Progress for search of neutral Supersymmetric Higgs boson h/A bb $h_0/A\,(h_0/A \rightarrow \mu^+\mu^-)$

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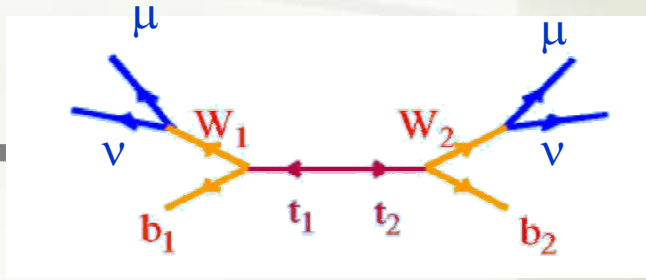
Outline

- Preselection
- Selection :
  - b-tag
  - muons
  - b-jets
  - Invariant mass
  - μ -isolation
- Conclusions & planning

Background:
- bb Z→ μ μ
- tt → bb μ μ
- ZZ → bb μ μ

• **Top decay: ≈ 100% t → bW**



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Selection

➢ **Preselection cuts:**

- At least a pair of opposite **muons** with $p_t > 10$ GeV and $|\eta| < 2.5$
- At least a pair of **jets** with $E_T > 10$ GeV **and** $|\eta| < 2.5$

➢ **Selection**

- **At least 1 b-jets ($p_T > 15$ GeV & b-tag weight>1)**
- $E_T^{miss} < 45$ GeV
- $25 \text{ GeV} < P_T^{\mu 1} < 95$ GeV
- $20 \text{ GeV} < P_T^{\mu 2} < 60$ GeV
- $P_T^{b2} < 40$ GeV
- $P_T^{b1} < 70$ GeV

for tt background

➢ **Final Cut**

- **Minv($\mu^+\mu^-$)** +/- ΔM (Γ_{A0}, Γ_{h0}, σ_m) (σ_m= exp. mass res.)
- **Isolation $\Sigma P_{Ttrack} < 5$ GeV around a cone $\Delta R < 0.2$**

$$\int Ldt = 30\ fb^{-1}$$

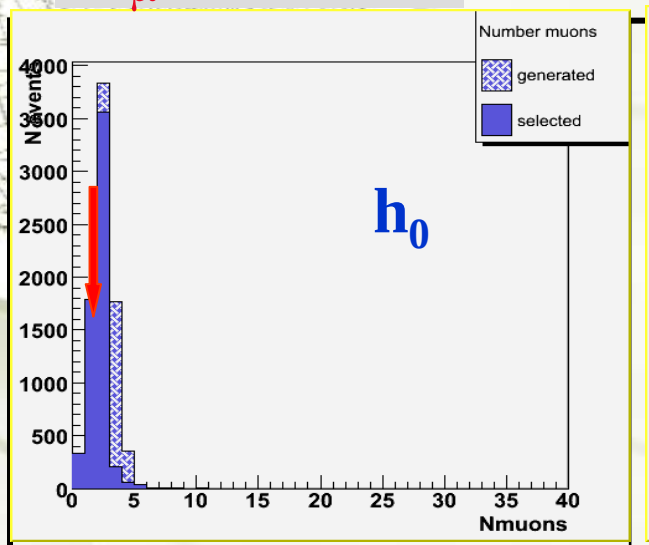
Sample

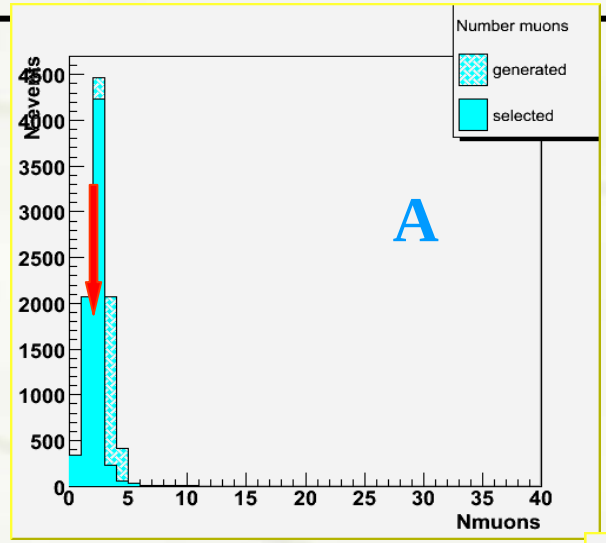
particle	L =30 fb^{-1}	sample		
h_0	6000	5999		
A_0	7000	7000		
Zbb	6.8×10^5	340502*		
tt	$1.7\ 10^4$	170110		
ZZ	3.8×10^3	3788		

*Corresponding to half luminosity

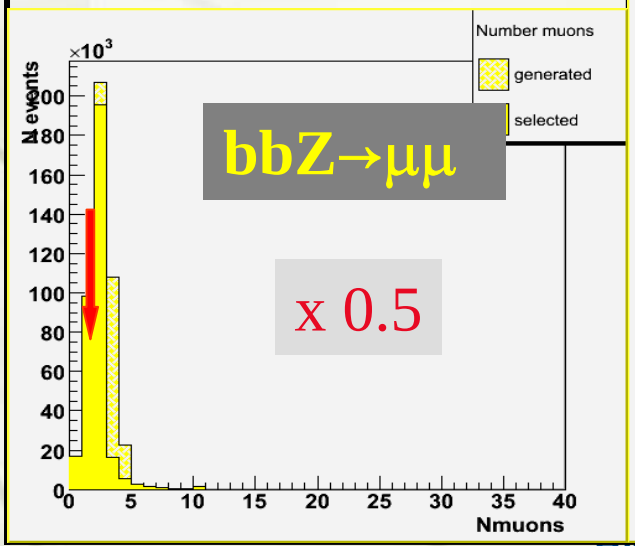
Number of muons: no cut

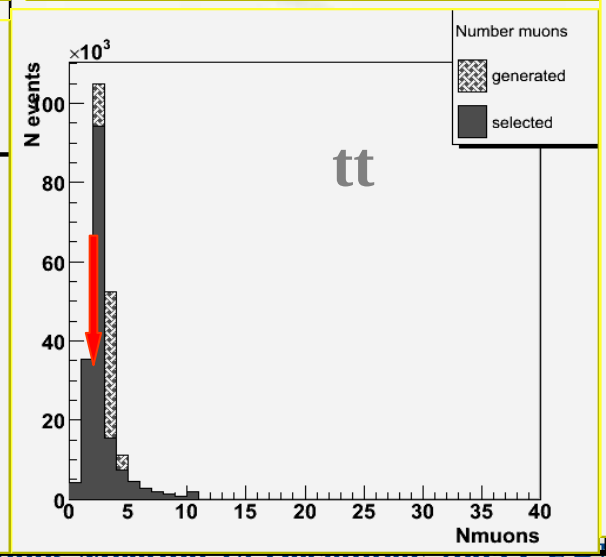
$N_\mu \geq 2$

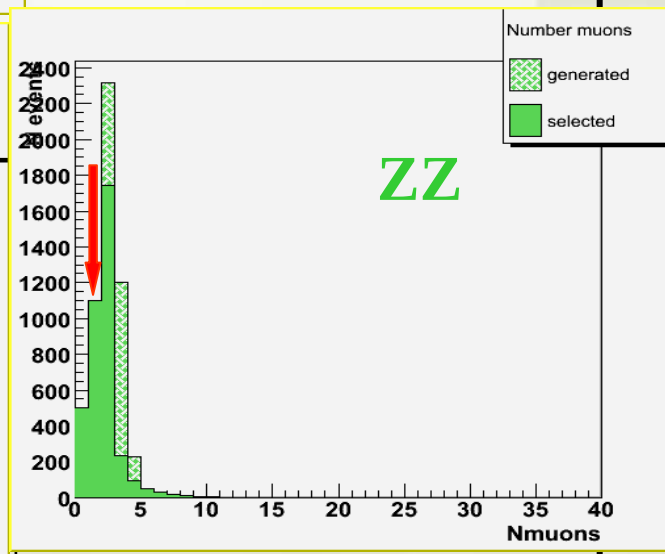




- MC distributions
- Reconstracted Distribution

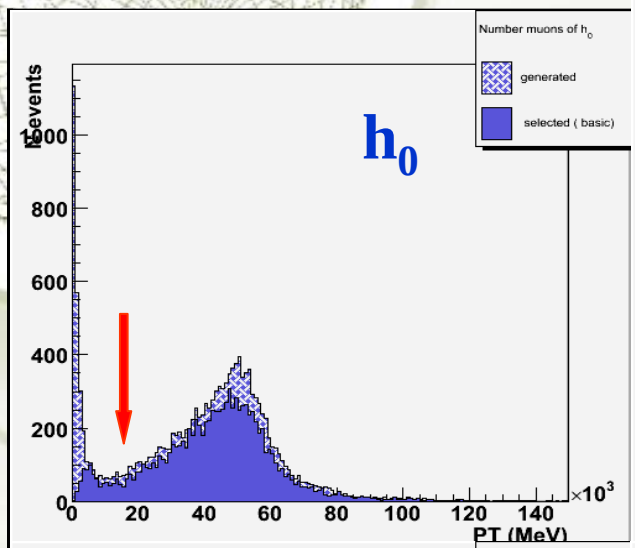


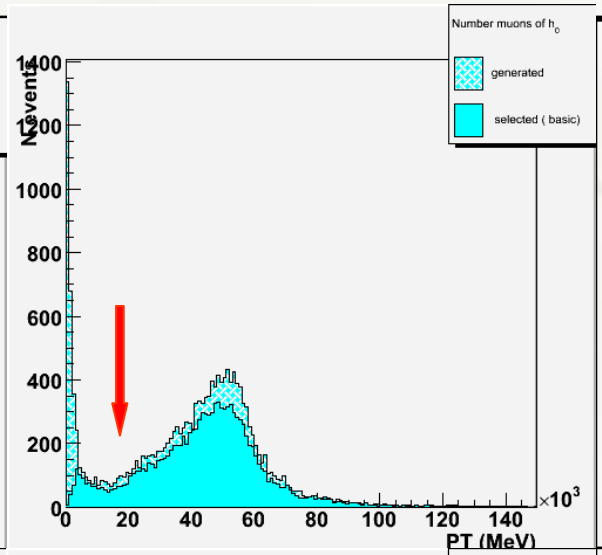




P_T of muons: no cut

p_T μ> 10 GeV

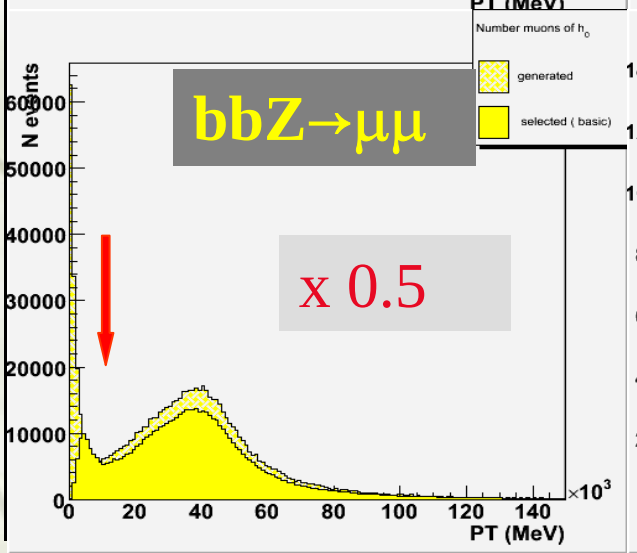


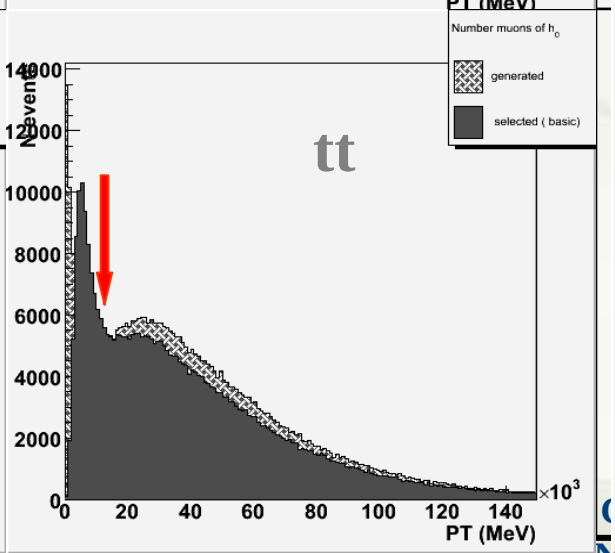


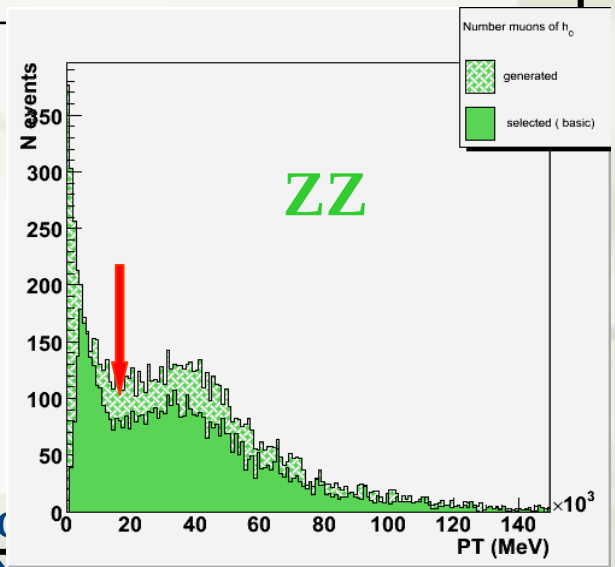
- MC , reconstructed distributions
- **tt :**

peaked at

lower P_T μ values

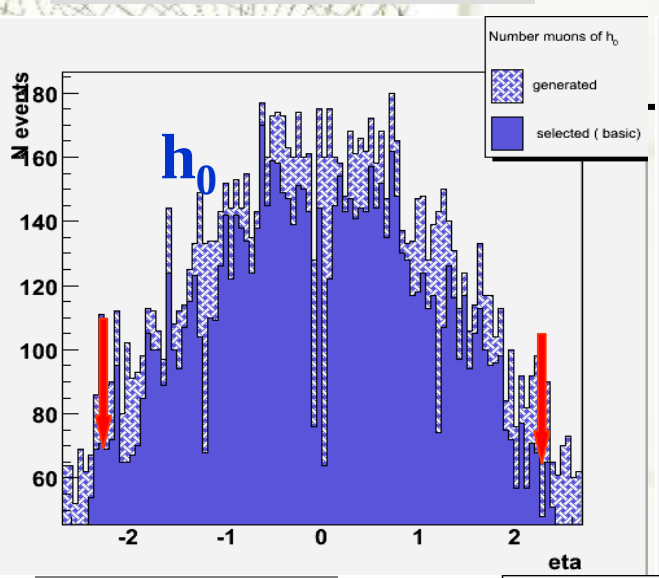


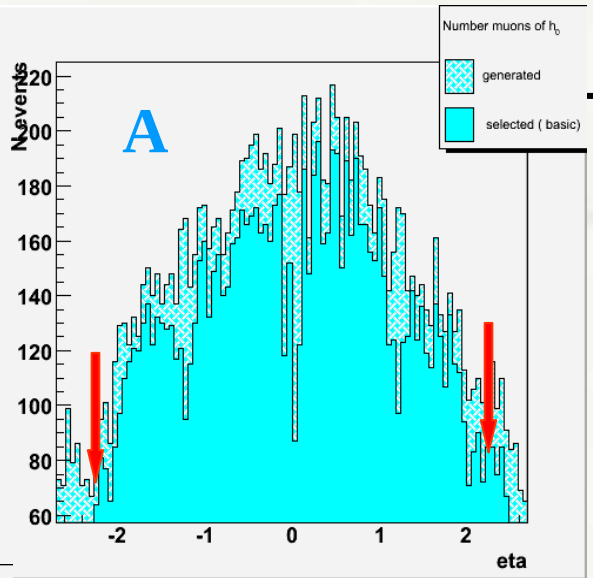




η of muons: no cut

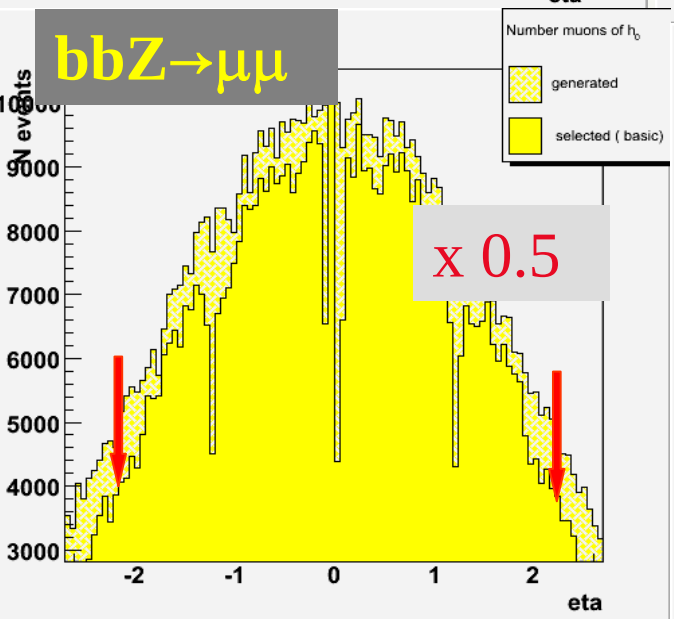
$\eta < 2.5$

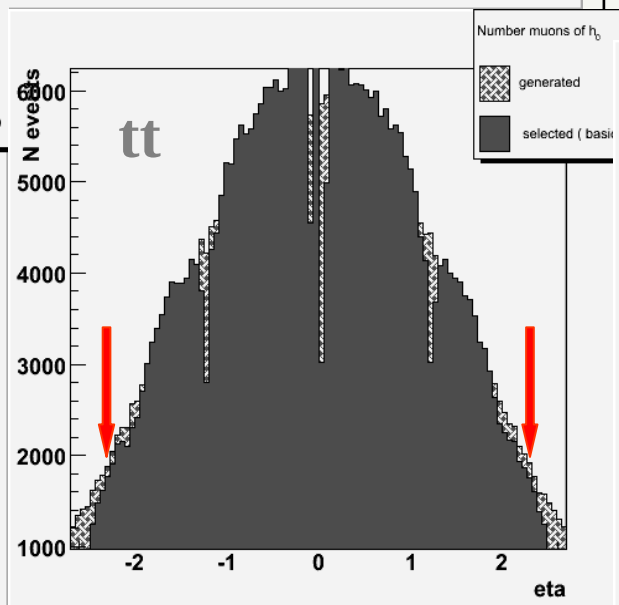


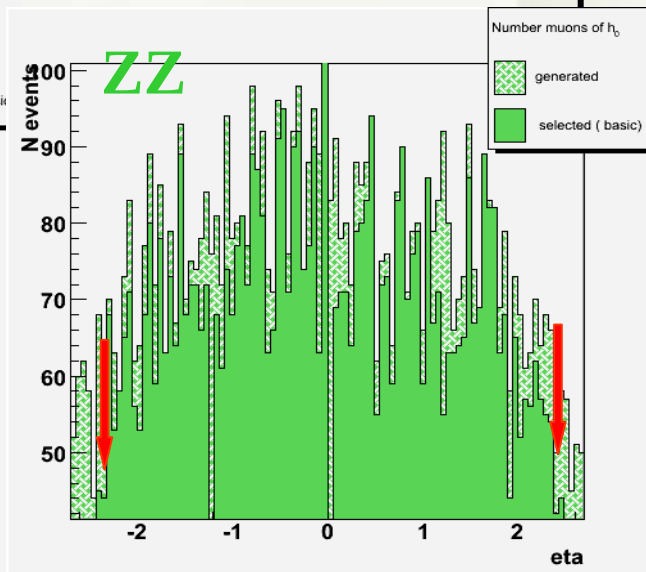


- MC distributions
- Reconstracted Distribution

bbZ→μμ







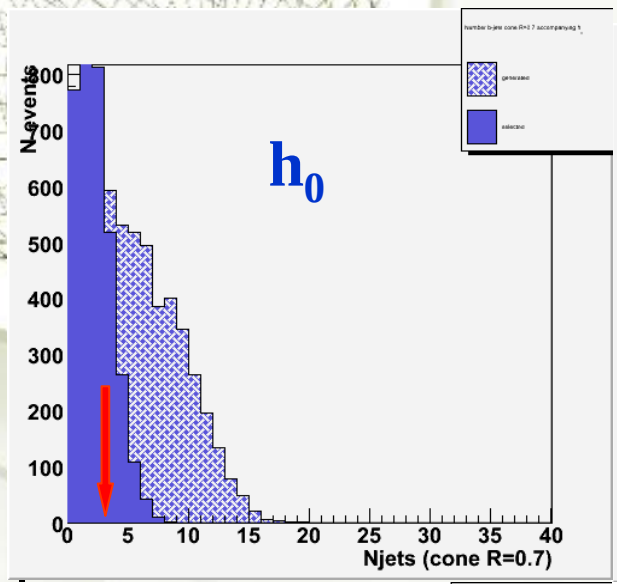
- At least a pair of $\mu^+ \mu^-$ with $\mathbf{p_t > 10\ GeV}$ $\mathbf{|\eta| < 2.5}$

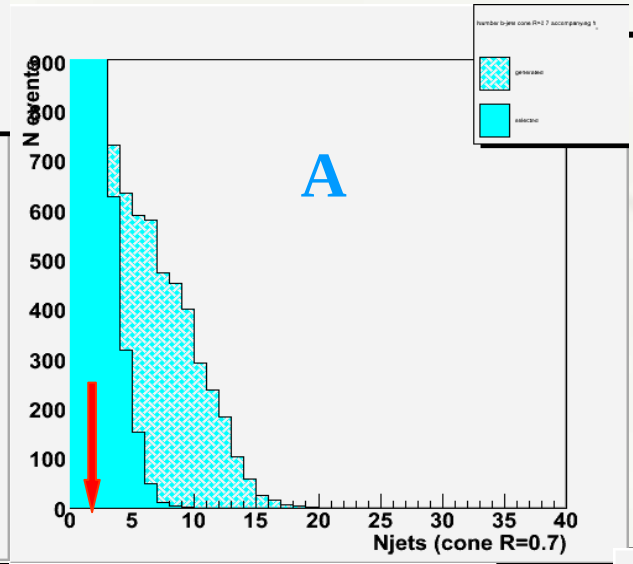
particle	L =30 fb^{-1}	sample	μ pair	
h_0	6000	5999	3643 (61%)	
A_0	7000	7000	4332 (62%)	
Zbb	6.8×10^5	340502*	206629 (61%)	
tt	$1.7\ 10^4$	170110	114718 (67%)	
ZZ	3.8×10^3	3788	1780 (47%)	

*Corresponding to half luminosity

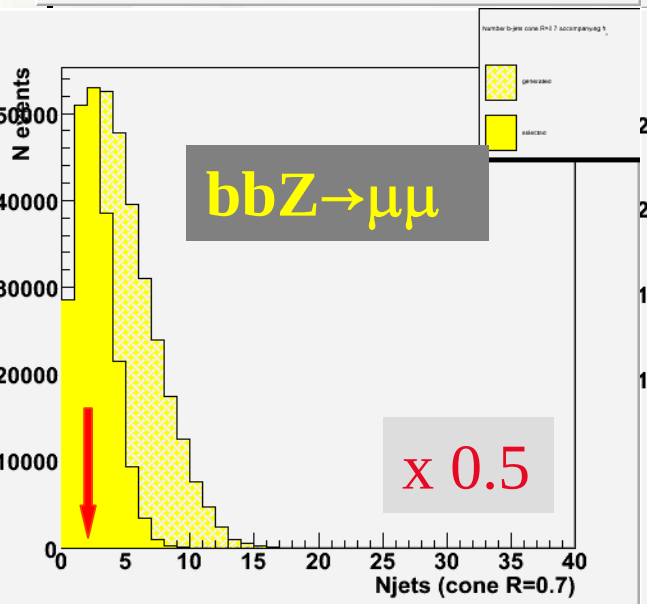
Number of jets: after 1 cut

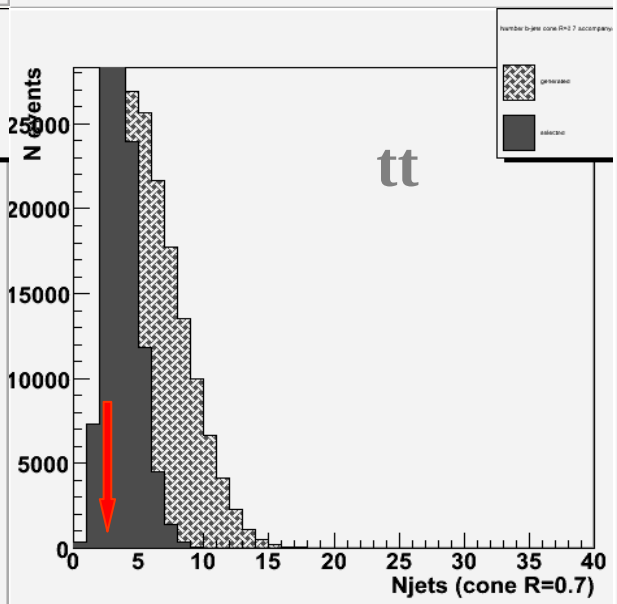
$N_{jet} \geq 2$

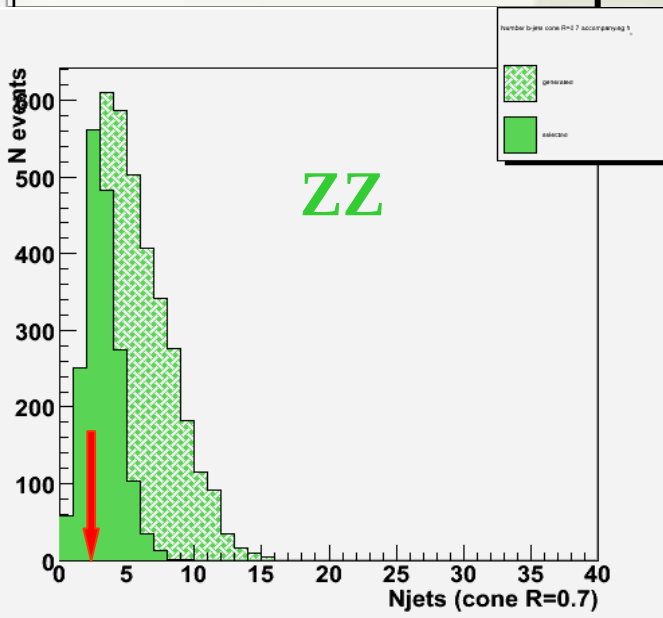




- MC distributions
- Reconstructed distribution

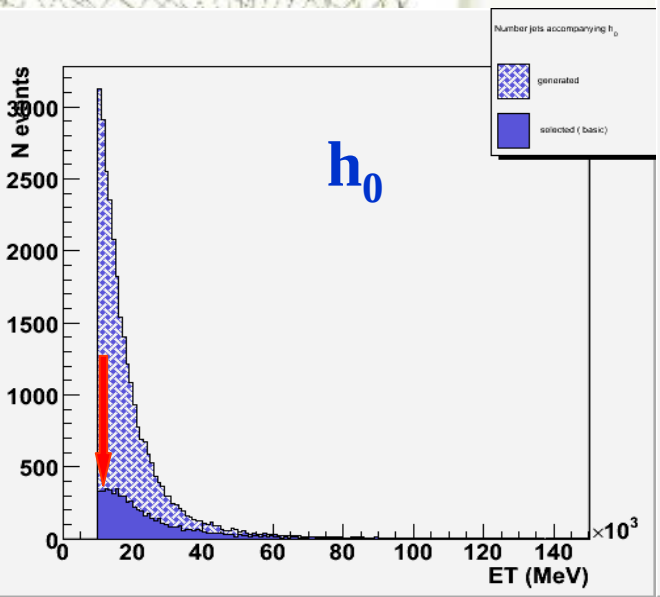


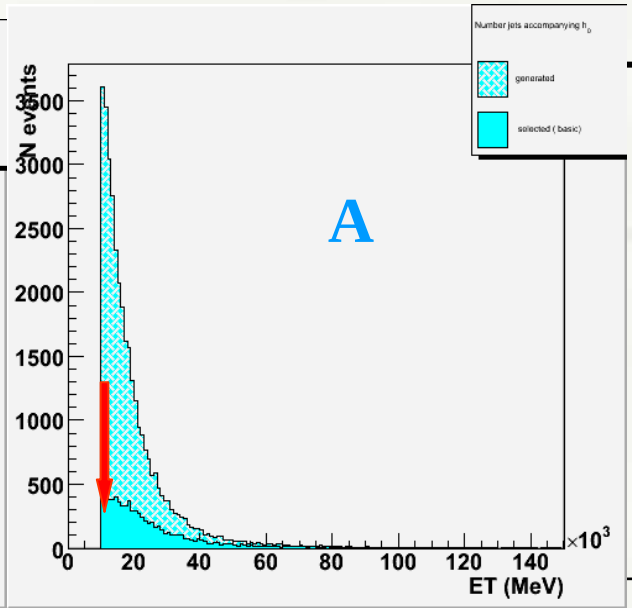




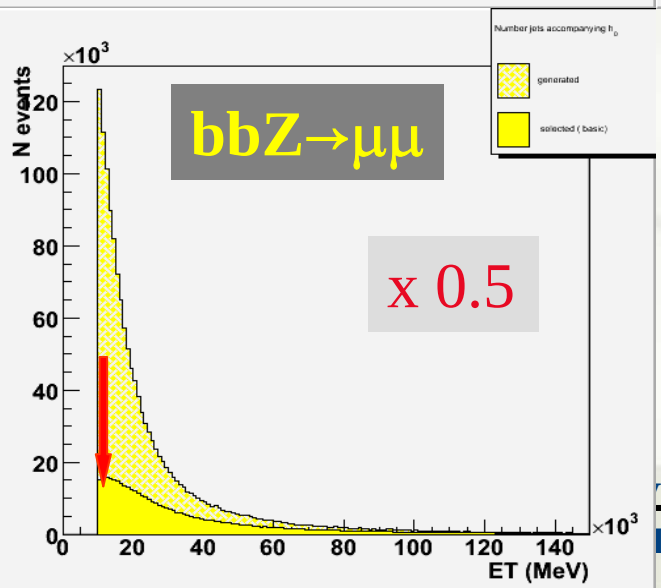
E_T of jets: after 1 cut

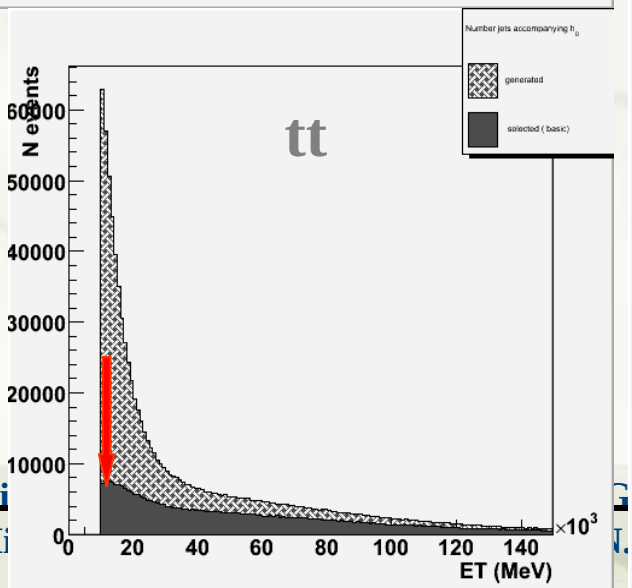
E_T > 10 GeV

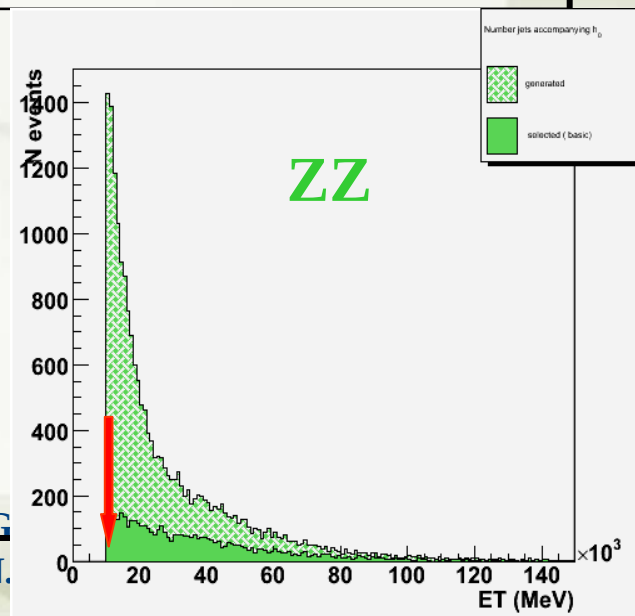




- MC distributions
- Reconstructed distribution







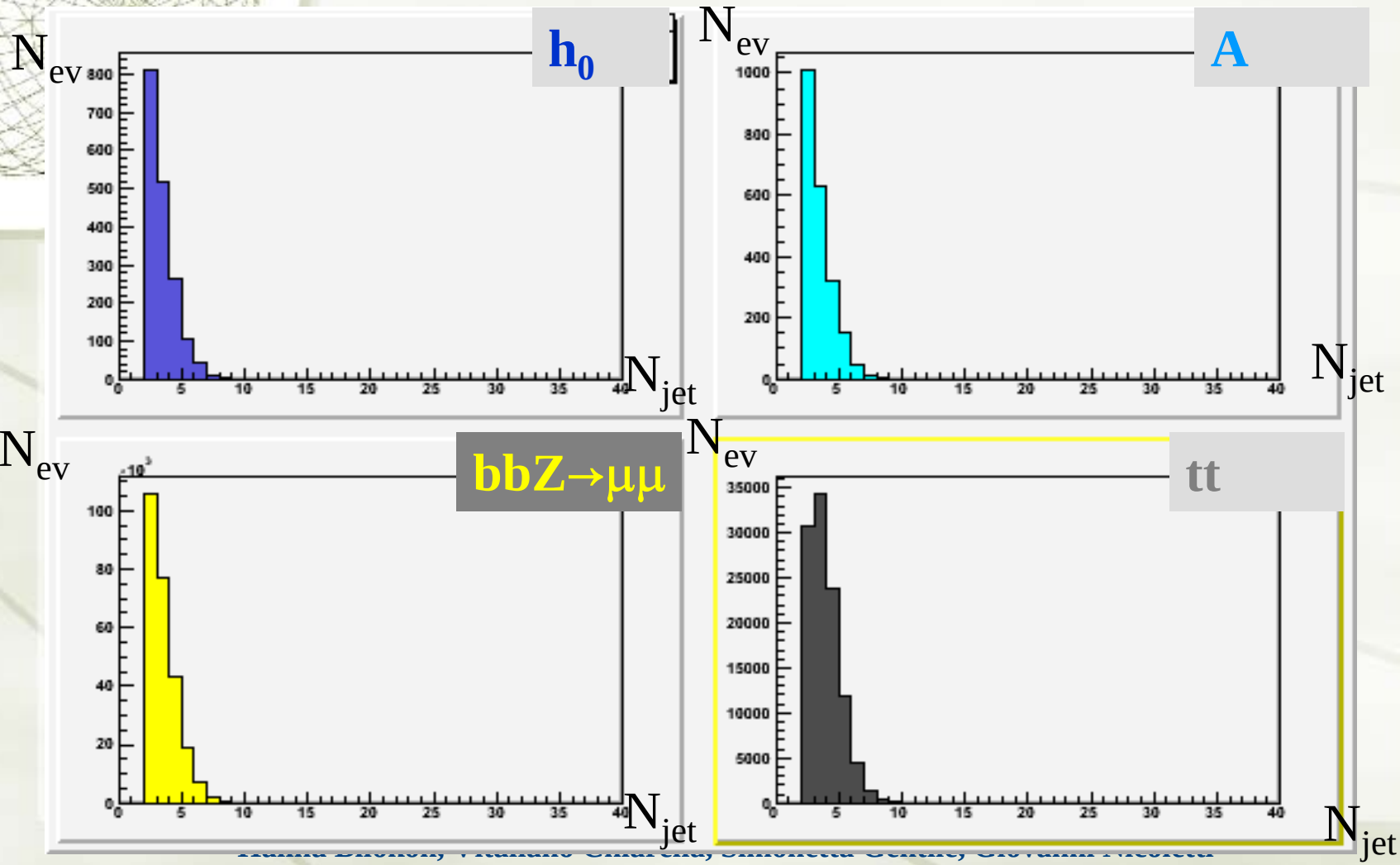
- A pair of **jets** with p_t > **10 GeV** $|\eta| < 2.5$

particle	L =30 fb^{-1}	sample	μ pair	jets
h_0	6000	5999	3643 (61%)	1758 (29%)
A_0	7000	7000	4332 (62%)	2178 (31%)
Zbb	6.8 x 10^5	340502*	206629 (61%)	127099 (37%)
tt	1.7 10^4	170110	114718 (67%)	107075 (63%)
ZZ	3.8 x 10^3	3788	1780 (47%)	1470 (39%)

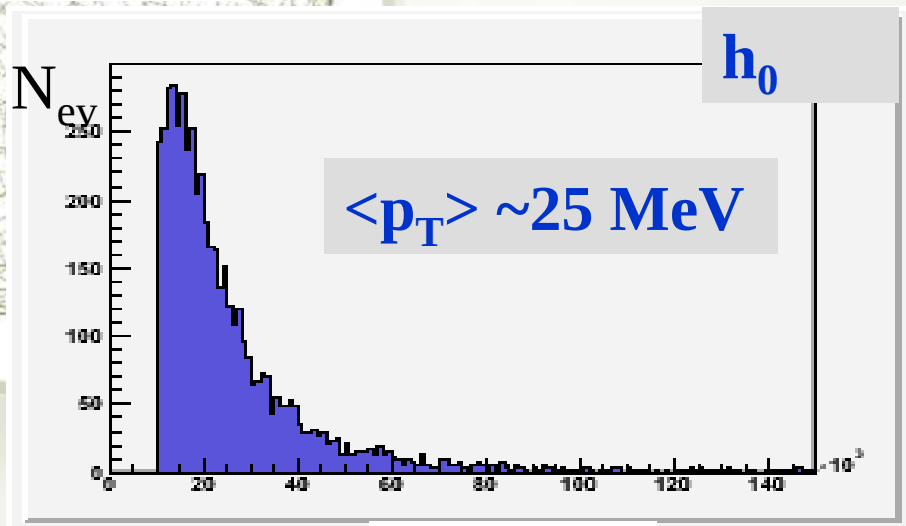
PRESELECTION

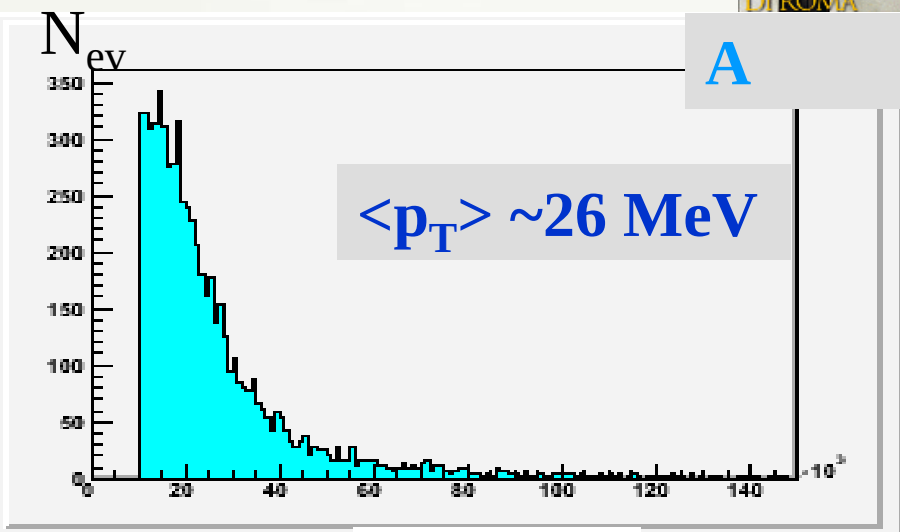
*Corresponding to half luminosity

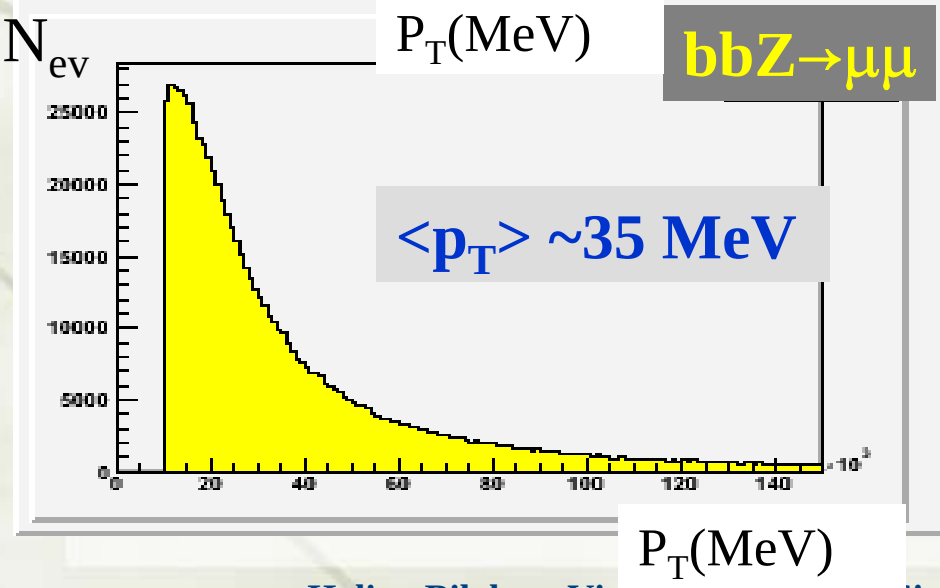
After preselection: Number of Jets ($\Delta R=0.7$)

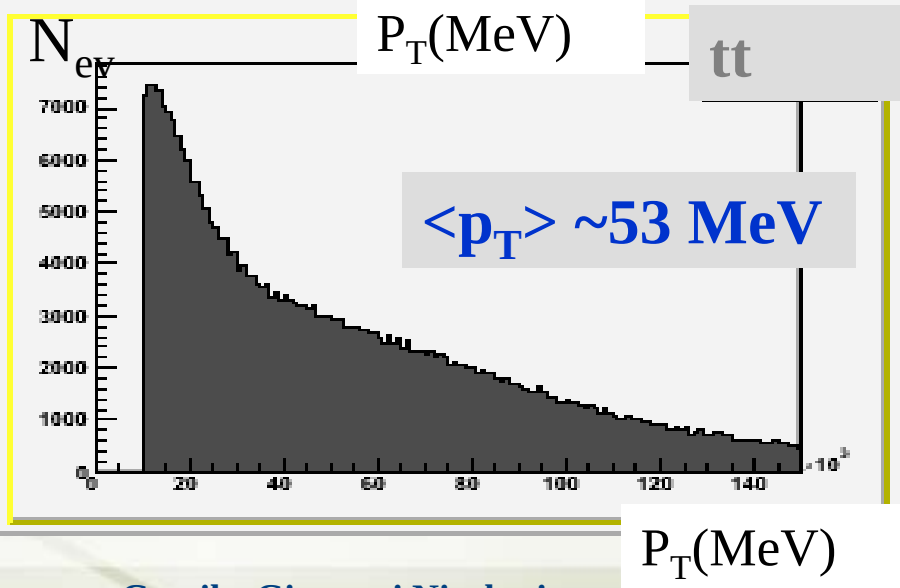


After preselection: jets p_T ($\Delta R=0.7$)









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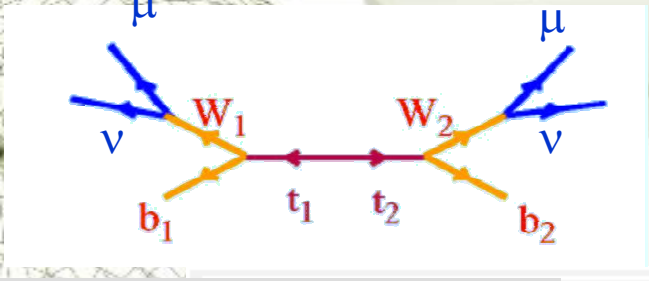
•At least 1 b-jets (p_T > 15 GeV & b-tag weight>1)

particle	initial	preselection	b-tag		
h_0	5999	1758 (29%)	572 (9.5%)		
A_0	7000	2178 (31%)	751 (10.7%)		
Zbb	340502*	127099 (37%)	62812 (18.4%)		
tt	170110	107075 (63%)	89684 (52.7%)		
ZZ	3788	1470 (39%)	1042 (27.5%)		

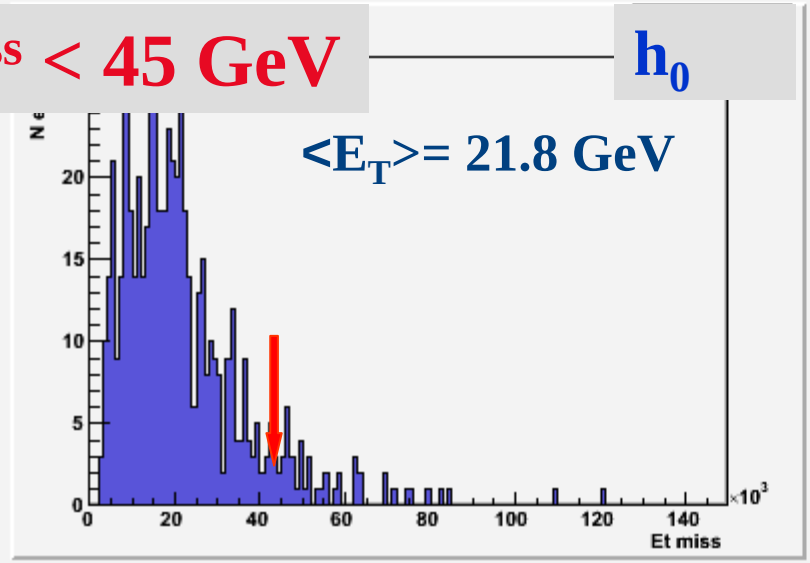
*Corresponding to half luminosity



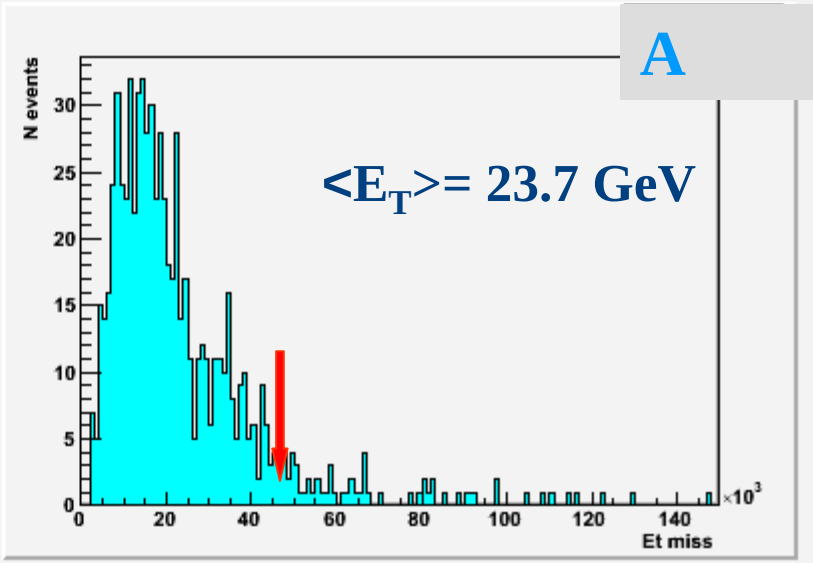
After b-tag cut: E_T^{miss}

$E_T^{miss} < 45$ GeV

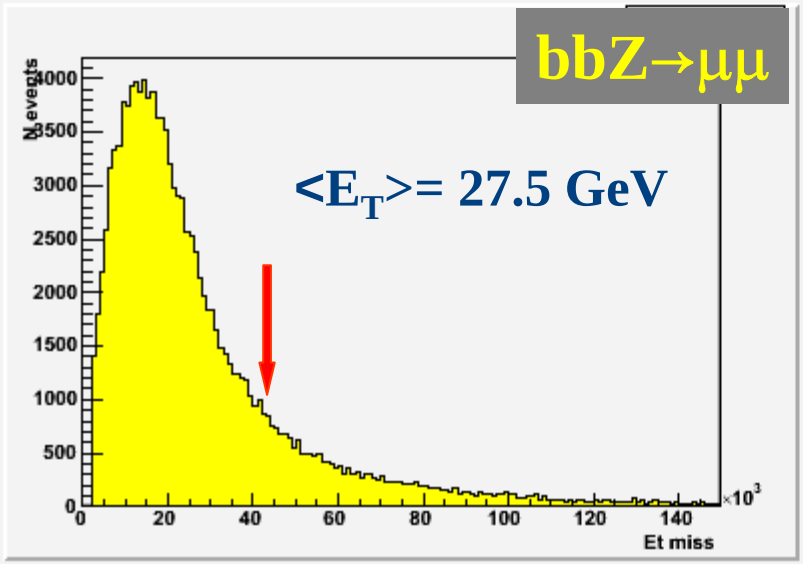
h_0



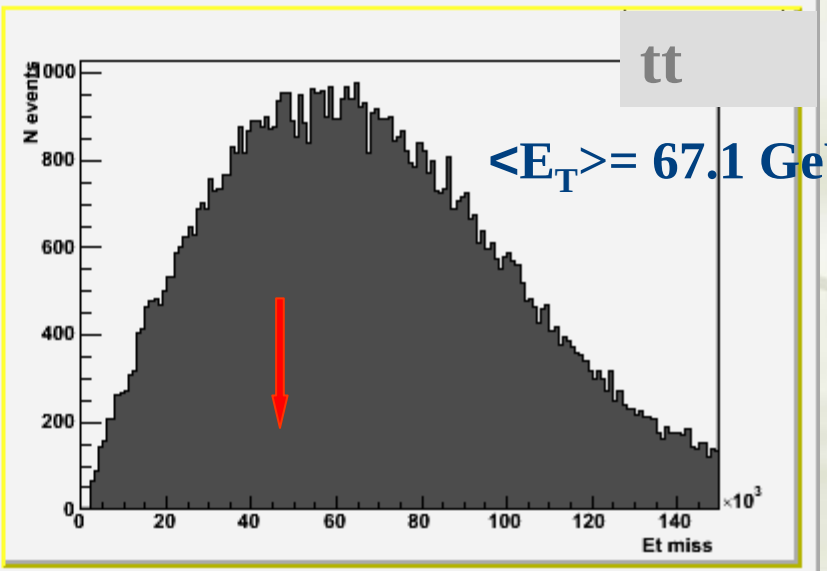
A



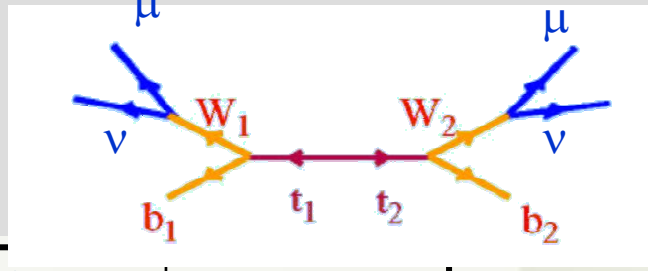
bbZ→μμ



tt

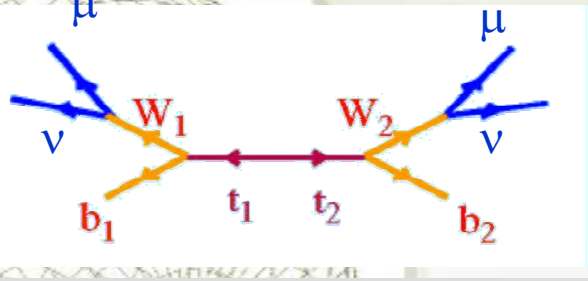


- $E_T^{miss} <$ 45 GeV



particle	initial	preselection	b-tag	E_T^{miss}	
h_0	5999	1758 (29%)	572 (9.5%)	526 (8.8%)	
A_0	7000	2178 (31%)	751 (10.7%)	675 (9.6%)	
Zbb	340502*	127099 (37%)	62812 (18.4%)	52012 (15.2%)	
tt	170110	107075 (63%)	89684 (52.7%)	24180 (14.2%)	
ZZ	3788	1470 (39%)	1042 (27.5%)	885 (23.3%)	

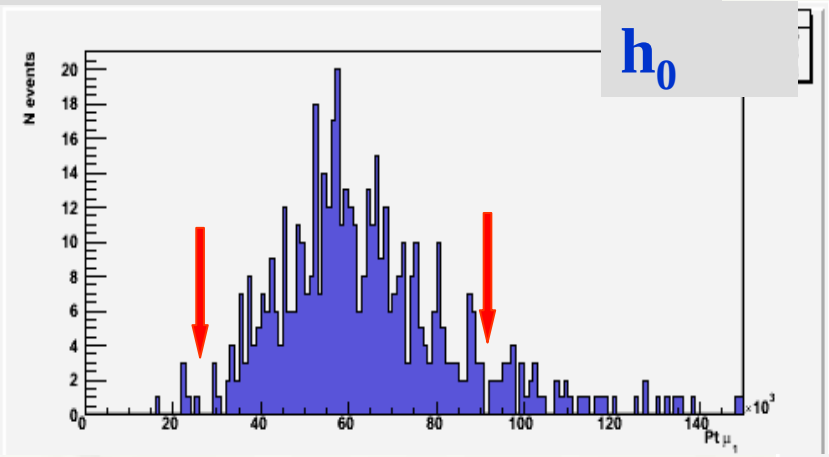
*Corresponding to half luminosity



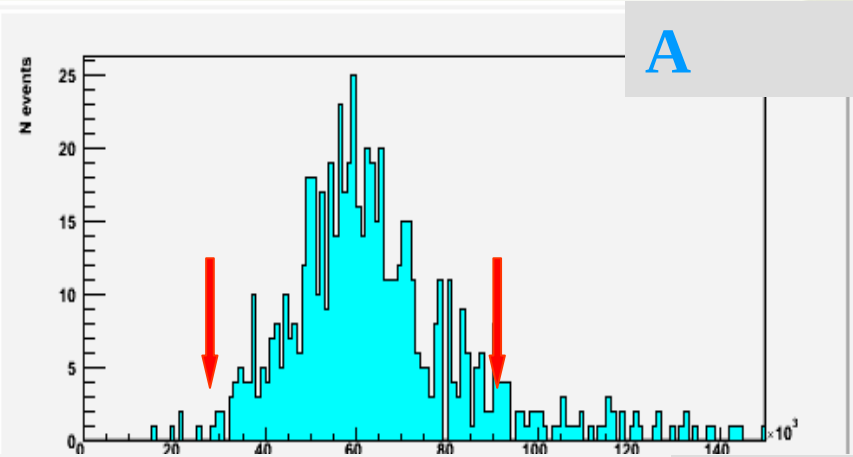
After E_T^{miss}: the most energetic μ $P_T^{\mu 1}$

25 GeV<p_T μ1 < 95 GeV

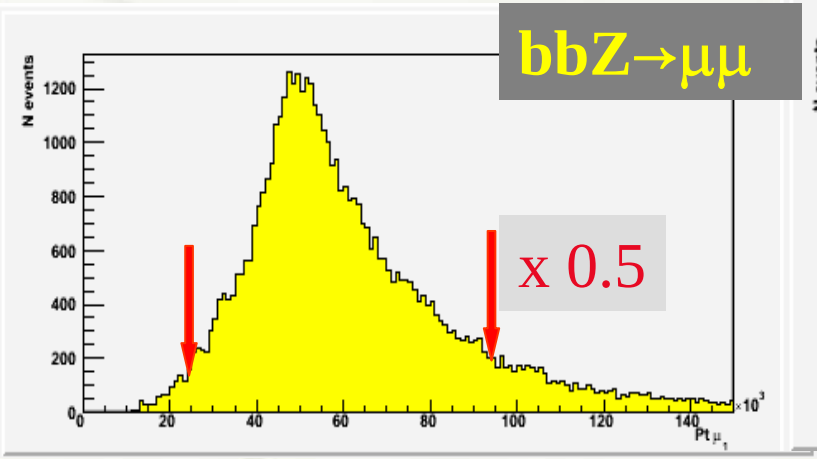
h_0



A

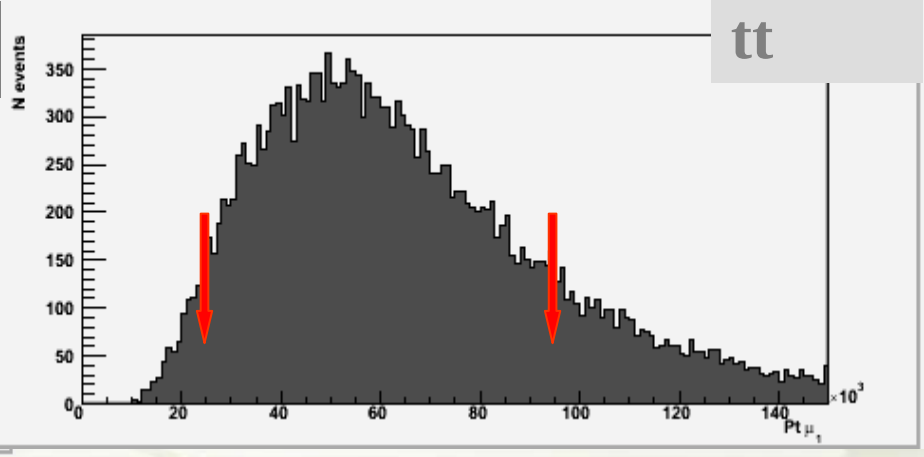


bbZ→μμ



x 0.5

tt



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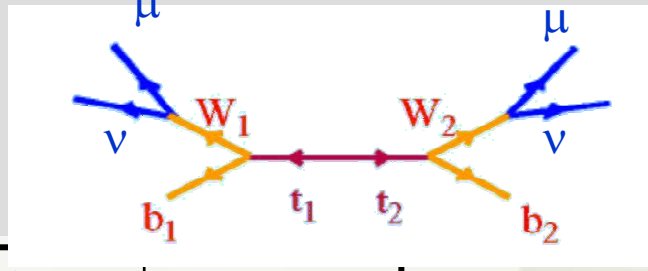
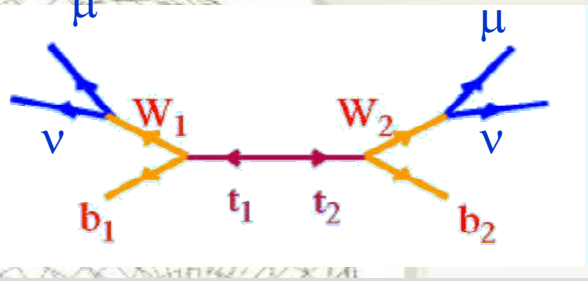
- **25 GeV<$p_T^{\mu 1}$< 95 GeV**



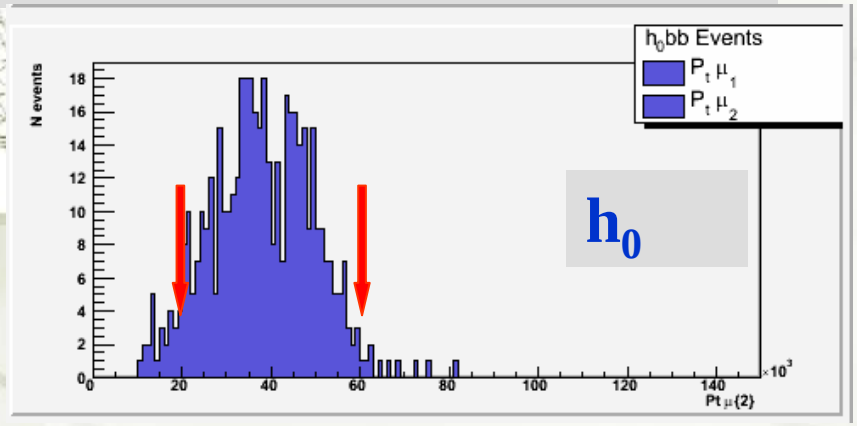
particle	initial	preselection	b-tag	E_T^{miss}	$p_T^{\mu 1}$
h_0	5999	1758 (29%)	572 (9.5%)	526 (8.8%)	464 (7.7%)
A_0	7000	2178 (31%)	751 (10.7%)	675 (9.6%)	597 (8.5%)
Zbb	340502*	127099 (37%)	62812 (18.4%)	52012 (15.2%)	43100 (12.6%)
tt	170110	107075 (63%)	89684 (52.7%)	24180 (14.2%)	17928 (10.5%)
ZZ	3788	1470 (39%)	1042 (27.5%)	885 (23.3%)	690 (18.2%)

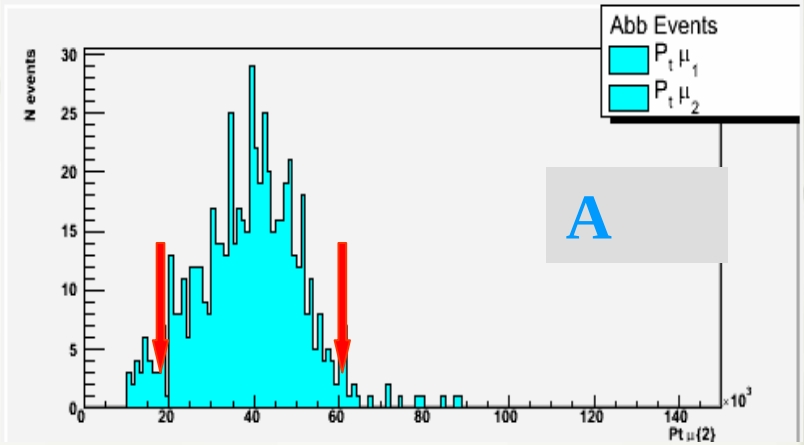
*Corresponding to half luminosity

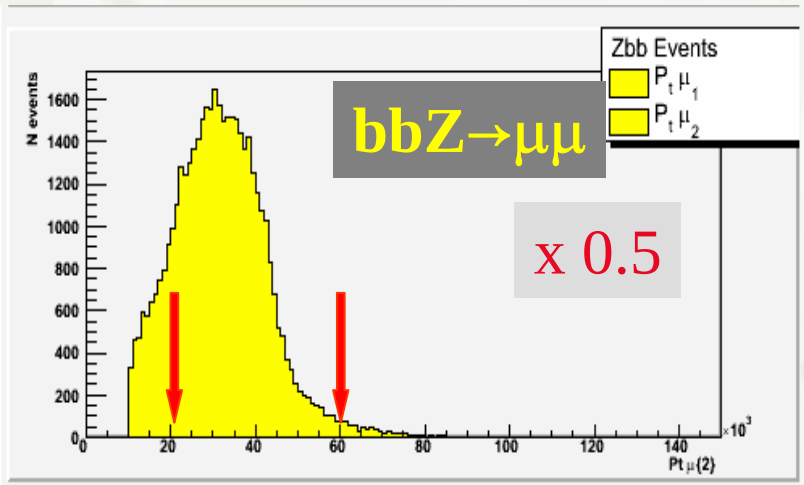


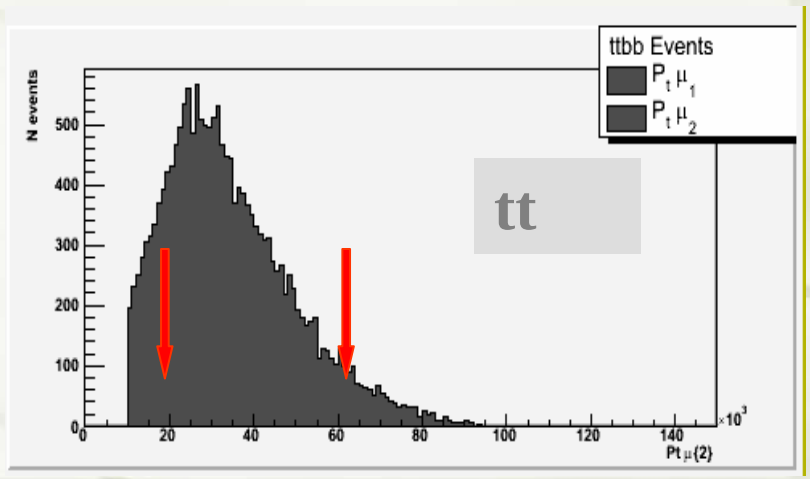
After $P_T^{\mu 1}$:the 2^{nd} most energetic μ $P_T^{\mu 2}$

20 GeV<p_T $\mu 1$ < 60 GeV









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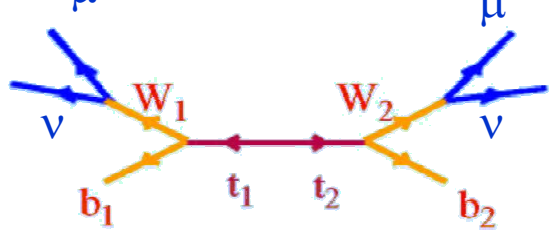
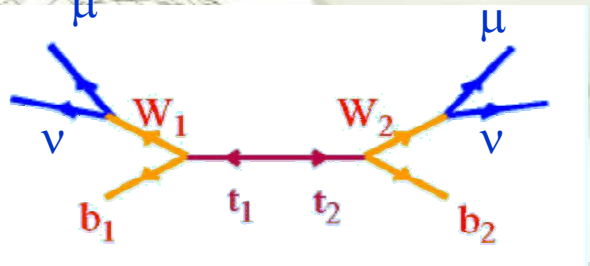
- **20 GeV<$p_T^{\mu 1}$< 60 GeV**



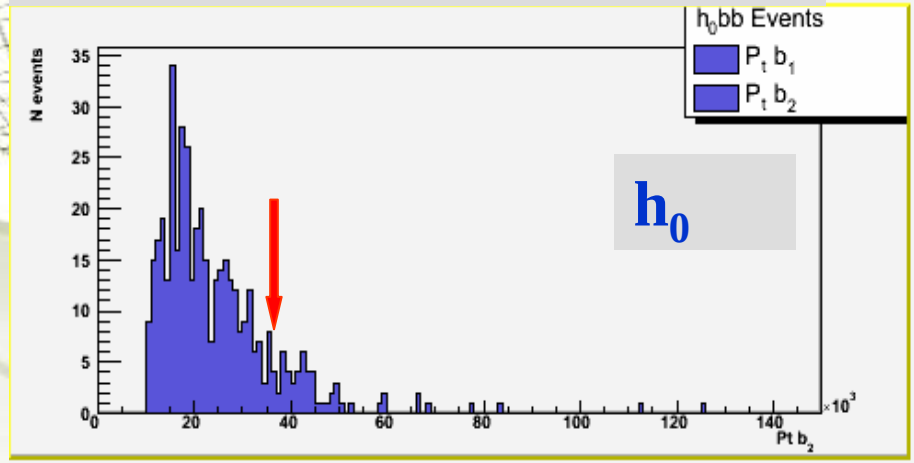
particle	initial	preselection	b-tag	E_T^{miss}	$p_T^{\mu 1}$	$p_T^{\mu 2}$
h_0	5999	1758 (29%)	572 (9.5%)	526 (8.8%)	464 (7.7%)	427 (7.1%)
A_0	7000	2178 (31%)	751 (10.7%)	675 (9.6%)	597 (8.5%)	536 (7.6%)
Zbb	340502*	127099 (37%)	62812 (18.4%)	52012 (15.2%)	43100 (12.6%)	36212 (10.6%)
tt	170110	107075 (63%)	89684 (52%)	24180 (14.2%)	17928 (10.5%)	13545 (7.9%)
ZZ	3788	1470 (39%)	1042 (27.5%)	885 (23.3%)	690 (18.2%)	589 (15.5%)

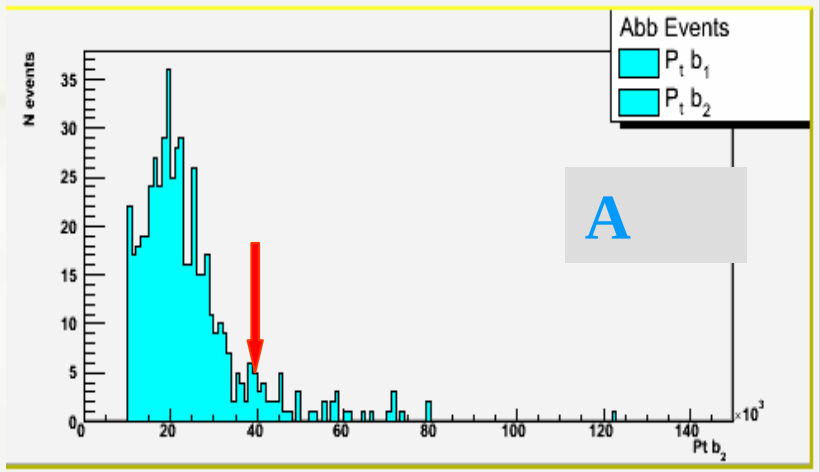
*Corresponding to half luminosity

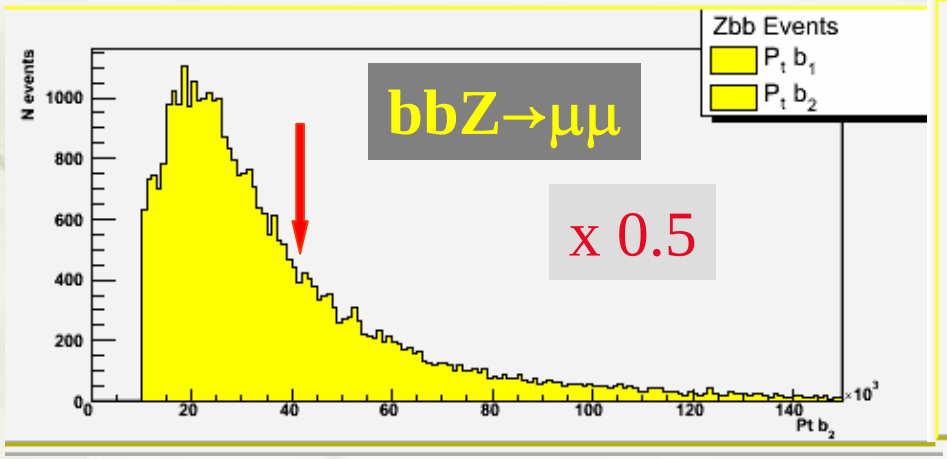


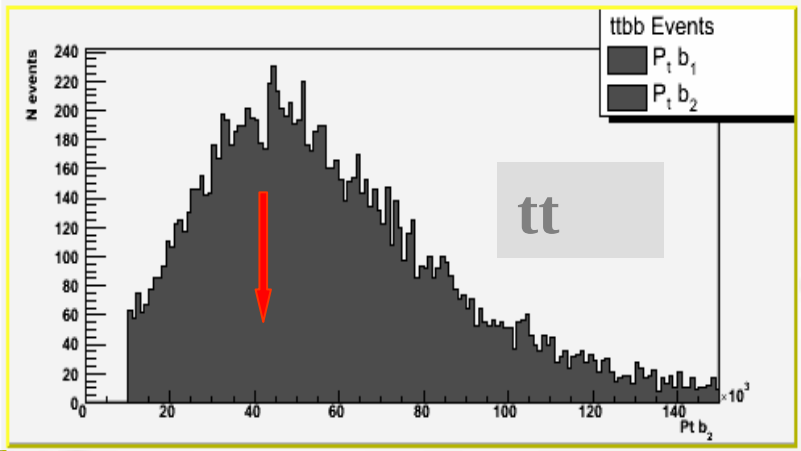
After P_T^{μ} cut: 2^{nd} most energetic b P_T^{b2}

$p_T^{b2} < 40$ GeV









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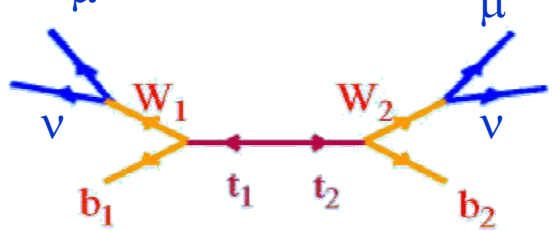
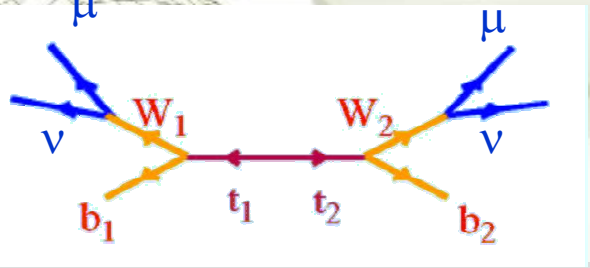
- $p_T^{b2} < 40$ GeV



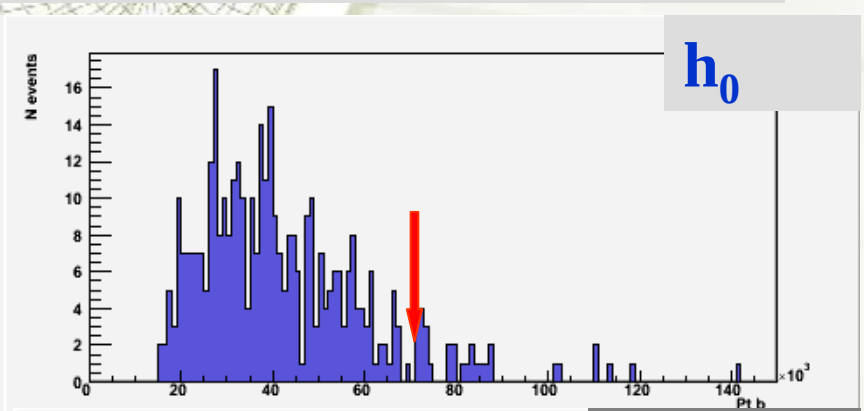
particle	initial	preselection	b-tag	E_T^{miss}	p_T^{μ}	p_T^{b2}
h_0	5999	1758 (29%)	572 (9.5%)	526 (8.8%)	427 (7.1%)	386 (6.5%)
A_0	7000	2178 (31%)	751 (10.7%)	675 (9.6%)	536 (7.6%)	492 (7.0%)
Zbb	340502 *	127099 (37%)	62812 (18.4%)	52012 (15%)	36212 (10.6%)	24067 (7.0%)
tt	170110	107075 (63%)	89684 (52%)	24180 (14%)	13545 (7.9%)	3983 (2.3%)
ZZ	3788	1470 (39%)	1042 (27.5%)	885 (23%)	589 (15.5%)	406 (10.7%)

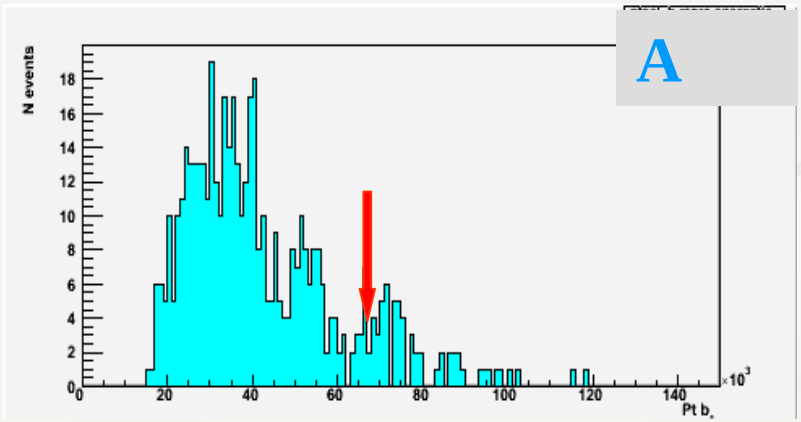
*Corresponding to half luminosity

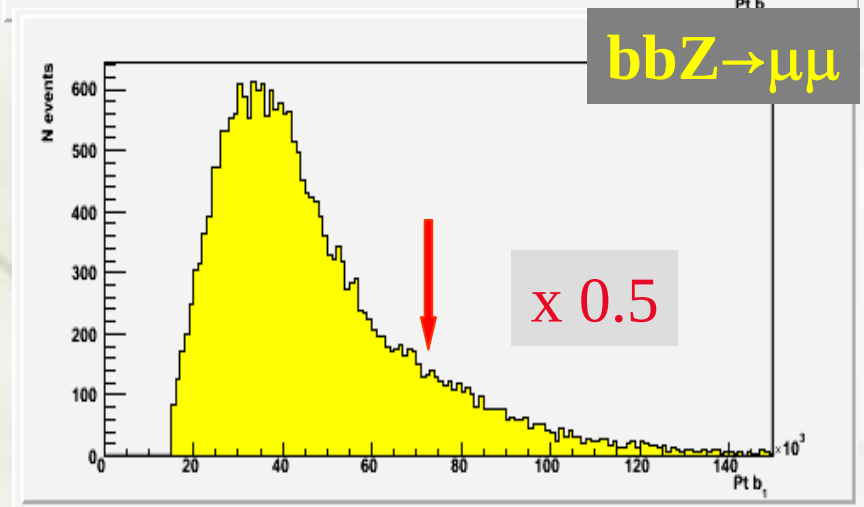


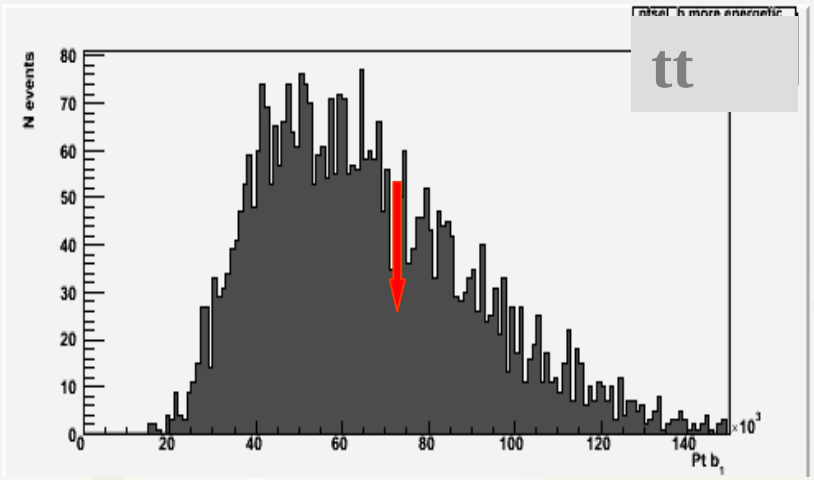
After P_T^{b2} cut: most energetic b P_T^{b1}

$p_T^{b1} < 70$ GeV









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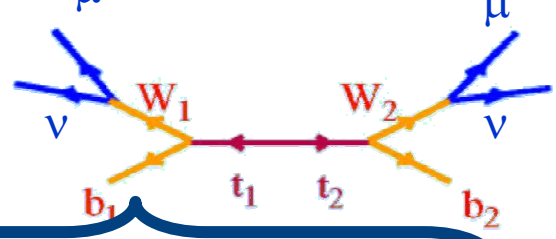
- $p_T^{b1} < 70$ GeV



particle	initial	preselection	b-tag	E_T^{miss}	p_T^{μ}	p_T^{b2}	p_T^{b1}
h_0	5999	1758 (29%)	572 (9.5%)	526 (8.8%)	427 (7.1%)	386 (6.5%)	356 (6.0%)
A_0	7000	2178 (31%)	751 (10.7%)	675 (9.6%)	536 (7.6%)	492 (7.0%)	441 (6.3%)
Zbb	340502 *	127099 (37%)	62812 (18.4%)	52012 (15%)	36212 (10%)	24067 (7.0%)	20473 (6.0%)
tt	170110	107075 (63%)	89684 (52%)	24180 (14%)	13545 (8.0%)	3983 (2.3%)	2438 (1.4%)
ZZ	3788	1470 (39%)	1042 (27.5%)	885 (23%)	589 (15.5%)	406 (10.7%)	334 (8.8%)

*Corresponding to half luminosity

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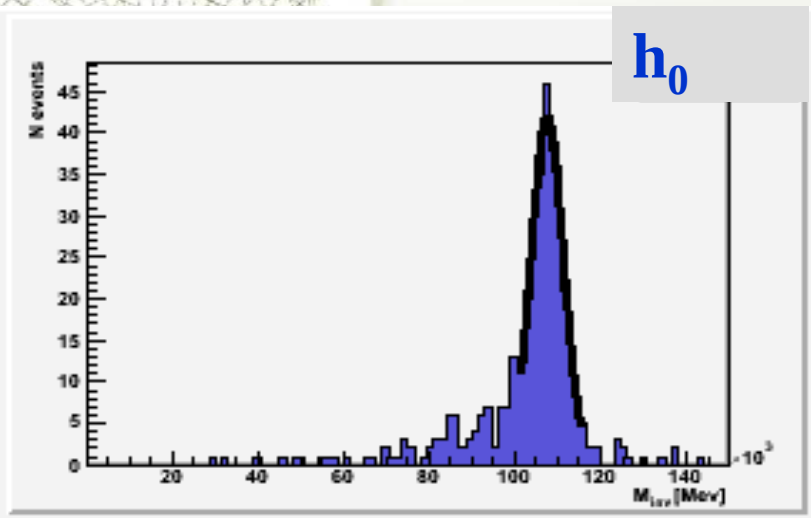
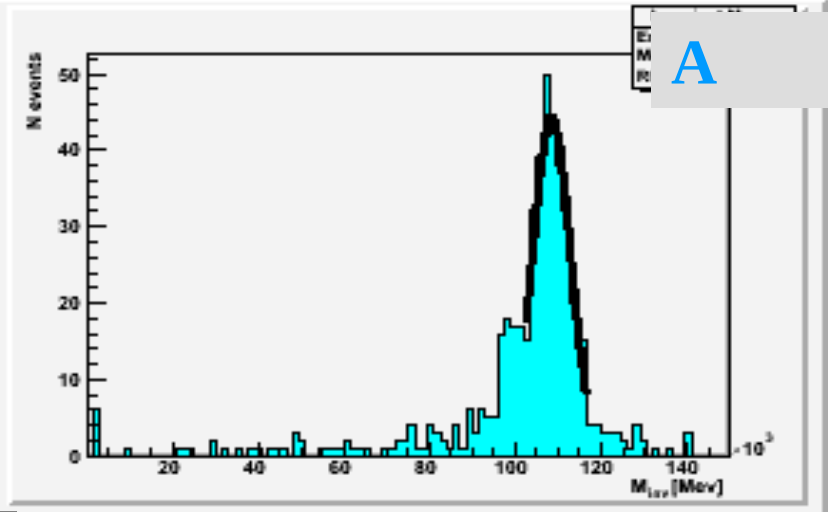
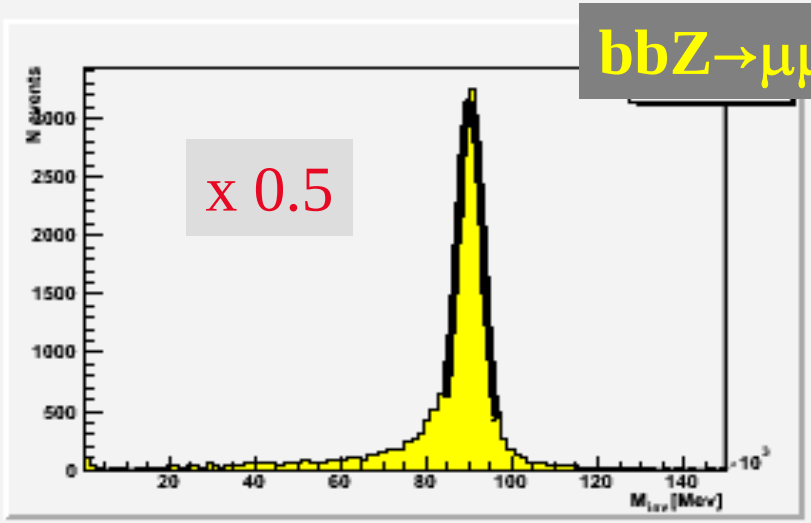
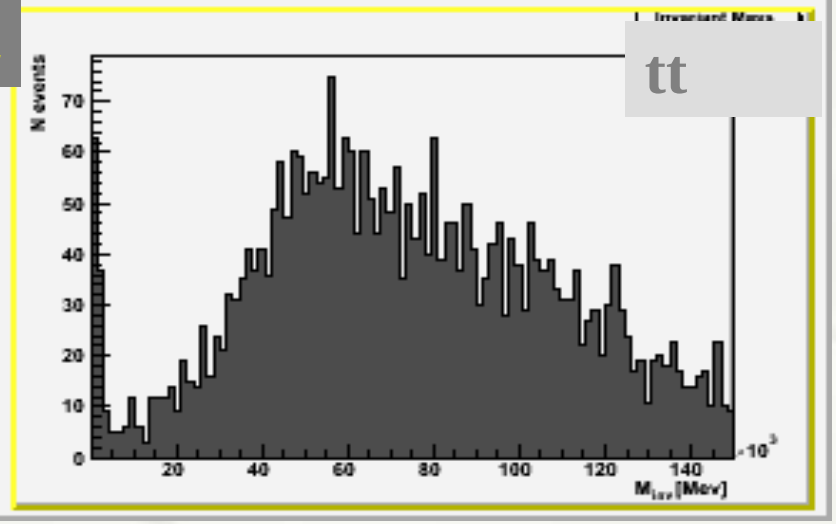
After tt cuts:Invariant mass distributions









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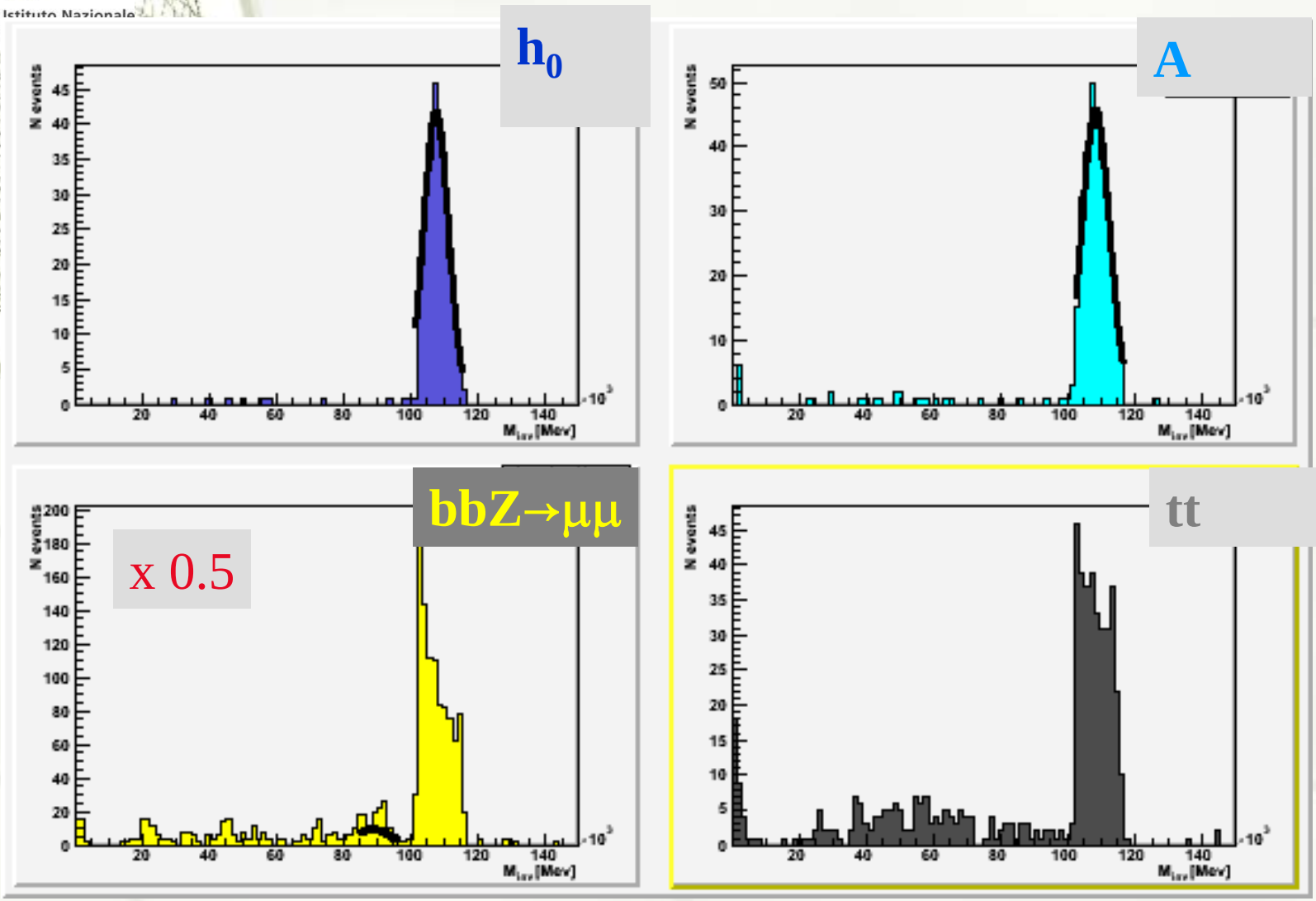
Mass selection window

- Fit results are consistent with detector mass resolution and natural with of particle

$$m_{h_0/A} - k \pm f\left(\left(\frac{\Gamma^{TOT}_{h_0/A}}{2.36}\right)^2 + \sigma^2_m\right)^{1/2}$$

- k = -820 MeV measured at Z mass
- f = standard deviation fraction corresponding to chosen probability: (*e.g.* f =2)
- Where Γ^{tot}_{h0} =3.31 GeV Γ^{tot}_{A} = 4.28 GeV
- σ_m= 2.6% measured at Z mass

Invariant mass



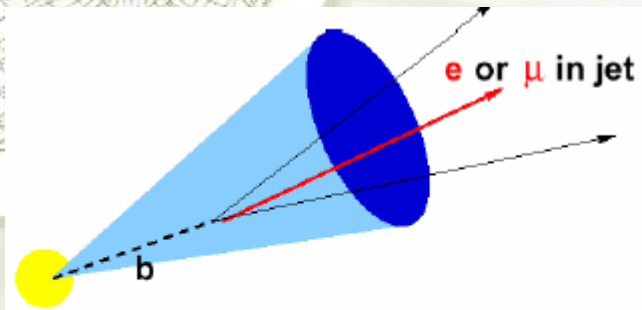
Fit results are consistent with detector mass resolution and natural with of particle

- $|M_{inv}| < |M_{h/A} \pm \text{window}|$

particle	initial	preselection	b-tag	tt cut	M_{inv}
h_0	5999	1758 (29%)	572 (9.5%)	356 (6.0%)	245 (4.0%)
A_0	7000	2178 (31%)	751 (10.7%)	441 (6.3%)	293 (4.1%)
Zbb	340502 *	127099 (37%)	62812 (18.4%)	20473 (6.0%)	490 (0.1%)
tt	170110	107075 (63%)	89684 (52.7%)	2438 (1.4%)	323 (0.2%)
ZZ	3788	1470 (39%)	1042 (27.5%)	334 (88.8%)	9 (0.02%)

*Corresponding to half luminosity

After invariant mass cut:isolation



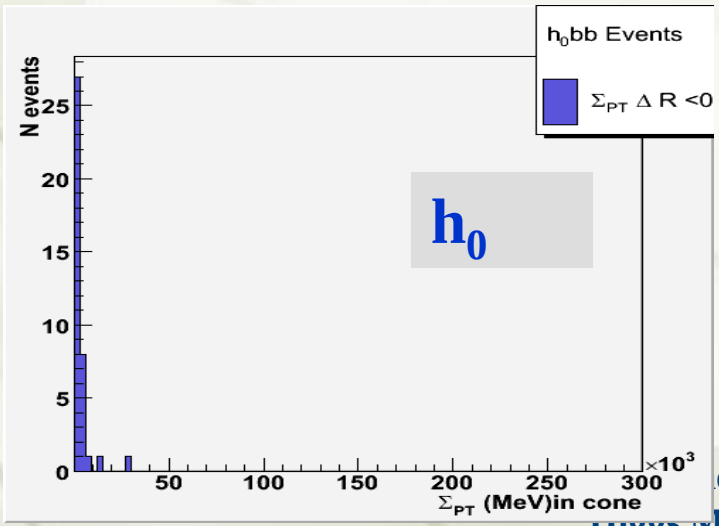
- $b \to \ell\nu c$ (BR $\sim$ 20%)
- $b \to c \to \ell\nu s$ (BR $\sim$ 20%)

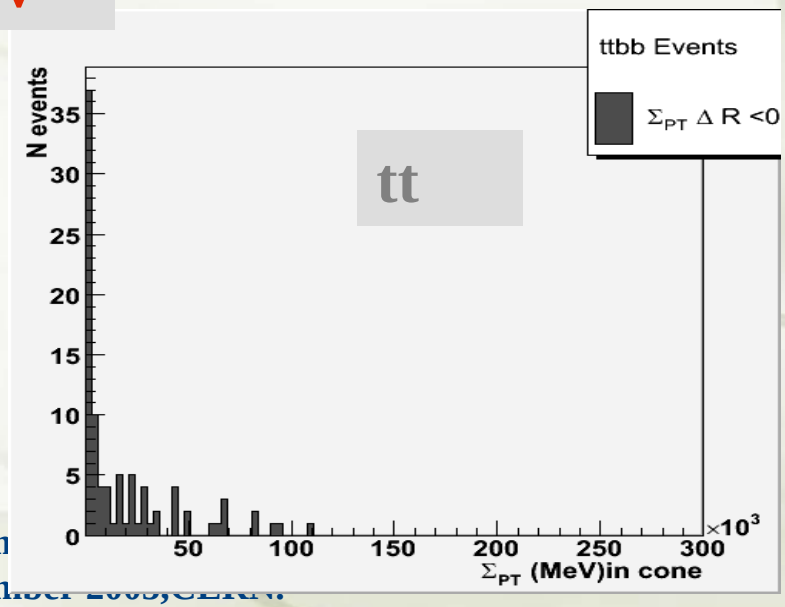
ΣP_T for tracks in $\Delta R < 0.2$

$\Sigma P_T < 5$ GeV

see Louis Flores Presentation Atlas week 28.10.05

$\Sigma P_T < 5$ GeV





- **Isolation $\Sigma P_T < 5$ GeV**

particle	initial	preselection	b-tag	tt cut	M_{inv}	isol
h_0	5999	1758 (29%)	572 (9.5%)	356 (6.0%)	245 (4.0%)	243 (4.0%)
A_0	7000	2178 (31%)	751 (10.7%)	441 (6.3%)	293 (4.1%)	291 (4.1%)
Zbb	340502 *	127099 (37%)	62812 (18.4%)	20473 (6.0%)	490 (0.4%)	465 (0.1%)
tt	170110	107075 (63%)	89684 (52%)	2438 (1.4%)	323 (0.3%)	306 (0.2%)
ZZ	3788	1470 (39%)	1042 (27.5%)	334 (8.8%)	9 (0.02%)	8 (0.02%)

*Corresponding to half luminosity

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Conclusions

- The possibility for a discovery of the neutral MSSM Higgs in bb $A/h_0 \rightarrow \mu\mu$ has been investigated in a test point of MSSM parameter space ($\tan\beta$, m_A): m_A=110.3 GeV, m_{h0} =109.25 GeV

- A study with $\int Ldt = 30\ fb^{-1}$ considering Zbb, tt, and ZZ background led to a significance $\frac{S}{\sqrt{B}} \approx 15$

Next future

- Background subtraction method using
  $bbZ \rightarrow e^+ e^-$ sample
- Consider other possible discriminator variable
- Develop an estimator in order to approach a near possible the Z peak
- Scan ($\tan\beta$, m_A) plane
- b-tag improvement (difficult)

Credit to Giovanni Nicoletti.
without him this work can never done

Riserve

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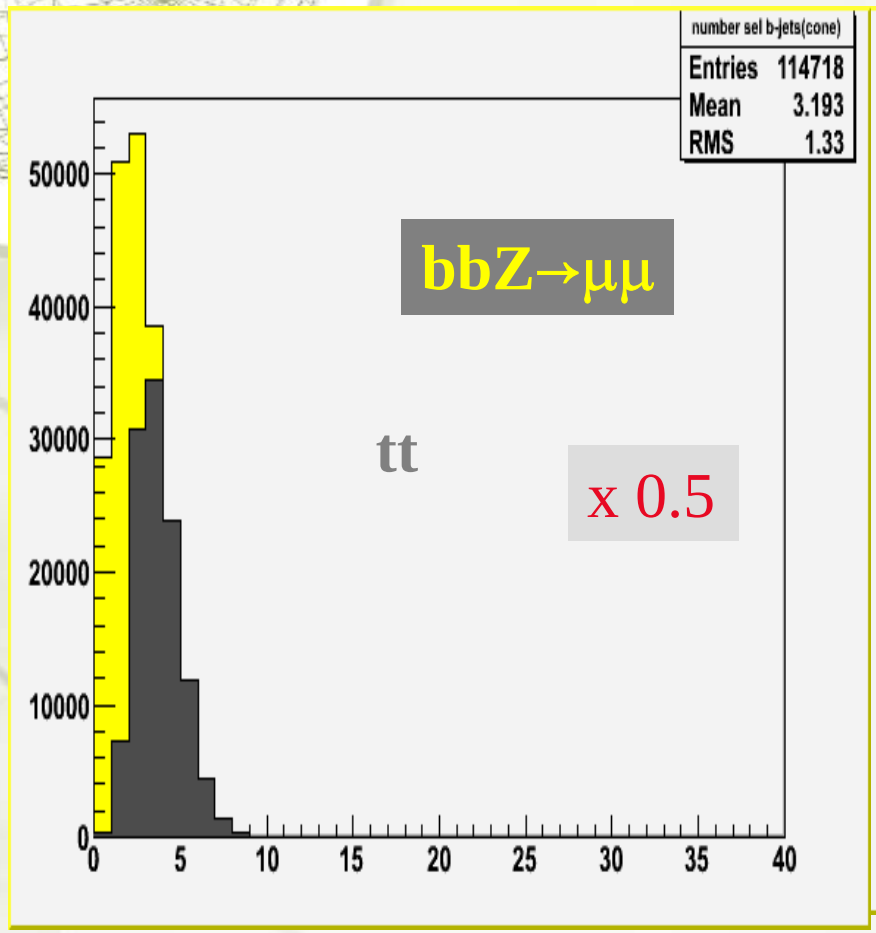
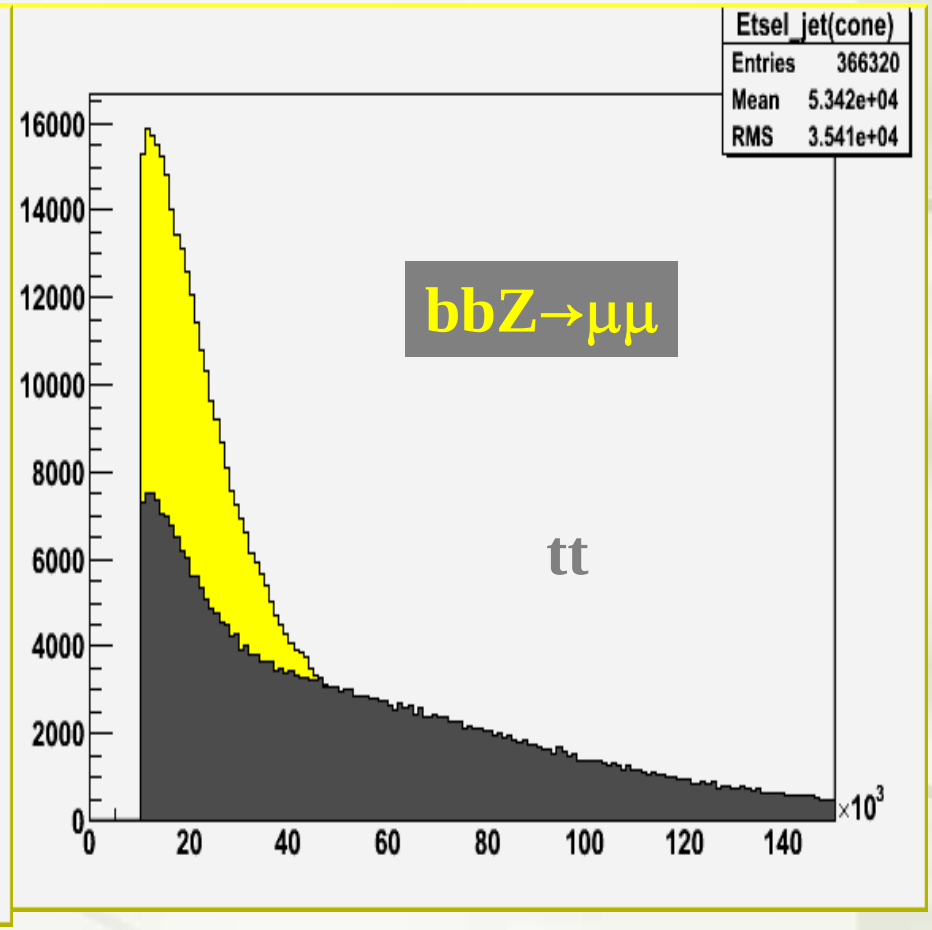
after 1 cut





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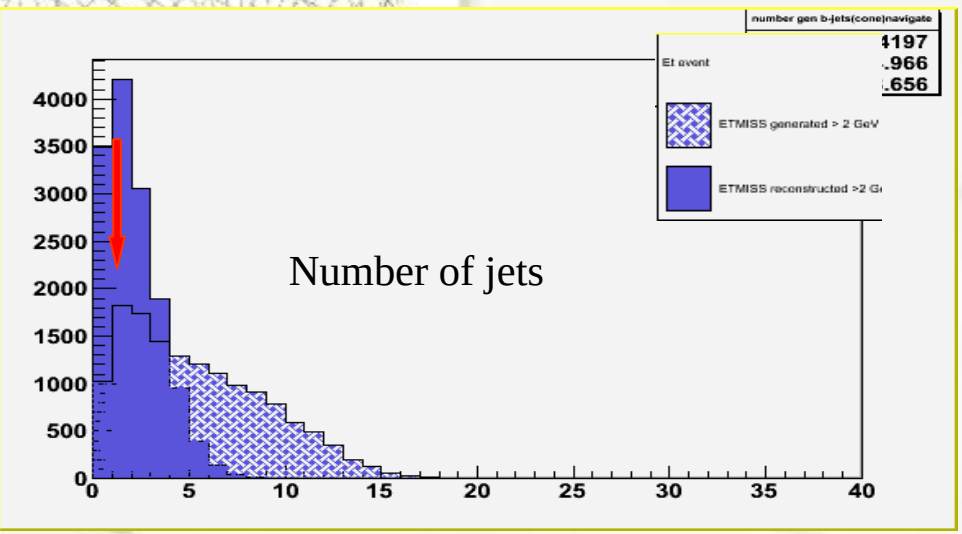
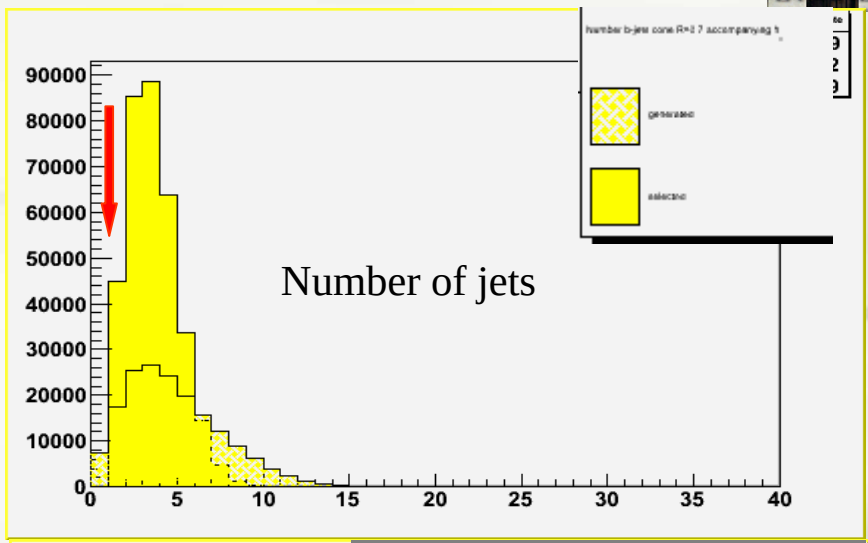
Study of sample: Jets

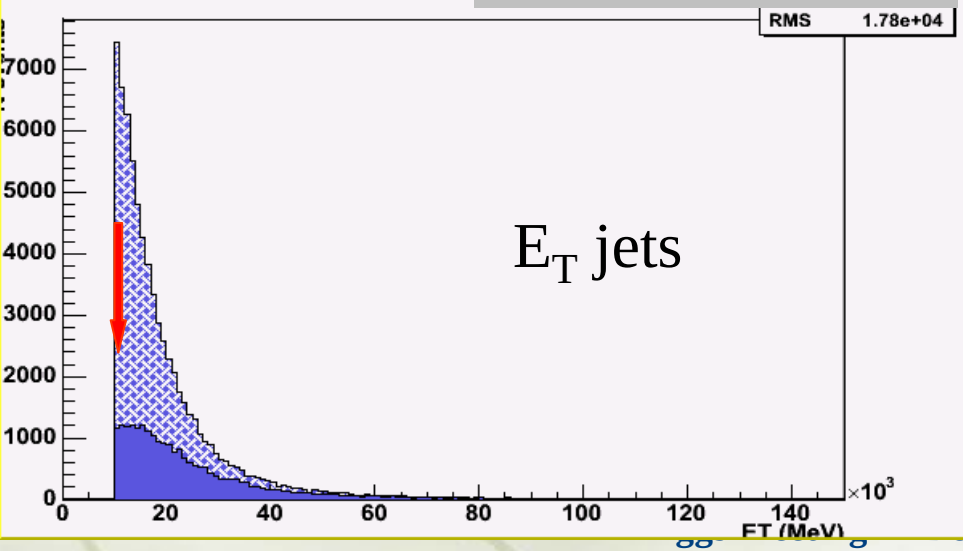
$h_0 \rightarrow \mu^+ \mu^-$

$Z \rightarrow \mu^+ \mu^-$

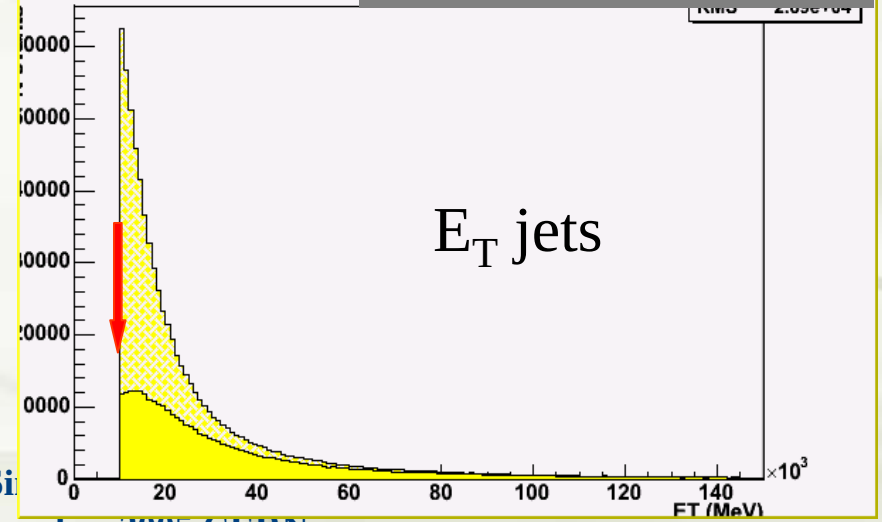




$\langle E_T^{gen} \rangle \sim 20$ GeV



$\langle E_T^{gen} \rangle \sim 26$ GeV



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