

New Fermions and New Vectors Searches with the CMS Experiment



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on behalf of the
CMS Collaborations

**Implications of LHC results for TeV-scale physics
WG3 meeting, 8-9 Dec 2011, CERN, Geneva**



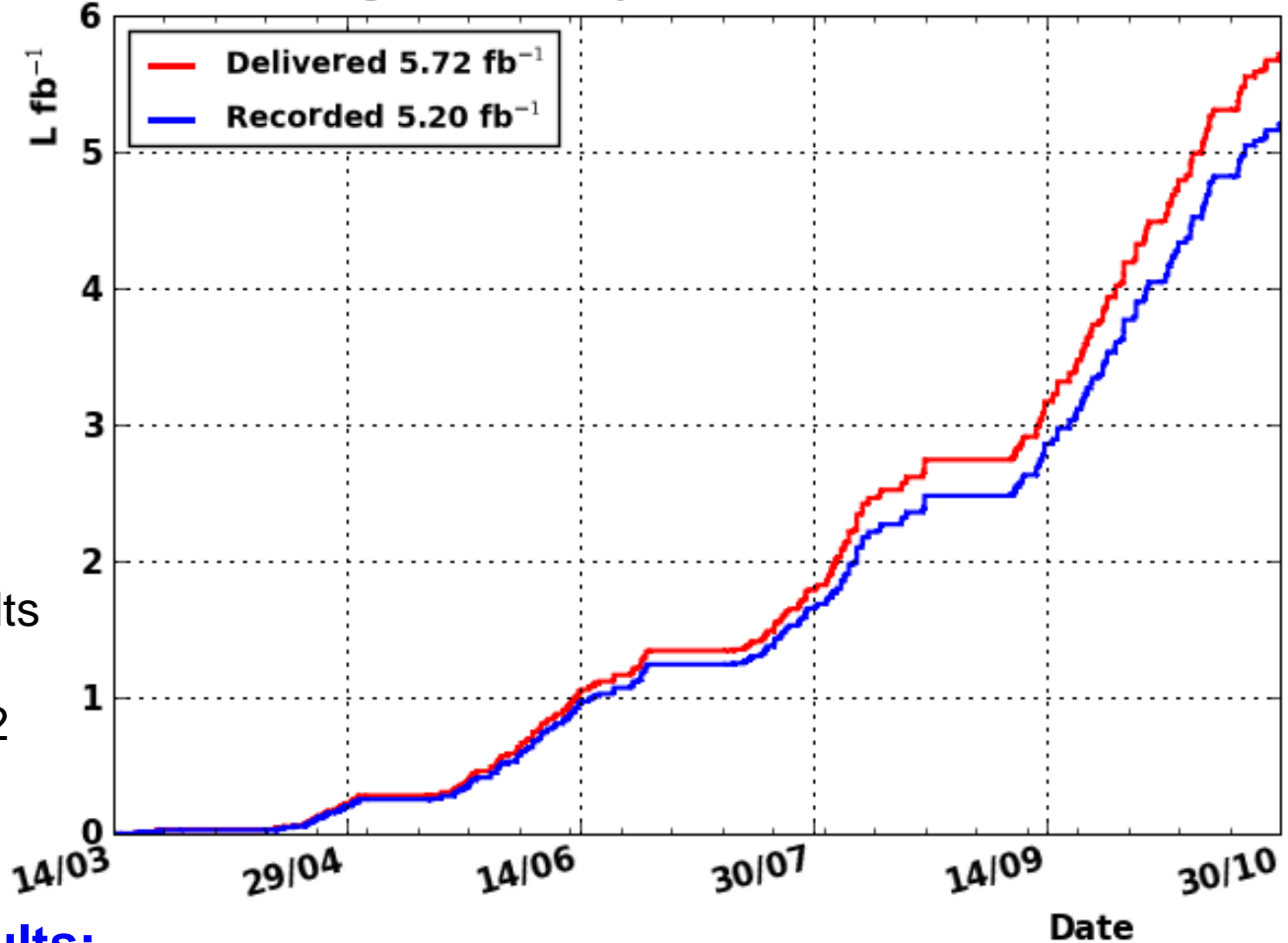
Overview – the 2011 data

CMS Integrated Luminosity Recorded in 2011 at $\sqrt{s} = 7$ TeV

Results presented here based on the first 1 to 2 fb^{-1}

Full 2011 luminosity results to be made public by Winter Conferences 2012

<https://twiki.cern.ch/twiki/bin/view/CMSPublic/LumiPublicResults>
CMS Total Integrated Luminosity 2011 (Mar 14 09:00 - Oct 30 16:10 UTC)



[Exotic searches Results:](https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsEXO)

<https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsEXO>

NEW FERMIONS

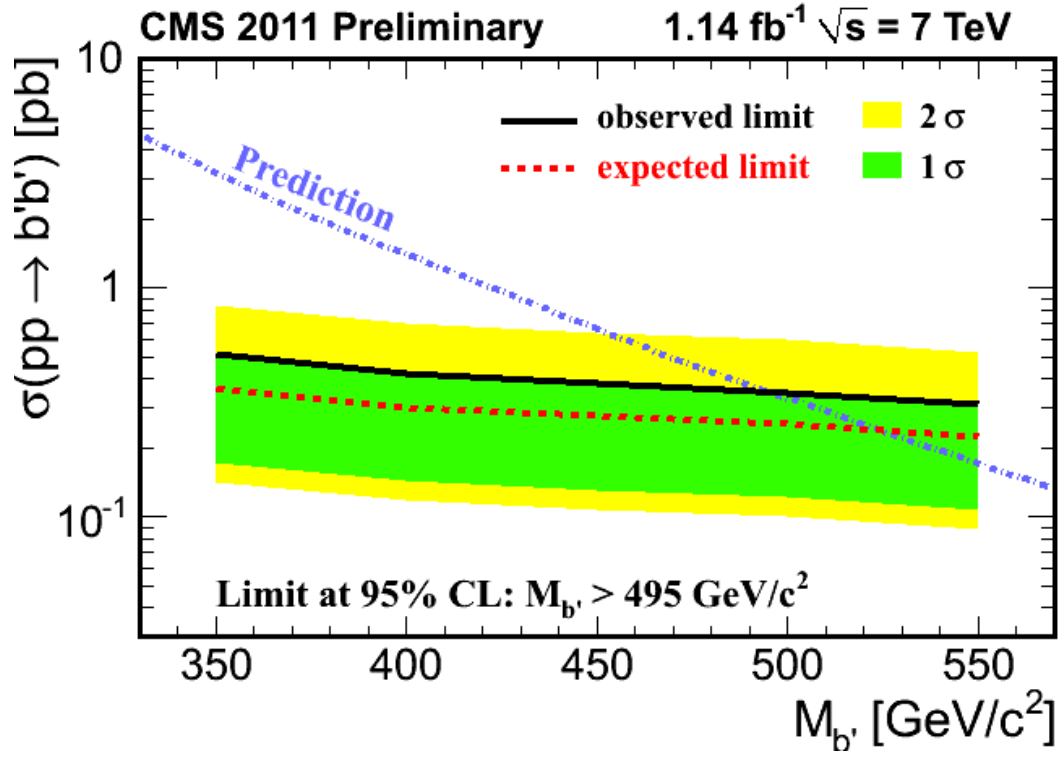
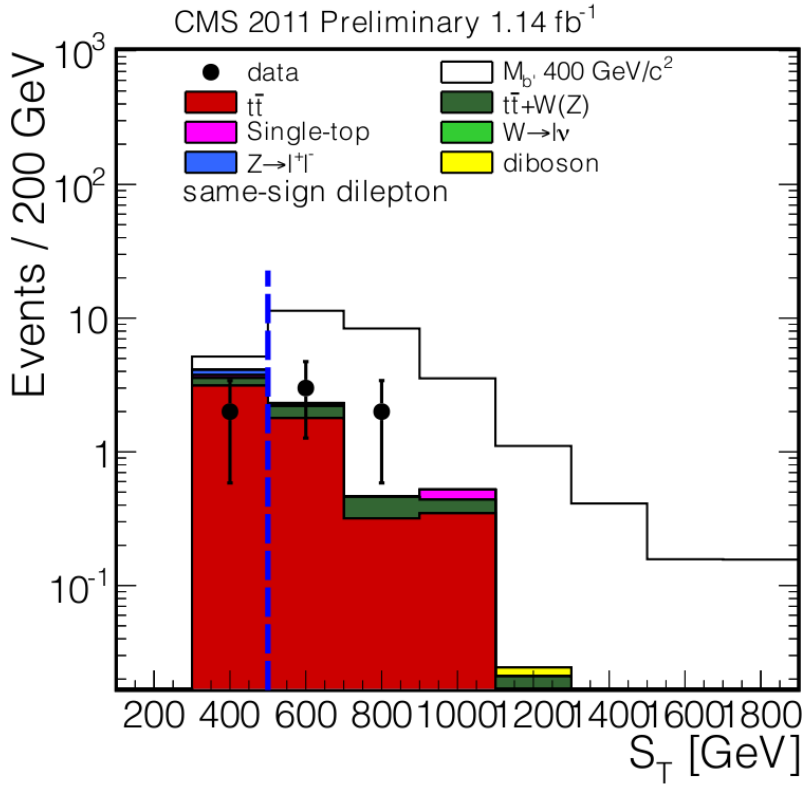


Heavy Bottom-like Quark $b' \rightarrow t + W$

CMS PAS EXO-11-036

Cross-section upper limit translating into **b' mass lower limit $M_{b'} > 495 \text{ GeV}$** for $\text{BR}(b' \rightarrow tW) = 100\%$

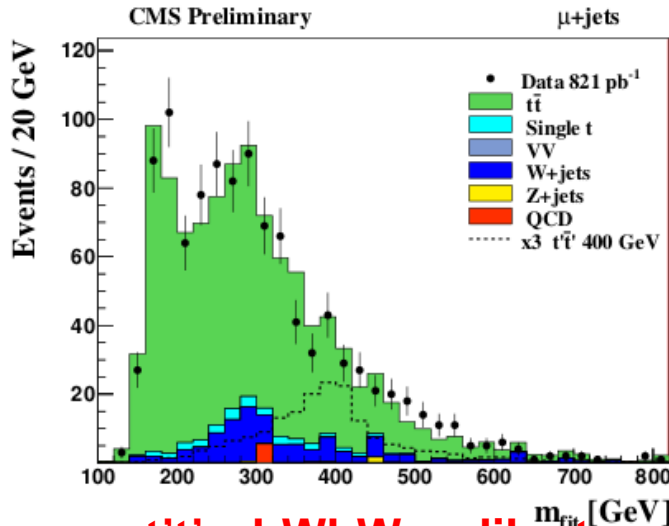
- $b'b'$ pair production
- $\text{BR}(b' \rightarrow tW) = 100\%$
- Decay : $b'b' \rightarrow tWtW \rightarrow \mathbf{bbW+W-W+W-}$
- **Same sign dileptons or trileptons**



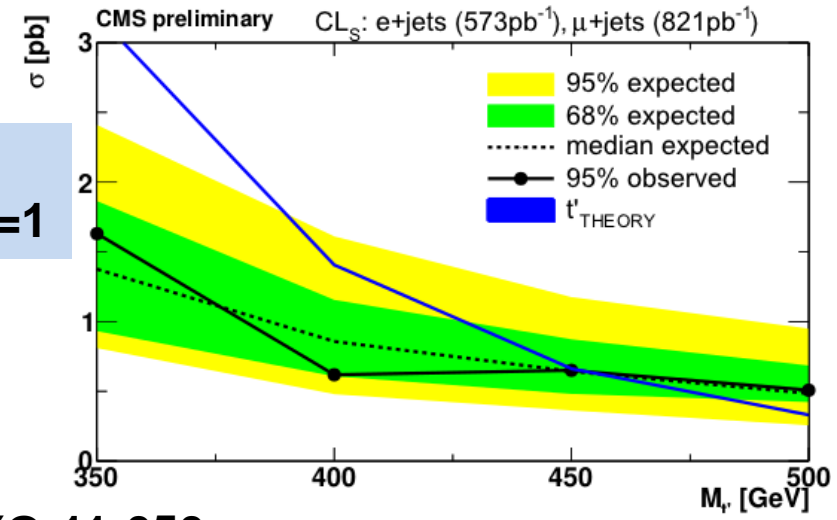


Heavy Top-Like Quark $t' \rightarrow b+W$

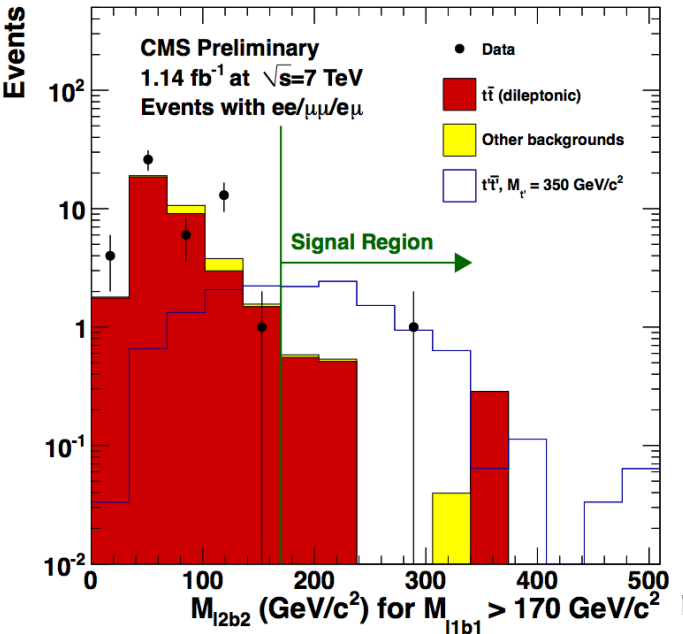
$t't' \rightarrow bWbW \rightarrow \text{lepton+jets}$ CMS PAS EXO-11-051



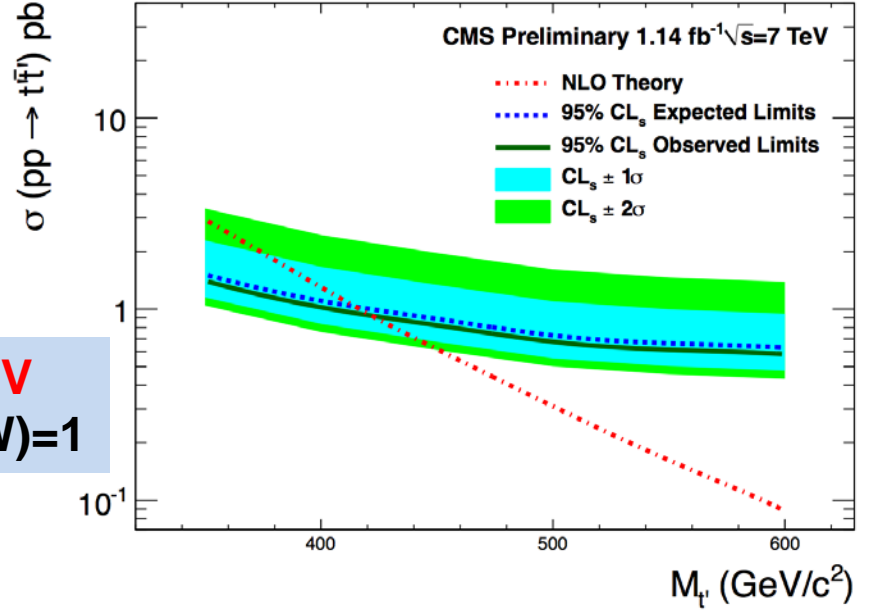
$m(t') > 450 \text{ GeV}$
for $\text{BR}(t' \rightarrow bW)=1$



$t't' \rightarrow bWbW \rightarrow \text{dilepton+jets}$ CMS PAS EXO-11-050



$m(t') > 422 \text{ GeV}$
for $\text{BR}(t' \rightarrow bW)=1$



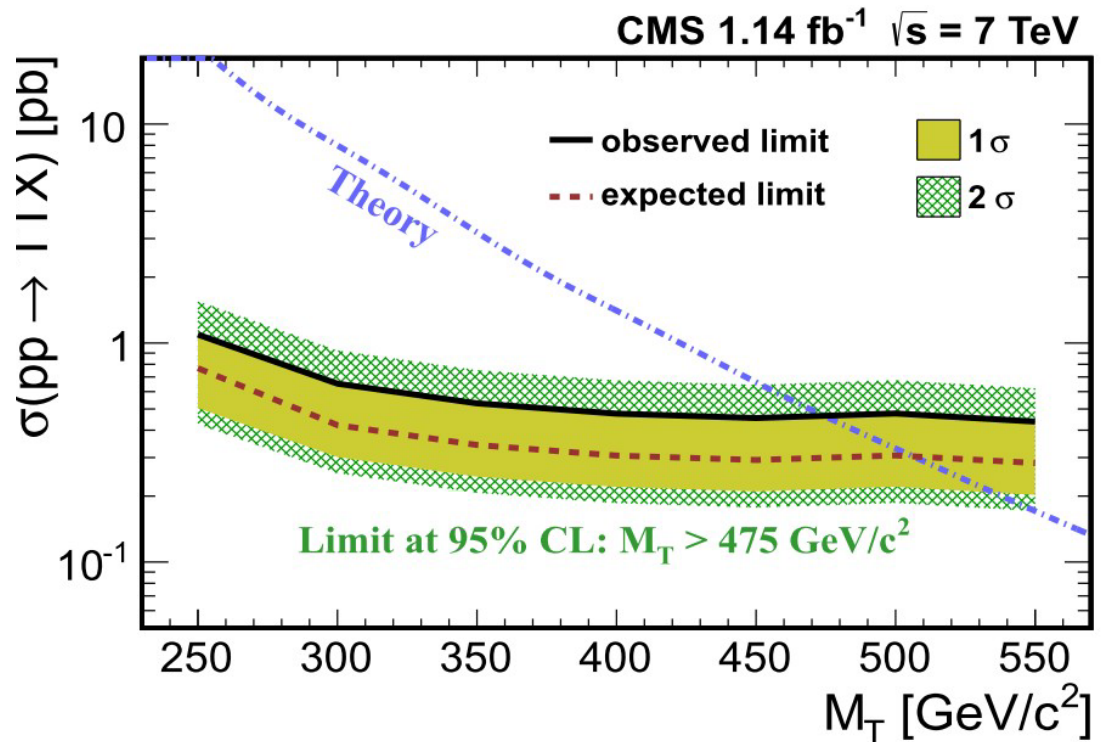
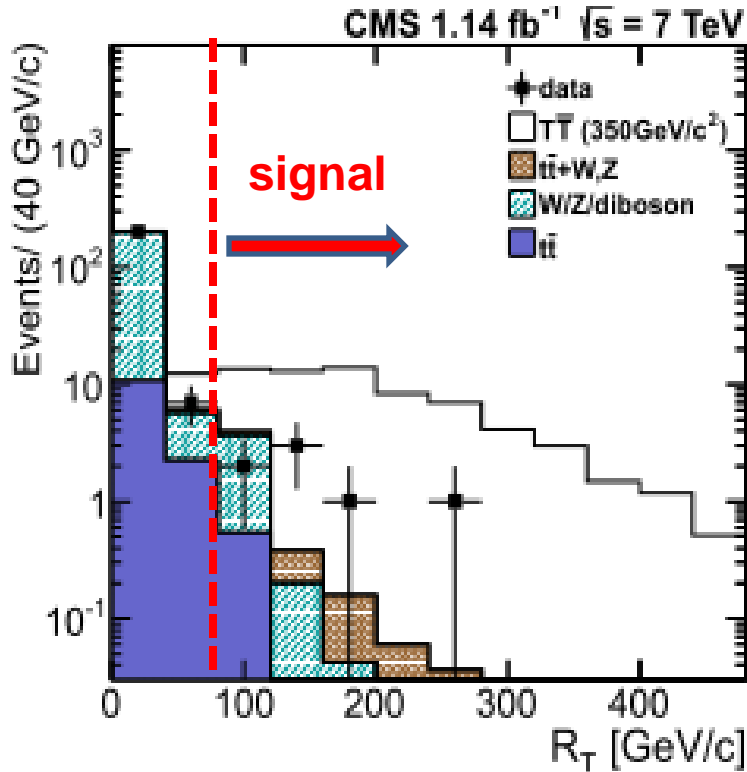


Vector-like Heavy Top $T \rightarrow tZ$

- **Vector-like charge 2/3 heavy top (T)**
- **FCNC tZ decay**
- Decay Chain: $TT \rightarrow tZtZ \rightarrow bbWWZZ$
- **Signature : 3 leptons+jets**

CMS-PAS-EXO-11-005 arXiv:1109.4985v1
Accepted by PRL

Cross-section upper limit translating into
T mass lower limit $M_T > 475$ GeV
for $BR(T \rightarrow tZ) = 100\%$





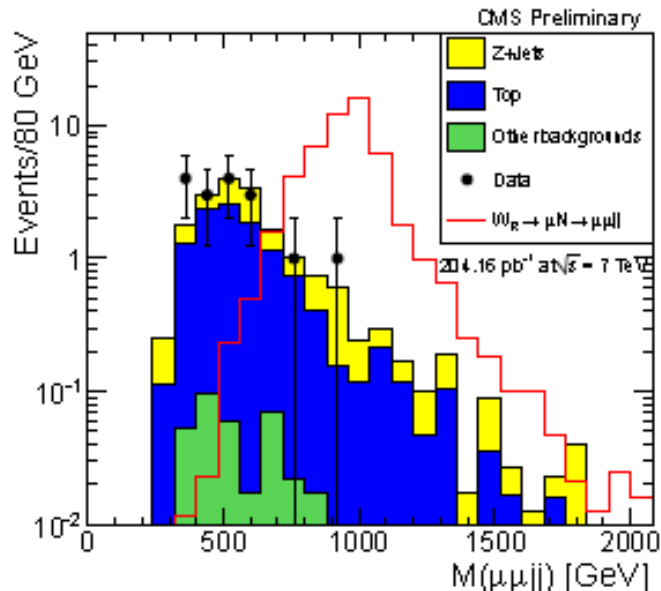
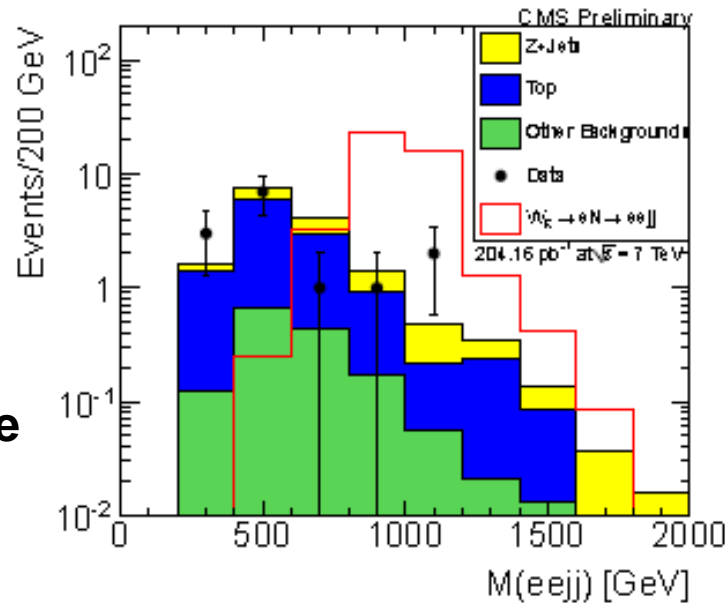
Heavy Neutrino and Right-handed W

$$pp \rightarrow W_R + X \rightarrow N_1 + l + X$$

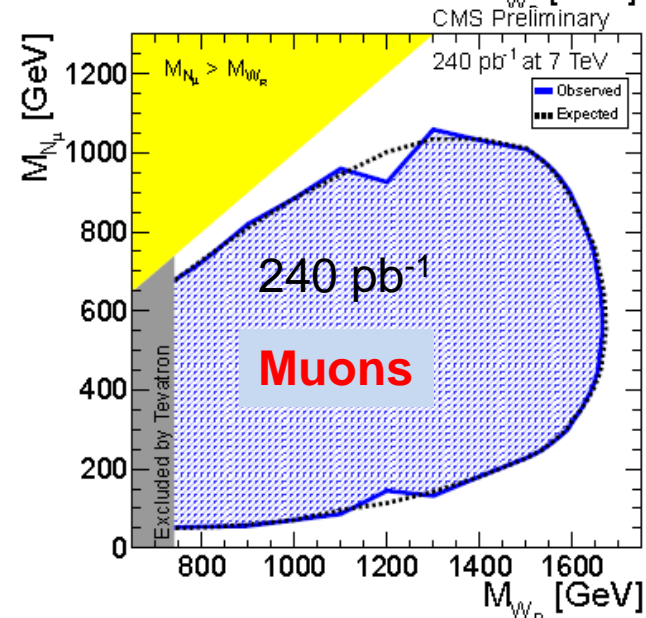
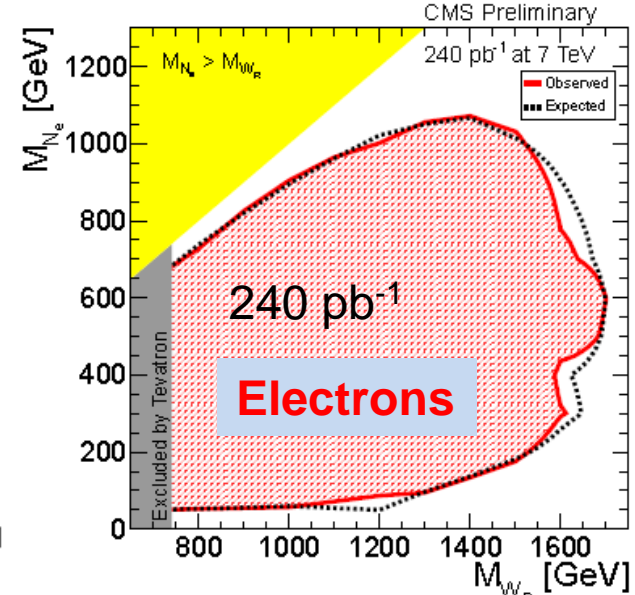
$$W_R \rightarrow N_1 + l \rightarrow lljj$$

Search for resonance $M(lljj)$ and $M(ljj)$ in $lljj$ final states

Mass limits extending to 1.7 TeV for $M(W_R)$ and 1.0 TeV for $M(N_1)$



CMS-PAS-EXO-11-002





Summary: New Fermions (Dec. 2011)

Reference	Title	Int. Lum (pb^{-1})	Result
CMS-PAS-EXO-11-002	Search for a heavy neutrino and right-handed W of the left-right symmetric model in pp collisions at 7 TeV	240	N up to 1000 GeV W' up to 1700 GeV
CMS-PAS-EXO-11-005 arXiv:1109.4985v1	Search for a Heavy Top-like Quark Pairs at CMS in pp Collisions	1140	T up to 475 GeV
CMS-PAS-EXO-11-036	Search for a Heavy Bottom-like Quark in pp Collisions at 7 TeV	1140	b' up to 495 GeV
CMS-PAS-EXO-11-050	Search for a Heavy Top-like Quark in the Dilepton Final State in pp Collisions at 7 TeV	1140	t' up to 422 GeV
CMS-PAS-EXO-11-051	Search for t' pair production in lepton+jets channel	821	t' up to 450 GeV
CMS-PAS-EXO-11-054 (see Ricardo's talk)	Inclusive search for a fourth generation of quarks with the CMS detector	1100	t' , b' 490 GeV

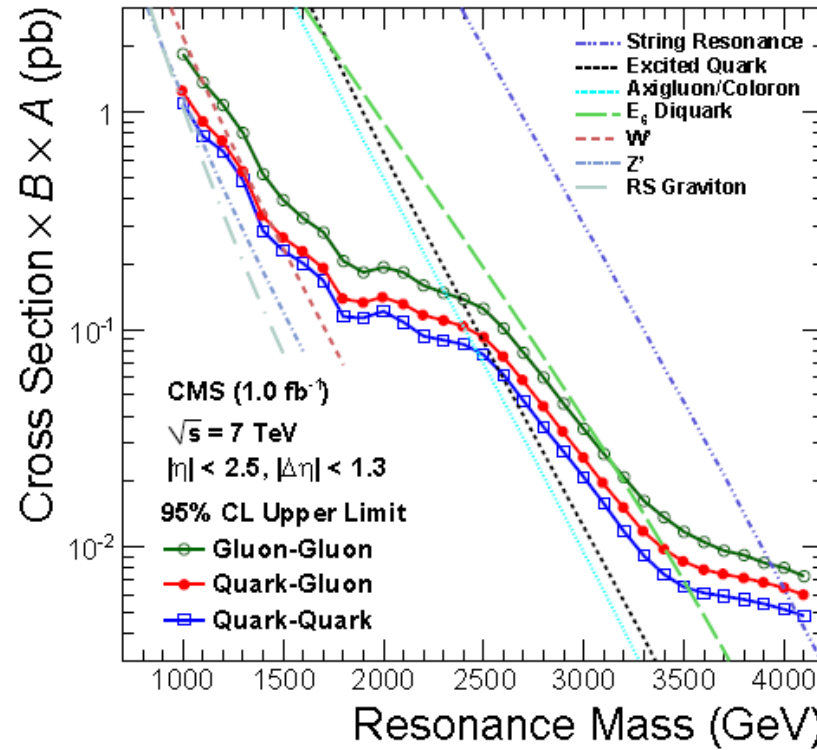
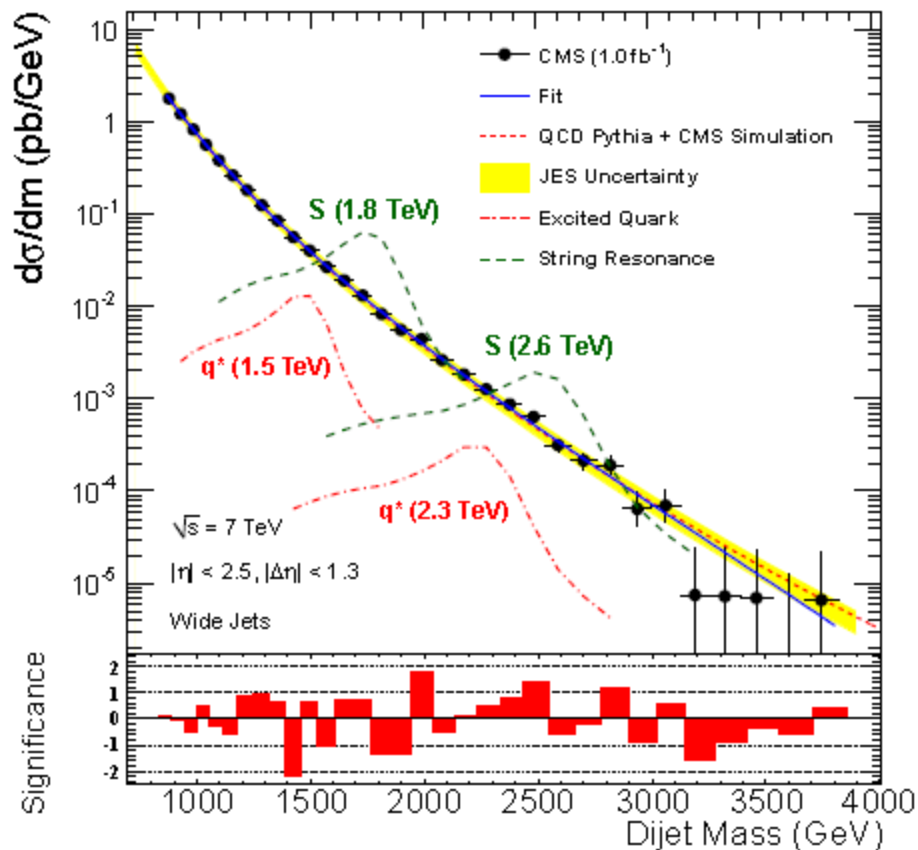
NEW VECTORS



W' to Dijet Resonance

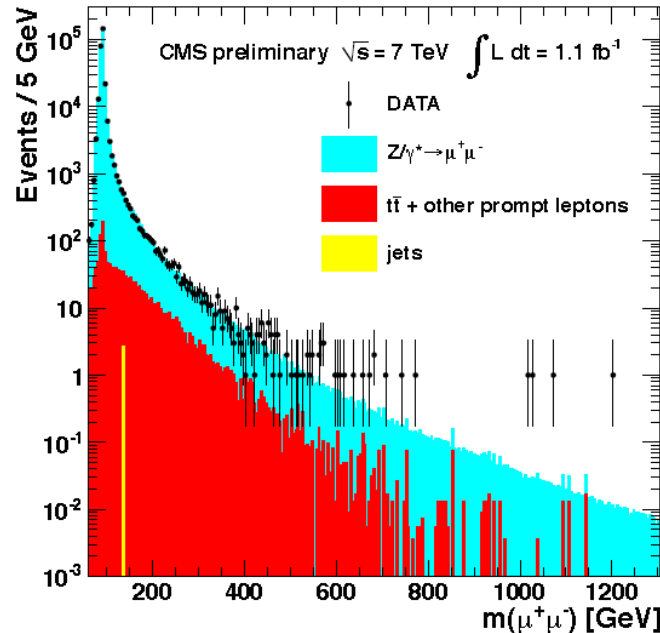
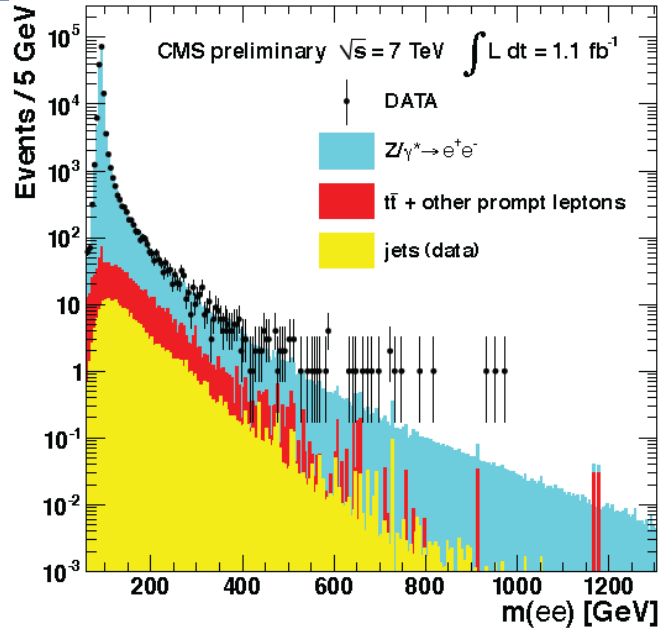
CMS-EXO-11-015 [arXiv:1107.4771v1](https://arxiv.org/abs/1107.4771v1)

Phys.Lett. B704 (2011) 123-142

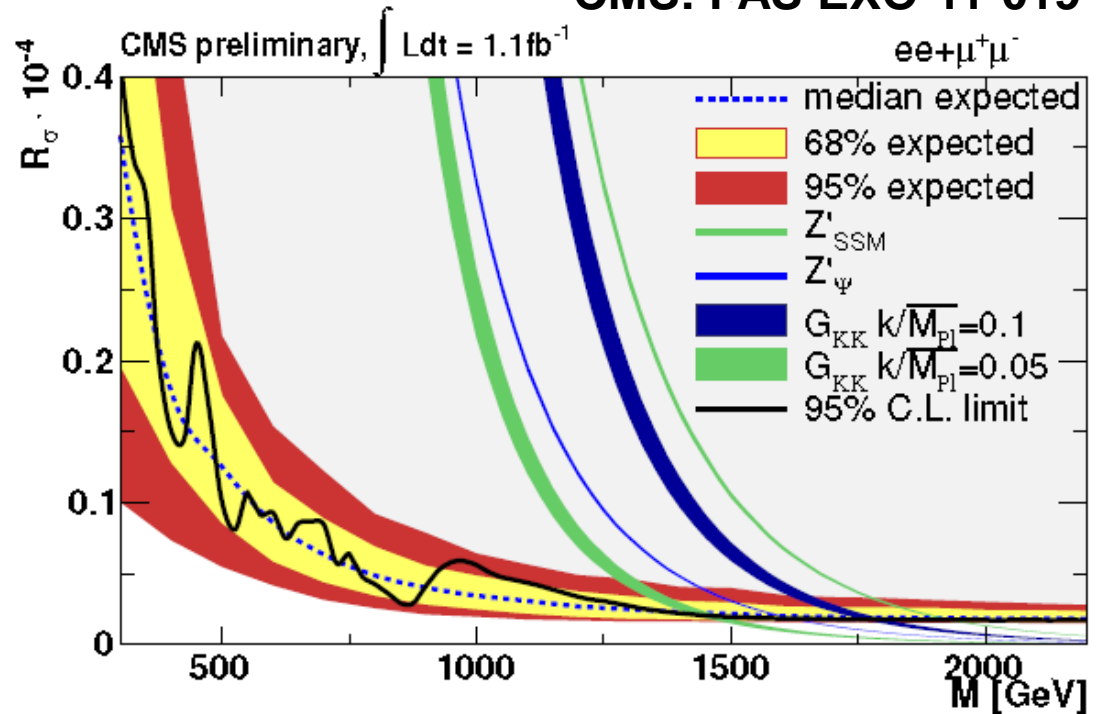


Signal	Mass Limit (TeV)
String resonances	4.0
E6 diquarks	3.52
Excited quarks	2.49
Axigluons and colorons	2.47
Sequential SM W'_{SSM}	1.51

Z' to Dilepton Resonance



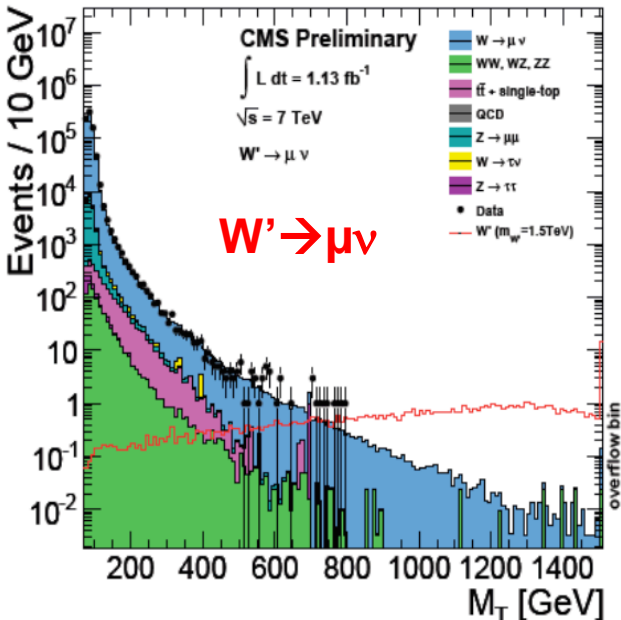
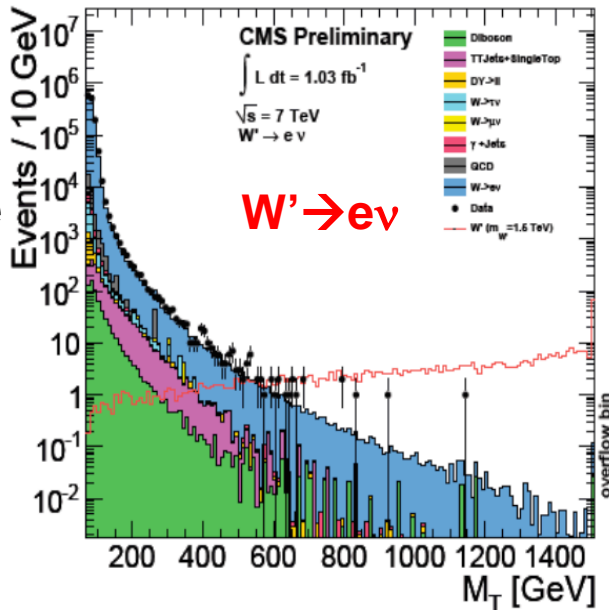
CMS: PAS EXO-11-019



Signal	Mass Limit (TeV)
RS KK Gravitons, $k/M_{\text{pl}} = 0.05-0.1$	1.45 - 1.78
Sequential Standard Model Z'_{SSM}	1.94
Super-String inspired models, Z'_{ψ}	1.62

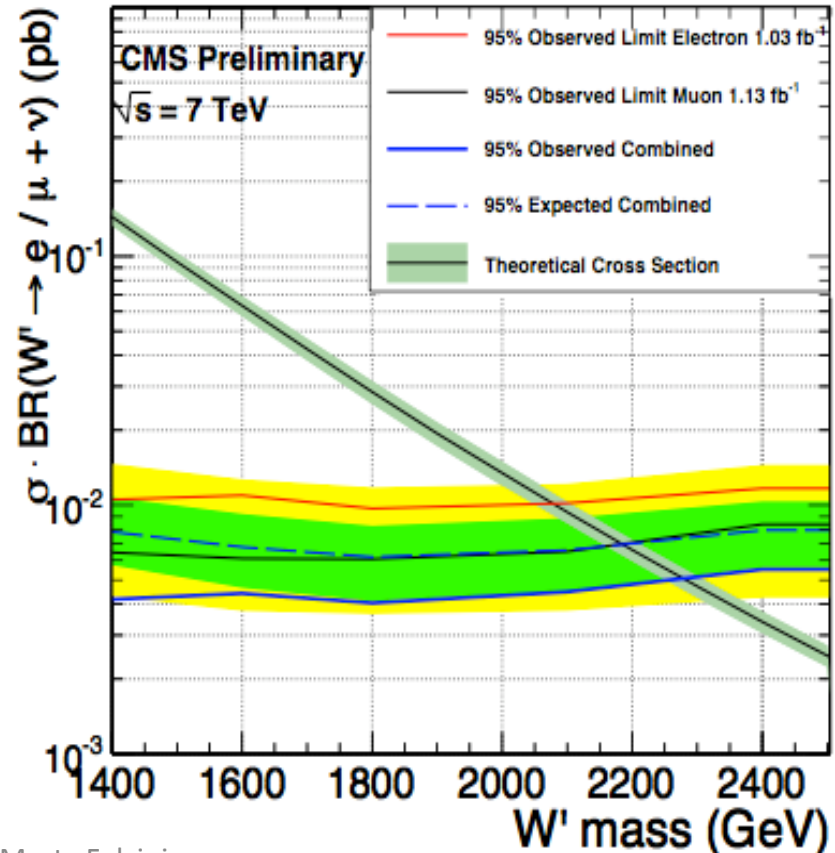
W' to lepton final states

Look for Jacobian peak in transverse mass



CMS: PAS EXO-11-024

Assuming standard-model-like couplings and decay branching fractions exclude a **SSM W' with mass <2.27 TeV (95%CL)**

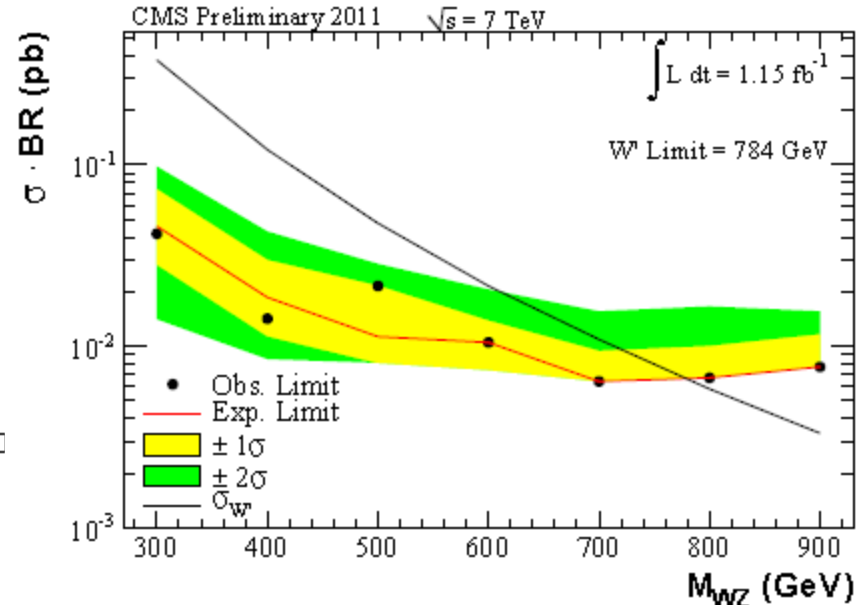
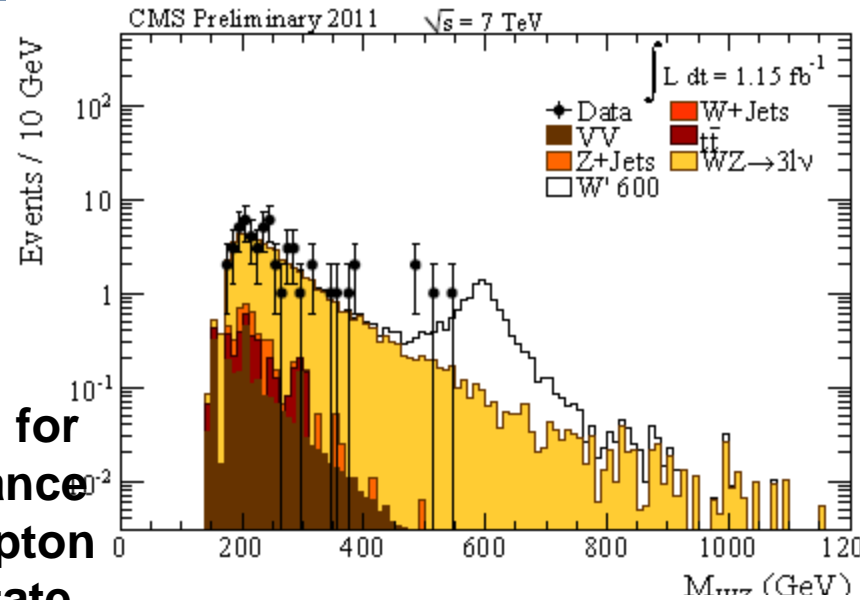




W' to WZ to trilepton final states

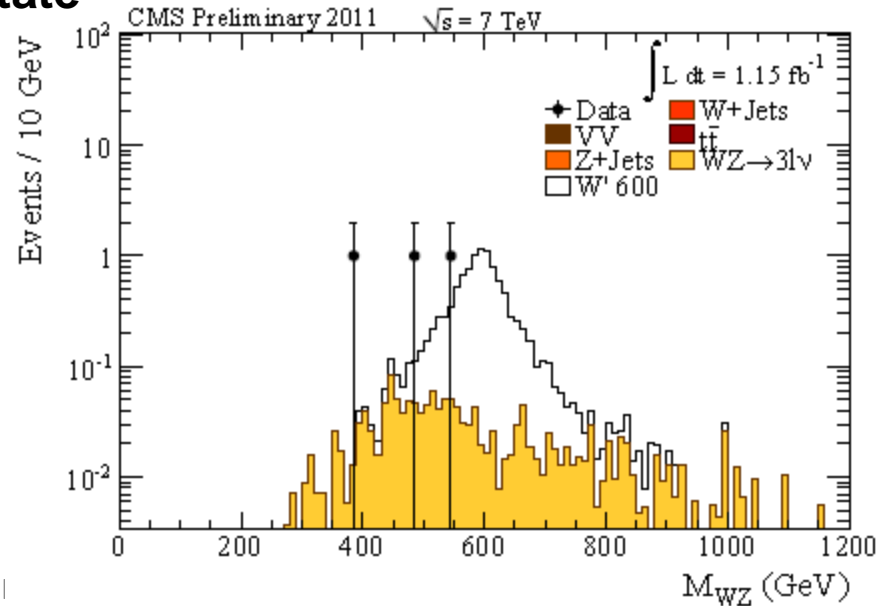
CMS: PAS EXO-11-041

search for resonance in trilepton final state



W' _{SSM} mass > 784 GeV

Also interpreted as limits on technipions masses
 $M(\rho_{TC}) > 436 \text{ GeV}$ for
 $M(\rho_{TC}) < M(\pi_{TC}) + M(W)$



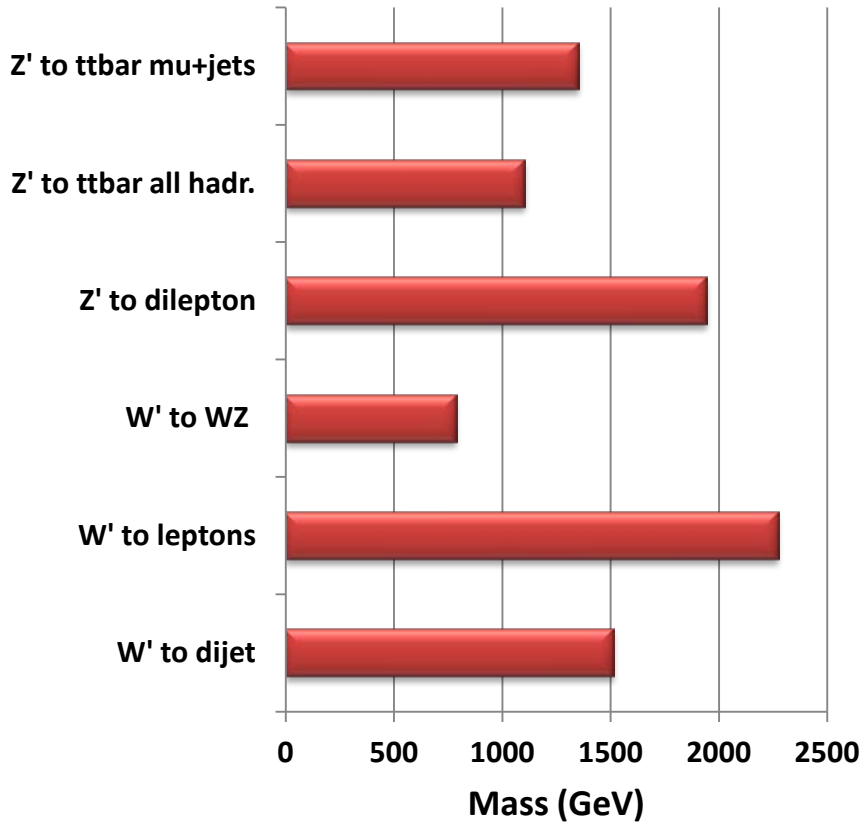


Summary: New Vectors (Dec. 2011)

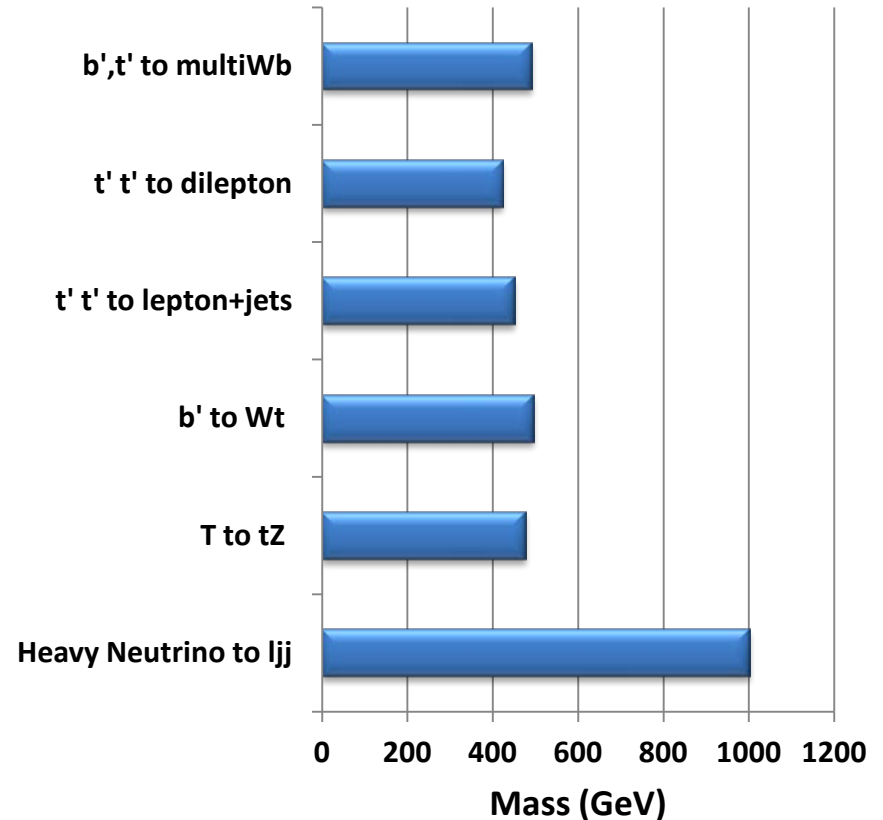
Reference	Title	Int. Lum (pb ⁻¹)	Result
CMS-PAS-EXO-11-006 (see Ricardo's talk)	Search for BSM ttbar Production in the Boosted All-Hadronic Final State	886	Z' 1100 GeV
CMS-PAS-EXO-11-015 arXiv:1107.4771 [hep-ex] Phys.Lett. B704 (2011) 123	Search for Resonances in the Dijet Mass Spectrum from 7 TeV pp Collisions at CMS	1000	W' 1510 GeV
CMS-PAS-EXO-11-019	Search for Resonances in the Dilepton Mass Distribution in pp Collisions at $\sqrt{s}=7$ TeV	1140	Z' 1940 GeV
CMS-PAS-EXO-11-024	Search for W' in the leptonic channels in pp Collisions at 7 TeV	1100	W' 2270 GeV
CMS-PAS-EXO-11-041	Search for W' (or techni-rho) to WZ	1150	W' 784 GeV
CMS-PAS-EXO-11-055 (see Ricardo's talk)	Search for heavy narrow resonances decaying to ttbar in the muon+jets channel	1140	Z' 1350 GeV

Implications

New Vectors Mass Limits (*)



New Fermions Mass Limits (*)



(*) Mass limits depend on decay branching fractions

If no discovery with up to 2012 data, simpler models to be excluded



Outlook

- ❑ All results being updated with full 2011 luminosity ($\sim 5 \text{ fb}^{-1}$)
- ❑ More signals/final states being searched for
- ❑ Updated 2011 results made public by Winter Conferences 2012
- ❑ With 2012 data mass reach extended by higher \sqrt{s} energy (8 TeV?) and additional luminosity (+ 10 fb^{-1})
- ❑ If no discovery with 2012 data, simpler models to be excluded
- ❑ Extended discovery reach with higher com energy in 2014+
- ❑ **There is still a lot to explore... and discover...**