ELS: Beam Path CST simulations

Alexander Smirnov

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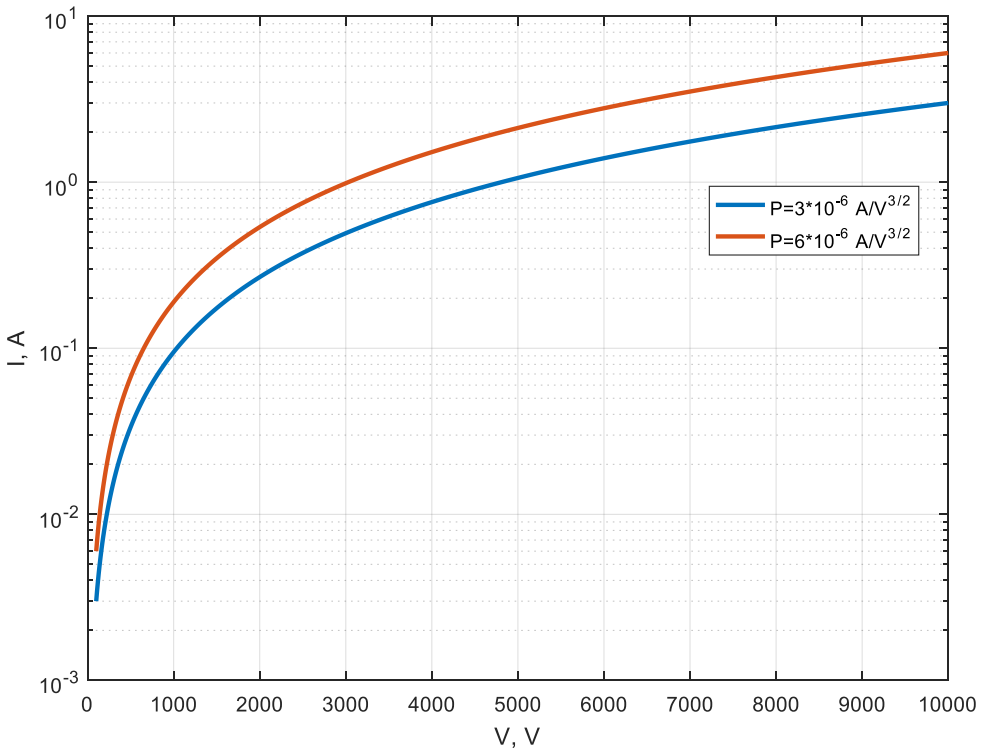
Gun output current

Parameter	Value
Cathode-anode voltage, V	0.1 – 10 kV
Electron-gun perveance, P	$(3-6)\times10^{-6}$ A/V$^{3/2}$
Peak current, $I = P\cdot V^{3/2}$	5 mA – 3 A
Cathode diameter	<30 mm
Current-density distribution	McMillan, Gaussian, flat
Main solenoid field	0.1–0.8 T
Gun and collector solenoid fields	0.1–0.4 T
Lattice amplitude functions	2–4 m
Circulating beam size (rms), e^-	0.1–0.5 mm
Circulating beam size (rms), p	1–5 mm

Output current vs. injection V

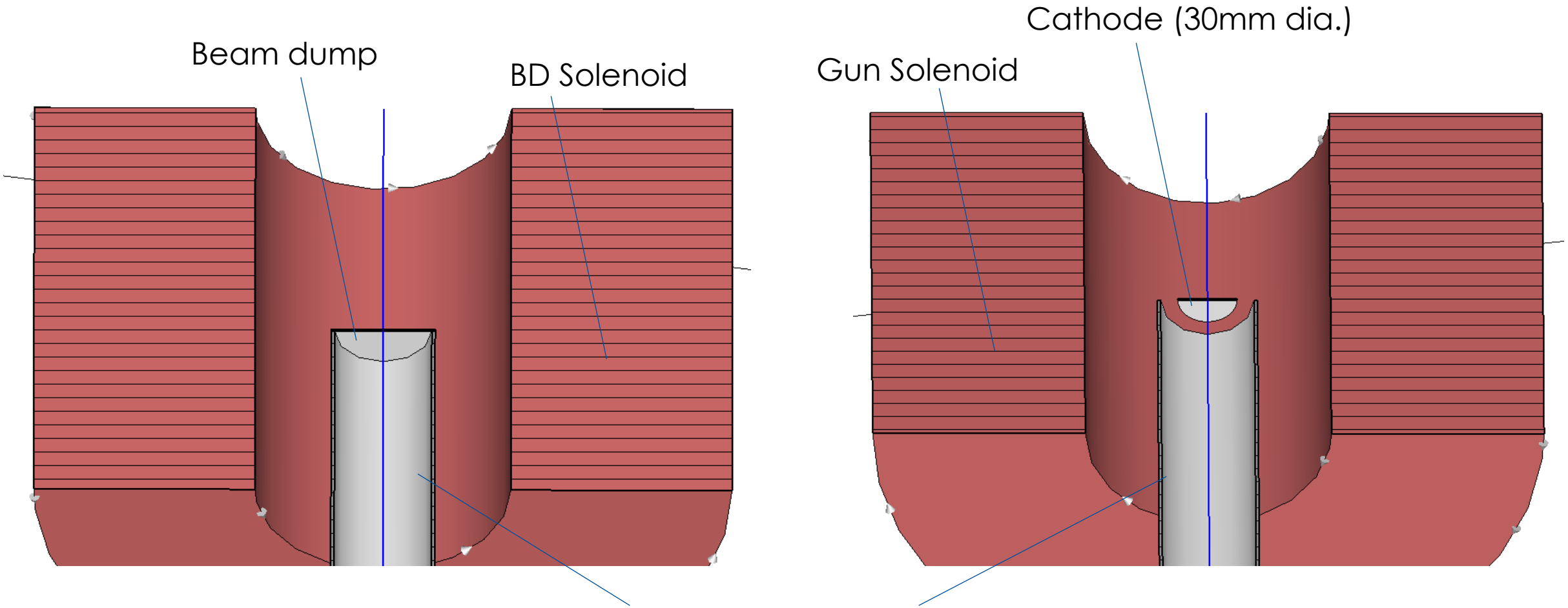


Optimized solenoid system parameters

RadiaBeam

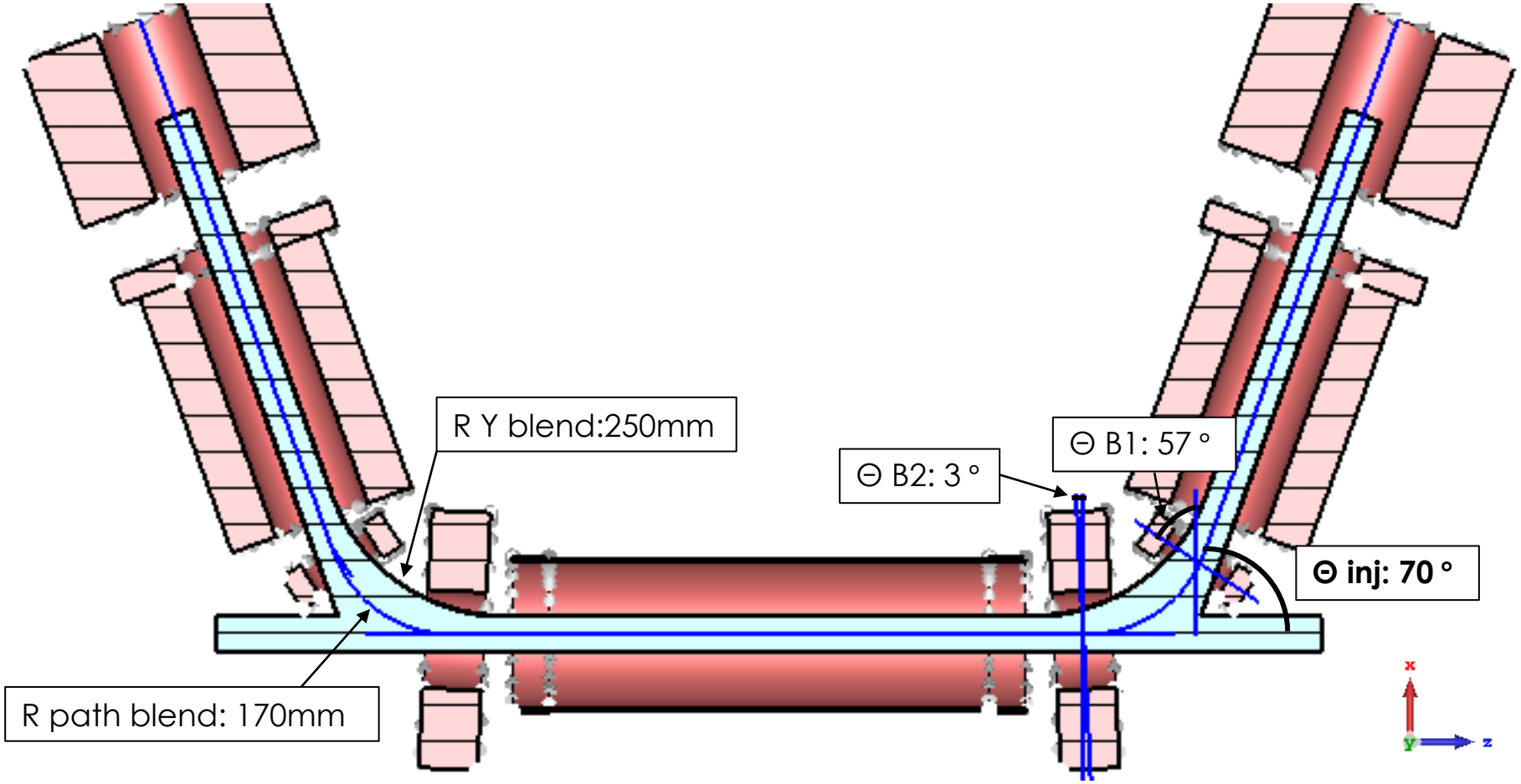
Solenoid	X, mm	Z, mm	Θ, deg	R out, mm	R in, mm	L, mm	I_0, Amp	N	Cable size, Hole diameter , mm	A, mm^2	j_0(Amp/mm^2)	B_0, T
Gun	724.503	816.413	70	170.5	62.5	240	128	180	12x12, 8	93.736	1.365	0.087
Transfer A in	519.180	741.681	70	157	67	36	210	40	9x9, 6	52.726	3.983	0.187
Transfer in	328.892	672.422	70	130	67	369	260	287	9x9, 6	52.726	4.931	
Bend 1 in	99.168	582.410	57	80	50	52.5	100	63	5x5, 3	17.931	5.577	0.058
Bend 2 in	-8.265	428.451	3	175.5	67	80	100	240	5x5, 3	17.931	5.577	0.126
Main A	0	-325	0	105.6	100	50	85	280	TBD	TBD	TBD	0.34
Main	0	0	0	103.2	100	600	85	1920	TBD	TBD	TBD	
Main B	0	325	0	105.6	100	50	85	280	TBD	TBD	TBD	

Injection and beamdump geometries



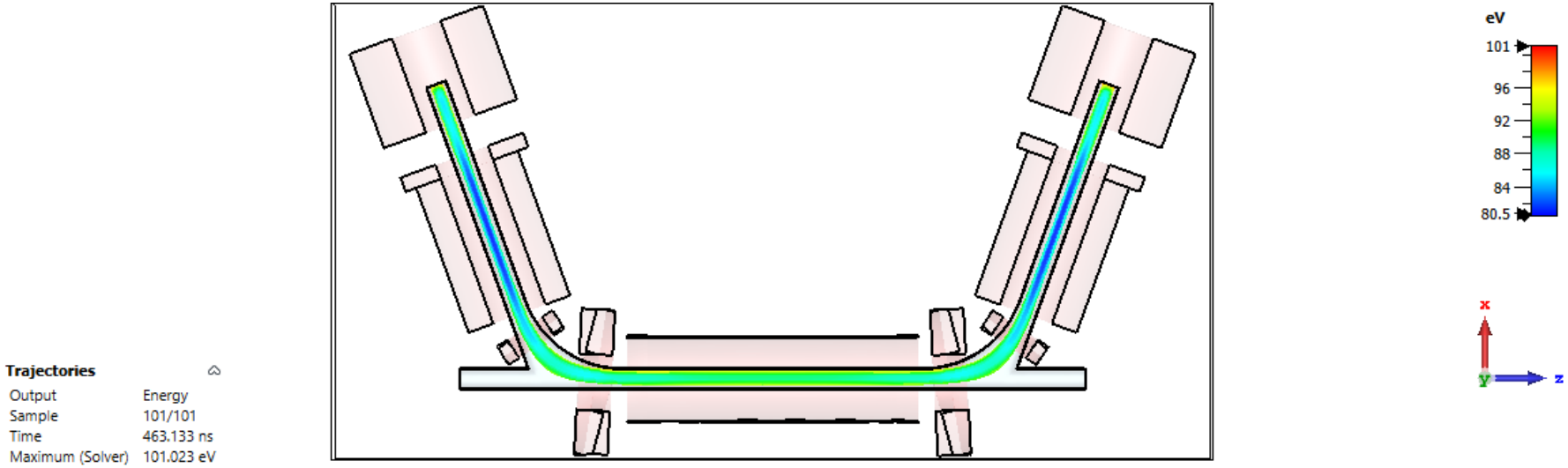
Beampipe: ID=47.498 mm, OD=50.80 mm

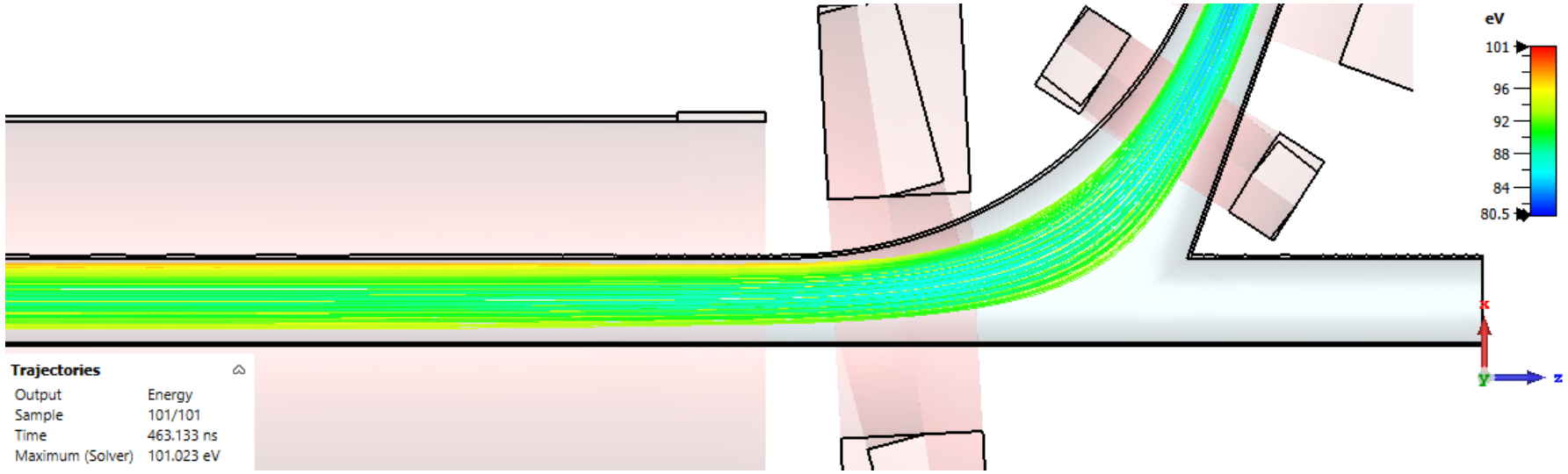
Optimized solenoid layout



Main solenoid B=0.2T 5mA 100 eV (flat, 30mm dia. beam in Gun)

Solenoid	B_max (T)	k	j_k(Amp/mm^2)
Gun	0.321	3.72	5.079
Transfer	0.561	3	14.793
Bend 1	0.092	1.596	8.901
Bend 2	0.181	1.44	8.031
Main	0.195	0.588	





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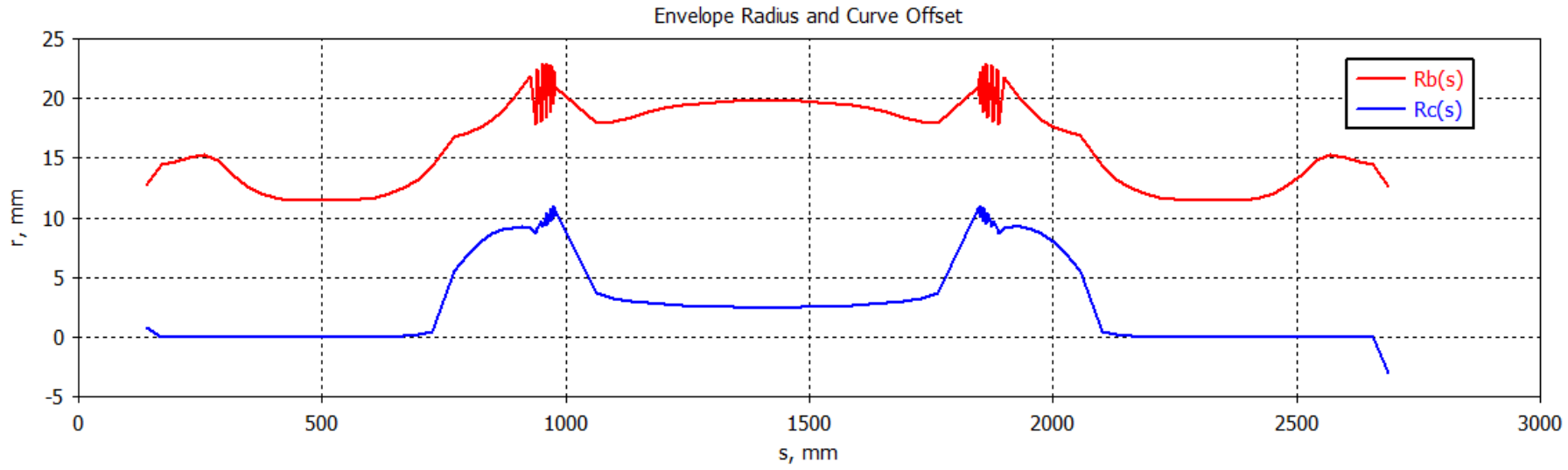
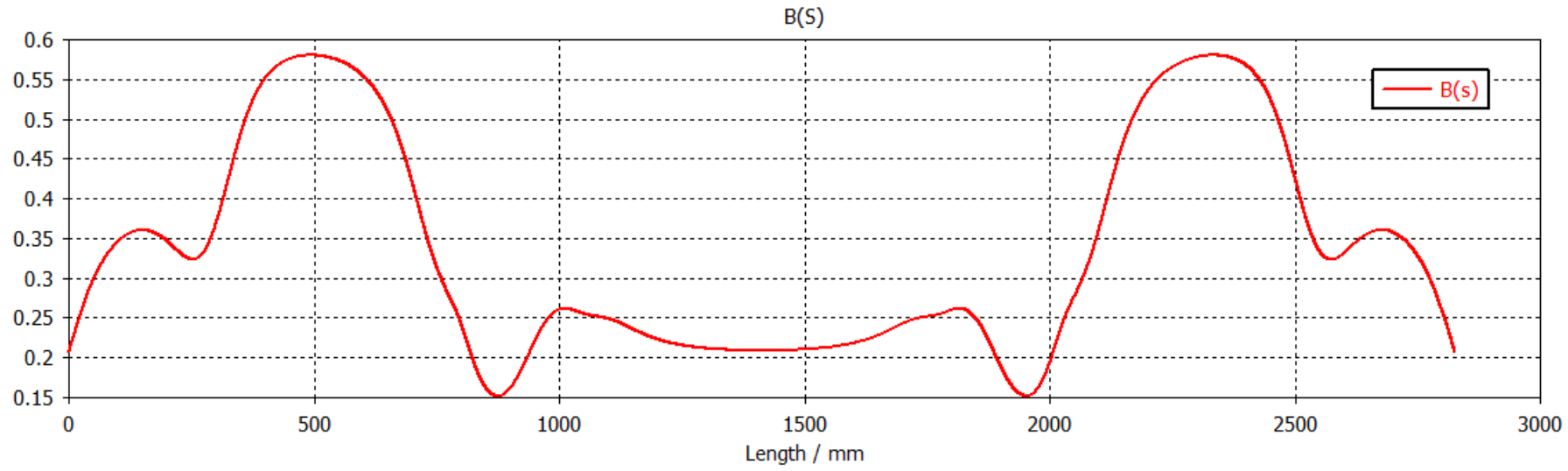
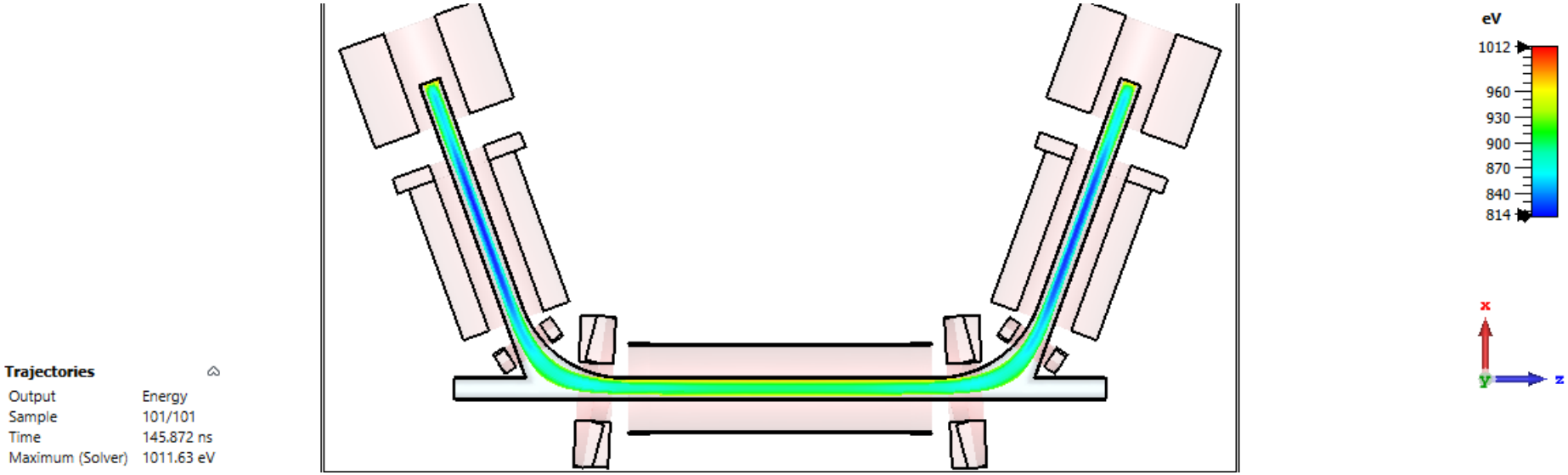


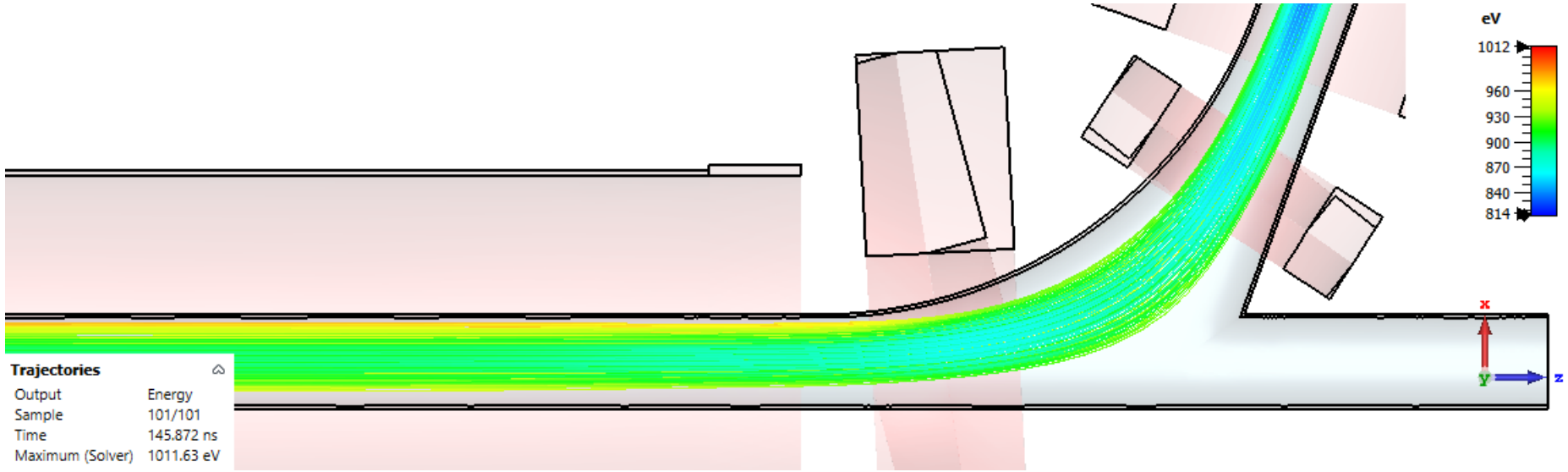


Transmission: 100%
Diameter in Main: 39.67mm
Fill ratio: 83.5%
Centroid Offset: 2.443mm

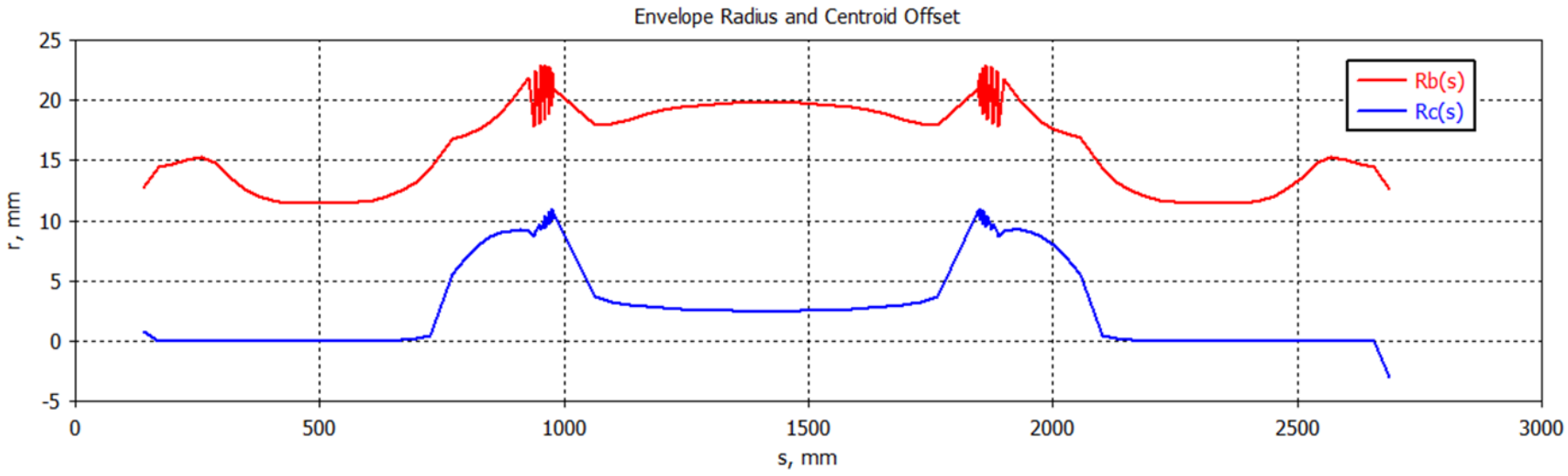
Main solenoid B=0.2T 152 mA 1000 eV (flat, 30mm dia. beam in Gun)

Solenoid	B_max (T)	k	j_k(Amp/mm^2)
Gun	0.321	3.7208	5.079
Transfer	0.561	3	14.793
Bend 1	0.092	1.596	8.901
Bend 2	0.181	1.44	8.031
Main	0.195	0.588	

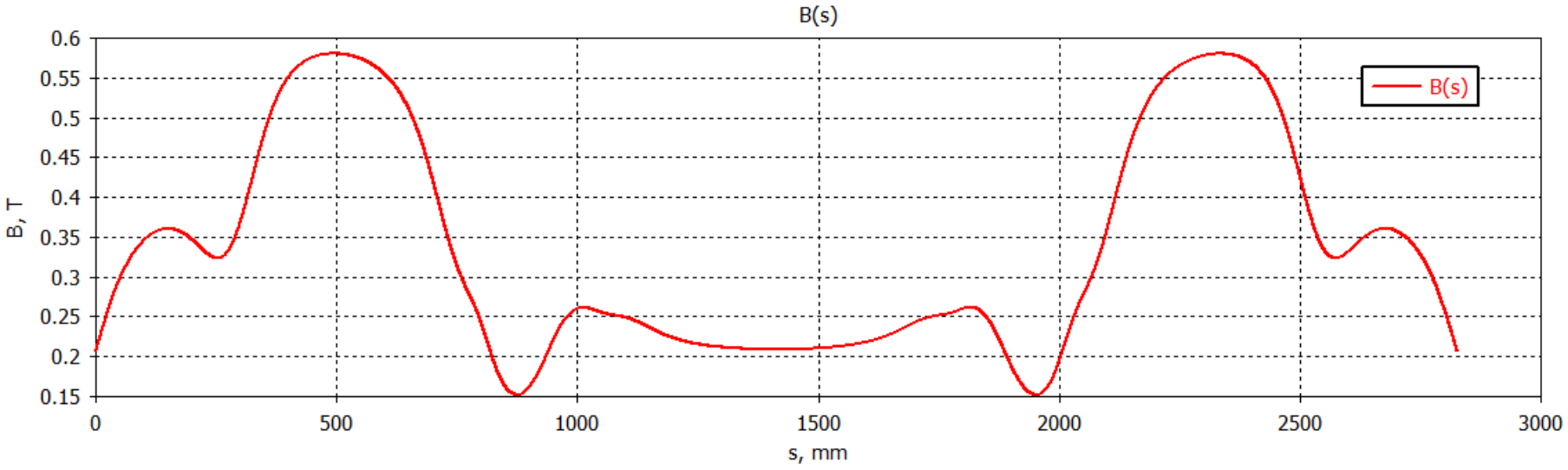




Main solenoid B=0.2T 152 mA 1000 eV (flat, 30mm dia. beam in Gun)



Transmission: 100%
Diameter in Main: 39.67mm
Fill ratio: 83.5%
Centroid Offset: 2.443mm



Main solenoid B=0.2T 3 A 10000 eV (flat, 30mm dia. beam in Gun)

Solenoid	B_max (T)	k	j_k(Amp/mm^2)
Gun	0.321	3.7208	5.079
Transfer	0.561	3	14.793
Bend 1	0.092	1.596	8.901
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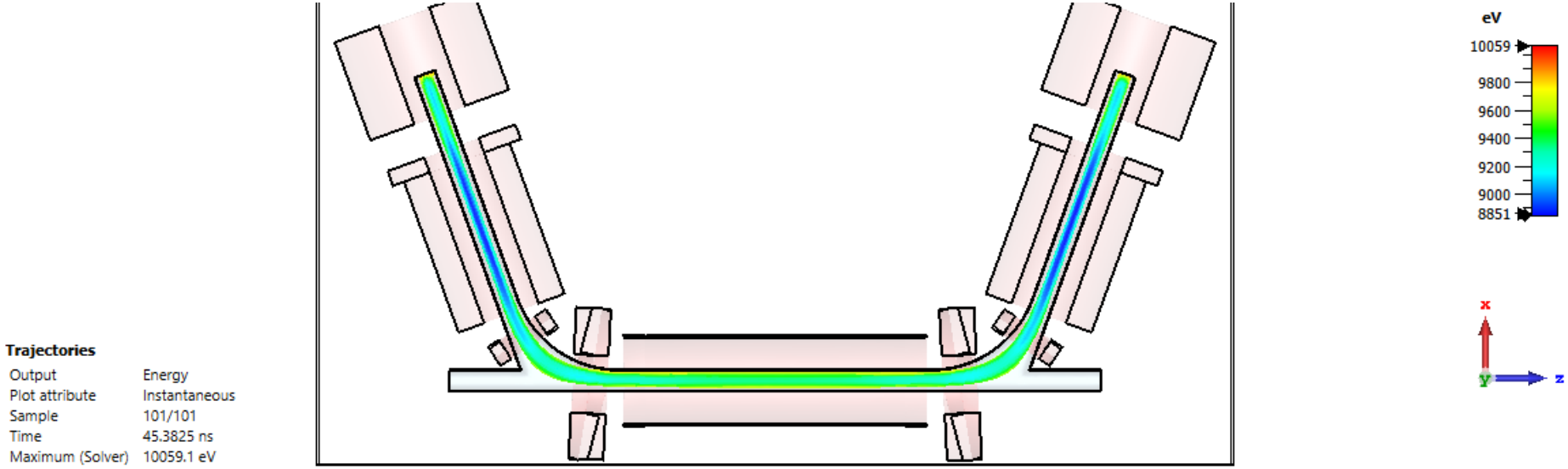
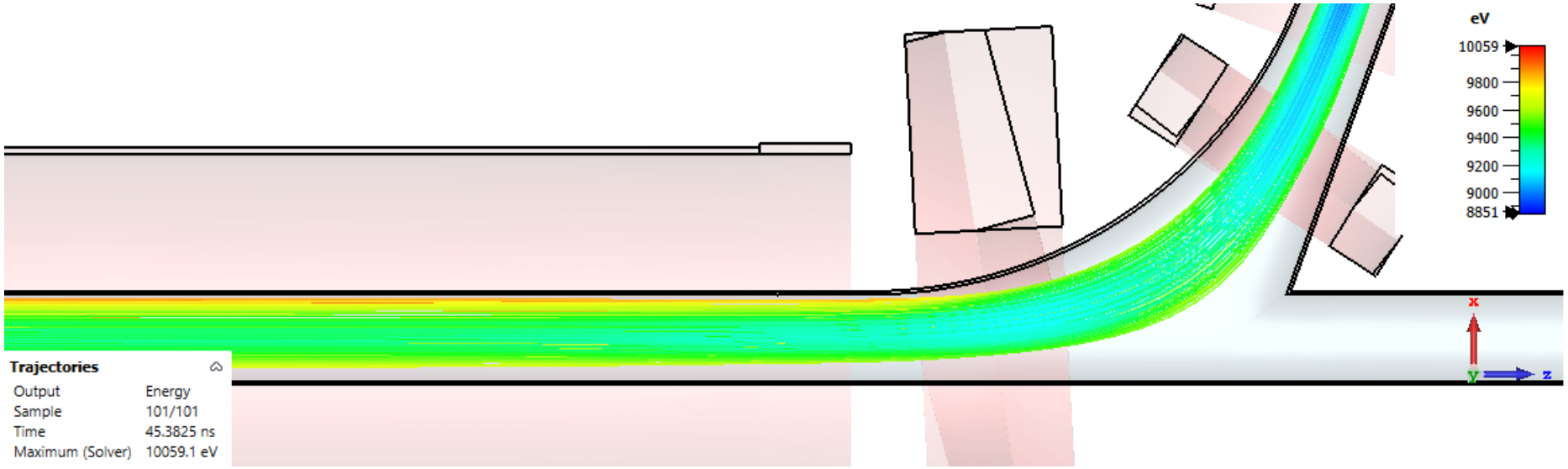
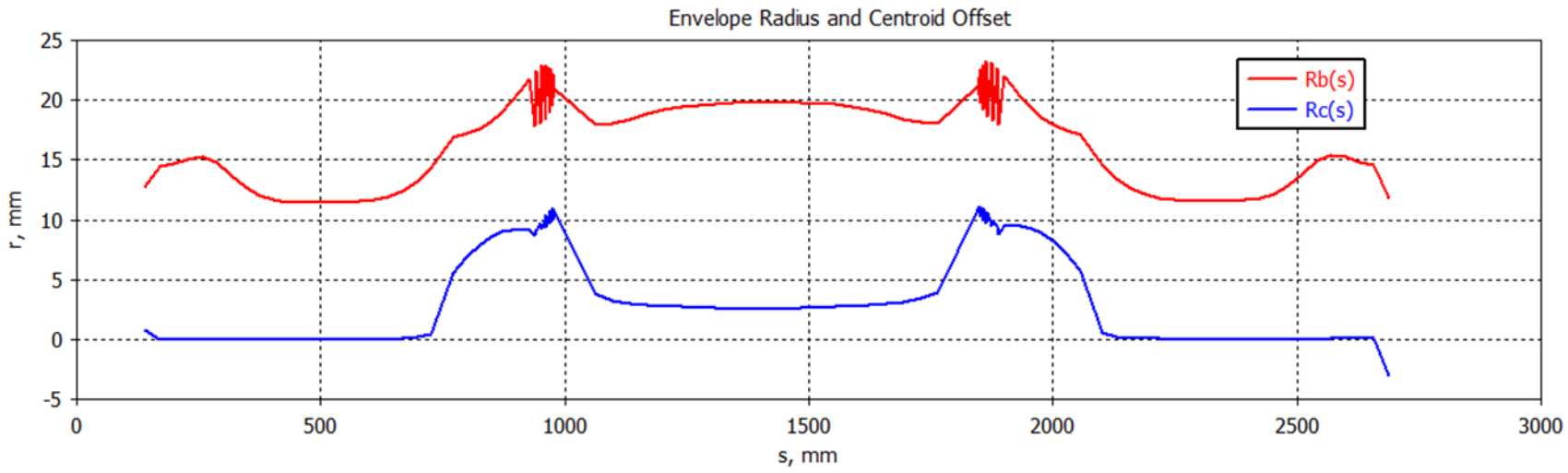
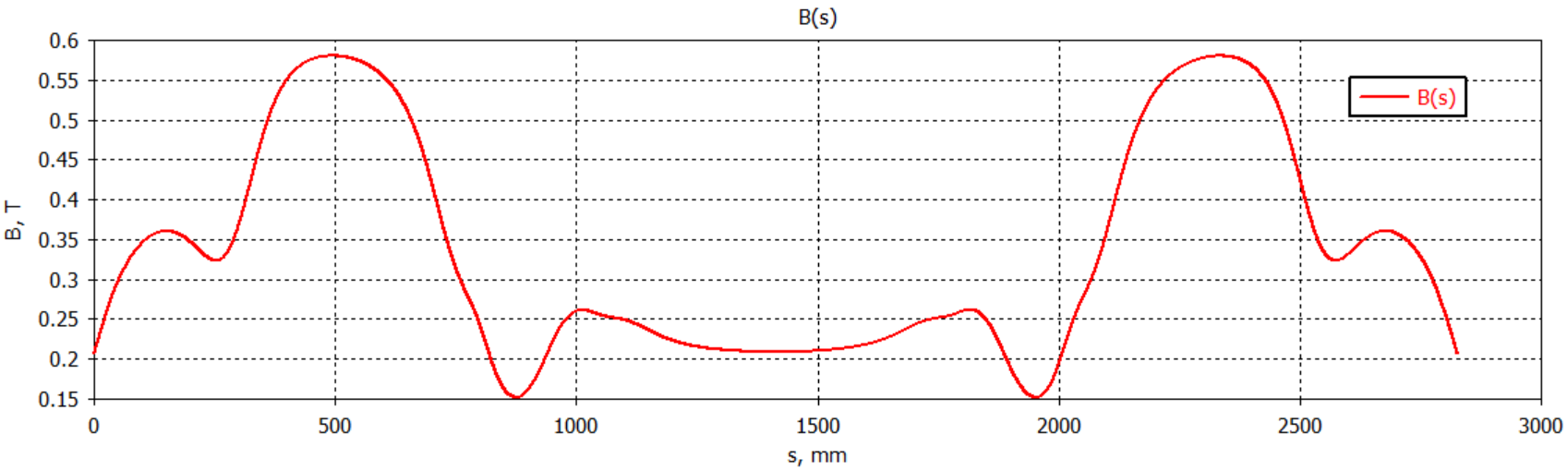
Main	0.195	0.588	





Main solenoid B=0.2T 3 A 10000 eV (flat, 30mm dia. beam in Gun)

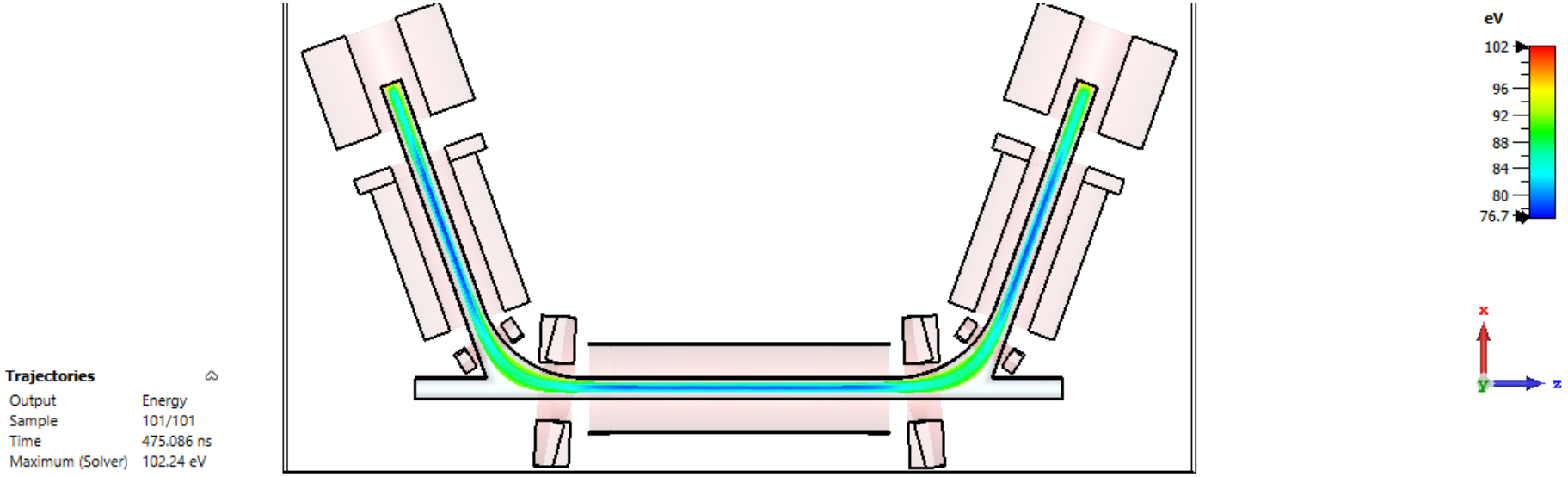


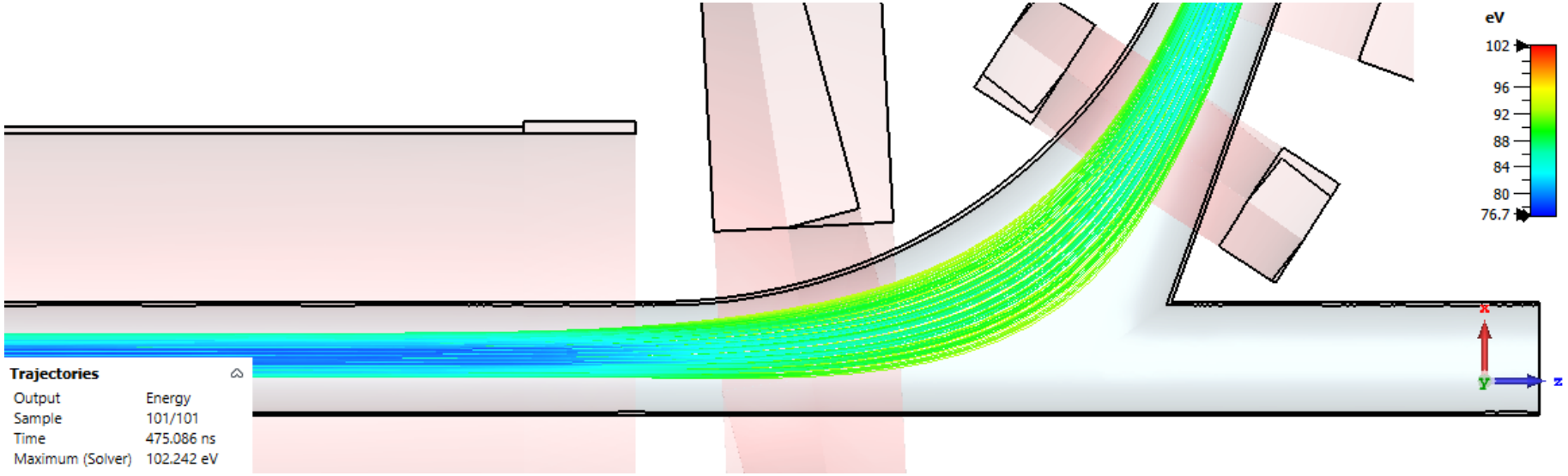


Transmission: 100%
Diameter in Main: 39.71mm
Fill ratio: 83.6%
Centroid Offset: 2.551mm

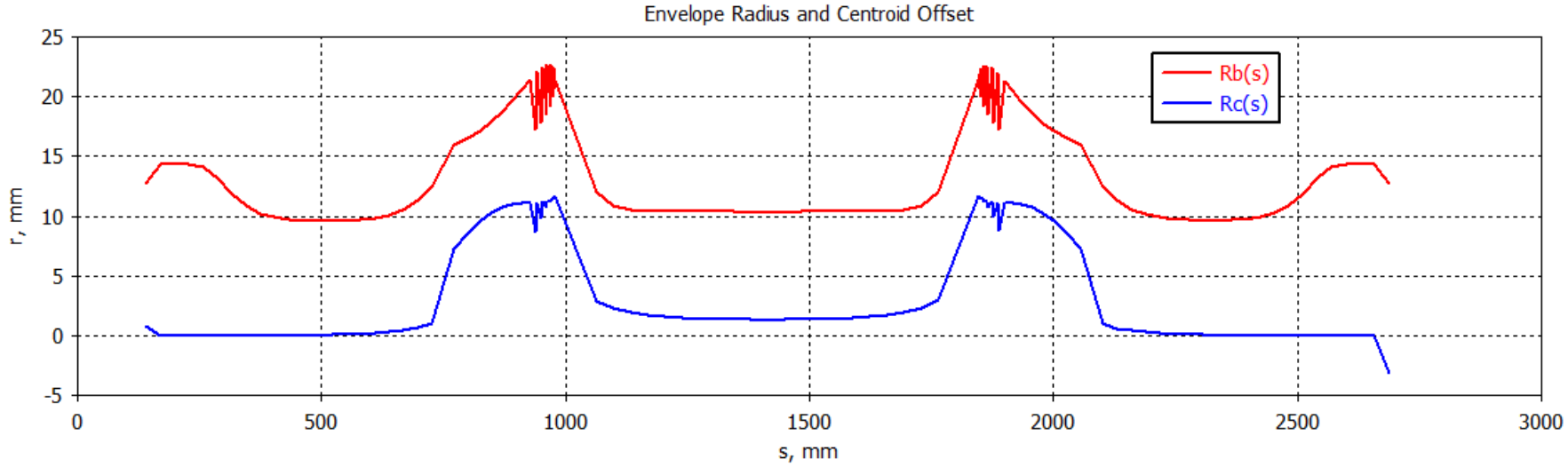
Main solenoid B=0.8T 5 mA 100 eV (flat, 30mm dia. beam in Gun)

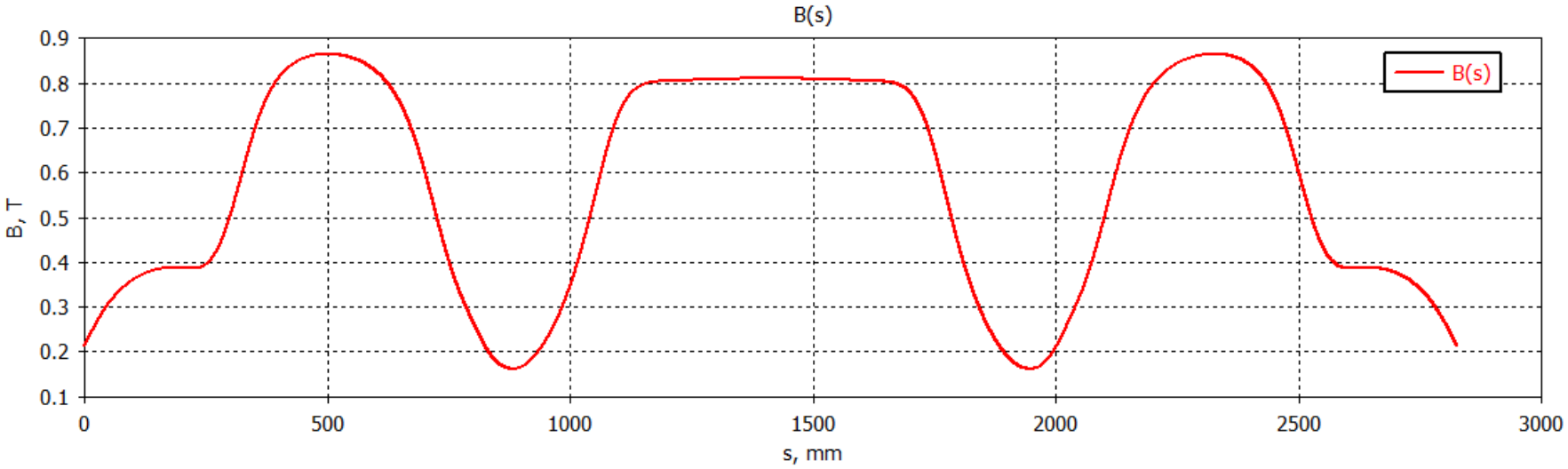
Solenoid	B_max (T)	k	j_k(Amp/mm^2)
Gun	0.321	3.7208	5.079
Transfer	0.842	4.5	22.190
Bend 1	0.057	1	5.577
Bend 2	0.063	0.5	2.788
Main	0.799	0.588	NA





Main solenoid B=0.8T 5 mA 100 eV (flat, 30mm dia. beam in Gun)

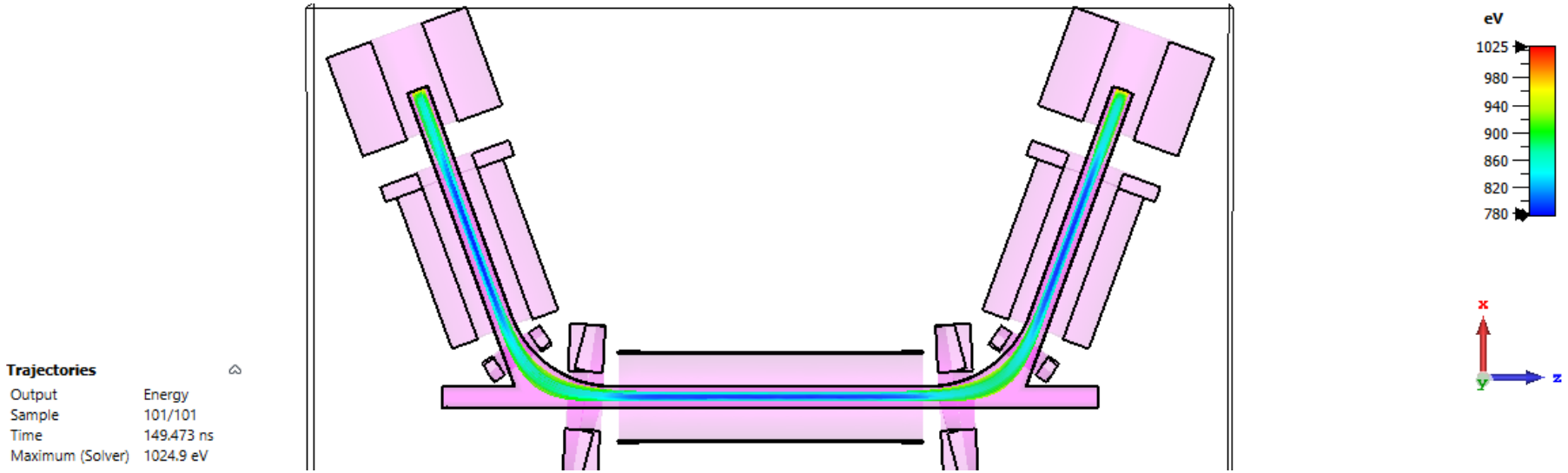


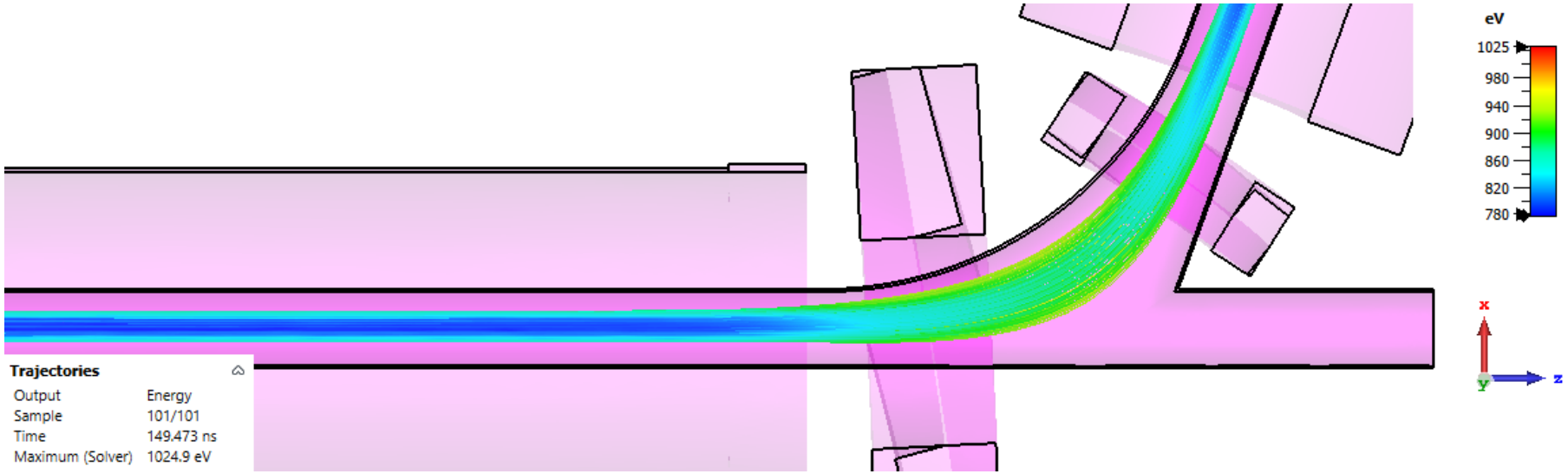


Transmission: 100%
Diameter in Main: 20.64mm
Fill ratio: 43.4%
Centroid Offset: 1.292mm

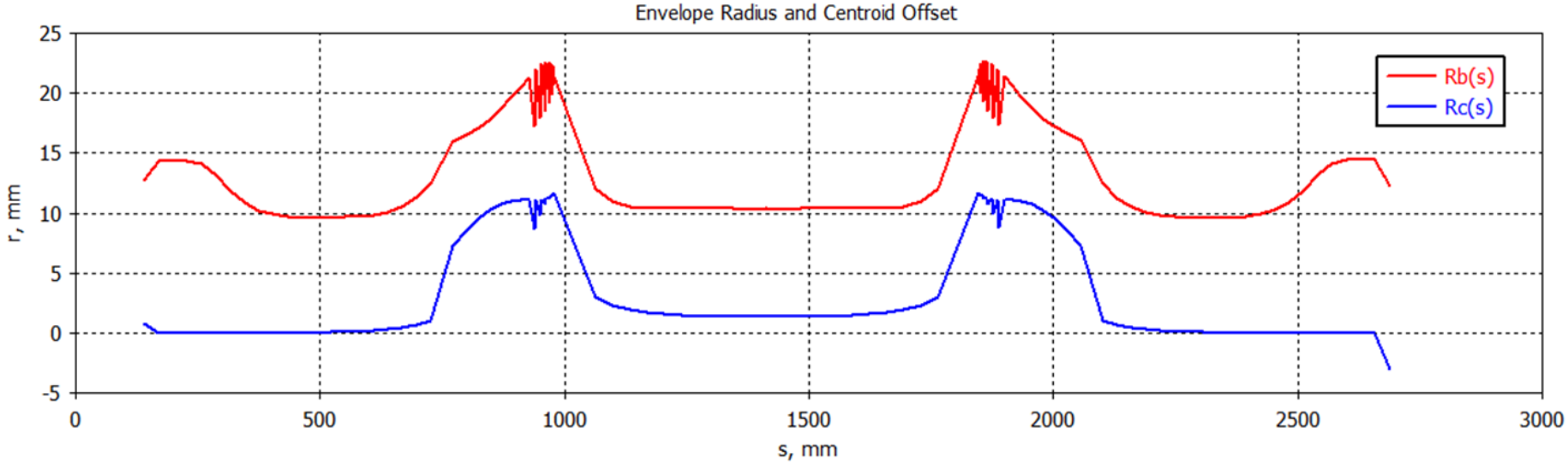
Main solenoid B=0.8T 152 mA 1000 eV (flat, 30mm dia. beam in Gun)

Solenoid	B_max (T)	k	j_k(Amp/ mm^2)
Gun	0.321	3.7208	5.079
Transfer	0.842	4.5	22.190
Bend 1	0.057	1	5.577
Bend 2	0.063	0.5	2.788
Main	0.799	0.588	NA

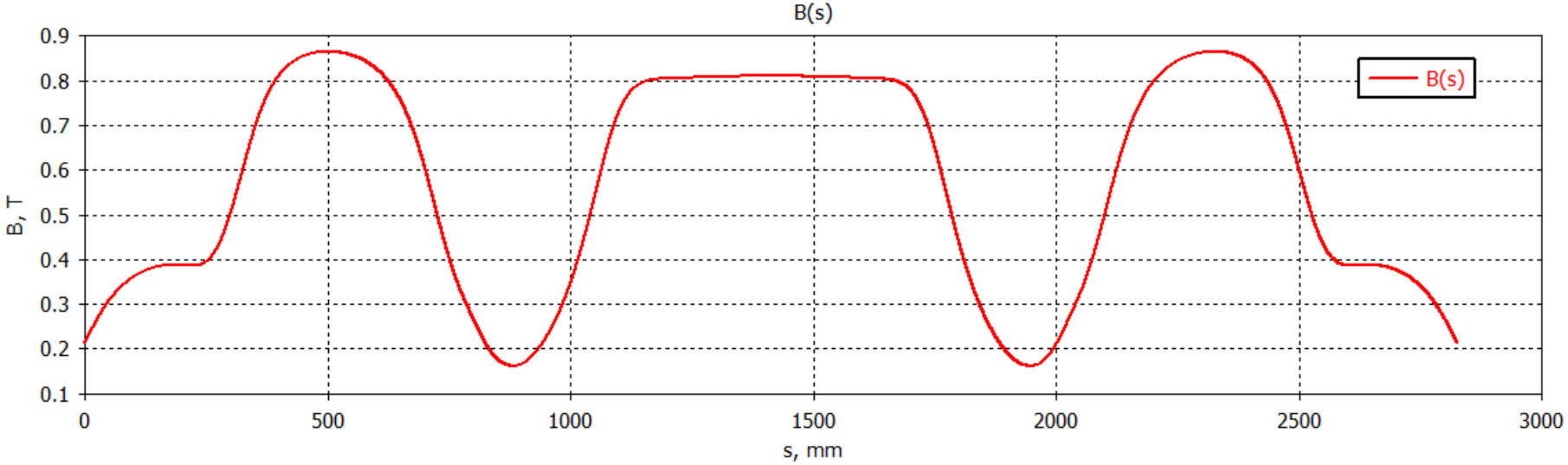




Main solenoid B=0.8T 152 mA 1000 eV (flat, 30mm dia. beam in Gun)



Transmission: 100%
Diameter in Main: 20.64 mm
Fill ratio: 43.6%
Centroid Offset: 1.295mm



Main solenoid B=0.8T 3 A 10000 eV (flat, 30mm dia. beam in Gun)

Solenoid	B_max (T)	k	j_k(Amp/mm^2)
Gun	0.321	3.7208	5.079
Transfer	0.842	4.5	22.190
Bend 1	0.057	1	5.577
Bend 2	0.063	0.5	2.788
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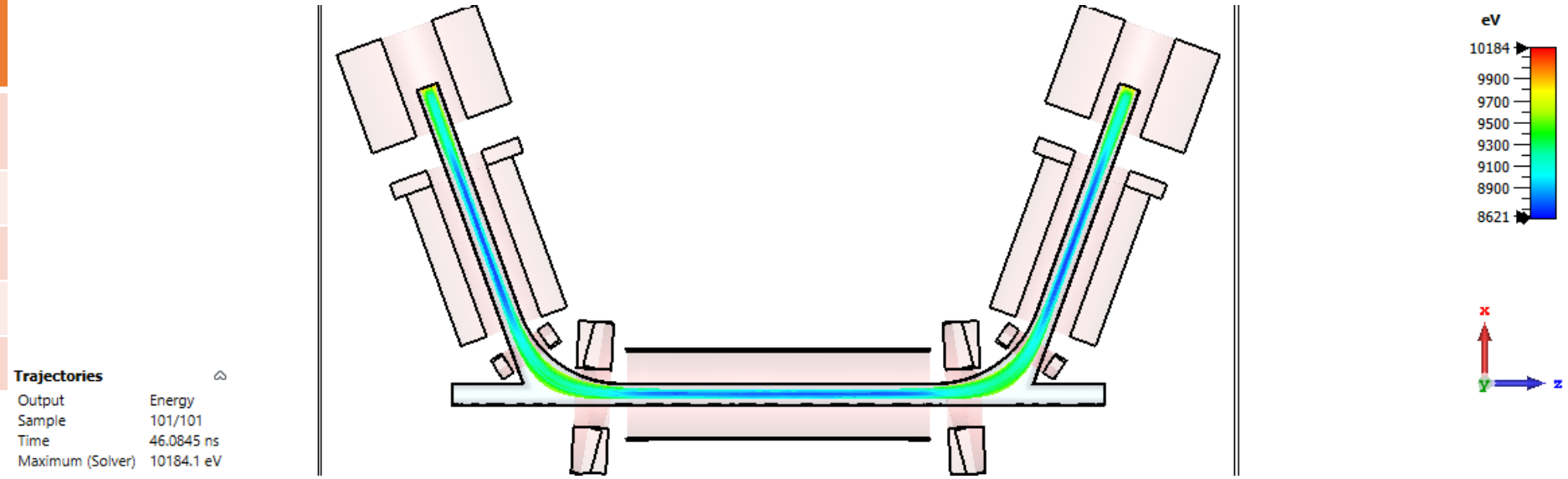
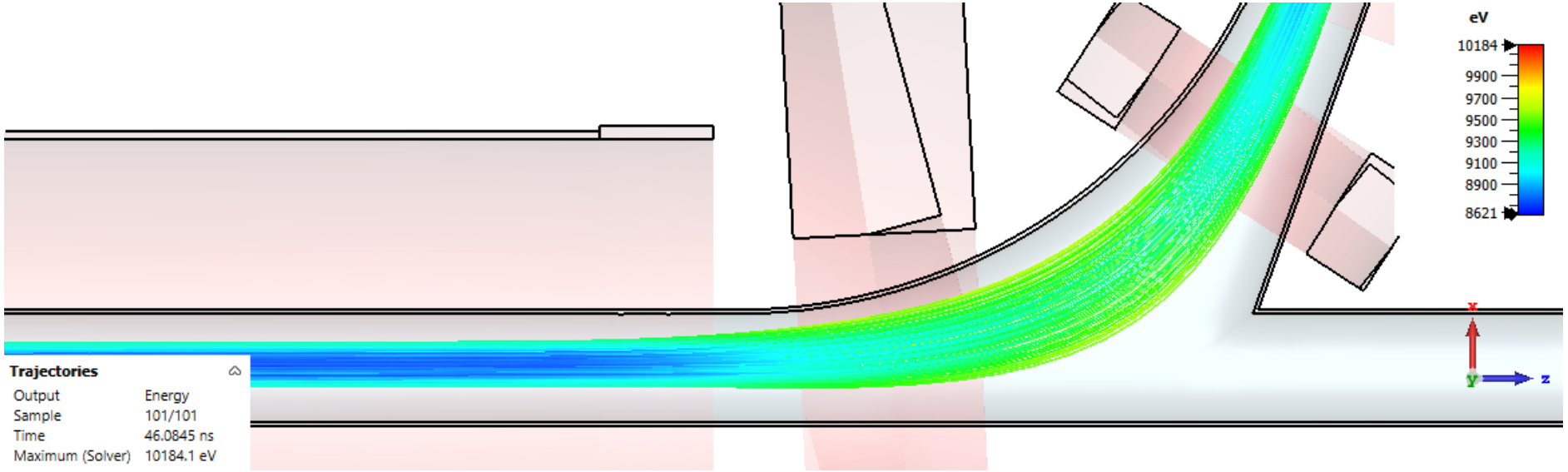
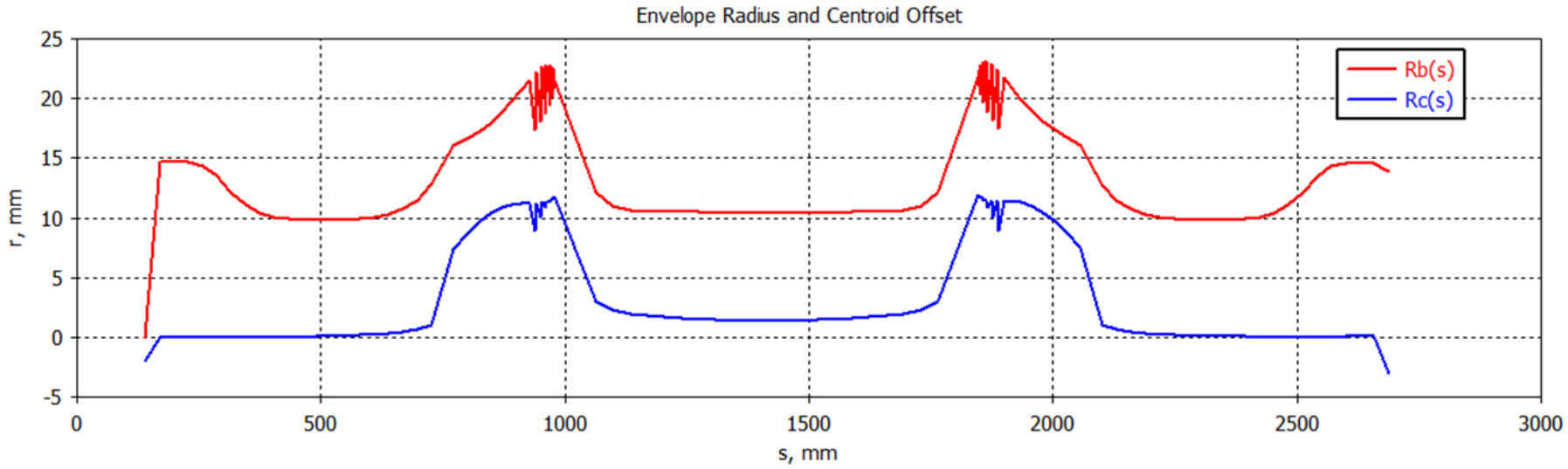
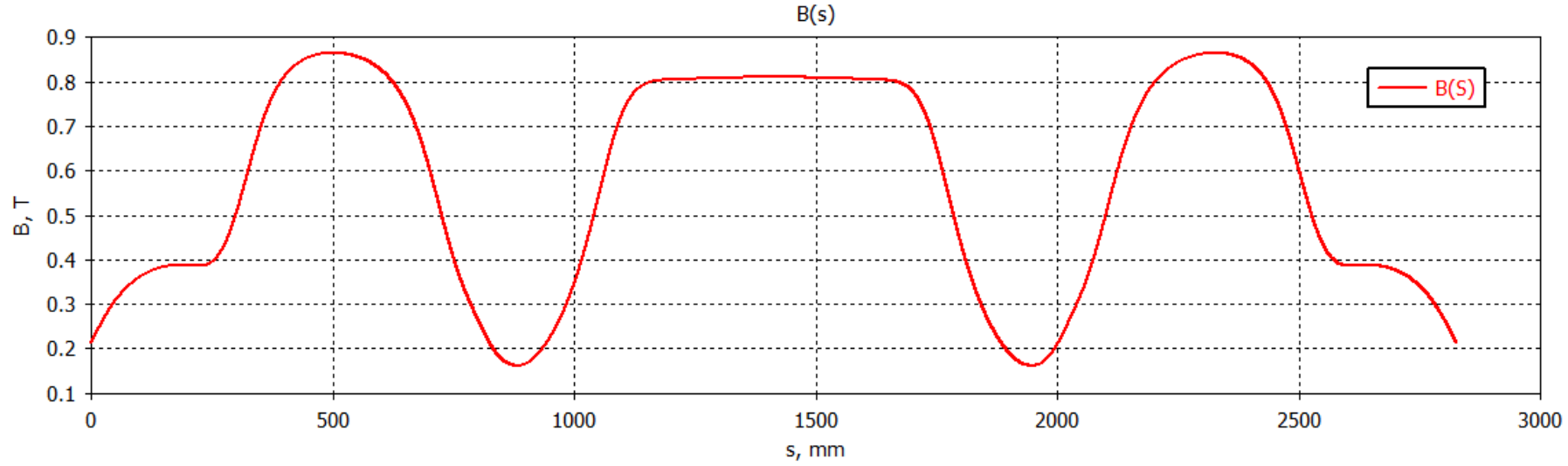




Main solenoid B=0.8T 3 A 10000 eV (flat, 30mm dia. beam in Gun)





Transmission: 100%
Diameter in Main: 20.67mm
Fill ratio: 43.5%
Centroid Offset: 1.318mm

Summary (flat, 30mm dia. beam in Gun)

RadiaBeam

Optimized magnet layout picture shown in Slide 5

Scaling factors k=1

Solenoid	X, mm	Z, mm	Θ, deg	R out, mm	R in, mm	L, mm	I_0, Amp	N	Cable size, Hole diameter , mm	A, mm²	j_0(Amp /mm²)	B_0, T
Gun	724.503	816.413	70	170.5	62.5	240	128	180	12x12, 8	93.736	1.365	0.087
Transfer A in	519.180	741.681	70	157	67	36	210	40	9x9, 6	52.726	3.983	0.187
Transfer in	328.892	672.422	70	130	67	369	260	287	9x9, 6	52.726	4.931	
Bend 1 in	99.168	582.410	57	80	50	52.5	100	63	5x5, 3	17.931	5.577	0.058
Bend 2 in	-8.265	428.451	3	175.5	67	80	100	240	5x5, 3	17.931	5.577	0.126
Main A	0	-325	0	105.6	100	50	85	280	TBD	TBD	TBD	0.34
Main	0	0	0	103.2	100	600	85	1920	TBD	TBD	TBD	
Main B	0	325	0	105.6	100	50	85	280	TBD	TBD	TBD	

Scaling k-s are tuned

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Regime 1

Solenoid	k	B_{max} (T)	j_k, (Amp/ mm²)
Gun	3.72	**0.321**	5.079
Transfer	3	0.561	14.793
Bend 1	1.596	0.092	8.901
Bend 2	1.44	0.181	8.031
Main	0.588	**0.195**	TBD

Transmission: 100% across 5mA@100 eV to 3A@10 keV
Diameter in Main: 39.67mm
Beampipe fill ratio: 83.5%
Centroid Offset: 2.443mm

Regime 2

Solenoid	k	B_{max} (T)	j_k, (Amp/mm²)
Gun	3.72	**0.321**	5.079
Transfer	4.5	0.842	22.190
Bend 1	1	0.057	5.577
Bend 2	0.5	0.063	2.788
Main	0.588	**0.799**	TBD

Transmission: 100% across 5mA@100 eV to 3A@10 keV
Diameter in Main: 20.67mm
Beampipe fill ratio : 43.5%
Centroid Offset: 1.318mm