# April $22^{nd}$ 2008
# Collimation working group meeting

June 9, 2008

Attending people: Ralph Wolfgang Assmann, Giulia Bellodi, Till Tobias Bohlen, Chiara Bracco, Francesco Cerutti, Alessandro Dallocchio, Doris Frokel-Wirth, John Jowett, Yacine Kadi, Daniel Kramer, Luisella Lari, Roberto Losito, Marco Mauri, Valentina Previtali, Thys Risselada, Federico Roncarolo, Lucia Sarchiapone, Geroge Smirnov, Vasilis Vlachoudis, Thomas Weiler.

**Topics:**

1. Reducing radiological impact in IR7. (R. Assmann)
   Ralph Assmann introduced the problem concerning high radiation dose on IR7 electronics referring to R. Losito (LTC) and T. Wijnands (ICC) talks. He also underlined the main scope of this special meeting that is to present a possible feedback solution to reduce the radiological impact in IR7 for the first years of the LHC operation. During this meetings the first results of efficiency studies for protons and ions were presented by the collimation team.

   RA pointed out that all the theoretical studies concerning radiation dose must take into account a safety margin of at least a factor 10 (highly recommended also by the DG) and that at now a detailed analysis does not exist. From the existing calculations the dose of radiation falling on IR7 electronics, due to the betatron cleaning insertion collimators, is so high to forbid the machine operation for more than few days and with more than 1% of the nominal beam intensity.
   The radiation dose on IR3 electronics is a factor 100 lower than in IR7. The main difference between IR7 and IR3 electronic is its location: In IR7 the UJ76 is in the middle of the IR and fully exposed to radiation

from the two beams while in IR3 the UJ33 station is located in an alcove, better shielded and feels only the radiation coming from beam 1. Aware of this risk the electronic for the betatron cleaning insertion and machine protection was relocated to TZ76 but some components for cryogeny and vacuum were anyhow placed in UJ76.
According to these assumptions RA proposed to strengthen IR3 transforming it in a momentum and betatron cleaning insertion and to commission the machine without relaying on IR7 collimators. Two supplementary TCP (one vertical and one skew) could be installed at the location of the scrapers while 4 vertical TCS could be placed at the location foreseen for phase 2 collimators. RA anticipated that the first results of the simulations fort this new setting show the possibility of operating the machine with a beam intensity up to 20% of the nominal one (see Thomas' talk). This option requires anyway a deep analysis of some complications like the higher load on the warm magnets and the possible quench of the superconducting link cables. The FLUKA team should take care of this calculations. R. Losito commented that the level of radiation in IR3 is already at the limit and this solutions could overload the electronics that cannot be moved elsewhere. Ralph replayed that this is anyhow a temporary solution only for low intensity beam, and it should not then compromise IR3 electronics.

2. Betatron cleaning in IR3 (C. Bracco)
C. Bracco showed a scheme of the new IR3 layout as implemented in the MAD-X sequence and she underlined that even if the new secondary are called TCSM they are standard CFC phase 1 collimators. CB summarized different scenarios which the collimation team has planed to simulate highlighting those for which the results are already available (see table). For these studies all the collimators of the ring but those in IR3 were kept fully retracted and the nominal squeezed 7 TeV optics was used. Thomas Weiler performed simulations for the vertical halo (next talk) while CB took care of the horizontal one, both considered only beam 1. She pointed out that the high horizontal dispersion at the location of the collimators in IR3 (2.5 m @ TCP.6L3.B1) plays an essential role in the effective betatron cleaning. She derived from fundamental optics equation the betatron amplitude cut performed by the collimator jaws on off-momentum particles and from that she plotted the phase space cut for the horizontal IR3 collimators set at the nominal betatron setting (TCP@6 $\sigma$, TCS@7 $\sigma$ and TCLA@10 $\sigma$). The scheme shows that particles of the RF bucket can be cut down to 3 betatron $\sigma$ by the TCPH and that this one stays the element closest to

the beam. CB presented the loss map derived simulating the standard $6\,\sigma$ betatron horizontal halo plus vertical $3\,\sigma$ gaussian distribution and nominal energy spread (0.01%). She explained that the high level of losses in IR5 superconducting magnets should be reduced closing the TCT, that the local efficiency in the dispersion suppressor downstream IR3 is higher than for the nominal phase 1 setting but that losses above the quench limit appear now in IR4 (MQY.6L4 magnet). She underlined that many particles experienced the first interaction with a collimator at the location of the TCS, the TCLA and also of the TCPV and this must be due to the combination of the energy spread, the vertical halo component and the phase advance of each particle respect to the collimators. She insisted that the tool for simulating an off-momentum halo is still missing and these results are unclear, for this reason she is running simulations for the same case but with a purely horizontal on-momentum halo. Also the losses in IR4 are quite controversial since the horizontal $\beta$ function and the dispersion are low in this region. RA commented that IR4 is a bottleneck and this could be the explanation for particles surviving in the arcs upstream and then being lost at this location. CB presented two different options suggested by S. Redaelli for future studies:

- Use of one jaw of each collimator for momentum cleaning and of the other for betatron cleaning (different settings depending on the sign of the dispersion and the phase space cut).
- Implementation of skew collimators based on phase advance optimization.

Regarding this last option she commented that there is a general agreement in keeping the installed collimators as they are playing instead with the new ones in order to reach the highest performance.

3. Betatron cleaning in IR3 (T. Weiler)
Thomas Weiler presented the results for vertical halo simulations. He considered as CB the standard $6\,\sigma$ betatron vertical halo plus horizontal $3\,\sigma$ gaussian distribution and nominal energy spread (0.01%). In this case the contribution of the dispersion is minimum and the results look reasonable. TW showed as first the loss maps for the nominal phase 1 collimation system (horizontal and vertical halo) pointing out that in this case we are limited to about 40% of the nominal intensity by losses in the dispersion suppressor downstream IR7. He presented then the results for different scenarios of betatron cleaning with IR3 collimators:

- Scenario0: horizontal collimators at the nominal setting (TCP@15 $\sigma$, TCS@18 $\sigma$, TCLA@20 $\sigma$) plus one vertical TCP at 6 $\sigma$ and the vertical TCLA at 10 $\sigma$. For this case the maximum allowed intensity is of $\sim$6% $I_{nom}$.
- Scenario1: as scenario0 plus all the planed vertical collimators at 7 $\sigma$. This option leads to a gain of less than a factor 2 ($\sim$10% $I_{nom}$) respect to the previous scenario.
- Scenario2: all the collimators at the nominal betatron setting (equivalent to CB studies). This is the most promising case allowing a beam intensity of about 20% of the nominal one: we lose only a factor 2 respect to the IR7 collimators performance.

TW underlined the presence of losses in IR4 already encountered in CB's simulations, explaining that anyhow that for the vertical halo the level of these losses stay below the quench limit. RL asked if it is possible to try to operate the machine with 20% $I_{nom}$ using the nominal collimation system but RA reaffirm that using IR7 we would be limited to less than 1%.

4. Simulations with CollTrack (V. Previtali)
V. Previtali represented shortly the scenarios simulated by TW and CB explaining that she performed same simulations but using the CollTrack code. This code does not take into account the dispersion of the machine and an aperture model is not available but VP underlined that this is a useful tool for fast evaluation of the global inefficiency. She compared the efficiency curves she obtained for the analyzed scenarios with the nominal one pointing out a factor 100 worsening for the vertical halo and a factor 10 for the horizontal plane. She also compared the efficiency of the scenario2 collimation system for the two halos and she underlined that, even if the IR3 insertion is not designed for vertical collimation, the performance of the new designed system is acceptable. More than this, for amplitude bigger than 12 $\sigma$ the vertical system looks more performing than the horizontal one, VP affirmed that the reason for this behavior is not yet fully understood.

Discussion
Y. Kadi asked if it is possible to play with the two collimation insertions in order to get the same performance but with a lower load either in IR7 and IR3. He and RL explained to be worried by the losses in IR4 since they could be an issue for the cryogenic environment of the RF cavities. RA replayed that our quench limit corresponds to a

very small number of particles lost (equivalent to 10 mWatt/cm$^3$ energy deposition) that should not cause major problems. V. Vlachoudis asked what could happen with this new setting in case of accident scenario and RA answered that he does not expect differences respect to IR7. He added that this is not the "miracle" solution but that he was going to present this at the LTC meeting as a worthy option for surviving 1-2 years without moving the electronic in IR7. RL asked what is the price of this back up solutions and RA replayed that it should coast about 5.000.000 CHF. RL objected that the coast estimated for replacing and relocating the full IR7 electronic is of 1.000.000 CHF and that this could be the best solution. RA underlined that in any case this option would require quite a long time and that it would be impossible to complete it during the first shutdown, RL answered that this could be the case also for the setting of the new collimation system. RA commented that what he proposes is not the "miracle" solution but that it is a worthy back up option if no other professional alternative is available especially considering the factor 10 margin requested by the DG. He added also that this could allow to go on working in a clean environment in IR7. YK asked the FLUKA team what they expected in terms of radiation load on the warm magnets, F. Cerutti answered that in IR3 there are less passive absorbers than in IR7 but since it is not planed to overcome 20% $I_{nom}$ the situation should not be too critical, this must anyway be investigated.

5. Ion collimation with IR3 (G. Bellodi)
   G. Bellodi presented the results for different scenarios of ion collimation with IR3. Differently from CB and TW she used also the skew TCP and she put the TCT at their nominal setting ($8.3\,\sigma$). She showed that, closing IR3 horizontal collimators at the nominal betatron setting, the global efficiency is close to the value obtained with the nominal IR7 collimation system but the loss pattern is completely different. In particular she found out losses in the arcs, upstream of IP3 and also in IR5 even if the TCT were closed. She made many tries closing more and more the collimators of IR3 but, even if the global efficiency improved, globally the loss pattern stayed the same. GB affirmed that the dispersion contribution at the location of the collimator in IR3 plays a bigger role for ions than for protons due to their high rigidity and she asked if the option of changing the optics could be feasible. T. Risselada confirmed that the optics in IR3 is not optimized for betatron cleaning and that the proposal of changing it during the ramp or the squeeze should be considered.

Discussion:
VV commented that the FLUKA team will start the implementation of the new collimators in IR3. TW and CB will then provide them the input for starting energy deposition studies taking into account also the superconducting link cable and the warm magnets load as recommended by RA. D. Forkel-Wirdth commented that from the point of view of the radiation protection IR3 must be reanalyzed especially in view of the construction of a new hotel close to point 3. F. Roncarolo asked what could be the impact on background studies since there is a strong dependance on the phase advance between the collimators and the experiments. RA remind again that we are considering a low intensity regime. RA concluded that on paper this can be a good solution, that we should lose only a factor 2 in efficiency and that we could already have part of the new setting ready for the end of June. He said that even if we have at now only one spare TCP, CERCA confirmed its availability in producing new collimators.