

Muon Cooling Project Updates

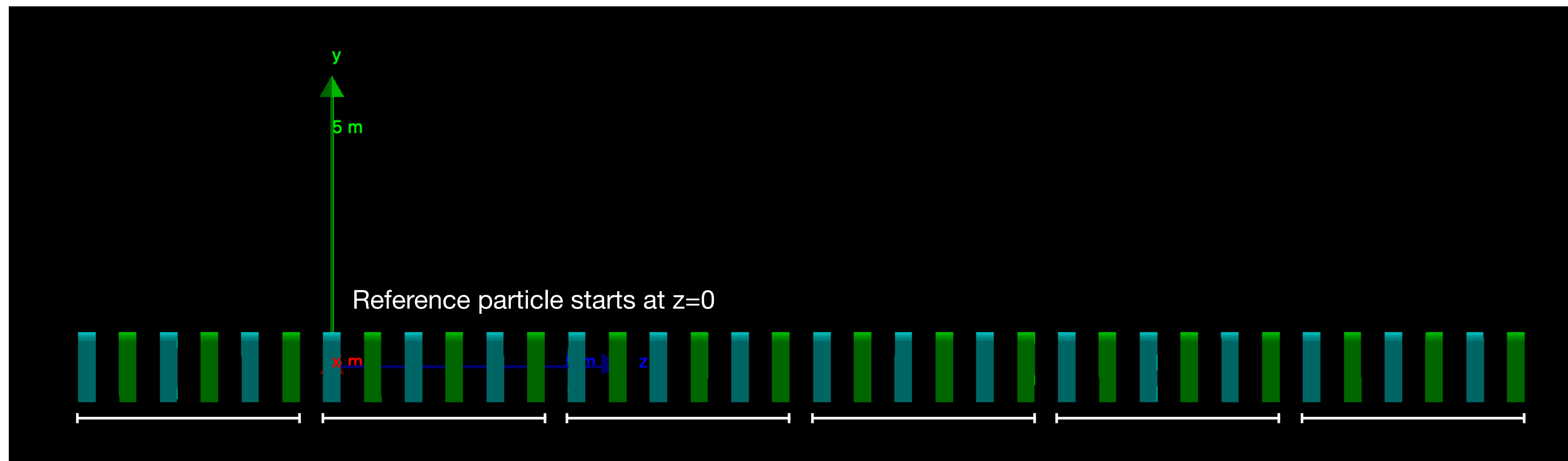
March 21, 2025

<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

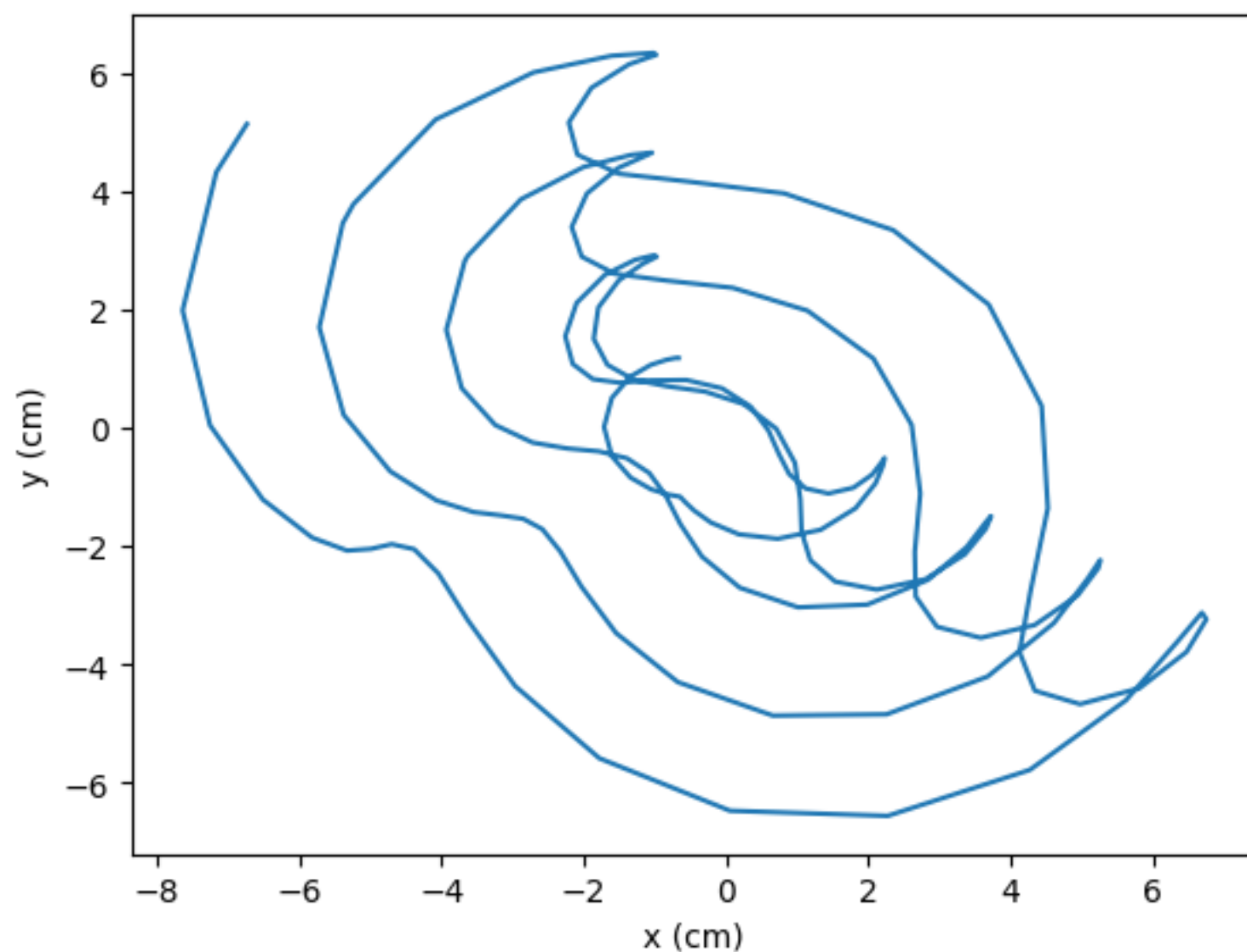
- Matching period in original channel ends at 8.2 m
- Place reference particle in simplified channel with initial x and y offset same as that of particle at 8.2 m in the original channel
- Is it problematic for the reference particle momentum to be different across these two simulations?

```
≡ simplified_hfofo_g4bl.in M    ≡ ReferenceParticle.txt ×
RF-Test > ref_p_scan > g4bl-output-sim19 > ≡ ReferenceParticle.txt
963 -6.50946 11.8222 8194.96 -3.87550 -2.28035 221.754 30.2049 -13 -1 1 0 1 0.0121251 0.0102999 -3.83192 0 0 0
964 -6.64746 11.7739 8199.5 -3.83156 -2.3613 221.754 30.3016 -13 -1 1 0 1 0.0133713 0.00806336 -3.83407 0 0 0
965 -6.6495 11.7726 8199.62 -3.83038 -2.36321 221.754 30.3021 -13 -1 1 0 1 0.0134049 0.00800421 -3.83413 0 0 0
966 -6.65427 11.7695 8199.9 -3.82762 -2.36763 221.754 30.3031 -13 -1 1 0 1 0.0134831 0.00786622 -3.83426 0 0 0
967 -6.65767 11.7673 8200.1 -3.82563 -2.37079 221.754 30.3038 -13 -1 1 0 1 0.0135389 0.00776759 -3.83427 0 0 0
968 -6.66244 11.7642 8200.38 -3.82283 -2.3752 221.754 30.3049 -13 -1 1 0 1 0.0136168 0.00762941 -3.83414 0 0 0
969 -6.66448 11.7629 8200.5 -3.82163 -2.37709 221.754 30.3053 -13 -1 1 0 1 0.0136502 0.0075702 -3.83408 0 0 0
970 -6.83434 11.6523 8210.5 -3.70993 -2.52707 221.755 30.3423 -13 -1 1 0 1 0.0164894 0.00269826 -3.82862 0 0 0
971 -6.99868 11.5353 8220.5 -3.57668 -2.6616 221.755 30.3792 -13 -1 1 0 1 0.0194405 -0.00208591 -3.81574 0 0 0
972 -7.15656 11.4125 8230.49 -3.4234 -2.77896 221.756 30.4161 -13 -1 1 0 1 0.0224789 -0.00674691 -3.79594 0 0 0
      x      y      z
reference referenceMomentum=$p particle=mu+ beamX=-6.65767 beamY=11.7673 beamZ=0.0
```

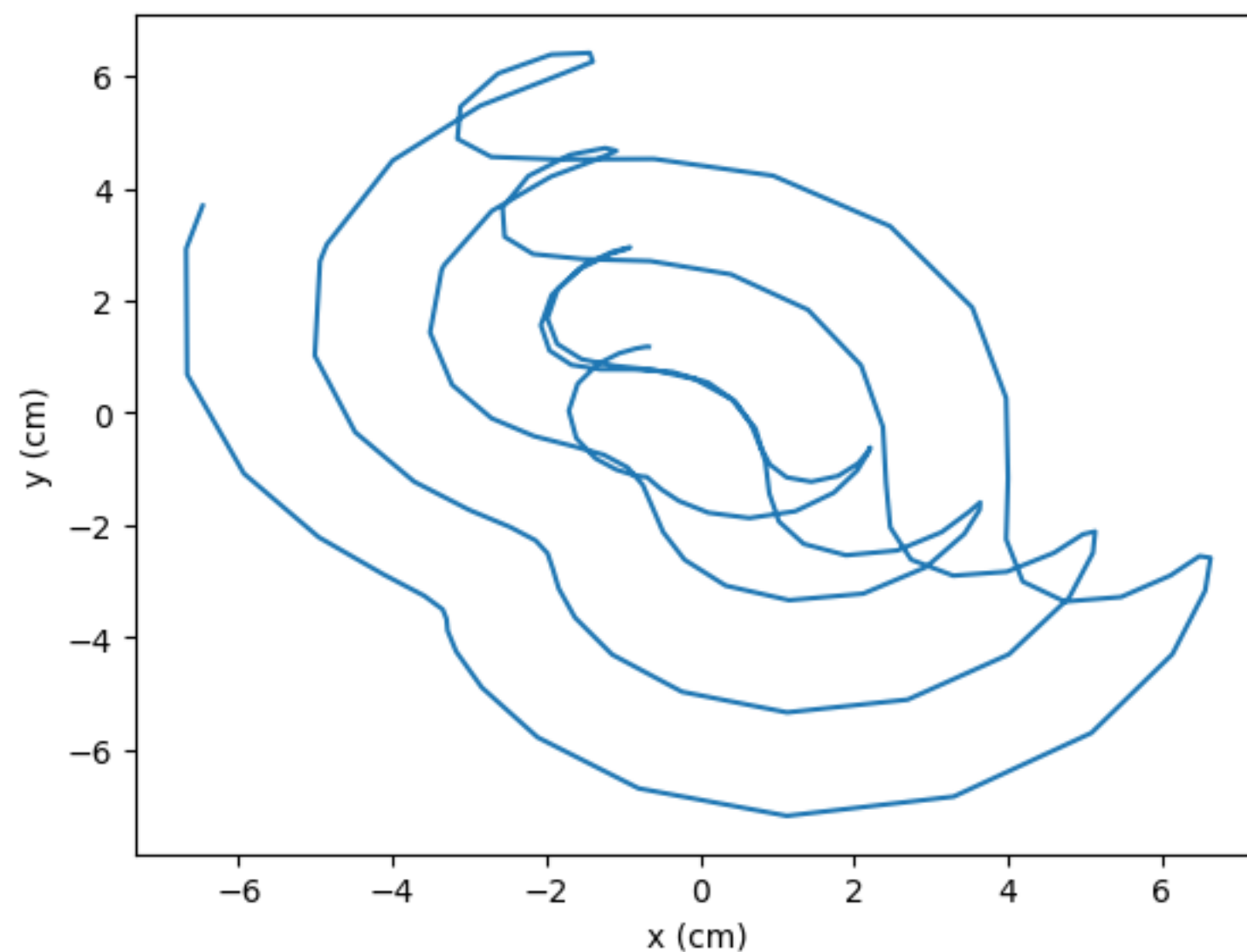

Finding the reference particle momentum

- 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

