SUSY Background Estimation with m_{T2}

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Event Topology

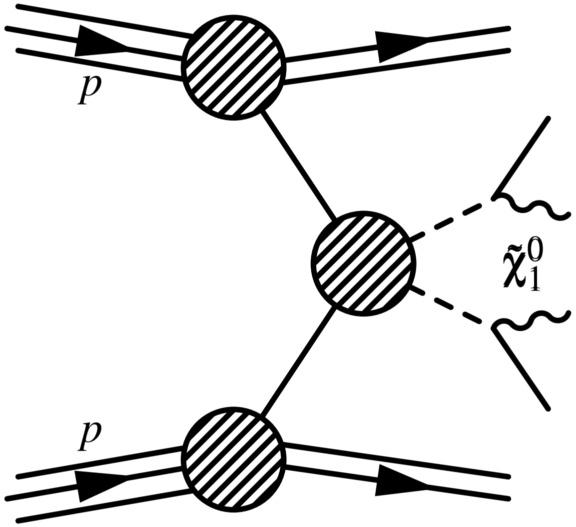
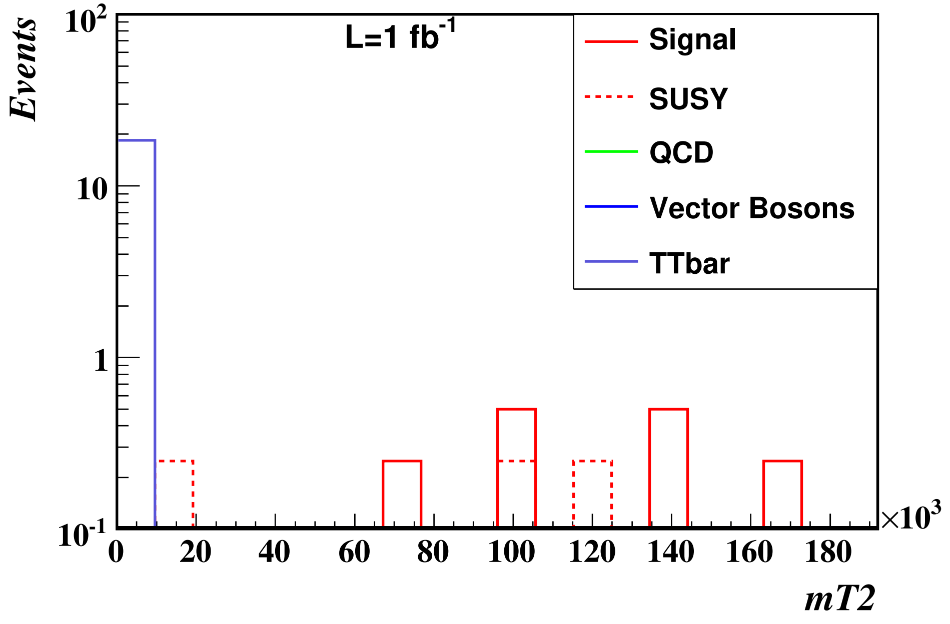


Figure 1: A generic SUSY pair production process and decay

- Looking for pair produced SUSY particles each decaying into one visible (SM particle) and one invisible LSP.
- Three general cases: Squarks, Selectrons, Smuons
- Many background processes can resemble or fake these signatures.
- There are many ongoing studies into Standard Model backgrounds
- Other SUSY processes can also fake such a signature. Particularly in the case of Squark production.

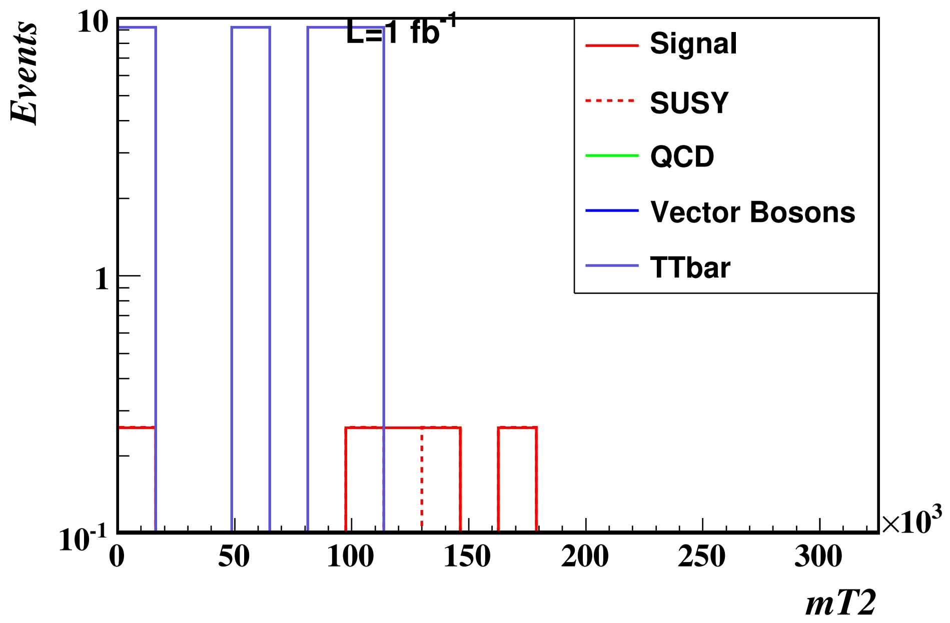
Di-Slepton Events

Di-Selectrons



- The important SUSY self background in both of these cases has been reduced to a manageable size by a harsh jet $\mathbf{p}_T$ cut.
- **Note**: this cut may not be so usable in real data as pile-up and underlying event have not yet been taken into account.

Di-Smuons



	Event Selection Cuts
0	2 isolated electrons (muons)
1	No isolated muon (electron) and highest $\mathbf{p}_T$ jet < 10 GeV
2	Leptons have opposite charge
3	$max(\not{E}_T, 0.2 * M_{eff}) > 100$ GeV

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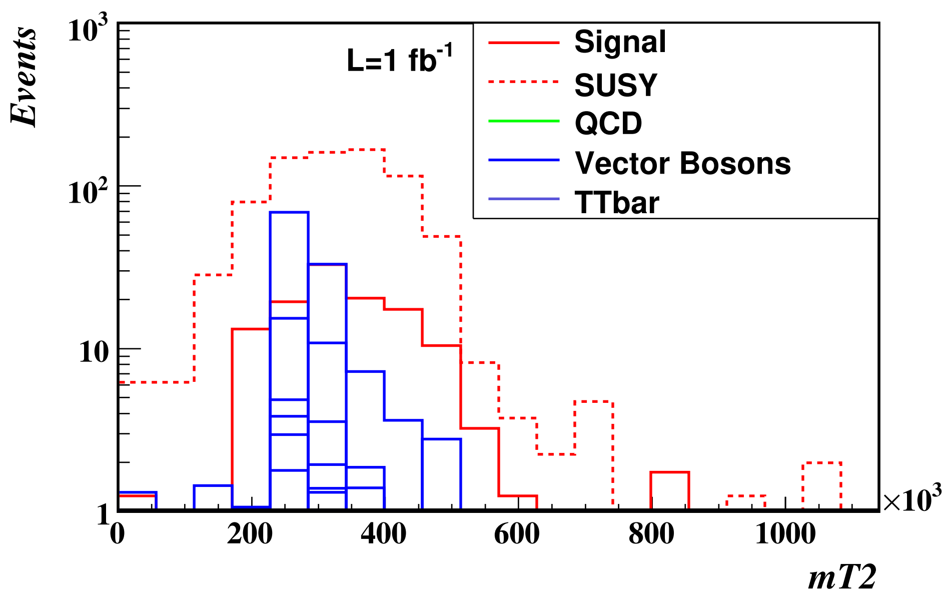
Di-Squark Events

- Using cuts similar to ATLAS CSC exclusive SUSY searches, can eliminate much of the SM background.
- However, a large amount of SUSY background remains.

	Event Selection Cuts
0	No isolated leptons, No b jets
1	$\lvert\eta_{j1,j2}\rvert < 1\ (j1, j2)$ highest $\mathbf{p}_T$ jets
2	$p_T^{j1,j2} > 200$ GeV
3	$p_T^{j3} < 200$ GeV
4	$\not{E}_T > max\left(0.25\,M_{eff}, 200\text{ GeV}\right)$
5	$M_{eff} > 500$ GeV
6	$S_T > 0.2$

m_{T2}



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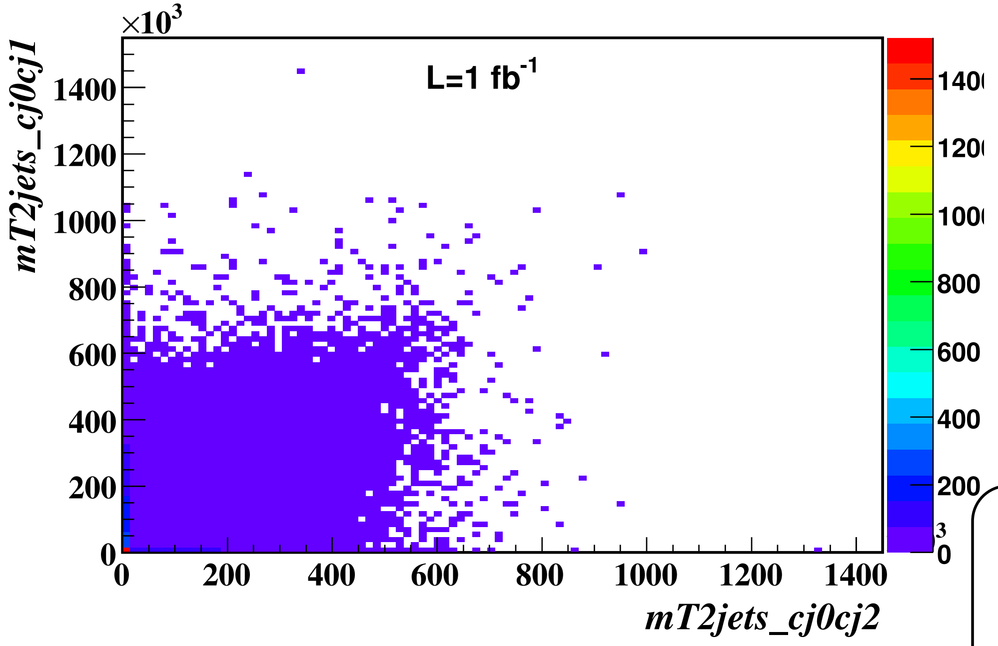
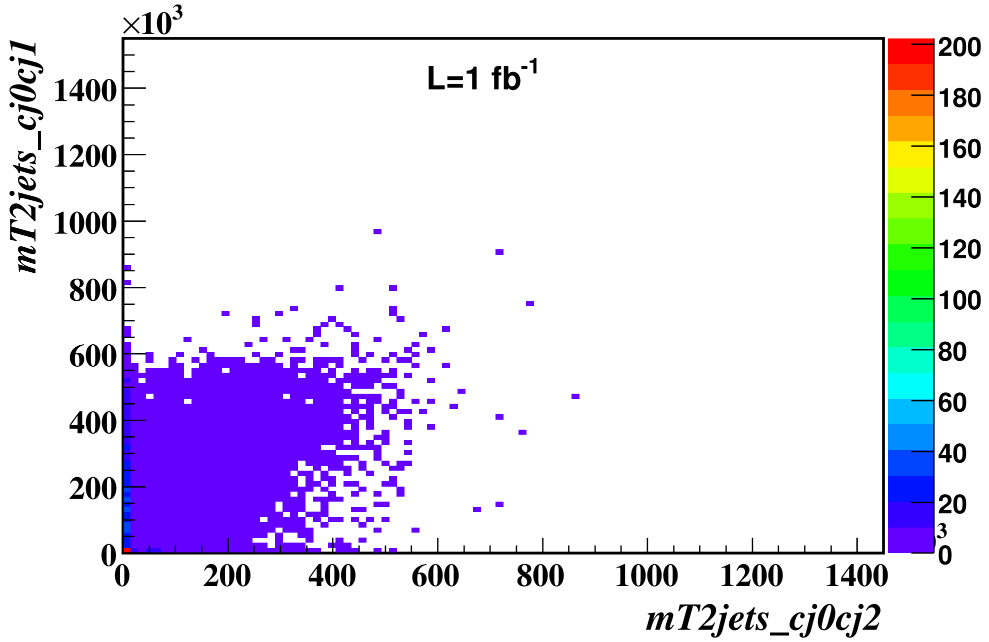
Jet Morphing

SUSY Background



- Is it possible to capitalise on symmetry in mT2 hardest two jets and mT2 hardest and third hardest jets?
- Transform third hardest jet $\mathbf{p}_T$ such that the transformed $\mathbf{p}_T$ jet spectrum resembles the second hardest jet $\mathbf{p}_T$ spectrum

SUSY Signal



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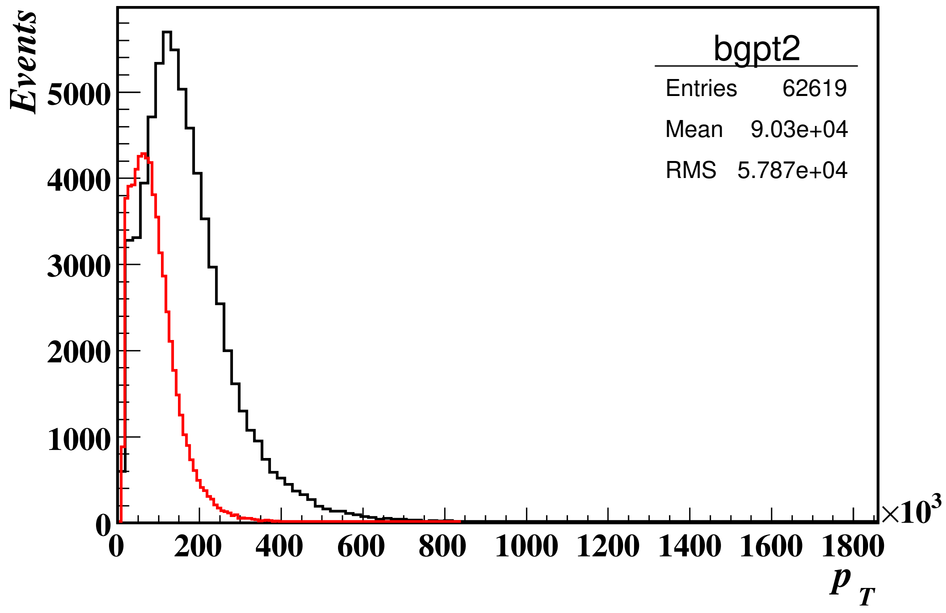
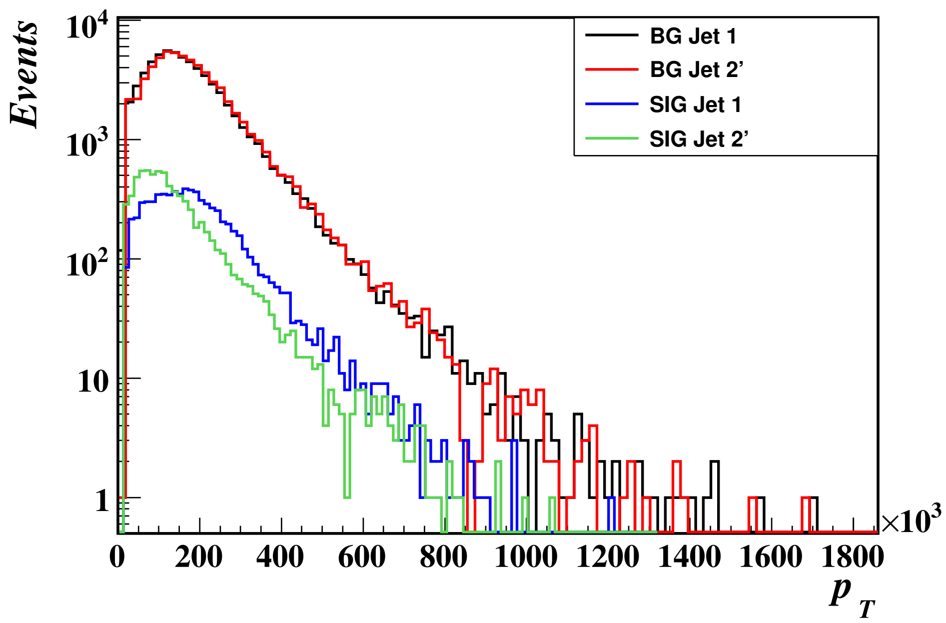
Jet Morphing

Jet $\mathbf{p}_T$



- Try to develop a function to transform the third hardest jet to match the second hardest jet $\mathbf{p}_T$ spectrum.
- Map $\mathbf{p}_T$ spectrum based on percentile of $\mathbf{p}_T$.

Morphed Jet $\mathbf{p}_T$ spectrum



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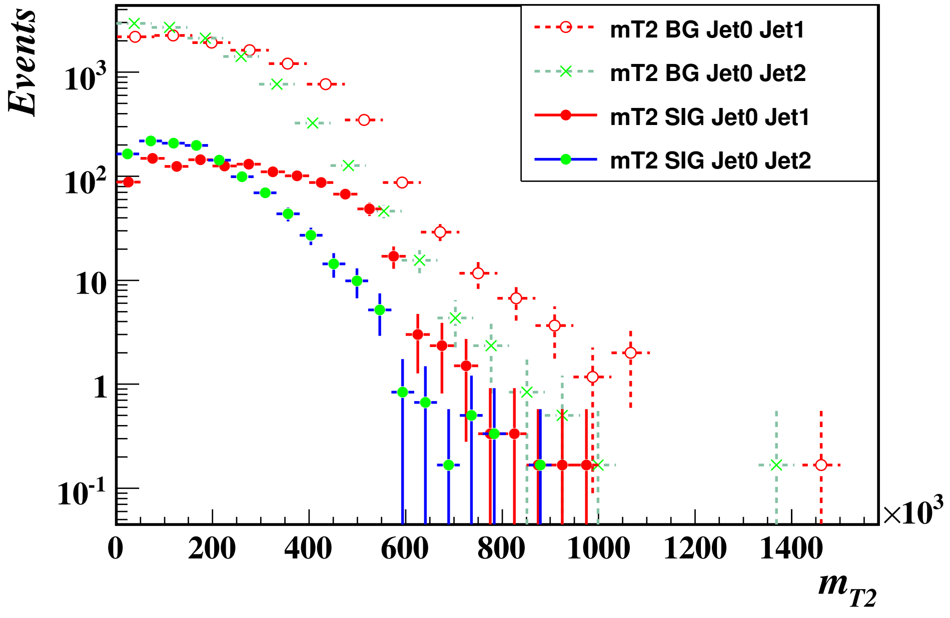
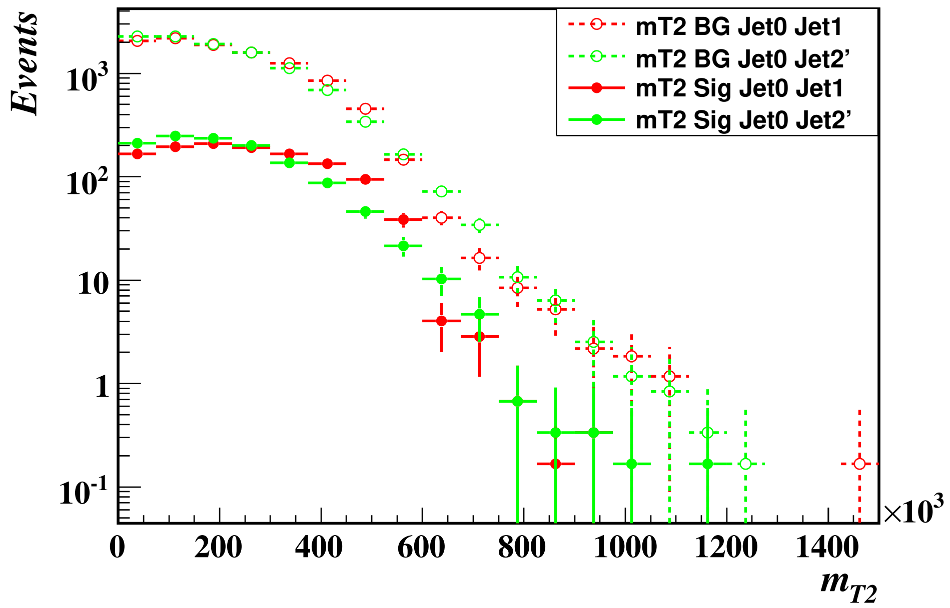
Jet Morphing

m_{T2} No Morphing



- Subtract $m_{T2}(0, 2')$ from $m_{T2}(0, 1)$
- This method seems to transform the signal too much. Subtraction removes almost everything.
- Tends to be an excess of transformed jets in m_{T2} distribution.

m_{T2} Morphed Jets



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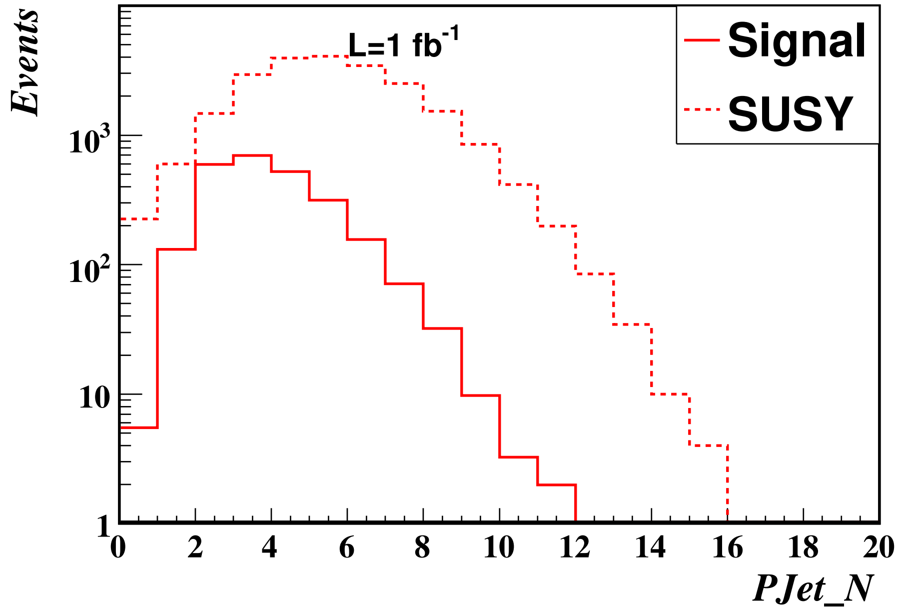
Jet Multiplicity

- Using a simple cone algorithm jet multiplicity does not necessarily match the topology of the event.
- Events with higher jet multiplicities tend to have softer jets.
- However it can still be difficult to ensure proper selection.

Jet Multiplicity



Jet Merging

- Merge jets into 2 super jets
- Poses many technical problems
  - Running jet reconstruction from AOD
  - Passing information from merging algorithm into ParticleJetCollection/Ntuples
  - Overlap removal
  - Distinguish underlying event from hard-process. (Not really specific to jet merging)

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Moving Forward

- Determine method/cuts to reduce SUSY background (i.e. jet-morphing or jet-merging techniques)
- Finalise selection cuts
- Understand background shapes
  - Setup control regions
  - Setup analysis to estimate SM and SUSY backgrounds using data driven techniques.

Questions/Comments

???

Background Samples

SM Process	Cross Section (pb)
$t\bar{t}$	461
$t\bar{t}$ hadronic decay	369
$Z \to ee + Jets$	1.19
$Z \to mumu + Jets$	1.2
$Z \to \nu\nu + 2Jets$	2.16e4
$Z \to \nu\nu + 2Jets$ and $\not{E}_T \geq 80$ GeV	246
$Z \to \nu\nu + 4Jets$	6.29
$Z \to \nu\nu + 5Jets$	1.9
$W \to e\nu + Jet$	11225
$W \to e\nu + 4Jets$	1.99
$W \to e\nu + 5Jets$	0.85
$W \to \mu\nu + Jet$	11225
$W \to \mu\nu + 4Jets$	1.85
$W \to \mu\nu + 5Jets$	0.86
$W \to \tau\nu + 2Jets$	3.73e4
$W \to \tau\nu + 2Jets$ and $\mathbf{p}_T \geq 80$ GeV	343
$W \to \tau\nu + 4Jets$	2.68
$W \to \tau\nu + 5Jets$	0.86

SM Process	CS
QCD di-jets 17 GeV $< \mathbf{p}_T < 35$ GeV	1.38e9
QCD di-jets 35 GeV $< \mathbf{p}_T < 70$ GeV	9.3e7
QCD di-jets 70 GeV $< \mathbf{p}_T < 140$ GeV	5.9e6
QCD di-jets 140 GeV $< \mathbf{p}_T < 280$ GeV	3.08e5
QCD di-jets 280 GeV $< \mathbf{p}_T < 560$ GeV	12500
QCD di-jets 560 GeV $< \mathbf{p}_T < 1120$ GeV	360
QCD di-jets 1120 GeV $< \mathbf{p}_T < 2280$ GeV	5.71
QCD di-jets $\mathbf{p}_T > 2280$ GeV	0.24

- Signal sample studied is SU3
- SU3 sample further split into SUSY signal and SUSY background

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