Correcting the beam transverse offset and the dispersion for the BC by moving dipole magnets

PITZ physics seminars 2023

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8 June 2023

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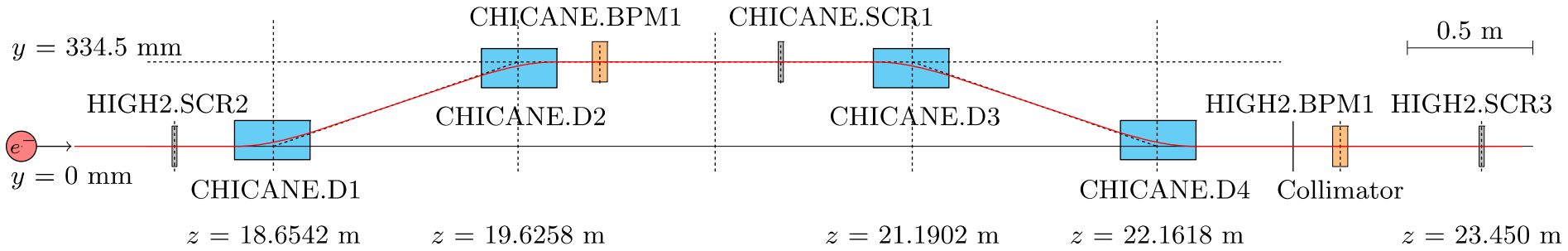
BC commissioning

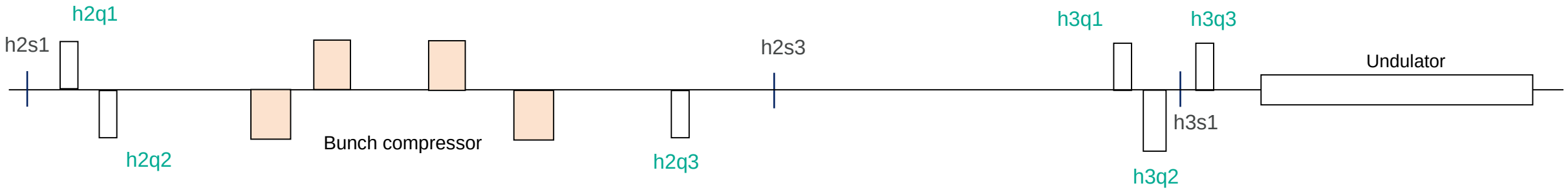
Dispersion measurements

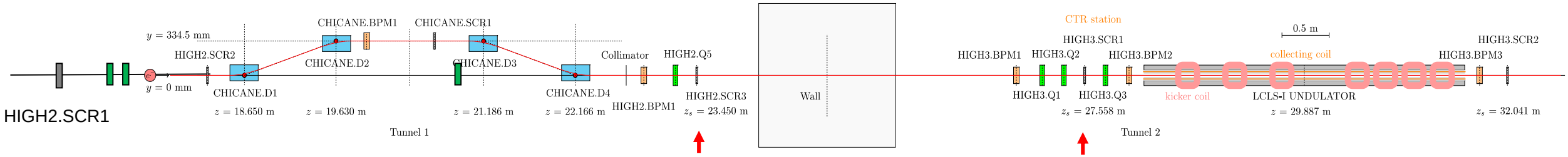


Measurement parameters	Symmetric currents method (D1 = -D3, -D2 = D4)	Independent currents method (Fixed offset, scan D3 and D4 tuning)
Dispersion after chicane	~ 0.00 m	~ 0.03 m (minimum)
Beam angle after chicane	~ 7 mrad	~ 1 mrad
Beam offset chicane arm	~ 12 mm	~ 8.5 mm

BC simulations and beam matching

Motivation and objective



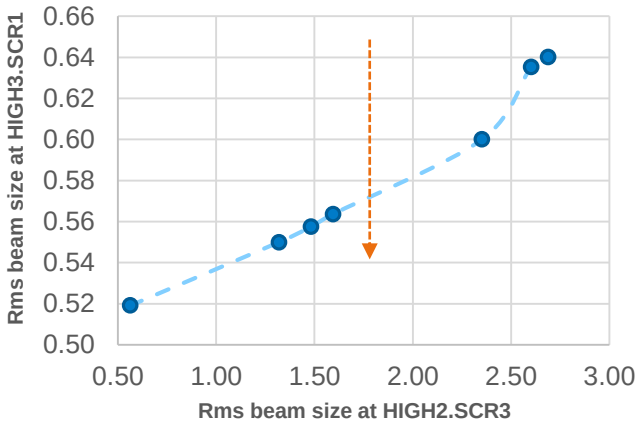


Requirement beam quality from BC

1. Zero dispersion
2. Zero beam offset
3. Zero angle after chicane

Reduce degrees of freedom

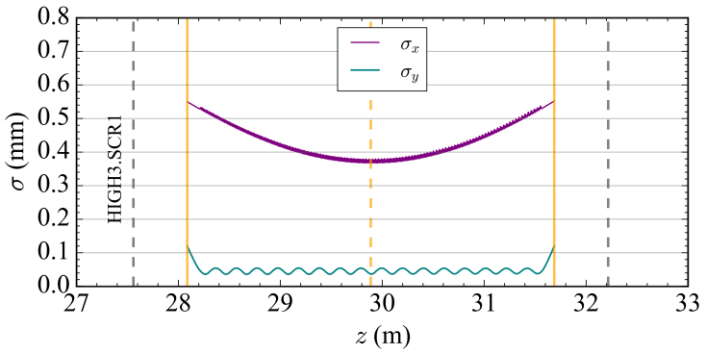
Can use identical currents for all dipoles to transport electron beam



$$\langle x_i^2 \rangle = \epsilon\beta$$

$$\langle x_i'^2 \rangle = \epsilon\gamma$$

$$\langle x_i x_i' \rangle = -\epsilon\alpha$$

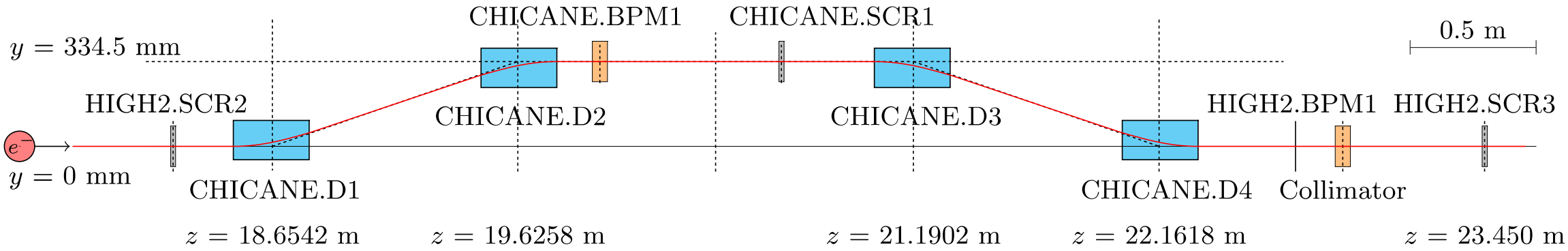


e.g., 250 pC

$$\epsilon_{n,x,y} = 1\ mm.mrad$$

BC simulations

Objective



After bunch compressor

1. Zero dispersion
2. Zero beam offset
3. Zero angle

- Beam momentum : 17 MeV/c
- Particle tracking without space charge effect using ASTRA
- 3D magnetic field from CST EM studio including fringe field was implemented in the simulation.
- 4D scan of the dipole currents.

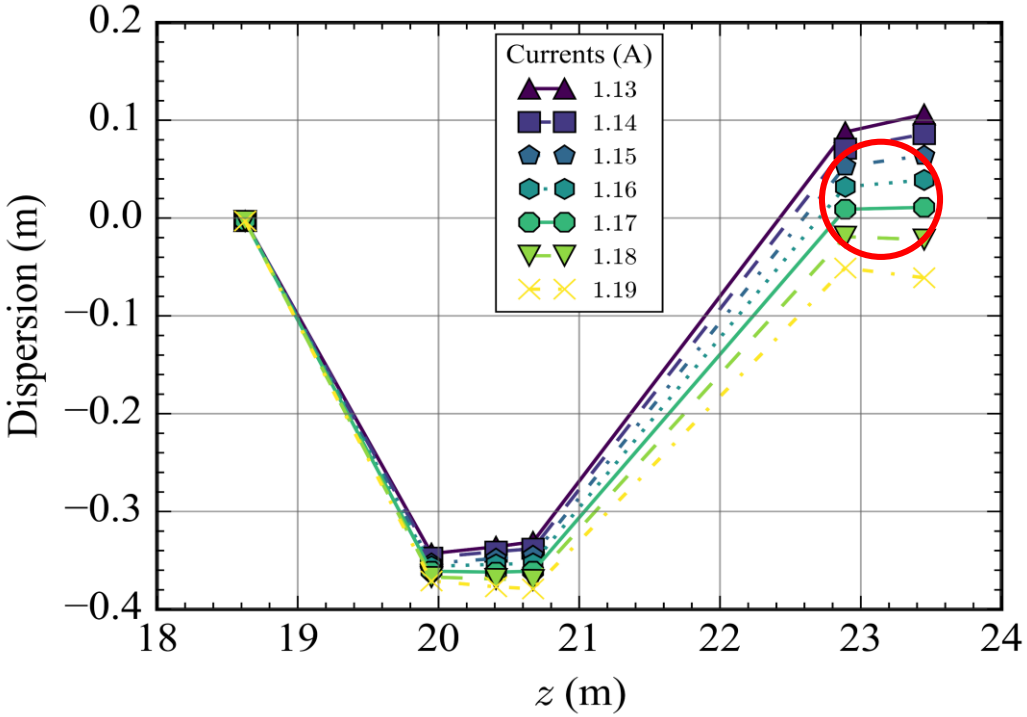
Between D2 and D3

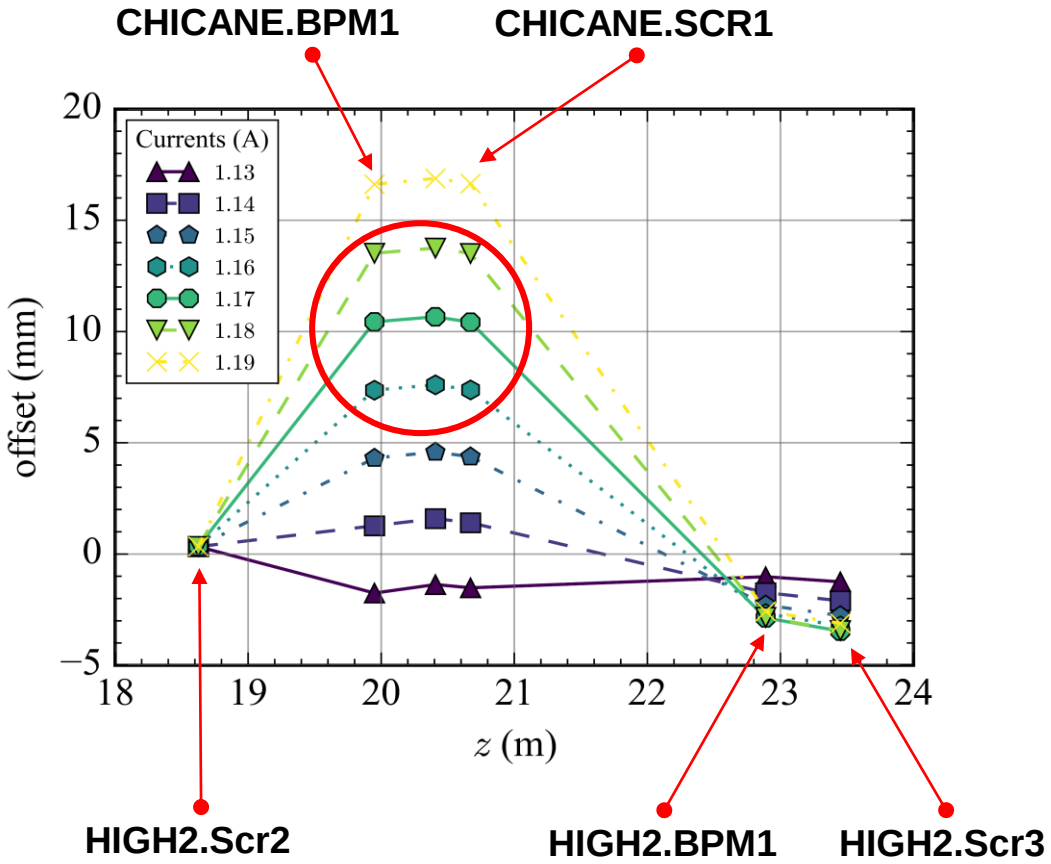
1. Constant dispersion
2. Zero beam offset or close to center of pipe → high charge beam transportation

Dispersion ~ 0.32 m

Beam trajectory simulations

Dispersion simulation for identical currents cases





After BC

→ Zero dispersion after BC

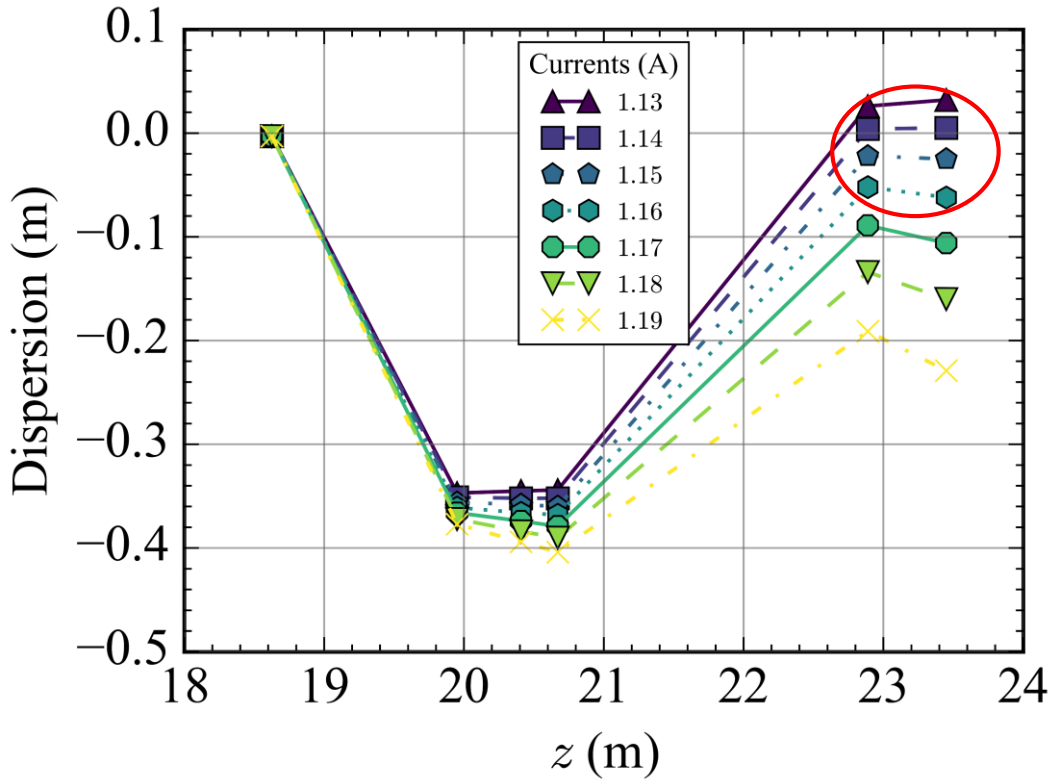
→ Negative beam offset and angle

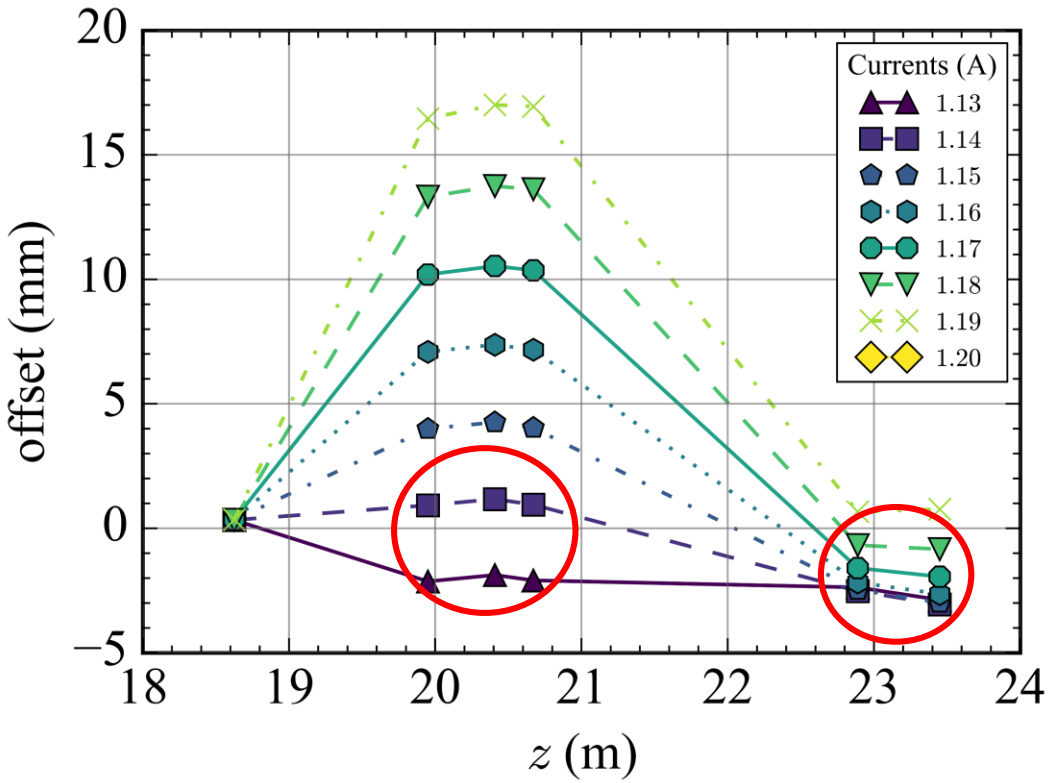
Between D2 and D3

→ Positive beam offset ~11 mm

Beam trajectory simulations

Moving by -9 mm downwards for D2 and D3 in the vertical direction w.r.t. center pipe





After BC

→ Zero dispersion after BC

→ Negative beam offset and angle

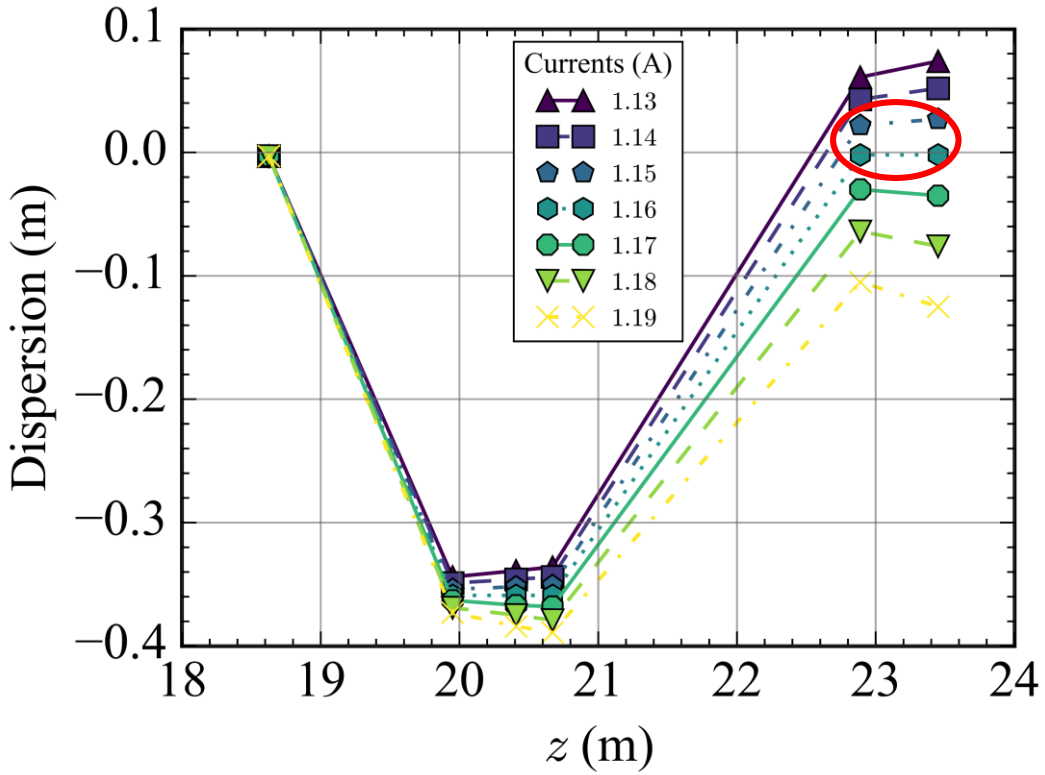
Between D2 and D3

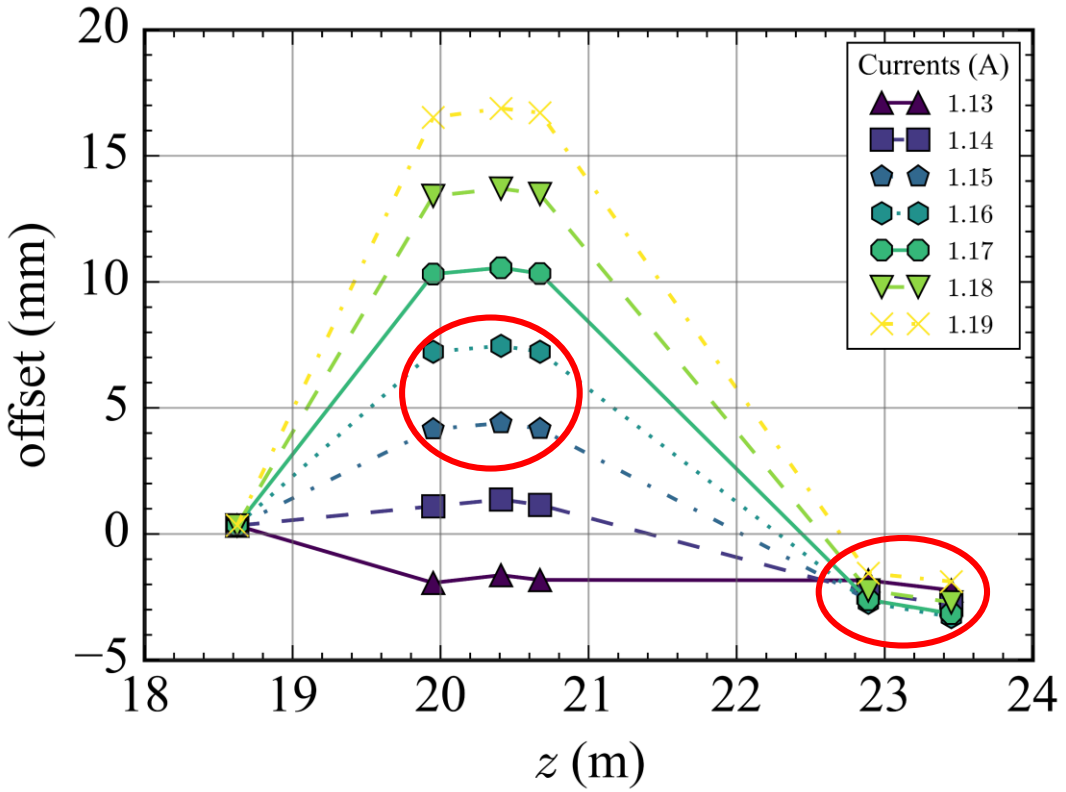
→ Positive beam offset ~1 mm

Maximum for D2 and D3 → ~ 4 mm downward

Beam trajectory simulations

|D2| = |D3| → -4 mm





After BC

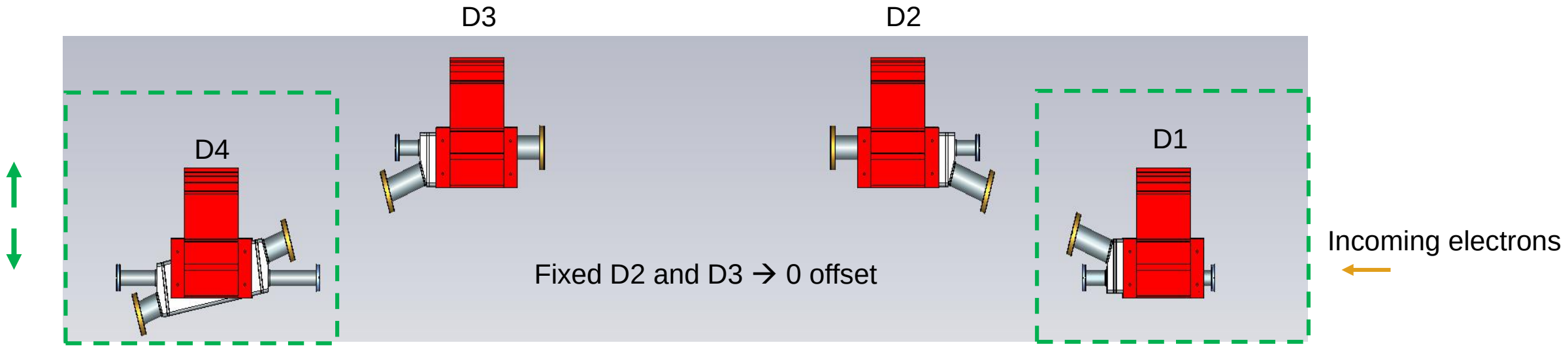
→ Zero dispersion after BC

→ Negative beam offset and angle

Between D2 and D3

→ Positive beam offset ~7 mm

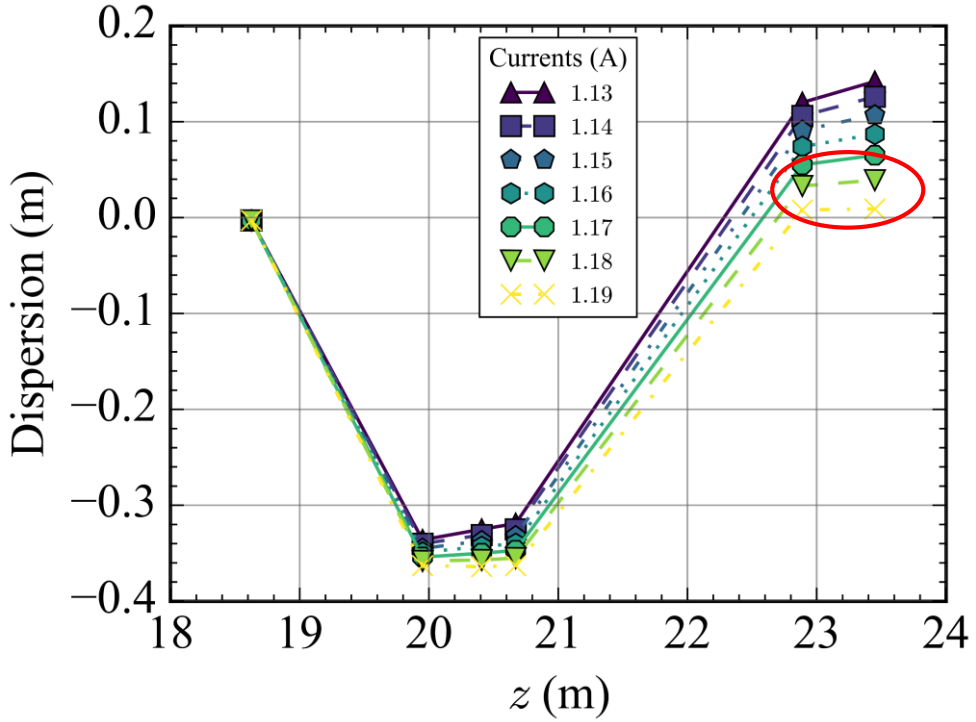
Moving D1 and D4 in vertical direction

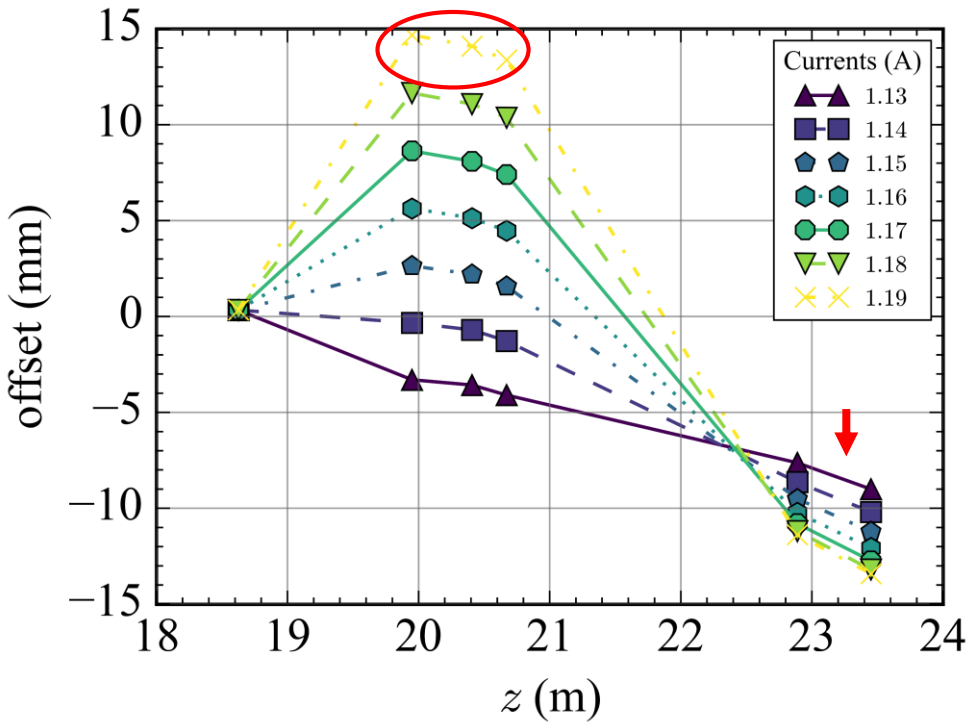


Beam trajectory simulations

|D1| and |D4| -15 mm

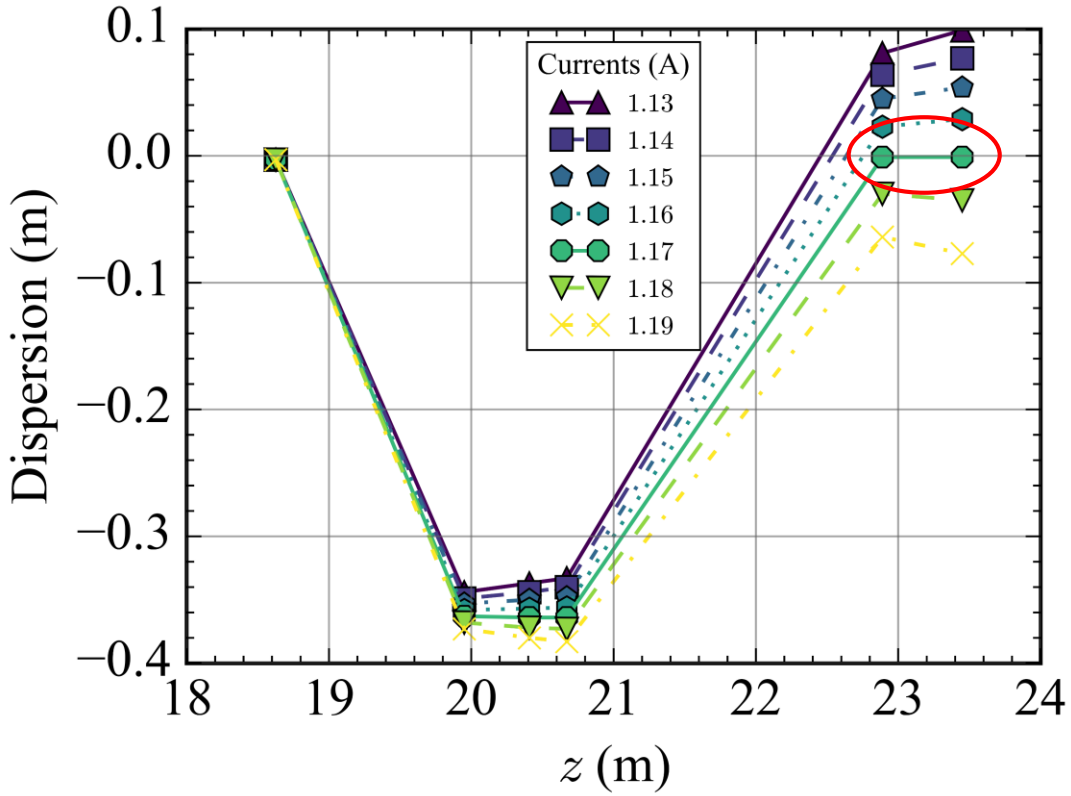
Wrong direction !!!!!!

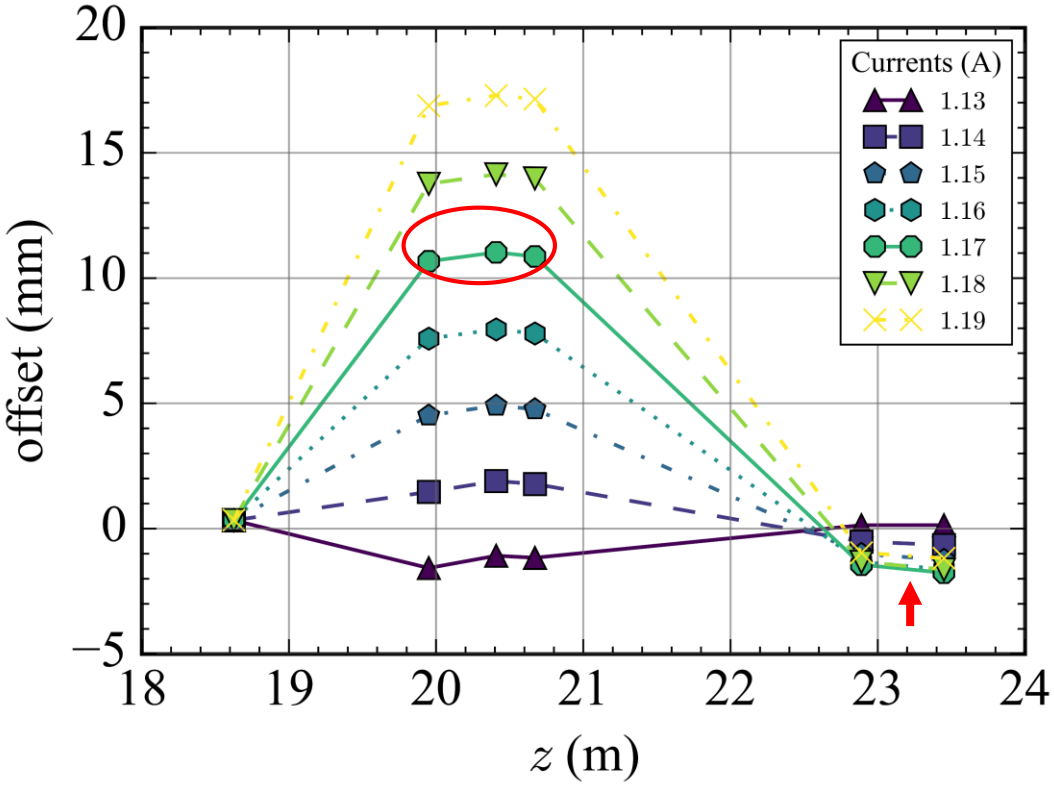




Beam trajectory simulations

|D1| and |D4| +5 mm





After BC

→ Zero dispersion after BC

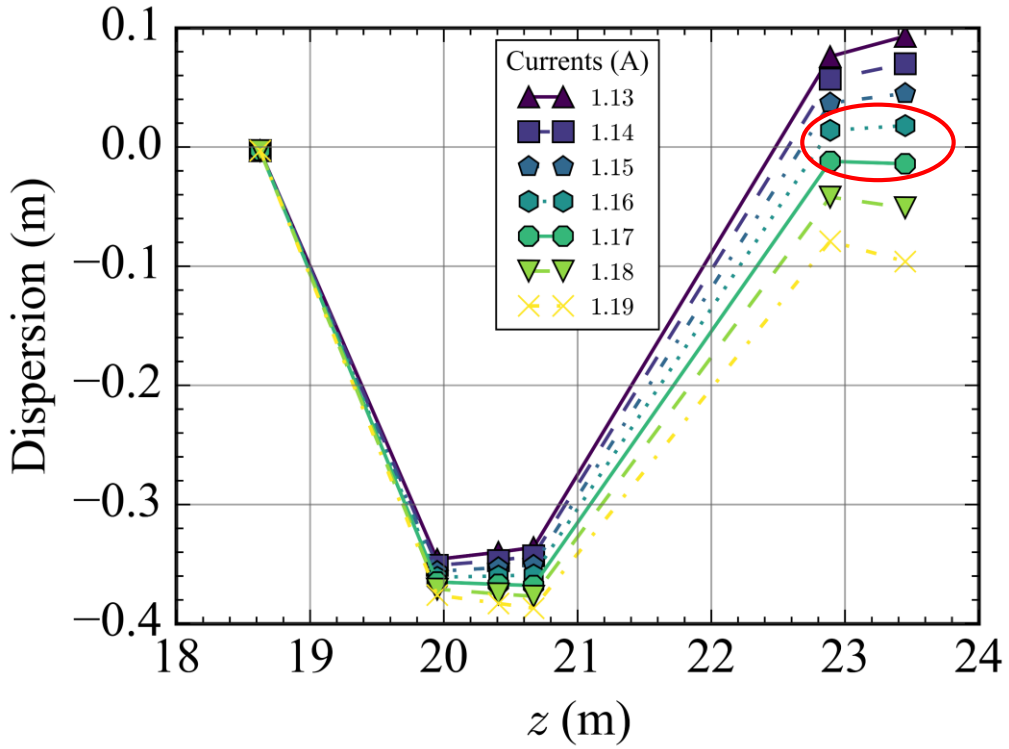
→ Negative beam offset and angle

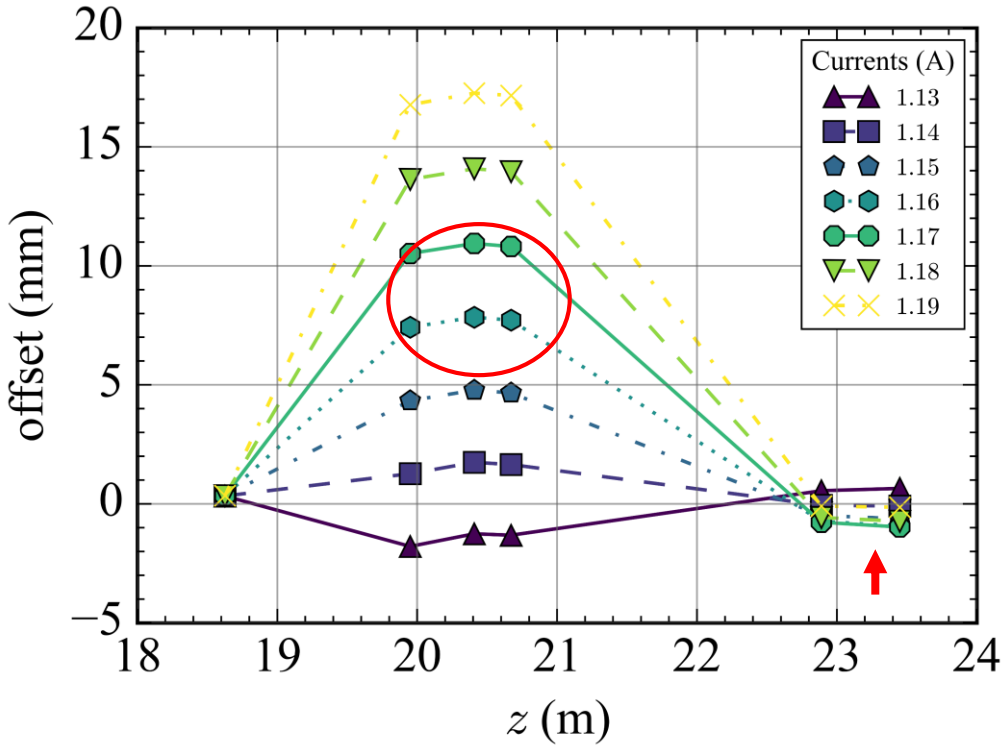
Between D2 and D3

→ Positive beam offset ~11 mm

Beam trajectory simulations

|D1| and |D4| +15 mm





After BC

→ Zero dispersion after BC
→ Negative beam offset and angle

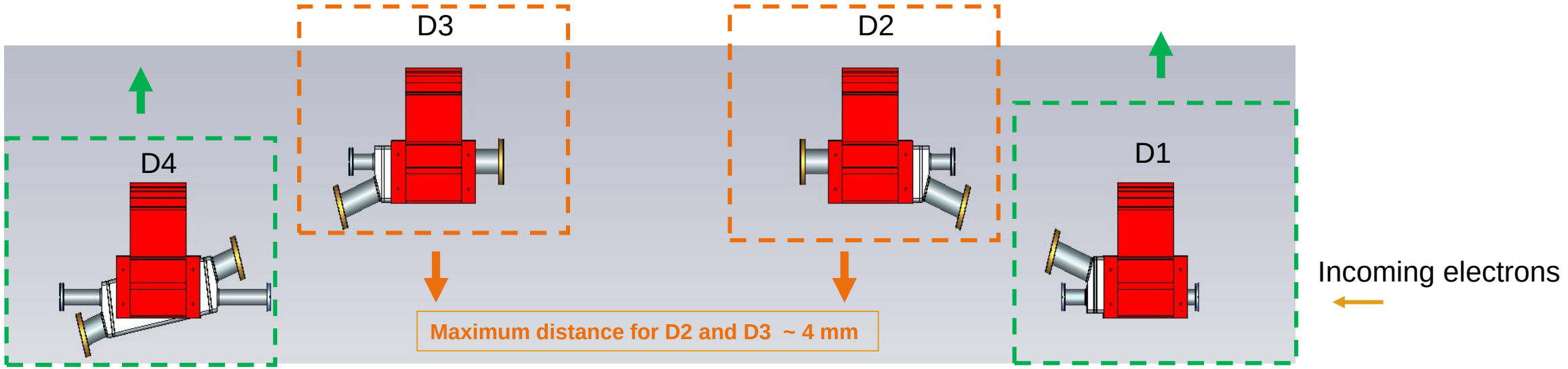
Between D2 and D3

→ Positive beam offset ~10 mm

Moving all dipoles in the vertical direction

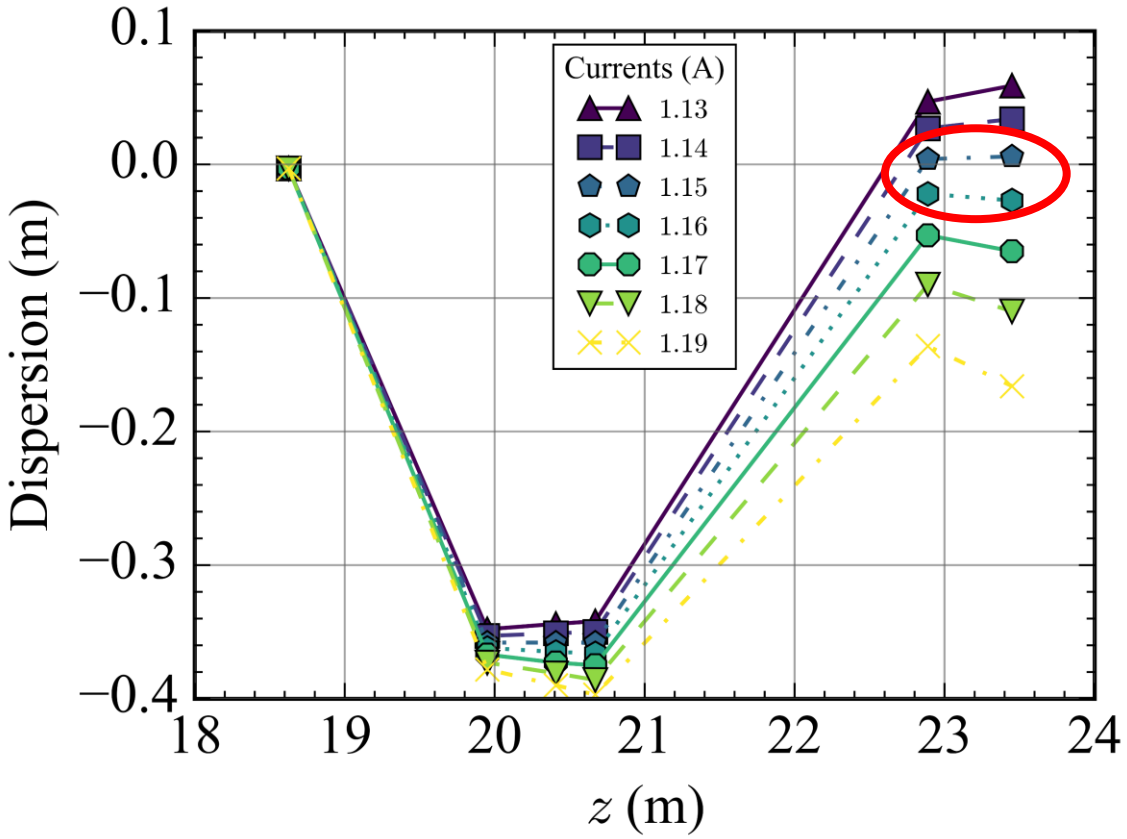
Move D2 and D3 **downward** → corrected dispersion and beam transverse offset between D2 and D3

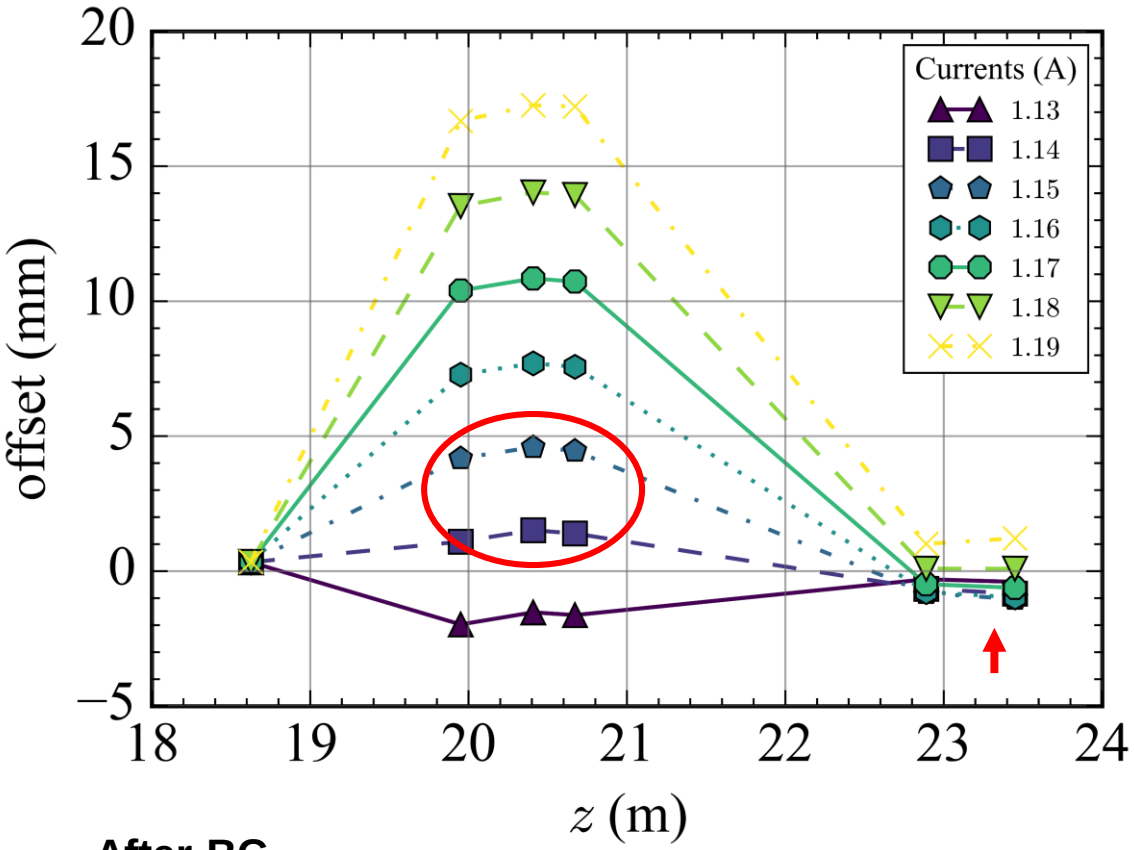
Move D1 and D4 **upward** → corrected dispersion and **beam transverse offset** after D4



Beam trajectory simulations

|D2| = |D3| = -4 mm and |D1| = |D4| +15





After BC

→ Zero dispersion after BC

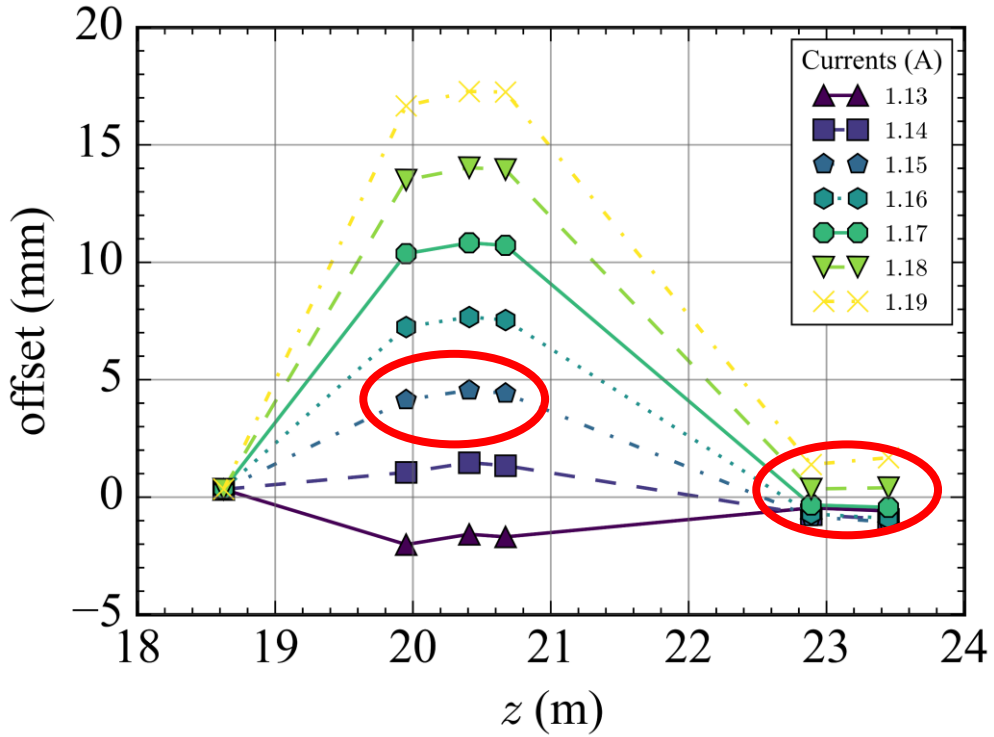
→ Negative beam offset and angle

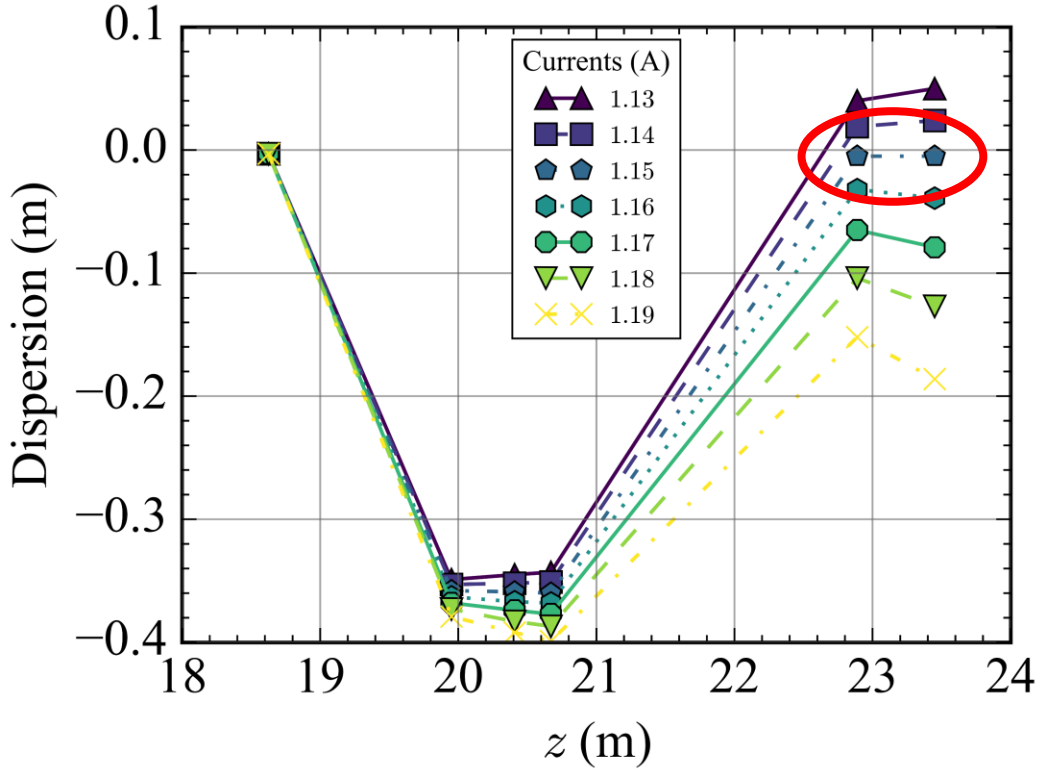
Between D2 and D3

→ Positive beam offset 5 mm

Beam trajectory simulations

|D2| = |D3| = -5 mm and |D1| = |D4| +15





After BC

→ Zero dispersion after BC

→ Negative beam offset and angle

Between D2 and D3

→ Positive beam offset 5 mm

Conclusion

Vertical offset w.r.t. center of pipe (mm)				After BC		Between D2 and D3
D1	D2	D3	D4	Dispersion (m)	Offset (mm)	Offset (mm)
0	0	0	0	0	-3 (negative divergence)	~ 11 mm
0	-9	-9	0	0	-3 (negative divergence)	~1 mm
0	-4	-4	0	0	-3 (negative divergence)	~ 7 mm
+5	0	0	+5	0	-2 (small negative divergence)	~ 11 mm
+15	0	0	+15	0	-1 (small negative divergence)	~ 11 mm
+15	-4	-4	+15	0	-1 (small negative divergence)	~ 5 mm

1. Move D2 and D3 **downward** → corrected dispersion and beam transverse offset between D2 and D3
2. Move D1 and D4 **upward** → corrected dispersion and **beam transverse offset** after D4