Upgrade of Accelerator Complex at Pohang Light Source Facility (PLS-II)

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PAL/POSTECH

On behalf of PAL Staffs Joined in the PLS-II Project

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PAL 포항가속기연구소
POHANG ACCELERATOR LABORATORY

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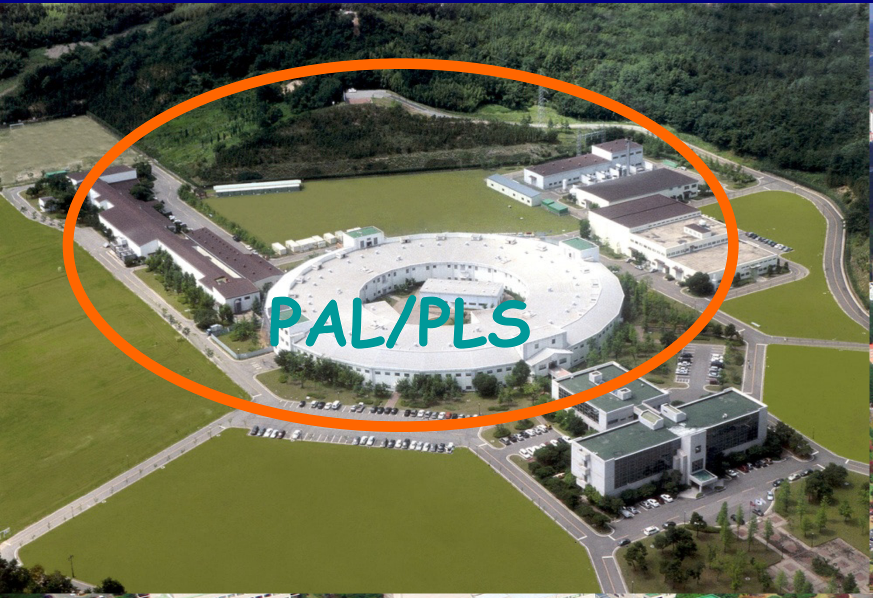
Aerial View of PAL/POSTECH Campus

Aerial View of PAL/POSTECH Campus



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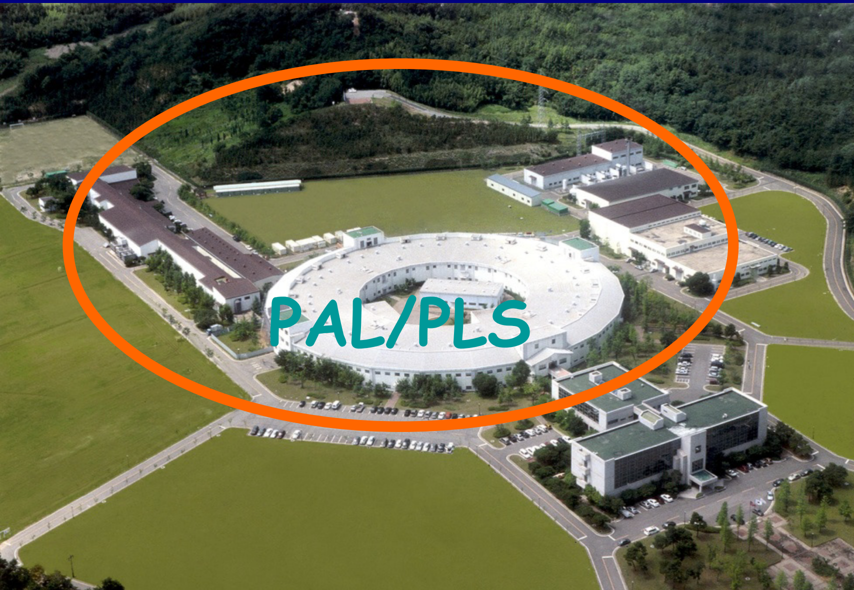

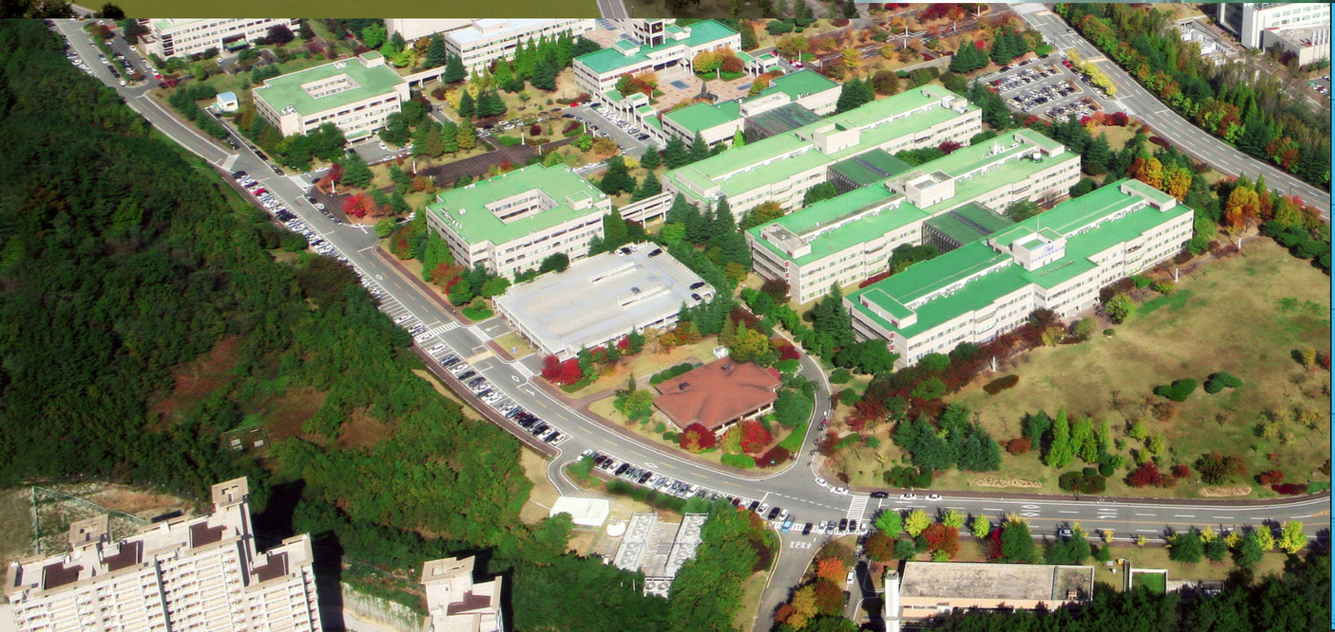

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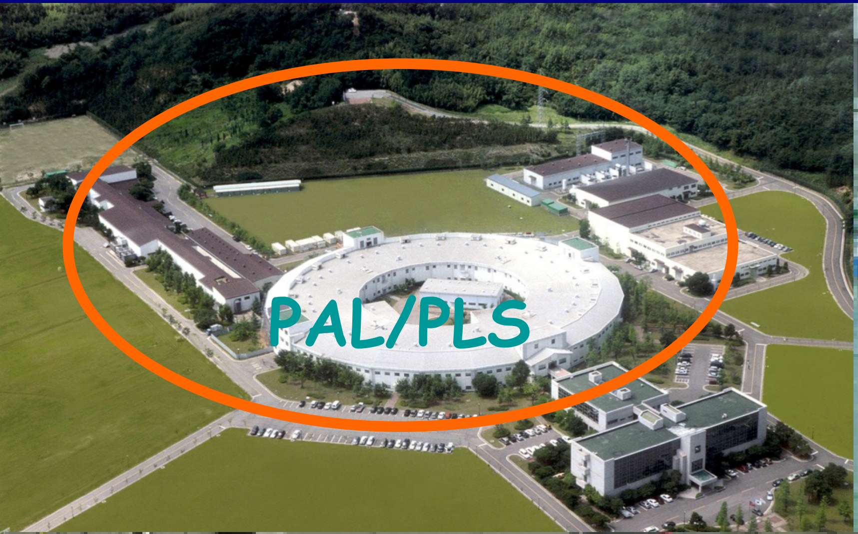

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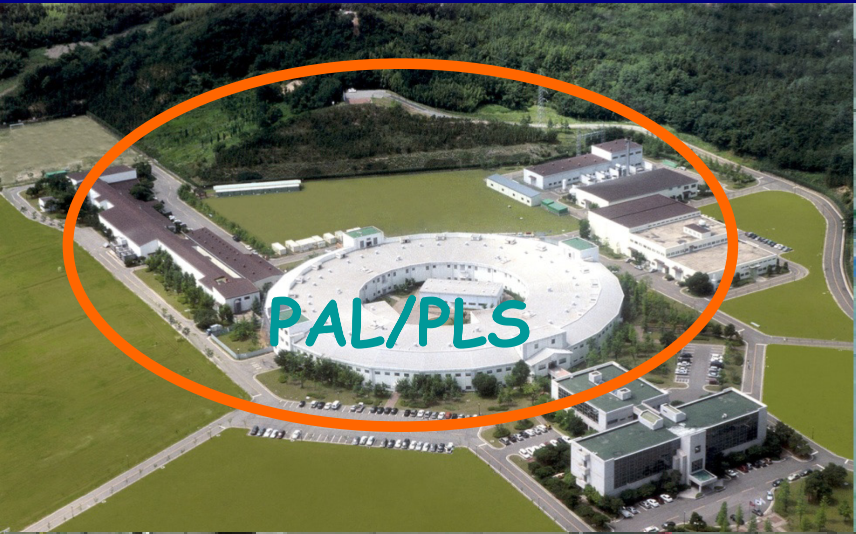

PLS Operation Issues and User's Demands

- Nation's Reliable and Mature Multi-user Large-Scale Light Source Facility
- Elaborate Cutting-Edge Scientific Needs from User Community

- **More Fine Beam Orbit Stability and Reliability**
  - Need more correlated analysis between e-beam performance and photon beam stability
  - Need well-established orbit control scheme to be adaptable into the proper PLS operation environment
  - Fine beam control requirements, especially ID users
- **High Flux and Brilliance Beam**
  - Meet advanced user's research demands
  - More ID beamlines at lower operation and construction costs through PLS upgrade (PLS-II)

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Overview of PLS-II Project

- PLS-II Project Schedule : FY 2009 – FY 2011 (3 years)
- Project Organization : PAL PLS-II Project Team (including domestic and abroad expertise joined) with a support of KOSUA
- Project Cost Breakdown (only machine upgrade) (US M$)

Systems	Fiscal Year			Total Budget
	2009	2010	2011	
Storage Ring	15.1	25.11	9.42	49.63
Linac	8.57	5.97	1.6	16.14
Beamline	5.46	11.82	6.62	23.9
Utility and Infrastructures	0.87	3.5	5.96	10.33
Total Budget	30.0	46.4	23.6	100.0

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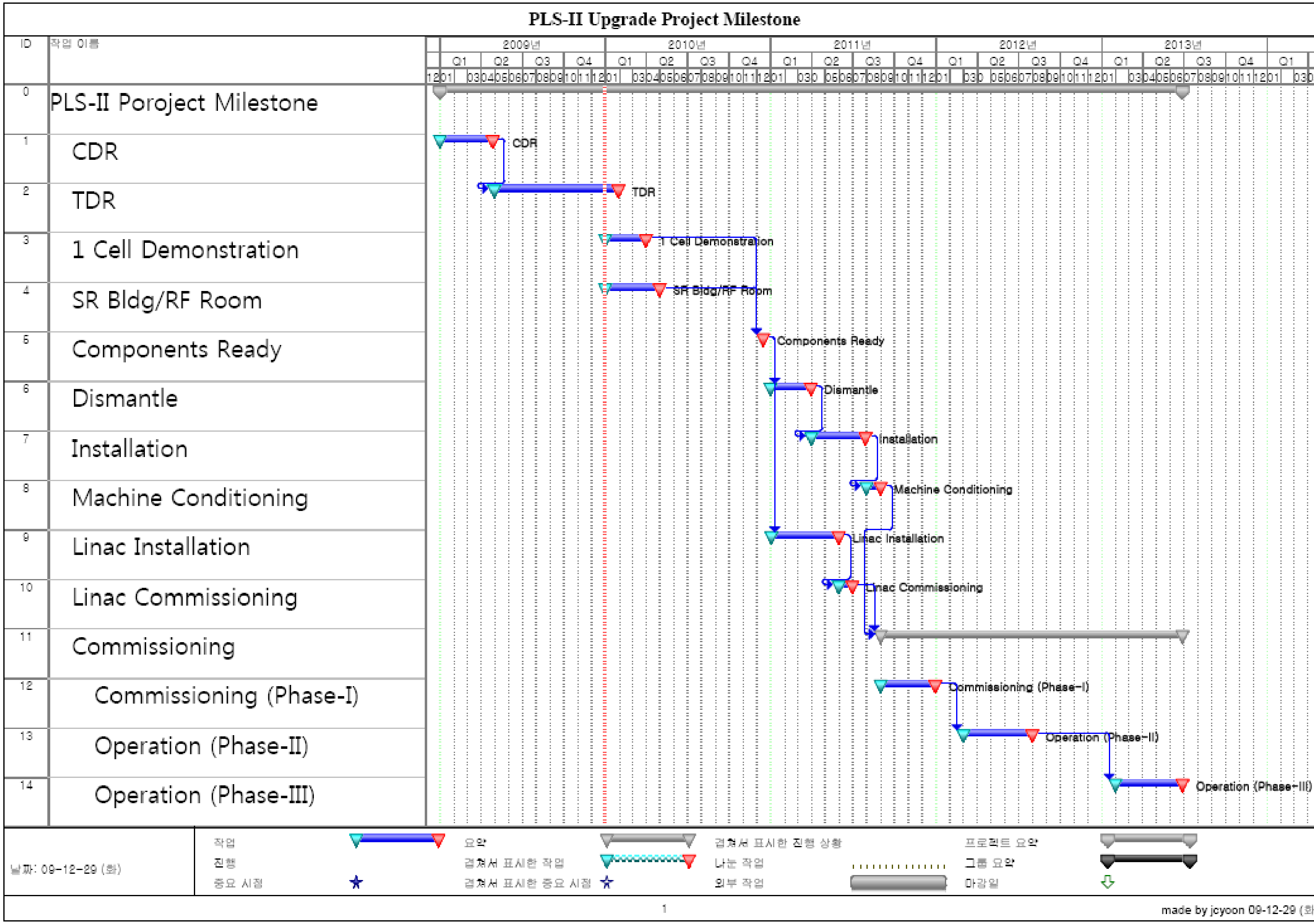
Key Milestones of PLS-II Project



Status of PLS-II Accelerator System

Foundation of PLS-II Accelerator System Upgrade

Concepts of PLS Upgrade Plan for the PLS-II

- **Established PLS-II design work with a great help from Prof. Helmut Wiedemann in October 2008.**
  - Justification of the PLS Upgrade (lower beam emittance, higher photon energies as well as more straight sections for insertion devices in the PLS-II)
  - Outlined the scope of upgrade (storage ring lattice, hardware systems, beam monitoring/diagnostics, top-up operation and linac energy upgrade in the PLS-II)
  - ID and photon source calculation (photon beam performance in the short and long straight sections)

Classification of PLS-II System Upgrade Structures

Scope of PLS-II Upgrade

- ✓ **Magnetic Lattice** : low emittance of 5-7 nm at 3 GeV with a number of 20 ID sections (TBA→DBA)
- ✓ **Bending Magnets** : small pole gap of 34 mm compared to 56 mm in PLS
- ✓ **Quadrupoles and Sextupoles** : new more sextupoles for much stronger focusing
- ✓ **Vacuum Chamber** : newly designed and constructed
- ✓ **Beam Position Monitors** : more stable support from the girder
- ✓ **Magnet Power Supplies** : depending on the number of magnets and adjustment of beam dynamics
- ✓ **RF System** : sustain the 400 mA at 3 GeV, HOM-damped style (NC, SC) cavity be implemented
- ✓ **Linac Upgrade for Top-up** : upgrade to 3 GeV and sustain stable beam condition
- ✓ **Photon Beamline-Relocation and Heat Load Issue** : newly designed for high heat load components such as photon mask, shutter
- ✓ **R&D on Key Components** : In-vac Undulator and DCM, Microwave Components, Others

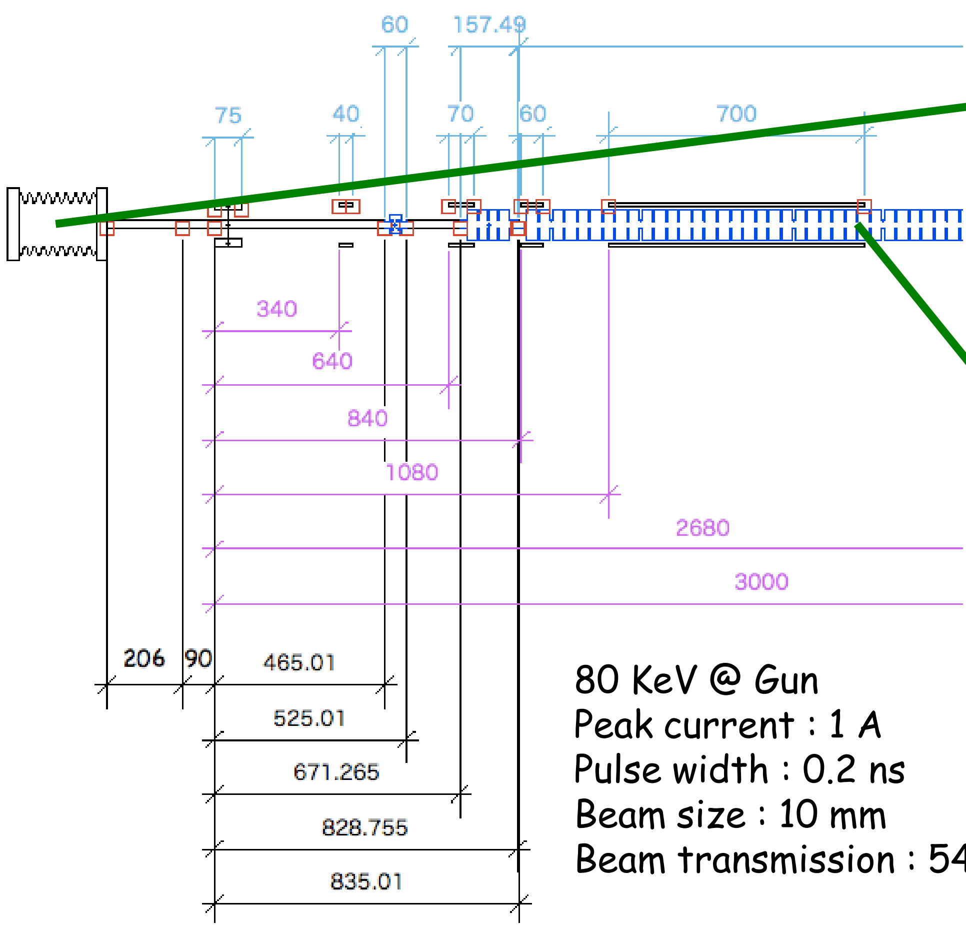
Upgrade of PLS-II Linac Full Energy Injector

PLS-II Linear Accelerator of 3.0 GeV

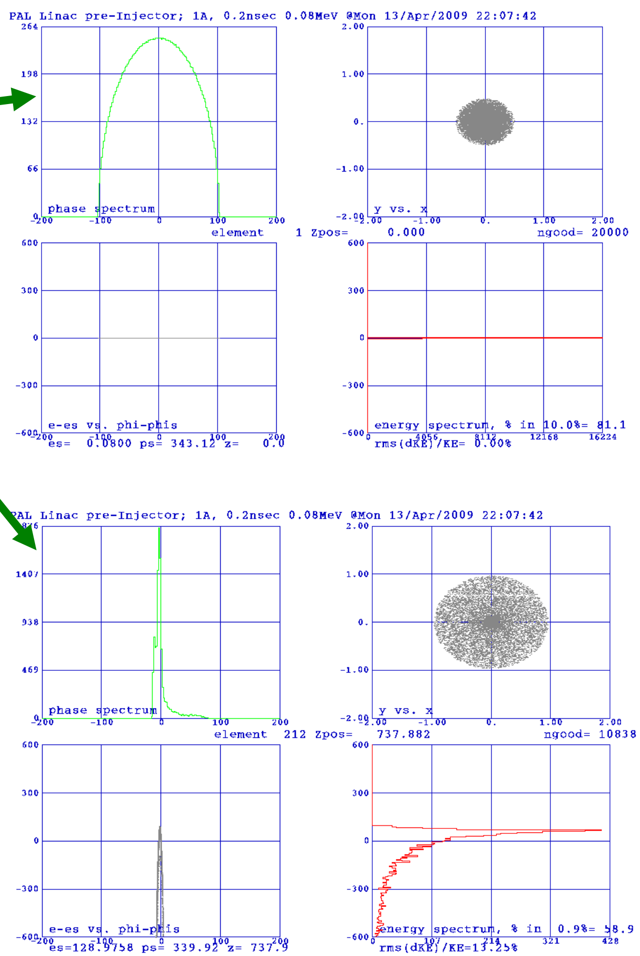
Parameters	PLS	PLS-II
Energy	2.5 GeV	3.0 GeV
Repetition Rate	10 Hz	10 - 30 Hz
Energy Stability	0.5% rms	0.1% rms
Energy Spread	0.6% rms	< 0.2% rms
Emittance (normalized, rms)	150 mm mrad	< 20 mm mrad
Gun Pulse Length	1.5 ns FWHM	< 1 ns FWHM or 0.5 us
Klystron Power (Operating Levels)	50 – 60 MW	70 – 80 MW
SLED Gain	1.5 – 1.6	1.6 – 1.7
Diagnostics	BCMs, BASs, BPRMs	+ BPMs, Slits, Wire Scanners

Upgrade of PLS-II Linac Full Energy Injector (cont.)

Preinjector Layout and Bunch Train

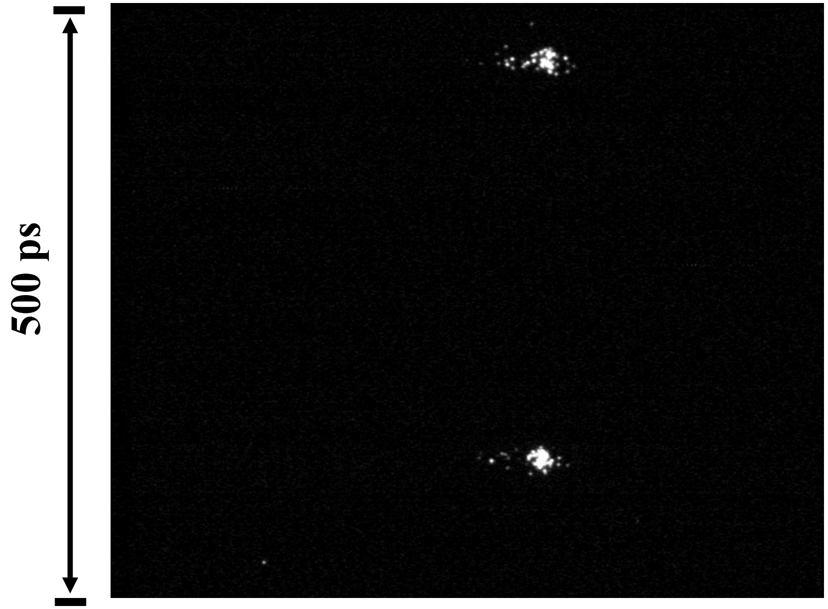


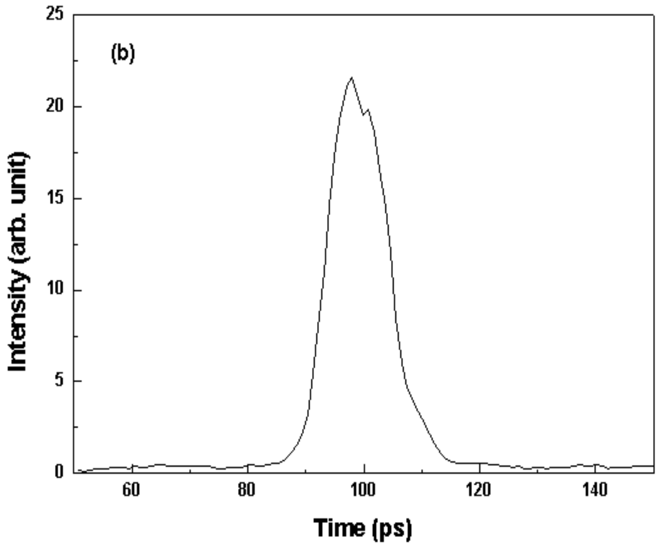
80 KeV @ Gun
Peak current : 1 A
Pulse width : 0.2 ns
Beam size : 10 mm
Beam transmission : 54 %



Upgrade of PLS-II Linac Full Energy Injector (cont.)

Preinjector Layout and Bunch Train



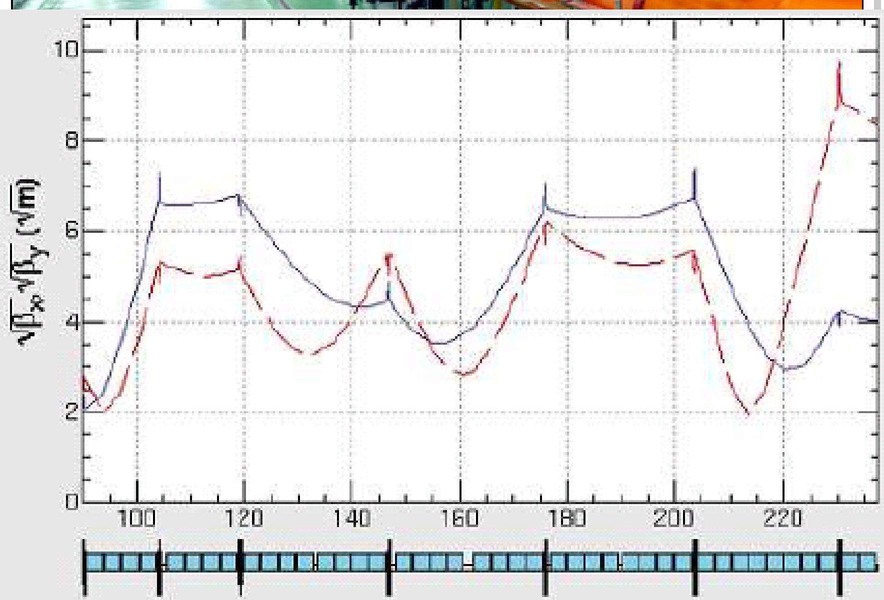


- **Parameter of bunching system has been optimally adjusted into Bunch Length of 12 psec.**

Upgrade of PLS-II Linac Full Energy Injector (cont.)

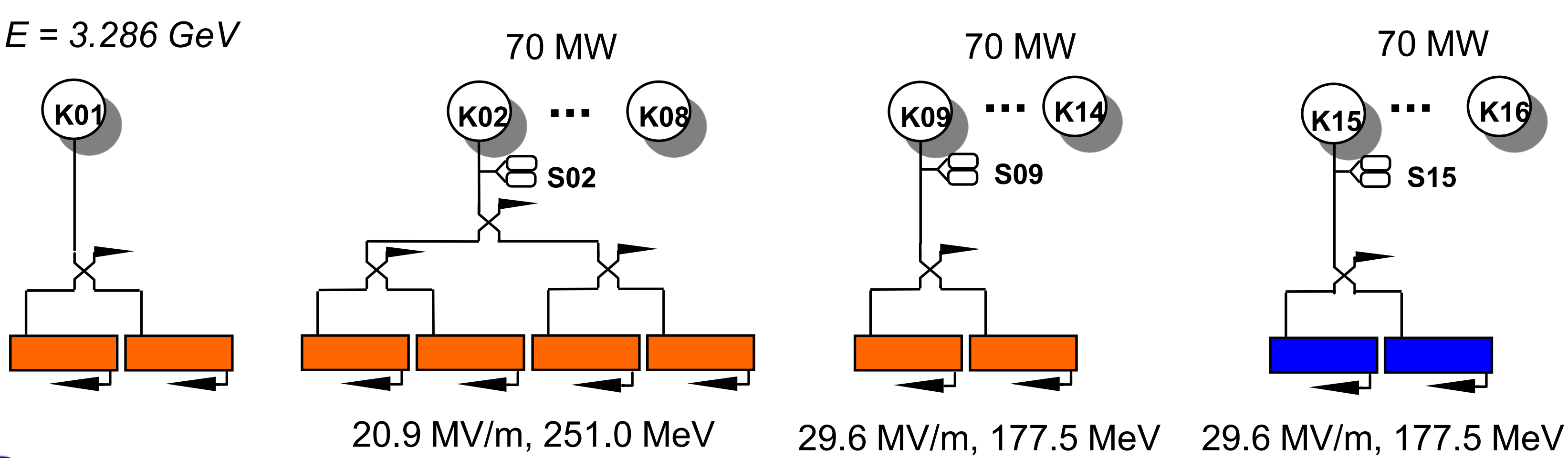
- Linac Layout and Energy Upgrade to 3.0 GeV

Number of klystrons	16
Klystron power (MW)	80
SLED Gain	1.5
No. of accelerating columns	46
Total length (m)	160



Upgrade of PLS-II Linac Full Energy Injector (cont.)

	MK1(1set)	MK2 – MK08(7set)	MK09-MK14(6set)	MK15-MK16(2set)
RF Power	60 MW	70MW	70 MW	70 MW
Klystron	SLAC5045	Toshiba E3712		
A/C	IHEP			Mitsubishi
SLED Gain	w/o	1.5		1.5
Gradient	18.3 MeV/m	20.9 MeV/m	29.6 MeV/m	29.6 MeV/m
Energy	105.8 MeV	251.0 MeV	177.5 MeV	177.5 MeV
Number of A/C	2	28	12	4



Upgrade of PLS-II Linac Full Energy Injector (cont.)

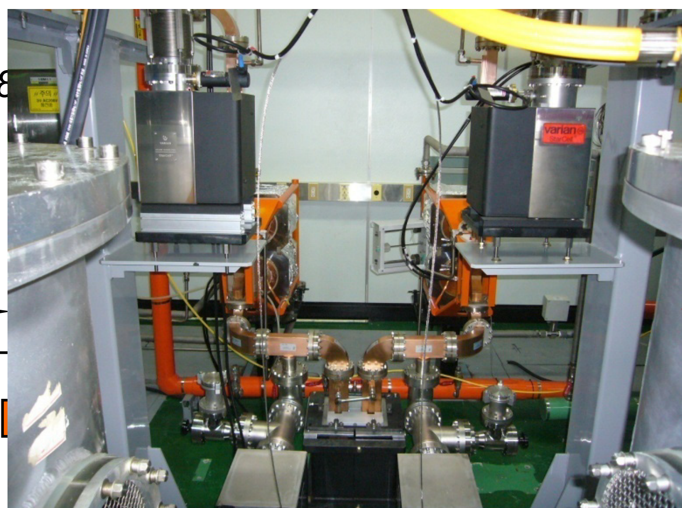
	MK1(	14(6set)	MK15-MK16(2set)
RF Power	60	W	70 MW
Klystron	SLAC	3712	
A/C			Mitsubishi
SLED Gain	w/		1.5
Gradient	18.3 M	eV/m	29.6 MeV/m
Energy	105.8	MeV	177.5 MeV
Number of A/C	2	2	4

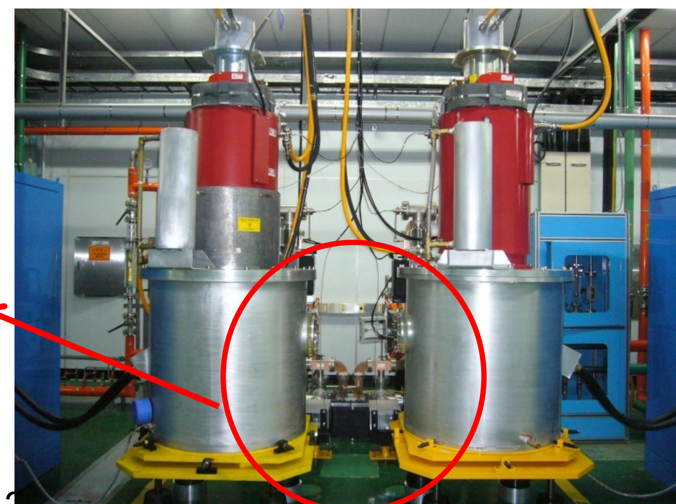
E = 3.28

K01

W

K16

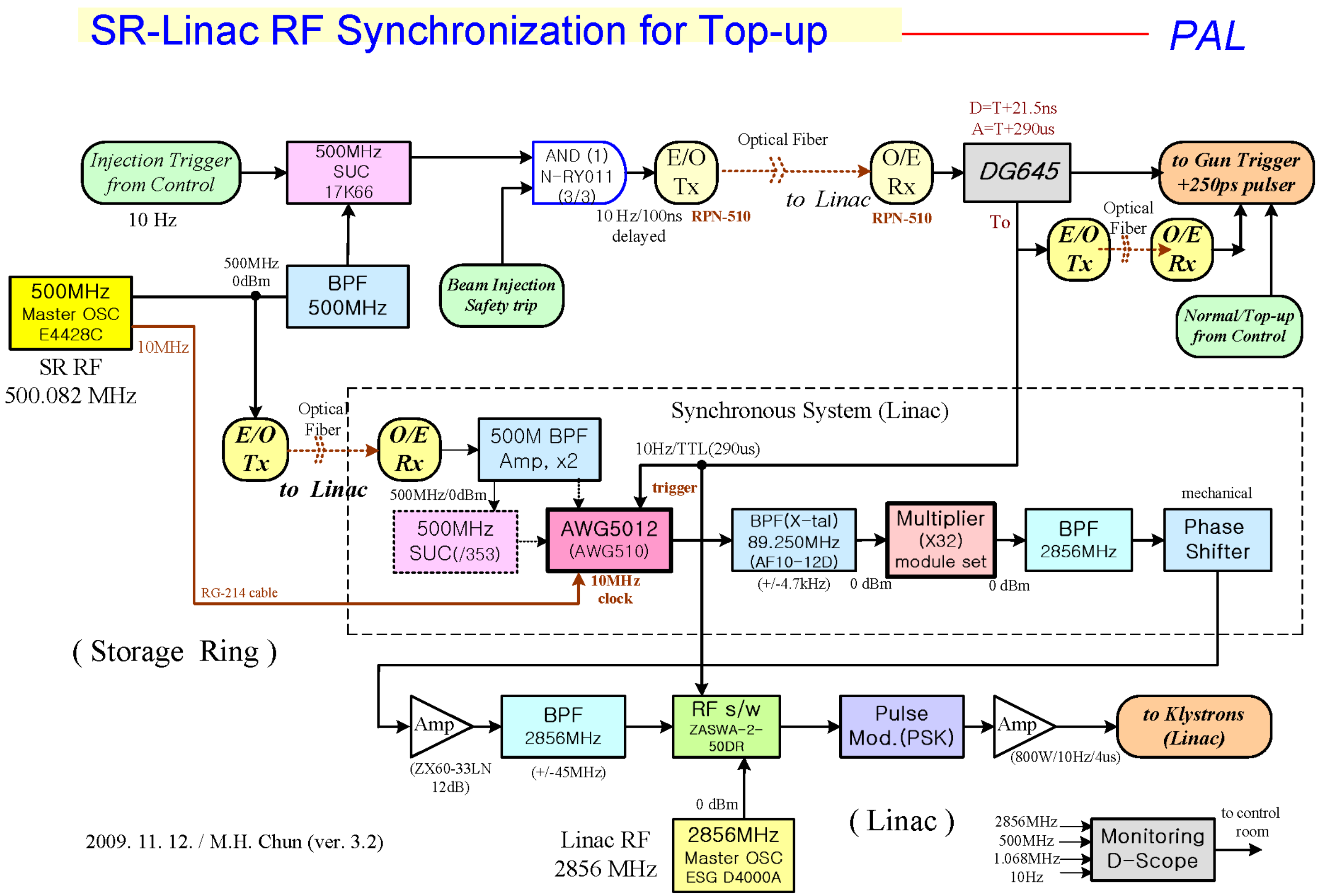




.5 MeV

Upgrade of PLS-II Linac Full Energy Injector (cont.)

RF Synchronization of SR and Linac

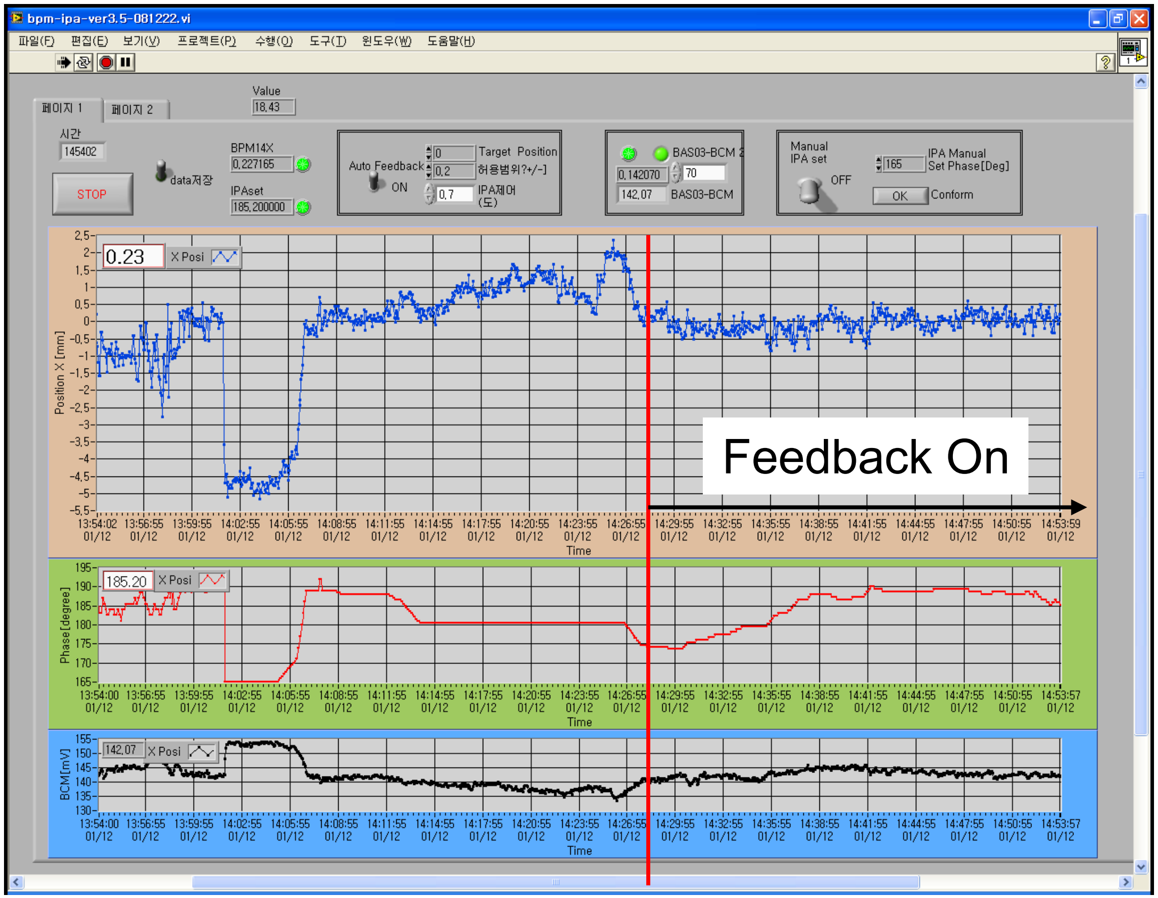


Upgrade of PLS-II Linac Full Energy Injector (cont.)

Linac Beam Energy Stabilization

Beam Position

#12 RF Phase

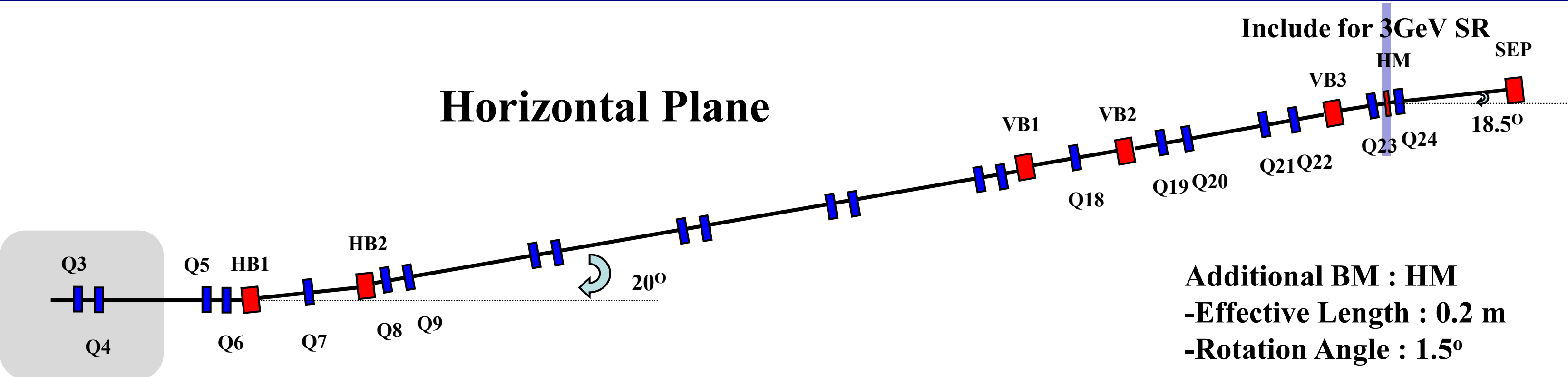


Fluctuation: ±0.5 mm
Resolution: 10 MeV/mm

PLS-II Linac requirement: 0.2% energy spread:
3 GeV x ±0.2% = ± 6 MeV => ± 0.6 mm @ BPM

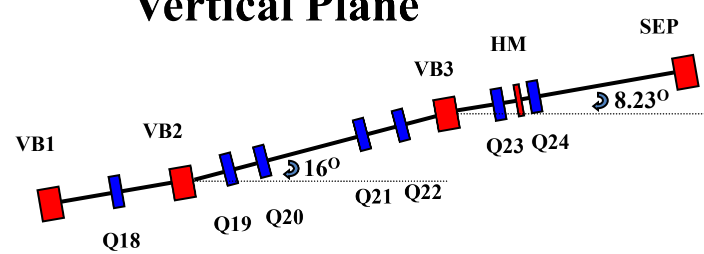
Upgrade of PLS-II Beam Injection

Horizontal Plane

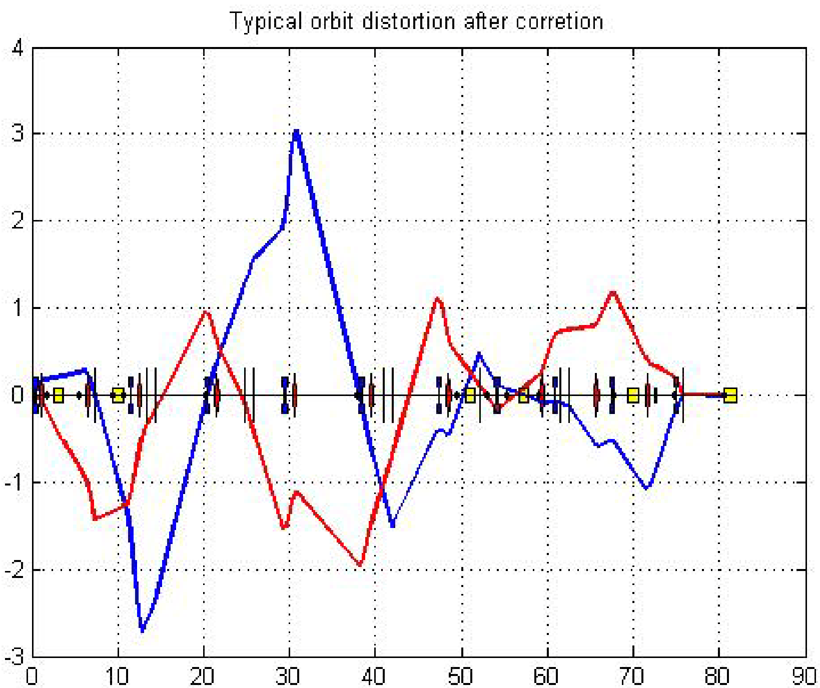


Additional BM : HM
-Effective Length : 0.2 m
-Rotation Angle : 1.5°

Vertical Plane

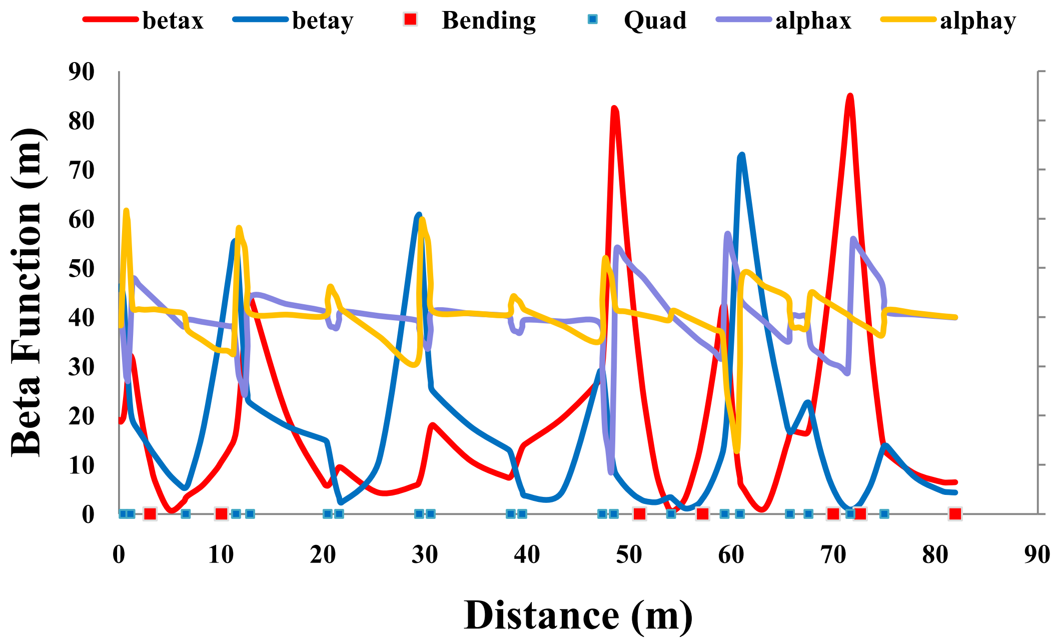


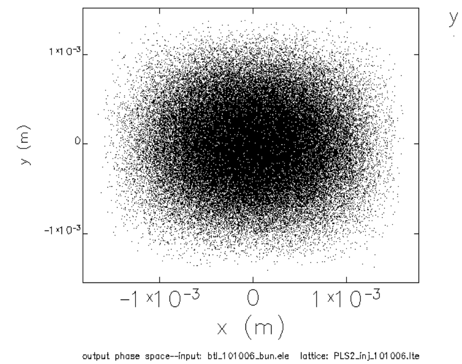
VB3 : Rotation Angle : 7.17° Downward
SEP : Rotation Angle : 8.234° Downward

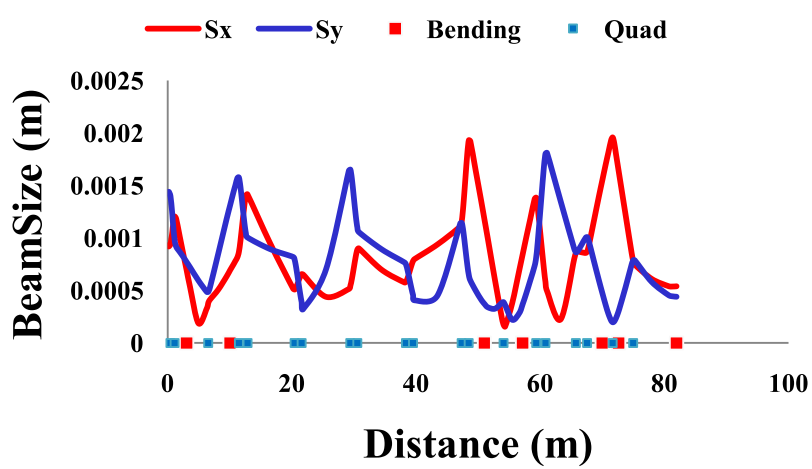


	PLS	PLS - II	Change
Kicker 1- Kicker 2 distance (center-to-center)	1.24 m	1.590 m	+0.35 m
Septum length (longitudinal)	1.068 m	1.335 m	+ 25%
Expected bump height	~ 12 mm	~ 15 mm	+ 3 mm
Vacuum pumps	3 x 240 l/s	6 x 120 l/s	

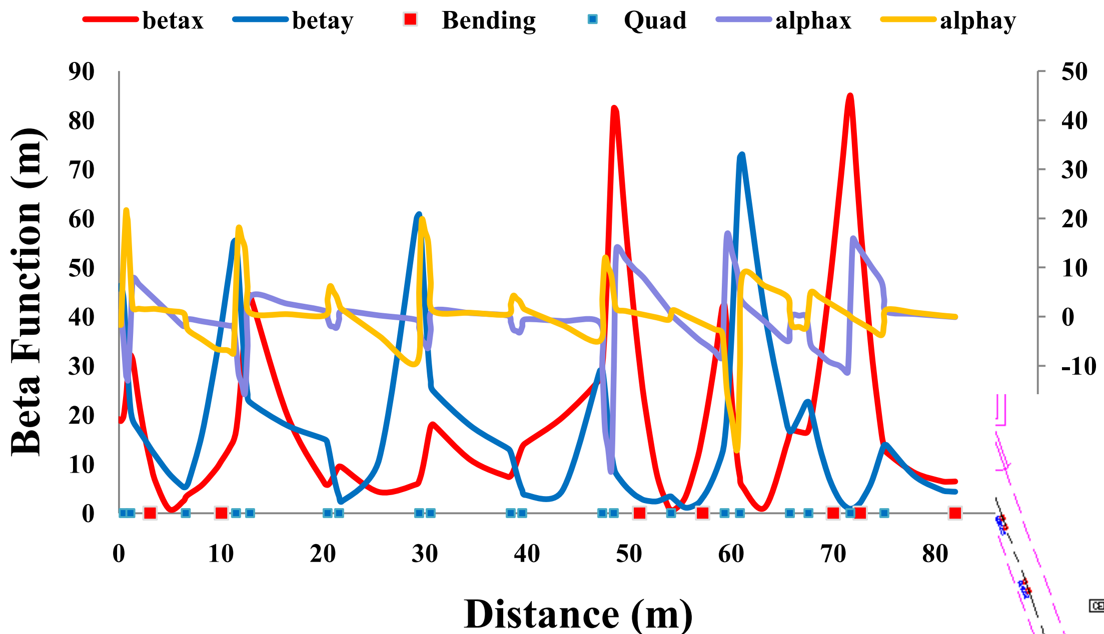
Upgrade of PLS-II Beam Injection

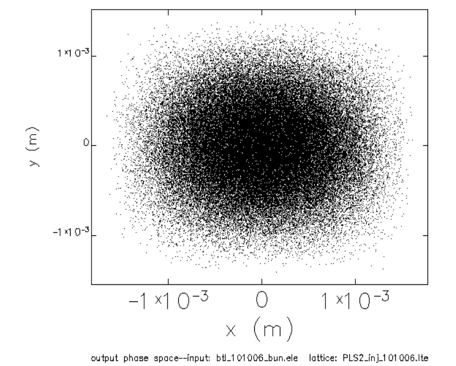


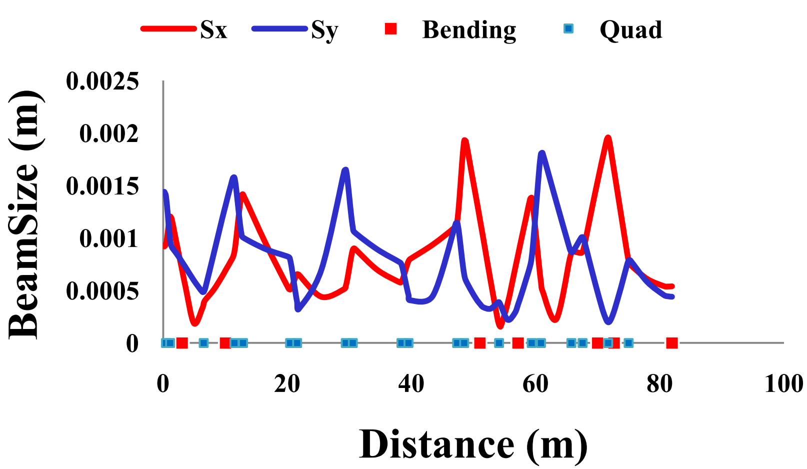


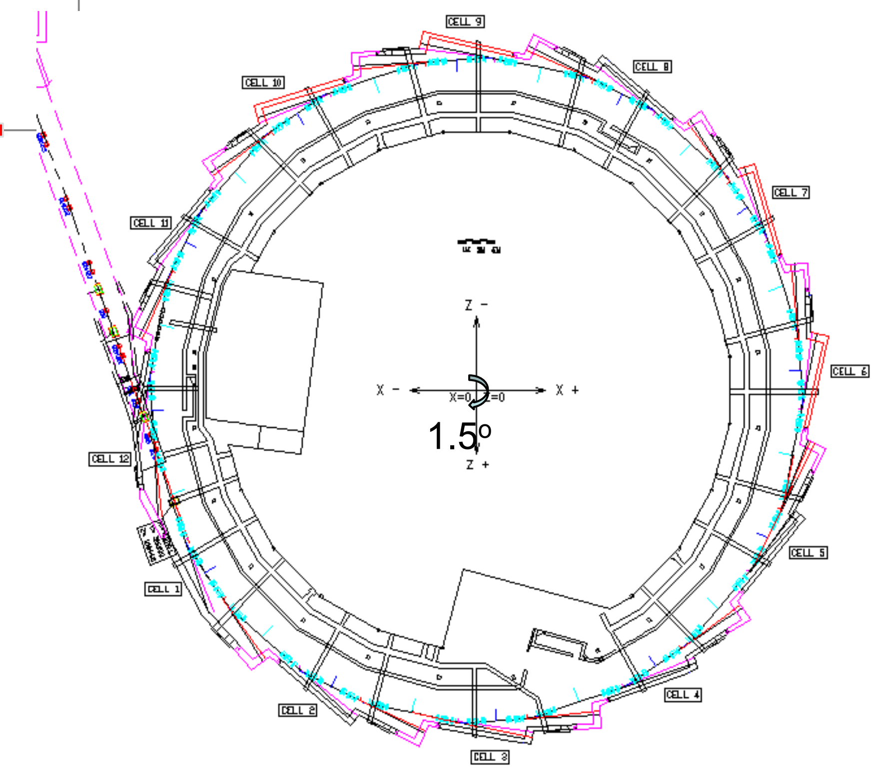


Upgrade of PLS-II Beam Injection



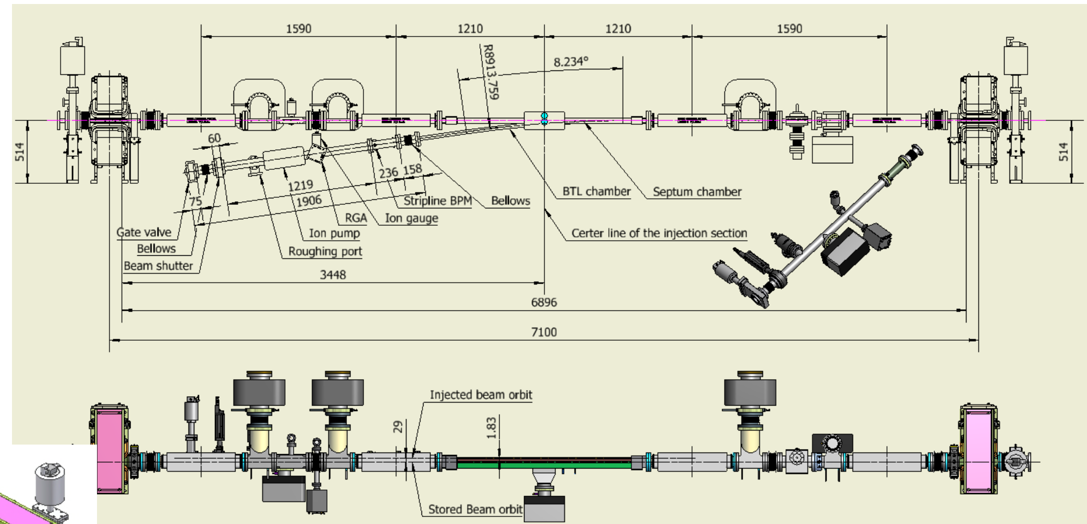


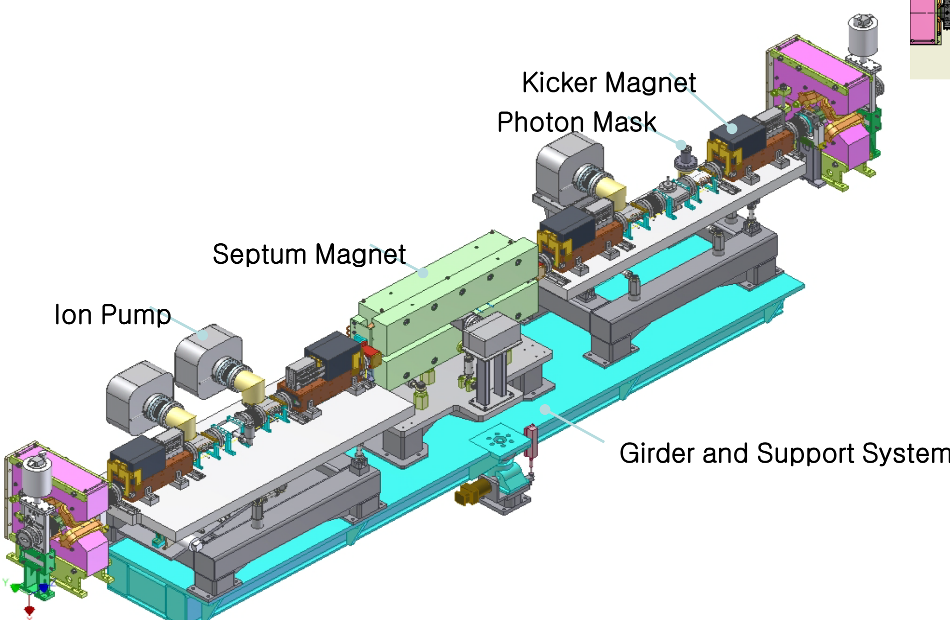




Upgrade of PLS-II Beam Injection

Layout of Injection Straight Section





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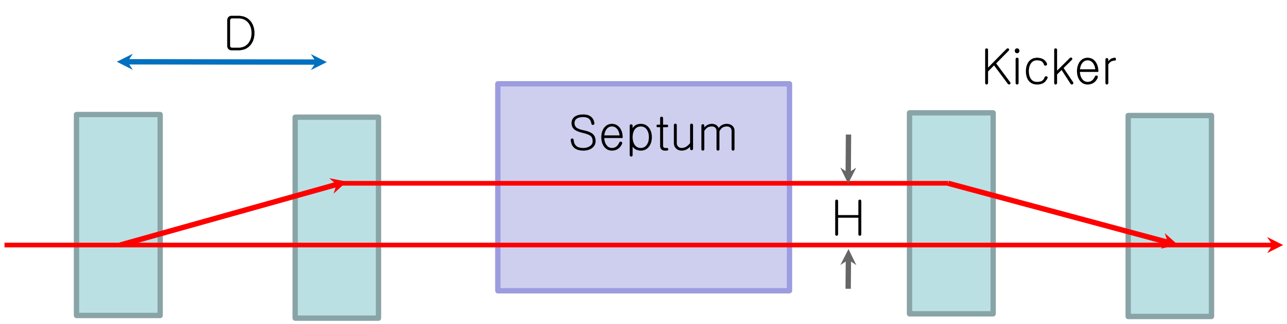
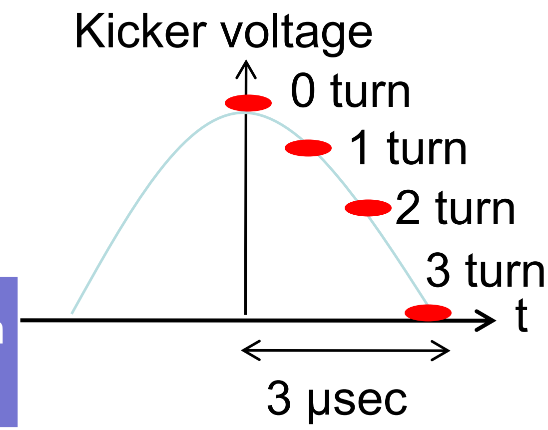
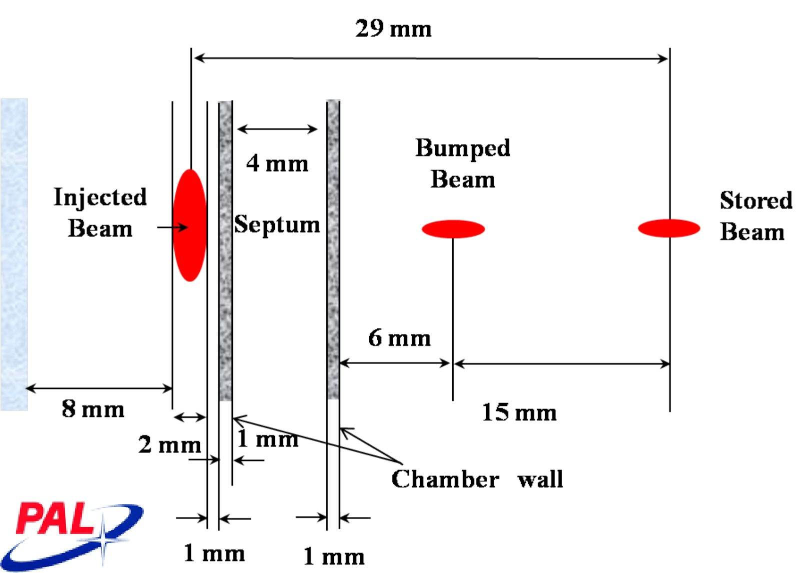
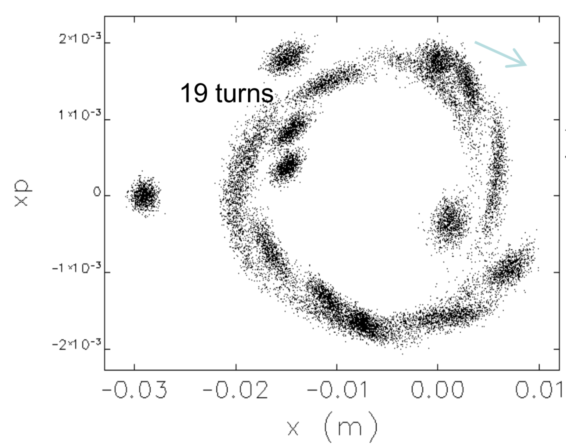
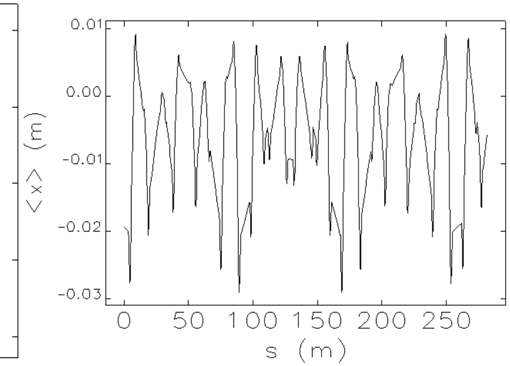




	Distance D (mm)	Field (T)	Angle (rad)	Energy (GeV)	Bump H (mm)	Length (m)
PLS	1260	0.165	0.011867	2.5	15.0	0.6
PLS-II	1590	0.165	0.009889	3.0	15.7	0.6







Magnet Lattice and Beam Dynamics

Electron Beam

Energy	3 GeV
Current	400 mA
Emittance	5.8 nm
Emittance coupling	< 1%
Energy spread	0.1%

Straight Section

Long	length, #	6.86 m × 9
	β_x / β_y/ η_x	6.46 m / 4.32 m / 0.25 m
	effective emittance	9.5 nm
Short	length, #	3.10 m × 11
	β_x / β_y/ η_x	2.95 m / 2.86 m / 0.14 m
	effective emittance	8.5 nm

Lattice

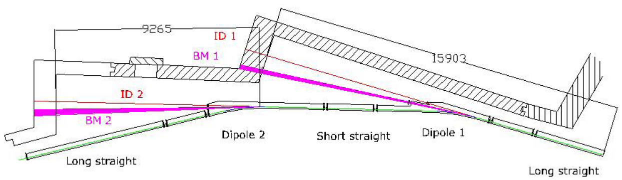
Circumference	281.82 m
Tune (h/v)	15.24 / 9.17
Natural chromaticity (h/v)	-32.88 / -15.49
Momentum compaction factor	0.0013

Magnet

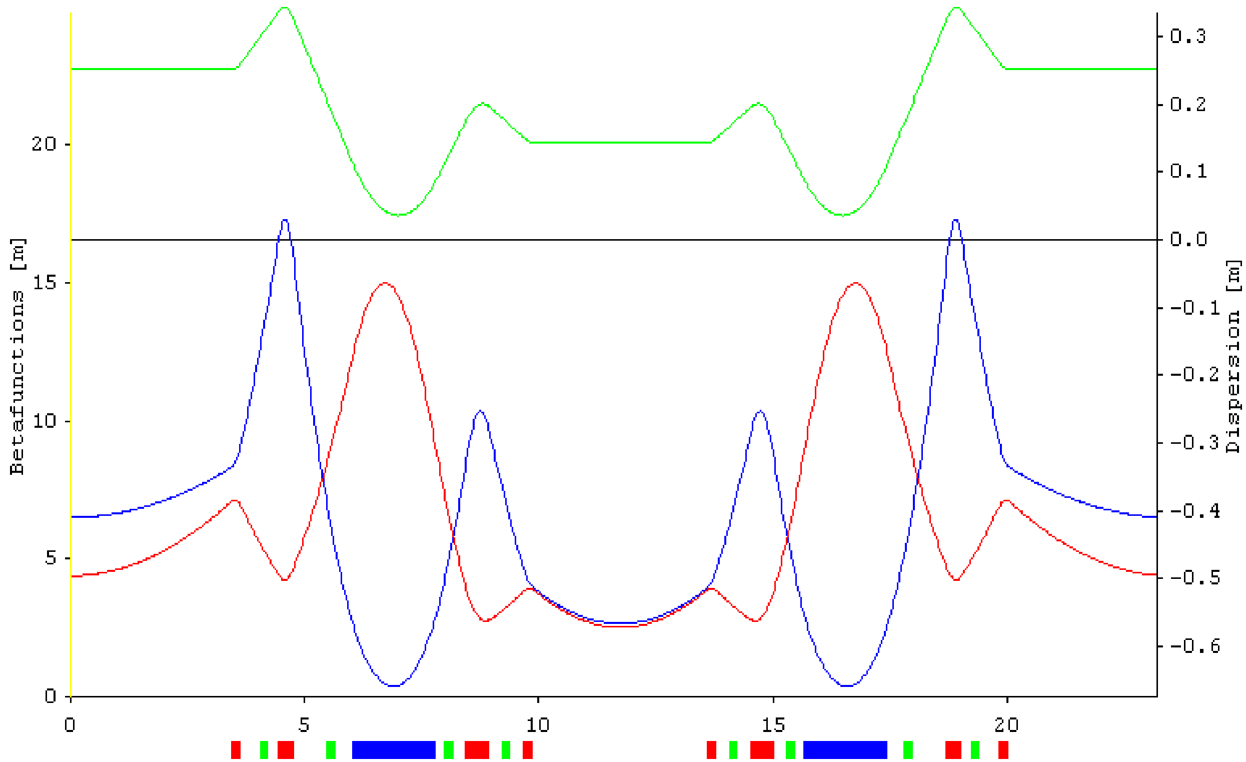
Bending	24 units, length 1.8m
Rectangular	Bending radius 6.875m
	field gradient -0.4 T/m
Quadrupole	96 units, length 0.24~0.53m
	field gradient ~22 T/m
Sextupole	144 units, length 0.1~0.2m
	2nd field derivative ~600 T/m^2

Magnet Lattice and Beam Dynamics (cont.)

Magnetic Lattice Design of PLS-II Storage Ring

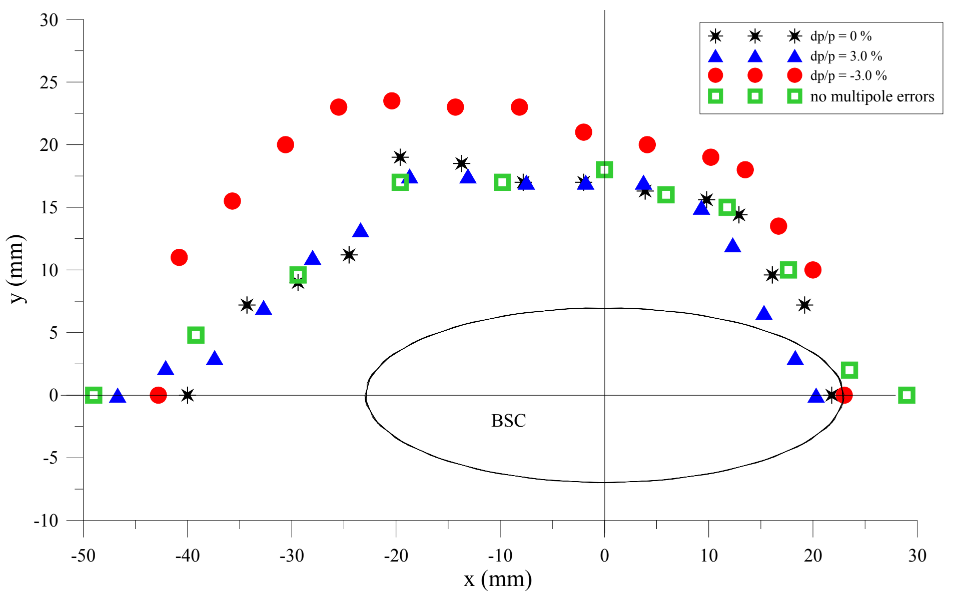


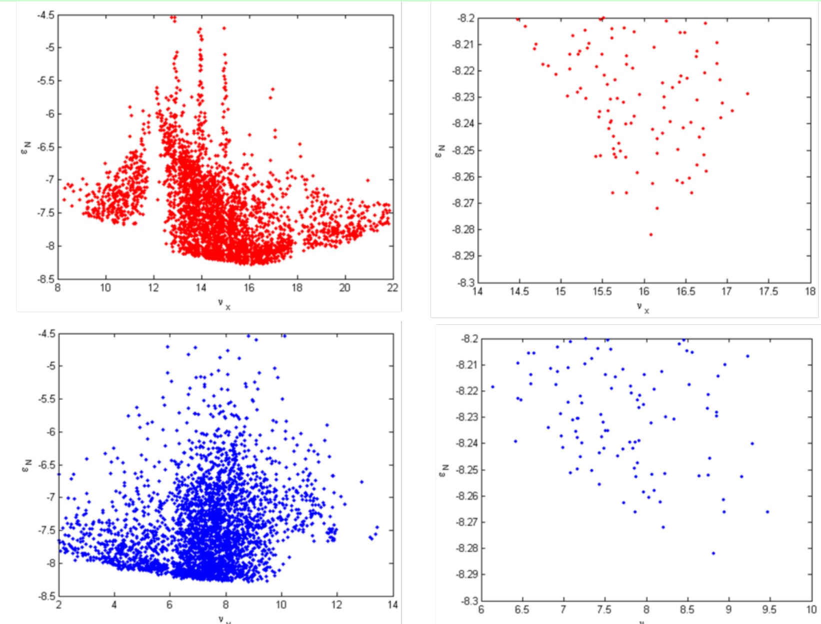
Electron Beam Parameters	
Energy	3.0 GeV
Current	400 mA
Emittance	5.8 nm·rad
Emittance coupling	< 1%
Energy spread	0.1%



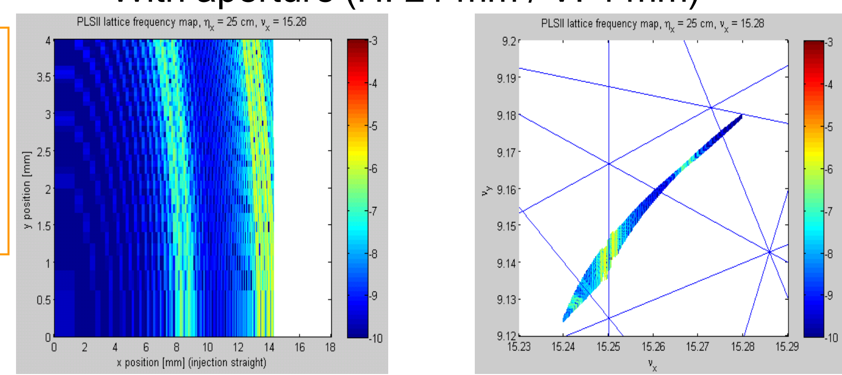
Magnet Lattice and Beam Dynamics (cont.)

Dynamic Aperture and Lattice Performance





With aperture (H: 21 mm / V: 4 mm)



The vertical BSC is limited by the vertical aperture of 13 mm in the bending magnet vacuum chamber. The horizontal limit of BSC is given by the standard chamber with an aperture of 36 mm in quadrupoles.

Magnet Lattice and Beam Dynamics (cont.)

Alignment error (rms)

Bending magnet : 150 μm

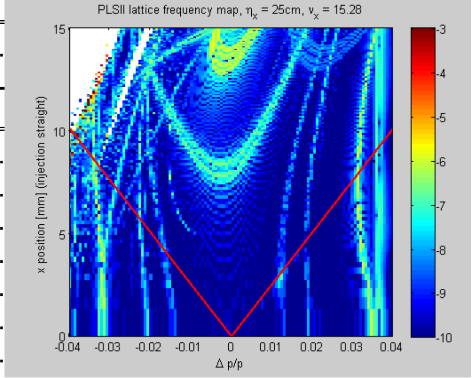
Roll for all magnets : 200 μrad

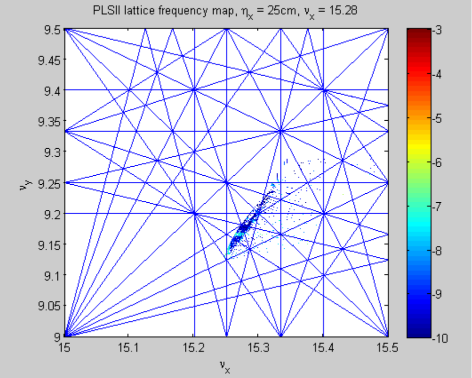
Quadrupole / Sextupole : 100 μm

Main magnet field error: $2\cdot10^{-4}$

Multipole contents

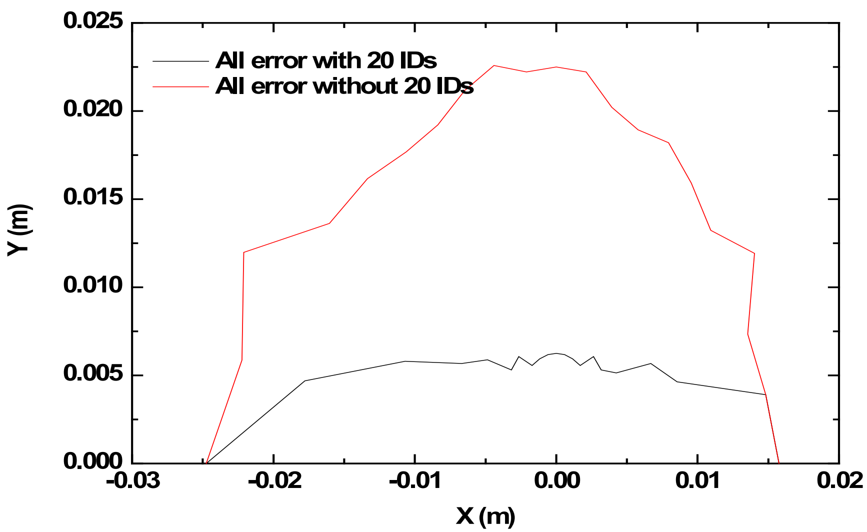
Dipole	Systematic errors	Random errors
3 (b3/b1)	-1.88e-4	2.0e-4
4	2.55e-4	2.0e-4
Quadrupoles	**Systematic errors**	**Random errors**
3	0	0.00013
4	0	7.20e-5
5	0	1.26e-5
6	4.57e-4	2.34e-5
7	0	2.34e-5
8	0	2.34e-5
9	0	2.34e-5
10	2.50e-5	2.34e-5
14	2.52e-4	2.34e-5
Sextupole	**Systematic errors**	**Random errors**
4	0	0.00075
5	0	0.00075
6	0	0.00075
7	0	0.00075
8	0	0.00075
9	0.003	0.00075
10	0	0.00075



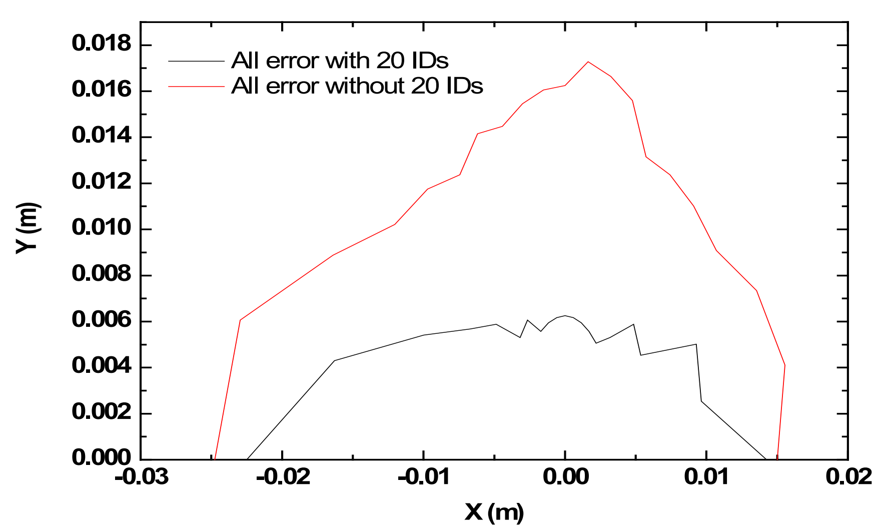


Magnet Lattice and Beam Dynamics (cont.)

Corrected chromaticity: ~ 0.2



Corrected chromaticity: ~ 5

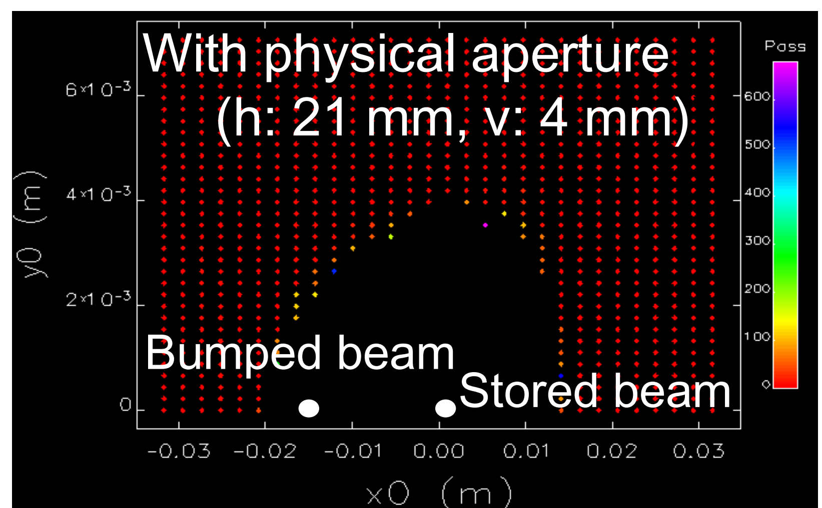


ID tracking

ELEGANT
(Ying Wu's canonical integration code)

$$B_y = -|B_0| \sum_{m,n} C_{mn} \cos(k_{xl}x) \cosh(k_{ym}y) \cos(k_{zn}z + \theta_{zn})$$

$$k_{ymn}^2 = k_{xm}^2 + k_{zn}^2 ; k_{zn} = 2\pi n / \lambda_w$$



Beam Diagnostics and Control

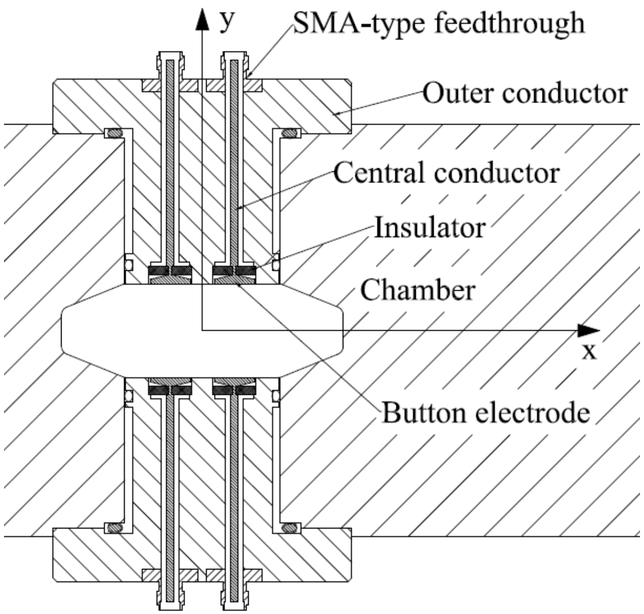
Beam Diagnostics System

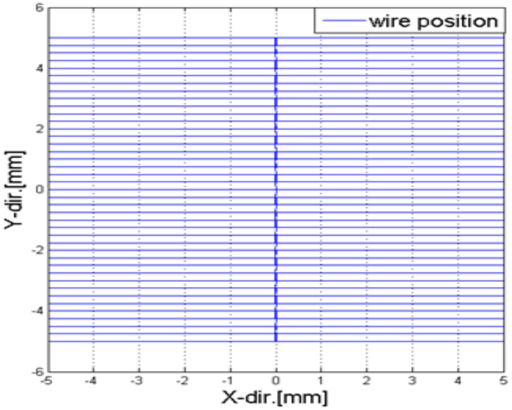
- Design Requirements of Beam Diagnostics
  - Satisfy the requirements of commissioning, machine study, routine operation and the performance upgrade
  - Provide beam intensity, orbit information, transverse and longitudinal profiles, energy and many beam parameters
  - Distribute the diagnostics tools around the accelerator, incorporating signal-processing electronics in analogue or digital way for data acquisition and further analysis

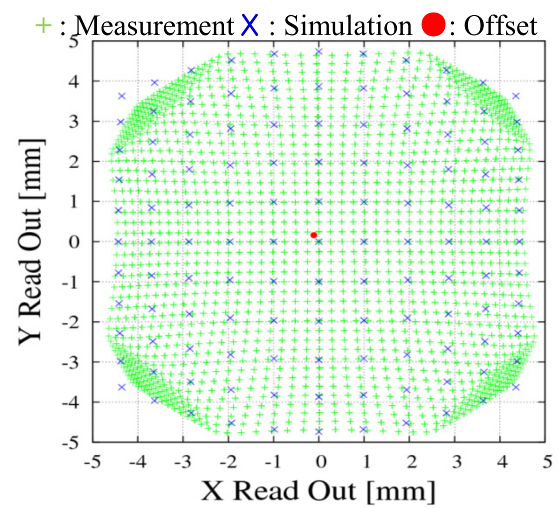
Electron Beam Parameters	Instruments	Description	Quantity
Beam position meas. (first-turn, turn-by-turn, closed orbit feedback)	Digital BPM	- Machine tuning and beam studies - Closed orbit meas. Orbit control and feedback	12×8=96
Average beam current	DC Current Transformer	-Built-in magnetic field shielding, low temperature coefficient, 1μA resolution	2
Betatron tune and beam damping	Stripline Electrode	- Beam spectrum and observation of instability - Used as transverse kickers for a transverse bunch-by-bunch feedback	2
Beam profile for commissioning	Screen Monitor	- Destructive position measusment	1
Beam trimming, dynamic aperture	Scraper	- To define the physical dynamic aperture	1

Beam Diagnostics and Control (cont.)

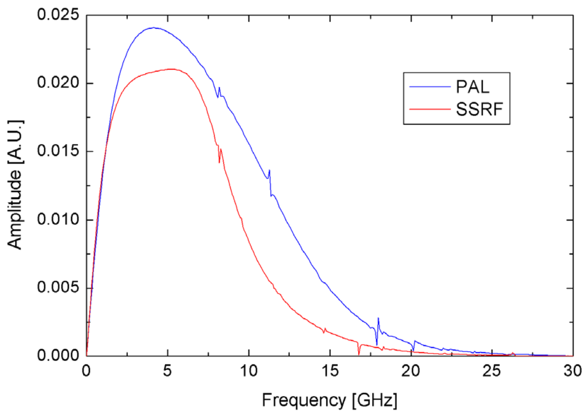
Beam Position Monitor Distributions in PLS-II







Position offset: X_0=-0.1107 mm, Y_0=0.1599 mm



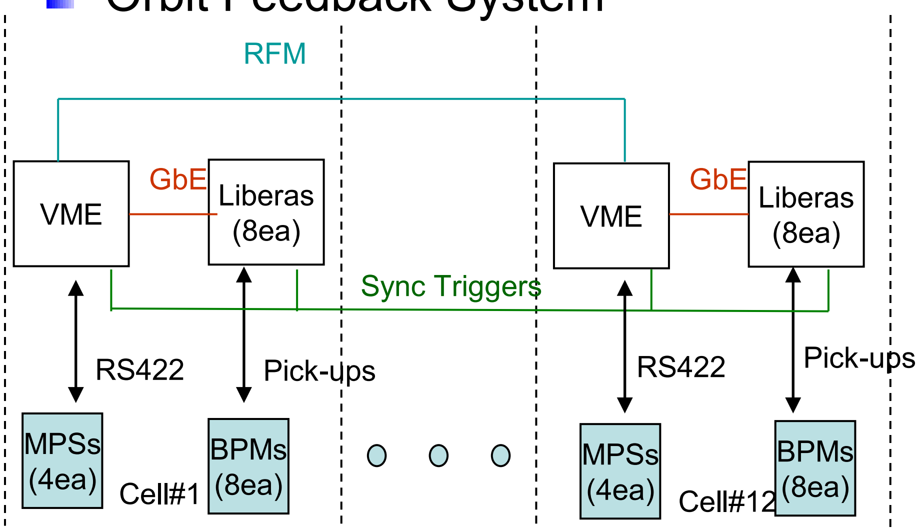
Beam Diagnostics and Control (cont.)

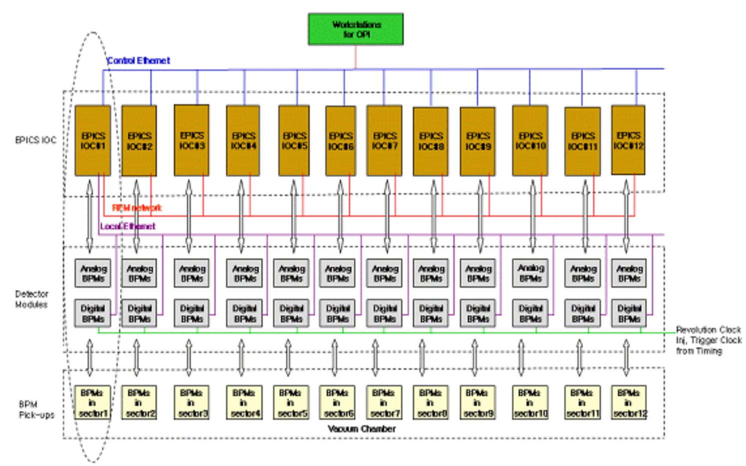
Orbit Control and Monitoring System

- Orbit Stability Requirements

Source	Beam Size (μm)		Orbit Stability (μm)	
	Horizontal	Vertical	Horizontal	Vertical
Bending Magnet	53	30	5.3	3
IDs at Long Straight Section	241	17	24.1	1.7
IDs at Short Straight Section	160	11	16	1.1

- Orbit Feedback System



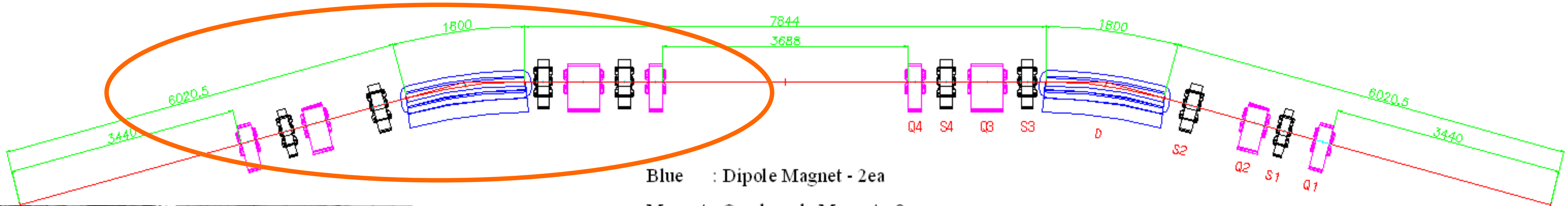


Beam Diagnostics and Control (cont.)

- Feedback Type
  - Hybrid Type (Fast + Slow Orbit Feedback)
  - Download + Interaction (Soleil Type)
- BPM, Corrector Number
  - Number of BPM: 96 (8 per cell)
  - Corrector: 48 (4 per cell, insertion device area)
- Feedback Bandwidth
  - BPM Sampling Rate > 4 kHz
  - Corrector Magnet Risetime < 1 ms
  - Feedback bandwidth > 100 Hz
- Corrector Strength
  - Corrector Magnet Strength : $\pm$20 μrad

SR Sources: Magnet and ID Systems

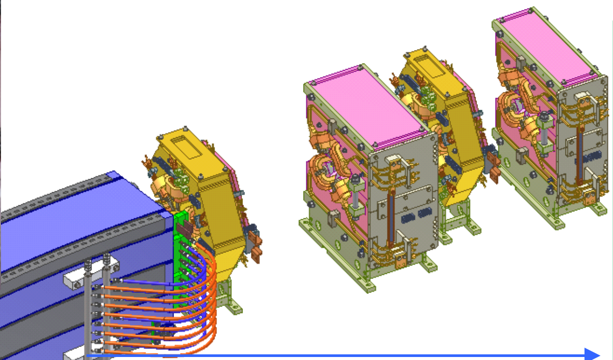
Magnet Layout in Half Cell of PLS-II

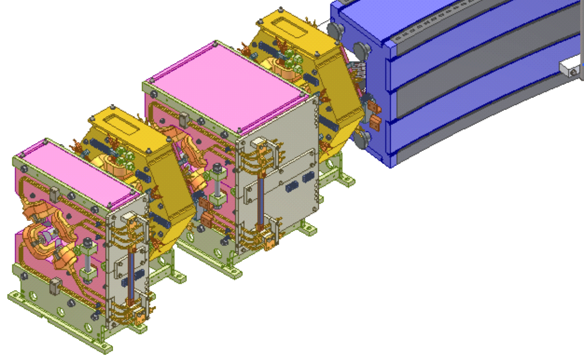


Blue : Dipole Magnet - 2ea

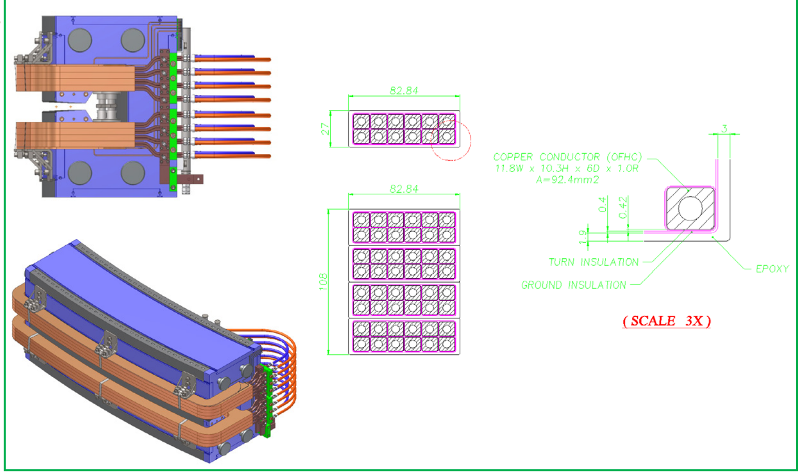
Magent : Quadrupole Magnet - 8ea

Black : Sextupole Magnet - 8ea



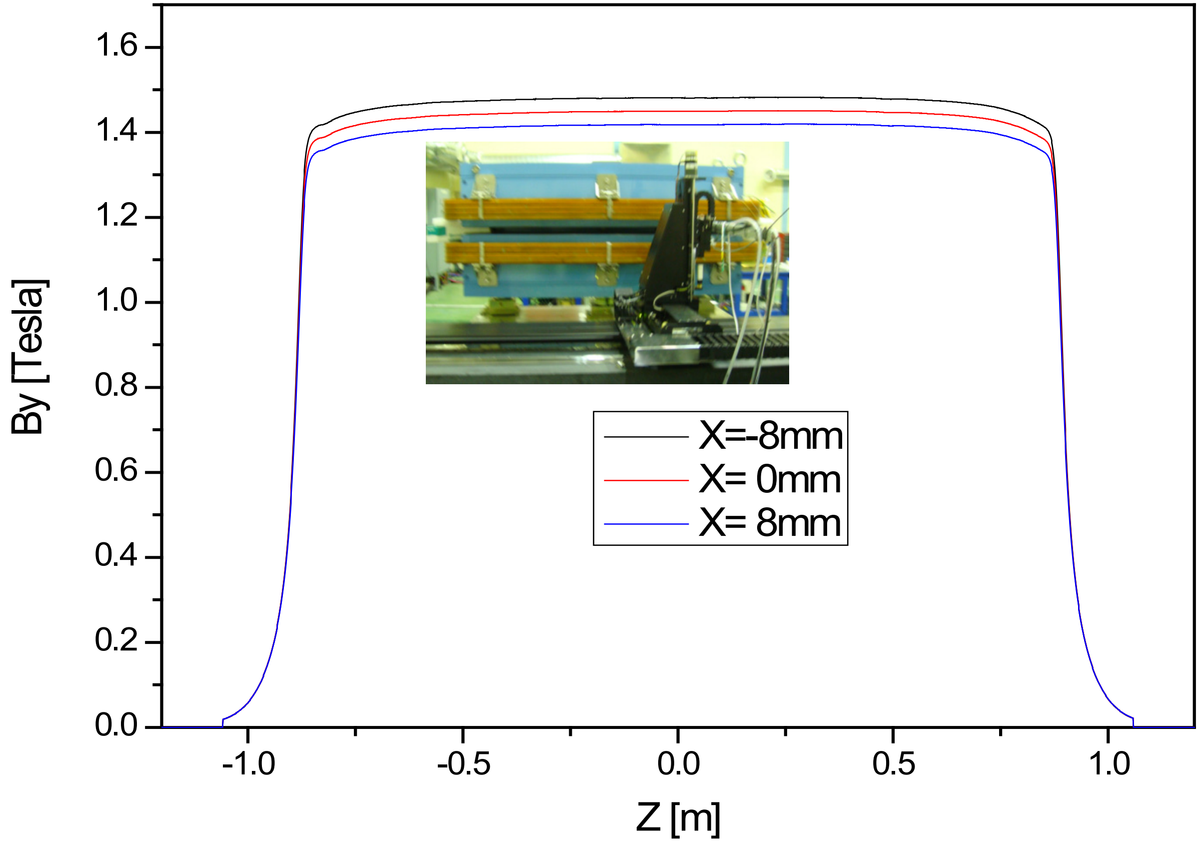


Gradient Magnet coils and 3D Drawings
Bus structure with two parallel conductors



SR Sources: Magnet and ID Systems

Central Field Distribution of Gradient BM



SR Sources: Magnet and ID Systems (cont.)

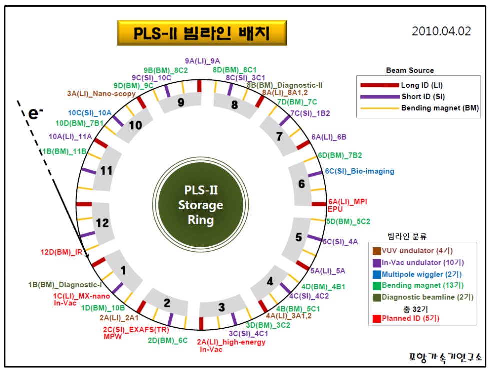
Magnet Systems for PLS-II

Type	Number	Key Parameters	Remarks
Gradient	2×12	1.4555 T, 4.0028 T/m Gap=34 mm, L_{eff}=1.800 m	All powered in series
Quadrupoles	8×12	4 types, Max Gradient 22T/m, R_c=36 mm	Powered in family series with independent aux coils.
Sextupoles	8 ×12	Max B”=550 T/m^2 R_c=39 mm, 2 types	SkewQ, V-corrector, H-corrector, combined function
Kicker Magnet	4		Recycle existing one
Lambertson Septum	1	3.0 GeV, 8.8 degree vertical bending,	

Energy, *E*	3.0	GeV
Bending radius, *r*	6.87549	m
Full aperture in bending magnet, *G*	34	mm
Aperture radius in quadrupole, R_Q	36	mm
Aperture radius in sextupole, R_S	39	mm

SR Sources: Magnet and ID Systems (cont.)

ID Installation Plan of PLS-II



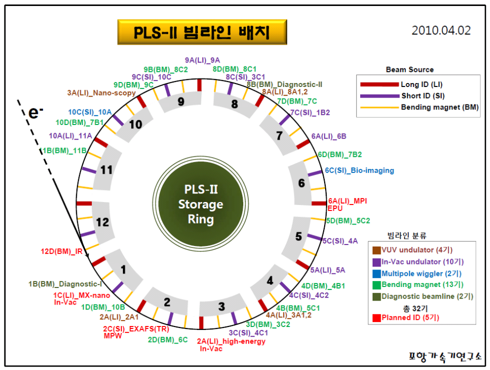
Vacuum pipe cross-section: 22 x 66 (mm)

Name	#	Pole-gap (mm)	Length (m)	Radius[1] (mm)	Total length[2] (m)
EPU	1	18	4	7	6
EPU	1	18	3.6	7	5.6
NanoScopy	1	18	3.6	7	5.6
U10	1	16	1.6	6	3.6
U6	1	18	2	7	4
MPW10	1	12	2	4	4
MPW10	1	12	1.1	4	3.1
MPW14	1	14	1.2	5	3.2
IVU	2	5	1.8	3[3]	1.8 x 2
IVU	9	5	1.35	3[3]	1.35 x 9
Rev.	1	4	1.02	3[3]	3.2

1. If out-vac, (pole-gap – 4mm) /2
2. If out-vac, +2m
3. Nominal operation @ 6mm full gap

SR Sources: Magnet and ID Systems (cont.)

ID Installation Plan of PLS-II



EPU7.2 : L=2.5m, λ=7.2cm, B=0.793T

Hybrid : L=3.0m, λ=6.6cm, B=0.989T

NanoScopy : L=2.5m, λ=7.2cm, B=0.793T

U10 : L=1.6m, λ=10.0cm, B=1.320T

U6 : L=2.0m, λ=6.0cm, B=0.910T

Revolver : L=1.02m, λ=2.4cm,B=1.10T

MPW10(2m) :L=2.0m, λ=10.0cm, B=1.80T

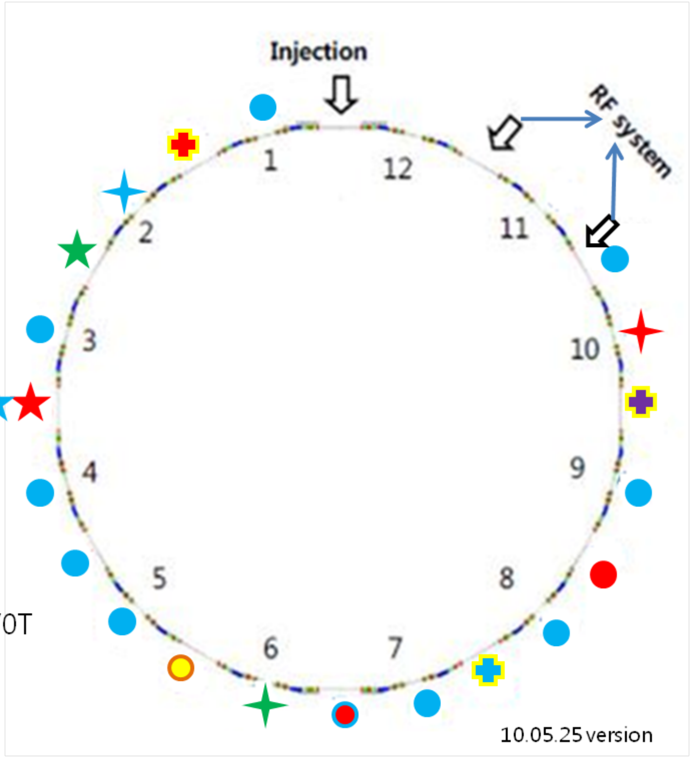
MPW10(1m) :L=1.1m, λ=10.0cm, B=1.80T

MPW14 :L=1.12m, λ=14.0cm, B=2.020T

IVU2 SSRF (ADC) :L=1.8m, λ=2.0cm, B=0.970T

IVU2 SFA :L=1.35m, λ=2.0cm, B=0.970T

MPI EPU SFA :L=2.5m, λ=6.4cm, B=0.734T



Vacuum pipe cross-section: 22 x 66 (mm)

1. If out-vac, (pole-gap – 4mm) /2
2. If out-vac, +2m
3. Nominal operation @ 6mm full gap

Magnet Power Supply System

Design Parameters of Magnet Power Supply

	BD	Main-quadrupole				Sextupole				Sept.
		MQ1	**MQ2**	**MQ3**	**MQ4**	**S1**	**S2**	**S3**	**S4**	
INPUT(3Φ, Y/Δ, V)	470	400	400	460	400	440	440	440	440	30
OUTPUT(A)	**1000**	**1000**	**1000**	**1000**	**1000**	**500**	**500**	**500**	**500**	**250**
Power conversion	4-paralleled buck converter					2-paralleled buck converter				**single buck**
Stability Short: <1 hour	+/- 5 ppm									
Stability long: >8 hour	+/- 10 ppm									
Controller	Full digital controller									
Resolution	20 bit									
cooling	water									
protection	OC, OT, OV, cooling water, Ext.									

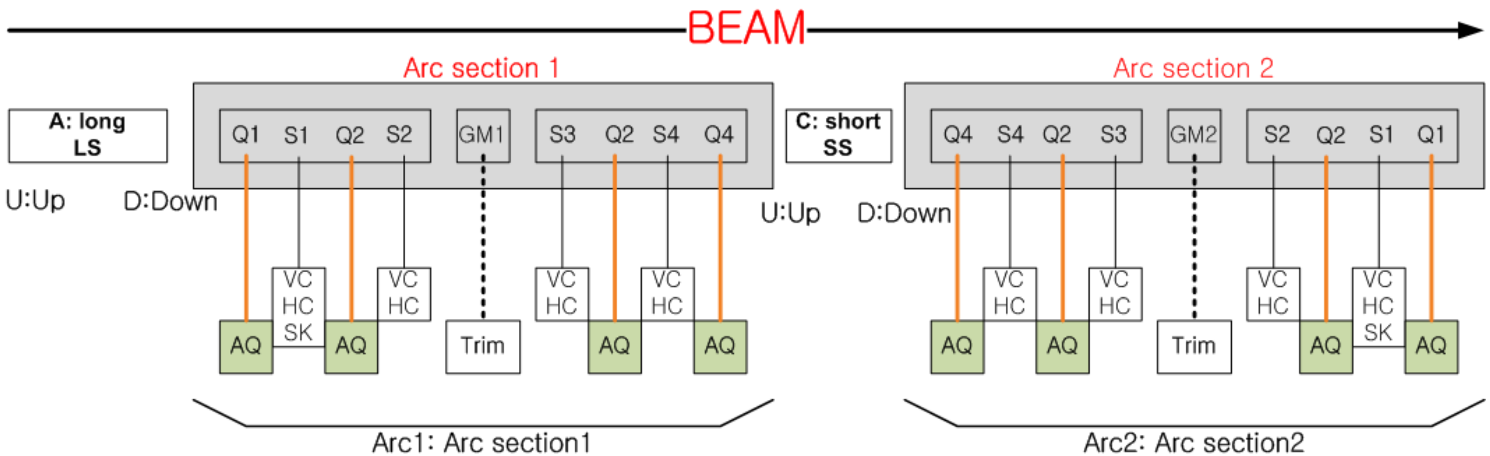
Magnet Power Supply System

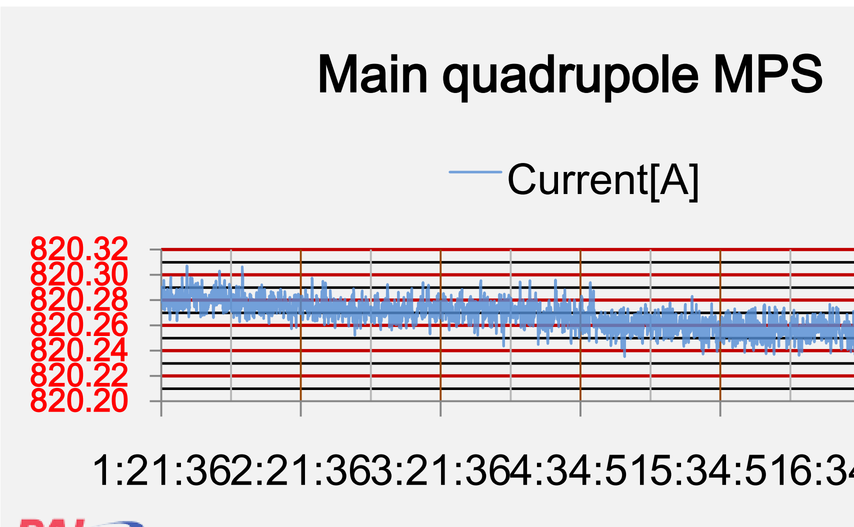
Design Parameters of Magnet Power Supply

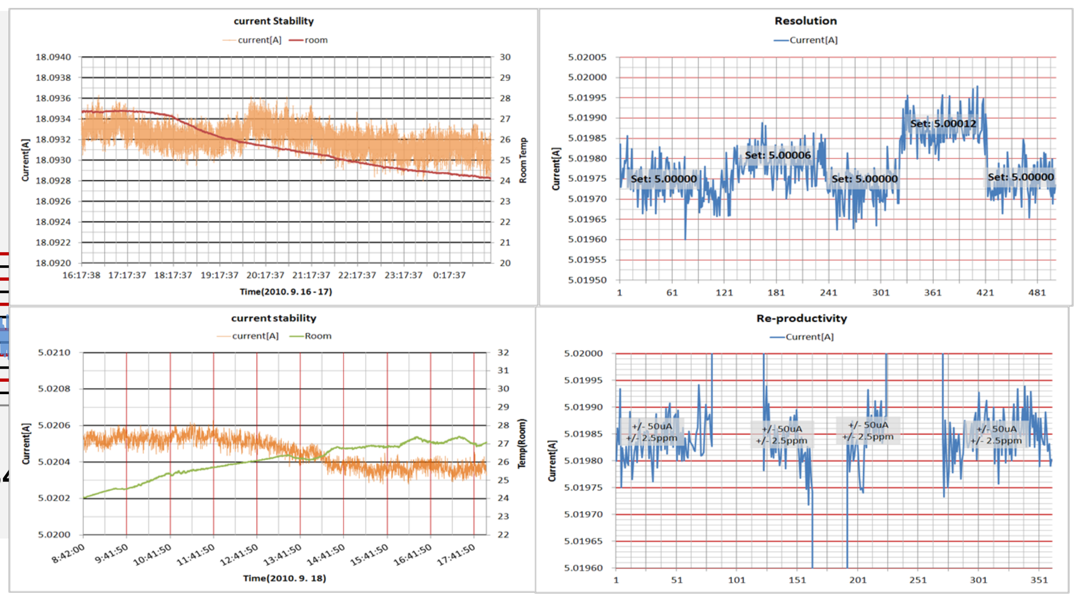
	Aux. Quad.	Skew	Slow corrector	Fast corrector	Trim coil (Gradient magnet)	ID corrector (ID no: 20)
No.	96	24	V: 96, H: 96	V: 48, H: 48	24	V: 40, H: 40
INPUT(3Φ, Δ, V)	23	15	23	15	15	15
OUTPUT(A)	20	20	20	15	15	10
Power conversion				H-bridge type		
Stability Short: <1 hour				+/- 5 ppm		
Stability long: >8 hour				+/- 10 ppm		
regulation	Line: +/-10 ppm for +/-10%, Load: +/-10 ppm for +/-10%					
Controller	Full digital controller					
Resolution	20 bit					
cooling	Water					
protection	OC, OT, OV, cooling water, Ext.					

Magnet Power Supply System

Arrangement of Magnet Power Supply in Typical Cell

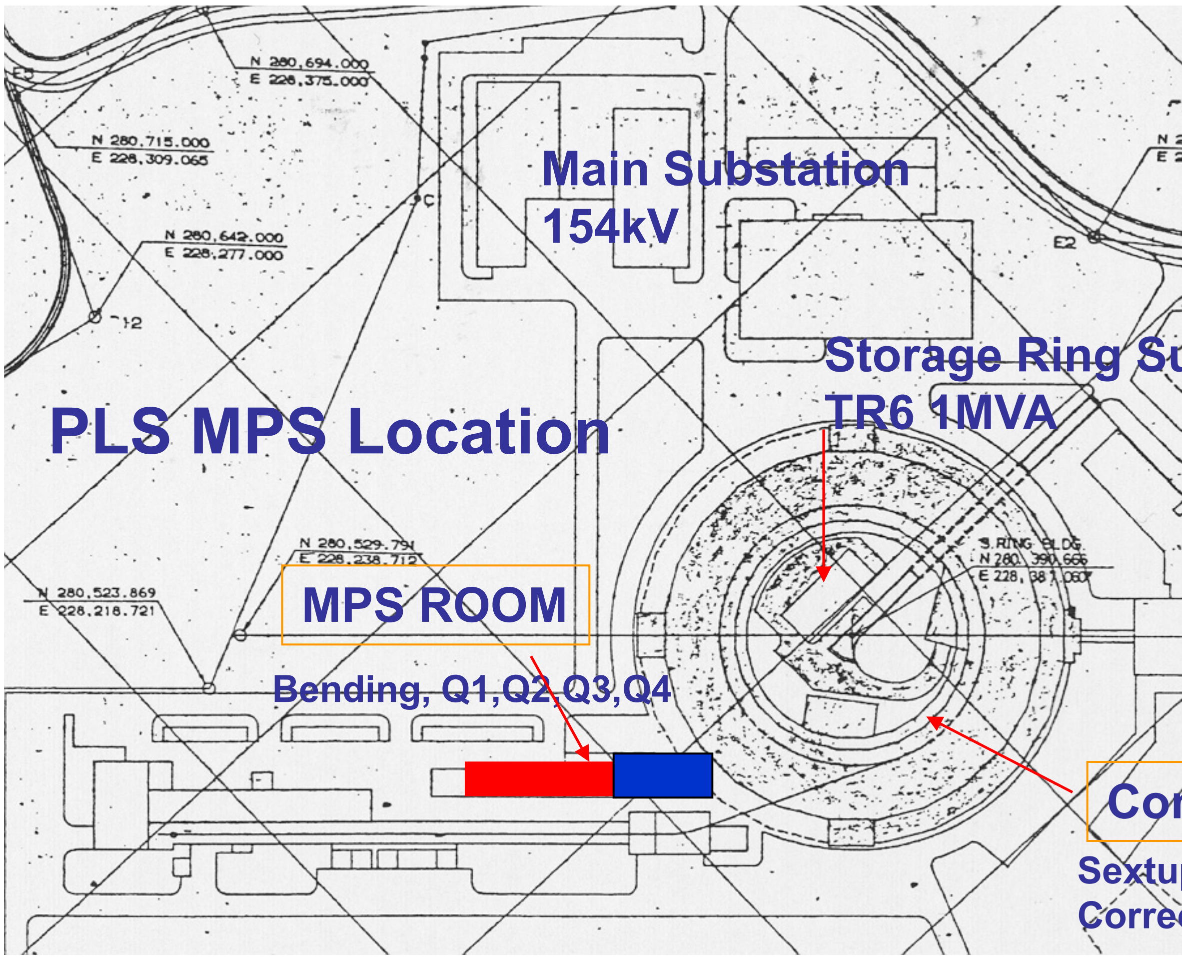


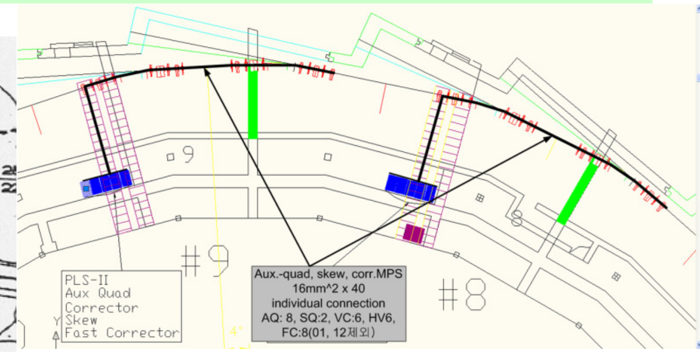




Magnet Power Supply System

Installation Layout of Magnet Power Supply





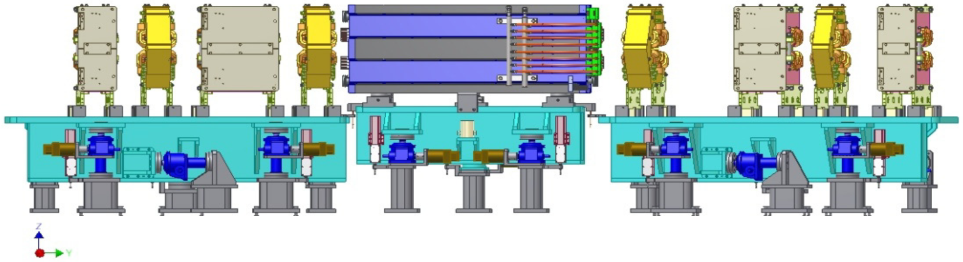
PLS-II MPS system is nicely under progress on the scheduled time.

More detailed status is given by S. -Ch. Kim.

Sector Girder and Alignment System

Mechanical Girder System

- System Design Criteria
  - Hold magnet center of 1,400 mm from the SR tunnel floor
  - Rigid enough to sustain higher natural frequency
  - Absorb the deformation coming from the ground movement
  - Allow the active adjustment in vertical direction
  - Install several diagnostic instruments to measure the deformation and get more flexible alignment (HLS, HPS, LVDT)



QM/SM Girder

BM Girder

- Screw Jack : 3 set
- Stepping Motor : 3 set
- Linear Absolute Encoder : 3 set
- Total weight : 2.0 ton

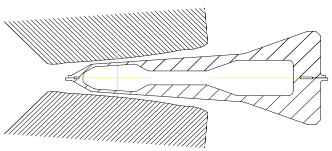
QM/SM Girder specifications:

- Screw Jack : 6 set
- Stepping Motor : 3 set
- Linear Absolute Encoder : 3 set
- Total weight : 3.0 ton

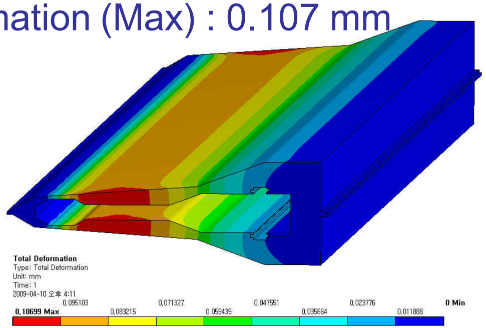
Vacuum System

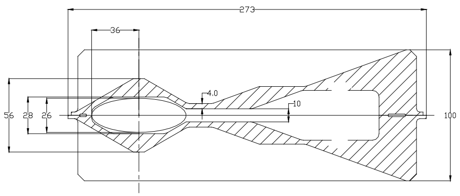
Configuration of Magnet Vacuum Chambers

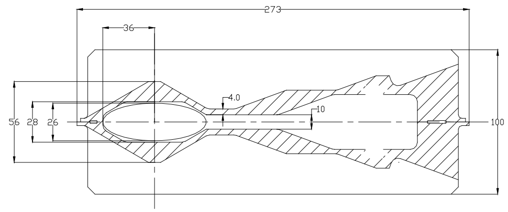
Gradient bending magnet vacuum chambers



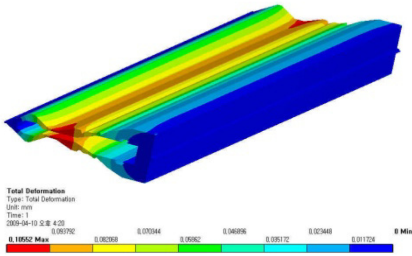
Diff. Pressure : 0.1 MPa
Support : Fixed (2point)
Material : Al 5083-H321
Deformation (Max) : 0.107 mm



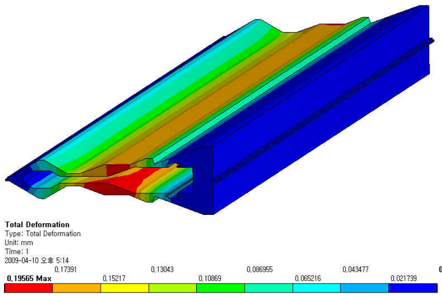




Mulipole magnet vacuum chambers



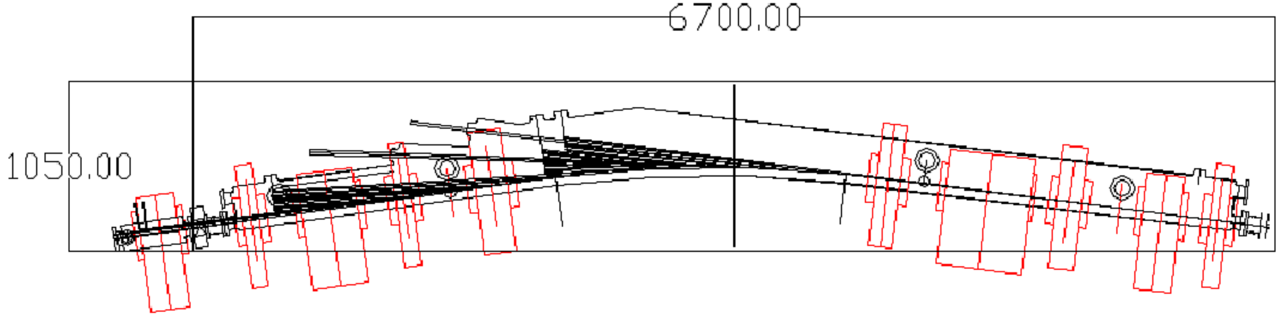
Diff. Pressure : 0.1 MPa
Support : Fixed (2point)
Material : Al 5083-H321
Deformation (Max) : 0.106 mm

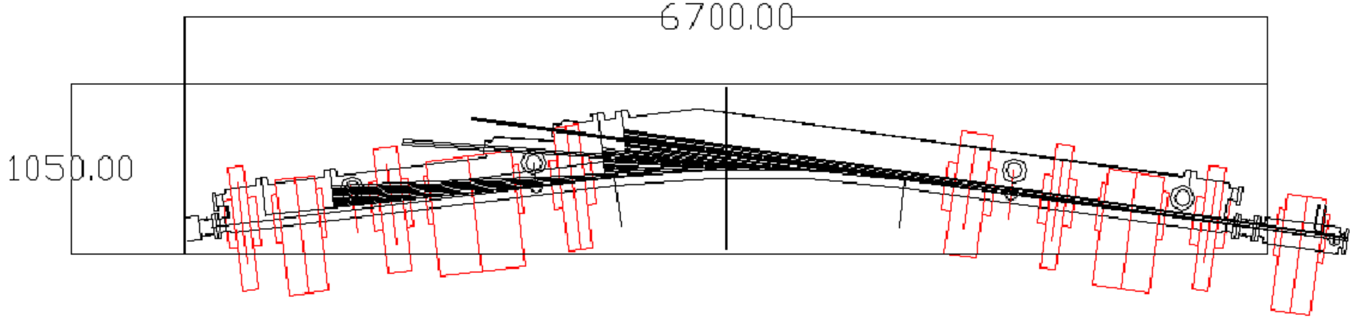


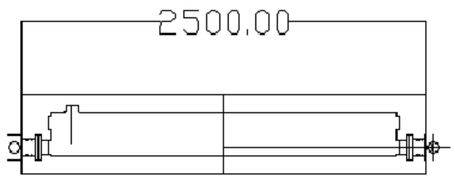
Diff. Pressure : 0.1 MPa
Support : Fixed (2point)
Material : Al 5083-H321
Deformation (Max) : 0.196 mm

Vacuum System

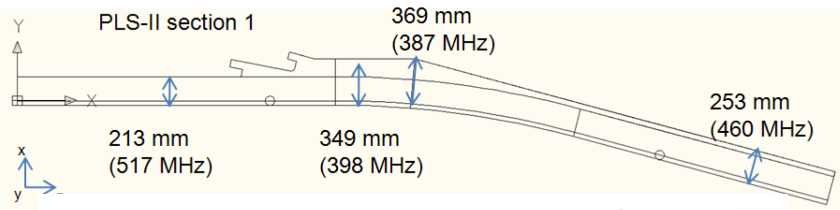
Configuration of Magnet Vacuum Chambers

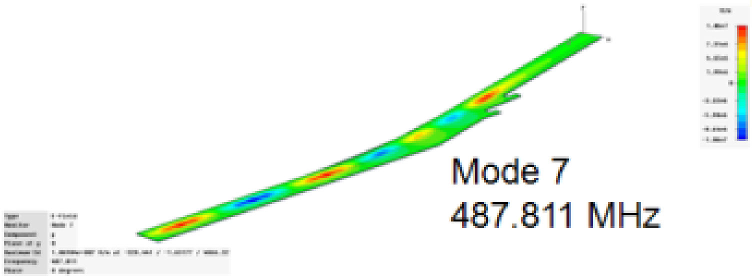


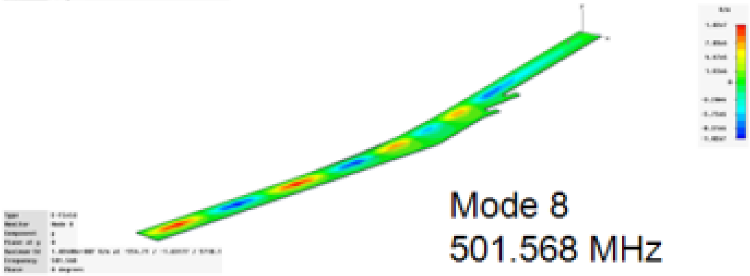


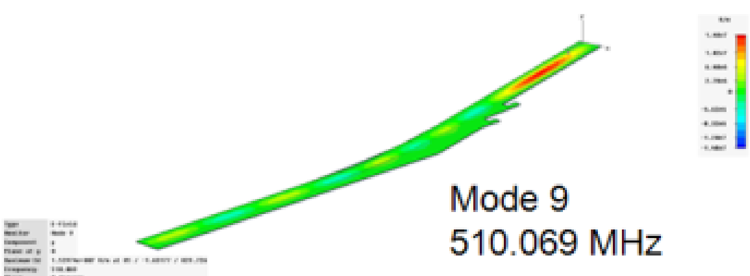


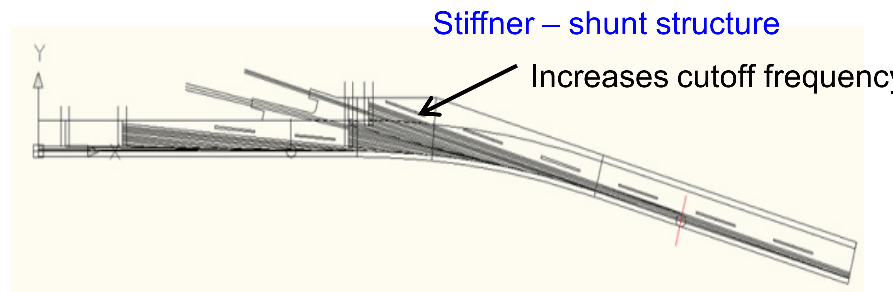
Vacuum System (cont.)

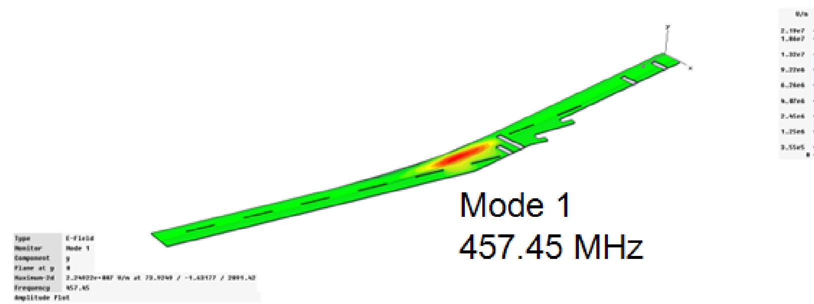


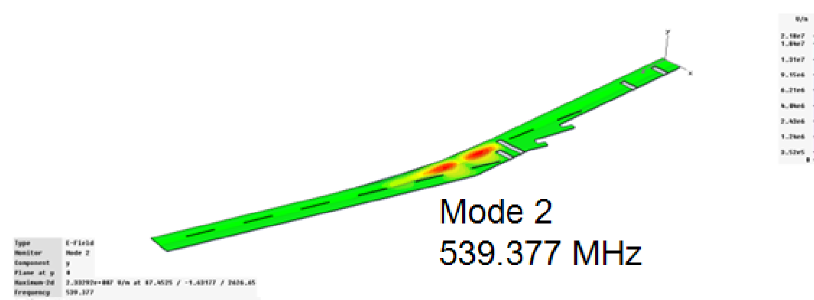












Vacuum System (cont.)

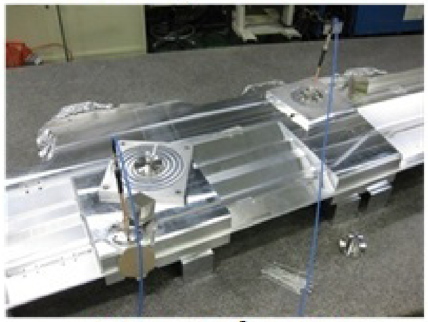
Vacuum Chamber Fabrication Process


machining


delivery/inspection


moving


measurement


TE mode test


cleaning


alignment

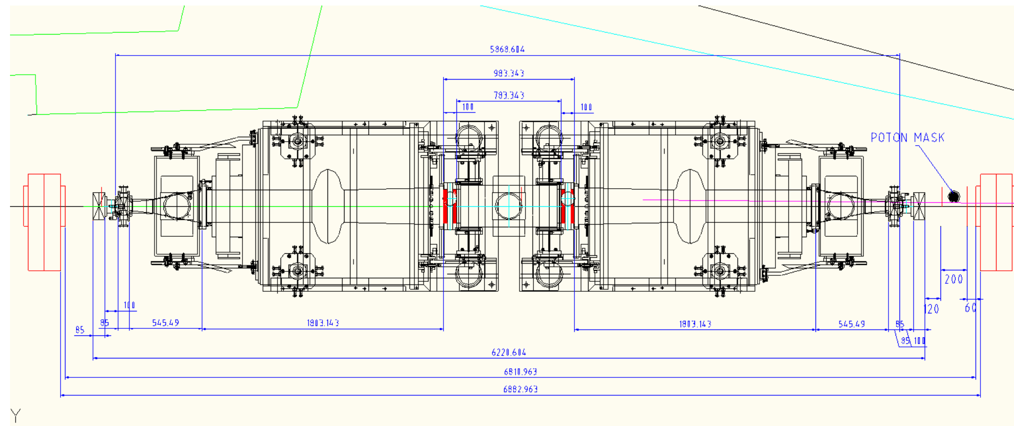

weld

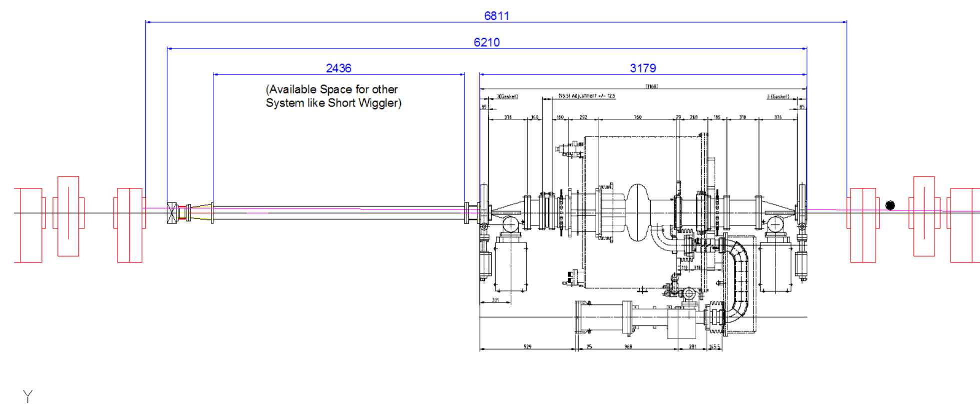

assembly/vacuum test

RF System

Design Parameters of Superconducting RF System

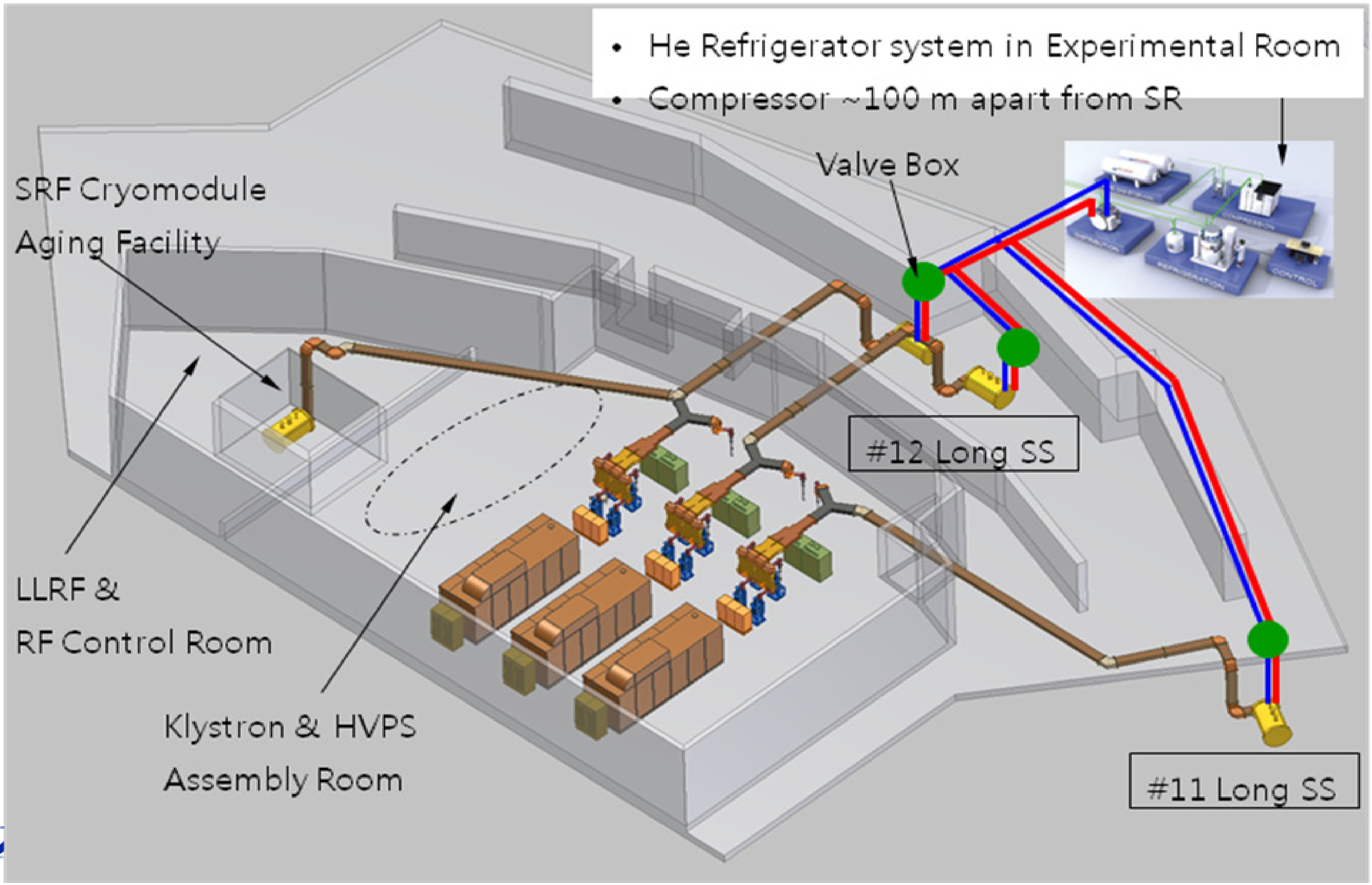
Parameters	
RF cavity	SC
Number of cryomodule	3
RF voltage per cavity	1200 kV
RF power per cavity ($P_{cavity} = P_{wall} + P_{beam}$)	232 kW
Wall loss power (P_{wall})	23 W
Beam Loading power (P_{beam})	232 kW
Number of power amplifier	300 kW × 3
SR tunnel space	1 and half -SS





RF System

Design Parameters of Superconducting RF System



RF System (cont.)

Parameters	PLS	PLS-II
Energy [GeV]	2.5	3.0
Current [mA]	200	400
Emittance [nm-rad]	18.9	5.8
Circumference [m]	280.56	281.82
Revolution frequency [MHz]	1.068	1.0638
Harmonic number	468	470
No. of Insertion Devices	10	20
Electron energy loss / turn from dipoles [keV]	548.4	1042
and insertion devices [keV]	160	250
Beam loss power by synchrotron radiation [kW]	142	517.0
RF frequency [MHz]	500.082	499.973
Cavity type	NC	SC
No. of RF cavities	5	3 (2)
Accelerating Voltage [MV]	2.0	4.5 (3.3)
RF Voltage per cavity [MV]	0.4	1.5 (1.65)
Klystron amplifier	Five 75 kW amplifiers	Three 300 kW amp.
Cryogenic Cooling Capacity @4.5 K [w]		700

- Baseline design: Three Cryomodules
- Two Cryomodules will be installed in Phase II commissioning periods.

RF System (cont.)

Digital Low Level RF System and Klystron System

- ✓ Cavity Field Control(Amplitude & Phase)
- ✓ Cavity Tuning & Beam Loading Compensation
- ✓ Beam Instability Suppression
- ✓ RF Reference Generation & Distribution
- ✓ High-power protection

- ✓ Analog + Digital Technology
- ✓ RF Signal Generation & Precision Clock Synchronization
- ✓ **RF & Digital Board Development with JLAB Collaboration**
- ✓ **PC/104 Based Single Board Computer with EPICS IOC with JLAB Collaboration**
- ✓ High Power Amplification : 2-75kW and 2-300kW Klystron

- ✓ ***Prototype***
  - ***~ February 2011***
- ✓ **Production Type**
  - ***~ April 2011***
- ✓ ***Overall Field Test & Commissioning***
  - ***~ July 2011***

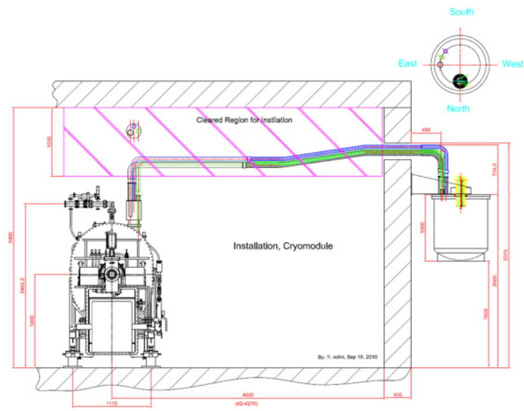
INSIDE KSU WITH HT DESK

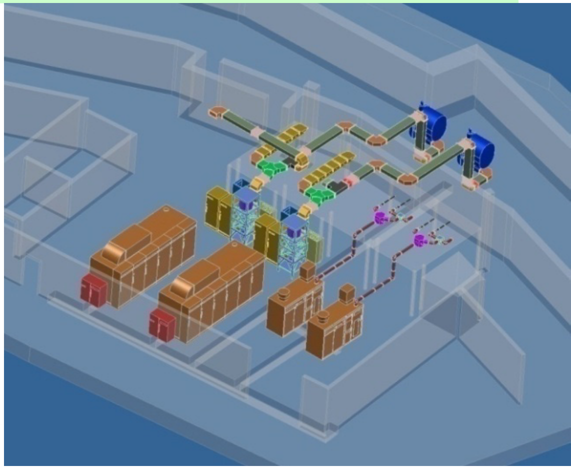
PAL

RF System (cont.)

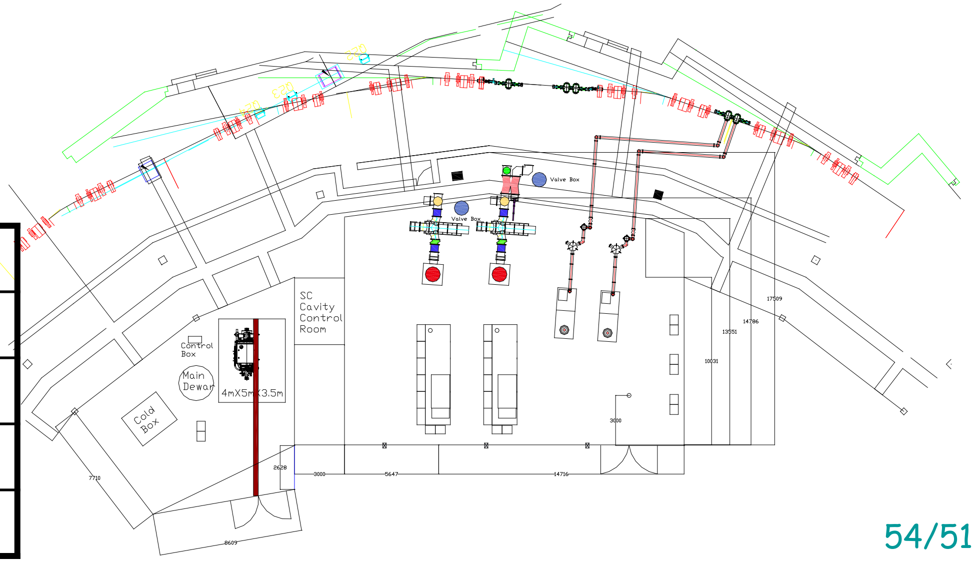
Design Parameters of PLS-II RF System

Parameters	
RF cavity	SC
Number of cryomodule	2
RF voltage per cavity	1200 kV
RF power per cavity ($P_{cavity} = P_{wall} + P_{beam}$)	232 kW
Wall loss power (P_{wall})	23 W
Beam Loading power (P_{beam})	232 kW
Number of power amplifier	300 kW $\times$ 3
SR tunnel space	1 and half -SS

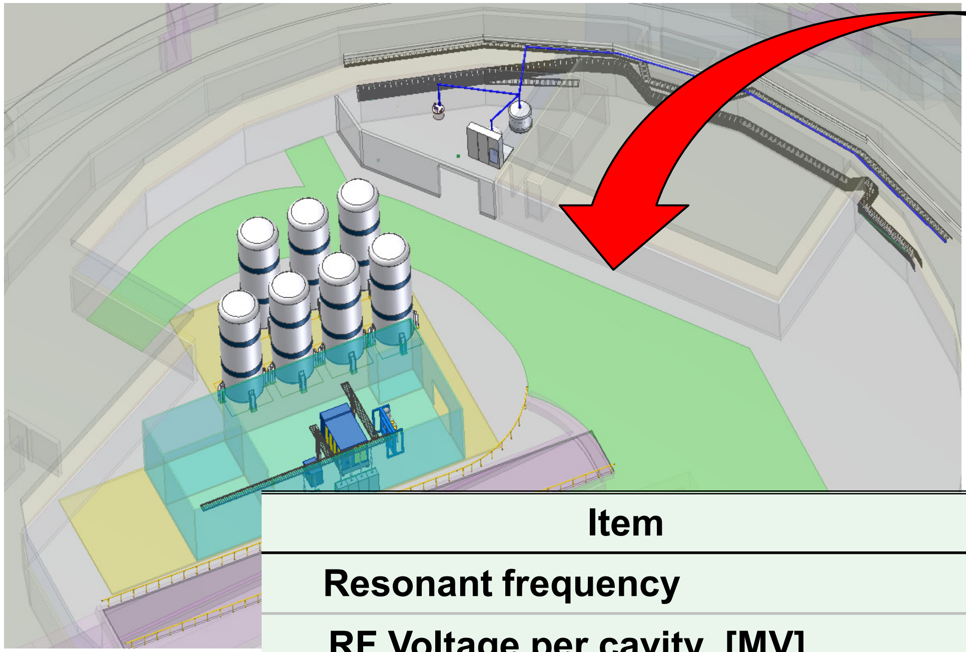


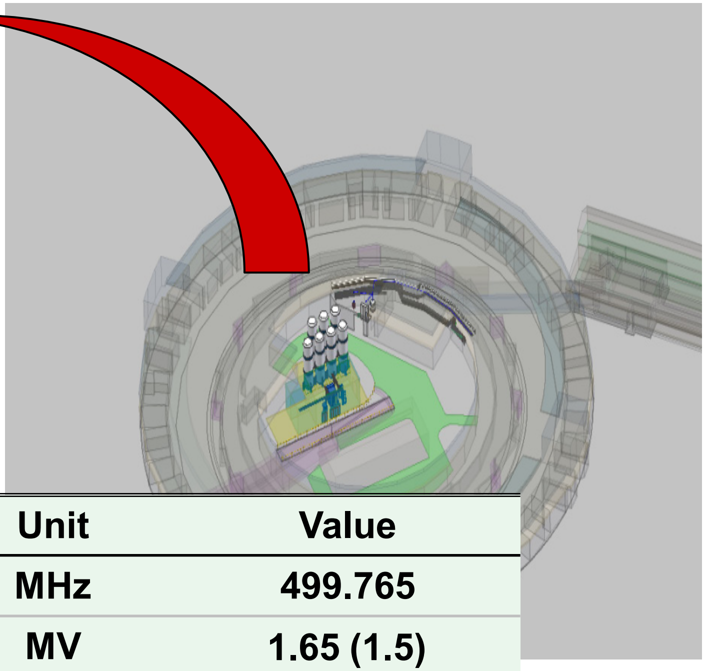


# of Amplifier/HVPS	3
Waveguide	WR1800
Circulator	~350kW
Amplifier	300kW klystron
HVPS	55kV/10A



RF System (cont.)



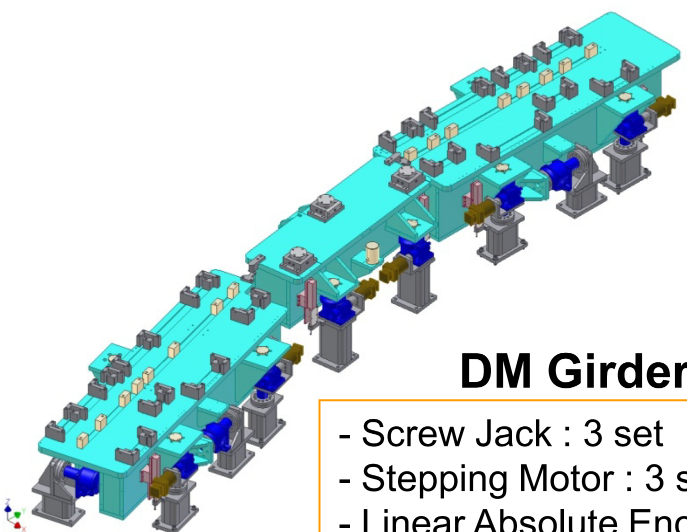


Item	Unit	Value
Resonant frequency	MHz	499.765
RF Voltage per cavity [MV]	MV	1.65 (1.5)
Accelerating voltage [MV]	MV	3.3 (4.5)
Operating temperature	K	4.5
Operating pressure	mbar	1.3
Pressure stability of LHe tank	mbar	± 3 @2.0 MV
Cryomodule helium level stability	%	± 1
LN2 pressure stability	mbar	± 50

Magnet Girder and Alignment System

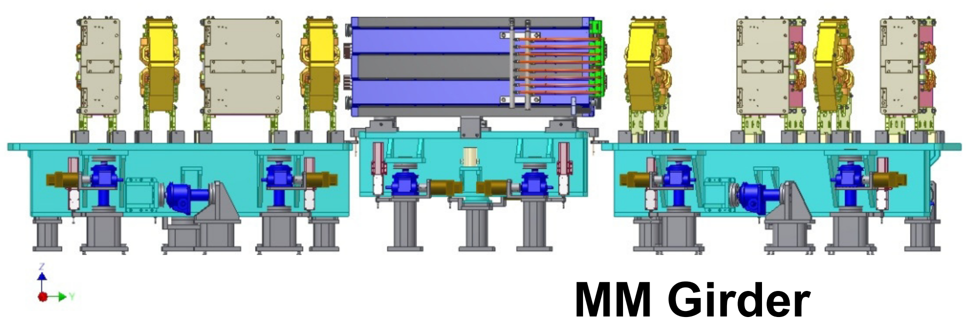
Mechanical Girder and Supporting Structures

- System Design Criteria
  - Hold magnet center of 1,400 mm from the SR tunnel floor
  - Rigid enough to sustain higher natural frequency
  - Absorb the deformation coming from the ground movement
  - Allow the active adjustment in vertical direction
  - Install several diagnostic instruments to measure the deformation and get more flexible alignment (HLS, HPS, LVDT)



DM Girder

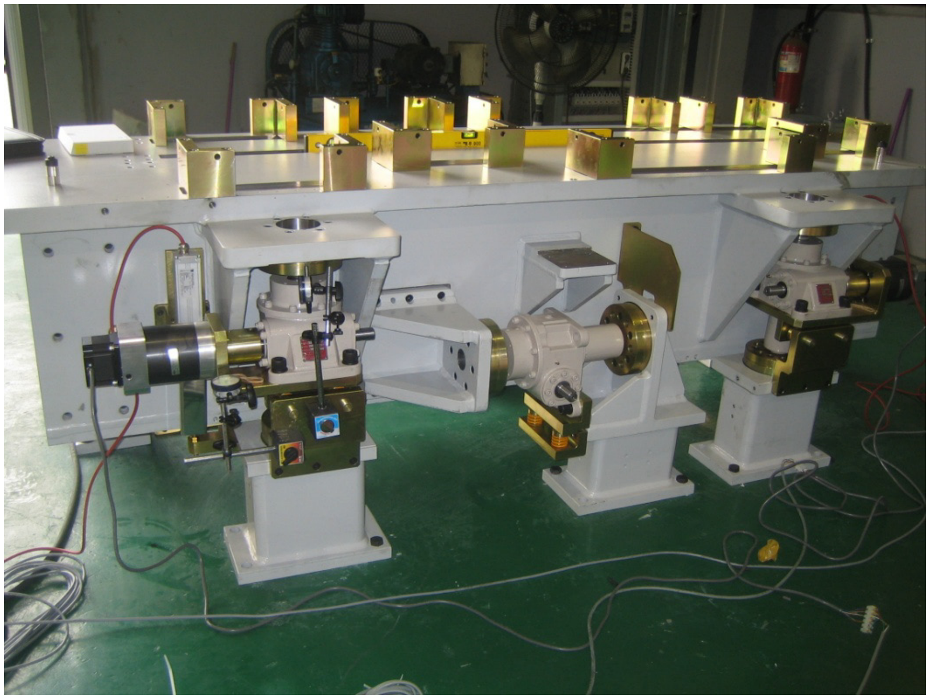
- Screw Jack : 3 set
- Stepping Motor : 3 set
- Linear Absolute Encoder : 3 set
- Total weight : 8.0 ton (w/magnet)



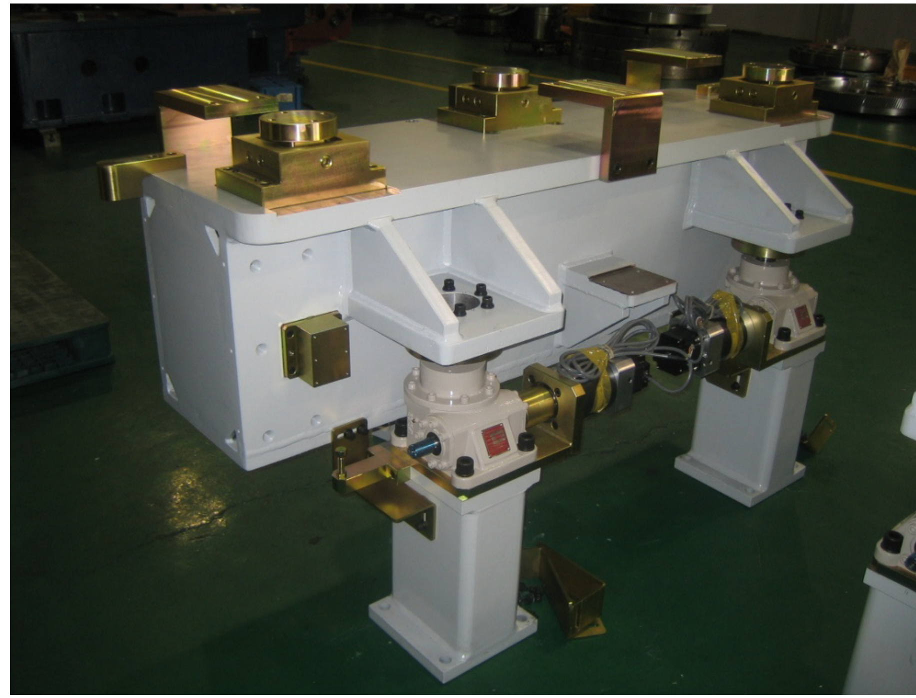
MM Girder

- Screw Jack : 6 set
- Stepping Motor : 3 set
- Linear Absolute Encoder : 3 set
- Total weight : 7.5 ton (w/magnet)

Magnet Girder and Alignment System

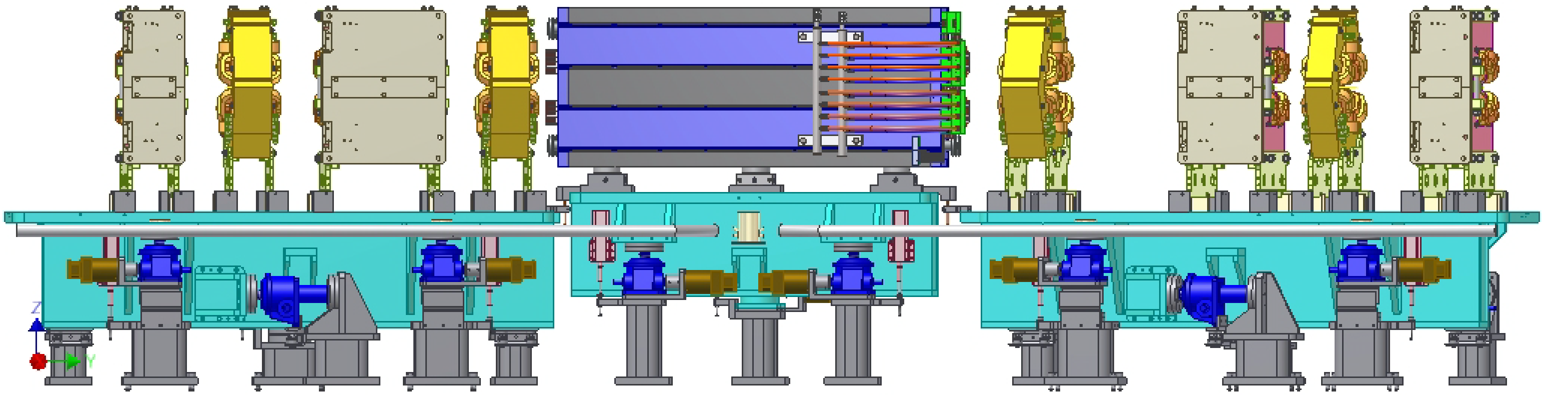


Multipole Magnet Girder



Dipole Magnet Girder

Magnet Girder and Alignment System



[Magnet Error Tolerance with respect to Girder]

• QM, SM : 50 ㎛ • BM : 150 ㎛

Storage Ring Total : 100 ㎛ (rms)

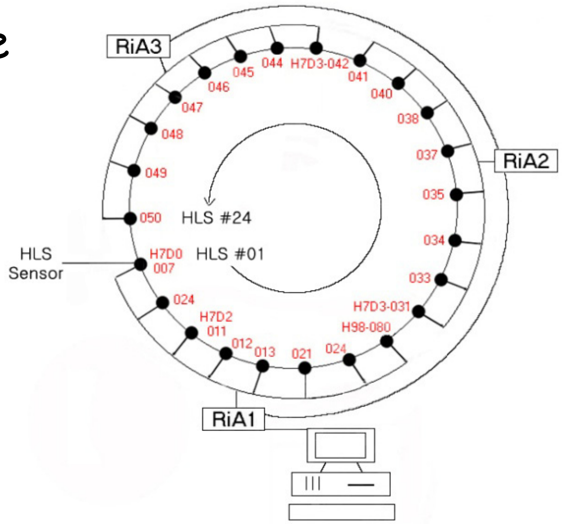
[Alignment System]

• HLS : Monitoring the Girder Movement
• Stepping Motor : Adjusting the Vertical Position
• Absolute Linear Encoder, Digital Probe : Recording the Position

Upgrade of PLS-II Utility/Infrastructures

Infrastructures for More Stable Beam of PLS-II

- Building and Ground Movement
  - Monitor ground displacement using the HLS in real time and countermeasure mechanically the movement with a active girder system
- Thermal Deformation
  - Prevent structural thermal deformation using isolating materials and low thermal expansion structures
  - Water temperature control, air-conditioning and dissipation of heat from electric power devices
- Mechanical Vibration
  - Increasing the resonance frequency of the mechanical structures, using damping materials and isolating vibration sources
- Electrical Power and Grounding System



PLS-II SR and Infrastructure Dismantling, Installation and Commissioning

Basic Strategy of PLS-II Installation and Commissioning

- Strategy to Achieve Technical Goals of PLS-II
  - Define Key Milestones
  - Analyze System Integration
  - Establish Dismantling and Installation Plan
  - Safety Issue and Radiation Shielding
  - High Heat Load Components (Vacuum)
  - Communication (Risk Management)
  - Experienced Experts (Manpower)
  - Planned Commissioning Scenario

Basic Strategy of PLS-II Installation and Commissioning

Concepts of Three Phase Construction Programs

- Separation of the construction activities into Three Phases to meet the overall dismantling/installation schedules based on the work duties

Installation Phases	Periods (Not Fixed)	Main Activities*	
		Storage Ring	Linac/BTL
Phase I	Dec. 15, 2010 – Jan. 15, 2011	Dismantling of PLS SR Components	Re-location of Linac MK09 downstream
Phase II	Jan. 16, 2011 – Feb. 11, 2011	Preparation of tunnel floor, ground marking, cable tray	Actual installation of systems and components of Linac
Phase III	Feb. 14, 2011 – June 30, 2011	Actual installation of systems and components of SR	Start-up and commissioning of Linac (May to June, 2011)

* The beamlines with front-end components should be interfaced with SR installation activities.

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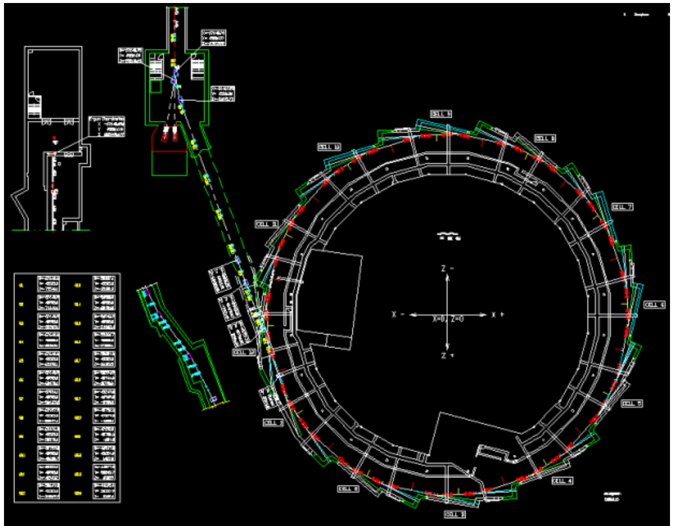
Procedures of Dismantling Program

Dismantling Procedures to Meet PLS-II Needs

1. Preparation of tug transport system for moving heavy-weight structures, chain blocks and jigs, etc
2. Three gates (doors) open to transfer from SR tunnel to outside (#5, 11 cell – shielding wall blocked)
3. Dismantling the HLS, power/signal cables, cooling pipes/tubes, cable trays, air/gas lines, vacuum vent/valve closing, sector by sector
4. Disassemble the re-cycled components in the SR tunnel and move out the components to outside building (reserved for final removal after radiation safety check)
5. Anchor removal, ground grouting/painting, ground floor survey/monument and marking, cable tray re-arrangement
6. Review and check the dismantling of the SR tunnel for PLS-II needs

Storage Ring Layout of PLS SR Tunnel



Demolition Status of PLS Storage Ring/Beamlines

Demolition Status of PLS Storage Ring/Beamlines

Demolition Status of PLS Storage Ring/Beamlines

Procedures of Installation Program

- <u>Installation Strategy of SR Components</u>
  - Detailed analysis and planning of manpower and resource distribution for intensive system integration on the scheduled time
    - ✓ Identification of equipment and systems – hardware readiness
    - ✓ Identification of assembly sequence between the main components and ancillary systems – interface procedure readiness
  - Safety process depending on the rules and regulations for no accidents
  - Installation crew training and coordination
  - Review of the readiness to verify the PLS-II start-up

Procedures of Installation Program

- Demonstration of Typical Cell of PLS-II for Identifying Installation Activities and Component Interfaces

Procedures of Installation Program

Installation Procedures of both Magnets and Girder Assembly

In the Workshop (Assembly Room)

- Set and lay out the girders to the imaginary orbit center line on the ground.
- Install the magnets and adjust the position locally.
- The magnet-girder assemblies will be transported independently in the tunnel by a tug transporter.

In Storage Ring Tunnel

- Check the ground level and grout the floor.
- Drill and insert the anchor nut into the ground with a precision less than 1 mm.
- Move and pre-install the magnet –girder assembly.
- Install the base plate and screw jack.
- Install the magnet-girder assembly on the screw jacks.
- Remove the upper part of the Quadrupole and Sextupole Magnets.
- Install the vacuum chamber.
- Set up the upper part of the Quadrupole and Sextupole Magnets.
- Install the dipole magnet.
- Survey and align the magnet and vacuum chamber cell by cell
- Whole ring survey and adjust the positions of the magnets.

Installation Status of PLS-II Storage Ring/Beamlines

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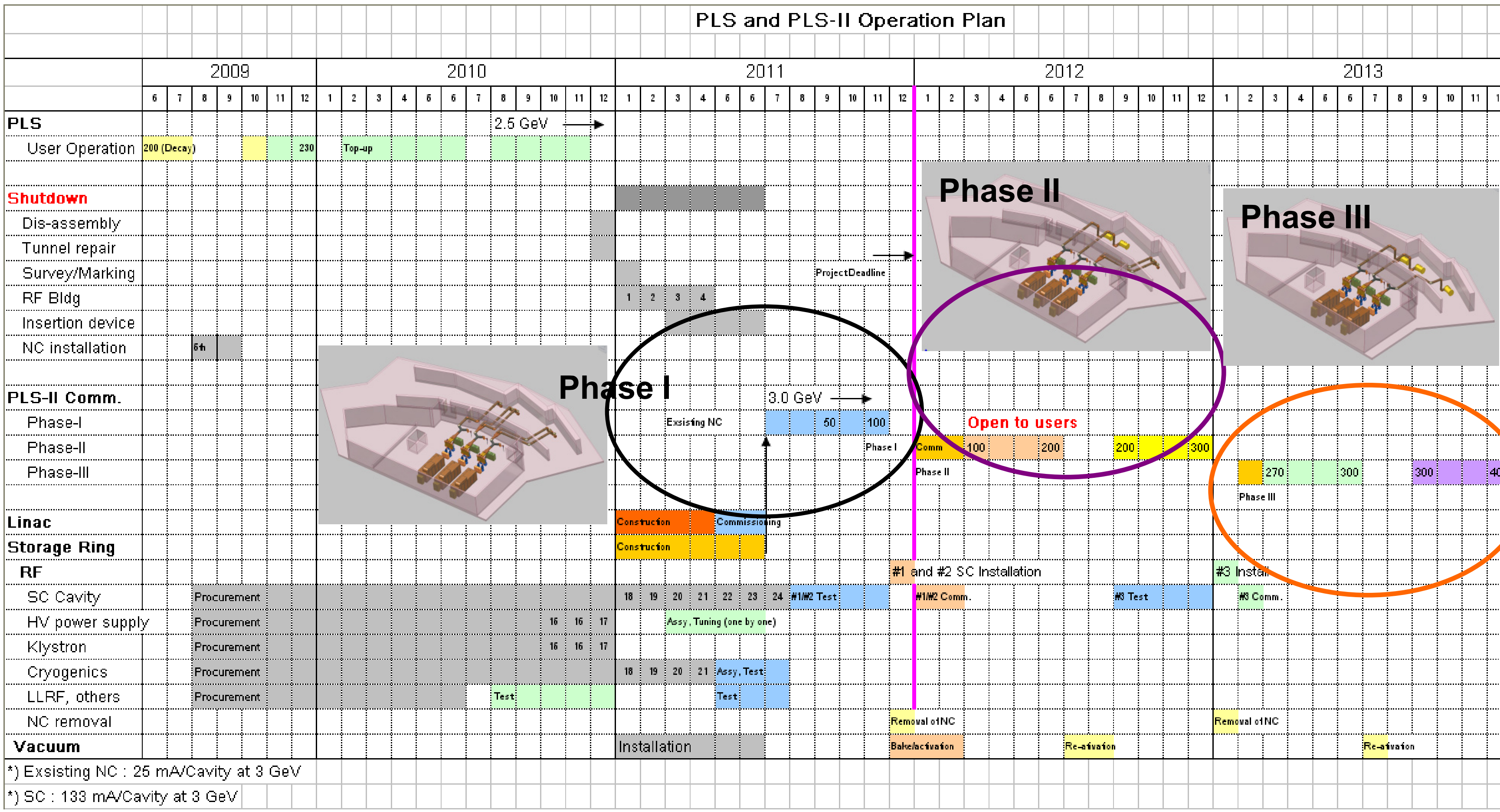
Start-up and Commissioning Plan of PLS-II

Tentative Machine Start-up and Commissioning Plan



On-going Activities and Outlook

- Be done an actual installation program of PLS-II accelerator systems including the dismantlement of current PLS SR and beamline components, including the modification of ancillary infrastructures to meet PLS-II requirements.
- Be defined key milestones depending on the system levels more clearly from construction to start-up or commissioning to achieve the technical goals of a complex projects
- Be confirmed on-time delivery of components with an accepted performance to prevent an interruption of the installation program of PLS-II within 6 months

On-going Activities and Outlook

Readiness of PLS-II Main Accelerator Components

- ✓ **Magnetic Lattice** : Completion of Linear/Nonlinear Beam Dynamics including error budget analysis and optimization (tune, DA, etc.)
- ✓ **Bending Magnets** : IHEP manufacturing (BM)
  prototype finished and under field measurement
  delivered on Jan., 2011
- ✓ **Quadrupoles and Sextupoles** : For aux coil, IHEP manufacturing (QM) and refurbished with PLS QM, domestic company manufacturing (SM) – on schedule (delivered on Dec. 2010)
- ✓ **Vacuum Chamber** : Domestic company manufacturing (Sector Chamber) – on schedule (delivered on Dec. 2010)
- ✓ **Beam Position Monitors** : IT (Libera) manufacturing (2nd procurement) and pick-up button (domestic) – on schedule (delivered on Jan. 2011)
- ✓ **Magnet Power Supplies** : domestic company manufacturing - on schedule (delivered on Dec. 2011)
- ✓ **RF System** : Crymodule system (RI-contracted), Cryogenics (AL-contracted), Klystron amplifier (Thales), Waveguide and others – on schedule
- ✓ **Linac Upgrade** : Klystron (Toshiba-contrcted), Acc. Section (Mitsubish-contracted, Modulator (domestic) and others – on and advanced schedule
- ✓ **R&D on Key Components** : In-vac Undulator (domestic)
- ✓ **Utilities and Safety** : Water, Electricity, Radiation Safety (domestic) –on schedule
- ✓ **SR Dismantling and Installation** : Under preparation of detailed work duties (domestic) –on schedule

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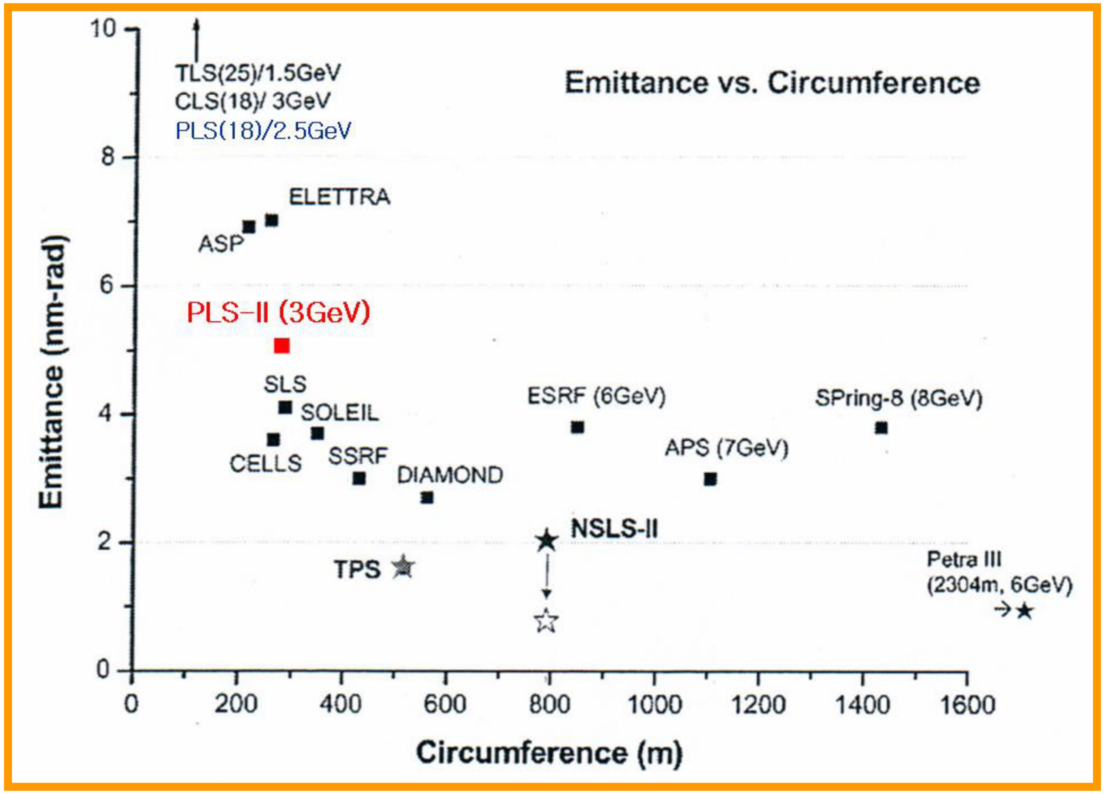
On-going Activities and Outlook

Outlook of PLS-II Light Source Facility

- The upgrade program (PLS-II) has been officially launched with a project period of three years from 2009 to 2011. The main goals of PLS-II are the increase of straight sections for more insertion devices, the energy increase from 2.5 GeV to 3.0 GeV, a stored beam current from 200 mA to 400 mA, a relatively low emittance of 5.9 nm·rad, and more stable beam conditions. During last year (2011) of project periods, the current PLS facility will be shutdown and components be built, and then the first stage commissioning of 100 mA with 3.0 GeV be finalized. New beamlines and experimental stations will be also relocated with newly established insertion devices (undulators and wigglers), while the existing insertion device beamlines may be preserved. The PLS-II is to open for user experiments in 2012 after the international review for assessment of the PLS-II performance and readiness.



Cited from TPS CDR, 2008

Acknowledgements

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Thank you very much for your kind attention