Initial INFN input on the update of the European Strategy for Particle Physics

The Astroparticle Physics Commission 2

Contact person:
Marco Pallavicini, marco.pallavicini@ge.infn.it
Chair of CSN2

Abstract

This document contains some initial input from the INFN Astroparticle Physics Commission 2 (CSN2) to the update of the European Strategy for Particle Physics.

It does not aim at providing a comprehensive overview of the CSN2 activities nor to cover all possible relevant aspects of the Strategy: this will be defined with the other actors all along the update process, from the Open Symposium of May 2019 to the Strategy Drafting Session of January 2020. It aims instead at emphasising the CSN2 activities which are or might be connected in the near future to Particle Physics programs and to CERN activities. In particular, is therefore devoted to a short description of the activities on: the study of neutrino oscillations by means of neutrino beams; the direct search of dark matter in underground laboratories, particularly by means of noble liquid detector; the observation of Gravitational Waves sources in the Universe and the study of fundamental laws of physics by means of Gravitational Waves.

The content of this document takes into account the information presented and the extensive discussions held at a National INFN “Town Meeting”, which took place in Rome on 6-7 September 2018: https://agenda.infn.it/conferenceOtherViews.py?view=standard&confId=15968 and the content of a document that is currently in preparation and that will be made public well before the May 2019 Symposium. This document will cover in details all scientific activities supported by the CSN2.

Programs for the study of neutrino oscillations with long base line experiments

The APPEC AstroParticle Physics EU Strategy 2017-2026 has identified three main goals in the field of Astroparticle Physics, and one of them is the detailed study of neutrino properties and of neutrino oscillations.

Neutrino oscillations are crucial to probe CP violation in the lepton sector. All elements of the PMNS neutrino mixing matrix have been measured, except the CP phase, the Neutrino Mass Hierarchy, and the octant of θ_{23}.

Firstly discovered by experiments dedicated to the observation of solar and atmospheric neutrinos, neutrino oscillations are also measured with neutrinos produced by artificial sources, such as accelerators and nuclear reactors. Next generation experiments at long base line accelerators aim at establishing the mass hierarchy, improve the precision of all parameters and, chiefly, discover CP violation and measure precisely the CP violating phase.

The CSN2 has been involved in the study of neutrino oscillations since the early '90s, with the successful completion of several important experiments, particularly at the Laboratori Nazionali del Gran Sasso, made with natural sources or by means of the CNGS beam or the participation to neutrino beam experiments around the world.

Today, the CSN2 strategy in the field of neutrino oscillations is based on the active participation of one running experiment (T2K at JPARC, Japan) and to two other experiments currently under construction: JUNO in China and DUNE in the United States. The future participation to the upgrade of T2K with the new HyperKamiokande detector, an effort in many ways complementary to the DUNE program, is still under discussion and no decision has been taken yet.

We believe that the CERN decision to support the neutrino community by building and operating the Neutrino Platform was very important. The neutrino platform is extremely beneficial for the European neutrino community and we believe that its existence is the key for the success of DUNE in particular. We strongly encourage CERN to continue and possibly strengthen this support, including the R&D activities for the development of the Near Detectors both in Japan and the USA.

Search of Dark Matter

The search of Dark Matter is actively pursued by three main techniques: the search of new particles by means of particle accelerators, and particularly at the LHC; the search of indirect signatures in the flux of cosmic particles (above all positrons, anti-protons and anti-nuclei, but also low and high energy photons); and, chiefly, by means of direct search of dark matter candidates in low background, high efficiency, high mass underground detectors.

The CSN2 is deeply involved with many important activities in both the second and the third of these approaches, being the first one managed at INFN by the CSN1 (Particle Physics Commission).

This document is not meant to provide any comprehensive or complete review of the many activities supported in space and in underground laboratories by CSN2. We focus here to one project in particular, the DarkSide project, which is already connected to CERN activities and which could be benefited by a further strengthening of the collaboration with CERN.

Darkside is a Dark Matter search experiment based on the technology of liquid argon double phase TPC. It features low ^{39}Ar, very low background TPC with SiPM technology and active tagging of neutron background as its main strengths.

The DarkSide project is also synergic with the effort already in progress on the Neutrino Platform for the construction of the DUNE single phase and double phase prototypes and the collaboration with CERN would be extremely beneficial in this direction.

We encourage therefore the continuation of the contribution of CERN to this important line of research, possibly enriching it with scientific contribution in addition to the technological ones already in place.

The DarkSide project will evolve in a Global Argon program, which will probably lead to experiments at the scale of hundreds of tons of active target in order to reach the ultimate goal, the so called “neutrino floor”.

The CERN involvement or support in this program would be of enormous importance and we therefore encourage it.

We believe that a scientific involvement of CERN scientists in this long term Argon program is also synergic with the search of dark matter candidates and new physics done at the LHC and particularly at the High Lumi program.

Third generation Gravitational Wave detectors

The discovery of gravitational waves made by the LIGO-VIRGO collaboration in 2015, the detection of the several black-hole mergers and, particularly, the detection of the first neutron-star neutron-star merger with the following extensive observation in virtually all electromagnetic bands are among the main scientific results of the last decades.

The LIGO-VIRGO detectors have an already defined program of observation and upgrades, which will be implemented in the next decade, eventually in collaboration with the KAGRA detector in Japan and possibly the third LIGO detector in India.

In the meantime, the design study for the next generation detector in Europe, the so called Einstein Telescope, has started.

CERN may indeed play an important role in the field of Multimessenger observation in the next decade and could bring an important added value to the field. In particular, technological know-how connected to the construction and operation of long underground tunnels, the realisation of extensive cryogenic systems, vacuum technology, distributed synchronisation systems, high performance computing, are crucial fields for which the contribution of CERN might be extremely valuable.

Besides, the participation to the science of the Gravitational Waves would also be an important enrichment and would be valuable for CERN itself too.

We recommend therefore that the existing and potential synergies between particle physics and GW physics in both science and technology be promoted and developed. We underline that the relation between CERN and the ET project could be implemented in many ways and at different levels, starting from a minimal technological support up to a complete scientific and programmatic involvement which could be extremely beneficial for CERN as well.

We refer to the document submitted by Michele Punturo on behalf of the Einstein Telescope Steering Committee for more details.