Learning how to count - The accidental boost

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SLAC – Stanford University

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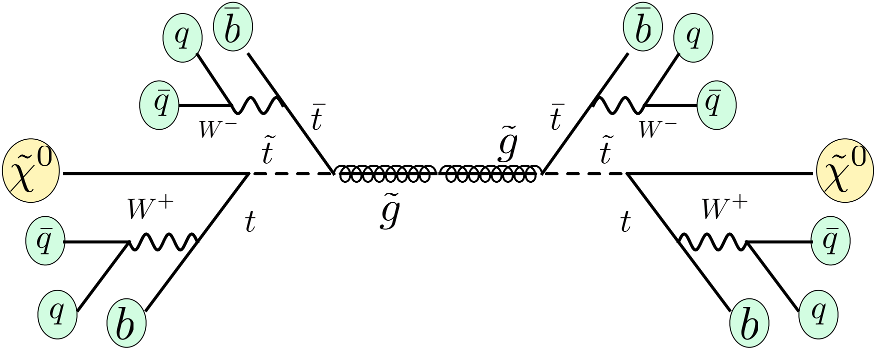
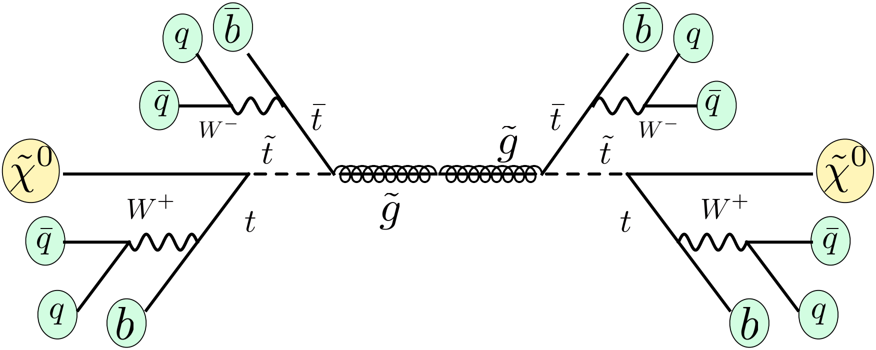
Natural SUSY high multiplicity signatures



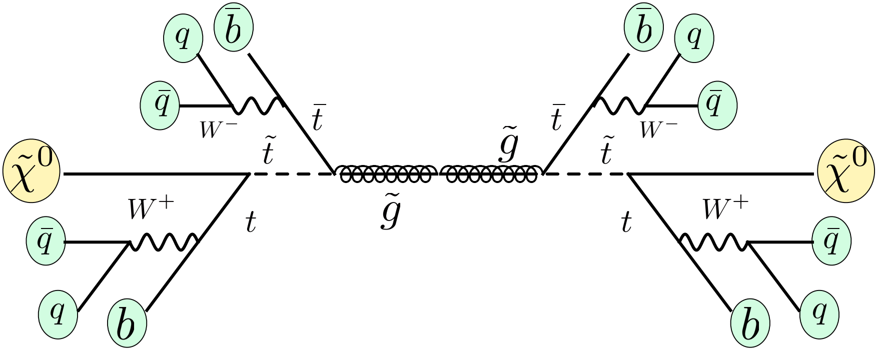
- Relatively soft jets ($p_T \gtrsim 50$ GeV)

Natural SUSY high multiplicity signatures



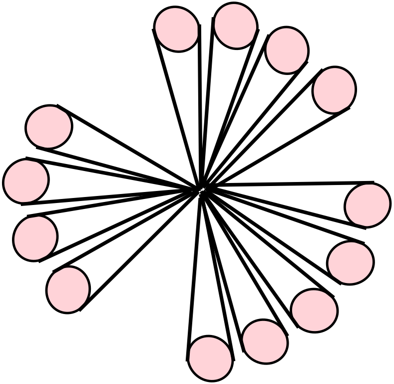
- Relatively soft jets ($p_T \gtrsim 50$ GeV)
- $\not{E}_T$ suppressed

Natural SUSY high multiplicity signatures

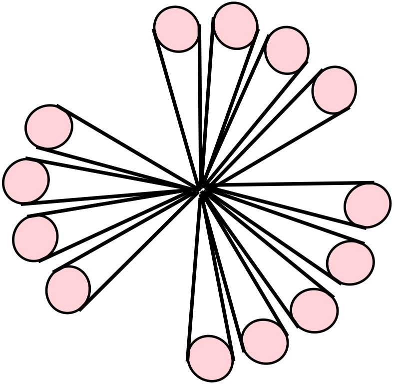


- Relatively soft jets ($p_T \gtrsim 50$ GeV)
- $\not{E}_T$ suppressed
- ≥ 12 jets (up to 18 with RPV)

The accidental boost

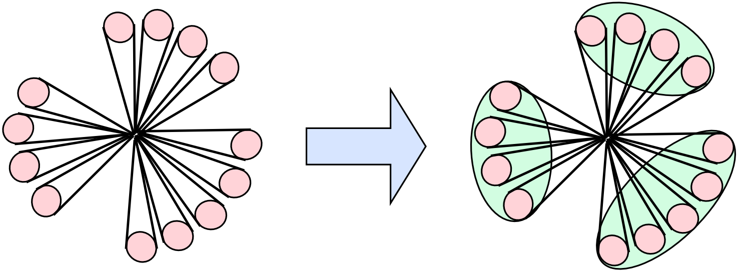


The accidental boost



The accidental boost

Cluster jets into fat jets ($R \sim 1$)



- Cut on $N_{fatjets}$

The accidental boost

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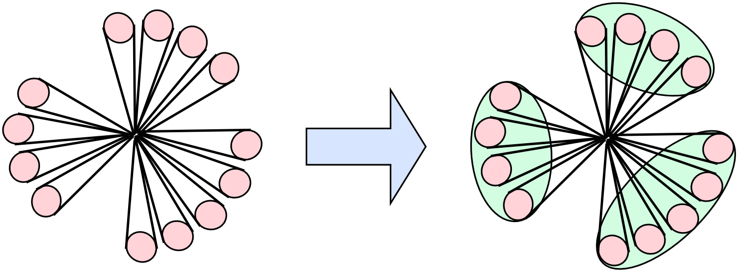

- Cut on $N_{fatjets}$
- Cut on $\not{E}_T$

The accidental boost

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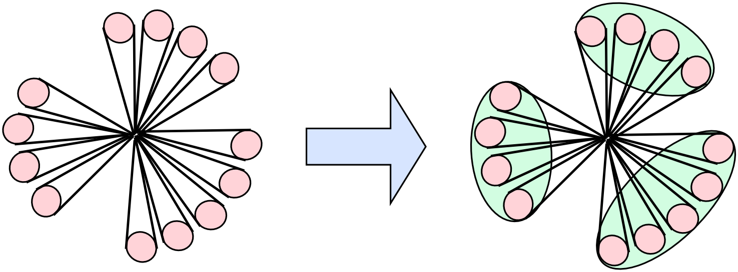
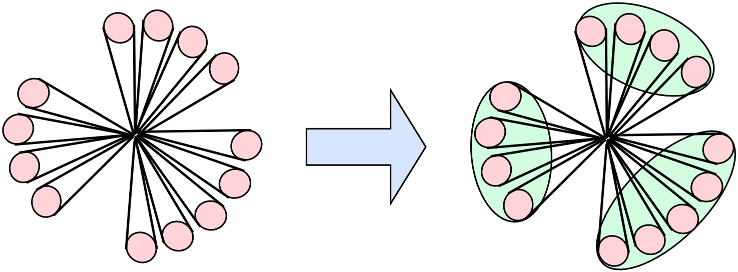


- Cut on $N_{fatjets}$
- Cut on $\not{E}_T$
- Cut on $M_J = \sum_j m_j$

The accidental boost

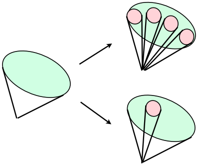
Cluster jets into fat jets ($R \sim 1$)

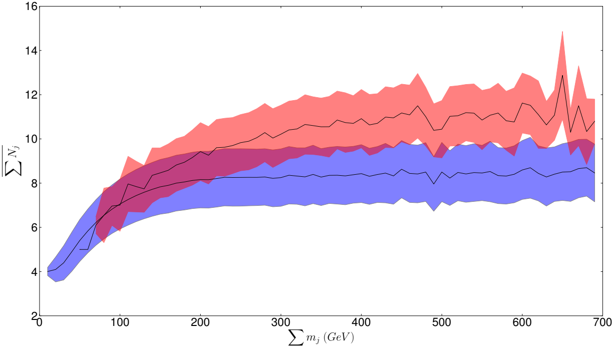


- Cut on $N_{fatjets}$
- Cut on $\not{E}_T$
- Cut on $M_J = \sum_j m_j$

No more discriminating variables?

Knowing how to count





- Recursively, using clustering algorithms
- Using N-subjettiness

Counting subjets recursively

Uncluster j into j_1 and j_2 (j_1 harder)

If $m_j \leq m_{cut}$ or $\Delta R(j_1, j_2) < R_{min}$, j is a subjet

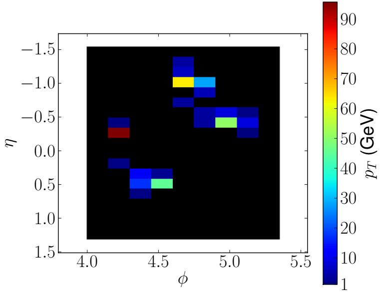
If $p_{T2} < y_{cut}.p_{Tj}$, throw out j_2

Repeat the procedure on the remaining jet(s)

$$m_{cut} = 30 \text{ GeV}, \; y_{cut} = 0.15, \; p_{Tcut} = 40 \text{ GeV}, \; R_{min} = 0.20$$

Using N-subjettiness

$$\tau_N = \sum_i \frac{p_{Ti}}{p_T} \min_{k=1\ldots N} \frac{\Delta R_{ik}}{R_0}$$



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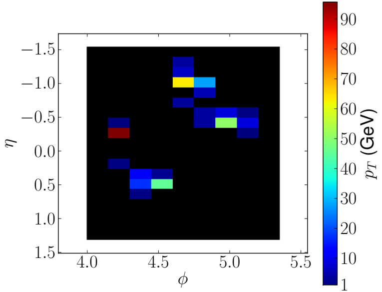
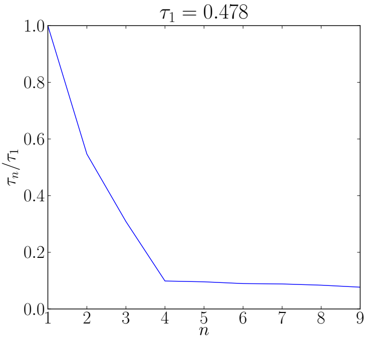
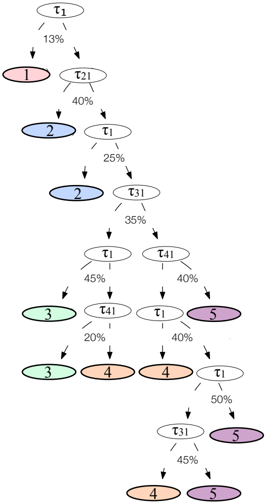


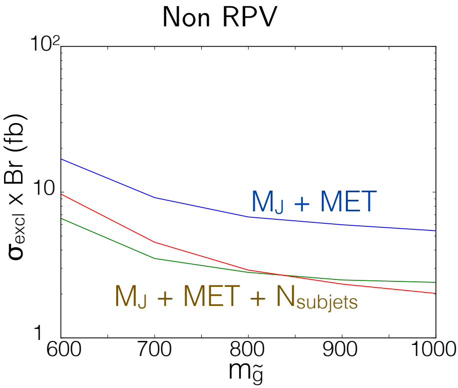


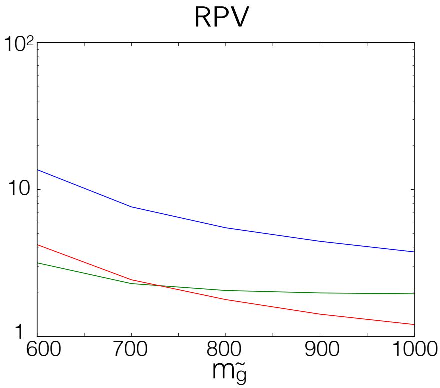
N-subjettiness - Boosted Decision Trees



N	τ_1	τ_{21}	τ_{31}	τ_{41}
1	<13%			
2	13% - 25%			
2	>25%	<40%		
3	25% - 45%	>40%	<35%	
3	>45%	>40%	<35%	<20%
4	>45%	>40%	<35%	>20%
4	25% - 40%	>40%	>35%	<40%
4	25% - 50%	>40%	35%-45%	<40%
5	>25%	>40%	>35%	>40%
5	25% - 50%	>40%	>45%	<40%
5	>50%	>40%	35%-45%	>40%

$$\tilde{g}\tilde{g} \to t\bar{t}t\bar{t} + 2\chi$$





Conclusion

- Natural SUSY scenarios favor the existence of very high multiplicity events with relatively soft jets and suppressed missing E_T
- Such events can be clustered into fat jets and studied using jet substructure techniques
- Algorithmic techniques and jet shape variables such as N-subjettiness allow to estimate the total number of subjets in an event
- Adding a cut on this number of subjets to the standard $M_J + \not{E}_T$ cuts allow an improvement of the exclusion limits by at least a factor of two.