Future Circular Collider Group - FCC

Proposal for a new research group at LIP

Following the 2020 update of the European Particle Physics Strategy (EPPS), a global collaboration was established, dedicated to producing a feasibility study for a Future Circular Collider (FCC) facility located in Geneva. If approved, this facility will represent the future high-energy frontier in accelerator physics that will succeed the High Luminosity LHC from around 2040 onwards. It will include an e+e- collider (FCC-ee) devoted to a wide physics programme, with highlights on Higgs, top and electroweak precision measurements. This will later be replaced by a hadron machine (FCC-hh), which will share most of the infrastructure of the previous collider and repeat the virtuous cycle represented by LEP and the LHC. It will enhance the current energy frontier by an order of magnitude, allowing a future generation of physicists to explore the limits of the Standard Model and possibly reach beyond, to a more fundamental theory.

We would like to propose the creation of a new research group at LIP, which will take part in the FCC Feasibility Study. This comes in the wake of past studies for the FCC Conceptual Design Review (CDR), a document elaborated for the 2020 EPPS update. LIP members have contributed to the CDR with projections of physics sensitivity and proposed analyses in top, Higgs, and heavy ion channels, and with detector studies towards a hadronic calorimeter for the FCC experiments. The intention is now to contribute to the Feasibility Study as a LIP group and as members of the newly created FCC Collaboration. The FCC group now proposed establishes a natural forum to discuss, coordinate and report on the Portuguese contributions towards the upcoming feasibility study. The scientific activity of the new FCC group includes studies of physics analysis and phenomenology, as well as technological R&D relevant for both the FCC-ee and the FCC-hh programmes.

Current plans for the FCC facility will lead to around 15 years of FCC-ee operation at collision energies from 90 to 365 GeV, starting around 2040. This will be followed by the FCC-hh operating for 25 years at around 100 TeV. The two will be housed in the same 90km tunnel and will use mostly the same infrastructure. The possibility of 4 interaction points is now being studied for the FCC-ee. The emphasis will clearly be on ultra precise machine and detectors, to achieve a new level of accuracy in measurements, and so a high level of the sensitivity to new physics. The initial lifetime of the new group is defined by the delivery date of the FCC feasibility study, in 2025, but is potentially the seed for an important long-term participation of LIP in this visionary endeavour. We believe that the creation of this group is very timely, to foster the Portuguese participation in this global activity, which is already under way in other countries. We hope it will congregate efforts and create opportunities within LIP and outside, attracting interested colleagues from the particle physics community in Portugal.

The FCC group will harbour both physics studies and technology developments relevant to the FCC. Due to its scientific and technological context, the new group will fit naturally into the LHC Experiments and Phenomenology research line (a future adjustment of the line's name would be appropriate). This group also fits very naturally in LIP's research portfolio, and will eventually become an important component of LIP's participation in CERN, at the forefront of collider-based physics exploration. The FCC group will have obvious links with the existing LHC-related groups such as ATLAS, CMS, Pheno, and Computing. Also with several LIP infrastructures such the Big Data competence centre, through computing and

simulation related issues. Potentially also with the Monitoring and Control competence centre and all the instrumentation-related infrastructures at LIP, through the opportunities to develop relevant technology, and participate in the future definition of experiments for the FCC.

With relation to funding, the intention is to start small and grow in ambition as the activity develops. Funding calls by the FCT, and specifically Fundo CERN, would be obvious way to provide the means for this activity. But negative interference with more urgent on-going projects, such as the LHC upgrade efforts, must be avoided. This activity provides a new area in which other funding calls may be answered, such as European Research Council calls or others. A small research project was submitted to the latest Fundo-CERN call that falls cleanly in the domain of the FCC group. The project includes two tasks:

1) Instrumentation studies, including the development of new plastic scintillators based on PET and PEN – in a collaboration with the Institute for Polymers and Composites at the University of Minho also involving LOMaC – and simulations of a scintillator-based calorimeter response;
2) Phenomenological studies for the FCC, divided into 3 different sub-tasks, to: a) optimize the precision of the extraction of α_s at the FCC-ee through N3LO calculations of the most important observables, b) study virtual photon scattering at the FCC-ee and probe the validity of the BFKL evolution equations; and explore new multi-loop methods for the calculation of electroweak observables.

This project will serve as a seed to initiate the group's activity, and gives initial examples of the many research opportunities for that the FCC project provides.

LIP members subscribing the FCC group proposal are listed below, together with their intended FTE dedication, and membership of other groups:

- Liliana Apolinário: 15%; Pheno group
- Nuno Castro: 10%; ATLAS group
- Grigorios Chachamis: 20%; Pheno group
- Patricia Conde: 15%; ATLAS group
- Michele Gallinaro: 5%; CMS group
- Ricardo Gonçalo: PI; 20%; ATLAS and Pheno groups
- Guilherme Milhano: 15%; Pheno group
- Inês Ochoa: 15%; ATLAS group
- Rute Pedro: 20%; ATLAS group
- Beatriz Pereira: 15%; ATLAS group
- João Pires: Co-PI; 35%; Pheno group

All current group members have either already made contributions to the FCC CDR or are in a good position due to their individual backgrounds in collider physics and technology to contribute to the Feasibility Study.