PLS-II Linac

2015. 4. 8.

Jae-Young Choi

On behalf of PLS-II Linac team

Accelerators in Pohang Accelerator Laboratory

PAL : Chronology

I. PLS

▪ Project started	Apr. 1. 1988
▪ Ground-breaking	Apr. 1. 1991
▪ 2-GeV Linac commissioning	Jun. 30. 1994
▪ Storage ring commissioning	Dec. 24. 1994
▪ User service started	Sep. 1. 1995
▪ 1st PLS Upgrade Completed	
✓ Energy ramping to 2.5 GeV	Sep. 1. 2000
✓ 2.5-GeV injection	Nov. 1. 2002

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

▪ 3.0 GeV PLS-II Upgrade began	Jan. 2009
▪ 3.0 GeV PLS-II Upgrade Completed	Dec. 2011
▪ User service started	Mar. 2012

III. PAL-XFEL Going On

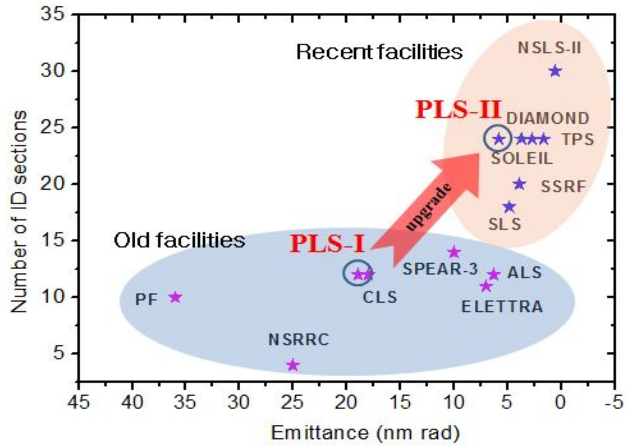
- 10GeV Linac Based 0.1 nm x-ray FEL (2011 ~)
- 2015 : machine installation
- 2016: commissioning

PLS-II upgrade project ('09~'11)

○ **Goals**

- Beam energy : 2.5 → 3.0 GeV
- Current : 200 → 400 mA
- Storage Ring Emittance : 18.9 → 5.8 nm·rad
- Top-up Operation mode
- No. of Insertion Device : 10 → 20 EA

The 3rd generation synchrotron facilities



PLS

PLS

Dismantling

DEC. '10

Re-installation

JAN. '11

PLS-II

PLS-II

Commissioning milestones

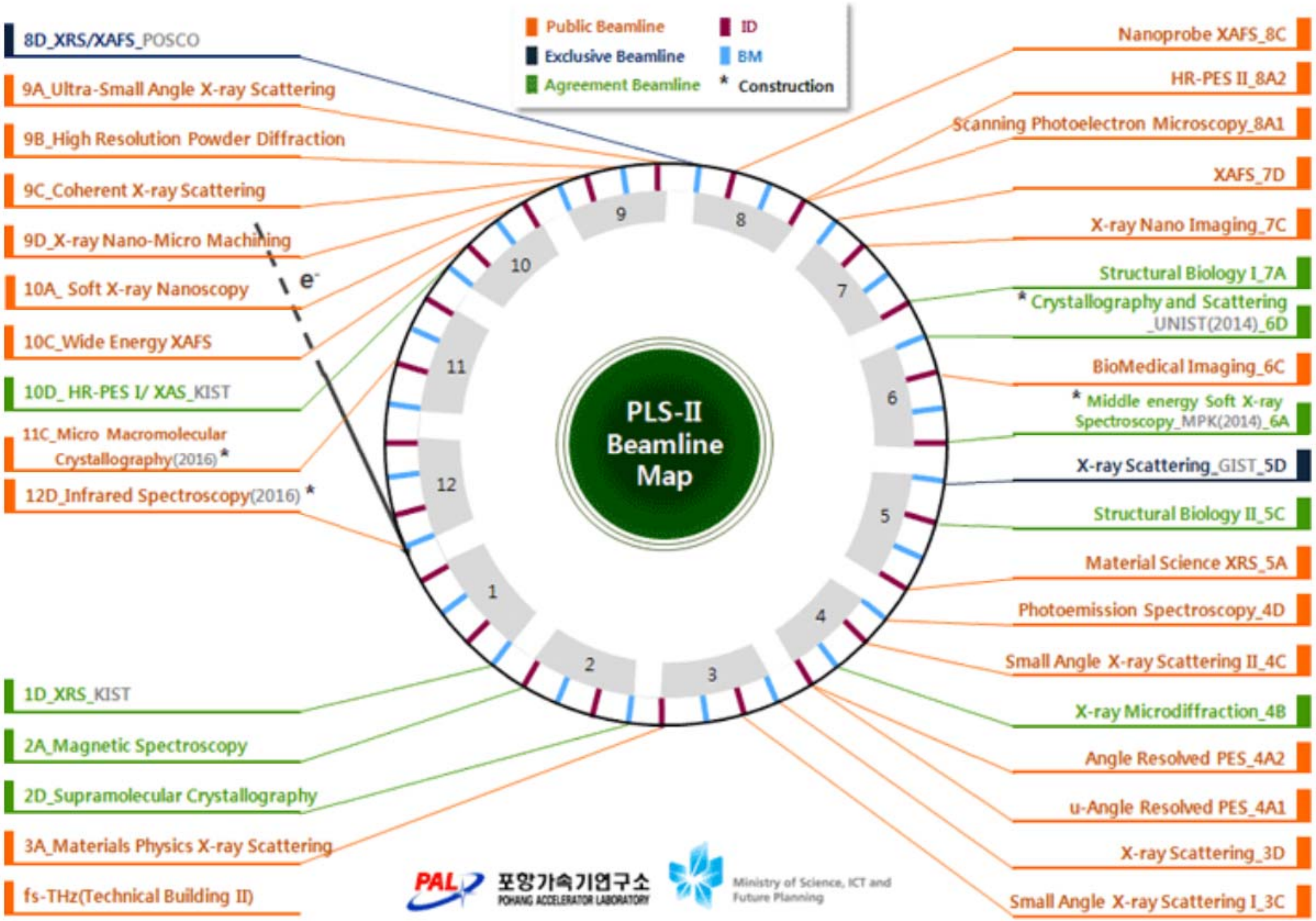
- **2011**

  - January 25, PLS-II installation begins
  - May 23, Linac commissioning begins
  - June 13, 3 GeV beam
  - June 15, SR installation finished and BTL commissioning begins
  - July 1, First turn
  - July, Kicker Modulator accident, fire
  - August 5, First accumulation
  - September, Shutdown for installing insertion devices
  - October 7, 100 mA stored
  - October 24, First photons to beamline
  - December, Shutdown for installing insertion devices

- **2012**

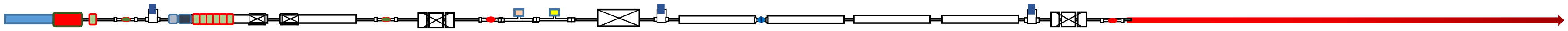
  - February 14, Commissioning with users
  - March 21, Start of operations

PLS-II Beam Line Map



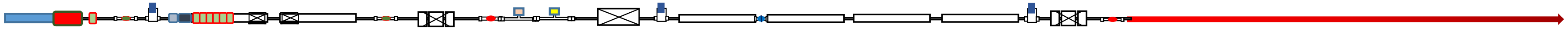
- 29 BL's in operation
  - 10 In-vac Undulators
  - 2 MPW's
  - 4 Out-vac. Undulators
  - 1 Linac based BL
- 2 Diagnostic BL's
- 4 BL's in construction

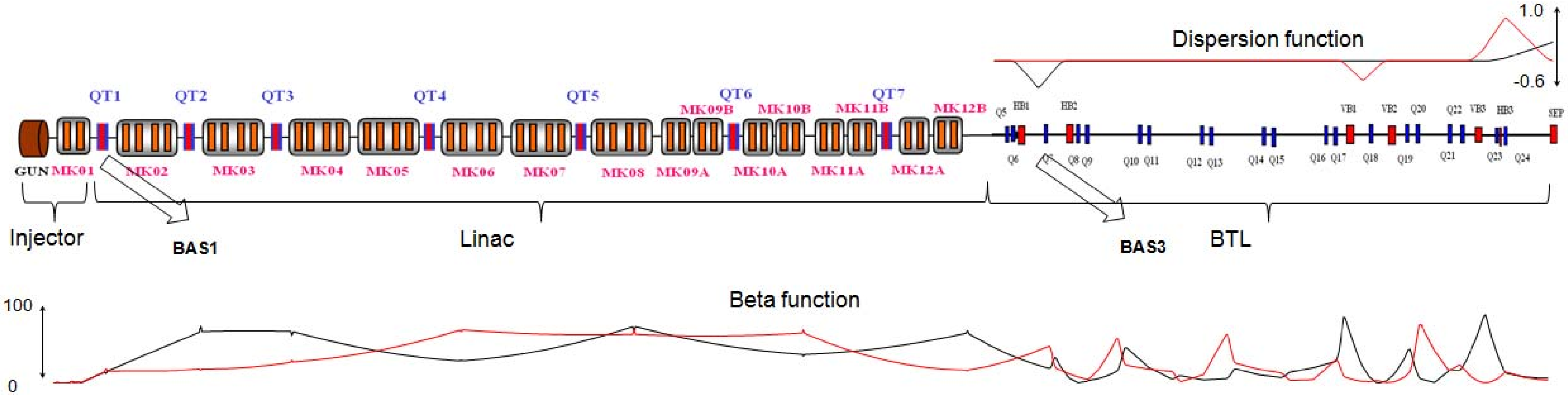
Chronology of PLS Linac



- **1991** Construction started
- **1993** Linac Operation Started with 2 GeV full energy Injection
  - 11 modules, 42 columns (Pre-injector 1*2 + Accelerating sections 10*4)
  - Linac 160 m, BTL 87 m
- **2002** Upgrade to 2.5 GeV
  - Add one module at the end of the linac, MK12 with two columns.
  - 12 modules, 44 columns (Pre-injector 1*2 + Accelerating sections 10*4+MK12 1*2).
- **2011** Upgrade to 3 GeV (PLS-II)
  - Add one module at the end of the linac, MK12B, with two columns.
  - Divide MK9~MK11 to feed two columns.
  - 16 M/K modules, 46 columns (1*2 + 7*4 + 8*2)
  - Linac 170 m, BTL 87 m
- **2015** Upgrade for more energy margin
  - Divide MK2 to feed two columns -> 70 MeV spare energy
  - 17 M/K modules, 46 columns (1*2 + 6*4 + 10*2)

PLS-II Linear accelerator

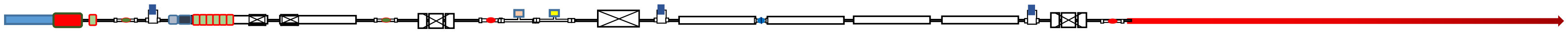




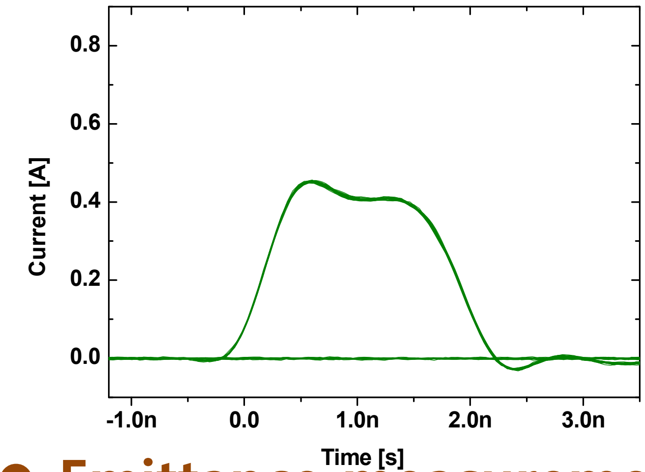
- Length = 170 m + 86 m
- 3.0GeV, full energy injection
- 2,856 MHz (S-band)
- 10Hz, 0.5 ns, 0.6A pulsed beam
- Norm. emittance 120μmrad

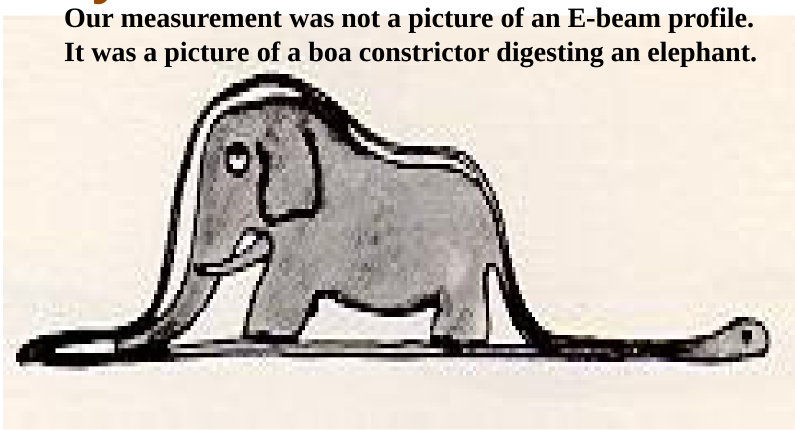
- Thermionic Electron Gun
- 17 Pulse Modulators (200MW, 7.5μs)
- 17 Klystrons (80 MW, 4μs)
- 16 Energy Doublers (g=1.5)
- 46 Accelerating Sections

Linac & BTL commissioning (PLS-II)

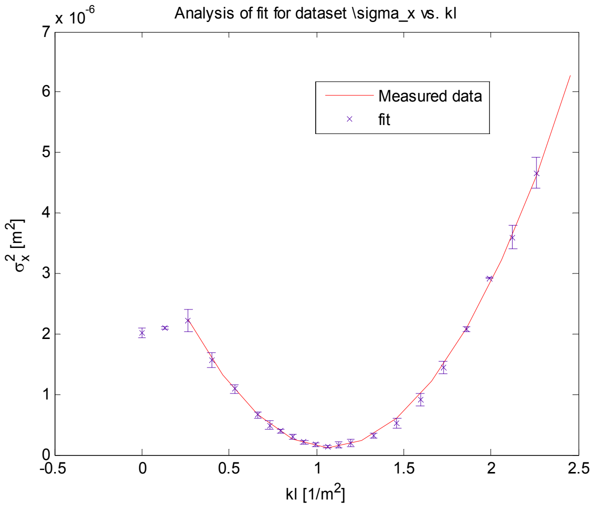


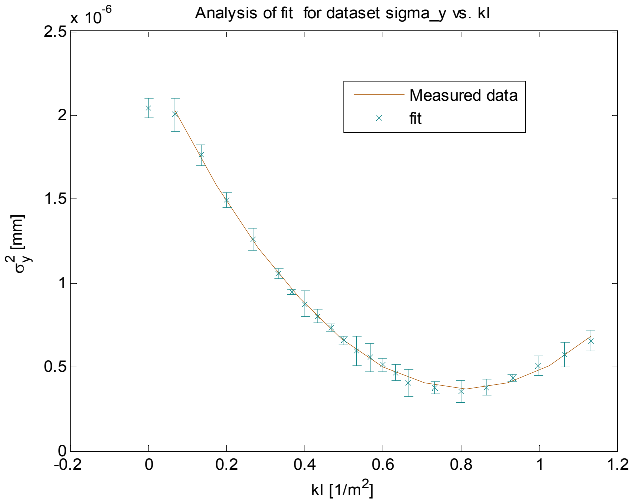
- First beam from gun (23 May 2011)



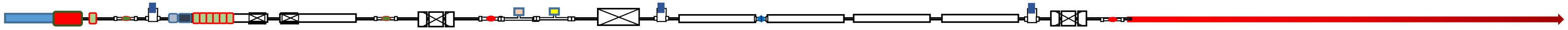


- Emittance measurement (H/V: 600 nm/800 nm @ 100 MeV)

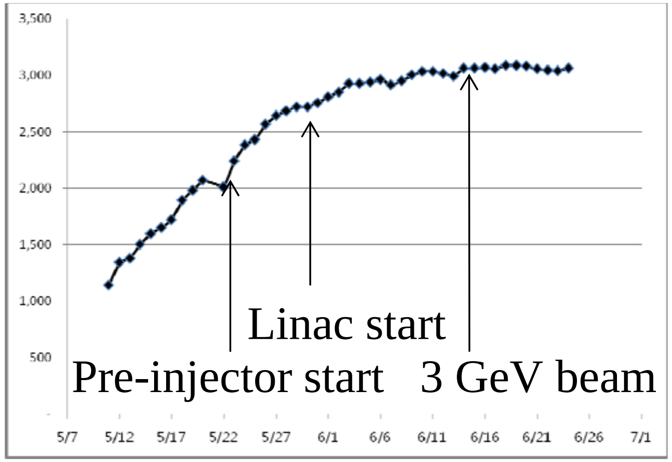




Linac & BTL commissioning

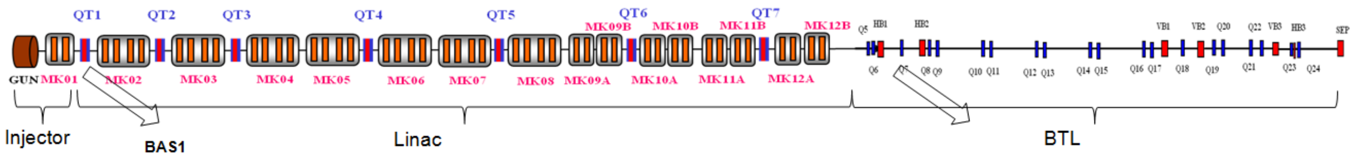


- 3 GeV beam (13 June)



- Beam at injection (29 June)

- Summary

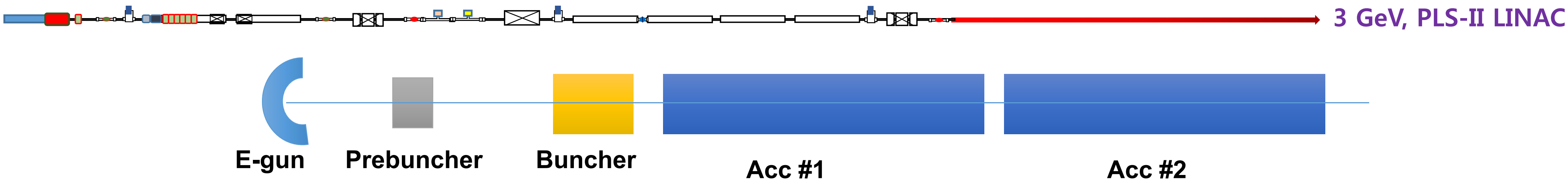


Charge 1.2 nC 0.6 nC 0.25 nC 0.2 nC

Emittance 150 um 180 um

Energy jitter 0.12 %

Pre-Injector of PLS-II Linac



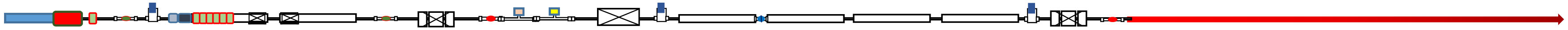
- **Electron gun**
  - Thermionic cathode : Y-824 ➔ Y-845
  - Accelerating voltage : DC 80 kV, β = 0.5
  - Beam pulse length : 250 ps, <1, 2 ~ 40 ns

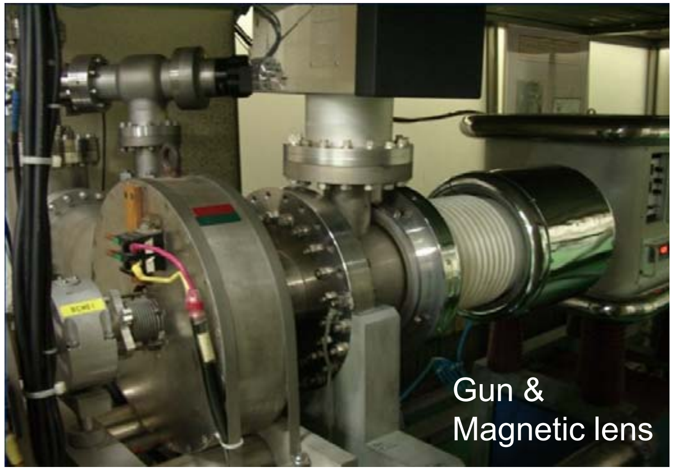
- **Prebuncher**
  - 2856 MHz, re-entrant type standing wave cavity
  - Velocity modulation to cause density modulation

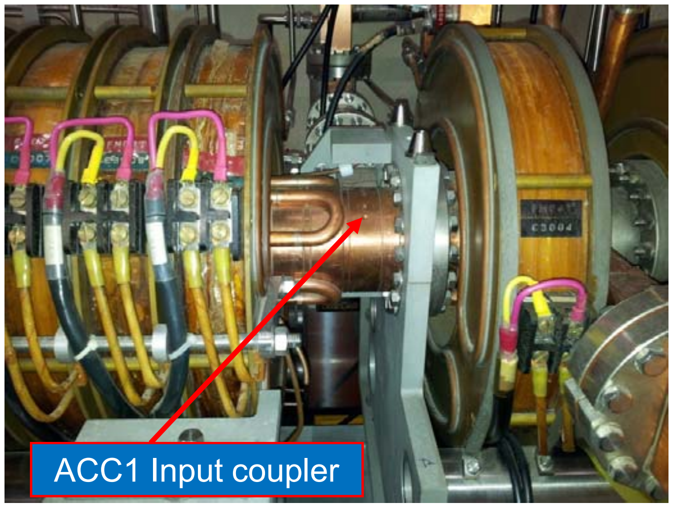
- **Buncher**
  - 2856 MHz, travelling wave type of 4 cavities (β = 0.75)

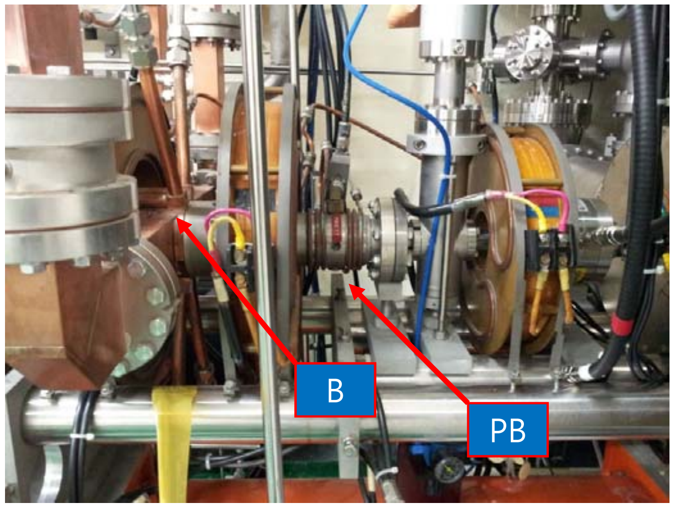
- **Accelerator Columns**
  - 2856 MHz, Two normal columns of 3m
  - 1 input coupler + 1 output coupler + 84 cavities), (β = 1)

Pre-injector

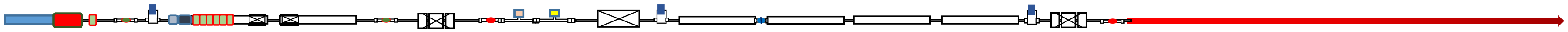




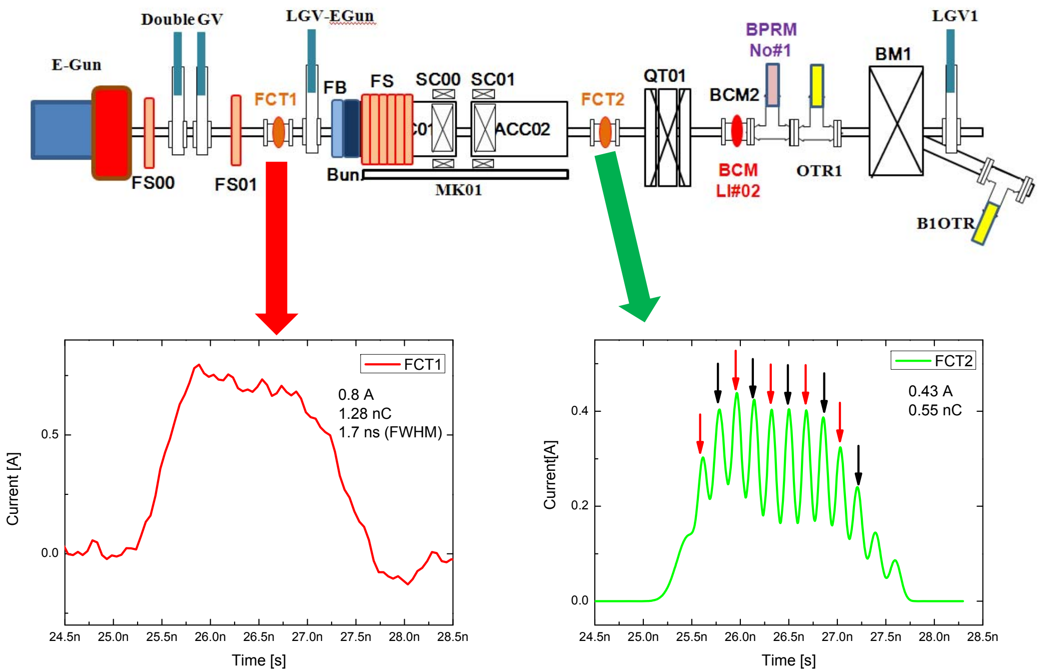




Pre-injector

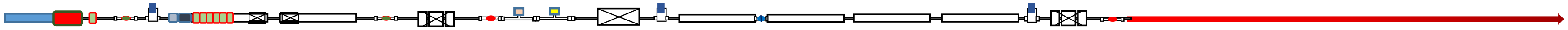


Peak current and charge from the gun and after bunching system



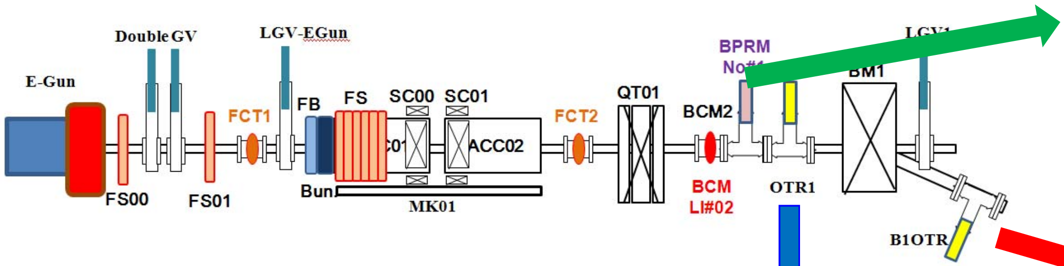
- E-gun: Y824 with a <1 ns pulser
- FCT1: peak current: 0.8 ~1 A, charge: 1~1.3 nC, FWHM: 1.4~1.8 ns
- FCT2: peak current: 0.4~0.5 A, charge: 500~600 pC
- Charge loss due to bunching system: 50~60 %
- Bunch #: 5 (red line), black line is superposition of the 2856 MHz EMI confirmed by BCM6 placing in the middle of Linac

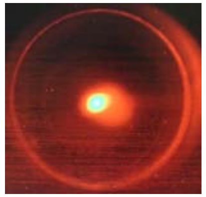
Pre-injector

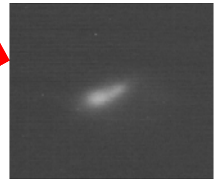


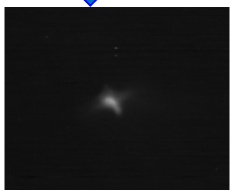
3 GeV, PLS-II LINAC

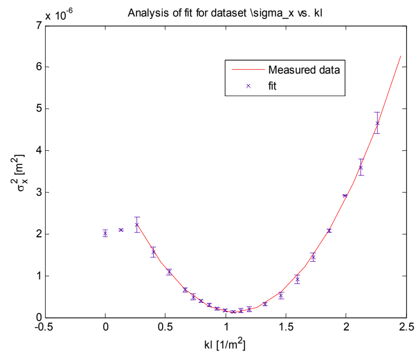
Beam diagnostics at pre-injector end and BAS1

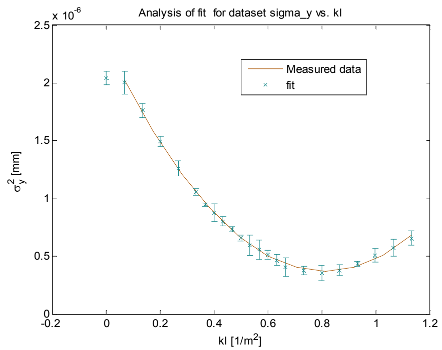










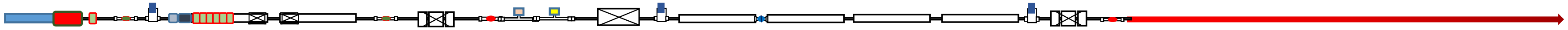


Quadrupole scan for emittance at the Pre-injector	
Horizontal	115 mm.mrad
Vertical	150 mm.mrad

Linac Efforts for Top-up Injection

- The linac commissioning was successfully finished on schedule.
- PLS-II was operated in decay mode during the first year, 2012.
- Radiation level was higher than the limit at the injection point and some undulator beamlines.
- Beam quality Improvement and monitoring was proved to be urgent and we took some measures to solve this problem.
  - E-gun :
    - Low emittance cathode (Y-824 → Y-845)
    - Shorter beam pulse (1 ns → 250 ps)
  - Energy feedback system
  - Install slits
  - In-situ energy monitoring
  - Injection angle measurement

E-gun Cathode : Y824 → Y 845

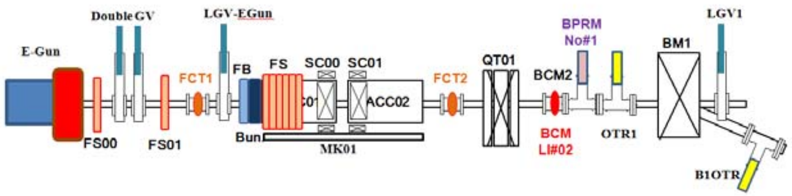


3 GeV, PLS-II LINAC

Cathode (Y-824)

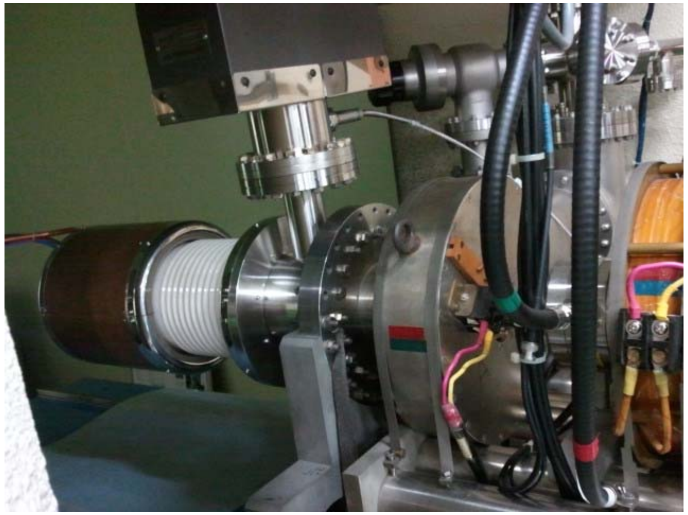
Cathode (Y-845)

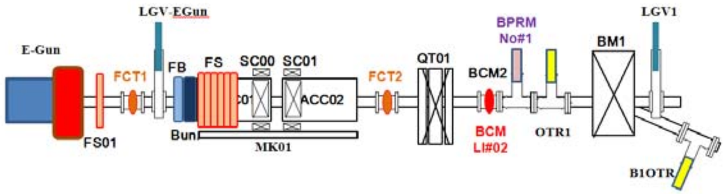
E-gun with dual vacuum valves



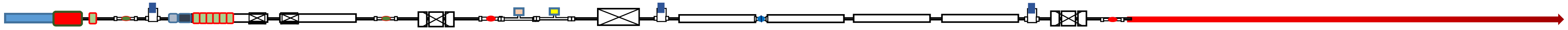
2012. 8

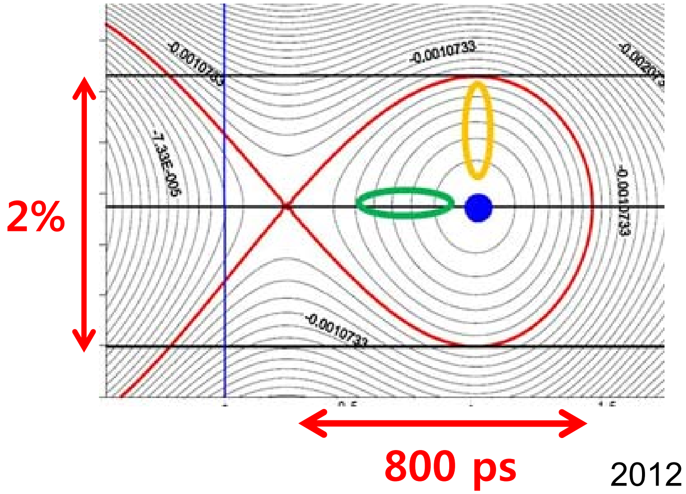
Dual vacuum valve removed





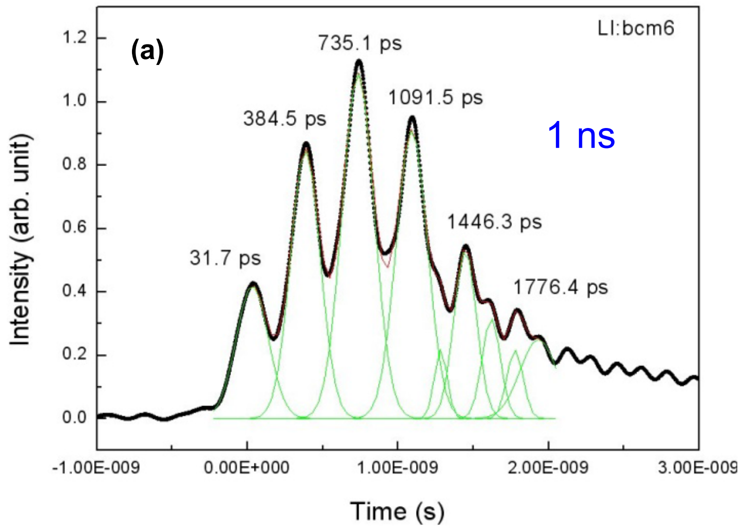
Shorter Electron Beam Pulse

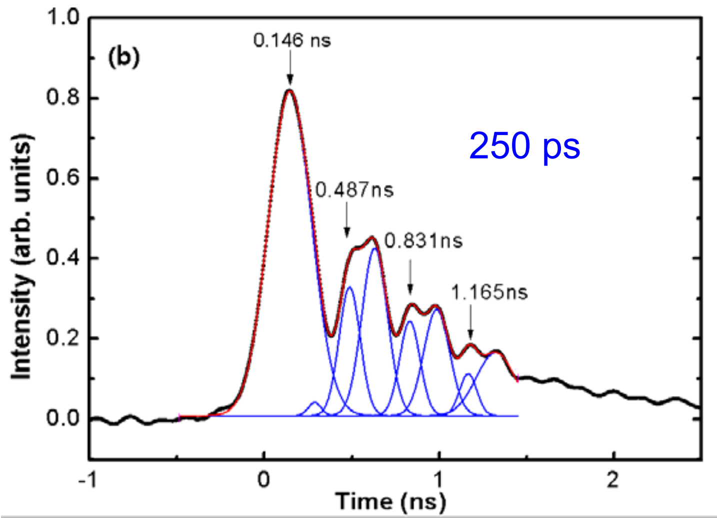




2012. 07. 28.

- The high radiation level was partly caused by the bunches which cannot be accommodated in a single SR RF bucket.
- The grid pulser was changed to shorter one. (1ns → 250 ps)
- The streak camera didn't work since too small beam charge per bunch.
- We used the wideband oscilloscope to get signal from WCM.

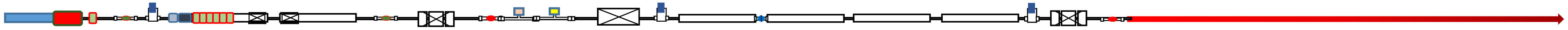




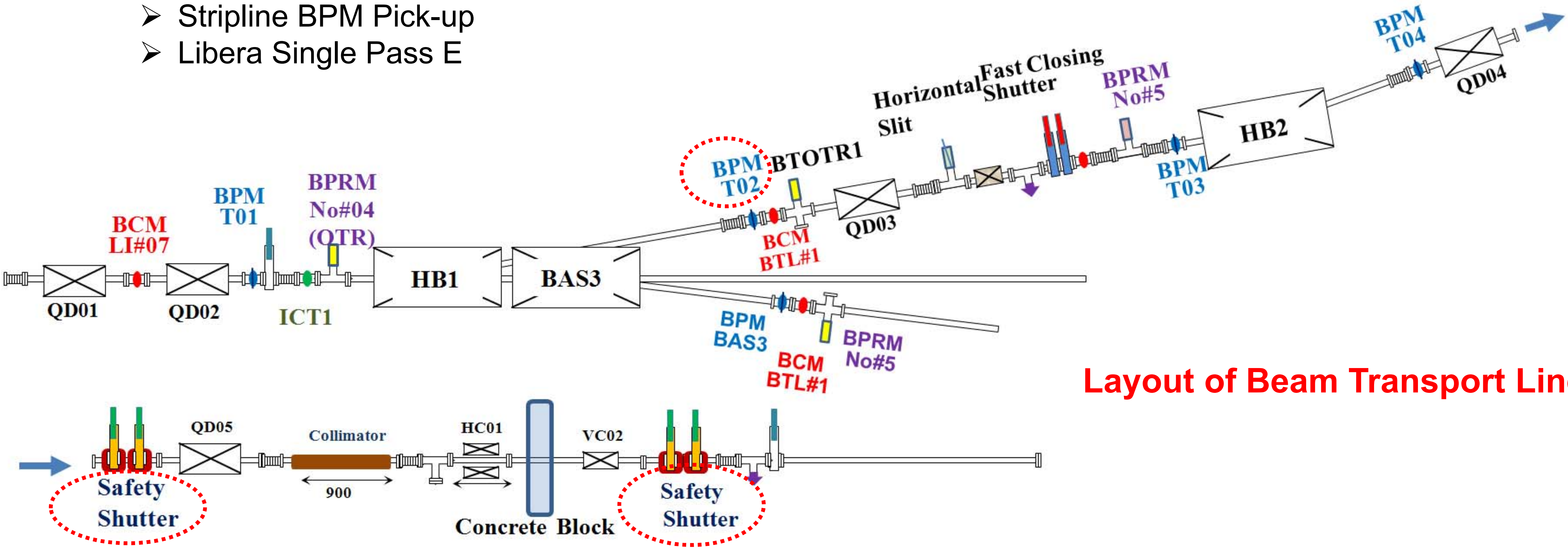
@ WCM06

Wideband oscilloscope
(Agilent 90604A, 6GHz, 20GS/s)

Energy Feedback Sytem

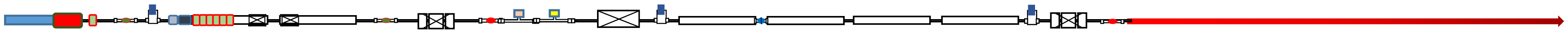


- MK12B Klystron + BPM T02 in dispersive region
- BPM T02
  - Stripline BPM Pick-up
  - Libera Single Pass E

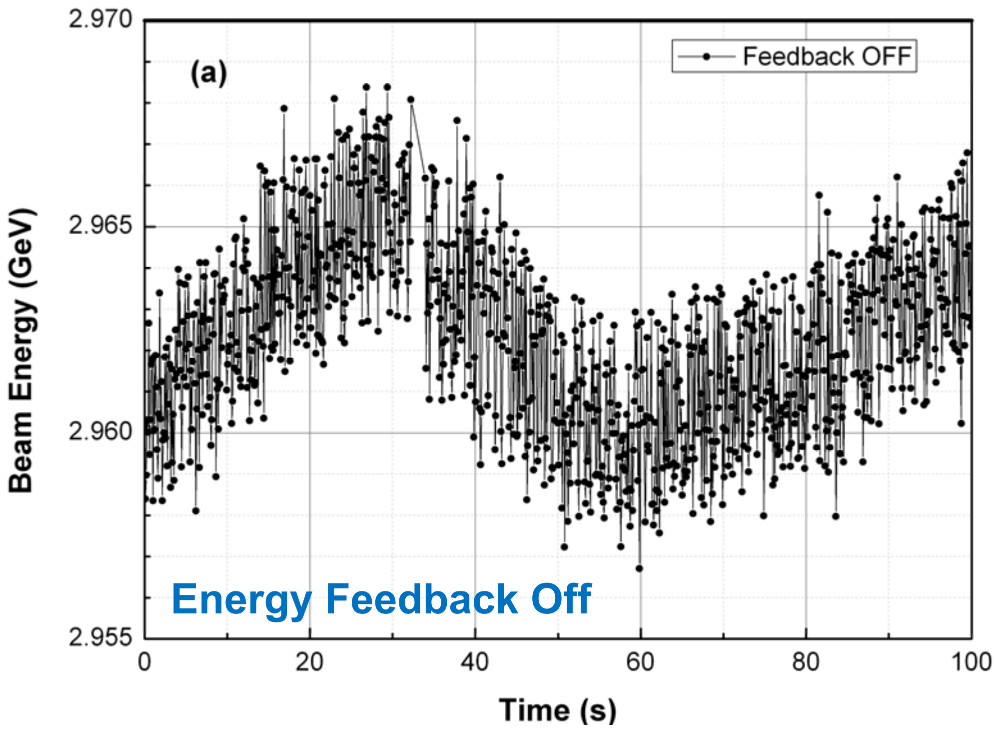


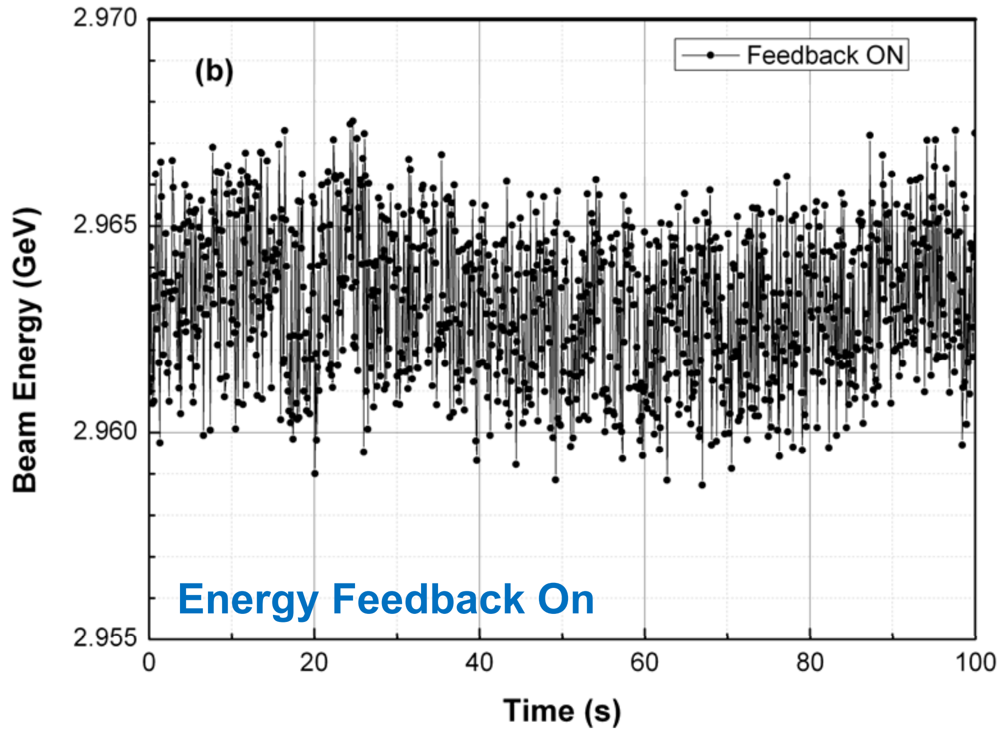
Layout of Beam Transport Line

Energy Feedback

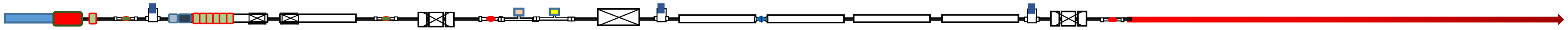


- Beam energy fluctuation with a period of 80 seconds caused by temporary LCW temperature fluctuation.

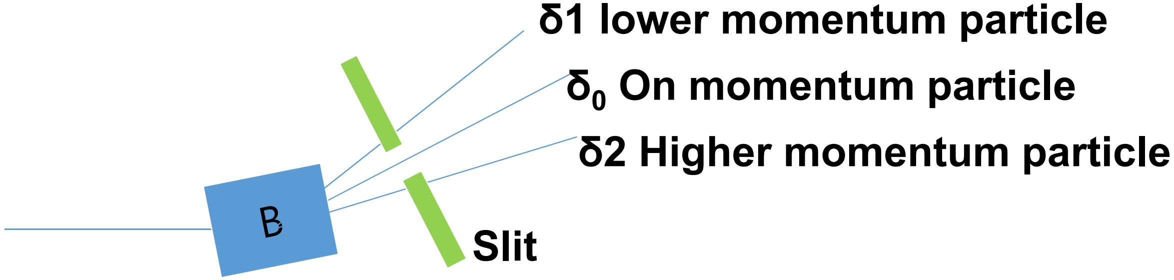


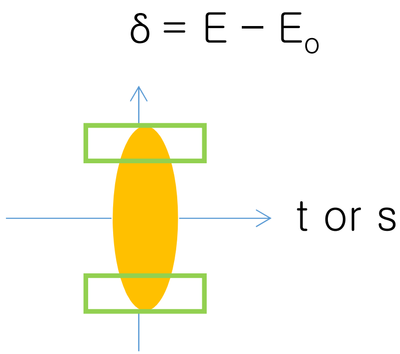


Slit Installation in BTL (Energy Slit)



○ Energy slit in dispersive region



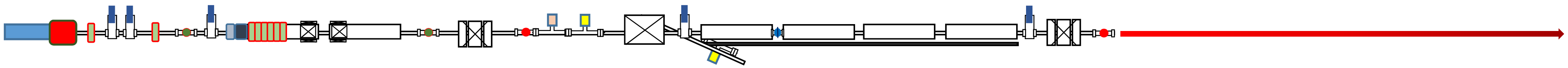


$$\sigma = \sqrt{(\varepsilon\beta) + (\delta\eta)^2}$$

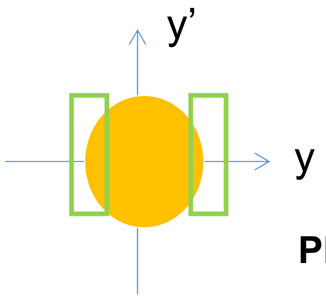
By reducing beta and increasing eta, we can do

Slit Installation in BTL (Emittance Slit)

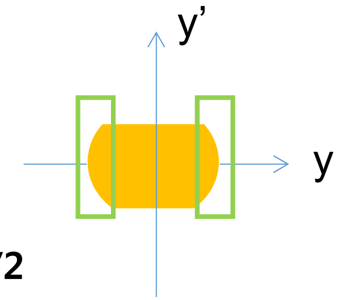
PAL PLS-II LINAC



- In PLS-II top-up mode, 10 in-vacuum undulators are being operated with small gap (full gap of 6 mm)
- Two vertical slits were installed to reduce the vertical beam size of the injected beam.

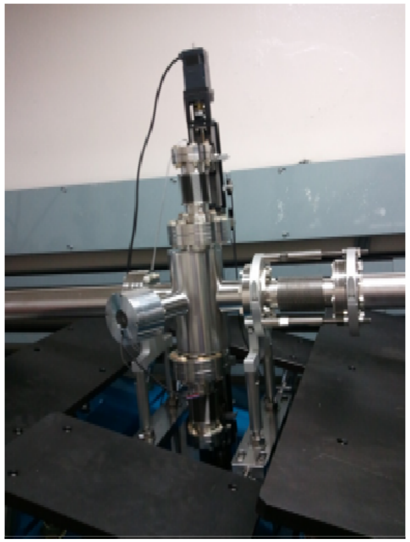


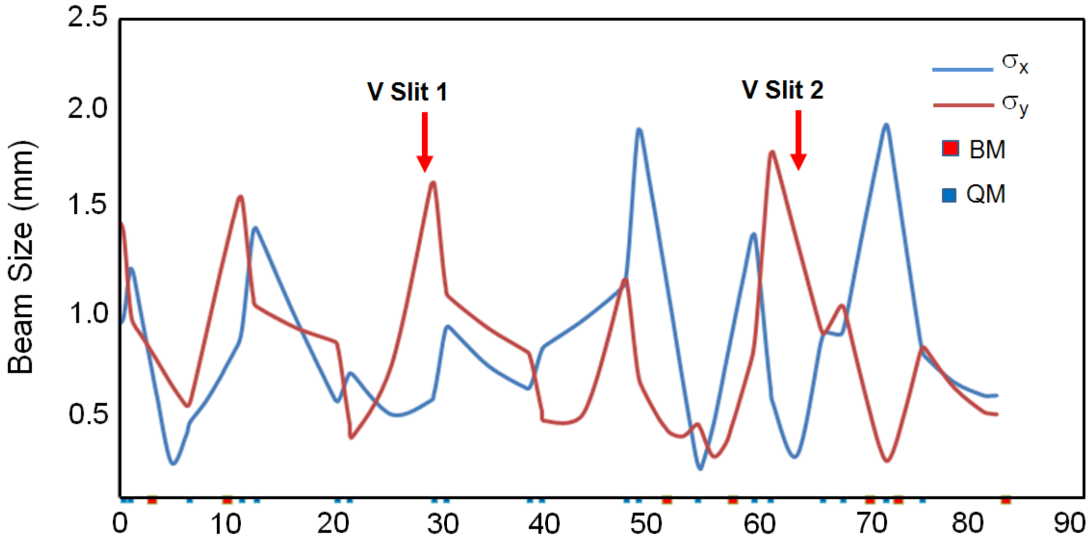
Phase advance π/2



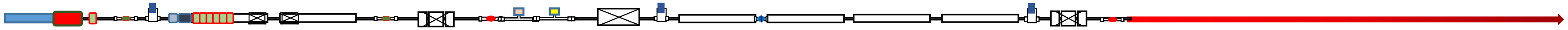
$$\sigma = \sqrt{(\varepsilon\beta) + (\delta\eta)^2}$$

V slit 2

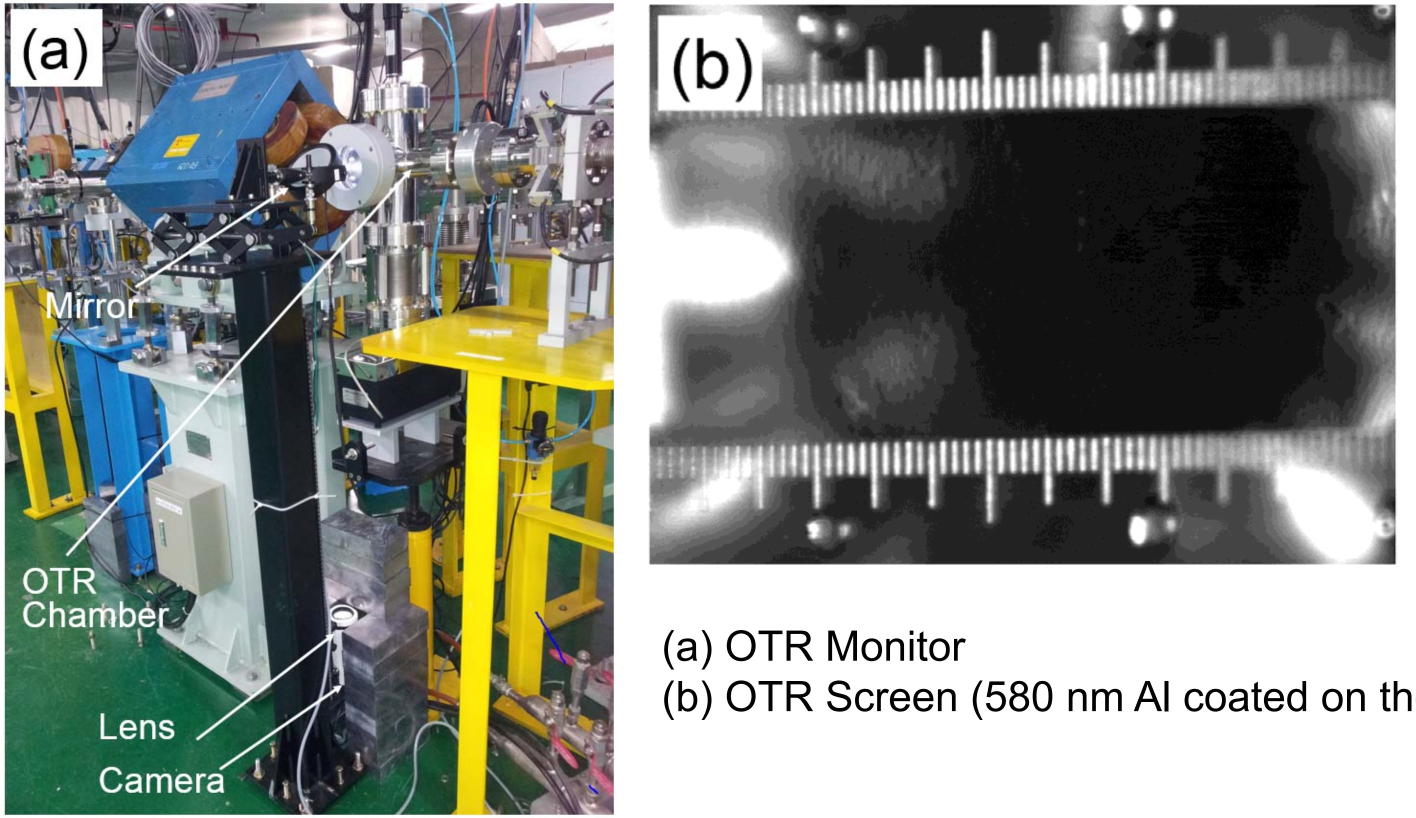




Beam Energy and Energy Spread Monitor

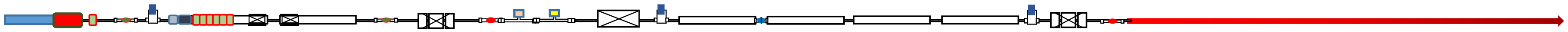


- A thin film OTR monitor was installed in the dispersion region to monitor the beam energy and the beam energy spread in real time.

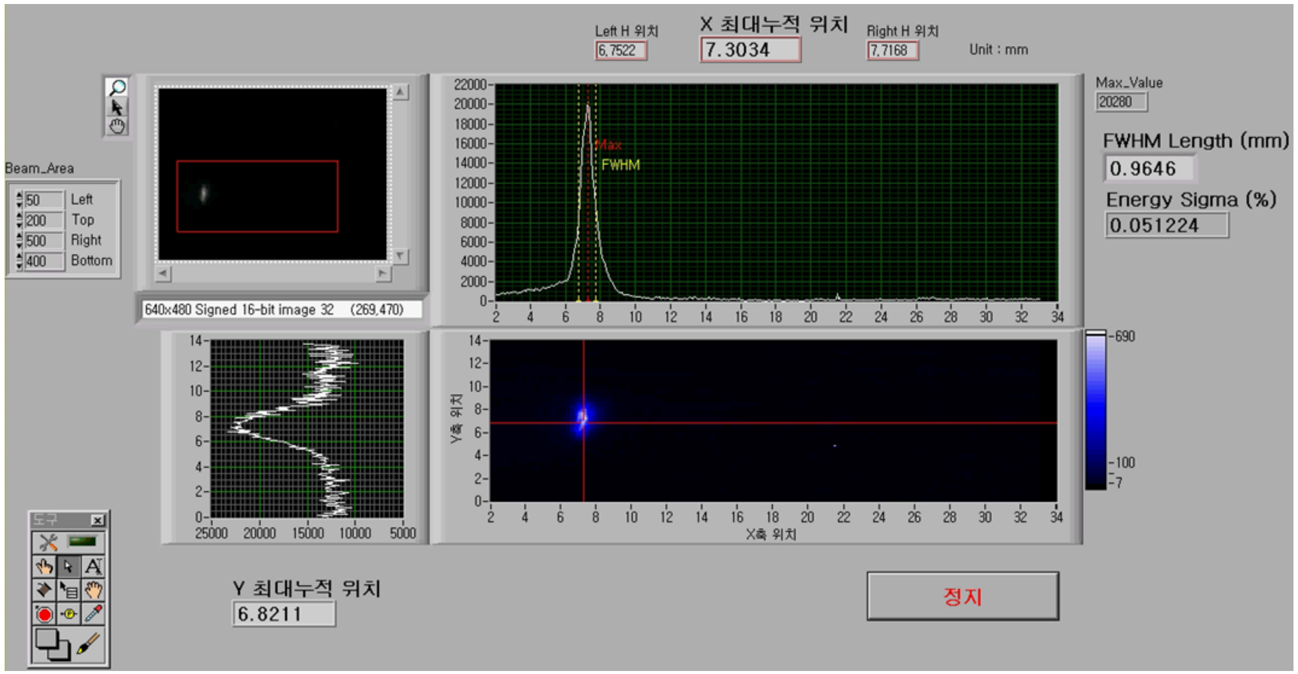


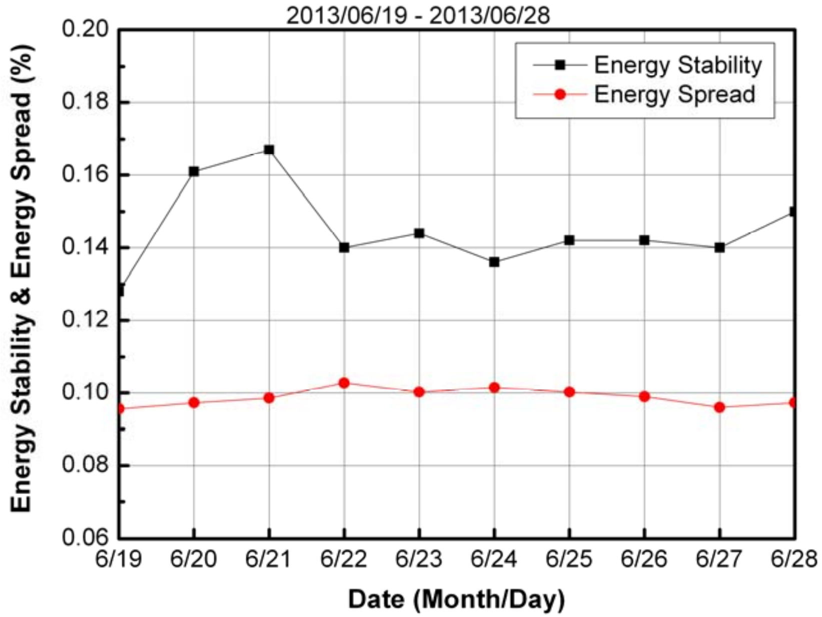
(a) OTR Monitor
(b) OTR Screen (580 nm Al coated on the 25 um polyimide film)

OTR Image Analysis Program

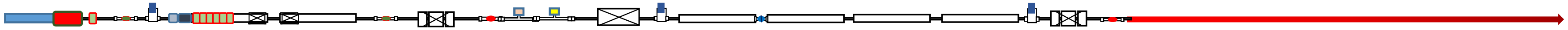


3 GeV, PLS-II LINAC

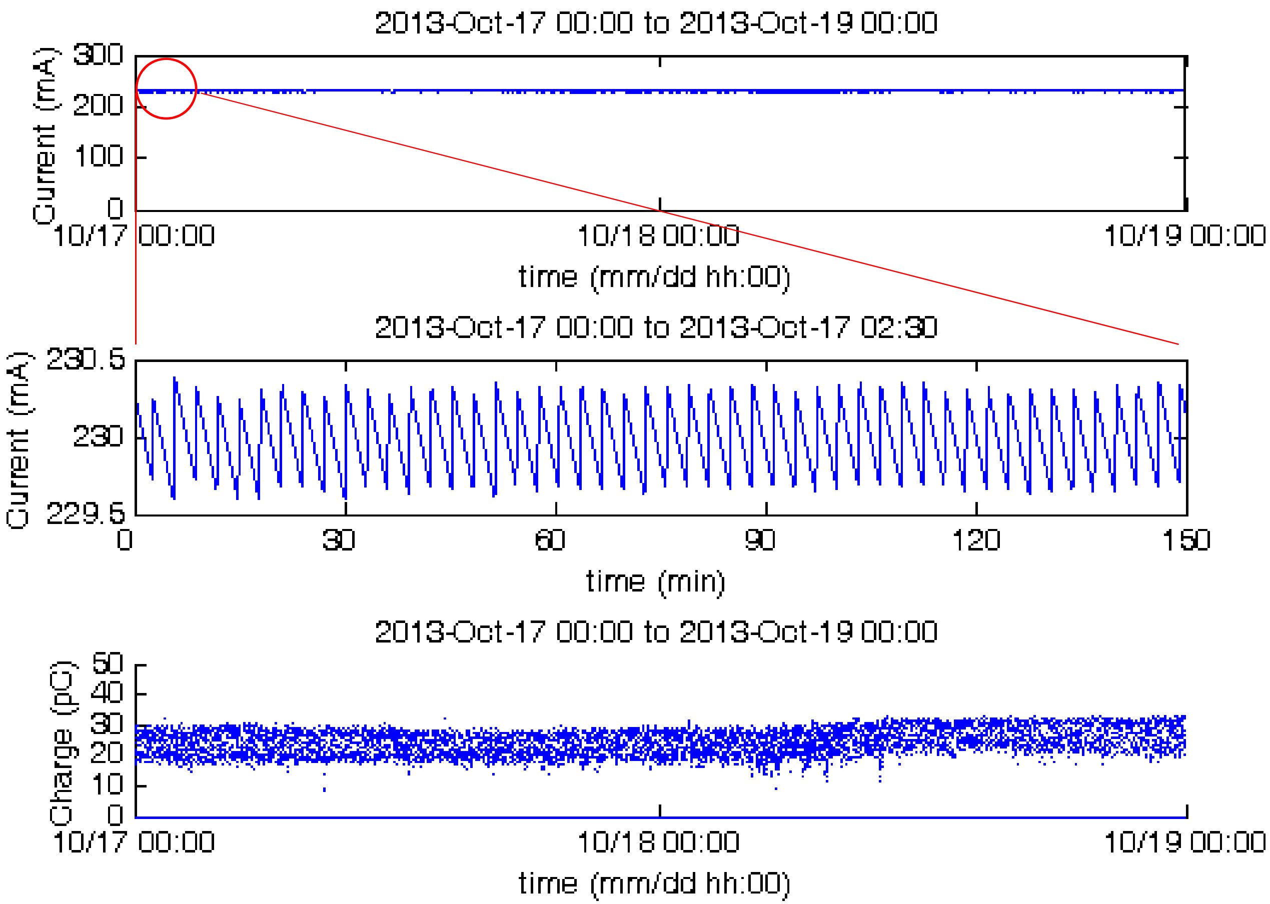




Top-up Operation of PLS-II Linac



3 GeV, PLS-II LINAC



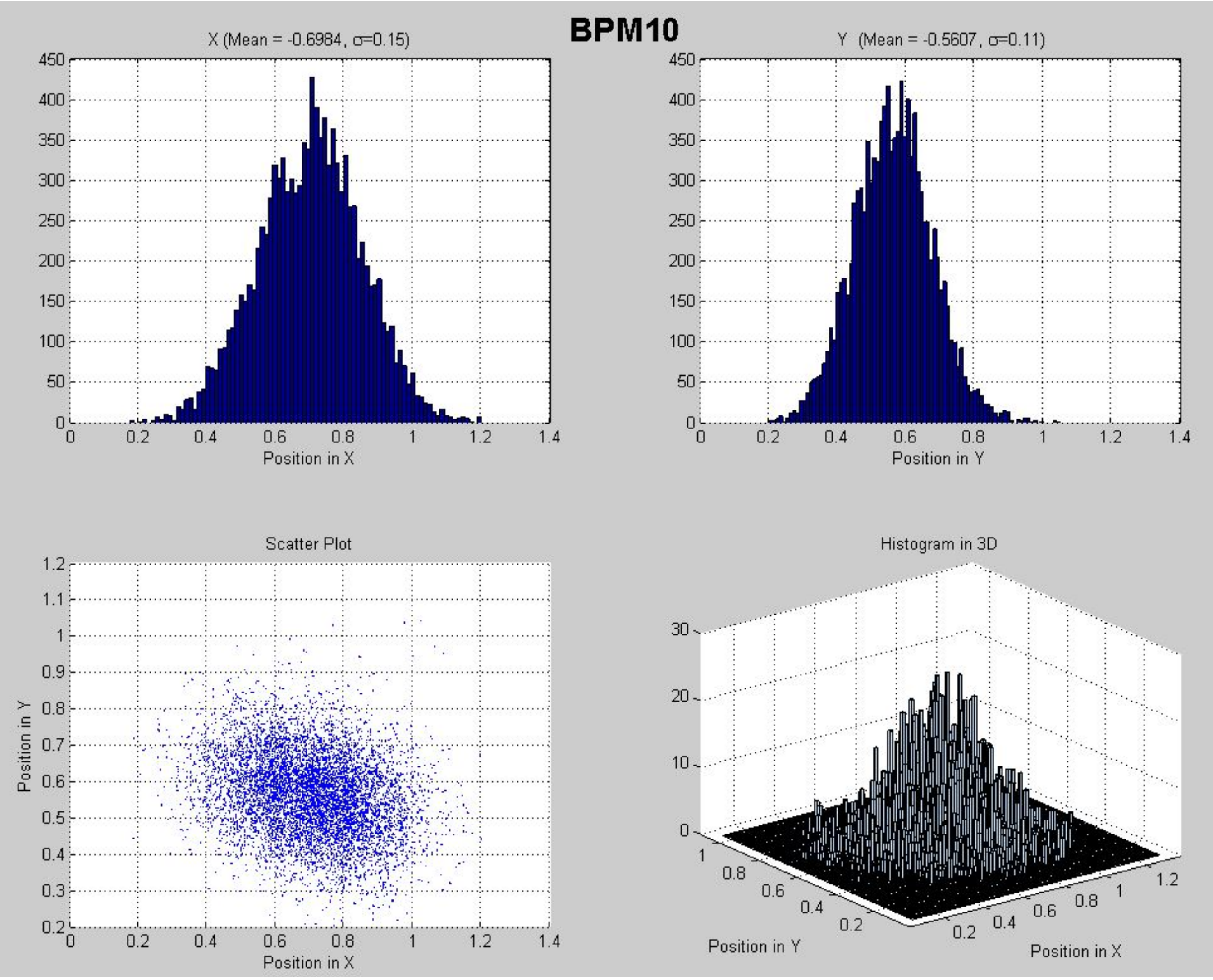
Top-up operation
for 48 hours

Top-up operation
for 150 minutes
(current band ±0.3%)

Injection Charge
in the top-up injection
(20~30pC)

LINAC Beam Stability

3 GeV, PLS-II LINAC

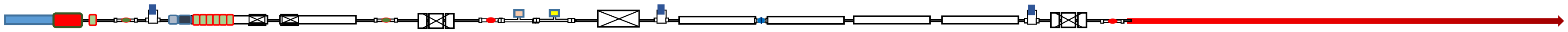


- Pulse-to-pulse beam orbit jitter at 3 GeV
- Top-up Injection for 1 hr

$\sigma_x = 0.15$ mm
$\sigma_y = 0.11$ mm

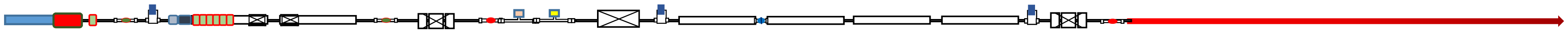
2015. 4. 2.

PLS-II LINAC Operation Parameters

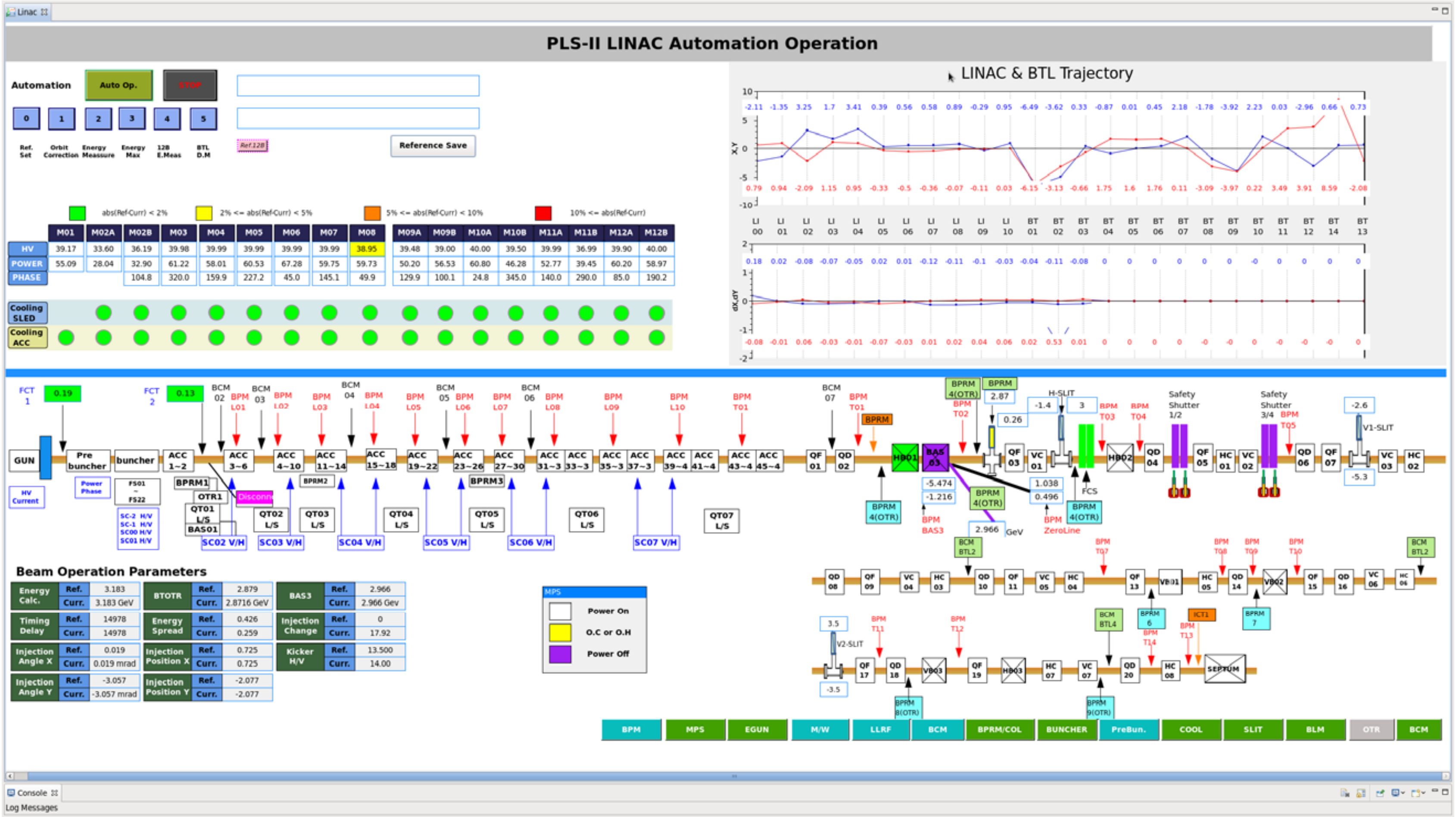


Parameters	
Energy [GeV] (max)	2.966 (3.060)
Energy Stability [%] std value	0.05 (in 10 min)
Energy Spread [%]	0.10 (in 10 min)
Injection Rate (Hz)	10
Injection Charge (pC)	15 ~ 25
Injection Time (sec)	5.5 (avg)
Injection Interval (sec)	190
Injection Efficiency (%)	96.0 (avg)

PLS-II LINAC Control Panel



3 GeV, PLS-II LINAC



Linac Automation Process in Normal Status

Step 1: orbit measurement

- set MPS, RF power and phase, etc

Step 2: energy measurement

- finding present energy

Step 3: achievement maximum energy in given MK power status

- Phasing using energy maximization

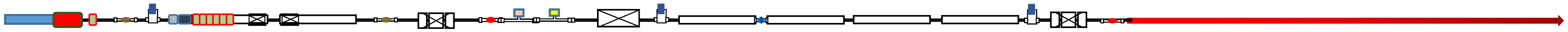
Step 4: set operation energy

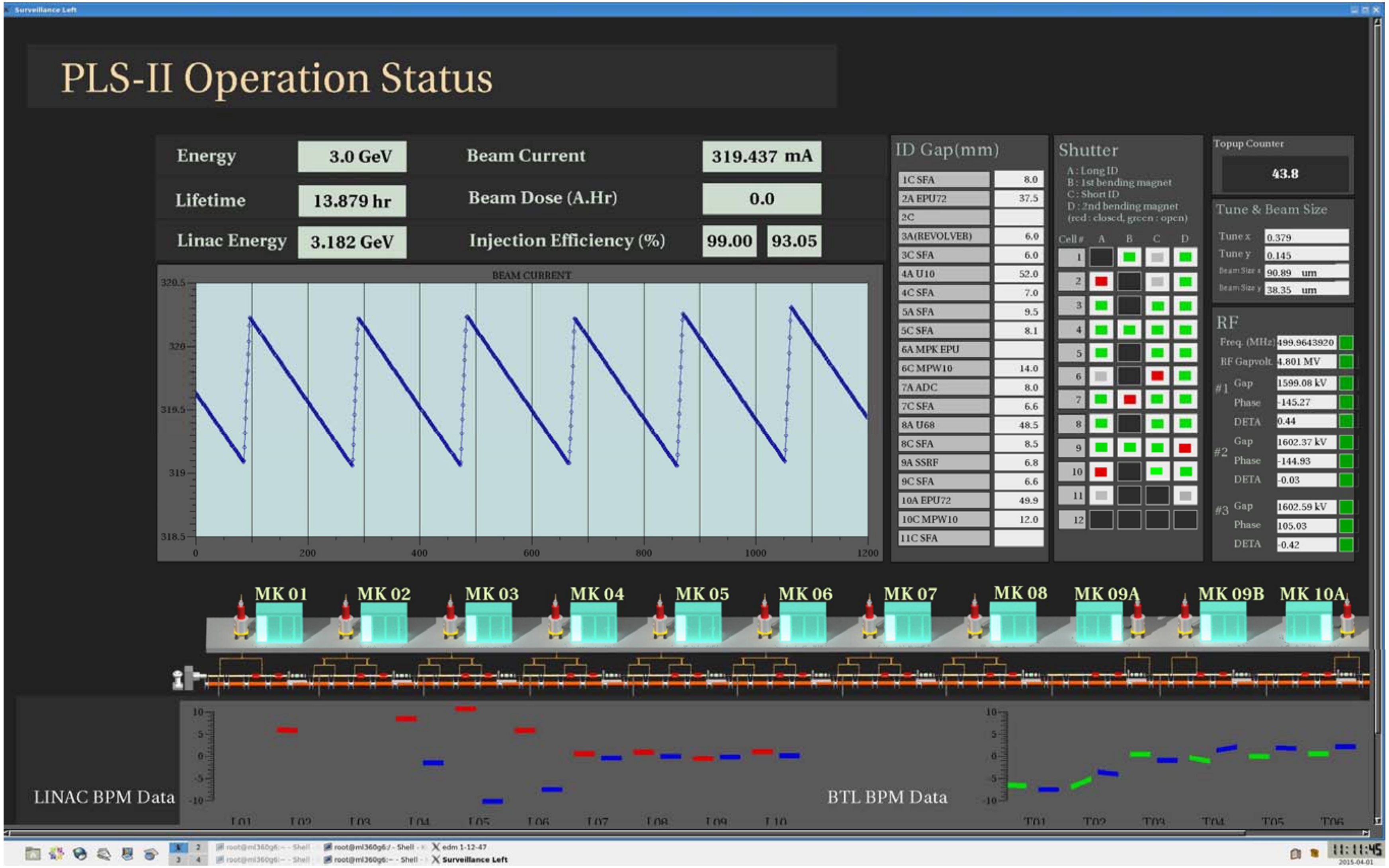
- measure IPA12B phase-energy relation

Step 5: set reference orbit

- orbit correction

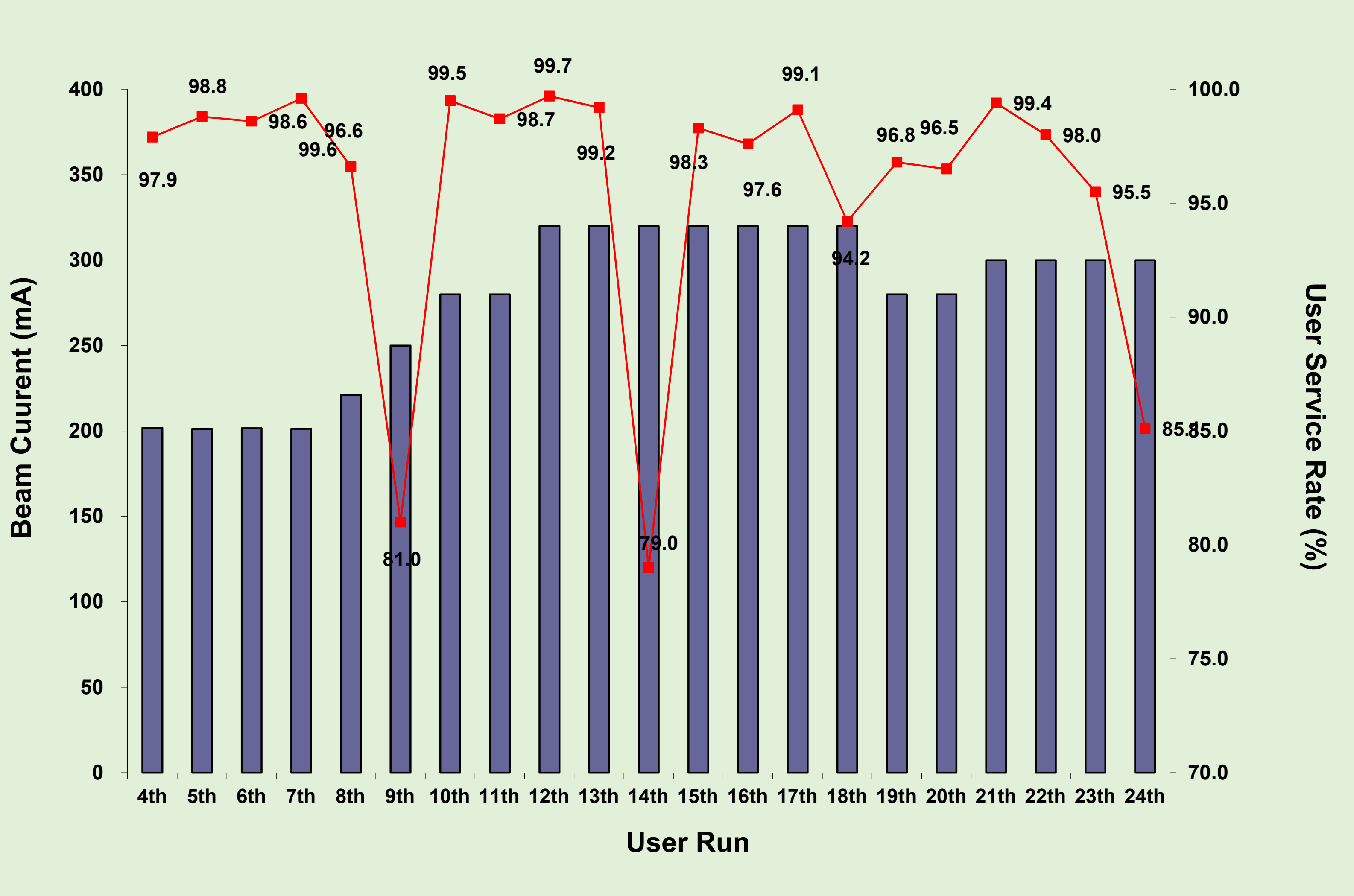
PLS-II Injection Monitoring Panel





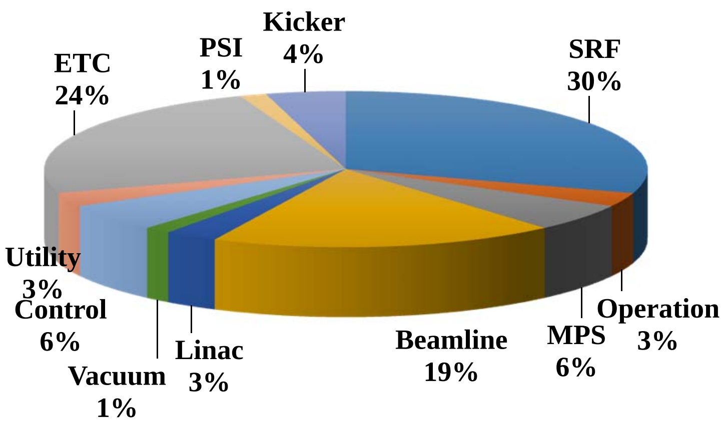
2014 User Service Current & Rate

3 GeV, PLS-II LINAC

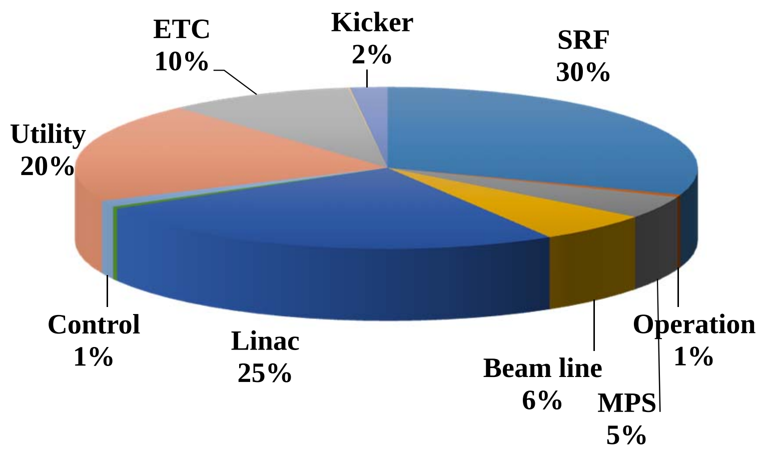


2014 Fault Report in the User Service

3 GeV, PLS-II LINAC

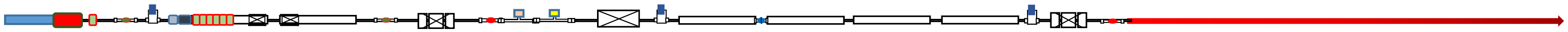


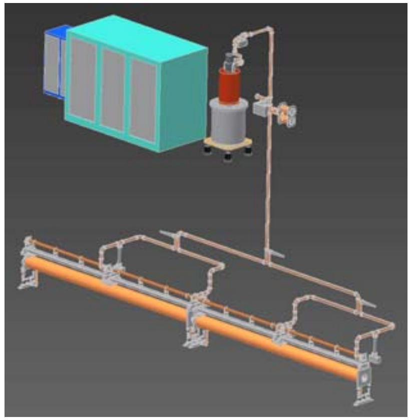
Number (56)

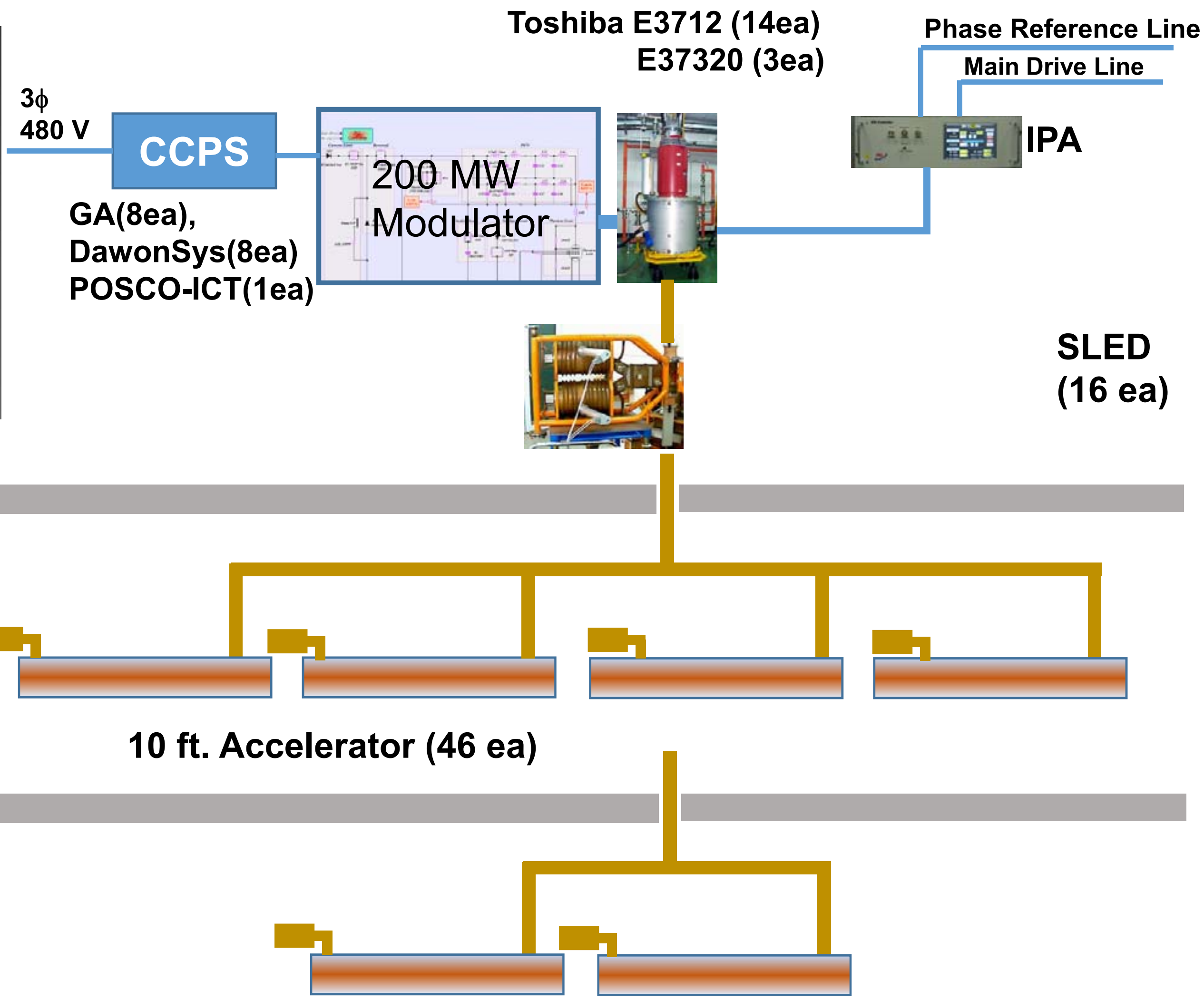


Time (11220 min)

Unit Module of PLS-II Linac

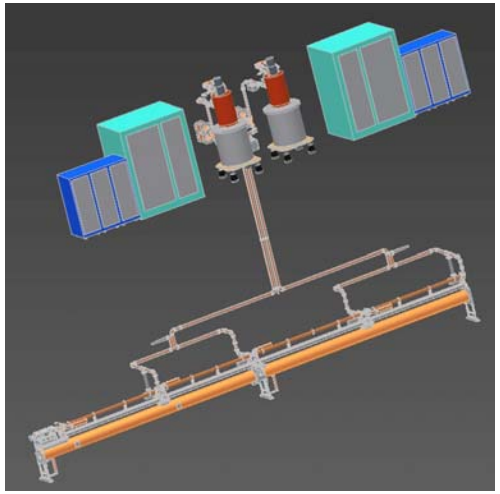




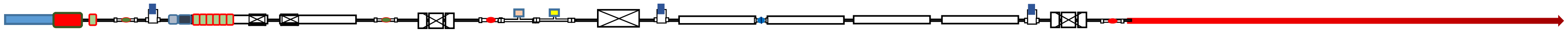


Frequency Range	2,856 +/- 1 MHz
Insertion Loss	<3.0 dB
VSWR	<1.2
Max. Input Power	4 kW, 4.5μsec., 60 Hz
Phase Shifter Range	360 degrees endless
Phase Feedback	+/- 0.3 degrees
Attenuation Range	20dB max. (0.1dB Step)
Isolation	>30dB

Mode	TE015
Cavity Diameter	205 mm
Cavity Length	346.2 mm
Q Value	100,000
Coupling Factor	4.8
Power Gain	7.4 dB
Energy Gain	1.5~1.6



200 MW Modulator

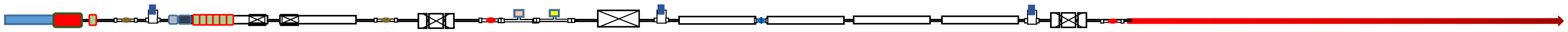


3 GeV, PLS-II LINAC

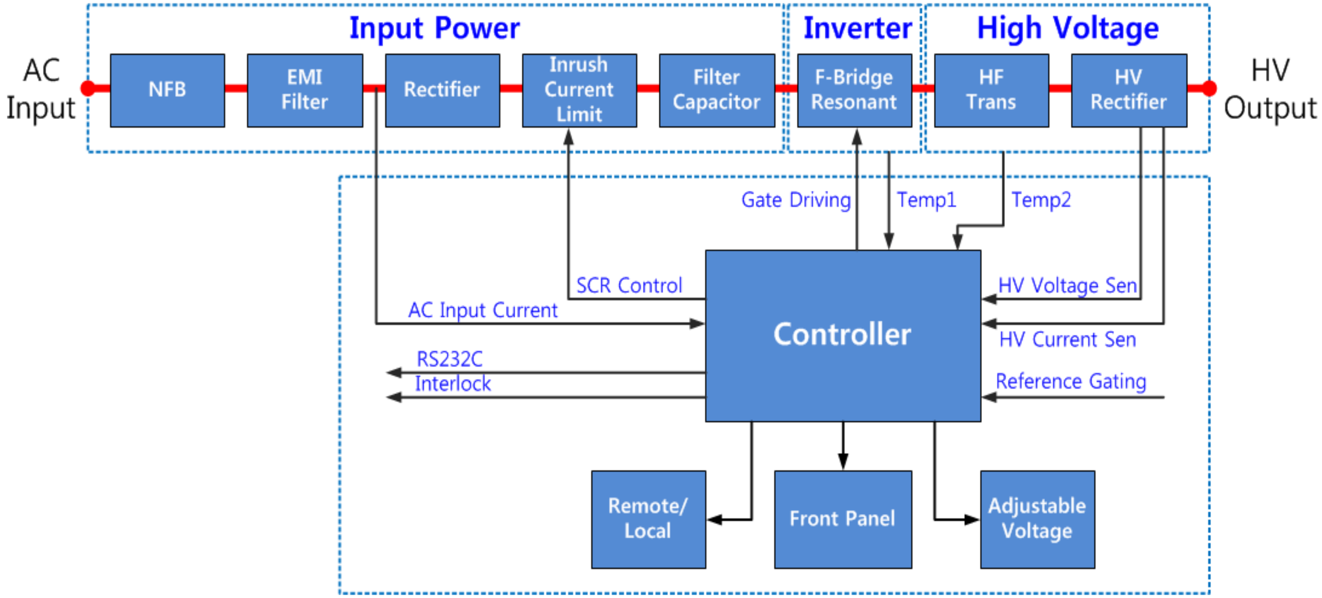
Two parallel networks of 14 elements of capacitors and inductors

Peak Power	200 MW
Charging Voltage	50 kV
PFN Output Voltage	25 kV
PFN Output Current	8.9 kA
HV Pulse Width	7.5 μs
Repetition Rate	10 pps
PFN Impedance	2.7 Ω
Total Capacitance	1.4 μF (50 nF x 28)
Total Inductance	10.5 μH (1.5 μH x 28)
Cabinet Dimension	1600 x 1600 x 2100 (mm^3)

Capacitor Charge Power Supply



3 GeV, PLS-II LINAC



Specification

- Average output power : 30kW
- Peak charging power : 37.5kJ/s
- Constant DC Power : 50kW
- Max output voltage : +50kV
- Max output current : 1.2A
- Power factor : 0.9
- Voltage regulation : <+/- 0.01%
- Efficiency at full load : >85%
- 3 phase input voltage : 480Vac/60Hz
- Cooling water : >5 l/m

PFN Voltage(10,000:1)

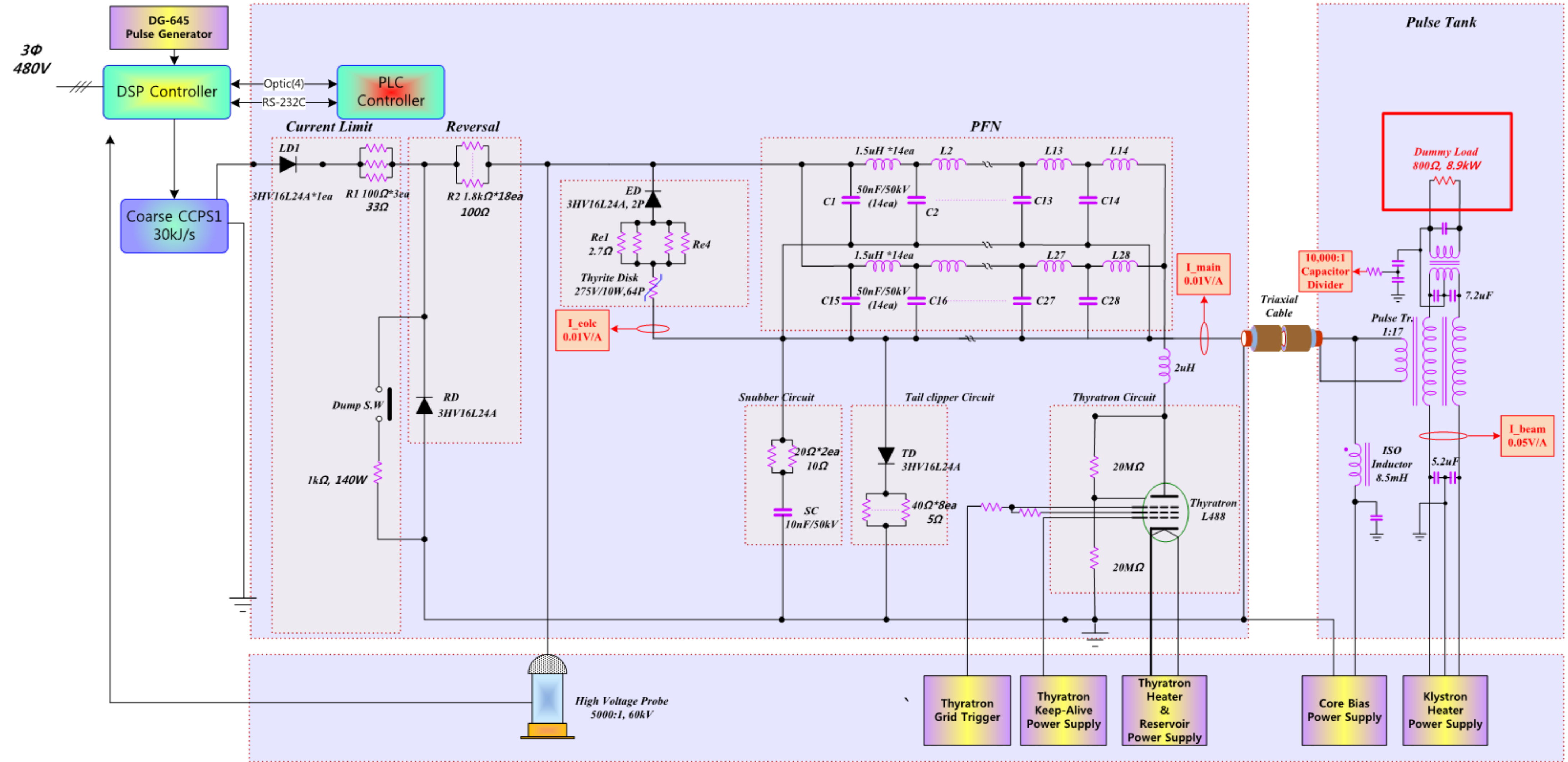
Resonant Current

<Condition>
PRF : 10Hz
Voltage : 40kV
Tc : 44.1ms
Load : 1.4uF
Ec : 31.7kW

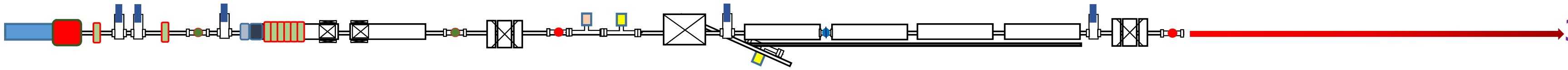
www.dawonsys.com

Modulator Circuit Diagram

3 GeV, PLS-II LINAC



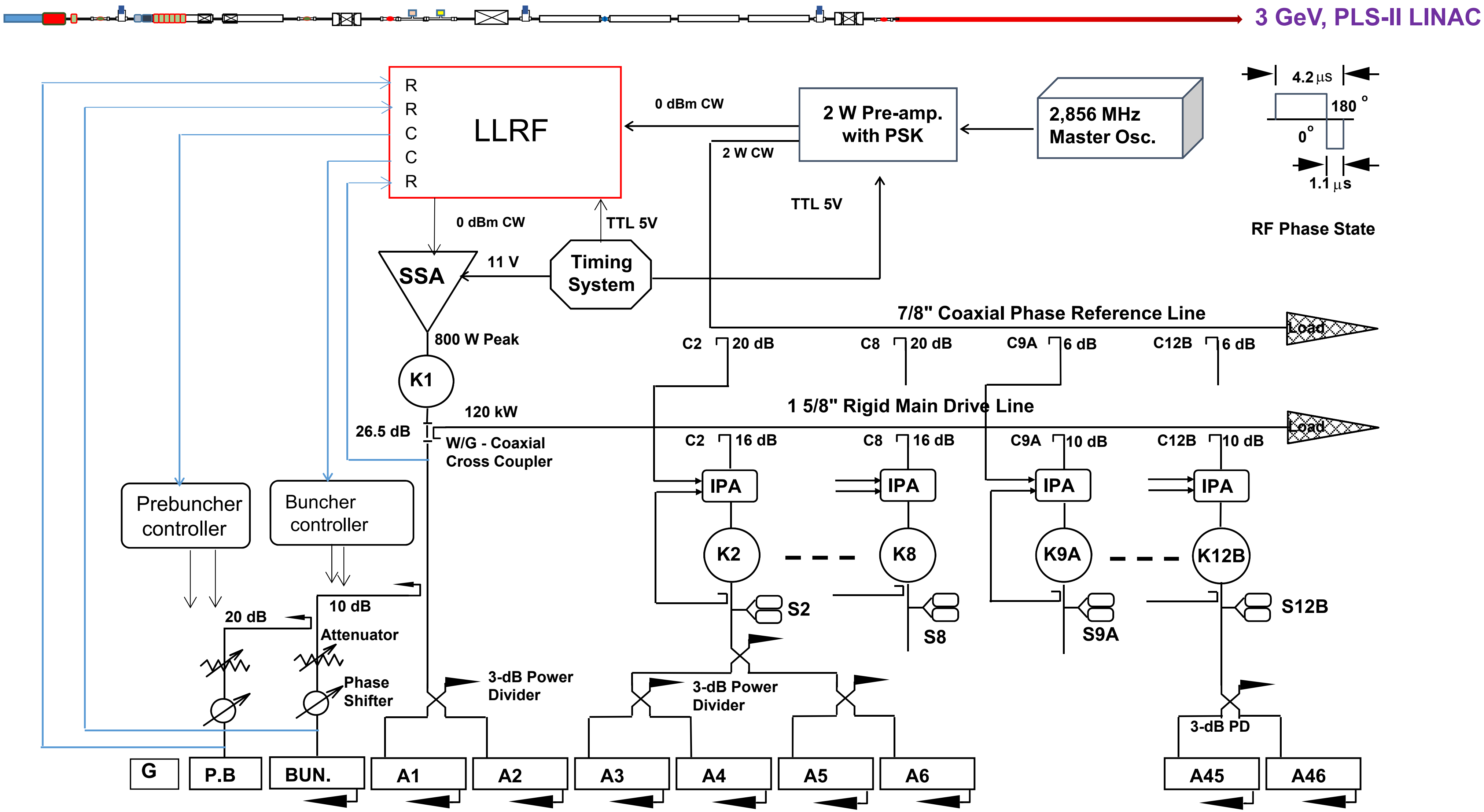
80 MW Klystron




Toshiba E3712 Klystron

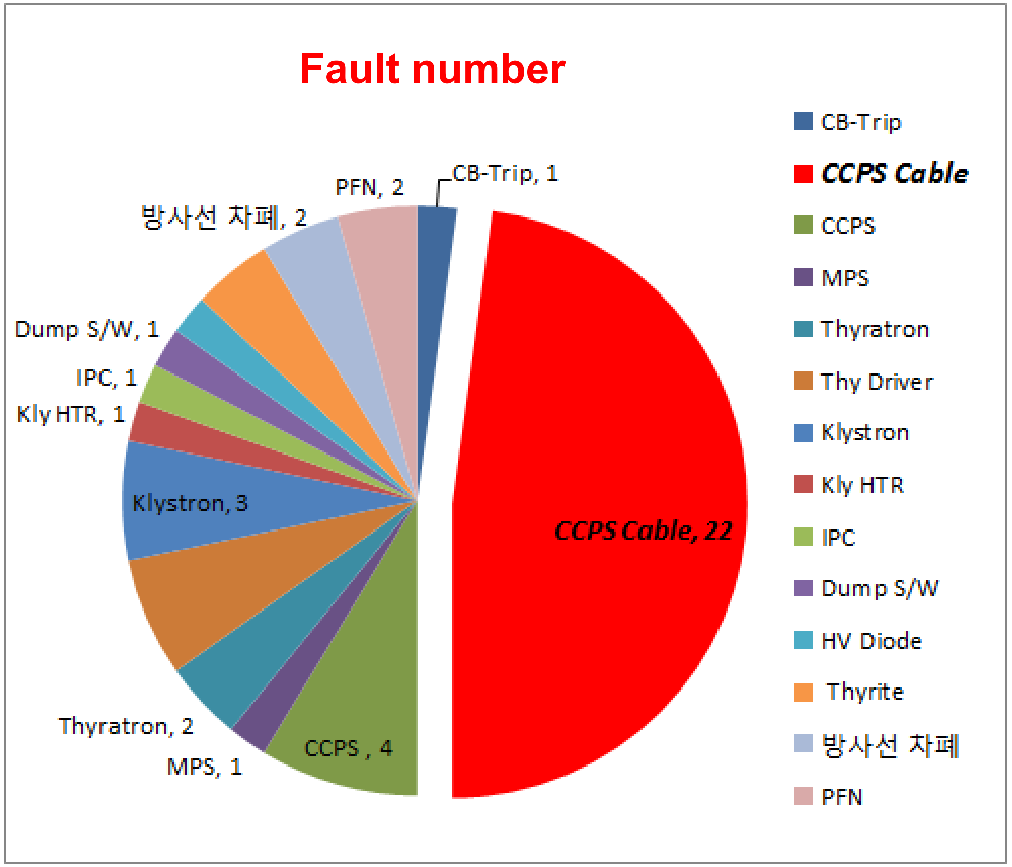
	Toshiba
Operation Frequency (MHz)	2,856
Max. Output Power (MW)	80
Max. Average Output Power (kW)	19
Max. Repetition Rate (Hz)	60
Operating Pulse Length (μs)	4.0
Gain (dB)	53
Efficiency (%)	42
Number of Cavities	5
Beam Voltage (kV)	400
Beam Current (A)	500
Perveance (μP)	*2*

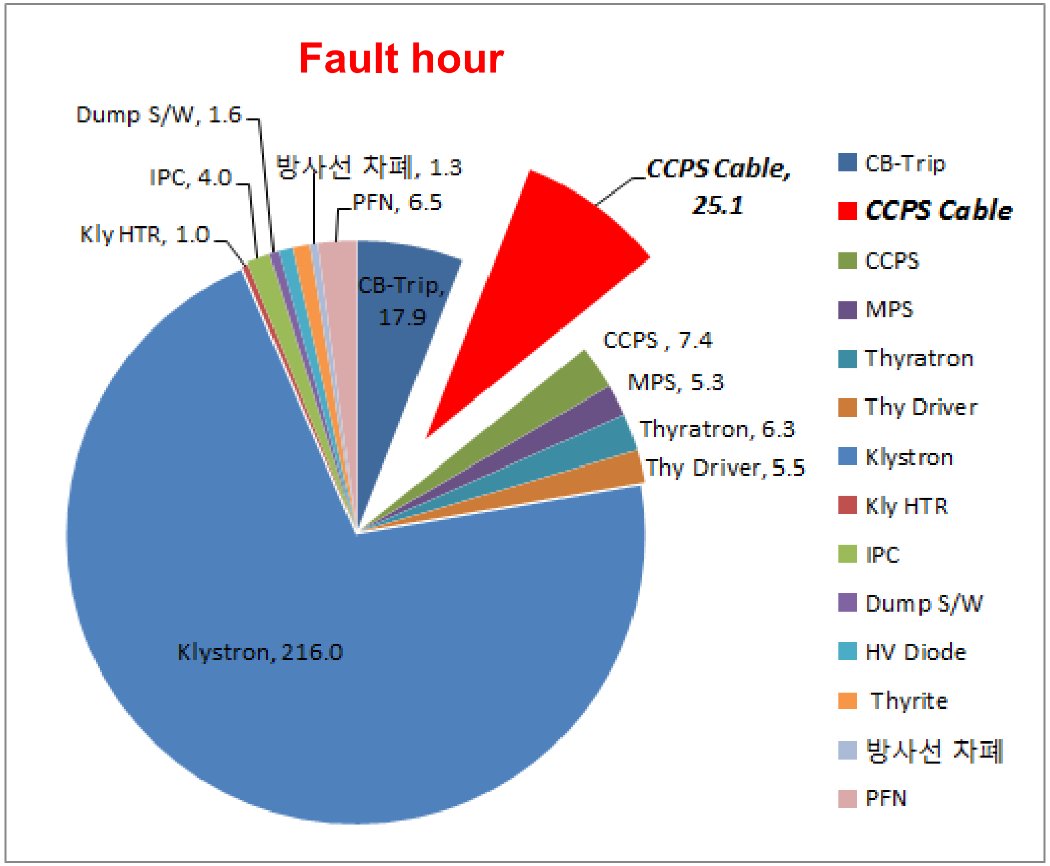
RF system of PLS-II Linac (before 2015)



Modulator Klystron Fault (2012)

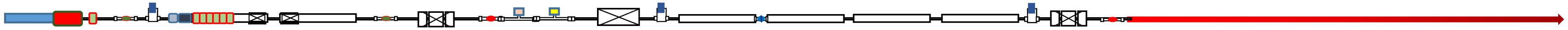
3 GeV, PLS-II LINAC

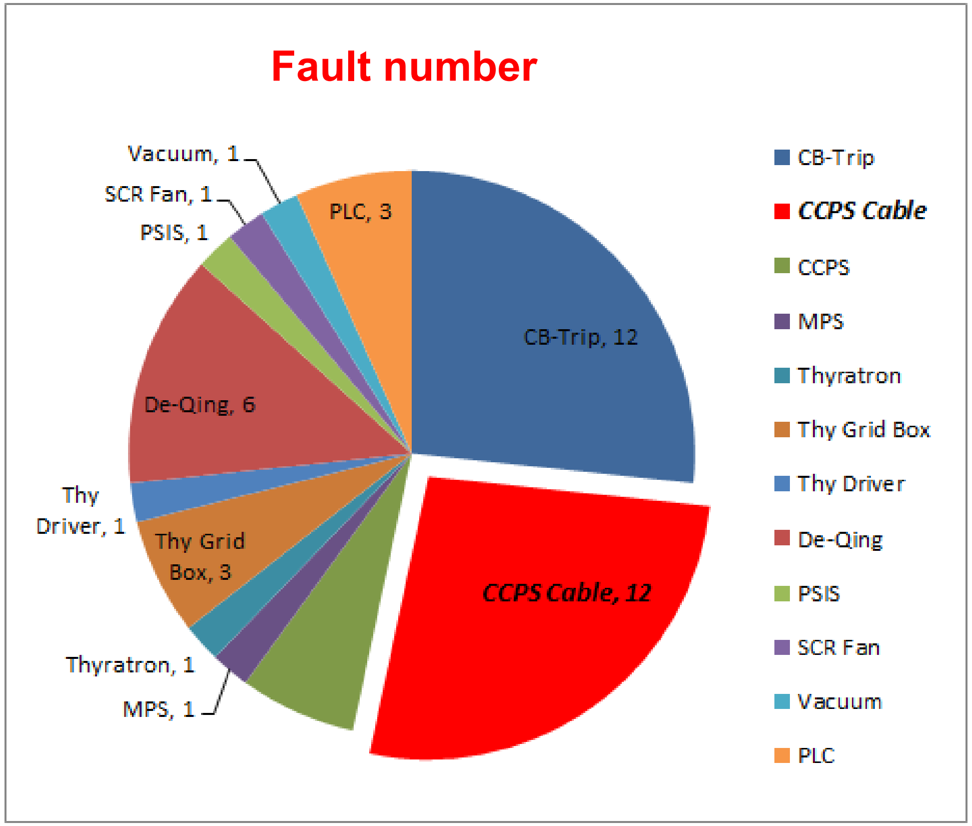


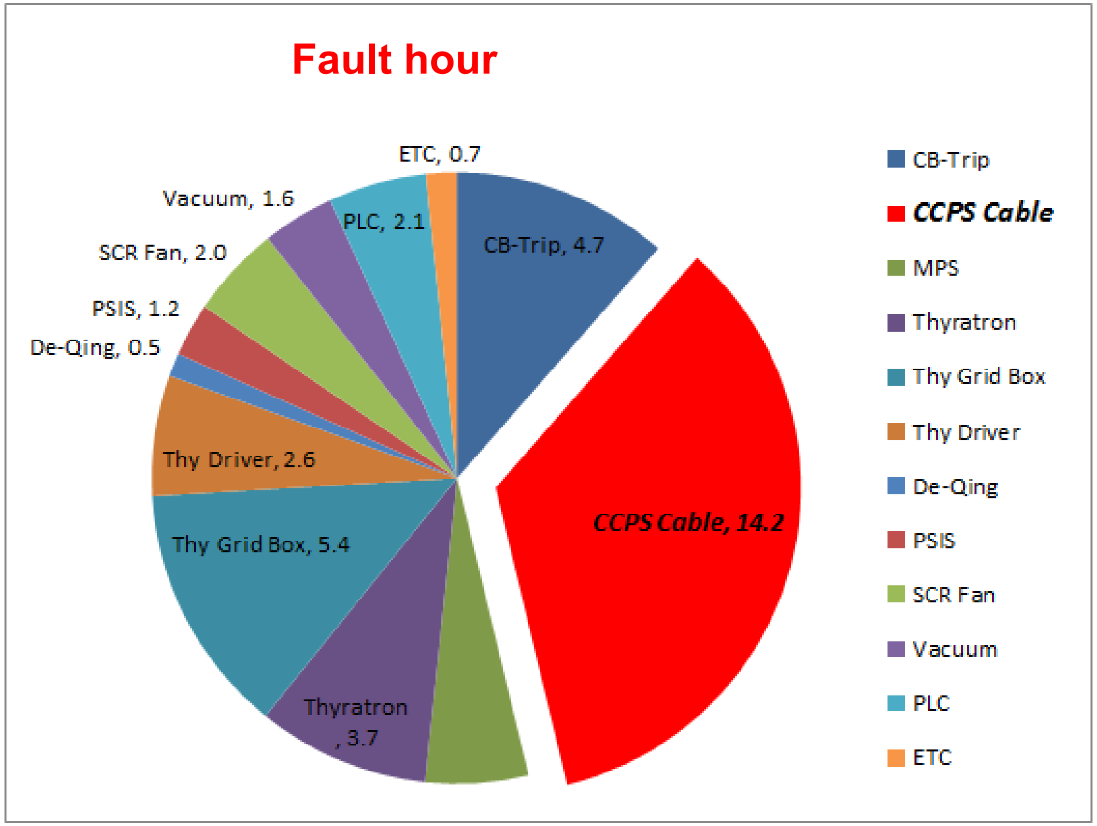


Linac Energy Availability : 95.1 % (Energy > 2.97 GeV)

Modulator Klystron Fault (2013)

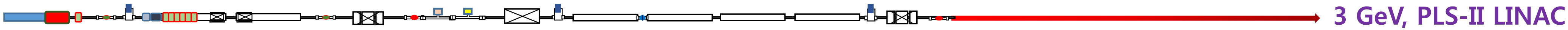


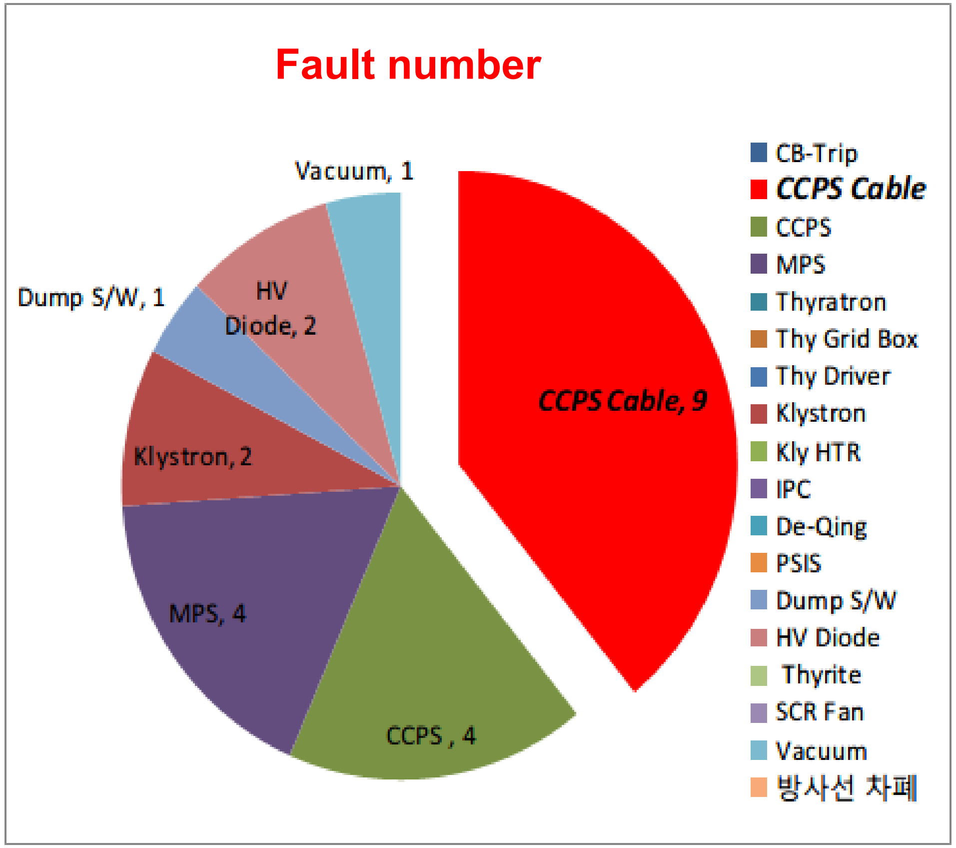


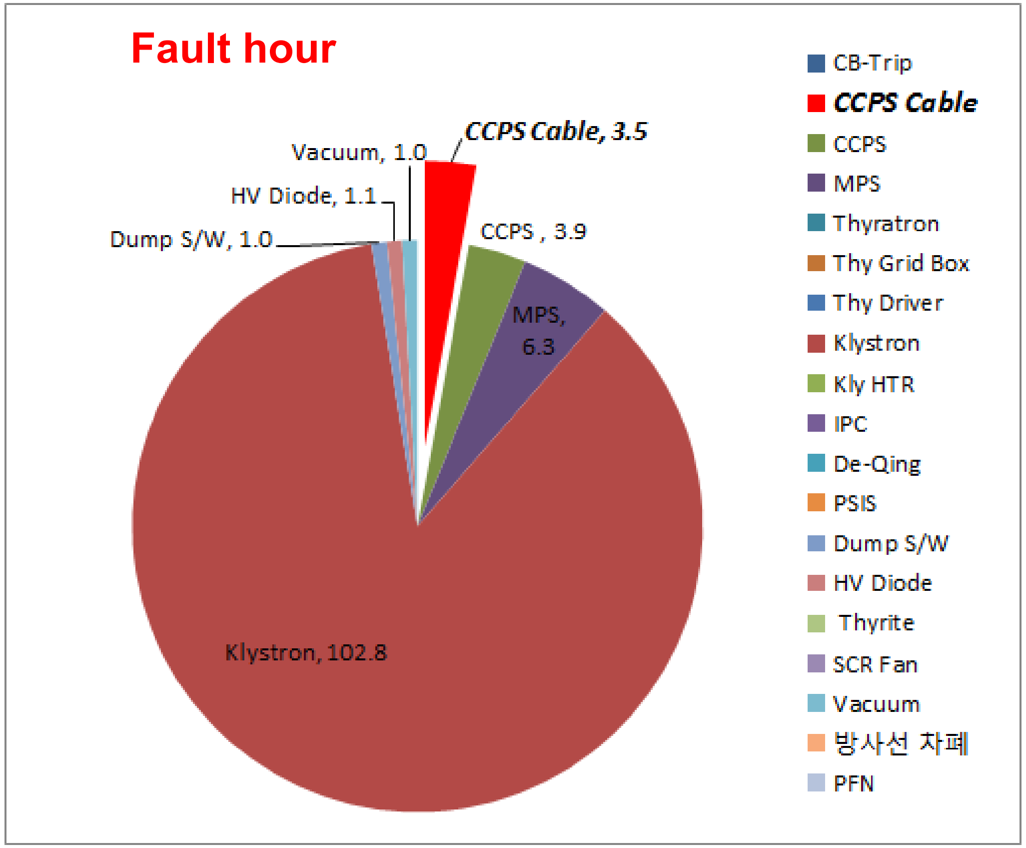


Linac Energy Availability : 96.1 % (Energy > 2.97 GeV)

Modulator Klystron Fault (2014)

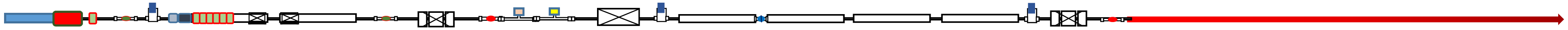






Linac Energy Availability : 96.4 % (Energy > 2.97 GeV)

Failed Klystron

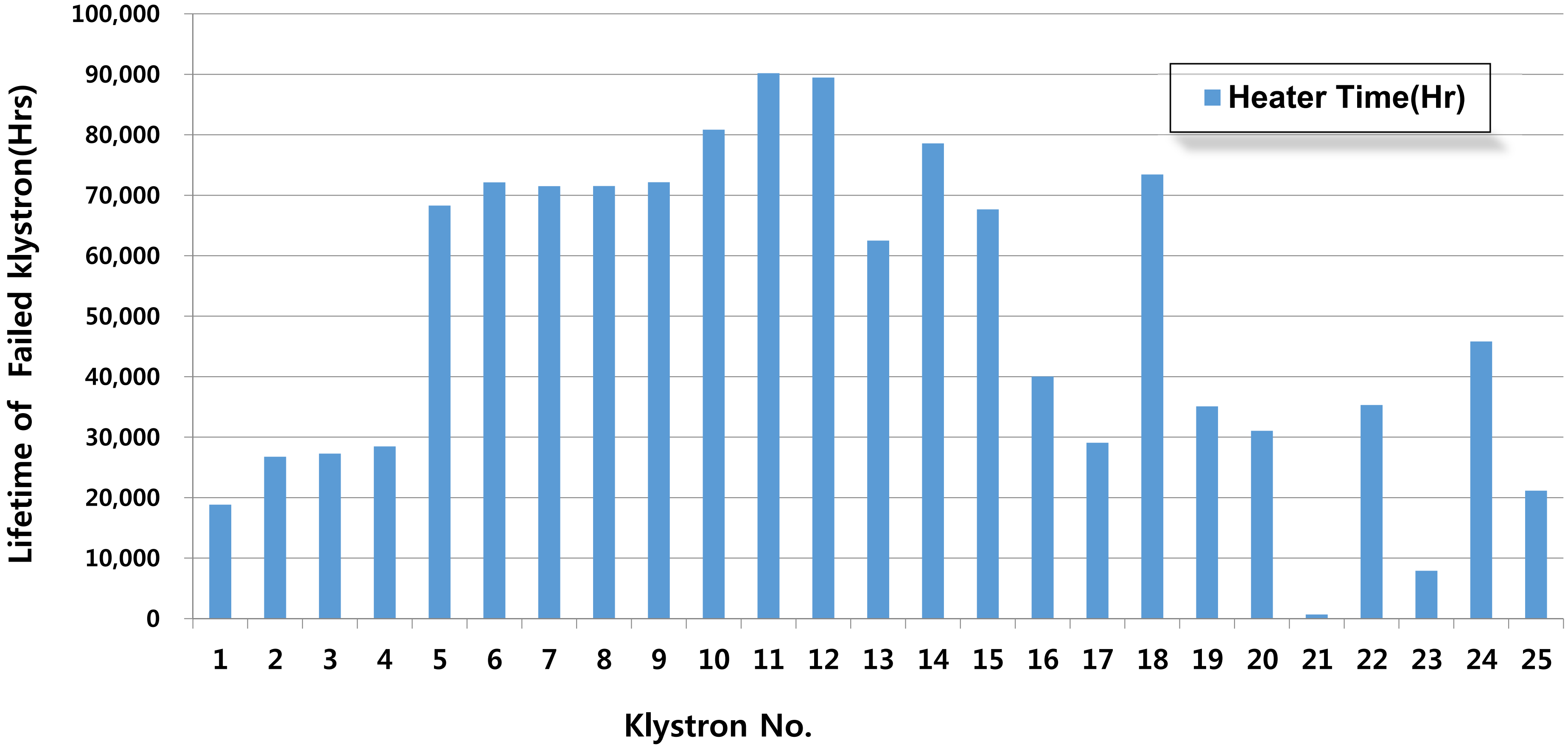


3 GeV, PLS-II LINAC

	Mod. No	Tube Type	Serial No.	Heater Time(Hr)	Removed	Problems
1	M02	E3712	PLS001	18,833	1995-08-12	Mag. coil short, Kly. Arc (13kV)
2	M06	E3712	51005PLS	26,772	1997-02-25	Kly. arc at DC 14kV
3	M08	E3712	65008PLS	27,290	1997-03-28	Heater internal short
4	M12	E3712	93015PLS	28,463	2001-12-26	Input cavaty damage
5	M09	E3712	41009PLS	68,300	2003-03-07	capacitor divider damage
6	M01	SLAC5045	511A	72,123	2003-05-21	Heater out of lifetime
7	MK07	E3712	65007PLS	71,500	2003-08-04	Heater out of lifetime
8	MK11	E3712	77006PLS	71,518	2003-08-20	Heater out of lifetime
9	MK10	E3712	98010PLS	72,158	2003-10-17	Heater out of lifetime
10	MK03	E3712	PLS002	80,844	2004-08-03	Heater out of lifetime
11	MK04	E3712	74003PLS	90,180	2005-12-26	Heater out of lifetime
12	MK05	E3712	89004PLS	89,465	2005-12-28	Heater out of lifetime
13	MK08	E3712	82013PLS	62,514	2006-02-24	Tube Collector Water leak
14	MK02	E3712	21011PLS	78,586	2006-08-22	Heater out of lifetime
15	MK06	E3712	14012PLS	67,660	2006-10-27	Heater out of lifetime (inner acing)
16	MK12	E3712	65008PLS-R	40,038	2007-07-31	Heater out of lifetime (Vacuum fault)
17	MK03	E3712	64019PLS	29,076	2008-11-14	Magnet Coil Cooling Leak
18	Test Linac	SLAC5045	571A	73,433	2009-10-19	1997.11.10. Installed, Window leak
19	MK05	E3712	79021PLS	35,085	2010-12-27	Internal gun arcing
20	M02	E3712	65023PLS	31,043	2011-05-16	Tank Pulse Tr breakdown
21	MK09A	E3712	66029PLS	667	2011-05-22	Inner acing-No power to Bucking coil (20130403)
22	M06	E3712	13024PLS	35,321	2012-01-24	Internal gun arcing
23	M03	E3712	60026PLS	7,916	2012-08-09	Cavity degradation
24	M01	SLAC5045	622A	45,832	2012-12-07	Tank Pulse Tr breakdown
25	MK12B	E3712	10032PLS	21,140	2013-10-14	gun internal arcing
26	MK02	E3712			2014-07-26	
			Average	48,491		

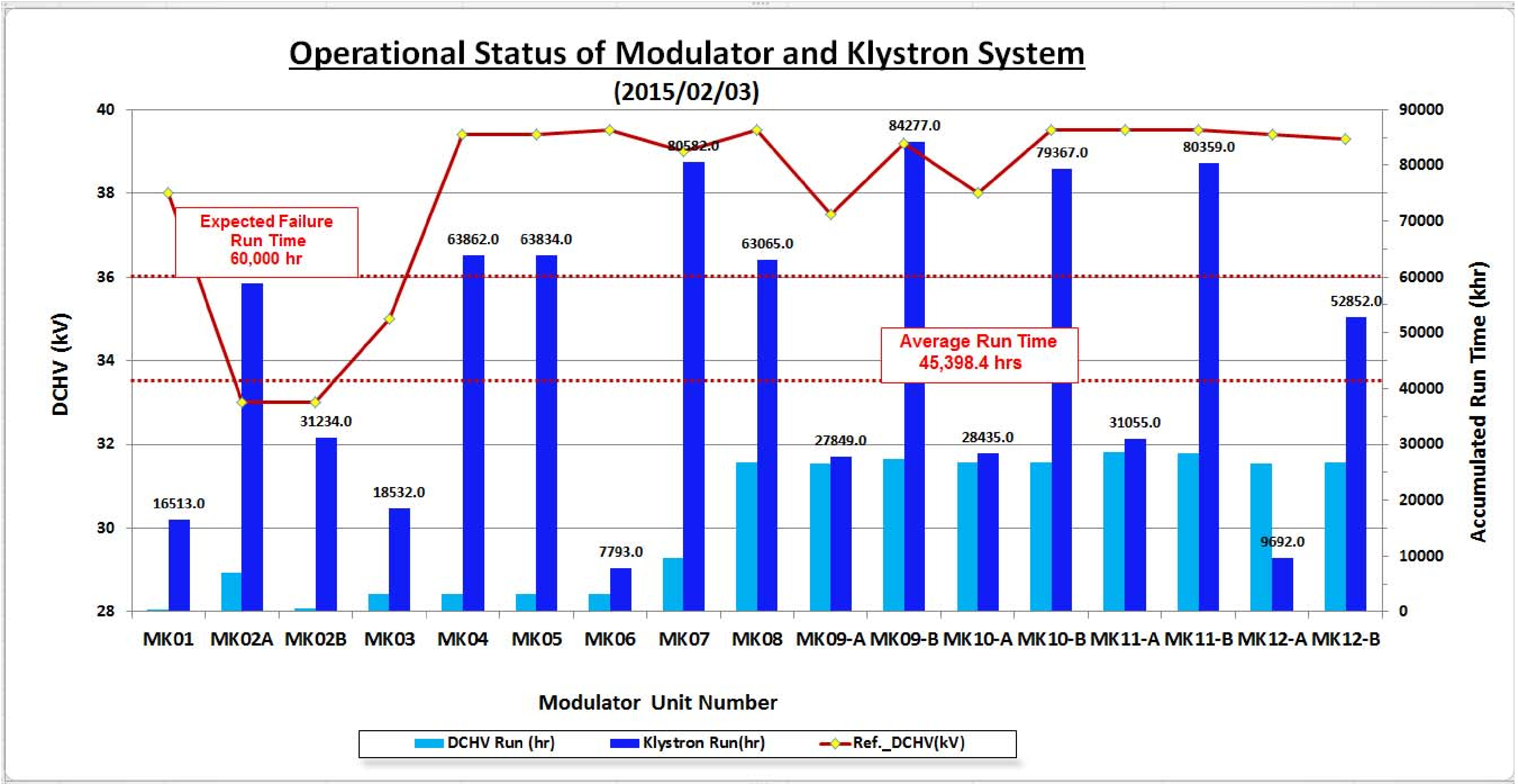
Lifetime Status of Failed Klystron (2014/2/5)

3 GeV, PLS-II LINAC

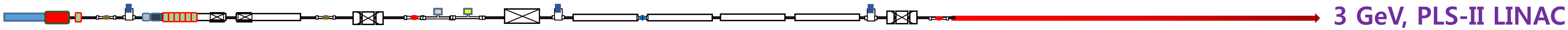


Operational Status of M/K System (2015/2/3)

3 GeV, PLS-II LINAC



Issues in PLS-II Linac



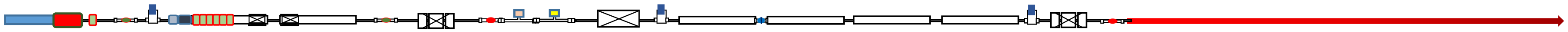
- **Beam voltage stability improvement**
  - All modulator system was changed from SCR-type to CCPS (August 2014)
  - High voltage stability less than 50 ppm was achieved leading to improved beam stability.

- **MK 01 LLRF installation**
  - Monitoring RF Phase and RF attenuation in prebuncher and buncher
  - MK01 Klystron phase feedback.

- **Energy upgrade for stable top-up operation**
  - ➢ At least 250 MeV required
  - ➢ One module already divided, two more modules to be divided.
  - ➢ Continue RF conditioning of newly divided module.
  - ➢ Replace the accelerator column with MHI.

- **Low energy top-up**
  - ➢ In case of a klystron fault, the top-up injection energy would be lowered temporarily, 2.7 GeV.
  - ➢ Machine study will be done with SR.

Issues in PLS-II Linac



3 GeV, PLS-II LINAC

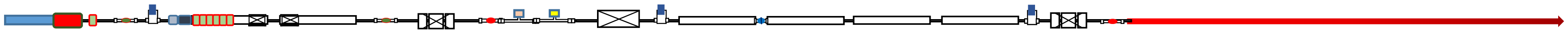
- **Minimize the faults of M/K system**
  - ➢ Add waveguide RF Window.
  - ➢ Improve high voltage CCPS cables.

- **Automated operation**
  - ➢ Reduce dependence of operation on the human labor.
  - ➢ Rapid set the optimum acceleration parameters in case of module trouble

- **Diagnostics upgrade**
  - ➢ Libera BPM (Single Pass E)
    - ✓ BTL section already replaced.
    - ✓ Beam energy measurement, beam charge, and angle of injected beam
    - ✓ Libera BPM's in linac acceleration section (2015)
  - ➢ BAS01 beam diagnostics
    - ✓ Beam energy and energy spread at pre-injector
    - ✓ new bending magnet
  - ➢ Emittance measurement at 3 GeV.

- **Beam repetition rate less than 10 Hz**
  - ➢ For energy saving
  - ➢ Requirement: Increase beam transmission rate

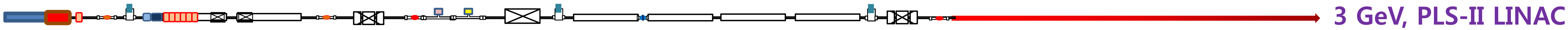
Issues in PLS-II Linac



- **Improve the energy stability**
  - One or two hours of energy drift without energy feedback system.
  - Identify the source of beam energy jitter and drift.
  - Better temperature control
  - Stability of the K&M system

- **Improve top-up injection efficiency**
  - Need accurate measurement for the reliability of radiation level in the experimental hall.
  - Calibration of BPM sum value with ICT (Integrating Current Transformer).

Energy Status of PLS-II Linac



- The linac energy was increased by dividing 4 modules to feed two accelerating columns.
- The linac is in operation with the energy availability larger than 96% (Energy>2.97 GeV).
- But no energy margin is secured, and top-up operation is in danger in case one module get trouble.

Design

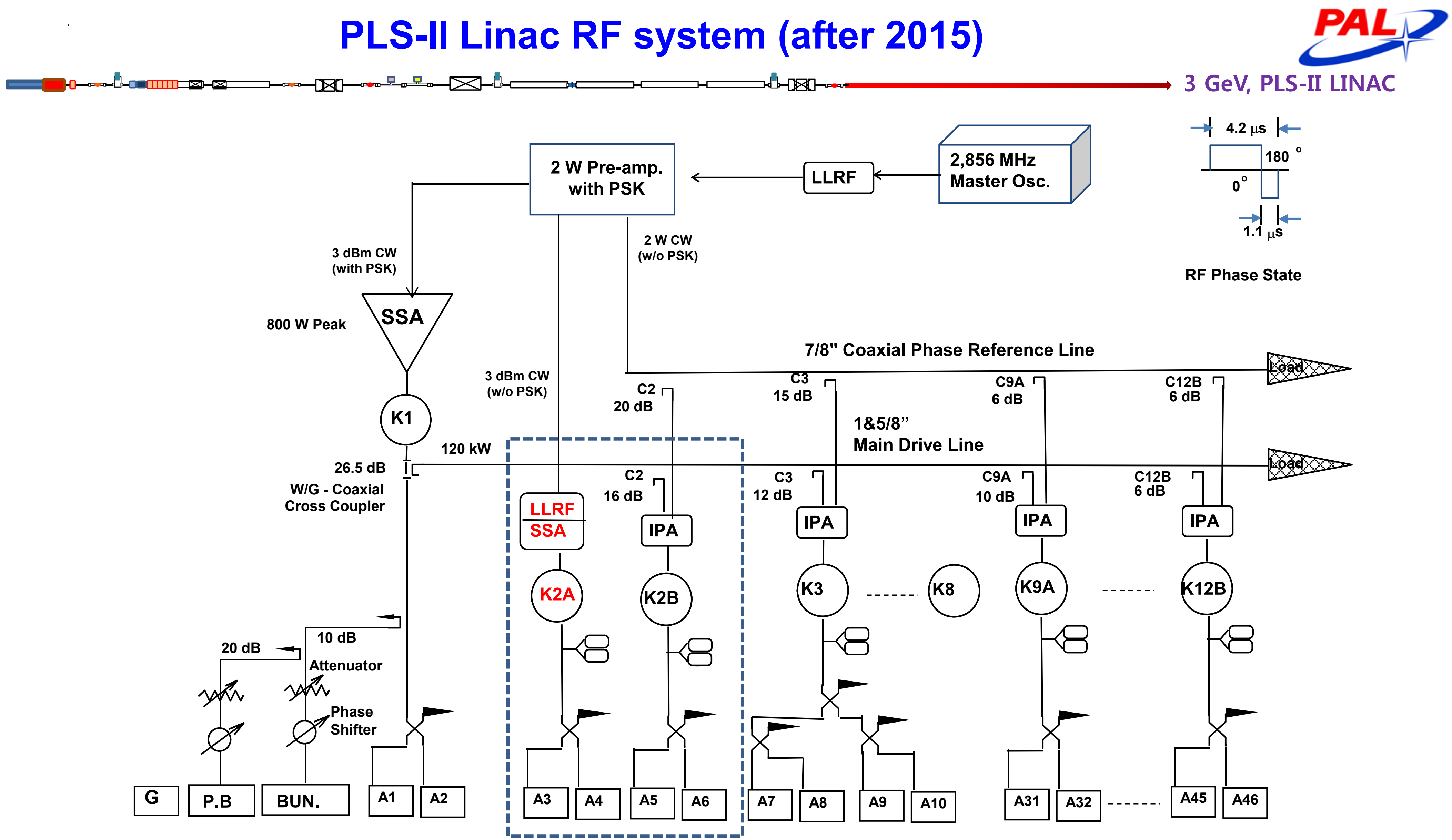
Mod. #	Kly. Power (MW)	SLED Gain	Energy (MeV)	Cumulative Energy (MeV)	Acc. Gradient (MV/m)	Supplier	A/C
1	50	1.0	100.0	100	16.4	IHEP	2
2	60	1.5	232.4	332	19.1	IHEP	4
3	60	1.5	232.4	565	19.1	IHEP	4
4	60	1.5	232.4	797	19.1	IHEP	4
5	60	1.5	232.4	1,030	19.1	IHEP	4
6	60	1.5	232.4	1,262	19.1	IHEP	4
7	60	1.5	232.4	1,494	19.1	IHEP	4
8	60	1.5	232.4	1,727	19.1	IHEP	4
9A	50	1.5	150.0	1,877	24.6	IHEP	2
9B	50	1.5	150.0	2,027	24.6	IHEP	2
10A	50	1.5	150.0	2,177	24.6	IHEP	2
10B	50	1.5	150.0	2,327	24.6	IHEP	2
11A	50	1.5	150.0	2,477	24.6	IHEP	2
11B	50	1.5	150.0	2,627	24.6	IHEP	2
12A	60	1.5	164.3	2,791	27.0	MHI	2
12B	60	1.5	164.3	2,955	27.0	MHI	2

Operation

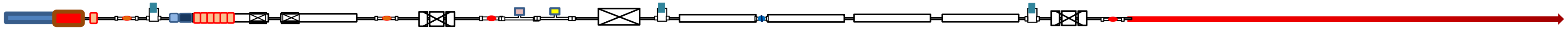
2014. 3. 19

Mod. #	Kly. Power (MW)	SLED Gain	Energy (MeV)	Cumulative Energy (MeV)	Acc. Gradient (MV/m)	Supplier	A/C
1	50	1.0	100.0	100	16.4	IHEP	2
2	64	1.58	252.8	353	20.7	IHEP	4
3	59	1.58	242.7	596	19.9	IHEP	4
4	54	1.58	232.2	828	19.0	IHEP	4
5	54	1.58	232.2	1,060	19.0	IHEP	4
6	32	1.58	178.8	1,239	14.7	IHEP	4
7	63	1.58	250.8	1,490	20.6	IHEP	4
8	57	1.58	238.6	1,728	19.6	IHEP	4
9A	52	1.58	161.1	1,889	26.4	IHEP	2
9B	47	1.58	153.2	2,042	25.1	IHEP	2
10A	60	1.58	173.1	2,215	28.4	IHEP	2
10B	50	1.58	158.0	2,373	25.9	IHEP	2
11A	54	1.58	164.2	2,538	26.9	IHEP	2
11B	48	1.58	154.8	2,692	25.4	IHEP	2
12A	48	1.58	154.8	2,847	25.4	MHI	2
12B	54	1.58	164.2	3,012	26.9	MHI	2

PLS-II Linac RF system (after 2015)



Further Energy Upgrade for PLS-II



- More energy is needed for stable operation of PLS-II Linac in case of K/M module trouble.
- Three additional modules will be divided to obtain 10 % energy margin.
- MK02A module was divided last winter.

Design

Mod. #	Kly. Power (MW)	SLED Gain	Energy (MeV)	Cumulative Energy (MeV)	Acc. Gradient (MV/m)	Supplier	A/C
1	50	1.00	100.0	100	16.7	IHEP	2
2A	50	1.58	158.0	258	25.9	IHEP	2
2B	50	1.58	158.0	416	25.9	IHEP	2
3A	50	1.58	158.0	574	25.9	IHEP	2
3B	50	1.58	158.0	732	25.9	IHEP	2
4A	50	1.58	158.0	890	25.9	IHEP	2
4B	50	1.58	158.0	1048	25.9	IHEP	2
5	60	1.58	244.8	1293	20.1	IHEP	4
6	60	1.58	244.8	1538	20.1	IHEP	4
7	60	1.58	244.8	1782	20.1	IHEP	4
8	60	1.58	244.8	2027	20.1	IHEP	4
9A	50	1.58	158.0	2185	25.9	IHEP	2
9B	50	1.58	158.0	2343	25.9	IHEP	2
10A	50	1.58	158.0	2501	25.9	IHEP	2
10B	50	1.58	158.0	2659	25.9	IHEP	2
11A	50	1.58	158.0	2817	25.9	IHEP	2
11B	50	1.58	158.0	2975	25.9	IHEP	2
12A	60	1.58	173.1	3148	28.4	MHI	2
12B	60	1.58	173.1	3321	28.4	MHI	2

Operation Example

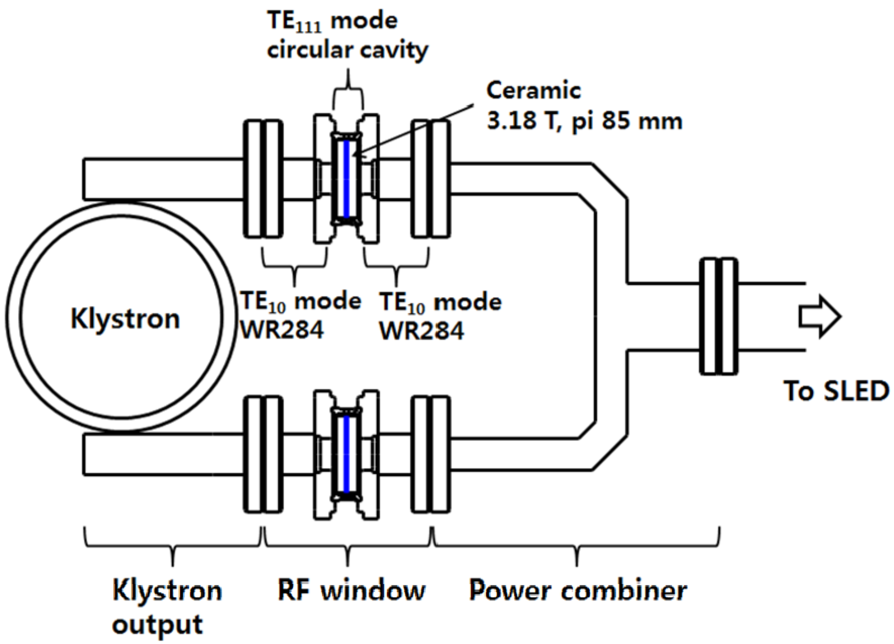
2015. 3. 25

Mod. #	Kly. Power (MW)	SLED Gain	Energy (MeV)	Cumulative Energy (MeV)	Acc. Gradient (MV/m)	Supplier	A/C
1	53	1.00	100.0	100	16.7	IHEP	2
2A	25	1.58	111.7	212	18.3	IHEP	2
2B	25	1.58	111.7	323	18.3	IHEP	2
3	60	1.58	244.8	568	20.1	IHEP	4
4	56	1.58	236.5	805	19.4	IHEP	4
5	60	1.58	244.8	1049	20.1	IHEP	4
6	62	1.58	248.8	1298	20.4	IHEP	4
7	58	1.58	240.7	1539	19.7	IHEP	4
8	55	1.58	234.4	1773	19.2	IHEP	4
9A	49	1.58	156.4	1930	25.7	IHEP	2
9B	60	1.58	173.1	2103	28.4	IHEP	2
10A	56	1.58	167.2	2270	27.4	IHEP	2
10B	40	1.58	141.3	2411	23.2	IHEP	2
11A	50	1.58	158.0	2569	25.9	IHEP	2
11B	45	1.58	149.9	2719	24.6	IHEP	2
12A	54	1.58	164.2	2883	26.9	MHI	2
12B	54	1.58	164.2	3048	26.9	MHI	2

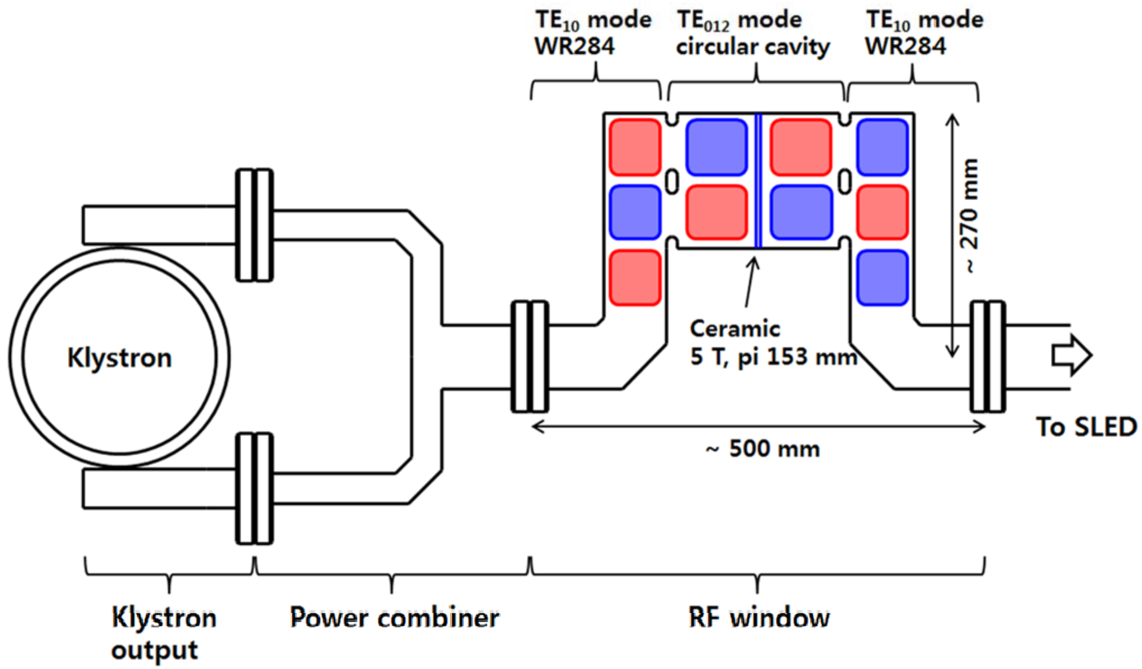
S-band High power TE012 mode RF Window

3 GeV, PLS-II LINAC

- Reduce the recovery time in case of klystron fault less than one day.
  - MK01 – MK08 : No RF Window
  - MK09A – MK12B : Double Window System
- Develop the Single RF window and attach it after Klystron combiner.
- Engineering design is in progress.

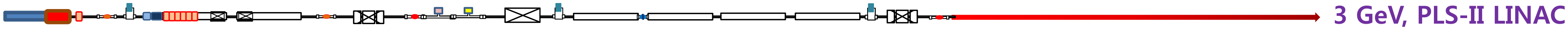


Present RF Window (MK09A, MK10A – MK12A)



Planned RF Window

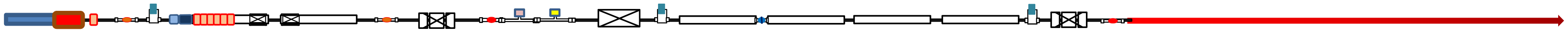
Long-term Plan



- **Increase beam energy**
  - ➢ Lengthen the accelerator length to accommodate additional accelerator columns.
    - lump-sum budget required.
  - ➢ Use C-band accelerator columns (?)
    - The higher accelerating gradient : ~ 40 MV/m

- **Pre-injector upgrade** (E-beam quality upgrade)
  - ➢ Thermionic gun => Photo-cathode gun, or
  - ➢ Increase E-gun voltage from 80 keV to ~200 keV
  - ➢ Option for single bunch acceleration

Agenda for this visit



Operation Related

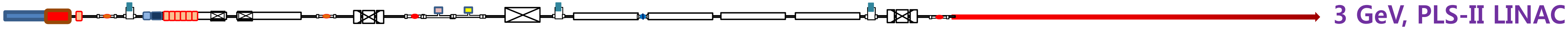
- Phasing method and algorithm
- Trajectory correction scheme
- Energy feedback
- Recovery scheme in case of M/K module fault
- Short and long-term energy stability
- Beam / Machine parameter taking and management
  - Machine start-up and Top-up operation
  - DB generation and management on beam and machine parameters.
  - Review parameter history
- Top-up related discussion (need to contact a PF person in charge)
  - Injection efficiency – measurement method
  - Injection optics management – injection angle etc.
  - Injection scheme
  - Injection perturbation and cure

Agenda for this visit

Linac Machine related

- High-power RF
  - Klystron output power measurement
  - SLED gain measurement
- RF Phase
  - Feedback : Klystron or SLED
  - Phase change speed
- Modulator high voltage cable issue
  - Termination design for reducing HV breakdown
- Cooling and Gallery air conditioning
- Radiation level regulation (injection point and experimental hall)
- Technical cooperation using video conference

PLS-II Linac Members



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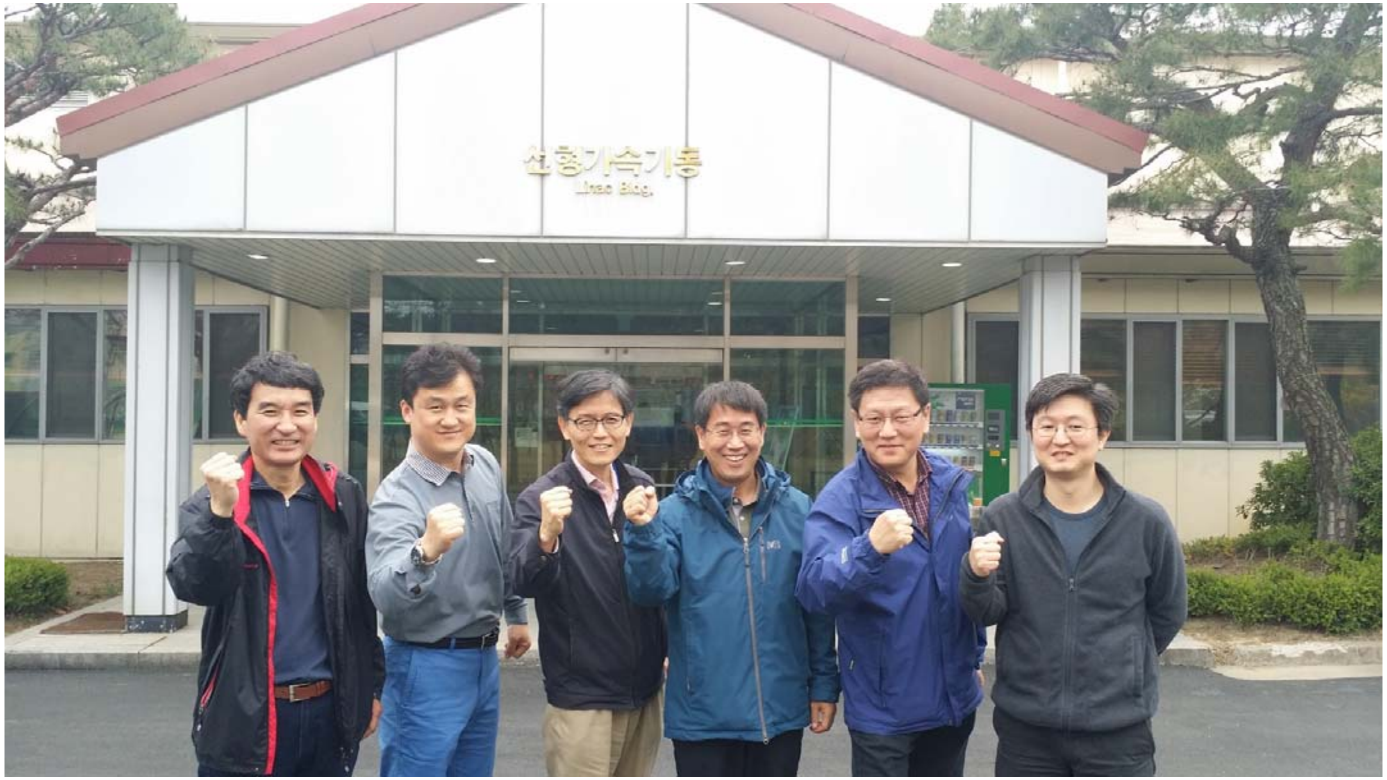

J. K. Oh
Maintenance

Thank for very much for your attention!