

Physics Prospects with the Upgraded ATLAS Detector

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for the ATLAS Collaboration

Overview

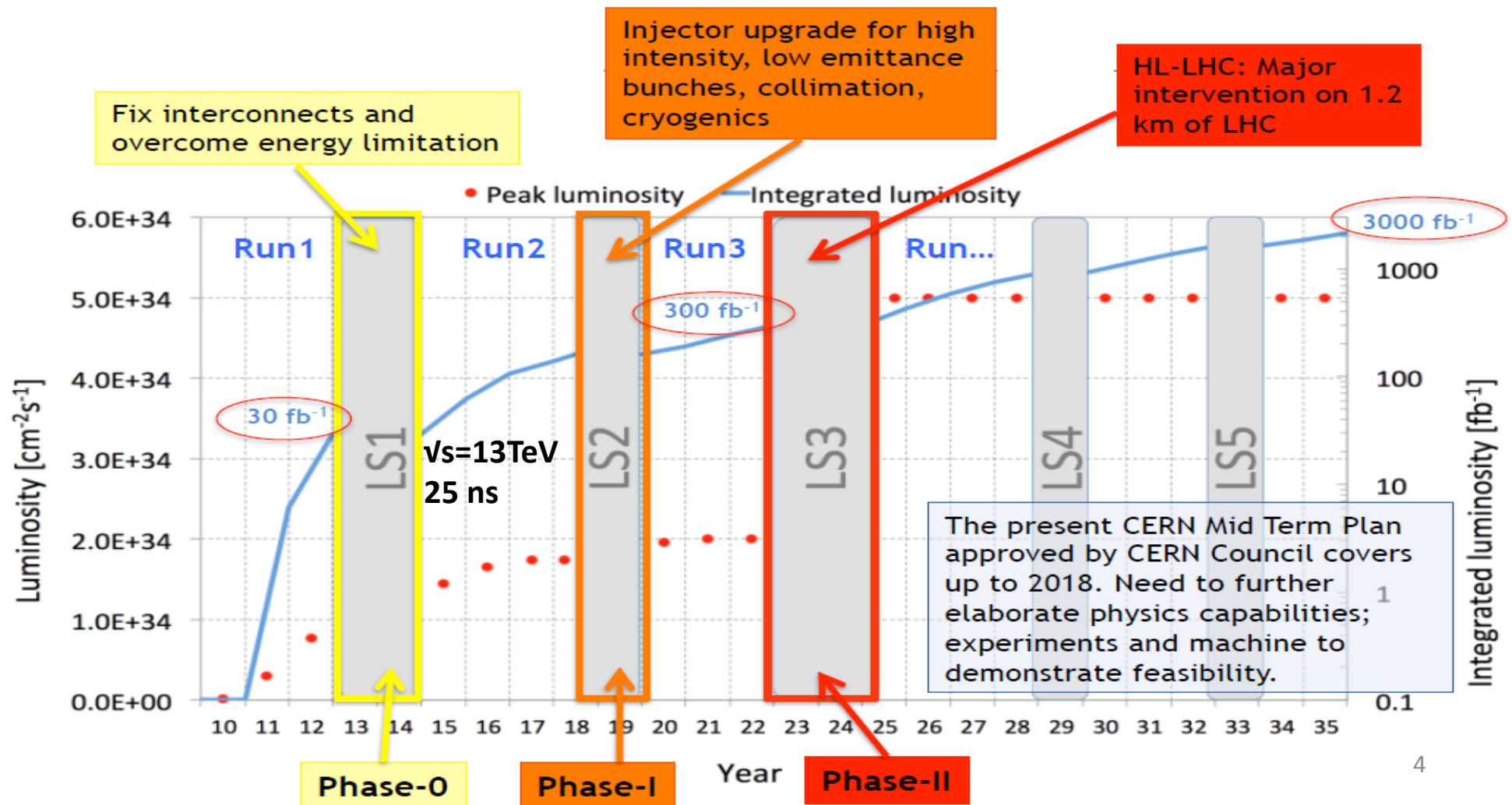
- Introduction
- Prospects for Higgs physics
- Prospects for searches for SuperSymmetry
- Exotic physics search potential
- Conclusions

Physics motivation for LHC upgrade

- Priorities after Higgs discovery:
 - precise measurements of the properties of the new particle
 - search for Higgs rare decays (e.g. $H \rightarrow \mu\mu$)
 - search for partners of the 125 GeV Higgs particle
- Open questions:
 - dark matter candidates
 - naturalness of the Higgs boson
- LHC has been recognized as a natural facility to perform these studies

Luminosity baseline

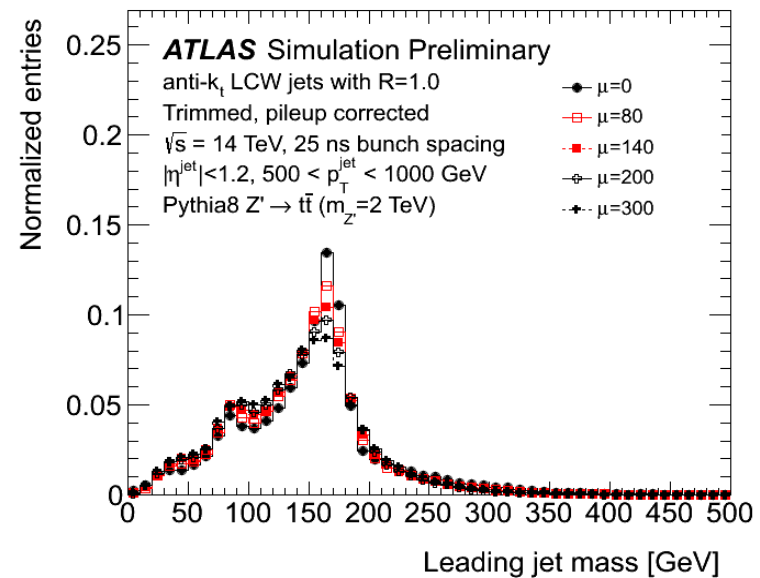
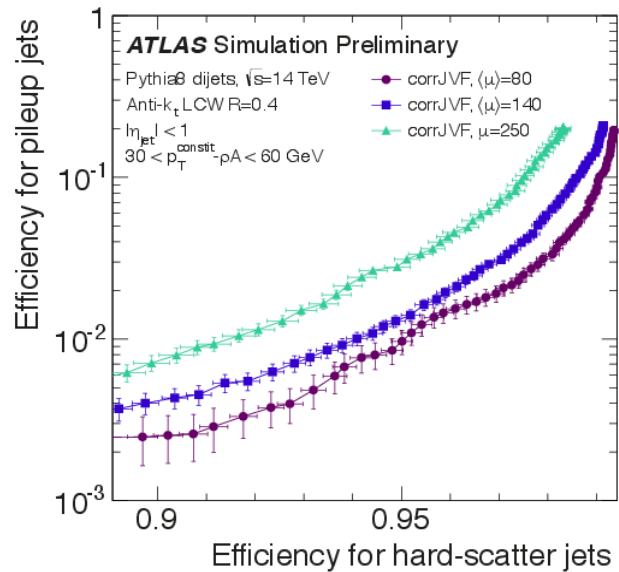
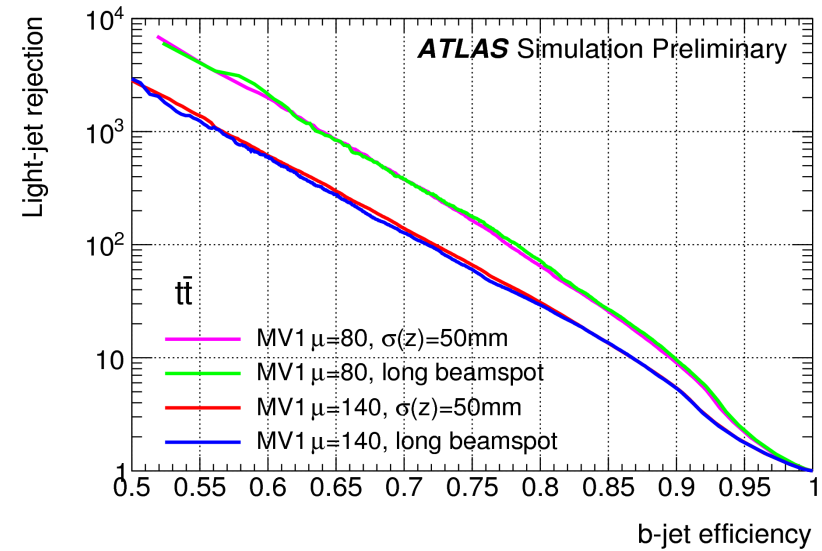
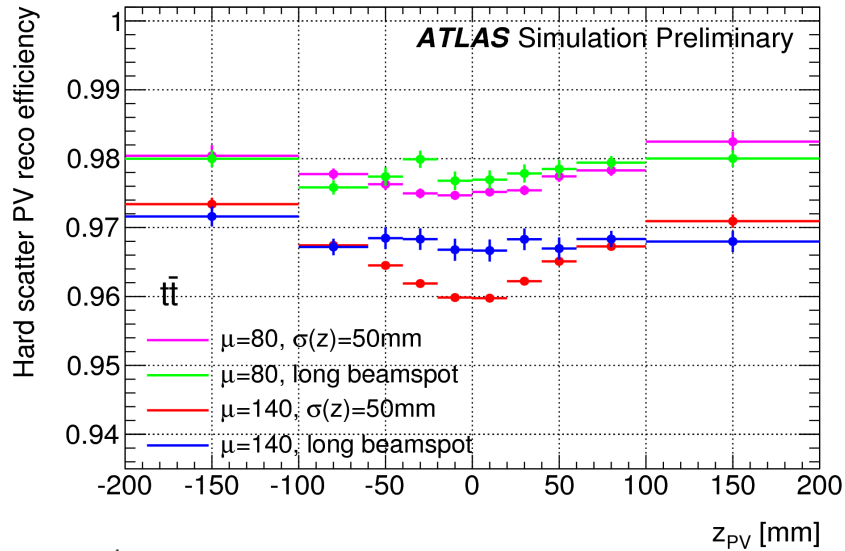
- Run 2 ATLAS upgrade: IBL and trigger
- HL ATLAS upgrade: Inner Tracker will replace the whole current tracking system (expect ~140 pileup events)



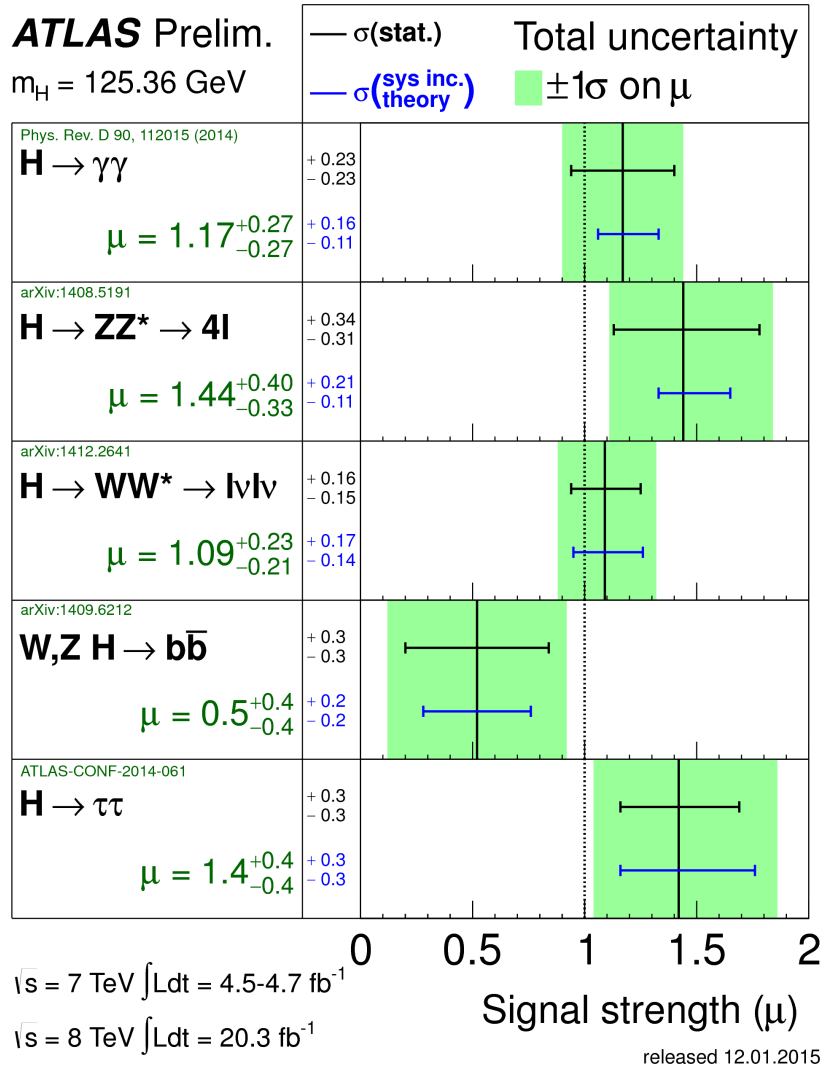
Methodology of evaluation of prospects

- Prospects in all areas of ATLAS physics program are studied by refining the current analyses and by starting design of new analyses
- Strategy:
 - evaluate the performance using full-simulation studies
 - using smearing functions applied to the truth-level objects
 - consider different scenarios related to the systematic uncertainties (which ones can be reduced)
- Parameterization functions obtained using full simulations:
 - Resolution and reconstruction efficiency for e, μ, γ, τ , jets and E_t^{miss}
 - Rates for light, c and b-quark jets to pass b-tagging criteria

ATLAS performance under HL LHC conditions



SM Higgs boson: current status



ATLAS $H \rightarrow \gamma\gamma$

CMS $H \rightarrow \gamma\gamma$

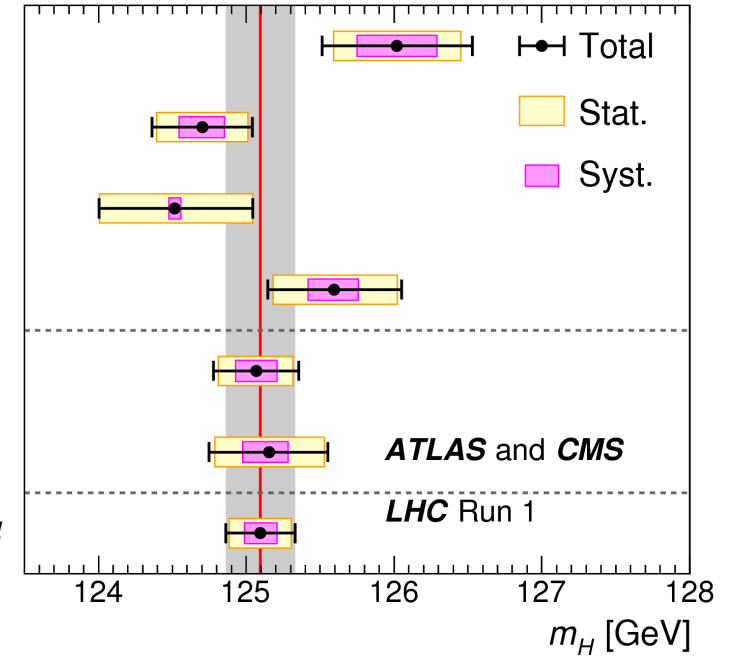
ATLAS $H \rightarrow ZZ \rightarrow 4l$

CMS $H \rightarrow ZZ \rightarrow 4l$

ATLAS+CMS $\gamma\gamma$

ATLAS+CMS $4l$

ATLAS+CMS $\gamma\gamma+4l$



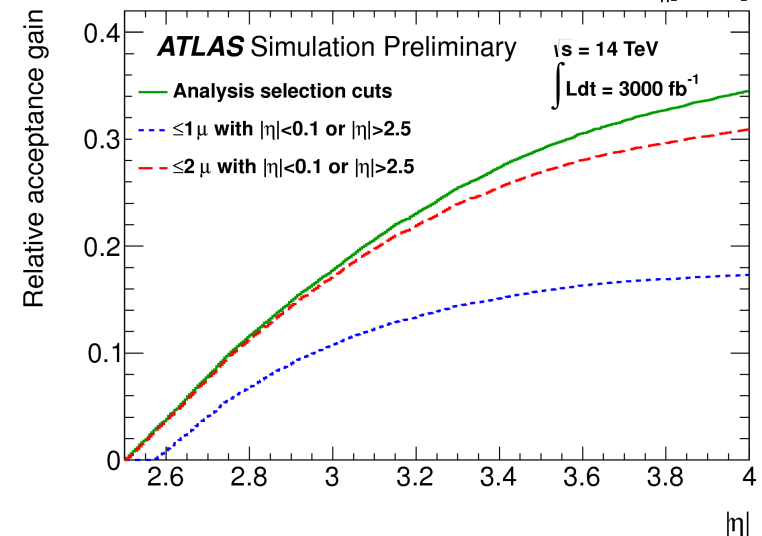
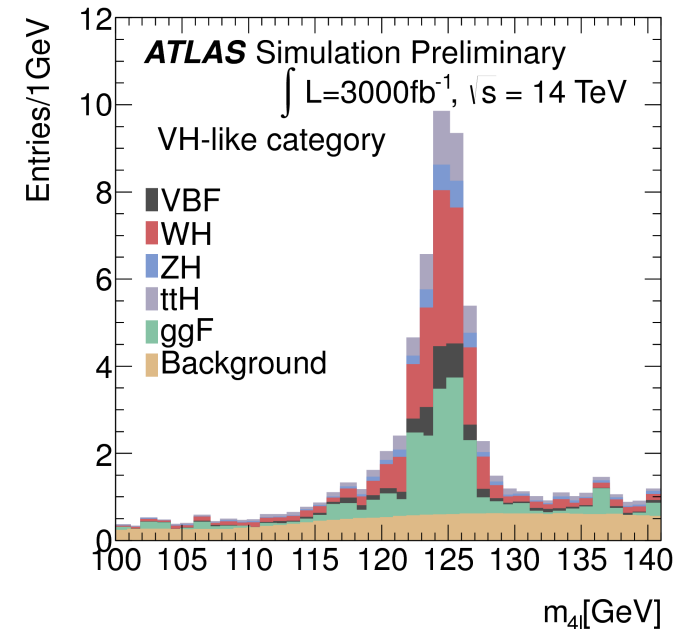
- $M_H = 125.09 \pm 0.24$ GeV

Prospects of observation of Higgs \rightarrow ZZ final state at HL

- Experimentally, very clean signal

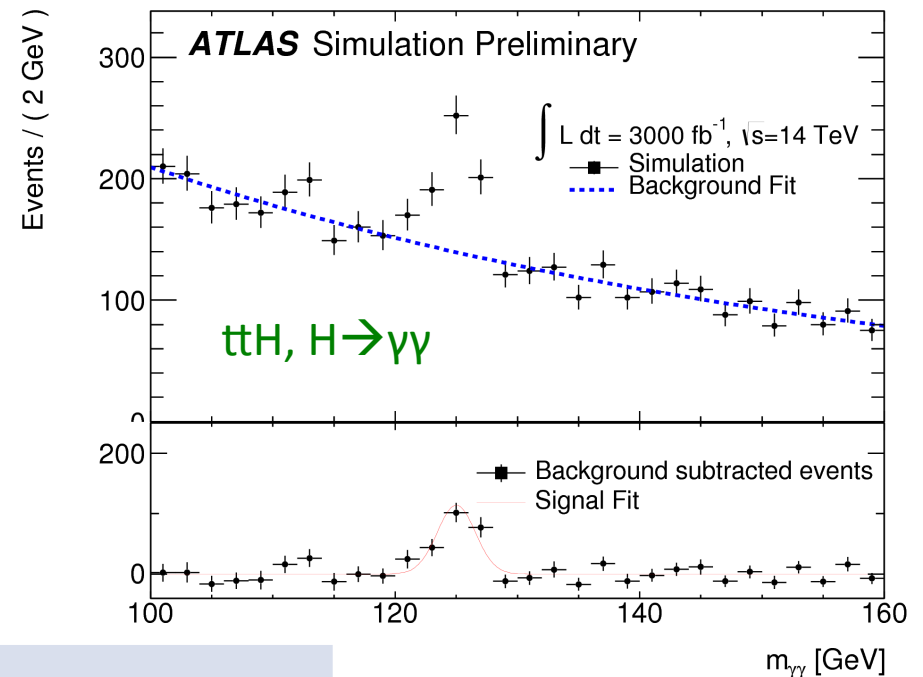
$\Delta\mu/\mu$	Total	Stat.	Expt. syst.	Theory
Production mode	300 fb ⁻¹			
ggF	0.152	0.066	0.053	0.124
VBF	0.625	0.545	0.233	0.226
WH	1.074	1.064	0.061	0.085
t \bar{t} H	0.535	0.516	0.038	0.120
Combined	0.125	0.042	0.044	0.108
	3000 fb ⁻¹			
ggF	0.131	0.025	0.040	0.124
VBF	0.371	0.187	0.225	0.226
WH	0.390	0.375	0.061	0.085
ZH	0.532	0.526	0.038	0.073
t \bar{t} H	0.224	0.184	0.034	0.120
Combined	0.100	0.016	0.036	0.093

- Significant acceptance gain is expected due to extension of muon η coverage



Higgs measurements in $\gamma\gamma$ final state

- Important for tH Yukawa coupling measurements
- ATLAS studied different channels; theoretical uncertainties are leading
- Combined signal strength uncertainty is $\sim 3.5\%$ (if drop theoretical uncertainties)



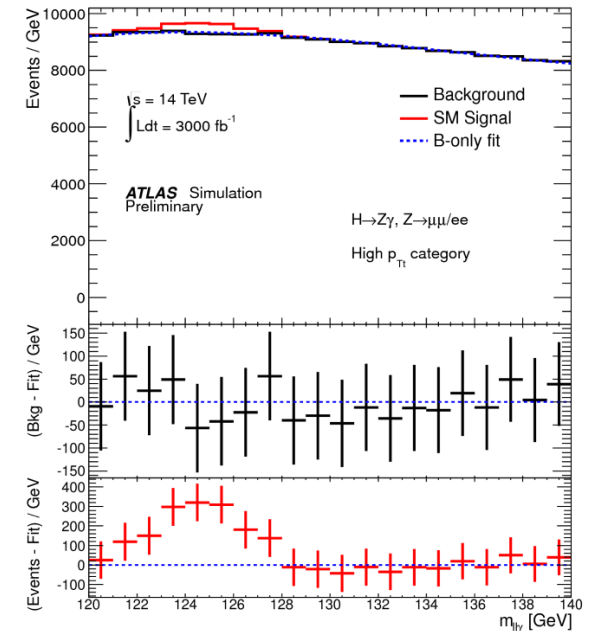
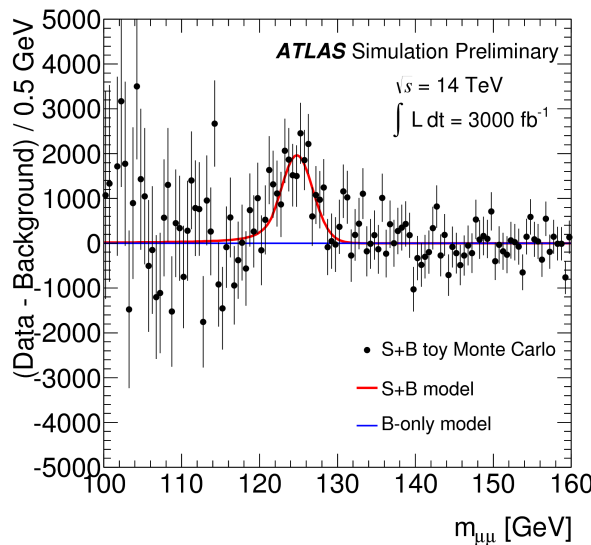
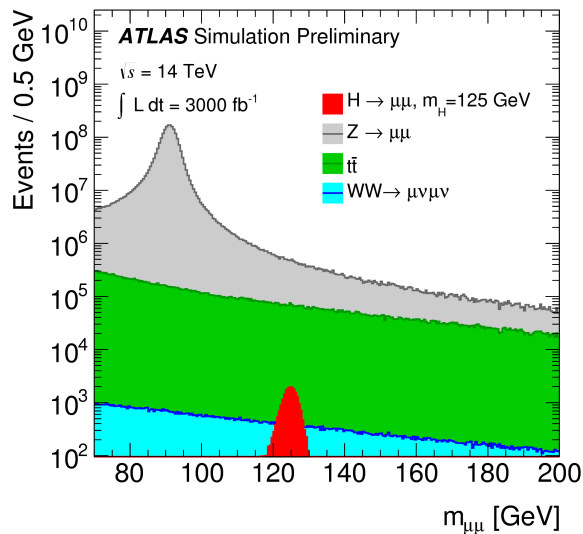
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Production mode	$\Delta\mu/\mu$ (%)			
	Total	Statistical	Experimental	Theoretical
ttH	+21 -17	+13 -12	+5 -4	+17 -11
WH	+26 -25	+21 -20	+13 -12	+10 -8
ZH	+35 -31	+32 -29	+7 -7	+12 -8
ggF	+19 -14	+3 -3	+1 -1	+19 -14
VBF	+29 -29	+18 -18	+1 -1	+23 -23

Rare Higgs boson decays

- $H \rightarrow Z\gamma$ is sensitive to potential new particles in the loop. ATLAS expects to observe $H \rightarrow Z\gamma$ decay at $\sim 4\sigma$ level on 3000 fb^{-1} dataset.
- Expected uncertainty on signal strength: 0.46 at $300 \text{ fb}^{-1} \rightarrow 0.30$ at 3000 fb^{-1}

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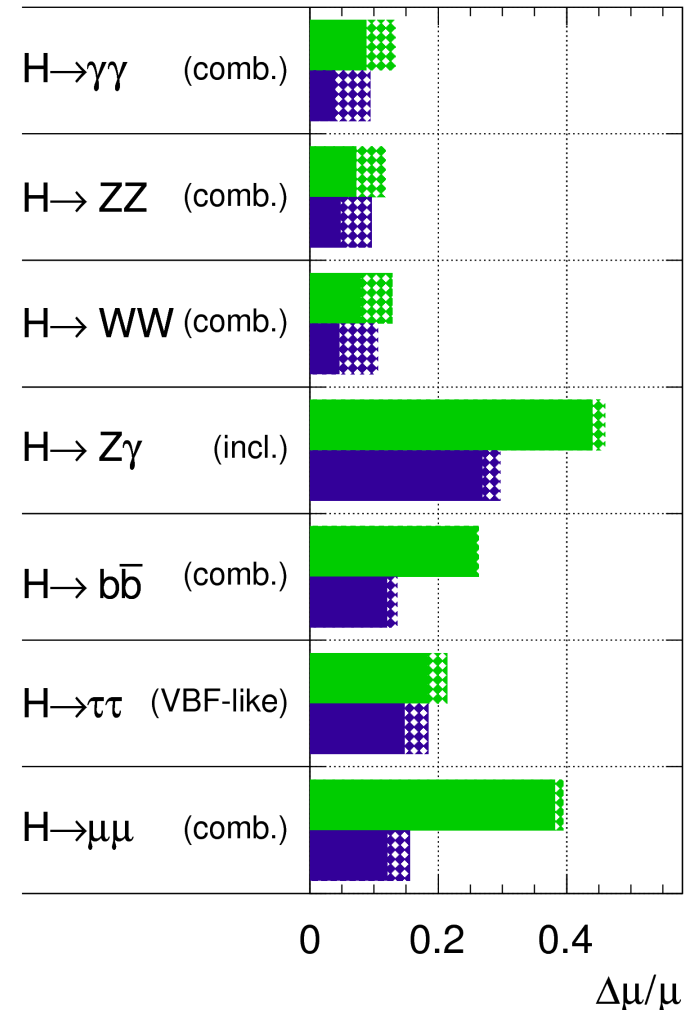
- $H \rightarrow \mu\mu$ is sensitive to the 2nd generation coupling
- Expect to see at 7σ level

Higgs signal strengths

- Signal strength $\mu = \sigma \times BR / (\sigma \times BR)_{SM}$
- Separation by production modes
 - Important for coupling measurements
- Projection assumptions:
 - 300/fb: $\mu = 60$, 3000/fb: $\mu = 140$
 - Used dedicated 14 TeV samples
- Systematics:
 - Conservative estimation (including propagation of the large statistics in control regions)
 - Large impact from theory uncertainties (shown by dashed areas), like QCD scale, PDFs

ATLAS Simulation Preliminary

$\sqrt{s} = 14$ TeV: $\int L dt = 300 \text{ fb}^{-1}$; $\int L dt = 3000 \text{ fb}^{-1}$



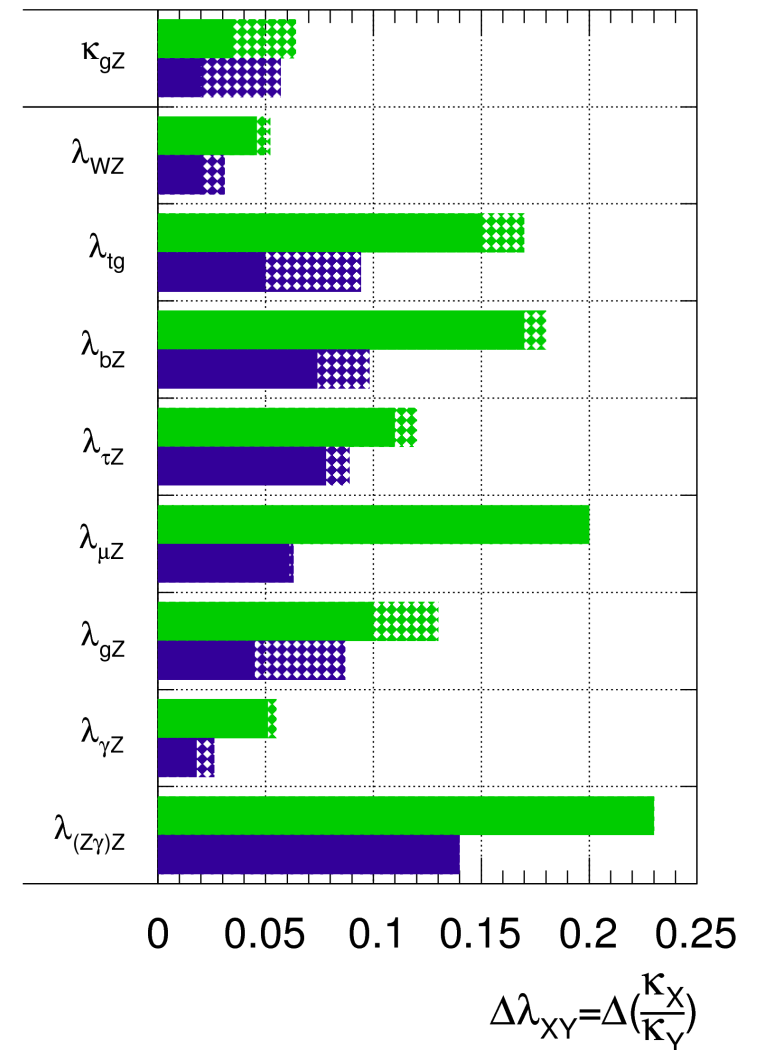
Higgs coupling ratios

- Ratios:
 - $\lambda_{ij} = k_i/k_j$; $k_{ij} = k_i k_j/k_h$
 - k_i are modifiers of the SM couplings, k_h is the width scale factor
- Overall, ~5% accuracy is achievable
 - don't rely on assumptions on total width
 - Free couplings to SM particles
 - Allow for BSM in loops and undetected final states
- Expected precision of couplings
(assuming that theoretical uncertainties will be reduced by factor of 2)

k(%)	k_z	k_w	k_t	k_b	k_τ	k_μ	k_g	k_γ	$k_{Z\gamma}$
300 fb ⁻¹	8	9	21	22	14	21	14	9	24
3000 fb ⁻¹	4	4.5	9	11	9	7	7	4	14

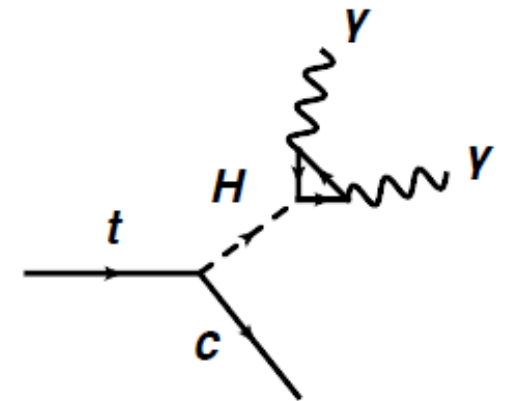
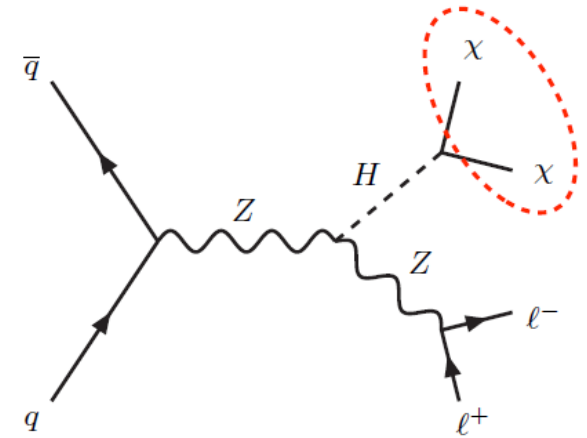
ATLAS Simulation Preliminary

$\sqrt{s} = 14$ TeV: $\int L dt = 300$ fb⁻¹ ; $\int L dt = 3000$ fb⁻¹



BSM Higgs searches

- Invisible Higgs: $ZH \rightarrow \ell\ell + X$
 - sensitivity $\text{Br}(H \rightarrow \text{invisible})$: 20-30% at 300/fb, 10% at 3000/fb
 - similar to sensitivity from couplings
- Top rare decays $t \rightarrow cH$ (FCNC)
 - SM: 3×10^{-15} , BSM: up to 10^{-5}
 - expected sensitivity at 3000/fb: 1.5×10^{-4}



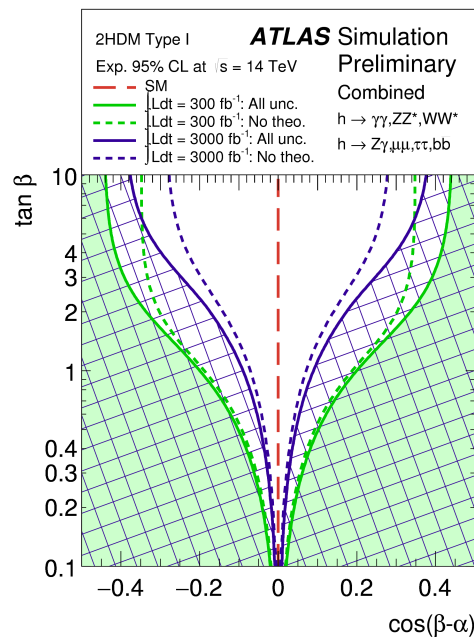
BSM Higgs couplings

- Additional electroweak singlet (H)
 - precision on κ_H : 2.5% at 300/fb, 1.6% at 3000/fb (w/o theor. uncertainties)

$$\kappa_h^2 + \kappa_H^2 = 1$$

SM-like Higgs (125 GeV)

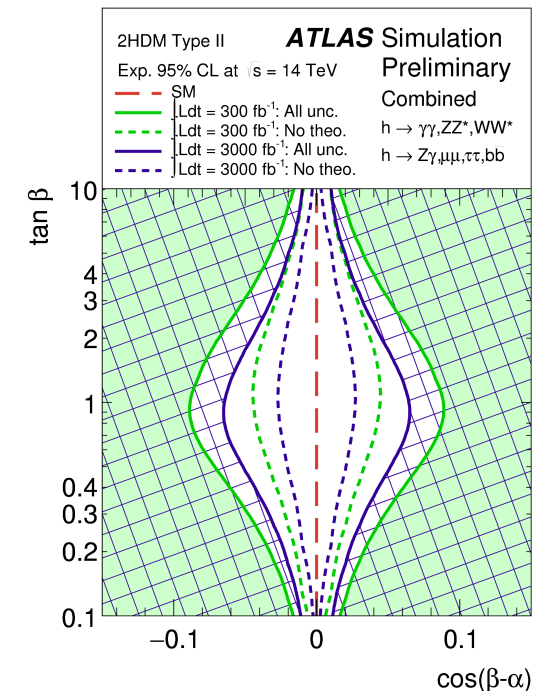
- 2HDM for Type I and Type 2



α – angle between 2 CP-even Higgs states.

Type 1: One Higgs doublet couples to vector bosons, the other – to fermions.

Type 2: One Higgs doublet couples to up-type quarks, the other – to down-type quarks.



SUSY: Current Status

ATLAS SUSY Searches* - 95% CL Lower Limits

Status: Feb 2015

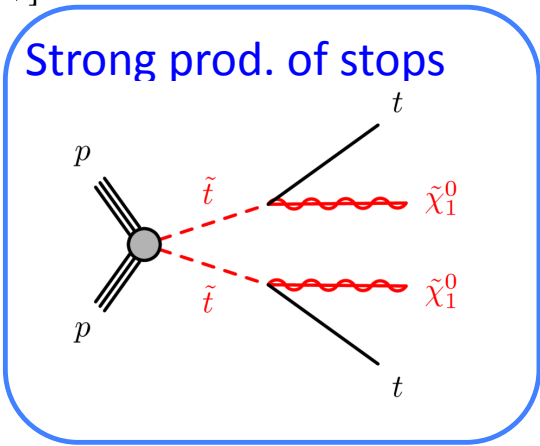
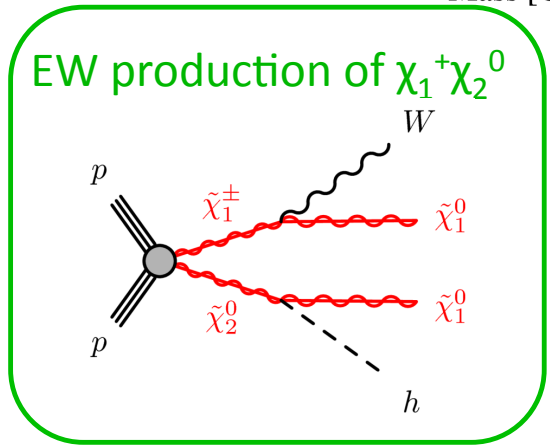
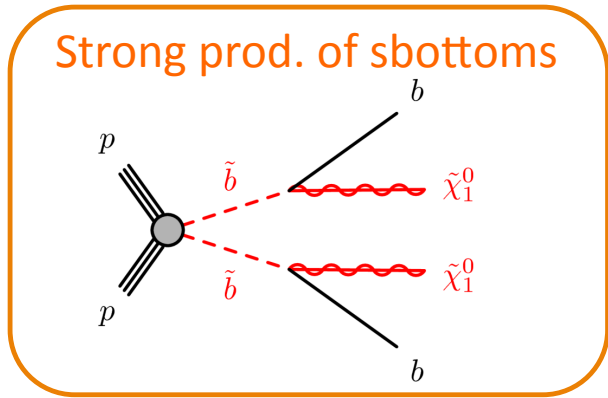
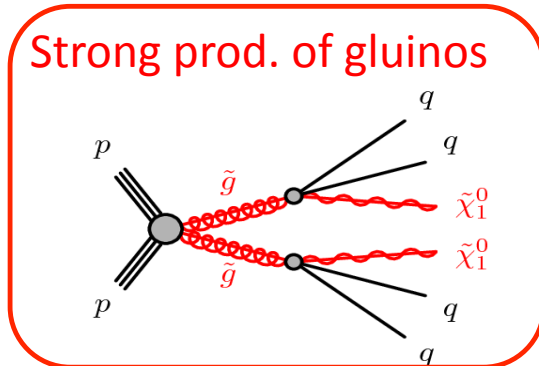
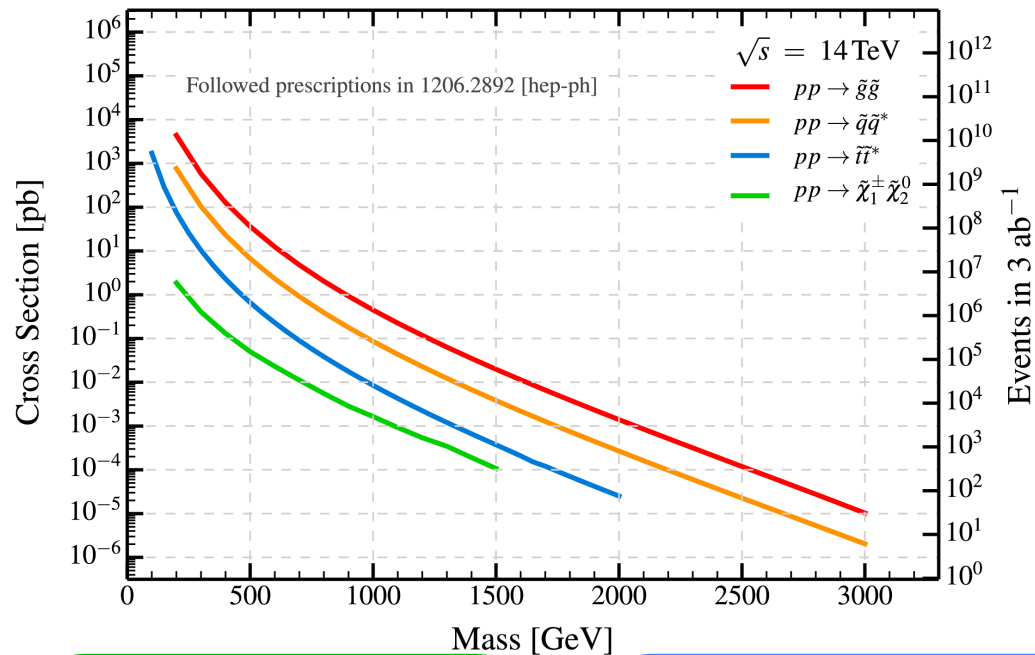
ATLAS Preliminary

$\sqrt{s} = 7, 8$ TeV

	Model	e, μ, τ, γ	Jets	E_T^{miss}	$\int \mathcal{L} dt [\text{fb}^{-1}]$	Mass limit	Reference	
Inclusive Searches	MSUGRA/CMSSM	0	2-6 jets	Yes	20.3	\tilde{q}, \tilde{g} 1.7 TeV	$m(\tilde{q})=m(\tilde{g})$	
	$\tilde{q}\tilde{q}, \tilde{q} \rightarrow q\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	850 GeV	$m(\tilde{\chi}_1^0)=0$ GeV, $m(1^{\text{st}} \text{ gen. } \tilde{q})=m(2^{\text{nd}} \text{ gen. } \tilde{q})$	
	$\tilde{q}\tilde{q}\gamma, \tilde{q} \rightarrow q\tilde{\chi}_1^0$ (compressed)	1 γ	0-1 jet	Yes	20.3	250 GeV	$m(\tilde{q})=m(\tilde{\chi}_1^0) = m(c)$	
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow q\tilde{q}\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	1.33 TeV	$m(\tilde{\chi}_1^0)=0$ GeV	
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow qg\tilde{\chi}_1^0 \rightarrow qgW\tilde{\chi}_1^\pm$	1 e, μ	3-6 jets	Yes	20	1.2 TeV	$m(\tilde{\chi}_1^0) < 300$ GeV, $m(\tilde{\chi}_1^\pm)=0.5(m(\tilde{\chi}_1^0)+m(\tilde{g}))$	
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow qg(\ell\ell/\nu\nu)\tilde{\chi}_1^0$	2 e, μ	0-3 jets	-	20	1.32 TeV	$m(\tilde{\chi}_1^0)=0$ GeV	
	GMSB ($\tilde{\ell}$ NLSP)	1-2 $\tau + 0-1 \ell$	0-2 jets	Yes	20.3	1.6 TeV	$\tan\beta > 20$	
	GGM (bino NLSP)	2 γ	-	Yes	20.3	1.28 TeV	$m(\tilde{\chi}_1^0) > 50$ GeV	
	GGM (wino NLSP)	1 $e, \mu + \gamma$	-	Yes	4.8	619 GeV	$m(\tilde{\chi}_1^0) > 50$ GeV	
	GGM (higgsino-bino NLSP)	γ	1 b	Yes	4.8	900 GeV	$m(\tilde{\chi}_1^0) > 220$ GeV	
3 rd gen. \tilde{g} med.	$\tilde{g} \rightarrow b\tilde{b}\tilde{\chi}_1^0$	0	3 b	Yes	20.1	1.25 TeV	$m(\tilde{\chi}_1^0) < 400$ GeV	
	$\tilde{g} \rightarrow t\tilde{t}\tilde{\chi}_1^0$	0	7-10 jets	Yes	20.3	1.1 TeV	$m(\tilde{\chi}_1^0) < 350$ GeV	
	$\tilde{g} \rightarrow t\tilde{t}\tilde{\chi}_1^\pm$	0-1 e, μ	3 b	Yes	20.1	1.34 TeV	$m(\tilde{\chi}_1^0) < 400$ GeV	
	$\tilde{g} \rightarrow b\tilde{t}\tilde{\chi}_1^\pm$	0-1 e, μ	3 b	Yes	20.1	1.3 TeV	$m(\tilde{\chi}_1^0) < 300$ GeV	
	3 rd gen. squarks direct production	$\tilde{t}_1\tilde{b}_1, \tilde{b}_1 \rightarrow b\tilde{\chi}_1^0$	0	2 b	Yes	20.1	100-620 GeV	$m(\tilde{\chi}_1^0) < 90$ GeV
		$\tilde{b}_1\tilde{b}_1, \tilde{b}_1 \rightarrow t\tilde{\chi}_1^\pm$	2 e, μ (SS)	0-3 b	Yes	20.3	275-440 GeV	$m(\tilde{\chi}_1^\pm)=2 m(\tilde{\chi}_1^0)$
		$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow b\tilde{\chi}_1^\pm$	1-2 e, μ	1-2 b	Yes	4.7	110-167 GeV	$m(\tilde{\chi}_1^\pm) = 2m(\tilde{\chi}_1^0), m(\tilde{\chi}_1^0)=55$ GeV
		$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow Wb\tilde{\chi}_1^0$ or $t\tilde{\chi}_1^0$	2 e, μ	0-2 jets	Yes	20.3	90-191 GeV	$m(\tilde{\chi}_1^0)=1$ GeV
		$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow t\tilde{\chi}_1^0$	0-1 e, μ	1-2 b	Yes	20	210-640 GeV	$m(\tilde{\chi}_1^0)=1$ GeV
		$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow c\tilde{\chi}_1^0$	0	mono-jet/ c -tag	Yes	20.3	90-240 GeV	$m(\tilde{t}_1)-m(\tilde{\chi}_1^0) < 85$ GeV
$\tilde{t}_1\tilde{t}_1$ (natural GMSB)		2 e, μ (Z)	1 b	Yes	20.3	150-580 GeV	$m(\tilde{\chi}_1^0) > 150$ GeV	
$\tilde{t}_2\tilde{t}_2, \tilde{t}_2 \rightarrow \tilde{t}_1 + Z$		3 e, μ (Z)	1 b	Yes	20.3	290-600 GeV	$m(\tilde{\chi}_1^0) < 200$ GeV	
EW direct		$\tilde{\chi}_{1,R}^+, \tilde{\chi}_{1,R}^-, \tilde{\chi} \rightarrow \ell\tilde{\chi}_1^0$	2 e, μ	0	Yes	20.3	90-325 GeV	$m(\tilde{\chi}_1^0)=0$ GeV
		$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+ \rightarrow \tilde{\nu}(\tilde{\nu})$	2 e, μ	0	Yes	20.3	140-465 GeV	$m(\tilde{\chi}_1^0)=0$ GeV, $m(\tilde{\nu})=0.5(m(\tilde{\chi}_1^+)+m(\tilde{\chi}_1^-))$
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+ \rightarrow \tilde{\tau}(\tilde{\tau})$	2 τ	-	Yes	20.3	100-350 GeV	$m(\tilde{\chi}_1^0)=0$ GeV, $m(\tilde{\tau}, \nu)=0.5(m(\tilde{\chi}_1^+)+m(\tilde{\chi}_1^-))$	
	$\tilde{\chi}_1^+\tilde{\chi}_2^0 \rightarrow \tilde{\ell}_L \nu \tilde{\ell}_L \ell(\tilde{\nu})$	3 e, μ	0	Yes	20.3	700 GeV	$m(\tilde{\chi}_1^+)=m(\tilde{\chi}_2^0), m(\tilde{\chi}_1^0)=0, m(\tilde{\nu})=0.5(m(\tilde{\chi}_1^+)+m(\tilde{\chi}_1^-))$	
	$\tilde{\chi}_1^+\tilde{\chi}_2^0 \rightarrow W\tilde{\chi}_1^0 Z\tilde{\chi}_1^0$	2-3 e, μ	0-2 jets	Yes	20.3	420 GeV	$m(\tilde{\chi}_1^+)=m(\tilde{\chi}_2^0), m(\tilde{\chi}_1^0)=0$, sleptons decoupled	
	$\tilde{\chi}_1^+\tilde{\chi}_2^0 \rightarrow W\tilde{\chi}_1^0 h\tilde{\chi}_1^0, h \rightarrow b\tilde{b}/WW/\tau\tau/\gamma\gamma$	e, μ, γ	0-2 b	Yes	20.3	250 GeV	$m(\tilde{\chi}_1^+)=m(\tilde{\chi}_2^0), m(\tilde{\chi}_1^0)=0$, sleptons decoupled	
	$\tilde{\chi}_2^0\tilde{\chi}_3^0, \tilde{\chi}_2^0 \rightarrow \tilde{\ell}_R \ell$	4 e, μ	0	Yes	20.3	620 GeV	$m(\tilde{\chi}_2^0)=m(\tilde{\chi}_3^0), m(\tilde{\chi}_1^0)=0, m(\tilde{\nu})=0.5(m(\tilde{\chi}_2^0)+m(\tilde{\chi}_1^0))$	
	Long-lived particles	Direct $\tilde{\chi}_1^+\tilde{\chi}_1^-$ prod., long-lived $\tilde{\chi}_1^\pm$	Disapp. trk	1 jet	Yes	20.3	270 GeV	$m(\tilde{\chi}_1^\pm)-m(\tilde{\chi}_1^0)=160$ MeV, $\tau(\tilde{\chi}_1^\pm)=0.2$ ns
		Stable, stopped \tilde{g} R-hadron	0	1-5 jets	Yes	27.9	832 GeV	$m(\tilde{\chi}_1^0)=100$ GeV, $10 \mu\text{s} < \tau(\tilde{g}) < 10000$ s
		Stable \tilde{g} R-hadron	trk	-	-	19.1	1.27 TeV	1411.6795
GMSB, stable $\tilde{\tau}, \tilde{\chi}_1^0 \rightarrow \tilde{\tau}(\tilde{\tau}, \tilde{\mu}) + \tau(e, \mu)$		1-2 μ	-	-	19.1	537 GeV	$10 < \tan\beta < 50$	
GMSB, $\tilde{\chi}_1^0 \rightarrow \gamma\tilde{G}$, long-lived $\tilde{\chi}_1^0$		2 γ	-	Yes	20.3	435 GeV	$2 < \tau(\tilde{\chi}_1^0) < 3$ ns, SPS8 model	
$\tilde{q}\tilde{q}, \tilde{\chi}_1^0 \rightarrow q\tilde{q}\mu$ (RPV)		1 μ , displ. vtx	-	-	20.3	1.0 TeV	$1.5 < \tau < 156$ mm, $BR(\mu)=1, m(\tilde{\chi}_1^0)=108$ GeV	
RPV	LFV $pp \rightarrow \tilde{\nu}_\tau + X, \tilde{\nu}_\tau \rightarrow e + \mu$	2 e, μ	-	-	4.6	1.61 TeV	$\lambda_{311}^e=0.10, \lambda_{132}=0.05$	
	LFV $pp \rightarrow \tilde{\nu}_\tau + X, \tilde{\nu}_\tau \rightarrow e(\mu) + \tau$	1 $e, \mu + \tau$	-	-	4.6	1.1 TeV	$\lambda_{311}^e=0.10, \lambda_{1(2)33}=0.05$	
	Bilinear RPV CMSSM	2 e, μ (SS)	0-3 b	Yes	20.3	1.35 TeV	$m(\tilde{q})=m(\tilde{g}), \epsilon_{T,US} < 1$ mm	
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+ \rightarrow W\tilde{\chi}_1^0, \tilde{\chi}_1^0 \rightarrow ee\tilde{\nu}_\mu, e\mu\tilde{\nu}_e$	4 e, μ	-	Yes	20.3	750 GeV	$m(\tilde{\chi}_1^0) > 0.2 \times m(\tilde{\chi}_1^\pm), \lambda_{121} \neq 0$	
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+ \rightarrow W\tilde{\chi}_1^0, \tilde{\chi}_1^0 \rightarrow \tau\tilde{\nu}_\tau, e\tau\tilde{\nu}_\tau$	3 $e, \mu + \tau$	-	Yes	20.3	450 GeV	$m(\tilde{\chi}_1^0) > 0.2 \times m(\tilde{\chi}_1^\pm), \lambda_{133} \neq 0$	
	$\tilde{g} \rightarrow q\tilde{q}\tilde{q}$	0	6-7 jets	-	20.3	916 GeV	$BR(\ell)=BR(b)=BR(c)=0\%$	
Other	$\tilde{g} \rightarrow \tilde{t}_1 t, \tilde{t}_1 \rightarrow bs$	2 e, μ (SS)	0-3 b	Yes	20.3	850 GeV	ATLAS-CONF-2013-091	
	Scalar charm, $\tilde{c} \rightarrow c\tilde{\chi}_1^0$	0	2 c	Yes	20.3	490 GeV	$m(\tilde{\chi}_1^0) < 200$ GeV	

*Only a selection of the available mass limits on new states or phenomena is shown. All limits quoted are observed minus 1 σ theoretical signal cross section uncertainty.

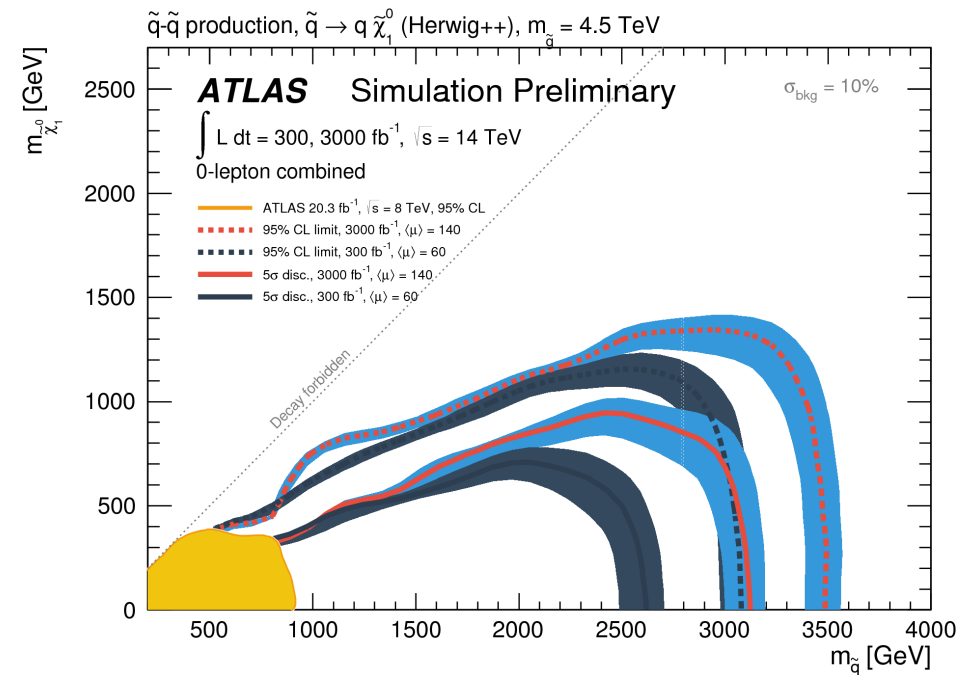
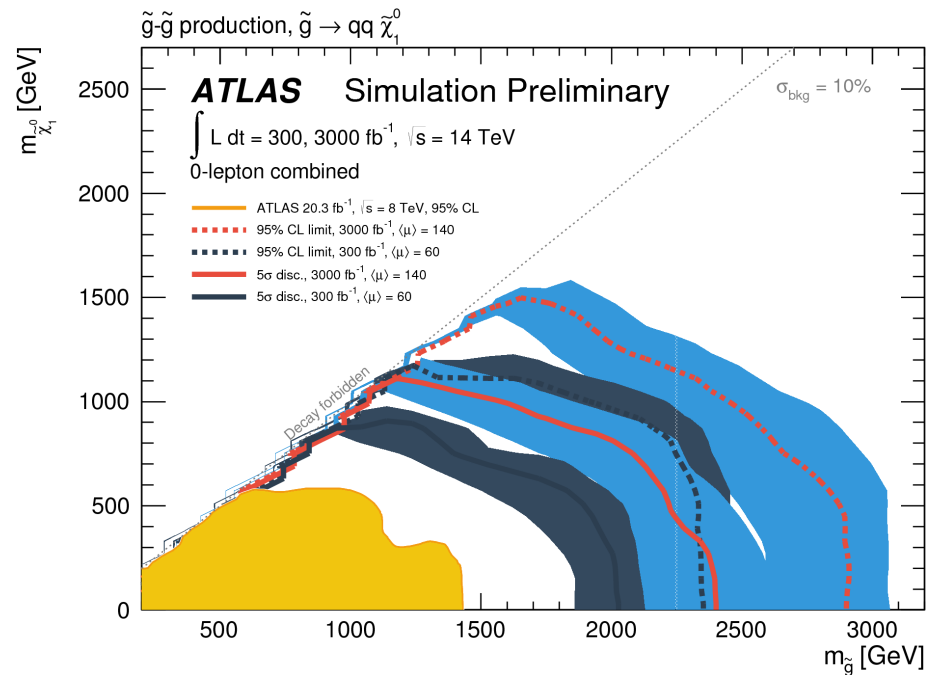
SUSY searches strategy at HL LHC



- Mass constraints depend on the assumed SUSY mass spectrum

Strong production of gluinos/squarks

- Search in 0 lepton + multiple b-jets + E_{miss} channel
- Current lower limit on gluino mass (1.4 TeV) can be extended to 2.3 TeV with 300 fb⁻¹ and 3 TeV with 3000 fb⁻¹

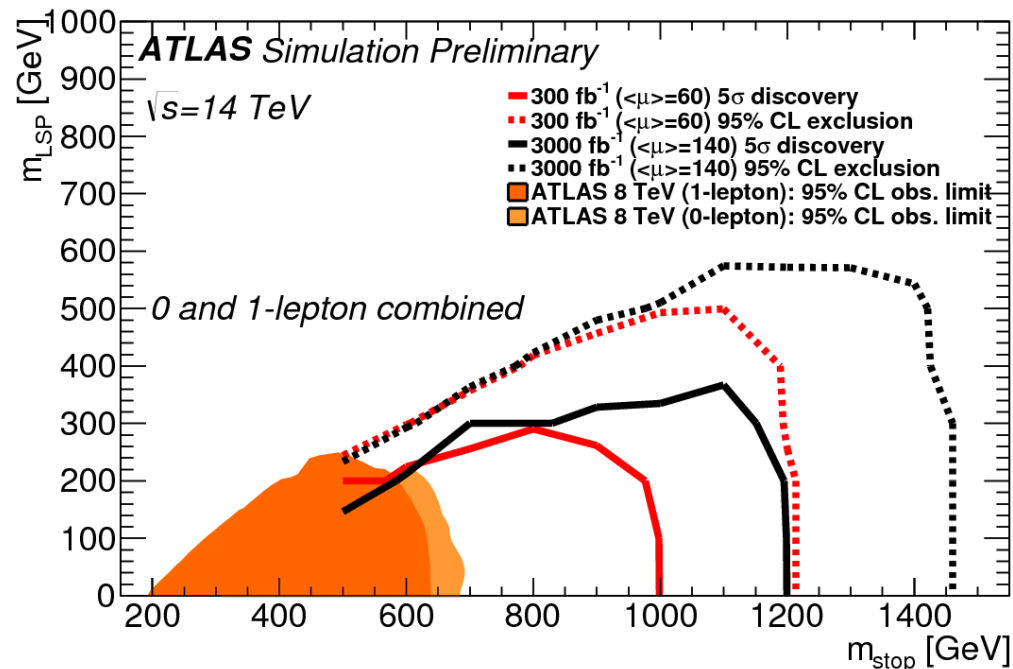


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Strong production of stop quarks

- Naturalness requires stop/sbottom mass to be $< \sim 1$ TeV
- Studies performed only for standard cases $t + \text{LSP}$
- Final state: $0/1$ lepton + $\geq 6/4$ jets + $\geq 2/1$ b-jets + E_{miss}
- 5σ discovery potential up to 1 TeV with 300 fb^{-1} and 1.2 TeV with 3000 fb^{-1} .

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Strong production of sbottom quarks

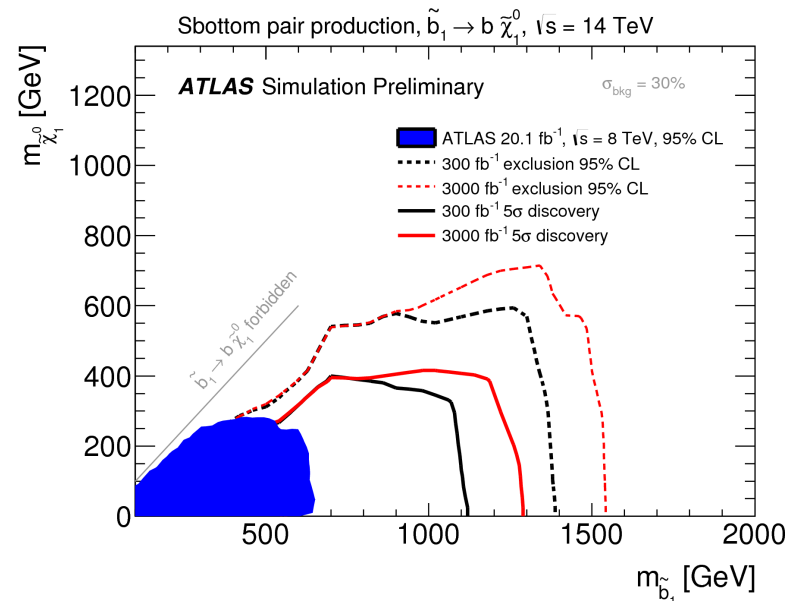
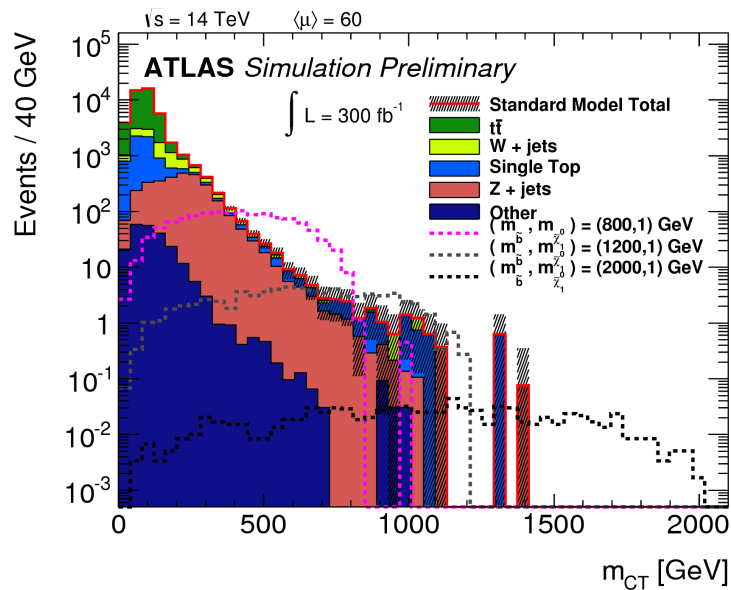
- Feasibility studies performed for direct production and decay (b+LSP)

- Discriminator between signal and main background (ttbar): boost-corrected contransverse mass

$$m_{CT} = \frac{m^2(\tilde{b}) - m^2(\tilde{\chi}_1^0)}{m(\tilde{b})}$$

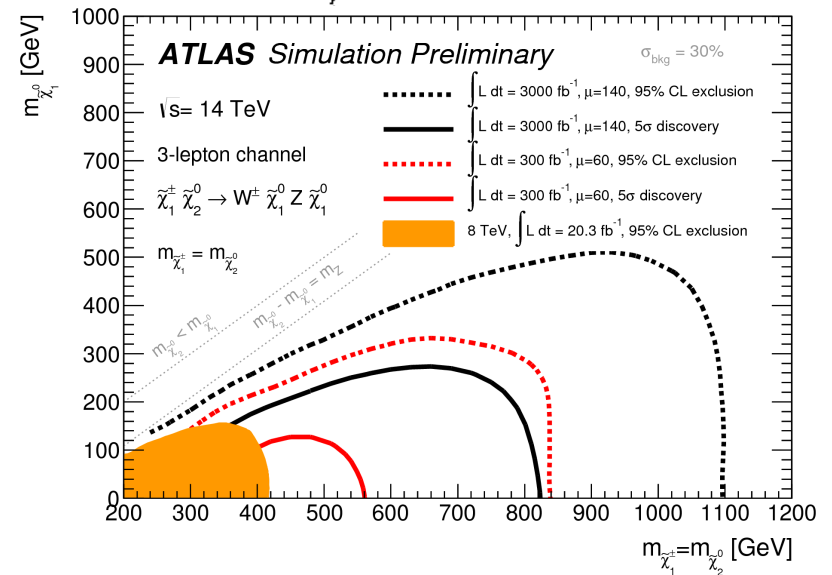
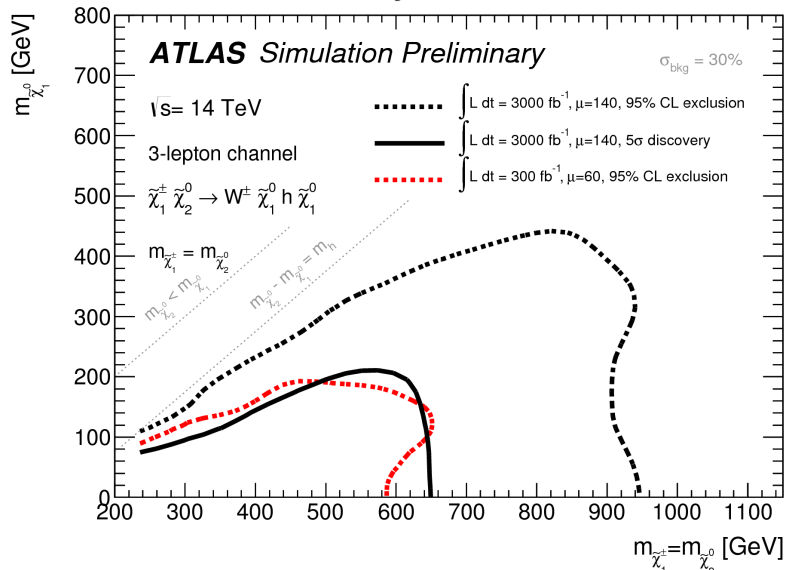
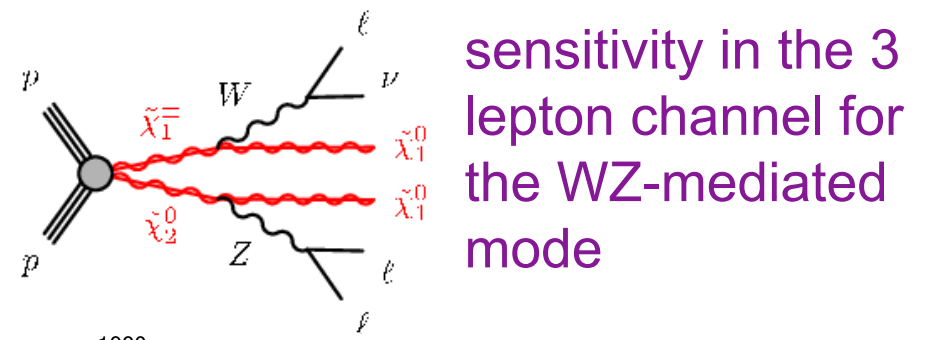
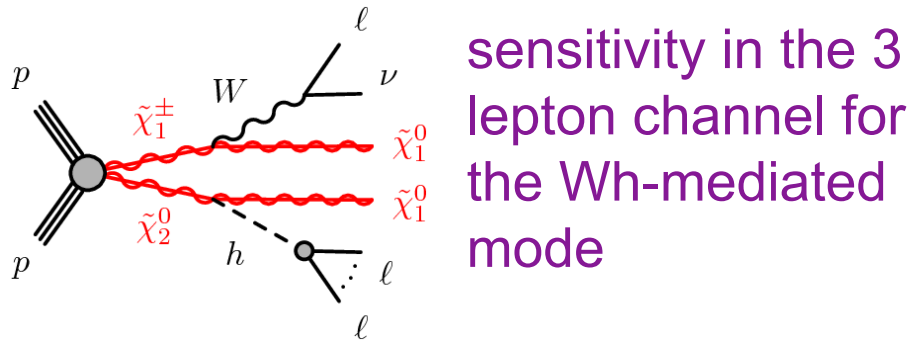
- 5 σ discovery potential up to 1.1 TeV with 300 fb⁻¹ and 1.3 TeV with 3000 fb⁻¹.

ATL-PHYS-PUB-2014-010



Electroweak production of charginos/neutralinos

- Increase of integrated luminosity from 300/fb to 3000/fb extends the sensitivity potential of $\tilde{\chi}_1^\pm \tilde{\chi}_2^0$ production by 300—350 GeV



Exotic physics: current status

ATLAS Exotics Searches* - 95% CL Exclusion

Status: March 2015

ATLAS Preliminary

$\int \mathcal{L} dt = (1.0 - 20.3) \text{ fb}^{-1}$ $\sqrt{s} = 7, 8 \text{ TeV}$

Model	ℓ, γ	Jets	E_T^{miss}	$\int \mathcal{L} dt [\text{fb}^{-1}]$	Mass limit	Reference	
Extra dimensions	ADD $G_{KK} + g/q$	-	$\geq 1j$	Yes	20.3	M_D 5.25 TeV	$n = 2$ 1502.01518
	ADD non-resonant $\ell\ell$	$2e, \mu$	-	-	20.3	M_S 4.7 TeV	$n = 3$ HLZ 1407.2410
	ADD QBH $\rightarrow \ell q$	$1e, \mu$	$1j$	-	20.3	M_{th} 5.2 TeV	$n = 6$ 1311.2006
	ADD QBH	-	$2j$	-	20.3	M_{th} 5.82 TeV	$n = 6$ 1407.1376
	ADD BH high N_{trk}	2μ (SS)	-	-	20.3	M_{th} 4.7 TeV	$n = 6, M_D = 3 \text{ TeV}$, non-rot BH 1308.4075
	ADD BH high Σp_T	$\geq 1e, \mu$	$\geq 2j$	-	20.3	M_{th} 5.8 TeV	$n = 6, M_D = 3 \text{ TeV}$, non-rot BH 1405.4254
	ADD BH high multijet	-	$\geq 2j$	-	20.3	M_{th} 5.8 TeV	$n = 6, M_D = 3 \text{ TeV}$, non-rot BH Preliminary
	RS1 $G_{KK} \rightarrow \ell\ell$	$2e, \mu$	-	-	20.3	G_{KK} mass 2.68 TeV	$k/M_{Pl} = 0.1$ 1405.4123
	RS1 $G_{KK} \rightarrow \gamma\gamma$	2γ	-	-	20.3	G_{KK} mass 2.66 TeV	$k/M_{Pl} = 0.1$ Preliminary
	Bulk RS $G_{KK} \rightarrow ZZ \rightarrow qq\ell\ell$	$2e, \mu$	$2j/1J$	-	20.3	G_{KK} mass 740 GeV	$k/M_{Pl} = 1.0$ 1409.6190
	Bulk RS $G_{KK} \rightarrow WW \rightarrow qq\ell\nu$	$1e, \mu$	$2j/1J$	Yes	20.3	W mass 700 GeV	$k/M_{Pl} = 1.0$ 1503.04677
	Bulk RS $G_{KK} \rightarrow HH \rightarrow b\bar{b}b\bar{b}$	-	$4b$	-	19.5	G_{KK} mass 590-710 GeV	$k/M_{Pl} = 1.0$ ATLAS-CONF-2014-005
Bulk RS $G_{KK} \rightarrow t\bar{t}$	$1e, \mu$	$\geq 1b, \geq 1J/2j$	Yes	20.3	G_{KK} mass 2.2 TeV	ATLAS-CONF-2015-009 Preliminary	
2UED / RPP	$2e, \mu$ (SS)	$\geq 1b, \geq 1j$	Yes	20.3	KK mass 960 GeV	Preliminary	
Gauge bosons	SSM $Z' \rightarrow \ell\ell$	$2e, \mu$	-	-	20.3	Z' mass 2.9 TeV	1405.4123
	SSM $Z' \rightarrow \tau\tau$	2τ	-	-	19.5	Z' mass 2.02 TeV	1502.07177
	SSM $W' \rightarrow \ell\nu$	$1e, \mu$	-	Yes	20.3	W' mass 3.24 TeV	1407.7494
	EGM $W' \rightarrow WZ \rightarrow \ell\nu \ell' \ell'$	$3e, \mu$	-	Yes	20.3	W' mass 1.52 TeV	1406.4456
	EGM $W' \rightarrow WZ \rightarrow qq\ell\ell$	$2e, \mu$	$2j/1J$	-	20.3	W' mass 1.59 TeV	1409.6190
	HVT $W' \rightarrow WH \rightarrow \ell\nu b\bar{b}$	$1e, \mu$	$2b$	Yes	20.3	W' mass 1.47 TeV	$g_V = 1$ Preliminary
	LRSM $W'_R \rightarrow t\bar{b}$	$1e, \mu$	$2b, 0-1j$	Yes	20.3	W' mass 1.92 TeV	1410.4103
LRSM $W'_R \rightarrow t\bar{b}$	$0e, \mu$	$\geq 1b, 1J$	-	20.3	W' mass 1.76 TeV	1408.0886	
CI	CI $qqqq$	-	$2j$	-	17.3	Λ 12.0 TeV	$\eta_{LL} = -1$ Preliminary
	CI $qq\ell\ell$	$2e, \mu$	-	-	20.3	Λ 21.6 TeV	$\eta_{LL} = -1$ 1407.2410
	CI $uutt$	$2e, \mu$ (SS)	$\geq 1b, \geq 1j$	Yes	20.3	Λ 4.35 TeV	$ C_{LL} = 1$ Preliminary
DM	EFT D5 operator (Dirac)	$0e, \mu$	$\geq 1j$	Yes	20.3	M_* 974 GeV	at 90% CL for $m(\chi) < 100 \text{ GeV}$ 1502.01518
	EFT D9 operator (Dirac)	$0e, \mu$	$1J, \leq 1j$	Yes	20.3	M_* 2.4 TeV	at 90% CL for $m(\chi) < 100 \text{ GeV}$ 1309.4017
LO	Scalar LQ 1 st gen	$2e$	$\geq 2j$	-	1.0	LO mass 660 GeV	$\beta = 1$ 1112.4828
	Scalar LQ 2 nd gen	2μ	$\geq 2j$	-	1.0	LO mass 685 GeV	$\beta = 1$ 1203.3172
	Scalar LQ 3 rd gen	$1e, \mu, 1\tau$	$1b, 1j$	-	4.7	LO mass 534 GeV	$\beta = 1$ 1303.0526
Heavy quarks	VLQ $TT \rightarrow Ht + X, Wb + X$	$1e, \mu$	$\geq 1b, \geq 3j$	Yes	20.3	T mass 785 GeV	isospin singlet ATLAS-CONF-2015-012
	VLQ $TT \rightarrow Zt + X$	$2/\geq 3e, \mu$	$\geq 2/\geq 1b$	-	20.3	T mass 735 GeV	T in (T,B) doublet 1409.5500
	VLQ $BB \rightarrow Zb + X$	$2/\geq 3e, \mu$	$\geq 2/\geq 1b$	-	20.3	B mass 755 GeV	B in (B,Y) doublet 1409.5500
	VLQ $BB \rightarrow Wt + X$	$1e, \mu$	$\geq 1b, \geq 5j$	Yes	20.3	B mass 640 GeV	isospin singlet Preliminary
$T_{5/3} \rightarrow Wt$	$1e, \mu$	$\geq 1b, \geq 5j$	Yes	20.3	$T_{5/3}$ mass 840 GeV	isospin singlet Preliminary	
Excited fermions	Excited quark $q^* \rightarrow q\gamma$	1γ	$1j$	-	20.3	q^* mass 3.5 TeV	only u^* and d^* , $\Lambda = m(q^*)$ 1309.3230
	Excited quark $q^* \rightarrow qg$	-	$2j$	-	20.3	q^* mass 4.09 TeV	only u^* and d^* , $\Lambda = m(q^*)$ 1407.1376
	Excited quark $b^* \rightarrow Wt$	1 or $2e, \mu, 1b, 2j$ or $1j$	Yes	4.7	13.0	b^* mass 870 GeV	left-handed coupling 1301.1583
	Excited lepton $\ell^* \rightarrow \ell\gamma$	$2e, \mu, 1\gamma$	-	-	13.0	ℓ^* mass 2.2 TeV	$\Lambda = 2.2 \text{ TeV}$ 1308.1364
	Excited lepton $\nu^* \rightarrow \ell W, \gamma Z$	$3e, \mu, \tau$	-	-	20.3	ν^* mass 1.6 TeV	$\Lambda = 1.6 \text{ TeV}$ 1411.2921
Other	LSTC $a_T \rightarrow W\gamma$	$1e, \mu, 1\gamma$	-	Yes	20.3	a_T mass 960 GeV	1407.8150
	LRSM Majorana ν	$2e, \mu$	$2j$	-	2.1	N^0 mass 1.5 TeV	$m(W_\alpha) = 2 \text{ TeV}$, no mixing 1203.5420
	Higgs triplet $H^{\pm\pm} \rightarrow \ell\ell$	$2e, \mu$ (SS)	-	-	20.3	$H^{\pm\pm}$ mass 551 GeV	DY production, $\text{BR}(H^{\pm\pm} \rightarrow \ell\ell) = 1$ 1412.0237
	Higgs triplet $H^{\pm\pm} \rightarrow \ell\tau$	$3e, \mu, \tau$	-	-	20.3	$H^{\pm\pm}$ mass 400 GeV	DY production, $\text{BR}(H^{\pm\pm} \rightarrow \ell\tau) = 1$ 1411.2921
	Monotop (non-res prod)	$1e, \mu$	$1b$	Yes	20.3	spin-1 invisible particle mass 657 GeV	$a_{\text{non-res}} = 0.2$ 1410.5404
	Multi-charged particles	-	-	-	20.3	multi-charged particle mass 785 GeV	DY production, $ g = 5e$ Preliminary
Magnetic monopoles	-	-	-	2.0	monopole mass 862 GeV	DY production, $ g = 1g_D$ 1207.6411	

*Only a selection of the available mass limits on new states or phenomena is shown.

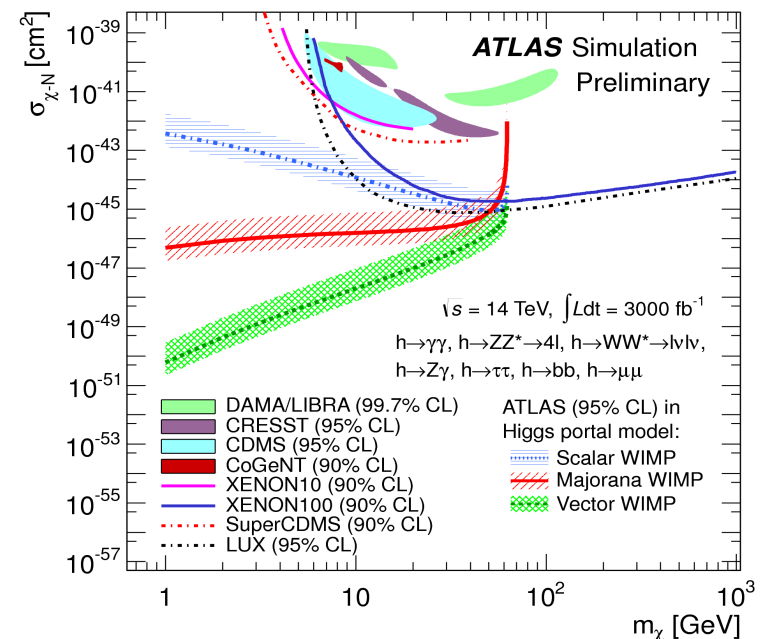
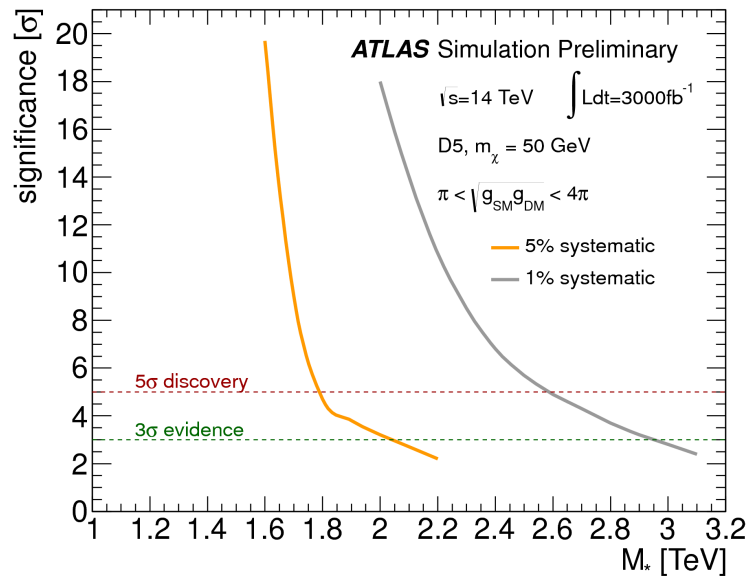
Searches for WIMP Dark Matter

- Models:

- contact interactions between SM and DM particles – EFT
- simplified models with mediators (e.g. Z')
- Higgs portal models – weak interaction with SM particles except the Higgs boson

- Signatures: mono-jet + E_{miss}

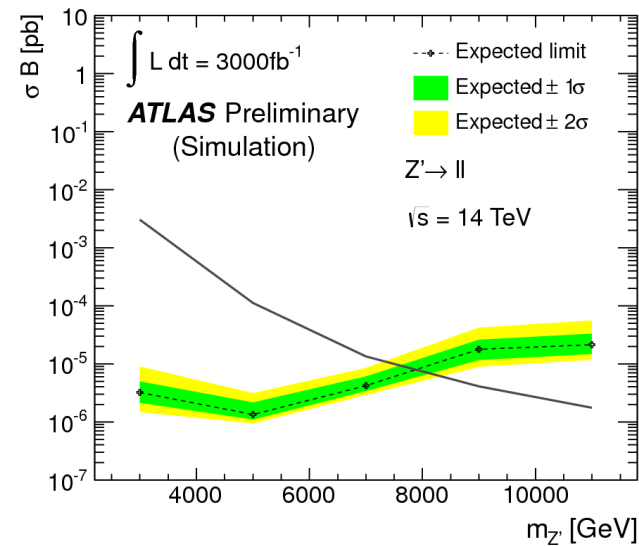
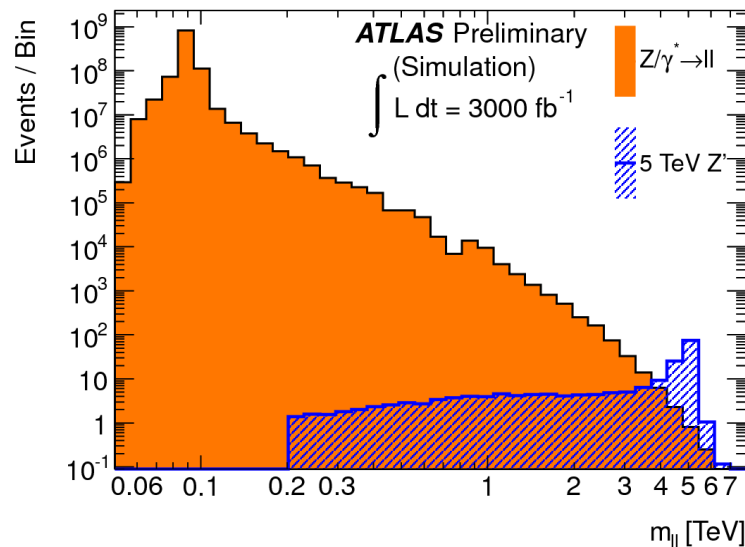
- any higgs-like event



Search for Dilepton/ditop resonances

- Characterization of ATLAS high mass reach
 - strongly produced wide resonances: Kaluza-Klein gluons (g_{KK}) in extra-dimensional models
 - weakly produced narrow resonances: $Z' \rightarrow tt/\ell\ell$
- With 3000/fb, can probe tt resonances up to 6.7 TeV, dilepton resonances up to 7.8 TeV

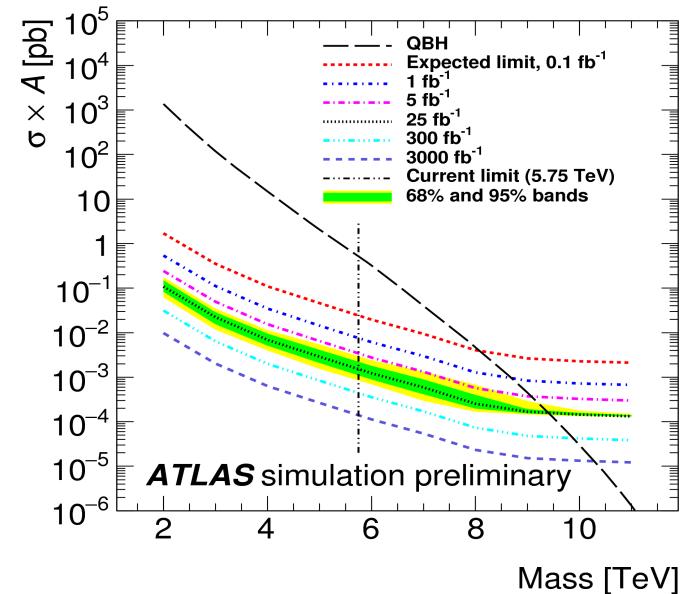
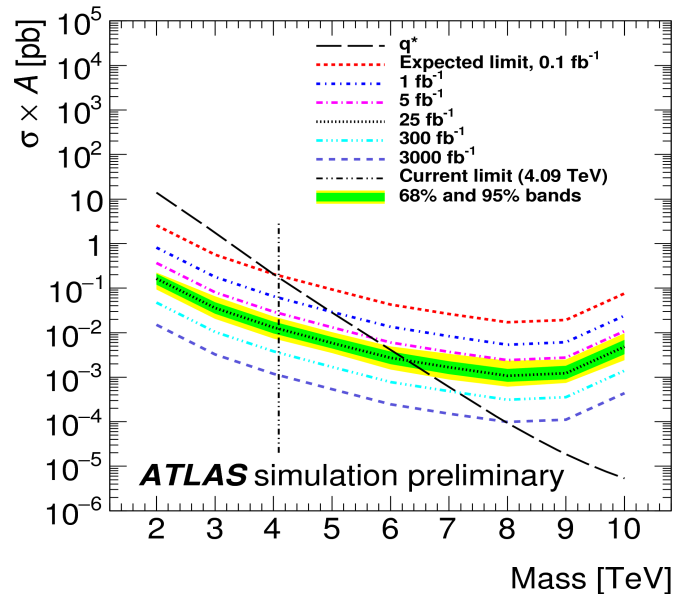
ATL-PHYS-PUB-2013-003



shown:
dielectrons
similar results
obtained for
dimuons

Search for Dijet resonances

- Benchmark processes: excited quarks q^* and Quantum Black Holes (QBH)
 - the signals are expected to surpass the backgrounds by an order of magnitude
- Sensitivity scans show that approx. 1/fb of data is sufficient for 5σ discovery of q^* up to 4 TeV and QBH up to 7 TeV
 - at 3000/fb discover q^* up to 7 TeV and QBH up to 10 TeV

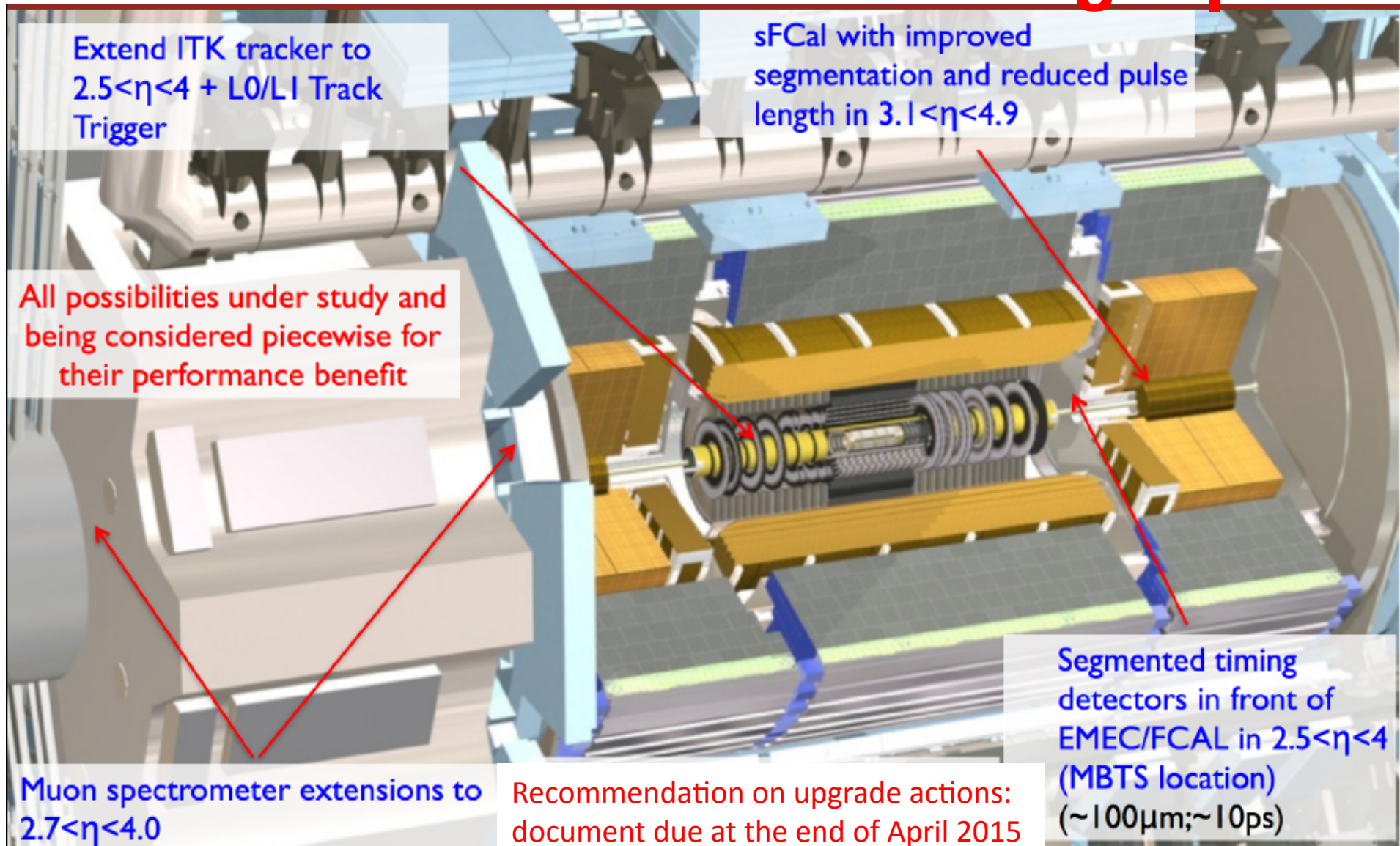


Conclusions

- ATLAS had very fruitful Run 1, resulted in the Higgs boson discovery, measurements of some of its properties, and wide searched for new physics
- After the HL LHC upgrade and the matching ATLAS upgrade, the ATLAS detector will collect up to 3000 fb⁻¹ of data at higher CM energy, 14 TeV
- High luminosity upgrades will significantly increase achievable parameter measurement precision and enhance the BSM reach
- It will provide the HEP community an opportunity to shed light on the fundamental questions about Dark Matter candidates, hierarchy, and to significantly expand searches for new physics scenarios

Backup

Extension of ATLAS to large η



Higgs signal strengths

- Signal strength $\mu = \sigma \times BR / (\sigma \times BR)_{SM}$
- Separation by production modes
 - Important for coupling measurements
- Projection assumptions:
 - 300/fb: $\mu = 60$, 3000/fb: $\mu = 140$
 - Used dedicated 14 TeV samples
- Systematics:
 - Same as Run 1
 - Large impact from theory uncertainties (shown by dashed areas), like QCD scale, PDFs

ATLAS Simulation Preliminary

$\sqrt{s} = 14$ TeV: $\int L dt = 300 \text{ fb}^{-1}$; $\int L dt = 3000 \text{ fb}^{-1}$

