Progress of the DEPU for Dreamline at SSRF

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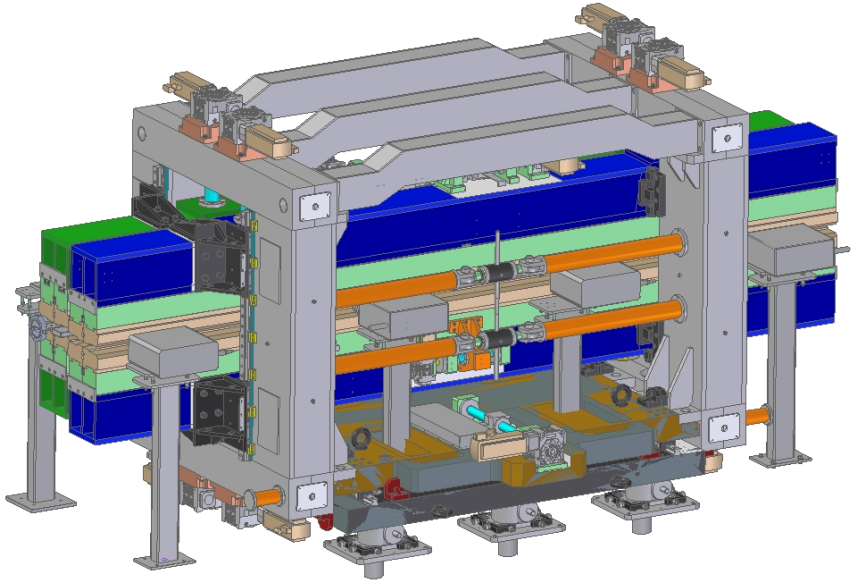
Outline

- Introduction
- DEPU fabrication and installation
  - Mechanical system
  - Vacuum system
- Orbit Compensation
- Summary

DEPU Main Parameters

Period length	148 mm	58 mm
Period number	32	84
Min. Gap	22 mm	16.5 mm
Peak By for H Mode	>0.66 T	>0.77 T
Peak. Bx,y for C Mode	>0.45 T	>0.43 T
Magnet length	4.88 m	4.97 m
Photon energy for H Mode	20- 200 eV	200 – 2000 eV
Photon energy for C Mode	20- 300 eV	300 – 2000 eV

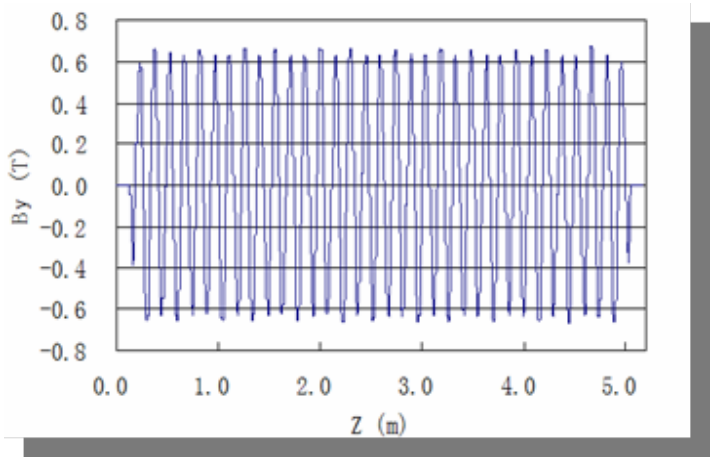


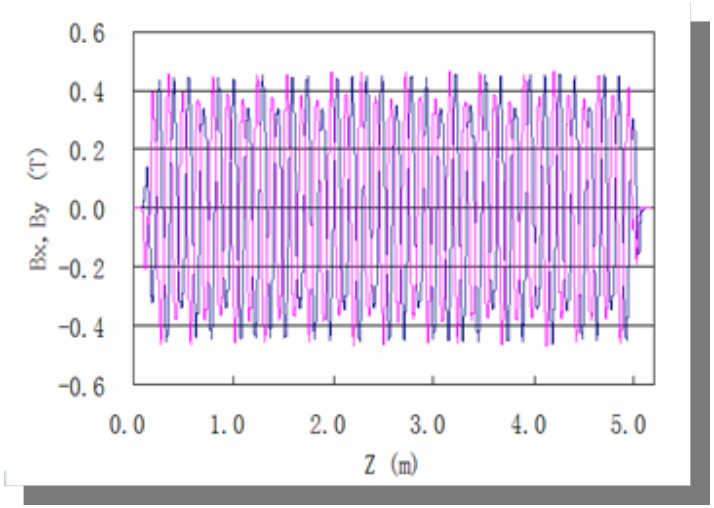
DEPU model

CPM

- 2010.10~2011.6 Design and review
- 2011.7~2012.4 Fabrication
- 2012.5~2013.2 Assembly, shimming and test
- 2013.3~2014.2 Beam commissioning and operation for beamline commissioning
- 2014.3~ Operation

DEPU Magnetic Performance

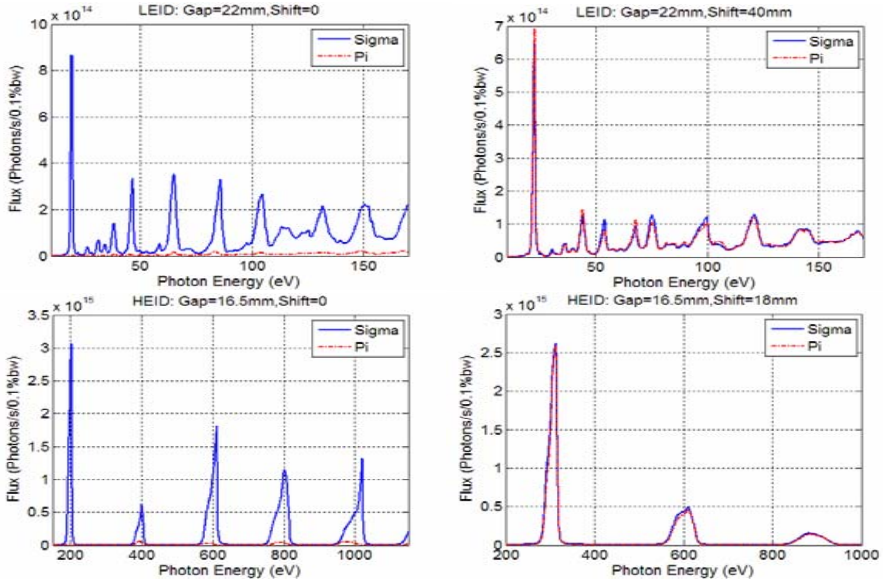




Quasi-periodic magnetic fields on axis of LEID : (upper) HP mode and (down) CP mode

Comparison of the Spectral Fluxes between Design and Simulated Results of LEID

	Design Results			Simulated Results		
n	En(eV)	Flux(ph/s/0.1%bw)		En(eV)	Flux(ph/s/0.1%bw)	
1	18.8	9.23E+14	1	19.3	8.93E+14	1
3	56.4	4.84E+13	5.2%	57.9	3.52E+13	4.0%
5	94.0	5.85E+13	6.3%	96.5	4.29E+13	4.8%
7	131.6	7.03E+13	7.6%	135.1	9.35E+13	10.5%



The simulated flux spectrum of LEID in the window ($0.36\times0.36mrad^2$ for LEID and $0.14\times0.22mrad^2$ for HEID) at min. gaps in H.P. mode and C.P. mode.

Mechanical Fabrication of DEPU

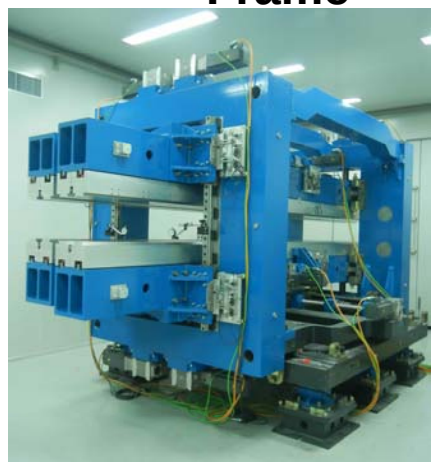
Steel plates

Backing beams

Frame

Aluminum beam

Assembly

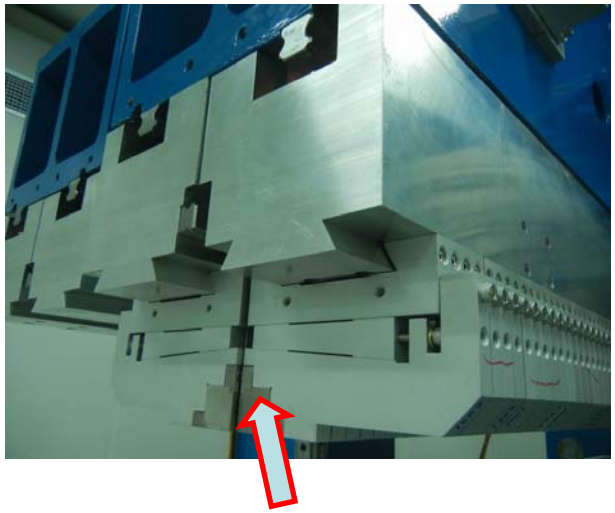


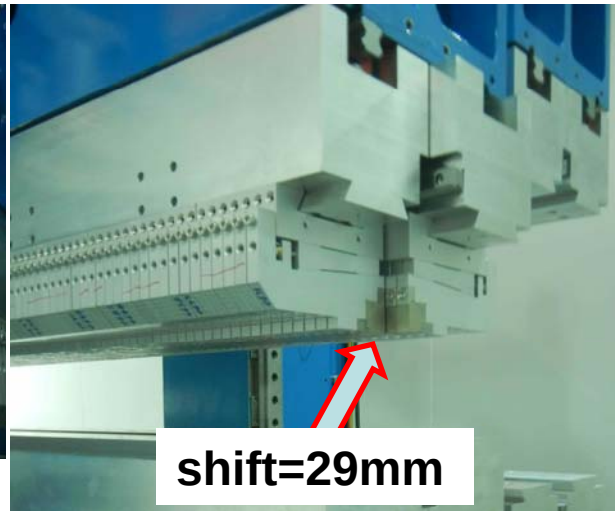
Ready for installation of magnet modules

Installation of magnet modules on upper beam of EPU58

Magnet modules

Start from middle to end



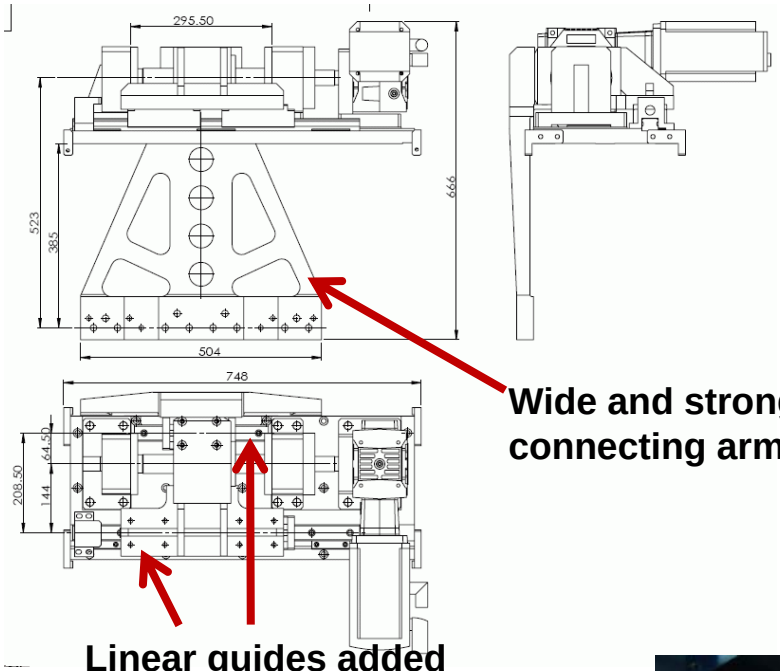


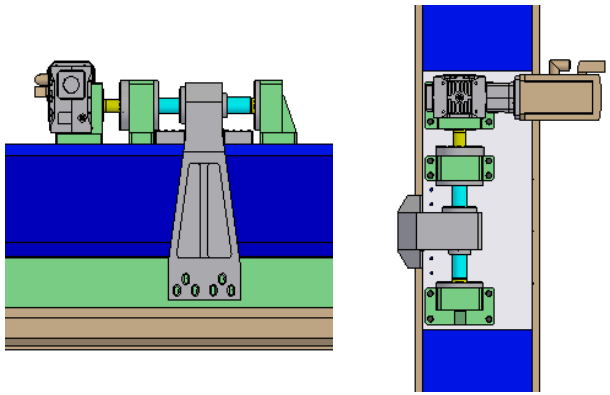
Problem:Shift between mobile beam and fixed beam

Magnetic forces

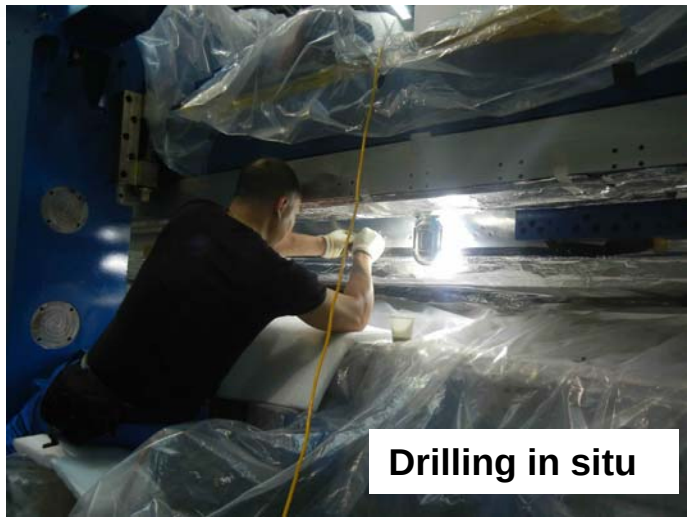
		EPU148(T)	EPU58(T)
Longitudinal	Max load at max. gap	0.6	1.9
	Max load at min. gap	0.16	0.75
vertical	Max attractive load	0.63	3.9
	Max repulsive load	0.36	2.5
horizontal	Max attractive load	1.07	4.2
	Max repulsive load	0.75	3.6

Revised design of upper shift driving system

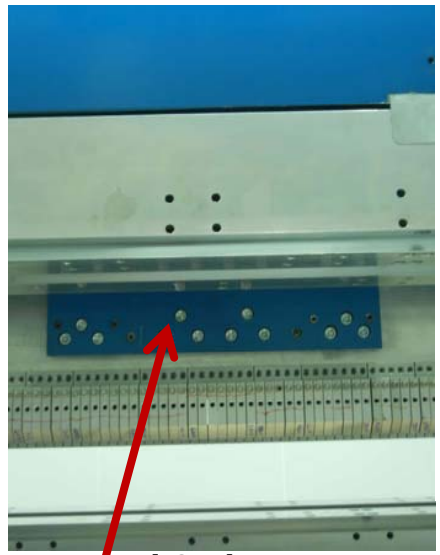




Initial design

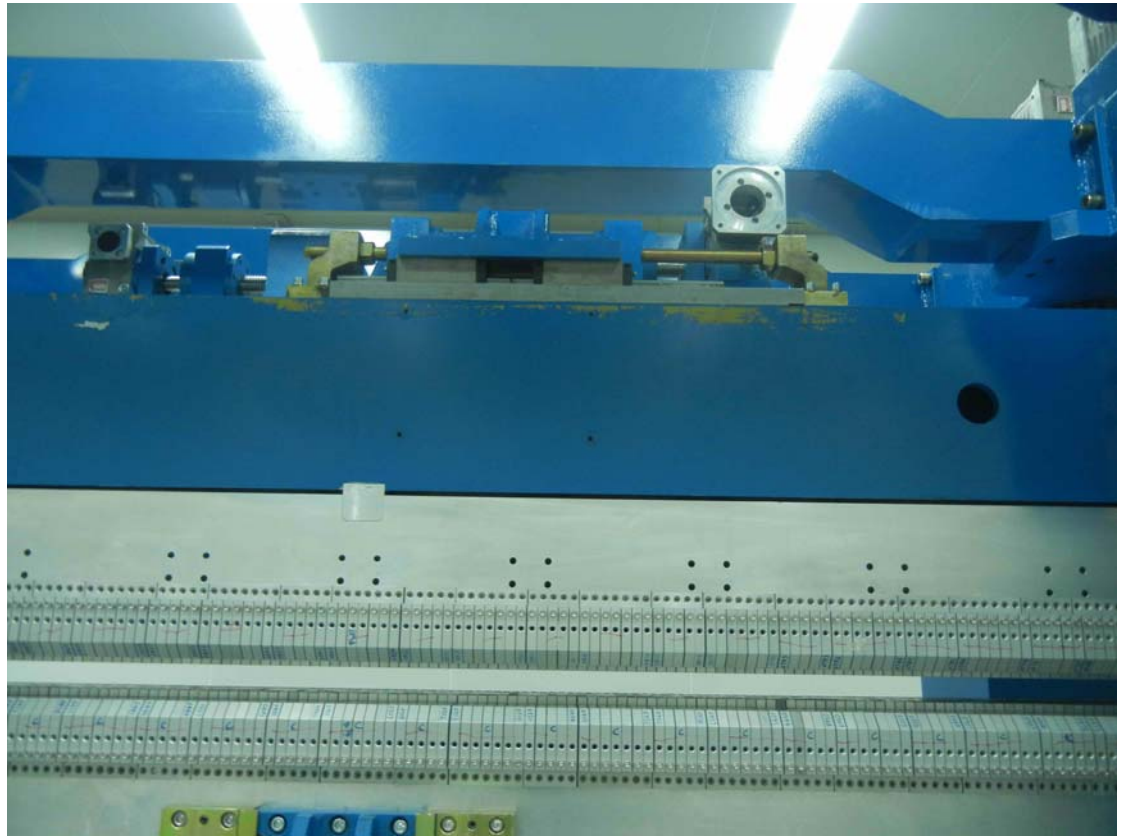


Drilling in situ



12 screws and 6 pins

Installation of magnet modules——completed



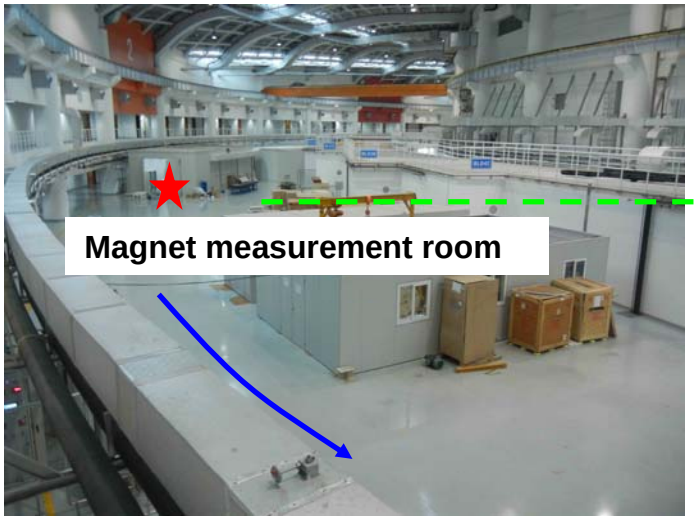
Magnetic Field Measurement for DEPU

Slide rail for HALL Probe

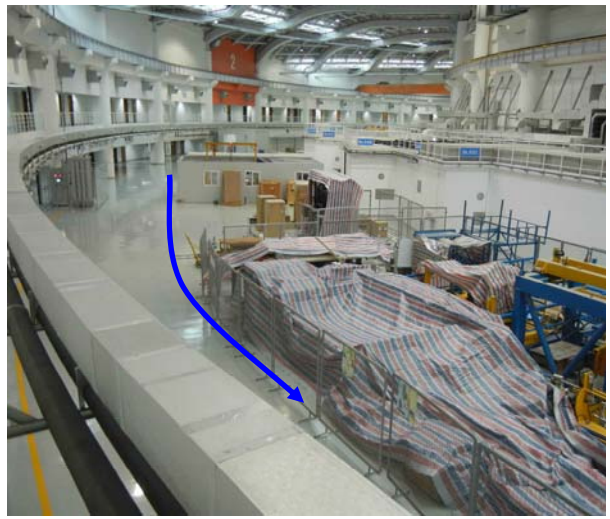
Survey

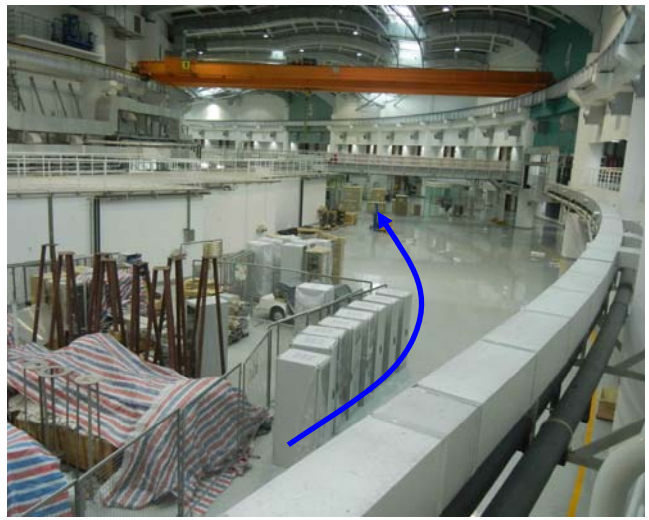
Point	X	Y	Z
A1	874.959	1393.616	1386.871
A2	874.979	-1384.99	1418.041
A3	1093.963	-1143.98	365.203
A4	1071.291	1128.897	365.631
A5	-1189.8	-1127.5	365.229
A6	-1196.18	1144.547	364.975
A9	789.062	1560.138	1299.348
F1	-974.96	-1385.5	702.04
F2	-974.969	-1385.5	1899.631
F3	-975.401	1390.765	1906.204
F4	-975.21	1383.928	696.369
F5	-889.567	1560.805	1295.592
F6	-889.851	-1558.7	1300.632
F8	-1275.89	-289.485	273.709
F9	788.633	-1559.37	1299.958

DEPU Installation route



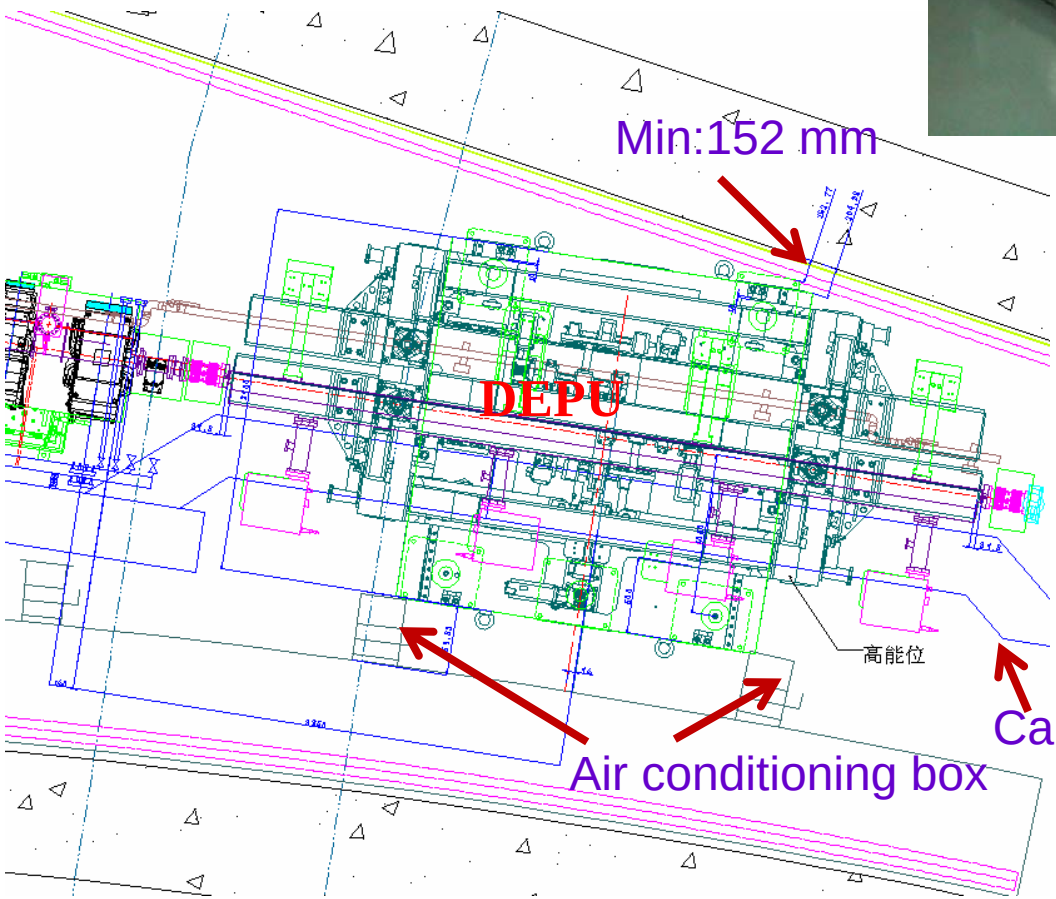
110m





Trailer truck (35T) carrying DEPU

Installation of DEPU into tunnel



Difficulties:

- **Big size (5×2.4×2.5m)**
- **Heavy (32T)**
- **Limited space**
- **Obstacles:**
  air conditioning box, cable bridge, etc

Mobile crane (200T) lifting DEPU out of magnet measurement room

DEPU into tunnel

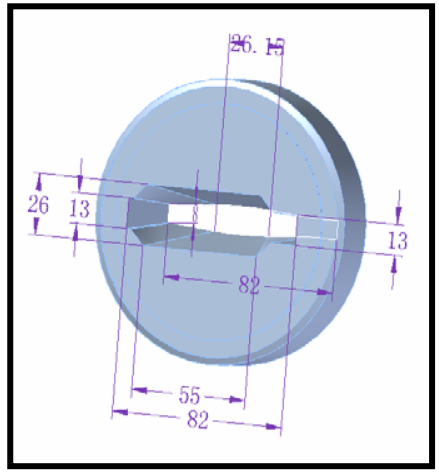
Alignment

Survey and alignment results

	Measurement value				Theoretical value			deviation value		
Point	X	Y	Z	Point	X	Y	Z	dX	dY	dZ
F1	-974.748	-1385.47	701.997	F1	-974.96	-1385.5	702.04	0.212	0.032	-0.043
F2	-974.925	-1385.27	1899.552	F2	-974.969	-1385.5	1899.631	0.044	0.233	-0.079
F3	-975.142	1390.799	1906.189	F3	-975.401	1390.765	1906.204	0.259	0.034	-0.015
F4	-975.182	1383.915	696.396	F4	-975.21	1383.928	696.369	0.028	-0.013	0.027

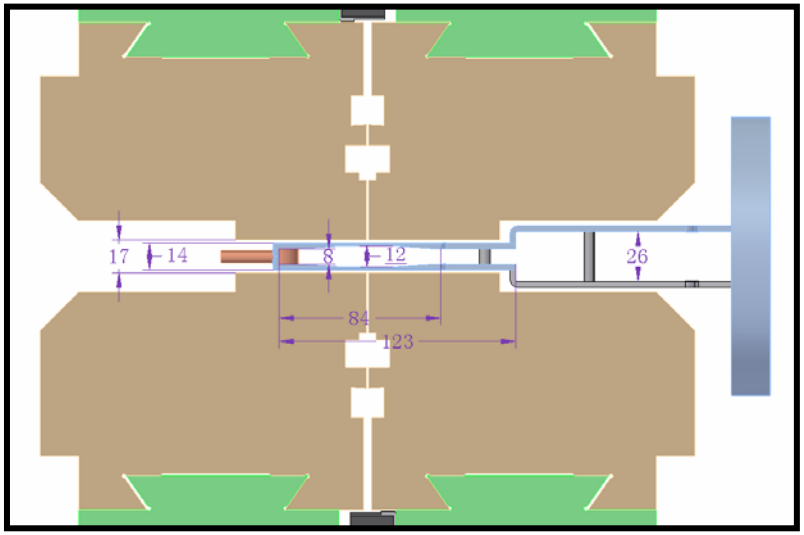
DEPU Vacuum System

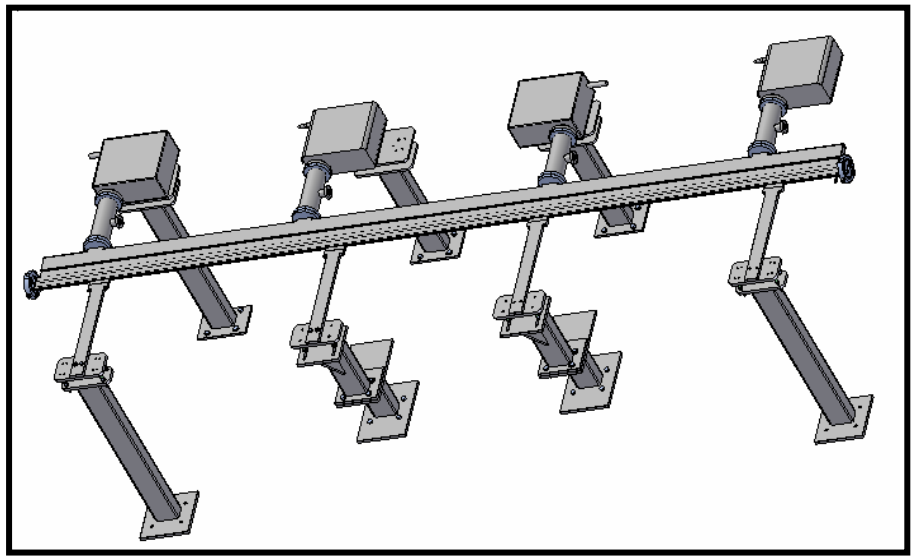
- Anti-chamber type with welding structure
- Stainless steel 316L chamber, 304 flange
- SIP+NEG pump
- OFHC tube absorber along beam channel, inner supports between beam channel and pumping channel
- Cu coating for beam channel
- Beam channel cross section transition in flange
- Chamber supports on both side, no interface with frame moving
- Key techniques: Cu coating, deformation control, magnetic permeability reducing



Cross section transition

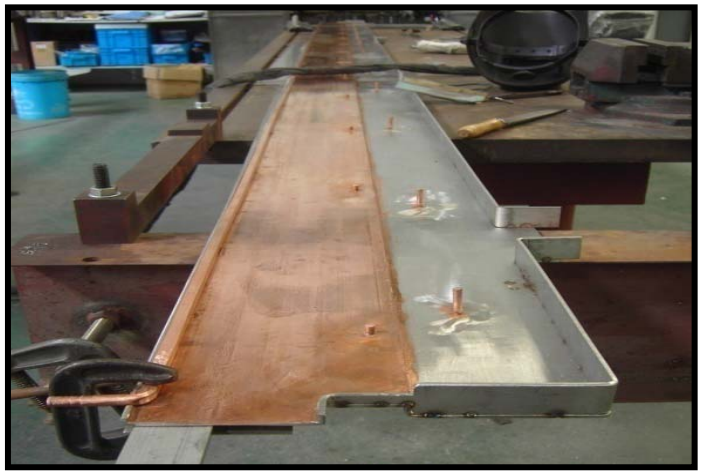
Cross section of chamber





Vacuum system for DEPU

Vacuum Chamber Fabrication and Installation



Vacuum chamber after Cu coating

Dimension inspection after welding

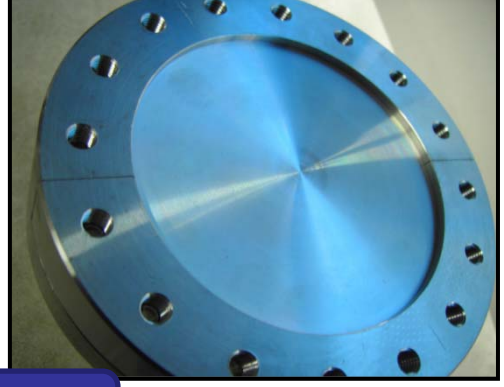
Demagnetized in vacuum furnace

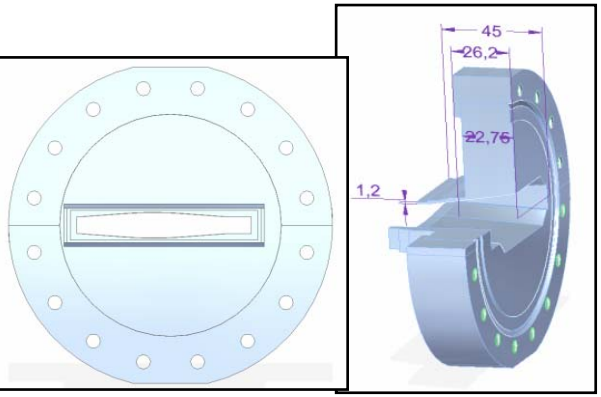
Vacuum chamber installed

Vacuum Chamber Problem 1

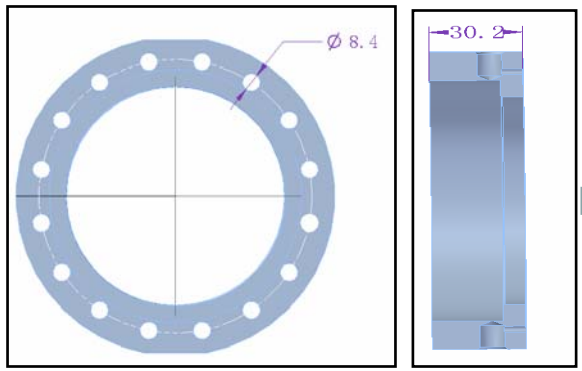
- Flange thickness error
- Interface with EPU magnet when shift to maximum
- Cut the rotation ring in situ, change new ring
  Two-half type ring
  Thickness from 30.2mm to 26.2mm
  Bolts hole from Ø8.4 to M8
- 3mm clearance between flange and magnet in maximum shift of ±74mm
- Interface problem solved, 2013.08

Two-half ring structure



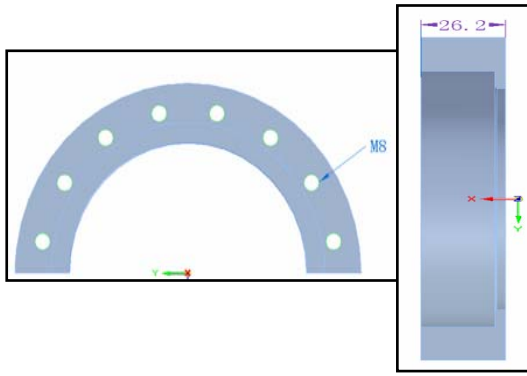


Corrector flange



Thick flange

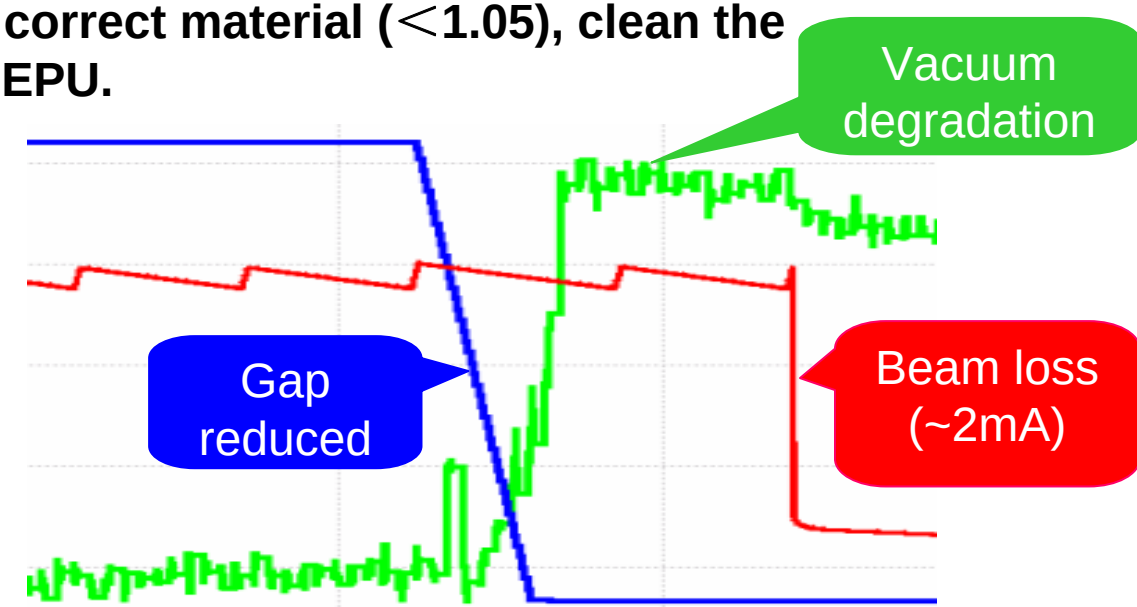
Modify



Modified flange

Vacuum Chamber Problem 2

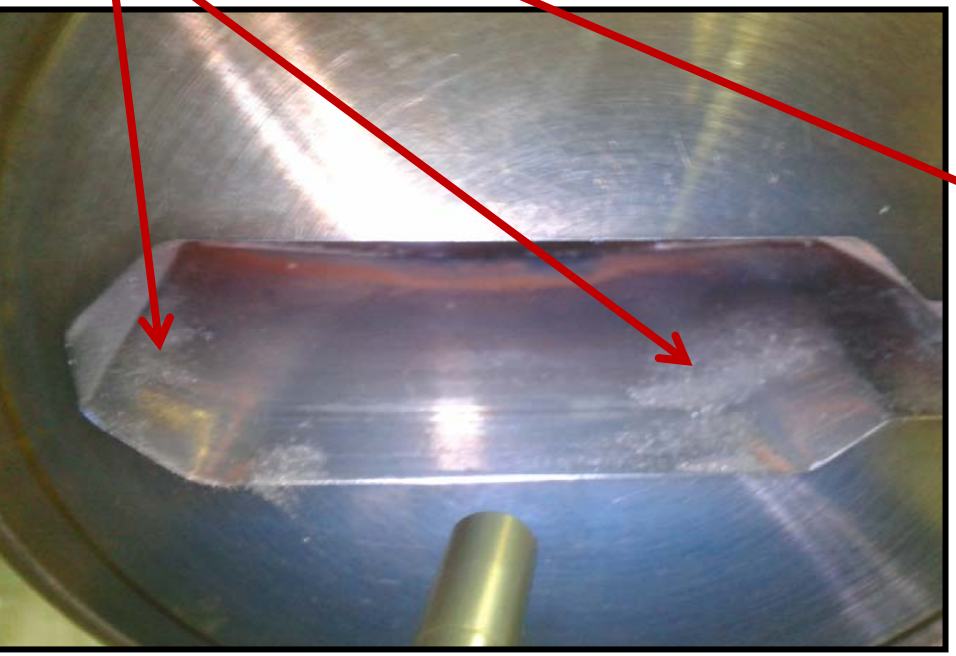
- BUT. Injection difficult in EPU small gap and beam lost when EPU gap change
- Guess: magnetic material inside the beam channel
- Clean (drag) the beam channel using magnet block from outside of the chamber, it works, but still some influence to the beam.
- Check the magnetic permeability of flange, ＞2.5!
- Open the chamber flange, found magnetic chips in the beam channel (it came from the flange cutting in situ in 2013.08)
- Dismount the chamber from Undulator. Cut the existing flanges, welded new flanges with correct material (＜1.05), clean the chamber, installed into DEPU.
- Problem solved, 2014.02

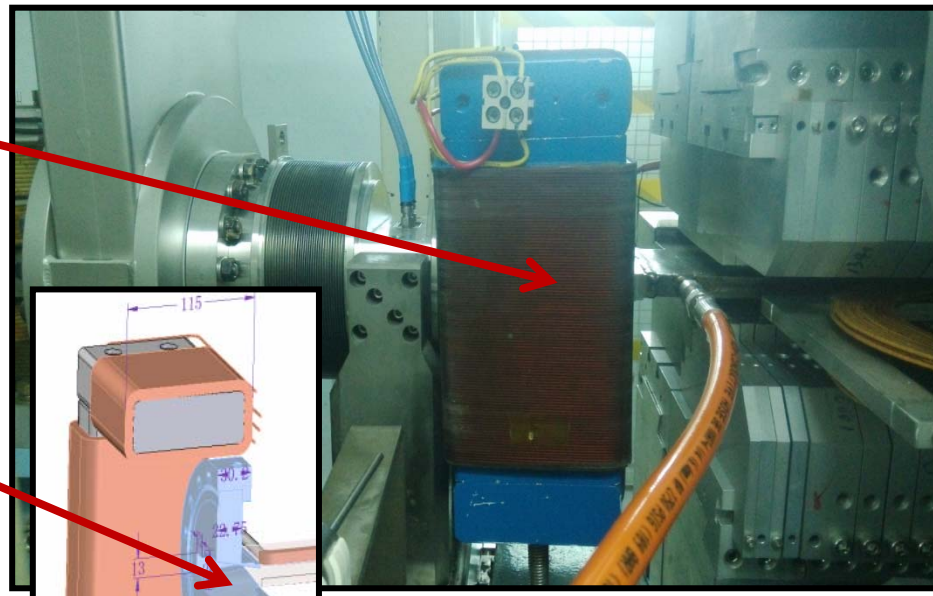


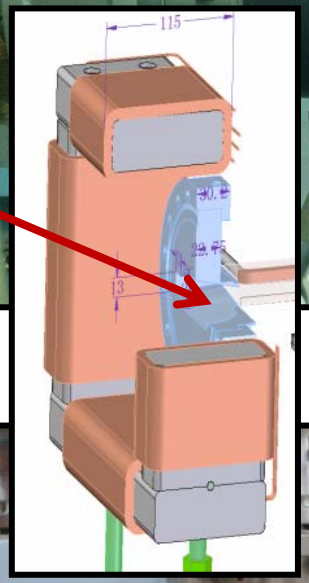
Beam lost when changing undulator gap

A correction magnet outside the beam chamber flange

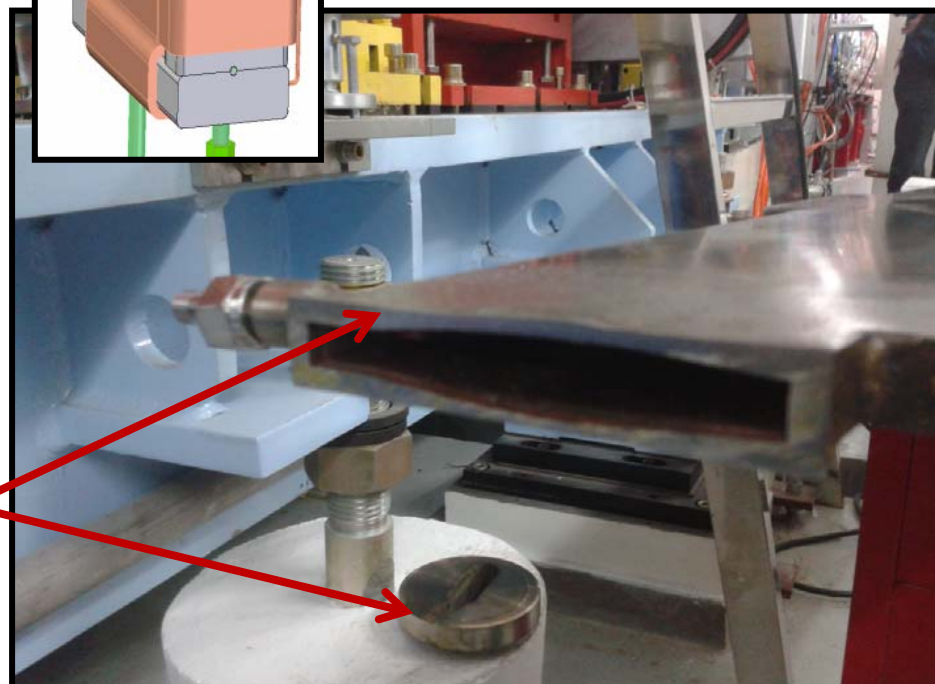
Chips in the beam channel







Chamber and flange in repairing



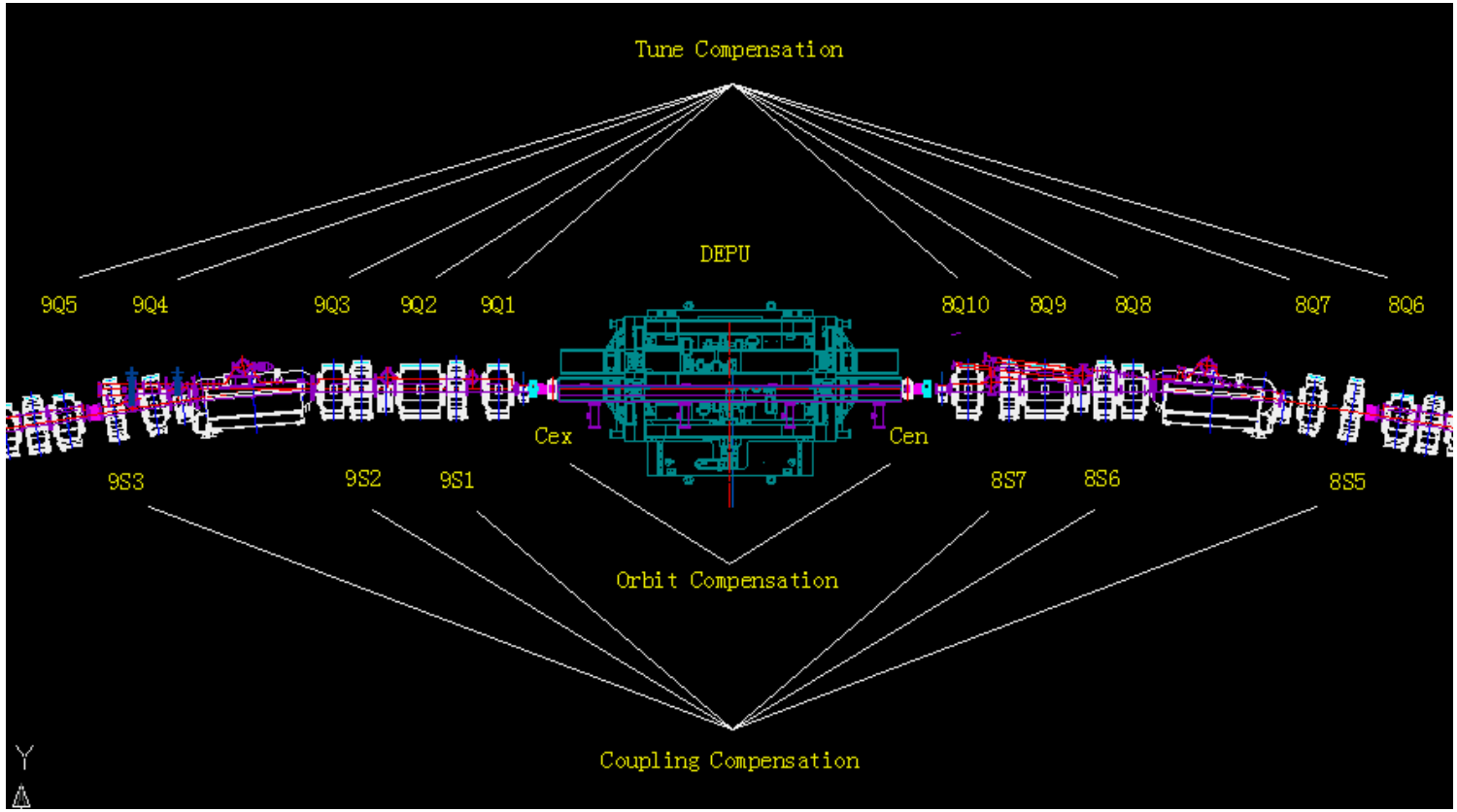
Feed Forward System

- EPU58
  - 10 quadrupoles feed-forward for tune compensation: $\Delta < 0.001$
  - 6 Sextupoles feed-forward for coupling compensation: $\Delta < 0.2\%$
  - Optimization to increase the injection efficiency: ~80%
  - Feed-forward for closed orbit distortion:

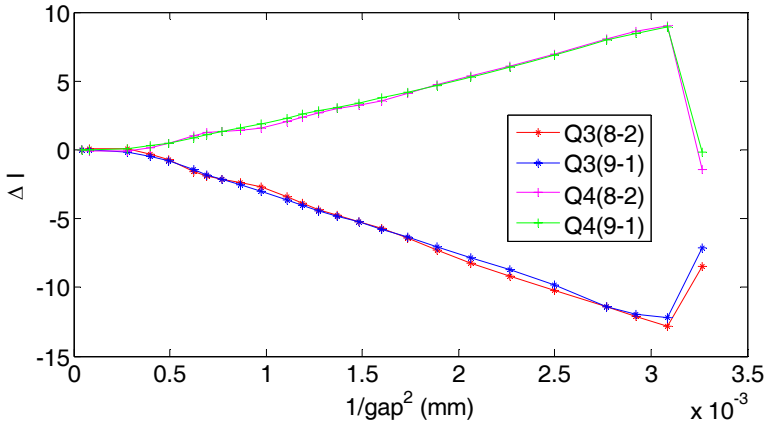
    Gap: $\Delta < 4/2\ \mu$m (H/V), shift: $\Delta < 2/2\ \mu$m (H/V)
- EPU148
  - Feed-forward for closed orbit distortion:

    Gap: $\Delta < 2/1\ \mu$m (H/V), shift: $\Delta < 2/2\ \mu$m (H/V)
- EPU58 -EPU148 transfer
  - Feed-forward for closed orbit distortion: $\Delta < 2/1\ \mu$m (H/V)

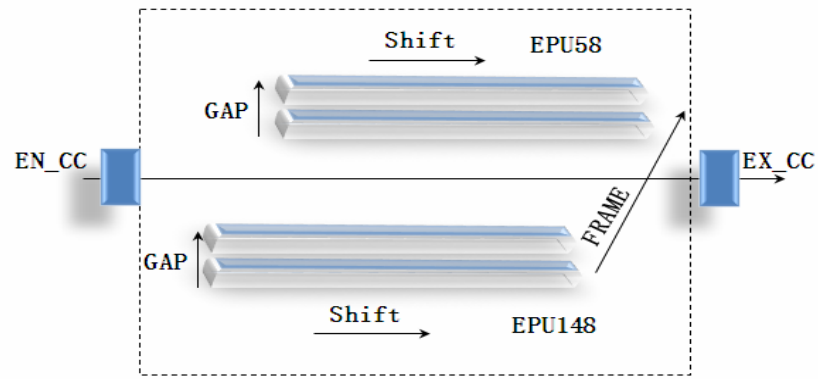
Tune and Coupling Compensation



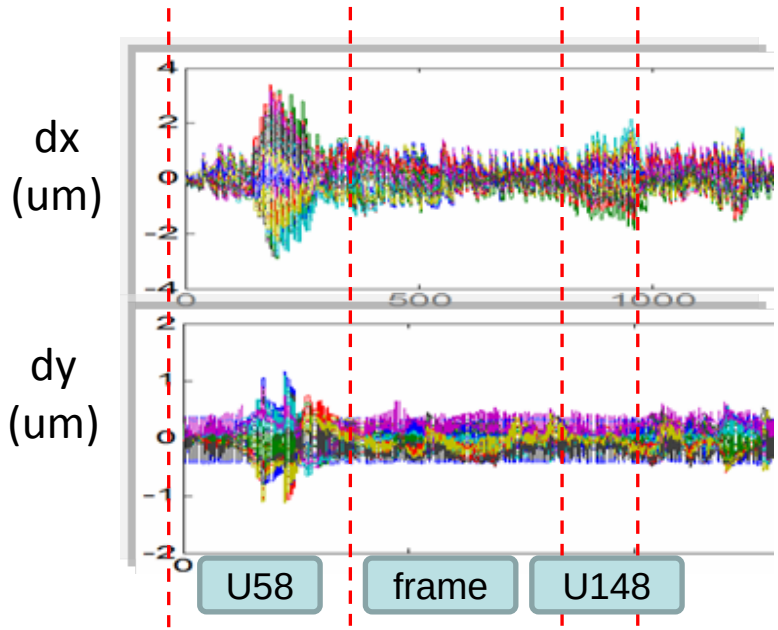
Tune compensation
Δ I – g curve
for Q3 and Q4



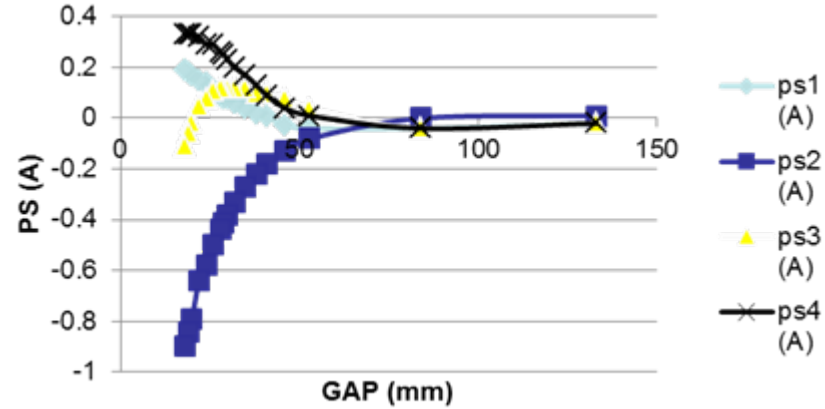
Orbit Compensation



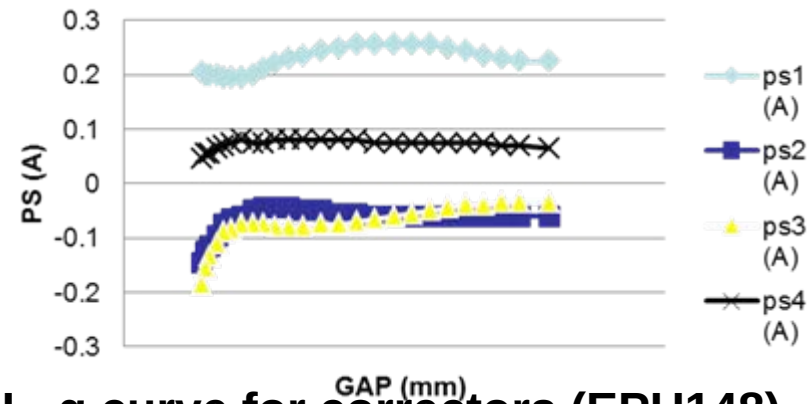
Feed Forward for Orbit



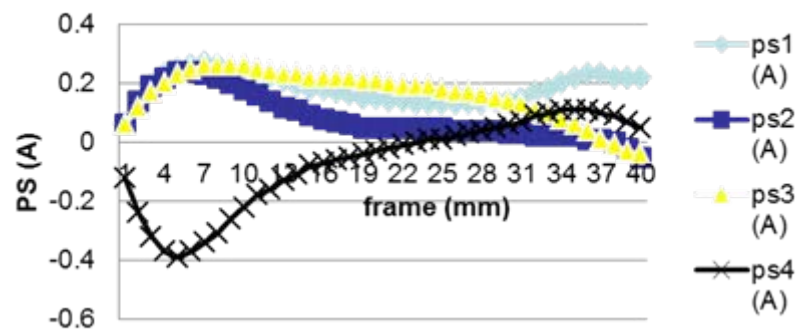
Beam orbit during gap change for DEPU



I - g curve for correctors (EPU58)



I - g curve for correctors (EPU148)



I - g curve for correctors (EPU148 –EPU58 transfer)

Summary

- Shift driving system design was modified to solve the mechanical problem occured during the magnets assembly.
- DEPU was installed and aligned into storage ring C09 from Feb.2013 to Mar. 2013.
- A series of trouble in the vacuum chamber, including the flange dimension error and magnetic dust left in the beam channel were found during the commissioning and solved at last in 2014 winter shut down.
- Orbit compensation was completed partly and the DEPU was operated to the beamline commissioning and user operation soon.

Thank you!