Overview of Magnetic Measurement Activities at Shanghai Synchrotron Radiation Facility (SSRF)

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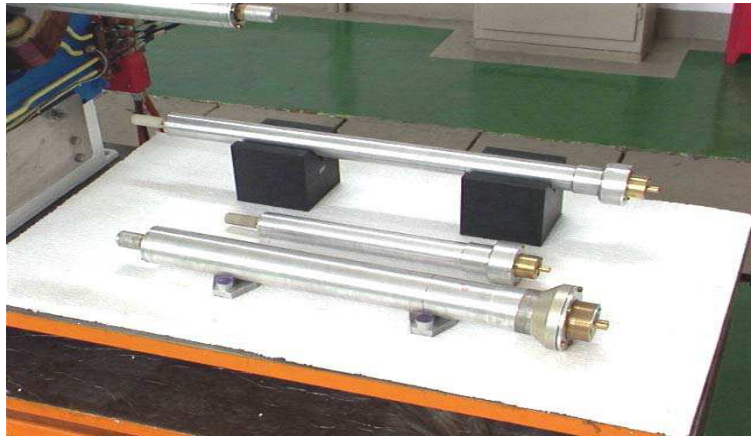
Outlines

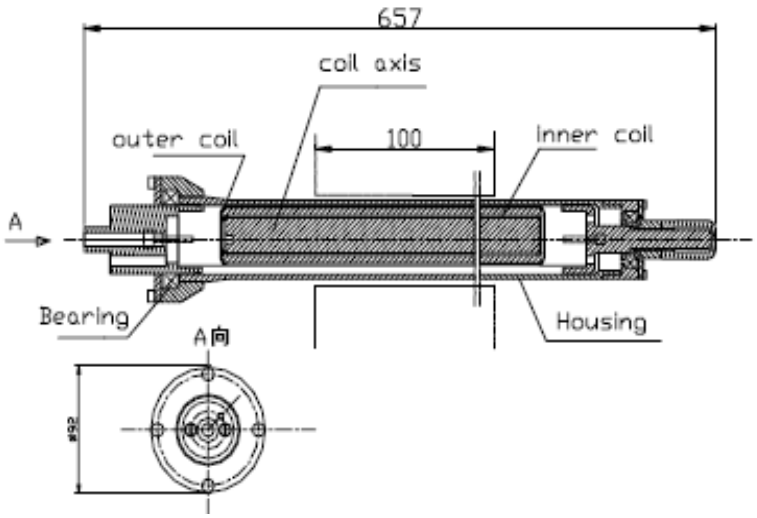
- Part I. Measurements of conventional magnets
  - 1.1 Rotating Coil System
  - 1.2 Translation Long Coil System (one coil)
  - 1.3 Hall probe System(1-D)
  - 1.4 Measured Magnets
- Part II. Measurements of insertion devices
  - 2.1 Hall probe System(3-D) and Flipping Coil System
  - 2.2 Translation dual Coils (Stretched coils-Bx & By)
  - 2.3 Helmholtz Coil
  - 2.4 Hall probe calibration system
  - 2.5 Built Insertion Devices

Part I:

Measurements of conventional magnets

1.1 Rotating Coil System



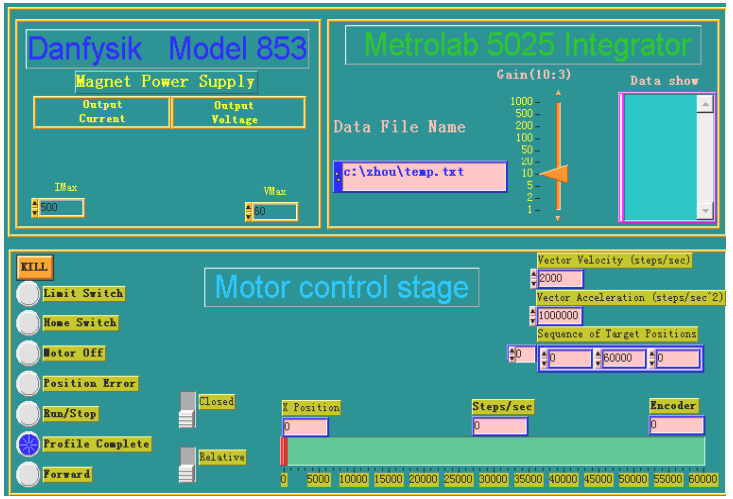


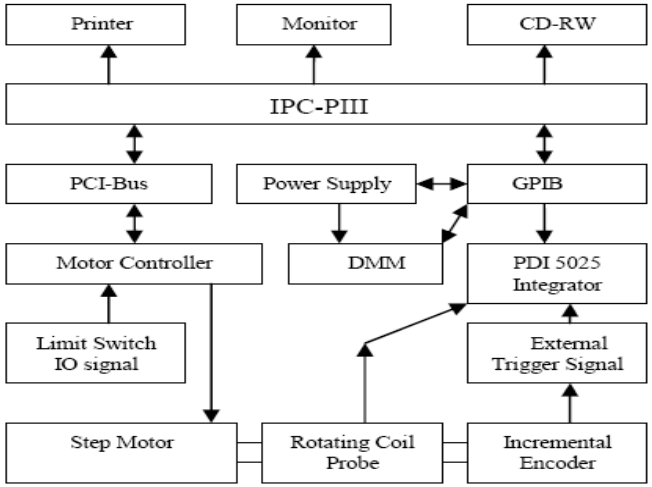
Magnet	Storage ring Quadrupole	Storage ring Sextupole	Booster Quadrupole	Booster Sextupole
r_1(mm)	28.00 (27.95)	35.00 (34.64)	24.00 (24.13)	24.00 (23.98)
r_3(mm)	-21.00 (-20.997)	-24.50 (-24.59)	-18.00 (-18.14)	-19.06 (-19.00)
r_2(mm)	19.820 (19.96)	25.04 (25.05)	17.00 (17.21)	18.72 (18.58)
r_4(mm)	-12.820 (-12.47)	-19.42 (-19.25)	-11.00 (-11.21)	-15.62 (-15.48)
N_1	400(288)	280(240)	400(320)	300(280)
N_2	600(432)	700(600)	600(480)	600(560)
L_{coil}(mm)	1000	600	780	360

r1 and r3 are the two radii of the outer coil (the main coil), N1 is the turn number

r2 and r4 are the two radii of the inner coil (the bucked coil) and N2 is the turn number.

1.1 Rotating Coil System





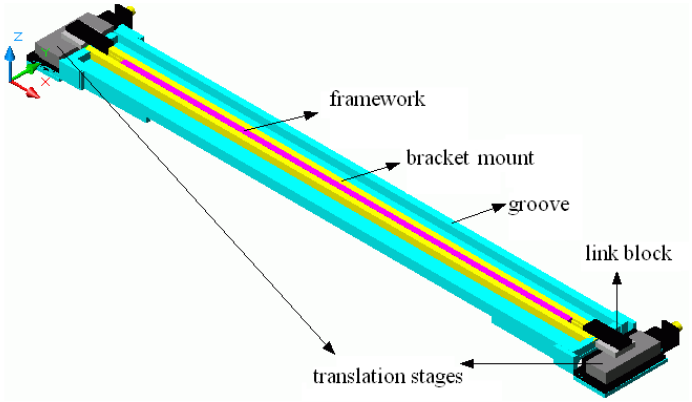
Mechanism : X-Y-Z Translation tables

Control : an industrial personal computer together with a step motor control card ;

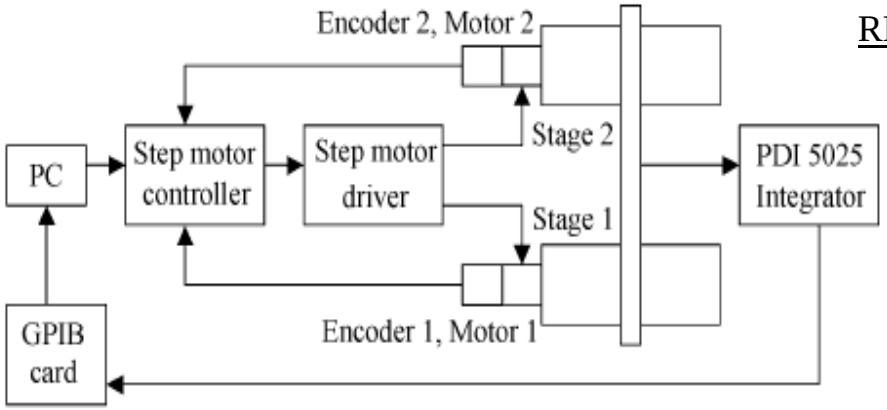
Data acquisition : a digital integrator (metrolab PDI5025) connected by GPIB, triggers from rotating encoder

Repeatability: <1×10-4

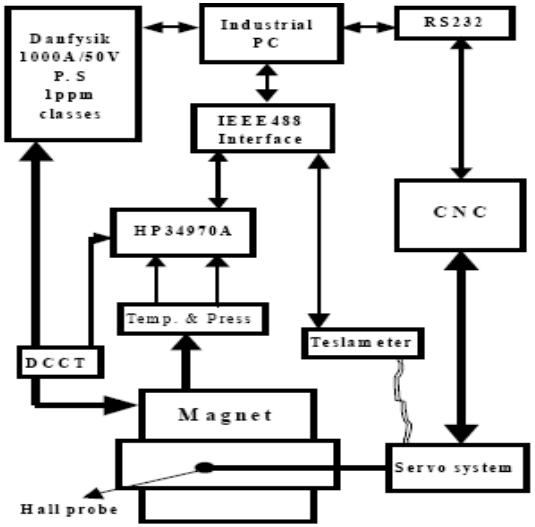
1.2 Translation Long Coil System



Turns of the coil: 400
Efficient Length of the coil: 2m
Efficient Width of the coil: 10mm
Mechanism : Two parallel translation table
Control : an industrial personal computer together with a step motor control card ;
Data acquisition : a digital integrator (metrolab PDI5025) connected by GPIB, triggers from LPT output of microcomputer
RMS repeatability: <1×10-4



1.3 Hall probe System(1-D)



Travel

Long Axis (Z Axis) – 2600mm,
Vertical Axis (Y Axis) – 150mm
Horizontal Axis (X Axis) – 400mm

Position accuracy

Long Axis – ±5μm,
Vertical Axis – ±10μm,
Horizontal Axis – ±10μm

Hall probe Model

DT141 from Group3

Trigger Distance

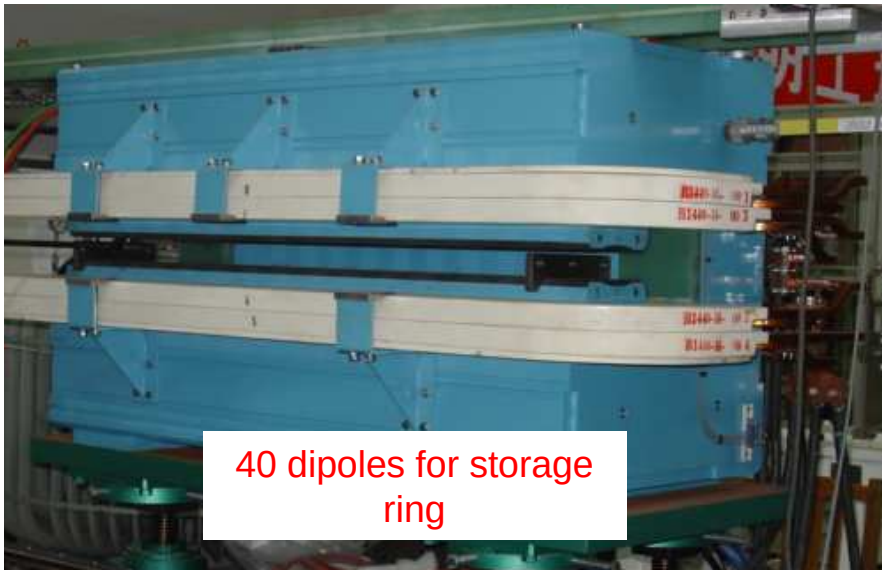
Minimum distance –0.5mm

Magnetic Field Measurement

resolution – 0.05 Gauss

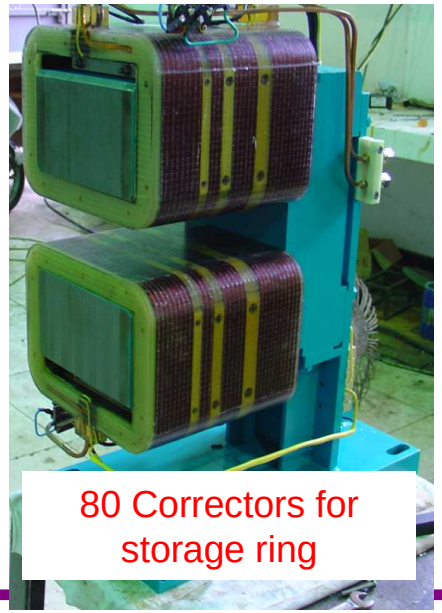
Conventional magnets in SSRF

200 Quadrupoles for storage ring

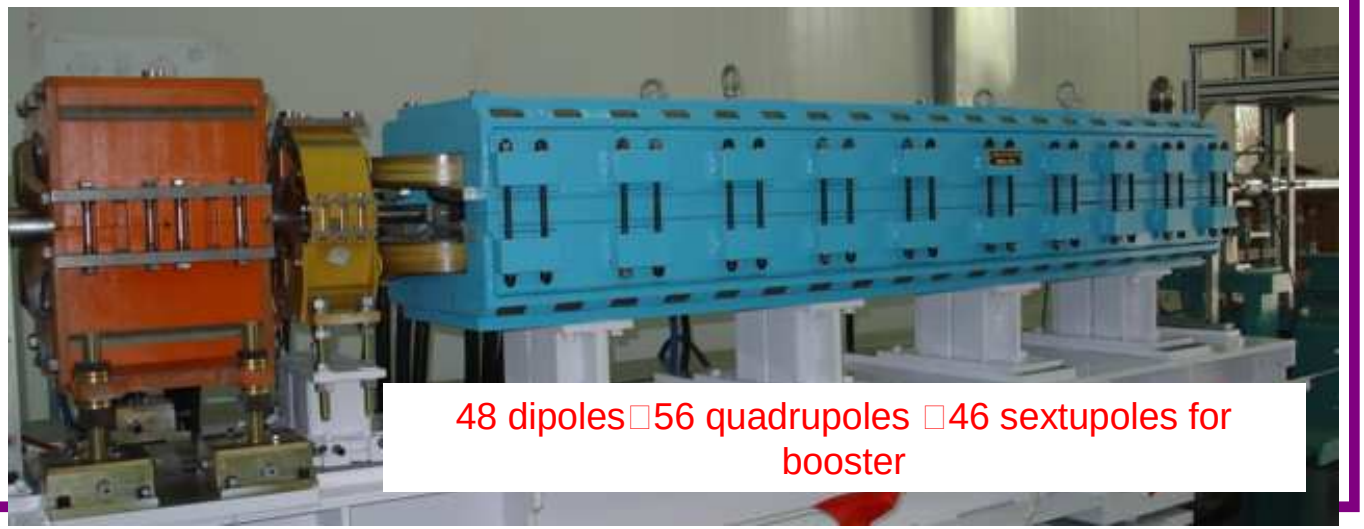


40 dipoles for storage ring

140 sextupoles for storage ring



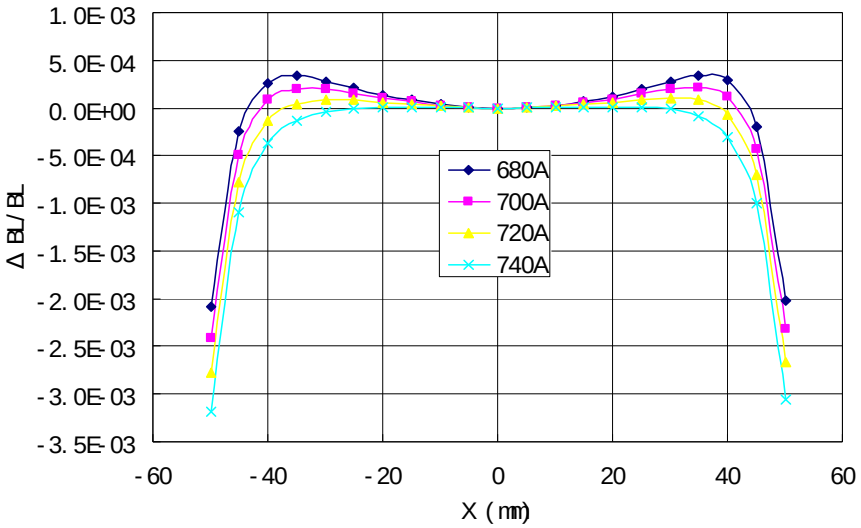
80 Correctors for storage ring



48 dipoles□56 quadrupoles □46 sextupoles for booster

1.4 Measured Magnets

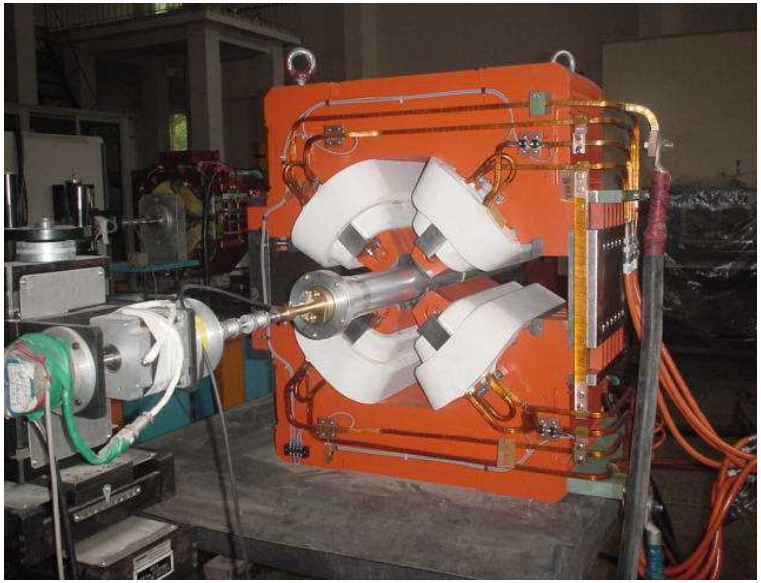
Dipole for Storage ring

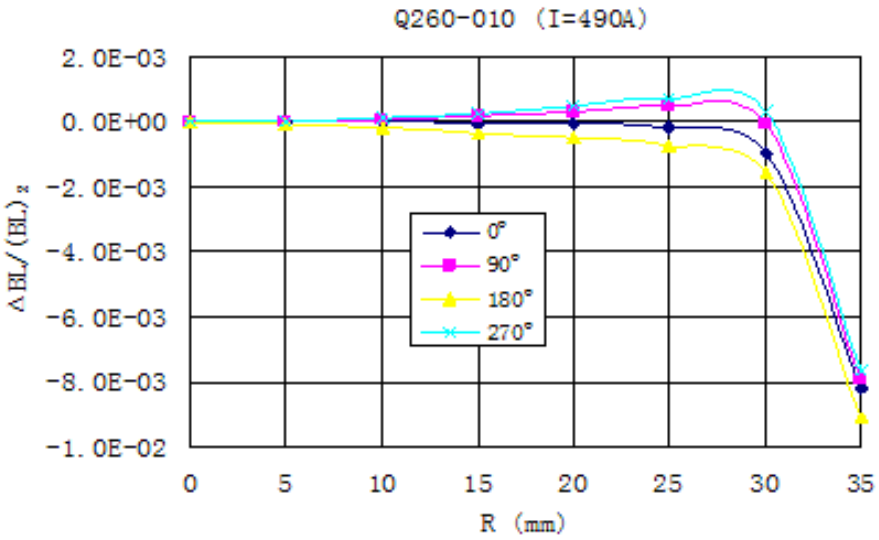


	Specification	Max. of Measured	RMS of Measured
B_n/B_1 @X=±27mm	3×10^{-4}	1.3×10^{-4}	0.8×10^{-4}
Integral Field Error @X≤±27mm	5×10^{-4}	1.5×10^{-4}	1.2×10^{-4}
Dispersion of Magnet to Magnet	1×10^{-3}	0.6×10^{-3}	0.3×10^{-3}

1.4 Measured Magnets

Quadrupole magnet for storage ring

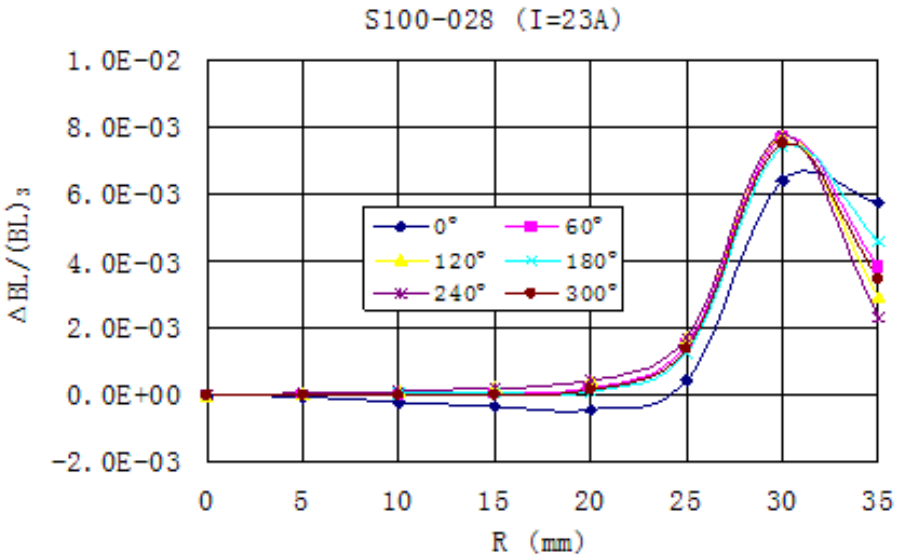




		Quadrupole	
Good Field Region		R≤25	
		Spec.	Meas.
Integral Field Error		2×10-3	2.0×10^{-3}
Dispersion of Magnet to Magnet @150MeV	Max.	5×10-3	3.4×10^{-3}
	RMS		1.7×10^{-3}
Dispersion of Magnet to Magnet @3.5GeV	Max.	2×10-3	3.1×10^{-3}
	RMS		1.3×10^{-3}

1.4 Measured Magnets

Sextupole magnet for storage ring

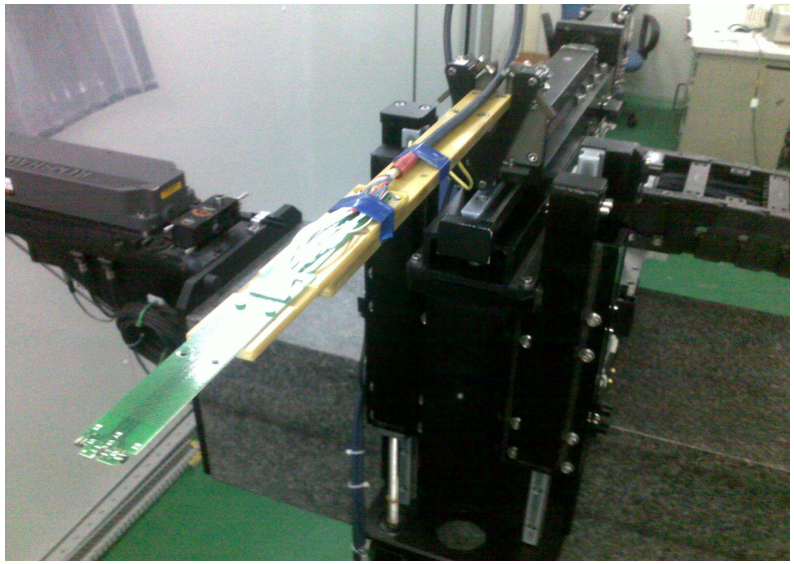


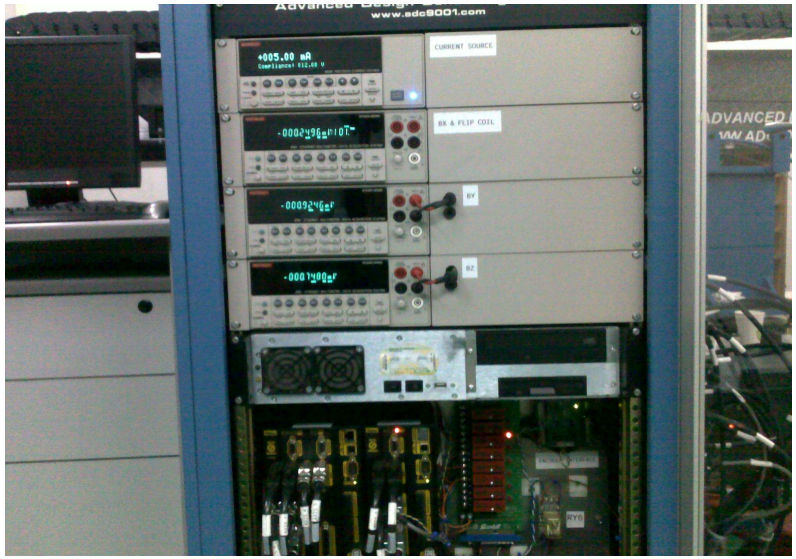
		Sextupole	
Good Field Region		R≤25	
		Spec.	Meas.
Integral Field Error		5×10-3	5.0×10^{-3}
Dispersion of Magnet to Magnet @150MeV	Max.	2×10-2	----
	RMS		----
Dispersion of Magnet to Magnet @3.5GeV	Max.	1×10-2	9.2×10^{-3}
	RMS		2.7×10^{-3}

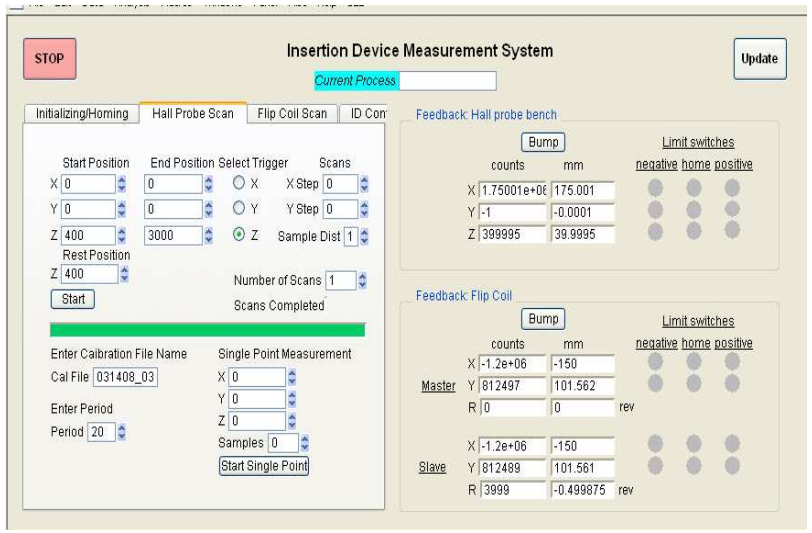
Part II

Measurements of insertion devices

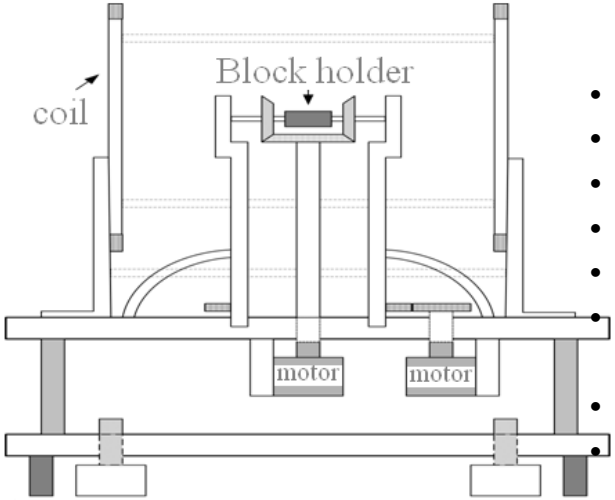
2.1 Hall probe System(3-D) and flipping coil system

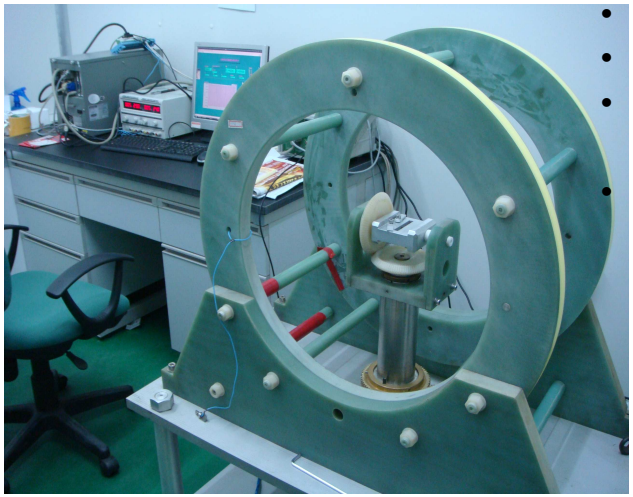






2.2 Helmholtz coil system





DESCRIPTION :

Coil: coil pair with parallel to each other, 1350 turns each coil

mechanism : a block holder, the three-degree rotation system,

motion control : a microcomputer together with a servo motor control card ;

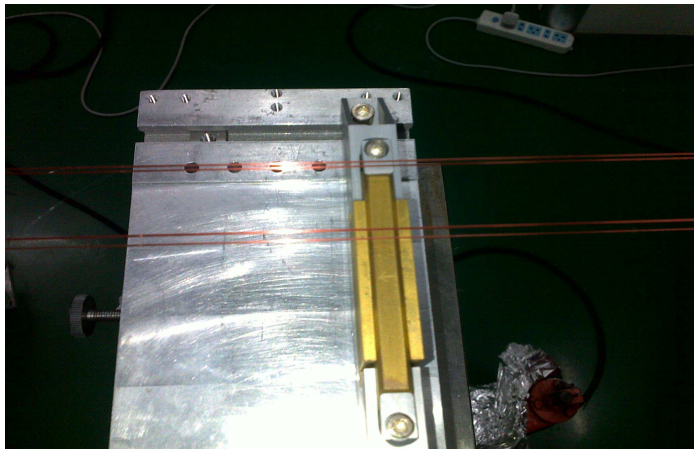
data acquisition : a digital integrator (metrolab PDI5025) connected by GPIB

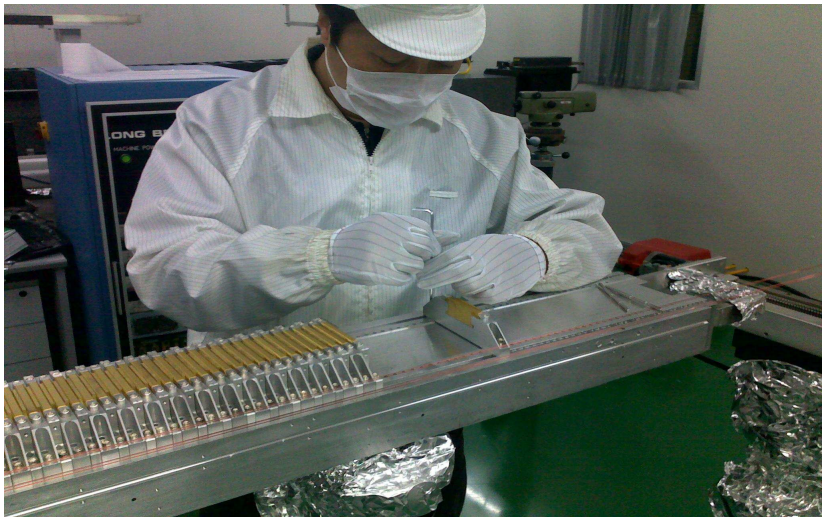
Efficient radius of the coil: 350mm

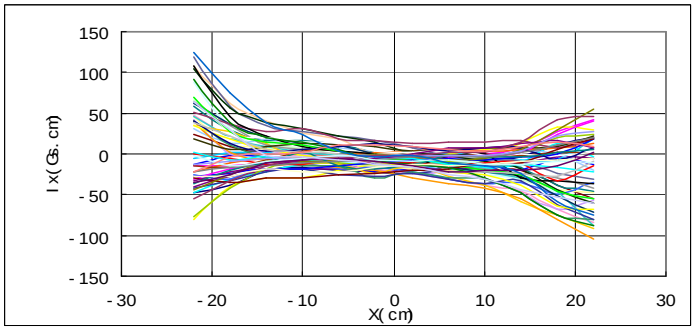
RMS repeatability: Magnetic moment -10Gs, deviation angel -0.1°

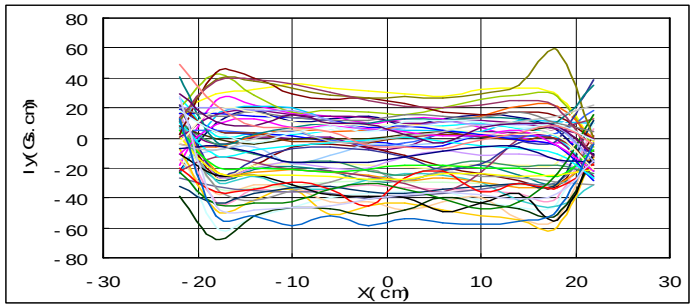
Measurement speed: 40 blocks per hour

2.3 Translation dual coils







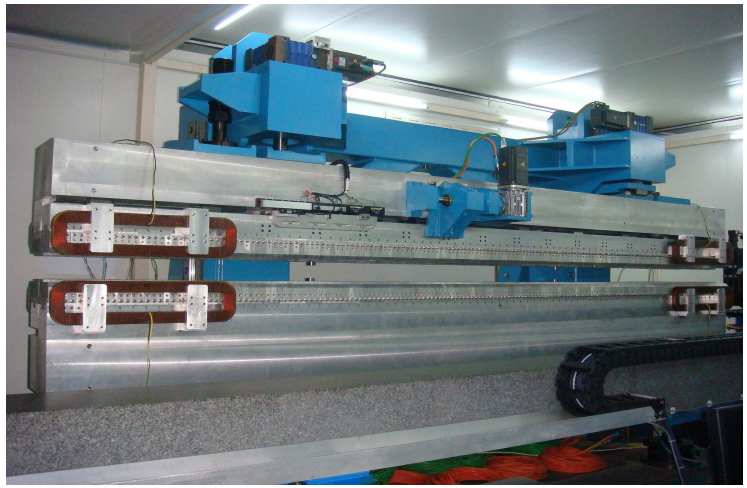


2.4 Hall probe calibration system

Standard Magnet

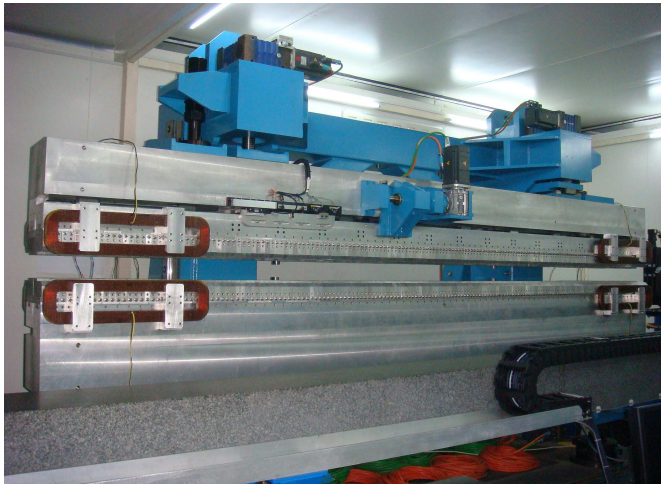
Control cabinet

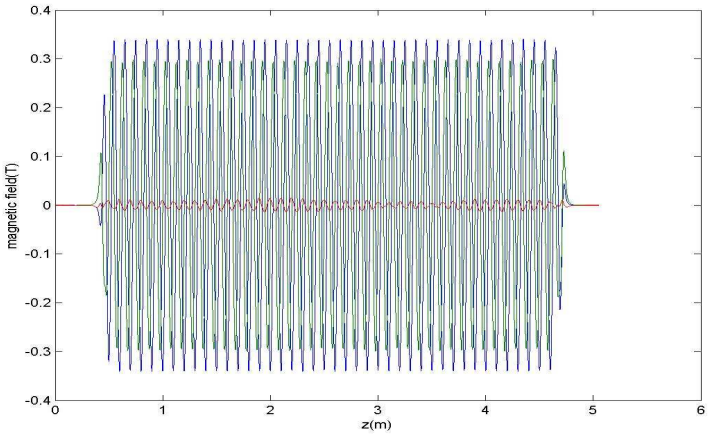
2.5 Built Insertion devices



2.5 Built Insertion devices

EPU100 for SSRF



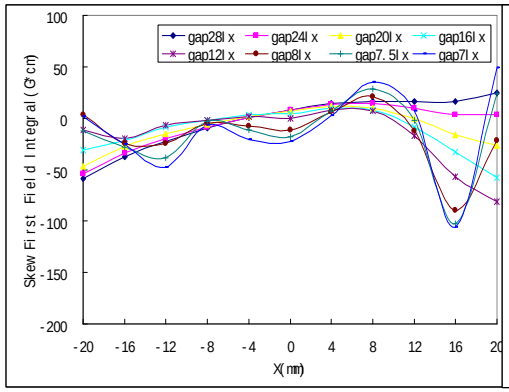


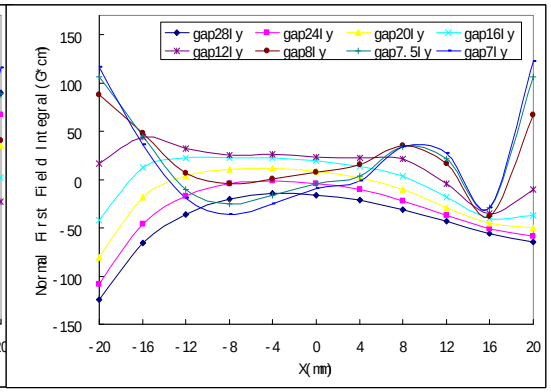
Main parameters and the measured magnetic performances of EPU100

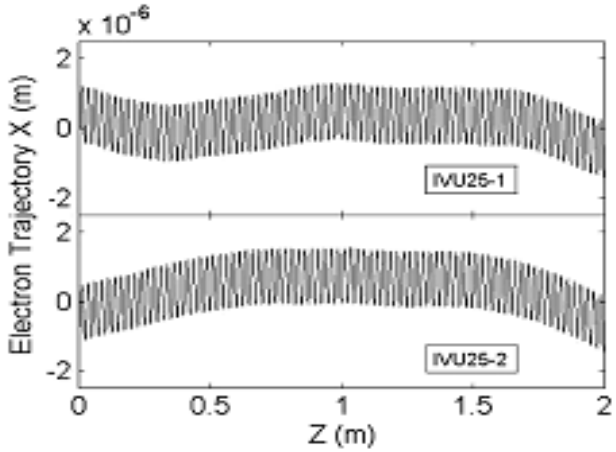
Period Length	100 mm
Number of Periods	42
Total Length	4.3 m
Gap Range	33 – 100 mm
Shift Range	±51 mm
Max. Peak Field B_y @H-Mode	0.60 T
Max. Peak Field B_x @V-Mode	0.39 T
Max. Peak Field $B_{x,y}$ @C-Mode	0.33 T
Field uniformity (roll-off) of B_x in $\lvert x \rvert \le 10$ mm	<30%
Field uniformity (roll-off) of B_y in $\lvert x \rvert \le 10$ mm	<3%
Phase Error (RMS)	<4°
First Field Integral	$<1.5\times10^{-5}$ T·m
Second Field Integral	$<0.6\times10^{-4}$ T·m^2
Multipole of Field Integral	
Quadrupole	$<8\times10^{-3}$ T
Sextupole	<1.2 T/m
Octupole	<30 T/m^2
Resolution of Setting Gap	<1 μm
Max. Speed of Gap Motion	1 mm/s
Resolution of Setting Phase Shift	<1 μm
Max. Speed of Phase Shift Motion	2 mm/s

2.5 Built Insertion devices

IVU25 for SSRF



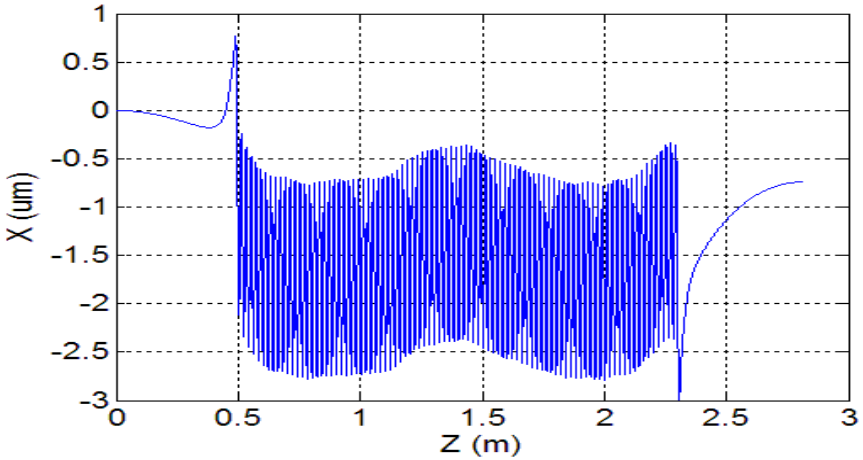


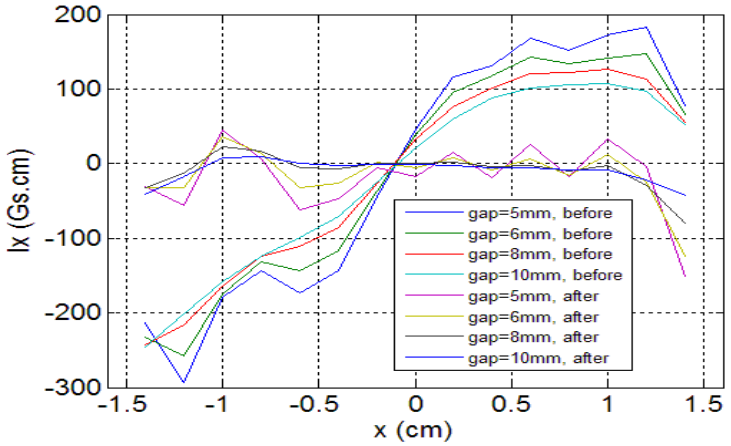


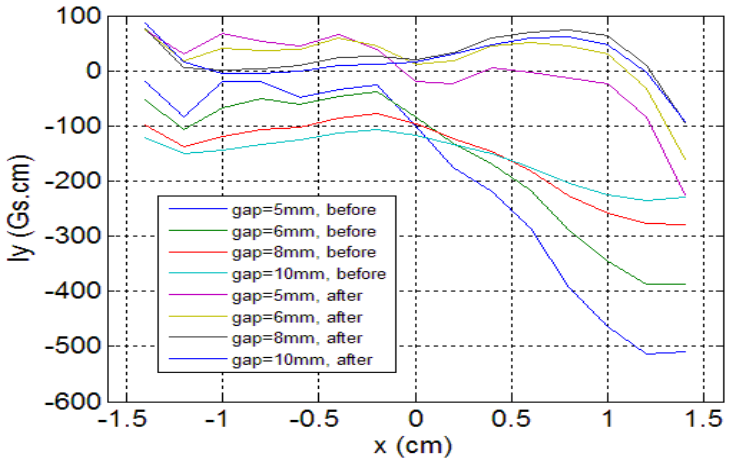
	IVU25-1	IVU25-2
Period Length	25 mm	25 mm
Number of Periods	80	80
Total Length	2.05 m	2.05 m
Gap Range	7 – 100 mm	7 – 100 mm
Peak Field at Minimum Gap	0.95 T	0.95 T
Number of Full Field Peak	160	160
Phase Error (RMS)	<3.1°	<2.2°
Average Orbit Off (x=0, y=0)	<1 μm	<1 μm
Multipole Error of the First Field Integrals in |x|≤10 mm	$<1.5\times10^{-4}$ T·m	$<6.8\times10^{-5}$ T·m
Multipole Error of the Second Field Integrals in |x|≤10 mm	$<1.8\times10^{-4}$ T·m^2	$<1.1\times10^{-4}$ T·m^2
Multipoles of Field Integral		
Quadrupole	$<4.4\times10^{-3}$ T	$<2.5\times10^{-3}$ T
Sextupole	<0.5 T/m	<0.5 T/m
Octupole	<55 T/m^2	<8 T/m^2
Max. Taper	0.2 mm	0.2 mm
Resolution of Setting Gap	<1 μm	<1 μm
Max. Speed of Gap Motion	1 mm/s	1 mm/s

2.5 Built Insertion devices

IVU20 for PLS







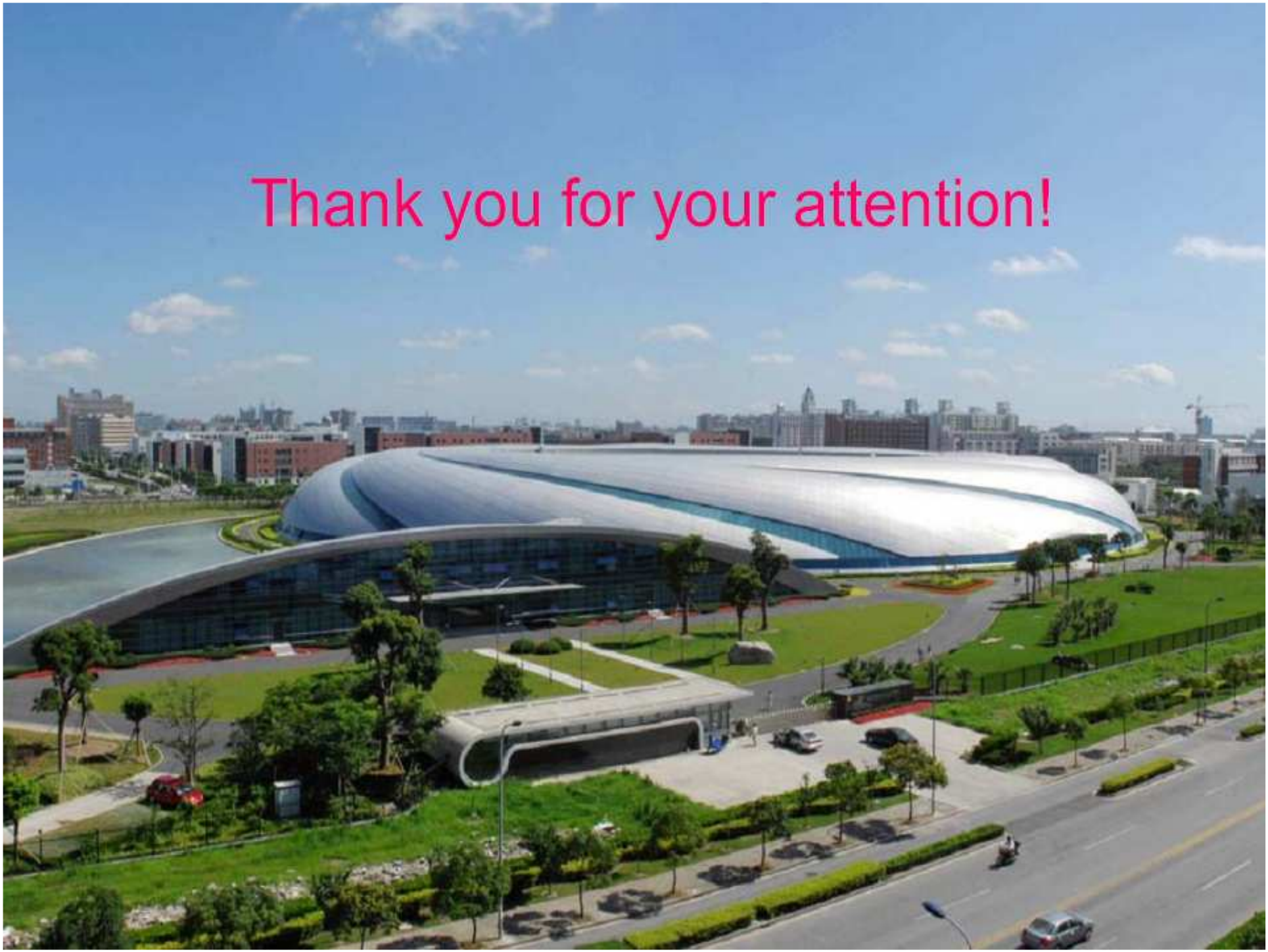
2.5 Built Insertion devices

Wigglers for SSRF

Photos of magnetic field integral measurement

Main parameters and the measured magnetic performances of two wigglers

	W80	W140
Period Length	80 mm	140 mm
Number of Periods	19	8
Total Length	1.71 m	1.42 m
Gap Range	15 – 140 mm	16 – 140 mm
Peak Field at Minimum Gap	1.21 T	1.98 T
Number of Full Field Peak	36	14
Dispersion of Peak to Peak	<1%	<1%
First Field Integral	$<5\times10^{-5}$ T·m	$<5\times10^{-5}$ T·m
Second Field Integral	$<2.5\times10^{-4}$ T·m^2	$<2.5\times10^{-4}$ T·m^2
Multipoles of Field Integral		
Quadrupole	$<4.5\times10^{-3}$ T	$<4.5\times10^{-3}$ T
Sextupole	<0.6 T/m	<0.6 T/m
Octupole	<65 T/m^2	<65 T/m^2
Resolution of Setting Gap	<1 μm	<1 μm
Max. Speed of Gap Motion	4 mm /s	4 mm /s


Thank you for your attention!