MACHINE LAYOUT COORDINATION			
Project			
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Title **Bunch Compressor Chicane Specification**			

1 Basic Lay Out

The compression scenario of the XFEL incorporates three bunch compressor magnet chicanes. They consist basically of four dipole magnets (for a sketch see Fig. 1) with focusing elements for optics adjustment grouped around them. The center straight section hosts beam diagnostic elements, namely an 'energy' BPM and an OTR station. Synchrotron radiation ports are foreseen to observe the incoherent synchrotron radiation that is produced in the 3rd bending magnet. Small quadrupole magnets (yet to be designed) have to be placed in the sections between the 1st and 2nd resp. 3rd and 4th bend.

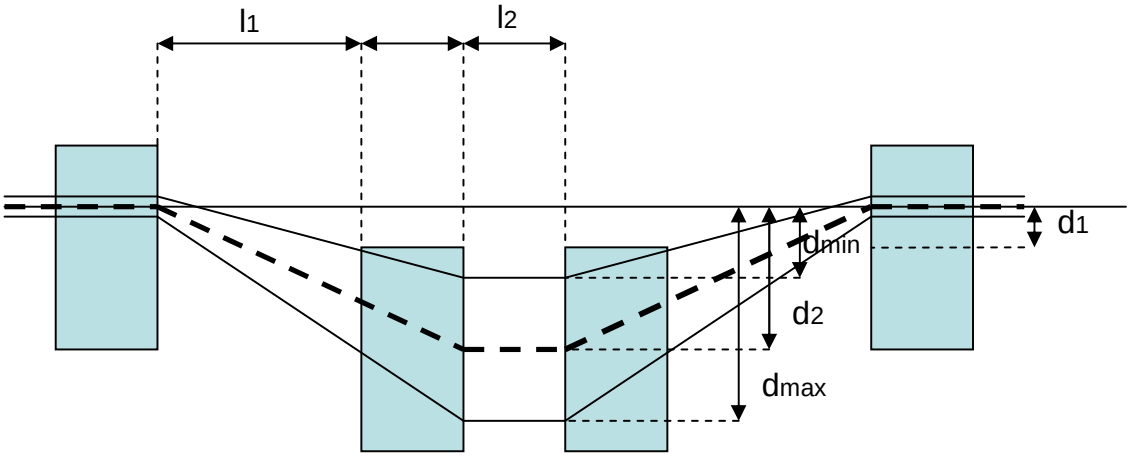

Figure 1: Sketch of XFEL BC chicane layout. The blue boxes are the dipole magnets. The deflection direction is vertical.

The 'longitudinal dispersion' R56, which determines the change in bunch length for a given rf chirp, must be variable over a broad range to accommodate different operational modes (different bunch length or peak currents) as well as being able to optimize machine stability (see table 1).

Chicane	Minimum R56 [mm]	Maximum R56 [mm]
BC0	0, 30	90
BC1	20	80
BC2	10	60

Table 1: R56 requirements for XFEL magnet compressor chicanes

The R56 value depends mostly on the drift length between outer and inner bending magnets (i.e., between first and second bending magnet) and the deflection angle, which absolute value is the same for all bending magnets. Simulation calculations have been done to optimize the geometry for minimal emittance growth (M. Dohlus).
Since a scheme is employed which at least partly cancels particle kicks in the upstream chicane with those in the downstream, the vacuum chamber has to have an inner height of 40 mm to avoid disturbance of this compensation scheme by shielding effects.
Fixed and movable chambers have been studied. Fixed chambers will be designed, since the cost advantage of the movable system is not big enough to justify the operational risk and the increase of projected emittance.

2 Beam Stay Clear and Magnet Width

The beam stay clear and thus vacuum chamber width and the magnetic good field region is extracted from the required working points. Table 2 gives the relevant parameters, where o_{min}, o_{max} is the smallest/largest beam center offset for the required R56 range, σ_{max} is the maximum beam width given by the dispersion and correlated energy spread (the later estimated for a 2-5-10 compression of an initial bunch length of 2 mm), $\Delta_{x,RF}$ is the additional space that is required to make a 15 deg phase change around the chosen working point and d_{min}, d_{max} is the thus derived closest outer vacuum chamber wall.

	R56 range [mm]	Bending Angle[1] [deg]	o_{min} [mm]	o_{max} [mm]	σ_{max} [mm]	$\Delta_{x,RF}$ [mm]	d_{min}[2] [mm]	d_{max} [mm]	Required Width [mm]
BC0	0, 30-90	0, 5.67 - 9.82	0, 168	294	3.4-3.0	5.7-10	141	322	330, 181
BC1	20-80	1.93 – 3.86	302	607	1.4-0.7	8-17	285	620	335
BC2	10-60	1.36– 3.34	214	525	0.4-0.2	5 – 13	195	546	351

Table 2: Summary of geometric constraints

To accommodate all possibilities the chamber width has been set to 400 mm. The magnet field width is the same.

[1] $R_{56} \approx -2\theta_0^2 (L_{12})$ with L_{12} the distance between 1st and 2nd dipole of chicane, and θ_0 the angle of the 1st dipole. Chicane offset is $O = L_{12} \tan\theta_0$.

[2] The minimum beam deviation is o_{min} - 6* σ_{max} – $\Delta_{x,RF}$, the maximum is o_{max}+6* σ_{max} + $\Delta_{x,RF}$

3 Chicane Layout

The following table summarizes the chicane layout parameters

	R56 range [mm]	Bending Angle [deg]	d_{min} [mm]	d_{max} [mm]	Bend offset d_1 [mm]	Bend offset d_2 [mm]	L_1 [mm]	L_2 [mm]
BC0	0, 30-90	0, 5.67 - 9.82	-20	380	100	200	1	1.5
BC1	20-80	1.93 – 3.86	250	650	100	450	8.5	1.5
BC2	10-60	1.36– 3.34	175	575	100	375	8.5	1.5

Table 3: R56 requirements, bending angle, chicane offset and required inner vacuum chamber width for XFEL magnet compressor chicanes

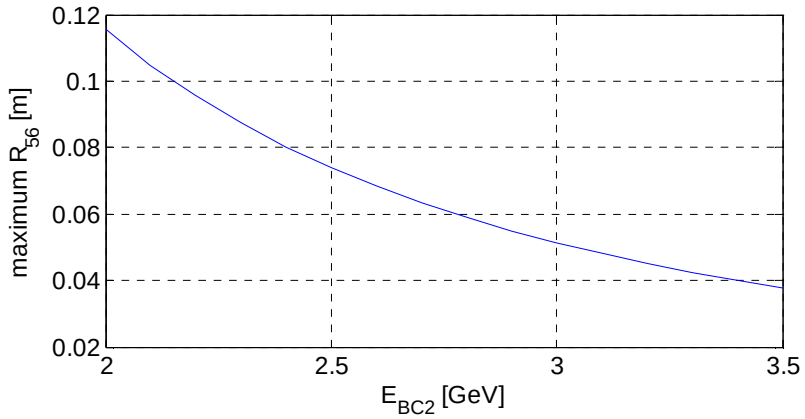

Figure 2: Maximum R56 of the BC1/BC2 chicane as limited by the maximum bend magnet field versus energy

The dipole magnets for the bunch compressor require excellent field quality and a small roll angle. A proposal from the Efremov Institute exists which undertakes to reach the high accuracy of the magnetic field with an extensive shimming procedure.
The dipole field requirements are summarized in Table 4.

	R56 range [mm]	Bending Angle [deg]	B_{min} [T]	B_{max} [T]	Good field region
BC0 (130 MeV)	0, 30-90	0, 5.67 - 9.82	0, 0.08	0.149	
BC1 (700 MeV)	20-80	1.93 – 3.86	0.16	0.31	
BC2 (2.4 GeV)	10-60	1.36– 3.34	0.38	0.93	

Table 4: Field Requirements for BC dipole magnets

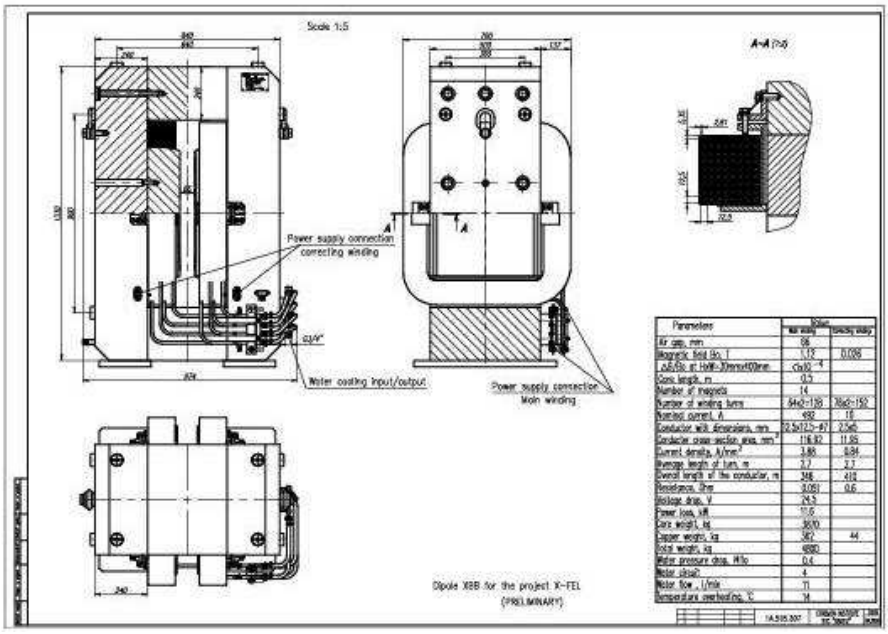

Figure 3: Technical drawing of the BC dipole magnet

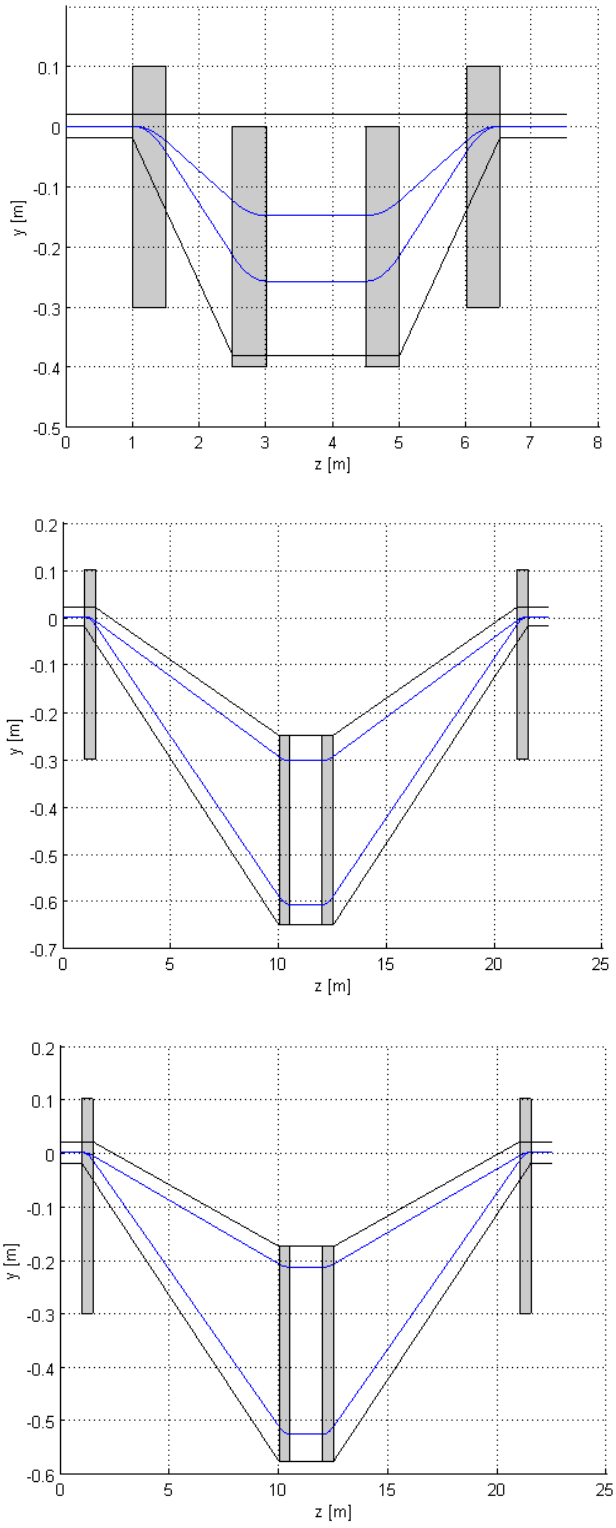

Figure 4: Layout of the BC-0, BC-1, BC-2 chicanes. Grey shaded boxes are dipole magnets, blue lines represent the trajectories for smallest/largest R56. Black lines show the respective vacuum chambers.

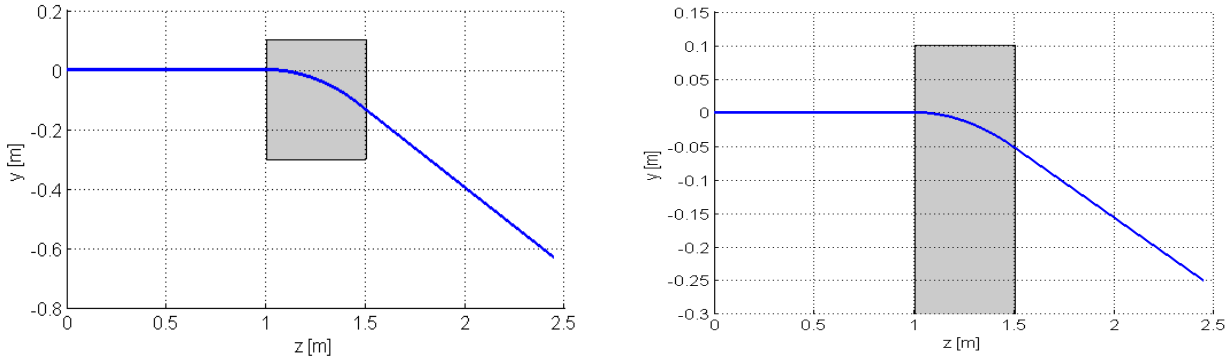

Figure 5: For reference the trajectories in the dipole magnets as used in the injector dump (left) and the BC1 dump (right).

4 Change History

Version	Date	Author	Changes
2.0	12.03.2010	W. Decking	Created
2.1	29.03.2010	W. Decking	Changed L1 of BC0 to 1.5 m
2.2	04.06.2010	W. Decking	Changed BC2 max R56 specification at 2 GeV Final R56 requirements
2.3	15.07.2011	W. Decking	Changed R56 requirements