KE3724/TE/HL-LHC - ADDENDUM No. 4

to

FRAMEWORK COLLABORATION AGREEMENT KN3083

between

THE EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH (“CERN”)

and

THE ISTITUTO NAZIONALE DI FISICA NUCLEARE (“INFN”)

concerning

Collaboration in synchrotron radiation studies in the framework of the High Luminosity upgrade for the LHC at CERN

CONSIDERING:

- Framework Collaboration Agreement KN3083 (the “Agreement”) concluded between CERN and INFN (individually the “Party” and collectively the “Parties”) defining the framework applicable to collaboration between them in areas of mutual interest, including but not limited to the domains of particle and accelerator physics;

- Article 2.1 of the Agreement provides that each Party’s contribution to a specific collaboration (“Project”) and all related details shall be set out in an Addendum to the Agreement;

- That the Parties have identified the Project set out below, which shall be covered by the provisions of this Addendum No.4 KE3724/TE/HL-LHC (the “Addendum”). This Addendum shall be subject to the provisions of the Agreement, it being understood that in case of divergence the provisions of this Addendum shall prevail;

- That INFN shall execute its contribution to the Project through INFN-LNF.

THE PARTIES AGREE AS FOLLOWS:

1. Project

The Project comprises tasks related to the use of synchrotron radiation-based material studies in the framework of the High Luminosity upgrade for the LHC and Future Circular Collider project study at CERN as described in Annex I.

2. Personnel of the Project

Contact persons:

CERN: Paolo Chiggiato, paolo.chiggiato@cern.ch
INFN-LNF: Roberto Cimino, roberto.cimino@lnf.infn.it

Or such successor as each Party may designate.

3. Duration

The collaboration commenced on 1 September 2017 and shall be completed no later than 31 August 2021. It is understood that this Addendum shall also cover any Project-related activities executed by the Parties prior to its entry into force.

4. Each Party's contribution

4.1 CERN's contribution:

4.1.1 CERN shall provide the following:
1) Definition of the samples to be tested and verification of their compliance with the HL-LHC and FCC specifications;
2) The material and components in accordance with section 1.3 of Annex 1;
3) Performance of the tests according to milestone schedule stated in section 1.2 of Annex 1.

4.1.2 CERN shall make a financial contribution that shall not exceed the amount(s) set out in Annex 2.

4.1.3 CERN's contribution under Article 4.1.2 shall be subject to receipt of a correct debit note. Payment details are set out in Annex 2.

4.2 INFN's contribution:

1) Preparation of the three SR beamlines in the VUV energy range of interest (two dipole line with monochromatic beam, and one with white beam) performed by INFN;
2) Follow-up of the measurements and reporting in written form of all results;
3) The material and components are in accordance with section 1.4 of Annex 1.

5. Work Packages

The Work Packages, related milestones and deliverables are defined in Annex 1.

6. Organization and coordination

6.1 Steering Committee

A Steering Committee shall be created with a composition of qualified representatives for each Party. Each Party shall have the right to replace its representatives subject to prior written notification to the other Party.

As and when required, each of the representatives may be assisted by any specialist of their choice, including its Technical Coordinator as defined in Article 6.2 below, subject to prior notice to the other representatives thereof in advance. These specialists shall participate in the Steering Committee's meetings only in an advisory capacity.

The Steering Committee shall monitor the performance of the work specified in this Addendum. It shall ensure compliance with the deliverables and the delivery schedule specified in Annex 1 and if necessary and upon the Technical Coordinator's advice, shall recommend solutions to the Parties in the event of execution problems. It may also propose any modification to this Addendum it deems useful in technical and financial matters.

The Steering Committee shall also act as a body enabling the Parties to resolve difficulties or disputes.

The Steering Committee shall meet at least once per year, or more frequently upon the request of a Party, in the presence of ad hoc representatives of the Parties.

The INFN representatives in the Steering Committee shall be:

Antonio Zoccoli
Eugenio Nappi

The CERN representatives in the Steering Committee shall be:

Frederick Bordry
Michael Benedikt
Lucio Rossi

Or such successor as each Party may designate.

6.2 Technical Coordinators

The Parties shall each nominate a Technical Coordinator whose role shall be to coordinate the activities related to the execution of the Work Packages within the Project. The Technical Coordinators shall also act as Safety Correspondents and be responsible for safety matters.

The Technical Coordinators shall report to the Steering Committee on the execution of the Work Packages. In case of difficulties in the execution of the Work Packages, they shall present solutions and options to the Steering Committee.

The CERN Technical Coordinator shall grant acceptance of the deliverables in accordance with Article 7 below.

The Technical Coordinators and Safety Correspondents shall be:

For CERN: Roberto Kersevan
For INFN: Roberto Cimino

Or such successor as each Party may designate.

7. Acceptance procedure(s):

7.1 CERN shall grant acceptance of a Work Package after the successful completion of each milestone or deliverable defined therein and the provision by INFN of the associated documentation, within two (2) months from the date of such completion.

7.2 All tested samples shall remain property of CERN. The tooling used for sample holders or other mechanical installation on the LNF site shall remain INFN property. Any CERN supplied tooling shall return to CERN after completion of the Project. This arrangement may change upon deliberation by the Steering Committee.

8. Miscellaneous

8.1 INFN shall grant access to CERN personnel, with modalities to be agreed, to INFN laboratories and sites where works (including component constructions) for the execution of this Addendum are carried out.

8.2 INFN shall intervene and repair any possible hidden defect that is caused by the non-compliant execution of the quality assurance procedures forming part of INFN's scope of delivery and that may be discovered within two (2) years from acceptance.

Subject to the continued validity of the Agreement, this Addendum shall remain in force for as long as necessary to give effect to the Parties' respective rights and obligations under this Addendum.

This Addendum may be amended by written agreement by the Parties.

Thus, drawn up in two copies in the English language and signed by the authorized representatives of the Parties.

The European Organization for Nuclear Research (CERN)	The Istituto Nazionale di Fisica Nucleare (INFN)
…………………..	……………………
Dr Fabiola GIANOTTI Director-General	Professor Fernando FERRONI President
Signed on:……………………2017	Signed on:…………………2017

ANNEX 1: Work Packages

1.1 Work Package content description:

Introduction

The HL-LHC project's main intervention will take place in the triplet areas of ATLAS and CMS. New vacuum chambers with integrated tungsten-shielded beam-screen (BS) will have to be installed. A thorough characterization of the surface properties of the BS needs to be done, in particular for the co-laminated copper with amorphous-carbon (a-C) thin film for electron cloud mitigation. An alternative to a-C is also worth consideration and study, namely laser-structured surfaces, with potential applications to the FCC design study.

In addition, recent studies have pointed out that heat load transferred by electron clouds to the LHC arcs' cryogenic systems will remain a subject of concern also in the HL-LHC era, when the number of SR photons will double. A better understanding of the role of synchrotron radiation in the electron cloud built-up process is essential. In HL-LHC the critical energy of the accelerator will be around 45 eV, so that Synchrotron radiation between 5 and 500 eV will allow the detailed study of all effects to be expected in the real machine.

The Prject comprises two Work Packages. The first Work Package aims at providing essential characteristics of technological materials that will improve electron cloud and heat load simulations. The second Work Package focuses more on vacuum properties of long beam pipes; white-spectrum light will impinge at grazing angle and photodesorption yields will be measured and used for simulations of gas-density profiles.

WP1 – Synchrotron radiation (SR) on small samples

Summary: This WP covers measurements of SR reflectivity and photoelectron (PE) production as a function of the angle of incidence, photon energy, and surface coverage of known gas species, for a number of sample materials. A monochromatic photon beam is necessary. The outcome of the WP will be useful to improve electron cloud simulations.

Technical description: Small samples of technical materials for the beam-screen and other vacuum system components will be prepared by CERN and sent to INFN. The temperature of some samples may need to be varied, from cryogenic to room temperature. The samples may also need to be heated to remove any water vapour (bake-out). The samples may need to be exposed to known quantities of gas species relevant to accelerator environment (e.g. H_2, CO, CH_4, etc…). The samples may also need to be subjected to temperature-programmed desorption studies (TPD), for which their temperature is increased in a controlled way and the layers of gases previously chemically and/or physically absorbed on their surface are released, identified, and measured.

Data collection: the measurements of the high-vacuum gauges (total and partial pressure) and the PE production shall be stored on computer in a format which allows a clear identification of the corresponding monochromatic photon fluxes, for proper calibration of the results. The temperature of the samples shall also be recorded. A typical data rate is of the order of 1 reading every few seconds; the residual gas analyser may need a longer time stamp depending on the acquisition mode (Faraday cup or SEM), which may take of the order of one (1) minute.

WP2 – Synchrotron radiation (SR) on tubular samples

Summary: This WP covers measurements of photon-induced desorption on samples of cylindrical geometry (tubes) made under white-beam SR photon fan irradiation, at grazing angles of incidence. This kind of measurements is "standard practice" in the vacuum community, and it has been revived recently by planned ultra-low emittance light sources. It is also relevant to the HL-LHC project, since the amount of SR will be higher as compared to the present LHC, both in the BS of the triplet areas and arcs. The photon flux spectrum of the radiation from the Bending magnet of DAFNE ("white beam") can cover easily the photon energy range of many different machines, light sources and HL-LHC as well.

Technical description: Tubes of different materials of length of the order of two (2) meters will be provided by CERN, equipped, if required, with standard ConFlat flanges (exact dimensions to be defined taking into account the size of the incoming photon fan). The tubes will be pre-tested at CERN for leak-tightness, and "ready to go" on the experimental station at LNF. The incoming photon flux, pre-collimated by the beamline optics, shall be distributed along the length of the tube, along a narrow strip.

The experimental beamline's test section shall be equipped with a known conductance disc and a set of ultra-high vacuum gauges (total and partial pressure) in order to be able to derive the molecular photodesorption yield of the tested tube material via the "conductance method". A high-vacuum pump (turbo or combination of ion- and non-evaporable getter pumps) shall be installed upstream of the known conductance, in order to create the pressure differential which is used to calculate the values of photon stimulated desorption yield.

On the exit side of the test tubes, a short chamber equipped with an electrically insulated photon collector, capable of measuring the photoelectron production, shall be installed; an electrometer of appropriate sensitivity shall be connected to the collector, in order to measure the induced photo-current.

The temperature of some test tubes may need to be varied, from liquid nitrogen (LN2) up to room temperature. In this case, the test tubes shall have a concentric double-wall geometry, where the external annular volume will be filled with LN2 from a Dewar. Appropriate disposal/venting of the N2 gas after evaporation must be insured compatibly with safety rules at LNF/INFN. A suitable external thermal insulation jacket will be provided by CERN, to minimize the evaporation of LN2. The samples may also need to be heated to remove any water vapour (bake-out). The tubes may need to be exposed to known quantities of gas species relevant to accelerator environment (e.g. H_2, CO, CH_4, etc.). All test tubes shall be instrumented with a suitable number of thermocouples, to make sure that there are no unwanted temperature gradients or hot spots.

Data collection: the measurements of the high-vacuum gauges (total and partial pressure) and the photon collector shall be stored on computer in a format, which allows a clear identification of the corresponding photon fluxes coming from DAFNE, for proper calibration of the results. A typical data rate is of the order of 1 reading every few seconds. The residual gas analyser may need a longer time stamp depending on the acquisition mode (Faraday cup or SEM), which may take of the order of 1 minute;

1.2 Work Package milestones and deliverables

It is agreed that some milestone dates are subject to beam availability at DAFNE, and may be necessarily shifted in time as a consequence of machine shutdowns or technical issues.

Milestones (covering the first 18 months, activities after that will be decided and re-scheduled upon review of the achievements of this period):

M1.1	Set-up of the dipole radiation beamline, for small samples	December 2017
M1.2	First Measurements of the reflectivity and photoelectron production of small samples (part 1, room temperature)	March 2018
M2.1	Set-up of the “white light” beamline for tubes	March 2018
M2.2	Measurement of the outgassing yield of a-C coated chamber, fully characterized at different temperatures (LN2 to room)	December 2018

Deliverables to be supplied by INFN:

D1.1	Technical report on measurements carried out so far	July 2018

1.3 Material and components provided by CERN

1.3.1 CERN shall provide INFN with the following material / components:

- Small samples (as per maximum dimensions accepted by INFN’s sample holders, which is 8x8x (0.1-4) mm). Such samples should cover most technologically viable vacuum materials, such as copper, stainless steel, aluminium, eventually with thin-films or laser-treatments on their surface. The samples shall be sent in an appropriate packaging from CERN to INFN, under vacuum conditions or controlled atmosphere to avoid contamination and/or degradation of performance;
- Tubes approximately two (2) m-long, eventually equipped with ConFlat-type flanges, fabricated and shipped under vacuum or controlled atmosphere conditions by CERN in wood boxes, which shall remain CERN property, and should be stored on LNF’s site for the duration of the experiments. Upon completion of the experiments, the tubes shall be shipped back to CERN using the original boxes, at CERN’s expense;
- CERN shall provide INFN-LNF with a number of new or already available, standard components (ion pumps, turbo pumps, UHV vacuum valves, Ion gauges, mass spectrometers, liquid nitrogen dewar, pico-meters, computer to control the experiments, etc.) as required by the detailed project of the new WL beamline and experimental setup.

1.3.2 Specific conditions applicable to CERN provided material / components:

1. INFN shall be solely liable for the use of the material / components until their return to CERN. CERN accepts no liability for such material / components, which it makes available in their existing condition and without any express or implied warranty.

2. INFN shall at its own expense and in accordance with professional standards maintain, and if lost or damaged, replace any material / components provided by CERN. It shall notify CERN immediately in writing of any damage to or loss of material / components.

3. Upon completion of their use under this Addendum, INFN shall forthwith and at its own expense return any remaining material / components to CERN. INFN shall be liable for any use of materials in excess of that agreed, but shall not be liable for normal wear and tear of the equipment or normal deterioration of the materials.

4. Title to the material / components shall remain vested in CERN. INFN shall take such measures as may be necessary to make known and protect CERN's title in the material / components concerned in accordance with laws, including by indicating the same in a visible and legible manner on the material / components.

1.4 Material and components provided by INFN

1.4.1 INFN shall provide CERN with the following material / components:

- Preferential access (minimum three (3) months/y) to the use of two existing beamlines equipped with two "State-of-the-art" UHV dedicated set-up for complete surface analysis of the properties of interest. The beamlines and available setups are described in the document: "Synchrotron radiation studies at LNF DAΦNE-L laboratories of reflectivity / photoelectrons /photo induced desorption in collaboration with CERN-TE-VSC-VSM", By R. Cimino, A. Balerna, C. Milardi, A. Ghigo, and P.Campana. LNF-INFN Frascati, July 25th, 2016. The value of the beamlines and of the two experimental setups can be estimated to be more than 3.0 M€, and will be optimized and maintained for the entire period of the Project;
- INFN shall design and put into operation a WL bending magnet beamline to study irradiation of long beam pipes;
- Parasitic use of synchrotron radiation produced by the DAFNE accelerator (minimum two (2) months/y) at least until first half of 2019 (years 1, 2 and 3 of this Addendum). For these runs no contribution to the cost of electrical power and of technical and scientific manpower requested to operate DAFNE, shall be billed to CERN;
- Dedicated periods where DAFNE runs especially for this Project can be arranged starting from 2020 onwards (year 4 of this Addendum). For these runs a contribution to the cost of electrical power and of technical and scientific manpower requested, could be billed to CERN. A separate Annex to this Addendum shall be prepared by the Parties at a due date.
-

1.4.2 Specific conditions applicable to INFN provided material / components:

All INFN material/ components shall remain INFN property and may be partially used by CERN, also during this Project, for activities outside this Project but of interest to INFN, subject to the latter's prior approval.

1.5 Personnel:

This Addendum includes the possibility of exchanging personnel up to 0.25 FTE during the Project (four (4) years) from INFN to CERN and up to the same number from CERN to INFN. Experts eventually coming from INFN to CERN shall have the status of Cooperation Associate (COAS) with a subsistence allowance provided by CERN subject to the conditions set out in CERN's Staff Rules and Regulations.

The cost of CERN personnel eventually joining INFN teams at INFN's premises shall be covered by CERN I accordance with its Staff Rules and Regulations.

INFN shall make available to the Project up to three FTE/y of specialized technical support (software, hardware, Vacuum, installation, alignment, etc.): one FTE for senior scientific supervision and one senior post doc shall be fully dedicated to this Project.

INFN shall make the DAFNE Synchrotron radiation facility available to the Project, in dedicated or in parasitic mode in accordance with the conditions set out in section 1.4.1 above.

ANNEX 2: CERN's financial contribution and payments details

Cost, resources and committed resources shall be shared between the Parties as follows:
The total cost (contribution to beamlines maintenance, optics and UHV chamber, experimental system, consumables, manpower cost) to be incurred by CERN in the execution of this Project is estimated at 745 k€, as described in the payment schedule below. CERN shall pay such amount to INFN. The CERN supplied materials in year no.1 are estimated at a maximum value of 100 k€ (deliverable D1.2), and the correspondent amount shall be deducted from CERN's contribution to INFN.

INFN's total contribution to the Project shall amount to 795 k€ (405 k€ in year no. 1, and 130 k€/year in following three years) including personnel, experimental systems and general expenditures.

Payment schedule:

Deliverable	Description	Date	Amount (k€)
D1.1	Signed Addendum	September 2017	65
D1.2	Approved project of the new WL beam line (part of this contribution in supplied material, 100 k€)	December 2017	100*
D1.3	Set-up of the "white light" beam-line	January 2018	90
D1.4	Yearly technical report	August 2018	140
D2.1	Yearly technical report	August 2019	140
D3.1	Yearly technical report	August 2020	140
D4.1	Yearly technical report	August 2021	70
Total			**745**

(*may include supplied material from CERN up to a maximum of 100 k€)

Payment details:

Payment within thirty (30) calendar days upon CERN's acceptance of a deliverable and receipt of a correct debit note.

Debit notes shall be sent to:

CERN — FAP Department
Accounts Payable
CH- 1211 GENEVA 23.