Contribution 20

Searches for New Physics: Les Houches Recommendations for the Presentation of LHC Results

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Abstract
We present a set of recommendations for the presentation of LHC results on searches for new physics, which are aimed at providing a more efficient flow of scientific information between the experimental collaborations and the rest of the high energy physics community, and at facilitating the interpretation of the results in a wide class of models. Implementing these recommendations would aid the full exploitation of the physics potential of the LHC.

1 INTRODUCTION

The LHC has very successfully begun to explore the TeV energy scale, and will be the energy frontier machine for the foreseeable future. Everyone who has had a hand in bringing this scientific and technological marvel to fruition deserves considerable credit and our thanks: the physicists and engineers who conceived, designed, and built it; those who operate the machine and its experiments; those who produce experimental results; those who try to understand them, and the public and its representatives whose generous support has enabled all this to happen.

The LHC was designed as a machine of discovery. There are high hopes that groundbreaking discoveries will indeed occur and shed light on electroweak symmetry breaking (be it via the Higgs mechanism or some other new dynamics) and new physics beyond the Standard Model (SM) of electroweak and strong interactions. It is of highest priority to our community to exploit fully the physics potential of the LHC. One aspect of this exploitation is the interpretation of LHC results in the contexts of different models of new physics. This is crucial if we are to unravel the correct new physics model, determine its parameters, and move beyond the SM.

The ATLAS and CMS collaborations are providing detailed experimental results [534, 535] of searches in many different channels. They are also providing interpretations in terms of popular models, such as the CMSSM[1], or in terms of Simplified Models[2]. These results

[1]Constrained Minimal Supersymmetric Standard Model, see e.g. [536].

[2]Simplified Models are designed as an effective-Lagrangian description of a small number of accessible new particles. This approach has a long heritage; for a recent paper advocating it see e.g. [537].

are being used to test as large a variety of beyond-the-SM (BSM) scenarios as possible. For example, the searches for supersymmetry (SUSY), including [199, 200, 233, 538–540], were interpreted in a number of different SUSY-breaking schemes, see e.g. [235, 277, 279, 281, 541, 542], as well as in the weak-scale "phenomenological" MSSM [191, 192]. The sensitivity to light stops was investigated in [543–545], while implications of compressed SUSY spectra were analyzed in [546]. Interpretations were also made for non-SUSY models, for instance for the minimal universal extra dimension (UED) model in [547]. Similar non-collaboration efforts to interpret Higgs search results [144, 402] in a large variety of BSM scenarios are also underway. These examples illustrate the community's interest in the LHC experimental results—interest that will surely grow as results become more comprehensive and readily available.

A systematic way of presenting LHC results will also greatly facilitate the comparison and combination of analyses within and across the LHC collaborations, as well as the assessment of the physics potential of future facilities. Furthermore, agreement on a set of recommendations and their implementation would be a further step towards a more comprehensive approach to the storage, persistence and future use of LHC results.

In this contribution, we therefore propose a set of recommendations for the presentation of LHC results aimed at maximizing its scientific return. Many of the experimental publications already implement several of the basic recommendations we make. But, as we shall see, our recommendations go substantially beyond current practice. Our wish is to work towards an agreement on a common standard for the presentation of results. The goal is to help the community make the most of an extraordinary scientific opportunity.

2 EXECUTIVE SUMMARY

We here summarize our recommendations, which we present in four broad categories: analysis description, detector modeling, analysis dissemination and analysis design. Moreover, we include some recommendations regarding the interpretation of the results. Where appropriate, we split our recommendations into options:

(a) "crucial" (mandatory) recommendations, defined as actions that we believe should be undertaken, following revision motivated by feedback from the experiments, and

(b), (c) "desirable steps", i.e. actions that would help, but whose implementation is recognized as either being controversial, and thus needing more debate, or requiring major efforts and a longer timescale.

Recommendations without such sub-division are understood as "crucial". An extensive discussion of these recommendations will be published as an independent document.

1. (a) Provide a clear, explicit description of the analysis in publications. In particular, the most crucial information such as basic object definitions and event selection should be clearly displayed in the publications, preferably in tabular form, and kinematic variables utilised should be unambiguously defined. Further information necessary to reproduce the analysis should be provided, as soon as it becomes available for release, on a suitable common platform.

   (b) The community should identify, develop and adopt a common platform to store analysis databases, collecting object definitions, cuts, and all other information, including well-encapsulated functions, necessary to reproduce or use the results of the

analyses, and as required by other recommendations.

2. (a) Provide histograms or functional forms of efficiency maps wherever possible in the auxiliary information, along with precise definitions of the efficiencies, and preferably provide them in standard electronic forms that can easily be interfaced with simulation or analysis software.

   (b) The community should take responsibility for providing, validating and maintaing a simplified simulation code for public use, reproducing the basic response of the LHC detectors. The validation and tuning of this tool should be based on comparisons with actual performance plots, and/or other inputs, made available by the experiments along the lines of Recommendation 2a. Limits of validity should be investigated and clearly documented.

3. (a) Provide all crucial numbers regarding the results of the analysis, preferably in tabulated form in the publication itself. Further relevant information, like fit functions or distributions, should be provided as auxiliary material.
   Addendum:
   For multi-bin results, provide an ensemble of sets of the numbers B, δB, $\mathcal{L}$, $\delta\mathcal{L}$, Q, k, etc in the auxiliary information. These would be created by sampling from the various experiment-specific systematic effects, such as the jet energy scale, jet energy resolution, etc. Results should be quoted without inclusion of systematic/theoretical uncertainties external to the experiment.

   (b) When feasible, provide a mathematical description of the final likelihood function in which experimental data and parameters are clearly distinguished, either in the publication or the auxiliary information. Limits of validity should always be clearly specified.

   (c) Additionally provide a digitized implementation of the likelihood that is consistent with the mathematical description.

4. In the interpretation of experimental results, preferably provide the final likelihood function (following Recommendations 3b/3c). When this is not possible or desirable, provide a grid of confidence levels over the parameter space. The expected constraints should be given in addition to the observed ones, and whatever sensitivity measure is applied must be precisely defined. Modeling of the acceptance needs to be precisely described.

5. For Higgs searches, provide all relevant information on a channel-by-channel basis for both production and decay processes.

6. When relevant, design analyses and signal regions that are based on disjoint sets of events.

3 CONCLUSIONS

This document presents a set of recommendations for the presentation of LHC results on searches for new physics, which are aimed at providing a more efficient flow of scientific information

and at facilitating the interpretation of the results in wide classes of models. It originated from discussions at this Les Houches "Physics at TeV Colliders 2011" workshop and was thoroughly discussed and refined, with valuable input from representatives of the ATLAS and CMS collaborations, in a dedicated miniworkshop organized by the LHC Physics Centre at CERN [548]. The target of these recommendations are physicists both within and outside the LHC experiments, interested in the best exploitation of the BSM search analyses.

The added value for the experiments, and the whole HEP community, in extending the scope of the information made available about the experimental results, is a faster and more precise feedback on the implications of these results for a broad range of theoretical scenarios. Correlations and consistency checks among the findings of different experiments, at the LHC and elsewhere, will be facilitated, and will provide crucial input in the choice of the best research directions in both the near and far future, at the LHC and elsewhere. Improving the way the results of the LHC searches are documented and stored furthermore provides a forum to explore alternative approaches to long-term data archiving.

The tools needed to provide extended experimental information will require some dedicated efforts in terms of resources and manpower, to be supported by both the experimental and the theory communities. Practical solutions towards the development of these tools and the implementation of the proposed recommendations will be addressed in dedicated Workshops and working groups.

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