

Report on the MITP Workshop, Summer 2016

Understanding the First Results from the LHC Run II

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After the discovery of a Standard-Model-like Higgs boson the MITP workshop focused on four major aspects of new physics searches at the LHC and other experiments

- searches for new physics effects in the Higgs sector;
- new strategies to search for dark matter candidates;
- ideas and tools to improve generic new physics searches at the LHC.

Due to the phenomenological nature of the workshop, the theme in all of these search directions was to confront new ideas on the model side, new analysis ideas, and new experimental ideas beyond the LHC with the most recent analysis tools and measurements. This bridge between pure theoretical physics and experimental results defined not only all talks, but also the typical discussions.

Experimentally, the most prominent anomaly observed by ATLAS and CMS was the di-photon mass peak around 750 GeV. While this was discussed in one of our weekly “Discussion Sessions”, the persistent rumors suggested the anomaly would not survive after new data was presented at ICHEP (August 3-10). For our workshop this meant that this anomaly played a role, but did not dominate the talks and discussions.

The workshop schedule followed our general aim to invite excellent young scientists at the postdoc stage from all over the world (North and South America, Asia, and all of Europe). We had two 30 minute talks with plenty of time for discussion every Monday, Tuesday, Thursday, and Friday; all talks were given by junior participants without a permanent position. Most Wednesdays we invited one or two more experienced participants to trigger and lead a discussion on a current topic of their choice. For the presentations we asked the audience not to bring their laptops. This worked very well and had a hugely positive effect on fostering discussions during and after the talks.

Given the mix of participants varying week to week, we did not define a physics focus for each

workshop week, but instead responded to the interest of the participants. The topics featured by our talks include

- the 750 GeV anomaly and possible interpretations, links to dark matter or other anomalies;
- Higgs portal models and links between dark matter, baryogenesis, and LHC physics;
- simplified dark matter models, to expand our interpretation towards lighter new particles;
- effective Lagrangians of the Higgs-gauge and top sectors, to interface theory and experiment;
- effective Lagrangians of dark matter, for example to link direct detection and LHC searches;
- subject-based searches and multi-jet searches at the LHC;
- new ideas to identify kinematic features of new physics;
- higher-order QCD effects on new physics signatures;
- new experiments to detect axion-line dark matter;
- new ways to detect light new particles or dark photons;
- physics at a future Higgs factory;
- physics at a future 100 TeV hadron collider;

A few general questions structured this wide range of topics and accompanied us through the four workshop weeks. First, in the presence of experimental anomalies as well as dealing with experimental constraints it is crucial that we keep in mind what physics questions we expect the LHC and other experiments to answer. Such fundamental questions are one way to organize the vast landscape for example of LHC searches.

Second, from the current LHC results it is clear that direct searches for highly visible signatures of new physics are not a promising approach to new physics effects at the LHC. Instead, we need to develop a framework to perform and interpret precision studies searching for direct and indirect effects of new physics, and to put the result into a theoretical context. During the workshop it became clear that effective Lagrangians describing the Higgs-gauge sector, the top sector, as well as dark matter require a unified approach. Moreover, these effective Lagrangians benefit from a well-defined link to established new physics models.

Third, in particular related to QCD effects, precision predictions, and improved understanding of backgrounds we have to develop powerful new tools for LHC searches in particular including multi-jet signatures.

Finally, There exists a large number of proposed new experiments covering a wide range of particle masses, energies, and cost. Especially searches for dark matter suffer from the fact that

we know very little about the underlying mass scales and interaction structures. A successful global search program has to coherently combine many experimental ideas as well as theoretical frameworks. The usual link between direct, indirect, and collider searches for WIMPs is only one of many such aspects.

Because of the great setup of the center, the organized discussions very often continued as informal discussions over coffee. Aside from general and targeted discussions, a wide range of papers on many of these topics got started, worked on, and published as part of the workshop. Many of the international young and high-profile visitors expressed an interest to come back to the area, so we have good reasons to expect long-term collaborations and projects triggered by the MITP program.