HiLumi LHC

FP7 High Luminosity Large Hadron Collider Design Study

Deliverable Report

Final Project Report

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The HiLumi LHC Design Study is included in the High Luminosity LHC project and is partly funded by the European Commission within the Framework Programme 7 Capacities Specific Programme, Grant Agreement 284404.

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Grant Agreement No: 284404

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Seventh Framework Programme, Capacities Specific Programme, Research Infrastructures, Collaborative Project

PROJECT FINAL REPORT

FINAL PROJECT REPORT

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PROJECT FINAL REPORT

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I. Publishable summary

1. EXECUTIVE SUMMARY

After four years of activity, the HiLumi LHC Design Study has fully achieved all its scientific and technical goals, preparing the construction phase of HiLumi, paving the way for the full exploitation of the Large Hadron Collider. The collaboration, which involved partners from US laboratories and Japan has gone way beyond the initial design study objectives. 6 European-funded Work Packages were involved in the project, working in close collaboration with another 11 non-EU funded work packages.

WP1 - Project Management and Technical Coordination has established a reasonable timeline and project scheduling, as well as a sustainable structure and governance of the HL-LHC, which will contribute to the full exploitation of the LHC- set out as the highest priority for particle physics for the next decade by the CERN Council. Key results were achieved also in the field of safety, quality assurance and dissemination to industry. Project members also contributed to physics outreach with 84 outreach talks that are now collected in an open access database, CDS. **WP2 – Accelerator Physics and Performance** determined a coherent set of beam parameters for the HL-LHC machine that will allow the LHC to reach an integrated luminosity of approx. 250 fb^{-1} per year enabling the final goal of 3000 fb^{-1}. The activity also delivered a complete set of optics to generate the required beam characteristics. A highlight of the project was the invention of the Achromatic Telescopic Squeeze, a new optics for reaching small beta star (β*). Amongst the main results of **WP3 – Magnet Design** was the definition of the quadrupole aperture, being fixed at 150mm, which necessitates the use of the more advanced Nb_3Sn superconductor technology. The activity also defined the use of superfluid helium cooling for best heat removal in the coils and heat transportation out of the magnet. The decision was also made in favour of using thick tungsten shield in the inner magnet bore to limit the radiation heat deposition density in the coils. The WP also completed the design of all magnets of the insertion region, which is a key step in the project. Studies within the **WP4 – Crab Cavities** led to a key decision in favour of the compact crab cavity. Another critical result was the progressive down selection of the various types of compact cavity. Based on the International Crab Cavity Review, the project selected the 2 types which have been built and successfully tested. The cryo-module concept is already advanced and the entire assembly and the engineering design are well underway to meet the goal of the test in the SPS in 2018. The main outcomes of **WP5 – IR Collimation** included: the development of a new layout of the insertion region collimators, suitable for the 150mm magnet aperture and for beam with brilliance increased by a factor of four. The WP studied a solution for the collimators based a new composition of molybdenum graphite. Studies in the WP have also shown the necessity of a new special collimation system in the LHC cold region to shield the first dipoles in the continuous cryostat. A major breakthrough was achieved within **WP6 – Cold Powering** with the development and industrialization of the magnesium diboride (MgB2) wire. The activity delivered a world record current of 20 kA at 24 K in a 40m-long electrical transmission line made of MgB2. The activity also developed the Superconducting Link system for HL-LHC. Finally, a crucial result was the development of a new design of the distribution feedbox, the cryostat accommodating the current leads and making the transition between cold and warm powering.

More than 100 experienced researchers have contributed to HiLumi LHC activities, and 25 PhD students were involved, resulting in 6 academic dissertations. In total, more than 35 people were recruited specifically for the project. Moreover, HiLumi LHC is also creating opportunities for the European industry with orders of an estimated total value of more than 500 M€ for the construction phase. Thanks to this project, Europe has secured to remain in the frontline of particle physics up to at least 2040 and will stay an attractive workplace for researchers from all over the world. The key result of the design study is the seamless transition into the HL-LHC construction phase.

2. PROJECT CONTEXT AND OBJECTIVES

2.1. CONTEXT

Thanks to the LHC, Europe has decisively regained world leadership in High Energy Physics (HEP), a key sector of knowledge and technology. The LHC can continue to act as catalyst for a global effort unrivalled by any other branch of science: out of the 10,000 CERN users, more than 7,000 are scientists and engineers using the LHC, half of which are from countries outside the EU.

The LHC will remain the most powerful accelerator in the world for at least the next two decades. Its full exploitation is the highest priority of the European Strategy for particle physics. This strategy has been adopted by the CERN Council, and is a reference point for the Particle Physics Strategy of the USA and, to a certain extent, Japan. To extend its discovery potential, the LHC will need a major upgrade in the 2020s to increase its luminosity (and thus event rate) by a factor of five beyond its nominal design value. The integrated luminosity goal is a ten-fold increase of the nominal design value. Since LHC is a highly complex and optimized machine, such an upgrade must be carefully studied. The necessary developments requires about 10 years of prototyping, testing and implementing. The novel machine configuration, the High Luminosity LHC (HL-LHC), will rely on a number of key innovative technologies representing exceptional technological challenges. These include among others: cutting-edge 11-12 tesla superconducting magnets; very compact with ultra-precise phase control superconducting crab cavities for beam rotation; new technology for beam collimation; and high-power superconducting links with zero energy dissipation.

This FP7 Design Study proposal (HiLumi LHC) was part of an overall project that federated efforts and R&D of a large community towards the ambitious HL-LHC objectives. HiLumi LHC involved 15 European laboratories, as well as participants from outside the European Research Area (ERA), in particular leading US and Japanese laboratories. This participation will be required for the execution of the construction phase as a global project. HiLumi LHC helped foster opportunities for the European industry to bid for contracts worth 300 M€ in innovative fields during the second half of this decade, and established the ERA as a focal point of a global research cooperation and a leader in frontier knowledge and technologies.

2.2. PROJECT OBJECTIVES

The main objective of the HiLumi LHC Design Study was to determine a hardware configuration and a set of beam parameters that would allow the LHC to reach the following targets:

1) A peak luminosity of $\times 10^{34}$ $cm^{-2}s^{-1}$ with levelling, allowing:
2) An integrated luminosity of 250 fb^{-1} per year, enabling the goal of 3000 fb^{-1} twelve years after the upgrade. The luminosity is more than ten times the luminosity reach of the first 10 years of the LHC lifetime.

To achieve this, the HiLumi LHC Design Study included 6 Work Packages.

WP1: Project Management and Technical Coordination

Beyond the management and coordination of all Work Packages (including the WPs not included in the FP7 Program) and the follow-up on the budget and plan, the management team was in charge of installing a HL-LHC Parameter and Layout Committee that served as a common reference for the vast community, canalizing and making the efforts of the other WPs more effective. Major objectives also included the development and endorsement of a strict Quality Assurance (QA) plan for the project; assuring that safety and environmental responsibility were built-in in the design study; assuring the coherence of the project with the LHC Physics Center and the LHC detector and injector upgrade plans. Finally, WP1 was in charge of the dissemination of information and innovation inside and outside the member of the consortium and to industry.

WP2: Accelerator Physics and Performance

Work Package 2 "Optics and Layout" task focused on the preparation of reference lattice and optics files for various configurations that could be used for further beam dynamic studies, the study of the performance limitations in terms of the optics design and the specification of critical magnet parameters for the various scenarios for all linear magnet systems, including the orbit correctors for generating the crossing angle generation and the skew quadrupole correction system. Under its "Particle Simulations" task, the WP aimed at studying the dependence of the Dynamic Aperture of the machine focusing system and the separation-recombination dipole magnets next to the experiments. The objective was to determine the field quality tolerances for the new magnetic elements and specifying tolerances of the correction of circuit settings. The goal of the "Intensity Limitation" task was to define key parameters such as maximum acceptable impedance of the new components and to provide specifications of the impact of electron cloud effects and of the emittance growth rates from intrabeam scattering. The "beam-beam effects" task aimed at evaluating the performance limitations arising from the interaction between two beams with the aim to define key parameters such as minimum required beam separation and maximum acceptable beam brightness values and to identify optimum beam configurations. Last but not least, the "Beam parameter and luminosity optimization" task was focusing on the determination of the optimum choice for the beam parameters based on the experience from the first years of LHC operation.

WP3: Magnet Design

WP3 focused on the analysis of Nb3Sn quadrupoles for the LHC inner triplet and the performance parameters that could be achieved. It aimed at elaborating a conceptual design study of a very large aperture option (150mm), including all requirements for the HL-LHC inner triplet of Nb3Sn quadrupole. The "Separation Dipoles" task was focusing on the conceptual design and prototyping of separation dipoles. A major goal of the "Cooling" task was to choose the operational temperature of the inner triplet and of the separation dipoles, considering and comparing both the superfluid and supercritical He options. The "Special Magnet Studies" task had the objective of designing a two-in-one quadrupole for the outer triplet (Q4-Q6) with nominal beam separation (192mm) and aperture as large as possible (80-100mm), as well as designing a two-in-one quadrupole for the inner triplet was also to be considered. The Nb-Ti option for the inner triplet was also to be considered, taking into account the new targets in luminosity and the follow-up tests of the short model built within the SLHC-PP project. Finally, it aimed at analyse the expect lifetime of resistance quadrupoles in IR1 and IR7, studying possible solutions for the time scale of 2030.

WP4: Crab Cavities

The primary objective of Work Package 4 was to prepare for the construction phase of Compact Crab Cavities, studying the integration of the Crab Cavities in the accelerator tunnels and the preparation of the tunnels for both SPS and LHC. The "Compact Crab Cavity" task was focusing on the conceptual design for each of the proposed compact crab cavities and included the power coupler as the wrong-order-mode couplers. It included the technical design of a 2-cavity cryo-module for a planned proof-of-principle verification in the SPS, including the couplers, tuning system, shielding and ancillary equipment. Prototyping and tests have been included in the Design Study only in the absolute minimum necessary to validate the design choices.

WP5: IR Collimation

Through simulations of beam loss and energy deposition in the experimental IRs, WP5 aimed at assessing locations and magnitudes of beam losses and energy depositions for various upgrades scenarios. It also studied the impact of imperfections on beam loss and explored the interplay between IR beam losses and machine parameters (beta*, crossing angle), specifying operational tolerances related to collimation and IR upgrade. The simulations of energy deposition in the Experimental IRs aimed at further investigating the potentially requirements for shielding. Finally, the "Design of collimation in the Experimental IRs" task was focusing on the required collimation to keep losses at the same level or below before the IR upgrade, with the aim of integrating the collimators in the new layout and optics.

WP6: Cold Powering

Work Package 6 addressed the different cooling options within the LHC cryogenic system, defining the cryogenic interfaces with the other system components, elaborating the optimized flow-scheme and defining cryogenic requirements and components for operation and protection. Its "Electrical transfer and cryostat" task covered the study of the thermal and electrical performance of the multi-circuit superconducting long transfer line, cooled by supercritical helium, both in steady state and in transient conditions. It studied and defined requirements for quench protection of superconducting components and designed a cryostat for the operation of the current leads. Finally, the "Energy deposition and material studies" focused on the maps of energy deposition from collision debris and beam losses and calculated the induced radiation on the cold powering components. It also studied the potential impact on the superconducting components and the consequent requirements for in terms of maximum operating temperature.

3. THE MAIN S&T RESULTS / FOREGROUNDS

In this chapter we summarize the main scientific and technical results. Since this program is a Design Study, we will underline the results that have enabled the passage of the High Luminosity LHC project form the conceptual phase to a phase of prototyping and initial construction

3.1. WP1: PROJECT MANAGEMENT AND TECHNICAL COORDINATION

The main result of this WP was establishing a reasonable timeline and project scheduling, as well as a sustainable structure and governance of the HL-LHC, which will contribute to the full exploitation of the LHC- set out as the highest priority for particle physics for the next decade by the CERN Council. Key results were achieved also in the field of safety, quality assurance and industry dissemination. Project members also contributed to physics outreach with 84 outreach talks that are now collected in an open access database, CDS.

Goals of the HL-LHC

First of all, the main goals of the design study have been all confirmed by the project and by the operation of LHC and by the main results obtained so far. The priority to fully exploit the potential of the LHC has been adopted as *first priority* among the "High priority large-scale scientific activities" in the new European Strategy for particle physics – Update 2013[1], with the following wording: *"Europe's top priority should be the exploitation of the full potential of the LHC, including the high-luminosity upgrade of the machine and detectors with a view to collecting ten times more data than in the initial design, by around 2030"*.

HiLumi LHC has become the most important project for particle physics in Europe for the next decade. The initial goals defined in the proposal (Section 2.2.) have also been confirmed, namely:

- A peak luminosity of **5×10^{34} cm^{-2}s^{-1} with levelling**, allowing:
- An integrated luminosity of 250 fb^{-1} per year with the **goal of 3000 fb^{-1}** in about a dozen years after the upgrade. This integrated luminosity is about ten times the expected luminosity reach of the first twelve years of the LHC lifetime.

These goals are based on a solid physics case which is well illustrated in the paper by M. Mangano in the HiLumi Book[2].

Timeline and scheduling

A key result of the FP7 Design Study has been the networking with the LHC Experiments community to envisage a reasonable timeline and proper scheduling of the project, suitable both in terms of physics and technical and financial feasibility. This has resulted in a new project time line that is illustrated in Figure 1.

[1] The European Strategy for Particle Physics Update 2013, CERN-Council-S/106, adopted at a special session in the Brussels on 30 May 2013. http://cern.ch/council/en/EuropeanStrategy/ESParticlePhysics.html

[2] M. Mangano (2015) The Physics Landscape of the High Luminosity LHC. The High Luminosity Large Hadron Collider: pp. 19-30. Available at: http://cds.cern.ch/record/1995532

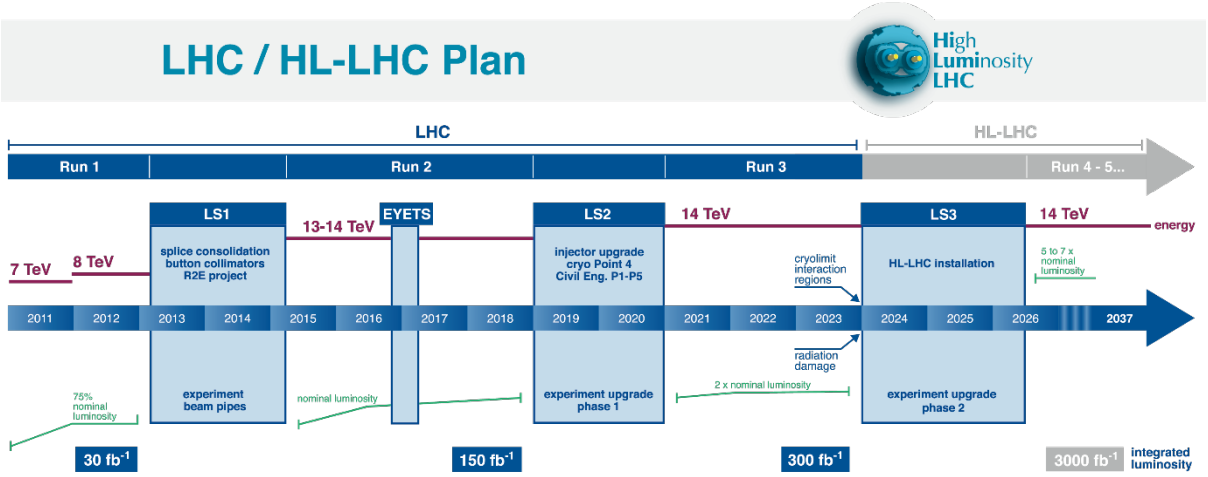

Figure 1: LHC/ HL-LHC Plan. The plan for arriving to the final HL-LHC goals. The installation for the HiLumi machine is foreseen to start in 2024

Formal approval of the project

Following the Cost and Schedule HL-LHC review in March 2015, the CERN Council approved in September 2015 the financing of HL-LHC in the frame of the MTP (5-year Medium Term Plan) with an integrated long term profile for the HiLumi Project (till 2025). This is summarized in a CERN press release on occasion of the last FP7-HiLumi Meeting at the end of October 2015[3].

Project structure and governance

In terms of project structure and governance; the collaboration board and committees set up for FP7 Design Study have proven to be very efficient. In practice the organization scheme and project governance that has been established for the FP7 part have been transposed and extended to the whole project. This organization proved to be very suitable and will continue all along the project construction phase. The PLC, Parameters and Layout Committee, will now be called Technical Coordination committee (unifying the function of PLC and of the Technical Committee): now the parameter and layout is basically frozen and only minor changes can be foreseen. The Steering Committee is now redefined into a Project Management Meeting, while the Coordination Group (making the link with the Experiment Upgrade Projects) will continue all along the project life. The new governance for the construction phase, approved by CERN and by the major stakeholders, has been an important results of the FP7 Design Study and is illustrated in the Figure 2 where it is clear the centrality of HL-LHC in the CERN Accelerator structure.

[3] CERN (2015), LHC luminosity upgrade project moving to next phase [Press Release]. Available at: http://press.web.cern.ch/press-releases/2015/10/lhc-luminosity-upgrade-project-moving-next-phase

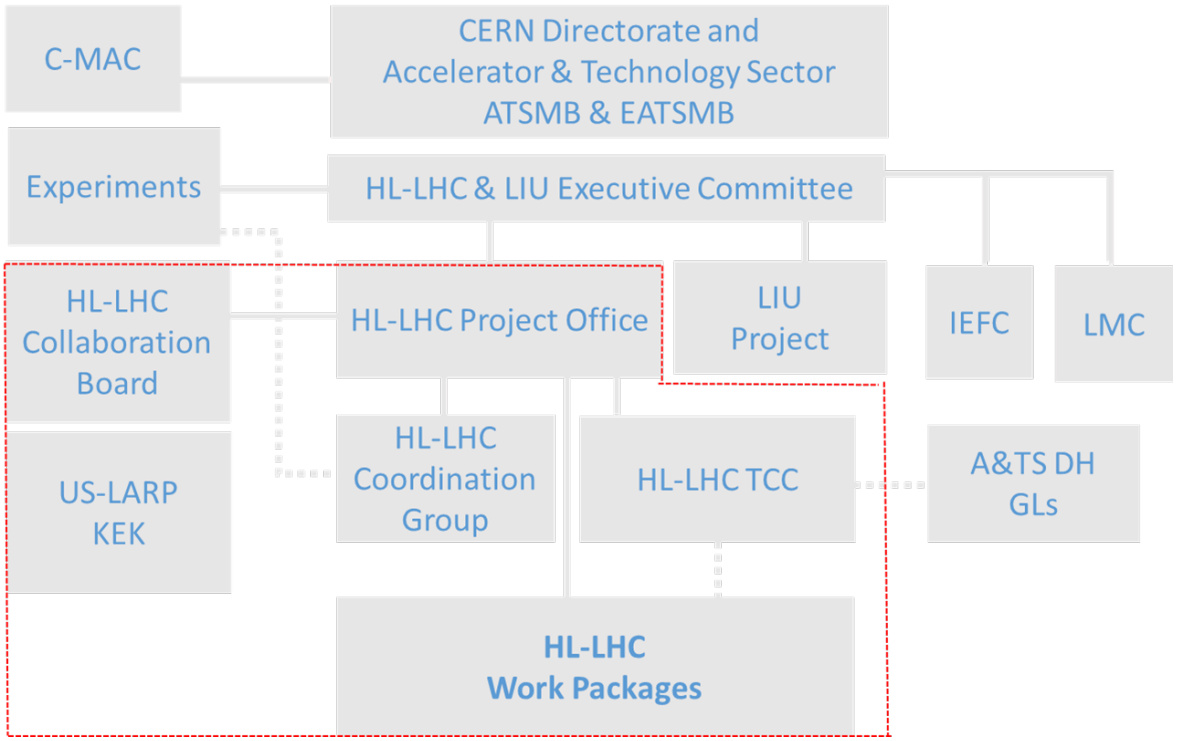

Figure 2: The High Luminosity LHC project structure and governance. The HL-LHC & LIU Committee is the point of official link to CERN Management and to the companion project LIU (LHC Injector Upgrade). The Experiments are also represented to assure coherence of goals, schedule and resources. The internal HL-LHC bodies are in the red box.

The work package structure of the HL-LHC upgrade as devised at the beginning of the design study is now complete. The non-FP7 funded WPs have been added directly to the already existing numbering. At the end of the design study, the project enters construction phase with 17 work packages, out of which the 6 FP7 funded ones will be kept as well. The Work Package structure, the technical core of the project is illustrated in Figure 3. The fact that FP7 structure has been retained also for the construction phase and that is open and flexible enough to easily support extensions is to be considered also a very good result of the FP7 program.

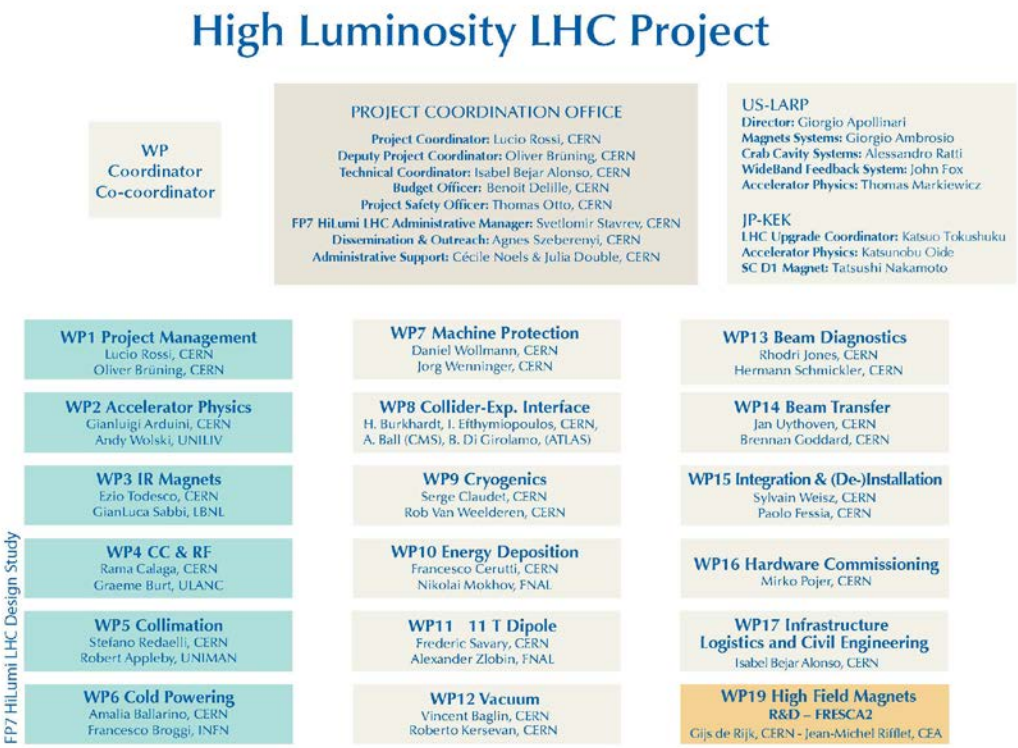

Figure 3: WP structure of the HL-LHC project, with the six FP7 WPs in blue on the left. WP19 is not included in the HiLumi project

Technical management

The FP7 HiLumi study had the ambition to provide management frame for technical coordination equally for the FP7 funded WPs and for the not funded ones as well. This has been very successful, especially in some critical areas for a project which proceeds to the construction phase: Quality Assurance, Safety, industry dissemination. Usually these topics are rarely covered in design phase of a physics oriented projects since they are not directly linked to increase the scientific and technical output of the project. The FP7 HiLumi has put these topics as key element of WP1. On the Quality assurance front the most important results have been:

a) Definition, at an early stage, of the life cycle of the equipment, of their documentation and of the various responsibility, which has been the base of the Preliminary Design Report, a key deliverable for FP7, and the technical base of the Cost & Schedule review;

b) Definition of equivalence among applicable standards, an important tool for a friendly and long-standing collaboration among institutes providing in-kind contributions. To set this frame a 3-day long QA & Standards workshop has been organised in 2014.

In the area of Safety, the priority has been given to radioprotection. Besides carrying out an early study to assess the dose for people intervening on the HiLumi machine the most tangible result is the institution of a new Working Group to merge the experience of Experiment and machine to face the formidable radiation challenges. The working group called ITHACA is now the frame where various innovative technology form remote manipulation to augmented reality are discussed for application in the HL-LHC.

In the area of the Industry outreach two workshops with Industry have greatly contributed to raise awareness of the project in the European industry. With more than 100 participants, they have been a real success and now a portfolio of future orders, classified by typology and size. The portfolio is being organized in collaboration with the Industrial Liaison Industry Officers of all EU Member States with CERN purchasing service. Various participation to national meetings, workshops and industry fairs and exhibitions has also been among the results of the project.

A brief description of the design study and how it is evolving toward the construction phase as well as the complete description, is in the Technical Design Report, which is the most important deliverable of the FP7 HiLumi[4].

3.2. WP2: ACCELERATOR PHYSICS AND PERFORMANCE

The main outcome of this WP was the determination of a coherent set of beam parameters to allow the HL-LHC machine to reach an integrated luminosity of approx. 250 fb^{-1} per year enabling the final goal of 3000 fb^{-1}. It also delivered a complete set of optics to generate the required beam characteristics. A key highlight – and in itself a jewel of the project – is the invention of the ATS (Achromatic Telescopic Squeeze), a new optics for reaching small beta star (β*), making the maximum profit of the large aperture quadrupoles provided by WP3. Another interesting feature is the possibility of controlling the pile up density level with the use of crab cavity in crab-kissing mode.

The first important outcome of WP2 is a coherent (coherent internally, with LIU and with LHC operational experience) set of beam parameters in the HL-LHC machine. This has allowed fixing the goals of the companion project LIU (LHC Injector Upgrade), a critical component for CERN injector complex. This set, illustrated in Figure 4 allows meeting the goal of the project of 250 fb^{-1} per year, which is the key ingredient to reach the final goal of 3000 fb^{-1} collected in a reasonable time. Actually, the table of Figure 4 is a short form of the beam parameter list and the complete table, which is available at the PLC website:

https://espace.cern.ch/HiLumi/PLC/_layouts/15/WopiFrame.aspx?sourcedoc=%2FHiLumi%2FPLC%2FSiteAssets%2FParameter%20Table%2Exlsx&action=view

[4] HL-LHC Technical Design Report: FP7 HiLumi LHC Deliverable D1.10, CERN-ACC-2015-0140 - Geneva: CERN, 2015. Available at: http://cds.cern.ch/record/2069130/files/CERN-ACC-2015-0140.pdf

Parameter	Nominal LHC (design report)	HL-LHC 25ns (standard)	HL-LHC 25ns (BCMS) [9]	HL-LHC 8b+4e [12]
Beam energy in collision [TeV]	7	7	7	7
Protons per bunch N_b	1.15E+11	2.2E+11	2.2E+11	2.3E+11
Number of bunches n_b	2808	2748	2604	1968
Number of collisions in IP1 and IP5 [1]	2808	2736	2592	1960
beam current [A]	0.58	1.09	1.03	0.82
x-ing angle [µrad]	285	590	590	554 [10]
β^* [m]	0.55	0.15	0.15	0.15
ε_n [µm]	3.75	2.50	2.50	2.20
ε_L [eVs]	2.50	2.50	2.50	2.50
r.m.s. bunch length [m]	7.55E-02	7.55E-02	7.55E-02	7.55E-02
Piwinski parameter	0.65	3.14	3.14	3.14
Total loss factor R0 without crab-cavity	0.836	0.305	0.305	0.304
Total loss factor R1 with crab-cavity [13]	(0.981)	0.829	0.829	0.828
Peak Luminosity without crab-cavity [cm^{-2} s^{-1}]	1.00E+34	7.18E+34	6.80E+34	6.38E+34
Virtual Luminosity with crab-cavity: Lpeak*R1/R0 [cm^{-2} s^{-1}] [13]	(1.18E+34)	19.54E+34	18.52E+34	17.40E+34
Events / crossing without levelling and without crab-cavity	27	198	198	246
Levelled Luminosity [cm^{-2} s^{-1}]	-	5.00E+34 [5]	5.00E+34	3.63E+34
Events / crossing (with leveling and crab-cavities for HL-LHC) [8]	27	138	146	140
Peak line density of pile up event [event/mm] (max over stable beams) [13]	0.21	1.25	1.31	1.28
Leveling time [h] (assuming no emittance growth) [8, 13]	-	8.3	7.6	9.5
N_b at LHC injection [2]	1.20E+11	2.30E+11	2.30E+11	2.40E+11
n_b / injection	288	288	288	224
ε_n at SPS extraction [µm] [3]	3.40	2.00	< 2.00 [6]	1.70

Figure 4: List of the main beam parameters of HL-LHC. The column tagged as standard is the baseline, the two left column represent possible variants. For comparison at left, the LHC nominal design beam parameters are reported, too.

Together with the beam parameters list, a key results of WP2 is a complete set of optics, with all optics files, that should generate the required beam characteristics. The optics design is complemented by many studies of beam-beam and other collective effective effect like impedance. Both Beam-Beam effects and Impedance evaluation have a strong implication on the hardware.

From the scientific point of view a key outcome of WP2 is the "invention" of the ATS (Achromatic Telescopic Squeeze), a new optics for reaching small beta star (β*), making the maximum profit of the large aperture quadrupoles provided by WP3. It is maybe the jewel of the project, since it is an original idea emerged in the study for the LHC upgrade. It is likely to become a built-in feature in the design of all next generation circular colliders. Figure 5 shows the beta wave generated in the arc (that are used as a giant matching section) and in the collision point.

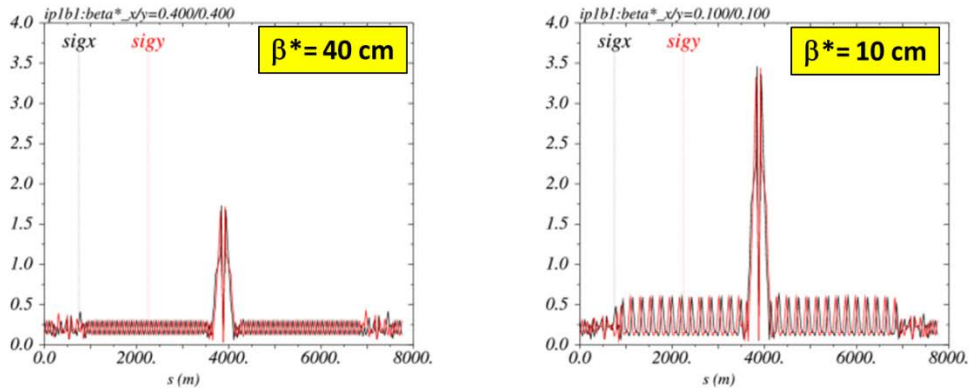

Figure 5: Beta star function around IP1 (ATLAS) and in the adjacent arcs during the squeeze with the ATS. 40 cm beta star (left is the maximum reach in the present LHC, while 10 cm is the possibility offered by the ATS, with large aperture quadrupoles. The HL-LHC baseline has been prudently fixed at 15 cm.

Another interesting feature, emerged in the Coordination Group and studied in WP2, is the possibility of controlling the pile up density level. This requires a complex beam manipulation making use of crab cavity in crab-kissing mode and of a new SCRF harmonic system. This pile up density control is illustrated by Figure 6 and can increase the quality of thee data collected by the Experiment. With pile up level of 140, four times what has been seen during Run1, spreading uniformly the events over a longer luminous zone can be an asset to avoid data taking degrading in the detector. This feature, called crab-kissing is not in the baseline, since it requires hardware that is not included in the Cost-to-Completion, and in one of the remaining topics of study, in close collaboration with LHC Experiments, for the luminosity upgrade.

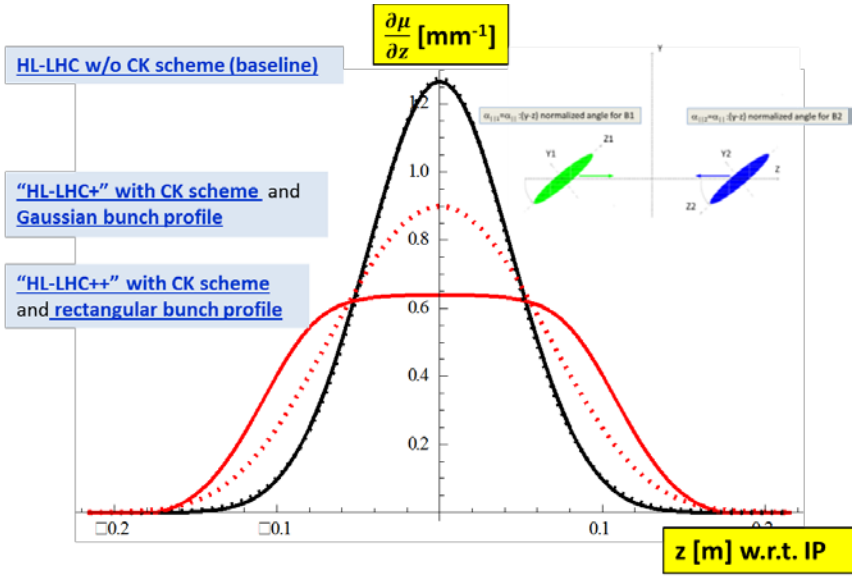

Figure 6: pile up linear density (μ is the number of event per bunch crossing) for the baseline case and two other cases based on Crab-Kissing (CK) scheme. One can see on the red curves the lowering of the pick pile density and the spreading over a 50% longer luminous region. At top right is well visible the tilt of the two beams generated by the particular use of crab cavities.

A key result of WP2 is the evolution of the robustness of the upgrade vs. variation of various parameters, not considered fixed value like in the table of Figure 4. This has brought to the concept of the enhanced, or ultimate, performance. HL-LHC might have the possibility to generate more collisions, if the Experiments can deal with higher pile up (up to 200 events/crossing) and if more collision time for proton is allowed. The results are summarized in the luminosity profile spanning from LHC starts until HL-LHC end of life in Figure 7. This is an upper limit that could be met (but not guaranteed) in case the hardware behaves as predicted and if there will not be unforeseen beam limitations in the new regimes.

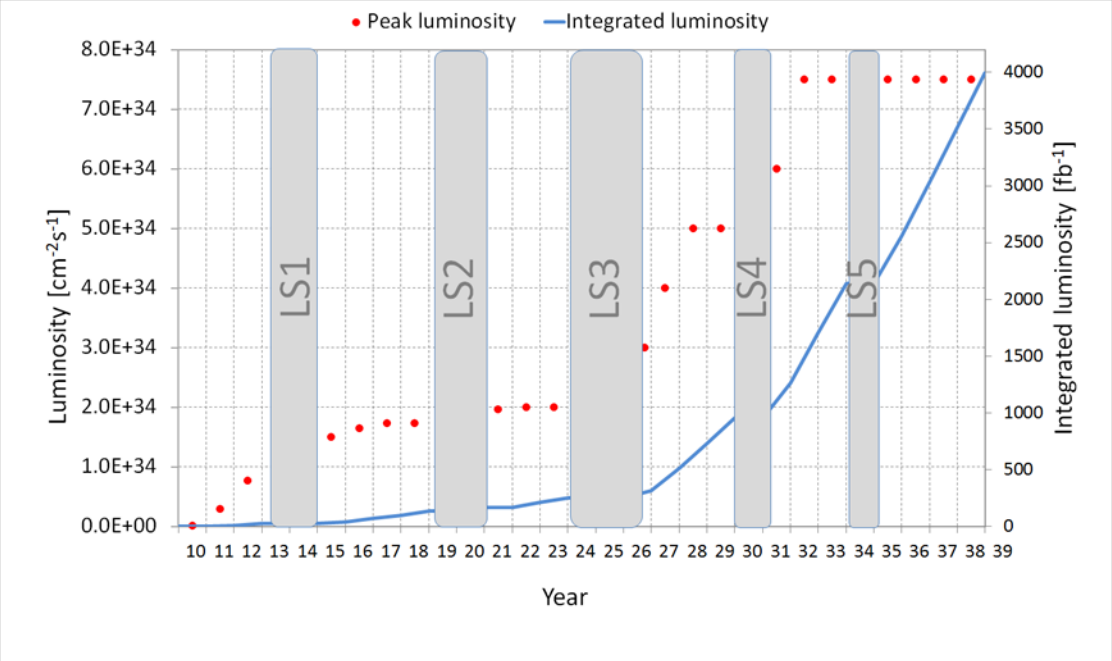

Figure 7: Evolution of peak and integrated luminosity along the LHC and HL-LHC lifetime. The goal of 3000 fb^{-1} might be overcome and 4000 or more fb^{-1} can be reached before year 2040.

3.3. WP3: MAGNET DESIGN

One of the key results of this WP was the definition of the quadrupole aperture, being fixed at 150mm, which necessitates the use of the more advanced Nb_3Sn technology. Moreover the WP defined the use of HEII cooling for best heat removal in the coils and heat transportation out of the magnet. The decision was also made in favour of using thick tungsten shield in the inner magnet bore to limit the radiation heat deposition density in the coils. Finally, the WP also completed the design of all magnets of the insertion region, which is a key step in the project.

The Inner Triplet quadrupole magnets are - from the hardware point of view - the cornerstone of the High Luminosity LHC project. The upgrade itself is triggered by the necessity to change the present at around 300 fb^{-1} of integrated luminosity, which gives the opportunity of a long stop (necessary also for the LHC Detectors) and then to install much larger aperture quadrupoles in the low beta luminosity insertion of ATLAS and CMS. The main results of the design study for the quadrupoles are:

a. The definition of the aperture, fixed as early as 2012 at 150 mm, entailing the necessity of using novel Nb_3Sn technology. Fixing the aperture so early has allowed making a cascade of

study and choices. The design of the quadrupole MQXF could be launched very early and the International Review called to assess the design itself at end of 2014, see https://indico.cern.ch/event/355818/ , found the design in very good stage, even one year earlier than the end of FP7 design phase. Figure 8 shows the cross section of the MQXF.

b. The definition of the type of cooling. The decision in favour of HEII cooling, while more expensive heavier from the technical infrastructure, has favoured the maximization of the performance. HEII is also the best for heat removal in the coils and heat transport out of the magnet, which are key issues in a high radiation environment like the one of the insertions of HL-LHC. The heat generated at 1.9 K is about three times the one of the present LHC.
c. Use of thick tungsten shield in the inner magnet bore (actually to the beam screen), to limit the radiation heat deposition density in the coil at the same level as the LHC, a few mW/cm^3. This reduce to increase in temperature to a few K, an acceptable value for Nb3Sn. In addition the W-shield limits the radiation damage. The dose in the triplet region magnets (IT quadrupoles, correctors and D1 magnet) is the same in HL-LHC at 3000 fb^{-1} as it is in the LHC at 300 fb^{-1}.

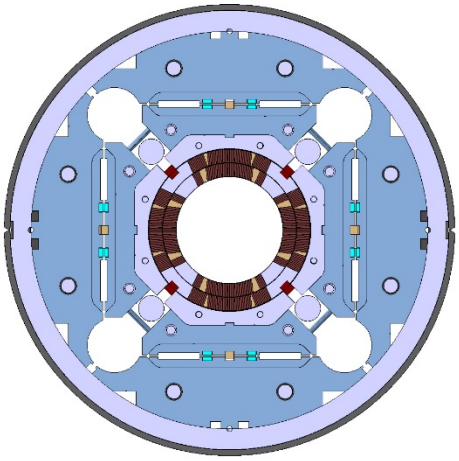

Figure 8: Cross section of the 150 mm aperture MQXF (IT quadrupole) with Nb_3Sn coils and based on a novel structure with bladders and keys (rather than collars and keys like in the LHC).

The project MQXF is well advanced and first test of the real magnets (thought short length, 1.5 m) is foreseen beginning of 2016. In Figure 9 the first Nb3Sn is shown during winding (the white colour is due to S2-glass fibre insulation).

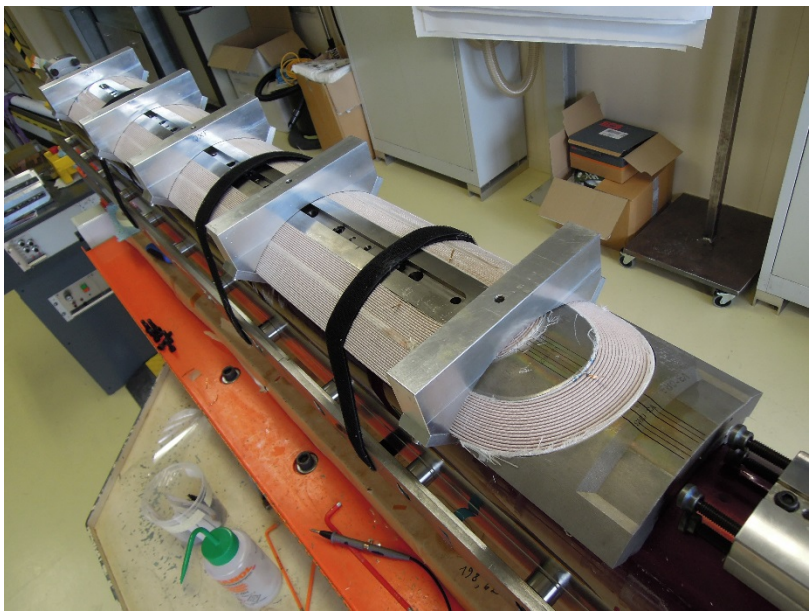

Figure 9: First Nb_3Sn short coil (1.5 m long) for the QXF magnet during winding operation at CERN.

Another main result is the design of all magnets of the insertion region. This has required an impressive work, comprising various dipoles and corrector magnets besides the IT quadrupoles. In Figure 10 the cross section of all magnets that need to be manufactured for HL-LHC is shown.

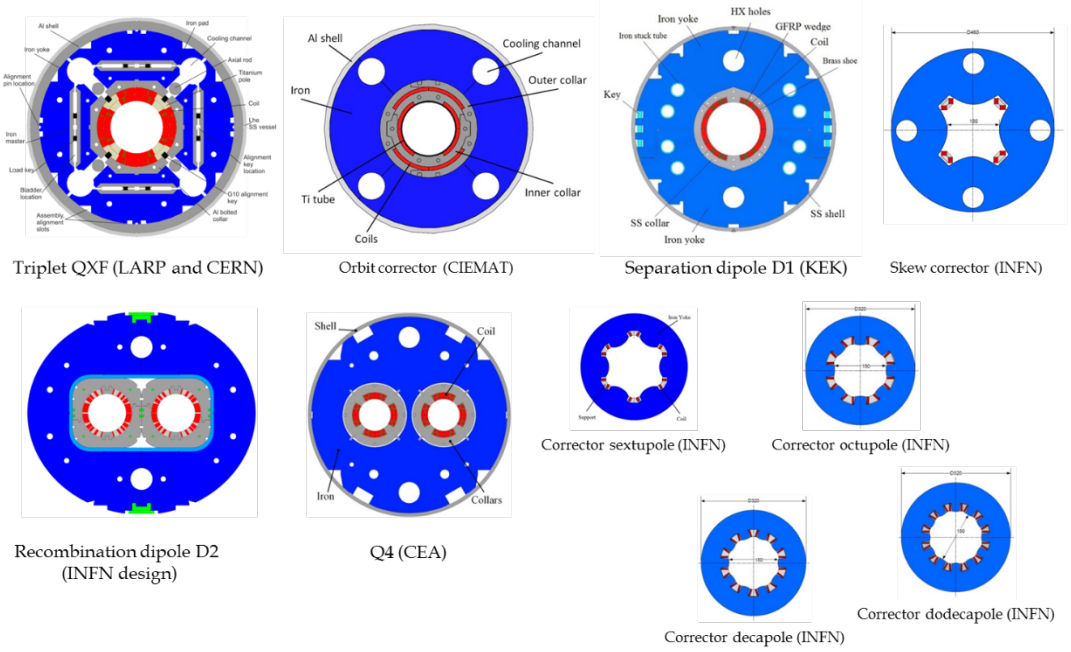

Figure 10: Cross sections (in scale) of the various magnets for HL-LHC insertions (the double aperture corrector are the only missing). All these are in advanced stage of design or prototyping.

3.4. WP4: CRAB CAVITIES

One key outcome of this WP was the decision to rule out the use of elliptical cavity in favour of the compact crab cavity. Another critical result was the progressive down selection of the various types of compact cavity, considering three types of cavity, the 4-rods, the RF dipole (RFD) and the double quarter wave (DQW) design.

Crab cavity is a new type of Superconducting radiofrequency (SCRF) equipment that is essential to boost the performance of HL-LHC to the desired level. Crab cavities have never been tested on a proton beam. Classical elliptical cavities used in crab-mode have been used for a short time in the Belle electron-positron ring at KEK in Japan. In HL-LHC the novelty is accentuated by the fact that they must be of compact type. Indeed one result of the design study has been to rule out the use of elliptical cavity, in favour of the compact crab cavity. This was a key decision taken very early in the project that has initiated a contractual amendment, allowing WP4 to concentrate all resources on the compact type, thus going beyond the initial scope of the design of a complete cryo-module.

Another critical result of this WP has been the progressive down selection of the various types of compact cavity. Rapidly the WP members agreed to consider three types of cavity, the 4-rods, the RF dipole and the double quarter wave design, see Figure 11. After a thorough campaign of test of the Proof-Of-Principle cavities and with then support of an international review held in BNL, see https://indico.bnl.gov/conferenceDisplay.py?confId=728 , the project was able to make a choice in favour of the RFD and of the DQW. Figure 12 shows the test results of the RF dipole the first cavity to be tested. Keeping two designs is the optimal choice since they better suit the different crossing scheme of ATLAS (vertical, RFD) and CMS (horizontal, DQW). Having two designs is consider also a safety measure: in case one of the two would show unexpected shortfalls, the other one can be used as a back-up solution, provided an adaptation of the cryo-module. The 4-Rod type is kept as an option.

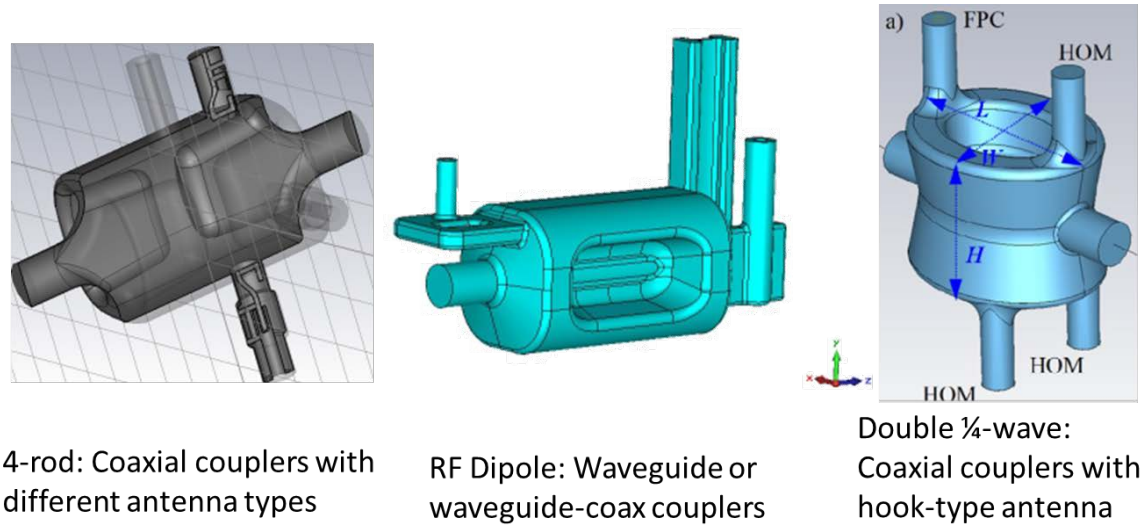

Figure 11: The three Crab Cavity layouts studied in FP7 HiLumi LHC. The layout is already an evolution of the initial concept since power couplers are integrated in the design.

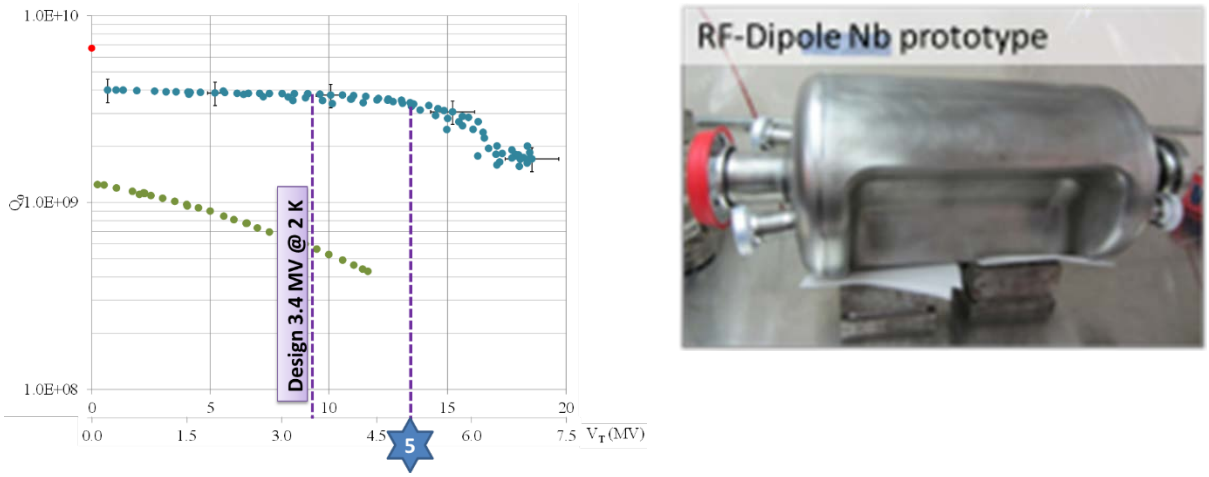

Figure 12: First Proof-Of-Principle test of compact crab cavity, the RF-dipole (shown at the right). The result of 5 MV has largely exceeded the design objective of 3.4 MV as indicated in the plot. Cavity and test courtesy of J. Delayen, ODU-USA.

Many important results have been obtained in the design study, which cannot be discussed here for brevity but are well documented in the various milestone and deliverable reports of WP4. Here it suffices to mention the big work to understand the field quality of the crab cavity and to reduce their impedance.

As mentioned above thanks to the early decision, the cryo-module concept is already advanced and as shown in Figure 13, we have now a full concept of the entire assembly and the engineering design is well advanced to meet the goal of the test in the SPS in 2018, an important milestone of the HL-LHC project.

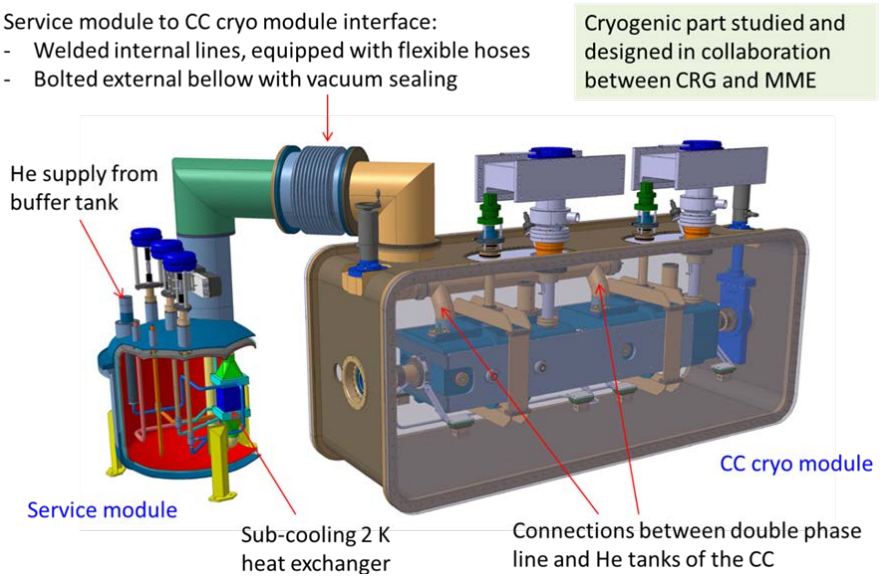

Figure 13: Layout of the complete cryo-module with cryogenic service which is under construction for the test in the SPS (DQW type).

3.5. WP5: IR COLLIMATION

A new layout of the insertion region collimators, suitable for the 150mm magnet aperture and for beam with brilliance increased by a factor of four, was developed by WP5. The WP studied a solution based on substituting the present graphite collimator with a new composition of molybdenum graphite (MoGR). Studies conducted by the WP have also shown the necessity of a new special collimation system in the LHC cold region to shield the first dipoles of the continuous cryostat.

In a high intensity machine like LHC, collimators (the ultimate barrier between beam and fragile superconducting magnets) are key equipment for machine protection and for machine availability. In HL-LHC the importance is enhanced by the increase in beam intensity by a factor of two with respect to the LHC and by the five-fold increase of the experiment radiation debris (these last proportional to luminosity). The main results of this WP can be summarized in the following three points:

1. New lay-out of the insertion region collimators, suitable for the 150 mm magnet aperture and beam with brilliance increase by a factor of four (two coming from intensity and another two from emittance). Higher energy density is even more difficult to deal with, since the impact tests in the HiRadMat facility show that very few material and special design are needed to withstand it. Figure 14 shows the new layout in the HiLumi insertion regions (around IP1 and IP2) as defined by FP7 Design Study. A complete new design has been also produced for the betatron cleaning of IR7.

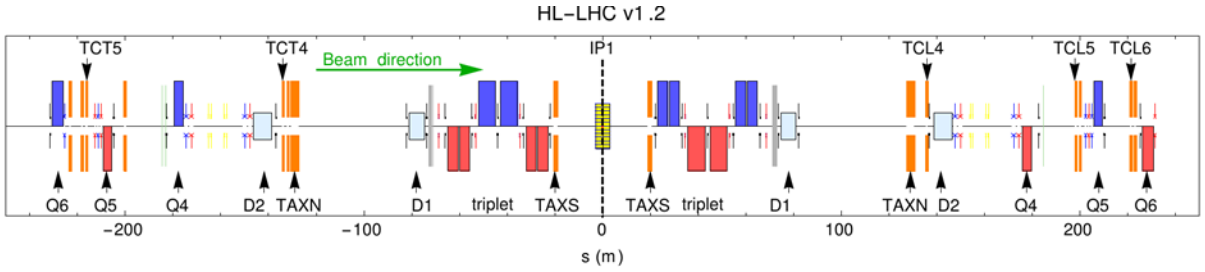

Figure 14: Layout of the new collimation system in IP1 (IP5 is identical). Optics files as for HL-LHC .v1.2 version

2. The collimators account already now for half of the total beam impedance in the LHC (despite they are less than 50 m long in a 27 km beam pipe!). By doubling the beam intensity, the collimator impedance may degrade the beam quality and even to raise severe instabilities. For these reason WP5 has conducted careful investigation on mew materials, also based on results of previous the FP7-EuCARD programme. Among various options, a solution based on substituting the present graphite collimator with a new composition of molybdenum-graphite (MoGR) coated with a thin Mo layer seems the most promising one. Simulation and beam studies has shown that replacing about ten secondary collimators with new MoGR collimators would reduce the total impedance by a factor two, at least, providing an effective solution to "digest" a double intensity beam.
3. The study has shown the necessity of a new special collimation system in the LHC cold region (Dispersion suppressor), to shield the first dipoles of the continuous cryostat. The study, conducted in conjunction with the 11 T dipole WP (not Hilumi) has produced a full

layout based on a collimator at warm temperature laying on a Cold-Warm-Cold bypass in between two 5.5m long 11 T dipoles. These unit of 11 T dipole, bypass and collimator replace an entire 15 m long 8 T LHC dipole. At the moment four such units, see Figure 15, are foreseen for HL-LHC.

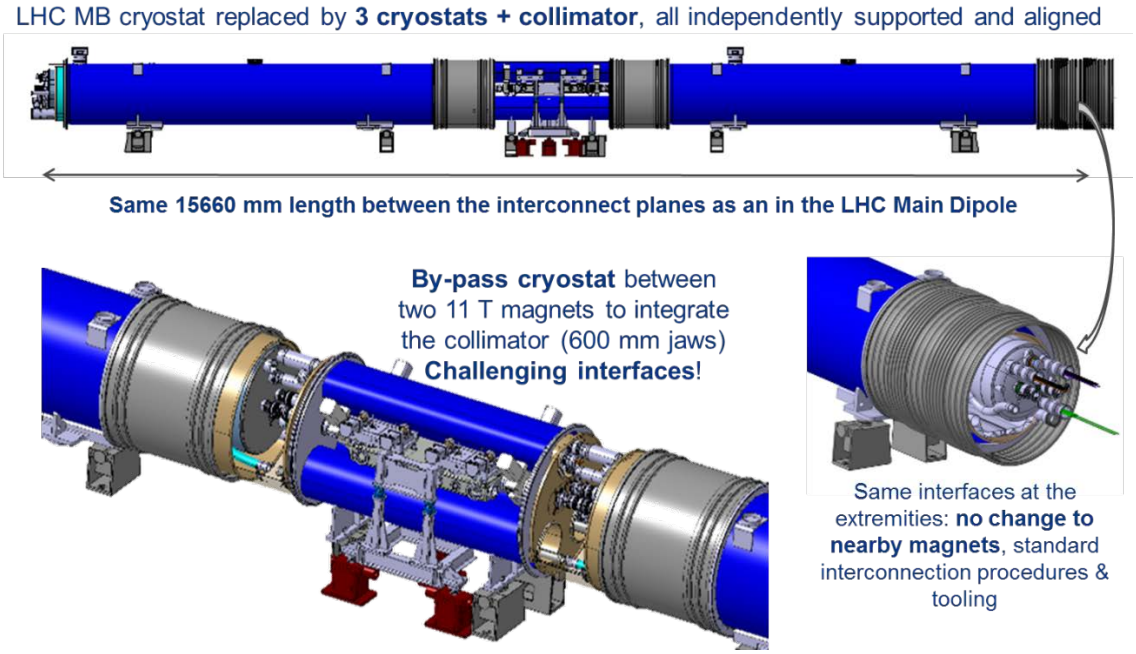

Figure 15: full layout of the new 15 m cry-assembly (11T-Bypass with collimator-11T) for dispersion suppression collimators that will substitute a standard 15 long LHC dipole cryo assembly.

3.6. WP6: COLD POWERING

A major breakthrough was achieved within Cold Powering with the development and industrialization of the MgB2 wire. The activity delivered a world record current of 20 kA at 24 K in a 40m-long electrical transmission line made of magnesium diboride (MgB2). The activity also developed the Superconducting Link system for HL-LHC. Finally, a crucial result was the development of a new design of the distribution feedbox, the cryostat accommodating the current leads and making the transition between cold and warm powering.

The main item of this WP is the design of the superconducting links that are the new element of the HL-LHC magnet cold powering. Indeed, in obedience to the ALARA principle we want to remove the HL-LHC magnet power supplies from the tunnel into a lateral technical gallery that will be excavated for HL-LHC project. This measure helps avoiding people taking up unjustified radiation during machine maintenance. However, this measure also should greatly increase the machine availability since the power and the control electronics will not suffer of single event effects that are unavoidable in the LHC tunnel (unless developing expensive *ad hoc* rad-hard electronics). These superconducting links started to be developed in FP7-EuCARD. In FP7-HiLumi, because of its lower cost and of the advantage for European Industry, the decision to develop SC link in MgB_2 was taken already at the beginning.

The main results of this WP can be summarized as following:

1. Round wire MgB2 has been developed, under CERN guidance and monitoring, by the company Columbus (Genova, I). This is a unique result that did not exist in 2010, paving the way for other Industrial applications (long and high current power transmission cable for electric distribution). Not only the MgB2 has been developed but also deeply characterised in terms of critical current and also in term so magnetization and losses, which is again a very original result, see Figure 16.
2. Design of the integration of the whole system, from Power converter to connection to the magnet bus bar, for Point 7, Point 1 and Point 5. Many technical and scientifically issues have been faced. One of the most interesting challenge were the joints capable of very high current (each link can carry 20 to 100 kA, with single cable of up to 20 kA for the inner triplet) with material resistive element, like the Monel barrier and the nickel matrix used for MgB2 wires. Another item that has been developed and designed is the 20 kA current leads, the end toward the warm end of the Sc links, with new solution illustrated in Figure 17.
3. A further novelty is the new original design of the distribution feedbox, the cryostat that accommodates the current leads and make the transition between cold and warm powering. The solution devised (see Figure 18) is simpler and more elegant than the one of the LHC. It seems also much easier to operate and as such can constitute a new paradigm for future accelerator feedboxes.

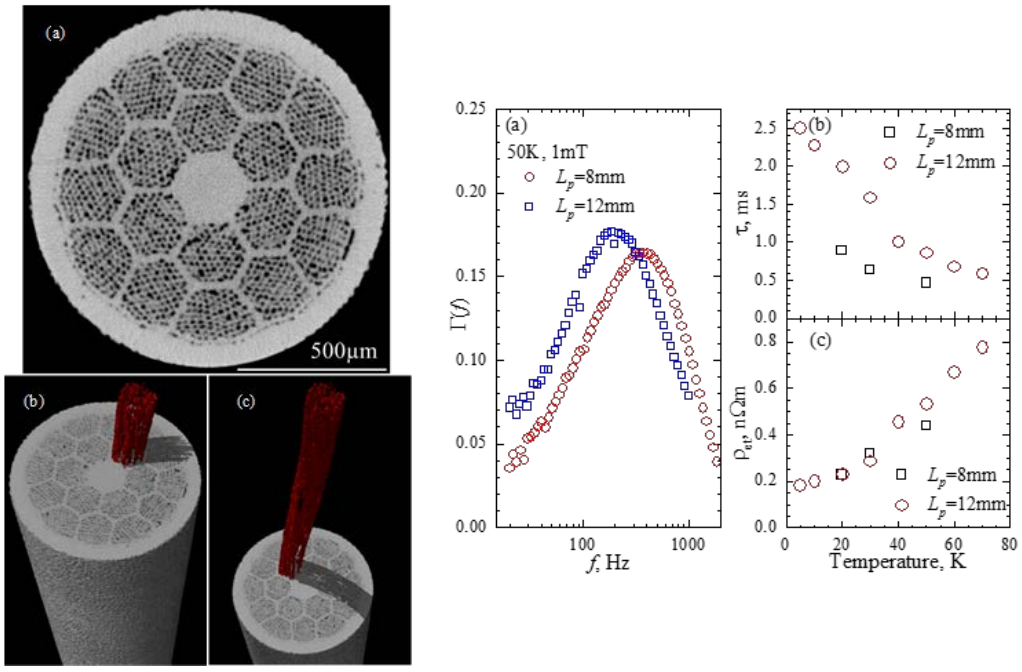

Figure 16: Left: architecture of a twisted MgB2 wires developed for the SC links. Right: Measured Losses as a function of frequency, with twist pitches of 8 and 12 mm.

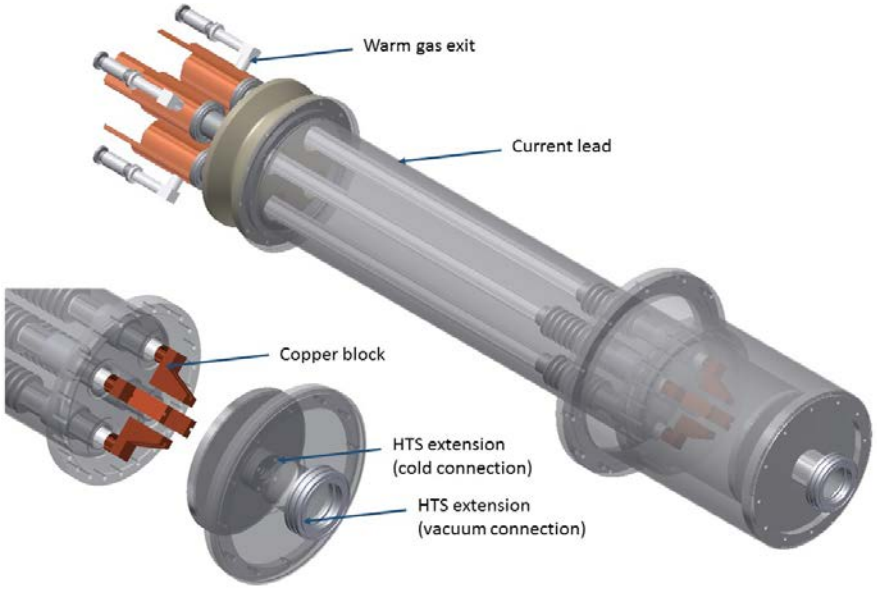

Figure 17: 3-D view of the 20 kA current lead for HL_LHC magnets, and the modification to the bottom of the lead to accommodate the HTS extension.

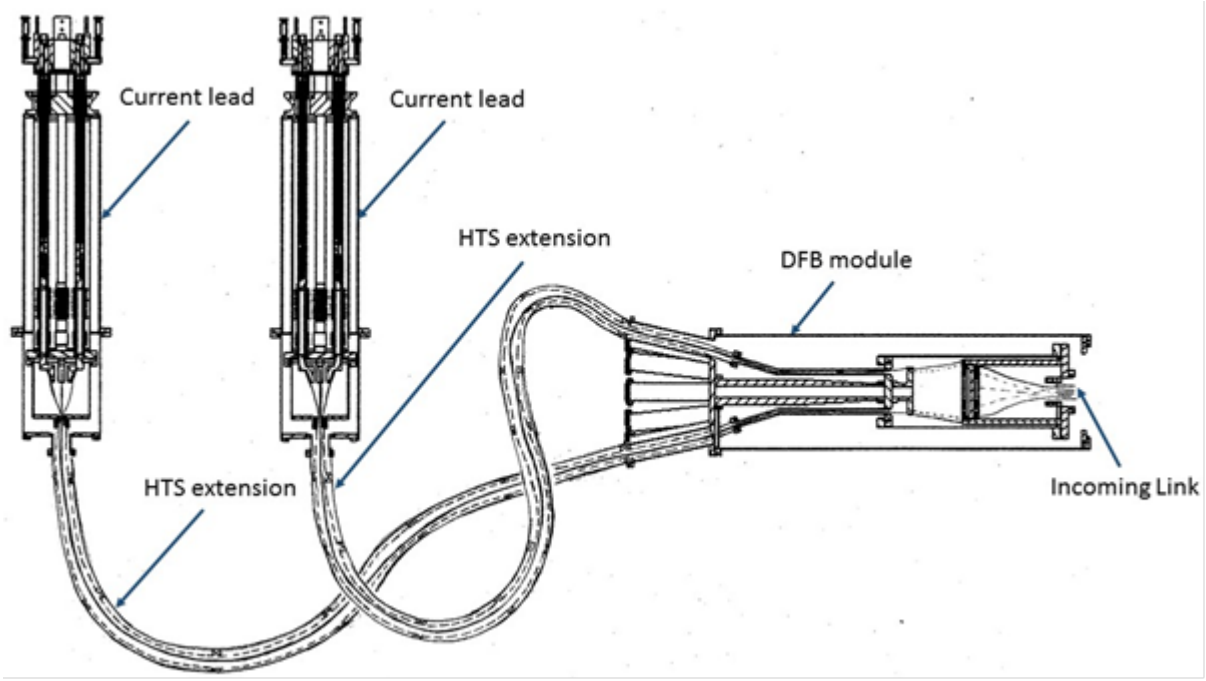

Figure 18: Design of the new HiLumi LHC feedbox (at warm end, called DFH).

4. POTENTIAL IMPACT, DISSEMINATION, EXPLOITATION OF RESULTS

4.1.1. Impact on technological development capacity of the ERA

HiLumi LHC involved 15 European laboratories, as well as participants from outside the European Research Area (ERA), in particular leading US and Japanese laboratories.
The most important impact of the design study is the preparation of the LHC for the High Luminosity upgrade construction phase.

The LHC High Luminosity Upgrade contributes to the implementation of the new European Strategy for particle physics, of which the top priority is the full exploitation of the LHC. Consequently, the CERN Council confirmed the priority status of the High Luminosity LHC (HL-LHC) project in the CERN scientific and financial programme in 2014, securing funding in CERN's medium term plan, until 2025.

The importance of the LHC luminosity upgrade for the future of High Energy Physics has been also re-affirmed by the May 2014 recommendation by the Particle Physics Project Prioritization Panel (P5) to the High Energy Physics Advisory Panel (HEPAP), which in turn advises the US Department of Energy (DOE)[5]. The recommendation, a critical step in updating the USA strategy for HEP, states the following: "*Recommendation 10: … The LHC upgrades constitute our highest-priority near-term large project.*"

In Japan the updated KEK roadmap in 2013 states that "*The main agenda at LHC/ATLAS is to continually participate in the experiment and to take a proactive initiative in upgrade programs within the international collaboration at both the accelerator and detector facilities.*"

The project delivered a number of important technological impacts, concerning the development of High Energy Physics (HEP) research infrastructures, medical and industrial applications of accelerators, and certain technologies not directly related to accelerators. The potential technological impact is exemplified in the following major areas:

4.1.1.1. Development of superconducting technology for magnets

The target of the project proposal was to 1) finalize a high quality superconducting Nb3SN cable; 2) make it suitable for large current compact cables; 3) trigger industrialization by bringing its cost down.

1) After having overcome many issues including instability, field quality and cabling degradation, thanks to the HiLumi LHC Design Study, Nb3Sn based superconducting cables are now reliably working in collider magnets. The Nb_3Sn triplet will be the first accelerator magnet to use a bladder and key mechanical structure. This concept, initially developed at Berkeley Laboratories, allows a more precise control of the mechanics of the high field magnets, and proving its efficiency in a small series can pave the way to extend it to other applications.

2) The project is currently in the process of placing a large order of several million euros of high quality and high current density Nb3SN cable. The current density reaches over Jc=2500 A/m2 at 12T, 4.2K. This is three times beyond the requirements and orders of the ITER project. The Nb_3Sn

[5] Building for Discovery: Strategic Plan for U.S. Particle Physics in the Global Context, in http://science.energy.gov/hep/hepap/reports/

triplet will use a novel protection system based on Coupling-loss Induced Quench (CLIQ). The principle is to uniformly heat the coils in case of quench through the rapid discharge of a capacitor. This concept, developed at CERN, has been proved on short models. In HL-LHC we will have the first application to an accelerator of this system that can also be extended to the protection of solenoids, NMR and MRI magnets.

3) The project also made industrialization possible, e.g. Bruker EAS (a European company based in Germany) is currently using routinely this type of material for their high field NMR magnets.

Development and Industrialization of MgB2 wire

A major breakthrough was achieved for the development and industrialization of the MgB2 wire: the first Powder-in-Tube (PIT) round wire with electrical and mechanical characteristics enabling cabling after reaction was developed in collaboration within CERN and industry (Columbus Superconductors, Italy). A procurement 80 km of wire was launched by CERN at the end of the development program in 2015.

Development of superconducting transmission lines for energy saving

The activity delivered a world record current of 20 kA at 24 K in a 40 m long electrical transmission line made of magnesium diboride (MgB2). This development, performed for the powering of the Hi-Lumi magnets, has been proposed to be used also for innovative transmission lines used for long-distance transport of GW of green power. The test results show that the MgB2 cables can be operated at high currents and at the temperature of liquid hydrogen and that the basic related technology is now proven. This has led first to a collaboration between CERN and the Institute for Advanced Sustainability Studies in Potsdam, and finally to an Industry-led FP7 European project (BEST PATHS), with CERN as a partner, that is very promising for the future of high power transmission cable for electrical industry. The French Transmission System Operator (RTE) is contributing to the BEST PATHS project. The success of the MgB2 and HTS superconducting lines will enable to move the power converters supplying current to the superconducting magnets either to the surface or to radiation free underground areas and to use superconducting transmission lines operated at higher temperatures to connect them.

4.1.1.2. Paving the way to a future increase of LHC energy

The future LHC upgrades critically depend on the success of high field accelerator magnet technology, beyond 10 teslas. Large accelerators can be made more compact with considerable savings in infrastructure and land occupation. The 11 Tesla dipole project aims to replace around 30 8T dipoles in the LHC tunnel with shorter, stronger 11T magnets. Thanks to this project, the space requirement of the magnets decreases significantly, which allows the installation of additional collimators for the HL-LHC upgrade. The first model magnets based on Nb_3Sn technology have been already completed and tested. Currently, the full-scale prototypes are being tested. The success of this technology under the umbrella of HiLumi is a significant milestone towards the LHC energy upgrade, which became the FCC (Future Circular Collider) design study, for which 11-13T magnets are essential.

With the 11 Tesla dipole project, the first model magnets based on Nb_3Sn technology have been completed and successfully tested. This activity aims to replace some 8T dipoles in the LHC tunnel with shorter, stronger 11T magnets. With this the space requirement decrease significantly, which allow the installation of additional collimators for the HL-LHC upgrade.

4.1.1.3. More compact accelerators for medical and industrial applications

A common requirement for medical and industrial applications is to reduce the volume and weight of accelerators, together with their cost. High field, and therefore more compact, accelerators and gantries could be a real breakthrough making hadron therapy centres smaller and hence more accessible to city hospitals or less wealthy countries. HiLumi contributed to the ongoing development of the first effective and small-sized PET superconducting cyclotron.
Accelerators and MRI (Magnetic Resonance Imaging) have followed parallel development, usually MRI profiting from accelerator technology.
In the same way that the LHC has reached the limit of Nb-Ti technology with its 9 T field magnets, MRI is designing to reach it with the 11.7 T of the solenoid of ISEULT[6]. Within the ISEULT MRI project many companies had been thinking of pushing for beyond 11-12 T. The HiLumi efforts contributed significantly to come to the conclusion that pushing beyond 11.7T is less efficient and therefore efforts are moving towards staying between 9-10T, based on Nb3Sn.
The NbSn technology is also being considered for Gantry (object to deliver beam to patient in hadron therapy) especially in the form of Canted Cos Theta coils.
Recently the use of very high field accelerators is being considered by security agencies and institutions for quick inspection and safety check of baggage and containers; an ultra-compact accelerator can generate penetrating beam to screen the contents of ship containers or allow fast checking of baggage, substituting intruding techniques.
The accurate design and measurement tools and simulation programmes developed for the HiLumi upgrade will also facilitate the design and optimization of accelerators required not only for medical applications but also for high intensity high brightness machines necessary for the production of intense neutron or X-ray beams for the study of the properties of existing and new materials and for the analysis of biological samples.

4.1.1.4. Beam manipulation with Crab cavities

Superconducting RF is the driving technology in the many of the recent and future accelerator projects in the world. Deflecting cavities (aka crab cavities) is increasingly becoming an essential component in future colliders, light sources and Free Electron Lasers for beam manipulation. The development of novel and compact crab cavities reaching very high surface fields in the framework of the HiLumi design study has opened a new paradigm in the field of deflecting cavities and superconducting RF. The immediate benefit for the HL-LHC project is from the gain in physics peak luminosity of more than 70% from the implementation of crab crossing and dramatically increase its efficiency. The realization of these complex structures requires a multitude of new and sophisticated engineering concepts and procedures to fabricate and assemble the cavity and cryo-module components to a precision level much higher than that of the existing structures. The stringent timing requirements at the sub-picosecond level for the operation the crab cavities in the LHC will push the limits of the RF controls beyond the state of the art.

4.1.1.5. Novel materials

In the quest for new materials for future collimators, novel materials with high shock resistance and excellent thermal conductivity are studied. Copper-Diamond and Molybdenum Carbide – Graphite (MoGR) composites are the two most promising examples. The latter is capable to withstand

[6] http://irfu.cea.fr/en/Phocea/Vie_des_labos/Ast/ast_visu.php?id_ast=3058

unprecedented thermo-mechanical shock as the ones induced by the HL-LHC beams. This development paves the ground for the design of performing collimators for future accelerators beyond the LHC and is also expected to have an impact on other applications in everyday life: braking systems for high-end automotives and aerospace, thermal management in high power electronics, hot parts for gas turbines and space components requiring extreme geometrical stability are but a few examples of potential applications.

4.1.2. Impact on international cooperation

The HL-LHC project has set new working methods in the area of large particle accelerators. The collaboration (see Figure 19), which involved partners from US laboratories and Japan has gone way beyond the initial design study objectives. The four year concrete collaboration within this Design Study opened the possibility of discussions among partners as to their implication in the construction phase and the choice of a sustainable collaboration model based on a concrete four years of experience. To extend future collaboration for the construction phase, collaboration agreements have been signed between CERN and almost all EU design study partners, including the US and Japanese partners. To extend the collaboration beyond the design study partners, a number of collaboration agreements were signed with universities and research laboratories and discussions are currently underway for further formalized agreements.
This collaboration model is paving the way to global Research Infrastructures in other fields of science.

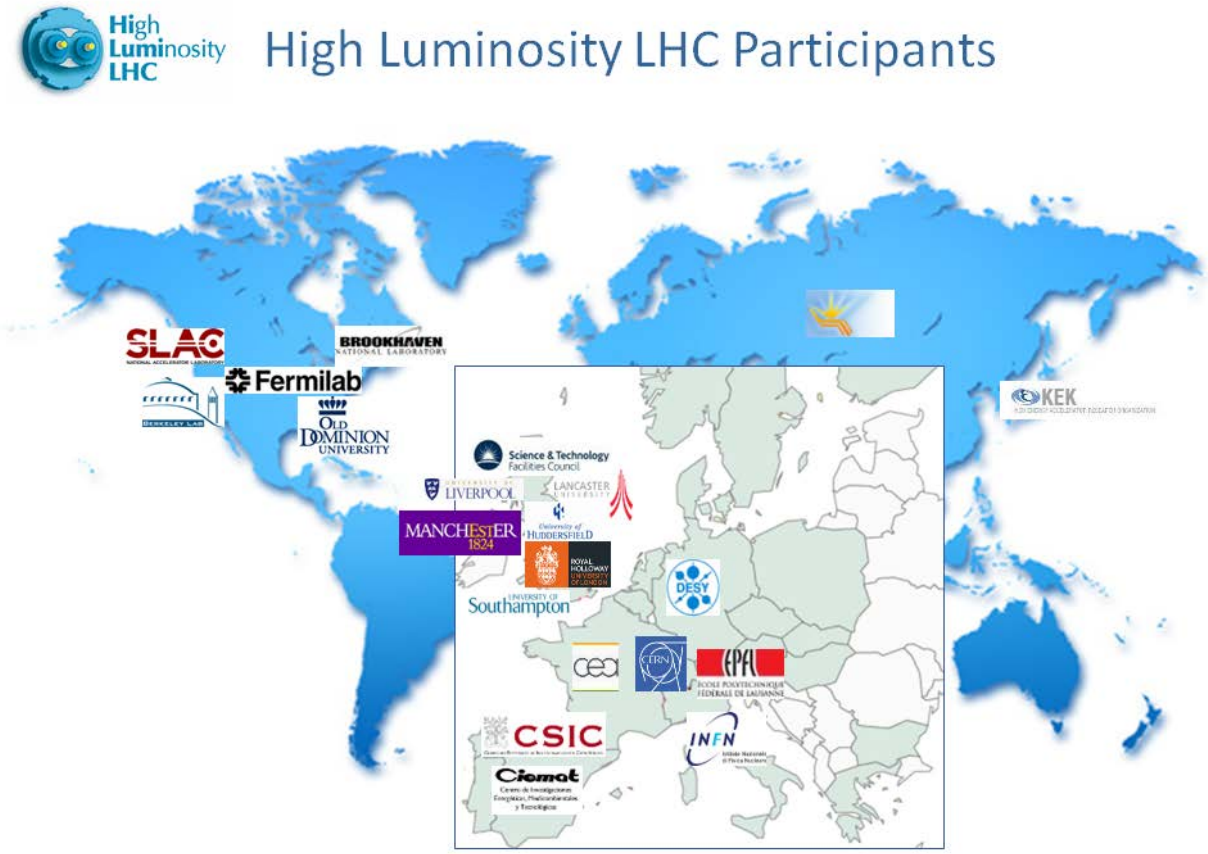

Figure 19: HiLumi LHC Design Study participants

4.1.3. Impact on European Industry

HiLumi LHC is preparing European industry in an optimal way to bid for industrial contracts, including in high-technology fields, with placing orders of an estimated total value of 500 M€ for the construction phase. A consistent fraction of this value is of high tech equipment. The project already placed orders of a value of 30 M€.

To enhance the co-operation with industry on the production of key technologies that are not yet considered by commercial partners due to their novelty and low production demand, HiLumi triggered the launch of the QUACO project, recently funded by the EU. This project brings together several research infrastructures with similar technical requirements in magnet development to act as a single buyer group. The efforts on the MgB2 wire has led to another EU project, which is an industry-led FP7 project, called BEST PATHS (see Section 4.1.1.1.)

Through task 1.6 (Dissemination of Information and Industry Outreach), HiLumi LHC involved Industry at an early stage to the needed development, in order to have industrial feedback about the Best Engineering Practice to be applied, to maximize the chance of technical success of the construction phase.

Through industrial liaison initiatives and Industrial Forums (Superconducting Technologies for Next Generation of Accelerators[7] in 2012, and HiLumi LHC goes to Industry[8] in 2015) the project also aimed to make European Industry aware of the opportunities to become an equipment or service provider in the construction phase. Leading companies in the fields of superconductivity, cryogenics, power electronics, electrical engineering and mechanics were invited to meet the CERN management, several procurement and legal officers and project engineers to explore the technical and commercial challenges emerging from the design and procurement of the LHC upgrade and to match them with the state-of-the-art industrial solutions.

4.1.4. Impact on European science and society

The importance of the LHC luminosity upgrade for European science was acknowledged by ESFRI and also by the P5 Panel of to the High Energy Physics Advisory Panel (HEPAP), which advises the US Department of Energy (DOE). Thanks to this project, Europe has secured to remain in front of science and research up to at least 2040 and will stay an attractive workplace for researchers from all over the world. The key result of the design study is the seamless transition into the HL-LHC construction phase.

More than 80 outreach talks given by project members of HiLumi LHC demonstrated the dynamism of fundamental sciences to the young generation. Via the project's university partners, HiLumi LHC also involved 35 PhD students and postdocs in high-tech research and implementation. Up to date, 6 university dissertations resulted from the project. (See under publications on CDS).

By means of regular working visits and workshops with partners from the USA, Japan, Russia and other countries, the project emphasised the importance of transnational exchanges of ideas and the mobility of researchers, portraying the excitement and potential of European research for the scientists of tomorrow.

The societal impacts of the HiLumi LHC technologies include medical applications as mentioned above, in addition, very compact PET cyclotrons and enhancements to magnetic resonance imaging

[7] https://indico.cern.ch/event/196164/

[8] https://indico.cern.ch/event/387162/

(MRI) scans. Technologies resulting from the project also foresee aiding the development of more compact accelerators, which save on cost, space and consumption. In addition the links with industry give the potential for more societal benefits, as spin-offs are discovered and exploited.

4.2. DISSEMINATION AND EXPLOITATION

The "Dissemination of Information and Industry Outreach" Task 1.6 ensured the effective dissemination of information and innovation inside and outside within the HiLumi LHC consortium and to target audiences by developing and implementing effective communication tools. Target audiences included the broader scientific community, as well as the general public. A specific attention was devoted to outreach to industry.

With the end of EU-funded activities, the High Luminosity LHC project has moved on to the construction phase. Communication activities will continue to be implemented under this new phase, ensuring the visibility of the project's outcomes and results.

4.2.1. Dissemination tools

Website

The HiLumi LHC website was one of the main communication tools for the project. Since its creation in October 2011, the website has been the entry point not only to the HiLumi LHC Design Study, but to the larger HL-LHC project too. Due to the increased interest in the HL-LHC activities and in the website, in September 2014 the project launched a completely redesigned user-friendly website that was easier to navigate (providing easily accessible information for stakeholders) and that ensured maximum visibility of the project and its results. The website introduced new features to grab visitors' attention, such as the colourful slideshow.

The website is activity maintained with Work packages highlights, news and event announcements. Project results were collected under the Deliverables and Milestones sections. An Education and Outreach section features educational resources related to the project and to accelerator's luminosity, including factsheets and explanatory videos. It is to be noted that analysis of the web traffic showed that the average number of visitors per month (1500 ca) exceeded the number of HiLumi members by a factor of 3. After the transition to the construction phase, the HiLumi website will continue to be the main entry point for information on HL-LHC.

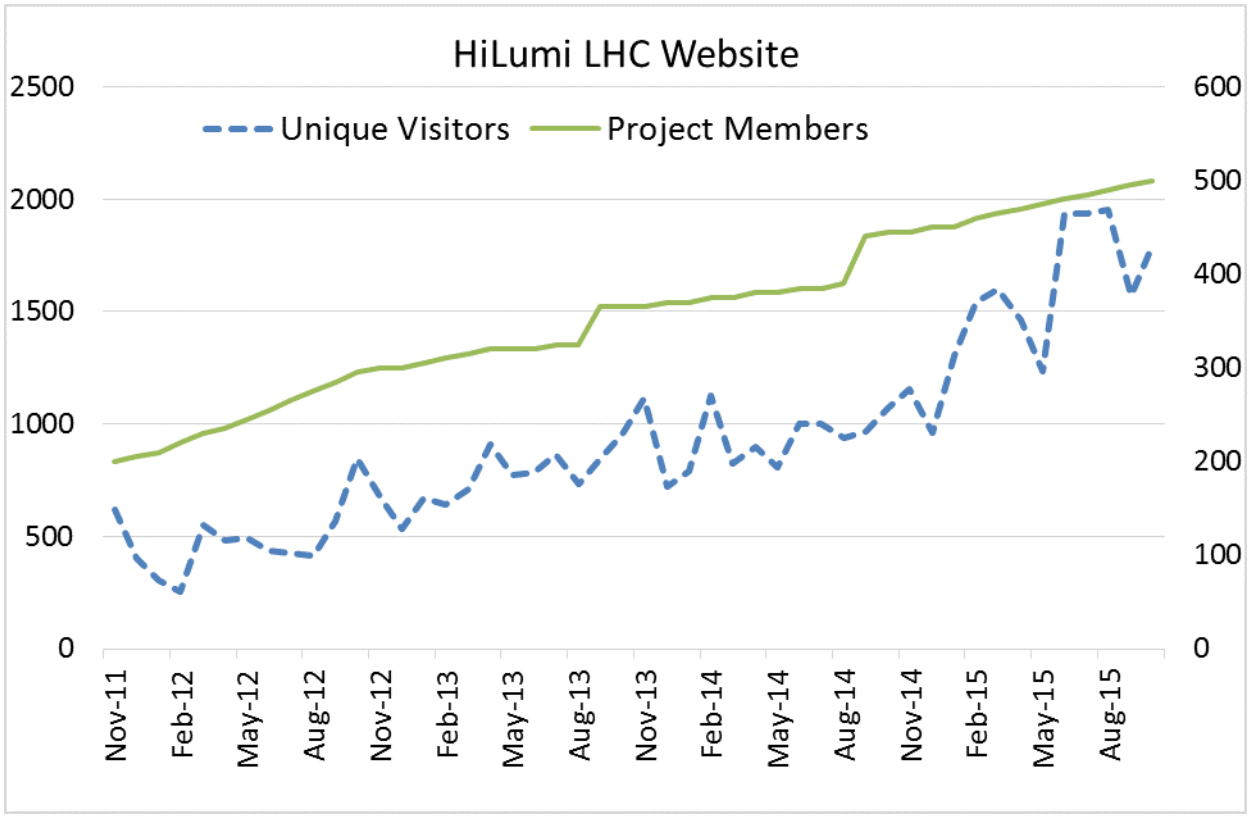

Figure 20: Number of unique visitors to HiLumi LHC website compared to number of project members (Nov 2011 – Oct 2015)

Newsletter

Under the Accelerating News newsletter showcases news and results from the biggest accelerator research and development projects, such as HiLumi LHC, EuCARD-2, TIARA, FCC, CERN-EC support to SESAME as well as interesting stories on other accelerator applications. The newsletter also collects upcoming accelerator research conferences and events.

The publication evolved from the EuCARD quarterly project newsletter, which was first published in June 2009 to a subscription list of approximately 200. The first edition of Accelerating News was published in April 2012, with HiLumi LHC being one of the first sponsors. A total of 29 stories from HiLumi were promoted, with highlights from several Work Packages. Over these 3 and a half years, the number of subscribers to Accelerating News rose from 800 to more than 1350 people, attesting to the success of the publication. With the transition to the construction phase, HL-LHC will remain one of the main sponsors of the publication, ensuring continued visibility of the project outputs and results.

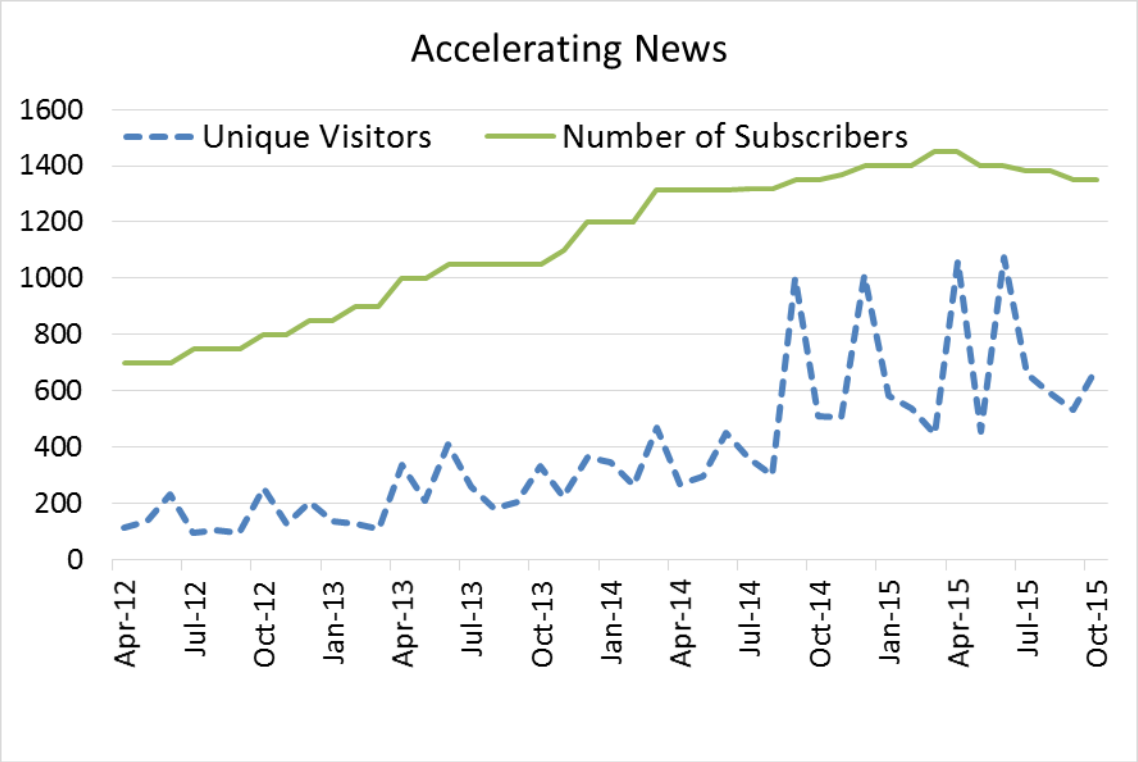

Figure 21: Number of unique visitors and subscribers to Accelerating News (Apr 2012 – Oct 2015)

Flyers and brochures

A factsheet was created at the beginning of the project to promote the projects at various events, such as conferences, workshops and exhibitions. The factsheet can also be found on the Education and Outreach section of the website.

4.2.2. Dissemination Activities

Publications and reports

All HiLumi LHC publications and reports are available in open access and can be browsed on the HiLumi LHC CDS collection. As of 14 December 2015, the publications logged in the CERN Documentation System (CDS) database amounted to:

Conference papers	*Peer reviewed Publications*	*Academic Dissertations*	*Books*	*Oral Presentations*	*Other Publications*	***Total***
148	41	6	1	114	85	**398**

In addition, HiLumi LHC has produced 43 deliverable reports and 61 milestones reports.

All scientific advances generated by HiLumi LHC have been synthetized in the HiLumi LHC Book "*The High Luminosity Large Hadron Collider : the new machine for illuminating the mysteries of Universe*". The book consists of a series of chapters touching on all issues of technology and

design, and each chapter can be read independently. The first few chapters give a summary of the whole project, of the physics motivation and of the accelerator challenges. The subsequent chapters cover the novel technologies, the new configurations of LHC and of its injectors as well as the expected operational implications. Altogether, the book brings the reader to the heart of technologies for the leading edge accelerator and gives insights into next generation hadron colliders.

The project scientific and technical results were published in 41 peer-reviewed publications such as:

- Physical Review Special Topics – Accelerators and Beams (APS Physics) – 8 publications
- Physical Review Letters (APS Physics) – 1 publication
- IEEE Transactions on Applied Superconductivity (IEEE) – 32 publications

In addition, 3 publications were submitted to the Open Access arXiv.org database.

HiLumi LHC results were also presented by project members at major international conferences including:

- *International Particle Accelerator Conference 2012 (IPAC12)* – 21 presentations and/or proceedings
- *International Particle Accelerator Conference 2013 (IPAC13)* – 36 presentations and/or proceedings
- *16th International Conference on RF Superconductivity (SRF 2013)* – 5 presentations and/or proceedings
- *2nd International Beam Instrumentation Conference (IBIC 2013)* – 2 presentations and/or proceedings
- *International Particle Accelerator Conference 2014 (IPAC14)* – 37 presentations and/or proceedings
- *International Particle Accelerator Conference 2015 (IPAC15)* – 29 presentations and/or proceedings
- *12th European Conference on Applied Superconductivity (EUCAS 2015)* – 2 presentations and/or proceedings

A number of HiLumi feature-articles were also published in the CERN Bulletin, CERN Courier, Symmetry newsletter, INFN Newsletter, and in several newspapers.

This large number of publications and oral presentations show the dynamism of project members. The detailed table of the publications and dissemination activities can be found in the Annex. Open access to publications and journals were continuously favoured, and WP leaders were encouraged to open WP owned websites with their key results. In addition, CERN has also bought the rights to make the HiLumi LHC book "*The High Luminosity Large Hadron Collider: the new machine for illuminating the mysteries of Universe*" an open access publication.

Joint HiLumi-LHC and LARP Annual Meetings

A total of 5 Annual Collaboration meetings were organized in the framework of the project. The meetings gathered on average 160 participants from about 26 institutes and laboratories and from more than 10 countries. The meetings were an opportunity for the HiLumi community to discuss the project scientific and technical achievements. Posters for the Annual Meetings were designed and then distributed to the HiLumi network so that the events could be suitably advertised.

Outreach activities

Outreach to the public has been enhanced with lectures and public talks, mostly by the Project Coordinator. Lucio Rossi has given more than 80 outreach talks with an average audience of 270 people of different ages and various backgrounds, including science festivals, schools and university seminars and colloquia. The country of the talks ranged from the United States to Japan, Italy, Germany and France. At the end of each talk, an open discussion with the public opened the floor to questions and debates. The list of events is available at http://goo.gl/4REsq. Some talks had an audience that exceeded 2000 people. The Project Coordinator was also featured several articles in public newspapers, e.g. Liberta, Corriere della Sera, etc, as well as in scientific magazines and newsletters.

Figure 22: Lucio Rossi talking in Rome

Figure 23 Leaflet for a public talk in Hamburg

A general presentation has been also prepared by the Project Coordinator to ease the work of the project member when giving an outreach talk on the scopes of the HL-LHC project. The presentations are available in English, German and Italian from the public website[9].

The year 2015 was proclaimed the International Year of Light and light-based technologies. CERN took this opportunity to launch a communication campaign about the High Luminosity LHC project, which included special events throughout 2015. HiLumi LHC was also contributed to the popular Light2015 UNESCO blog. The HiLumi LHC contribution will also be included in a booklet produced be the International Year of Light on the topic. The booklet will be published by February 2016. Outreach to industry has been a major component of HiLumi LHC communication efforts. Liaison with industry was coordinated by an Industry and Technology Board, which aimed at preparing the participation of European Industry in the HL-LHC construction. A total of two workshops and one Industry Forum were organized to connect companies with research infrastructures, providing them with updated information on the technical and technological challenges of HL-LHC and gathering efforts to face the commercial challenges emerging from the design and procurement of the LHC upgrade. Overall, more than 400 participants took part in the events.

[9] http://hilumilhc.web.cern.ch/about/education-outreach

II. Use and dissemination of foreground

5. USE AND DISSEMINATION OF FOREGROUND

5.1. SECTION A: DISSEMINATION MEASURES (PUBLIC)

Below you can find Table A1: list of scientific peer-reviewed publications. In total the project generated 41 peer-reviewed publications. Table A2 can be found in Annex I. Up to date (15 December 2015), 357 dissemination activities were accounted for as a result of the project.

Table A1: List of scientific (peer reviewed) publications

No	Title	Main author	Title of the periodical or the series	Number, date or frequency	Publisher	Place of publication	Year of publication	Relevant pages	Permanent identifiers[10] (if available)	Is/Will open access[11] provided to this publication?
1	Response of colliding beam-beam system to harmonic excitation due to crab-cavity rf phase modulation	Ohmi, K (KEK, Tsukuba) et al	Physical Review Special Topics - Accelerators And Beams	Volume 14, n. 11	APS Physics	USA	2011	111003	CDS Link	Yes
2	Simulations of Electron-Cloud Heat Load for the Cold Arcs of the CERN Large Hadron Collider and Its High-Luminosity Upgrade Scenarios	Maury Cuna, H. et al	Physical Review Special Topics - Accelerators And Beams	Volume 15, N. 5	APS Physics	USA	2012	051001	CDS Link	Yes
3	Cryogenic test of a proof-of-	De Silva S. et	Physical Review	Volume 16,	APS Physics	USA	2013	082001	Link	Yes

[10] A permanent identifier should be a persistent link to the published version full text if open access or abstract if article is pay per view) or to the final manuscript accepted for publication (link to article in repository).

[11] Open Access is defined as free of charge access for anyone via Internet. Please answer "yes" if the open access to the publication is already established and also if the embargo period for open access is not yet over but you intend to establish open access afterwards.

	principle superconducting rf-dipole deflecting and crabbing cavity	al	Special Topics - Accelerators And Beams	N. 8						
4	Achromatic Telescopic Squeezing Scheme and Application to the LHC and Its Luminosity Upgrade	Fartoukh, S. ET AL	Physical Review Special Topics - Accelerators And Beams	Volume 16, N. 11	APS Physics	USA	2013	111002	CDS Link	Yes
5	DAFNE Operation with Electron-Cloud-Clearing Electrodes	Alesini D. (CERN) et al	Physical Review Letters	Volume 11, No. 12	APS Physics	USA	2013	124801	Link	Yes
6	Design Studies for the Low-Beta Quadrupoles for the LHC Luminosity Upgrade	Todesco, E. (CERN) et al	IEEE Transactions on Applied Superconductivity	Volume 23, N. 3	IEEE	USA	2013	4002405	CDS Link	Yes
7	Design of a Large Single-Aperture Dipole Magnet for HL-LHC Upgrade	Qingjin, X. et al	IEEE Transactions on Applied Superconductivity	Volume 23, N. 3	IEEE	USA	2013	4001305	Link	Yes
8	Testing Results for Nb-Ti, 120-mm-Aperture, Low-B Quadrupole Models for the LHC High-Luminosity Insertion	Kirby, G. et al	IEEE Transactions on Applied Superconductivity	Volume 23, N. 3	IEEE	USA	2013	4002105	CDS Link	Yes
9	Cold Test Results of the LARP HQ Nb3Sn Quadrupole Magnet at 1.9 K	Bajas, H et al	IEEE Transactions on Applied Superconductivity	Volume 23, N. 3	IEEE	USA	2013	4002606	CDS Link	Yes
10	Critical current and stability of MgB2 Twisted-Pair DC cable assembly cooled by helium gas	Yifeng Y. et al	IEEE Transactions on Applied Superconductivity	Volume 23, N. 3	IEEE	USA	2013	4801204	Link	Yes
11	Quench Protection Study of a Single-Aperture 11 T Nb3Sn Demonstrator Dipole for LHC Upgrades	Chlachidze, G. et al	IEEE Transactions on Applied Superconductivity	Volume 23, N. 3	IEEE	USA	2013	4001205	CDS Link	Yes
12	Field Quality Measurements in a Single-Aperture 11 T Nb3Sn Demonstrator Dipole for LHC Upgrades	Andreev, N. et al	IEEE Transactions on Applied Superconductivity	Volume 23, N. 3	IEEE	USA	2013	4001804	CDS Link	Yes

13	Development and Test of a Single-Aperture 11 T Nb3Sn Demonstrator Dipole for LHC Upgrades	Zlobin, A. et al	IEEE Transactions on Applied Superconductivity	Volume 23, N. 3	IEEE	USA	2013	4000904	Link	Yes
14	A First Baseline for the Magnets in the High Luminosity LHC Insertion Regions	Todesco, E. et al	IEEE Transactions on Applied Superconductivity	Volume 24 No. 3	IEEE	USA	2014	4003305	CDS Link	Yes
15	Magnet Design of the 150 mm Aperture Low-beta Quadrupoles for the High Luminosity LHC	Ferracin, P. et al	IEEE Transactions on Applied Superconductivity	Volume 24 No. 3	IEEE	USA	2014	4002306	CDS Link	Yes
16	LHC IR Upgrade Nb-Ti 120mm aperture model quadrupole test results at 1.9 K	Kirby, GA. et al	IEEE Transactions on Applied Superconductivity	Volume 24 No. 3	IEEE	USA	2014	4002405	CDS Link	Yes
17	Quench Performance of a 1 m Long Single-Aperture 11 T Nb3Sn Dipole Model for LHC Upgrades	Zlobin, A. et al	IEEE Transactions on Applied Superconductivity	Volume 24 No. 3	IEEE	USA	2014	4000305	Link	Yes
18	Quench Protection Study of the Nb3Sn Low-β Quadrupole for the LHC Luminosity Upgrade (HiLumi-LHC)	Manfreda, G. et al	IEEE Transactions on Applied Superconductivity	Volume 24 No. 3	IEEE	USA	2014	4700405	Link	Yes
19	Multipoles Induced by Inter-Strand Coupling Currents in LARP Nb3Sn Quadrupoles	Wang, X. et al	IEEE Transactions on Applied Superconductivity	Volume 24 No. 3	IEEE	USA	2014	4002607	Link	Yes
20	Magnetic Design Optimization of a 150 mm Aperture Nb3Sn Low-Beta Quadrupole for the HiLumi LHC	Borgnolutti, F. et al	IEEE Transactions on Applied Superconductivity	Volume 24 No. 3	IEEE	USA	2014	4000405	CDS Link	Yes
21	Field Quality Measurements of LARP Nb3Sn Magnet HQ02	DiMarco, J. et al	IEEE Transactions on Applied Superconductivity	Volume 24 No. 3	IEEE	USA	2014	4003905	CDS Link	Yes
22	Design of a 150-mm Coil Support Structure With Accelerator Integration	Cozzolino, J. et al	IEEE Transactions on Applied Superconductivity	Volume 24 No. 3	IEEE	USA	2014	4003704	CDS Link	Yes

	Features for LARP Nb3Sn Quadrupole Magnets									
23	Design Optimization of the New D1 Dipole for HL-LHC Upgrade	Xu, Q. et al	IEEE Transactions on Applied Superconductivity	Volume 24 No. 3	IEEE	USA	2014	4000104	CDS Link	Yes
24	Deduction of Steady-State Cable Quench Limits for Various Electrical Insulation Schemes with Application to LHC and HL-LHC Magnets	Granieri, P. et al	IEEE Transactions on Applied Superconductivity	Volume 24 No. 3	IEEE	USA	2014	4802806	CDS Link	Yes
25	Development of superconducting links for the Large Hadron Collider machine	Ballarino, A.	Superconductor Science and Technology	Volume 27, No. 4	IOP Publishing	UK	2014	044024	CDS Link	Yes
26	Simulations of fast crab cavity failures in the high luminosity Large Hadron Collider	Yee-Rendon, B. et al	Physical Review Special Topics - Accelerators And Beams	Volume 17, N. 5	APS Physics	USA	2014	051001	CDS Link	Yes
27	Pile up management at the high-luminosity LHC and introduction to the crab-kissing concept	Fartoukh, S.	Physical Review Special Topics - Accelerators And Beams	Volume 17, N. 11	APS Physics	USA	2014	111001	CDS Link	Yes
28	Characterization of Mechanical Properties of MgB2 conductor for the Superconducting Link Project at CERN	Sugano, M. et al	IEEE Transactions on Applied Superconductivity	Volume 25, N. 3	IEEE	USA	2015	4801004	Link	Yes
29	Coil End Optimization of the Nb3Sn Quadrupole for the High Luminosity LHC	Izquierdo, S. et al	IEEE Transactions on Applied Superconductivity	Volume 25, N. 3	IEEE	USA	2015	4001504	CDS Link	Yes
30	Support Structure Design of the Nb3Sn Quadrupole for the High Luminosity LHC	Juchno, M. et al	IEEE Transactions on Applied Superconductivity	Volume 25, N. 3	IEEE	USA	2015	4001804	Link	Yes
31	Test Results of the LARP HQ02b Magnet at 1.9 K	Bajas, H. et al	IEEE Transactions on Applied Superconductivity	Volume 25, N. 3	IEEE	USA	2015	4003306	CDS Link	Yes

32	Model Magnet Development of D1 Beam Separation Dipole for the HL-LHC Upgrade	Nakamoto, T. et al	IEEE Transactions on Applied Superconductivity	Volume 25, N. 3	IEEE	USA	2015	4000505	Link	Yes
33	NbTi Superferric Corrector Magnets for the LHC Luminosity Upgrade'	Volpini, G. et al	IEEE Transactions on Applied Superconductivity	Volume 25, N. 3	IEEE	USA	2015	4002605	Link	Yes
34	A Nb-Ti 90 mm Double-aperture Quadrupole for the High Luminosity LHC Upgrade	Segreti, M. et al	IEEE Transactions on Applied Superconductivity	Volume 25, N. 3	IEEE	USA	2015	4001905	Link	Yes
35	Quench Property of Twisted-Pair MgB2 Superconducting Cables in Helium Gas	Spurrell, J. et al	IEEE Transactions on Applied Superconductivity	Volume 25, N. 3	IEEE	USA	2015	6200105	Link	Yes
36	Support Structure Design of the Nb3Sn Quadrupole for the High Luminosity LHC	Juchno, M. et al	IEEE Transactions on Applied Superconductivity	Volume 25, N. 3	IEEE	USA	2015	4001804	Link	Yes
37	Study of Quench Protection for the Nb3Sn Low-β Quadrupole for the LHC Luminosity Upgrade (HiLumi-LHC)	Todesco, E (CERN) et al	IEEE Transactions on Applied Superconductivity	Volume 25, N. 3	IEEE	USA	2015	4002905	CDS Link	Yes
38	Quench Propagation in Nb3Sn Rutherford Cables for the Hi-Lumi Quadrupole Magnets	Fleiter, J. et al	IEEE Transactions on Applied Superconductivity	Volume 25, N. 3	IEEE	USA	2015	4802504	Link	Yes
39	Nb3Sn High Field Magnets for the High Luminosity LHC Upgrade Project	Volpini, G. et al	IEEE Transactions on Applied Superconductivity	Volume 25, N. 3	IEEE	USA	2015	4002107	Link	Yes
40	Field Quality and Mechanical Analysis of the Beam Separation Dipole for HL-LHC Upgrade	Sugano, M. et al	IEEE Transactions on Applied Superconductivity	Volume 25, N. 3	IEEE	USA	2015	4001105	Link	Yes
41	Prototyping, and testing of a compact superconducting double quarter wave crab cavity	Xiao, B. et al	Physical Review Special Topics - Accelerators And Beams	Volume 18, N. 4	APS Physics	USA	2015	041004	Link	Yes

5.2. SECTION B: EXPLOITABLE FOREGROUND

5.2.1. List of applications for patents

Table B1: List of applications for patents, trademarks, registered designs, etc.

Type of IP Rights: Patents, Trademarks, Registered designs, Utility models, Others	Confidential (yes, no)	Foreseen embargo date dd/mm/yyyy	Application reference(s) (e.g. EP123456)	Subject or title of application	Applicant(s) (as on the application)	Intellectual property Organization
Patent	No	N/A	WO2014207130	AC-Current Induced Quench Protection System	CERN	WIPO
Patent	Yes	10/06/2016	14197216.6	Closed Cycle Cryogen Recirculation System and Method	CERN	EPO
Patent	No	N/A	WO2015062657	A molybdenum carbide / carbon composite and manufacturing method	CERN, Brevetti Bizz	WIPO
Patent	Yes	03/03/2017	15179513.5	Continuously transposed conducting cable	CERN	EPO

5.2.2. Exploitable foreground

	Table B2: Exploitable foreground								
Foreground Number	**Type of Exploitable Foreground[12]**	**Description of exploitable foreground**	**Confidential (yes, no)**	**Foreseen embargo date dd/mm/yyyy**	**Exploitable product(s) or measure(s)**	**Sector(s) of application[13]**	**Timetable for commercial or any other use**	**Patents or other IPR exploitation (licences)**	**Owner & Other Beneficiary(s) involved**
1.1	Exploitation of R&D results via standards	Component Standards and QA for in-kind contribution	No	N/A	QA documentation	Scientific research and development	Now	--	CERN, UK Universities and STFC, INFN, CEA, KEK
1.2	General advancement of knowledge	Radioprotection Studies in highly activated areas	No	N/A	International network of ITHACA, radiation safety studies	Scientific research and development	Now	--	CERN
1.3	General advancement of knowledge	New Collaboration Model for HiLumi construction phase	No	N/A	Number of in-kind contribution, Collaboration Agreements	Scientific research and development	Now	--	CERN
1.4	General advancement of knowledge	Presentation of HiLumi and Particle Physics to general public	No	N/A	Database of HiLumi outreach talks	Scientific research and development and Cultural Education	Now	--	CERN
2.1	General advancement of knowledge	Field Quality for high field magnets	No	N/A	Parameter list for the HL-LHC machine and	Scientific research and development	Now	--	CERN

[12] Type of foreground: General advancement of knowledge, Commercial exploitation of R&D results, Exploitation of R&D results via standards, exploitation of results through EU policies, exploitation of results through (social) innovation.

[13] Type of sector (NACE nomenclature): http://ec.europa.eu/competition/mergers/cases/index/nace_all.html

					new optics design				
2.2	General advancement of knowledge	Beam-Beam effects	No	N/A	Study report	Scientific research and development	Now	--	CERN
2.3	General advancement of knowledge	ATS Scheme	No	N/A	New optics design	Scientific research and development	Now	--	CERN
2.4	General advancement of knowledge	Crab-kissing scheme	No	N/A	Scientific report	Scientific research and development	Medium Term	--	CERN
3.1	General advancement of knowledge	Design of Nb3Sn collider magnets	No	N/A	First hardware model	Scientific research and development	Now	--	CERN, associated US laboratories (LARP)
3.2	General advancement of knowledge	Magnet cooling studies	No	N/A	Report on study	Scientific research and development	Medium & Long Term	--	CERN, associated US laboratories (LARP)
3.3	General advancement of knowledge	Superferric corrector magnets	No	N/A	Hardware models and scientific publication	Scientific research and development	Medium & Long Term	--	INFN, CERN, CEA, CIEMAT
4.1	General advancement of knowledge	Compact crab cavity design	No	N/A	Hardware models and scientific publication	Scientific research and development	Medium & Long Term	--	CERN, associated US laboratories (LARP), KEK
4.2	General advancement of knowledge	Complete cryo-module design and construction for SPS	No	N/A	Engineering design and scientific publication	Scientific research and development	Medium Term	--	CERN, associated US laboratories (LARP), KEK
5.1	General advancement of knowledge	Energy deposition by radiation	No	N/A	High energy density impact test and scientific	Scientific research and development	Short & Medium Term	--	CERN

					publication				
5.2	General advancement of knowledge	Beam halo Studies for Dispersion Suppressor	No	N/A	Report on studies	Scientific research and development	Short, Medium & Long Term	--	CERN
6.1	Commercial exploitation of R&D results	Development of high quality round wires of MgB2	No	N/A	Publications and first industrial production	Scientific research and development, Electric Power Generation, Transmission and Distribution	Short, Medium & Long Term	--	CERN
6.2	Commercial exploitation of R&D results	Development of a Superconducting Link system	No	N/A	Publication and hardware model	Scientific research and development, Electric Power Generation, Transmission and Distribution	Short, Medium & Long Term	--	CERN

In the following table, we summarize for a selection of major foreground topics, relevant information under the headings requested by the Commission. This table and Table B2 are indexed by a foreground number ["WP#.#"].

Foreground no.	Its purpose	How the foreground might be exploited, when and by whom	IPR exploitable measures taken or intended	Further research necessary, if any	Potential/expected impact (quantify where possible)
1.1	In HiLumi some critical components are designed and manufactured by non-CERN Member State collaborators. Assuring a coherent QA and best engineering practice is critical, and the use of national/regional standards is also critical for keeping cost low without compromising quality.	HL-LHC is the first large accelerator project where the common QA and the exchange on best practices are built-in from the beginning of the construction phase. All Institutes will learn how to collaborate in a way that guarantees quality without increasing cost. Industry will also learn from the exercise. All HL-LHC beneficiaries, FCC (Eurocircle) members will benefit from this.	Open	The system put in place for HiLumi needs to be tested up to the end and then compared with systems of other large projects, like ITER, ESS, etc.	A coherent European accelerator community operating a "distributed" laboratory, including CERN, including national labs, universities and specialized institutes
1.2	Applying ALARA (As Low As Reasonable Achievable, a radiation safety principle for minimizing doses and releases) principle at an early stage of design will have a better impact on what happens at late stage of the project (e.g. assessing the dose for people intervening on the HiLumi machine).	It will be exploited by HL-LHC. The foreground is triggering the use of a new system at CERN (remote handling, remote survey, augmented reality) and is considered for FCC and CLIC and other High intensity accelerators.	Open	The use of remote handling suitable for large superconducting magnets needs further development and augmented reality needs to enter in the culture of maintenance for HL-LHC.	Less dose to personnel involved in maintenance and increase in machine availability.
1.3	Enable the HiLumi project to be built in a true collaborative way, making the best use not only of the resources but also of the intellectual contribution of external Institutes.	It is being exploited already by HL-LHC and in perspective by future large projects like FCC or any future accelerator done in collaborative manner.	Open	Assess sustainability of the model during the project evolution.	Transforming the model of accelerator construction toward a collaborative effort from its conception.

1.4	Via HiLumi results, to publicize the strong technological impact of fundemental research while making aware of the intrinsic value increase of basic science.	The database of outreach talks from HiLumi members, collected in CDS are available for schools professors, and other education operators to be freely used and adapted at courses for pupils and students of different background and age.	Open	N/A	Make it clear for the policy makers and the public that basic research, and Higgs boson discovery, rely on technologies beyond the state-of-the-art, with very significant spin-off to society.
2.1	Determine a set of Field Quality targets valid for new generation superconducting magnets (Nb3Sn) with higher field than the one in LHC.	The next generation of accelerators will rely on this work for optics design, since HL-LHC is the first accelerator using Nb3Sn. It might be exploited by FCC, the Chinese electron-proton / hh collider (CEPC-hh). EuCARD-2 is also considering benefitting from it.	Open	Make sure that the values can be maintained during construction and devise mitigation measure of the Field Quality.	Release field quality targets to lower value may have a big impact on the magnet cost with potential large savings in large accelerators.
2.2	Intense beam collider with high luminosity have strong beam-beam interaction, strongly influencing stability.	Exploited by LHC already now and in perspective exploitable by any large hadron colliders, making beam-beam as part of the initial design. It will be exploited by HL-LHC, FCC and any intense beam collider, like the CEPC-hh.	Open	To verify if the measures taken under HiLumi to compensate the beam-beam are successful.	Strong impact on HiLumi luminosity regime and on FCC design.
2.3	ATS improves dramatically the luminosity performance in any circular collider. In HiLumi it makes possible exploiting the large aperture offered by Nb3Sn.	HiLumi will use it in all its life, but is likeable that present LHC will also exploit it. BNL is considering applying ATS for RHIC. It can be exploited by FCC, EuCARD2 and any high luminosity circular colliders.	Open	Verify ATS viability in machine with real imperfection and that is not endangering machine protection.	ATS may enhance the luminosity of any hadron collider by a factor 2-3. FCC design may depend critically on it.
2.4	To enhance effective luminosity. It will improve the quality of data taking of the experiments.	HL-LHC may use it in all its life, but is likeable that present LHC will also exploit it. It is potentially interesting for FCC as well.	Open	It is not included in the baseline as it still requires machine development (MD) studies to experimentally prove the soundness of the theory.	It may enhance the effective luminosity by decreasing the pile up density by a factor of 2.
3.1	Nb3Sn magnets are needed for larger	The foreground will be exploited by	open	Check that long prototypes behave	This foreground is the

	apertures and higher field, strongly increasing the performance of accelerators.	the HL-LHC project now and in the next decade. Nb3Sn will be used in future large accelerators (FCC, CEPC-hh…). It might be also exploited in relation to medical accelerators, NMR, MRI.		as good as short models.	technological proof necessary for FCC and/or any other hadron colliders beyond LHC, so it will have a large impact on particle physics.
3.2	Cooling has a large influence on performance and cost of superconducting accelerators (choice between HEII, or supercritical He or saturated He)	Using the results of the project, HL-LHC magnets and new cryogenics plant are being designed. The study is being used also by FCC (EuroCirCol Design Study) for cryogenic/field optimization. It might be also exploited in relation to medical accelerators, NMR, MRI.	open	N/A	Impact on HL-LHC and FCC infrastructure and potentially on CEPC-hh), as well as on performance (luminosity for HL-LHC and energy reach or tunnel length for FCC)
3.3	Design of compact corrector magnets of sharp edge effects, robust in high radiation environment and with negligible power consumption.	HL-LHC is based on this foreground that can possibly be used also for FCC and nuclear physics accelerators, as well as medical accelerators	open	Test of a prototype of each high order magnets (quadrupole, sextupole, etc..)	The accelerator interaction regions become shorter and more efficient and less expensive. Future accelerators (FCC, CEPC-hh but also smaller ones) will also use this feature.
4.1	Crab cavity is a new device that is able to manipulate transversally beams at tens of fs level and therefore can increase luminosity by compensating the crossing angle.	This object is already part of the HL-LHC baseline. It will also be used for electron linear colliders, ILC and CLIC	open	Carry out Crab cavity test on hadron beam in the SPS	Increase integrated luminosity in any future accelerators.
4.2	Given the absolute novelty of Crab Cavity, a test in the SPS is necessary to assess their actual behaviour. For these tests a complete system with cryo-module including all cryogenics and RF service, is needed.	HL-LHC and LARP in 2018. It might be used for electron linear colliders, ILC and CLIC	open	Test of cryo-module in the cryogenic test facility (at CERN or Uppsala)	Enable the use of Crab cavity. Open the way for use this device routinely in future accelerators such as FCC and CEPC-hh.
5.1	Hilumi assessing the robustness of the collimator vs energy deposition by beam or by debris was critical regarding the correct design and choice	HL-LHC includes the robust collimator, low impedance, halo removal in the baseline. Also FCC or other hadron collider (FAIR-	open	Some mechanical and thermal tests remain to be done	Can be of relevance for any equipment facing severe irradiation, like frontier accelerators, nuclear reactors,

	of material. The robustness is coupled with low impedance material for which energy deposition studies are critical.	SIS300) could use it. Other potential benefiters are EuCARD2, FCC any other high intensity machine			tokamaks…
5.2	The halo studies have evidenced the need for collimation in the cold region (Dispersion Suppressor) of LHC	HL-LHC includes the robust collimator, low impedance, halo removal in the baseline. Also FCC or other hadron colliders (e.g. FAIR-SIS300) could use it. Other potential benefiter is EuCARD2	open	Two more years to demonstrate performance and integration with 11T dipole	Overcome limitation due to the diffraction limit in future accelerators.
6.1	The choice of MgB2 provides the lowest cost of the new superconductors: round wire is the best geometry for making superconducting cables for high currents and high temperature (>20K), necessary for the HiLumi SC links.	The SC Links are now included in the HL-LHC baseline design. Any future accelerator with large amperage at low temperatures will consider it. FCC or CEPC-hh. Electrical distribution companies are also already considering its exploitation.	open	Test of long cable prototypes	Bedside large impact on accelerators there will be impact of medium field magnets for energy markets and on power transmission cable
6.2	To remove the power converter from the tunnel the cold powering needs a complete SC link system, where the cable functionality is integrated in the system (junctions, protection, current leads, their feedbox- cryostat, etc.…)	SC link system is included in the HL-LHC baseline. FCC and other future accelerators will use these developments. Electrical distribution companies are also already considering the exploitation of the power transmission lines	open	Test of long powering system with SC links	Large impact can be foreseen on Transmission power cables, especially for renewable energy (solar farms and, off-shore Eolic parks need long transmission lines), so Electrical Distribution companies may strongly benefit by this.

ANNEX I: TABLE A2 - LIST OF DISSEMINATION ACTIVITIES

Table A2: List of dissemination activities								
No	**Type of activities[14]**	**Lead author (institute)**	**Title**	**Date/Period**	**Place**	**Type of audience[15]**	**Size of audience**	**Countries addressed**
1 CDS Link	Article/Misc	CERN Bulletin	EU supports the LHC high-luminosity study, *CERN Bulletin*	7 Nov 2011	Geneva, Switzerland	Scientific Community, Civil Society	--	International
2 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	LHC, un'impresa scientifica, un'avventura Umana	11 Nov 2011	Lecce, Italy	Civil Society	50	Italy
3 Link	Oral Presentation to a Scientific Event	Burov, A. (Fermilab)	Beam stability in LHC with crab cavities, *LHC-CC11 workshop*	14 Nov 2011	Geneva, Switzerland	Scientific Community		International
4 CDS Link	Press release	CERN Press Office	CERN has 2020 vision for LHC upgrade	16 Nov 2011	Geneva, Switzerland	Civil Society, Scientific Community, Medias	--	International
5 Link	Article /Misc	Phys.org	CERN has 2020 vision for LHC upgrade, *Phys.org*	16 Nov 2011	Geneva, Switzerland	Civil Society, Scientific Community	--	International
6 Link	Article /Misc	Interactions. org	CERN has 2020 vision for LHC upgrade, *Interactions.org*	16 Nov 2011	Geneva, Switzerland	Civil Society, Scientific Community	--	International
7 CDS Link	Article	Evans, R. (Reuters)	"Big Bang" machine to get huge upgrade in 2020, *Reuters*	17 Nov 2011	Geneva, Switzerland	Civil Society	--	International
8	Article / Misc	Heuer, R.	The LHC: a week for taking stock, pushing	21 Nov 2011	Geneva,	Scientific	--	International

[14] Dissemination activities: publications, conferences, workshops, web, press releases, flyers, articles published in the popular press, videos, media briefings, presentations, exhibitions, thesis, interviews, films, TV clips, posters, Other.

[15] Type of public: Scientific Community (higher education, Research), Industry, Civil Society, Policy makers, Medias, Other ('multiple choices' is possible).

CDS Link		(CERN)	boundaries and for long-term planning		Switzerland	Community		
9 CDS Link	Article published in the popular press	Evans, R. (Reuters)	"Big Bang" Machine to Get Huge Upgrade in 2020, *Onislam*.	21 Nov 2011	Geneva, Switzerland	Civil Society	--	International
10 CDS Link	Article / Misc	Sutton, C. (CERN)	IPAC'11 brings the world to San Sebastián, *CERN Courier*	23 Nov 2011	Geneva, Switzerland	Scientific Community	--	International
11 CDS Link	Article / Misc	INFN LHC Italia	A LHC si guarda al futuro	24 Nov 2011	Geneva, Switzerland	Scientific Community	--	International
12 CDS Link	Oral Presentation to a Scientific Event	Rossi, L. (CERN)	LHC del CERN, la vista piu' profonda, *Congresso Nazionale SOI – Societa Italiana di Oftamologia*	24 Nov 2011	Milan, Italy	Scientific Community, Civil Society	100	Italy
13 CDS Link	Article published in the popular press	--	Il CERN ha stanato il "bosone di Higgs", *Il giornale del popolo.*	14 Dec 2011	Lugano, Switzerland	Civil Society	--	Switzerland
14 CDS Link	Article / Misc	Kahle, K.	HiLumi LHC begins	15 Dec 2011	Geneva, Switzerland	Scientific Community, Civil Society	--	International
15 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	Domande e certezze nel mondo dei quark: il Large Hadron Collider (LHC) del CERN	19 Dec 2011	Pesaro, Italy	Civil Society	500	Italy
16 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	Quando l'avventura della conoscenza diventa una grande impresa scientifica	20 Dec 2011	Pesaro, Italy	Civil Society	50	Italy
17 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	Domande e certezze nel mondo dei quark: il Large Hadron Collider (LHC) del CERN	20 Jan 2012	Varese, Italy	Civil Society	50	Italy
18 CDS Link	Article / Misc	CERN Courier	Meeting sets scene for LHC-luminosity upgrade, *CERN Courier*	25 Jan 2012	Geneva, Switzerland	Scientific Community	--	International
19 CDS Link	Article / Misc	CERN Bulletin	4th report from the LHC performance workshop, *CERN Bulletin*	6 Feb 2012	Geneva, Switzerland	Scientific Community, Civil Society	--	International
20 CDS Link	Article / Misc	O'Luanaigh, C. (CERN)	Chamonix: Challenges for the High Luminosity LHC	6 Feb 2012	Geneva, Switzerland	Scientific Community	--	International
21	Paper in	Calaga, R.	Crab Cavities for the LHC Upgrade,	6 Feb 2012	Geneva,	Scientific	--	International

CDS Link	proceedings of a Conference/ Workshop	(CERN)	*Proceedings of Chamonix 2012 workshop on LHC Performance, Chamonix, France, 6-10 Feb 2012, pp. 363.*		Switzerland	Community		
22 Link	Paper in proceedings of a Conference/ Workshop	Brunning, O. (CERN) et al	HL-LHC Parameter Space and Scenarios, *Proceedings of Chamonix 2012 workshop on LHC Performance, Chamonix, France, 6-10 Feb 2012, pp. 315.*	6 Feb 2012	Chamonix, France	Scientific Community	--	International
23 CDS Link	Paper in proceedings of a Conference/ Workshop	Rossi, L. (CERN) et al	Summary of Session 9 "LHC-related Projects and Studies (II)", *Proceedings of Chamonix 2012 workshop on LHC Performance, Chamonix, France, 6-10 Feb 2012*	6 Feb 2012	Chamonix, France	Scientific Community	--	International
24 CDS Link	Article / Misc	Kahle, K. (CERN) et al	Designs on higher luminosity, *CERN Courier*	23 Feb 2012	Geneva, Switzerland	Scientific Community, Civil Society	--	International
25 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	Gewissheit über Dinge, die wir noch nie gesehen haben	2 Mar 2012	Cologne, Germany	Civil Society	300	Germany
26 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	HiLumi Program, technologies and opportunities, *ILO Forum*	15 Mar 2012	CERN, Switzerland	Industry	100	International
27 CDS Link	Article / Misc	Schaffer, A. (CERN)	The LHC and its successors, *CERN Bulletin*	19 Mar 2012	Geneva, Switzerland	Scientific Community, Civil Society	--	International
28 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	LHC, per vedere piu in là…della materia	20 Mar 2012	Rimini, Italy	Civil Society	4000	Italy
29 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	Atomo indivisibile? Domande e certezze nella Scienza	22 Mar 2012	Saronno, Italy	Civil Society	100	Italy
30 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	Atomo indivisible? LHC e la nuova frontiera dell'infinitamente piccolo a cent'anni da Rutherford	23 Mar 2012	Trento, Italy	Civil Society	100	Italy
31 CDS Link	Workshop Summary	Arduini, G. (CERN) et al	5th LHC Crab Cavity Workshop, LHC-CC11 Workshop Summary Report	5 Apr 2012	Geneva, Switzerland	Scientific Community	--	International

32 CDS Link	Article / Misc	Fartoukh, S. (CERN) et al	A first layout for the High Luminosity LHC	8 Apr 2012	Geneva, Switzerland	Scientific Community	--	International
33 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	Di cosa è fatta la materia? Domande e certezze nell'LHC del CERN	12 Apr 2012	Seveso, Italy	Civil Society	100	Italy
34 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	LHC del CERN e le nuove frontiere dell'infinitamente piccolo	13 Apr 2012	Bassano del Grappa, Italy	Civil Society	150	Italy
35 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	Quando l'avventura della conoscenza diventa una grande impresa scientifica	13 Apr 2012	Milano, Italy	Civil Society	100	Italy
36 CDS Link	Oral Presentation to a Scientific Event	Rossi, L. (CERN)	LHC and the role of Superconductivity in the hunt for the Higgs boson	15 Apr 2012	Houston, USA	Scientific Community, Policy Makers	120	USA
37 CDS Link	Paper in proceedings of a Conference/ Workshop	Baer, T. (CERN) et al	LHC Machine Protection Against Very Fast Crab Cavity Failures, *Proceedings of IPAC2011, SAN Sebastian, Spain,, 4-9 sEP 2011, pp. 1816.*	23 Apr 2012	San Sebastian, Spain	Scientific Community	--	International
38 CDS Link	Article / Misc	Kahle, K. et al	Accelerating News Issue 1	24 Apr 2012	Geneva, Switzerland	Civil Society, Scientific Community	--	International
39 CDS Link	Oral Presentation to a Scientific Event	Rossi, L. (CERN)	HiLumi Program, technologies and opportunities, *EUSPEN*	3 May 2012	Thoriy, France	Industry	100	International
40 CDS Link	Paper in proceedings of a Conference/ Workshop	Fartoukh, S. (CERN) et al	Optics and Layout Solutions for HL-LHC with Large Aperture NB3SN and NB-TI Inner Triplets, P*resented at the International Particle Accelerator Conference (IPAC'12), New Orleans, Louisiana, USA, 20-25 May 2012.*	21 May 2012	New Orleans, USA	Scientific Community	--	International
41 CDS Link	Paper in proceedings of a Conference/ Workshop	Hall, B. (ULANC) et al	Analysis of the Four Rod Crab Cavity for HL-LHC, *Proceedings of IPAC12, New Orleans, Louisiana, USA, 20-25 May 2012, pp. 2275.*	21 May 2012	New Orleans, USA	Scientific Community	--	International
42	Paper in	De Silva, S.	Design and Development of Superconducting	21 May 2012	New Orleans,	Scientific	--	International

CDS Link	proceedings of a Conference/ Workshop	(ODU) et al	Parallel-bar Deflecting/Crabbing Cavities, *Proceedings of IPAC12, New Orleans, Louisiana, USA, 20-25 May 2012, pp. 2453.*		USA	Community		
43 CDS Link	Paper in proceedings of a Conference/ Workshop	Nosochkov, Y (SLAC), et al	Field Tolerances for the Triplet Quadrupoles of the LHC High Luminosity Lattice, *Proceedings of IPAC12, New Orleans, Louisiana, USA, 20-25 May 2012, pp. 169-171.*	21 May 2012	New Orleans, USA	Scientific Community	--	International
44 CDS Link	Paper in proceedings of a Conference/ Workshop	Holzer, B. et al	Optics and lattice optimizations for the LHC upgrade project, *Proceedings of IPAC12, New Orleans, Louisiana, USA, 20-25 May 2012, pp.151*	21 May 2012	New Orleans, USA	Scientific Community	--	International
45 CDS Link	Paper in proceedings of a Conference/ Workshop	De Maria, R. (CERN) et al	Parametric Study of Optics Options for the HL-LHC Project, *Proceedings of IPAC12, New Orleans, Louisiana, USA, 20-25 May 2012, pp.1873.*	21 May 2012	New Orleans, USA	Scientific Community	--	International
46 CDS Link	Paper in proceedings of a Conference/ Workshop	Barranco García, J (CERN) et al	Study of Multipolar RF Kicks from the main deflecting mode in Compact Crab Cavities for LHC, *Proceedings of IPAC12, New Orleans, Louisiana, USA, 20-25 May 2012, pp.142.*	21 May 2012	New Orleans, USA	Scientific Community	--	International
47 CDS Link	Paper in proceedings of a Conference/ Workshop	Metral, E. (CERN) et al	Collective effects in the LHC and its injector complex, *Proceedings of IPAC12, New Orleans, Louisiana, USA, 20-25 May 2012.*	21 May 2012	New Orleans, USA	Scientific Community	--	International
48 Link	Paper in proceedings of a Conference/ Workshop	Alesini, D. (CERN) et al	Experimental measurements clearing electrodes in the Dafne collider, *Proceedings of IPAC12, New Orleans, Louisiana, USA, 20-25 May 2012.*	21 May 2012	New Orleans, USA	Scientific Community	--	International
49 CDS Link	Paper in proceedings of a Conference/ Workshop	Rijoff, T. (CERN) et al	Simulation studies for the LHC long-range beam-beam compensators, *Proceedings of IPAC12, New Orleans, Louisiana, USA, 20-25 May 2012.*	21 May 2012	New Orleans, USA	Scientific Community	--	International
50 CDS Link	Paper in proceedings of a Conference/ Workshop	Bruning, O. (CERN) et al	Parameter Space for the LHC High-Luminosity Upgrade, *Proceedings of IPAC12, New Orleans, Louisiana, USA, 20-25 May 2012.*	21 May 2012	New Orleans, USA	Scientific Community	--	International
51	Paper in	Barranco	Study of Multipolar RF Kicks from the main	21 May 2012	New Orleans,	Scientific	--	International

CDS Link	proceedings of a Conference/ Workshop	García, R (CERN) et al	deflecting mode in Compact Crab Cavities for LHC, *Proceedings of IPAC12, New Orleans, Louisiana, USA, 20-25 May 2012, pp. 1873.*		USA	Community		
52 CDS Link	Paper in proceedings of a Conference/ Workshop	Ficcadenti, L (CERN) et al	Slim elliptical cavity at 800 MHz for local crab crossing, *Proceedings of IPAC12, New Orleans, Louisiana, USA, 20-25 May 2012, pp. 2263.*	21 May 2012	New Orleans, USA	Scientific Community	--	International
53 CDS Link	Paper in proceedings of a Conference/ Workshop	Calaga, R (CERN) et al	A quarter wave design for crab crossing in the LHC, *Proceedings of IPAC12, New Orleans, Louisiana, USA, 20-25 May 2012, pp. 2260.*	21 May 2012	New Orleans, USA	Scientific Community	--	International
54 CDS Link	Paper in proceedings of a Conference/ Workshop	Baer, T. (CERN) et al	Very fast LHC Crab cavity failures and their mitigation, *Proceedings of IPAC12, New Orleans, Louisiana, USA, 20-25 May 2012.*	21 May 2012	New Orleans, USA	Scientific Community	--	International
55 CDS Link	Paper in proceedings of a Conference/ Workshop	Hall, B. (ULANC) et al	Analysis of the Four Rod Crab Cavity for HL-LHC, *Proceedings of IPAC12, New Orleans, Louisiana, USA, 20-25 May 2012, pp. 2275.*	21 May 2012	New Orleans, USA	Scientific Community	--	International
56 CDS Link	Paper in proceedings of a Conference/ Workshop	De Silva, S U (ODU) et al	Design and Development of Superconducting Parallel-bar Deflecting/Crabbing Cavities, *Proceedings of IPAC12, New Orleans, Louisiana, USA, 20-25 May 2012, pp. 2453.*	21 May 2012	New Orleans, USA	Scientific Community	--	International
57 CDS Link	Paper in proceedings of a Conference/ Workshop	Barranco García, J (CERN) et al	Study of Multipolar RF Kicks from the main deflecting mode in Compact Crab Cavities for LHC, *Proceedings of IPAC12, New Orleans, Louisiana, USA, 20-25 May 2012, pp. 1873.*	21 May 2012	New Orleans, USA	Scientific Community	--	International
58 CDS Link	Paper in proceedings of a Conference/ Workshop	Calaga, R (CERN) et al	Proton-beam emittance growth in SPS coasts, *Proceedings of IPAC12, New Orleans, Louisiana, USA, 20-25 May 2012, pp. 3737.*	21 May 2012	New Orleans, USA	Scientific Community	--	International
59 Link	Paper in proceedings of a Conference/ Workshop	Gorelov, D. et al	Engineering of a Superconducting 400 MHz Crabbing Cavity for the LHC HiLumi Upgrade, *Proceedings of IPAC12, New Orleans, Louisiana, USA, 20-25 May 2012, pp. 2411.*	21 May 2012	New Orleans, USA	Scientific Community	--	International

60 CDS Link	Paper in proceedings of a Conference/ Workshop	Wu, Q (Brookhaven) et al	HOM Damping and Multipacting Analysis of the Quarter-wave Crab Cavity, *Proceedings of IPAC12, New Orleans, Louisiana, USA, 20-25 May 2012, pp. 2020.*	21 May 2012	New Orleans, USA	Scientific Community	--	International
61 CDS Link	Paper in proceedings of a Conference/ Workshop	Auchmann, B. et al	Magnetic Analysis of a Single-Aperture 11T Nb3Sn Demonstrator Dipole for LHC Upgrades, *Proceedings of IPAC12, New Orleans, Louisiana, USA, 20-25 May 2012, pp. 3596.*	21 May 2012	New Orleans, USA	Scientific Community	--	International
62 CDS Link	Oral Presentation to a Scientific Event	Rossi, L. (CERN)	LHC & LHC uprages(s), *10emes Journees de Xryogenie et de Supraconductivite*	5-8 Jun 2012	Aussois	Scientific Community, Policy Makers	50	International
63 CDS Link	Oral Presentation to a Scientific Event	Rossi, L. (CERN)	LHC Upgrade(s)	21 Jun 2012	Daresbury, UK	Scientific Community	--	International
64 CDS Link	Article / Misc	Kahle, K. et al	Accelerating News Issue 2	27 Jun 2012	Geneva, Switzerland	Civil Society, Scientific Community	--	International
65 CDS Link	Article Published in the Popular Press	Braga, E.	Perche fermarsi al penultimo passo?, *Rivista internazionale di comunione e liberazioone*	1 Jul 2012	--	Civil Society	--	Italy
66 CDS Link	Article Published in the Popular Press	Casotto, U. (Tempi)	La certezza del mistero, *Tempi.*	18 Jul 2012	--	Civil Society	--	Italy
67 CDS Link	Oral Presentation to a Scientific Event	Rossi, L. (CERN)	DOE review of LARP	9 July 2012	SLAC, USA	Scientific Community, Policy Makers	50	International
68 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	Tecnologie avanzate per l'avventura della conoscenza: il Large Hadron Collider (LHC) del CERN	27 July 2012	San Miniato, Italy	Civil Society	100	Italy
69 CDS Link	Scientific / Technical Note	Brining, O. et al	High Energy LHC - Document prepared for the European HEP strategy update	1 Aug 2012	Geneva, Switzerland	Scientific Community	--	International
70 CDS Link	Scientific / Technical Note	Rossi, L. (CERN) et al	High Luminosity Large Hadron Collider - A description for the European Strategy Preparatory Group	1 Aug 2012	Geneva, Switzerland	Scientific Community	--	International

71 CDS Link	Article/Misc	Schaeffer, A.	Small but powerful, *CERN Bulletin*	27 Aug 2012	Geneva, Switzerland	Scientific Community, Civil Society	--	International
72 CDS Link	Article/Misc	Schaeffer, A.	Warmer amps for the LHC, *CERN Bulletin*	27 Aug 2012	Geneva, Switzerland	Scientific Community, Civil Society	--	International
73 CDS Link	Oral Presentation to a Scientific Event	Rossi, L. (CERN)	Plan and Options for LHC Upgrades, *GFA & SwissFEL Accelerator Seminar*	3 Sep 2012	PSI, Villigen, Switzerland	Scientific Community	100	International
74 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	All'origine dell'universo: Fede e scienza, scontro o dialogo?	13 Sep 2012	Caorso, Italy	Civil Society	150	Italy
75 Link	Thesis/Dissertation	Takala, E.	The laser quenching technique for studying the magneto-thermal instability in high critical current density superconducting strands for accelerator magnets.	Sept 2012	Turku, Finland	Scientific Community	--	International
76 CDS Link	Oral Presentation to a Scientific Event	Rossi, L. (CERN)	Superconducting and cryogenics tecnologies for the LHC upgrades, *SIF - Societa Italiana di Fisica*	18 Sep 2012	Napoli, Italy	Scientific Community	100	Italy
77 CDS Link	Article / Misc	Kahle, K. at al	Accelerating News Issue 3	26 Sept 2012	Geneva, Switzerland	Civil Society, Scientific Community	--	International
78 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	Il Bosone di Higgs – la particella di Dio - Domande e certezze nella scienza	28 Sep 2012	Seregno, Italy	Civil Society	100	Italy
79 CDS Link	Article published in the popular press	Caprara, G. (Corriere della Sera))	Il signor Rossi e la particella di Dio, *Corriere della Sera*	28 Sept 2012	Milan, Italy	Civil Society	--	Italy
80 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	The mystery of matter: the Higgs boson	3 Oct 2012	Menlo Park, USA	Civil Society	200	USA
81 CDS Link	Oral Presentation to a Scientific Event	Rossi, L. (CERN)	Advances in Applied Superconductivity Technologies for High Luminosity LHC Project, *ASC12 - Advances in Applied SC Conference*	9 Oct 2012	Portland, USA	Scientific Community, Policy Makers	50	International

82 CDS Link	Scientific / Technical Note	Buffat, X. (EPFL) et al	Results of β* luminosity leveling MD	11 Oct 2012	Geneva, Switzerland	Scientific Community	--	International
83 CDS Link	Article / Misc	Schaffer, A. (CERN)	Like hams in a smokehouse, *CERN Bulletin*	22 Oct 2012	Geneva, Switzerland	Scientific Community, Civil Society	--	International
84 CDS Link	Scientific / Technical Note	Schaumann, M. (RWTH Aachen) et al	Intra-beam Scattering and Luminosity Evolution for HL-LHC Proton Beams	22 Oct 2012	Geneva, Switzerland	Scientific Community	--	International
85 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	LHC E l'avventura della persona nell'impresa del più grande strumento scientifico	23 Oct 2012	Milan, Italy	Civil Society	30	Italy
86 CDS Link	Oral Presentation to a Scientific Event	Rossi, L. (CERN)	La scienza e l'idea di ragione, *Festival della Scienza di Genova*	28 Oct 2012	Genova, Italy	Civil Society	150	Italy
87 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	LHC UpgradesTechnolgy & opportunities	6 Nov 2012	CERN, Switzerland	Industry	20	Germany
88 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	DI CERTEZZA IN CERTEZZA - Il motore della ricerca scientifica LHC del CERN	7 Nov 2012	Torino, Italy	Civil Society	50	Italy
89 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	LHC des CERN: Abenteuer der Erkenntnis bei einem großen wissenschaftlichen Vorhaben	27 Nov 2012	Bruchsal, Germany	Civil Society	500	Germany
90 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	LHC des CERN: Abenteuer der Erkenntnis bei einem großen wissenschaftlichen Vorhaben	28 Nov 2012	Heidelberg, Germany	Civil Society	350	Germany
91 CDS Link	Oral Presentation to a Scientific Event	Rossi, L. (CERN)	The High Luminosity LHC Project, *Superconducting technologies for the next generation of accelerators*	4 Dec 2012	CERN, Switzerland	Industry		International
92 CDS Link	Article / Misc	Giampietro, M. (CERN)	Exchanging knowledge with industry on superconducting tech	4 Dec 2012	Geneva, Switzerland	Scientific Community	--	International
93 CDS Link	Article / Misc	Kahle, K. et al	Accelerating News Issue 4	12 Dec 2012	Geneva, Switzerland	Civil Society, Scientific	--	International

						Community		
94 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	Domande e certezze nel mondo dei quark: il Large Hadron Collider (LHC) del CERN	20 Dec 2012	Varese, Italy	Civil Society	55	Italy
95 CDS Link	Scientific / Technical Note	Buffat X. (EPFL) et al.	MD on squeeze with colliding beams	Jan 2013	Geneva, Switzerland	Scientific Community	--	International
96 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	La particella di Higgs: Fine della caccia o inizio di una nuova avventura?	18 Jan 2013	Forli, Italy	Civil Society	250	Italy
97 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	La particella di Higgs: Fine della caccia o inizio di una nuova avventura?	19 Jan 2013	Pesaro, Italy	Civil Society	600	Italy
98 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	La scoperta della "particella di Dio" all'LHC del CERN Scienza e Fede alla ricerca della verità	25 Jan 2013	Lugano, Switzerland	Civil Society	250	Switzerland
99 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	La scoperta della "particella di Dio" all'LHC del CERN Scienza e Fede alla ricerca della verità	26 Jan 2013	Cucciago, Italy	Civil Society	200	Italy
100 CDS Link	Article / Misc	Rossi, L. (CERN)	Superconductivity leads the way to high luminosity, *CERN Courier*	28 Jan 2013	Geneva, Switzerland	Scientific Community	--	International
101 CDS Link	Article / Misc	Sutton, C. (CERN)	Superconductivity leads the way to high luminosity, *CERN Courier*	28 Jan 2013	Geneva, Switzerland	Scientific Community	--	International
102 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	Il Mistero della Materia e la scoperta del bosone di Higgs al CERN	15 Feb 2013	Piacenza, Italy	Civil Society	150	Italy
103 CDS Link	Scientific/ Technical Note	Baudrenghien, P.	Functional Specifications of the LHC Prototype Crab Cavity System	28 Feb 2013	Geneva, Switzerland	Scientific Community	--	International
104 CDS Link	Scientific/ Technical Note	Burov, A (Fermilab)	Three-Beam Instability in the LHC	4 Mar 2013	Geneva, Switzerland	Scientific Community	--	International
105 CDS Link	Oral Presentation to a Scientific Event	Rossi, L. (CERN)	LHC and new technologies to go beyond the Higgs Boson	13 Mar 2013	Milano, Italy	Scientific Community, Policy Makers	80	Italy
106	Oral	Rossi, L.	The LHC, the Higgs boson and	14 Mar 2013	Bologna, Italy	Scientific	250	Italy

CDS Link	Presentation to a Scientific Event	(CERN)	Superconductivity for next generation accelerators at CERN			Community, Policy Makers		
107 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	LHC, per vedere piu in là… della materia	15 Mar 2013	Rimini, Italy	Civil Society	1500	Italy
108 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	Il Bosone di Higgs e il Mistero della Materia: LHC, la nuova frontiera al CERN	16 Mar 2013	Gallarate, Italy	Civil Society	200	Italy
109 CDS Link	arXiv	Stancari, G. (Fermilab) et al	Measurements of the effect of collisions on transverse beam halo diffusion in the Tevatron and in the LHC	18 Mar 2013	Geneva, Switzerland	Scientific Community	--	International
110 CDS Link	Article / Misc	Szeberenyi, A. (CERN) et al	Accelerating News Issue 5	20 Mar 2013	Geneva, Switzerland	Civil Society, Scientific Community	--	International
111 CDS Link	Scientific / technical Note	Buffat, X. (EPFL) et al	Stability of beams colliding with a transverse offset	28 Mar 2013	Geneva, Switzerland	Scientific Community	--	International
112 CDS link	Scientific / technical Note	Wanzenberg , R. (DESY)	Calculation of Wakefield and Higher Order Modes for the New Design of the Vacuum Chamber of the CMS Experiment for the HL-LHC	10 Apr 2013	Geneva, Switzerland	Scientific Community	--	International
113 CDS Link	Oral Presentation to a Scientific Event	Rossi, L. (CERN)	Superconductivity: its Role and Challenges for Next-generation Colliders	11 Apr 2013	Berkley, USA	Scientific Community, Policy Makers	60	USA
114 CDS Link	Oral Presentation to a Scientific Event	Rossi, L. (CERN)	LHC and the role of Superconductivity in the hunt for the Higgs boson	16 Apr 2013	Houston, USA	Scientific Community, Policy Makers	25	USA
115 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	The Mystery of Matter and the hunt for the “God particle"	16 Apr 2013	Houston, USA	Civil Society	600	USA
116 CDS Link	Article / Misc	CERN	The High Luminosity Large Hadron Collider	23 Apr 2013	Geneva, Switzerland	Scientific Community, Civil Society	--	International
117 CDS Link	Article / Misc	CERN Bulletin	The success of the 11-Tesla project and its potential beyond particle physics, *CERN Bulletin*	6 May 2013	Geneva, Switzerland	Scientific Community, Civil Society	--	International

118	Oral Presentation to a Scientific Event	Rossi, L. (CERN)	Manufacturing and Testing based on LHC SC magnet production	8 May 2013	CERN, Switzerland	Scientific Community	--	International
119 CDS Link	Paper in proceedings of a Conference/ Workshop	De Maria, R. (CERN) et al	HLLHCV1.0: HL-LHC layout and optics models for 150 mm Nb3Sn triplets and local crab-cavities, *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013*	12 May 2013	Shanghai, China	Scientific Community	--	International
120 CDS Link	Paper in proceedings of a Conference/ Workshop	Korostelev, M. et al	Optics Transition Between Injection and Collision Optics for the HL-LHC Upgrade Project, *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013*	12 May 2013	Shanghai, China	Scientific Community	--	International
121 CDS Link	Paper in proceedings of a Conference/ Workshop	Dalena, B. et al	High Luminosity LHC matching section layout vs crab cavity voltage, *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013, pp. 1328.*	12 May 2013	Shanghai, China	Scientific Community	--	International
122 CDS Link	Paper in proceedings of a Conference/ Workshop	Nosochkov, Y. et al	Optimization of Triplet Quadrupoles Field Quality for the LHC High Luminosity Lattice at Collision Energy, *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013, pp. 1364.*	12 May 2013	Shanghai, China	Scientific Community	--	International
123 CDS Link	Paper in proceedings of a Conference/ Workshop	De Maria, R. (CERN) et al	Specification of a System of Correctors for the Triplets and Separation Dipoles of the LHC Upgrade, *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013.*	12 May 2013	Shanghai, China	Scientific Community	--	International
124 CDS Link	Paper in proceedings of a Conference/ Workshop	De Maria, R. (CERN) et al	Dynamic Aperture Performance for Different Collision Optics Scenarios for the LHC Luminosity Upgrade, *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013, pp.2609.*	12 May 2013	Shanghai, China	Scientific Community	--	International
125 CDS Link	Paper in proceedings of a Conference/ Workshop	Nosochkov, Y. et al	Evaluation of Field Quality for Separation Dipoles and Matching Section Quadrupoles for the LHC High Luminosity Lattice at Collision Energy, *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013, pp. 1367.*	12 May 2013	Shanghai, China	Scientific Community	--	International
126 CDS Link	Paper in proceedings of a Conference/ Workshop	De Maria, R. (CERN) et al	Specifications of the Field Quality at Injection Energy of the New Magnets for the HL-LHC Upgrade Project, *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013, pp.2603.*	12 May 2013	Shanghai, China	Scientific Community	--	International

127 CDS Link	Paper in proceedings of a Conference/ Workshop	Bogomyagkov, A. et al	Analysis of the Non-linear Fringe Effects of Large Aperture Triplets for the HL-LHC Project, *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013, pp.2615.*	12 May 2013	Shanghai, China	Scientific Community	--	International
128 CDS Link	Paper in proceedings of a Conference/ Workshop	Giovannozzi, M. et al	Analysis of Possible Functional Forms of the Scaling Law for Dynamic Aperture as a Function of Time, *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013, pp.2618.*	12 May 2013	Shanghai, China	Scientific Community	--	International
129 CDS Link	Paper in proceedings of a Conference/ Workshop	De Maria, R. (CERN) et al	Recent Developments and Future Plans for SixTrack, *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013, pp. 948*	12 May 2013	Shanghai, China	Scientific Community	--	International
130 CDS Link	Paper in proceedings of a Conference/ Workshop	De Maria, R. (CERN) et al	Investigation of Numerical Precision Issues of Long Term Single Particle Tracking, *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013, pp. 942*	12 May 2013	Shanghai, China	Scientific Community	--	International
131 Link	Paper in proceedings of a Conference/ Workshop	De Maria, R. (CERN) et al	Study of the IR2 and IR8 Squeezeability for HL-LHC Upgrade *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013, pp. 1361*	12 May 2013	Shanghai, China	Scientific Community	--	International
132 CDS Link	Paper in proceedings of a Conference/ Workshop	Salvant, B (CERN) et al	Update on Beam Induced RF Heating in the LHC, *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013, pp. 1646*	12 May 2013	Shanghai, China	Scientific Community	--	International
133 CDS Link	Paper in proceedings of a Conference/ Workshop	Iadarola, G (U. Naples) et al	Electron Cloud and Scrubbing Studies for the LHC, *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013, pp. 1331*	12 May 2013	Shanghai, China	Scientific Community	--	International
134 CDS Link	Paper in proceedings of a Conference/ Workshop	Métral, E (CERN) et al	Lessons Learnt and Mitigation Measures for the CERN LHC Equipment with RF fingers, *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013, pp. 1802*	12 May 2013	Shanghai, China	Scientific Community	--	International
135 CDS Link	Paper in proceedings of a Conference/	Buffat, X. (EPFL) et al.	Colliding during the squeeze and β levelling in the LHC, *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013, pp. 1415.*	12 May 2013	Shanghai, China	Scientific Community	--	International

	Workshop							
136 CDS Link	Paper in proceedings of a Conference/ Workshop	Esposito, L. et al	Fluka energy deposition studies for the HL-LHC, *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013, pp. 1379.*	12 May 2013	Shanghai, China	Scientific Community	--	International
137 CDS Link	Paper in proceedings of a Conference/ Workshop	Calaga, R. (CERN) et al	First Test Results of the 4-ROD Crab Cavity, *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013, pp. 2405.*	12 May 2013	Shanghai, China	Scientific Community	--	International
138 Link	Paper in proceedings of a Conference/ Workshop	De Silva, S. et al	Compact Superconducting RF-Dipole Cavity Designs for Deflecting and Crabbing Applications, *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013, pp. 2483.*	12 May 2013	Shanghai, China	Scientific Community	--	International
139 CDS Link	Paper in proceedings of a Conference/ Workshop	Li, Zenghai (SLAC) et al	HOM Damping Coupler Design for the 400-MHz RF Dipole Compact Crab Cavity for the LHC HiLumi Upgrade, *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013, pp. 2468.*	12 May 2013	Shanghai, China	Scientific Community	--	International
140 CDS Link	Paper in proceedings of a Conference/ Workshop	Burt, G. (Lancaster U.) et al	Manufacture of a Compact Prototype 4R Crab Cavity for HL-LHC, *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013, pp. 2420.*	12 May 2013	Shanghai, China	Scientific Community	--	International
141 CDS Link	Paper in proceedings of a Conference/ Workshop	Xiao, B. (RIKEN BNL) et al	Mechanical Study of 400 MHz Double Quarter Wave Crab Cavity for LHC Luminosity Upgrade, *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013, pp. 2417.*	12 May 2013	Shanghai, China	Scientific Community	--	International
142 CDS Link	Paper in proceedings of a Conference/ Workshop	Yee-Rendon, B (CINVESTAV Mexico) et al	Machine Protection Studies for a Crab Cavity in the LHC, *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013.*	12 May 2013	Shanghai, China	Scientific Community	--	International
143 CDS Link	Paper in proceedings of a Conference/ Workshop	Navarro M. et al	RF multipolar studies of the latest crab cavities, *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013, pp. 2402.*	12 May 2013	Shanghai, China	Scientific Community	--	International
144	Paper in	Paret, S.	Tune Studies with Beam-Beam Effects in	12 May 2013	Shanghai,	Scientific	--	International

CDS Link	proceedings of a Conference/ Workshop	(LBNL, Berkeley) et al	LHC, *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013, pp. 1703.*		China	Community		
145 CDS Link	Paper in proceedings of a Conference/ Workshop	Calaga, R. (CERN) et al	A double-quarter wave design for the LHC, *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013, pp. 2408.*	12 May 2013	Shanghai, China	Scientific Community	--	International
146 CDS Link	Paper in proceedings of a Conference/ Workshop	Marsili, A. (CERN) et al	Simulations and Measurements of Physics Debris Losses at the 4 Tev LHC, *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013, pp. 984*	12 May 2013	Shanghai, China	Scientific Community	--	International
147 CDS Link	Paper in proceedings of a Conference/ Workshop	Marsili, A. (CERN) et al	Simulations of Collimation Cleaning Performance with HL-LHC Optics, *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013, pp. 987*	12 May 2013	Shanghai, China	Scientific Community	--	International
148 CDS Link	Paper in proceedings of a Conference/ Workshop	Mirarchi, D (CERN) et al	Layouts for Crystal Collimation Tests at the LHC, *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013, pp. 966.*	12 May 2013	Shanghai, China	Scientific Community	--	International
149 CDS Link	Paper in proceedings of a Conference/ Workshop	Kelly, S. et al	Study of the Impact of Fringe Fields of the Large Aperture Triplets on the Linear Optics of the HL-LHC *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013, pp. 2642.*	12 May 2013	Shanghai, China	Scientific Community	--	International
150 CDS Link	Paper in proceedings of a Conference/ Workshop	Lari, L. et al	Studies of Thermal Loads on Collimators for HL-LHC Optics in Case of Fast Losses *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013, pp. 999*	12 May 2013	Shanghai, China	Scientific Community	--	International
151 Link	Paper in proceedings of a Conference/ Workshop	Giovannozzi, M. et al	Specification of a System of Correctors for the Triplets and Separation Dipoles of the LHC Upgrade, *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013, pp. 2612*	12 May 2013	Shanghai, China	Scientific Community	--	International
152 CDS Link	Paper in proceedings of a Conference/ Workshop	Holzer, B. et al	Optics Design and Lattice Optimisation for the HL-LHC *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013, pp. 1385*	12 May 2013	Shanghai, China	Scientific Community	--	International
153	Paper in	Appleby, R.	LSS Layout Optimizations for Low-beta	12 May 2013	Shanghai,	Scientific	--	International

CDS Link	proceedings of a Conference/ Workshop	et al	Optics for the HL-LHC, *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013, pp. 2639*		China	Community		
154 CDS Link	Paper in proceedings of a Conference/ Workshop	Zlobin, A. et al	Fabrication and Test of a 1 M Long Single-aperture 11 T Nb3Sn Dipole for LHC Upgrades, *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013, pp. 3609*	12 May 2013	Shanghai, China	Scientific Community	--	International
155 CDS Link	Paper in proceedings of a Conference/ Workshop	Brett, D. et al	Comparison of Taylor Maps with Radio Frequency Multipoles in a Thin Lens 6D Tracking Code, *Proceedings of IPAC 13, Shanghai, China, 12-17 May 2013, pp. 2687*	12 May 2013	Shanghai, China	Scientific Community	--	International
156 CDS Link	Oral Presentation to a Scientific Event	Rossi, L. (CERN)	Advanced SC Magnets and devices for the LHC upgrade	27 May 2013	CERN, Switzerland	Scientific Community	--	International
157 CDS Link	Status Report	Dominguez, O.	Electron cloud studies for alternative train configurations and bunch spacings at the HL-LHC	5 June 2013	Geneva, Switzerland	Scientific Community	--	International
158 CDS Link	Article	Chaudron, M. et al	Accelerating News Issue 6	20 Jun 2013	Geneva, Switzerland	Civil Society, Scientific Community	--	International
159 CDS Link	Article	Yarris, L. (Berkeley Lab)	Successful Test of New U.S. Magnet Puts Large Hadron Collider on Track for Major Upgrade	11 Jul 2013	Geneva, Switzerland	Scientific Community	--	International
160 Link	Thesis	Bignami, A.	Studio delle connessioni superconduttive in MgB2 per il progetto Hi-Lumi-LHC	23 Jul 2013	Milan, Italy	Scientific Community	--	International
161 Link	Oral Presentation to a Scientific Event	Xiao, B. P. et al	Proof of Principle Cavity Preparation and Testing: BNL Double Quarter Wave Design, *SFR 13.*	12 Sep 2013	Paris, France	Scientific Community	--	International
162 CDS Link	Article	Rossi, L. (CERN) et al	LARP Testing Newest High-field Quadrupole Magnet, *Superconductor Week*	16 Sep 2013	Geneva, Switzerland	Scientific Community	--	International
163 CDS Link	Paper in proceedings of a Conference/ Workshop	Métral, E (CERN)	RF heating from wake losses in diagnostics structures, *Proceedings of IBIC2013, Oxford, UK, 16-19 September 2013, pp. 929.*	16 Sep 2013	Oxford, UK	Scientific Community	--	International

164 CDS Link	Paper in proceedings of a Conference/ Workshop	Boogert, S T (Royal Holloway, U. of London) et al	Beam delivery simulation (BDSIM) : a Geant4 based toolkit for diagnostic and loss simulation, *Proceedings of IBIC2013, Oxford, UK, 16-19 September 2013, pp. 799.*	16 Sep 2013	Oxford, UK	Scientific Community	--	International
165 Link	Paper in proceedings of a Conference/ Workshop	Verdu, S. et al	Optimization of the double quarter wave cavity for testing in SPS, *Proceedings of SFR 2013, Paris, France, 23-27 Sep 2013, pp. 975.*	23-27 Sep 2013	Paris, France	Scientific Community	--	International
166 Link	Paper in proceedings of a Conference/ Workshop	Xiao, B. et al	Compact HOM filter for crab cavities in the LHC, *Proceedings of SFR 2013, Paris, France, 23-27 Sep 2013, pp. 1006.*	23-27 Sep 2013	Paris, France	Scientific Community	--	International
167 Link	Paper in proceedings of a Conference/ Workshop	Calaga, R. (CERN) et al	LHC Crab Cavity. Progress and Outlook, *Proceedings of SFR 2013, Paris, France, 23-27 Sep 2013, pp. 1161.*	23-27 Sep 2013	Paris, France	Scientific Community	--	International
168 Link	Paper in proceedings of a Conference/ Workshop	Burt, G. et al	Design of a 4 rod crab cavity cryomodule system for HL-LHC, *Proceedings of SFR 2013, Paris, France, 23-27 Sep 2013, pp. 982.*	23-27 Sep 2013	Paris, France	Scientific Community	--	International
169 Link	Paper in proceedings of a Conference/ Workshop	Pattalwar, S. et al	Conceptual Design of a Cryomodule for Compact Crab Cavities for Hi-Lumi LHC, *Proceedings of SFR 2013, Paris, France, 23-27 Sep 2013, pp. 353.*	23-27 Sep 2013	Paris, France	Scientific Community	--	International
170 Link	Oral Presentation to a Scientific Event	De Silva, S.	Superconducting RF-Dipole Deflecting and Crabbing Cavities, *Proceedings of SFR 2013, Paris, France, 23-27 Sep 2013.*	23-27 Sep 2013	Paris, France	Scientific Community	--	International
171 CDS Link	Article	Wogan, T. (CERN)	Magnet sets path for high luminosity, *Physics World*	1 Oct 2013	Geneva, Switzerland	Scientific Community	--	International
172 CDS Link	Oral Presentation to a Scientific Event	Fartoukh, S. (CERN)	Pile-Up density at HL-LHC with new shaping and leveling techniques, *ECFA High Luminosity LHC Experiments Workshop*	1-3 Oct 2013	Aix-les-Bains, France	Scientific Community	--	International
173 CDS Link	Article	Szeberenyi, A. et al	Accelerating News Issue 7	2 Oct 2013	Geneva, Switzerland	Civil Society, Scientific	--	International

						Community		
174 CDS Link	Scientific / Technical Note	Bruning, O. (CERN) et al	HL-LHC: How to achieve Upgrade Scenario 1 goals in the LHC?	29 Oct 2013	Geneva, Switzerland	Scientific Community	--	International
175 CDS Link	Scientific / Technical Note	Arduini, G. (CERN) et al	How to maximize the HL-LHC performance (HL-LHC)?	29 Oct 2013	Geneva, Switzerland	Scientific Community	--	International
176 CDS Link	Scientific / technical Note	Tomas, R. (CERN) et al	HL-LHC: Exploring alternative ideas	29 Oct 2013	Geneva, Switzerland	Scientific Community	--	International
177 CDS Link	Paper in proceedings of a Conference/ Workshop	Arduini, G. (CERN) et al	Pics: what do we gain in beam performance, *Proceedings of RLIUP: Review of LHC and Injector Upgrade Plans, Centre de Convention, Archamps, France, 29-31 October 2013, pp. 49-56.*	29 Oct 2013	Archamps, France	Scientific Community	--	International
178 CDS Link	Paper in proceedings of a Conference	Todesco, E. (CERN)	Upgrade Scenario One: Work Effort, *Proceedings of RLIUP: Review of LHC and Injector Upgrade Plans, Centre de Convention, Archamps, France, 29–31 October 2013*	29 – 31 Oct 2013	Archamps, France	Scientific Community	--	International
179 CDS Link	Paper in proceedings of a Conference	Rossi, L. (CERN) et al	Session 3: PICs and Upgrade Scenario 1, *Proceedings of RLIUP: Review of LHC and Injector Upgrade Plans, Centre de Convention, Archamps, France, 29–31 October 2013*	29 – 31 Oct 2013	Archamps, France	Scientific Community	--	International
180 CDS Link	Paper in proceedings of a Conference	Myers, S. et al	Review of LHC and Injector Upgrade Plans – Summary, *Proceedings of RLIUP: Review of LHC and Injector Upgrade Plans, Centre de Convention, Archamps, France, 29–31 October 2013*	29 – 31 Oct 2013	Archamps, France	Scientific Community	--	International
181 CDS Link	Paper in proceedings of a Conference	Arduini, G. et al	How to Maximize the HL-LHC Performance (HL-LHC)? , *Proceedings of RLIUP: Review of LHC and Injector Upgrade Plans, Centre de Convention, Archamps, France*	29 – 31 Oct 2013	Archamps, France	Scientific Community	--	International
182 CDS Link	Paper in proceedings of a Conference	Rossi, L. et al	How to Implement all HL-LHC Upgrades? *Proceedings of RLIUP: Review of LHC and Injector Upgrade Plans, Centre de Convention, Archamps, France*	29 – 31 Oct 2013	Archamps, France	Scientific Community	--	International

183 Link	Oral Presentation to a Scientific Event	Bruning, O. (CERN)	HL-LHC: How to achieve Upgrade Scenario 1 goals in the LHC? *RLIUP: Review of LHC and Injector Upgrade Plans*	30 Oct 2013	Archamps, France	Scientific Community	--	International
184 Link	Oral Presentation to a Scientific Event	Jowett, J. et al	Future Heavy-Ion Performance of the LHC, *Review of LHC and Injector Upgrade Plans*	31 Oct 2013	Archamps, France	Scientific Community	--	International
185 CDS Link	Oral Presentation to a Scientific Event	Dalena, B. (CERN) et al	Alternative design of the matching section (option to increase crab cavity kicks) *3rd Joint Hilumi LHCLARP Meeting*	11 Nov 2013	Geneva, Switzerland	Scientific Community	--	International
186 CDS Link	Oral Presentation to a Scientific Event	Pieloni, T. (CERN)	Beam-beam studies and code development update, *3rd Joint Hilumi LHCLARP Meeting*	11 Nov 2013	Geneva, Switzerland	Scientific Community	--	International
187 CDS Link	Oral Presentation to a Scientific Event	Iadarola, G. (CERN) et al	Electron cloud effects and expected limitations in the HL-LHC era (stability, heat load in existing and new components, ountermeasures), *3rd Joint Hilumi LHCLARP Meeting*	11 Nov 2013	Geneva, Switzerland	Scientific Community	--	International
188 CDS Link	Oral Presentation to a Scientific Event	Rumolo, G. (CERN) et al	Possible strategy for scrubbing LHC for 25 ns operation	27 Nov 2013	Geneva, Switzerland	Scientific Community	--	International
189 CDS Link	Oral Presentation to a Scientific Event	White, S. (CERN)	Impact of a 200MHz RF System, *6th LHC crab cavity workshop.*	9 Dec 2013	Geneva, Switzerland	Scientific Community	--	International
190 CDS Link	Article	Szeberenyi, A. (CERN) et al	Accelerating News Issue 8	10 Dec 2013	Geneva, Switzerland	Civil Society, Scientific Community	--	International
191 CDS Link	Oral Presentation to a Scientific Event	Fartoukh, S. (CERN)	The crab-kissing scheme: concept and motivations, *6th LHC crab cavity workshop*	10 Dec 2013	Geneva, Switzerland	Scientific Community	--	International
192 CDS Link	Scientific / technical Note	Wanzenberg, R. (DESY)	Calculation of Wakefield and Higher Order Modes for the New Design of the Vacuum Chamber of the ATLAS Experiment for the HL-LHC	17 Dec 2013	Geneva, Switzerland	Scientific Community	--	International
193 CDS Link	arXiv	Todesco, E. (CERN)	Quench limits in the next generation of magnets	16 Jan 2014	Geneva, Switzerland	Scientific Community	--	International

194 CDS Link	Article / Misc	Rossi, L. (CERN) et al	HiLumi LHC design study moves towards HL-LHC	22 Jan 2014	Geneva, Switzerland	Scientific Community	--	International
195 CDS Link	Article / Misc	Allport, P. (CERN) et al.	Workshop looks towards High-Luminosity LHC, *CERN Courier*	22 Jan 2014	Geneva, Switzerland	Scientific Community	--	International
196 Link	Article / Misc	Charley, S. (Simmetry)	Labs work together toward high-luminosity LHC, *Simmetry.*	23 Jan 2014	Geneva, Switzerland	Scientific Community	--	International
197 CDS Link	Scientific / Technical Note	Metral, E. (CERN) et al	Summary of the 2-day internal review of LHC performance limitations (linked to transverse collective effects) during run I	31 Jan 2014	Geneva, Switzerland	Scientific Community	--	International
198 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	LHC, il bosone di Higgs e le nuove frontiere della fisica e tecnologia al CERN di Ginevra	8 Feb 2014	Piacenza, Italy	Civil Society	500	Italy
199 Link	Oral Presentation to a Scientific Event	Qiong W. (CERN)	Double Quarter-wave Cavity Design and Plans, *LARP Review*	17 Feb 2014	Batavia, IL, USA	Scientific Community	--	International
200 Link	Article	Szeberenyi, A. et al	Accelerating News Issue 9	Mar 2014	Geneva, Switzerland	Civil Society, Scientific Community	--	International
201 CDS Link	Oral Presentation to a Scientific Event	Mounet, R. (CERN) et al	Impedance Considerations for the Design of the Triplet / D1 Beam Screen, *Technical Meeting on Vacuum for HL-LHC*	5 Mar 2014	Geneva, Switzerland	Scientific Community	--	International
202 CDS Link	Oral Presentation to a Scientific Event	Iadarola, G. (CERN) et al	Electron cloud estimates in the HL-LHC triplets/D1	5 Mar 2014	Geneva, Switzerland	Scientific Community	--	International
203 CDS Link	Oral Presentation to a Scientific Event	De Maria, R. (CERN)	Review of the aperture margins for the new HL-LHC magnets	5 Mar 2014	Geneva, Switzerland	Scientific Community	--	International
204 CDS Link	Oral Presentation to a Scientific Event	Calaga, R. (CERN) et al	Impedance aspects of Crab cavities	5 Mar 2014	Geneva, Switzerland	Scientific Community	--	International
205 CDS Link	Oral Presentation to a Scientific Event	Arduini, G. (CERN) et al	Heat load from impedance on existing and new hardware in the LHC era	5 Mar 2014	Geneva, Switzerland	Scientific Community	--	International

206 CDS Link	Oral Presentation to a Scientific Event	Arduini, G. (CERN)	LHC Machine Upgrade, *IFD 2014*	11-13 Mar 2014	Trento, Italy	Scientific Community	--	International
207 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	The frontier of knoweldge and the CERN's Large Hadron Collider: A world success of European Identity and of international collaboration	15 Mar 2014	Cologne, Germany	Civil Society, Scientific Community	400	Germany
208 CDS Link CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	LHC, il bosone di Higgs e le nuove frontiere della fisica e tecnologia al CERN di Ginevra	21 Mar 2014	Padova, Italy	Civil Society	100	Italy
209 CDS Link	Oral Presentation to a Scientific Event	Metral, E. (CERN)	Recommendations (from Collective Effects Considerations) for the LHC 2015 Run	25 Mar 2014	Geneva, Switzerland	Scientific Community	--	International
210 CDS Link	Oral Presentation to a Scientific Event	Spurrell, J (SOTON) et al	Quench property of twisted-pair MgB2 superconducting cables in helium gas	26 Mar 2014	Geneva, Switzerland	Scientific Community	--	International
211 CDS Link	Article	Sassone Corsi, E. (MAINN)	Al CERN per parlare di Superconduttivita e Trasferimento Tecnologico, *MAINN*	1 Apr 2014	Italy	Civil Society, Industry	--	Italy
212	Oral Presentation to a Scientific Event	Rossi, L. (CERN)	Innovative metal-matrix composite for thermal management	7-11 Apr 2014	Hannover, Germany	Industry	-	Germany
213 CDS Link	Article	Del Rosso, A. (CERN)	World-record current in a superconductor	14 Apr 2014	Geneva, Switzerland	Scientific Community, Civil Society	--	International
214	Oral Presentation to a Scientific Event	Rossi, L. (CERN)	LHC: the accelerator, the discovery, and plan for the future developments	16 Apr 2014	Houston, USA	Scientific Community, Policy Makers	100	USA
215 Link	Thesis	Tedesco, L.	Caratterizzazione delle connessioni superconduttive per il progetto HL-LHC del CERN	29 Apr 2014	Milan, Italy	Scientific Community	--	International
216 CDS Link	Scientific / Technical Note	Calaga, R. (CERN) et al	Ranking Criteria, LHC crab cavities	6 May 2014	Geneva, Switzerland	Scientific Community	--	International
217	Oral	Salvant B.	Impedance Aspects for SPS & LHC, *HiLumi-*	6 May 2014	BNL, USA	Scientific	--	International

Link	Presentation to a Scientific Event	(CERN) et al	*LHC/LARP Crab Cavity System External Review*			Community		
218 CDS Link	Oral Presentation to a Scientific Event	Mounet, N. (CERN)	DELPHI: an Analytic Vlasov Solver for Impedance-Driven Modes	7 May 2014	Geneva, Switzerland	Scientific Community	--	International
219 CDS Link	Scientific / Technical Note	Fitterer, M (CERN)	Optics Considerations for PIC and US1 scenarios for HL-LHC in the framework of the RLIUP review	7 May 2014	Geneva, Switzerland	Scientific Community	--	International
220 Link	Oral Presentation to a Scientific Event	Cai, Y. (SLAC)	Field Quality and Dynamic Aperture Simulations, *LARP / HiLumi-LHC Collaboration Meeting, Brookhaven National Laboratory*	7-9 May 2014	Uptown, NY, USA	Scientific Community	--	International
221 Link	Oral Presentation to a Scientific Event	De Maria, R. (CERN) et al	Optics and Layout Update, *LARP / HiLumi-LHC Collaboration Meeting, Brookhaven National Laboratory.*	7-9 May 2014	Uptown, NY, USA	Scientific Community	--	International
222 Link	Oral Presentation to a Scientific Event	Banfi, D. (EPFL) et al	Beam-beam effects and limitations in HL-LHC, *LARP / HiLumi-LHC Collaboration Meeting, Brookhaven National Laboratory.*	7-9 May 2014	Uptown, NY, USA	Scientific Community	--	International
223 Link	Oral Presentation to a Scientific Event	Valishev, A. (Fermilab) et al	BBLR compensation for HL-LHC, *LARP / HiLumi-LHC Collaboration Meeting, Brookhaven National Laboratory.*	7-9 May 2014	Uptown, NY, USA	Scientific Community	--	International
224 Link	Oral Presentation to a Scientific Event	Qiang, J. (LBNL) et al	Strong-strong simulations: benchmark with LHC observations, *LARP / HiLumi-LHC Collaboration Meeting, Brookhaven National Laboratory.*	7-9 May 2014	Uptown, NY, USA	Scientific Community	--	International
225 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	Die Erfahrung des Forschers und das Staunen des Menschen	21 May 2014	Hamburg, Germany	Civil Society	300	Germany
226 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	Il bosone di Higgs e i nuovi territori di caccia all'LHC del CERN	30 May 2014	Piacenza, Italy	Civil Society	60	Italy
227 CDS Link	Scientific / Technical note	Bruce, R (CERN) et al	Parameters for HL-LHC aperture calculations and comparison with aperture measurements	30 Apr 2014	Geneva, Switzerland	Scientific Community	--	International
228	Article	Szeberenyi,	Accelerating News Issue 10	Jun 2014	Geneva,	Civil Society,	--	International

Link		A. et al			Switzerland	Scientific Community		
229 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	LHC E l'avventura della persona nella piu' grande impresa scientifica	1 Jun 2014	La Thuile, Italy	Civil Society	80	Italy
230 CDS Link	Status Report	Champion, M. et al	Report of the HiLumi-LHC/LARP Crab Cavity System External Review Committee	6 Jun 2014	Geneva, Switzerland	Scientific Community	--	International
231 CDS Link	Paper in proceedings of a Conference	Shashkov, Y. (NRNU) et al	Comparison of high order modes damping techniques for 800 MHz single cell superconducting cavities, *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014, pp. 784. .*	15 Jun 2014	Dresden, Germany.	Scientific Community	--	International
232 CDS Link	Paper in proceedings of a Conference	Frasciello, O. et al	Geometric beam coupling impedance of LHC secondary collimators, *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014, pp. 1677.*	15 Jun 2014	Dresden, Germany.	Scientific Community	--	International
233 CDS Link	Paper in proceedings of a Conference	Serluca, M. (UNIMAN) et al	Hi-Lumi LHC Collimation Studies with MERLIN Code, *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014, pp. 2558.*	15 Jun 2014	Dresden, Germany.	Scientific Community	--	International
234 CDS Link	Paper in proceedings of a Conference	Banfi, D. (EPFL) et al	Weak-Strong Beam-Beam Simulations For Hl-Lhc, *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014, pp. 3079.*	15 Jun 2014	Dresden, Germany.	Scientific Community	--	International
235 CDS Link	Paper in proceedings of a Conference	Crouch, M (UNIMAN) et al	Simulations of emittance growth due to an external noise in colliding beams in the LHC, *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014, pp. 1071.*	15 Jun 2014	Dresden, Germany.	Scientific Community	--	International
236 CDS Link	Paper in proceedings of a Conference	Qiang, Ji (LBNL)	Strong-strong Beam-beam Simulation for the LHC Upgrade, *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014, pp. 1006.*	15 Jun 2014	Dresden, Germany.	Scientific Community	--	International
237 CDS Link	Paper in proceedings of a Conference	Nosochkov, Y. et al	Specification of Field Quality of the Interaction Region Magnets of the High Luminosity LHC Based on Dynamic Aperture, *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014.*	15 Jun 2014	Dresden, Germany.	Scientific Community	--	International
238 CDS Link	Paper in proceedings of a Conference	Dalena, B. (IRFU) et al	Fringe fields modeling for the high luminosity LHC large aperture quadrupoles, *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014.*	15 Jun 2014	Dresden, Germany.	Scientific Community	--	International

239 CDS Link	Paper in proceedings of a Conference	Appleby, R B. (Manchester U.) et al	Modelling and long term dynamics of crab cavities in the LHC, *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014.*	15 Jun 2014	Dresden, Germany.	Scientific Community	--	International
240 CDS Link	Paper in proceedings of a Conference	Dalena, B. (IRFU) et al	Alternative high luminosity LHC matching section layout, *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014.*	15 Jun 2014	Dresden, Germany.	Scientific Community	--	International
241 CDS Link	Paper in proceedings of a Conference	Angal-Kalinin, D. (STFC) et al	Benchmarking Studies of Intra Beam Scattering for HL-LHC, *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014, pp. 1064.*	15 Jun 2014	Dresden, Germany.	Scientific Community	--	International
242 CDS Link	Paper in proceedings of a Conference	Pattalwar, S. (Daresbury)	Key Design Features of Crab-Cavity Cryomodule for HiLumi LHC, *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014, pp. 2580.*	15 Jun 2014	Dresden, Germany.	Scientific Community	--	International
243 CDS Link	Paper in proceedings of a Conference	Jones, T. (Daresbury)	Testing and Dressed Cavity Design for the HL-LHC 4R Crab Cavity, *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014, pp. 2589.*	15 Jun 2014	Dresden, Germany.	Scientific Community	--	International
244 CDS Link	Paper in proceedings of a Conference	Yee-Rendon, B (CINVESTAV-IPN)	Fast crab cavity failures in HL-LHC, *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014.*	15 Jun 2014	Dresden, Germany.	Scientific Community	--	International
245 CDS Link	Paper in proceedings of a Conference	Marsili, A. (CERN) et al	Collimation Cleaning for HL-LHC Optics Scenarios with Error Models, *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014, pp. 163.*	15 Jun 2014	Dresden, Germany.	Scientific Community	--	International
246 CDS Link	Paper in proceedings of a Conference	Marsili, A. (CERN) et al	Multi-turn tracking of collision products at the LHC, *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014, pp. 166.*	15 Jun 2014	Dresden, Germany.	Scientific Community	--	International
247 CDS Link	Paper in proceedings of a Conference	Marsili, A. (CERN) et al	Final layout and expected cleaning for the first crystal-assisted collimation test at the LHC, *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014, pp. 882.*	15 Jun 2014	Dresden, Germany.	Scientific Community	--	International
248 CDS Link	Paper in proceedings of a Conference	Stancari, G (Fermilab) et al	Electron lenses for the large hadron collider, *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014, pp. 918.*	15 Jun 2014	Dresden, Germany.	Scientific Community	--	International

249 CDS Link	Paper in proceedings of a Conference	Bruce, R (CERN) et al	Cleaning Performance with 11T Dipoles and Local Dispersion Suppressor Collimation at the LHC, *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014, pp. 170.*	15 Jun 2014	Dresden, Germany.	Scientific Community	--	International
250 CDS Link	Paper in proceedings of a Conference	Bruce, R (CERN) et al	Integrated simulation tools for collimation cleaning in HL-LHC, *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014, pp. 160.*	15 Jun 2014	Dresden, Germany.	Scientific Community	--	International
251 CDS Link	Paper in proceedings of a Conference	Serluca , M (U. Manchester) et al	Comparison of MERLIN/SixTrack for LHC Collimation Studies, *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014, pp. 185.*	15 Jun 2014	Dresden, Germany.	Scientific Community	--	International
252 CDS Link	Paper in proceedings of a Conference	Lari, L. (IFIC) et al	Collimator fast failure losses for various HL-LHC configurations, *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014, pp. 157.*	15 Jun 2014	Dresden, Germany.	Scientific Community	--	International
253 CDS Link	Paper in proceedings of a Conference	Lechner, A. (CERN) et al	Power Deposition in LHC Magnets With and Without Dispersion Suppressor Collimators Downstream of the Betatron Cleaning Insertion, *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014, pp. 112.*	15 Jun 2014	Dresden, Germany.	Scientific Community	--	International
254 CDS Link	Paper in proceedings of a Conference	Markiewicz, T (SLAC) et al	Construction and bench testing of a prototype rotatable collimator for the LHC, *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014.*	15 Jun 2014	Dresden, Germany.	Scientific Community	--	International
255 Link	Paper in proceedings of a Conference	Nevay, L. et al	Beam delivery simulations: BDSIM - development & optimization, *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014.*	15 Jun 2014	Dresden, Germany.	Scientific Community	--	International
253 CDS Link	Paper in proceedings of a Conference	Kwee-Hinzmann, R (Royal Holloway, U. of London) et al	First beam background simulation studies at ir1 for high luminosity LHC, *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014*	15 Jun 2014	Dresden, Germany.	Scientific Community	--	International
257 CDS Link	Paper in proceedings of a Conference	Zlobin, A. et al	Testing of a Single 11 T Nb3Sn Dipole Coil Using a Dipole Mirror Structure, *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014.*	15 Jun 2014	Dresden, Germany.	Scientific Community	--	International

258 Link	Paper in proceedings of a Conference	Zlobin, A. et al	Status of 11 T 2-in-1 Nb3Sn Dipole Development for LHC, *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014,.*	15 Jun 2014	Dresden, Germany.	Scientific Community	--	International
259 CDS Link	Paper in proceedings of a Conference	Bouly, F. et al	Preliminary Study of Risks and Failure Scenarios for the High Luminosity Experiments in HL-LHC *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014,.*	15 Jun 2014	Dresden, Germany.	Scientific Community	--	International
260 CDS Link	Paper in proceedings of a Conference/ Workshop	Frasciello, O. et al	Geometric Beam Coupling Impedance of LHC Secondary Collimators *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014, pp. 1676*	15 Jun 2014	Dresden, Germany	Scientific Community	--	International
261 CDS Link	Paper in proceedings of a Conference/ Workshop	Mirarchi, D. et al	Final Layout and Expected Cleaning for the First Crystal-Assisted Collimation Test at the LHC *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014, pp. 882*	15 Jun 2014	Dresden, Germany	Scientific Community	--	International
262 CDS Link	Paper in proceedings of a Conference/ Workshop	Mokhov, N. et al	Energy Deposition Studies for the Hi-Lumi LHC Inner Triplet Magnets *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014, pp. 1078*	15 Jun 2014	Dresden, Germany	Scientific Community	--	International
263 CDS Link	Paper in proceedings of a Conference/ Workshop	Gupta, R.	Conceptual Magnetic Design of the Large Aperture D2 Dipole for LHC Upgrade, *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014, pp. 2737*	15 Jun 2014	Dresden, Germany	Scientific Community	--	International
264 CDS Link	Paper in proceedings of a Conference/ Workshop	Sabbi, G. et al	Conceptual Design Study of the High Luminosity LHC Recombination Dipole, *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014, pp. 2712*	15 Jun 2014	Dresden, Germany	Scientific Community	--	International
265 CDS Link	Paper in proceedings of a Conference/ Workshop	Zobov, M. et al	Comparison of Higher Order Modes Damping Techniques for 800 MHz Single Cell Superconducting Cavities, *Proceedings of IPAC14, Dresden, DE, 15-20 June 2014.*	15 Jun 2014	Dresden, Germany	Scientific Community	--	International
266	Paper in proceedings of a	Zobov, M. et al	A Wideband Slotted Kicker Design for SPS Transverse Intra-Bunch Feedback *Proceedings*	15 Jun 2014	Dresden, Germany	Scientific Community	--	International

CDS Link	Conference/ Workshop		*of IPAC14, Dresden, DE, 15-20 June 2014, pp. 1772*					
267 CDS Link	Article published in the popular press	Novara, N. (Liberta)	A caccia dell'infinitamente piccolo, *Liberta*	1 Jul 2014	Piacenza, Italy	Civil Society	--	Italy
268 CDS Link	Article / Misc	ICHEP	Interview with Lucio Rossi, *ICHEP Newsletter*	4 Jul 2014	Valencia, Spain	Scientific Community	--	International
269 CDS Link	Oral Presentation to a Scientific Event	Rossi, L. (CERN)	HL-LHC Project -Status and Perspectives, *ICHEP 2014*	7 Jul 2014	Valencia, Spain	Scientific Community, Policy Makers	200	Spain
270 CDS Link	Article published in the popular press	Malacaza, E. (Liberta)	"Settimana della Letteratura": Bobbio torna capitale dei libri : Il fisico del CERN di Ginevra Lucio Rossi e il "Piacentino dell'anno", *Liberta.*	1 Aug 2014	Piacenza, Italy	Civil Society	--	Italy
271 CDS Link	Article / Misc	Schaeffer, A. (CERN)	The light at the end of the tunnel gets brighter, *CERN Bulletin*	4 Aug 2014	Geneva, Switzerland	Scientific Community, Civil Society	--	International
272 CDS Link	Oral Presentation to a Scientific Event	Rossi, L. (CERN)	The plan for the post-LHC(and why SC is so important) –plenary, *ASC 2014*	13 Aug 2014	Charlotte, USA	Scientific Community, Policy Makers	1600	International
273 CDS Link	Oral Presentation to a Scientific Event	Rossi, L. (CERN)	The EuCARD-2 Future Magnets European collaboration for accelerator quality HTS magnets, *ASC 2014*	13 Aug 2014	Charlotte, USA	Scientific Community, Policy Makers	150	International
274 CDS Link	Oral Presentation to a Scientific Event	Bruning, O. et al	High Luminosity LHC, *Physics at LHC and beyond, Rencontres du Vietnam.*	10-17 Aug 2014	Qui Nhon, Vietnam	Scientific Community	--	International
275 CDS Link	Oral Presentation to a Scientific Event	Tabasco, C. (CERN) et al	HL-LHC Stability Diagrams: octupoles and beam-beam long range, *Beam-beam meeting*	21 Aug 2014	Geneva, Switzerland	Scientific Community	--	International
276 Link	Article	Szeberenyi, A. et al	Accelerating News Issue 11	Sep 2014	Geneva, Switzerland	Civil Society, Scientific Community	--	International
277 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	La scienza a servizio del desiderio di conoscenza dell'Uomo	12 Sep 2014	Bisuschio, Italy	Civil Society	150	Italy

278 CDS Link	Oral Presentation to a scientific event	Rossi, L. (CERN)	LHC machine upgradeRun II and HL-LHC	18 Sep 2014	Uppsala, Sweden	Scientific Community, Policy Makers	80	International
279 CDS Link	Paper in proceedings of a Conference	Redaelli, S. (CERN) et al	Collimation Upgrades for HL-LHC, *Proceedings of Chamonix 2014 workshop on LHC Performance, Chamonix, France.*	22-25 Sep 2014	Chamonix, France	Scientific Community	--	International
280 CDS Link	Paper in proceedings of a Conference	Paret, S. (LNBL) et al	Coherent Instability due to beam-beam interaction in hadron colliders, *Proceedings of PAC2013, Pasadena, CA USA.*	8 Oct 2014	Pasadena, CA	Scientific Community	--	International
281 CDS Link	Paper in proceedings of a Conference	Valishev, A. (FNAL) et al	Beam-beam studies for HL-LHC, *Proceedings of PAC2013, Pasadena, CA USA.*	8 Oct 2014	Pasadena, CA	Scientific Community	--	International
282 Link	Paper in proceedings of a Conference	Olave, R et al	Study of cavity imperfection impact on rf-parameters and multipole components in a superconducting RF-dipole cavity, *Proceedings of PAC2013, Pasadena, CA USA.*	8 Oct 2014	Pasadena, CA	Scientific Community	--	International
283 CDS Link	Paper in proceedings of a Conference	Stancari, G. et al	Collimation with Hollow Electron Beams : a Proposed Design for the LHC Upgrade, *Proceedings of PAC2013, Pasadena, CA USA*	8 Oct 2014	Pasadena, CA	Scientific Community	--	International
284 CDS Link	Oral Presentation to a wider public	Anelli, G. (CERN)	Knowledge and technology transfer @CERN, *Italy @ CERN 2014*	8 Oct 2014	Geneva, Switzerland	Scientific Community, Civil Society	--	Italy
285 CDS Link	Oral Presentation to a Scientific Event	Todesco, E. (CERN)	HL-LHC IR magnets, *CERN TE Seminar*.	9 Oct 2014	Geneva, Switzerland	Scientific Community	--	International
286 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	Il vuoto, la materia,la ricerca	11 Oct 2014	Rome, Italy	Civil Society	250	Italy
287 CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	Il bosone di Higgs e i nuovi territori di caccia all'LHC del CERN	20 Oct 2014	Piacenza, Italy	Civil Society	150	Italy
288 CDS Link	Article Published in the popular press	Novara, N. (Liberta)	Lucio Rossi al Politecnico: Tra voi un ricercatore CERN, *Liberta.*	21 Oct 2014	Piacenza, Italy	Civil Society	--	Italy
289	Oral	Arduini, G.	The LHC and its upgrade to HL-LHC ,	28- 31 Oct	Torino, Italy	Scientific	--	Italy

CDS Link	Presentation to a Scientific Event	(CERN)	*Giornate di Studio sui Rivelatori*	2014		Community, Policy Makers		
290 CDS Link CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	Alla scoperta della realtà: le nuove frontiere di Fisica e tecnologia al CERN	29 Oct 2014	Trieste, Italy	Civil Society	200	Italy
291 CDS Link CDS Link	Oral Presentation to a wider public	Rossi, L. (CERN)	Che cos'è la Realtà? Come Conoscerla?	30 Oct 2014	Ferrara, Italy	Civil Society	300	Italy
292 CDS Link	Status Report	Karppinen, M. (CERN)	New Mechanical Concept for Nb3Sn Quadrupole	30 Oct 2014	Geneva, Switzerland	Scientific Community	--	International
293 CDS Link	arXiv	Stancari, G (Fermilab) et al	Conceptual design of hollow electron lenses for beam halo control in the Large Hadron Collider	30 Oct 2014	Geneva, Switzerland	Scientific Community	--	International
294 CDS Link	Oral Presentation to a Scientific Event	Markiewicz, T. (SLAC)	Advanced Collimators for Future Colliders or Status of R&D on Collimators for e+e- LCs & HL-LHC, *US-CERN-JAPAN-RUSSIA Joint International Accelerator School: Beam Losses and Accelerator Protection*	12 Nov 2014	Newport Beach, USA	Scientific Community	--	International
295	Oral Presentation to a wider public	Rossi, L. (CERN)	Alla scoperta della realtà: le nuove frontiere di Fisica e tecnologia al CERN	7 Nov 2014	Monza, Italy	Civil Society	50	Italy
296 Link	Paper in proceedings of a Conference	Bertarelli, A. (CERN) et al	Novel Materials For Collimators At LHC And Its Upgrades, *Proceedings of HB2014, East-Lansing, MI, USA.*	10-14 Nov 2014	East-Lansing, MI, USA	Scientific Community	--	International
297 CDS Link	Paper in proceedings of a Conference	De Maria, R. (CERN) et al	The High Luminosity Challenge: Potential and Limitations of High Intensity High Brightness in the LHC and Its Injectors, *Proceedings of HB2014, East-Lansing, MI, USA.*	10-14 Nov 2014	East-Lansing, MI, USA	Scientific Community	--	International
298 CDS Link	Oral Presentation to a Scientific Event	Redaelli, S. (CERN)	Beam Cleaning and Collimation Systems, *US-CERN-JAPAN-RUSSIA Joint International Accelerator School: Beam Losses and Accelerator Protection*	17 Nov 2014	Newport Beach, CA, USA	Scientific Community	--	International
299 Link	Article	Szeberenyi, A. et al	Accelerating News Issue 12	Dec 2014	Geneva, Switzerland	Civil Society, Scientific Community	--	International

300 CDS Link	Status Report	Apollinari, G. (FNAL) et al	High Luminosity LHC Project Description	5 Dec 2014	Geneva, Switzerland	Scientific Community	--	International
301 Link	Thesis	Santini, C.	Studio degli effetti del campo di radiazione sulle connessioni superconduttive per il progetto HiLumi LHC	18 Dec 2014	Milan, Italy	Scientific Community	--	International
302 CDS Link	Status Report	Fitterer, M (CERN) et al	Crossing scheme and orbit correction in IR1/5 for HL-LHC	19 Jan 2015	Geneva, Switzerland	Scientific Community	--	International
303	Oral Presentation to a wider public	Rossi, L. (CERN)	LHC, il bosone di Higgs e le nuove frontiere dell'infinitamente piccolo al CERN di Ginevra	27 Jan 2015	Carate Brianza, Italy	Civil Society	90	Italy
304	Oral Presentation to a wider public	Rossi, L. (CERN) et al	LHC, il bosone di Higgs e le nuove frontiere dell'infinitamente piccolo al CERN di Ginevra	28 Jan 2015	Varese, Italy	Civil Society	200	Italy
305	Oral Presentation to a wider public	Rossi, L. (CERN)	LHC, il bosone di Higgs e le nuove frontiere dell'infinitamente piccolo al CERN di Ginevra	29 Jan 2015	Desio, Italy	Civil Society	130	Italy
306	Oral Presentation to a wider public	Rossi, L. (CERN)	Certi di cose mai viste... LHC, il bosone di Higgs e le nuove frontiere dell'infinitamente piccolo al CERN di Ginevra	29 Jan 2015	Lecco, Italy	Civil Society	250	Italy
307	Oral Presentation to a wider public	Rossi, L. (CERN)	LHC, il bosone di Higgs e le nuove frontiere dell'infinitamente piccolo al CERN di Ginevra	30 Jan 2015	Piacenza, Italy	Civil Society	80	Italy
308	Oral Presentation to a wider public	Rossi, L. (CERN)	Oltre il bosone di Higgs: LHC riprende l'esplorazione al CERN	6 Mar 2015	Piacenza, Italy	Civil Society	100	Italy
309	Oral Presentation to a wider public	Rossi, L. (CERN)	A Glimpse into the Unknown: the Wonder that Inspires Scientific Discovery	31 Mar 2015	Houston, USA	Civil Society	80	USA
310 Link	Article	Szeberenyi, A. et al	Accelerating News Issue 13	Apr 2015	Geneva, Switzerland	Civil Society, Scientific Community	--	International
311	Oral Presentation to a	Rossi, L. (CERN)	Au delà de nos limites: le LHC du CERN vers l'infinimment petit et l'origine de la matière	13 Apr 2015	Fribourg, Switzerland	Civil Society	80	Switzerland

	wider public							
312 CDS Link	Article published in the popular press	Catapano, P. (CERN)	IYL2015 al CERN: Einstein, luce e ... luminosita, *Prima pagina.*	22 Apr 2015	Geneva, Switzerland	Civil Society	--	Italy
313	Oral Presentation to a wider public	Rossi, L. (CERN)	L'impresa scientifica e l'avventura umana	24 Apr 2015	Bologna, Italy	Civil Society	80	Italy
314 Link	Paper in proceedings of a Conference	Fitterer, M. (CERN) et al	Beam Dynamics Requirements for the Powering Scheme of the HL-LHC Triplet, *Proceedings of IPAC 2015, Richmond, VA, USA, 3-8 May 2015.*	3-8 May 2015	Richmond, VA, USA	Scientific Community	--	International
315 Link	Paper in proceedings of a Conference	De Maria, R. (CERN) et al	HLLHCV1.1 Optics Version for the HL-LHC Upgrade, *Proceedings of IPAC 2015, Richmond, VA, USA, 3-8 May 2015.*	3-8 May 2015	Richmond, VA, USA	Scientific Community	--	International
316 Link	Paper in proceedings of a Conference	De Maria, R. (CERN) et al	BPM Tolerances for HL-LHC Orbit Correction in the Inner Triplet Area, *Proceedings of IPAC 2015, Richmond, VA, USA, 3-8 May 2015.*	3-8 May 2015	Richmond, VA, USA	Scientific Community	--	International
317 Link	Paper in proceedings of a Conference	Giovannozzi, M. (CERN) et al	Dynamic Aperture Studies for the LHC High Luminosity Lattice, *Proceedings of IPAC 2015, Richmond, VA, USA, 3-8 May 2015.*	3-8 May 2015	Richmond, VA, USA	Scientific Community	--	International
318 Link	Paper in proceedings of a Conference	Qiang, J. (CERN) et al	Beam-Beam Simulation of Crab Cavity White Noise for LHC Upgrade, *Proceedings of IPAC 2015, Richmond, VA, USA, 3-8 May 2015.*	3-8 May 2015	Richmond, VA, USA	Scientific Community	--	International
319 Link	Paper in proceedings of a Conference	Qiang, J. (CERN) et al	Strong-Strong Beam-Beam Simulation of Bunch Length Splitting at the LHC, *Proceedings of IPAC 2015, Richmond, VA, USA, 3-8 May 2015.*	3-8 May 2015	Richmond, VA, USA	Scientific Community	--	International
320 Link	Paper in proceedings of a Conference	Valishev, A. (CERN) et al	Numerical Analysis of Parasitic Crossing Compensation with Wires in DAFNE, *Proceedings of IPAC 2015, Richmond, VA, USA, 3-8 May 2015.*	3-8 May 2015	Richmond, VA, USA	Scientific Community	--	International
321 Link	Paper in proceedings of a Conference	Fartoukh, S. (CERN) et al	An Alternative High Luminosity LHC with Flat Optics and Long-Range Beam-Beam Compensation, *Proceedings of IPAC 2015,*	3-8 May 2015	Richmond, VA, USA	Scientific Community	--	International

			Richmond, VA, USA, 3-8 May 2015.					
322 Link	Paper in proceedings of a Conference	Crouch, M. (UNIMAN) et al	Analytical Approach to the Beam-Beam Interaction with the Hourglass effect, *Proceedings of IPAC 2015, Richmond, VA, USA, 3-8 May 2015.*	3-8 May 2015	Richmond, VA, USA	Scientific Community	--	International
323 Link	Paper in proceedings of a Conference	Crouch, M. (UNIMAN) et al	Strong-Strong Simulations of β∗ Levelling for Flat and Round Beams, *Proceedings of IPAC 2015, Richmond, VA, USA, 3-8 May 2015.*	3-8 May 2015	Richmond, VA, USA	Scientific Community	--	International
324 Link	Paper in proceedings of a Conference	Verdu-Andres, S. (BNL) et al	Design and Prototyping of HL-LHC Double Quarter Wave Crab Cavities, *Proceedings of IPAC 2015, Richmond, VA, USA, 3-8 May 2015*	3-8 May 2015	Richmond, VA, USA	Scientific Community	--	International
325 Link	Paper in proceedings of a Conference	Li, Z. (SLAC) et al	FPC and Hi-Pass Filter HOM Coupler Design for the RF Dipole Crab Cavity for the LHC HiLumi Upgrade, *Proceedings of IPAC 2015, Richmond, VA, USA, 3-8 May 2015*	3-8 May 2015	Richmond, VA, USA	Scientific Community	--	International
326 Link	Paper in proceedings of a Conference	De Silva, S. (JLAB) et al	Design and Prototyping of a 400 MHz RF-dipole Crabbing Cavity for the LHC High-Luminosity Upgrade, *Proceedings of IPAC 2015, Richmond, VA, USA, 3-8 May 2015.*	3-8 May 2015	Richmond, VA, USA	Scientific Community	--	International
327 Link	Paper in proceedings of a Conference	Park, H. (JLAB) et al	Engineering Study of Crab Cavity HOM Couplers for LHC High Luminosity Upgrade, *Proceedings of IPAC 2015, Richmond, VA, USA, 3-8 May 2015.*	3-8 May 2015	Richmond, VA, USA	Scientific Community	--	International
328 Link	Paper in proceedings of a Conference	Xiao, B. (BNL) et al	Higher Order Mode Filter Design for Double Quarter Wave Crab Cavity for the LHC High Luminosity Upgrade, *Proceedings of IPAC 2015, Richmond, VA, USA, 3-8 May 2015.*	3-8 May 2015	Richmond, VA, USA	Scientific Community	--	International
329 Link	Paper in proceedings of a Conference	Xiao, B. (BNL) et al	Cryogenic Test of Double Quarter Wave Crab Cavity for the LHC High Luminosity Upgrade, *Proceedings of IPAC 2015, Richmond, VA, USA, 3-8 May 2015.*	3-8 May 2015	Richmond, VA, USA	Scientific Community	--	International
330 Link	Paper in proceedings of a Conference	Wu, Q. (BNL)	Crab Cavities:Past, Present, and Future of a Challenging Device, *Proceedings of IPAC 2015, Richmond, VA, USA, 3-8 May 2015.*	3-8 May 2015	Richmond, VA, USA	Scientific Community	--	International

331 Link	Paper in proceedings of a Conference	Garcia, H. (CERN) et al	Beam Cleaning in Experimental IRs in HL-LHC for Incoming Beam, *Proceedings of IPAC 2015, Richmond, VA, USA, 3-8 May 2015.*	3-8 May 2015	Richmond, VA, USA	Scientific Community	--	International
332 Link	Paper in proceedings of a Conference	Snuverink, J. (Royal Academi, U. London) et al	Beam Delivery Simulation - Recent Developments and Optimization, *Proceedings of IPAC 2015, Richmond, VA, USA, 3-8 May 2015.*	3-8 May 2015	Richmond, VA, USA	Scientific Community	--	International
333 Link	Paper in proceedings of a Conference	Bruce, R. (CERN) et al	Collimator Layouts for HL-LHC in the Experimental Insertions, *Proceedings of IPAC 2015, Richmond, VA, USA, 3-8 May 2015.*	3-8 May 2015	Richmond, VA, USA	Scientific Community	--	International
334 Link	Paper in proceedings of a Conference	Hermes, P. (CERN) et al	Betatron Cleaning for Heavy Ion Beams with IR7 Dispersion Suppressor Collimators, *Proceedings of IPAC 2015, Richmond, VA, USA, 3-8 May 2015.*	3-8 May 2015	Richmond, VA, USA	Scientific Community	--	International
335 Link	Paper in proceedings of a Conference	Quaranta, E. (CERN) et al	Updated Simulation Studies of Damage Limit of LHC Tertiary Collimators, *Proceedings of IPAC 2015, Richmond, VA, USA, 3-8 May 2015.*	3-8 May 2015	Richmond, VA, USA	Scientific Community	--	International
336 Link	Paper in proceedings of a Conference	Quaranta, E. (CERN) et al	Collimation Cleaning at the LHC with Advanced Secondary Collimator Materials, *Proceedings of IPAC 2015, Richmond, VA, USA, 3-8 May 2015.*	3-8 May 2015	Richmond, VA, USA	Scientific Community	--	International
337 Link	Paper in proceedings of a Conference	Redaelli, S. (CERN)	Plans for Deployment of Hollow Electron Lenses at the LHC for Enhanced Beam Collimation, *Proceedings of IPAC 2015, Richmond, VA, USA, 3-8 May 2015.*	3-8 May 2015	Richmond, VA, USA	Scientific Community	--	International
338 Link	Paper in proceedings of a Conference	Rafique, H. (HUD)	Simulation of Hollow Electron Lenses as LHC Beam Halo Reducers using Merlin, *Proceedings of IPAC 2015, Richmond, VA, USA, 3-8 May 2015.*	3-8 May 2015	Richmond, VA, USA	Scientific Community	--	International
339 Link	Paper in proceedings of a Conference	Kwee, R. (Royal Accademy,	Beam Induced Background Simulation Studies at IR1 with New High Luminosity LHC Layout, *Proceedings of IPAC 2015, Richmond,*	3-8 May 2015	Richmond, VA, USA	Scientific Community	--	International

		U. London) et al	*VA, USA, 3-8 May 2015.*					
340 Link	Paper in proceedings of a Conference	Bignami, A. (CERN) et al	Energy Deposition and DPA in the Superconducting Links for the HILUMI LHC Project at the LHC Interaction Points, *Proceedings of IPAC 2015, Richmond, VA, USA, 3-8 May 2015.*	3-8 May 2015	Richmond, VA, USA	Scientific Community	--	International
341 CDS Link	Scientific / Technical Note	Metral, E. (CERN) et al	HL-LHC Operational Scenarios	18 May 2015	Geneva, Switzerland	Scientific Community	--	International
342 Link	Article	Szeberenyi, A. et al	Accelerating News Issue 14	Jun 2015	Geneva, Switzerland	Civil Society, Scientific Community	--	International
343 CDS Link	Thesis / Dissertation	Ravaioli, Emmanuele (Twente U.) et al	CLIQ. A new quench protection technology for superconducting magnets	19 Jun 2015	Enschede, the Netherlands	Scientific Community	--	International
344	Oral Presentation to a Scientific Event	Rossi, L. (CERN)	High Field Magnets for CERN's future accelerators	19 Jun 2015	Ensdchede, Netherlands	Scientific Community	50	International
345	Oral Presentation to a wider public	Rossi, L. (CERN)	LHC and next generation colliders at CERN	22 Jun 2015	Rome, Italy	Civil Society	80	Italy
346	Oral Presentation to a wider public	Rossi, L. (CERN)	L'avventura di uomini alla scoperta della struttura della materia. L'imprevisto e la possibilità dello stupore nella ricerca scientifica.	23 Jun 2015	Pescara, Italy	Civil Society	250	Italy
347	Oral Presentation to a wider public	Rossi, L. (CERN)	L'avventura di uomini alla scoperta della struttura della materia. L'imprevisto e la possibilità dello stupore nella ricerca scientifica.	24 Jun 2015	Chieti, Italy	Civil Society	300	Italy
348	Oral Presentation to a Scientific Event	Rossi, L. (CERN)	Workshop on Future Research Infrastructure; Challenges and Opportunities.	9 Jul 2015	Varenna, Italy	Scientific Community	80	International
349	Paper in	Zobov, M.	Simulation of Crab Waist Collisions In	24 Jun 2015	Richmond,	Scientific	--	International

CDS Link	proceedings of a Conference	(Frascati) et al	DAFNE With KLOE-2 Interaction Region, *Proceedings of IPAC15, Richmond, VA, USA, 3 - 8 May 2015*		USA	Community		
350 CDS Link	Paper in proceedings of a Conference	Zobov, M. et al	Numerical analysis of parasitic crossing compensation with wires in DAΦNE, *Proceedings of IPAC15, Richmond, VA, USA, 3 - 8 May 2015*	24 Jun 2015	Richmond, USA	Scientific Community	--	International
351 CDS Link	Scientific / Technical Note	Navarro-Tapia, M. (CERN) et al	Bead-PullMeasurements on the Fundamental Mode of the Double-Quarter-Wave Crab Cavity	6 Aug 2015	Geneva, Switzerland	Scientific Community	--	International
352	Thesis/Dissertation	Salmi, T.	Optimization of quench protection heater performance in high-field accelerator magnets through computational and experimental analysis	20 Aug 2015	Tampere, Finland	Scientific Community	--	International
353 CDS Link	Article published in the popular press	Communication office (INFN)	HiLumi, at CERN the biggest particle physics project over the next decade	31 Aug 2015	Frascati, Italy	Scientific Community	--	International
354	Paper in proceedings of a Conference	Giannelli, S. (CERN) et al	Quench propagation in helium gas cooled MgB2 cables, *Presented at EUCAS2015, Lyon, France, 6-10 Sep 2015*	6-10 Sep 2015	Lyon, France	Scientific Community	--	International
355	Paper in proceedings of a Conference	Hagner, M. et al	3D analysis of the porosity in MgB2 wires using FIB nanotomography, *Presented at EUCAS2015, Lyon, France, 6-10 Sep 2015.*	6-10 Sep 2015	Lyon, France	Scientific Community	--	International
356 CDS Link	Status Report	Fartoukh, S (CERN) et al	Compensation of the long-range beam-beam interactions as a path towards new configurations for the High Luminosity LHC	14 Sep 2015	Geneva, Switzerland	Scientific Community	--	International
357 CDS Link	Scientific Monograph	Rossi, L. (CERN) et al	The High Luminosity Large Hadron Collider: the New Machine for Illuminating the Mysteries of Universe	27 Oct 2015	Geneva, Switzerland	Civil Society, Scientific Community	--	International

ANNEX II: LIST OF ACRONYMS

a-C	Amorphous carbon
ADT	Transverse damper
ALARA	As low as reasonable achievable
ASIC	Application specific integrated circuit
ATS	Achromatic telescopic squeezing
AUG	Emergency stop buttons
BCMS	Bach compression and beam merging scheme
BETS	Beam energy tracking system
BFPP	Bound-free pair production
BGV	Beam gas vertex profile monitor
BIS	Beam interlock system
BLM	LHC beam loss monitoring system
BPM	Beam position monitor
BRAN	TAN luminosity monitor
BS	Beam screen
BSRT	Synchrotron radiation telescope monitor
CC	Crab cavities
CCB	Cold compressor box
CDD	CERN design directory
CDP	Conductor development programme
CFC	Carbon fibre carbon composites
CMOS	Complementary metal-oxide-semiconductor
COTS	Commercial-off-the-shelf
CVD	Chemical vapour deposition
DA	Dynamic Aperture
DAC	Digital-to-analog converter
DAQ	Data acquisition
DF	Distribution feedbox
DFBAM	Distribution feedbox for arc – IR 7/L
DFBAN	Distribution feedbox for arc – IR 7/R
DPA	Displacements-per-atom
DQW	Double quarter wave cavity
DSs	Dispersion suppressors
DVB	Cryogenic distribution valve box
DWR	Extraction resistors

EC	Electron cloud
EE	Energy extraction systems
ElQA	High voltage qualification
EMD	Electromagnetic dissociation
ERA	European Research Area
ESFRI	European Strategy Forum on Research Infrastructure
EUCARD	Enhanced European Coordination for Accelerator Research and Development
EYETS	Extended yearly technical stop
FMCM	Fast magnet current change monitors
FNAL	Fermi National Accelerator Laboratory
HEB	Hollow electron beam
HL-LHC	High Luminosity Large Hadron Collider
HFM	High-field magnet
HOM	High-order modes
HTS	High temperature superconductor
IBS	Intra-beam scattering
IP	Interaction point
IR	Interaction region
IT	Inner triplet magnets
LARP	LHC Accelerator Research Program
LBDS	LHC beam dumping system
LCB	Lower cold box
LIU	LHC injector complex upgrade
LLRF	Low level RF
LRBB	Long-range beam–beam
LS[X]	Long shutdown [Id Number]
LSS	Long straight section
LVDT	Linear variable differential transformer
MB	Main LHC dipoles
MBH	11 T dipole
MBU	Multiple bit upsets
MCDO	Magnet corrector decapole/octupole
MCS	Magnet corrector sextupole
MD	Machine development
MIM	Multi-band instability monitor
MKB	Diluter dump kicker
MKI	Magnet injection kicker

MP3	Magnet circuits, powering and performance panel
MPP	Machine protection panel
MPS	Machine protection system
MQY	Insertion region wide aperture quadrupole
MS	Matching section
NEG	Non-evaporable getter
NIEL	Non-ionizing energy losses
NIMS	National Institute of Materials Science
P5	Particle Physics Project Prioritization Panel
PIC	Powering interlock system
PIT	Powder-in-tube process
PLC	Programmable logic controller
PU	Pile-up
QPS	Quench protection system
QRL	cryogenic distribution line
QV	Quench buffer
r.m.s.	Root mean square
R2E	Radiation To Electronics
RF	Radio frequency
RFD	RF dipole cavity
RHQT	Rapid-heating, quenching transformation
RRP	Restacked rod process
SC	Superconductor
SCL	Superconducting link
SCRF	Superconducting radio frequency
SEE	Single event effects
SEU	Single bit upsets
SEY	Secondary electron yield
SIL	Safety integrity level
SM	Service module
SPS	Super Proton Synchrotron
SPT	Scheduled proton physics time
SR	Synchrotron radiation
SRF	Superconducting radio frequency
TAXN	Target absorber for insertion region neutrals
TAXS	Target absorber for insertion region secondary
TCAP	Target collimator absorber passive

TCDQ	Collimator for Q4 protection
TCL	Long collimator
TCLA	Target collimator long absorber
TCLD	Auxiliary collimators in DS area
TCPP	Primary collimator with BPM
TCSG	Target collimator secondary graphite
TCSMP	Secondary collimator metallic prototype
TCSP	Secondary collimator with pick-up
TCSPM	Secondary collimator with pick-up metallic
TCT	Target collimators tertiary
TCTP	Target collimator tertiary with pick-up
TCTPM	Target collimator tertiary with pick-up metallic
TDE	Target dump for ejected beam
TDI	Beam absorber for injection
TID	Total ionizing dose
TMCI	Transverse mode coupling instability
TS[X]	Technical stop [Id number]
UA[X]	Service and access tunnel [point number]
UCB	Upper cold box
UFO	Falling particles
UJ[X]	Service cavern [point number]
UPS	Uninterruptable power supplies
VCT	Vacuum chamber transition
VDWB	Vacuum – dump lines – window
VELO	Vertex locator
WBTN	Wide band time normalizer
WCS	Warm compressor station
WIC	Warm magnet interlock system

ANNEX III: GLOSSARY AND DEFINITIONS

Term	**Definition**
β^*	Optical β-function at the IP.
η	Machine slip factor.
η_D	Normalized dispersion, $\eta D = D/\sqrt{\beta}$, where D is the machine dispersion.
γ	Optic gamma function, $\gamma(s) = (1 + \alpha 2(s))/\beta(s)$ where $\beta(s)$ is the optical betatron function along the machine and $\alpha(s) = \frac{d\beta}{2\,ds}$.
γ_r	The relativistic gamma factor.
Abort gap	Area without any bunches in the bunch train that fits the time required for building up the nominal field of the LHC dump kicker.
Arc	The part of the ring occupied by regular half-cells. Each arc contains 46 half cells. The arc does not contain the dispersion suppressor.
Arc cell	Consists of two arc half-cells and presents the basic period of the optic functions.
Arc half-cell	Periodic part of the LHC arc lattice. Each half-cell consists of a string of three twin aperture main dipole magnets and one short straight section. The cryo magnets of all arc half-cells follow the same orientation with the dipole lead end pointing upstream of Beam 1 (downstream of Beam 2).
Batch	PS batch: train of 72 bunches that is injected into the SPS in one PS to SPS transfer. SPS batch: Train of 4 × 72 or 3 × 72 bunches that is injected into the LHC in one SPS to LHC transfer.
Beam 1 and Beam 2	Beam 1 and Beam 2 refer to the two LHC beams. Beam 1 circulates clockwise in Ring 1 and Beam 2 circulates counter clockwise in Ring 2. If colours are used for beams, Beam 1 is marked blue and Beam 2 is marked red.
Beam cleaning	Removal of the large amplitude (larger than 6 σ) particles from the beam halo. The LHC has two beam cleaning insertions: one is dedicated to the removal of particles with large transverse oscillation amplitudes (IR7) and one dedicated to the removal of particles with large longitudinal oscillation amplitudes (IR3). These insertions are also referred to as the betatron and momentum cleaning or collimation insertions.
Beam crossing angle	Dedicated orbit bumps separate the two LHC beams at the parasitic beam crossing points of the common beam pipe of Ring 1 and Ring 2. The crossing angle bumps do not separate the beams at the IP, but only at the parasitic crossing points. These orbit bumps generate an angle between the orbit of Beam 1 and Beam 2 at the IP. The full angle between the orbit of Beam 1 and Beam 2 is called the crossing angle. In IR2 and IR8 the crossing angle orbit bumps consist of two separate contributions. One external bump generated for the beam

	separation at the parasitic beam crossing points and one internal bump generated by the experimental spectrometer and its compensator magnets. The LHC baseline foresees vertical crossing angles in IR1 and IR2 and horizontal crossing angles in IR5 and IR8.
Beam half-life	Time during beam collision after which half the beam intensity is lost.
Beam screen	Perforated tube inserted into the cold bore of the superconducting magnets in order to protect the cold bore from synchrotron radiation and ion bombardment.
Beam types	**Pilot beam:** consists of a single bunch of 0.5×10^{10} protons. It corresponds to the maximum beam current that can be lost without inducing a magnet quench. **Commissioning beam:** beam tailored for a maximum luminosity with reduced total beam power (i.e. increased operational margins related to beam losses and magnet quenches) and possibly smaller beam sizes (i.e. increased mechanical acceptance in terms or the transverse beam size and larger tolerances for orbit and β-beat). **Intermediate beam:** beam tailored for a high accuracy of the beam measurements with reduced total beam power (i.e. increased operational margins related to beam losses and magnet quenches). **Nominal beam:** beam required to reach the design luminosity of $L = 10^{34}$ cm^{-2} s^{-1} with $\beta^* = 0.55$ m ($\rightarrow$ normalized emittance $\varepsilon_n = 3.75$ μm; $N_b = 1.15 \times 10^{11}$; $n_b = 2808$). **Ultimate beam:** beam consisting of the nominal number of bunches with nominal emittances (normalized emittance of 3.75 μm) and ultimate bunch intensities ($I = 0.86$ A $\rightarrow N_b = 1.7 \times 10^{11}$). Assuming the nominal value of $\beta^* = 0.55$ m and 2808 bunches, the ultimate beam can generate a peak luminosity of $L = 2.3 \times 10^{34}$ cm^{-2} s^{-1} in the two high luminosity experiments.
BPM	Beam position monitor.
Bunch	Collection of particles captured within one RF bucket.
Bunch duration	The bunch duration is defined as $$\sigma_t = \frac{\sigma_s}{v},$$ where σ_s is the bunch length and v is the speed of the particles in the storage rings.
Bunch length	The bunch length is defined as the r.m.s. value of the longitudinal particle distribution in one RF bucket. The bunch length is denoted as σ_s.
Busbar	Main cable that carries the current for powering the magnets outside the magnet coil.
Channel	The two apertures of the double bore magnets form two channels through the LHC. Each arc has one outer and one inner channel.
Cold mass	The cold mass refers to the part of a magnet that needs to be cooled by the cryogenic system, i.e. the assembly of magnet coils, collars, iron yoke, and helium vessel.

Crossings	The two machine channels cross at the experimental insertions, i.e. at IP1, IP2, IP5, and IP8.
Cryo magnet	Complete magnet system integrated into one cryostat, i.e. main magnet coils, collars and cryostat, correction magnets, and powering circuits.
DA	See dynamic aperture
Damper	Transverse or longitudinal feedback system used to damp injection oscillations and/or multi-bunch instabilities of a beam.
Damping time	Time after which an oscillation amplitude has been reduced by a factor $1/e$. **Longitudinal emittance damping time:** Half of the longitudinal amplitude damping time for a Gaussian approximation of the bunch distribution. **Transverse emittance damping time:** half of the transverse amplitude damping time for a Gaussian approximation of the transverse bunch distribution. If no explicit mentioning of the types of damping times is given the damping times refer to the amplitude damping times.
Decay and snap back	Persistent current decay is a change in the persistent current contribution to the total magnetic field in superconducting magnets powered at constant current (e.g. at injection). This effect varies among magnets and is a function of the powering history (i.e. previous current cycles). When the magnet current is changed (e.g. during the acceleration ramp) the magnetic field comes back to the original value before the decay. This effect is called snap back and occurs for the LHC main dipole magnets within the first 50 A change of the LHC ramp.
Dispersion suppressor	The dispersion suppressor refers to the transition between the LHC arcs and insertions. The dispersion suppressor aims at a reduction of the machine dispersion inside the insertions. Each LHC arc has one dispersion suppressor on each end. The length of the dispersion suppressors is determined by the tunnel geometry. Each LHC dispersion suppressor consists of four individually powered quadrupole magnets that are separated by two dipole magnets. This arrangement of four quadrupole and eight dipole magnets is referred to as two missing dipole cells. For the machine lattice these two missing dipole cells are referred to as one dispersion suppressor. However, reducing the dispersion at the IPs to zero requires a special powering of two more quadrupole magnets on each side of the arc. In terms of the machine optics the dispersion suppressor refers therefore to the two missing dipole cells plus one additional arc cell.
Dogleg magnets	Special dipole magnet used for increasing the separation of the two machine channels from standard arc separation. The dogleg magnets are installed in the cleaning insertions IR3 and IR7 and the RF insertion IR4.
Dynamic aperture	Maximum initial oscillation amplitude that guarantees stable particle motion over a given number of turns. The dynamic aperture is

	normally expressed in multiples of the RMS beam size (σ) and together with the associated number of turns.
Eddy currents	Eddy currents are screening currents that tend to shield the interior of a conductor or a superconducting cable from external magnetic field changes. In the case of a strand the eddy currents flow along the superconducting filaments in the strand (without loss) and close across the resistive matrix of the strand (copper for the LHC). In the case of a cable the eddy currents flow along the strands (without loss) and close resistively at the contact points among strands in the cable. Eddy currents are also referred to as coupling currents.
Energy spread	The energy spread is defined as the 'RMS' value of the relative energy deviations from the nominal beam energy in a particle distribution. The energy spread is denoted as $\sigma_{\delta E/E0}$.
Experimental insertion region	Insertion region that hosts one of the four LHC experiments.
Filament	Superconducting filaments are fine wires of bulk superconducting material with typical dimension in the range of a few microns. The superconducting filaments are embedded in the resistive matrix in a strand.
Hourglass effect *H*	Luminosity loss due to longitudinal modulation of beta function over the length of the bunch for small β^*.
Insertion region (IR)	Machine region between the dispersion suppressors of two neighboring arcs. The insertion region consists of two matching sections and, in the case of the experimental insertions, of two triplet assemblies and the separation/recombination dipoles.
Interaction point (IP)	Middle of the insertion region (except for IP8). In the insertions where the two LHC beams cross over, the IP indicates the point where the two LHC beams can intersect. In IR8 the experimental detector is shifted by 3/2 RF wavelength and the IP refers to the point where the two LHC beams can intersect and does not coincide with the geometric centre of the insertion.
Ions	The LHC foresees collisions between heavy ions, $^{208}Pb^{82+}$ (fully stripped) during the first years (208 is the number of nucleons, 82 the number of protons of this particular nucleus).
Ions, nominal scheme	Approximately 600 bunches per beam, with 7×10^7 Pb ions each, are colliding at 2.76 TeV/u to yield an initial luminosity of $L = 1.0 \times 1027$ cm^{-2} s^{-1} where $\beta^* = 0.5$ m.
Ions, early scheme	Approximately 60 bunches per beam, with 7×10^7 Pb ions each, are colliding to yield an initial luminosity of $L = 5.0 \times 10^{25}$ cm^{-2} s^{-1} with ($\beta^* = 0.5$ m).
Lattice correction magnets	Correction magnets that are installed inside the short straight section assembly.
Lattice version	Lattice version refers to a particular hardware installation in the tunnel. It is clearly separated from the optics version and one lattice version can have more than one optics version.

Left, right	See the definition under 'right and left'.
Long-range interactions	Interaction between the two LHC beams in the common part of Ring 1 and Ring 2 where the two beams are separated by the crossing angle orbit bumps.
Long straight section (LSS)	The quasi-straight sections between the upstream and downstream dispersion suppressor of an insertion, including the separation/recombination dipole magnets.
Longitudinal emittance	The longitudinal emittance is defined as: $\epsilon_s = 4\pi\sigma_t\sigma_{\delta E/E0}E_0,$ where σ_t is the bunch duration in seconds, and $\sigma_{\delta E/E0}$ the relative energy spread.
Luminosity half-life	Time during beam collision after which the luminosity is halved. The luminosity half-life is generally smaller than the beam half-life.
Luminous region	The 3D distribution of the collision event vertices.
Luminosity reduction	**Geometric luminosity reduction factor due to beam offset R:** Reduced beam overlap due to transversal offset of collisions, frequently used for reduction of luminosity (levelling) and VdM scans.Luminosity reduction factor due to crossing angle *S*: reduced beam overlap due to tilted bunch shape due to crossing angle. Total luminosity reduction factor $F = R^*H^*S$ (Strictly speaking here there is no direct multiplication, but provides a reasonable indication of the different contributions, while dominated by the crossing angle contribution).
Machine cycle	The machine cycle refers to one complete operation cycle of a machine, i.e. injection, ramp-up, possible collision flat-top, ejection, and ramp-down. The minimum cycle time refers to the minimum time required for a complete machine cycle.
Machine statistics	Run time: annual time allocated to running with beam [days]. Scheduled physics time: annual time allocated to physics (excluding initial beam commissioning, scrubbing, TS, recovery from TS, MDs, special physics) [days]. Physics efficiency: time with both beams present and stable beams, versus scheduled physics time [%]. Machine availability: time during which the machine is in a state allowing operations to take beam and run through a nominal physics cycle, versus run time [%]. Turnaround time: time between the end of one and the start of the next physics run/data taking by the experiments (delimited by the loss of beam presence/beam dump back to declaration of stable beams) [hours]. Recovery time: time between the end of one cycle and the readiness for injection of new particles for the next cycle (delimited by the loss of beam presence/beam dump and resumption of the normal operational cycle) [hours].
Magnet quench	Loss of the superconducting state in the coils of a superconducting magnet.

Main lattice magnets	Main magnets of the LHC arcs, i.e. the arc dipole and quadrupole magnets.
Matching section	Arrangement of quadrupole magnets located between the dispersion suppressor and the triplet magnets (or the IP for those insertions without triplet magnets). Each insertion has two matching sections: one upstream and one downstream from the IP.
n_1	The effective mechanical aperture n_1 defines the maximum primary collimator opening in terms of the r.m.s. beam size that still guarantees a protection of the machine aperture against losses from the secondary beam halo. It depends on the magnet aperture and geometry and the local optics perturbations.
N_b	Number of particles per bunch.
n_b	Number of bunches per beam.
Nominal bunch	Bunch parameters required to reach the design luminosity of L = 1034 cm−2 s−1 where β* = 0.55 m. The nominal bunch intensity is N_b = 1.15 × 1011 protons.
Nominal powering	Hardware powering required to reach the design beam energy of 7 TeV.
Normalized transverse emittance	The beam emittance decreases with increasing beam energy during acceleration and a convenient quantity for the operation of a hadron storage rings (and linear accelerators) is the 'normalized emittance' defined as $\epsilon_n = \epsilon\gamma_r\beta_r,$ where γ_r and β_r are the relativistic gamma and beta factors $\beta_r = \frac{v}{c}$ $\gamma_r = \frac{1}{\sqrt{1-\beta_r^2}}$ where v is the particle velocity and c the speed of light in vacuum. The nominal normalized transverse emittance for the LHC is ε_n = 3.75 μm.
Octant	An octant starts in the center of an arc and goes to the centre of the next downstream arc. An octant consists of an upstream and a downstream half-octant. A half-octant and a half-sector cover the same part of the machine even though they may not have the same number.
Optical configuration	An optical configuration refers to a particular powering of the LHC magnets. Each optics version has several optical configurations corresponding to the different operational modes of the LHC. For example, each optics version has a different optical configuration for injection and luminosity operation, and for luminosity operation the optics features different optical configurations corresponding to different β^* values in the four experimental insertions of the LHC.
Optics version	The optics version refers to a consistent set of optical configurations.

	There can be several different optics versions for one lattice version.
Pacman bunches	Bunches that do not experience the same number of long-range beam–beam interactions left and right from the IP.
Parallel separation	Dedicated orbit bumps separate the two LHC beams at the IP during injection, ramp, and the optics squeeze. The total beam separation at the IP is called the parallel separation. The LHC baseline foresees horizontal parallel separations in IR1 and IR2 and vertical separations in IR5 and IR8.
Parasitic crossing points	Positions in the common part of the Ring 1 and Ring 2 where the two beams can experience long-range interactions.
Persistent currents	Persistent currents are eddy currents with (ideally) infinitely long time constants that flow in the bulk of the superconducting filaments of a strand and tend to shield the interior of the filament from the external magnetic field changes. These screening currents close inside the superconducting filament, with zero resistance (in steady state). Hence, for practical purposes, they do not decay in time and for this reason they are referred to as 'persistent'.
Physics run	Machine operation at top energy with luminosity optics configuration and beam collisions.
Pile-up	**Event pile-up μ:** number of visible inelastic proton–proton interactions in a given bunch crossing. Average pile-up: mean value of the pile-up over a fill (averaged over all bunchcrossings). Peak pile-up: maximum pile-up in any bunch crossing at any time (usually at the start of the fill). Peak average pile-up: mean pile-up at the beginning of the fill. It corresponds to the peak luminosity of the fill. In practice, it is determined as the maximum of the pile-up values obtained by averaging over all bunch crossings within time intervals of typically one minute. Average pile-up density: number of inelastic proton–proton interactions in a given bunch-crossing divided by the size of the luminous region in *Z*.
Pilot bunch	Bunch intensity that assures no magnet quench at injection energy for an abrupt loss of a single bunch but is still large enough provide BPM readings. The pilot bunch intensity of the LHC corresponds to 0.5×10^{10} protons in one bunch.
Piwinski parameter	Parameterization of reduced beam overlap due to finite crossing angle.
Ramp	Change of the magnet current. During the beam acceleration the magnets are 'ramped up' and after the end of a physics store the magnets are 'ramped down'.
Resistive matrix	One of the two main constituents of the strand. The resistive matrix embeds the filaments in the strand and provides a low resistance current shunt in case of quench (transition of superconducting material to the normal state).

RF bucket	The RF system provide a longitudinal focusing that constrains particle motion in the longitudinal phase space to a confined region called the RF bucket.
Right, left	Describes the position in the tunnel relative to an observer inside the ring looking out (same definition as for LEP).
Ring 1 and Ring 2	There are two rings in the LHC, one ring per beam. Ring 1 corresponds to Beam 1, which circulates clockwise, and Ring 2 corresponds to Beam 2, which circulates counter-clockwise in the LHC.
Satellite bunch	Collection of particles inside RF buckets that do not correspond to nominal bunch positions. The nominal bunch spacing for the LHC is 25 ns, while the separation of RF buckets is 2.5 ns. In other words, there are nine RF buckets between two nominal LHC bunch positions that should be empty.
Sector	The part of a ring between two successive insertion points (IP) is called a sector. Sector 1-2 is situated between IP1 and IP2.
Separation/recombination magnets	Special dipole magnets left and right from the triplet magnets that generate the beam crossings in the experimental insertions.
Short straight section (SSS)	Assembly of the arc quadrupole and the lattice corrector magnets. Each SSS consists of one quadrupole magnet, one beam position monitor (BPM), one orbit corrector dipole (horizontal deflection for focusing and vertical deflection for defocusing quadrupoles), one lattice correction element (i.e. trim or skew quadrupole elements or octupole magnets). and one lattice sextupole or skew sextupole magnet.
Special straight section (SPSS)	Quadrupole assemblies of the insertion regions. The SPSS features no lattice corrector and sextupole magnets and has only orbit correction dipole magnets and BPMs.
Spool piece correction magnets	Correction magnets directly attached to the main dipole magnets. The spool piece correction magnets are included in the dipole cryostat assembly
Strand	A superconducting strand is a composite wire containing several thousands of superconducting filaments dispersed in a matrix with suitably small electrical resistivity properties. The LHC strands have Nb-Ti as their superconducting material and copper as the resistive matrix.
Superconducting cable	Superconducting cables are formed from several superconducting strands in parallel, geometrically arranged in the cabling process to achieve well-controlled cable geometry and dimensions, while limiting strand deformation in the process. Cabling several strands in parallel results in an increase of the current carrying capability and a decrease of the inductance of the magnet, easing protection. The LHC cables are flat, keystoned cables of the so-called Rutherford type.
Super pacman bunches	Bunches that do not collide head-on with a bunch of the other beam in one of experimental IPs.
Synchrotron radiation	**Longitudinal amplitude damping time:** the ratio of the average rate

damping times	of energy loss (energy lost over one turn divided by the revolution time) and the nominal particle energy. **Transverse amplitude damping time:** time after which the transverse oscillation amplitude has been reduced by a factor 1/*e* due to the emission of synchrotron radiation. For a proton beam it is just twice the longitudinal amplitude damping time due to the emission of synchrotron radiation. If no explicit mentioning of the types of damping times is given the damping times refer to the amplitude damping times.
TAN	Target absorber neutral: absorber for the neutral particles leaving the IP. It is located just in front of the D1 separation/recombination dipole magnet on the side facing the IP.
TAS	Target absorber secondaries: absorber for particles leaving the IP at large angles. It is located just in front of the Q1 triplet quadrupole magnet on the side facing the IP.
Transverse beam size	The transverse beam size is defined as the r.m.s. value of the transverse particle distribution.
Transverse emittance	The transverse emittance is defined through the invariance of the area enclosed by the single particle phase space ellipse. The single particle invariant under the transformation through the storage ring is given by $$A = \gamma x^2 + 2\alpha x x' + \beta x'^2,$$ where α, β, and γ are the optical functions. The area enclosed by the single particle phase space ellipse is given by $$\text{area of ellipse} = \pi A$$. For an ensemble of particles the emittance is defined as the average of all single particle invariants (areas enclosed by the single particle phase space ellipsoids divided by π). The transverse betatron beam size in the storage ring can be written in terms of the beam emittance as $$\sigma_{x,y}(s) = \sqrt{\beta_{x,y}(s)\epsilon_{x,y}},$$ where $\beta x,y$ (s) is the optical β-function along the storage ring. The transverse emittance is given by the following expression: $$\epsilon_z = \sqrt{\langle z^2\rangle\langle z'^2\rangle - \langle zz'\rangle^2}; z = x, y,$$ where it is assumed that the particle coordinates are taken at a place with vanishing dispersion and where $\langle\ \rangle$ defines the average value of the coordinates over the distribution. z and z' are the canonical transverse coordinates ($z = x,y$).

Triplet	Assembly of three quadrupole magnets used for a reduction of the optical β-functions at the IPs. The LHC triplet assembly consists in fact of four quadrupole magnets but the central two quadrupole magnets form one functional entity. The LHC has triplet assemblies in IR1, IR2, IR5, and IR8.
Tune	Number of particle trajectory oscillations during one revolution in the storage ring (transverse and longitudinal).
Ultimate bunch intensity	Bunch intensity corresponding to the expected maximum acceptable beam–beam tune shift with two operating experimental insertions. Assuming the nominal emittance (normalized emittance of 3.75 μm) the ultimate bunch intensity corresponds to 1.7×10^{11} protons per bunch.
Ultimate powering	Hardware powering required to reach the ultimate beam energy of 7.54 TeV, corresponding to a dipole field of 9 T.
Upstream and downstream	Always related to the direction of one of the two beams. If no beam is specified then Beam 1 is taken as the default. This implies that stating a position as being 'upstream' without indicating any beam is equivalent to stating that the position is to the left.