



# Gearing up for LHC13

Arcetri, 31/08/15 - 16/10/15

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**Abstract.** 2015 has been a crucial and fruitful year for the Large Hadron Collider. With the start of Run 2 at a centre of mass energy of 13 TeV a new era of particle physics has begun that will determine much of the future of the field for decades. This workshop brought together experimentalists and theorists to discuss early Run 2 results and their implications for the present and the future of particle physics.

**Keywords.** LHC, Higgs, Beyond the Standard Model, Dark Matter

The workshop “Gearing up for LHC 13” took place at the Galileo Galilei Institute (GGI) in September-October 2015 gathering over 200 physicists from all over the world. The main focus was physics beyond the Standard Model (SM). The GGI was the perfect environment to get ready for the upcoming results of the LHC that has just restarted operations at higher energy. The workshop ended in mid-October with an international conference held in Arcetri attended by leading scientists in the field of physics beyond the Standard Model (SM).

A few conference statistics:

- 79 registered participants over 4 days, including over 50% from abroad.
- 44 plenary lectures delivered; about 25% of these were experimental.

All the talks from the conference can be found at: <https://indico.cern.ch/event/356452/>

The main focus of the activities was the restart of the LHC that just began to record data at the highest energy ever achieved in a laboratory during the summer 2015. We were more interested in the future of particle physics than in the past which is why we encouraged participation by young researchers as much as possible. Run II of the LHC will be crucial for the future of the field. During Run I the Higgs boson was discovered. This was a great triumph for both theory and experiments, completing the particles predicted by the SM over 40 years ago. It confirmed among other things that the simple description of the generation of

mass in the SM is at least approximately correct. While we cannot understate the importance of this result, the particle physics community has already taken the next step, starting to look at the future. In hindsight the presence of the Higgs boson was largely expected and no surprises were found in Run I, rather constraining many extensions of the SM, supersymmetry and composite Higgs models in particular, which were considered by many people the most compelling extensions of the SM. In view of this, finding the Higgs with SM properties and nothing else was also disappointing for many theorists.

Run II will tell us more about the mysteries of the SM and whether new physics related to the hierarchy problem lies at the TeV scale. Theoretical arguments suggest that the electro-weak scale is unstable in the SM so that new physics should be present close by and possibly observable at the LHC, directly or indirectly. On the other hand, failure to find any sign of new physics in a variety of experiments has called this belief into question. Moreover, the LHC has the chance to observe new physics not motivated by the hierarchy problem which would pose further questions on the role of naturalness in the Standard Model.

All these were strong motivations for the organization of the workshop. We had a very broad range of subjects that were discussed during the 7 weeks. Our field is about exploring the unknown and, given the lack of clear experimental hints, many possibilities are open, including that the plain SM will be valid up to much higher energies.

A partial list of activities included:

- Upcoming results from the LHC Run II
- Implications for physics beyond the Standard Model
- New searches at LHC
- Future of particle physics

The workshop was structured so that each week would be devoted to a specific topic in order to gather people working in a similar field as much as possible. The focus was:

- weeks 1-2: supersymmetry
- weeks 3-4: Higgs couplings, composite Higgs, extended Higgs sectors
- weeks 5-6: exotics, dark matter

Each week we had typically 1 experimental talk at the beginning of the week followed by related theoretical talks.

During the workshop we constantly tried to foster interaction between participants, in particular giving space to junior people to present their results. Beside regular talks that took place in the morning we also organized discussion sessions in the afternoon on topics of general interest. We asked some of the more experienced participants to lead a discussion rather than presenting a talk. This was very fruitful and we had very lively discussions about future directions. We had interesting sessions about hot topics such as: relaxation of the electro-weak scale, axion physics, twin Higgs and new directions in dark matter.

The workshop greatly benefited from the possibility of inviting renowned scientists to stay at the GGI for an extended period of time. This was made possible by a grant funded by the Simons foundation. In particular we had the pleasure to host Matthew Strassler (Harvard U.), Alex Pomarol (IFAE & CERN), Marcus Luty (Davis U.), Asimina Arvanitaki (Perimeter Institute) and John March-Russell (Oxford U.) each participating for 4 weeks or longer. The stable presence of top scientists at GGI was very beneficial to the workshop attracting many high level researchers. Many people stayed longer than the 2 weeks that was the minimum allowed.

The workshop was very successful in all aspects. The response of the community was impressive showing how lively the field is. The mixture of young post-docs and more established scientists from all over the world was very refreshing. We covered the most compelling alternatives to the SM that could be unveiled in Run II of LHC. It was also clear that the community must be ready for the unexpected.

Soon after the end of the workshop the LHC announced striking deviations from SM that could be the first sign of the long-awaited new physics beyond the SM. This unexpected signal, if confirmed, will certainly demand a number of studies.



Figure 1. Workshop participants.