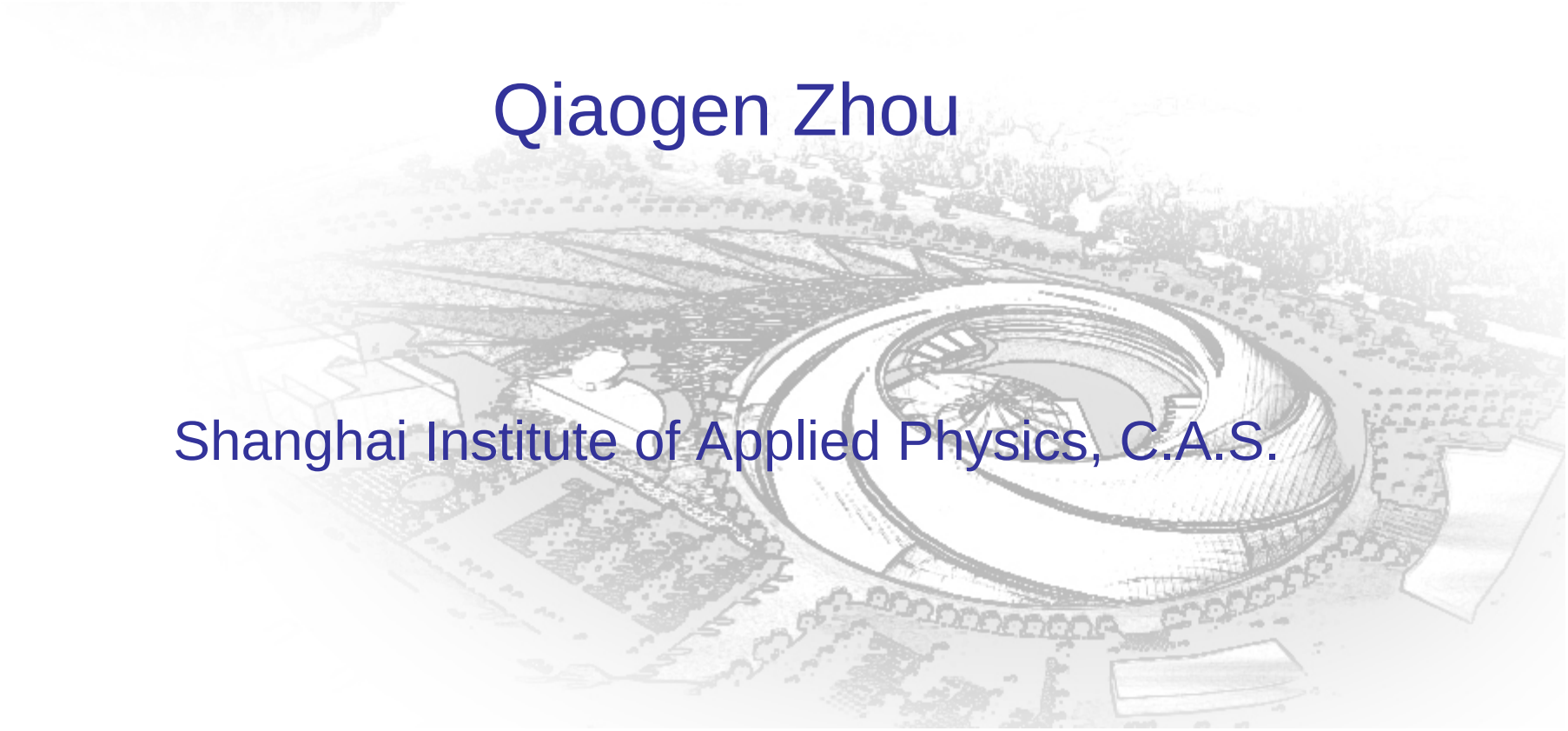
中国科学院上海应用物理研究所
Shanghai Institute of Applied Physics, Chinese Academy of Sciences

IDs and ID development at SSRF

Qiaogen Zhou

Shanghai Institute of Applied Physics, C.A.S.



Outline

- Introduction to SSRF
- IDs for SSRF Phase-I
- IDs for SSRF in Commissioning
- IDs for SSRF Phase-II
- Summary

Introduction to SSRF

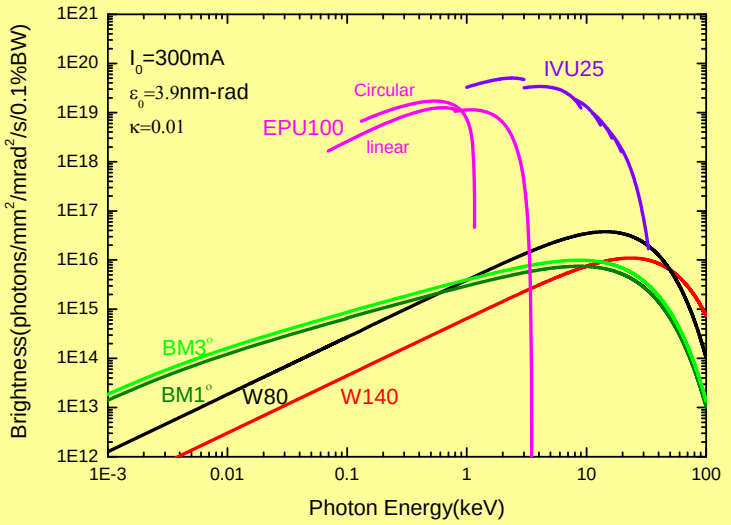
- SSRF is an intermediate energy 3rd generation light source funded by Chinese Academy of Sciences (CAS), Shanghai local government and central government of China.
- SSRF project was finally launched in 2004 with the ground breaking made on Dec.25, 2004; The first stored and accumulated beam in the ring was achieved on Dec. 24, 2007.
- SSRF accelerator complex consists of a 150MeV Linac, a full energy booster and a 3.5GeV storage ring.
- SSRF has 7 beamlines in operation, 6 beamlines in construction and 23 more for Phase-II in planning and proposal.

The First SSRF Beamlines

- Macromolecular Crystallography (IVU)
- High-Resolution X-ray Diffraction (Bend)
- X-ray Absorption Fine Structure Spectroscopy (Wiggler)
- Hard X-ray Micro-focus and Application (IVU)
- X-ray Imaging and Biomedical Application (Wiggler)
- Small Angel X-ray Scattering (Bend)
- Soft X-ray Spectromicroscopy (EPU)

SSRF Phase-I IDs (in operating)

	Beamline	λ_u (mm)	N_u	K_m	ε_n (keV)
W80	XAFS	80	19	8.9	3.5～50
W140	XI	140	8	25.4	8～75
EPU100	STXM	100	42	5.6(H.P.) 3.2(V.P.) 2.8(C.P.)	0.07～2 0.2～2 0.13～1
IVU25-1	HXM	25	80	2.2	3.5～22.5
IVU25-2	MX	25	80	2.2	5～20



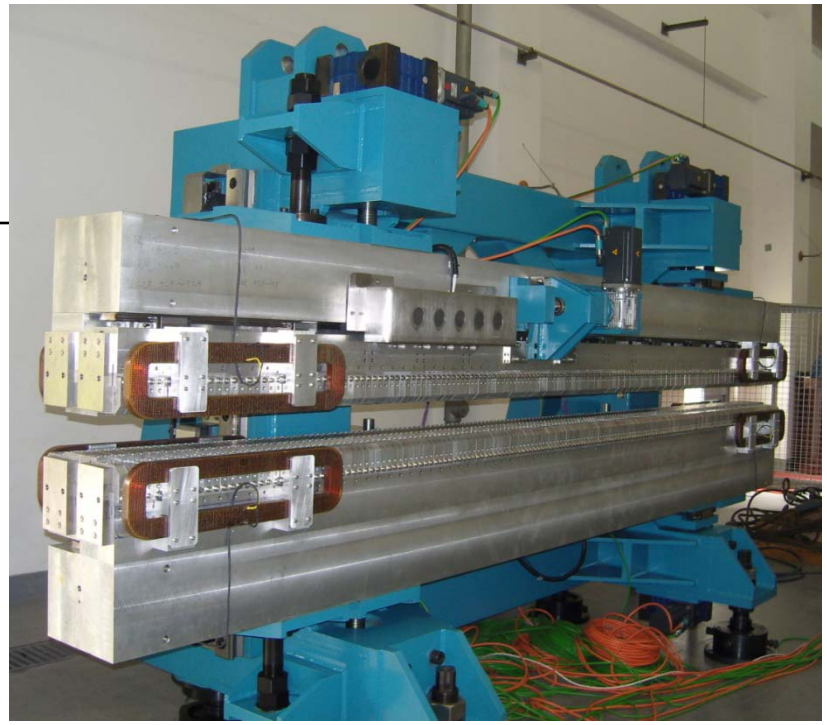
W80 W140 W140 EPU100

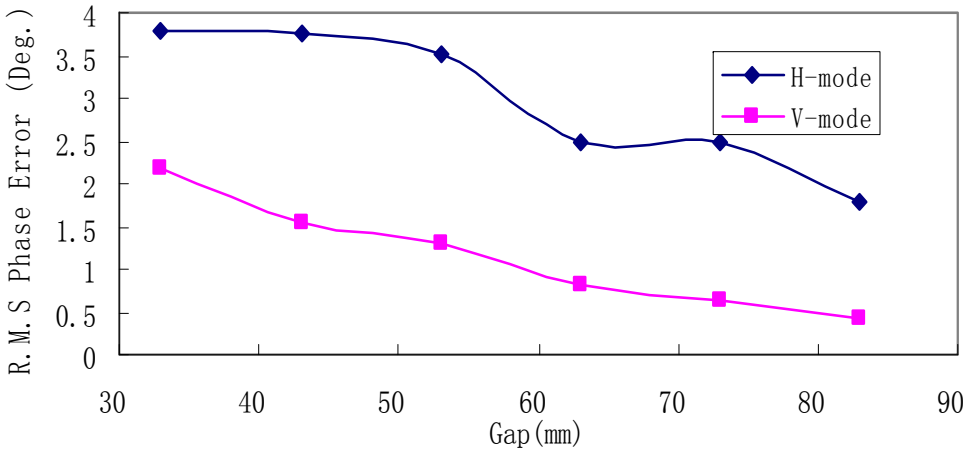
Two Wigglers

	W80	W140
Period(mm)	80	140
No. of Periods	19	8
No. of Full Peak	36	14
Total Length (m)	1.71	1.42
Gap (mm)	14 -140	14 - 140
Max. Peak Field (T)	1.20	1.94
Magnet Structure	Hybrid, Anti-Symmetric	
Magnet Material	NdFeB	
Pole Material	Vanadium Permendur	

EPU100

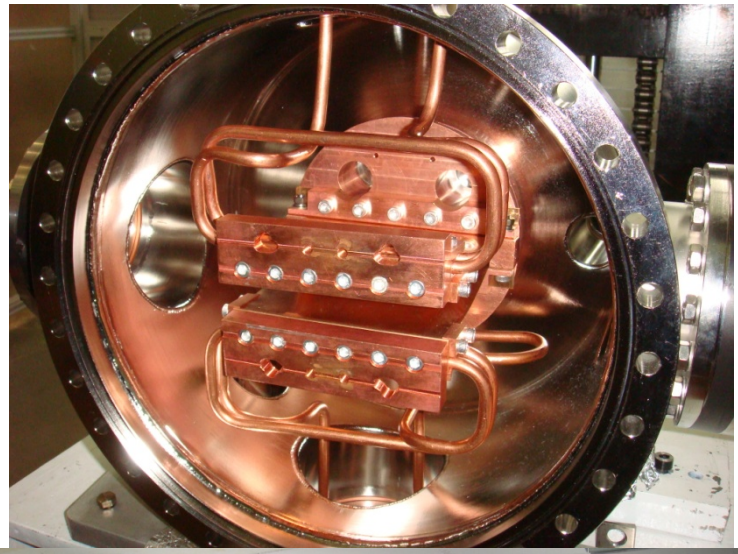
Period Length (mm)	100
Number of Periods	42
Total Length (m)	4.3
Gap (mm)	33 - 100
Magnet Structure	APPLE-II
Magnet Block Material	NdFeB
Shift Range (mm)	±55
Max. By (T) @H-mode	0.6
Max. Bx (T) @V-mode	0.3
Max. Bx,y (T) @C-mode	0.3

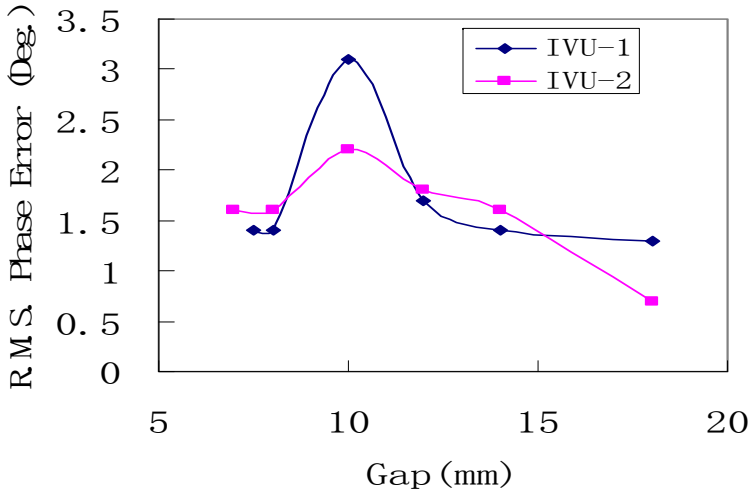




First Two IVU25s

Period Length (mm)	25
No. of Periods	80
Magnet Length (m)	2.05
Gap (mm)	7 - 30
Max. Peak Field (T)	0.95
Magnet Structure	Hybrid, Anti-Symmetric
Magnet Material	Shin-Etsu, Sm_2Co_{17}, with Ni Coating

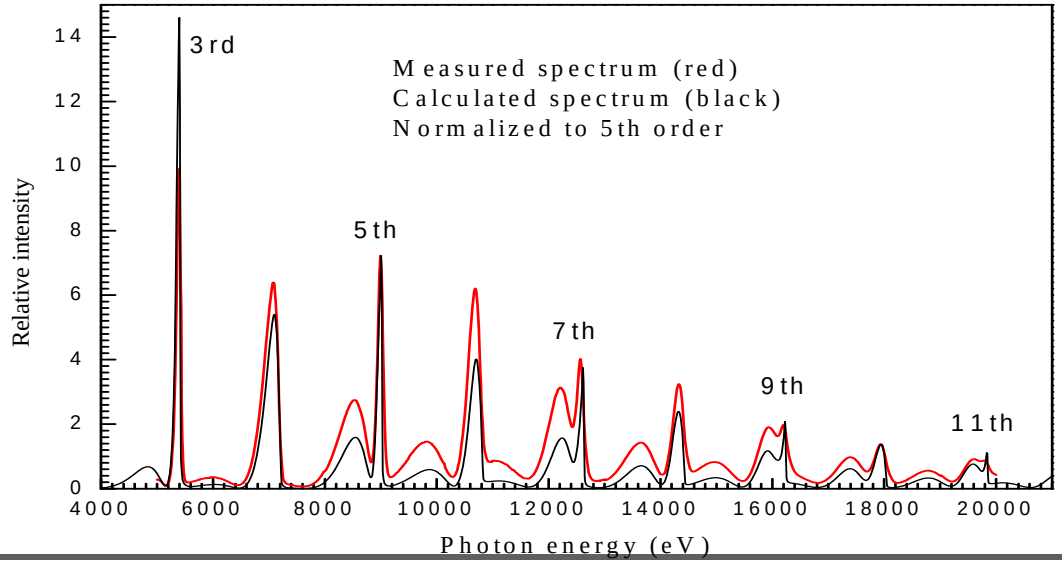




Commissioning of SSRF Phase-I IDs (2008.10-2009.4)

- ☑ The tunes change too small to be corrected;
- ☑ The orbit perturbations are corrected for each ID, the rms values of ~5um in horizontal and ~4um in vertical have been achieved;
- ☑ The maximum orbit perturbation of 0.2mm comes from EPU, and it is corrected to be less than 10 um.

Spectrum of the First IVU25 for SSRF



Six Beamlines in Commissioning

- Three Protein crystallography beamlines (2 IVUs+BM)
- Small angle X-ray scattering beamline, Bio-SAXS(IVU)
- IR Beamline with two end-stations(BM)
- soft X-ray beamline for ARPES and PEEM (Double EPU)

IDs for SSRF (in commissioning)

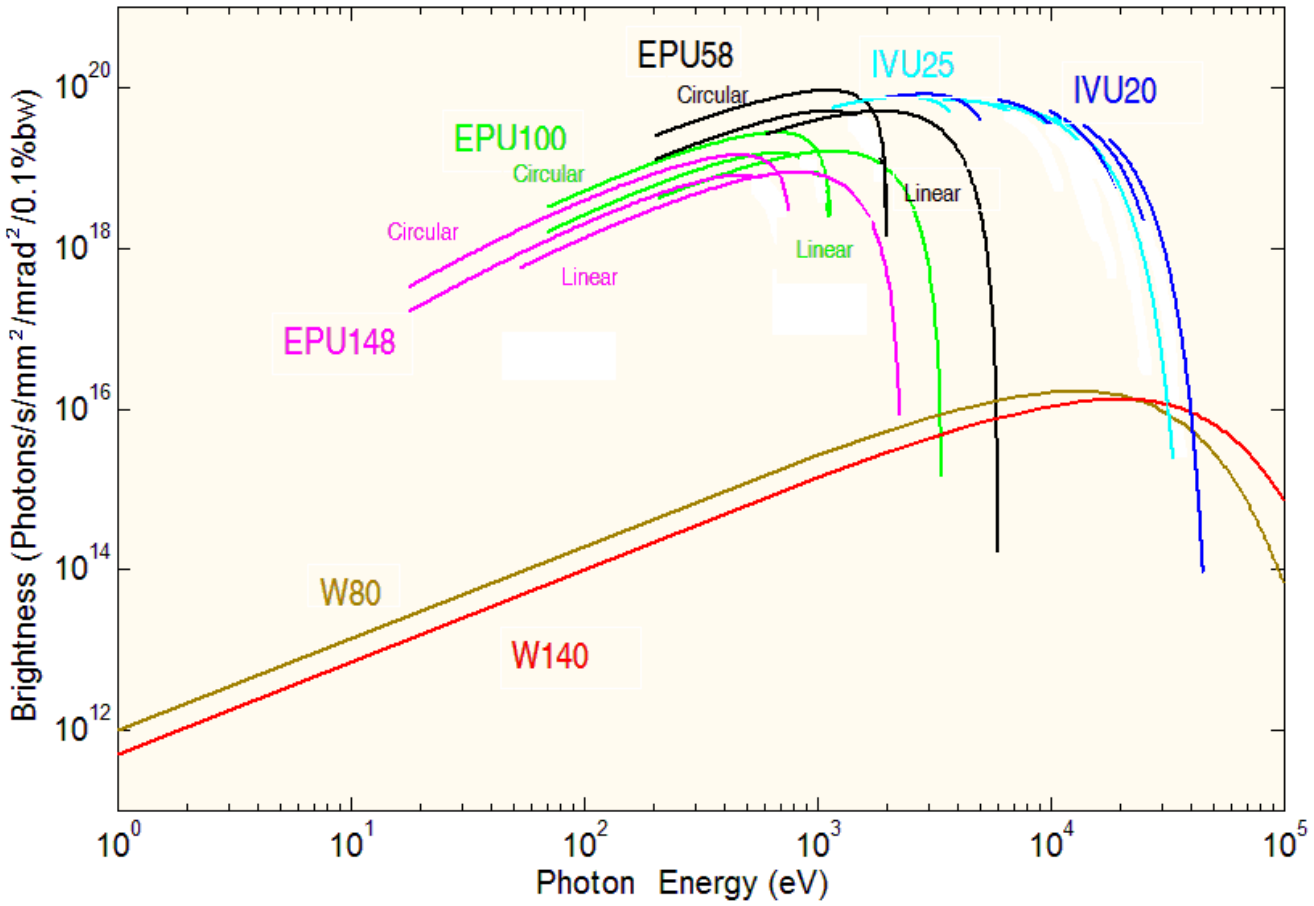
	Beamline	λ_u (mm)	N_u	K_m	ε_n (keV)
IVU20-1	LMCA	20	80	1.94	6～20
IVU20-2	Bio-SAXS	20	80	1.94	6～20
IVU25-3	PMC	25	80	2.23	4～20
DEPU	ARPES/ PEEM	148	32	9.68	0.02～0.2
		58	84	4.28	0.2～2

DEPU

Two IVU20s (Canted)

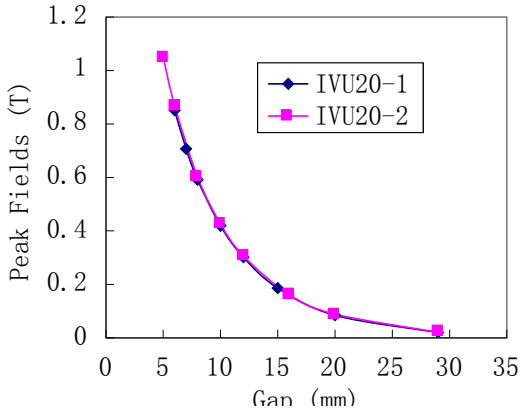
IVU25-3

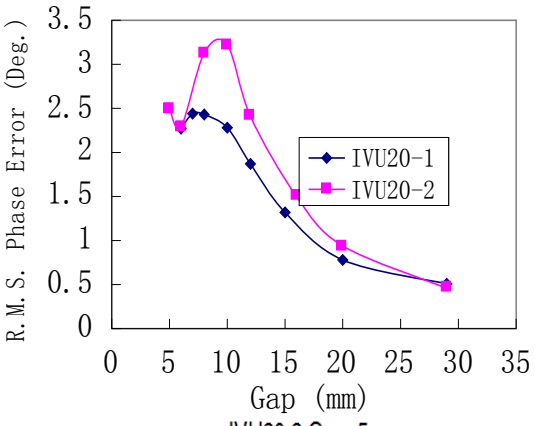
Spectra of IDs for SSRF

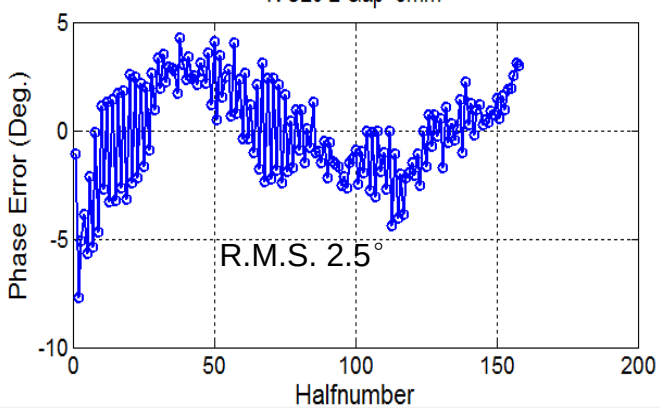


Two IVU20s

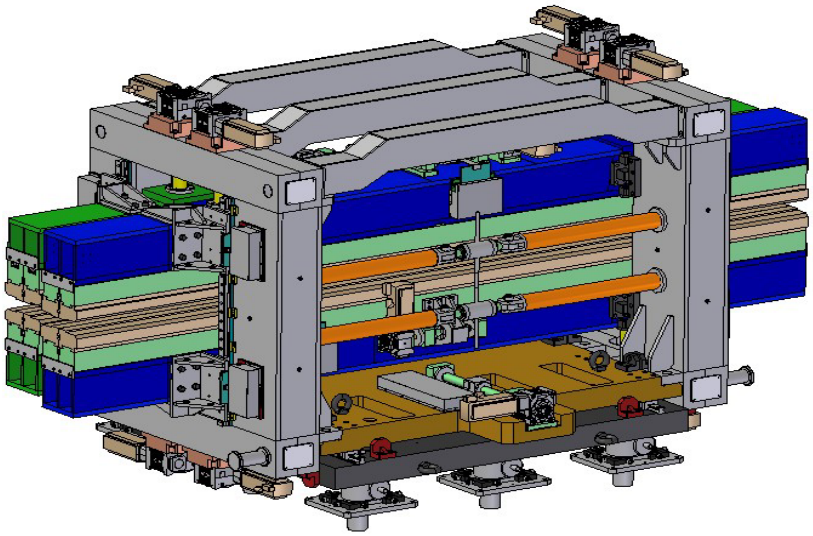
Period Length (mm)	20
Number of Periods	80
Magnet Length (m)	1.65
Gap (mm)	5 - 30
Max. Peak Field (T)	1.05
Magnet Structure	Hybrid, Anti-Symmetric
Magnet Material	Chengdu Sm_2Co_{17}, with TiN Coating
Pole Material	DT4 Soft Iron

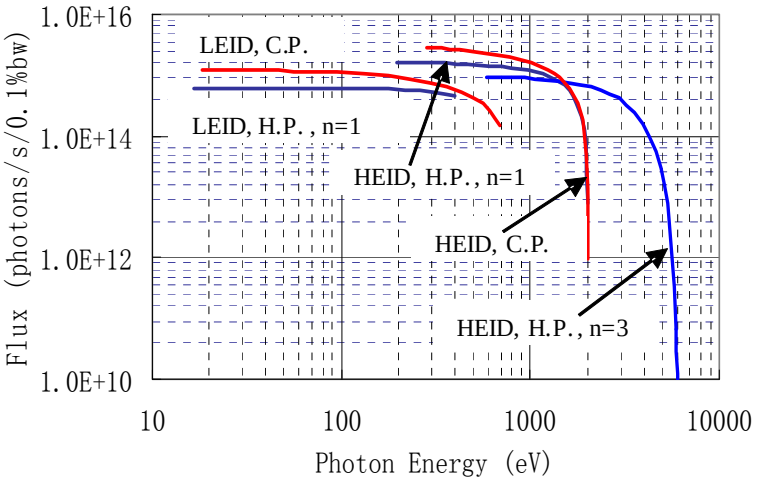






Double EPU





Name of Undulator	LEID	HEID
Period Length (mm)	148	58
Number of Periods	32	84
Gap Range (mm)	22 ~ 130	16.5 ~ 120
Magnet Array Length (mm)	4884	4968
Max. Eff. Peak Field in H.P. Mode(T)	0.70	0.79
Max. Eff. Peak Field in C.P. Mod(T)	0.47	0.45

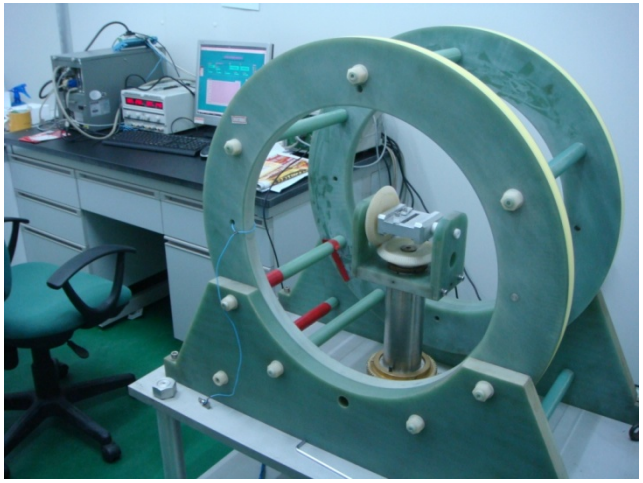
- A pair of EPUs which covers the energy range from 20eV to 2000eV with arbitrary polarized light will be used in a soft X-ray beamline for ARPES and PEEM in SSRF.
- Two APPLE-II type undulators LEID and HEID are in building. LEID with the period length of 148mm and 32 periods will produce the low energy photons from 20eV to 200eV, HEID with the period length of 58 and 84 periods will produce the high energy photons from 200eV to 2000eV.
- **Two undulators have the roughly same magnet array lengths of about 5m and share a common support system with H-type which can move transversely to switch two undulators.** 13 motors are used to control the gaps, the phase shifts and the switch of two IDs. The gaps and phase shifts of two IDs are controlled indenpendently.
- With the quasi-periodic undulator of LEID, the contribution of higher orders for the low energy photons can be reduced to less than 20%.

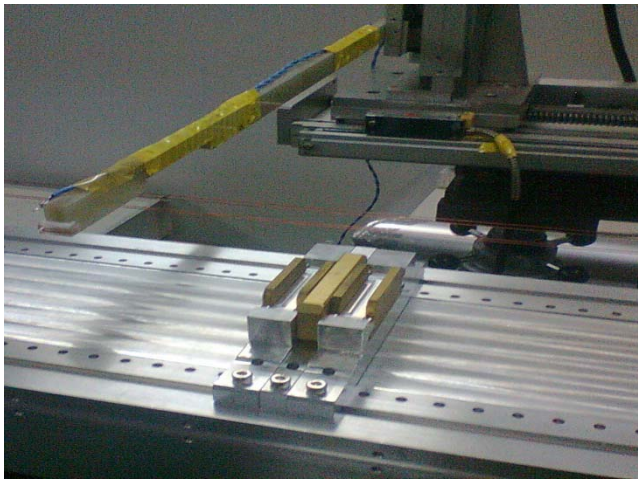
Magnetic Field Measurement and Shimming

- ☑ Magnet block measurement and sorting;
- ☑ Field map meaurement;
- ☑ Field integrals measurement;
- ☑ Phase shimming;
- ☑ corretion of the field integrals.

Magnet Block Measurement and Sorting

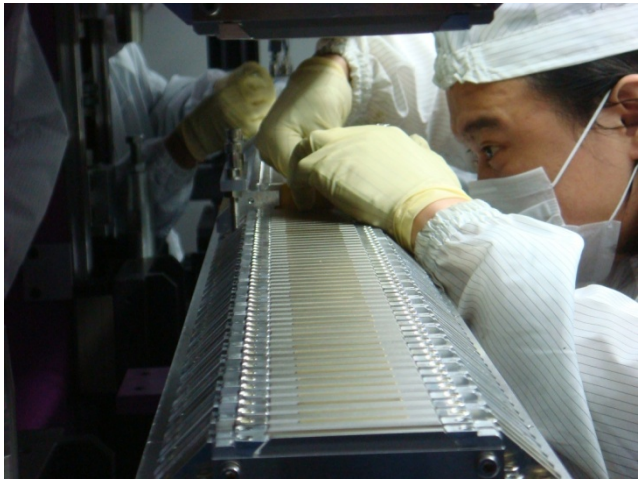
- The remanance and the magnetization angle of each magnet block are measured by using the Helmhertz coil.
- The first field integral distributions and the half period integral of blocks each with 4 poles are measured by using two moving coils and a half-period coil to performance block sorting.



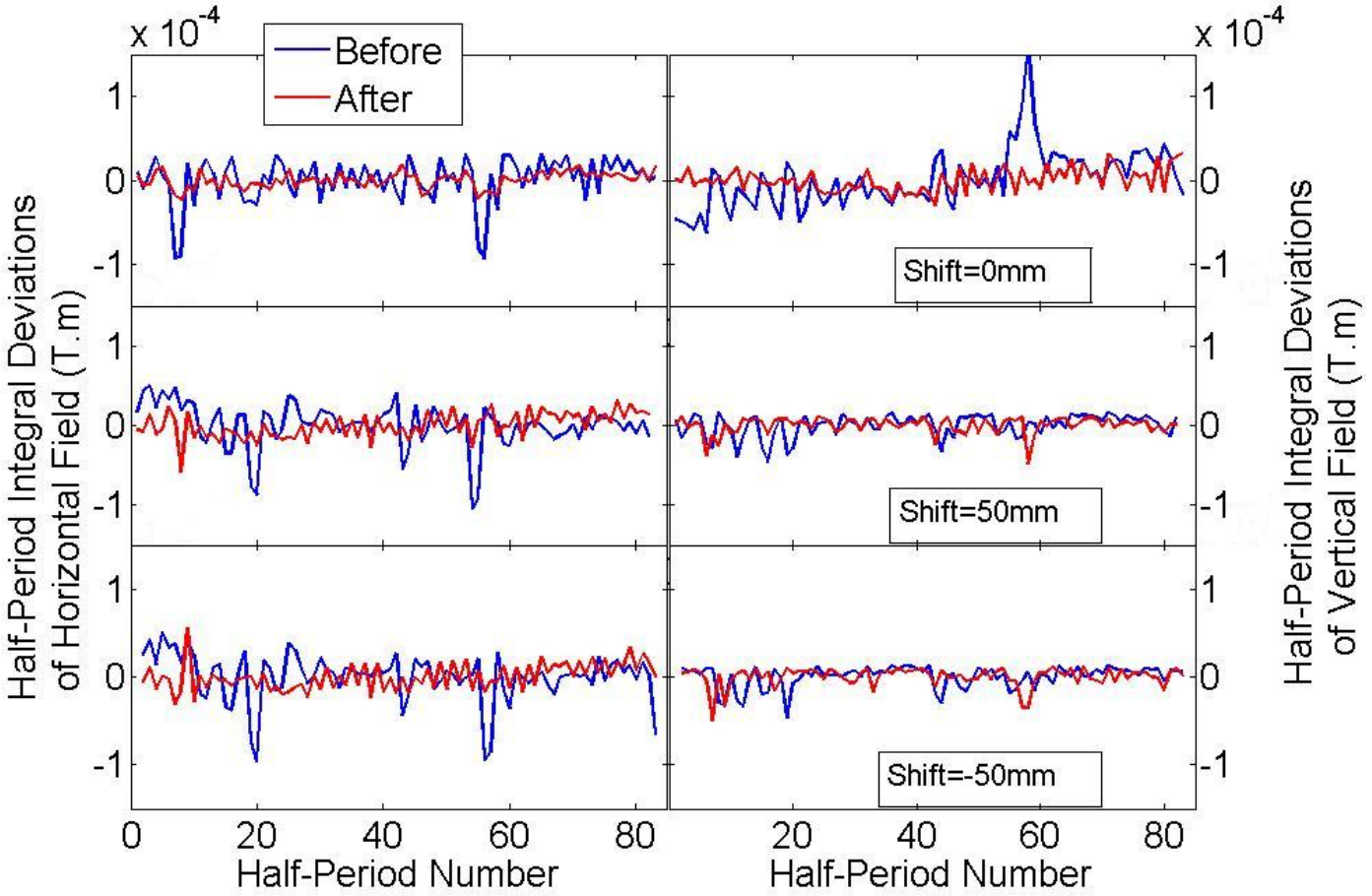


Magnetic Field Measurement and Shimming

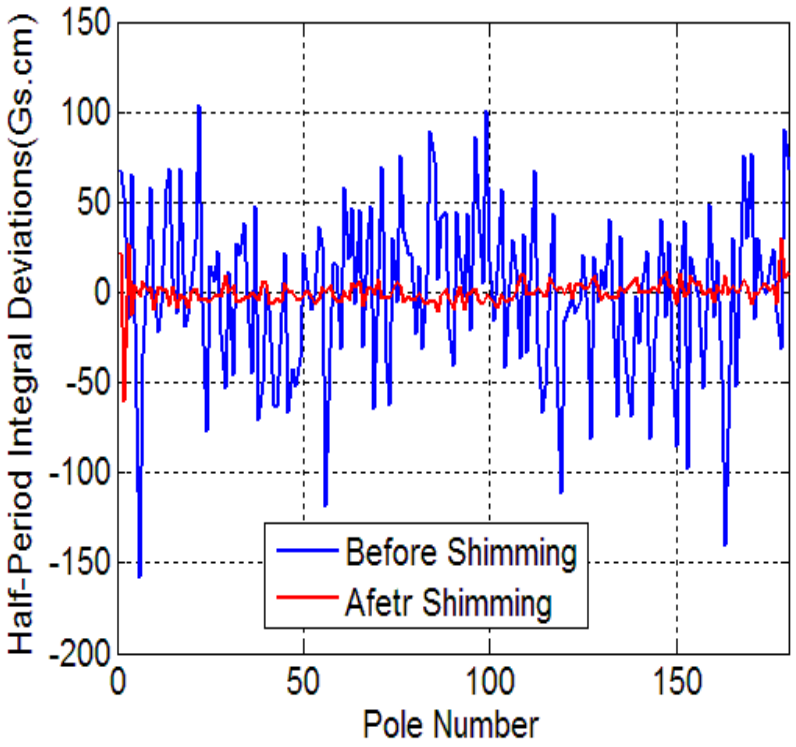
- The magnetic field mapping is measured with a Hall probe bench. Three Hall probe sensors sticked to a plate are used to measure the three field componens.
- The phase shimming was performed by minimizing the difference between the half-period integrals of the magnetic fields.
- The first and second field integrals were measured in the range of good field region by flipping coils and were corrected by “Magic Fingers”.

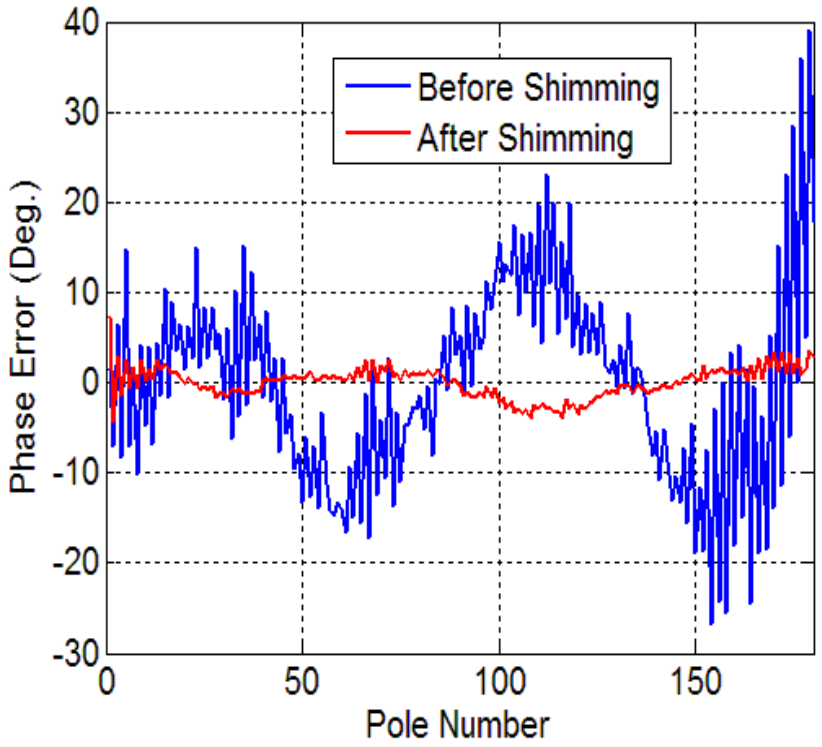


Half-period Field Integral deviations of EPU100 @ Gap=33mm

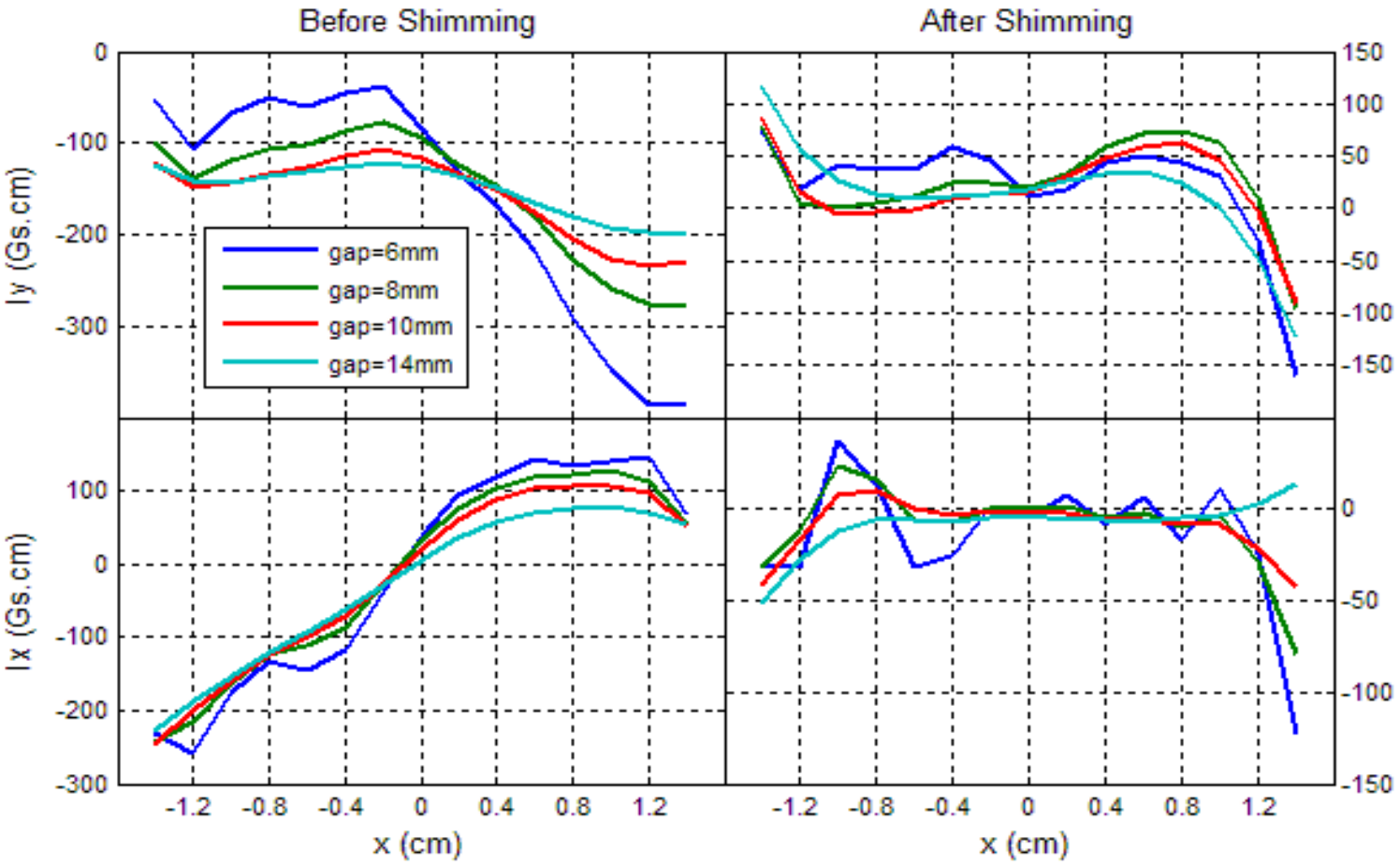


Half-period Integral Deviations and Phase Errors of an IVU20@Gap=6mm

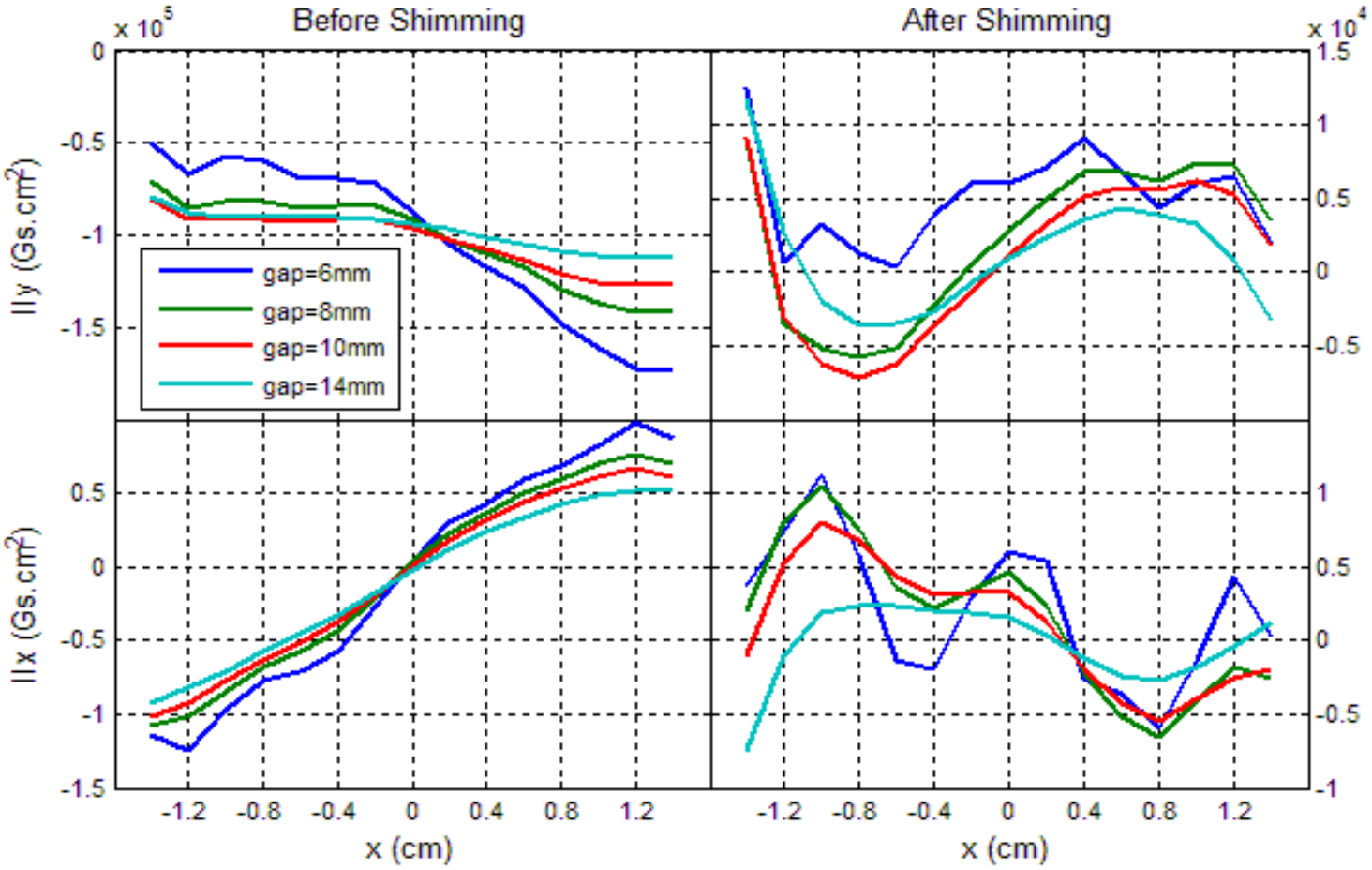




First Field Integrals Before and After Correction of an IVU20



Second Field Integrals Before and After Correction of an IVU20

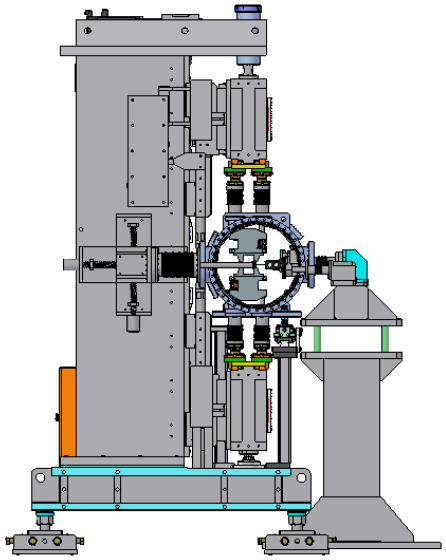


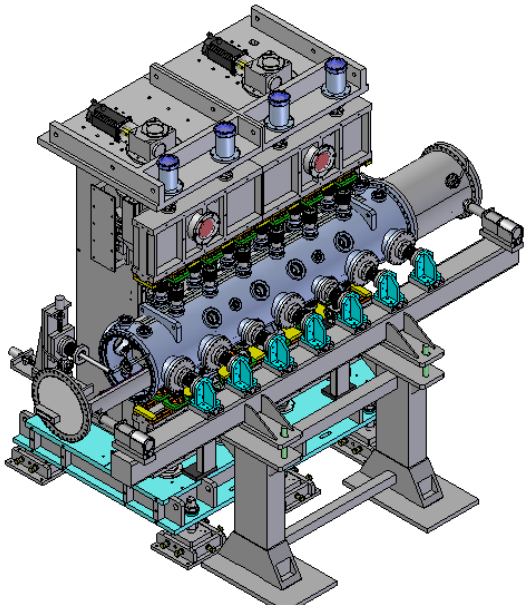
Parts of IDs for SSRF-II

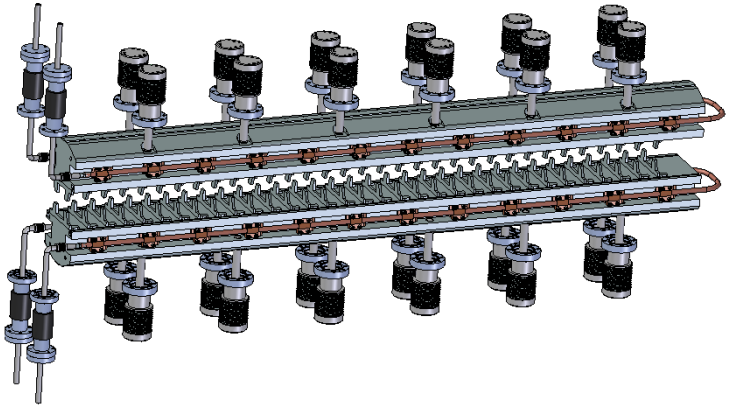
IDs	No.	Photon Energy	Period Length	Max. Peak Field	Mini. Gap
IVU	5	5-25keV	20-25mm	0.9-1.0T	5-6mm
CPMU	4	5-35keV	16-20mm	0.9-1.1T	5-6mm
EPU	1+2	10-100eV 350-2000eV			
SCW	1	30-300keV		4.5T	

R&D of IDs: CPMU

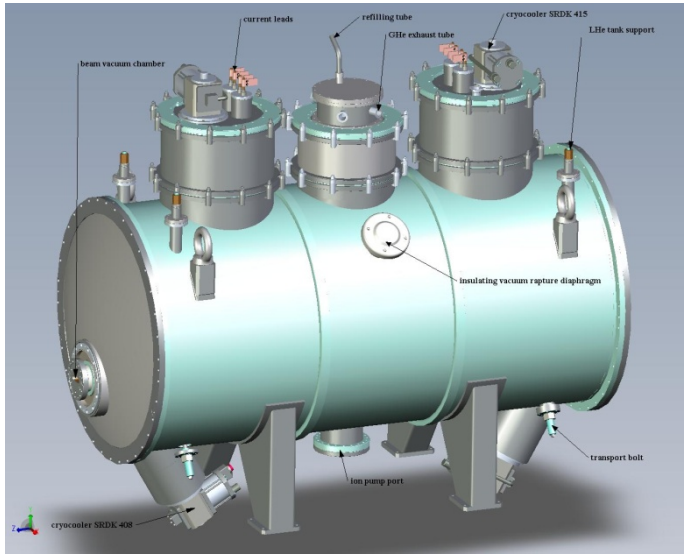
Period length	**20mm**
Period number	**80**
Operatng Temeperature	**～120K**
Min. Gap	**5mm**
Eff. Peak Field	**1.2T**

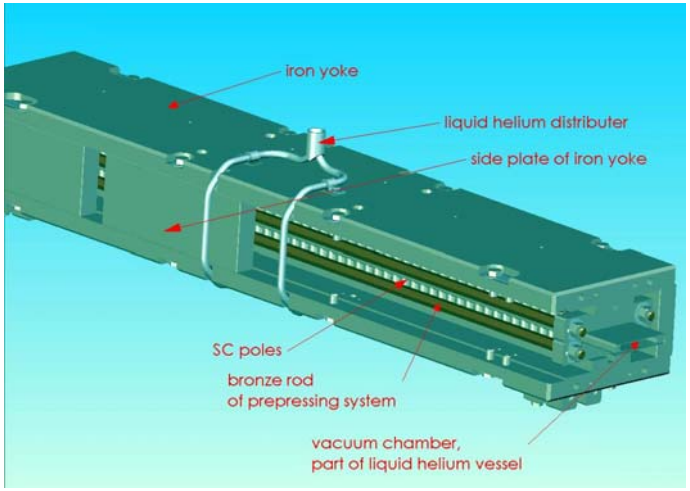






SW R&D





Required Parameters

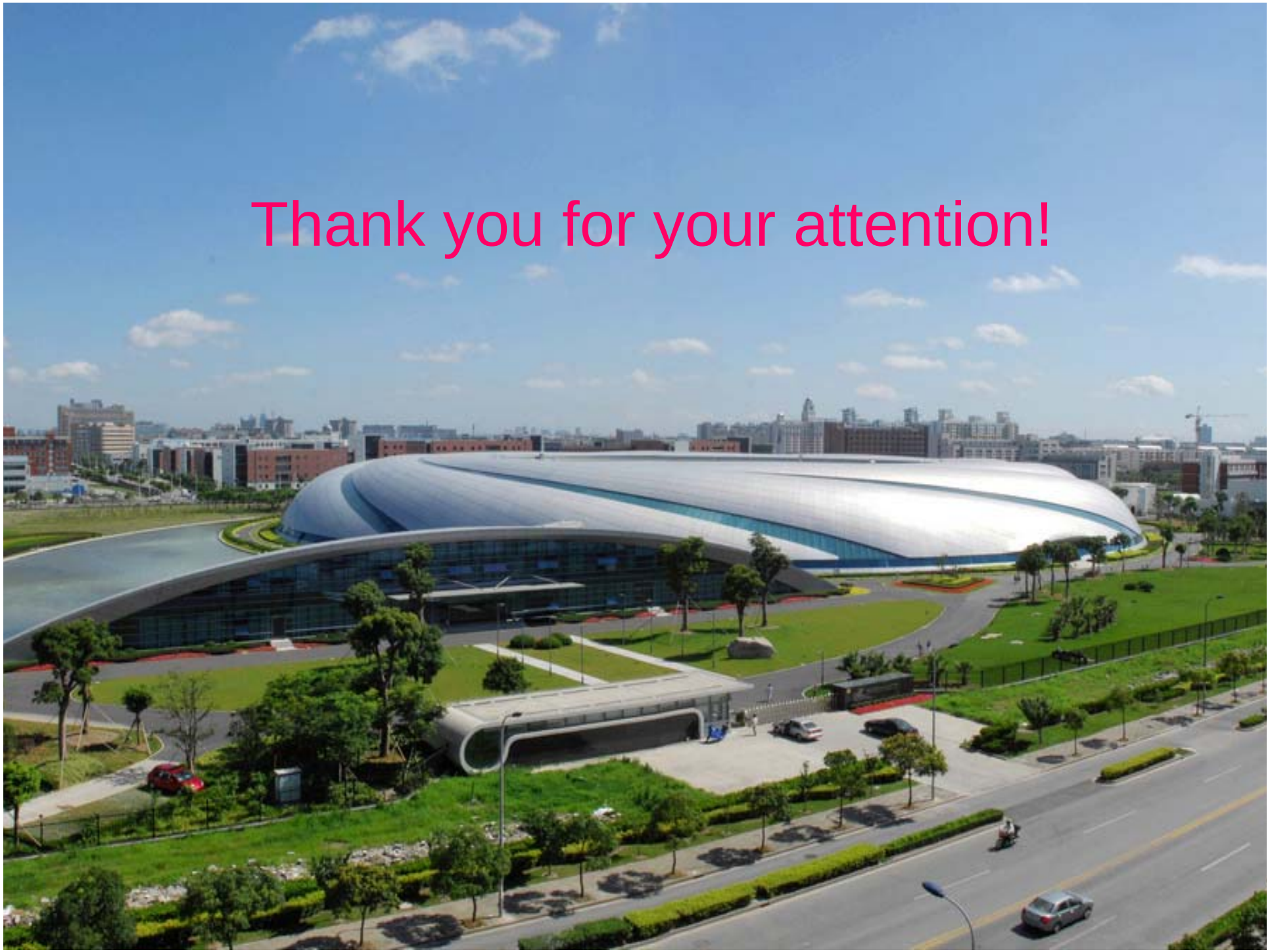
Storage ring energy, GeV	3.5
Storage ring current, mA	200-250
Maximum Magnet Peak Field, esla	4.2
Period Length, mm	48
Period number	22.5
Beam aperture VxH, mm	10x50

Superconducting Wire Characteristics

Diameter (mm)	0.85 (0.91 with insulation)
Ratio of NbTi:Cu	1.4
Number of NbTi filaments	312
Critical current of modified/enhanced SC wire (A)	~650 (at 7 Tesla, 4.2K)

Summary

- Five IDs including two wigglers, two in-vacuum undulators and one EPU were build in SSRF-I project and is operating normally now.
- Six beamlines are in construction and three in-vacuum undulators and one double EPU have been installed in the SSRF storage ring and are in commissioning now.
- More than 20 beamlines will be build in next six years and a large number of IDs including four CPMU and one SCW will be used. A prototype of CPMU is being building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