

SUSY searches in events with minimum two isolated leptons

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Outline

- ▷ Introduction
- ▷ Signal, Background
- ▷ Object definition - efficiencies
- ▷ Event selection
- ▷ 3-lepton signature
- ▷ $ll+\gamma$ signature
- ▷ Summary - Outlook



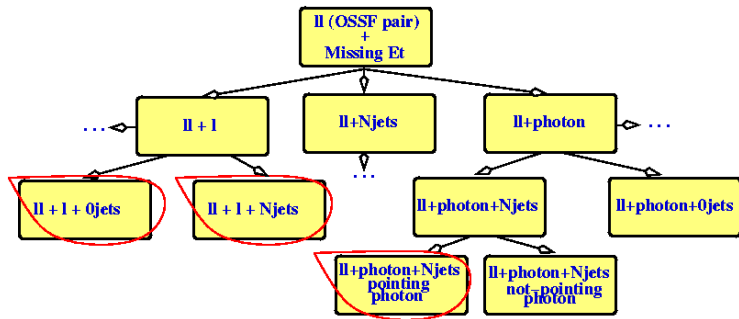
Introduction

- ▶ Supersymmetry - one of the most promising “beyond Standard-Model theories”
 - ▷ SUSY - broken symmetry
 - ▷ Different symmetry breaking mechanisms lead to different phenomenology and final states
 - ▷ MSSM - 105 parameters → reduced parameter spaces for different breaking mechanisms, typically 4-5 parameters
 - ▷ SUSY searches are performed in these reduced parameter spaces
 - ▷ Benchmark points represent some characteristic scenarios
- ▶ Majority of MSSM models have high-pt isolated leptons and missing E_T as a signature
- ▶ If nature is supersymmetric, leptons can provide some hints about how it is realized



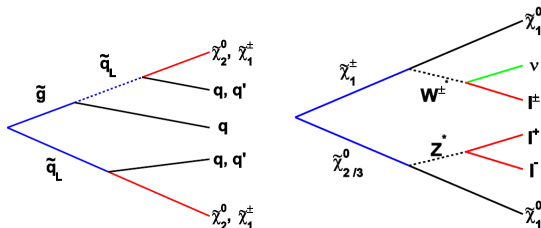
SUSY searches in events with leptons

- ▶ Search strategy: Signature based searches
 - ▷ Searches for final states with two isolated leptons plus additional signatures
 - ▷ Two examples of signature based searches:
 - ▷ processes giving three leptons in final state
 - ▷ processes providing typical SUSY signal with two leptons and characteristic additional photons

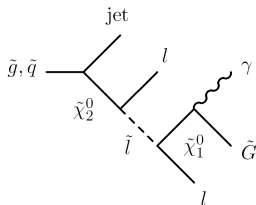


Signal - final states with 3 leptons

- ▶ mSUGRA
- ▶ Jet inclusive search:
 - ▷ Signatures: 2+1 isolated leptons + jets + \cancel{E}_T
 - ▷ Benchmark points: low $m_{1/2}$ and m_0 , low mass squarks, gluons, relatively high cross sections (SU4, SU3)
 - ▷ Typical events: $\tilde{g}\tilde{q}$, $\tilde{q}\tilde{q}$, $\tilde{g}\tilde{g}$
- ▶ This signature can also be studied in a jet exclusive mode:
 - ▷ Signatures: 2+1 isolated leptons + “no jets” + \cancel{E}_T
 - ▷ Benchmark point: high m_0 heavy \tilde{g} \tilde{q} , Focus Point region, SU2 - discovery
 - ▷ Ongoing study, but it requires high integrated luminosity. Not early physics



Signal - final states with 2 leptons and a photon



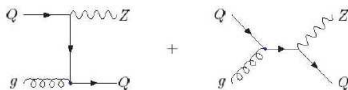
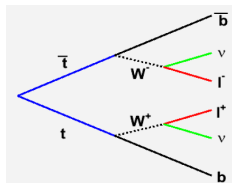
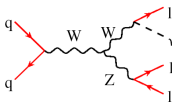
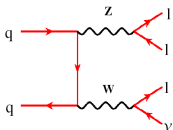
- ▶ GMSB
- ▶ Signatures: 2 isolated leptons and a photon + \cancel{E}_T
 - ▶ Benchmark point: $N_5 = 1$, small $\tan\beta$, short lived neutralino, heavy $\tilde{g} \tilde{q}$
 - ▶ 2 lepton (SFOS) plus an additional photon
 - ▶ Characteristic distributions
 - ▶ Large missing E_T
 - ▶ One more high- p_T photons
 - ▶ p_T of leading photon



SM Background

Some of the main backgrounds

- ▶ Top pair production (high cross section)
- ▶ Zb (high cross section)
- ▶ SM counterpart: diboson production, WZ, ZZ, WW
- ▶ $Z\gamma$ with photon conversion
- ▶ QCD jets
- ▶ single gauge boson production (Z,W)



Object definitions - event selection

- ▶ Standard ATLAS reconstruction
- ▶ Quality cuts

Additional cuts:

Leptons:

$|\eta| < 2.5$, $p_T > 10$ GeV , the third lepton has typically low p_T

Common for Electrons, Muons:

Isolation energy in cone $\Delta R = 0.2 < 10$ GeV, distance to closest jet $\Delta R > 0.4$

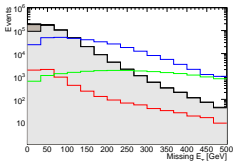
Photon:

$|\eta| < 2.5$, $p_T > 15$ GeV

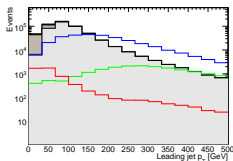
$$(\Delta R = \sqrt{\Delta\eta^2 + \Delta\phi^2})$$



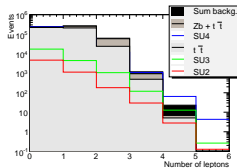
Object definitions - event selection



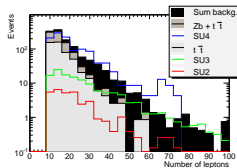
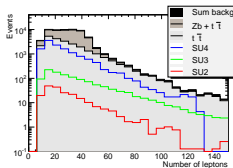
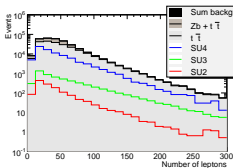
\cancel{E}_T ,



p_T leading jet,



Number of leptons



p_T leptons: leading lepton, sub-leading lepton, third lepton

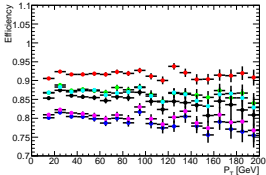
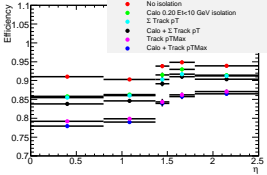
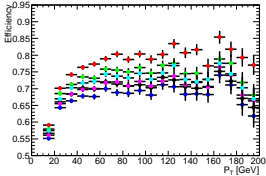
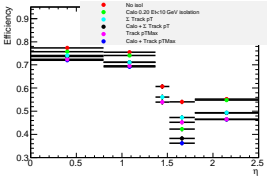


Lepton Efficiencies

$$\text{Efficiency} = \frac{\# \text{ Truth matched to Reco}(\Delta R < 0.02)}{\text{Total Number of Truth}} \tag{1}$$

Different isolation requirements have been studied

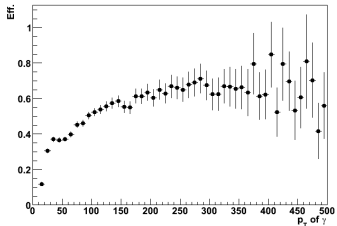
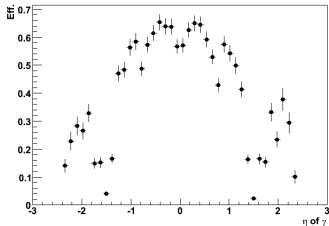
electrons $69.2 \pm 0.2 \%$, muons $87.3 \pm 0.2 \%$ (SU3, 200 000 events):



Photon Efficiency

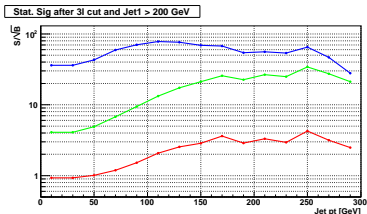
$$\text{Efficiency} = \frac{\# \text{ Truth matched to Reco}(\Delta R < 0.02)}{\text{Total Number of Truth}} \quad (2)$$

photons $46 \pm 1\%$ (GMSB $\sim 20\,000$ events)



mSUGRA - 3 lepton: Event selection

After 3 lep. $M_{SFOS} < 20$ GeV cut



Event selection:

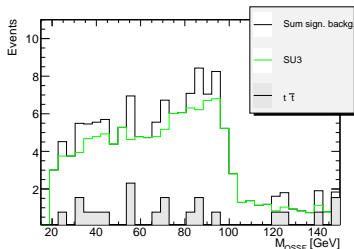
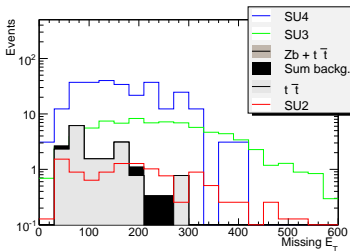
Simple and general

Cuts:

3 or more leptons

If $M_{SFOS} < 20$ GeV

Leading jet $p_T > 200$ GeV



mSUGRA - 3 lepton: Cut Flow, Significance

Cut flow for integrated luminosity 1 fb^{-1} . PRELIMINARY

Signal	SU4	SU3	SU2
No Cuts	327500.0	23240.0	6080.0
3 leptons	1232.8	131.7	32.5
$M_{SFOS} > 20$	1109.2	122.5	29.7
1.jet >200	278.1	82.7	11.1

Background	ZZ	Z γ	WZ	Zb	T1
No Cuts	3920.0	3350.0	16080.0	102000.0	461000.0
3 leptons	61.2	9.4	195.7	449.5	490.3
$M_{SFOS} > 20$	58.9	9.4	193.0	434.3	460.2
1.jet >200	0.0	0.0	1.3	0.0	16.2

Significance S/\sqrt{B}

S/\sqrt{B}	SU4	SU3	SU2
3 leptons	35.5	3.8	0.9
$M_{SFOS} > 20$	32.6	3.6	0.9
1.jet >200	66.4	19.7	2.6
All cuts $S/\sqrt{2B}$	46.9	14.0	1.9

Based on $S/\sqrt{2B}$.

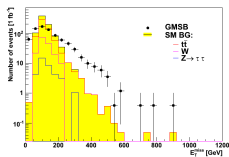
Luminosity required for 5σ .

Point	Luminosity for 5σ
SU2	6.9 fb^{-1}
SU3	128 pb^{-1}
SU4	11 pb^{-1}

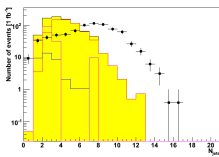


GMSB - event selection: 2 leptons

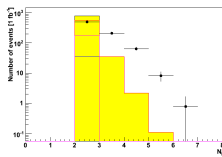
For integrated luminosity 1 fb^{-1}



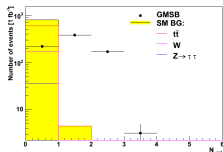
E_T^{miss} ,



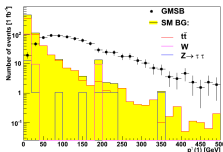
Number of jets,



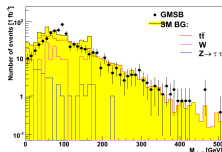
Number of leptons



Number of photons,



p_T leading photon,

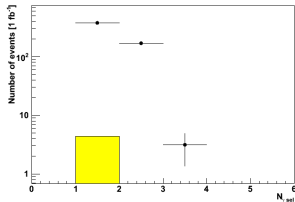


Mass OSSF



GMSB - 2 leptons + photon event selection

Number of photons



Event selection:

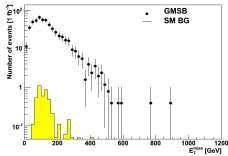
2 or more leptons

1 or more photons

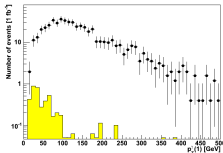
The photon requirements removes most of the background giving high S/\sqrt{B}

However...

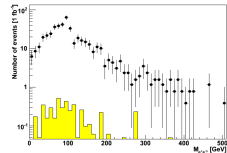
- all backgrounds not included
- no systematic effects



E_T^{miss}



p_T^l leading photon,



Mass OSSE (electrons)



Summary - Outlook

- ▶ Two signatures have been studied as examples of SUSY searches in events with two leptons
 - ▷ 3-leptons + jets
 - ▷ $2l + \gamma$: GMSB - neutralino short time
- ▶ Preliminary results look encouraging

Outlook:

- ▶ Cut optimization
- ▶ Further background study
- ▶ More signatures will be included in analysis
- ▶ Pile-up, trigger study ...

