Preliminary beam dynamics studies on the dogleg with 3D field map

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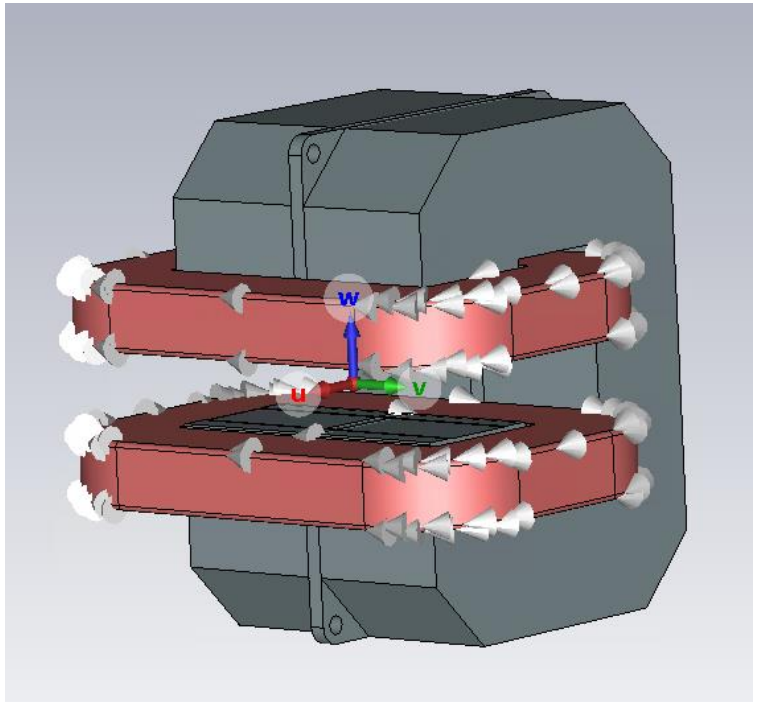
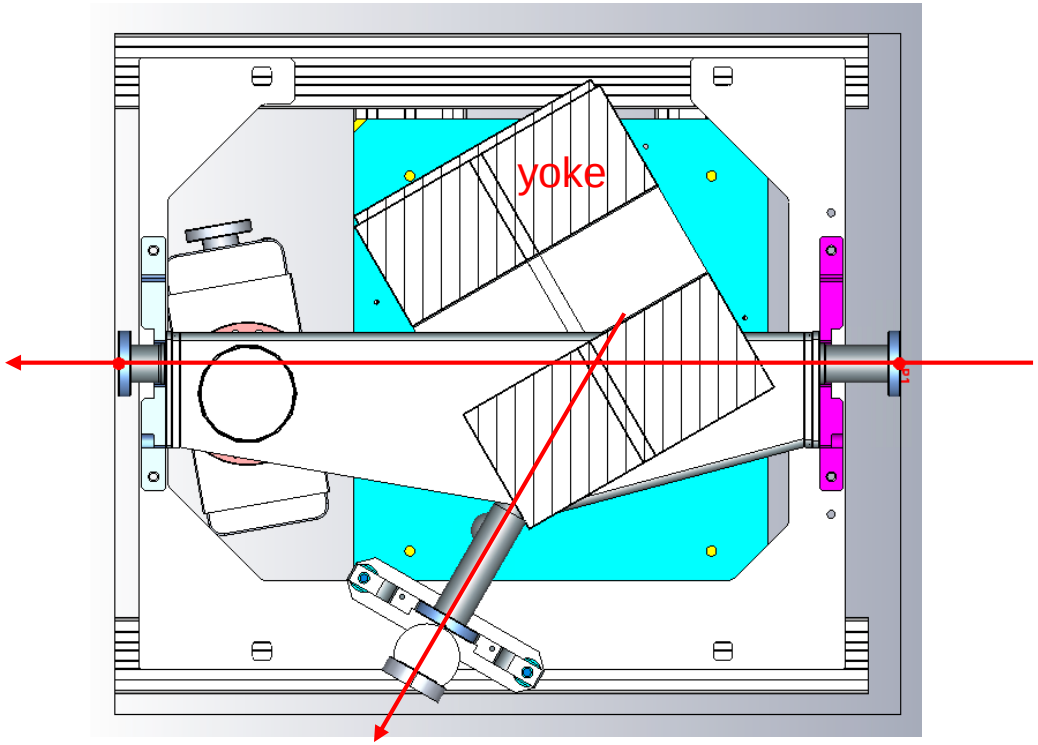
PPS/PITZ upgrade, 30.03.2023

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

DESY.

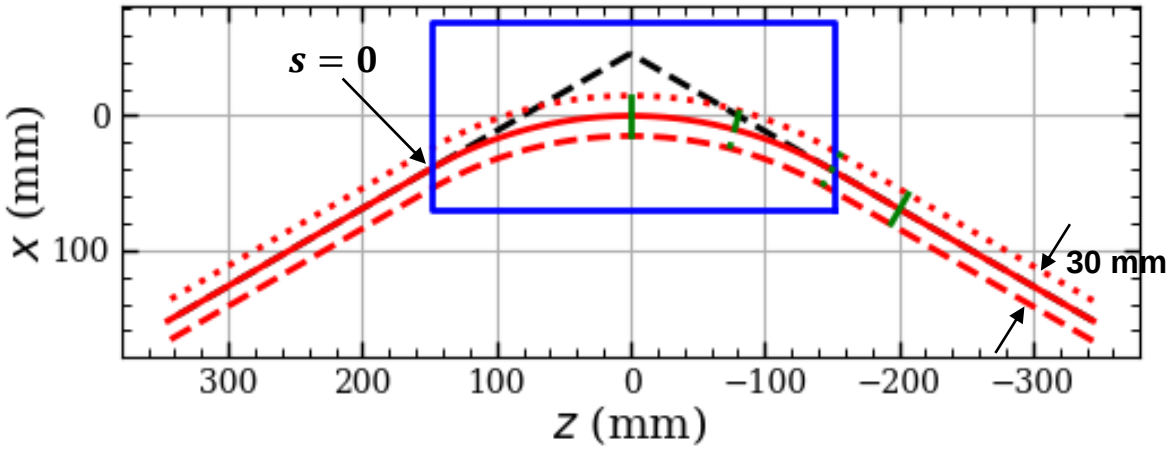
CST model of the dipole

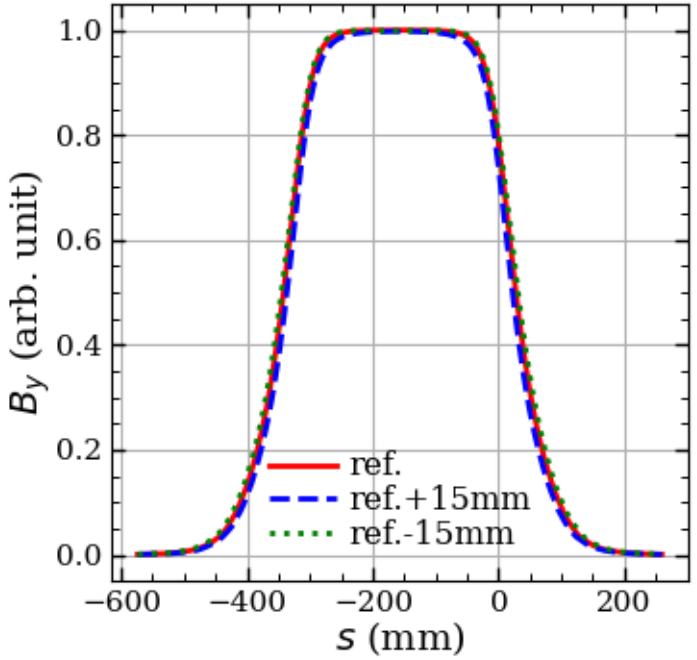




CST model of the dipole

Field along the ref. traj.

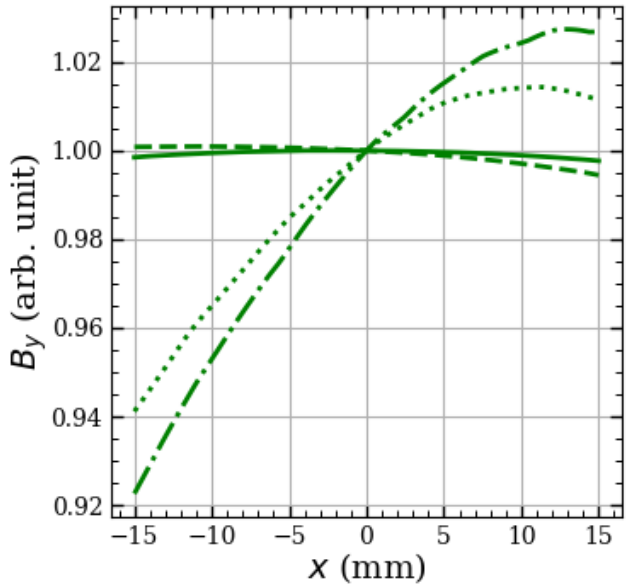


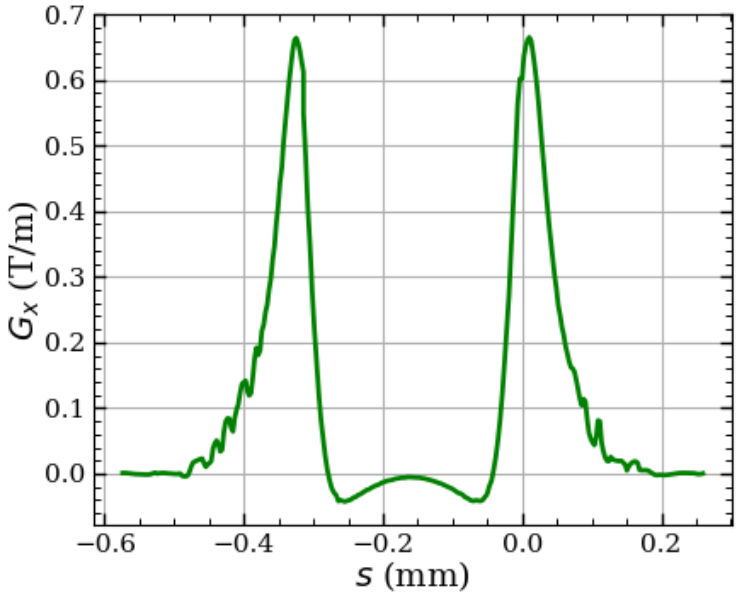


- By vs s is uniform inside the dipole

CST model of the dipole

Quadruple field along the ref. traj.





- By-x dependence produces weak focusing forces in the horizontal plane
- For 22 MeV, < 1 T/m

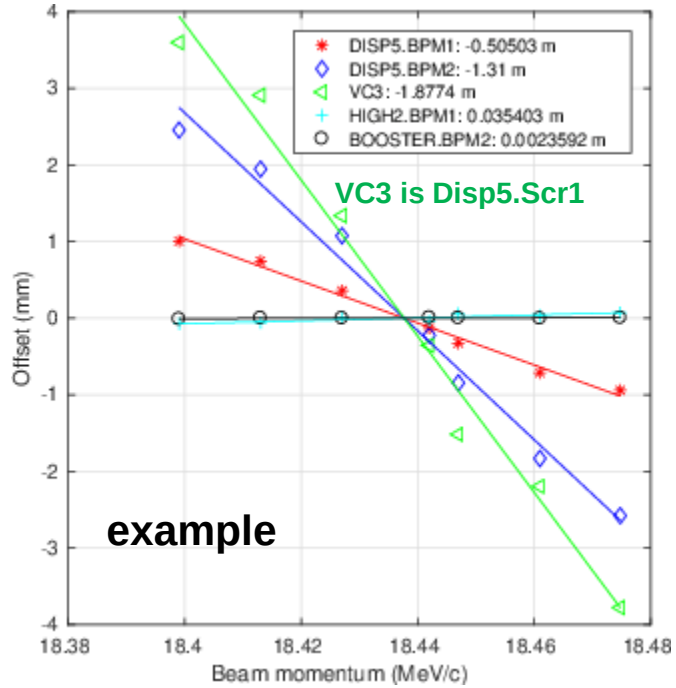
Dispersion at Disp5

Comparison

- The dispersion at Disp5.Scr1 can be calculated by hardedge model or using field map from CST 3D model

	R16 (m)	R26
Pole face ($\rho = 0.3$ m)	-2.175	-1.155
Hard edge ($\rho = 0.3$ m)	-2.163	-1.155
3D model	-1.791	-0.941
Measured	-1.866±0.146	-1.014±0.075*

* R26 is calculated from R16 measured at Disp5.BPM1 and Disp5.Scr1

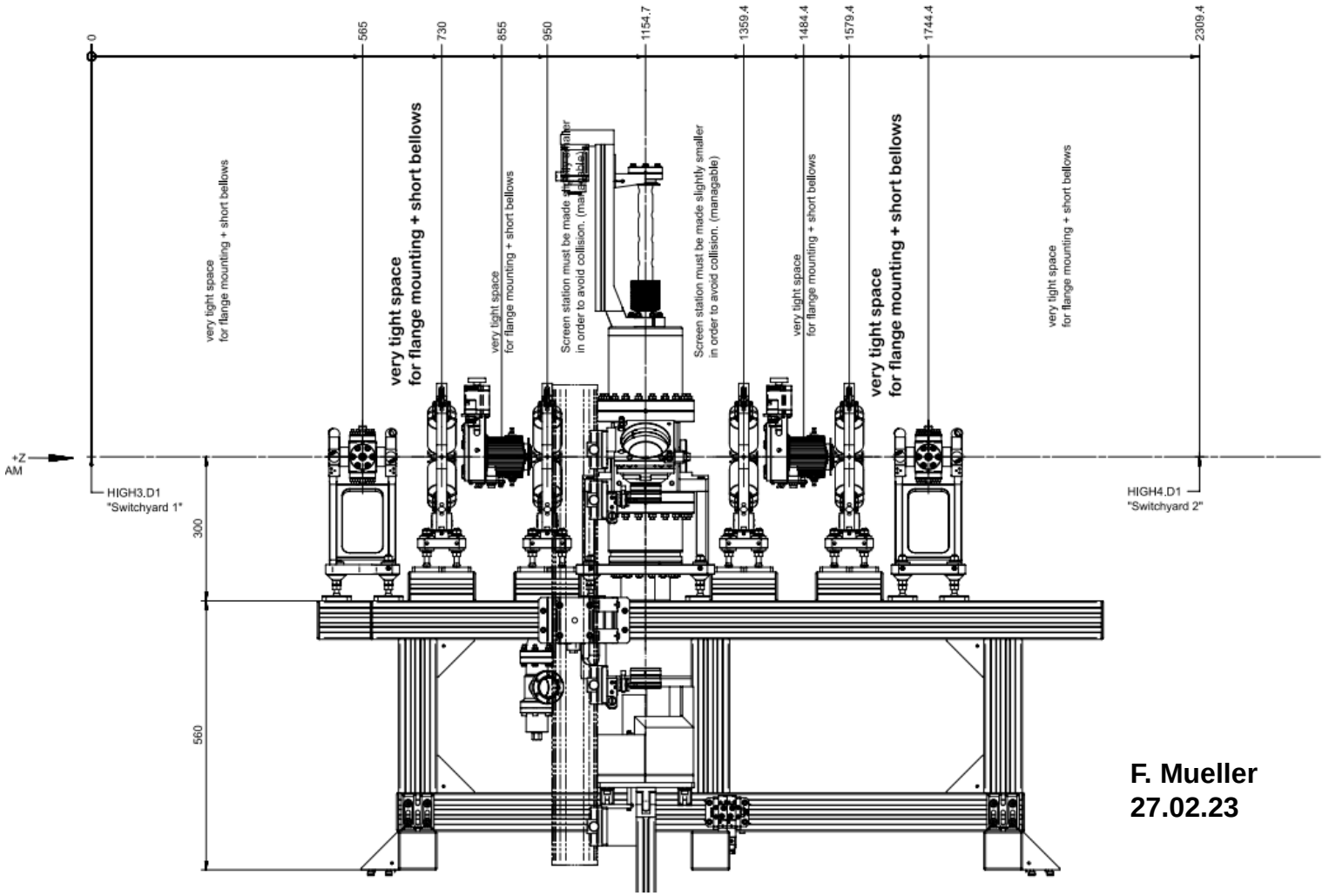


The measurement was affected by beam jitter

Current setup

- Currently, the distance between PITZ main beamline and FLASHlab@PITZ beamline is reduced from 2.23 m to 2 m in order to leave more space on the wall side
- First/last quadrupole is also moved downstream/upstream for vacuum/BPM installation
- **Stronger quadrupole strengths** required in order to reach zero dispersion

Distance between beam axes straight/FLASHLab reduced from 2230mm to 2000mm.
Dogleg-angle still 60°



F. Mueller
27.02.23

Achromatic design

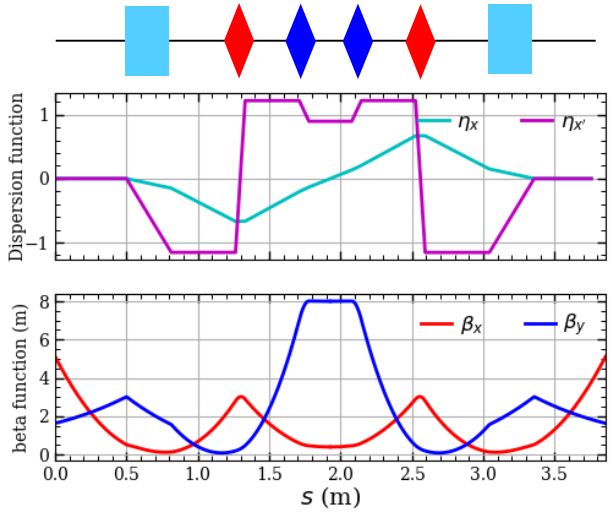
Comparison

- Assuming **P0=22.5 MeV/c (22 MeV)** for beam momentum and **G/I = 0.7 T/m/A** for quadrupoles

		K1 (m)	I1 (A)
Initial design	Hard edge	51.4	-8. 8
Current design	Hard edge	64.5	-11
	Hard edge*	58.5	-10
	3D model	63.6	-10.8
	3D model*	57.1	-9.7

***Switch BPM and Q1**

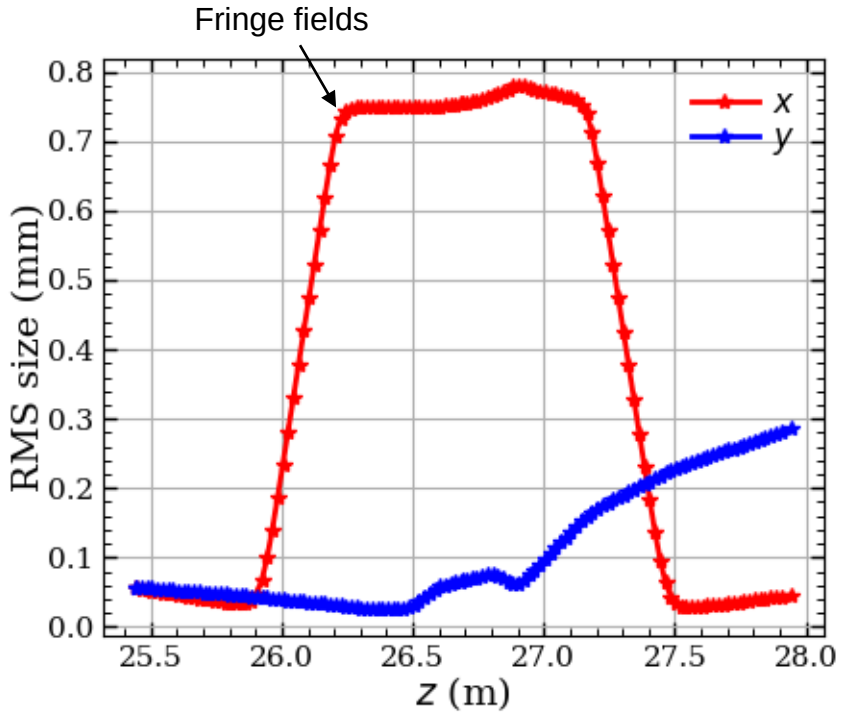
- Quadrupole strength or current doesn't reduce much because Q1 is too close to the plane of symmetry

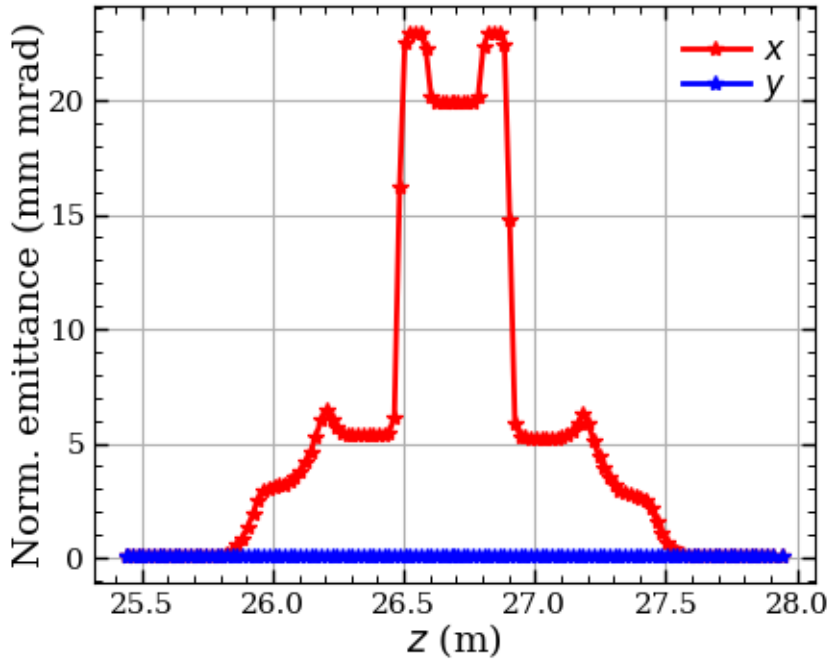


Dispersion and beta functions along the dogleg for the old design

Tracking with Astra

1 pC, no space charge

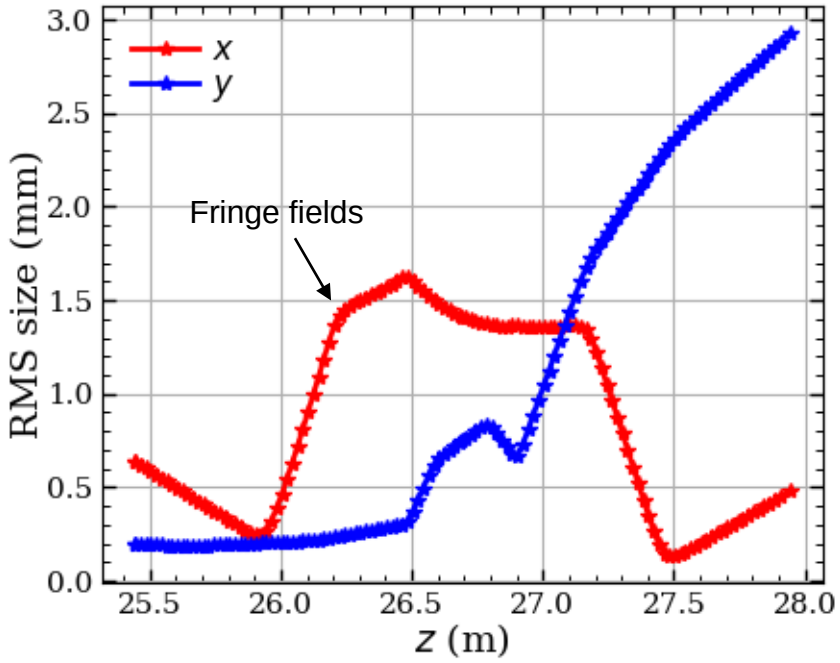


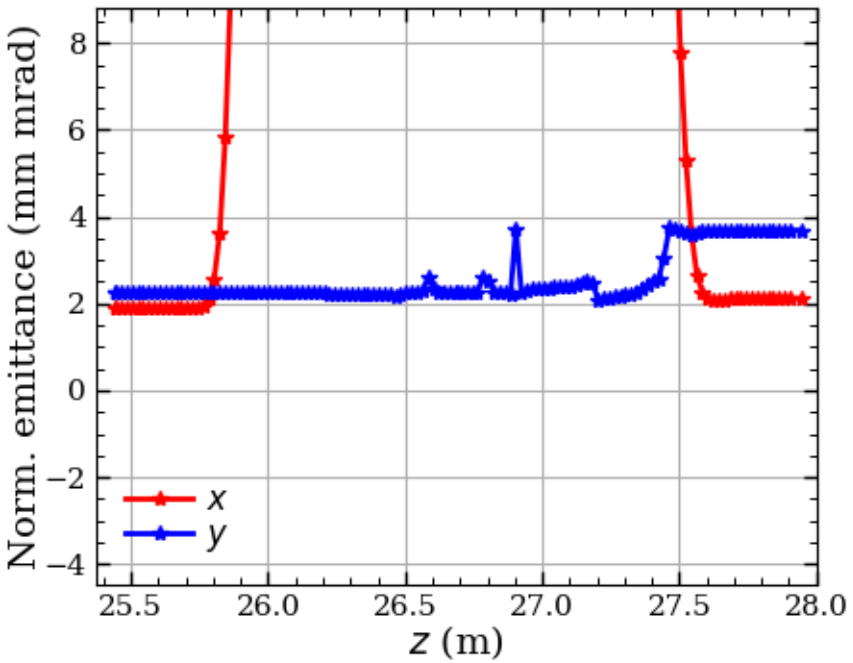


- Beam envelope not very nice, but emittance was back after the dogleg, meaning dispersion free

Tracking with Astra

1 nC, no space charge

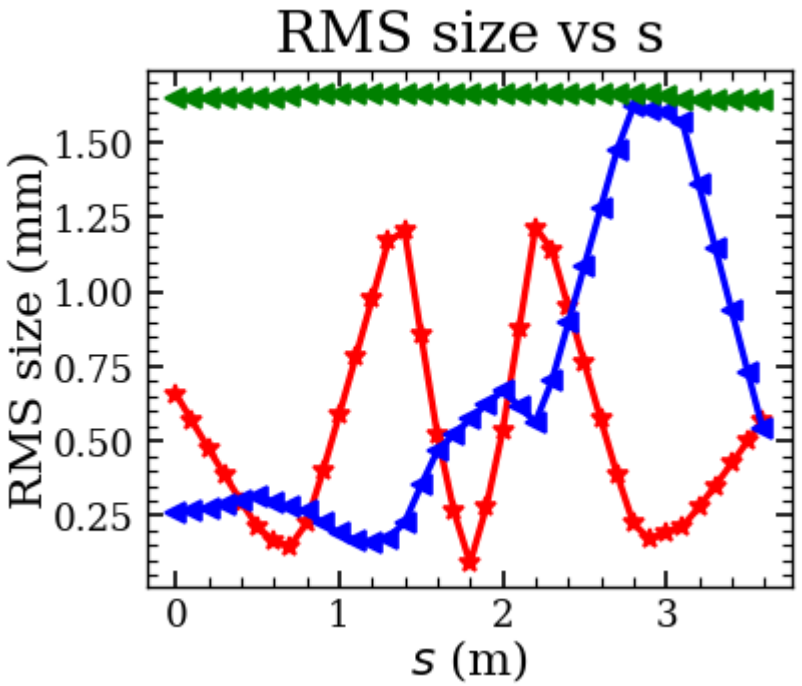


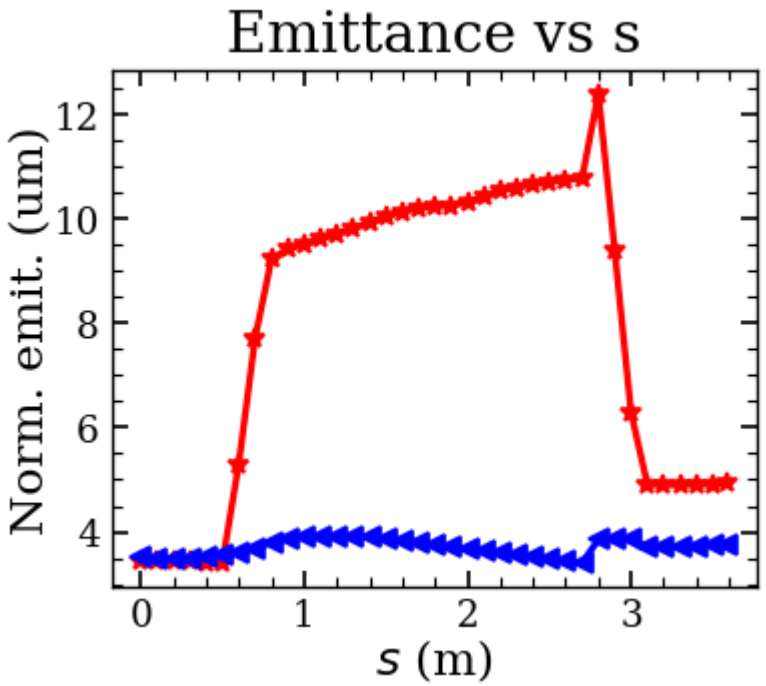


- Beam envelope also not nice
- X emittance was back after the dogleg, Y emittance increased due to not matched beam

Tracking with Ocelot

1 nC, with space charge

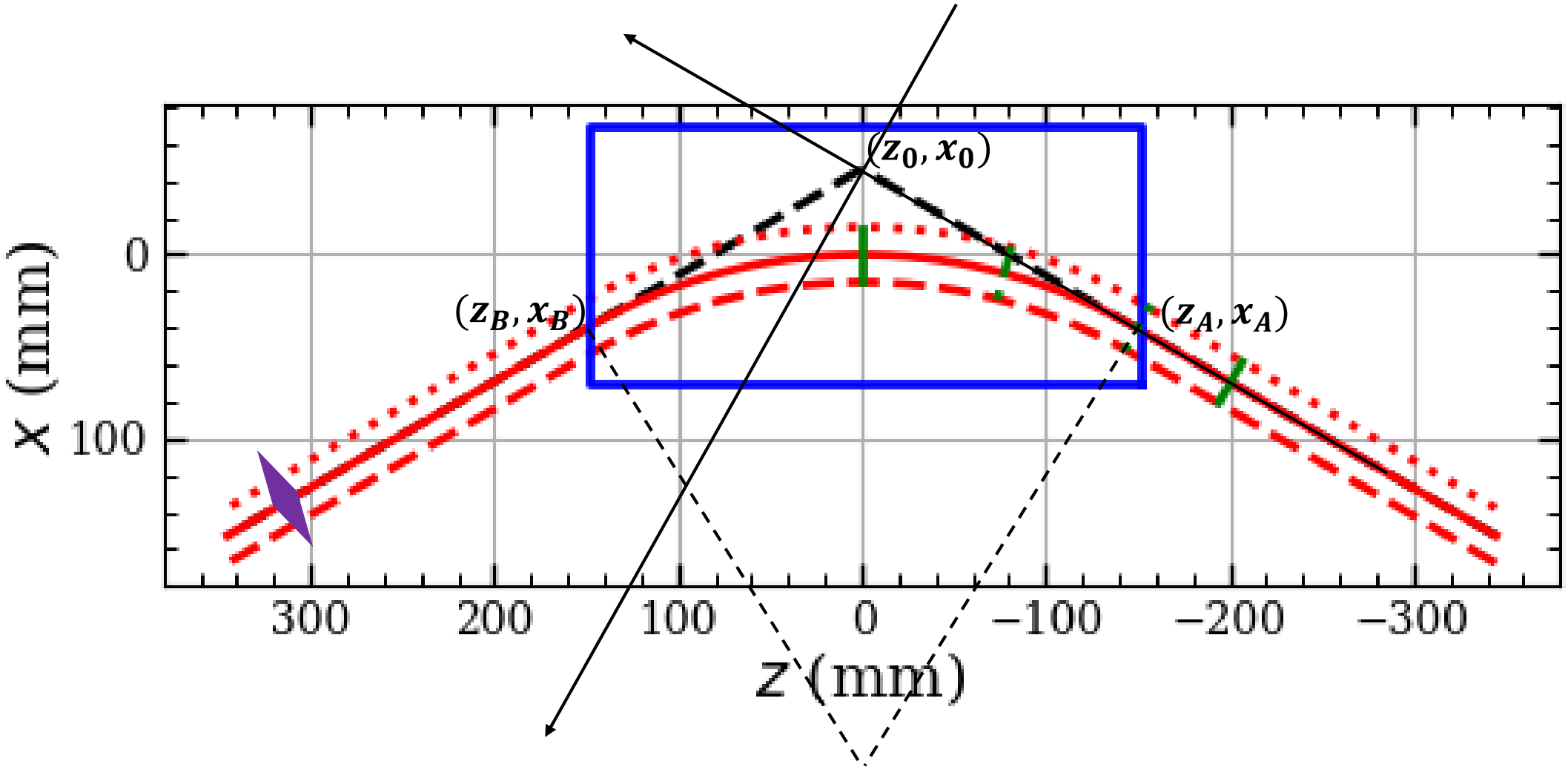




- X beam size is also fine
- X emittance was back after the dogleg, Y emittance increased due to not matched beam

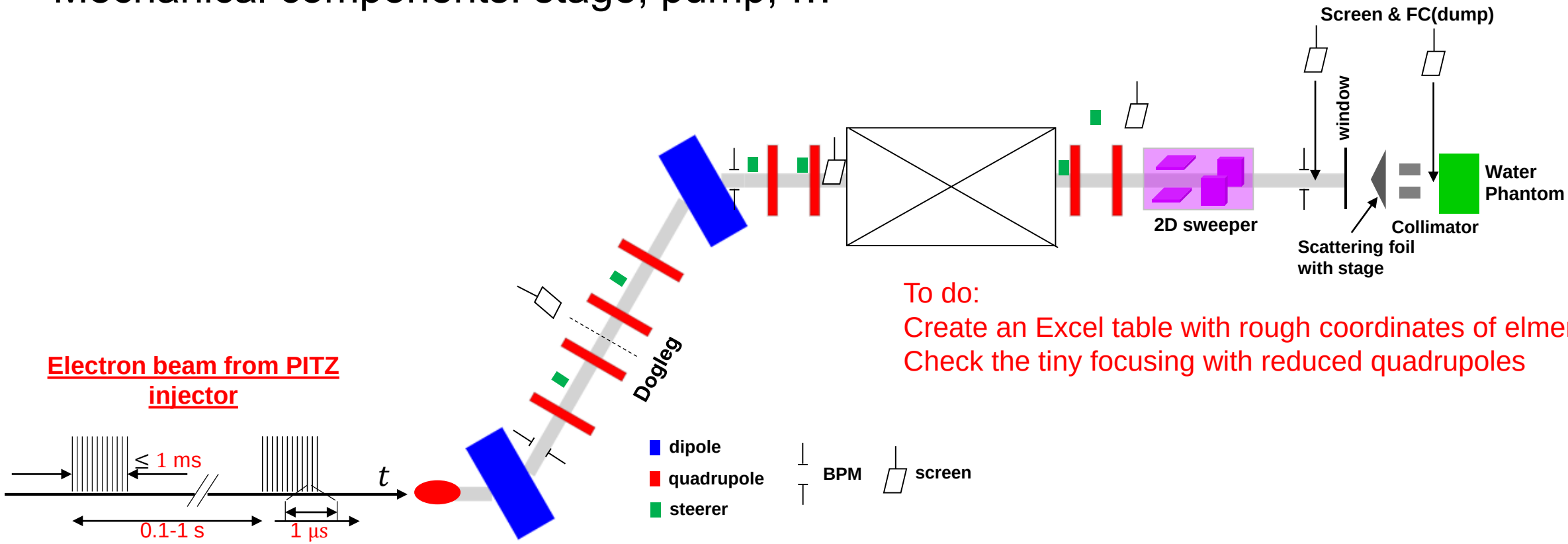
Summary

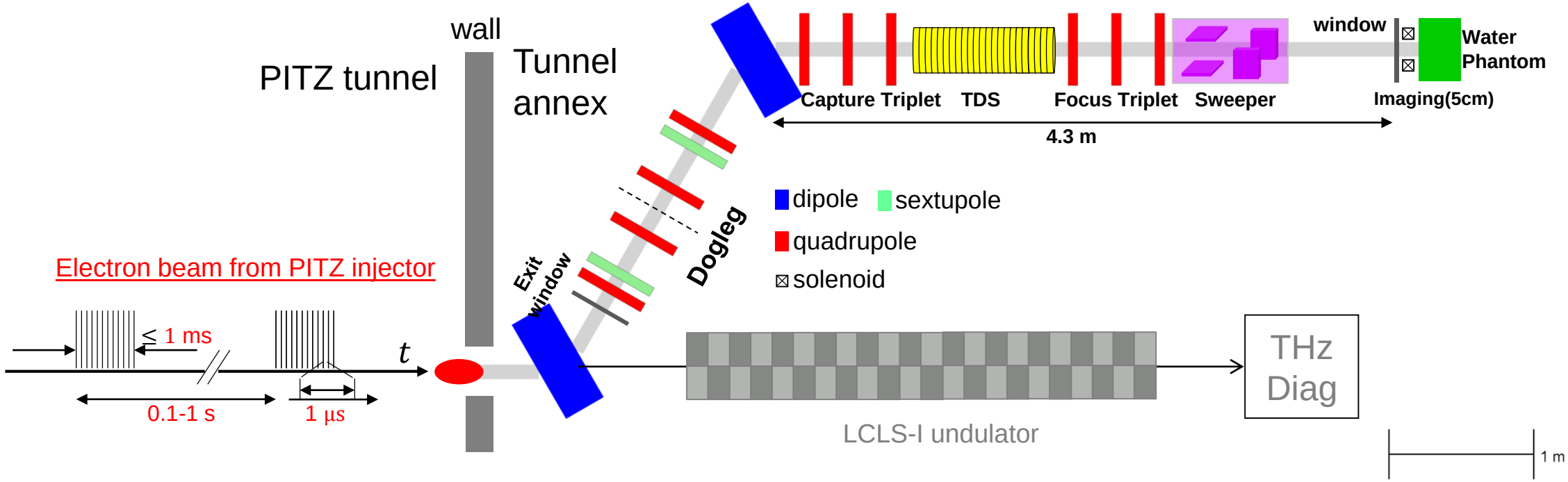
- The fringe fields of the dipole have a horizontal gradient (By vs x), which focuses the beam in the deflection plane
- Measured dispersion in Disp5 agreed more with simulation with 3D field map
- Current setup of the dogleg requires almost 11 A of quadrupole current in order to close dispersion (Q1 is too close to the plane of symmetry)
- Particle tracking with different beams show no big problem with beam transport; the matching condition needs to be updated according to new setup


(z_0, x_0)
(z_B, x_B)
(z_A, x_A)
x (mm)
0
100
300
200
100
0
−100
−200
−300
z (mm)

FLASHLab beamline (after discussion)

- Beam manipulation and monitoring: BPM, Screen, FC, ICT, Steerer
- Mechanical components: stage, pump, …



To do:
Create an Excel table with rough coordinates of elments
Check the tiny focusing with reduced quadrupoles

Previous setup from physics design