Searches for light- and heavy-flavor three-jet resonances in pp collisions with the CMS detector at $\sqrt{s}$ = 8 TeV

Claudia Seitz, DESY
for the CMS Collaboration

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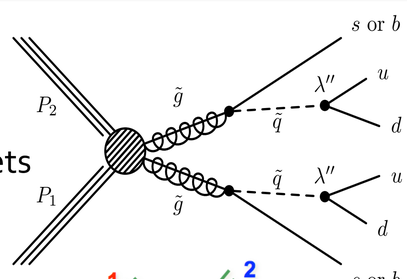
Abstract

A search for **three-jet hadronic resonance** production in pp collisions at a center-of-mass energy of 8 TeV using 19.4fb^{-1} of data collected by the CMS experiment in 2012 is presented. The search method **is model independent**, and events are selected that have high jet multiplicity and large values of jet transverse momenta.

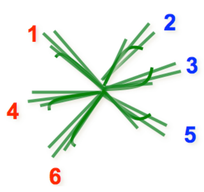
The results are interpreted in the context of **R-parity-violating supersymmetric gluino** pair production resulting in **a six-jet final state, including light- and heavy-flavor jets**. The analysis technique is validated with a known standard model particle decaying into three jets, the **top quark.**

Introduction and Strategy

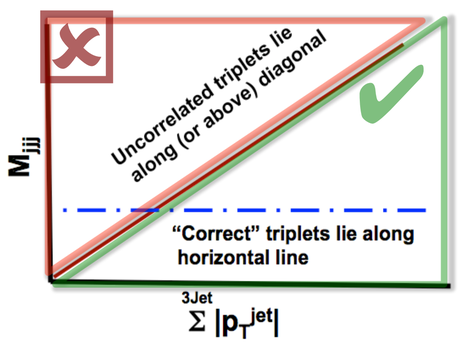
- R-parity violating (RPV) decay of gluinos:
  gluino + gluino ➔ 3j + 3j **or** 2j + 1b + 2j + 1b

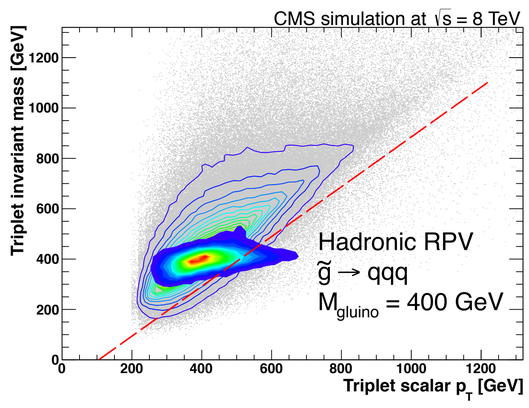


- 20 unique triplets per event from 6 highest p_T jets
- Plot M_{jjj} vs . $\Sigma^{3Jet}|p_T|$
  - Correct combination will pile-up along a horizontal line representing the resonance mass
  - Incorrect combinations will lie above the diagonal



- Select the triplet in the event that satisfies the requirement of $M_{jjj} < \Sigma^{3Jet}|p_T| - \Delta$





- Trigger: at least 6 calorimeter jets (4^{th}-jet p_T > 60 GeV, 6^{th}-jet p_T> 20 GeV)
- Basic selection: at least 6 anti-k_T Particle Flow jets with R=0.5
  - 4^{th}-jet p_T > 80 GeV, 6^{th}-jet p_T > 60 GeV

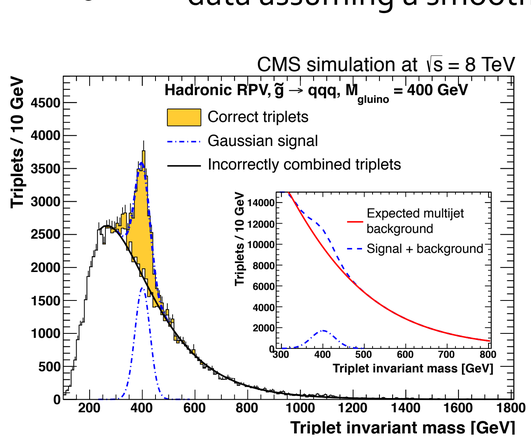
Selection Optimization

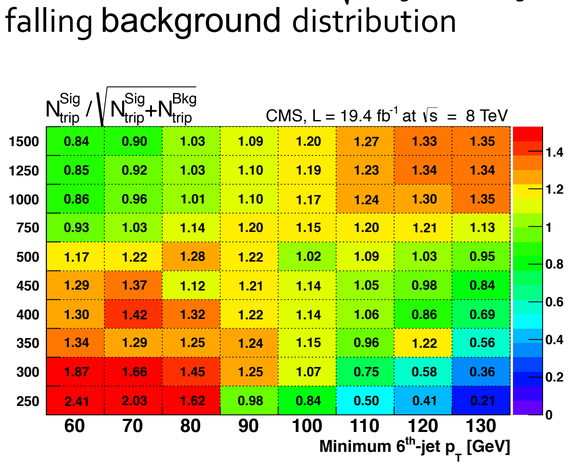
The choice of Δ is driven by the goal to access the largest mass range possible, and is chosen to be at 110 GeV. With the diagonal offset determined, the 6^{th}-jet p_T and b-tagging selection criteria are applied to maximize signal significance.

$N_{Sig}^{Triplet}$ ⇒ Number of triplets in Gaussian signal peak

$N_{Bkg}^{Triplet}$ ⇒ Number of triplets in the data assuming a smoothly falling background distribution

$$\text{Signal Significance} = \frac{N_{Sig}^{Triplet}}{\sqrt{N_{Sig}^{Triplet}+N_{Bkg}^{Triplet}}}$$



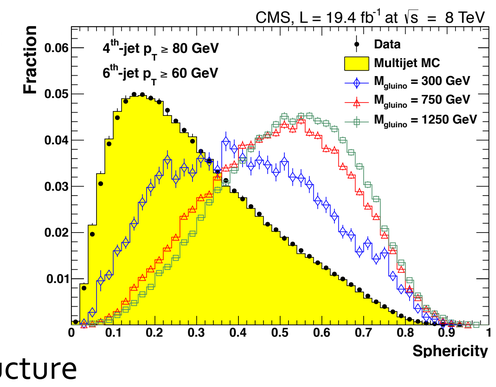


Event shape variable from sphericity tensor:

$$S^{\alpha\beta} = \frac{\sum p_j^{\alpha} p_j^{\beta}}{\sum |p_j|^2}$$

Sphericity = 3/2 $(\lambda_2 + \lambda_3)$

λ_2, λ_3 are eigenvalues of $S^{\alpha\beta}$



- Measure of event's isotropic nature
- Signal resonances exhibit an isotropic jet distribution
- QCD background has more dijet-like structure

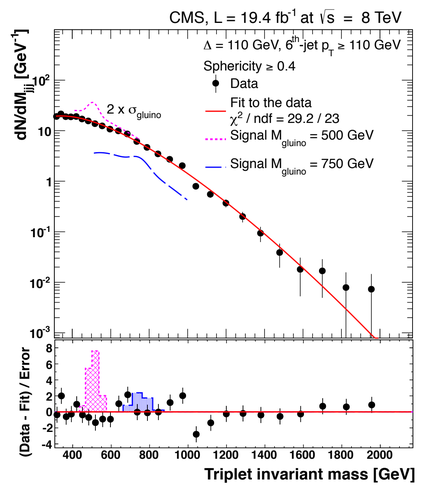
Final Selection and Background

Selection criteria	Inclusive search	Heavy-flavor search	
		Low mass	High mass
Mass range	400 – 1500 GeV	200 – 600 GeV	600 – 1500 GeV
Jets	At least six jets with $p_T \geq 35$ GeV and $\eta \leq 2.5$		
Δ	110 GeV	110 GeV	110 GeV
4^{th}-jet p_T	110 GeV	80 GeV	110 GeV
6^{th}-jet p_T	110 GeV	60 GeV	110 GeV
b-tagging	-	≥ 1 b tags in triplet	
Sphericity	0.4	-	0.4

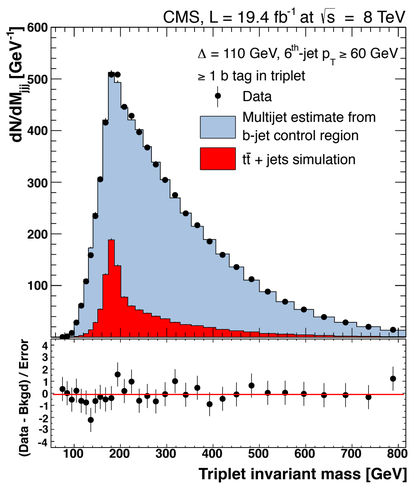
- **Inclusive search**
  - Background fit directly to the data

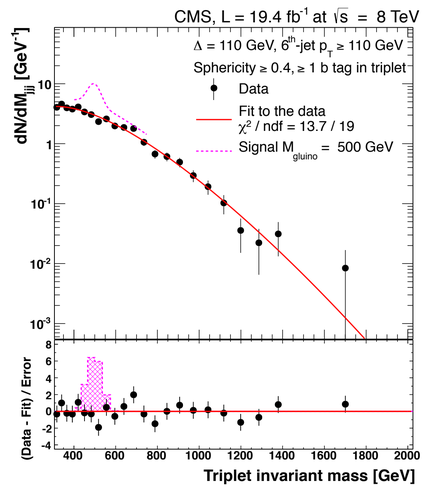
Fit function: $P4 = a\frac{(1-x/\sqrt{s})\ b}{(x/\sqrt{s})^{c+d\ \log(x/\sqrt{s})}}$

- **Heavy-flavor search**
  - Low mass range
    - Template for $t\bar{t}$ from simulation
    - QCD from data control region
  - High mass range
    - Fit directly to the the data



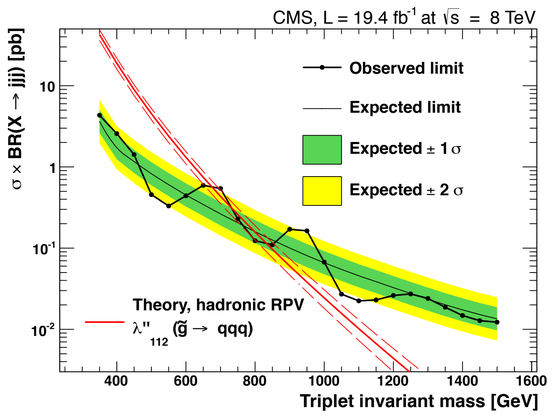
Hadronic top is used to validate the analysis technique.



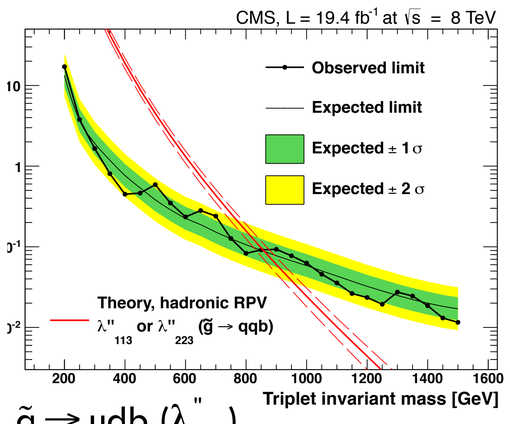


Results: Limits on hadronic RPV

Good agreement is found between selected events and the expected backgrounds from standard model multijet processes and top pair production. Stringent limits are placed on the production of R-parity-violating supersymmetric gluinos decaying exclusively into light-flavor jets and those decaying into one heavy- and two light-flavor jets.



$\tilde{g} \rightarrow uds$ (λ''_{112}) Limit: 650 GeV



$\tilde{g} \rightarrow udb$ (λ''_{113})
$\tilde{g} \rightarrow csb$ (λ''_{223}) Limit: 835 GeV

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