

IR'07 PROCEEDINGS

SUMMARY OF CARE-HHH IR'07

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Abstract

We summarize the highlights and main conclusions of the CARE-HHH-APD mini-workshop on the LHC Interaction Region (IR) upgrade "IR'07" held in Frascati from the 7th to the 9th of November 2007.

OVERVIEW

The IR'07 CARE-HHH-APD mini-workshop was organized at INFN Frascati from the 7th to the 9th of November 2007. The workshop was attended by 39 experts (Fig. 1), about half of whom came from CERN. The workshop scope covered the upgrade of the LHC interaction region (IR), the DAFNE IR upgrade, and plans for SuperB. More specifically, the key topics included the performance and limitations of the LHC-IR upgrade optics, the optimization of new LHC IR triplet magnets, the US-LARP magnet strategy (response to Lucio Rossi's "challenge"), heat deposition, early-separation dipoles, detector-integrated quadrupoles, crab cavities wire compensators and crab-waist collisions. The goals of IR'07 were threefold: (1) to narrow down the possible IR optics options and to converge on magnet parameters, (2) to identify the ingredients of the two LHC upgrade phases, and (3) to strengthen the collaboration with DAFNE/SuperB studies as well as to explore the applicability of advanced IR concepts to the LHC. The workshop web site <http://care-hhh.web.cern.ch/CARE-HHH/IR07> comprises a link to the agenda and talks posted on INDICO.



Figure 1: The IR'07 participants on the workshop site (photo courtesy A. Mostacci and C. Bosteels).

The workshop was structured in 9 sessions:

- **Session 1: introduction**, convener Walter Scandale, with presentations by M. Calvetti, C. Milardi, M. Biagini, W. Scandale, S. Peggs, E. Todesco and D. Tommasini;
- **Session 2: IR triplet magnets**, convener James Strait, with presentations by P. Wanderer, G.L. Sabbi, G. Ambrosio, A. Zlobin and R. Ostojic;
- **Session 3: early separation**, convener Catia Milardi, with presentations by J.-P. Koutchouk, P. Limon, G. Sterbini, W. Scandale and F. Zimmermann;
- **Session 4: optics**, convener Steve Peggs, with presentations by M. Giovannozzi, R. De Maria, R. Tomas, E. Laface and G. Robert-Demolaize;
- **Session 5: energy deposition**, convener Jean-Pierre Koutchouk, with presentations by F. Broggi and E. Wildner;
- **Session 6: D0 and Q0 detector interference**, convener Peter Limon, with presentations by M. Nessi, J. Nash, E. Tsesmelis and S. Peggs;
- **Session 7: beam-beam compensation and crab cavities**, convener Frank Zimmermann, with presentations by U. Dorda, C. Milardi, again U. Dorda, R. Calaga and F. Zimmermann;
- **Session 8: crab waists and flat beams**, convener Marica Biagini, with presentations by M. Zobov, E. Levitchev and P. Raimondi;
- **Session 9: final round table and conclusions**, conveners Walter Scandale and Frank Zimmermann.

A total of 42 talks were delivered in 3 days. They were complemented by four round-table discussions. All presentations were of highest quality and to the point.

HIGHLIGHTS

Unfortunately, due to space and time limitations, we can only present a few selected highlights, somewhat subjectively extracted from the various presentations, as well as from the four round-table discussions.

News from LARP

S. Peggs and A. Zlobin described recent changes in the organization of the US-LARP [1, 2]. T. Markiewicz now is in charge of the accelerator systems, and P. Wanderer

responsible for magnet systems, including HQ model magnets managed by G.L. Sabbi and LQ magnets organized by G. Ambrosio.

Most importantly a new working group was created, called "Joint IR studies" (JIRS), which is the US equivalent of R. Ostojic's LHC IR Upgrade Working Group (LIUWG) at CERN. Both LIUWG and JIRS bring together magnet experts and beam dynamicists. However, JIRS also, and in particular, looks at Nb₃Sn magnets and it investigates other Nb₃Sn magnet applications for an LHC upgrade such as early separation dipoles, Q6, dispersion suppressor dipoles etc., all of which LIUWG does not.

A recent DOE review encouraged LARP to engage in crab-cavity R&D and to participate in a broad crab-cavity collaboration [1]. A Small Business (SBIR) proposal by the Long-Island company Advanced Energy Systems (AES) aims at fabricating an 800-MHz prototype LHC crab cavity. Also a merger of light-source and LHC deflecting-cavity efforts is foreseen.

L. Rossi had "challenged" the US LARP to provide 4–8 Nb₃Sn quadrupoles for the phase-1 upgrade, with the NbTi complement made by CERN. This challenge has formally been expressed in a memo of S. Peggs, who stressed that the single strategic goal of LARP is to make Nb₃Sn magnet technology fully mature for phase 2. The delivery of several cold masses is no longer R&D but would require a "construction project" separate from LARP. Lastly, any Nb₃Sn magnet for phase 1 would need to perform at least as well as the NbTi magnets built at CERN [1].

A. Zlobin presented details of the JIRS organization, which includes two "simulations" task forces, one on operating margins headed by N. Mokhov, the other on accelerator quality and tracking, supervised by G. Robert-Demolaize, and two "studies" task forces, one on optics& layout guided by J. Johnstone, and the second on magnet feasibility led by P. Wanderer [2].

Phase-1 Triplet Magnets

E. Todesco discussed a 130-mm aperture triplet [3]. Quadrupoles based on NbTi could provide $\beta^* = 0.25$ m with 3σ margin for collimation. A conceptual design of such NbTi magnet was presented, including issues related to field quality, stresses and protection. This same triplet could be replaced by one made of Nb₃Sn, which would give more than a factor 2 higher temperature margin.

Magnet R&D

G.L. Sabbi stressed that the LARP HQ130 prototype magnet already meets the specifications on field gradient and aperture for an LHC upgrade [4].

D. Tommasini described a novel procedure of ceramic wet winding for producing high-performance Nb₃Sn dipole coils, developed at CERN. With this production technique a 12-T field was reached at 4.2 K with zero training quenches [5].

Early Separation

J.-P. Koutchouk presented an update on the early-separation upgrade scenario [6]. Full early separation at 25-ns spacing requires the D0 dipole to be at 1.9-m distance from the IP, which can be discarded due to an incompatibility with the detector. J.-P. Koutchouk retained the options of a full early separation scheme with 50-ns spacing, needing a first magnet at 3.8 m from the IP, and of a partial early separation scheme with 1 or 2 long-range encounters at 5σ separation, that would allow moving the D0 dipole further away from the IP towards a distance of 5.6–9.4 m.

To boost the luminosity performance, a partial early separation scheme can be enhanced by an electron lens at a separation of 3σ or by a crab cavity. The latter would yield a 50–70% increase in luminosity. J.-P. Koutchouk also illustrated the benefits from luminosity leveling. The performance which was estimated for the improved early-separation scenario was almost doubled compared with that shown at LUMI'06 [7], while the projected pile up was reduced by a factor 3 or 4.

Quoting the experience at the ISR, where a β^* decrease was implemented within a few weeks, and applying a statistical law ("CPT theorem") for the performance improvement of accelerators that had earlier been proposed by V. Shiltsev [9], J.-P. Koutchouk concluded that 3–4 years are required for an LHC upgrade based on beam-current increase, compared with no more than 1 year for an upgrade aiming at smaller β^* values.

P. Limon studied the integration of D0 or Q0 magnets with the CMS detector [8]. He concluded that the magnets themselves can be built, but that the consequences for the experiment are potentially severe. He sketched a possible organizational path towards a solution.

Round Table Discussion after 3 Sessions

The discussion focused on L. Rossi's challenge. A primary question was whether the magnet development for phase-1 and phase-2 would represent a complementing synergy or divergent goals, and if there actually was a need for Nb₃Sn magnets in the upgrade phase 1. Nb₃Sn promises to be better suited for increased beam losses, and to provide a larger temperature margin, since the available cooling capacity is improved (D. Tommasini, A. Zlobin). There is some evidence to support these positive statements, but not yet a full experimental verification. P. Limon stressed that building phase-1 Nb₃Sn magnets in the US would not be a good return on investment.

It seems unlikely that one can build fully functional phase-2 quadrupoles in time for phase 1. Radiation survival is a concern for intermediate magnets. J. Strait emphasized that one should be sure these magnets do not become a failure point.

Which β^* value might one hope for in phase-1? Reducing β^* to 0.25 m alone gives a marginal return (about 20% increase in the average luminosity). J.-P. Koutchouk explained that the main idea of phase 1 is "to provide margins

in case". The phase-1 IR upgrade must be complemented by other improvements, e.g. crab cavities, collimator upgrade, and linac4, in order to yield a large benefit, as was pointed out by both R. Ostojic and W. Scandale.

Concerning the new technique for fabricating Nb₃Sn coils developed at CERN, how fast could this new procedure become beneficial (if)? Should it be explored in parallel to other magnet development activities? D. Tommasini elaborated that no epoxy is employed in this scheme. However, the mechanical, electrical & thermal properties of the coils still need to be confirmed. Perhaps the question was still premature at this workshop.

How can the effort on the D0 & Q0 detector-embedded magnets be streamlined? P. Limon emphasized that background studies by the experiments are urgently needed. J. Nash qualified that such studies are very expensive, and that a reasonable starting point must be found first. The detector studies involve an intricate shielding optimization for each new set of parameters. S. Peggs stressed that the LARP involvement in this area is limited. Machine experiments in RHIC on the acceptable number of long-range collisions are underway, but given the multidimensional parameter space and the inherent difficulties of beam-beam experiments and their interpretation, no clear final answer should be expected soon, though we might get some hints. J.-P. Koutchouk and J. Nash recommended to proceed in steps and to converge, together with the experiments, towards an optimal solution. P. Limon added that the detector solenoids, the support structures, and the expected heat load all require that the first accelerator magnets be placed more than 6 m away from the IP.

Is the production of a mixed quadrupole triplet in a competitive bid an efficient idea? S. Peggs remarked that the bid was not competitive, and that "perception is not reality". He recommended that the mandate of the CERN LIUWG be adjusted to include Nb₃Sn options and magnetic elements other than the triplets, and that it be aligned with the JIRS mandate. E. Todesco summarized that the reactions to the challenge of L. Rossi were controversial. P. Limon emphasized that the LARP goal consists of only design, papers and one prototype. D. Tommasini commented that a hybrid solution minimizes the risk. He added that spare NbTi quadrupoles will be available as a backup. Field quality in a mixed triplet is another possible matter of concern.

Concerning the crab-cavity experience at KEKB, S. Peggs observed that KEKB is running with crab cavities. R. Calaga and F. Zimmermann pointed out that the KEKB crab cavities restore the geometric luminosity and even increase the beam-beam tune shift, while the KEKB beam current is presently limited by an unrelated problem. The question "would CERN be ready to install crab cavities in the LHC?" was posed by S. Peggs. The effect of crab-cavity noise could in principle be checked in any hadron storage ring.

What are the possible experimental tests of various types of leveling? At BEAM'07 the talks by V. Lebedev and

V. Shiltsev reported on the experience at the Tevatron [10]. The interpretation of this experience was controversial. Experimental tests e.g. at RHIC (and at LHC) would be useful.

Should the LHC luminosity be increased via higher current and/or lower beta*? Both approaches may be needed. F. Zimmermann recalled that the Tevatron and the SPS had increased their luminosity primarily with a higher beam current. At the ISR reducing beta* was successful, but the ISR beam currents were extremely high.

What is the minimum acceptable luminosity lifetime? Representatives of the experiments responded that 5 hours would be acceptable. Another statement from the experiments – how fast they can turn on after establishing collisions – was requested and not readily available.

It was speculated whether a large off-momentum beta beating might be acceptable for the "less-critical momentum cleaning" (J.-P. Koutchouk). Answering this question requires a study of the collimation performance with such type of beta beating.

It was already shown that larger-aperture magnets can be produced without increasing the outer magnet diameter. As part of the phase-1 upgrade, the only modification to the LHC IR cryoplants that may be necessary is one for the rf in point 4 (R. Ostojic).

Upgrade Optics

M. Giovannozzi reviewed the optics constraints for the upgrade [12]. He highlighted that aperture and off-momentum beta beating can make a big impact on the collimation performance. He argued that the beta beating is more readily accepted in the momentum cleaning insertion than on the other half of the ring. The available aperture may be optimally used by colliding "flat beams", e.g. beams with unequal IP beta functions [13]. The optimum trade off between beam screen and beam aspect ratio needs to be found.

R. De Maria discussed the choice of the quadrupole gradient for the new triplet magnets [14]. He compared three upgrade optics solutions — the so-called "modular" [15], "low β max" [15] and "symmetric" solution [16] —, and he examined aperture bottlenecks at other IR magnets. He concluded that the long straight sections are pushed to their limits, that optimization at the percent level gives rather large performance differences, and that flat beams will probably be the preferred scheme for pushing the performance at the edge.

R. Tomas presented a correction scheme for nonlinear triplet field errors which is based on minimizing the norm of a Taylor map characterizing the optical transport, using the Python code "MAPCLASS" [17]. The minimization with a set of higher-order correctors reduces the value of the norm by at least 5 orders of magnitude. As a result of this correction, the dynamic aperture increases by 1–2 σ , in tracking simulations. R. Tomas also found that the presently chosen quadrupole aperture is about the smallest acceptable value with regard to dynamic aperture: For even

slightly smaller quadrupole diameter the dynamic aperture quickly collapses. Standard scaling laws for the field errors were assumed in his study.

Energy Deposition

E. Wildner described simulations of heat deposition in the triplet quadrupoles for the so-called “symmetric” and “compact” upgrade optics [18]. For the same luminosity, the total heat load per magnet is reduced by up to 50–60% for the larger aperture quadrupoles of the upgrade. As a further mitigation the introduction of a tungsten mask between quadrupoles Q1 and Q2 was studied, as was a 2 cm stainless steel liner covering the inside of the quadrupoles. In particular the liner was very efficient in reducing the peak power density by a factor 20, from 21.5 mW/cm^{-3} to 1.1 mW/cm^{-3} . The latter value is more than a factor 3 below the acceptable design limit of NbTi magnets. E. Wildner also simulated the effect of an early-separation dipole D0 on the peak energy deposition, and she found that the D0 magnet does not increase local heat loads, rather the opposite. Summarizing, the largest aperture quadrupoles are most favorable in view of the heat load from collision debris, and a 2-cm thick liner leads to a dramatic improvement, making a luminosity of $10^{35} \text{ cm}^{-2}\text{s}^{-1}$ look like a realistic possibility.

Detector Interference

M. Nessi discussed the view of ATLAS. He identified several regions where D0 or Q0 magnets might be embedded in the ATLAS detector [19]. The least problematic region is at the border of the forward shield (JF) and the nose shield (JN), which would also offer a convenient retractable support.

J. Nash, representing CMS, first reminded the audience that the SLHC's priority is the particle physics programme [20]. The performance will be characterized not only by the peak luminosity and not alone by the integrated luminosity, but backgrounds, acceptance and detector pile up also matter. Different physics channels require different conditions. Depending on the channel luminosity, leveling or forward acceptance could prove important. The scenario chosen by nature will not be known until the first data from LHC are available. J. Nash stressed that therefore it is important not to exclude any option at the present stage. On its own, CMS has no need for any changes to the forward region and shielding of its detector. Pile-up studies have been launched, but no definite statement can yet be made on how much pile up CMS will be able to withstand. Any IR modification can lead to rather costly changes of the CMS infrastructure.

Beam-Beam Compensation and Crab Cavities

U. Dorda presented results of long-range beam-beam simulations for the LHC upgrade [21]. He found that at the nominal bunch intensity the dynamic aperture for the “low

β max” upgrade optics is about 5.5σ , which decreases to 4.5σ if a D0 magnet is added. The value of the dynamic aperture was determined using the Lyapunov criterion for the detection of an extended region of chaotic trajectories. At the ultimate intensity of 1.7×10^{11} protons per bunch the dynamic aperture with D0 shrinks to about 3σ , suggesting that an electron lens compensator may become indispensable for this upgrade path. For the alternative “large Piwinski angle” (LPA) upgrade scheme, the dynamic aperture, with wire compensator, is about 5σ .

R. Calaga compared the global and local crab cavity schemes for the LHC [22]. He showed a schematic drawing and parameters for a prototype LHC crab cavity operating at 400 or 800 MHz. The global crab scheme leads to a peak orbit change of about 2.5 mm for head and tail particles and to a tune shift on the order of 10^{-4} . RF noise measurements are available from the 500-MHz KEKB crab cavities. Introducing the measured KEKB noise spectrum in LHC simulations, the resulting transverse emittance growth is found to be negligible. R. Calaga outlined an R&D programme which will first lead to a prototype and which should ultimately pave the way towards full crab crossing in the LHC. In addition to the prototype fabrication, other important items in the sketched programme are the cavity design optimization, couplers, amplifiers, rf controls, tuning, low level rf, processing, rf testing and beam testing. Crab cavities will be helpful already for the nominal LHC, and even more so for the upgrade phases 1 and 2.

U. Dorda reported progress on wire compensation and, in particular, on the development of a novel “RF wire”, a pulsed compensator [23]. Instead of using fast switches the “RF BBLR” is based on an rf resonator circuit. Its advantages are feasibility and much reduced timing-jitter tolerances. F. Caspers had first proposed this type of device. An early prototype was assembled and its characteristic rise time measured and adjusted in the laboratory. In parallel the rf properties of the conventional wire compensators installed in the SPS were measured, as well as the beam-induced signals on these wires. The ongoing studies prepare the ground for an ultimate implementation of pulsed wire compensators in the LHC.

Round Table on Long-Range Collisions, Wire Compensators, and Crab Cavities

The round-table discussion after this session reached the following conclusions. With the upgrade, the long-range beam-beam effects become more important, but they are no showstopper. The wire compensator is essential for upgrade phase 2 and even before. It typically gains 2σ in aperture for the various upgrade schemes. A controversial question was the maximum number of “low-distance” ($\sim 5\sigma$) long-range encounters that can be accepted. The answer may depend on many other parameters, such as beam energy, lattice, chromaticity and tunes. The interpretation of the experience at Tevatron, RHIC and SPS appears ambiguous. Reliable simulation tools are needed to answer the

question for a specific case. The interplay of the long-range collisions with the head-on beam-beam interaction is also important and must be taken into account.

Another critical question raised at the round table is whether, with the large triplet quadrupoles, we can open the collimators to 9σ if the dynamic aperture is at a lower amplitude of $5-7\sigma$. This question should be addressed by the collimation team.

A wire compensator was successful at DAFNE, where it yielded a higher average luminosity. There is a good understanding of its beneficial effect. Also a partial compensation with octupoles had a positive influence in DAFNE.

The SPS wire machine experiments of 2007 at 37 and 5 GeV indicate the existence of a current "threshold" for the long-range beam-beam effect. Below the threshold the beam lifetime is not affected by the long-range collisions. If confirmed, this threshold would drive the parameters of the early-separation upgrade scheme.

In LHC simulations, a dc wire can have a beneficial effect, but a pulsed wire would further improve the dynamic aperture of all bunches and, hence, the overall beam lifetime.

The impact of crab cavities on the collimation system will also need to be studied by the collimation team, in particular for the global crab scheme.

The funding of the auxiliary upgrade devices is an unresolved issue. An SBIR proposal was submitted by a Long Island company (AES) to the US DOE for building an LHC crab-cavity prototype. Funding for LHC wire compensators and especially for pulsed wire compensators must still be found.

Crab Waist

M. Zobov explained the ideas underlying the "crab waist" scheme, which combines a large Piwinski angle, a vertical IP beta function comparable to the overlap area, and a crab-waist sextupole transformation which shifts the location of the vertical waist as a function of the horizontal position so as to maximize the luminosity [24]. The betatron phase advance from the sextupole to the collision point is $\pi/2$ in the vertical plane, and π horizontally. The "crab waist" scheme was first proposed by P. Raimondi for the SuperB factory [25]. The recently completed DAFNE IR upgrade includes a large crossing angle with crab waist (see Fig. 2). The crab-waist arrangement suppresses X-Y resonances, leading to much reduced sensitivity to the working point and much higher luminosity. The absence of X-Y resonances is intuitively clear, and this as well as the higher luminosity are confirmed in beam-beam simulations. Instead of the X-Y resonances, the crab-waist simulations reveals sets of narrow synchrotron sideband resonances localized around the integer and half integer tunes. Weak strong beam-beam simulations for the DAFNE upgrade indicate a possible luminosity gain by a factor of 10 or more, partly thanks to the crab waist (which alone contributes a factor 2-10 depending on the working point). The

luminosity is further raised by shortening bunches, reducing the vertical beam size and increasing the beam current. According to the simulations, the beam-beam limit is well above the reachable current values (~ 2 A).

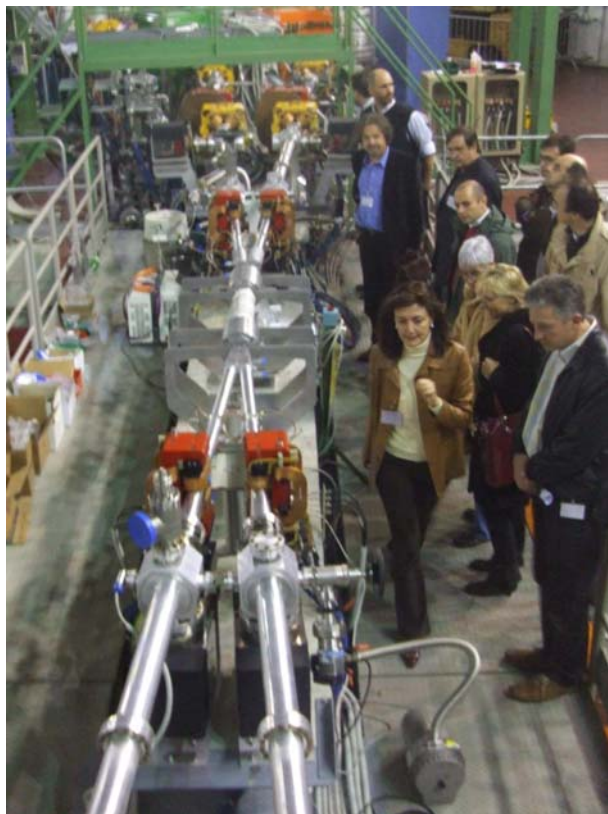


Figure 2: IR07 tour of the new DAFNE IR with large Piwinski angle and crab waist.

IR'07 CONCLUSIONS

The final round table discussion addressed 7 issues: (1) strategy for scenarios, (2) trade off between experiments & accelerator, (3) leveling and large Piwinski angle - where, how, real test?, (4) strategy for magnets, (5) strategy for wires, (6) strategy for crab cavities, and (7) strategy for crab waist in hadron colliders. We now report the answers and comments on each of these issues one by one.

Strategy for Scenarios

The convergence on the triplet-magnet parameters should be easy, which is good since the triplet development also has the longest lead time among all upgrade components. For lowest β^* values, the early separation scheme is not the only option, but full crab crossing would be an interesting alternative not requiring magnets embedded inside the detectors.

The various upgrade components should be decoupled from each other. A possible approach is to wait for the

LHC beam before optimizing phase-2 parameters or even the earlier phase 1; in the words of S. Peggs, "what will beam say?".

Possibly the phase-2 upgrade could consist solely of adding crab cavities.

Trade Off between Experiments & Accelerator

The input from the machine to the experiments should ideally come now. However, the experiments need to wait for the first physics results before being able to conclude on the viability of various upgrade scenarios. It was pointed out that, therefore, we need to take some risk.

Leveling and Large Piwinski Angle - Where, How, Real Test?

Experimental tests of hadron-beam collisions with a large Piwinski angle could be performed either at RHIC or in the LHC itself. Such tests could be decisive for proving the feasibility of the "LPA" upgrade scheme.

For the purpose of luminosity leveling, the orbit angle can be varied either with the early separation dipole or with the crab voltage. Leveling with β^* could be attempted right from the start, even at the nominal LHC. The experiments remarked that they have no interest in luminosity leveling for the nominal LHC, neither for its phase-1 upgrade, but only for phase 2. However, there is yet another reason for leveling with the crossing angle: it may circumvent the beam-beam limit and allow for higher bunch charges, resulting in higher integrated luminosities. An IP feedback will assist in any form of leveling, "or perhaps not" (the example of RHIC was quoted).

Strategy for Magnets

Magnet issues involve cost, technicalities, and even power converters. A large-aperture D1 dipole as a standalone object could be another possibility for US-LARP contributions, with the advantage of being asynchronous with the phase 1 upgrade.

It was asked whether today we already have a definition of D1 for phase 2. However, the D1 parameters will depend on the optics solution adopted. The D1 magnet is by no means trivial, but challenging as well.

Also, the time scale of the phase 2 upgrade must be kept in mind. It is not easy to make a decision now.

The aperture of new triplet quadrupoles should be 130 mm in view of collimator requirements.

Nb₃Sn options and financial aspects were also discussed.

Strategy for Wires

Wire compensators should be installed as soon as possible in the LHC, or, rather, as soon as the beam current requires it. The installation could be paid from the LHC operations budget.

Strategy for Crab Cavities

Different types of crab cavity schemes can be distinguished: global and local ones; small angle vs. large angle crab crossing etc. The recommendation of IR'07 is to gain experience with small-angle crab crossing in phase 1. If successful, one could go to larger angles in phase 2. Feedback from the collimation study concerning the impact of crab cavities on the cleaning efficiency is needed. A global crab cavity scheme might be the most attractive to start with, since it is the cheapest and one could easily adjust in case of problems and e.g. switch back to no-crab collisions. Crab cavities neatly fit into the US program, and they might also be included in the European FP7.

Strategy for Crab Waist in Hadron Colliders

The crab waist could be useful in conjunction with higher brightness from a new injector complex. A "flat" optics with NbTi quadrupoles might provide β^* values of 15 cm \times 30 cm; possibly slightly smaller beam sizes could be reached with Nb₃Sn magnets. Crab waists are well adapted to the large Piwinski angle regime, combined with the lowest possible β^* . The DAFNE experience with crab waist will be an important input for this upgrade option.

SUMMARY OF IR'07 SUMMARY

All auxiliary systems, particularly wires and crab cavities, received a strong boost.

The energy deposition adds an important criterion to the optics requirements; more realistic configurations should be explored. A 2-cm stainless steel linear was considered as a first attempt.

Improved upgrade designs were presented which promise higher and better luminosity than forecast at LUMI'06 in Valencia.

The field quality and temperature margin of Nb₃Sn magnets remain uncertain.

Only two phase-1 IR optics solutions were retained, namely the so-called "low β max" and the "symmetric" optics.

Conflicting time scales were evidenced between the experiment and accelerator upgrades: though the machine input to the experiments is requested now, the experiments need LHC physics results to determine the essential constraints for narrowing down the options of the machine upgrade.

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