International Muon Collider Design Study

Accelerator Design meeting
Monday 17/10/2022, 16:30 – 17:30
(https://indico.cern.ch/event/1211848/)

Chair:	Daniel Schulte
Speakers:	Daniel Schulte, Andrea Latina
Participants (zoom): 14	*Adrian Cross, Andrea Latina, Bernd Stechauner, Chris Rogers, Christian Carli, Daniel Schulte, David Amorim, Daniele Calzolari, Edda Gschwendtner , Elias Métral, Fabien Batsch, Francisco Javier Saura Esteban, Jose Antonio Ferreira Somoza, Pieter Sievers.*

MEETING DECISIONS

- None.

MEETING ACTIONS

1: Everybody   Send to ChristianC and LucaB any comments / feedbacks you would have from the 1st Muon Collider Collaboration meeting (https://indico.cern.ch/event/1175126/) to take them into account for the future editions.

1. NEWS (DANIEL SCHULTE)

- Following the 1st Muon Collider Collaboration meeting, which took place last week (**see Action 1 above**), DanielS reminded us that Nadia Pastrone has been elected as the 1st Muon Collider ICB chair. Furthermore, the Study Leader (Daniel Schulte) and his deputies (Andrea Wulzer, Donatella Lucchesi and Chris Rogers) have been confirmed by the ICB => Congratulations to all!

- DanielS mentioned that we will have soon to write an implementation plan for the LDG and then Council and that we will have to present also at some point the muon collider study at the CERN SPC and also for ECFA.

- Finally, DanielS mentioned some positive signs as concerns the CERN budget, which had been requested (to be confirmed in the future).

- Today we go back to more technical aspects with a meeting devoted to the RF-Track code from Andrea Latina, which seems to be a good tool for our cooling studies. DanielS noted that this activity started during Summer and that it seems very promising.

2. RF-TRACK (ANDREA LATINA)

- AndreaL explained in detail his code RF-Track, which was written in modern C++, and which can be used for beam tracking in complex accelerator scenarios

  o **Motivation**: The motivation for developing RF-Track came with the TULIP Project (High-gradient proton linac for proton therapy) and the need of 1) 6-D tracking in 3D EM field maps of backward traveling wave structures, 2) the possibility to maximise the transmission changing any parameter (RF input power, quadrupole strengths, quadrupole positions, input distribution, etc.), 3) tracking protons as well as carbon ions; 4) something flexible and fast to enable non trivial optimisations => Decided to develop a new code from scratch.

  o **Highlights**:

    ⇨ It handles Complex 3D field maps of oscillating RF EM fields (with the capability of simulating of Backward and Forward travelling waves, as well as static fields)

    ⇨ It's fully relativistic (no approximations are made, like $\beta \simeq 1$ or $\gamma \gg 1$; can simulate any particle, and was successfully used with: electrons, positrons, protons, antiprotons, ions, at various energies, recently photons and muons)

    ⇨ Implements high-order integration algorithms

    ⇨ Implements space-charge effects, wakefields

    ⇨ Tracks mixed-species beams, with collective effects

    ⇨ It's flexible and fast

  o **Tracking**: can be done with **beam moving in space** or **beam moving in time**. RF-Track can simulate mixed-specie beams and particle's creation and the beam can be tracked backward in time, including collective effects.

  o **Tracking environment**:

    ⇨ **Lattice: a list of elements**

      • It uses Bunch6d to track the particles element-by-element, along S

- Like in textbooks, suitable for matrix-based tracking

⇨ **Volume**: **a portion of 3D space**

- It uses Bunch6dT to track the particles in time

- Allows in particular element overlap and particles creation

⇨ Lattice and Volume are meant to be used together

o **Field map: can be 1D or 2D or 3D**

o **Absorber**: it is a special element, implementing Multiple Coulomb Scatterring => AndreaL showed us a live demo

o **LaserBeam**: it is another special element, simulating Inverse-Compton Scattering (ThomX example)

o **Single-particle and collective effects**

⇨ "Effects" can be attached to any element and an arbitrary number of them can be used

⇨ Single-particle

- Incoherent Synchrotron Radiation (in any fields)

- Multipole kicks for magnetic-imperfection studies

- Multiple Coulomb Scattering (new)

⇨ Collective

- Space charge => 3D with P2P or PIC and it can also simulate beam-beam forces

- Short-range wakefields (Karl Bane's approximation or arbitrary Spline)

- Long-range wakefields

- Self-consistent Beam Loading effect in TW structures (SW in progress)

o **Example: RFQ commissioning at LIGHT (ADAM)**

⇨ "LIGHT is a normal conducting 230 MeV medical proton linear accelerator being constructed by ADAM

o **How to get it** => Pre-compiled binaries and in-progress documentation are available here: https://gitlab.cern.ch/rf-track

o **Acknowledgements**: Contributions from Avni Aksoy, Javier Olivares Herrador, and Mohsen Dayyani Kelisani.

- Discussion

- o AndreaL confirmed that he already benchmarked his code against others for both space charge and wakefields and that his code can do fast acceleration with many RF systems, etc., i.e. everything we need for our studies with the muon collider.

- o As concerns counter-rotating bunches, AndreaL mentioned that there is a plan already to do this with PLACET2 (a spin-off of the code PLACET written in the past by DanielS).

- o RF-Track is too big to be integrated in X-Suite but it can be easily loaded and used from within Octave or Python (as used for X-Suite).

- o RF-track simulate electron cooling.

3. AOB (EVERYBODY)

- EliasM mentioned that Jacques Fichet started the mounting of the short movie he did during the 1st Muon Collider Collaboration meeting with interviews from DanielS, Karri Folan Di Petrillo from FNAL (with the nice T-shirt), MikeL and SteinarS. EliasM and JacquesF will try and finalise it in the coming days before sending it to DanielS, KarriFDP, MikeL and SteinarS for approval.

- The next meeting will be announced in due time.

Reported by E. Métral and D. Schulte