Muon Cooling Project Updates

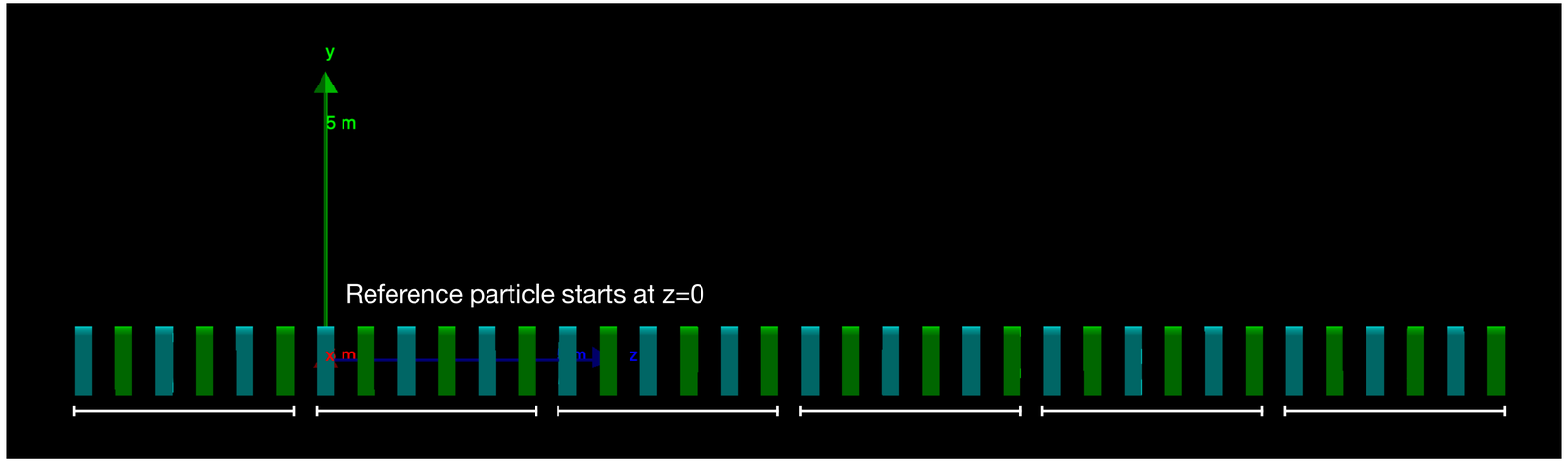
March 21, 2025

https://github.com/criggall/muon-cooling/tree/main/Simplified-HFOFO

Progress

Also reading through emittance calculation papers + Mathematica script — maybe I could present my understanding at an upcoming meeting?

- Added solenoid rotations to simplified channel
- Adjusted initial offset of reference particle to mimic end of HFOFO matching channel
- Added an additional period to start and end of channel to mitigate end field effects
- Trying to find matching reference particle momentum (constant)



Adding solenoid rotations

One period of the channel is schematically shown in Figure 1 (top). Its length is $L_{\text{period}} = 4.2$ m. There are $N_s = 6$ solenoids per period, each inclined by 2.5 mrad about axes that rotate about the channel axis by $\phi_k = 4\pi/3, 0, 2\pi/3, 4\pi/3, 0, 2\pi/3$, where $\phi = 0$ corresponds to inclination about the horizontal axis.

```
# Solenoid pitch:
param pitch=-0.0025*180/pi #deg (2.5 mrad)
```

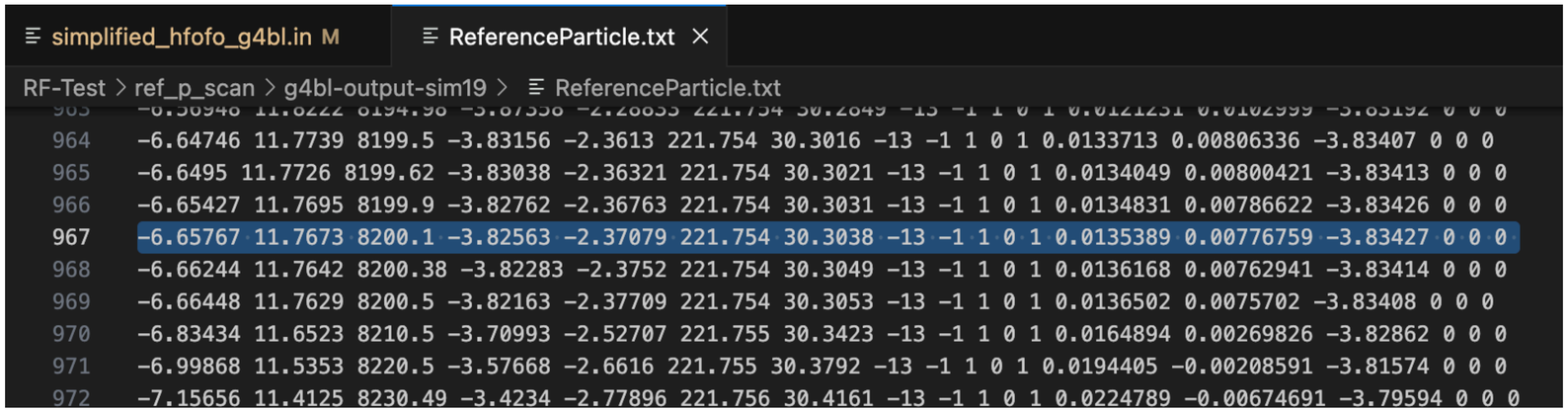
simplified_hfofo_g4bl.in

```
place SolPos z=700*0+$period_len*$num current=$sol_current rotation=X$pitch,Z240
place SolNeg z=700*1+$period_len*$num current=-$sol_current rotation=X$pitch
place SolPos z=700*2+$period_len*$num current=$sol_current rotation=X$pitch,Z120
place SolNeg z=700*3+$period_len*$num current=-$sol_current rotation=X$pitch,Z240
place SolPos z=700*4+$period_len*$num current=$sol_current rotation=X$pitch
place SolNeg z=700*5+$period_len*$num current=-$sol_current rotation=X$pitch,Z120
```

sol_place.txt

Adjusting reference particle offset

- Matching period in original channel ends at 8.2 m
- Place reference particle in simplified channel with initial x and y offset same as that of particle at 8.2 m in the original channel
  - Is it problematic for the reference particle momentum to be different across these two simulations?

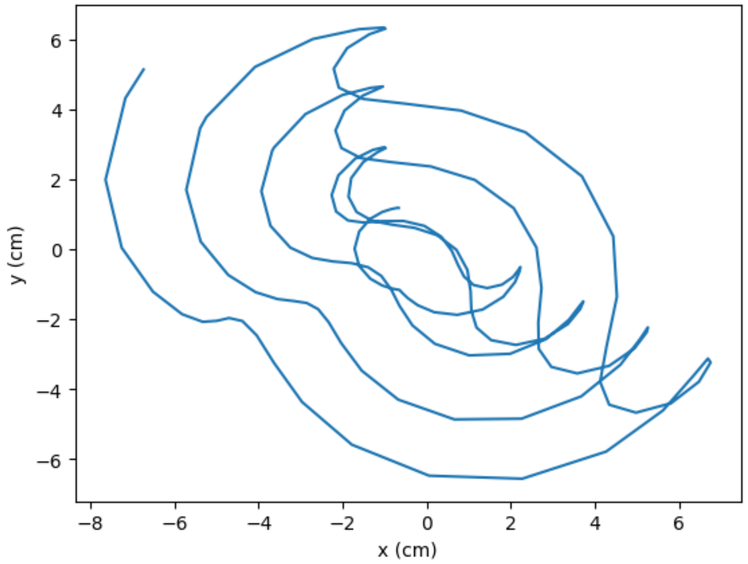



```
reference referenceMomentum=$p particle=mu+ beamX=-6.65767 beamY=11.7673 beamZ=0.0
```

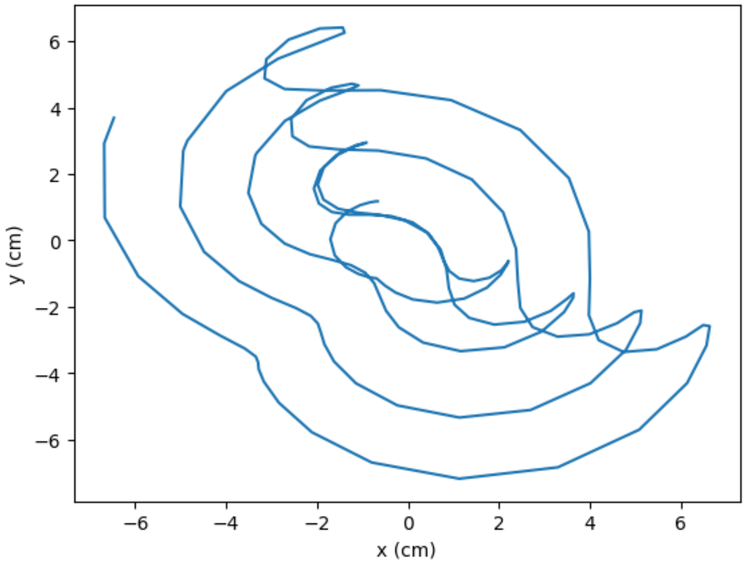
Finding the reference particle momentum

- Can we determine this analytically as the current is constant, or does the inclusion of solenoid rotations complicate the Hamiltonian?
- Constant current = 90 amps

265 MeV/c



270 MeV/c



275 MeV/c