13th Meeting of the HL-LHC Parameter and Lay-out Committee

Participants: C.Adorisio, G.Arduini, V.Baglin, I.Bejar Alonso, C.Bertone, H.Burkhardt, O.Bruning (Chair), R.Calaga, F.Cerutti, L.Esposito, P.Fessia, C.Garion, M.Giovanozzi, R.Jones, T.Lefevre, Y.Papaphilippou, H.Prin, S.Redaelli, L.Rossi, F.Savary, H.Schmickler, E.Todesco, S.Weisz, D.Wollmann, M.Zerlauth.

Excused:, A.Ballarino, L.Bottura, J.-P.Burnet, I.Efthymiopoulos, S.Fartoukh, Q.King, M.Lamont G.De Rijk, Y.Uythoven, R.Van Weelderen.

The slides of all presentations can be found on the website and Indico pages of the PLC:

HL-LHC PLC/TC homepage: https://espace.cern.ch/HiLumi/PLC/default.aspx

Indico link: https://indico.cern.ch/event/364435/

O.Bruning opened the meeting by briefly introducing today's agenda. Regarding the pending actions, G.Arduini mentioned that the impact of layout modifications on optics and performance will be discussed by R.de Maria during one of the following TCs. P. Fessia and E.Todesco stressed that it is important to have a final answer for magnet lengths in order to transmit the information to the LARP colleagues at the beginning of February. It was thus decided to have the presentation during the TC of February 12th.

Regarding the pending action for studying further the option including the additional Q5, both from a technical and planning point of view, P.Fessia mentioned that from the side of the integration team, H.Prin is studying this with the design office and will report the outcome in a future PLC/TC meeting.

Finally, regarding the issue raised during the presentation of the HL-LHC ultimate parameters and the compatibility with the brightness provided by the SPS, the SPS LIU team should report on what the injectors could provide as ultimate parameters, taking also into account the machine protection limits for transferring the high-brightness BCMS beams through the TI2 and TI8 transfer lines.

AOB: Crane limitations linked to refrigeration cold box in TX46, C. Bertone – slides

C.Bertone reports the possible crane limitations connected to the integration of the additional cryo-station foreseen for RF in P4. The integration has been done by WP15 for surface and underground areas (reported during the 10th-TC), with space in TX46 to be reserved for both transport and cryogenics. The cryogenics group validated this and the present slides provide the feed-back of the transport team. C.Bertone stressed that any further development envisaged should comply with the present principle or its impact should at least be evaluated.

C.Bertone explained that a minimal necessary handling volume has been identified. Due to 140m depth of the shaft and crane rope opening, the coverage of the hook at the bottom of the shaft is limited to the center. The axe of the shaft and TX46 should be preserved for transport. This is agreed by both cryogenics and transport teams and documented.

In conclusion, the reserved volume shall be respected to preserve transport functionality of the shaft. For the new cryo-station, a row of pipes will be installed in the shaft. For preventing the free rotation of the load during lowering, a rotational blocking of the hook should be installed before LS2. This is a banal modification with a cost of around 15-20kCHF.

BBLR Roadmap, H. Schmickler – slides

H.Schmickler reviewed the roadmap for the BBLR compensation studies. The project is broken in 4 WPs, including the demonstrator (wires embedded in collimators) and its tests to the LHC during 2016-2017, the related beam instrumentation, the parameter optimization for HILUMI (work of WP2) and the BBLR compensation using e-lenses (generic R&D on interaction of e-lenses with hadron beams). Y.Papaphilippou commented that the baseline schedule for the demonstrator foresees installation during this winter shut-down (2015-2016) and S.Redaelli agreed.

Regarding the demonstrator, there is a simulation effort coordinated by Y.Papaphilippou and S.Valishev of FNAL, which aims on establishing observables with and without the compensation in order to specify the necessary instrumentation for the experiments. This will be further treated in a mini-workshop to be organized during next summer. O.Bruning reminded the necessity to prove the 2σ gain on dynamic aperture translated to an equivalent reduction of the beam separation (crossing angle). H. Schmickler stressed that the aim of these studies including the SPS and LHC experiments is to have enough evidence by 2017 in order to prove that BBLR compensation should be part of the HL-LHC baseline.

Regarding the existing SPS water-cooled wires, the plan is to refurbish the power convertors controlling them in order to be able to regain experience on their impact on the beam by having tests in parallel MDs (and not only in dedicated coasting beam studies). Responding to a question of Y.Papaphilippou about the air cooled wires that they were built at BNL for beam tests, H.Schmickler invited him to contact the BNL colleagues to find out more about them.

H.Schmickler continued by explaining the initial ideas for the “ideal” location of the wires in between the triplet and the TAN which was abandoned due to the difficulty to integrate wires in between the two beams in the common beam pipe. The present plan is to have wires embedded in 4 wire-in-jaw collimators ordered from SINEL. Again, at this point, S.Redaelli stressed that the delivery is scheduled for September 2015 and the equipment could be installed in the next winter stop, depending on the work and the availability of the vacuum colleagues.

Regarding the positioning of the wires, H.Schmickler presented two options: Full compensation of one beam by four wires in either sides of the two IPs and compensation of both beams but only in one IP. The preference of WP2 (Y. Papaphilippou) is the first option with the ability to control independently the 4 wires (4 power convertors).

Action: O.Bruning invited H. Schmicler to present in a future PLC in March the two scenarios explaining the existing infrastructure, the impact to cost for any additional work (e.g. cabling) and the optimization of the configuration for the experiments. It should be followed by the launching of an ECR.

H.Schmickler proceeded on describing the e-lens, which, in his opinion, may have much better chances to work as a compensator, due to its ability to approach the beam to distances of only 6-7σ without the same implications on machine protection/collimator hierarchy as the BBLR. Y.Papaphilippou pointed out that the idea of a simple wire should not be abandonded that easily because there may be other mechanical configurations (e.g. different materials) that allow the wire be placed closer to the beam.

H.Schmickler proceeded with the description of the instrumentation development for measuring the compensating effect of the wire, including the need to launch simulations for understanding the measurement capabilities of the beam tune-spectrum. The principle effort is now focused on instrumentation for halo monitoring with the intrinsic difficulty of needing 5-6 orders of dynamic range to be able to resolve halo. In addition, the use of synchrotron light is very challenging due to the high-energy (opening angle~1/γ), which makes the effect of diffraction dominant and masks the halo signal. L.Rossi asked if using a stronger wiggler could be beneficial. H.Schmickler replied that this would imply using Xrays but then the main limitation comes from the optics.

There are two options currently followed. First, a coronograph will be installed in BSRT (collaboration with T. Mitsuhashi from KEK). There are on-going simulations for understanding of how to reduce the diffraction by using an astronomical technique called apodisation (using a mask for reducing secondary diffraction rings). The other option is the use of a high dynamic range camera (collaboration with A.Fisher from SLAC and D.Rubin from Cornell), combined with an apodised telescope. Progress is slow due to the fact that CERN experts are quite busy right now with the LHC start-up.

Finally, H.Schmicler presented the latest idea on using beam gas interaction (like in the vertex detectors), for measuring beam profiles. This has the advantage of being free of diffraction but has the limit of needing very long integration times (minutes) for resolving even the average halo coming from a full LHC nominal beam train. G.Arduini asked if bunch-by-bunch is possible and H.Schmickler answered positively but for longer integration time. There are indeed ideas to combine this with a gas jet for better resolution and G.Arduini recalled that there was a cluster jet installed in SppS. H.Schmickler invited him to contact B.Dehning who is following up this development.

Finally, H.Schmickler finished by describing a collaborative project on low-energy electron beams as actuators on hadron beams, including e-coolers (AD, LEIR, ELENA), halo cleaning for the LHC, the LHC BBLR compensation but also space-charge tune-spread reduction. There are several needs for R&D including increased current intensity, fast modulation (for BBLR compensation of pacman bunches) and improved diagnostics. O.Bruning added that there is significant work to be done on the solenoid for confining this high-intensity beam. L.Rossi also added that there is a need to specify the required current because the uncertainty is still quite large. H.Schmickler said that all this will be hopefully studied at CERN in a test stand (Blg. 236), where a TEVATRON e-lens will be installed in the 2nd half of 2015 (after certain modification of the experimental area).

H.Schmickler concluded that most of the effort is now on simulations and advanced instrumentation. There will be a refined cost and schedule in a couple of months. L.Rossi asked if the proposal for the e-beam R&D is included in the BI cost to be presented in the March cost and schedule review. H.Schmickler replied that this R&D presently does not rely on HL-LHC funding.

Interconnection length for triplet magnets, P.Fessia – slides, C.Garion – slides, T.Lefevre – slides

There were three presentations explaining the need for changes of the interconnection length and impact for vacuum and diagnostics (BPMs). First, P.Fessia explained the necessity to have a significant shift in Q1, D1, D2 and Q4, with respect to the present layout. In the region between the Q1 and TAS there is a need of a 1m increase for reduction of the dose in case of intervention. Upon the question of O.Bruning regarding the frequency of intervening in that region, V.Baglin answered that this is usually done during long shutdowns only. In fact, the vacuum valves to isolate the experiments are located in that area. G.Arduini wondered if there is any possibility to move them in another area (e.g. on the other side of the shielding wall). P.Fessia proceeded by explaining that one possibility for reducing this length increase would be to move the BPM from warm to cold (inside the Q1 cryostat), having several advantages (better alignment, reduced vacuum leak risk) but also disadvantages (difficult to replace in case of problems, maybe not ideal position wrt LR encounters). Another option is to revise completely the area and, by optimizing the TAS location, achieve a simplified vacuum layout and eliminate access needs. The third option is to check if the Q1 and Q3 cryostats can be kept the same even when adding the BPM, by gaining some length.

C.Garion presented the vacuum layout principle in that area. The fixed point is located on the IP side and there are bellows between the beam screen and the cold bore, on the other side of Q1. There are also shielded bellows (PIM) between the two quads. Contraction values for the bellows were considered based on the String II test. A similar concept is used for RF fingers (deformable). In conclusion, the minimum space for vacuum components sums up to 630mm. Future steps include a 3D model of beam vacuum interconnections and, in parallel, with the design of components, the design of the interfaces with BPM to optimize the longitudinal space (in collaboration with BE/BI) and finally fix the interconnection length. A prototype of beam screen extremities and interconnection should be ready by the end of this year. H.Prin asked if it is still possible to exchange the PIM with a cutting machine. C.Garion answered that a neighboring element or a sleeve can be used around the PIM to attach the cutting machine. G.Arduini had a question regarding the control of the RF fingers wedge angle and its possible impact to impedance. C.Garion replied that they were tested and there is no risk that only one of them remains stretched.

T.Lefevre reviews the BPM design status which is focused on optimizing the strip-line directivity (ratio of signal power at the upstream and downstream ports) to provide the best possible accuracy for counter propagating beams and studying the effects of tungsten absorbers installed to reduce the amount of collision debris. Directional couplers can achieve typically 20dB directivity. H.Schmickler recalls sensitivities of around 35db and T.Lefevre answers that this may be true for stripline pick-ups with optimal geometry providing the typical 50Ω characteristic impedance, which is not the case of these BPMs. The present work in progress is focused on the redesign of the electrode shapes, the transitions between them and the coax connector (loss minimization) and a new design with absorbers and new beam screen. The round cross-section design and tubular electrodes provides a directivity of 24dB. A second design with octagonal shape provides a slightly better directivity of 27dB, but nothing spectacular. There is a reduction of signal due to the presence of the absorber of the order of 30% but there is no issue as voltage is already too high and most of the time the single is attenuated. In addition, the directivity is not affected. In conclusion, a first design of the IR pickups was done for two stripline geometries. Mechanical work has started with EN/MME (drawings) in order to proceed to a feasibility study of the current design and understand the necessity of the absorbers (FLUKA simulations needed).

Regarding the question of the length, T.Lefevre stressed that the design is adapted to existing electronics. New electronics may enable the shortening of the device. On the other hand, he is not sure if the gain in length (around 60mm) is that significant to justify the effort. G.Arduini asked whether a shorter BPM could have a reduced sensitivity for low intensity beams (e.g. pilots). T.Lefevre answered that the reduced length will not compromise this. F.Cerruti stated that the absorber is not that critical for the area between Q1 and Q2. On the other hand, it is important for the area between Q2 and Q3 and between Q3 and the corrector. Indeed, all this has to be reevaluated properly with FLUKA simulations. Upon the question of G.Arduini if the aluminum part of the interconnection will be coated, V.Baglin answered positively. E.Todesco reiterated the request of the magnet WP to have the requested space and magnet enlargement approved. G.Arduini said that this will be indeed discussed by R.de Maria in the TC of the 12th of February.

O.Bruning summarized that the PLC endorses the idea of including the BPM in the cryostat. A future TC should make the definite decision, after the input of WP2, for the approval of the layout changes. The general feeling about the BPM absorbers is that they should be kept but detailed FLUKA studies are needed (ACTION: F.Cerruti). The possibility to move the position of the vacuum valve should be also discussed in a future TC (Action: V.Baglin).

Feedback from the MQXF Review, E. Todesco – slides

E.Todesco reports (for P.Ferracin) on the MQFX super-conducting (SC) cable and magnet design reviews (November and December 2014, respectively). For the SC cable, the charge of the committee was to review functional and technical specifications, whether the design meets (or will meet) the specifications, based also on the international experience (LARP, Europe), the management of the two strand types, the procurement schedule, the associated QA and test plan. The outcome and recommendations of the review were that the design goals should be conservative. The critical current goal is not satisfied and this is where the request of lower gradient in the triplets comes from (and thereby triggering the discussion about longer triplet magnets). It was also recommended to keep two suppliers for the strand, as it is strategically good, although it creates additional workload. They also recommended going ahead with the 132/169 lower Sn content for the RPR strand and promote a substantive development program with BEAS for the PIT strand. The technical specs are not yet complete and the specifications are optimistic, so there should be a margin (on critical current and minimum RRR). Regarding the procurement schedule, quality assurance and test plan, there should be a better coordination between US and CERN.

E.Todesco proceeded to the presentation of the review committee charge on the triplet design. The principal points asked were whether the specifications are finalized and if the basic design could meet them with sufficient margin, whether the engineering design is adequate, the plan for models and prototypes well thought, the work share between CERN and LARP the best possible and if there are any important technical and managerial risks. The committee fully supported the choice of 150 mm aperture and the scale up of LARP HQ magnet design. The committee pointed out that MQXF is the hardest magnet to be accessed (and replaced) and one needs to be conservative also due to the additional heat load coming from the collision debris. The target should be an operating point of ~75% on load line (it was ~80%). At production, the magnet should be tested to 105% of nominal. O.Bruning asked if the magnets could be tested to higher than 105% during the string test. E.Todesco answered that this is in principle possible but due to the radiation load, half a degree corresponding to around 5% is lost. L.Rossi stressed that conclusions should be drawn during the prototype test, as the string test is too late for applying any changes. E.Todesco added that the committee recommended the consideration of the half-length magnet as a backup option for Q2. G.Arduini pointed out that once a gradient is fixed, the length should also be optimized. E.Todesco answered that indeed the problem is to produce twice the magnets with respect to manpower and tooling.

Finally the committee stressed that there is a need for more resources on development of test facilities. The specifications are not yet finalized but are converging and the LARP experience is being well employed. The basic design will very likely meet specifications with margin. The engineering design is sufficiently developed and the procedure of the magnet replacement and safety issues should be well addressed. The plan for models and prototypes seems very tight and a contingency plan should be defined. Some technical points may hide potential risks and need special attention (operation margin, beam screen design and integration, use of PIT conductor in CERN quads, inner-layer protection heaters and their effect on coil cooling). E.Todesco concluded that both reviews stressed the uniqueness of the opportunity for the Nb_3Sn development, the engagement of enthusiastic teams composed by a new generation of scientists and engineers, with good communication between LARP and CERN and that the project needs to move from R&D towards construction.