Beam Position Measurement System with Libera instrument in HLS II

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NSRL(National Synchrotron Radiation Laboratory)

- NSRL is the first dedicated synchrotron radiation facility in China
- Its construction began on Nov. 20, 1984, and completed in Dec. 1991.
- It is mainly composed of a 200 MeV Linac injector, a transport line, an 800 MeV electron storage ring, 14 beamlines and endstations.
- spectrally strongest in VUV and soft X-ray, designed and constructed in 1980's, accepted to regular service in 1991.

Main parameters of the linac

MaximumÂ achievedÂ energy	~220MeV
LengthÂ ofÂ macroÂ pulse	0.2~1.0Âµs
EnergyÂ spread	~1%
Emittance	~0.5mmÂ·mrad
MicrowaveÂ frequency	2856MHz
TypeÂ ofÂ acceleratingÂ structure	Constant-impedance
MaximumÂ electricÂ field	~13MV/m
TotalÂ lengthÂ ofÂ acceleratingÂ tube	~35m

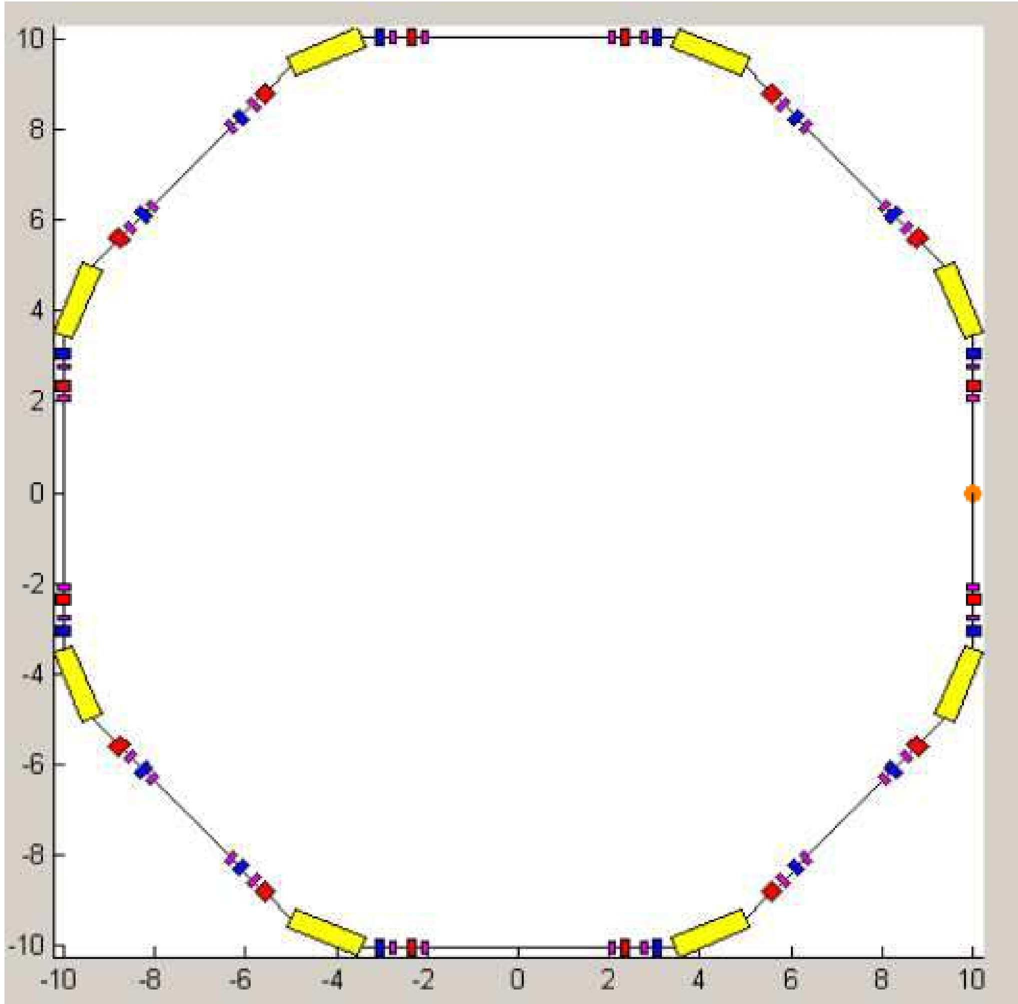
Main parameters of the storage ring

Injection/operationÂ energy	200/800MeV
Circumference	~66m
FocusingÂ type	4Â TBA
EmittanceÂ (horizontal/vertical)	~160/16nmÂ·rad
HarmonicÂ number	45
RadiationÂ lossÂ perÂ turn	16.3keV
RadiationÂ dampingÂ time	20/20/10ms
BetatronÂ tunes	3.54/2.60
OperationÂ beamÂ current	250~300mA
BeamÂ lifetime	>8Â hrs
CriticalÂ wavelengthÂ ofÂ dipoleÂ radiation	2.4nm
Critical/UsableÂ wavelengthÂ ofÂ WLS	0.48/0.1nm
NumberÂ ofÂ VUVÂ undulatorÂ period	29
KÂ rangeÂ ofÂ VUVÂ undulator	3.9~0.5
PeriodÂ lengthÂ ofÂ VUVÂ undulator	0.092m
WavelengthÂ ofÂ firstÂ harmonic	160~21nm

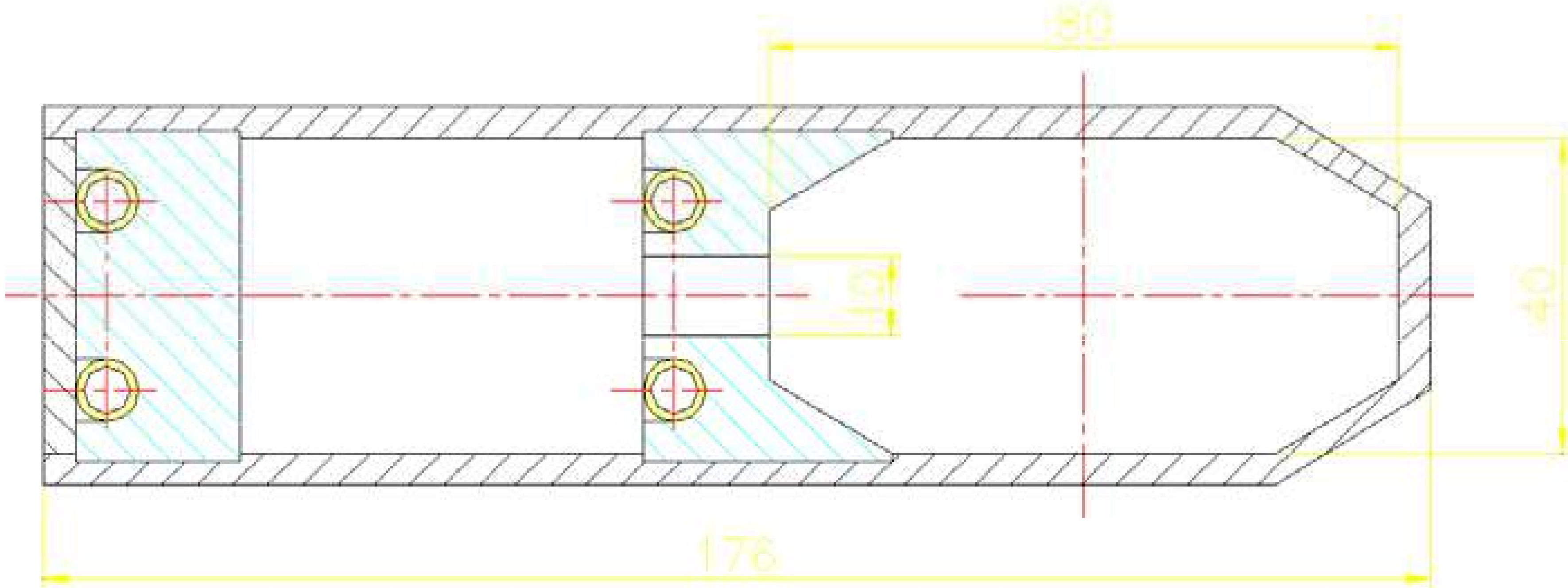
The upgrade of HLS – HLS II

- Starting mid of 2009 the HLS will be upgraded, the energy of the storage ring will remain 800MeV, and the energy of the linac will be improved from 200MeV to 800MeV.
- Reduce the horizontal emittance to 40 nm.rad
- 8 long straight section (RF system, injection system, 6undulators)
- Drift of the orbit -- 5~10μm
- Finish the upgrade at the end of next year

The upgrade of HLS – HLS II



Chamber of the storage ring



The upgrade of HLS – HLS II

- Need a completely new BPM-system.

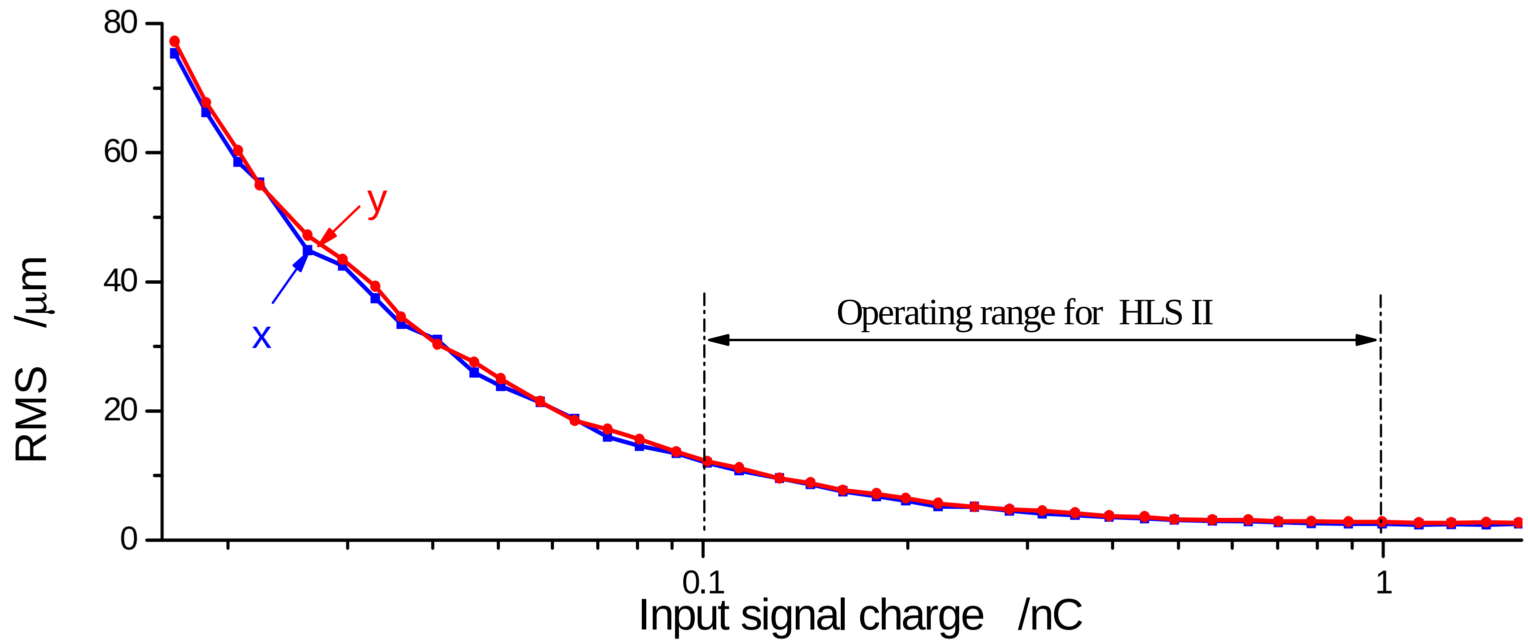
- Injector BPM system: 20 stripline BPMs (Libera Brilliance Single Pass)
- Storage Ring BPM system: 32 button BPMs (12 Libera Brilliance together with 20 bergoz electronics)

Libera application in HLS

- Done many test on existing system (offline, online)
- Is using on the upgrade project.
- Will play a greater role in the future

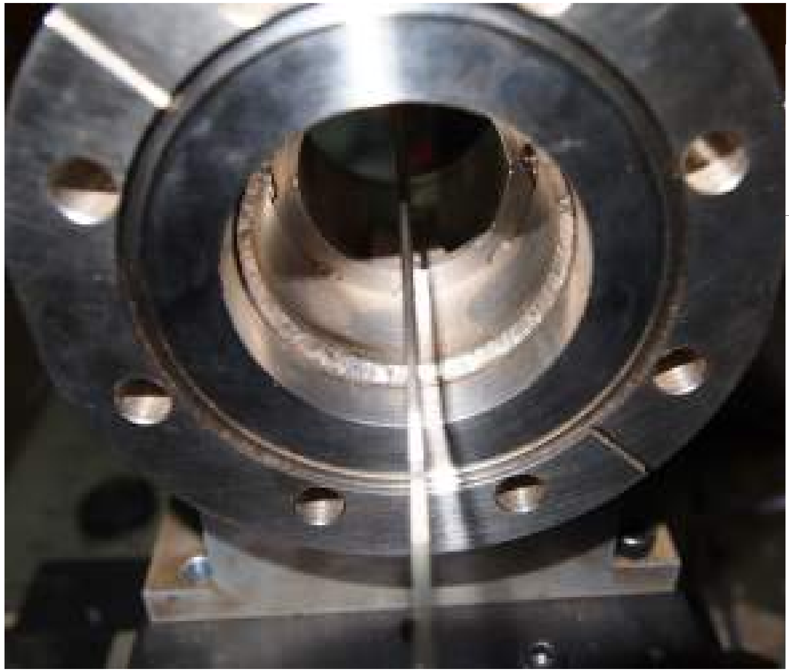
RMS of Laboratory test

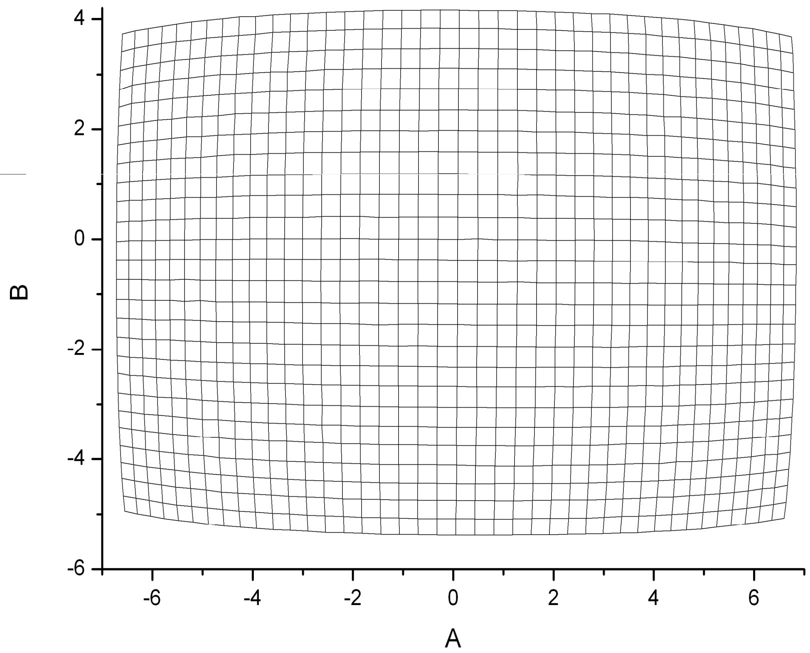
- Simulate the beam signal(~1ns), get the RMS results of position data
- About 10um (Operating range for HLS II)



The calibration

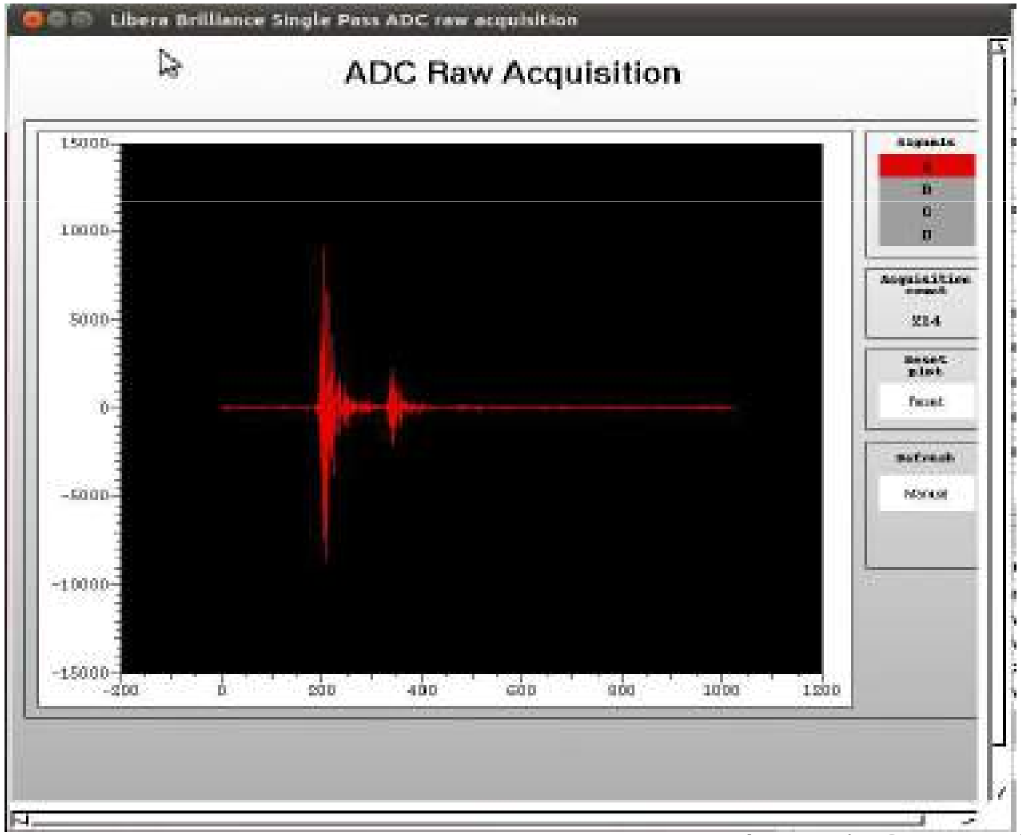
- Using stepping motor to control the wire.
- Two problems: the wire material, how precise positioning of the physical center position



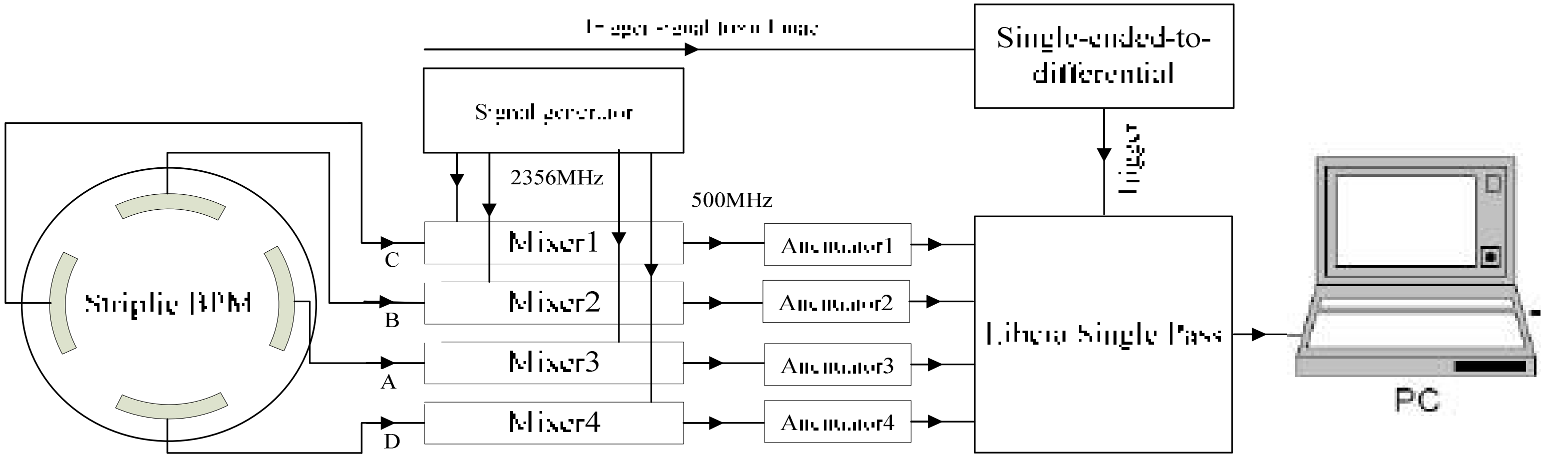


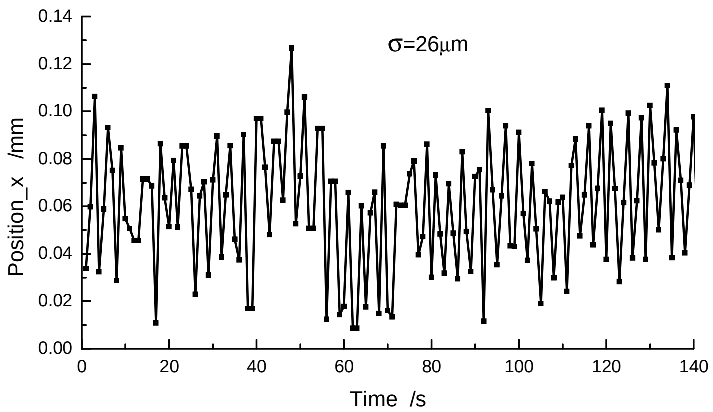
Real beam test

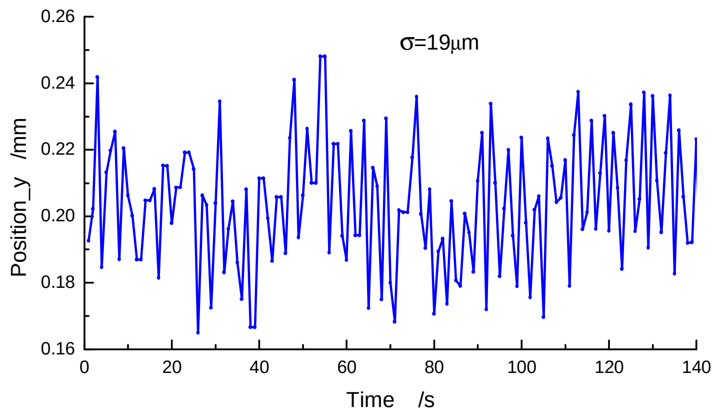
- In the HLS Linac, the frequency of micropulse is 2856MHz , the bunch width is 1μs.
- but these signals were frist get through a 500MHz SAW filter before position calculating.



Real beam test



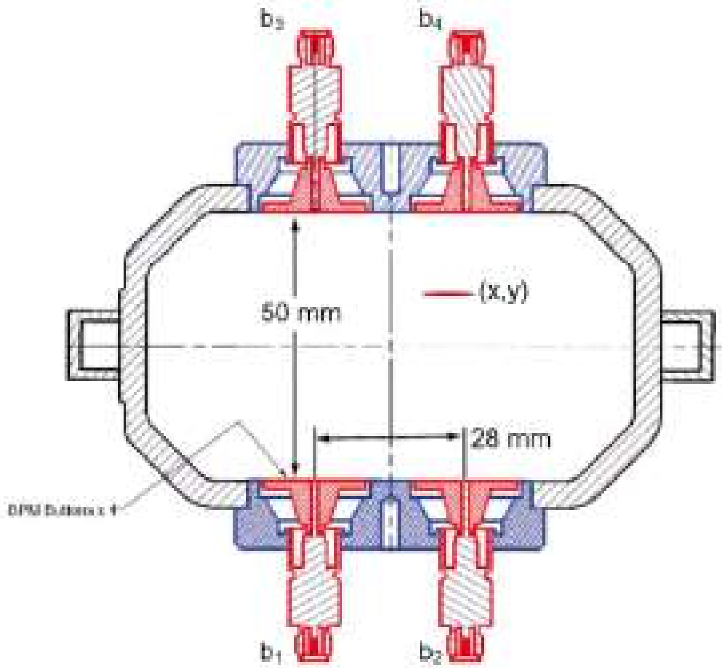




Calibration of electrode gain coefficient

- There are difference between the response signal of the electrodes on the beam
  - Electronics differences
  - Mechanical installation error
- Online Calibration
  - Setting an electrode coefficient of 1, the fitting for the other three electrodes coefficient
  - Of 4 electrodes, respectively for the above operation, and obtaining the average value

Electrodode signal fitting formula（1）



$$B1 = kf(x, y) \approx k(c_0 + c_1 x + c_2 y + c_3 x^2 + c_4 y^2 + c_5 xy)$$

$$B2 = kf(-x, y) \approx k(c_0 - c_1 x + c_2 y + c_3 x^2 + c_4 y^2 - c_5 xy)$$

$$B3 = kf(x, -y) \approx k(c_0 + c_1 x - c_2 y + c_3 x^2 + c_4 y^2 - c_5 xy)$$

$$B4 = kf(-x, -y) \approx k(c_0 - c_1 x - c_2 y + c_3 x^2 + c_4 y^2 + c_5 xy)$$

Electrode signal fitting formula（2）

$$B_{+--+} \equiv B_1 - B_2 - B_3 + B_4 = 4kc_5xy$$

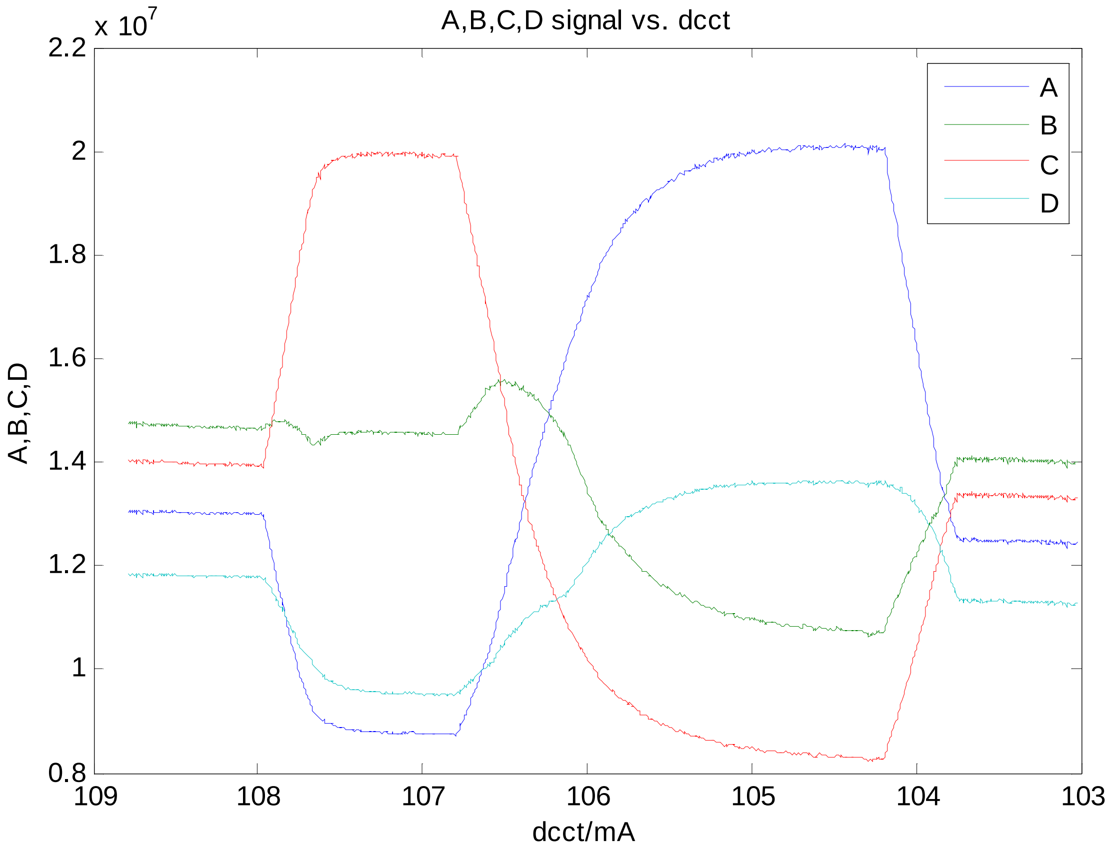
$$B_{+-+-} \equiv B_1 - B_2 + B_3 - B_4 = 4kc_1x$$

$$B_{++--} \equiv B_1 + B_2 - B_3 - B_4 = 4kc_2y$$

$$B_{+--+} = \frac{c_5}{kc_1c_2} B_{+-+-} B_{++--}$$

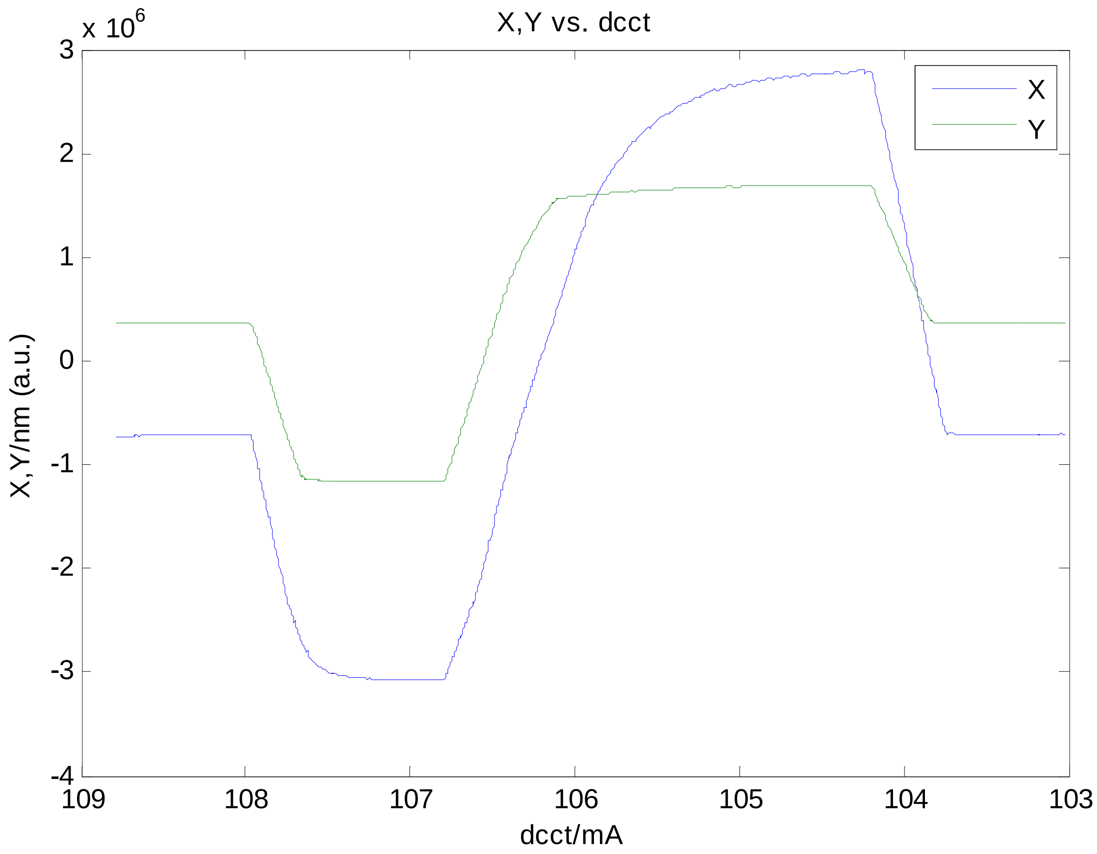
$$\chi 2 = \sum_i^n \begin{pmatrix} (g_1B_1^{\,i} - g_2B_2^{\,i} - g_3B_3^{\,i} + g_4B_4^{\,i}) \\ -\frac{c}{I}(g_1B_1^{\,i} - g_2B_2^{\,i} + g_3B_3^{\,i} - g_4B_4^{\,i}) \\ \times(g_1B_1^{\,i} + g_2B_2^{\,i} - g_3B_3^{\,i} - g_4B_4^{\,i}) \end{pmatrix}^2$$

Data curve（1）



A,B,C,D signal vs. dcct
x 10^7
2.2
2
1.8
1.6
1.4
1.2
1
0.8
A,B,C,D
109
108
107
106
105
104
103
dcct/mA
A
B
C
D

Data curve（2）



X,Y vs. dcct
x 10^6
3
2
1
0
-1
-2
-3
-4
X,Y/nm (a.u.)
109
108
107
106
105
104
103
dcct/mA
X
Y

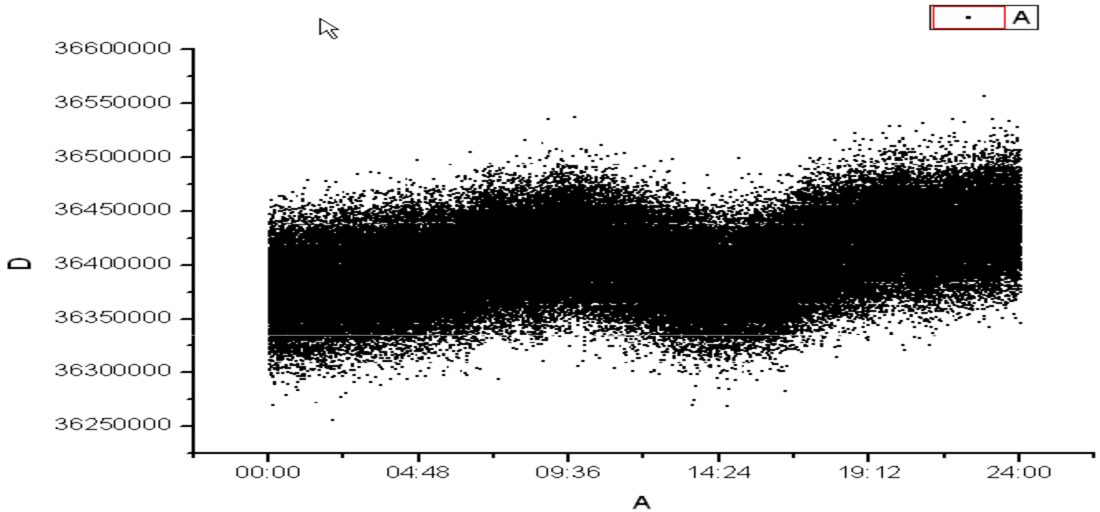
Fitting results

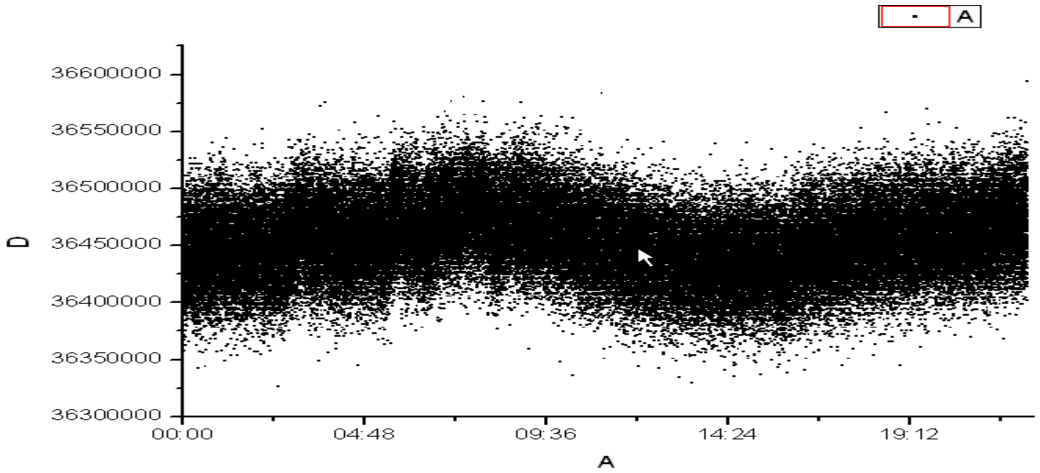
	G1	G2	G3	G4
	1	0.977505978790154	1.19265827658503	1.11722313727588
	1.01710348033664	1	1.20937919039628	1.13944451287849
	0.837077333792273	0.815806418546622	1	0.93393339954765
	0.89388328400245	0.87614571724025	1.06464562038685	1
Average	0.937016	0.917365	1.116671	1.04765

The four fitting averaging results substantially in the near 1, the most about 10% of the error.

Libera presentation under radiation

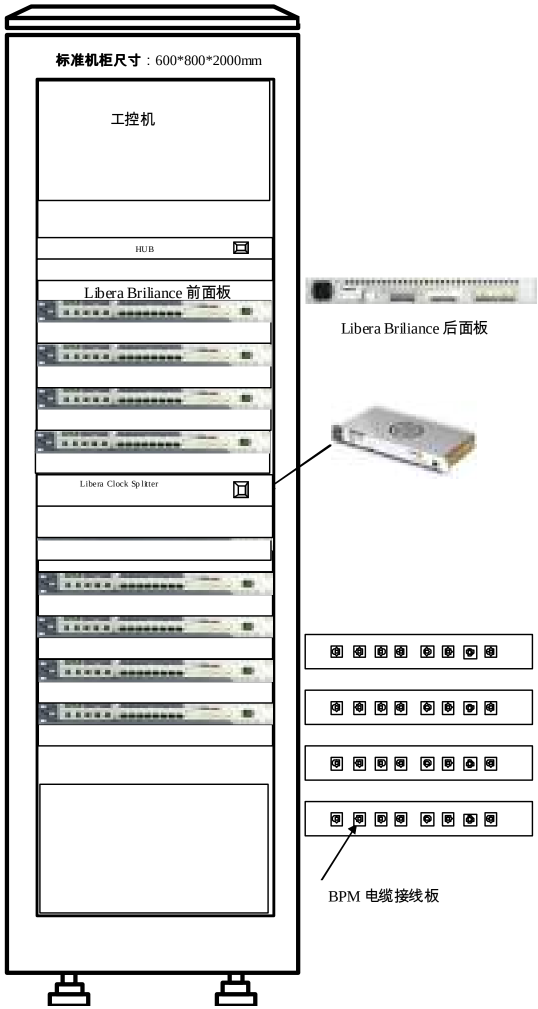
- Put Libera beside the klystron (30 MW).
- Same RMS compare with no radiation (position data)



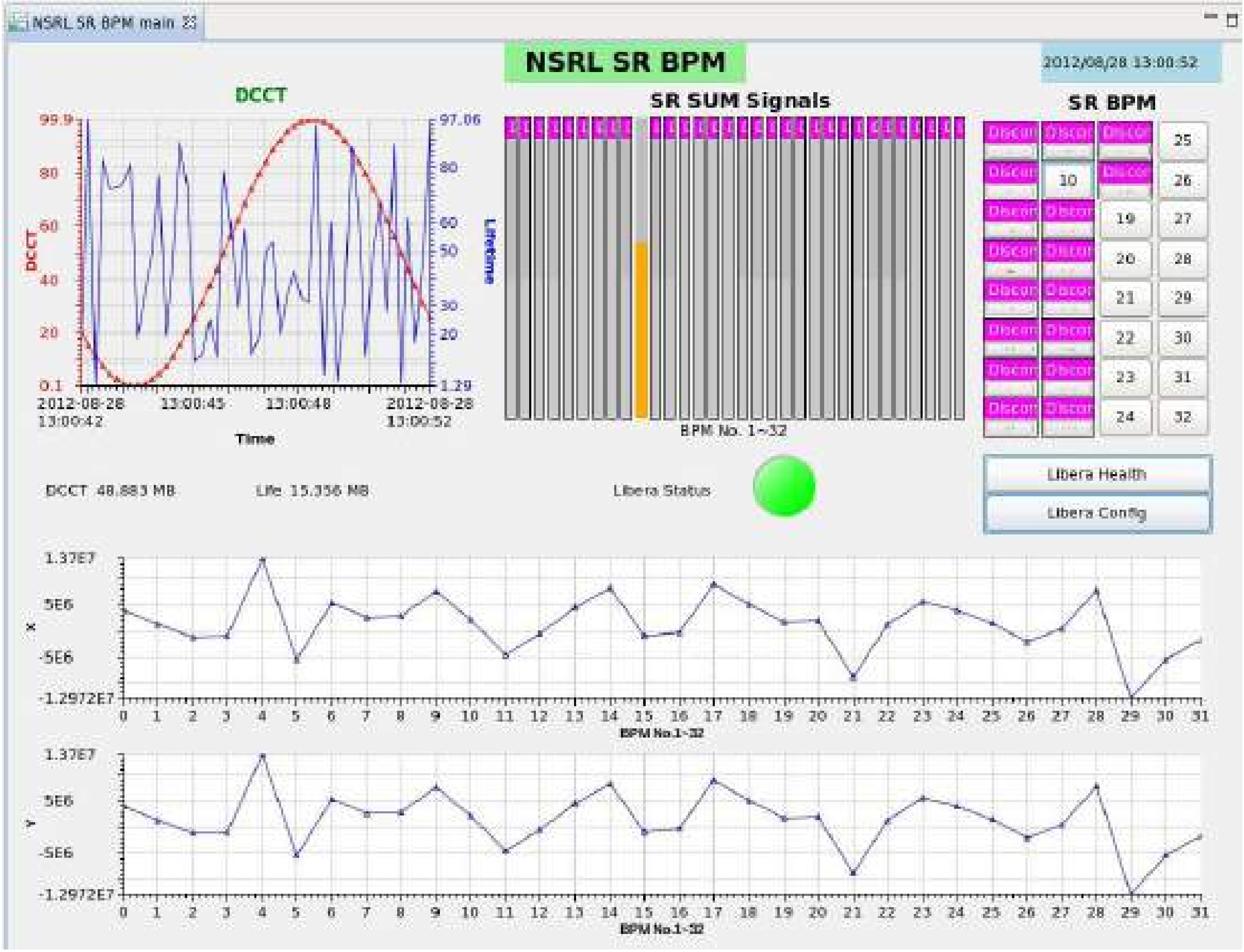


The effects of the temperature of the environment

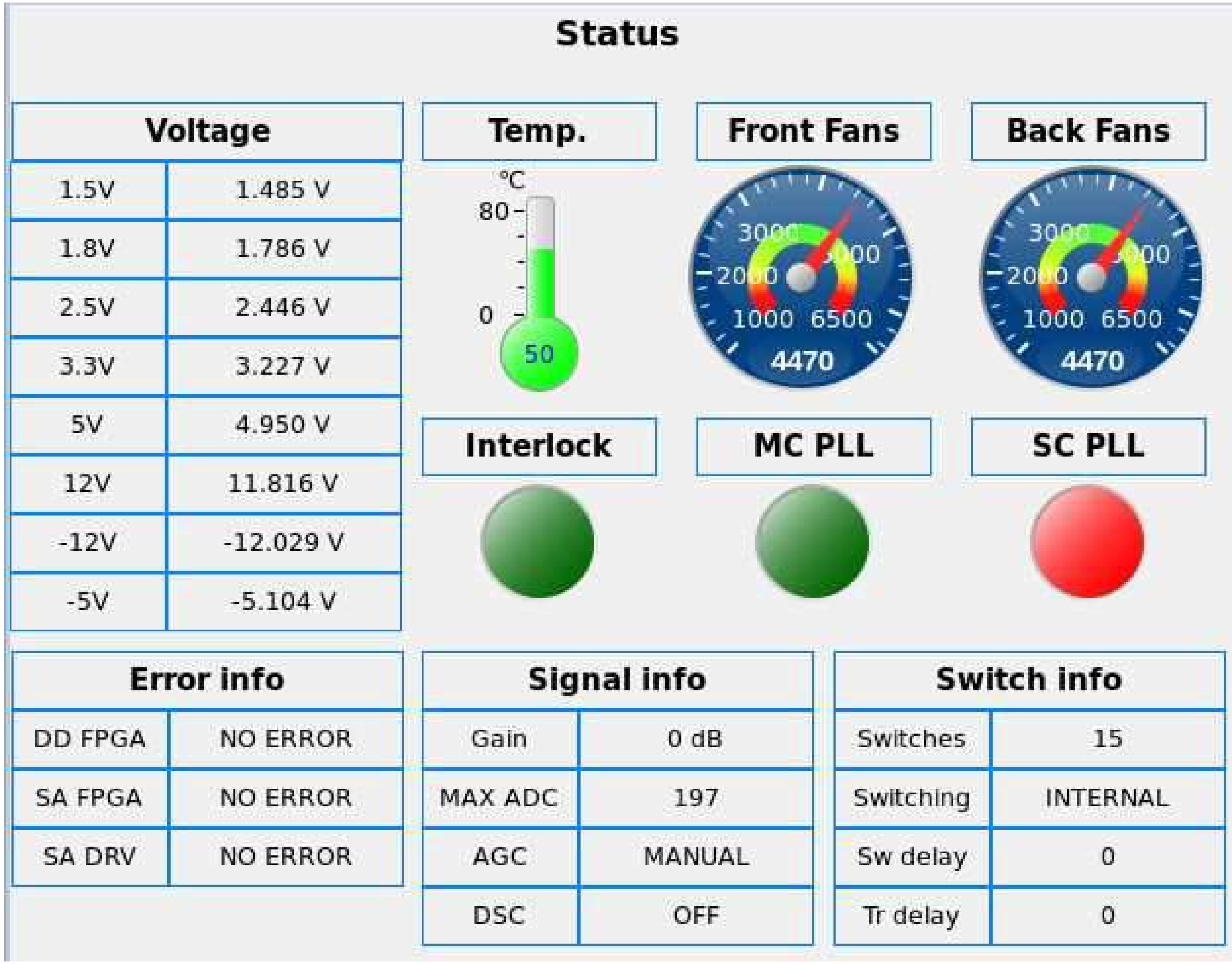
- The hardware temperature is OK
- The fan speed changes



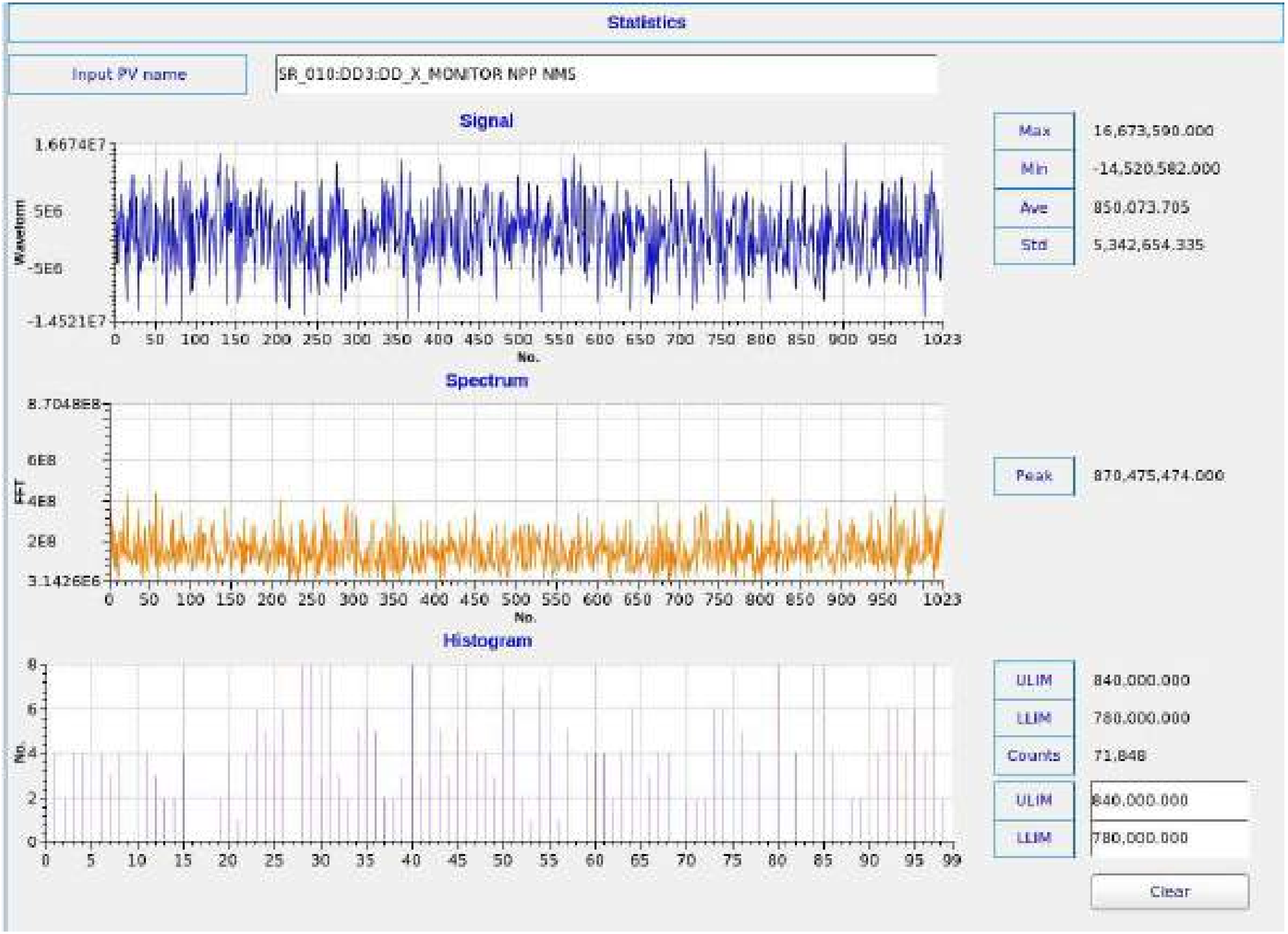
HLS II BPM system



HLS II BPM system



HLS II BPM system (FFT)



Conclusion

- Have done many test with Libera
- Is working on the BPM system of HLS II
- Further use (feedback system)
- Libera: Efficient, Accurate, Convenient, Kind (nice after-sale service) .

Thank you!