HL-LHC WP2/WP13 HL-LHC Satellite Meeting

Date: 2019-10-17	***Project/Activity:*** Wire Compensation

Attendees: A. Bertarelli, O. Brüning, M. Giovannozzi, A. Mereghetti, C. Noels, F.-X. Nuiry, A. Poyet (remotely), Y. Papaphilippou, D. Perini, A. Rossi, L. Rossi, K. Skoufaris (remotely), S. Sadovich, G. Sterbini, M. Wendt, G. Apollinari, V. Shiltsev, G. Stancari, A. Valishev, P. Bélanger, D. Kaltchev (remotely), O. Kester, M. Marchetto

Agenda: https://indico.cern.ch/event/844153

- Welcoming Remarks
- Introduction/Motivation and current wire HW
- MD results during LHC Run-II and plans for Run-III
- Modelling of MD results and effect of crossing angles (remote presentation)
- Simulations for HL-LHC configuration (remote presentation)
- Correction of resonant driving terms with wires
- Scenarios and timeline for wire compensation in the HL-LHC
- Wire HW design for HL-LHC and integration
- TRIUMF contribution to the BBLR Compensation Project for HL-LHC
- Discussion

DISCUSSION

O. Brüning opened the meeting thanking the FERMILAB colleagues for their hospitality and the TRIUMF colleagues for showing interest in the wire compensation studies for HL-LHC. He clarified that the wire compensation option is not in the HL-LHC baseline. He explained that the HL-LHC project comes with a budget envelope and a tight schedule and, consequently, the project has to limit its scope to the baseline solutions. Nevertheless, options excluded for the aforementioned limits could be still envisaged if additional resources (namely, in-kind contributions) could be allocated. The HL-LHC management supports and recommends initiatives along this direction. In particular, a potential contribution from TRIUMF in the Beam Dynamics studies, in the wire compensator technical design and in its fabrication, is welcome, desired and praised.

Introduction/Motivation and current wire HW

A. Rossi introduced the scope of the meeting as being an occasion to discuss the latest experimental and simulation results at LHC with the present demonstrator of wire for Beam-Beam Long-Range (BBLR) Compensation, the predictions for the HL-LHC, and first ideas for the wire hardware design and its possible implementation. Building upon the existing collaboration between TRIUMF and CERN, the goal is to look for a framework for future contributions from TRIUMF to HL-LHC for BBLR wire compensation.

After a brief introduction to BBLR, the design of the current wire demonstrator was recalled. Following scaling laws from analytical estimations of BBLR wire compensation (it was underlined that simulations and experiments explored a wider range of parameters and configurations than

initially proposed with this scaling law), the wire needs to carry few hundreds Amps-meter of current, approach the beam at few mm distance and be located at a specific optics where βx/βy≈0.5 and 2 on both sides of the IP. The tertiary collimators are located at approximately the right position, the jaws are water-cooled, allowing to cool as well a wire brazed on a dedicated support. In the plane of beam crossing the jaw can be moved with a measured reproducible accuracy of 5 µm, with < 200 µrad tilt, and with about 0.5 mm accuracy on the transverse axis (5th axis).
The drawback of this design is that, in order to guarantee a nominal current of 350 A and maintain the tertiary collimators functionality, the centre of the wire section must sit at 3 mm from the surface of the collimator jaw, which represents almost 3 beam σ at the demonstrator location and with the typical collision optics. Given that the performance of the compensation depends on the wire-beam distance, a new design for HL-LHC must be studied.
A. Rossi mentioned all tests performed under vacuum on a spare jaw equipped with wire, that allowed to dimension an interlock system switching the wire off in case of loss of cooling, to protect both the collimator and the wire, and tests performed in the machine to measure the temperature of the jaw at maximum current, and the accuracy of the transverse movement using pick-up buttons as measuring devices.

The different stages of installation of the wire-in-jaw collimators were shown:

- EYETS (Extended End of Year Technical Stop) 2016-17: replacement of TCTPH.4R5.B2 and TCL.4L5.B2, horizontal collimators left and right of CMS Experiment on Beam 2. Experiments with weak-strong beam configuration already showed a positive effect of the wire on beam lifetime.
- YETS (End of Year Technical Stop) 2017-18: replacement of TCTPV.4R1.B2 and installation of new TCLVW.A5L1.B2, vertical collimators left and right of ATLAS Experiment on Beam 2 (B2), with position on the left hand side further away (since there are no vertical collimator downstream the experiments, a new slot had to be created). This asymmetry has measurable effects on the compensation. In this configuration both weak-strong (low intensity) and strong-strong (high intensity) tests with beam successfully showed the wire compensation. At low intensity, only 1 wire per collimator (the one positioned between the 2 circulating beams) was powered, at high intensity both jaws in each of the right collimators (TCT) were reconnected to obtain the “quadrupolar” configuration where the wire current could be doubled, and provide global compensation. More details in **G. Sterbini’s** presentation.
- LS2 (Long Shut-Down 2) intervention before Run-III: Moving of two wire collimators for BBLR compensation from B2 to B1 on IR1 and IR5. This will produce a symmetric configuration for both B1 and B2 at LHC, where the TCT collimators, on the right hand side for B2 (left hand side for B1) of the high luminosity experiments, will be equipped with wire. This configuration will allow to gain in operational experience with wires during operation in Run-III and prove potential for HL-LHC since the wires will be used operationally.

For HL-LHC there is space reserved between the matching quadrupoles Q4 and Q5 on both sides of ATLAS and CMS, as well as room for the required racks.

MD results during LHC Run-II and plans for Run-III

G. Sterbini recalled the wire demonstrator experimental setup and, particularly, the constrains in the transverse positioning of the wires. Given these constraints, two classes of experiments were performed, referred in the following as Low Intensity (LI) and High Intensity (HI) experiments.

- In the LI setup, the Beam 2 (B2) consisted of two bunches (one experiencing only head-on, HO, and the other head-on and long-ranges, LR) and the Beam 1 (B1) consisted of three trains. Given the limited B2 intensity, the wire collimator could be approached up to 5.5 σ (assuming ϵn=3.5 mm mrad).
- In the HI setup, the filling scheme was symmetric for the two beams. Given the high intensity in B2, the wire collimators were configured at nominal settings (8.5 σ). To overcome the limited effect of the wire due to the relative large distance from the beam, a two-jaws powering scheme was adopted (i.e., the two wires of the same demonstrator tank were powered in series, doubling the effective strength of the quadrupolar, octupolar field and making the dipolar, sextupolar…vanishing).

Before the experiments, the wires were aligned using the pick-ups (PU) embedded in the collimator jaws.

During the experiment, particular emphasis was given to the local correction of the linear effect of the wire (dipolar and quadrupolar) by means of convenient feed-forwards.

The goal of the LI experiments was to prove that the wire would improve the lifetime of the bunch affected by BBLR without impacting negatively (overcompensation) on the bunch suffering only of the HO. Indeed, this was observed in a clear and reproducible way during the LI experiments. In addition, it was evident that compensation was even more visible at reduced crossing angle.

For the HI experiments, the wires compensation showed a measurable reduction of the losses. In particular, the trailing bunches within a train are the ones benefiting more from the compensation (being the ones suffering more from the combined effect of BB and e-cloud). In this experiment, only 2 out of 4 wire-collimator demonstrators were used (due to the collimation settings, 2 wires were too far to interact in a significant way with the beam).

From the HI experiments, starting from

1. the observation of the losses reduction,
2. the availability of two “unused” wires from B2,
3. the fact that the beam and machine parameters at the end of the levelling in Run-III (2021, round optics) will be similar to the one of HI experiment,

it was proposed to move the two unused B2 wire demonstrators from B2 to B1 and test the wires during Run-III physics production in a B1/B2 symmetric configuration.

O. Brüning commented that the key ingredient for the future of the project is to show that BBLR affects the beam core diffusion (taking into account the radiation damping and the hollow electron lens, HEL). Otherwise one could object that in the HiLumi project we already have a device (HEL) to reduce the tails.

L. Rossi asked if there will be a potential gain of integrated luminosity during Run-III by using the wire. **Y. Papaphilippou** answered that an eventual performance gain in terms of integrate luminosity will be marginal, due to the present limitations of the demonstrator. The main interest is

- getting direct experience with the operation with wires
- observe the wire effect on B1 (B1 has a worse lifetime than B2)
- reducing the losses.

L. Rossi commented that it is very important to pass the message to the community that no significant improvement of the beam performance is expected from the wire compensation in Run-III.

V. Shiltsev asked why, in the LI experiment, the wire is not affecting the head-on bunch. **G. Sterbini** answered that the compensation is partial and it is a trade-off between compensating the bunch suffering the LRs without over-compensating the bunch without LRs.

L. Rossi commented that the use of the effective cross-section as observable can be misleading, and that he would prefer to refer to losses.

O. Kester commented that we should extrapolate the LHC results to HL-LHC. How does the wire compare with the second half of crabbing? **L. Rossi** commented that it will be no longer possible to install the 4 crab cavities (CC), after HiLumi project choices. Now one has to compare cost of CC with the cost of wires. **O. Brüning** added that the first half of CC give the big improvement, the second half only a, relatively, small one (few %). In addition, the wire was shown to help with flat optics. **Y. Papaphilippou** added that the wire clearly helps also with round optics, as it will be demonstrated in the following presentations.

A. Valishev asked if simulations on the BB and e-cloud interplay are available. **G. Sterbini** answer that, presently, there are effort in this direction. During the HL-LHC Collaboration Meeting, **G. Iadarola** presented the status of the study. Most of the results were addressing to the coherent effects. The inter-bunch motion induced by the e-cloud is damped by the transverse feedback. The incoherent effects (diffusion, emittance blow-up, lifetime…) have still to be assessed. **O. Brüning** added that the coherent intra-bunch motion (beyond the transverse feedback bandwidth) could be still problematic.

Modelling of MD results and e effect of crossing angles (remote presentation)

A. Poyet presented the parameters of the wire compensation tracking campaign in LHC. After having recalled the theory (first order perturbation) of the analytical wire compensation, he showed the bench-marking of the simulation with respect to the analytical prediction. He emphasized that, despite the optimal Dynamic Aperture (DA) gain for the analytical wire current and wire transverse position, the "good compensation" area is quite large and, in principle, possible also by considering larger beam-wire distance and larger current.
In that spirit the LI experiment was simulated showing an improvement of ≈ 1 σ DA, in qualitative agreement with the experimental results.
During the experiment one of the wire could not be aligned (orthogonal to the plane defined by the beam and the wire, referred as "5-th axis") with respect to the beam (mechanical interference

of the wire collimator with the B1 vacuum chamber). A DA parameter scan with respect to the 5th axis alignment errors showed a negligible effect on the DA gain up to 1 mm error.

Simulations of the 2-jaws powered configurations, showed a gain of 0.8 σ.
In addition, the wires also improve the tune acceptance of the machine and could be used in combination with the octupoles for further improving the DA. It is worth noting that by using only the octupoles the DA gain is very modest.

Finally, it was shown the potential of the wire for reducing the crossing angle keeping 5 σ of DA up to 150 μrad (at 1.2e11 ppb) and 135 μrad (at 0.8e11 ppb).
A. Valishev asked if in the simulation considering the combined effect from wire compensation and octupole, the tolerance and sensitivity to errors (for example, the effect of the β-beating) was included, given that global compensation can heavily suffer from that. **A. Poyet** answered that the optics consider was the nominal one. **Y. Papaphilippou** commented that the dominant effect is the dynamic β, which is taken into consideration in the simulations. We should nevertheless introduce also β-beating, but he does not expect it will make a big difference.
M. Wendt asked if tolerances of alignment of 1 mm are valid also for HL-LHC. **K. Skoufaris** replied that currently there are no DA simulation with wire misalignment, but we should have enough margin in DA to accept such a misalignment.

M. Wendt suggested that the one could also use the signal induced from the beam in the wire to centre it. This assumes to have the beam between two wires and therefore compare the induced signal to the two side.

Simulations for HL-LHC configuration (remote presentation)

K. Skoufaris presented the simulations for the HL-LHC configuration.
The most critical regime for the BB effect in the HL-LHC is at the end of the β-levelling (nominal scenario with β* = 15 cm and 1.2e11 ppb corresponds to a DA=6.17 σ for the optimized machine). BBLR causes a 5.5 drop in DA without wire. Then, assuming 4 wires per beam placed at ± 195 m from the IP1/5 and with a transverse position D>10.4 σ (tertiary limits) one can improve significantly the machine DA (0.7 σ).
It was shown that the wire is very effective in the tune spread compensation due to the LR.

Moreover, it was shown that solution with D>10.4 σ exists for improving the machine DA (slide 6, +0.7 σ).
The gain due to the wire is even more visible in the ultimate configuration (β* = 15 cm and 1.52e11 ppb). Indeed, there are no ultimate viable configurations, at the moment, with DA > 6 σ, whereas the wire compensation could make this scenario well within reach (DA≈ 6.7 σ).
The flexibility of the wire was shown also for reducing the crossing angle with the nominal or ultimate bunch population at the end of the levelling (200 or even 190 μrad).
In other words, the wire potential could be used for keeping constant the WP during the leveling, reach the ultimate performance, reduce the crossing angle (i.e., reduce CC voltage, triplets irradiation, increase luminosity performance).

O. Brüning commented that the HL-LHC has now the hollow-elens as baseline. The wire performance should be considered with the hollow-elens installed. This device could cut the tails

up to 3 σ. In that respect, it is important to qualify the wire effect not with respect to its potential to stabilize the tail (most likely lost with the elens) but to reduce the core diffusion.
Y. Papaphilippou commented that indeed this is the next step to cover. An intimate connection between DA and lifetime was formulated by the work of **M. Giovannozzi**. **O. Brüning** asked to clarify the assumptions behind the lifetime computation and the aperture versus lifetime. **M. Giovannozzi** explained that by assuming the initial distribution to be Gaussian and by observing the DA behaviour in the first N turns (typically N=1e6). In doing so one can infer the lifetime on the first N turns but also compute the DA (and then the lifetime), for the next M turns (typically M>>1e6) assuming that the system is time invariant (e.g., multipoles errors).

L. Rossi commented that 5% in peak luminosity corresponds to 2% in integrated luminosity. **V. Shiltsev** stated that even 2-3% in luminosity is 3 months of operation for LHC!

O. Kester asked about the ratio of filling time to operation time at LHC. **O. Brüning** replied that the min turnaround time is 2 h, 3-5 h average. For HL-LHC will be 1/3 of the time, so it is important to gain on each fill.

Scenarios and timeline for wire compensation in the HL-LHC

Y. Papaphilippou presented the scenarios and timeline for wire compensation in the HL-LHC.

The HL-LHC beam-dynamics studies are heavily based on the Dynamic Aperture (DA) performance of the machine. During Run-II, it has been observed the correlation between the DA and the beam lifetime. This correlation was analytically established and compared against measurements in the paper by **M. Giovannozzi** [PRST-AB 15, 024001]. As results, a DA of 6 σ is targeted in the HL-LHC beam-dynamics studies, as it guarantees lifetimes which at least one order of magnitude larger than the ones given by burn-off.
Following this rationale, the baseline scenario assumes half-crossing angle of 250 μrad during the whole levelling. The control of the tune during the levelling is crucial for maintaining the lifetime in the baseline scenario whereas, in the ultimate scenario, it was not possible to guarantee the 6 σ DA, at the end of the levelling.
In addition to the coherent stability limit when the beams are not colliding (pre-squeeze), the effect of the arc octupoles has to be enhanced by high tele-index, thereby reducing DA (to be conveniently reduced at the start of the β-levelling).
In this constrained scenarios, the wire can introduce some flexibility in several directions. For the baseline scenario, wires located at beam distance beyond TCTs (>10.4 σ) enable to reduce half x-ing angle to 190 μrad (by 25 %), while maintaining 6 σ DA

- Enhance minimum β* reach to 13 cm
- Reduce triplet irradiation, i.e., increase their lifetime and overall integrated luminosity by around 15-20 %
- Allow full crabbing during the whole levelling period (or minimize impact of reduced CC voltage)
- Increase the luminosity region (less pile-up density)
- Allow full flexibility in the WP choice during the levelling.

In addition, the wire allows to achieve the 6 σ DA target also with the ultimate intensity.

The experimental observations in the LHC and the numerical simulations show that the PACMAN lifetime is not affected by overcompensation.

In parallel to the (round) baseline optics, studies for flat-optics are on-going. Flat-optics strongly depend on wire compensation for the control of the BBLR induced tune shift. With wire compensation, the flat optics can reach the 6 σ (β* = 35.2/8.8 cm, half-crossing angle of 162 µrad, Q=7, I_MO=-100 A, slide 21).
In terms of performance (integrated luminosity per day), in absence of crab cavities there is a loss of -13% (scenario: baseline but w/o CC). The wire compensation can recover partly it reaching -6% with respect to baseline (scenario: baseline, w/o CC, w/ wire compensation). In case of the baseline scenario, the wire compensation can improve by 3 % the performance (scenario: baseline with wire). For flat-optics (no CC), where the use of the wire is crucial, the performance is -5% with respect to the baseline scenarios.

Y. Papaphilippou presented a possible timeline: after the experimental verification in Run-II and the extensive simulation campaign in the last two year for round optics, one should focus in refining the flat-optics operational scenario (2020). The wire operation during Run-III (2021-2023) will clarify operational and machine protection issues. The hardware design and short prototype hardware tests for HL-LHC should come in 2020 and followed by a full review (beam physics, hardware and budget) for using the wire compensation in the HL-LHC era. Depending on the results of the review one could prepare the interfaces for the wire installation during the LS3 and install the wires during the Run-IV.

O. Brüning asked what assumption was made on particles distribution. **M. Giovannozzi** replied that they have a model/scaling low on how DA scales with turn, which assumes that each particle beyond the min DA are lost, integrating for a Gaussian distribution up to infinity. **Y. Papaphilippou** commented that 4 σ DA impact of the beam lifetime is very comparable to the one of the burn-off. At around 5 σ DA one can guarantee 100 h lifetime. This is how we optimized the machine during Run-II.

Correction of resonant driving terms with wires

Y. Papaphilippou presented on behalf of **D. Kaltchev** the correction of the resonant driving terms of the wires using the Fourier coefficient of the Hamiltonian connected to the beam-beam long-range/wire kick.

This approach is alternative to the one presented by **S. Fartoukh** et al. [PRST-AB 18, 121001] which was based on the kick expansions (the phase advance between the different parasitic encounters is neglected in both cases).

The rationale is to represent the different Hamiltonian associated with the long-range encounter as a 2-D Fourier series using the 2-D generalized Bessel functions. The wire can be thought as a long-range with vanishing strong beam σ. To prove that the wire can compensate the LR one can show that given a particular position and current of the wire Fourier coefficients compensate all Fourier coefficients of the LR.
D. Kaltchev solved numerically the problem assuming horizontal crossing angle. Differently from the approach of [PRST-AB 18, 121001] he did not constrain the left and right wires to have the

same physical distance from the weak beam and allowing the wire compensation of all Fourier coefficients for any wire longitudinal positions.

In addition, using the recursive relation of the Fourier coefficients (1D case) **D. Kaltchev** showed that by compensating the first two non-linear Fourier coefficients one compensates all of them.

O. Kester praised the results and commented that it is now important to extend the formalism to the 2-D general problem and assuming the 190 μrad of half-crossing angle.

Wire HW design for HL-LHC and integration

A. Bertarelli presented the preliminary hardware design currently under consideration for HL-LHC. The mechanical design is based on a preliminary set of given requirements which may evolve or be scaled.

- 1 wire per beam per side of IP1 and IP5 → 8 wires.
- Single wire positioned in a Cu vacuum chamber per beam.
- Round wire 1 mm cross-section.
- Wire total active length 3 m.
- 450 Am DC per wire, i.e., 150 Am/m.
- Wire entirely positioned in the shadow of Tertiary collimators (> 10.4 σ).
- Beam losses considered negligible.

To be noted that at this stage, the design has yet to be checked for impedance effects, vacuum, etc… The Impedance Working Group at CERN made encouraging remarks, saying that, provided we can design proper RF shielding for the wire terminations, the design should comply with HL-LHC constraints.

A. Bertarelli proposes a design with:

- Wire made of Mo brazed onto aluminium nitride (AlN) ceramic that should conduct the heat (for cooling) and be a good electrical insulator. Mo is chosen, despite its higher electrical resistivity compared to copper, because it better matches the thermal expansion coefficient of AlN and is a refractory.
- Copper chamber (for cooling).
- Ceramic insulator clamped onto the vacuum chamber.
- Brazing of St-St flanges and copper, and of wire on the ceramic insert.
- Modules of ~1 m long that could be put in series to compose the total length (module length may change).
- Wire exiting the chamber via commercial feedthroughs (185 A max current in the presented design).
- NEG coating was initially not considered; its need should be further assessed.
- Estimated 14 V/m voltage drop at 150 A and 90-140 ^{o}C wire temperature (2.1 kW power loss), with thermal deformation foreseen of 30 μm.

A. Bertarelli said that the initial mandate was to produce a design with a limited budget; it was then decided to allocate part of this money to build a proof of concept prototype, about 300 mm long. The scope of this prototype is to test the brazing, mechanical tolerances, feedthroughs, vacuum, and possibly RF behaviour.

O. Kester asked why choosing a wire as this as 1 mm and more details about possible electrostatic charging of the insulator. **A. Bertarelli** replied that technically it would be possible to go to larger diameter, but that at the moment we wanted to keep it as small as possible. **M. Wendt** stated that one should check the impact of the ceramic on impedance; in this sense, coating may be considered. However, no electrostatic charge should be expected. **A. Bertarelli** reminded that no metallic coating can extend beyond a limited portion of the ceramic as this may jeopardize its insulation role. **M. Wendt** asked how do we plan to design the transition of cross section. To keep modularity you may want to do it at beginning and end of each module. **A. Bertarelli** replied that this has not yet been studied: RF fingers may be considered. **M. Marchetto** asked about the requirements on vacuum and radiation damage, why a copper chamber and wire round cross section. **A. Bertarelli** replied that this device should not be very exposed to radiation (the neutrons are already absorbed at TAN, the rest is negligible). Copper, thanks to its conductivity, ensures a good thermal stability of the chamber, limiting its deformation; and even if the chamber thickness poses a stability issue, it can be easily increased, also benefitting the global rigidity of the system. For the wire, a not-round cross section is feasible but technologically more complicated to braze. **Y. Papaphilippou** added that considering the wire position (in the shade of the tertiary collimators), its cross section is not playing a role, at least for round optics. **A. Valishev** asked why limiting the temperature at ~100 degrees. **A. Bertarelli** replied that a higher temperature would lead to higher gradients, larger deflection, higher mechanical stresses, possible vacuum issues etc. **O. Kester** asked the requirements on straightness. It was answered that longitudinally, if we follow the same requirements as for collimators, a straightness of 50 µm, while transversally we should be able to tolerate 1 mm error in the alignment beam/wire. If we allow for larger tolerances on straightness, we will have to include them in the beam-wire distance. Yet to be specified.
A. Mereghetti raised the point that we should check in simulations (e.g., SixTrack and FLUKA) if the interplay between the collimation system and the wire compensator is negligible, and that the compensator has little impact on the loss pattern at the downstream cold magnets (e.g., inner triplet).
O. Kester enquired about the price, **A. Bertarelli** replied that it is very hard at this stage to provide a reliable estimate, but that for the presented conceptual mechanical design one can roughly expect about 80 kCHF for each 1-m module and in the ballpark of 4 MCHF for the complete system (including motors, supports, instrumentation, …). **M. Marchetto** asked the assumed cost for brazing process. **A. Bertarelli** replied that the cost depends on the failure rate, 10 kCHF per unit if all goes well. **P. Bélanger** asked if the curvature at the end of the wire has an effect on the electromagnetic field and therefore on the compensation **Y. Papaphilippou** said that we did not notice any effect with the demonstrator.

TRIUMF contribution to the BBLR Compensation Project for HL-LHC

O. Kester explained TRIUMF have already been collaborating with CERN on this project with beam physics studies of **D. Kaltchev**. TRIUMF is happy to continue beam physics support, with also an additional PhD student (here present), **P. Bélanger**. TRIUMF is very interested also in contributing to the HW and production.

O. Brüning commented that HiLumi can provide a collaboration agreement.

O. Kester said that they could request funds at the CFI: next round in 2023 (to be put in proposal in 2021, evaluated in 2022 and funding comes in 2023).

Discussion

O. Kester expressed the wish of a strong connection with CERN, and to start collaboration asap, including participation to the beam tests during Run-III in 2021.

Y. Papaphilippou proposed that the TRIUMF team in involved as from the wire commissioning in the machine.

A. Rossi proposed that the collaboration starts early also on studies of mechanics and TRIUMF welcome the proposal. **O. Kester** and **M. Marchetto** say that this could be translated in an engineering student if for long time at CERN, or a TRIUMF engineer if shorter.

It is repeated that by end of 2020 we should have an external (not CERN only) review where we:

- Present detailed plans for Run-III.
- With more details on operational scenarios at HL-LHC (round optics), show the clear impact of the wire on lifetime (particle diffusion in the beam core) and in presence of the HEL with and w/o CC.
- Give an estimate of irradiation reduction to the triplets as a function of Xing angles.
- Review thermo-mechanical design including all thermal loads (wire current, beam induced heating via RF coupling or losses).
- Check compliance of the HW design with impedance, vacuum, …
- Review instrumentation for the wire and alignment.
- Verify that the position proposed for wire operations is compatible with Machine Protection (in case of asynch dump), and irradiation (also caused by the wire) to elements downstream the wires (collimation studies + FLUKA simulation).
- Present strategy of interlock on the wire for Machine Protection.
- Review machine integration and staging of installation.
- Discuss a budget envelop.
- Present preliminary results on flat optics if additional manpower is allocated.

The review should be a support to the preparation of the TRIUMF proposal for funds.

ACTIONS

Verb, action to be done, by when	NS	M#
Present meeting summary at HiLumi-Work Package 2 (HL-WP2,already scheduled for November 26th, https://indico.cern.ch/event/860231/) and HiLumi Technical Coordination Committee (TCC)		
Organise a Beam-Beam and Luminosity Meeting with TRIUMF colleagues (to be scheduled on November 29th), for a discussion regarding HW design and prototype timeline, but also theoretical studies program.		

In view of an external review (to be scheduled around November 2020): define the agenda and the review topics. Starting from this agenda, prepare a roadmap of studies to be addressed before the review and their relative milestones/deadlines. The roadmap can be presented at Beam-Beam and Luminosity Meeting and at possibly at the TCC.		
Consider whether to send a senior engineering student or a junior engineer at CERN for several months as of early 2020 to take part to the design phase and proof of concept manufacturing.		
Discuss Run-III scenarios (including the Machine Protection Panel, MPP, and Collimation team in the discussion) and presented them to the LHC Beam Operation Committee (LBOC) in January 2020 and to the LHC Machine Committee (LMC).		
Study the impact of the wire on HL-LHC lifetime (particle diffusion in the beam core) and in presence of the hollow electron lens (HEL) with and w/o CC, both at nominal and ultimate luminosity.		
Estimate irradiation reduction to the triplets at HL-LHC as a function of crossing angle.		
Studies on flat optics if additional manpower is allocated.		
Provide performance estimates for the wire at ultimate luminosity.		

Documents:

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Approved by: G. Arduini, O. Brüning, R. Jones	***Date:*** 2019-11-20

Distribution List: Participant of the meeting, WP2 and WP13 members