

## Leptons

$e, \mu, \tau$   
 $\nu_e, \nu_\mu, \nu_\tau$

## Quarks

# Experimental summary of the EWK session



Maxime Gouzevitch, Anna Kaczmarska,  
Milada Mühlleitner, Krzysztof Turzynski

# EWK session

## Tuesday 29.04 morning

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**8 contributions (3 theory + 5 experimental):** T. Kasprzyk, E.-S. Protopapadaki, B. Zhou, M. Gouzevitch, M. Rauch, R. Bellan, M. Luszczak, J. Fischer

**Measurements covered in this session:**

- **VV production at LHC:**
  - SM production
  - $\alpha$ TGC
  - $H \rightarrow VV$  searches/measurements and interplay with SM backgrounds
  - EWK production of Z boson
- **VVV and EWK scattering:**
  - First look into EWK scattering:  $WWWW$
  - First look on VVV production:  $WV\gamma$
  - $\alpha$ QGC
  - Interplay between EWSB mechanism and  $VV \rightarrow VV$  unitarisation

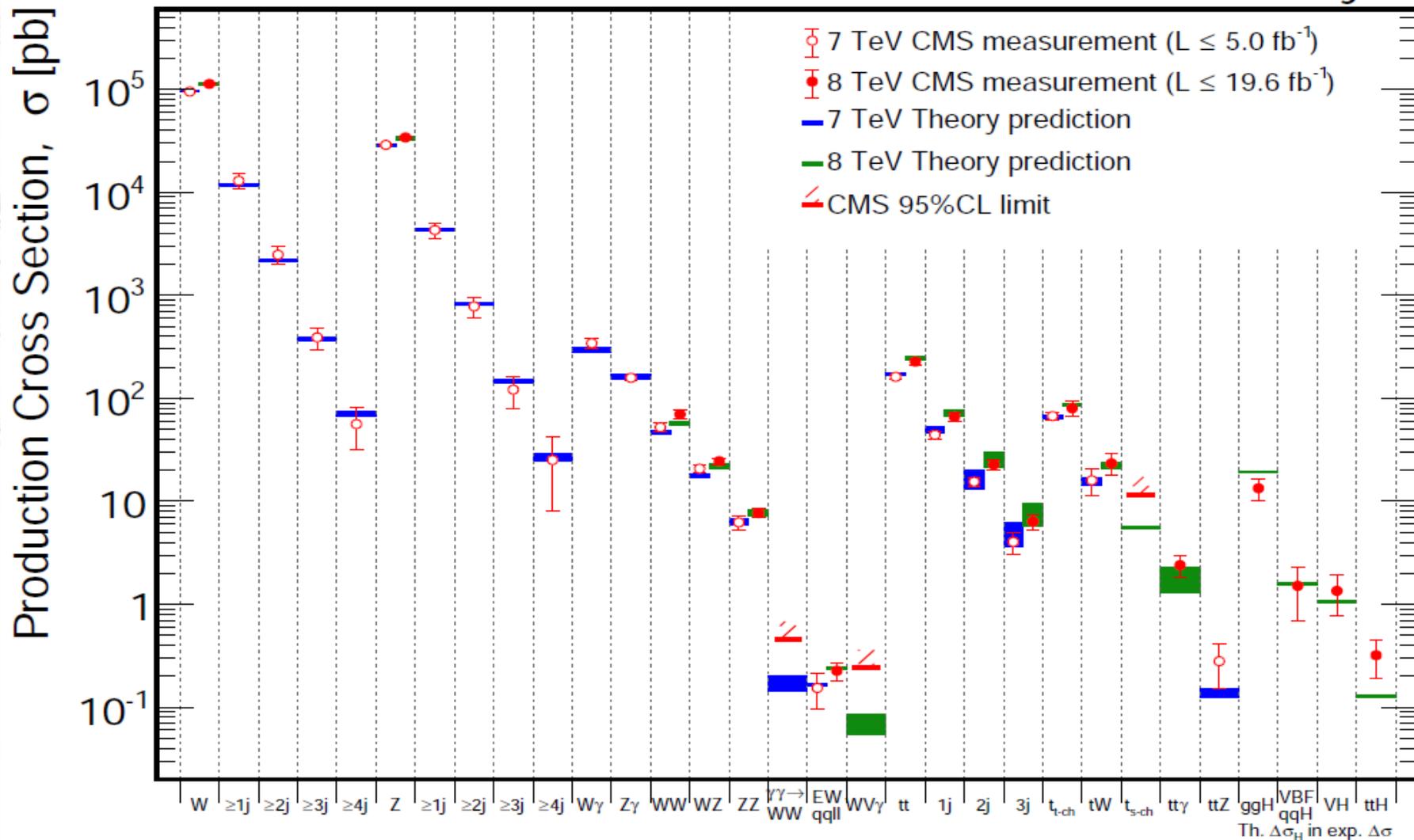
**We show the most recent and tantalising results and invite you to look into the talks for more details**

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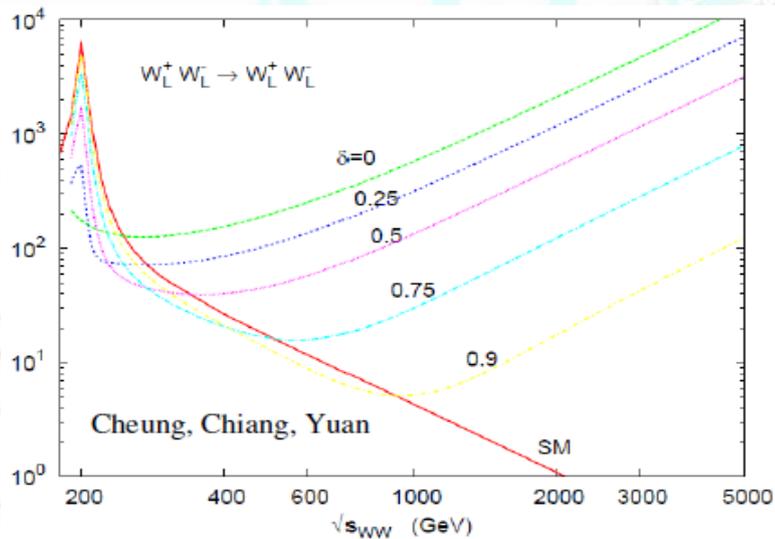
# Stairway to Hell

Feb 2014

CMS Preliminary

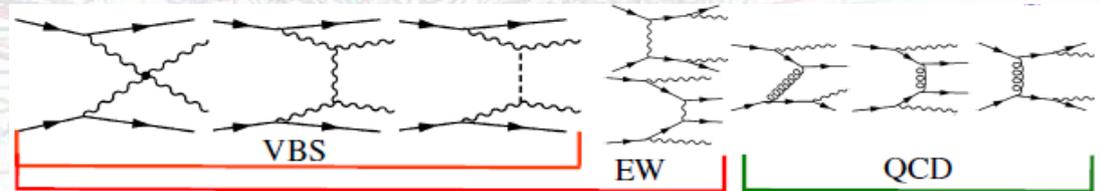


# Evidence of VV EWK scattering

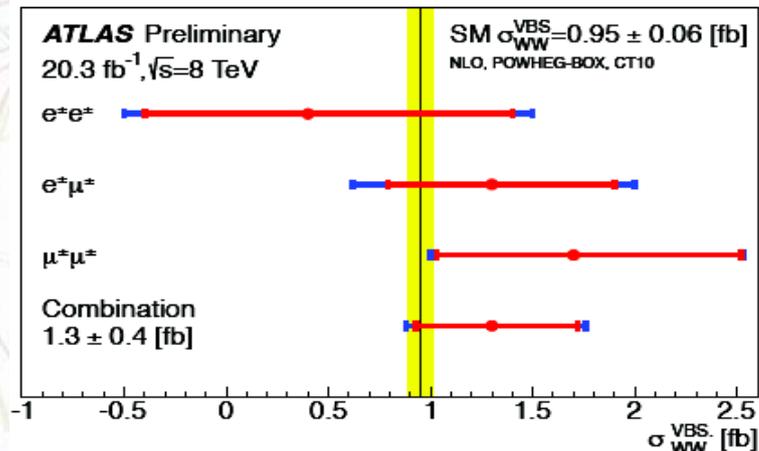
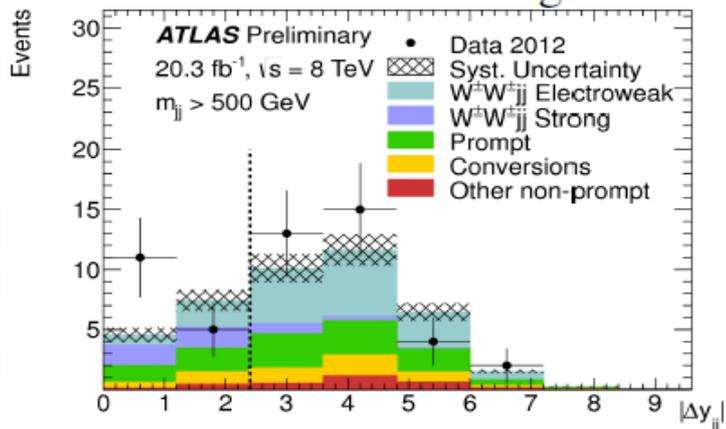


- Higgs mechanism unitarise the deviations in  $VV \rightarrow VV$  scattering.
- No enough statistics in Run I to measure it.
- But we can extract an evidence of the EWK scattering.

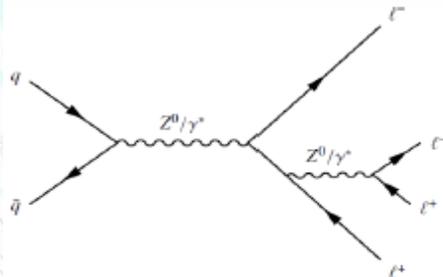
- $M_{jj} > 500$  GeV
- VBS region:  
Additional  $|\Delta\eta_{jj}| > 2.4$



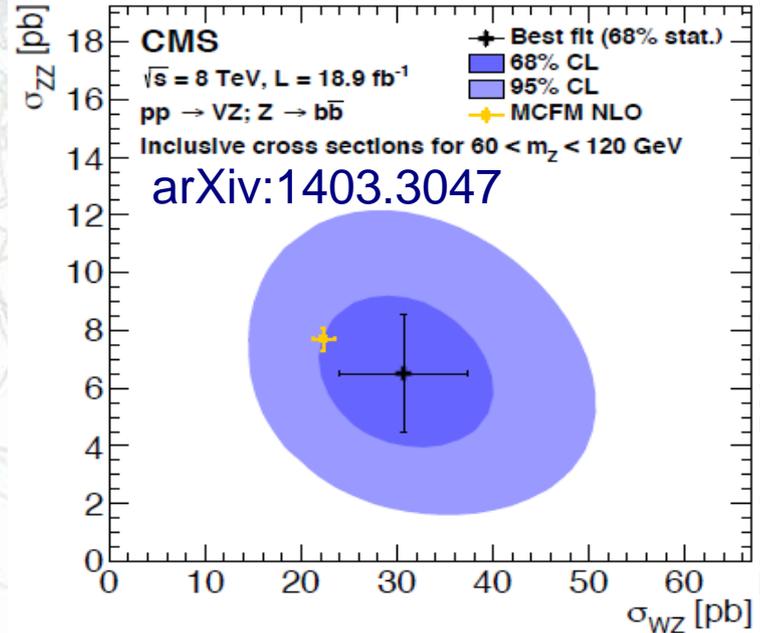
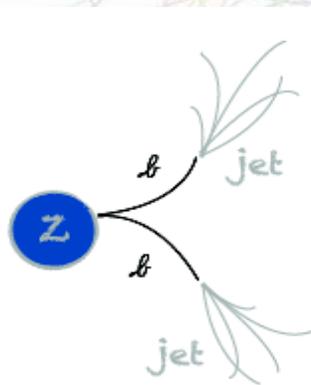
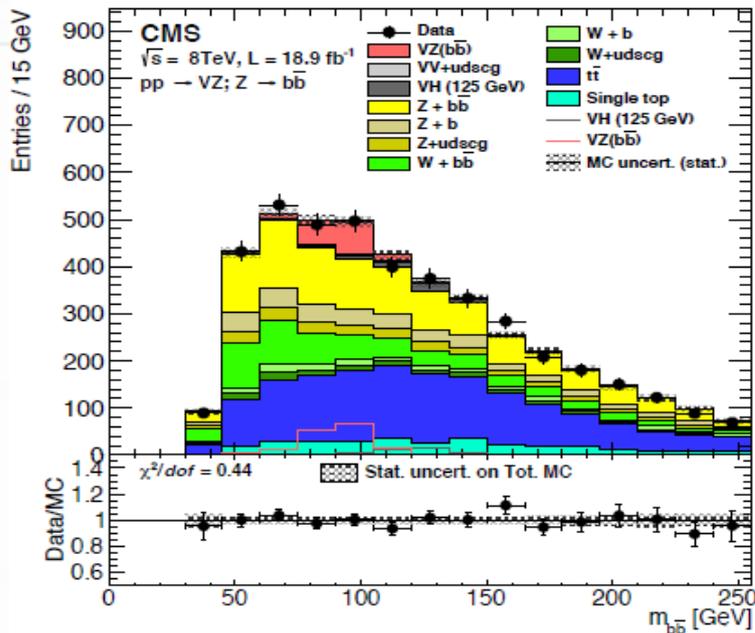
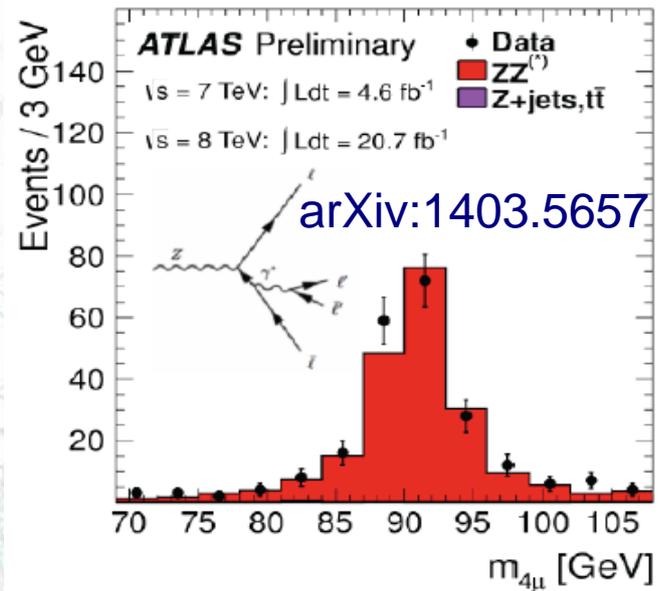
## VBS enriched region



# Experimentally complex BF of Z boson



- Z boson massive neutral particle like Higgs. Similar final states. Support Higgs discoveries.
- First Observation of  $Z \rightarrow 4l$  decay.
- First Observation of  $Z \rightarrow b\bar{b}$  in hadron colliders.



# Higgs session

## Wednesday 30.04 afternoon

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**8 contributions (4 theory + 7 experimental):** V. Sanz, N. Venturi, L. Finco, T. Baroncelli, J. M. Vizan Garcia, P. Jiang, J. Baglio, A. Massorini, T. Du Pree, D. Sidorov, R. Santos

**Measurements covered in this session:**

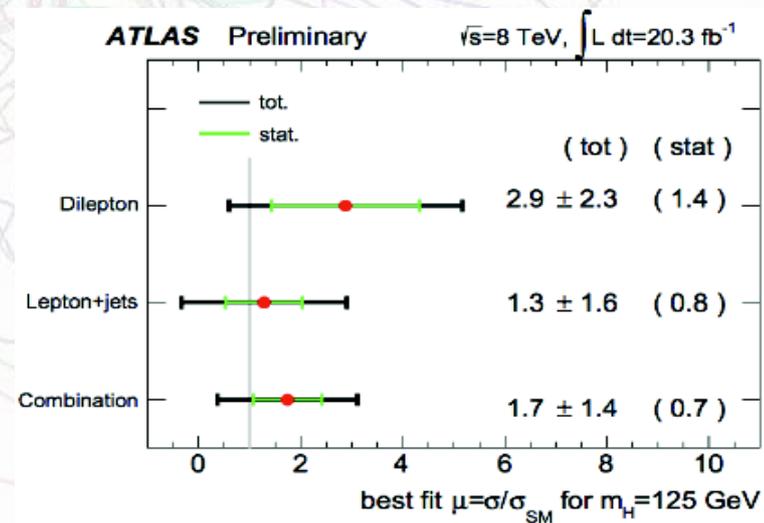
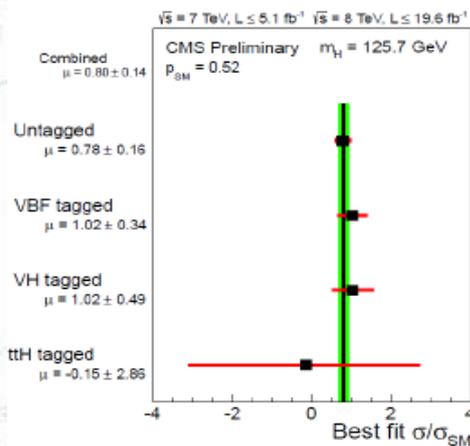
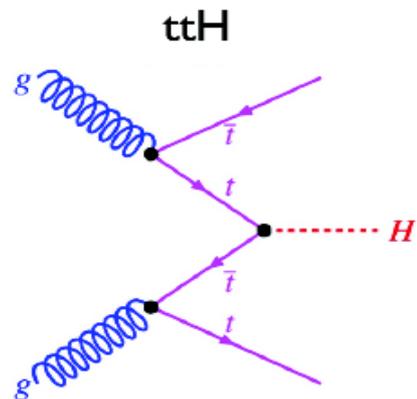
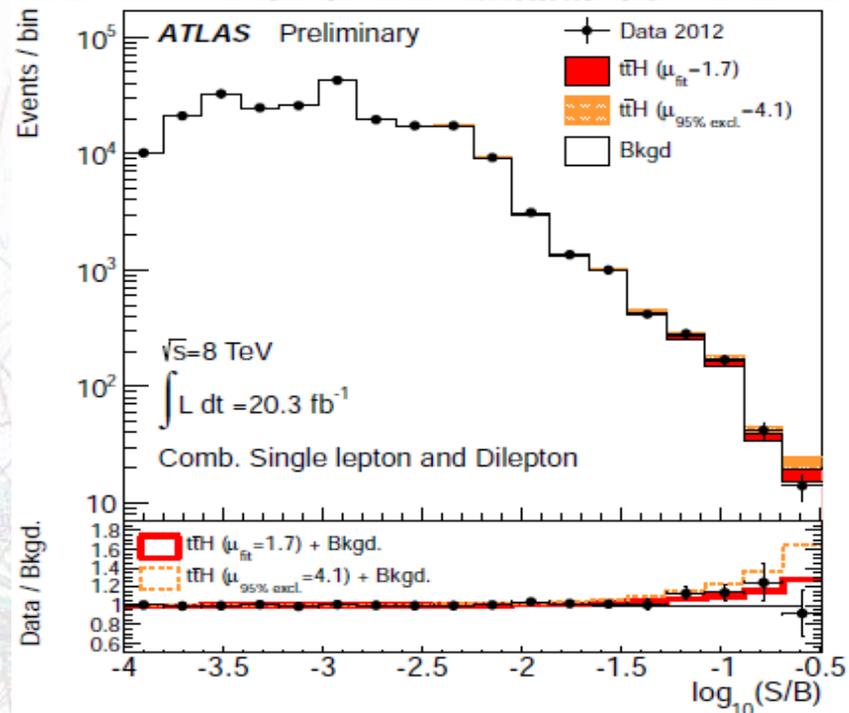
- Higgs properties:
  - General fits CMS/ATLAS
  - Higgs coupling to fermions: CMS/ATLAS
- Search for Exotic Higgs models:
  - CMS/ATLAS

**We show the most recent and tantalising results and invite you to look into the talks for more details**

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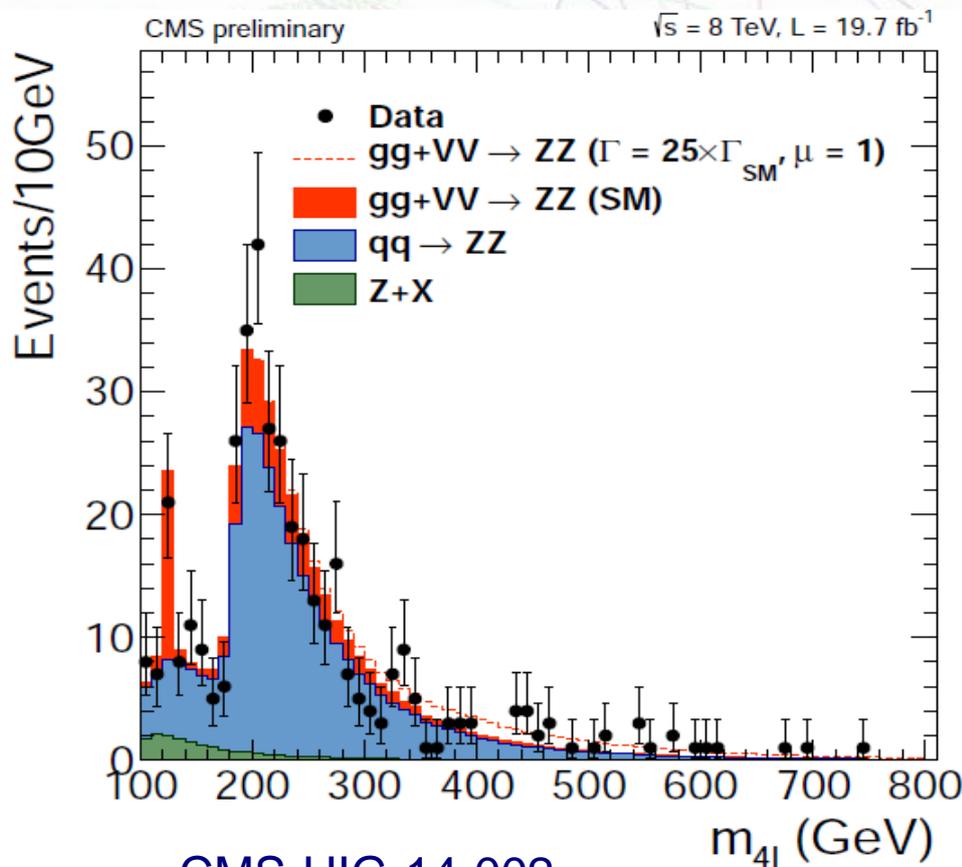
# ttH

- Higgs production mechanisms starts to be well constraint.
- ttH is the direct way to measure top-Higgs coupling
- It is still the most challenging due to its small cross section

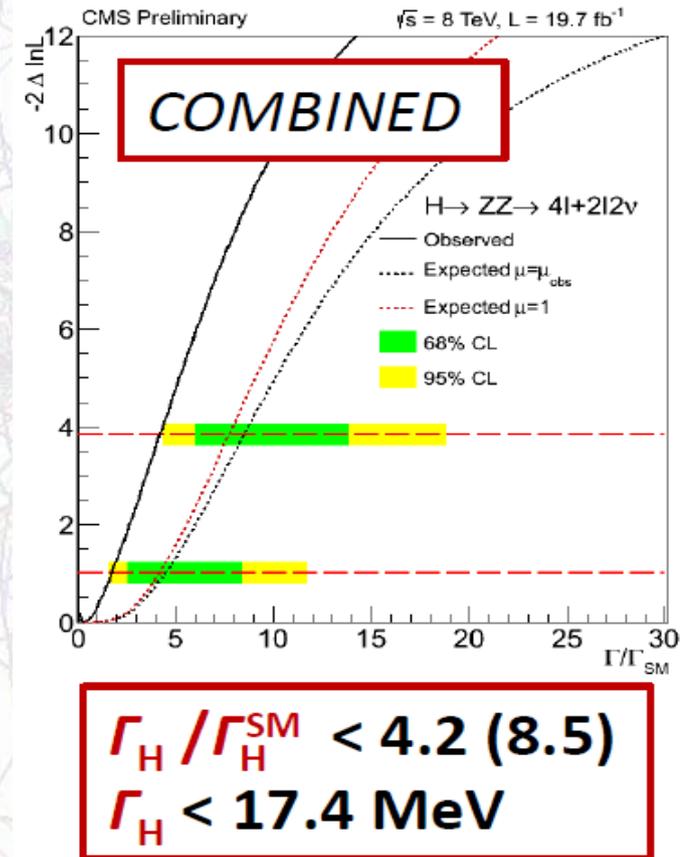


# Higgs width measurement

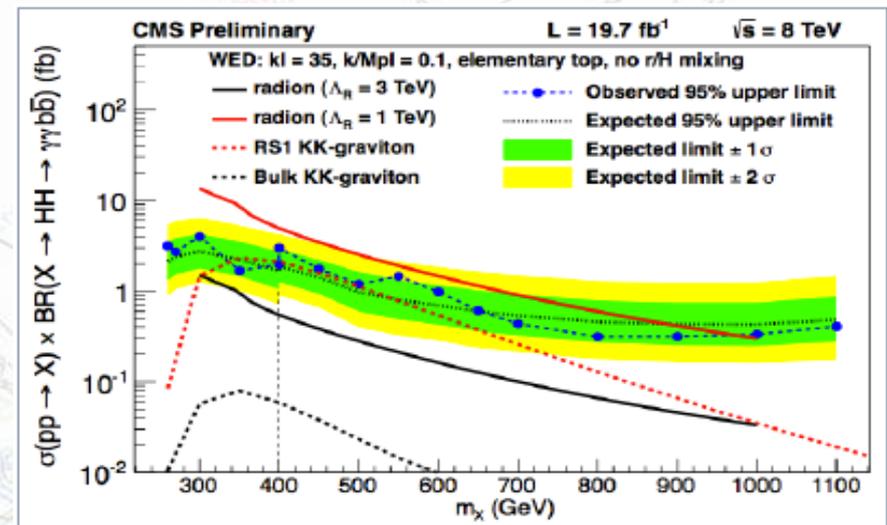
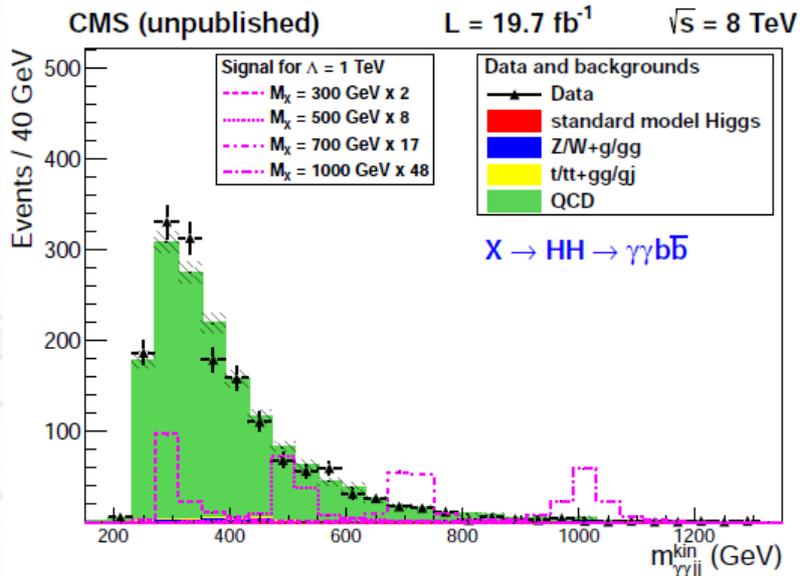
- Higgs has a (small) width: only 4 MeV impossible to measure given the small statistics
- Higgs couples to mass: right tail of the BW is enhanced when ZZ channel opens.



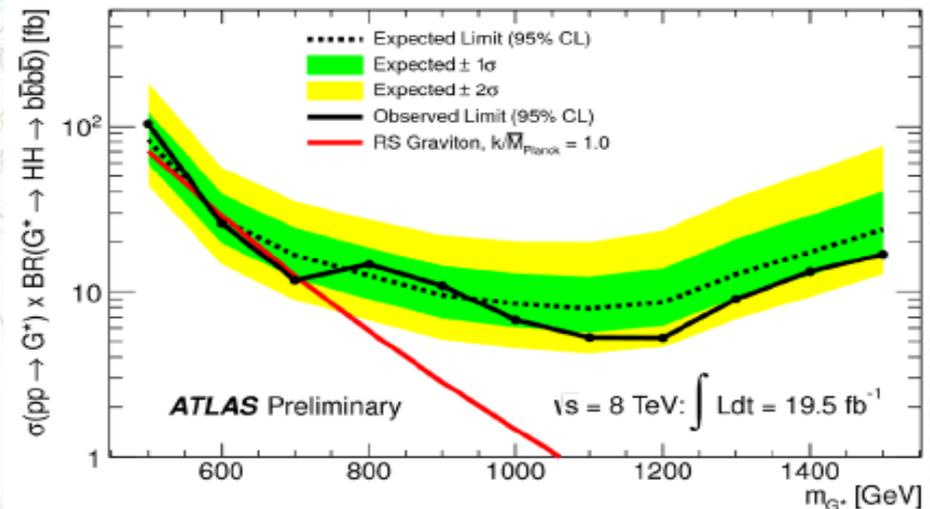
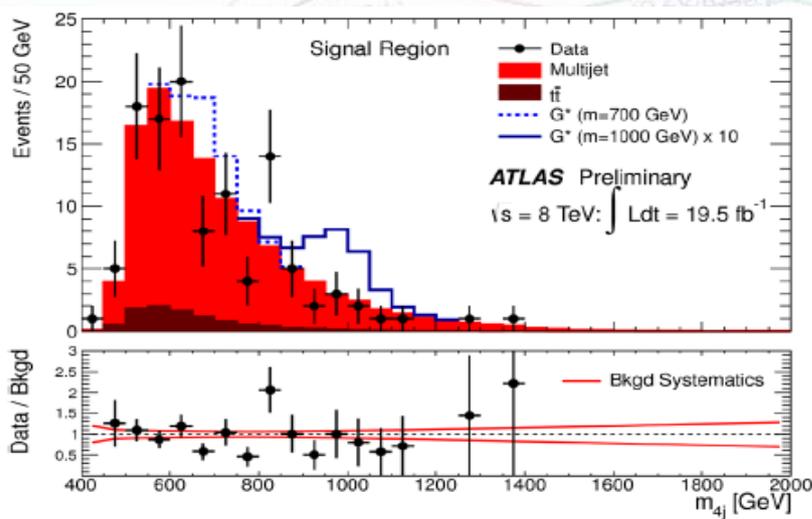
CMS-HIG-14-002



# Resonant HH production



CMS-HIG-13-032



ATLAS-CONF-2014-005

# Exotica searches session

## Thursday 01.05 morning (1)

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**8 contributions (3 theory + 5 experimental):** S. Gupta, A. Saha, M. Mozer, G. Busoni, Ki-Young Choi, A. C. Gonzalez, O. Igonkina, T. Peiffer

**Searches covered in this session:**

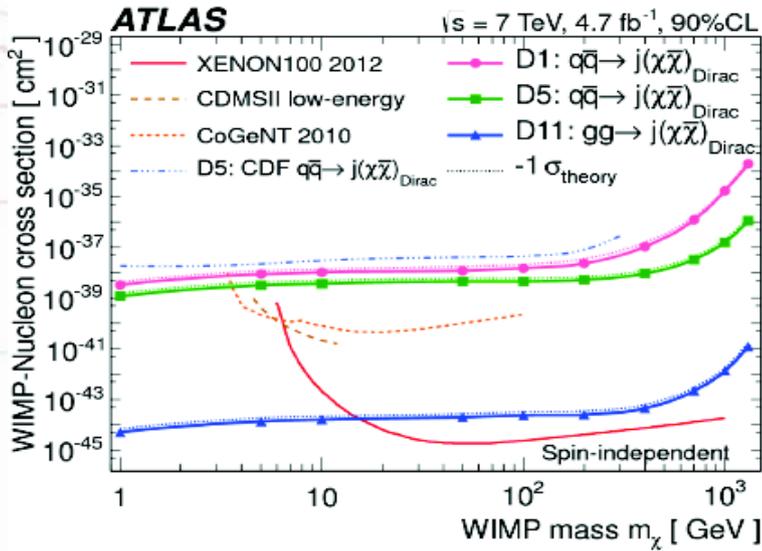
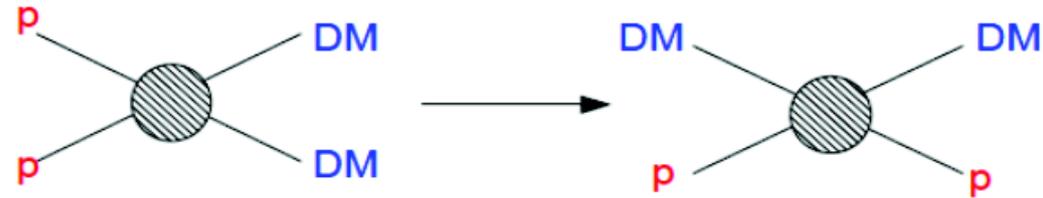
- heavy resonances
- di-leptons and lepton+MET
- di-bosons
  - extra dimensions, new strong Sector (technicolor, Little Higgs etc.)
- excited quarks
- leptoquarks
- mono-X
- mono-jets, mono-photons, mono-W/Z
- Dark Matter, Large Extra Dimensions, SUSY, Higgs to invisible particles
- vector-like quarks,  $t\bar{t}$  resonances and  $W'$  to  $t\bar{b}$
- topcolor  $Z'$ , Kaluza Klein excitations, heavy Higgs, Little Higgs models, technicolor, extra dimensions
- multiple leptons
- excited leptons, LRSM, WR, heavy neutrinos, heavy fermion triplet

**Again we pick out only a few results today, and refer you to the talks in the session for more details**

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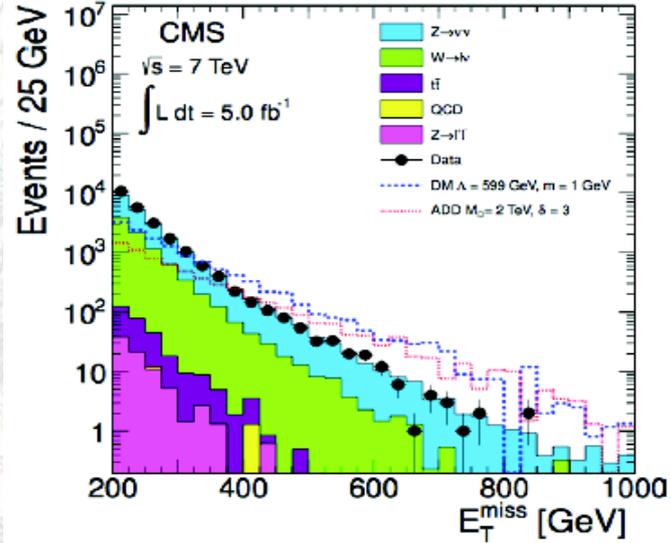
# Dark matter constraints from Hadron colliders

- Mono-X (jet, photon, V) is reinterpreted for the DM search.
- Under EFT approximation those results can be compared with direct WIMP searches.



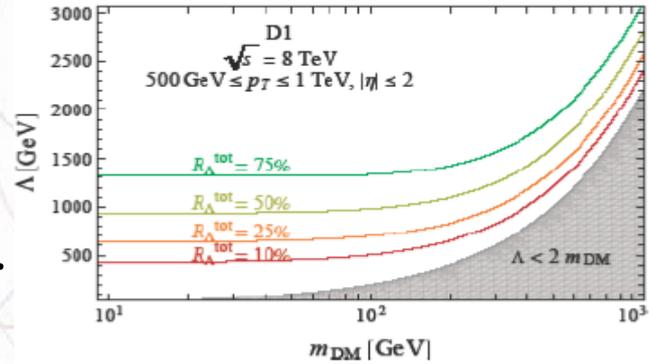
JHEP 09 (2012) 94

JHEP 04 (2013) 75



$$g^2 \frac{-i}{Q_{transf}^2 - M^2} = \frac{ig^2}{M^2} \left( 1 + \frac{Q_{transf}^2}{M^2} + \left( \frac{Q_{transf}^2}{M^2} \right)^2 + \dots \right) \sim \frac{i}{\Lambda^2}$$

- Approximation valid only if  $Q_{transf}^2 \ll M^2$
- It can be valid for many events but not for all.

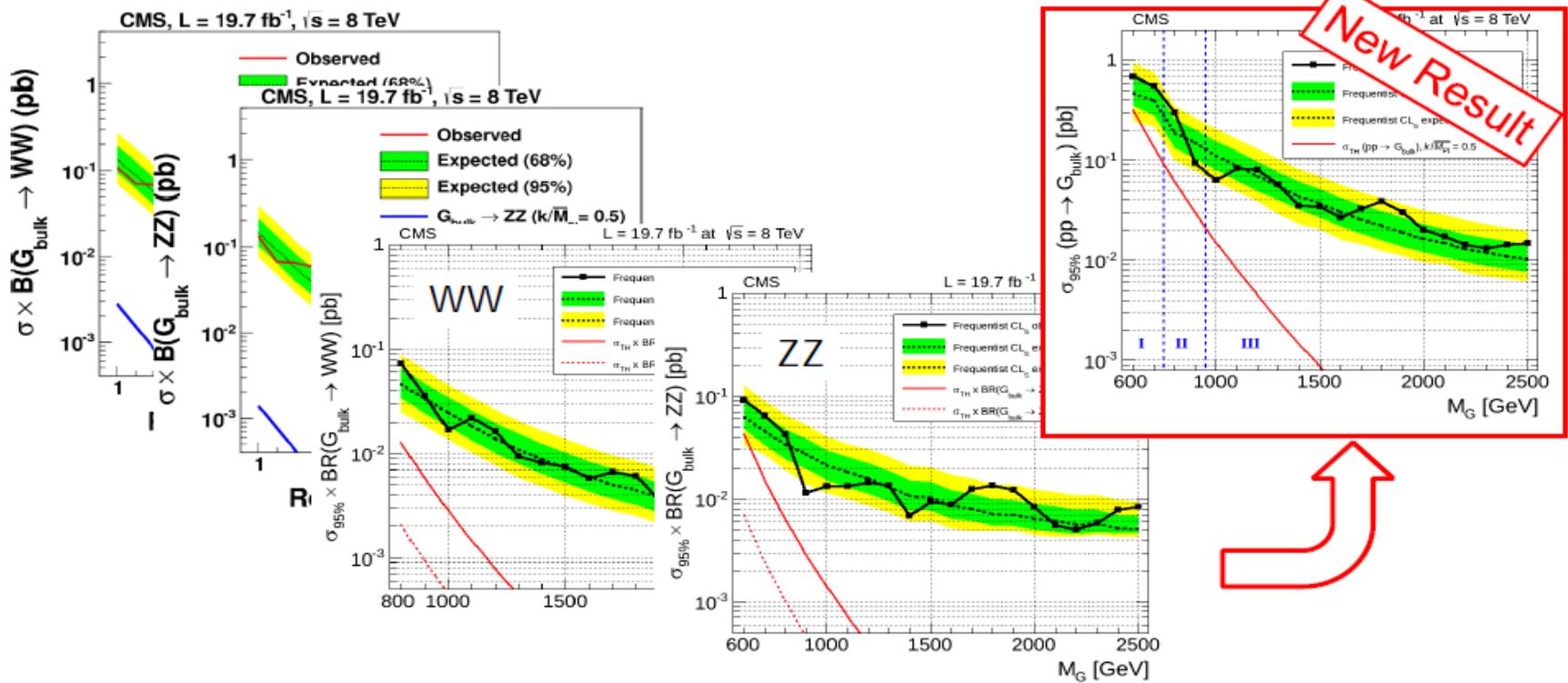
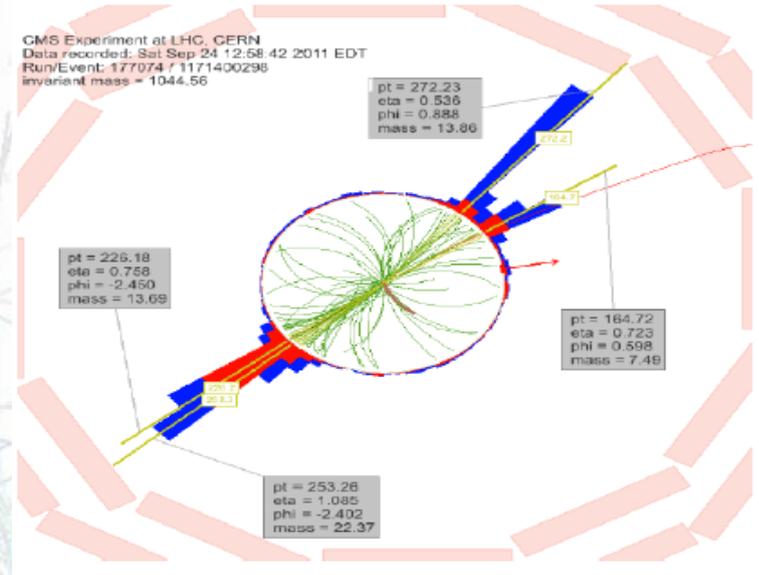
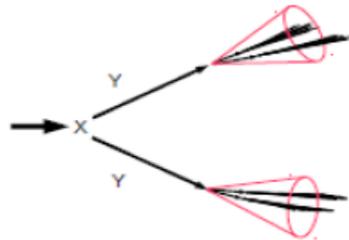


$$R_{\Lambda}^{tot} = \frac{\sigma_{eff}|_{Q_{transf} < \Lambda}}{\sigma_{eff}}$$

Busoni

# VV searches

- Bump searches in VV final state.
- Model coupling preferentially to vector bosons
- Not excluded by precise loop measurements
- Substructure technique used above TeV



[CMS EXO-13-009]

# SUSY searches session

## Wednesday 30.04 morning

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**10 contributions (3 theory + 7 experimental):** S. Henrot-Versille, R. Nagai, H. Bakhshiansohi, T. Gillam, N. Saoulidou, E. Popena, A. Kalogeropoulos, S. Guy Muanza, S. Vallecorsa, B. Dumont

### Searches covered in this session:

- **Strong production (1st+2nd generation squarks and gluinos)**
- dominated by inclusive searches
- many SUSY models e.g. MSUGRA/ CMSSM dominated by strong production
- **Strong production 3rd generation squarks**
- smaller cross sections
- motivation from natural SUSY
- **EW production**
- if colored SUSY particles are too heavy, electroweak production can be dominant SUSY production mechanism at the LHC
- **Long-lived particles and R-parity violating scenarios**
- experimentally challenging

**Many interesting results shown, usually several analyses in one talk.**

**It is difficult to give a comprehensive summary in short time...**

**We pick out only a few today, and refer you to the talks in the session for more results.**

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# SUSY searches

- A variety of **inclusive SUSY searches** successfully deployed
- No indication of super-partners
- Naturalness and simplified SUSY models under constraint
- Searches now goes into: RPV, EWKinos, sleptons, stop, low splitting.

## 0-Lepton Inclusive Search

### ATLAS SUSY Searches\* - 95% CL Lower Limits

Status: Moriond 2014

LSP mass [GeV]

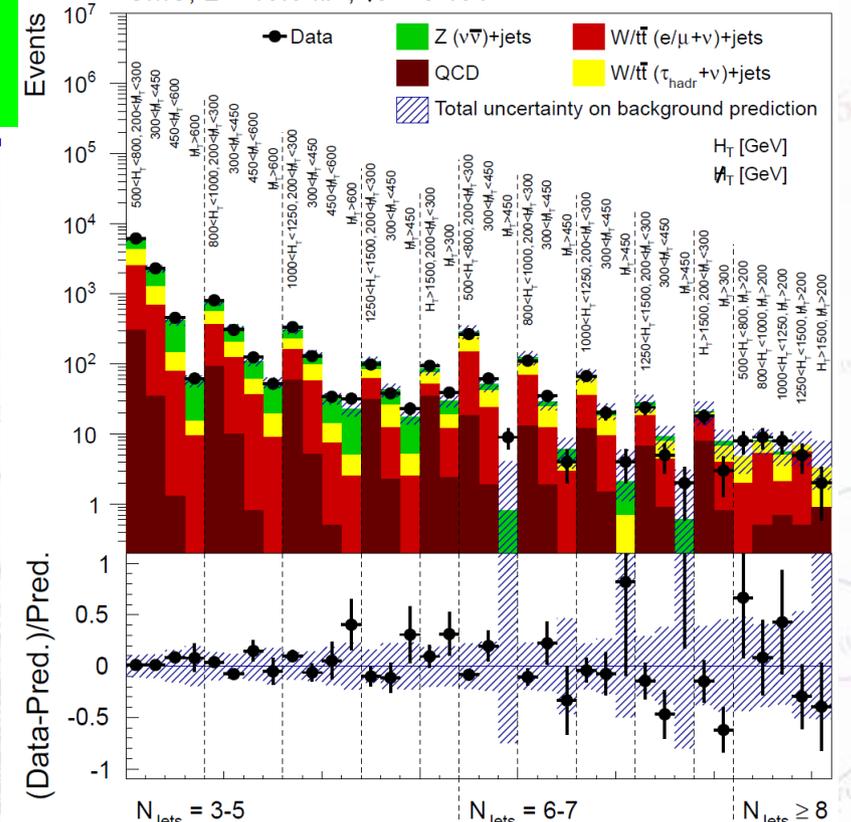
Model	$e, \mu, \tau, \gamma$	Jets	$E_T^{\text{miss}}$	$\int \mathcal{L} dt [\text{fb}^{-1}]$	Mass limit	Reference
<b>Long-lived particles</b>	Direct $\tilde{\chi}_1^+ \tilde{\chi}_1^-$ prod., long-lived $\tilde{\chi}_1^\pm$	Disapp. trk	1 jet	Yes	20.3	$\tilde{\chi}_1^\pm$ 270 GeV
	Stable, stopped $\tilde{g}$ R-hadron	0	1-5 jets	Yes	22.9	$\tilde{g}$ 832 GeV
	GMSB, stable $\tilde{\tau}, \tilde{\chi}_1^0 \rightarrow \tilde{\tau}(\tilde{\nu}, \tilde{\mu}) + \tau(e, \mu)$	1-2 $\mu$	-	-	15.9	$\tilde{\chi}_1^0$ 475 GeV
	GMSB, $\tilde{\chi}_1^0 \rightarrow \gamma \tilde{G}$ , long-lived $\tilde{\chi}_1^0$	2 $\gamma$	-	Yes	4.7	$\tilde{\chi}_1^0$ 230 GeV
	$q\bar{q}, \tilde{\chi}_1^0 \rightarrow q\bar{q}\mu$ (RPV)	1 $\mu$ , displ. vtx	-	-	20.3	$\tilde{q}$ 1.0 TeV
<b>RPV</b>	LFV $pp \rightarrow \tilde{\nu}_\tau + X, \tilde{\nu}_\tau \rightarrow e + \mu$	2 $e, \mu$	-	-	4.6	$\tilde{\nu}_\tau$ 1.61 TeV
	LFV $pp \rightarrow \tilde{\nu}_\tau + X, \tilde{\nu}_\tau \rightarrow e(\mu) + \tau$	1 $e, \mu + \tau$	-	-	4.6	$\tilde{\nu}_\tau$ 1.1 TeV
	Bilinear RPV CMSSM	1 $e, \mu$	7 jets	Yes	4.7	$\tilde{q}, \tilde{g}$ 1.2 TeV
	$\tilde{\chi}_1^+ \tilde{\chi}_1^-, \tilde{\chi}_1^+ \rightarrow W \tilde{\chi}_1^0, \tilde{\chi}_1^0 \rightarrow ee\tilde{\nu}_\mu, e\mu\tilde{\nu}_e$	4 $e, \mu$	-	Yes	20.7	$\tilde{\chi}_1^\pm$ 760 GeV
	$\tilde{\chi}_1^+ \tilde{\chi}_1^-, \tilde{\chi}_1^+ \rightarrow W \tilde{\chi}_1^0, \tilde{\chi}_1^0 \rightarrow \tau\tau\tilde{\nu}_e, e\tau\tilde{\nu}_\tau$	3 $e, \mu + \tau$	-	Yes	20.7	$\tilde{\chi}_1^\pm$ 350 GeV
	$\tilde{g} \rightarrow q\bar{q}q$	0	6-7 jets	-	20.3	$\tilde{g}$ 916 GeV
	$\tilde{g} \rightarrow \tilde{t}_1 t, \tilde{t}_1 \rightarrow b s$	2 $e, \mu$ (SS)	0-3 $b$	Yes	20.7	$\tilde{g}$ 880 GeV
<b>Other</b>	Scalar gluon pair, $\text{sgluon} \rightarrow q\bar{q}$	0	4 jets	-	4.6	sgluon 100-287 GeV
	Scalar gluon pair, $\text{sgluon} \rightarrow t\bar{t}$	2 $e, \mu$ (SS)	2 $b$	Yes	14.3	sgluon 350-800 GeV
	WIMP interaction (D5, Dirac $\chi$ )	0	mono-jet	Yes	10.5	$M^*$ scale 704 GeV

$\sqrt{s} = 7$  TeV full data     $\sqrt{s} = 8$  TeV partial data     $\sqrt{s} = 8$  TeV full data

gluino mass [GeV]

stop mass [GeV]

CMS, L = 19.5 fb<sup>-1</sup>,  $\sqrt{s} = 8$  TeV



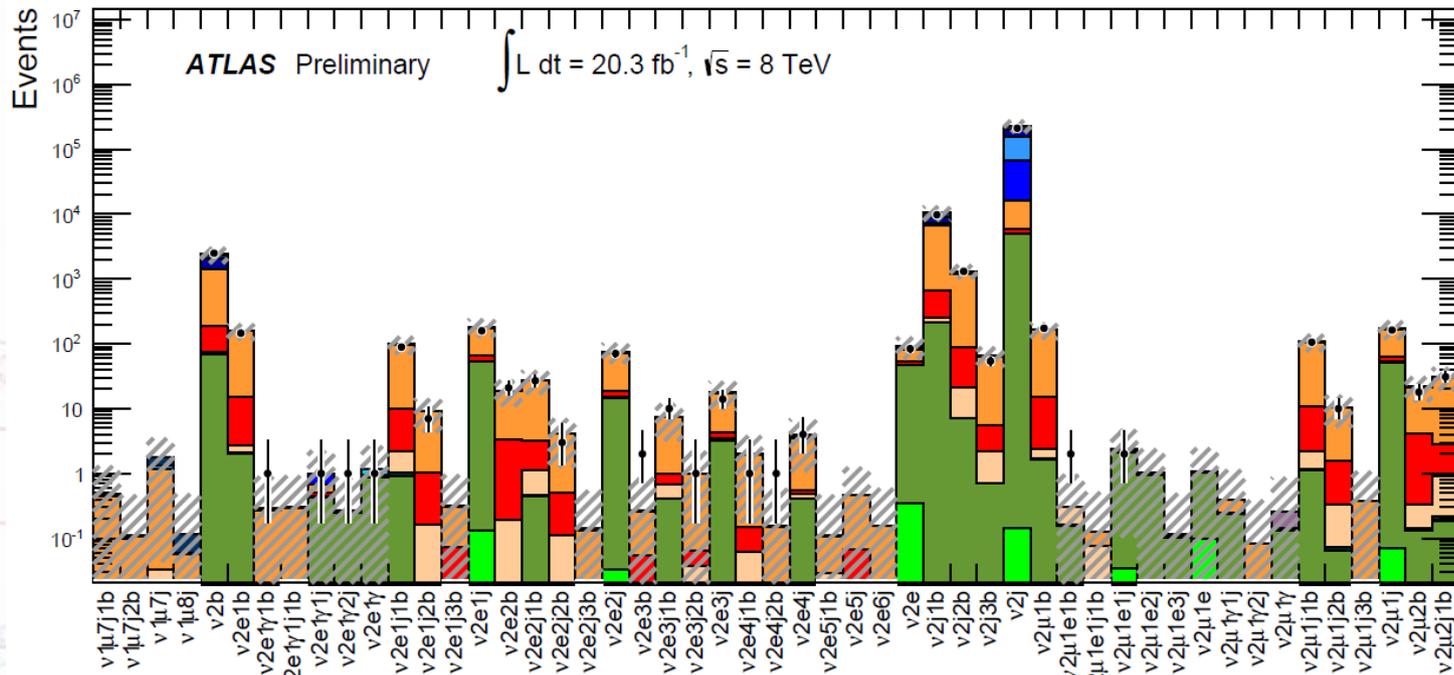
ATLAS Preliminary  
 $\int \mathcal{L} dt = (4.6 - 22.9) \text{ fb}^{-1}$      $\sqrt{s} = 7, 8$  TeV

Reference

$m(\tilde{\chi}_1^\pm) - m(\tilde{\chi}_1^0) = 160$  MeV,  $\tau(\tilde{\chi}_1^\pm) = 0.2$  ns  
 $m(\tilde{\chi}_1^0) = 100$  GeV,  $10 \mu\text{s} < \tau(\tilde{g}) < 1000$  s  
 $10 < \tan\beta < 50$   
 $0.4 < \tau(\tilde{\chi}_1^0) < 2$  ns  
 $1.5 < ct < 156$  mm,  $\text{BR}(\mu) = 1$ ,  $m(\tilde{\chi}_1^0) = 108$  GeV

1210.4826  
 ATLAS-CONF-2013-051  
 ATLAS-CONF-2012-147

# Generic searches



## Inclusive SUSY searches: General Search

- Purely discovery analysis
- Select most discrepant part of each channel
  - 697 exclusive channels!
- Work out a p-value for any discrepancy
- Account for very large look-elsewhere effect by performing pseudoexperiments