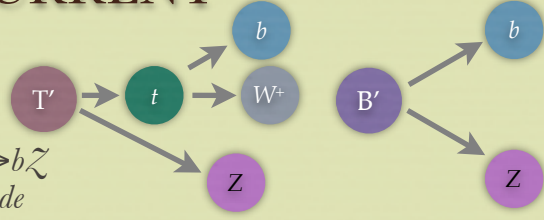




SEARCH FOR VECTOR-LIKE QUARKS AT CMS

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VECTOR-LIKE QUARKS DECAYS WITH NEUTRAL CURRENT



Very unique signatures: $T' \rightarrow tZ$ and $B' \rightarrow bZ$
Pair-produced, but only reconstruct one-side

- ❖ New quarks are predicted in various extensions of the standard model.
- ❖ Unlike the sequential fourth generation quarks, the vector-like quarks are less constrained either from theory or from experimental results.
- ❖ Tree-level flavor-changing neutral current coupling is allowed, large branching fraction is expected.

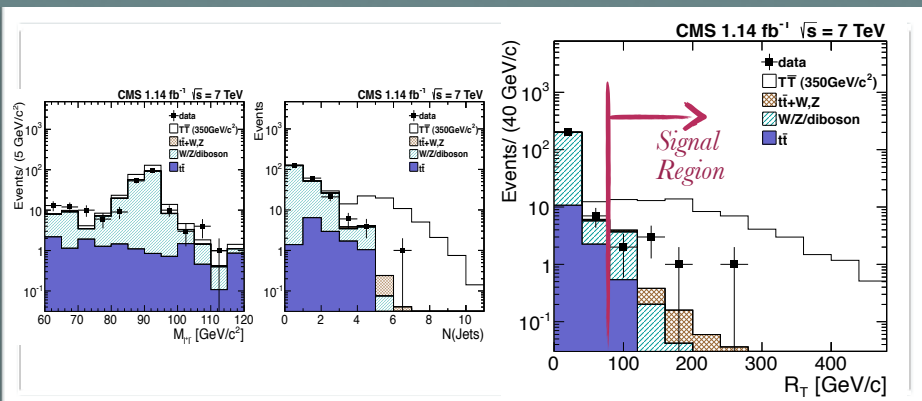
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SEARCH FOR T' QUARK IN TRILEPTON CHANNEL

PRINCIPLE OF ANALYSIS

- ❖ The first search for pair-produced T' quark in tZ decays.
- ❖ A very clean signature if Z decays to e^+e^- or $\mu^+\mu^-$ and an additional isolated charged lepton from W (or Z). Yield a very low background from the known standard model processes.
- ❖ A Z -boson candidate with $60 < M(l^+l^-) < 120 \text{ GeV}/c^2$, and at least two jets with $p_T > 25 \text{ GeV}/c$.
- ❖ An additional reduction of the SM background is obtained by requiring $R_T > 80 \text{ GeV}$:

$$R_T \equiv \sum_{i \neq 1,2} p_T(\text{jet}_i) + \sum_{j \neq 1,2} p_T(\text{lepton}_j) \quad \begin{array}{l} \text{leading 2} \\ \text{objects} \\ \text{excluded} \end{array}$$



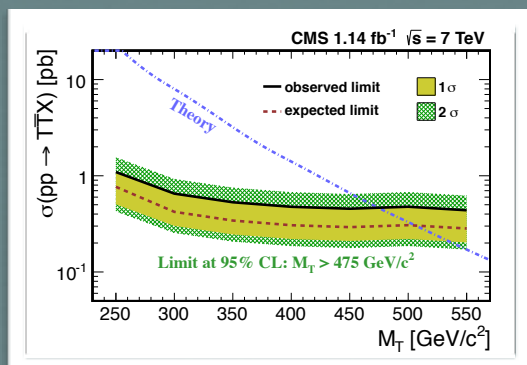
	Yield
$T'(350 \text{ GeV}/c^2)$	58
Estimated background	4.6 ± 1.0
Data	7

BACKGROUND STUDY

- ❖ Events with two prompt leptons and a non-prompt (fake) lepton from a jet: tt +jets, Z +jets
⇒ Estimated with data
- ❖ Events with three prompt leptons: dibosons, $tt+W$, $tt+Z$
⇒ Estimated with simulations

LIMIT DETERMINATION

- ❖ Data is consistent with a background only hypothesis
- ❖ Upper limits on the cross section are calculated using a Bayesian method with a flat prior for the signal, and a log-normal model for integration over the nuisance parameters.



For 100% $T' \rightarrow tZ$ decays,
 $M(T') > 475 \text{ GeV}$ at 95% C.L.

CMS PAS EXO-11-066

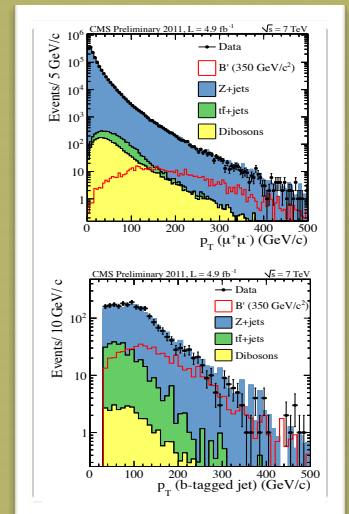
SEARCH FOR B' QUARK WITH BUMP HUNTING

EVENT RECONSTRUCTION

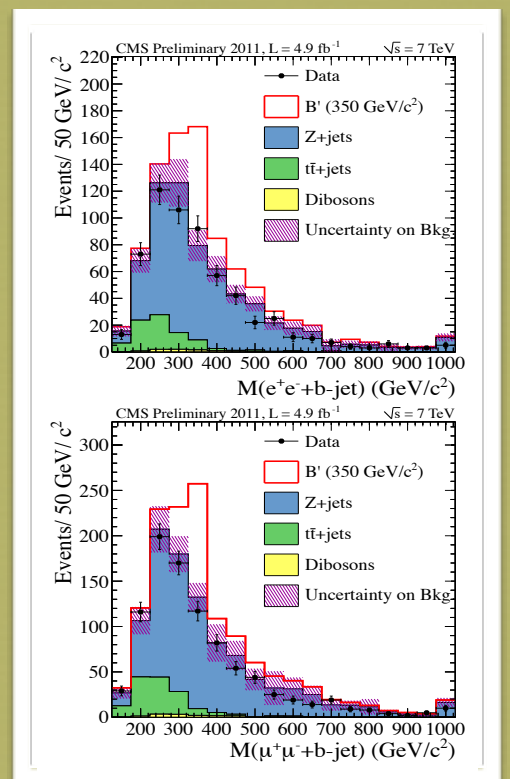
- ❖ Physics objects are reconstructed using the CMS particle-flow algorithm.
- ❖ Isolated electrons and muons are used to reconstruct Z boson candidates. Z boson candidates are defined by a pair of leptons with opposite charge and an invariant mass $60 < M(l^+l^-) < 120 \text{ GeV}/c^2$.
- ❖ At least one Z candidate with $p_T > 95 \text{ GeV}/c$, one b -tagged jet with $p_T > 65 \text{ GeV}/c$, and at least another jet with $p_T > 30 \text{ GeV}/c$.

BUMP HUNTING

- ❖ The highest- p_T Z candidate and the highest- p_T b -tagged jet are used to reconstruct the candidate B' quark in each event.
- ❖ Perform a template fit to the reconstructed invariant mass distributions.

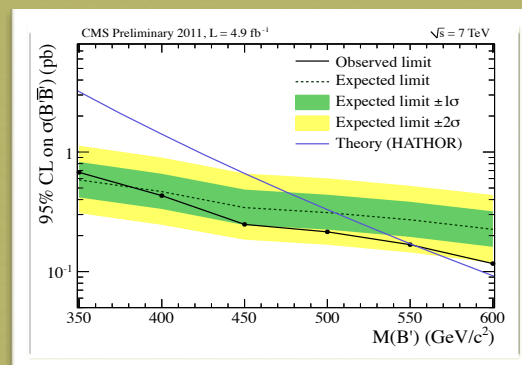


	e^+e^-	$\mu^+\mu^-$
$B'B'$ (350 GeV)	222	345
Z +jets	557 ± 15	847 ± 25
tt +jets	80 ± 4	137 ± 7
WZ	3.6 ± 0.3	6.1 ± 0.5
ZZ	5.9 ± 0.2	9.2 ± 0.3
Total	648 ± 15	999 ± 26
Data	604	928



LIMIT DETERMINATION

- ❖ An upper limit on the $pp \rightarrow B'B'$ production cross section is calculated for various masses of the B' quark.
- ❖ The modified-frequentist (CL_s) approach is used to place the upper limit on the cross section. The cross section limit drops below the theoretical predictions which are given by HATHOR calculator, are excluded at 95% C.L.



For 100% $B' \rightarrow bZ$ decays,
 $M(B') > 550 \text{ GeV}$ at 95% C.L.

