Searches for Extra Dimensions, Leptoquarks, and Technicolor at the LHC

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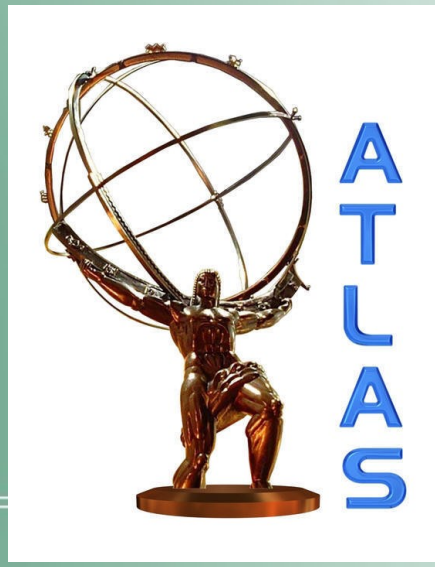
Rencontres de Blois on "Particle Physics and Cosmology"

26-31 May 2013



Extra Dimensions

- Arkani-Hamed, Dimopoulos, Dvali (ADD)
  - Gravity propagate in (4+n)-dimensional space, SM confined
  - Fundamental M_D Planck scale
  - Size of extra dimensions R
- Quantum black holes with n=1

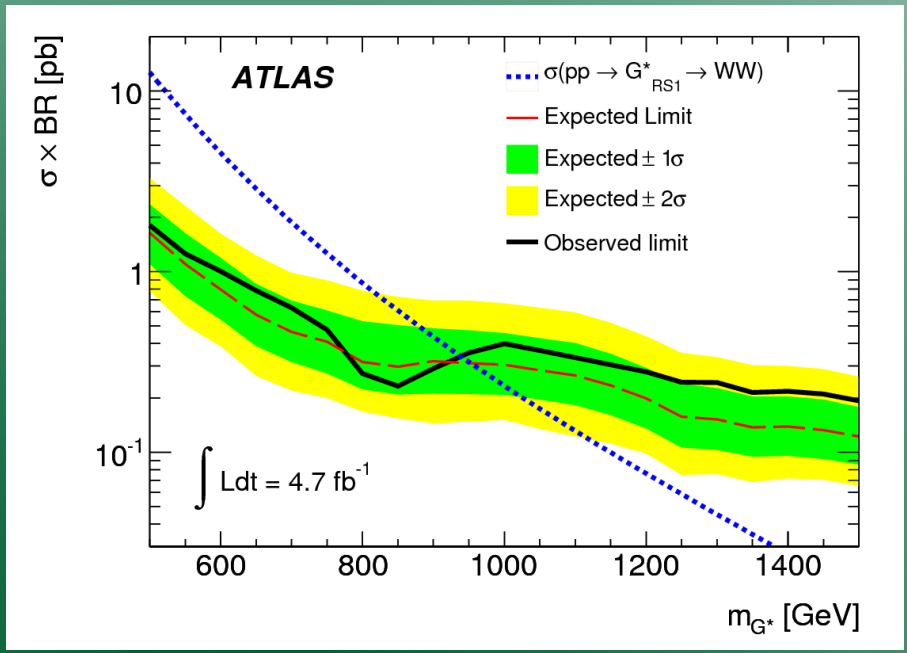
- Randall-Sundrum invokes extra dim with curvature k
  - Predicts excited Kaluza-Klein modes of the graviton
  - Appear as spin-2 resonances, first excitation G*
  - Intrinsic narrow G* width when $\tilde{k}=k/\overline{M}_{Pl}<0.1$
  - Extension to SM fields propagating in the bulk extra dimensions (bulk RS)

Extra Dimensions

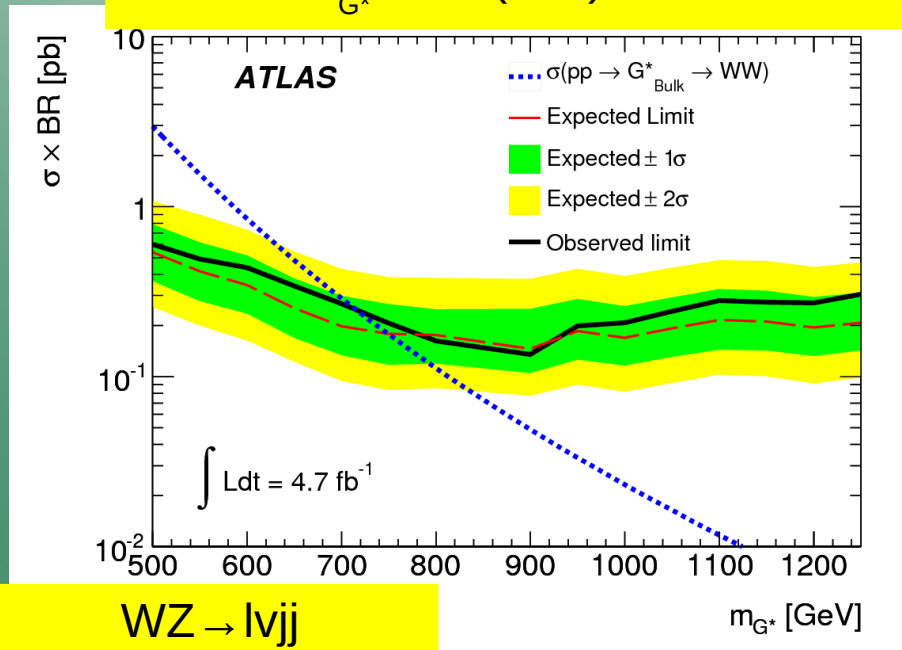
- Resonant diboson production WW, ZZ
- Dilepton resonances ee, μμ, and same-sign
- Monojet and missing energy
- Microscopic black holes in multiparticle events
- Resonances in $b\bar{b}$ and bg final states
- $t\bar{t}$ resonances in lepton+jets and all hadronic final states

Resonant diboson

ATLAS 4.7fb^{-1}@7TeV arXiv:1305.0125



G* → WW → lνjj spin-2 RS1 (bulk RS)
M_{G^*}<940 (710) GeV



WZ → lνjj
$M_{W'}$<950 GeV

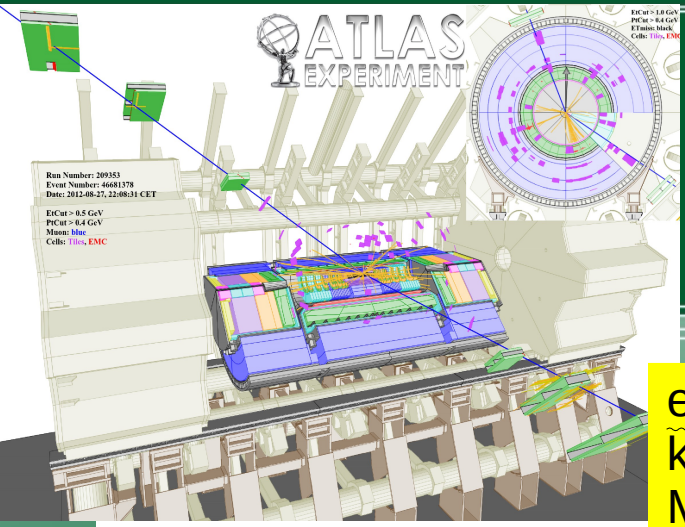
G* → ZZ → lljj $\tilde{k}$=0.1 RS1 ($\tilde{k}$=0.5 bulk)
M_{G^*}<945 (610) GeV

$\tilde{k}$=1 bulk G* → ZZ → lljj
M_{G^*}<850 GeV

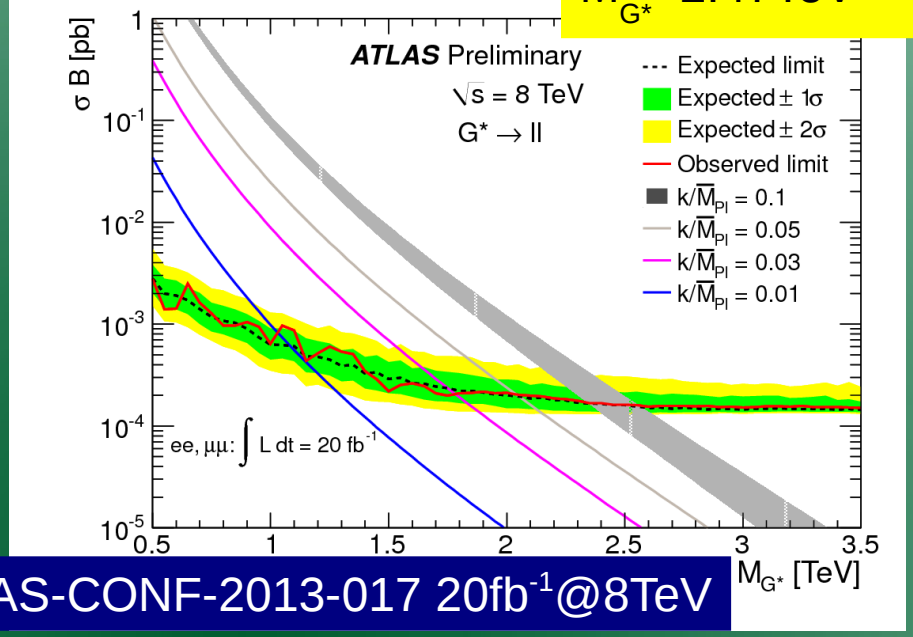
CMS 4.9fb^{-1}@7TeV
10.1016/j.physletb.2012.11.063

ATLAS 7.2fb^{-1}@8TeV
ATLAS-CONF-2012-150

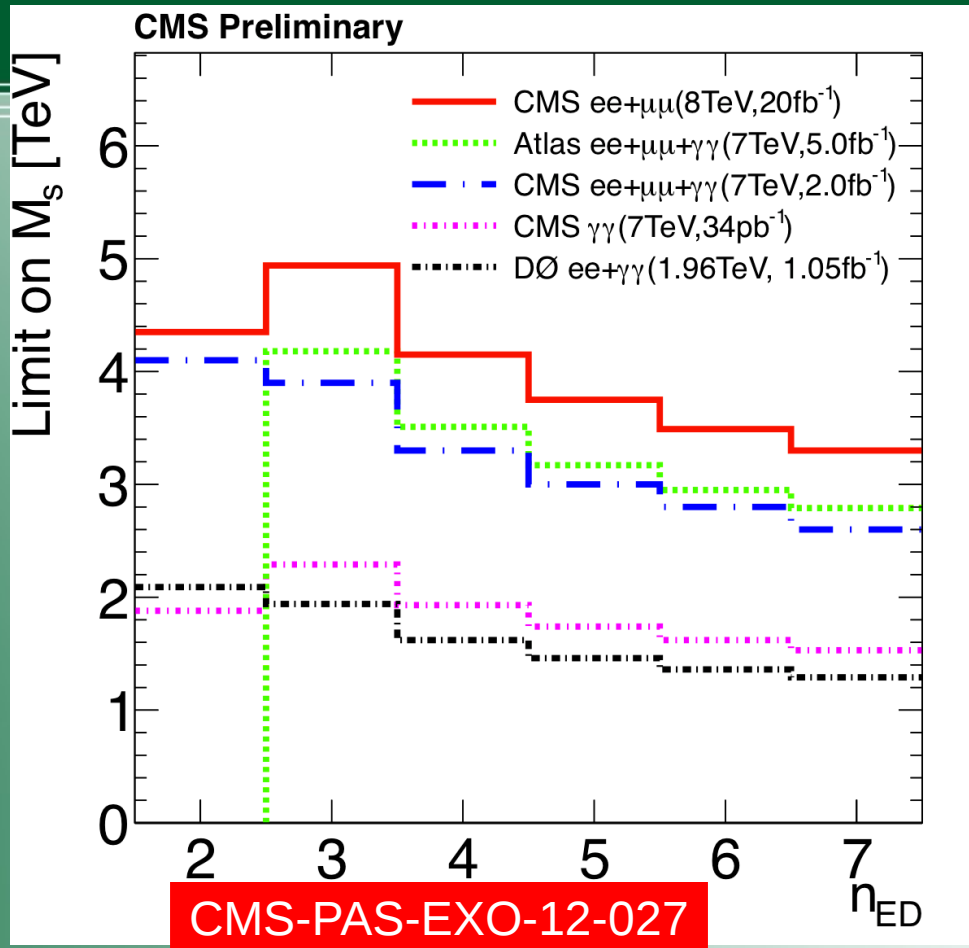
Dilepton resonances



ee, μμ combined
$\tilde{k}$=0.1 RS1
M_{G^*}<2.47TeV



ATLAS-CONF-2013-017 20fb^{-1}@8TeV



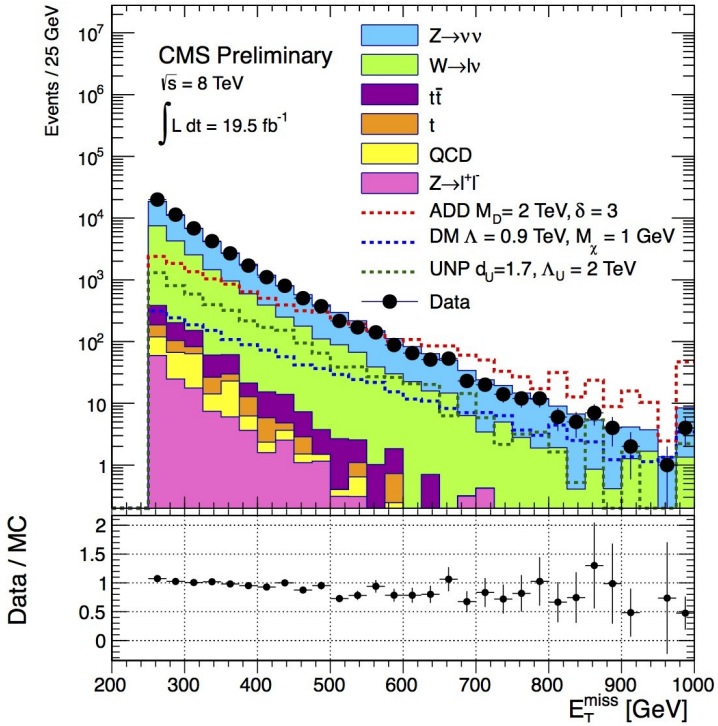
CMS-PAS-EXO-12-027
CMS-PAS-EXO-12-031

$\tilde{k}$=0.1 RS1
M_{G^*}<2.39TeV

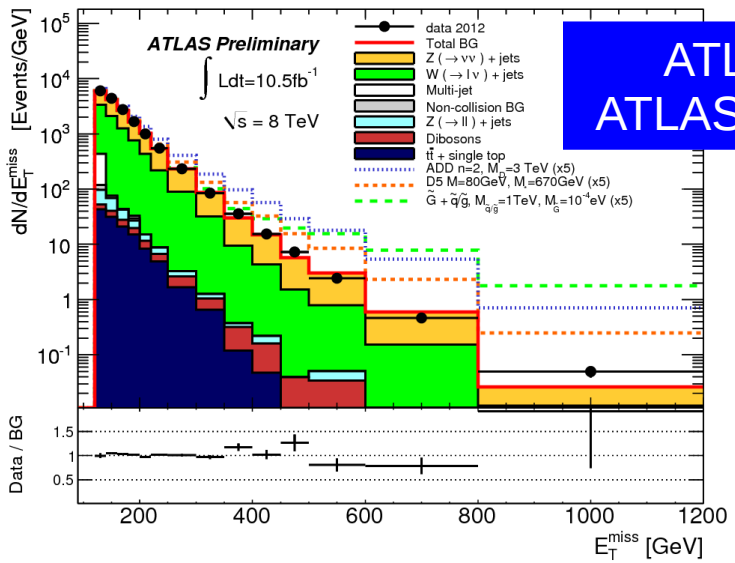
CMS 5.3fb^{-1}@7TeV+4.1fb^{-1}@8TeV
10.1016/j.physletb.2013.02.003

Monojet and missing energy

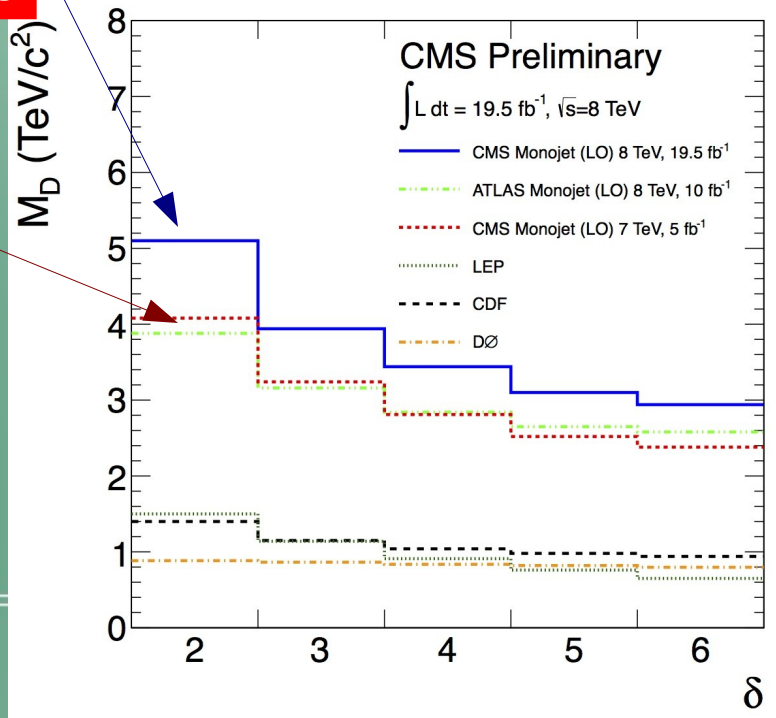
- $qg \to qG$, $gg \to gG$, $q\bar{q} \to gG$
- Not interacting gravitons



CMS 19.5fb^{-1}@8TeV
CMS-PAS-EXO-12-048

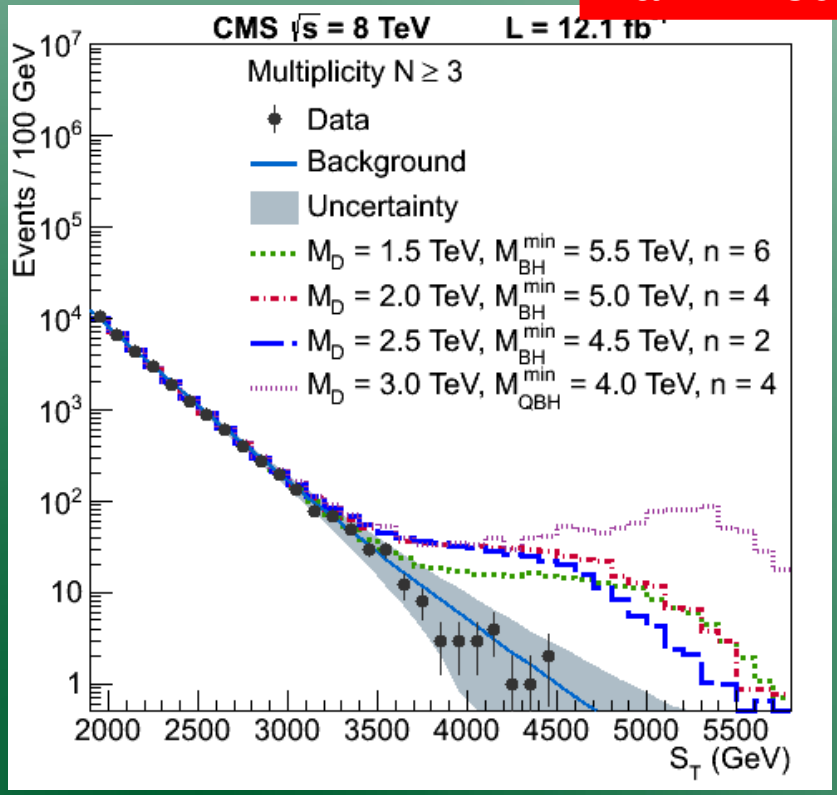


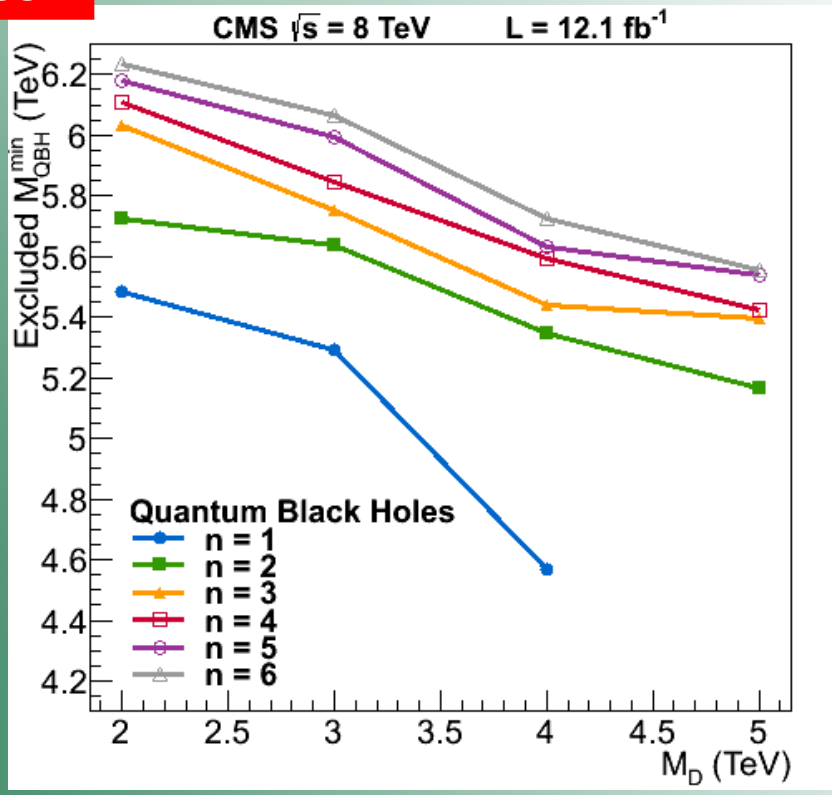
ATLAS 10fb^{-1}@8TeV
ATLAS-CONF-2012-147



Microscopic black holes

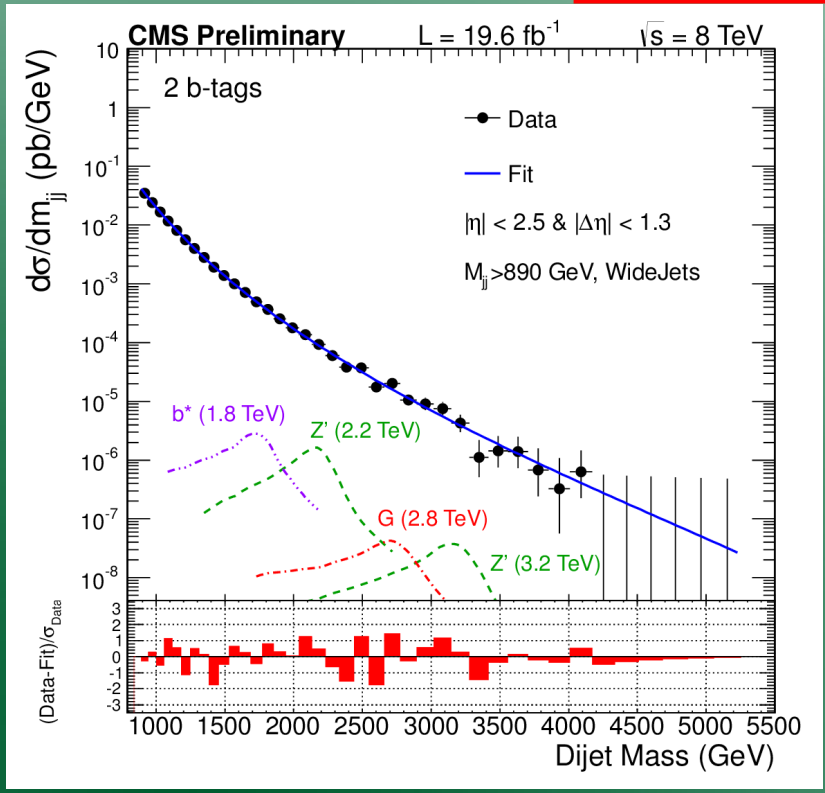
CMS 12fb^{-1}@8TeV
arXiv:1303.5338

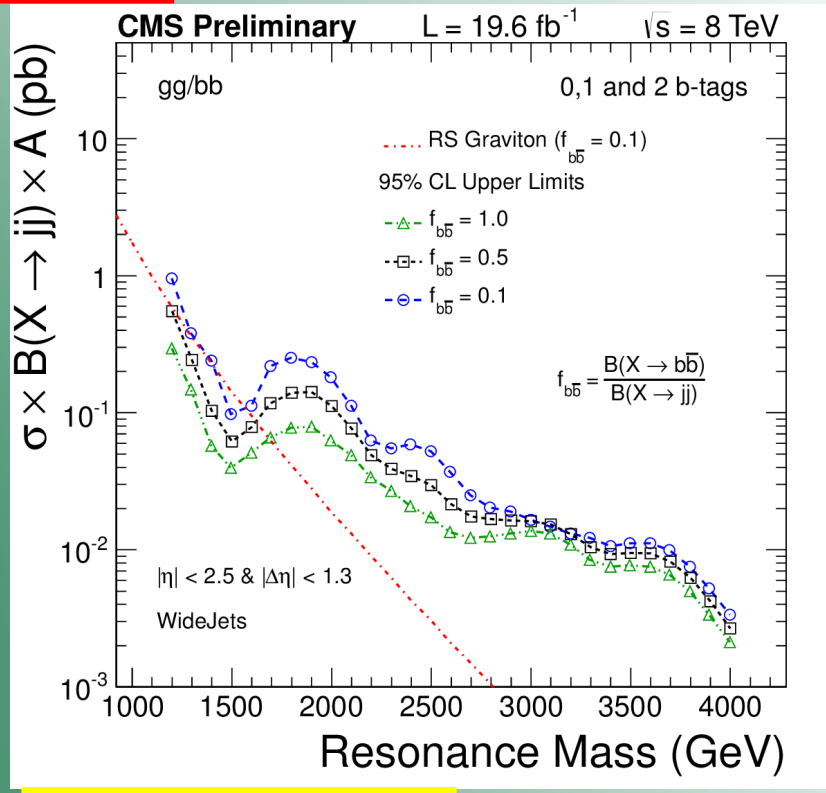




Resonances in $b\bar{b}$ and bg

CMS 19.6fb^{-1}@8TeV
CMS-PAS-EXO-12-023

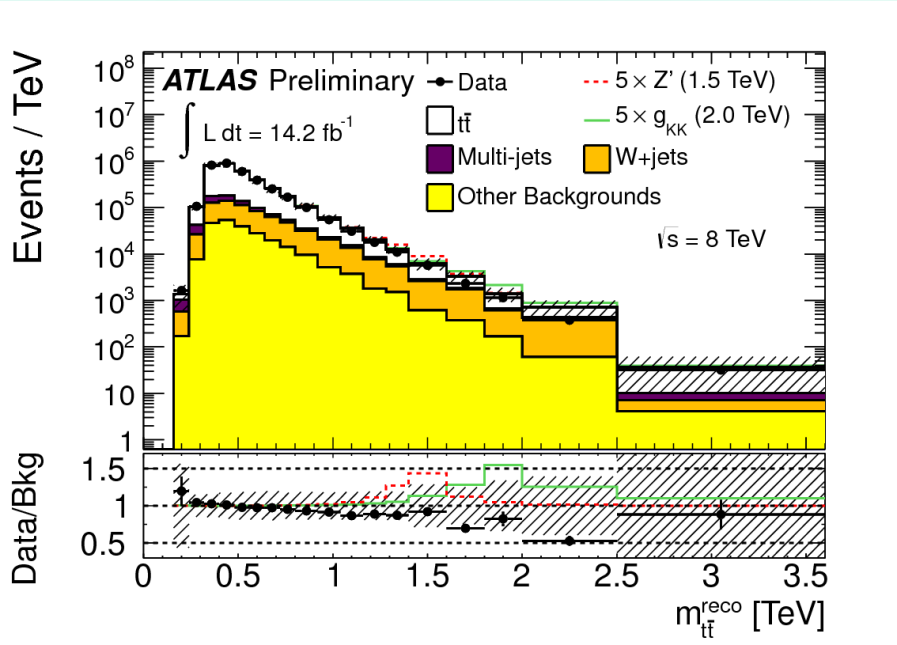




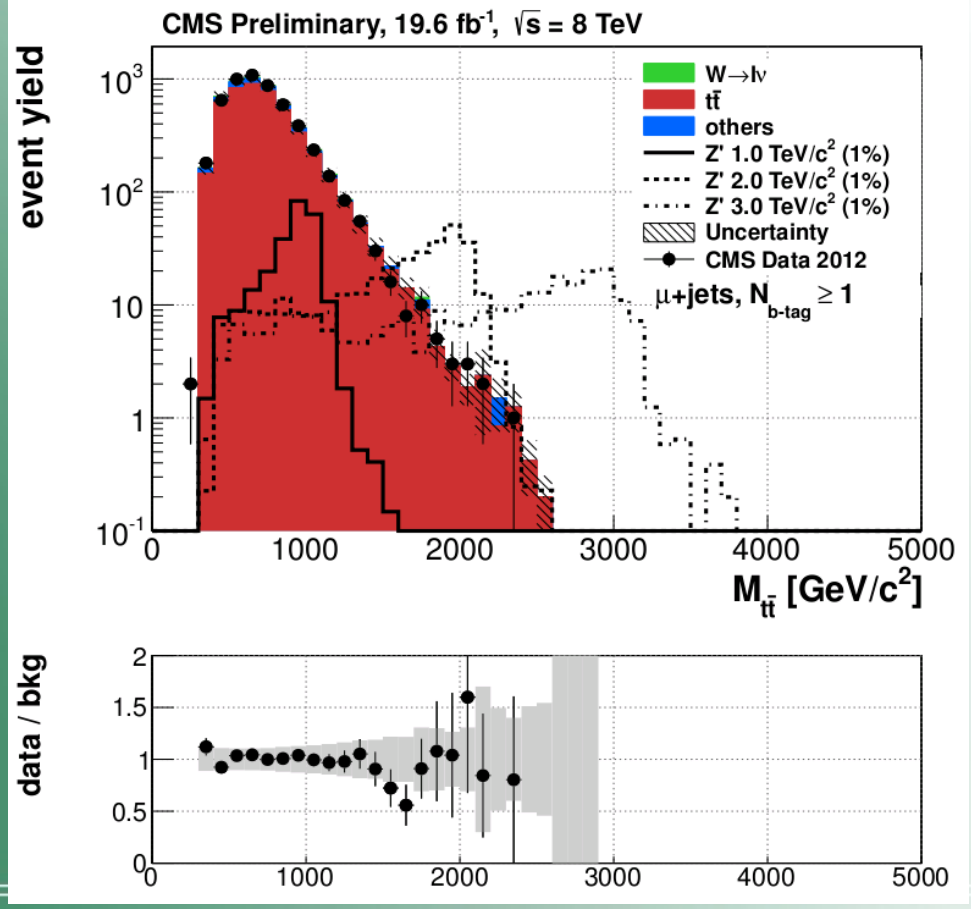
$L \tilde{k}=0.1$, $f_{b\bar{b}}=0.1$
$1.42<M_{G^*}<1.57$TeV

$t\bar{t}$ resonances (l+jets)

ATLAS-CONF-2013-052 14fb^{-1}@8TeV

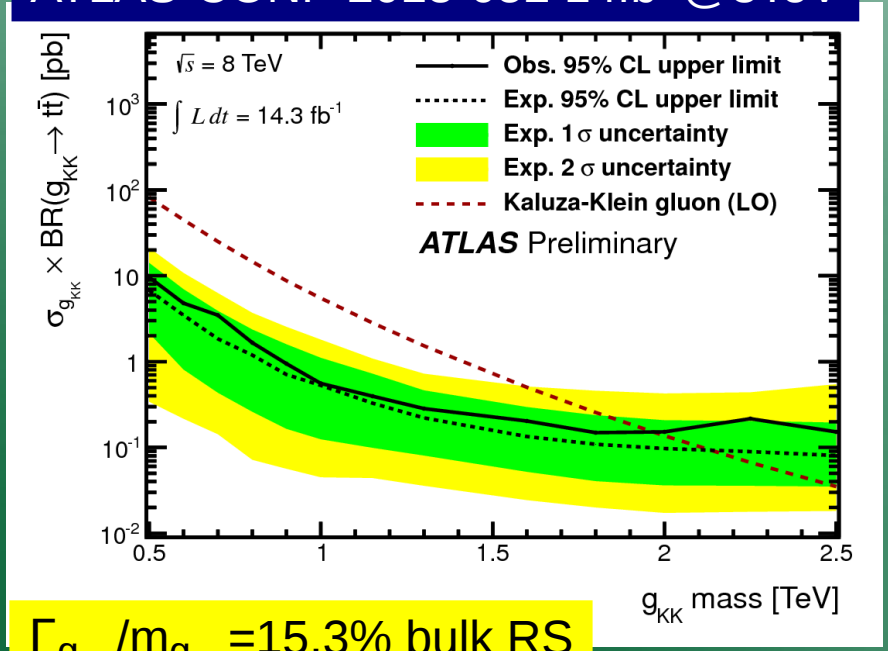


CMS-PAS-B2G-12-006 19.6fb^{-1}@8TeV



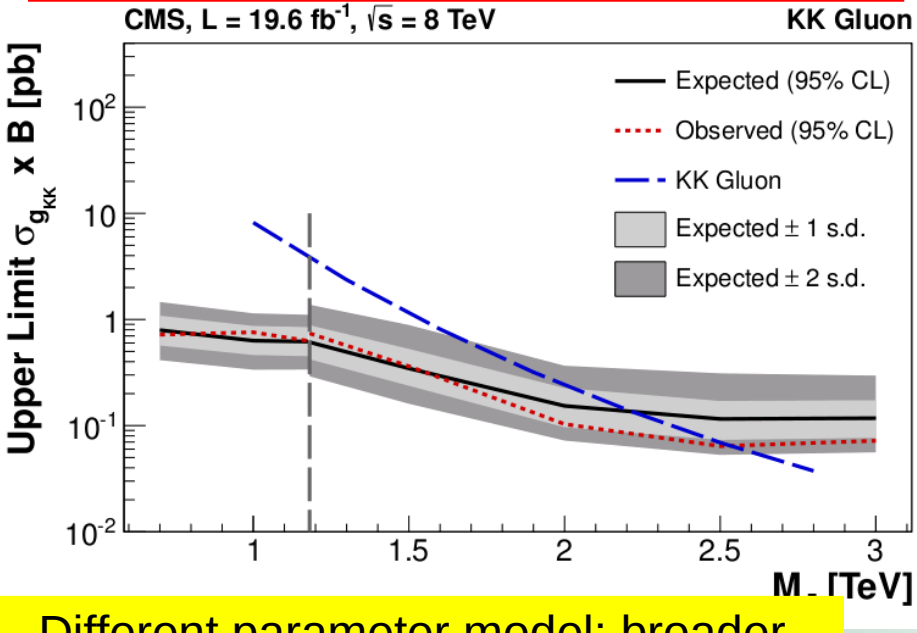
$t\bar{t}$ resonances (l+jets)

ATLAS-CONF-2013-052 14fb^{-1}@8TeV



$\Gamma_{g_{KK}}/m_{g_{KK}}$=15.3% bulk RS
$0.5<m_{g_{KK}}<2.0$TeV

CMS-PAS-B2G-12-006 19.6fb^{-1}@8TeV



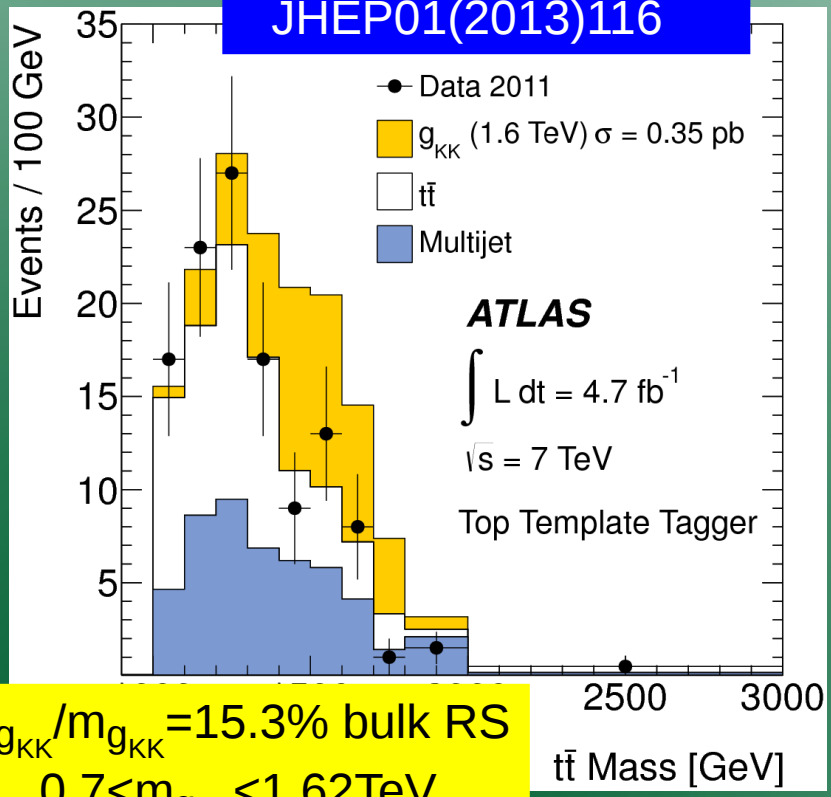
Different parameter model: broader and larger x-sec
bulk RS $m_{g_{KK}}<2.54$TeV

Lillie et al. arXiv:hep-ph/0701166v1

Agashe et al. Phys. Rev. D77 (2008)015003

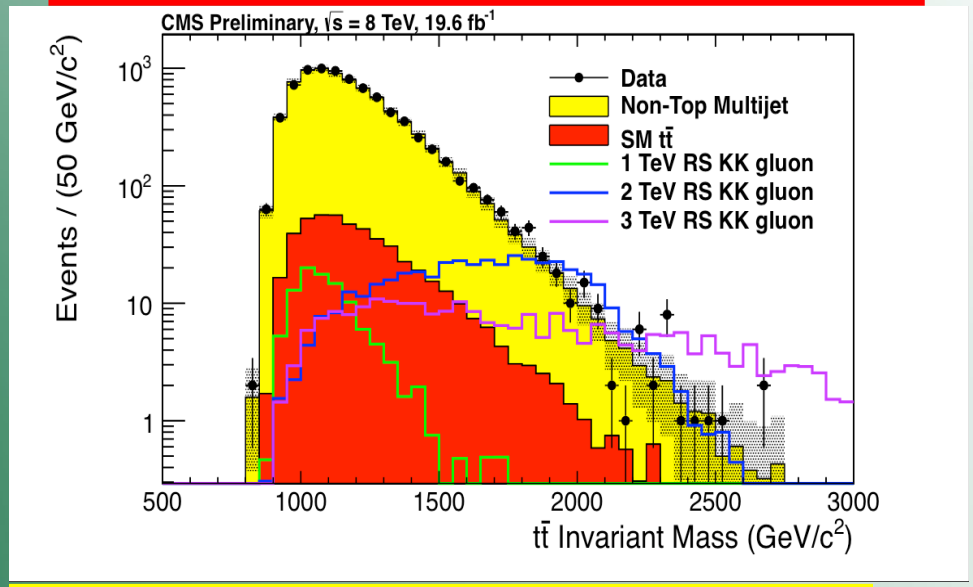
$t\bar{t}$ resonances (all hadronic)

ATLAS 4.7fb^{-1}@7TeV
JHEP01(2013)116



$\Gamma_{g_{KK}}/m_{g_{KK}}$=15.3% bulk RS
0.7<$m_{g_{KK}}$<1.62TeV

CMS-PAS-B2G-12-005 19.6fb^{-1}@8TeV



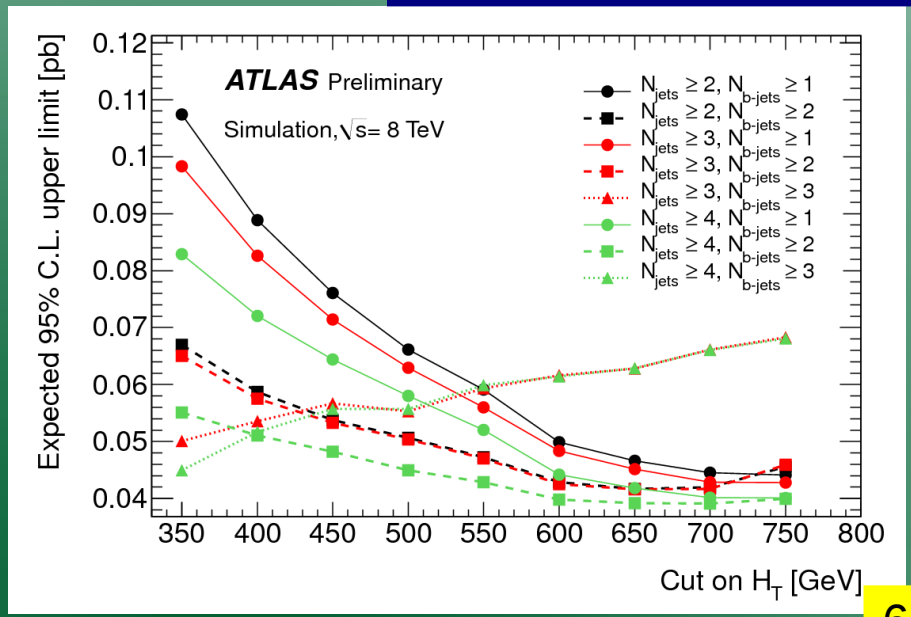
Different parameter model: broader and larger x-sec
bulk RS $m_{g_{KK}}$<1.8TeV

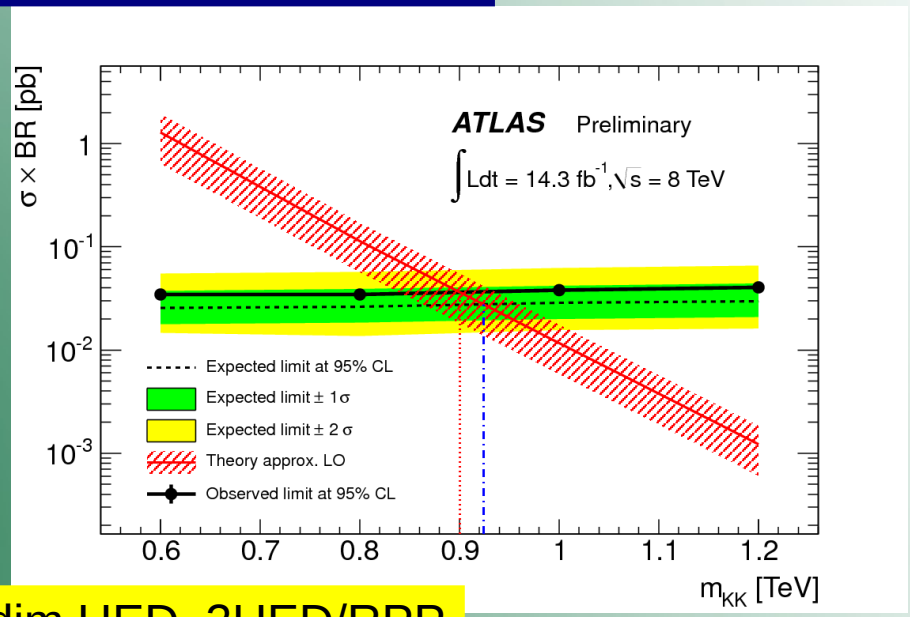
Lillie et al. arXiv:hep-ph/0701166v1

Agashe et al. Phys. Rev. D77 (2008)015003

Same-sign dilepton searches

ATLAS 14.3fb^{-1}@8TeV ATLAS-CONF-2013-051





6-dim UED, 2UED/RPP
$M_{g_{KK}}$<0.9TeV

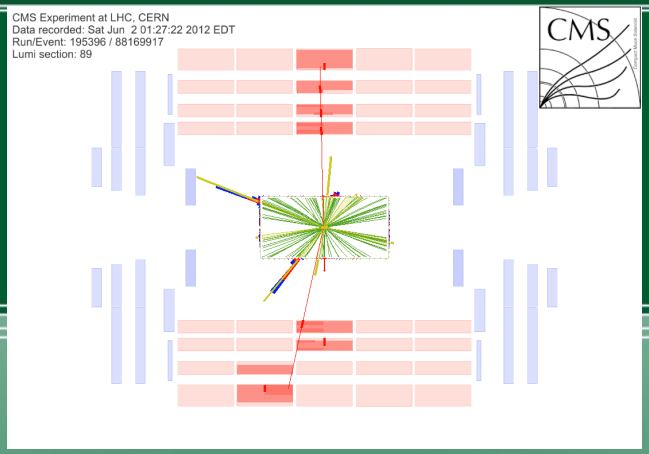
Different models

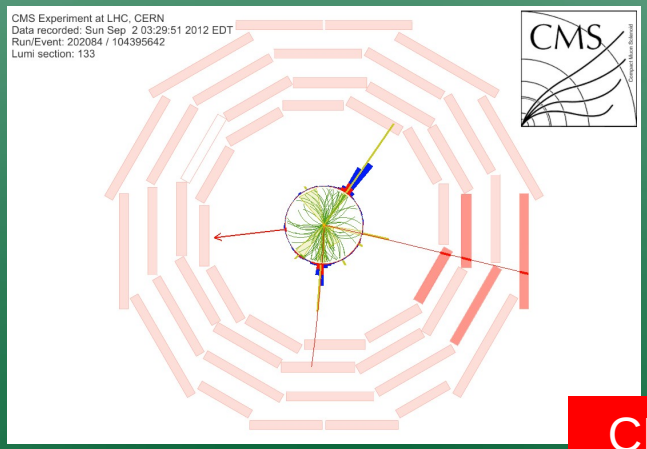
CMS 19.6fb^{-1}@8TeV
CMS-PAS-B2G-12-012

Leptoquarks

- Second generation scalar leptoquark
  - Two muons and at least two jets
  - One muon, at least two jets and missing energy
- Third generation leptoquark
  - b-jet and τ lepton
  - Pair production assumed
    - One τ decaying hadronically, the other leptonically
    - One lepton (e or μ), large missing energy, 2 jets

Second generation



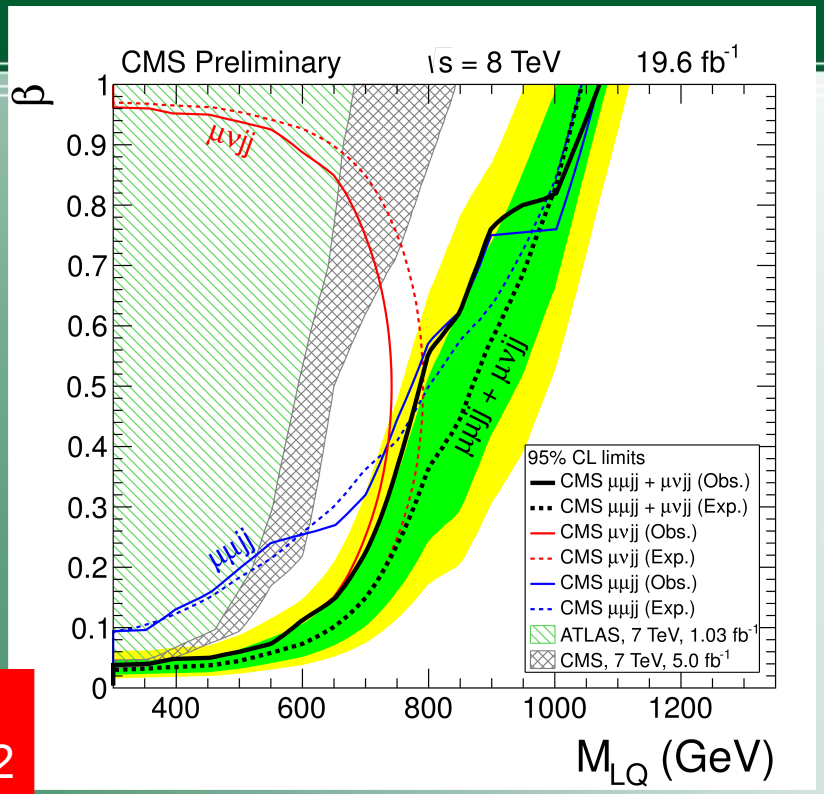


Channels:

$\mu\mu$ + ≥2jets

μ + E_T + ≥2jets

CMS 19.6fb^{-1}@8TeV
CMS-PAS-EXO-12-042

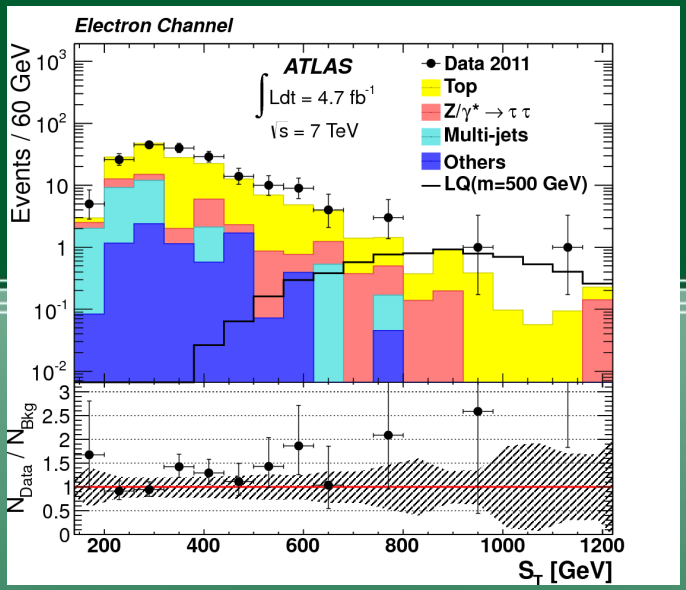


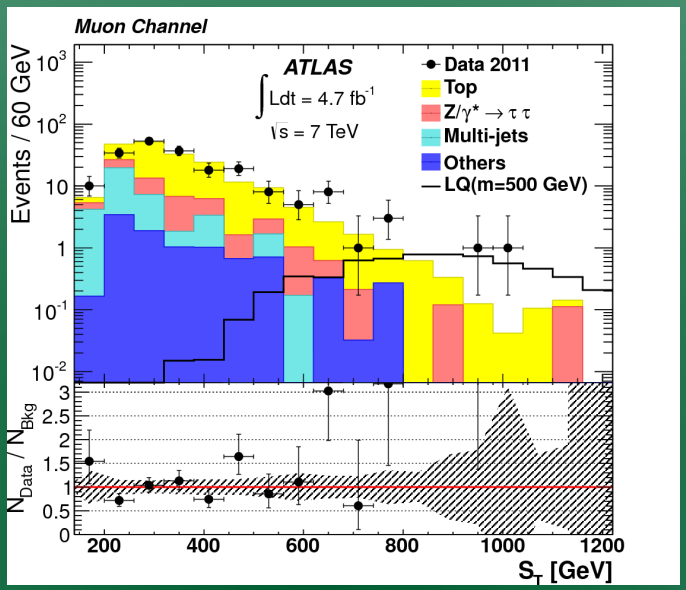
Assuming BR(LQ→μq)=100% (50%)
M_{LQ}<1070 (785) GeV

Assuming BR(LQ→μq)=100% (50%)
M_{LQ}<685 (594) GeV

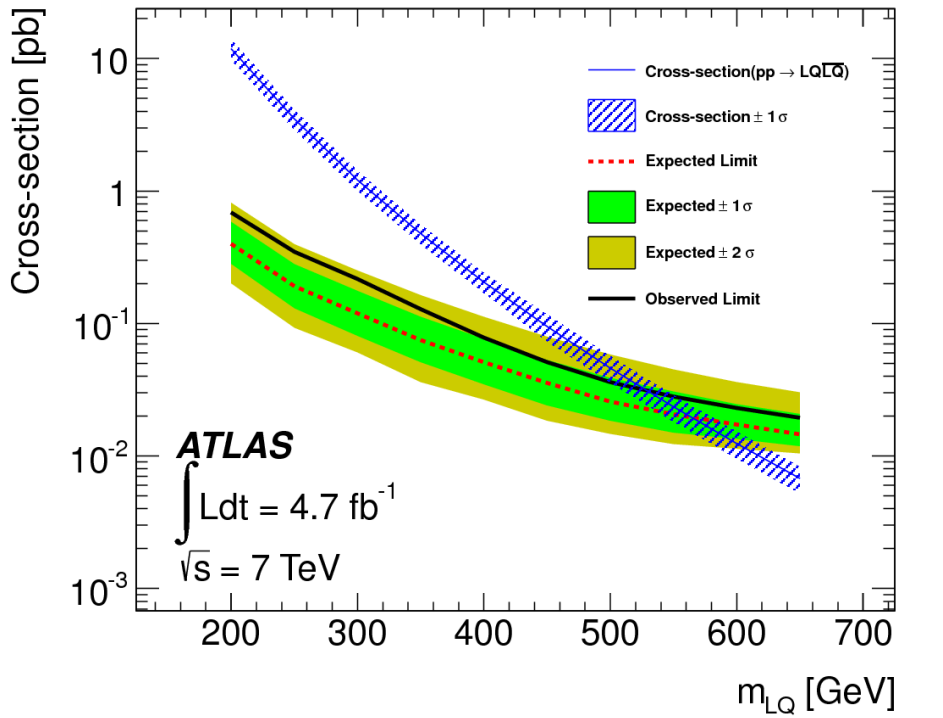
ATLAS 1.03fb^{-1}@7TeV
EPJ C72 (2012) 2151

Third generation





ATLAS 4.7fb^{-1}@7TeV arXiv:1303.0526



Assuming BR(LQ → τb)=100% : M_{LQ}<534 GeV

Assuming BR(LQ → τb)=100% : M_{LQ}<525 GeV
Assuming SU(5) vector leptoquarks : M_{VLQ}<760 GeV

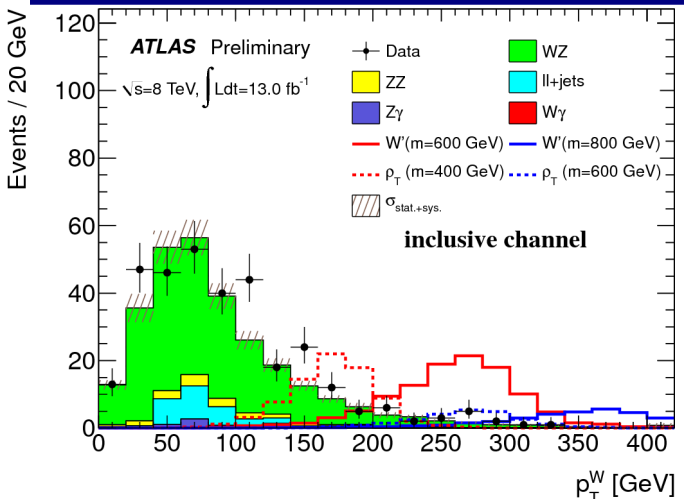
CMS 4.8fb^{-1}@7TeV
10.1007/JHEP12(2012)055

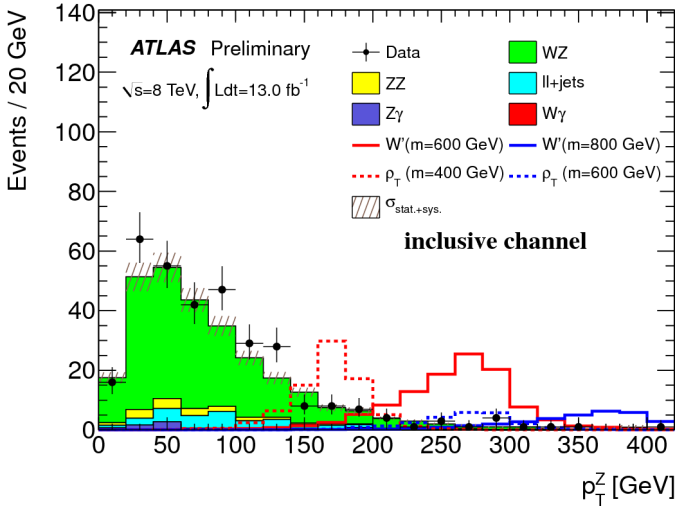
Technicolor

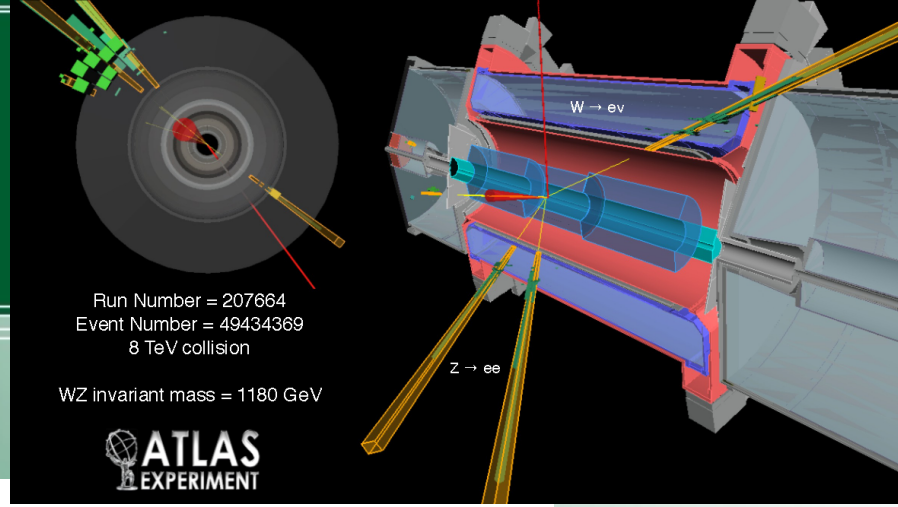
- Resonant WZ
  - Low Scale Technicolor (LSCT) viable option for EWSB
  - Narrow widths technimesons to WZ
  - Lightest vector technirho, axial-vector techni-a
  - Specific assumptions on mass hierarchy and mixing with electroweak gauge bosons
- Leptophobic topcolor, narrow resonance Z'
  - BR($Z' \rightarrow t\bar{t}$)=33% for masses > 700 GeV

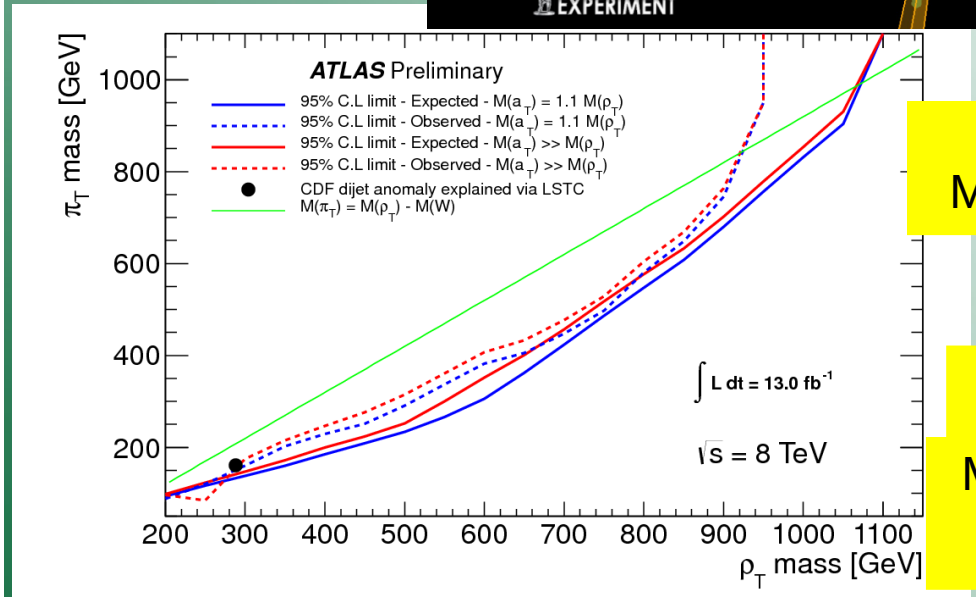
Resonant WZ → lvll

ATLAS 13fb^{-1}@8TeV ATLAS-CONF-2013-015









WZ → lvll
$M_{W'}$<1180 GeV

M_{ρ_T}<920 GeV

$M_{\rho_T} = M_{\pi_T} + M_W$

sinχ =1/3

CMS 5fb^{-1}@7TeV
10.1103/PhysRevLett.109.141801

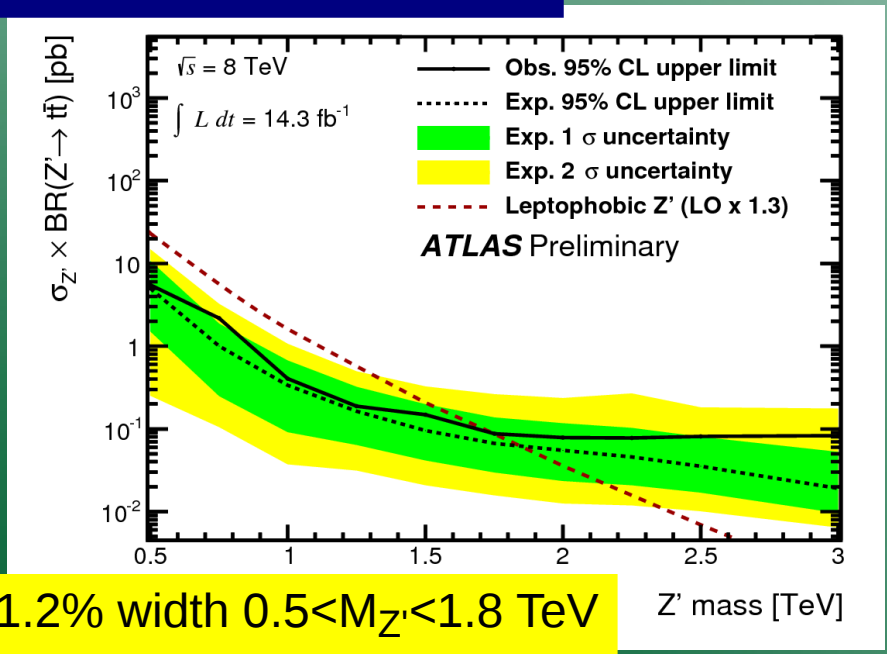
Assuming M_{π_T}=3/4M_{ρ_T}-25GeV : 167<M_{ρ_T}<687 GeV

Assuming M_{ρ_T}<M_{π_T}+M_W : 180<M_{ρ_T}<938 GeV

Serg

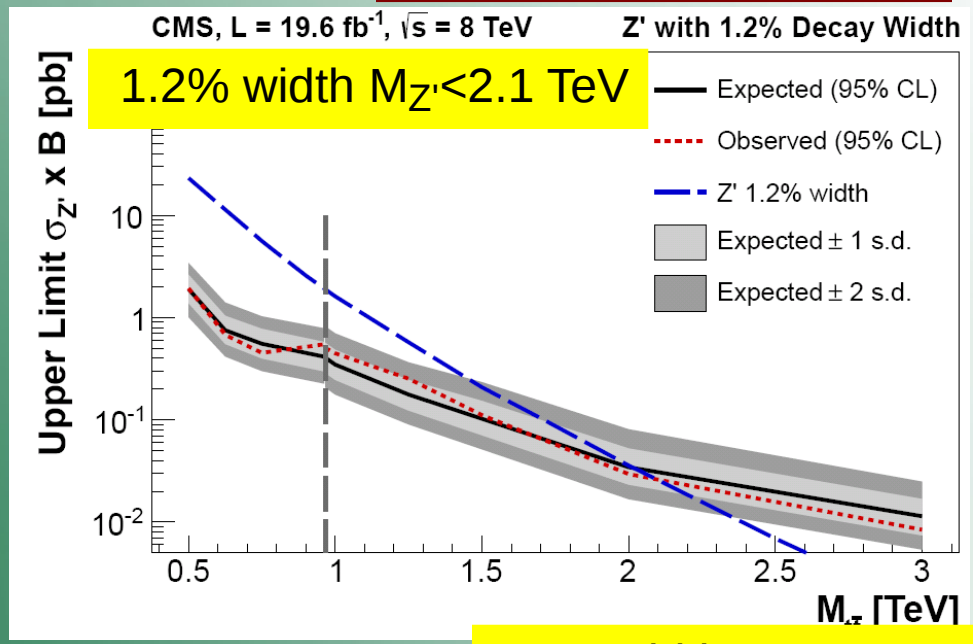
topcolor (l+jets)

ATLAS 14fb^{-1}@8TeV
ATLAS-CONF-2013-052



1.2% width 0.5<$M_{Z'}$<1.8 TeV

CMS 19.6fb^{-1}@8TeV
CMS-PAS-B2G-12-006

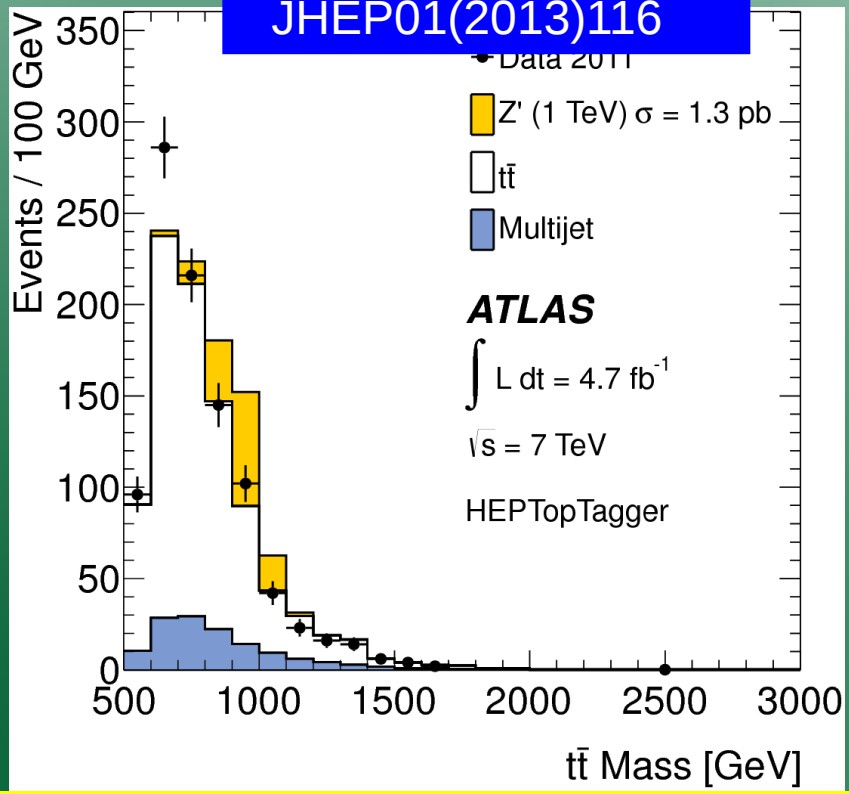


1.2% width $M_{Z'}$<2.1 TeV

10% width $M_{Z'}$<2.7 TeV

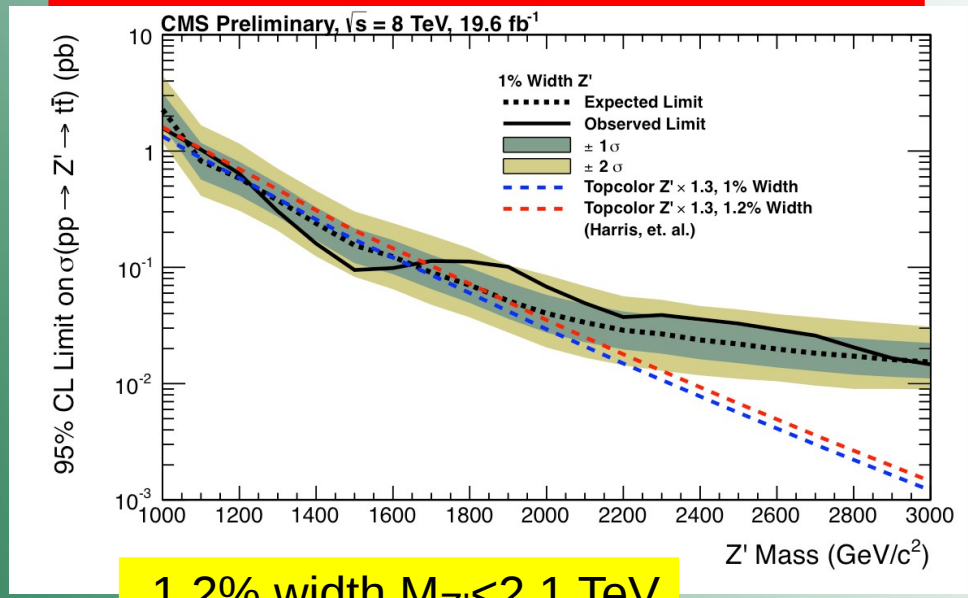
topcolor (all hadronic)

ATLAS 4.7fb^{-1}@7TeV
JHEP01(2013)116



1.2% width 0.7<$M_{Z'}$<1 TeV, 1.28<$M_{Z'}$<1.32 TeV

CMS-PAS-B2G-12-005 19.6fb^{-1}@8TeV



1.2% width $M_{Z'}$<2.1 TeV

10% width $M_{Z'}$<2.7 TeV

Conclusions

- ATLAS and CMS are running many searches in different channels
  - Presented last results on extra-dimensions, leptoquarks and technicolors
  - No evidence of new signal after SM was observed
- Full 2011-2012 dataset not yet fully exploited
  - Stay tuned for next results, while waiting for the restart after the first long shutdown!

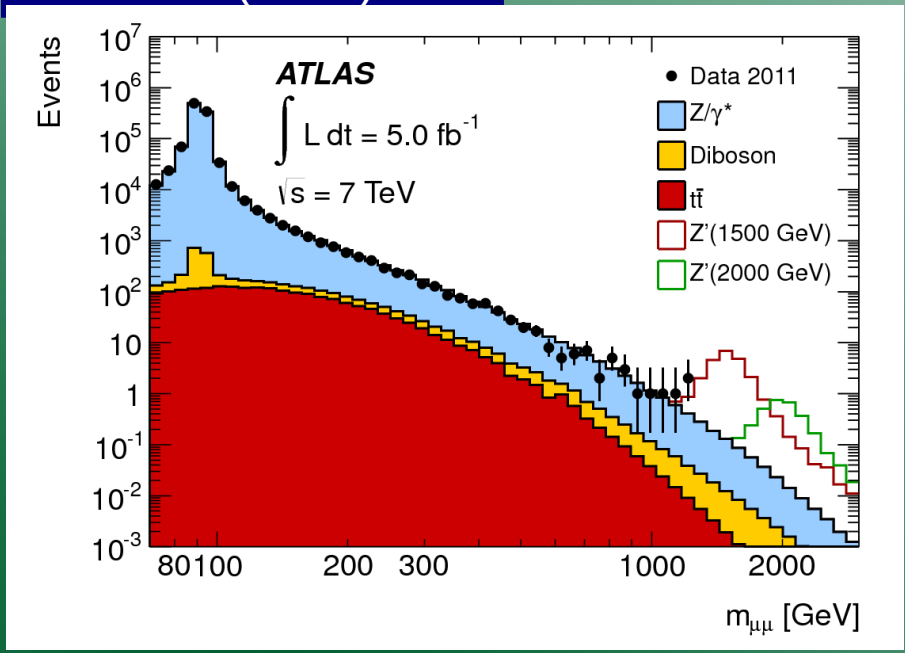
References

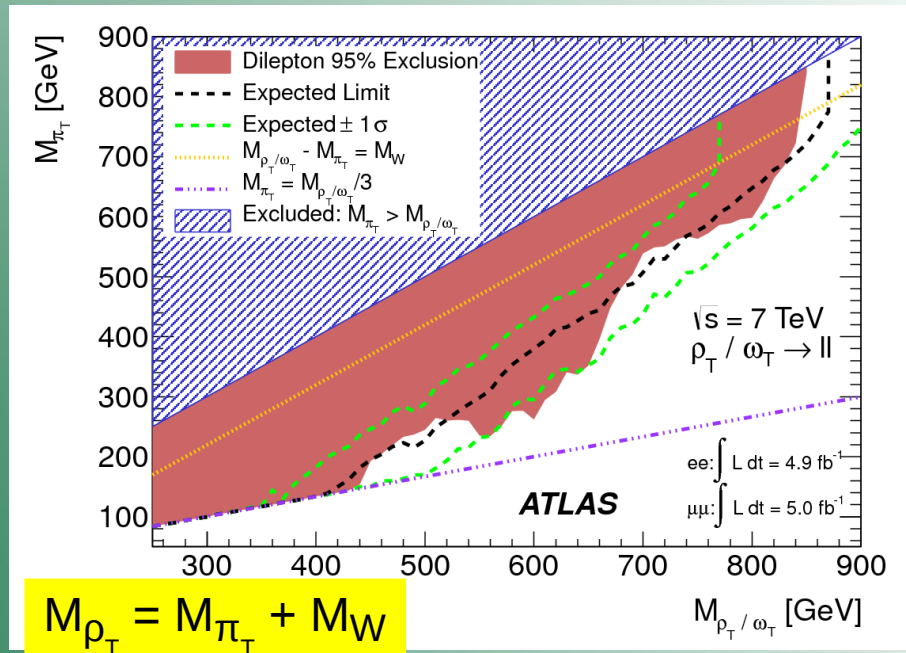
- arXiv:1305.0125
- 10.1016/j.physletb.2012.11.063
- ATLAS-CONF-2012-150
- ATLAS-CONF-2013-017
- 10.1016/j.physletb.2013.02.003
- CMS-PAS-EXO-12-048
- arXiv:1210.4491
- arXiv:1303.5338
- CMS-PAS-EXO-12-023
- arXiv:1305.2756
- CMS-PAS-EXO-11-093
- ATLAS-CONF-2013-051
- ATLAS-CONF-2013-051
- CMS-PAS-B2G-12-012
- CMS-PAS-EXO-12-042
- EPJ C72 (2012) 2151
- arXiv:1303.0526
- 10.1007/JHEP12(2012)055
- ATLAS-CONF-2013-015
- 10.1103/PhysRevLett.109.141801
- arXiv:1305.2756
- CMS-PAS-EXO-11-093
- JHEP11(2012)138
- CMS-PAS-EXO-12-061

Backup

LSCT limits in dilepton

ATLAS 4.9fb^{-1}@7TeV
JHEP11(2012)138





M$_{\rho_T}$ = M$_{\pi_T}$ + M$_W$

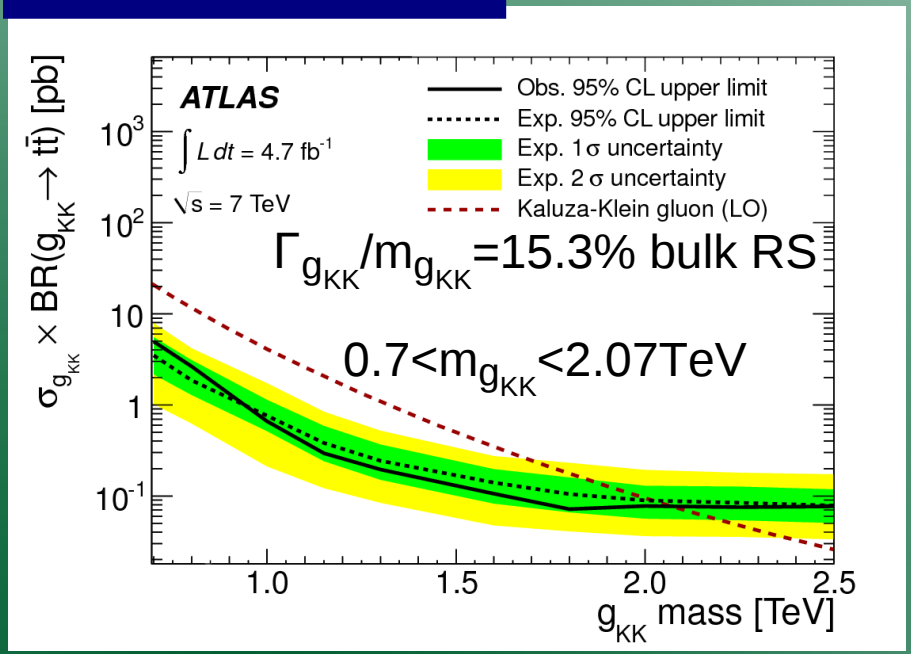
M$_{\rho_T}$<85LSCT0 GeV

Different models

CMS 20.6fb^{-1}@8TeV
CMS-PAS-EXO-12-061

KK resonances in $t\bar{t}$

ATLAS 4.7fb^{-1}@7TeV
arXiv:1305.2756



ATLAS-CONF-2013-052 14fb^{-1}@8TeV