Participants: Markus Aicheler (BE/RF), Suleyman Askar (BE/RF), Nuria Catalan Lasheras (BE/RF), Steffen Doebert (BE/RF), Daniel Esperante (BE/RF), Hossein Ghasem (BE/ABP), Alexej Grudiev (BE/RF), Andrea Latina (BE/ABP), Helene Mainaud-Durand (EN/ACE), Michele Modena (TE/MSC), Juergen Pfingstner (BE/ABP), Carlo Rossi (BE/RF), Hermann Schmickler (BE/BI), Daniel Schulte (BE/ABP), Igor Syratchev (BE/RF), Anastasiya Solodko (BE/RF), Steinar Stapnes (ATS/DO), Xavier Stragier (BE/RF), Jukka Vainola (BE/RF), Alex Vamvakas (BE/RF), Walter Wuensch (BE/RF).

Chair: H. Schmickler
Scientific Secretary: C. Rossi

Agenda:
Minutes approval and follow-up of the previous meeting (HS)
Minutes of the previous meeting
H. Schmickler's slides
Limits when Manufacturing RF Units (NC)
N. Catalan's presentation
AOB: Date and goals for next meeting

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1. Approval of minutes and follow-up of the previous meeting

H. Schmickler: shows some slides concerning the CV installation for the Main Linac tunnel. The transverse ventilation concept, as it has been adopted in the CLIC CDR, is shown, assuming shafts at 5 km distance; also, at the time the constraint of using a 5.6 m boring machine was considered, since it was estimated that seven machines were required to dig the tunnels in parallel, to save time. In that configuration the temperature difference would be of 20 degrees assuming the 150 W/m of envisaged dissipation. **S. Stapnes**: asks if we could review the figure of 150 W/m and if that figure was including all heat sources available at the time of the study. After a short discussion there is agreement that the figure of 150 W/m was a rough estimate and that a deeper investigation would be required to understand what this number includes, beyond the heat transfer to air from the AS. **W. Wuensch** states that one can always think to insulate AS, if needed. **H. Schmickler** points out that the air speed in the ventilation ducts of the CDR design appears unreasonably high, due to the civil engineering constraints. He also informs that M. Nonis at that time in charge of the study has admitted that there were some inconsistencies and that the system should be re-evaluated starting from the specified requirements.
After the optimization of the 380 GeV case the Main Linac tunnel will look different from the CDR design, certainly shorter and probably larger, if needed, with the possibility of a more free choice of the tunnel diameter due to the fact that only two boring machines will be required. The distance between shafts could be reduced to 800 m and a longitudinal cooling scheme could be envisaged in this case. Not to forget that also safety consideration should come into play, since fire walls and escape doors will have to be considered. **H. Schmi**ckler remarks that the drive beam recirculation tunnel might be considered in the safety system. The fresh and extracted air could be made pass through the ducts that will be foreseen for the line of sight of the survey team. **H. Mainaud-Durand** comments that so frequent view points may not be beneficial to achieve a good final alignment result.
Having considered the alternative between an open or closed loop air circuit, **H. Schmickler** points out that the closed loop circuit must be evaluated in order to mitigate seasonal and daily air temperature changes. **S. Stapnes** asks if we know how much power is released to air in the LHC and FCC design, just for a comparison. **D. Schulte** comments that the heat transfer to the tunnel wall should not be neglected, **H. Schmickler** replies that, in his view, the heat transfer to the wall stone is very limited. He proposes that the situation with two very different air

temperatures (10 and 35 deg) is simulated by the module team to understand the effectiveness of the heat exchange between AS and air, while normal water cooling is running. **H. Schmickler** reports that, in accordance to what discussed with M. Nonis, a fellow staff in CV should perform a study of the heat model of the Main Linac tunnel. The aim is to reduce the operating range of the model so to fit the requirements of alignement in the tunnel. **S. Doebert** makes the remark that the difference between the temperature at initial alignment and during operation is the main question, requiring a considerable correction of the initial alignment values; the ideal situation would be, of course, that the temperature remains stable at the initial alignment value all the time. So the real question is to how to minimize the temperature gradients. Following a discussion about the type of material that should be used for the supporting girders, **S. Doebert** comments that the heat transfer from the structures to the girder is a fraction and not very important in the final balance.

2. Limits when Manufacturing RF Units

N. Catalan: reports on some considerations about the possibility to build longer AS. She starts by summarizing the present fabrication procedure, she points out that the expected accuracy of machining is achieved, structures with a diameter size of 20 to 30 cm can be built, then the availability of the appropriate oven becomes a relevant factor for the structure fabrication. An experiment was done at KEK to build 1.8 m stack of disks, with prebonding in the inclined position and a final bonding in the vertical position. In this case excellent results were achieved with the disk to disk alignment, but a large bow was observed.
In PSI the 2 m long C-band stack of disks used for the fabrication of their accelerating structures has been successful, disk to disk misalignment is large and randomly distributed but bow is absent. In this case disks are interlocked; **W. Wuensch** observes that the alignement with the V-shaped tool appears a better method with respect to interlocking, if one considers the disk to disk alignment. **N. Catalan** shows samples of what is produced in industry: S and C-band structures are routinely built there, but the alignment accuracy remains unknown. In CLIC the realization of a 0.5 m structure was tried reaching a good disk to disk alignment, however some bow was measured at the level of 20 μm. A study performed with simulations has shown that the inclination of the base disk can produce this bow effect; by taking this into account during the fabrication process 2 m long structures should not represent a problem.
After some discussion it is clarified that the fundamental unit shown in Nuria's slide is the CLEX version which does not reflect the baseline unit of the CLIC CDR; however in Nuria's view this is a better example of what the module should be as it contains an input for the pets necessary during assembly and directional coupler for RF measurements. There is anyway a general agreement on the fact that the waveguide network around the SAS appears complicate and difficult to assemble. Looking into the possibility of providing a consistent simplification a new design from A. Grudiev is shown, with bent waveguides housing the HOM suppressors, a vacuum manifold and cooling ducts integrated in a single piece: a test fabrication is under way. A discussion follows clarifying that it does not look feasible to build a rigid unit that include SAS, PETS and waveguides: each element should be fabricated separately and then rigidly assembled in a single RF unit, which becomes the elementary brick for the module construction. The following slides show proposals for simplifying the AS construction and compact components that could facilitate the realization of more compact and easy-to-assemble RF units.
D. Schulte reminds that the granularity in the lattice for AS should stay around 0.6 – 1.0 m; longer structures would make the first part of the linac inefficient, by reducing the filling factor. It is then clear that we cannot just restrict ourselves to 2 m long AS only. *After the meeting **N. Catalan** stressed that only two or four basic structures can be assembled at the same time.*

N. Catalan continues her presentation by showing that compact loads are being prototyped, by using the additive manufacturing technique, and completes her presentation emphasizing that a lot can be gained on the side of the RF network in terms of simplification.
H. Schmickler proposes to use girders with the same expansion coefficient of copper to assemble basic RF unit on it, for transportation; however, since the girder will be thermalized at the surrounding air temperature, it turns out that the opposite is true and materials with low expansion coefficient should be adopted, since the cooling system should take care of limiting the expansion of copper structures.
H. Schmickler asks then what the minimum distance between the DB and the MB should be, he is answered that the intrabeam distance is given by the size of the two quads and by the need to avoid interference of the two beams, so to allow enough space for the assembly work. **M. Modena** comments that the quads power increases by reducing the size and also employing permanent magnets a lot of space is needed by the mechanics to assure the movement required for tuning, so the trend is to have as much space as possible.
D. Schulte points out that the fact of going towards a single girder configuration produces more supports for the independent DB quads as a result and asks if there is any advantage with this. A discussion follows on the fact that when adjusting the MB to minimize wakefields the DB is moved, in a single girder configuration, and if this requires that the DB quads follow or not. The option of having movable components on the girder is also mentioned. **S. Doebert** comments that the implications of a single girder from the point of view of beam dynamics vs the two girders should be clearly presented to decide the direction to go.

3. Conclusions.

H. Schmickler The minutes of the previous meeting, held on 28th October, are approved with no further changes.
H. Schmickler suggests to delay S. Doebert's presentation to the next meeting, on the 2nd December, and asks the Module WG to elaborate a proposal for the new module design. M. Aicheler is asked to present this proposal at the next CLIC Implementation meeting, together with an analysis of the possible impact of temperature differences between AS and PETS on the module behavior during operation.