Abstract. This article reviews the recent results from the two energy frontier experiments, ATLAS and CMS at the large hadron collider (LHC), using the data collected during 2011 corresponding up to 4.9 fb$^{-1}$ integrated luminosity of $\sqrt{s} = 7$ TeV proton proton collisions. The recent results of searches for the Standard Model Higgs boson, and searches for beyond Standard Model physics based on supersymmetry and other new exotic models are presented.

INTRODUCTION

This review, a general overview of the recent results from the two experiments, ATLAS and CMS regarding the two main topics are presented, namely the SM Higgs boson search, and the searches for any physics beyond the Standard Model. The field to be covered is fairly broad, hence interested readers should consult with the references at the end of this note for more detailed write-ups. The year 2011 was quite successful for both LHC accelerator and the LHC experiments. The LHC delivered more than 5 fb$^{-1}$ of luminosity to each experiment, and both ATLAS and CMS experiments collected them with the excellent data taking efficiencies (ATLAS 93.5%, CMS 91.0%). In the second half of the data-taking period the luminosity was approximately doubled. The average number of vertices was approximately twice compared with the former half. This caused the difficulties at many areas in analyses due to the high number of multiple interactions per bunch crossing. The proper modeling of the pile-up events in Monte Carlo simulation became a high priority matter. The detailed descriptions of the two general purpose detectors are found elsewhere (ATLAS [1], CMS [2]).

Standard Model Measurements

Although the main topics of this report are searches for the SM Higgs boson and the BSM physics, it is useful to reconfirm the level of the current understanding on the SM processes. Figure 1 shows the comparisons of cross sections measured at 7 TeV to the predictions at NLO or higher order calculations both in ATLAS and CMS. Good agreement over four orders of magnitude is observed. Especially interesting is the measurement of the $\text{ZZ}$ cross-section [3][4], corresponding to about 40 fb which is comparable to the size of the SM Higgs to 4 lepton channel. This implies that the Higgs measurement is feasible with the current measurement precision and understanding of the detectors and the of the SM physics processes.

STANDARD MODEL HIGGS SEARCHES

One of the major targets of the LHC program is the search for the SM Higgs boson. At Hadron Collider Physics Symposium at Paris in 2011 November, a preliminary result of the ATLAS and CMS combined exclusion limit of 1.0 – 2.3 fb$^{-1}$ LHC data was presented [5], which excluded the SM Higgs boson in region $141 - 476$ GeV at 95 % observed CL. The CERN LEP experiment had excluded the region of SM Higgs with $m_H < 114.4$ GeV at 95% CL [6]. The remained allowed region is either between $114.4 - 141$ GeV or more than 476 GeV. On the theory side, requirements from the perturbativity and stability constraints allow narrow mass band less than about 170 GeV if the
SM were to survive at very high energy [7]. Electroweak fit with indirect measurement data, again prefers the low SM Higgs mass. 95% CL upper limit is 169 GeV [8]. In this article we only consider a SM Higgs boson, for which the above considerations are valid. The branching fractions from the SM Higgs depend on SM Higgs boson mass. Especially in the low mass region, multiple decay channels are available. Channel combination of the analyses over multiple decay channels is necessary over the whole considered range, in order to cross check the results between channels, and to increase the sensitivities. Since the expected cross section for these channels are at most a few pb, the statistics used for the analysis and the performance of the signal to background ratio are the two key elements for this Higgs boson hunt. The data analysis with the full luminosity in 2011 for the three most sensitive decay channels are discussed in this article. These are $\gamma\gamma$ final state, $ZZ^\ast \rightarrow 4\ell$ final state, and $WW^\ast \rightarrow 2\ell + 2\nu$ final state. The combined results are prepared for each experiment separately with all additional channels other than these major three channels.

**$H \rightarrow \gamma\gamma$ Channel**

Higgs to diphoton mode has a very clean signature with limited background, and it is considered as the golden channel in low mass region below 150 GeV, despite its low cross section of less than 0.1 pb. In both ATLAS and CMS, the analysis looks for the photon pairs with tight identification and isolation requirements with 4.9 and 4.76 fb$^{-1}$ integrated luminosity respectively. A narrow mass peak is expected over the smooth backgrounds composed of large fraction of irreducible background from SM direct diphoton process, and the reducible ones with one or two photons are fake from the jets. As a general strategy, mass resolution and the fake photon rejection are the most important. The datasets are categorized in terms of photon conversion flag and the kinematics to reach the best sensitivities in each categories. The reconstructed mass is based on the opening angle of the two photons, and the pile-up events deteriorate the performance of the diphoton mass measurements due to the multiple primary vertices distributed along the beam line whose spot size is a order of 6 cm. ATLAS makes the best use of the longitudinal separation and the fine lateral segmentation of the EM calorimeters, where the photon direction is measured and the original vertex is determined with the uncertainties of 1 cm. CMS on the other hand selects the best vertex candidate by checking the balance between the sum of the transverse momenta of the tracks belongs to the particular vertex and the photon pair, the resulting vertex association efficiency is 83% in average through the run 2011.

ATLAS uses the cut based analysis with the optimization for orthogonal nine data categories [9]. CMS introduced multivariate analysis (MVA) [10], based on several variables, including event by event mass resolution and photon ID variable, which are combined into a boost decision tree algorithm. In parallel CMS carried out a cut based analysis [11]. The results from the two methods are found consistent.

Figures 2 show the invariant mass of the two photons for ATLAS (left) and CMS (right), summed over all the data categories mentioned above. 95% CLs observed limits are obtained. 113-115, 134.5-136 GeV are excluded by ATLAS, 110.0-111.0, 117.5-120.5, 128.5-132.0, 139.0-140.0 and 146.0-147.0 GeV are excluded by CMS with this channel. MVA improved the sensitivity by about 20 % compared to the cut based analysis. From the local $p_0$ value, which represents the consistency of the data with the background only hypothesis, large excess at 126.5/125 GeV are obtained at ATLAS/CMS respectively. By taking into account the look elsewhere effect (LEE) [12], the global significance is obtained. The largest local/global significances are $2.8\sigma / 1.5\sigma$ for ATLAS and $2.9\sigma / 1.6\sigma$ for CMS.
Higgs to ZZ* and subsequently decays into 4\ell is a very clean signature with the good sensitivities in full mass range, thus considered as the golden channel. In the low mass region, a mass resolution of order of 1-2% is expected. A peak structure is expected on top of a very small background. This is possible thanks to the excellent control of the lepton measurement and identification, which are well modeled in the simulation. Thanks to the low background level, the impact of one event in the signal region is very high, a few candidate events would significantly change the structure in p_0 and limit calculation. In ATLAS and CMS, the analysis selects the events with four isolated leptons from common vertex, requiring also that the leptons in each pair to have the same flavor and the opposite sign. The main backgrounds for this channels are the standard model ZZ which is irreducible, also the reducible sources with fake leptons from jets. Figures 3 show the invariant mass distributions of the 4 lepton final states after all the event selections, and data points are superimposed on the expected background distributions. With 4.7fb^{-1} of data, 95% CLs observed limits are obtained with this channel. In ATLAS, 134-156, 182-233, 256-265 and 268-415 GeV are excluded [13] while 134-158, 180-305, 340-465 GeV ranges are excluded in CMS [14]. The local p_0 significances are 2.1\sigma/2.2\sigma for (125 GeV, 500 GeV)/244 GeV in ATLAS, and 2.5\sigma at 119.5 GeV in CMS. The significances decrease below 2\sigma once the LEE effect is accounted for in both experiments.

Searches for BSM and Higgs boson at LHC

June 16, 2012

3
\begin{equation*}
H \rightarrow WW^* \rightarrow 2\ell + 2\nu \text{ channel}
\end{equation*}

Higgs to \( WW^* \) with subsequent decay into \( \ell\nu\bar{\nu} \) is not a clean channel, but it has the best sensitivity in the low Higgs mass range, owing to a large branching ratio from Higgs. Due to the two missing neutrinos, Higgs invariant mass cannot be reconstructed, hence the analysis has to rely on the event counting in the signal region which demands a good understanding of the background. Two isolated opposite sign leptons are required, and the events are categorized in the number of jets (\( n_{\text{jet}} \)). The events with \( n_{\text{jet}} = 0, 1 \) are for Gluon Fusion (GF) process, while \( n_{\text{jet}} = 2 \) is used for Vector Boson Fusion (VBF) process. The dominant top pair background is highly suppressed by requiring a b-jet veto. The irreducible background is a SM WW, which could be slightly suppressed by a cut on the opening angle between the two leptons.

The missing \( E_T \) which is the most critical variable in this analysis, since the signal region contains both fake and real missing \( E_T \), is well described by current simulation. The cut criteria on \( m_T \) is set in accordance with the assumed \( m_H \). In CMS, the multivariate technique is also introduced which resulted in slightly better sensitivity.

Observed 95% CLs limits are obtained. 130-260 GeV / 132-238 GeV ranges are excluded by ATLAS [15] and CMS [16] respectively with cut based analysis, while the range 129-270 GeV is excluded with multivariate technique in CMS.

### channel combinations

Preliminary channel combination results are obtained independently with the full datasets corresponding to the integrated luminosity of up to 4.9/4.8 fb\(^{-1}\) for ATLAS [17] and CMS [18] respectively. Used channels for combination other than the ones already introduced are, for low mass range, \( VH \rightarrow V\ell\ell \) in ATLAS (4.6-4.7 fb\(^{-1}\) [19]), in CMS (4.7 fb\(^{-1}\) [20]), \( \tau\tau \rightarrow \ell\ell \) or \( \tau\nu\bar{\nu} \) had in ATLAS (4.7 fb\(^{-1}\) [21]), in CMS (4.6 fb\(^{-1}\) [22]), for high mass range, \( WW \rightarrow \ell\nu j \) in ATLAS (4.7 fb\(^{-1}\) [23]), \( ZZ \rightarrow \ell\ell\nu\nu \) in ATLAS (4.7 fb\(^{-1}\) [24]), in CMS (4.6 fb\(^{-1}\) [25]), and \( ZZ \rightarrow \ell\ell jj \) in ATLAS (4.7 fb\(^{-1}\) [26]), in CMS (4.6 fb\(^{-1}\) [27]). For ATLAS, the observed and the expected upper limit of 95% CL for the

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure4}
\caption{(Left) The upper limit of the SM Higgs boson production cross section divided by the SM expectation as a function of assumed \( m_H \) in ATLAS. The observed limits is indicated by a solid line, while median expected limit is expressed by a dashed line with green/yellow bands corresponding to 1 \( \sigma \)/2 \( \sigma \) uncertainties respectively. (Right) The observed and expected \( p_0 \)-value as a function of the assumed \( m_H \) for ATLAS. The LEE correction is not taken into account for this. Both figures are from [17].}
\end{figure}

Higgs production cross section, normalized to the SM value, for all the channels combined is shown in Fig. 4 (left). The expected limit excludes 120-555 GeV. The observed limit excludes the ranges between 110.0-117.5, 118.5-122.5 and 129-539 GeV, where the first range extended the long standing LEP limit of 114.4 GeV. Figure 4 (right) is the local \( p_0 \) distribution for the combined results. The maximum observed local significance is 2.5 \( \sigma \) at \( m_H = 126 \) GeV which is close to the expected value of 2.8 \( \sigma \) from SM Higgs. The observed event excess, i.e. signal strength at 126 GeV is consistent with SM Higgs assumption. After the LEE correction, \( p_0 \) significance decreases to 15-35% estimated over 110-600 GeV range.

For CMS, as shown in Fig. 5 (left) the expected limit excludes 114.5-543 GeV. The observed limit excludes 127.5-600 GeV at 95% CL. The maximum deviation of inconsistency with background hypothesis, \( p_0 \), is observed as 2.8 \( \sigma \) at 125 GeV as shown in Fig. 5 (right), which is mostly originated from \( H \rightarrow \gamma\gamma \) channel. After the LEE correction, the significance decreased down to 0.8 \( \sigma \).
**Summary of SM Higgs searches**

ATLAS and CMS have performed Higgs boson searches with the datasets up to 4.9 fb\(^{-1}\). The 95% CL allowed regions are narrowed down to very small areas in both experiments. In addition, there is a modest excess in similar place in both experiments. These are 2.5 and 2.8 \(\sigma\) local significance in ATLAS and CMS respectively, and corresponding to less than 2 \(\sigma\) once the LEE correction is considered. Definitive conclusion of either its existence or ruling out of the Standard Model Higgs boson could be drawn by the end of 2012.

**BEYOND THE STANDARD MODEL**

Using the datasets of 5 fb\(^{-1}\) integrated luminosity out of very successful year of LHC operation, a huge number of interesting studies for beyond the Standard Model were carried out and covered by two experiments. Generally speaking, the mass limits for the heavy particle searches already reach up to 1 TeV for supersymmetry searches, and 2-3 TeV for exotic searches. The results hugely exceeded Tevatron results in many places. However the published and preliminary results so far have seen no significant excess yet.

In searching for the yet unknown beyond Standard Model phenomena, there could be several experimental approaches. The first attempt is to search for the simple signatures of resonance in mass, or transverse mass distribution, of two-body objects, as leptons, jets, or even more complex places as di-photons, di-bosons, t\(t\)\(\bar{b}\)bar, etc. Also the angular correlation between these di-objects is of interests. Secondarily, the specific signatures bases on well defined BSM physics models can be explored. Famous examples are the supersymmetry, the extra dimension models, and many others. Following sections are ordered according to this menu.

**Search for new particles in simple signature**

A resonance search in the di-lepton invariant mass distribution is a relatively simple and robust analysis. Figures 6 are the \(e^+e^-\) (left) and \(\mu^+\mu^-\) (right) channels with full statistics of 2011 run in ATLAS [28]. The model dependent lower mass limit of the \(Z'\) at 95% CL are obtained for ATLAS (\(e^+e^-\) at 4.9 fb\(^{-1}\) and \(\mu^+\mu^-\) at 5.0 fb\(^{-1}\)), for CMS (at 1.1 fb\(^{-1}\)) on SSM model \(m_{Z'} > 2.21(1.94)\) TeV [29], and on RS graviton \(m_{G} > 2.16(1.98)\) TeV for ATLAS (and CMS) respectively. For the RS graviton limit, coupling strength \(k/M_{pl} = 0.1\) is assumed. A similar search, looking for a Jacobian peak in the transverse mass spectrum for a lepton and missing \(E_T\) is also carried out in both experiments (ATLAS 1.04 fb\(^{-1}\) [30], CMS 5.0 fb\(^{-1}\) [31]). Figure 7 (left) shows the transverse mass distributions of the data points for electron (red) and for muon (blue) obtained in CMS with background expectations and signal distributions.

**FIGURE 5.** Similar plots as Fig. 4 but for CMS. (left) The upper limit plot for CMS. (right) local \(p_0\) values. The observed value for combination is drawn by black line. Both figures are from [18].
FIGURE 6. The invariant mass distributions for the di-lepton system for the $e^+e^-$ channel (left) and the $\mu^+\mu^-$ channel (right) after final selection in ATLAS, compared to the stacked sum of all expected backgrounds, with three example $Z_{\text{SSM}}$ signals overlaid. Both figures are from [28].

superimposed on the same plot with the same color index. Since the data points are consistent with the background

FIGURE 7. (left) Observed transverse mass distributions for electron and muon channels in CMS. Simulated signal distributions for a W' of 2.5 TeV mass are also shown. (right) Upper limit of cross section at 95% CL on $\sigma(W') \times Br(W' \rightarrow \ell\nu)$ with $\ell = e, \mu$, and their combination [31]. The theoretical cross section is displayed with and without a mass-dependent NNLO K-factor.

only expectation, the model independent upper limit on cross section times branching ratio is obtained as in Fig. 7 (right). Model specific limit is also obtained for W' mass in Sequential Standard Model. $m_{W'} > 2.5(2.15)$ TeV are obtained for CMS (ATLAS) respectively.

The dijet signature is also an active area in the two-object state search. There are many phenomenology models which predict the high mass resonance in di-jet distribution, for instance the excited quarks, axigluons, string balls, etc. ATLAS set the lower limit on excited quark mass at 3.35 TeV (4.8 fb$^{-1}$) [32], so does the CMS at 2.49 TeV (1.0 fb$^{-1}$) [33]. Non-resonant heavy central object is also searched for by measuring the angular correlation between two jets. 4 quarks contact interaction may reveal itself in such search. A lower limit of contact interaction scale is obtained, for ATLAS 7.6 TeV (4.8 fb$^{-1}$) [32], for CMS 7.5-14.5 TeV (2.2 fb$^{-1}$) [34].

Search for model specific signature in supersymmetry

ATLAS and CMS have searched for supersymmetric (SUSY) signatures in canonical scenarios through strong production of squarks and gluinos. Typical signature contains multi high-$p_T$ jets, large missing $E_T$ and sometimes leptons. Under the $R$–parity conserving models, squarks and gluinos are produced in pairs and decay via $\tilde{q} \rightarrow q\tilde{\chi}^0_1$.
and $\tilde{g} \rightarrow q\tilde{g}^0$, where two $\tilde{g}^0$ in an event escape detection. In ATLAS, the scalar sum of missing $E_T$ and $p_T$ of leading jets is called effective mass, $m_{eff}$, which is used to distinguish the signal from the backgrounds. The SUSY signal would manifest itself as an excess in the tail of the $m_{eff}$ distribution, thus the precise estimation of the SM background is the most important task in SUSY hunt. A data driven background estimation is generally used, in which for each background a control region is defined to test and normalize for the background processes, and these are transferred to the signal region by the help of Monte Carlo.

An example is seen in the ATLAS $m_{eff}$ search with no-lepton channel, where four jets (130, 60, 60, 60 GeV cuts) with missing $E_T$ cut on 160 GeV are required [35]. Figure 8 (left) shows the $m_{eff}$ distribution in this signal region, where data is well described by the sum of the SM backgrounds. To achieve maximal reach in the parameter space, 6 signal regions are defined. Figure 8 (right) is the 95% CLs exclusion limits obtained with simplified MSSM scenario based on the 4.7 fb$^{-1}$ data. $m_{\tilde{q}} < 940$ GeV, $m_{\tilde{g}} < 1380$ GeV are excluded [35]. No-lepton with high jet multiplicity channels ($n_{JET} \geq 6$ to $\geq 9$) are also assessed, and obtained the limit $m_{\tilde{g}} < 880$ GeV [36].

CMS has introduced a new search methodology basing on the set of variables called Razor, which associate the momentum of the each particles after boosting the system back to the center of the mass frame. The Razor analysis changes the strategy of general SUSY searches from hunting the excess in the tail region into a bump search in a $M_{T2}$ distribution. With another variable called $R$, the SM backgrounds are efficiently eliminated. The analysis can handle the samples of different lepton multiplicities at the same time. The $M_{T2}$ distribution from data is well reproduced by the total SM expectation as shown in Fig. 9 (left) [37]. The Razor analysis with the data samples corresponding to 4.4 fb$^{-1}$, squark and gluino masses up to 1.35 TeV are excluded with 95% CL [37].

SUSY can also be searched for in the same-sign di-lepton final states arising from the strong production. The SM backgrounds are highly suppressed by the same sign leptons requirement. A number of analyses were carried out looking into different search regions in order to investigate the different mass spectrum splittings, e.g. the different $H_T$ and missing $E_T$ regions, low $p_T$ leptons, and also events including $\tau's$. The data are in good agreement with the SM expectation both in ATLAS [38] and CMS [39].

The general result of the inclusive searches is that squarks and gluinos are not light, or the conventional simple model searches based on the jets and missing $E_T$ may not be the answer. There are on going newly developed areas looking for non-conventional SUSY signatures. Searching for the SUSY third generation is one of the most active area in two experiments [40, 41, 42]. In this scenario, gluino/squark could be very heavy but the fine-tuning issue in the SM is non-problematic if the third generation squarks are light. ATLAS searches for the decay chain $\tilde{t}_1 \rightarrow b + \tilde{g}^+ \rightarrow b + Z/h + G + f f'$ in the GMSB context with 2.05 fb$^{-1}$. A $\tilde{t}_1$ mass up to 330 GeV was excluded [43]. CMS extends the same sign di-lepton analysis by requiring at least two b-tagged jets, and looks for di-leptons, di-b-jets, and missing $E_T$. The $\tilde{b}_1$ mass up to 380 GeV was excluded [44]. A second active topic is the studies in the gaugino and

**FIGURE 8.** (left) Observed $m_{eff}$ distributions for one of the signal regions [35]. The histograms show the SM background expectations from MC. The $W$+jets, $Z$+jets and $t\bar{t}$ and single top distributions are normalized to data in corresponding control regions. The multi-jet background is estimated via data driven way. The yellow band shows only the combined JES, JER, and MC statistics uncertainty. (right) 95% CLs exclusion limits obtained by using the signal region with the best expected sensitivity at each point in a simplified MSSM scenario [35]. The red line show the observed limits, the dashed blue line is the median expected limits.
slepton sectors. Scalar τ production in the context of GMSB model is also explored by ATLAS, where large mixing in slepton sector could lead to light $\tilde{\tau}$. ATLAS has explored di-tau [45], one tau [46], and di-lepton [47] final states. The limit in terms of the effective SUSY breaking scale $\Lambda$ is obtained, i.e. $\Lambda < 40 - 47$ TeV ($\tan\beta = 15 - 37$) out of these three studies. Di-photons plus missing $E_T$ is also a sensitive channel for GMSB. In this scenario, the bino is NLSP and as a final state, two high-$p_T$ photons and missing $E_T$ created from gravitinos is expected. In ATLAS, di-photon both with $p_T > 25$ GeV + missing $E_T > 125$ GeV event selection is applied, while CMS additionally requires one jet with reduced cut on missing $E_T$. Dominant backgrounds are one fake photon with real missing $E_T$ from electro weak processes, e.g. $t\bar{t}$+jets, $W$+jets, and the QCD di-photon process with fake missing $E_T$ which is estimated in data driven way. ATLAS has set the limit $m_{\tilde{g}} > 805$ GeV based on General Gauge Mediation (GGM) model with 1.07 fb$^{-1}$ data [48], on the other hand, CMS has set $m_{\tilde{g}} > 1$ TeV with 4.7 fb$^{-1}$ datasets [49].

Significant number of analyses are carried out for R-parity violation scenarios, where for instance, resonant sneutrinos are searched for, or the displaced vertex signatures are looked for. Even more striking signature is explored in ATLAS [50], a disappearing track in the inner tracking volume is looked for which is inspired by the anomaly mediated SUSY breaking model, where the lightest chargino and neutralino is almost degenerate, thus in the decay $\tilde{\chi}_1^+ \rightarrow \tilde{\chi}_0^0 + \pi^+$, the pions are too soft to be reconstructed, and looks as if $\tilde{\chi}_1^+$ track disappears in the middle of the inner tracker. ATLAS can realize such search owing to the continuous track trajectory reconstruction in TRT. The requirement on number of hits in the last TRT layer less than five significantly reduce the normal tracks. Backgrounds are mostly hadron interactions whose shape and amount are estimated in data driven way. The limit was set on the lightest chargino mass as $m_{\tilde{\chi}_1^0} > 118$ GeV, which extended the limit set by LEP2 [51, 52, 53] as $m_{\tilde{\chi}_1^0} > 92$ GeV.

**Search for model specific signature in exotics**

Many model specific signatures not based on the SUSY scenarios are explored by both experiments.

One such category is the 4th generation quark searches, which look for the decays, $T \rightarrow W + b$, $T \rightarrow Z + b$, $B \rightarrow W + t$ and $B \rightarrow Z + b$ etc., where the complex final states are expected with varieties of analyses and results. In ATLAS, one of the analyses looks for the 1-lepton, missing $E_T$, and more than 6 jets, in which 4 of them are identified from W’s. Enriched signals were to be expected in very large jet multiplicities. The current limit was set on $B$ quark at 480 GeV [54]. CMS looks for the top pair production like signature, but with significantly large invariant mass. Minimum invariant mass is set at 170 GeV to discriminate from the top backgrounds. The limit was set on $T$ quark mass at 552 GeV [55].

Searches for pair-produced vector-like quarks $T$ are also carried out in both experiments. In this scenario, the 4th generation top quark are allowed to decay into $Z$ and top, $T \rightarrow Z + t$, which is a flavor changing neutral current decay, thus suppressed in the SM. CMS searches for the $Z$ plus one charged lepton candidates, and looked into the deviation in number of jet distribution, or in the $p_T$ sum of the leading jets and leptons except the two highest ones. CMS has
set the limit, $m_T > 475$ GeV, with 1.14 fb$^{-1}$ \cite{56}. On the other hand, ATLAS searched for the VLQs coupling to light quarks in 1 fb$^{-1}$ data and set the limits $m_Q > 900$ GeV in charged current mode, and $m_Q > 760$ GeV in neutral current mode \cite{57}.

The last topic in this article is the search for the excited leptons. The composite model provides the new interactions which produce excited states of leptons. The production rate is very small, hence one has to look into single production at beginning. The isolated photons are expected to be emitted from the radiative decays of excited leptons. With 5 fb$^{-1}$ of data, ATLAS has set the limits, $m_{\tau^*} > 2.0$ TeV, $m_{\mu^*} > 1.9$ TeV with the assumption on compositeness scale $\Lambda = m_{\nu_e}$ \cite{58}.

### Concluding remarks

It was a magnificent year for all the LHC experiments. A large amount of data with good quality has been recorded and analyzed. In many areas, new exclusion results are obtained which extended the existing limits.

For the search for the SM Higgs boson, two experiments significantly narrowed down the allowed region. In addition, a modest excess of events were observed around 126 TeV in ATLAS and 125 GeV in CMS.

Concerning the beyond SM physics searches, a huge spectrum of channels is covered by both experiments. So far no symptom of new findings has been seen.

With the on going new data taking of 2012 with $\sqrt{s} = 8$ TeV, we should be able to either confirm the current Higgs excess or rule it out. We are also looking forward to seeing the hint of any surprise in beyond standard model physics.

### ACKNOWLEDGMENTS

Thanks to both ATLAS and CMS collaborations for helping me in preparing the talk and this proceeding texts.

### REFERENCES

15. ATLAS Collaboration, Search for the Standard Model Higgs boson in the $H \rightarrow WW \rightarrow \nu\nu\nu\nu$ decay mode with 4.7 fb$^{-1}$ of ATLAS data at $\sqrt{s} = 7$ TeV, Tech. Rep. ATLAS-CONF-2012-012, CERN (2012).
23. ATLAS Collaboration, Search for the Higgs boson in the $H \rightarrow WW \rightarrow \ell\nu\ell\nu$ decay channel using 4.7 fb$^{-1}$ of pp collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector, Tech. Rep. ATLAS-CONF-2012-018, CERN (2012).
47. ATLAS Collaboration, Search for supersymmetry with jets, missing transverse momentum and one or more tau leptons in proton-proton collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector, Tech. Rep. ATLAS-CONF-2012-005, CERN (2012).