ATLAS results with 13 TeV data

Séminaire LAL

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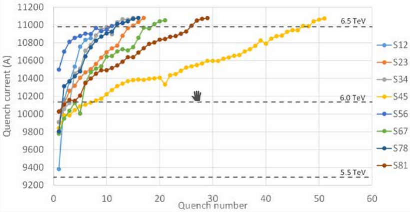
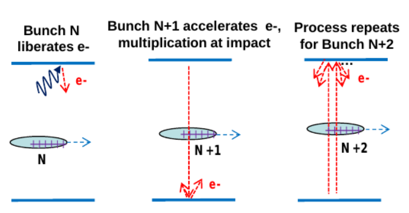
A highly subjective selection of ATLAS results with 2015 data

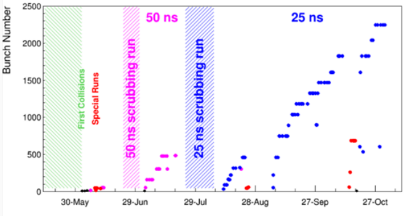
Introduction

Results of 2 years of consolidation works

- All sectors trained to 6.5 TeV ⇒ 13 TeV collisions !
- 25 ns bunch spacing
- 2200 bunches per beam (design: 2800)
- Limitations: e-cloud effect ⇒ requires dedicated scrubbing runs
- 2015: beginning of intensity ramp-up
- 2016: $\beta^* = 40$ cm

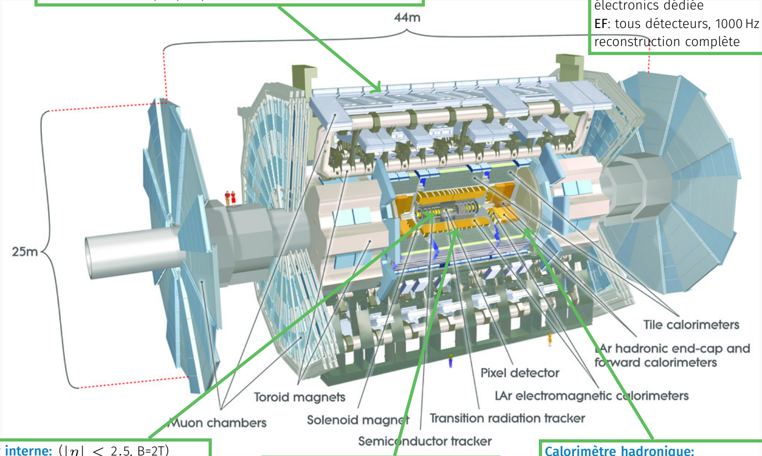






Spectromètre à muons: ($|\eta| < 2.7$)
Toroïde à air avec chambres à dérive,
fournit déclenchement μ et mesure de l'impulsion
résolution $< 10\%$ jusqu'à $p \sim 1\,\mathrm{TeV}$

Système de déclenchement:
3 niveaux
L1: calo et muons, 100 kHz
électronics dédiée
EF: tous détecteurs, 1000 Hz
reconstruction complète



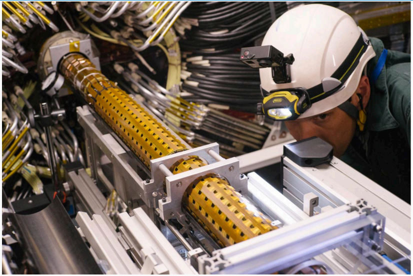
Détecteur interne: ($|\eta| < 2.5$, B=2T)
Pixels Si, Pistes Si, TRT
Trajectographie de précision,
reconstruction des vertex,
séparation e/π
$\sigma/p_T \sim 3.8\,10^{-4} p_T \oplus 0.015$

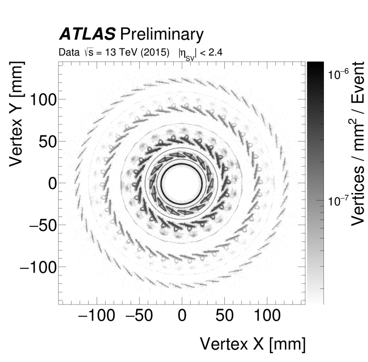
Calorimètre EM: ($|\eta| < 3.2$)
Pb-LAr, structure en accordéon
fournit déclenchement sur e/γ,
identification et mesure
$\sigma/E \sim 10\%/\sqrt{E} \oplus 0.7\%$

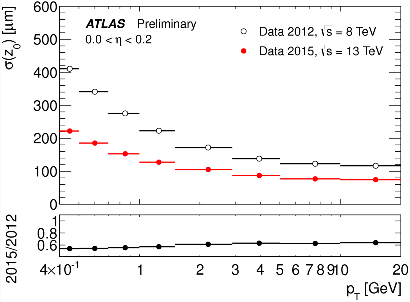
Calorimètre hadronique:
Tuiles Scint/Fe dans le tonneau ($|\eta| < 1.7$)
W/Cu-LAr vers l'avant ($|\eta| < 4.9$)
fournit déclenchement et mesure des jets,
$\sigma/E \sim 50\%/\sqrt{E} \oplus 3\%$
énergie transverse manquante

The Insertable B-Layer

- New pixel layer inserted in the existing tracker
- 3 cm from the beam axis
- Improve track IP resolutions at lower p_T
- Greatly help *b*-tagging in high pileup environments

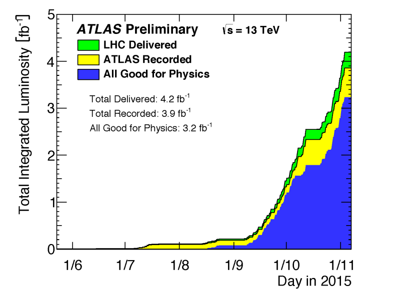






A good start

- Very good data-taking efficiency and high data quality
- 3.2fb^{-1} of data used by most analyses out of 3.9fb^{-1} recorded
- 100pb^{-1} at 50ns bunch spacing, the rest at 25ns
- Lower pile-up than 2012 for similar instantaneous lumi

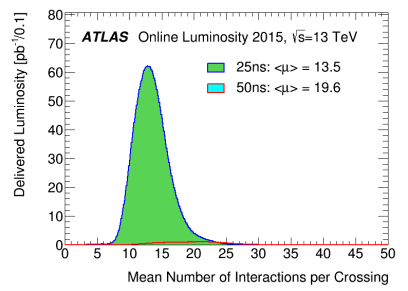


ATLAS pp 25ns run: August-November 2015

Inner Tracker			Calorimeters		Muon Spectrometer				Magnets	
Pixel	SCT	TRT	LAr	Tile	MDT	RPC	CSC	TGC	Solenoid	Toroid
93.5	99.4	98.3	99.4	100	100	100	100	100	100	97.8

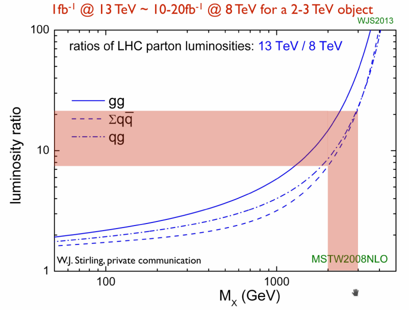
All Good for physics: 87.1% (3.2 fb^{-1})

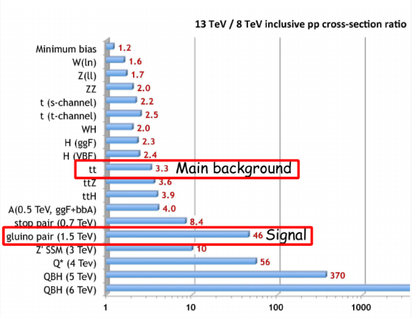
Luminosity weighted relative detector uptime and good data quality (DQ) efficiencies (in %) during stable beam in pp collisions with 25ns bunch spacing at √s=13 TeV between August-November 2015, corresponding to an integrated luminosity of 3.7 fb^{-1}. The lower DQ efficiency in the Pixel detector is due to the IBL being turned off for two runs, corresponding to 0.2 fb^{-1}. Analyses that don't rely on the IBL can use those runs and thus use 3.4 fb^{-1} with a corresponding DQ efficiency of 93.1%.



- Huge boost in cross-sections for high mass states

⇒ Searches are focus of first year of data-taking

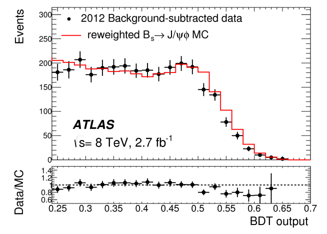


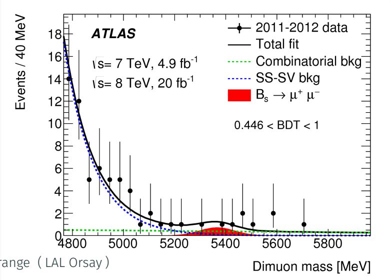


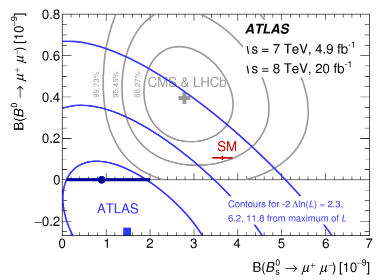
Standard Model

A recent 8 TeV result

- Detection of $B_s(\mu\mu)$ at rate compatible with SM one of the Run1 achievements
  Very sensitive probe for new states in loops
- ATLAS less optimized than LHCb or CMS
- BDT to separate signal from main background combinatorics of B and C hadron decays + partially reconstructed B decays
- Then fit invariant mass in BDT bins
- Results:
  - $BR(B_0 \to \mu\mu) < 4.2 \times 10^{-10}$ (stat dominated)
  - $BR(B_s^0 \to \mu\mu) = 0.9^{+1.1}_{-0.8} \times 10^{-9}$ (stat dominated)
  - Compatibility with SM: 2.0σ

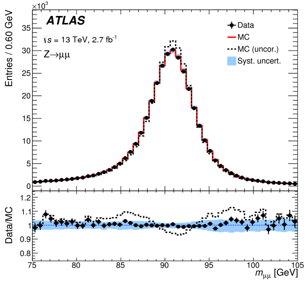


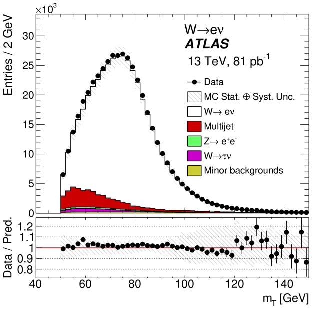


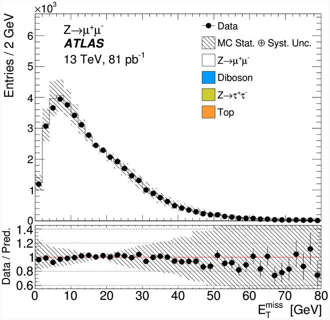


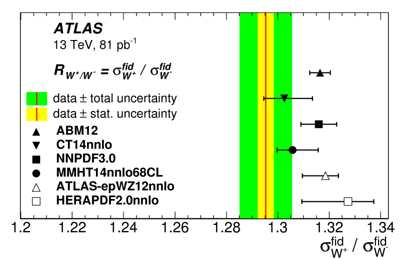
Starting with the basics

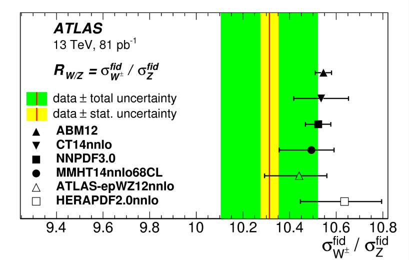
- Standard candles
- Allow to check performances of electrons, muons, MET
- High cross-sections → little data needed for first measurements





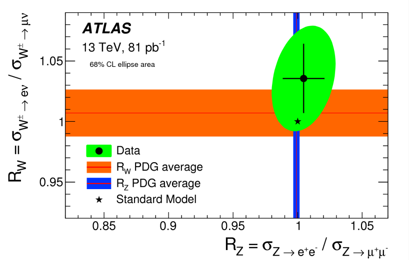






Cross-section ratios

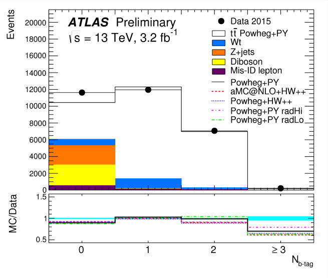
- Even with inclusive measurements, x-sec ratios powerful tools
- Partial cancellation of systematics
- Stil systs dominated: JES in MET, multijet bkg in *W* channels
- PDF discrimination with W/Z or W^+/W^-

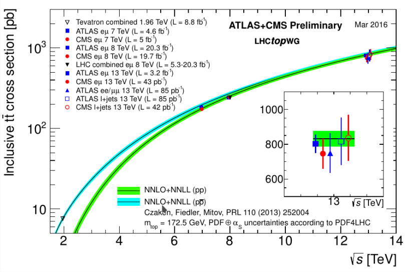


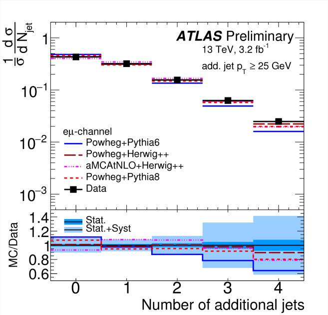
Next step after W and Z

- Add jets and b-tagging to the game
- Measurements use single or dileptonic decays
- Very pure $e\mu$ channel leading the cross-section measurements
- Also perform unfolded measurements of $t\bar{t}$+jets

$\Rightarrow$ Valuable input on MC generators modelling for searches

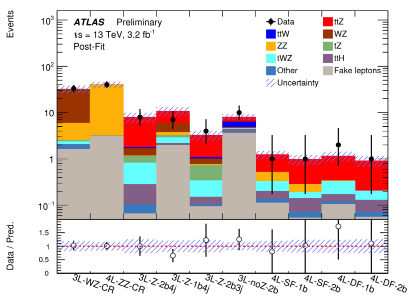


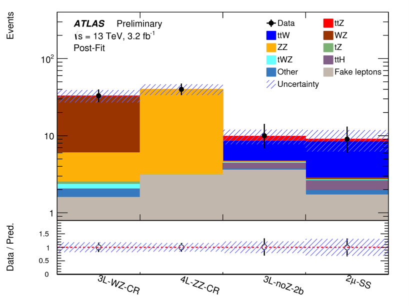




Why early $t\bar{t} + V$ measurements ?

- Relatively rare processes: $\sigma \sim 0.6\,\mathrm{pb}$
- Important backgrounds to $t\bar{t}H$, especially in multilepton channels
- Also backgrounds in SUSY multilepton searches
- Probe neutral current coupling of t quark





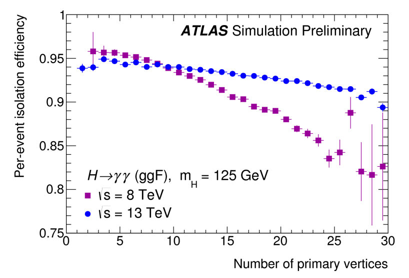
Analysis

- Select events with 2 SS, 3, or 4 leptons
- Rely on control regions to normalize main backgrounds
- Results:
  - Stat-dominated by factor 2-3
  - $\sigma_{t\bar{t}Z} = 0.9 \pm 0.3\,\mathrm{pb}$ (NLO: 0.76 ± 0.08)
  - $\sigma_{t\bar{t}W} = 1.4 \pm 0.8\,\mathrm{pb}$ (NLO: 0.57 ± 0.06)

Higgs

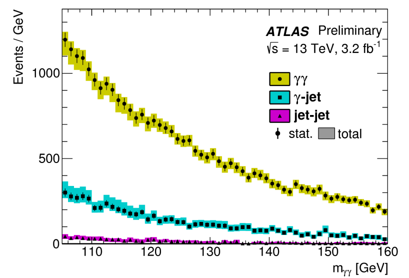
Only $\gamma\gamma$ and 4ℓ channels ?

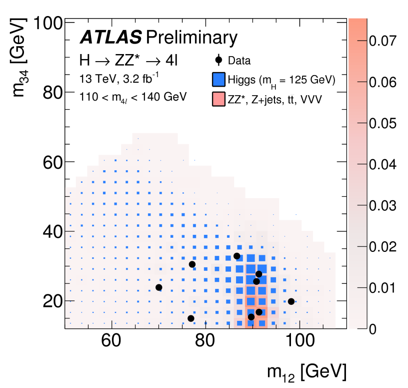
- Higgs does not benefit that much from increased $\sqrt{s}$
- Except $t\bar{t}H$
- Results from high resolution channels very stat dominated
- Other channels (WW, $\tau\tau$, $VHbb$) are complicated and delicate analyses, and cannot be competive with 3.2fb^{-1} of data



Analysis

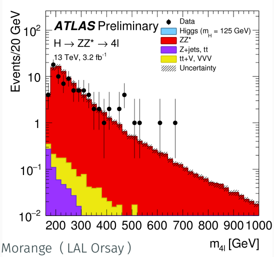
- Selection of a pair of tight photons with $E_T/m_{\gamma\gamma} > 0.35(0.25)$ for leading (subleading) γ
- wrt Run1: isolation cuts made more robust at high pile-up
- Data-driven study of background composition
- Background fit using functional form

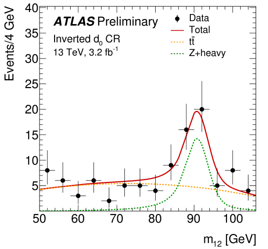


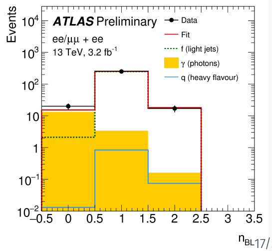


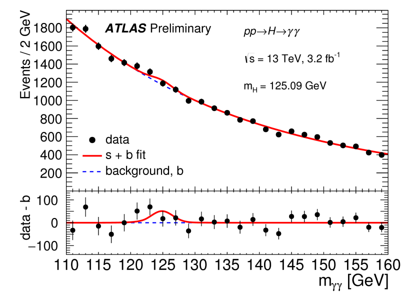
Analysis

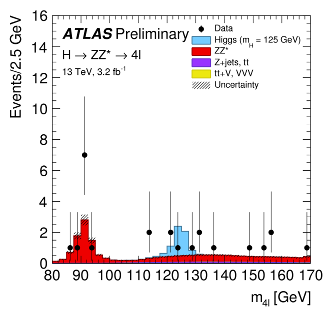
- Selection of leptons with wide acceptance
- Pair of leptons compatible with Z ; second pair lower inv mass
- Main background ZZ from MC, checked in high masses
- Reducible backgrounds from fakes and havy flavours estimated with control regions

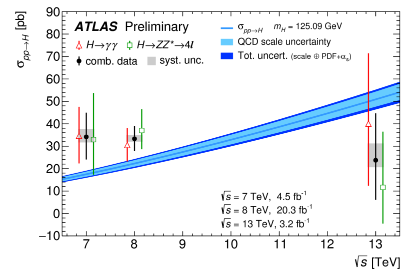












Results

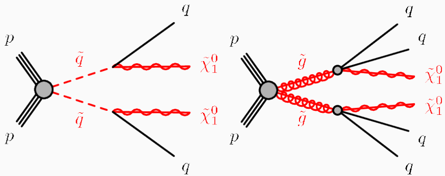
- Individual results obtained assuming $m_H = 125.09$ GeV
- Expressed in ficudial x-sec then total x-sec
- Total x-secs vs $\sqrt{s}$: the most funny plot of the year
- very large stat uncertainties

SUSY is still not dead

A classic SUSY testbench

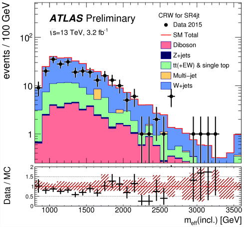
- Strong squark and gluino production
- Simple decay chains to neutralino (LSP)
  - ⇒ final states: jets + large MET ; large effective mass
- Interpretation: simplified models with other SUSY particles at very high masses

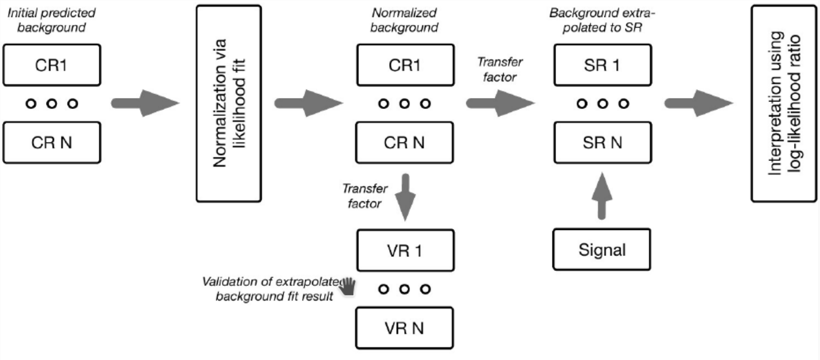
Requirement	Signal Region						
	2jl	**2jm**	**2jt**	**4jt**	**5j**	**6jm**	**6jt**
$E_{\rm T}^{\rm miss}$ [GeV] >	200						
$p_{\rm T}(j_1)$ [GeV] >	200	300	200				
$p_{\rm T}(j_2)$ [GeV] >	200	50	200	100			
$p_{\rm T}(j_3)$ [GeV] >	–			100			
$p_{\rm T}(j_4)$ [GeV] >	–			100			
$p_{\rm T}(j_5)$ [GeV] >	–				100		
$p_{\rm T}(j_6)$ [GeV] >	–					100	
$\Delta\phi({\rm jet}_{1,2,(3)}, \boldsymbol{E}_{\rm T}^{\rm miss})_{\rm min}$ >	0.8	0.4	0.8	0.4			
$\Delta\phi({\rm jet}_{i>3}, \boldsymbol{E}_{\rm T}^{\rm miss})_{\rm min}$ >	–			0.2			
$E_{\rm T}^{\rm miss}/\sqrt{H_{\rm T}}$ [GeV$^{1/2}$] >	15		20	–			
Aplanarity >	–			0.04			
$E_{\rm T}^{\rm miss}/m_{\rm eff}(N_{\rm j})$ >	–			0.2	0.25		0.2
$m_{\rm eff}$(incl.) [GeV] >	1200	1600	2000	2200	1600	1600	2000



Analysis strategy

- Simple and robust analysis: cut-and-count in signal (SR) and control regions (CR)
- SR are designed to maximize sensitivity for some benchmark signal samples
- CR used to do data estimates of all backgrounds, in regions close to SR

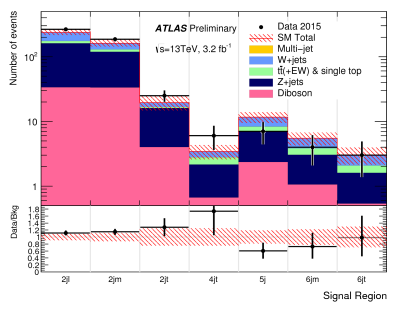


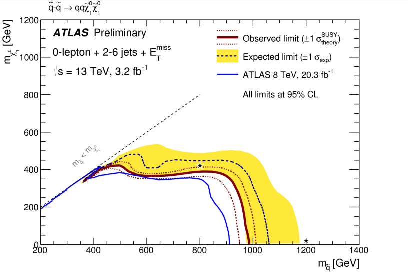


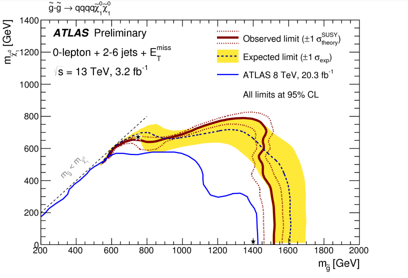
[Eur.Phys.J. C75 (2015) 153]

Results

- Background uncertainties in range 10–30%
- When interpreting limits in SUSY plane, chose for each point the SR with best sensitivity
- Limits already exceed significantly the Run1 results

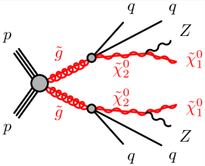


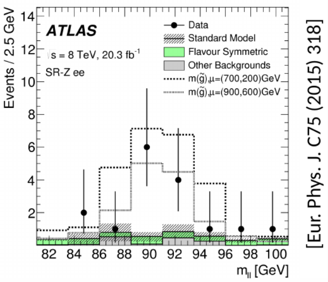




Z+jets+MET search

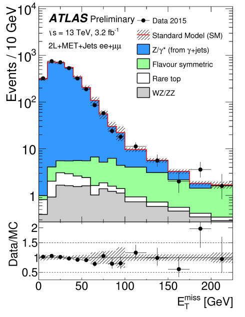
- Targets a different gluino decay chain
- Sparked some interest after ATLAS reported a 3σ excess in Run1





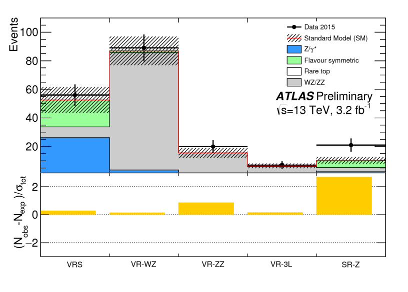
Analysis strategy

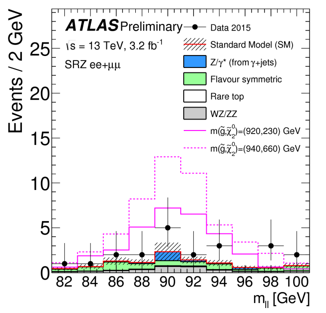
- 1 signal region: leptonic Z + $\geq$ 2 jets + MET$>$ 225 GeV + HT$>$ 600 GeV
- Otherwise same strategy as for 0 lepton: backgrounds estimated through CR, validated in other regions

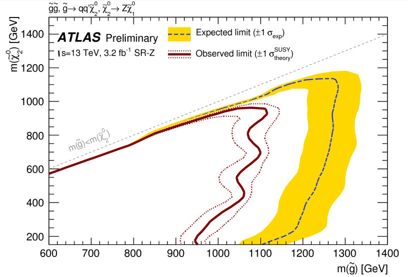


Results

- 21 observed versus 10.3 ± 2.3 expected (2.2σ) symmetric in ee and μμ channels.
- not conclusive to confirm or disprove Run1 result
- (but on the other side of the LHC, CMS sees nothing)

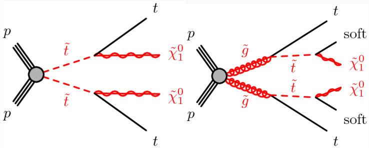


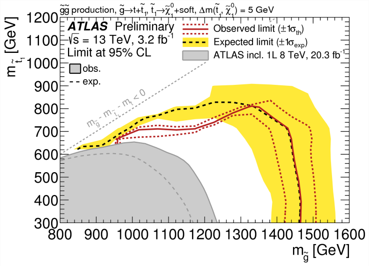


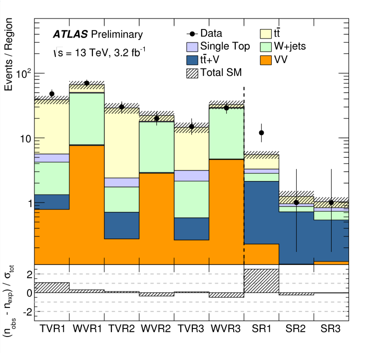


Stop searches

- Naturalness in SUSY: stop is relatively light
- Several searches in different final states depending on assumed SUSY spectrum
- Here, final state with $t\bar{t}$ pair + MET, in semileptonic decays







Analysis

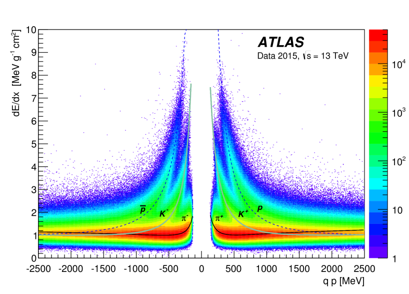
- Basic selection: 1 good lepton, $\geq$ 4 jets, $\geq$1 b-jet
- Then define regions based on MET and other kinematics
- SR2 and SR3 quite boosted: use large-R jet kinematics for additional discrimination
- Limits exceeding Run1 results

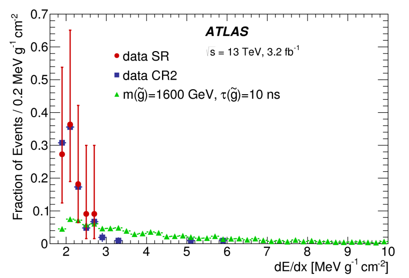
Unconventional signatures

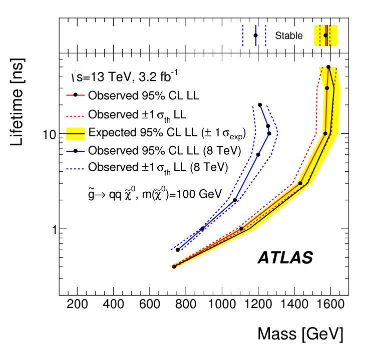
- Long-lived high mass particles
- e.g split SUSY: R-hadron containing a gluino, with $\sim$ 1 ns lifetime
- $\beta < 1$, high dE/dx in pixel detector

$\Rightarrow$ Look for isolated and high-pT track with high dE/dx

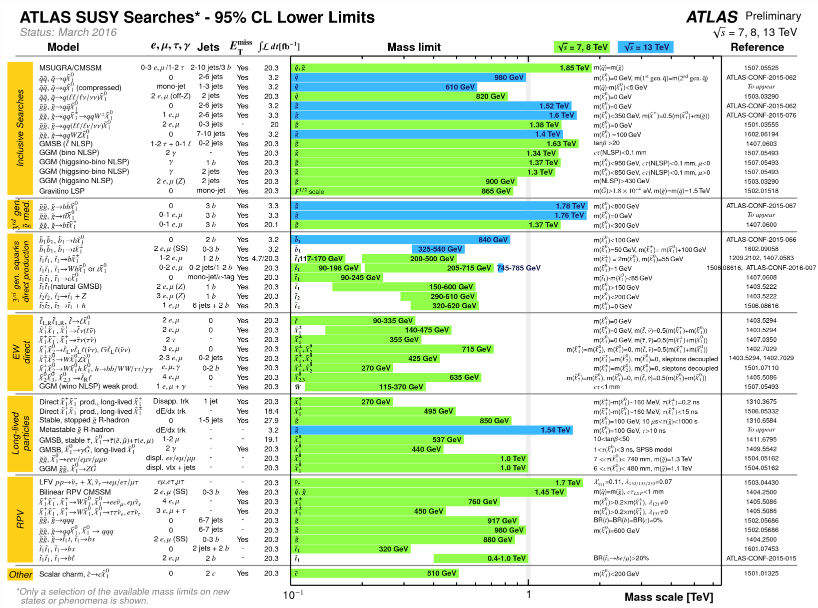
- IBL helps to reduce tails: -50% above 1.8 MeV cm^2 g^{-1}
- Trigger on MET

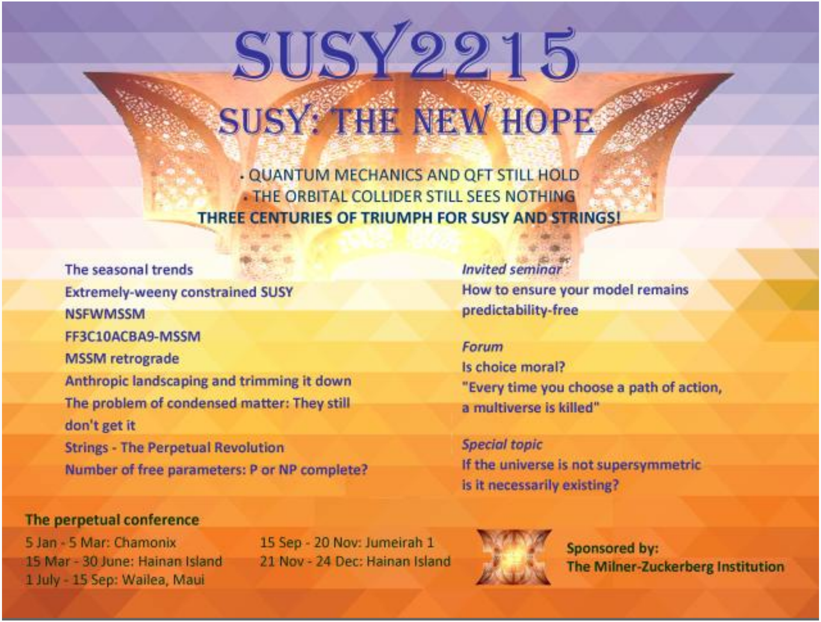






ATLAS EXPERIMENT

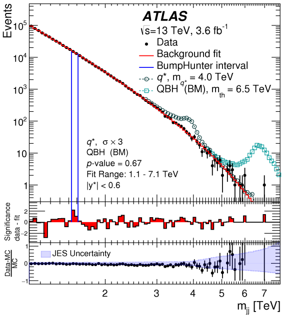


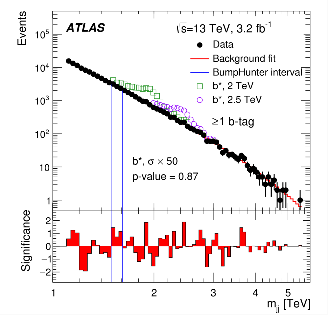

SUSY2215
SUSY: THE NEW HOPE
· QUANTUM MECHANICS AND QFT STILL HOLD
· THE ORBITAL COLLIDER STILL SEES NOTHING
THREE CENTURIES OF TRIUMPH FOR SUSY AND STRINGS!
The seasonal trends
Extremely-weeny constrained SUSY
NSFWMSSM
FF3C10ACBA9-MSSM
MSSM retrograde
Anthropic landscaping and trimming it down
The problem of condensed matter: They still don't get it
Strings - The Perpetual Revolution
Number of free parameters: P or NP complete?
Invited seminar
How to ensure your model remains predictability-free
Forum
Is choice moral?
"Every time you choose a path of action, a multiverse is killed"
Special topic
If the universe is not supersymmetric is it necessarily existing?
The perpetual conference
5 Jan - 5 Mar: Chamonix
15 Mar - 30 June: Hainan Island
1 July - 15 Sep: Wailea, Maui
15 Sep - 20 Nov: Jumeirah 1
21 Nov - 24 Dec: Hainan Island
Sponsored by:
The Milner-Zuckerberg Institution

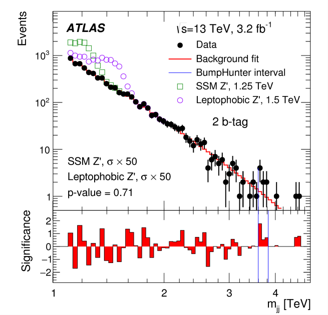
Resonances Everywhere

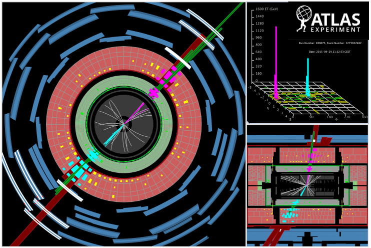
Dijet search

- Most basic search at a hadron collider
- Strong production and large BR
- Can probe very high mass resonances
- Simple analysis: dijet events
- Can also use angular variables
- Can also use *b*-jets
- Dijet resolution ∼ 1% at high mass. Jet energy scale known to 1–3%

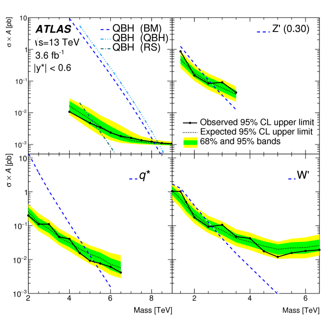


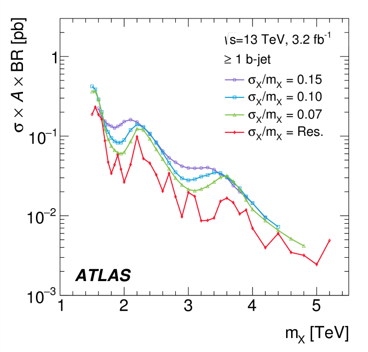






$m_{jj} = 6.9\,\text{TeV},\ p_T(j) = 3.2\,\text{TeV}$

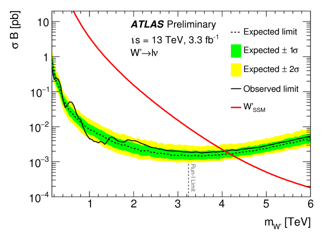




Model-independent limit, ≥ 1 b-tag

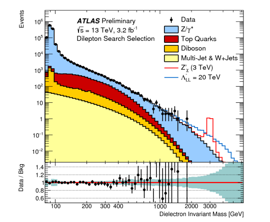
Results

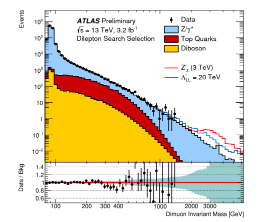
- Fit background with simple functional form
- Extract limit on various scenarios (QBH, excited quarks, contact interactions)
- Also model-independent limits

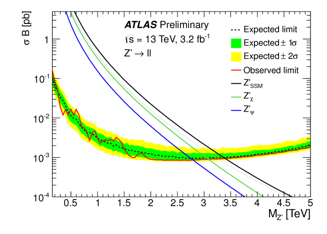


Analysis

- Similar simple searches with leptons (e and μ)
- Z' and W' signatures: dilepton or lepton+MET
- Specific difficulty: control of very high p_{T} leptons
- Contrary to J/Ψ or Z resonances, better sensitivity achieved in the electron channel



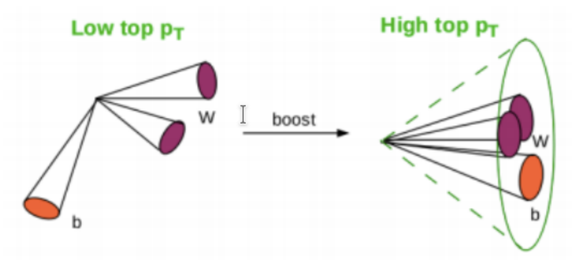




Large-R jets

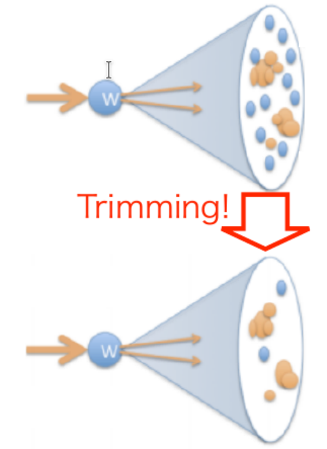
- Decay products of massive particle are within $\Delta R = 2M/p_{\mathrm{T}}$
- At high boost, hadronic decays of W, Z or top not resolved using Anti-kt $R = 0.4$ jets
- Reconstruct decays in 1 large jet (Anti-kt $R = 1.0$)

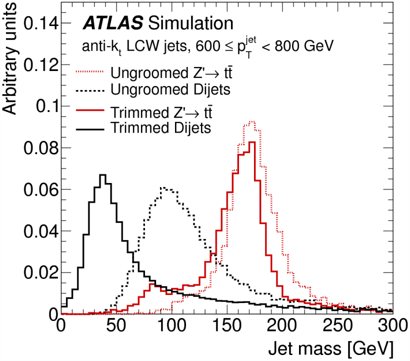
⇒ ”boson-tagging” or ”top-tagging” crucial in many searches



Trimming

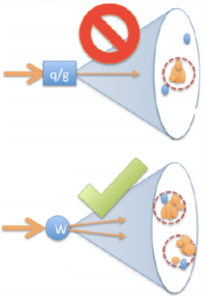
- Aim: get rid of pile-up and soft QCD components
- How: find subjets with kt algorithm (R=0.2) ; remove if they carry <5% of jet p_T
- Achieve: much improved mass resolution

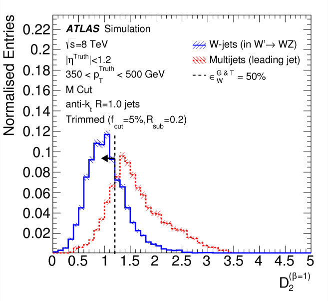


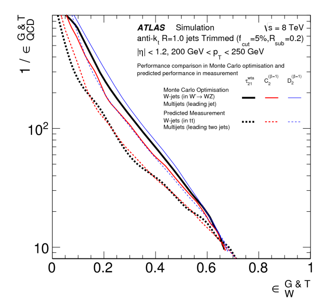


Substructure

- Aim: discrimination between QCD, V-boson (2-prong) or $t\bar{t}$ (3-prong) jets
- How: many discriminant variables, typically using declustering techniques or energy correlations
- Achieve: additional discrimination on top of mass window

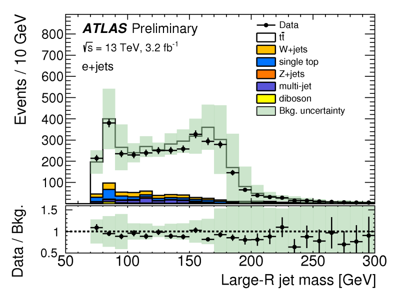


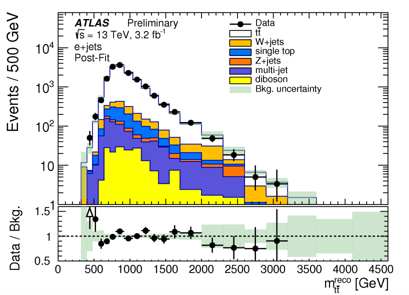


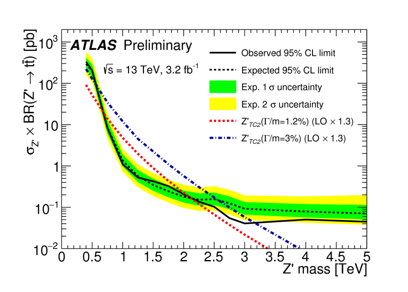


Analysis

- Semileptonic decays: BR$\sim$ 35%, low background
- Leptonic side: easy trigger (lepton $p_{\mathrm{T}} > 25\,\mathrm{GeV}$), close-by jet
- Hadronic side: large jet compatible with top (subjettiness + mass)
- b-tagging
- Main backgrounds estimated using data-driven techniques



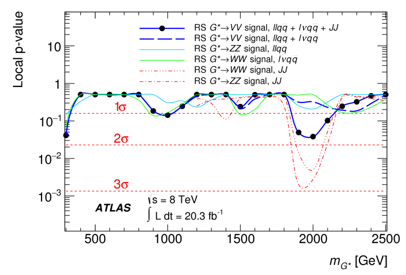


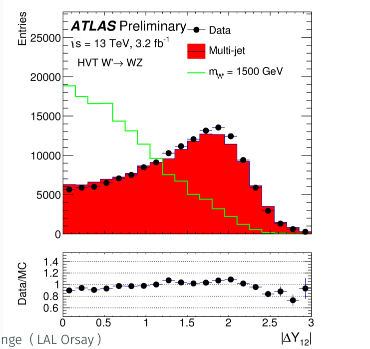


Benchmark model: topcolour-assisted-technicolour

WW/WZ/ZZ searches

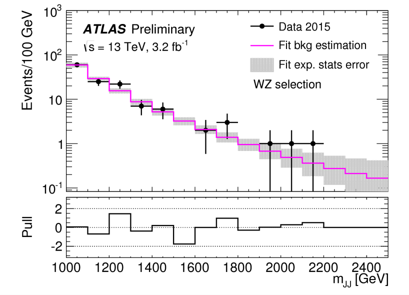
- Some interest due to excess in all-hadronic channel in Run1
- (not seen in semi-leptonic channels)
- Models: generic Heavy Vector Triplets, or RS graviton
- *ZZ* and *WW* can also be results of heavy scalar decay
- High mass resonances: 2 boosted hadronic decays, or semileptonic

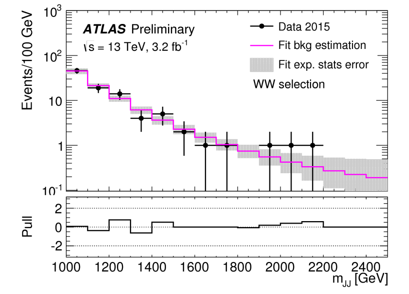




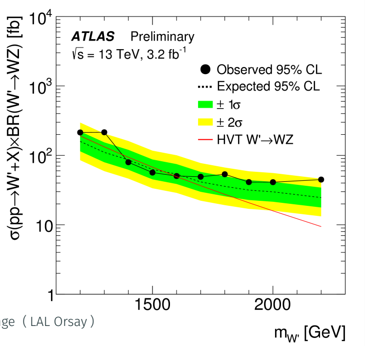
All hadronic analysis

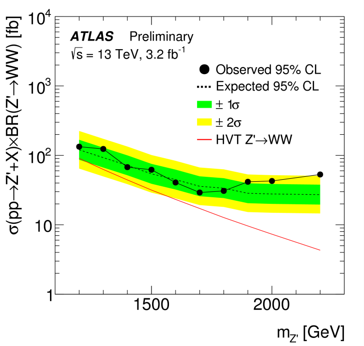
- Overwhelming background: multijet
- 2 large-R jets
- boson tagging: mass + energy correlation + track multiplicity (50% efficiency)
- Kinematics: good p_T balance, small rapidity difference
- Fit of invariant mass using analytical form





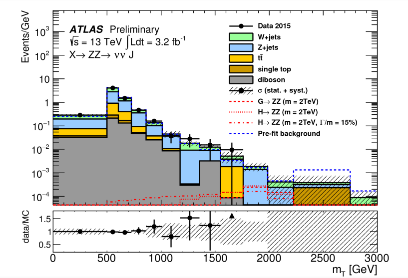
Not much to be seen...

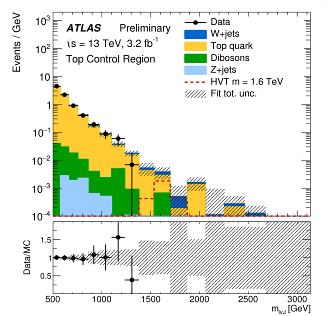


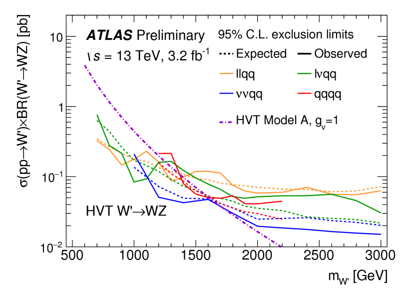


Semileptonic analyses

- Use $Z \to \ell\ell$, $W \to \ell\nu$, $Z \to \nu\nu$ with high-pt leptons and large MET requirements
- Boson-tagged high-pt fat jet
- Main backgrounds: W+jets, Z+jets, $t\bar{t}$
- Control regions defined by inverting jet mass cuts, or playing with b-tagging
- Results from shape fits

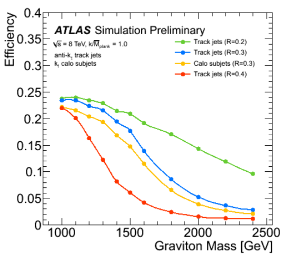




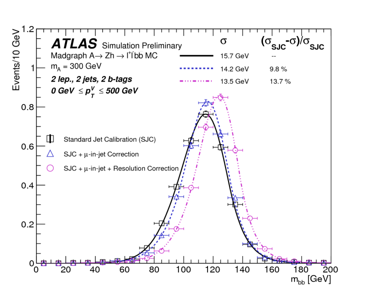


One step further

- Replace W or Z with $H \to b\bar{b}$
- Models: HVT or simple 2HDM $A \to Zh$
- Forget about substructure: b-tagging of small R track jets matched to large-R jet
- Search A in 200 GeV – 2 TeV range: handle both resolved and merged $h \to b\bar{b}$ decays

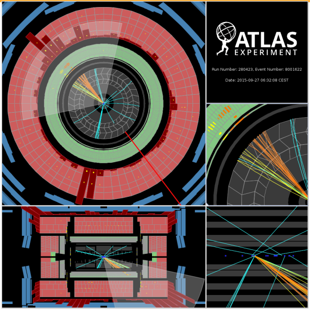


Track jet tagging performance



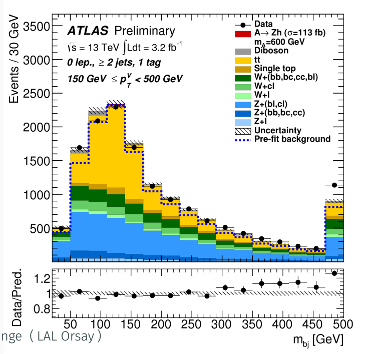
Analysis

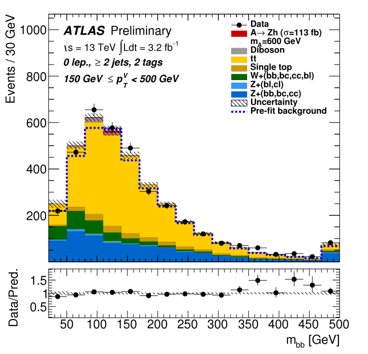
- Select Z with pair of e, μ, or MET
- Add pair of b-tagged jets (low $p_{\mathrm{T}}(Z)$), or large-R jet with matched b-tagged track jets (high $p_{\mathrm{T}}(Z)$)
- Specific corrections to improve b-jet energy resolution
- Then cut on m_{bb}
- Backgrounds: $t\bar{t}$, Z+hf, W+hf



Analysis cont'd

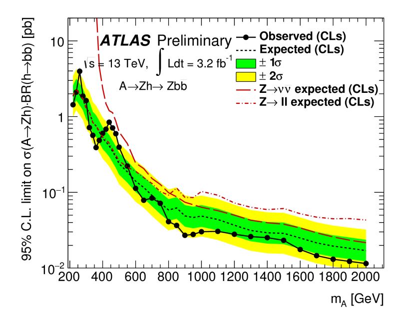
- Control of backgrounds normalizations and shapes:
  - Make use of 1-tag vs 2-tag regions to control flavour composition
  - Higgs mass sidebands
  - 0 and 2 lepton fitted together
- Then fit m_{Zh}

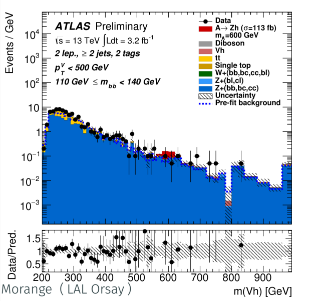


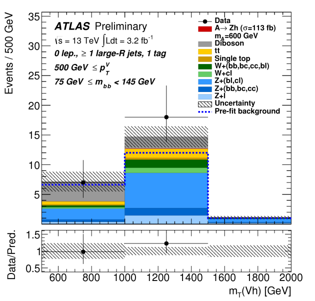


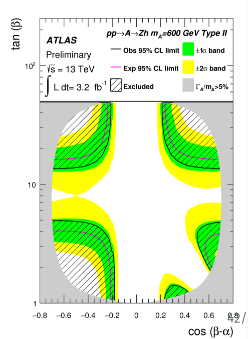
Results

- High resolution *llbb* leads at low masses
- High BR $\nu\nu bb$ leads at high masses
- Resolved / merged signal regions turnover point $\sim$ 1 TeV
- Interpretation in 2HDM plane ($\tan\beta, \cos(\beta-\alpha)$)
- Better than Run1 results for masses $\gtrsim$ 700 GeV









ATLAS EXPERIMENT

ATLAS Exotics Searches* - 95% CL Exclusion

Status: March 2016

ATLAS Preliminary

$\int \mathcal{L}\, dt = (3.2 - 20.3)$ fb^{-1} $\sqrt{s}$ = 8, 13 TeV

	Model	ℓ, γ	Jets†	E_T^{miss}	$\int \mathcal{L}\, dt$[fb^{-1}]	Limit		Reference
Extra dimensions	ADD $G_{KK} + g/q$	–	≥ 1 j	Yes	3.2	M_D 6.86 TeV	$n = 2$	Preliminary
	ADD non-resonant $\ell\ell$	2 e, μ	–	–	20.3	M_S 4.7 TeV	$n = 3$ HLZ	1407.2410
	ADD QBH $\rightarrow \ell q$	1 e, μ	1 j	–	20.3	M_{th} 5.2 TeV	$n = 6$	1311.2006
	ADD QBH	–	2 j	–	3.6	M_{th} 8.3 TeV	$n = 6$	1512.01530
	ADD BH high $\sum p_T$	≥ 1 e, μ	≥ 2 j	–	3.2	M_{th} 8.2 TeV	$n = 6$, $M_D = 3$ TeV, rot BH	ATLAS-CONF-2016-006
	ADD BH multijet	–	≥ 3 j	–	3.6	M_{th} 9.55 TeV	$n = 6$, $M_D = 3$ TeV, rot BH	1512.02586
	RS1 $G_{KK} \rightarrow \ell\ell$	2 e, μ	–	–	20.3	G_{KK} mass 2.68 TeV	$k/\overline{M}_{Pl} = 0.1$	1405.4123
	RS1 $G_{KK} \rightarrow \gamma\gamma$	2 γ	–	–	20.3	G_{KK} mass 2.66 TeV	$k/\overline{M}_{Pl} = 0.1$	1504.05511
	Bulk RS $G_{KK} \rightarrow WW \rightarrow qq\ell\nu$	1 e, μ	1 J	Yes	3.2	G_{KK} mass 1.06 TeV	$k/\overline{M}_{Pl} = 1.0$	ATLAS-CONF-2015-075
	Bulk RS $G_{KK} \rightarrow HH \rightarrow bbbb$	–	4 b	–	3.2	G_{KK} mass 475-785 GeV	$k/\overline{M}_{Pl} = 1.0$	ATLAS-CONF-2016-017
	Bulk RS $g_{KK} \rightarrow tt$	1 e, μ	≥ 1 b, ≥ 1J/2j	Yes	20.3	g_{KK} mass 2.2 TeV	BR = 0.925	1505.07018
	2UED / RPP	1 e, μ	≥ 2 b, ≥ 4 j	Yes	3.2	KK mass 1.46 TeV	Tier (1,1), BR($A^{(1,1)} \rightarrow tt$) = 1	ATLAS-CONF-2016-013
Gauge bosons	SSM $Z' \rightarrow \ell\ell$	2 e, μ	–	–	3.2	Z' mass 3.4 TeV		ATLAS-CONF-2015-070
	SSM $Z' \rightarrow \tau\tau$	2 τ	–	–	19.5	Z' mass 2.02 TeV		1502.07177
	Leptophobic $Z' \rightarrow bb$	–	2 b	–	3.2	Z' mass 1.5 TeV		Preliminary
	SSM $W' \rightarrow \ell\nu$	1 e, μ	–	Yes	3.2	W' mass 4.07 TeV		ATLAS-CONF-2015-063
	HVT $W' \rightarrow WZ \rightarrow qq\nu\nu$ model A	0 e, μ	1 J	Yes	3.2	W' mass 1.6 TeV	$g_V = 1$	ATLAS-CONF-2015-068
	HVT $W' \rightarrow WZ \rightarrow qqqq$ model A	–	2 J	–	3.2	W' mass 1.38-1.6 TeV	$g_V = 1$	ATLAS-CONF-2015-073
	HVT $W' \rightarrow WH \rightarrow \ell\nu bb$ model B	1 e, μ	1-2 b, 1-0 j	Yes	3.2	W' mass 1.62 TeV	$g_V = 3$	ATLAS-CONF-2015-074
	HVT $Z' \rightarrow ZH \rightarrow \nu\nu bb$ model B	0 e, μ	1-2 b, 1-0 j	Yes	3.2	Z' mass 1.76 TeV	$g_V = 3$	ATLAS-CONF-2015-074
	LRSM $W'_R \rightarrow tb$	1 e, μ	2 b, 0-1 j	Yes	20.3	W' mass 1.92 TeV		1410.4103
	LRSM $W'_R \rightarrow tb$	0 e, μ	≥ 1 b, 1 J	–	20.3	W' mass 1.76 TeV		1408.0886
CI	CI $qqqq$	–	2 j	–	3.6	Λ 17.5 TeV	$\eta_{LL} = -1$	1512.01530
	CI $qq\ell\ell$	2 e, μ	–	–	3.2	Λ 23.1 TeV	$\eta_{LL} = -1$	ATLAS-CONF-2015-070
	CI $uutt$	2 e, μ (SS)	≥ 1 b, 1-4 j	Yes	20.3	Λ 4.3 TeV	$\lvert C_{LL}\rvert = 1$	1504.04605
DM	Axial-vector mediator (Dirac DM)	0 e, μ	≥ 1 j	Yes	3.2	m_A 1.0 TeV	g_q=0.25, g_χ=1.0, $m(\chi)$ < 140 GeV	Preliminary
	Axial-vector mediator (Dirac DM)	0 e, μ, 1 γ	1 j	Yes	3.2	m_A 650 GeV	g_q=0.25, g_χ=1.0, $m(\chi)$ < 10 GeV	Preliminary
	$ZZ\chi\chi$ EFT (Dirac DM)	0 e, μ	1 J, ≤ 1 j	Yes	3.2	M_* 550 GeV	$m(\chi)$ < 150 GeV	ATLAS-CONF-2015-080
LQ	Scalar LQ 1st gen	2 e	≥ 2 j	–	3.2	LQ mass 1.07 TeV	$\beta = 1$	Preliminary
	Scalar LQ 2nd gen	2 μ	≥ 2 j	–	3.2	LQ mass 1.03 TeV	$\beta = 1$	Preliminary
	Scalar LQ 3rd gen	1 e, μ	≥1 b, ≥3 j	Yes	20.3	LQ mass 640 GeV	$\beta = 0$	1508.04735
Heavy quarks	VLQ $TT \rightarrow Ht + X$	1 e, μ	≥ 2 b, ≥ 3 j	Yes	20.3	T mass 855 GeV	T in (T,B) doublet	1505.04306
	VLQ $YY \rightarrow Wb + X$	1 e, μ	≥ 1 b, ≥ 3 j	Yes	20.3	Y mass 770 GeV	Y in (B,Y) doublet	1505.04306
	VLQ $BB \rightarrow Hb + X$	1 e, μ	≥ 2 b, ≥ 3 j	Yes	20.3	B mass 735 GeV	isospin singlet	1505.04306
	VLQ $BB \rightarrow Zb + X$	2/≥3 e, μ	≥2/≥1 b	–	20.3	B mass 755 GeV	B in (B,Y) doublet	1409.5500
	VLQ $QQ \rightarrow WqWq$	1 e, μ	≥ 4 j	Yes	20.3	Q mass 690 GeV		1509.04261
	$T_{5/3} \rightarrow Wt$	1 e, μ	≥ 1 b, ≥ 5 j	Yes	20.3	$T_{5/3}$ mass 840 GeV		1503.05425
Excited fermions	Excited quark $q^* \rightarrow q\gamma$	1 γ	1 j	–	3.2	q* mass 4.4 TeV	only u^* and d^*, $\Lambda = m(q^*)$	1512.05910
	Excited quark $q^* \rightarrow qg$	–	2 j	–	3.6	q* mass 5.2 TeV	only u^* and d^*, $\Lambda = m(q^*)$	1512.01530
	Excited quark $b^* \rightarrow bg$	–	1 b, 1 j	–	3.2	b* mass 2.1 TeV		Preliminary
	Excited quark $b^* \rightarrow Wt$	1 or 2 e, μ	1 b, 2-0 j	Yes	20.3	b* mass 1.5 TeV	$f_g = f_L = f_R = 1$	1510.02664
	Excited lepton ℓ^*	3 e, μ	–	–	20.3	ℓ^* mass 3.0 TeV	$\Lambda = 3.0$ TeV	1411.2921
	Excited lepton ν^*	3 e, μ, τ	–	–	20.3	ν^* mass 1.6 TeV	$\Lambda = 1.6$ TeV	1411.2921
Other	LSTC $a_T \rightarrow W\gamma$	1 e, μ, 1 γ	–	Yes	20.3	a_T mass 960 GeV		1407.8150
	LRSM Majorana ν	2 e, μ	2 j	–	20.3	N^0 mass 2.0 TeV	$m(W_R) = 2.4$ TeV, no mixing	1506.06020
	Higgs triplet $H^{\pm\pm} \rightarrow \ell\ell$	2 e, μ (SS)	–	–	20.3	$H^{\pm\pm}$ mass 551 GeV	DY production, BR($H_L^{\pm\pm} \rightarrow \ell\ell$)=1	1412.0237
	Higgs triplet $H^{\pm\pm} \rightarrow \ell\tau$	3 e, μ, τ	–	–	20.3	$H^{\pm\pm}$ mass 400 GeV	DY production, BR($H_L^{\pm\pm} \rightarrow \ell\tau$)=1	1411.2921
	Monotop (non-res prod)	1 e, μ	1 b	Yes	20.3	spin-1 invisible particle mass 657 GeV	$a_{non-res} = 0.2$	1410.5404
	Multi-charged particles	–	–	–	20.3	multi-charged particle mass 785 GeV	DY production, $\lvert q\rvert = 5e$	1504.04188
	Magnetic monopoles	–	–	–	7.0	monopole mass 1.34 TeV	DY production, $\lvert g\rvert = 1g_D$, spin 1/2	1509.08059

$\sqrt{s}$ = 8 TeV $\sqrt{s}$ = 13 TeV

10^{-1} 1 10 **Mass scale [TeV]**

*Only a selection of the available mass limits on new states or phenomena is shown. Lower bounds are specified only when explicitly not excluded.

†Small-radius (large-radius) jets are denoted by the letter j (J).

The diphoton thing

Can I hit the journalist as well ?

Tout est aujourd'hui possible ! Car en novembre, alors qu'il était lancé à pleine puissance, le LHC a détecté un signal anormal... dont tout indique qu'il s'agit d'une nouvelle particule. Sauf que cette "particule X" ne cadre en rien avec tout ce qu'on sait de la matière ! Avant d'être détectée, nul ne soupçonnait son existence.

Starting point

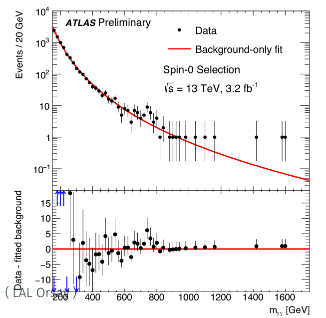
- It all started like any other resonance searches
- Well, 2 actually: optimal selections depend on what you look for

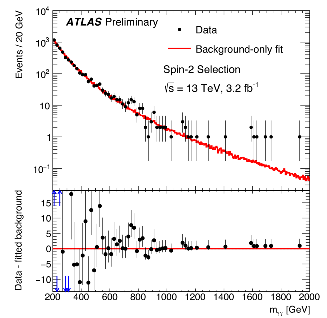
Spin-0 search

- Targets extended scalar sector, like 2HDM
- Pair of tight, well isolated photons
- $E_T(\gamma) > 0.4(0.3)m_{\gamma\gamma}$ for leading (subleading) γ
- Background fit with functional form

Spin-2 search

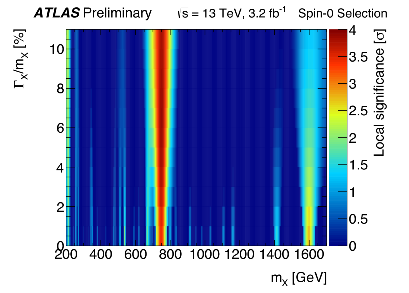
- Targets Randall-Sundrum graviton
- Pair of tight, well isolated photons
- $E_T(\gamma) > 55$ GeV
- Use NLO diphoton MC for background
  - Do not use functional form at very high masses
  - Sensitive to broad non-resonant signals





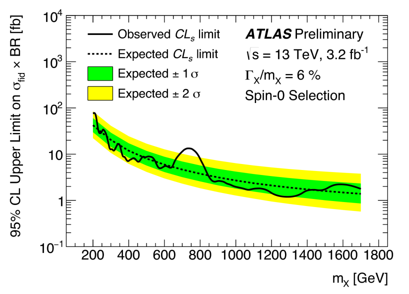
p0

- Perform 2D p0 scan
- Largest deviation from bkg-only hypothesis:
  - Near 750 GeV
  - Width = 45 GeV (6%)
- Local significance: 3.9σ
- Global significance: 2.0σ



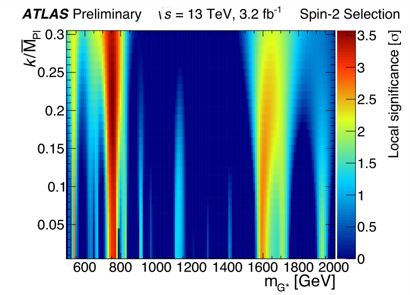
Limits

- Limits on fiducial cross-section
- Function of mass
- For different widths



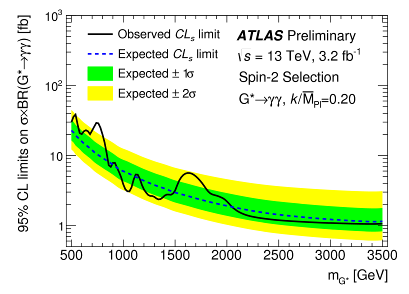
p0

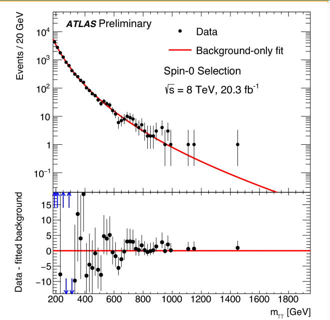
- Perform 2D p0 scan
- Largest deviation from bkg-only hypothesis:
  - Near 750 GeV
  - $\kappa/M_{Pl} = 0.2$ (6% width)
- Local significance: 3.6σ
- Global significance: 1.8σ



Limits

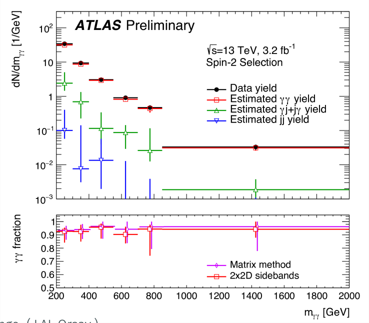
- Limits on fiducial cross-section
- Function of mass
- For different widths





Compatibility with 8 TeV results

- 1.9σ deviation from B-only hypothesis in spin-0 search at 750 GeV ; nothing in spin-2 search
- Under *gg* production hypo: 1.2σ compatibility for spin-0, 2.7σ compatibility for spin-2

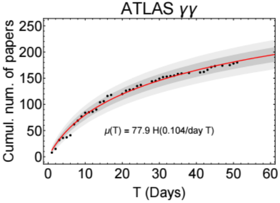


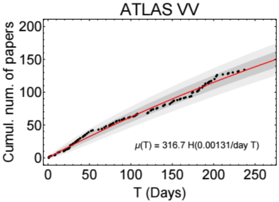
Other checks

- Data-driven estimation of background composition
- Object and event properties around 750 GeV vs sidebands

ANOMALIES

8 th talks out of 28!





arXiv:1603.0204

Understandable: Little BSM experimental data, for too many theorists

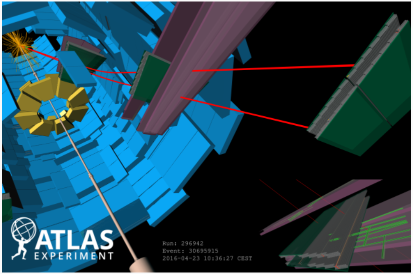
Conclusions

Productive data-taking at 13 TeV

- Many results, covering wide physics reach
- Measurements of basic SM processes
- Re-start of Higgs measurements at 13 TeV

But of course this year was devoted mostly to searches

- Important SUSY channels
- The big resonances hunt



And then there is this excess...

- Whether we believe in it or not, it will attract lots of attention until the summer

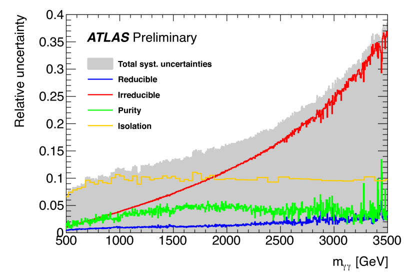
It's now time for 2016 data !

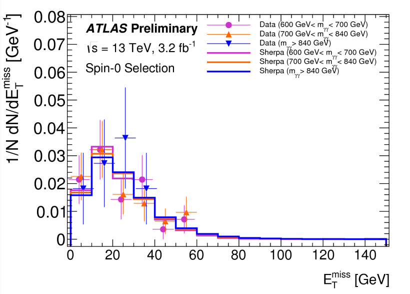
Links

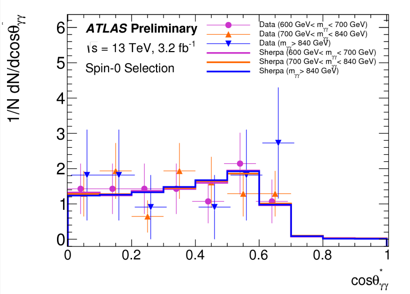
All the results shown today and many more can be found under

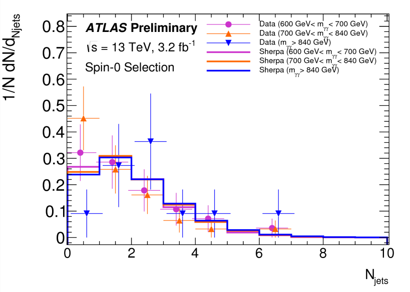
- https://twiki.cern.ch/twiki/bin/view/AtlasPublic/December2015-13TeV
- https://twiki.cern.ch/twiki/bin/view/AtlasPublic/Winter2016-13TeV

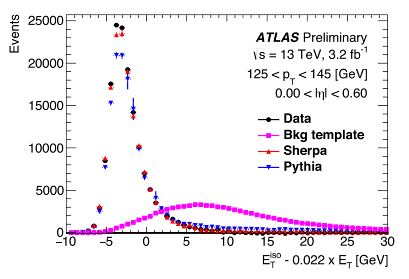
Uncertainty	spin-2 search	spin-0 search	
Background (mass dependent)	± 7% to ± 35%	spurious signal 20 – 0.04 events for Γ/M=6%	p_0 and limit
Signal mass resolution (mass dependent)	$(^{+55}_{-20})\% - (^{+110}_{-40})\%$		p_0 and limit
Signal photon identification (mass dependent)	$\pm(3-2)\%$		limit
Signal photon isolation (mass dependent)	±(3-1)%	±(4-1)%	limit
Signal production process	N/A	±(3-6)% depending on Γ	limit
Trigger efficiency	±0.6%		limit
Luminosity	±5.0%		limit




ATLAS Preliminary
√s = 13 TeV, 3.2 fb-1
Spin-0 Selection
Data (600 GeV< mγγ < 700 GeV)
Data (700 GeV< mγγ < 840 GeV)
Data (mγγ > 840 GeV)
Sherpa (600 GeV< mγγ < 700 GeV)
Sherpa (700 GeV< mγγ < 840 GeV)
Sherpa (mγγ > 840 GeV)
1/N dN/dETmiss [GeV-1]
ETmiss [GeV]


ATLAS Preliminary
√s = 13 TeV, 3.2 fb-1
Spin-0 Selection
Data (600 GeV< mγγ < 700 GeV)
Data (700 GeV< mγγ < 840 GeV)
Data (mγγ > 840 GeV)
Sherpa (600 GeV< mγγ < 700 GeV)
Sherpa (700 GeV< mγγ < 840 GeV)
Sherpa (mγγ > 840 GeV)
1/N dN/dcosθ*γγ
cosθ*γγ


ATLAS Preliminary
√s = 13 TeV, 3.2 fb-1
Spin-0 Selection
Data (600 GeV< mγγ < 700 GeV)
Data (700 GeV< mγγ < 840 GeV)
Data (mγγ > 840 GeV)
Sherpa (600 GeV< mγγ < 700 GeV)
Sherpa (700 GeV< mγγ < 840 GeV)
Sherpa (mγγ > 840 GeV)
1/N dN/dNjets
Njets


ATLAS Preliminary
√s = 13 TeV, 3.2 fb-1
125 < pT < 145 [GeV]
0.00 < |η| < 0.60
Data
Bkg template
Sherpa
Pythia
Events
ETiso - 0.022 x ET [GeV]