TeV Scale Physics at LHC

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- 1. Overview of TeV-Scale physics program (KAKEN 2303, 新学術領域研究)
- 2. Upgrade plan, where Japanese groups contribute most of part.
- 3. Latest result of Higgs measurements
- 4. Neutrino physics at LHC

TeV-Scale Physics Program (KAKEN 2303, 2011-2015)

「先端加速器LHCが切り拓くテラスケールの素粒子物理学 ~真空と時空への新たな挑戦」



LHC and upgrade plan



December.22.2014

ATLAS detector (Run-1, 2010-2012)

Key parameter for upgrade:

- LHC beam collision : 30MHz
 - 3-step trigger : <u>L1 75kHz / L2 2kHz / EF ~400Hz</u>

Upgrade is designed to improve these two parameters.



ATLAS upgrade plan

LS1:2013-2015

- Install new IBL silicon detector, 1)
- 2) Improve the muon trigger logic,
- 3) Upgrade of trigger architecture,

4)

LS2: 2018 - 2019

- 1) Upgrade trigger read-out in calorimeter,
- 2) Install muon small wheel.

LS3: 2022 - 2025

- Full replacement of the inner tracker, 1)
- 2) many many...



LHC runs ~2035 (?)

ATLAS upgrade plan (LS1, 2013-2015)

1) Introduction of 4th Pixel layer on beam pipe at r=33mm.

Placing further inner region of already-existing Pixel (3-layer) detectors.

The beam-pipe : 35mm -> 24mm.



Good resolution for vertexing.

KEK, Tokyo Tech.





>30% better b-tagging performance

Tolerable up to L=450fb⁻¹ Pixel +12M ch. (current 80M ch) 2) Upgrade read-out system in muon trigger

L1 muon rate was dominated by fake at large |η| region, which comes from particles produced at EndCap-toroid / beam-shields.





To suppress forward-fake background,

- Tight coincidence window in inner side,
- Combined read-out with Tile calorimeter.

Allowing pT>20GeV threshold at L1

KEK, Kyoto, Nagoya, Kobe, Tokyo

December.22.2014

December.22.2014

- 3) Introduction of Fast Tracker (FTK) after Level 1
- 4) Improved L1 scheme (topological trigger)
- 5) Now, 2-step trigger (L1 100kHz / HLT 1000Hz)



ニュートリノ研究会2014

Run-2 DAQ

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LS1 upgrade, 2013-2015

December.22.2014



- 4) Improved L1 scheme (topological trigger)
- 5) Now, 2-step trigger (L1 100kHz / HLT 1000Hz)



<u>Run-2 DAQ</u>

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LS1 upgrade, 2013-2015







ATLAS upgrade plan (LS2, 2018-2019)

1) Upgrade LAr. Calorimeter read-out trigger system.

 $\Delta \eta = 0.025$ Fine segment at L1. 1. Rol location based on current Level-1 trigger system Allowing sophisticated clustering, $\Delta \phi = 0.1$ forming shower shape. 2. Algorithm seeded by most energetic $\Delta\eta x \Delta\phi = 0.025 x 0.1$ Super-cell Development of filtering algorithm. 3. 2nd most energetic neighbour in ϕ η (above or below) define cluster $\Delta\eta x \Delta \phi = 0.2 \times 0.2$ core Currently, operating 5-sampling mode. 4. Add neighbours in η,ϕ to form cluster. But 32-sampling points are maximally usable. Wider eta environment for isolation/



LS2 upgrade, 2018-2019

2) Construction of new small wheel (muon)

Need fine pitch fast muon chamber. So far, current gas chamber can not sustainable to 300kHz output rate.

replace to sTGC / Micromegas







Micromegas, foil

Kobe, Tokyo

ニュートリノ研究会2014

ATLAS upgrade plan (LS3, 2022-2025)

1) Full replacement of the inner tracker.

Si area : 62 m² -> **193 m²**

- Sensor development (low cost, radiation tolerable...)
- Optimal layout (small surface without performance degradation)
- L1 track trigger





KEK, Osaka, Kyushu, Tokyo Tech. December.22.2014





Highlight and perspective

	Higgs appears in PDG(2014) !
H	0 – L
	Mass m = 125.7 ± 0.4 GeV
	H ⁰ Signal Strengths in Different Channels Combined Final States = 1.17 ± 0.17 (S = 1.2) $W W^* = 0.87 \stackrel{+0.24}{-0.22}$ $Z Z^* = 1.11 \stackrel{+0.34}{-0.28}$ (S = 1.3) $\gamma \gamma = 1.58 \stackrel{+0.27}{-0.23}$ $b \overline{b} = 1.1 \pm 0.5$ $\tau^+ \tau^- = 0.4 \pm 0.6$ $Z \gamma < 9.5$, CL = 95%

Higgs summary

Signal strength : $\mu = \sigma / \sigma_{SM}$

where σ_{SM} is based on NNLO.

Statistics and systematics uncertainties are almost comparable.

Last update :

H->WW observation paper 30% improvement, 6.1σ (arXiv:1412.2641)

c.f.

H-> $\tau\tau$ evidence paper (4.5 σ)

(ATLAS-CONF-2014-061)

Update : December 2014



Mass measurements Phys.Rev.D90 (2014) 052004

Energy calibration : e / γ : 0.2-0.3% µ : 0.1-0.2%

Measured value (combined) :

$$m_{H} = 125.36 \pm 0.37 \text{ (stat)} \pm 0.18 \text{ (syst)} \text{ GeV}$$

Slight deviation seen between channels.

 \rightarrow

could be checked by H->Zγ, μμ mode (not observed yet) in Run-2.









Property measurements

Phys.Lett.B726 (2013) 120

SM Higgs boson : $J^P = 0^+$

Test several hypothesis : 0^- , 1^+ , 1^- , 2^+

from H->WW, H->ZZ, H->yy

H->ττ is coming soon.



Z'

 Φ_1

 θ_1

 u^{-}

Data

CL_s expected

assuming $J^{P} = 0^{+}$

 θ_2

ATLAS

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

√s = 7 TeV ∫Ldt = 4.6 fb⁻¹

 $H \rightarrow ZZ^* \rightarrow 4I$

 $H \rightarrow \gamma \gamma$

Beyond SM

Conventional MSSM scenario is almost died.

m_h-max scenario : Obsolete parameter space...

All Higgs measurements supports SM-like.

Find parameter space in $sin(\beta-\alpha) \approx 1$



... direct probe of the top Yukawa coupling.

... cross reference of Higgs mass measurement.

What will be important in Run 2 and beyond "I fusion:

Important Higgs measurements in Run-2/3 (L=100-300 fb⁻¹):

- 1. ttH production
- 2. Establish H->ττ / bb mode ... strengthen fermion coupling.
- 3. Rare decay H->Ζγ, μμ
- 4. Nature of VBF production ... Vector Boson Scattering.

High-Luminosity LHC (Run-4, L=3000fb⁻¹)

- 1. Higgs self coupling ... so far, ~30% accuracy
- 2. Higgs factory

Link to neutrino physics. (I think...)





ATLAS SUSY Searches* - 95% CL Lower Limits

Status: ICHEP 2014

010									$v^{3} = 7,010v$
	Model	e, μ, τ, γ	Jets	$E_{ m T}^{ m miss}$	$\int \mathcal{L} dt [\mathbf{f}]$	b ⁻¹]	Mass limit		Reference
Inclusive Searches	$ \begin{array}{l} \text{MSUGRA/CMSSM} \\ \text{MSUGRA/CMSSM} \\ \text{MSUGRA/CMSSM} \\ \tilde{q}\tilde{q}, \tilde{q} \rightarrow q \tilde{\chi}_{1}^{0} \\ \tilde{g}\tilde{g}, \tilde{g} \rightarrow q \tilde{q} \tilde{\chi}_{1}^{0} \\ \tilde{g}\tilde{g}, \tilde{g} \rightarrow q q \tilde{\chi}_{1}^{0} \\ \tilde{g}\tilde{g}, \tilde{g} \rightarrow q q \tilde{\chi}_{1}^{+} \rightarrow q q W^{\pm} \tilde{\chi}_{1}^{0} \\ \tilde{g}\tilde{g}, \tilde{g} \rightarrow q q (\ell \ell / \ell \nu / \nu \nu \tilde{\chi}_{1}^{0} \\ \text{GMSB} (\ell \text{ NLSP}) \\ \text{GMSB} (\ell \text{ NLSP}) \\ \text{GGM (bino NLSP)} \\ \text{GGM (wino NLSP)} \\ \text{GGM (higgsino-bino NLSP)} \\ \text{GGM (higgsino NLSP)} \\ \text{Gravitino LSP} \\ \end{array} $	$\begin{matrix} 0 \\ 1 \ e, \mu \\ 0 \\ 0 \\ 0 \\ 1 \ e, \mu \\ 2 \ e, \mu \\ 2 \ e, \mu \\ 1 - 2 \ \tau + 0 - 1 \ \ell \\ 2 \ \gamma \\ 1 \ e, \mu + \gamma \\ \gamma \\ 2 \ e, \mu (Z) \\ 0 \end{matrix}$	2-6 jets 3-6 jets 2-6 jets 2-6 jets 3-6 jets 3-6 jets 0-2 jets - 1 b 0-3 jets mono-jet	Yes Yes Yes Yes Yes Yes Yes Yes Yes Yes	20.3 20.3 20.3 20.3 20.3 20.3 20.3 4.7 20.3 20.3 4.8 4.8 5.8 10.5	\tilde{q}, \tilde{g}	1.2 TeV 1.1 TeV 850 GeV 1.33 T 1.18 TeV 1.12 TeV 1.24 Te 1.24 Te 619 GeV 900 GeV 690 GeV 645 GeV	1.7 TeV $m(\tilde{q}) = m(\tilde{g})$ any $m(\tilde{q})$ any $m(\tilde{q})$ $m(\tilde{k}_{1}^{0}) = 0$ GeV, $m(1^{st} \text{ gen.} \tilde{q}) = m(2^{sd} \text{ gen.} \tilde{q})$ feV $m(\tilde{k}_{1}^{0}) = 0$ GeV $m(\tilde{k}_{1}^{0}) < 200$ GeV, $m(\tilde{\chi}^{\pm}) = 0.5(m(\tilde{\chi}_{1}^{0}) + m(\tilde{g}))$ $m(\tilde{\chi}_{1}^{0}) = 0$ GeV t $an\beta < 15$ 1.6 TeV $tan\beta > 20$ eV $m(\tilde{\chi}_{1}^{0}) > 50$ GeV $m(\tilde{\chi}_{1}^{0}) > 50$ GeV $m(\tilde{\chi}_{1}^{0}) > 50$ GeV $m(\tilde{\chi}_{1}^{0}) > 200$ GeV $m(\tilde{\chi}_{1}^{0}) > 200$ GeV $m(\tilde{d}) > 10^{-4}$ eV	1405.7875 ATLAS-CONF-2013-062 1308.1841 1405.7875 1405.7875 ATLAS-CONF-2013-062 ATLAS-CONF-2013-089 1208.4688 1407.0603 ATLAS-CONF-2012-014 ATLAS-CONF-2012-144 1211.1167 ATLAS-CONF-2012-152 ATLAS-CONF-2012-147
ğ med.	$\begin{array}{c} \tilde{g} \rightarrow b \bar{b} \tilde{\chi}_{1}^{0} \\ \tilde{g} \rightarrow t \bar{\lambda}_{1}^{0} \\ \tilde{g} \rightarrow t \bar{t} \tilde{\chi}_{1}^{0} \\ \tilde{g} \rightarrow b \bar{\chi}_{1}^{i} \end{array}$	0 0 0-1 <i>e</i> ,μ 0-1 <i>e</i> ,μ	3 <i>b</i> 7-10 jets 3 <i>b</i> 3 <i>b</i>	Yes Yes Yes Yes	20.1 20.3 20.1 20.1	55 55 55		$ \begin{array}{l} \mathbf{V} & \mathbf{m}(\tilde{k}_{1}^{0}) < 400 \mathrm{GeV} \\ & \mathbf{m}(\tilde{k}_{1}^{0}) < 350 \mathrm{GeV} \\ \end{array} \\ \begin{array}{l} \mathbf{TeV} & \mathbf{m}(\tilde{k}_{1}^{0}) < 400 \mathrm{GeV} \\ \mathbf{m}(\tilde{k}_{1}^{0}) < 300 \mathrm{GeV} \end{array} $	1407.0600 1308.1841 1407.0600 1407.0600
3 rd gen. squarks direct production	$\begin{split} \tilde{b}_1 \tilde{b}_1 \cdot \tilde{b}_1 \rightarrow b \tilde{\chi}_1^0 \\ \tilde{b}_1 \tilde{b}_1 \cdot \tilde{b}_1 \rightarrow t \tilde{\chi}_1^{\pm} \\ \tilde{t}_1 \tilde{t}_1 (\text{light}), \tilde{t}_1 \rightarrow t \tilde{\chi}_1^{\pm} \\ \tilde{t}_1 \tilde{t}_1 (\text{light}), \tilde{t}_1 \rightarrow W b \tilde{\chi}_1^0 \\ \tilde{t}_1 \tilde{t}_1 (\text{medium}), \tilde{t}_1 \rightarrow t \tilde{\chi}_1^0 \\ \tilde{t}_1 \tilde{t}_1 (\text{medium}), \tilde{t}_1 \rightarrow t \tilde{\chi}_1^0 \\ \tilde{t}_1 \tilde{t}_1 (\text{neavy}), \tilde{t}_1 \rightarrow t \tilde{\chi}_1^0 \\ \tilde{t}_1 \tilde{t}_1 (\text{neavy}), \tilde{t}_1 \rightarrow t \tilde{\chi}_1^0 \\ \tilde{t}_1 \tilde{t}_1 (\text{neavy}) = 0 \end{split}$	$\begin{array}{c} 0\\ 2\ e,\mu\ ({\rm SS})\\ 1-2\ e,\mu\\ 2\ e,\mu\\ 2\ e,\mu\\ 0\\ 1\ e,\mu\\ 0\\ 0\\ 3\ e,\mu\ (Z) \end{array}$	2 b 0-3 b 1-2 b 0-2 jets 2 jets 2 b 1 b 2 b nono-jet/c-t 1 b 1 b	Yes Yes Yes Yes Yes Yes Yes Yes Yes Yes	20.1 20.3 4.7 20.3 20.3 20.1 20 20.1 20.3 20.3 20.3	$ \vec{b}_1 \\ \vec{b}_1 \\ \vec{c}_1 \\ \vec{c}_2 $	100-620 GeV 275-440 GeV 110 <mark>-167 GeV</mark> 130-210 GeV 215-530 GeV 210-640 GeV 260-640 GeV 90-240 GeV 150-580 GeV 290-600 GeV	$\begin{split} & m(\tilde{\chi}_{1}^{0}) < 90 GeV \\ & m(\tilde{\chi}_{1}^{0}) = 2 m(\tilde{\chi}_{1}^{0}) \\ & m(\tilde{\chi}_{1}^{0}) = 55 GeV \\ & m(\tilde{\chi}_{1}^{0}) = m(\tilde{r}_{1}) - m(W) - 50 GeV, m(\tilde{r}_{1}) < $	1308.2631 1404.2500 1208.4305, 1209.2102 1403.4853 1403.4853 1308.2631 1407.0583 1406.1122 1407.0608 1403.5222 1403.5222
EVV direct	$ \begin{array}{c} \tilde{\ell}_{L_{\mathbf{K}}} \tilde{\ell}_{L_{\mathbf{K}}}, \tilde{\ell} \rightarrow \ell \tilde{\chi}_{1}^{0} \\ \tilde{\chi}_{1}^{+} \tilde{\chi}_{1}^{-}, \tilde{\chi}_{1}^{+} \rightarrow \tilde{\ell} \nu(\ell \tilde{\nu}) \\ \tilde{\chi}_{1}^{+} \tilde{\chi}_{0}^{-}, \tilde{\chi}_{1}^{+} \rightarrow \tilde{\nu} \nu(\tau \tilde{\nu}) \\ \tilde{\chi}_{1}^{+} \tilde{\chi}_{0}^{0} \rightarrow \tilde{\ell}_{L} \nu \tilde{\ell}_{L} \ell(\tilde{\nu}\nu), \ell \tilde{\nu} \tilde{\ell}_{L} \ell(\tilde{\nu}\nu) \\ \tilde{\chi}_{1}^{+} \tilde{\chi}_{0}^{0} \rightarrow W \tilde{\chi}_{1}^{0} Z \tilde{\chi}_{1}^{0} \\ \tilde{\chi}_{1}^{+} \tilde{\chi}_{0}^{0} \rightarrow W \tilde{\chi}_{1}^{0} h \tilde{\chi}_{1}^{0} \\ \tilde{\chi}_{2}^{+} \tilde{\chi}_{0}^{0} \rightarrow W \tilde{\chi}_{1}^{0} h \tilde{\chi}_{1}^{0} \\ \tilde{\chi}_{2}^{+} \tilde{\chi}_{3}^{0}, \tilde{\chi}_{2,3}^{0} \rightarrow \tilde{\ell}_{R} \ell \end{array} $	$\begin{array}{c} 2 \ e, \mu \\ 2 \ e, \mu \\ 2 \ \tau \\ 3 \ e, \mu \\ 2 \ 3 \ e, \mu \\ 2 \ 3 \ e, \mu \\ 1 \ e, \mu \\ 4 \ e, \mu \end{array}$	0 0 - 0 2 <i>b</i> 0	Yes Yes Yes Yes Yes Yes Yes	20.3 20.3 20.3 20.3 20.3 20.3 20.3 20.3	$ \begin{array}{c} \tilde{\ell} \\ \tilde{\chi}_{1}^{\pm} \\ \tilde{\chi}_{1}^{\pm} \\ \tilde{\chi}_{1}^{\pm} \\ \tilde{\chi}_{2}^{\pm} \\ \tilde{\chi}_{2}^{\pm} \\ \tilde{\chi}_{2}^{\pm} \\ \tilde{\chi}_{2}^{\pm} \\ \tilde{\chi}_{2}^{\pm} \\ \tilde{\chi}_{2}^{\pm} \end{array} $	90-325 GeV 140-465 GeV 100-350 GeV 700 GeV 420 GeV 285 GeV 620 GeV	$\begin{split} & m(\tilde{\chi}_{1}^{0}){=}0~GeV \\ & m(\tilde{\chi}_{1}^{0}){=}0~GeV, ~m(\tilde{\ell},\tilde{\nu}){=}0.5(m(\tilde{\chi}_{1}^{\pm}){+}m(\tilde{\chi}_{1}^{0})) \\ & m(\tilde{\chi}_{1}^{0}){=}0~GeV, ~m(\tilde{\tau},\tilde{\nu}){=}0.5(m(\tilde{\chi}_{1}^{\pm}){+}m(\tilde{\chi}_{1}^{0})) \\ & m(\tilde{\chi}_{1}^{\pm}){=}m(\tilde{\chi}_{2}^{0}), ~m(\tilde{\chi}_{1}^{0}){=}0, ~m(\tilde{\ell},\tilde{\nu}){=}0.5(m(\tilde{\chi}_{1}^{\pm}){+}m(\tilde{\chi}_{1}^{0})) \\ & m(\tilde{\chi}_{1}^{\pm}){=}m(\tilde{\chi}_{2}^{0}), ~m(\tilde{\chi}_{1}^{0}){=}0, ~sleptons decoupled \\ & m(\tilde{\chi}_{2}^{0}){=}m(\tilde{\chi}_{2}^{0}), ~m(\tilde{\chi}_{1}^{0}){=}0, ~m(\tilde{\ell},\tilde{\nu}){=}0.5(m(\tilde{\chi}_{2}^{0}){+}m(\tilde{\chi}_{1}^{0})) \end{split}$	1403.5294 1403.5294 1407.0350 1402.7029 1403.5294, 1402.7029 ATLAS-CONF-2013-093 1405.5086
Long-ilved particles	Direct $\tilde{\chi}_1^+ \tilde{\chi}_1^-$ prod., long-lived $\tilde{\chi}_1^+$ Stable, stopped \tilde{g} R-hadron GMSB, stable $\tilde{\tau}, \tilde{\chi}_1^0 \rightarrow \tilde{\tau}(\tilde{e}, \tilde{\mu}) + \tau(e, GMSB, \tilde{\chi}_1^0 \rightarrow \gamma \tilde{G}, \log-lived \tilde{\chi}_1^0$ $\tilde{q}\tilde{q}, \tilde{\chi}_1^0 \rightarrow qq\mu$ (RPV)	Disapp. trk 0 μ) 1-2 μ 2 γ 1 μ, displ. vtx	1 jet 1-5 jets - - -	Yes Yes - Yes -	20.3 27.9 15.9 4.7 20.3	$ \begin{array}{c} \tilde{\chi}_{1}^{\pm} \\ \tilde{g} \\ \tilde{\chi}_{1}^{0} \\ \tilde{\chi}_{1}^{0} \\ \tilde{q} \end{array} $	270 GeV 832 GeV 832 GeV 475 GeV 230 GeV 1.0 TeV	$\begin{array}{l} m(\tilde{\chi}_{1}^{+})\text{-}m(\tilde{\chi}_{1}^{0})\text{=}160~\text{MeV},~\tau(\tilde{\chi}_{1}^{+})\text{=}0.2~\text{ns}\\ m(\tilde{\chi}_{1}^{0})\text{=}100~\text{GeV},~10~\mu\text{s}\text{<}\tau(\tilde{g})\text{<}1000~\text{s}\\ 10\text{<}\tan\beta\text{<}50\\ 0.4\text{<}\tau(\tilde{\chi}_{1}^{0})\text{<}2~\text{ns}\\ 1.5\text{<}c\tau\text{<}156~\text{mm},~\text{BR}(\mu)\text{=}1,~m(\tilde{\chi}_{1}^{0})\text{=}108~\text{GeV} \end{array}$	ATLAS-CONF-2013-069 1310.6584 ATLAS-CONF-2013-058 1304.6310 ATLAS-CONF-2013-092
RPV	$ \begin{array}{l} LFV pp \rightarrow \tilde{v}_{\tau} + X, \tilde{v}_{\tau} \rightarrow e + \mu \\ LFV pp \rightarrow \tilde{v}_{\tau} + X, \tilde{v}_{\tau} \rightarrow e(\mu) + \tau \\ Bilinear \ RPV \ CMSSM \\ \tilde{\chi}_{1}^{+} \tilde{\chi}_{1}^{-}, \tilde{\chi}_{1}^{+} \rightarrow W \tilde{\chi}_{1}^{0}, \tilde{\chi}_{1}^{0} \rightarrow e e \tilde{\nu}_{\mu}, e \mu \tilde{\nu}_{e} \\ \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} \\ \tilde{g} \rightarrow q q \\ \tilde{g} \rightarrow \tilde{t}_{1} t, \tilde{t}_{1} \rightarrow b s \end{array} $	$2 e, \mu 1 e, \mu + \tau 2 e, \mu (SS) 4 e, \mu 3 e, \mu + \tau 0 2 e, \mu (SS)$	- 	- Yes Yes Yes - Yes	4.6 4.6 20.3 20.3 20.3 20.3 20.3 20.3		1 1.1 TeV 1.35 1 750 GeV 450 GeV 916 GeV 850 GeV	1.61 TeV $\lambda'_{311}=0.10, \lambda_{132}=0.05$ $\lambda'_{311}=0.10, \lambda_{1(2)33}=0.05$ TeV $\mathbf{m}(\tilde{q})=\mathbf{m}(\tilde{g}), cT_{LSP} < 1 \text{ mm}$ $\mathbf{m}(\tilde{\chi}^0_1)>0.2\times\mathbf{m}(\tilde{\chi}^\pm_1), \lambda_{121}\neq 0$ $\mathbf{m}(\tilde{\chi}^0_1)>0.2\times\mathbf{m}(\tilde{\chi}^\pm_1), \lambda_{133}\neq 0$ $\mathbf{BR}(t)=\mathbf{BR}(b)=\mathbf{BR}(c)=0\%$	1212.1272 1212.1272 1404.2500 1405.5086 1405.5086 ATLAS-CONF-2013-091 1404.250
Other	Scalar gluon pair, sgluon $\rightarrow q\bar{q}$ Scalar gluon pair, sgluon $\rightarrow t\bar{t}$ WIMP interaction (D5, Dirac χ)	0 2 <i>e</i> ,μ (SS) 0	4 jets 2 <i>b</i> mono-jet	- Yes Yes	4.6 14.3 10.5	sgluon sgluon M* scale	100-287 GeV 350-800 GeV 704 GeV	incl. limit from 1110.2693 $m(\chi) {<} 80 \ {\rm GeV}, \ {\rm limit} \ {\rm of} {<} 687 \ {\rm GeV} \ {\rm for} \ {\rm D8}$	1210.4826 ATLAS-CONF-2013-051 ATLAS-CONF-2012-147
	Decemperate 2.2	$\sqrt{s} = 8$ TeV artial data	$\sqrt{s} = $ full	8 TeV data			1011-トリノ研究会2014 1	Mass scale [TeV]	23

*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.

ATLAS Preliminary

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

ATLAS Exotics Searches* - 95% CL Exclusion

Status: ICHEP 2014

Extra dimensions

_

Gauge bosons

5

DM

LQ

Heavy quarks

Excited fermions

Other

Model f, γ Jet Fight Jet (h-1) Mass limit Reference ADD Concression (L $2e_1$ - 12 - 0.0 8.7.764 $n=2$ 17.04641 ATACOMPANDED $n=2$ 17.04641 ATACOMPANDED $n=2$ 17.04641 ATACOMPANDED $n=2$ $n=2$ 17.04641 ATACOMPANDED $n=2$	tus: ICHEP 2014						$\int \mathcal{L} dt = (1.0 - 20.3) \text{ fb}^{-1}$	\sqrt{s} = 7, 8 TeV
ADD Conversion Conversion State State </th <th>Model</th> <th><i>ℓ</i>,γ</th> <th>Jets</th> <th>$\mathbf{E}_{\mathrm{T}}^{\mathrm{miss}}$</th> <th>∫£ dt[ft</th> <th>Mass limit</th> <th>0</th> <th>Reference</th>	Model	<i>ℓ</i> ,γ	Jets	$\mathbf{E}_{\mathrm{T}}^{\mathrm{miss}}$	∫£ dt[ft	Mass limit	0	Reference
ADD Composition (f) $2 \mu_{\mu}$ $-1 - 2$	ADD $G_{KK} + g/g$	_	1-2 i	Yes	4.7	Mp 4.37 TeV	n=2	1210.4491
ADD CoBH $1 e_{\mu}$	ADD non-resonant <i>ff</i>	2e,μ		_	20.3	Ms 5.2 TeV	n = 3 HLZ	ATLAS-CONF-2014-030
ADD Cols - 2 - 2.0 Max Set Twit $n = 6$	ADD QBH $\rightarrow \ell q$	1 e.u	1 i	_	20.3	Mth 5.2 TeV	n = 6	1311.2006
ADD B Hings N_{ab} 2 $p(8)$ - - 20.3 Max 52.7 W// 6.2 E/W $n = 6.0 = 15.7 W/rows HIP Host 000000000000000000000000000000000000$	ADD OBH	_	2 i	_	20.3	M _{th} 5.82 TeV	n = 6	to be submitted to PBD
ADD BH Inpy $\sum prime 2 + a_{e,h} = 2 + j 2 + a_{e,h} = 2 + j 2 + a_{e,h} = 1 + j 1 + a_{e,h} = 1 $	ADD BH high Next	2 µ (SS)	_,	_	20.3	Mat 57 TeV	$n = 6$ $M_{\rm D} = 1.5$ TeV, non-rot BH	1308 4075
Bit Correct M $2 e \mu$ $ -$ <td>ADD BH high $\sum p_T$</td> <td>> 1 e. u</td> <td>> 2 i</td> <td>_</td> <td>20.3</td> <td>M_{th} 6 2 TeV</td> <td>$n = 6$, $M_{\rm D} = 1.5$ TeV, non-rot BH</td> <td>1405 4254</td>	ADD BH high $\sum p_T$	> 1 e. u	> 2 i	_	20.3	M _{th} 6 2 TeV	$n = 6$, $M_{\rm D} = 1.5$ TeV, non-rot BH	1405 4254
NSI $G_{1,m} \rightarrow WW \rightarrow WV$ $2 + \mu$ $-\psi_{8}$ 2π $6 + \mu$ $123 \text{ (M}^{-1)}$ 100 (M^{-1	$BS1 G_{KK} \rightarrow \ell\ell$	2 6 11		_	20.0	Guy mass 2 68 ToV	$k/\overline{M} = 0.1$	1405 4123
Dake HS $(a_{n+1}, Z_n + r(a_n) = 21, b_n > 1/2, 1/2, 1/2, 1/2, 1/2, 1/2, 1/2, 1/2,$	$BS1 G_{KK} \rightarrow WW \rightarrow fyfy$	20,4	_	Voc	20.5		$k/\overline{M} = 0.1$	1208 2880
Dotation Description	Bulk BS $C_{WK} \rightarrow ZZ \rightarrow ffag$	2 c, µ 2 o µ	21/11	165	20.2		$k/M_{Pl} = 0.1$	ATLAS CONE 2014 020
Build Start All All All All All All All All All Al	$Duik PS G_{KK} \to ZZ \to trqq$	Ζ θ, μ	2] / 1 0	_	10.5		$\kappa/M_{Pl} = 1.0$	ATLAS-CONF-2014-039
Burk P Age (- Ft) $1 e_{\mu} = 2 h_{\mu} = 1$, $2 h_{\mu} = 1$, $3 h_{\mu} = 1$, $3 h_{\mu} = 1$, $2 h_{\mu} = 1$, $4 h_{\mu} = 1$, $2 h_{\mu} = 1$, $4 h_{\mu} = 1$	Bulk RS $G_{KK} \rightarrow HH \rightarrow bbbb$	-	4D	-	19.5		$k/M_{Pl} = 1.0$	ATLAS-CONF-2014-005
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	BUIK RS $g_{KK} \rightarrow tt$	1 e, μ	≥ 1 D, ≥ 1 J/2	≤j res	14.3	2.0 lev	BR = 0.925	ATLAS-CONF-2013-052
UED 2γ $-$ Yes 4.8 Compact scale k^{ch} 1.11 feV ATLAS-CORF-2012 d72 SSM $Z' \to t'$ $2r$ $ 2r$ $2r$ $2r$ $2r$ $4r$ $4r$ $2r$ $4r$ $4r$ $2r$ $4r$ <	S^{1}/Z_{2} ED	2 e, µ	-	_	5.0	M _{KK} ≈ R ^{-⊥} 4.71 TeV		1209.2535
$\begin{aligned} & SM 2' \rightarrow r' & 2 & \mu & - & - & - & 20.3 \\ SSM 2' \rightarrow r' & 2 & - & - & - & 19.5 \\ SSM 2' \rightarrow r' & 2 & - & - & 19.5 \\ SSM 2' \rightarrow r' & 2 & - & - & 19.5 \\ SSM 2' \rightarrow r' & 2 & - & - & 19.5 \\ SSM 2' \rightarrow r' & 2 & - & - & 19.5 \\ SSM 2' \rightarrow r' & 2 & - & - & 19.5 \\ SSM 2' \rightarrow r' & 2 & - & - & 19.5 \\ SSM 2' \rightarrow r' & 2 & - & - & 19.5 \\ SSM 2' \rightarrow r' & 2 & - & - & 19.5 \\ SSM 2' \rightarrow r' & 2 & - & - & 19.5 \\ SSM 2' \rightarrow r' & 2 & - & - & 19.5 \\ SSM 2' \rightarrow r' & 2 & - & - & 19.5 \\ SSM 2' \rightarrow r' & 2 & - & - & 19.5 \\ SSM 2' \rightarrow r' & 2 & - & - & 19.5 \\ SSM 2' \rightarrow r' & 2 & - & - & 19.5 \\ SSM 2' \rightarrow r' & 2 & - & - & 2.1 \\ SSM 2'' \rightarrow r' & 2 & - & - & 2.1 \\ SSM 2'' \rightarrow r' & 2 & - & - & 2.1 \\ SSM 2'' \rightarrow r' & 2 & - & - & 2.1 \\ SSM 2'' \rightarrow r' & 2 & - & - & 2.1 \\ SSM 2'' \rightarrow r' & 2 & - & - & 2.1 \\ SSM 2'' \rightarrow r' & 2 & - & - & 2.1 \\ SSM 2'' \rightarrow r' & 2 & - & - & 2.1 \\ SSM 2'' \rightarrow r' & 2 & - & - & 2.1 \\ SSM 2'' \rightarrow r' & 2 & - & - & 2.1 \\ SSM 2'' \rightarrow r' & 2 & - & - & 2.1 \\ SSM 2'' \rightarrow r' & 2 & - & - & 2.1 \\ SSM 2'' \rightarrow r' & - & - & 2.1 \\ SSM 2'' \rightarrow r' & - & - & 2.1 \\ SSM 2'' \rightarrow r' & - & - & 2.1 \\ SSM 2'' \rightarrow r'' & 2 & - & - & 2.1 \\ SSM 2'' \rightarrow r'' & 2 & - & - & 2.1 \\ SSM 2'' \rightarrow r'' & - & - & 2.1 \\ SSM 2'' \rightarrow r'' & - & - & 2.1 \\ SSM 2'' \rightarrow r'' & - & - & 2.1 \\ SSM 2'' \rightarrow r'' & - & - & 1.0 \\ SSM 2'' \rightarrow r'' & - & - & 1.0 \\ SSM 2'' \rightarrow r'' & - & - & 1.0 \\ SSM 2'' \rightarrow r'' & - & - & 1.0 \\ SSM 2'' \rightarrow r'' & - & - & 1.0 \\ SSM 2'' \rightarrow r'' & - & - & 1.0 \\ SSM 2'' \rightarrow r'' & - & - & 1.0 \\ SSM 2'' \rightarrow r'' & - & - & 1.0 \\ SSM 2'' \rightarrow r'' & - & - & 1.0 \\ SSM 2'' \rightarrow r'' & - & - & 1.0 \\ SSM 2'' \rightarrow r'' & - & - & 1.0 \\ SSM 2'' \rightarrow r'' & - & - & 1.0 \\ SSM 2'' \rightarrow r'' & - & - & 1.0 \\ SSM 2'' \rightarrow r'' & - & - & 1.0 \\ SSM 2'' \rightarrow r'' & - & - & 1.0 \\ SSM 2'' \rightarrow r'' & - & - & 1.0 \\ SSM 2'' \rightarrow r'' & - & - & 1.0 \\ SSM 2'' \rightarrow r'' & - & - & 1.0 \\ SSM 2'' \rightarrow r'' & - & - & 1.0 \\ SSM 2'' \rightarrow r''' & - & - & 1.0 \\ SSM 2'' \rightarrow r''' & - & - & 1.0 \\ SSM 2'' \rightarrow r''' & - & - & 1.0 \\ SSM 2'' \rightarrow r''' & - & - & 1.0 \\ SSM 2'' \rightarrow r'''' & - & - & 1.0 \\ SSM 2'' \rightarrow r''''' & - & - & 1.0 \\ SSM 2'' \rightarrow r''''' & - & - & 1.0 \\ SSM 2'' \rightarrow r''''' & - & - & 1.0 \\ SSM 2'' \rightarrow r'''''''''''''''''''''''''$	UED	2γ	_	Yes	4.8	Compact. scale R ⁻¹ 1.41 TeV		ATLAS-CONF-2012-072
SSM $U' \rightarrow r$ 2 τ - - 15.7 Z max 1.9 TeV ATLAS-CONF-201-007 SSM $U' \rightarrow v'$ 1 e, μ 2 v_{μ} 2/1 J - Vis a 3.2 TeV ATLAS-CONF-201-007 MTLAS-CONF-201-007 EGM $W' \rightarrow WZ \rightarrow tr /t'$ 3 e, μ 2/1 J - Vis a 1.5 TeV $\pi - H$ ATLAS-CONF-201-007 EGM $W' \rightarrow WZ \rightarrow tr /t'$ 3 e, μ 2/1 J - Vis a 1.5 TeV $\pi - H$ ATLAS-CONF-201-008 $\pi - H$ ATLAS-CONF-201-008 $\pi - H$ $\pi $	SSM $Z' \to \ell \ell$	2 e, µ	-	-	20.3	Z' mass 2.9 TeV		1405.4123
SSM $W'_{r} \rightarrow (r)$ 1 e, μ - Yes 20.3 W mass 328 TeV MAS-COM-2014071 Autor (M-2) Autor (M-2) <td>SSM $Z' \rightarrow \tau \tau$</td> <td>2 τ</td> <td>-</td> <td>-</td> <td>19.5</td> <td>Z' mass 1.9 TeV</td> <td></td> <td>ATLAS-CONF-2013-066</td>	SSM $Z' \rightarrow \tau \tau$	2 τ	-	-	19.5	Z' mass 1.9 TeV		ATLAS-CONF-2013-066
EGM W' - WZ $- fv (t')$ 3 e, μ - Yes 203 W mass 152 TeV Muss 160 A456 EGM W' - WZ $- qq(t')$ 2 e, μ 2 b, 0 - 1 j Yes 203 W mass 159 TeV All A500 MP 201 020 A115 MP 201	SSM $W' \to \ell v$	1 e, µ	-	Yes	20.3	W' mass 3.28 TeV		ATLAS-CONF-2014-017
EGM $W_{ij} \rightarrow b\bar{b}$ $2 e_{ij} + 2j/1J = -203$ W mass 1.58 TeV ATLAS-CONF-2013-090 LRSM $W_{ij} \rightarrow b\bar{b}$ $0 e_{ij} + 2b, 1J - 203$ W mass 1.84 TeV ATLAS-CONF-2013-090 LRSM $W_{ij} \rightarrow b\bar{b}$ $0 e_{ij} + 2b, 1J - 203$ W mass 1.84 TeV ATLAS-CONF-2013-090 Cl qq/q $-2j$ -48 A 7.5 TeV $n = +1$ 1210.1718 ATLAS-CONF-2013-090 $0 e_{ij} + 2b$ $1b < 2i + 2i + 2i$ A A 216 TeV $n = +1$ ATLAS-CONF-2014-090 Cl qq/l $2 e_{ij}$ (S) $2 b > 2 b > 2 $ N ATLAS-CONF-2014-090 ATLAS-CONF-2014-090 ATLAS-CONF-2014-090 EFT D5 operator (Dirac) $0 e_{ij}$ $12j$ Yes 10.5 M. 24 TeV at 50% CL br $m(z) < 60$ GeV ATLAS-CONF-2012-147 Scalar LO 2 ^{id} gen $2 \mu \geq 2j$ -1 10.0 mass 688 GeV $\beta = 1$ 1124828 32 3 TeV 112 4828 32 3 TeV 112 4828 32 3 TeV 112 4828 32 3 TeV 112 3 3 3 TeV 112 3 3 3 TeV	EGM $W' \to WZ \to \ell_V \ell' \ell'$	3 e, µ	_	Yes	20.3	W' mass 1.52 TeV		1406.4456
Instruction 1 $\mu = 2$ 2 0 1 $\mu = 2$ 2 0 $\mu = 1$ $\pi LAS = CONF-2519.655$ $b = summlet = EPL$ LBSM $W'_{R} \rightarrow t5$ 0 $e, \mu \geq 15$ 0 $e, \mu \geq 15$ 1 $\mu = 1$ $\pi LAS = CONF-2519.655$ $b = summlet = EPL$ $a = 1$	EGM $W' \to WZ \to aa\ell\ell$	2 e. µ	2i/1J	_	20.3	W' mass 1 59 TeV		ATLAS-CONE-2014-039
Liss M $w_{k}^{n} + 15$ 0 e_{μ} 21 b 1 4 203 W mass 177 TeV Iso and the formation of the submitted to EPUC Cl qqq - 2 - 4.8 A 21.6 TeV n_{LL} 121.0178 Cl qqq 2 e., μ (Sb) 2 b. 2 J Ys 1.3 A 3.3 TeV ICI = 1 ATLAS CORF-2014-06 Cl qqq 0 e., μ 1.2 j Ys 10.5 M. 7.3 i GeV at 90% CL for $m(x) < 80 GeV$	$LBSM W' \rightarrow t\overline{b}$	1 <i>e µ</i>	2 h 0-1 i	Vas	14.3	W/ mass 184 TeV		ATLAS-CONE-2013-050
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	$LBSM W'_R \rightarrow tb$	0eu	>1h1.	-	20.3			to be submitted to EP IC
Cl qaqq - 2 = k + 2		00, μ	210,10		20.0			to be submitted to Er bo
Cl $qd\ell$ $2 e, \mu$ $ 2$ A $TLAS-CONF-2014-030$ Cl $uutt$ $2 e, \mu$ (S) $\geq 1 b, \geq 1 j$ Ves 14.3 A 3.3 TeV $ C = 1$ $ATLAS-CONF-2014-030$ EFT D5 operator (Dirac) $0 e, \mu$ $1.j \leq 1 j$ Yes 20.3 M 731 GeV $at 90\%$ CL for $m(\chi) < 80 \text{ GeV}$ $ATLAS-CONF-2014-030$ Scalar LQ ¹⁴ gen $2 e$ $\geq 2 j$ $ 10$ LO mass 6600 GeV $\beta = 1$ $at 90\%$ CL for $m(\chi) < 80 \text{ GeV}$ $ATLAS-CONF-2014-030$ Scalar LQ ²⁴ gen $2 e$ $\geq 2 j$ $ 10$ LO mass 6600 GeV $\beta = 1$ 11124288 13030526 Scalar LQ ²⁴ gen $2 e$ $\geq 2 j$ $ 10$ LO mass 6600 GeV $\beta = 1$ 11024326 12033172	CI qqqq	-	2 j	-	4.8	۸ 7.6 TeV	$\eta=+1$	1210.1718
Cl $uutt$ 2 e, μ (SS) ≥ 1 b, ≥ 1 Yes 14.3 A 3.3 TeV IC1=1 ATLAS-CONF-2013-051 EFT D5 operator (Dirac) 0 e, μ 1.2 i j Yes 10.5 M. 731 GeV at 90% CL for $m(\chi) < 80$ GeV ATLAS-CONF-2012-051 EFT D5 operator (Dirac) 0 e, μ 1.3 ≤ 1 j Yes 20.5 M. 731 GeV at 90% CL for $m(\chi) < 80$ GeV ATLAS-CONF-2012-051 Scalar LQ 2 rd gen 2 $e \mu$ ≥ 2 j - 1.0 LO mass 660 GeV $\beta = 1$ at 90% CL for $m(\chi) < 100$ GeV TIAS-CONF-2013-051 Scalar LQ 2 rd gen 2 $e \mu$ ≥ 2 j - 1.0 LO mass 534 GeV $\beta = 1$ 100 mass 685 GeV $\beta = 1$ 100 mass 685 GeV $\beta = 1$ 100 mass 685 CeV $\beta = 1$ 100 mass 680 CeV $\beta = 1$ 100 mass	Cl qqℓℓ	2 e, µ	-	-	20.3	٨	21.6 TeV $\eta_{LL} = -1$	ATLAS-CONF-2014-030
EFT D5 operator (Dirac) 0 e, μ 1-2 yes 10.5 M. 731 GeV at 90% CL for $m(\chi) < 80 GeV$ ATLAS-CONF-2012-147 Scalar L0 1 st gen 2 e 2.3 - 1.0 L0 mass 660 GeV $\beta = 1$ 1112-428 1109% CL for $m(\chi) < 80 GeV$ ATLAS-CONF-2012-147 Scalar L0 2 ^{std} gen 2 $k \ge 2$ - 1.0 L0 mass 660 GeV $\beta = 1$ 1112-428 1109% CL for $m(\chi) < 80 GeV$ $\beta = 1$ 1112-428 Scalar L0 3 ^{std} gen 1 $\mu = k \ge 2$ j - 1.0 L0 mass 534 GeV $\beta = 1$ 1112-428 11030.626 Vector-like quark $TT \rightarrow Ht + X$ 1 $\mu, \mu \ge 2$ k j mass 670 GeV Tin (T.B) doublet ATLAS-CONF-2013-018 Vector-like quark $BT \rightarrow Xb + X$ 2.8, $\mu \ge 22/z$ b - 20.3 Timass 735 GeV Tin (T.B) doublet ATLAS-CONF-2013-018 Vector-like quark $B \rightarrow Zb + X$ 2.9, $\mu \ge 2/z$ b - 20.3 Timass 725 GeV Tin (T.B) doublet ATLAS-CONF-2013-038 Vector-like quark $B \rightarrow Wt + X$ 2.9, $\mu \ge 2/$	CI uutt	2 e, μ (SS)	≥ 1 b, ≥ 1 j	Yes	14.3	Λ 3.3 TeV	C = 1	ATLAS-CONF-2013-051
EFT D9 operator (Dirac) 0 e, μ 1 d, 5 1 j Vois M. 2.4 TeV at 90% CL for $m(x) < 100 \text{ GeV}$ 130e, 4017 Scalar LQ ¹⁴ gen 2 e 2 j - 1.0 L0 mass 660 GeV $\beta = 1$ 1112.4828 Scalar LQ ²⁴ gen 2 μ 2 j - 1.0 L0 mass 685 GeV $\beta = 1$ 1303.0562 Scalar LQ ²⁴ gen 1 e, μ , 1 τ 1 b, j - 4.7 L0 mass 534 GeV $\beta = 1$ 1303.0563 Scalar LQ ²⁴ gen 1 e, μ , 1 τ 1 b, 2 j - 2.0 ATLAS-CONF-2013.018 ATLAS-CONF-2013.018 Vector-like quark $TT \rightarrow Wb + X$ 1 e, μ 2 b, 2 j - 2.0.3 T mass 735 GeV Tin (T.B) doublet ATLAS-CONF-2013.018 Vector-like quark $TT \rightarrow Wb + X$ 1 e, μ 2 b, 2 j - 2.0.3 T mass 735 GeV Bin (B.Y) doublet ATLAS-CONF-2013.018 Vector-like quark $T \rightarrow \chi^2 + X$ 2/2 a, μ 2/2 - b 2.0.3 T mass 720 GeV Tin (T.B) doublet ATLAS-CONF-2013.020 Excited quark $q^+ \rightarrow qq$ 1 y 1 j - 2	EET D5 operator (Dirac)	0 e.u	1-2 i	Yes	10.5	M. 731 GeV	at 90% CL for $m(y) < 80$ GeV	ATLAS-CONF-2012-147
Let to operation (bits) C + \mu Find the point of	EET D9 operator (Dirac)	0 e u	1.l < 1 i	Vae	20.3		at 90% CL for $m(\chi) < 100$ GeV	1309 4017
Scalar LQ 1st gen 2 e $\geq 2 $ - 1.0 LQ mass 660 GeV $\beta = 1$ 11124828 Scalar LQ 2nd gen 2μ $\geq 2 $ - 1.0 LQ mass 660 GeV $\beta = 1$ 1124828 Scalar LQ 3rd gen 1 e, μ , 1τ 1 b, $1 j$ - 4.7 LQ mass 685 GeV $\beta = 1$ 1124828 Vector-like quark $TT \rightarrow Ht + X$ 1 e, $\mu \geq 2b, \geq 4j$ Yes 1.4.3 T mass 790 GeV Tin (T.B) doublet ATLAS-CONF-2013-018 Vector-like quark $TT \rightarrow Wb + X$ 1 e, $\mu \geq 2b, \geq 4j$ Yes 1.4.3 T mass 735 GeV Bin (R.Y) doublet ATLAS-CONF-2014-036 Vector-like quark $B \rightarrow Wt + X$ $2e, \mu \geq 2b_{2} = b, \mu \geq 2$		0.01		100	20.0			1000.4017
Scalar LQ 2 nd gen 2μ 22 j $ 10$ L0 mass 685 GeV $\beta = 1$ 1203.3172 Scalar LQ 3 rd gen $1e, \mu, 1\tau$ $1b, 1j$ $ 4.7$ L0 mass 534 GeV $\beta = 1$ 1203.3172 Scalar LQ 3 rd gen $1e, \mu, 1\tau$ $1b, 1j$ $ 4.7$ L0 mass 534 GeV $\beta = 1$ 1203.3172 Vector-like quark $TT \rightarrow Ht + X$ $1e, \mu, 2b, 24j$ $ie, \mu, 2b, 2j$ $ie, \mu, 2b, 2j$ <td>Scalar LQ 1st gen</td> <td>2 e</td> <td>≥ 2 j</td> <td>-</td> <td>1.0</td> <td>LQ mass 660 GeV</td> <td>eta=1</td> <td>1112.4828</td>	Scalar LQ 1 st gen	2 e	≥ 2 j	-	1.0	LQ mass 660 GeV	eta=1	1112.4828
Scalar LQ 3rd gen 1 e, μ , 1 τ 1 b, 1 j - 4.7 LO mass 534 GeV $\beta = 1$ 1933.0526 Vector-like quark $TT \to Ht + X$ 1 e, μ 2 b, 2 d, j yes 14.3 T mass 790 GeV isospin singlet ATLAS-CONF-2013-060 Vector-like quark $TT \to Wb + X$ 1 e, μ 2 l, b 2 d, j yes 14.3 T mass 670 GeV isospin singlet ATLAS-CONF-2013-060 Vector-like quark $TT \to Wb + X$ 1 e, μ 2 l, b 2 d, j yes 14.3 T mass 670 GeV isospin singlet ATLAS-CONF-2013-060 Vector-like quark $TT \to Wb + X$ 1 e, μ , 1 y - 20.3 B mass 735 GeV B in (B) doublet ATLAS-CONF-2014-036 Vector-like quark $g^* \to qy$ 1 y 1 j - 20.3 B mass 720 GeV B in (B) doublet ATLAS-CONF-2013-061 Excited quark $q^* \to qy$ 1 y 1 j - 20.3 q* mass 720 GeV only u* and d*, A = m(q*) only u* and d*, A = m(q*) 1309.3230 to be submitted to PRD 1309.3230 to be submitted to PRD 1301.533 1308.1584 1308.1584 1308.1584 1308.158	Scalar LQ 2 nd gen	2 μ	≥ 2 j	-	1.0	LQ mass 685 GeV	eta=1	1203.3172
Vector-like quark $TT \rightarrow Ht + X$ $1 e, \mu \ge 2 b, \ge 4 j$ Yes 14.3 T massT mass790 GeVVector-like quark $TT \rightarrow Wb + X$ $1 e, \mu \ge 1 b, \ge 3 j$ Yes 14.3 T mass 670 GeV T in (T,B) doubletATLAS-CONF-2013-080Vector-like quark $Bb \rightarrow Zb + X$ $2/2 s, \mu \ge 2/2$ i b $ 20.3$ B mass 735 GeV B in (B,Y) doubletATLAS-CONF-2013-080Vector-like quark $Bb \rightarrow Zb + X$ $2/2 s, \mu \ge 2/2$ i b $ 20.3$ B mass 735 GeV B in (B,Y) doubletATLAS-CONF-2013-080Vector-like quark $q^* \rightarrow qp$ 1γ $1 j$ $ 20.3$ B mass 720 GeV B in (B,Y) doubletATLAS-CONF-2013-080Excited quark $q^* \rightarrow qq$ 1γ $1 j$ $ 20.3$ B mass 720 GeV B in (B,Y) doubletATLAS-CONF-2013-080Excited quark $q^* \rightarrow qq$ $ 2 j$ $ 20.3$ q^* mass 720 GeV B in (T,B) doubletATLAS-CONF-2013-080Excited quark $q^* \rightarrow qq$ 1γ $ 20.3$ q^* mass 3.5 TeV only u^* and $d^*, \Lambda = m(q^*)$ $000 u^*$ and $d^*, \Lambda = m(q^*)$ $100 u^*$ and $d^*, \Lambda = m(q^*)$ Excited quark $q^* \rightarrow qq$ $1 \circ 2 e, \mu, 1 \gamma$ $ 130$ $7 mass$ 3.5 TeV $000 u^*$ and $d^*, \Lambda = m(q^*)$ 1309.320 Excited quark $b^* \rightarrow Wt$ $1 \circ 2 e, \mu, 1 \gamma$ $ 130$ $7 mass$ 2.2 TeV $\Lambda = 2.2 \text{ TeV}$ $\Lambda = 2.0 \text{ electro-like quark } 000 \text{ electro-like quark } 000 \text{ electro-like quark } 0000 \text{ electro-like quark } 000000$	Scalar LQ 3 rd gen	1 e, μ, 1 τ	1 b, 1 j	-	4.7	LQ mass 534 GeV	eta=1	1303.0526
Vector-like quark $TT \rightarrow Wb + X$ $1 e, \mu \ge 1 b, \ge 3 j$ Yes 14.3 T mass670 GeVisospin singletATLAS-CONF-2013-060Vector-like quark $TT \rightarrow Zt + X$ $2/23 e, \mu \ge 2/21 b$ $ 20.3$ T mass735 GeVB in (T, B) doubletATLAS-CONF-2014-036Vector-like quark $BB \rightarrow Zb + X$ $2/23 e, \mu \ge 2/21 b$ $ 20.3$ B mass755 GeVB in (B, Y) doubletATLAS-CONF-2014-036Vector-like quark $A^* \rightarrow qq$ 1γ $1 j$ $ 20.3$ G mass720 GeVB in (B, Y) doubletATLAS-CONF-2014-036Excited quark $q^* \rightarrow qq$ 1γ $1 j$ $ 20.3$ G mass720 GeVOnly u^* and $d^*, \Lambda = m(q^*)$ 1309.3200 Excited quark $q^* \rightarrow qq$ $ 2 j$ $ 20.3$ G mass 3.5 TeVOnly u^* and $d^*, \Lambda = m(q^*)$ 1309.3200 Excited quark $b^* \rightarrow Wt$ $1 o 2 e, \mu, 1 j$ $ 13.0$ T mass 870 GeV $0 nly u^*$ and $d^*, \Lambda = m(q^*)$ 1309.3200 Excited quark $b^* \rightarrow Wt$ $1 o 2 e, \mu, 1 j$ $ 13.0$ T mass 870 GeV $nl (W_R) = 2$ TeV $N = 2.2$ TeVExcited quark $b^* \rightarrow Wy$ $1 e, \mu, 1 j$ $ 10 mass$ 1.5 TeV $m mass$ 1.5 TeV $nl (W_R) = 2$ TeV, no mixing $10 20.542$ LISS Majorana v $2 e, \mu$ $2 j$ $ 2.1$ N^m mass 245 GeV $m(W_R) = 2$ TeV, no mixing 120.562 Multi-charged particles $ 4.7$ $m(W_R) = 2$	Vector-like quark $TT \rightarrow Ht + X$	1 e, µ	≥ 2 b, ≥ 4 j	Yes	14.3	T mass 790 GeV	T in (T,B) doublet	ATLAS-CONF-2013-018
Vector-like quark $TT \rightarrow Zt + X$ $2/2$ 3 $e, \mu \geq 2/2$ 1 b c 20.3 T mass 735 GeVT in (T,B) doubletATLAS-CONF-2014-036Vector-like quark $BB \rightarrow Zb + X$ $2/2$ 3 $e, \mu \geq 2/2$ 1 b $ 20.3$ B mass 755 GeVB in (B,Y) doubletATLAS-CONF-2014-036Vector-like quark $BB \rightarrow Wt + X$ $2 e, \mu$ (SS) ≥ 1 b, ≥ 1 jYes14.3B mass 720 GeVonly u^* and $d^*, \Lambda = m(q^*)$ $TLAS-CONF-2013-051$ Excited quark $q^* \rightarrow qg$ $ 2$ j $ 20.3$ q^* mass 3.5 TeVonly u^* and $d^*, \Lambda = m(q^*)$ 1309.3230 Excited quark $b^* \rightarrow Wt$ 1 or $2 e, \mu$ 1 b, 2 j or 1 jYes 4.7 b^* mass 870 GeVonly u^* and $d^*, \Lambda = m(q^*)$ 1309.3230 Excited quark $b^* \rightarrow Wt$ 1 or $2 e, \mu$ 1 b, 2 j or 1 jYes 4.7 b^* mass 870 GeVonly u^* and $d^*, \Lambda = m(q^*)$ 1309.3230 Excited lepton $\ell^* \rightarrow \ell\gamma$ $2 e, \mu, 1 \gamma$ $ 13.0$ ℓ^* mass 2.2 TeV $\Lambda = 2.2$ TeV $\Lambda = 2.2$ TeVLSC $a_T \rightarrow W\gamma$ $1 e, \mu, 1 \gamma$ $-$ Yes 20.3 a_T mass 260 GeV $m(W_R) = 2$ TeV, no mixing 1308.1364 LSC $a_T \rightarrow W\gamma$ $1 e, \mu, 1 \gamma$ $ 5.8$ N^* mass 245 GeV $m(W_R) = 2$ TeV, no mixing $10 e, \dots e - e - e - e - e - e - e - e - e - e$	Vector-like quark $TT \rightarrow Wb + X$	(1 <i>e</i> ,μ	$\geq 1 \text{ b}, \geq 3 \text{ j}$	Yes	14.3	T mass 670 GeV	isospin singlet	ATLAS-CONF-2013-060
Vector-like quark $BB \rightarrow Zb + X$ $2p_{2}$ 1 b $2p_{2}$	Vector-like quark $TT \rightarrow Zt + X$	2/>3 e. u	>2/>1 b	_	20.3	T mass 735 GeV	T in (T.B) doublet	ATLAS-CONF-2014-036
Note of the constrained quark $BB \rightarrow Wt + X = 2 e, \mu$ (S) $\geq 1 b, \geq 1 j$ Yes14.3B mass720 GeVB mile (F) God (F)ATLAS-CONF-2013-051Excited quark $g^* \rightarrow qy$ 1 γ 1 j -20.3q mass3.5 TeVonly u^* and d^* , $\Lambda = m(q^*)$ 1309.3230Excited quark $g^* \rightarrow qy$ -2 j -20.3q mass870 GeVonly u^* and d^* , $\Lambda = m(q^*)$ 1309.3230Excited quark $b^* \rightarrow Wt$ 1 or $2 e, \mu$ 1 $b, 2$ j or 1 j Yes4.3 f^* mass870 GeVonly u^* and d^* , $\Lambda = m(q^*)$ 1309.3230Excited lepton $\ell^* \rightarrow \ell\gamma$ 2 $e, \mu, 1 \gamma$ 13.0 ℓ^* mass870 GeVonly u^* and d^* , $\Lambda = m(q^*)$ 1309.3230LSC $a_T \rightarrow W\gamma$ 1 $e, \mu, 1 \gamma$ -Yes20.3a mass870 GeV $\Lambda = 2.2$ TeV1308.1364LSC $a_T \rightarrow W\gamma$ 1 $e, \mu, 1 \gamma$ -Yes20.3a mass960 GeV $\Lambda = (-2, 1)^{1/2} M' $	Vector-like quark $BB \rightarrow Zb + X$	2/>3 e //	>2/>1 h	_	20.3	B mass 755 GeV	B in (B.Y) doublet	ATLAS-CONE-2014-036
Excited quark $q^* \rightarrow qy$ 1 y1 j-20.3q* mass3.5 TeVonly u* and d*, $\Lambda = m(q^*)$ 1309.3230Excited quark $q^* \rightarrow qg$ -2 j-20.3q* mass870 GeVonly u* and d*, $\Lambda = m(q^*)$ to be submitted to PRDExcited quark b* \rightarrow Wt1 or $2e, \mu$ 1 b, 2 j or 1 j Yes4.7b* mass870 GeVeth-handed coupling1301.1583Excited lepton $\ell^* \rightarrow \ell y$ $2e, \mu, 1 \gamma$ 13.0the mass960 GeV $\Lambda = 2.2 \text{ TeV}$ 100 be submitted to PRDLSTC $a_T \rightarrow W\gamma$ $1e, \mu, 1 \gamma$ -Yes20.3ar mass960 GeV $\Lambda = 2.2 \text{ TeV}$ to be submitted to PLBLRSM Majorana v $2e, \mu$ $2j$ -2.1 N^0 mass1.5 TeV $m(W_R) = 2 \text{ TeV}, no mixing$ to be submitted to PLBHiggs triplet $H^{\pm\pm} \rightarrow \ell \ell$ $2e, \mu$ $2e, \mu$ 4.7 $H^{\pm\pm}$ mass409 GeV $M'''' mass$ 1.5 TeV $M''''''''''''''''''''''''''''''''''''$	Vector-like quark $BB \rightarrow Wt + X$	2 e, µ (SS)	≥ 1 b, ≥ 1 j	Yes	14.3	B mass 720 GeV	B in (T,B) doublet	ATLAS-CONF-2013-051
Excited quark $q \rightarrow qy$ 1 y1 j-20.3q mass3.5 TeVonly u and σ , $h = m(q')$ 1309.3230Excited quark $q^* \rightarrow qg$ -2 j-20.3q' mass4.09 TeVonly u^* and d^* , $h = m(q')$ to be submitted to PRDExcited quark $b^* \rightarrow Wt$ 1 or $2 e, \mu$ 1 b, 2 j or 1 j Yes4.7b' mass870 GeVleft-handed coupling1301.1583Excited lepton $\ell^* \rightarrow \ell \gamma$ 2 $e, \mu, 1 \gamma$ 13.0 ℓ' mass960 GeV $h = 2.2 \text{ TeV}$ $h = 2.2 \text{ TeV}$ 1308.1364LSTC $a_T \rightarrow W\gamma$ 1 $e, \mu, 1 \gamma$ -Yes20.3ar mass960 GeV $m(W_R) = 2 \text{ TeV}$, no mixing1308.1364LRSM Majorana v 2 e, μ 2 j-2.1N ⁰ mass1.5 TeV $m(W_R) = 2 \text{ TeV}$, no mixing1203.5420Type III Seesaw2 e, μ 2 e, μ 5.8N [±] mass245 GeV $m(W_R) = 2 \text{ TeV}$, no mixing1203.5420Multi-charged particles4.4N [±] mass409 GeVDY production, $ R = 4e$ 1210.5070Multi-charged particles2.0monopole mass862 GeVDY production, $ g = 1 g_D$ 1301.5272December.22.2014 $\sqrt{s} = 7 \text{ TeV}$ $\sqrt{s} = 8 \text{ TeV}$ $\sqrt{s} = 8 \text{ TeV}$ 1024	Fuelded events at a	4						
Excited quark $q^{-} \rightarrow qg$ -2]-20.3q mass4.09 revonly u^{*} and d^{*} , $A = m(q^{*})$ to be submitted to PRDExcited quark $b^{*} \rightarrow Wt$ 1 or $2e, \mu$ 1 b, 2 j or 1 j Yes4.7b mass870 GeVleft-handed coupling1301.1583Excited lepton $\ell^{*} \rightarrow \ell\gamma$ $2e, \mu, 1 \gamma$ 13.0 ℓ^{*} mass960 GeV $A = 2.2 \text{ TeV}$ 1008.1364LSTC $a_{T} \rightarrow W\gamma$ $1e, \mu, 1 \gamma$ -Yes20.3at mass960 GeV $M(W_R) = 2 \text{ TeV}$, no mixing1308.1364LSTC $a_{T} \rightarrow W\gamma$ $1e, \mu, 1 \gamma$ -Yes20.3at mass960 GeV $m(W_R) = 2 \text{ TeV}$, no mixing1203.5420LRSM Majorana v $2e, \mu$ 2 i-2.1N ⁰ mass1.5 TeV $m(W_R) = 2 \text{ TeV}$, no mixing1203.5420Higgs triplet $H^{\pm\pm} \rightarrow \ell\ell$ $2e, \mu$ (SS)4.7H^{\pm} mass409 GeVDY production, BR($H^{\pm\pm} \rightarrow \ell\ell$)=1DY production, $ q = 4e$ Multi-charged particles4.4multi-charged particle mass490 GeVDY production, $ g = 1g_D$ 1207.6411December.22.2014 $\sqrt{s} = 7 \text{ TeV}$ $\sqrt{s} = 8 \text{ TeV}$ $\sqrt{s} = 8 \text{ TeV}$ $\sqrt{s} = 8 \text{ TeV}$ 24	Excited quark $q \rightarrow q\gamma$	Γγ	1]	-	20.3	q mass 3.5 lev	only u and a, $\Lambda = m(q)$	1309.3230
Excited quark $b^{2} \rightarrow Wt$ 1 or $2e, \mu$ 1 b, $2j$ or 1 j Yes4.7b* mass870 GeVleft-handed coupling1301.1583Excited lepton $\ell^{*} \rightarrow \ell\gamma$ $2e, \mu, 1\gamma$ 13.0 ℓ^{*} mass2.2 TeV $\Lambda = 2.2$ TeV1308.1364LSTC $a_{T} \rightarrow W\gamma$ $1e, \mu, 1\gamma$ -Yes20.3 a_{T} mass960 GeV $M_{R}(w_{R}) = 2$ TeV, no mixing1501.1583LRSM Majorana v $2e, \mu$ $2j$ -2.1 N^{0} mass1.5 TeV $m(W_{R}) = 2$ TeV, no mixing10 be submitted to PLBLRSM Majorana v $2e, \mu$ $2e, \mu$ 5.8 N^{*} mass245 GeV $m(W_{R}) = 2$ TeV, no mixing1203.5420Higgs triplet $H^{\pm\pm} \rightarrow \ell\ell$ $2e, \mu$ (SS)4.7 $H^{\pm\pm}$ mass409 GeVDY production, $BR(H^{\pm\pm} \rightarrow \ell) = 1$ DY production, $ q = 4e$ DY production, $ q = 4e$ 10	Excited quark $q^* \rightarrow qg$	-	2]		20.3	q* mass 4.09 TeV	only u^* and d^* , $\Lambda = m(q^*)$	to be submitted to PRD
Excited lepton $l^* \rightarrow l\gamma$ $2e, \mu, 1\gamma$ $ 13.0$ l^* mass 2.2 TeV $\Lambda = 2.2 \text{ TeV}$ $\Lambda = 2.2 \text{ TeV}$ 1308.1364 LSTC $a_T \rightarrow W\gamma$ $1e, \mu, 1\gamma$ $ Yes$ 20.3 a_T mass 960 GeV $m(W_R) = 2 \text{ TeV}, no mixing$ to be submitted to PLBLRSM Majorana ν $2e, \mu$ $2j$ $ 2.1$ N^0 mass 1.5 TeV $m(W_R) = 2 \text{ TeV}, no mixing$ 1203.5420 Type III Seesaw $2e, \mu$ $ 5.8$ N^{\pm} mass 245 GeV DY production, $BR(H^{\pm\pm} \rightarrow \ell)=1$ DY production, $BR(H^{\pm\pm} \rightarrow \ell)=1$ 120.5070 Higgs triplet $H^{\pm\pm} \rightarrow \ell\ell$ $2e, \mu$ (SS) $ 4.4$ multi-charged particle mass 409 GeV DY production, $ q = 4e$ DY production, $ q = 1g_D$ 1207.6411 December, 22, 2014 $\sqrt{s} = 7 \text{ TeV}$ $\sqrt{s} = 8 \text{ TeV}$ $\sqrt{s} = 8 \text{ TeV}$ $10^{-T} = -1^{-1} U/UTTS 2014110^{-T} = -1^{-1} 24$	Excited quark $b^* \rightarrow VVt$	1 or 2 e, μ	1 b, 2 j or 1	j Yes	4.7	b* mass 870 GeV	left-handed coupling	1301.1583
LSTC $a_T \rightarrow W\gamma$ 1 $e, \mu, 1\gamma$ - Yes 20.3 at mass 960 GeV LRSM Majorana ν 2 e, μ 2 j - 2.1 N ⁰ mass 1.5 TeV Type III Seesaw 2 e, μ 5.8 N [±] mass 245 GeV Higgs triplet $H^{\pm\pm} \rightarrow \ell\ell$ 2 e, μ (SS) 4.7 H ^{\pm\pm} mass 409 GeV Multi-charged particles 4.4 multi-charged particle mass 490 GeV Magnetic monopoles 2.0 monopole mass 862 GeV December .22.2014 $\sqrt{s} = 7 \text{ TeV}$ $\sqrt{s} = 8 \text{ TeV}$ $\sqrt{s} = 0.2 \text{ TeV}$	Excited lepton $\ell^* \to \ell \gamma$	2 e, μ, 1 γ	-	-	13.0	<i>l</i> * mass 2.2 TeV	$\Lambda = 2.2 \text{ TeV}$	1308.1364
LRSM Majorana v 2 e, μ 2 j - 2.1 N ⁰ mass 1.5 TeV $m(W_R) = 2$ TeV, no mixing 1203.5420 Type III Seesaw 2 e, μ - - 5.8 N [±] mass 245 GeV $m(W_R) = 2$ TeV, no mixing ATLAS-CONF-2013-019 Higgs triplet $H^{\pm\pm} \rightarrow \ell\ell$ 2 $e, \mu(SS)$ - - 4.7 H ^{±±} mass 409 GeV DY production, BR($H^{\pm\pm} \rightarrow \ell \ell$)=1 DY production, $B(H^{\pm\pm} \rightarrow \ell)=1$ 1210.5070 Multi-charged particles - - 4.4 multi-charged particle mass 490 GeV DY production, $ q = 4e$ DY production, $ g = 1g_D$ 1207.6411 December.22.2014 $\sqrt{s} = 7$ TeV $\sqrt{s} = 8$ TeV $\sqrt{s} = 8$ TeV $\sqrt{s} = 8$ TeV 10 24	LSTC $a_T \to W\gamma$	1 e, μ, 1 γ	_	Yes	20.3	a _T mass 960 GeV		to be submitted to PLB
Type III Seesaw $2 e, \mu$ $ 5.8$ N \pm mass245 GeVIV.= 0.055, IV.µ = 0.063, IV.= 0ATLAS-CONF-2013-019Higgs triplet $H^{\pm\pm} \rightarrow \ell\ell$ $2 e, \mu$ (SS) $ 4.7$ $H^{\pm\pm}$ mass409 GeVDY production, BR($H^{\pm\pm} \rightarrow \ell\ell$)=1DY production, R($H^{\pm\pm} \rightarrow \ell\ell$)=11210.5070Multi-charged particles $ 4.4$ multi-charged particle mass490 GeVDY production, $ q = 4e$ DY production, $ q = 1g_D$ 1207.6411December .22.2014 $\sqrt{s} = 7 \text{ TeV}$ $\sqrt{s} = 8 \text{ TeV}$ 10 24	LRSM Majorana ν	2 e, µ	2 j	_	2.1	N ⁰ mass 1.5 TeV	$m(W_R) = 2$ TeV, no mixing	1203.5420
Higgs triplet $H^{\pm\pm} \rightarrow \ell\ell$ 2 e, μ (SS) - 4.7 H $\pm \pm$ mass 409 GeV DV production, BR($H^{\pm\pm} \rightarrow \ell\ell$)=1 1210.5070 Multi-charged particles - - 4.4 multi-charged particle mass 490 GeV DV production, BR($H^{\pm\pm} \rightarrow \ell\ell$)=1 1210.5070 1301.5272 Magnetic monopoles - - 2.0 monopole mass 862 GeV DV production, $ q = 4e$ 1301.5272 1207.6411 December.22.2014 $\sqrt{s} = 7 \text{ TeV}$ $\sqrt{s} = 8 \text{ TeV}$ 10^{-} 10^{-} 24	Type III Seesaw	2 e, µ	-	_	5.8	N [±] mass 245 GeV	$ V_e =0.055, V_{\mu} =0.063, V_{\tau} =0$	ATLAS-CONF-2013-019
Multi-charged particles - - 4.4 Multi-charged particle mass 490 GeV DY production, $ q = 4e$ 1301.5272 Magnetic monopoles - - 2.0 Multi-charged particle mass 490 GeV DY production, $ q = 4e$ 1301.5272 December.22.2014 $\sqrt{s} = 7 \text{ TeV}$ $\sqrt{s} = 8 \text{ TeV}$ $\sqrt{s} = 7 \text{ TeV}$ $\sqrt{s} = 8 \text{ TeV}$ 24	Higgs triplet $H^{\pm\pm} \rightarrow \ell \ell$	2 e (SS)		_	47	H ^{±±} mass 409 GeV	DY production. BR $(H^{\pm\pm} \rightarrow \ell\ell)=1$	1210 5070
Magnetic monopoles 2.0 December.22.2014 √s = 7 TeV √s = 8 TeV 10-エュートリノ研究会2014 1 10 24	Multi-charged particles	(30)	_	_	4.4	multi-charged particle mass 490 GeV	DY production $ a = 4e$	1301 5272
December.22.2014 vs = 7 TeV vs = 8 TeV 10-エュートリノ研究会20141 10 24	Magnetic monopoles	_	_	_	20	monopole mass 862 CoV	DY production $ q = 1 q_p$	1207 6/11
December.22.2014 √s=7 TeV √s=8 TeV 10-エュートリノ研究会20141 10 24	Magnetie monopoles	-	_	-	2.0			1207.0411
	December.22.201	14 √s =	7 TeV	$\sqrt{s} = 3$	8 TeV	10-エュートリノ研究会20141	10	24

December.22.2014

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

ATLAS Preliminary $\sqrt{c} = 7.8 \text{ TeV}$

Mass scale [TeV]

Diboson Cross	Sectior	n Mea	asure	ment	S	Status:	July 2014	1			∫£ dt [fb ⁻¹]	Reference
$\sigma^{\rm fid}(\gamma\gamma)[\Delta R_{\gamma\gamma} > 0.4]$	$\sigma = 44.0 \pm 0.0 + 3.2 $	2 – 4.2 pb (da (theory)	ta)		0		I	•			4.9	JHEP 01, 086 (2013)
$\sigma^{\rm fid}(W\gamma \to \ell v \gamma)$	$\sigma = 2.77 \pm 0.03 \pm 0.03$ (t	.36 pb (data) heory)					•				4.6	PRD 87, 112003 (2013)
$-\left[n_{\mathrm{jet}}=0 ight]$	$\sigma = 1.76 \pm 0.03 \pm 0.03$ (t	0.22 pb (data) heory)				•					4.6	PRD 87, 112003 (2013)
$\sigma^{\rm fid}(Z\gamma \to \ell\ell\gamma)$	$\sigma = 1.31 \pm 0.02 \pm 0.02$ MCFM (t	0.12 pb (data) heory)				•	ΑΤΙ	L AS F	Prelimina	ry	4.6	PRD 87, 112003 (2013)
$-[n_{jet}=0]$	$\sigma = \mathbf{Persc}$	nally	,		C		Run	1 \sqrt{s}	= 7, 8 T	eV	4.6	PRD 87, 112003 (2013)
$\sigma^{\text{total}}(pp \rightarrow WW + WZ)$	$\sigma = \mathbf{V} \mathbf{e}_{\mathbf{M}} \mathbf{e}_{\mathbf$	nstere	esting			•					4.7	ATLAS-CONF-2012-157
$\sigma^{ m fid}({\sf W}^{\pm}{\sf W}^{\pm}{ m jj})$ EWK	$\sigma = this_{\pm} fa$	Box (theory)	_								20.3	arXiv:1405.6241 [hep-ex]
$\sigma^{\text{total}}(pp \rightarrow WW)$	$\sigma = 51.9 \pm 2.0 \pm 4.$ MCFM (t $\sigma = 71.4 \pm 1.2 \pm 5.$ MCFM (t	4 pb (data) heory) 5 – 4.9 pb (da heory)	ta)	~ý			ì				4.6 20.3	PRD 87, 112001 (2013) ATLAS-CONF-2014-033
$-\sigma^{\sf fid}({\sf WW} ightarrow { m ee})$	$\sigma = 56.4 \pm 6.8 \pm 10$ MCFM (t).0 fb (data) heory)		Ì,			1				4.6	PRD 87, 112001 (2013)
$-\sigma^{\sf fid}({\sf WW} o\mu\mu)$	$\sigma = 73.9 \pm 5.9 \pm 7.$ MCFM (t	5 fb (data) heory)				•					4.6	PRD 87, 112001 (2013)
$-\sigma^{\sf fid}({\sf WW} ightarrow {f e}\mu)$	$\sigma = 262.3 \pm 12.3 \pm \text{MCFM (t)}$	23.1 fb (data) heory)				•		LHC pp	√ <i>s</i> = 7 Te V	'	4.6	PRD 87, 112001 (2013)
$\sigma^{\text{total}}(pp \rightarrow WZ)$	$\sigma = 19.0 + 1.4 - 1.$ MCFM (t $\sigma = 20.3 + 0.8 - 0.$ MCFM (t	$3 \pm 1.0 \text{ pb}$ (da heory) 7 + 1.4 - 1.3	ta) ob (data)					-	Theory Data		4.6 13.0	EPJC 72, 2173 (2012) ATLAS-CONF-2013-021
$-\sigma^{fid}(WZ \rightarrow \ell \nu \ell \ell)$	$\sigma = 99.2 + 3.8 - 3$ MCFM (t	0 + 6.0 - 6.2 heory)	íb (data)		A			•	stat stat+syst		13.0	ATLAS-CONF-2013-021
$\sigma^{\text{total}}(pp \rightarrow ZZ)$	$\sigma = 6.7 \pm 0.7 + 0.5$ MCFM (t) $\sigma = 7.1 + 0.5 - 0.4$ MCFM (t)	-0.4 pb (data heory) $\pm 0.4 \text{ pb}$ (data heory)	ı) 1)			0		LHC pp	√ <i>s</i> = 8 TeV	,	4.6 20.3	JHEP 03, 128 (2013) ATLAS-CONF-2013-020
$-\sigma^{ ext{total}}(pp ightarrow ZZ ightarrow 4\ell)$	$\sigma = 76.0 \pm 18.0 \pm 2$ Powheg $\sigma = 107.0 \pm 9.0 \pm 5$ Powheg	1.0 fb (data) (theory) 5.0 fb (data) (theory)		0					Theory		4.5 20.3	arXiv:1403.5657 [hep-ex] arXiv:1403.5657 [hep-ex]
$-\sigma^{fid}(ZZ o 4\ell)$	$\sigma = 25.4 + 3.3 - 3$ Powheel $\sigma = 20.7 + 1.3 - 1$ MCFM (f	0 + 1.6 - 1.4 Box & gg2ZZ (t 2 ± 1.0 fb (dat	fb (data) heory) <mark>a)</mark>			•			Data stat		4.6 20.3	JHEP 03, 128 (2013) ATLAS-CONF-2013-020
$-\sigma^{fid}(ZZ^* o 4\ell)$	$\sigma = 29.8 + 3.8 - 3.$ Powhege	5 + 2.1 - 1.9 3ox & gg2ZZ (t	íb (data) heory)			•			stat+syst		4.6	JHEP 03, 128 (2013)
$-\sigma^{\mathrm{fid}}(ZZ^* \to \ell\ell\nu\nu)$	$\sigma = 12.7 + 3.1 - 2.$ Powheel	9 ± 1.8 fb (dat 3ox & gg2ZZ (t	a) heory)		•			. 1			4.6	JHEP 03, 128 (2013)
	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0		
December.22.2014				—	レートリノ研	研究会201	4	data	a/theo	ry		25

Neutrino physics at LHC

Feynman diagram of T2K experiment (Just example)



Analogy at LHC

We could do this analogy at LHC.





Possible neutrino program at LHC@14TeV

SM 10000 events @ L=100fb⁻¹





up to a few TeV(?)

	Opposite sign	Same sign
Same flavor	Precision measurements (negative interference, TGC, GIM, # of v-phase(?))	Search for heavy Majonara v, LR-symmetry model, Type-I(III) Seesaw, H ⁺⁺
Different flavor	Search for Lepton Flavor Violating process through H ⁺ , SUSY	?? too exotics?? H ⁺⁺

Possible neutrino program at LHC@14TeV

	SM 10000 ev	ents @ L=100fb ⁻¹)		up to a few Te	∧ V(?)
		Opposite sign	Same	sign	
	Same flavor	Precision measurements (negative interference, TGC, GIM, # of v-phase(?))	Search v, LR-s Type-li	for heavy Majonara ymmetry model, (III) Seesaw, H ⁺⁺	
	Different flavor	Search for Lepton Flavor Violating process through H ⁺ , SUSY	?? too H++	exotics??	
V		Probing 0.1% BR of LFV ∧		<u>This number is not</u> Supposing 10% acc we still have 1000 e	<u>t bad.</u> eptance, events.

Search for heavy Majorana neutrino

Neutrinoless same sign di-lepton events.

Counting experiment:

Source	$\mu^{\pm}\mu^{\pm}$
WZ	$1.0 \pm 0.2 \pm 0.3$
ZZ	$0.22 \pm 0.05 \substack{+0.07 \\ -0.06}$
$W^{\pm}W^{\pm}$	$0.15 \pm 0.04 \pm 0.08$
$t\bar{t} + V$	$0.23 \pm 0.04 \pm 0.12$
Charge mis-measurement	< 0.03
Non-prompt	$1.1 \pm 0.5 \substack{+0.6 \\ -0.5}$
Total background	$2.7 \pm 0.5 +0.7$
Data	3

Validate data at control region:







95% C.L. > 120GeV @ |VμN|=0.01

8 TeV analysis in pile line on the paper release.

But preliminary, ~180GeV

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Search for Type-III Seesaw heavy fermion

Type-III Seasaw model predicts extra fermion, which may sequentially decay into Z/W and leptons.

- Search 4-leptons in the final state.
- Make invariant mass from 3-leptons.
- Validate data at control region.



e/μ

e/μ, v

e/μ

e/μ

e/μ, v

Z/W

Z/W

Summary

We plan "three-step" LHC upgrades up to 2025. (Then, HL-LHC will run ~2035(?))

These development (Japanese contribution) has been covered by our "TeV-scale physics program".

- Higgs measurements and SUSY direct search are primary goal for the next LHC running.
- Some connection to the neutrino physics program should exist in LHC.

Neutrino physics with a name of "TeV-scale phenomena"

Now, **"di-boson" processes** are fully opened with high statistics at Run-2. di-boson : major background for new physics searches, but also good source of the neutrino in "propagator".

Any idea is welcome.