Alessandro Dallocchio 21-04-2008

LHC Collimation PHASE II
6th Design Meeting - 10/04/2008

Present: Gonzalo Arnau Izquierdo, Arnaud Pierre Bouzoud, Ralph Assmann, Gilles Favre, Roger Perret, Ivo Wevers, Wihelmus Vollenberg, Elias Metral, Fritz Caspers, Alessandro Bertarelli (chairman), Alessandro Dallocchio (scientific secretary).

1. RF issues: first answers to questions raised during the 5th CDM2 (E. Metral)

The meeting started with the presentation held by *E. Metral*. First part of the talk was dedicated to the clarification of the issues posed by *Bertarelli* in the 5th CDM2 (see Bertarelli's presentation). The following points were mainly discussed:

1. The choice of the material for the collimator jaws depends on the stabilization method of the transverse coupled-bunch instability:
   - If Landau damping (octupoles) will be used it is important to decrease the imaginary part of the impedance. This entails the use of metal jaws (with the best electrical conductivity).
   - If the transverse feedback works, it is better to decrease the real part of the impedance. This probably means (to be confirmed) that the use of ceramics could help the stabilization of the particle beam. *Metral* remarked that, at low frequencies, the real part of the impedance can be decreased by using ceramic-made jaws; this will help the feedback but could provoke single bunch instability at high frequency (this is probably a minor problem that will be evaluated soon).
2. If ceramic blocks are used, the jaw can be made up of many tails with gaps in between without any problem (the image current is farer from the beam and the gaps on the surface have no influence). On the contrary, in case of metallic block the jaw must be monolithic (no gaps on the surface).
3. If a ceramic material is used for the jaw, it is sufficient to have 5-10mm of dielectric material (ceramic tail) bonded on a good conductor.
4. The heating of a ceramic collimator during operation will change the characteristics of the material (electrical conductivity etc.) and this effect should not be forgotten, as one might enter into a bad regime.
5. The transition between a ceramic and a metal is different from the transition between 2 metals. It is important to avoid the step in the induced current (see slide 4 in the presentation).
6. Detailed simulations with a 3D model of the Phase II collimator must be performed to study possible resonances.

E. Metral presented also some preliminary analytical computations of the transverse impedance for a ceramic collimator, in a range of resistivity $10^{-6} < \rho < 10^{20}$ Ωm. In this case the simplified formula used for conductive materials is no more valid, and the transverse impedance versus frequency presents a different behavior:

- Imaginary part: the maximum of the imaginary part is no more independent on the material.
- Real part: it has two peaks, whose frequencies vary with the resistivity of the material. The first peak frequency is directly proportional to ρ, while the second one is proportional 1/ ρ.

Metral presented other results showing the influence of parameters like thickness of the ceramic material, dielectric constant and imaginary part of the dielectric constant on the impedance.
These results confirm that the real part of the impedance can be decrease by using ceramic jaws but the values strongly depend on the resistivity of the material.
Caspers remarked that we should not consider values of resistivity higher than 10^6 Ωm in order to avoid problem of accumulation of electrostatic charge. On the base of the results showed by *Metral* it was proposed to focus the attention on ceramics with electrical resistivity in a range 1-10 Ωm (*Caspers* indicated the SiC as a suitable material in terms of impedance performance). It is important to verify the influence of temperature and ionization (due to radiation) on the electrical resistivity of ceramics.
Bertarelli posed a question: assuming a configuration with ceramic tails bonded on a high conductivity metallic support, the thickness of the metallic conductor could have an influence on the resulting impedance? *Metral* will evaluate this point.

2. Discussion on current design status

Assmann remarked that the design of the cooling system, based on brazed components, could be potentially dangerous: the effects of radiation on brazed joints must be experimentally evaluated.
On this subject, the solution of cooling pipes without brazing joint (similar to Phase I design) embedded in a block should be considered more in details. *Izquierdo* proposed the use of Zirconium alloys which are commonly used in nuclear application highly exposed to radiation.
Assmann focused on the importance of including pickups in the collimator jaws (4-6 pickups on each jaw); furthermore he asked to evaluate the possibility of having an active control (maybe based on the central pickups signal) of the central adjustment system in order to compensate the flatness of the jaw during the operation.
The discussion focused on the requirements coming from cleaning efficiency: *Assmann* explained that the best must be done compatibly with RF requirements. Further upgrade in terms of efficiency could be obtained with special devices (in addition to Phase II collimators) that should be installed in particular locations in order to absorb the localized losses.

3. Follow up of the 5th Specification meeting

Present: R. Assmann, W. Hofle, C. Bracco, L. Lari, E. metral, G. Bellodi, A. Bertarelli, A. Dallocchio

W. Hofle described the damping system used in the LHC. He confirmed that transverse feedback works correctly over the frequency range of interest. Data provided by *Hofle* about performance and limits of the transverse feedback system seem to confirm the prediction of *Metral*: the transverse feedback is a reliable method that can be used with a good safety margin (to be confirmed by further and more detailed studies of impedance). *Assmann* remarked that we cannot rely only on calculations, we should wait for the beginning of LHC activity in order to better understand the limits of the machine. On this assumption it is very important to have different solutions for the Phase II collimators. Both metallic and ceramic jaws must be considered.

4. Action list

ACTION	MANAGED BY	OPENED	CLOSED
Prepare an overview of suitable materials	G. Izquierdo	31/01/2008	In Progress
Discussion with vacuum experts on the possibility of having welded components inside vacuum tank.		14/02/2008	28/02/2008
Preparation of a list with specification requirements on Cu-Diamond composite to be given to Ludger Weber (EPFL) in order to start a more detailed study on this potential material for collimator jaw.	G. Izquierdo A. Bertarelli A. Dallocchio	28/02/2008	19/03/2008
Verify potential problems relative to machining and brazing of Molybdenum	G. Favre	28/02/2008	In Progress
Supply of metal-diamond composite samples.	L. Weber	14/03/2008	
Validation of the material to UHV requirements.	I. Wevers W. Vollenberg	14/03/2008	
Provide to E. Metral properties of ceramics that can be potentially used**.**	G. Izquierdo	27/03/2008	28/03/2008
Verify the feasibility of a "comb" jaw using GLIDCOP.	R. Perret	27/03/2008	In Progress
Verify with R. Assmann the cleaning efficiency of a "comb" jaw.	A. Bertarelli A. Dallocchio	27/03/2008	
Find ceramics with electrical resistivity within the range: 1-10 Ωm (evaluate the proposal of Caspers of using SiC). Verify the influence of temperature on the electrical conductivity.	G. Izquierdo	10/04/2008	
Take contact with Rhodri Jones for the BPM and with Bernt Denhing for the BLM that should be installed on the jaw.	R. Perret A. Bouzoud A. Dallocchio	10/04/2008	22/04/2008

Next Phase II Design meeting will be on April 24th, 2008.
Room 376-1-016