Search for supersymmetry in multileptonic final states with the ATLAS-Detector

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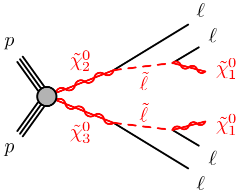
ATLAS EXPERIMENT

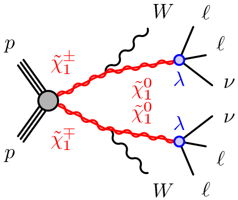
3/3/2016

Why search in multi leptonic events?

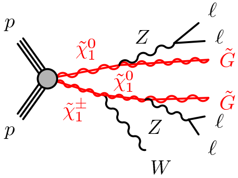
- Very low standard model background
- Sensitive to wide variety of SUSY models, if decays to leptons are favored



(a) RPC



(b) RPV



(c) GGM

Figure : lepton rich processes in SUSY

- This talk deals with 4 leptons in the final state

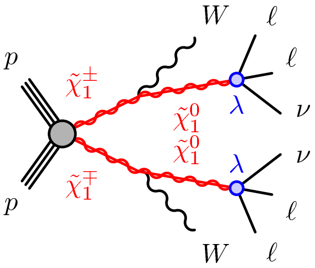
- looked for at least 4 leptons in final state
- Strategy: 9 signal region selections
- no significant deviation from SM
- limits placed on many SUSY models

ATLAS constraints in the pMSSM [JHEP 10 (2015) 134]

RPV Summary [ATLAS-CONF-2015-018]

Electroweak production of SUSY particles [arXiv:1509.07152]

4 lepton RUN 1 [Phys. Rev. D. 90, 052001 (2014)]



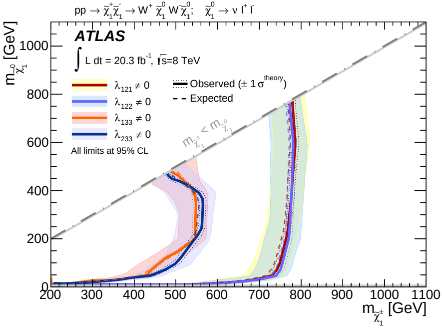


Figure : e.g. RPV: Exclusion limits found in run 1

SR0 $\geq 4\ell$	**SR1** $3\ell, \geq 1\tau$	**SR2** $2\ell, \geq 2\tau$

$\times$

Z requirement +minimum $E_{\mathrm{T}}^{\mathrm{miss}}$	**noZa** Z veto +min. $E_{\mathrm{T}}^{\mathrm{miss}}$	**noZb** Z veto +min. $E_{\mathrm{T}}^{\mathrm{miss}}$ or m_{eff}

- Z requirement: Passed if

$$|m(\ell^+\ell^-) - m_Z| < 10\ \mathrm{GeV}$$

- Z veto: Fails if

$$|m(\ell^+\ell^-) - m_Z| < 10\ \mathrm{GeV}$$
$$\text{or } |m(\ell^+\ell^-\ell'^{\pm}) - m_Z| < 10\ \mathrm{GeV}$$
$$\text{or } |m(\ell^+\ell^-\ell'^{+}\ell'^{-}) - m_Z| < 10\ \mathrm{GeV}$$

- Effective mass

$$m_{eff} = \sum_{i \in lep} p_{\mathrm{T},i} + \sum_{\substack{i \in jets \\ (p_{\mathrm{T}} > 40\ \mathrm{GeV})}} p_{T,i} + E_T^{miss}$$

SR0	SR1	SR2
$\geq 4\ell$	$3\ell, \geq 1\tau$	$2\ell, \geq 2\tau$

$\times$

Z requirement	noZa Z veto	noZb Z veto
+minimum $E_{\mathrm{T}}^{\mathrm{miss}}$	+min. $E_{\mathrm{T}}^{\mathrm{miss}}$	+min. $E_{\mathrm{T}}^{\mathrm{miss}}$ or m_{eff}

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this talk is about
4 light leptons with a Z veto
(SR0noZa, SR0noZb)

SR0noZa

$E_{\mathrm{T}}^{\mathrm{miss}} > 50$ GeV

SR0noZb

$E_{\mathrm{T}}^{\mathrm{miss}} > 75$ GeV or $m_{\mathrm{eff}} > 600$ GeV

preselection: (e, μ) = ℓ, jets

	p_T [GeV]	$\|y\|$
electrons	≥ 10	≤ 2.47
muons	≥ 10	≤ 2.5
jets	≥ 20	≤ 2.8

j-ℓ ambiguities resolved

low mass processes:
$\ell^+\ell^-$ removed if $m(\ell^+\ell^-) < 12 GeV$

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baseline

Object selection

preselection: (e, μ) = ℓ, jets

	p_T [GeV]	$\|y\|$
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j-ℓ ambiguities resolved

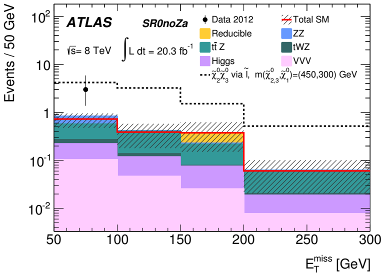
low mass processes:
$\ell^+\ell^-$ removed if $m(\ell^+\ell^-) < 12 GeV$

$\downarrow$

baseline	
signal	**loose**

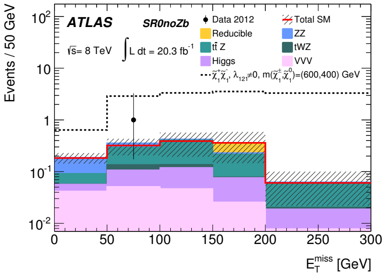
Signal object selection
based on
d_0, z_0, ID and isolation

the rest



(a) **SR0noZa**

Z veto , $E_T^{miss} > 50$ GeV

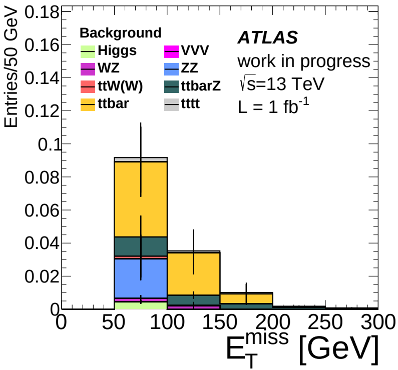


(b) **SR0noZb**

Z veto , $E_T^{miss} > 75$ GeV or $m_{eff} > 600$ GeV

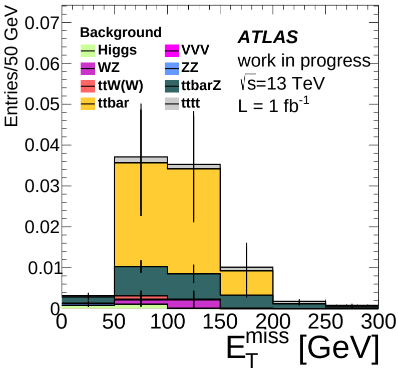
Dominant background processes:

- $t\bar{t}Z^*$ ($\sim$ 50%)
- Z^*Z^* ($\sim$ 18%)
- Higgs decay ($\sim$ 17%)
- VVV ($\sim$ 12%)
- $t\bar{t}$ ($\sim$ 5%) **reducible**



(a) **SR0noZa**

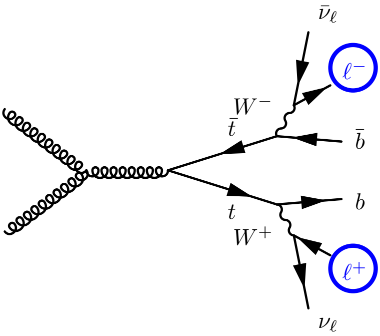
Z veto , $E_T^{miss} > 50$ GeV



(b) **SR0noZb**

Z veto , $E_T^{miss} > 75$ GeV or $m_{eff} > 600$ GeV

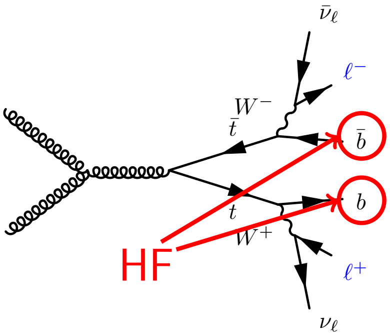
Improved lepton reconstruction since run 1
more leptons from b-jets
$\Longrightarrow$ **$t\bar{t}$ more than 50 % of background now**



In 4L events with a Z veto the main sources of leptons are

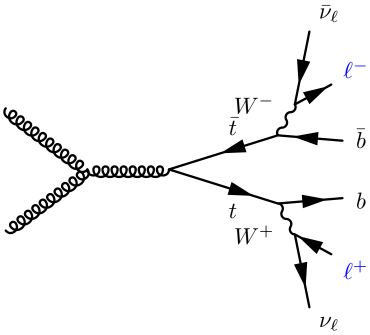
- real: W $\rightarrow \ell\nu$

How does this $t\bar{t}$ background arise



In 4L events with a Z veto the main sources of leptons are

- real: W $\rightarrow \ell\nu$
- heavy flavor hadron decays (HF)



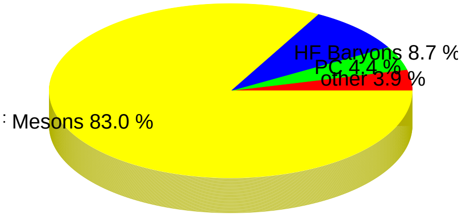


Figure : $t\bar{t}$ fake/secondary leptons origin

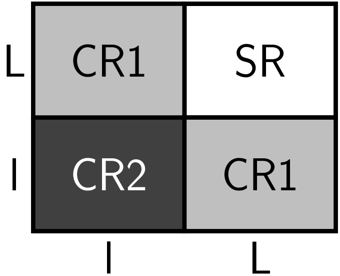
In 4L events with a Z veto the main sources of leptons are

- real: W $\rightarrow \ell\nu$
- heavy flavor hadron decays (HF)
- $\gamma \rightarrow e^+e^-$ (PC)
- others (π, K)

background estimation strategy

How to estimate the $t\bar{t}$ background?

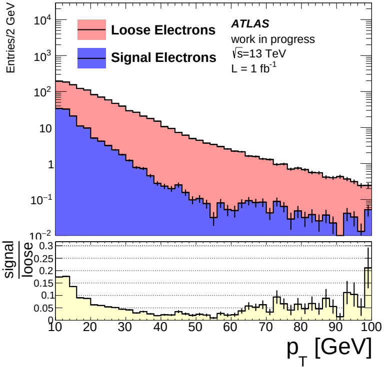
1. introducing data "control regions", as in run 1.
   - CR1: only 3 signal and one loose lepton (3L1l)
   - CR2: only 2 signal and two loose leptons (2L2l)
2. estimate reducible background by scaling CRs
3. to start, study the fake ratio $F(l, X)$ on $t\bar{t}$ simulation.



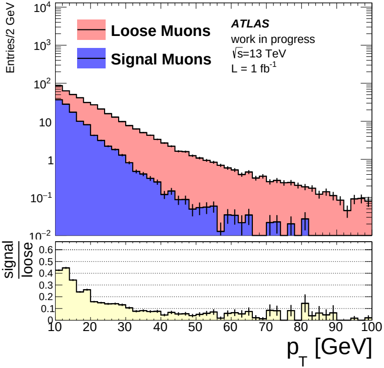
Fake Ratio

$$F_{\mathrm{Type}}(l, X) = \frac{N_{signal}(l, X)}{N_{loose}(l, X)}$$

with $l = \mu, e$
$X = p_T, y, \#jets$
$\mathrm{Type} = \mathrm{HF},\ \mathrm{PC},\ \ldots$



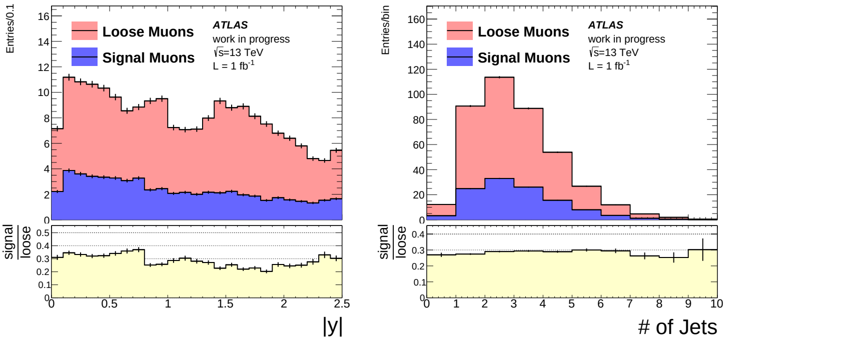
(a) $F_{\mathrm{HF}}(e,\ p_T)$



(b) $F_{\mathrm{HF}}(\mu,\ p_T)$

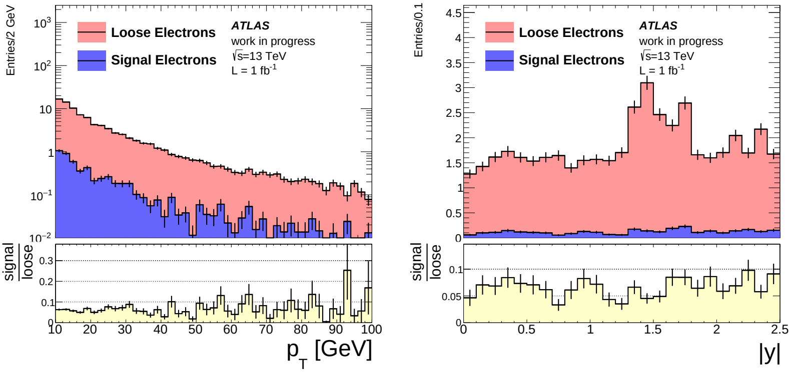
Figure : Heavy flavour fake ratio

heavy flavour jets: fake ratio depends, as in run 1, strongly on p_T. but fake ratio is bigger than in run 1,



(a) $F_{\mathrm{HF}}(\mu,\ |y|)$ (b) $F_{\mathrm{HF}}(\mu,\#Jets)$

only little dependance on $|y|$ and no dependance on the number of jets in the event



(a) $F_{\mathrm{PC}}(e,\ p_{\mathrm{T}})$

(b) $F_{\mathrm{PC}}(e,\ |y|)$

Summary

- studying events with at least **4 light leptons** in the final state
- compared to run 1 there is a significant fraction of **reducible background** ($t\bar{t}$)
- estimation of $t\bar{t}$ using **data control regions**
- first look at **fake ratios** for CR→SR extrapolation

Plans

- measure heavy flavour fake ratio in data
- apply to control region data