Muon Cooling Project Updates

March 14, 2025

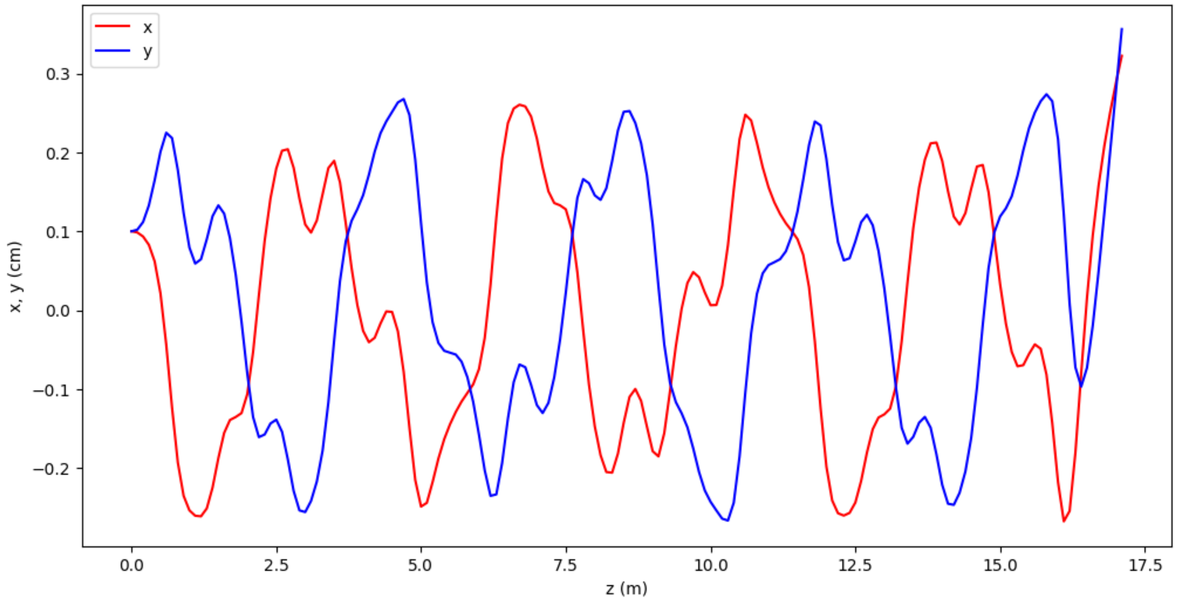
https://github.com/criggall/muon-cooling

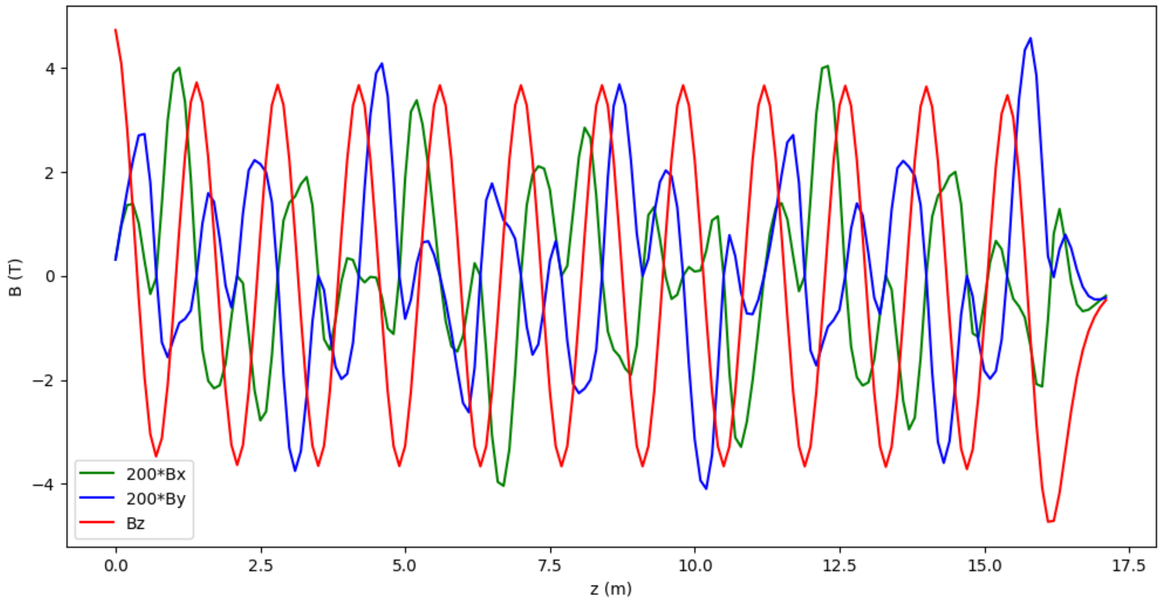
Progress

- Constructed solenoid-only channel
- Tested with reference particle at origin
  - Yields no transverse momentum as expected
- Tested with particle arbitrarily offset from origin
  - Results in motion in xy-plane
  - In the actual design, this would be achieved via the matching section
- Investigated magnetic field in simplified and original channels

```
reference referenceMomentum=$p particle=mu+ beamX=1.0 beamY=1.0 beamZ=0.0
```

p = 230 MeV/c

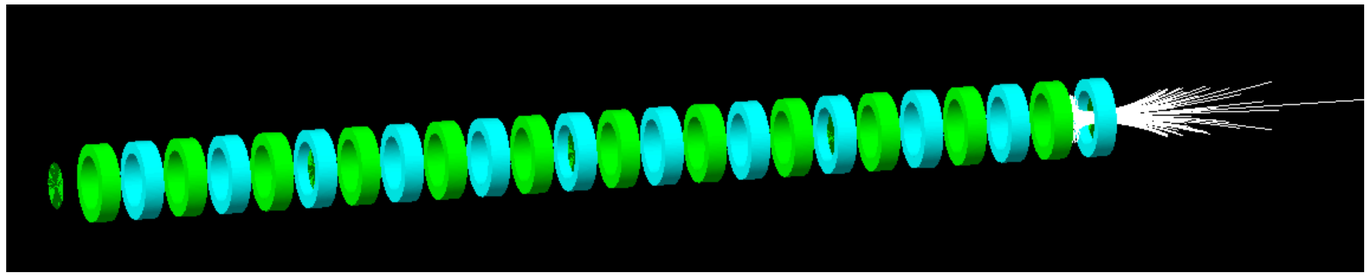




Simplified channel

GitHub link

- 4 periods
- Only solenoids
- Same size and placement as original file
- Constant current set to 90 amps (around starting current in original design)



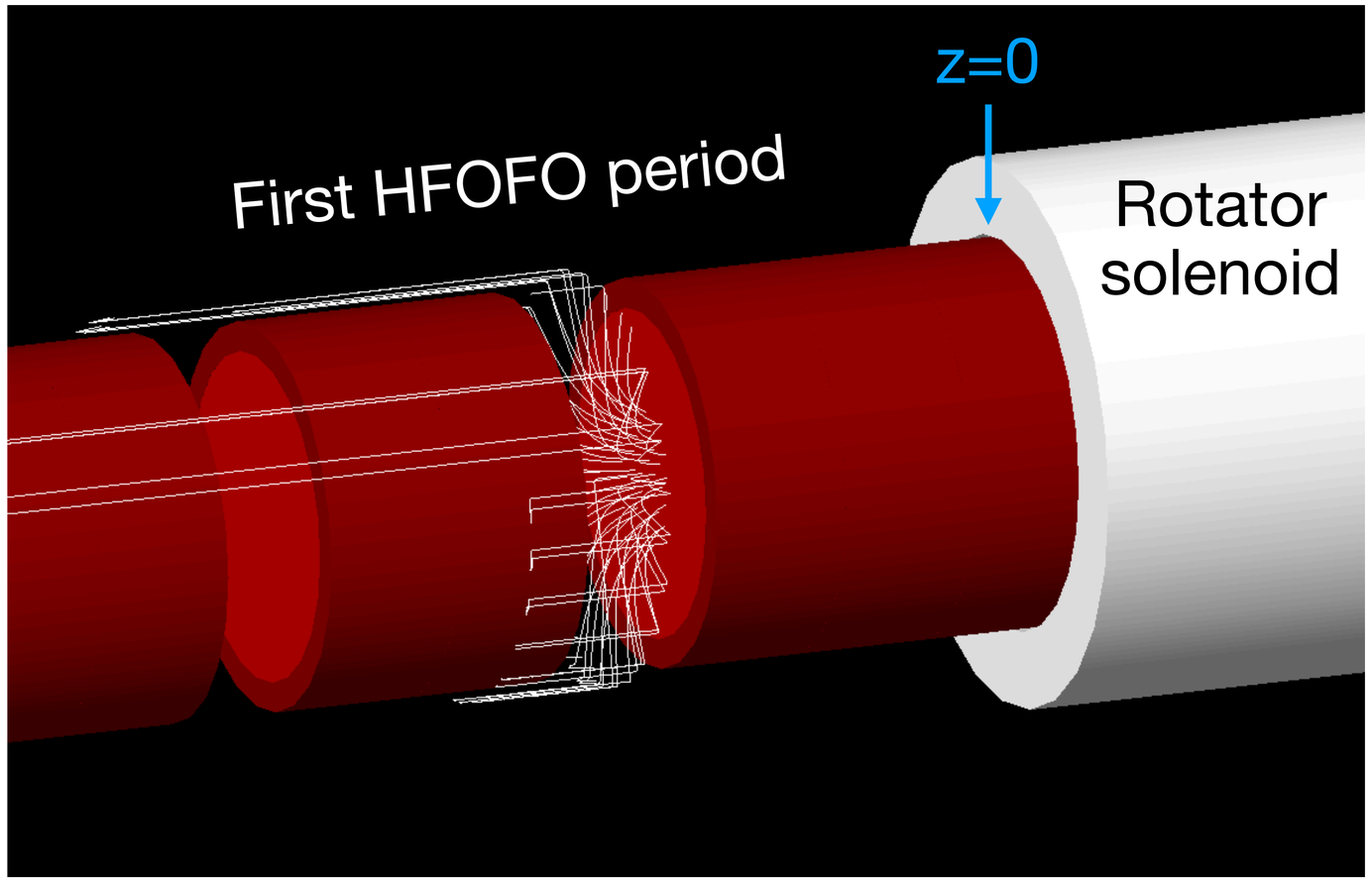
Simplified-HFOFO > sol_place.txt

```
param num=0
place SolPos z=700*0+$period_len*$num current=$sol_current+$current_step*0
place SolNeg z=700*1+$period_len*$num current=-($sol_current+$current_step*1)
place SolPos z=700*2+$period_len*$num current=$sol_current+$current_step*2
place SolNeg z=700*3+$period_len*$num current=-($sol_current+$current_step*3)
place SolPos z=700*4+$period_len*$num current=$sol_current+$current_step*4
place SolNeg z=700*5+$period_len*$num current=-($sol_current+$current_step*5)

param num=1
place SolPos z=700*0+$period_len*$num current=$sol_current+$current_step*6
place SolNeg z=700*1+$period_len*$num current=-($sol_current+$current_step*7)
place SolPos z=700*2+$period_len*$num current=$sol_current+$current_step*8
place SolNeg z=700*3+$period_len*$num current=-($sol_current+$current_step*9)
place SolPos z=700*4+$period_len*$num current=$sol_current+$current_step*10
place SolNeg z=700*5+$period_len*$num current=-($sol_current+$current_step*11)

param num=2
place SolPos z=700*0+$period_len*$num current=$sol_current+$current_step*12
place SolNeg z=700*1+$period_len*$num current=-($sol_current+$current_step*13)
place SolPos z=700*2+$period_len*$num current=$sol_current+$current_step*14
place SolNeg z=700*3+$period_len*$num current=-($sol_current+$current_step*15)
place SolPos z=700*4+$period_len*$num current=$sol_current+$current_step*16
place SolNeg z=700*5+$period_len*$num current=-($sol_current+$current_step*17)

param num=3
place SolPos z=700*0+$period_len*$num current=$sol_current+$current_step*18
place SolNeg z=700*1+$period_len*$num current=-($sol_current+$current_step*19)
place SolPos z=700*2+$period_len*$num current=$sol_current+$current_step*20
place SolNeg z=700*3+$period_len*$num current=-($sol_current+$current_step*21)
place SolPos z=700*4+$period_len*$num current=$sol_current+$current_step*22
place SolNeg z=700*5+$period_len*$num current=-($sol_current+$current_step*23)
```

Constant current when current_step set to 0

Visualizing B field in original HFOFO channel

- Since B field is along z, particles should execute cyclotron motion
- This is what we see in the original channel
- Matching section is required to offset reference particle from initial placement at origin — otherwise no transverse motion



Investigating fringe fields

Animation of reference particle coordinate in xy-plane along z (original design)

Solenoids placed at z values of:

1. 0 cm
2. 70 cm
3. 140 cm
4. 210 cm
5. 280 cm
6. 350 cm

+ 70 cm until start of next period

= 420 cm period length ✓