Search for resonant VH production with a W or Z boson decaying leptonically

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Motivations

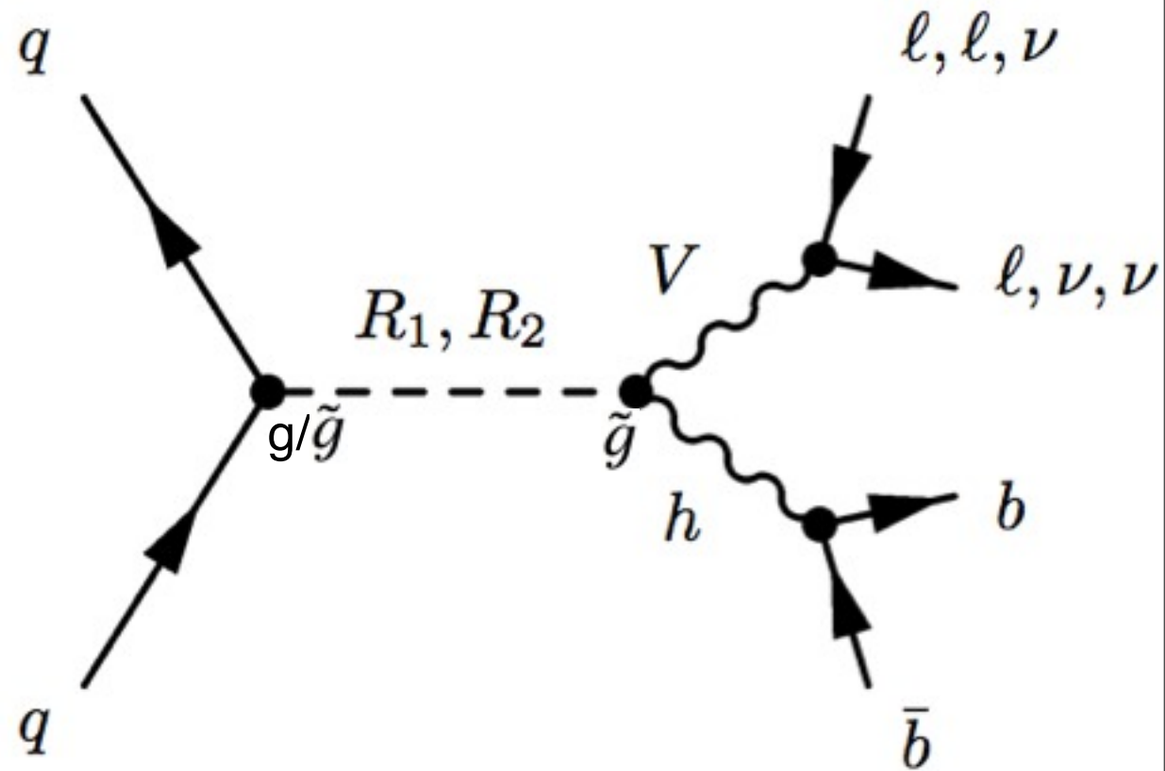
- Higgs discovery : Strong constraint on BSM theories
  - is SM valid at the TeV scale?
- Dynamical electroweak symmetry breaking scenarios
  - new strong interactions
  - new resonances that couple to W, Z and Higgs
  - Minimal Walking Technicolor, Little Higgs, Composite Higgs, ...

- Previous CONF note ATL-CONF-2013-074

Analysis is still blinded,
no results available yet :(

Minimal Walking Technicolor

- Search for resonant dijet in associated production with a vector boson
  - final states : 0, 1 and 2 leptons
  - electron and muon channel
- 20.3 fb^{-1} of data collected by the ATLAS detector
- Test of Minimal Walking Technicolor (MWT) model
  - Composite Higgs model based on Walking Technicolor
  - Agrees with EW precision measurements (S-parameter ~0.3)
  - New resonances : R_1 and R_2
  - gtilde : coupling constant to SM particles
  - ~$\tilde{g}$: mesons-bosons, ~g/$\tilde{g}$: mesons-fermions
  - M_A : mass scale (sets mass for R_1 and R_2)

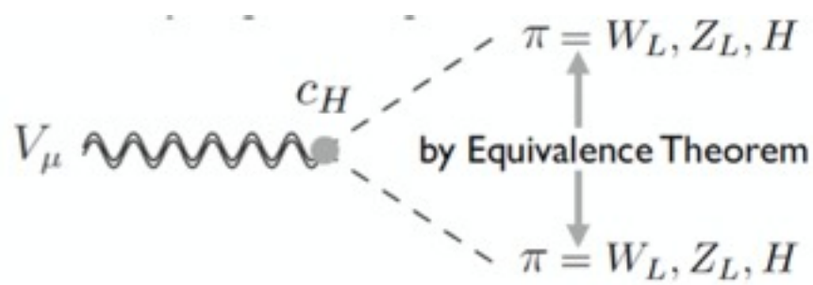


F. Sannino *et al* 0809.0793

Heavy Vector Triplet

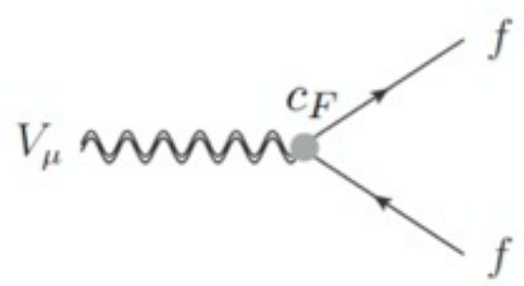
- Interpretation in Heavy Vector Triplet models
  - new heavy vector couples to SM particles
  - $g_V c_H$: Higgs and gauge bosons
  - $g^2 c_F / g_V$: SM fermions
  - Two benchmark models
    - Model A : extension of the SM gauge group (weakly coupled)
    - Model B : Composite Higgs model (strongly coupled)
      - fermionic couplings suppressed

$$i g_V c_H V_\mu^a H^\dagger \tau^a \overleftrightarrow{D^\mu} H$$



$$\frac{g^2}{g_V} c_F V_\mu^a J_F^{\mu a}$$

$$c_F \to \{c_l, c_q, c_3\}$$



R. Torre *et al.* 1402.4431

Leptons

- Follow Higgs group working on associated production VH

Signal electron

Cut	Loose electron	ZH signal electron	WH signal electron
Algorithm	Author = 1 or 3	Author = 1 or 3	Author = 1 or 3
e-ID	VeryLoose Likelihood	VeryLoose Likelihood	VeryTight Likelihood
$\|\eta_{clus}\|$ range	$\|\eta_{clus}\| < 2.47$	$\|\eta_{clus}\| < 2.47$	$\|\eta_{clus}\| < 2.47$
E_T range	7 GeV	25 GeV	25 GeV
track Isolation cone 0.2	sum pT tracks/pT < 0.1	sum pT tracks/pT < 0.1	sum pT tracks/pT < 0.04
calo isolation cone 0.3	-	-	topoEtcone30/ET < 0.04
Object Cleaning	OQ cut	OQ cut	OQ cut

Work in progress

Cut	Loose Muon			ZH muon selection	WH muon selection
Type	Combined/ST	Standalone	Calo	Combined/ST	Combined/ST
ID Track Cuts	passMCP	none	passMCP	passMCP	passMCP
d_0	$\|d_0\| < 0.1$ mm	none	$\|d_0\| < 0.1$ mm	$\|d_0\| < 0.1$ mm	$\|d_0\| < 0.1$ mm
Z_0	$Z_0 - Z_{vtx} < 10$ mm	none	$Z_0 - Z_{vtx} < 10$ mm	$Z_0 - Z_{vtx} < 10$ mm	$Z_0 - Z_{vtx} < 10$ mm
$\|d_{0,sig}\|$					$\|d_{0,sig}\| < 3.5$
η	$\eta < 2.7$	$2.5 < \eta < 2.7$	$\|\eta\| < 0.1$	$\eta < 2.5$	$\eta < 2.5$
p_T	$p_T > 7$ GeV	7GeV	20 GeV	$p_T > 25$ GeV	$p_T > 25$ GeV
track Iso cone0.2		$\sum_{tracks} p_T/p_T < 0.1$		$\sum_{tracks} p_T/p_T < 0.1$	$\sum_{tracks} p_T/p_T < 0.04$
calo Iso cone0.3	-			-	topoEtcone30/ET < 0.04
ID - MS cuts					$\|(q/p)_{ID} - (q/p)_{MS}\|/\sigma_C < 5$

Jets

- Anti-kt algorithm, R = 0.4
- $p_T > 30$ GeV
- $|\eta| < 2.5$
- b-tagging : MV1c at 70%
  - superior c-jet rejection than MV1 (smaller for light jet)
- **Overlap removal**
  - jets within $\Delta R < 0.4$ of loose electrons
  - low p_T muons (< 20 GeV) within $\Delta R < 0.4$ of a jet
  - loose electrons within $\Delta R < 0.1$ of a loose muon

Event selection

- At least two jets in the event to form the Higgs mass
  - most selections following Higgs group

W→lν selection

- One electron or one muon with $E_T > 25$ GeV
- 2nd loose electron or muon veto
- Missing $E_T > 30$ GeV
- $M_T(W) > 40$ GeV

Z→ll selection

- Two electrons, one tight with $E_T > 25$ GeV and one VL with $E_T > 7$ GeV
- One tight muon ($E_T > 25$ GeV) and one VL ($E_T > 7$ GeV)
- Missing $E_T < 60$ GeV
- $83 < M(ll) < 99$ GeV
- Same flavor requirement

Z→νν selection

- Missing $E_T > 120$ GeV
- Missing $p_T > 30$ GeV
- $\Delta\phi(MET,MPT) < \pi/2$
- $\Delta\phi(MET, j) > 1.5$

Backgrounds

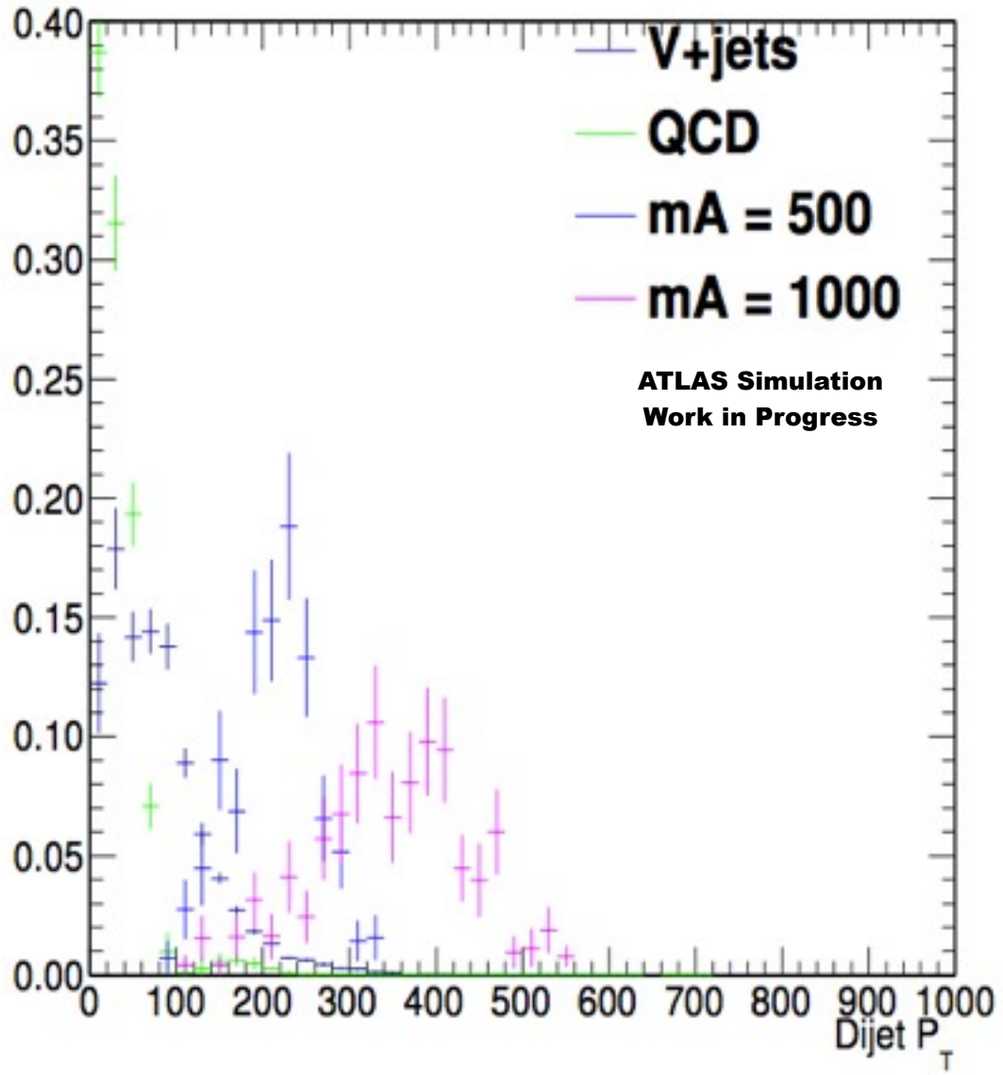
Process	Generator	$\sigma \times BR$	N_{events}
$W \to \ell\nu$	SHERPA 1.4.1	10.97 nb	168M
$Z/\gamma* \to \ell\ell$	SHERPA 1.4.1		42M
$m_{\ell\ell} > 40$ GeV		1.24 nb	
$Z/\gamma* \to \nu\nu$	SHERPA 1.4.1		77M
$m_{\nu\nu} > 5$ GeV		6.71 nb	
WW	POWHEG+PYTHIA	55.43 pb	10M
WZ	POWHEG+PYTHIA		20M
$66 < m_{\ell\ell} < 116$ GeV		22.69 pb	
ZZ	POWHEG+PYTHIA		7.5M
$66 < m_{\ell\ell} < 116$ GeV		7.697 pb	
Top-quark			
$t\bar{t}$	POWHEG	238.06 pb	75M
t−channel	ACER	87.76 pb	9M
s−channel	POWHEG	5.61 pb	6M
Wt−channel	POWHEG	22.37 pb	20M

- V+jets : shape from MC, rate from data
- ttbar : shape + rate from MC
- diboson : shape + rate from MC
- QCD multijet is data driven

Signal region

- $105 < M_{bb} < 145$ GeV
- kinematic cuts on *lljj* or *lvjj* candidate
- $p_T(j) > 0.1 \times M_{lljj}$
- $p_T(V) > -77 + 0.48 \times M_{Vjj}$
- $\Delta\Phi(ll) > 9.7 \times 10^7/M_{lljj}^{3.28} + 1$ (2-lepton only)
- single BG shape as M_{lljj} is varied
- optimized by Higgs group for this analysis

MC Only



Control regions

V+jets CR

- selection of W/Z candidate + 2 jets with $p_T > 30$ GeV
- 0, 1 and 2 b-tag regions
  - SR cuts in M_{jj} sideband (1 and 2 tag)

ttbar CR

- 1-lepton : at least 4 jets in the event
- 2-lepton : eμ events

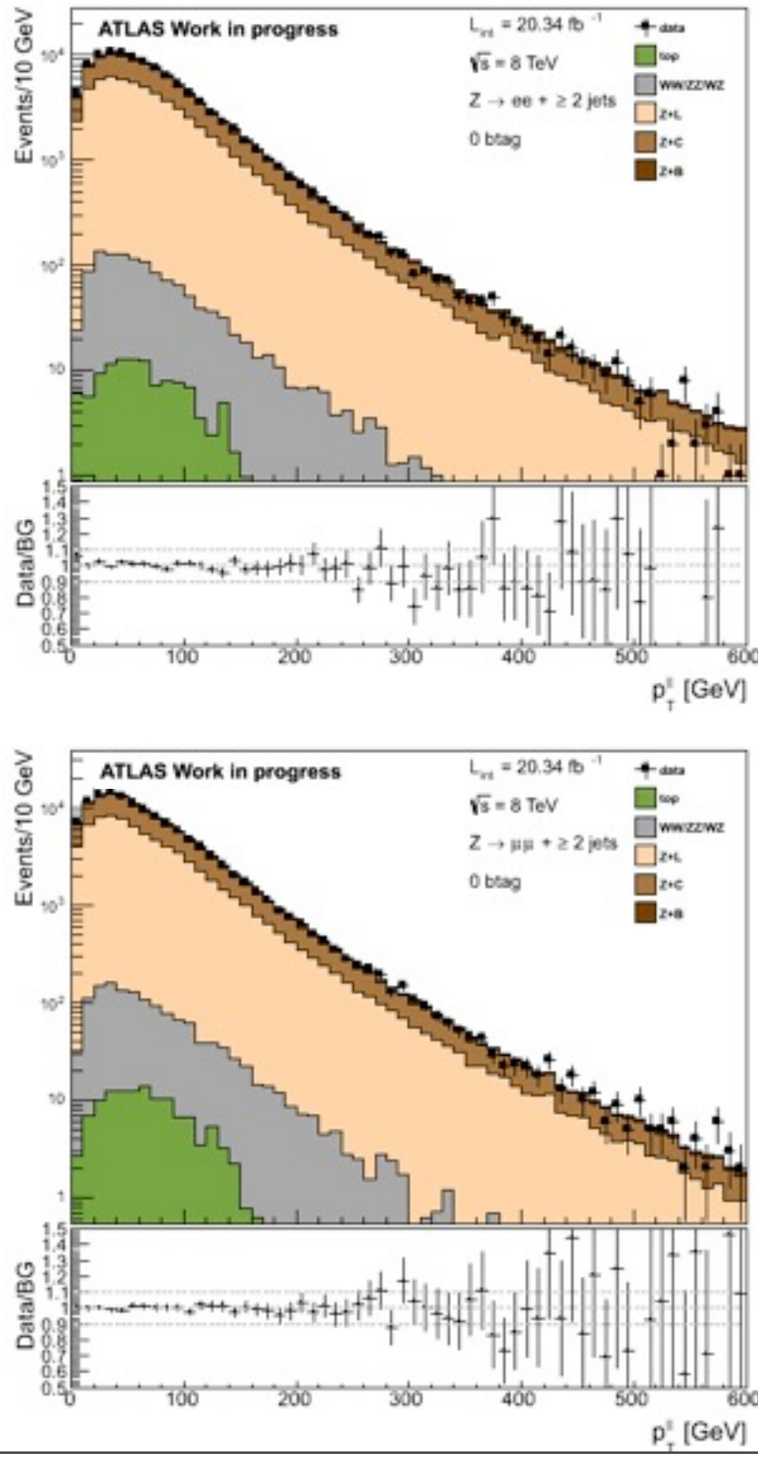
QCD CR

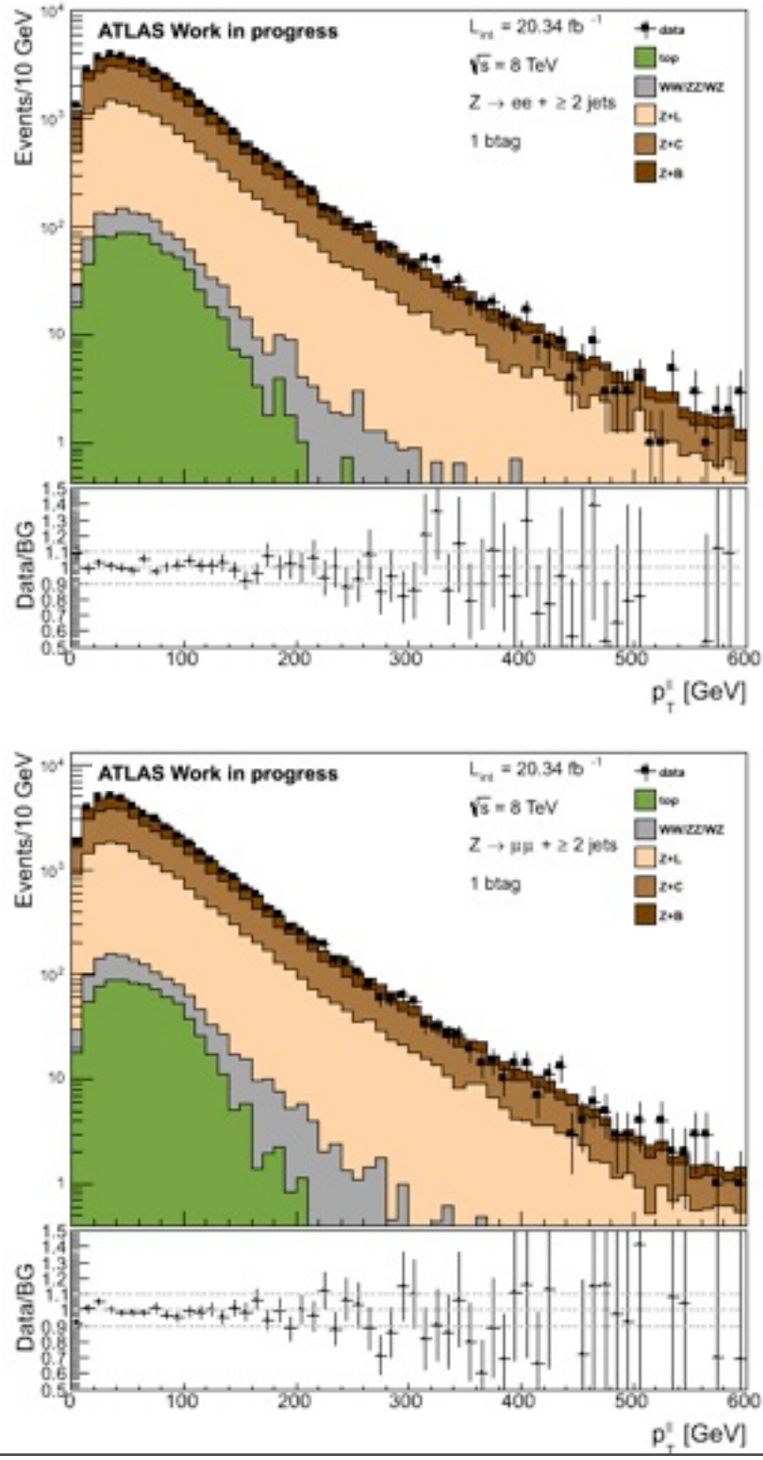
- missing $E_T < 30$ GeV
- no $\Delta\phi$(jet, ME_T) cut

Control regions (2)

Preliminary results

0 tag **Blinded!** **1 tag**





Systematics

Objects

- 14 independant components for JES
- JER
- Energy scale + smearing for leptons
- p_T reconstruction + b-jet corrections
- b-tagging efficiencies :
  - Light jet b-tagging : 10 NP
  - c-jet b-tagging : 15 NP
  - b-jet b-tagging : 10 NP

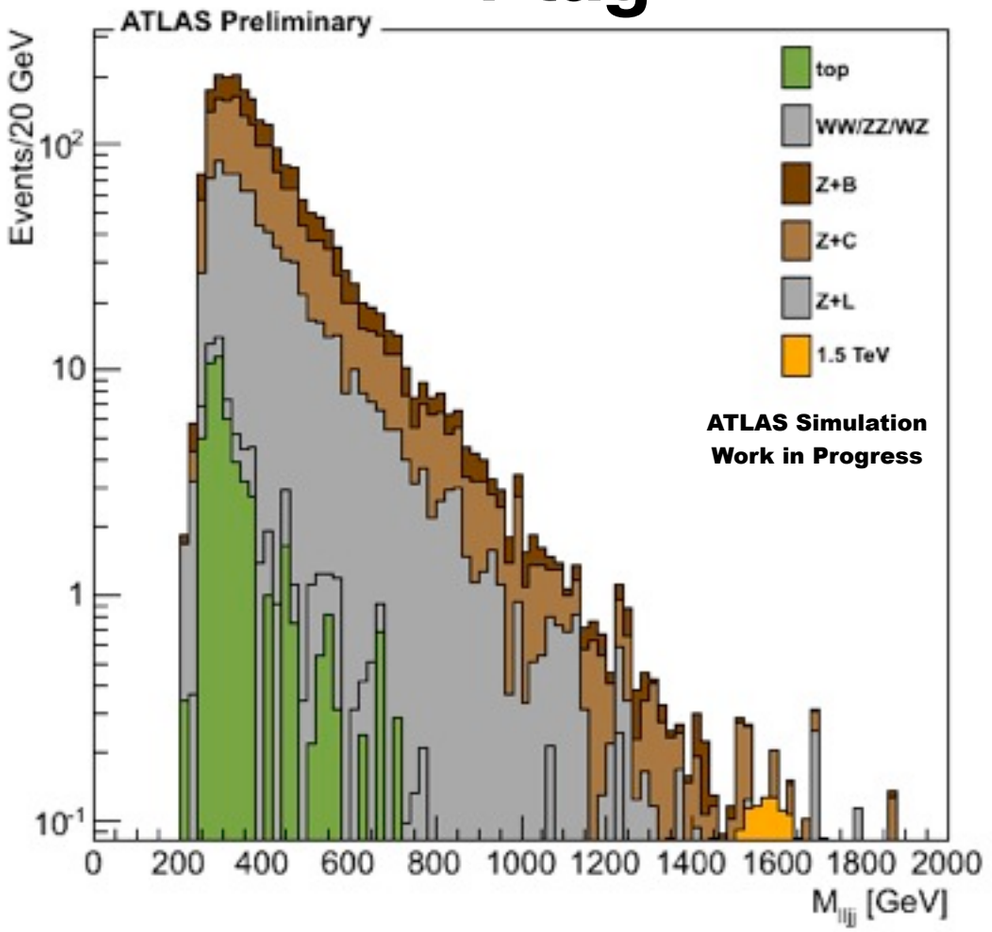
Shape

- Diboson → Herwig vs Pythia
- QCD → invert lepton isolation (one lepton analysis)
- Signal → renormalization factor, eigenvectors with CTEQ66

Significance

Very Preliminary results

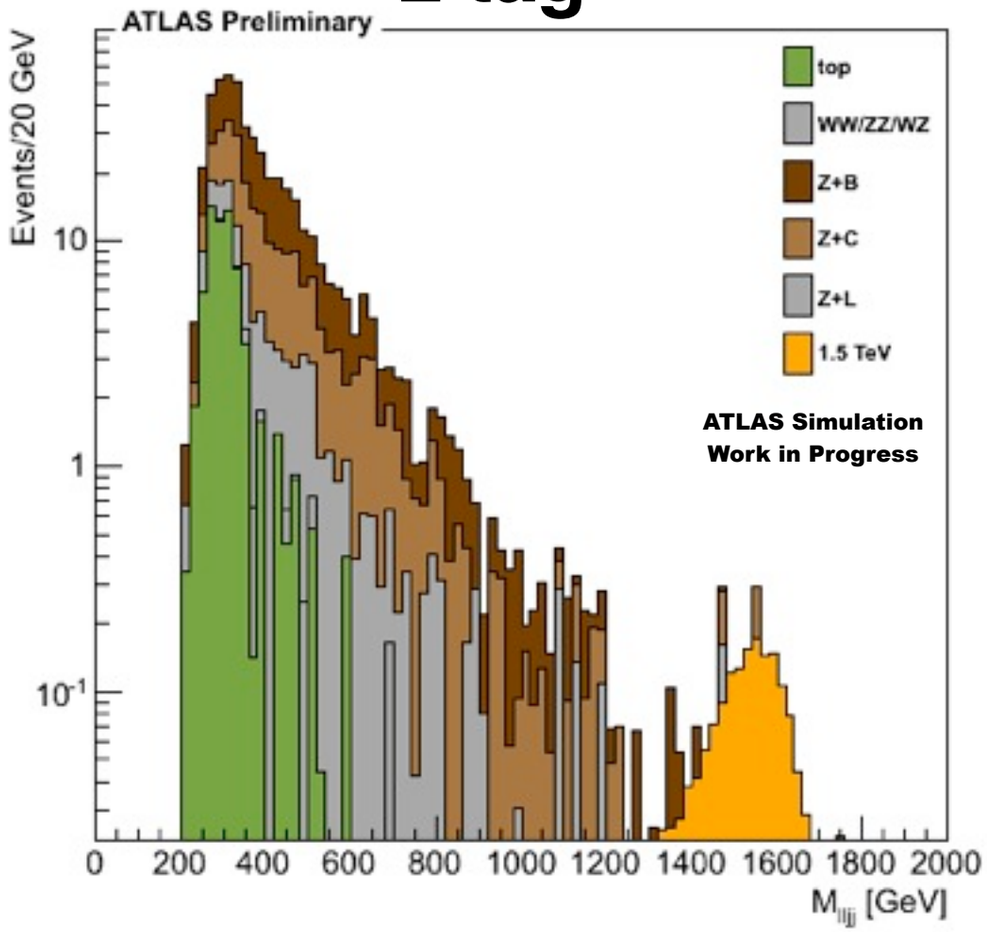
1 tag



S/√B ~ 0.9

MC Only

2 tag



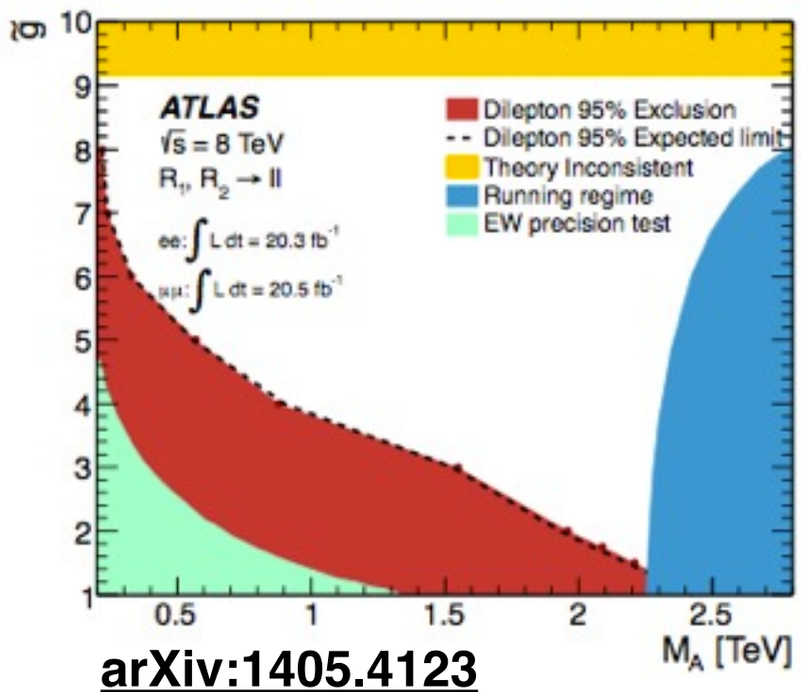
S/√B ~ 1.6

- expect to have a sensitivity for masses up to ~1.2 TeV

Samples

Dataset Number	M_A [GeV]	S parameter	$\tilde{g}$	Higgs mass [GeV]	σ x BR [fb]	σ x BR [fb]
182177	300	0.3	2	126	50.48	74.03
182178	400	0.3	2	126	6.467	8.612
182179	500	0.3	2	126	0.7784	0.9767
182180	600	0.3	2	126	0.3002	0.3573
182181	700	0.3	2	126	0.5161	0.6060
182182	800	0.3	2	126	0.7266	0.8312
182183	900	0.3	2	126	0.8146	0.9175
182184	1000	0.3	2	126	0.7636	0.8523
182185	1100	0.3	2	126	0.6540	0.7207
182186	1200	0.3	2	126	0.5382	0.5860
182187	1300	0.3	2	126	0.4527	0.4805
182188	1400	0.3	2	126	0.3922	0.4209
182189	1500	0.3	2	126	0.3358	0.3572

- Produced with MadGraph4
- Samples generated for only one value of gtilde
  - cross sections are affected, not kinematics
- Limits in the M_A vs gtilde plane
  - parton level for gtilde > 2



arXiv:1405.4123

Conclusion

- Latest version of the paper to be circulated to the Editorial Board by the end of the week
  - hopefully a meeting next week
- We should get the green light for unblinding