Muon Collider Final Cooling

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NATIONAL LABORATORY

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FINAL COOLING

Goal: Muon collider luminosity $10^{34}\ cm^{-2}\ sec^{-1}$

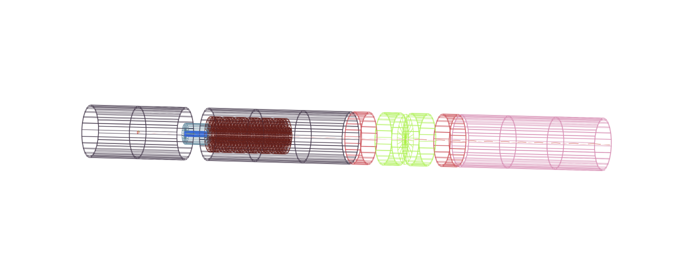
- $\epsilon_{trans.} = 25\ \mu m$
- $\epsilon_{long.} = 72\ mm$

Final Cooling scheme

- Final cooling starting point
  - $\epsilon_{trans.} = 400\ \mu m$ (new $\epsilon_{trans.} = 310\ \mu m$)
  - $\epsilon_{long.} = 1\ mm$ (new $\epsilon_{long.} = 1.5\ mm$)
- Cool in the transverse dimensions while the longitudinal emittance grows
- Concept: LH absorbers in High field regions B=30-50 T
- Full simulation and optimization study of the final cooling

Short cooling magnet + High frequency RF

- New G4BL Magnet Lattice
- New Codes & scripts : High performance optimization algorithms integration with G4BL on NERSC
- Integration of twiss calculations with G4BL & Optimization codes
- First Stage looks promising
- Working on the field flip match



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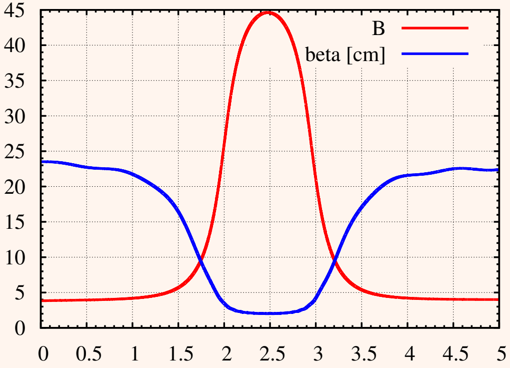
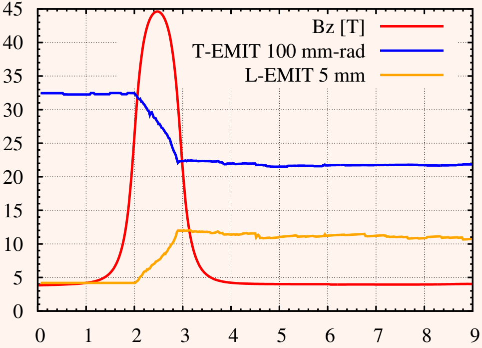
Short cooling magnet + High frequency RF

New magnet - almost flat top - enough decay length



Short cooling magnet + High frequency RF



- Optimized G4BL coils for transport and 40 T peak
- Stage structure: high field - small bore solenoid around LH absorber - Magnet shorter by factor of 3
- First stage with 160 MHz (16 MV/m) accelerating RF
- Secondary RF interleaved for nonlinear correction 325 MHz 5 MV/m

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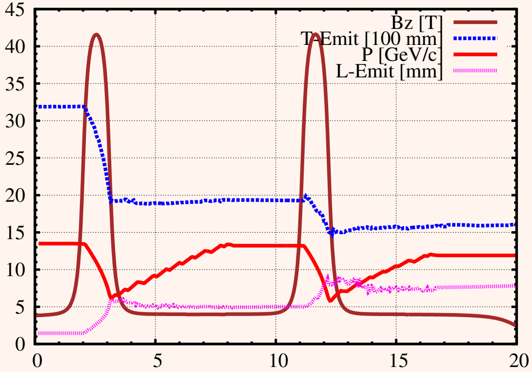
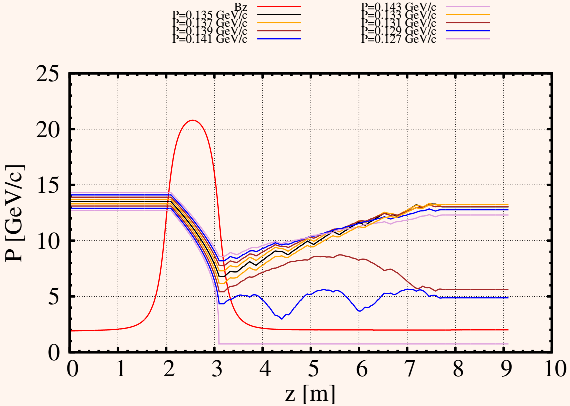
Short cooling magnet + High frequency RF



- Optimized G4BL coils for transport and 40 T peak - 2 Stages
- Stage structure: high field - small bore solenoid around LH absorber - Magnet shorter by factor of 3
- First stage with 160 MHz (16 MV/m) accelerating RF
- Secondary RF interleaved for nonlinear correction 325 MHz
- Third RF for phase rotation 325 MHz 5 MV/m

Calculation of twiss function inside absorber+RF



- In order to match for the field flip one needs to be able to calculate twiss functions correctly inside absorber + RF
- Integrated a C++ code with G4BL to calculate twiss functions within absorber + RF
- Nest step is to match the traced lines longitudinally and transvresely

First Pass of cooling 17 stages - Transverse emittance reduction by factor of 6

- 17 Stages - each with 40-42 T solenoid (no field flip - will be added soon)
- LH absorbers 60 cm - 1 cm
- RF 162 MHz-15 MHz
- Transverse dynamics is stable in and out of the 40 T solenoids
- Energy phase rotation during acceleration introduced particle losses
- Energy phase rotation is not included (working on adding two sections for rotation) Rotation is artificially introduced in the following results
- Longitudinal emittance is not optimized on the last 5 stages (limited cooling)
- Working on replacing the RF cavities with induction linac (may provide better control over the momentum spread and hence cooling)

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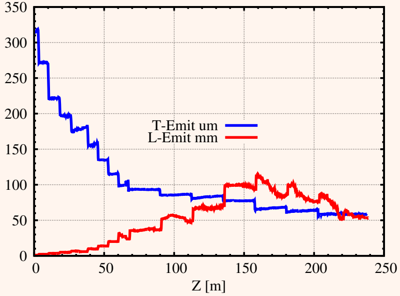

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