Final Technical Report

Project Title : "To continue to explore the energy frontier with the ATLAS detector"

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1. Overview

The LHC completed the first data-taking run in 2012 (Run1, 7-8 TeV CM energy, ~25 fb^{-1}) and, after a two-year shutdown, started Run 2 at 13 TeV CM energy, (collected ~ 3fb^{-1} in 2015, and over 20.3fb^{-1} in 2016 till now). During this shutdown, upgrades like the new innermost layer of the Pixel detector (Insertable B-layer: IBL [1]), were completed (Phase 0). Phase 1 (2019-2020) has started and Phase 2 (2024-2026) upgrades to the ATLAS experiment are planned in the future. The goal of the LHC is to uncover what is beyond the Standard Model (SM).

The UIowa group of Professor Usha Mallik has been exploring the SM Electroweak (EW) sector and searching for beyond SM (BSM) phenomena in the ATLAS experiment. The group, during the past years, consisted of three postdocs; typically, two supported by the DOE (and partially by MRI from NSF), and one supported by the ATLAS management for central software. The strength of the UIowa group has been in physics analysis, software and specific hardware projects. We carried out upgrade studies as well as upgrade construction projects. We took a leading role in the Standard Model $V+ h\ (h \rightarrow b\bar{b})$, *with* $V = W/Z$ analysis in Run 1, in the "hbb" analysis group, which consisted of over 80 physicists; and are continuing it in Run 2 at the 13 TeV energy frontier. The UIowa group is also searching for Higgs-related BSM physics in the *Vh* channels, which includes any resonances. We have had a leadership role in the b-tagging algorithm development in dense environments and at higher transverse momenta (p_T) for Run 2, where the IBL has made a noticeable impact. The b-tagging group as a whole consists of more than 70 ATLAS physicists. The UIowa group contributed to other key areas of the experiment: experimental operations (ATLAS control room shifts and experts), upgrades, and ATLAS central software. We constructed the Low Voltage Patch Panel 4 (LVPP4) for the IBL. We performed the Phase I Liquid Argon calorimeter (LAr) trigger upgrade study for electrons and photons for the Technical Design Report (TDR). We assumed responsibilities for Phase 2 LAr upgrade, in the High Granularity Timing Detector (HGTD); started simulation studies by initiating in GEANT4 in ATLAS simulation. Professor Mallik also has the responsibility of all of the detector control system for the HGTD. We have been participating in LAr operations, with one postdoc (Jose Benitez) as a Run-coordinator from late August (fall 2015).

The current group consists of postdocs **Dr Jose Benitez** (since Jan, 2015), **Dr Spyridon Argyropoulos (**since Jun, 2015**)** and **Dr Siqi Wang,** who joined very recently (joined in June 2016), after the previous grant period. Two new graduate students have also just joined our group, taking courses at Iowa. Postdoc Dr Nicolas Morange left the group in November 2014 for a permanent CNRS position at Orsay (LAL). *Professor Mallik moved to CERN in June (2015) to work very closely with the new postdocs on the 13 TeV data. She taught remotely from CERN in the fall semester (2015), followed by a sabbatical during the spring semester (2016).* She was in day-to-day contact with her group prioritizing the analyses steps and directions, attending relevant meetings, keeping abreast with the ATLAS physics management, analysis group coordinators, and, a few theorists at CERN.

In the following sections we first highlight the group's physics contributions from Run 1 and Run 2 data, and the analysis strategy to continue our leadership roles in Run 2. We then discuss our past achievements in software and Phase 1 upgrades, followed by Phase 2 upgrade work.

2. Highlights of UIowa Contributions in Physics Analysis from Run 1

The Higgs boson (*h*) was discovered through decays into vector bosons. It is critical to measure its decays into fermions in order to confirm whether or not it is the SM Higgs. Professor Mallik explored the $\boldsymbol{b\bar{b}}$ final state with the UIowa postdocs in 2011, before *h* was discovered. Although the SM branching fraction (BF) into $\boldsymbol{b\bar{b}}$ in the *h* mass region is very high (~60%), the $\boldsymbol{h \rightarrow b\bar{b}}$ decay is overshadowed by high-rate SM processes which produce two *b*-jets in the final states. Therefore, associated production of the *h* with a vector boson (*W/Z*), a Higgsstrahlung process [2], was selected. The analysis was classified according to the number of leptons in the final states of the *W/Z* decay, "0-lepton" (*Zh*, $\boldsymbol{Z \rightarrow \nu\bar{\nu}}$), "1-lepton" (*Wh*, $\boldsymbol{W \rightarrow \ell\nu}$) and "2-lepton" (*Zh*, $\boldsymbol{Z \rightarrow \ell^{+}\ell^{-}}$), where $\ell = e$ or μ. The principal backgrounds arise from $\boldsymbol{t\bar{t}}$, and *W* and *Z* (with jets) production, specifically *W/Z + bb, bc, cc , bq, cq, qq,* where *q* signifies light quark jets. Single top and diboson productions were the next most copious backgrounds. Multi-jet (QCD) production also contributed significantly in 1-lepton channel. The background composition varies in each leptonic channel.

A very early analysis of the 7 TeV data in ATLAS led to a very early publication in 2011 [3] with a limit, before we joined the analysis group. We started with the *Wh* production, then got involved in the overall *Vh* analyses ("hbb" analysis group). The essentials of the *Vh* analysis [4,5] are described below followed by details of the UIowa contributions.

The main challenges were understanding, removing and modeling the various backgrounds, especially as the Monte Carlo (MC) did not reproduce the data properly for many of the background processes. This led to an intensive effort to estimate and model the backgrounds (**Zaidan, Morange, Halladjian** (in MSU since August 2013)) using "control regions" and "validation regions" from data (see later). The analysis strategy for each of the 0-, 1- and 2-lepton channels was defined accordingly, e,g., p_T of *V* (p_{TV}) > 100 GeV was used for 0-lepton to reduce multijet-QCD background and to utilize the missing transverse energy ($E_T miss$) trigger. Data were divided into p_{TV} bins for the cut-based analysis because of the strong dependence of the signal-to-background ratio. The signal event selection allowed for two or three jets. For signal regions both b-jets (2-tags) were separated into tight, medium and loose b-tagging categories. In addition to the 2-tagged categories, both 1-tag and 0-tag data samples were used for control and validation regions.

The 2011 and 2012 datasets were analyzed differently because of differences in reconstruction (e.g.,b-tagging). A Boosted Decision Tree (BDT) analysis was used (**Zaidan**) for the final result with the cut-based analysis as a cross-check. The BDT [6,7] analysis used p_{TV} as a variable and thus the number of p_{TV} regions was drastically reduced (two) for this analysis. The variables used in the BDT were selected coherently for all three channels, with the b-tagging discriminant used as a variable (**Zaidan**) only in the 2012 data (20.3 fb^{-1}). Systematic uncertainties from modeling and from measurements were treated separately. The modeling uncertainties included shapes of kinematic variables (e.g., p_{TV}, m_{bb}, $\Delta\phi$), parton showers, the ratio of 3 and 2 jets, cross-sections and heavy flavor composition (e.g., *Wbb/Wcc* ratios); several scale factors were required. Measurement uncertainties included jet energy scale, jet energy resolution, b-tagging, triggering, resolutions and scale of $E_T miss$, lepton identifications etc. All of these uncertainties were included as nuisance parameters. Finally, a complex and comprehensive fit was performed for both cut-based and BDT analyses using a profiling technique [8] (**Morange**).

2.1 Important UIowa Contributions to the ATLAS-wide hbb Analysis Group

W/Z + jets Background Modeling:

Dr. Halladjian led the modeling of the *W+jets* processes, discussing it frequently with the group and Professor Mallik. He investigated the shapes of several kinematic variables, comparing data and MC, and developed a $\Delta\phi(j1,j2)$ correction between the two leading jets with an assigned systematic uncertainty. This correction was shown to improve the modeling of several other variables such as p_{TV} for the *Vh* and a few other analyses. (This led to a joint task-force with the MC generator community.)

Multijet-QCD Background Modeling:
Multijet-QCD background is hard to model accurately, often being non-perturbative in origin. **Dr.**

Morange devised a data-driven estimate of the multijet-QCD background. He then identified selections to reduce this background without introducing biases in the distributions of the kinematic variables.

MVA (BDT) Analysis and Performance Optimization (Dr. Zaidan):
In early discussion with the postdocs Professor Mallik had decided that a multivariate analysis (MVA) would be best suited to a complex analysis like *Vh*. Dr. Zaidan optimized an initial BDT set-up with the available MC, and observed around 40% improvement in statistical sensitivity with respect to the cut-based analysis in the 1-lepton channel. Dr. Zaidan established the optimal training configuration and the set of input variables; he introduced continuous b-tagging [9,10] in the BDT for the 2012 data, with a 15% improvement in performance at that time. After EPS2013, Dr. Zaidan's BDT was adopted by the 0- and 2-lepton groups, replacing the cut-based analysis. He also showed the need for larger MC signal samples for BDT training, convincing the analysis group to request a ten-fold increase of the signal samples, which improved the BDT sensitivity by ~10%.

The Final Fit Program Development (Dr. Morange):
Upon joining the group in late 2012, Dr. Morange explored the profiling technique and modified the generic ATLAS profiling program for use with the *Vh(bb)* analysis. Working initially with Gabriel Facini (then a CERN fellow) Dr. Morange soon took this over fully and developed the fit program with over 200 nuisance parameters and led a four-person group. The fit program took inputs from all three channels, data from 2011 and 2012, and all different p_{TV} regions for both signal and control regions as well as the backgrounds. All nuisance parameters and correlations between them were checked, tested and understood. This led to deeper insights into the analysis. Afterwards, he used a smoothing of the nuisance parameters to shorten the fit CPU time from a day to a few hours. He also reduced the number of parameters to approximately 180 by removing the ones which had less than a 1% effect on the other parameters as well as in the final results.

The Final Fit Input Distributions (Dr. Zaidan):
The preparation of the data, MC signal and background shape distributions from the BDT output and cut-based analysis derived from the datasets, in the correct format for the final fit program, is a critical and painstaking effort requiring expertise in software and physics. Events from each of the thousands of files needed to be carefully accounted for. Dr Zaidan took on this important responsibility for both cut-based and the BDT analyses (for the 1-lepton channel).

Representative to the Higgs Combination Group (Dr. Morange):
Dr Morange was the representative of the hbb analysis group to the group that formed the combined results from all of the Higgs's decay modes (γγ, ZZ, WW, ττ and bb). This group worked toward combining the results after understanding the analysis and related uncertainties from each decay mode, so each representative was an expert selected by the respective analysis group.

2.2 Results from the Vh(bb) Analysis

The published result [5] for the significance of the observed (expected) deviation from the no-Higgs hypothesis corresponded to 1.4 (2.6) standard deviations (s.d.) for the combined 7 and 8 TeV data. This was a significant improvement in performance compared to the cut-based analysis with which the expected significance was 1.8 s.d. presented at the EPS2013 [4]. The observed result corresponds to a ratio of the cross-section with respect to the standard model expectation μ (= σ/σ_{SM}) = $0.51^{+0.40}_{-0.37}$ statistical and systematic uncertainties combined, consistent with the SM expectation.

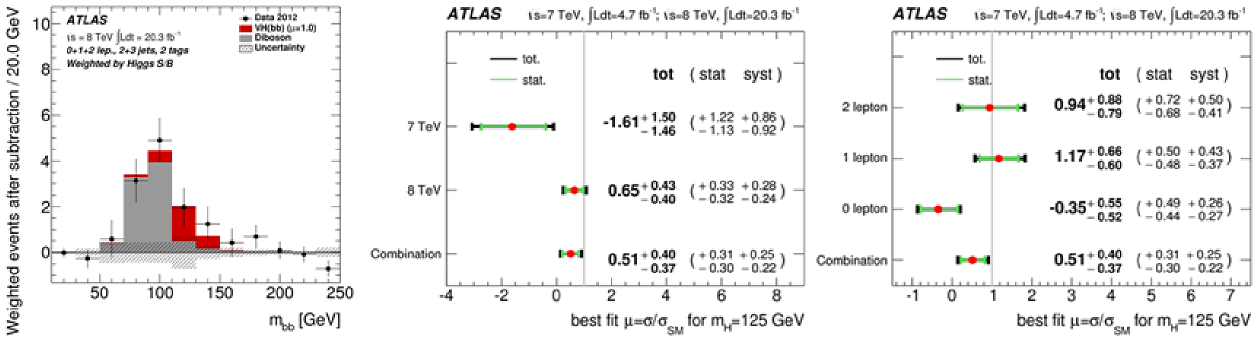

Figure 1: Left: Background-subtracted distribution of the invariant mass of two b-jets, weighted by S/B according to the BDT output. In gray is shown the contribution from the WZ and ZZ processes. The fitted signal strength (μ) is shown separately for (center) the contribution of the 7 TeV vs 8 TeV data, and for (right) the individual 0, 1 and 2 lepton channels.

Presentations at conferences and workshops by group members in the past three years are listed in [27], and the ATLAS notes authored during the same period are listed in [28].

3a. Run 2 Analysis Results

The goal after the *h* discovery is to understand what lies beyond the SM. The high CM energy for the current run, 13 TeV, affords an exciting and unique opportunity to search for new objects at scales never probed before. The integrated luminosity delivered by the LHC in the initial phase with 50 ns bunch spacing is ~100 pb^{-1}, was used for performance studies. In 2015 LHC delievered 3-5 fb^{-1} luminosity with 25 ns bunch crossing time. In 2016 the accelerator started to give a lot more data. By ICHEP 2016 the it delivered ~xx fb^{-1} luminosity, and one hopes to achieve quite a bit over 30 fb^{-1} in 2016 p-p collisions. The Iowa group concentrated on ***i) a generic search for a high mass Vh (h→ $b\bar{b}$) resonance, ii) a search for A →Zh*** [11-14], and, ***iii) a measurement of the h→ $b\bar{b}$ coupling strength,*** following up on Run 1 studies. A publication for the ***Vh*** resonance search was submitted to Moriond 2016 [29] and has been submitted for publication[29]. Dr. Benitez was responsible for the 2-lpeton channel of the ***Vh (h→ $b\bar{b}$)*** resonance analysis.
Searches for ***A →Zh*** and ***Z'*** and ***W'***, also in HVT model were submitted to Moriond 2016 [29] and is now being prepared for a publication with 2016 data with both resolved (low pT Higgs) and merged (high pT Higgs where the b-quark jets might overlap) event kinematics. Dr Argyropoulos is *leading* these analyses efforts for the 0- and 2-lepton channels. Dr. Benitez is an editor for the ATLAS note in preparation.

A measurement of the h→ $b\bar{b}$ coupling strength: For ICHEP 2016, we had enough data to start the study of the *h* branching fraction measurement into *bb* at 13 TeV energy . New strategies for background suppression need to be developed for Run 2, as the $t\bar{t}$ production is more copious than the *Vh* process at 13 TeV. A preliminary study result was shown at the ICHEP 2016 [29]. This analysis is now being optimized with more data and a publication is expected in combination of Run 1 results. Depending on the quality and quantity of luminosity acquired in 2016, a measurement of the branching fraction might be possible. Dr. Yang is pursuing the Zh decay in the 2-lepton channel with Dr. Benitez focusing on the Zh decay in the 0-lepton channel.

This coupling strength measurement is critical to determine; e.g., a measurement of the ratio of the BFs of $h \to b\bar{b}$ and $h \to \tau\tau$ could distinguish whether it is a MSSM Higgs or a SM or non-SUSY 2HDM Higgs

[18] in a non-trivial amount of phase space. MADGRAPH[20] and POWHEG[21].

4. Leading Roles in Other Areas

4.1 Identification of jets originating from b-quarks: b-tagging

Dr Zaidan was appointed as the **convener of the b-tagging Algorithm Optimization** group in early 2015. b-tagging is an important tool for our physics interests but also for many other physics analyses. Additional challenges to the b-tagging algorithms arise especially at high jet p_T and high pileup; at high momenta, tracks in jets are more collimated causing ambiguities in track and vertex reconstruction, and for high pile-up conditions, tracks from nearby interactions can be associated to the wrong vertex.

Installation of the IBL has helped in both areas by improving tracking and clustering performances. A better tracking and clustering technique was developed during the LHC shut-down. The systematics of b-tagging algorithm (dependent on tracking performance) from tracking uncertainties, was established by Dr. Zaidan. He also studied benefits of using the new tracking algorithm tuned for dense environments. All this culminated in substantial improvements in the b-tagging performance from Run 1 to Run 2, and demonstrated the effectiveness of introducing the IBL and of using advanced algorithms.

The new BDT-based **b-tagging algorithm** in Run 2 [22] combines all the outputs of the basic b-tagging algorithms, improving overall performance while simplifying selection criteria. The new algorithm **improved charm rejection** by allowing a better tradeoff between light and charm jet rejection. It provides a tunable **high p_T performance**; achieving a flat b-tagging efficiency vs. jet p_T is possible in Run 2 by smoothly relaxing the b-tagging criteria at high jet p_T (at the cost of lower light jet reduction). Different b-tagging strategies can be employed by different physics analysis groups depending on their requirements. Overall, the b-tagging performance in Run 2 is considerably improved (up to 300% improvement in light jet rejection for a given b-jet efficiency). The algorithm is continuously evolving with improving performance, Dr.Zaidan was an editor of the b-tagging performance document [22].

4.2 Detector Operations

After serving as a LAr expert on call **Dr. Benitez** has served as a **LAr Run coordinator** from Aug 2015, he also holds training sessions for LAr activities for the ATLAS shift personnel.
Mr. Mikhael Borodin, a software engineer, is engaged in the central ATLAS processing (PRODSYS2) as an Iowa group member, he is supported by US-ATLAS. He is responsible for smooth and fast production of ATLAS simulation jobs, debug any glitches in the turnover process, produce user friendly interfaces such that the status of specific production chains can be glimpsed and understood easily. He will continue to perform in this capacity in near future.

5. Upgrade Contributions

5.1 (IBL) in Pixel System

Upon joining the ATLAS experiment in 2007, the Iowa group was involved in the Pixel system. In Phase 0 upgrade, we joined the IBL project [1], with responsibility for constructing the LVPP4s (patch panels) for the Pixel Detector Control System (DCS) including modifying the original design by an Iowa senior technician for improvements. These modules (with the inner electronic boards) and sufficient spares were constructed in Iowa mechanical and electrical shops, initially calibrated, then sent to CERN and were more accurately calibrated with the DCS software at a test bench by Dr. Zaidan, with occasional debugging as the conventions changed. They were all delivered ahead of schedule and are used in the IBL operation. This work was supported by an NSF MRI grant for IBL construction (PI Professor Abe Seiden).

5.2 Phase 1 Trigger Upgrade

We joined the LAr Phase 1 upgrade [23], and Dr. Morange took responsibility for the electron and photon identification triggers. He designed an algorithm defining kinematic objects from the measurements by the LAr, and established acceptable p_T thresholds for the EM objects (for a reasonable trigger rate) with the planned granularity at high luminosity (2×10^{34} cm^{-2} s^{-1}) and pileup rates. (Professor Mallik has a history in calorimetry; Dr. Halladjian had worked on the systematics of the jet energy scale for high pile-up conditions with the 2011 data.)

5.3 Phase II Upgrade

The Phase II upgrade [24]. requires the detectors to operate at very high luminosity (recently raised by the LHC machine group to ~ 10^{35} cm^{-2} s^{-1}), with a typical pile-up of 200. The detectors, the trigger-DAQ, the reconstruction software and the analyses algorithms, all need serious modifications to work effectively under such high intense radiation, rate and pile-up. A prime focus is in improving performance in the forward regions, especially, the sensitivity to the vector boson fusion processes. A state-of-the-art High Granularity Timing Detector (HGTD) has been proposed with ~30 ps time resolution and fine granularity with Si, in order to help in selecting the hard scatter vertex from pile-ups among the vertices in the same bunch crossing (25 ns).

Under the 275 MCHF funding scenario (The Research Review Board of CERN has approved a number very close), the HGTD should not pose a financial hardship, provided it is approved by the ATLAS Collaboration. To this end Iowa group established the HGTD in the ATLAS detector simulation with GEANT4 and initiated the study of detector performance and physics justification. Dr. Benitez is very involved in this process. Professor Mallik was given the responsibility for the Detector Control System of the HGTD. She gave two presentations with her early general plans, details will be developed as the HGTD plans develop.

The HGTD will use thin ultrafast Si detectors [25,26]. R&D for Low gain avalanche diode (LGAD) production and performance test have started along with radiation hardness studies. Two options are considered: a presampler option with four Si layers with a thin interleaved layer of tungsten (W), while the simple timing detector option will have only four Si layers. An Initial Design Report (IDR) for the HGTD is due toward the end of 2016, early 2017 with that of the LAr.

6. Summary

The University of Iowa group under Professor Mallik's leadership has been a very productive and important part of the ATLAS collaboration in all areas of the experiment. First and foremost in the area of Electroweak Symmetry breaking by understanding the real nature of the Higgs boson at 125 GeV, by exploring its fermionic decays. Simultaneously, at 13 TeV, the group is exploring any possible BSM extension of other Higgs-like boson with their expertise developed with the b-pair decays and b-tagging. They are providing leadership in analysis (Argyropoulos), in performance areas (Zaidan), in Operations (Benitez LAr Run coordinator), and in Phase II upgrade (Mallik). Now with the addition of the software engineer Borodin, the group is also a serious contributor to the central reconstruction operation, a major and continuously evolving challenge. Current postdocs and graduate students are listed in [30]. The Above work was only possible with funding from the DOE, and we wish to thank them for the critical support, which allowed us to make such significant contributions.

Table 2: Percent of FTE effort spent by each postdoc by year from approx. Oct 2012-Aug 2015 (2013 includes Oct-Dec 12), Dr. Morange left in Nov 2014. Dr. Zaidan leaves in mid-Sep 2015, Dr.s Benitez and Argylopoulos joined in Jan and Jun 2015, respectively.

Task list	Remi Zaidan			Nicolas Morange		Rocco Mandrysch		Jose Benitez	Spyridon Argyropoulos
	2013	2014	2015	2013	2014	2013	2014	2015	2015
Analysis activity	75%	80%	15%	75%	100%			50%	85%
ATLAS reconstruction						100%	100%		
LVPP4 calibration	20%	5%							
LAr activities				25%				50%	
b-tagging activities	5%	15%	85%						15%

Bibliography

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2. *Associated production of Higgs bosons and Z particles.* **S. Glashow, D. V. Nanopoulos, and A. Yildiz.** Phys. Rev. D 18 (1978) 1724.

3. *Search for the Standard Model Higgs boson production in association with a vector boson and decaying to a b-quark pair with the ATLAS detector.* **The ATLAS Collaboration.** Phys Lett. B 718 (2012) 369 [arXiv:1207.0210 [hep-ex]].

4. *Search for the bb decay of the Standard Model Higgs boson in associated W/ZH production with the ATLAS detector.* **The ATLAS Collaboration.** ATLAS-CONF-2013-079.

5. *Search for the $b\bar{b}$ decay of the Standard Model Higgs boson in associated (W/Z)H production with the ATLAS detector.* **The ATLAS Collaboration.** JHEP01(2015)069 [arXiv:1409.6212 [hep-ex]].

6. **L. Breiman, J. Friedman, R. Olshen and C. Stone.** *Classification and Regression Trees.* Monterey, CA U.S.A. : Wadsworth and Brooks, 1984.

7. *Toolkit for Multivariate Data Analysis with ROOT.* **A. Hoecker, et al.** 2013. CERN-OPEN-2007-007.

8. Systematic Uncertainties and Profiling, **Wouter Verkerke,** Talk at IN2P3 School of Statistics 2014, https://indico.in2p3.fr/event/9742/contribution/16/material/1/0.pdf

9. *Calibration of the performance of b-tagging for c and light-flavour jets in the 2012 ATLAS data.* **The ATLAS Collaboration.** 2014. ATLAS-CONF-2014-046.

10. *Calibration of b-tagging using dileptonic top pair events in a combinatorial likelihood approach with the ATLAS experiment .* **The ATLAS Collaboration.** 2014. ATLAS-CONF-2014-004.

11. *Theory and phenomenology of two-Higgs-doublet models .* **G. Branco, P. Ferreira, L. Lavoura, M. Rebelo, M. Sher, et al.,.** Phys. Rep., (2012) 516.

12. **J.F. Gunion, Sally Dawson, Howard E. Haber, Gordon L. Kane.** *The Higgs Hunter's Guide.* 1989.

13. *Search for a CP-odd Higgs boson decaying to Zh in pp collisions at sqrt(s) = 8 TeV with the ATLAS detector.* **The ATLAS Collaboration .** Physics Letters B (2015) 744.

14. *Search for a pseudoscalar boson decaying into a Z boson and the 125 GeV Higgs boson in $\ell^+\ell^- b\bar{b}$ final states,* **The CMS Collaboration.** Phys. Lett. B 748 (2015) 221.

15. *Search for high-mass diboson resonances with boson-tagged jets in proton-proton collisions at $\sqrt{s}$ = 8 TeV with the ATLAS detector,* **The ATLAS Collaboration .** 2015. arXiv:1506.00962v2.

16. *Doubly charged Higgs bosons,* **Marachek, H. Georgi and M.** Nucl. Phys. B (1985) 463.

17. *Higgs boson triplets with Mw=Mzcos ϑ_w,* **M.S. Chanowitz and M. Golden,** Phys. Lett. B 165 (1985) 105.

18. *Discriminating between SUSY and Non-SUSY Higgs Sectors through the Ratio $H\to b\bar{b}$ /$H\to\tau^+\tau^-$ with a 125 GeV Higgs boson,* **E. Arganda, J. Guasch, W. Hollik, S. Penaranda.** hep-ph arXiv:1506.08462v2, and references therein.

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20. *MADGRAPH 5, going beyond*, J. Alwall, M. Herquet, F. Maltoni, O. Mattelaer, T. Stelzer. JHEP 1106 (2011) 126.

21. *A New method for combining NLO QCD with with shower Monte Carlo algorithms*, P. Nason. JHEP 11 (2004) 040; *Matching NLO QCD with Parton Shower simulations, S. Frixione, P. Nason and C. Oleari*. JHEP 11 (2007) 070; For descriptions of the POWHEG generator for various processes, see references in http://powhegbox.mib.infn.it/

22. *Expected performance of the ATLAS b-tagging algorithms in Run-2,* **The ATLAS Collaboration.** 2015. ATL-PHYS-PUB-2015-022.

23. *ATLAS Liquid Argon Calorimeter Phase-I Upgrade Technical Design Report,* **The ATLAS collaboration.** 2013. CERN-LHCC-2013-017.

24. *ATLAS Phase-II Upgrade Scoping Document,* **The ATLAS Collaboration.** ATL-COM-UPGRADE-2015-024.

25. *Performance of Ultra-Fast Silicon Detector,.* **N. Cartiglia, et al.** 2013. arXiv:1312.1080 [physics.ins-det] NIMA.

26. *Beam test results of a 15 ps timing system based on ultra-fast silicon detectors, ,.* **N. Cartiglia, et al.** 2016. arXiv:1608.0868 [physics.ins-det].

27. **Invited talks by group members (Oct. 2012- Aug. 2015)**

by **Usha Mallik**:

- *LHC and the Energy Frontier*, Saha Institute of Nuclear Physics, Dec 22, 2014, Kolkata, India.
- *Our Universe and the Higgs Field*, Indian Institute of Technology (Madras), Dec 12, 2014, Chennai, India.

- *About the Higgs boson and its role*, Models of Gravity workshop, Mar 9-11, 2013, University of Oldenburg, Germany.
- *News from CERN about the Higgs*, Lightcone, Relativistic Hadronic and Particle Physics, Dec 10-15, 2012, University of Delhi, India.

by **Rocco Mandrysch:**

- *ATLAS Online Software Monitoring and Performance*, CHEP 2013, Oct 14-18, 2013, Amsterdam, NL.

by **Nicola Morange:**

- *Higgs in Fermion Decays (at ATLAS)*, SUSY 2014, Manchester, UK.
- *Treatment of Experimental Uncertainties in Extrapolating from Control Region to Signal Region*, ATLAS Higgs Workshop, Apr 14-18, 2014, Rome, IT.
- *Search for the Higgs boson in associated production with a vector boson and decaying to b-quarks in ATLAS*, IPNL Seminar, Feb 2, 2014, Lyon, FR.
- *Expected Performance of an Upgraded L1 Calorimeter Trigger and Search for VH(bb)*, Meeting with DOE and NSF representatives, Sep 30, 2013, CERN.
- *Search for Associated Production of VH(bb) at ATLAS: Analysis Strategy,* Division of Particles and Fields of APS meeting, Aug 15, 2013, UCSC, Santa Cruz, CA, USA.

by **Remi Zaidan:**

- *Search for the Higgs boson in the VH(bb) channel using the ATLAS Detector*, US-ATLAS Physics Workshop, Aug 4-7, 2014, Seattle, Washinton, USA.
- *Search for the Higgs boson in the VH(bb) channel using the ATLAS Detector*, International Conference on New Frontiers in Physics, Aug 28- Sep 5, 2013, Kolymbari, Crete, Greece.
- *Search for the Higgs boson in the VH(bb) channel using the ATLAS Detector*, US-ATLAS Physics Workshop, Jul 15-18, 2013, ANL, IL, USA.
- *Search for the Higgs boson in the* ($H\rightarrow bb$) *Decay mode*, US-LHC Annual Users Meeting, Oct 19-20, 2012, FNAL, IL, USA.

28. Internal and External ATLAS Notes by Group Members [Oct 2012-Aug 2015]

- *Expected performance of the ATLAS b-tagging algorithms in Run-2*, The ATLAS Collaboration, 2015. ATL-PHYS-PUB-2015-022 (co-editor Remi Zaidan).
- *Search for the bb decay of the Standard Model Higgs boson in associated (W/Z)H production with the ATLAS detector*, The ATLAS Collaboration, 2015. JHEP01(2015)069 [arXiv:1409.6212 [hep-ex]].
- *Supporting Document for the Search for the bb decay of the Standard Model Higgs boson in associated (W/Z)H production with the ATLAS detector,* 2014, ATL-COM-2014-051. (internal document)
- *Search for the bb decay of the Standard Model Higgs boson in the VH(bb) final state with the ATLAS detector, 2013,* The ATLAS Collaboration. ATLAS-CONF-2013-079.

- *Search for the bb decay of the Standard Model Higgs boson in associated (W/Z)H production with the ATLAS detector, 2013*, ATLAS-COM-CONF-2013-080. (internal document)
- *ATLAS Liquid Argon Calorimeter Phase-I Upgrade Technical Design Report*, The ATLAS Collaboration, 2013. CERN-LHCC-2013-017.

29. (contd from 28) Search for new physics in VH resonances at 13 TeV, by ATLAS Collaboration, ATL-CONF-2015-074; Search for the 2HDM A->Zh with h->bb-bar decay, by ATLAS Collaboration, ATL-CONF-2016-015; Search for VH resonances in the semileptonic mode using 13 TeV data, ***submitted to Phys.Lett. B,*** CONF-EXOT-2016-18 (temp):

30. **Current postdocs**:

Dr. Spyridon Argyropoulos: Ph.D. Humboldt University, Berlin [2015]; Research Experience: Measurement of ttbb production with 8 TeV data, Modeling of color reconnection and its effects on the top mass measurement.

Dr. Jose F. Benitez: Ph.D. Stanford University [2011]; CERN Fellow [2011-2013], Physics Lecturer at Florida International Univ. [2014]. Research Experience: Search for decays of the SM and MSSM Higgs bosons into tau pairs at CMS; Measurement of rare leptonic decays & search for excited charm mesons at the SLAC B-factory BABAR; Development of Cherenkov detectors for particle id at super B-factories.

Dr. Siqi Yang: Ph.D. USTC, Anhui, Chiana [2016]; recipient of the CHENGUANG AWARD (Aug, 2016) for the best young scientist (less than 35 years of age) in Particle Physics in two years.