# A more realistic scheme for the front-end of the NF and MC

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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 (Neuffer)
- Modify this lattice toward a “more realistic” configuration:
  - Include discrete magnetic field
  - Include discrete rf cavity frequency
  - Add Be-windows on buncher/rotator/cooler
- Optimize and examine lattice performance
- Discuss future steps and derive conclusion

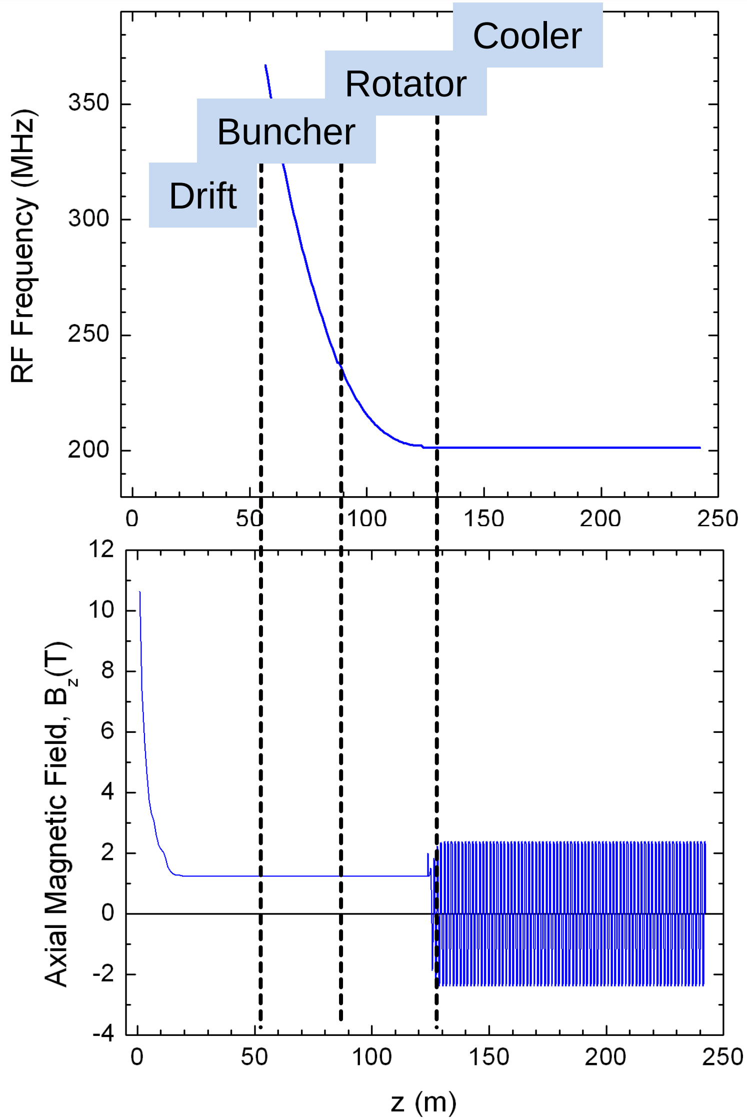
# Simulation Details

- 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]

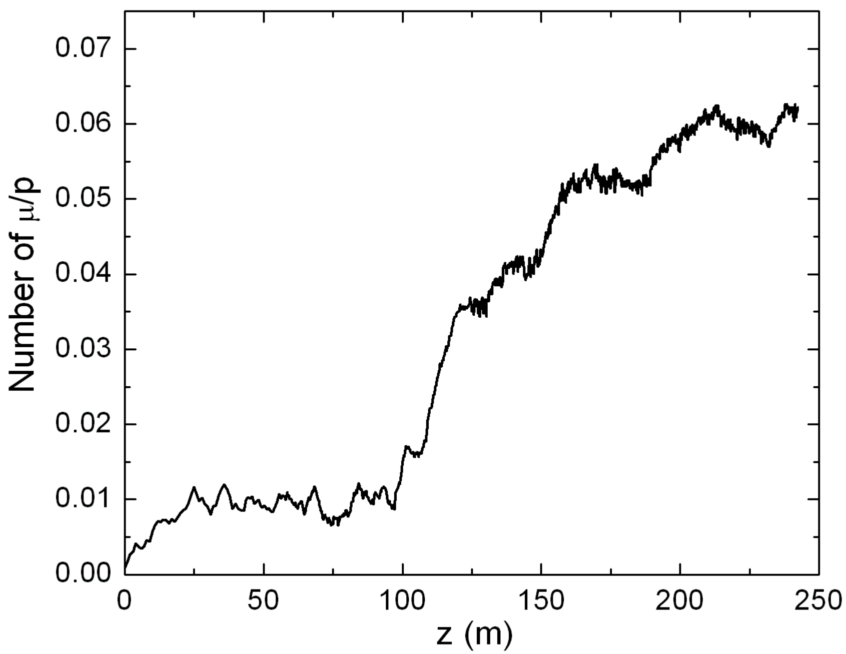
[1] H. G. Kirk and X. Ding

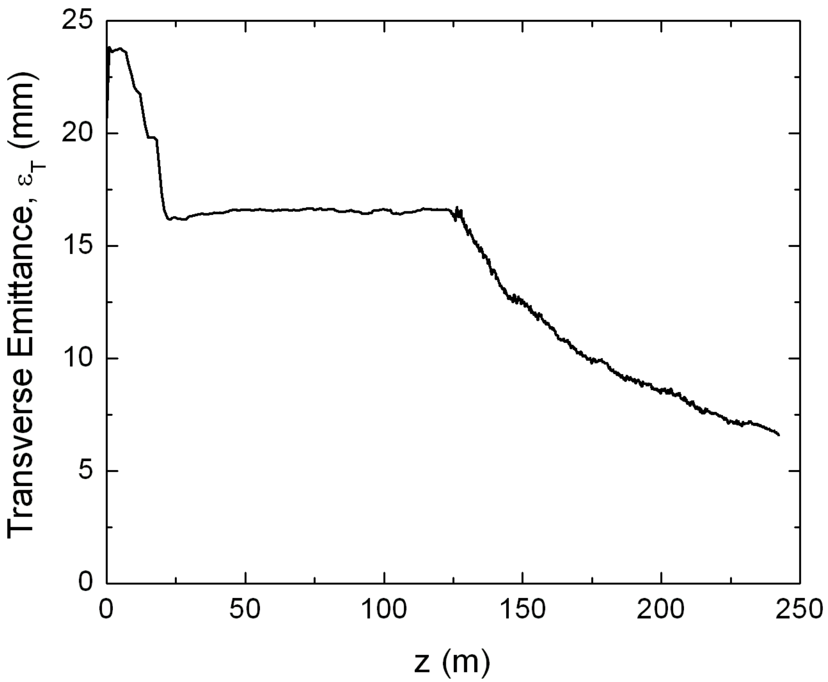
# Parameters of "Continuous" Lattice (D. Neuffer)

- Drift from target to buncher is 56.4 m
  - B drop from ~20 T to 1.227 T
- Buncher length is 31.5 m
  - Continuous freq. 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
  - Actual coil geometry



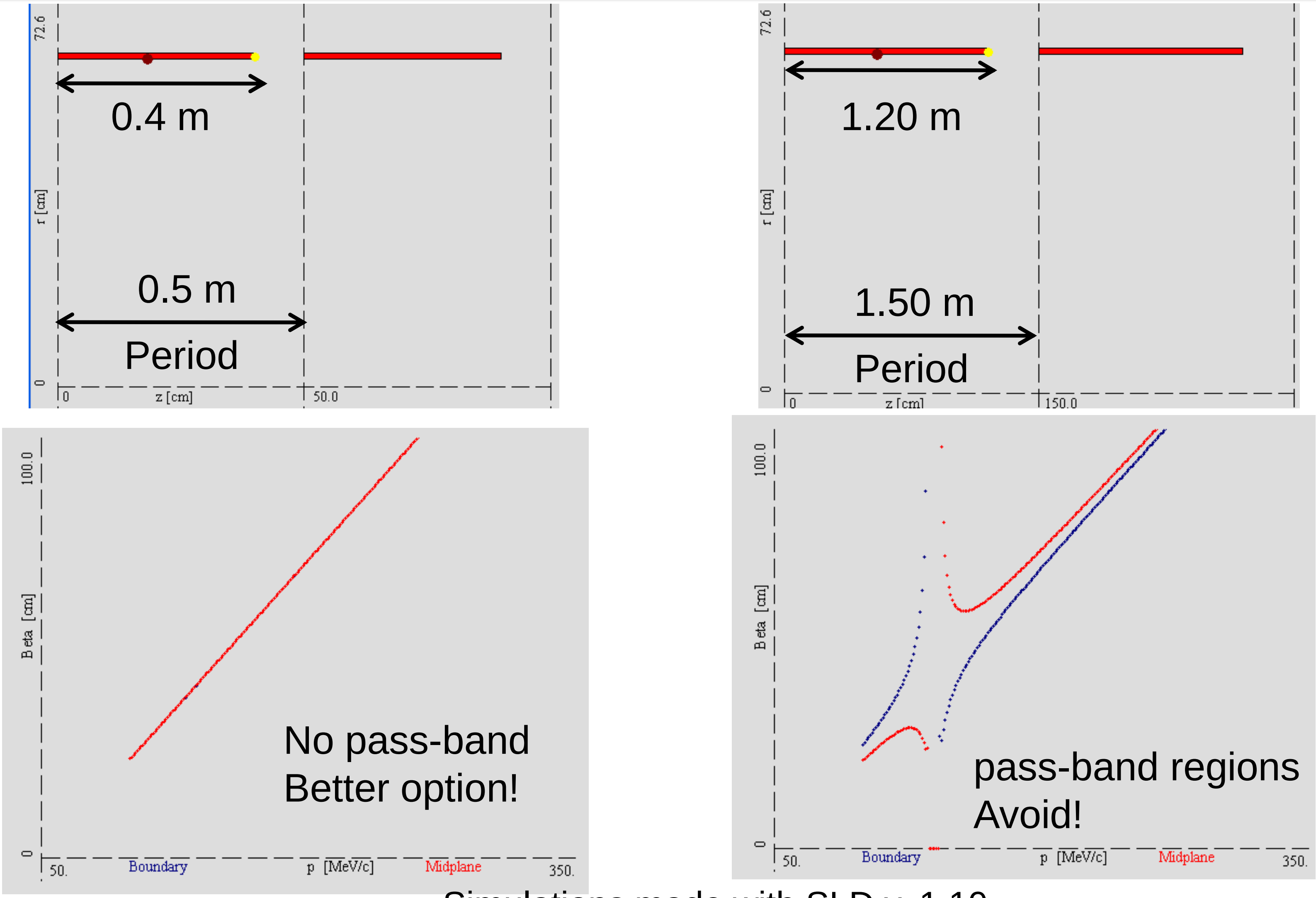
# Performance of Continuous Lattice



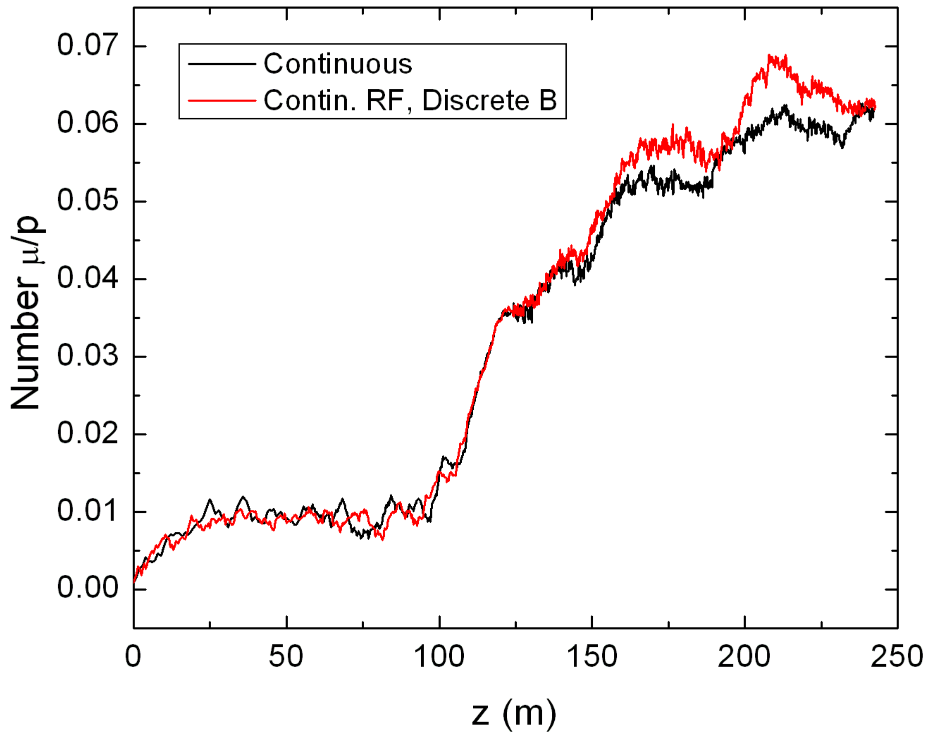

- The muon per proton rate within acceptance $A_T < 30$ mm and $A_L < 150$ mm and cut in momentum $100 < Pz < 300$ MeV/c is ~0.06
- Transverse emittance "cools" to ~ 6 mm

# Replacement of Continuous Mag. Field




Simulations made with SLD v. 1.10

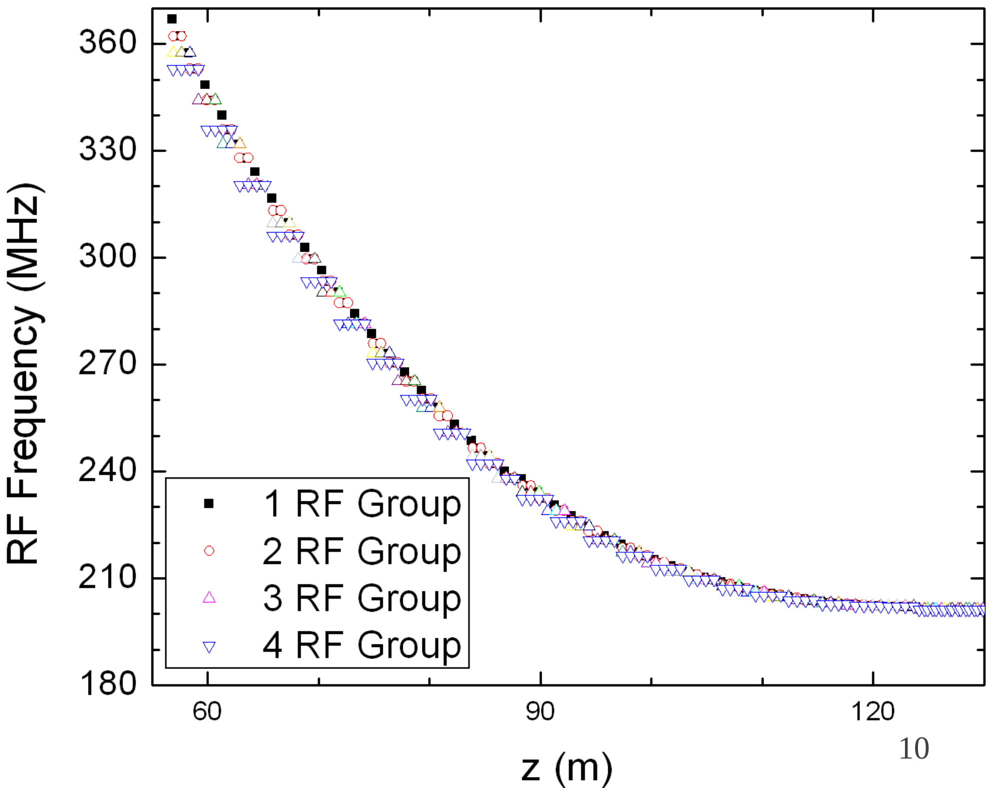
# Continuous vs. Discrete Mag. Field



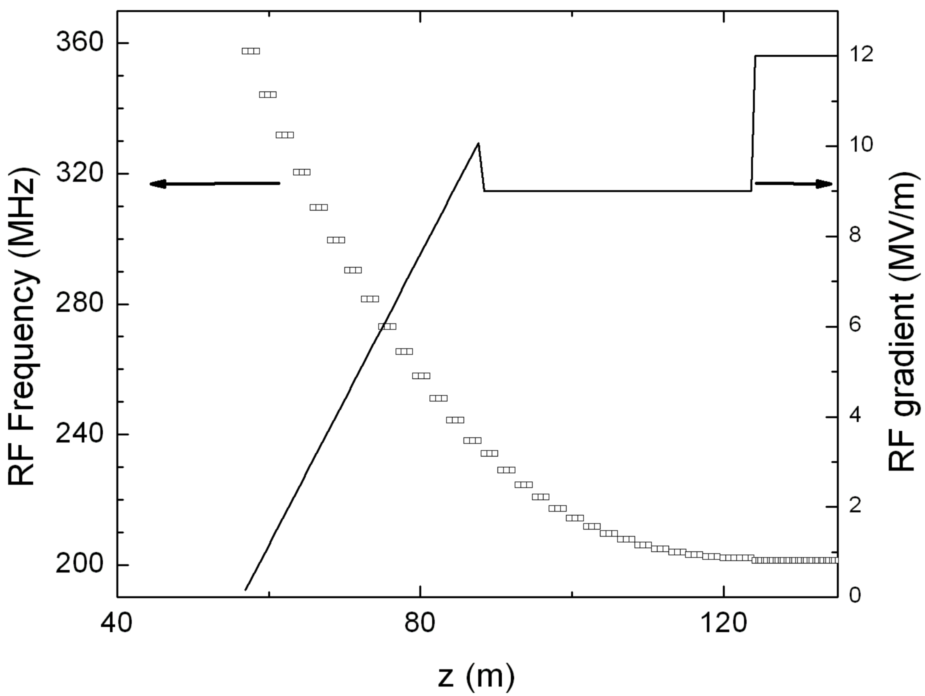

- Conclusion: Likely, discretization of the magnetic field is not affecting the muon production (i.e. ~0.06 as before).

# Continuous Frequency Replacement

- 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.

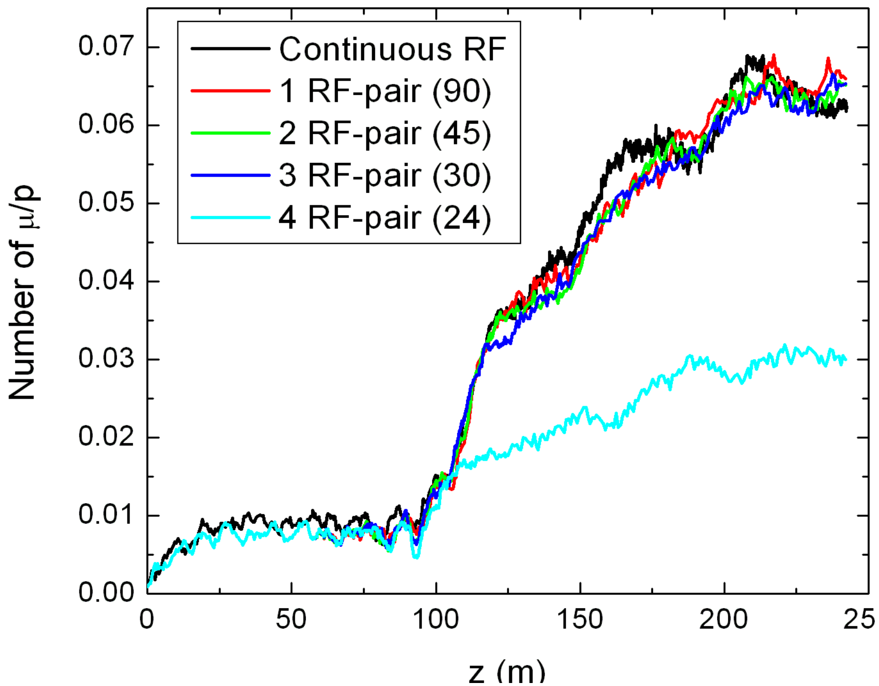


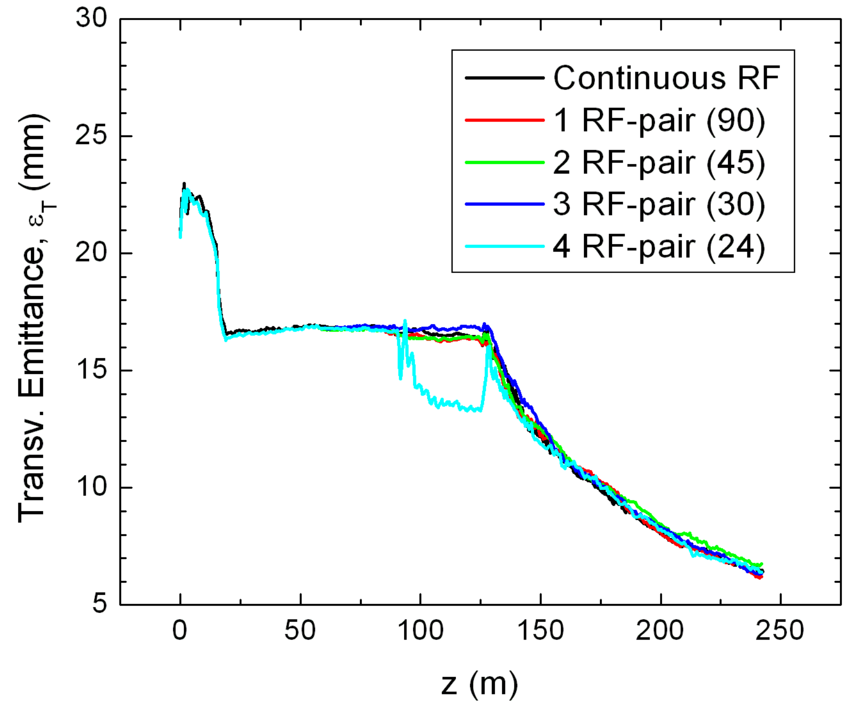
# Example: 3 RF-Pair




- 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



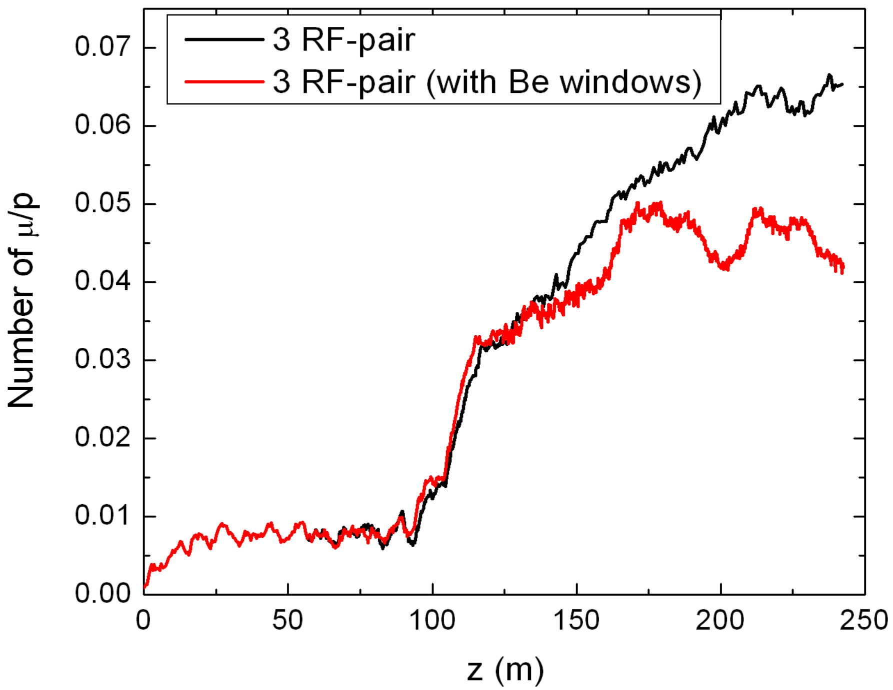

- Conclusion: Again, likely RF discretization is not reducing the μ/p
- The 3 RF-pair seems a good candidate (only 30 rf freq.)

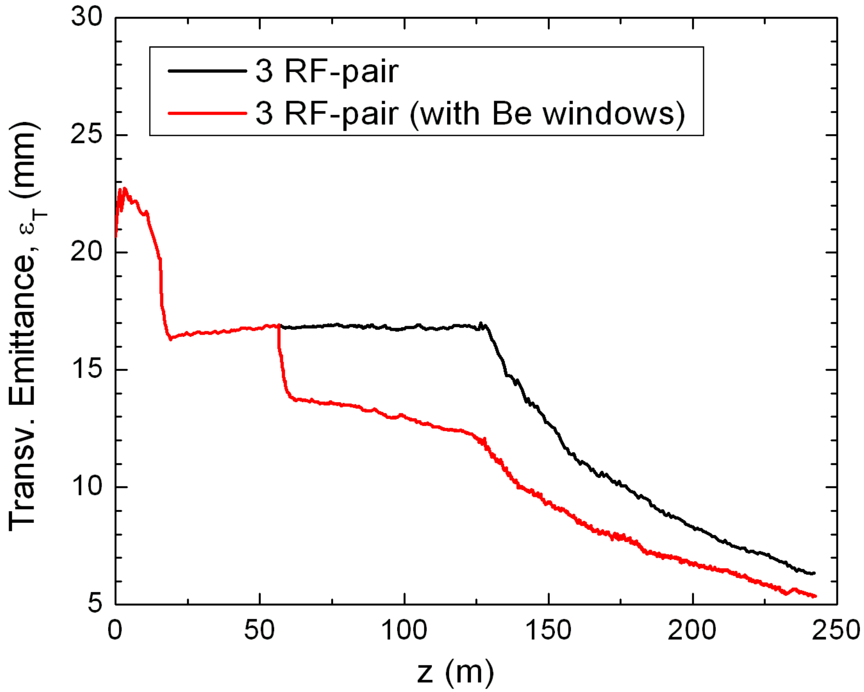
# Lattice sensitivity to rf windows (1)

- I will assume that I have a discrete 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)

# Lattice sensitivity to rf windows (2)

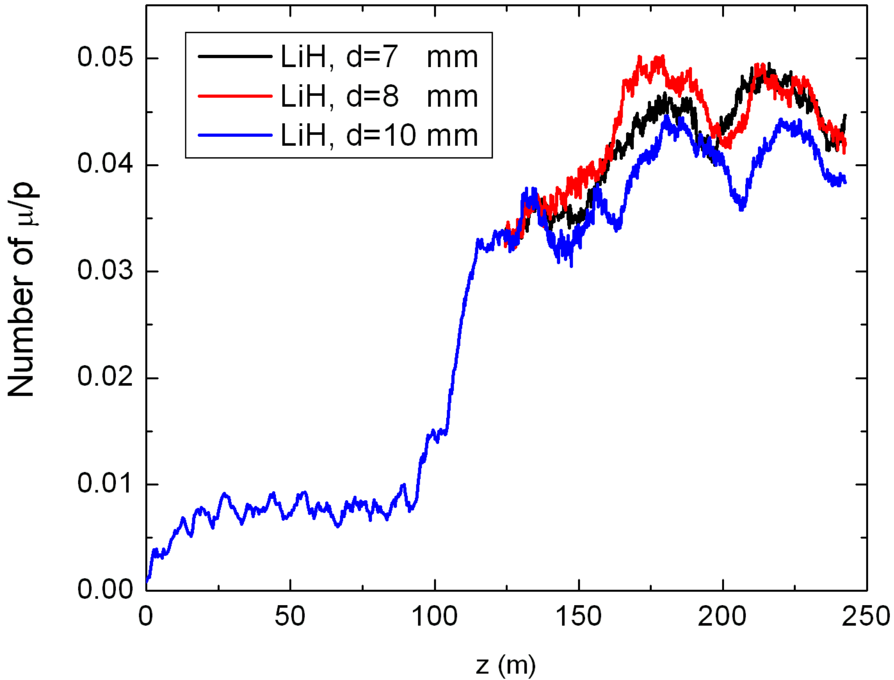



- Conclusion: It appears that by inserting windows an additional 15% drop occurs on muon production

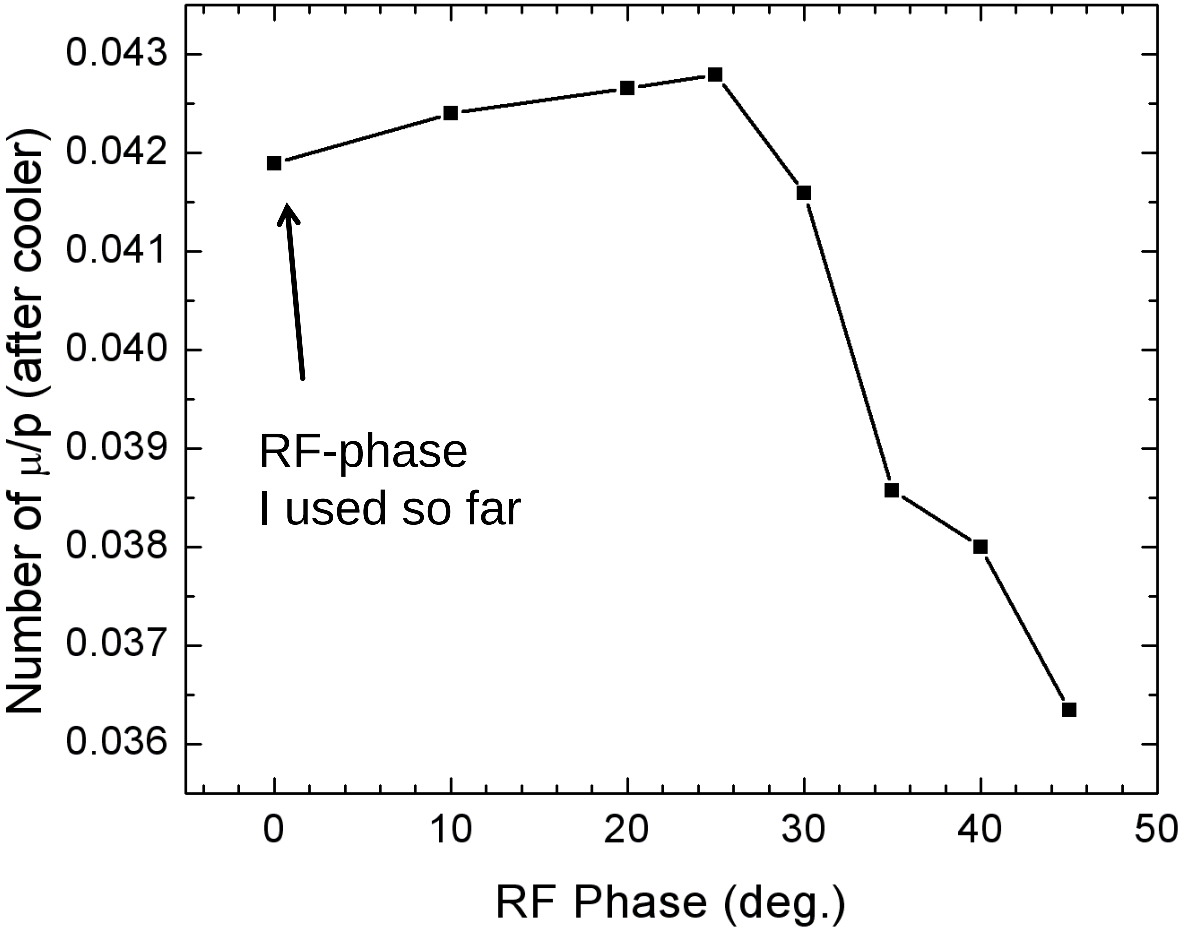
# Lattice sensitivity to absorber length

- I will assume that I have a discrete 3rf-pair lattice with Be windows (previous slide)
- Vary the absorber thickness in cooler and look at the lattice performance
- A layer of 7-8 mm LiH looks appropriate



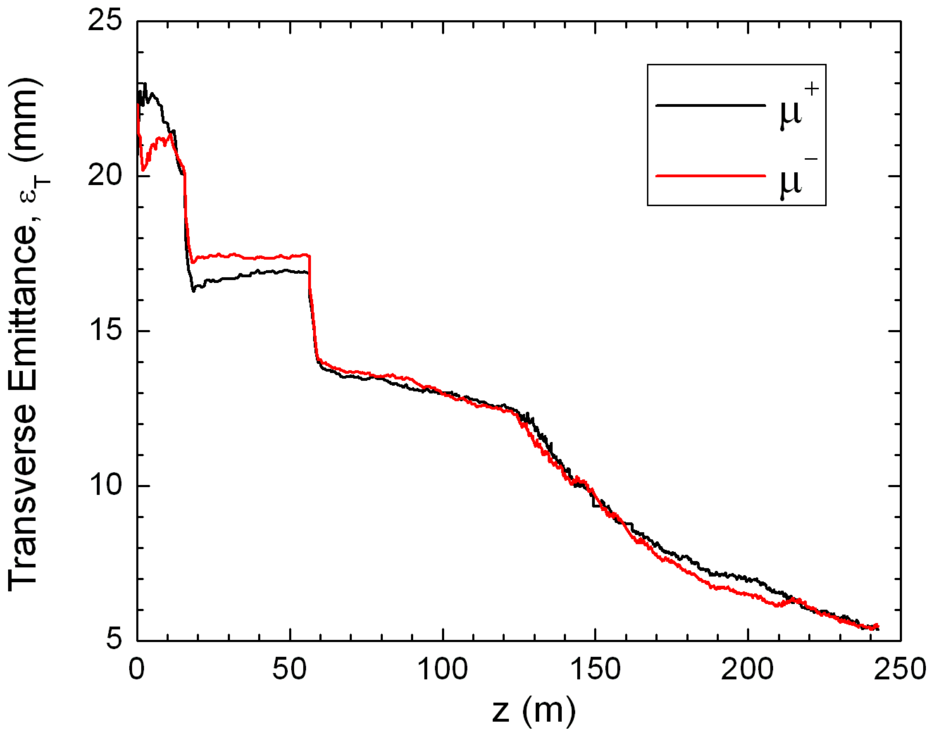
# Lattice sensitivity to RF Phase

- I varied the RF Phase in buncher/rotator



# Lattice Sensitivity to $\mu^+\mu^-$

- Lattice performs similarly for both positive and negative muons



# Conclusions

- This study provided a more realistic scheme for the front of the MC and NF.
- Discretization of the Bfield and RF frequencies is not affecting the number of muons per proton
- Adding Be-windows reduces the number by ~ 10-15%
- We didn’t vary front-end lengths but this may prove helpful.
- Alter cavity shape (magnetic insulation) or cavity properties (pressure)