Searches for supersymmetry using the sum of masses of large radius jets

Ryan Heller, UC Santa Barbara
on behalf of the CMS collaboration

52nd Rencontres de Moriond, EWK
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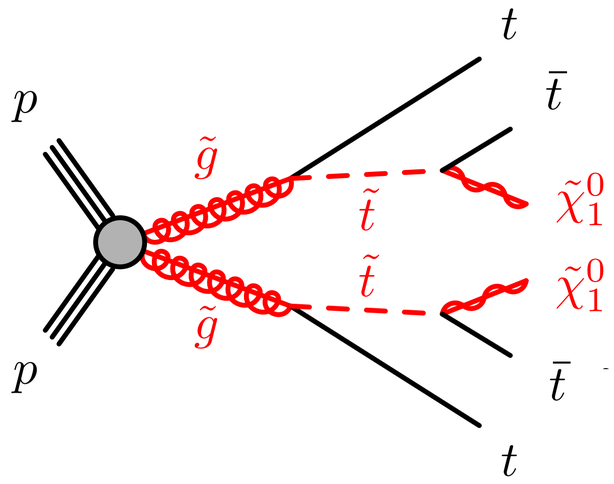
Two high-mass, high-multiplicity SUSY searches

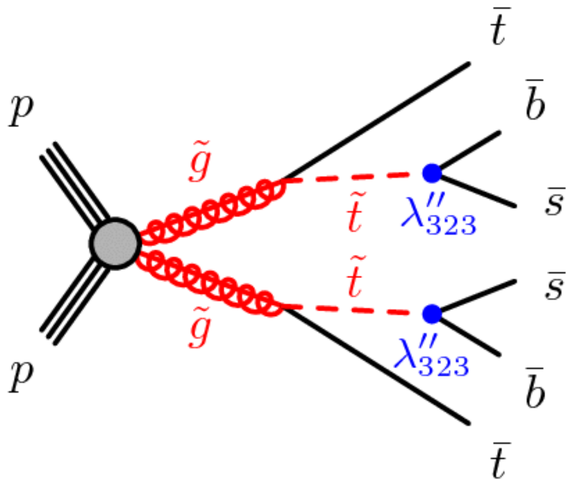
1-lepton, high E_T^{miss}
many jets and b-jets



NEW, 35.9 fb^{-1}

CMS-PAS-SUS-16-037 (Moriond '17)
JHEP 08 (2016) 122 (Moriond '16)

RPV: no E_T^{miss}, 0 + 1 lepton
many jets and b-jets

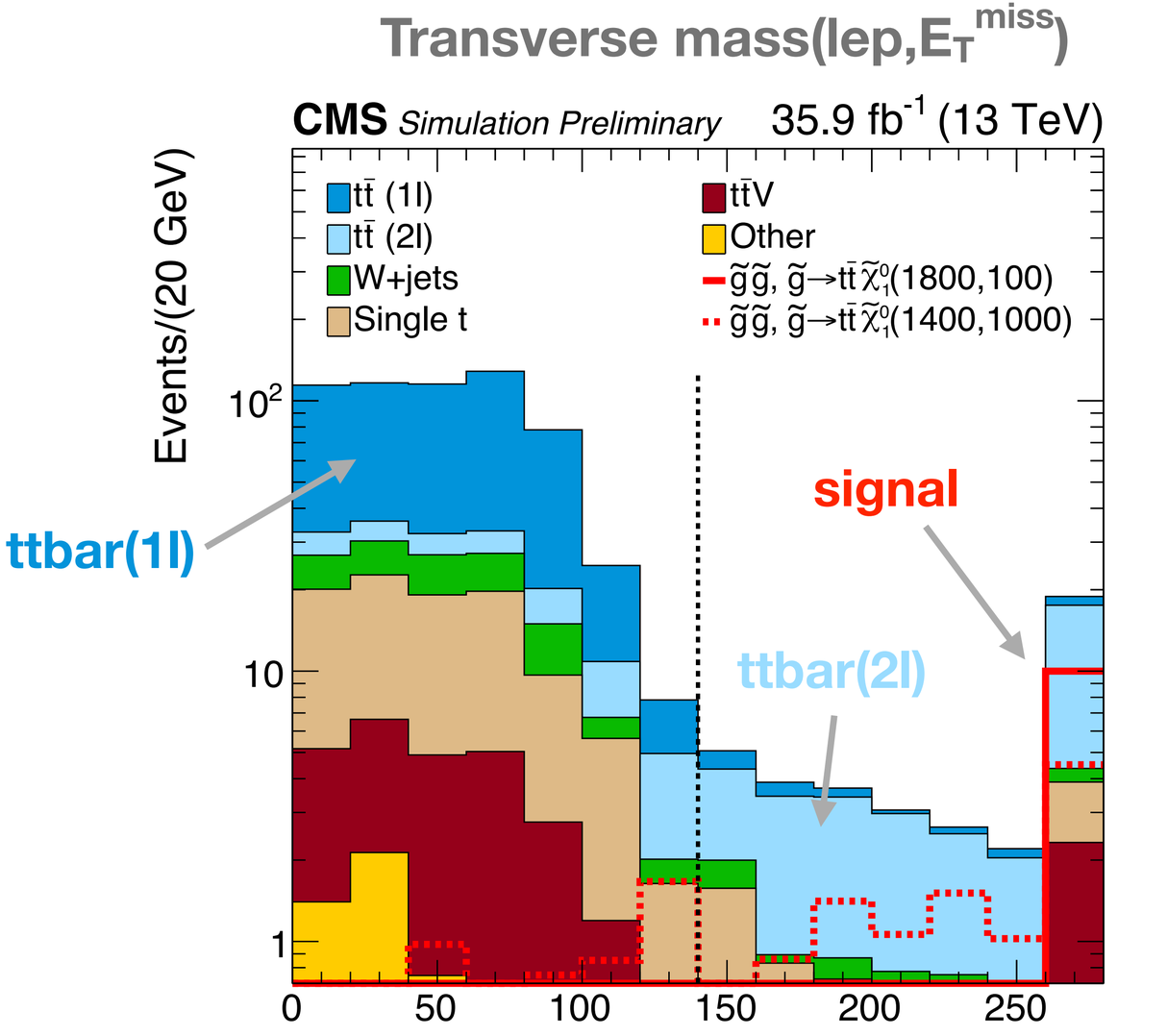


CMS-PAS-SUS-16-013
(ICHEP 2016)

Common themes

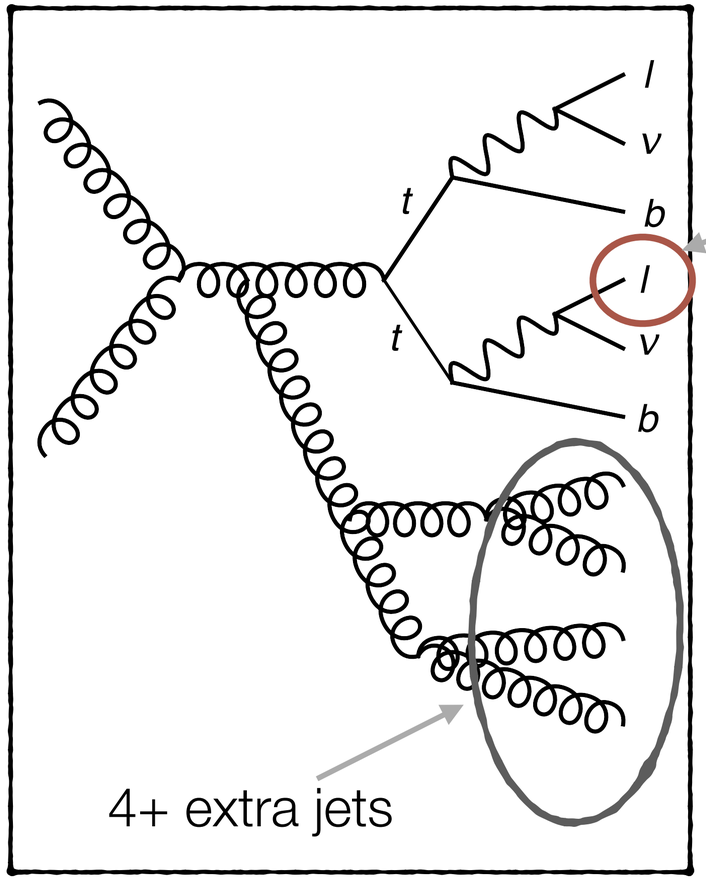
- Spectactular final states
- Key challenge: robust and trustworthy background estimate
- Use M_J, scalar sum of large-R jet masses, to measure BG in data

Challenging backgrounds



($N_{jets} \geq 6$, $N_b \geq 2$, $E_T^{miss} > 350$ GeV)

Dilepton ttbar with 6+ jets



Lepton is not reconstructed

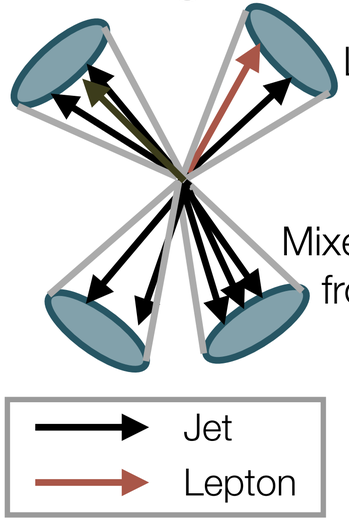
Can't rely on MC in this regime, need data-driven estimate

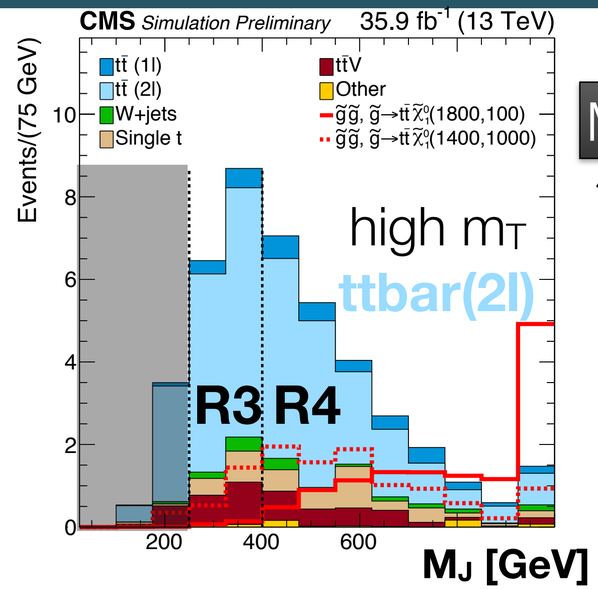
Measuring background with M_J

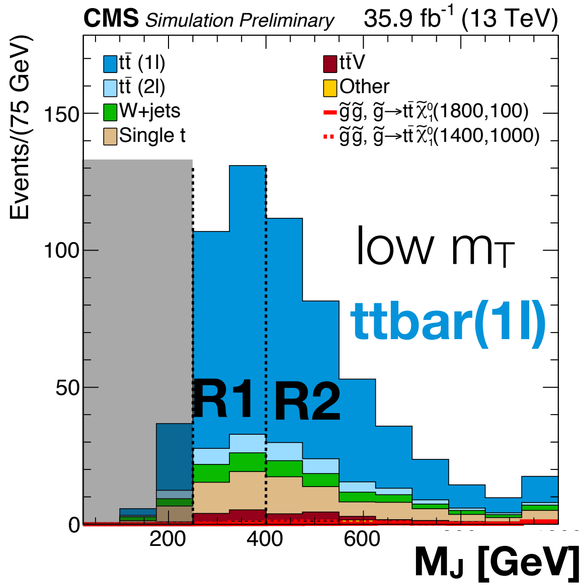
Cluster all jets and leptons into anti-k_T jets with R=1.2, 1.4

$$M_J = \sum_{J_i = \text{large-}R\text{ jets}} m(J_i)$$

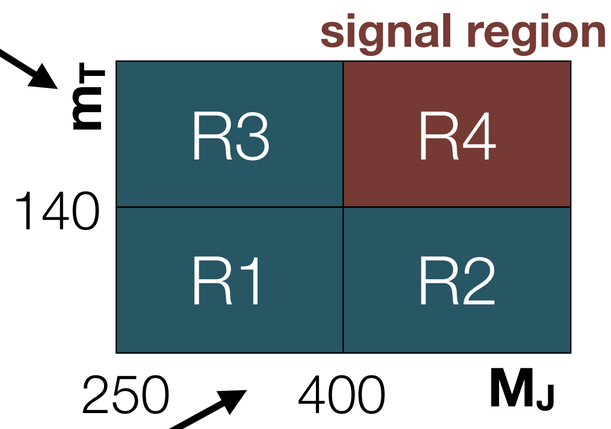
High M_J signal event







Measure high m_T normalization



Measure M_J shape

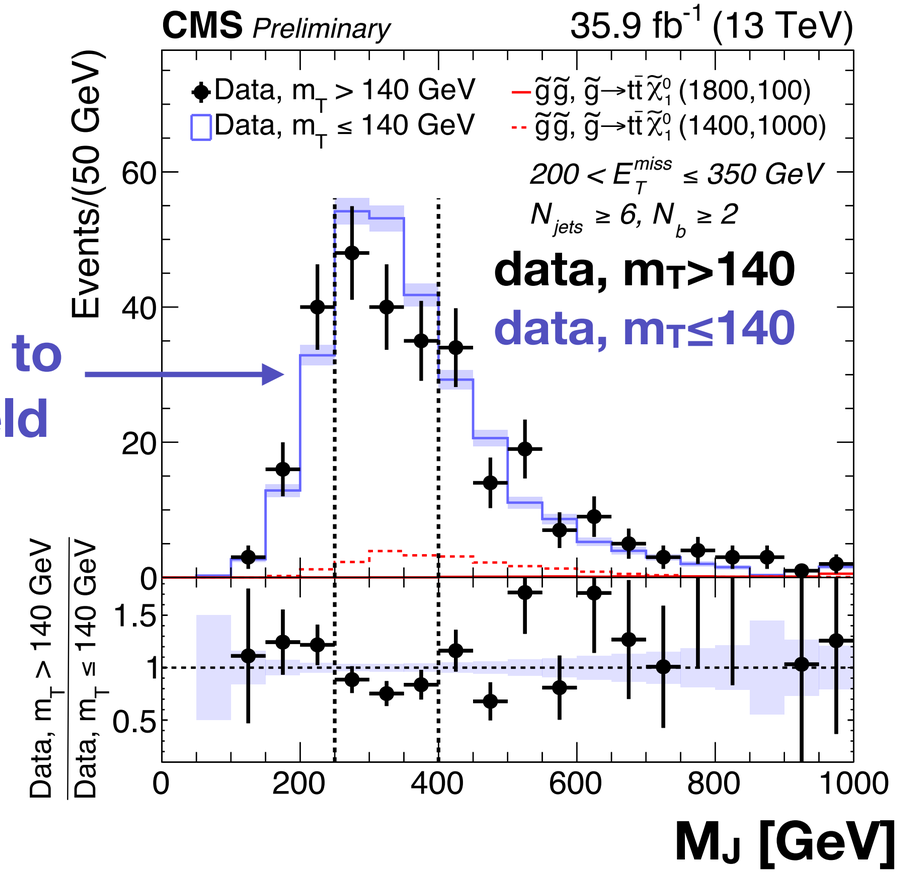
M_J-m_T independence:

$$N_{R4} = \left(N_{R3} \times \frac{N_{R2}}{N_{R1}} \right)_{data} \times \kappa_{mc}$$

ATLAS search with M_J: Phys. Rev. D 91, 112016
M_J introduced by J. Wacker et al, Phys. Rev. D 85, 055029

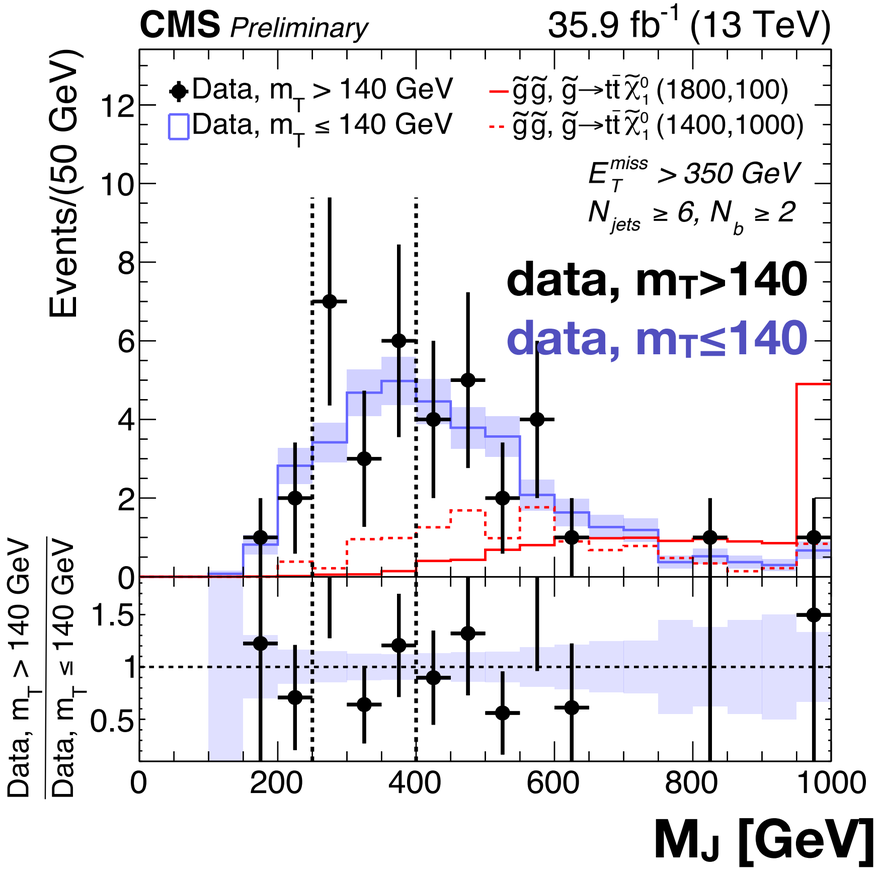
M_J shape comparisons in data

$200 < E_T^{miss} \leq 350$ GeV



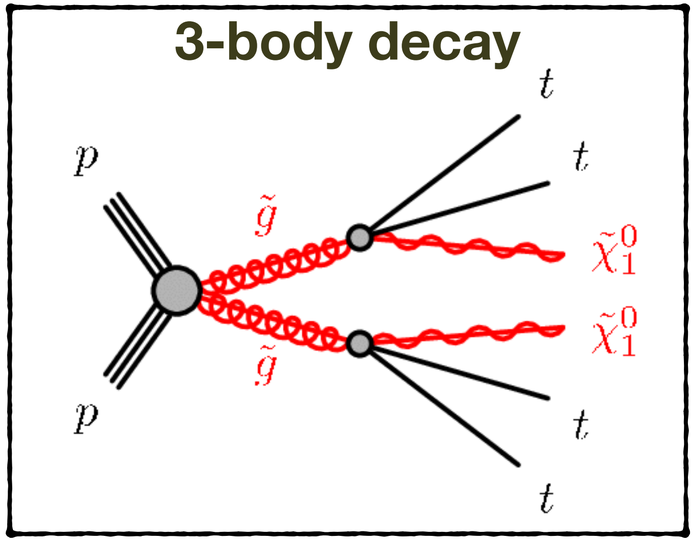
Normalized to high m_T yield

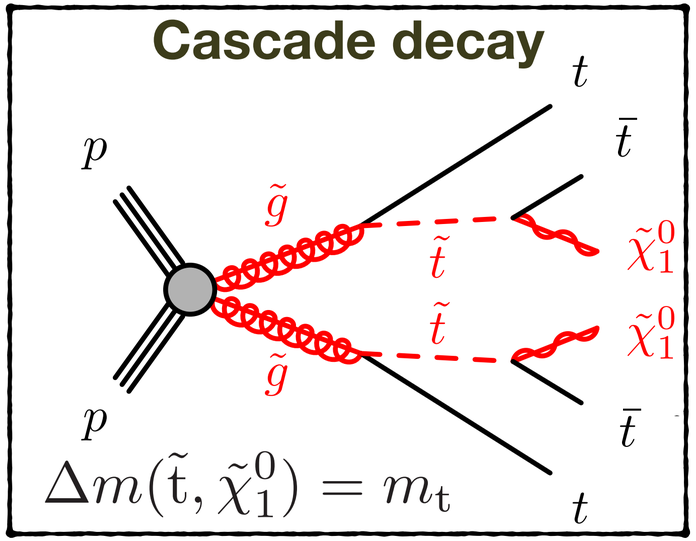
$E_T^{miss} > 350$ GeV

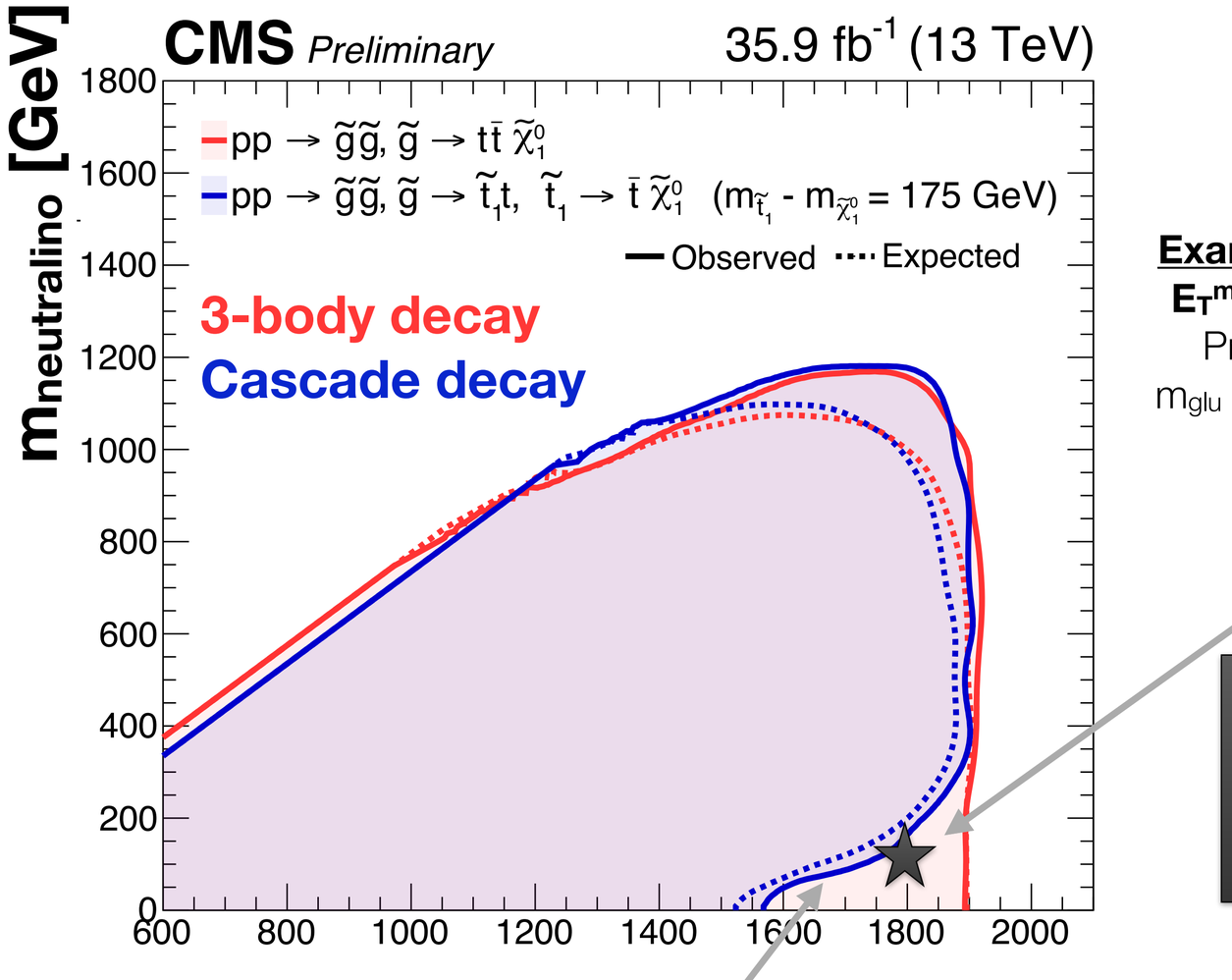


Observations consistent with background in all 18 search bins in N_{jets}, N_b and E_T^{miss}

Results







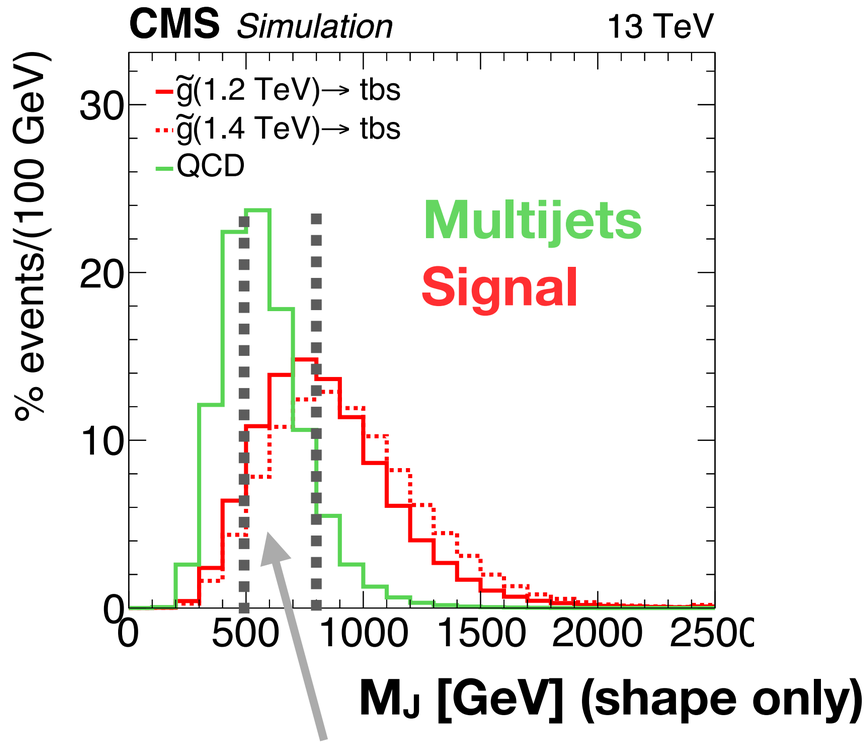
Example yields in subset of SR:
E_T^{miss} > 500, 6+ jets, 3+ b-jets:
Predict 0.5 events, observe 1
m_{glu} =1800, m_{LSP}= 100: **5.4 events**
→ **easily excluded**

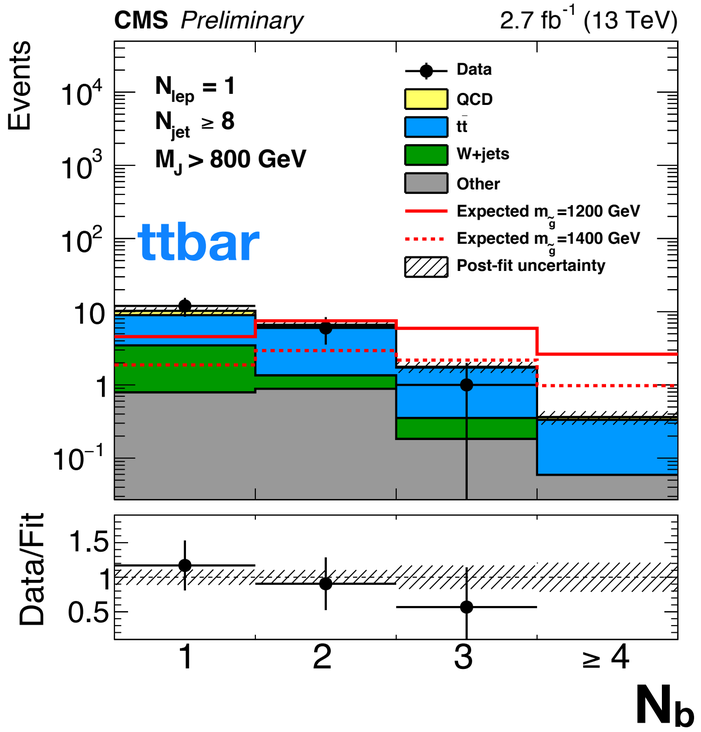
Exclude gluinos up to 1.9 TeV (σ = 1.6 fb)

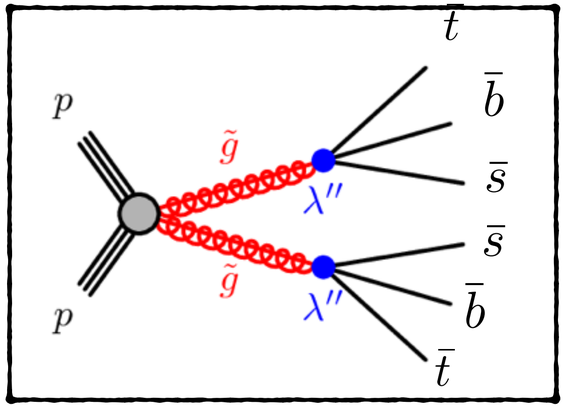
Neutralino p_T → 0 as m_{stop} → m_{top}

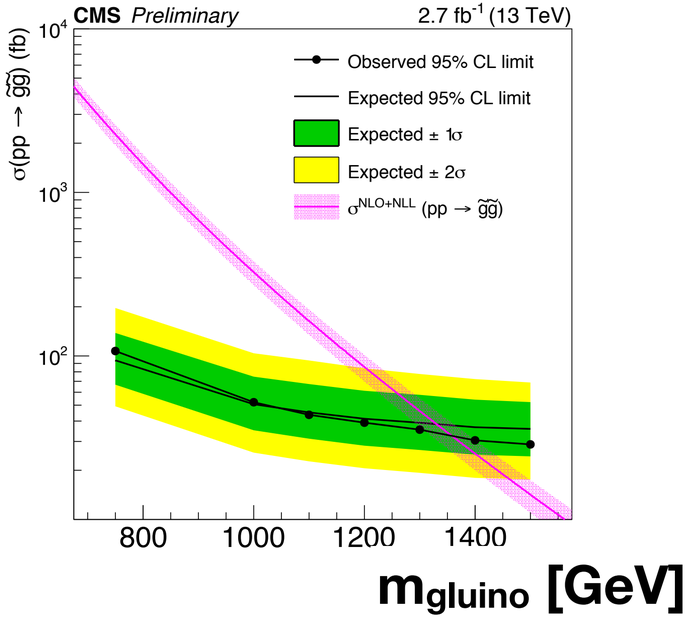
RPV gluino search in N_b

- Focus on **N_b** distribution, 0 and 1 lepton (no E_T^{miss})









Constrain gluon splitting, b-tag efficiencies, flavor composition, etc

($N_{jets} \geq 8$, $N_b \geq 1$, $H_T > 1500$ GeV)

Stay tuned for 2016 update!

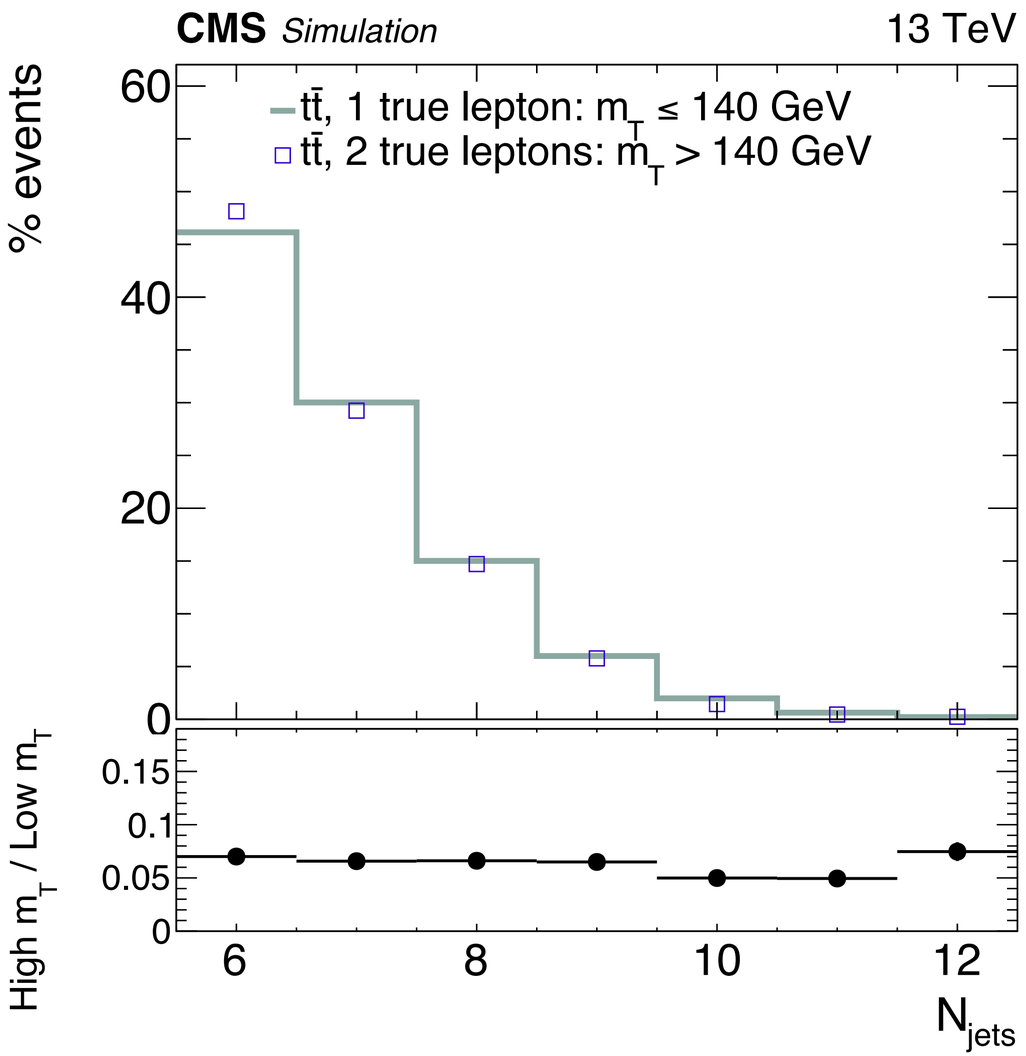
Backup

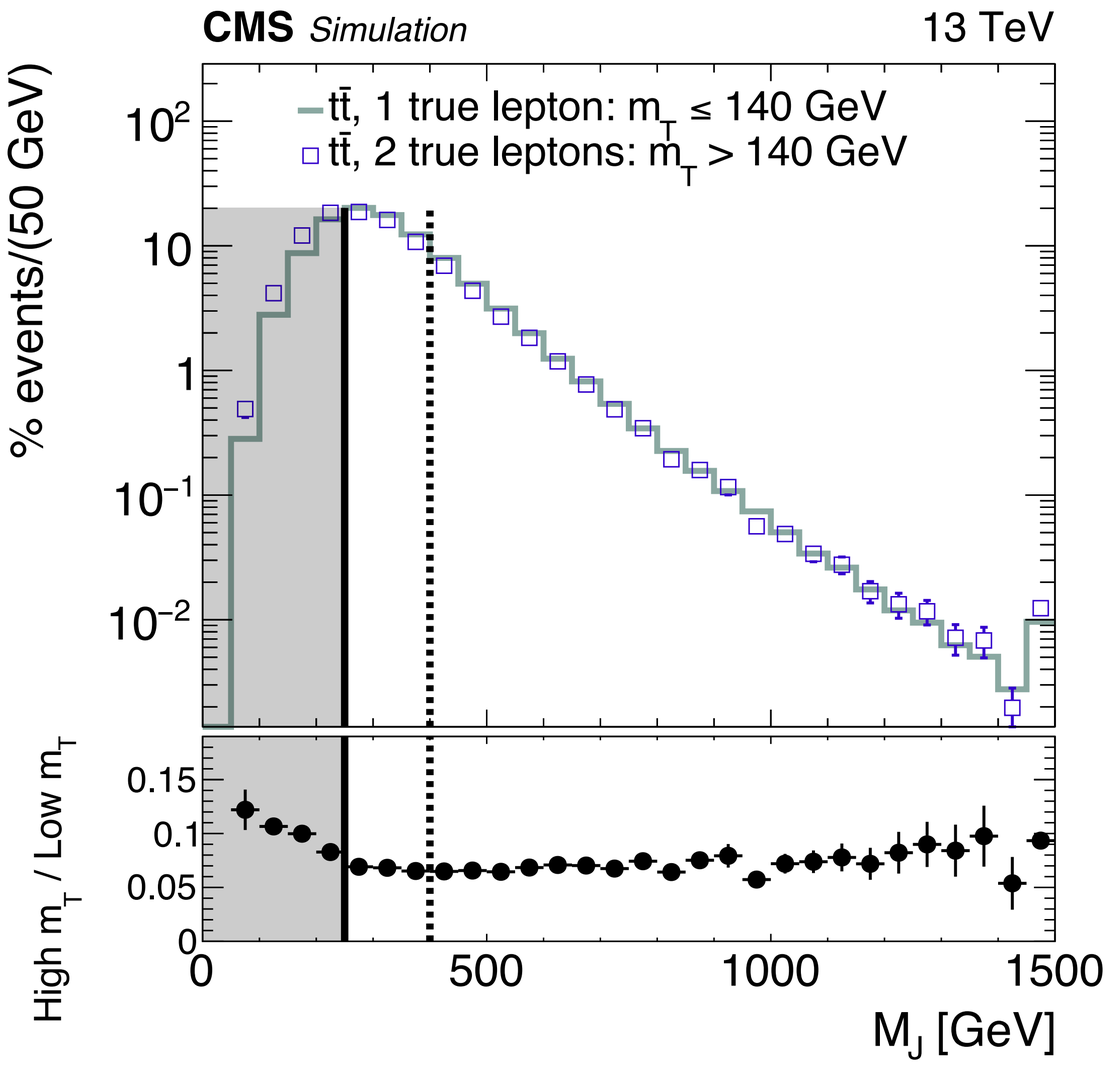
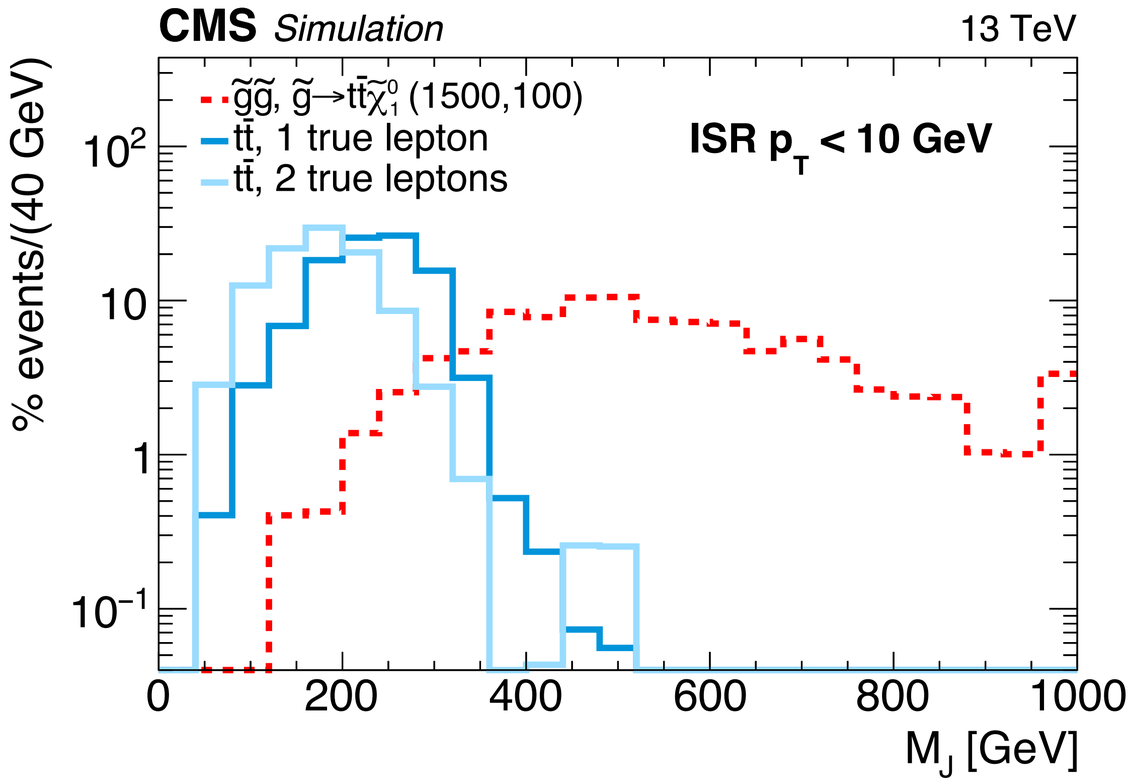
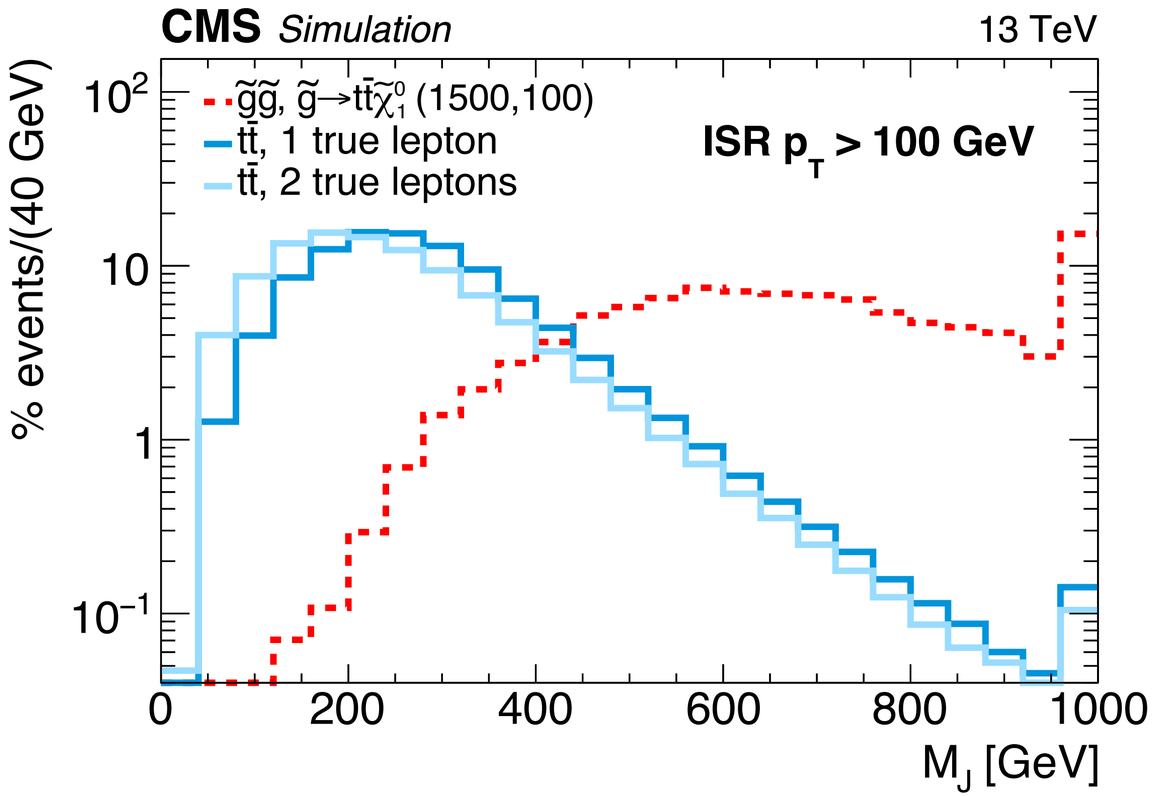
Yields in 1-lepton + E_T^{miss} search

Table 1: Observed event yields and mean background yields from the predictive fit in the 18 bins of the signal region R4. The uncertainties in κ include (in order) both a statistical component from the size of the MC samples and a systematic component assessed from data control samples. The uncertainty in the predicted event yield includes both these and the statistical uncertainties associated with the control regions in the data. Also shown are the expected signal yields for two SUSY benchmark models.

Bin in R4	T1tttt (1800,100)	T1tttt (1400,1000)	κ	Pred.	Obs.
$200\ \text{GeV} < p_T^{miss} \leq 350\ \text{GeV}$					
$6 \leq N_{jets} \leq 8$, $N_b = 1$	0.4	1.9	$1.2 \pm 0.0 \pm 0.2$	84.6 ± 14.3	106
$6 \leq N_{jets} \leq 8$, $N_b = 2$	0.6	3.0	$1.2 \pm 0.0 \pm 0.2$	55.1 ± 9.3	75
$6 \leq N_{jets} \leq 8$, $N_b \geq 3$	0.6	2.2	$1.5 \pm 0.1 \pm 0.2$	16.4 ± 3.0	16
$N_{jets} \geq 9$, $N_b = 1$	0.2	1.6	$1.0 \pm 0.1 \pm 0.2$	6.5 ± 1.5	11
$N_{jets} \geq 9$, $N_b = 2$	0.3	2.1	$1.2 \pm 0.1 \pm 0.3$	7.6 ± 1.9	11
$N_{jets} \geq 9$, $N_b \geq 3$	0.4	3.1	$1.4 \pm 0.1 \pm 0.3$	2.3 ± 0.7	2
$350\ \text{GeV} < p_T^{miss} \leq 500\ \text{GeV}$					
$6 \leq N_{jets} \leq 8$, $N_b = 1$	0.7	1.1	$1.0 \pm 0.1 \pm 0.3$	17.4 ± 6.6	25
$6 \leq N_{jets} \leq 8$, $N_b = 2$	0.9	1.3	$1.1 \pm 0.1 \pm 0.4$	13.7 ± 5.3	10
$6 \leq N_{jets} \leq 8$, $N_b \geq 3$	0.8	0.9	$1.3 \pm 0.1 \pm 0.4$	3.8 ± 1.6	1
$N_{jets} \geq 9$, $N_b = 1$	0.3	1.0	$1.1 \pm 0.1 \pm 0.4$	1.3 ± 0.6	2
$N_{jets} \geq 9$, $N_b = 2$	0.5	1.1	$0.8 \pm 0.1 \pm 0.3$	1.6 ± 0.8	2
$N_{jets} \geq 9$, $N_b \geq 3$	0.7	2.1	$1.2 \pm 0.2 \pm 0.4$	0.6 ± 0.4	0
$p_T^{miss} > 500\ \text{GeV}$					
$6 \leq N_{jets} \leq 8$, $N_b = 1$	2.5	0.6	$1.0 \pm 0.1 \pm 0.3$	1.9 ± 1.5	8
$6 \leq N_{jets} \leq 8$, $N_b = 2$	3.6	1.0	$1.0 \pm 0.1 \pm 0.3$	0.9 ± 0.7	4
$6 \leq N_{jets} \leq 8$, $N_b \geq 3$	3.2	0.4	$1.5 \pm 0.3 \pm 0.5$	0.4 ± 0.4	1
$N_{jets} \geq 9$, $N_b = 1$	1.0	0.7	$1.0 \pm 0.3 \pm 0.4$	0.2 ± 0.2	2
$N_{jets} \geq 9$, $N_b = 2$	1.8	1.2	$1.0 \pm 0.3 \pm 0.3$	0.1 ± 0.1	0
$N_{jets} \geq 9$, $N_b \geq 3$	2.3	1.7	$3.1 \pm 1.0 \pm 1.1$	0.1 ± 0.1	0

M_J-m_T independence





M_J shapes with and without ISR