Report from the GDR-InF workshop on future experiments

June 4, 2018

1 Introduction

The GDR-InF workshop "The future of the intensity frontier?" took place at CERN on February 1^{st} and 2^{nd} 2018. The purpose of this workshop was to stimulate discussion about the future of the Intensity Frontier from the perspective of the French community. The full agenda and slides can be accessed here: https://indico.cern.ch/event/686737/overview

On Thursday afternoon, after an experimental overview, four theorists proposed their views on some of the topics of most relevance and interest. Friday morning was devoted to several short overviews of the ongoing or planned experiments.

The roundtable on Friday afternoon provided an opportunity to further discuss the future of the field keeping in mind the theory and experimental talks. Some highlights of this roundtable discussion are reported below. This is not an exhaustive summary of the GDR-InF view on the topic, but just a collection of thoughts to be further developed and integrated. It can be used, together with the inputs from the talks, as a base to build our input for the European Strategy of Particle Physics.

2 Round table discussion: highlights

2.1 The motivation for the intensity frontier

- There are strong experimental motivations for the field: evidence of existence of dark matter; the fact that neutrinos have a mass; the baryon asymmetry in the universe; lepton flavor which is not fully understood.
- All theory motivations are well based. Theorists are widening the motivations and scopes. Beyond SM physics might be in fact very near to the SM, like in the case of neutrino oscillation.
- It is more difficult to predict where new physics lies as naturalness and elegance are not longer as strong arguments as previously thought.

2.2 Interplay theory-experiment

- Theorists provide precise calculations, which are needed to clearly establish deviations. They also provide solid suggestions for guiding the experiments.
- It would be good if theory would provides predictions well in advance. For example, if we assume that one of the current deviations is true, then how should we proceed? How we should prepare ourselves to understand where it comes from? What should we measure next? Apparently it is difficult to do so at the moment, because there are too many theoretical options possible to accommodate the current deviations.
- New experimental results are killing many models, providing guide for the model builders.

2.3 Experimental strategy

- For experiments, we need to think on two lines. On one side, we need to exploit the current machines at a maximum. We should look at windows of opportunity at existing machines: for example, explore the option of beam dumps experiments at SPS. On the other hand, we should push for having technology breakthrough, like new ways of accelerating particles.
- Experiments upgrade are crucial and often they are not just incremental steps from the technical point of view: there is always a technological breakthrough.
- Intensity frontier is seen at the moment as a parasite of the colliders program. If we want to have an impact, we need to point to few things to be done at the same level of colliders. We want more than complementarity: we want resources assigned.
- In the upgrade of current experiments, we should put a threshold on the sensitivity gain. It is important to improve technologies that could radically improve sensitivity.
- We should keep the field alive to ensure the next discovery, even if it means a not optimal choice for the next generation of colliders.
- People invent regularly new ways of doing measurements (for example, cooling muon before accelerating as tried in Japan, it would take time but will be very interesting), with no need of 100km accelerator. Maybe we should push also into this direction, less difficult to sell than big projects.

2.4 Experimental overview

- **Precision quark flavour**
  - LHCb is well understood and with a clear established physics program, reinforced by the current deviations observed in flavour. In 10 years from now factors of improvements in many measurements are expected.
  - Belle2 is starting and has a program complementary to the one of LHCb, including unique capabilities for tau physics.
  - NA62 will have results soon, of an impact comparable to the golden measurements of LHCb. In kaon physics $\epsilon'\backslash\epsilon$ is becoming constraining.
- **Precision lepton flavour**
  - Lepton flavor experiments should increase sensibility of some order of magnitudes.
  - Double beta decays experiments sensitivities maybe will increase a bit less.
- **Search for hidden particles**
  - Beam dump experiments like SHIP can explore the right handed neutrinos scenario, but are also a good way to find new things when you have no precise idea on which new physics you would expect.
  - High intensity axions searches experiments allow to eventually discover a new particle and learn of it. We should increase the priority on axion searches and neutrinos, and in general on discovery experiments at the intensity frontier.
- **Large circular colliders**
  - The FCC at 100 TeV is both an high energy and high intensity frontier machine, having a consistent program.
  - For HL-LHC: on one side one might wonder if it makes sense to just increase the luminosity if there is no new physics found after the LHC run2. On the other hand, HL-LHC is extremely good for ensuring a constant funding and securing a generation of students for the next new experiments.

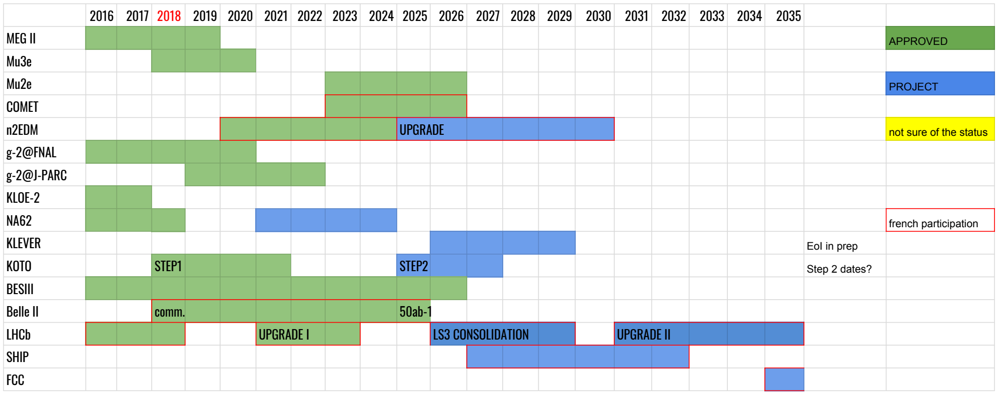

Figure 1: Overview of the upcoming experiments at the intensity frontier.

2.5 Interplay among experimental fields

- Strong CP violation has been suffering from being a corner of physics. In fact, it is difficult to put together experimentalists to do some experiments like searches for axions, because they require interaction of experimental fields which are usually separated. An example of how a better interaction of the fields could help is provided by the role of the high intensity lasers in the gravitational waves searches. There are many other experimental techniques which are not specific to high energy physics but could help developing the field.

2.6 Interplay with other fields

- **Energy frontier:** Indirect measurements, even if one deviation is certain, do not show the full way: you need a direct search. The current anomalies can not be explained with a 200 TeV particles. It means that, if confirmed, you have something new not too far away, and so you need an higher energy collider to complete the search. These anomalies will not narrow so much model building, but will tell you that there is something.

- **Astroparticles and cosmology:** It is important to keep the diversity of small experiments and the bounds with astroparticle and cosmology: the field has to be presented as a whole in order to survive.

- **Higgs precision experiments:** Precision physics is great and probably we will find confirmation of the deviations. Anther mission is doing precision physics of the Higgs: that will tell us the way to go. In fact, an highest priority should be given to study the Higgs boson, not to find new particles. It is a failure of the field not having sold this argument: we need a machine to measure and study precisely the Higgs. If ILC is not done in Japan, precision physics should still be present, either with circular or linear machine.