International Muon Collider Design Study

Accelerator Design meeting

Monday 12/09/2022, 16:00 – 17:30

(https://indico.cern.ch/event/1199792/)

Chair:	Daniel Schulte
Speakers:	Daniel Schulte, David Amorim
Participants (zoom): 26	*Andrea Bersani, Anton Lechner, Bernd Stechauner, Chris Rogers, Christian Carli, Claude Marchand, Daniel Schulte, David Amorim, David Kelliher, David Neuffer, Daniele Calzolari, Donatella Lucchesi, Elena Fol, Elias Métral, Fabien Batsch, Francisco Saura, Heiko Damerau, J.S. Berg, Luca Bottura, Machida Shinji, Massimo Casarsa, Mark Palmer, Qiang Li, Rober Losito, Roger Ruber, Yifeng Yang.*

MEETING DECISIONS

- None.

MEETING ACTIONS

1: Alexej Grudiev	Provide DavidA with the information (related to the fundamental mode and HOMs, required numbers, etc.) about the ILC/TESLA cavities such that he can compare to the results he presented (and hopefully check that there are no issues…).
2: David Amorim	Check the very low resistivity of Tungsten at low temperature.
3: Luca Bottura and magnets team	Provide DavidA with more complex chamber geometries for the 3 TeV collider (if you think there is a need to study them).

1. News (Daniel Schulte)

- DanielS presented the Muon Collider at IPA2022 (Interplay between Particle and Astroparticle Physics 2022) conference in Wien, 05-09/09/2022 => I added also the talk on our website (https://muoncollider.web.cern.ch/talks). Direct link: https://indico.cern.ch/event/837621/contributions/4988870/attachments/2504154/4302617/IPA_2022_final.pdf.
- ChrisR mentioned some progress on some reports.
- ChristianC (and LucaB) gave an update on the progress with the organisation of the Collaboration Annual meeting on 11-14/10/2022
    - There was a meeting last week and they solved some issues. Most organisers contacted the speakers. The programme is in reasonable shape concerning the parallel sessions. Still some ongoing discussions now for plenaries and the fees. Tomorrow the programme should be finalised and made public in the following days.

2. Transverse Stability Thresholds of the First RCS and the 3 TeV Collider (David Amorim)

- DavidA presented 2 sets of slides
    - The first on the single-turn and multi-turn transverse stability limits for the RCS1 (from resonators, as they are anticipated to dominate the transverse impedance => Wall impedance to be added in the future).
    - The second on the transverse beam stability studies for the 3 TeV collider (from the wall impedance, to help defining the minimum required aperture of the magnets => Impedance model to be updated in the future as well as studying the 10 TeV option)
- For the RCS1
    - The summary is shown on the slides 22 and 23, where it can be seen that
        - ⇨ **If fr/Q < ~ 10^5**, then the **multi-turn regime** applies and the (total) **transverse shunt impedance Rt should be smaller than 10 TOhm/m**.
        - ⇨ **If fr/Q > ~ 10^5**, then the **single-turn regime** applies and the (total) **transverse shunt impedance Rt should verify that: (Rt/Q)*fr^2 < 100 [MΩ/m*GHz^2]** (as better expressed by AlexejG after the meeting => Many thanks again AlexejG!)
    - Next steps
        - ⇨ Refine simulations with finer parameter space
            - In particular the resonator shunt impedance Rt

        - Convergence check with large number of macroparticles (convergence study) and wakefield slices
        - Etc.
    - ⇨ Investigate in details the beam behavior during an instability
        - Dependence on number of RF stations and acceleration
        - Dependence on wake-field parameters
        - Etc.
- Discussion
    - ⇨ ScottB mentioned that he was surprised to see such high values which is good news => To be checked of course and confirmed!
    - ⇨ Following a question from DanielS on the effect of the transverse tune on the multi-turn case, DavidA answered that the most critical case is assumed here, with the peak of the resonance exactly on top of a betatron line.
    - ⇨ DanielS mentioned that we should take the cavities from ILC/TESLA and see what we get (see **Action 1**).

- For the 3 TeV collider
    - DavidA concluded (see slide 21) that
        - ⇨ Chamber radii below 18 mm are challenging damper-wise or require cryogenic material
        - ⇨ Radii between 20 and 30 mm allow to use all material with classic damper setting (100, 200 or 500-turn damping) => Meaning also that above ~ 30 mm, no issues are foreseen
        - ⇨ Muon decay has a beneficial effect on transverse beam stability – Gain between 1 and 5 mm on chamber radius for a given material and damper setting.
    - Next steps
        - ⇨ Ongoing: repeat the study for the 10 TeV c.o.m collider (10 km circumference)
        - ⇨ Investigate more complex chamber geometries (if needed)
        - ⇨ If we want to use tighter (< 17 mm) beam chamber, investigate supplementary mitigation measures for beam instabilities
            - Effect of sextupoles (chromaticity)
            - Effect of octupoles (tune spread to enhance Landau damping)
    - Discussion

- ⇨ MarkP mentioned that for MAP they considered significantly larger apertures than those where we start to see some issues => MarkP stressed that anything larger than 30 mm radius is a none issue, which is indeed what was found by David.
- ⇨ Following a question from ScottB on the modelling of the transverse damper, DavidA answered that an ideal (fully bunch-by-bunch damper was used). Furthermore, ScottB was surprised by the very low resistivity of the Tungsten at low temperature => **Action 2**.
- ⇨ LucaB mentioned that this study is of course very useful for them. As mentioned above, DavidA is now ready to study more complex chamber geometries (**Action 3**).
- ⇨ AntonL also mentioned that this info is very useful and that for the shielding we need Tungsten (but this does not mean that we cannot have a coating inside, which can be thin). AntonL asked about the scaling to the 10 TeV option => DavidA is currently looking at that and some results should be available for the Annual Meeting.
- ⇨ In some discussions by email after the meeting, ScottB wrote: "…considering things from a different direction, I am generally more concerned about the short-range wake, which is a very different point of view for looking at the issue. The reason for my flagging this is that a) we know that a significant fraction of the stored energy in the cavity is extracted from the fundamental mode, thus leading to a significant short-range wake, and b) I believe that the short range wake from the fundamental mode is only a fraction of the total short range wake from a cavity. For analysis, I think in terms of the typical two-part analysis of this: first, determining the "potential-well distortion," i.e., the effect voltage the bunch sees including the wakefield. One then adjusts the distribution to be matched to that potential (easier said than done in a real machine or even in simulation), then analyzes if that is stable under perturbations. With the added complexity that muon decays mean that even for a constant distribution, the wake is dynamic." **=> To be followed up in the future**.

3. AOB (EVERYBODY)

- The next meeting will take place next Monday 19/09/2022 (see https://indico.cern.ch/event/1201114/).

Reported by E. Métral and D. Schulte