Search for SUSY with same-sign or three leptons and jets at $\sqrt{s} = 13$ TeV

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CENTRE DE PHYSIQUE DES PARTICULES DE MARSEILLE

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General information

SUSY SS2l/3l+jets subgroup of ATLAS experiment

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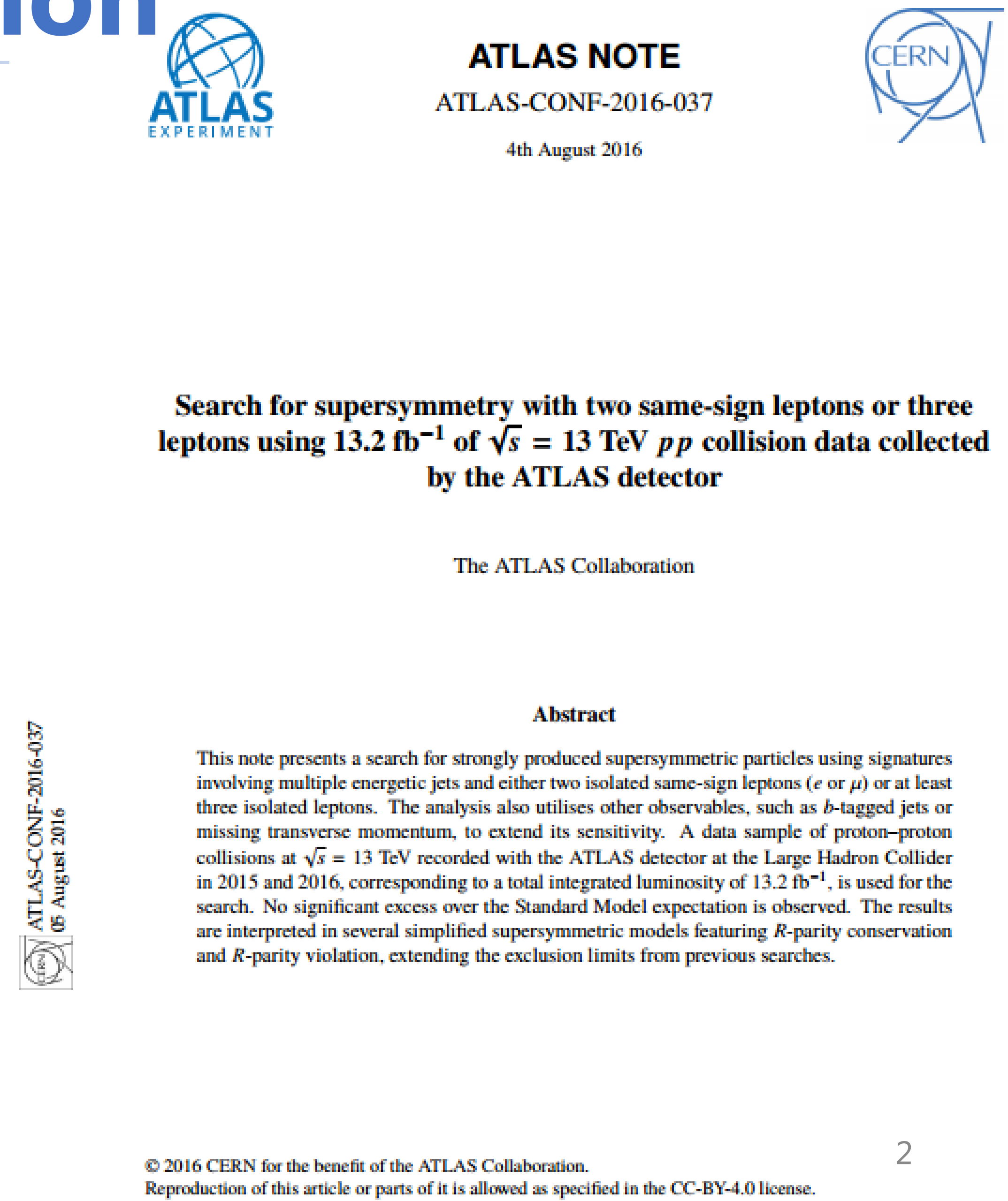


ATLAS NOTE

ATLAS-CONF-2016-037

4th August 2016

Search for supersymmetry with two same-sign leptons or three leptons using 13.2 fb^{-1} of $\sqrt{s}$ = 13 TeV pp collision data collected by the ATLAS detector

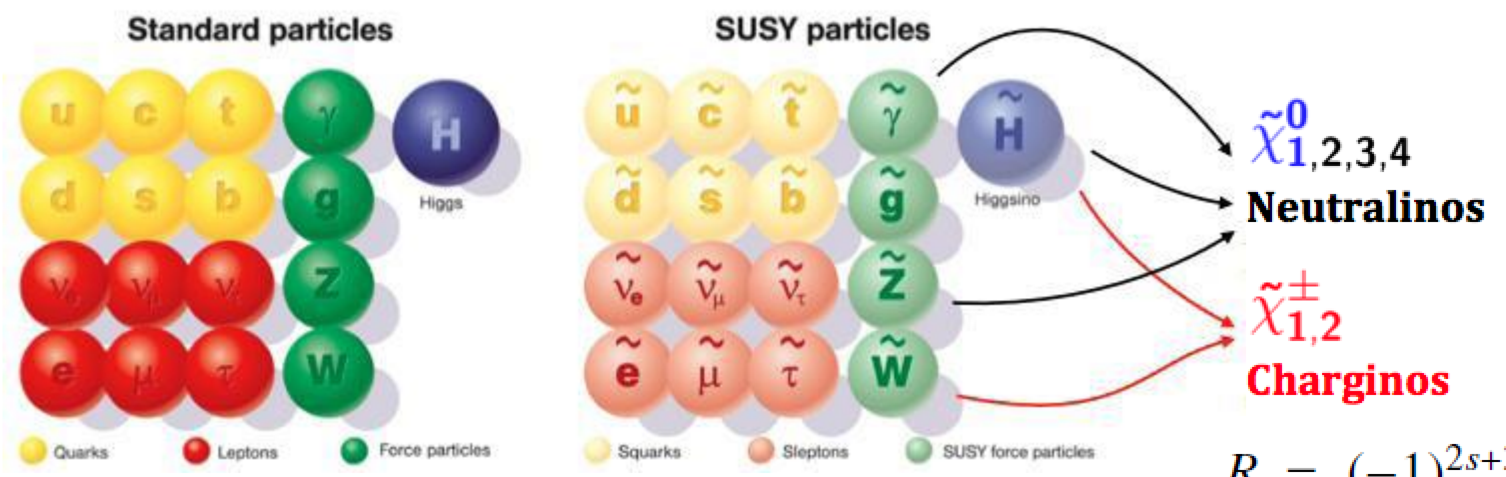
The ATLAS Collaboration

ATLAS-CONF-2016-037
05 August 2016

Abstract

This note presents a search for strongly produced supersymmetric particles using signatures involving multiple energetic jets and either two isolated same-sign leptons (e or μ) or at least three isolated leptons. The analysis also utilises other observables, such as b-tagged jets or missing transverse momentum, to extend its sensitivity. A data sample of proton–proton collisions at $\sqrt{s}$ = 13 TeV recorded with the ATLAS detector at the Large Hadron Collider in 2015 and 2016, corresponding to a total integrated luminosity of 13.2 fb^{-1}, is used for the search. No significant excess over the Standard Model expectation is observed. The results are interpreted in several simplified supersymmetric models featuring R-parity conservation and R-parity violation, extending the exclusion limits from previous searches.

SUSY introduction



$$R = (-1)^{2s+3B+L}$$

Supersymmetry - one of the most appealing Beyond Standard Model theories.

◆Moderates the hierarchy problem

◆Helps with the grand unification of gauge couplings.

◆Provides a suitable dark matter candidate

Strongly produced gluino and squark:

◆Large cross-section

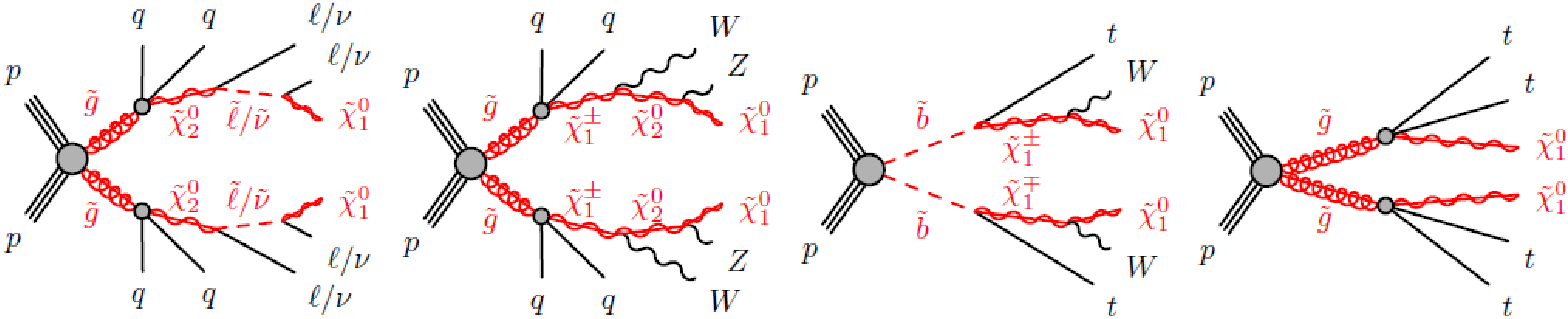
◆Natural signature: multi-leptons, multi-jets and large Missing Transverse Energy

Analysis motivation

Search gluino and squark initiated decay chains with multi-leptons in the final state

- Natural SUSY signature:
  - gluino, stop and sbottom masses expected to be at TeV scale .
- **Gluinos** are majorana particles:
  - allow for same-sign lepton pair production
- Rare processes in Standard Model:
  - very low background expectation.

Signal Region definition



Signal scenario:

- **Same-sign** (SS) lepton pairs or **three leptons** (3L)

  + jets (pT > 25, 40, 50 GeV) and/or b-jets (pT > 20 GeV)

- large E_T^{miss},
  $M_{eff} = \sum p_T^{lep} + \sum p_T^{jet} + E_T^{miss}$
  (high kinematic regions)

R-Parity Conserving(RPC) Signal regions

6 RPC signal regions defined as a function of b-jet & lepton multiplicity:

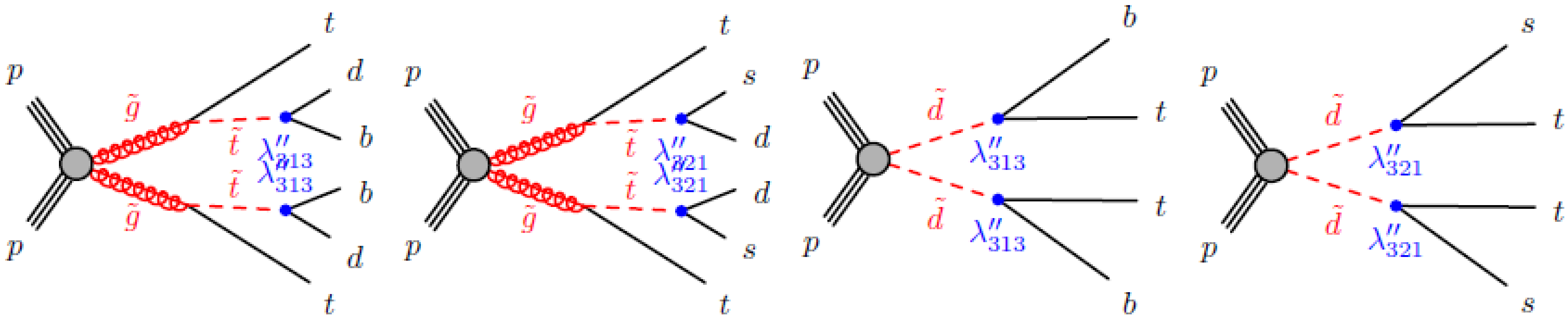
SR	N_ℓ	$N^{20}_{b\text{-jets}}$	N_{jets}	p_T^{jets}	E_T^{miss} [GeV]	m_{eff} [GeV]
SR3L1	≥3	=0	≥4	40	>150	-
SR3L2	≥3	=0	≥4	40	>200	1500
SR0b1	≥2	=0	≥6	25	>150	>500
SR0b2	≥2	=0	≥6	40	>150	>900
SR1b	≥2	≥1	≥6	25	>200	>650
SR3b	≥2	≥3	≥6	25	>150	>600

Also investigating more SRs with 2 leptons for 36.5 fb-1. Working in progress

R-Parity Violating(RPV) signal regions

3 RPV signal regions also defined, as a function of b-jets and jet multiplicity

SR	N_ℓ	$N^{20}_{b\text{-jets}}$	N_{jets}	p_T^{jets}	E_T^{miss} [GeV]	m_{eff} [GeV]	Other
SR1b-DD	≥2	≥1	≥4	50	-	>1200	≥ 2 negatively-charged leptons
SR3b-DD	≥2	≥3	≥4	50	-	>1000	≥ 2 negatively-charged leptons
SR1b-GG	≥2	≥1	≥6	50	-	>1800	-



(a) (b) (c) (d)

RPV SUSY processes featuring gluino (a,b) or down squark (c,d) pair production and decays via baryon number-violating couplings λ'' considered in this analysis.

Will consider 3 more SRs for the PRV model with 36.5 fb-1 data.

Background estimation

background events with prompt SS/3l :

- ✓ $t\bar{t}W$, $t\bar{t}Z$
- ✓ **Diboson (dominant in 0b SRs)**
- ✓ **Other rare process**

$t\bar{t}H, t\bar{t}t\bar{t}, t\bar{t}t, tZ, t\bar{t}WW, tWZ, Wh, Zh,$ tri-boson

Estimated by Monte-Carlo simulation

- Dedicated Validation Region(VR) for most of the backgrounds

Data-driven estimation for electron charge-misID background

- Events with OS lepton pair are assigned with weight: $w_{\text{flip}} = \xi_1(1-\xi_2) + (1-\xi_1)\xi_2$

  where for muons: $\xi_{(i)} = 0$
- **Charge-flip rate are measured using Z->ee events using likelihood method**

Fake leptons(Dominant source in most of the SRs)

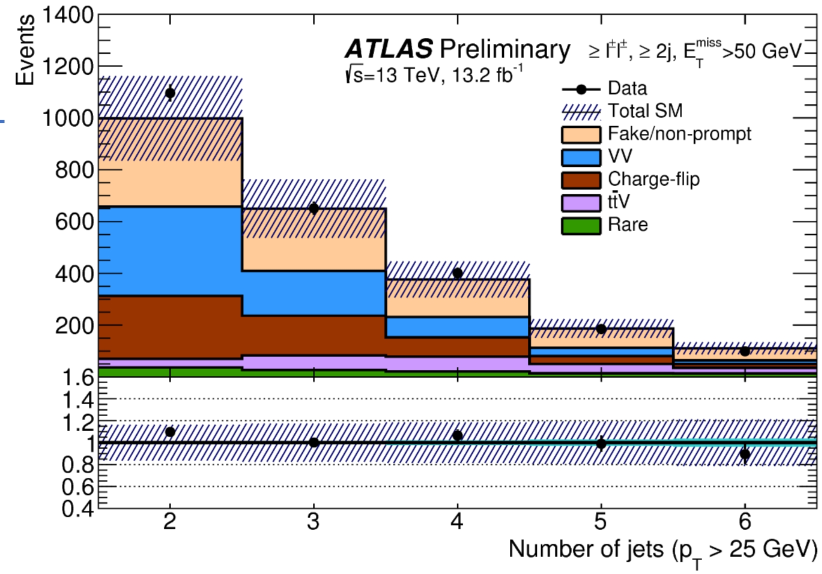
- Mainly from B hadrons decay (semi-leptonic ttbar process)

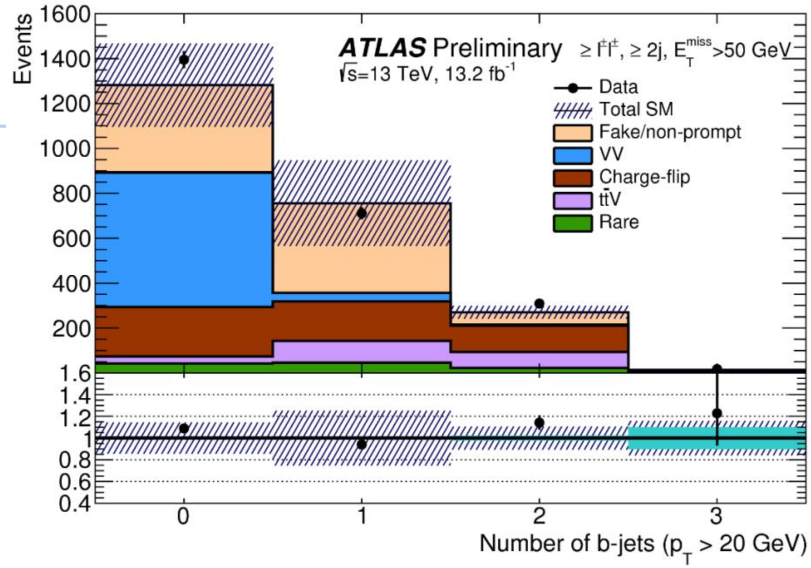
Estimated using pure data-driven - Matrix Method

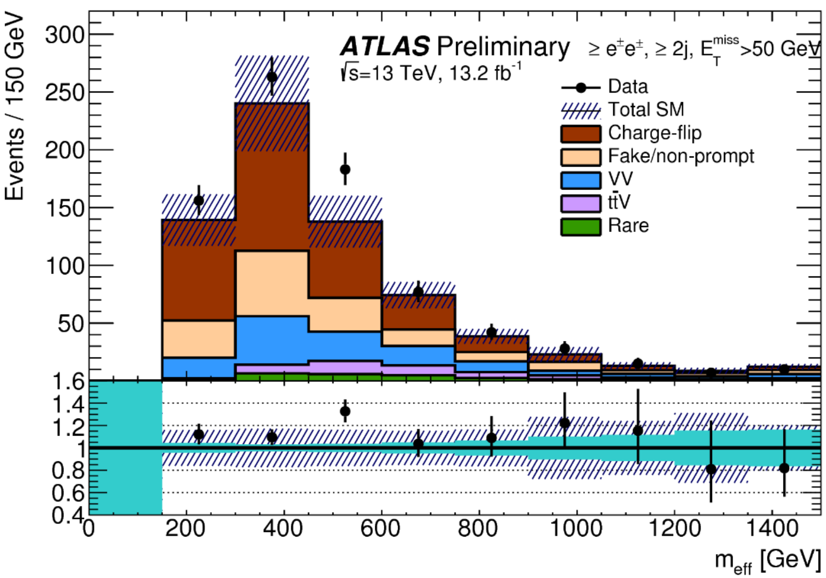
$$\begin{pmatrix} n_{\text{pass}} \\ n_{\text{fail}} \end{pmatrix} = \begin{pmatrix} 1 & 1 \\ \frac{1-\varepsilon}{\varepsilon} & \frac{1-\zeta}{\zeta} \end{pmatrix} \begin{pmatrix} n_{\text{real}} \\ n_{\text{fake}} \end{pmatrix}$$

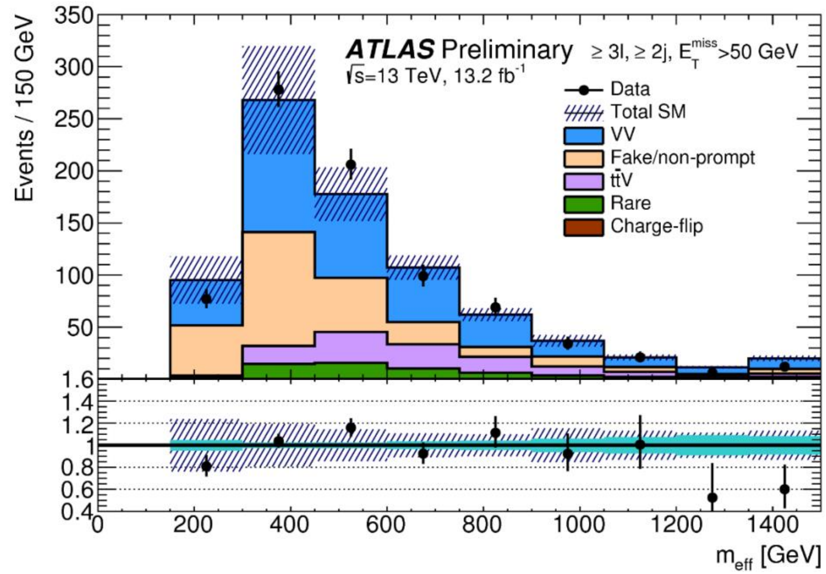
- **real efficiency** → Z->ll tag-and-probe
- **fake rate** → data in CR enriched in ttbar.

Validation plots for SM background estimation









Uncertainties include statistical sources, as well as systematic uncertainties for the data-driven backgrounds; for illustration, statistical uncertainties alone are shown in the light-coloured error bands in the ratio plots.

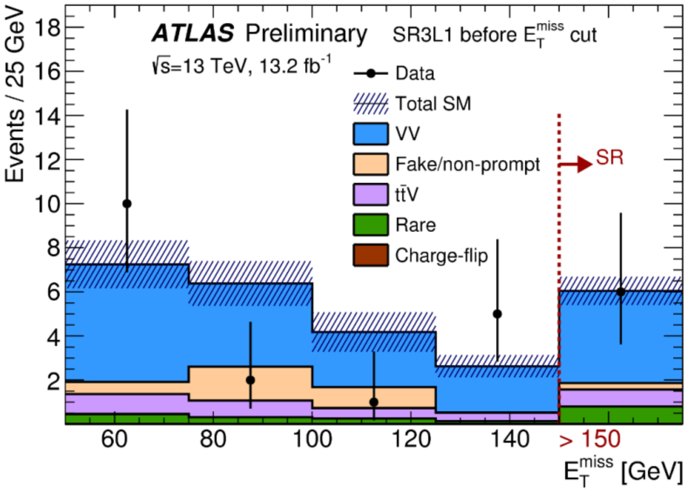
Results in Signal Regions

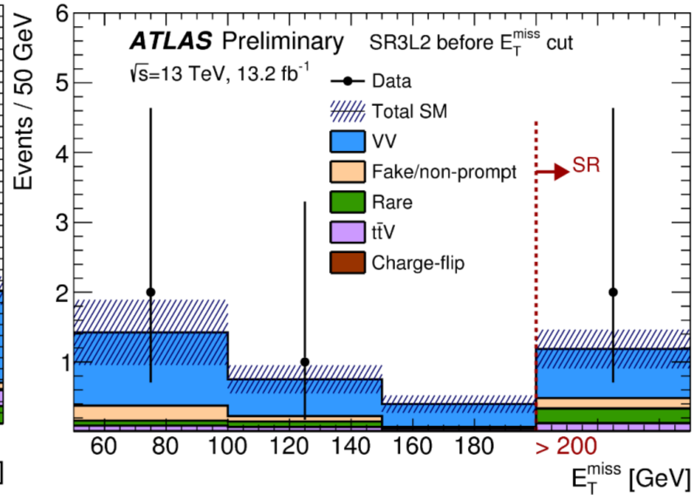
Yields in signal regions.

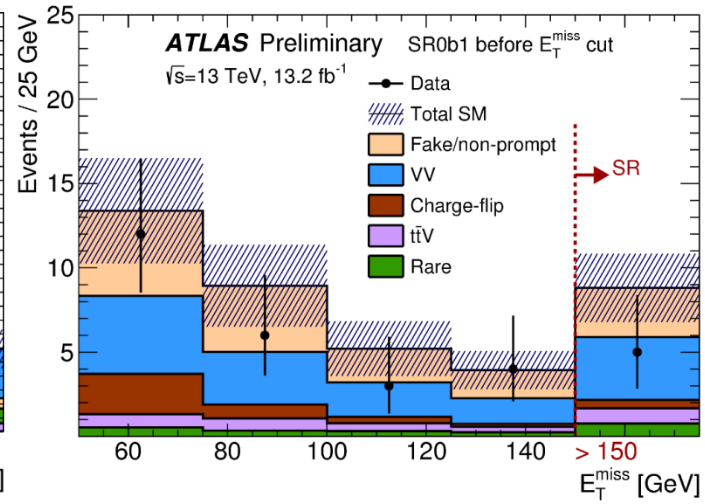
- **No excess observed**

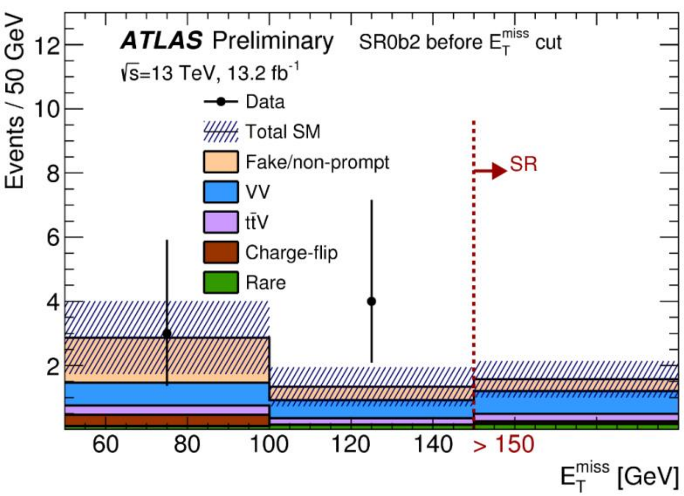
	SR3L1	SR3L2	SR0b1	SR0b2	SR1b	SR3b	SR1b-GG	SR1b-DD	SR3b-DD
Observed	6	2	5	0	12	2	2	12	4
Total SM	6.05 ± 2.15	1.18 ± 0.49	8.81 ± 2.87	1.57 ± 0.77	11.40 ± 2.76	1.60 ± 0.61	1.69 ± 0.57	12.03 ± 2.68	1.86 ± 0.75
ttZ	0.69 ± 0.25	0.10 ± 0.04	0.45 ± 0.18	0.10 ± 0.04	1.58 ± 0.55	0.19 ± 0.07	0.26 ± 0.08	2.81 ± 0.89	0.30 ± 0.10
ttW	0.09 ± 0.04	0.02 ± 0.01	0.45 ± 0.17	0.13 ± 0.06	1.97 ± 0.68	0.17 ± 0.06	0.33 ± 0.11	1.81 ± 0.58	0.18 ± 0.07
Diboson	4.18 ± 1.96	0.70 ± 0.43	3.72 ± 1.86	0.71 ± 0.52	0.47 ± 0.41	0.00 ± 0.00	$0.08^{+0.19}_{-0.09}$	0.61 ± 0.42	0.00 ± 0.00
Rare	0.80 ± 0.44	0.21 ± 0.13	0.76 ± 0.44	0.18 ± 0.12	2.69 ± 0.90	0.89 ± 0.31	0.64 ± 0.34	2.57 ± 1.32	0.76 ± 0.40
Fakes	0.29 ± 0.29	0.15 ± 0.15	2.92 ± 1.97	0.37 ± 0.53	3.25 ± 2.08	$0.20^{+0.49}_{-0.48}$	$0.21^{+0.33}_{-0.32}$	2.48 ± 1.66	0.48 ± 0.59
MisCharge	0.00 ± 0.00	0.00 ± 0.00	0.50 ± 0.09	0.08 ± 0.03	1.43 ± 0.19	0.14 ± 0.03	0.18 ± 0.07	1.74 ± 0.22	0.14 ± 0.03

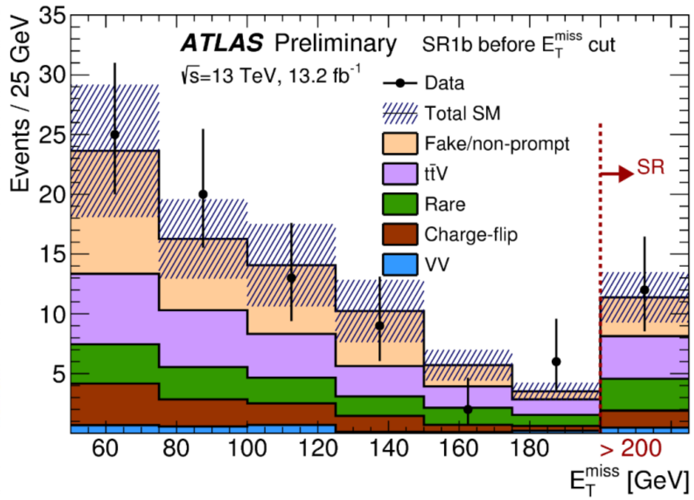
MET distributions for RPC SRs without the Meff cut

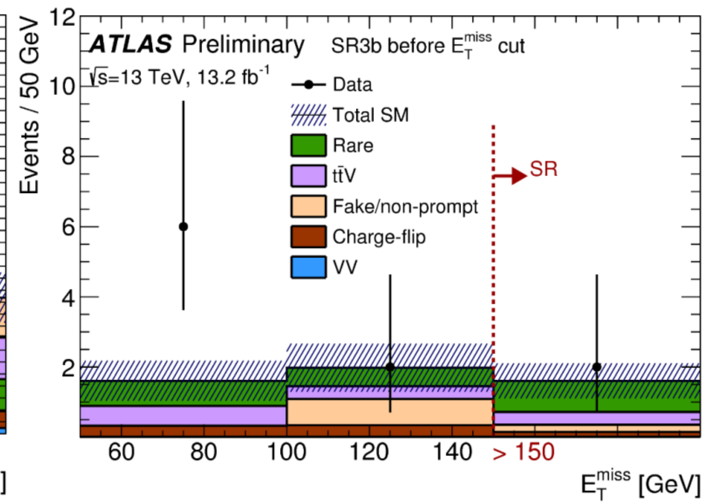




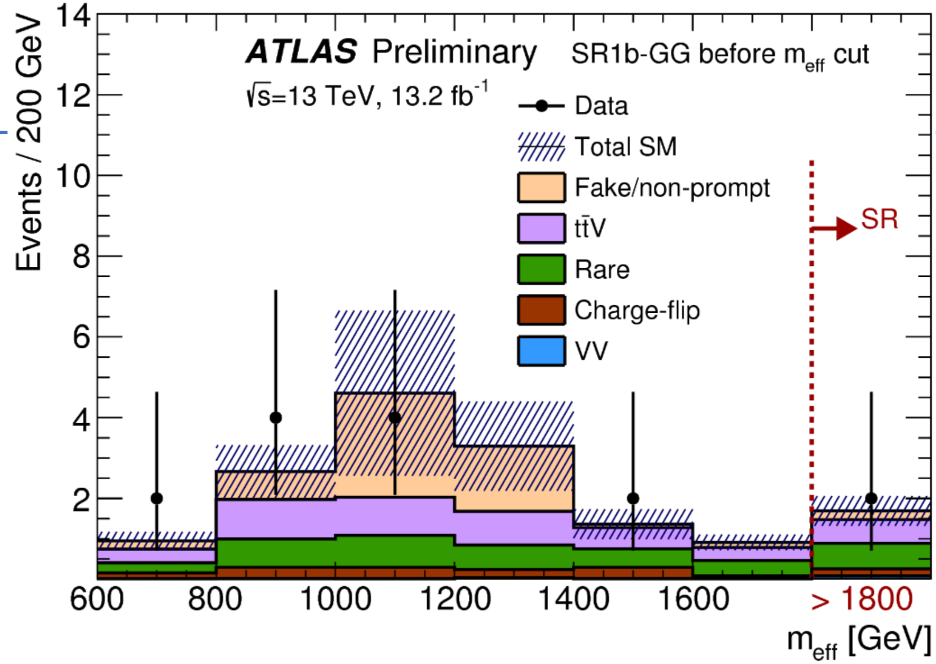


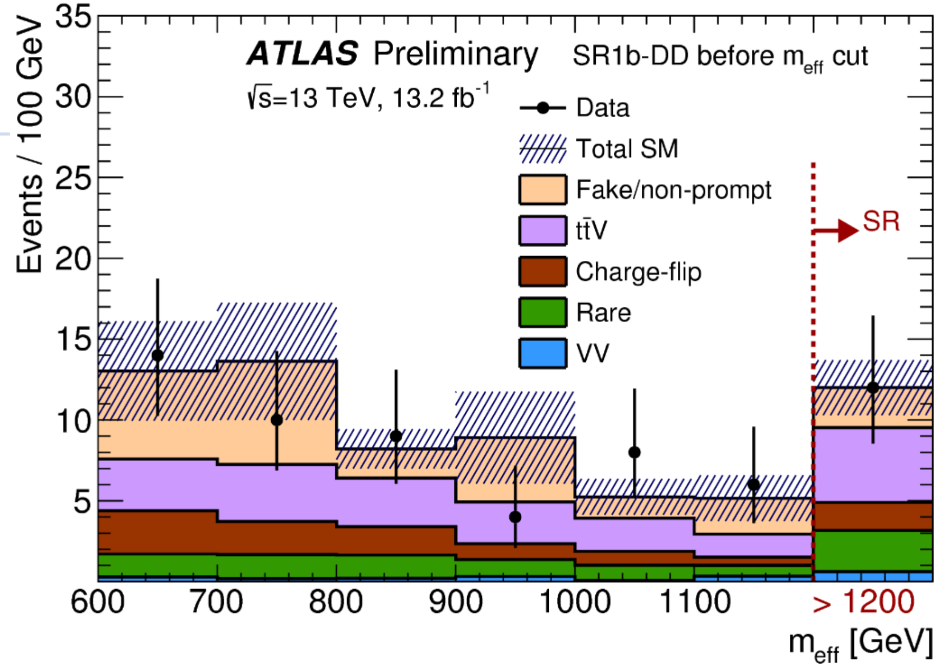


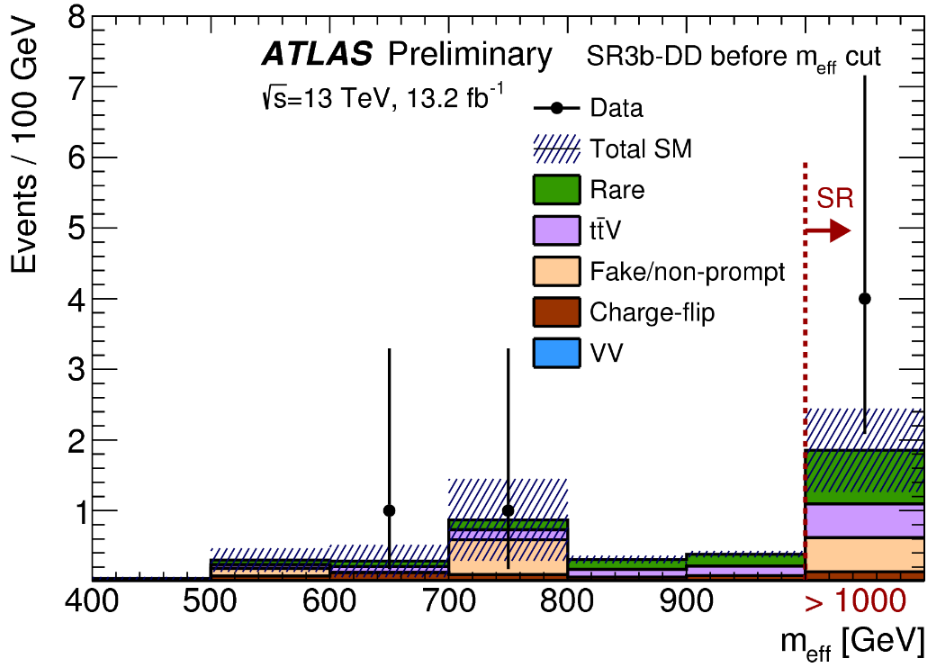




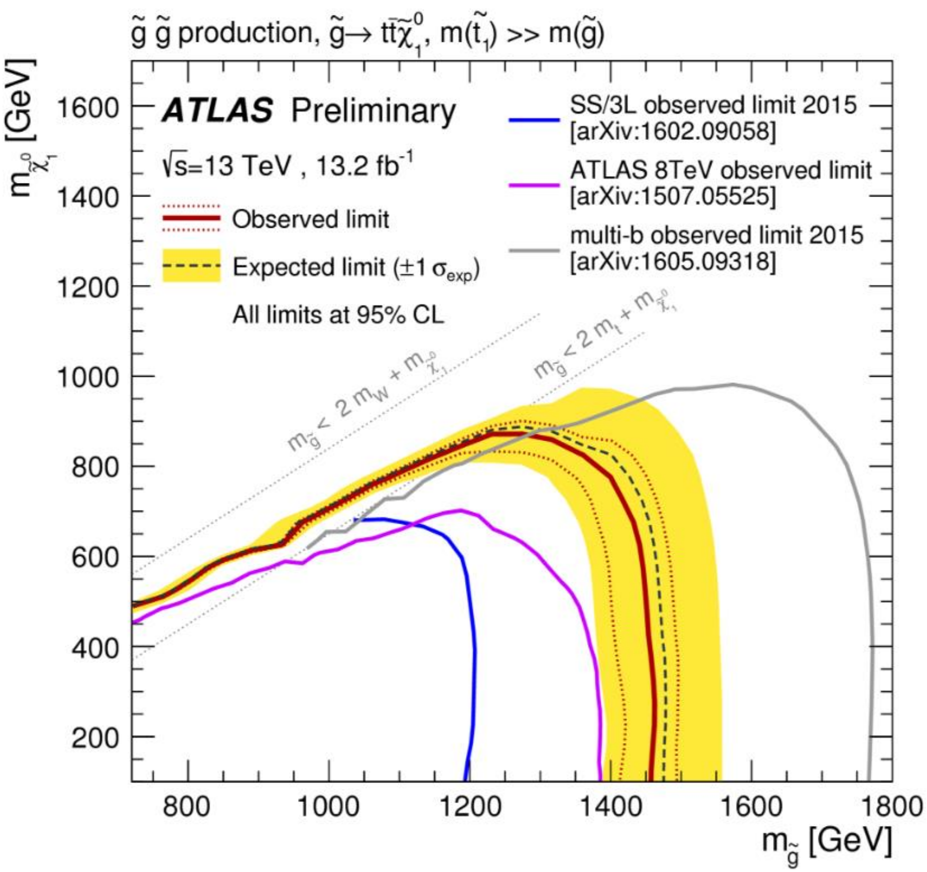
Meff distributions for PRV SRs without the Meff cut

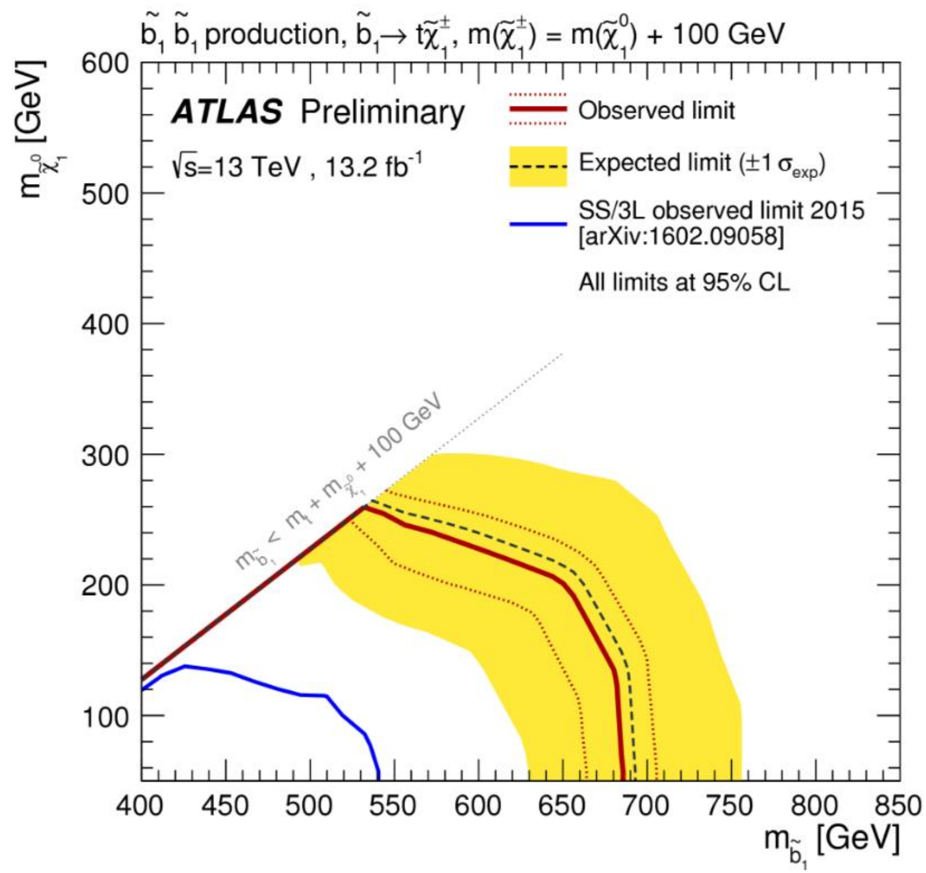




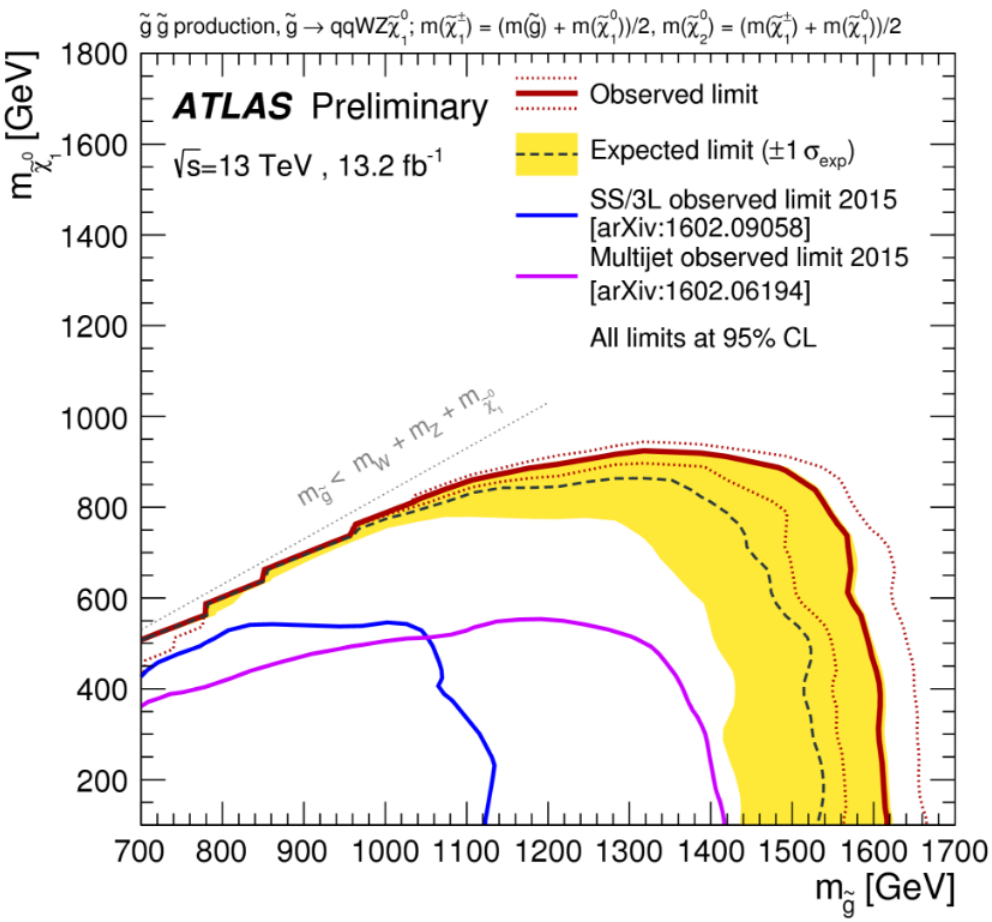


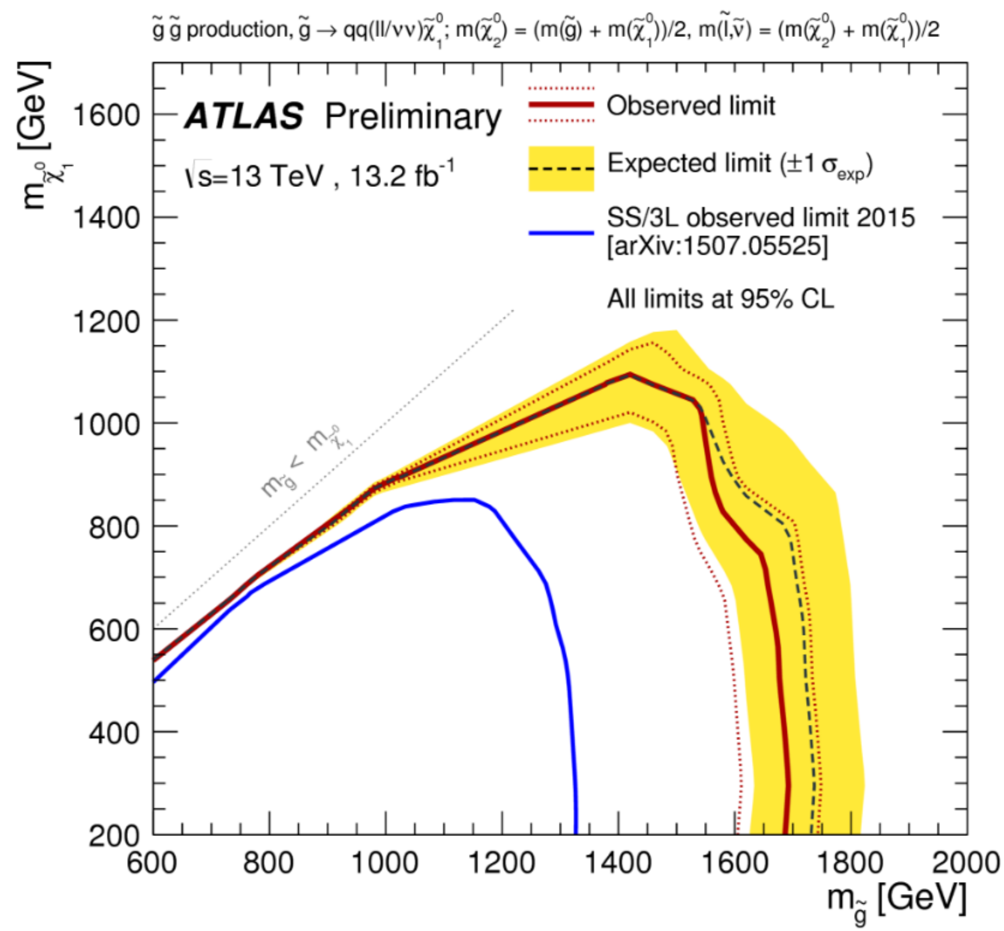
Interpretation – Gtt and direct sbottom



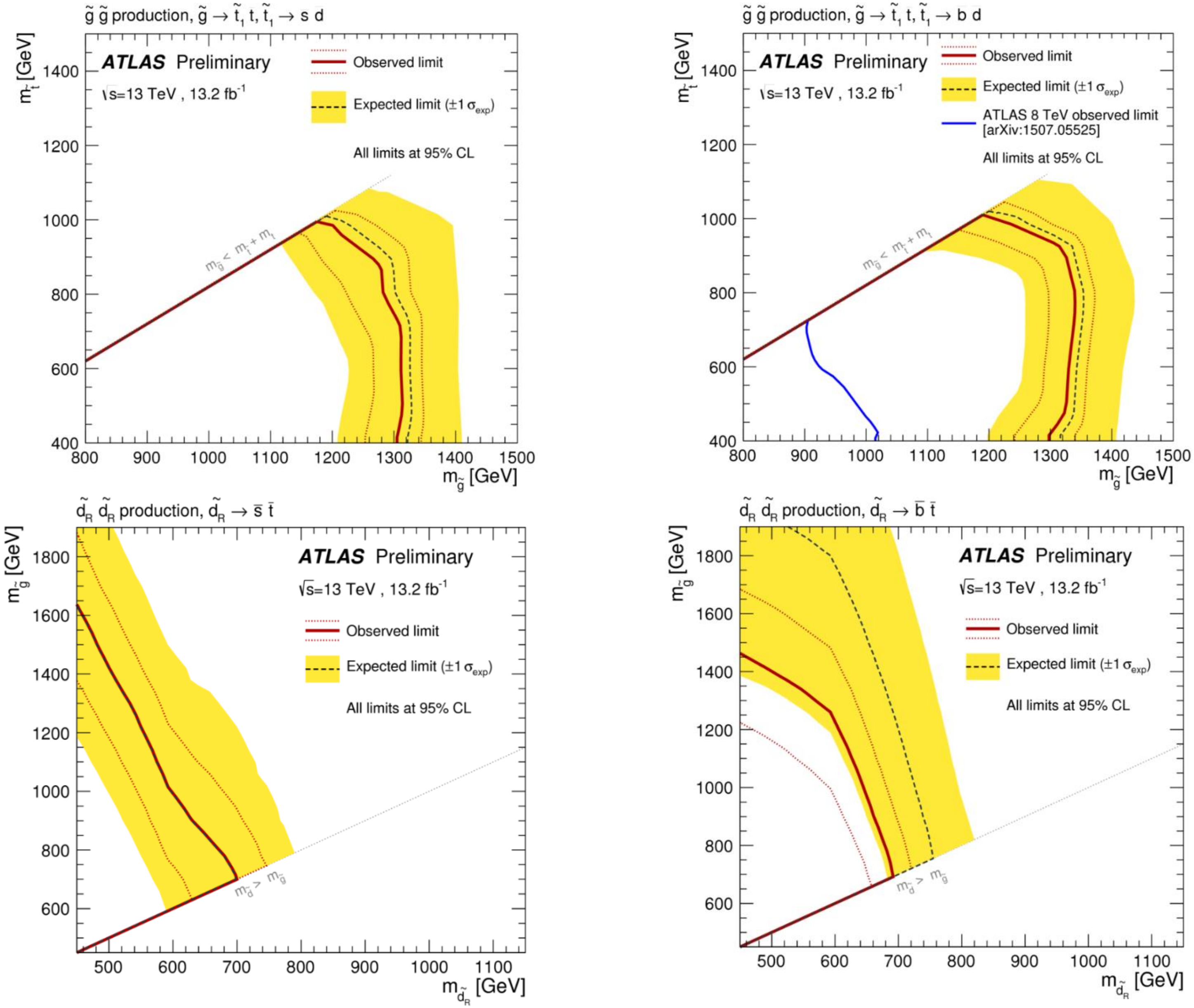


Interpretation – 2step via W/Z/sleptons





Interpretation – RPV SRs



conclusion

- We presented a search for the production of gluinos and squarks in $\sqrt{S} = 13TeV$ pp collisions, in final states with jets and same-sign leptons.
- Data to SM expectations in 9 SRs shows **no significant excess**.
- We set exclusion limits on the masses of gluinos, bottom squarks and neutralinos in various benchmark scenarios, **extending significantly** the limits set previously.
- With 36.5 fb-1 data obtained by the end of last year, more SRs are defined and will have larger sensitivity for the SS/3l search. The 2015+2016 full data analysis is in progress for SUSY approval.
- One paper EPJC(2016)76(5), 1-26 published based on 2015 data
- CONF number of ICHEP: ATLAS-CONF-2016-037

backup

Data/ & MC samples

- **Data(5.80fb-1)**
  - **2015 data(3.19fb-1):** reconstruction 20.7.3.8 (tag r7562), derivation 20.7.6.4 (tag r2667)
  - **2016 data(2.61fb-1):** derivation 20.7.6.4 (tag r2667)
    - Period A: reconstruction 20.7.5.8 – 20.7.6.4 (tags f694-f706)
    - Period B: reconstruction 20.7.6.4 (tags f705-f708)

- **Monte Carlo**
  - All generated with **25-ns** bunch spacing configuration, derivation 20.7
  - $t\bar{t}W$ with 0-2 extra partons $t\bar{t}Z/\gamma^*$ with 0-1 extra partons
  - WZ ZZ $W^{\pm}W^{\pm}$ tree-induced qq->VV, loop induced gg->VV , EWK production VBS
  - Rare process: $t\bar{t}H, t\bar{t}t\bar{t}, t\bar{t}t, tZ, t\bar{t}WW, tWZ, Wh, Zh$

- **Analysis framework**
  - Based on the SUSYAnalysisExample EventLoop package and various tags of SUSYTools up to 00-07-69 and analysis release up to

Object definition & event selections

Object selections

	Pre-selected Electron	Pre-selected Muon
Acceptance	$p_T > 10$ GeV, $\|\eta^{clust}\| < 2.47$ except $1.37 < \|\eta^{clust}\| < 1.52$	$p_T > 10$ GeV, $\|\eta\| < 2.5$
Quality	`LooseAndBLayerLLH`	`xAOD::Muon::Medium`
ℓ-jet Isolation	see section 4.4	
Impact parameter	$\|d_0/\sigma(d_0)\| < 5.0$	
	Signal Electron	**Signal Muon**
Quality	`MediumLLH` $\|\eta\| < 2.0$	- -
Isolation	"FixedCutTight "	"FixedCutTightTrackOnly"
Impact parameter	$\|z_0 \cdot \sin(\theta)\| < 0.5$ mm	$\|z_0 \cdot \sin(\theta)\| < 0.5$ mm $\|d_0/\sigma(d_0)\| < 3.0$

Pre-selected jet	
Collection	AntiKt4EMTopo
Acceptance	$p_T > 20$ GeV, $\|\eta\| < 2.8$
Overlap	see section 4.4
Jet vertex tagger	reject jets with $p_T < 60$ GeV, $\|\eta\| < 2.4$ and JVT<0.59 after overlap removal
b-jets	
Acceptance	$p_T > 20$ GeV, $\|\eta\| < 2.5$
b-tagging	MV2c10 algorithm 70% OP MV2c10 algorithm 85% OP for overlap removal

Event slections:

- **Cleaning requirements**

  Bad jet, bad muons and cosmic muons

- **At least 2 leptons**

  At least 2 signal leptons

  2 leading leptons have pT>20GeV

- **Then sorted into 3l events or SS2l events:**
  - ✓ Event containing a 3rd signal-lepton with pT>10GeV is regarded as **3l event**
  - ✓ Otherwise, if the 2 leading leptons have identical charge, the event is regarded as **SS2l events**

triggers

Trigger strategy - data

- **2015 data with $E_T^{miss} < 250GeV$:**

  logical **OR** of **dilepton** triggers

  HLT_2e12_lhloose_L12EM10VH

  HLT_e17_lhloose_mu14

  HLT_mu18_mu8noL1

- **2015 data with $E_T^{miss} > 250GeV$:**

  logical OR of the dilepton triggers and HLT_xe70

- **2016 data with $E_T^{miss} < 250GeV$**

  logical **OR** of **dilepton** triggers

  HLT_2e17_lhvloose

  HLT_e17_lhloose_nod0_mu14

  HLT_mu20_mu8noL1

- **2016 data with $E_T^{miss} > 250GeV$:**

  logical OR of the dilepton triggers and HLT_xe80_tc_lcw_L1XE50

  ***will be switched to HLT_xe100_mht**

Trigger strategy – MC

chosen randomly between the two options(data2015 or data 2016)

according to the relative luminosities and $<\mu>$profiles of the 2015 and 2016 datasets

Trigger match

Considered only for signal leptons with $p_T > 20GeV$

Also for muons with pT>10 GeV in the case of the dimuon trigger

Trigger scale factor

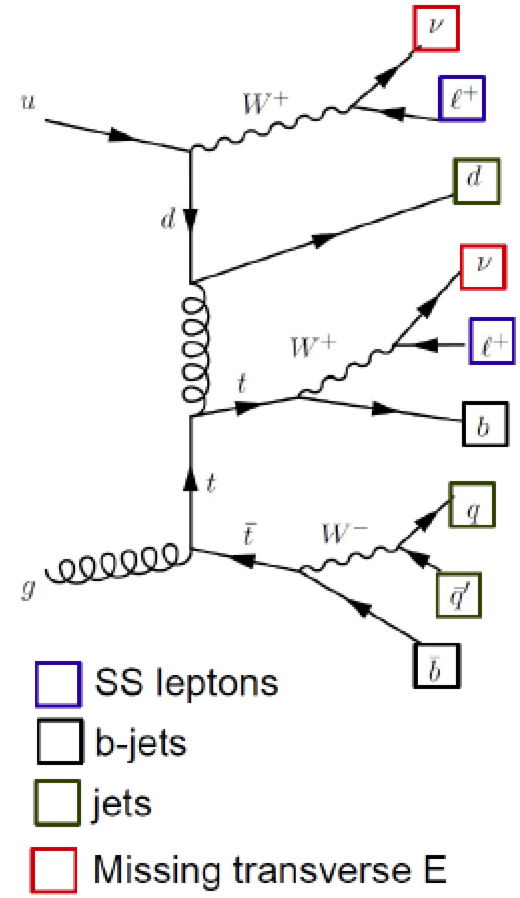
Will be consider for MC events not passing the E_T^{miss} triggers

Background estimation

background events with prompt SS/3l in the final state:

- ✓ $t\bar{t}W$, $t\bar{t}Z$
- ✓ **Diboson (dominant in 0b SRs)**
- ✓ **Other rare process**

$$t\bar{t}H,\ t\bar{t}t\bar{t},\ t\bar{t}t,\ tZ,\ t\bar{t}WW,\ tWZ,\ Wh,\ Zh,\ tri\text{-}boson$$



Estimated by Monte-Carlo simulation

- Dedicated VR for most of the backgrounds

All systematic sources for RPC SRs

Uncertainty of channel	SR3L1
Total background expectation	2.95
Total statistical ($\sqrt{N_{exp}}$)	±1.72
Total background systematic	±0.85 [28.72%]
alpha_theoryUncertWZ_SR3L1	±0.62
gamma_stat_SR3L1_cuts_bin_0	±0.49
alpha_JET_reso	±0.29
alpha_JET_scale_NP1	±0.28
alpha_JET_scale_NP3	±0.15
alpha_FT_JVT	±0.14
Lumi	±0.14
alpha_theoryUncertRare	±0.11
alpha_theoryUncertTTbarV_SR3L1	±0.11
alpha_pileupBKG	±0.09
alpha_FT_B	±0.07
alpha_elID	±0.04
alpha_FT_Extra1	±0.03
alpha_muSys	±0.03
alpha_FT_Light	±0.03
alpha_elIso	±0.02
alpha_elReco	±0.02
alpha_FT_C	±0.01
alpha_muIsoSys	±0.01
alpha_JET_scale_NP2	±0.01
alpha_Mu_MS	±0.01
alpha_MET_Soft_reso_Para	±0.01
alpha_Mu_Scale	±0.01
alpha_muStat	±0.01
alpha_EG_Resolution	±0.01
alpha_EG_Scale	±0.01
alpha_muIsoStat	±0.00
alpha_theoryUncertOtherMB	±0.00
alpha_JET_EtaIntercalibration	±0.00
alpha_MET_Soft_Scale	±0.00
alpha_Mu_ID	±0.00
alpha_FT_Extra2	±0.00
alpha_muStat_lowpt	±0.00
alpha_MET_Soft_reso_Perp	±0.00
alpha_muSys_lowpt	±0.00

Uncertainty of channel	SR3L2
Total background expectation	0.86
Total statistical ($\sqrt{N_{exp}}$)	±0.93
Total background systematic	±0.42 [48.46%]
gamma_stat_SR3L2_cuts_bin_0	±0.36
alpha_theoryUncertWZ_SR3L2	±0.17
alpha_pileupBKG	±0.13
alpha_JET_scale_NP1	±0.06
alpha_JET_reso	±0.06
alpha_JET_scale_NP3	±0.05
Lumi	±0.04
alpha_theoryUncertRare	±0.03
alpha_FT_JVT	±0.03
alpha_FT_Extra1	±0.02
alpha_JET_scale_NP2	±0.02
alpha_FT_B	±0.02
alpha_theoryUncertTTbarV_SR3L2	±0.02
alpha_muSys	±0.01
alpha_Mu_ID	±0.01
alpha_FT_Light	±0.01
alpha_elIso	±0.01
alpha_elID	±0.01
alpha_FT_C	±0.00
alpha_muIsoSys	±0.00
alpha_EG_Scale	±0.00
alpha_elReco	±0.00
alpha_muStat	±0.00
alpha_MET_Soft_reso_Para	±0.00
alpha_EG_Resolution	±0.00
alpha_Mu_MS	±0.00
alpha_muIsoStat	±0.00
alpha_FT_Extra2	±0.00
alpha_theoryUncertOtherMB	±0.00
alpha_muStat_lowpt	±0.00
alpha_muSys_lowpt	±0.00
alpha_Mu_Scale	±0.00
alpha_MET_Soft_reso_Perp	±0.00
alpha_JET_EtaIntercalibration	±0.00
alpha_MET_Soft_Scale	±0.00

Uncertainty of channel	SR0b1
Total background expectation	5.10
Total statistical ($\sqrt{N_{exp}}$)	±2.26
Total background systematic	±1.55 [30.48%]
alpha_syst_fake_SR0b1	±1.40
gamma_stat_SR0b1_cuts_bin_0	±1.08
alpha_JET_reso	±0.47
alpha_theoryUncertWZ_SR0b1	±0.44
alpha_JET_scale_NP1	±0.36
alpha_Mu_MS	±0.16
alpha_Mu_Scale	±0.16
alpha_FT_JVT	±0.15
alpha_pileupBKG	±0.15
alpha_Mu_ID	±0.15
alpha_JET_scale_NP2	±0.13
alpha_theoryUncertRare	±0.13
alpha_theoryUncertTTbarV_SR0b1	±0.13
Lumi	±0.12
alpha_JET_scale_NP3	±0.11
alpha_FT_B	±0.09
alpha_theoryUncertWWjj_SR0b1	±0.06
alpha_FT_Extra1	±0.04
alpha_elID	±0.03
alpha_FT_Light	±0.02
alpha_muSys	±0.02
alpha_FT_C	±0.02
alpha_elIso	±0.01
alpha_MET_Soft_Scale	±0.01
alpha_elReco	±0.01
alpha_syst_misch_SR0b1	±0.01
alpha_muIsoSys	±0.01
alpha_JET_EtaIntercalibration	±0.01
alpha_muStat	±0.01
alpha_EG_Resolution	±0.01
alpha_MET_Soft_reso_Para	±0.00
alpha_muIsoStat	±0.00
alpha_theoryUncertOtherMB	±0.00
alpha_EG_Scale	±0.00
alpha_FT_Extra2	±0.00
alpha_MET_Soft_reso_Perp	±0.00
alpha_muStat_lowpt	±0.00
alpha_muSys_lowpt	±0.00

All systematic sources for RPC SRs

Uncertainty of channel	SR0b2
Total background expectation	0.68
Total statistical ($\sqrt{N_{exp}}$)	±0.82
Total background systematic	±0.25 [37.18%]
gamma_stat_SR0b2_cuts_bin_0	±0.20
alpha_pileupBKG	±0.10
alpha_JET_scale_NP1	±0.07
alpha_theoryUncertWZ_SR0b2	±0.07
alpha_JET_scale_NP3	±0.04
alpha_theoryUncertTTbarV_SR0b2	±0.03
alpha_FT_JVT	±0.03
alpha_theoryUncertWWjj_SR0b2	±0.03
alpha_theoryUncertRare	±0.03
Lumi	±0.02
alpha_FT_B	±0.02
alpha_JET_scale_NP2	±0.02
alpha_FT_Extra1	±0.02
alpha_EG_Scale	±0.01
alpha_JET_reso	±0.01
alpha_MET_Soft_reso_Para	±0.01
alpha_FT_C	±0.01
alpha_MET_Soft_Scale	±0.01
alpha_EG_Resolution	±0.01
alpha_FT_Light	±0.01
alpha_elID	±0.01
alpha_muSys	±0.00
alpha_MET_Soft_reso_Perp	±0.00
alpha_elIso	±0.00
alpha_muIsoSys	±0.00
alpha_elReco	±0.00
alpha_Mu_ID	±0.00
alpha_Mu_MS	±0.00
alpha_muStat	±0.00
alpha_JET_EtaIntercalibration	±0.00
alpha_muIsoStat	±0.00
alpha_FT_Extra2	±0.00
alpha_theoryUncertOtherMB	±0.00
alpha_muStat_lowpt	±0.00
alpha_muSys_lowpt	±0.00
alpha_Mu_Scale	±0.00

Uncertainty of channel	SR1b
Total background expectation	6.37
Total statistical ($\sqrt{N_{exp}}$)	±2.52
Total background systematic	±1.61 [25.26%]
alpha_syst_fake_SR1b	±1.35
gamma_stat_SR1b_cuts_bin_0	±1.05
alpha_theoryUncertRare	±0.59
alpha_theoryUncertTTbarV_SR1b	±0.46
alpha_JET_scale_NP1	±0.46
alpha_JET_reso	±0.22
alpha_FT_JVT	±0.22
Lumi	±0.16
alpha_JET_scale_NP2	±0.11
alpha_theoryUncertWZ_SR1b	±0.10
alpha_JET_scale_NP3	±0.09
alpha_FT_B	±0.07
alpha_elID	±0.04
alpha_syst_misch_SR1b	±0.04
alpha_EG_Scale	±0.03
alpha_elIso	±0.03
alpha_muSys	±0.02
alpha_MET_Soft_reso_Perp	±0.02
alpha_FT_Extra1	±0.02
alpha_pileupBKG	±0.02
alpha_elReco	±0.02
alpha_FT_C	±0.01
alpha_MET_Soft_Scale	±0.01
alpha_muIsoSys	±0.01
alpha_Mu_ID	±0.01
alpha_muStat	±0.01
alpha_theoryUncertOtherMB	±0.01
alpha_EG_Resolution	±0.01
alpha_JET_EtaIntercalibration	±0.00
alpha_Mu_MS	±0.00
alpha_muIsoStat	±0.00
alpha_FT_Light	±0.00
alpha_Mu_Scale	±0.00
alpha_FT_Extra2	±0.00
alpha_MET_Soft_reso_Para	±0.00
alpha_muSys_lowpt	±0.00
alpha_muStat_lowpt	±0.00

Uncertainty of channel	SR3b
Total background expectation	0.91
Total statistical ($\sqrt{N_{exp}}$)	±0.96
Total background systematic	±0.55 [59.70%]
gamma_stat_SR3b_cuts_bin_0	±0.50
alpha_syst_fake_SR3b	±0.30
alpha_theoryUncertRare	±0.19
alpha_FT_B	±0.05
alpha_theoryUncertTTbarV_SR3b	±0.04
alpha_FT_JVT	±0.04
alpha_JET_scale_NP1	±0.03
Lumi	±0.03
alpha_FT_C	±0.02
alpha_FT_Extra1	±0.02
alpha_FT_Light	±0.02
alpha_JET_reso	±0.01
alpha_pileupBKG	±0.01
alpha_JET_scale_NP3	±0.01
alpha_syst_misch_SR3b	±0.01
alpha_JET_scale_NP2	±0.01
alpha_elID	±0.01
alpha_muSys	±0.00
alpha_elIso	±0.00
alpha_EG_Scale	±0.00
alpha_elReco	±0.00
alpha_MET_Soft_reso_Perp	±0.00
alpha_muIsoSys	±0.00
alpha_muStat	±0.00
alpha_Mu_ID	±0.00
alpha_FT_Extra2	±0.00
alpha_MET_Soft_reso_Para	±0.00
alpha_JET_EtaIntercalibration	±0.00
alpha_MET_Soft_Scale	±0.00
alpha_muIsoStat	±0.00
alpha_Mu_Scale	±0.00
alpha_EG_Resolution	±0.00
alpha_Mu_MS	±0.00
alpha_muSys_lowpt	±0.00
alpha_muStat_lowpt	±0.00

All systematic sources for RPV SRs

Uncertainty of channel	SR_RPV1bGG
Total background expectation	1.43
Total statistical ($\sqrt{N_{exp}}$)	±1.19
Total background systematic	±0.37 [25.71%]
alpha_theoryUncertRare	±0.24
gamma_stat_SR_RPV1bGG_cuts_bin_0	±0.22
alpha_theoryUncertTTbarV_SR_RPV1bGG	±0.14
alpha_JET_scale_NP1	±0.09
alpha_FT_JVT	±0.06
Lumi	±0.05
alpha_JET_scale_NP2	±0.02
alpha_EG_Scale	±0.02
alpha_JET_scale_NP3	±0.02
alpha_FT_B	±0.02
alpha_FT_Extra1	±0.02
alpha_JET_reso	±0.01
alpha_elID	±0.01
alpha_theoryUncertWZ_SR_RPV1bGG	±0.01
alpha_elIso	±0.01
alpha_muSys	±0.01
alpha_FT_Light	±0.01
alpha_FT_C	±0.01
alpha_elReco	±0.00
alpha_muIsoSys	±0.00
alpha_syst_misch_SR_RPV1bGG	±0.00
alpha_pileupBKG	±0.00
alpha_muStat	±0.00
alpha_MET_Soft_reso_Para	±0.00
alpha_muIsoStat	±0.00
alpha_Mu_ID	±0.00
alpha_MET_Soft_reso_Perp	±0.00
alpha_FT_Extra2	±0.00
alpha_JET_EtaIntercalibration	±0.00
alpha_Mu_MS	±0.00
alpha_EG_Resolution	±0.00
alpha_MET_Soft_Scale	±0.00
alpha_muSys_lowpt	±0.00
alpha_muStat_lowpt	±0.00
alpha_Mu_Scale	±0.00

Uncertainty of channel	SR_RPV3bDD
Total background expectation	1.30
Total statistical ($\sqrt{N_{exp}}$)	±1.14
Total background systematic	±0.37 [28.88%]
alpha_theoryUncertRare	±0.28
gamma_stat_SR_RPV3bDD_cuts_bin_0	±0.20
alpha_theoryUncertTTbarV_SR_RPV3bDD	±0.11
alpha_FT_B	±0.08
alpha_FT_JVT	±0.06
alpha_JET_scale_NP1	±0.05
Lumi	±0.05
alpha_FT_Extra1	±0.04
alpha_FT_C	±0.04
alpha_FT_Light	±0.02
alpha_pileupBKG	±0.02
alpha_JET_scale_NP2	±0.02
alpha_EG_Scale	±0.01
alpha_elID	±0.01
alpha_JET_scale_NP3	±0.01
alpha_muSys	±0.01
alpha_elIso	±0.01
alpha_FT_Extra2	±0.01
alpha_MET_Soft_reso_Para	±0.00
alpha_elReco	±0.00
alpha_muIsoSys	±0.00
alpha_muStat	±0.00
alpha_JET_EtaIntercalibration	±0.00
alpha_EG_Resolution	±0.00
alpha_muIsoStat	±0.00
alpha_JET_reso	±0.00
alpha_Mu_MS	±0.00
alpha_MET_Soft_reso_Perp	±0.00
alpha_MET_Soft_Scale	±0.00
alpha_muSys_lowpt	±0.00
alpha_muStat_lowpt	±0.00
alpha_Mu_Scale	±0.00
alpha_Mu_ID	±0.00

Uncertainty of channel	SR_RPV1bDD
Total background expectation	9.93
Total statistical ($\sqrt{N_{exp}}$)	±3.15
Total background systematic	±2.18 [21.93%]
alpha_syst_fake_SR_RPV1bDD	±2.03
gamma_stat_SR_RPV1bDD_cuts_bin_0	±1.11
alpha_theoryUncertTTbarV_SR_RPV1bDD	±1.07
alpha_theoryUncertRare	±0.97
alpha_JET_scale_NP1	±0.56
alpha_JET_reso	±0.35
Lumi	±0.31
alpha_FT_JVT	±0.30
alpha_syst_misch_SR_RPV1bDD	±0.20
alpha_JET_scale_NP2	±0.16
alpha_pileupBKG	±0.16
alpha_JET_scale_NP3	±0.12
alpha_FT_B	±0.12
alpha_theoryUncertOtherMB	±0.10
alpha_elID	±0.09
alpha_EG_Scale	±0.08
alpha_elIso	±0.06
alpha_muSys	±0.06
alpha_FT_Extra1	±0.06
alpha_theoryUncertWZ_SR_RPV1bDD	±0.05
alpha_FT_Light	±0.05
alpha_elReco	±0.03
alpha_MET_Soft_reso_Para	±0.02
alpha_FT_C	±0.02
alpha_muIsoSys	±0.02
alpha_muStat	±0.01
alpha_Mu_MS	±0.01
alpha_MET_Soft_reso_Perp	±0.01
alpha_muIsoStat	±0.01
alpha_FT_Extra2	±0.01
alpha_Mu_ID	±0.00
alpha_MET_Soft_Scale	±0.00
alpha_Mu_Scale	±0.00
alpha_JET_EtaIntercalibration	±0.00
alpha_EG_Resolution	±0.00
alpha_muSys_lowpt	±0.00
alpha_muStat_lowpt	±0.00
alpha_theoryUncertWWjj_SR_RPV1bDD	±0.00

Results in Signal Regions - RPV

Yields in RPV signal regions.

- **No excess observed**
- Observed data and background expectation for 5.8 fb-1
- And the background prediction normalized to 10 fb-1

	SR1b-GG	SR1b-DD	SR3b-DD
Observed	0	3	1
Total SM	0.83 ± 0.25	5.76 ± 1.56	0.75 ± 0.25
WWjj	0.00 ± 0.00	$0.00^{+0.00}_{-0.00}$	0.00 ± 0.00
WZ	0.02 ± 0.02	$0.10^{+0.23}_{-0.12}$	0.00 ± 0.00
ttZ	0.12 ± 0.04	1.29 ± 0.41	0.13 ± 0.04
ttW	0.16 ± 0.05	0.85 ± 0.28	0.08 ± 0.04
Rare	0.29 ± 0.16	1.16 ± 0.60	0.34 ± 0.18
OtherMultiBoson	0.00 ± 0.00	0.19 ± 0.08	0.00 ± 0.00
Fakes	0.15 ± 0.15	1.18 ± 1.17	0.15 ± 0.15
MisCharge	0.09 ± 0.05	0.98 ± 0.16	0.05 ± 0.02