



Non-SUSY searches at CMS

Piotr Zalewski

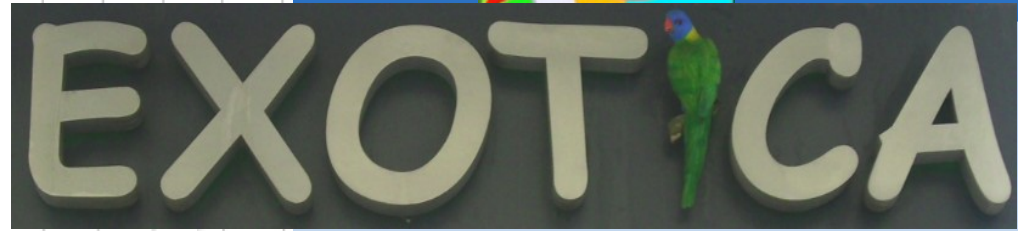
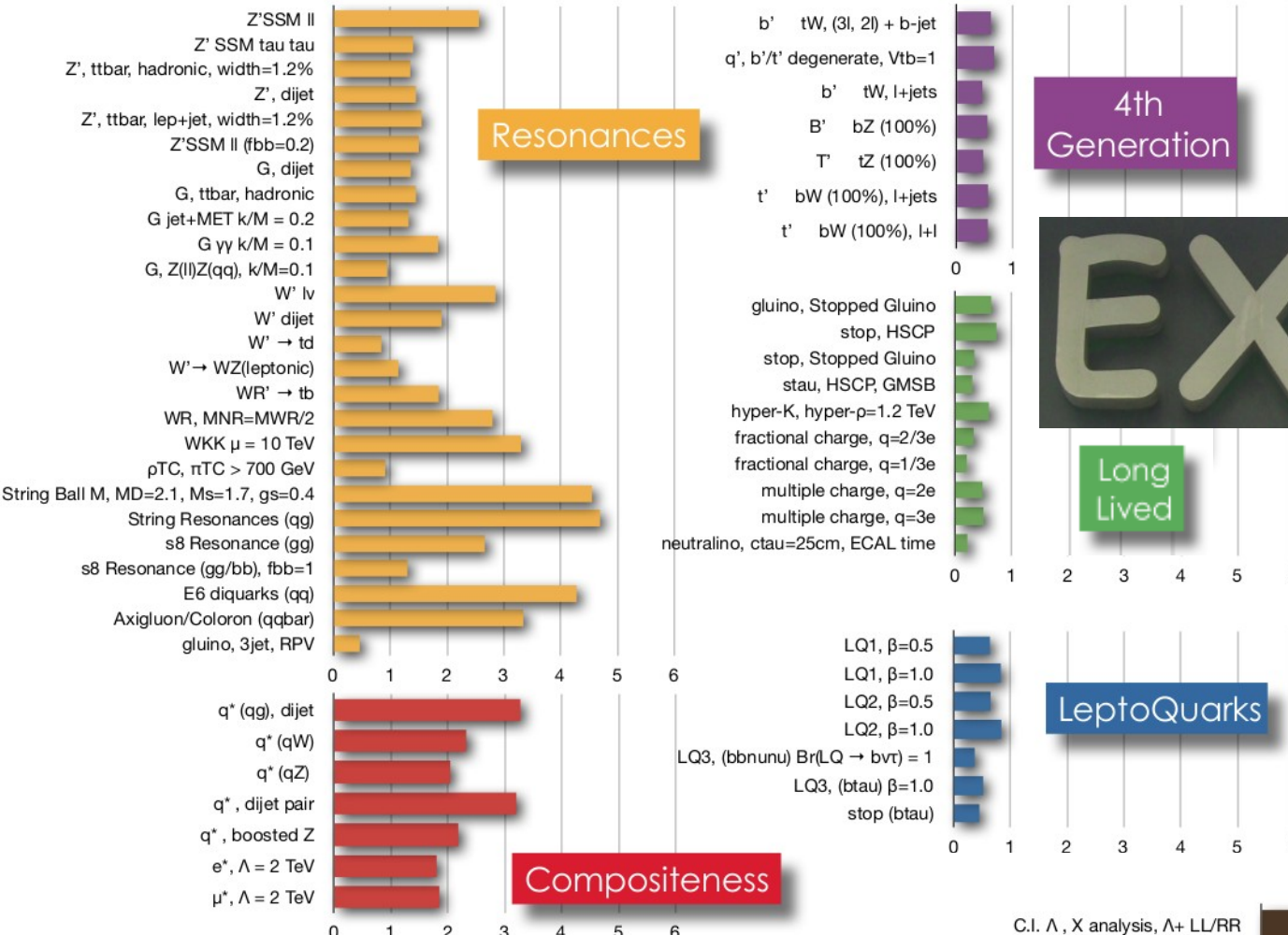
on behalf of the CMS Collaboration

National Centre for Nuclear Research
Warsaw, Poland



VIIIth Rencontres du Vietnam
Quy Nhon 17/12/2012



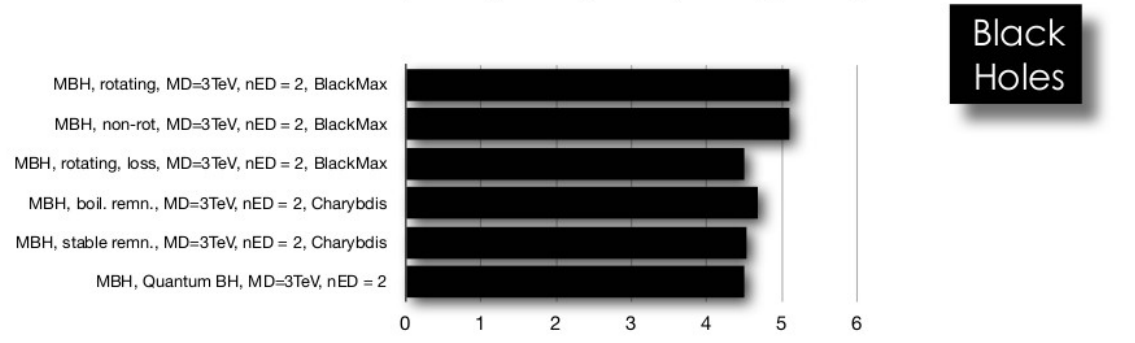
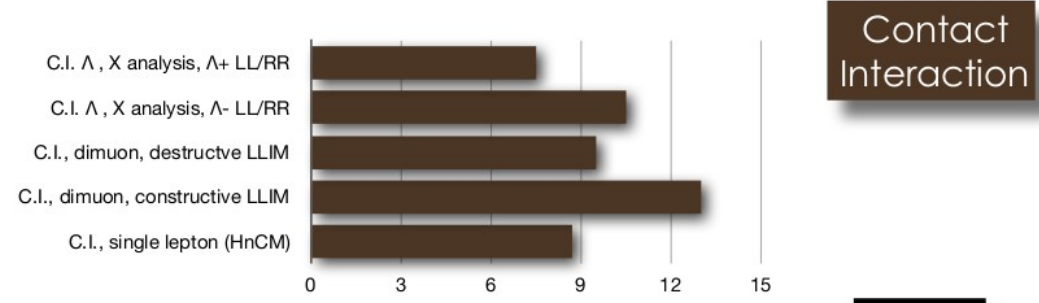


Results summary Summer 2012

based mainly
on 7 TeV data

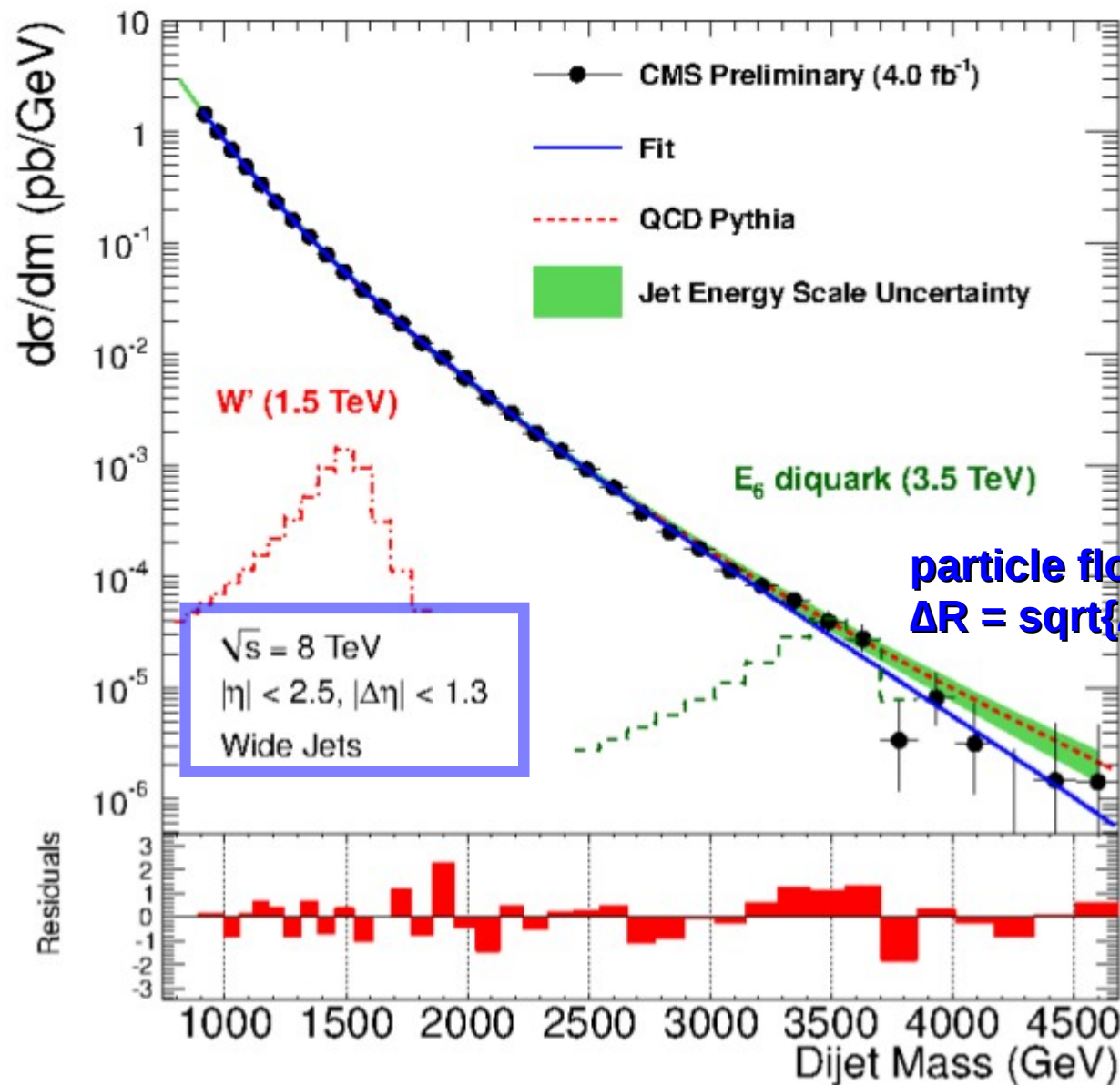
Almost only partial
& preliminary 8 TeV results
will be presented

Much more will be
ready for Moriond



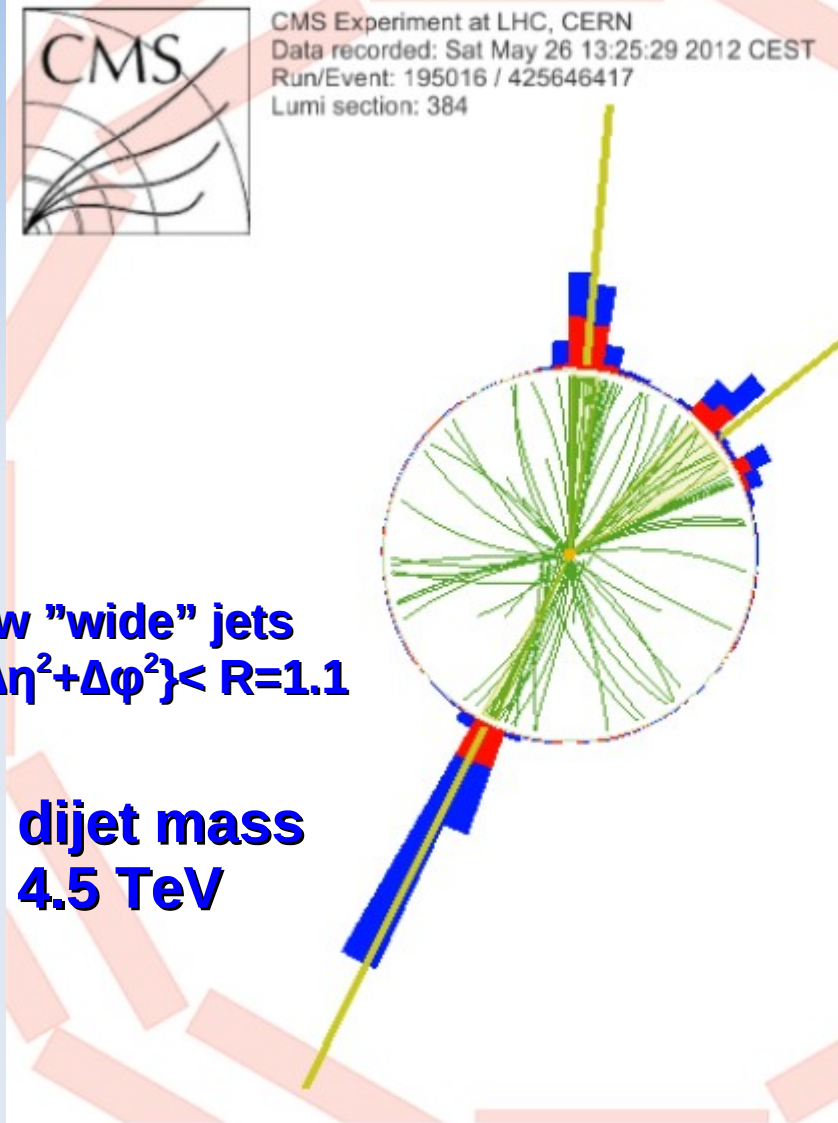


Search for Narrow Resonances using the Dijet Mass Spectrum in pp Collisions at $\sqrt{s} = 8$ TeV **CMS PAS EXO-12-016**

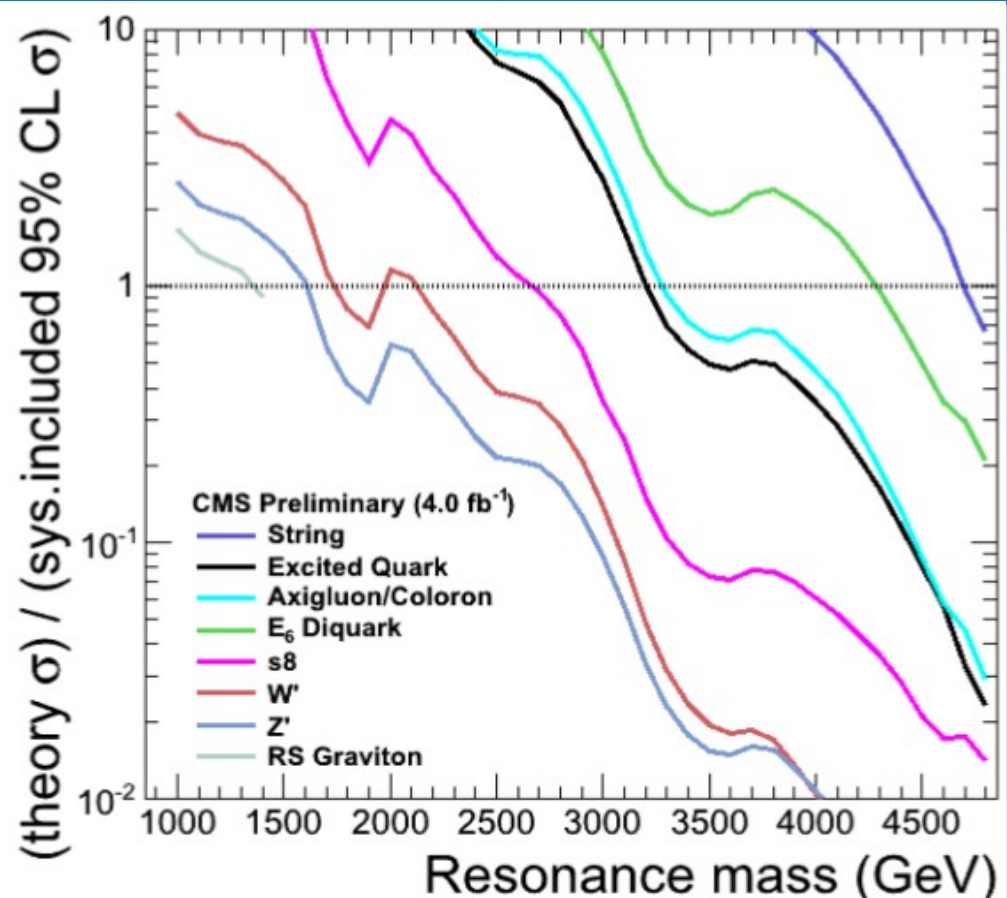
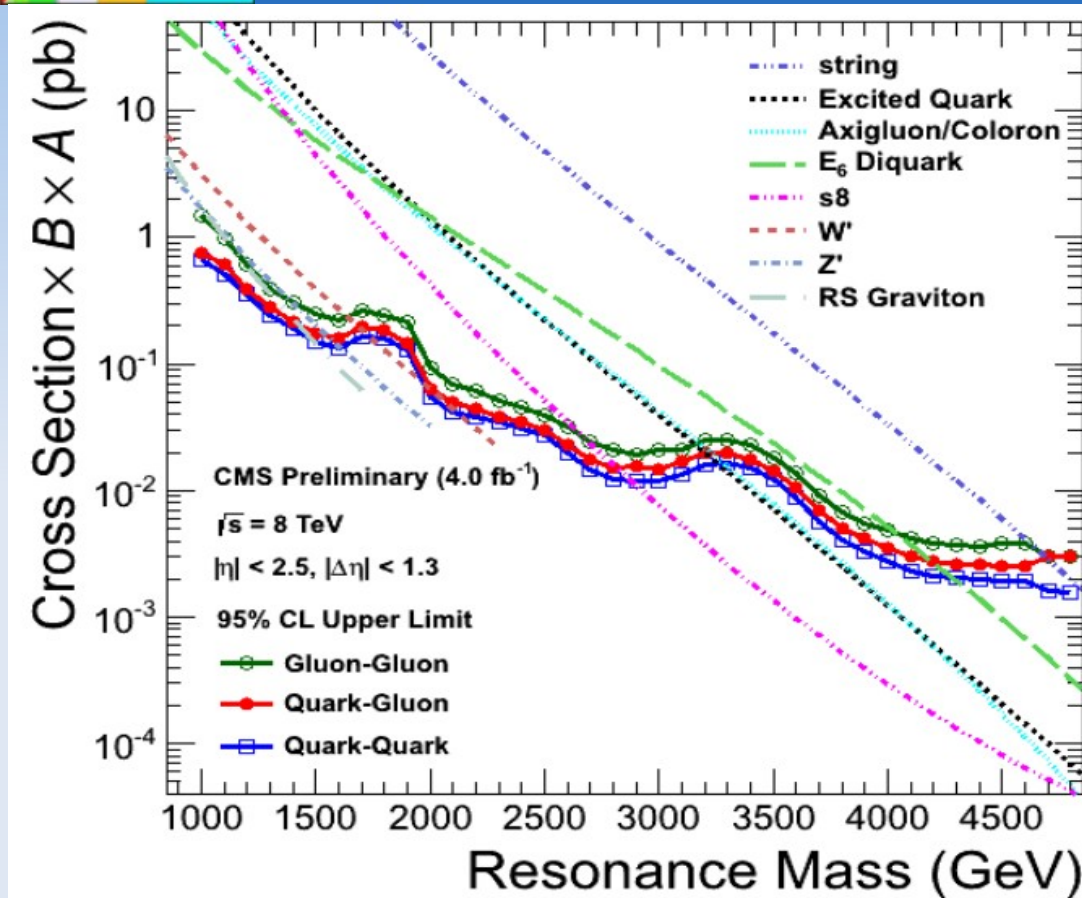


particle flow "wide" jets
 $\Delta R = \sqrt{\Delta\eta^2 + \Delta\phi^2} < R=1.1$

dijet mass
 4.5 TeV



**Trigger: $H_T > 650 \text{ GeV}$.or.
 dijet mass $> 750 \text{ GeV}$ & $|\Delta\eta_{jj}| < 1.5$**



Generic upper limits on the product $\sigma \times B \times A$

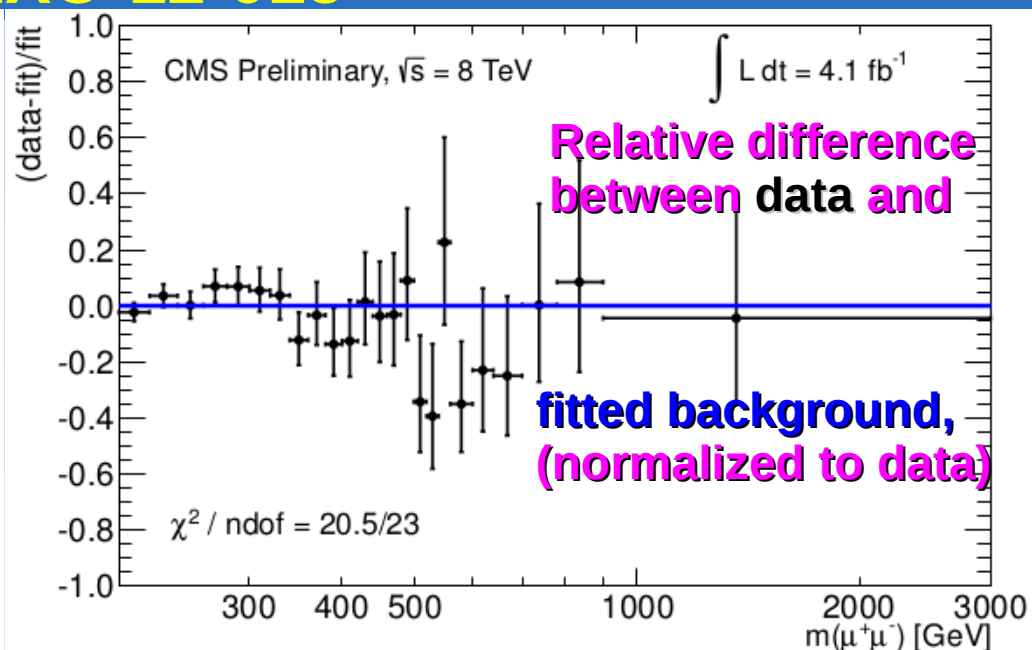
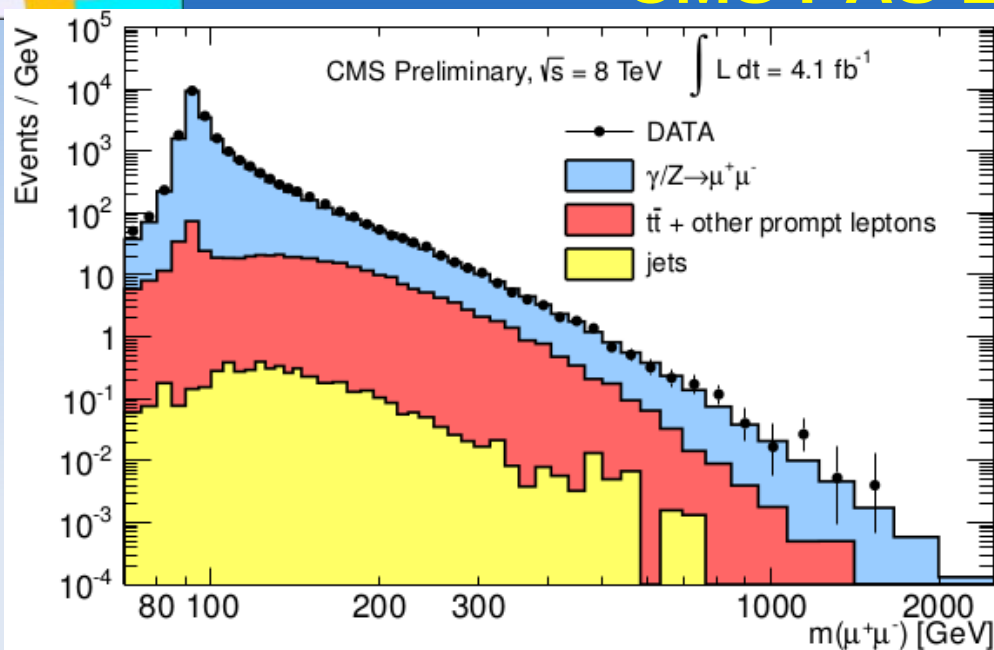
It can be applied to any model of dijet resonance production.

Specific lower limits on the mass of string resonances, excited quarks, axigluons, colorons, s8 resonances, E6 diquarks, W' and Z' bosons, and RS gravitons

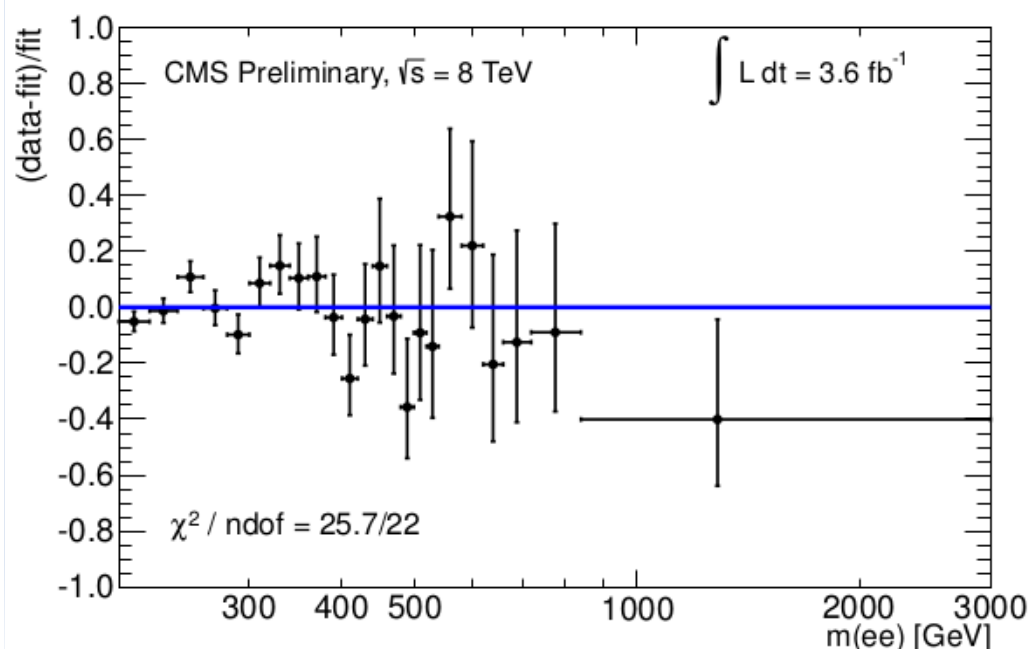
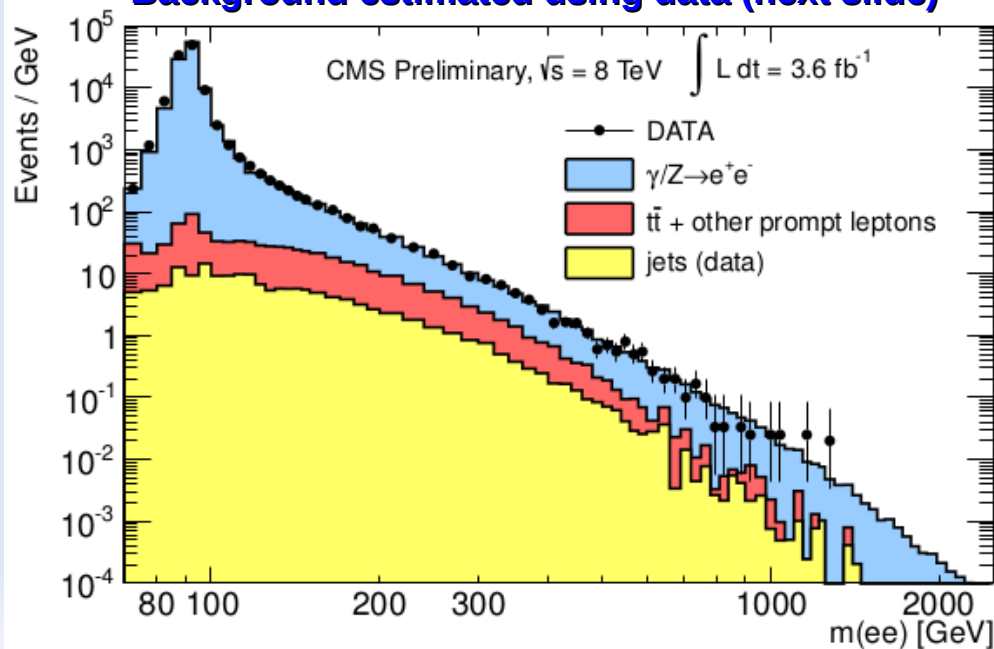
Many extend previous exclusions from the dijet mass search technique

Search for Resonances in Dilepton Mass Spectra in pp Collisions at $\sqrt{s}=8\text{TeV}$

CMS PAS EXO-12-015

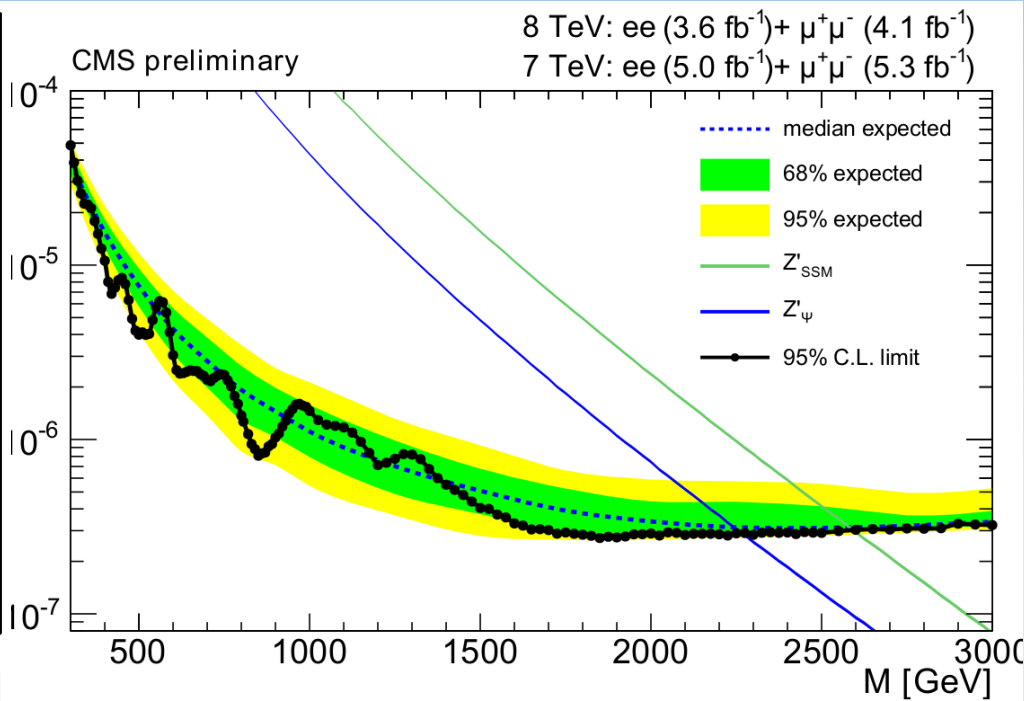
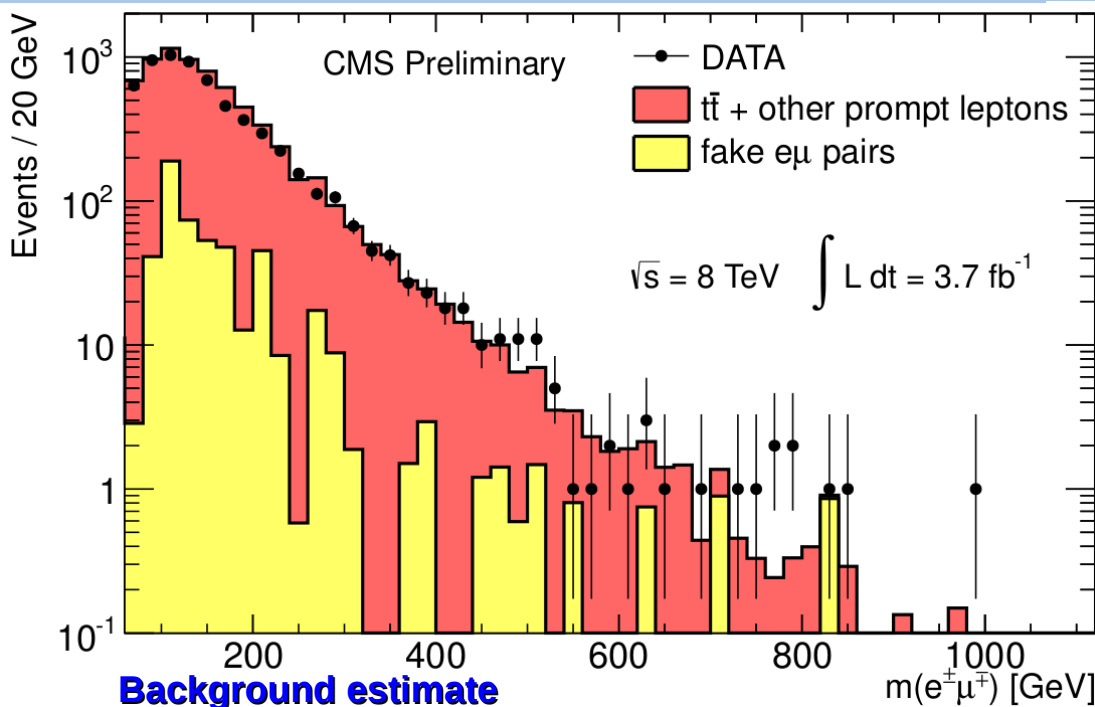


Background estimated using data (next slide)



Search for Resonances in Dilepton Mass Spectra in pp Collisions at $\sqrt{s}=8\text{TeV}$

CMS PAS EXO-12-015

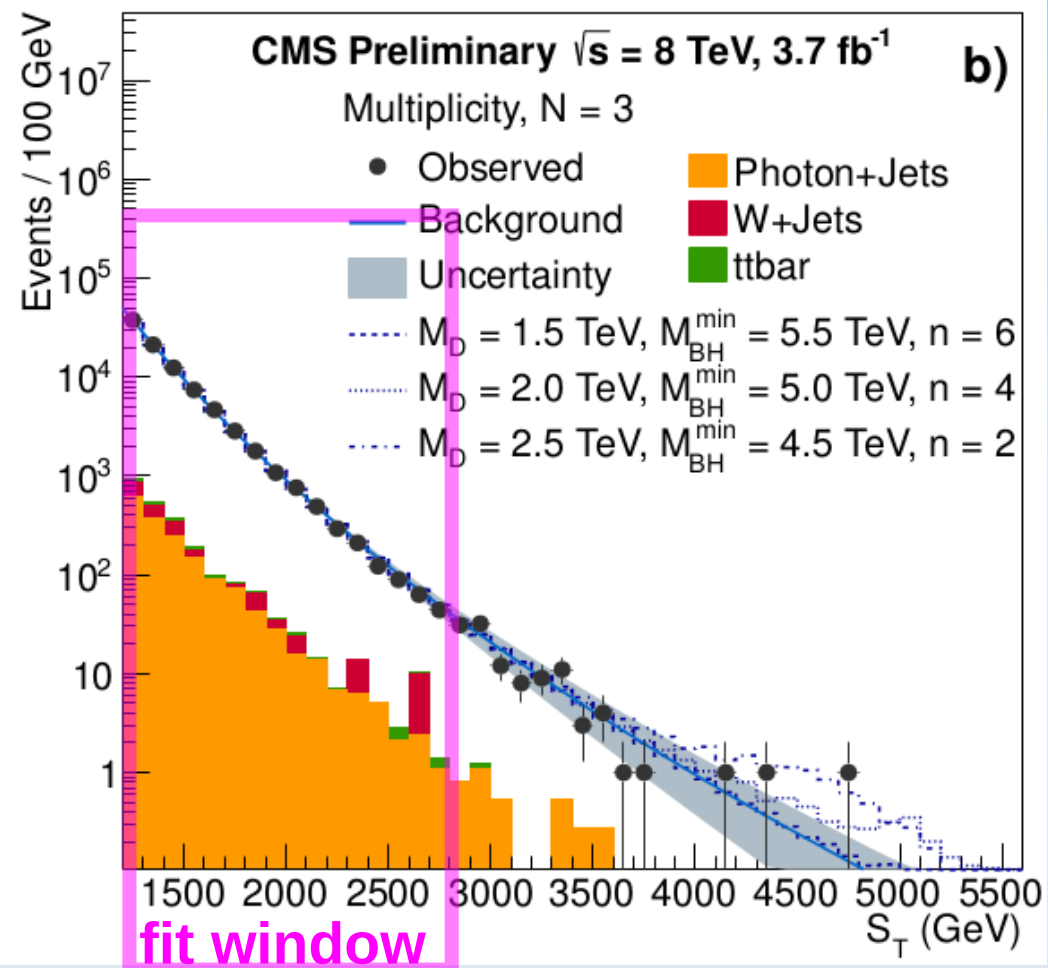
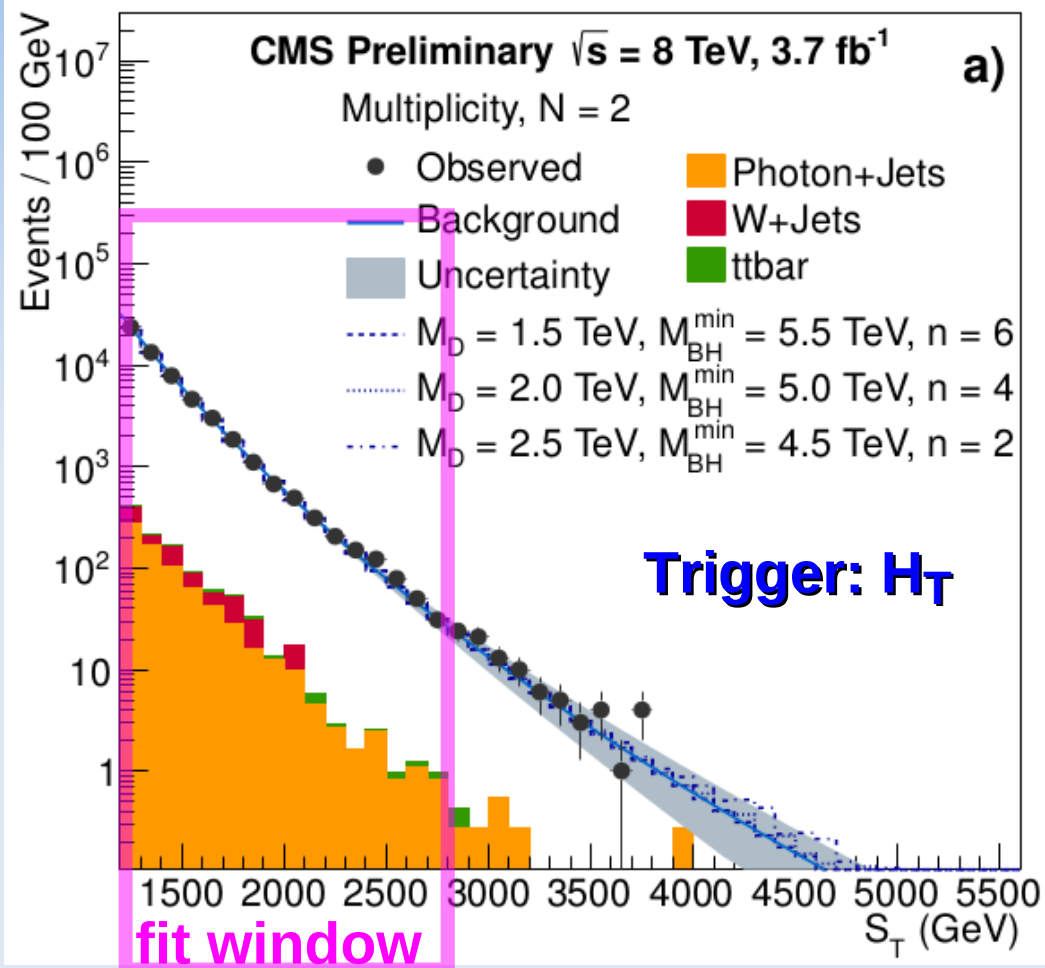


Source	Number of events			
	Dimuon sample		Dielectron sample	
	(120 – 200) GeV	>200 GeV	(120 – 200) GeV	>200 GeV
Data	13831	3503	12030	2904
Total background	13007 ± 589	3627 ± 160	12241 ± 592	2968 ± 258
Z/γ^*	11703 ± 571	2919 ± 139	10657 ± 533	2198 ± 220
$t\bar{t}$ + others	1278 ± 146	698 ± 78	1222 ± 183	557 ± 84
jets	26 ± 3	10 ± 1	362 ± 181	213 ± 106

Upper limits on $\sigma \cdot \text{BR}$ for new boson vs Z prod.

$m(Z') > 2590 \text{ GeV}$;

**superstring-inspired
 $m(Z_\psi) > 2260 \text{ GeV}$**

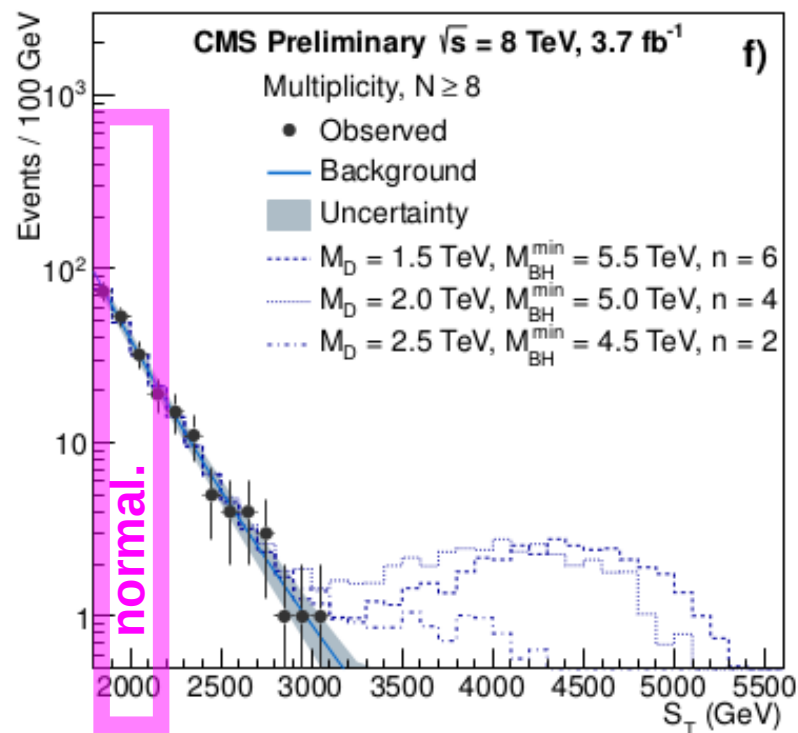
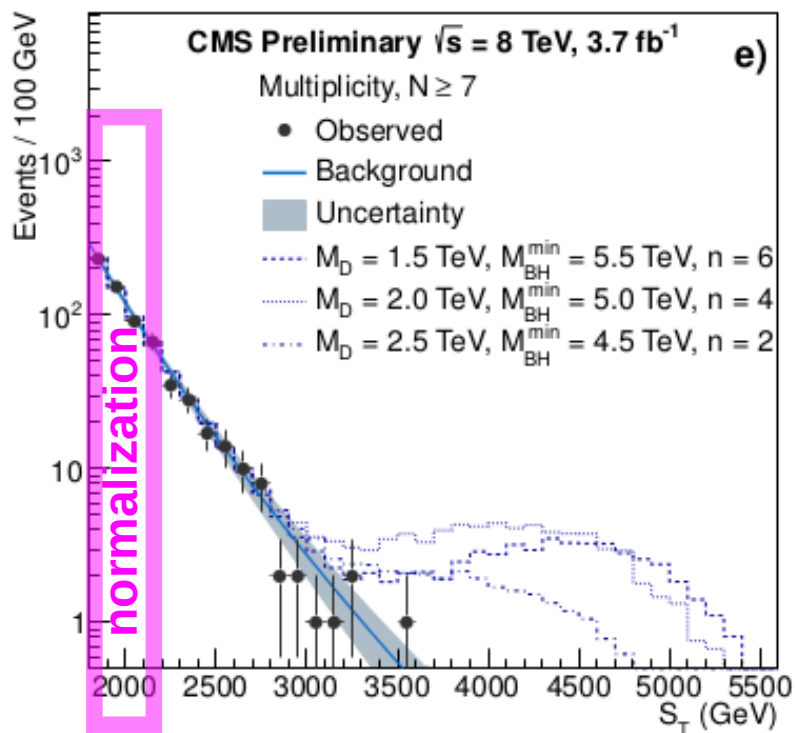
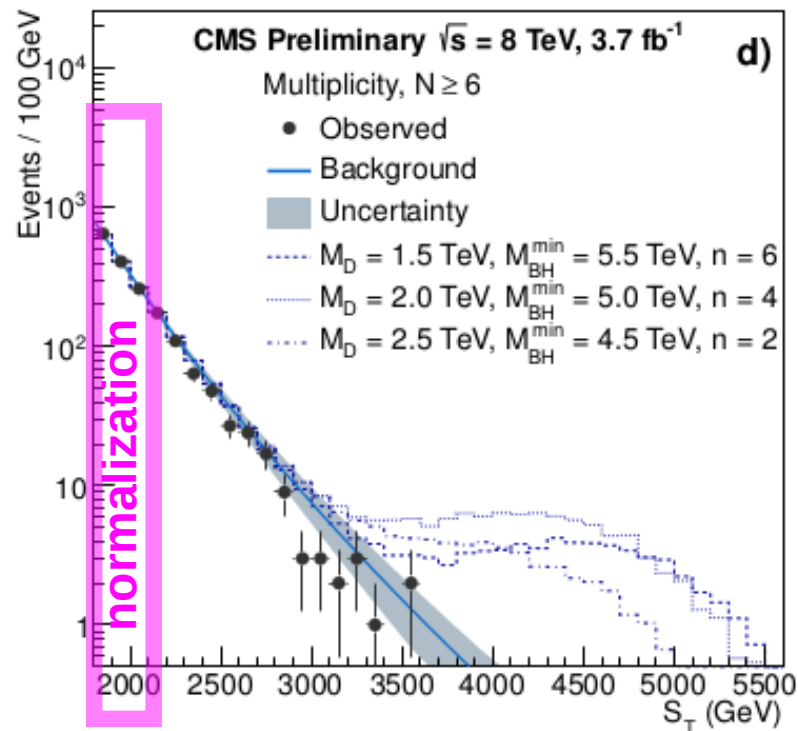
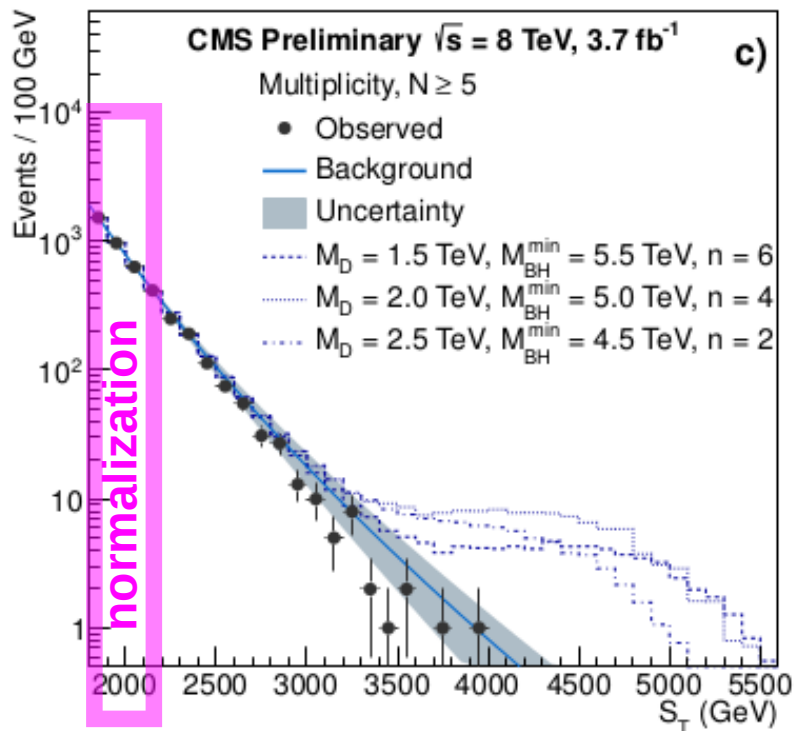


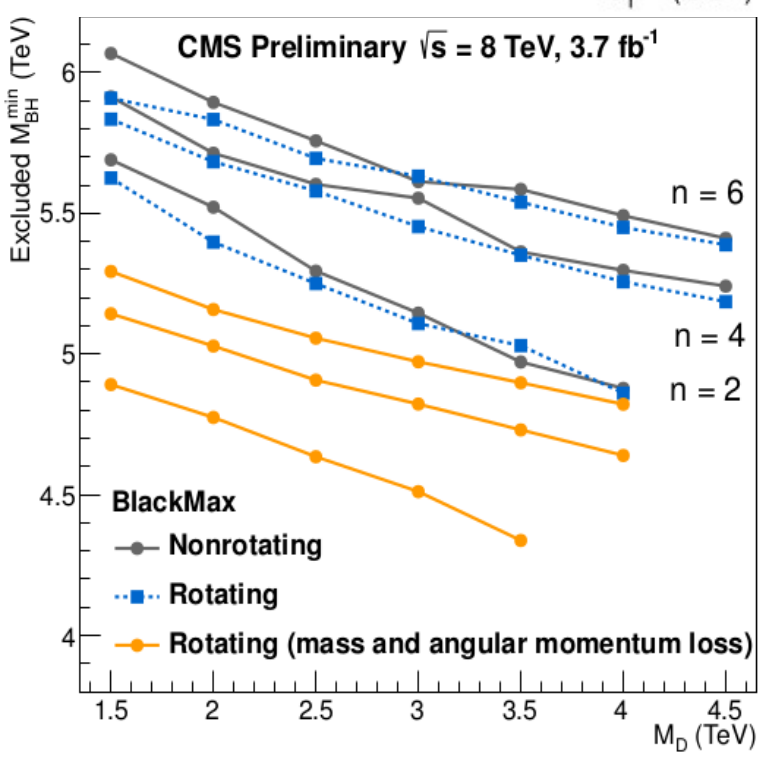
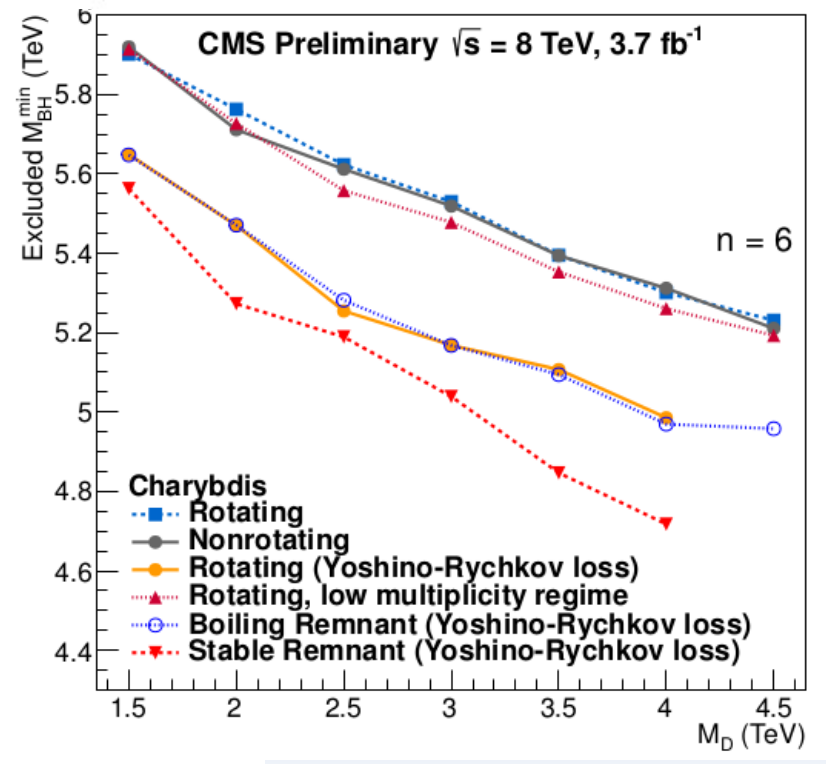
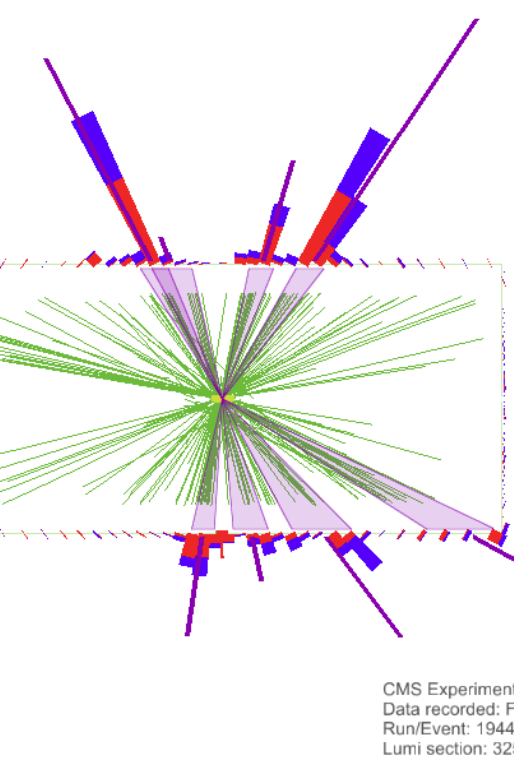
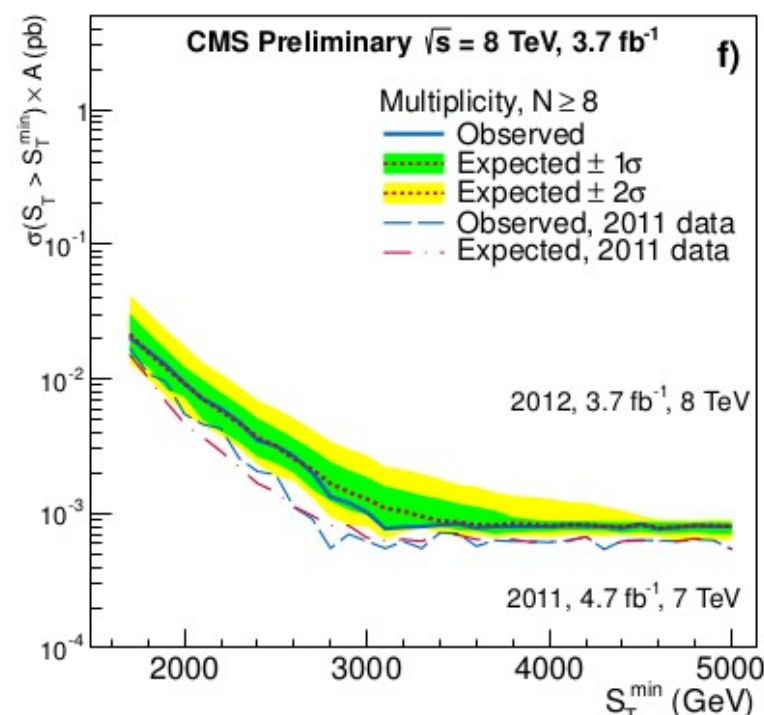
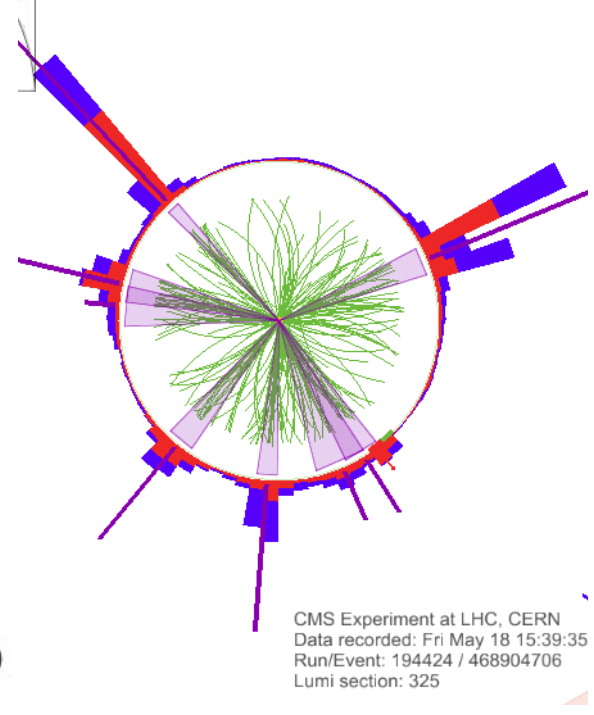
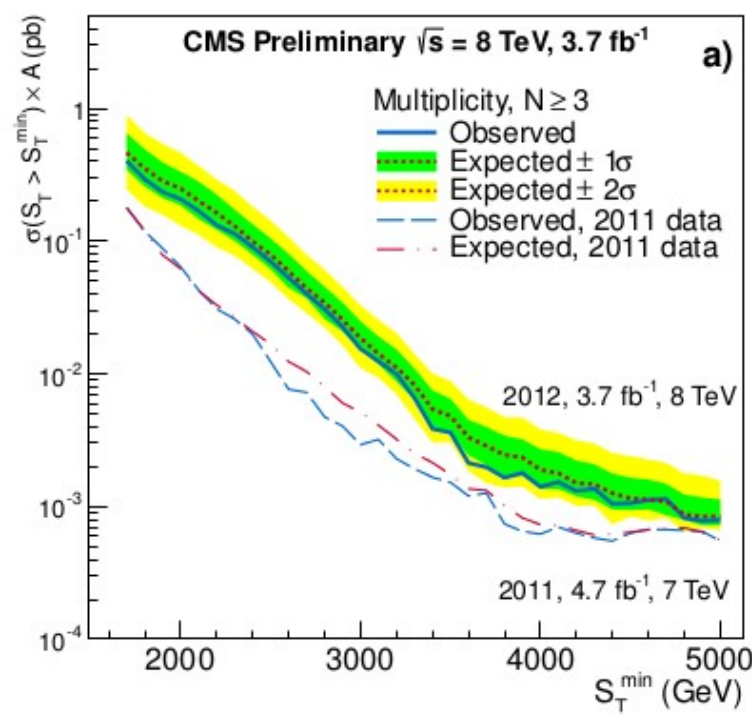
$S_T \rightarrow$ scalar sum of the transverse momenta of individual objects(with $p_T > 50$ GeV):
jets, electrons, photons, muons and missing E_T
all such objects except missing E_T are counted towards the final-state multiplicity N



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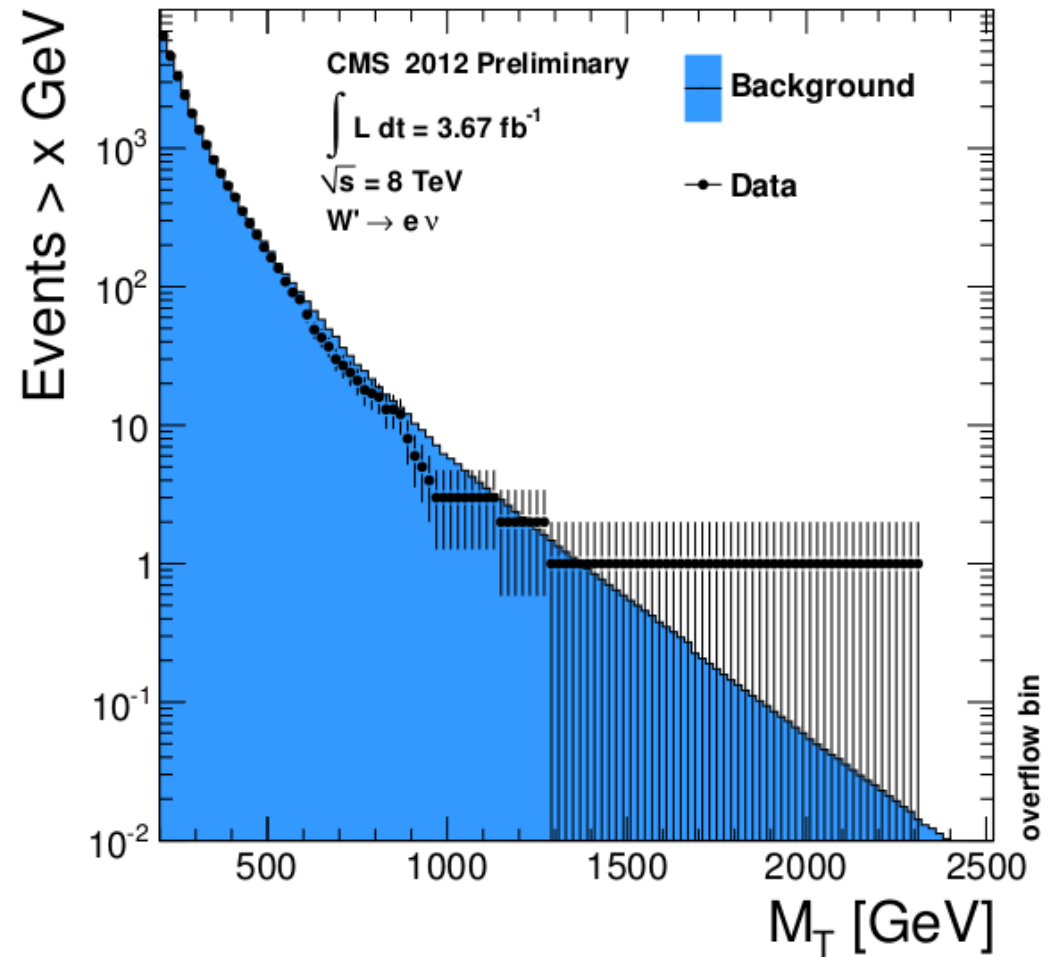
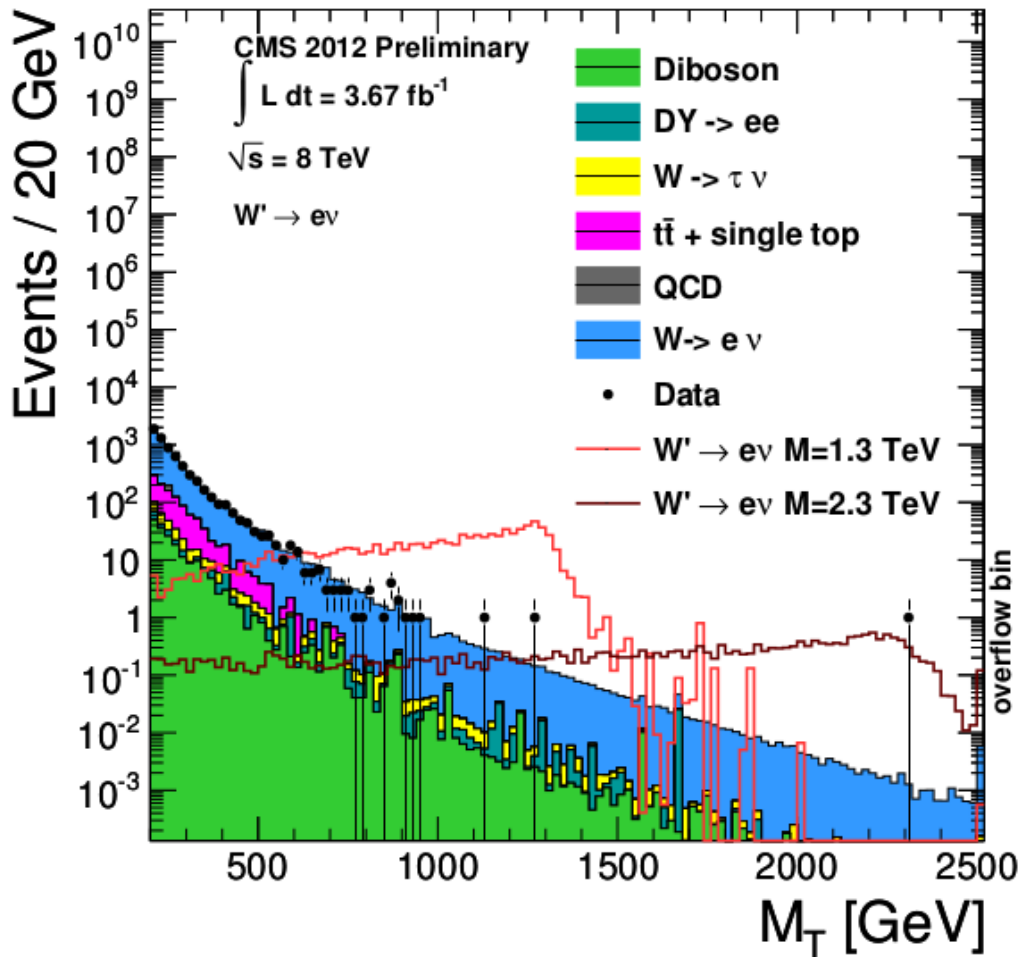
S_T multiplicity invariance method at work





Search for leptonic decays of W' bosons in pp collisions at $\sqrt{s} = 8$ TeV

CMS PAS EXO-12-010

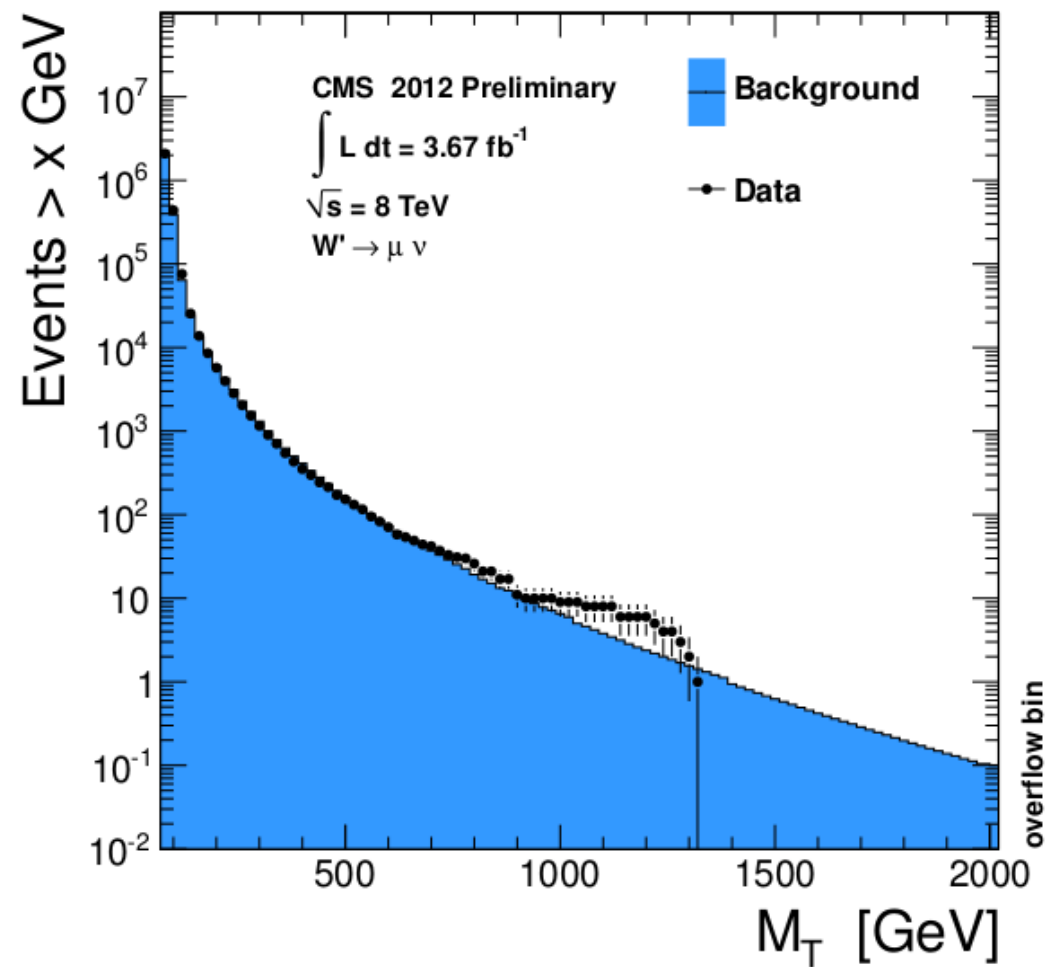
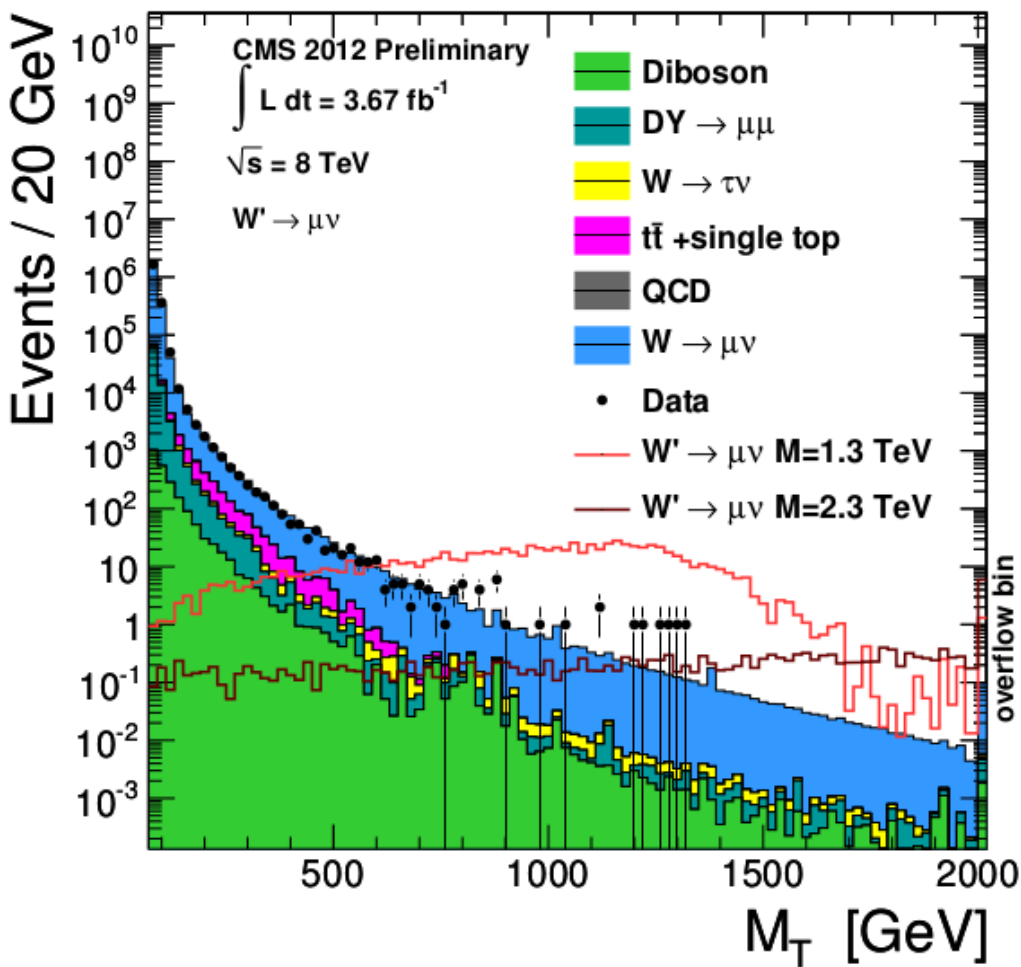


$$M_T = \sqrt{2 \cdot p_T^l \cdot E_T^{\text{miss}} \cdot (1 - \cos \Delta\phi_{l,\nu})}$$

single-electron trigger
 $p_T > 85$ GeV

Search for leptonic decays of W' bosons in pp collisions at $\sqrt{s} = 8$ TeV

CMS PAS EXO-12-010



$$M_T = \sqrt{2 \cdot p_T^l \cdot E_T^{\text{miss}} \cdot (1 - \cos \Delta\phi_{l,\nu})}$$

single-muon trigger
 $p_T > 40 \text{ GeV}$

Search for leptonic decays of W' bosons in pp collisions at $\sqrt{s} = 8$ TeV

CMS PAS EXO-12-010



CMS Experiment at LHC, CERN
Data recorded: Tue May 8 08:19:45 2012 CE
Run/Event: 193621 / 1180868279
Lumi section: 1557

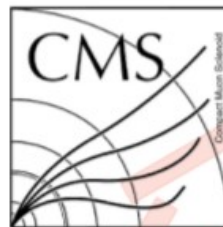
Electron
pt = 1153.51 GeV
eta = 0.066
phi = 1.949

electronGsfTrack
pt = 970.68 GeV
eta = 0.066
phi = 1.949

$M_T = 2312.0$ GeV

pfMet
pt = 1211.16 GeV
phi = -1.145
caloMet
pt = 1213.9 GeV
phi = -1.157

electron + MET
 $M_T = 2.3$ TeV



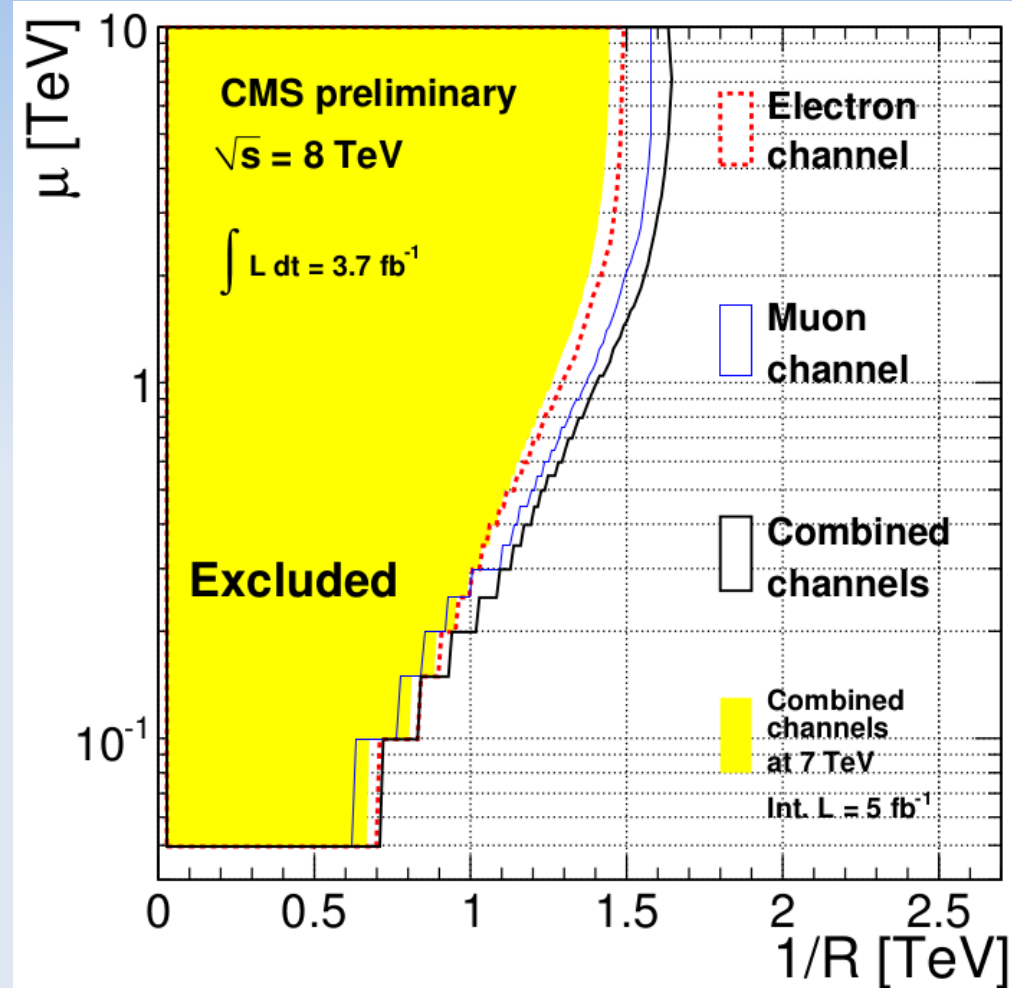
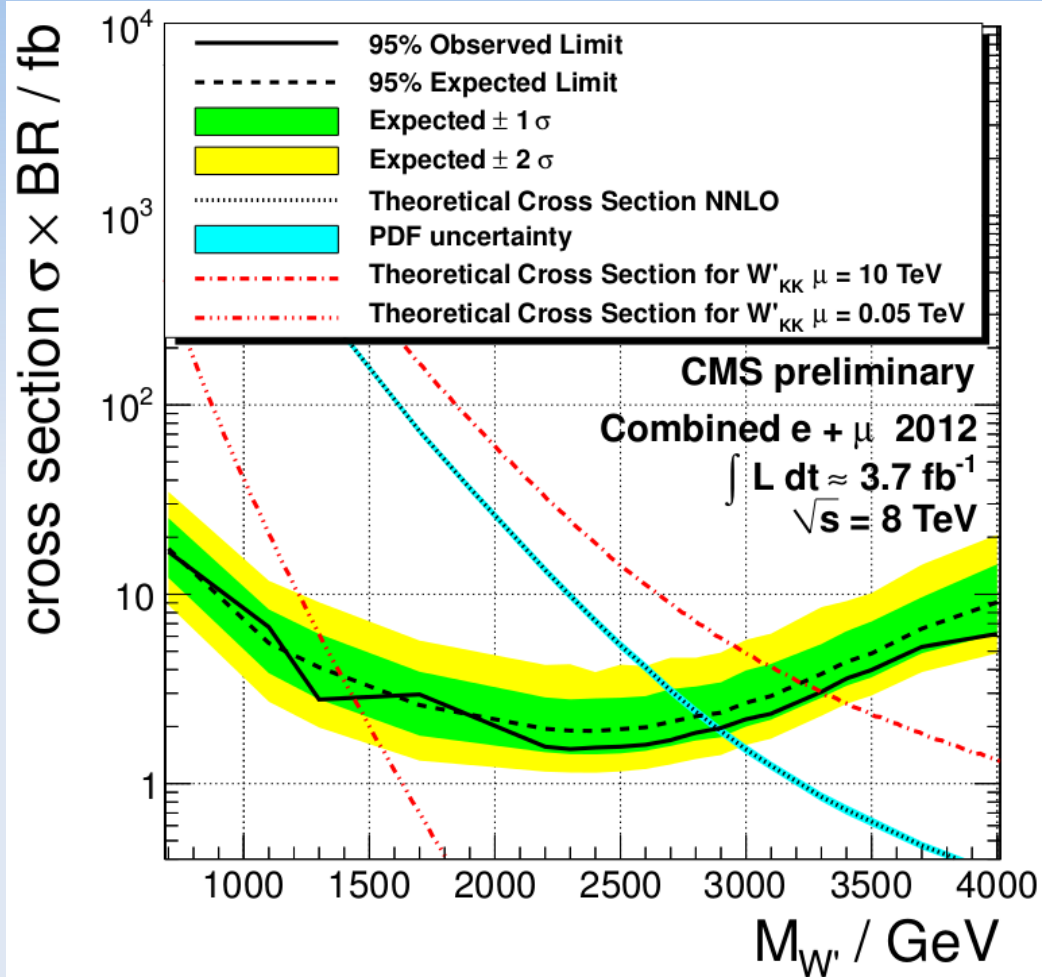
CMS Experiment at LHC, CERN
Data recorded: Sat May 12 13:57:28 2012 CEST
Run/Event: 194050 / 796689537
Lumi section: 843

$M_T = 1332.8$ GeV

MET
pT = 643.2 GeV
phi = 3.04

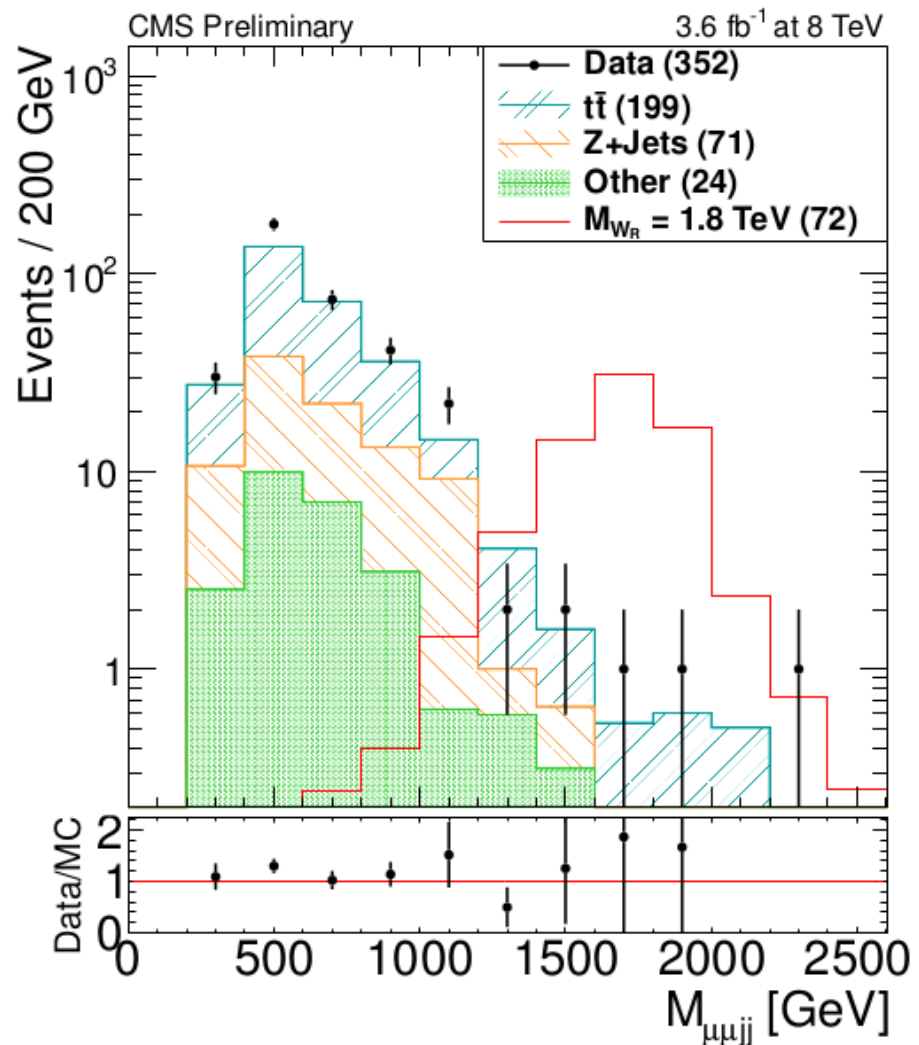
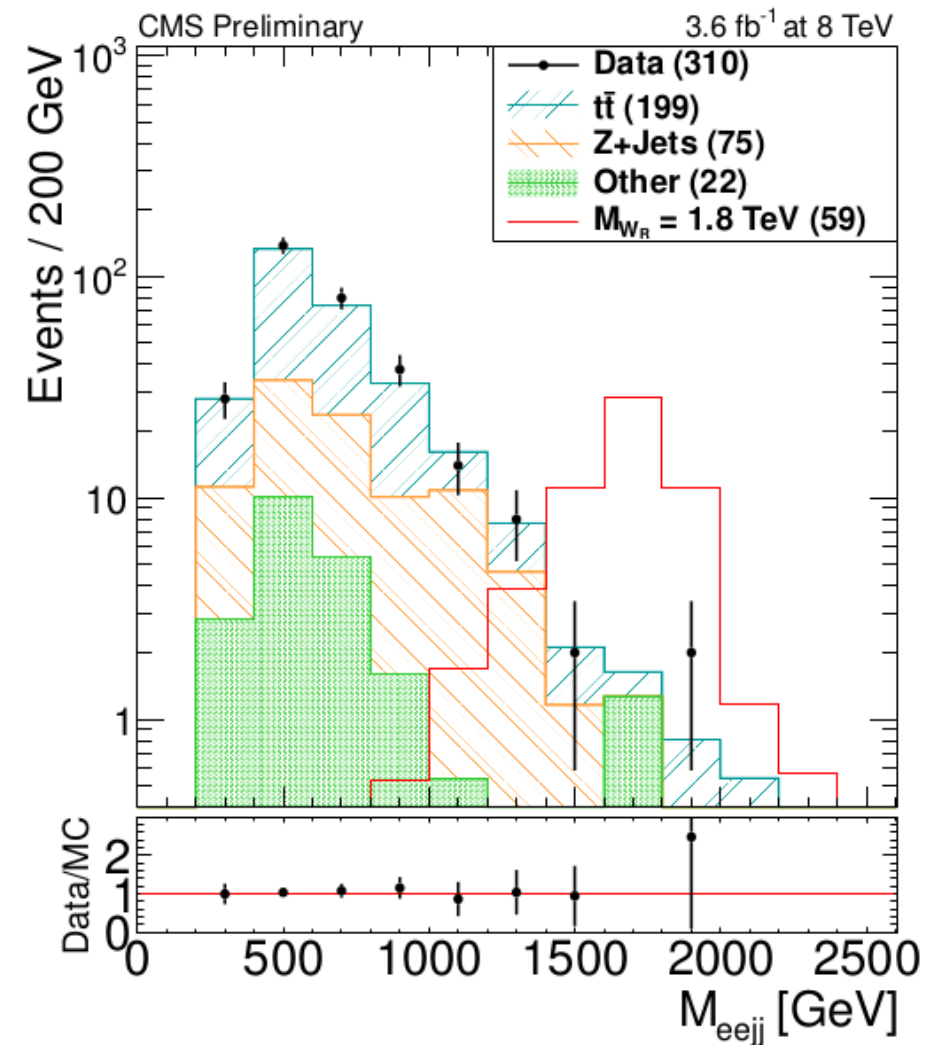
Muon
pT = 690.5 +/- 22.4 GeV
eta = -0.64
phi = -0.09

muon + MET
 $M_T = 1.3$ TeV



**Combination of 2012
electron and muon channel.**

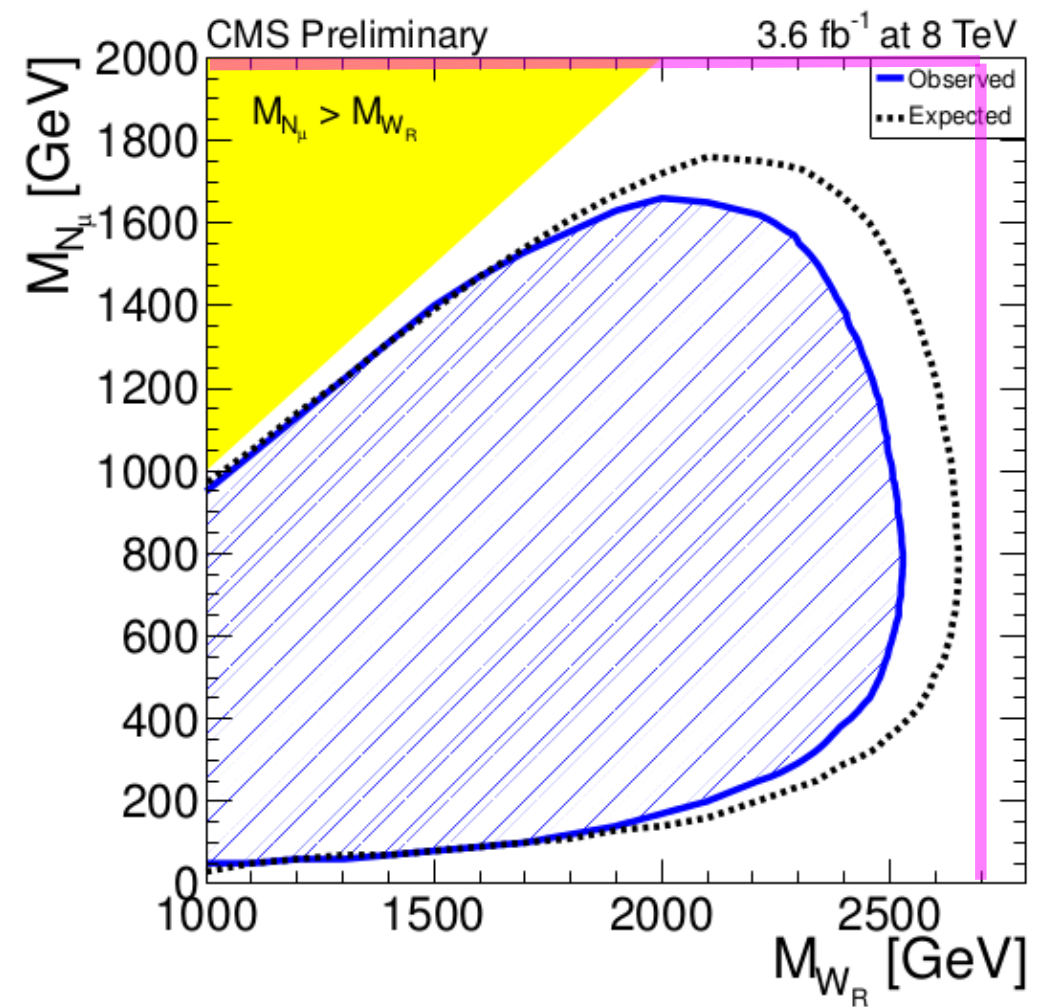
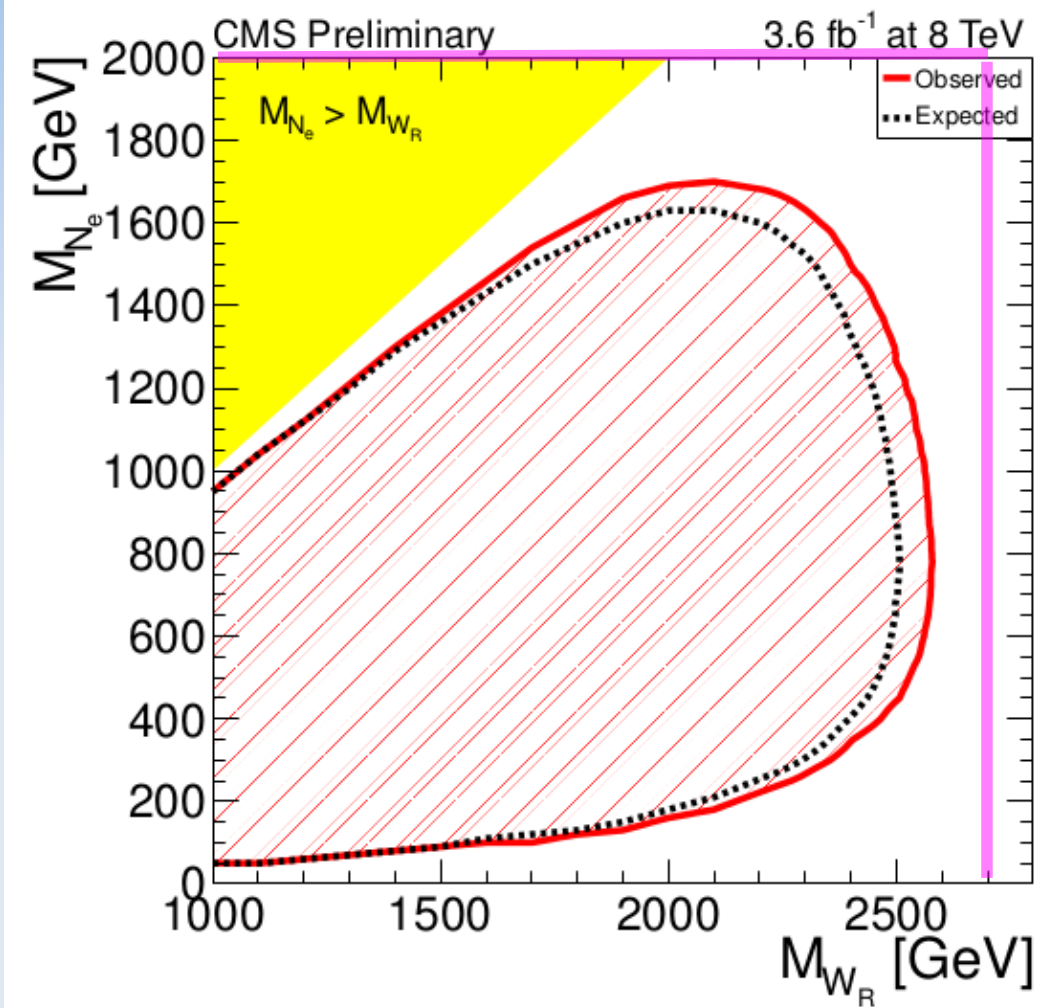
**95% CL on μ & $1/R$ (split-UED)
derived from the W' mass limits
taking into account the corresponding
width of the W'^2_{KK} state**

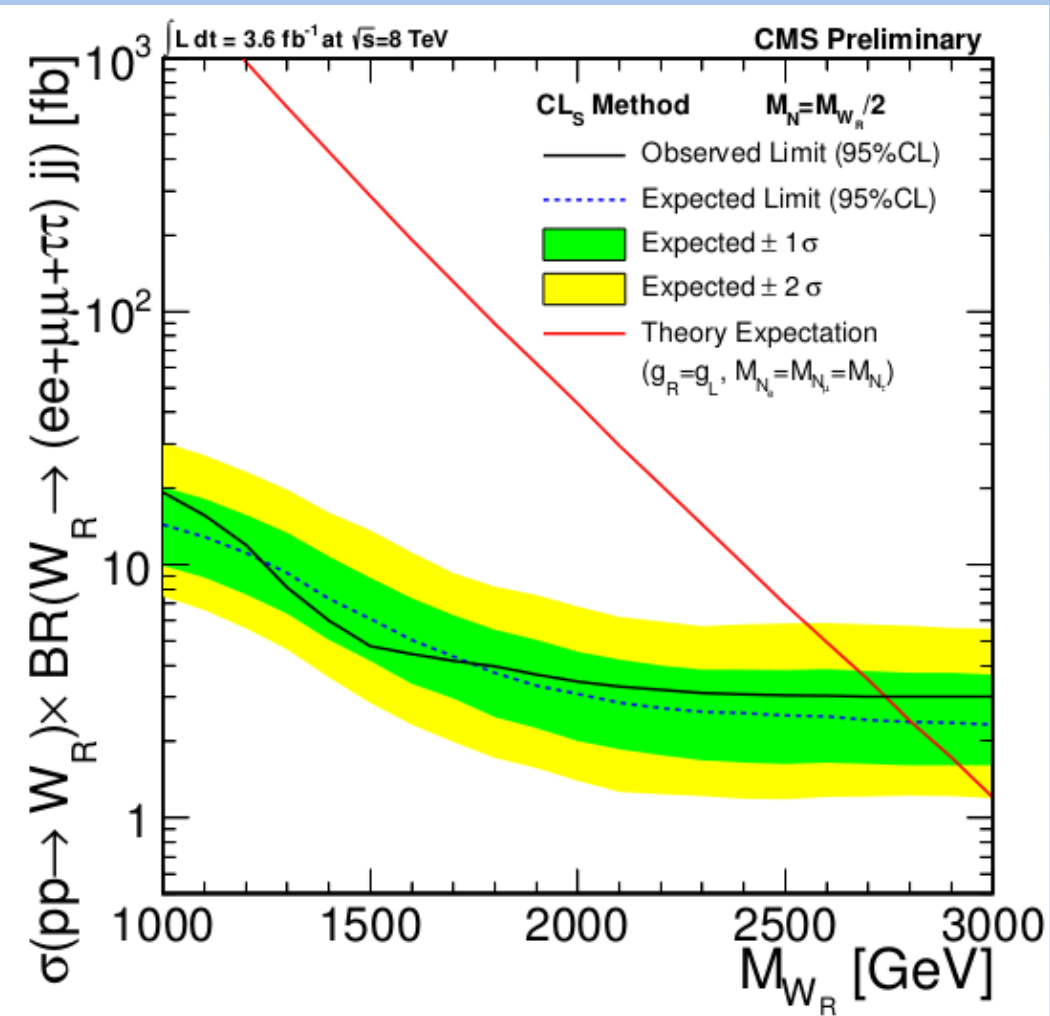
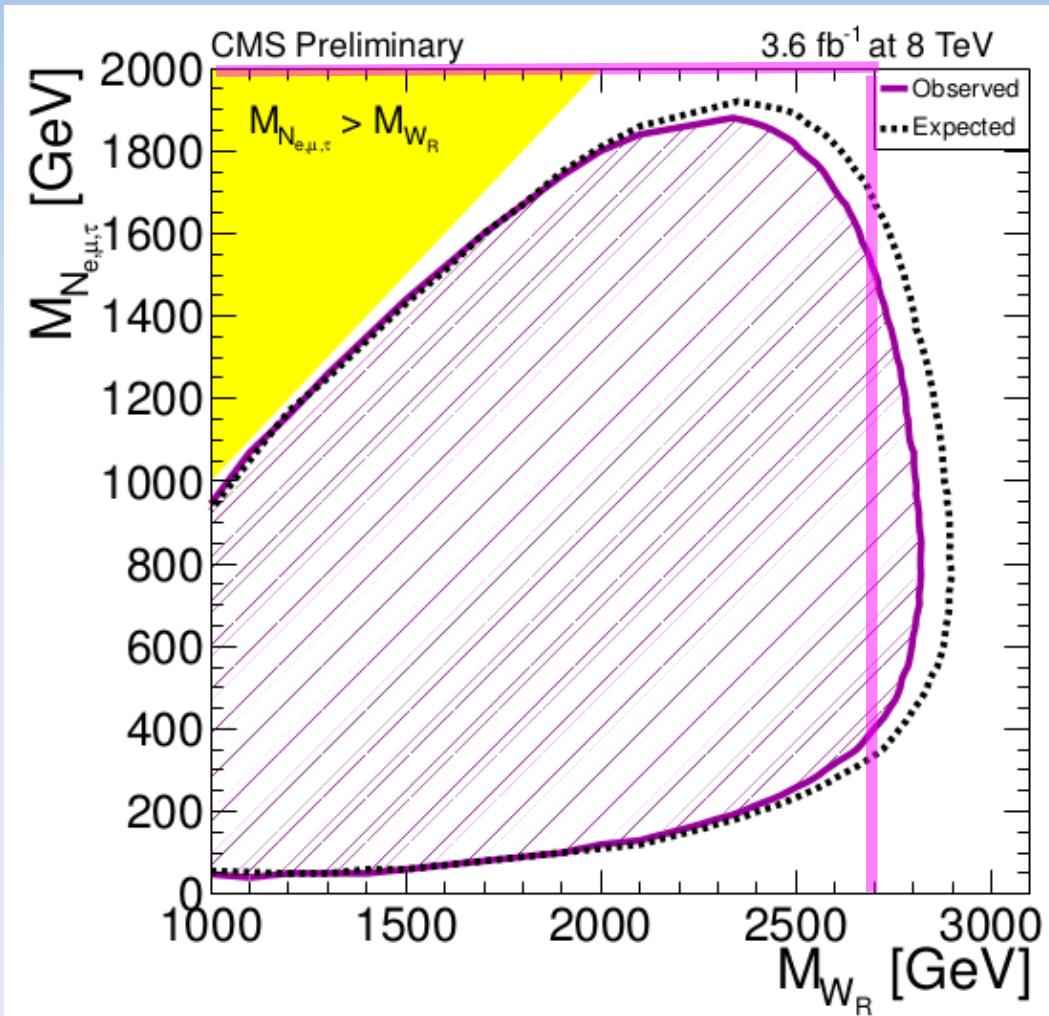


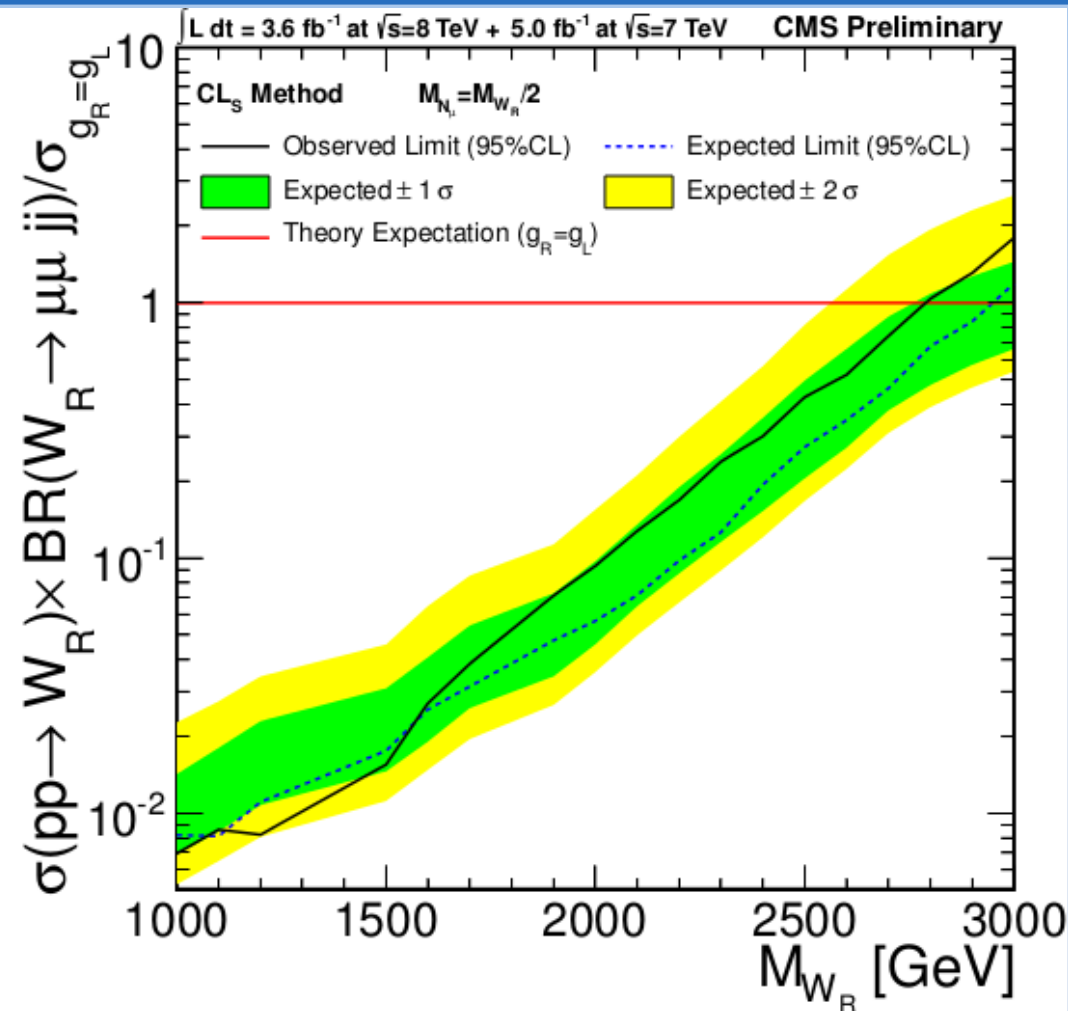
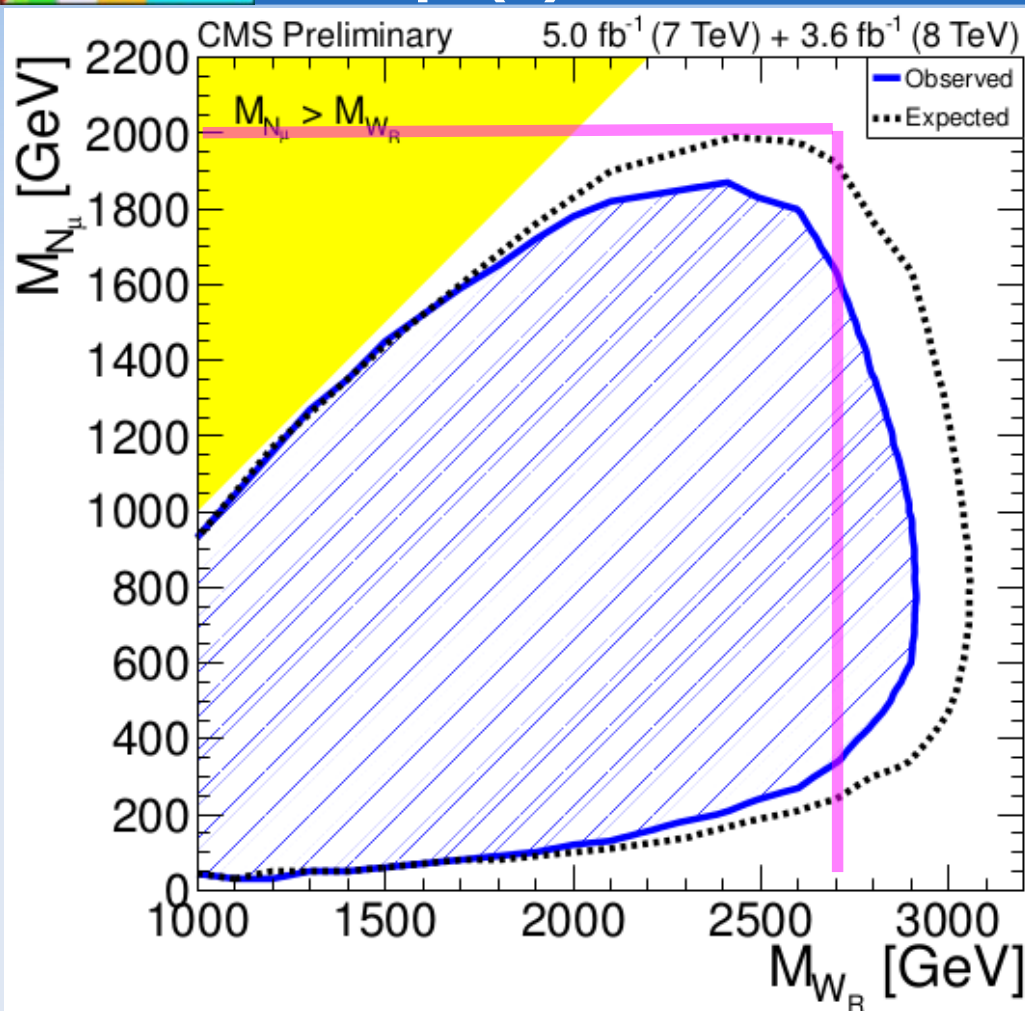
double-electron trigger

single-muon trigger

$$W_R \rightarrow l_1 N_\ell \rightarrow l_1 l_2 W_R^* \rightarrow l_1 l_2 q q' \rightarrow l_1 l_2 j j$$



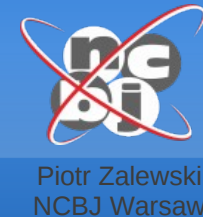






Search for heavy quarks decaying into a top quark and a W or Z boson using lepton + jets events in pp collisions at $\sqrt{s}=7$ TeV

CMS-B2G-12-004 **arXiv:1210.7471**



New heavy quarks (Q) that decay to top quarks and electroweak bosons (W, Z, or Higgs) appear in many theoretical scenarios.

The simplest being the sequential fourth generation model

For heavy down-type quarks decaying exclusively into a top quark and a W boson, the full decay chain is $QQ \rightarrow tWtW \rightarrow bWWbWW$,

For up-type quarks decaying exclusively into a t quark and a Z boson, it is $QQ \rightarrow tZtZ \rightarrow bWZbWZ$.

The search is performed in events in which one of the W bosons decays leptonically, while the other bosons decay into quark-antiquark pairs.

Selected events are required to have

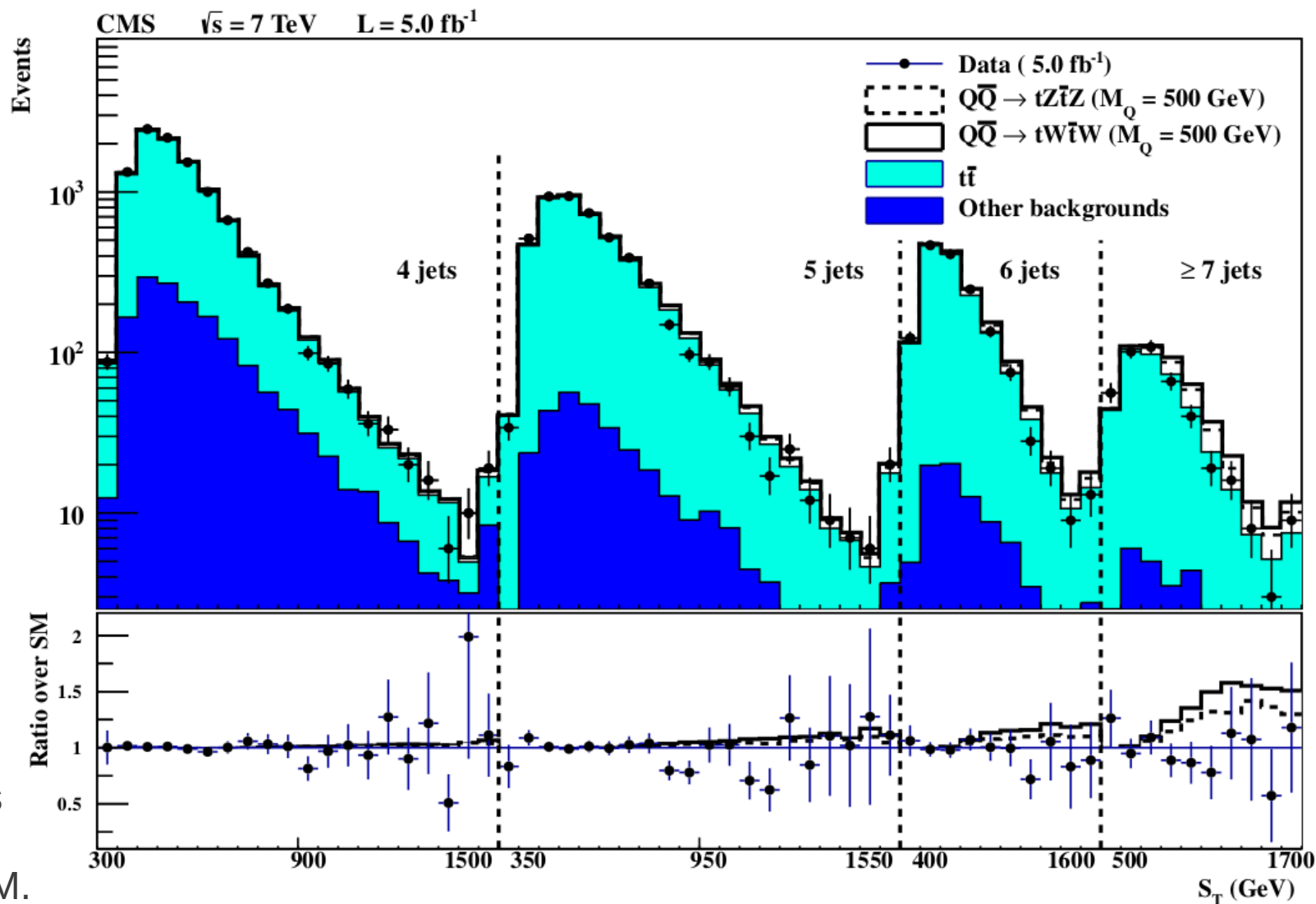
- exactly one charged lepton,
- an imbalance in transverse momentum,
- at least four jets with high transverse momenta
 - at least one of which is consistent with the decay of a bottom quark.

Isolated lepton at least 4 jets at least one b-tagged jet

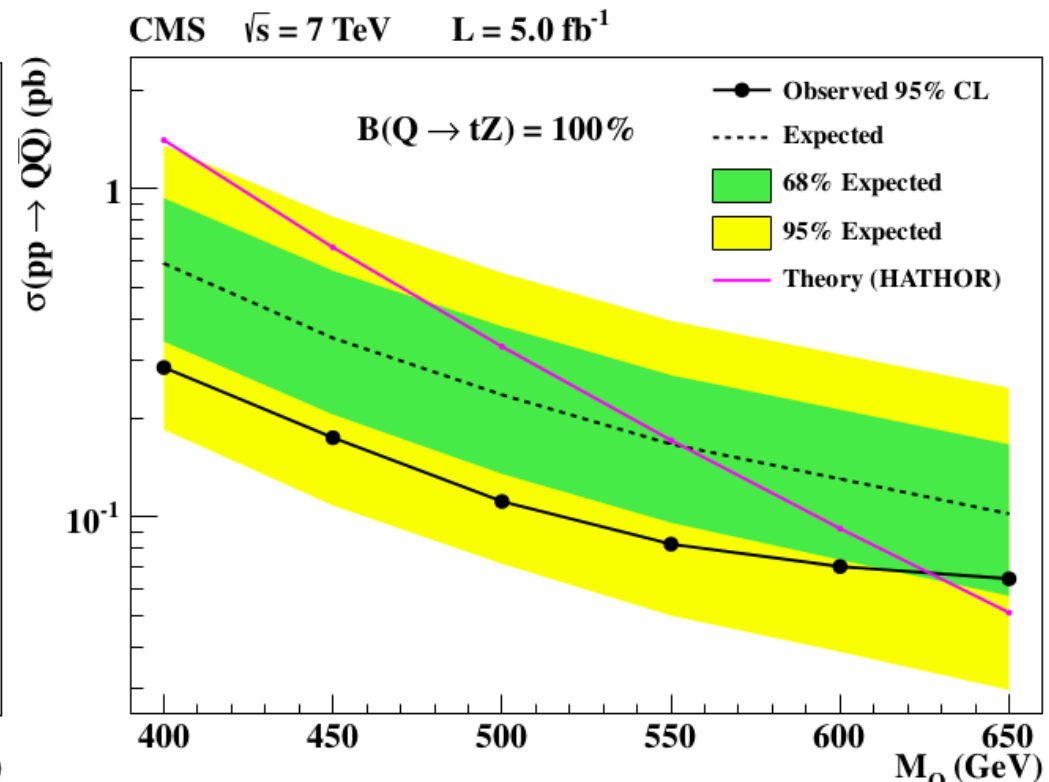
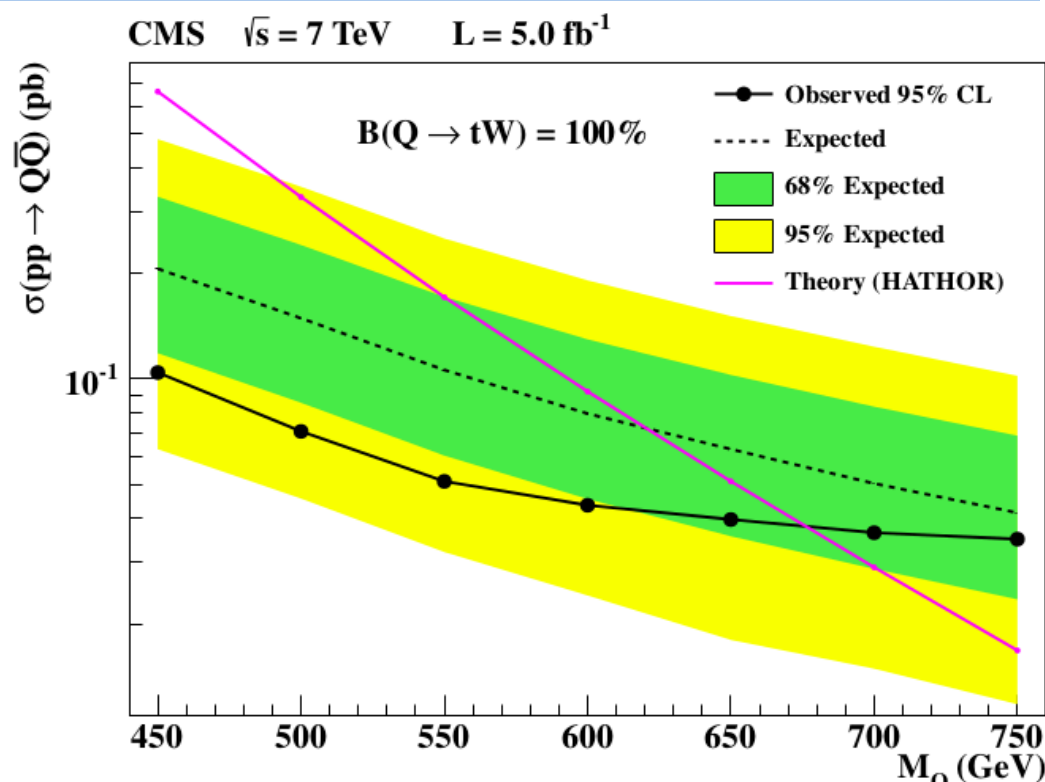
Distribution in S_T for different jet multiplicities after the maximum-likelihood fit to data.

The last bin in each subfigure is the overflow bin.

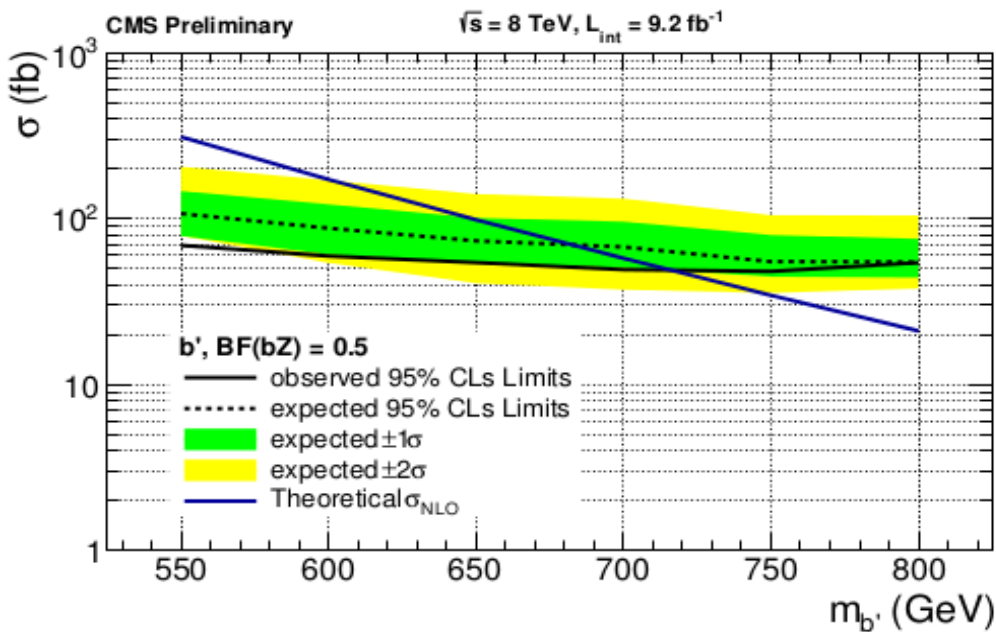
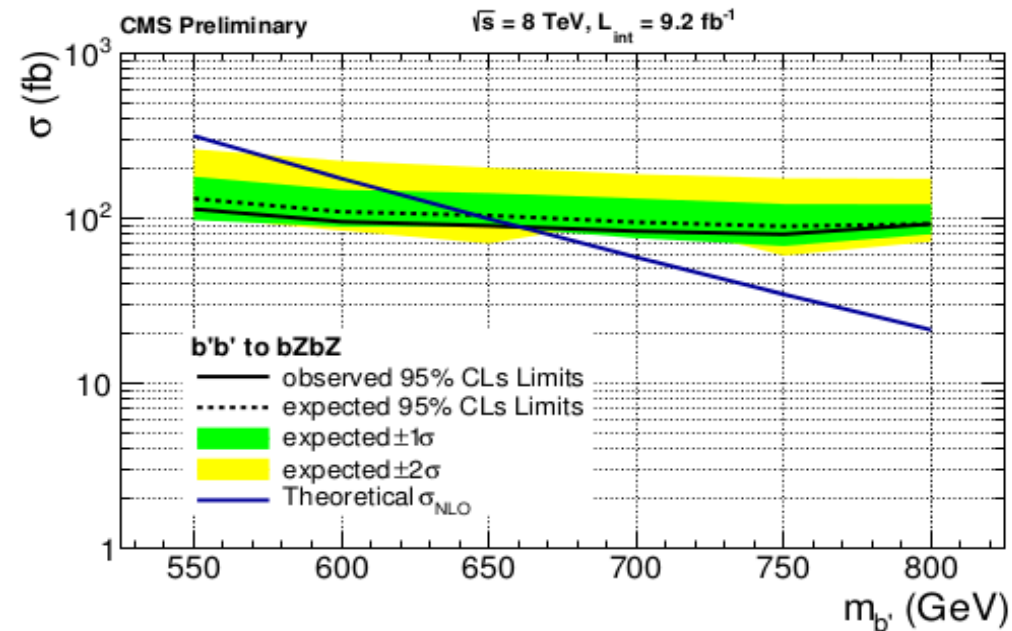
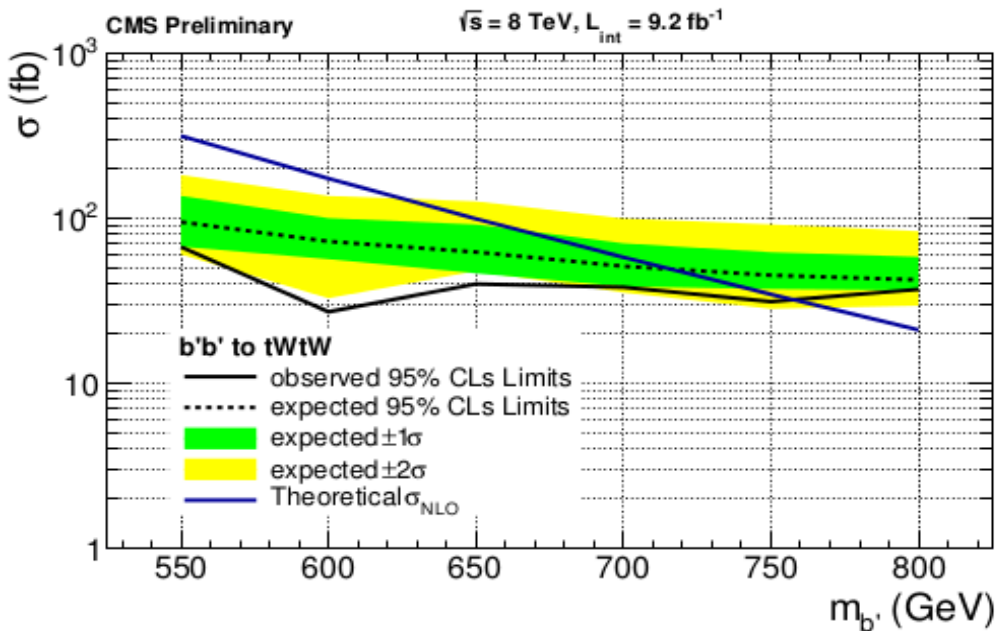
The bottom plot shows the ratios of data and SM plus signal over SM.



$Q \rightarrow tW$ and $Q \rightarrow tZ$ distributions are shown for illustrative purposes for $M_Q = 500$ GeV.



Background process	Cross section	e+jets events	μ +jets events
$t\bar{t}$ +jets	154 ± 19 pb	7521 ± 38	7190 ± 37
Single top	84.9 ± 2.5 pb	399 ± 4	391 ± 4
W+jets	31 ± 2 nb	798 ± 16	790 ± 16
Z+jets	3.1 ± 0.3 nb	104 ± 3	63 ± 2
Diboson (WW, WZ, ZZ)	67 ± 2 pb	17 ± 1	15 ± 1
Multijet	from data	334 ± 8	–
Total background		9173 ± 42	8449 ± 44
Data		9105	8211



**Interpretation
of the RPV result (shown today by Daniel)
as a $b' \rightarrow tW$
or $b' \rightarrow bZ$**

Sequential, exotic quarks, the heavier partner of the bottom quark, denoted by b' , could decay either to a top-quark with a W-boson (tW mode) or a bottom-quark and a Z-boson (bZ mode).

Conclusions & references

We (CMS) have not yet found any exotic beast,
but we keep searching.
Analyses with full 2012 data set are at an approval stage.



- [1] Search for Narrow Resonances using the Dijet Mass Spectrum
in pp Collisions at $\sqrt{s} = 8$ TeV CMS PAS EXO-12-016
- [2] Search for Resonances in Dilepton Mass Spectra in pp Collisions at $\sqrt{s}=8$ TeV
CMS PAS EXO-12-015
- [3] Search for microscopic black holes at $\sqrt{s} = 8$ TeV with the CMS detector
CMS PAS EXO-12-009
- [4] Search for leptonic decays of W' bosons in pp collisions at $\sqrt{s} = 8$ TeV
CMS PAS EXO-12-010
- [5] Search for a heavy neutrino and right-handed W of the left-right symmetric model
in pp collisions at $\sqrt{s} = 8$ TeV CMS PAS EXO-12-017
- [6] Search for heavy quarks decaying into a top quark and a W or Z boson using lepton
+ jets events in pp collisions at $\sqrt{s}=7$ TeV CMS PAS B2G-12-004; arXiv:1210.7471
- [7] Search for RPV supersymmetry with three or more leptons and b-tags
CMS PAS SUS-12-027

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