R&D on FCC and Future Colliders at IN2P3:

FCC-NPC

Summary

New accelerator facilities and in particular colliders are being considered for the future scientific advances in High-Energy Particle Physics. A rich R&D programme is driving the development and buildup of these future facilities. A strong cooperation between national institutes, CERN and others global laboratories or collaborations is vital for the progress of the field and also for preserving the expertise. In this context the main goal of the **FCC-Next Particle Colliders (NPC)** project is to ensure an appropriate contribution to this vibrant and diverse R&D Collider programme focusing on: nanobeams handling and its stabilization and positioning techniques, luminosity monitoring, high-intensity e^+ sources, e^+e^- polarimetry and dynamics vacuum and material studies, where the NPC team has already demonstrated their know-how and expertise. This expertise is presently being applied in different current and future colliders projects mainly: SuperKEKB, ILC/CLIC and FCC.

1. Context, State of the Art and Scientific Issues

Many mysteries about the universe remain to be explored, such as the nature of dark matter, the preponderance of matter over antimatter and the origin and the pattern of neutrino masses. In this context given the unique nature of the Higgs, there are compelling scientific arguments for a new e^+e^- collider operating as a "**Higgs factory".** Such a collider would measure the Higgs properties in a very clean environment and would make dramatic progress in mapping the diverse interactions of the Higgs boson with other particles including the flavour puzzle and the neutrino sector. Besides the Higgs boson pair-production study is key to understanding the fabric of the universe, for this a collider with significantly higher energies than a Higgs factory is needed. The vision given by the **European Strategy Update for Particle Physics** 2020 (EPPSU2020) is to **prepare a Higgs factory, followed by a future hadron collider** with sensitivity to energy scales an order of magnitude higher than those of the LHC, while addressing the associated technical and environmental challenges.

This Strategy presents exciting and ambitious scientific goals that will drive technological and scientific exploration into new and uncharted territory for the benefit of the field and of society. More in detail 20 strategy statements have been unanimously adopted by the European Strategy Group (ESG) in January 2020 and are summarized in Figure 1 [32].

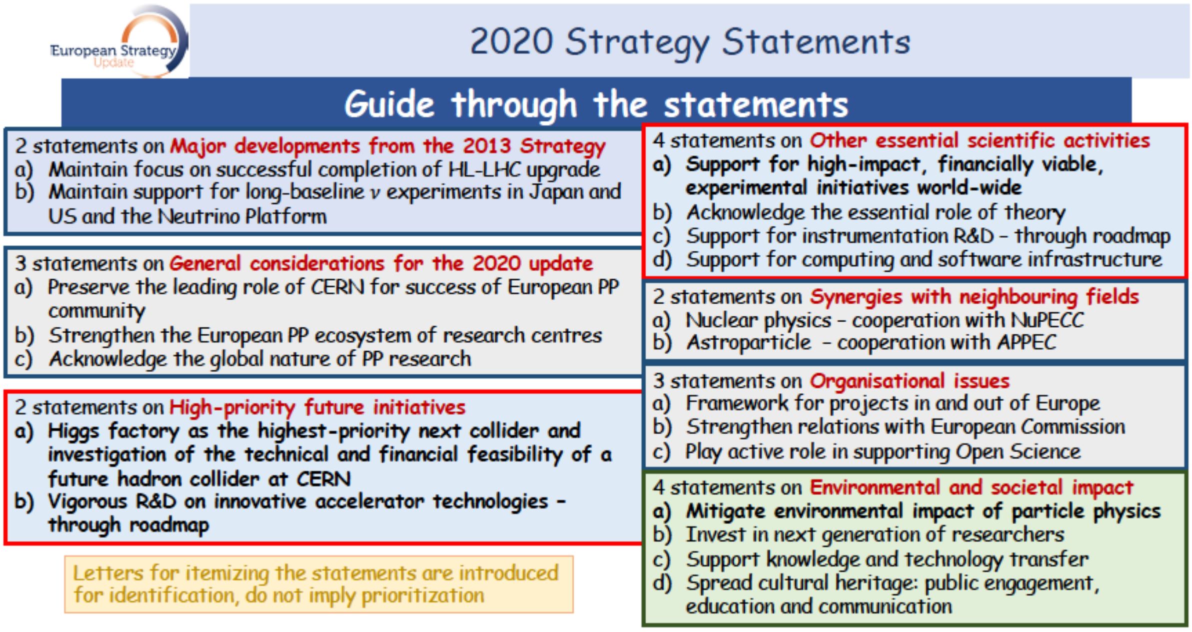

Figure 1: 2020 Strategy Statements adopted by ESG in January 2020 from H. Abramowizc.

In this context different future accelerator facilities are being considered worldwide (Figure 2), Europe can propose both: CLIC or FCCee as Higgs factory, CLIC (3 TeV) or FCChh (100 TeV) for the energy frontier.

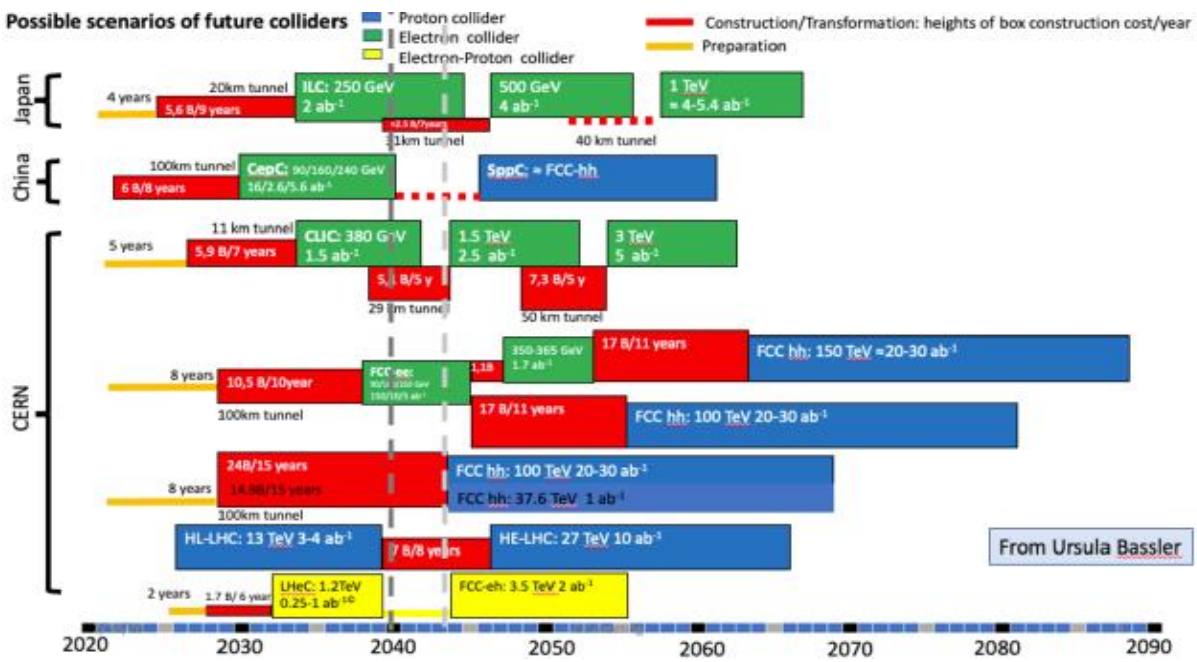

Figure 2: Map of possible future facilities submitted as input to the Strategy Update from U. Bassler.

An e^+e^- Higgs factory is the highest-priority next collider. For the longer term, the European particle physics community has the ambition to operate a pp collider at the highest achievable energy. Accomplishing these compelling goals will require innovation and cutting-edge technology: the particle physics community should ramp up its R&D effort focused on advanced accelerator technologies, in particular the high field magnets including high temperature superconductors, plasma wakefield acceleration and other high-gradient accelerating structures, bright muon beams and energy recovery linacs. All of this taking into account the synergies with other communities such as photon and neutron sources, fusion energy and industry.

Europe, together with its international partners, should investigate the technical and financial feasibility of a future hadron collider at CERN with a centre-of-mass energy of at least 100 TeV and with an e^+e^- Higgs and electroweak factory as a possible first stage. Such a feasibility study of the colliders and related infrastructure should be established as a global endeavour and be completed on the timescale of the next Strategy update (2027). Besides, the timely realisation of the e^+e^- International Linear Collider (ILC) in Japan would be compatible with this strategy and, in that case, the European particle physics community would wish to collaborate.

Accelerator R&D is crucial to prepare future colliders (Figure 3). A strong cooperation between national institutes, CERN and others global laboratories or collaborations is vital for the progress of the field and also for preserving the expertise [1] [32].

Figure 3: Relative timeline expected for realizing lepton and hadron colliders (from A. Yamamoto presented at the 2019 Open Symposium in Granada, and updated on the discussion followed).

In this context and being aligned with the high-priority future initiatives of the EPPSU 2020 the main goal of the **FCC-Next Particle Collider project (NPC)** is to ensure an appropriate contribution to this vibrant and diverse R&D Collider programme focusing on: **nanobeams handling** and its **stabilization** and **positioning** techniques, **luminosity monitoring**, **high-intensity e^+ sources**, **e^+e^- polarimetry** and **dynamics vacuum** and **material studies**, where the NPC team has already demonstrated their know-how and expertise. This expertise is presently being applied in different current and future colliders projects mainly: SuperKEKB, ILC/CLIC and FCC.

Luminosity in colliders

Luminosity is one of the key parameters of a collider, to maximize this parameter and in agreement with the basic expression of the luminosity:

$$L = f_{coll} \frac{N_b^2}{4\pi\sqrt{\epsilon_x \beta_x^* \epsilon_y \beta_y^*}}$$

very small beam sizes at the Interaction Point (IP), high collision frequencies and high number of particles per bunch are needed.

Between 1999 and 2008 PEPII and KEKB circular e^+e^- circular colliders have operated at peak luminosities around 10^{34} cm^{-2}s^{-1} with beam currents in PEPII as high as 2.1 A for e- and 3.2 A for e^+ and vertical IP β-function as low at 6 mm. Recently in SuperKEKB a record high peak luminosity of 2.4 10^{34} cm^{-2}s^{-1} has been obtained. The crab-waist collision scheme was demonstrated at DAPΦNE around 2008, in order to increase the peak luminosity and is incorporated into all future circular e^+e^-. Regarding the linear e^+e^- colliders SLC at SLAC, operating between 1988-1998, has been the only LC implemented to date. The world record for positron production rates is still held by the SLC positron source. Since then an important R&D effort has been made in order to get high-gradient /high frequency linacs in room temperature RF for CLIC and with superconductive RF for the ILC. Based on these technologies high-energy linacs have been or are being built to serve X-ray FELs (SwissFEL, EU-XFEL, LCLS and LCLSII). Besides, significant experience in the operation and development of techniques to achieve beams with nanometre transverse sizes has been accumulated in test facilities (FACET, ATF/ATF2). A 41 nm beam size has been obtained in ATF2 with a reduced aberration optics and with reduced intensity to mitigate the impact of wakefield effects.

All present proposals for future e+e- Higgs factories have very ambitious luminosity targets which are based on combinations and extrapolations from previous facilities (LEP, B-factories, DAPΦNE, SLC, Light sources and FELs), test-facility results and theoretical predictions.

Nanobeam Size handling

One of the **key ingredients** for achieving a very **high peak luminosity** is the **nanometre transverse beam size** at the IP (FCC-ee 30-70 nm, ILC 3-8 nm, CLIC 1-3 nm). To **demagnify** the beams to the required spot sizes, complex **Interaction Regions (IR)** and **Final Focus Systems (FFS)** are needed for the circular and linear designs, respectively.

Based on the expertise and experience accumulated in the last years in the ATF/ATF2 facility and in SuperKEKB, the **NPC project addresses** the problem of the **nanometre beam size handling** and its stabilization in **ILC-CLIC FFS (ATF/ATF2 ATF3)** and in the **FCC-ee IR**. More in detail:

ILC/CLIC scaled FFS: ATF/ATF2 ATF3

The **ATF2 FFS** was designed as an **energy-scaled version of the ILC FFS**, with two main aims: (i) to demonstrate the effectiveness of the local chromaticity correction scheme to achieve an IP vertical beam size as small as 37 nm, and (ii) to demonstrate the feasibility of beam orbit stabilisation to the nanometer level. The effectiveness of the local chromaticity correction scheme was successfully demonstrated, and the potential or direct beam orbit stabilisation to the nanometer level has also been shown [21] To date an electron vertical beam size as small as 41 nm, essentially meeting the ATF2 design goal, and a stabilization with feedback latency of 133 ns (366 designed) have been achieved.
These are unique and outstanding results but regarding the vertical beam size this result has been obtained only at a bunch population of roughly 10% of the nominal value of 10^{10} electrons. Given the very large-β involved and the presence of the non-linear elements make it sensitive to imperfections as wakefields, magnet misalignments and jitter. Recent studies indicate that the vertical beam size grows with the beam intensity is due to the effects of wakefields. The high content of wakefield sources in ATF2 could be explained by the fact that most of the vacuum chambers are re-used or replicated, not dedicated design. On the other hand, to mitigate the impact of aberrations, an optics with reduced aberration, the so-called ($10\beta_x^* \times \beta_y^*$) optics with a 10 times larger IP horizontal β-function than the original design, is being used in recent operations [56-57].

It is recognized that the **achievements at ATF/ATF2** have already verified the **minimum technical feasibility of the FFS of ILC**. However, to **maximize the luminosity potential of the ILC** a further investigation of the intensity dependence effects on the spot size and the optical aberrations specially with smaller β_x^*, design optics ($\beta_x^* \times \beta_y^*$), are crucial. Furthermore and to address the issue of the CLIC smaller sizes ultra-low β^* are also necessary.

In order to overcome these issues and in the framework of the ILC International Development Team (ILC-IDT) WG2 (DR/BDS/DUMPs) [61] (Appendix 1), a targeted action to pursue the necessary R&D to maximize the luminosity potential of ILC is being set-up. In particular the assessment of the ILC FFS system design from the point of view of the beam dynamics aspects and the technological/hardware choices and the long-term stability operation issues. For carrying out this program and based on the outstanding and unique results achieved by the ATF/ATF2 collaboration, an **ATF3 collaboration** is being established with the ATF2 partners and with new possible partners worldwide, being the NPC team involved in the project as one of the active participants.

In this framework and as a continuation of our ATF/ATF2 participation during these last years (Appendix 1), one of the objectives of this project, will be the participation in the future ATF3 optics design, long term stability and high-order aberration studies. A MoU for ATF3 taking into account these activities during the ILC-prelab period (2022-2024) will be prepared between KEK and IN2P3 during 2021.

FCCee IR studies: Monochomatization issues

One of the challenges of the FCCee IR beam optics is to provide the small β-functions at the IP down to $\beta_{xy}^* = 0.5$ m/1 mm. Although these values are still higher than those of modern B-factories, the associated vertical chromaticity around the IP is comparable, since L^*=2.2 m is larger than those in B-factories. As in the case of LCs, a local chromaticity correction scheme only in the vertical plane is needed in the two sides of the IP. Beam lines and IR are separated for the two beams and a full horizontal crossing angle of 30 mrads together with a crab waist scheme is implemented at each of the two IPs for all the energies. In "standard" configuration the **natural collision energy spread** is given by Synchrotron Radiation (SR) and its varying from 0.038 % for 45 GeV to 0.141 % for 175 GeV. In some **"special" IR configurations** this **energy spread could be reduced**.

The FCC-ee could allow the measurement of the electron Yukawa coupling, in dedicated runs at ~125 GeV centre-of-mass energy, provided that the centre-of-mass energy spread, can be reduced to about 5–10 MeV to be comparable to the width of the standard model Higgs boson. The natural collision-energy spread at 125 GeV, due to synchrotron radiation, is about 50 MeV. Its reduction to the desired level can be accomplished by means of **monochromatisation**, e.g., through introducing non-zero horizontal dispersion of opposite sign at the IP, for the two colliding beams. At these **high-energies** the nonzero IP dispersion leads to an increase of the transverse horizontal emittance from **beamstrahlung**. Self-consistent IP parameters need to be determined and optimized for maximum sensitivity to the electron Yukawa coupling. Modifications of the standard FF optics are required for generating the required IP dispersion and for the possible accommodation of crab cavities. Alternative monochromatization scenarios could also be possible [44-55].

The **NPC project will address** in one hand the **parametric study** in order to achieve the **maximum sensitivity** to the coupling, **including beamsstrahlung** and crossing angle possibility between others. And in the other hand the **optics design of the FFS** to generate the necessary antisymmetric dispersion at the IP and the possible accommodation of crab cavities compatible with the baseline and providing the transition from a crossing-angle to a head-on collision scheme. Either the additional bending magnets or electro-static separators needed to realize the head-on collision could be used to generate the needed IP dispersion, or we can maintain a crossing geometry and deploy crab cavities together with horizontal IP dispersion. Finally a detailed simulation including beam-beam has also to be realized to assure the final performances of such a scheme.

Given the experience of the IJClab-NPC team in monochromatization optics implementation, the work is already started in the framework of the FCCee collaboration. An addendum to the present FCC MoU between the CERN and IN2P3 including this task is being considered to frame this activity (Appendix 1).

Nanobeam Stabilization and Positioning techniques

In order to obtain the desired **luminosity** in future colliders, **vibrations mitigation and misalignments** are one of the **main identified critical issues**. Based on the current experience of the LAPP-NPC team in ATF/ATF2 and SuperKEKB, the NPC project will address the study of the **nanobeam stabilization** and its monitoring as well as the **positioning techniques** in future colliders in particular in FCCee.

Nanobeam stabilization

Nanobeam stabilization is one of the critical issues in order to reach high-luminosity in the next particle collider generation. Indeed, a nanobeam is very sensitive to all imperfections of the Beam Delivery System (BDS) and FFS. For example, to guarantee the luminosity of CLIC, the specification of the final focus magnet displacement was 0,2 nm rms at 4Hz. Even if a circular collider like FCCee is less sensitive to disturbances than the e^+e^- linear colliders, the specifications of the focusing magnet motions and their coherence will probably be critical.

The main causes which affect beam brightness and beam position stability at the IP are the **Ground Motion (GM)**, the **structural vibrations effects** and the **elements position inaccuracies**. In this prospect, different R&D programs were performed in various fields during the last years for many experiments [17-20]. The NPC-LAPP team was mainly involved in CLIC and a feasibility demonstration of an active control at a sub-nanometer scale (0.6 nm rms at 4Hz) with developed and patented vibrations sensors has been achieved. This development has allowed proving that the CLIC specifications (the most stringent for a collider) could be envisaged. In this context a Final Doublet (FD) stabilization strategy based on the coherence optimization between the FD and the target allowed to reach the specifications of the differential motions between the various elements has also been carried out, as well as a new beam control approach named “feedforward”, which consists to control the beam trajectory thanks to kickers with the estimation of the induced beam deflection in function of the measured focusing magnets motions. Furthermore the vibrations monitoring allows to evaluating the pattern of the seismic motion and of the cultural noise for this site to complete the various worldwide ground motion models and the associated coherences, which are essential to define the vibration mitigation strategy of the future colliders.

As continuation of the ATF/ATF2 and SuperKEKB current activities in this topic the **NPC project will address** the study of the **vibrations mitigation of the FCCee MDI** in collaboration with CERN and the INFN (FCC_IS EU project) [59], including the impact of the vibrations on the luminosity.

Positioning techniques
FCCee with nearly 100 km circumference and around 2900 quadrupole magnets, will be the biggest collider ever achieved and will be a very demanding project in terms of positioning accuracy. Therefore, the classical method for positioning, which consists of adjusting individually each element during beam operation in order to complete the prior mechanical alignment seems very complex to implement. Given the huge number of magnets and components needing positioning and the stringent alignment requirements, a **dynamic positioning approach by girder** seems more adapted.

This strategy of positioning based on the management of the girder position, on which the elements are very well mechanically aligned, is already developed for various recent and future facilities like ESRF, the Swiss Light Source (SLS) at PSI and CepC respectively. Depending on the final specifications (have to be refined by optical simulations), this system could be coupled with distributed positioning system for specific elements which require very fine tuning on a reduced scale as was planned for the CLIC experiment [40-43].

To permit the rapid realignment of the machine as soon as significant alignment deterioration is measured, specific instrumentation has to be used. Concerning the actuators, depending on the experiments, the constraints and the specifications, cam mover for specific components (i.e. magnets), controlled systems such as dedicated nano-positioning system could be deployed. For the sensors, various technologies could be implemented like Hydrostatic Leveling System (HLS), Wire Positioning System (WPS) or differential sensors, between others. The best setup will be obviously selected in function of the specifications, but also in taking into account the costs and the complexity of the processing due to the huge numbers of girders all along the collider. Given the experience of the LAPP-NPC team in the automatization with precise positioning, the **NPC project will evaluate** the various **options for the positioning system strategy for FCCee**.

Note that the both items are closely coupled because the quality of the positioning will impact the luminosity and will be integrated in the optics simulations. Furthermore the positioning system of the FD girder has to be considered and modelled in the MDI setup in terms of stiffness for the vibrations aspects.

Luminosity Monitoring

At SuperKEKB, the nominal beam sizeat the IP is about 60 nm in the vertical plane. Due to the very small (nominally 300 μm) vertical β function at the IP, the luminosity is highly sensitive to any residual offset between the colliding beams, which must therefore be corrected dynamically, in both vertical and horizontal dimensions and at different time scales depending on the frequencies of the different sources of variation (e.g. mechanical vibration, pulsed elements, thermal drifts). Sufficiently **fast luminosity** (or luminosity-related) **observables** are **essential** as input to the **feedback systems** which **stabilize** the **colliding beams** and **minimise** their **residual** horizontal and vertical **offsets.**

Moreover, achieving the very small specified beam sizes at the IP requires a sophisticated optical demagnification scheme, similar to that in the FFS developed for linear colliders, and involving correctors for both linear and nonlinear, geometric and chromo-geometric optical aberrations. Such **aberrations**, after minimisation in the initial design of the optics, also arise from the unavoidable imperfections in the field quality and alignment of the magnets. They must be **corrected** in any practical system, and for that purpose an **experimental luminosity observable** is crucial as **input**.

For both of the above tasks, a luminosity monitoring system: "LumiBelle2" has been designed and implemented for SuperKEKB by the IJClab-NPC team [14]. It is based on single crystal CVD diamond sensors located on both sides of the IP, read out continuously by fast electronics. This system has operated since the start of the commissioning of colliding beams in 2018. It is an essential tool used daily by the SuperKEKB operators and physicists, for instance for the "collision tuning" at the IP. The monitoring was specified to be at the same time fast (up to 1 kHz), precise (1 % statistical accuracy), and have a very wide dynamic range (from luminosities of 10^{32} to 10^{36} cm^{-2} s^{-1}).

Besides the technical challenge of operating this instrument and maintaining it in the medium and long term at the KEK laboratory, as a French contribution to the SuperKEKB facility, the LumiBelle2 system provides the involved IN2P3 physicists and engineers with a natural access to the beam tuning activities which it serves. More generally, it also enables a direct connection and involvement in the performance optimisation of a collider which is truly at the state of the art in the field, and which is considered in the HEP community as "the" model for all future e^+e^- colliders, where many of the concepts and techniques which are envisioned can be tested experimentally and validated.

We expect that the **NPC-IJClab contribution** to the **optimisation** of the **SuperKEKB luminosity** during the years needed to achieve its design value using the LumiBelle2 information as input will directly impact our capability to contribute to any future collider project in the field, notably FCCee. In this context the FCCee design team at CERN is building up its involvement in the commissioning and optimisation of SuperKEKB.

High-Intensity e^+ sources

Positron sources are essential to the future lepton collider projects as: ILC, CLIC, FCCee, CepC, LEMMA [15,16, 25, 26, 11], with challenging critical requirements of high-beam intensity and low emittance necessary to **achieve high-luminosity**. In all positron sources used for accelerators, positrons are produced from the electromagnetic shower cascade generated by high-energy electrons hitting a target of high-Z material. The shower production processes involved in the positron production, associated with the multiple scattering in the material, increase the transverse momenta and energy spread. As a result, the 6D phase space at the target exit is orders of magnitude higher than in e^- sources. Therefore, the positrons emerging from the target are immediately focused with magnetic fields tailored for maximum capture efficiency and are subsequently accelerated in the positron capture RF section. Often damping rings (DR) are needed to cool the positron beam after the first acceleration stage for achieving the required emittance values. Eventually, the fraction of the positrons, which is captured for further acceleration is defined by the capture system acceptance. This scheme has been used for all circular e^+e^- colliders (ADA, ACO, DCI, SPEAR, ADONE, VEPP, LEP, KEKB, SuperKEKB, PEP-II) and also for the first linear collider SLC. In the conventional positron-generation system, a possible scheme to increase the positron intensity is to increase the incident electron beam power (intensity and/or energy). However, the allowable heat load as well as the thermo-mechanical stresses in the target severely limit the allowable beam power of the incident electrons.

In this context, **hybrid schemes** based on relatively new kind of e^+ source, using an **intense photon production** by high energy (some GeV) **e^- channelled along** a **crystal axis** (i.e. channelling radiation) has been proposed. Several experiments at CERN, KEK and Orsay, have been performed to investigate such a possibility [33-34]. They have shown very promising results for the enhancement of the positron yield and the reduction of the energy deposition in the target, if compared to the conventional one especially applying the so called hybrid scheme where the photon and the positron production are physically separated [35]. Moreover, a new option of the **target-converter** can be also considered implying the use of a **granular target** made of small spheres providing better heat dissipation and better resistance to thermal shocks. The hybrid scheme, thus, has been adopted by CLIC as a baseline for the unpolarized e^+ source [15].

Almost all the e^+ sources ever built (past or currently in operation) were integrated to the injector complex of a circular lepton collider. Thus, the required bunch population from these sources has been a few 1×10^{10} e^+/bunch corresponding to average currents less than 1 μA except the PEP-II/SLC case ~1 μA [6]. At present, the positron production rate obtained at the SLC (~ 8×10^{12} e+/second) is considered as a world record for the existing accelerators. However, the intensities required from the e^+ sources at the future colliders CLIC or ILC are a few orders of magnitude higher (up to ~10^{16} e^+/second) than that delivered by ever existing facilities. In the case of the FCC-ee, the requirements are more relaxed given the possibility of stacking and top-up injection, yet will still require a low-emittance positron beam with intensity high enough to shorten the injection time. A positron bunch intensity of 2.1×10^{10} particles (3.35 nC) is required at the injection into the pre-booster ring allowing for a positron yield of 0.5 e^+/e^- if safety margins are neglected. This value is comparable with the positron yield envisaged at the SuperKEKB. The positron flux, however, is estimated to be about one order of magnitude higher than the flux obtained at the SLC (taking into account the increased number of bunches in the recent FCC-ee injector studies). The first step toward higher e^+ intensities is foreseen at SuperKEKB facility with intense R&D and optimization studies to reach this goal.

Intense e^+ sources may play also an important role for even higher-luminosity colliders and, in particular, for positron-based muon production (LEMMA) [11]. In this context, profound studies of the positron source capable of delivering an exceptional flux of about ~ 10^{16} e+/second are needed to narrow down the possible design choices and define the R&D directions to mitigate the critical issues. Creating low-emittance energetic muon beams would open the door to a new generation of lepton colliders.

The anticipated beam intensities and emittances impose technological challenges for the e^+ source design (target design, cooling systems, capture optics, power dissipated on the structures, and remote handling/target removal engineering design). Investigations, novel solutions, technological R&D and experimental testing are all mandatory for more robust and reliable e^+ source designs to meet future needs.

The objectives of the **NPC project** are to contribute to innovation and development of accelerator concepts beyond existing lepton injector technology as far as the e^+ sources are concerned. The main goal is the investigation of the **novel types of e^+ source** based on the **hybrid scheme** with new **granular targets** and **positron capture systems**. In particular, the innovative proposal to use a superconducting **(SC) solenoid** as the matching device for the capture system is of great interest. Another innovative aspect that will be developed is the use of the Artificial Intelligence (AI) global optimization of the positron injector parameters including the electron drive beam and the final system acceptance [22-24, 37].
This R&D effort will be mainly developed in a dedicated FCC-ee Injector Study project of the Swiss Accelerator Research and Technology (CHART) collaboration, between PSI and CERN and having the IJClab and LNF as external collaborators. The activities related to muon colliders will be developed in the context of the I-FAST EU project [58].

e+e- Polarimetry

One of the **key ingredients** of the next generation of particle colliders, ILC and CLIC projects and to a lower extent FCC-ee, is the ability to **collide beams of polarized leptons**. An upgrade of SuperKEKB with polarized beams is also being discussed. In order to do so, beyond the ability to produce such polarized lepton beams with appropriate currents, it is critical to have r**apid measurements of the polarization** of the beams in the accelerator to optimize it for collisions. **Compton polarimetry** is the baseline solution for such measurements in any of the forthcoming particle colliders where polarized beams are involved. Indeed this technique has been employed in the past at HERA, SLC, JLAB, and was found to be a critical asset. The IJCLab-NPC team was in particular involved in building and operating a polarimeter, for the measurement of the longitudinal polarization of the electron beam of HERA, where it performed precise and reliable measurements of the beam polarization [38]. Since then the very same team continued to develop its expertise in the field of the interaction of lasers with electron beams, developing a worldwide renowned expertise in this field. In this context the main **objectives of the NPC project** will be the **revisiting** of the **design of the laser systems** for the **upstream polarimeter of ILC** [39] and the design of a **Compton polarimeter** for the aforementioned **SuperKEKB upgrade**. The **precision** of these polarimeters must attain the **per-mil level** in the case of the ILC [25, 27], which poses challenges in terms of the real time monitoring of the laser-beam polarization that enters as an unavoidable systematic uncertainty in the lepton beam polarization extraction.

Dynamic Vacuum and Material studies

One of the main **potential limitation** in the all future colliders is the **dynamic pressure**. Ideally, charged particles should be generated, accelerated, transported and manipulated without any residual gas molecules. However, these molecules are always present in a real vacuum chamber. The energetic charged particles interact with gas molecules and these interactions cause many unwanted effects, such losses of the accelerated particles, the change of a charge state, residual gas ionization and the creation of a charged particle cloud (electrons for positive accelerated particle beams or ions for accelerated electron beams). The space charge affects the beam quality leading to beam emittance growth, and beam instabilities. It is worth noting that all of these dynamic pressure phenomena represent one of the most important limitation to reach the ultimate luminosity, and thus limit the accelerator performances and represent a real barrier for high energy physics research. **Specifications of the vacuum system** and vacuum studies are of paramount importance. Moreover, dynamic pressure depends strongly on the **materials constituting the accelerators**. Thus, it is essential to conduct fine analysis of the materials in order to improve their properties and to increase the performance of future machines.

To face the next challenges, both fundamental (the origin of matter and dark energy, nuclear energy, etc.) and practical (construction and operating costs), the technologies of the future accelerators must evolve with the development of **new materials**. Many phenomena limiting the performance of accelerators are directly related to the interactions between particles (electrons, ions, photons) and the surface of a material constituting the vacuum chambers or SRF cavities. The nature of the material as well as the morphology and the surface chemistry can thus directly affect the overall behavior of the components in an accelerator. These limiting phenomena are between others the **stimulated desorption** leading to degradation of the vacuum in the beam lines and the **collective effects** (multipacting, e^- clouds) leading to the instability of particle beams in the accelerator.

In order to improve the material properties and to reduce dynamic pressure effects, it is necessary to study these limiting phenomena and to finally mitigate their effects in future accelerators. Different materials are of interest: references (Cu, Stainless steel), new materials (carbon coated, laser treated, 3D printed) and NEG (Non-Evaporable Getter) coatings.

The NPC project will focus on three main axes, in which the investigated properties strongly depend on surface chemistry: (i) the measurement of the **Secondary Emission Yield (SEY)** a fundamental parameter for multipacting, (ii) the **Ion Stimulated Desorption (ISD)** in particular the different yields of production in collaboration with the CERN and focused in FCCee and (iii) the **dynamic pressure simulation code** development (DYVACS) [28-29].

3. Project and Methodology

The NPC project structure, R&D areas, colliders projects, lab, teams and funding are summarized in Figure 4.

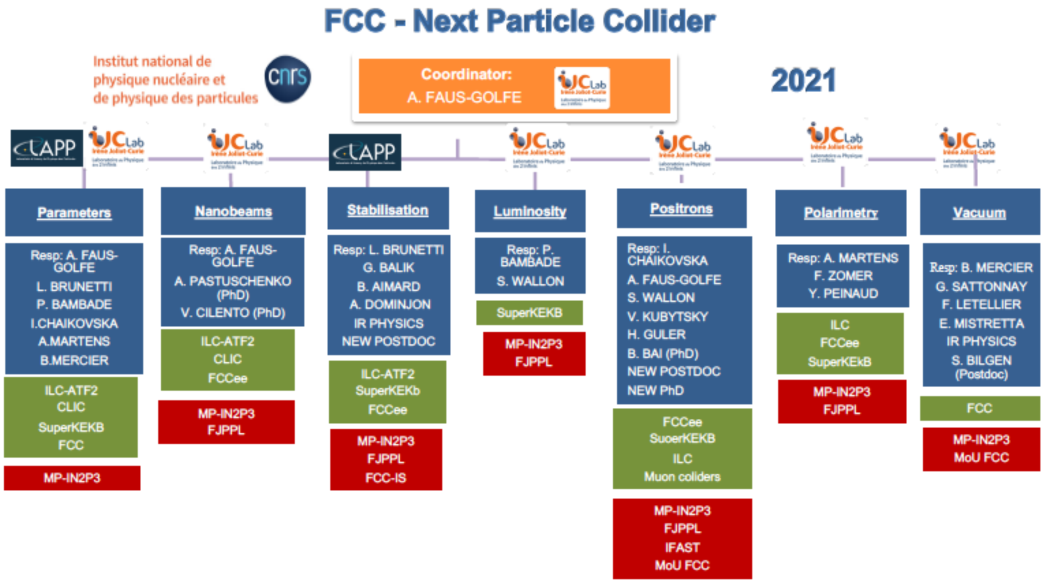

Figure 4: NPC project in a nutshell.

As stated in section 1 the main objective of the NPC project is to pursue a R&D on Colliders with a focus on: nanobeams handling and its stabilization and positioning techniques, luminosity monitoring, high-intensity e^+ sources, e^+e^- polarimetry and dynamics vacuum and material studies.
More in detail:

Objective 1: Participation in the future ATF3 ILC-CLIC FFS facility test optics design, long term stability operation and tuning and high-order aberration studies in order to maximize the potential luminosity of ILC.
Objective 2: Parametric study of a monochromatic scheme to maximize the sensitivity to the Yukawa coupling in FCCee, including beamsstrahlung and crossing angle effects between others and IR optics design implementation and integration of such scheme without luminosity degradation.
Objective 3: Definition of the FCCee MDI setup and strategy which respect the vibration specifications. These last ones have to be estimated with optics simulations and the acquired expertise on the ATF/ATF2 and SuperKEKB experiment.
Objective 4: Develop the most adapted positioning system for FCCee girders to reduce misalignments during beam operation.
Objective 5: Conducting dedicated experiments at the SuperKEKB colliders, aiming at maximising its performance, including for specific tests and validations of concepts and methods being developed in the context of future colliders such as FCCee, in particular with respect to luminosity optimisation using LumiBelle2, study and mitigation of effects from mechanical vibration near the IP.
Objective 6: Approach the positron production rate 10^{15}-10^{16} e^+/second requested by the future collider projects, by means of novel types of e^+ sources based on the hybrid scheme with new granular targets and positron capture systems based on superconducting (SC) solenoids.
Objective 7: Design and optimization of laser systems for the Compton polarimeters, including the implementation and the laser beam transport for SuperKEKB and ILC. In particular for the ILC to obtain the required one per-mille precision on the determination of the laser polarization in the

accelerator, in a reliable and reproducible way, which otherwise may become a limiting systematic uncertainty.

Objective 8: Contribute to a better understanding of the global dynamic pressure phenomena related to stimulated desorption, charged particle creation and charged particle cloud build-up in next generation of particle collider. Furthermore special attention will be paid to the materials properties studies, including innovative materials (high electrical conductivity, high radiation resistance, high mechanical strength, low desorption yield, low SEY with a fast conditioning, weak magnetic permeability and, if possible, with a pumping action).

These objectives will be implemented in 7 WPs:
- **WP1:** Performance, Parameters and Synergies
- **WP2:** Nanobeam size handling
- **WP3:** Nanobeam Stabilization and Positioning techniques
- **WP4:** Luminosity monitoring
- **WP5**: High-Intensity e^+ Sources
- **WP6:** e^+e^- polarimetry
- **WP7:** Dynamic Vacuum and Material studies

These WPs will extend in different colliders projects as described in Table 1.

NPC R&D areas	Nanobeam size handling	Nanobeam stabilization	Luminosity monitoring	High-Intensity e+	e+e- Polarimetry	Vacuum & Materials
LABS	IJClab	LAPP	IJClab	IJClab	IJClab	IJClab
PROJECTS						
LHC (FCChh)						X
SUPERKEKB		X	X	X	X	
ILC/CLIC ATF3	X	X		X	X	
FCCee	X	X		X	X	X
μ collider				X		

Table 1: NPC Matrix with the R&D areas, Projects and Labs.

WP1: Performance, Parameters and Synergies for Future Colliders Projects

WP1 leaded by A. Faus-Golfe, where all the WPs leaders participate, will survey the boundaries and explore the synergies of the next colliders proposed and asses all the others WPs, in order to develop a long term strategy for consolidating in some cases, boosting in others and opening new ones in each of the R&D subjects aforementioned before.

WP1 Tasks are:
T1.1: Organization of regular meetings to review the work progress in the different WPs and to discuss the future perspectives.
T1.2: Exploration of new projects opportunities and calls, preparation of requests and funding MoUs and documentation.
WP1 Deliverables are:
D1.1: IN2P3 project sheet for each R&D area/WP (June 2021) (all).
D1.2: MoU ILC-IDT: ATF3-FFS, FD and e^+ sources Technical preparation ILC pre-lab (2021) (A. Faus-Golfe, L. Brunetti, I. Chaikovska).
D1.3: MoU FCCee: Monochomatization studies (2021) (A. Faus-Golfe).
D1.4: MoU FCC-ee: Proof of Principle positron capture in SwissFEL (PSI): CHART program (2021) (A. Faus-Golfe, I. Chaikovska).
D1.5: MoU FCCee vacuum and material studies (2021) (A. Faus-Golfe, B. Mercier)
D1.6: MoU renewal MNPP-01 with SuperKEKB (2022) (A. Faus-Golfe, P. Bambade, L. Brunetti).

D1.7: MoU with SuperKEKB for polarimetry (2023) (A. Faus-Golfe, A. Martens F. Zomer).

WP2: Nanobeam size handling

WP2 led by A. Faus-Golfe, is dedicated in one hand to participate in the new ATF3/ILC-CLIC test facility in order to optimize the luminosity potential of ILC/CLIC and in the other hand to perform a parametric and feasibility study of a monochromatics scheme in FCCee. The specific goals in the 2022-2024 ILC-prelab period in this sense are: (i) the ATF3 ILC-FFS assessment system design, in particular the hardware optimization (Vacuum chambers, Magnets, IP-BSM laser, CBPMs, IP-BPMs) and the realistic (wakefields, jitter, magnet error) start-to-end (s2e) beam line "driven design" and IP optimization; and (ii) the ATF3 ILC-FFS oriented beam tests: long-term stability: nominal ($10\beta_x^* \times \beta_y^*$) routine operation assessment , vibration monitoring, intra-train feedback, intensity dependence and beam based mitigation techniques (orbit, wakefields), high-order aberrations: design optics ($\beta_x^* \times \beta_y^*$), ultra-low β_y^* (octupoles, long L^*) and other ILC R&D complementary studies: ILC DR injection/extraction kickers, ILC collimation issues, ILC type CPBMs, and new instrumentation (ultra-violet wavelength OTR sub-m resolution). For the FCCee monochromatization scheme the objectives are at first the parametric study to maximize the sensitivity to Yukawa coupling, including beamsstrahlung and crossing angle possibility between others; secondly the optics design of the FFS to generate the necessary antisymmetric dispersion at the IP and the possible accommodation of crab cavities compatible with the baseline and providing the transition from a crossing-angle to a head-on collision scheme, including beam-beam.

WP2 Tasks are:
T2.1: ATF3 ILC-FFS assessment system design: Realistic (wakefields, jitter, magnet error) "st2" beam line "driven design" .
T2.2: ATF3 ILC-FFS oriented beam tests: long-term stability: nominal ($10\beta_x^* \times \beta_y^*$) routine operation assessment, intensity dependence and beam based mitigation techniques (orbit, wakefields) and high-order aberrations: design optics ($\beta_x^* \times \beta_y^*$), ultra-low β_y^* (octupoles, long L^*).
T2.3: Monochromatization parametric study optimization for maximum sensitivity for Yukawa coupling including beamsstrahlung and crossing angle.
T2.4: FCCee IR optics design implementation, integration and tracking simulations including beam-beam.
WP2 Deliverables are:
D2.1: ATF3 optics design, (2022) (A. Faus-Golfe, PhD2.1).
D2.2: Report on commissioning and first operation of ATF3, (2024) (A. Faus-Golfe, PhD2.1).
D2.3: Parametric optimization study for FCCee monochromatization (2021) (A.Faus-Golfe, V. Cilento/PhD2.2).
D2.4: FCCee monochromatization optics, (2021) (A. Faus-Golfe, V.Cilento/PhD2.2).

WP3: Nanobeam Stabilization and Positioning techniques

WP3 will be led by L. Brunetti has four tasks: (i) is to ensure the vibrations mitigation of FCCee in the MDI area needed for the nanobeam stabilization, taking as starting point the acquired expertise in passive and active vibrations controls deployed in CLIC MDI solutions, ATF2 FD setup and SuperKEKB. The specifications will be determined by the optics simulation integrating the various worldwide ground motion models with the associated coherences and by taking into account the misalignment tolerances, the beam feedbacks and, possibly, the beam-beam effect. This procedure will also give a more complete view of the interplay among all these effects and their influence on the luminosity. (ii) In this prospect, the team is actively participating in the monitoring of the ground motion and the cryostat support motion of the SuperKEKB MDI area and is evaluating their impacts on the luminosity in collaboration with NPC-IJClab and KEK. Such way, the variation of the dynamics part of the luminosity (which is not present without perturbations) is analyzed in function of the disturbances particularities like type, frequency, direction, amplitude, coherence and of collider aspects like beam intensity, beam control, etc. Concerning FCCee the work will be focused in the development of a global approach vibration mitigation strategy including the impact of vibrations either coherent, or localized or amplified by mechanics. This study which will be completed with the beam orbit analysis.

(iii) Regarding the dynamic positioning techniques for FCCee, the first task will be related to study the different existing working system for further application in an experimental demonstration setup. (iv) Two possibilities are envisaged, first for the new NC FD in the future ATF3 or in the ILC SC FD test develop by BNL in the context of the ILC-IDT WG2 [61] (Appendix1). This setup will be the first step for a FCCee FD mock-up girder equipped with a global positioning system.

WP3 Tasks are:

T3.1: Participation/Continuation in ground motion and cryostat support motion monitoring SuperKEKB data taking, including the luminosity impact, (L. Brunetti, G. Balik, A. Dominjon, Postdoc 3.1).

T3.2: FCCee global vibration mitigation strategy specifications, (L. Brunetti, G. Balik, B. Aimard, A. Dominjon, Postdoc3.1).

T3.3: Study of different existing dynamic positioning system, (L. Brunetti, G. Balik, B. Aimard, Postdoc3.1).

T3.4: Design of an experimental demonstration setup (L. Brunetti, G. Balik, B. Aimard).

WP3 Deliverables are:

D3.1: Report of the vibration monitoring in SuperKEKb including impact on luminosity (2022).

D3.2: Strategy for FCCee vibration mitigation strategy (2024).

D3.3: Design of a positioning experimental mock-up system (2022).

WP4: Luminosity monitoring

This work package led by P. Bambade has three main tasks. The first one is the natural continuation, maintenance and possible improvement of the LumiBelle2 fast luminosity monitor. At present, basic operation and limited maintenance actions of the existing system are partly covered as a technical contribution of the IJCLab Belle II group to the SuperKEKB & Belle II projects at KEK, including with assistance from KEK staff. However securing the operation of LumiBelle2 for the life of the SuperKEKB & Belle II projects will require improvements or upgrades, which cannot be considered without additional technical and financial support, and which will need to be defined in the context of a close collaboration with the KEK team, by updating the present MoU MNPP-01, possibly including also some level of co-funding. The second one is the online and offline studies using the LumiBelle2 data. Three different data streams are provided by LumiBelle2 continuously during SuperKEKB operation: (i) Continuous 1 Hz integrated luminosity monitoring over an extended dynamic range which includes very low luminosities / beam currents, (ii) Continuous 1 kHz integrated luminosity monitoring. (iii) Continuous 1 kHz integrated luminosity per individual bunch crossing. These data are archived locally on our NAS at KEK, and transferred automatically on a daily basis to the IN2P3 computing centre in Lyon. The third one is the investigation of requirements and specifications of luminosity monitoring at future e^+e^- colliders. The experience with LumiBelle2 puts the NPC-IJClab group in an excellent position to evaluate requirements and suitable specifications for luminosity monitoring at future e^+e^- colliders, including feasibility of the different methods and technologies that will be needed. A distinction is needed here between the luminosity (or luminosity related) observables required for the tuning of the collider parameters, and the absolute luminosity measurements needed as part of the particle physics program planned at the collider (e.g. for determining cross sections). As part of this task, participation in the working groups and review panels of future collider projects will be efficient to transfer and apply our accumulated knowledge.

WP4 Tasks are:

T4.1: Continued operation, maintenance and improvement of the LumiBelle2 fast luminosity monitor already implemented at KEK for the SuperKEKB collider

T4.2: Online and offline studies using the LumiBelle2 data.

T4.3: Investigation of requirements and specifications of luminosity monitoring at future e^+e^- colliders.

WP4 Deliverables are:

D4.1: Report on operation and performance of LumiBelle2 fast luminosity monitor, accompanied by initial report on studies pertaining to QED cross section suppression effects, monitoring of fast variations and position feedback, (2021) (P. Bambade, S. Wallon, Master Internship Student).

D4.2 Renewal of MNPP-01 MoU with KEK, with report on improvements / upgrades considered to be needed to operate LumiBelle2 from 2023, (2022) (P. Bambade, S. Wallon, in collaboration with NPC-LAPP team).
D4.3 Specification for LumiBelle2 upgrade and initial report on investigating luminosity monitoring at future e^+e^- colliders under consideration (e.g. FCCee, CEPC and ILC), (2022) (P. Bambade, S. Wallon, PhD4.1).
D4.4 Report on design of upgraded version of LumiBelle2 including consolidated report on studies pertaining to QED cross section suppression effects, monitoring of fast variations and position feedback, (2023) (P. Bambade, S. Wallon, Postdoc4.1).
D4.5 Final report on the luminosity monitoring task, including assessment of luminosity monitoring at future colliders and report on IP beam size tuning experiments using LumiBelle2, (2024) (P. Bambade, S. Wallon, PhD4.2).

WP5: High Intensity e^+ Sources

WP5 is led by I. Chaikovska and consist of three tasks: (i) The first one is the development of a reliable concept of the target and capture system based on the innovative approaches, including target thermodynamics studies, identified as one of the main performance limitation in the future e^+e^- colliders. The feasibility of using a SC solenoid in the capture system will be also evaluated. This task will also define the detailed specifications for the e^+ source demonstrator being constructed at PSI SwissFEL line (ii) The second one is the experimental test and data analysis in three facilities: beam tests at MAMI to study the reliability of the crystal and conversion target, beam tests at SuperKEKB to study the innovative targets and the proof-of-principle experiment at finally in the new e^+ source test at PSI SwissFEL line for the novel target and capture system. (iii) Finally the third one will make use of advanced optimization techniques (ML and Bayesian) to improve the performances of the e^+ injector. All these result will be the base of the definition of an optimized injector scheme for FCCee, but also could be a suitable option for the demanding ILC e^+ production option based on an e^- driven e^+ source.

WP5 Tasks are:
T5.1: Simulation studies: physics design of the positron target and capture system. Beam dynamics, (I. Chaikovska, S. Wallon, Postdoc5.1, PhD5.1).
T5.2: Experimental tests and data analysis, (I. Chaikovska, PhD5.1, Postdoc5.1).
T5.3: Advanced optimisation techniques for positron injector, (V. Kubytskyi, H. Guler).
WP5 Deliverables are:
D5.1: Design of a novel target and capture system for the new e^+ source test facility at PSI FEL line (2022).
D5.2: Report on commissioning and first experimental tests (2024).
D5.3: Specifications of FCCee injector (2023).

WP6: e+e- Polarimetry

WP6 is led by A. Martens and F. Zomer. The two main tasks of WP6 are: (i) The design and optimization of laser systems for Compton polarimeters, in particular the specification of these laser systems and their implementation, including laser beam transport where needed. In particular for SuperKEKB in a first phase, allowing to start with smaller, less expensive, less powerful laser systems, to reach the target performance and demonstration and further improve it with more powerful laser systems for the ILC. (ii) Feasibility study to obtain the required one per-mille precision (targeted for ILC) on the determination of the laser polarization in the accelerator, in a reliable and reproducible way, which otherwise may become a limiting systematic uncertainty. The obtained results will pave the way towards the final design of Compton polarimeter at any future e+e- collider, and particularly of their laser systems. This will be performed first at low power (laser system for SuperKEKB) and further extended to ILC, where thermally induced systematic effects are indeed expected to be a limiting factor, thus requiring additional dedicated R&D. Note that the R&D that will be performed will also be beneficial to the EIC project.

WP6 Tasks are:

T6.1: Participation of the design of Compton polarimeters for future e^+e^- colliders, with emphasis on SuperKEKB upgrade, (A. Martens, F. Zomer, Y. Peinaud).
T6.2: Feasibility study of a per-mille control and monitoring of circular laser polarization for implementing Compton polarimeters for the future e^+e^- colliders, (A. Martens, F. Zomer, Y. Peinaud).
WP6 Deliverables are:
D6.1: White report for the polarization upgrade of the SuperKEKB accelerator (2021)
D6.2: Conceptual design report for the polarization upgrade of the SuperKEKB accelerator (2022).
D6.3: Technical design report for the polarization upgrade of the SuperKEKB accelerator (2023)
D6.4: Demonstration of per-mille level monitoring of the polarization in view at laser power compatible with the SuperKEKB implementation.
D6.5: Demonstration of per-mille level monitoring of the polarization in view at laser power compatible with the ILC implementation.

WP7: Dynamics Vacuum and Material studies

WP7 will be led by B. Mercier, as a continuation of the PhD thesis [31] on dynamic pressure studies in particle accelerators. WP7 will consist of four tasks: (i) SEY measurements of OFE copper, amorphous carbon and other alternative materials as the NEG alloys (Ti, V, Zr alloy) with controlled thickness deposition. These last are of special interest for FCCee vacuum chambers. The fabrication of the NEG samples, the measurement of the secondary electron emission efficiency and the study of the evolution of the surface chemistry as a function of the received dose of e^- will be carried out on the "vacuum and surface" platform at IJCLAB. (ii) Improvement and qualification of the CERN's ionic desorption set-up, more in detail: the differential pumping, the beam size estimation and the development of the sample introduction line, etc. At the same time measurements on co-laminated copper (LHC beam screen) to determine the ionic desorption yields for molecules of interest such as H_2, CO, CO_2 and CH_4 as a function of the ions incident energy, in order to complete the first results obtained in 2020 [28], will be carried out. Other materials could also be studied as: amorphous carbon coating or NEG coating. (iii) Experimental measurement campaign in the next LHC run (June 2022), on the Vacuum Pilot Sector (VPS) at LHC. (iv) Perform dynamic pressure simulations with the DYVACS code using the new experimental results to predict the dynamic pressure levels for FCCee in a first stage and later for FCChh**.**

WP7 Tasks are:
T7.1: SEY measurements of interest materials. (OFE copper, NEG alloys, amorphous carbon), (B. Mercier, G. Sattonnay, E. Mistretta, F. Letelier).
T7.2: Improvement and qualification of CERN's ionic desorption set-up, (B. Mercier, S. Bilgen, G. Sattonay).
T7.3: Measurement of pressure changes on VPS during the next LHC run (S. Bilgen).
T7.4: Development of the DYVACS dynamic vacuum simulation code, (B. Mercier, S. Bilgen, G. Sattonnay).
WP7 Deliverables are:
D7.1: SEY measurements and conditioning effect for Cu, C and NEG coatings (2022).
D7.2: ISD yields for H_2, CO, CO_2 and CH_4 for several incident ion energies (in priority on Cu and NEG coatings) (2023).
D7.3: Dynamic pressure prediction for FCCee and FCChh.(2022)
D7.4: Report on data acquisition at LHC VPS and benchmarking with calculated pressure simulation using DYVACS code (2024).

The WPs, major tasks and time schedule are summarized in Table 2.

FCC-NPC WPs and Tasks	2021		2022		2023		2024	
	S1	S2	S1	S2	S1	S2	S1	S2
WP1: Performances, Parameters and Synergies for FC								
T1.1: Meetings, Review, Perspectives								
T1.2: Calls, Requests Funding, MoUs, Documentation								
WP2: Nanobeam size handling								
T2.1: ATF3 ILC-FFS assessment system design								
T2.2: ATF3 ILC-FFS oriented beam experiments								
T2.3: Monochrom parametric study for FCCee								
T2.4: FCCee monochrome optics implementation								
WP3: Nanobeam stabilization and Monitoring								
T3.1: Ground motion/Mech. Vibrations SuperKEKB								
T3.2: FCCee global vibration mitigation strategy								
T3.3: Dynamic Positioning system studies								
T3.4: Design of positioning experimental set-up								
WP4: Luminosity Monitoring								
T4.1: Operation, Maintenance of LumiBELLE2								
T4.2: Online/Offline analysis of LumiBELLE2 data								
T4.3: Specifications of luminosity monitoring for FCCeee								
WP5: High-Intensity e+ sources								
T5.1: Simulation of e^+ target and capture system								
T5.2: Experimental test and data analysis								
T5.3: Advance optimization for e^+ injector								
WP6: e+e- Polarimetry								
T6.1: Compton polarimeter for SuperKEKB								
T6.2: Feasibility study of per-mil polarization precision								
WP7: Dynamic Vacuum and Material studies								
T7.1: SEY measurements (OFE Cu NEG alloys, amorphous C)								
T7.2: ISD – CERN qualification set-up								
T7.3: VPS – CERN setup measurements								
T7.4: DYVACS code developments								

Table 2: NPC WPs, Major Tasks and Time schedule.

4. Team, Resources and Budget

The team is composed of experts in the field of accelerator physics and engineering, who are recognized experts in the aforementioned research topics. Table 3 summarize the personnel, FTEs per year for each WP, tasks and expertise. Concerning the personnel the table lists the permanents and the non-permanent including also the non-permanents in hiring process that have an assured funding. WP's responsible are noticed in bold.

FCC-NPC – 11.05 FTEs			
Team members	**Lab**	**FTE/year**	**Tasks & Expertise**
WP1: Performances, Parameters and Synergies for FC – 0.1 FTEs			
A.Faus-Golfe	IJClab	0.1	Coordination, Collider performances, Synergies
WPs leaders	IJClab / LAPP		
WP2: Nanobeam size handling - 2.2 FTEs			
A.Faus-Golfe	IJClab	0.2	Optics design, Beam dynamics, Beam experiments
A.Pastushenko (PhD)	IJClab / CERN	1.0 (end Oct 2021)	Optics design, Beam dynamics, Beam experiments
V. Cilento (PhD)	IJClab / CERN	1.0 (end Oct 2021)	Optics design, Beam dynamics, Beam experiments
WP3: Nanobeam stabilization and Monitoring - 3.3 FTEs			
L. Brunetti	LAPP	0.5	Control science
G. Balik	LAPP	0.5	Control science
B. Aimard	LAPP	0.2	Mechanical engineer
A.Dominjon	LAPP	0.1	Instrumentation
IR Physicist	LAPP	1.0	Beam dynamics, Beam diagnostics
Postdoc3.1 IN2P3	LAPP	1.0	Beam dynamics, Beam diagnostics
WP4: Luminosity Monitoring – 0.5 FTEs			
P. Bambade	IJClab	0.2 (+ 0.3 Belle2)	Beam experiments and analysis
S. Wallon	IJClab	0.3	Mechanics, Beam experiments and analysis
WP5: High-Intensity e+ sources – 2.8			
I.**Chaikovska**	IJClab	0.4	Beam dynamics, Beam experiments
A.Faus-Golfe	IJClab	0.1	Optics design, Beam dynamics
S. Wallon	IJClab	0.2	Thermo-mechanics
V. Kubytsky	IJClab	0.05	Machine Learning
H. Guler	IJClab	0.05	Machine Learning
B.Bai (PhD)	IJClab / IHEP	1.0 (end Oct 2021)	Optics design, Beam dynamics
Postdoc5.1 FCC MoU	IJClab	1.0 (start May 2021)	Beam dynamics, Beam experiments
PhD5.1 IN2P3	IJClab	1.0 (start Oct 2021)	Beam dynamics, Beam experiments

WP6: e+e- Polarimetry – 0.45 FTEs			
A.Martens	IJClab	0.2	Design, Performances
F. Zomer	IJClab	0.1	Design, Performances
Y. Peinaud	IJClab	0.15	Mechanics, Integration
WP7: Dynamic Vacuum and Material studies – 1.7 FTEs			
B.Mercier	IJClab	0.4	Vacuum, Materials, Beam experiments
G.Sattonnay	IJClab	0.3	Vacuum, Materials, Beam experiments
F. Letellier	IJClab	0.1	Vacuum
E. Mistretta	IJClab	0.1	Vacuum
IR Physicist	IJClab	0.8 (start Dec 2021)	Vacuum, Materials, Beam experiments
S. Bilgen (Postdoc lab)	IJClab	0.8 (end Dec 2021)	Vacuum, Materials, Beam experiments

Table 3: NPC Personnel, FTEs per year and major Tasks

The financial resources allocated for the NPC project for last year 2020, current year 2021 and a first attempt request for 2022 are summarized in Tables 4, 5 and 6 respectively. The Tables include the different funding sources, per WP and labs.

2020							
FCC-NPC R&D	**WP1: Parameters & Synergies**	**WP2: Nanobeam size handling**	**WP3: Nanobeam stabilization & Positioning system**	**WP4: Luminosity monitoring**	**WP5: High-Intensity e+**	**WP6: e+e- Polarimetry**	**WP7: Vacuum & Materials**
LABS	**IJClab LAPP**	**IJClab**	**LAPP**	**IJClab**	**IJClab**	**IJClab**	**IJClab**
FUNDING	**Material and Travelling: 64.5 (k€)**						
MP-IN2P3	**7 (4 Covid19)**		**30 (6 Cov19)**	**12 (2 Cov19)**	**19 (2 Cov19)**		**4**
FJPPL		**2**	**Cov19**		**Cov19**	**Cov19**	
MoUs							**2.5**
	3	**2**	**24**	**10**	**17**		**8.5**
	Personnel: 3 Phds 2 Postdocs						
MP-IN2P3					**1 Postdoc (end Oct 2020)**		
Lab. funds			**1 Postdoc (end Oct 2020)**				
CSC-UPSay					**1 PhD (end Oct 2021)**		
CERN-PhD		**2 PhD (end Oct 2021)**					

* Scenario COVID 19 (8.06 kEu are uploaded to the Direction budget for IJClab and 6.0kEu for LAPP.

Table 4: NPC Matrix with the WPs, Funding sources and Labs allocated for 2020.

2021							
FCC-NPC R&D	**WP1: Parameters & Synergies**	**WP2: Nanobeam size handling**	**WP3: Nanobeam stabilization & Positioning system**	**WP4: Luminosity monitoring**	**WP5: High-Intensity e+**	**WP6: e+e- Polarime try**	**WP7: Vacuum & Materials**
LABS	**IJClab-LAPP**	**IJClab**	**LAPP**	**IJClab**	**IJClab**	**IJClab**	**IJClab**
FUNDING	**Material and Travelling: 46 + EU + R (k€)**						
MP-IN2P3	6	3	12	7	12	3	3
FJPPL		R	R		R	R	
FCPPL		R					
EU projects			FCC_IS		I_FAST		
MoUs							
	6	**3**	**12**	**7**	**12**	**3**	**3**
	Personnel: 4 PhDs 3 Postdocs						
MP-IN2P3			1 Postdoc (start Jan 2021)		1 PhD (start Oct 2021)		
Lab. fund							1 Postdoc (start Jan 2021)
MoUs					1 Postdoc (start Feb 2021)		
CSC-UPSay					1 PhD (end Oct 2021)		
CERN-PhD		2 PhD (end Oct 2021)					

* R means requested

Table 5: NPC Matrix with the WPs, Funding sources and Labs allocated currently for 2021.

Concerning the Budget for 2021 there is some requests ongoing from: FJPPL and FCPPL programs mainly for travelling to KEK and IHEP respectively and a Chinese Scholarship Council – UPSay PhD program for PhD2.1 (Monochromatization FCCee).

2022							
FCC-NPC R&D	**WP1:** Parameters & Synergies	**WP2:** Nanobeam size handling	**WP3:** Nanobeam stabilization & Positioning system	**WP4:** Luminosity monitoring	**WP5:** High-Intensity e+	**WP6:** e+e- Polarimetry	**WP7:** Vacuum & Materials
LABS	**IJClab-LAPP**	**IJClab**	**LAPP**	**IJClab**	**IJClab**	**IJClab**	**IJClab**
TOTAL (k€)							
Material (k€)							
115			**30**		**30**	**35**	**30**
Travelling (k€)							
70	**5**	**10**	**15**	**10**	**15**	**10**	**5**
185		**10**	**45**	**10**	**45**	**45**	**35**
Personnel							
4 PhD		**1**			**1**	**1**	**1**
3 Postdoc			**1**	**1**	**1**		

Table 6: NPC Matrix with the WPs and tentative Budget request for 2022.

5. Equipment Needs and Use of Platforms/Infrastructures

For tasks related with mechanical design, assembly, integration and construction of devices or prototypes the NPC teams is making use of the mechanical workshops, electronic services and clean rooms in the IJClab and LAPP respectively. In some cases they make also use of some dedicated laboratories or platforms as: the analysis and control of vibrations platform at LAPP (WP3), the optical rooms at IJClab (WP6), the vacuum and surfaces platform and the ANDROMEDE platform at IJCLab (WP7). A detailed description of these platforms is given in Appendix II.
Regarding the tasks where a beam is needed the NPC team make use of Large Infrastructures as: ATF/AFT2 (WP2, WP3), SuperKEKB (WP3, WP4, WP5, WP6), MAMI (WP5) and LHC (WP7).
Table 7 summarizes the use.

Platforms & Infrastructures							
FCC-NPC R&D	**WP1:** Parameters & Synergies	**WP2:** Nanobeam size handling	**WP3:** Nanobeam stabilization & Positioning system	**WP4:** Luminosity monitoring	**WP5:** High-Intensity e+	**WP6:** e+e- Polarimetry	**WP7:** Vacuum & Materials
LABS	IJClab-LAPP	IJClab	LAPP	IJClab	IJClab	IJClab	IJClab
EQUIPMENTS							
Mechanical Ws			X	X	X	X	X
Electronics			X	X	X		
Optical rooms						X	
Vac & Surfaces							X
Andromede							X
Vibrations			X				
ATF2/ATF3		X	X				
SuperKEKB			X	X	X	X	
LHC							X
MAMI					X		

Table 7: NPC Matrix with the WPs and use of Workshops, Platforms and Large Infrastrucures.

6. Genesis, Perspectives and Records

The NPC IN2P3 Master Project (MP) was born in 2019 as a result of the fusion of the Future Linear Collider (FLC) and Future Circular Collider (FCC) IN2P3 MPs. The FLC project was led by P. Bambade and was focused mainly in ATF/ATF2 activities involving old LAL and LAPP and the high intensity e^+ sources activities of IJClab at SuperKEKB. The FCC project was led by A. Faus-Golfe and was focused in the FCChh collimation in the framework of the EU project EuroCircol involving old LAL and IPNO.

Since 2020 the NPC project integrates the IN2P3 R&D accelerator activities related with current and future colliders at IJClab and LAPP. During the first year of life of the project we have tried to unify, harmonize and synergize the activities and we start to run as a “project”. In this sense a contribution with similar contents has been presented to the IN2P3 National Perspectives 2020-2030 in the GT07: Accelerators and Instrumentation area [60].

In the medium and long term the ambition of the project is in one hand to consolidate the R&D areas and contribution to the projects already mentioned and in the other hand to identify the approaches with greatest potential for the next generation of colliders or possible applications of accelerators. All of this in alignment with the IN2P3 strategy and the next EPPSU strategy update.

Achievements 2019-2020

-FCC CDR published January 2019 https://fcc-cdr.web.cern.ch

-European Strategy Update Document 2019

-NPC proposal for Prospectives IN2P3 20-20-2030 (G707)

-Conferences and Workshops 2019-2020:

•FCC 2019 week (2talks) https://indico.cern.ch/event/727555/timetable/
•FCPPL Annual workshop 24-27 April 2019 (talk, organizer) https://indico.ihep.ac.cn/event/9587/
•TYL-FJPPL Annual workshop 2019 8-10 May http://nuclear.korea.ac.kr/indico/conferenceTimeTable.py?confId=395#20190508
•FCC-ee MDI workshop 9-20 September 2019. https://indico.cern.ch/event/839155/timetable/#20190909
•FCC-ee Injector kick-off meeting, 2 October 2019, https://indico.lal.in2p3.fr/event/5829/
•FCC-ee positron source studies and planned beam test at PSI, LAL, 17 October 2019
•LCWS2019, 28 October-1 Nov (talk)
•FCC France (talks organizer) 14-15 November 2019
•CepC 2019 18-20 November 2019 https://indico.ihep.ac.cn/event/9960/timetable/
•ACN2020 - ARIES Workshop on Application of Crystals and Nanotubes for Beam Acceleration and Manipulation (10-11 March 2020), "Crystal-assisted positron source" (talk), https://indico.cern.ch/event/867535/overview
•Muon Collider Workshop (31 March 2020 to 2 April 2020), " Positron source performances", https://indico.cern.ch/event/886491/
• Mini-Workshop: Accelerator - Machine Detector Interface for Future Colliders, Hong-Kong 16-17 January 2020 http://iasprogram.ust.hk/hep/2020/workshop_accelerator.php
•Review ATF2 at KEK, 29 septembre https://agenda.linearcollider.org/event/8626/
•Mini-CLIC workshop 2020 30 September-1 October, https://indico.cern.ch/event/952778/overview
• Kickoff meeting FCC IS 9-13 November 2020.
• CepC 2020 18-20 November 2019
• FCC France 2021

-Invited collaborators:

•P. Martyshkin Flux concentrator for positron source - October 2019, (P2I grant research stay).

-Experimental campaigns:

CERN

•Measurement of ions in the VPS (Vacuum Sector Pilot) of the LHC 2019, (FCC MoU CERN-IN2P3) (S. Bilgen).

KEK

•Restart of the positron injector for the phase 3 commissioning of superKeKB - February 2019, (FJPPL-positrons, FCC) (I. Chaivskoska, Y. Han).
•Participation in the Lumibelle2 and stabilization at SuperKekB (2019-2020) (P. Bambade).
• Participation in the ATF2 winter run- February 2020, (FJPPL-nanobeams) (A. Faus-Golfe, A. Pastushenko).

-New funding proposals:

Funded:

•H2020-INFRADEV-01-2019-2020, "Frontier Circular Collider Innovation Study (FCC IS)".
•CHART Swiss Research Foundation: PSI-GFA-CERN FCC-ee Study group, "FCC-ee Injector Design and Test Stand at PSI" (External partners: IJClab, INFN-LNF) (2020-2024).
• H2020-INFRAINNOV-04-2020 RIA, "Innovation Fostering in Accelerator Science and Technology (I_FAST) 2021-2025.

-In Preparation:

•ILC-International Development Team (ILC-IDT) WG2 Accelerators: "Technical preparation for ILC-prelab", 2022-2025 [61] (Appendix 1).
•China Scholarship Council and UPSay PhD program " Implementation of a monochromatic scheme for the direct s-channel Higgs production at FCC-ee", 2020.

•FJPPL and FCPPL 2021-2022

Publications 2019-2020

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9. D. Banon Caballero, W. Wuensch, K. Szypula, N. Catalan Lasheras, B. Gimeno, A. Faus Golfe, "Combined Fied Emission and Multipactor simulation in High-Gradient RF Accelerating structures", IPAC19.
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PhDs since 2015

1. **Title:** *Striplines Kickers for CLIC Damping Ring,* Student: C. Belver Aguilar, **University:** Valencia, Date: October 2015.
2. **Title**: *Development of Diamond Sensors for Beam Halo and Compton Spectrum Diagnostics after the Interaction Point of ATF2,* Student: S. Liu, **University**: Paris-Sud, Orsay, Date: June 2015
3. **Title**: *Beam dynamics in the final focus section of the future linear collider,* Student: O. Blanco, **University:** Paris-Sud, Orsay, Date: June 2015
4. **Title:** *BPM system for the Drive Beam of CTF3,* Student: A. Benot Morell **University:** Politecnica de Valencia, Date: February 2016.
5. **Title**: *Fast Luminosity Monitoring Using Diamond Sensors for SuperKEKB,* Student: D. El Khechen, **University:** Paris-Saclay, Orsay, Date: December 2016
6. **Title:** *Breakdown studies for high gradient RF warm technology in: CLIC and hadrontherapy linacs,* Student: J. Giner Navarro, **University:** Valencia, Date: February 2017.
7. **Title**: *Beam Halo Collimation and Induced Wakefield Studies for Future Linear Colliders: the ATF2 Case,* Student: N. Fuster Martinez, **University:** Valencia, Date: July 2017.
8. **Title**: *Development of direct measurement techniques for the in-situ internal alignment of accelerating structures,* Student: N. Galindo Muñoz, **University**: Politecnica de Valencia, Date: February 2018
9. **Title**: *Diagnostics and characterization of beam halo at the KEK Accelerator Test Facility,* Student: R. Yang, **University:** Paris-Saclay, Orsay, Date: October 2018
10. **Title**: *Optics optimization of longer L* Beam Delivery System designs for CLIC and tuning of the ATF2 final focus system at ultra-low β* using octupoles*, Student: F. Plassard, **University:** Paris-Saclay, Orsay, Date: July 2018
11. **Title**: *Fast luminosity monitoring and feedback using monocrystalline CVD diamond detectors at the SuperKEKB electron-positron collider in Japan*, Student: C.G. Pang, **University:** Paris-Saclay, Orsay, Date: September 2019
12. **Title**: *High-Gradient issues in S-band RF Acceleration Structure for Hadrontherapy accelerators and Radio Frequency Quadrupoles,* Student: A. Vnuchenko, **University:** Valencia, Date: June 2020.
13. **Title**: *Dynamic pressure in particle accelerators: Experimental measurements and simulation for the LHC,* Student: S. Bilgen, **University:** UPSay, Date: December 2020.

Under Supervision

1. **Title:** *Simulations and Measurements of Vacuum discharge in High-Gradient RF Accelerators,* Student: D. Bañon Caballero, **University:** Valencia, Starting Date: October 2017.
2. **Title**: *Optimization of the optics for the FFS of CLIC 380 GeV and experimental studies for ATF2*, Student: A. Pastushenko, **University:** Paris-Saclay, Starting Date: October 2018.
3. **Title:** *Optics Design of a dual beam delivery system for lepton colliders and experimental measurements of the ATF2 ultra-low nanometer beam size,* Student: V. Cilento, **University:** Paris-Saclay, Starting Date: October 2018.
4. **Title**: *Injector linac optimizations for FCCee and applications for PRAE*, Student: B. Bowen, **University:** Paris-Saclay / University Chinese Academy of Sciences, Starting Date: October 2018.

7. SWOT self-analysis

STRENGTHS	WEAKNESSES
• International, national and local projects - Participation in both the design and implementation of accelerator projects (LHC, ILC-CLIC, FCC, ...), with major responsibilities. - Existence of local accelerators and platforms in operation, under construction or at the proposal stage (ALTO, SUPRATECH, PHIL, Vacuum&Surfaces, IGLEX: ThomX and Andromede) - Excellent integration in expert teams of two state of the art projects currently in operation at KEK (ATF2 and SuperKEKB) **• Team** - Pioneering and multidisciplinary teams with broad expertise (Beam dynamics, Beam instrumentation, Mechanics, Material science…) - Global view of the field built up over years of involvement in international collaborations - Culture of engineer / researcher collaboration and project - Framed by the largest Accelerator Physics community in France. **• Teaching** - Training of doctoral students and Master 2: "Grands Instruments-PLATO" and NPAC -Possibility of internships and practical work **• Industrial relations** - Existence of links with manufacturers (Amplitude Systems, etc.)	**• Team** - Small teams, difficult to have impact, dispersion - Insufficiently coordinated and coherent approach by a set of skilled but diverse teams with little overlap in expertise or interests - Few recruitments, few permanent staff and posts at the University - Undersized technical groups to ensure international, national and local projects - Low mobility of some of the team members **• Teaching** - Low share of research professors - Few PhD theses for some of the team members - Very low number of HDRs in the accelerator field - Too restrictive conditions to obtain support for PhD students in comparison with competing teams abroad strongly limit our competitiveness internationally **• Technical resources** - Lack of available resources in electronics and online data acquisition systems (e.g. FPGA programming and online data handling) - Lack of appropriate / convenient local facilities for the testing / calibration of instrumentation, e.g. with suitable radioactive sources
OPPORTUNITIES	**THREATS**
• International, national and local projects - Major contribution in several current and new global projects and European networks (EUCARD2, EuroCircol, EuPRAXIA, ARIES, AMICI, CompactLight, FCC_IS, I-FAST ...) and local platforms under construction - Strong links with major international labs (CERN, DESY, KEK, Fermilab, SLAC, IHEP….) - Development of transversal projects in the field of health and other applications - Strengthen ties with industrialists - Direct participation in currently the only operating state of the art high-energy electron-positron collider in the world, also serving as main test facility for accelerator concepts being developed for FCCee, CEPC, future tau-charm factories (and more generally also ILC). • **Major role** in **strengthening** existing collaborations, efficient pooling of resources and cooperation with others labs. • Promote **targeted projects** for concept studies and “high risk” technologies. • Very strong **pool** of brilliant **students** at UPSay	• **Teams** Reduction in human resources and loss of technical know-how in certain areas of expertise • Uncompetitive salaries compared to those in industry, and foreign research institutes and laboratories **• Projects** - Mismatch between short-term offers (3-5 years) and the actual duration of the projects. - Time spent responding to calls for tenders for insignificant returns - Managing contracts becomes more and more restrictive, complex and therefore time-consuming, requiring human resources of the project engineer type - Insufficient consideration of an appropriate balance between supporting local accelerator projects and R&D activities and direct involvement in major international projects

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[58] H2020-INFRADEV-01-2019-2020, "Frontier Circular Collider Innovation Study (FCC IS)".

[59] H2020-INFRAINNOV-04-2020 RIA, "Innovation Fostering in Accelerator Science and Technology (I_FAST) 2021-2025.

[60] https://indico.in2p3.fr/event/19783/timetable/#20200120.detailed

[61] https://agenda.linearcollider.org/event/9047/

Appendix I:

ATF/ATF2 MoU – ILC-IDT WG2

formation of the healthy international collaborative relationship among all the participants, we have come to the notion that it is now appropriate re-clarify the organization of the international collaboration at ATF/ATF2 and formalize them in the form of an MoU.

2. Mission of ATF/ATF2

The primary mission of ATF/ATF2 is three-fold:

- ATF, to establish the technologies associated with producing the electron beams with the quality required for ILC and provide such beams to ATF2 in a stable and reliable manner.
- ATF2, to use the beams extracted from ATF at a test final focus beamline which is similar to what is envisaged at ILC. The goal is to demonstrate the beam focusing technologies that are consistent with ILC requirements. For this purpose, ATF2 aims to focus the beam down to a few tens of nm (rms) with a beam centroid stability within a few nm for a prolonged period of time
- Both the ATF and ATF2, to serve the mission of providing the young scientists and engineers with training opportunities of participating in R&D programs for advanced accelerator technologies.

3. Organization of ATF/ATF2

To execute the scientific programs at ATF/ATF2, the following bodies will be instituted:

- International Collaboration Board (ICB)
- Technical Board (TB)
- Spokesperson (SP) with his/her Deputies
- System/Group Coordinators (SGCs)

3.1 International Collaboration Board (ICB)

The International Collaboration Board (ICB) is the decision making body for executive matters related to the ATF collaboration. Each collaborating institute will delegate one member to the ICB. In addition, the ICB is joined by three GDE Regional Directors, who represent Asian, North American and European regions.

One of the members of the ICB is to serve as the ICB Chair. The nomination of the ICB Chair is done through mutual voting by all of the ICB members.

The ICB serves the following tasks –

- Nominate the Spokesperson (SP) of the ATF collaboration.
- Approve the appointment of the Deputies and System/Group Coordinators of important subsystems or subprograms.
- Review and approve the ATF Annual Activity Plan.
- Receive the reports from the SP, as found appropriate, and oversee the progress made by the collaboration.
- Approve the new membership and withdrawals of collaborating institutes.
- Help communicate the progress being made at ATF with members of the home institutes.

3.2 Technical Board (TB)

The TB consists of approximately 4~5 members from each of the Asian, North American and European regions. The members of the ATF Technical Board (TB) are nominated and appointed by ICB. The TB serves the following tasks:

- At the request of ICB, assist the Spokesperson in formulating the ATF Annual Activity Plan, which outlines the activity plans of ATF/ATF2 including the budget and beamtime allocation for each Japanese fiscal year.
- Assist the ICB in assessing the scientific progress that is being made by the ATF collaboration.

3.3 Spokesperson (SP)

The ATF Spokesperson (SP) is nominated by ICB and is appointed by the director of KEK. The SP serves the following tasks:

- Direct and coordinate the work required at ATF/ATF2 in accordance with the ATF Annual Activity Plan.
- Report the progress made by the collaboration to the ICB and the director of KEK.
- Report the matters related to KEK budget and KEK properties to the director of KEK.

To carry out these tasks, the SP will:

- Appoint, with an approval of ICB, up to three Deputies to assist his/her tasks in the areas of
  - Beam operation,
  - Hardware maintenance, and
  - Design, construction and commissioning of ATF2.

- Appoint, with an approval of ICB, the System/Group Coordinators (SGCs) on critical ATF/ATF2 subsystems and study programs.
- Organize a "Coordination Group" with the Deputies and System/Group Coordinators for coordinating the details of the operation and development at ATF/ATF2 on a daily (during the beam operation period) or weekly (during the maintenance and construction period) basis.

3.3 System/Group Coordinators (SGCs)

- The System/Group Coordinators will be appointed by the Spokesperson with an approval of ICB.
- The appointment of the System/Group Coordinators shall be made in a manner consistent with the ATF Annual Activity Plan.
- The System/Group Coordinators will coordinate the tasks charged to the assigned Systems or Groups, and will assist the Spokespersons and the Deputies coordinate the ATF/ATF2 research programs.

In case of small study groups with less than 5 members, the Spokesperson or the Deputies may assume the role of its Coordinator on an acting basis.

4. Execution of Research Programs at ATF/ATF2

The ATF Spokesperson (SP) supervises the construction and operation programs of ATF/ATF2 in accordance with the ATF Annual Activity Plan, as approved by the ICB. The ATF SP can delegate part of his tasks to the Deputies and System/Group Coordinators, as deemed appropriate. The planning and execution of the construction and operation programs of ATF/ATF2 must be conducted in a manner consistent with the Japanese laws, KEK internal regulations and other rules applicable in case of activities by non-KEK members of the collaboration. Details of the group structures are to be formulated in ways optimized in accordance with the technical nature of each program in question, e.g.. activities such as design, simulation, testing, construction, commissioning, operation, and investigation.

Additional agreements concerning the matters related to execution of non-KEK budget, management of non-KEK properties at the premise of ATF, together with handling of KEK properties at the premises outside KEK, are to be individually dealt with in Annexes attached to this MoU.

The detailed coordination of beam time allocation will be done by the Coordination

Group.

The expenses associated with the electricity, water and gas for operating ATF/ATF2 will be financed by KEK, in accordance with the spirit of ICFA Guidelines and ICFA Statement on Test Beam Availability (http://www.fnal.gov/directorate/icfa/icfa_guidelines.html; http://www.fnal.gov/directorate/icfa/icfa_testbeam.html). The expenses for preparing specific equipments for each of the Work Groups are to be supported by the Work Group members' home institutes.

An institute who has not signed on this MoU may participate in part of the research programs at ATF, with an authorization of the ATF SP, in as much as the proposed activity is:

- within the ATF Annual Activity Plan,
- under the consent by the relevant the Deputies or System/Group Coordinators, and
- promptly reported to the ICB.

Should a conflict of interests occur among the members or Work Groups within the collaboration, the Spokesperson will make the best efforts to resolve it in an amicable manner. When a suitable resolution could not be reached, the Spokesperson will bring the matter to the ICB for further negotiation towards a resolution.

5. Intellectual Property

The scientific knowledge obtained and technological inventions made through the research programs at ATF/ATF2 shall be deemed, in principle, to stay in the public domain. When a patent right is claimed by member institutes for inventions made through the research programs at ATF/ATF2, its ownership is to be determined through negotiation based on the contributions by the members and member institutes therein. KEK reserves the rights to part of the ownership of such patents as a host institute.

6. Membership of the Collaboration

Membership of new institutes for the ATF collaboration is subject to approval of the ICB. Institutes who desire to join the ATF collaboration shall submit a proposal to the Spokesperson, who will relay the matter to ICB.

Withdrawal of a member institute from the ATF collaboration is subject to acknowledgement by the ICB. Institutes who desire to withdraw from the ATF collaboration shall submit a notification to the Spokesperson, who will relay the matter to ICB.

7. Benefits and Insurances during Work at KEK

While conducting the work at KEK on ATF-related research, non-KEK members of the ATF collaboration are assumed to be covered by suitable insurances at the expenses of their home institutes. Otherwise, the non-KEK members of the ATF collaboration shall enjoy all the benefits offered by KEK to visiting scientists and KEK employees according to the KEK regulations.

8. Terms and Concurrence

This MoU is effective starting August 1, 2005 and is valid through the end of March, 2008. This MoU may be amended by addenda as approved by ICB in mutual agreement. This MoU is to be signed by representatives of member institutes and the director general of KEK.

Signatories

Asia: Signature:___________________________ Date:___________________________

Advanced Research Institute for Science and Engineering, Waseda University,

Prof. Yoshimasa Hama

Signature:___________________________ Date:___________________________

Department of Physics, Kyoto University,

Prof. Noboru Sasao

Signature:___________________________ Date:___________________________

Department of Physics, Nagoya University,

Prof. Tsutomu Nakanishi

Signature:___________________________ Date:___________________________

High Energy Accelerator Research Organization (KEK),

Director General Yoji Totsuka

Signature:___________________________ Date:___________________________

ICEPP, University of Tokyo,

Prof. Sachio Komamiya

Signature:___________________________ Date:___________________________

Institute of High Energy Physics, Beijing (IHEP),

Dr. Jiuqing Wang

Signature:___________________________ Date:___________________________

Pohang Accelerator Laboratory (PAL),

Director General In Soo Ko

Europe: Signature:___________________________ Date:___________________________

Department of Physics and Astronomy, University College London,

Prof. Jonathan M. Butterworth

Signature:__________________________ Date:__________________________

Deutsches Elektronen-Synchrotron (DESY),

Director General Albrecht Wagner

Signature:__________________________ Date:__________________________

European Organization for Nuclear Research (CERN),

Director General Robert Aymar

Signature:__________________________ Date:__________________________

John Adams Institute for accelerator science,

Prof. Ken Peach

Signature:__________________________ Date:__________________________

Physics Department, Queen.Mary, University of London,

Prof. Philip Burrows

Signature:__________________________ Date:__________________________

Royal Holloway, University of London (RHUL),

Prof. Steven Wilson

North America: Signature:__________________________ Date:__________________________

Fermi National Accelerator Laboratory (Fermilab),

Associate Director of Accelerator and Technology, Dr. Stephen D. Holmes

Signature:__________________________ Date:__________________________

Laboratory for Elementary-Particle Physics, Cornell University (LEPP),

Prof. Maury Tigner

Signature:__________________________ Date:__________________________

Lawrence. Berkeley National Laboratory (LBNL),

Prof. James Siegrist

Signature:__________________________ Date:__________________________

Stanford Linear Accelerator Center (SLAC),

Director Particle and Particle Astrophysics, Prof. Persis Drell

CONCURRENCE

The following concur in the terms of this MoU. These terms will be updated as appropriate by appendices to this MoU.

Asia:

Advanced Research Institute for Science and Engineering, Waseda University,
Prof. Yoshimasa Hama
Signature ______________________

Department of Physics, Kyoto University,
Prof. Noboru Sasao
Signature ______________________

Department of Physics, Nagoya University,
Prof. Tsutomu Nakanishi
Signature ______________________

High Energy Accelerator Research Organization (KEK),
DG Yoji Totsuka
Signature ______________________

ICEPP, University of Tokyo,
Prof. Sachio Komamiya
Signature ______________________

Institute of High Energy Physics, Beijing (IHEP),
Dr. Jiuqing Wang
Signature ______________________

Pohang Accelerator Laboratory (PAL),
DG In Soo Ko
Signature ______________________

Europe:

Department of Physics and Astronomy, University College London,
Prof. Jonathan M. Butterworth
Signature ______________________

Deutsches Elektronen-Synchrotron (DESY),
DG Albrecht Wagner
Signature

European Organization for Nuclear Research (CERN),
DG Robert Aymar
Signature

John Adams Institute for accelerator science,
Prof. Ken Peach
Signature

Physics Department, Queen.Mary, University of London,
Prof. Philip Burrows
Signature

Royal Holloway, University of London (RHUL),
Prof. Steven Wilson
Signature

North America: Fermi National Accelerator Laboratory (Fermilab),
Associate Director for Accelerators, Dr. Stephen D. Holmes
Signature

Laboratory for Elementary-Particle Physics, Cornell University (LEPP),
Prof. Maury Tigner
Signature

Lawrence. Berkeley National Laboratory (LBNL),
Prof. James Siegrist
Signature

Stanford Linear Accelerator Center (SLAC),
Director Particle and Particle Astrophysics, Prof. Persis Drell
Signature

Addenda of the Memorandum of Understanding for the ATF International Collaboration

CONCURRENCE

Signatories

Asia: Signature:________________ Date:________________

Graduate School of Advanced Sciences of Matter, Hiroshima University

Prof. Takeo Jo

Europe:

Signature:________________ Date: 14. 11. 2006

Applied Physics Department, Tomsk Polytechnic University

Prof. Alexander Potylitsyn

Signature:________________ Date: 15 NOV. 2006

Institut National de Physique Nucléaire et de Physique des Particules

Prof. Michel Spiro

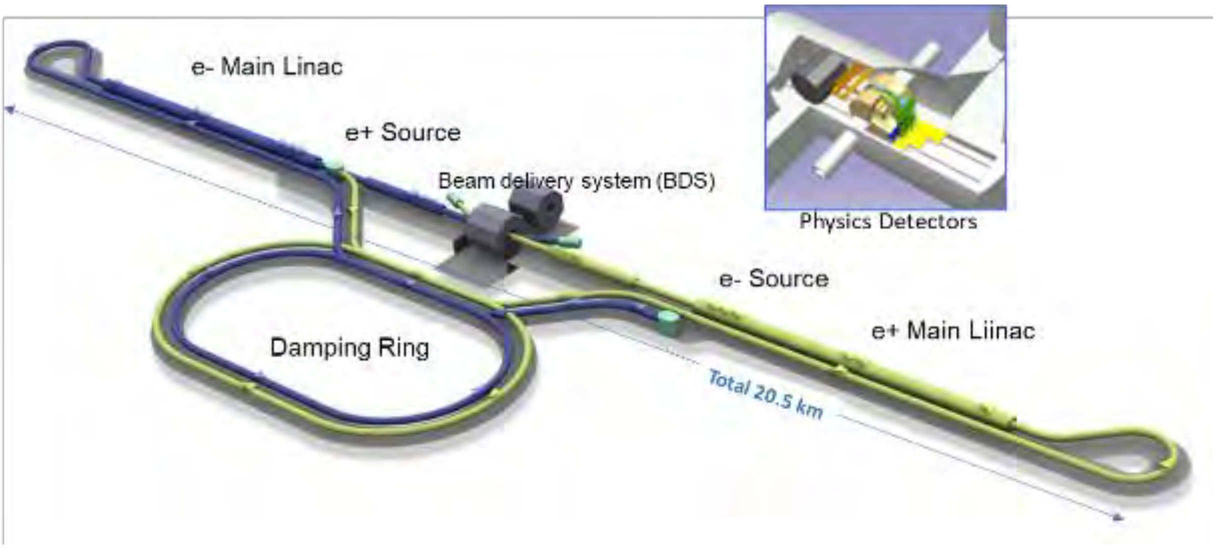
Technical Preparation and Work Packages (WPs) during ILC Pre-lab

IDT-WG2
(Ver.1,2020-Dec-29)

Outline :

The International Linear Collider (ILC) is an electron–positron collider with a total length of approximately 20 km. The ILC consists of the following components: (1) electron and positron sources, (2) damping rings (DRs) to reduce the emittance (a value corresponding to the spread of the beam) of the e-/e+ beams, (3) beam transportation from the damping rings to the main linear accelerators (RTML), (4) the main linear accelerators (MLs), including bunch compressors (to compress the beam bunch length) to accelerate the e-/e+ beams using superconducting RF technology, beam delivery, and a final focusing system (BDS) to focus and adjust the final beam to increase the luminosity, and (5) the beam interaction region for the machine and detector interface (MDI) where the detectors are installed. After passing through the interaction region, the beams go to the beam dumps (DUMP).

The technical preparation plan defines all activities necessary during the main preparation phase to prepare



for the construction phase of the ILC. The technical preparation plan will be conducted by ILC Pre-Lab. The plan assumes that most of the preparation tasks will involve international collaboration based on memoranda of understanding (MOUs) between laboratories/institutions. The technical preparation work packages (WPs) were discussed and defined by IDT-WG2.

The WPs include:

- ML and SRF: Cavity and Cryomodule (CM) production readiness, which is based on the global cavity fabrication of ~ 3 × 40 cavities and the required RF performance achievement with ≥ 90% success, and on the global CM fabrication of 3 × 2 CMs using 40% of the cavities fabricated.
- The global CM transfer program is conducted to simulate all the CM fabrication processes that satisfy high-pressure regulation, safe transport across oceans, and the qualification of the CM performance

after shipping from Europe and the Americas to Japan across oceans. One of the two CMs in each region is used for this purpose.

- Positron source: The final design selection with either an undulator-driven or an electron-driven option and technology readiness to be demonstrated.
- DR and BDS: Readiness of nanobeam technology (ATF3 and related) based on DR and BDS subsystems to be demonstrated, particularly for fast kicker and feedback controls, and
- Beam dump: system design to be established, including beam window handling, cooling water circulation, and safety assurance.

A total of 18 (3 SRF, 8 Sources, 3 DR, 2 BDS and 2 Dumps) are proposed.

Each work package includes:

- Technical readiness evaluation (listed in each technical proposal)
- Engineering Design Report (EDR) documentation with cost estimate confirmation for the ILC construction

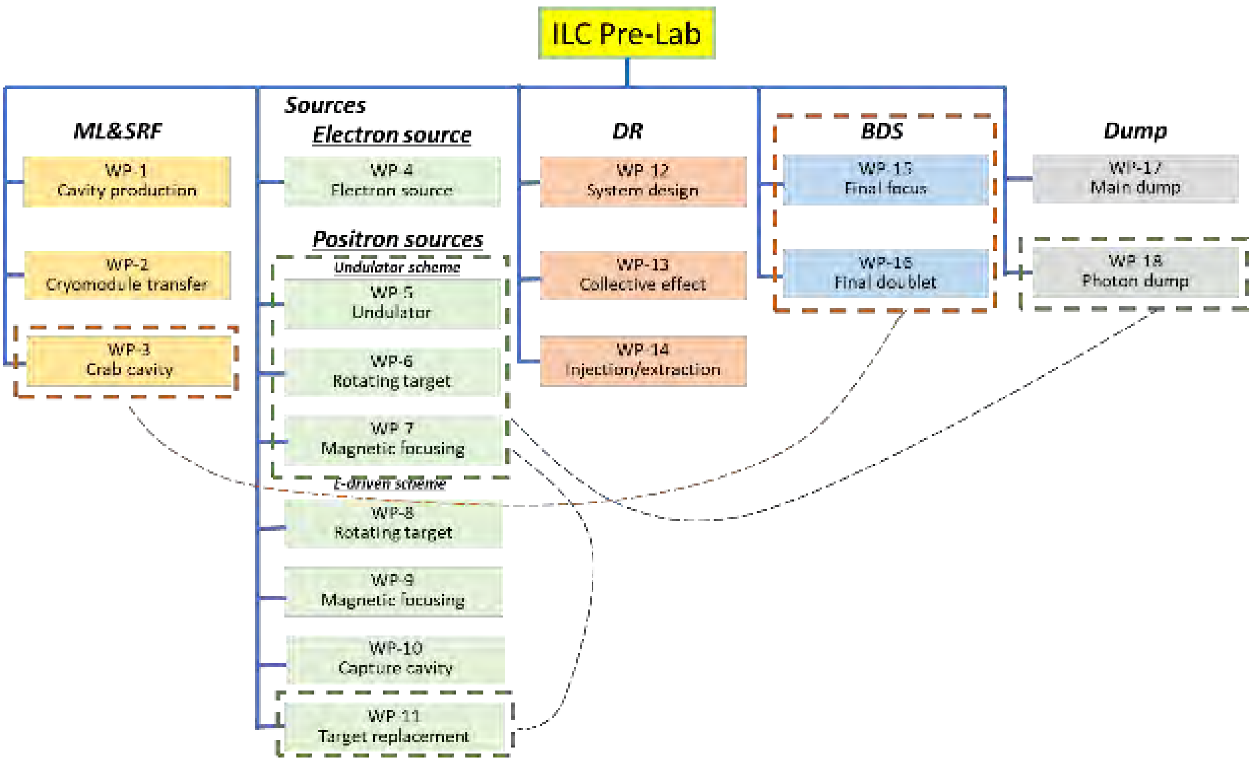


Figure 1: Summary of work packages.

Timeline (example of SCRF and positron)

A four-year preparation period is assumed. In the case of the SCRF and positron, the following schedule is considered.

1st year:

- Extend SRF cost-reduction R&D, and start a pre-series SCRF cavity production for industrialization readiness, and
- Continue positron source technology survey and evaluation.

2nd year:

- Select positron scheme (essential preparation for positron selection is assumed to be finished by the 1st year)
- Complete SRF cost-reduction R&D and commence work for the assembly of the cavities with CMs.

3rd year:

- Demonstrate "Global CM transfer, including legal process for high-press-gas equipment, shipment, and SRF QA test after surface shipment across the ocean
- Mature ILC Lab. planning and preparing the lab. including its management and site
- Complete prototyping of critical items (such as positron target)
- Prepare for the EDR and proceed with the EDR cost-review

4th year:

- Evaluate CM performance based on CM shipment, and prepare for Hub lab. functioning
- Progress prototyping of critical items (such as positron target)
- Publish the EDR, and
  - Prepare for large procurement process, in particular for civil engineering and SRF.

FCC MoU

ADDENDUM FCC-GOV-CC-0167 / KE4418/ATS

The European Organization for Nuclear Research ("CERN"), an Intergovernmental Organization having its seat at Geneva, Switzerland and Centre National de la Recherche Scientifique (CNRS)/IN2P3: Laboratoire de l'Accélérateur Linéaire (LAL) having its seat in France (the "Participants").
This Addendum defines the contributions of the Participants under Article 6 of the Memorandum of Understanding for the FCC Study (**FCC-GOV-CC-0004, EDMS 1390795**).

Address for payment:	Laboratoire de l'Accélérateur Linéaire, UNIVERSITE PARIS-SUD bat. 200, André Ampère, BP 34, 91405 ORSAY CEDEX, France **Suppliers code:** UNIV43 **Address code :** MA01 **Budget code:** 100% on 10810

SCOPE OF WORK

The FCC study has as long-term objective the design of a hadron collider (FCC-hh) with a center-of-mass energy of 100TeV in a new tunnel of 80-100 km circumference for studying physics at the highest energies. The hadron collider and its detectors shall determine the basic requirements for the tunnel, and technical infrastructure.

The FCC study also includes a lepton collider (FCC-ee) and its detectors as a potential first step towards the realisation of the hadron facility. The design of the lepton collider complex has to be compatible with the hadron collider design.

In this framework and taking into account the work already realized in addendum FCC-GOV-0016 (EDMS 1400872) August 2014, we agree on continue the collaborate on:

- Study of beam-surface interactions and dynamic pressure generated by electron clouds and ions for FCC-hh
- Design and performance evaluation of FCC-ee positron production system

PROJECT CONTACTS

The following contacts may, on behalf of the Participant and of CERN as the Host Organization, update the contents of this Addendum by issuing a revised Addendum that will cancel and replace all previous versions.

Participant Project Contact:	Jean-Luc Biarrotte (jlbiarrotte@admin.in2p3.fr), tel. +33 144964451
CERN Project Contact:	Michael Benedikt (Michael.Benedikt@cern.ch), tel. +41 227673380

Work Units

Identifier	Title
LAL-HH-3	Study of beam-surface interactions and dynamic pressure generated by electron clouds and ions for FCC-hh
LAL-EE-1	Design and performance evaluation of FCC-ee positron system

Deliverables

Identifier	Title
LAL-HH-3.1	Report on data acquisition at LHC Vacuum Pilot sector project and comparison with pressure simulation
LAL-HH-3.2	Measurement and characterization of ion-desorption rate according to surface, energy and ion species
LAL-HH-3.3	Report on possible cures and implications in the present LHC, HL-LHC and in the future FCC-hh
LAL-EE-1.1	Evaluation of the positron production and capture scheme

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LAL-EE-1.2	Description of the simulation model and validation of the proposed e+ production/capture scheme satisfying the FCC-ee requirements
LAL-EE-1.3	Report with characterization of the FCC-ee e+ source system performance

DETAILED WORK DESCRIPTION

WORK UNIT	
LAL-HH-3	**Study of beam-surface interactions and dynamic pressure generated by electron clouds and ions for the LHC, HL-LHC and the future FCC-hh**
Reference:	1.2.3.16 Vacuum system requirements and conceptual design
Objectives:	• Acquire data at LHC Vacuum Pilot Sector Project and evaluate the performance • In collaboration with the CERN vacuum team, contribute to desorption measurements, ion irradiation, experimental simulation of spraying and material characterization at LAL and CERN • Determine possible cures and implications for the present LHC, HL-LHC and in the future FCC-hh
Participant Work Unit Contact:	Bruno Mercier, mercier@lal.in2p3.fr
CERN Work Unit Contact:	Vincent Baglin, vincent.baglin@cern.ch, +41 22 767 33 88

WORK UNIT DELIVERABLE	
Identifier/Type	**LAL-HH-3.1/Document**
Participant's deliverable:	Report on data acquisition at LHC Vacuum Pilot sector project and comparison with pressure simulation
Required delivery date:	31/12/2019
CERN's support (if any is required)	Access to the LHC Vacuum Pilot Sector
Identifier/Type	**LAL-HH-3.2/Document**
Participant's deliverable:	Measurement and characterization of ion-desorption rate according to surface, energy and ion species.
Required delivery date:	30/06/2020
CERN's support (if any is required)	Access to Ion test chamber in vacuum laboratory
Identifier/Type	**LAL-HH-3.3/Document**
Participant's deliverable:	Report on Possible cures and implications in the present LHC, HL-LHC and in the future FCC-hh.
Required delivery date:	31/12/2020
CERN's support (if any is required)	Access to Ion test chamber in vacuum laboratory
Acceptance:	Angeles Faus-Golfe for CNRS/IN2P3-LAL Paolo Chiggiato for CERN Paolo.Chiggiato@cern.ch +41 22 767 3687

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PS

WORK UNIT	
LAL-EE-1	**Design and performance evaluation of FCC-ee positron system**
Reference:	1.3.3.8 Electron and positron sources
Objectives:	• As work unit leader collaborate with other participants, regularly participate in design meetings, integrate results of other participants (BINP, KEK, PSI, CERN) • Develop a conceptual design and set up a detailed simulation model for FCC-ee e+ target and capture system • Study different positron production schemes taking into account the thermo-mechanical constraints imposed by the target material • Compare several options of the positron accelerating-capture system to optimize the design and simulate the performance of the optimized FCC-ee e+ system
Participant Work Unit Contact:	Iryna Chaikovska, chaikovs@lal.in2p3.fr , + 33 1 6446 8328
CERN Work Unit Contact:	

WORK UNIT DELIVERABLE	
Identifier/Type	**LAL-EE-1.1/Document**
Participant's deliverable:	Evaluation of the positron production and capture scheme
Required delivery date:	31.12.2019
CERN's support (if any is required)	The FCC-ee injector team will provide the e- linac parameters, and acceptances of energy-compressor and damping-ring complex
Identifier/Type	**LAL-EE-1.2/Document**
Participant's deliverable:	Description of the simulation model and validation of the proposed e+ production/capture scheme satisfying the FCC-ee requirements
Required delivery date:	30.04.2020
CERN's support (if any is required)	The FCC-ee injector team will provide the upstream and downstream beam parameters and optics
Identifier/Type	**LAL-EE-1.3/Document**
Participant's deliverable:	Characterization of the FCC-ee e+ system performance
Required delivery date:	30.04.2021
CERN's support (if any is required)	The FCC-ee teams will provide the upstream and downstream beam parameters and optics; acceptances of energy-compressor and damping-ring complex
Acceptance:	Angeles Faus-Golfe for CNRS/IN2P3 Frank Zimmermann for CERN Frank.Zimmermann@cern.ch +41 22 767 9054

REPORTING

For each Work Unit Deliverable, the Participant Work Unit Contact shall provide the CERN Project Contact with a brief report containing the following information twice per calendar year (no later than each of 1st February and 1st September):

- **Deliverable**: name and identifier;
- **Status description**: short report on work achieved, work still to be done, 'showstoppers', possible technical and project related risks, reasons for non-acceptance or cancellation;
- **Envisaged delivery date**

A copy of the periodic reports shall be directly sent by e-mail to fcc.office@cern.ch.

RESOURCES

The following table lists all resources (personnel, equipment, material, infrastructure, travel, subsistence and services) required for the Participant's deliverable and CERN's support (if any), as defined above, and as required to accomplish the defined Scope of Work:

	Resources	**From Date**	**To Date**
WORK UNIT: LAL-HH-3			
Personnel	1 FTE (PhD) x 3 years = 3 person years 0.2 FTE (B. Mercier) x 3 years = 0.6 person years (all cost taken in charge by CNRS/IN2P3-LAL).	01.01.2018	31.12.2020
Equipment, material and infrastructure	Covering CNRS/IN2P3-LAL personnel requirements.	01.01.2018	31.12.2020
Travel, subsistence and services	Occasional visits to CERN by the CNRS/IN2P3-LAL work-unit contacts. PhD student to be granted Cooperation Associate (COAS) status during stays at CERN, in accordance with Articles 4.2 and 4.3 of the Memorandum of Understanding for the FCC Study and CERN's Staff Rules and Regulations.	01.01.2018	31.12.2020
CERN:			
Personnel	Contact persons and technical collaborators as needed for supporting the research	01.01.2018	31.12.2020
Equipment, material and infrastructure	Office and computing infrastructures for the CNRS/IN2P3-LAL PhD researcher during possible stays at CERN.	01.01.2018	31.12.2020
Travel, subsistence and services	Occasional visits to LAL by the CERN work-unit contacts.	01.01.2018	31.12.2020

	Resources	From Date	To Date
WORK UNIT: LAL-EE-1 Provided by the participant:			
Personnel	1 FTE (Postdoc) x 2 years = 2 person years (cost shared between CERN and CNRS/IN2P3-LAL) 0.33 FTE (I. Chaikovska) x 2 years = 0.67 person years (cost covered by CNRS/IN2P3-LAL)	01.05.2019	30.04.2021
Equipment, material and infrastructure	Covering CNRS personnel requirements.	01.05.2019	30.04.2021
Travel, subsistence and services	Occasional visits to CERN by the CNRS/IN2P3-LAL work-unit contacts. Postdoc to be granted Cooperation Associate (COAS) status during stays at CERN, in accordance with Articles 4.2 and 4.3 of the Memorandum of Understanding for the FCC Study and CERN's Staff Rules and Regulations.	01.05.2019	30.04.2021
Provided by CERN:			
Personnel	Contact persons and technical collaborators as needed for supporting the research	01.05.2019	30.04.2021
Equipment, material and infrastructure	Office and computing infrastructures for the LAL PhD researcher during possible stays at CERN.	01.05.2019	30.04.2021
Travel, subsistence and services	Occasional visits to LAL by the CERN work-unit contacts.	01.05.2019	30.04.2021

Payment conditions LAL-EE-1:

The estimated total cost (for 2 years) of the post-doc personnel resource for the LAL-EE-1 is about 120,000 CHF. CERN will contribute to the LAL-EE-1 activity with a lump-sum payment 60,000 CHF, to be paid after the acceptance of deliverables LAL-EE-1.1 and LAL-EE-1.2. The remaining personnel resources will be covered by CNRS/IN2P3-LAL. No other payments from CERN to IN2P3 are foreseen in the frame of this specific collaboration.

Date:	Amount:	Description:
30.04.2020	60,000 CHF	Acceptance of LAL-EE-1.1 and LAL-EE-1.2

Payments will be made by CERN within 30 days upon receipt of a correct invoice. Invoices shall be sent in PDF file format by e-mail to accounts.payable@cern.ch mentioning the identification identifiers of this Addendum (see title on first page).

For the European Organization for Nuclear Research (CERN) as the Host Organization

Michael Benedikt
FCC Study Leader

Date: 11/06/2019

Dana Svanidze
Procurement Officer

Date: 10/06/2019

Jerome Pierlot
Head of Accelerators and Technology Section, Procurement and Industrial Services

Date: 10/06/2019.

For Centre National de Recherche Scientifique (CNRS) IN2P3

Reynald Pain
CNRS/IN2P3 Director

Date: 27.06.2019

MoU MNPP-01 for collaboration on SuperKEKB

Specific Convention

to

the Cooperation Agreement for scientific collaboration between
CNRS and KEK

R&D for high luminosity colliders (MNPP-01)
in the framework of KEK's programme as a Multi-national
Partnership Laboratory

between

THE NATIONAL INSTITUTE FOR NUCLEAR PHYSICS AND PARTICLE
PHYSICS OF THE CNRS (IN2P3)

and

THE HIGH ENERGY ACCELERATOR RESEARCH ORGANIZATION
(KEK)

2017

THE NATIONAL INSTITUTE FOR NUCLEAR PHYSICS AND PARTICLE PHYSICS (IN2P3) OF THE CNRS, a public scientific and technological organization having its seat 3, rue Michel-Ange, 75794 Paris Cedex 16, France, represented by its Director, Reynald Pain,

and

THE HIGH ENERGY ACCELERATOR RESEARCH ORGANIZATION (“KEK”), established at Ibaraki-ken, Japan,

hereinafter individually “Party” and collectively “Parties,”

CONSIDERING:

That International cooperation is essential for the development of accelerator science;

That the Parties have concluded a cooperation agreement (hereinafter referred to as the “Cooperation Agreement”) for scientific collaboration in the domains of high energy physics, astroparticules, nuclear and accelerator physics, and science of materials on August 30, 2004, which has been renewed twice on August 28, 2009 and on August 29, 2014;

That the Cooperation Agreement for scientific collaboration stipulates that it shall be implemented through specific conventions that specify the modalities of each collaborative project between the Parties;

That the purpose of KEK’s Multi-national Partnership Laboratory framework is to develop multi-national cooperation based on the utilization of state-of-the-art research facilities at KEK, in particular through R&D activities between foreign as well as domestic research institutes on the one hand, and KEK as the host Laboratory on the other hand;

That KEK’s programme for R&D for high luminosity colliders (hereinafter referred to as “the MNPP-01 Project”) involves various Japanese, US as well as European partners;

The Parties’ mutual interest in collaborating in the MNPP-01 Project, the results of which are of relevance, in particular, for their respective future accelerator programmes,

AGREE AS FOLLOWS:

Article 1
Purpose

1.1 This specific convention sets out the terms and conditions governing the Parties’ collaboration in the MNPP-01 Project. The Parties’ collaboration, including the provision of any services and other deliverables, is on a best-effort basis, without warranties of any kind and subject to availability of resources.

1.2 It is KEK’s role to enter into arrangements with other scientific research institutes in respect of their participation in the MNPP-01 Project. KEK shall inform IN2P3 each time a new participant has joined the MNPP-01 Project.

Article 2
The MNPP-01 Project and IN2P3's contribution

2.1 The scope and governance of the MNPP-01 Project is set out in Annex 1, which may be updated as necessary with the unanimous written agreement of the Project Manager and the Contact Persons of the MNPP-01, the latter having contacted their authorized representatives to this effect as soon a proposal for an upgrade has been established.

2.2 IN2P3's contribution to the MNPP-01 Project is set out in Annex 2.

Article 3
Contact persons

KEK designates Makoto Tobiyama, Professor, Accelerator Laboratory, as the Project Manager coordinating the MNPP-01 Project, and as KEK's Contact Person for the implementation of this specific convention, and IN2P3 designates Dr. Philip Bambade, IN2P3 Research Staff, Laboratoire de Physique des 2 infinis Irène Joliot-Curie (hereinafter referred to as "IJC-Lab"), as its Contact Person. They shall together monitor and follow up on the collaboration. The Parties shall inform each other whenever a successor is designated.

Article 4
Usage of KEK facilities and administrative support

4.1 KEK shall make its facilities, equipment and materials available to IN2P3 in so far as required for the implementation of IN2P3's contribution. IN2P3 shall in their use comply with the KEK safety regulations and any other relevant KEK rules.

4.2 In addition to the facilities made available through the existing Toshiko Yuasa Laboratory (hereinafter referred to as "TYL") Office at KEK, KEK shall provide office space, utilities and administrative support in so far as required for the implementation of IN2P3's contribution.

Article 5
Funding

Except as the Parties agree otherwise, each Party shall be responsible for the funding of its activities under this specific convention.

Article 6
Personnel participating in the collaboration

6.1 Each Party shall be responsible for selecting the experts having the necessary qualifications to participate in the collaboration.

6.2 IN2P3 may deploy its personnel (hereinafter referred to as "Personnel") and/or experts of its different research units in France (hereinafter referred to as "Experts") at KEK in so far as required for the MNPP-01 Project.

6.3 Such Personnel and Experts shall be liable for loss and damages to KEK's equipment/facilities in case that such loss and damages are incurred from gross negligence or willful misconduct of the Personnel or the Experts.

6.4 IN2P3 shall be responsible for salaries, medical/liability insurances of the Personnel. Responsibility for the Experts lies with their home institute, or that failing, with themselves. IN2P3 shall inform the Experts and/or their home institute of such liability.

6.5 Subject to eligibility, KEK may grant the status of "Joint Research Visiting Scientist" to the Personnel and the Experts for the duration of their stay at KEK. Such Personnel and Experts shall comply with applicable rules and regulations of KEK, including, in respect of their use of its computing facilities, with KEK's Information Security Policy. KEK shall provide the Personnel and the Experts with copies of applicable regulations.

6.6 Except as the Parties agree otherwise and in application of Article 5 above, each Party shall bear the travel and living expenses of its personnel, in accordance with its own rules and regulations. KEK shall provide assistance for entry applications, permits and travel arrangements for the Personnel and the Experts.

6.7 Concerning the radiation protection, the Personnel and the Experts have to furnish a certificate proving that they received a specific training and a follow-up by the occupational medicine. KEK shall provide a compulsory annual training and a system of access badges and dosimeters for the relevant experimental areas within its accelerator facilities. It shall provide dosimetry reports to IN2P3.

Article 7
Facilities, equipment and materials provided by IN2P3

7.1 KEK shall provide assistance for the importation into Japan of any facilities, equipment and materials provided by IN2P3. Unless agreed otherwise, any equipment sent and made available by IN2P3 to KEK for the purpose of the implementation of MNPP-01 Project will remain the property of IN2P3. IN2P3 shall be responsible, at its expense, for arranging transportation, including transportation insurance for the full replacement value, and for the payment of any taxes and duties imposed by Japan.
Unless agreed otherwise, IN2P3 shall be responsible for compliance with export and import regulations, including any fiscal issues.

7.2 KEK shall hold IN2P3 free and harmless from liability related to the use, if any, of such facilities, equipment and materials by itself and by other scientific research institutes participating in the MNPP-01 Project.

7.3 Except as the Parties agree otherwise, IN2P3 shall be responsible for the installation at KEK of such facilities, equipment and materials. The Parties shall consult with each other on their possible return to IN2P3 or their possible disposal at KEK upon completion of their use for the MNPP-01 Project or completion of the Project, whichever is earlier. Except if the Parties agree otherwise, IN2P3 shall pay for their return to IN2P3 and KEK shall pay for their disposal at KEK, in which case ownership shall transfer to KEK.

Article 8

Confidentiality and Personal information

8.1 All information held by one Party prior to the commencement of or outside the scope of the MNPP-01, and provided to the other Party in the course of MNPP-01 shall remain the property of the providing Party, shall be kept confidential by the receiving Party, and shall not be disclosed to any third party or used for any purpose other than MNPP-01 without prior written consent from the providing Party.

8.2 Each Party shall protect the privacy of personal information provided to it by the other Party in accordance with applicable rules and regulations.

Article 9
Intellectual Property Rights

9.1 The intellectual property developed by a Party in the execution of this specific convention shall be vested in that Party. If it is developed jointly by the Parties, the intellectual property shall be vested in the Parties. The Parties shall grant the other participating institutes in the MNPP-01 Project a free and non-exclusive license of such intellectual property within the purpose of the_MNPP-01 Project.

9.2 The providing Party/Parties shall have no liability to any other parties in respect of such intellectual property. Any parties using such intellectual property shall bear any cost and expense resulting from such use.

Article 10
Publications

All publications shall acknowledge that the research has been performed in the MNPP-01 Project under KEK's Multi-national Partnership Laboratory framework.

Article 11
Relation with Existing Agreement

If any agreement previously concluded between the Parties exists, this specific convention may be attached to it as integral part. However, it is understood that in case of contradiction or ambiguity, the provisions of this specific convention shall prevail.

Article 12
Liability

Except as expressly provided in Article 6.3 or elsewhere, or except in case of gross negligence or intentional misconduct by a Party or participating personnel, the Parties shall have no liability for any damages and loss in connection with this specific convention.

Article 13
Disputes

13.1 Any disputes, controversies or differences arising out of, in relation to or in connection with this specific convention shall be settled amicably, if necessary, with assistance of one or more independent arbitrators.

13.2 All disputes, controversies or differences which cannot be settled between the Parties in accordance with the Article 13.1 shall be finally settled by arbitration of the International Chamber of Commerce.

Article 14
Entry into force, duration and termination

14.1 This specific convention shall enter into effect on the date of signature by the Parties, and shall remain in effect for five (5) years.

14.2 This specific convention may be terminated at any time at the discretion of one Party, subject prior written notice to the other Party of at least three (3) months. Notwithstanding the foregoing, except as the Parties agree otherwise, any facilities, equipment and materials made available by IN2P3 in the implementation of the MNPP-01 Project shall remain at KEK for as long as required for such implementation, and the provisions of this specific convention shall apply in full thereto.

14.3 This specific convention, including the Annexes, may be modified by written agreement between the Parties.

14.4 Articles 6, 7, 8, 9 and 10 of this specific convention shall survive its termination, howsoever caused.

Thus drawn up in two copies, exclusively in the English language.

Signed by the authorized representatives of:

The National Institute for Nuclear Physics and Particle Physics (IN2P3)	The High Energy Accelerator Research Organization (KEK)
Signature: ___________________________	**Signature:** ___________________________
Date :___________________________	**Date :**___________________________
Dr Reynald Pain **Director**	**Dr Masanori Yamauchi** **Director-General**

Annex- 1 [Overview of MNPP-01]

1. **Scope of** MNPP-01

- Title of the Project
  R&D for high luminosity colliders (MNPP-01)

- Outline including the project objectives

  1. Purpose of the project:
  We plan to support the achievement of the performance goals of high luminosity colliders, especially SuperKEKB, via international collaboration.

  2. Preparation status up to now:
  We have been collaborating with accelerator laboratories and universities under the US-Japan Collaboration in High Energy Physics since FY 2003, especially with SLAC National Accelerator Laboratory.
  KEK has also been collaborating with IJC-Lab, as well as, more recently, with the Laboratoire d'Annecy de Physique des Particules (hereafter referred to as "LAPP"), both in France, on SuperKEKB, under the Associated International Laboratory Toshiko Yuasa Laboratory (TYL), since 2012 and 2018 respectively.

  3. Achievements up to now:
  We seek the achievements in the following fields:
  - Realization of general purpose bunch-by-bunch feedback systems
  - Development of a new bunch-by-bunch X-ray size monitor for ultra-low emittance beams
  - Study of electron-cloud instabilities and their cure
  - Phase-1 commissioning

- Organizational structure

KEK designates the following personnel to manage and coordinate MNPP-01 (hereinafter referred to as “Project Manager” ; Makoto Tobiyama, Professor, Accelerator Laboratory, KEK).

This collaborative research group has formed four task groups dedicated to the following tasks, and the following persons shall be in charge of the achievement of each task:

1. Development of IP feedback systems:

   Project Engineer: Mika Masuzawa (Professor of ACCL, KEK)
   SLAC National Accelerator Laboratory: Dr. Alan Fisher
   IN2P3 (IJC-Lab and LAPP) : Dr. Philip Bambade

2. Development of advanced bunch feedback systems:

Project Engineer: Makoto Tobiyama (Professor of ACCL, KEK)
SLAC: Dr. John D. Fox
INFN-LNF: Dr. Alessandro Drago

3. Minimization of gap transients:

   Project Engineer: Tetsuya Kobayashi (Assoc. Professor, ACCL, KEK)
   Ca Poly: Prof. Themis Mastoridis
   Jefferson Lab: Dr. Andrew Hutton
   SLAC: Dr. John D. Fox

4. Beam commissioning of the SuperKEKB accelerators:

   Project Engineer: Yoshihiro Funakoshi (Professor of ACCL, KEK)
   SLAC: Dr. John T. Seeman
   INFN-LNF: Dr. Maria Enrica Biagini
   CERN: Dr. Frank Zimmermann

- Facilities in KEK necessary for implementing the project

SuperKEKB HER and LER, injector linac, positron damping ring, and associated infrastructure.

- Task assignment for each participating institute including necessary expenses

1. SLAC National Accelerator Laboratory (SLAC)
   - Design and fabrication of dithering-base IP feedback system
   - Beam commissioning of SuperKEKB accelerators (Injector, Damping ring, Main ring)
   - Study for the gap-transient effect.

2. Istituto Nazionale di Fisica Nucleare, Laboratori Nazionali di Frascati (INFN-LNF)
   - Commissioning of SuperKEKB accelerators.

3. Jefferson Lab
   - Study of gap transient effect.

4. California Polytechnic State University
   - Study of gap transient effect.

5. CERN
   - Beam commissioning of SuperKEKB accelerators (Injector, Damping ring, Main ring).
   - Design study of future circular colliders.

6. IN2P3:

- Support to the maintenance, operation and optimisation studies of the fast luminosity monitor developed so far
- Monitoring, analysis and simulation of mechanical vibrations

- Annual project plan

JFY2017 (April 2017 – March 2018):
- Phase1 commissioning of SuperKEKB, preparation of Phase 2 operation, injector linac commissioning.
- Continue development of components such as bunch feedback systems and IP feedback systems. Start study of gap transient.

JFY2018 (April 2018 – March 2019):
- Prepare phase 2 operation, beam commissioning of Phase 2 operation, commissioning of positron damping ring.

JFY2019- JFY2021 (April 2019 – March 2022):
- Phase 2 and Phase 3 commissioning

2. Governance of the project

2.1 Decision-making

Final decisions will be made by the Project Manager, in consultation with other members of the collaboration.

2.2 Management of progress and achievements

The Project Engineer of each task group will be in charge of scheduling for that group.

3. List of participating institutes

1. SLAC National Accelerator Laboratory (SLAC)
2. Institute Nazionale di Fisica Nucleare, Laboratori Nazionali di Frascati (INFN-LNF)
3. Jefferson Lab
4. California Polytechnic State University
5. CERN
6. IN2P3

4. Expected achievements with this project

We anticipate the following results:
1. Steady progress towards realization of the design performance of SuperKEKB.
2. Deeper understanding of accelerator physics issues via the collaboration.
3. Development of technologies useful for future high luminosity colliders.
4. Development of human resources for the field of accelerators.

5. Budget

- We anticipate some part of the budget will be supported by the US-Japan project.
- Visits from CERN to KEK can be supported by the EU funded E-JADE European Contract until the end of 2018 and/or by the CERN/FCC. Visits from KEK can be supported by CERN.
- Visits from IN2P3 to KEK can be supported by the Toshiko Yuasa Laboratory, by IN2P3 and/or other resources.
- INFN-LNF members are now applying for travel budget from E-JADE for the bilateral collaboration between KEK and INFN.
- It may be necessary to establish a common fund in the future.

<History of Amendments in Annex 1>

Date of amendment (date/month/ year)	Version No.	Person who amended (name, title and affiliation)	Date of approval by a Project Manager
05/05/17	MNPP-01 Convention KEK-CNRS VF 05052017	Marine MOGUEN-TOURSEL, CNRS / IN2P3 Head of IN2P3 International Office	15/05/2017

25/05/2017	MNPP-01 Convention KEK-CNRS VF 05052017_20170525 KEK edits	KEK, modified annual project plan	31/05/2017

Annex-2 [Contribution of IN2P3 in MNPP-01 Project]

1. Research and cost allocation of IN2P3

The Personnel and the Experts will participate in SuperKEKB commissioning, with financial support from the TYL, according to the Memorandum of the International Associated Laboratory, from IN2P3 and/or from other resources.

2. IN2P3 participation

Since 2018, several IN2P3 team members have participated in the successive commissioning activities at SuperKEKB, for month long periods for some of them, with in particular engineers, postdoctoral and senior researchers, and doctoral students.
Participation from IN2P3 is also foreseen on a best effort basis in 2020, 2021 and 2022, for the Phase 3 and subsequent operation and performance optimization..

3. Participant List

Prior to the commencement of the MNPP-01 Project, each Contact Person shall send Project Manager their participant list in the MNPP-01 Project. Contact Persons shall inform each time a new participant has joined in the MNPP-01 Project.

<History of Amendments in Annex 2>

Date of amendment (date/month/ year)	Version No.	Amended Part	Date of approval by Project Manager
25/05/17	MNPP-01 Convention KEK-CNRS VF 05052017_20170525 KEK edits	3. Participation List added	31/05/2017

Appendix II: Platforms Used

Analysis and Control of vibration Platform (LAPP)

Thanks to the acquired expertise in the analysis and control of vibrations, a dedicated platform was created at LAPP and has allowed providing a support to different projects (Figure 1).

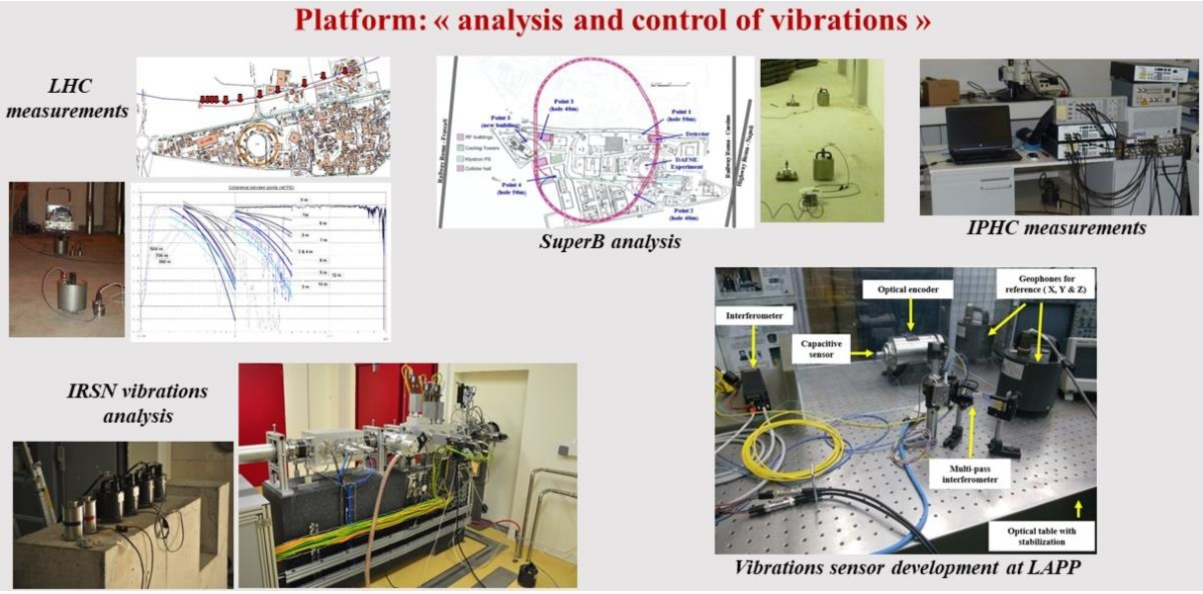

Figure 1: Analysis and Control of vibrations platform at LAPP.

For example, the team has done the vibrations analysis of a beam laser at ISRN of Cadarache, a vibration qualification of an experimental room at IPHC of Strasbourg where a welding machine for the ATLAS experiment was installed and the group has also evaluated the two potential locations of the SuperB experiment at Frascati.

Vacuum and Surfaces Platform (IJClab)

The study of the relationship between conditioning effects and the surface chemistry of the materials identified as the most promising for constituting chamber wall of future accelerators (copper, NEG alloys, amorphous carbon, etc.) requires laboratory experimental facilities for: (i) surface analysis; (ii) thin film coating deposition; (iii) stimulated desorption measurements; (iv) investigation of secondary particles emitted from a surface subjected to a particle bombardment.

The "vide et surfaces" platform at the IJCLAB laboratory is equipped with surface analysis equipment such as a confocal optical microscope (for measuring surface roughness and imaging), an X-ray diffractometer (structural analysis of thin films) and a secondary ion mass spectrometer (SIMS, analysis of the elementary and chemical composition of the surface). A scanning electron microscope (SEM) with the associated analysis (EDS for elemental analysis and EBSD for crystalline orientation studies) will be available in the spring of 2021.

The "vide et surfaces" platform has a magnetron sputtering deposition set-up (Figure 2) to produce films of NEG alloy (Titanium, Vanadium, Zirconium) on inner walls of accelerator chambers. This set-up allows us to measure the molecular sticking coefficients of the film and to study the surface saturation phenomena.

The experimental set up for secondary electron yield (SEY) measurements is an in-house build set-up developed at IJCLab ("Vide & Surfaces" platform) (Figure 3). It consists of a single UHV chamber (base pressure: 5x10-10 mbar) equipped with an electron gun providing a pulsed electron beam (with a pulse length of 30 ms) in the energy range 10 to 1500 eV, with an intensity from few nanoamperes to

10 µA. The sample is carried by a single manipulator allowing for a precise positioning of the sample in the chamber.

Figure 2: Set-up for Magnetron sputtering deposition.

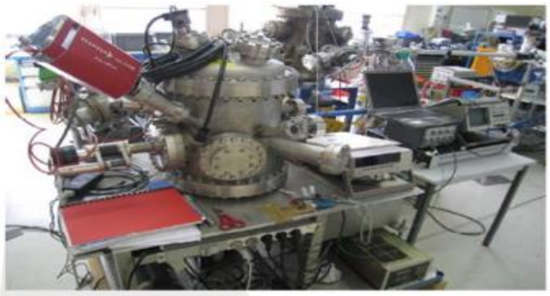

Figure 3: The experimental set up for secondary electron yield (SEY) measurements.

ANDROMEDE Platform (IJClab)

Figure 4: Andromede platform at IJClab.

The IJCLAB laboratory has on the Andromede platform a high-resolution secondary ion mass spectrometer with time-of-flight detection (Figure 4). The atomic, polyatomic, molecular and nanoparticle ion beams are produced with two ion sources: a liquid metal ion source (LMIS) and an electron cyclotron resonance source (ECR). Its main feature is its wide range of available beams from protons to gold nanoparticles. This device allows us to obtain atomic and molecular composition of a solid surface (10-20 nm) with a high sensitivity.

The Memorandum of Understanding
for the ATF International Collaboration

1. Preamble

The purpose of this Memorandum of Understanding (MoU) is to define the organization of the international collaboration to carry out the research programs at Accelerator Test Facility (ATF) and its extension ATF2 which is located at KEK, so as to maximally contribute to the world design and development efforts in the areas of particle sources, damping rings, beam focusing and beam instrumentation towards the International Linear Collider (ILC) project.

The construction and operation of ATF was initiated at KEK in 1991 to bolster the R&D efforts for JLC (Japan Linear Collider) which has started in 1987. The accelerator system of ATF presently consists of: an S-band electron linac, a damping ring, and a beam extraction line. Active participants in the research programs at ATF include the members from KEK, a number of Japanese universities and overseas institutions, including, SLAC, DESY, CERN, PAL , IHEP and UK universities.

The recent development in the international affairs towards the linear collider has come to warrant reevaluation of the mission goals and the focuses of activities at ATF:

- ICFA/ITRP in August of 2004 announced the adoption of the "cold technologies" (superconducting RF) for use at the main linacs of the ILC, and the Global Design Efforts (GDE) are being initiated under the auspices of ICFA for design development of ILC.
- Some hardware reconfiguration and additional studies are subject of urgent research which is expected to clarify some key design issues of the injector systems at the "cold" ILC.
- With the technology choice for the main linacs resolved, a renewed attention is being drawn to the issues pertaining to the beam focusing and control in the beam delivery sections of ILC. ATF is expected to make a major contribution in this area by providing the ultra-low emittance beam for beam focusing studies. Thus very vigorous design efforts are currently under way for ATF2, which is expected to serve as a test bed for the ILC final focus system, starting operation in 2007.

To yield the maximum amount of scientific and technical outputs as well as to promote