Insertion Devices at the CLS

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Installed Insertion Devices – Effect on Electron Beam and Corrective Measures

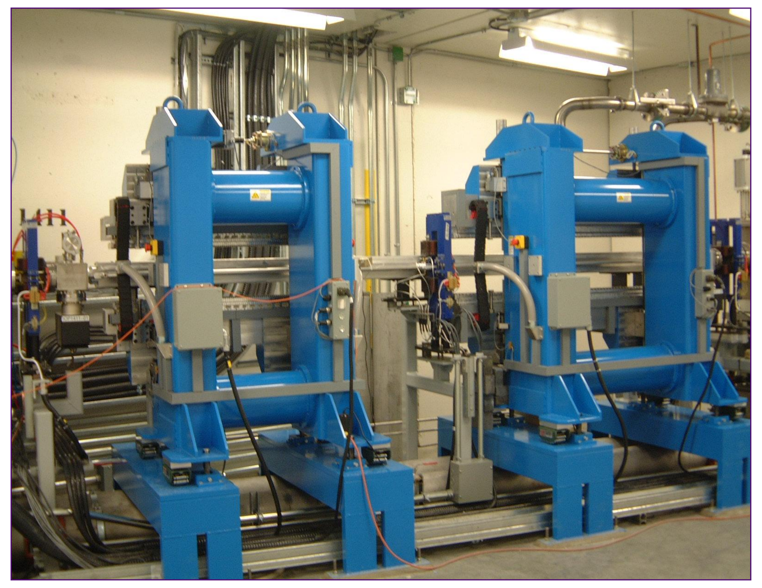
Phase I and II beam lines included seven insertions devices of the types described below. Plans for Phase III are under development and may include up to six more IDs.

Ideally, the electron beam should exit an ID with the same angle, offset and profile as it had upon entering it. Simple air coils mounted on the magnetic girders or the undulator support structure can be used to correct the first (angular kick) and second (spatial offset) field integrals as well as normal and skew quadrupole components that are generated by the ID as the gap and/or polarization are changed. Feed-forward tables for the 1st and 2nd integrals are generated based on minimizing perturbations to the electrons beam position around the entire ring. Tables for normal quadrupole corrections are generated based on tune shift (not currently implemented) and for skew quadrupole component from vertical/horizontal beam size.

With the exception of the in-vacuum undulator, injections can take place at operating gaps with no appreciable decrease in injection efficiency.

Permanent Magnet Undulators

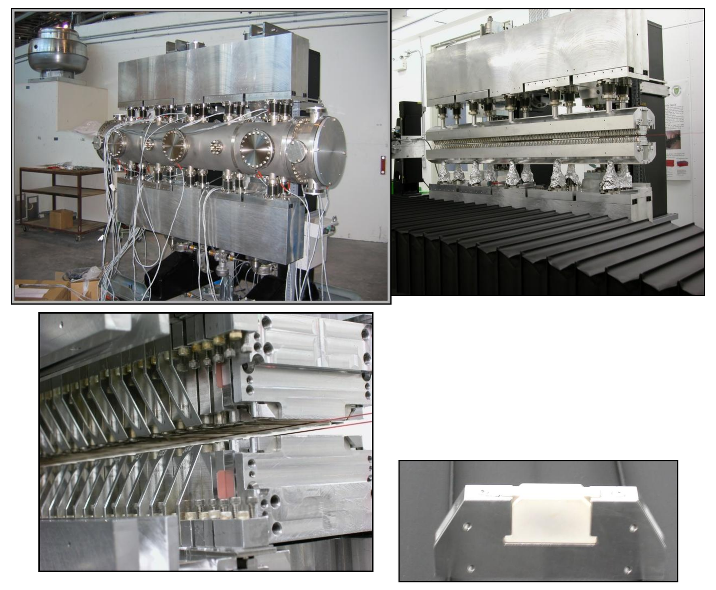
Two permanent magnet devices were the first devices installed in Phase I. These devices share a straight section (see figure) with a 1.2 m-rad magnetic chicane used to direct x-rays from each device to separate beam lines. The planar magnetic structure is made with NdFeB magnet blocks.



Planar undulators installed in same straight

In-Vacuum Small Gap Hybrid Undulator

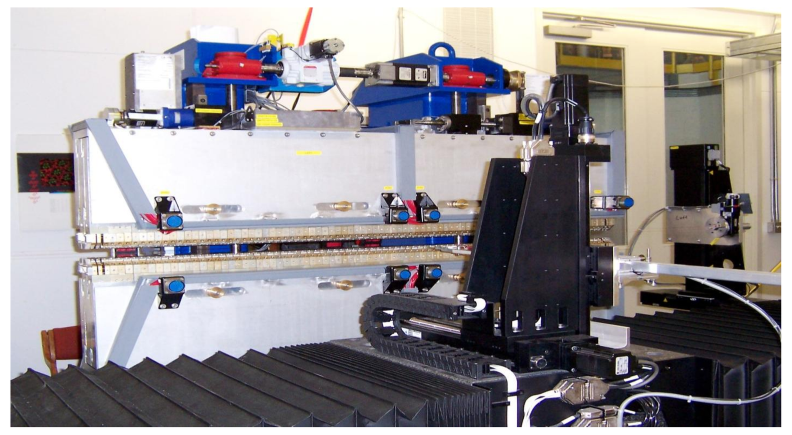
One in-vacuum device was installed in Phase I. The minimum gap of this device is 5.5 mm and is a 20 mm period hybrid magnetic structure consisting of Vanadium Permendur® poles and Sm-Co magnet blocks. This device has an operating range of 6.5-18 keV.



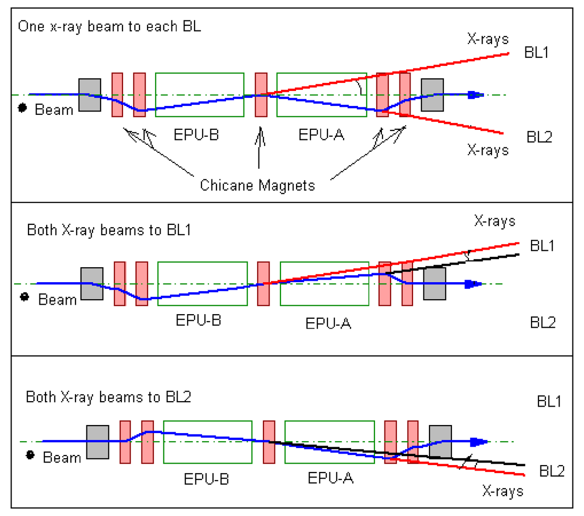
SGU support structure, vacuum chamber magnetic assembly, single pole piece

Elliptically Polarizing Permanent Magnet Undulators

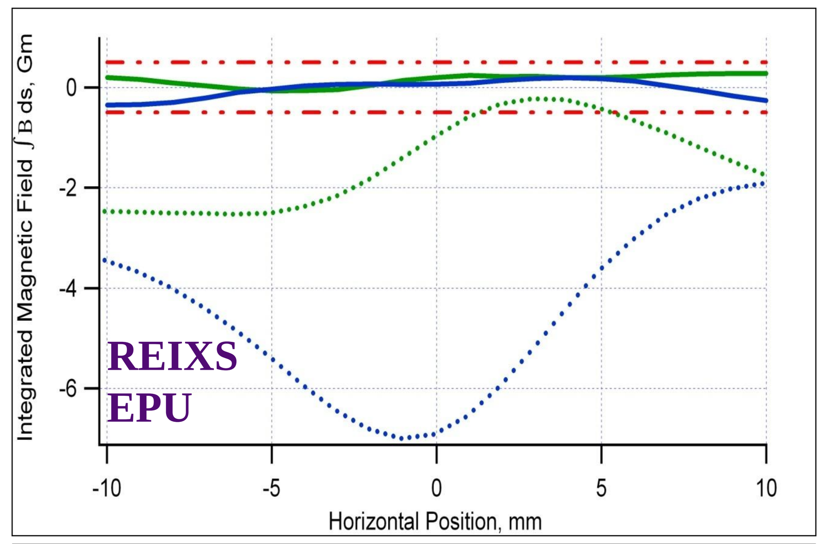
Two elliptically polarizing undulators with identical Apple-II type magnetic structures have been installed in Phase I and Phase II. All four sub-girders can move allowing for linear polarization selection between -90° to +90° and left and right circular light polarization. A unique chicaning scheme allows for the light from these devices installed in the same straight sections to be directed down either of two adjacent beamlines.



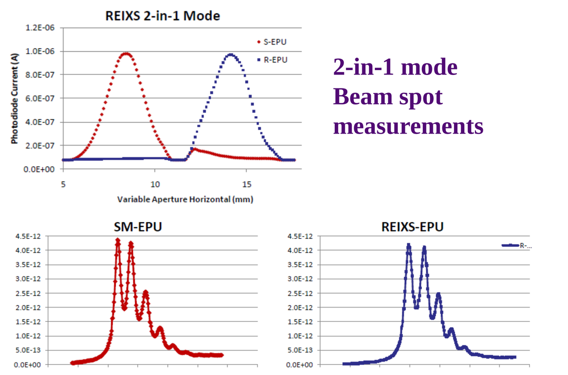
SM EPU including mounted correction coils, multipole trim magnets, and Hall probe bench (front)

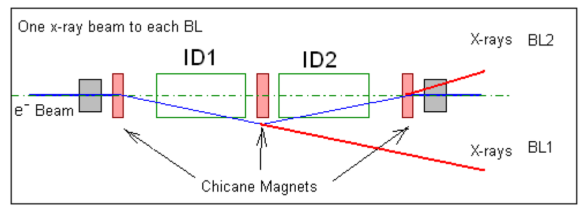


Five horizontal chicane magnet arrangement and modes of operation (exaggerated trajectories)

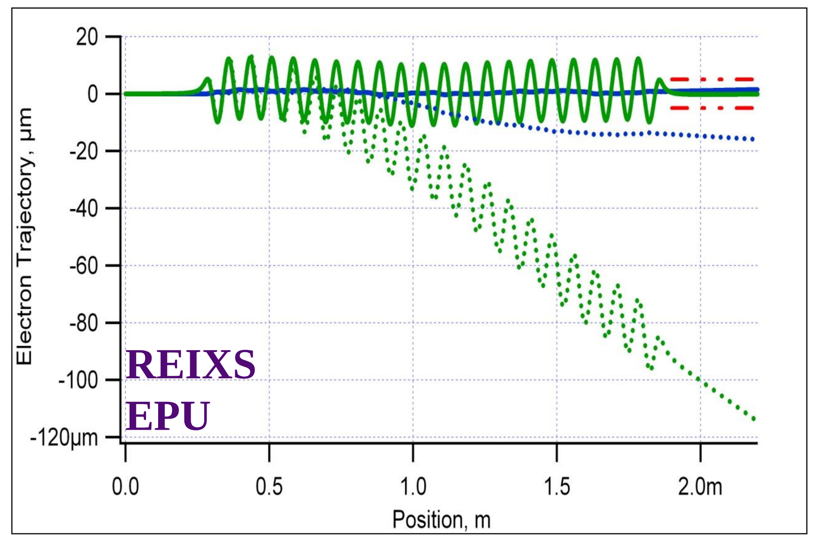


Horizontal (green) and Vertical (blue) Integrated Fields at minimum gap in planar mode.
- Immediately following assembly - dotted
- Completion of shimming, 2 months later - solid





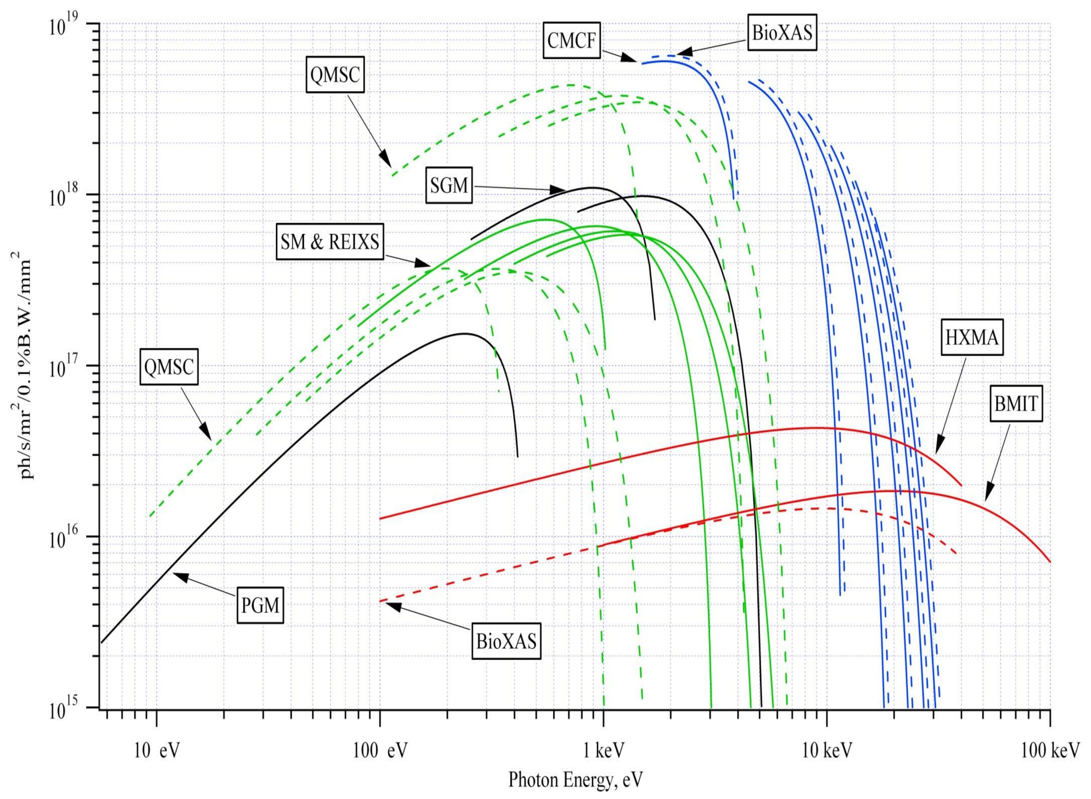
Standard three horizontal chicane magnet arrangement



Horizontal and Vertical e- Trajectory at minimum gap in planar mode.
- Immediately following assembly - dotted
- Completion of shimming, 2 months later - solid

Beamline	PGM	SGM	CMCF	SM	HXMA	REIXS	BMIT	Bio-Xas	Bio-Xas	QMSC	QMSC
Location	11-2	11-1	8-1	10-1	6-2	10-1	5-2	7-2	7-1	9-both	9-both
Type of Device	Pure Permanent Magnet Planar undulator	PPM Planar undulator	In-Vac Hybrid Undulator	APPLE-II type Elliptical Und	Super Conducting Wiggler	APPLE-II type Elliptical Und	SC Wiggler	PM Hybrid Wiggler	In-Vac Hybrid Undulator	APPLE-II type QuasiPeriodic EPU	APPLE-II type QuasiPeriodic EPU
Photon Energy	5-250 eV	250-1900 eV	6-18 keV	Planar 100-4000eV Circular 100-100eV	5-40keV Critical E 10keV	Planar 100-4000eV Circular 100-100eV	20-100keV Critical E 22keV	Critical E ~12keV	3-15 keV	15-200 eV	200-1000 eV
Polarization	Horizontally polarized light	Horizontally polarized light	Horizontally polarized light	Variable linear polarization angle or Left and Right Circular	Horizontally polarized light	Variable linear polarization angle or Left and Right Circular	Horizontally polarized light	Horizontally polarized light	Horizontally polarized light	Variable linear polarization angle or Left and Right Circular	Variable linear polarization angle or Left and Right Circular
Number of Poles	19	55	159	43	63	43	27	22	167	43	145
Total Length, m	1.66m	1.22m	1.58m	1.59m	-	1.59m	-	1.638m	1.586m	~3.6m	~3.6m
Peak Field, B(Tesla)	0.71T	0.82T	1.017T	0.71T	1.94T	0.71T	4.3T	2.1T	0.99T	0.45T	0.97T
Period, (mm)	185mm	45mm	20mm	75mm	33mm	75mm	48mm	150mm	19mm	180mm	~54mm
Effective K	12.3	3.5	2.2	5	6	5	18	~35	2.2	7.5	4.9
Min. Gap (mm)	25mm	12.5mm	5mm	16mm	9.5mm aperture	16mm	10mm aperture	11mm	5mm	25mm	12mm
RMS Phase angle error	<2.0	<1.6	<4	<6	N/A	<4	N/A	--	--	--	--
Magnet Material	$Nd_2Fe_{14}B$ Neodymium-Iron-Boron	$Nd_2Fe_{14}B$ Neodymium-Iron-Boron	Sm_2Co_{17} blocks Samarium-Cobalt V,Co,Fe alloy poles	$Nd_2Fe_{14}B$ Neodymium-Iron-Boron	SC Coils NbTi wire Niobium-Titanium	$Nd_2Fe_{14}B$ Neodymium-Iron-Boron	SC Coils NbTi wire Niobium-Titanium	$Nd_2Fe_{14}B$ blocks V,Co,Fe alloy poles	$Nd_2Fe_{14}B$ blocks Soft Steel poles	$Nd_2Fe_{14}B$ Neodymium-Iron-Boron	$Nd_2Fe_{14}B$ Neodymium-Iron-Boron
Installation Date	May-04	Jan-04	Aug-05	Apr-06	Jan-05	Dec-07	Oct-07	proposed	proposed	proposed	proposed

Present Operating Parameters, 250mA, 0.5% coupling



Quasi-Periodic APPLE-II type IDs

Phase III will include two 3.6m IDs in the same 4m straight section on one beam line. The user will be able to select either device which can be moved in place in the storage ring on a horizontal translation system. The devices will be optimised for a high and low energy range s to maximise photon flux. The APPLE-II design will allow full variable linear and circular polarised radiation and a quasi-periodic modification will suppress higher harmonics to reduce contamination of the experimental data from higher energy harmonics which can not be filtered out by the monochromator.

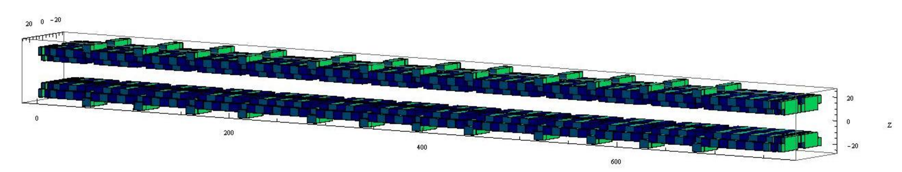
Selection of h-blocks for quasiperiodic modification using general fibionacci sequence:

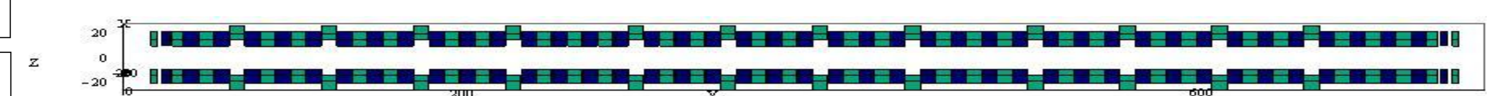
$$z_n = n + \left(\frac{1}{\eta} - 1\right) \cdot Floor\left[\frac{n}{(\eta+1)} + 1\right]$$

$$Step(m) = z_m - z_{m-1}$$

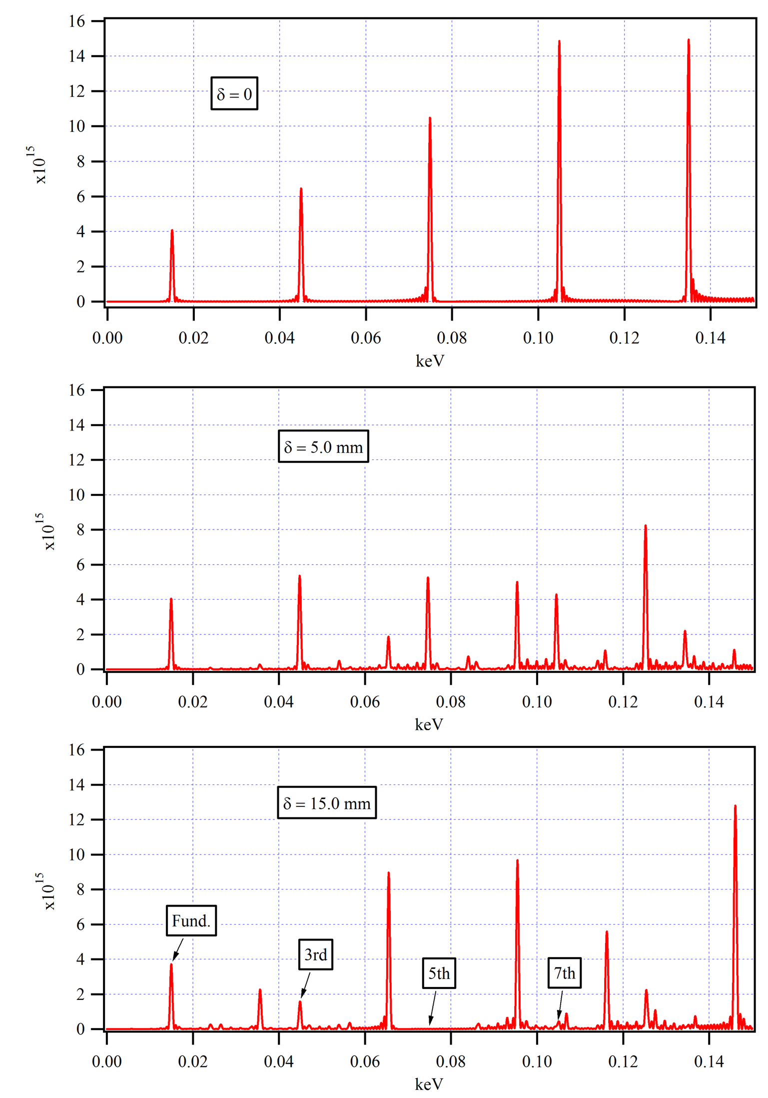
$$Step(1) = 1$$

Step(m) is either 1 or 1/η when it is 1/η the m[th] block is moved vertically by distance δ

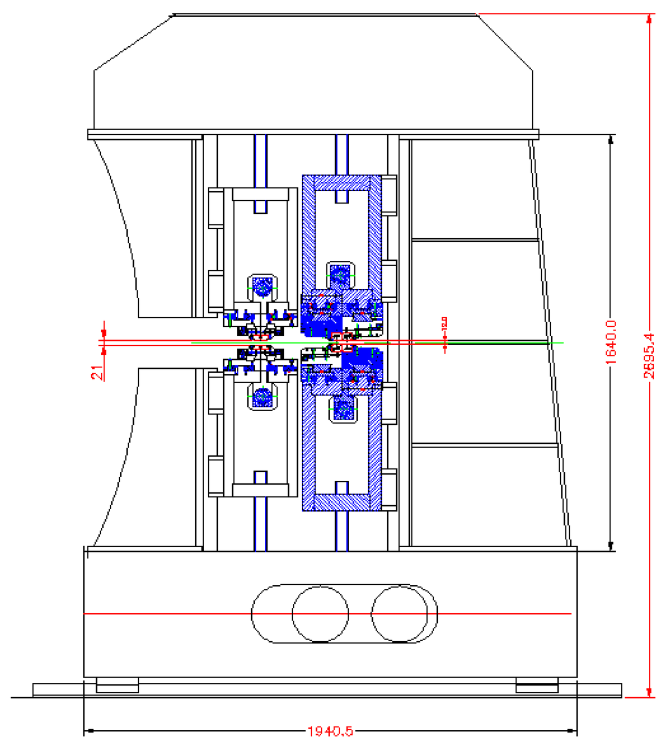




Effect of Quasi-periodic Structure



Dual EPU structure for selectable IDs



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