INPUTS FOR THE GDR-INF DOCUMENT
ON THE EUROPEAN STRATEGY FOR PARTICLE PHYSICS (ESPP)

Instructions:

- *This document collects the contribution of the GDR-InF members to the ESPP.*
- *They will be used as input for writing a max 2 pages document that will be sent to the IN2P3 on behalf of the GDR-InF.*
- *Given the small size of the final document, please keep your contribution short (half page maximum). Please, be direct and clear on the message that you want to pass to the ESPP.*
- *If you fully share a point of view already expressed, just subscribe adding your name.*

Name: Olivier Leroy, Vladimir Vava Gligorov, Stéphane Monteil
Text:
In an international context where the direct searches for new physics at the energy frontier do not bring out any signal, the indirect searches at the intensity frontier appear more than ever essential and inescapable. The latter allows to probe energy scales well beyond the reach of current colliders. It is precisely this research that is conducted in experiments like LHCb and its future upgrade phases.
The French community has played a major role in LHCb since its beginning. Five IN2P3 laboratories are currently involved the collaboration: LAL, LPNHE, CPPM, LAPP and LPC. On Februrary 2017, we submitted to the LHCC an expression of interest for an “Upgrade II” of the LHCb experiment, during the Long-Shut Down 4 of the LHC (2030),
http://cds.cern.ch/record/2244311/files/PII_EoI_final_v3.pdf
In September 2018, the detailed Physics case for this Upgrade II will be submitted to the LHCC. This experiment will allow a full exploitation of High-Luminosity LHC for Flavor Physics. Not only it will greatly improve our knowledge of many observables sensitive to New Physics, but it will widen the set of observables beyond those currently accessible and open new measurement possibilities.
We would like to emphasize the fundamental role of this project in the European Strategy for Particle Physics.

Name: Frederic Kapusta
Text:
The search for new physics through COherent Muon to Electron Transition at J-PARC involves now three IN2P3 laboratories : LPC, LPC-Caen and LPNHE. COMET will improve the current limits by two to four orders of magnitude in five years from now. Such a measurement will have a strong impact on the Worldwide Strategy. And in the context of looking for physics beyond the

Standard Model with fundamental observables within a decade, g-2/EDM at J-PARC will bring a new measurement with an original design.

Name: Thomas Lefort

Text: The search for permanent electric dipole moments probes potential New Physics at energy scales, between 1 TeV and 10^3 TeV. With the present experimental sensitivities, a non-zero measurement would either reveal a tiny value of the θ_{QCD} term or new sources of CP violation. In this context, the measurements of EDM from various systems (neutron, electron and so on …) is required to disentangle the origin of the CP violation process. Along with the Hg EDM; the neutron EDM offers the most sensitive probe to the θ_{QCD} term. It is also a tool to investigate the electroweak baryogenesis scenarii.

The neutron EDM experiment at the Paul Scherrer Institute participates to this EDMs quest. It is the leading neutron EDM experiment worldwide with a new limit about to be published (at the level of 10^{-26} ecm). A new experiment, n2EDM is currently under construction and it will start operating in 2021. It aims at improving the sensitivity level by one order of magnitude in the next decade and explore the 10^{-28} *ecm* region in a second phase at the 2030 horizon. Three French laboratories are involved in the project: the CSNSM, the LPC Caen and the LPSC.

Name: Vladimir Vava Gligorov

Text: Long-lived particles (LLPs) arise naturally in many models of New Physics, as in the Standard Model (SM) itself, with possible masses and lifetimes which span many orders of magnitude. Because of this wide range of lifetimes and masses, it is extremely difficult to build a single experiment which has good direct sensitivity to all LLPs. A mixture of collider and beam-dump based LLPs is therefore necessary to probe the biggest possible area of parameter space, with the additional benefit that different experiments may have complementary backgrounds, providing a powerful cross-check in the event of any discovery. One particularly attractive proposed LLP experiment is CODEX-b, which would take advantage of the old DELPHI cavern situated behind a concrete wall next to the LHCb experimental area. This area of around 1000 cubic metres, which will become free once LHCb’s readout and trigger move to the surface in 2021, would only require a small amount of additional shielding in order to suppress SM backgrounds to 0, while greatly extending the reach of the LHCb experiment for LLPs. This area could be instrumented cheaply, for example with RPCs, and if datataking occurs throughout the 300 fb-1 of LHCb’s Upgrade 2 CODEX-b would achieve a very significant part of the reach (see http://inspirehep.net/record/1620901 for details) of other much bigger and more expensive proposed LLP experiments. More advanced technologies, for example tracker layers with timing measurements, would allow CODEX-b to also measure the LLP mass for certain classes of LLP models. CODEX-b could also be trivially integrated into LHCb readout, thus providing an interesting capability to “tag” any signal candidates and examine what happened in the rest of the LHCb interaction.

Name: Jacques Chauveau for the SHiP Collaboration. The following text is still evolving within the Collaboration
Text:
SHIP is an experiment to be carried out at the new Beam Dump Facility (BDF), located in the North Area of CERN.

The 400 GeV proton beam extracted from the SPS will be dumped on a heavy target with the aim of integrating 2x10^{20} p.o.t. in 5 years. A dedicated detector, based on a long vacuum tank followed by a spectrometer and particle identification detectors, will allow probing a variety of models with light long-lived exotic particles and masses below O(10) GeV/c^2. The main focus will be the physics of the Hidden Portals, i.e. search for Dark Photons, Light scalars and pseudo-scalars, and Heavy Neutrinos. The sensitivity to Heavy Neutrinos will allow for the first time to probe, in the mass range between the kaon and the charm mesons, a coupling range for which Baryogenesis and active neutrino masses could also be explained.

SHiP is designed to be a discovery experiment, with less than 0.1 expected background events from Standard Model particle interactions.

A dedicated section of the SHiP detector will allow the study of Hidden Sector particles interacting with atomic electrons and nuclei in an unexplored parameter range.
With this detector, neutrino cross-sections and angular distributions can also be studied. Tau neutrino and antineutrino deep inelastic scattering cross sections will be measured with a statistics 1000 times larger than currently available, with the prospect to extract the F4 and F5 structure functions, never measured so far and to perform new tests of lepton universality.

SHiP is a leading experiment in the context of the emerging field of physics of the Hidden Sectors, that with the best sensitivity for most of the modelled channels. A strong institutional support for all such experiments proposed in Europe will be welcome whether they would take place at the LHC (present detectors, and new experiments: MATHUSLA, FASER) or at the SPS. SHiP and Codex-b are followed by scientists from IN2P3.

Name: Aoife Bharucha for the members of the theory community
Text: Physics at the intensity frontier is crucial in allowing us to detect and interpret signs of new physics. If new particles are found by direct searches, then indirect tests are needed to study the new physics structure and couplings. If on the other hand no direct evidence for new

physics is found in collisions, higher scales and/or smaller couplings can be probed by experiments at the intensity frontier. Theoretical predictions and interpretations, crucial for advances in the field, may involve a large variety of tools, from formal approaches to phenomenological and numerical techniques.
If most theoretical activites essentially require only manpower, numerical simulations are also demanding in terms of computing power and algorithmic techniques.
Note that the interpretation of results, model independent in terms of effective field theories or model dependent, serves as inspiration for model building and further leads to new ideas for experiments. Theoretical progress is clearly dependent on experiments for guidance, but inversely theoretical ideas can frame future experiments. Therefore any strategy on the future of experimental particle physics must be accompanied by a vision
concerning the support to provide to particle theory.

Name: Stéphane Monteil about the Flavour Physics case at large in the FCC-ee project
Text: A possible long-term strategy for high-energy physics at colliders, after the exploitation of the Large Hadron Collider (LHC) and its High Luminosity upgrade, considers a tunnel of about 100 km circumference, which takes advantage of the present CERN accelerator complex.
The Future Circular Colliders (FCC) concept follows on the successful experience and outcomes of the LEP-LHC machines. A possible first step of the project is to fit in the tunnel a high-luminosity e+e- collider aimed at studying comprehensively the electroweak scale with centre-of-mass energies ranging from the Z pole up to beyond the ttbar production threshold. A 100 TeV proton-proton collider is considered as the ultimate goal of the project and defines the infrastructure.
Future Circular Collider study groups have been formed in a 5 years design study hosted by CERN, aiming at a Conceptual Design Report and a review cost in time for next European Strategy milestone at the horizon of 2020, when the full statistics of the LHC Run I and Run 2 will have been analyzed.
The unprecedented statistics at the Z pole [O(5.10^{12})]Z decays) potentially delivered by the high-luminosity e+e- collider can be studied in particular to explore further the flavour Physics case at large (quarks and leptons). It benefits, in addition to the statistics, of the large boost experienced by b-hadrons formed in Z decays, the cleanliness of the e+e- experimental environment, the production of all heavy-flavoured hadrons, and, not the least, the highly-resolved vertexing of heavy-flavoured weakly-decaying particles. Only the surface of the Physics potential has been explored so far by means of flagship measurements which can complement in an unique way the knowledge and anticipated results from the current and foreseen b-Physics programs (LHCb upgrade and Belle II experiment). The large statistics at the Z pole can be used (as well in an unique way) to scrutinize Lepton Flavour Violating (LFV) Z decays.

The mainstream Physics Case of this machine is driven by the four electroweak thresholds which are crossed [Z, W, H, top high-luminosity factories] where all relevant electroweak parameters can be measured with unprecedented precision, pinpointing if needed the complete two-loops calculations in the SM. The Flavour Physics program can be seen as an invaluable complement to this Physics case, in particular if the current Flavour anomalies are persistent.

A Conceptual Design Report and a cost review will be available by the end of 2018 and will serve as an input to educate the next update european strategy. Our GDR community could provide a support for this long-term vision for High Energy Physics in Europe.

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