

Новые результаты эксперимента АТЛАС



Леонид Гладилин
НИИЯФ МГУ



Сессия СЯФ ОФН РАН, Протвино, 5-8.11.2013



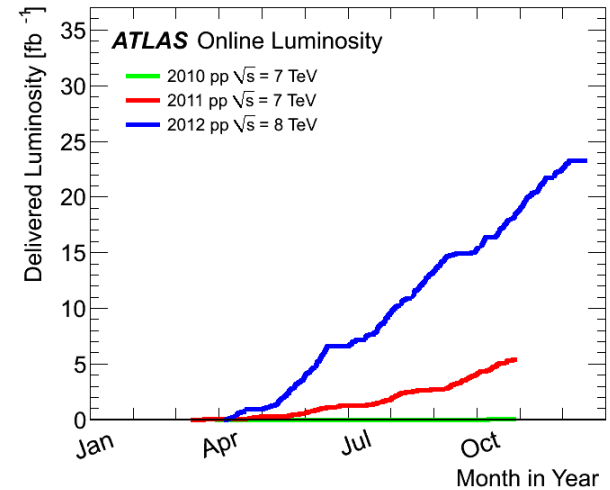
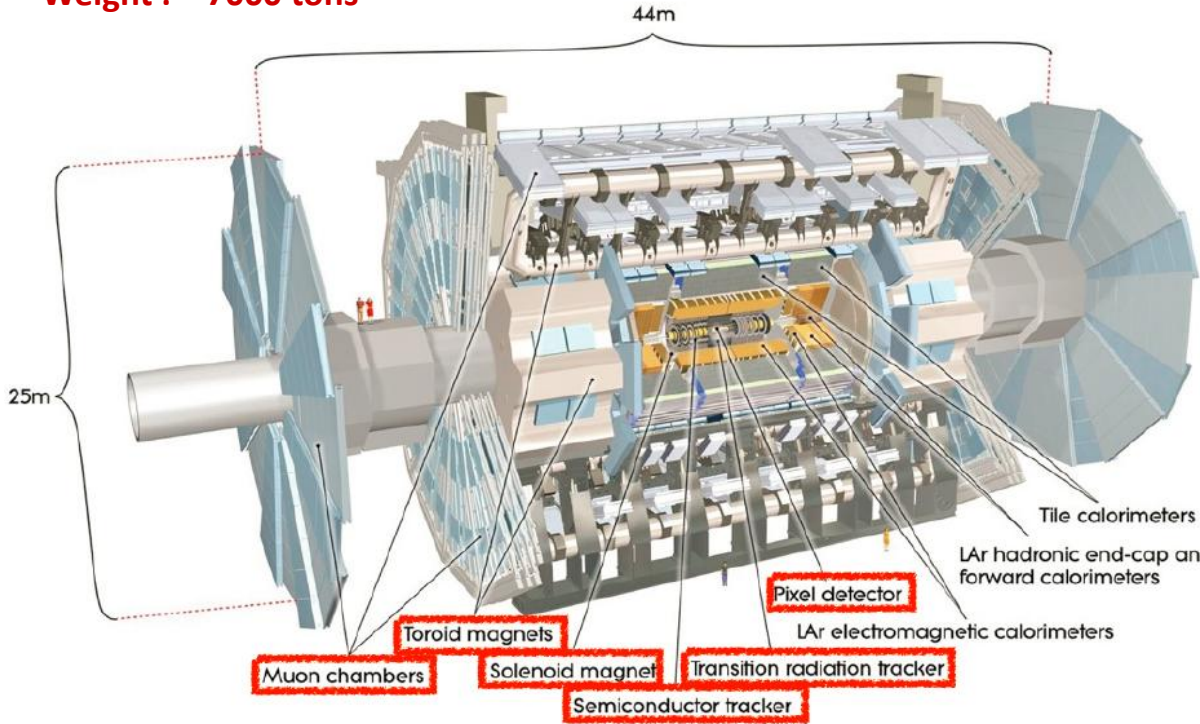
Содержание :

- Введение
- бозон Хиггса: рождение, распады, масса, спин-чётность
- поиск заряженного бозона Хиггса
- поиски суперсимметрии
- поиск тяжёлых двух-лептонных резонансов
- поиск микроскопических чёрных дыр
- измерение рождения кваркониев χ_{c1} , χ_{c2} , $\psi(2S)$
- рождение струй в Pb+Pb столкновениях
- Заключение

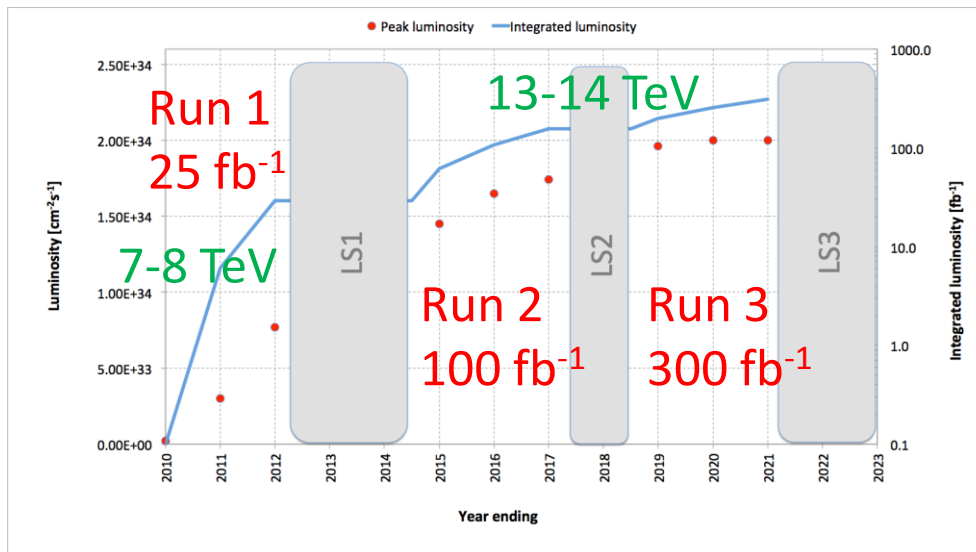
новые результаты ATLAS по электро-слабой физике в докладе Александра Солодкова сегодня в 15:00

ATLAS @ LHC

Weight : ~ 7000 tons

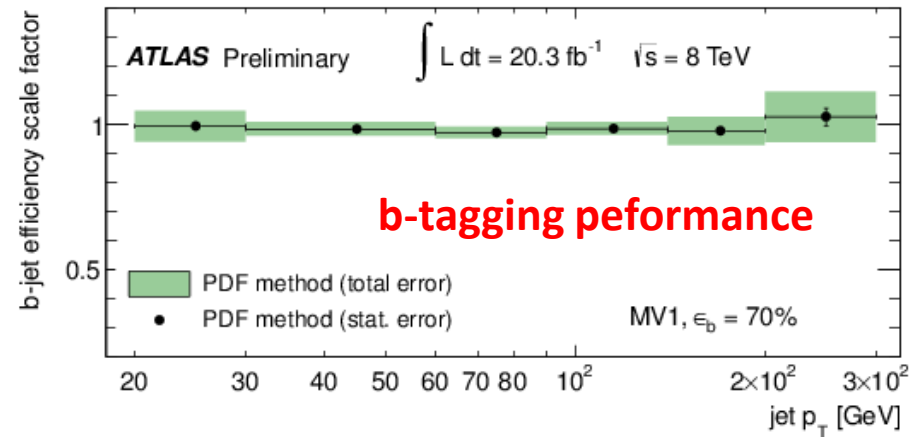
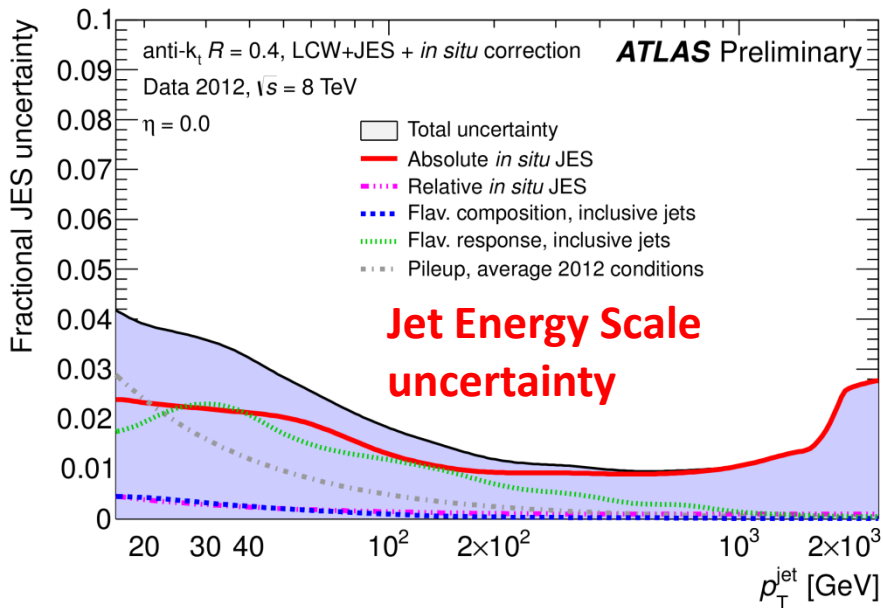
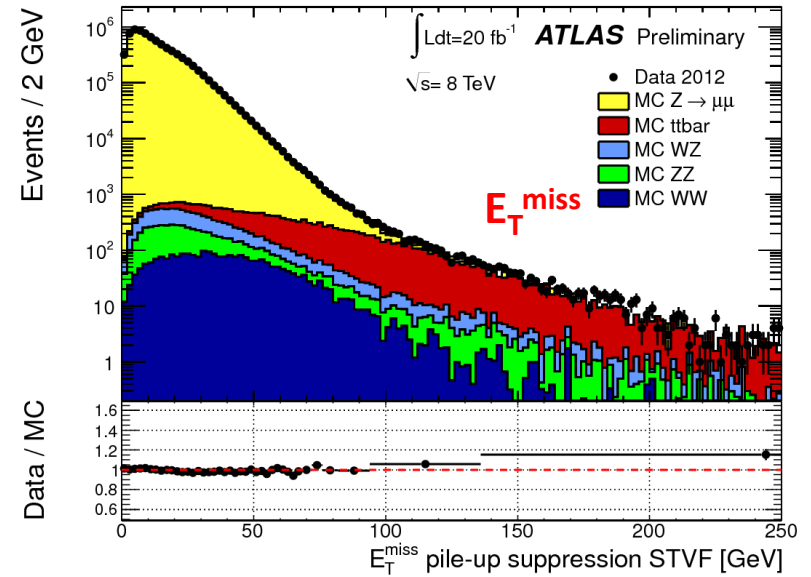
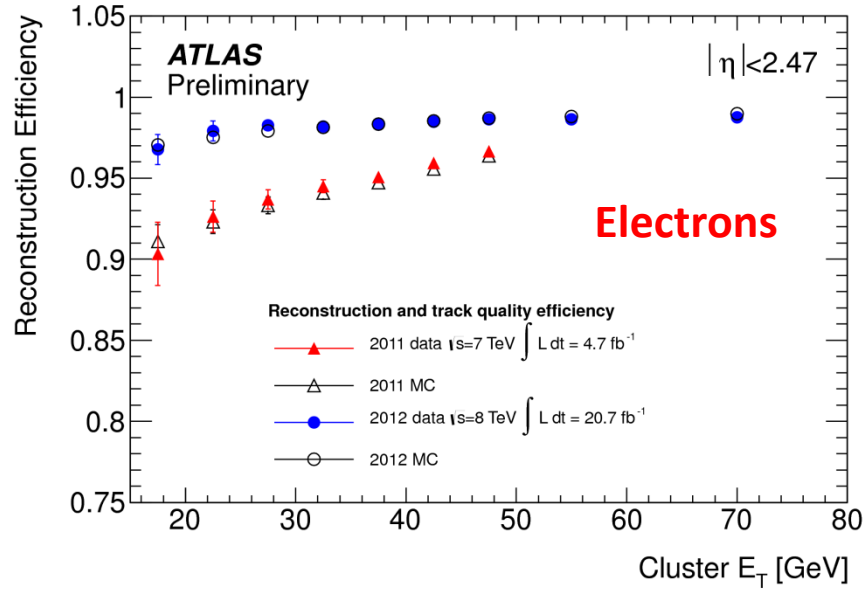


Peak Lumi: $6.76 \times 10^{33} \text{ cm}^{-2} \text{ s}^{-1}$

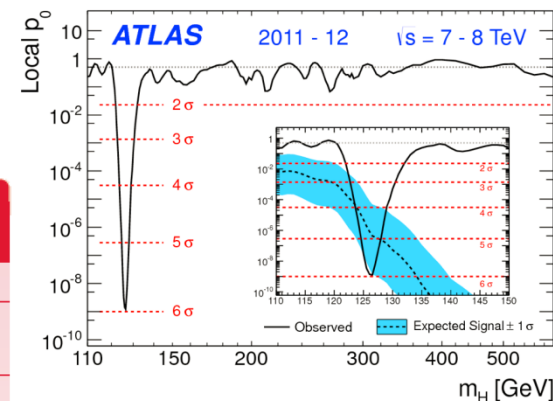


Run 4
HL-LHC
3000 fb^{-1}

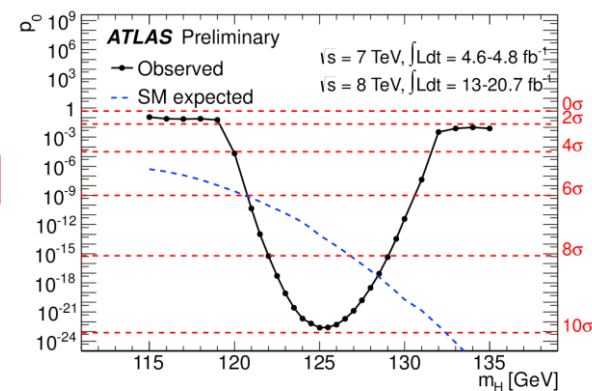
Реконструкция и моделирование объектов



Бозон Хиггса на ЛНС - картина ATLAS'а



July 2012



March 2013



October 2013

Higgs Decay	Sub. Decay	Sub-Channels	$\int L dt [fb^{-1}]$
2011 $\sqrt{s} = 7 TeV$			
$H \rightarrow ZZ^*$	4ℓ	$\{4e, 2e2\mu, 2\mu 2e, 4\mu, 2\text{-jet VBF}, \ell\text{-tag}\}$	4.6
$H \rightarrow \gamma\gamma$	-	10 categories $\{p_{T_i} \otimes \eta_\gamma \otimes \text{conversion}\} \oplus \{2\text{-jet VBF}\}$	4.8
$H \rightarrow WW^*$	$\ell\nu\ell\nu$	$\{ee, e\mu, \mu e, \mu\mu\} \otimes \{0\text{-jet}, 1\text{-jet}, 2\text{-jet VBF}\}$	4.6
$H \rightarrow \tau\tau$	$\tau_{lep}\tau_{lep}$	$\{e\mu\} \otimes \{0\text{-jet}\} \oplus \{\ell\ell\} \otimes \{1\text{-jet}, 2\text{-jet}, p_{T,\tau\tau} > 100 GeV, VH\}$	4.6
	$\tau_{lep}\tau_{had}$	$\{e,\mu\} \otimes \{0\text{-jet}, 1\text{-jet}, p_{T,\tau\tau} > 100 GeV, 2\text{-jet}\}$	4.6
	$\tau_{had}\tau_{had}$	$\{1\text{-jet}, 2\text{-jet}\}$	4.6
$VH \rightarrow Vbb$	$Z \rightarrow \nu\nu$	$E_T^{miss} \in \{120 - 160, 160 - 200, \geq 200 GeV\} \otimes \{2\text{-jet}, 3\text{-jet}\}$	4.6
	$W \rightarrow \ell\nu$	$p_T^W \in \{< 50, 50 - 100, 100 - 150, 150 - 200, \geq 200 GeV\}$	4.7
	$Z \rightarrow \ell\ell$	$p_T^Z \in \{< 50, 50 - 100, 100 - 150, 150 - 200, \geq 200 GeV\}$	4.7
2012 $\sqrt{s} = 8 TeV$			
$H \rightarrow ZZ^*$	4ℓ	$\{4e, 2e2\mu, 2\mu 2e, 4\mu, 2\text{-jet VBF}, \ell\text{-tag}\}$	20.7
$H \rightarrow \gamma\gamma$	-	14 categories $\{p_{T_i} \otimes \eta_\gamma \otimes \text{conversion}\} \oplus \{2\text{-jet VBF}\} \oplus \{\ell\text{-tag}, E_T^{miss}\text{-tag}, 2\text{-jet VH}\}$	20.7
$H \rightarrow WW^*$	$\ell\nu\ell\nu$	$\{ee, e\mu, \mu e, \mu\mu\} \otimes \{0\text{-jet}, 1\text{-jet}, 2\text{-jet VBF}\}$	20.7
$H \rightarrow \tau\tau$	$\tau_{lep}\tau_{lep}$	$\{\ell\ell\} \otimes \{1\text{-jet}, 2\text{-jet}, p_{T,\tau\tau} > 100 GeV, VH\}$	13
	$\tau_{lep}\tau_{had}$	$\{e,\mu\} \otimes \{0\text{-jet}, 1\text{-jet}, p_{T,\tau\tau} > 100 GeV, 2\text{-jet}\}$	13
	$\tau_{had}\tau_{had}$	$\{1\text{-jet}, 2\text{-jet}\}$	13
$VH \rightarrow Vbb$	$Z \rightarrow \nu\nu$	$E_T^{miss} \in \{120 - 160, 160 - 200, \geq 200 GeV\} \otimes \{2\text{-jet}, 3\text{-jet}\}$	13
	$W \rightarrow \ell\nu$	$p_T^W \in \{< 50, 50 - 100, 100 - 150, 150 - 200, \geq 200 GeV\}$	13
	$Z \rightarrow \ell\ell$	$p_T^Z \in \{< 50, 50 - 100, 100 - 150, 150 - 200, \geq 200 GeV\}$	13

Рождение бозона Хиггса на LHC

Dominant process is gluon-gluon fusion (ggF)

- Proceeds mainly through the top quark loop
- Indirect probe of Higgs-fermion coupling

Vector Boson Fusion (VBF)

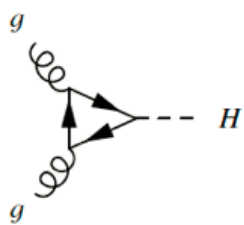
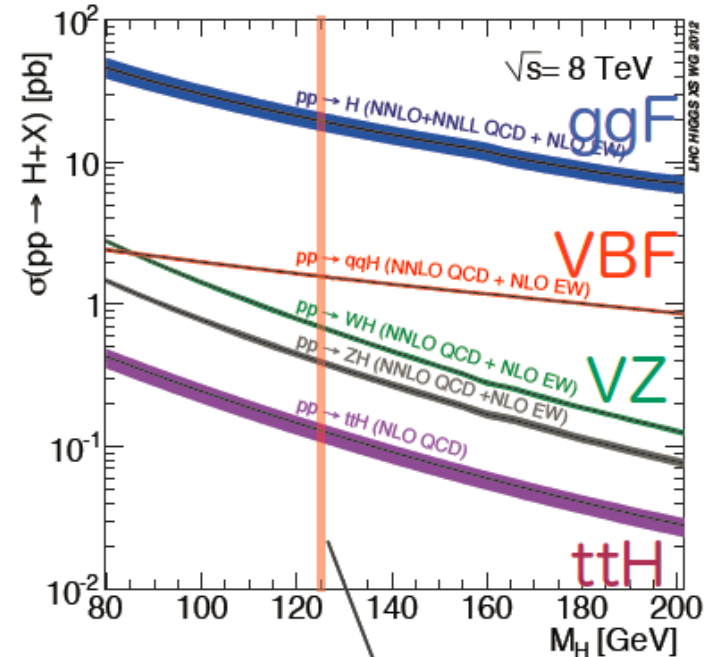
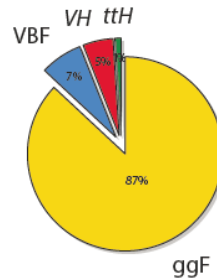
- Direct probe of vector boson coupling
- Signature includes two forward high- p_T jets with a large rapidity-gap

Associated production with W/Z (VZ)

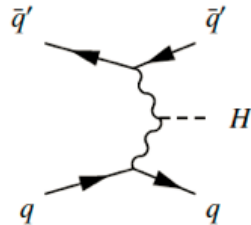
- Direct probe of vector boson coupling
- Signature includes high- p_T leptons

Associated production with a top quark pair (ttH)

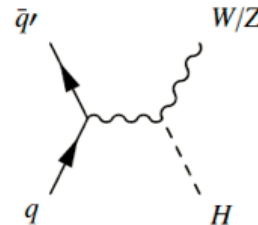
- Direct probe of Higgs-top quark coupling



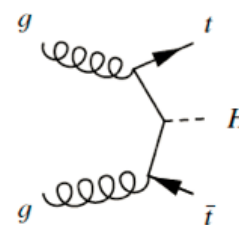
(a) $gg \rightarrow H$



(b) VBF



(c) VH

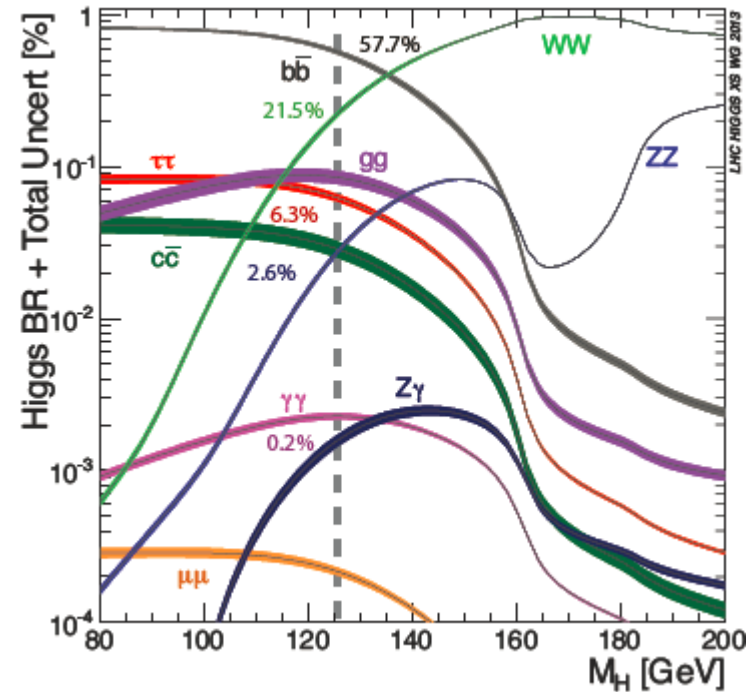


(d) $t\bar{t}H$

σ (pb)	7TeV	8TeV
ggF	15	19
VBF	1.2	1.6
WH	0.57	0.70
ZH	0.33	0.41
ttH	0.09	0.13

Распады бозона Хиггса на LHC

$m_H=125.5\text{GeV}$	BR(%)		BR(%)
$H \rightarrow \gamma\gamma$	0.23	$H \rightarrow Z\gamma$	0.16
$H \rightarrow ZZ$	2.8	$H \rightarrow \mu\mu$	0.02
$H \rightarrow WW$	22		
$H \rightarrow \tau\tau$	6.2		
$H \rightarrow bb$	57		



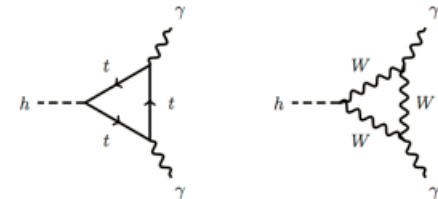
Higgs boson can decay into a photon pair via W or t-quark loop.

- Negative interference between W-boson loop and t-quark loop helps the indirect measurement of the coupling to fermions

Final states with leptons or photons are easier to measure

- Discovery channels : $H \rightarrow \gamma\gamma$, $ZZ(\rightarrow 4\ell)$, $WW(\rightarrow \ell\nu\ell\nu)$

Decays to jets or τ s are more difficult to separate from QCD background, but they are very important for the direct measurement of the coupling to fermions.⁶

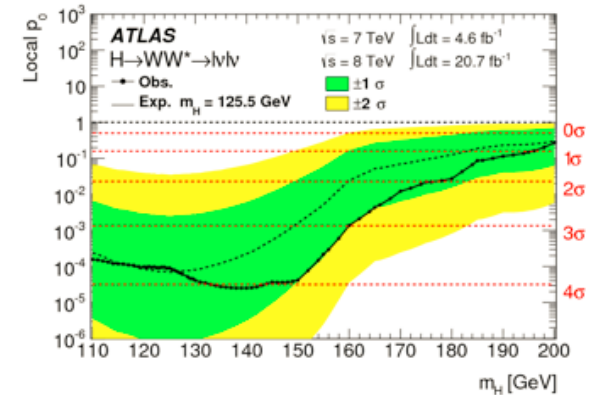
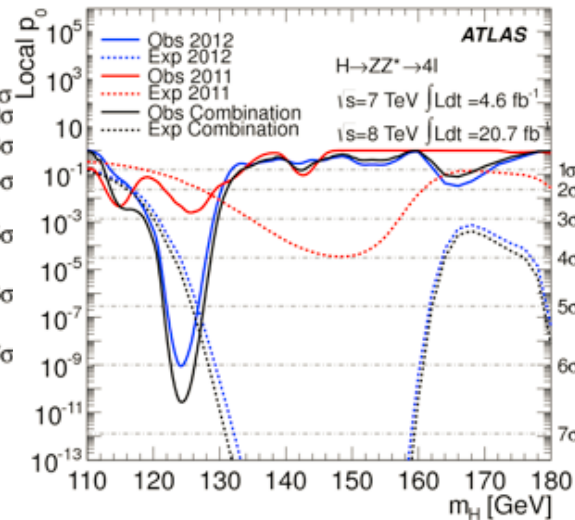
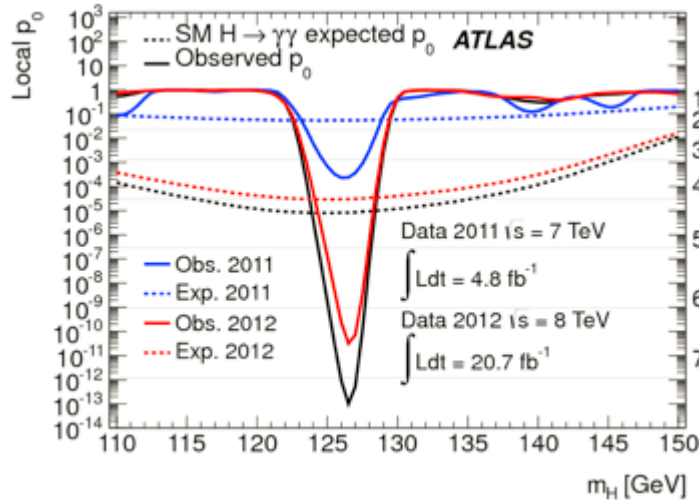
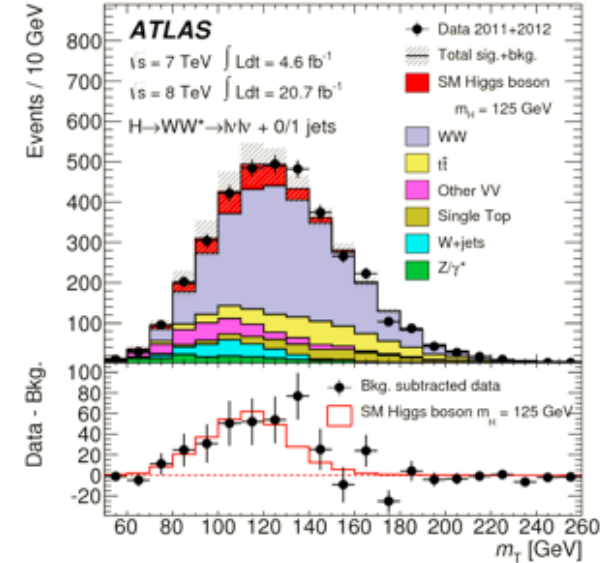
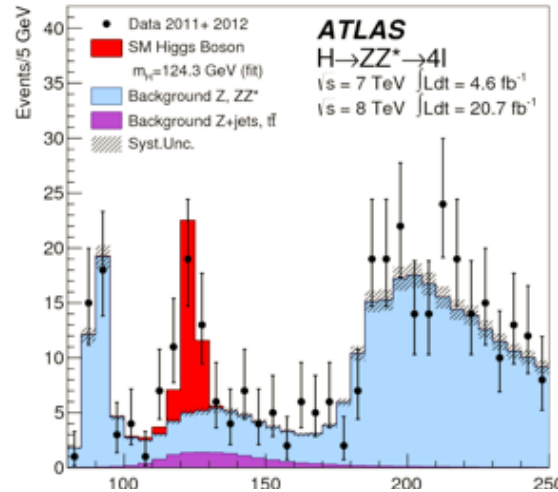
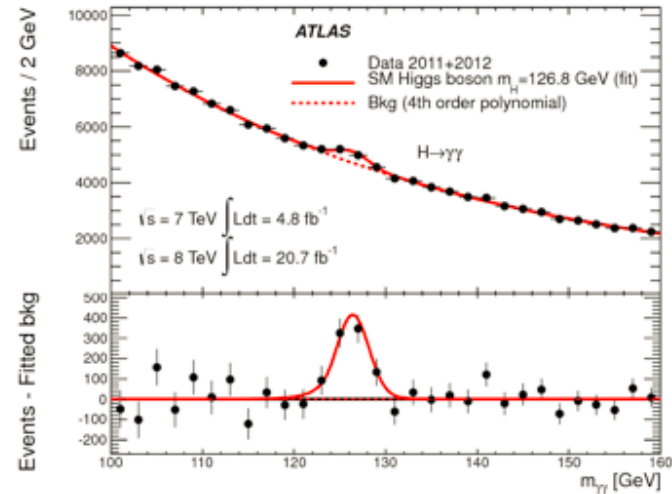


Основные каналы наблюдения H

$$H \rightarrow \gamma\gamma$$

$$H \rightarrow ZZ$$

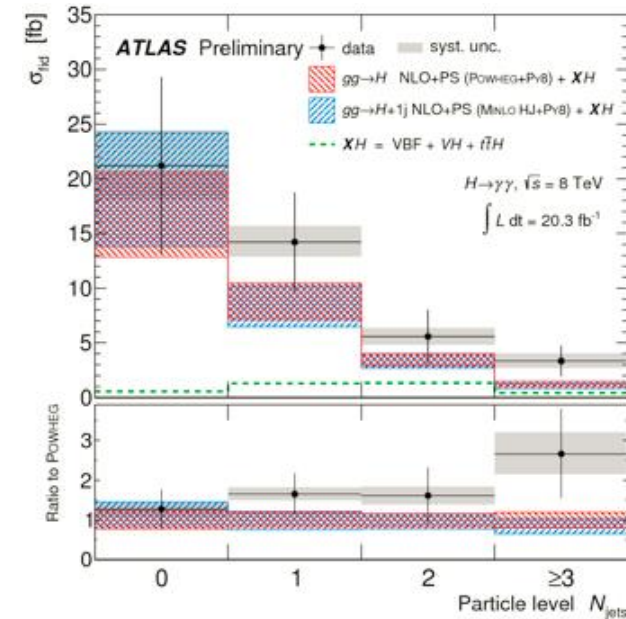
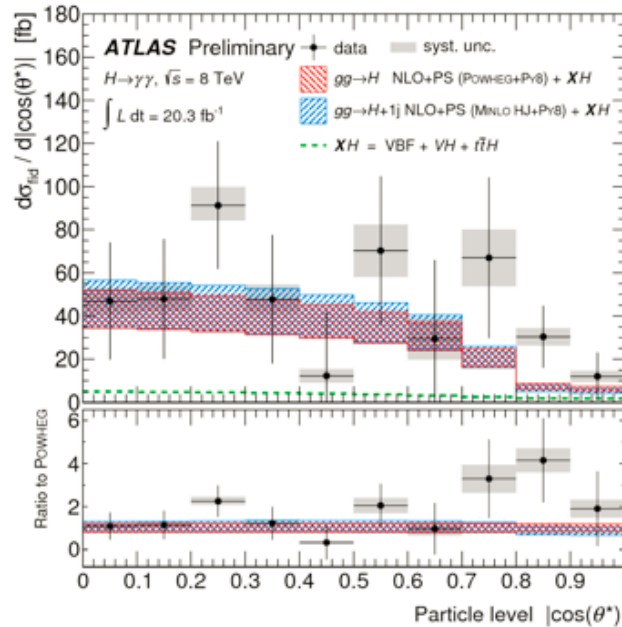
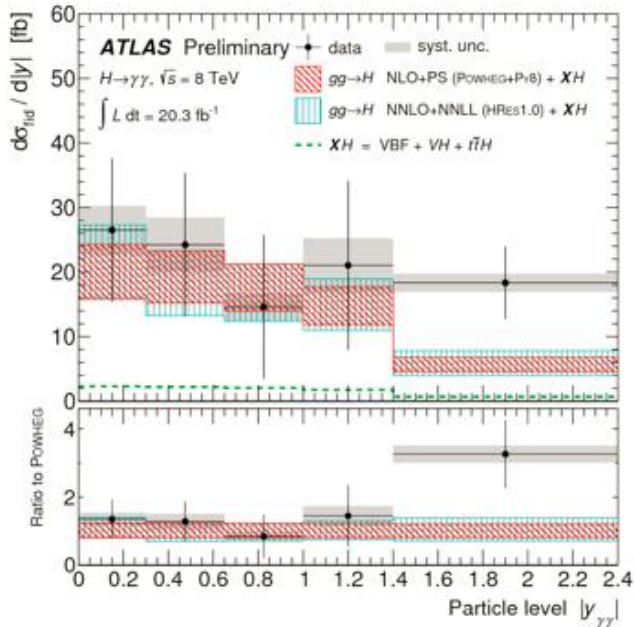
$$H \rightarrow WW$$



Дифференциальные сечения $H \rightarrow \gamma\gamma$

ATLAS-CONF-2013-072

- 8 observables : $p_T^{\gamma\gamma}$, $|y^{\gamma\gamma}|$, $|\cos\theta^*|$, N_{jets} , Φ_{jj} , ...
- The distributions are unfolded to particle level and compared with MC generators
- Sensitive to PDF, radiative correction, relative rate of Higgs production, spin,...



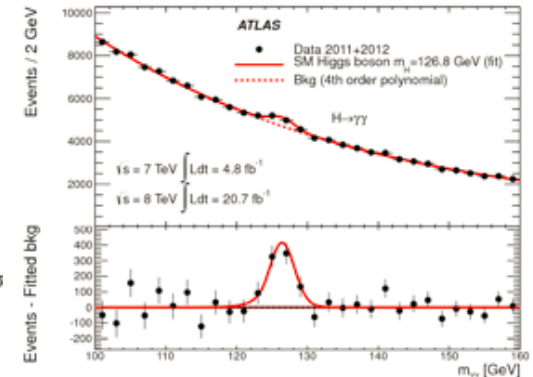
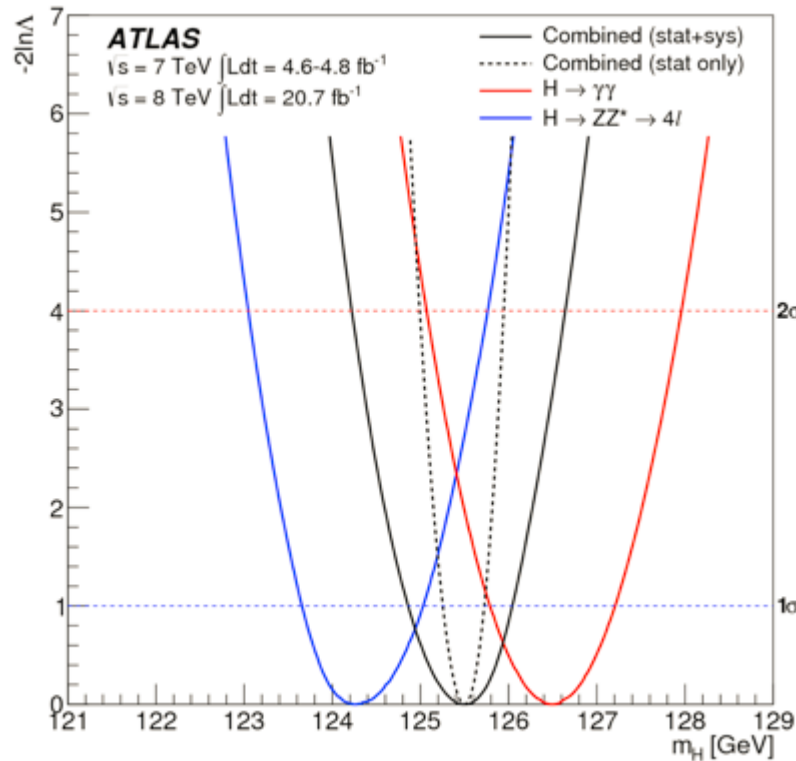
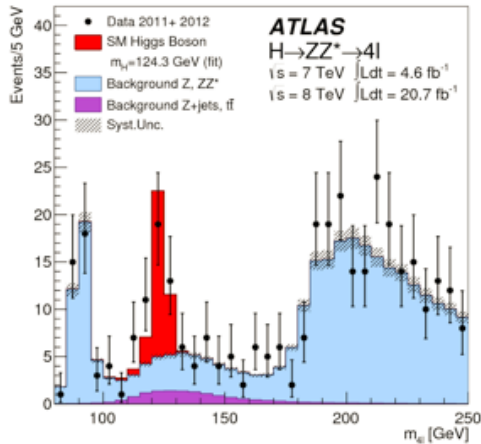
Probability of χ^2 test

	N_{jets}	$p_T^{\gamma\gamma}$	$ y^{\gamma\gamma} $	$ \cos\theta^* $	p_T^{j1}	$\Delta\phi_{jj}$	$p_T^{\gamma\gamma jj}$
POWHEG	0.54	0.55	0.38	0.69	0.79	0.42	0.50
MINLO	0.44	—	—	0.67	0.73	0.45	0.49
HRES 1.0	—	0.39	0.44	—	—	—	—

No significant deviation from SM (POWHEG, MINLO, HRES1.0) is observed.

Масса бозона Хиггса

arXiv:1307.1427



$$\text{Combined } m_H = 125.5 \pm 0.2 \text{ (stat)} \quad {}^{+0.5}_{-0.6} \text{ (sys) GeV}$$

$$\Delta m_H = m_H^{\gamma\gamma} - m_H^{ZZ} = 2.3 \quad {}^{+0.3}_{-0.7} \text{ (stat)} \pm 0.6 \text{ (sys) GeV}$$

Mass difference $\sim 2.4\sigma$ - not a problem yet
 to be clarified with Run2 data

“Сила” сигнала бозона Хиггса

arXiv:1307.1427

$$\mu = \frac{\sigma \times \text{BR}}{(\sigma \times \text{BR})_{\text{SM}}}$$

$\mu=1$ (if SM Higgs), $\mu=0$ (if no SM Higgs)

combined

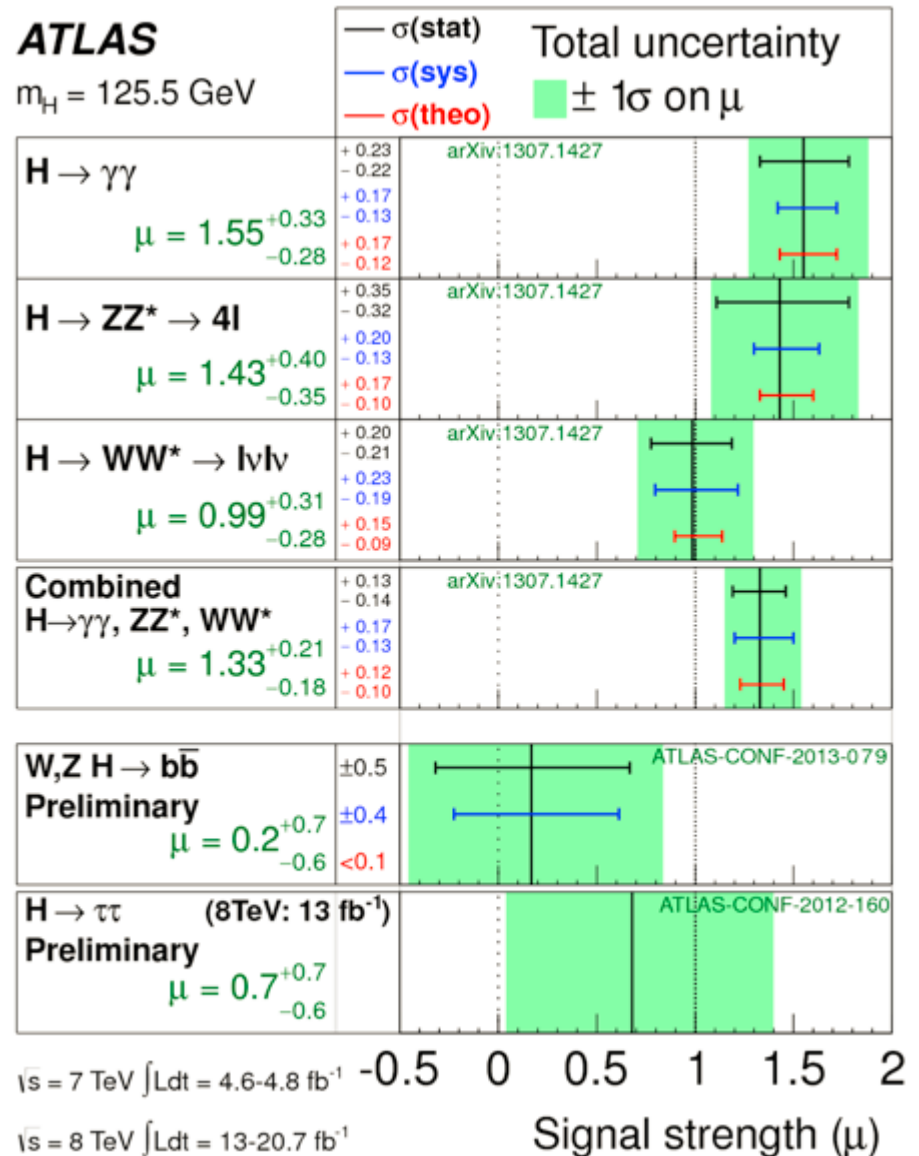
$$\mu = 1.33 \pm 0.14(\text{stat}) \pm 0.15(\text{sys})$$

($m_H=125.5\text{GeV}$)

Result is consistent with the SM prediction with 15% precision.

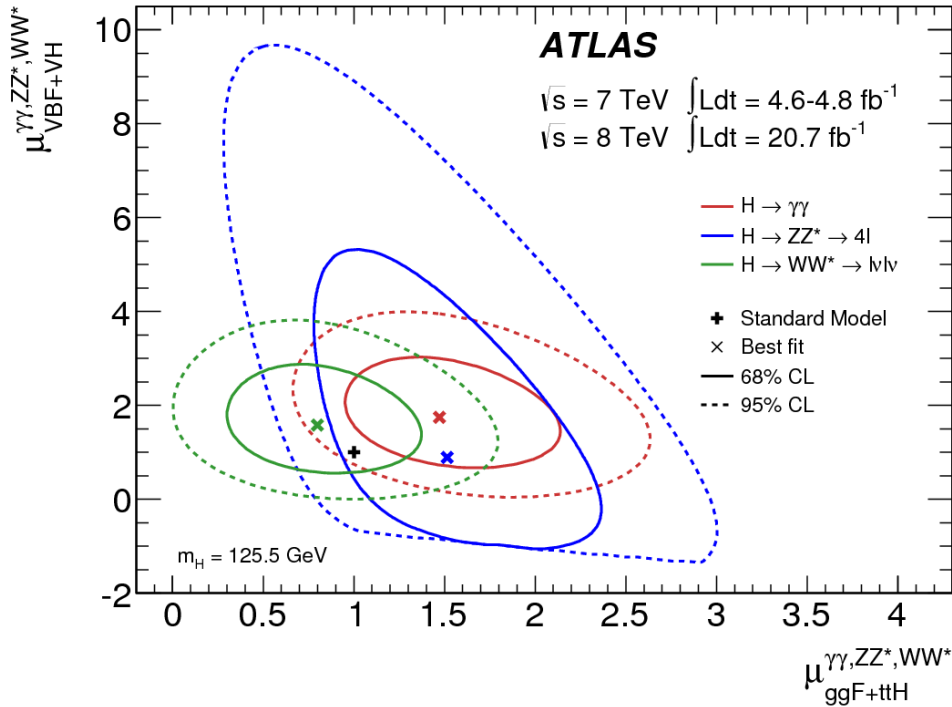
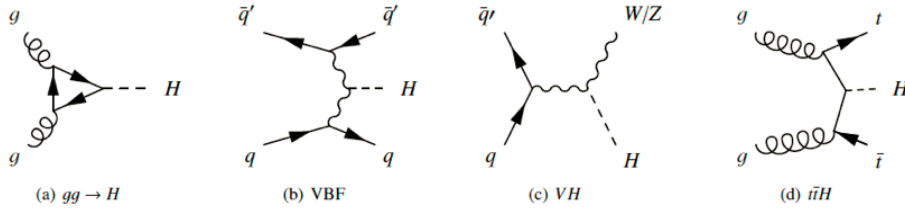
$H \rightarrow b\bar{b}$ and $H \rightarrow \tau\tau$ not in the combination

Statistical, systematic and theory (QCD scale, PDF) uncertainties are already comparable.



Наблюдение VBF рождения бозона Хиггса

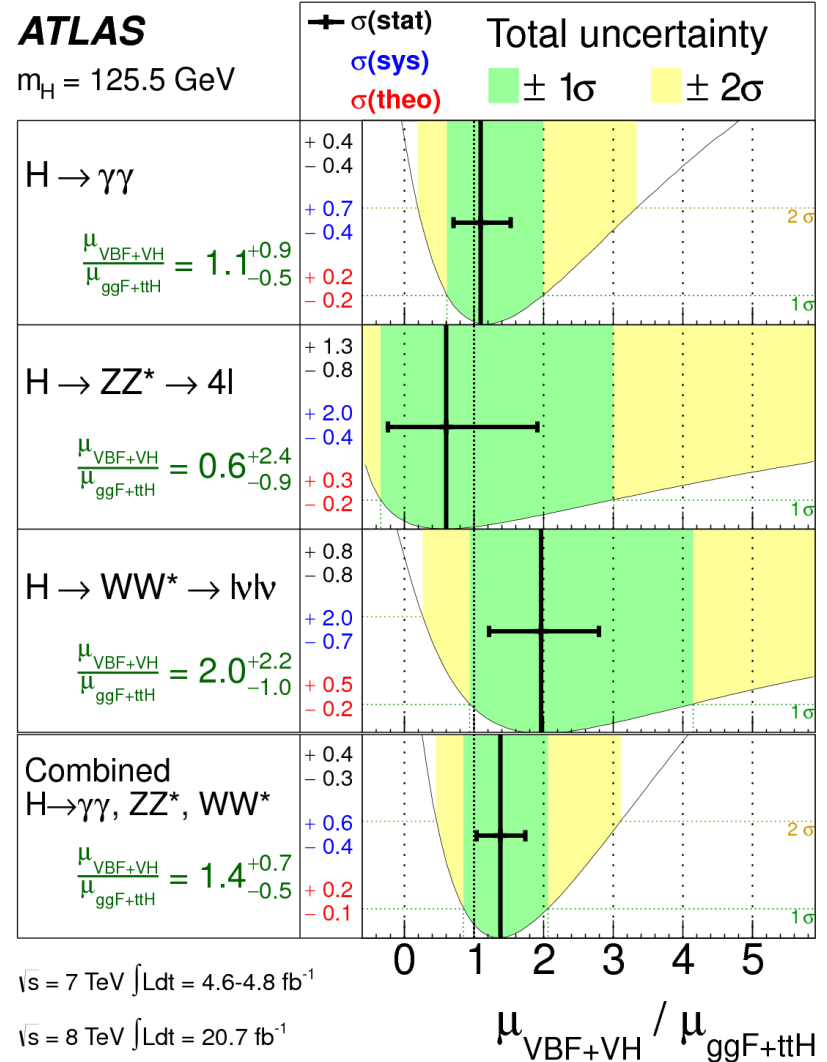
arXiv:1307.1427



3.3 σ evidence that a fraction of Higgs boson production occurs through VBF

ATLAS

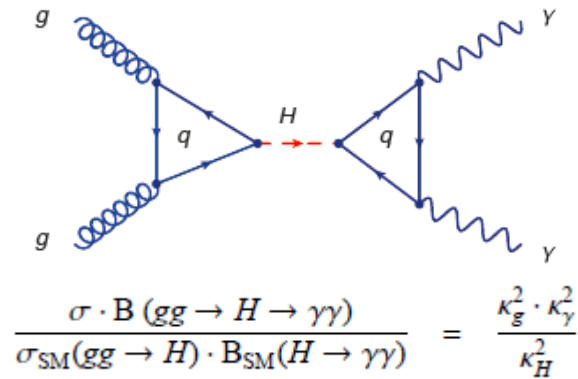
$m_H = 125.5 \text{ GeV}$



Константы связи бозона Хиггса

arXiv:1307.1427

coupling scale factors are considered

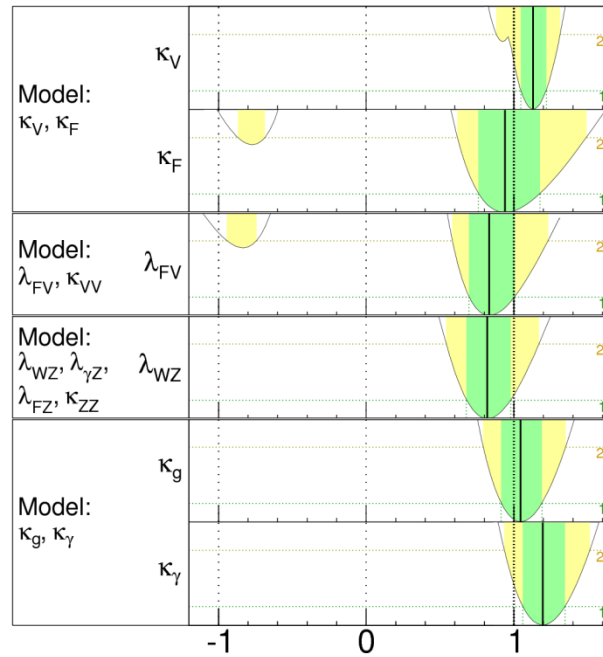


ATLAS

$m_H = 125.5$ GeV

Total uncertainty

$\pm 1\sigma$ $\pm 2\sigma$



$$\kappa_F \in [0.76, 1.18]$$

$$\kappa_V \in [1.05, 1.22]$$

$$\lambda_{FV} \in [0.70, 1.01]$$

$$\lambda_{WZ} = 0.82 \pm 0.15$$

$$\kappa_g = 1.04 \pm 0.14$$

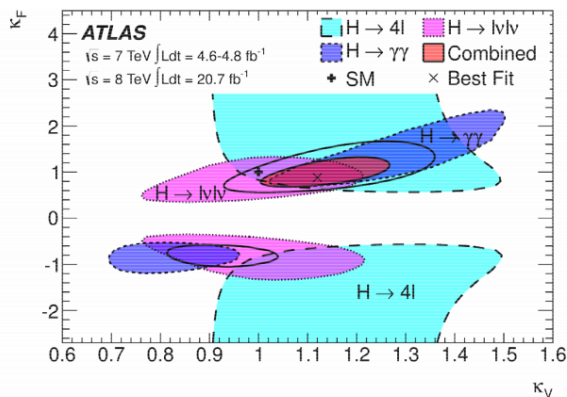
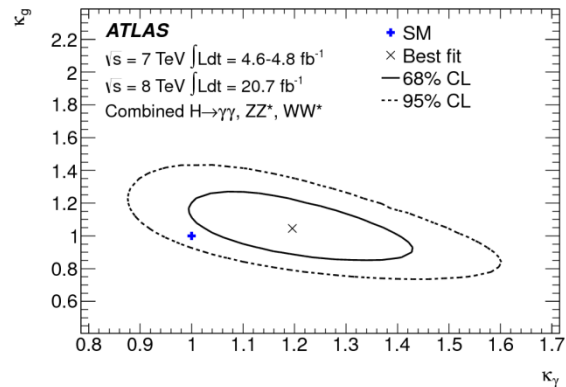
$$\kappa_\gamma = 1.20 \pm 0.15$$

$\sqrt{s} = 7$ TeV $\int \mathcal{L} dt = 4.6-4.8 \text{ fb}^{-1}$

$\sqrt{s} = 8$ TeV $\int \mathcal{L} dt = 20.7 \text{ fb}^{-1}$

Parameter value

Combined $H \rightarrow \gamma\gamma, ZZ^*, WW^*$

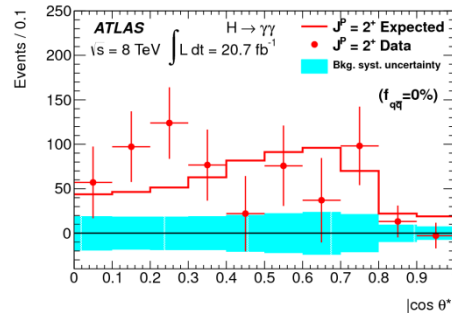
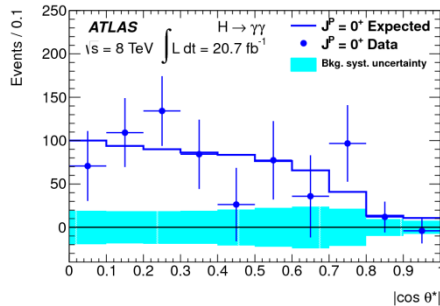
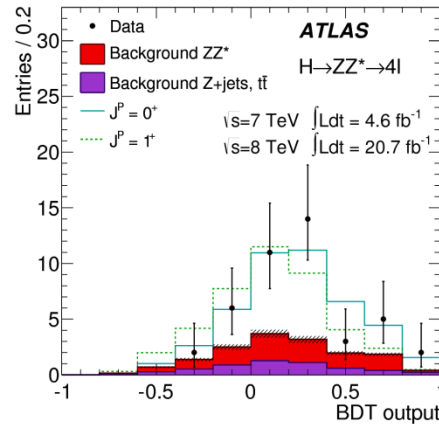
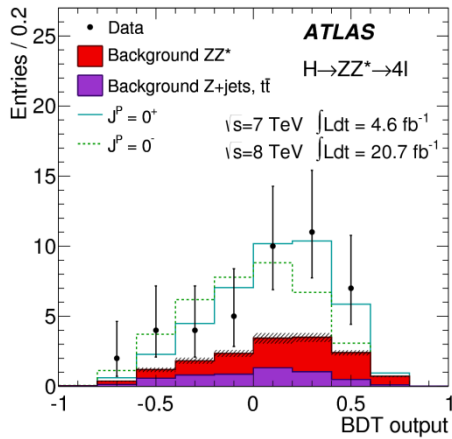


good agreement with SM expectations

Спин-чётность бозона Хиггса

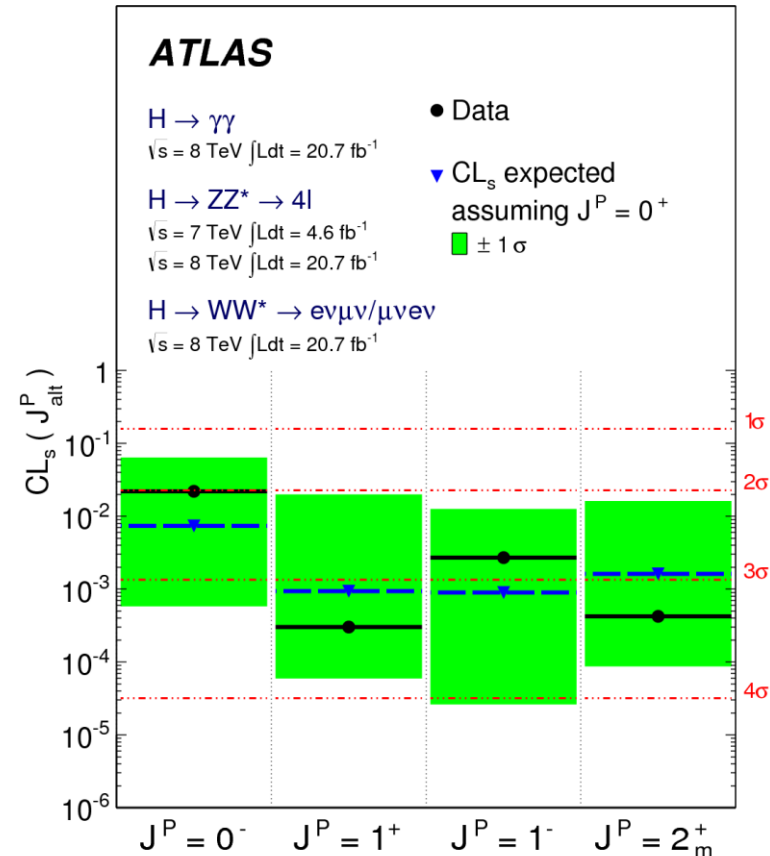
arXiv:1307.1432

0^+ is expected; test it vs $0^-, 1^+, 1^-, 2^+$



$$|\cos \theta^*| = \frac{|\sinh(\Delta\eta^{\gamma\gamma})|}{\sqrt{1 + (p_T^{\gamma\gamma}/m_{\gamma\gamma})^2}} \frac{2p_T^{\gamma 1} p_T^{\gamma 2}}{m_{\gamma\gamma}^2}$$

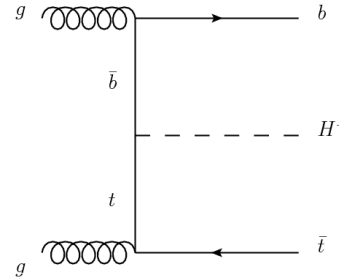
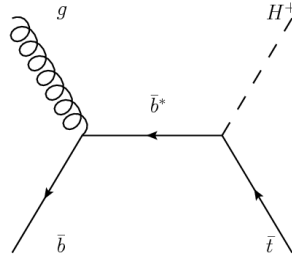
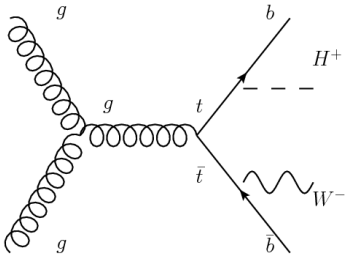
Spin-Parity 0^+ confirmed



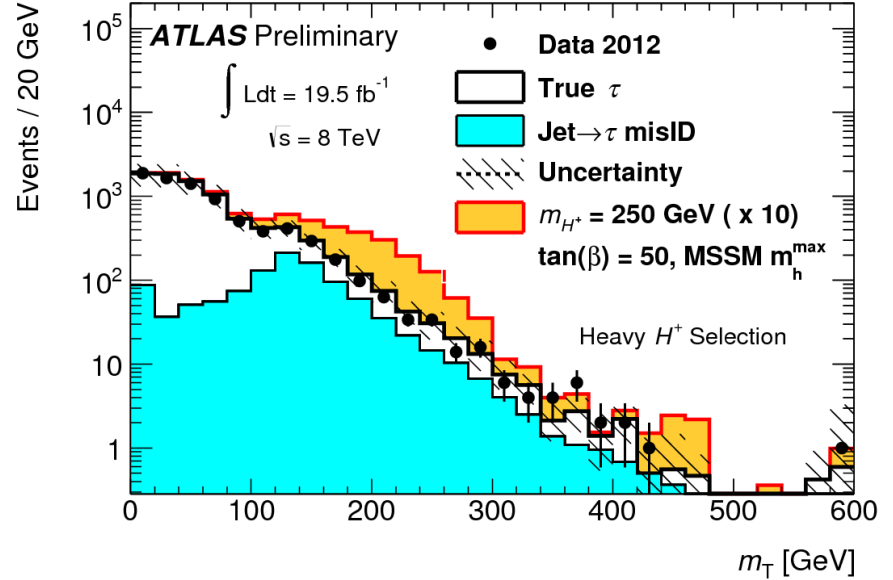
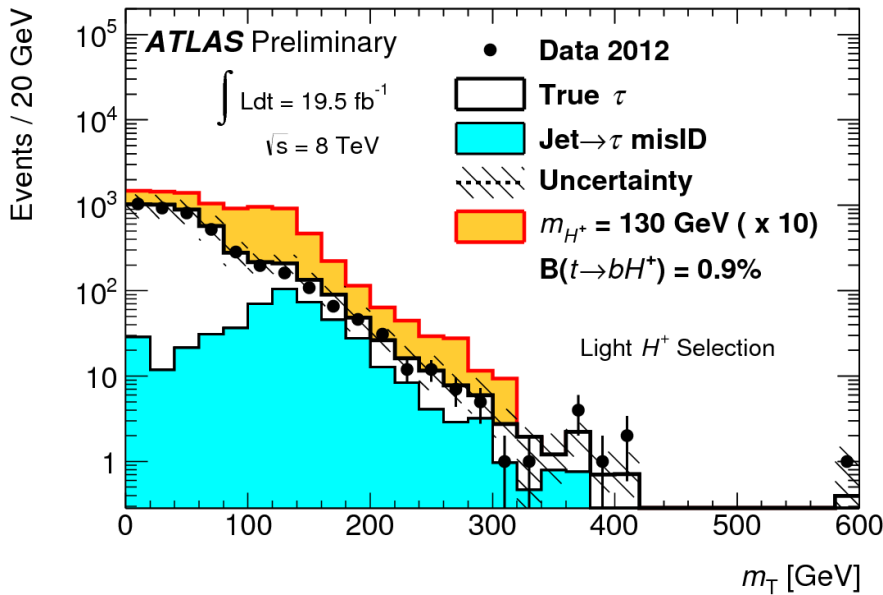
J^P hypo	Exclusion CL	Source
0^-	97.8%	$H \rightarrow ZZ^* \rightarrow 4l$
1^-	99.7%	Combined ZZ^*/WW^*
1^+	99.97%	Combined ZZ^*/WW^*
2^+	99.9%	Combined $\gamma\gamma/ZZ^*/WW^*$

лёгкий

тяжёлый

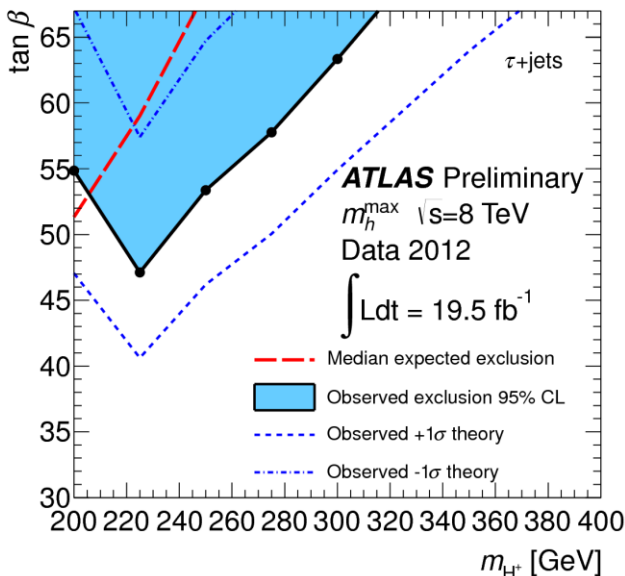
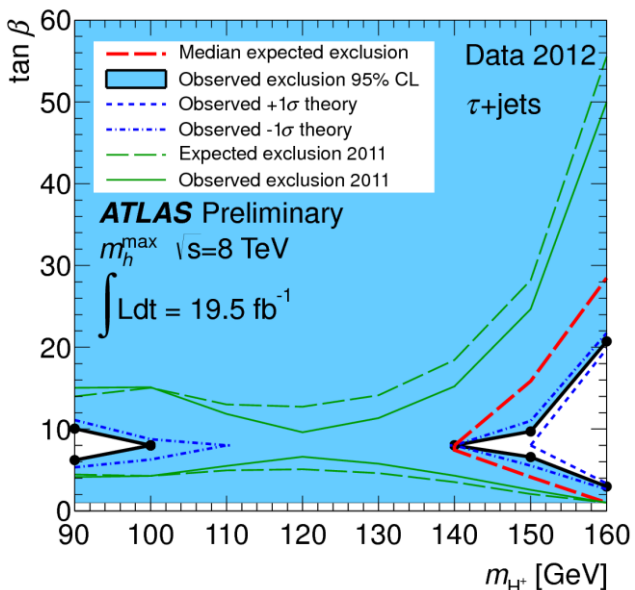
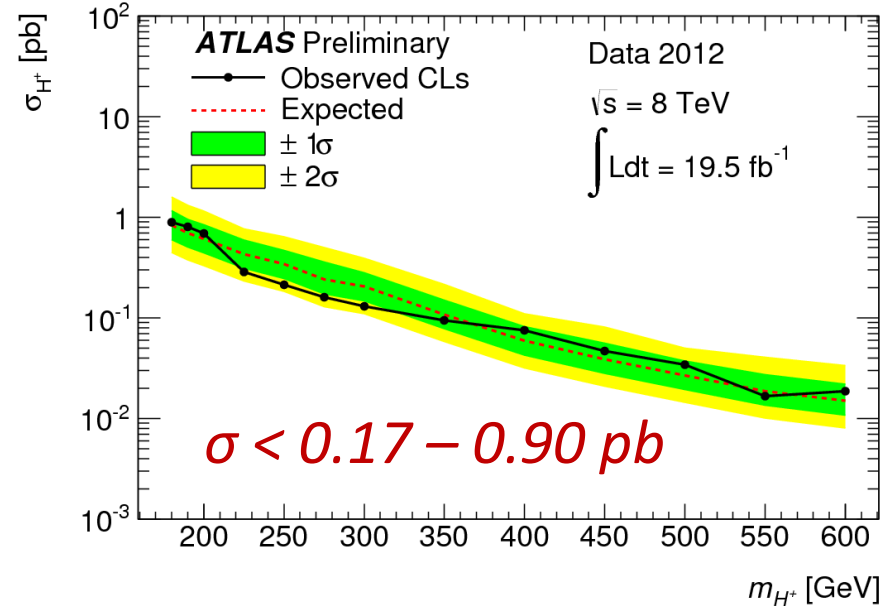
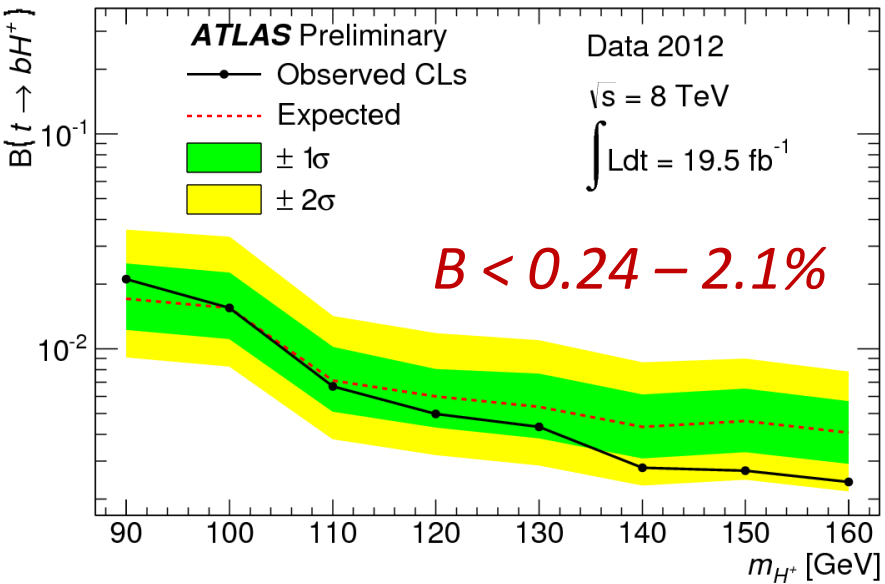


Signature: 3-4 jets, at least one jet b-tagged, exactly one τ (narrow jet), E_T^{miss}



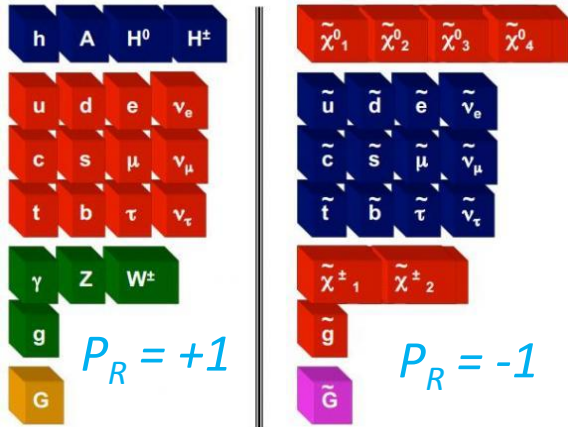
$$m_T = \sqrt{2p_T^\tau E_T^{miss}(1 - \cos \Delta\phi_{\tau,miss})}$$

лёгкий $B(H^\pm \rightarrow \tau \nu) = 100\%$ тяжёлый



MSSM
 (m_h^{max} scenario)
 interpretation

Поиски Суперсимметрии в эксперименте ATLAS

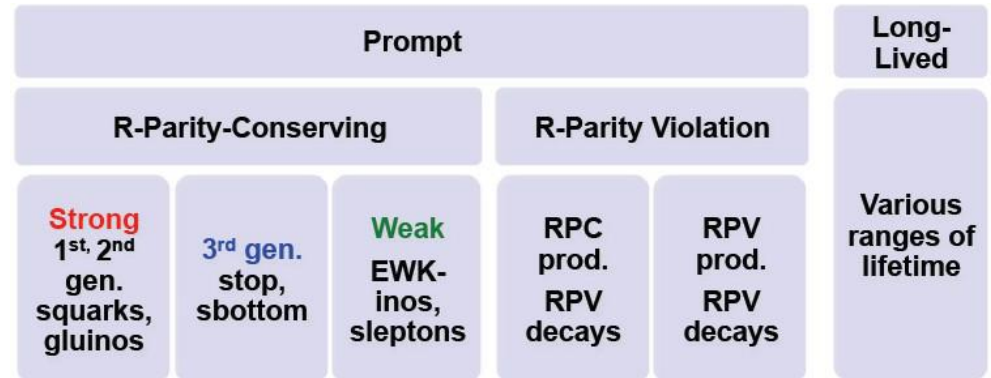
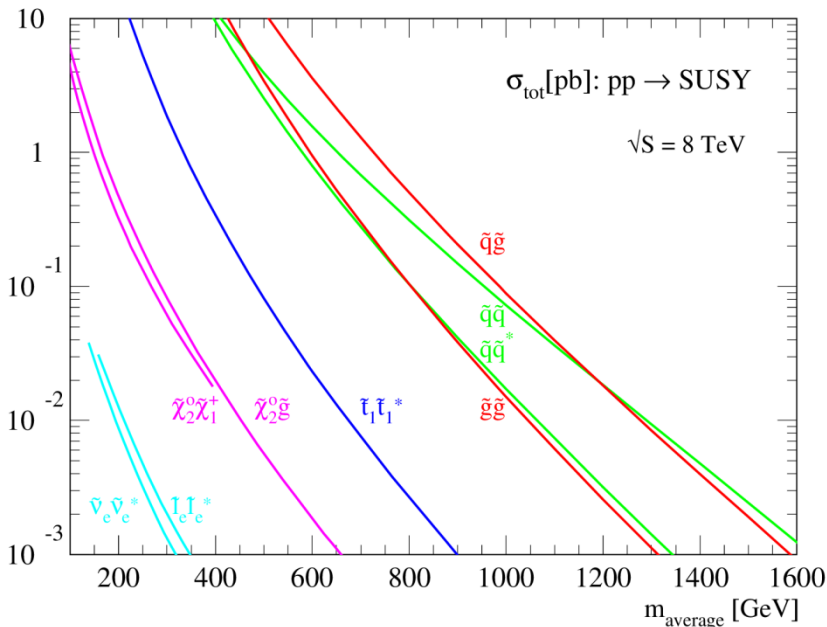


SUSY can

- eliminate quadratic divergences in Higgs mass corrections
- unify forces at high scales
- explain nature of Dark Matter (if LSP stable or long-lived)

$$R\text{-Parity } P_R = (-1)^{3(B-L)+2S}$$

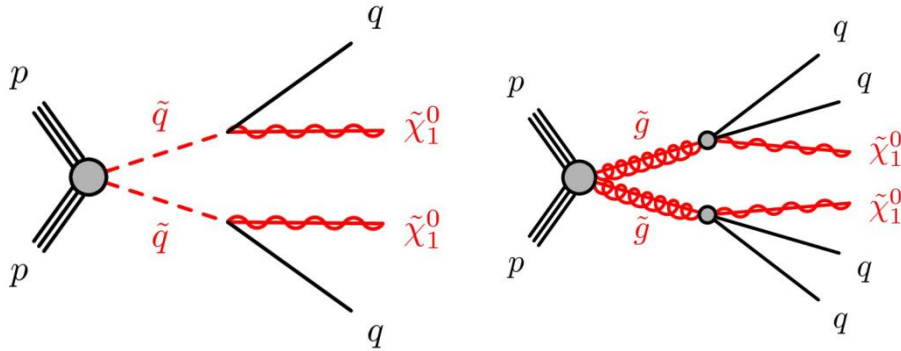
Search strategy designed to provide coverage for a broad class of SUSY models



For each search, a number of signal regions is optimized based on a variety of models

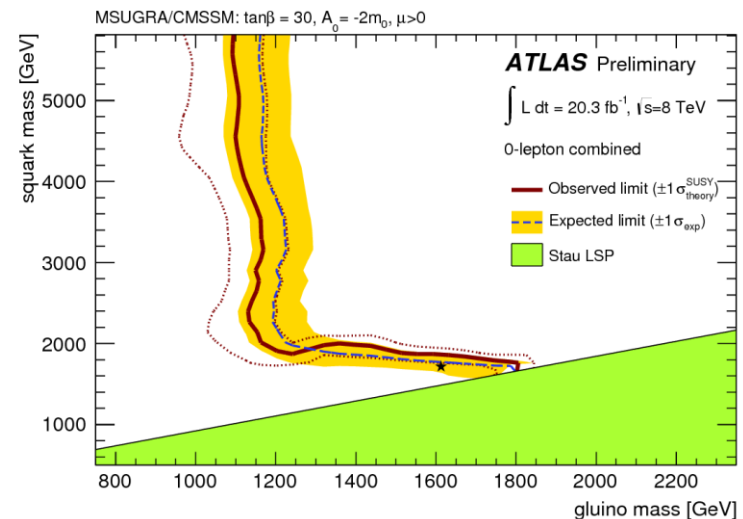
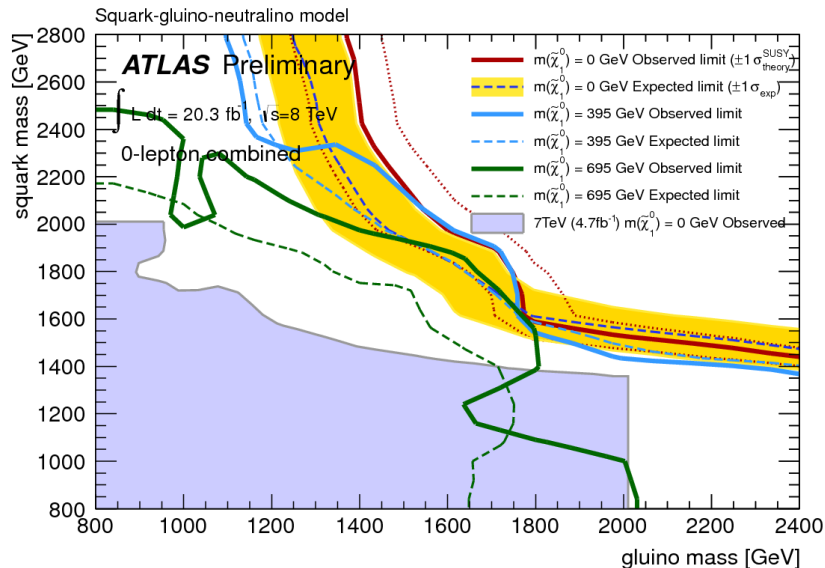
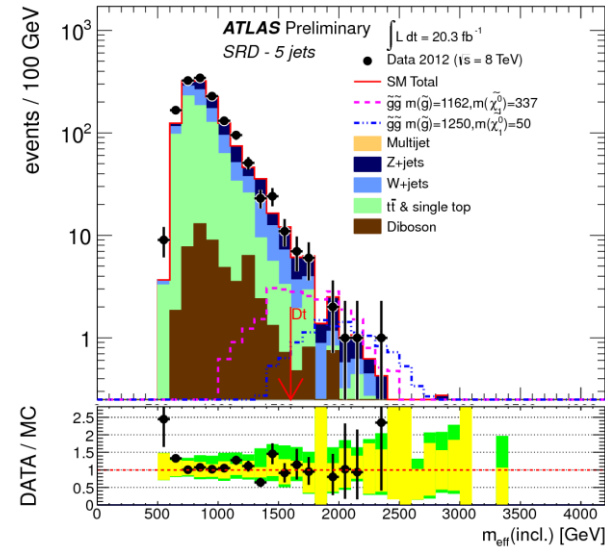
Поиски \tilde{q} и \tilde{g} в событиях без лептонов, с 2-6 струями и большим E_T^{miss}

ATLAS-CONF-2013-047



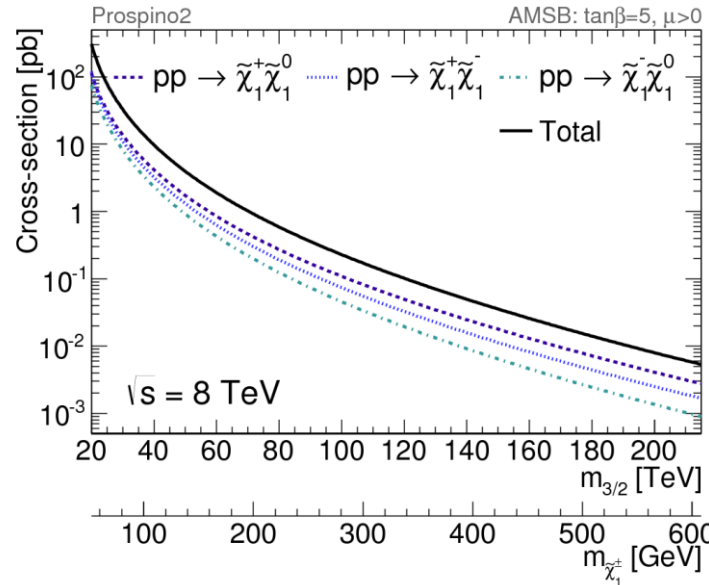
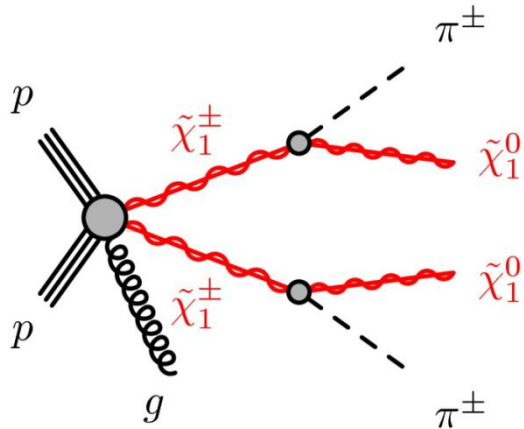
$$m_{eff} = E_T^{miss} + \sum p_T^{jets}$$

simplified phenomenological MSSM scenario with only strong production of gluinos and first- and second-generation squarks (of common mass), with direct decays to jets and lightest neutralinos



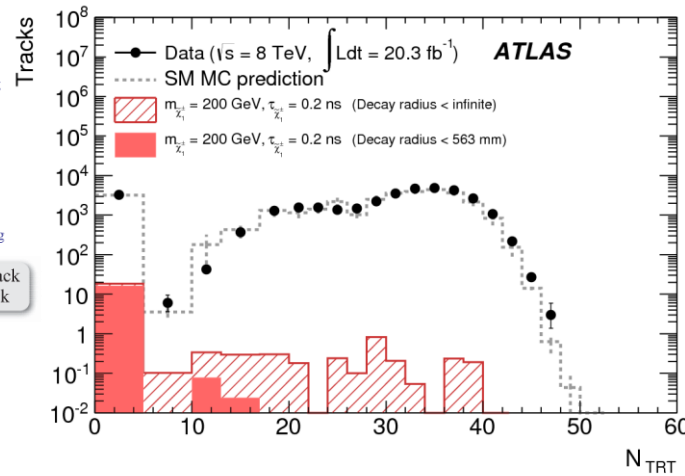
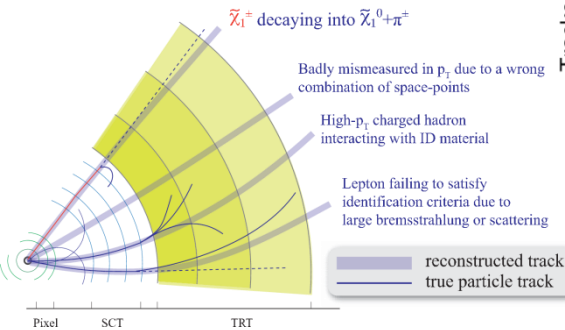
Поиск $\tilde{\chi}_1^\pm$ с $m(\tilde{\chi}_1^\pm) \approx m(\tilde{\chi}_1^0)$ в событиях с большим E_T^{miss} и “исчезающим” треком

arXiv:1310.3675

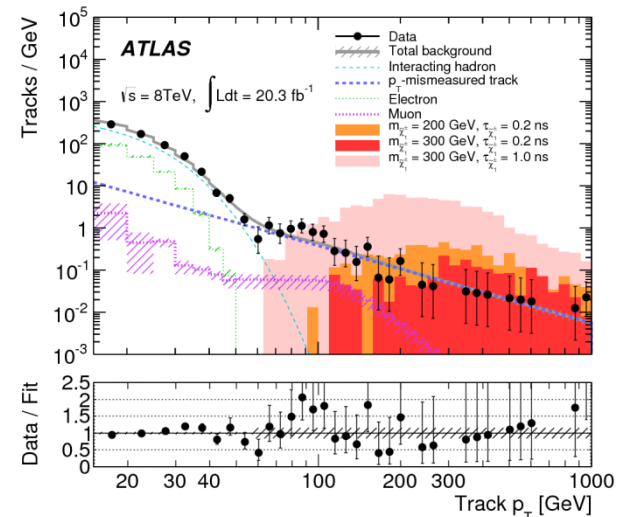


Many SUSY model e.g. AMSB have almost mass degenerate chargino and LSP \rightarrow long-lived chargino

$\Delta m \sim 160$ MeV

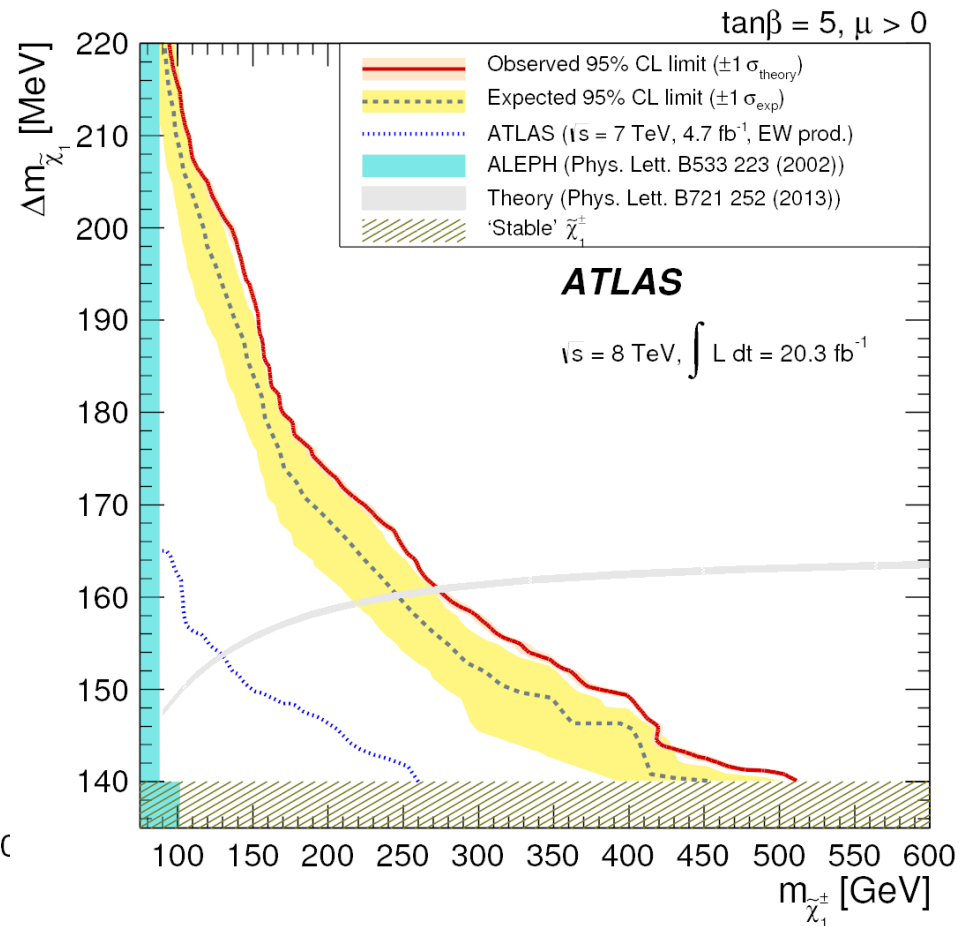
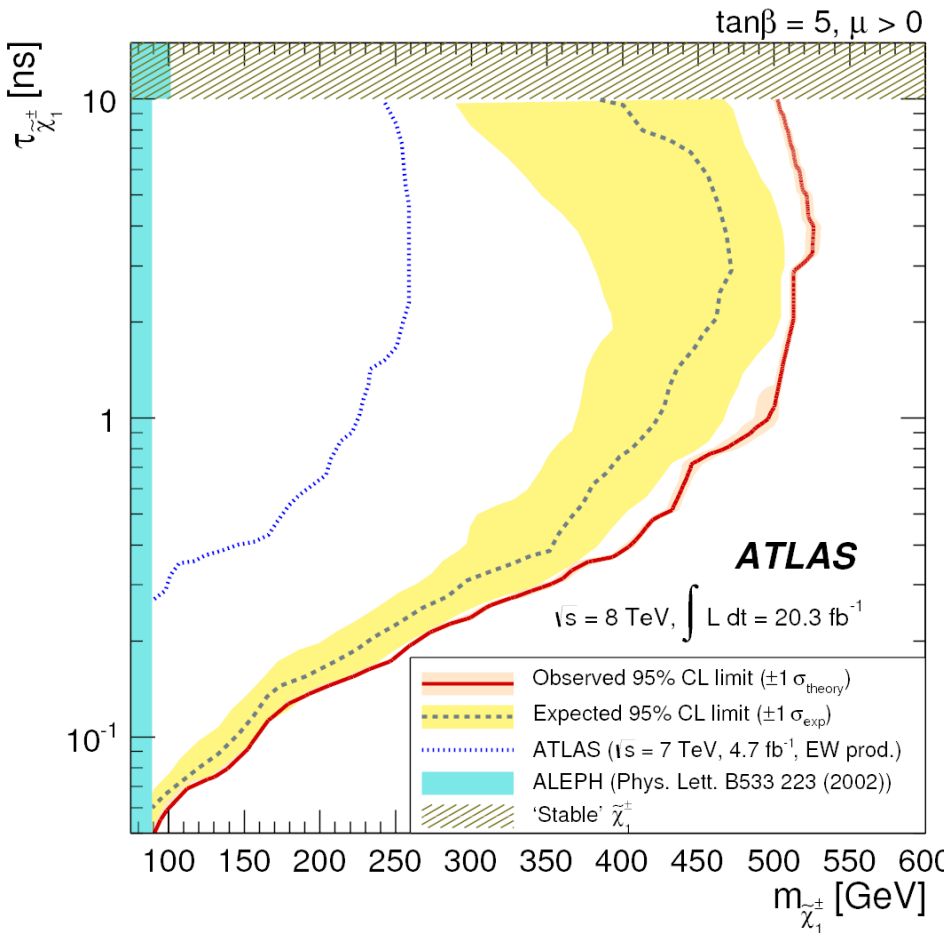


$N_{TRT} < 5$



$p_T^{track} > 75, 100, 150, 200$ GeV

Ограничения на $m(\tilde{\chi}_1^\pm)$, $\tau(\tilde{\chi}_1^\pm)$ и $m(\tilde{\chi}_1^\pm)-m(\tilde{\chi}_1^0)$ в событиях с большим E_T^{miss} и “исчезающим” треком arXiv:1310.3675



For $\tau \sim 0.2 \text{ ns}$, charginos excluded up to 270 GeV
 For $\tau \sim 1\text{--}10 \text{ ns}$, chargino excluded up to 520 GeV

Поиск долгоживущих остановившихся R-адронов

“decaying out of time with pp collisions” arXiv:1310.6584

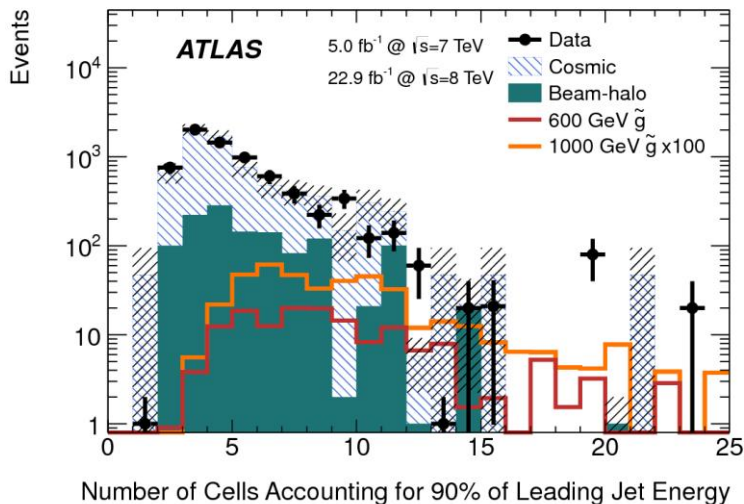
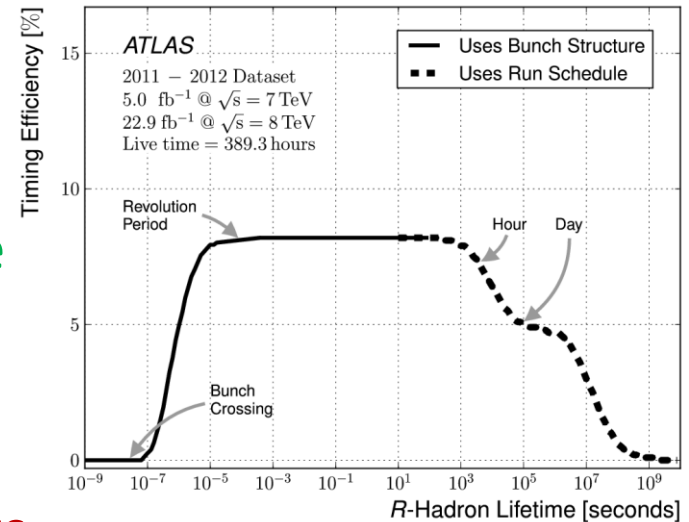
long-lived gluino: $(\tilde{g}q\bar{q}), (\tilde{g}qqq), (\tilde{g}g)$

long-lived squark: $(\tilde{t}\bar{q}), (\tilde{b}\bar{q})$

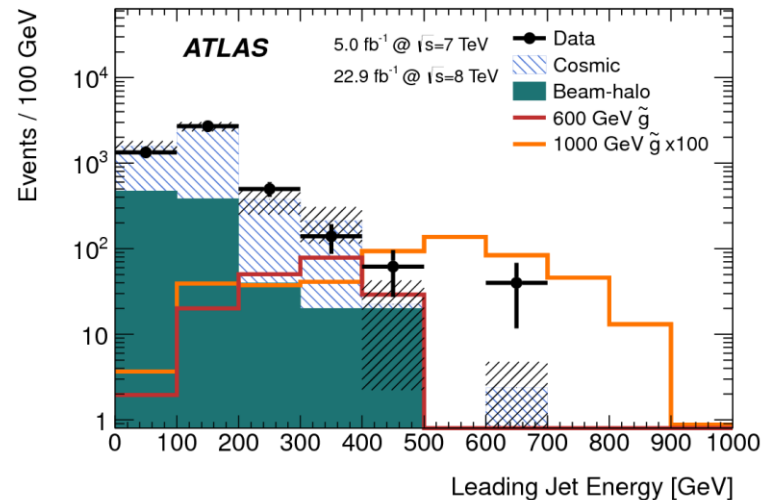
$R_{hadron} \rightarrow \tilde{\chi}^0 + hadronic jets$ at a later time

signature: large E_T^{miss} and jet activity in empty bunch crossings

$E_T^{miss} / E_T^{leading jet} > 0.5$, no muons segments



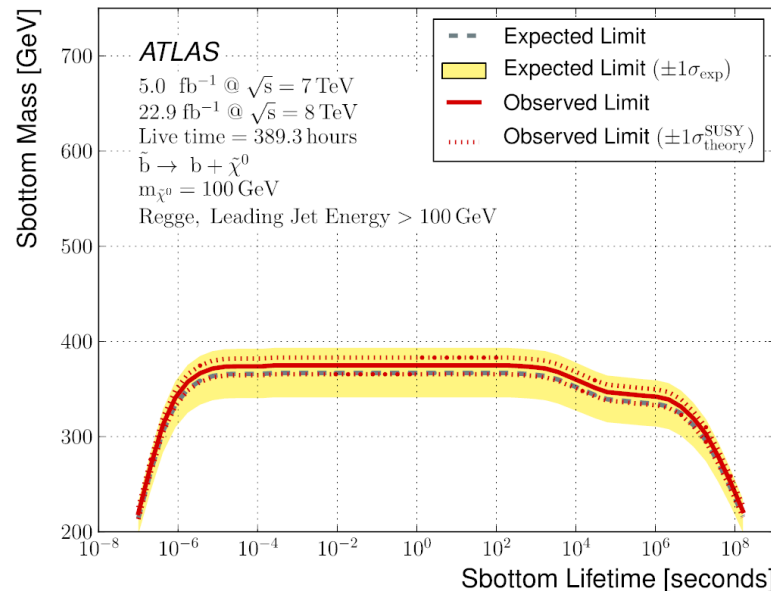
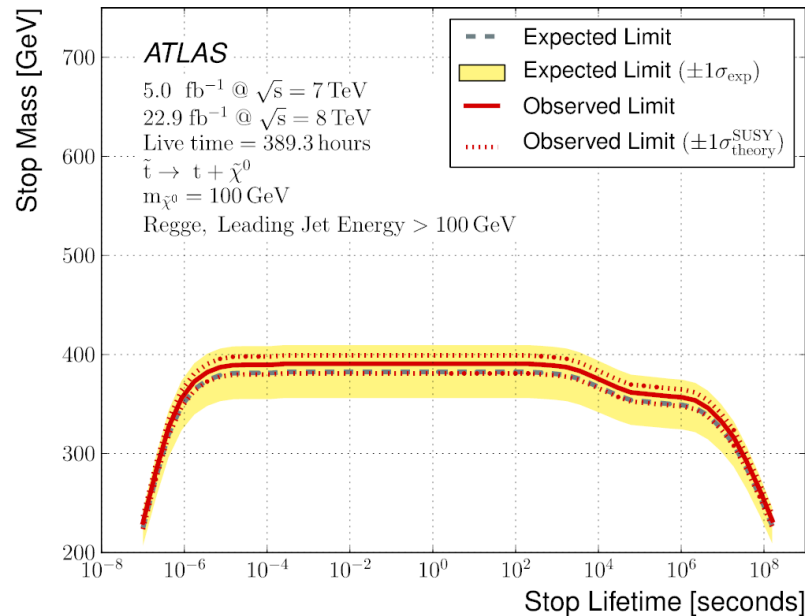
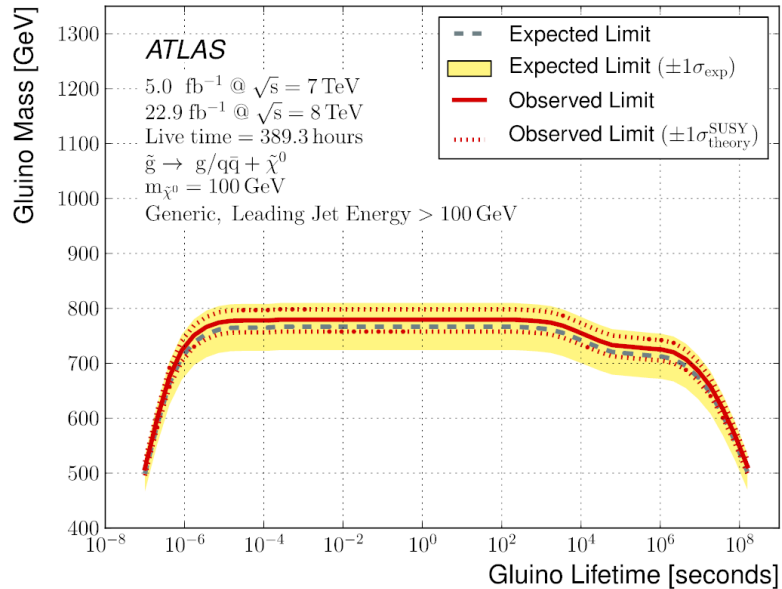
> 3



$> 100, 300 GeV$

Ограничения на характеристики \tilde{g} , \tilde{t} и \tilde{b} из долгоживущих остановившихся R-адронов

arXiv:1310.6584



Limits are somewhat model dependent

Conclusion is general –
 No SUSY signature (yet?)

Ограничения на массы суперсимметричных партнёров

ATLAS SUSY Searches* - 95% CL Lower Limits

Status: SUSY 2013

ATLAS Preliminary

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

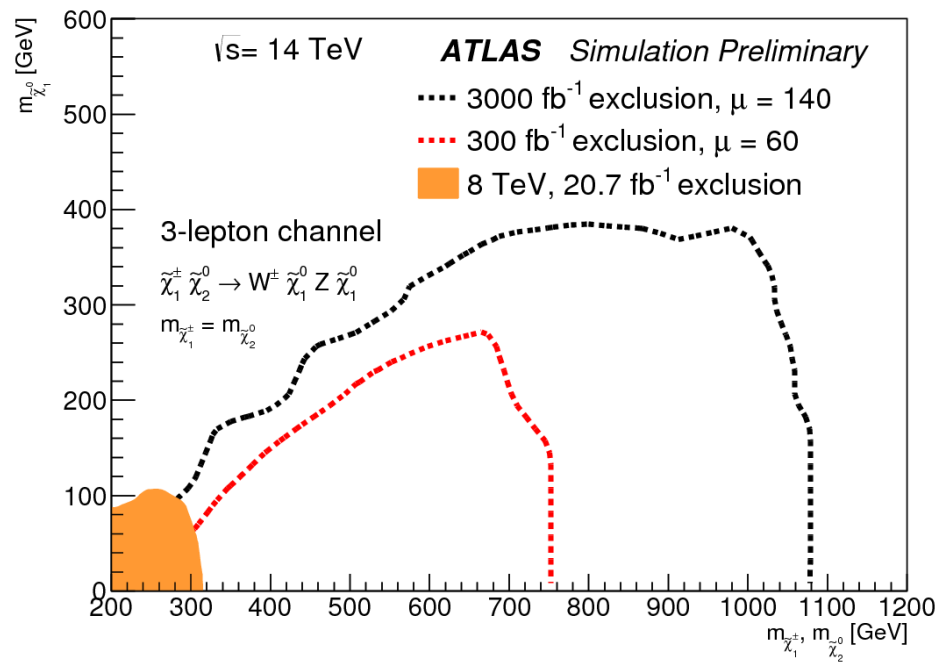
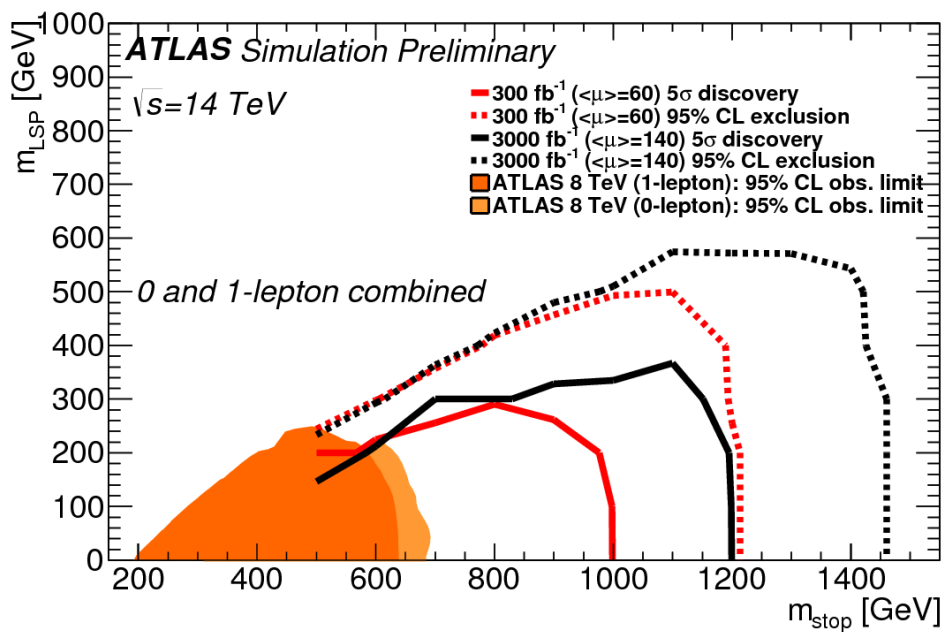
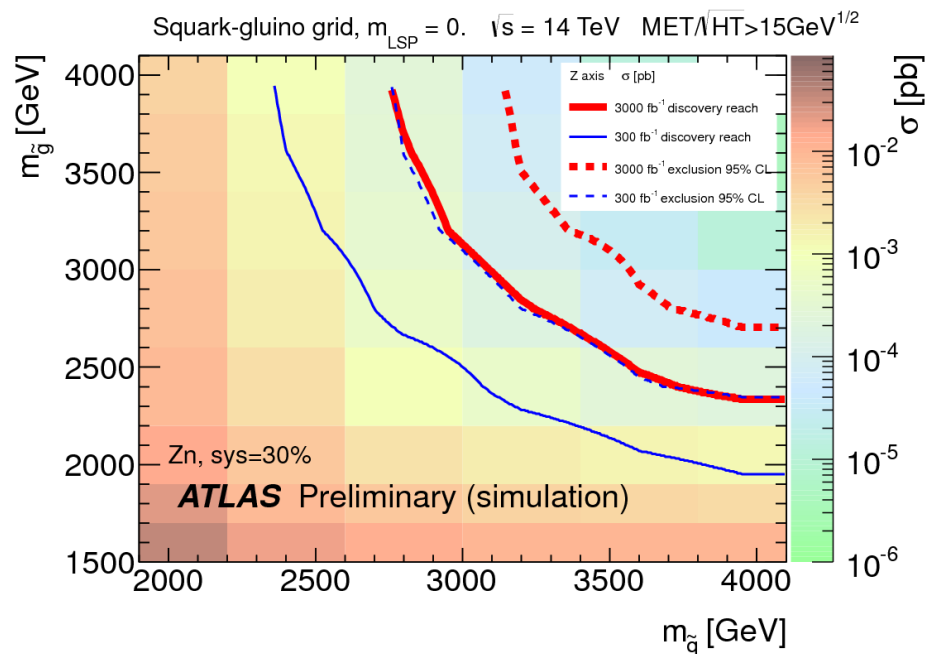
Model	e, μ, τ, γ	Jets	E_T^{miss}	$\int \mathcal{L} dt [\text{fb}^{-1}]$	Mass limit	Reference	
Inclusive Searches	MSUGRA/CMSSM	0	2-6 jets	Yes	20.3	\tilde{q}, \tilde{g} 1.7 TeV	$m(\tilde{q})=m(\tilde{g})$ ATLAS-CONF-2013-047
	MSUGRA/CMSSM	1 e, μ	3-6 jets	Yes	20.3	\tilde{g} 1.2 TeV	any $m(\tilde{q})$ ATLAS-CONF-2013-062
	MSUGRA/CMSSM	0	7-10 jets	Yes	20.3	\tilde{g} 1.1 TeV	any $m(\tilde{q})$ 1308.1841
	$\tilde{q}\tilde{q}, \tilde{q} \rightarrow q\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	\tilde{q} 740 GeV	$m(\tilde{\chi}_1^0)=0 \text{ GeV}$ ATLAS-CONF-2013-047
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow q\tilde{q}\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	\tilde{g} 1.3 TeV	$m(\tilde{\chi}_1^0)=0 \text{ GeV}$ ATLAS-CONF-2013-047
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow q\tilde{q}\tilde{\chi}_1^0 \rightarrow q\tilde{q}W^\pm\tilde{\chi}_1^0$	1 e, μ	3-6 jets	Yes	20.3	\tilde{g} 1.18 TeV	$m(\tilde{\chi}_1^0)<200 \text{ GeV}, m(\tilde{\chi}^\pm)=0.5(m(\tilde{\chi}_1^0)+m(\tilde{g}))$ ATLAS-CONF-2013-062
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow q\tilde{q}(\ell\ell/\ell\nu/\nu\nu)\tilde{\chi}_1^0$	2 e, μ	0-3 jets	-	20.3	\tilde{g} 1.12 TeV	$m(\tilde{\chi}_1^0)=0 \text{ GeV}$ ATLAS-CONF-2013-089
	GMSB ($\tilde{\ell}$ NLSP)	2 e, μ	2-4 jets	Yes	4.7	\tilde{g} 1.24 TeV	$\tan\beta<15$ 1208.4688
	GMSB ($\tilde{\ell}$ NLSP)	1-2 τ	0-2 jets	Yes	20.7	\tilde{g} 1.4 TeV	$\tan\beta>18$ ATLAS-CONF-2013-026
	GGM (bino NLSP)	2 γ	-	Yes	4.8	\tilde{g} 1.07 TeV	$m(\tilde{\chi}_1^0)>50 \text{ GeV}$ 1209.0753
	GGM (wino NLSP)	1 $e, \mu + \gamma$	-	Yes	4.8	\tilde{g} 619 GeV	$m(\tilde{\chi}_1^0)>50 \text{ GeV}$ ATLAS-CONF-2012-144
	GGM (higgsino-bino NLSP)	γ	1 b	Yes	4.8	\tilde{g} 900 GeV	$m(\tilde{\chi}_1^0)>220 \text{ GeV}$ 1211.1167
GGM (higgsino NLSP)	2 e, μ (Z)	0-3 jets	Yes	5.8	\tilde{g} 690 GeV	$m(\tilde{H})>200 \text{ GeV}$ ATLAS-CONF-2012-152	
Gravitino LSP	0	mono-jet	Yes	10.5	$F^{1/2}$ scale 645 GeV	$m(\tilde{g})>10^{-4} \text{ eV}$ ATLAS-CONF-2012-147	
3 rd gen. \tilde{g} med.	$\tilde{g} \rightarrow b\tilde{b}\tilde{\chi}_1^0$	0	3 b	Yes	20.1	\tilde{g} 1.2 TeV	$m(\tilde{\chi}_1^0)<600 \text{ GeV}$ ATLAS-CONF-2013-061
	$\tilde{g} \rightarrow t\tilde{t}\tilde{\chi}_1^0$	0	7-10 jets	Yes	20.3	\tilde{g} 1.1 TeV	$m(\tilde{\chi}_1^0)<350 \text{ GeV}$ 1308.1841
	$\tilde{g} \rightarrow t\tilde{t}\tilde{\chi}_1^0$	0-1 e, μ	3 b	Yes	20.1	\tilde{g} 1.34 TeV	$m(\tilde{\chi}_1^0)<400 \text{ GeV}$ ATLAS-CONF-2013-061
	$\tilde{g} \rightarrow b\tilde{t}\tilde{\chi}_1^0$	0-1 e, μ	3 b	Yes	20.1	\tilde{g} 1.3 TeV	$m(\tilde{\chi}_1^0)<300 \text{ GeV}$ ATLAS-CONF-2013-061
3 rd gen. squarks direct production	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1 \rightarrow b\tilde{\chi}_1^0$	0	2 b	Yes	20.1	\tilde{b}_1 100-620 GeV	$m(\tilde{\chi}_1^0)<90 \text{ GeV}$ 1308.2631
	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1 \rightarrow t\tilde{\chi}_1^0$	2 e, μ (SS)	0-3 b	Yes	20.7	\tilde{b}_1 275-430 GeV	$m(\tilde{\chi}_1^0)=2 m(\tilde{\chi}_1^\pm)$ ATLAS-CONF-2013-007
	$\tilde{t}_1\tilde{t}_1$ (light), $\tilde{t}_1 \rightarrow b\tilde{\chi}_1^0$	1-2 e, μ	1-2 b	Yes	4.7	\tilde{t}_1 110-167 GeV	$m(\tilde{\chi}_1^0)=55 \text{ GeV}$ 1208.4305, 1209.2102
	$\tilde{t}_1\tilde{t}_1$ (light), $\tilde{t}_1 \rightarrow Wb\tilde{\chi}_1^0$	2 e, μ	0-2 jets	Yes	20.3	\tilde{t}_1 130-220 GeV	$m(\tilde{\chi}_1^0) = m(\tilde{t}_1) - m(W) - 50 \text{ GeV}, m(\tilde{t}_1) < m(\tilde{\chi}_1^\pm)$ ATLAS-CONF-2013-048
	$\tilde{t}_1\tilde{t}_1$ (medium), $\tilde{t}_1 \rightarrow t\tilde{\chi}_1^0$	2 e, μ	2 jets	Yes	20.3	\tilde{t}_1 225-525 GeV	$m(\tilde{\chi}_1^0)=0 \text{ GeV}$ ATLAS-CONF-2013-065
	$\tilde{t}_1\tilde{t}_1$ (medium), $\tilde{t}_1 \rightarrow b\tilde{\chi}_1^0$	0	2 b	Yes	20.1	\tilde{t}_1 150-580 GeV	$m(\tilde{\chi}_1^0)<200 \text{ GeV}, m(\tilde{\chi}_1^\pm) - m(\tilde{\chi}_1^0) = 5 \text{ GeV}$ 1308.2631
	$\tilde{t}_1\tilde{t}_1$ (heavy), $\tilde{t}_1 \rightarrow t\tilde{\chi}_1^0$	1 e, μ	1 b	Yes	20.7	\tilde{t}_1 200-610 GeV	$m(\tilde{\chi}_1^0)=0 \text{ GeV}$ ATLAS-CONF-2013-037
	$\tilde{t}_1\tilde{t}_1$ (heavy), $\tilde{t}_1 \rightarrow t\tilde{\chi}_1^0$	0	2 b	Yes	20.5	\tilde{t}_1 320-660 GeV	$m(\tilde{\chi}_1^0)=0 \text{ GeV}$ ATLAS-CONF-2013-024
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow c\tilde{\chi}_1^0$	0	mono-jet/c-tag	Yes	20.3	\tilde{t}_1 90-200 GeV	$m(\tilde{t}_1) - m(\tilde{\chi}_1^0) < 85 \text{ GeV}$ ATLAS-CONF-2013-068
	$\tilde{t}_1\tilde{t}_1$ (natural GMSB)	2 e, μ (Z)	1 b	Yes	20.7	\tilde{t}_1 500 GeV	$m(\tilde{\chi}_1^0)>150 \text{ GeV}$ ATLAS-CONF-2013-025
$\tilde{b}_2\tilde{b}_2, \tilde{b}_2 \rightarrow \tilde{t}_1 + Z$	3 e, μ (Z)	1 b	Yes	20.7	\tilde{b}_2 271-520 GeV	$m(\tilde{t}_1) = m(\tilde{\chi}_1^0) + 180 \text{ GeV}$ ATLAS-CONF-2013-025	
EW direct	$\tilde{\ell}_L\tilde{\ell}_L, \tilde{\ell}_L \rightarrow \tilde{\chi}_1^0$	2 e, μ	0	Yes	20.3	$\tilde{\ell}$ 85-315 GeV	$m(\tilde{\chi}_1^0)=0 \text{ GeV}$ ATLAS-CONF-2013-049
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm, \tilde{\chi}_1^\pm \rightarrow \tilde{\ell}\nu(\tilde{\ell}\bar{\nu})$	2 e, μ	0	Yes	20.3	$\tilde{\chi}_1^\pm$ 125-450 GeV	$m(\tilde{\chi}_1^0)=0 \text{ GeV}, m(\tilde{\ell}, \bar{\nu}) = 0.5(m(\tilde{\chi}_1^\pm) + m(\tilde{\chi}_1^0))$ ATLAS-CONF-2013-049
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm, \tilde{\chi}_1^\pm \rightarrow \tilde{\tau}\nu(\tilde{\tau}\bar{\nu})$	2 τ	-	Yes	20.7	$\tilde{\chi}_1^\pm$ 180-330 GeV	$m(\tilde{\chi}_1^0)=0 \text{ GeV}, m(\tilde{\tau}, \bar{\nu}) = 0.5(m(\tilde{\chi}_1^\pm) + m(\tilde{\chi}_1^0))$ ATLAS-CONF-2013-028
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0 \rightarrow \tilde{\ell}_1\tilde{\ell}_1\ell(\tilde{\nu}\bar{\nu}), \tilde{\nu}\tilde{\ell}_1\ell(\tilde{\nu}\bar{\nu})$	3 e, μ	0	Yes	20.7	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$ 600 GeV	$m(\tilde{\chi}_1^0)=m(\tilde{\chi}_2^0), m(\tilde{\chi}_1^0)=0, m(\tilde{\ell}, \bar{\nu}) = 0.5(m(\tilde{\chi}_1^\pm) + m(\tilde{\chi}_1^0))$ ATLAS-CONF-2013-035
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0 \rightarrow W\tilde{\chi}_1^0 Z$	3 e, μ	0	Yes	20.7	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$ 315 GeV	$m(\tilde{\chi}_1^0)=m(\tilde{\chi}_2^0), m(\tilde{\chi}_1^0)=0, \text{ sleptons decoupled}$ ATLAS-CONF-2013-035
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0 \rightarrow W\tilde{\chi}_1^0 h\tilde{\chi}_1^0$	1 e, μ	2 b	Yes	20.3	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$ 285 GeV	$m(\tilde{\chi}_1^0)=m(\tilde{\chi}_2^0), m(\tilde{\chi}_1^0)=0, \text{ sleptons decoupled}$ ATLAS-CONF-2013-093
Long-lived particles	Direct $\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm$ prod., long-lived $\tilde{\chi}_1^\pm$	Disapp. trk	1 jet	Yes	20.3	$\tilde{\chi}_1^\pm$ 270 GeV	$m(\tilde{\chi}_1^0) - m(\tilde{\chi}_1^\pm) = 160 \text{ MeV}, \tau(\tilde{\chi}_1^\pm) = 0.2 \text{ ns}$ ATLAS-CONF-2013-069
	Stable, stopped \tilde{g} R-hadron	0	1-5 jets	Yes	22.9	\tilde{g} 832 GeV	$m(\tilde{\chi}_1^0)=100 \text{ GeV}, 10 \mu\text{s} < \tau(\tilde{g}) < 1000 \text{ s}$ ATLAS-CONF-2013-057
	GMSB, stable $\tilde{\tau}, \tilde{\chi}_1^0 \rightarrow \tilde{\tau}(\tilde{e}, \tilde{\mu}) + \tau(e, \mu)$	1-2 μ	-	-	15.9	$\tilde{\chi}_1^0$ 475 GeV	$10 < \tan\beta < 50$ ATLAS-CONF-2013-058
	GMSB, $\tilde{\chi}_1^0 \rightarrow \tilde{G}$, long-lived $\tilde{\chi}_1^0$	2 γ	-	Yes	4.7	$\tilde{\chi}_1^0$ 230 GeV	$0.4 < \tau(\tilde{\chi}_1^0) < 2 \text{ ns}$ 1304.6310
$\tilde{q}\tilde{q}, \tilde{\chi}_1^0 \rightarrow q\tilde{q}\mu$ (RPV)	1 μ , displ. vtx	-	-	20.3	\tilde{q} 1.0 TeV	$1.5 < c\tau < 156 \text{ mm}, \text{BR}(\mu)=1, m(\tilde{\chi}_1^0)=108 \text{ GeV}$ ATLAS-CONF-2013-092	
RPV	LFV $pp \rightarrow \tilde{\nu}_\tau + X, \tilde{\nu}_\tau \rightarrow e + \mu$	2 e, μ	-	-	4.6	$\tilde{\nu}_\tau$ 1.61 TeV	$\lambda'_{311}=0.10, \lambda'_{332}=0.05$ 1212.1272
	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	$\lambda'_{311}=0.10, \lambda'_{323}=0.05$ 1212.1272
	Bilinear RPV CMSSM	1 e, μ	7 jets	Yes	4.7	\tilde{q}, \tilde{g} 1.2 TeV	$m(\tilde{q})=m(\tilde{g}), c\tau_{\text{LSP}} < 1 \text{ mm}$ ATLAS-CONF-2012-140
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm, \tilde{\chi}_1^\pm \rightarrow W\tilde{\chi}_1^0, \tilde{\chi}_1^0 \rightarrow ee\tilde{\nu}_\mu, e\tilde{\nu}_\mu$	4 e, μ	-	Yes	20.7	$\tilde{\chi}_1^\pm$ 760 GeV	$m(\tilde{\chi}_1^0) > 300 \text{ GeV}, \lambda'_{121} > 0$ ATLAS-CONF-2013-036
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm, \tilde{\chi}_1^\pm \rightarrow W\tilde{\chi}_1^0, \tilde{\chi}_1^0 \rightarrow \tau\tilde{\nu}_\tau, e\tilde{\nu}_\tau$	3 $e, \mu + \tau$	-	Yes	20.7	$\tilde{\chi}_1^\pm$ 350 GeV	$m(\tilde{\chi}_1^0) > 80 \text{ GeV}, \lambda'_{133} > 0$ ATLAS-CONF-2013-036
	$\tilde{g} \rightarrow q\tilde{q}q$	0	6-7 jets	-	20.3	\tilde{g} 916 GeV	$\text{BR}(t)=\text{BR}(b)=\text{BR}(c)=0\%$ ATLAS-CONF-2013-091
$\tilde{g} \rightarrow \tilde{t}_1 t, \tilde{t}_1 \rightarrow bs$	2 e, μ (SS)	0-3 b	Yes	20.7	\tilde{g} 880 GeV	ATLAS-CONF-2013-007	
Other	Scalar gluon pair, $\text{sgluon} \rightarrow q\tilde{q}$	0	4 jets	-	4.6	sgluon 100-287 GeV	incl. limit from 1110.2693 1210.4826
	Scalar gluon pair, $\text{sgluon} \rightarrow t\tilde{t}$	2 e, μ (SS)	1 b	Yes	14.3	sgluon 800 GeV	ATLAS-CONF-2013-051
	WIMP interaction (D5, Dirac χ)	0	mono-jet	Yes	10.5	M^* scale 704 GeV	$m(\chi) < 80 \text{ GeV}, \text{limit of } < 687 \text{ GeV for D8}$ ATLAS-CONF-2012-147

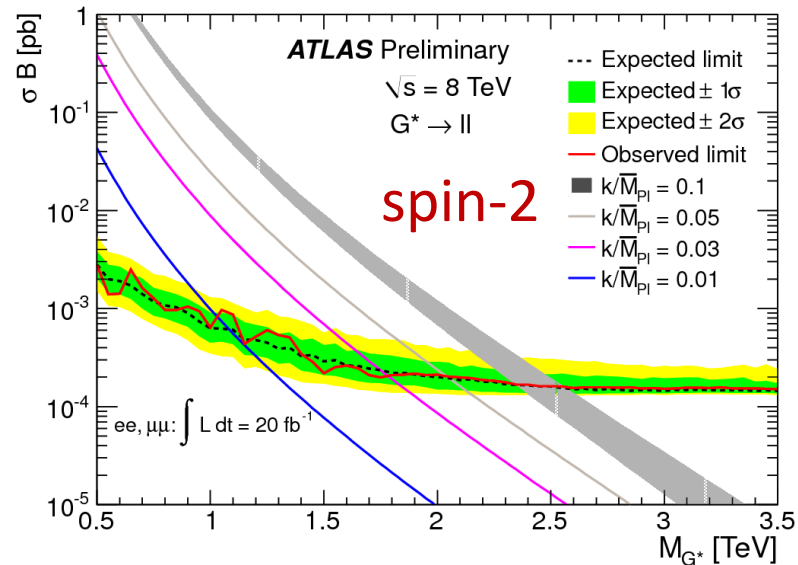
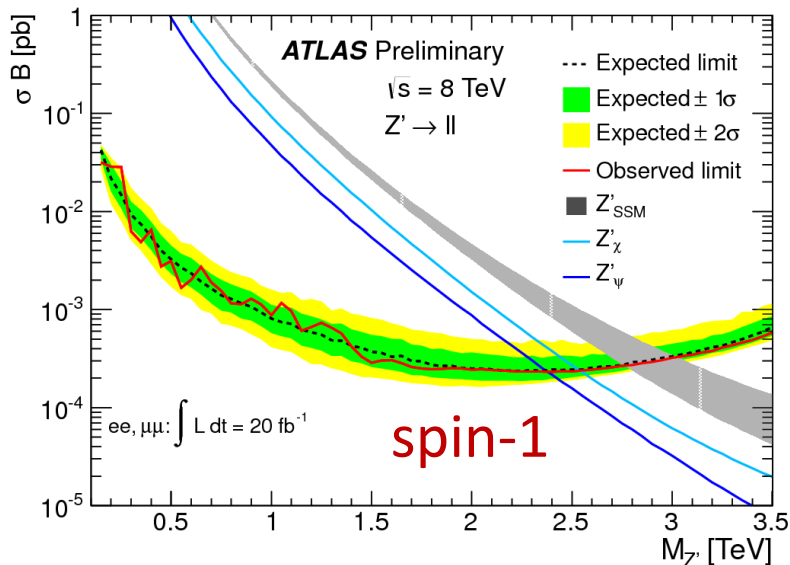
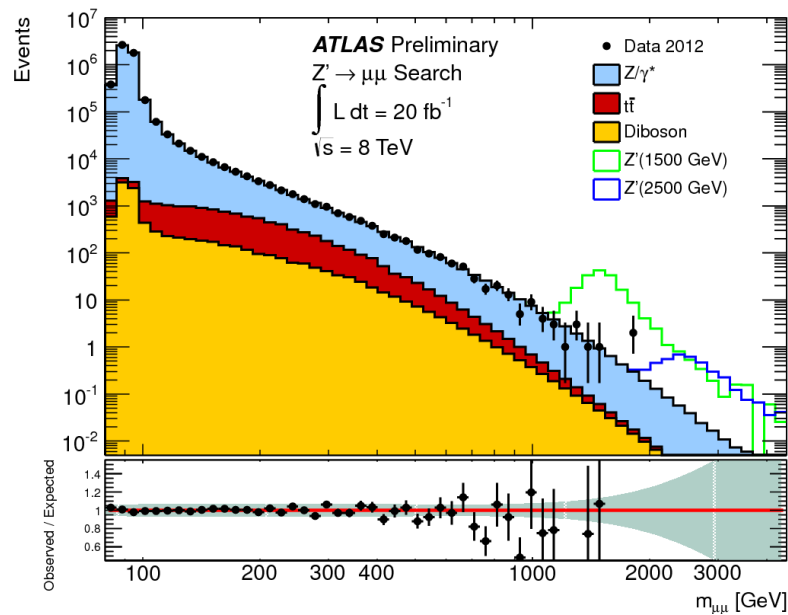
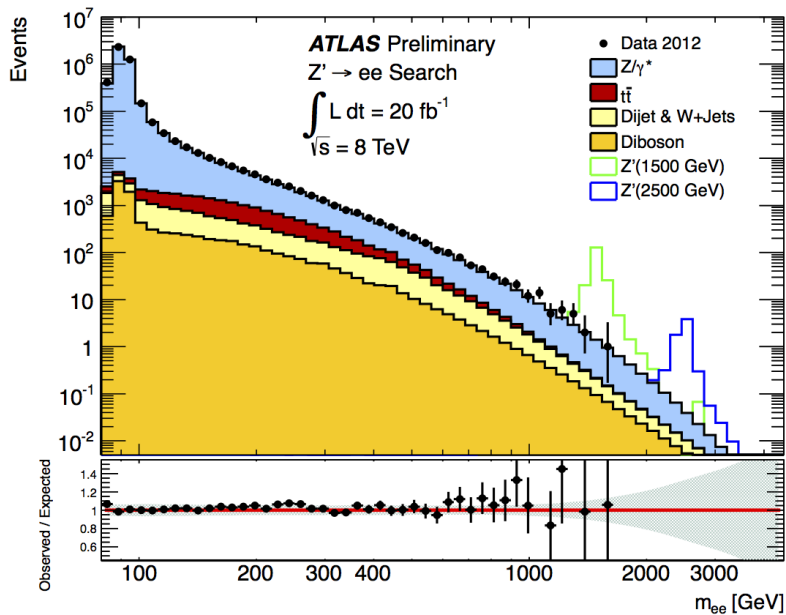
$\sqrt{s} = 7 \text{ TeV}$ full data
 $\sqrt{s} = 8 \text{ TeV}$ partial data
 $\sqrt{s} = 8 \text{ TeV}$ full data

10⁻¹ 1 Mass scale [TeV]

*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.

Перспективы обнаружения SUSY в эксперименте ATLAS



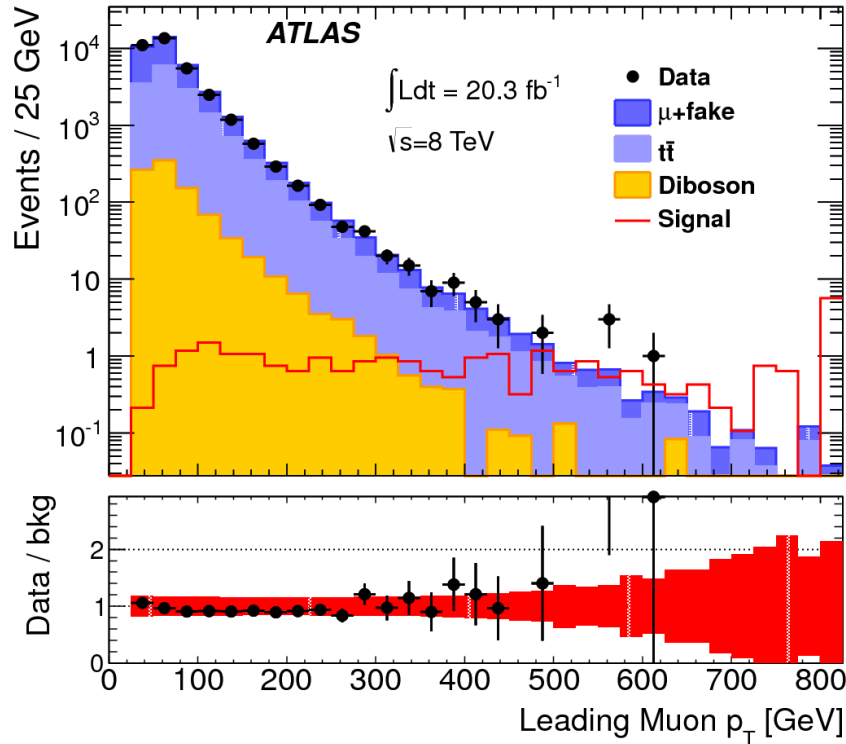


limits on $m(Z')$ (SSM and GU E6)

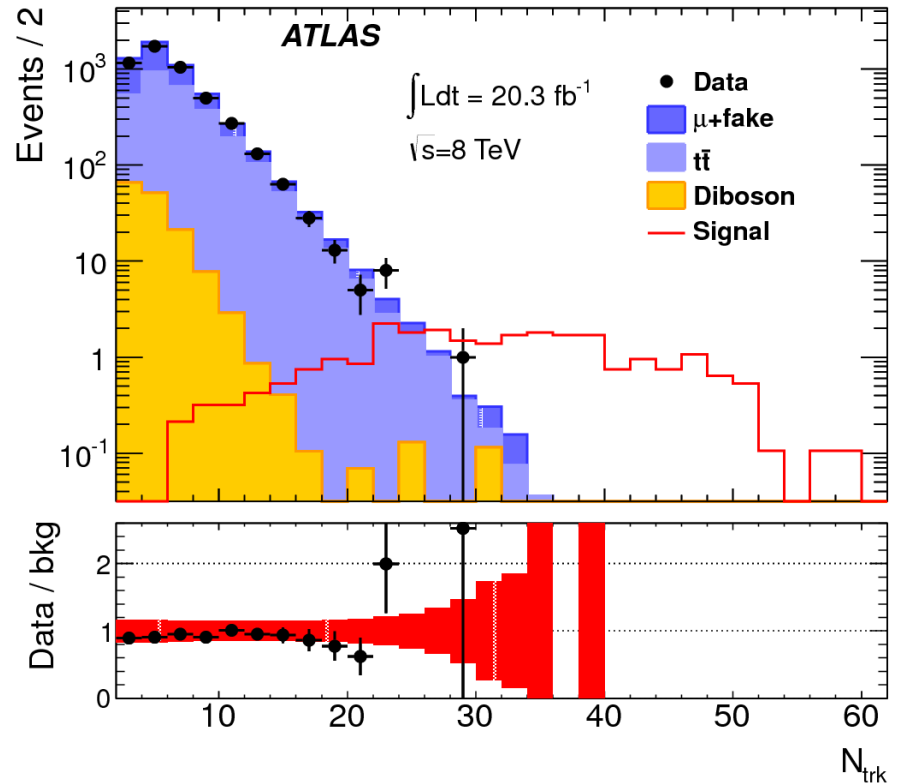
limits on $m(G^*)$ (RS graviton)

Поиск микроскопических чёрных дыр в событиях с большой множественностью и двумя мюонами одного знака

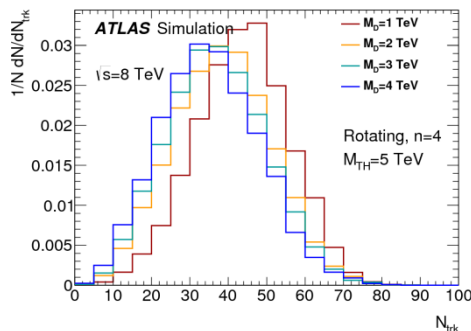
arXiv:1308.4075



$p_T(\mu) > 100 \text{ GeV}$



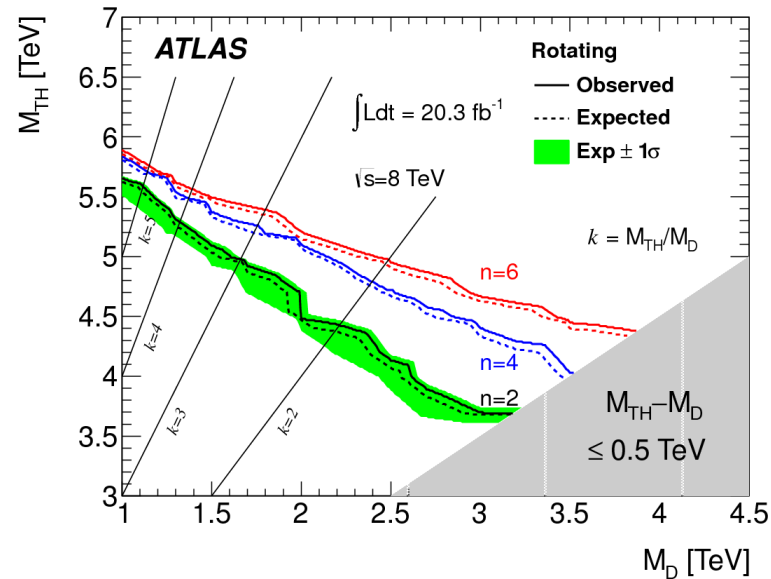
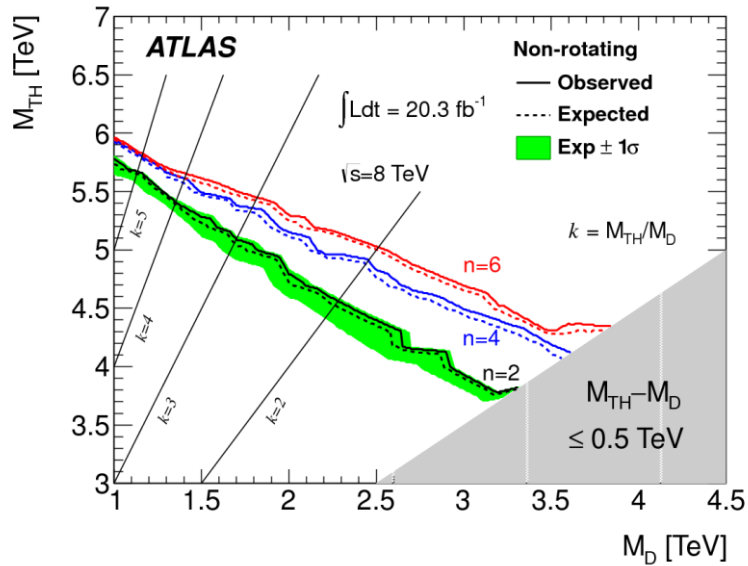
$N_{\text{trk}} > 30$ ($p_T^{\text{track}} > 10 \text{ GeV}$)



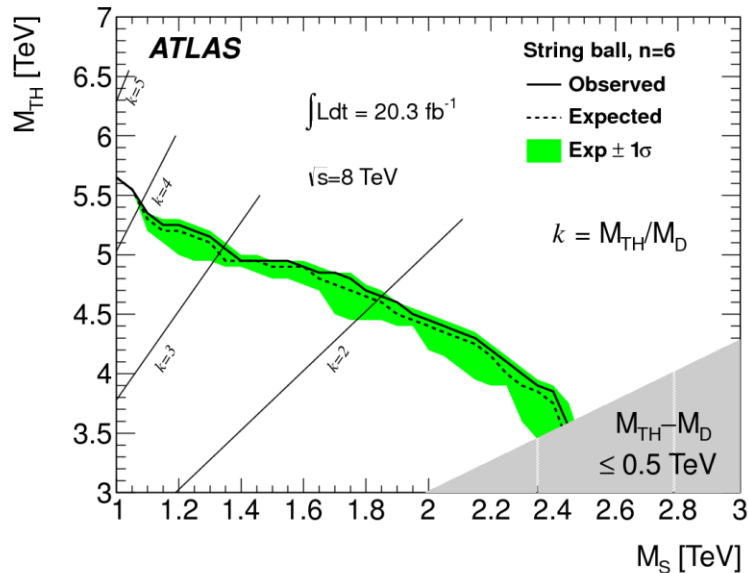
“Signal” – rotating black hole for
 $n=4, M_{\text{TH}}=5 \text{ TeV}, M_D=1.5 \text{ TeV}$

Ограничения на рождение микроскопических чёрных дыр и “струнных клубков” (BlackMax)

arXiv:1308.4075



$k = M_{TH}/M_D$, $k \gg 1$ corresponds to physical models



Weakly-coupled string model

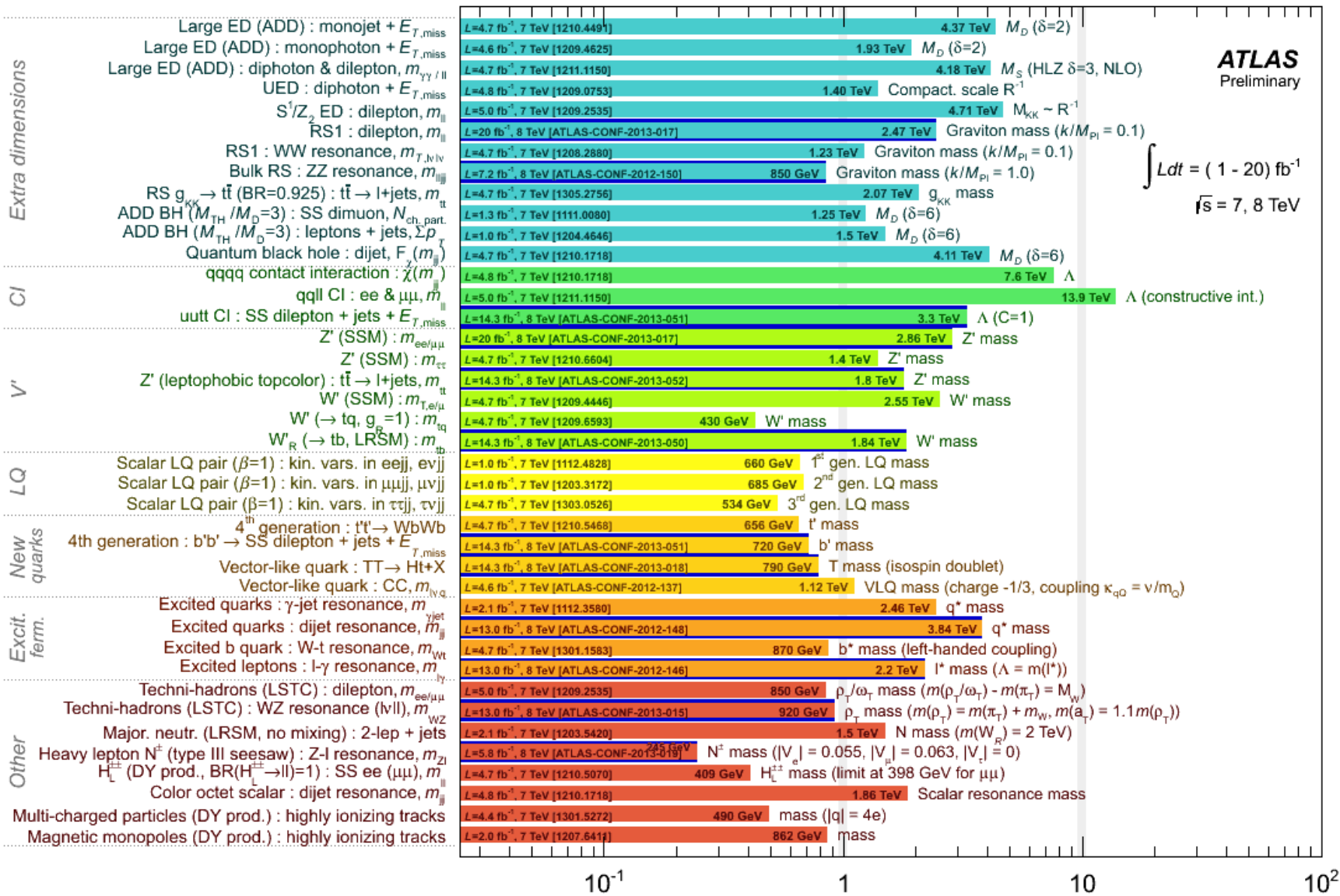
$$M_D = 5^{1/(n+1)} M_S$$

$$g_S^2 = 1/5^{(n+2)/(n+1)}$$

Model	n	$M_{TH}[\text{TeV}] \geq$
Non-rotating black hole	2	5.3
Non-rotating black hole	4	5.6
Non-rotating black hole	6	5.7
Rotating black hole	2	5.1
Rotating black hole	4	5.4
Rotating black hole	6	5.5
String ball	6	5.3

Ограничения на массы “новых” частиц (не SUSY)

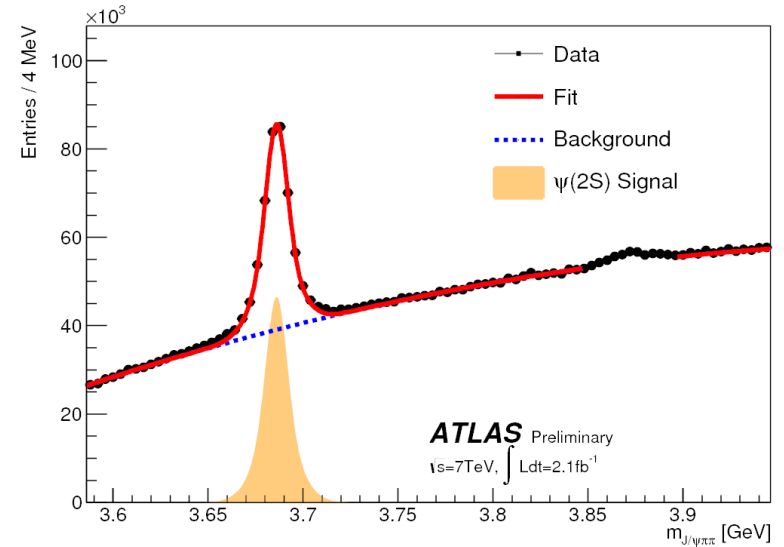
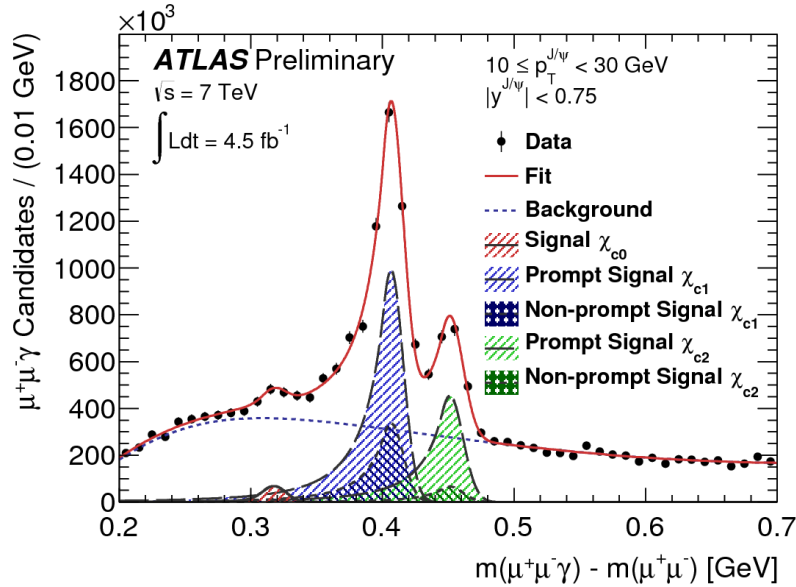
ATLAS Exotics Searches* - 95% CL Lower Limits (Status: May 2013)



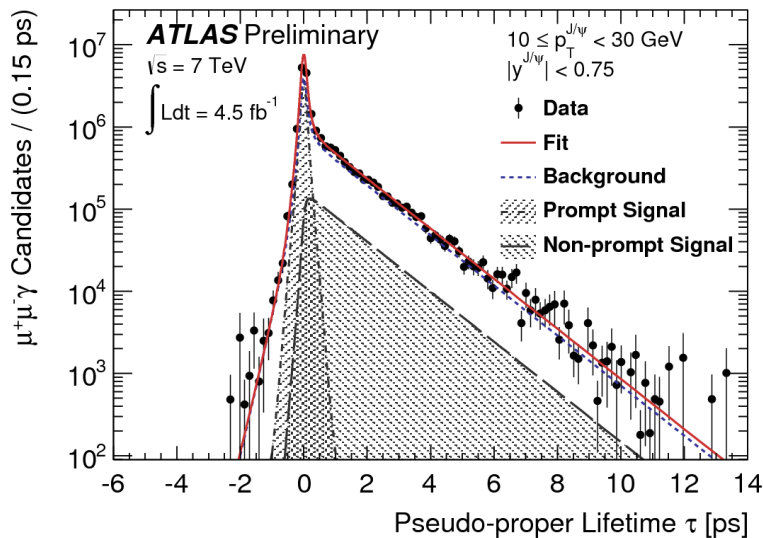
*Only a selection of the available mass limits on new states or phenomena shown

Измерение рождения кваркониев $\chi_{c1}, \chi_{c2}, \psi(2S)$

ATLAS-CONF-2013-094, ATLAS-CONF-2013-095



only photon conversions are used

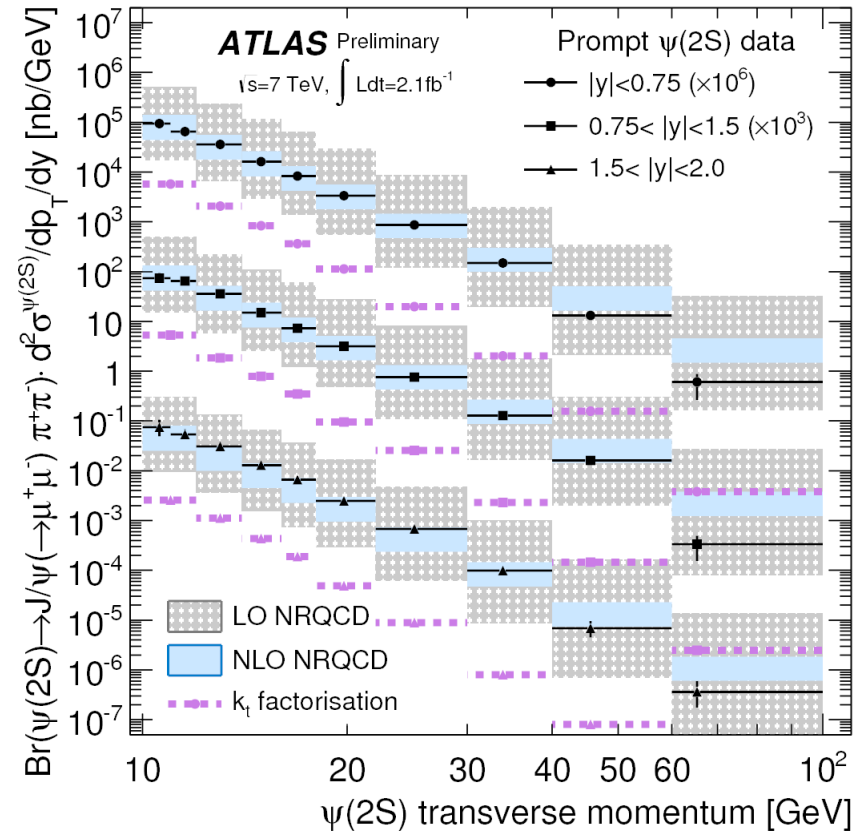
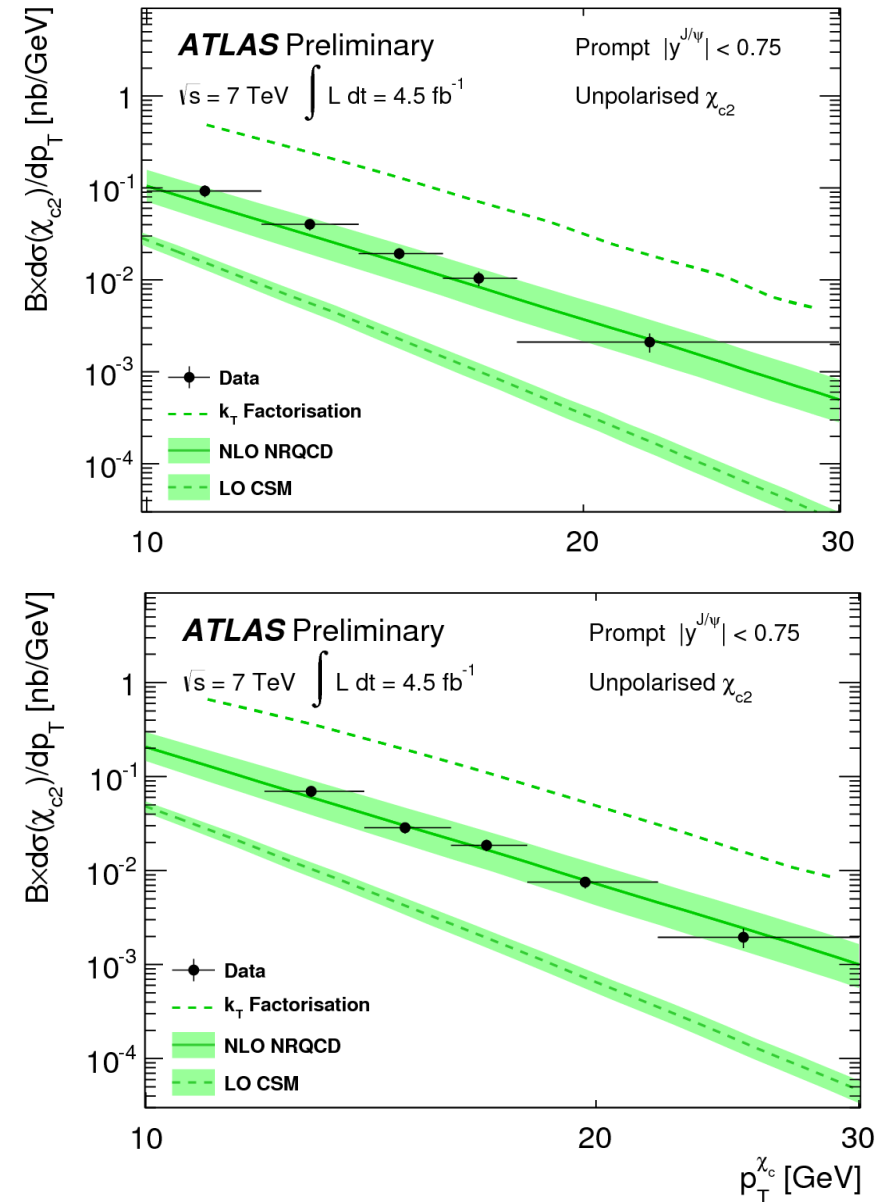


To separate prompt and non-prompt
(from B decays) production
pseudo-proper lifetime is used

$$\tau = \frac{L_{xy} \cdot m_{J/\psi}}{|\vec{p}_T^{\psi}|} \quad L_{xy} = \frac{\vec{L} \cdot \vec{p}_T^{\psi}}{|\vec{p}_T^{\psi}|}$$

Сечения прямого рождения кваркониев $\chi_{c1}, \chi_{c2}, \psi(2S)$

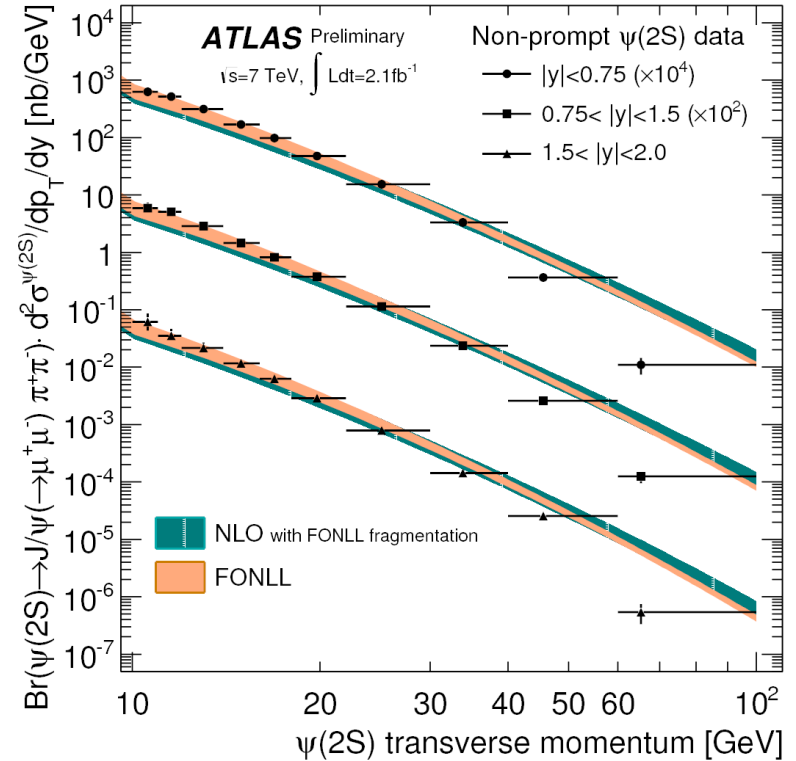
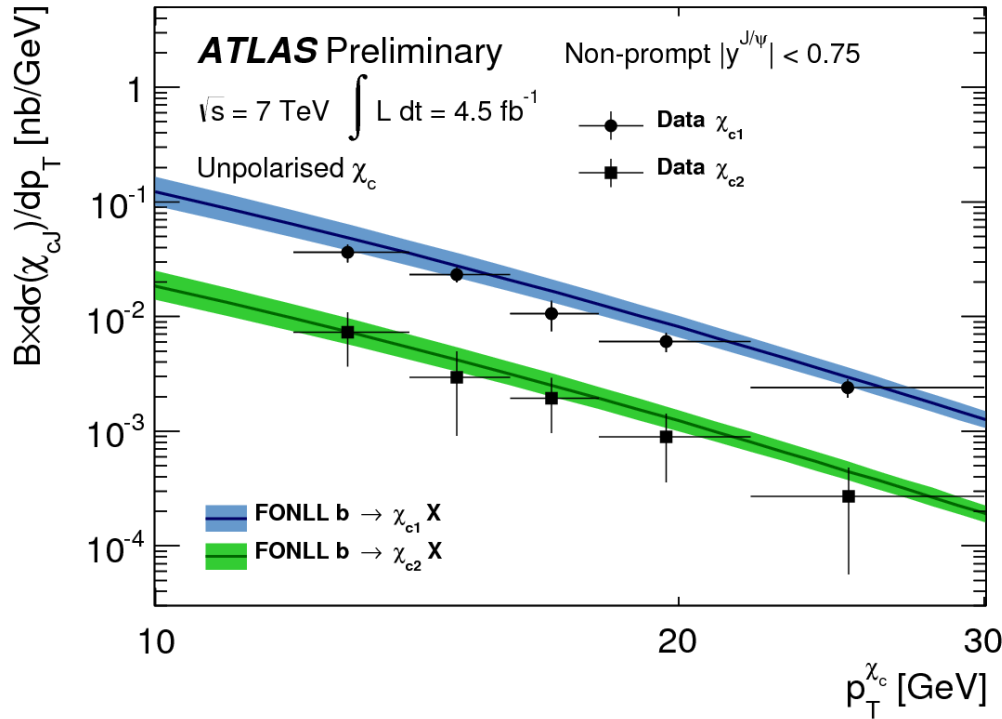
ATLAS-CONF-2013-094, ATLAS-CONF-2013-095



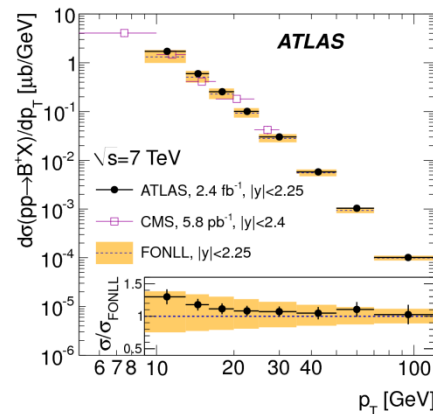
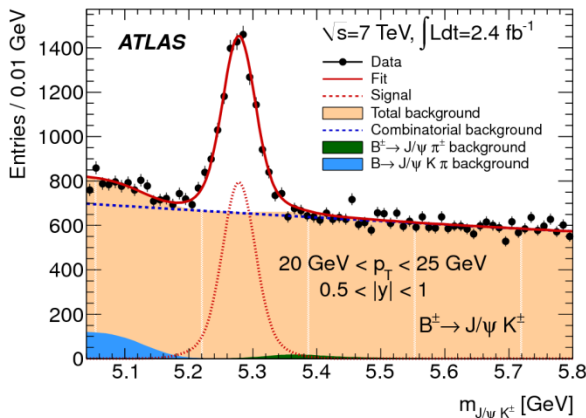
LO CSM - too low
 NLO NRQCD - o.k. (somewhat harder)
 k_T factorisation - problems?

Сечения непрямого рождения $\chi_{c1}, \chi_{c2}, \psi(2S)$

ATLAS-CONF-2013-094, ATLAS-CONF-2013-095



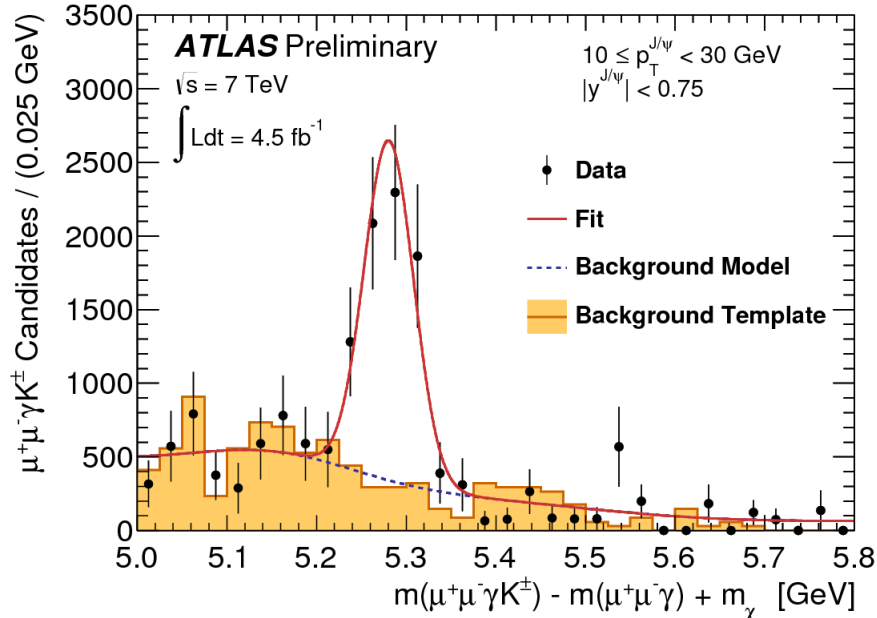
сечение рождения B^\pm arXiv:1307.0126



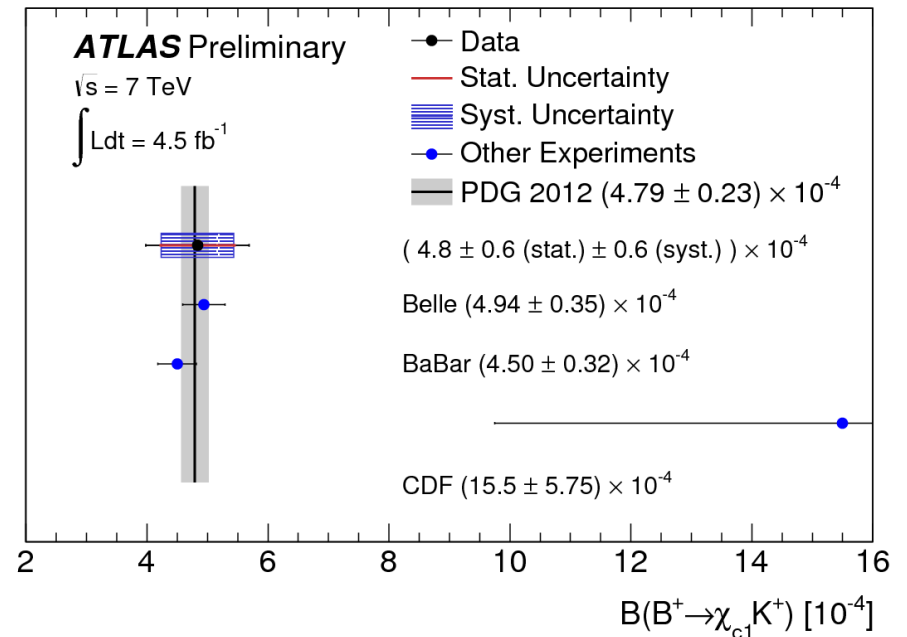
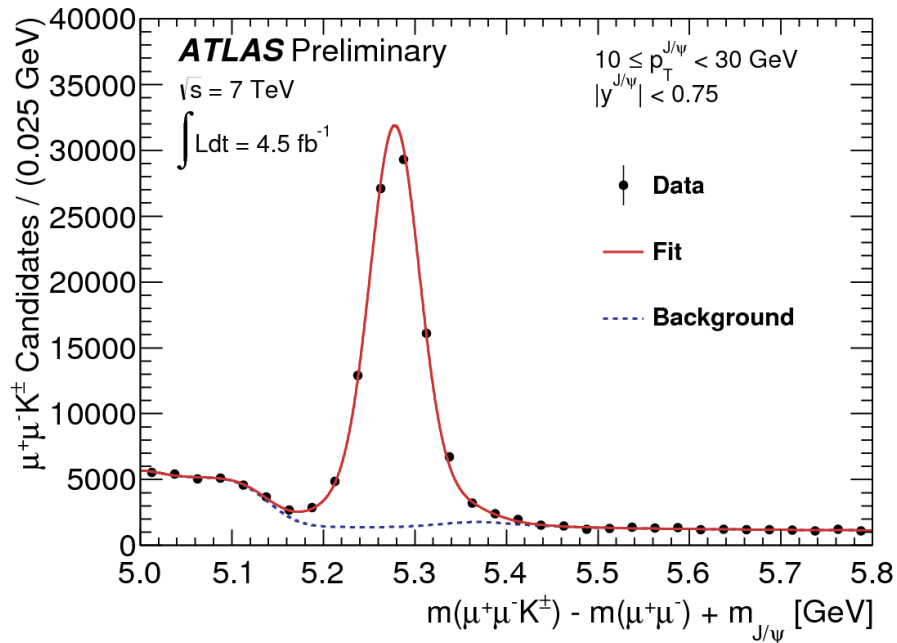
FONLL – o.k. within uncertainties (somewhat harder)

Парциальная ширина распада $B^+ \rightarrow \chi_{c1} K^+$

ATLAS-CONF-2013-095

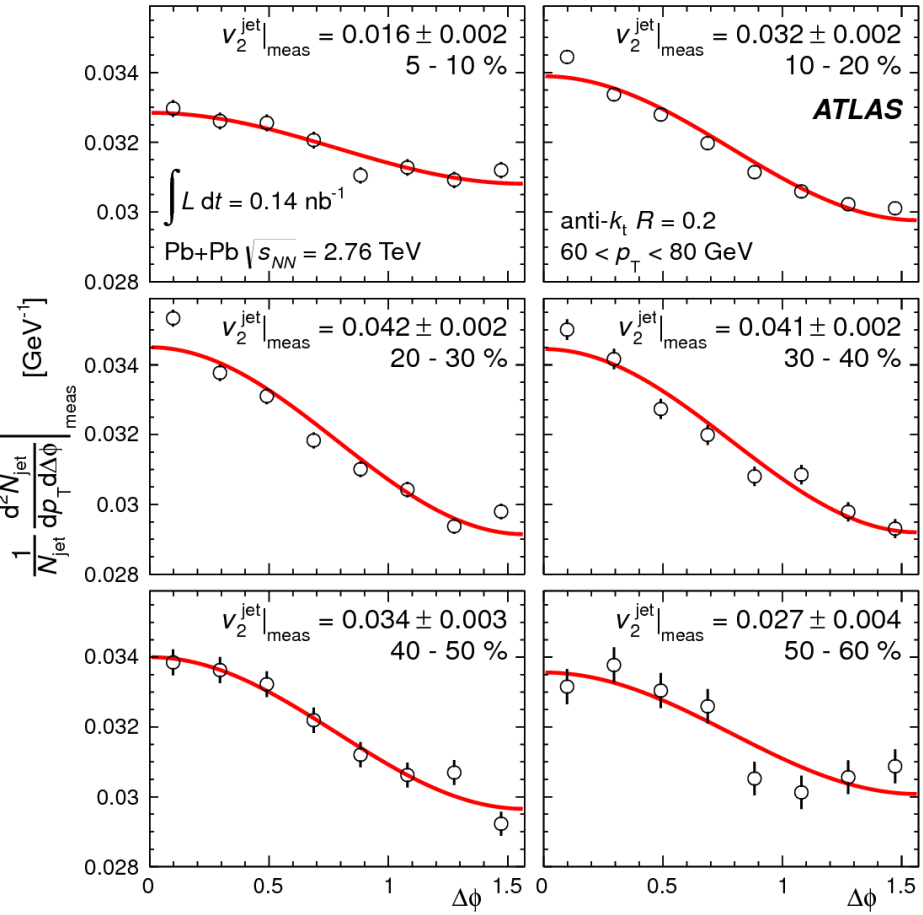
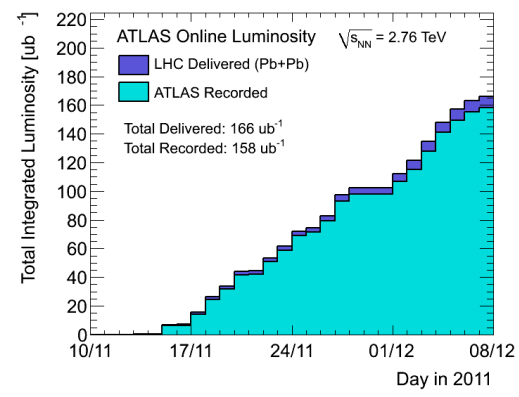


$$\mathcal{B}(B^\pm \rightarrow \chi_{c1} K^\pm) = \mathcal{A}_B \cdot \frac{N_{\chi_{c1}}^B}{N_{J/\psi}^B} \cdot \frac{\mathcal{B}(B^\pm \rightarrow J/\psi K^\pm)}{\mathcal{B}(\chi_{c1} \rightarrow J/\psi \gamma)}$$



Azimутальная зависимость инклюзивного рождения струй в Pb+Pb столкновениях

PRL 105(2010)252303, PLB 719(2013)220,
 PRL 111(2013)152301 (arXiv:1306.6469)

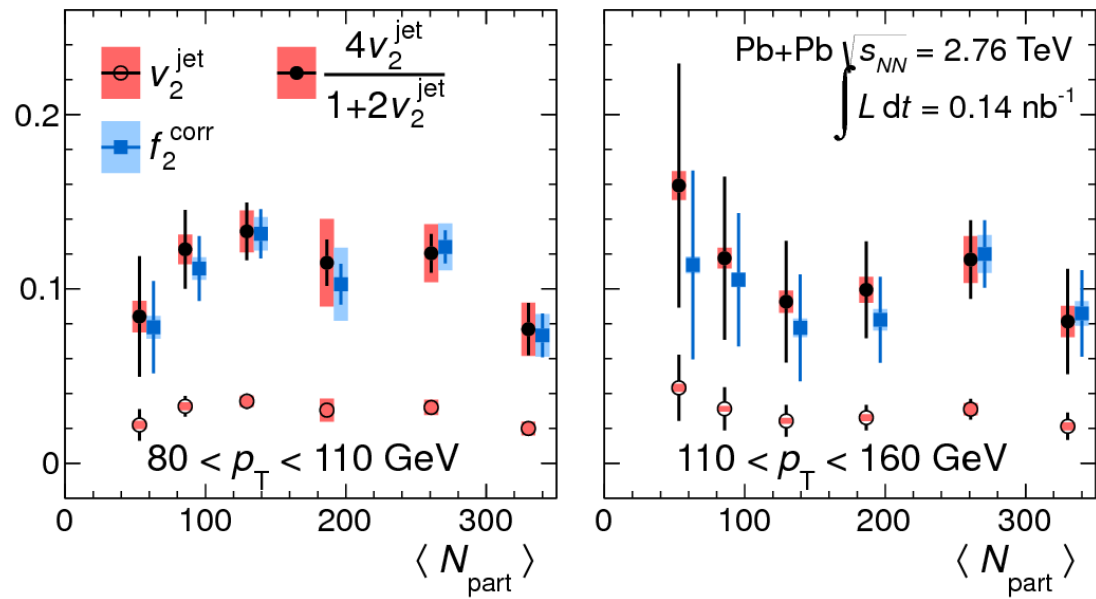
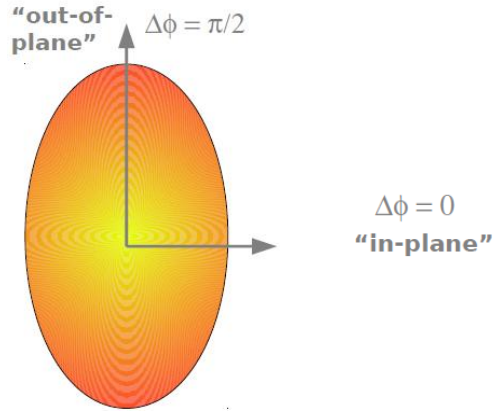
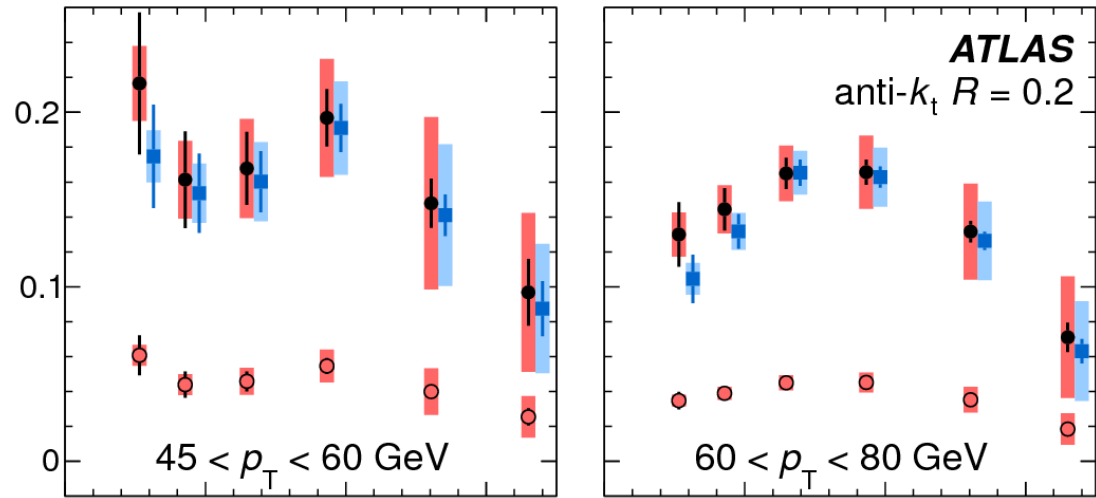


Azimuthal angle distribution
 parametrized by:
 $\frac{dN}{d\phi} \propto 1 + 2v_2 \cos 2(\phi - \Psi_2)$
 Ψ_2 is the elliptic event plane angle
 v_2 is the magnitude of the modulation

Significant $\Delta\phi$ variation in the jet yield is observed for all centrality intervals

Азимутальная зависимость инклюзивного рождения струй в Pb+Pb столкновениях

PRL 111(2013)152301
(arXiv:1306.6469)



a suppression by as much as 20%
seen for out-of-plane jets
comparing to in-plane jets

smaller suppression in the
peripheral (small quenching) and
the most central (small eccentricity)
collisions for $60 < p_T < 110$ GeV

$$f_2 = 1 - \left. \frac{d^2 N_{\text{jet}}}{dp_T d\Delta\phi} \right|_{\text{out}} / \left. \frac{d^2 N_{\text{jet}}}{dp_T d\Delta\phi} \right|_{\text{in}}$$

Заключение

Higgs boson established

$$m_H = 125.5 \pm 0.2^{+0.5}_{-0.6} \text{ GeV}$$

$$J^P = 0^+$$

production and decay properties consistent with SM expectations

Searches for new physics (H^\pm , SUSY, extra dimensions, heavy resonances, ...) performed

no new physics observed

limits are set

Many new measurements in QCD and B-physics areas, in particular

measurements of prompt and non-prompt $\chi_{c1}, \chi_{c2}, \psi(2S)$ production
measurement of $B^+ \rightarrow \chi_{c1} K^+$ decay branching

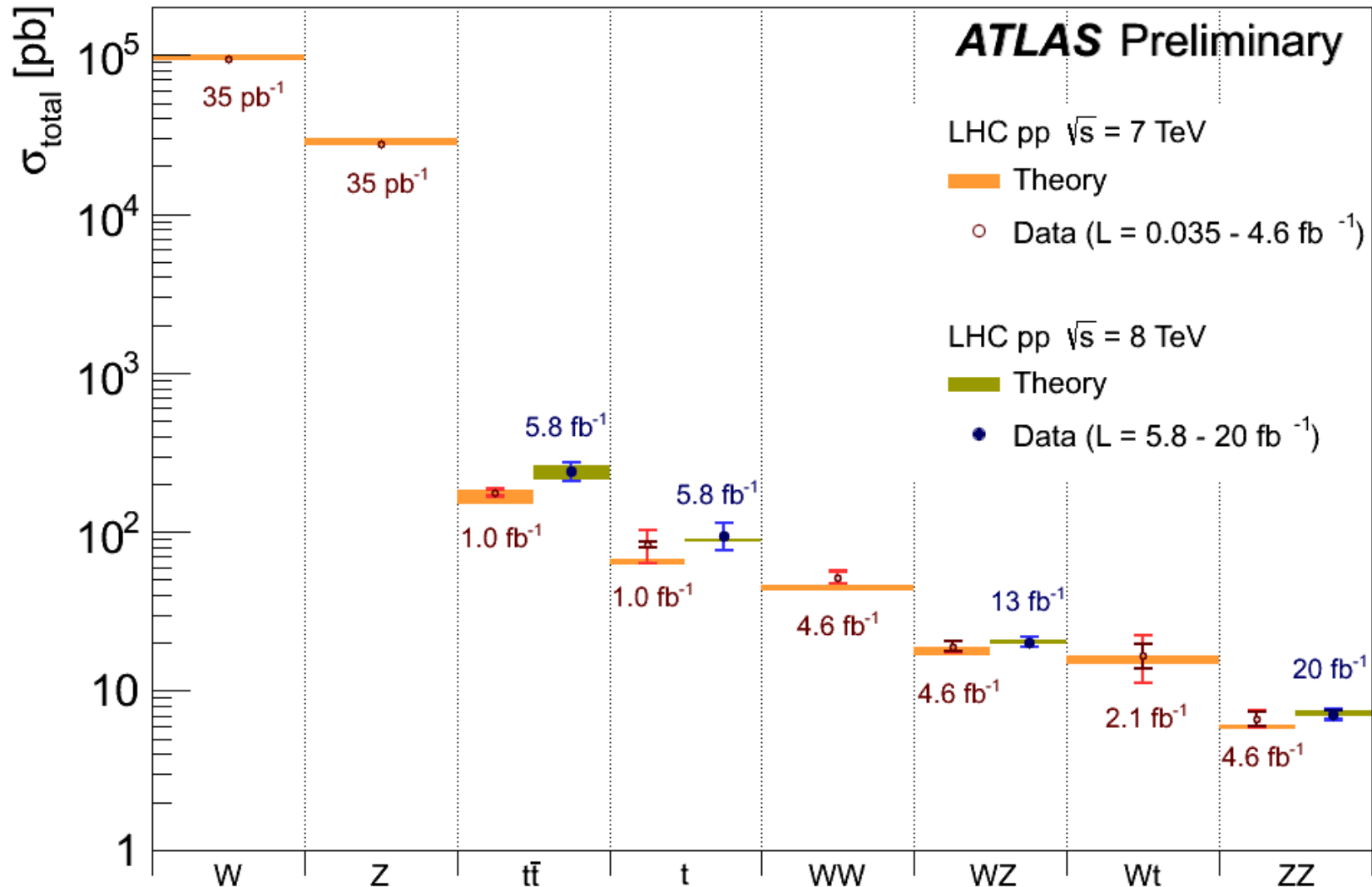
New measurement with Pb+Pb collisions, in particular

azimuthal angle dependence of inclusive jet yields

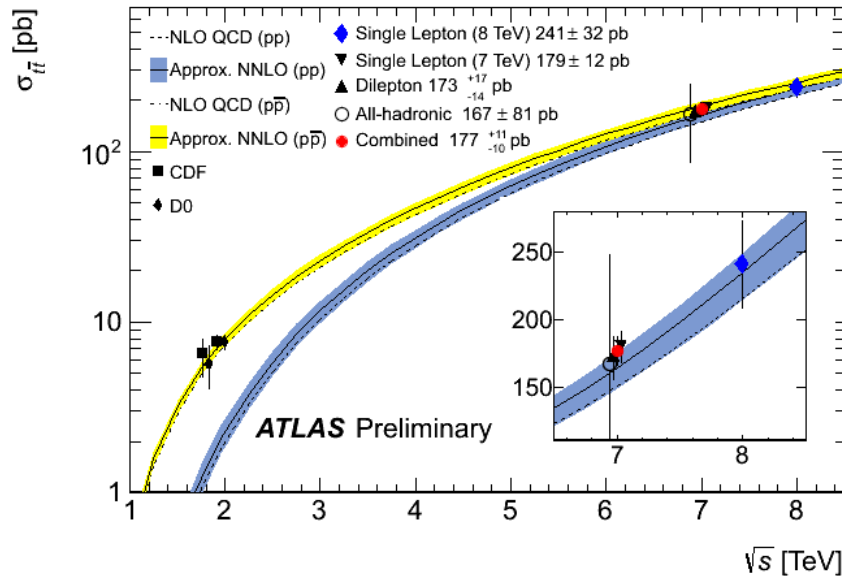
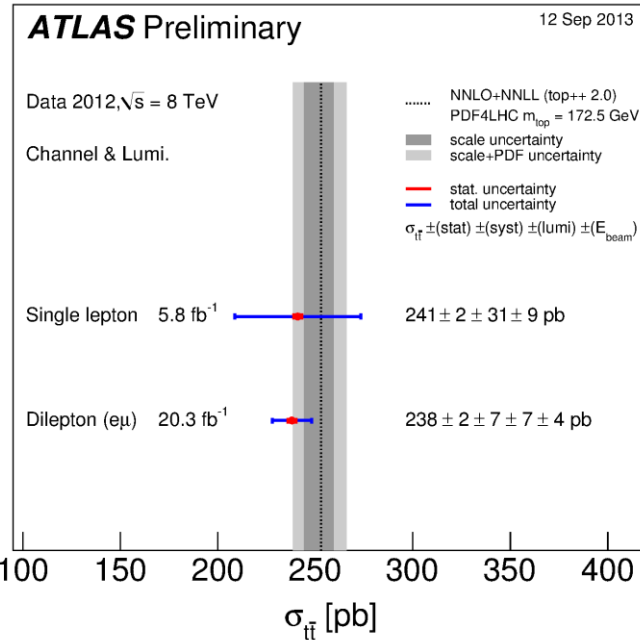
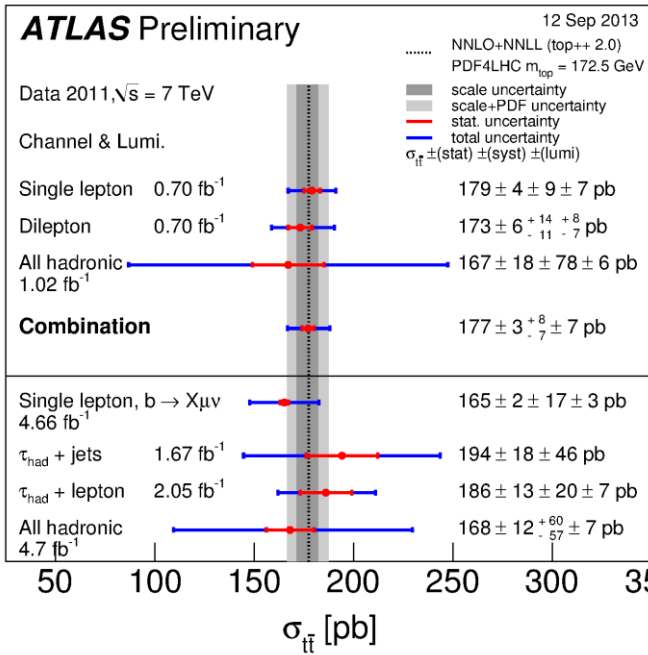
(varied up-to 20% between in-plane and out-of-plane directions)

Back-up

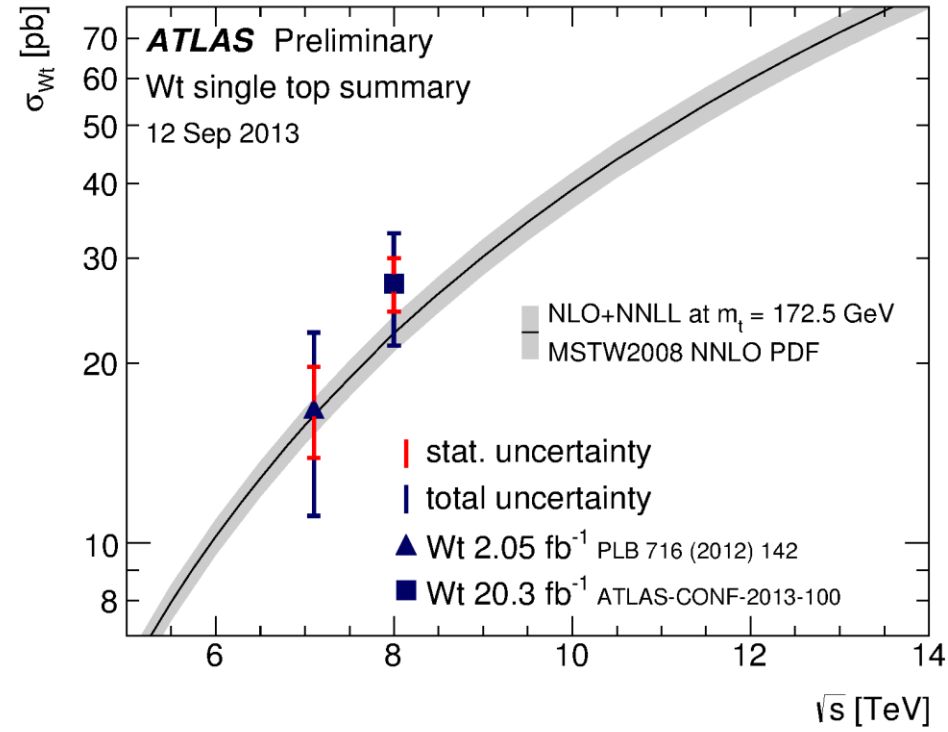
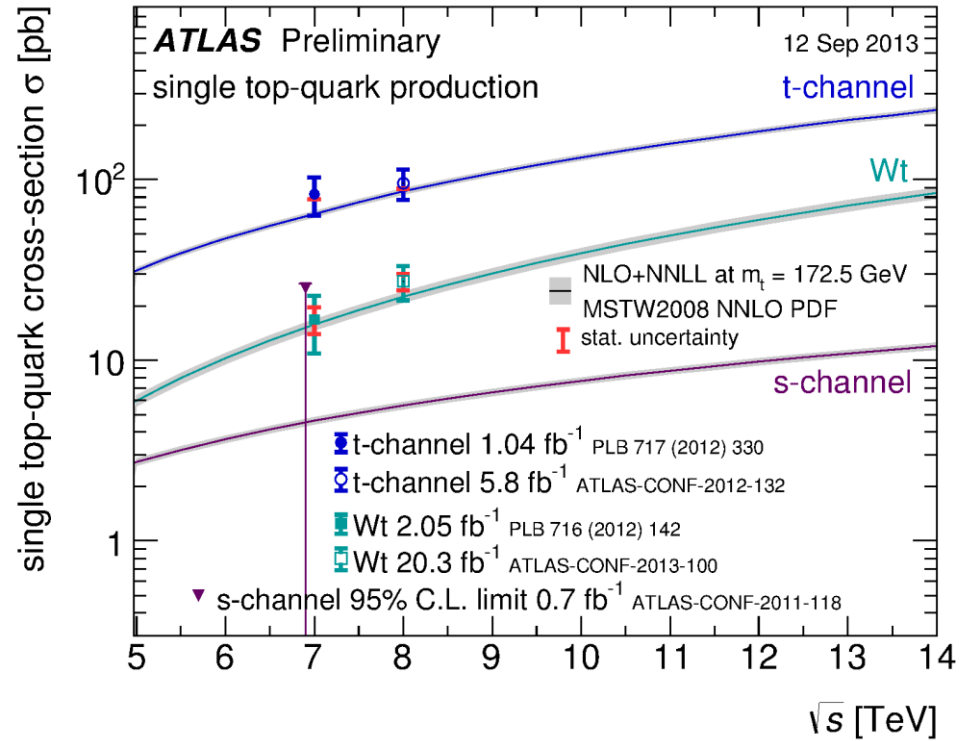
SM measurements



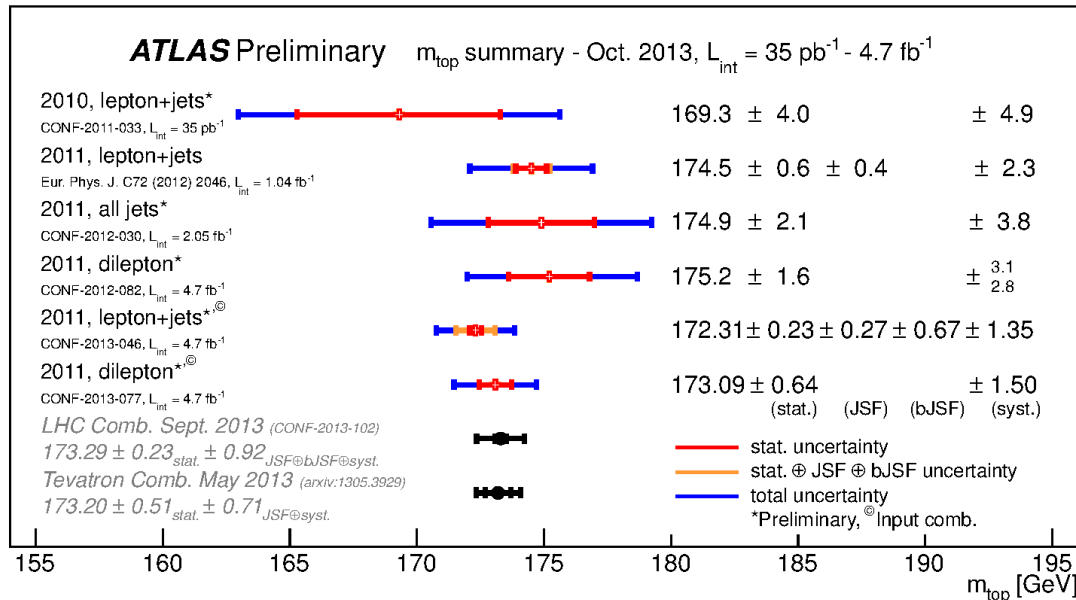
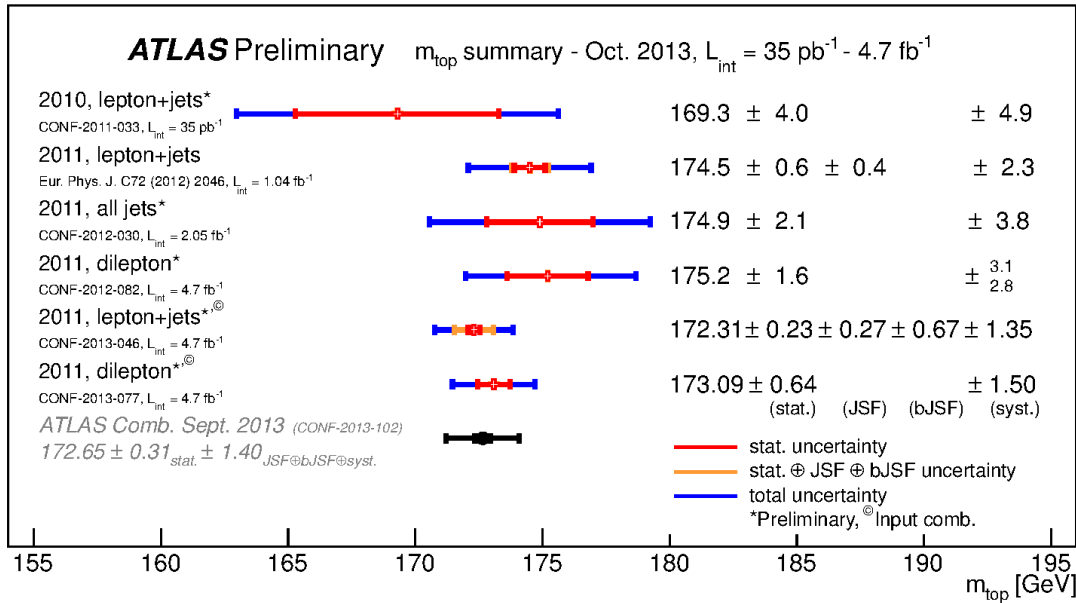
$t\bar{t}$ production



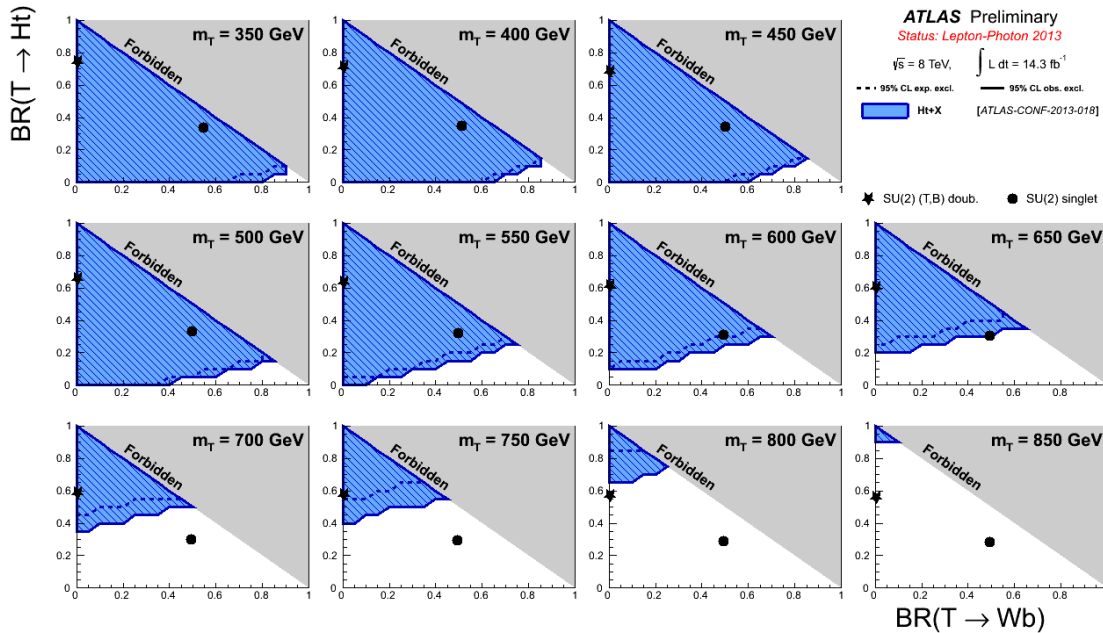
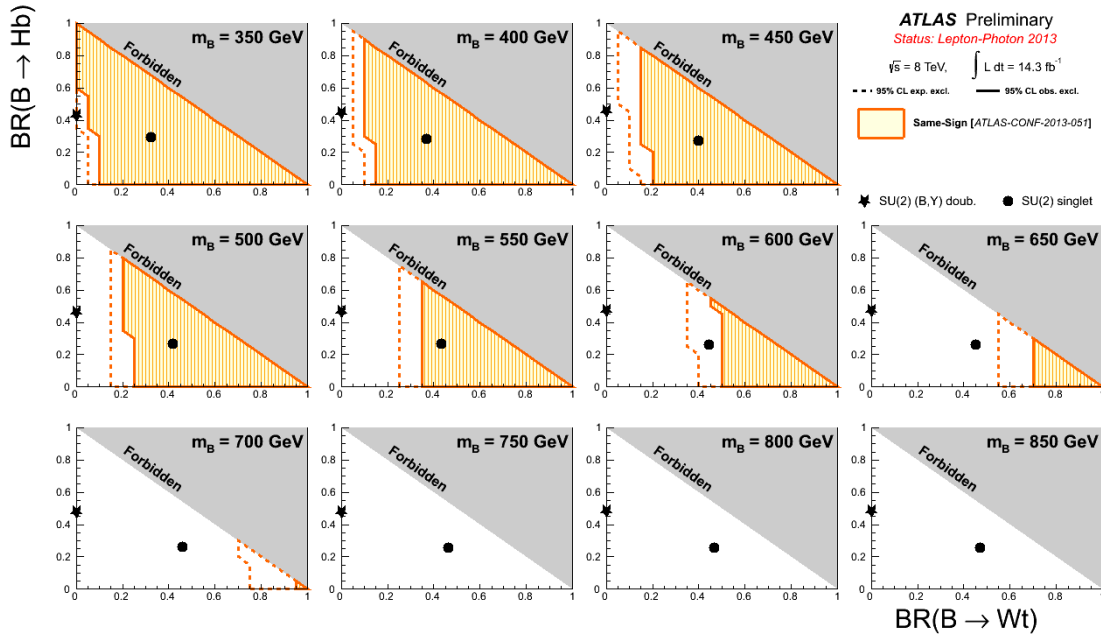
single top production



$m(t)$ measurements



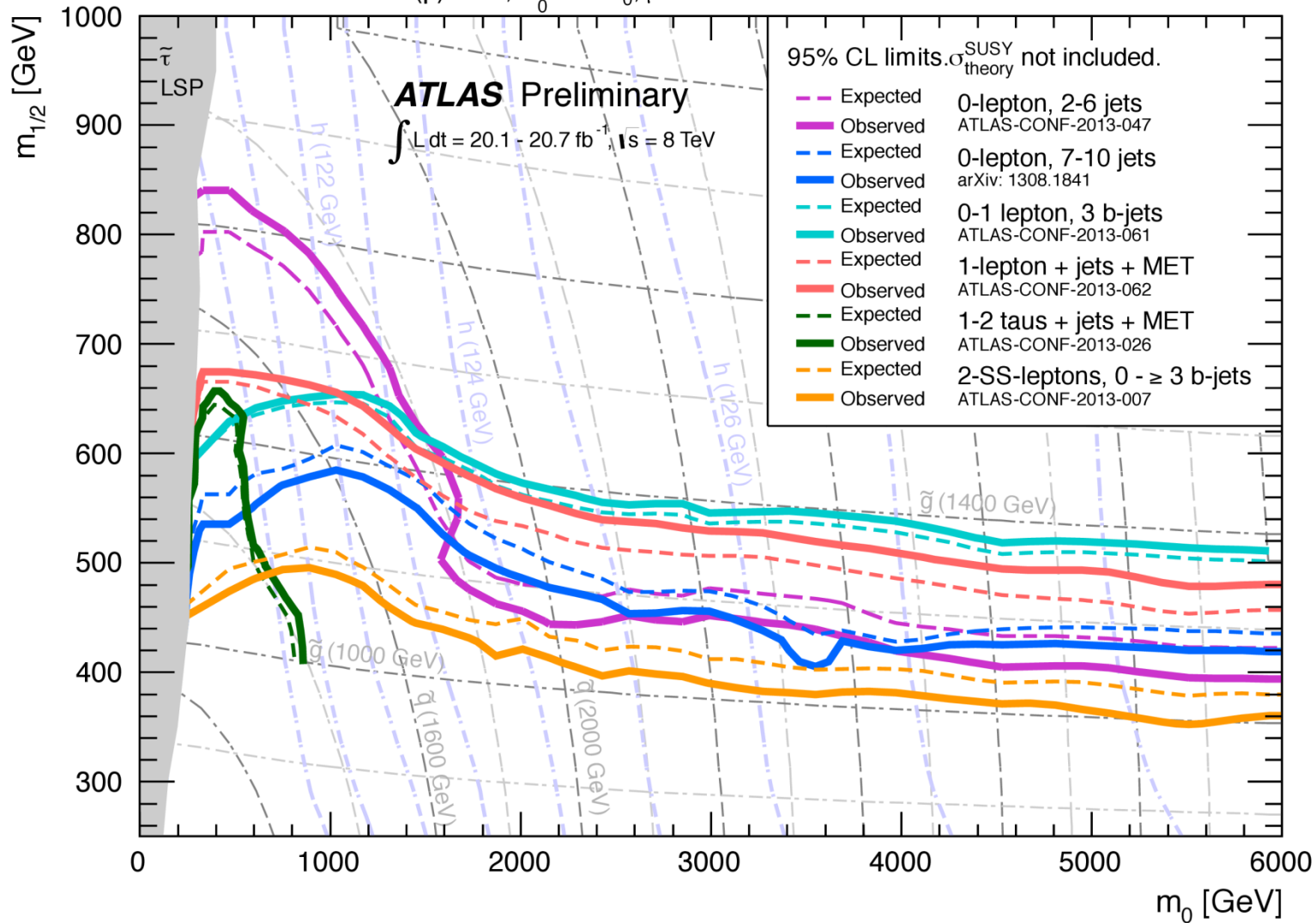
Searches for vector-like B and T quarks



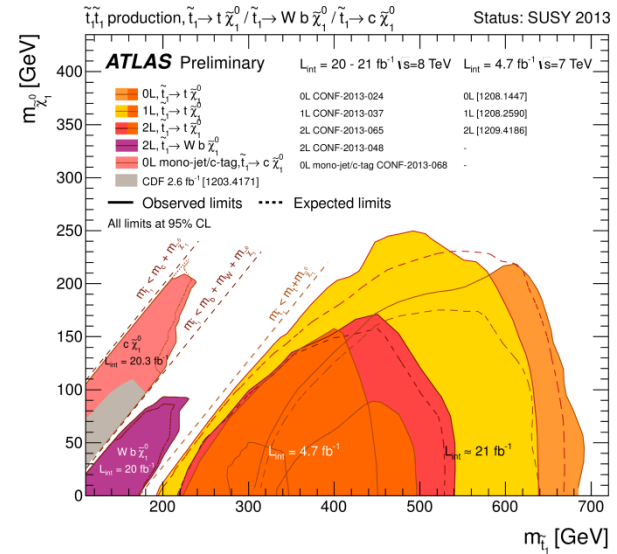
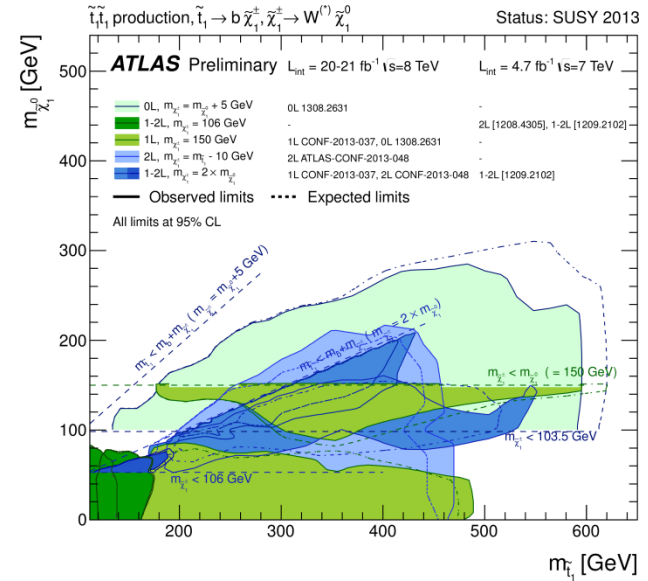
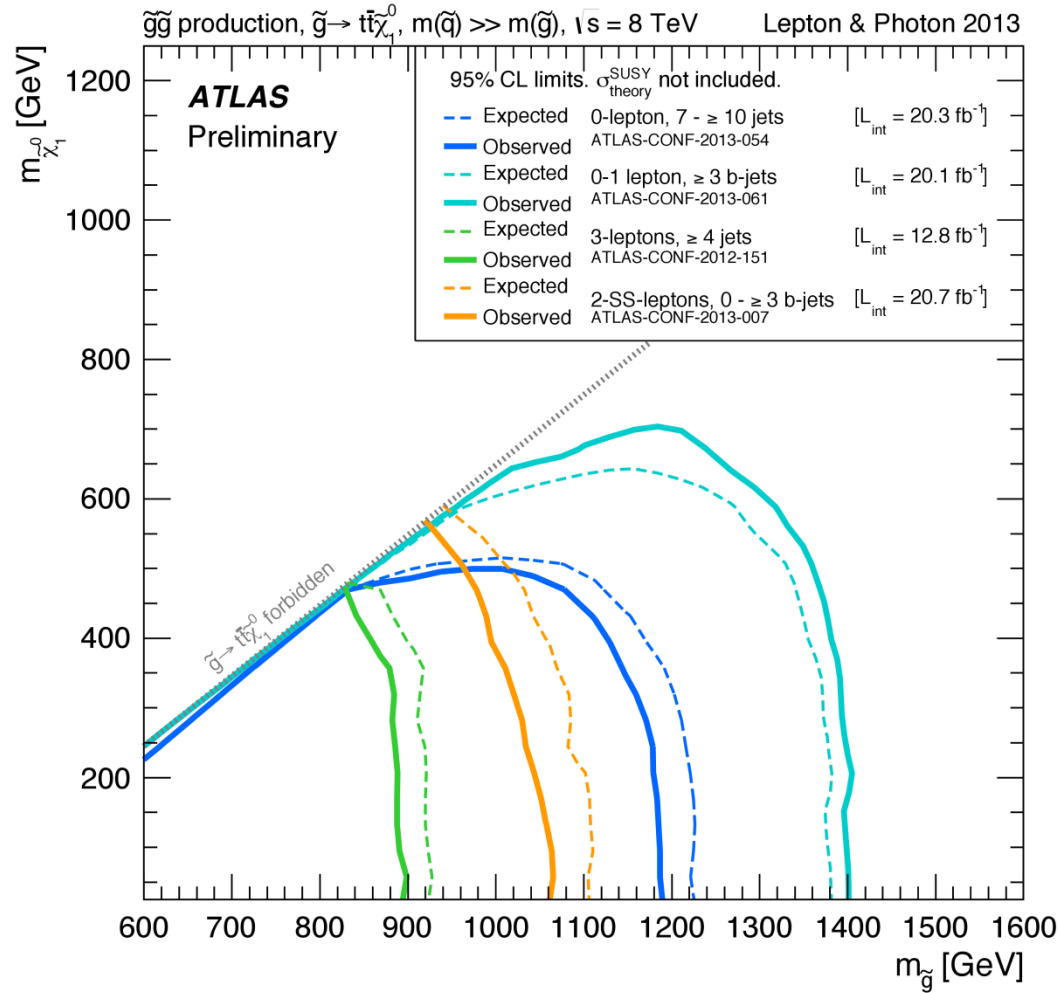
MSUGRA/CMSSM limits

MSUGRA/CMSSM: $\tan(\beta) = 30$, $A_0 = -2m_0$, $\mu > 0$

Status: SUSY 2013



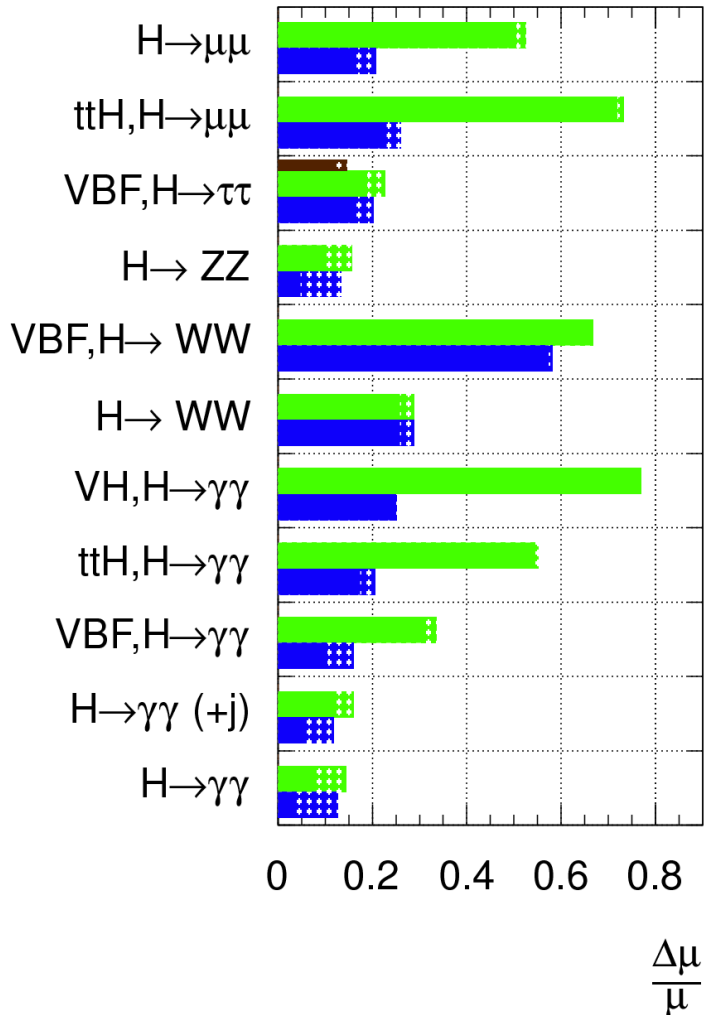
Limits for gluino and stop



Future Higgs measurements

ATLAS Simulation

$\sqrt{s} = 14$ TeV: $\int Ldt=300 \text{ fb}^{-1}$; $\int Ldt=3000 \text{ fb}^{-1}$
 $\int Ldt=300 \text{ fb}^{-1}$ extrapolated from 7+8 TeV



ATLAS Simulation

$\sqrt{s} = 14$ TeV: $\int Ldt=300 \text{ fb}^{-1}$; $\int Ldt=3000 \text{ fb}^{-1}$
 $\int Ldt=300 \text{ fb}^{-1}$ extrapolated from 7+8 TeV

