

SR at CEPC with BDSIM

Chenguang Zhang, 08/Sep/2025

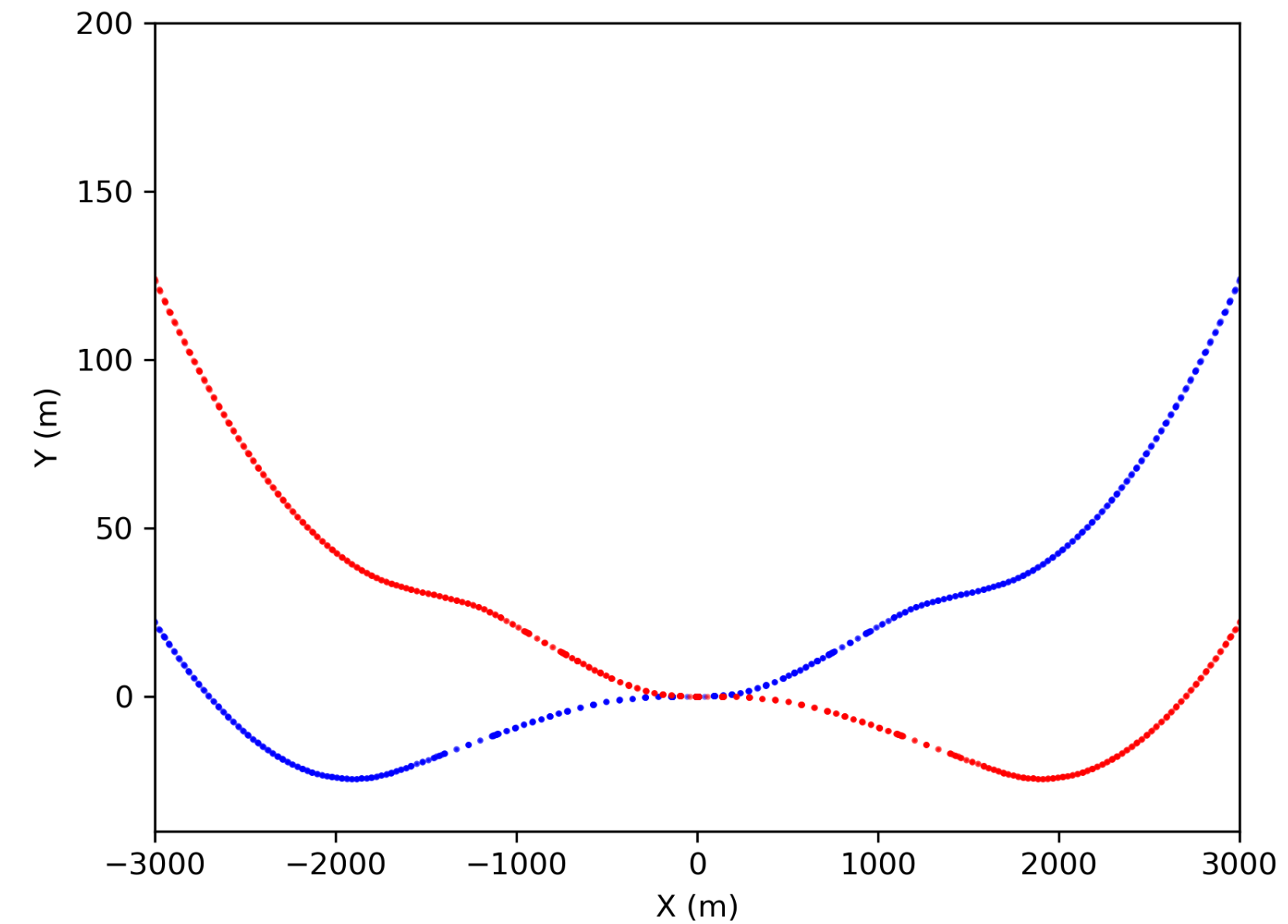
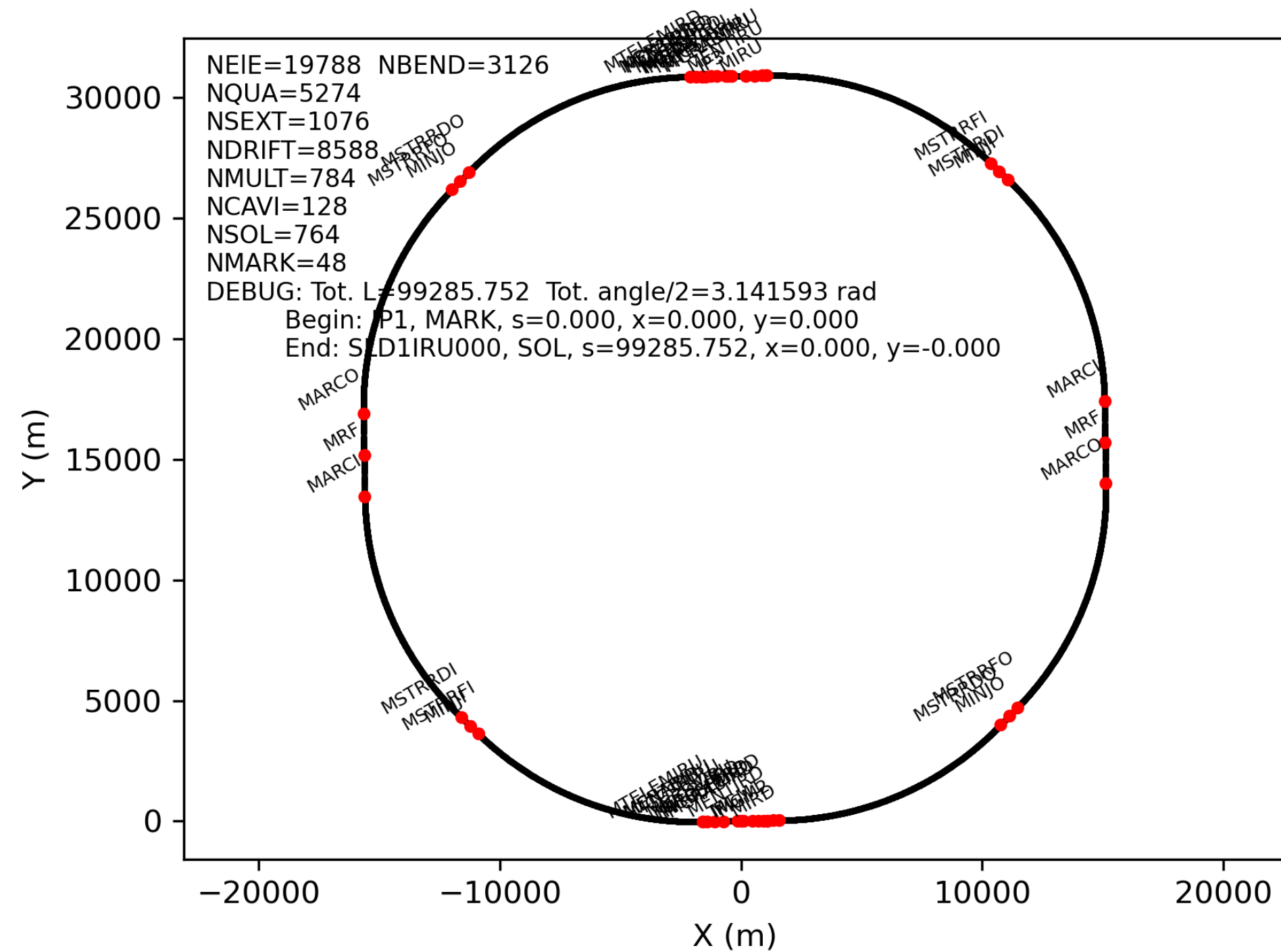
Introduction

- MAD[Methodical Accelerator Design]/SAD[Strategic Accelerator Design] are from Europe/Japan
 - Accelerator optics design, lattice description, and beam dynamics studies
 - NO NEED to simulate particle-material interaction
- BDSIM[Beam Delivery Simulation]
 - MAD + GEANT₄ is effective for studying beam induced background
 - Lattice language used by BDSIM is compatible with MAD
- The CEPC lattice is described using the SAD language
 - SAD to MAD translation is not one-to-one
 - The optics performance may differ slightly, but not significantly

SAD -> BDSIM, Geometry

	SAD		BDSIM
Drift	L	$x \rightarrow x + (p_x/p_z) * L$; p_x , p_z determined by beam shape	1-1
Bend	L, alpha, e1,e2	BDSIM provides both sbend and rbend. Both need the same parameters. The treatment of surface effects may be different	1-2 [sbend used]
Multipole	L, Kn	Kn: dBy/dx, SAD: Integrated, BDSIM: Per-length	1-1
Solenoid	BZ	SLDs in CEPC_lattice.sad have 0-length; BDSIM does not accept any element with L=0	not implemented
Aperture	R	APT is a 0-length element in SAD. But in BDSIM it is an attribute of all other elements	not implemented
RF cavity	T.B.D.		not implemented

Sanity checks



- Lattice.sad provided by the accelerator group
 - Before importing the lattice to BDSIM, make sure a correct understanding
 - Red dots correspond to sad_type=MARK where the beam parameters are specified

- Focus on the IP region
- Looks like the lattice only needs to describe one ring
- The blue line is the left one
- Red corresponds to $(-1 \cdot x_{\text{blue}}, y_{\text{blue}})$
- For SR, a single ring is enough?

Sanity checks

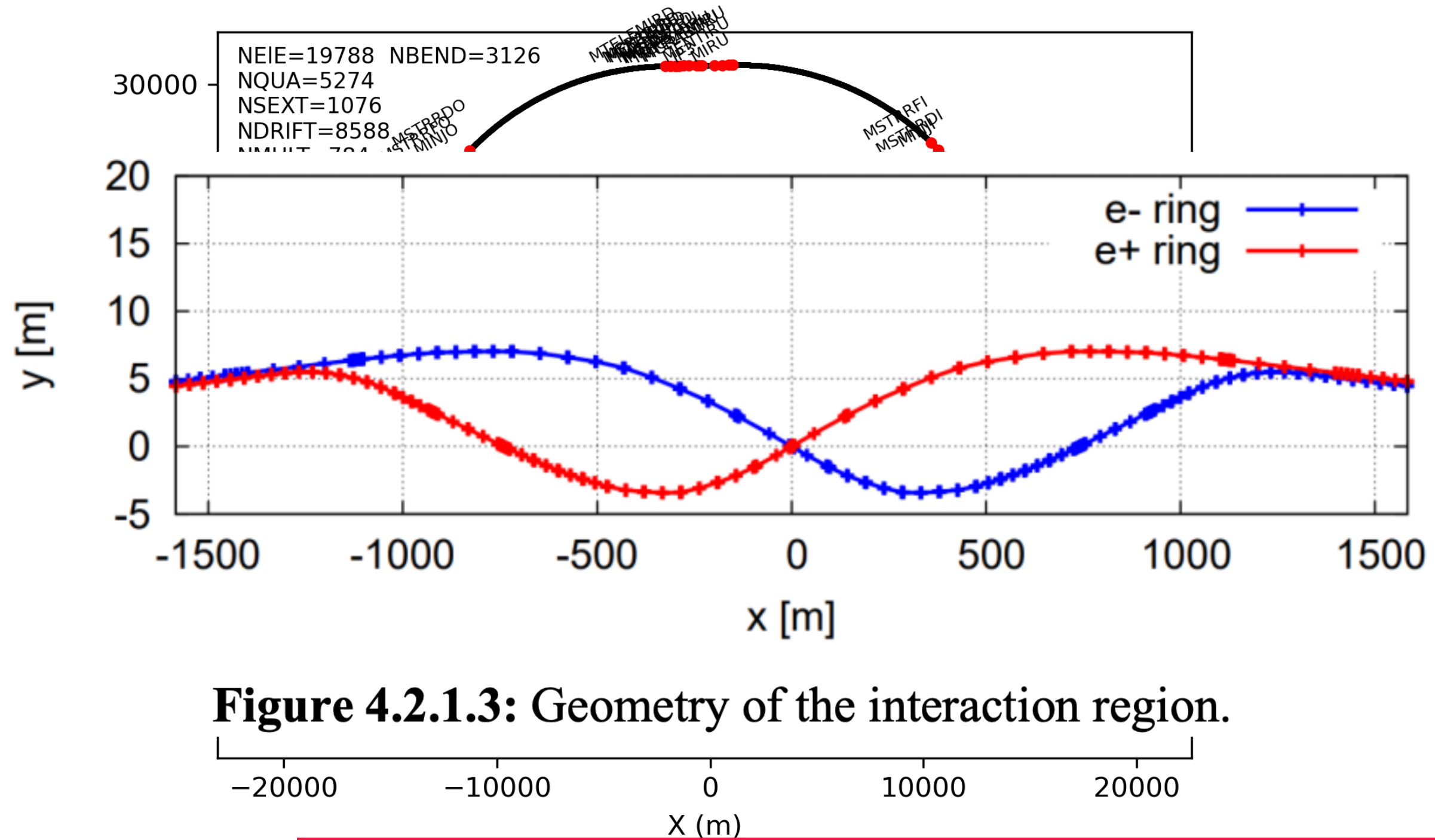
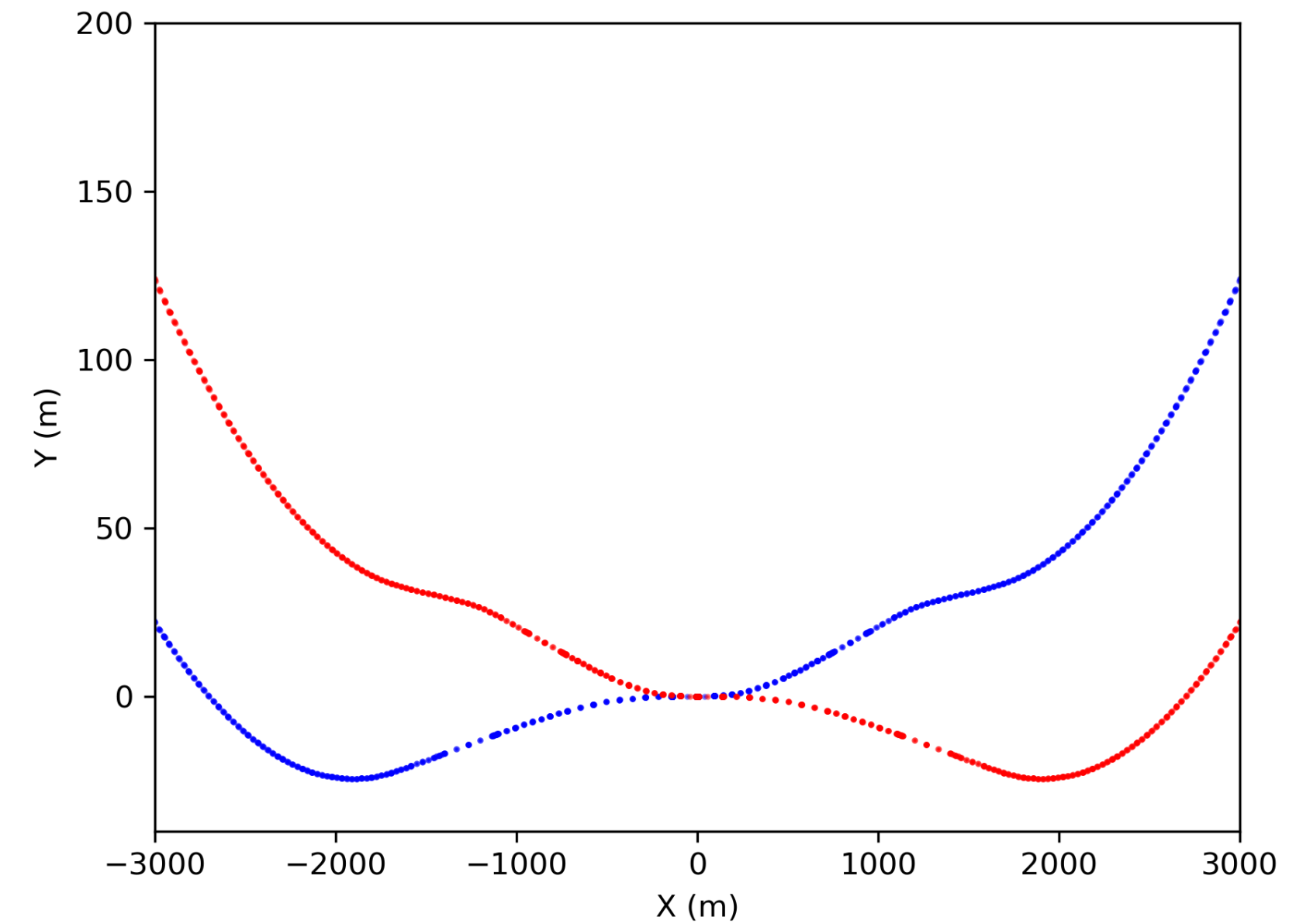


Figure 4.2.1.3: Geometry of the interaction region.



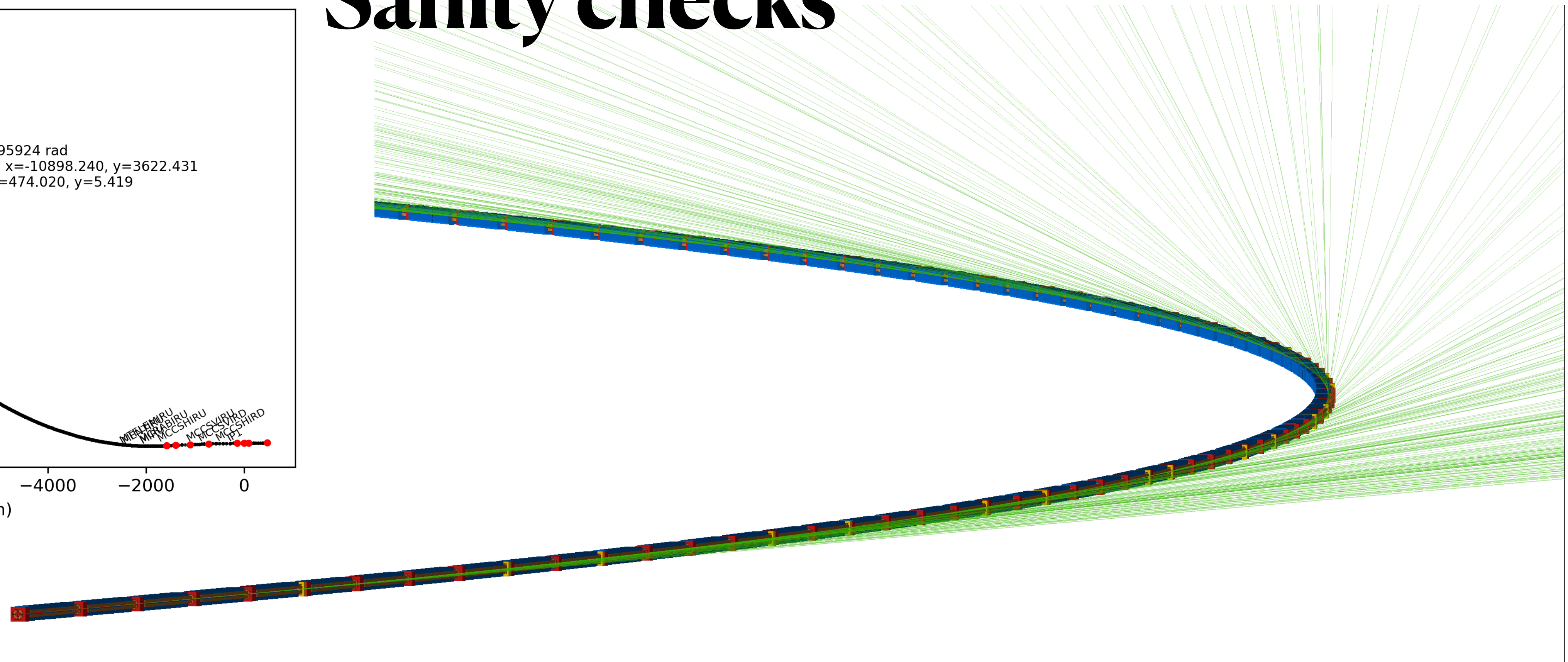
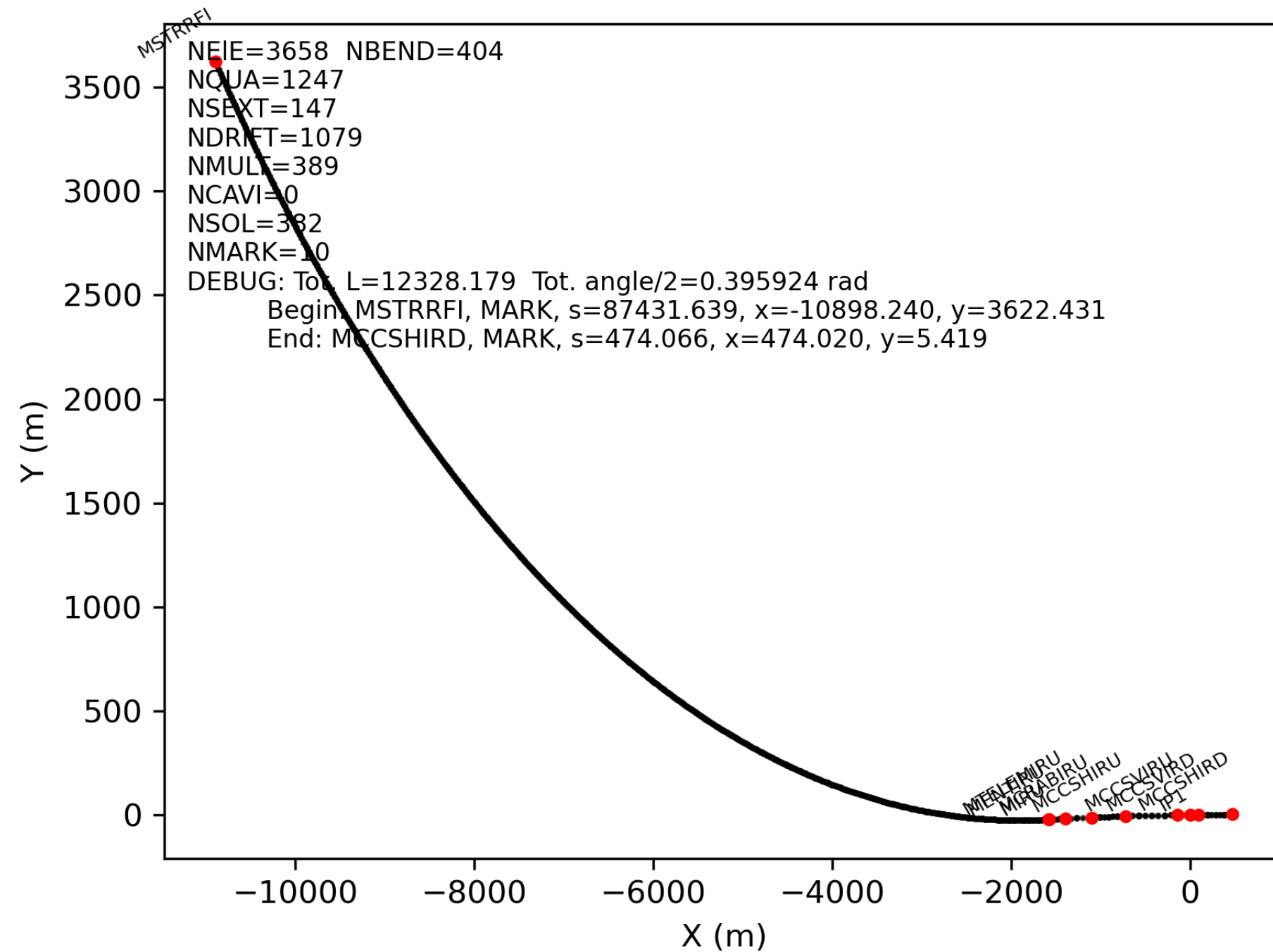
- Lattice
 - Beam
 - Red dots are sad_type=MARK where the beam parameters are provided
 - Red is $(-1 \cdot x_{\text{blue}}, y_{\text{blue}})$
 - For SR, a single ring is enough?

Can not reproduce the TDR results

Not a breaker for BDSIM implementation

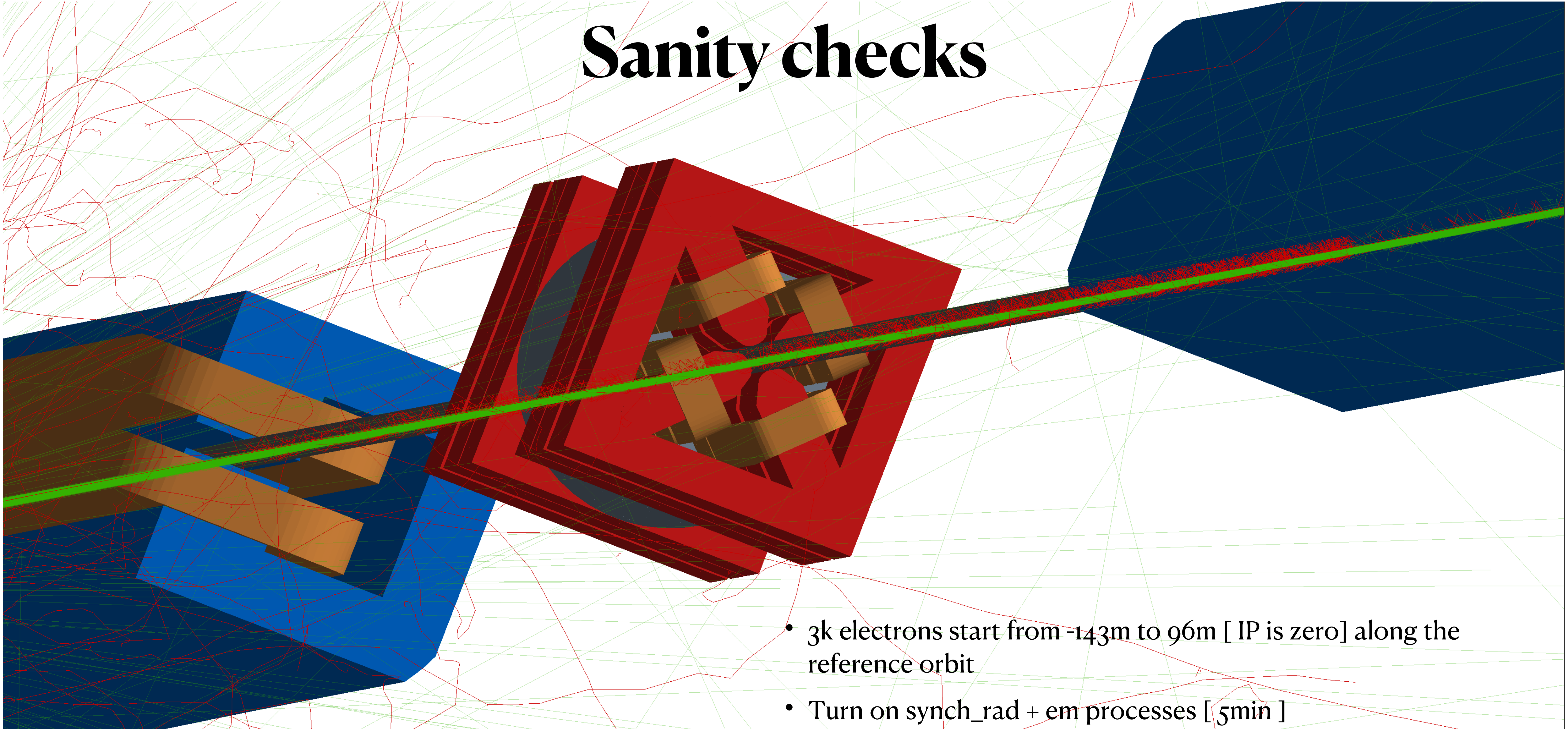
describe one ring

Sanity checks



- For SR visualisation, a long arc [12km] is shown
 - If longer, BDSIM exits with a “memory exhausted” error
 - For SR, do we really need to simulate the full ring?
- A beam of 10 particles on the reference orbit
 - Reference orbit: NO beam optics evaluation, no offset, no dispersion, etc
 - Synch_rad only; 100 s with my laptop
 - Is SR sensitive to the beam shape?

Sanity checks



- 3k electrons start from -143m to 96m [IP is zero] along the reference orbit
- Turn on synch_rad + em processes [5min]
- Background particles are properly tracked

Todo: SAD -> BDSIM, Beam Parameters

Beam parameters

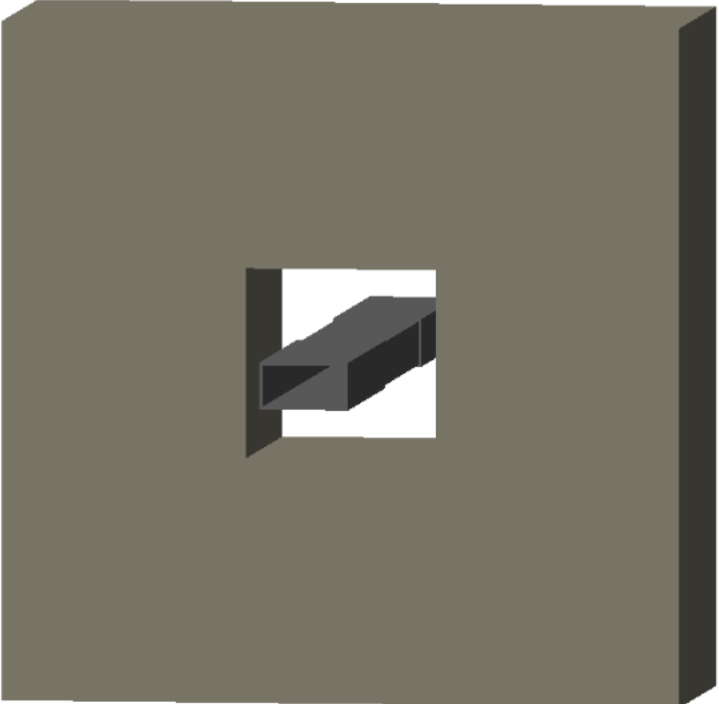
index	SAD	SAD	index	BDSIM	BDSIM
1	AX	α_x	1	alfx	
2	BX	β_x	2	betx	
3	AY	α_y	3	alfy	
4	BY	β_y	4	bety	
5	AZ	α_z			
6	BZ	β_z			
7	EX	dispersion_X	5	dispx	
8	EPX	dispersion_PX	6	dispxp	
9	EY	dispersion_Y	7	dispy	
10	EPY	dispersion_PY	8	dispyy	
11	R1				
12	R2				
13	R3				
14	R4				
15	DETR	R1R4-R2R3			
16	DX	dx			
17	DPX	dpx			
18	DY	dy			
19	DPY	dpy			
31	DZ	dz			
25	DP	-	9	sigmaP	
20	DDP	delta=dp/p0			
21	ZX	z-dispersion_X			
22	ZPX	z-dispersion_PX			
23	ZY	z-dispersion_Y			
24	ZPY	z-dispersion_PY			
26	EMITX		10	emitx	
27	EMITY		11	emity	
28	PSIX				
29	PSIY				
30	PSIZ				

- Simulate a short arc around the IP
 - Feed the beam parameters at starting point [from SAD] into BDSIM
 - Beam parameters at end point from BDSIM should match the SAD values
 - The GaussianTwiss beam model in BDSIM needs 11 parameters; all can be mapped from SAD; some need verification with accelerator experts
 - To simulate the real beam dynamics instead of just the reference orbit

Todo

- Confirm the CEPC lattice is correct
 - The layout around the interaction region?
 - A single ring is sufficient for SR study?
- How to translate solenoids and apertures from SAD to BDSIM
 - If anti-solenoid added. should the detector solenoid be included?
- Beam optics
 - Do not expect them to be identical, but they should be similar
- Add shield
 - BDSIM provides shield element; but the parameters need to come from Haoyu
- Analysis

shield



shield defines a square block of material with a square aperture. The user may c width and inner horizontal and vertical apertures of the block. A beam pipe is al aperture. If the beam pipe dimensions (including thickness) are greater than the pipe will not be created.

Parameter	Description	Default	Required
<i>l</i>	Length [m]	0	Yes
<i>material</i>	Outer material	Iron	No
<i>horizontalWidth</i>	Outer full width [m]	global	No
<i>xsize</i>	Horizontal inner half aperture [m]	0	Yes
<i>ysize</i>	Vertical inner half aperture [m]	0	No
<i>colour</i>	Colour of block. See Colours	""	No