PLS Operation and The Tools

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PAL 포항가속기연구소
POHANG ACCELERATOR LABORATORY

Talk about

- PLS
- PLS II
- Accelerator Model
- Case of Application

Aerial view of PLS

History of PLS

● Project started	Apr. 1	1988
● 2-GeV PLS Commissioning	Dec. 24	1994
● User Service Start	Sept. 1	1995
● 2.5 GeV Ramping	Sept. 1	2000
● 2.5-GeV Injection	Nov. 1	2002

● TOP-UP operation	September	2010
● PLS-II Project (3 GeV)		
Commissioning	July	2011

PLS(Pohang Light Source)

Linac

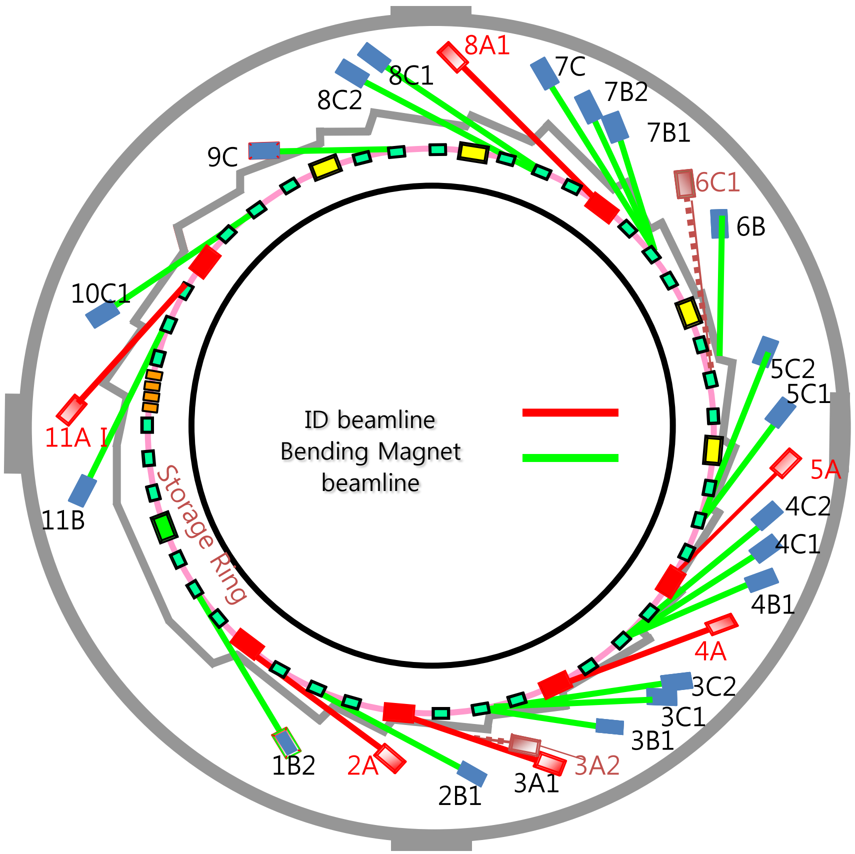
- Beam Energy 2.5GeV
- Frequency 2,856Mhz
- Energy Spread 0.26%
- Number of Klystrons 12
- No. of Accelerating columns 44
- Total Length 160M

Storage Ring

- Beam Energy 2.5GeV
- Beam Current 190 mA
- Lattice TBA
- Period 12
- Circumference 280.56 m
- Emittance 18.9 nm-rad
- Tune 14.28 / 8.18

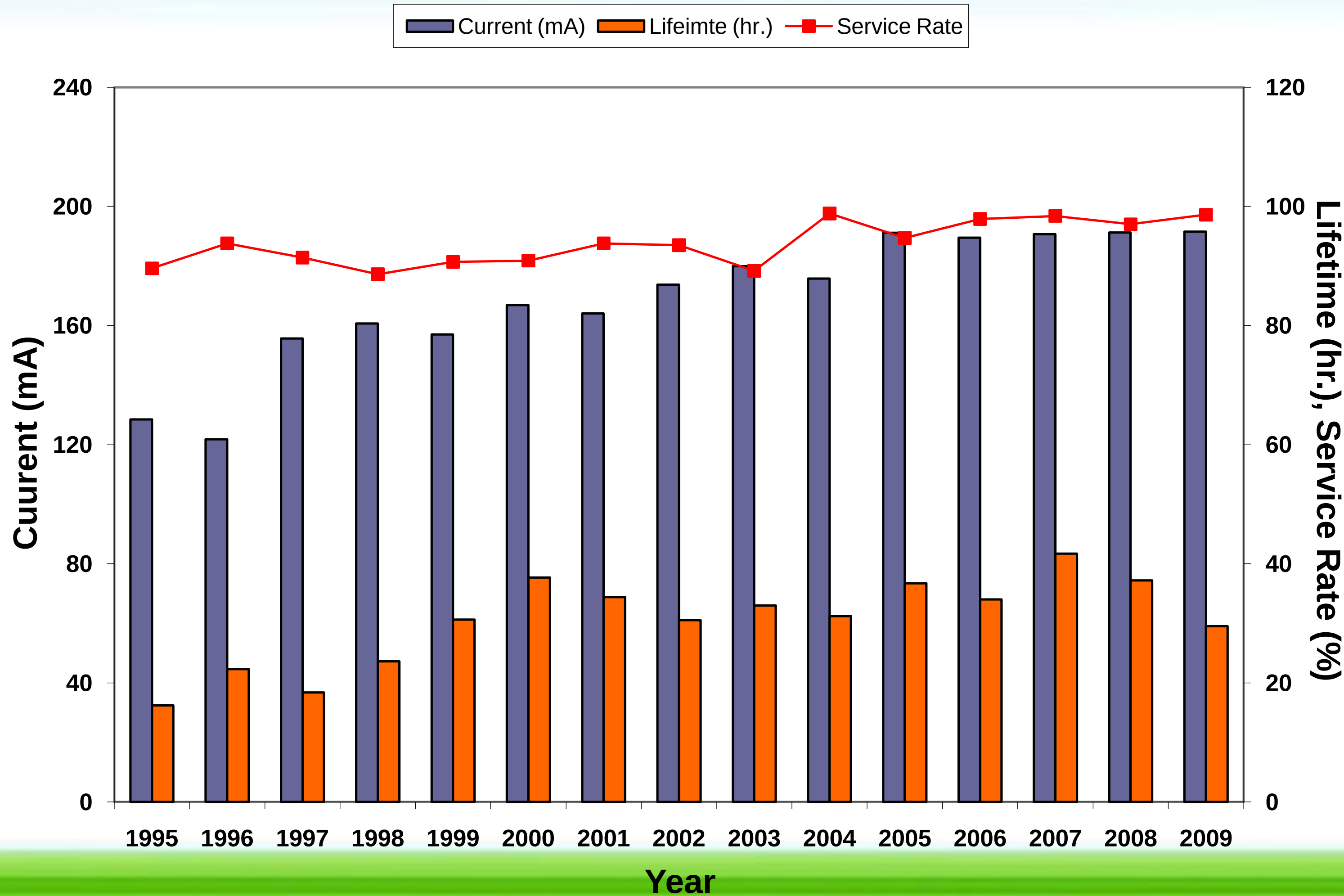
Beam Lines in Service

(2 0 Bending + 7 ID Beamlines)



Beamline	Source	Minimum Gap
2A	EPU (EPU6)	18 mm
3A1 / 3A2	Undulator (U6 / U10)	
4A	Wiggler (MPW14)	8mm Fixed
5A	Wiggler (MPW14)	8mm Fixed
8A1 / 8A2	Undulator (U7)	20 mm
11A	Revolver (Revolver)	6 mm
9A	IVU	Not installed
10A	Wiggler (MPW10)	Installed, not used

Operational Statistics: User Service Rate



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PLS II

Parameter	PLS	PLS II
Beam Enegy[GeV]	2.5	3.0
Beam Emittance[nm·rad]	18.9	~5 - 10
Stored Beam Current[mA]	200	400
Total Number of IDs	10	20
Lattice	TBA /12 Cell	DBA /12 Cell
Operating Mode	Decay /Topup/	Topup
Brightness	~2 x 10^{18}	~10^{20}
*RF Cavity	Conventional	SC Cavity
*Bending Magnet Type	Separated	Combined
Circumference[m]	280.56	281.82

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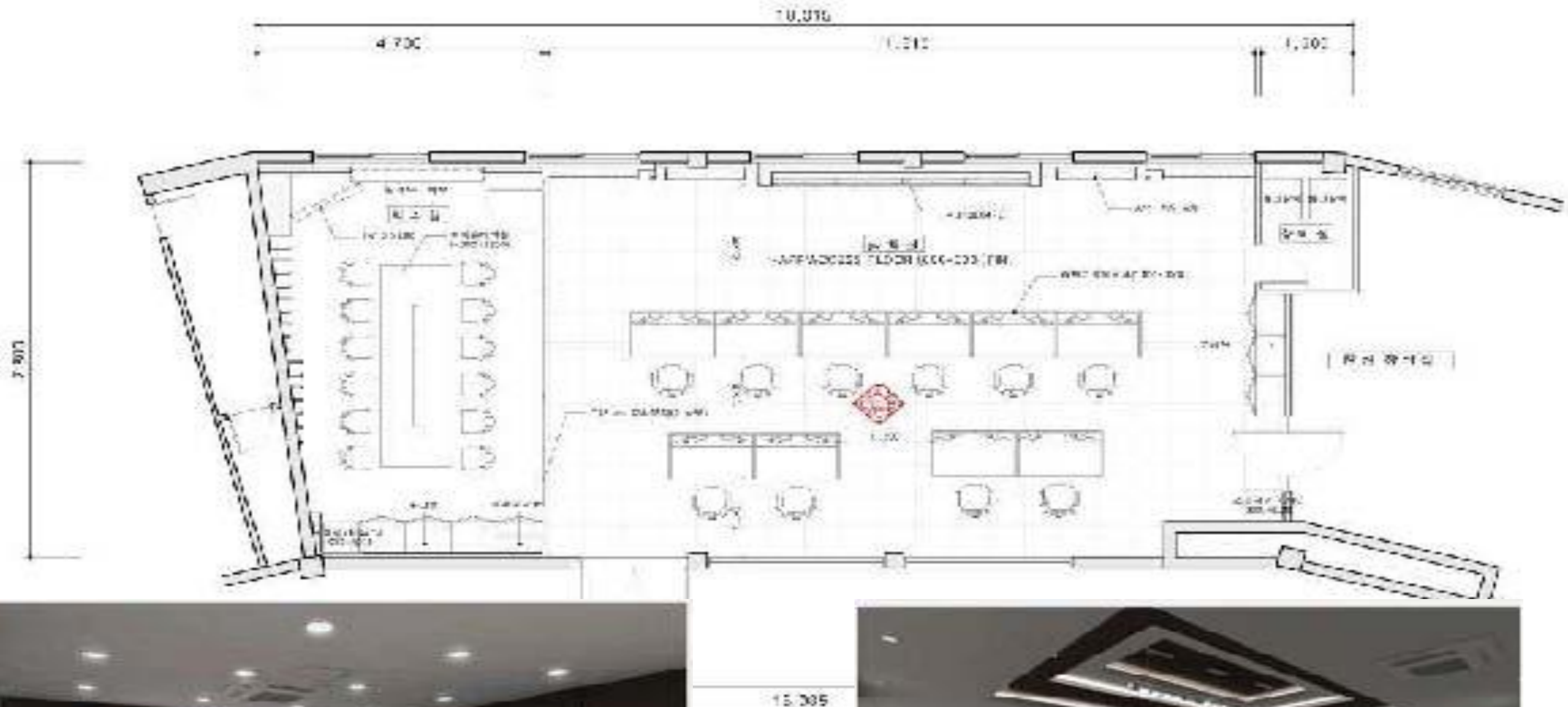
LATTICE FOR PLS-II

In Dreaming of PLS II Control Room



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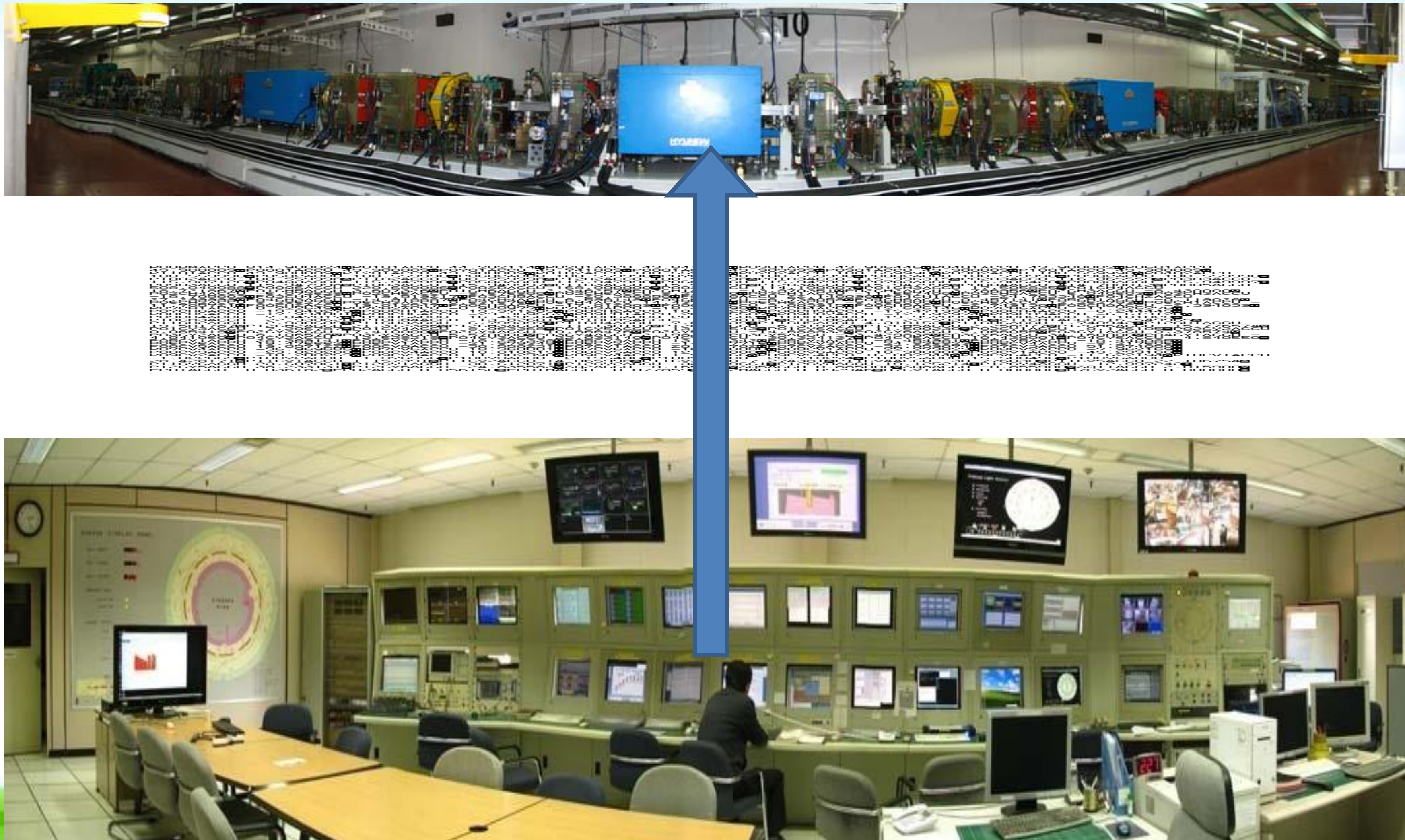
Accelerator Model of PLS



How do you know which part of this file should be rewritten?

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43.900009◙P06Q1ACCU 43.900009◙P07Q1ACCU 43.741009◙P08Q1ACCU 43.903999◙P09Q1ACCU 43.900009◙P10Q1ACCU 43.900009◙
P11Q1ACCU 43.900009◙P12Q1ACCU 43.900009◙P01Q2ACCU 100.559998◙P02Q2ACCU 100.559998◙P03Q2ACCU 100.559998◙P04Q2ACCU
100.559998◙P05Q2ACCU 100.559998◙P06Q2ACCU 100.559998◙P07Q2ACCU 100.559998◙P08Q2ACCU 100.559998◙P09Q2ACCU 100.559998◙
P10Q2ACCU 100.559998◙P11Q2ACCU 100.559998◙P12Q2ACCU 100.559998◙P01Q3ACCU 115.996315◙P02Q3ACCU 116.065559◙P03Q3ACCU
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-18.705603◙P03CH4ACCU -19.519217◙P03CH5ACCU -20.366856◙P03CH6ACCU 22.148098◙P04CH1ACCU -24.703348◙P04CH2ACCU
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11.785721◙P06CH2ACCU 19.612547◙P06CH3ACCU -17.012669◙P06CH4ACCU 3.603915◙P06CH5ACCU -2.749138◙P06CH6ACCU -2.394039◙
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4.941060◙P04CV2ACCU -12.528218◙P04CV3ACCU 22.933140◙P04CV4ACCU -30.324137◙P04CV5ACCU 19.430901◙P04CV6ACCU -4.849559◙
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P07CV4ACCU -35.969685◙P07CV5ACCU 18.360001◙P07CV6ACCU -16.900000◙P08CV1ACCU 22.273823◙P08CV2ACCU -7.962169◙
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P12CV5ACCU 38.233131◙P12CV6ACCU -24.835583◙SQ2ACCU -0.165700◙SQ5ACCU 0.885000◙SQ8ACCU -0.855900◙SQ11ACCU 2.015900◙
EPU1ACCU -0.036182◙EPU2ACCU 0.056150◙EPU1HACCU -0.077859◙EPU2HACCU 0.092946◙U7CV1ACCU 0.000000◙U7CV2ACCU 0.000000◙
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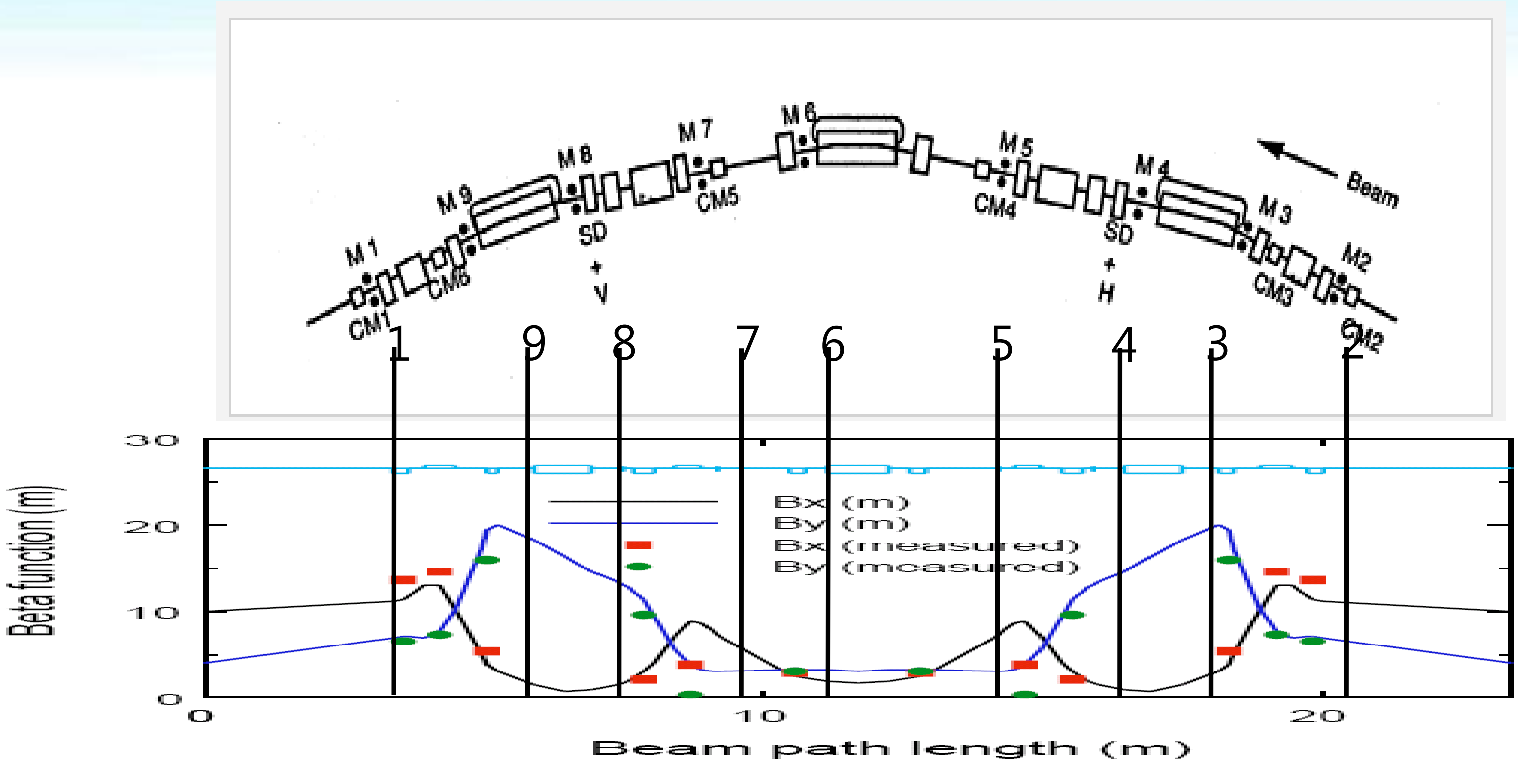
A file of PLS magnet settings consists of 300 elements

Modeling of Accelerator



$V = M \cdot dU$: Modeling

$dU = M^{-1} \cdot V$: Inverse Modeling

V : Beam Parameters

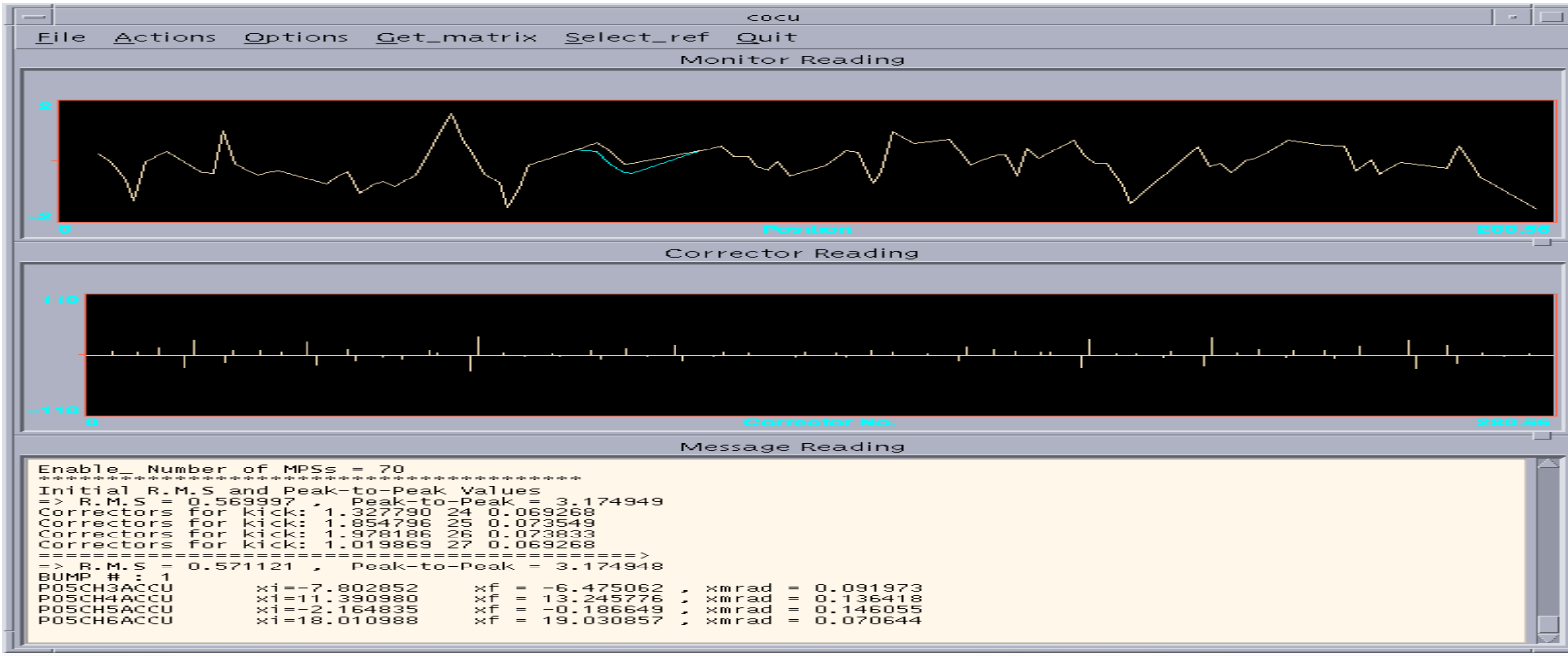
U : Strengths

M_designed M_measured

COCU   (Closed Orbit Correction Unit)

Developed at CERN)

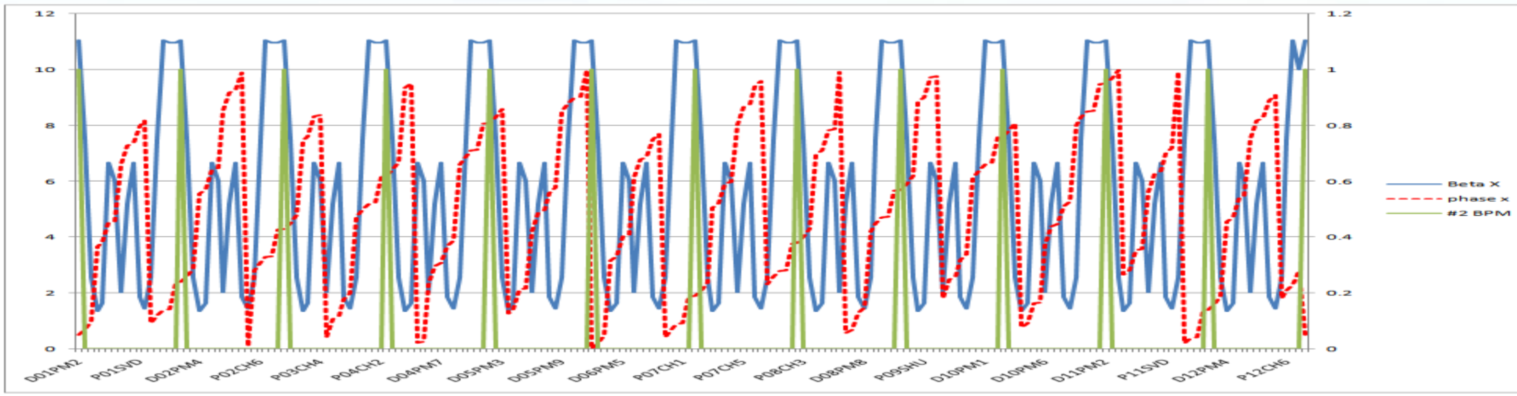
- Global Correction :   MICADO
- Local Correction   :   BUMP4S



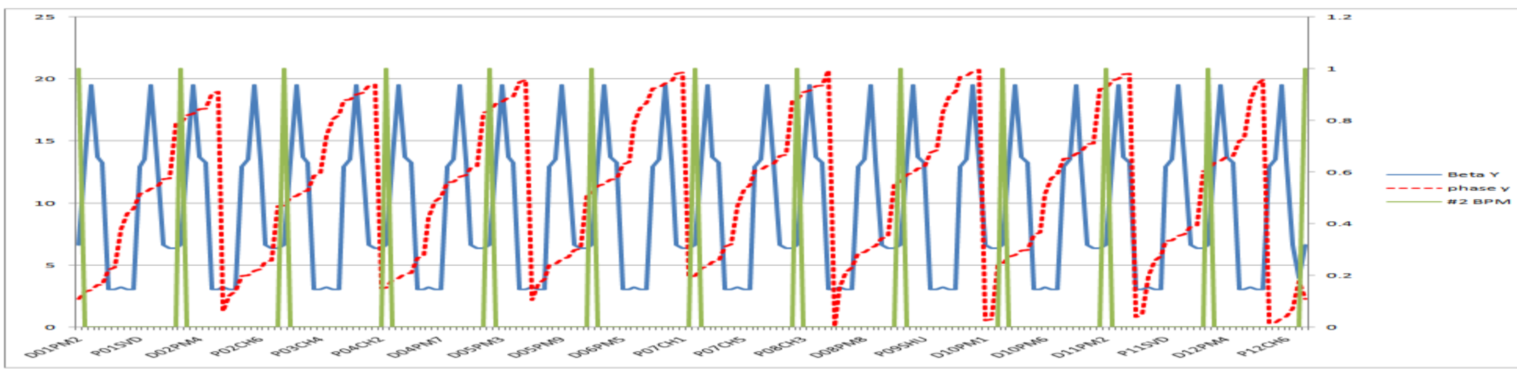
The Phase advance of T used in COCU

(Calculated using MAD8 in 1998)

Hor



Ver



- Model(COCU) Tune (14.28 / 8.18)
- Measured Tune (14.26 / 8.20)

MML : PLS Modeling

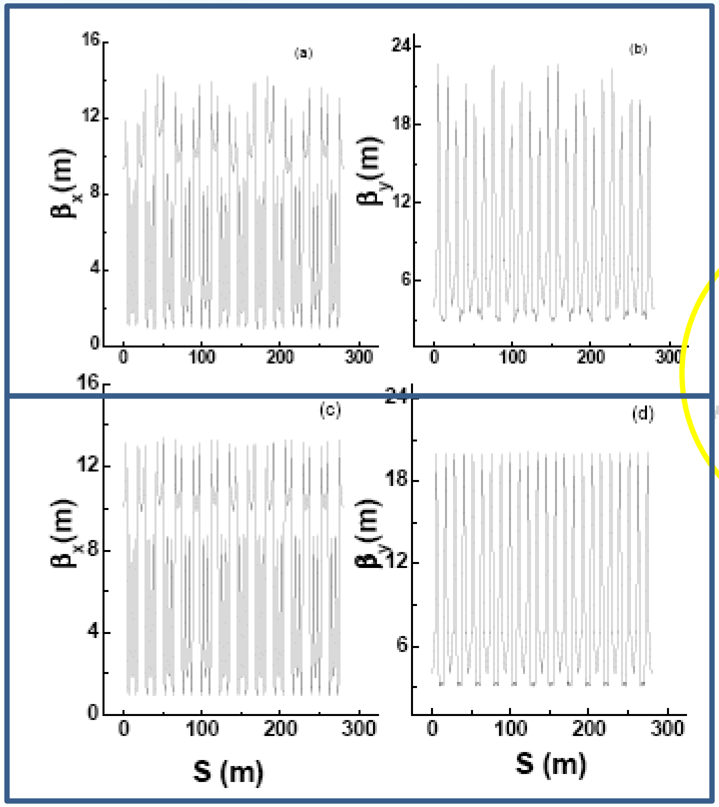
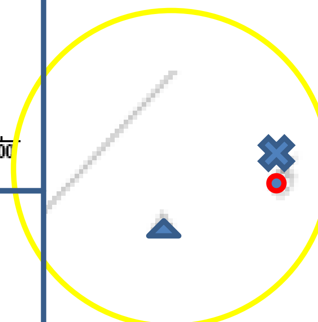
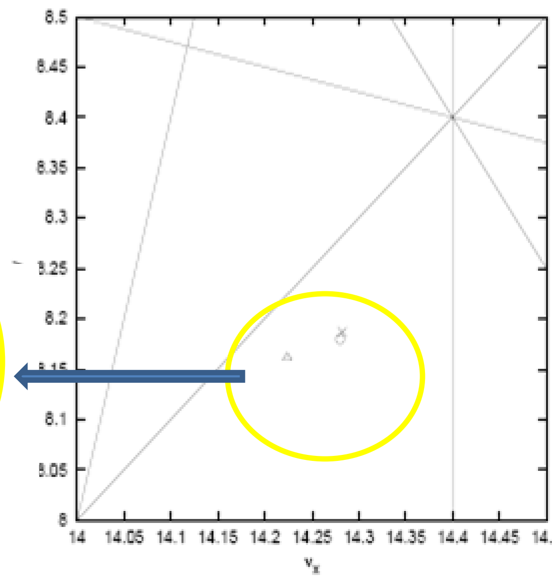


Fig. 13. Predicted β functions ((a) and (b)) before and ((c) and (d)) after correction. After correction, the β functions are seen to be very close to the designed values (see Figure 1), and the near twelve-fold symmetry of the ring was restored.





Model Tune
(14.407 / 8.487)
Measured Tune
(14.26 / 8.20)

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Correction of $M_{measured}$ with MML

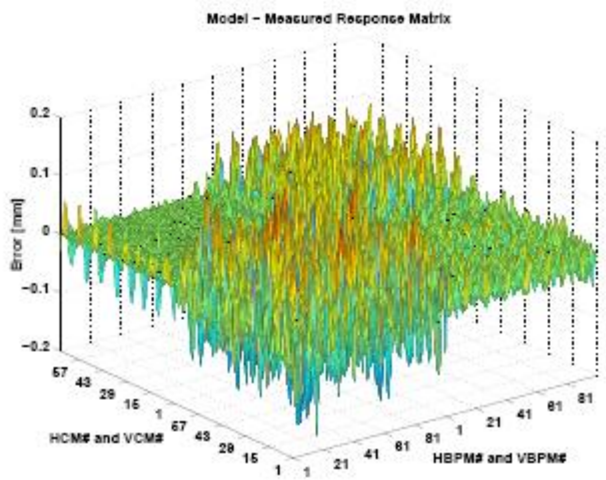

Fig. 8. Difference between the measured response matrix and the model response matrix before correction.

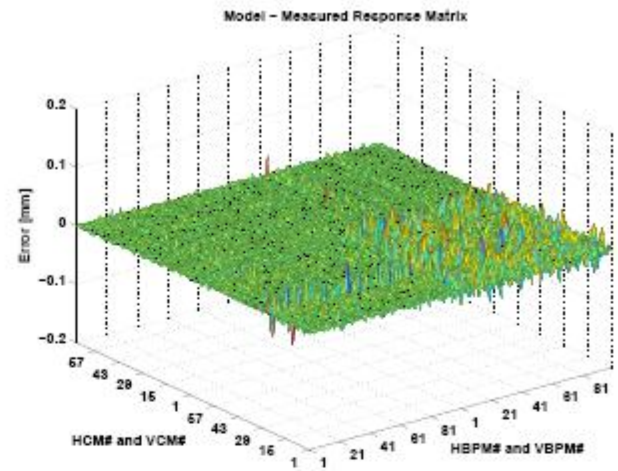

Fig. 9. Difference between the measured response matrix and the model response matrix after correction. Comparing with Figure 8, we can see a significant reduction in the difference.

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Typical Startup Procedure after a long Shutdown

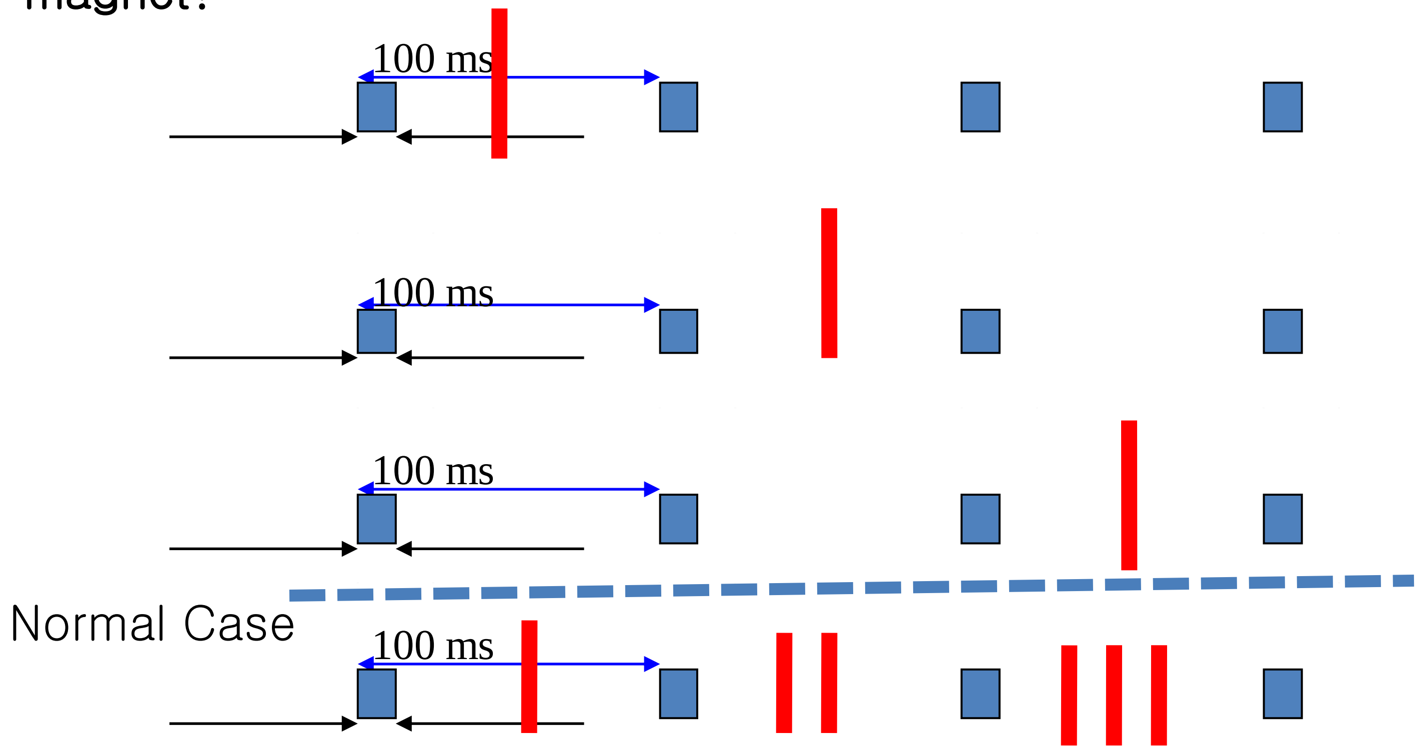
1. Orbit Determination after Summer Maintenance
   - Previous corrector settings do not work-

2. Local Correction for Beamlines
   - Photon beams to be steered locally

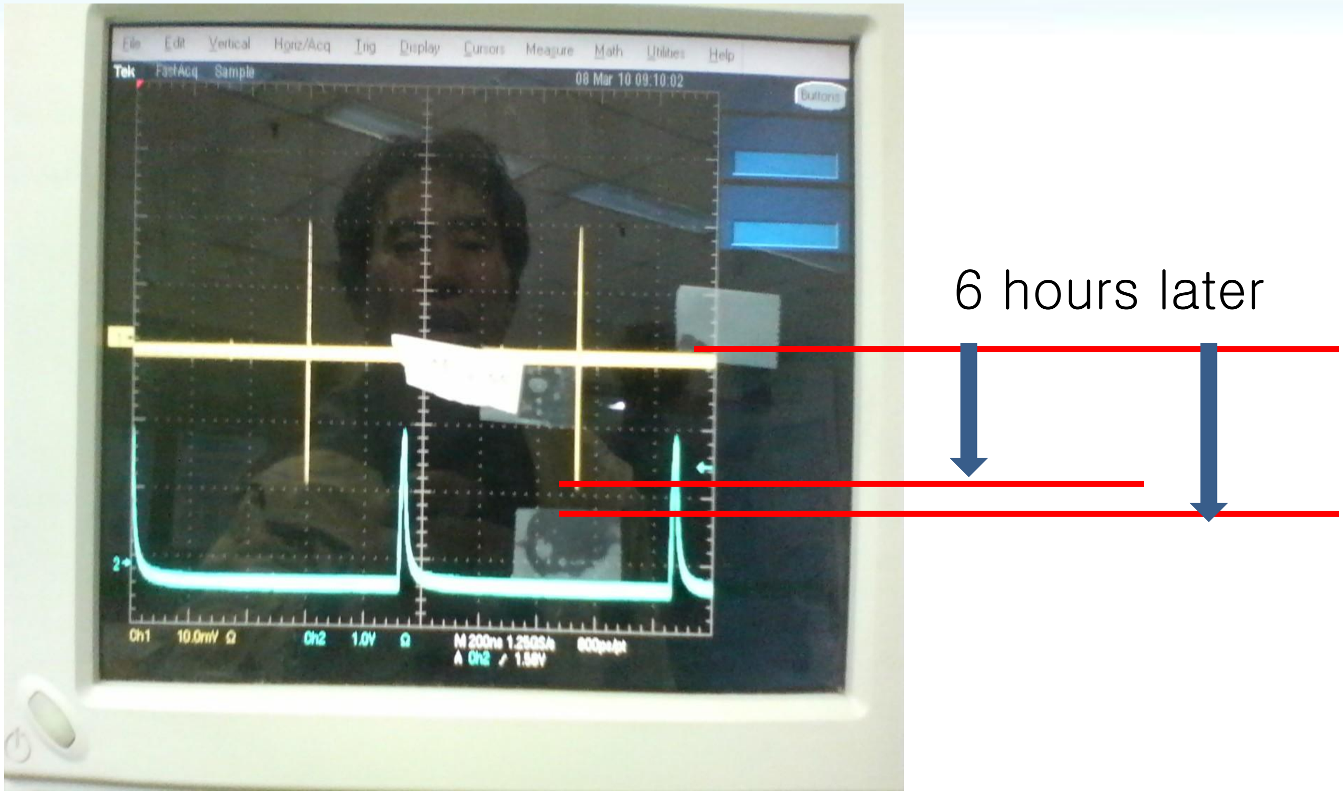
3. Keep Orbit Stability in User Service
   - Tunes should be kept around (14.28, 8.18)

Unusual Consequences

Why is the stored beam is killed by the operation of the kicker magnet?

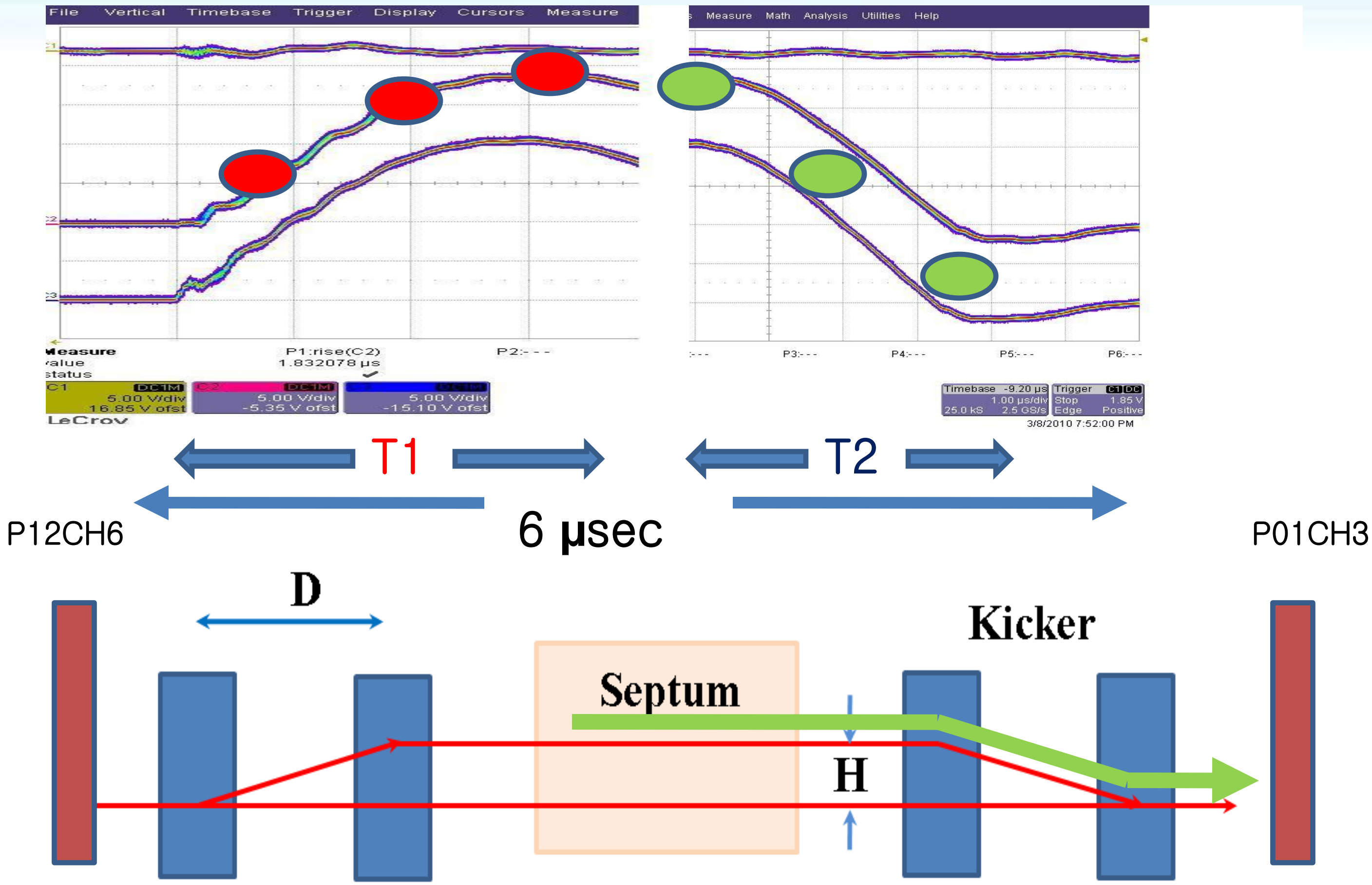


Lifetime of stored one bunch



One bunch, but remained stable

Time structure



Test of what conditions make the bunch survive

1. Change the storage ring corrector from −35A to 20A, covering maximum kick angle.

2. Change the timing of two bump kicks by inserting cables, whose time delays are from 5ns to 30ns, respectively.

3. Test
   - From the kick of 2kV the upstream corrector range was narrowed.
   - At −8.0A setting the bunch was safe from the kick of 6kV.

4. Result
   The injected bunch could be safe always if the kick power would be remained under 6kV.

5. But with this kick the Linac Beam could not be injected into. A great shortcoming!

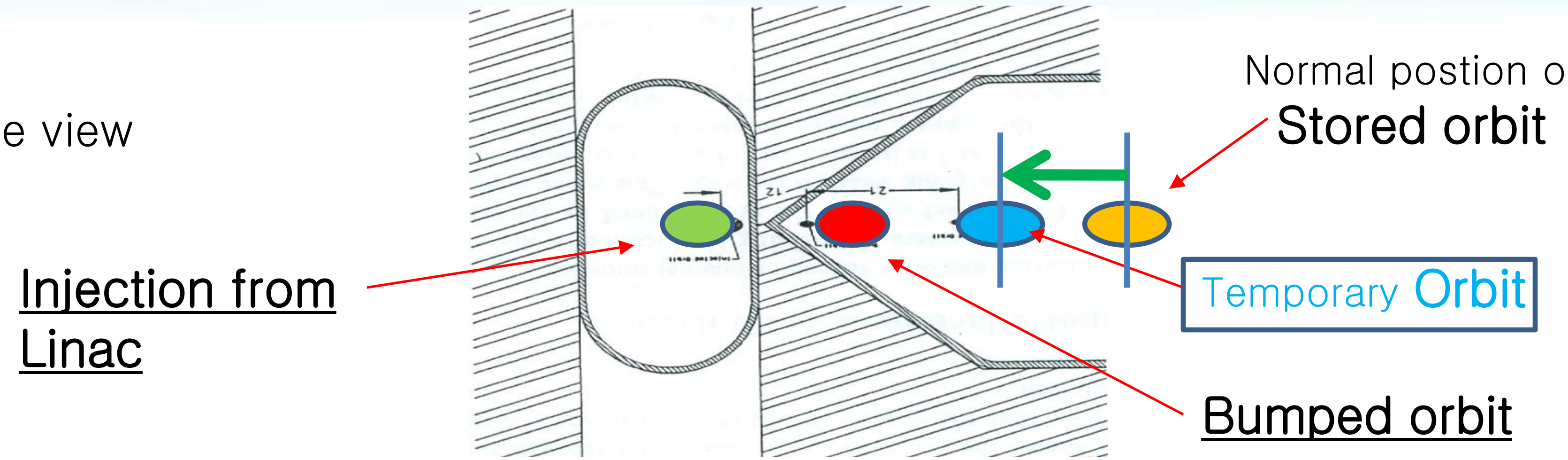
Table showing the Bump Kick verse SR corrector kick

P12CH6 Corrector Setting

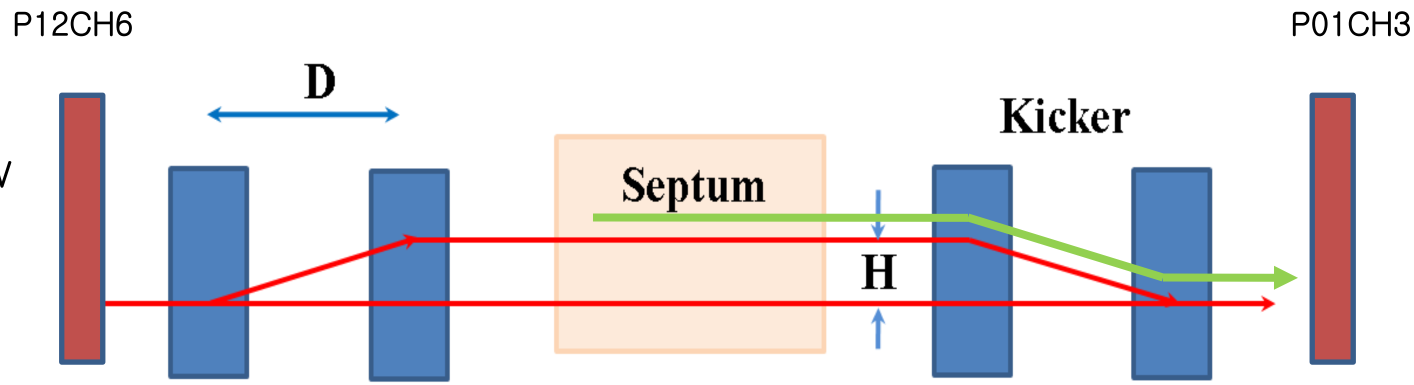
Kicker	-8.0A(Stored orbit Current)	-35A	20A
2,000			alive slow loss
4,000	alive	alive	quick loss
4,500	alive	alive	
5,000	alive	alive	
5,500	alive	very slow loss	
5,700	alive		
**6,000	alive	quick loss	
6,300	alive		
6,700	slow loss		
7,000			
7,200	loss within 1~2 sec		
7,500			
8,000	quick loss		
15,400			

Need a local bump generated by an upstream SR correctors

Side view



Plan view



Kicker Strength verse Bump Height

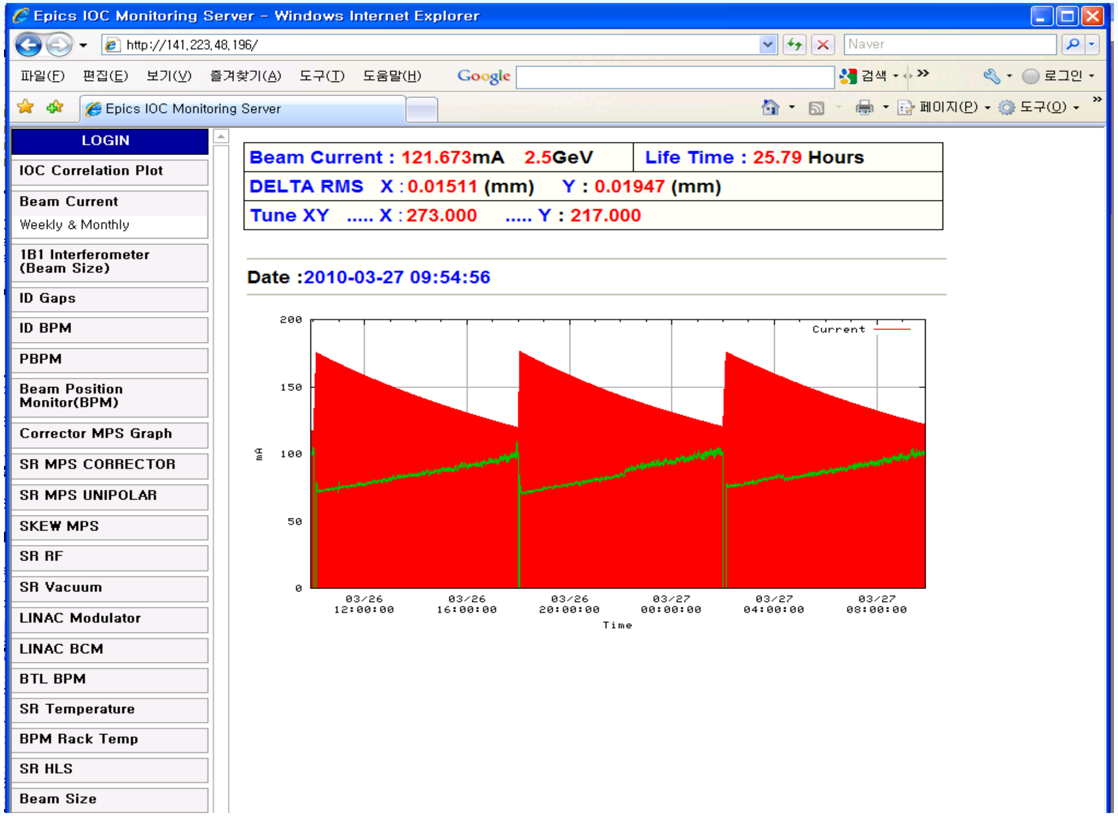
While *changing the time delay of two kicks* It was possible to save the stored bump with the reduced powers of 6kV from 15.4kV.

Distance between Kicker	Kicker voltage	angle(rad)	Bump height(mm)	Kicker length(mm)
1260	5000	0.003865	4.870	600
1260	5500	0.0042515	5.357	600
1260	*6000*	*0.004638*	*5.844*	*600*
1260	6500	0.0050245	6.331	600
1260	7000	0.005411	6.818	600
1260	7500	0.0057975	7.305	600
1260	8000	0.006184	7.792	600
1260	10000	0.00773	9.740	600
1260	12000	0.009276	11.688	600
1260	15400	0.0119042	15.000	600

Getting to be accumulated without loss

Not killed by the next kicks

The reference orbit was restored to the normal reference orbit



A snapshot of Web-based monitoring software on March, 27.

In Conclusion

– PLS has $M_{designed}$ such that $dU = M^{-1} \cdot V$
where U is the required strength
and V is the desired Orbit.

– $M_{designed}$ and $M_{measured}$ work well.

– Matlab-based code MML will be in active
to develop the $M_{calibrateded}$
and adjust the quadrupole strengths using this $M_{calibrateded}$.

This MML with COCU could be
a great help to the operation of the PLS II.

Thank you! And Welcome to PLS !

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