Objectives, Deliverables and Resources
for the BD-WG

International MUON Collider Collaboration

Objectives							
A list of key performance specifications to ensure that the beam quality target is met and to guide the design; supported by analytical and computational calculations							
High-level Deliverables							
1) RF design of the RCS chain							
1) Assessment of collective effects induced limitations in high-energy accelerator design (including collider)							
1) Assessment of collective effects induced limitations in muon cooling design							
2) Development of a self-consistent simulation tool for beam-matter interaction							
1) Assessment of fundamental limit of proton beam density							
Resources	1	2	3		1	2	3
Staff	2.8			Student		12	
Postdoc	2 (in Oct.)+3 (CERN fall 2021 com.)			Material			
Interested partners							
CERN, INFN, UK (STFC), US (BNL, SLAC, LBNL), EPFL, TUD/GSI, LAL Orsay, others?							

Resources are given in total number of FTE-years for the whole duration and in kEuro for material

Tasks and Resources

International MUON Collider Collaboration

	Task description	Resource estimate staff [FTEy]	postdoc [FTEy]	PhD [FTEy]	material [kEuro]
1	**RF design of the RCS chain** (new beam dynamics regime during acceleration)	0.8	2		
1	**Assessment of collective effects induced limitations on high-energy accelerator design** (impedance models; opposite sign bunches – beam crossing and wakes; longitudinal and transverse beam dynamics studies in the collider operating close to transition; mitigation measures; development of simulation tools)	0.5	0.75	3	
1	**Assessment of collective effects induced limitations in muon cooling design** (check of cooling studies with a second code; elaborate models that describe the electromagnetic wake fields generated by the beams passing through matter, as well as the dynamics of the charges generated by ionization including their generation, interaction with the beam and recombination; collective instabilities during ionization cooling)	0.5	0.75	3	
2	**Development of simulation tool for beam-matter interaction**	0.5	0.75	3	
1	**Assessment of fundamental limit of proton beam density** (detailed simulation studies to check that there are no major beam quality degradations and study in detail the halo formation and beam losses)	0.5	0.75	3	
		2.8	**5**	**12**	

Work Package Description

International MUON Collider Collaboration

Workpackage Description

For the BD-WG, the idea is to have some staff (Elias Métral, Xavier Buffat, Heiko Damerau and Ivan Karpov from CERN) with an RF fellow who will start in October to work on the RF design of the RCS chain (with Ivan as supervisor). We are currently looking for 4 university PHD supervisors (still to be determined) to coordinate the work of 4 PHD students (still to be determined) who will, each, work on one of the 4 other main topics mentioned before. To help in this work, a fellow will soon be hired and supervised by Elias (a candidate has been already identified for the CERN fall 2021 committee) who will first have a look, with the staff members, at the 4 topics to prepare the work of the PHD students:

1) Assessment of collective effects induced limitations on high-energy accelerator design: we will start by building realistic impedance models of the machines, which should be dominated by the RF cavities and the resistive-wall impedance. Longitudinal and transverse emittances need to be preserved to reach the required collider's luminosity and control the orbit. The issue is that we need to handle 2 high-charge muon bunches with opposite signs with a lot of RF (which means a strong longitudinal focusing and a high impedance) and we need to be fast. There will be 2 beam-beam collision points with wakes in the cavities, which will vary depending on where the cavities are in the ring (cavities must be distributed in several uniformly-spaced stations in the ring). This is a unique regime for collective dynamics, and the consequences for beam stability and operation need to be understood.

2) Assessment of collective effects induced limitations in muon cooling design: we will start by checking the cooling studies with a second code as cooling is the key ingredient for a muon collider, and therefore it has to be fully understood and optimized (in particular the final cooling). One should not rely on only 1 code (ICOOL, for which the most complete simulation studies were made) and use G4BL and/or G4MICE to check all the past results (e.g. ICOOL does not do hadronic interactions). Then, we will elaborate models that describe the electromagnetic wake fields generated by the beams passing through matter, as well as the dynamics of the charges generated by ionization including their generation, interaction with the beam and recombination. Finally, the possible collective instabilities which could appear during ionization cooling will be analysed in detail.

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3) Development of simulation tool for beam-matter interaction: The tool is a code to estimate beam instabilities in matter, if required after first analyses (see point 2)). It has to be self-consistent in the sense that it needs to correctly take into account the intensity-dependent effects.

4) Assessment of fundamental limit of proton beam density: It is very important to understand this limit because the more protons (and therefore the more muons we create), the easier it is afterwards. The issue is that we need a high (few MW) beam power, with a short (1-2 ns) bunch length and in particular a low (5 Hz) repetition rate. Detailed simulation studies should therefore be performed to check that there are no major beam quality degradations and study in detail the halo formation and beam losses.