Snowmass2021 - Letter of Interest

Digging for elusive BSM with simplified models

Thematic Areas:

■ CompF7: Reinterpretation and long-term preservation of data and code — **primary area**
■ CompF3: Machine Learning
■ EF09: BSM: More general explorations

Submitted by:

Sabine Kraml – LPSC Grenoble, France – sabine.kraml@gmail.com
Andre Lessa – UFABC Santo Andre, Sao Paulo, Brazil – lessa.a.p@gmail.com
Wolfgang Waltenberger – HEPHY Vienna, ÖAW, Vienna, Austria – wolfgang.waltenberger@gmail.com

While there is strong consensus in our community that the Standard Model (SM) cannot be the last word in particle physics, so far no clear sign of new physics has surfaced in any of the myriads of the experimental analyses at the LHC. So, despite a slew of postulated Beyond the Standard Model (BSM) theories, we are still very much in the dark as to which will be the best direction to take for future experimental and theoretical explorations.

We therefore find it interesting and worthwhile to attempt a new approach to the quest for new physics at the LHC and beyond: instead of postulating BSM theories and then testing them one-by-one against the experimental data, we aim at identifying dispersed signals in the slew of published LHC analyses while at the same time building candidate "proto-models" from them in terms of simplified model spectra. Such proto-models may then be scrutinised further in dedicated analyses, help guide future experimental efforts, and, in case of a discovery, help to eventually unravel the concrete underlying BSM theory.

We have recently been developing a first working prototype of a statistical learning algorithm that achieves this based on the SModelS software framework [1, 2, 3, 4, 5]. It employs a random walk algorithm to build precursor theories, dubbed "proto-models" above. Such models are constructed to fit observed excesses in the data and at the same time remain compatible with the entirety of LHC results (from more than 100 published ATLAS and CMS searches for supersymmetry) in the SModelS database. One of the advantages of our approach with respect to more traditional data fits of BSM models lies on the flexibility of the proto-models, which can have a variable number of particles and are not constrained by the usual theoretical requirements of a full BSM theory. With a multi-level optimization procedure, we can identify potential dispersed signals that might otherwise be missed simply because each individual experimental analysis only looks at a fraction of the LHC data, while our algorithm combines the individual results in a well-defined, global manner. Of course, potential correlations of different analyses need to be carefully accounted for.

Aspects that we want to study in the near future, and that we think may be interesting for the Snowmass 2021 initiative, include:

- the statistical learning method for dispersed signals, for example trying different information criteria to judge the quality of a proto-model;
- the importance of full likelihood information [6, 7] in such a procedure (based on the pyhf likeli-

hoods [8] that ATLAS started to provide for their full Run 2 search results);

- machine learning of simplified-model results for a much faster database;
- possibilities to include results from SM measurements as complementary constraints;
- consistency of proto-models with full or effective theories;
- usage of gradient-based methods as accelerators, with inductive differentiable reasoning as a long-term goal.

In addition to current BSM (re)interpretation efforts, this work should also be relevant for the long-term preservation and reuse of experimental results.

References

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