

# Accelerator Design meeting

Monday 08/11/2021, 16:00 – 17:30

(<https://indico.cern.ch/event/1094485/>)

*Chair:* Daniel Schulte

*Speaker:* Daniel Schulte and Herbert De Gersem

*Participants  
(zoom): 40* *Adrian Cross, Akira Yamamoto, Alessandra Pampaloni, Alex Bogacz, Alexej Grudiev, Andrea Bersani, Antoine Chance, Anton Lechner, Bernd Stechauner, Cary Yoshikawa, Chris Densham, Chris Rogers, Daniel Schulte, Daniele Calzolari, David Kelliher, David Neuffer, Elena Fol, Elias Métral, Francisco Javier Saura, Fulvio Boattini, Herbert de Gersem, J. Scott Berg, Kyriacos Skoufaris, Jean-Baptiste Lagrange, Jean-Pierre Delahaye, Jose Antonio Ferreira Somoza, Katsuya Yonehara, Mark PLamer, Manfred, Nadia Pastrone, Patricia Tavares, Philippe Lebrun, Rob Van Weelderen, Rob Ryne, Roberto Losito, Roger Ruber, Sergo, Stefania Farinon, Ursula Van Rienen, Romagnoni.*

## MEETING DECISIONS

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- None.

## MEETING ACTIONS

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| <b>1: Daniel and Chris</b>      | Finalise the final report to be sent to the LDG tomorrow morning (instead of next Friday as initially foreseen), with the latest comments received from the LDG during lunch time. |
| <b>2: ScottB</b>                | Try and find back what he did in the past with grain-oriented steel etc. and discuss this with HerbertDG who is willing to collaborate on this.                                    |
| <b>3: HerbertDG and FulvioB</b> | Start to collaborate and discuss also with the CERN magnet group and Stephan Russenschuk (who knows a lot about magnet modelling) in particular.                                   |
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## NEWS (DANIEL SCHULTE)

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- Daniel mentioned that the report for the LDG is in its final form and that he got everything on a very short notice (see Action 1).

## 1. SIMULATION AND DESIGN OF ACCELERATOR MAGNETS (HERBERT DE GERSEM)

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- Herbert started by mentioning that he will not show things linked to muon colliders but the goal is to show what can be done from TUD. He discussed the FE simulation scheme (including Eddy currents), the losses in accelerator magnets (ramped/AC magnets with Joule losses, Eddy-current losses in the coil and yoke and hysteresis losses in the yoke; prevention; appropriate cooling), the modelling and simulation challenges (with the adaptive time stepping needed, many geometric delays needed and numerical accuracy), the homogenisation of coils (with the example of the Rutherford cable: adjacency and cross-over Eddy currents due to the perpendicular magnetic field), the homogenisation of the lamination stacks (with the example of the FAIR SIS100 magnet with a  $dB/dt$  of 4 T/s), the uncertainty quantification and optimisation, and the data-driven field simulation.
- On slide 19, with the example of the FAIR SIS100 magnet, the red line is obtained with the old-fashioned FE method while the blue line is obtained with the new FE method.
- Daniel commented that this is very nice and interesting and would like to see now what would happen in a regime closer to a muon collider with few hundreds T/s.
- PhilippeL asked more about the hysteresis losses in the yoke. Herbert mentioned that there we need a model for the hysteresis and the parameters of this model have to be determined by measurements, which is the difficult and challenging part.

- Daniel mentioned that for the fast ramping magnets of a muon collider we speak about huge power losses (order of 10 GW peak power), so calculating at 1% would be enough in a first step, and he asked if a simplified model would be enough to predict the field. Herbert answered yes.
- The major difficulty for the aperture field is that we need to do a transient simulation and we need to identify the small field deviation with a very good accuracy.
- ScottB asked if they can look at anisotropic materials (they look at grain-oriented steel for instance in the past)? Herbert said that ferromagnetic materials are anisotropic so yes they can do it. The issue is when the anisotropy is nonlinear as the convergence of the system can become very difficult. Herbert would be interested to see what had been done in the past by ScottB (see Action 2).
- PhilippeL reminded us that every magnetic steel is anisotropic.
- FulvioB (who started to work on the power converters) asked if they could try and find an optimised design with magnets, considering the coupling to the power sources. HerbertDG is willing to collaborate on this and he said that they should start with a 2D model first, which is usually  $\sim 10\%$  off. This gives the good order of magnitude and it can be calculated on a laptop in a few seconds before going to the more involved 3D model. Daniel confirmed that it would be indeed great to have a simple model including the power source and the magnet (see Action 3).
- Daniel asked how important measurements at the proper (high) frequency are, if/when we want to characterise a material (as it is much more difficult to measure at high frequency). Herbert said that it is important to do measurements in the full range of operation.

## 2. AOB (EVERYBODY)

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- Info from VladimirS after the meeting about the “APS News” (quite upbeat article on MC): <https://www.aps.org/publications/apsnews/202111/muon.cfm>, where it is said in particular that “If the US community decided that this was important, we could build a 1 to 5 TeV muon collider on a 10 to 15-year timeline”.
- The next meeting will be announced in due time.

*Reported by E. Métral and D. Schulte*