Accelerator Design meeting

Monday 13/02/2023, 16:00 – 17:00

(https://indico.cern.ch/event/1252027/)

Chair	Daniel Schulte
Speakers	Anton Lechner
Participants (Zoom)	Akira Yamamoto, Andrea Wulzer, Antoine Chancé, Anton Lechner, Bernd Stechauner, Carlo Carrelli, Christian Carli, Claudia Ahdida, Daniel Schulte, Daniele Calzolari, David Amorim, David Neuffer, Donatella Lucchesi, Elena Fol, Elias Metral, Fabian Batsch, Francisco J. Saura, Fulvio Boattini, Heiko Damerau, J. Scott Berg, Jonathan Pavan, Jose Antonio Ferreira Somoza, Kyriacos Skoufaris, Luca Bottura, Maha Rhandi, Max Topp-Mugglestone, Nadia Pastrone, Nazar Bartosik, Patricia Borges de Sousa, Philip Burrows, Roger Ruber, Rui Franqueira Ximenes

Meeting Actions

1. None

1. News (Daniel Schulte)

- The kickoff meeting for the MUCOL EU study will take place on March 28th, via Zoom. The two main parts will be:
  - Presentation of the Work Packages.
  - Governing board and Collaboration board meetings.
- Andrea Wulzer: the EPJC paper is being finalized, submission is planned for 14/02 evening. A last round of author name collection occurred.

2. Report from WG on Beam-matter interaction / target systems (Anton Lechner)

- Anton Lechner reported the team's work on beam-matter interaction. Four main subjects are presented:
  - Muon production: heat load and radiation in the target area.
  - Accelerator and collider magnets: muon yield, as well as heat load and radiation in the target area.
  - Detectors: radiation damage and background reduction.
  - Neutrino-induced dose calcuations.

- These studies are linked to different topics (magnets, target, machine-detector interface) and can be found in the following Indico categories:
  - Muon Production and Cooling Working Group (target part)
    - https://indico.cern.ch/category/12766/
  - Muon Magnets Working Group (collider magnets heating and shielding part)
    - https://indico.cern.ch/category/13958/
  - Machine-Detector Interface Working Group (beam-induced background part)
    - https://indico.cern.ch/category/14574/

- The first part covered the muon production and target region.
  - The main differences from the MAP studies are:
    - A graphite target is considered as the baseline (liquid lead or fluidized tungsten are studied as alternatives).
    - High Temperature Superconductor (HTS) are used for the solenoid magnets. Normal Conducting (NC) magnets are not used in the front-end.
  - The baseline proton beam power used for the target and chicane design is 1.5 MW. The 4 MW option is kept in mind, but this would require a redesign of the front-end.
  - The muon yield was studied for a range of parameters: target length, target radius, target vessel aperture. The proposed design accounts for this first optimization.
  - Some technological options must be investigated, in coordination with other WP:
    - The Superconducting (SC) magnets materials behavior with high Displacement per Atom (DPA). Neutrons are a large driver of the DPA, and experience from the fusion community will be valuable.
    - The impact of total ionizing dose on the insulation materials.

        - The need for a dedicated dump line for the proton beam remaining after the target.

- The second part covered the heat load and radiation damage to the collider magnets.
    - The power load caused by muon decay products and secondary emissions (electrons, synchrotron radiation...) is in the order of 500 W/m in superconducting magnets, an unprecedented value. Two main aspects must be investigated:
        - The instantaneous heat deposition to remain below quench level in the magnets and avoid excessive heating of the cold mass.
        - The long-term radiation damage to the magnets.
    - A generic radial build model for the magnet was used, and the simulations were performed for the 3 TeV and 10 TeV c.o.m colliders.
    - With a 3-4 cm thick tungsten shield, the power penetrating the cold mass would be 1-2 % of the power carried by the decay products.
        - The power density in the SC magnet coils remains much lower than the quench limit, even with a thin (2 cm) shielding.
    - With a 3-4 cm thick tungsten shield, the cumulative ionizing dose in the coils is in the 20-60 MGy range (assuming 10 years of operation). The insulation materials will have to be carefully selected.
        - The DPA remain however at an acceptable level for superconducting materials.

- The third part covered the Beam-induced background (BIB) and machine-detector interface (MDI) aspects.
    - Both 3 TeV c.o.m and 10 TeV c.o.m colliders were studied. Recent work focused on the 10 TeV collider.
    - The lattice design for the final focusing region are an important input to BIB studies.
        - Effect of additional dipole field in the triplets or change of L* were investigated. No significant gains in terms of BIB reduction were found to justify these options.
    - A first optimized nozzle design for the 10 TeV collider has been studied, showing a particle fluence reduction in the detector. It might be further reduced with design refinement.

- The fourth part covered the neutrino induced dose model
    - More detailed FLUKA simulations were performed to refine the dose kernel used by the Radioprotection group
        - The contribution of different neutrino flavours to the dose distribution has been studied.
    - The dose kernel can be used for placement and civil engineering studies

- Luca Bottura remarked that a radioprotection study of the target area would be helpful, as it will drive some technological and operational choices (robotic only maintenance for example).

- Scott Berg asked if there is a simple scaling for the high-energy accelerator chain and collider? Would the shield thickness be proportional to the beam energy/power?
  - "Anton Lechner answered that the shielding thickness depends on the limiting factor that is reached first: the total power deposition or the cumulative peak dose in the magnets.
  - Daniele Calzolari added that the bending radius is an important parameter: a less rigid beam (lower energy machines) affects the impact angles of particles lost on the aperture, which can in turn affect the shielding efficiency.

- Daniel Schulte remarked that the target value for the heat deposition in the superconducting coils was based on Low Temperature Superconductor. The requirement might be changed with HTS.

- Anton Lechner inquired what is the proton driver beam power that should be used, since going from 1.5 MW to 4 MW implies different target geometry and technology.
  - Daniel Schulte answered that we should work the other way around: for a given technology and the subsequent design, what is the maximum beam power reachable and the performance obtained.

- Anton Lechner inquired if the proton driver could be operated at lower energy, keeping the same beam power?
  - Daniel Schulte answered that this could be investigated if there is a strong interest for the target design.

3. AOB (Everybody)

- The next General Design meeting will take place on the 27th of February. Fabian Batsch will report on the RF studies progress. The Indico page is https://indico.cern.ch/event/1254683/

Reported by D. Amorim, E. Métral and D. Schulte