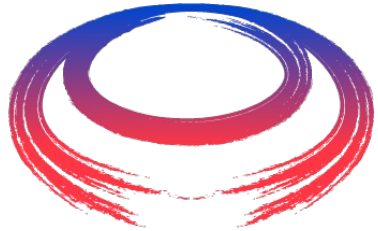
Demonstrator Magnetic Lattice



International MUON Collider Collaboration

C. T. Rogers
Rutherford Appleton Laboratory

Science & Technology Facilities Council
ISIS

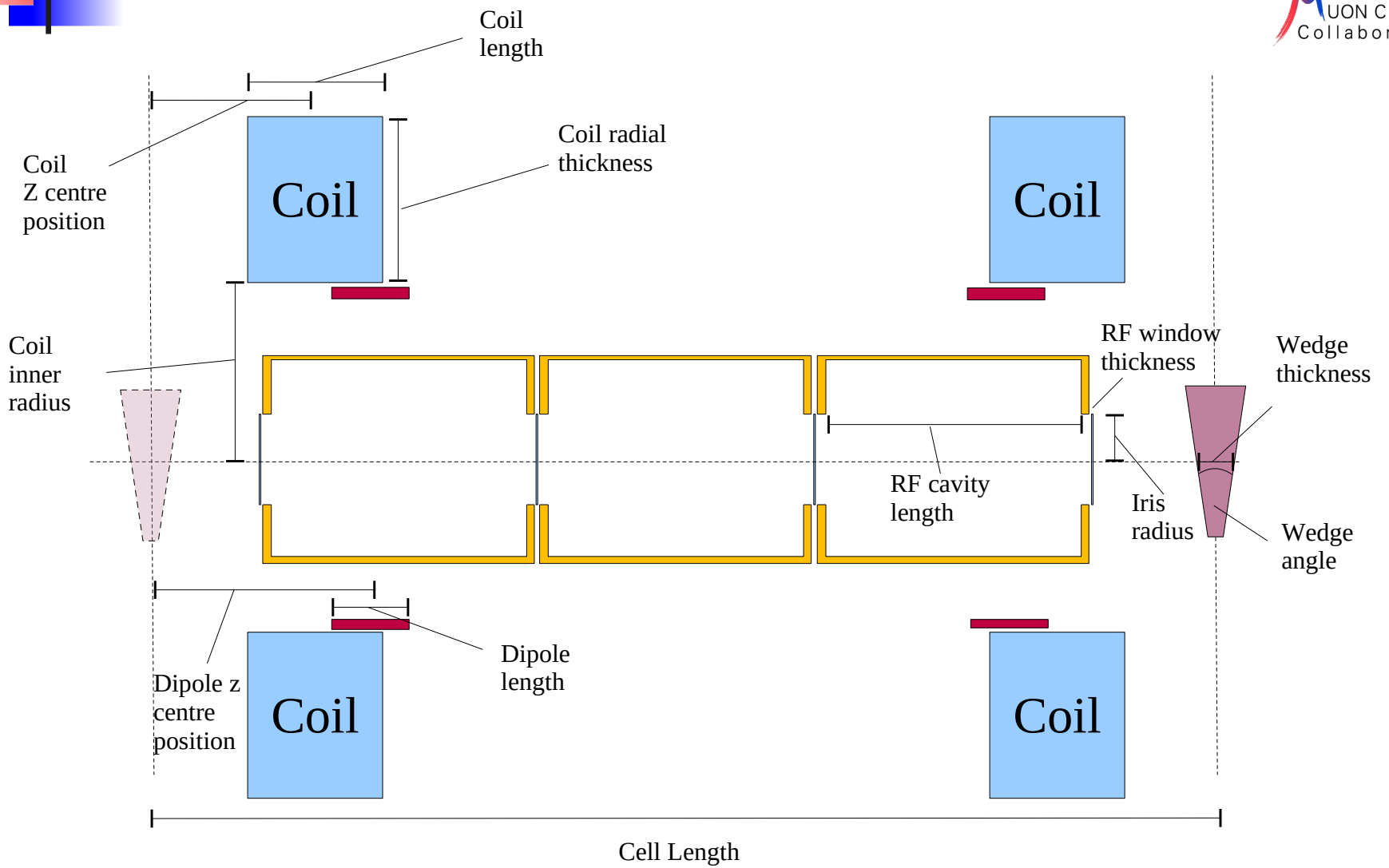
Lattice design process

- Understand basic parameter dependencies
  - Solenoid optics
  - RF/longitudinal optics
  - Dipole field/dispersion ← I am here
- Lattice design
  - Choose working point based on parameter dependencies
  - By-hand optimisation based on reasoned arguments
- Final optimisation
  - Throw into some optimiser

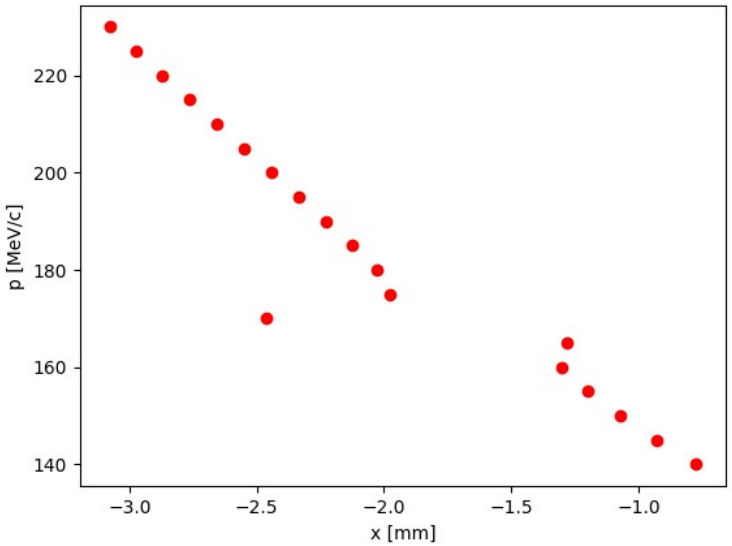
Last time...

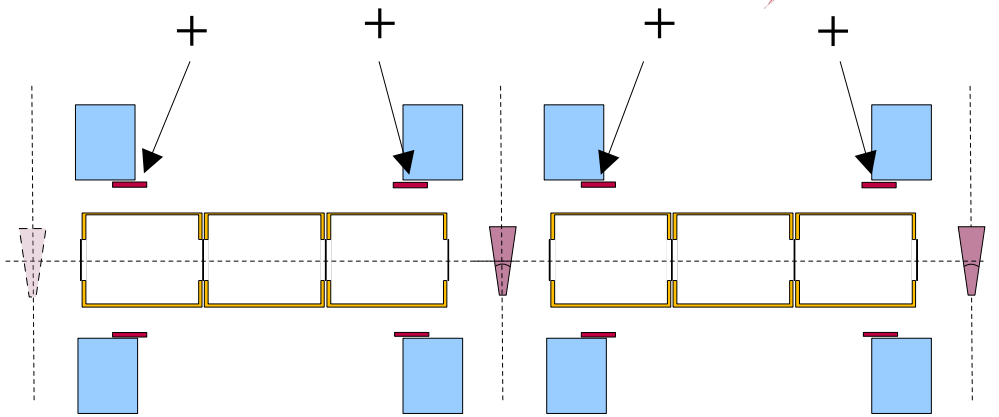
- Last time
  - Found some good working magnet parameters
  - Started looking at RF
  - Started looking at dispersion control
- This time
  - Settle on cooling cell parameters
  - Look at performance indicators

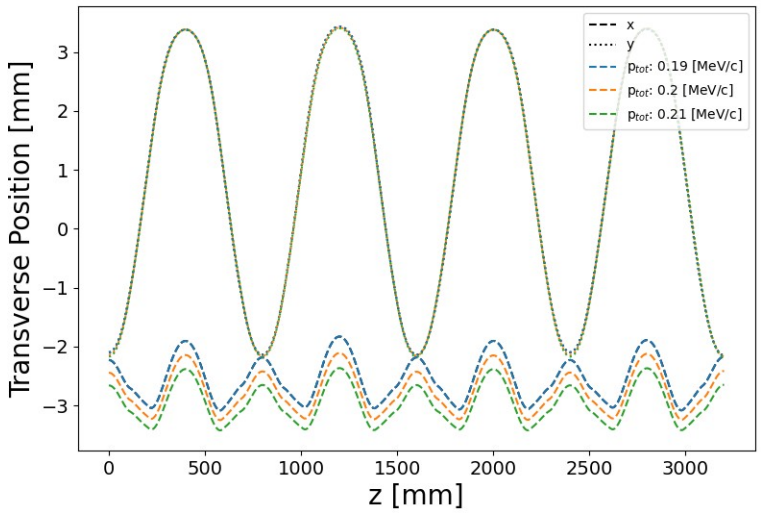
Schematic – one (half) cell

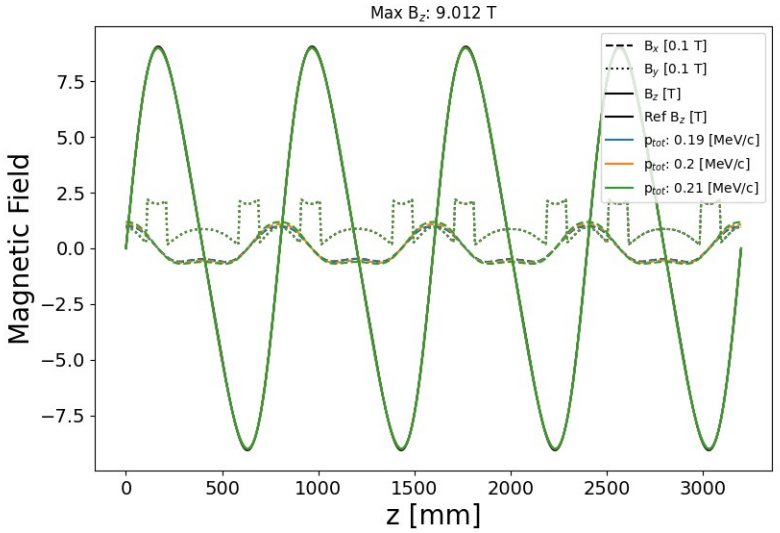


Closed Orbit: ++++

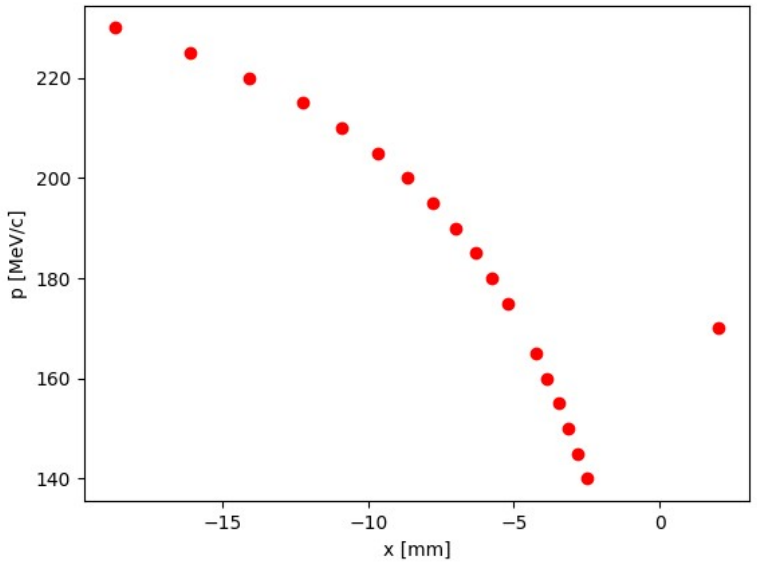


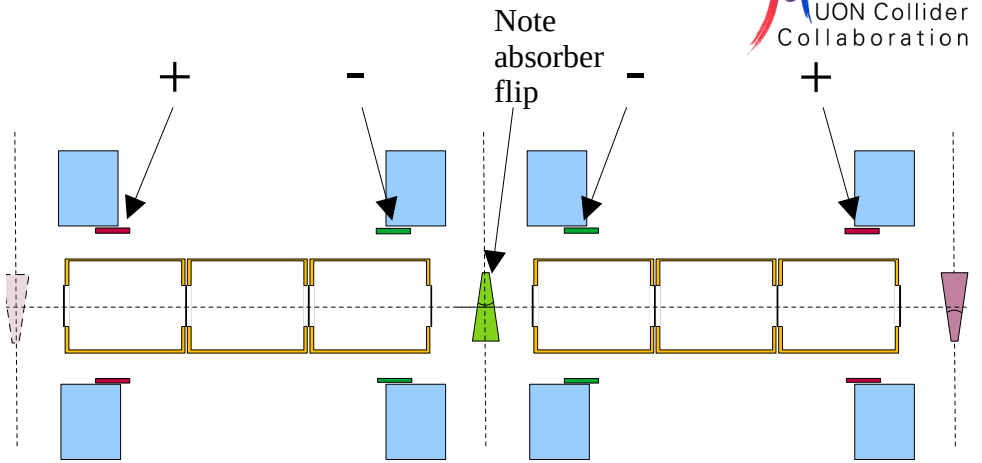


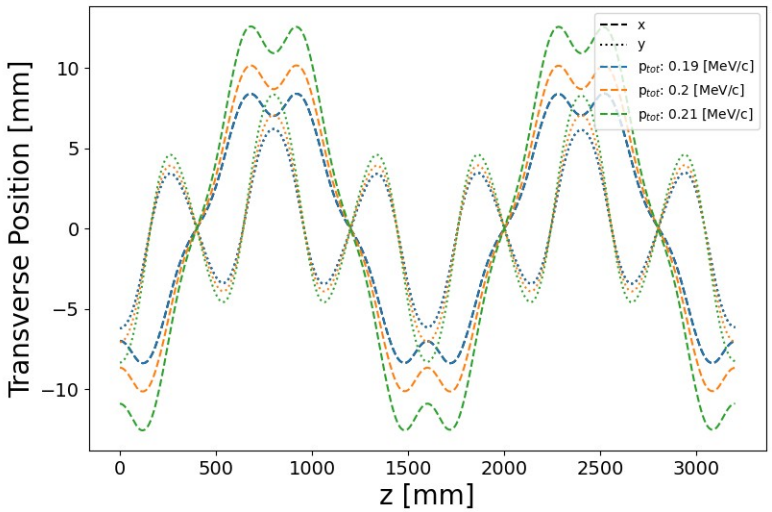


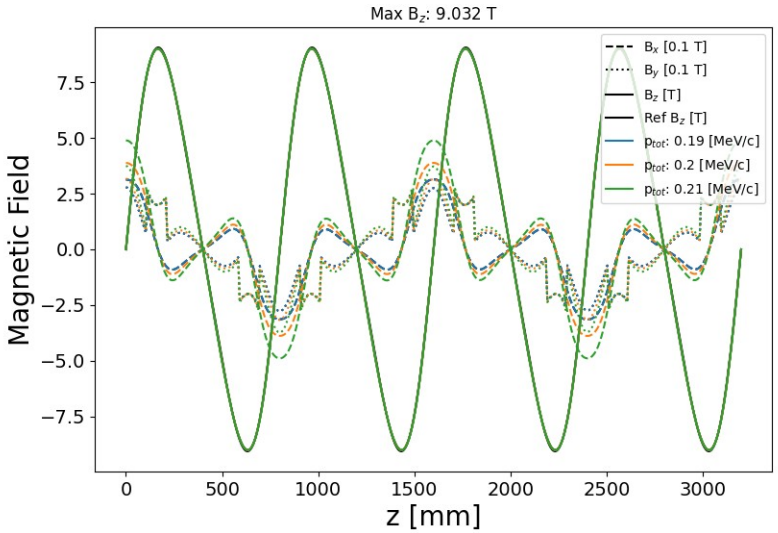


Closed orbit: +--+

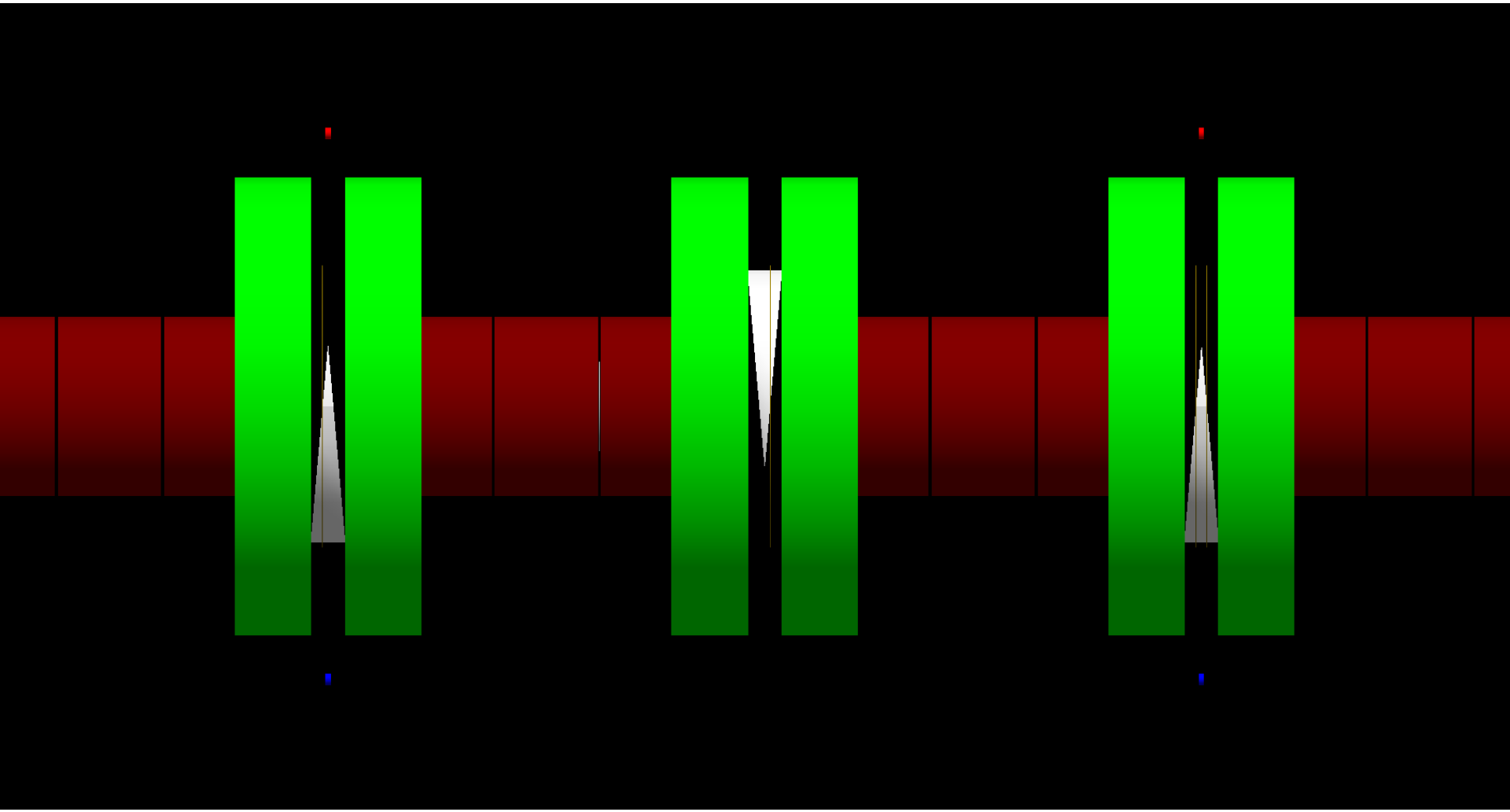






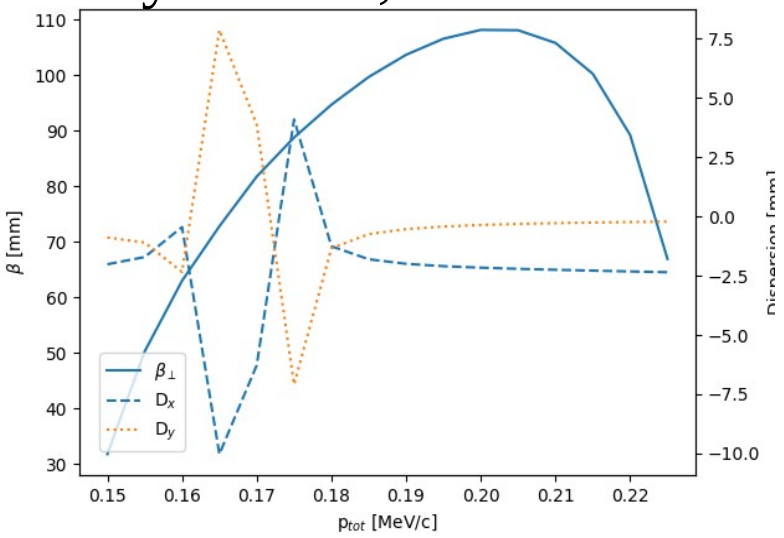


Schematic – one (half) cell

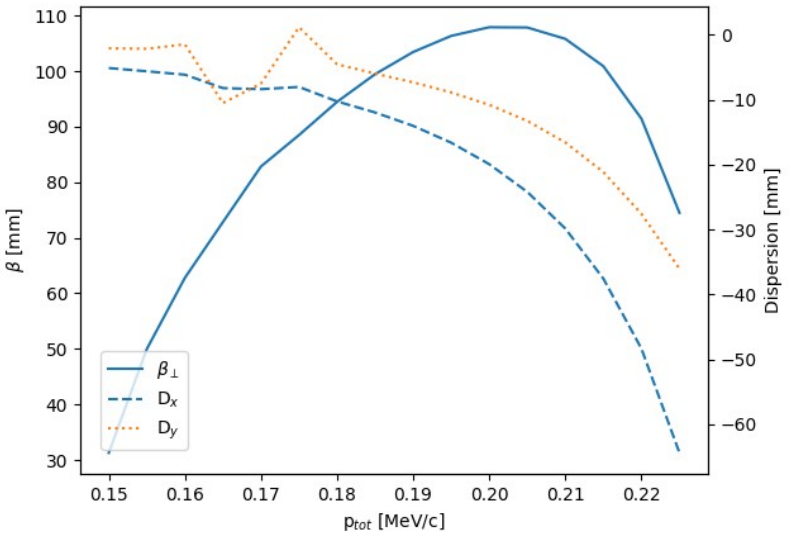


Dispersion

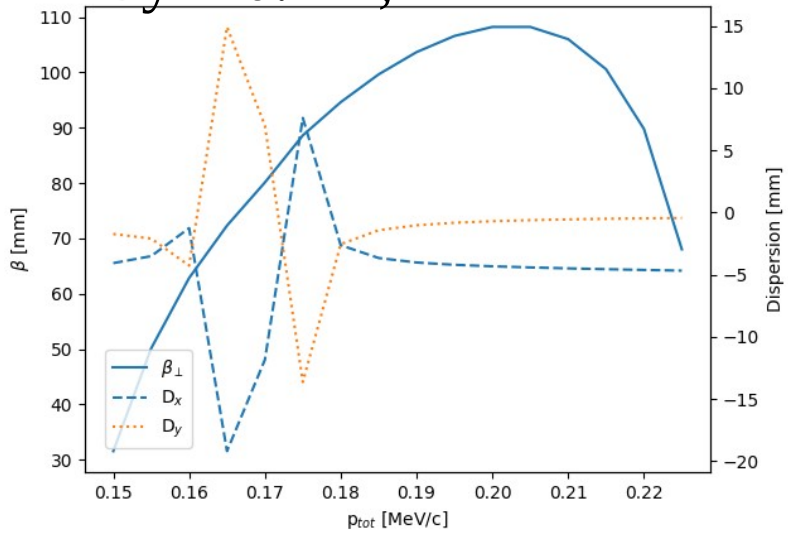
By = 0.1 T; ++++



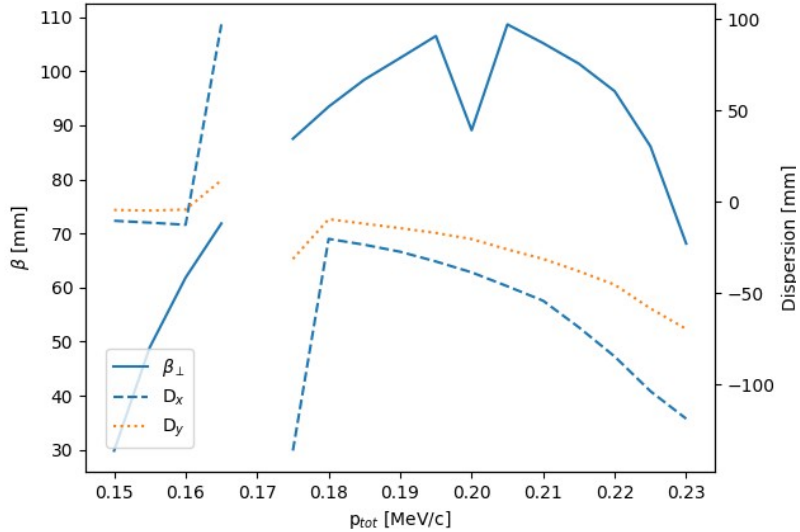
By = 0.1 T; +--+



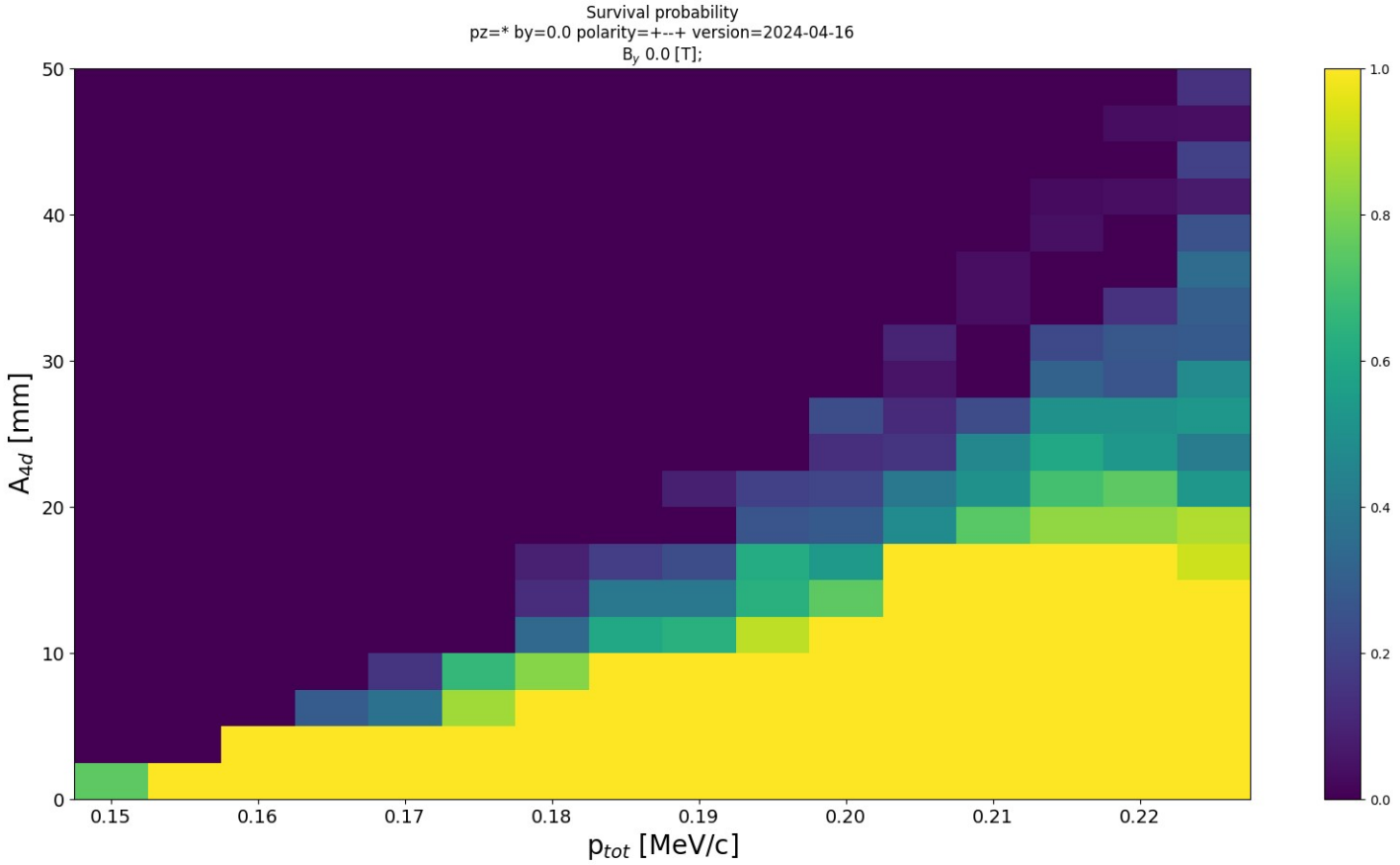
By = 0.2 T; ++++



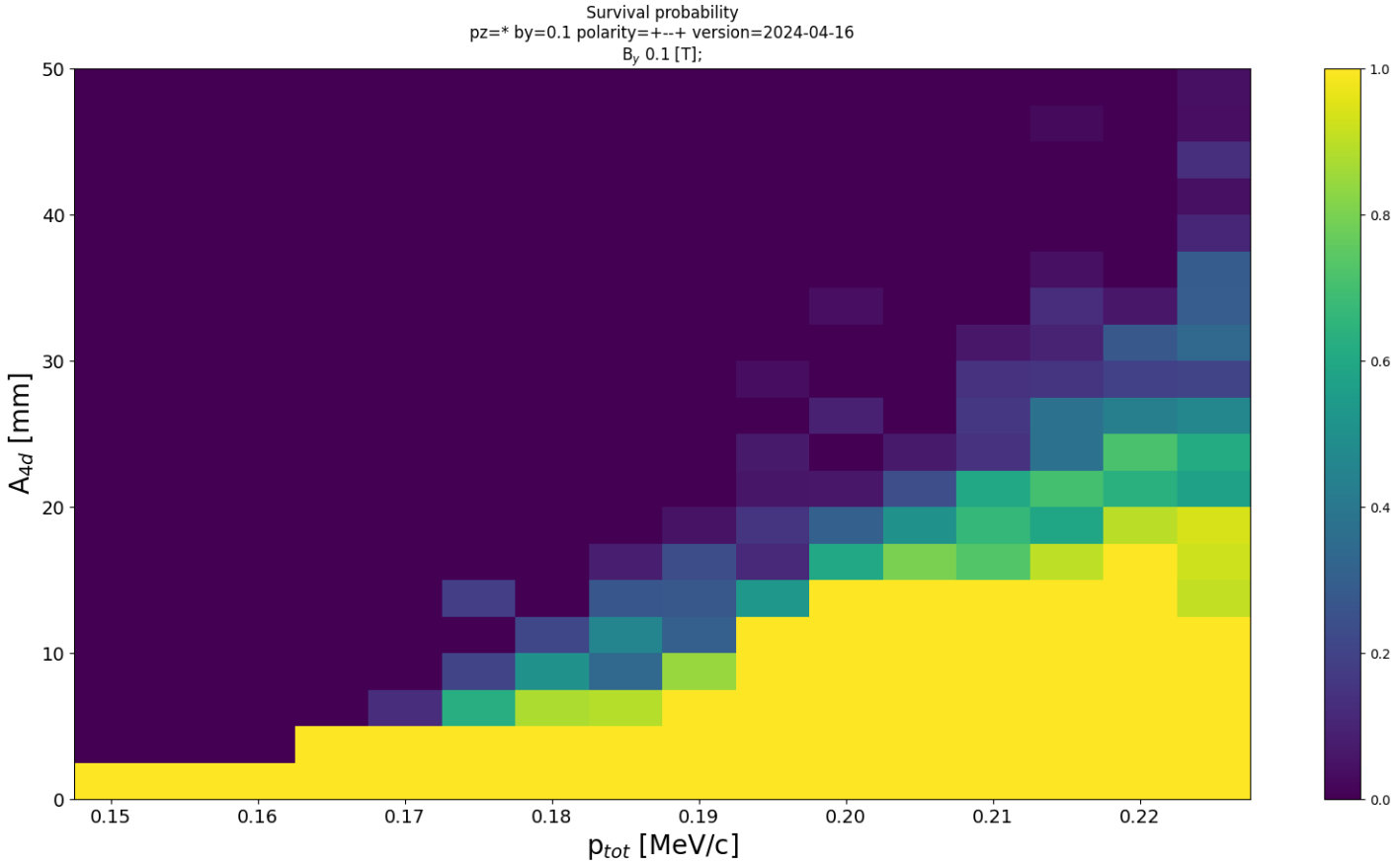
By = 0.2 T; +--+



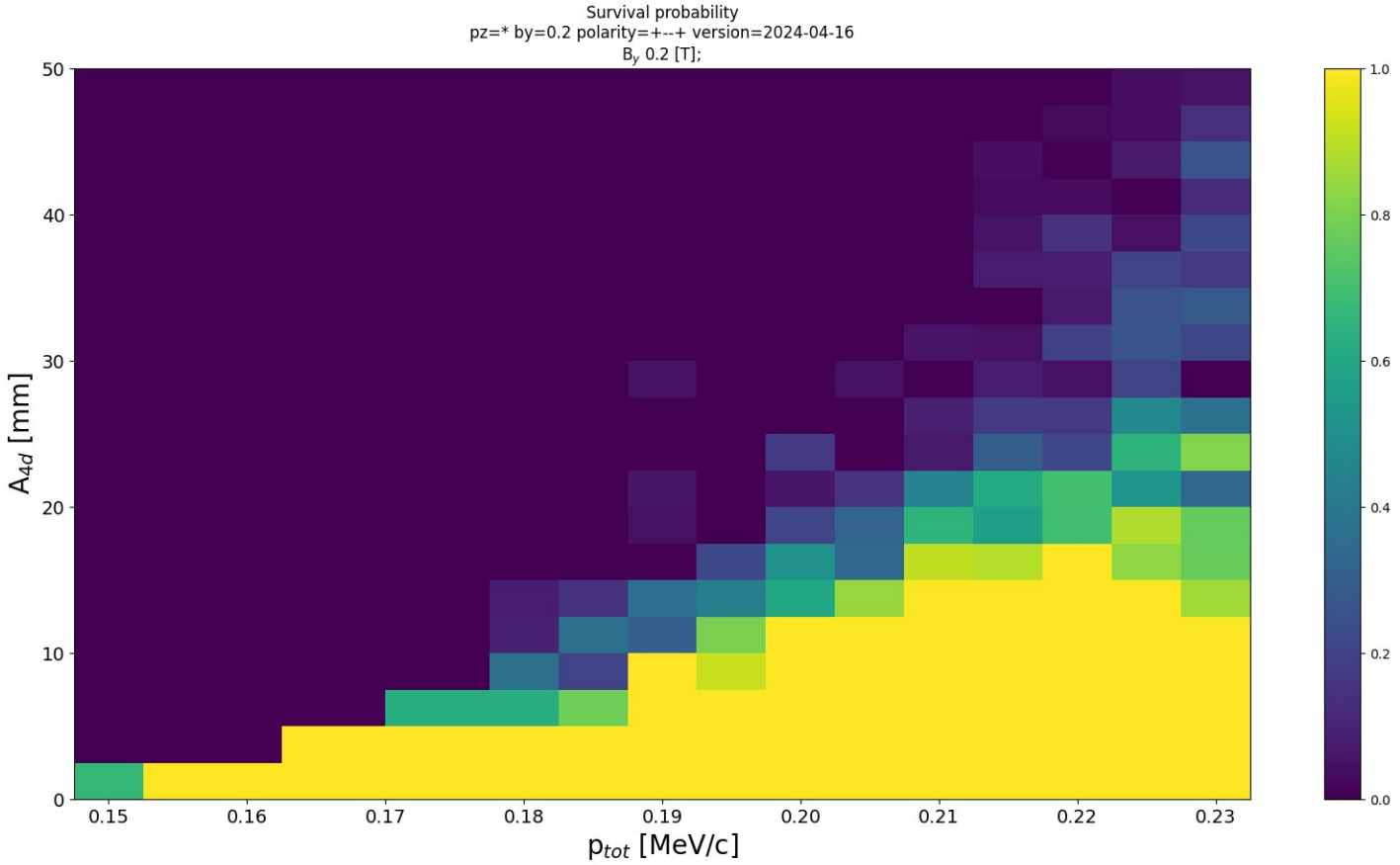
DA – no dipole


Survival probability
pz=* by=0.0 polarity=+--+ version=2024-04-16
B_y 0.0 [T];
A_{4d} [mm]
p_{tot} [MeV/c]
0
10
20
30
40
50
0.15
0.16
0.17
0.18
0.19
0.20
0.21
0.22
0.0
0.2
0.4
0.6
0.8
1.0

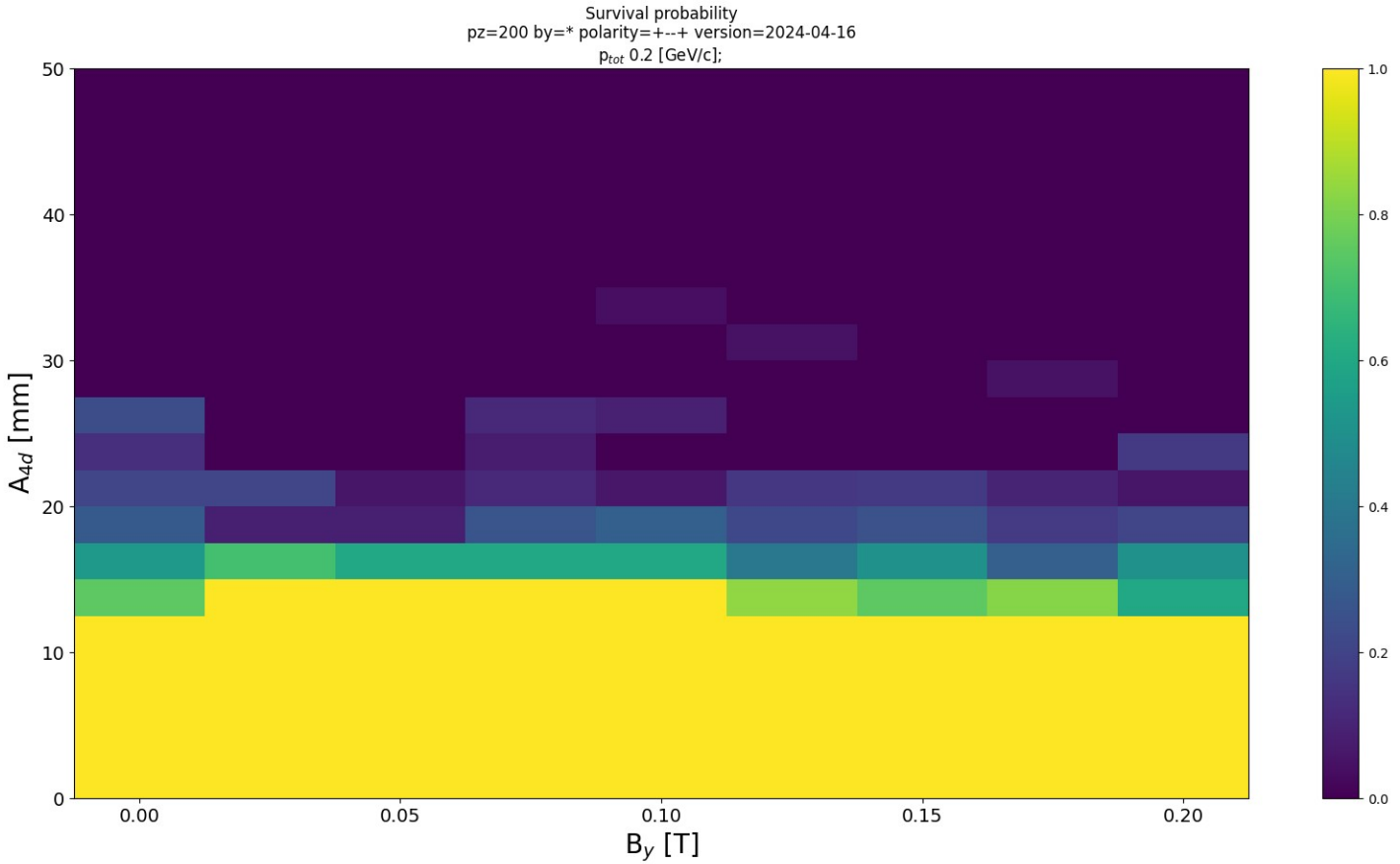
DA – 0.1 T +--+


Survival probability
pz=* by=0.1 polarity=+--+ version=2024-04-16
B_y 0.1 [T];
A_{4d} [mm]
p_{tot} [MeV/c]
0
10
20
30
40
50
0.15
0.16
0.17
0.18
0.19
0.20
0.21
0.22
0.0
0.2
0.4
0.6
0.8
1.0

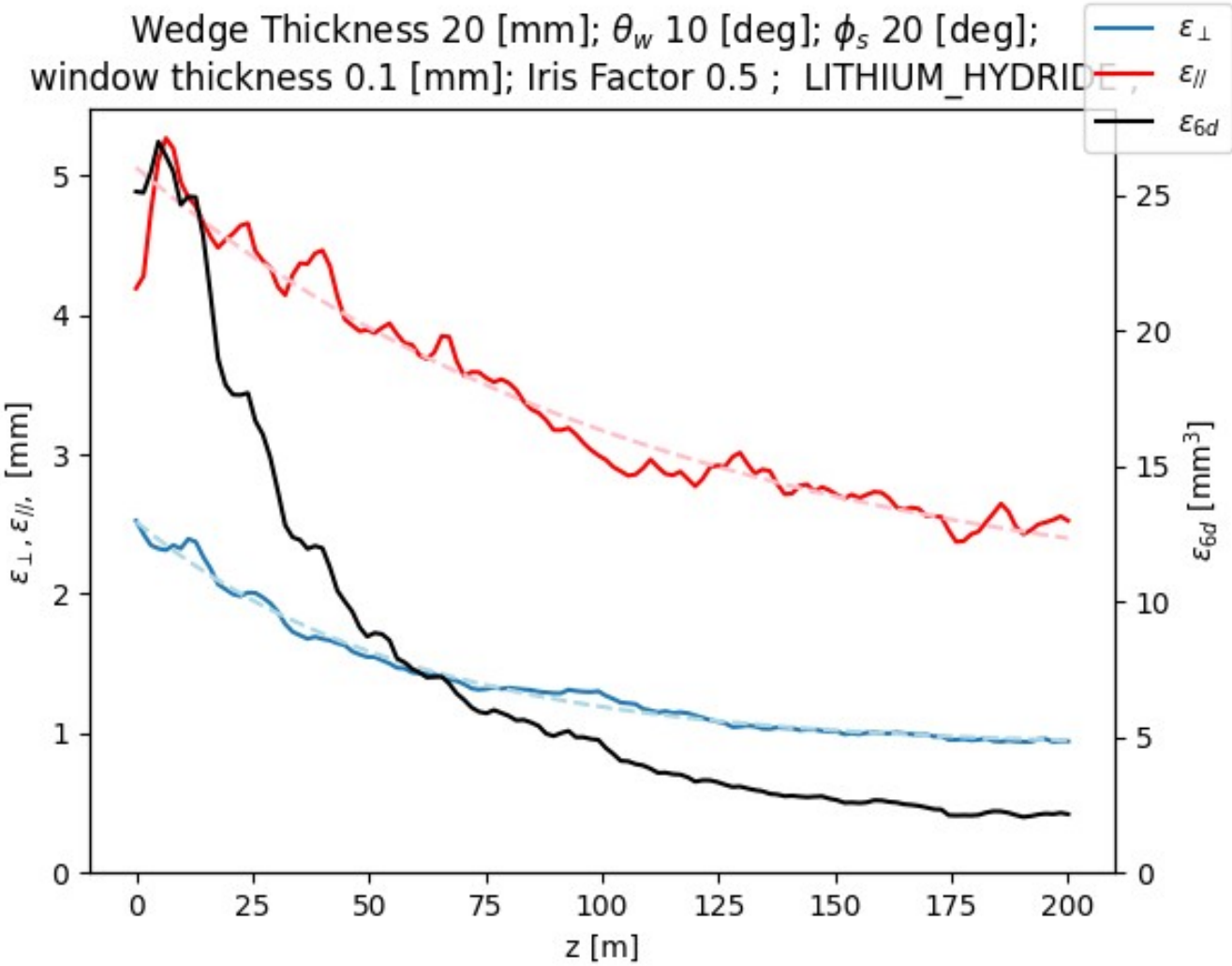
DA – 0.2 T +--+


Survival probability
pz=* by=0.2 polarity=+--+ version=2024-04-16
B_y 0.2 [T];
A_{4d} [mm]
p_{tot} [MeV/c]
0
10
20
30
40
50
0.15
0.16
0.17
0.18
0.19
0.20
0.21
0.22
0.23
0.0
0.2
0.4
0.6
0.8
1.0

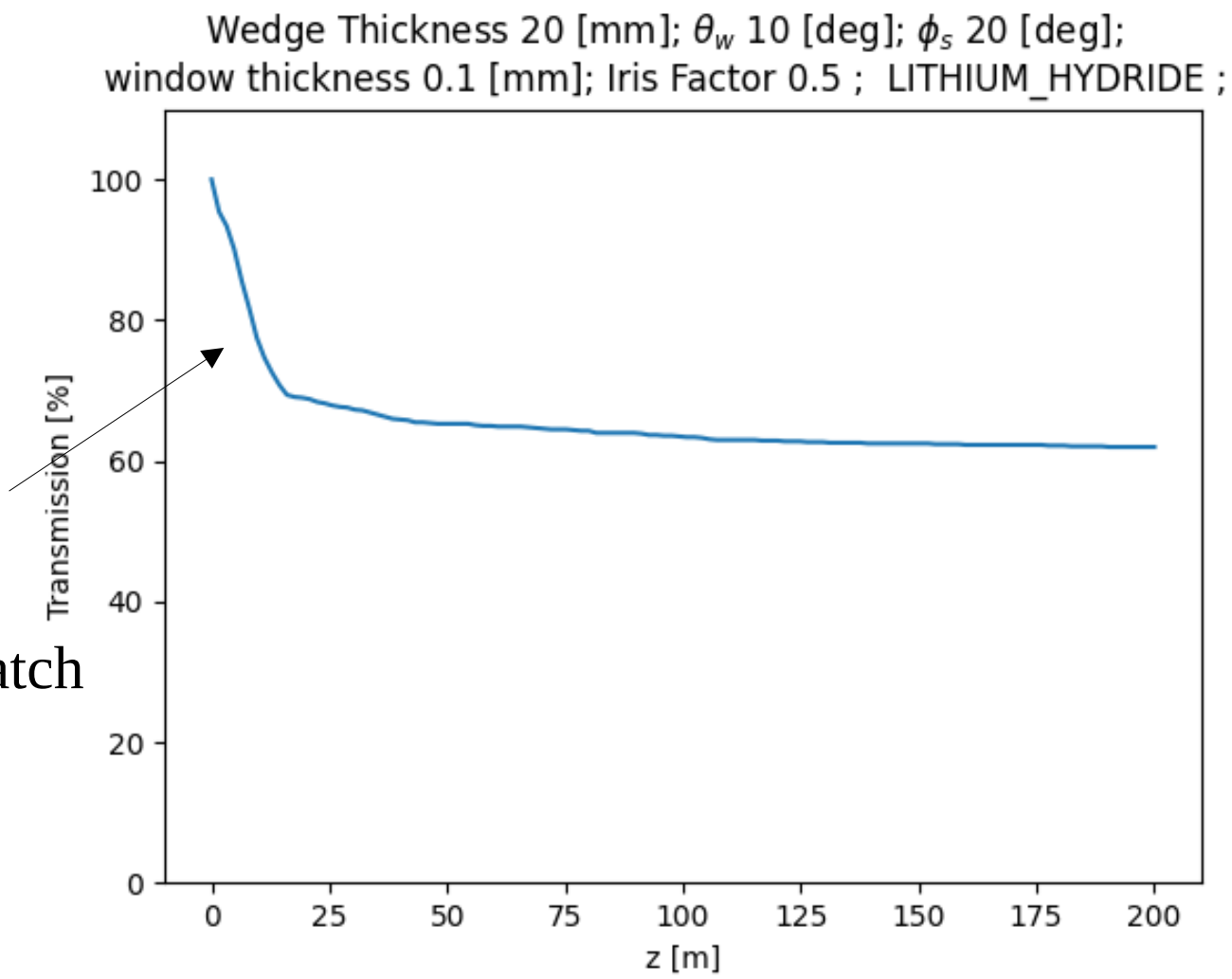
DA – 200 MeV/c +--+


Survival probability
pz=200 by=* polarity=+--+ version=2024-04-16
p_{tot} 0.2 [GeV/c];
A_{4d} [mm]
B_y [T]
0
10
20
30
40
50
0.00
0.05
0.10
0.15
0.20
0.0
0.2
0.4
0.6
0.8
1.0

Introducing Wedge/cooling

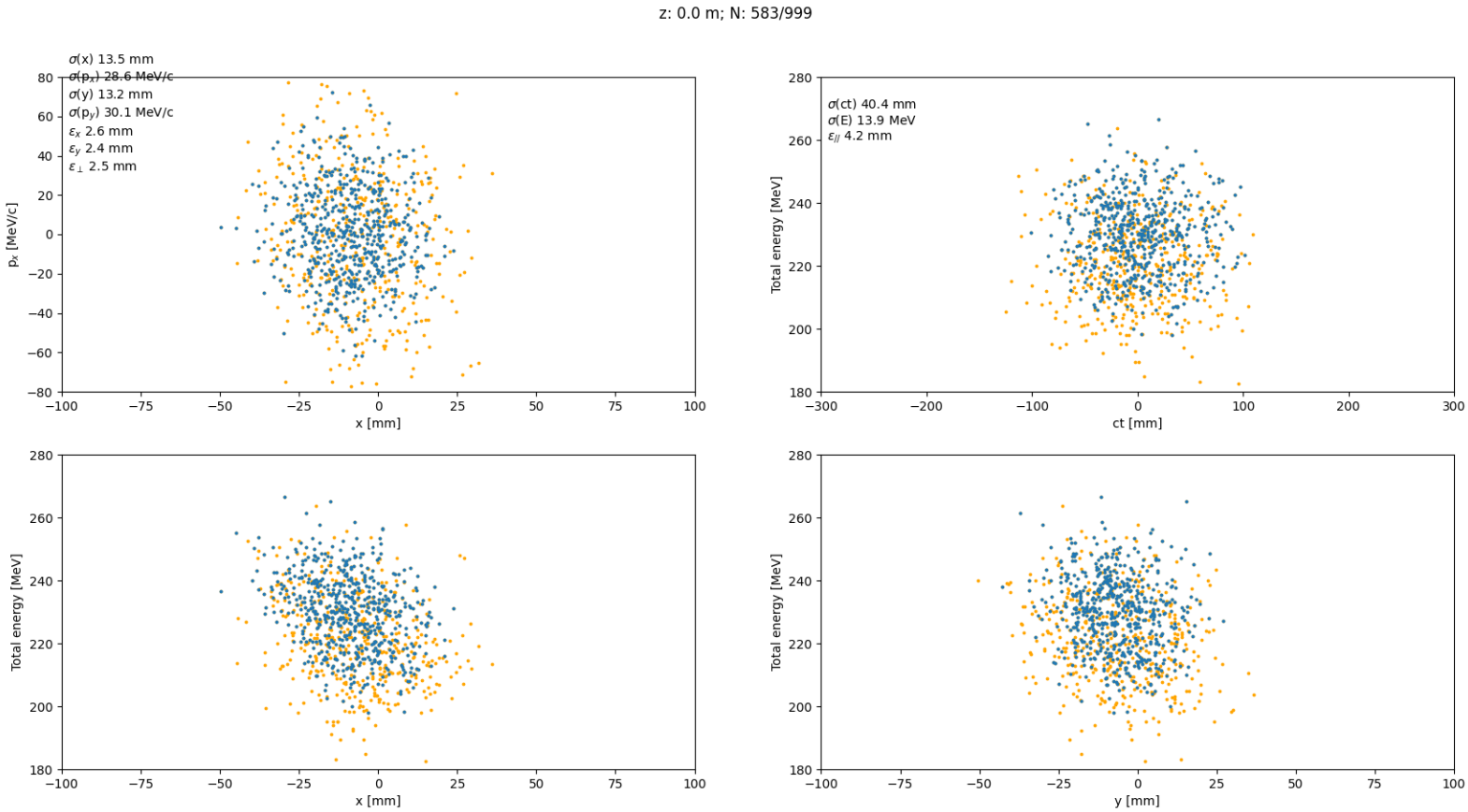


Introducing Wedge/cooling



Note Initial mismatch

Transmission

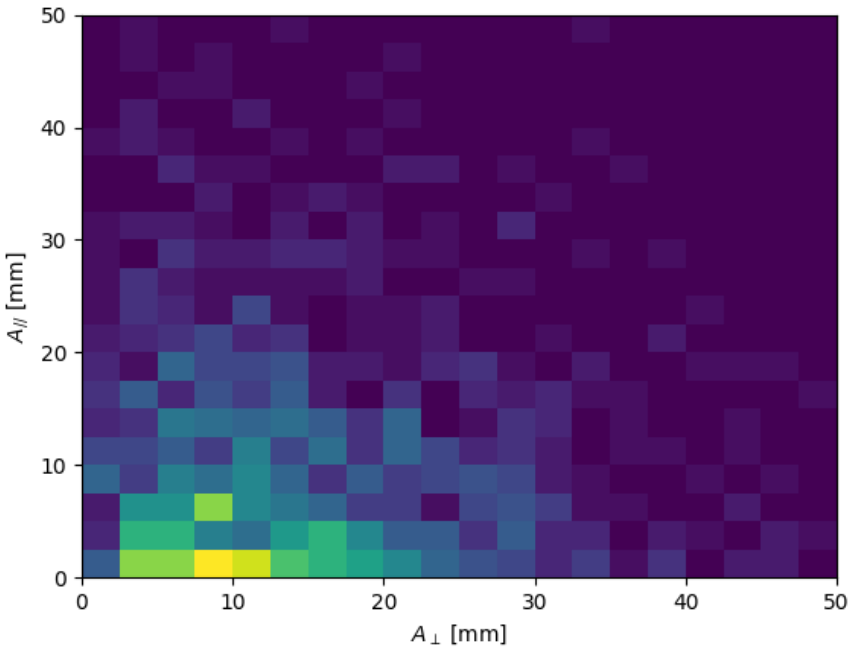


Blue – transmitted particles

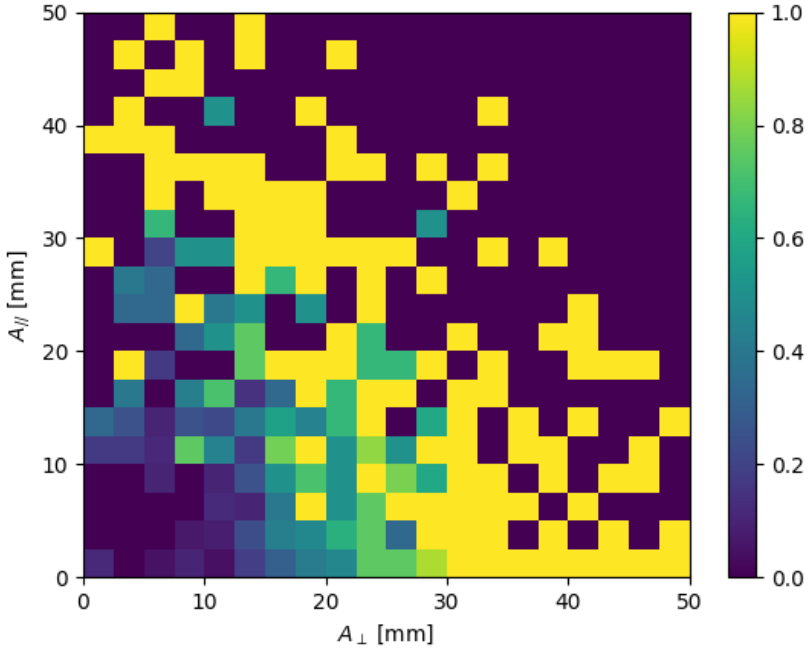
Orange – scraped particles

Acceptance

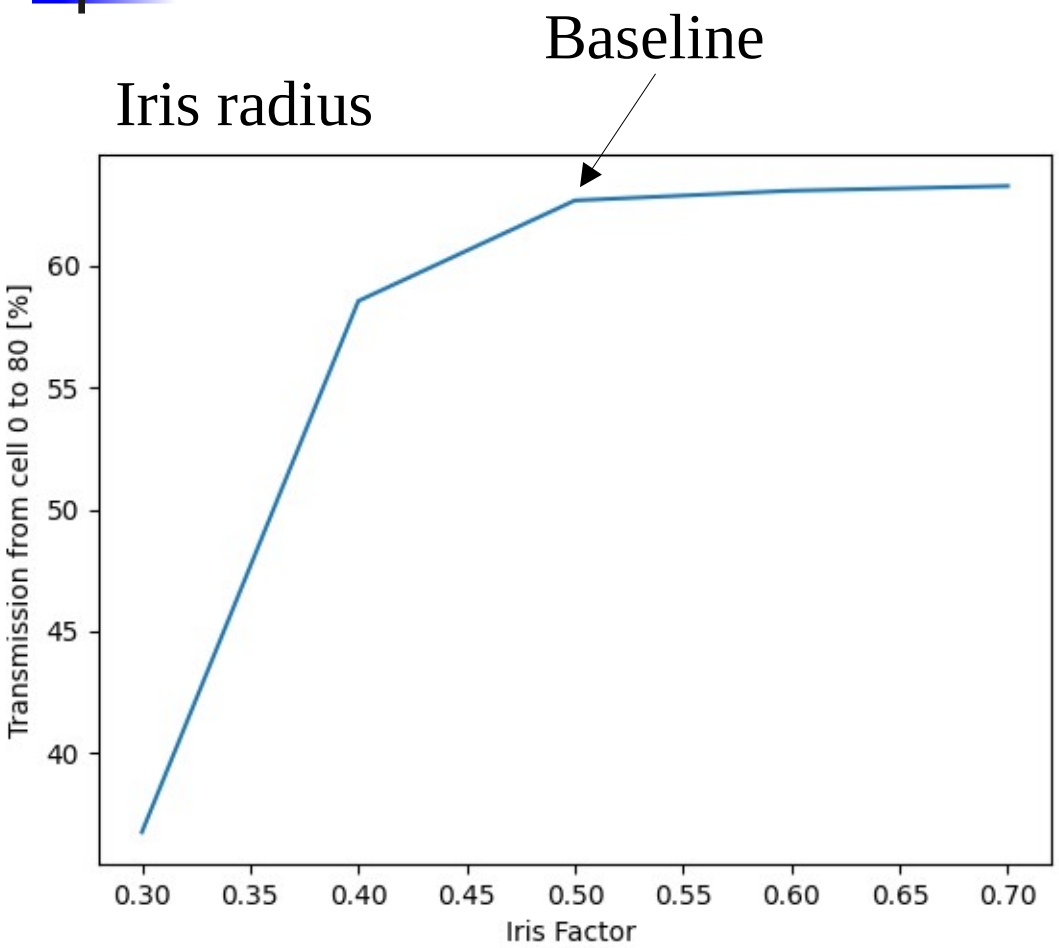
Initial distribution



Fraction that scrape in each bin

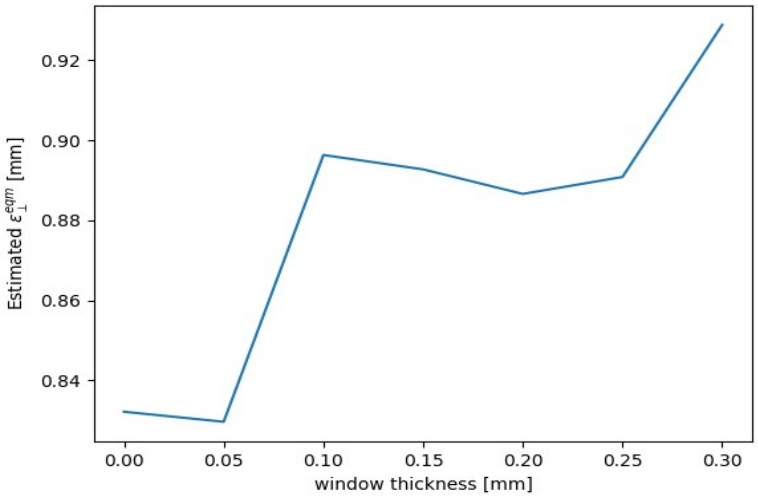


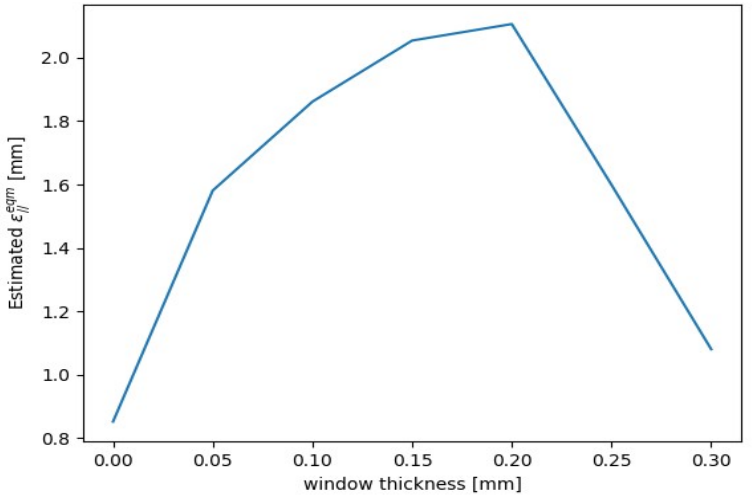
Iris factor

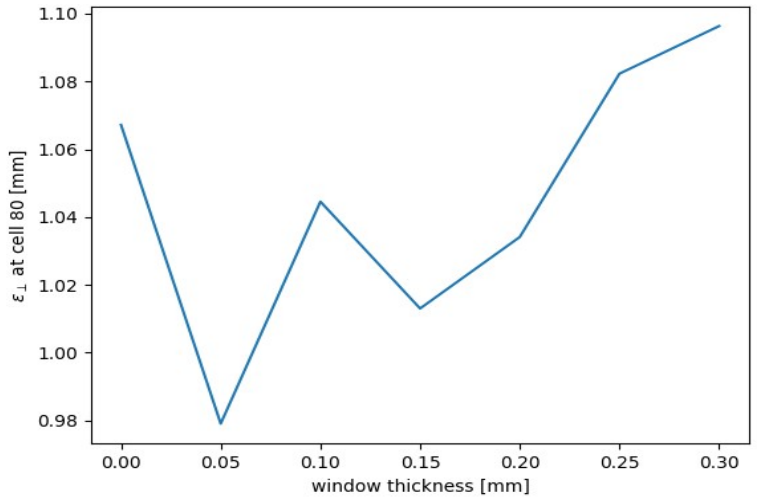


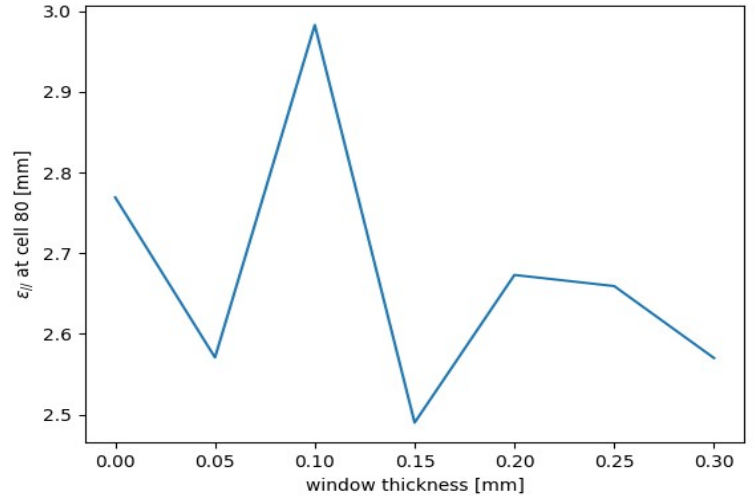
- Iris factor – ratio of RF aperture to ideal cavity radius
  - Nominal radius @ 704 MHz is 163.1 mm
  - Choose baseline 0.5 (81.6 mm)

Window thickness

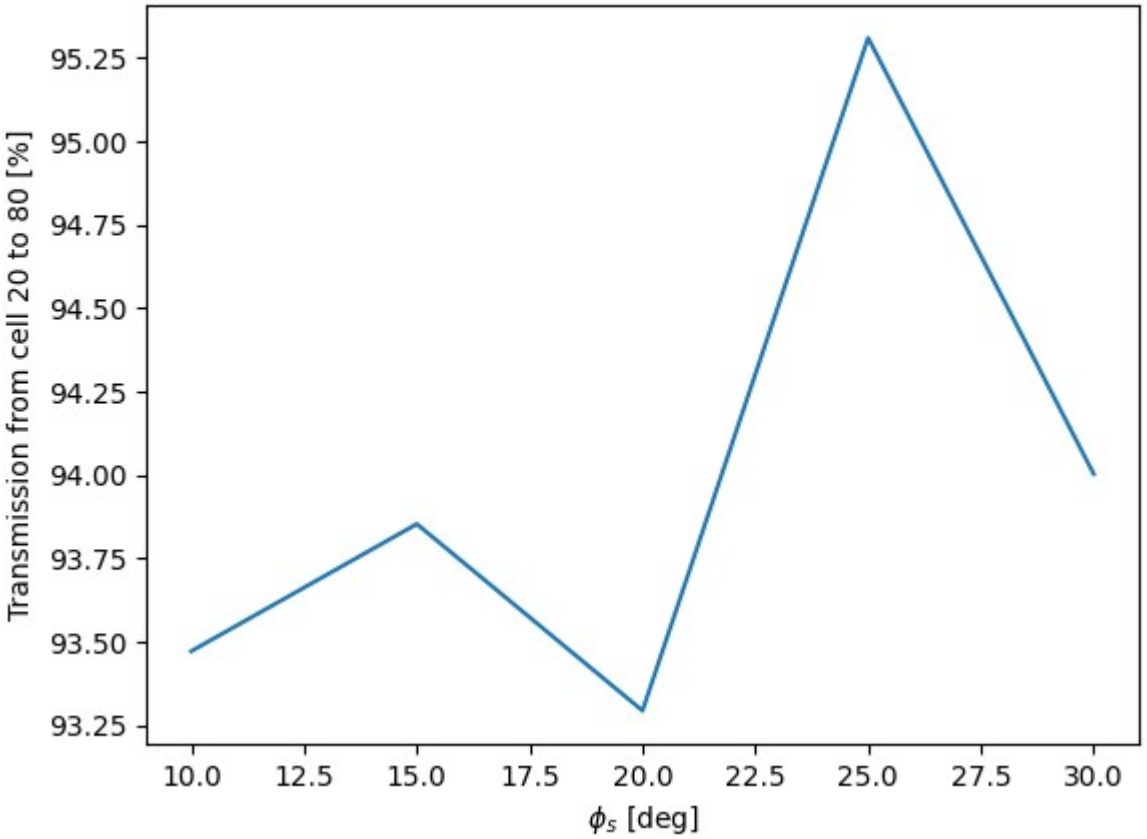




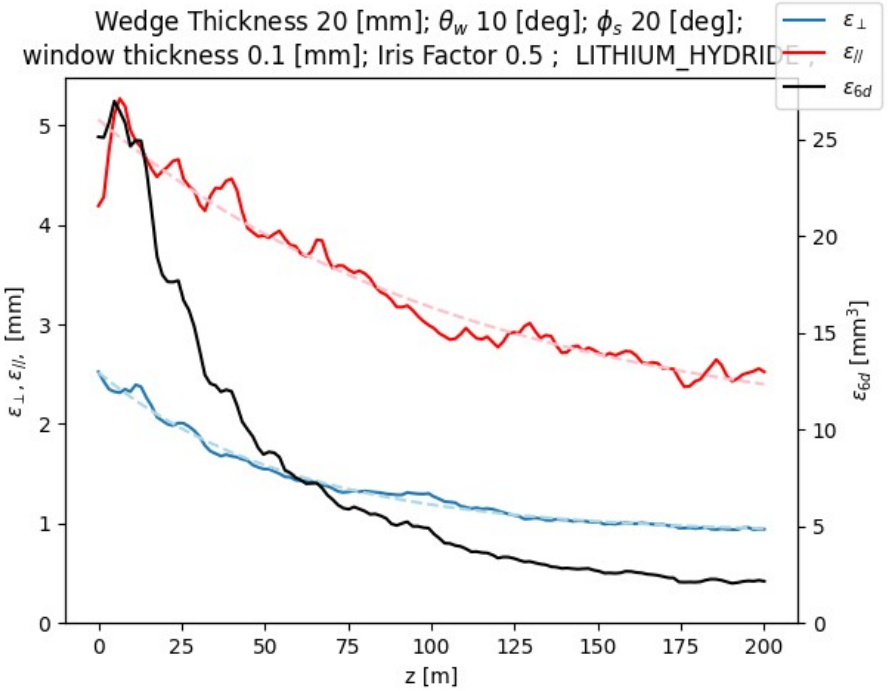


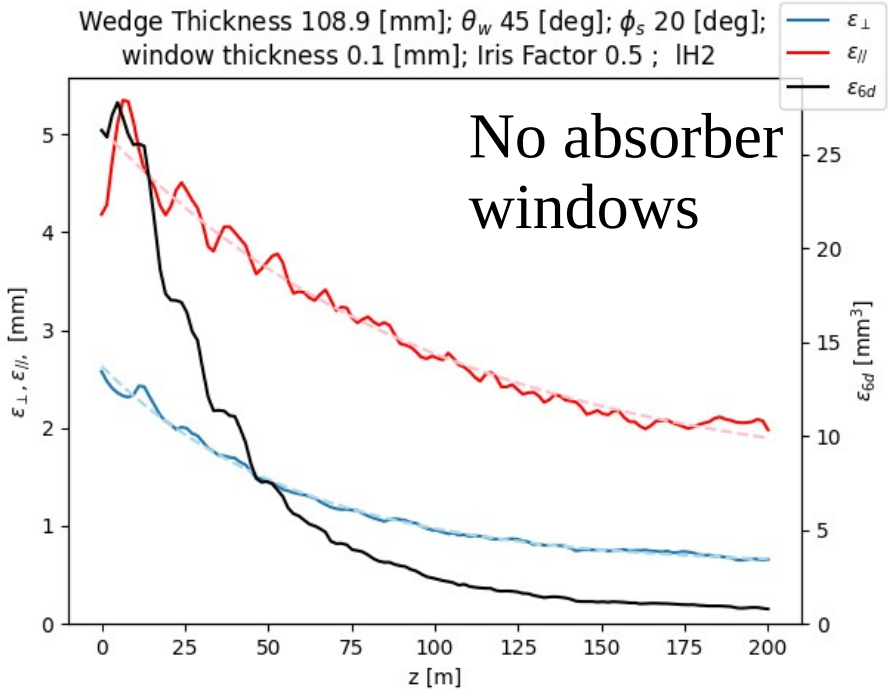


RF phase


Transmission from cell 20 to 80 [%]
95.25
95.00
94.75
94.50
94.25
94.00
93.75
93.50
93.25
10.0
12.5
15.0
17.5
20.0
22.5
25.0
27.5
30.0
ϕ_s [deg]

Absorber material





Absorber material

Cooling Cell Parameters	
Beam Physics Parameters	
Momentum	200 MeV/c
Twiss beta function	107 mm
Dispersion in x	38.5 mm
Dispersion in y	20.3 mm
Beam pipe radius	81.6 mm
Design solenoid parameters*	
B0.5	0 T
B0	8.75 T
B1	1.25 T
B2	0 T
Cooling Cell length	800 mm
B0 tolerance	0.25 T
B1 tolerance	0.025 T
B0.5 tolerance	0.02 T
B2 tolerance	0.5 T
Simulated coil geometry	
Inner radius	250 mm
Coil Length	140 mm
Coil radial thickness	169.3 mm
Coil z centre position	100.7 mm
Current Density	500 A/mm^2

RF Cavity	
RF Cell length	188.6 mm
RF Gradient	30 MV/m
Iris radius	81.6 mm
Number of RF cells	3
Frequency	0.704 GHz
Synchronous phase	20 degree
RF window	0.1 mm
Wedge	
Material	Lithium Hydride
Opening Angle	10 degree
Thickness	20 mm
Transverse offset	8.7 mm
Dipole	
Length	100 mm
Polarity	+--+
Field	0.2 T
Dipole z centre position	160 mm

***B = B0.5 sin(pi z/L) + B0 sin(2 pi z/L) + B1 sin(4 pi z/L) + B2 sin (6 pi z/L)**

Dipole

- Understand basic parameter dependencies
  - Solenoid optics
  - RF/longitudinal optics
  - Dipole field/dispersion ← Work in progress
  - Introduce wedge (maybe cooling without stochastics?)
- Lattice design
  - Choose working point based on parameter dependencies
  - By-hand optimisation based on reasoned arguments
- Final optimisation ← Work in progress
  - Throw into some optimiser
- Tagged as 2024-05-23_prerelease on github