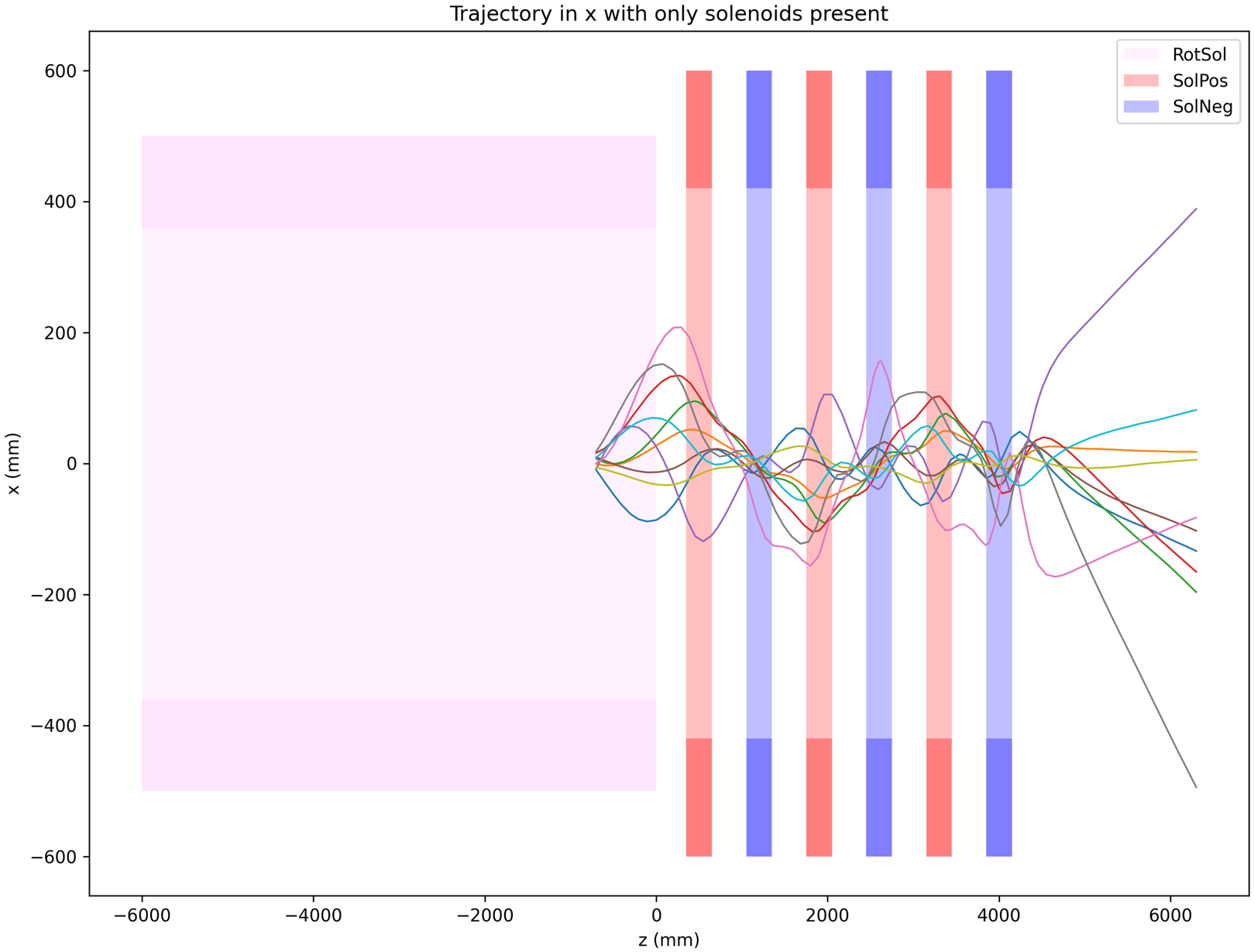
Muon Cooling

Week 3 | June 16, 2025 — June 22, 2025

Rithika Ganesan

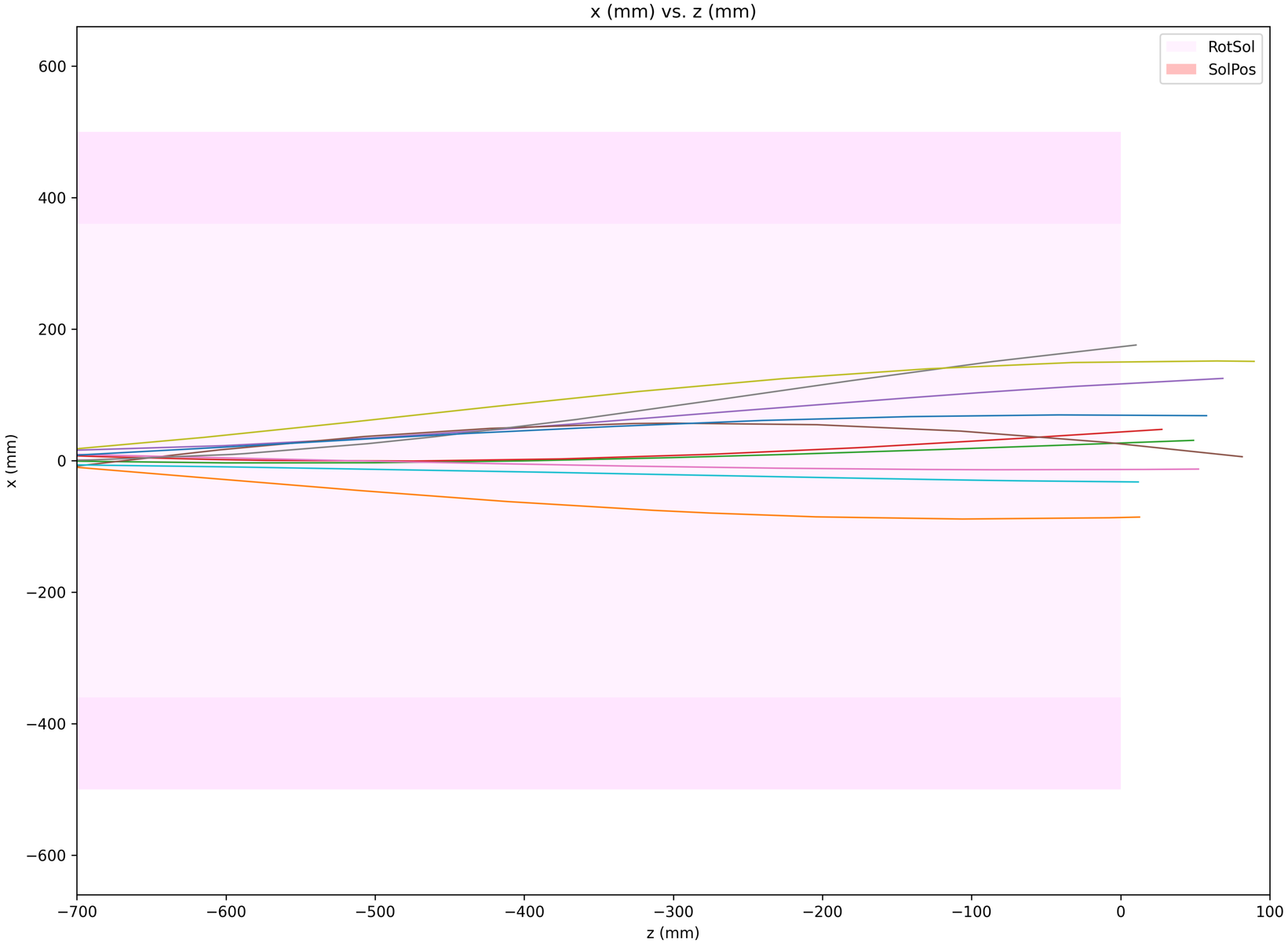
Schematic (only solenoids)



Pitches not visible but present!

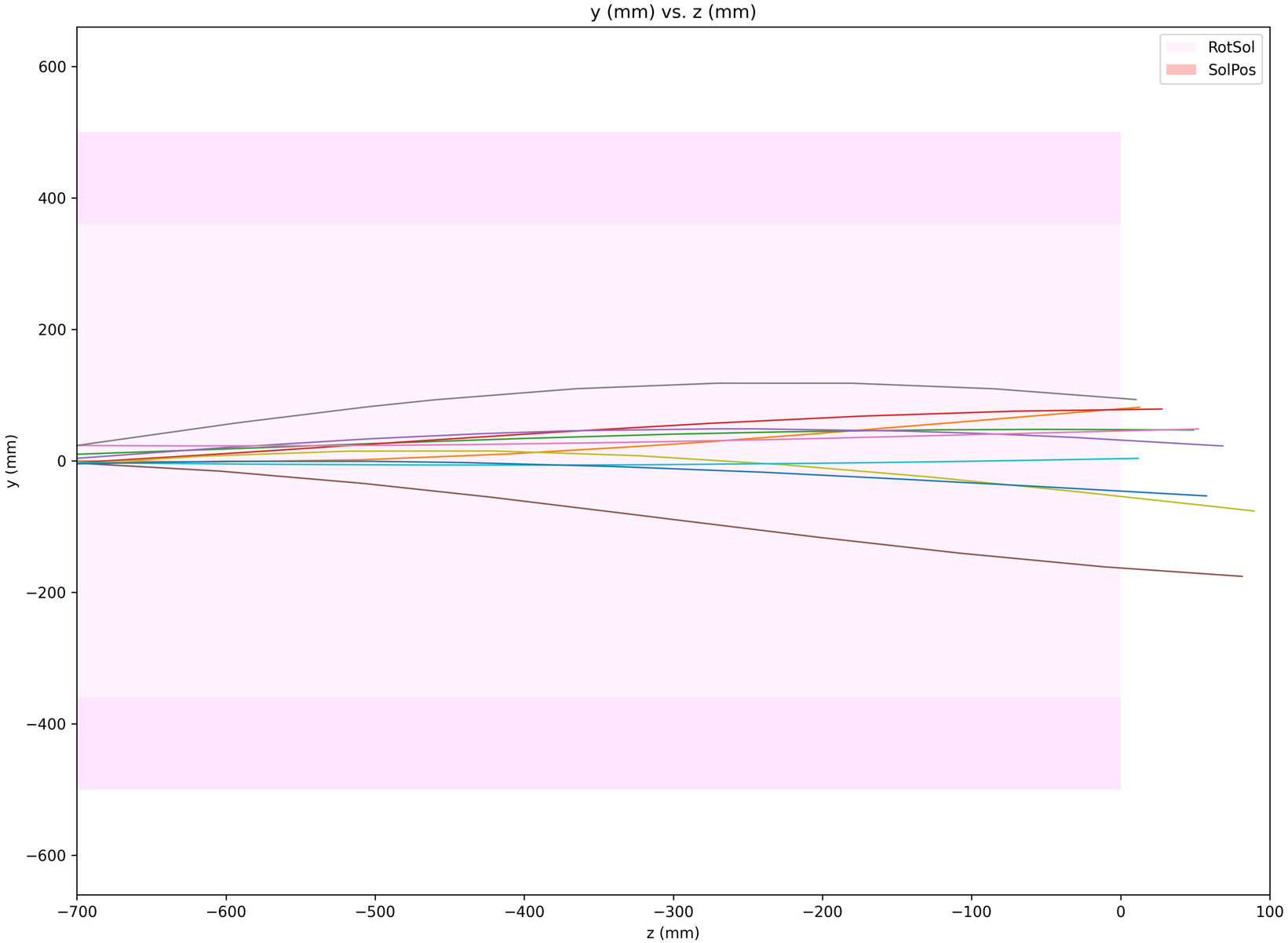
Rotational solenoid

x vs. z



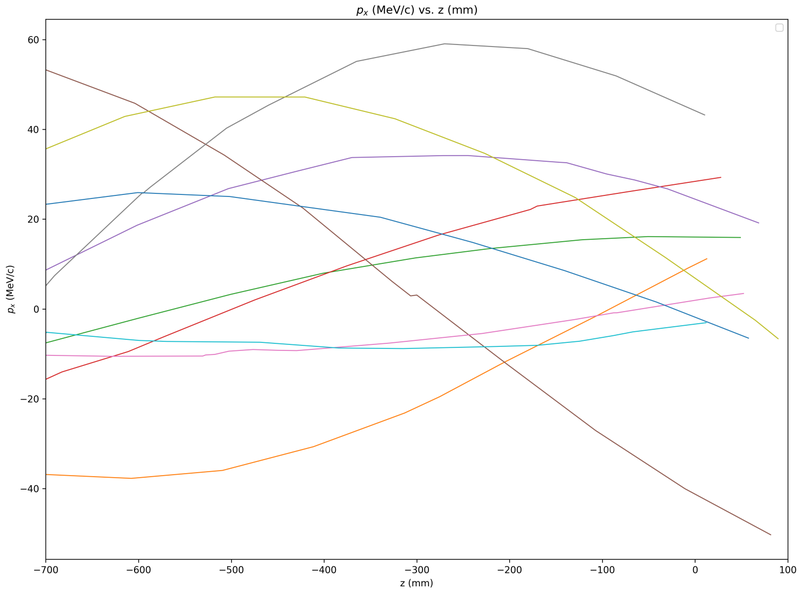
Rotational solenoid

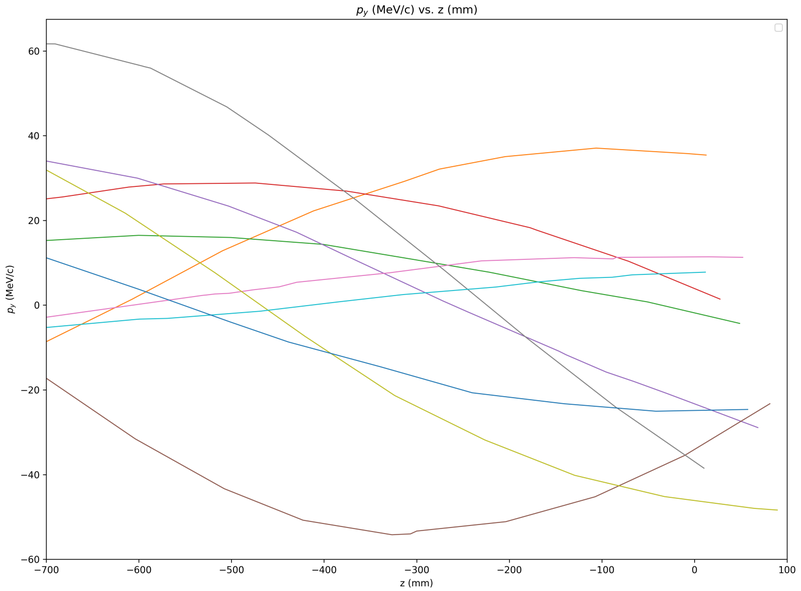
y vs. z

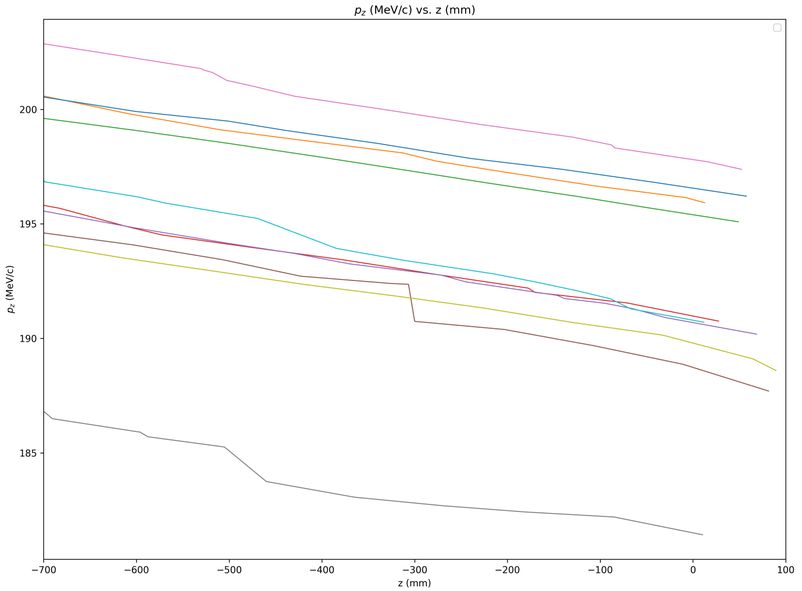


Rotational solenoid

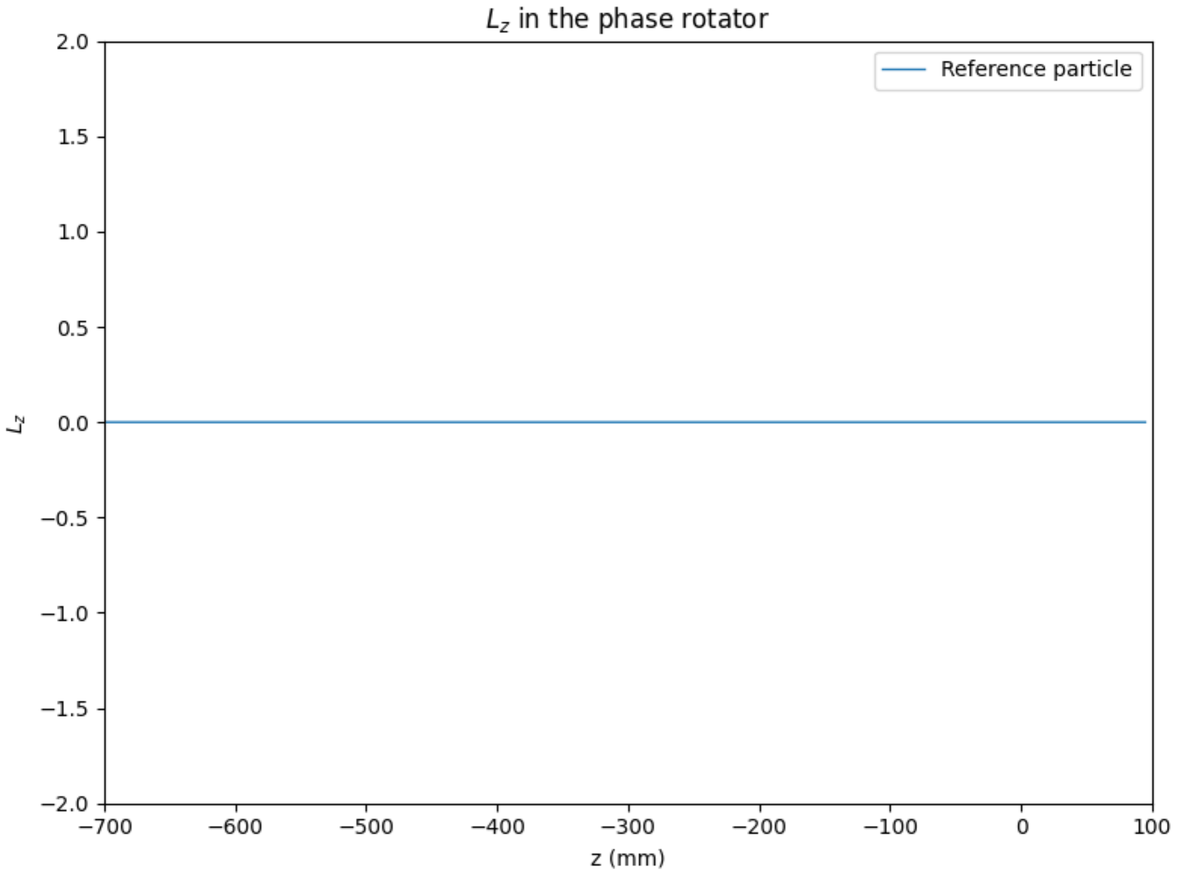
p_i vs. z

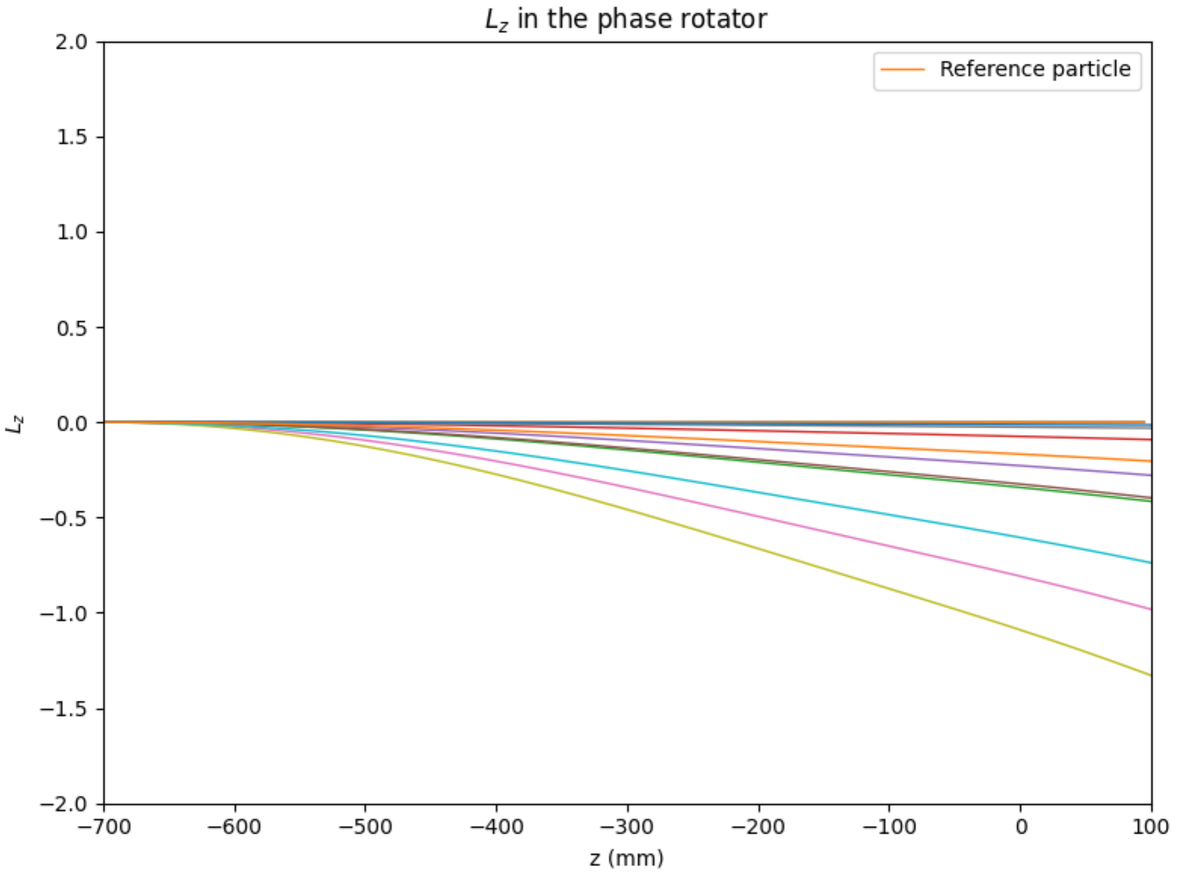




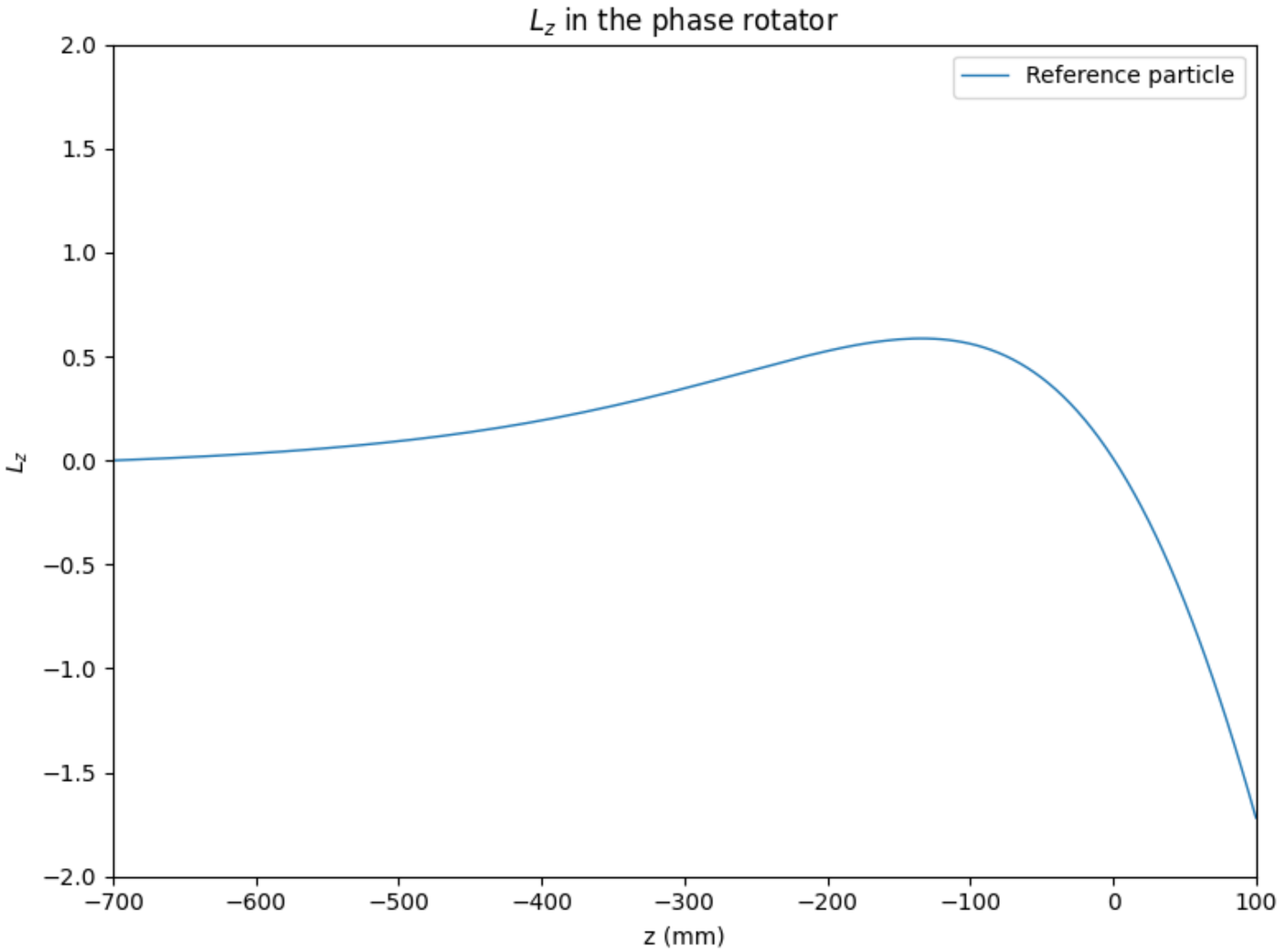


Angular momentum, no offset reference particle





Angular momentum (reference particle with offset)



Switching to .root files

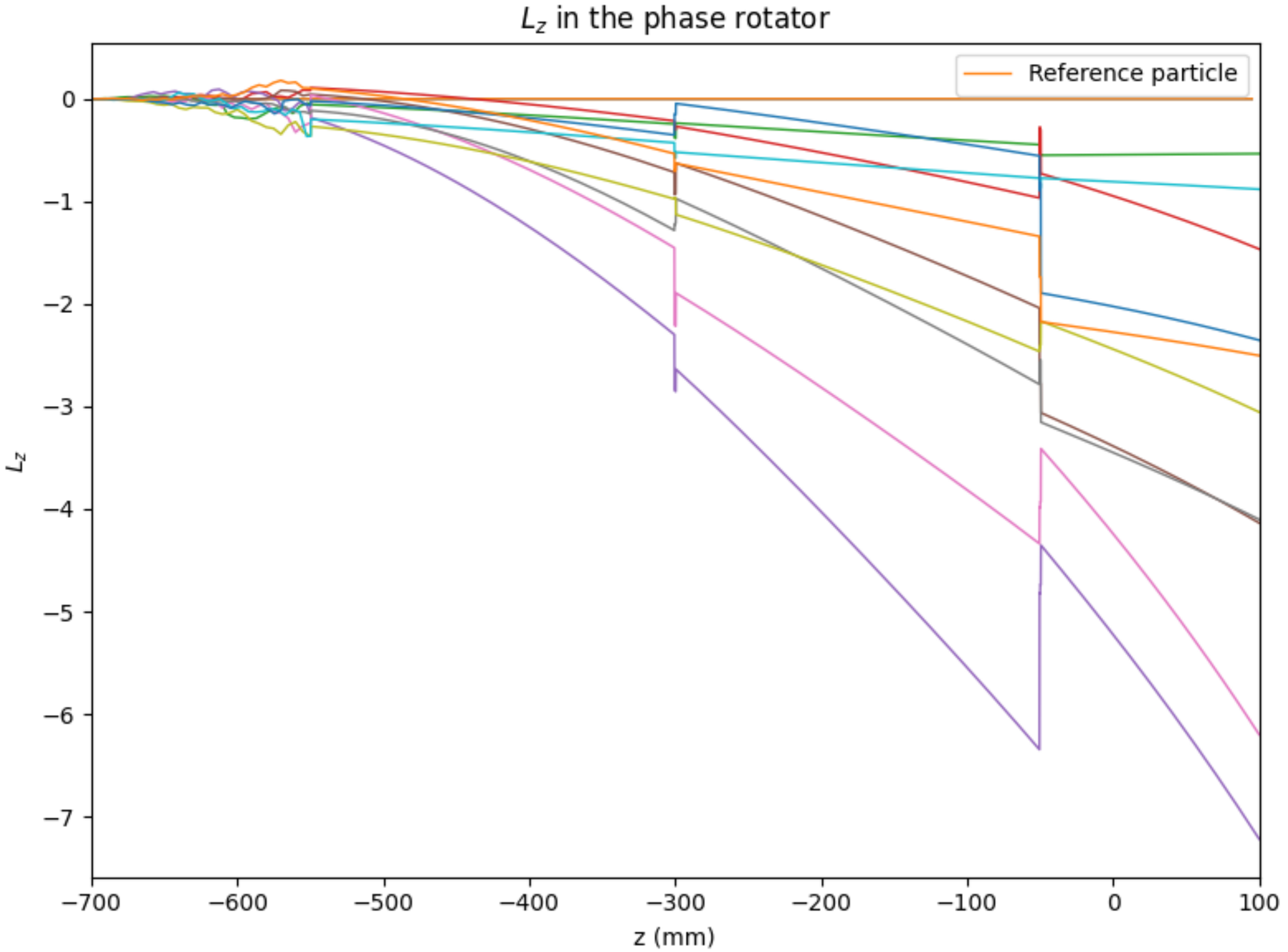
- Ran g4bl with docker
- Could produce root files
- Root file data → all columns float32
- Set up pandas workflow with uproot

name	typename	interpretation
x	float	AsDtype('>f4')
y	float	AsDtype('>f4')
z	float	AsDtype('>f4')
Px	float	AsDtype('>f4')
Py	float	AsDtype('>f4')
Pz	float	AsDtype('>f4')
t	float	AsDtype('>f4')
PDGid	float	AsDtype('>f4')
EventID	float	AsDtype('>f4')
TrackID	float	AsDtype('>f4')
ParentID	float	AsDtype('>f4')
Weight	float	AsDtype('>f4')
Bx	float	AsDtype('>f4')
By	float	AsDtype('>f4')
Bz	float	AsDtype('>f4')
Ex	float	AsDtype('>f4')
Ey	float	AsDtype('>f4')
Ez	float	AsDtype('>f4')

Angular momentum (with RFC, absorbers, collimators)

```
place RFC0 z=-425. timeOffset=$toffs0-0.77123842
place RFC0 z=-175. timeOffset=$toffs0+0.13491993
place RFC0 z=75. timeOffset=$toffs0+1.0410783
```

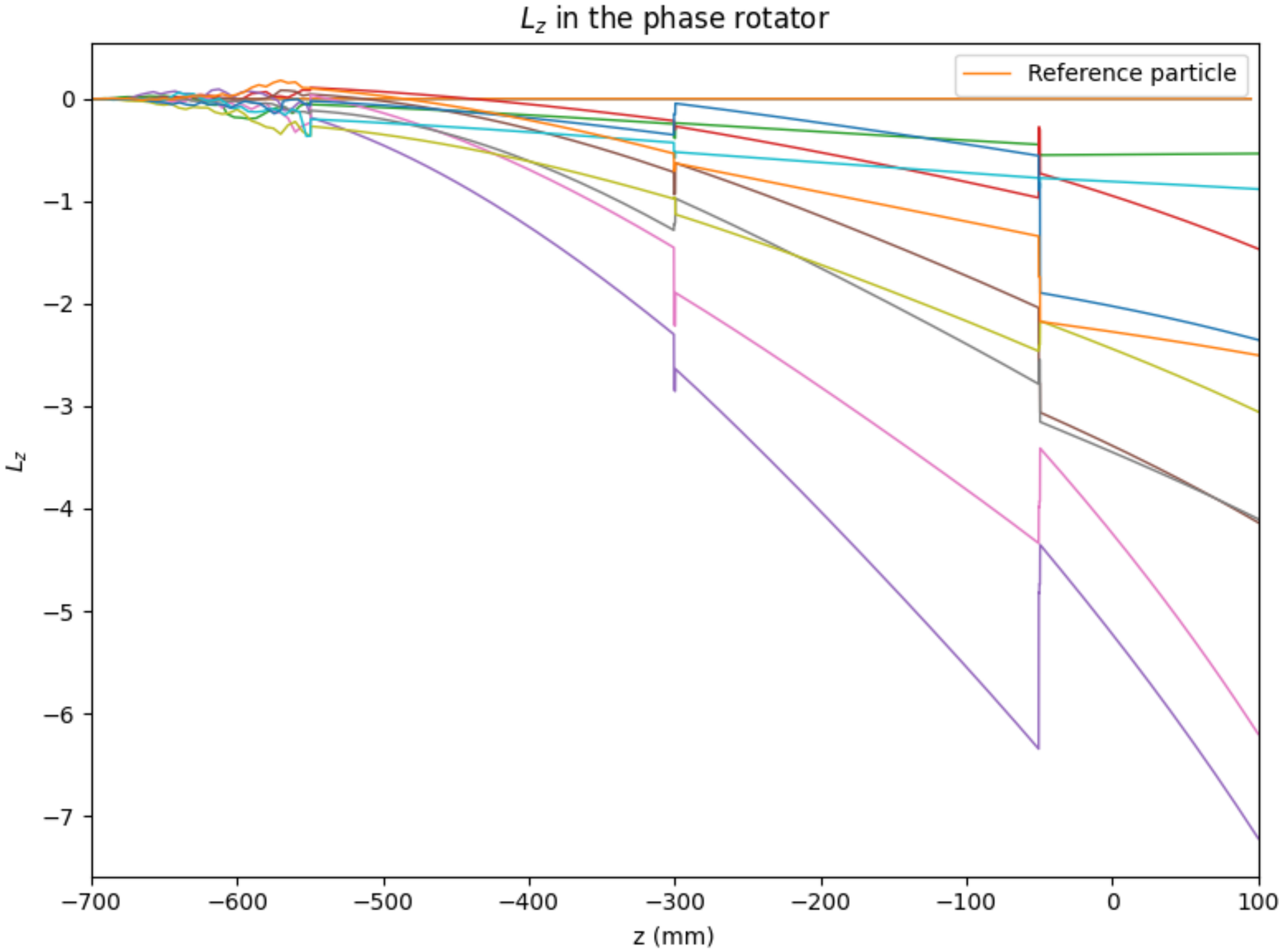
```
beam gaussian particle=mu+ \
    nEvents=100 \
    beamZ=$beamstart \
    sigmaX=0.0 \
    sigmaY=0.0 \
    sigmaXp=0.001 \
    sigmaYp=0.001 \
    meanMomentum=200.0 \
    sigmaP=0.0 \
    meanT=0.0 \
    sigmaT=0.0

reference particle=mu+ \
    beamX=0.0 beamY=0.0 \
    beamZ=$beamstart \
    beamXp=0 beamYp=0 \
    referenceMomentum=200.0
```



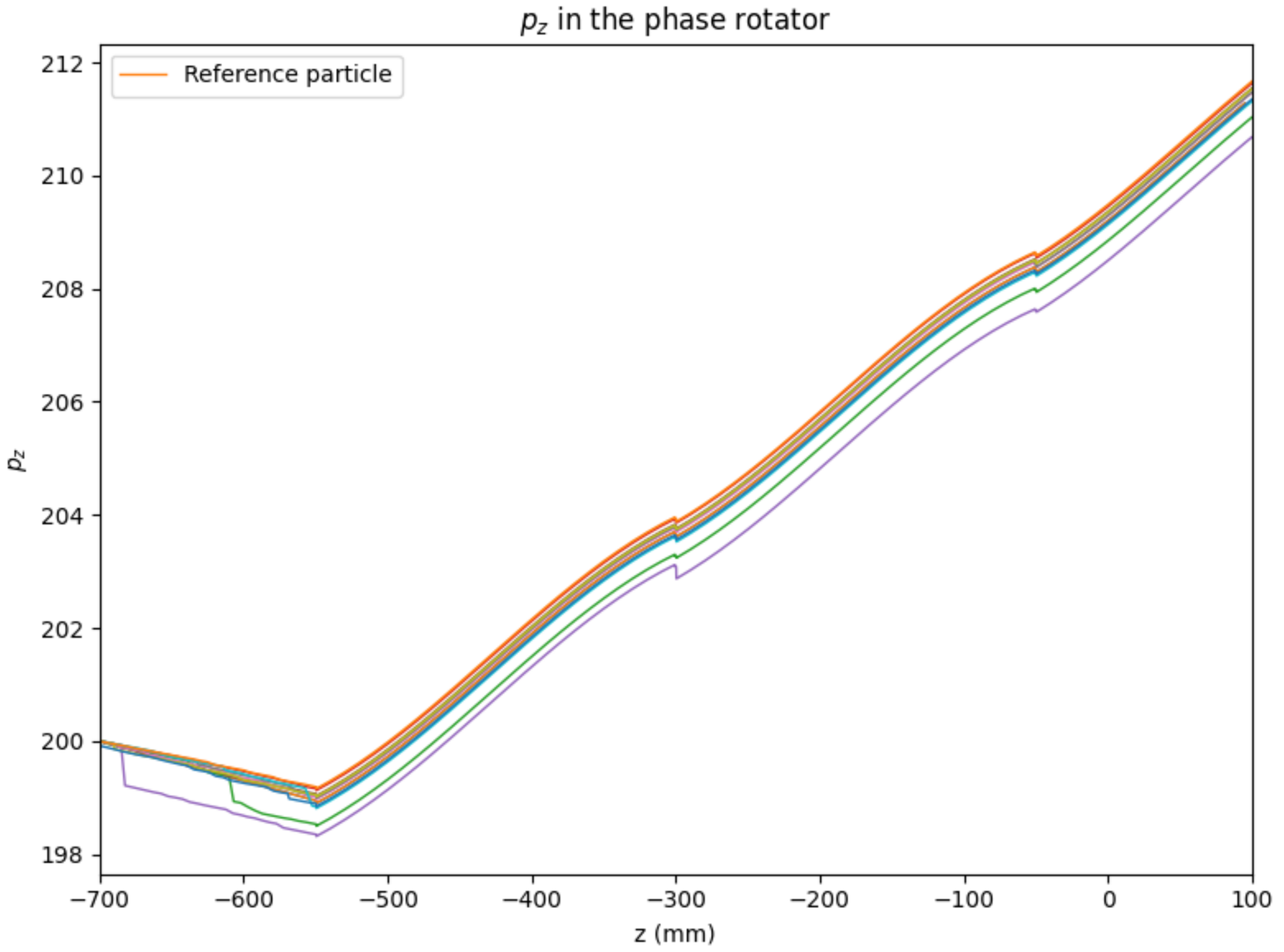
Angular momentum, with RF + terminus

```
place RFC0 z=-425. timeOffset=$toffs0-0.77123842
place RFC0 z=-175. timeOffset=$toffs0+0.13491993
place RFC0 z=75. timeOffset=$toffs0+1.0410783
```

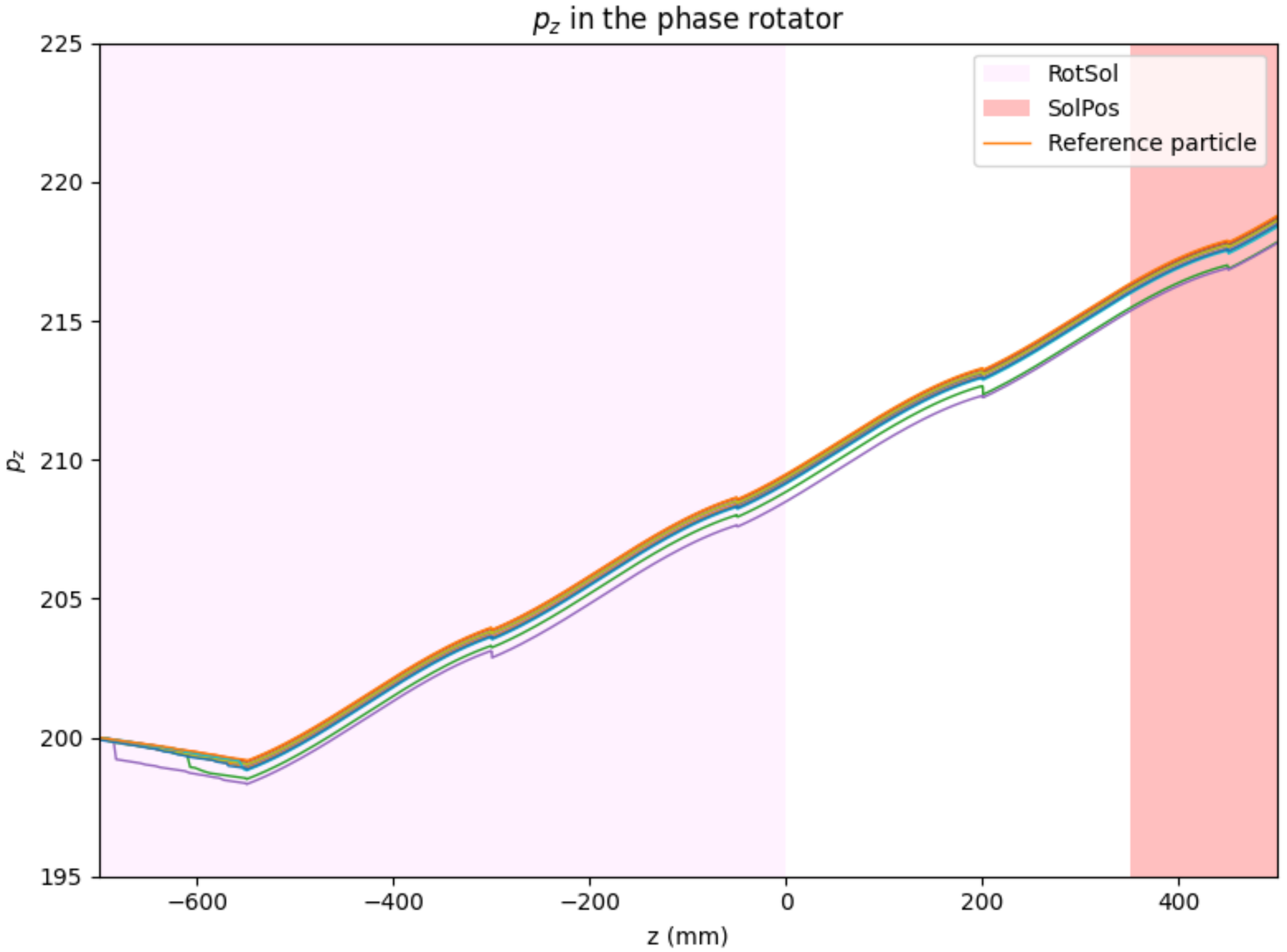
```
beam gaussian particle=mu+ \
    nEvents=100 \
    beamZ=$beamstart \
    sigmaX=0.0 \
    sigmaY=0.0 \
    sigmaXp=0.001 \
    sigmaYp=0.001 \
    meanMomentum=200.0 \
    sigmaP=0.0 \
    meanT=0.0 \
    sigmaT=0.0

reference particle=mu+ \
    beamX=0.0 beamY=0.0 \
    beamZ=$beamstart \
    beamXp=0 beamYp=0 \
    referenceMomentum=200.0
```



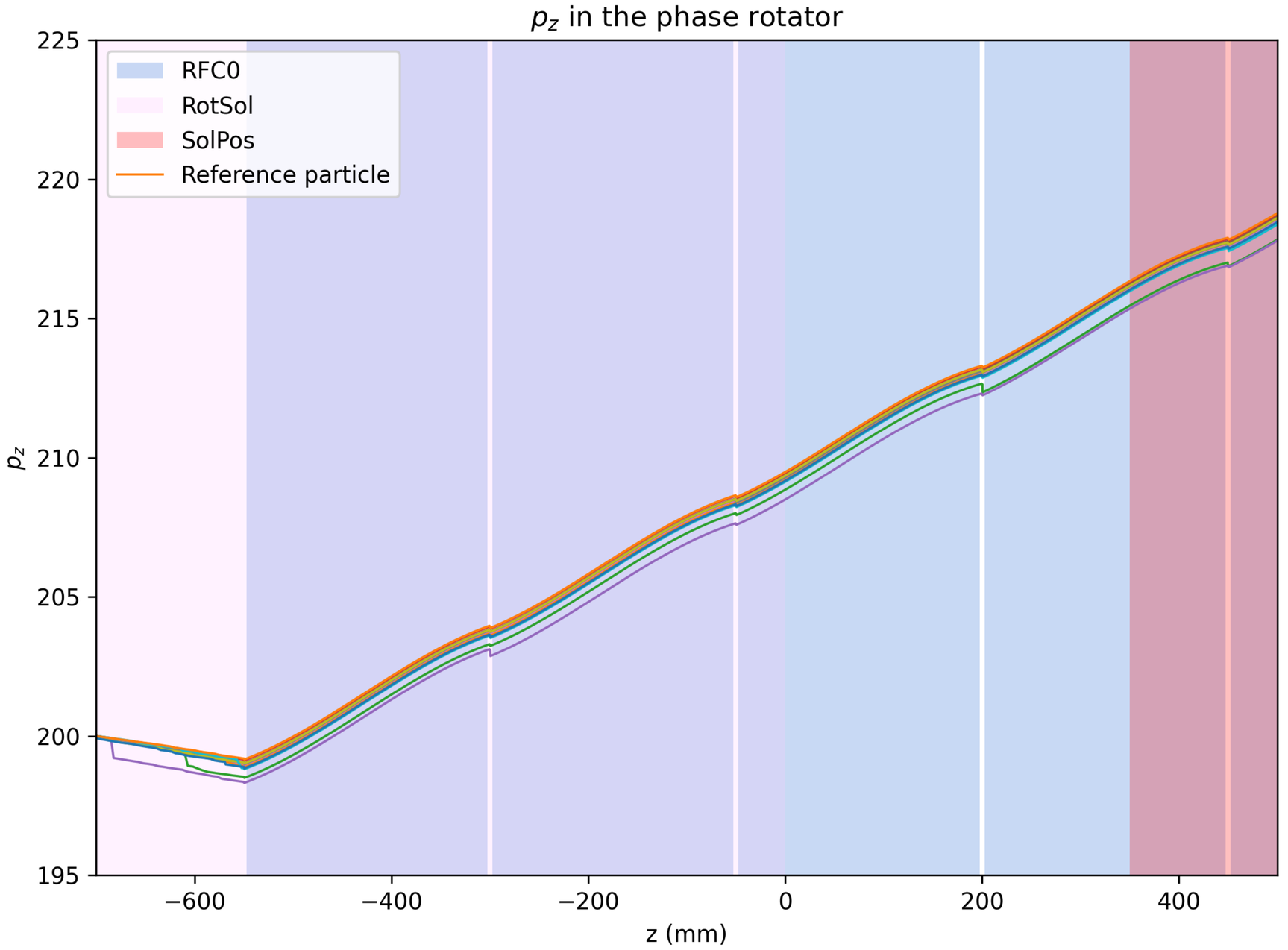
p_z


p_z in the phase rotator
Reference particle
212
210
208
206
204
202
200
198
p_z
−700
−600
−500
−400
−300
−200
−100
0
100
z (mm)

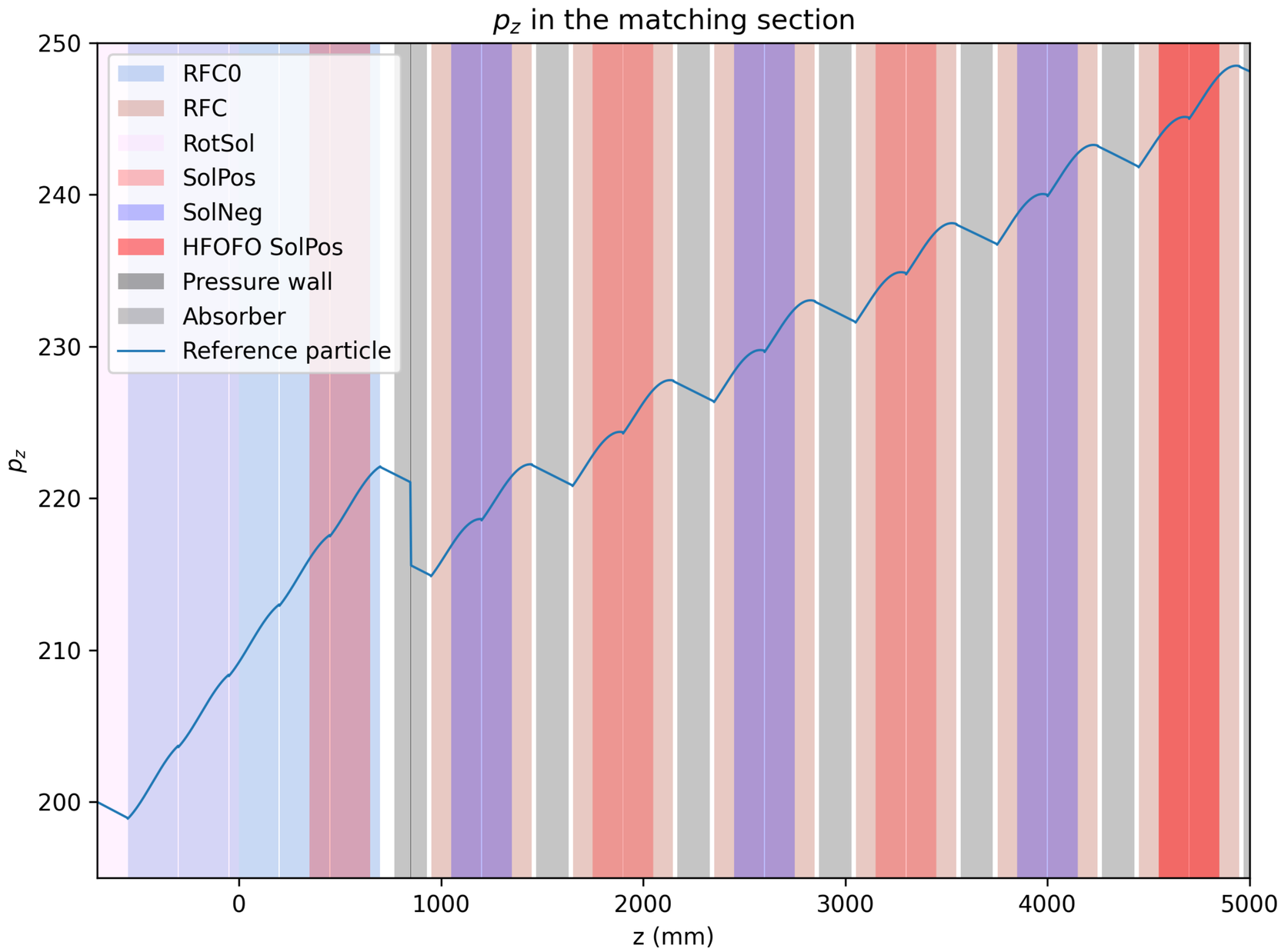
p_z


p_z in the phase rotator
RotSol
SolPos
Reference particle
225
220
215
210
205
200
195
p_z
−600
−400
−200
0
200
400
z (mm)

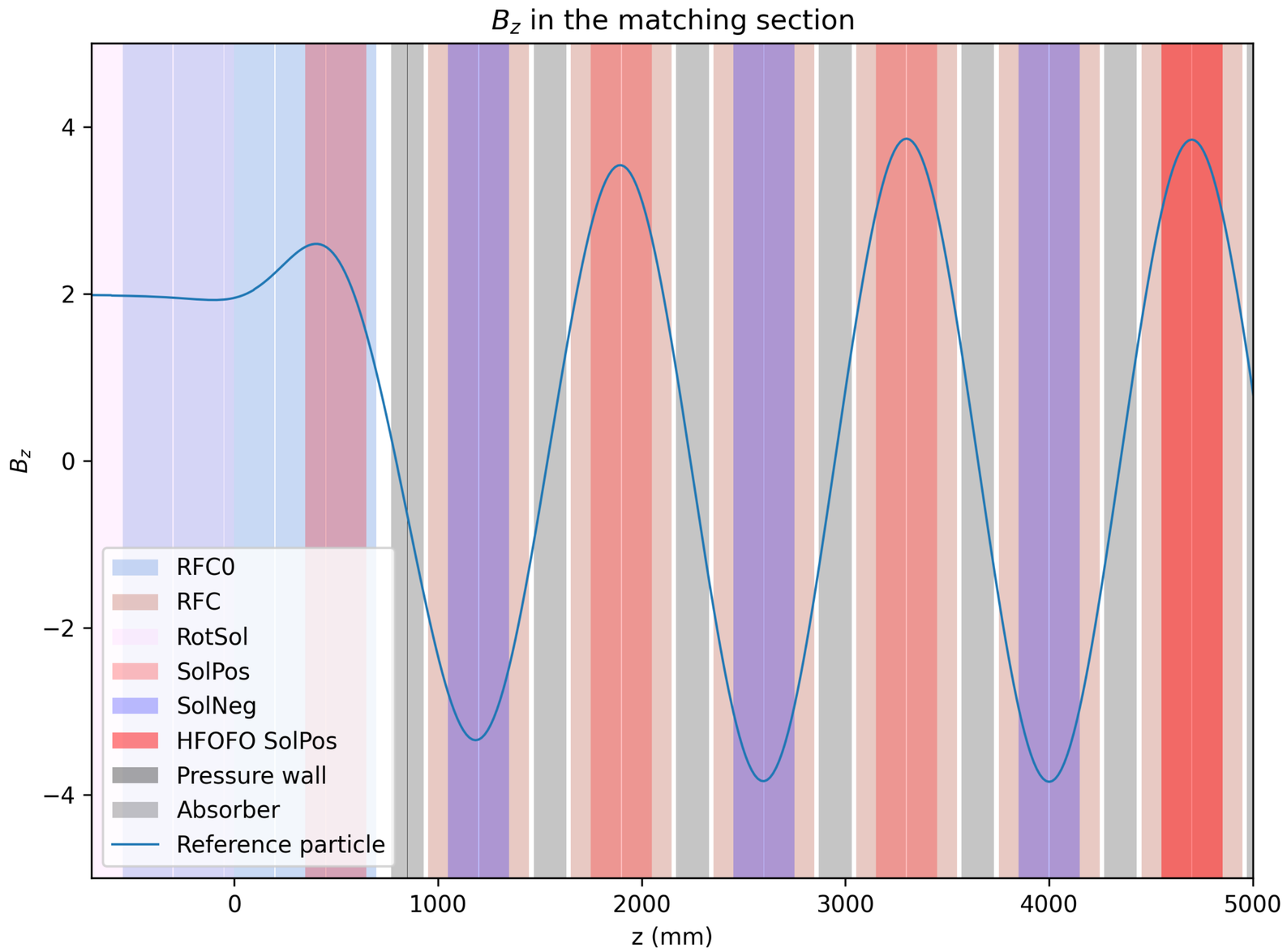
p_z


p_z in the phase rotator
RFC0
RotSol
SolPos
Reference particle
225
220
215
210
205
200
195
p_z
−600
−400
−200
0
200
400
z (mm)

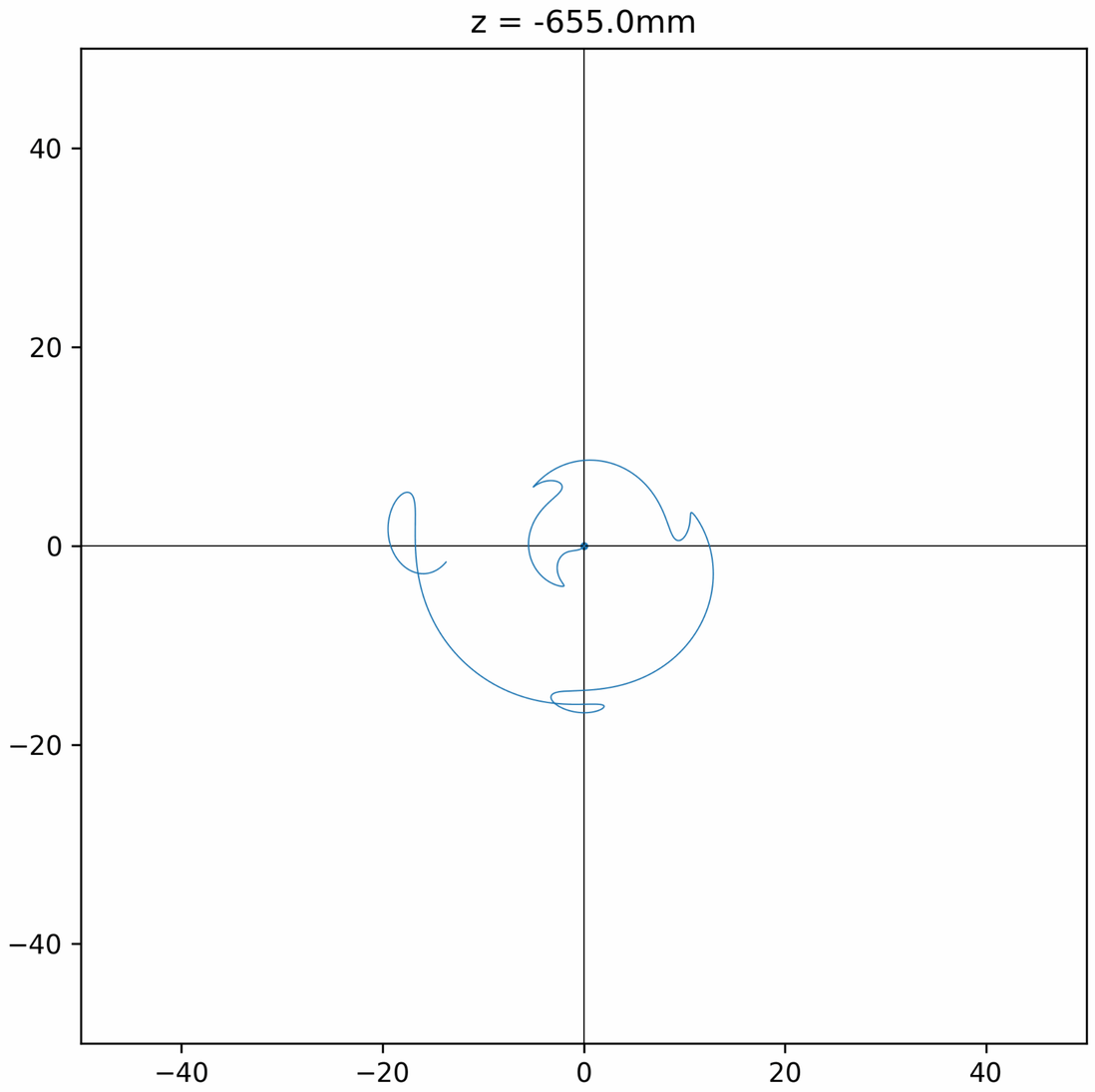
p_z – full matching section



B-field

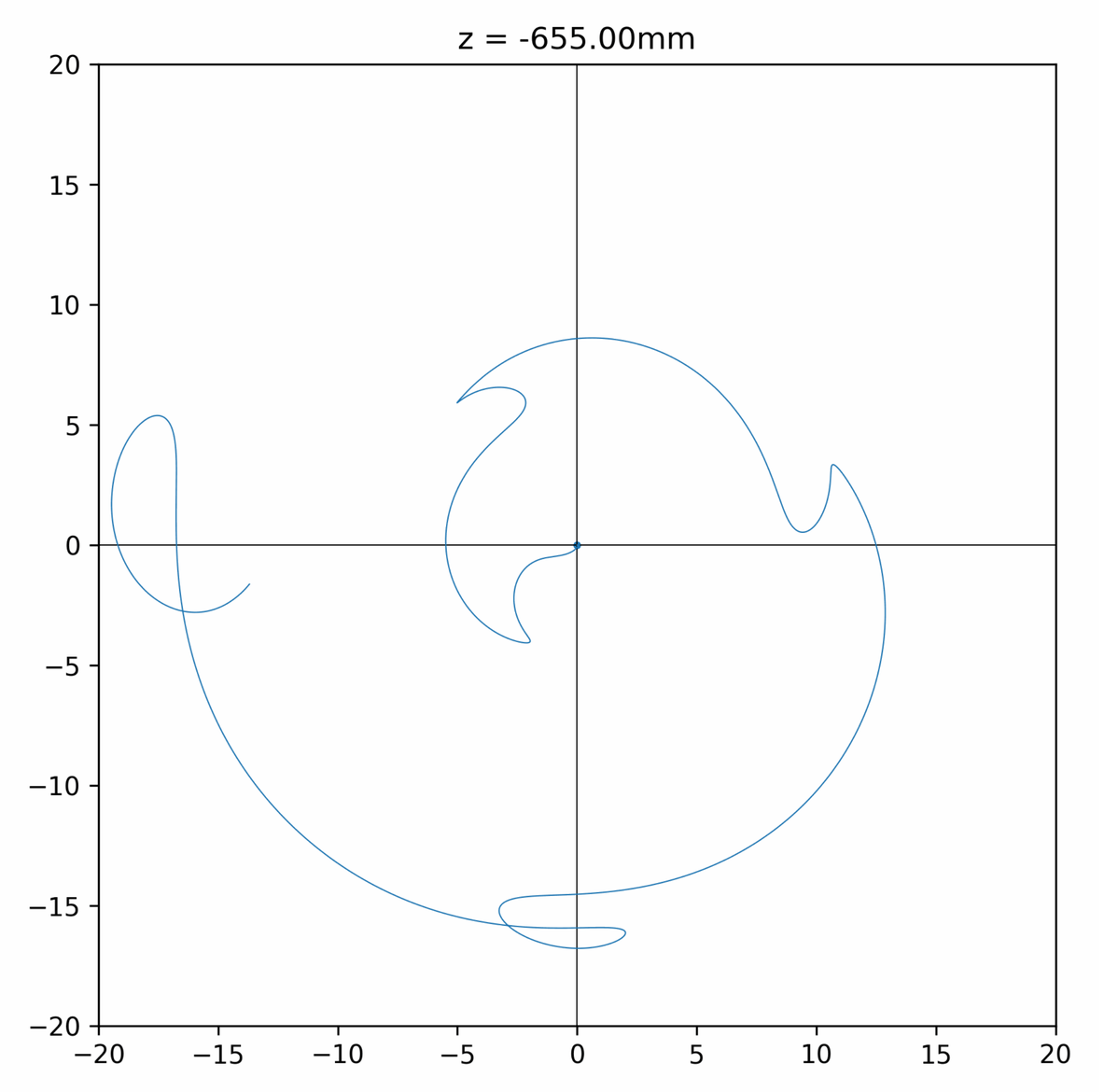

B_z in the matching section
B_z
z (mm)
4
2
0
−2
−4
0
1000
2000
3000
4000
5000
RFC0
RFC
RotSol
SolPos
SolNeg
HFOFO SolPos
Pressure wall
Absorber
Reference particle

Transverse plane: I = 90.1884

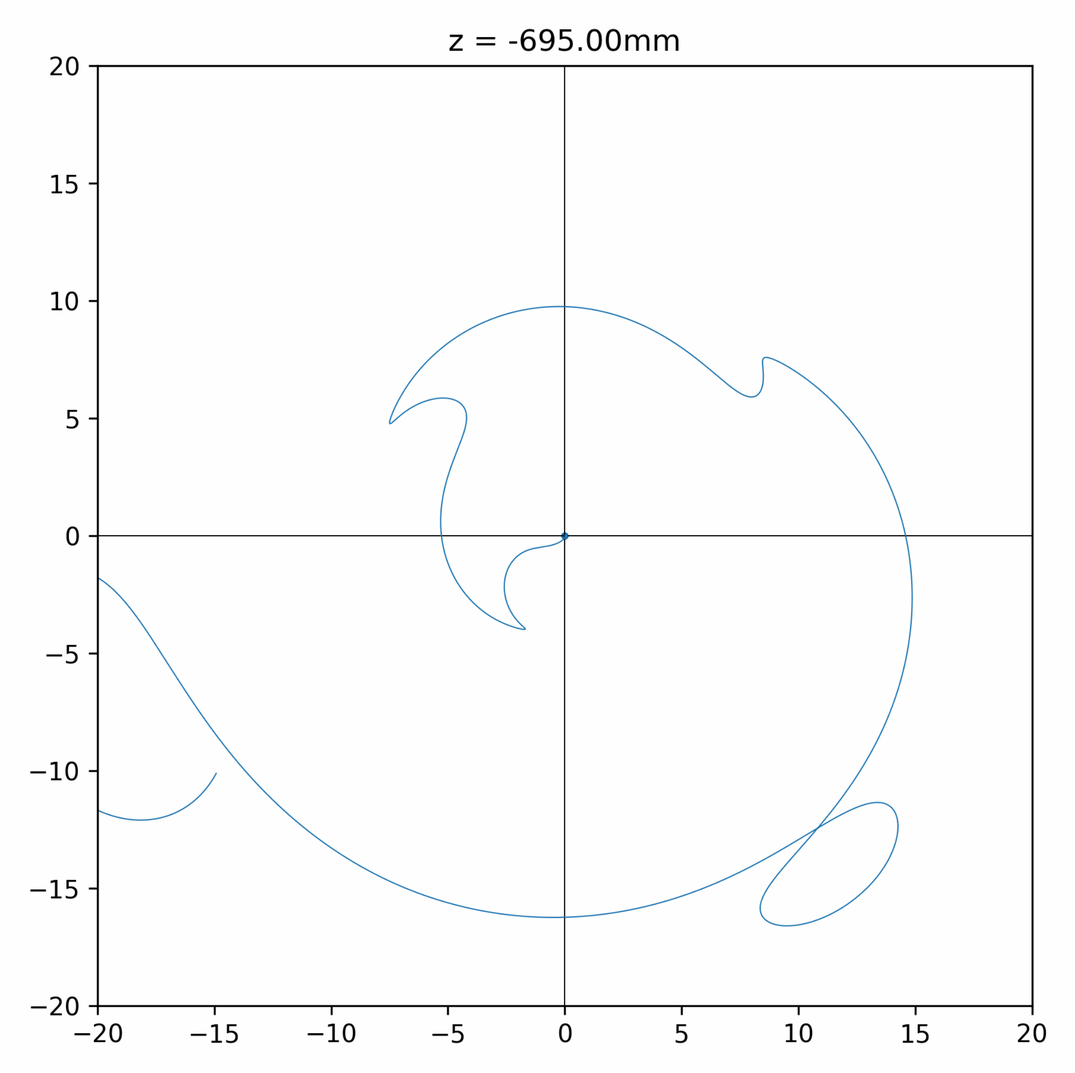


I = 4.421 * BLS

Transverse plane zoomed: I = 90.1884

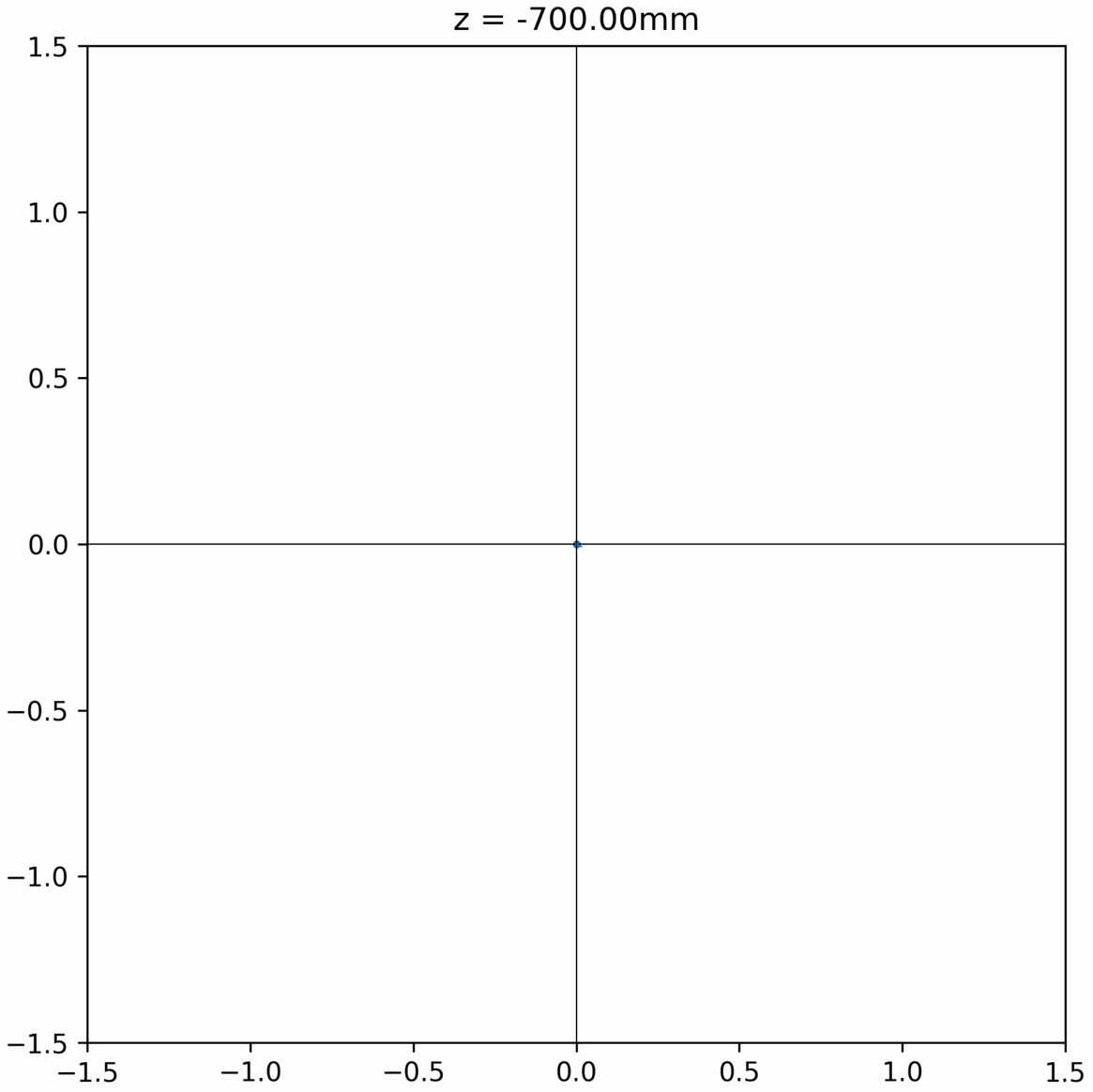


Transverse plane: I = 81.3464



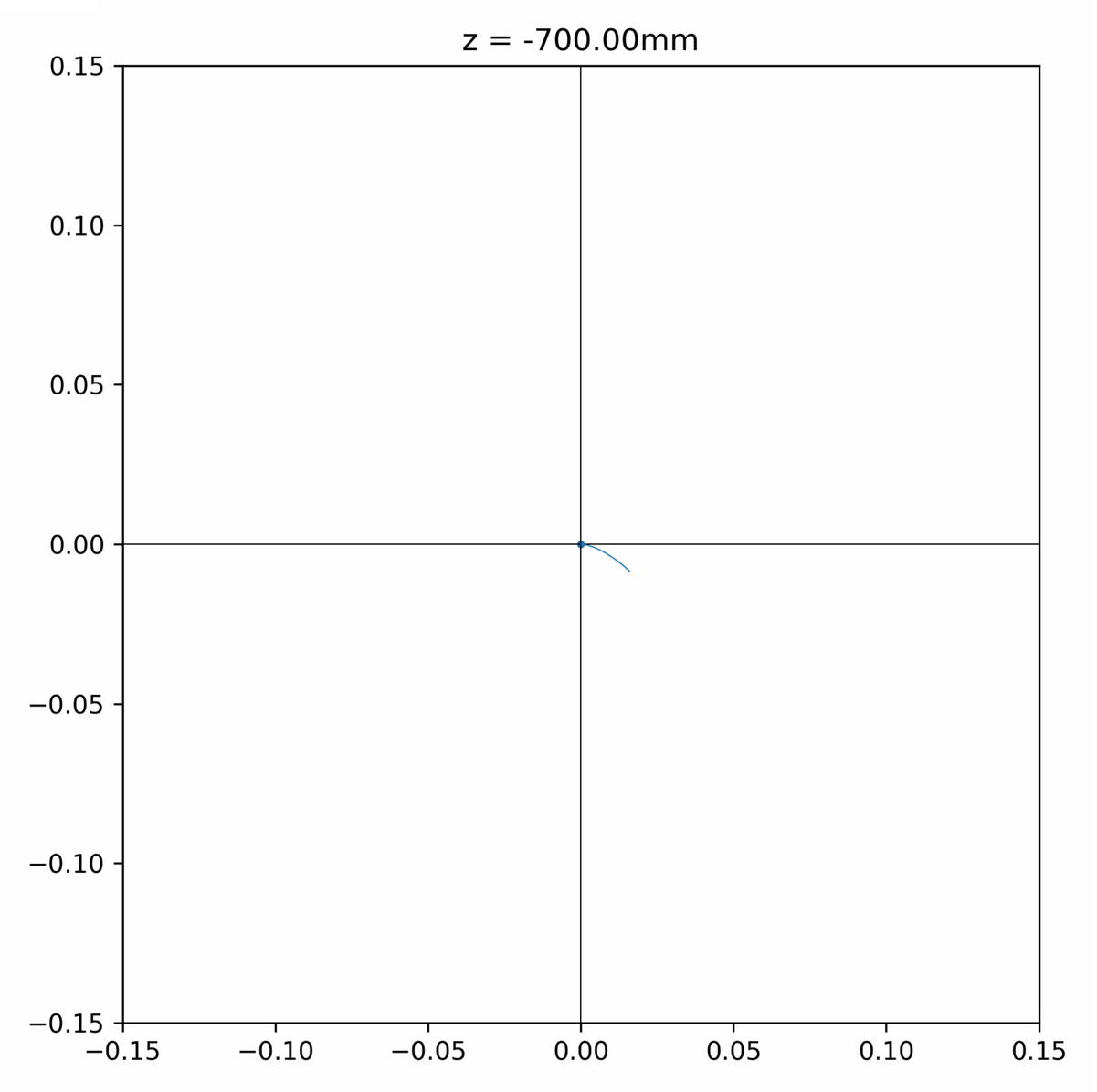
Transverse plane: I = 81.3464

Phase rotator



Transverse plane: I = 81.3464

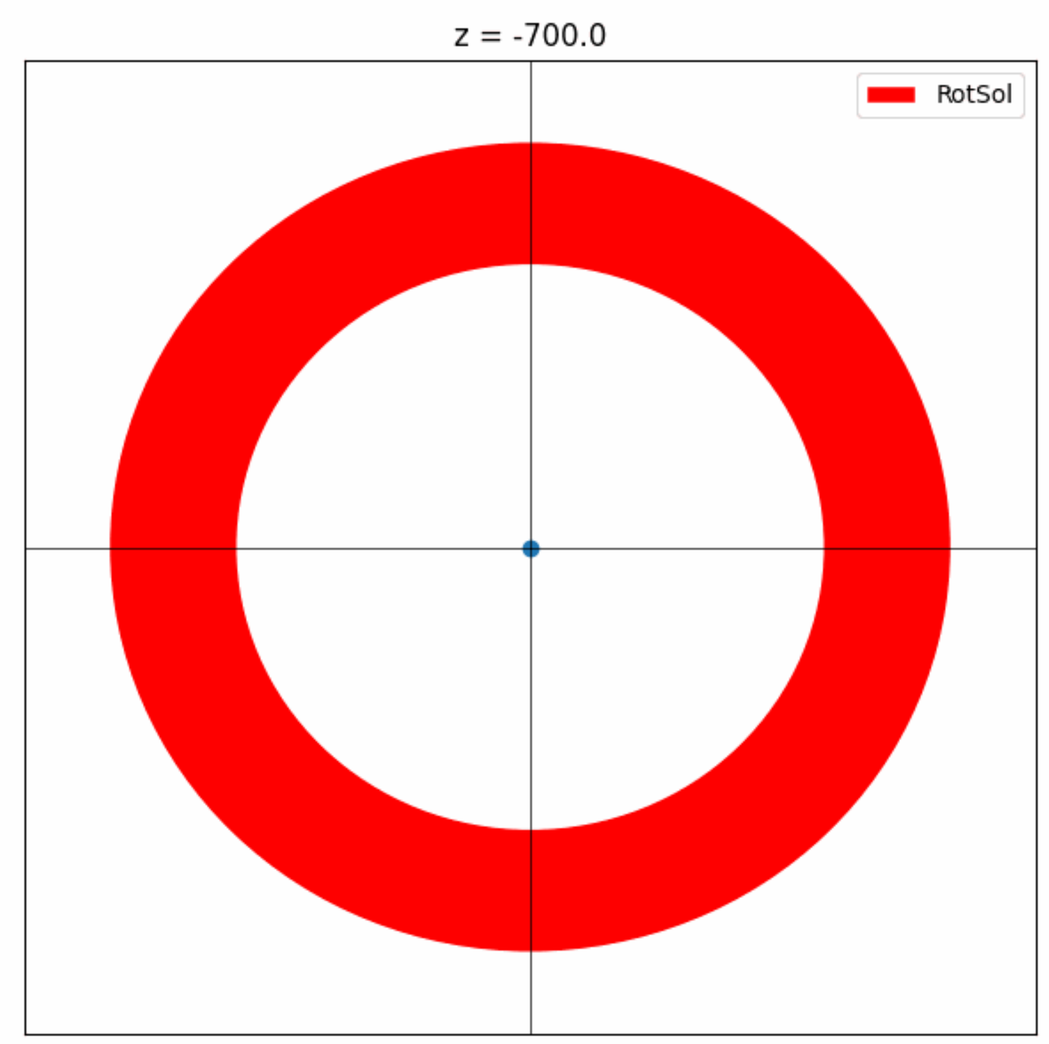
Phase rotator

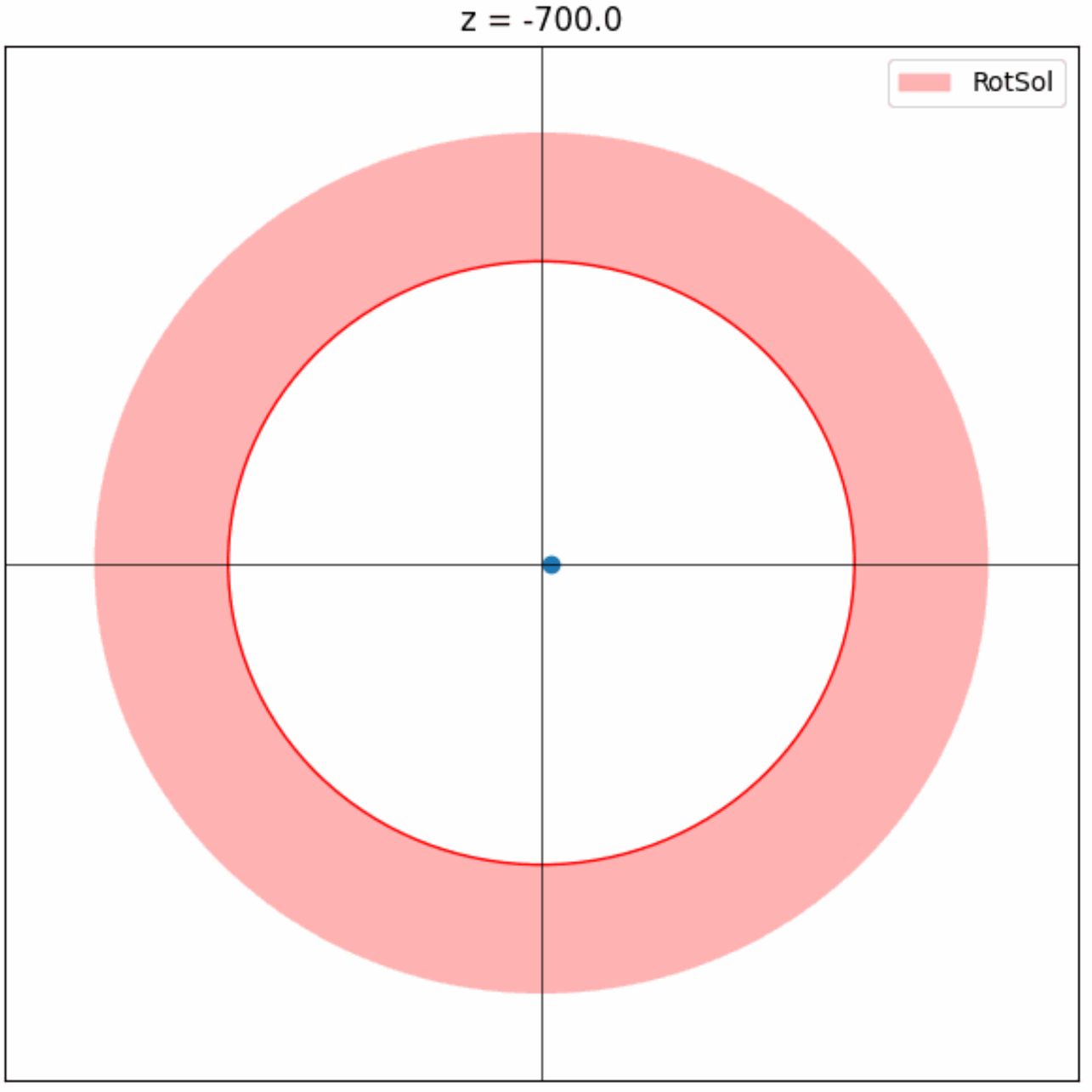


Questions

- Phase rotation → how to study / characterize?
- Studying tilts, currents, RF time offsets: lots of hardcoded parameters, is there an optimal way to approach this?
- Any other parameters/features other than L_z, p_z, transverse B-fields to look at?
- Matching B-field to 200 MeV/c → better approach?
- Beam packet → can I place multiple detectors to study behavior at different z-values?
- Absorbers and RF cavities?

other slides


z = -700.0
RotSol


z = -700.0
RotSol