A NEW INJECTION SYSTEM FOR KURCHATOV SOURCE OF SR

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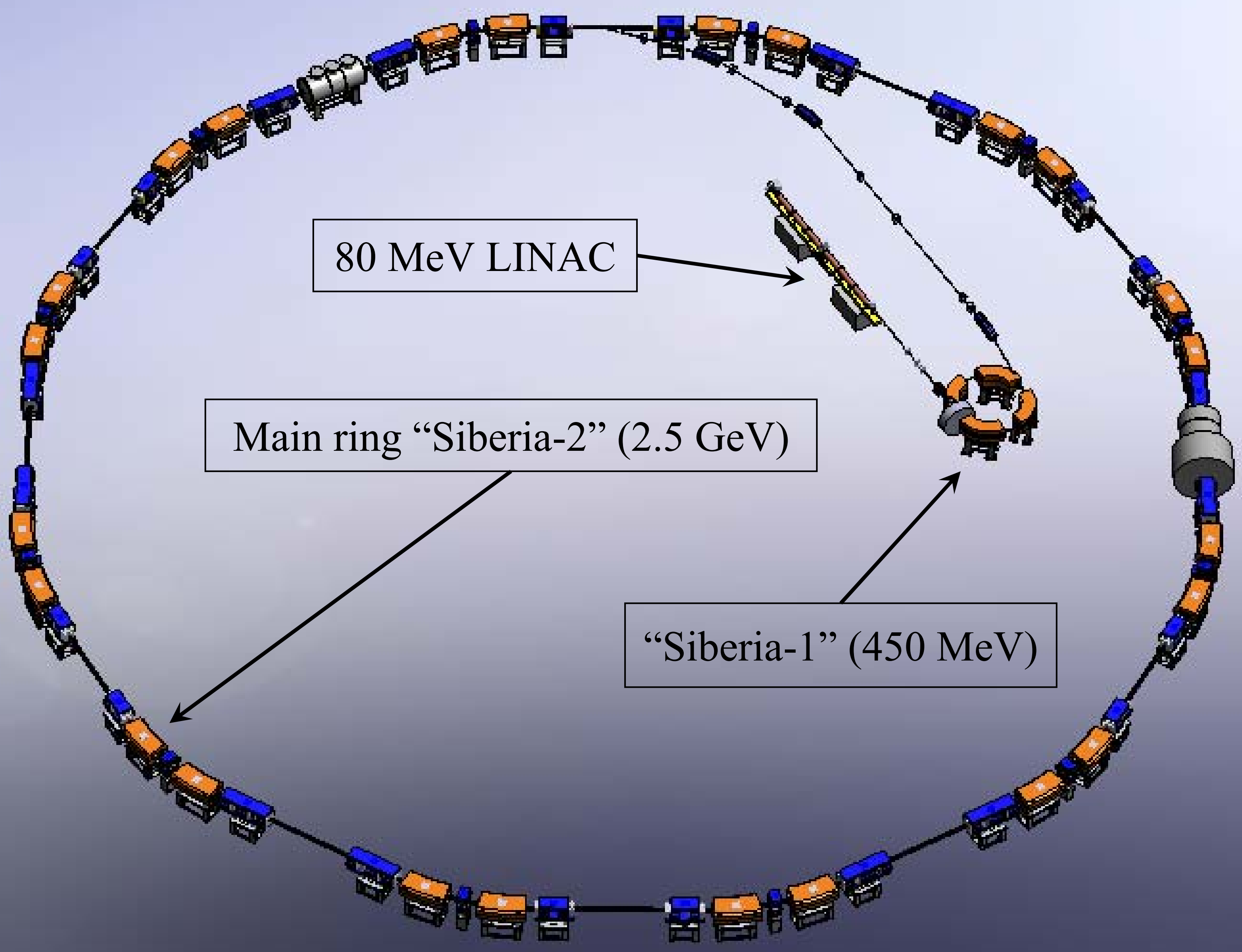
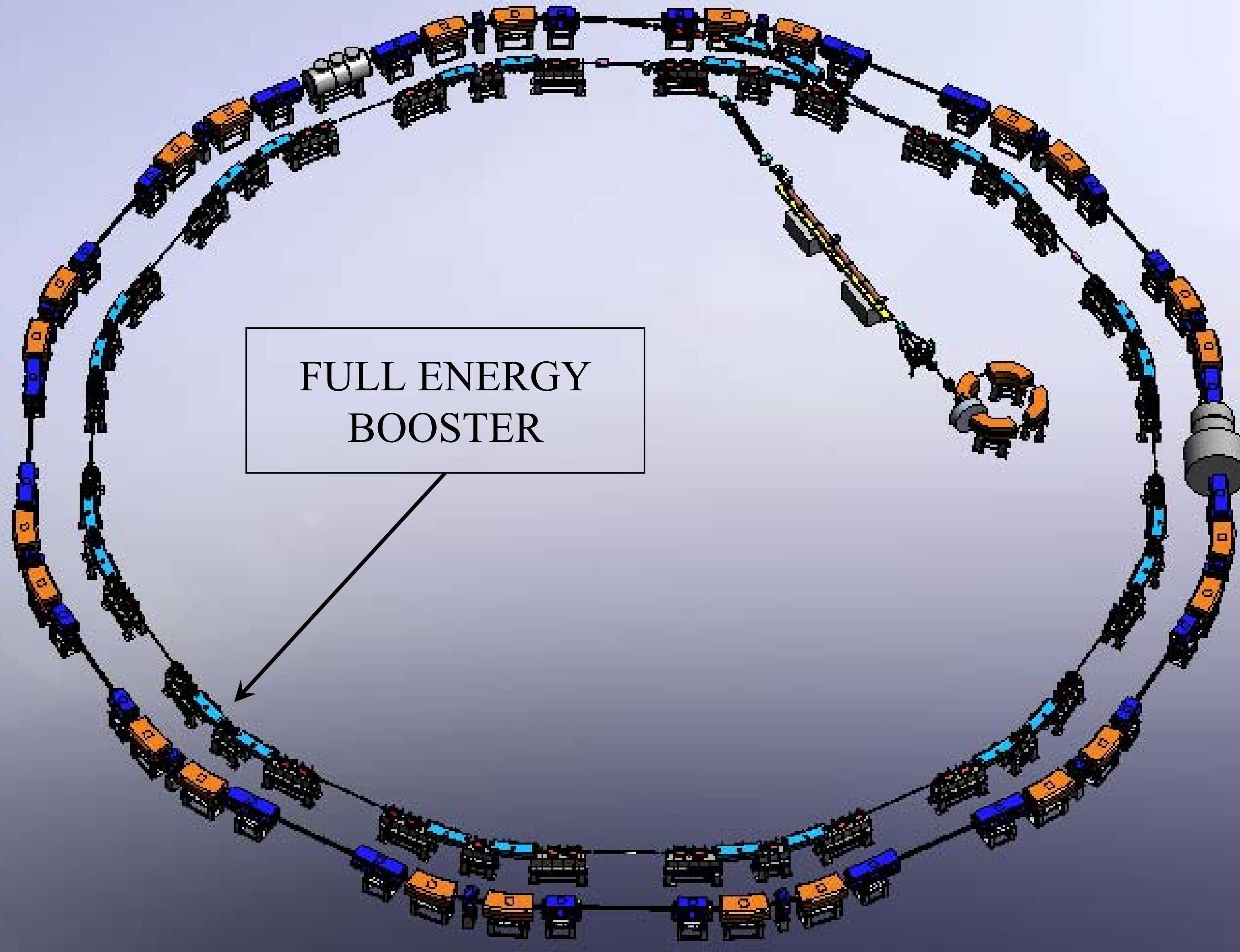
Content

- Full energy Booster Synchrotron lattice
- Magnetic elements
- Preinjector modernization
- Injection – Extraction
- Conclusion

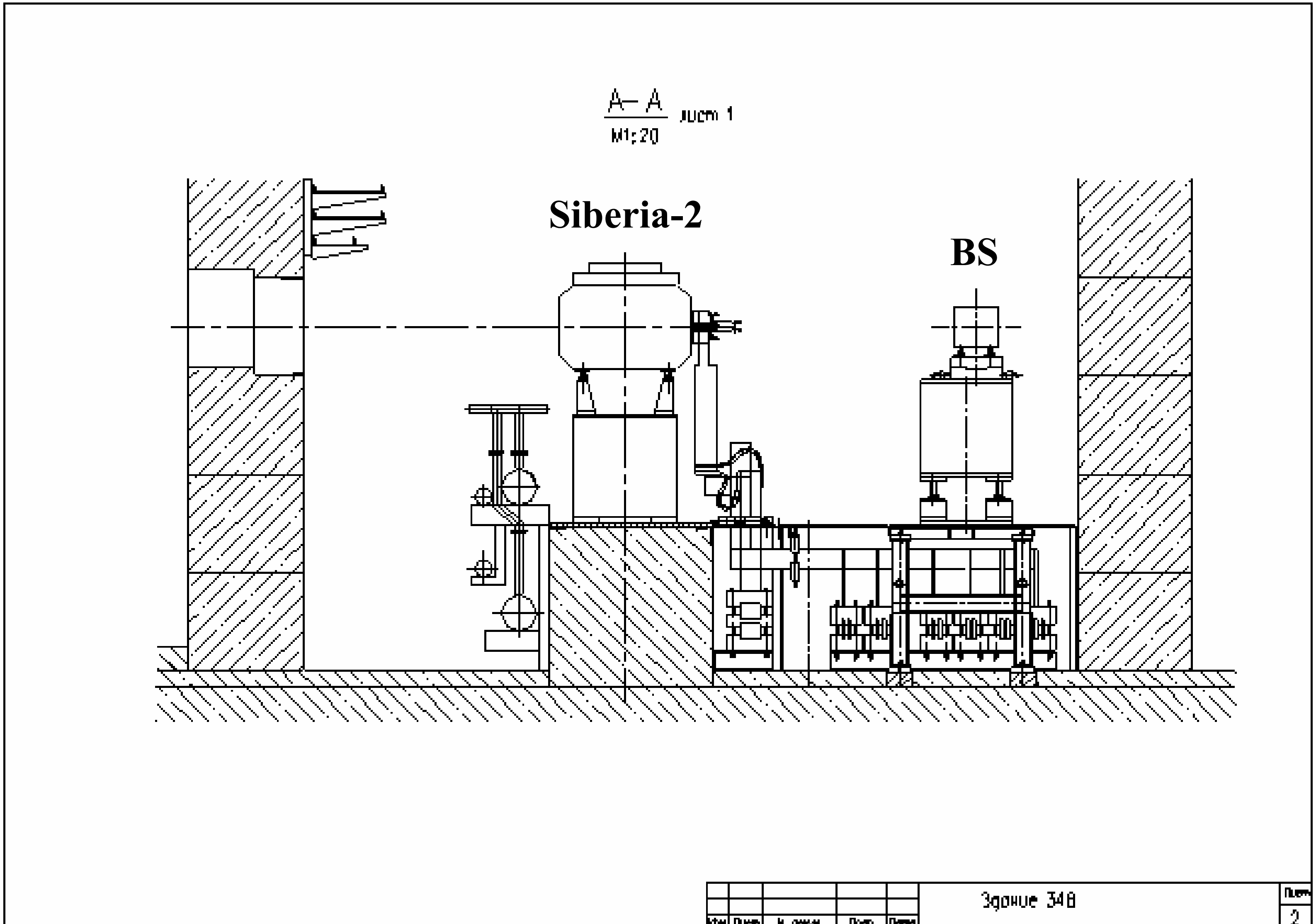
Accelerator complex layout



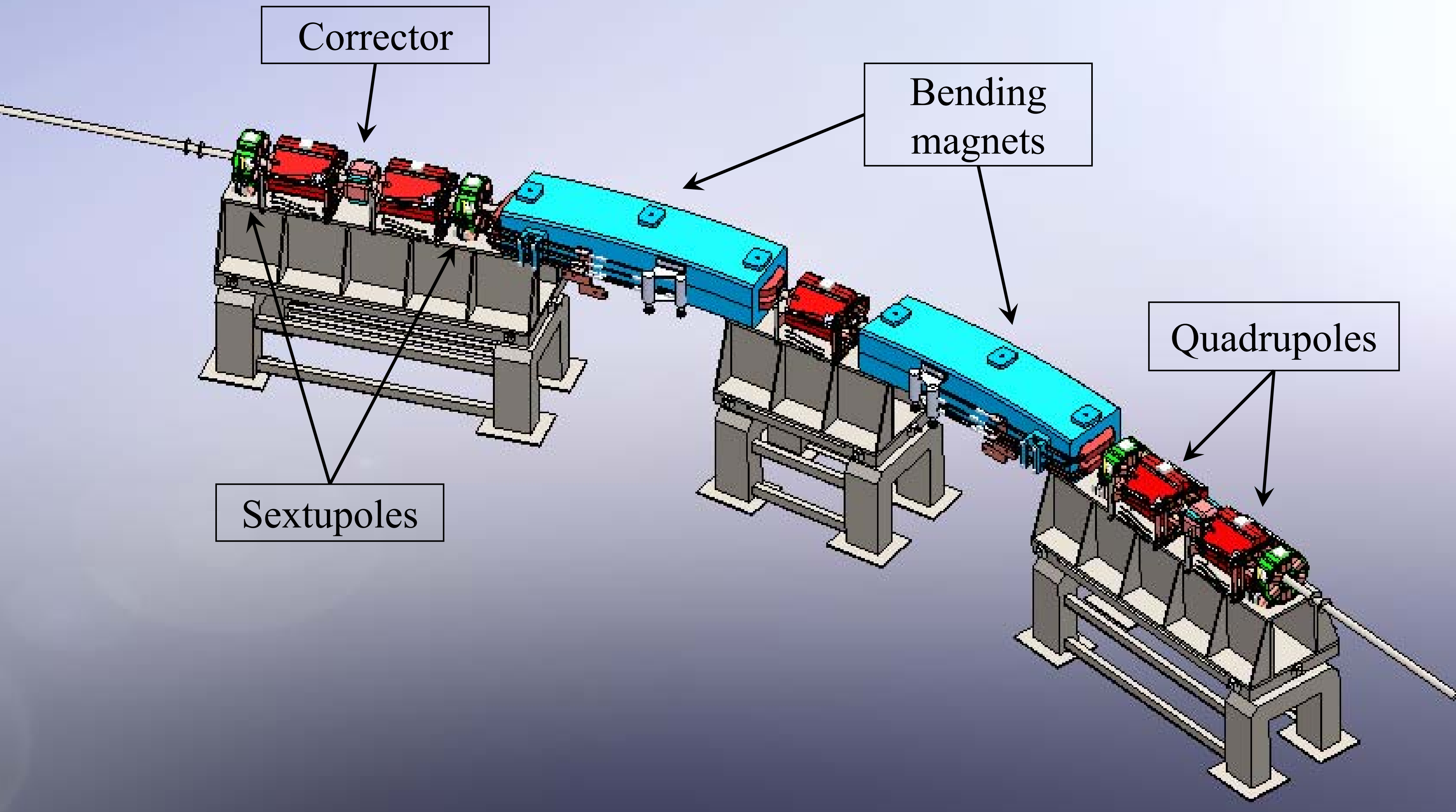
Accelerator complex after upgrade



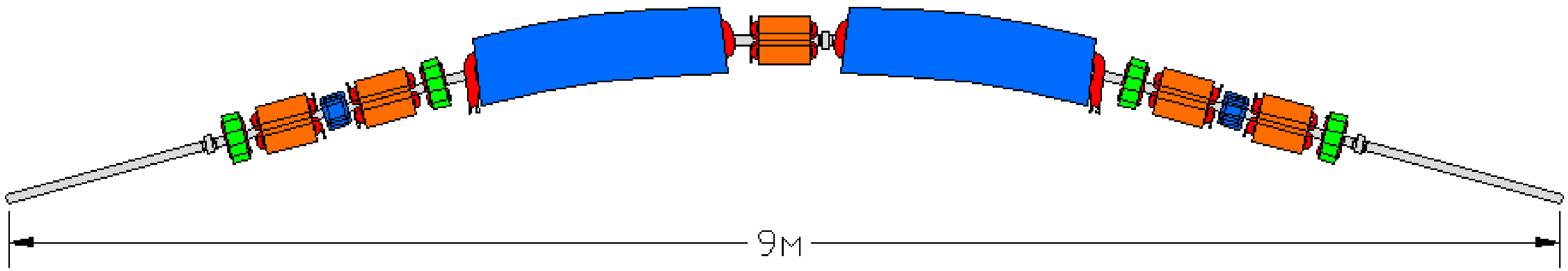
Transversal cross-section of shielding tunnel with SIBERIA-2 storage ring and Booster

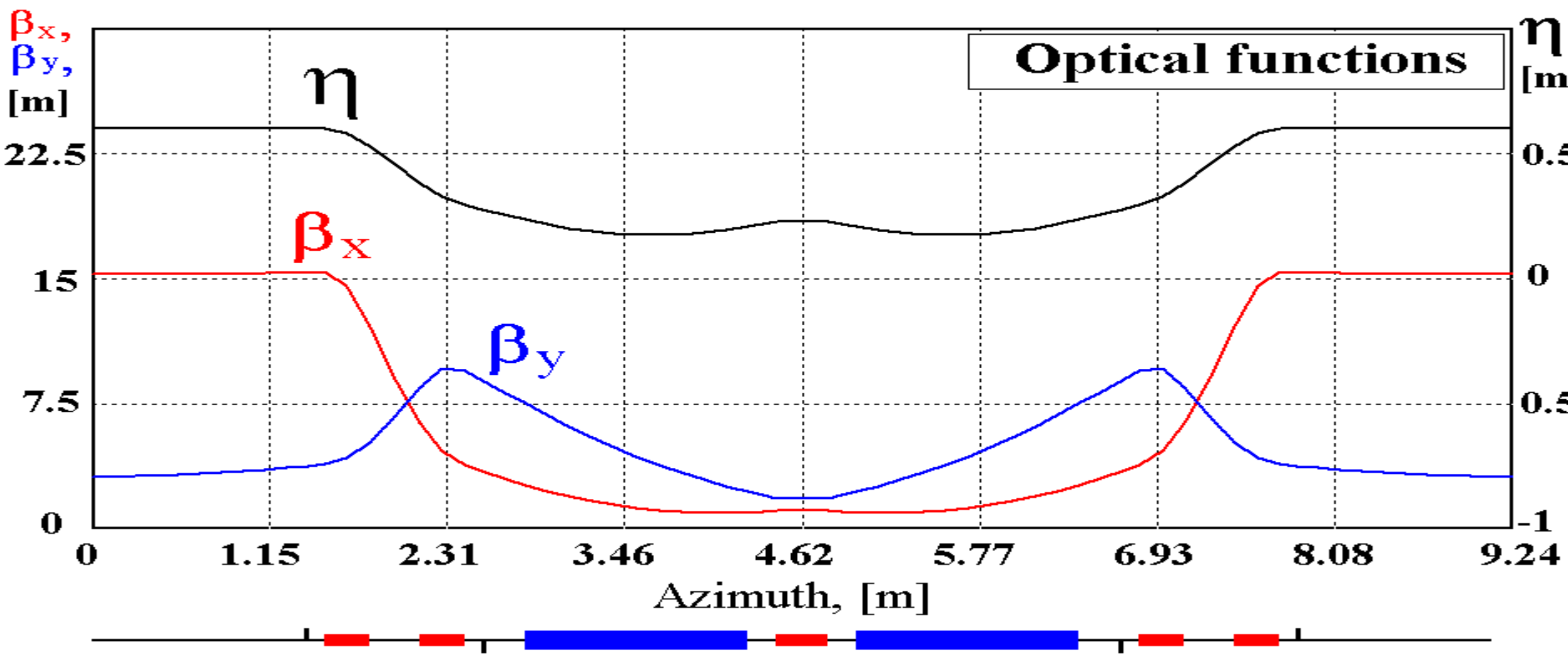


One superperiod of the booster

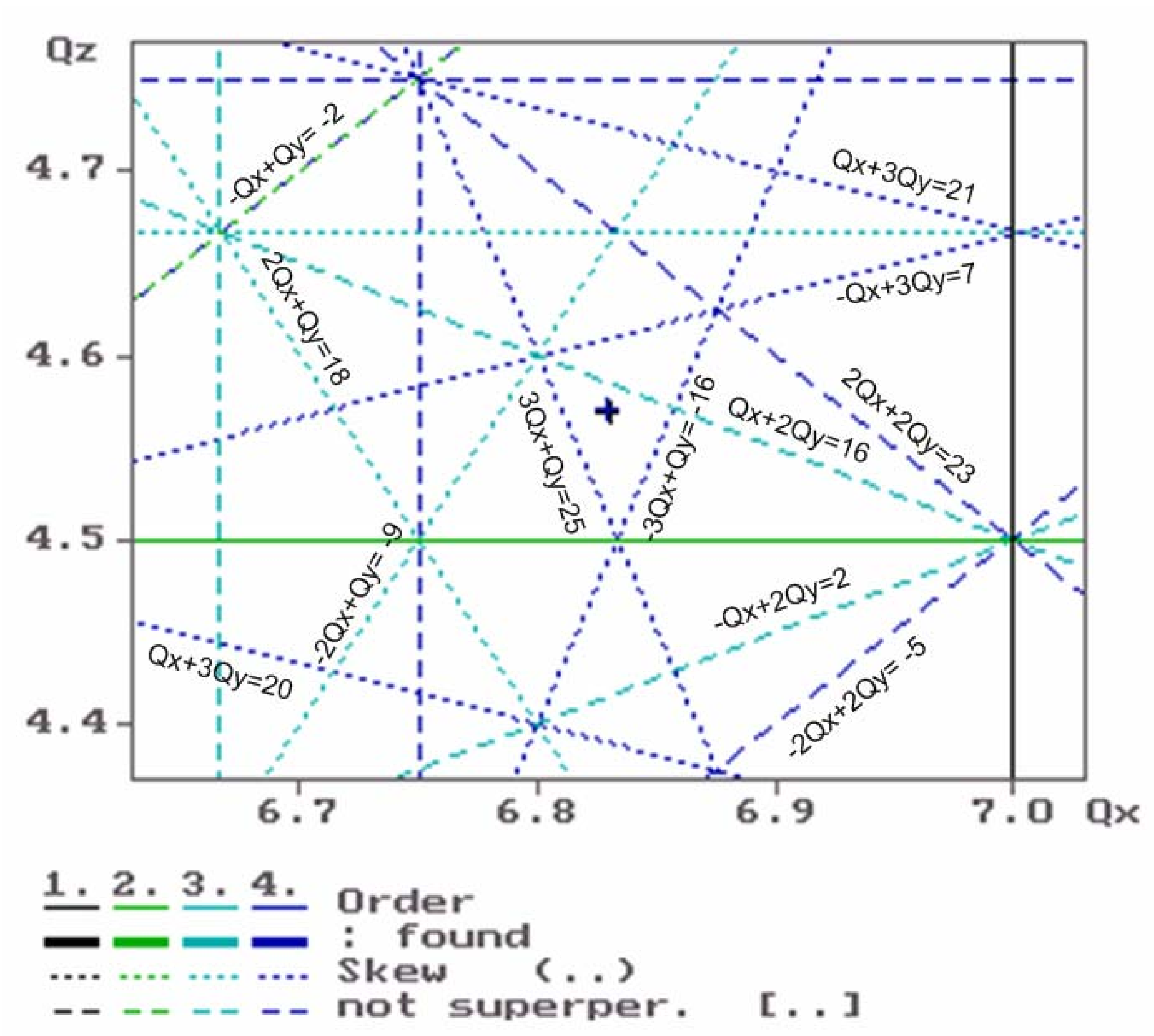


Optical functions of the booster





Tune diagram and working point



$Q_x = 6.83$; $Q_z = 4.57$

Main booster parameters

Beam energy, MeV	80 MeV	2500 MeV
Electron current, mA	10 mA	
Circumference	110.89 m	
Repetition rate	1 Hz	
Number of superperiods	12	
Betatron tunes Q_x / Q_y	6.83 / 4.57	
Revolution frequency	2.70 MHz	
RF harmonics	67	
RF frequency	181.13 MHz	
Momentum compaction	0.011	
Chromaticities ξ_x/ξ_y	- 13.3 / - 8.8	
Damping times: τ_x, τ_y, τ_s	94.4, 90.8, 44.6 s	3.1, 3.0, 1.5 ms
Energy spread	± 3.5 %	0.09 %
Energy loss per turn	0.65 eV	622 keV
Natural emittance	< 10^{-5} m-rad	51 nm-rad

Errors used in COD simulation

Error type	**σ**
Magnet displacement: $\Delta x, \Delta y, \Delta s$	0.2, 0.2, 0.2 mm
Magnet rotation angle	0.2 mrad
Dipole field error $\Delta B/B$	2×10^{-4}

Orbit distortions and corrector strength (1000 sets)

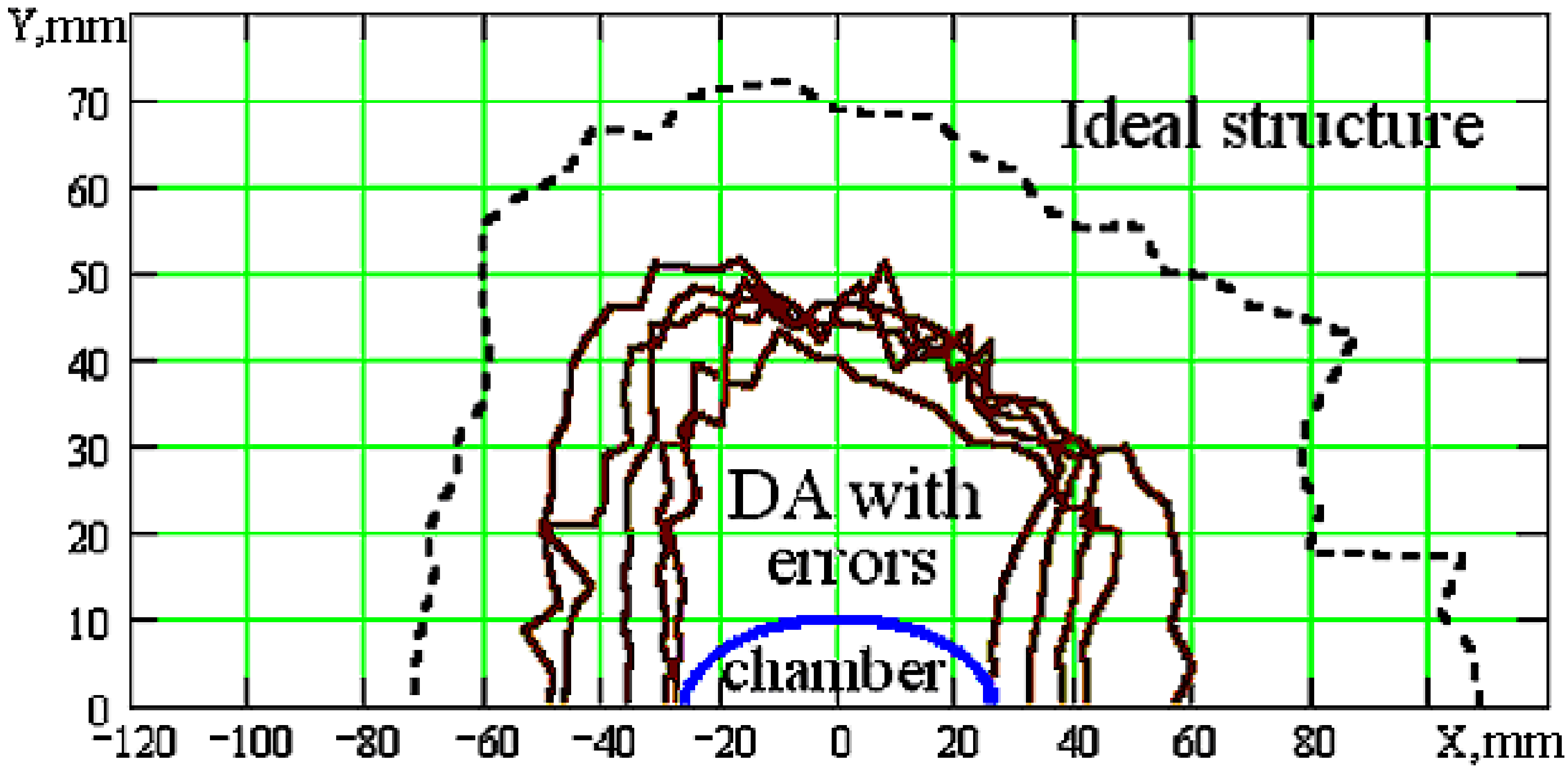
	$\langle x \rangle$	σ_x	$\langle y \rangle$	σ_y
Max. random COD, mm	12.6	5.8	6.6	1.9
Max. corrected COD, mm	0.38	0.06	0.09	0.01
Correctors strength, mrad	0.54	0.1	0.41	0.07

Electron beam size during injection into the synchrotron

$\Delta E/E = 0.07$ (from linac), $\eta_{booster} = 0.6$ m $\Rightarrow \Delta X_{inj} = 46$ mm

We have adopted for the aperture in all elements of the booster:
$Ax = \pm 25$ mm, $Ay = \pm 10$ mm

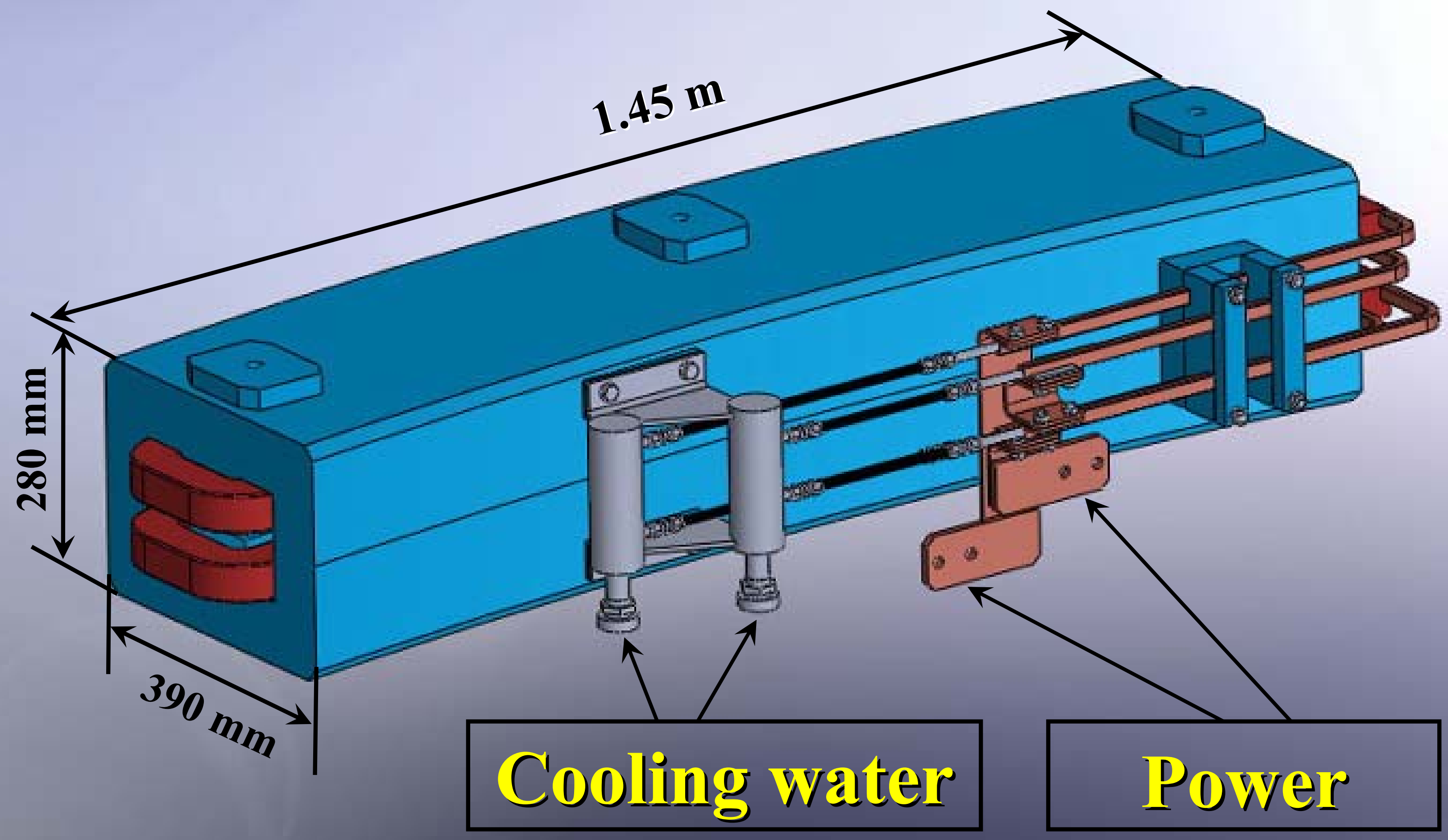
Dynamic aperture

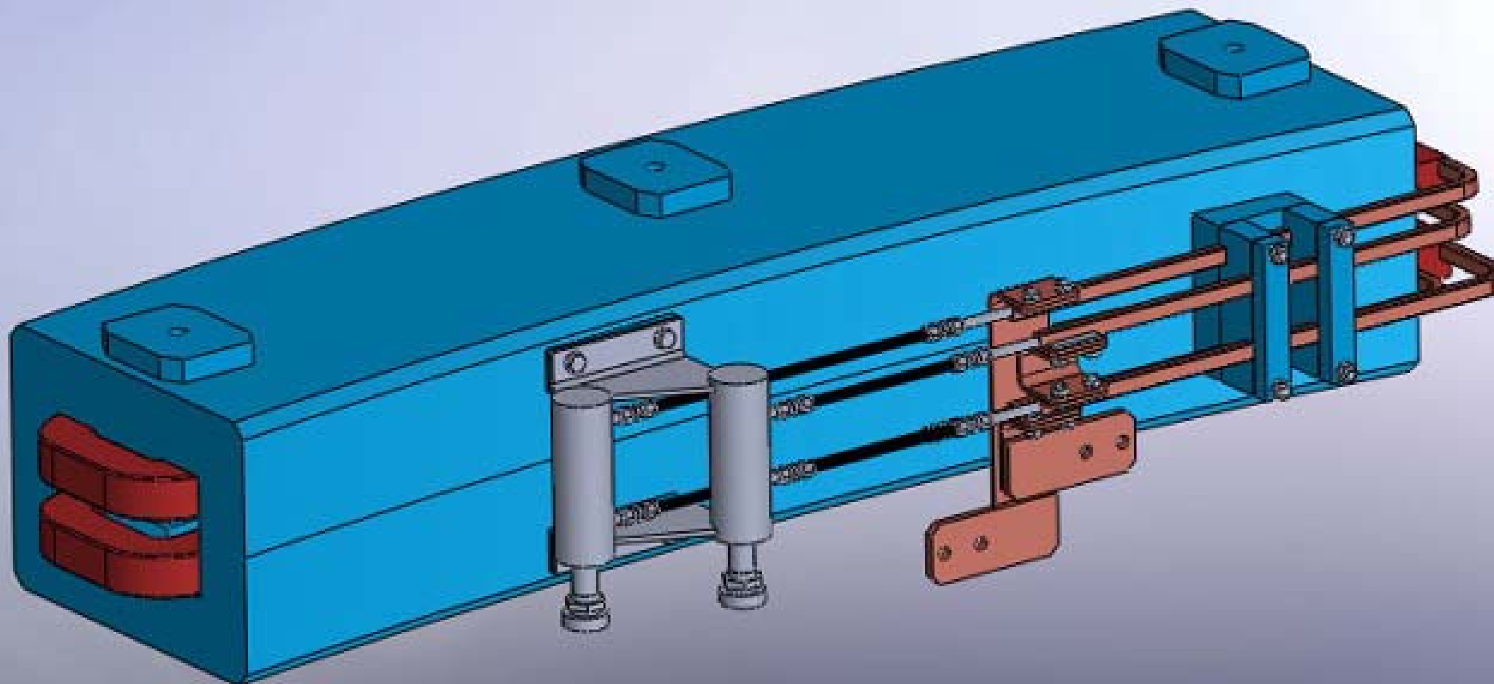


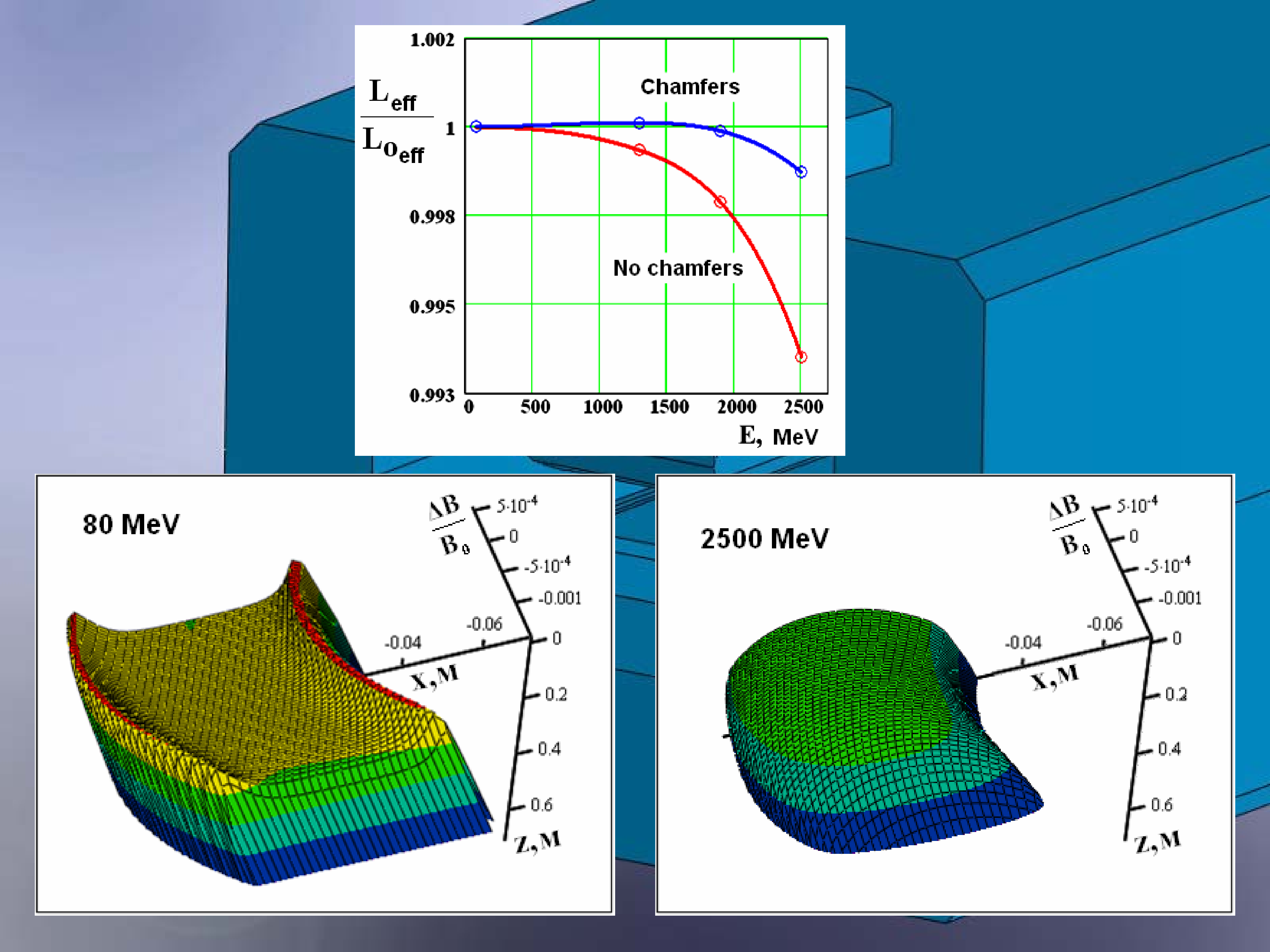
Magnetic elements

All booster magnets will be made laminated and glued. The lamination sheet thickness is 1 mm.

Dipole bending magnets are H-type with parallel edges.
All dipoles are connected in series.





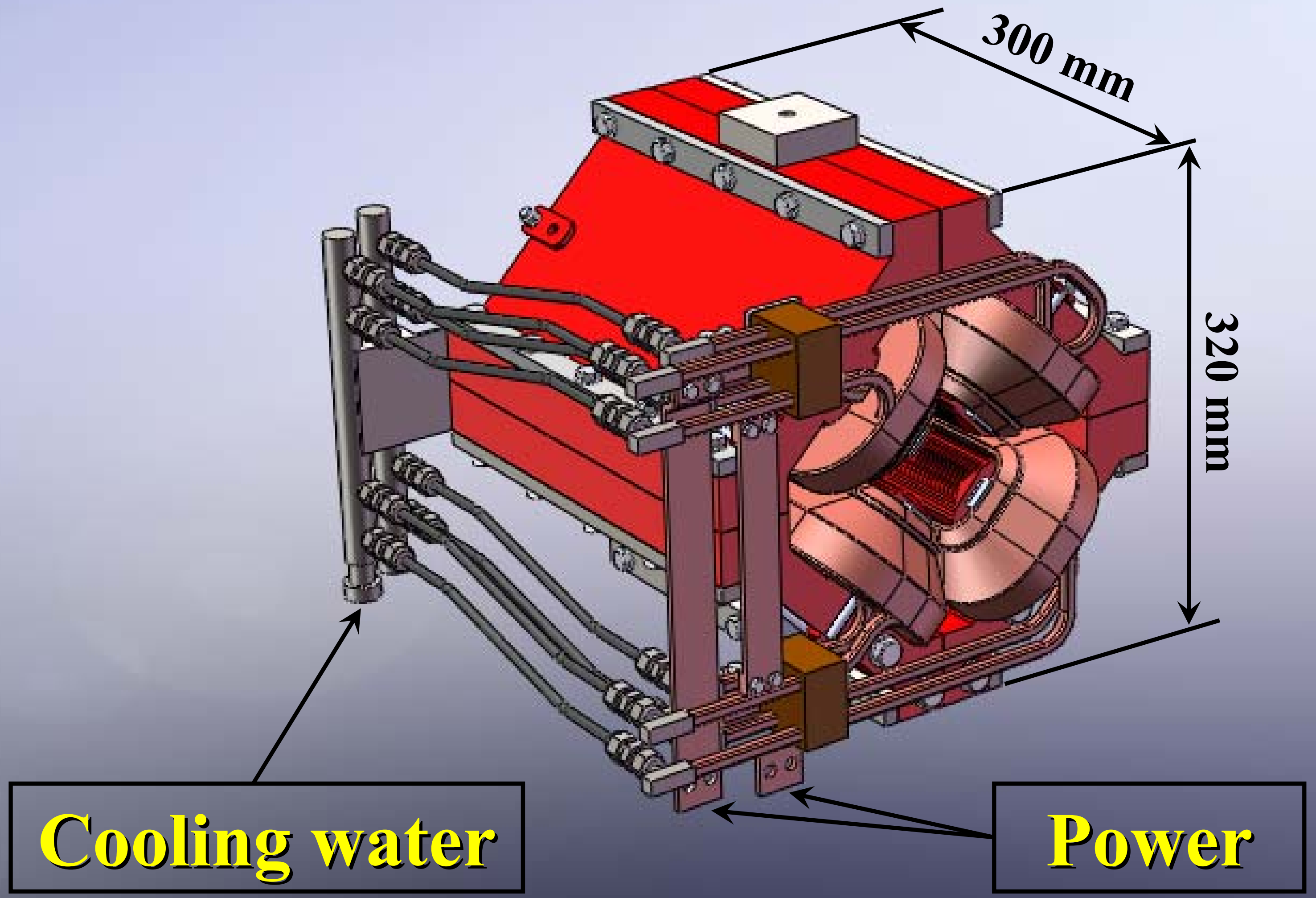


$\frac{L_{eff}}{Lo_{eff}}$
1.002
1
0.998
0.995
0.993
Chamfers
No chamfers
0
500
1000
1500
2000
2500
E, MeV
80 MeV
2500 MeV
$\frac{\Delta B}{B_0}$
$5\cdot10^{-4}$
0
$-5\cdot10^{-4}$
-0.001
-0.04
-0.06
X, M
0.2
0.4
0.6
Z, M

Main parameters of the dipole

Number of magnets	unit	27
Yoke mass	kg	~ 1000
Bending angle		15°
Bending radius	m	5.55
Maximum field	T	1.5
Gap	mm	24
Integral inhomogeneity $\int \Delta B / \int B$ (in 50×20 mm^2)		$\pm 2.5 \times 10^{-4}$
Terns per coil		8
Maximum current	kA	1.82
Maximum power	kW	19.5
Mean power	kW	7.3
Max./min. voltage on all 27 magnets	V	547/-254

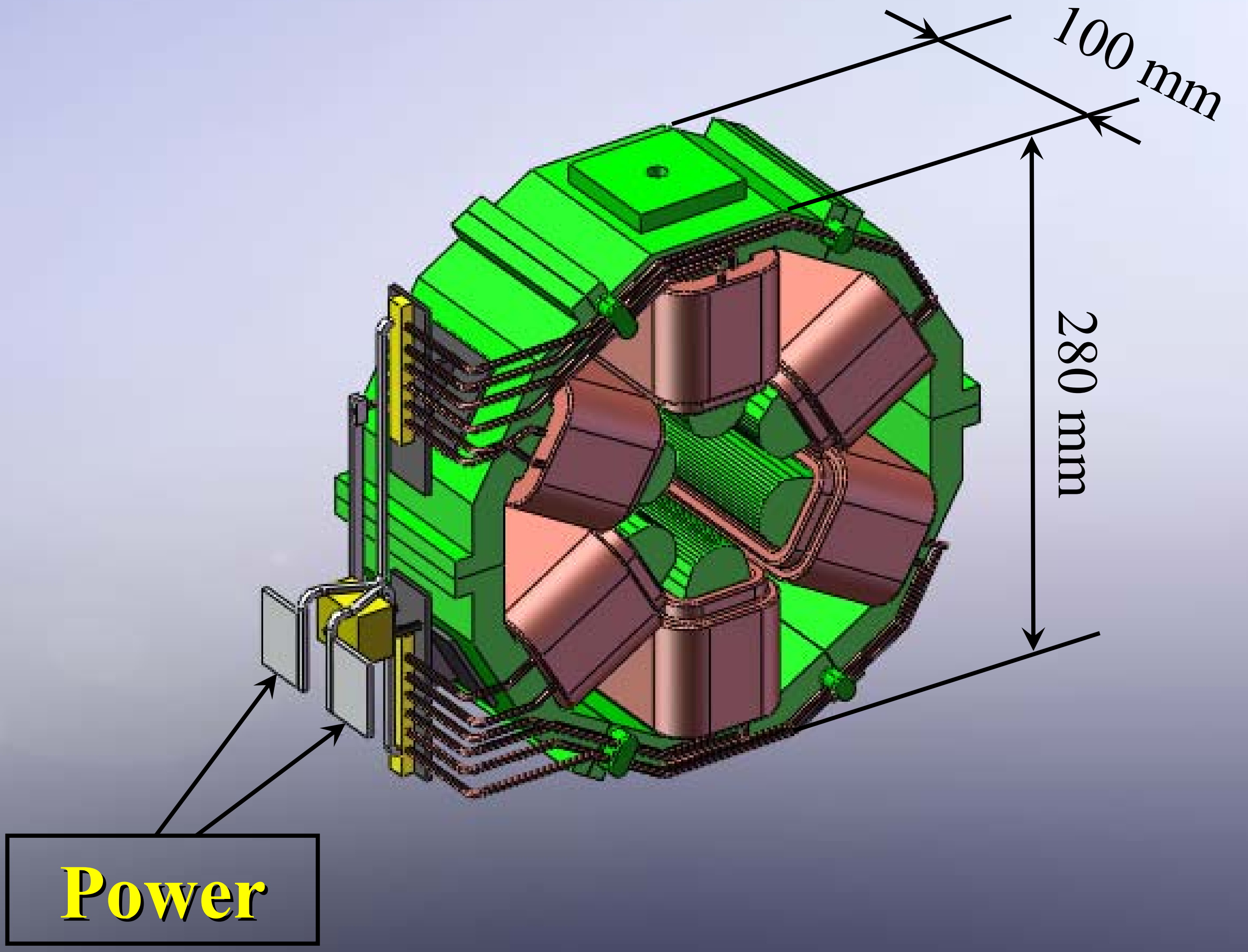
Quadrupole magnets, 3 families



Main quadrupole parameters

Lens family	unit	**QF1**	**QD**	**QF2**
Number of magnets		24	24	12
Bore diameter	mm	50		
Yoke mass	kg	40		
Terns per coil		18		
Maximum gradient	T/m	22.5	26.4	24.6
Maximum current	A	313	370	345
Maximum power	kW	2.5	3.47	3
Mean power	kW	0.94	1.32	1.14
Maximum voltage on all magnets	V	235	278	131
Gradient inhomogeneity $\Delta G/G$ inside bore diameter		$5 \cdot 10^{-4}$		

Sextupole magnets, 2 families



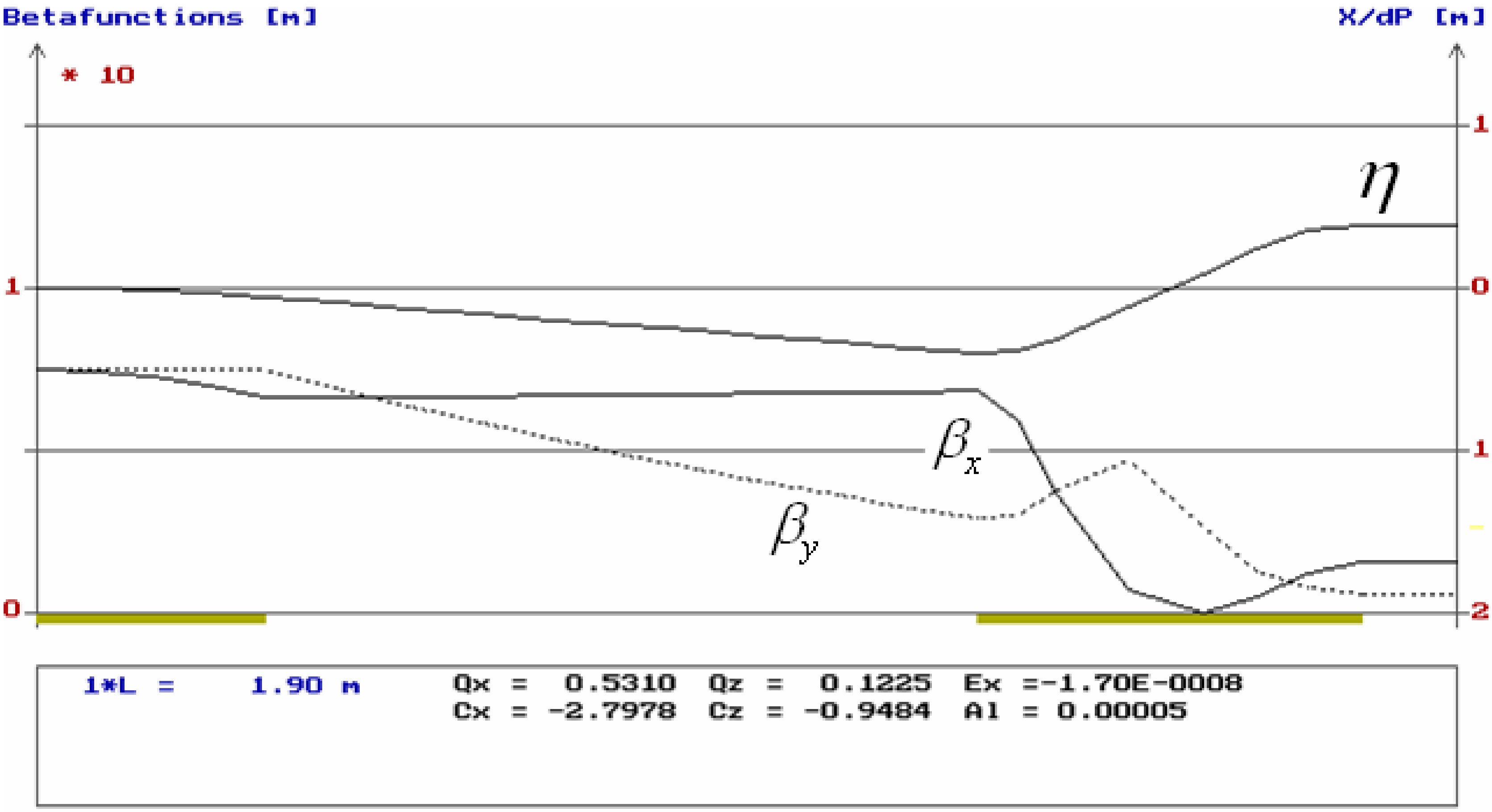
Main sextupole parameters

Magnet type	unit	SD	SF
Yoke mass	kg	14	
Number of magnets		24	24
Bore diameter	mm	60	60
Terns per coil		86	
Maximum current	A	11.2	4.2
Maximum strength	T/m^2	270	-100
Maximum power	W	58	8
Mean power	W	22	3
Sextupole field inhomogeneity $\Delta B/B$		$5\cdot 10^{-4}$	$5\cdot 10^{-4}$

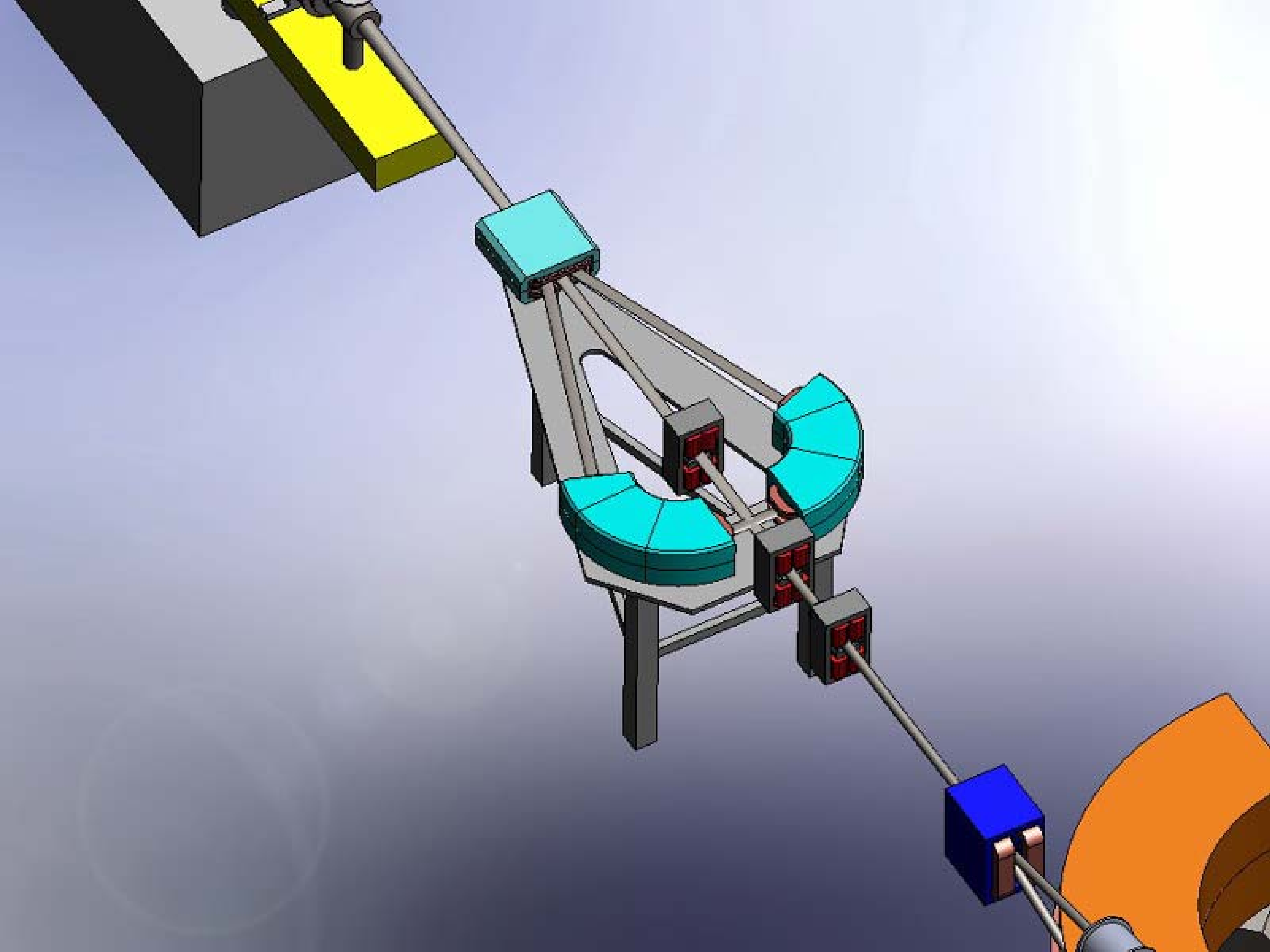
Preinjector modernization

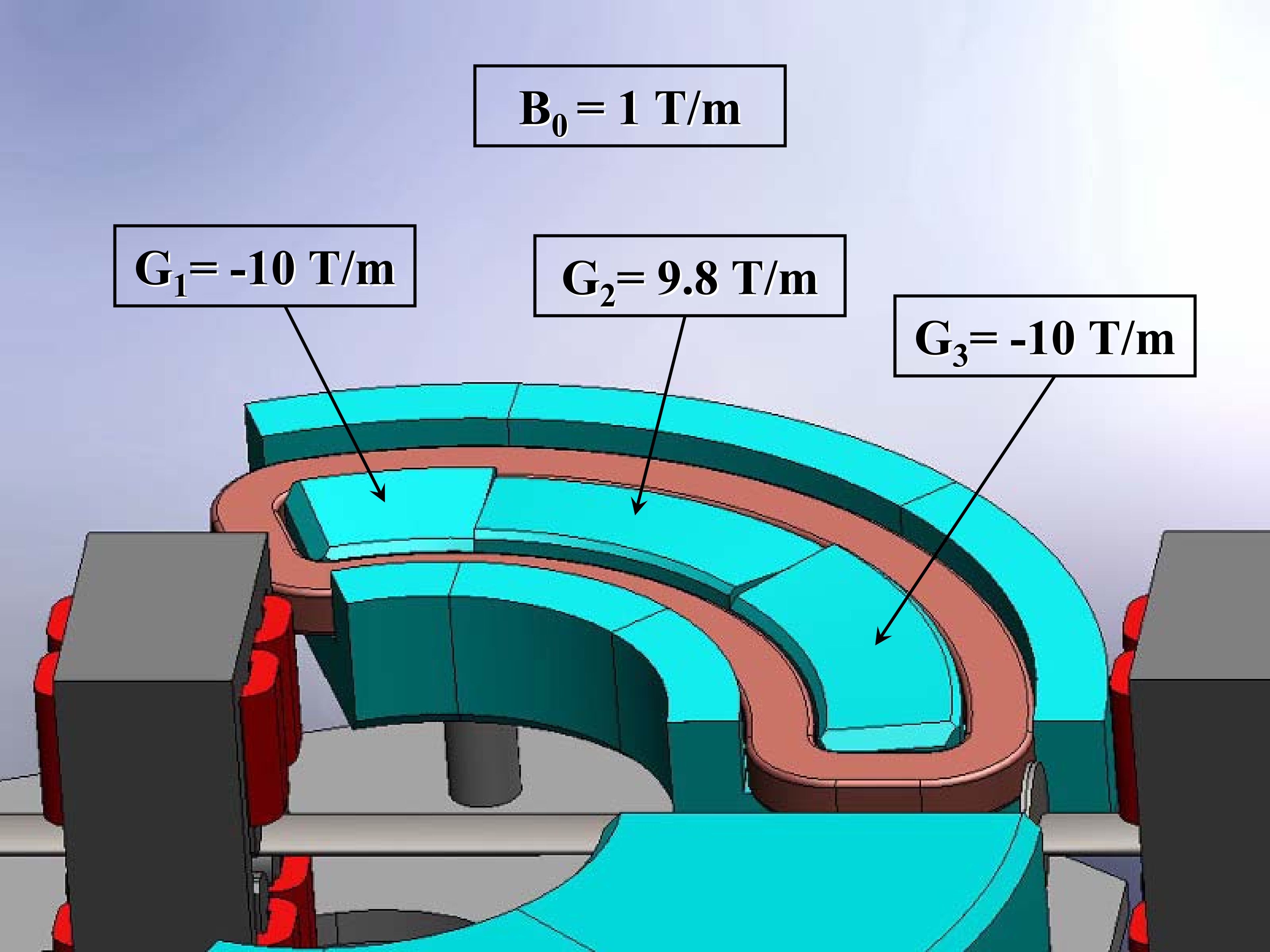
Modernization project provides for a possibility to increase injection energy from linac to BS from 80 MeV to 160 MeV by electron bunches transition twice through linac structure

Magnetic mirror optical functions

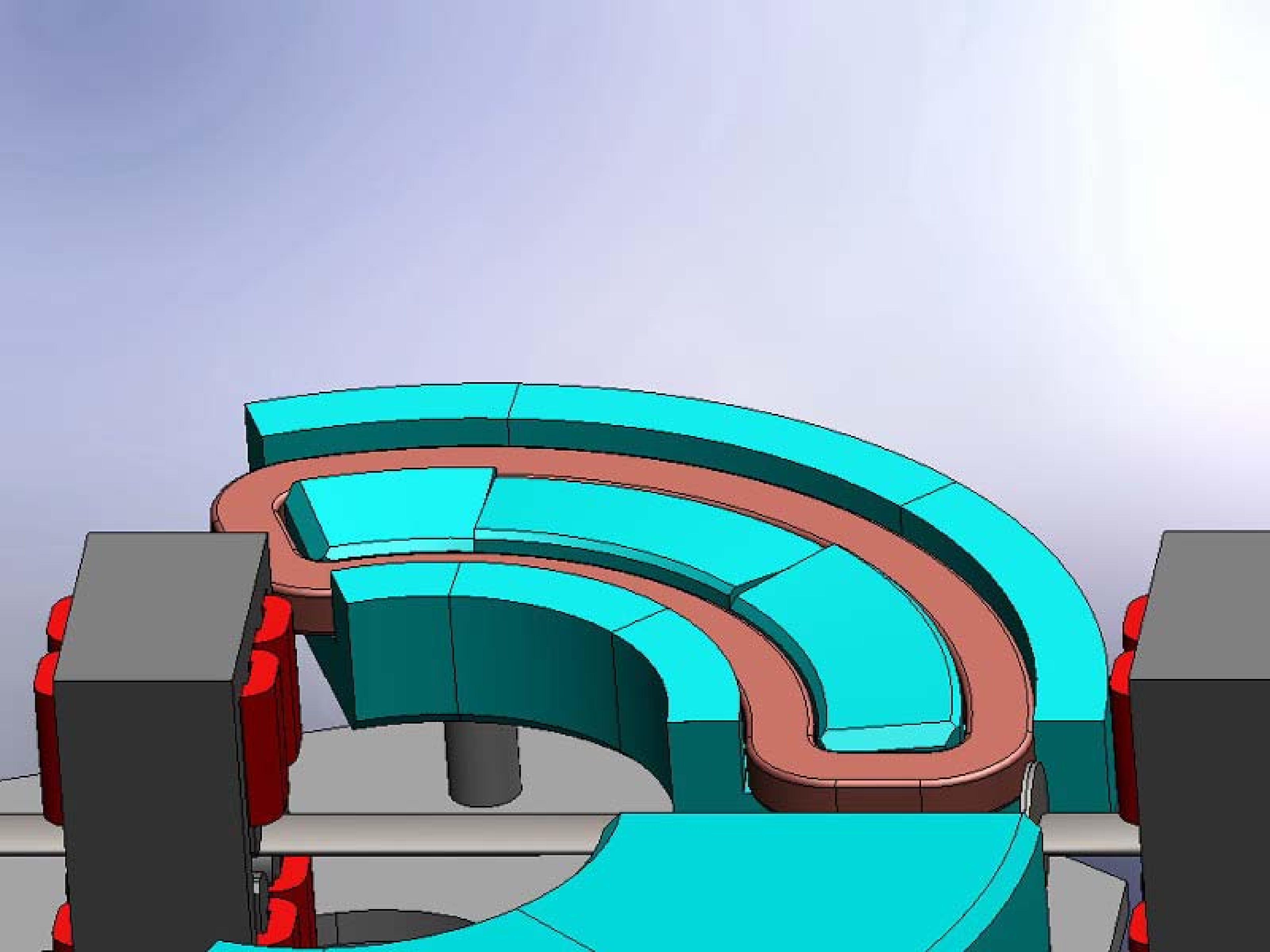


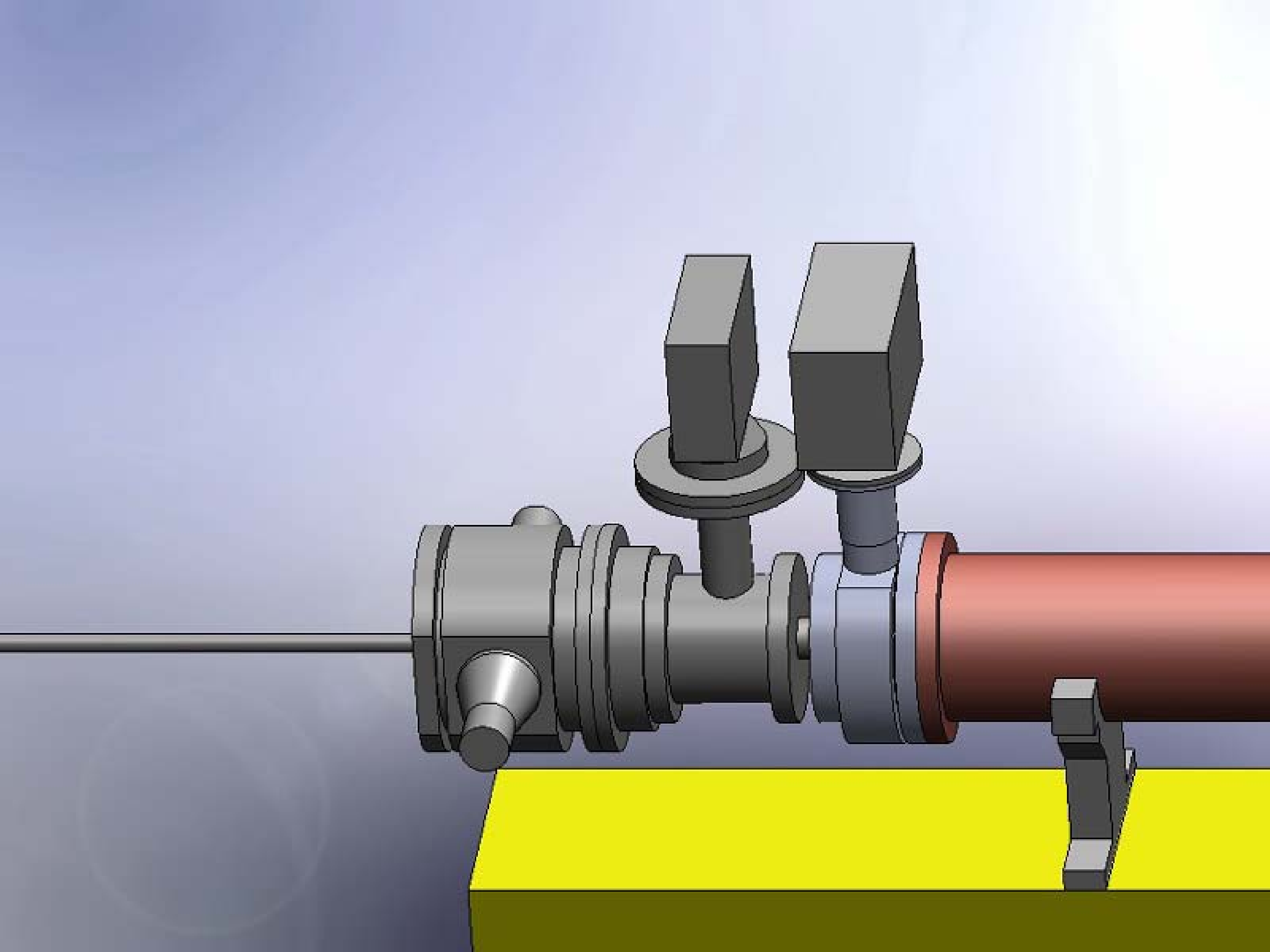
$$\Delta L(\Delta E) = 0, \eta = 0$$

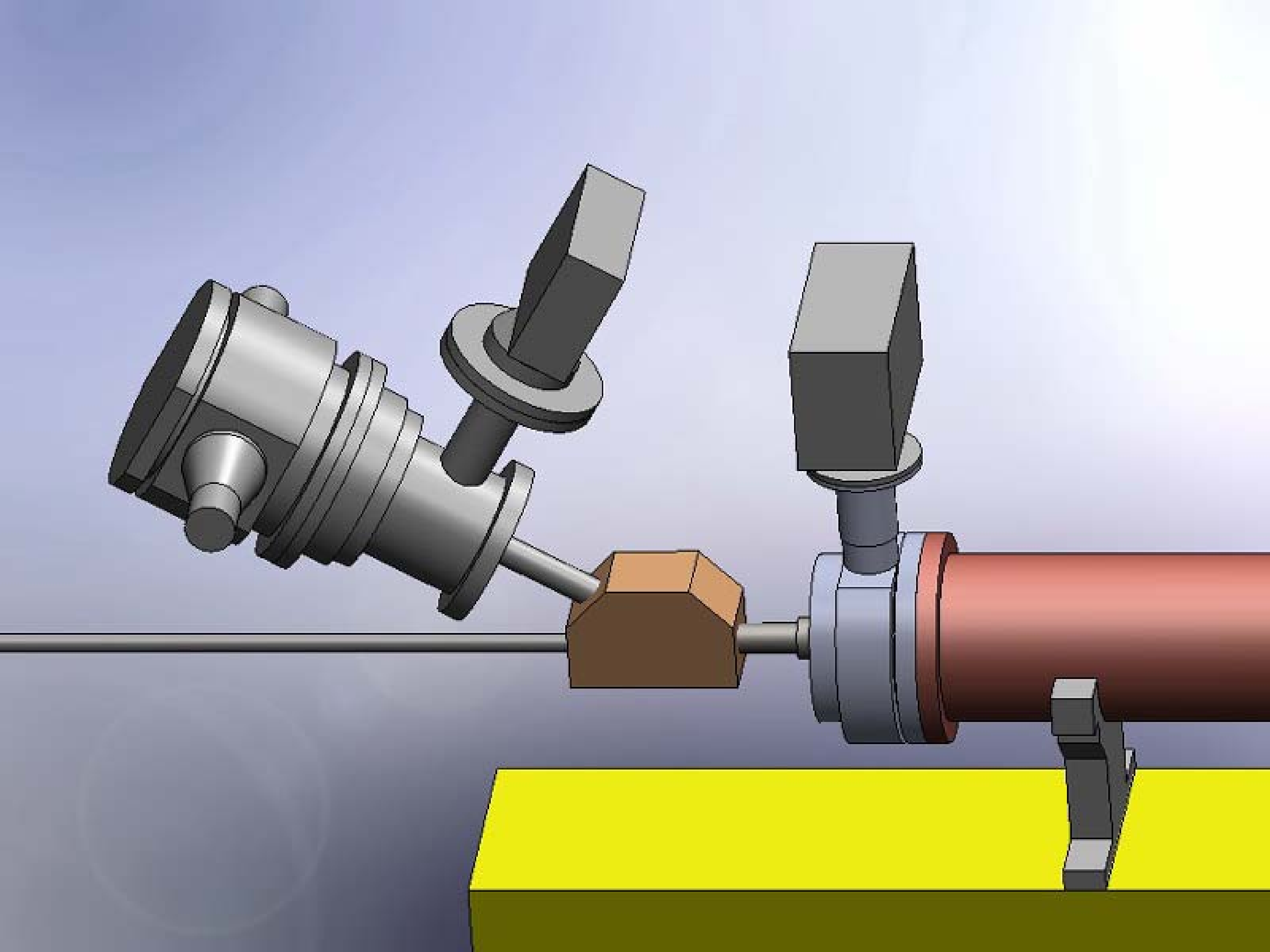


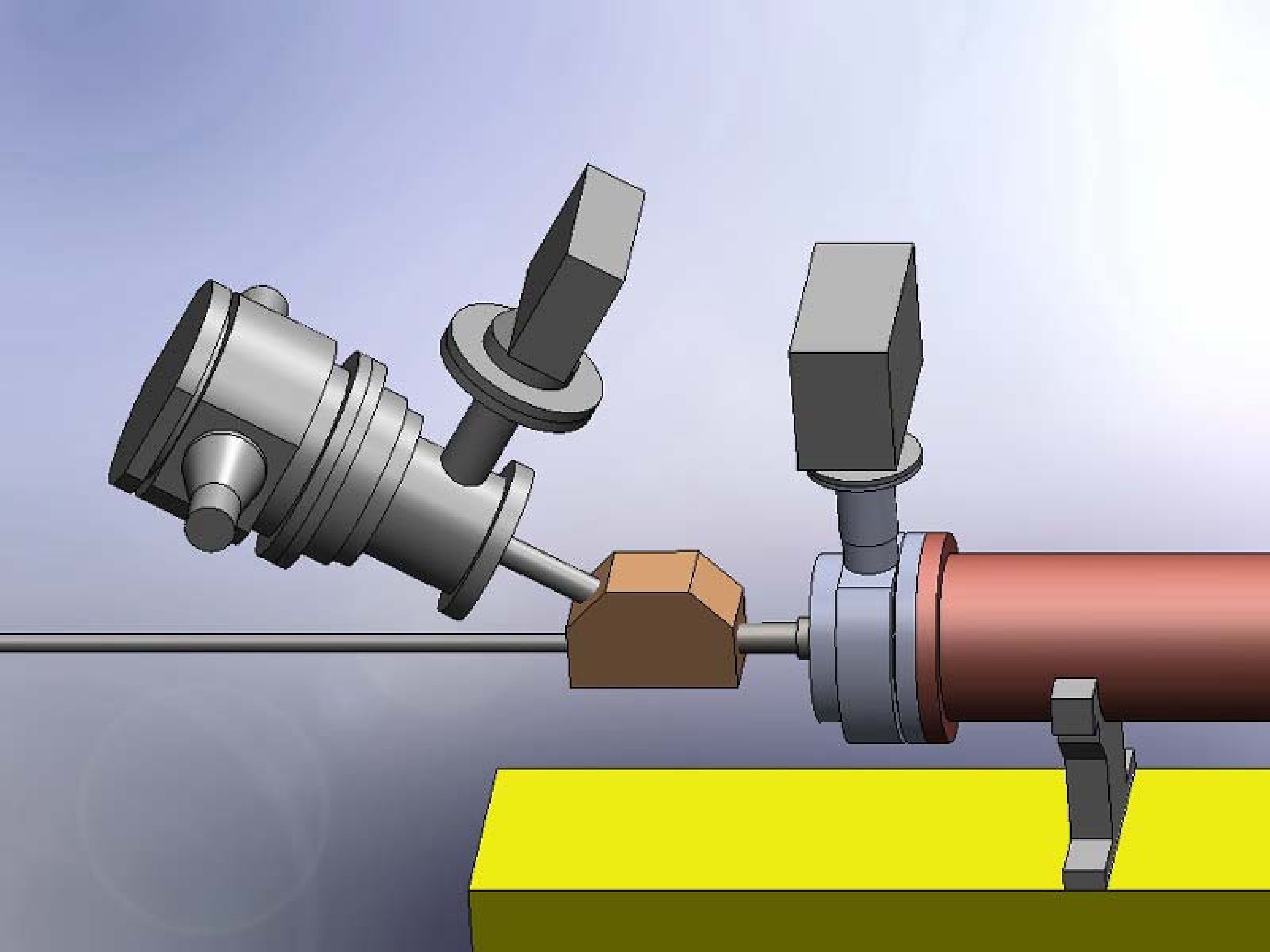


$B_0 = 1$ T/m
$G_1 = -10$ T/m
$G_2 = 9.8$ T/m
$G_3 = -10$ T/m

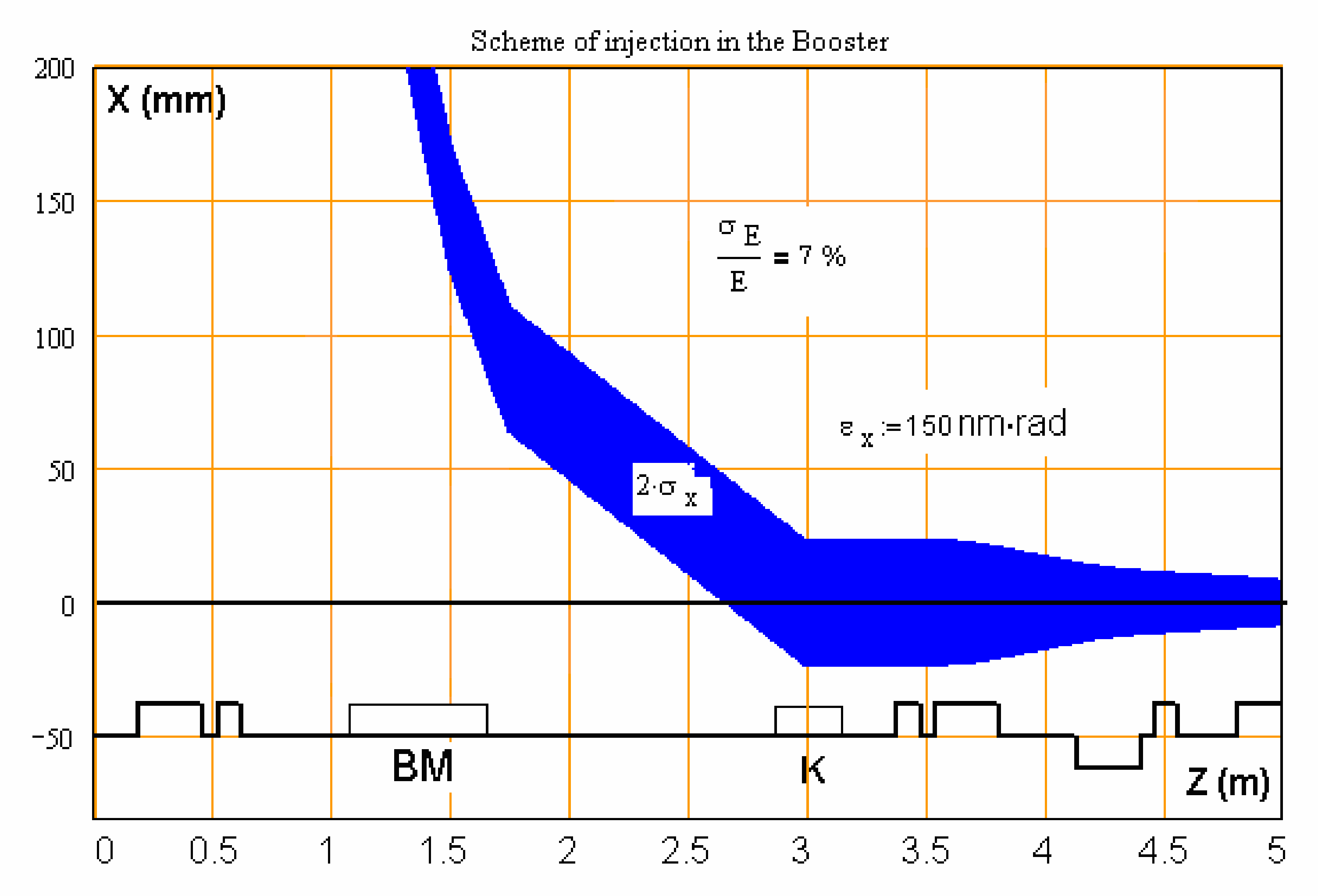


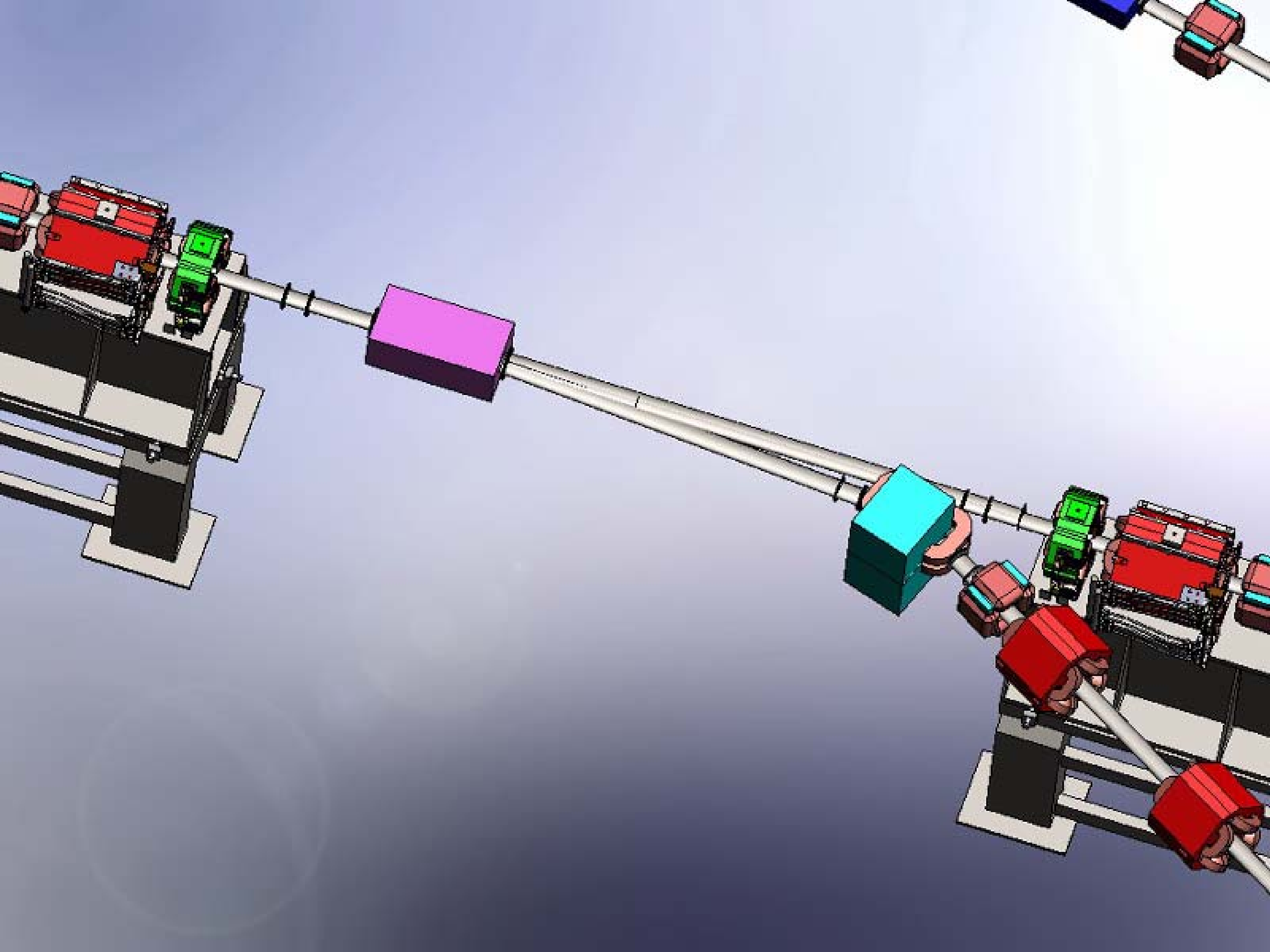




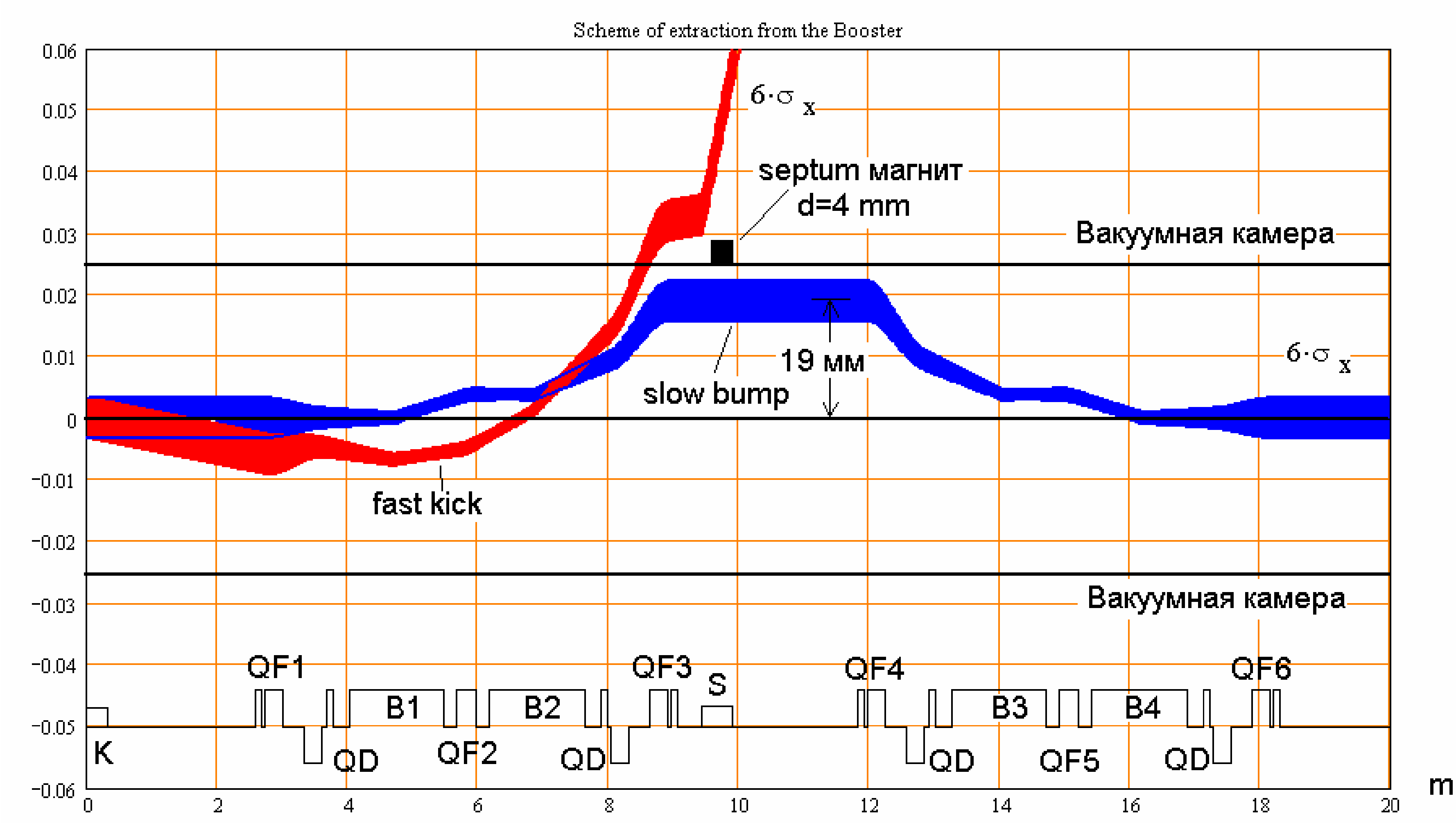


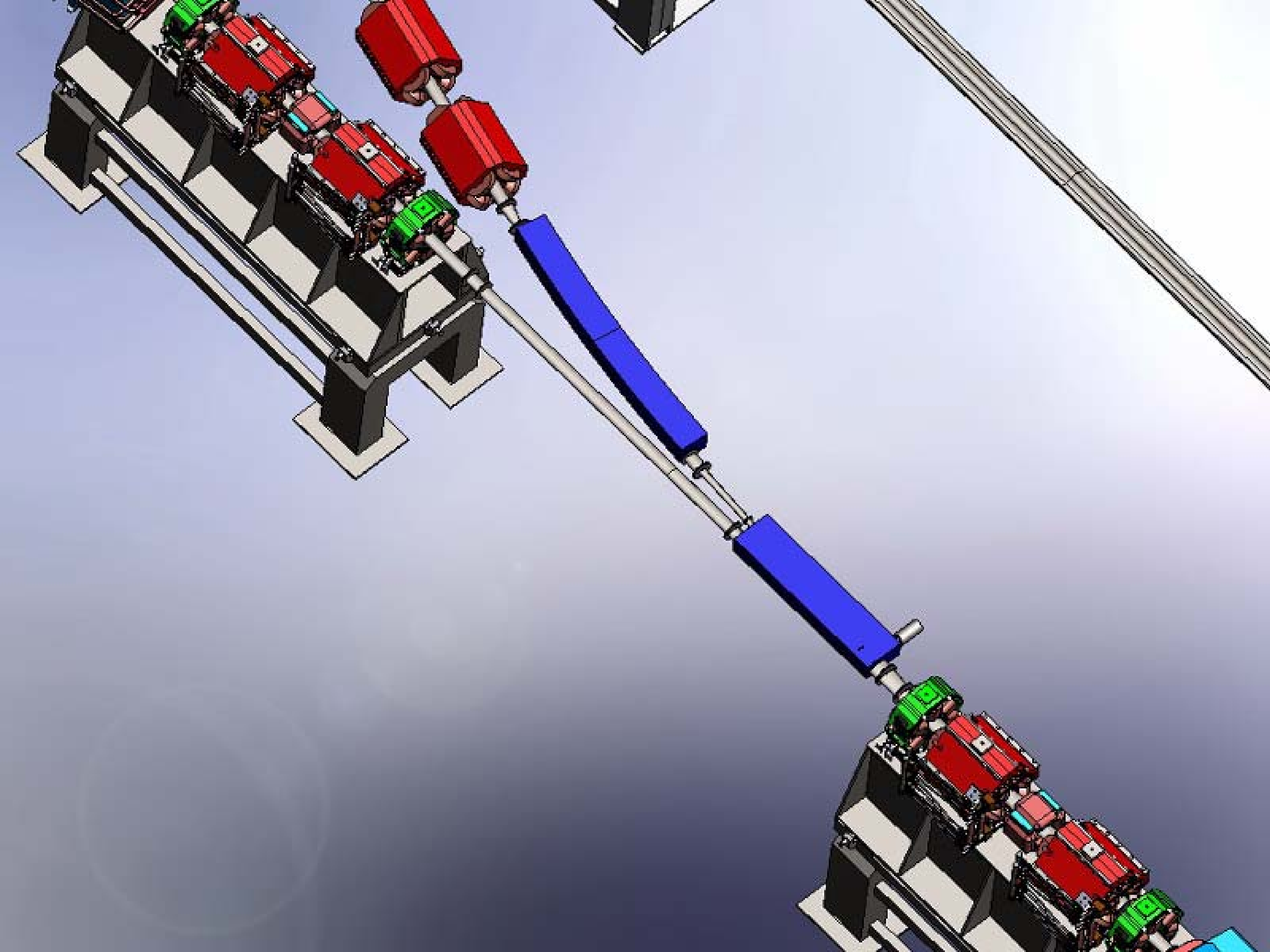
Scheme of injection in the Booster



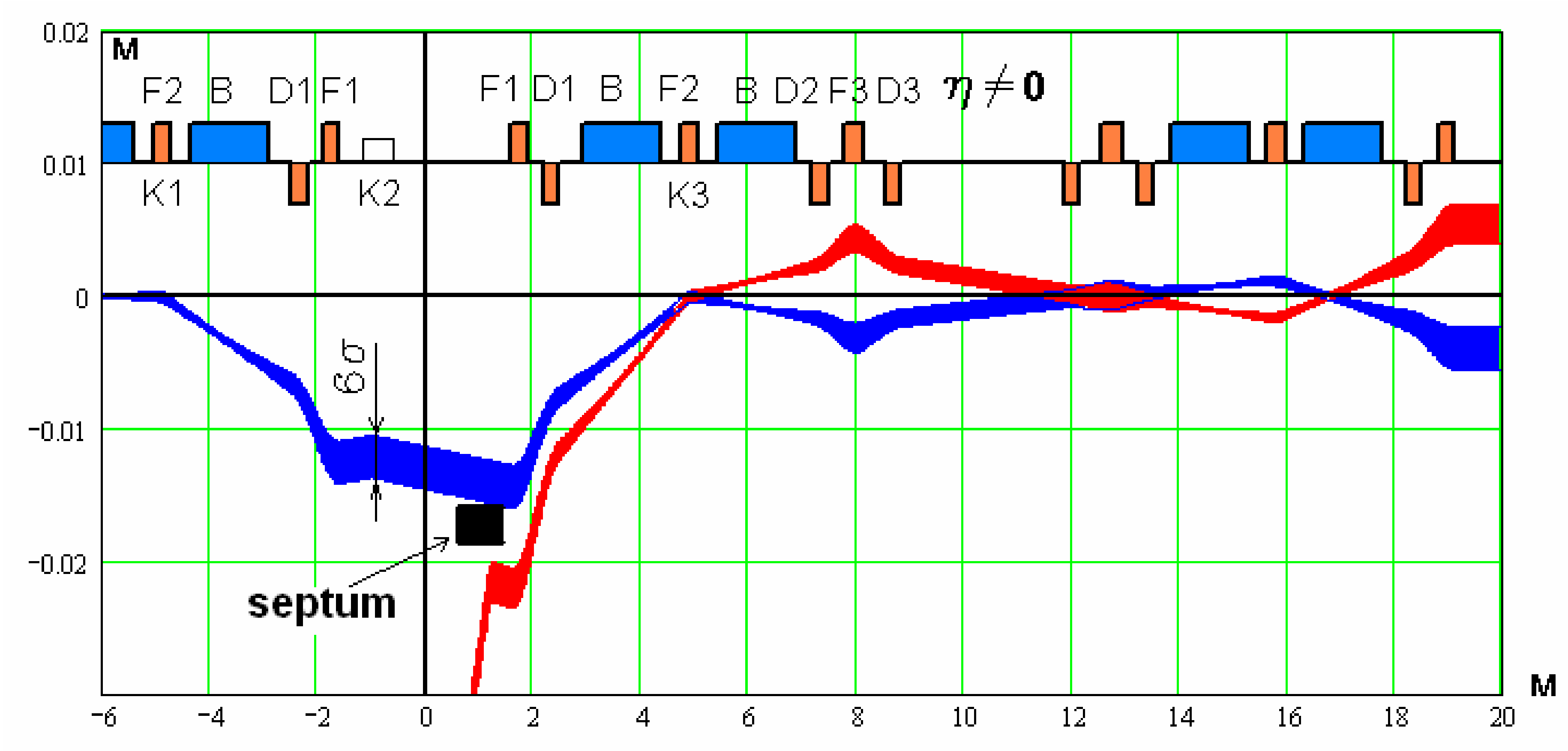


Scheme of extraction from the Booster





Scheme of injection into Siberia-2



18 nm·rad mode

Conclusions

1) Reliability of Siberia-2 work at 2.5 GeV.

a) The increase of radiation decrements in 170 times results in the strongest suppression collective instabilities especially during an injection;

b) The magnetic and RF systems are not changed, because the energy is fixed (stable betatron and synchrotron tunes in a time as a result).

2) An optimality of injection, an opportunity of accumulation at small apertures.

The booster electron beam has small phase volumes, so there is an opportunity of accumulation in Siberia-2 at work with small DA (in small emittances structures).

3) Improvement of consumer parameters of SR beams.

a) A stability of photon beams (temperature stability of the magnetic elements and an environment);

b) A periodical injection for reaching an "infinite" life time, the experiments at constant intensity of SR;

Thank you for attention