



Results of LHC-ATLAS 8TeV Run Makoto Tomoto

Tau-Lepton Physics Research Center Graduate School of Science Nagoya University

> Nagaya University Tau Lepton Physics Research Center

Contents

LHC experiments 2010 : started physics run 2011 : physics data (√s=7) 2012 : physics data (√s=8) 2012, July : Higgs discovery 2013 : upgrade





ATLAS published >270 papers Today, show a part of them. Mathy, Higgs-Physics!



Toroid Magnets Solenoid Magnet SCT Tracker Pixel Detector TRT Tracker

LHC Run I performed very well

2011 : $\sqrt{s}=7$ TeV, $\int Ldt = 5$ fb⁻¹, $\langle \mu \rangle = 9$ 2012 : $\sqrt{s}=8$ TeV, $\int Ldt = 21$ fb⁻¹, $\langle \mu \rangle = 21$



ATLAS detector

The ATLAS detector was designed with discovery of the Higgs boson new physics



- Precise measurement of the charged tracks by inner detectors
- Identification of electrons and photons against QCD jets
- Excellent calorimeter hermeticity and energy resolution
- Precise muon reconstruction and triggering by muon detectors

in mind





Higgs discovery

July 2012, We observed a Higgs-like resonance at $m_H=125.5$ GeV



Since then, we focus our interests on whether : this resonance is really the Higgs predicted by SM? there are any signs of physics beyond the SM ? They are addressed by Precise measurements on <u>Higgs property</u> signal strength, couplings and spin-parity Direct searches for the physics beyond the SM

Nagoya contributions

1.L1 muon trigger system Installation/commissioning/operation



2. Physic analysis

Top quark physics Higgs, new physics searches

ATLAS Prelimin	20 Dec 2012 Theory (approx. NNLO) for m, = 172.5 GeV			
Data 2011, √s = 7 TeV		<pre>stat. uncertainty total uncertainty </pre>		
Single lepton 0.70 fb ⁻¹		$3_{t\bar{t}} \pm (stat) \pm (syst) \pm (turn)$ $179 \pm 4 \pm 9 \pm 7 \text{ pb}$		
Dilepton 0.70 fb ⁻¹		$173 \pm 6 \begin{array}{c} + 14 \\ - 11 \\ - 7 \end{array} pb$		
All hadronic 1.02 fb ⁻¹		167 ± 18 ± 78 ± 6 pb		
Combination		177 ± 3 $^{+8}_{-7}$ ± 7 pb		
Single lepton, $b \rightarrow X\mu\nu$ 4.66 fb ⁻¹		$165 \pm 2 \pm 17 \pm 3 \text{ pb}$		
τ _{hod} + jets 1.67 fb ⁻¹		194 ± 18 ± 46 pb		
τ_{had} + lepton 2.05 fb ⁻¹		$186\pm13\pm20\pm~7~\text{pb}$		
All hadronic		→ 168 ± 12 ^{+ 60} _{- 57} ± 6 pb		
50 100 1	50 200	250 300 35		
σ _{tī} [pb]				

Trying to extend the research area to the Higgs and new physics through top quark productions and decays.

Higgs Physics

Higgs productions and decays



Decays Mass of m_H~125.5GeV gives us maximally rich decay modes !!





Events

10⁻¹³



 6σ

170 180

m_H [GeV]

m_µ [GeV]

10⁻⁹

10-11

10⁻¹³

m_H [GeV]

Signal strength

arXiv:1307.1427

 $\mu = \frac{\sigma \times BR}{(\sigma \times BR)}_{SM}$ $\mu=1 \text{ (if SM Higgs), } \mu=0 \text{ (if no SM Higgs)}$ combined (H $\rightarrow \gamma \gamma$, ZZ, WW) $\mu = 1.33 \pm 0.14(\text{stat}) \pm 0.15(\text{sys})_{(\text{MH}=125.5\text{GeV})}$

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



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

Evidence for production via VBF

13

arXiv:1307.1427

Signal strength is categorized by vector-boson-mediated processes gluon-mediated processes and \bar{q}' W/Z4000 ggF ttH VBF VH Η 2000 g $\times {\rm B/B_{SM}}$ 2 In A ATLAS ATLAS 14 vs = 7 TeV Ldt = 4.6-4.8 fb⁻¹ vs = 7 TeV Ldt = 4.6-4.8 fb⁻¹ vs = 8 TeV Ldt = 20.7 fb⁻¹ vs = 8 TeV Ldt = 20.7 fb⁻¹ 12 mн=125.5GeV mн=125.5GeV 3.3σ 10 Standard Model — Combined H→γγ, ZZ*, WW* Best fit $\mu VBF+VH$ ---- SM expected 68% CL 95% CL 2.5 3.5 -0.5 2 0.5 3.5 0 1.5 2 2.5 3 $\mu_{ggF+ttH} \times B/B_{SM}$ $\mu_{VBF}/\mu_{ggF+ttH}$ $\mu_{VBF}/\mu_{ggF+ttH} = 1.4^{+0.4}_{-0.3}(\text{stat})^{+0.6}_{-0.4}(\text{sys})$

 $3.3\,\sigma$ evidence that a fraction of Higgs boson production occurs through VBF

Coupling measurements

In the standard model, coupling to fermion $g_F^{\rm SM} = \sqrt{2} \frac{m_F}{v}$ coupling to gauge boson $g_V^{\rm SM} = 2 \frac{m_V^2}{v}$ SM couplings are tested introducing coupling scale factors $\kappa: g_i = g_i^{\mathrm{SM}} imes \kappa_i$ The total Higgs boson width is also tested introducing $K H^2$: $\Gamma_H = \Gamma_H^{SM} \times \kappa_H^2$ $\sigma \cdot B(i \to H \to f) = \frac{\sigma_i \cdot \Gamma_f}{\Gamma_H} \to \text{signal strength can be written by } \kappa \text{ s}$ For example, $gg \rightarrow H \rightarrow \gamma \gamma$ process can be written as $\frac{\sigma \cdot \mathbf{B}(\mathbf{gg} \to \mathbf{H} \to \gamma \gamma)}{\sigma_{\rm SM}(gg \to H) \cdot \mathbf{B}_{\rm SM}(\mathbf{H} \to \gamma \gamma)} = \frac{\kappa_g^2 \cdot \kappa_\gamma^2}{\kappa_H^2}$ $\kappa_{\rm H}$ and effective scale factors κ_{r} , $\kappa_{\rm g}$ (loop induced processes) Expressed as a function of the SM coupling scale factors $\kappa_{\gamma}(\kappa_W,\kappa_t)$ $\kappa_g(\kappa_b,\kappa_t)$ $\kappa_H(\kappa_b,\kappa_W,\kappa_Z,...)$ Treated as free parameters to test BSM contributions

Couplings to fermions and bosons arXiv:1307.1427

In this analysis, we assume

- One coupling scale factor for fermions $\kappa_F = \kappa_t = \kappa_b = \kappa_\tau =$
- One coupling scale factor for bosons $\kappa_V = \kappa_W = \kappa_Z$
- κ_g , κ_γ , and κ_H depends only on κ_F and $\kappa_V \rightarrow No$ contributions from BSM



 $\kappa_F \in [0.76, 1.18]$ $\kappa_V \in [1.05, 1.22]$ at 68% C.L.

compatibility of the SM is 12%

$$\kappa_{\gamma}^2 \simeq |1.26\kappa_V - 0.26\kappa_F|^2$$



 $H \rightarrow \gamma \gamma$ prefers the minimum with positive relative sign

• Thanks to the negative interference between W-boson loop and t-quark loop $\kappa_{F}=0$ is excluded at >5 $\sigma \rightarrow$ Indirect evidence of the Higgs-fermion coupling!!

Summary of the Higgs couplings



Their compatibilities are 12%~20%

H \rightarrow bb direct measurement ATLAS-CONF-2013-079 W/Z+H (H \rightarrow bb) : 2, 1, 0(large ET^{miss})-lepton + 2 b-jets





We need more data to obtain evidence of $H \rightarrow bb$

$H \rightarrow \tau \tau \tau$ direct measurement

ATLAS-CONF-2013-108

Both hadronic and leptonic τ decays(τ had, τ lep) are used

Events are categorized by "VBF" and "Boosted"

 $\tau \tau$ +di-jets with large η $\tau \tau$ with large $p_{\tau}^{\tau \tau}$

Signals are extracted from the fit of the BDT score dist.

BDT (boosted decision tree) : multivariate analysis based on E_T^{miss} , $m_{\tau \tau}$,



$H \rightarrow \tau \tau$ direct measurement



Spin-parity measurements_{arXiv:1307.1432} Spin-Parity J^P=0⁻,1⁺,1⁻, 2⁺ are tested against SM (J^P=0⁺)

20

Existence of $H \rightarrow \gamma \gamma$ rules out J=1 (Landau-Yang theorem)

Kinematics and angular distributions of the decay products sensitive to spinparity measurement



New physics searches

New physics has not been observed yet

We start excluding the large area of the parameter space of the new physics (ex. SUSY)

SUSY exclusion

22

ATLAS Preliminary

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

 $\int \mathcal{L} dt = (4.6 - 22.9) \text{ fb}^{-1}$

ATLAS SUSY Searches* - 95% CL Lower Limits

Status: SUSY 2013

E^{miss} e, μ, τ, γ Jets $\int \mathcal{L} dt [fb^{-1}]$ Model Mass limit Reference MSUGRA/CMSSM 0 2-6 jets Yes 20.3 $m(\tilde{q})=m(\tilde{g})$ ATLAS-CONF-2013-047 1.7 TeV MSUGRA/CMSSM 3-6 jets 1 e.µ Yes 20.3 1.2 TeV any m(q) ATLAS-CONF-2013-062 MSUGRA/CMSSM 7-10 jets 0 Yes 20.3 1.1 TeV any m(q) 1308.1841 Inclusive Searches 0 2-6 jets Yes 20.3 740 GeV m(x1)=0 GeV ATLAS-CONF-2013-047 $\bar{q}\bar{q}, \bar{q} \rightarrow q\bar{l}_1$ 0 2-6 jets Yes 20.3 1.3 TeV m(k1)=0 GeV ATLAS-CONF-2013-047 $\tilde{g}\tilde{g}, \tilde{g} \rightarrow q\bar{q}\tilde{\chi}_1$ 1 e.µ 3-6 jets Yes 20.3 ATLAS-CONF-2013-062 $\tilde{g}\tilde{g}, \tilde{g} \rightarrow qq\tilde{\chi}_1^{\pm} \rightarrow qqW^{\pm}\tilde{\chi}_1$ 1.18 TeV $m(\tilde{\chi}_{1}^{0}) < 200 \text{ GeV}, m(\tilde{\chi}^{''}) = 0.5(m(\tilde{\chi}_{1}^{0}) + m(\tilde{g}))$ $\tilde{g}\tilde{g}, \tilde{g} \rightarrow gq(\ell\ell/\ell\nu/\nu\nu)\tilde{\ell}_1$ 2 e.µ 0-3 jets 20.3 1.12 TeV $m(\tilde{k}_1^0)=0 \text{ GeV}$ ATLAS-CONF-2013-089 GMSB ((NLSP) 2 e.µ 2-4 jets tan//<15 Yes 4.7 1.24 TeV 1208.4688 GMSB (2 NLSP) 1-2 7 0-2 jets Yes 20.7 1.4 TeV $\tan\beta > 18$ ATLAS-CONF-2013-026 2γ GGM (bino NLSP) Yes 4.8 1.07 TeV m(x1)>50 GeV 1209.0753 GGM (wino NLSP) . Yes 4.8 619 GeV m(k1)>50 GeV ATLAS-CONF-2012-144 $1 e_{\mu} + \gamma$ GGM (higgsino-bino NLSP) Yes 4.8 m(x1)>220 GeV 1 b900 GeV 1211.1167 GGM (higgsino NLSP) 2 e, µ (Z) 0-3 jets Yes 5.8 m(H)>200 GeV ATLAS-CONF-2012-152 690 GeV m(g)>10-4 eV Gravitino LSP mono-jet ATLAS-CONF-2012-147 0 Yes 10.5 645 GeV $\tilde{g} \rightarrow b \bar{b} \tilde{l}$ 0 3 b 20.1 1.2 TeV m(x3)<600 GeV ATLAS-CONF-2013-061 Yes gen $\tilde{g} \rightarrow t \bar{t} \tilde{\chi}$ 0 7-10 jets Yes 20.3 1.1 TeV m(x) <350 GeV 1308.1841 0-1 e, µ 3 b Yes 20.1 1.34 TeV m(R) <400 GeV ATLAS-CONF-2013-061 $\tilde{g} \rightarrow t \tilde{t} \tilde{\chi}$ 20 100 m(t))<300 GeV 0-1 e.µ 20.1 1.3 TeV 3 b Yes ATLAS-CONF-2013-061 ğ→bīΫ 20.1 100-620 GeV m(R1)<90 GeV $b_1 \bar{b}_1, \bar{b}_1 \rightarrow b \bar{\ell}_1$ 0 2bYes б1 1308.2631 2 e. µ (SS) 275-430 GeV 20.7 ATLAS-CONF-2013-007 0-3 b Yes $m(\tilde{t}_{1}^{+})=2 m(\tilde{t}_{1}^{0})$ $b_1b_1, b_1 \rightarrow t\hat{x}_1$ Б, squarks 1-2 e, µ 110-167 GeV 1208.4305. 1209.2102 $t_1 t_1$ (light), $t_1 \rightarrow b t_1$ 1.2 bYes 4.7 ĩ, m(x1)=55 GeV 2 e, µ 0-2 jets Yes 20.3 130-220 GeV $m(\tilde{t}_1^0) = m(\tilde{t}_1) - m(W) - 50 \text{ GeV}, m(\tilde{t}_1) < < m(\tilde{t}_1^*)$ ATLAS-CONF-2013-048 $\tilde{t}_1 \tilde{t}_1 (\text{light}), \tilde{t}_1 \rightarrow Wb\tilde{t}_1$ ī, 2 e.µ 2 jets 225-525 GeV ATLAS-CONF-2013-065 $\tilde{t}_1 \tilde{t}_1 (medium), \tilde{t}_1 \rightarrow t \tilde{k}_1$ Yes 20.3 ÷, m(x1)=0 GeV 0 2 b 150-580 GeV m(\$\tilde{k}_1^0)<200 GeV, m(\$\tilde{k}_1^0)=5 GeV $\tilde{t}_1 \tilde{t}_1 (\text{medium}), \tilde{t}_1 \rightarrow b \tilde{t}_1$ Yes 20.1 1308.2631 gen. 1 e,µ 200-610 GeV ATLAS-CONF-2013-037 $\tilde{t}_1 \tilde{t}_1$ (heavy), $\tilde{t}_1 \rightarrow t \tilde{\chi}_1$ 1 b Yes 20.7 m(x1)=0 GeV Ť, 320-660 GeV m(x1)=0 GeV ATLAS-CONF-2013-024 $\tilde{t}_1 \tilde{t}_1$ (heavy), $\tilde{t}_1 \rightarrow t \tilde{t}_1$ 0 2 b Yes 20.5 3 gil 90-200 GeV m(t1)-m(t10)<85 GeV ATLAS-CONF-2013-068 $\tilde{t}_1 \tilde{t}_1, \tilde{t}_1 \rightarrow c \tilde{t}_1$ 0 mono-jet/c tag Yes 20.3 ÷. t1 t1 (natural GMSB) 2 e, µ (Z) 500 GeV 1 b Yes 20.7 m(k1)>150 GeV ATLAS-CONF-2013-025 $\tilde{t}_2 \tilde{t}_2, \tilde{t}_2 \rightarrow \tilde{t}_1 + Z$ 3 e, µ (Z) 271-520 GeV m(t1)=m(t10)+180 GeV ATLAS-CONF-2013-025 1 b Yes 20.7 ī, 85-315 GeV $\tilde{l}_{L,R}\tilde{l}_{L,R}, \tilde{l} \rightarrow l\tilde{\chi}_{1}^{0}$ 2 e.µ Ö Yes 20.3 m(x1)=0 GeV ATLAS-CONF-2013-049 $\chi_1 \chi_1, \chi_1 \rightarrow \ell \nu(\ell \bar{\nu})$ $m(\tilde{\ell}_1^0)=0$ GeV, $m(\tilde{\ell}, \tilde{\nu})=0.5(m(\tilde{\ell}_1^0)+m(\tilde{\ell}_1^0))$ 2 e.µ 0 Yes 20.3 125-450 GeV ATLAS-CONF-2013-049 Ň $\tilde{\chi}_1, \tilde{\chi}_1 \rightarrow \tilde{\tau} \nu(\tau \tilde{\nu})$ 2т Yes 20.7 180-330 GeV $m(\tilde{\ell}_{1}^{0})=0$ GeV, $m(\tilde{\tau}, \tilde{\nu})=0.5(m(\tilde{\ell}_{1}^{+})+m(\tilde{\ell}_{1}^{0}))$ ATLAS-CONF-2013-028 $\tilde{\chi}_{1}^{\pm}\tilde{\chi}_{2}^{0} \rightarrow \tilde{\ell}_{L} v \tilde{\ell}_{L} \ell(\tilde{\nu}_{V}), \ell \tilde{\nu} \tilde{\ell}_{L} \ell(\tilde{\nu}_{V})$ 3 e.µ 0 Yes 20.7 600 GeV $m(\tilde{t}_1^*)=m(\tilde{t}_2^0), m(\tilde{t}_1^0)=0, m(\tilde{t}, \tilde{v})=0.5(m(\tilde{t}_1^*)+m(\tilde{t}_1^0))$ ATLAS-CONF-2013-035 315 GeV $\tilde{\chi}_{2}^{0} \rightarrow W \tilde{\chi}_{1}^{0} Z \tilde{\chi}_{1}^{0}$ 3 e.µ 0 Yes 20.7 $m(\tilde{k}_1^n)=m(\tilde{k}_2^n), m(\tilde{k}_1^n)=0$, sleptons decoupled ATLAS-CONF-2013-035 1 e.µ 2bYes 20.3 $m(\tilde{k}_{1}^{n})=m(\tilde{k}_{2}^{0}), m(\tilde{k}_{1}^{0})=0$, sleptons decoupled ATLAS-CONF-2013-093 $\tilde{\chi}_{1}^{\pm}\tilde{\chi}_{2}^{0} \rightarrow W \tilde{\chi}_{1}^{0} h \tilde{\chi}_{1}^{0}$ 285 GeV lived Disapp. trk 270 GeV $m(\tilde{\ell}_1^{\pm})-m(\tilde{\ell}_1^{0})=160 \text{ MeV}, \tau(\tilde{\ell}_1^{\pm})=0.2 \text{ ns}$ Direct $\tilde{\chi}_{1}^{+} \tilde{\chi}_{1}^{-}$ prod., long-lived $\tilde{\chi}_{1}^{\pm}$ 1 jet Yes 20.3 ATLAS-CONF-2013-069 Stable, stopped g R-hadron 832 GeV $m(\tilde{\ell}_1^0)=100 \text{ GeV}, 10 \,\mu \text{s} < r(\tilde{g}) < 1000 \text{ s}$ 0 1-5 jets Yes 22.9 ATLAS-CONF-2013-057 10<tan/3<50 -oud-475 GeV GMSB, stable $\tilde{\tau}, \tilde{\chi}_1^0 \rightarrow \tilde{\tau}(\tilde{e}, \tilde{\mu}) + \tau(e, \mu) = 1 \cdot 2 \mu$ 15.9 ATLAS-CONF-2013-058 GMSB, $\tilde{\chi}_1^0 \rightarrow \gamma \tilde{G}$, long-lived $\tilde{\chi}_1^0$ 2γ Yes 4.7 230 GeV 0.4<r(2)</t 1304.6310 1 µ, displ. vtx $\tilde{q}\tilde{q}, \tilde{\chi}_{1}^{0} \rightarrow qq\mu$ (RPV) . 20.3 1.0 TeV 1.5 <cr<156 mm, BR(µ)=1, m(t1)=108 GeV ATLAS-CONF-2013-092 *X*₃₁₁=0.10, *X*₁₃₂=0.05 LFV $pp \rightarrow \tilde{v}_r + X, \tilde{v}_r \rightarrow e + \mu$ 2 e.µ 4.6 1.61 TeV 1212.1272 J's11=0.10, J1(2)33=0.05 LFV $pp \rightarrow \tilde{v}_{\tau} + X, \tilde{v}_{\tau} \rightarrow e(\mu) + \tau$ $1 e_{\mu} + \tau$ 4.6 1.1 TeV 1212.1272 Bilinear RPV CMSSM 1 e.µ $m(\bar{q})=m(\bar{g}), c_{T_LSP}<1 mm$ P 7 jets Yes 4.7 1.2 TeV ATLAS-CONF-2012-140 4 e,µ $\tilde{\chi}_{1}^{+}\tilde{\chi}_{1}^{-}, \tilde{\chi}_{1}^{+} \rightarrow W \tilde{\chi}_{1}^{0}, \tilde{\chi}_{1}^{0} \rightarrow ee \tilde{v}_{\mu}, e \mu \tilde{v}_{e}$ Yes 20.7 760 GeV ATLAS-CONF-2013-036 m(k²)>300 GeV, J₁₂₁>0 $3e, \mu + \tau$ 20.7 350 GeV ATLAS-CONF-2013-036 $\tilde{\chi}_{1}^{+}\tilde{\chi}_{1}^{-}, \tilde{\chi}_{1}^{+} \rightarrow W \tilde{\chi}_{1}^{0}, \tilde{\chi}_{1}^{0} \rightarrow \tau \tau \tilde{\nu}_{e}, e \tau \tilde{\nu}_{\tau}$ Yes m(X1)>80 GeV, A133>0 6-7 jets BR(t)=BR(b)=BR(c)=0% 0 20.3 916 GeV ATLAS-CONF-2013-091 $\tilde{g} \rightarrow q q q$ 2 e, µ (SS) 0-3 b 20.7 880 GeV ATLAS-CONF-2013-007 $\tilde{g} \rightarrow \tilde{t}_1 t, \tilde{t}_1 \rightarrow bs$ Yes Scalar gluon pair, sgluon→qq 0 4 jets 4.6 soluor 100-287 GeV incl. limit from 1110.2693 1210.4826 Other Scalar gluon pair, sgluon→tž 2 e, µ (SS) 1 b Yes 14.3 800 GeV ATLAS-CONF-2013-051 WIMP interaction (D5, Dirac x) 0 mono-jet Yes 10.5 m(¿)<80 GeV, limit of <687 GeV for D8 ATLAS-CONF-2012-147 $\sqrt{s} = 8 \text{ TeV}$ $\sqrt{s} = 7 \text{ TeV}$ $\sqrt{s} = 8 \text{ TeV}$ 10^{-1} Mass scale [TeV] full data partial data full data

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

SUSY exclusion

22

ATLAS Preliminary

ATLAS SUSY Searches* - 95% CL Lower Limits

Status: SUSY 2013



*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.

Prospects of LHC upgrades



The 14TeV run (Run 2) will start 2015. Two other shutdowns after Run-2 are scheduled Luminosity improvements will be achieved

To discover new physics beyond the SM To measure the Higgs property precisely

LHC-Run I ends with great success.

- SM physics has been precisely measured and understood.
- A Higgs-like resonance at 125.5GeV has been discovered.
 - \rightarrow All measured properties are compatible with SM Higgs boson, so far
- The large area of the new physics parameter space has been excluded.

Nagoya-ATLAS group contributes greatly to :

- detector installation/commissioning/operation
- physics analysis (in particular top quark physics)

Enlarge our group activity, towards 14 TeV LHC-Run !!

End

LHC-ATLAS Run I performance

LHC has performed very well

- Peak luminosity : 7.7 x 10³³ cm⁻² s⁻¹
- Delivered luminosity to ATLAS ~29 fb⁻¹

ATLAS collects good quality of data 95% of the time

For physics analysis presented here, we use

- ~5fb⁻¹ collected in 2011 $\sqrt{s} = 7 \text{ TeV}$
- ~21fb⁻¹ collected in 2012 $\sqrt{s} = 8 \text{ TeV}$

With increase of the luminosity, pile-up becomes higher.

Typically, we must reconstruct ~20 vertices within the space of ~5 cm (=p-beam length)





Detector Performance













Loop induced couplings ($\kappa_g v.s.\kappa_r$)

arXiv:1307.1427

35

We assume

Couplings of the known particles to the Higgs boson have SM strength

$$\kappa_W = \kappa_Z = \kappa_t = \kappa_b = \kappa_\tau = \dots = 1$$

New particles do not contribute to the Higgs boson width Γ_H

$$\begin{split} \kappa_g &= 1.04 \pm 0.14 \\ \kappa_\gamma &= 1.20 \pm 0.15 \\ &\text{at 68\% C.L.} \end{split}$$

Compatibility of the SM is 14%

Inclusive search

ATLAS-CONF-2013-047

38

High pT jets (up to 6 jets) + 0 lepton + ETmiss>160GeV

"Natural" SUSY

To stabilize the Higgs mass • 3rd generation squark • Higgsino(chargino/neutralino)

should be light

direct neutralino/chargino

 $m_{ ilde{\chi}^0_2}, m_{ ilde{\chi}^\pm_1} < 315~{
m GeV}$ excluded

New physics search summary

ATLAS Exotics Searches* - 95% CL Lower Limits (St	tatus: May	y 2013)
---	------------	---------

42

	Large ED (ADD) : monojet + E _{7 miss}	L=4.7 fb ⁻¹ , 7 TeV [1210.4491]		4.37 TeV M _D (δ=2)	
SL	Large ED (ADD) : monophoton + E _{T,miss}	L=4.6 fb ⁻¹ , 7 TeV [1209.4625]		1.93 TeV M _D (δ=2)	ATLAS
	Large ED (ADD) : diphoton & dilepton, may / II	L=4.7 fb ⁻¹ , 7 TeV [1211.1150]	100 C	4.18 TeV M _S (HLZ δ=3,	NLO) AILAS
0	UED : diphoton + $E_{T,miss}$	L=4.8 fb ⁻¹ , 7 TeV [1209.0753]	1.4	Tev. Compact. scale R ⁻¹	Preliminary
ns	S ¹ /Z ₂ ED : dilepton, m _i	L=5.0 fb ⁻¹ , 7 TeV [1209.2535]		4.71 TeV M _{KK} ~ R ⁻¹	
hе	RS1 : dilepton, m	L=20 fb ⁻¹ , 8 TeV [ATLAS-CONF-2013-017]		2.47 TeV Graviton mass (k/M _{PI}	= 0.1)
-iii	RS1 : WW resonance, m _{T,MN}	L=4.7 fb ⁻¹ , 7 TeV [1208.2880]	1.23 1	Graviton mass (k/M _{Pl} = 0.1)	f
an an	Bulk RS : ZZ resonance, m	L=7.2 fb ⁻¹ , 8 TeV [ATLAS-CONF-2012-150]	850 GeV	raviton mass (k/M _{PI} = 1.0)	$Ldt = (1 - 20) \text{ fb}^{-1}$
xtr	RS $g_{\mu\nu} \rightarrow t\bar{t}$ (BR=0.925) : $t\bar{t} \rightarrow l+jets, m_{\mu}$	L=4.7 fb ⁻¹ , 7 TeV [1305.2755]		2.07 TeV g _{KX} mass	
LLI	ADD BH (M _{TH} /M _p =3) : SS dimuon, N _{ch, part}	L=1.3 fb ⁻¹ , 7 TeV [1111.0080]	1.25	M M _D (δ=6)	s = 7, o lev
	ADD BH $(M_{TH}/M_D=3)$: leptons + jets, Σp_T	L=1.0 fb ⁻¹ , 7 TeV [1204.4645]	1	5 TeV M _D (δ=6)	
	Quantum black hole : dijet, $F_{\chi}(m_{j})$	L=4.7 fb ⁻¹ , 7 TeV [1210.1718]		4.11 TeV M _D (δ=6)	
_	qqqq contact interaction : $\chi(m)$	L=4.8 fb ⁻¹ , 7 TeV [1210.1718]		7.6 TeV A	
G	qqll CI : ee & μμ, m	L=5.0 fb ⁻¹ , 7 TeV [1211.1150]		13.9 Te	 A (constructive int.)
	uutt CI : SS dilepton + jets + E _{T.miss}	L=14.3 fb ⁻¹ , 8 TeV [ATLAS-CONF-2013-051]		3.3 TeV Λ (C=1)	
	Z' (SSM) : m _{ee(µµ}	L=20 fb ⁻¹ , 8 TeV [ATLAS-CONF-2013-017]		2.86 TeV Z' mass	
	Z' (SSM) : m _{et}	L=4.7 fb ⁻¹ , 7 TeV [1210.6604]	1.	Tev Z' mass	
~	Z' (leptophobic topcolor) : $t\bar{t} \rightarrow l+jets, m_{\pi}$	L=14.3 fb ⁻¹ , 8 TeV [ATLAS-CONF-2013-052]		1.8 TeV Z' mass	
~	W' (SSM) : m _{T,e/µ}	L=4.7 fb ⁻¹ , 7 TeV [1209.4445]		2.55 TeV W' mass	
	$W' (\rightarrow tq, g_g=1) : m_{tq}$	L=4.7 fb ⁻¹ , 7 TeV [1209.6593]	430 GeV W mass		
	$W_R^{\circ} (\rightarrow tb, LRSM) : m_{tb}$	L=14.3 fb ⁻¹ . 8 TeV [ATLAS-CONF-2013-050]		1.84 TeV W' mass	
a	Scalar LQ pair (β =1) : kin. vars. in eejj, evjj	L=1.0 fb ⁻¹ , 7 TeV [1112.4828]	660 GeV 1" ge	n. LQ mass	
Ľ	Scalar LQ pair (β=1) : kin. vars. in μμjj, μvjj	L=1.0 fb ⁻¹ , 7 TeV [1203.3172]	685 GeV 2~ 9	en. LQ mass	
	Scalar LQ pair (β=1) : kin. vars. in ττjj, τvjj	L=4.7 fb ⁻¹ , 7 TeV [1303.0526]	534 GeV 3" gen.	.Q mass	
S	4" generation : t't' \rightarrow WbWb	L=4.7 fb ⁻¹ , 7 TeV [1210.5468]	656 GeV t' ma	S	
ark	4 un generation : D D \rightarrow 35 dilepton + jets + E T.miss	L=14.3 fb", 8 TeV [ATLAS-CONF-2013-051]	720 GeV b' r	ass	
Ζ'n	Vector-like quark : TT→ Ht+X	L=14.3 fb ⁻¹ , 8 TeV [ATLAS-CONF-2013-018]	790 GeV	nass (isospin doublet)	
	Vector-like quark : CC, ming	L=4.6 fb ⁻¹ , 7 TeV [ATLAS-CONF-2012-137]	1.12 Te	VLQ mass (charge -1/3, coupling	$\kappa_{q0} = v/m_0$
the state	Excited quarks : γ -jet resonance, m	L=2.1 fb", 7 TeV [1112.3580]		2.46 TeV q* mass	
D) E	Excited quarks : dijet resonance, m	L=13.0 fb", 8 TeV [ATLAS-CONF-2012-148]		3.84 TeV q* mass	
Шæ	Excited b quark : W-t resonance, m	L=4.7 fb ⁻¹ , 7 TeV [1301.1583]	870 GeV	mass (left-handed coupling)	
	Table badress (LCTO) a dilastes m	L=13.0 fb", 8 TeV [ATLAS-CONF-2012-146]		2.2 TeV I* mass $(\Lambda = m(I^*))$	
	Techni-hadrons (LSTC) : dilepton, meduju Techni hadrons (LSTC) : WZ reconcerce (hill)	L=5.0 fb", 7 TeV [1209.2535]	850 GeV	$/\omega_{\rm T}$ mass $(m(\rho_{\rm T}/\omega_{\rm T}) - m(\pi_{\rm T}) = M_{\rm W})$	
	Techni-hadrons (LSTC) . WZ resonance (Wil), m	L=13.0 fb", 8 TeV [ATLAS-CONF-2013-015]	920 GeV	$p_{\rm T}$ mass $(m(p_{\rm T}) = m(\pi_{\rm T}) + m_{\rm W}, m(a_{\rm T})$	$= 1.1 m(\rho_{T}))$
Major. neutr. (LRSM, no mixing) : 2-lep		L=2.1 fb ⁻⁷ , 7 TeV [1203.5420]	Ni	TeV N mass $(m(W_R) = 2 \text{ TeV})$	
5 H	eavy lepton N ⁻ (type III seesaw) : Z-I resonance, m ₂₁	L=5.8 fb", 8 TeV [ATLAS-CONF-2013-019]*	N° mass $(V_a = 0.0$	$ 5, V_{\mu} = 0.063, V_{\tau} = 0$	
õ	H_{L} (DT prod., BR($H_{L} \rightarrow II$)=1): SS ee (µµ), m	L=4.7 fb ⁻⁷ , 7 TeV [1210.5070] 4	09 GeV H[" mass (I	hit at 398 GeV for µµ)	
	Color octet scalar : dijet resonance, m _{jj}	L=4.8 fb ⁻¹ , 7 TeV [1210.1718]		1.86 TeV Scalar resonance mass	
Multi-	charged particles (DY prod.) : highly ionizing tracks	L=4.4 fb ⁻ , 7 TeV [1301.5272]	490 GeV mass (q	= 4e)	
Ma	gnetic monopoles (DY prod.) : highly ionizing tracks	L=2.0 fb ⁻¹ , 7 TeV [1207.6411]	862 GeV 1	ass	
		10 ⁻¹	1	10	10 ²
		10		10	Mass seels (T-) (
*0-4	a selection of the suplichle mass limits on new states a	categoriana abour			wass scale [leV]

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

New physics search summary

AS Exotics Searches* - 95% CL Lower Limits (Status: May 2012

42

Mass scale [TeV]

			of the cover climits (Status, may 2013)
	Large ED (ADD) : monoiet + E		177 TOY M (S=2)
	Large ED (ADD) : monophoton + E	L=4.7 T0 , 7 TeV [1210,4491]	$4.37 \text{ tev} = M_D (0-2)$
\$	Large ED (ADD) : diphoton & dilecton m	L=4.010 . 7 16V [1200.4020]	$\frac{1}{100} \frac{1}{100} \frac{1}$
ю	UED : diphoton + E_{-}	L=4.8 fb ⁻¹ 7 Tay (\$200.0753)	Preliminary
S	S ¹ /7 ED : dilector m	L = 5.0 fb ⁻¹ 7 TeV [1209.0753]	471 TeV M~ R ⁻¹
θU	RS1: dilepton, m	/ =20 fb ⁻¹ / Tay (ATI AS-CONE-2013-017)	2.47 TeV Graviton mass $(k/M_{\odot} = 0.1)$
E.	RS1 : WW resonance, m	/ #4.7 fb ⁻¹ 7 TeV (1208.2880) 1.23.1	Graviton mass $(k/M_{\odot} = 0.1)$
D	Bulk RS : ZZ resonance, m	L =7.2 fb ⁻¹ , 8 TeV IATLAS/CONF-2012-1501 850 GeV	raviton mass $(k/M_{\odot} = 1.0)$ $Ldt = (1 - 20) \text{ fb}^{-1}$
tra	RS $q \rightarrow t\bar{t}$ (BR=0.925) : $t\bar{t} \rightarrow t$ iets m	L=4.7 fb ⁻¹ , 7 TeV [1305.2755]	2.07 TeV g mass
щ	ADD BH $(M_{ru}/M_{o}=3)$; SS dimuon, N_{ru}	L=1.3 fb ⁻¹ , 7 TeV [1111.0080] 1.25	$M_{o}(\delta=6)$ (s = 7, 8 TeV
	ADD BH $(M_{TH}/M_{p}=3)$: leptons + jets, Σp_{p}	L=1.0 fb ⁻¹ , 7 TeV [1204.4646]	τεν Μ _α (δ=6)
	Quantum black hole : dijet, F (m)	L=4.7 fb ⁻¹ , 7 TeV [1210.1718]	4.11 TeV M _c (δ=6)
	qqqq contact interaction : $\chi(m_{\perp})$	L=4.8 fb ⁻¹ , 7 TeV [1210.1718]	7.6 TeV A
0	qqll Cl : ee & μμ, m	L=5.0 fb ⁻¹ , 7 TeV [1211.1150]	13.9 TeV A (constructive int.)
0	uutt CI : SS dilepton + jets + ET miss	L=14.3 fb1, 8 TeV [ATLAS-CONF-2013-051]	3.3 TeV A (C=1)
	Z' (SSM) : master	£+20 ft/_ 6 TeV (ATLAS-CONF-2013-017)	2.86 TeV Z' mass
	Z' (SSM) : m	To/ ovelude	Z' mass
2	Z' (leptophobic topcolor) : $t\bar{t} \rightarrow +jets, m$		Z'mass
\geq	W (SSM) : m _{T.e/a}	L=4.7 fb ⁻ , 7 TeV [1209.4445]	2.55 TeV W' mass
	W' $(\rightarrow tq, g_p=1): m_{tq}$	L=4.7 fb ⁻⁴ , 7 TeV [1209.6593] 430 GeV W mass	
	$W'_{R} (\rightarrow tb, LRSM) : m_{m}$	L=14.3 fb ⁻¹ . 8 TeV [ATLAS-CONF-2013-050]	1.84 TeV W' mass
\sim	Scalar LQ pair (β=1) : kin. vars. in eejj, evjj	L=1.0 fb ⁻¹ , 7 TeV [1112.4828] 660 GeV 1 ⁵¹ gi	n. LQ mass
LC C	Scalar LQ pair (β=1) : kin. vars. in μμjj, μvjj	L=1.0 fb ⁻¹ , 7 TeV [1203.3172] 685 GeV 2 nd (en. LQ mass
	Scalar LQ pair (β=1) : kin. vars. in ττjj, τvjj	L=4.7 fb ⁻¹ , 7 TeV [1303.0526] 534 GeV 3 rd gen.	.Q mass
0	4 th generation : t't'→ WbWb	L=4.7 fb ⁻¹ , 7 TeV [1210.5468] 656 GeV [¹ ma	s
NK N	4th generation : b'b' \rightarrow SS dilepton + jets + E T,miss	L=14.3 fb ⁻¹ , 8 TeV [ATLAS-CONF-2013-051] 720 GeV b' r	ass
N S	Vector-like quark : TT→ Ht+X	L=14.3 fb ⁻¹ , 8 TeV [ATLAS-CONF-2013-018] 790 GeV	nass (isospin doublet)
0	Vector-like quark : CC, mirg	L=4.6 fb ⁻¹ . 7 TeV [ATLAS-CONF-2012-137] 1.12 Te	VLQ mass (charge -1/3, coupling $\kappa_{q0} = v/m_0$)
÷	Excited quarks : γ -jet resonance, m	L=2.1 fb ⁻¹ , 7 TeV [1112.3580]	2.46 TeV q* mass
E Ci	Excited quarks : dijet resonance, m	L=13.0 fb ⁻¹ , 8 TeV [ATLAS-CONF-2012-148]	3.84 TeV q* mass
Щæ	Excited b quark : W-t resonance, m _{wt}	L=4.7 fb ⁻¹ , 7 TeV [1301.1583] 870 GeV	mass (left-handed coupling)
	Excited leptons : I-y resonance, m	L=13.0 fb ⁻¹ , 8 TeV [ATLAS-CONF-2012-146]	2.2 TeV I* mass (A = m(I*))
	Techni-hadrons (LSTC) : dilepton, meeiuu	L=5.0 fb ⁻¹ , 7 TeV [1209.2535] 850 GeV	$/\omega_{\rm T}$ mass $(m(\rho_{\rm T}/\omega_{\rm T}) - m(\pi_{\rm T}) = M_{\rm W})$
	Techni-hadrons (LSTC) : WZ resonance (MII), m	L=13.0 fb ⁻¹ , 8 TeV [ATLAS-CONF-2013-015] 920 GeV	p_{T} mass $(m(p_{T}) = m(\pi_{T}) + m_{W}, m(a_{T}) = 1.1m(p_{T}))$
h	Major. neutr. (LRSM, no mixing) : 2-lep + jets	L=2.1 fb ⁻¹ , 7 TeV [1203.5420]	TeV N mass $(m(W_R) = 2 \text{ TeV})$
e He	eavy lepton N ^z (type III seesaw) : Z-I resonance, m _{zi}	L=5.8 fb ⁻¹ , 8 TeV [ATLAS-CONF-2013-819] N° mass (V = 0.0	$ 5, V_{\mu} = 0.063, V_{\tau} = 0$
õ	$H_{[}^{-}(DY \text{ prod.}, BR(H_{[}^{-} \rightarrow II)=1): SS ee (\mu\mu), m_{II}$	L=4.7 fb ^{-,} 7 TeV [1210.5070] 409 GeV H ^{2,2} mass (I	nit at 398 GeV for μμ)
	Color octet scalar : dijet resonance, m	L=4.8 fb ⁻ , 7 TeV [1210.1718]	1.86 TeV Scalar resonance mass
Multi-	charged particles (DY prod.) : highly ionizing tracks	L=4.4 fb ⁻ , 7 TeV [1301.5272] 490 GeV mass ([q	= 4e)
Mag	anetic monopoles (DY prod.) : highly ionizing tracks	L=2.0 fb ⁻¹ , 7 TeV [1207.641] 862 GeV (ass I I I I I I I I I I I I I I I I I I
		10-1	1 10 10

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

Higgs prospects

Higgs prospects

SUSY prospects

