BROOKHAVEN NATIONAL LABORATORY

A more realistic scheme for the front-end of a muon accelerator

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Motivation

- Adopted from the 5-year proposal[1] :

Decay, bunching, and phase rotation. The first section of the front end captures the pions produced at the target, allows them to decay into muons, bunches the muon beam and reduces its energy spread. Two new alternatives need to be compared with Study 2a—the Neuffer 12-bunch scheme and the LEMC approach using high-pressure hydrogen-gas-filled rf cavities. The former scheme is suitable for either a NF or a MC. However, to assess its performance and cost it must be studied under more realistic assumptions that correspond to a practical implementation. There are several steps needed for this:

- replace continuous magnetic fields with an actual coil geometry
- use "families" of rf cavity frequencies rather than continuously decreasing frequencies where each cavity is different
- include absorbers and rf windows in the simulation
- examine an alternative magnetic lattice having partially bucked fields to reduce the field on the rf cavities
- check the sensitivity to errors of the final configuration

○ Completed (presented in this work)

◌ In Progress…

[1]NFMCC-MCTF proposal: http://www.cap.bnl.gov/mumu

Outline

- Review the existing “continuous” front-end lattice
- Modify it toward a “more realistic” configuration:
  - Actual coil geometry
  - Family of rf-frequencies
  - Add Be-windows on buncher/rotator/cooler
- Optimize and examine lattice performance
- Discuss future steps and derive conclusion

Simulation Tools

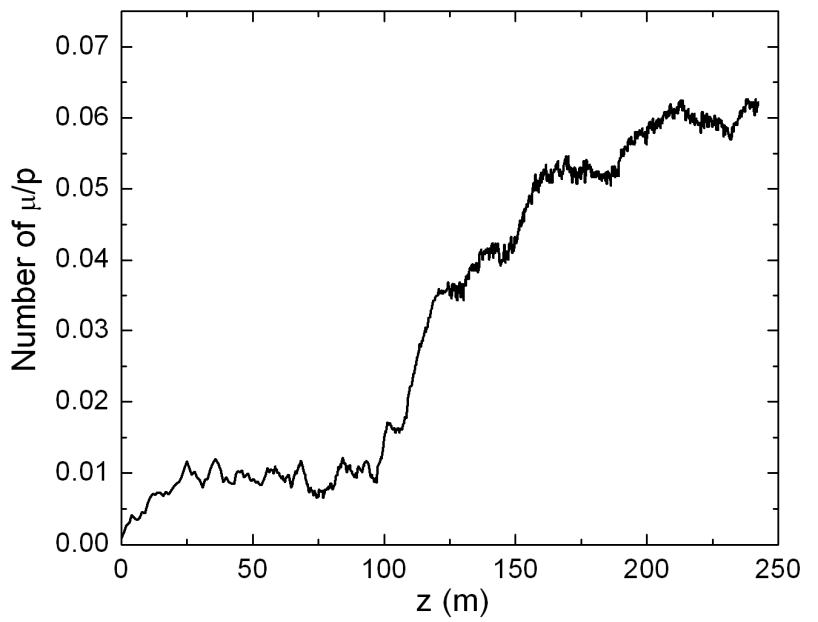
- I use ICOOL version 3.23
- Front-end deck kindly provided by D. Neuffer and J. C. Gallardo
- Simulate 10,000 particles
- I use the input distribution for 8 GeV protons obtained from MARS runs[1]

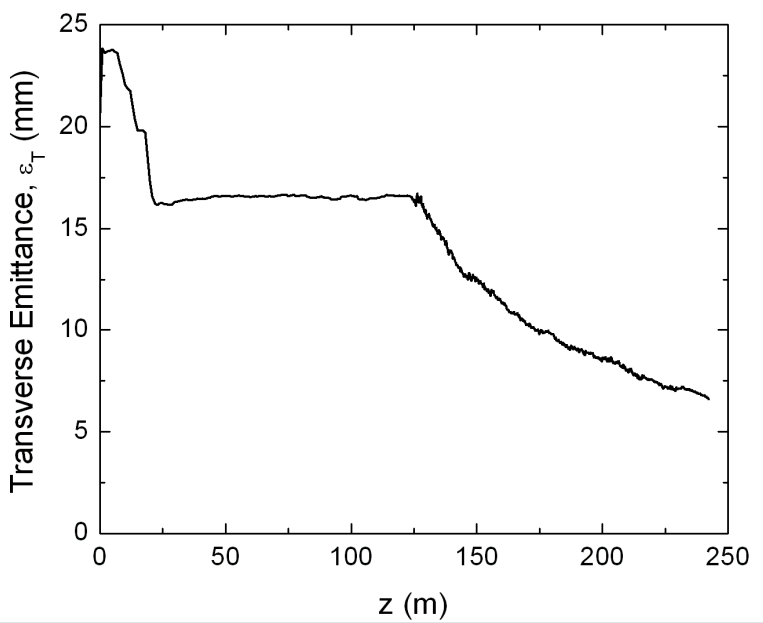
[1] H. G. Kirk and X. Ding

Parameters of "Continuous Lattice

- Target to buncher length is 56.4 m
  - B drop from ~20 T to 1.227 T
- Buncher length is 31.5 m
  - Continuous frequency drop: 366.9 MHz to 238.02 MHz
  - Uniform B=1.227 T, Gradient: 0-10 MV/m
- Phase Rotator length is 36.5 m
  - Continuous freq. drop: 238 MHz to 202 MHz
  - Uniform B=1.227 T, Gradient: 9 MV/m
- Cooler length is 118.5 m
  - Pillbox RF=12 MV/m, with LiH absorber, no windows

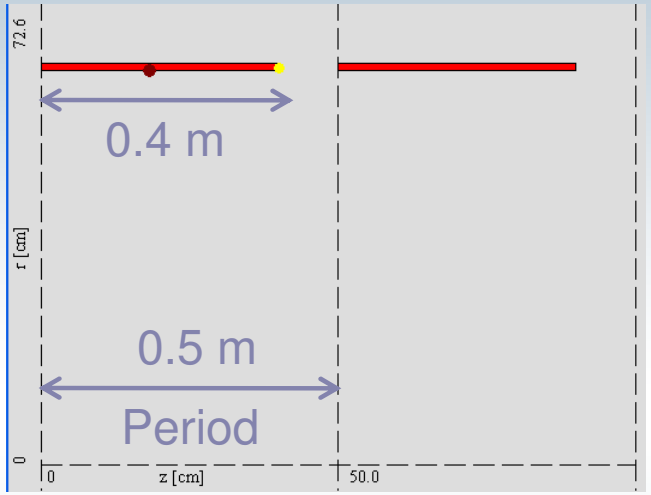
Continuous Lattice Performance

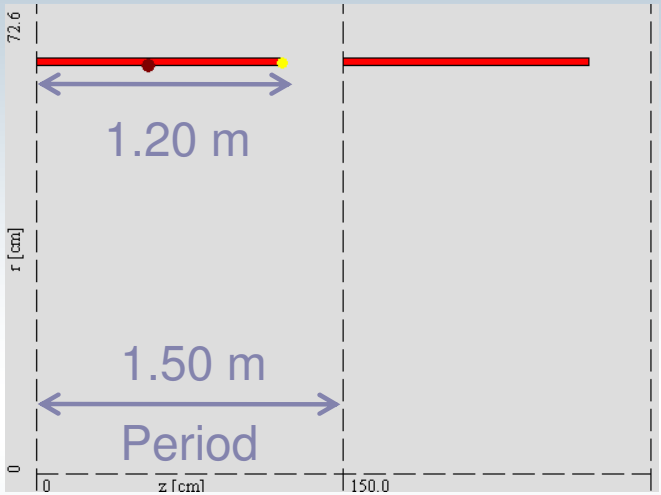


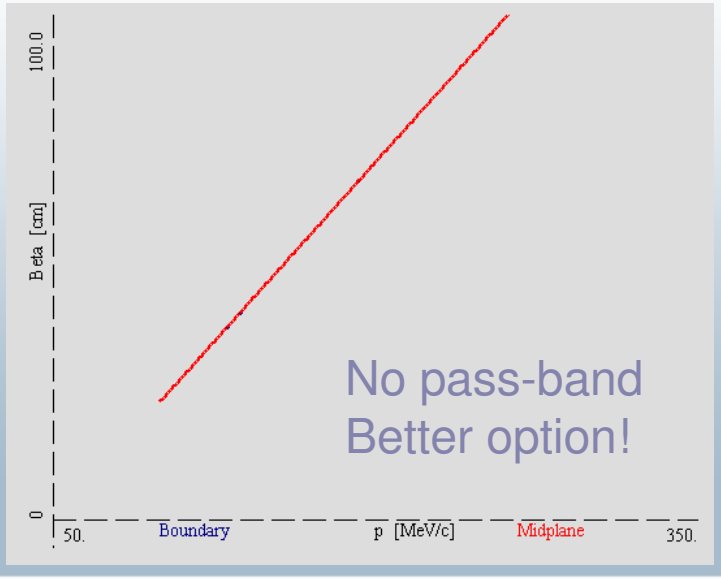


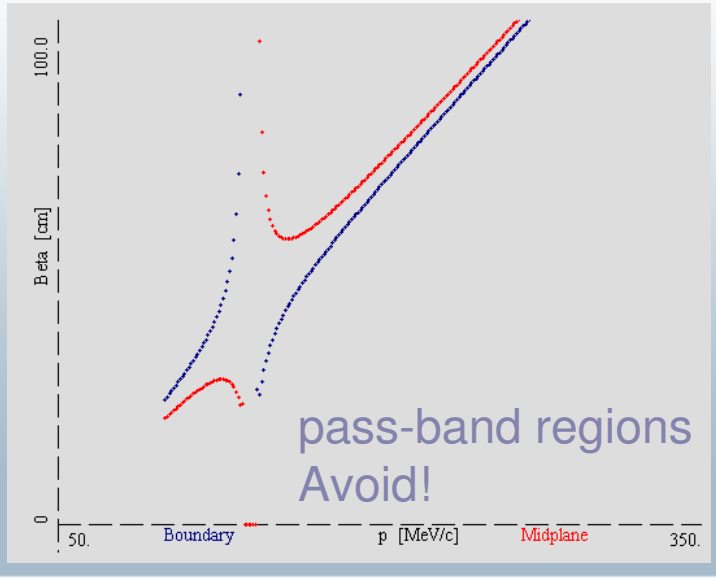
- The μ/p rate within acceptance $A_T < 30$ mm, $A_L < 150$ mm and cut in momentum $100 < Pz < 300$ MeV/c is ~0.06
- Transverse emittance drops to ~ 6 mm

Coil Discretization









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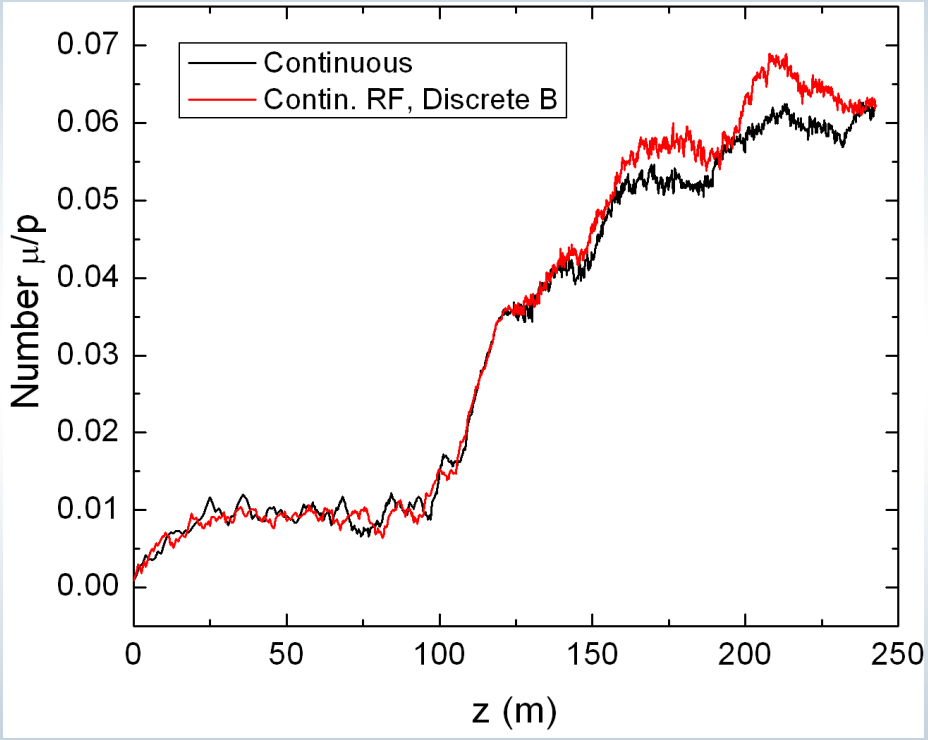
Discrete vs. Continuous Coils



- Including the actual coil geometry is not affecting the μ/p (i.e. ~0.06 as before).

Discretization of rf Frequencies

- Test 4 scenarios: keep total rf cavities same (90) but pair a # of cavities into single frequency groups:
  - 1 RF-pair:

    Buncher/ Rotator: 42/ 48 Freq.
  - 2 RF-pair

    Buncher/ Rotator: 21/ 24 Freq.
  - 3 RF-pair

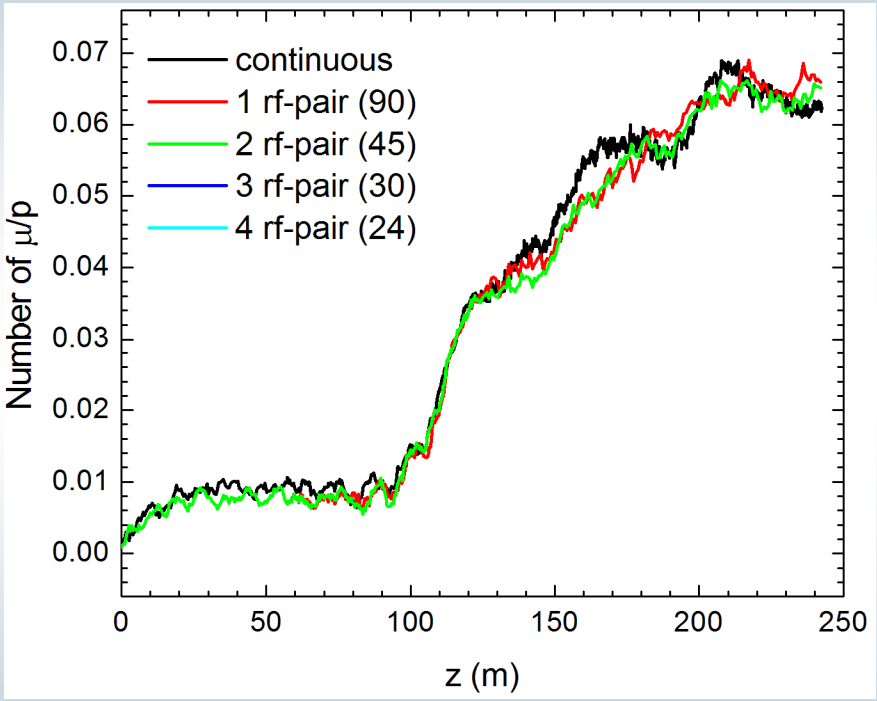
    Buncher/ Rotator: 14/ 16 Freq.
  - 4 RF-pair

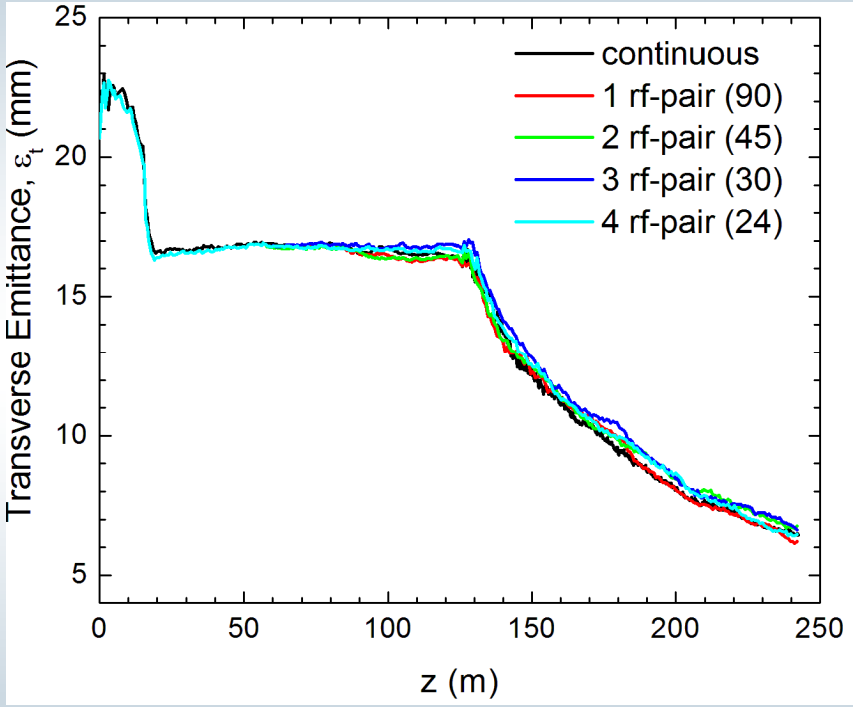
    Buncher/ Rotator: 12/ 12 Freq.

Example: 3 rf-pair

- Buncher Freq. (MHz)=14
  - 357.4, 344.2, 331.8, 320.3, 309.6, 299.6, 290.2, 281.4, 273.1, 265.3, 257.9, 250.9, 244.3 , 238.0
- Rotator Freq.(MHz)=16
  - 234.1, 229.0, 224.5, 220.6, 217.2, 214.3, 211.7, 209.5, 207.6, 206.1, 204.8, 203.7, 202.9, 202.4, 202.1, 202.06,
- Cooler Frequencies (MHz)
  - 201.25

Discrete rf: Results





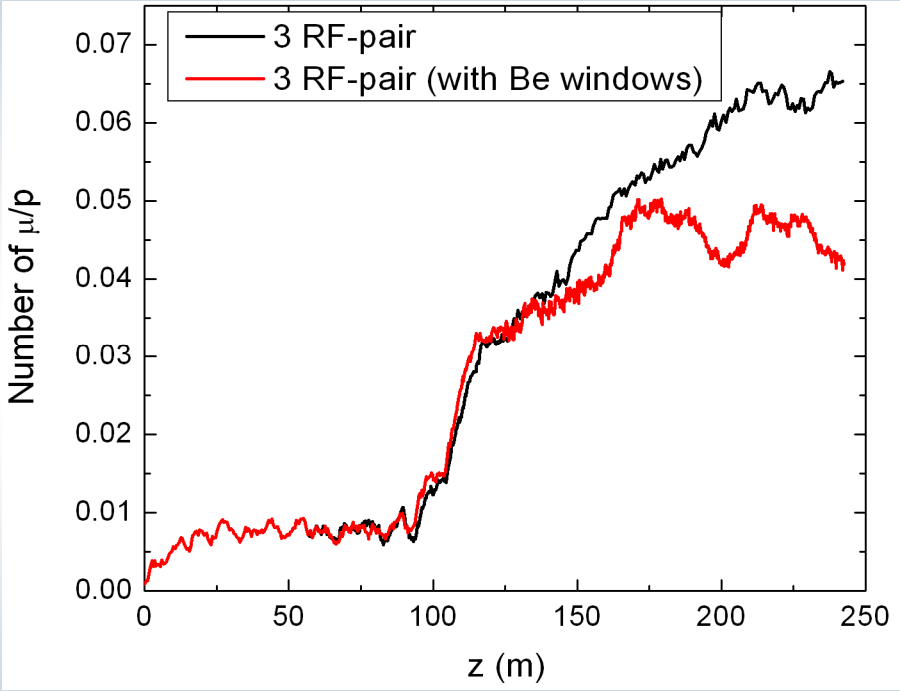
- rf discretization is not reducing the μ/p
- The 3 rf or 4-rf pair looks promising

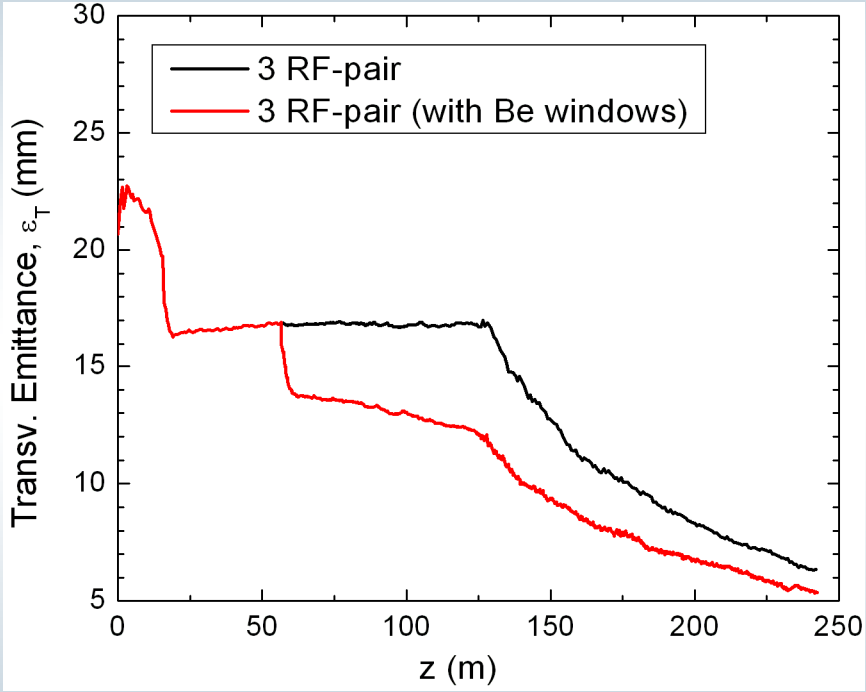
Addition of Windows

- I will assume that I have a 3rf-pair lattice
- I adopt the window parameters from study-2a[1]:
  - In buncher, cavity iris is covered with a 200 μm Be window
  - In rotator, graded 750-1500 μm Be window
  - In cooler, the window consists of a 8 mm LiH absorber covered by a 25 μm Be coating
  - Later, I will vary the absorber thickness

[1]MUC-NOTE-COOL-THEORY-296 (2004)

Addition of Windows

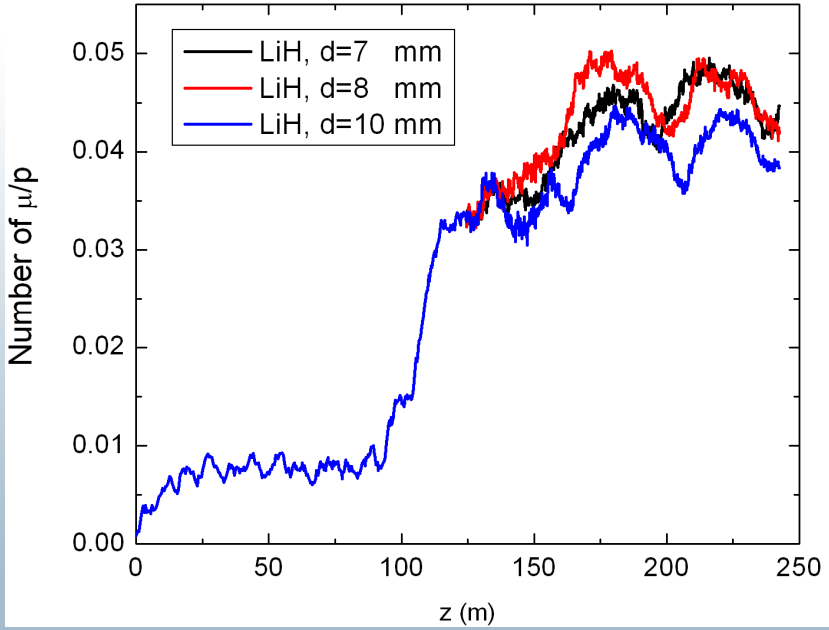




- By inserting windows the μ/p drops by an additional 15%

Lattice Performance vs. Absorber Width

- Vary the absorber thickness in cooler
- A layer of 7-8 mm LiH looks appropriate



Summary

- This study provided a more realistic scheme for the front of the MC and NF.
- Including the actual coil geometry and a family of rf frequencies is not affecting the μ/p (~about 25-30 frequencies)
- Adding Be-windows reduces the number by ~ 10-15%
- Alter cavity shape (magnetic insulation) or cavity properties (pressure)