
Comparison of Simulations for the NMSSM No-Lose Theorem

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Outline

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2. EGHM Analysis
3. EGHM Simulation versus ALS
4. Conclusion

Introduction

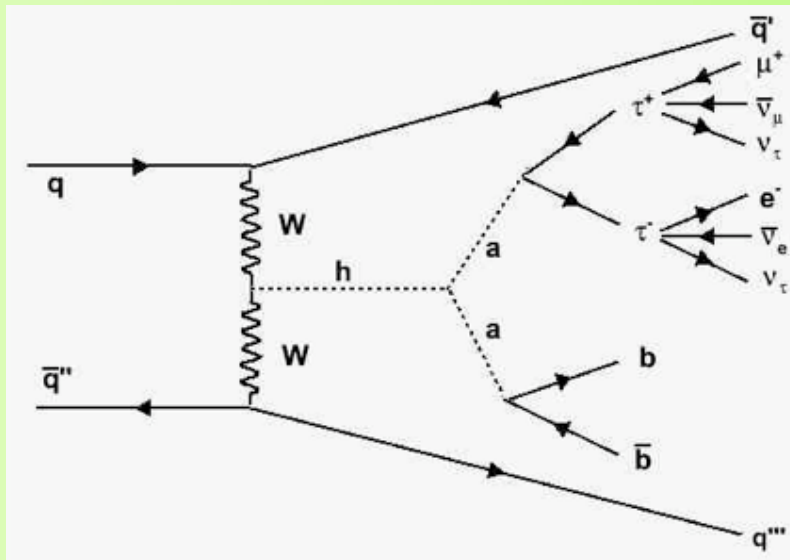
- MSSM: SM + Higgs doublet + SUSY particles
- NMSSM: extends MSSM by superfield
 - generates μ parameter naturally (Higgsino mass parameter)
- Extended Higgs sector:

MSSM	NMSSM
h^0, H^0, A^0, H^\pm	$h_{1,2,3}, a_{1,2}, h^\pm$
$h^0 \rightarrow A^0 A^0$ rare	$h_i \rightarrow a_j a_j$ possible

- Parameter sets where standard Higgs searches fail?
 - ➡ Yes ➡ new channel
- 10 different parameter sets
(EGHM: Ellwanger, Gunion, Hugonie, Moretti, 2003)

Detection Mode

- $WW \rightarrow h \rightarrow aa$
- Channel:



mass	h^0	119.5 GeV
	a^0	~ 30 GeV
BR	$h^0 \rightarrow a^0 a^0$	0.9909
	$a^0 \rightarrow bb$	0.9899
	$a^0 \rightarrow \tau^+ \tau^-$	0.0069
	$h^0 \rightarrow bb \tau^+ \tau^-$	0.0135

- Signature:
 - 2 fwd jets
 - $2\tau \rightarrow ll + 4\nu$
 - min. 2 central jets

The Status

	<i>EGHM, 2003</i>	<i>Stephanie Baffioni (ATLAS)</i>
<i>Event Generator</i>	Herwig	Pythia
<i>Simulation</i>	homemade for leptons, CALSIM, GETJET by F. Paige, analysis	ALS
<i>Analysis</i>		similar analysis

- Aim: reproduce EGHM's results
- Observation: large differences in signal cut efficiencies
- Order of magnitude ~ 100

This Study

<i>Event Generator</i>	Herwig	
<i>Simulation</i>	EGHM	ALS
<i>Analysis</i>	EGHM	

- Understand cut efficiencies on signal (ignore background)
- Event by event comparison
- Interface to ALS
- Translate analysis to ALS
- Identify differences
- Quantify influence of calorimeter simulation/reconstruction on result

First Analysis: Cut Flow

<i>EGHM</i>	<i>ALS</i>	<i>EGHMs' Analysis</i>	
$N_{\text{events}} = 2685393$			
1562539	11331	Leptons	reconstructed ≥ 2
47766	1803		$P_T > 10 \text{ GeV}$
31270	1250		opposite sign
24142	348	Jets	≥ 4
21761	306		forward: $\eta > 0$, backward: $\eta < 0$
15633	234		$\Delta\eta > 4$
14274	225		τ invariant mass reconstruction
10053	152		b-jets (central): $P_T > 40 \text{ GeV}$
8380	114		forward: $P_T > 25 \text{ GeV}$
6947	92		backward: $P_T > 25 \text{ GeV}$

Blind Application

Point	No. of events	
	EGHM	ALS
	ratio	

- all points:

1	2627511	
	1342	256
	5.2 ± 0.5	

2	2646495	
	1836	317
	5.8 ± 0.5	

3	2663677	
	6486	39
	166 ± 28	

4	2687284	
	6244	64
	97 ± 13	

5	2685393	
	6947	92
	75 ± 9	

6	2687852	
	7740	106
	73 ± 8	

7	2682976	
	4403	8
	550 ± 203	

8	2687081	
	5697	35
	162 ± 30	

-1	2687491	
	7375	406
	18 ± 1	

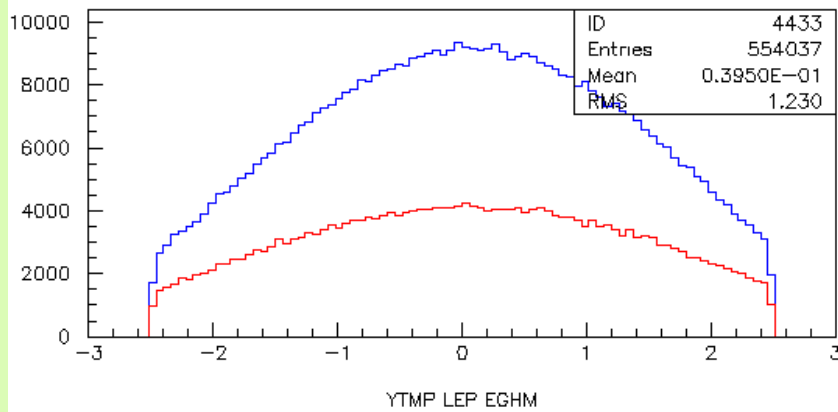
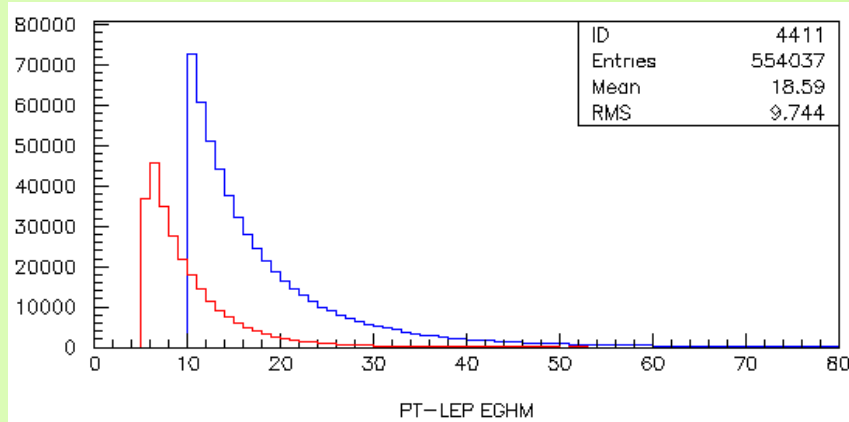
Acceptance Efficiencies

channel	generated	accepted		efficiency in %	
		EGHM	ALS	EGHM	ALS
bbbb	2593378	6684	51	0.258(3)	0.0020(3)
bb$\tau^+\tau^-$	45787	159	40	0.35(3)	0.087(14)
$\tau^+\tau^-\tau^+\tau^-$	188	1	0	0.5(5)	0.0
glu glu	21381	25	1	0.12(2)	0.005(5)
no a^0a^0	24659	78	0	0.32(4)	0.0
$N_{\text{events}} = 2685393$					

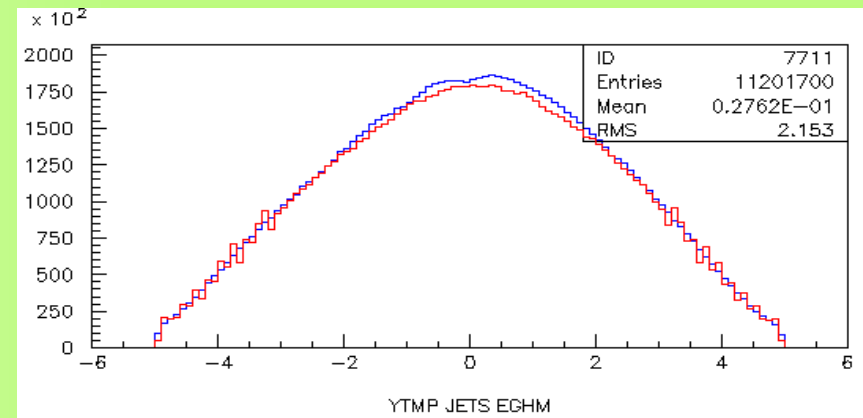
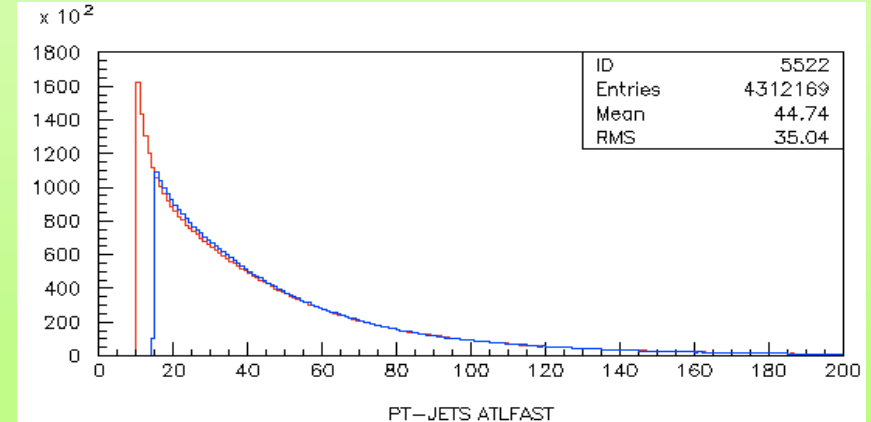
- EGHM: bbbb and bb $\tau^+\tau^-$ efficiency same order of magnitude
- ALS: bb $\tau^+\tau^-$ well distinguished as it should be

First Check

- P_T, η Leptons



- P_T, η Jets



Lepton Reconstruction

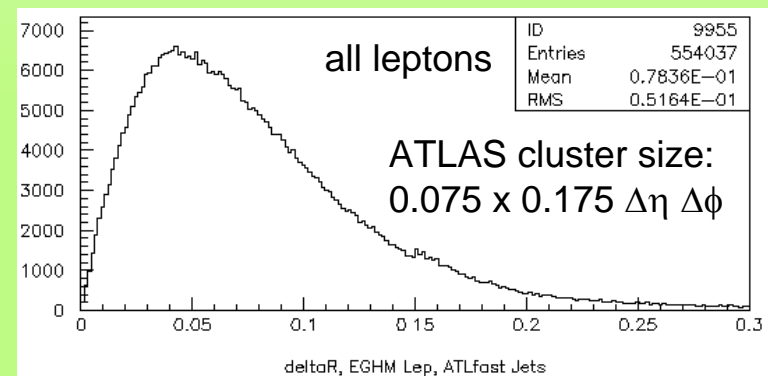
- Compare lepton acceptance eventwise

- identify $\Delta R_l < 0.2$
- every accepted ALS lepton also accepted by EGHM's code
- all further leptons found by EGHM within $\Delta R_{lj} < 0.2$ to jet

Accepted by EGHM	550000
Accepted by ALS	98000
EGHM, ALS leptons: $\Delta R_l < 0.2$	94738

- EGHM: any lepton
- ALS: only isolated leptons
- Conclusions

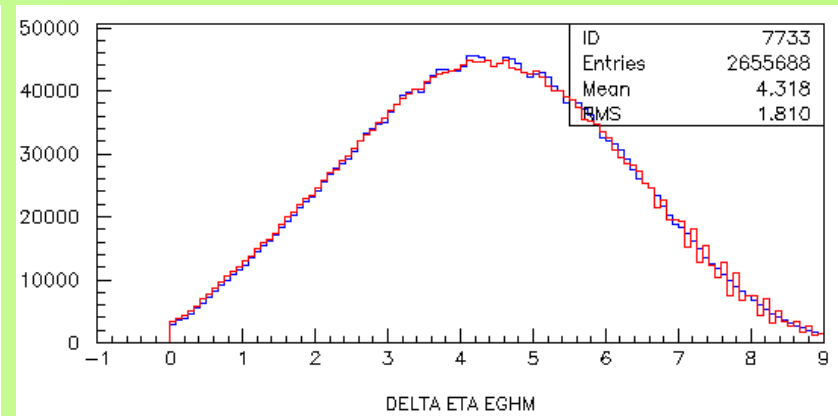
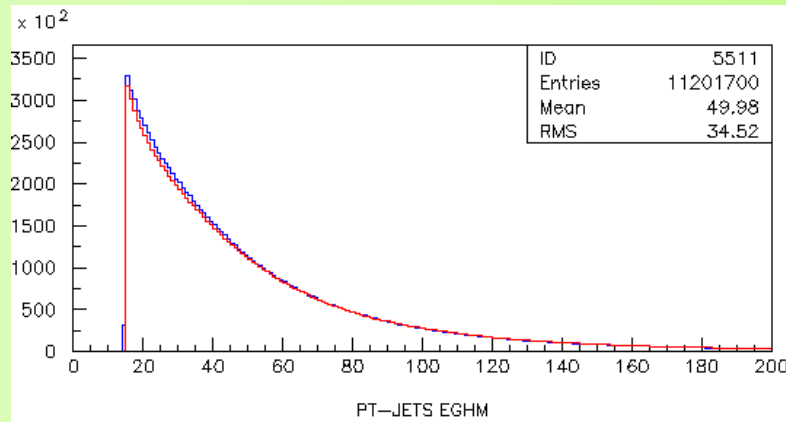
- differences in lepton sector fully understood
- EGHMs' results too optimistic



Jets: P_T

EGHM	ALS	Cuts
70.4 %	67.6 %	b-jets: $P_T > 40$ GeV
83.4 %	75.0 %	FWD: $P_T > 25$ GeV
82.9 %	80.7 %	BWD: $P_T > 25$ GeV

- Moved internal ALS cut to 15 GeV
- $\Delta\eta$ the same
- Smaller differences

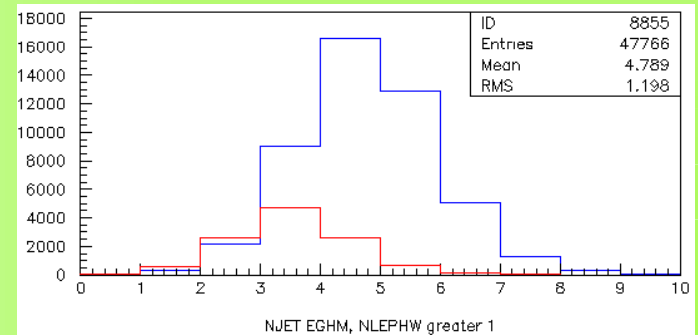
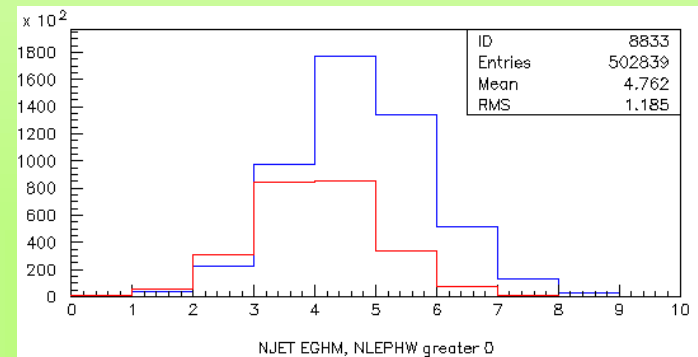
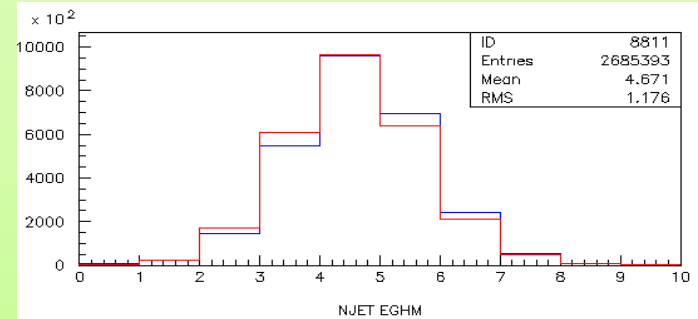


Jet Reconstruction

EGHM	ALS	Cuts
77.2 %	27.8 %	Number ≥ 4

- EGHMs' code: only two leptons with highest P_T marked
 \rightarrow leptons incorrectly reconstructed as jets

BR	$h^0 \rightarrow a^0 a^0$	0.9909
	$a^0 \rightarrow bb$	0.9899
	$a^0 \rightarrow \tau^+ \tau^-$	0.0069



Conclusion

- Calorimeter simulations differ in
 - Lepton identification
 - Jet reconstruction
- EGHM: results too optimistic
 - Dominant $b\bar{b}b\bar{b}$ signal for $b\bar{b}\tau^+\tau^-$ analysis
 - Non-zero efficiency for non-isolated leptons
- Results confirmed by EGHM
 - No special treatment of $b\bar{b}b\bar{b}$ final states