LyRICS - Li Rod Ionization Cooling Simulation

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0. Introduction

Why We need muon collider?

- The LEP the largest e^+e^- collider ever constructed, has been the practical limit for cyclic electron-positron colliders because of SR.
- The LHC is currently the energy frontier facility[a], but proton, as any hadron, is not a fundamental pointlike particle, but a conglomerate of fundamental particles of quark-gluon nature.

[a] It will provide high luminosity proton-proton collisions with a maximum center-of-mass energy of up to 14 TeV.

Further Posibilities:

- Muon Collider
- Linear e^+e^- Collider

MC vs. ILC

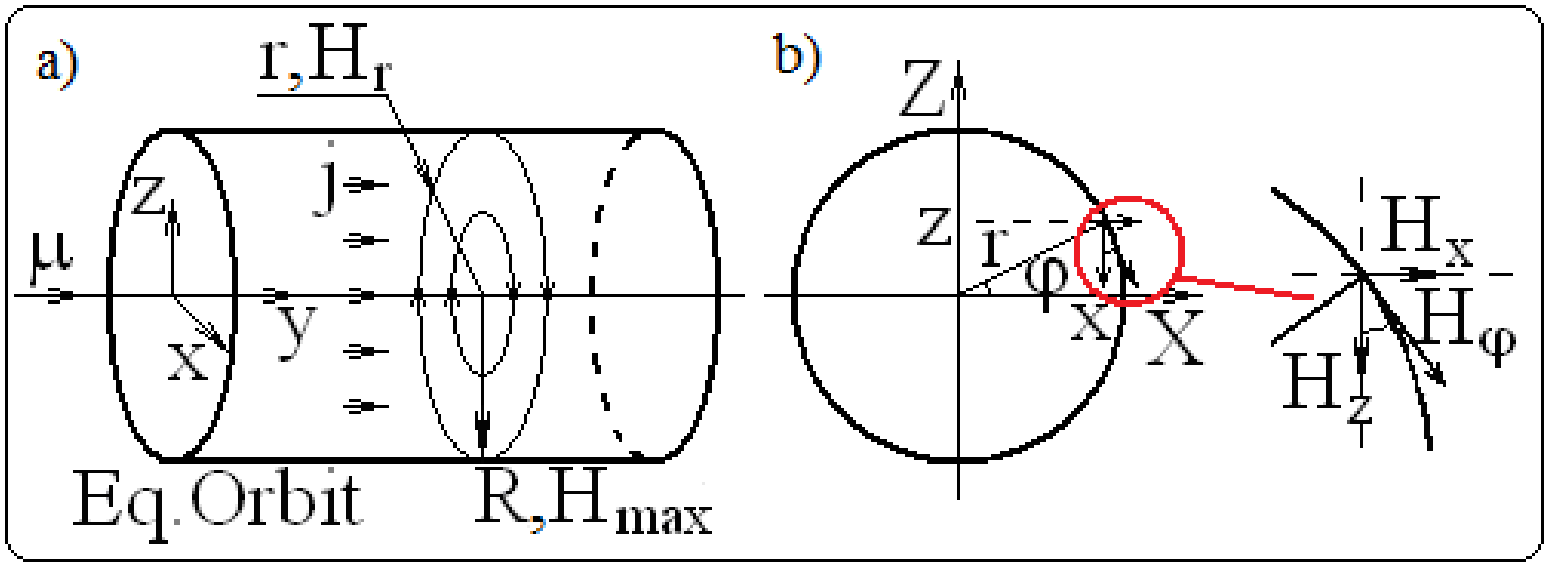
Technical advantages

- MC needs less area than ILC.
- MC can be used as a neutrino factory.
- Up to 1000 bunch collisions prior to the muon decay.

Physics advantages

- High-density electron (positron) bunches produce very high focusing radial electric and azimuthal magnetic fields, so primary particles emit too many photons and at center-of-mass energies of 1 TeV the eective energy spread reaches several tens percent.
- It is very important to study identity of $\mu^+\mu^-$ interaction to e^+e^- one from fundamental point of view.

Ionization Cooling with Lithium Rod Usage



It is easy to show, that:

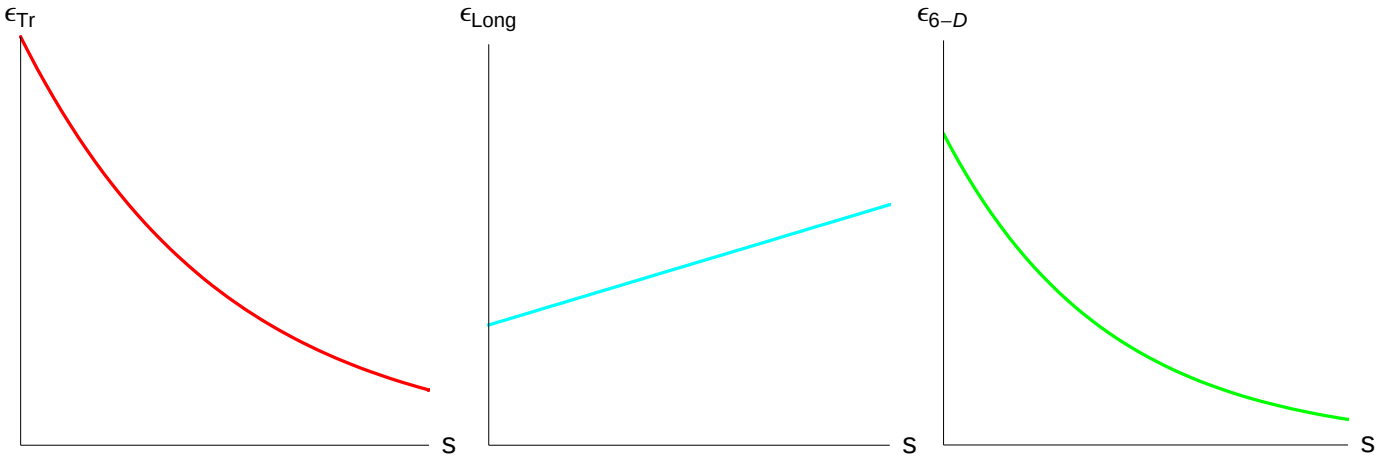
The equilibrium angular spread of a particle moving through matter does not depend on the properties of the focusing (i.e. does not depend on the β-function value):

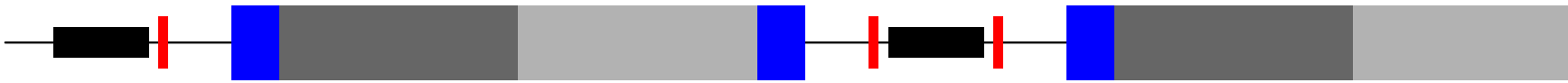
$$\min(\varepsilon_{tr}) \rightarrow \min(\theta^2_{x,y}\beta_{x,y}) \rightarrow \theta^2_{x,y}\min(\beta_{x,y}) \rightarrow \max \textit{focusing}$$

1. Final Cooling

It is very essential to use LiRods for very final part of cooling

This is only 4-D Cooling, but full 6-D emittance reduction observed.

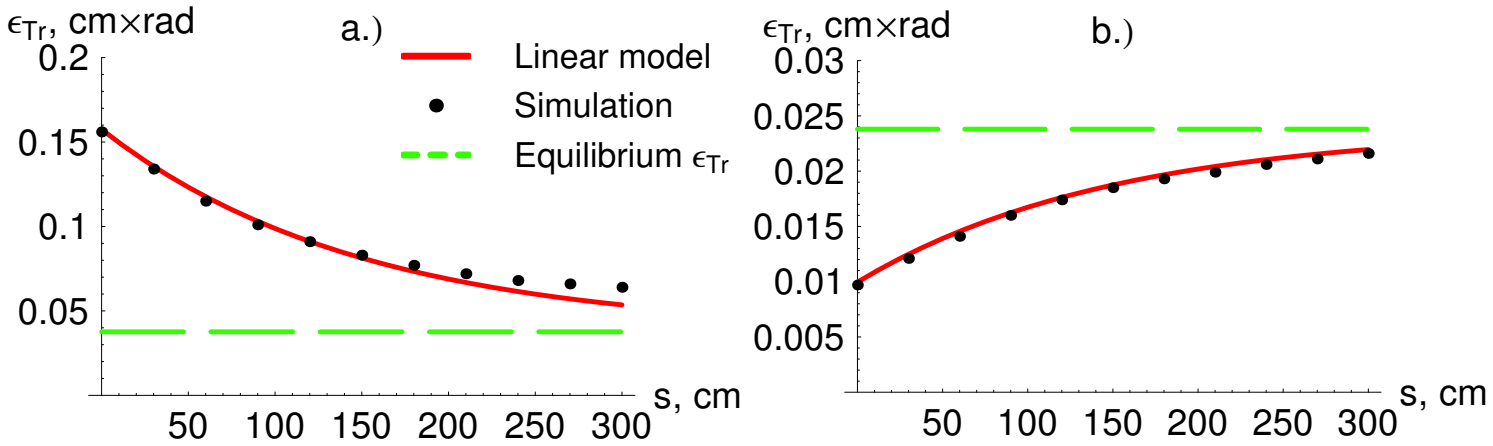




1.1 Transversal Motion

Transversal motion determined by two processes concurrence:

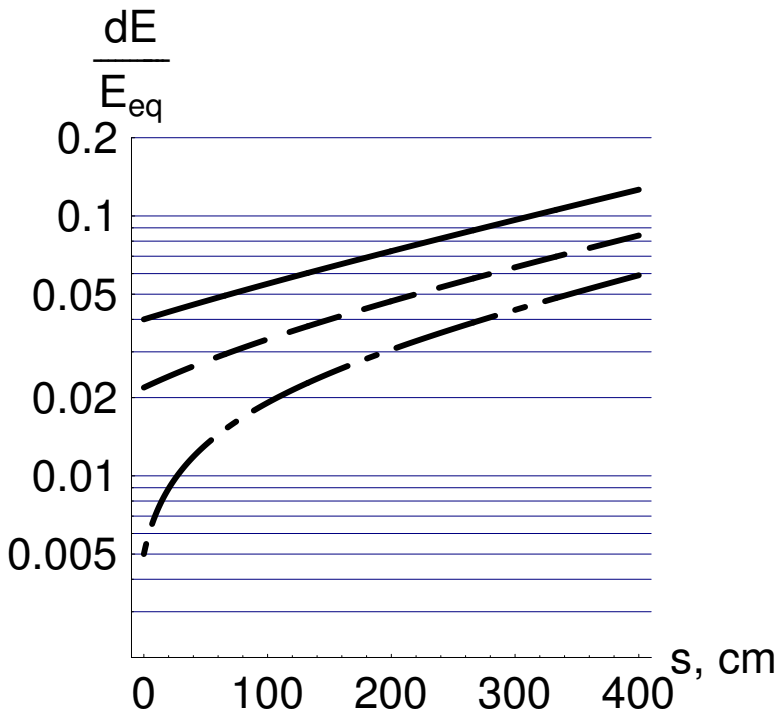
- "Diffusion" - Coulomb scattering
- "Damping" - due to Ionization Friction Force

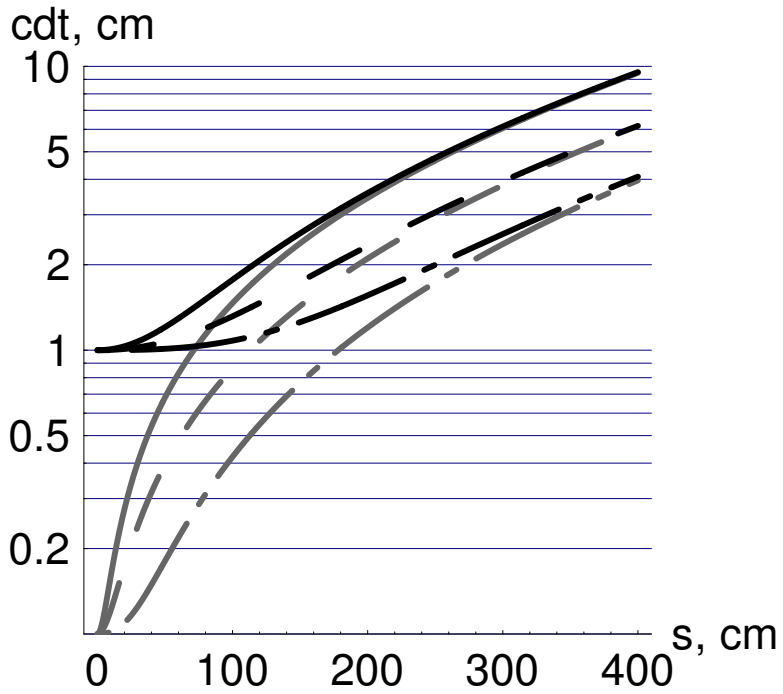


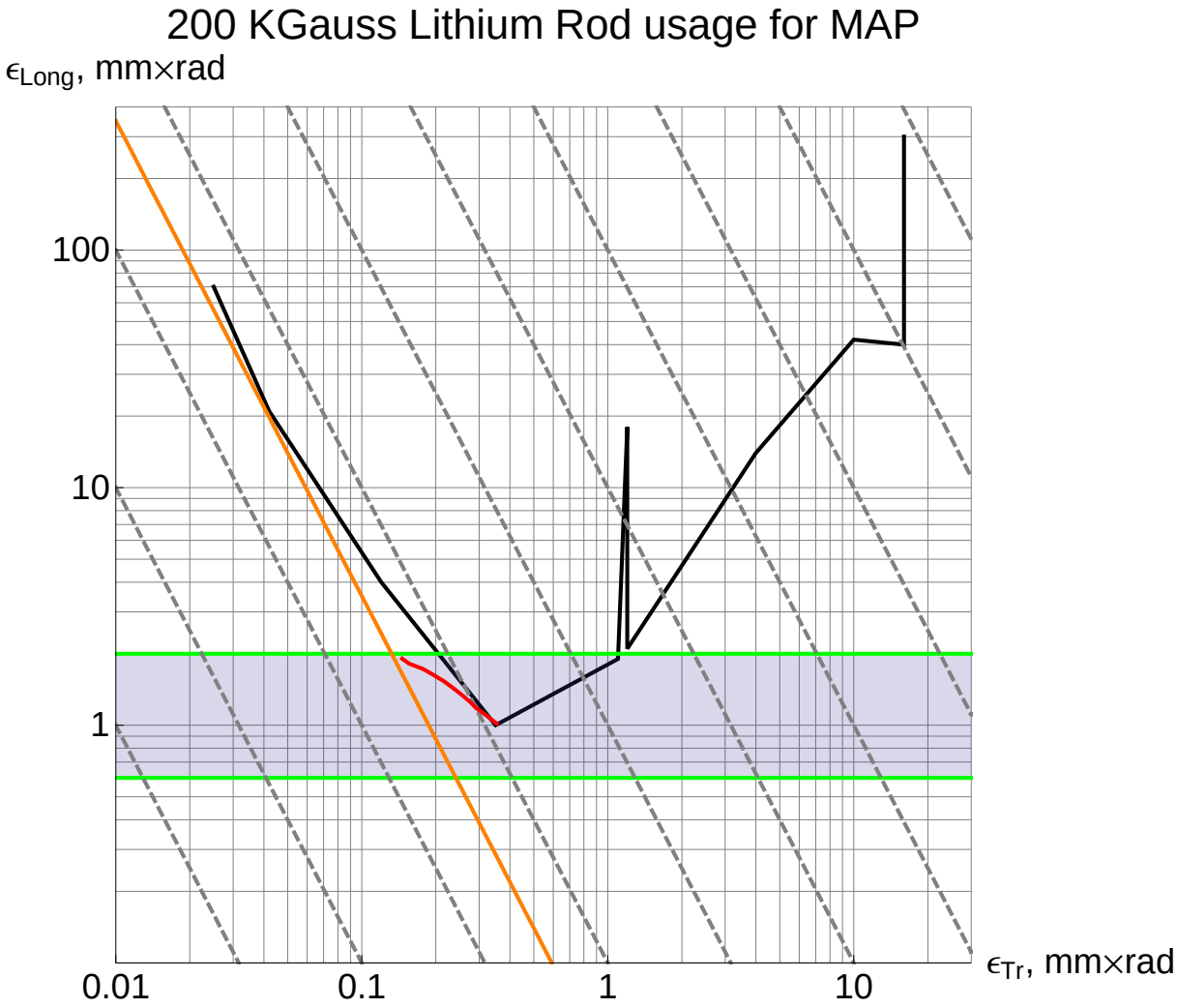
1.2 Longitudinal Motion

Longitudinal heating determined by two processes concurrence:

- "Diffusion" - Ionization Losses Fluctuation
- "Anti-Damping" - negative derivative of Ionization Friction Force







- 200 KGauss: $\epsilon_{Full} = 3 \times 10^{-5}$
- 150 KGauss: $\epsilon_{Full} = 5 \times 10^{-5}$
- 100 KGauss: $\epsilon_{Full} = 10 \times 10^{-5}$

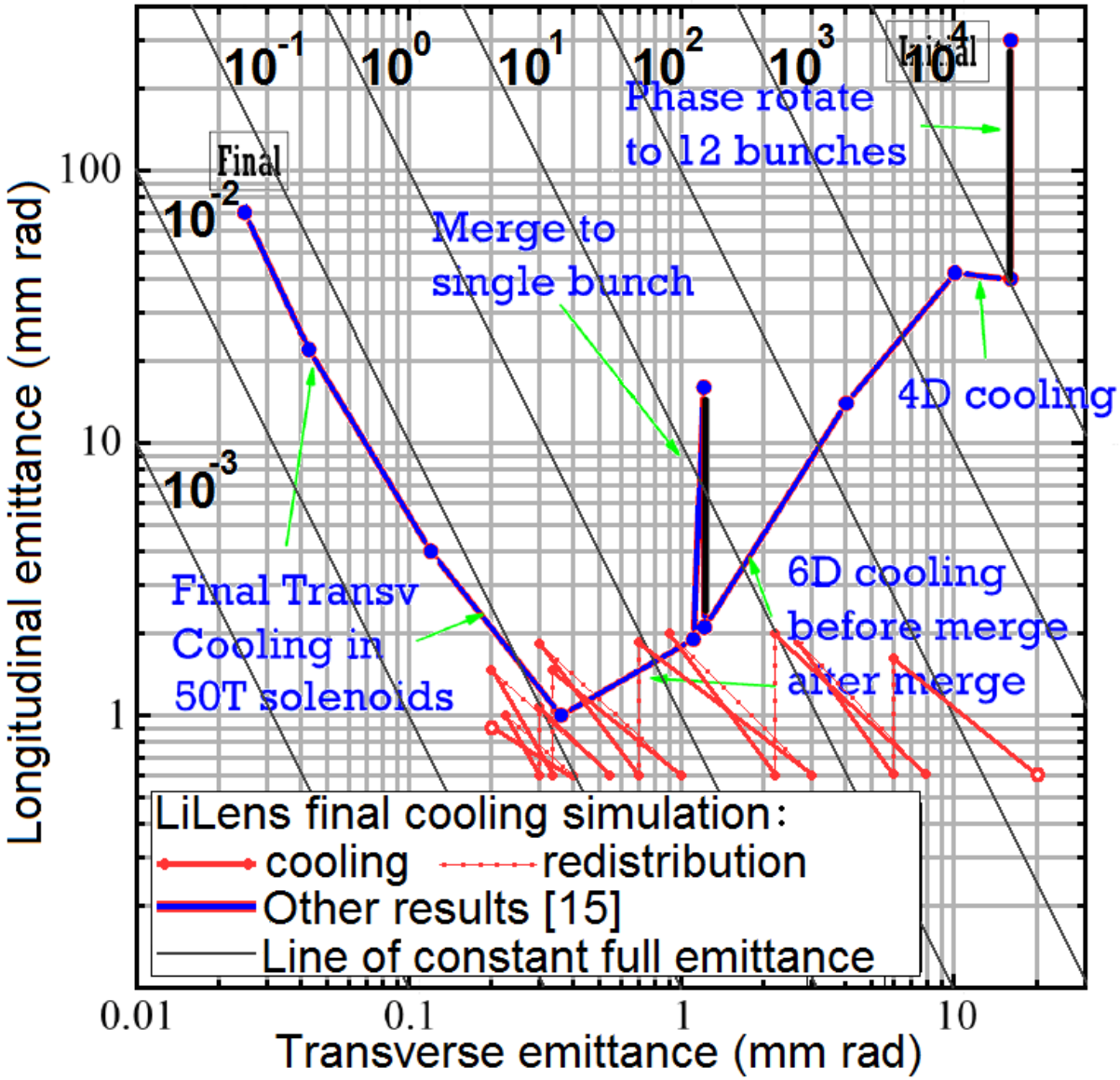
2. How we can obtain 6-D Cooling or enlrge 4-D Cooling

There is 3 possibility:

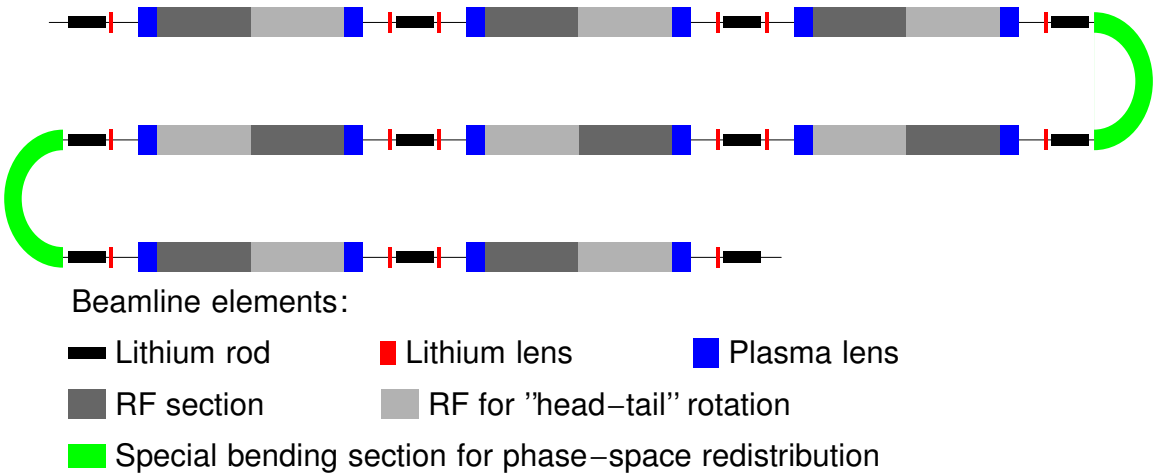
- Decrement redistribution
- Emittance redistribution
- Emittance exchange

2.1 LiRod with decrement redistibution?

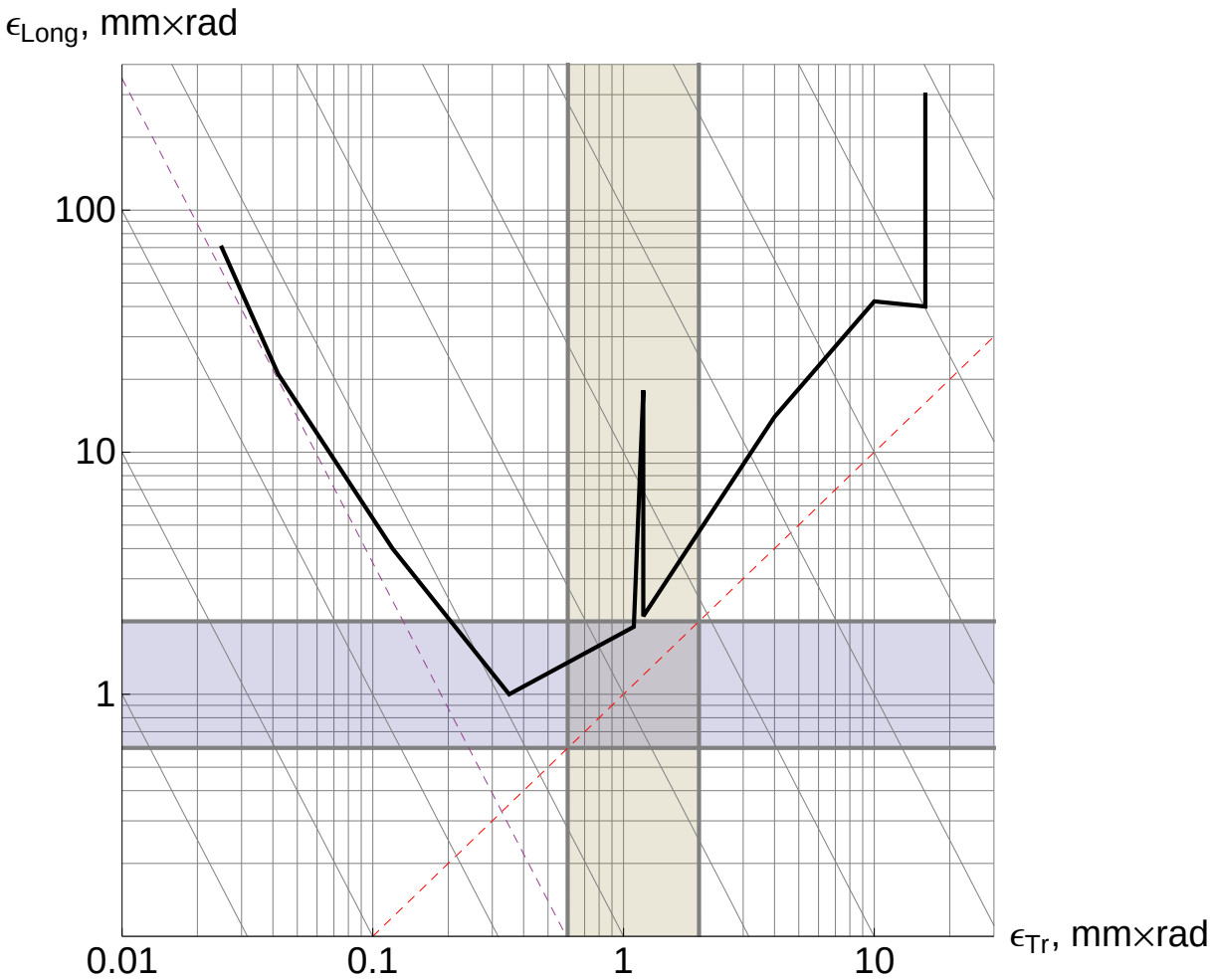
2.2 LiRod with emittance redistibution?



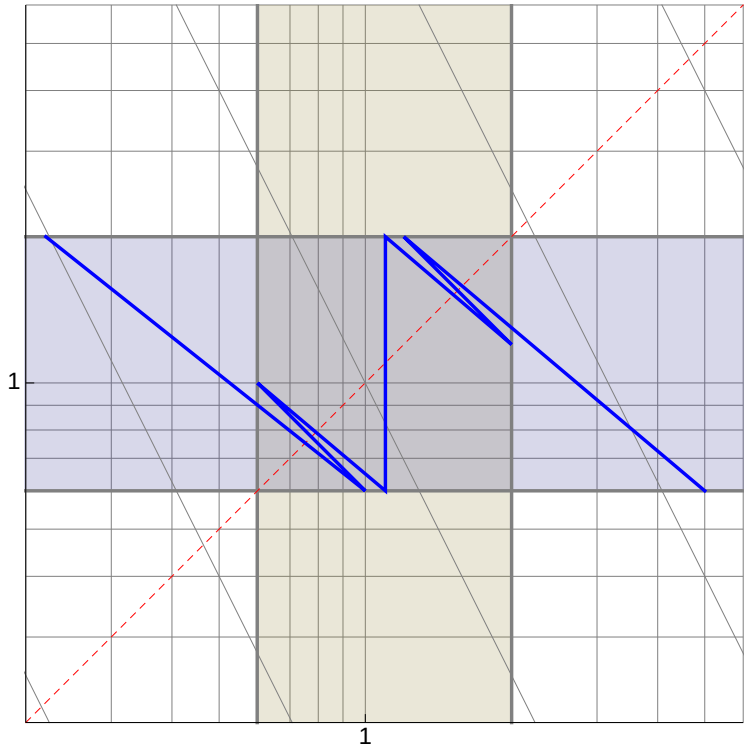
2.2 LiRod with emittance redistibution?

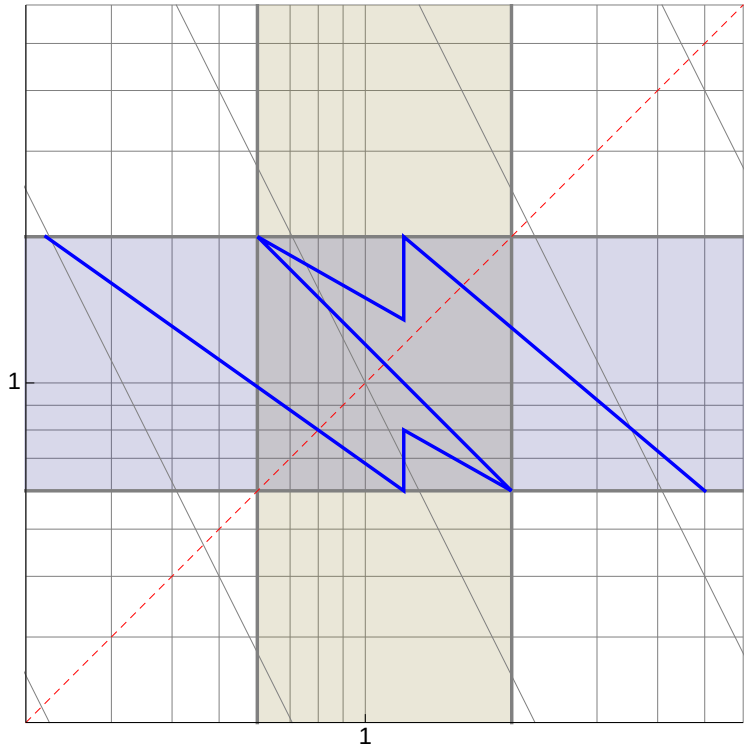


2.3 LiRod with emittance exchange?

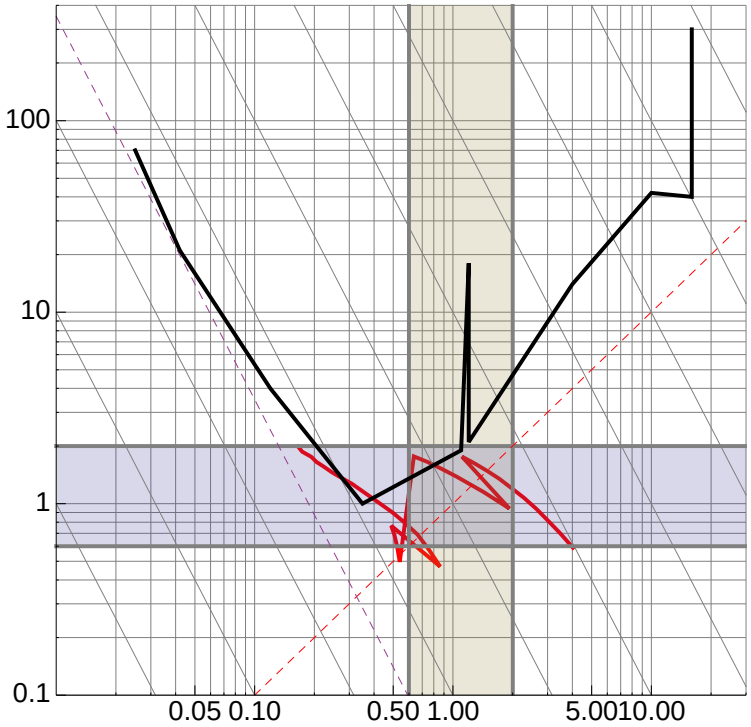


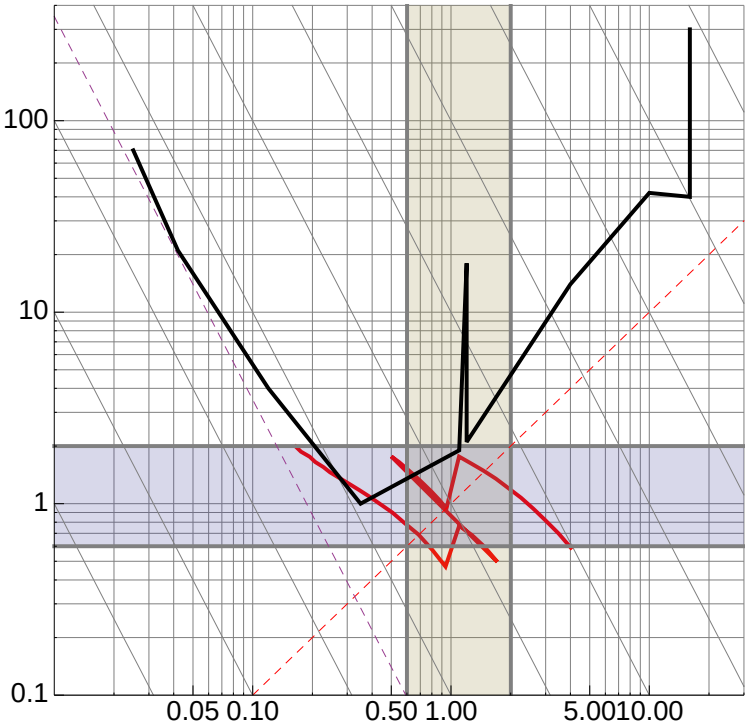
Idea of emittance exchange usage for LiRod cooling scheme





Simulation of emittance exchange usage for LiRod cooling scheme





Simulation of emittance exchange usage for LiRod cooling scheme