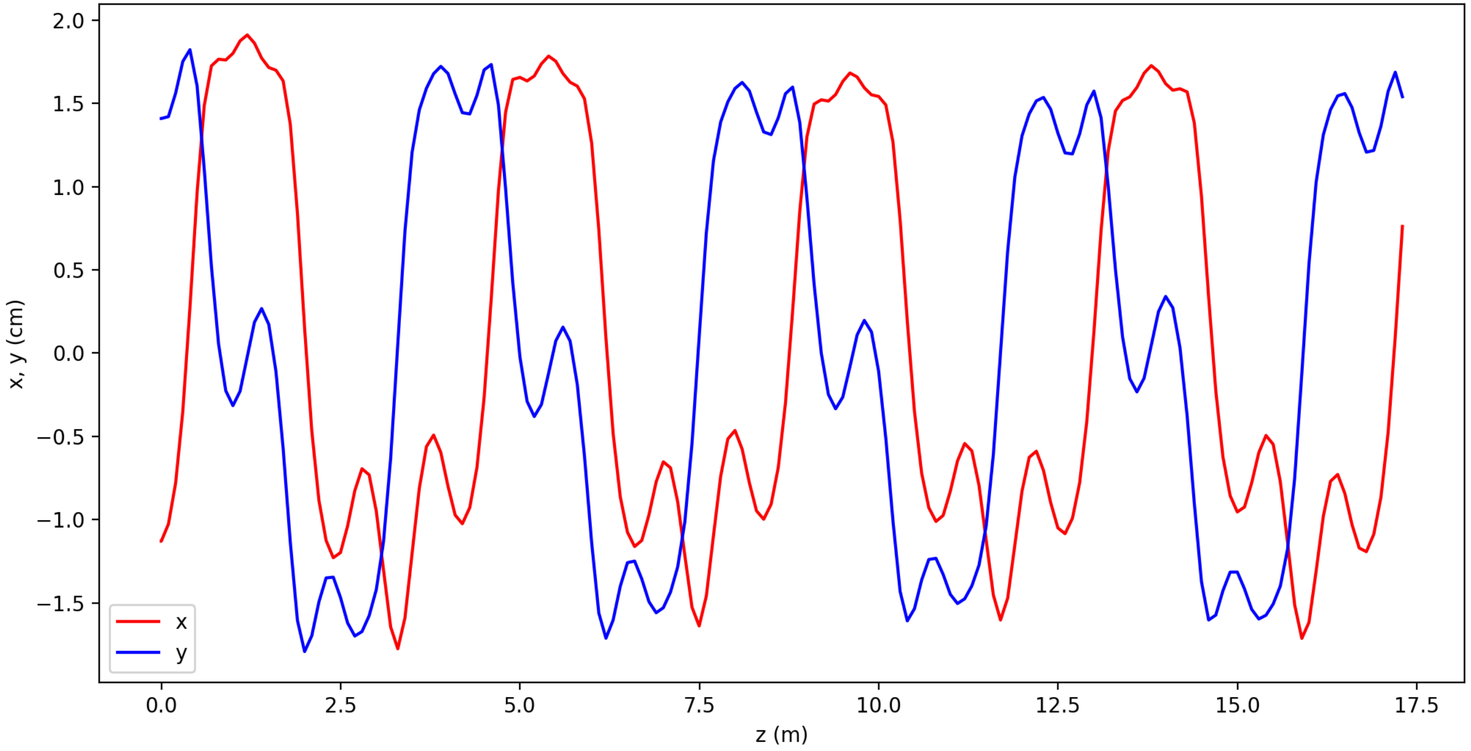
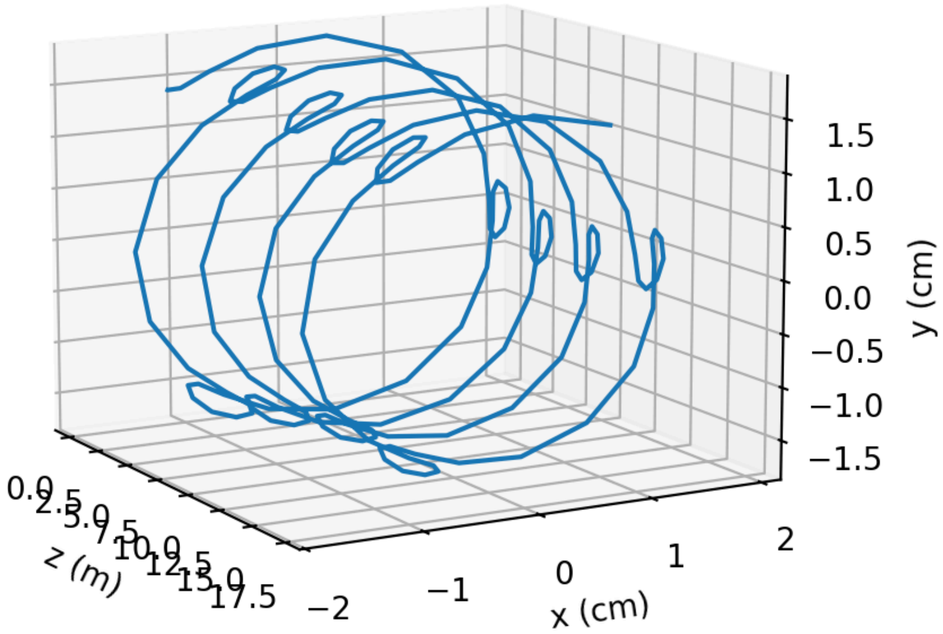
Muon Cooling Project Updates

April 4, 2025

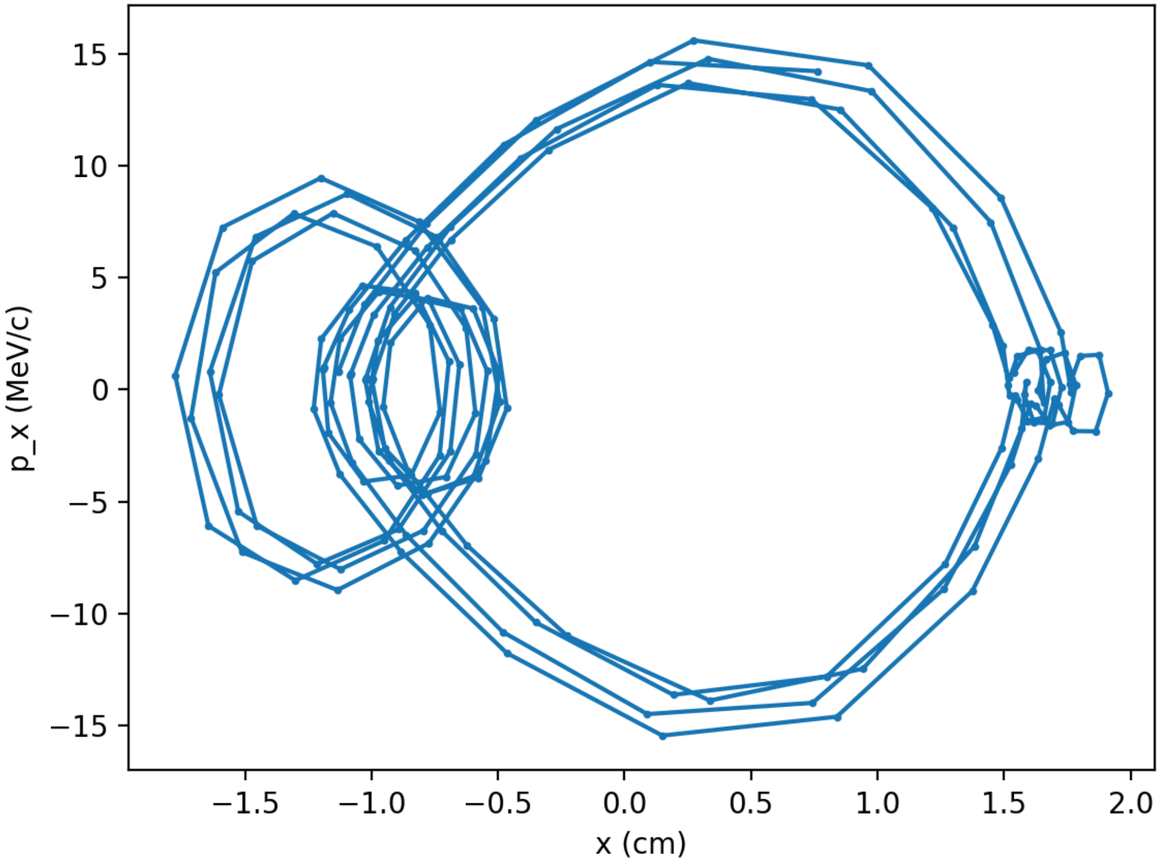
https://github.com/criggall/muon-cooling

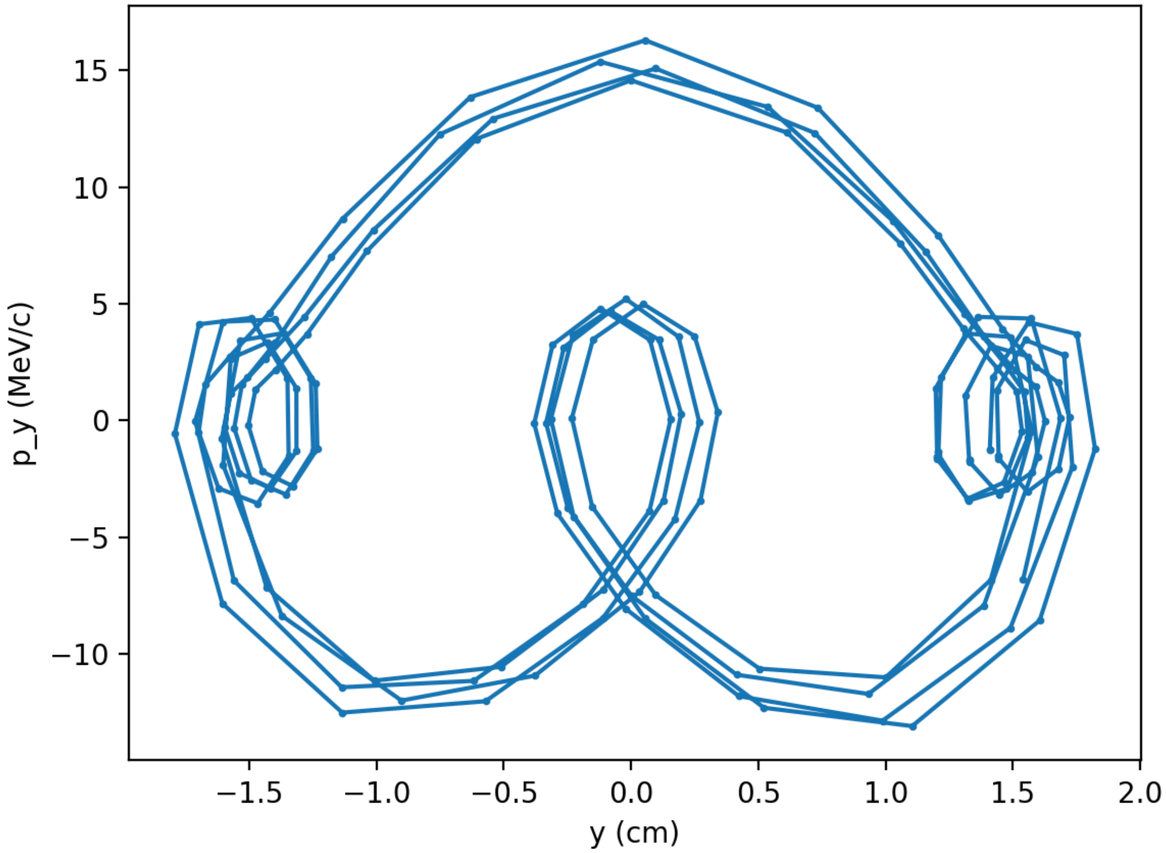
Trajectory along simplified channel



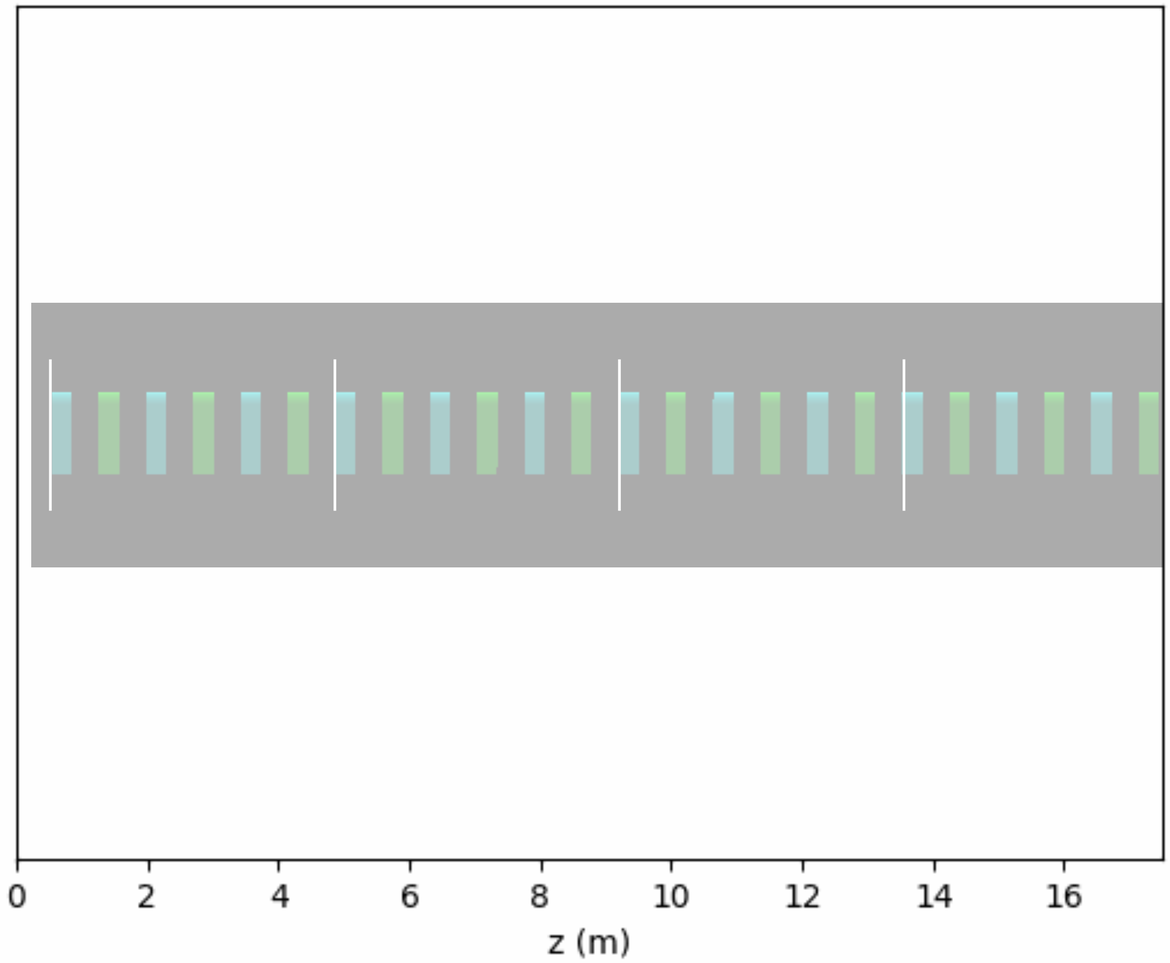


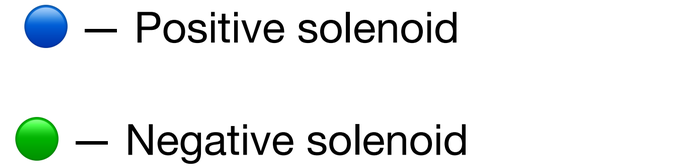
In phase space

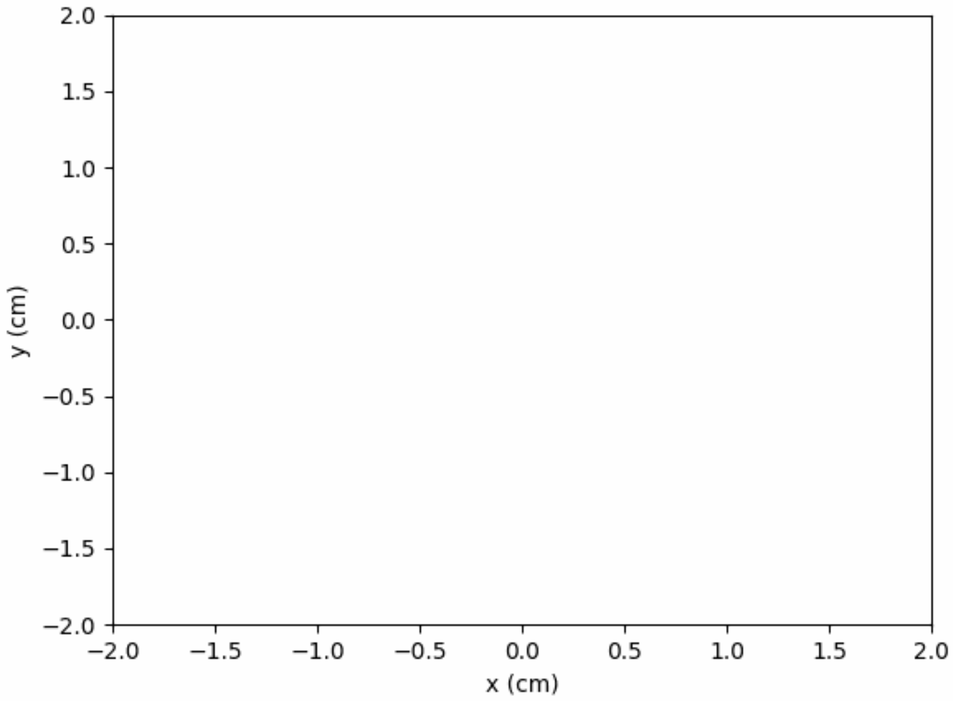




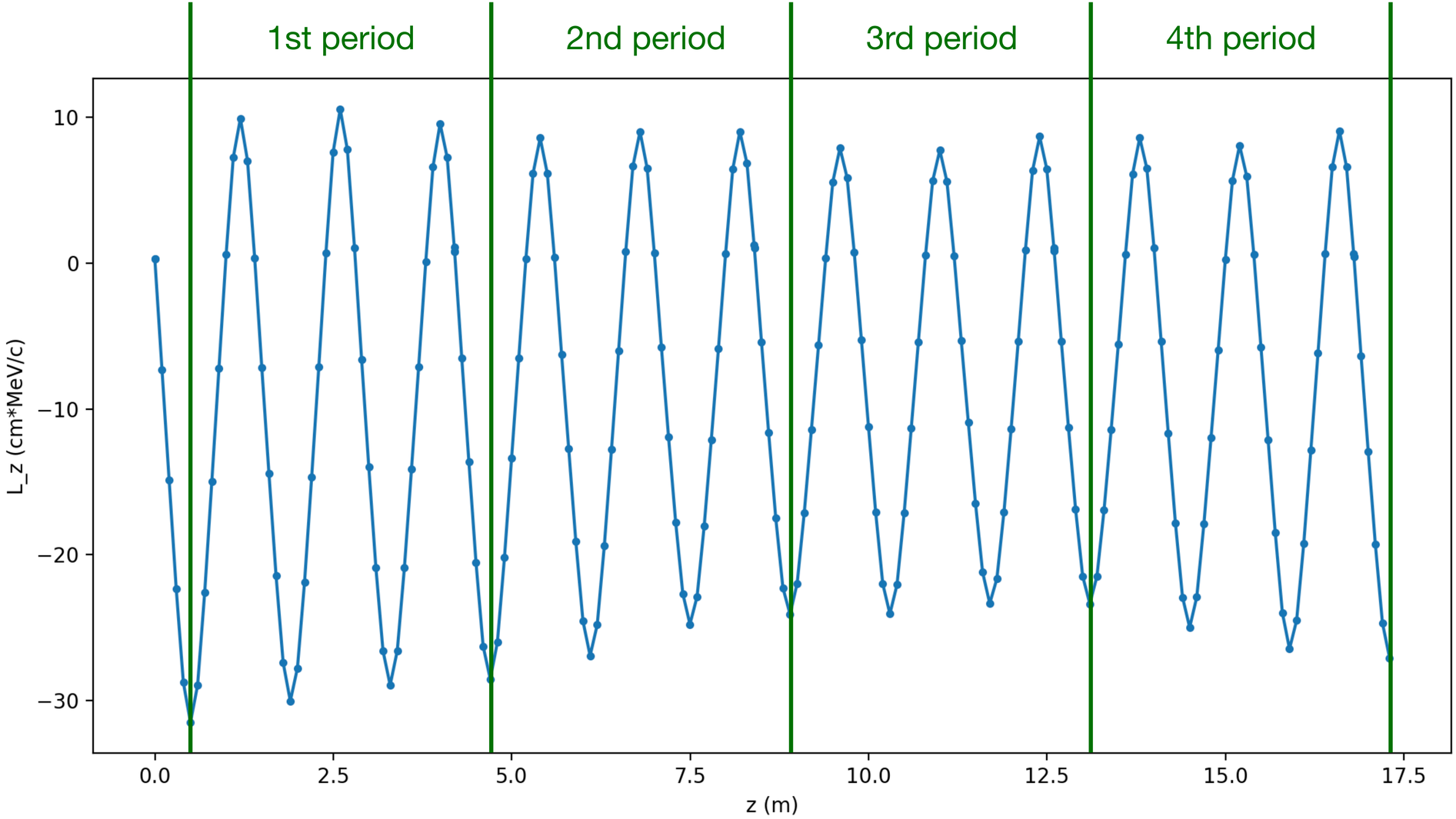
Animation of x,y trajectory along z



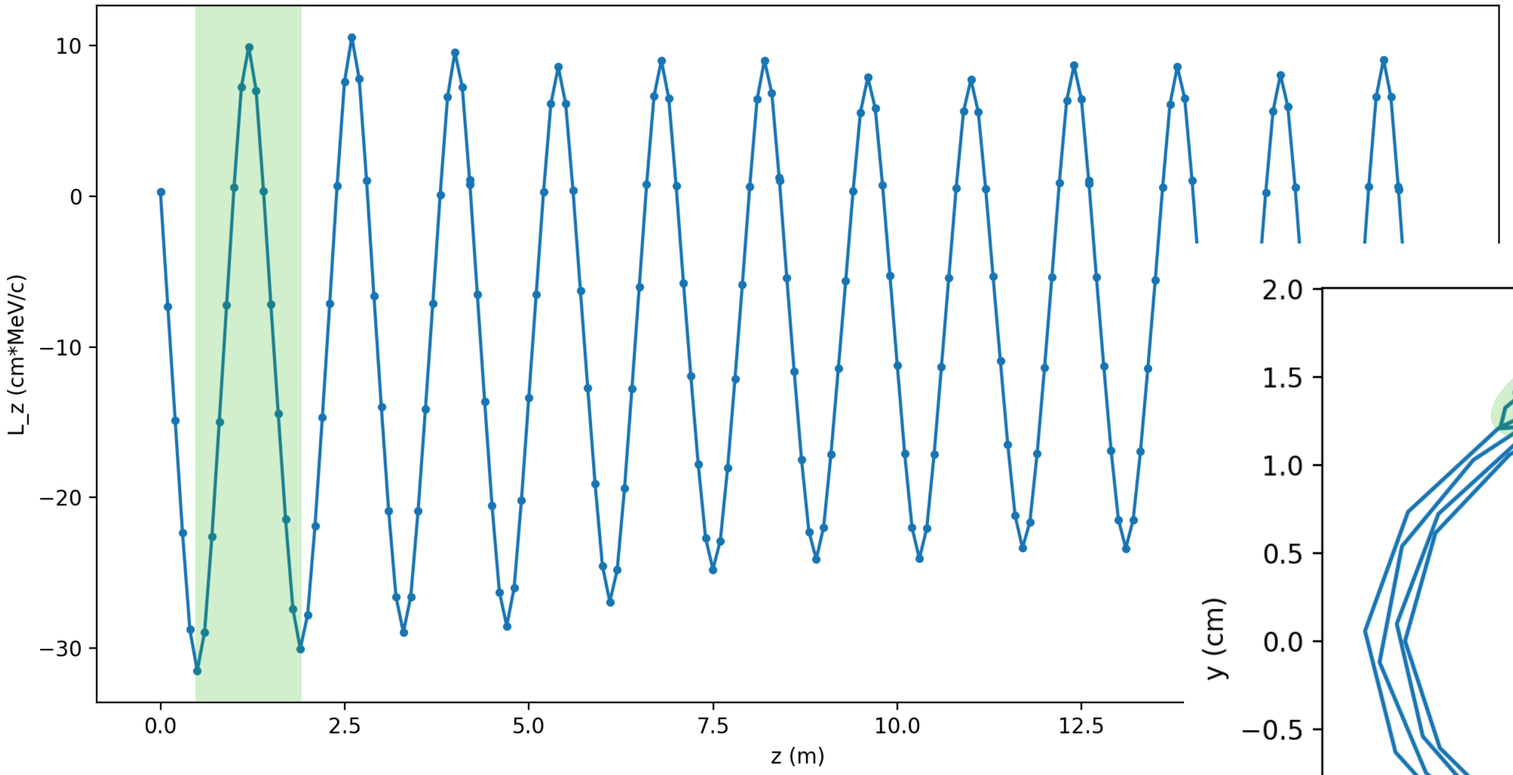


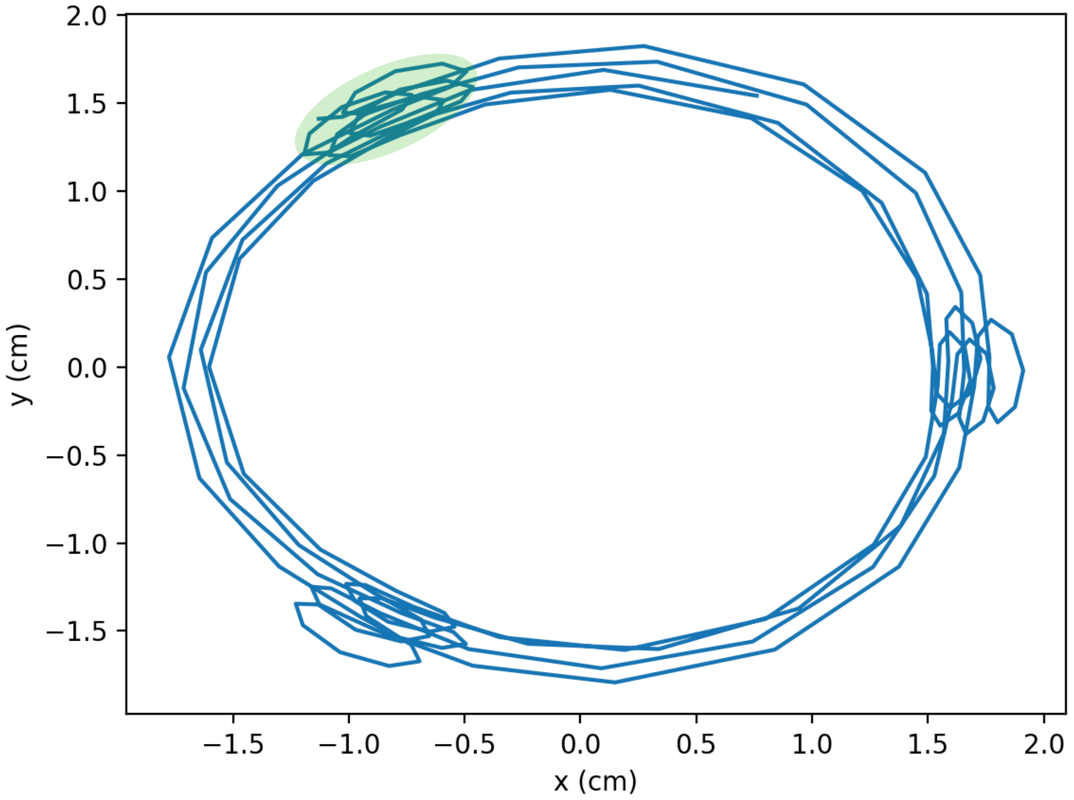


L_z along simplified channel

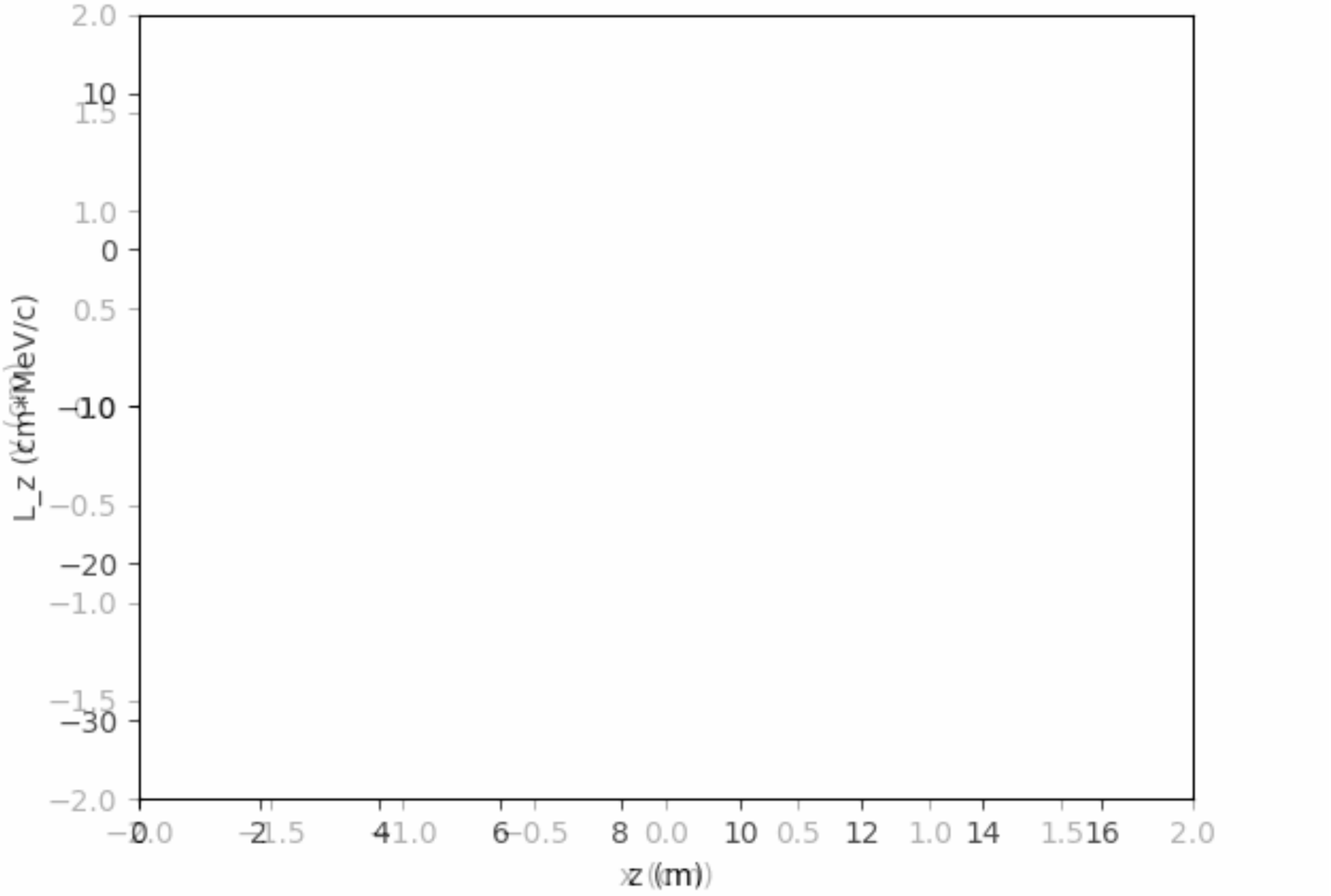


L_z along simplified channel

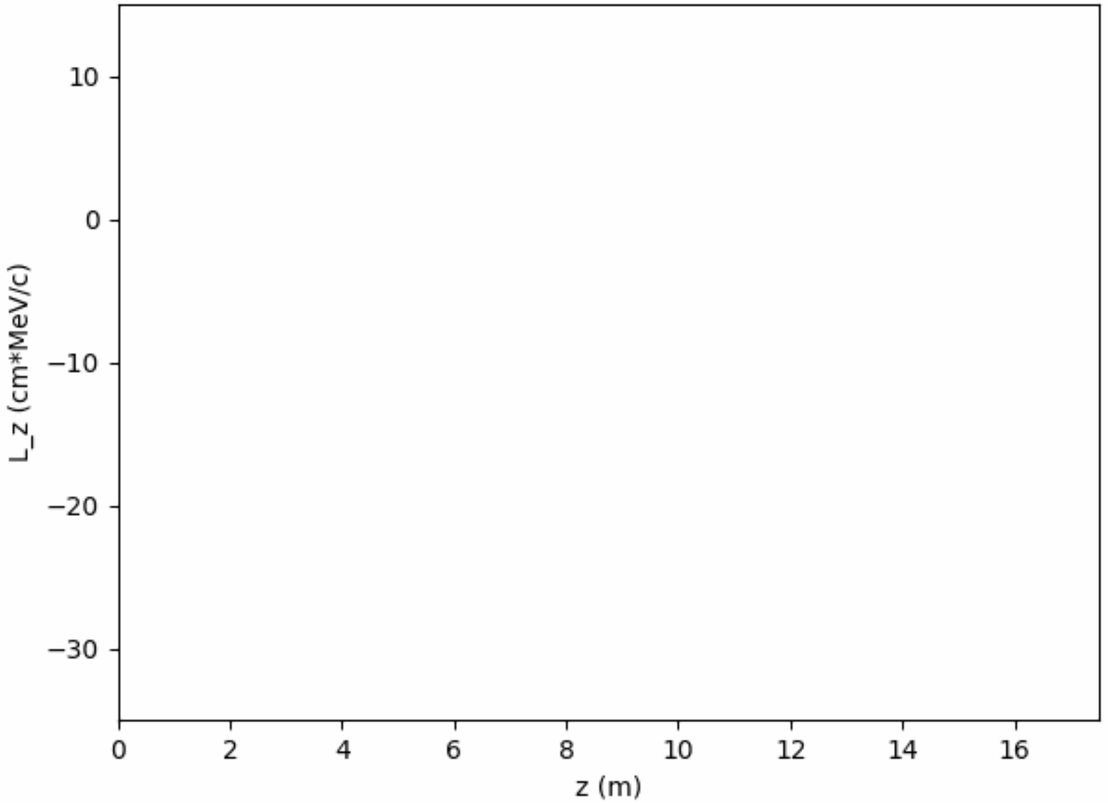


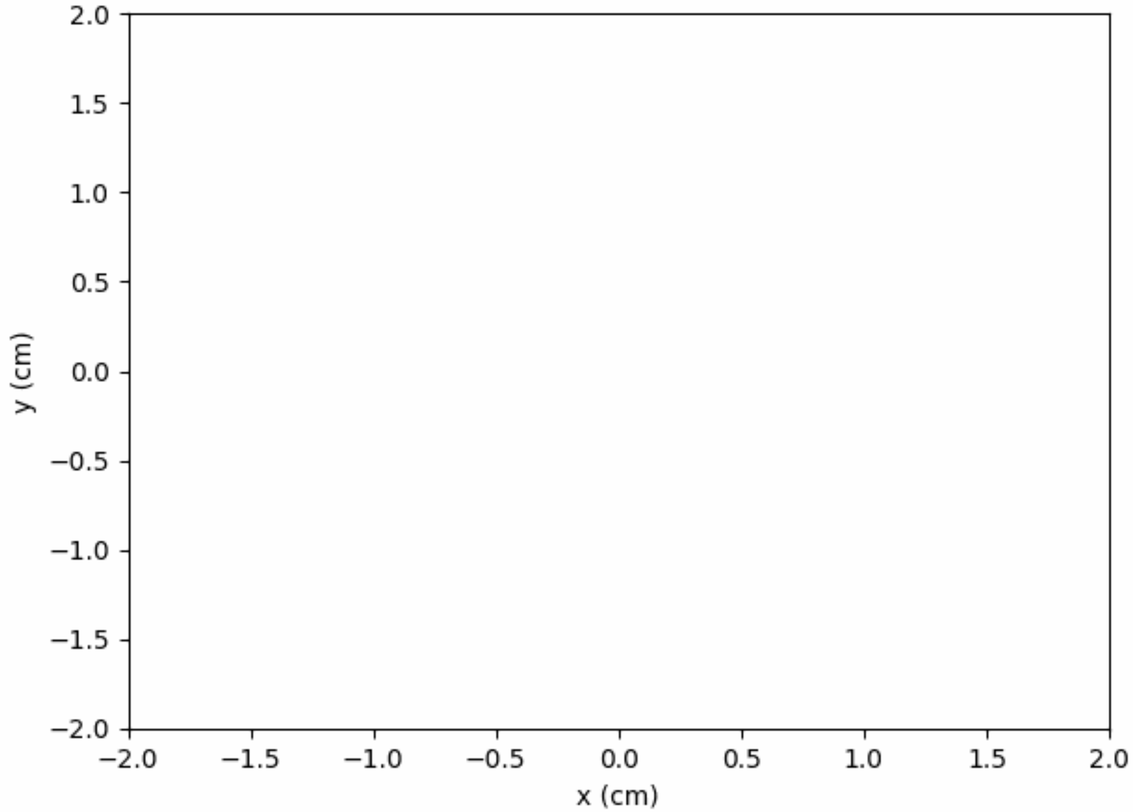


Animations of L_z and xy trajectory along z



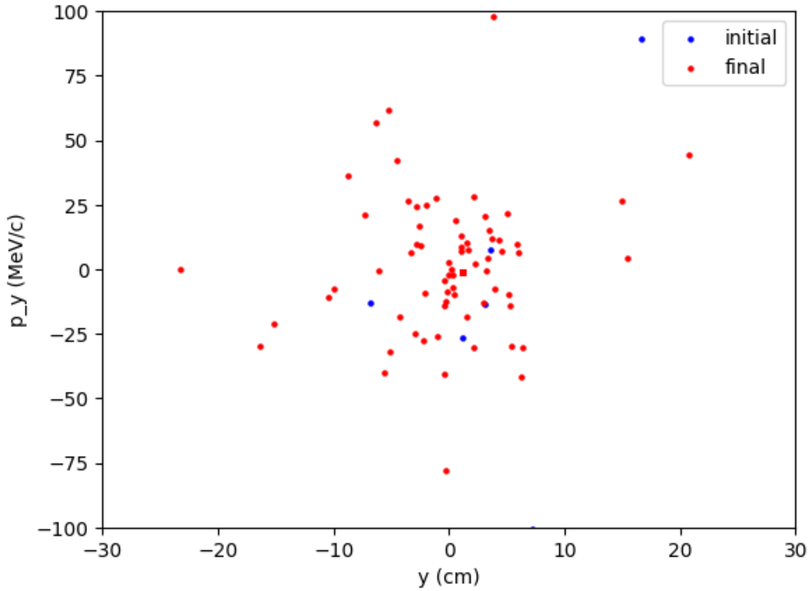
Animations of L_z and xy trajectory along z

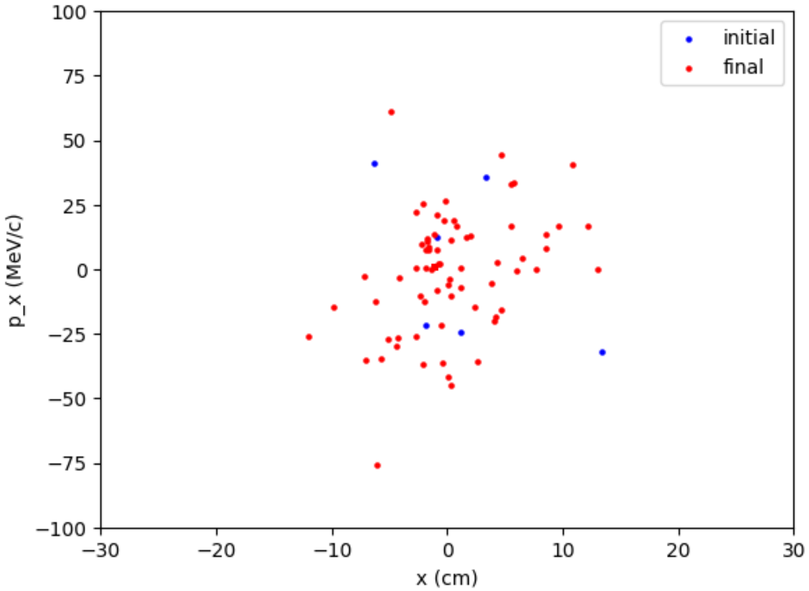




Inputting a beam — Gaussian

- Inputting a Gaussian beam with 10,000 events outputs fewer than 10 at the first detector
- And duplicate events at the subsequent detectors
- Adjusting width of distribution was unhelpful





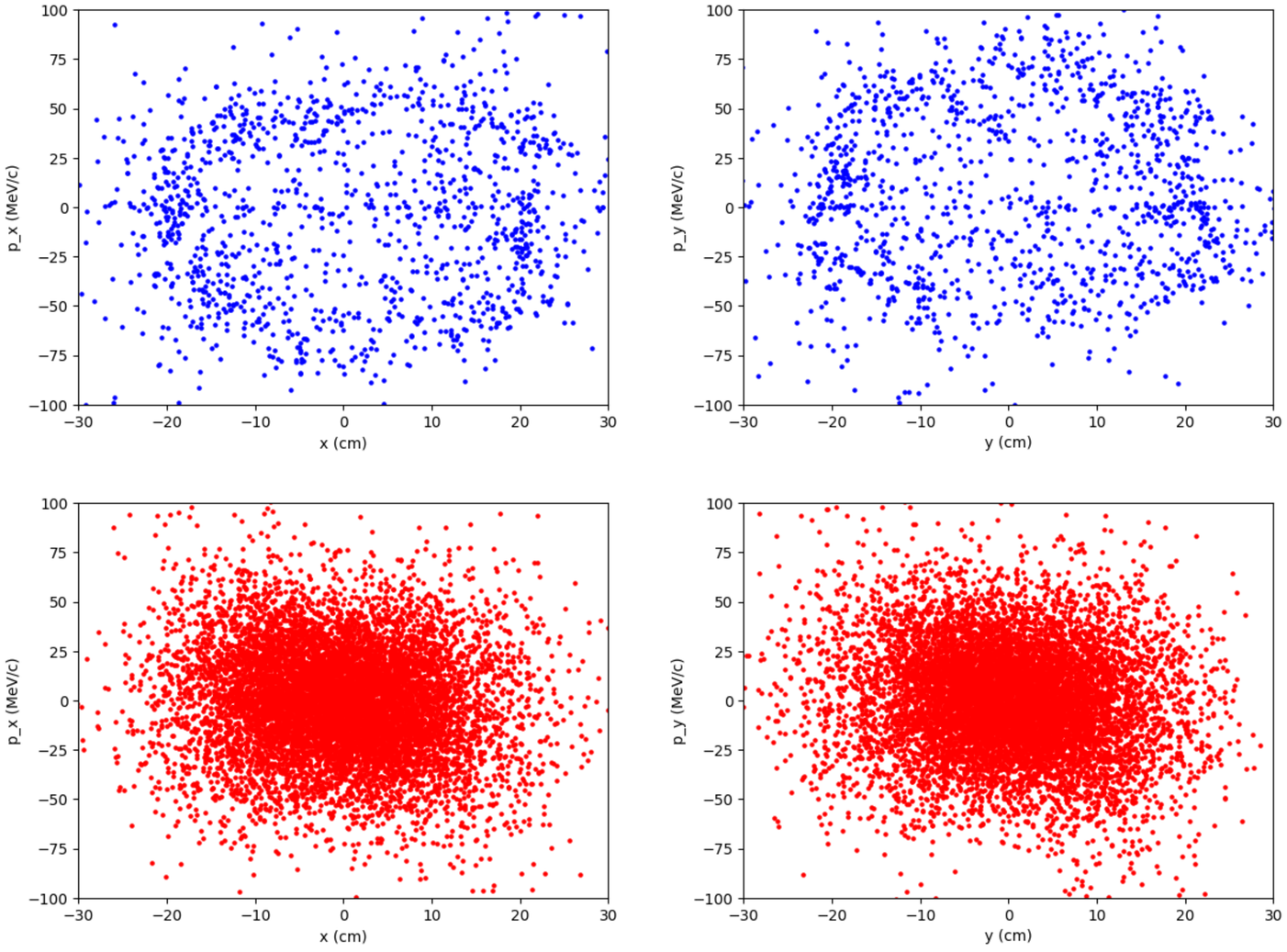
G4bl input:

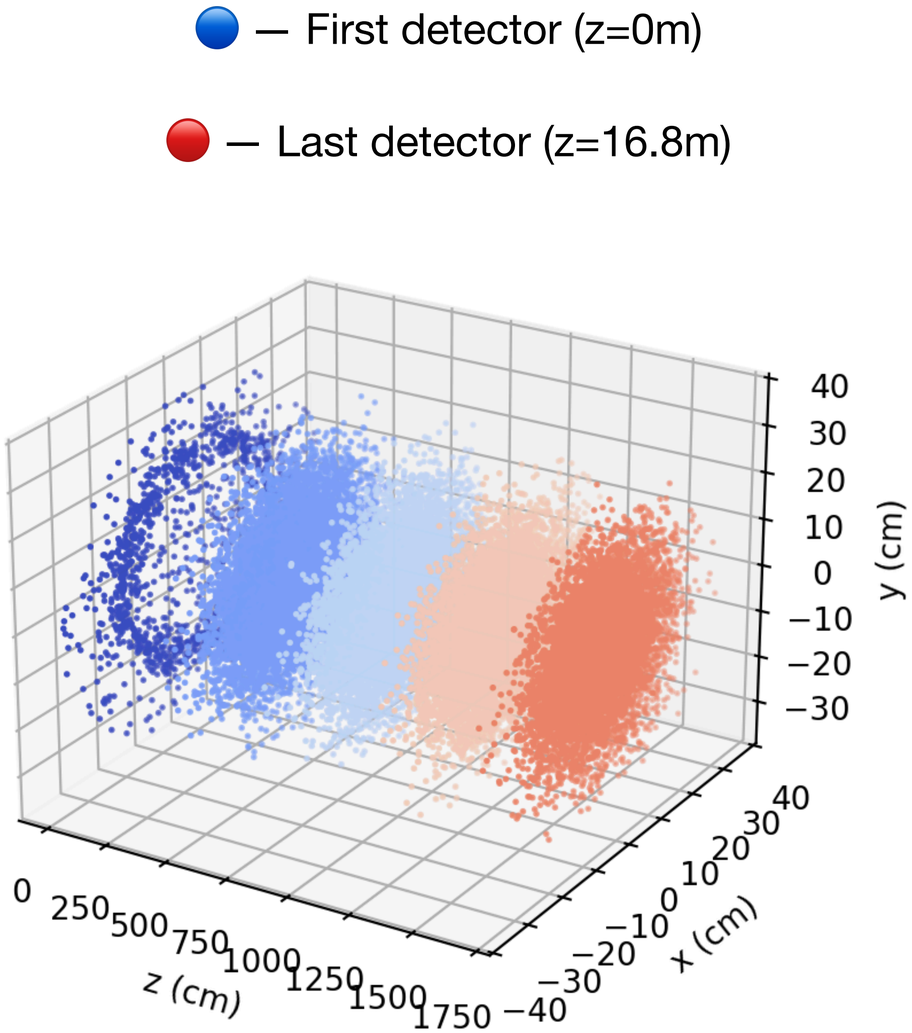
```
### BEAM ###

param X=-11.2945
param Y=14.0917
param Xp=0.823201/224.995
param Yp=-1.27215/224.995

beam gaussian particle=mu+ nEvents=10000 beamZ=0.0 beamX=$X beamY=$Y beamXp=$Xp beamYp=$Yp \
 sigmaX=0.0 sigmaY=0.0 sigmaXp=0.00 sigmaYp=0.00 meanMomentum=$p sigmaP=0.0 meanT=0.0 sigmaT=0.0
```

Detector 1 output:

```
#BLTrackFile VirtualDetector/Det1
#x y z Px Py Pz t PDGid EventID TrackID ParentID Weight
#mm mm mm MeV/c MeV/c MeV/c ns - - - - -
12.1098 35.5339 0.0005 -24.3662 7.55786 -1.16435 14.8636 -11 1042 1001 1 1
-18.5092 31.4966 -0.0005 -21.7161 -13.3905 1.13691 14.97 -11 1042 1001 1 1
133.796 166.07 0.0005 -31.7064 89.338 -71.0039 55.0386 -11 4301 1001 1 1
-63.8621 72.578 -0.0005 40.9852 -100.478 47.4611 56.274 -11 4301 1001 1 1
-9.03882 11.9482 0.0005 12.2069 -26.5815 -49.3012 164.478 -11 6860 1001 1 1
32.8796 -68.4133 -0.0005 35.6469 -13.2666 42.8905 172.795 -11 6860 1001 1 1

```

Inputting a beam — from file

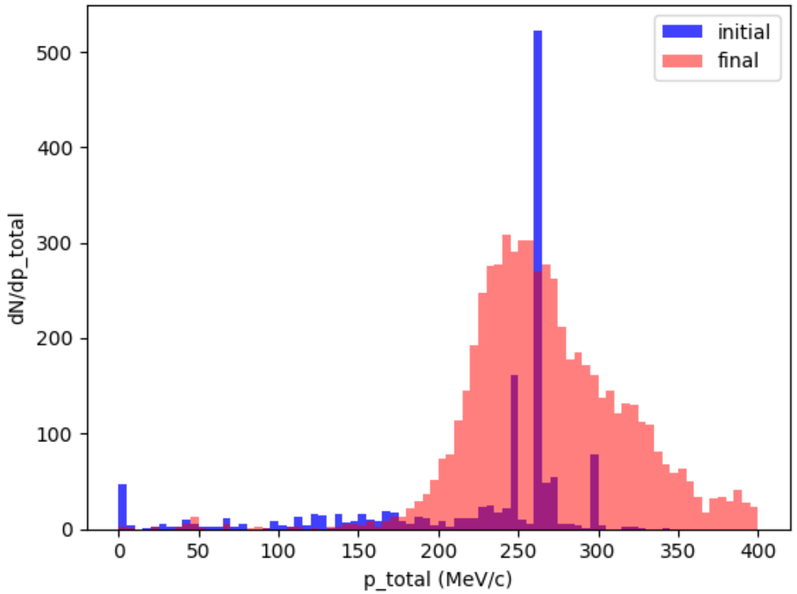




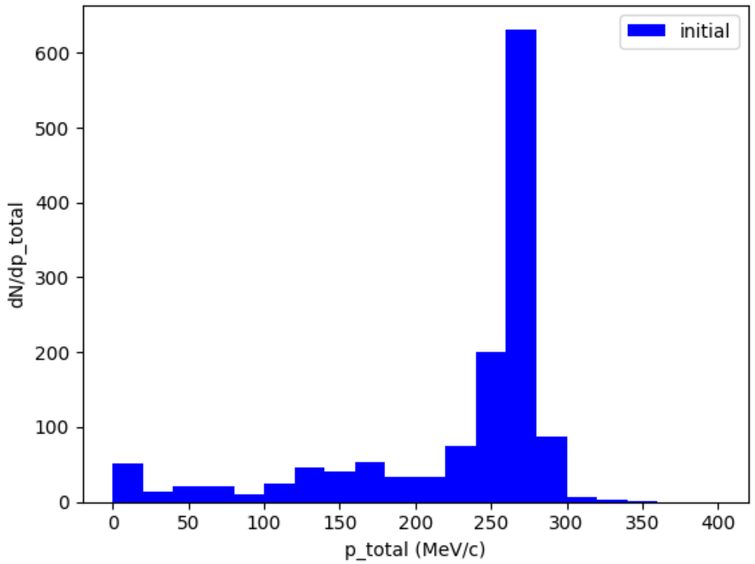
Inputting a beam — from file

- Why does the first detector give such unexpected results?

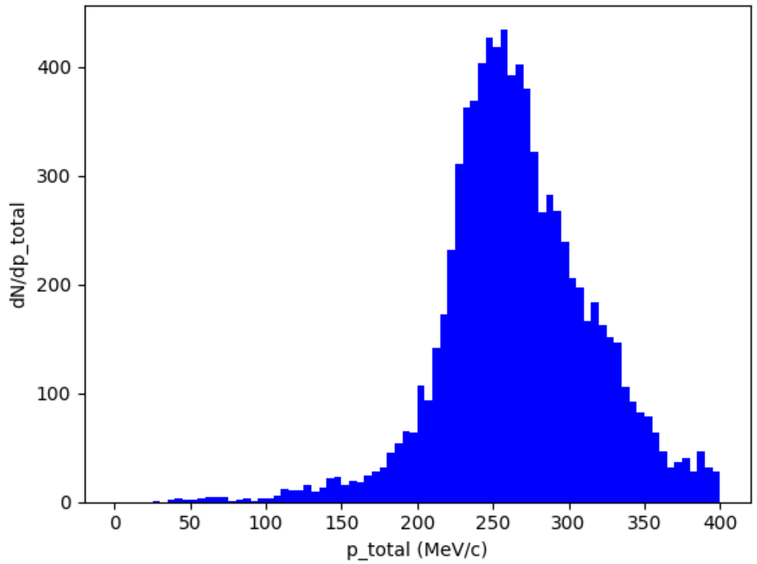
Observed distributions at first and last detectors:



Isolating and re-binning the distribution for the first detector:

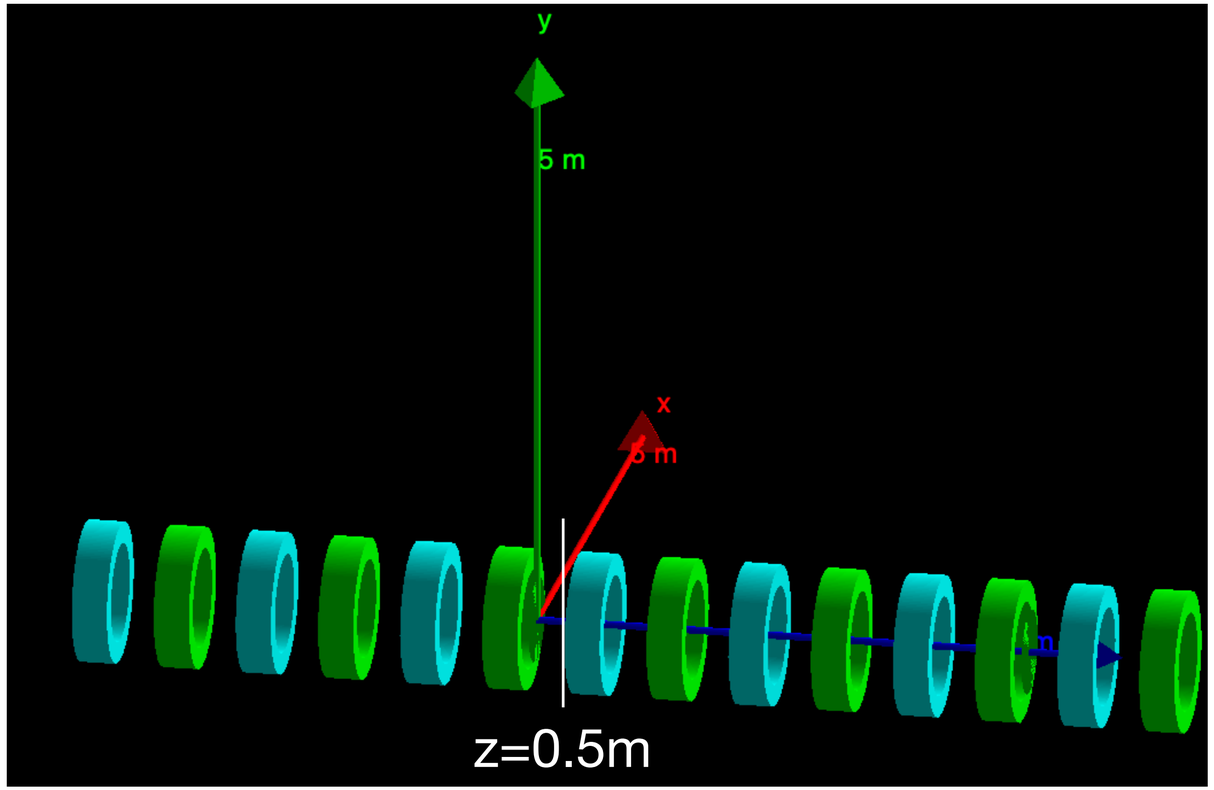


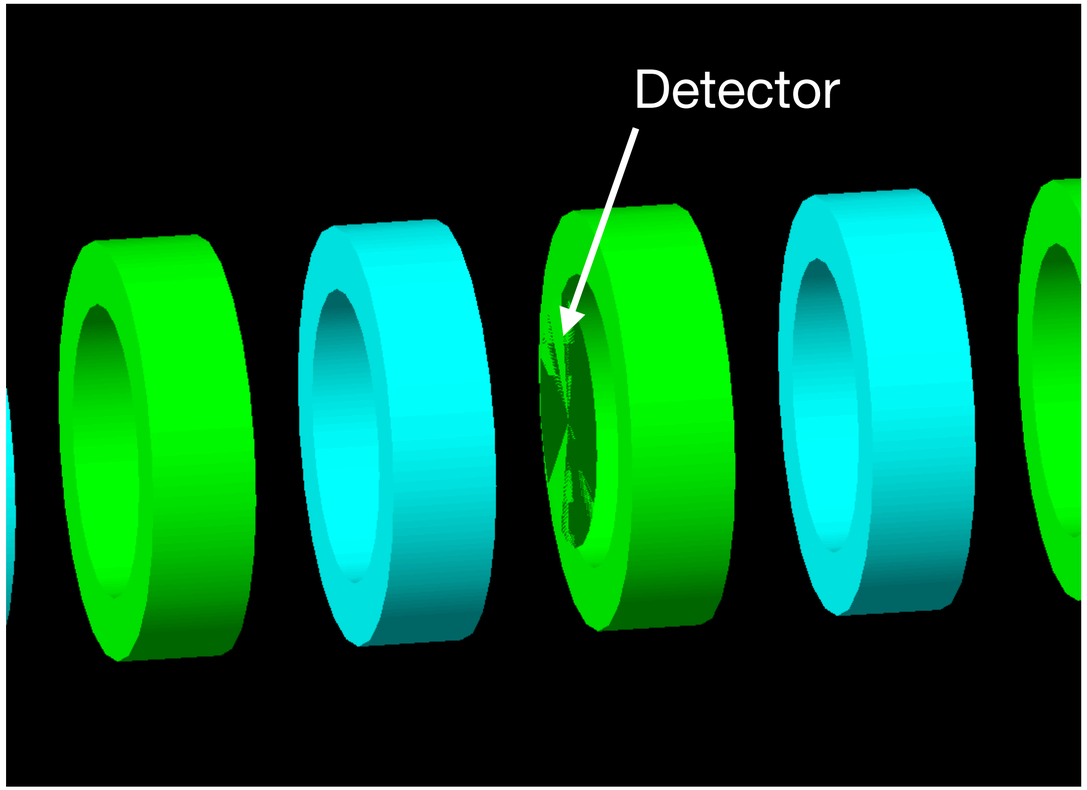
Expected starting distribution, from file:



Considering detector placement

- First solenoid is offset from origin by 0.5m, as in Yuri's design — what is the purpose of this?





Proposed next steps

- Resolve the anomalous beam results
- Characterize beam behavior in simplified channel — starting with a Gaussian
- Write script to compute Twiss parameters, emittance, etc.
- Establish setup for comparing configurations as we add RF, cooling elements, etc.