Major Upgrade Activity of the PLS in PAL: PLS-II

S. H. Nam
on behalf of the PAL staff

Pohang Accelerator Laboratory (PAL)
POSTECH

May 7, 2009

Particle Accelerator Conference 2009
Vancouver, British Columbia, Canada

PAL: Geology

- Total Land Area : 651,031 m²
- Total Building Area: 41,846 m²
- Number of Building: 15

PAL: Chronology

I. PLS

- Project started — Apr. 1 1988
- Ground-breaking — Apr. 1 1991
- 2-GeV Linac commissioning — June 30 1994
- Storage ring commissioning — Dec. 24 1994
- User's service started — Sept. 1 1995
- 1st PLS Upgrade Complete — Nov. 1 2002
  - ✓ Energy ramping to 2.5 GeV — Sept. 1 2000
  - ✓ 2.5-GeV injection — Nov. 1 2002

II. 2nd Major Upgrade of the PLS (PLS-II)

- 3.0 GeV PLS-II Upgrade begin — Jan. 2009
- 3.0 GeV PLS-II Upgrade Complete — Dec. 2011

Major Goal of the PLS-II Upgrade

Item	**PLS**	**PLS-II**
Increase Energy	2.5 GeV	3.0 GeV
Lower Emittance	18.9 nm·rad	5.6 nm·rad
Increase Stored Beam Current	200 mA	400 mA
Increase No. of IDs	**10**	**>20**
Increase Brightness	**$\sim 2 \times 10^{18}$**	**$\sim 10^{20}$**
Change Lattice Type	TBA	DBA
Change Operation Mode	Decay	Top-up

PLS-II Project Summary

- Project Period: 3 years (2009 – 2011)
- Total Budget: US 100 M$

- Yearly Budget: in US M$ (1U$ = 1000 Won)

Item	Year			Total
	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	**0.87**	**3.5**	**5.96**	**10.33**
Total	**30.0**	**46.4**	**23.6**	**100.0**

Linac & BTL

Current Linac

Injector LINAC

- Length = 160m
- 2.5GeV, full energy injection
- 2,856 MHz (S-band)
- 10Hz, 1.5 ns, 1A pulsed beam

- Thermionic Electron Gun
- 12 Pulse Modulators (200MW)
- 12 Klystrons (80 MW, 4us)
- 11 Energy Doublers (g=1.6)
- 44 Accelerating Sections

Performance Upgrade Goal of the PLS-II Linac

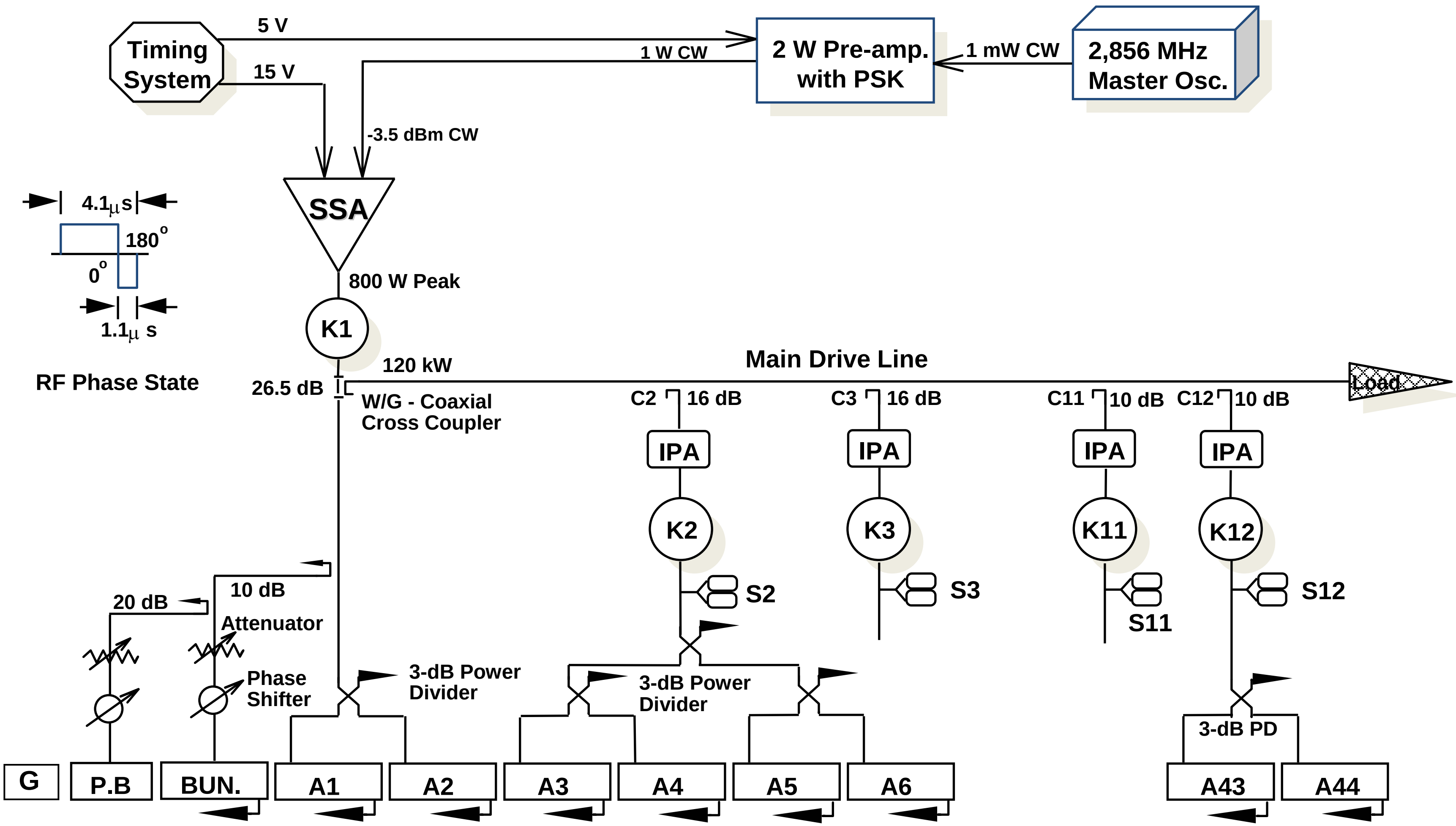
	PLS	PLS-II
Energy	2.5 GeV	3 GeV
Repetition Rate	10 Hz	10 - 30 Hz
Energy Stability	0.5% rms	0.1% rms
Energy Spread	0.6% rms	< 0.2% rms
Emittance (normalized, rms)	150 mm mrad	< 20 mm mrad
Gun Pulse Length	1.5 ns FWHM	< 1 ns FWHM or 0.5 us
Klystron Power (Operating Levels)	50 – 60 MW	70 – 80 MW
SLED Gain	1.5 – 1.6	1.6 – 1.7
Diagnostics	BCMs, BASs, BPRMs	+ BPMs, Slits, Wire Scanners

PLS-II Gun: Comparison of Various Gun Systems

	PLS	PLS-II	
Number of Guns	Single Gun	Single Gun with fast replacement	Dual Gun
Beam Energy	80 keV	80 keV	180 keV
Beam Current	1 A peak	1 A peak	1 A peak
Pulse Length	1.5 ns FWHM	< 1 ns FWHM or 0.5 – 1 us	< 1 ns FWHM or 0.5 – 1 us
HVPS Type	DC	DC	Pulse
Beam Transmission	80%	60%	70%
Pro & Cons		1. Compact & Economic 2. Good for Short Pulse Generation	1. On-line Switching between Guns is Possible 2. Large Pulse Lengthening 3. Complex & Expensive

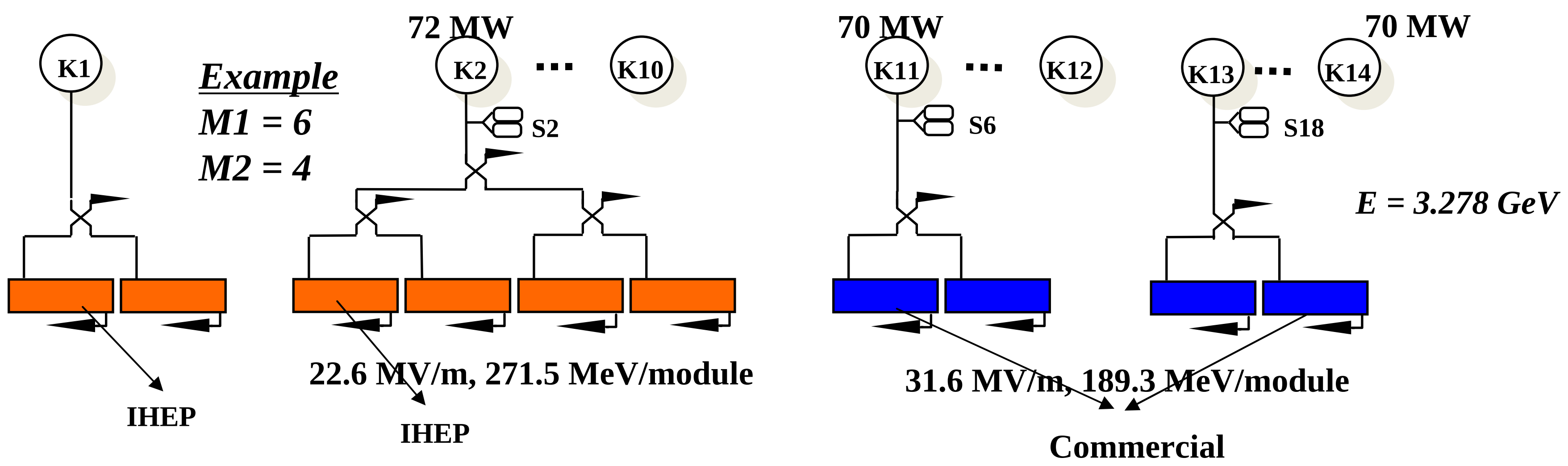
MW System: Current 2.5 GeV Linac

1. 12 klystron&modulator systems
2. MK01&12: two accelerating columns
3. MK2 to MK11: four accelerating columns
4. The klystron drive uses main drive line.
5. Klystron Out Power: 50-60 MW (~19 MV/m)

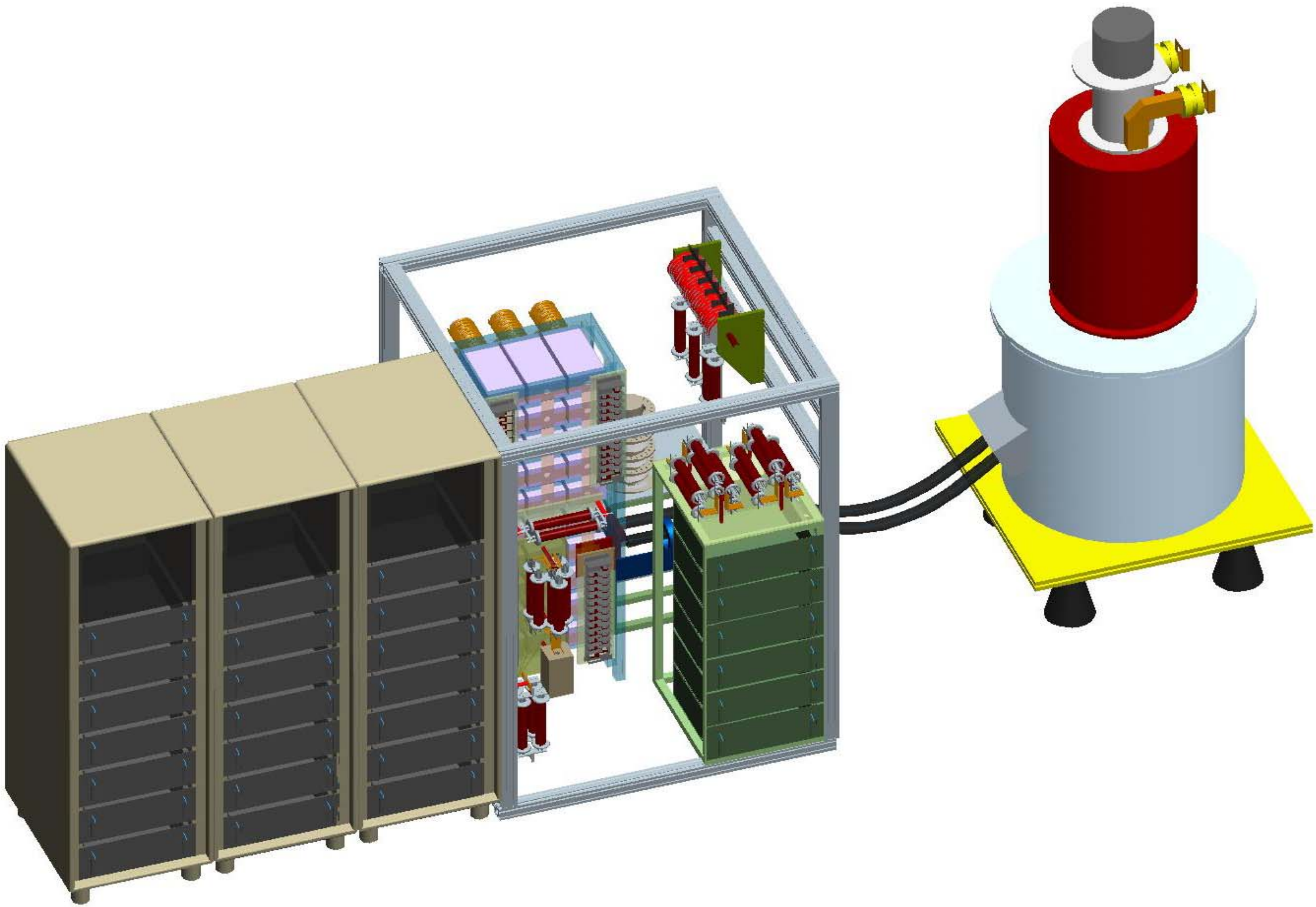


Linac MW Layout (2.5GeV → 3.0GeV Energy Upgrade)

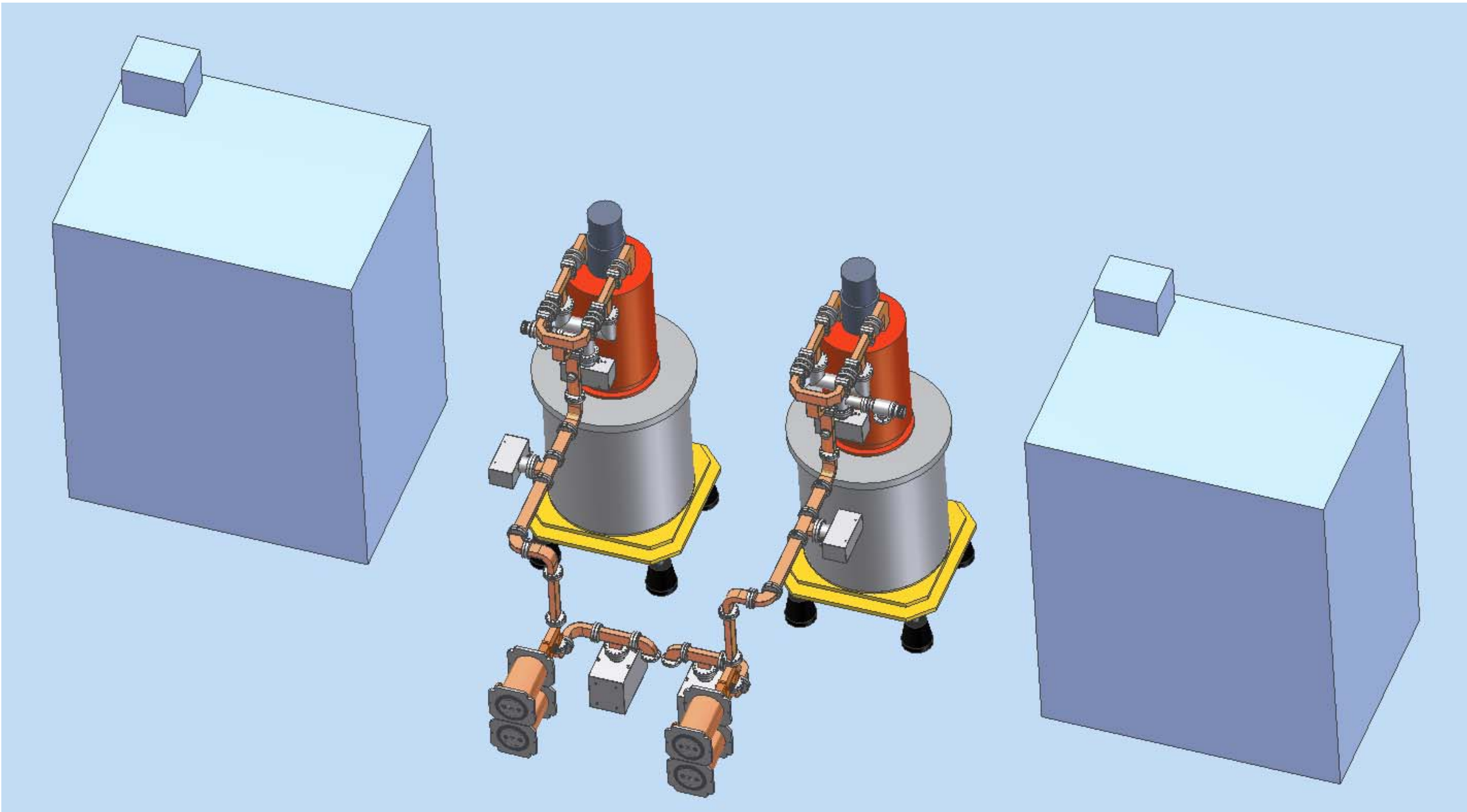
	MK1 1(set)	MK2 - MK10 9(set)	MK11 – MK14 4(set)
Klystron output power	60 MW	72 MW	70 MW
Model	SLAC5045	Toshiba E3712	
Number of A/C	2	36	8
Type of A/C	IHEP		Commercial
Av. energy gain of SLED	NA	~1.6	
Gradient of A/C		22.6 MV/m	31.6 MV/m



Klystron-Modulator



Waveguide Windows and SLEDs in the Gallery

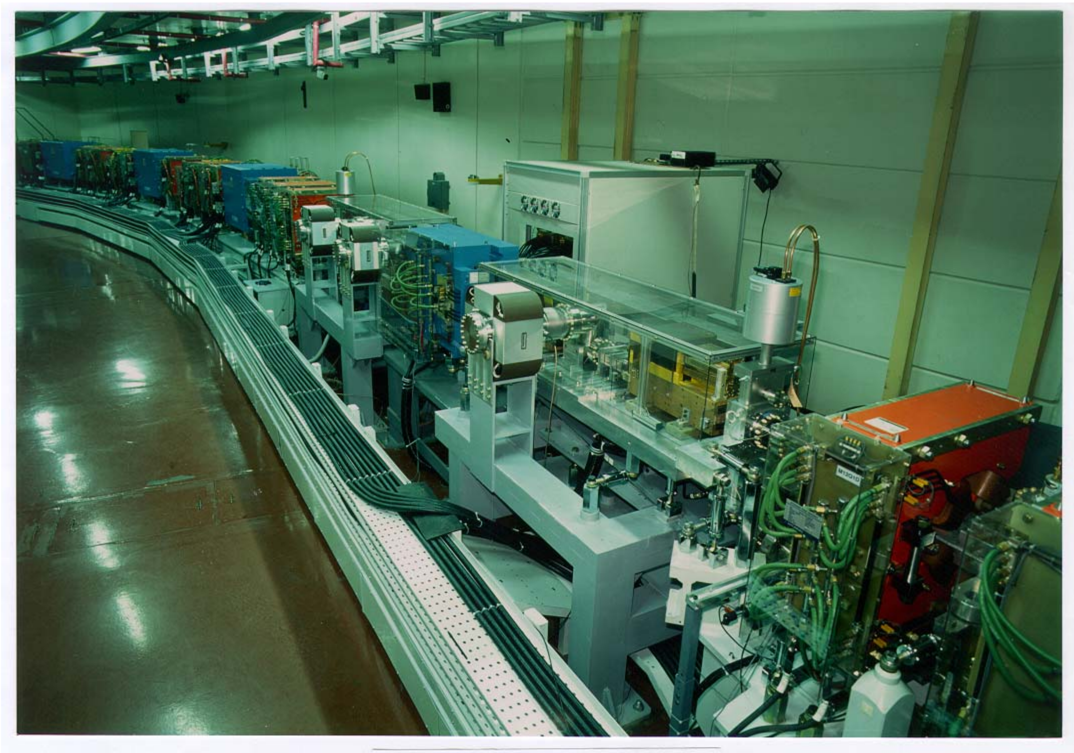


Linac/BTL Beam Instrument of the PLS

Instrument	No.		Operation	Remark
	Linac	BTL(BAS)		
BCM	7	5(1)	O	OK
BPRM	4	5(1)	O	OK
BLM	42	12	O	Need controller
BPM	13	13(1)	Linac pickup install(~2009.8)	Need DAQ
			BTL pickup ok	Operation
Beam Charge Monitor		1(1)	ICT install	Need DAQ
YAG screen monitor		1(1)	screen	Need Controller
Gallery environment	1		operation	SLED, gallery, driver line
Beam slit		1(1)	X	Need controller/monitor

Storage Ring

Current PLS Storage Ring

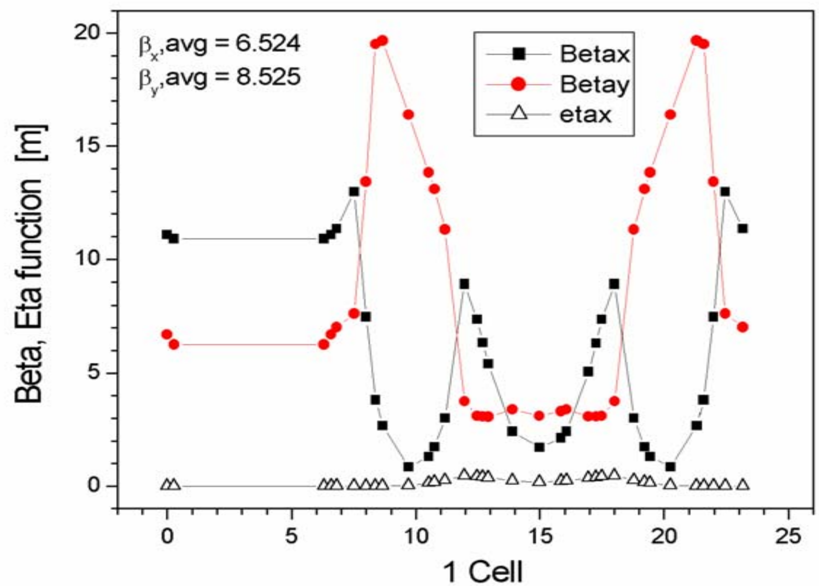


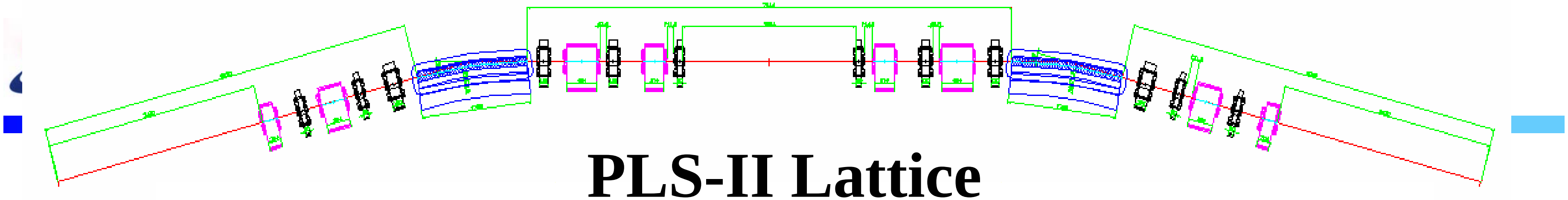
- **Beam Energy** 2.5GeV
- **Beam Current** 200mA
- **Lattice** TBA
- **Superperiods** 12
- **Circumference** 280 m
- **Emittance** 18.9 nm-rad
- **Tune** 14.28 / 8.18
- **RF Frequency** 500 MHz
- **Energy spread** 8.5×10^{-4}

PLS Orbit Requirements

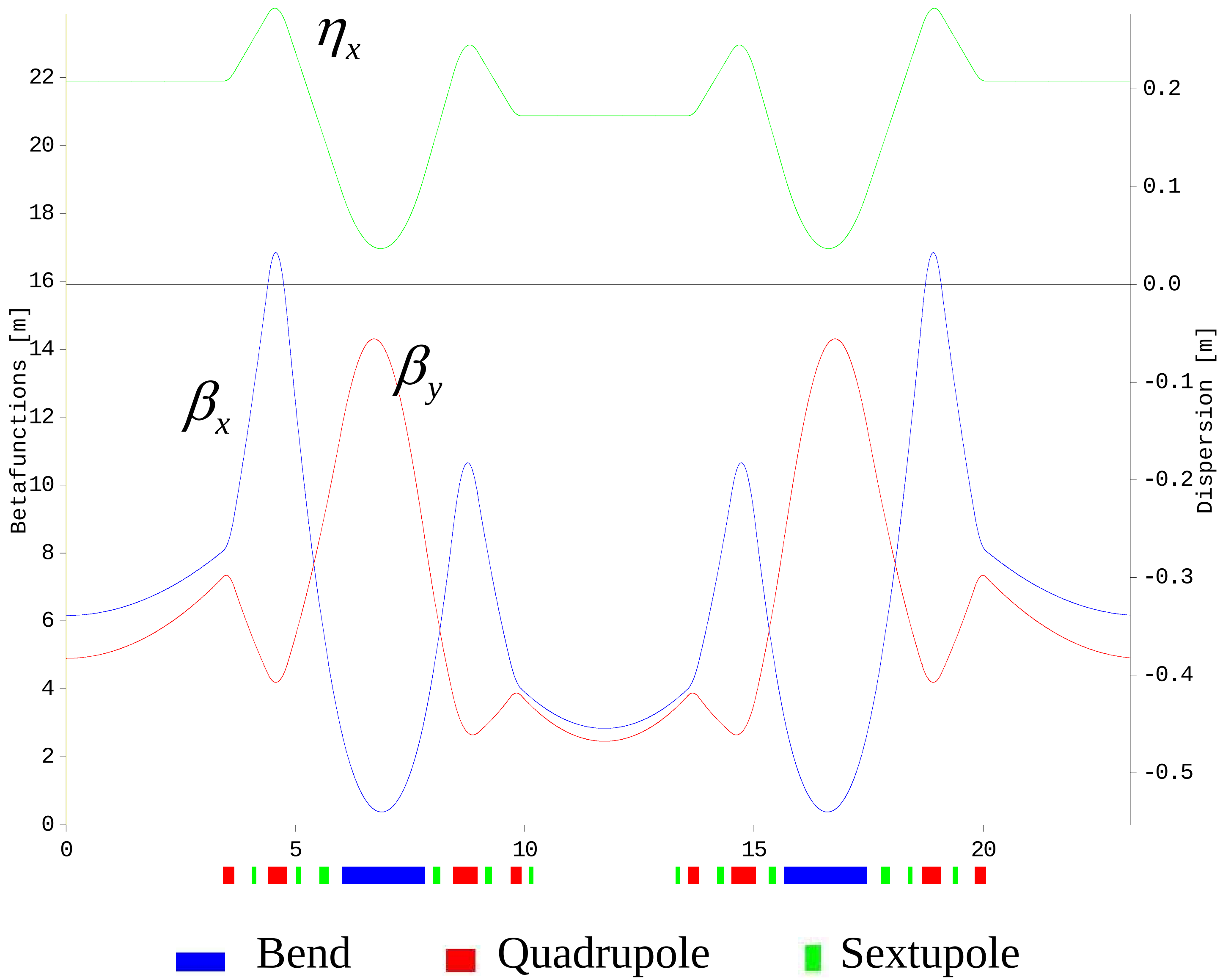
<1% x-y coupling>

	Beam Size		Orbit Stability	
	Horizontal	Vertical	Horizontal	Vertical
Bending Magnet	230 μm	24 μm	23 μm	2.4 μm
Insertion Devices	455 μm	35 μm	45 μm	3.5 μm





PLS-II Lattice

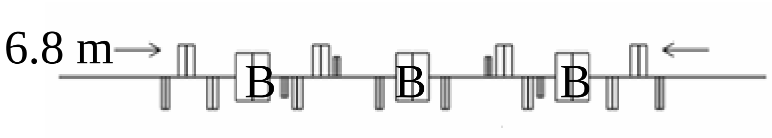


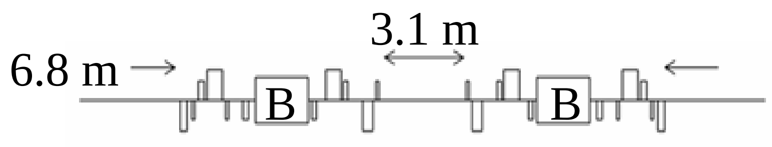
PLS-II Photon Source Parameters

	Long SS	Short SS	Bending Magnet
Number	9 or 10	11	24
Length or Bending R (m)	6.8	3.1	6.875
β_x (m)	6.16	2.84	0.38
β_y (m)	4.90	2.46	14.14
η_x (m)	0.21	0.17	0.037
σ_x x σ_y (mm^2)	234 x 17	167 x 12	47 x 28

Issues on lattice design / Limitation overcome

Straight section for IDs





12 long straight sections ⇒ 12 long straight sections, 12 short straight sections ⇒ **21 straight sections are available!**

Usage of present wall

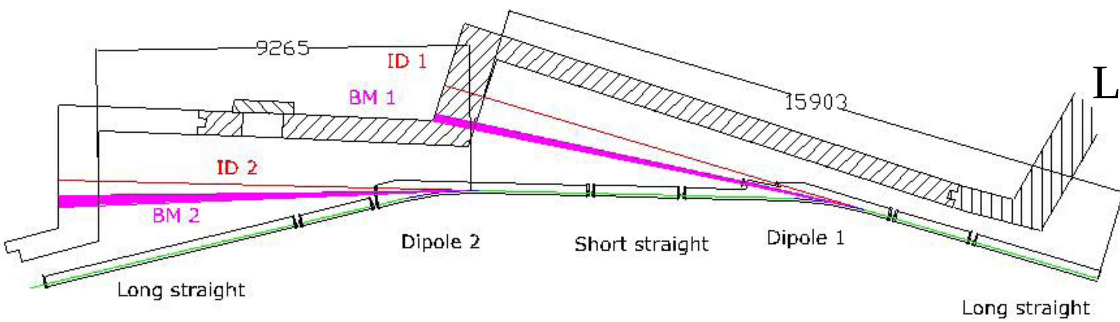
Circumference (m) : 280.56 -> 281.82

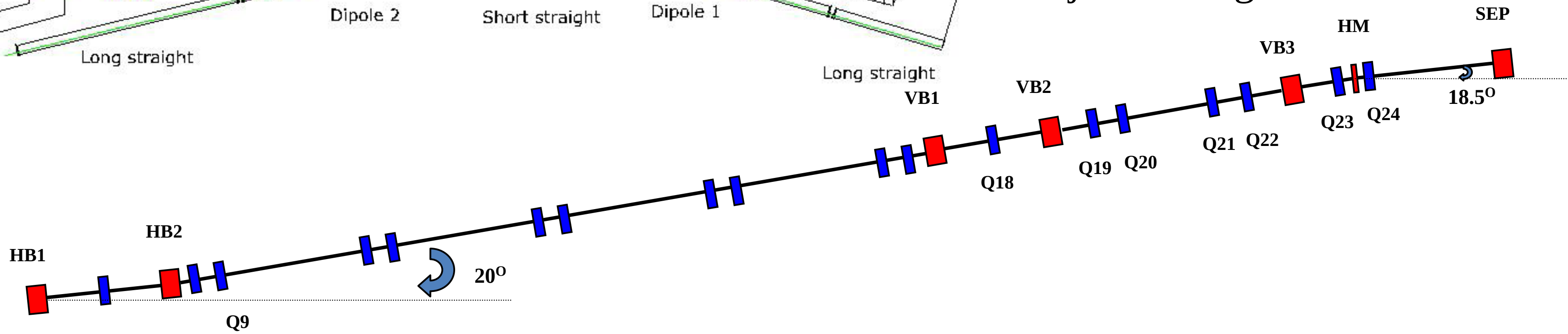
⇓

Lattice is rotated by 1.5 degree.

⇓

Injection angle is corrected.





PLS-II IDs and Expected Photon Beam Performance

Species of ID (Tentative, Not fixed yet)

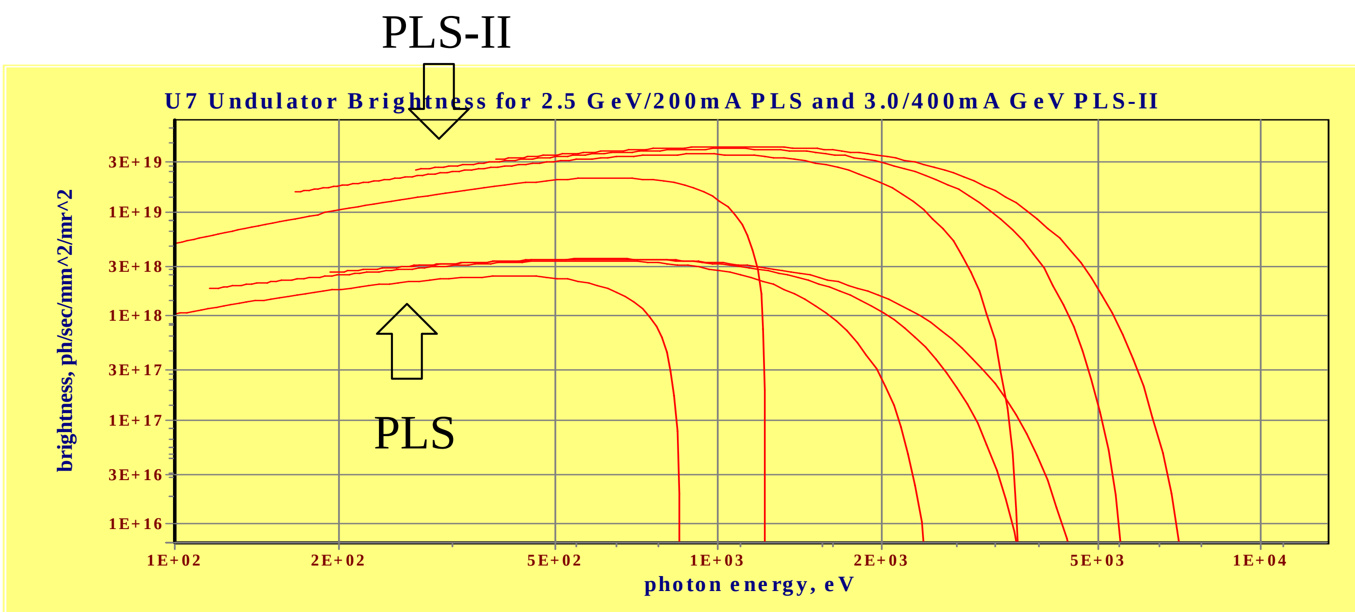
X-ray undulator (6EA)
Period : 2 cm Length : 2 m Field : 1.2 T
Brightness : 4E19 @ 2 keV

U7 (4EA)
Period : 7cm   Length : 4m   Field : 0.99T

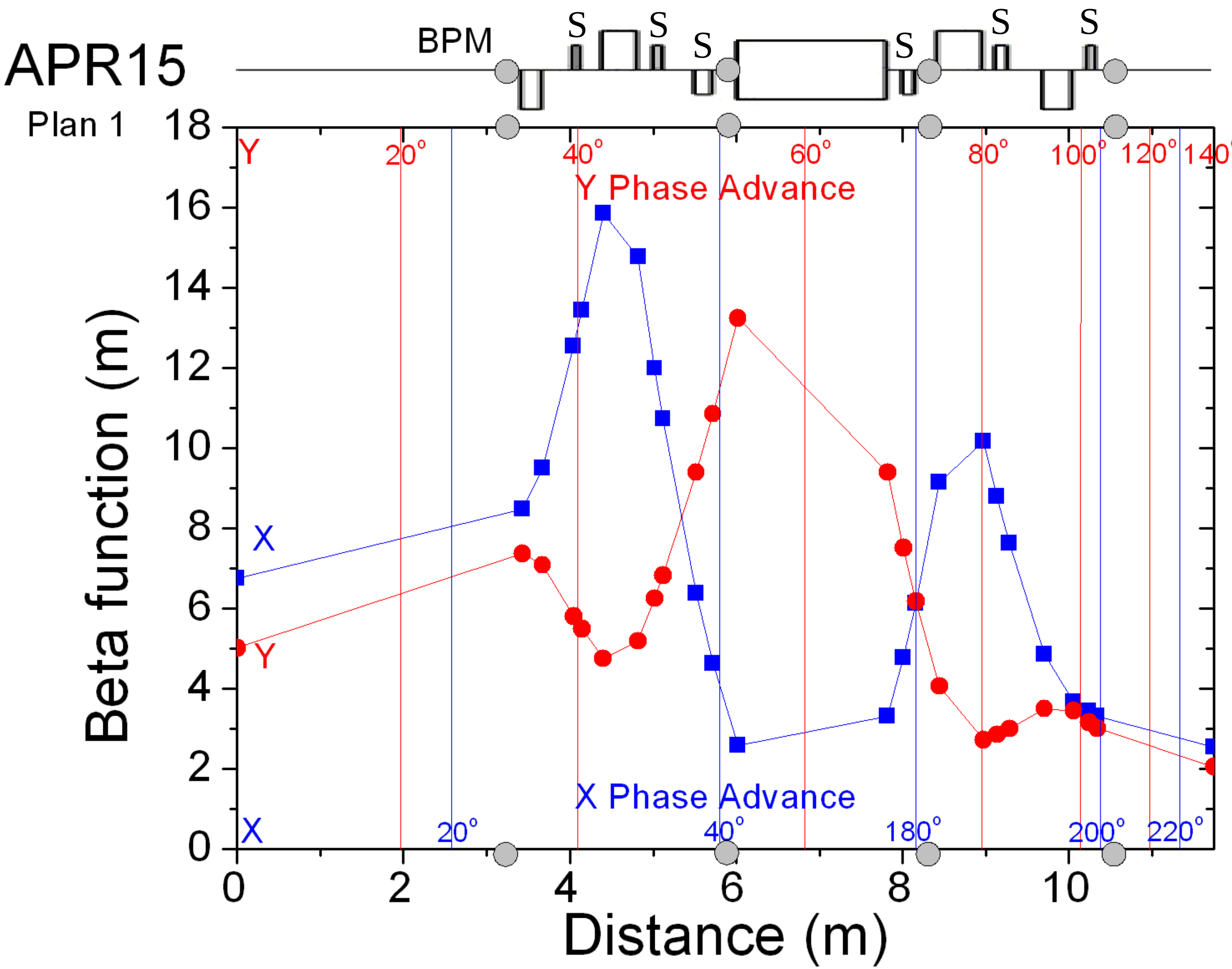
EPU6 (6 EA)
Period : 6cm Length : 4 m Field : 0.69 T
Brightness : 1E19 @ 0.8 keV

MPW (4EA)
Period : 14 cm Length : 2 m Field : 2 T

U7-Undulator brightness



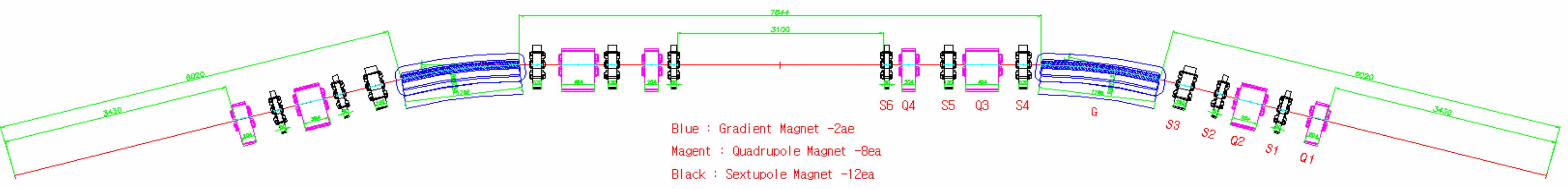
BPM & corrector positions

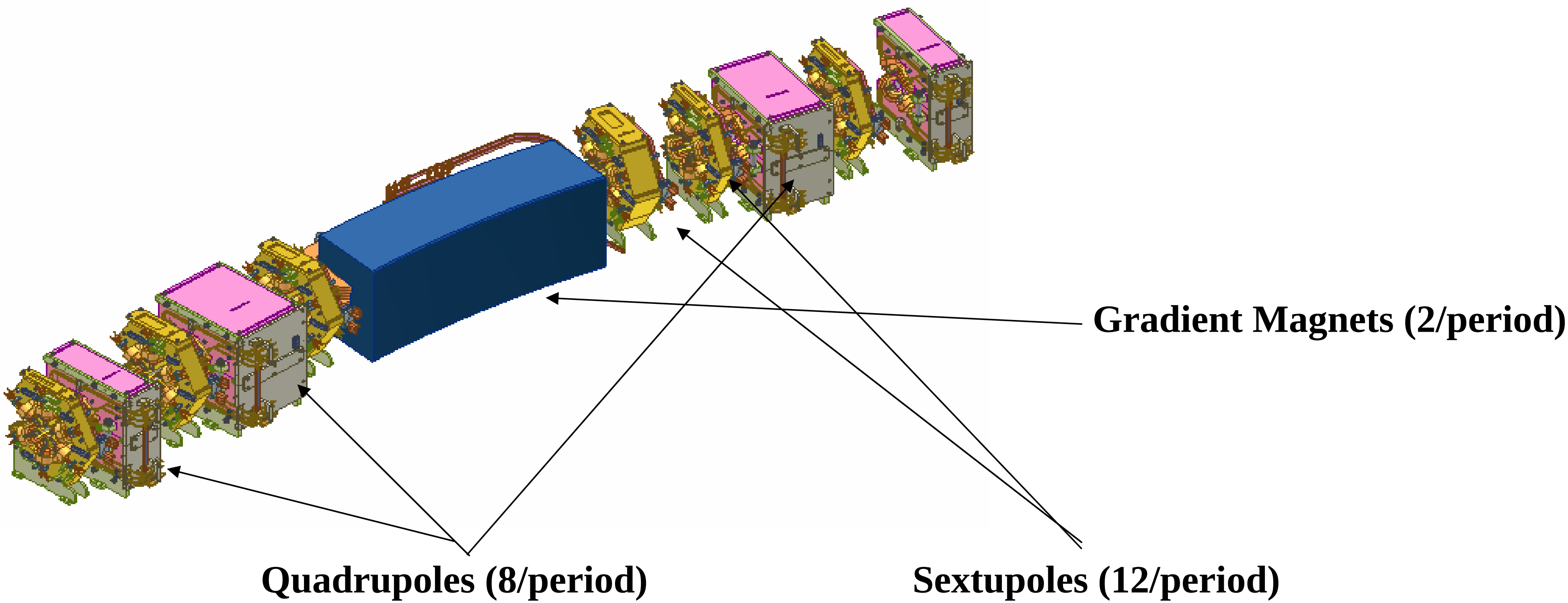


Diagnostics in PLS-II

	Monitor	Qty.	Function
Electron	**Beam Position Monitor**	**96**	**Beam Position**
	DC Current Transformer	**1**	**Average Beam Current**
	Stripline Electrode	**2**	**Tune, Beam Damping**
	Screen Monitor	**3**	**Beam Position (Commissioning)**
	Scraper	**1**	**Beam Trimming, Dynamic Aperture**
Photon	**Photon Beam Position Monitor**	**36**	**Frontend Beam Position**
	Diagnostic Beamline		
	X-ray	**1**	**Beam Profile, Beam Size**
	Visible Light	**1**	**Beam Size, Bunch Length**

PLS-II Magnet System Layout





Magnet System for PLSII

Type	Number	Key Parameters	Remarks
Gradient	24 (2 X12)	1.4555 T, 4.0828 T/m Gap=34 mm, L_{eff}=1.800 m	All powered in series
Quadrupoles	96 (8 X12)	4 types, Max Gradient 22T/m, R_c=36 mm	Powered in family series with independent aux coils.
Sextupoles	144 (12 X12)	Max B'=550 T/m2 R_c=39 mm, 6 types	SkewQ, V-corrector, H-corrector, combined function
Kicker Magnet	4		Recycle existing one
Lambertson Septum	1	3.0 GeV, 8 or 6 vertical bending,	

PLS-II RF system

Parameters	**PLS-II RF**	**PLS RF**
Current [mA]	**400**	**200**
RF frequency [MHz]	499.66	500.082
Total beam loss power (kW)	**696**	**130.2**
Accelerating Voltage [MV]	**3.3**	**1.6**

- To provide the required RF power and control beam instabilities at higher energy and beam currents with more high field IDs, the current PLS RF needs to be fully replaced with a new system.

PLS-II RF system

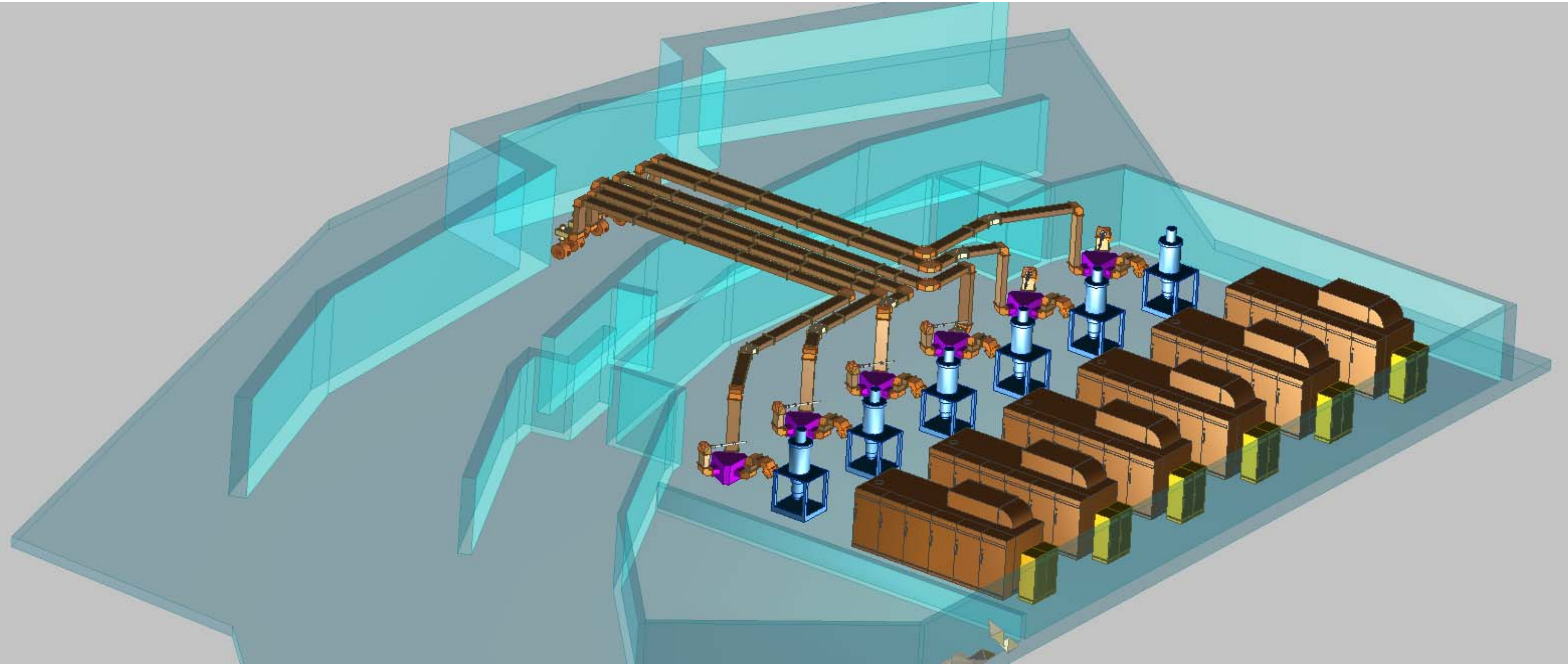
Possible cavity choice and its corresponding facilities

	NC	SC
Number of cavity	6	3
RF voltage per cavity [MV]	0.55	1.1
Wall loss power per cavity [kW]	44.5	0.013
Beam load power per cavity [kW]	112	223
RF Power need per cavity [kW]	163	232
Number of high power system	250 kW × 6	300 kW × 3
Number of LLRF system	6	3
Cryogenic heat load power (W)	0	650
Need for the storage ring tunnel space	1–Long SS	1.5Long-SS * 1 Long-SS+1Short-SS ** 1 Long-SS **

- *3 CESR or KEKB SRF cavities;
- ** 2 CESR or KEKB SRF cavities+1 modified SRF cavity;
- *** 1 cryomodule installed with 3 single-cell cavities.

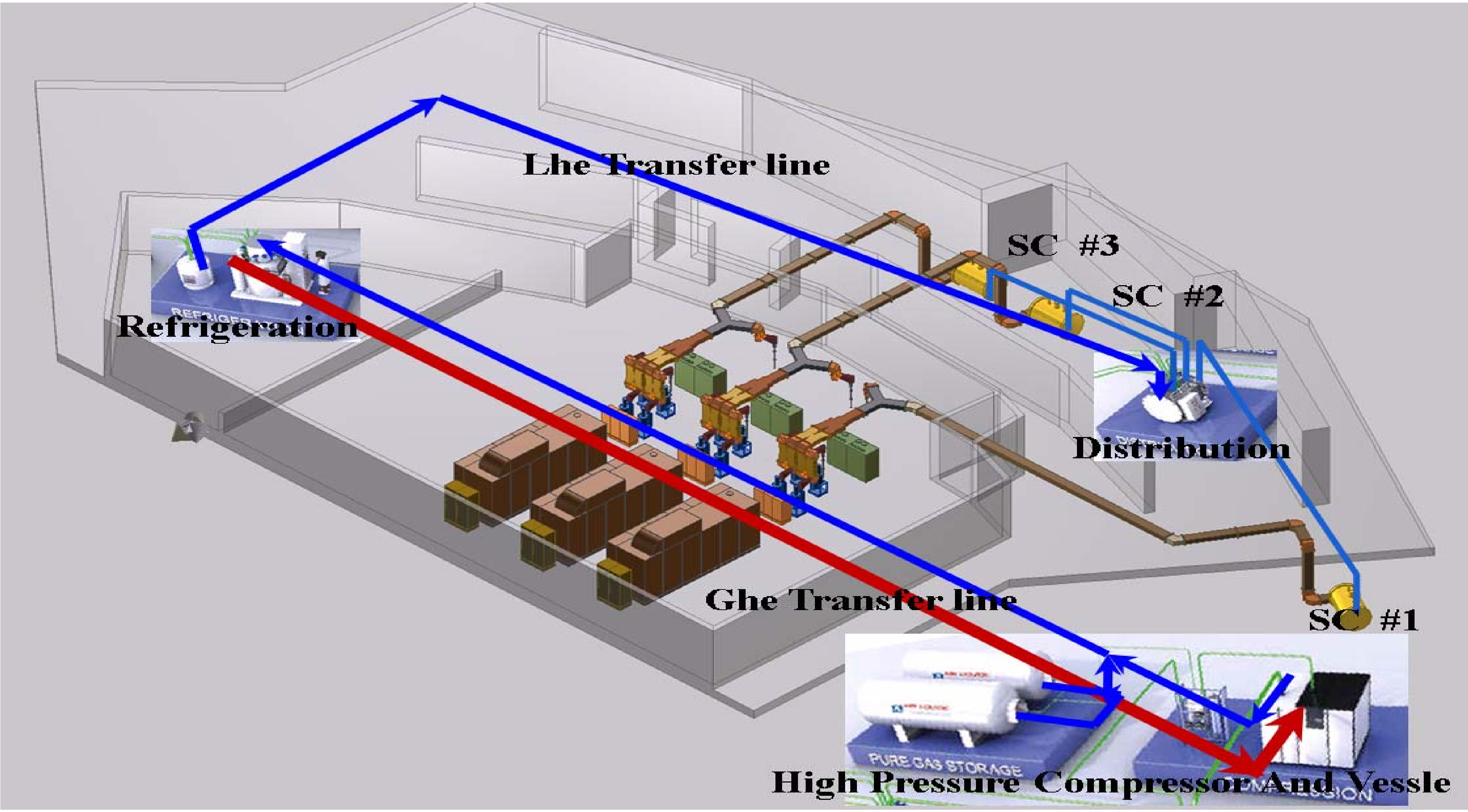
PLS-II RF system

6 sets of normal conducting RF system.

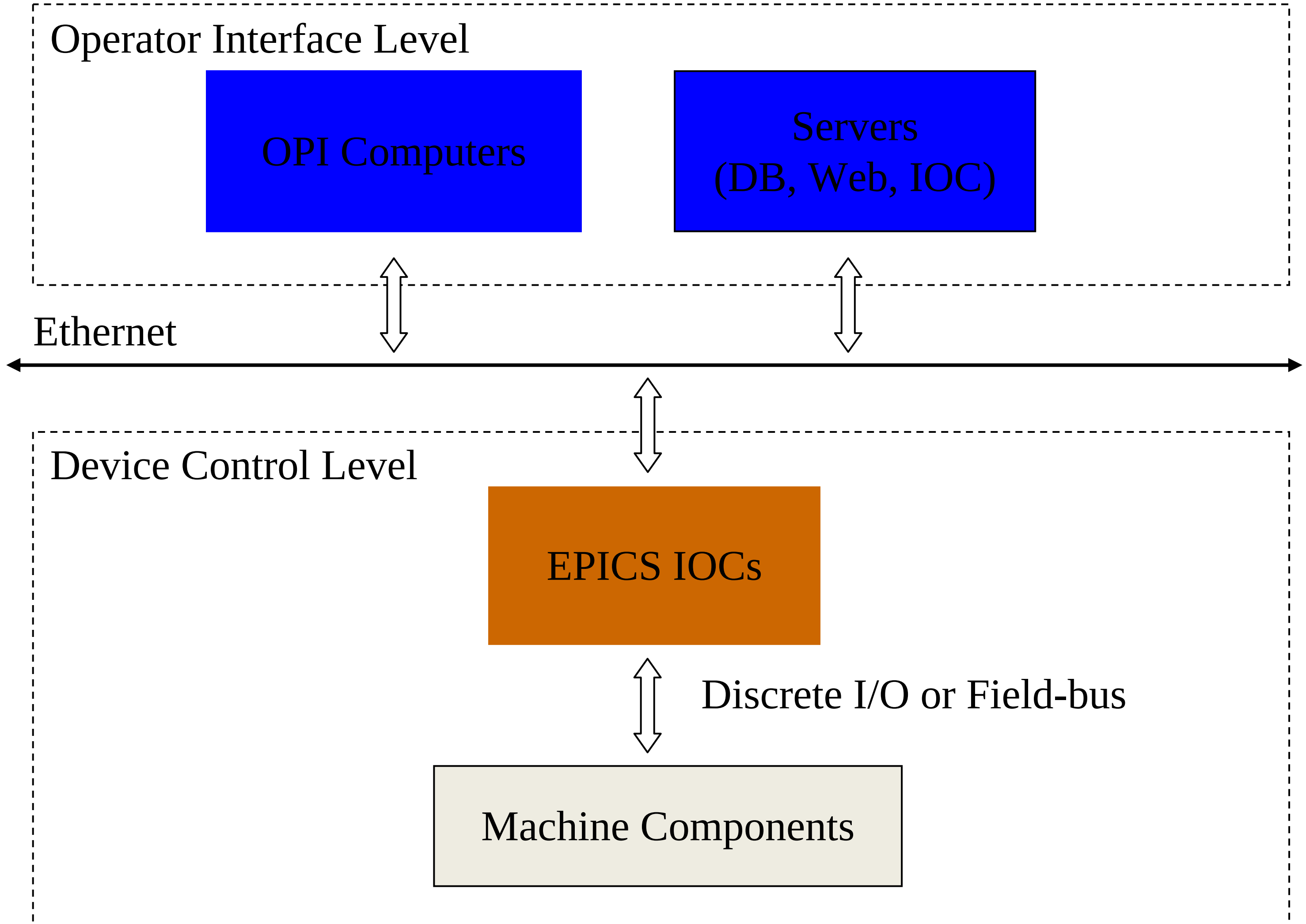


PLS-II RF system

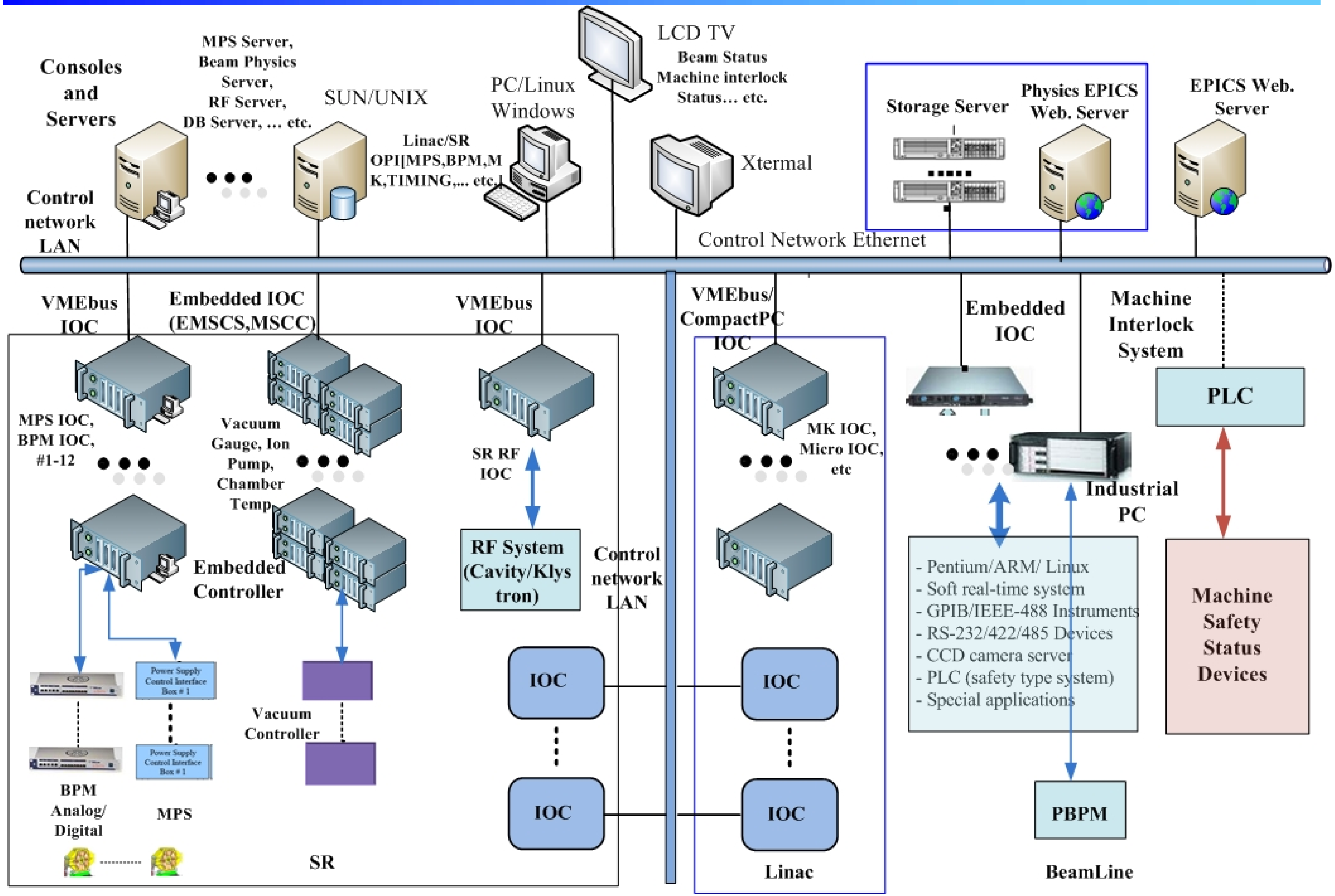
3 sets of superconducting RF system.



Control System Standard Open Architecture



Control System : Overall Configuration



Girder System

- Design Consideration

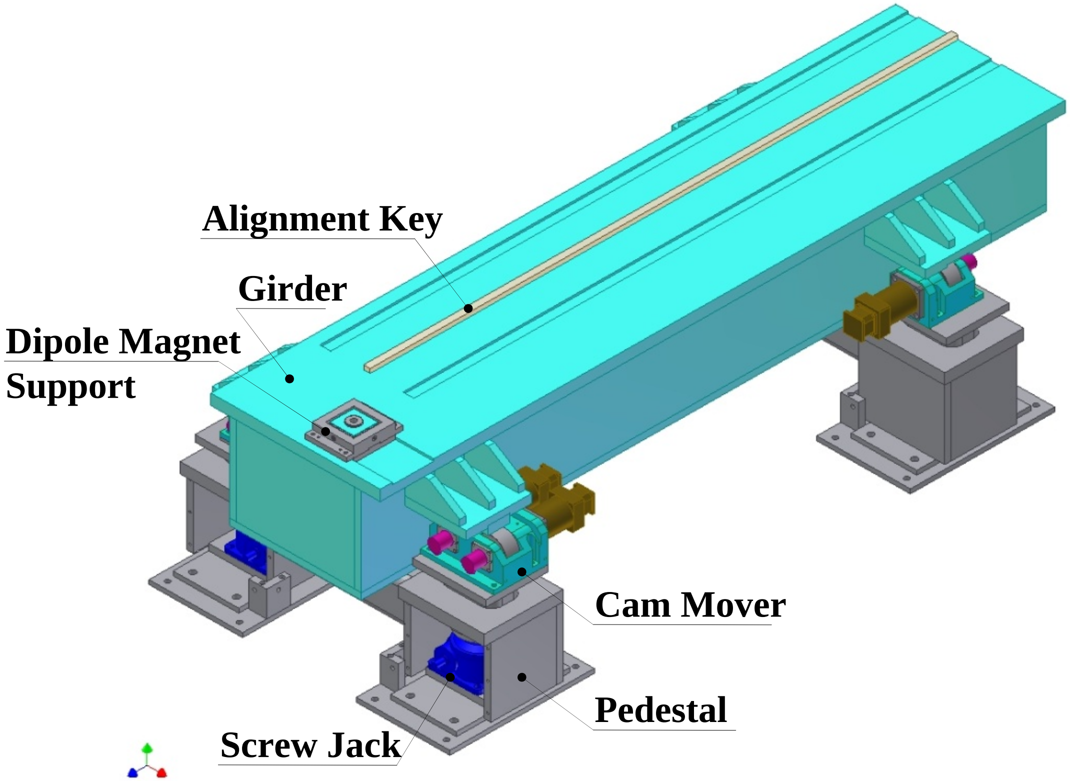
- ➢ **Natural Frequency : >30 Hz**
  - ✓ **Horizontal SR Building : 3.48 – 4.26 Hz**
  - ✓ **Vertical SR Building : 5.67 – 6.93 Hz**
  - ✓ **Outstanding Frequency : 19.2, 23.8, 29.8 Hz**
- ➢ **Girder System Basic Requirement**
  - ✓ **Girder Adjustment Full Range : >50 mm**
  - ✓ **Girder Deformation : ±30 .**
  - ✓ **Active Mover System : Cam Mover and Screw Jack**
    - Cam Mover Full Range : ±**5 mm**

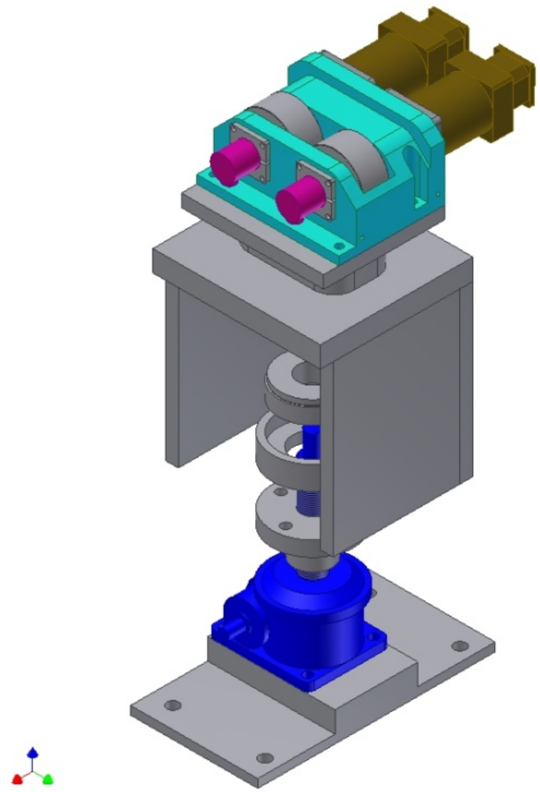
      - Remote Automatic Control (HLS, HPS, LVDT)
    - Screw Jack Full Range : ±**50 mm**

      - Localized Manual Control

PLSII Girder System

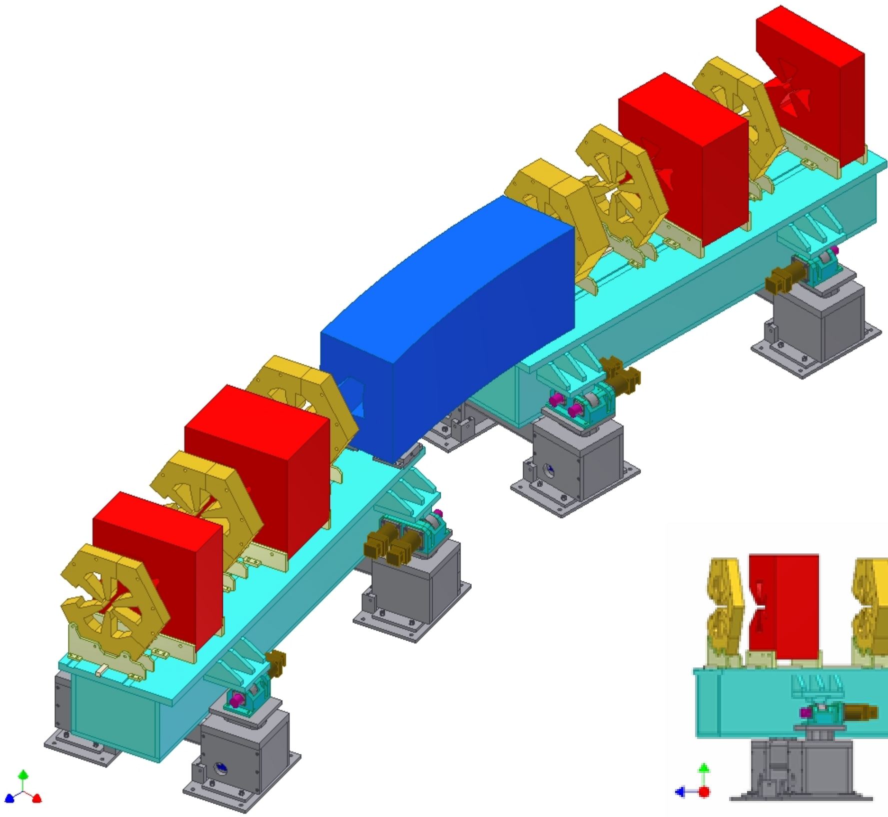
◉ Modeling of girder system



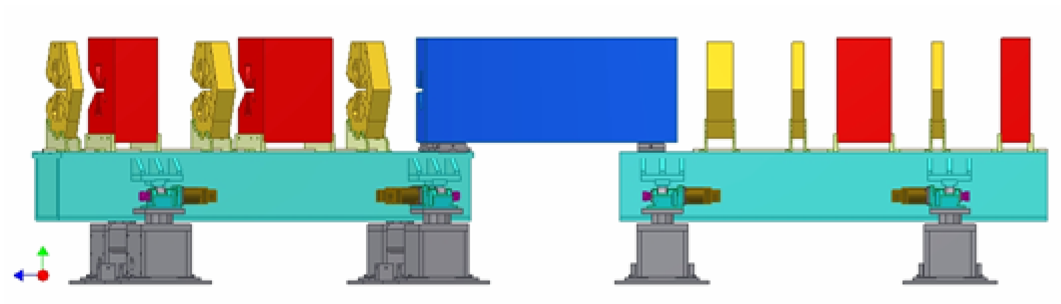


PLS-II Girder System

◉ Magnet Girder of Half Cell



- **The girder consist of two girders, which we denote girder long(GL) and girder short(GS)**
- **The half cell is composed of a dipole magnet, 4 quadrupole magnets and 6 sextupole magnets.**
- **Dipole magnet, equipped with three supports, will form a bridge between the two adjacent girders.**



Summary

- PLS-II has completed its major design and started component purchase.
- Final detail design will be reviewed by the PAL international advisory committee (IAC) on June 2009.
- TDR will be published in June 2009.
- The project is expected to finish on time and budget.

Thank you for your attention!!

As usual, we are expecting very close collaboration and help from light source facilities all around world!