Rectilinear Cooling Channel Status

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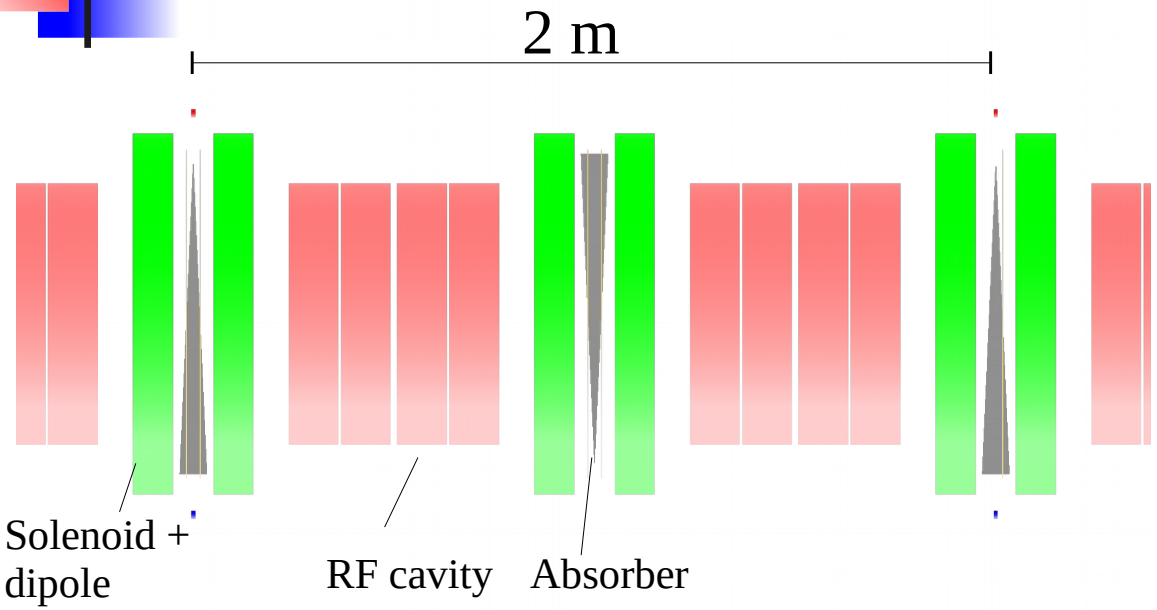
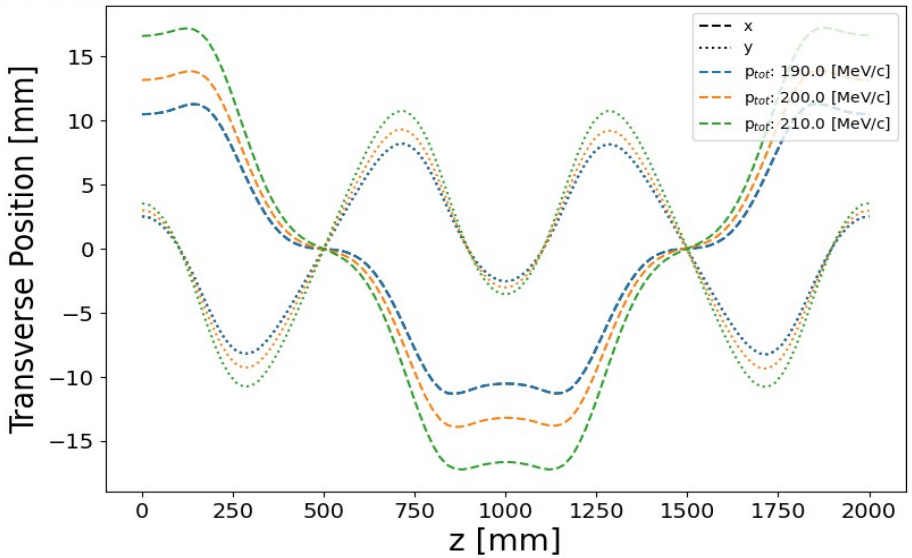
Intro

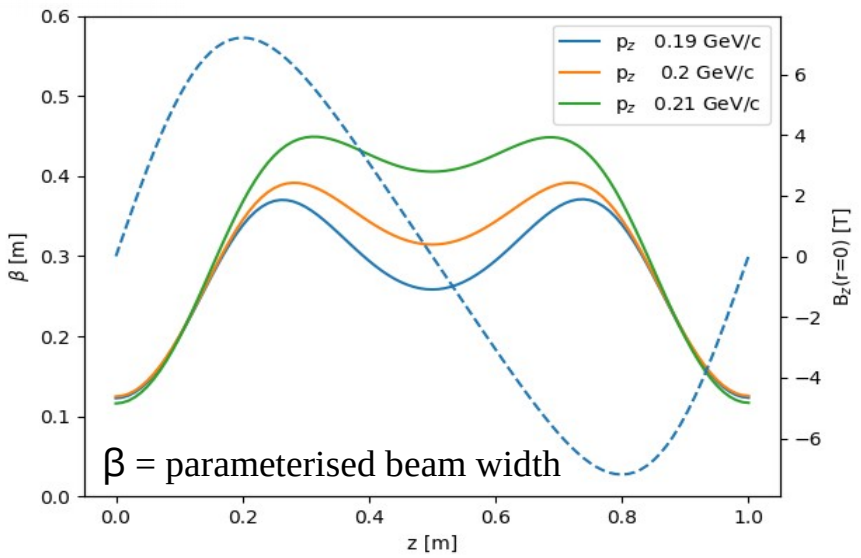
- Acceptance is a crucial part of the cooling optimisation
  - Acceptance of solenoid lattices is not well understood (by me)
  - i.e. no “easy” formula for the acceptance
- Looking at acceptance scalings
  - Scaling with momentum
  - Scaling with beta
- Just looking at solenoids
  - No dipoles
  - No RF
  - No wedges
  - Assume the other stuff is a (small) perturbation

Preliminary Cooling Cell Concept

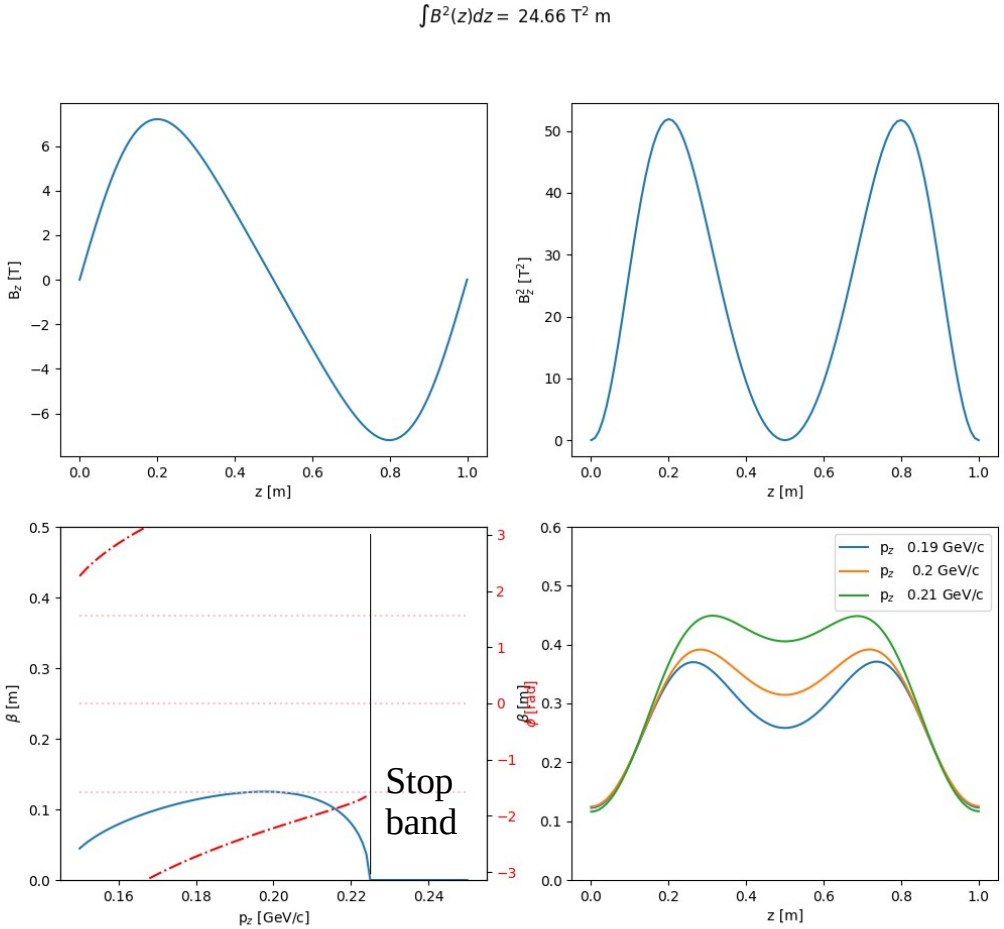


Cooling System	
Cell length	2 m
Peak solenoid field on-axis	7.2 T
Dipole field	0.2 T
Dipole length	0.1 m
RF real estate gradient	22 MV/m
RF nominal phase	20°
RF frequency	704 MHz
Wedge thickness on-axis	0.0342 m
Wedge apex angle	5°
Wedge material	LiH



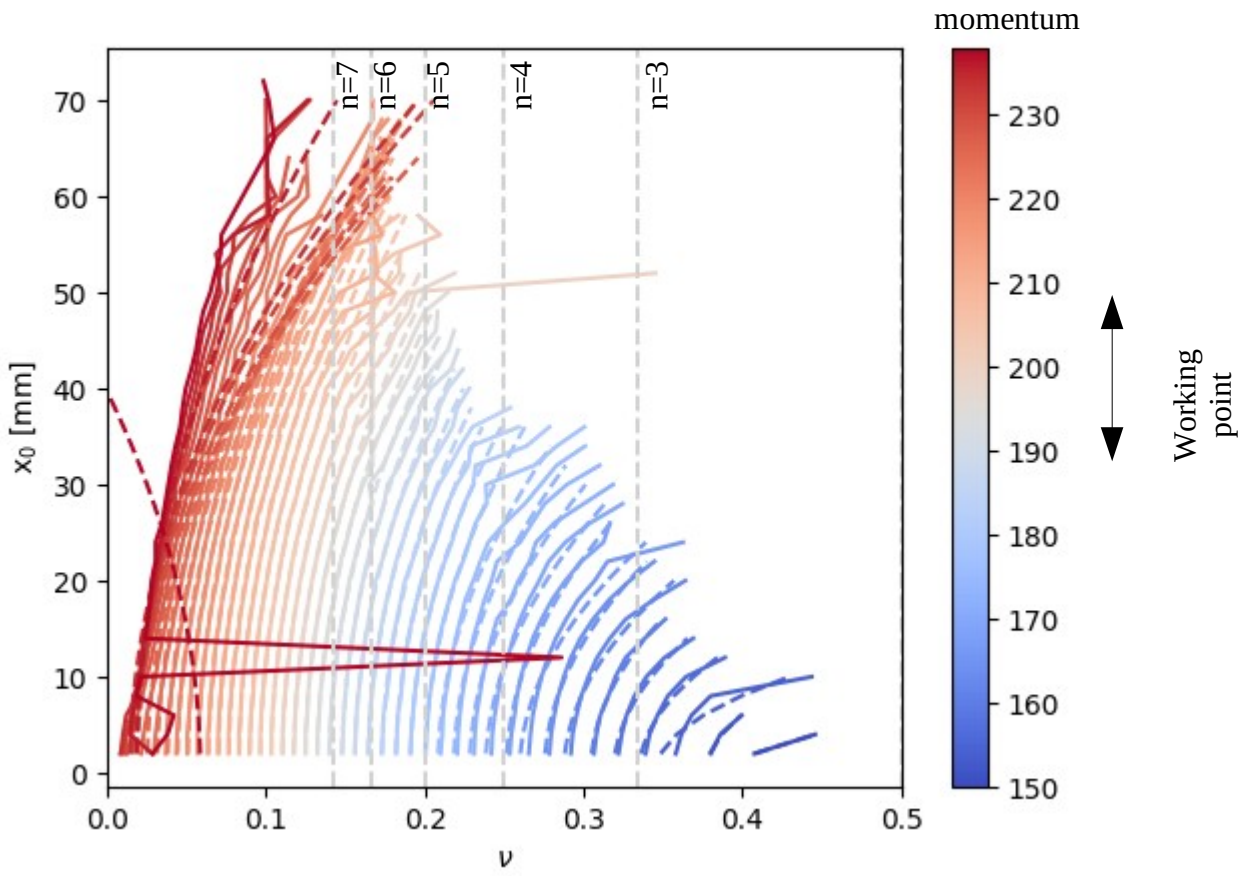


Optics



- Note optics dependence on momentum

Detuning – vs momentum

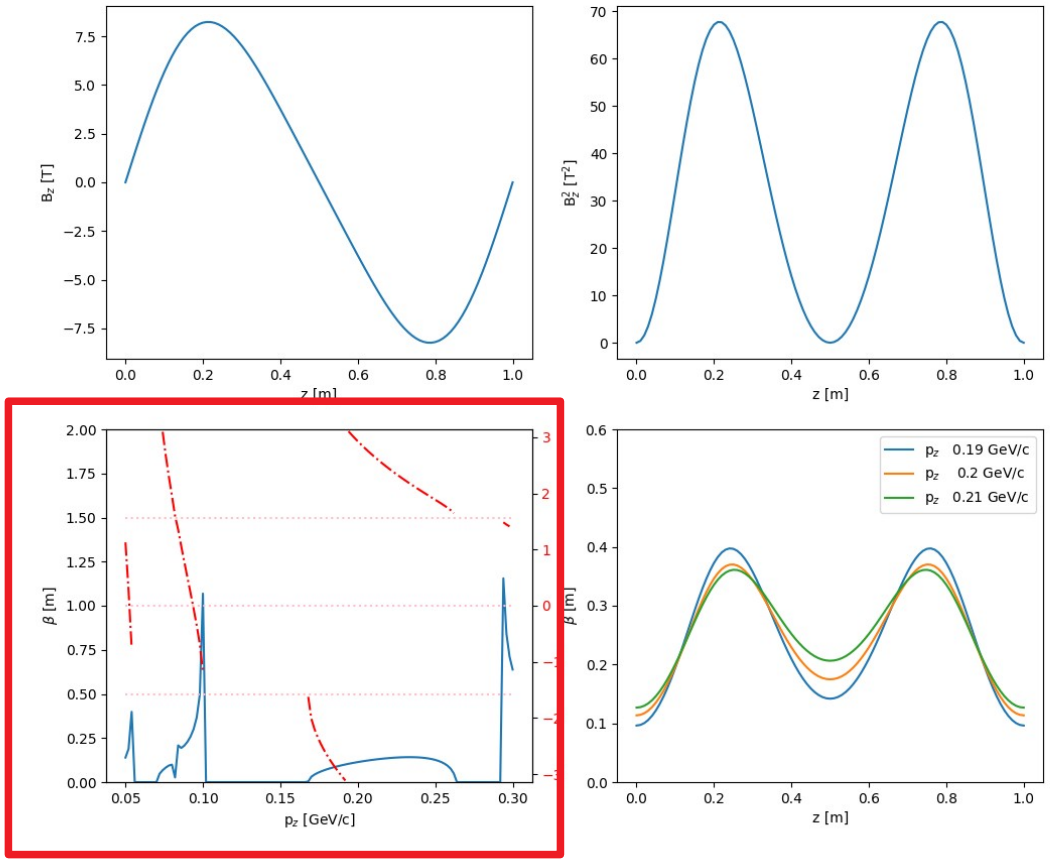


- Tune dependence on amplitude
  - Particle initial coordinates are (x,px,y,py) = (x0, 0, 0, 0)
  - Momentum scan, indicated by colour

Momentum scaling (movie 1)

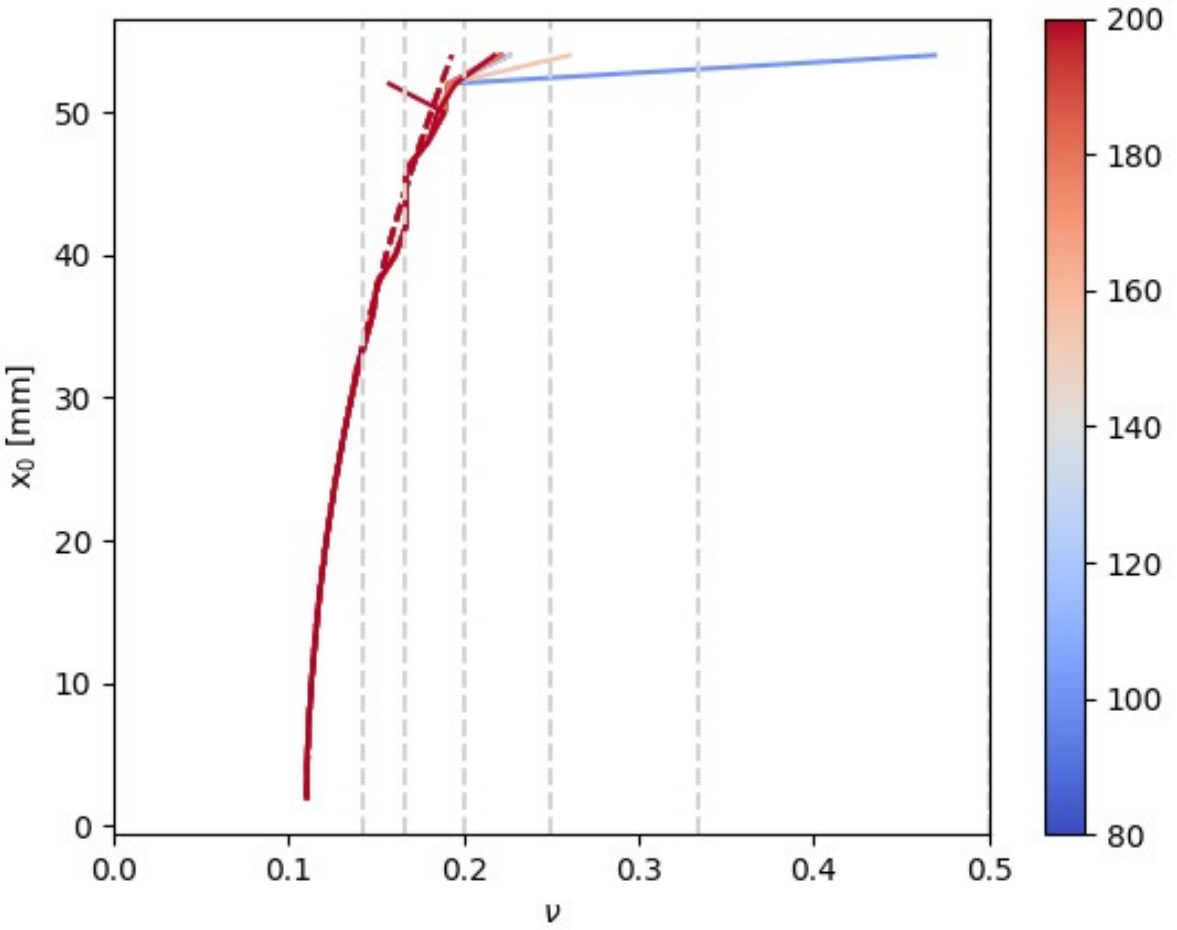
$L = 1; b_0 = 0; b_1 = 8; b_2 = 1; b_3 = 0; b_4 = 0; b_5 = 0$

$\int B^2(z)dz = 32.5\ \mathrm{T}^2\ \mathrm{m}$



Momentum scaling

- Scales perfectly



Acceptance

- Normalised Amplitude ~ x^2

$$A_\perp^2 = \frac{1}{\beta_\perp}\left(x^2 + y^2\right) + \beta_\perp\left(\frac{\mathcal{P}_x}{P_z} + \frac{\alpha_\perp}{\beta_\perp}x + \frac{\mathcal{L}}{\beta_\perp}y\right)^2 + \beta_\perp\left(\frac{\mathcal{P}_y}{P_z} + \frac{\alpha_\perp}{\beta_\perp}y - \frac{\mathcal{L}}{\beta_\perp}x\right)^2,$$

0

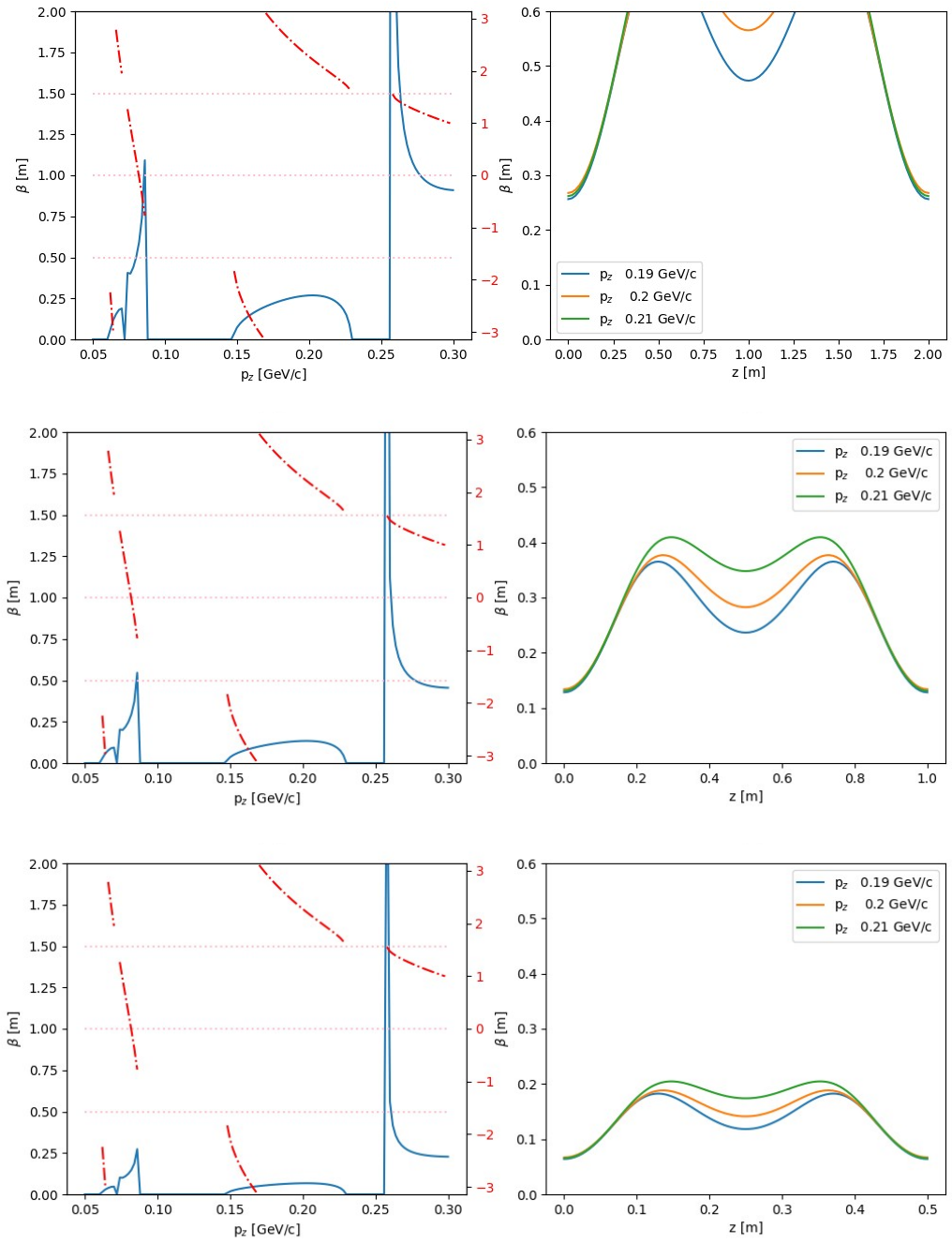
0

Transverse beta - constant

- Acceptance is constant with momentum
- Probably obvious from equations of motion
  - $dp/dz = q\, d\underline{x}/dz \times \underline{B}$

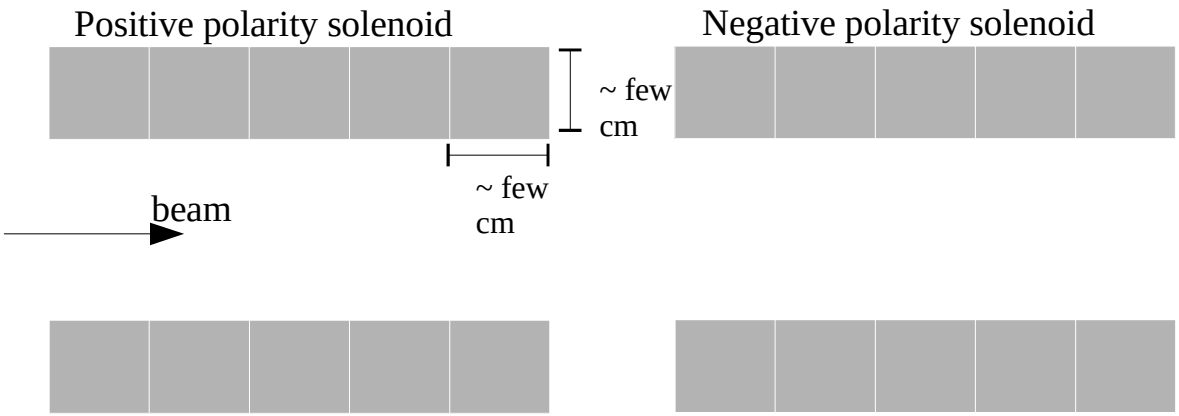
Beta Scaling

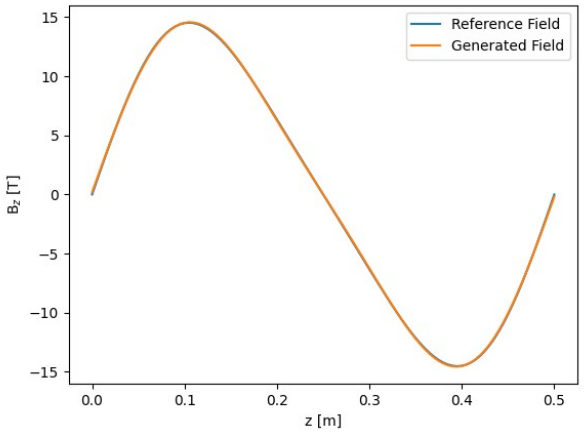
- What about if we scale $\beta_\perp$?
  - Set B and 1/L

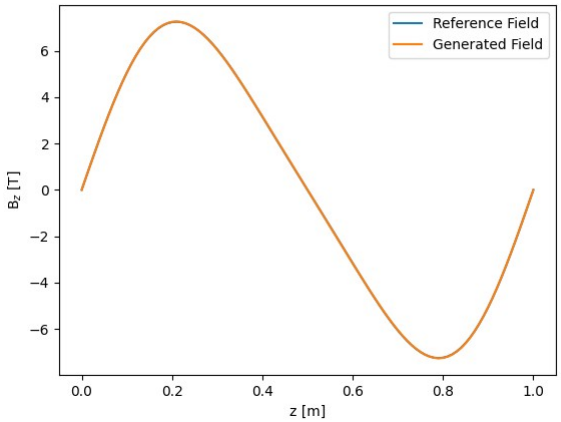


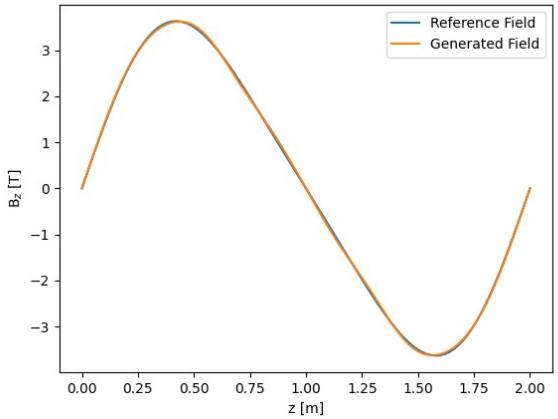
Beta Scaling

- Use “pixel” model to generate fields in G4BL



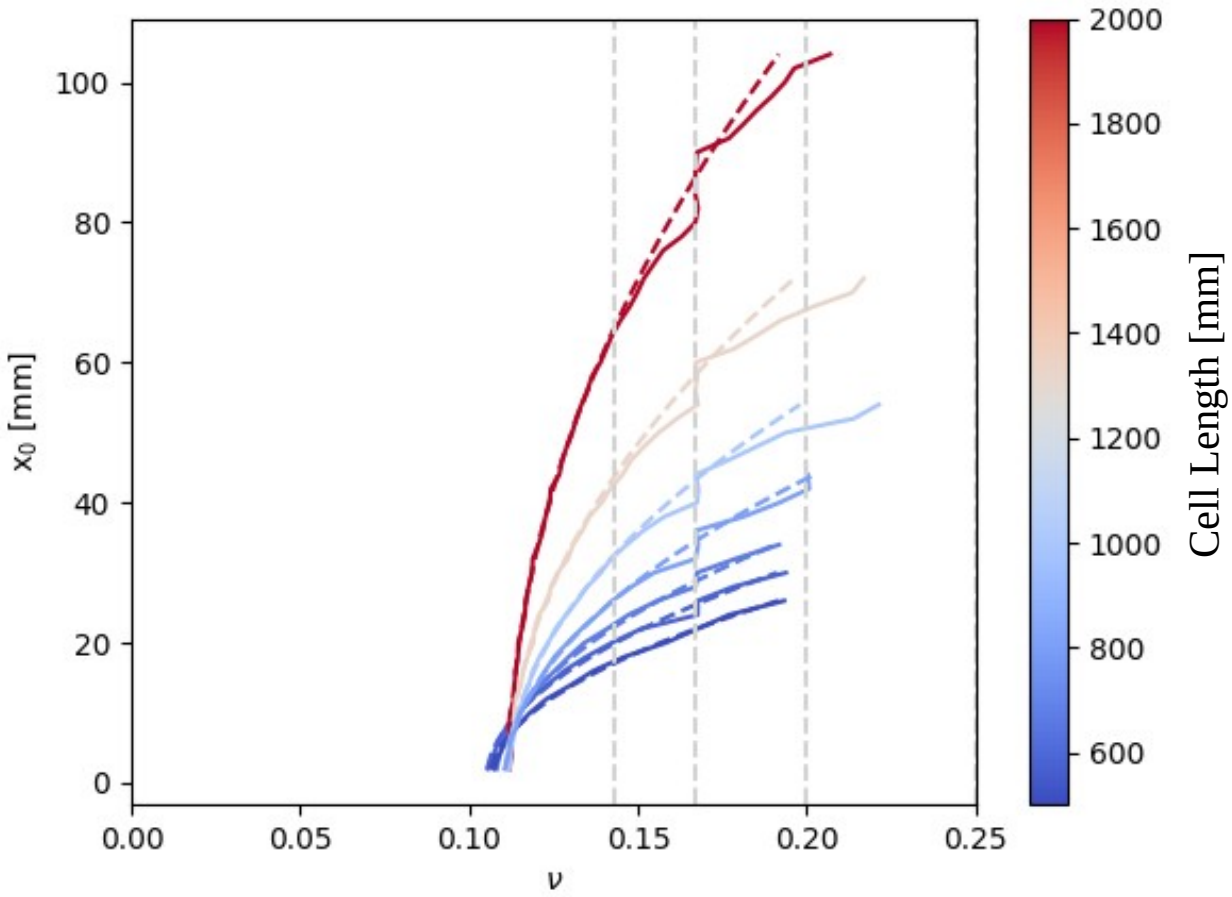






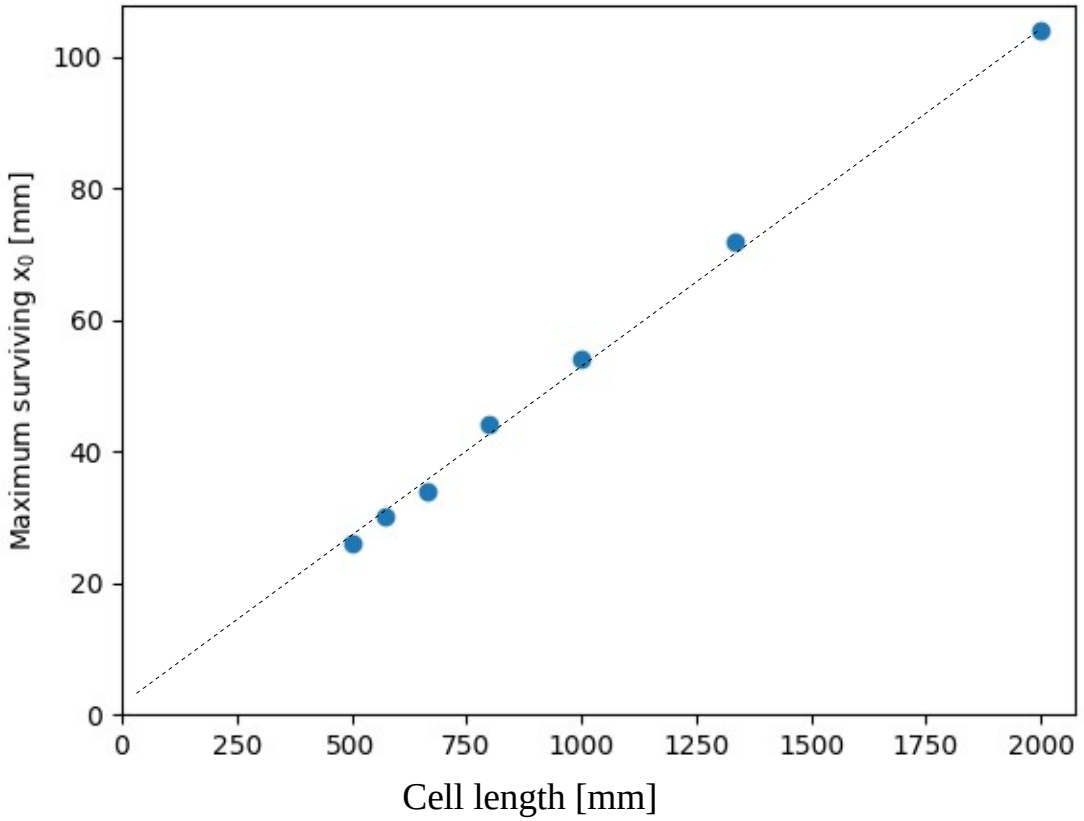
Tune dependence

- Tune dependence



Acceptance

- Acceptance
  - Line is for guidance only – I haven't properly fitted
  - "cell length" is proportional to $1/B_z$ and $\beta_\perp$



ToDo

- Should be able to phrase the acceptances in terms of theory
- Should use amplitude, not "x_0"
- Compare with cooling formulae; look at where is the optimum

ToDo (2)

Mu

In general deliverables should come in the form of a document.

Objective	Level	WBS	Activity/Deliverables	Responsible
2	1	2	Rectilinear Cooling	
	2	2.1	Beam physics design	
	3	2.1.1	Optics design, including tapering, understanding dynamic aperture	
	3	2.1.2	Tapering and matching between sections; further optimisation of the lattices	
	3	2.1.3	Alignment and tolerances	
	3	2.1.4	Collimation systems and radiation protection	
	3	2.1.5	Radiation load on SC magnets and other equipment	
	3	2.1.6	Liaison with RF and magnets	
	2	2.2	Beam loading	
	3	2.2.1	Effect of beam loading for each cell	
	3	2.2.2	Investigate mitigation, together with RF team	
2	2	2.3	Estimate significance of space charge	
	2	2.4	Beam instrumentation	
	3	2.4.1	Preliminary ideas for beam instrumentation - time, energy, beam profile	
	3	2.4.2	Physics design	
	2	2.5	Absorber design	
	3	2.5.1	Estimate magnitude of heat deposition	
	3	2.5.2	Absorber design	
	2	2.6	Engineering integration	
	3	2.6.1	Integration of magnets and RF	
	3	2.6.2	Alignment system	
	3	2.6.3	Integrated thermal design	
	3	2.6.4	Vacuum systems