Field Quality Requirements for Solenoids

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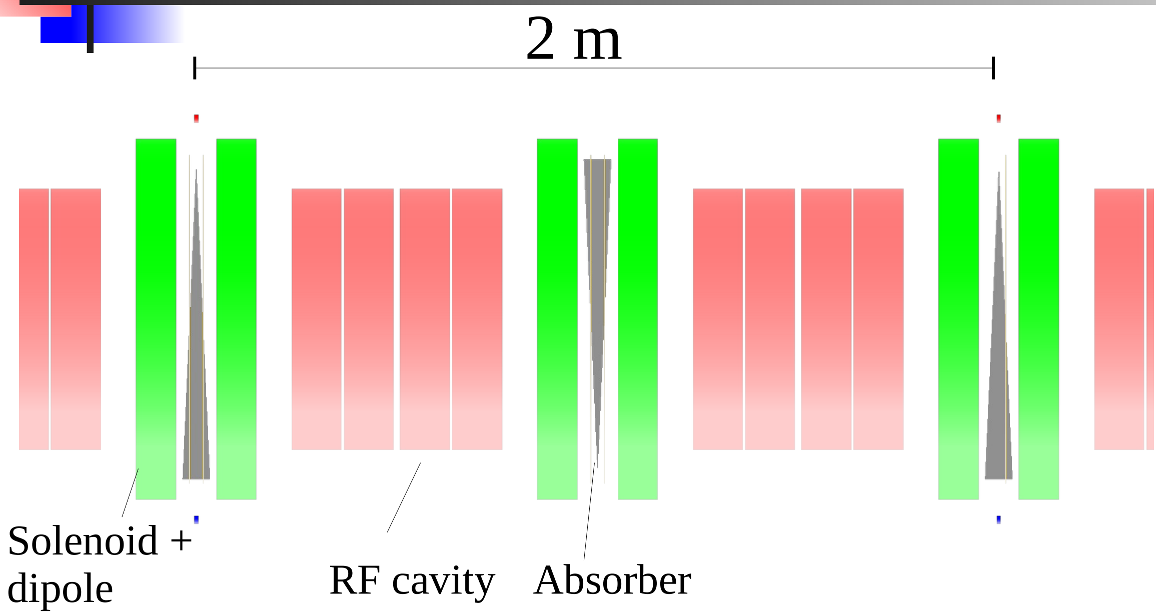
International MUON Collider Collaboration

Science & Technology Facilities Council ISIS

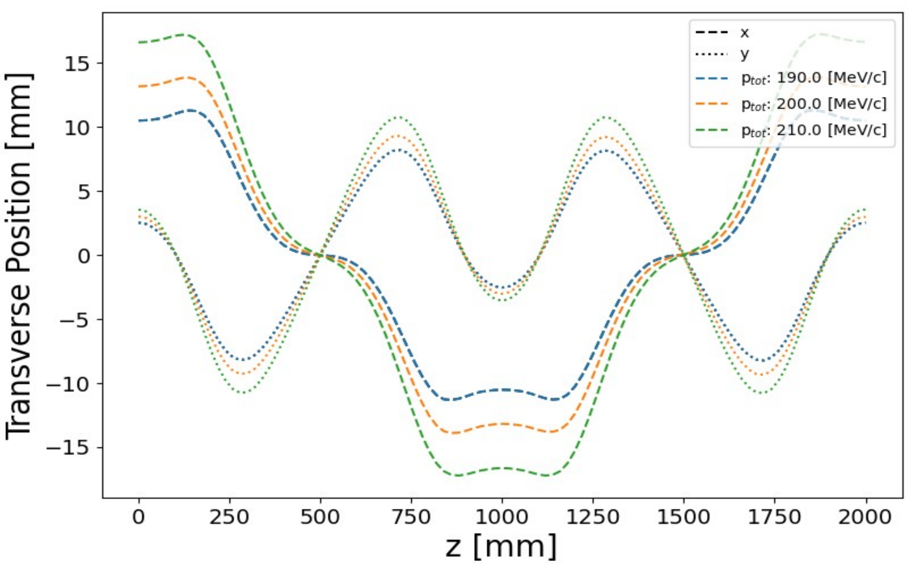
Solenoids

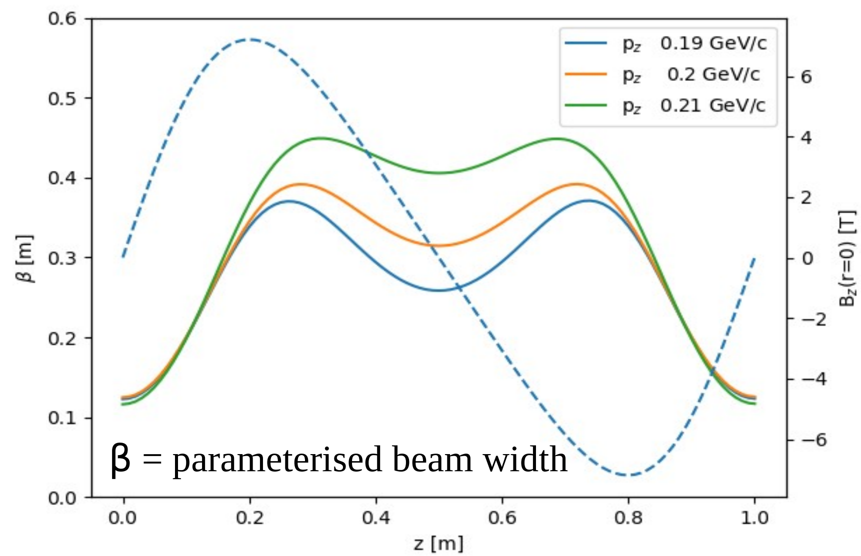
- Many solenoid lattices in the muon production region
  - Target solenoid and taper
  - Solenoid chicanes (beam cleaning, charge separation)
  - Uniform field solenoid in front end
  - Rectilinear cooling channel and demonstrator
  - Final cooling
- Focus is mostly on rectilinear cooling channel for now
  - Will use demonstrator as a basis
- Reminder of lattice

Preliminary Cooling Cell Concept



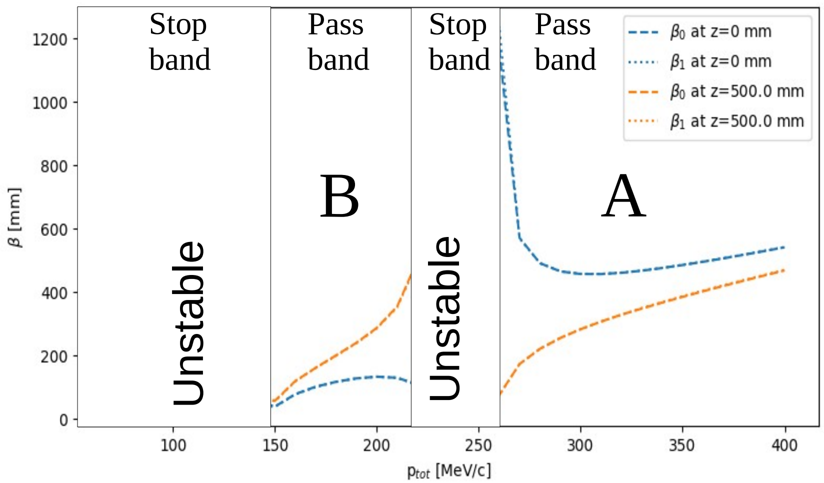
Cooling System	
Cell length	2 m
Peak solenoid field on-axis	7.2 T
Dipole field	0.2 T
Dipole length	0.1 m
RF real estate gradient	22 MV/m
RF nominal phase	20°
RF frequency	704 MHz
Wedge thickness on-axis	0.0342 m
Wedge apex angle	5°
Wedge material	LiH

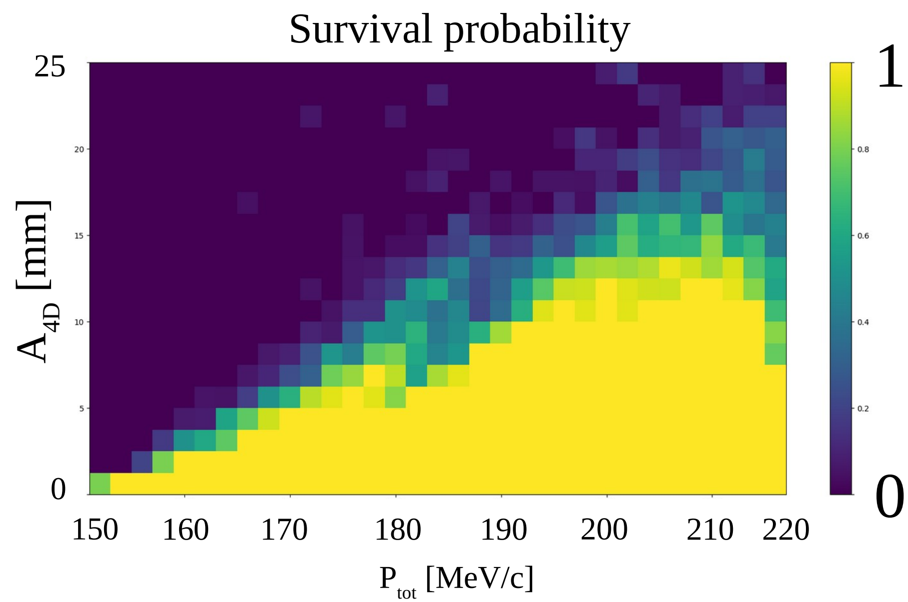




Optics vs momentum

- Operation in area **A**
  - High dynamic aperture
  - Larger β
  - Larger emittances
- Operation in area **B**
  - Lower dynamic aperture
  - Smaller β
  - Lower emittances
- Demo lattice operates in area **B**
- Solenoid lattice quality characterised by
  - Focus at the absorber
  - Acceptance
- For this study I will look at focus strength

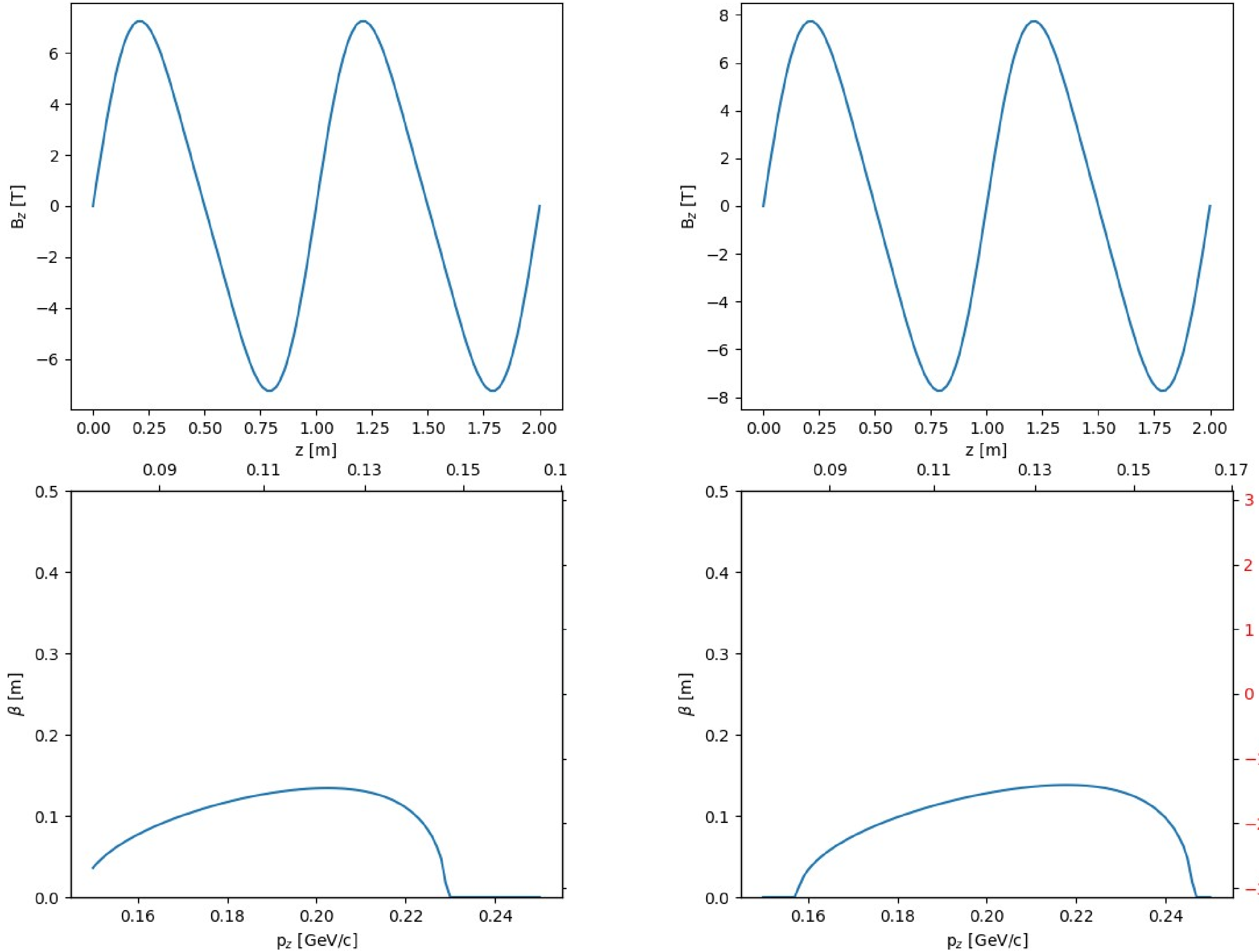




Magnet Errors

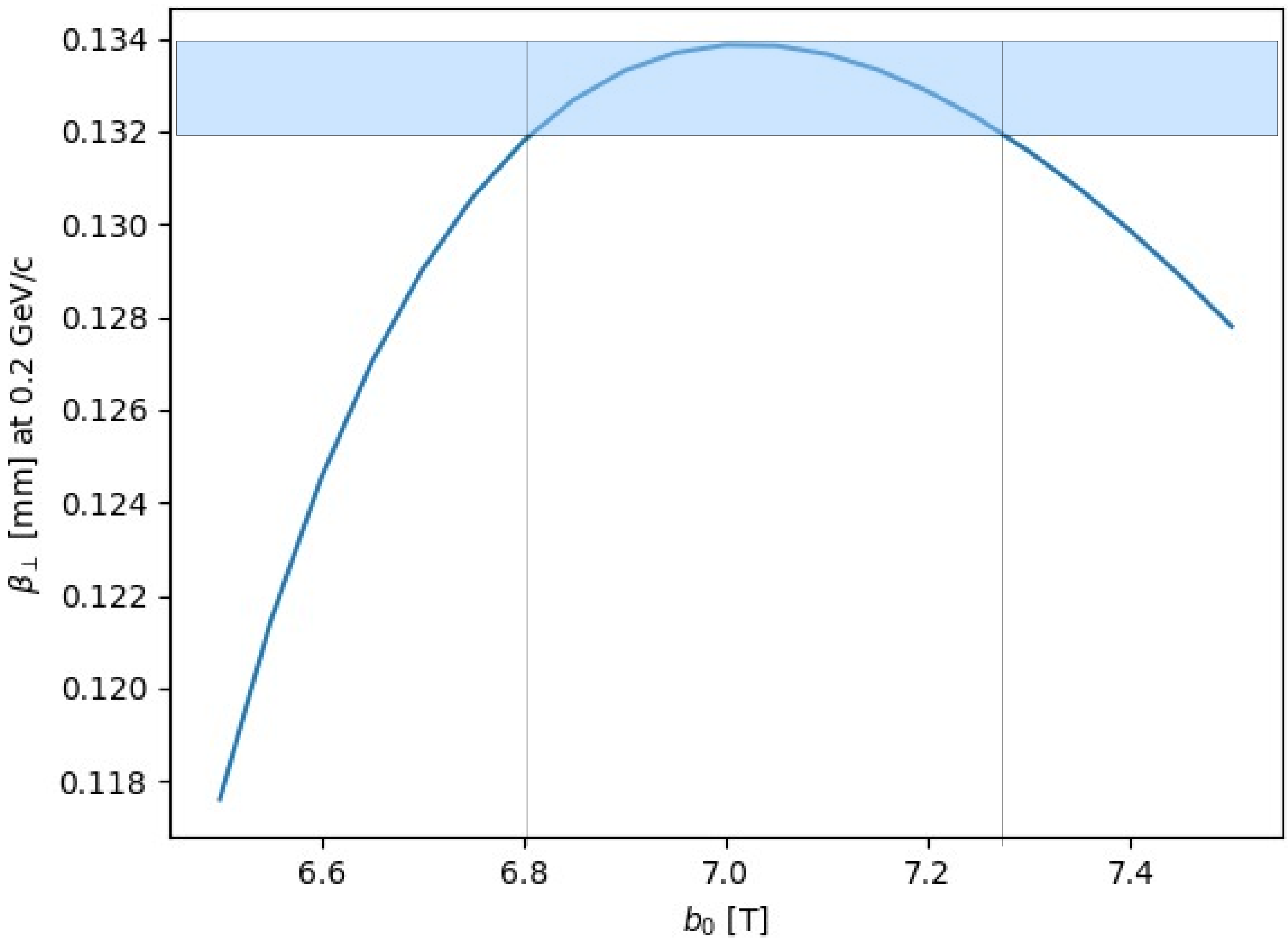
- Various different forms for errors in magnets, e.g.
  - Misalignments
  - Effect of power leads/wiring geometry
- From beam point of view, class these as
  - Solenoid error field
  - Dipole error field
  - Quadrupole error field
- For now I focus on solenoid errors

k=1



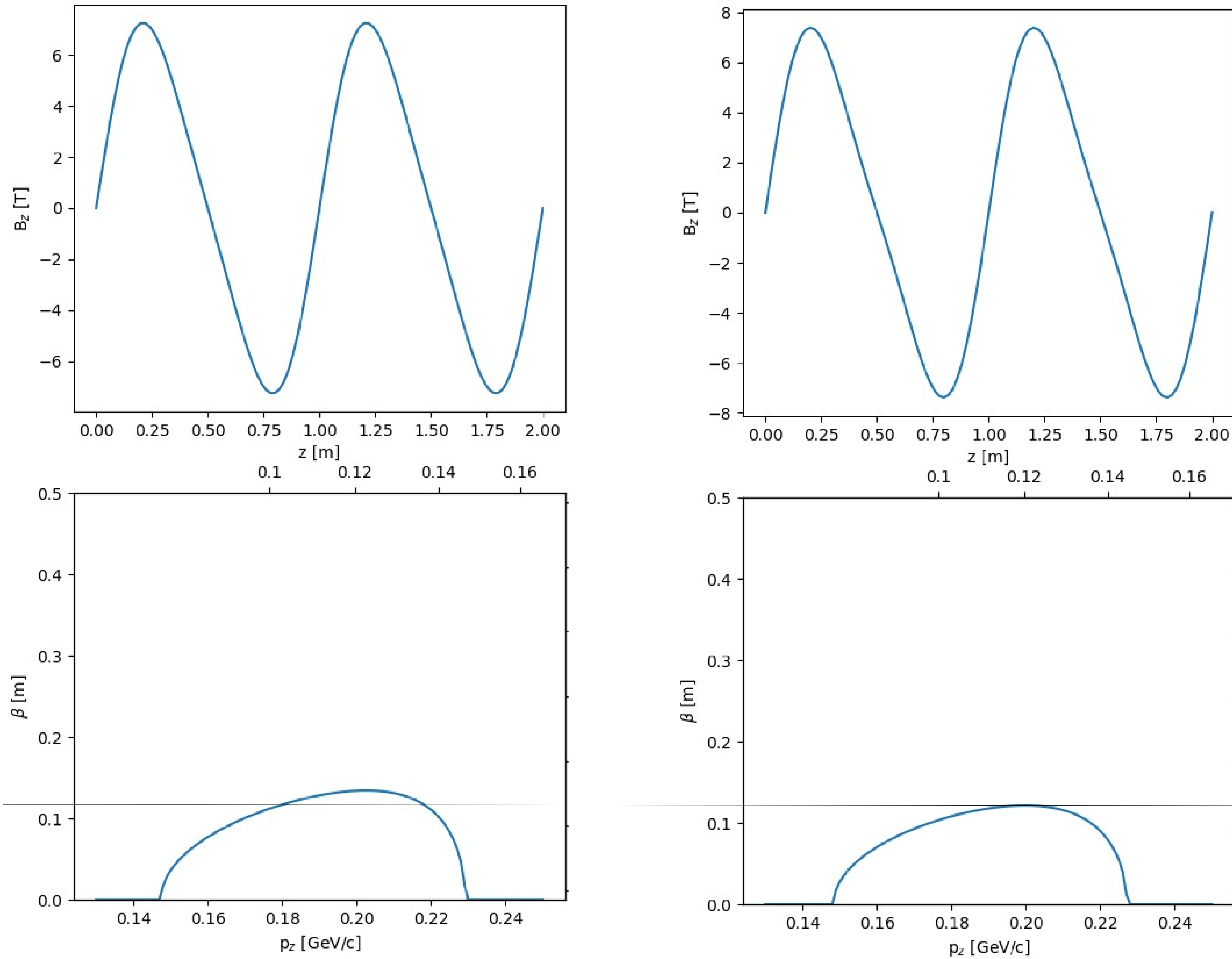
Moving b1 = 7.0 T → 7.5 T

K=1 - trend



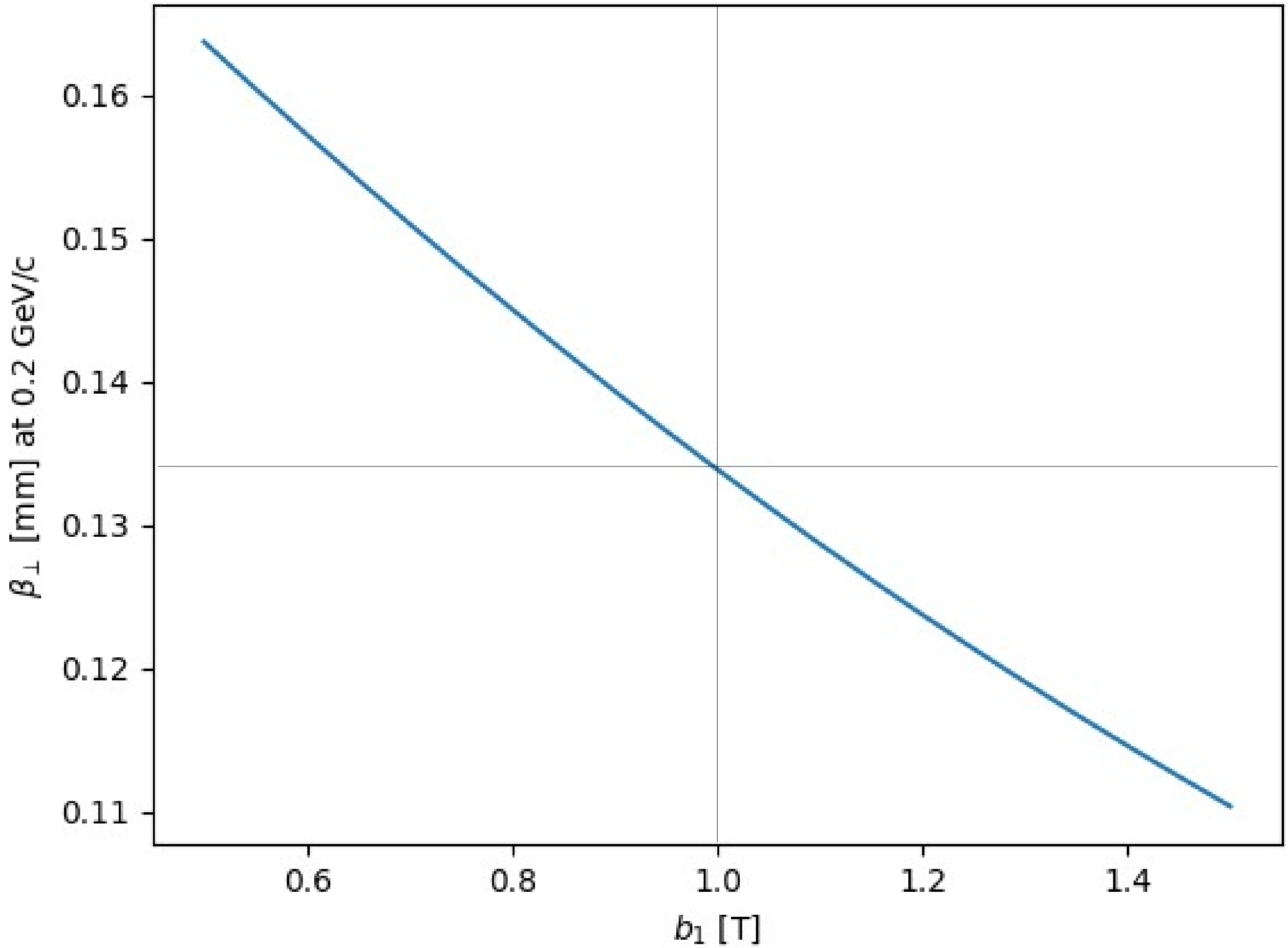
0.134
0.132
0.130
0.128
0.126
0.124
0.122
0.120
0.118
$\beta_\perp$ [mm] at 0.2 GeV/c
6.6
6.8
7.0
7.2
7.4
b_0 [T]

k=2



Moving b2 = 1.0 T → 1.25 T

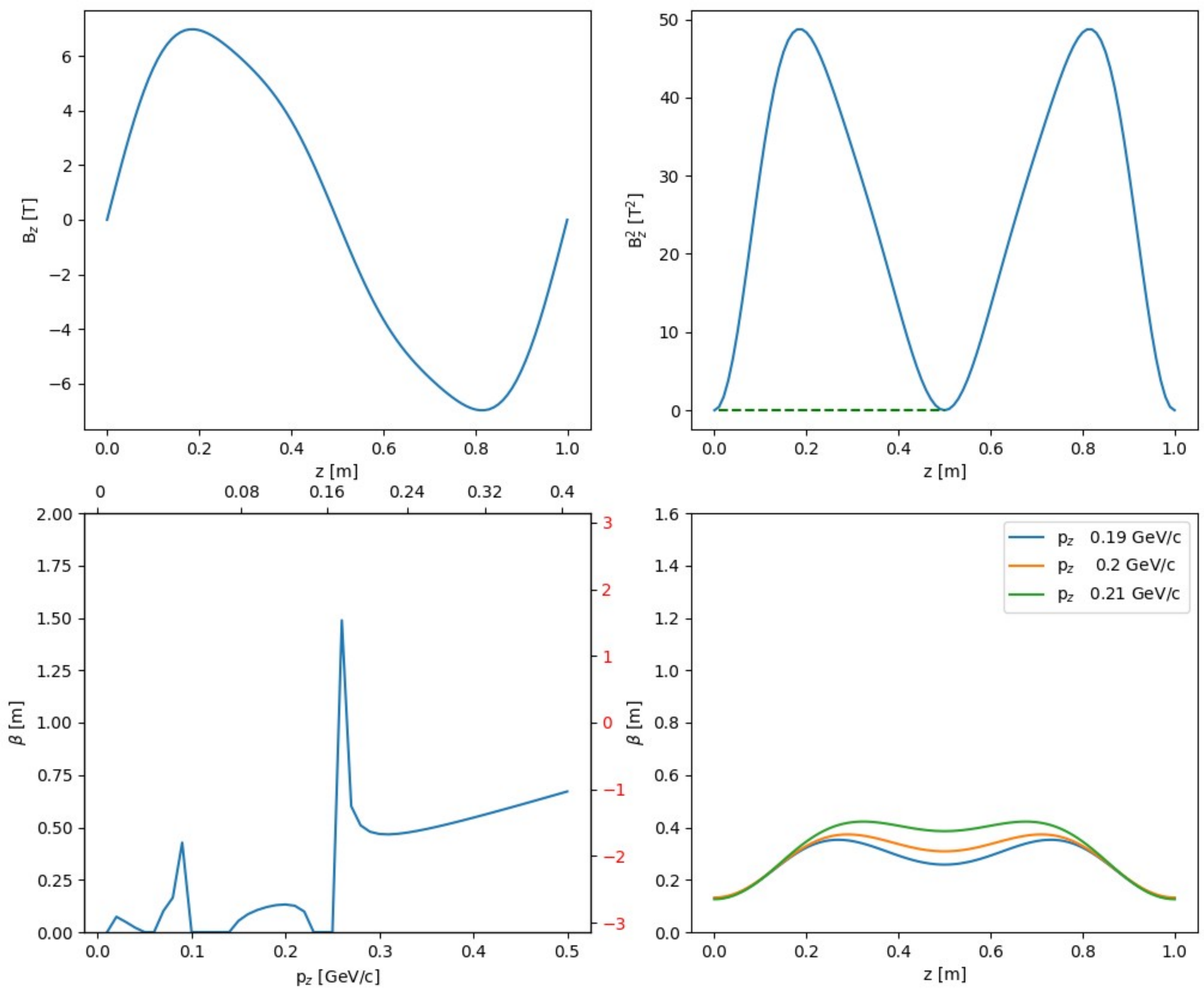
K = 2 - trend



k=3

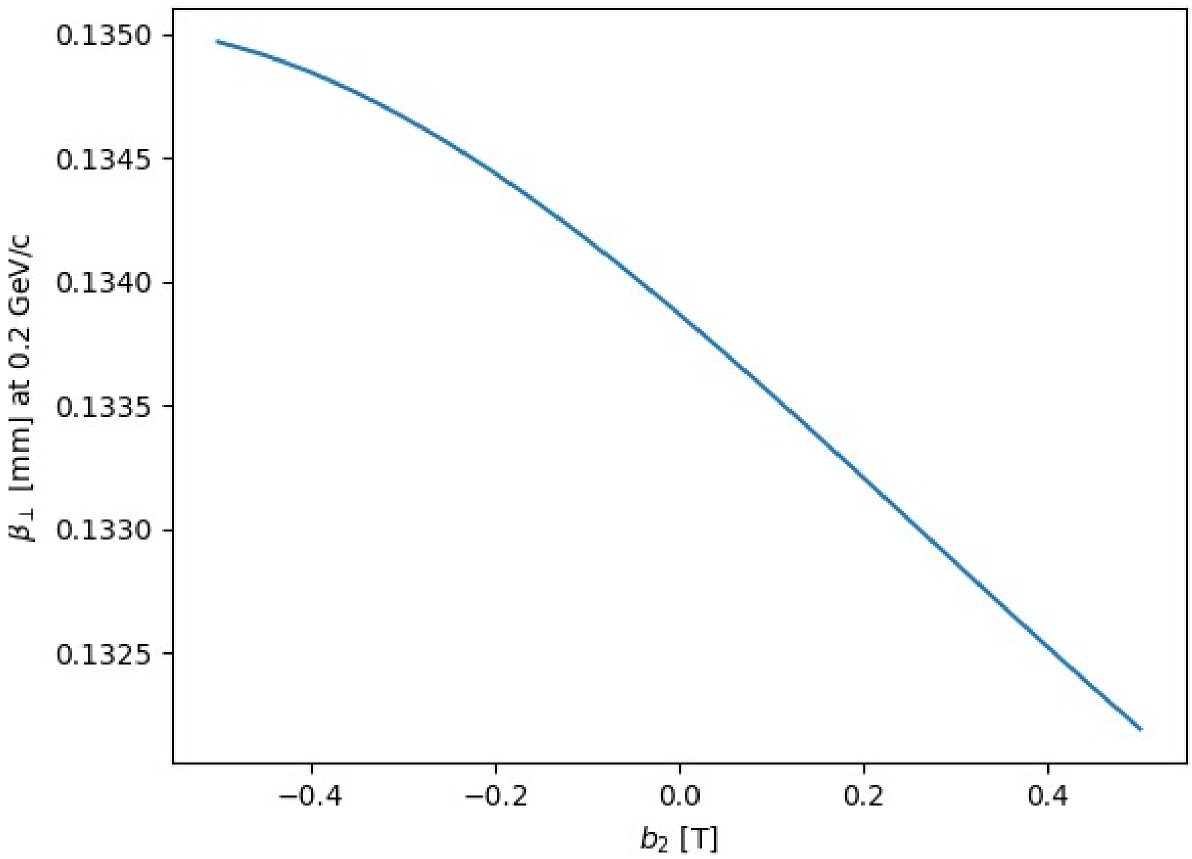
$L = 1; b_0 = 0; b_1 = 7; b_2 = 1; b_3 = 0.5; b_4 = 0; b_5 = 0$

$\int B^2(z)dz = 25.13\ T^2\ m$



b3 = 0 → 0.5 T

K=3 - trend



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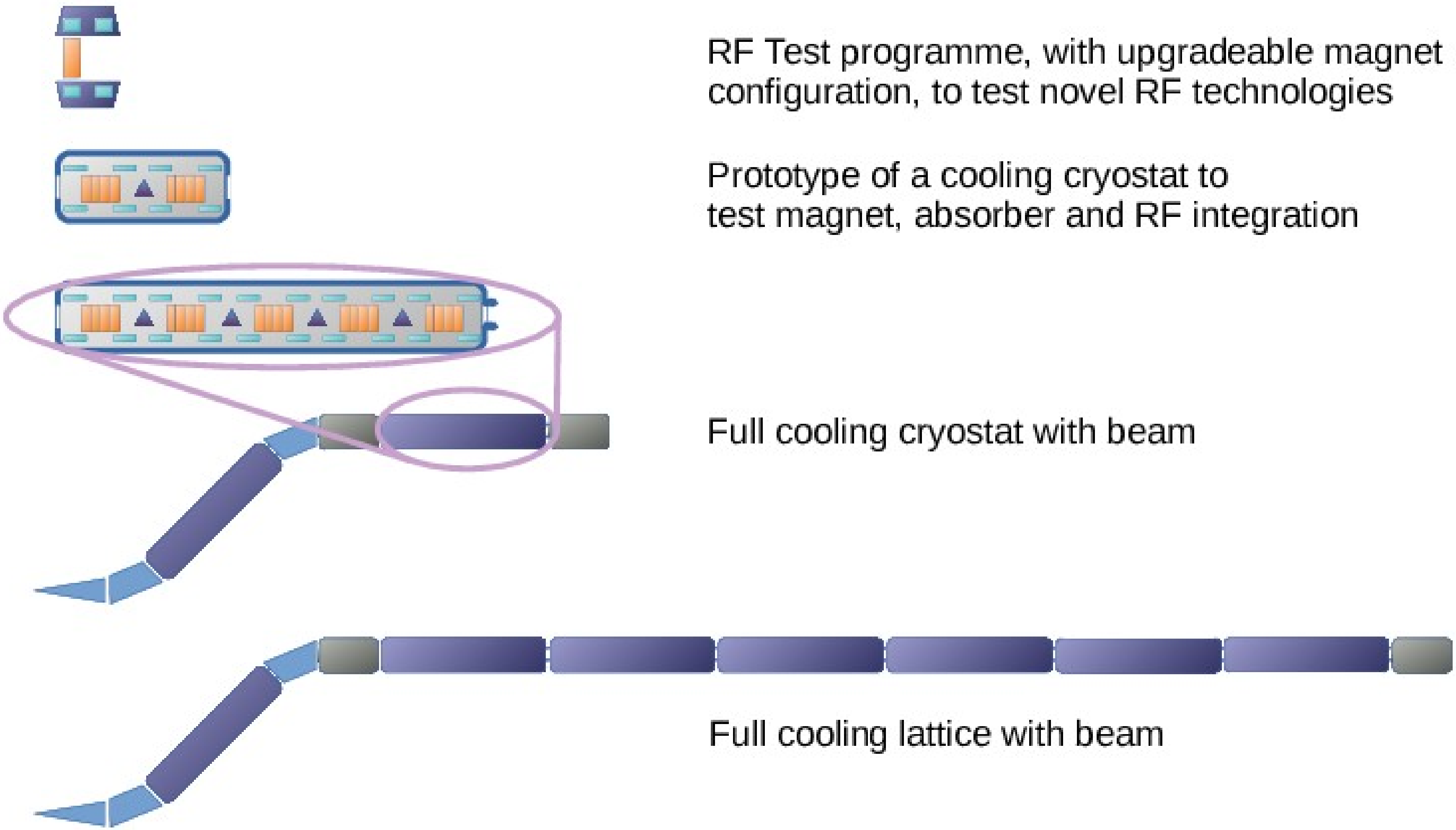
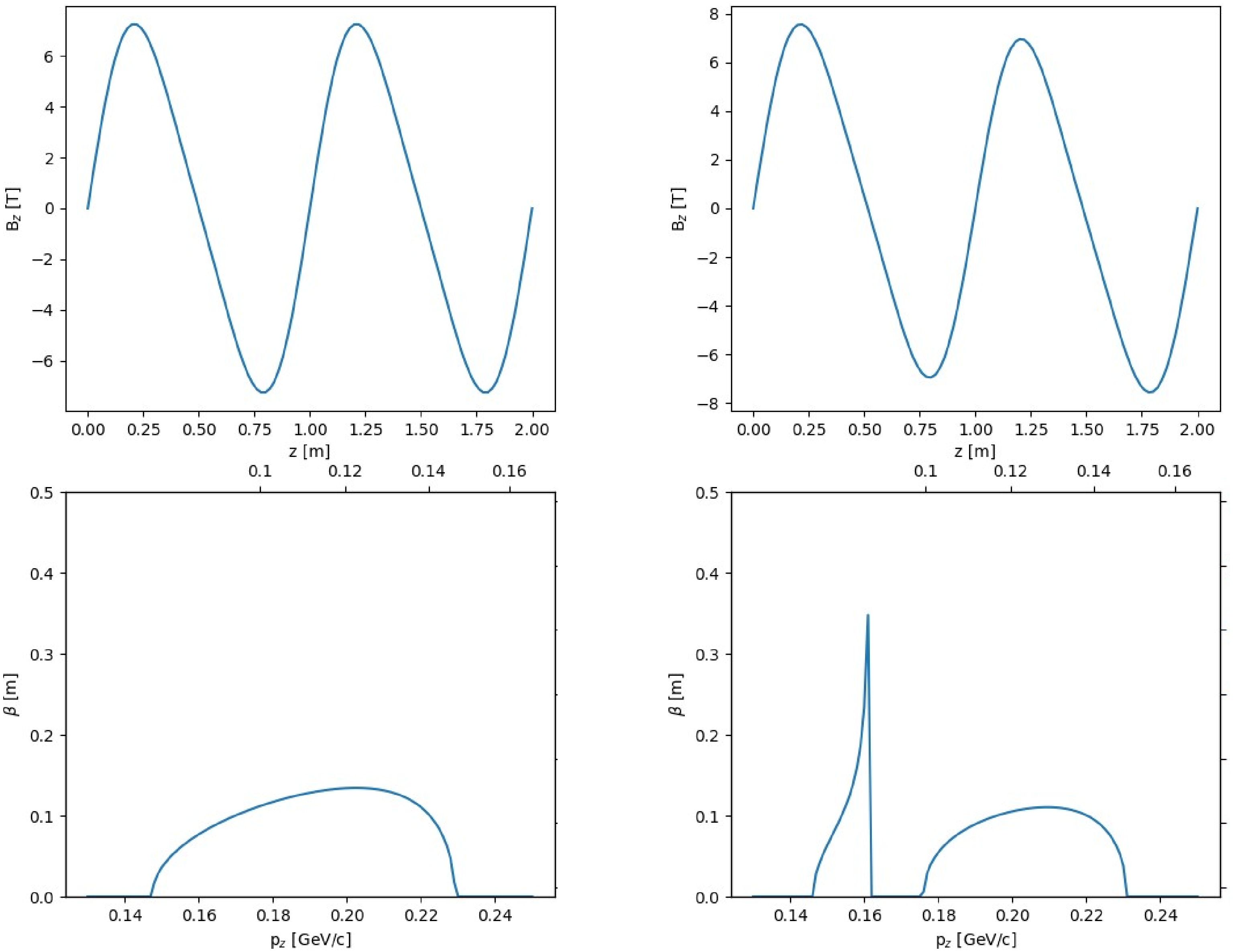
Muon cooling - plan

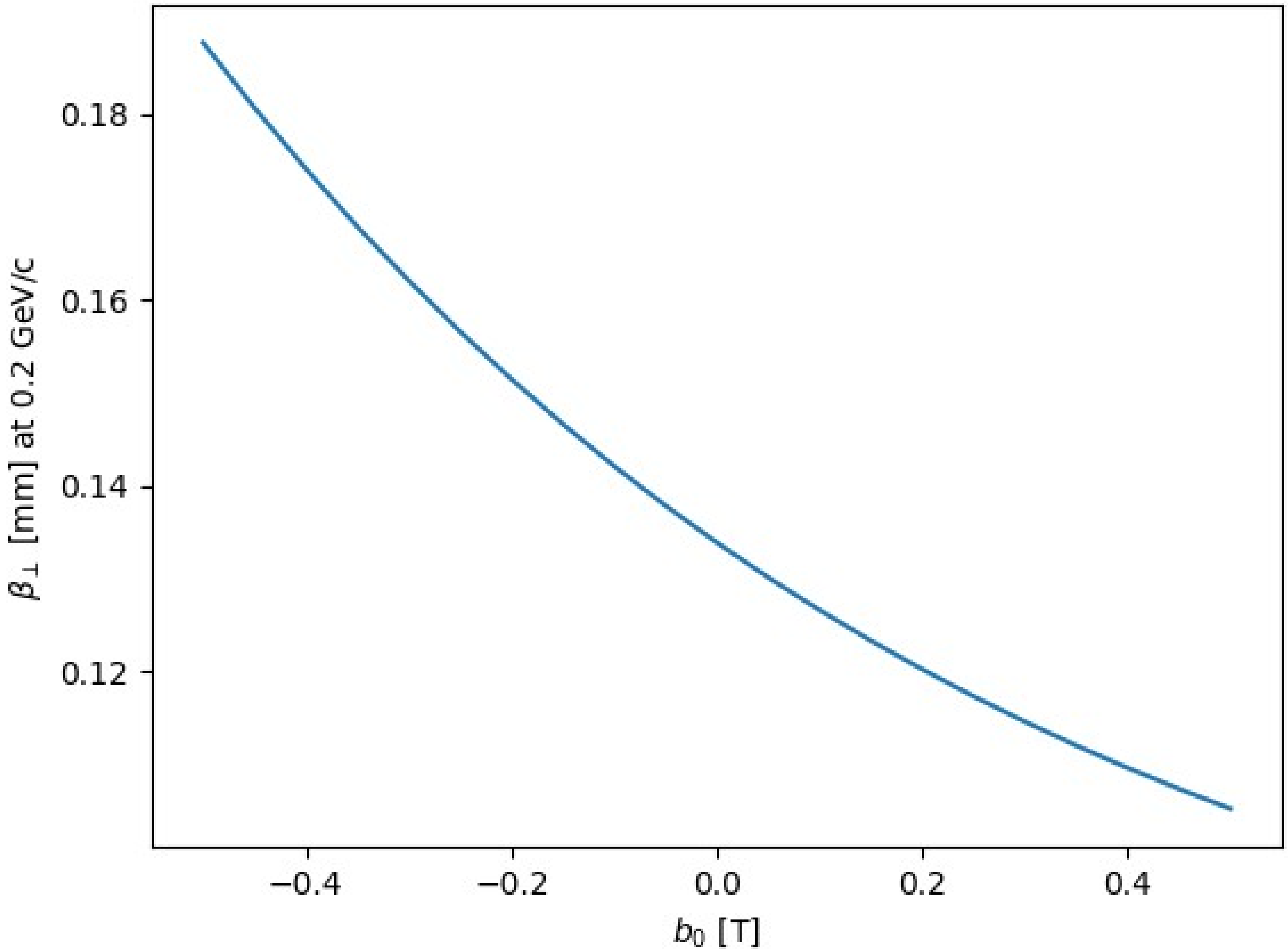


K = 0.5



Bz [T]
z [m]
0.00 0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00
6 4 2 0 −2 −4 −6
8 6 4 2 0 −2 −4 −6 −8
β [m]
pz [GeV/c]
0.14 0.16 0.18 0.20 0.22 0.24
0.1 0.12 0.14 0.16
0.0 0.1 0.2 0.3 0.4 0.5

K = 0.5



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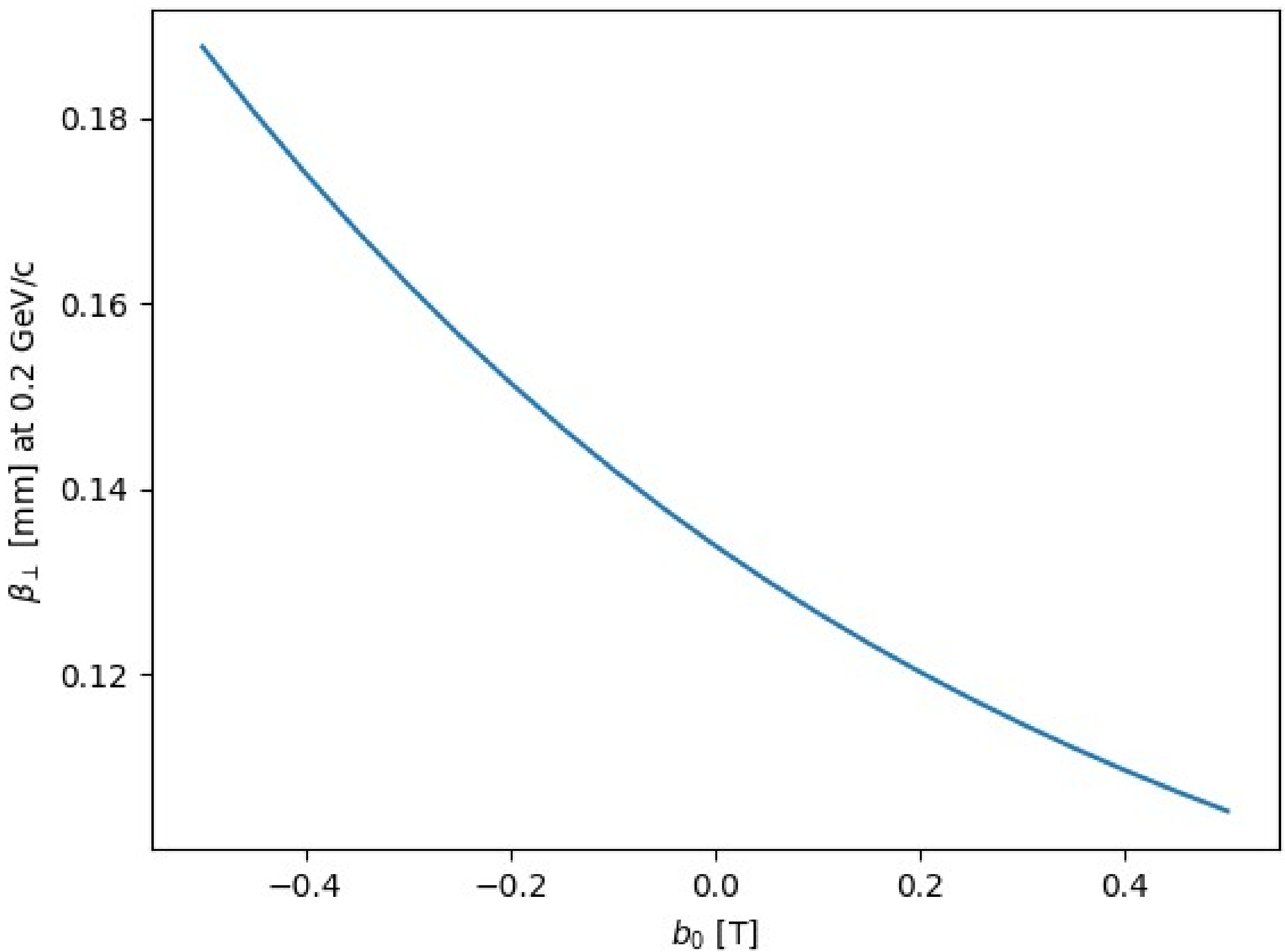
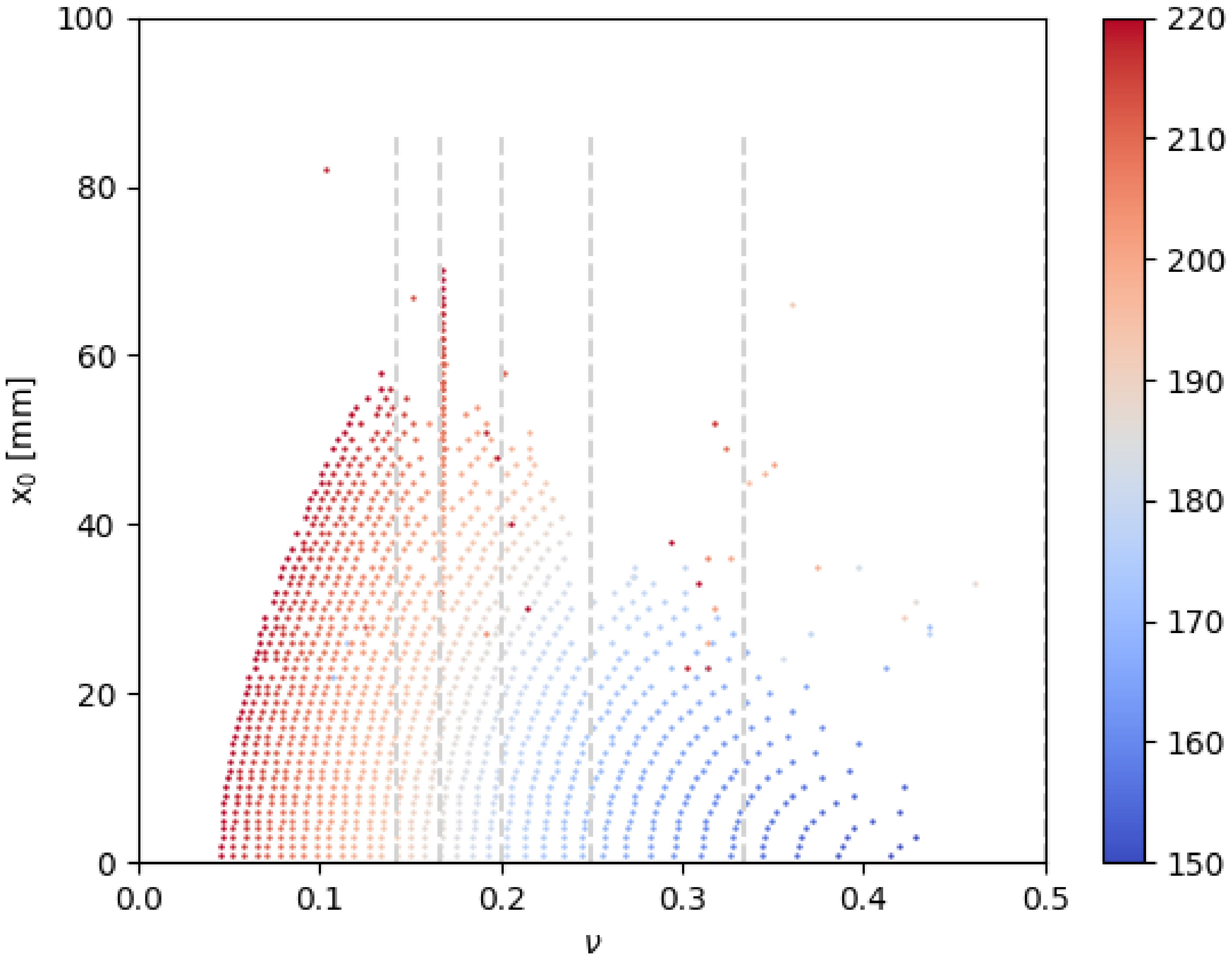
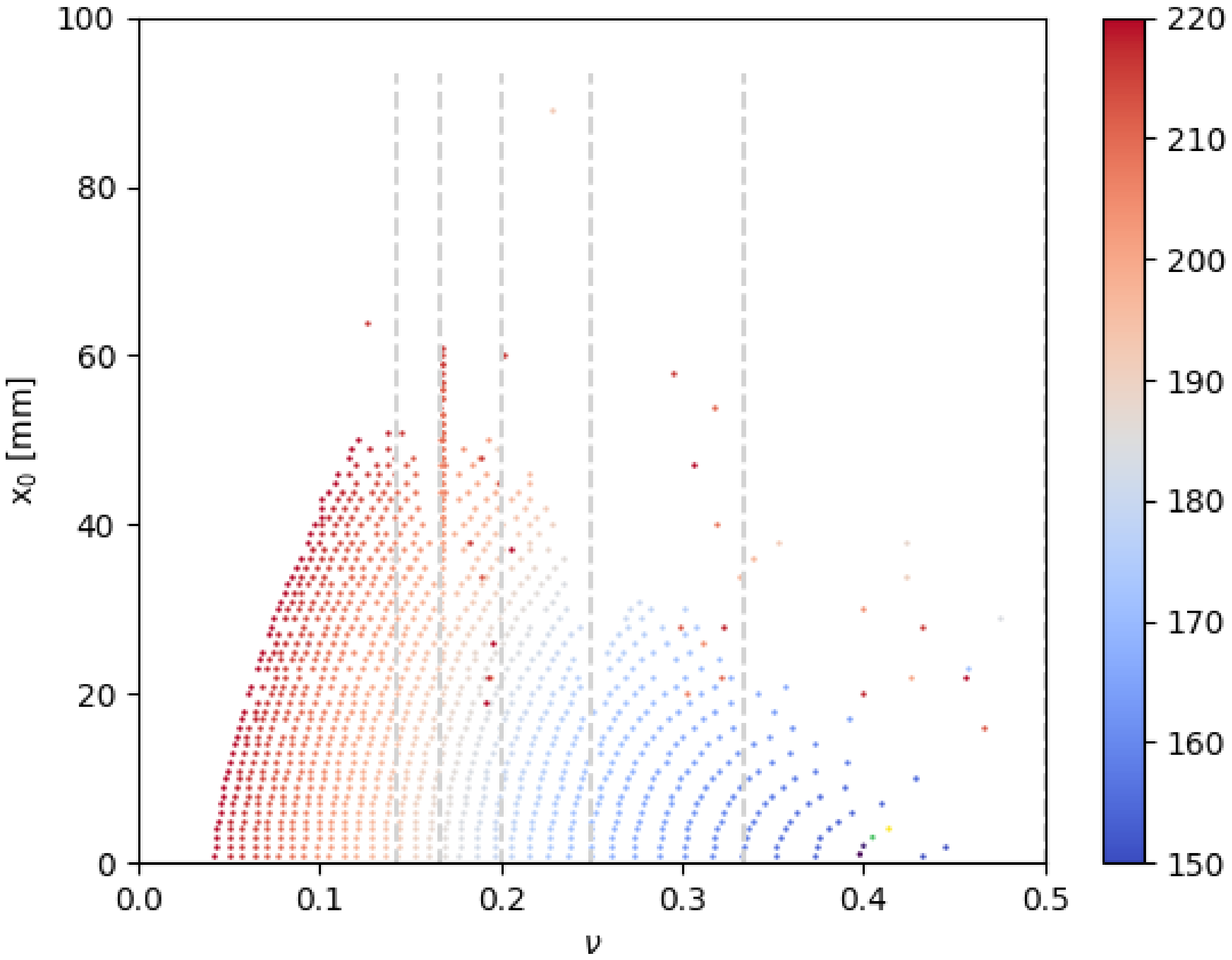
K = 0.5



Tune distortion/DA – b2 = 1



Tune distortion/DA – b2 = 1.25



Conclusions

- Looked at solenoid errors in demonstrator lattice
- Tolerances, assuming 1 % dilution of beta is tolerable
  - K=1 → 0.2 T vs 7 T nominal
  - K=2 → 0.02 T vs 1 T nominal
  - K=3 → 0.5 T vs 0 T nominal
  - K=0.5 → 0.02 T vs 0 T nominal
- May wish to consider structure of vacuum vessels to avoid systematic effects (e.g. k=0.5 issue)