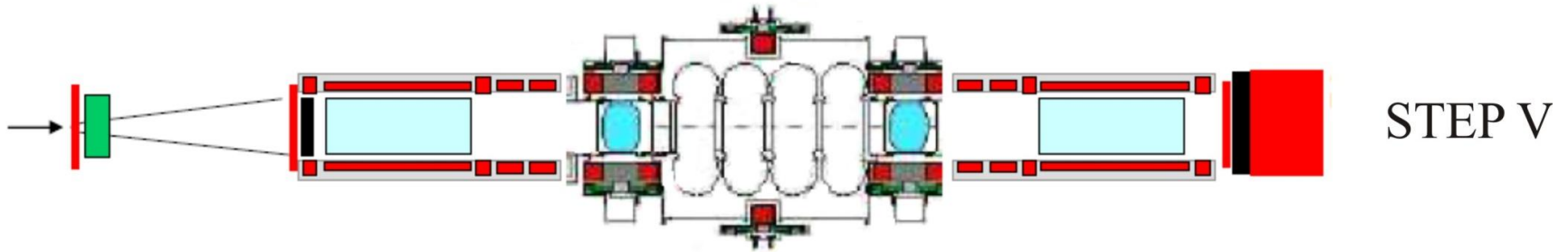# CM31: **Step V.0**
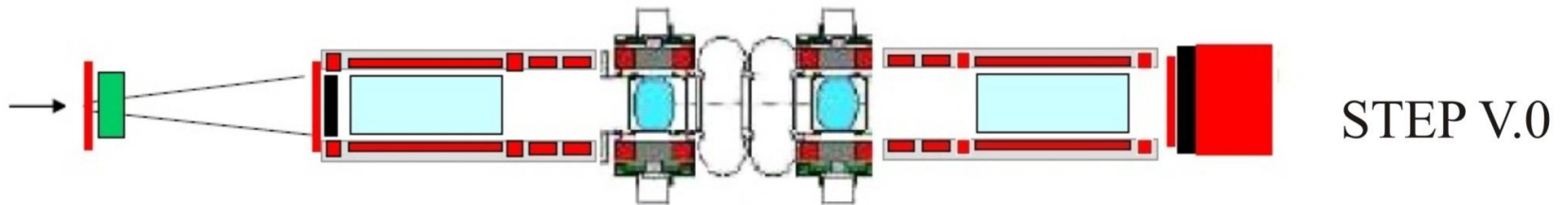
Timothy Carlisle

University of Oxford

Life after Step IV…
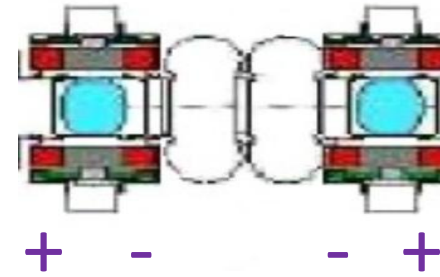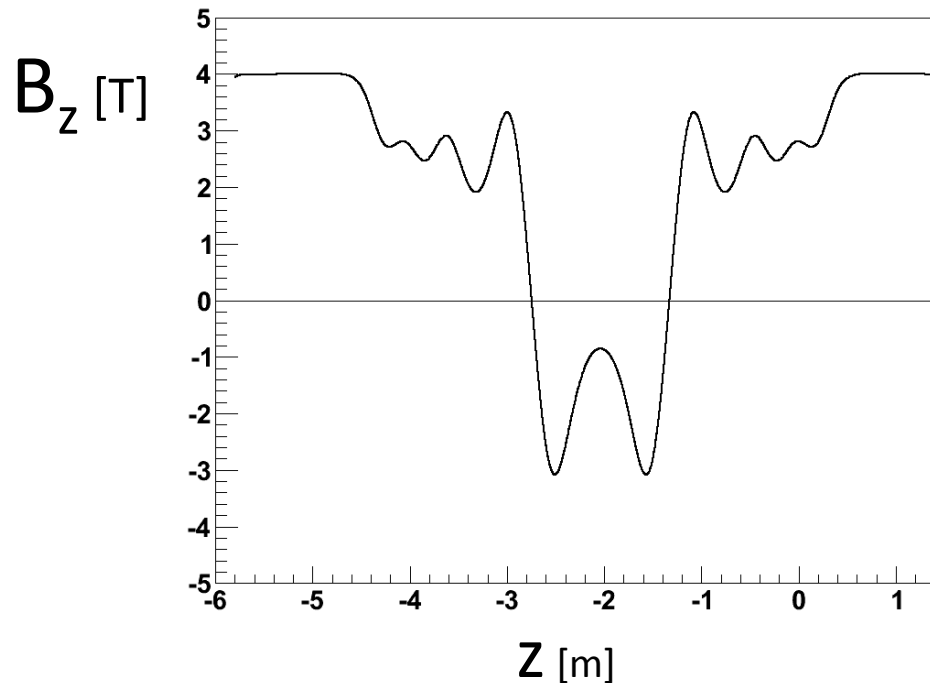

STEP V

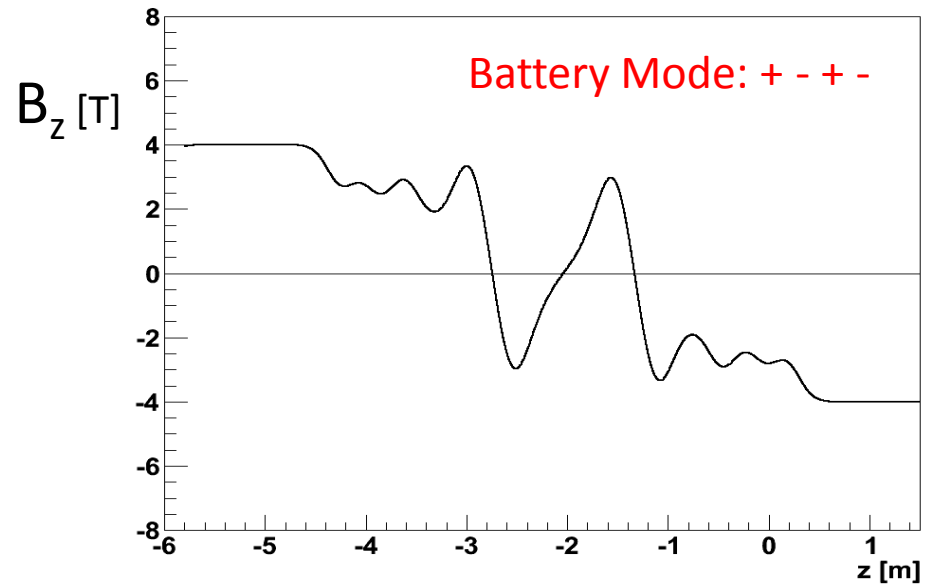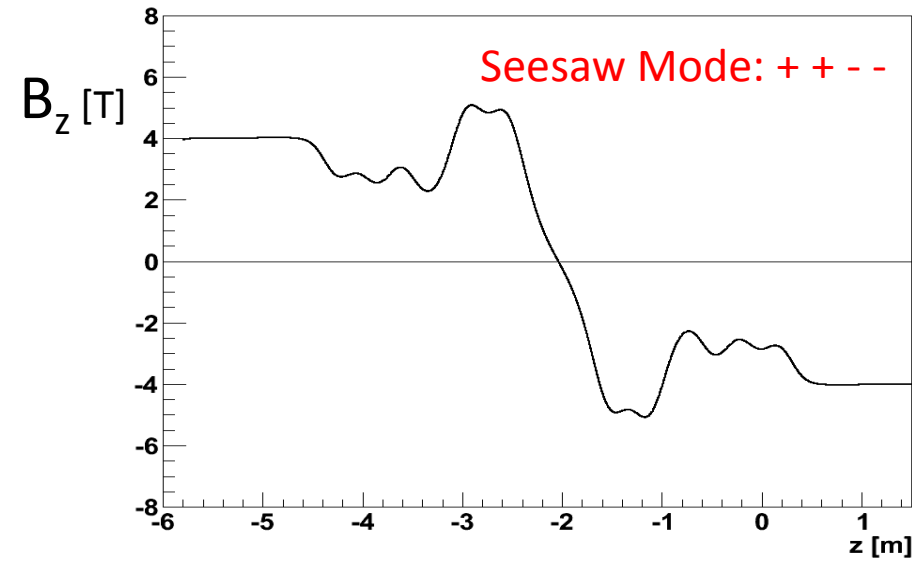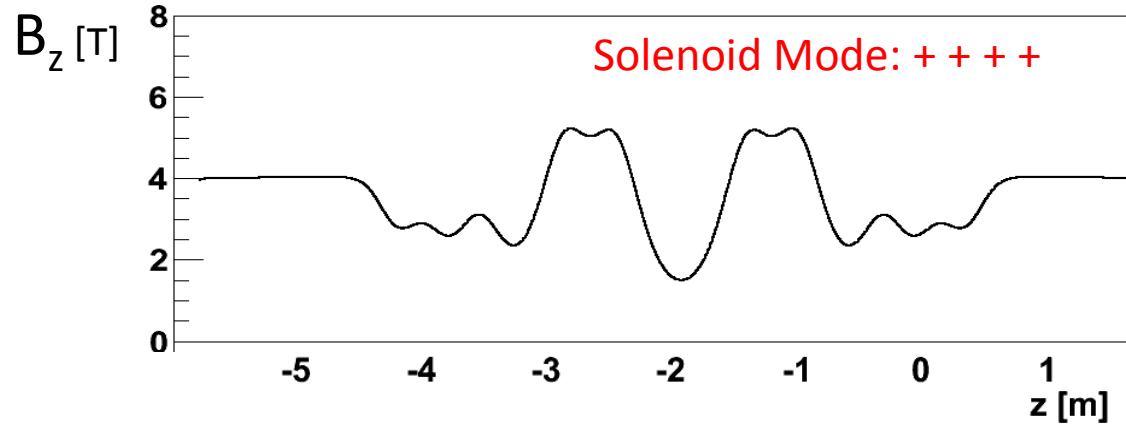No Coupling Coil…?

STEP V.0

Step V.0 Operating Modes

- FCs share the same power supply ($|J_{FC}|$)
  - Can flip sign
  → different running modes for Step V.0?

- Match Coils also tuneable (M1,2)

+   -   -   +

Flip Mode

B_z [T]

Z [m]

Other possibilities:

Matching Step V.0

- Want operating currents for FC & M1,2
- **Evolve Beta Fn. through MICE** with:

$$2\beta\beta'' - (\beta')^2 + 4\beta^2\kappa^2 - 4 = 0$$

- Minimize: $F = \dfrac{1}{2}\left(\beta_0\gamma - 2\alpha_0\alpha + \beta\gamma_0\right)$

1. Match beam between FCs
   → Find β_0, J_{FC}
2. Match beam from solenoid
   → Find J_{M1}, J_{M2}
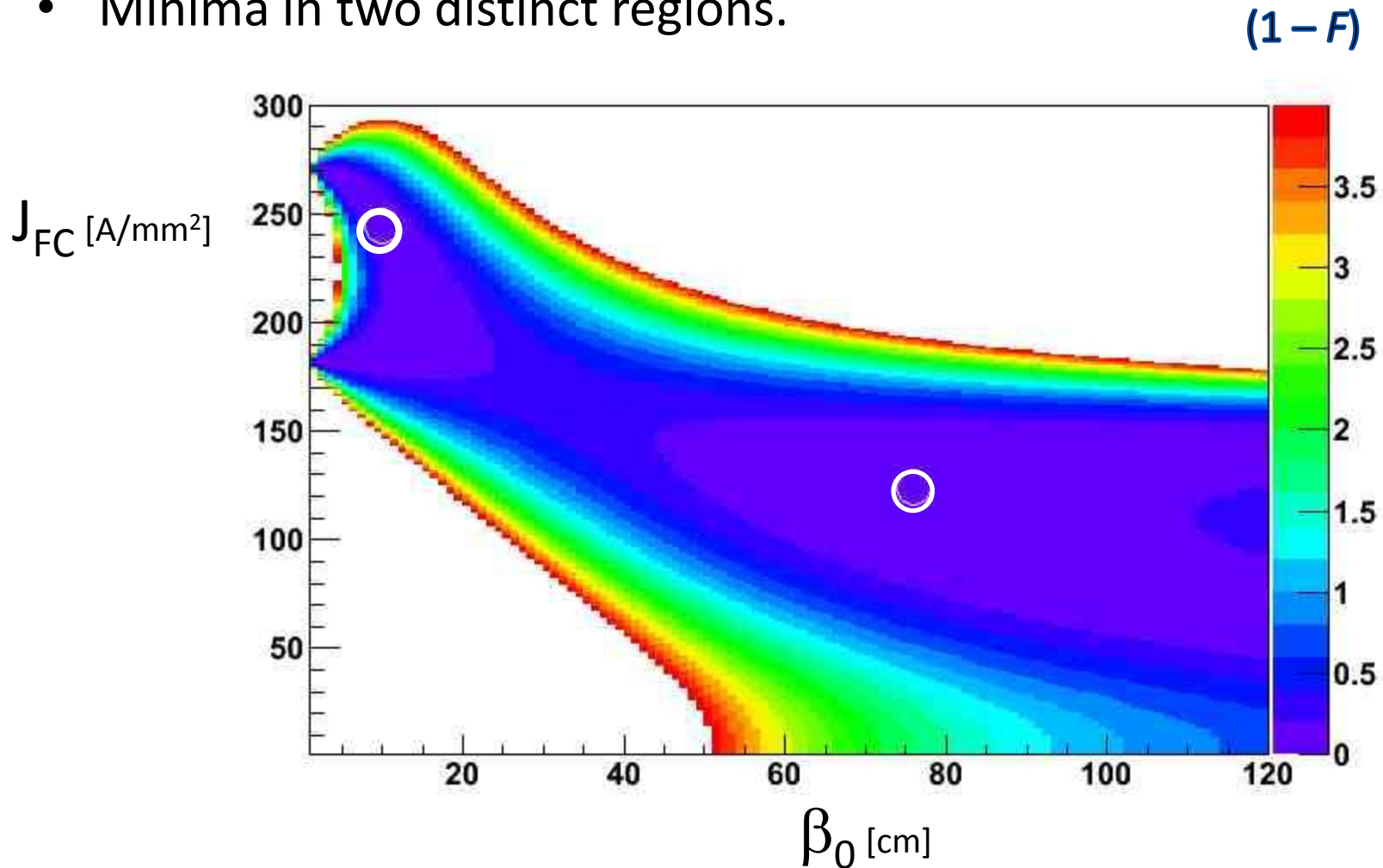
- **Tune MICE optics** for all modes.
- **Ignore current limits for now.**

1st FC centre   **2nd FC centre**

β [cm]

Z [m]
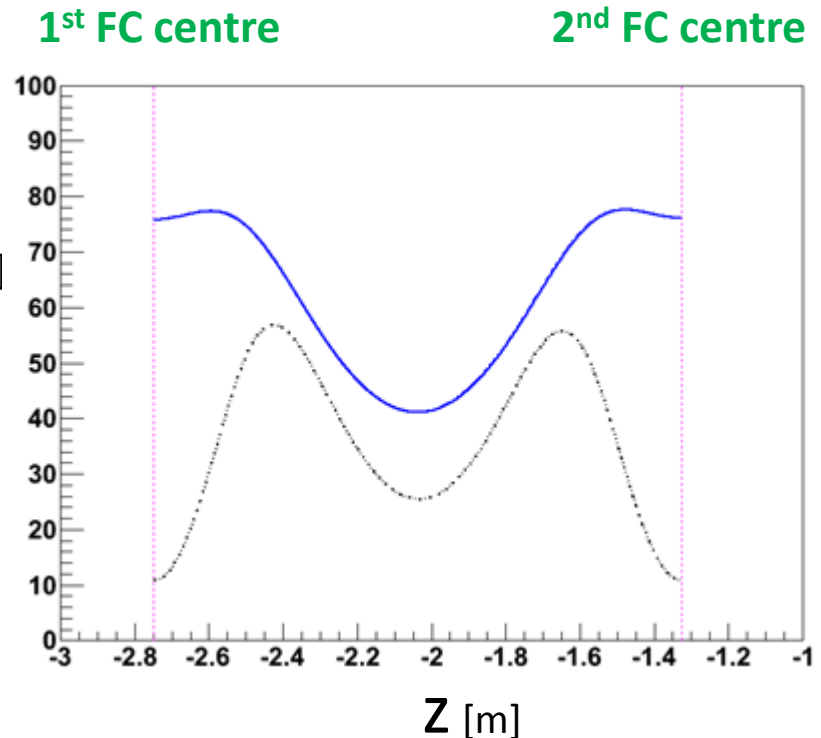
Flip Mode

- Use Minuit to **search parameter space**
- Minima in two distinct regions.

$(1 - F)$

Solutions

Mode	J_{FC}	J_{M2}	J_{M1}	β_0 [cm]	p_z [MeV/c]
Flip	241.90	168.64	229.32	10.41	200
+ - - +	124.00	233.99	211.80	76.00	200
Battery	270.99	62.84	241.04	7.03	200
+ - + -	116.00	254.18	231.11	82.00	200
Solenoid + + + + Seesaw	**no fit**				

(J in units of A/mm^2)

- Battery Mode not discussed any further
  - → Flip Mode better.

Flip Mode – 4T

- High & low β sols.

β [cm]

B$_z$ [T]

Z [m]

Z [m]
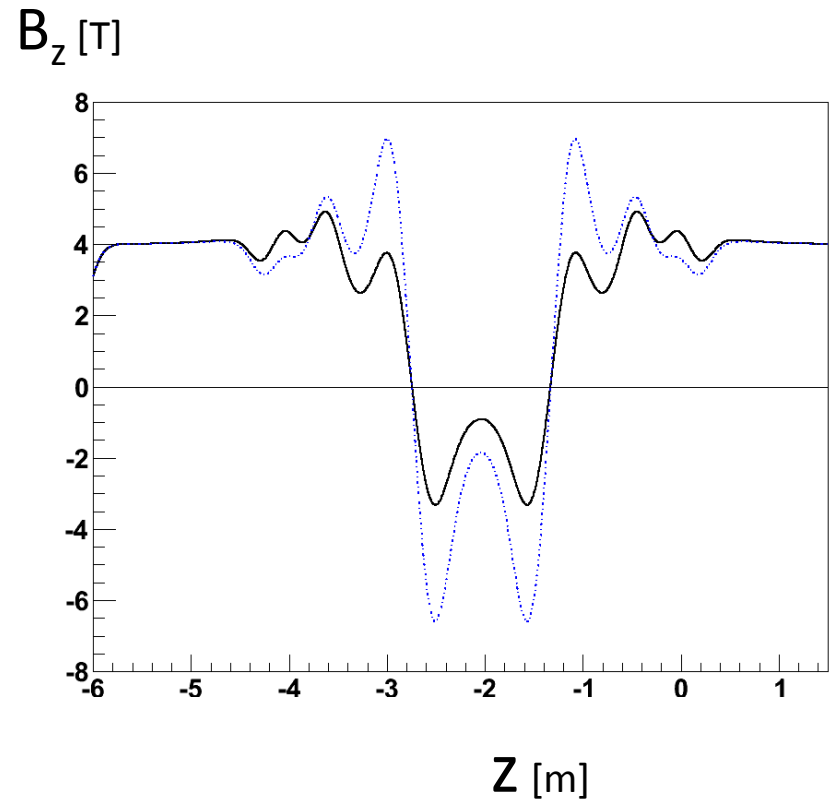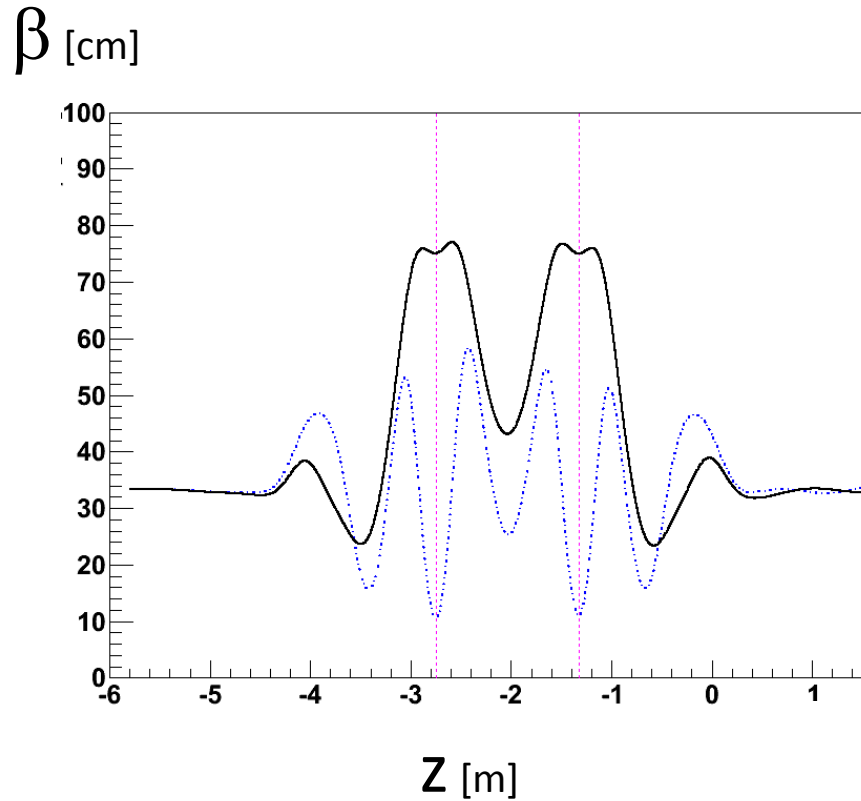
Scaled Solutions

- However: $|J_{FC}|<$ 140 & $|J_{M1,2}|<$ 160

- Options:

1) Scale down **all coil currents**
   - **3 T** in SS, reduce p_z → β_{in} = 33.3cm

2) Scale down FC & M1, M2.
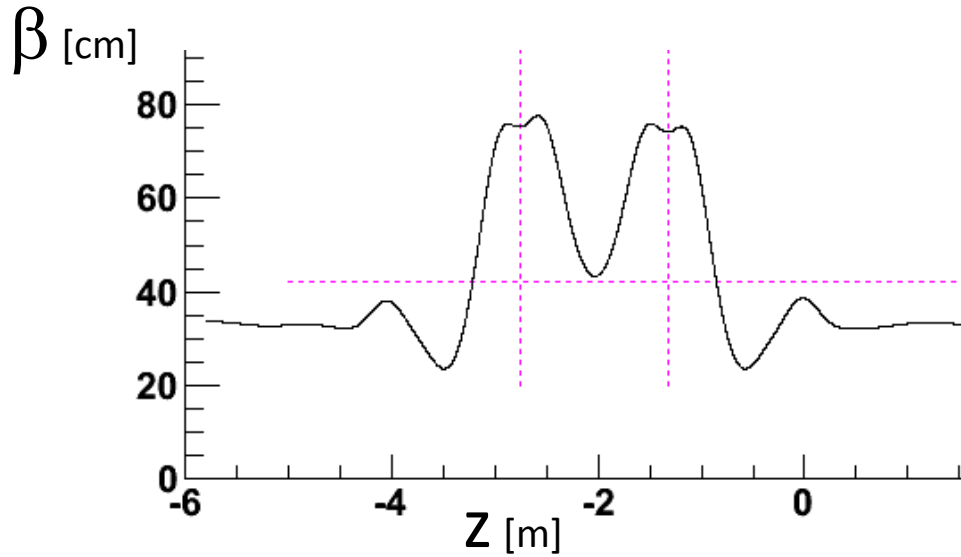   - Run at 4T in SS, reduce p_z → β_{in} **reduced**.

Matching Condition

$$\beta\kappa = 1$$

$$\kappa = \frac{0.15 B_z}{p_z}$$

$$\beta \propto \frac{p_z}{B_z}$$

β_0 [cm]	J_{FC}	J_{M2}	J_{M1}	p_z [MeV/c]
10	137	96	130	113
76	85	160	144	136

1) Scale down all coil currents

β [cm]

Flip **3T**

β_0 **= 76 cm** solution

p_z **= 136 MeV/c**
no material

B_z [T]
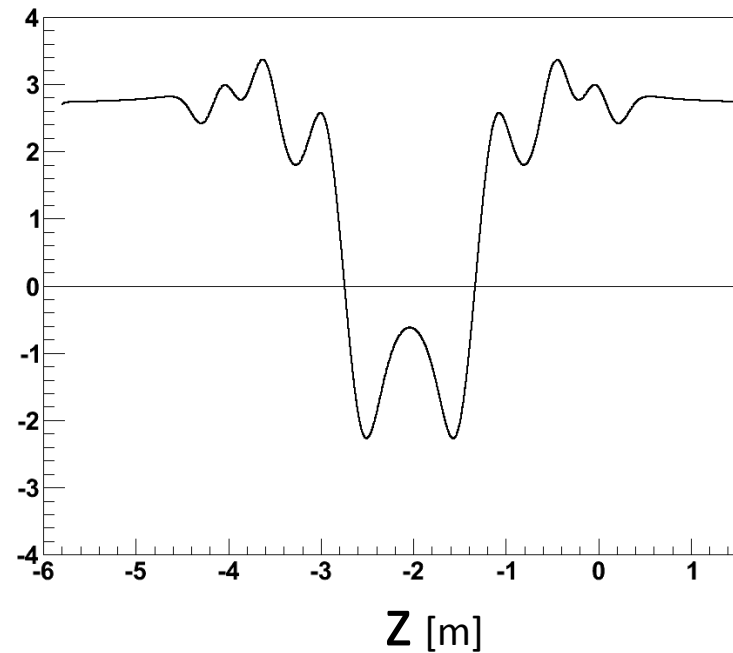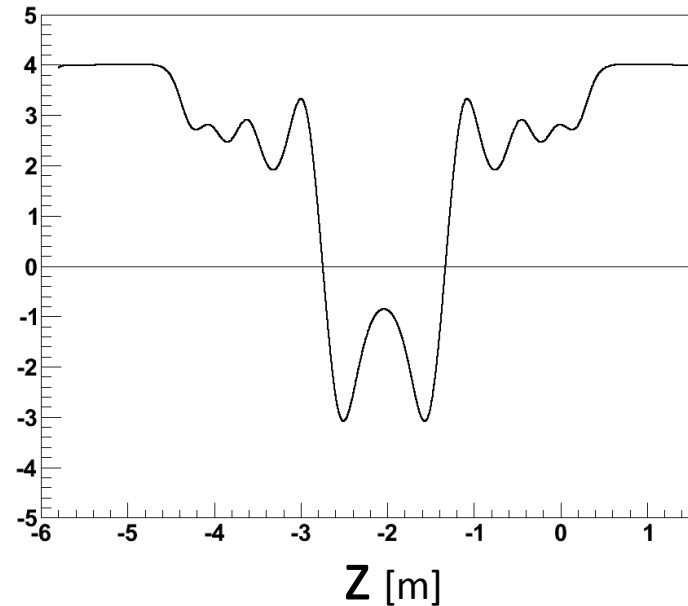
2) Scale down only FC & M1,2

β [cm]
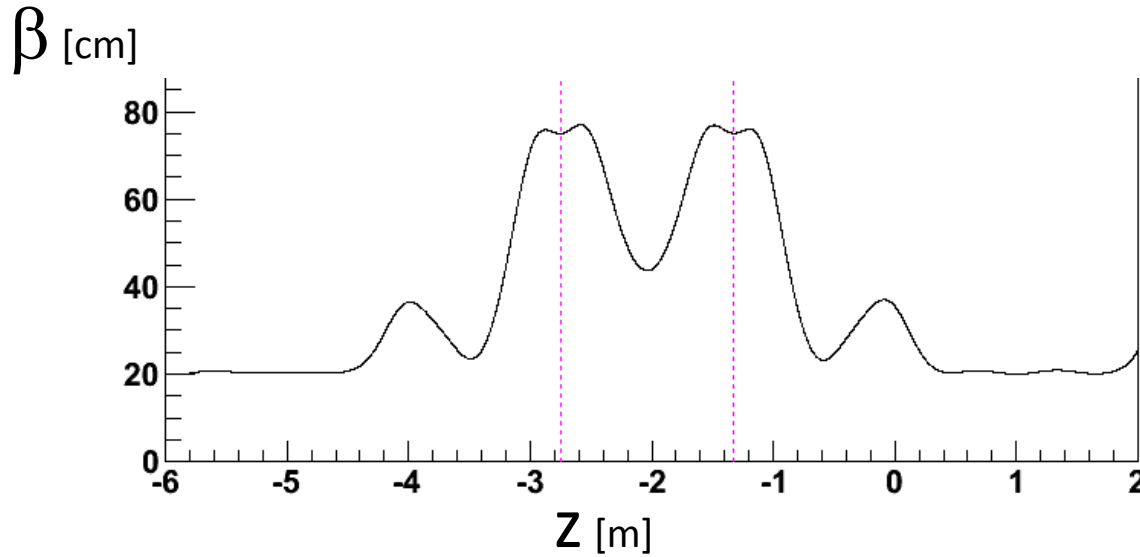
Flip **4T**

β_0 = **76 cm** solution

p_z = **123 MeV/c**
no material

B_z [T]

$\beta_0 \sim$ **76** cm
J_{FC}=76.284
J_{M1}=125.66
J_{M2}=149.80

Step V.0: Modes (scaled)

Mode	JFC		J4 (M2)		J5 (M1)		β_0	p_z [MeV/c]	
Flip	241.90	137.00	168.64	95.51	229.32	129.87	10.41	200	113.27
+ - - +	124.00	84.79	233.99	**160**	211.80	144.82	76.00	200	136.76
Battery	270.99	137.00	62.84	31.77	241.04	121.86	7.03	200	101.11
+ - + -	116.00	73.02	254.18	**160**	231.11	145.48	82.00	200	125.90
Solenoid + + + + Seesaw + + - -	no fit								
			Max. J_{FC}	137					
			Max. J_{MC}	160					

Limiting parameter **underlined**
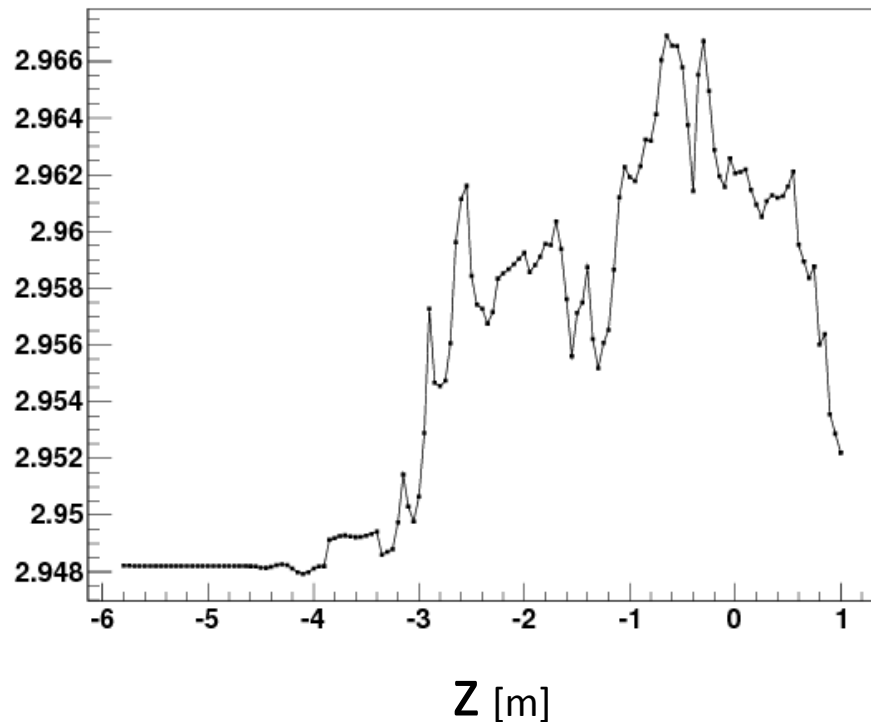
Step V.0 in G4MICE
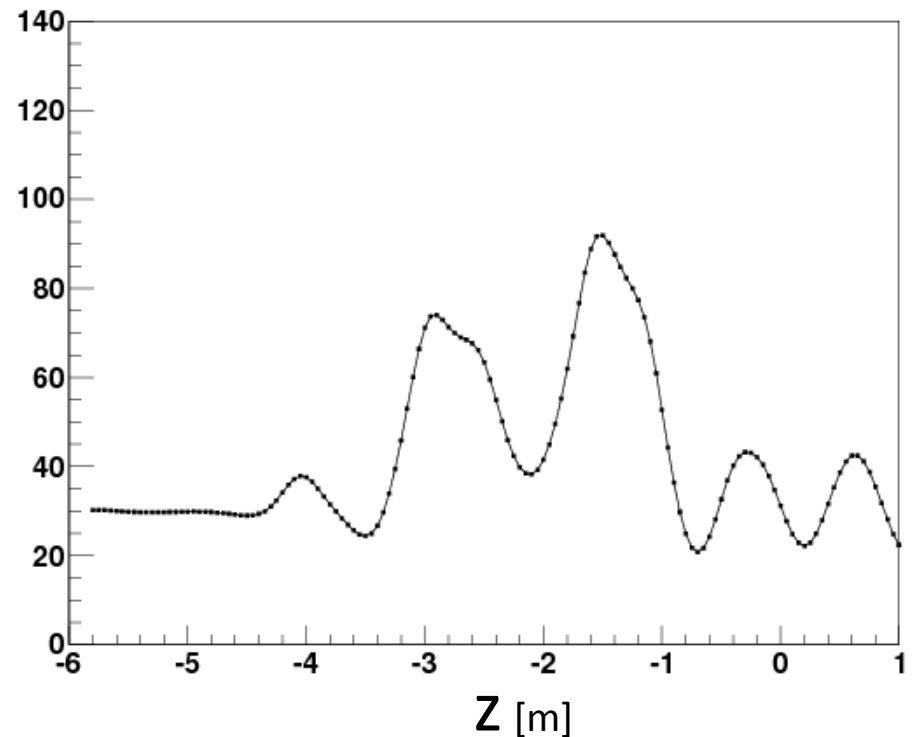
Flip **3T**
β_0 = 76 cm sol.

ε = 3mm
σ_{pz}=1 MeV/c

emittance [mm]

β [cm]

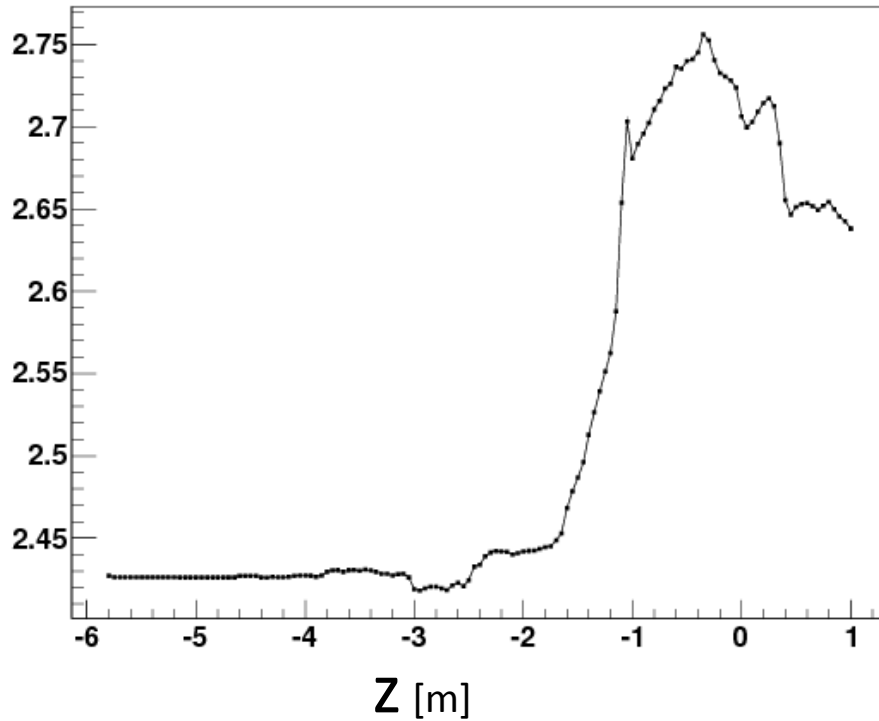p_z = 136 MeV/c
no material

Step V.0 in G4MICE
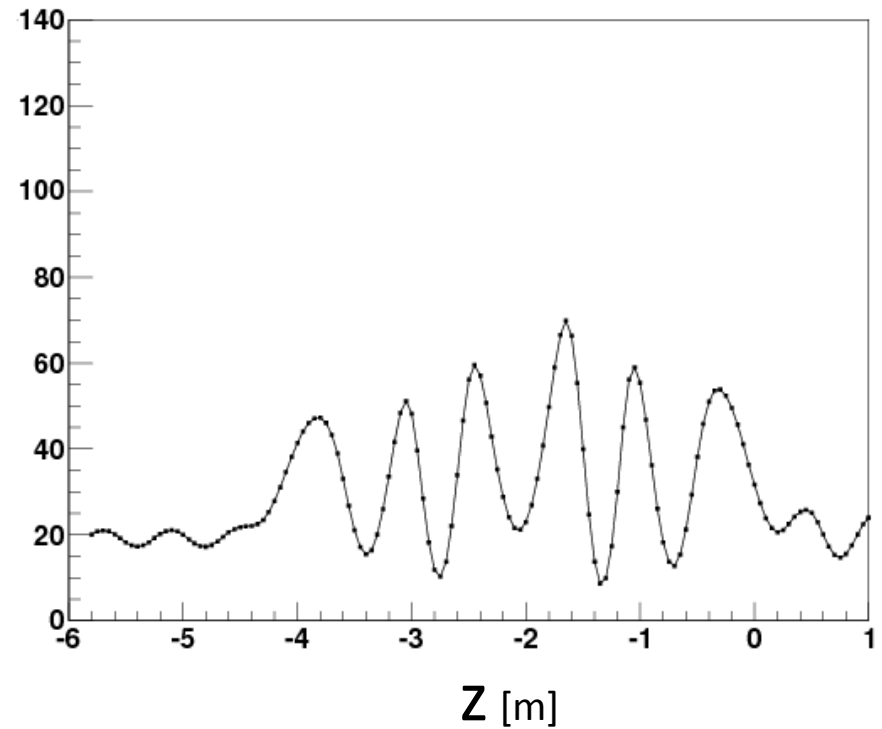
Flip **4T**
β_0 = 10 cm sol.

ε = 3 mm
σ_{pz}=1 MeV/c

emittance [mm]

β [cm]

p_z = 113 MeV/c
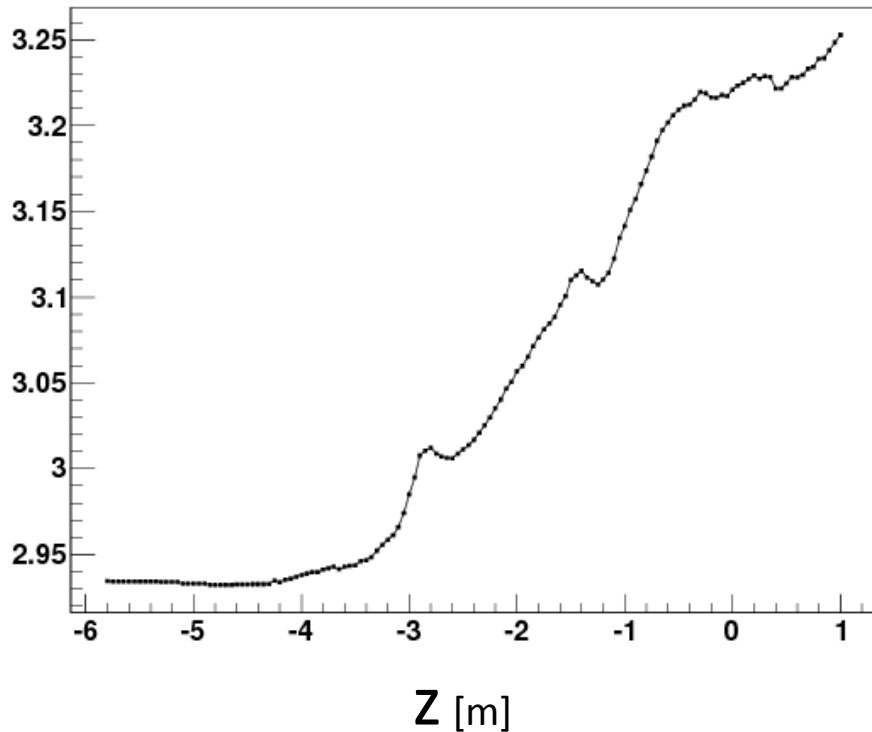no material

Step V.0 in G4MICE
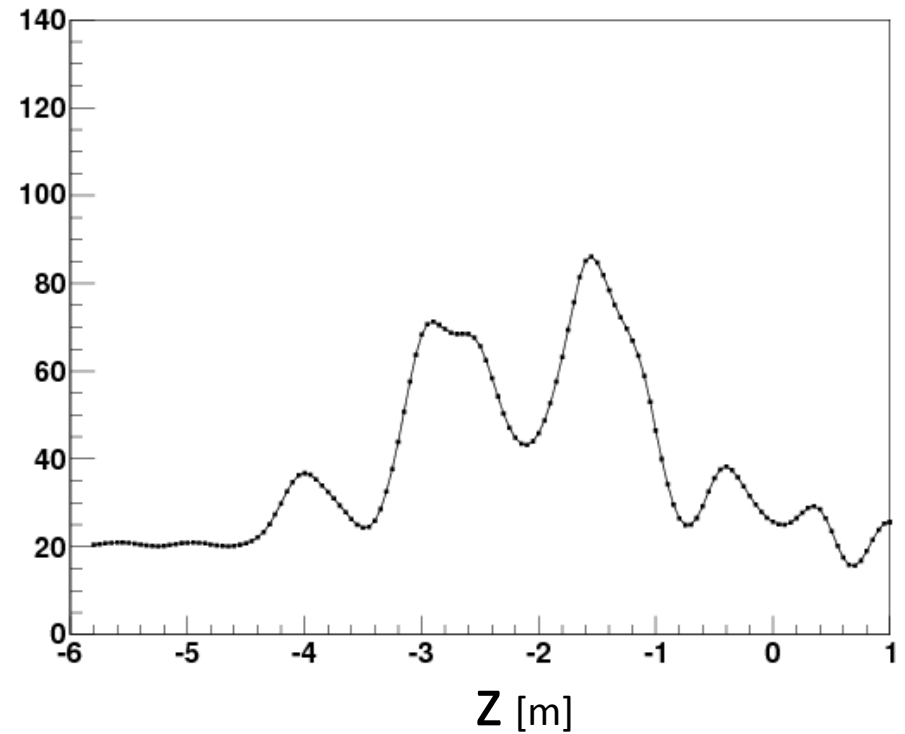
Flip **4T**
β_0 = 76 cm sol.

ε = 3 mm
σ_{pz}=1 MeV/c

emitttance [mm]

β [cm]

Z [m]

Z [m]

p_z = 136 MeV/c
no material

Summary

- **Step V.0** – RF without the Coupling Coil.
- Matched solutions found for Step V.0 in Flip Mode.
  - Evolve beam envelope eqns (on axis beams)
- Require $p_z < 140$ **MeV/c**
  - Too low?

- **Not matched** with "real" beams in G4MICE
  - Non-linear effects wreck matching

- Alternative matching techniques?
- ➤ Step V.0 a **non-starter** at present