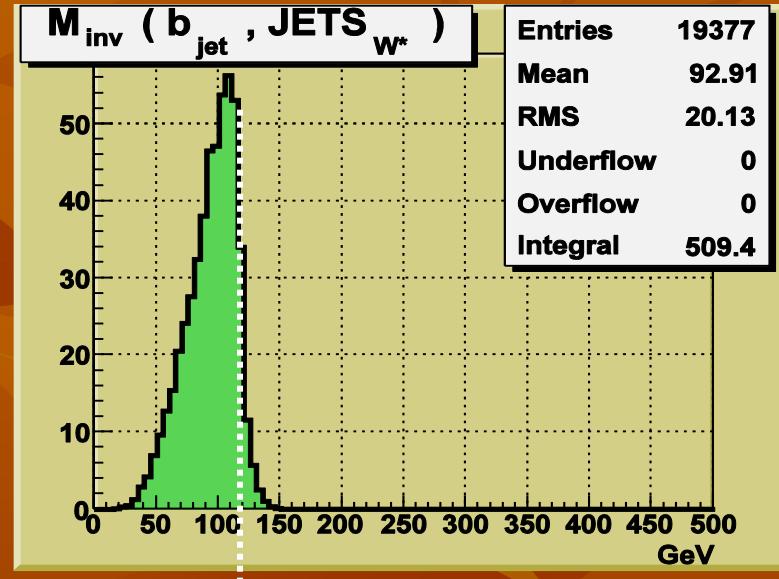
$$M_{\chi_1^0} \approx 80 \text{ GeV}$$

$$\begin{aligned} M_{stop} &= M_{\chi_1^0} + M_{inv}(B_{jet}, 2jetW) = \\ &= 167 \text{ GeV} \end{aligned}$$



# The test of the other Scalar top mass

- $M_{stop} = 200.1 \text{ GeV}$
- $M_{\chi_1^0} = 80.9 \text{ GeV}$
- $M_{\chi_1^+} = 159.6 \text{ GeV}$



Right edge of the peak of  $M_{inv}(b_{jet}, 2jet_W)$

$$\approx 120 \text{ GeV}$$

$$M_{\chi_1^0} \approx 80 \text{ GeV}$$

$$M_{stop} = M_{\chi_1^0} + M_{inv}(b_{jet}, 2jet_W) = 200 \text{ GeV}$$

Polarization : +- / -+    ++/-

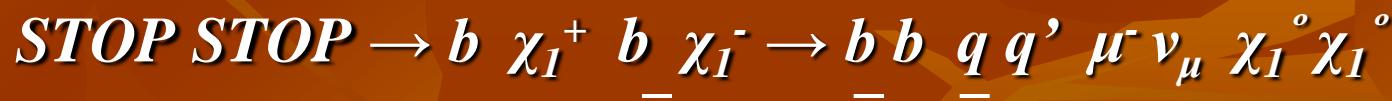
Events/year : 347    1379

# Conclusion

## The main results:

1. New code for cross section of STOP pairs production that allows to take into account the polarizations of colliding photons is implemented into PYTHIA 6.  
An account of the energy spectrum of colliding photons is done by use of CIRCE 2.
2. It is shown also that the invariant mass of the final jets and the visible energy variables turns out to be most efficient for signal / background separation.
3. A possibility of a good  $M_{\text{STOP}}$  reconstruction from right-hand edge point of 3 jets ( Bjet + 2 jets<sub>W</sub> ) is demonstrated.

So, finally, it is shown that in a region of small values of stop mass  $\sim 167$  GeV  
the channel



is very promising for the STOP-quark search!



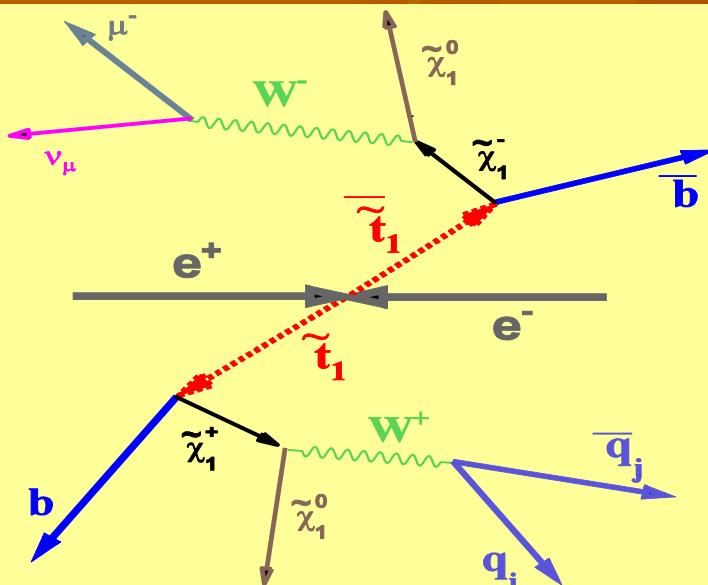
# Publications

- “*Pair production of scalar top quarks in polarized photon-photon collisions at ILC.*”

Authors: A.Bartl, W.Majerotto, K.Mönig,  
A.N.Skachkova, N.B.Skachkov

arXiv: **0804.1700v2**, ILC-NOTE-2007-036

# The case of $e^+e^-$ collisions



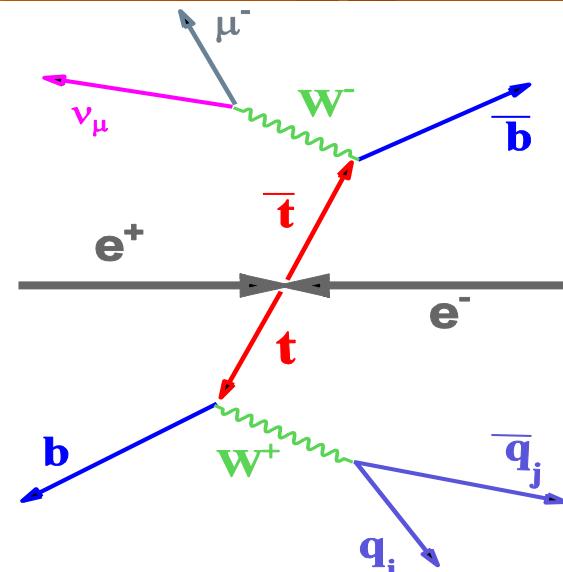
TOP pair production  
cross section

$\sigma = 35.9 \text{ fb}$

$e^+ e^- \text{ CM energy} = 500 \text{ GeV}$

STOP pair production  
cross section

$\sigma = 2.37 \text{ fb}$



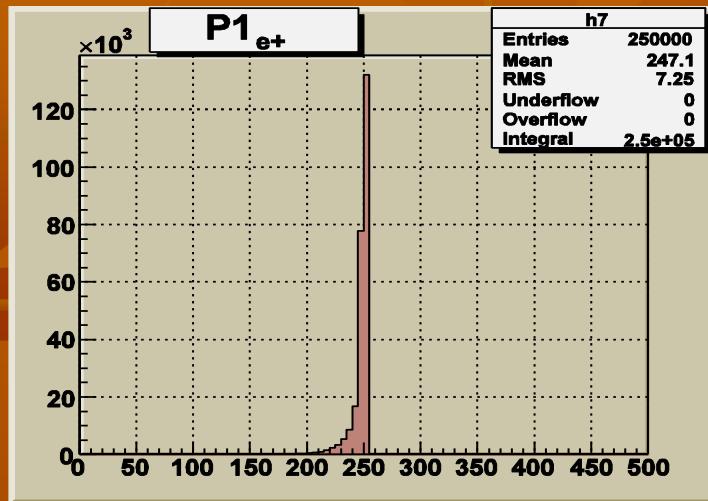
*Simulation is done by use of PYTHIA 6.4 + CIRCE 1*

# Cross section dependence on E<sub>beam</sub>

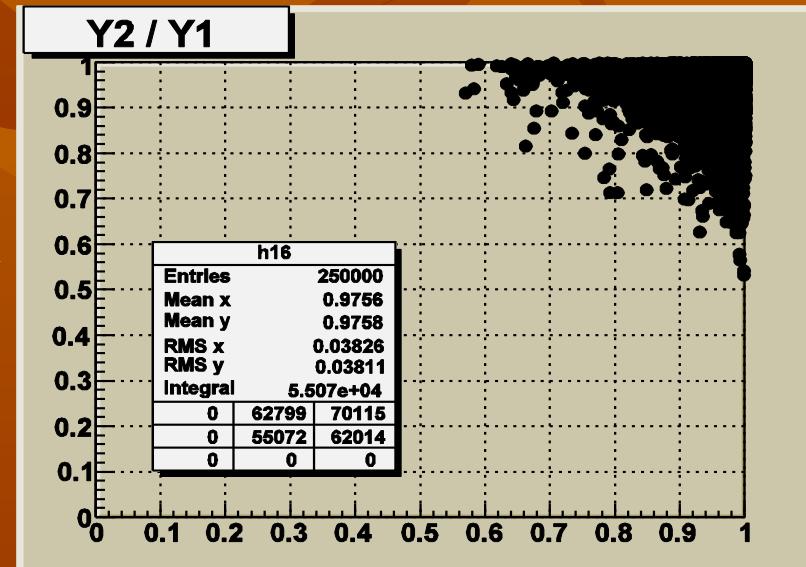
(without any cuts)

2E <sub>beam</sub> [GeV]	$\sigma_{\text{stop}}$ [fb]	N <sub>stop</sub>	$\sigma_{\text{top}}$ [fb]	N <sub>top</sub>
350	0.23	233	13.76	13750
400	1.34	1347	38.79	38740
<u>500</u>	<u>2.37</u>	<u>2378</u>	<u>35.94</u>	<u>35950</u>
800	1.89	1809	17.36	17359
1000	1.42	1265	11.66	11656

# $e^+, e^-$ beam energy spectrum from CIRCE 1



Electron  $e^-$  (positron  $e^+$ ) beam energy  
with account of beamstrahlung



Correlation between  $e^+$  and  $e^-$  beam spectra

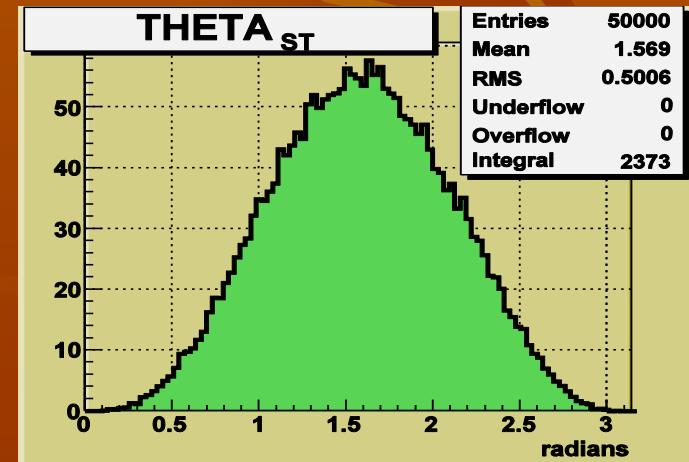
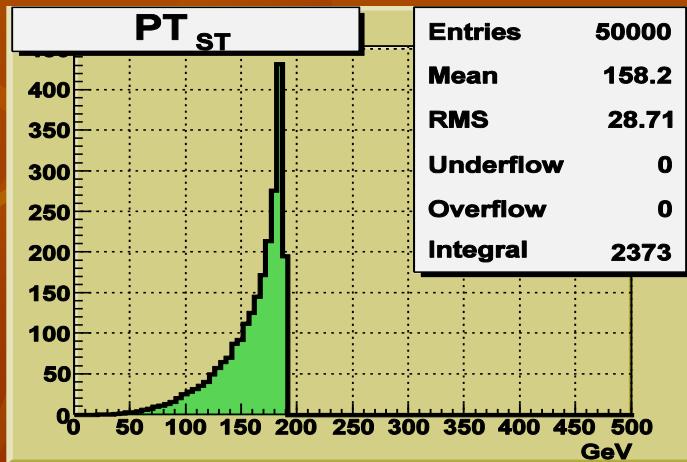
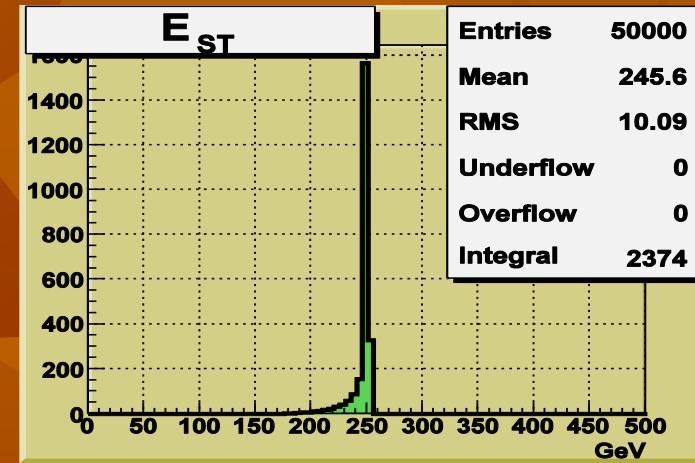
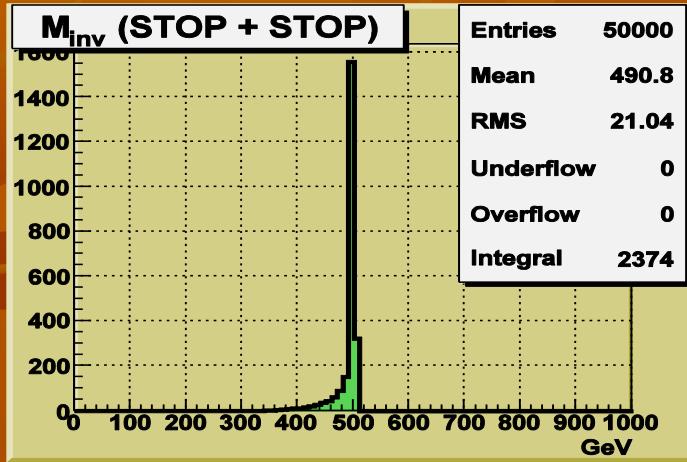
$$Y_i = E^i / E_{\text{beam}}^i \quad (i = e^+, e^-)$$

The peak luminosity is supposed to be  $2 \times 10^{34} \text{ cm}^{-2} \text{s}^{-1}$ .

The total luminosity required is  $1000 \text{ fb}^{-1}$  during the first phase of operation at

$$2E_{\text{beam}}^e = \sqrt{S_{ee}} = 500 \text{ GeV.}$$

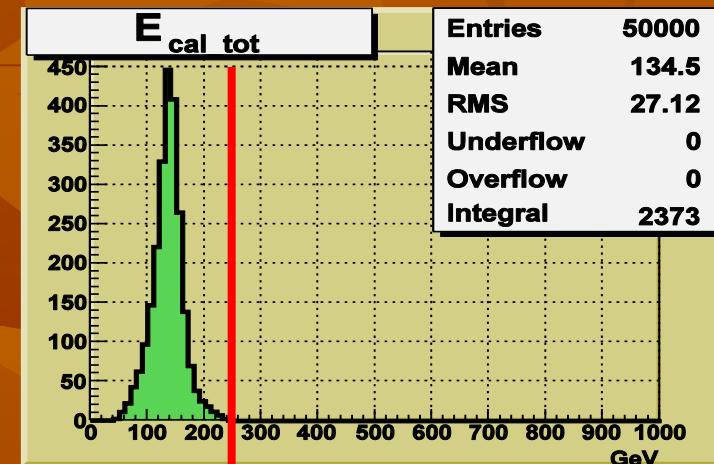
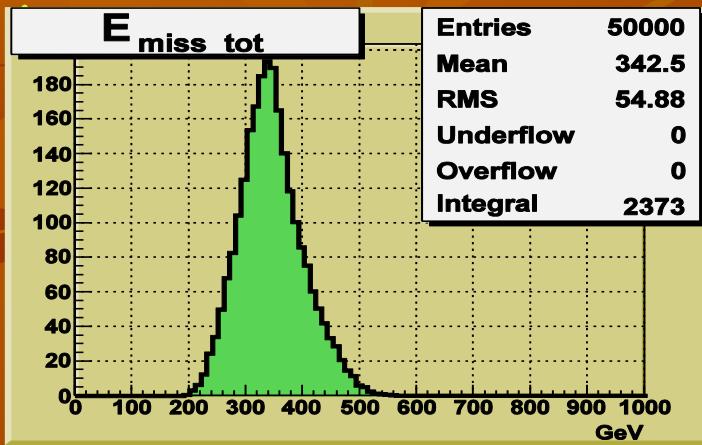
# Main Scalar top quark distributions



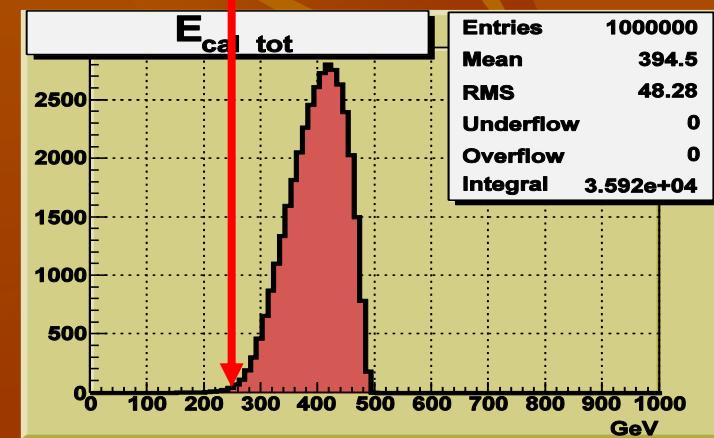
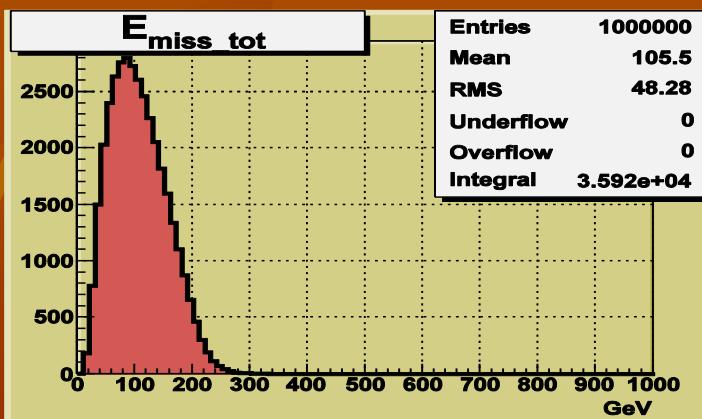
# Missing energy ( $v_\mu$ , $\sim\chi_1^0$ , beam pipe) and detected (visible) energy distributions

*Good for Signal / Background separation with cut  $E_{cal\_tot} < 220 \text{ GeV}$*

STOP



TOP



Missing energy

Detected energy

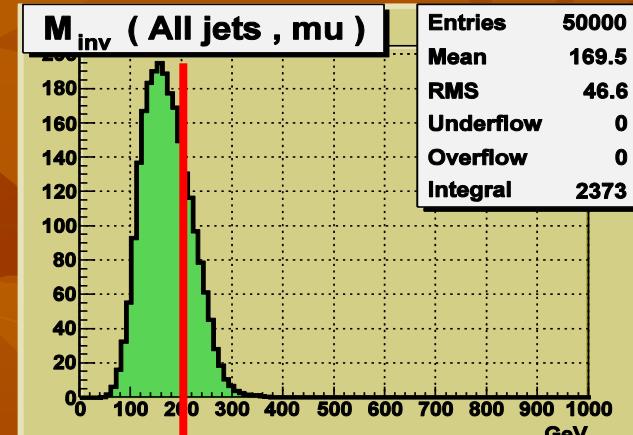
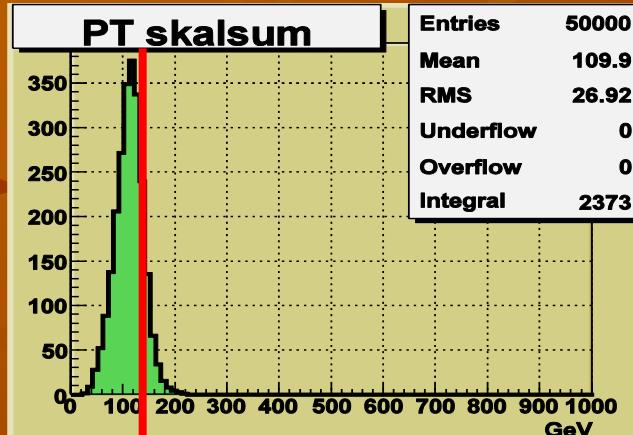
# Total scalar $\Sigma$ PT and Invariant mass of 4jets + $\mu$



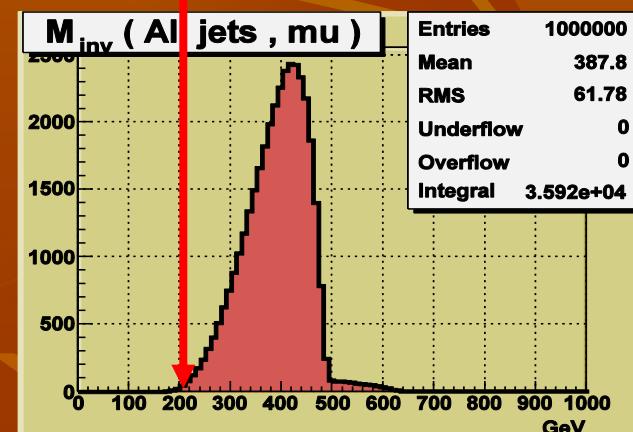
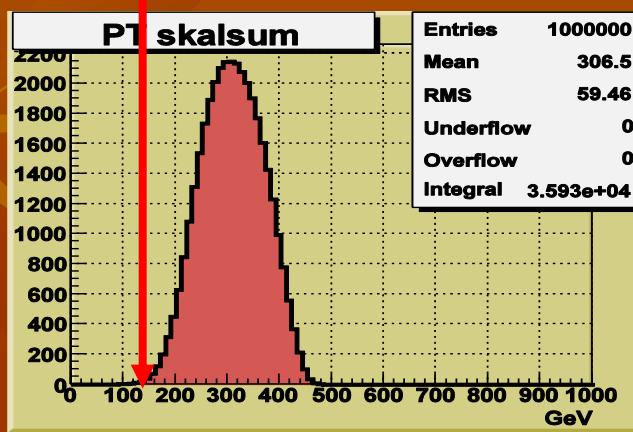
*Good for Signal / Background separation with the cuts*

$PT_{skalsum} < 150 \text{ GeV}$  and  $M_{inv}(4\text{jets} + \mu) < 200 \text{ GeV}!$

STOP



TOP



Scalar  $\Sigma$  PT

$M_{inv}(4\text{jets} + \mu)$

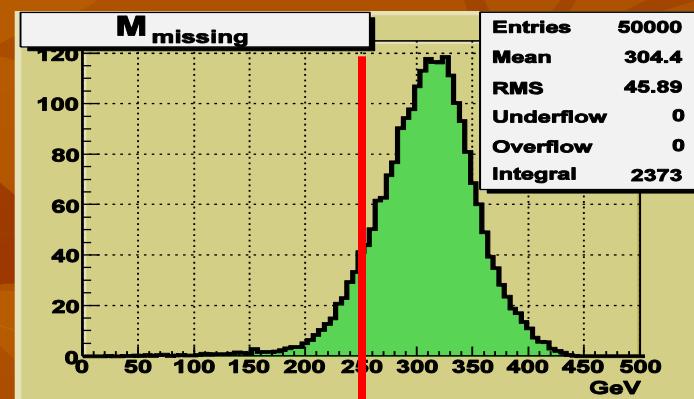
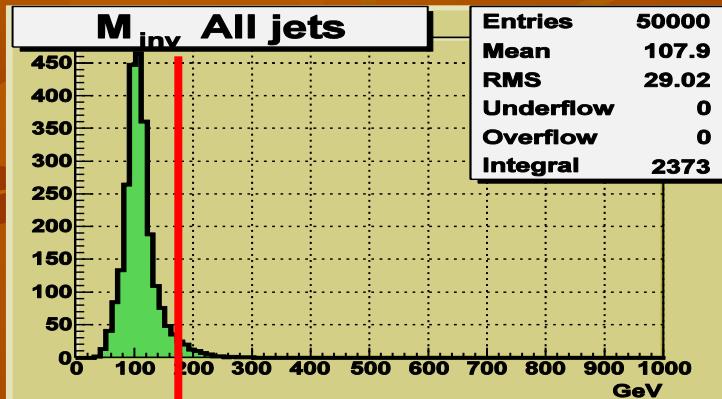
# Invariant mass of 4 jets and $M_{\text{missing}}$ variable



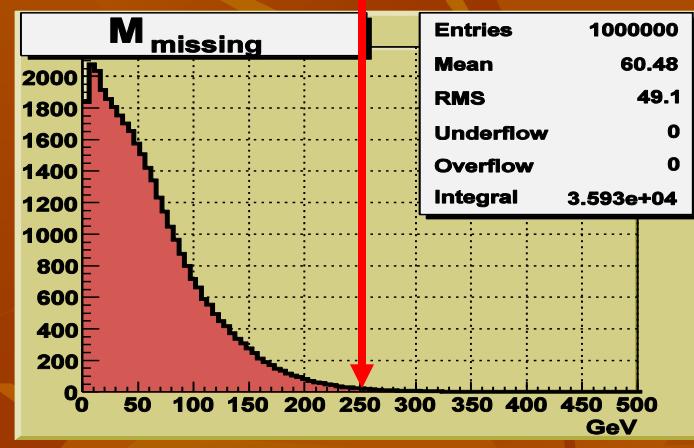
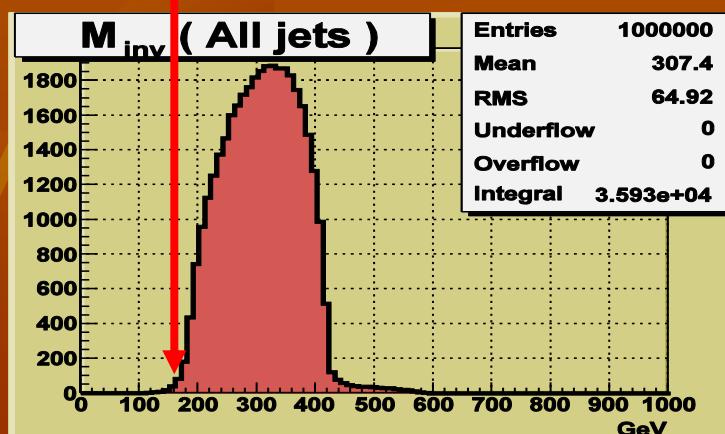
PERFECT for Signal / Background separation cut

$M_{\text{inv}}(4 \text{ jets}) < 160 \text{ GeV}$  and  $M_{\text{missing}} > 250 \text{ GeV}$

STOP



TOP



$M_{\text{inv}}$  ( 4 jets )

$M_{\text{missing}}$

# Used cuts for S/B separation

- 1.) The events with clear recognized 2 B-jets (according to PYTHIA)  
*(B-jet is determined as a jet that includes b-meson)*

*Stop cut efficiency = 0.84*

*Top cut efficiency = 0.94*

But, in the experiment only 50% efficiency of the B-jets and B<sub>bar</sub>-jets separation and the 80% of the corresponding purity is expected

- 2.) Invariant mass of 4 jets ( $b_{jet}$ ,  $b\bar{b}_{jet}$ ,  $2j_{etW}$ )  $M_{inv}$  (All jets)  $< 160$  GeV  
*together with the cut above*

*Stop cut efficiency = 0.78*

*Top cut efficiency = 0.001*

3. ) Invariant Missing mass  $M_{missing} > 250$  GeV  
*together with the cuts above*

*Stop cut efficiency = 0.76*

*Top cut efficiency =  $3.3 \cdot 10^{-4}$*

*Achieved S/B ratio = 143*

*The rest is only 13 background events per year, while for the Signal events – 1086/year (for the integrated Luminosity  $L=1000 fb^{-1}/year$ )*

# Cross section dependence on E<sub>beam</sub>

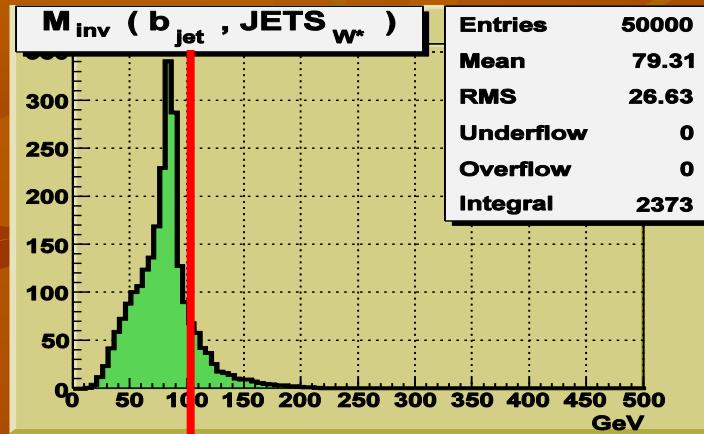
(with the cuts above)

2E <sub>beam</sub> [GeV]	$\sigma_{\text{stop}}$ [fb]	N <sub>stop</sub>	$\sigma_{\text{top}}$ [fb]	N <sub>top</sub>
350	0.0089	8	0	0
400	0.52	521	$2.32 * 10^{-4}$	0.2
<u>500</u>	<u>1.80</u>	<u>1806</u>	<u><math>2.26 * 10^{-2}</math></u>	<u>12.6</u>
800	0.99	995	$1.08 * 10^{-2}$	10
1000	0.41	410	$6.26 * 10^{-3}$	6

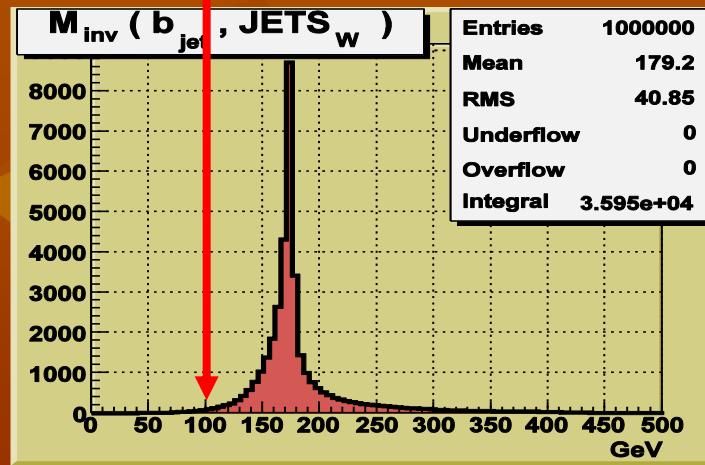
# Invariant mass of $b_{jet}$ & 2jets<sub>W</sub>

Can also be used for Signal / Background separation cut  $M_{inv}(b_{jet}, 2\text{jets}_W) < 100 \text{ GeV!}$

STOP



TOP



$M_{inv}(b_{jet}, 2\text{jets}_W)$

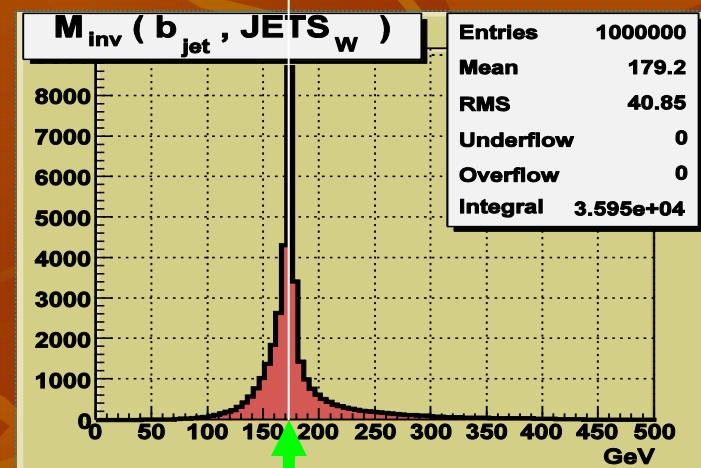
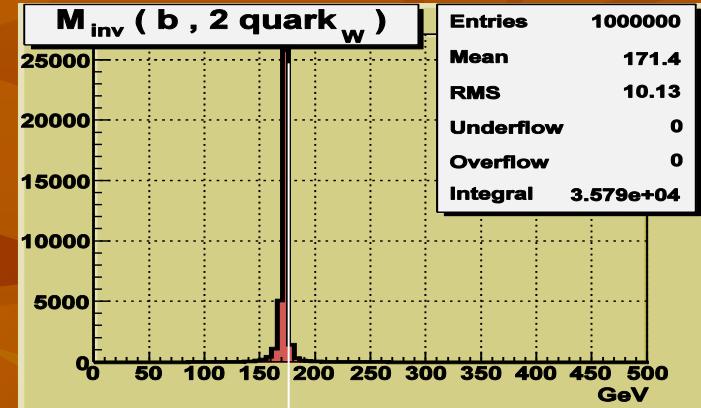
# The most important variable - invariant mass of $b_{jet}$ & 2jets<sub>W</sub>

In the case of *TOP pair* production it gives

The mass reconstruction of the

top-quark  $M_{Top}$  (175 GeV) :

$$M_{inv}(B_{jet} \& 2jets_W) = M_{Top}$$



# Stop invariant mass

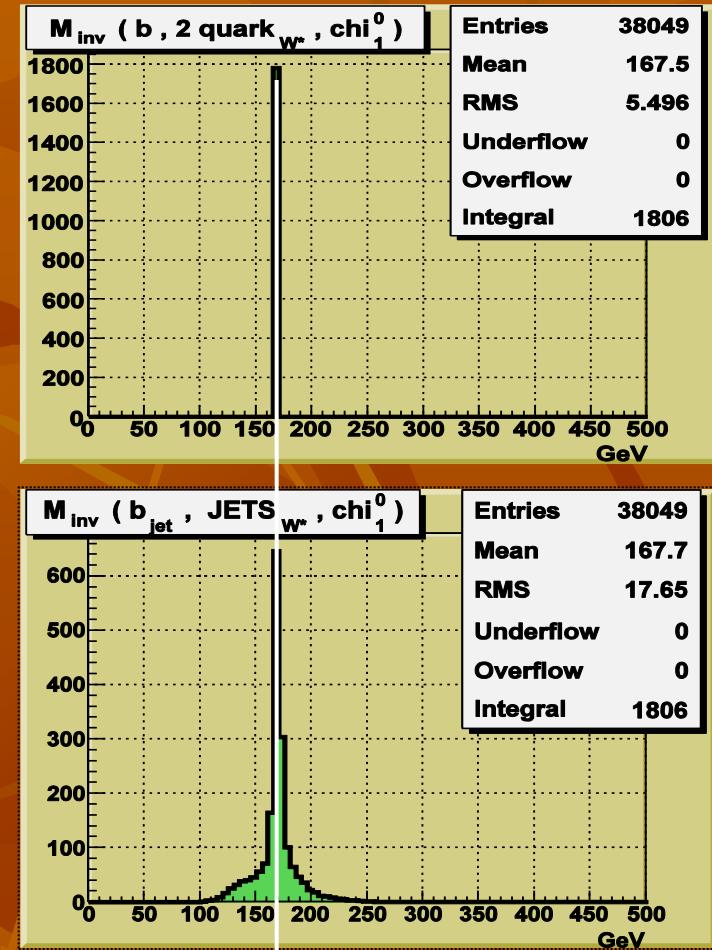
The reconstruction of the STOP invariant mass  $M_{STOP}$  (167.9 GeV):

$$M_{inv}(STOP) =$$

$$M_{\chi_1^0} + M_{inv}(b_{jet}, 2jets_W) =$$

$$= M_{\chi_1^0} + \sqrt{(P_{b_{jet}} + P_{jet1W} + P_{jet2W})}$$

But  $\chi_1^0$  - is not detectable particle



# Invariant mass of $B_{jet}$ & $2jets_W$ gives

For the case of *STOP pair* production gives

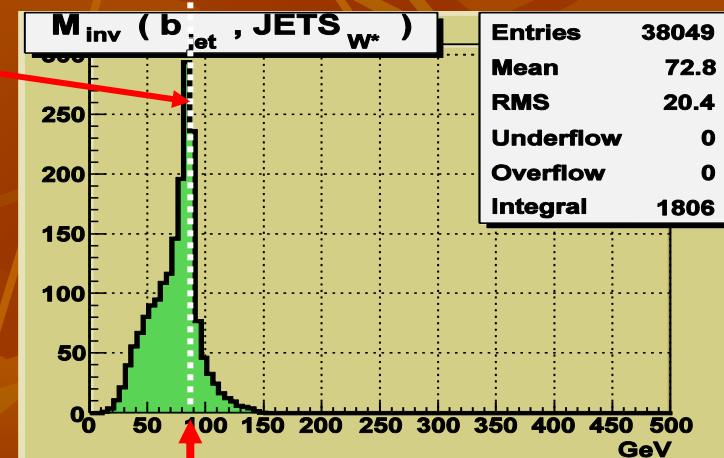
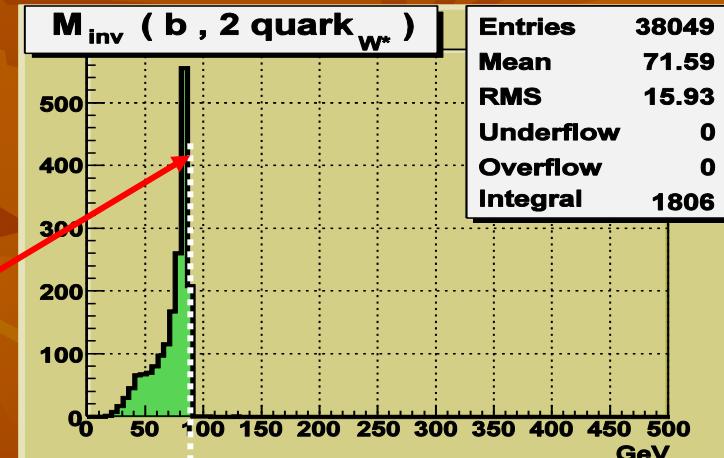
$$M_{inv}(B_{jet}, 2jets_W) = M_{inv}(STOP) - M_{\chi_1^0}$$

The right edge of the peak of

$$M_{inv}(b_{jet}, 2jets_W) \approx 87 \text{ GeV}$$

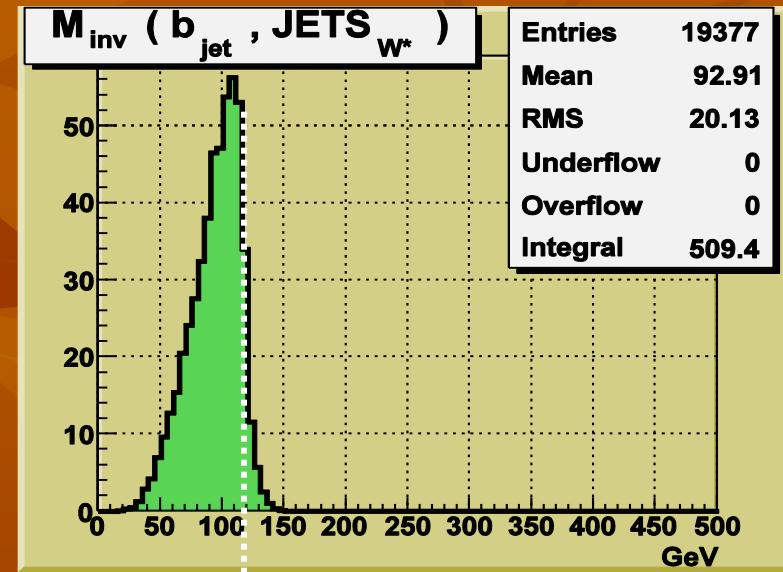
$$M_{\chi_1^0} \approx 80.9 \text{ GeV}$$

$$\begin{aligned} M_{stop} &= M_{\chi_1^0} + M_{inv}(b_{jet}, 2jets_W) = \\ &= 167.9 \text{ GeV} \end{aligned}$$



# The test of the other Scalar top mass

- $M_{stop} = 200.1 \text{ GeV}$
- $M_{\chi_1^0} = 80.9 \text{ GeV}$
- $M_{\chi_1^+} = 159.6 \text{ GeV}$



Right edge of the peak of  $M_{inv}(b_{jet}, 2jet_W)$   
 $\approx 120 \text{ GeV}$

509 events  
 $S/B = 40$

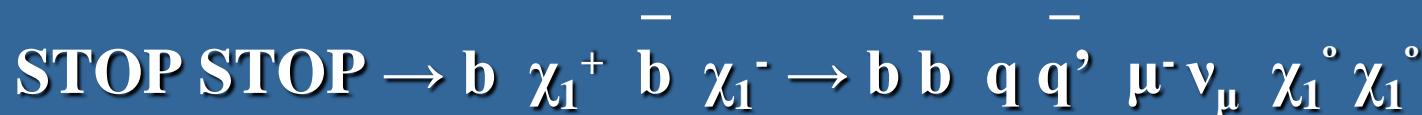
$$M_{\chi_1^0} \approx 80 \text{ GeV}$$

$$M_{stop} = M_{\chi_1^0} + M_{inv}(b_{jet}, 2jet_W) = 200 \text{ GeV}$$

# Conclusion

1. The MC (PYTHIA 6.4 + CIRCE 1) study of stop pair production in  $e^+e^-$  collisions was done at  $\sqrt{S}_{ee} = 350, 400, 500, 800, 1000$  GeV.
2. The detailed analysis done at  $\sqrt{S}_{ee} = 500$  GeV has shown that proposed 3 cuts allow to reach S/B = 143.
3. A possibility of a good reconstruction of the  $M_{STOP}$  from the peak position of  $M_{inv}$  (3 jets, i.e.  $b_{jet} + 2 \text{ jets}_W$ ) distribution is demonstrated.

So, finally, the channel



is very promising for STOP quark search!



# Publications

- “*Pair production of scalar top quarks in  $e^+e^-$  collisions at ILC.*”

Authors: A.Bartl, W.Majerotto, K.Möniq, A.N.Skachkova,  
N.B.Skachkov

[arXiv: 0804.2125v3,](#)

**ILC-NOTE-2008-042**

- “*On pair production of scalar top quarks in  $e^+e^-$  collisions at ILC and a possibility of their mass reconstruction*”

Authors: [A.Bartl](#), [W.Majerotto](#), [K.Moenig](#), [A.N.Skachkova](#),  
[N.B.Skachkov](#)

[arXiv:0906.3805,](#)

**Phys.Part.Nucl.Lett.6:181-189,2009**

# Outback

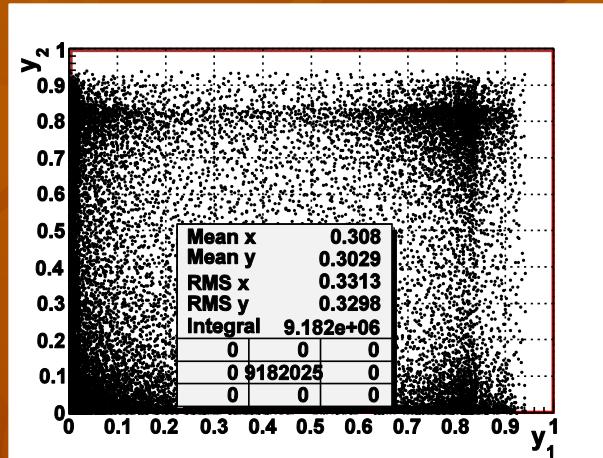
# Photon beam characteristics

The *monochromaticity* of the backscattered photon beams is considerably increased if the mean helicities  $\lambda_e$  and  $P_c$  of the electron beam and laser photon beam are chosen such that  $2\lambda_e P_c \approx -1$ .

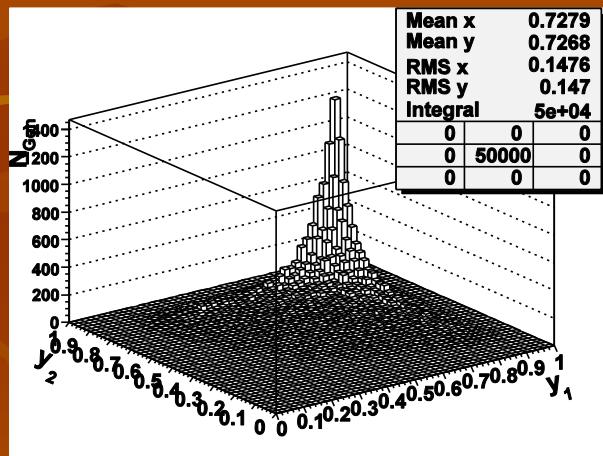
In this case the relative *number of hard photons* becomes nearly *twice as large* in the region of the photon energy fraction  $Y = E_i^{\gamma} / E_{beam}^e \approx 0.7-0.85$  ( $i=1,2$ ) and the *luminosity* in collisions of these photons increases by a factor of 3-4.

# energy correlation $Y_1/Y_2$ spectra for $J=2$ enhanced

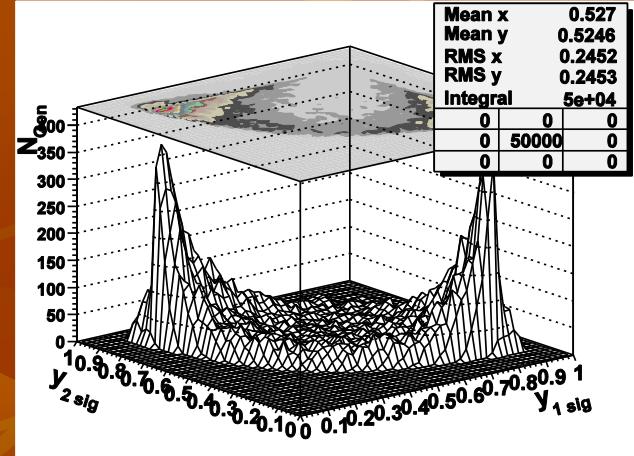
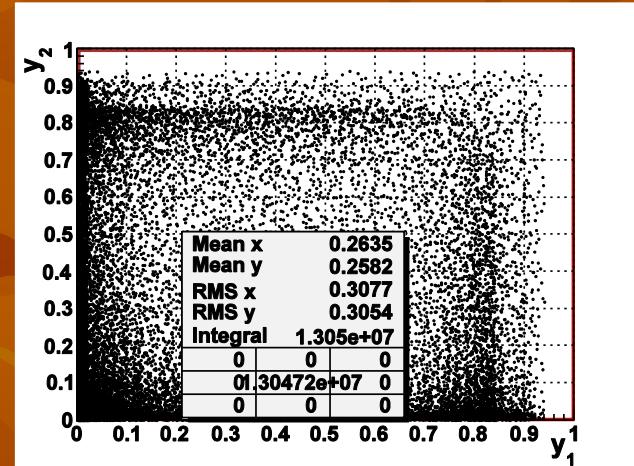
Whole  $\gamma$  spectrum



$\gamma$  spectrum  
above  
stop pair  
production  
threshold

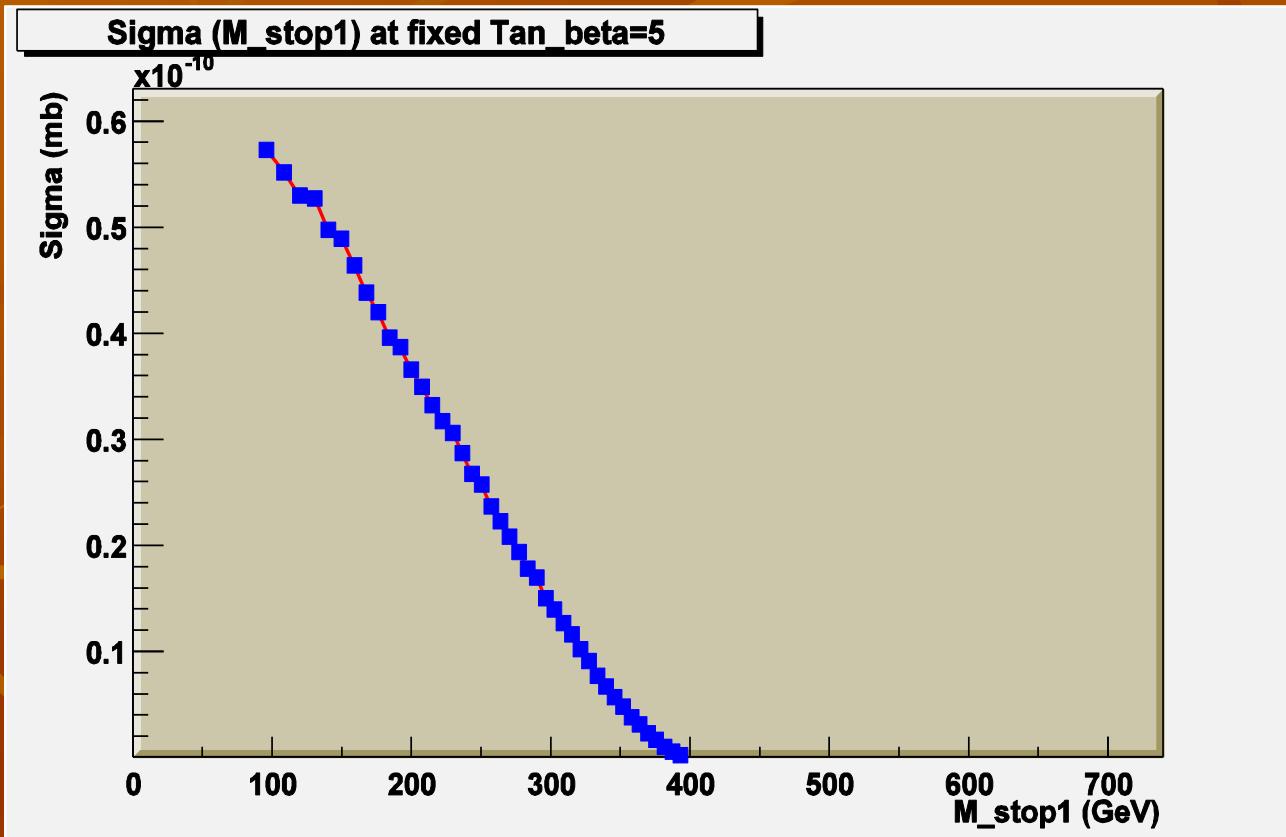


Polarizations + - / - +



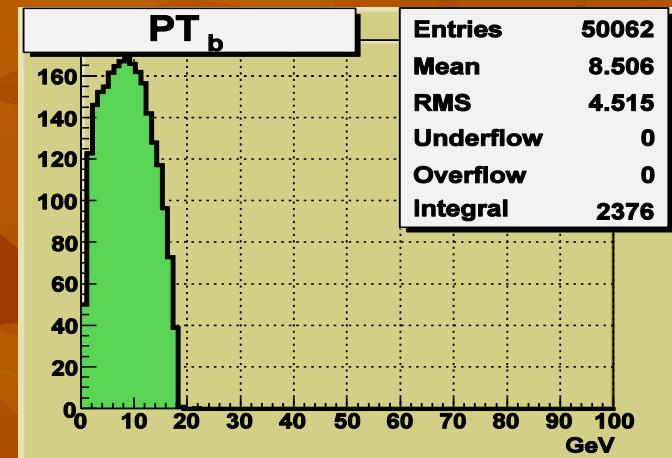
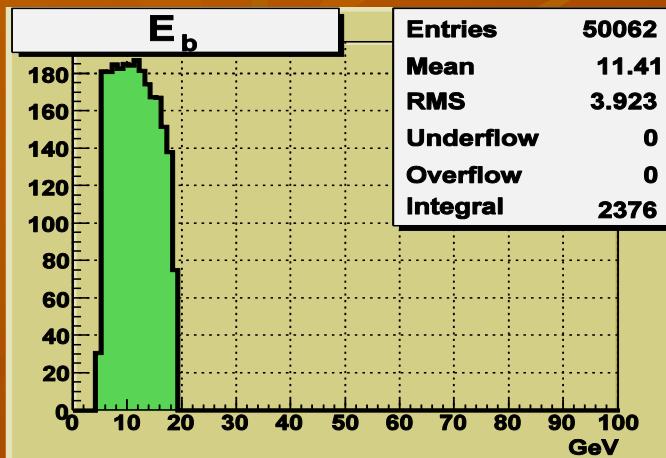
Polarizations + + / - -

# Cross-section $\sigma$ dependence on $M_{\text{stop}}$

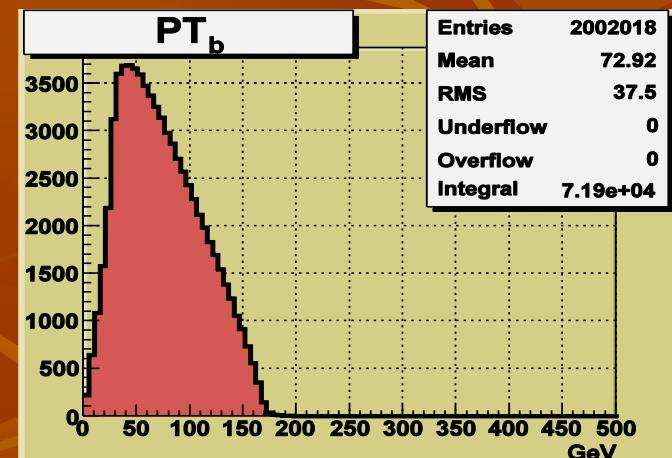
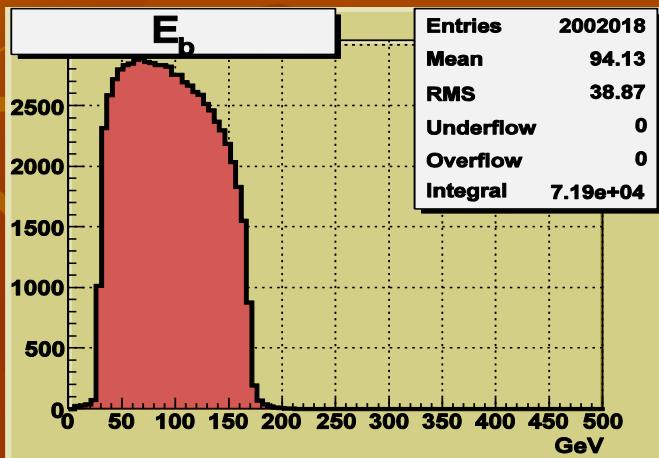


# B-quarks distributions

**STOP**

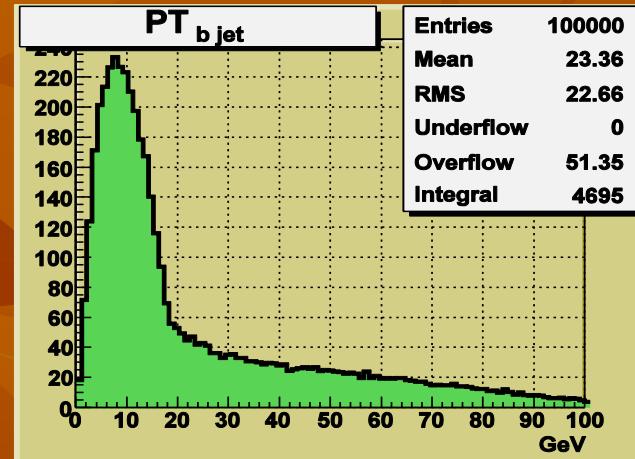
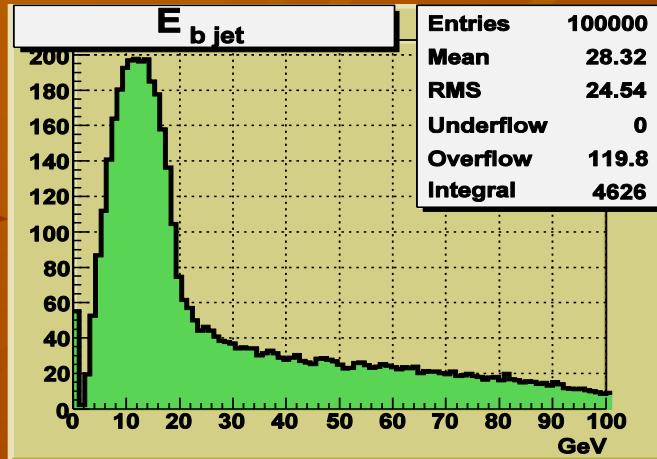


**TOP**

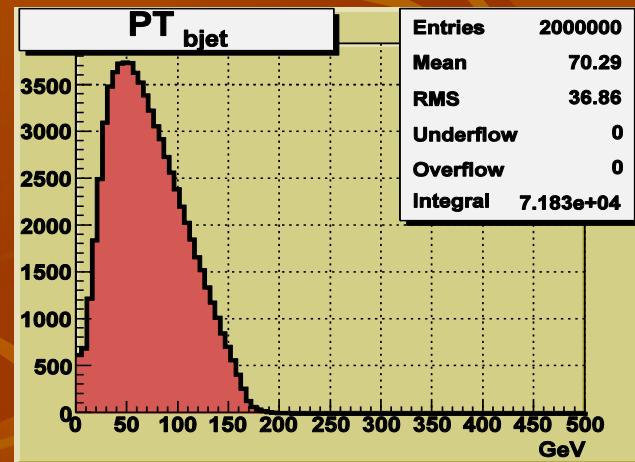
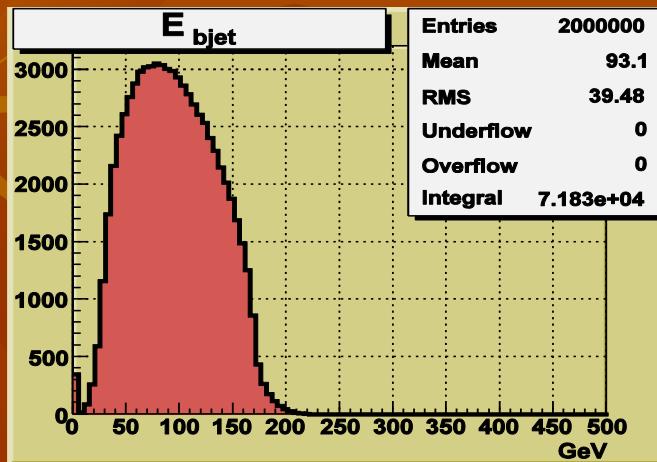


# B-jets distributions

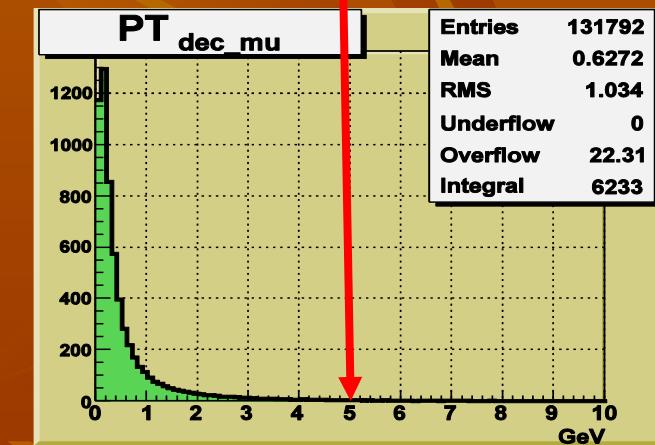
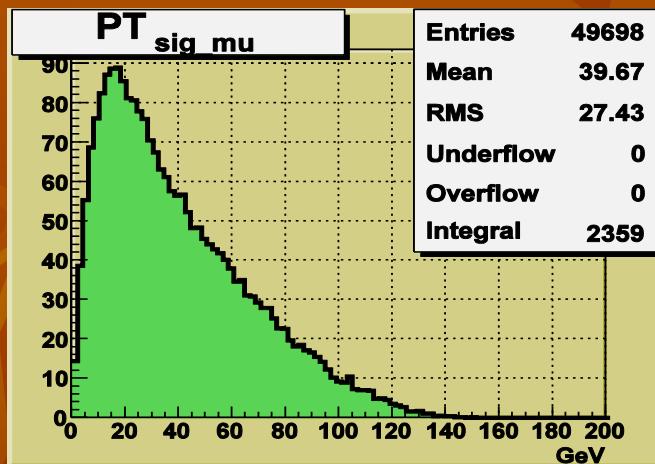
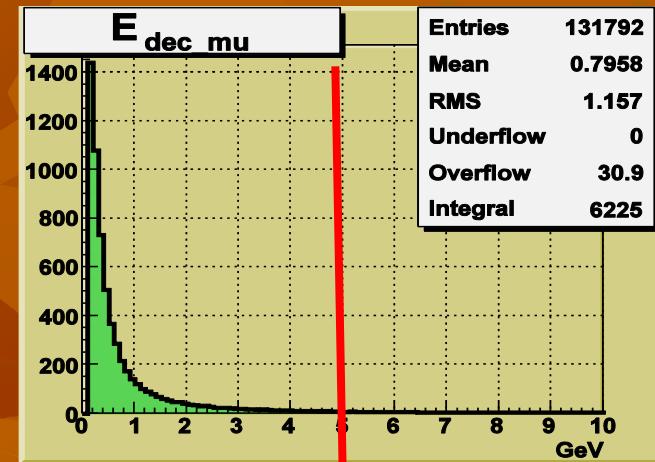
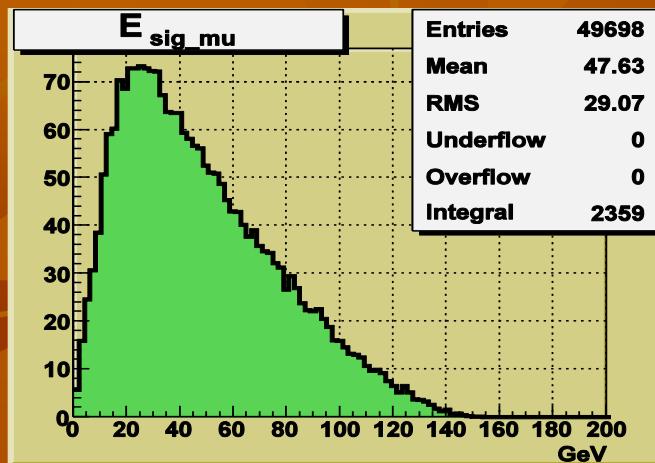
**STOP**



**TOP**



# $\mu$ distributions in the signal events



Signal  $\mu$ 's

Fake  $\mu$ 's