Beam commission plan for the IPBPM system with reference cavities after October run

Siwon Jang (KNU)

Contents

- New IP-BPM system
  - 11cm low-Q IP-BPM
  - The electronics for IP-BPMs
  - Phase shifter with software
  - The reference cavity BPM for low-Q IP-BPM
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- Future beam commissioning plan of IP-BPMs
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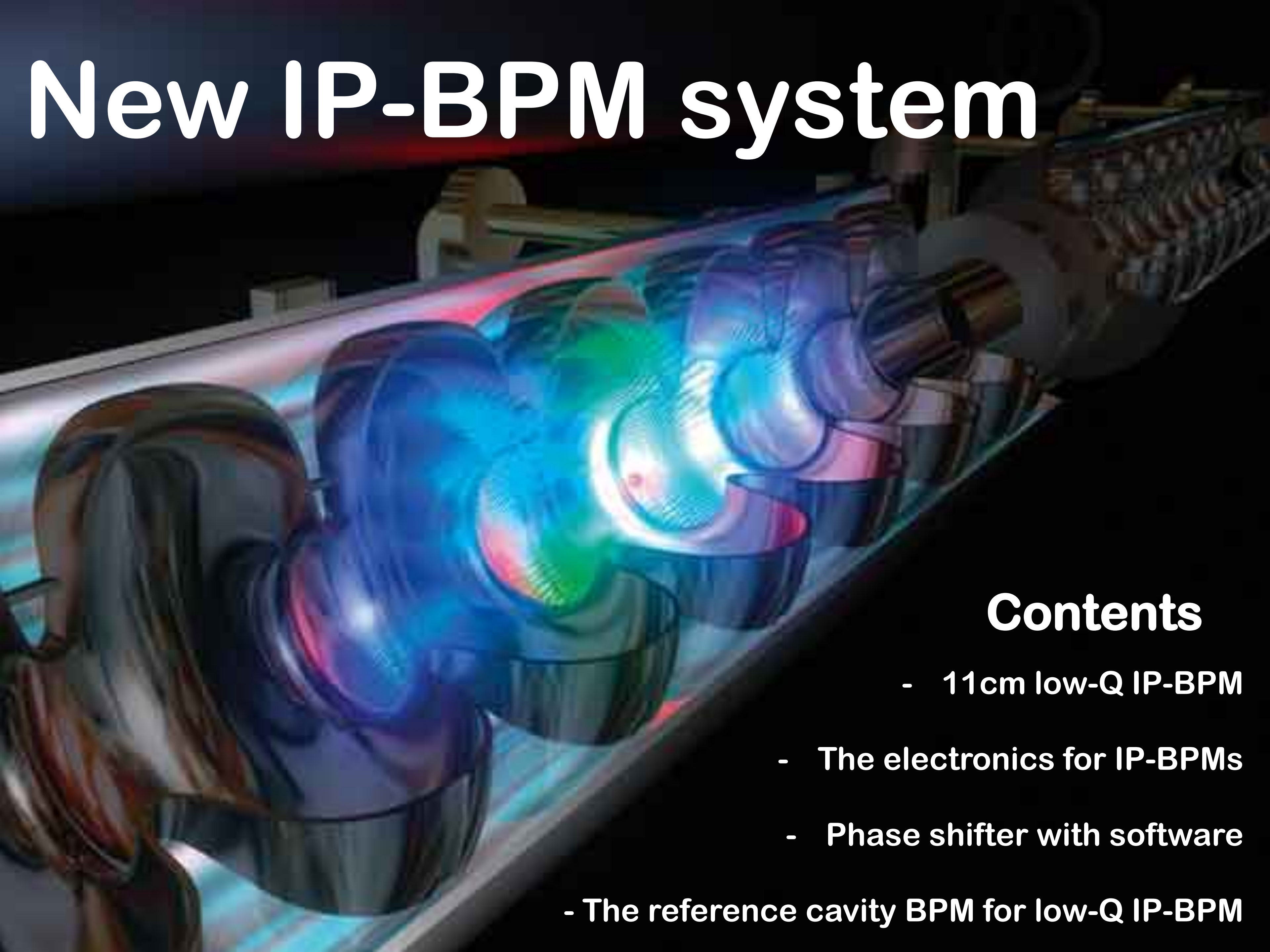
- Summary

New IP-BPM system



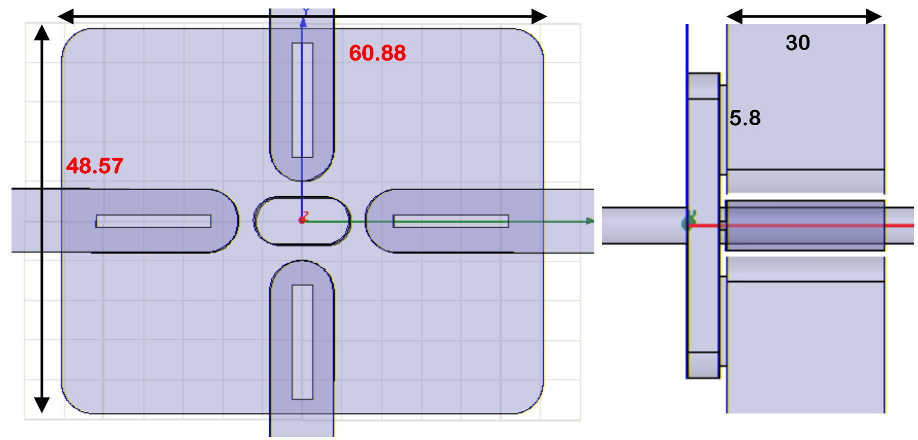
Contents

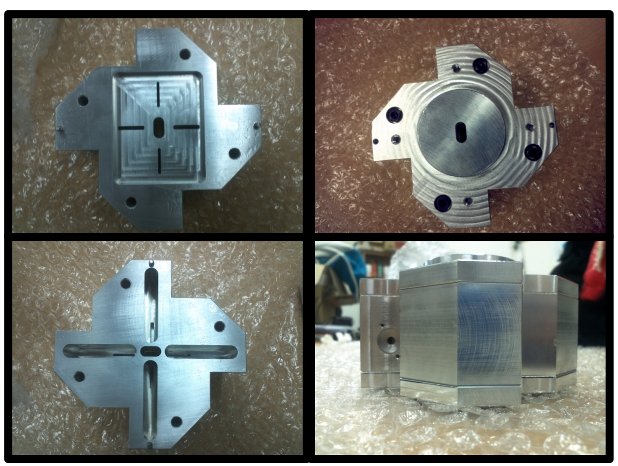
- 11cm low-Q IP-BPM
- The electronics for IP-BPMs
- Phase shifter with software
- The reference cavity BPM for low-Q IP-BPM

11cm Low-Q IP-BPM made by Aluminum

- **Motivation of 11cm Low-Q IP-BPM design**
  - More shorter decay time ~ 20ns
  - More lighter BPM weight.
  - Single BPM correspond to 1kg

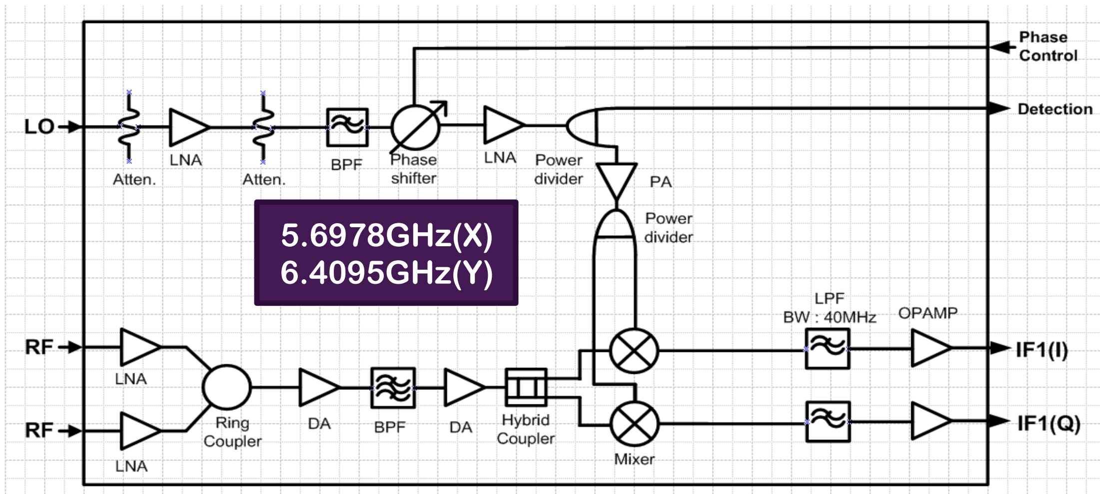
  with 11cm x 11cm cavity size.





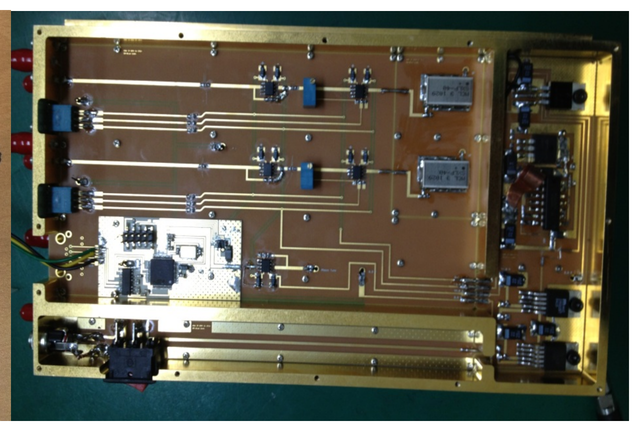
	Port	f_0 (GHz)	β	Q_0	Q_{ext}	Q_L	τ (ns)	V_out (uV/2nm)
Designed	X-port	5.713	5.6	4959	872	741	18.7	7.739
	Y-port	6.428	5.6	4670	821	698	17.2	7.448

The electronics for IP-BPMs



Simplified schematic of the IP-BPM signal processing electronics.

	New electronics
BW of LPF	40MHz
Gain	54~44dB
Thermal Noise	-96.1dBm
Estimated Resolution due to thermal noise	2nm
Cascaded NF	1.88dB
RF $P1_{in}$dB	-22dB
Estimated Latency	25ns

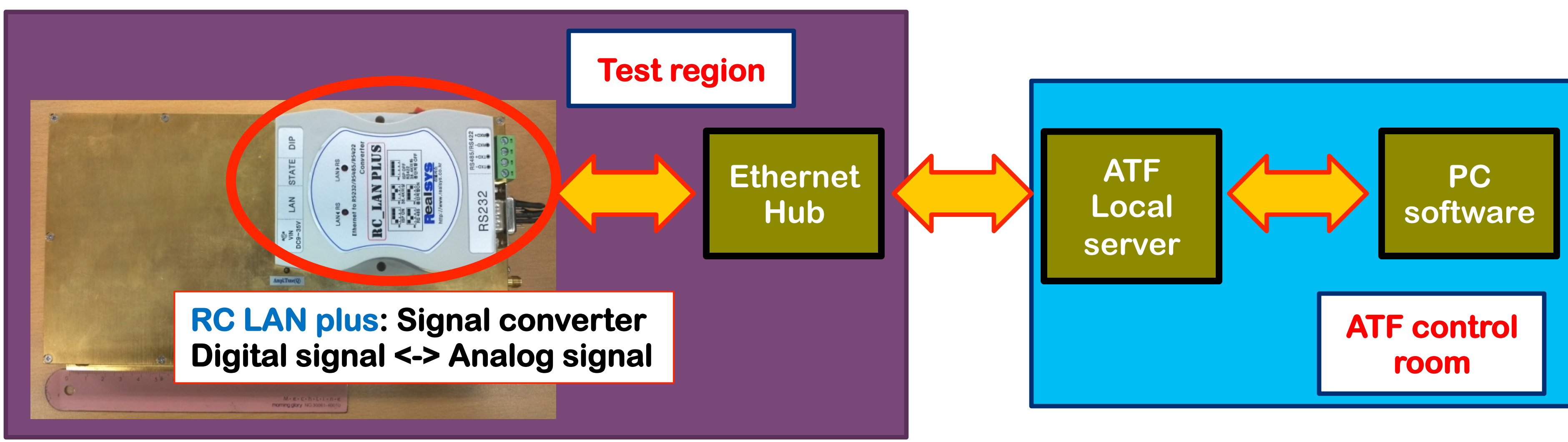


- Conversion Gain : 54~44dB(X,Y)
- Variable OPAMP: 10dB
- BW of LPF : 40MHz
- Cascaded N.F : 1.88dBdB

- Remote phase shifter: 0 ~ 360 degree
- Estimated position resolution : 2nm
- Estimated Latency : 25ns

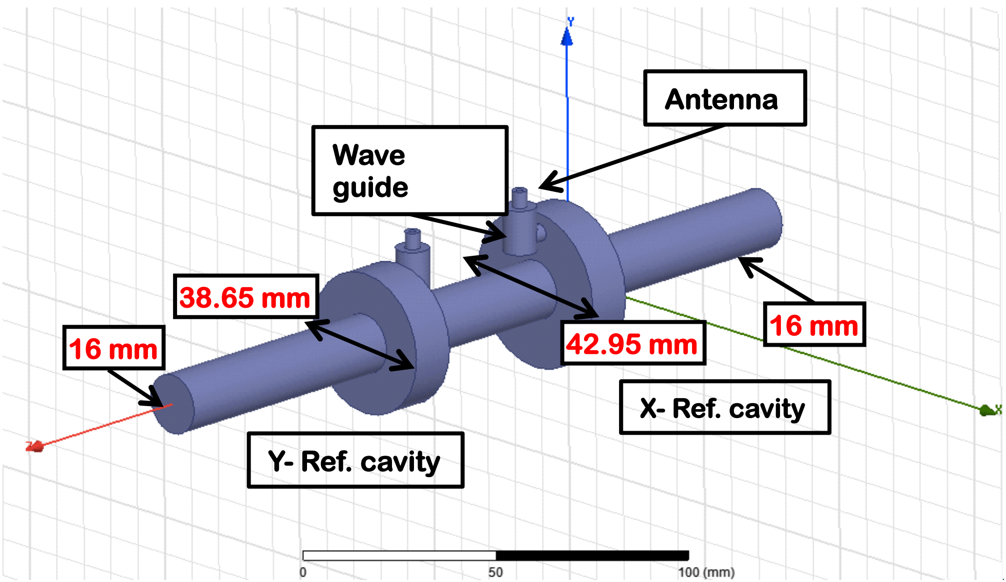
Phase shifter with remote control software

- The phase shifter was connected to RC LAN plus to control due to digital signal. The LO signal phase was controlled from 0 degree to more than 360 degree.
- The control program software will be changed to run on the Linux system. (Now, Windows software)



Reference cavity BPM design

- Cavity shape for HFSS simulation



- Cavity size :
  42.95mm,38.65mm
- Beam Pipe radius:
  8 mm (circular pipe)
- Material of BPM:
  Stainless steel (SUS304)

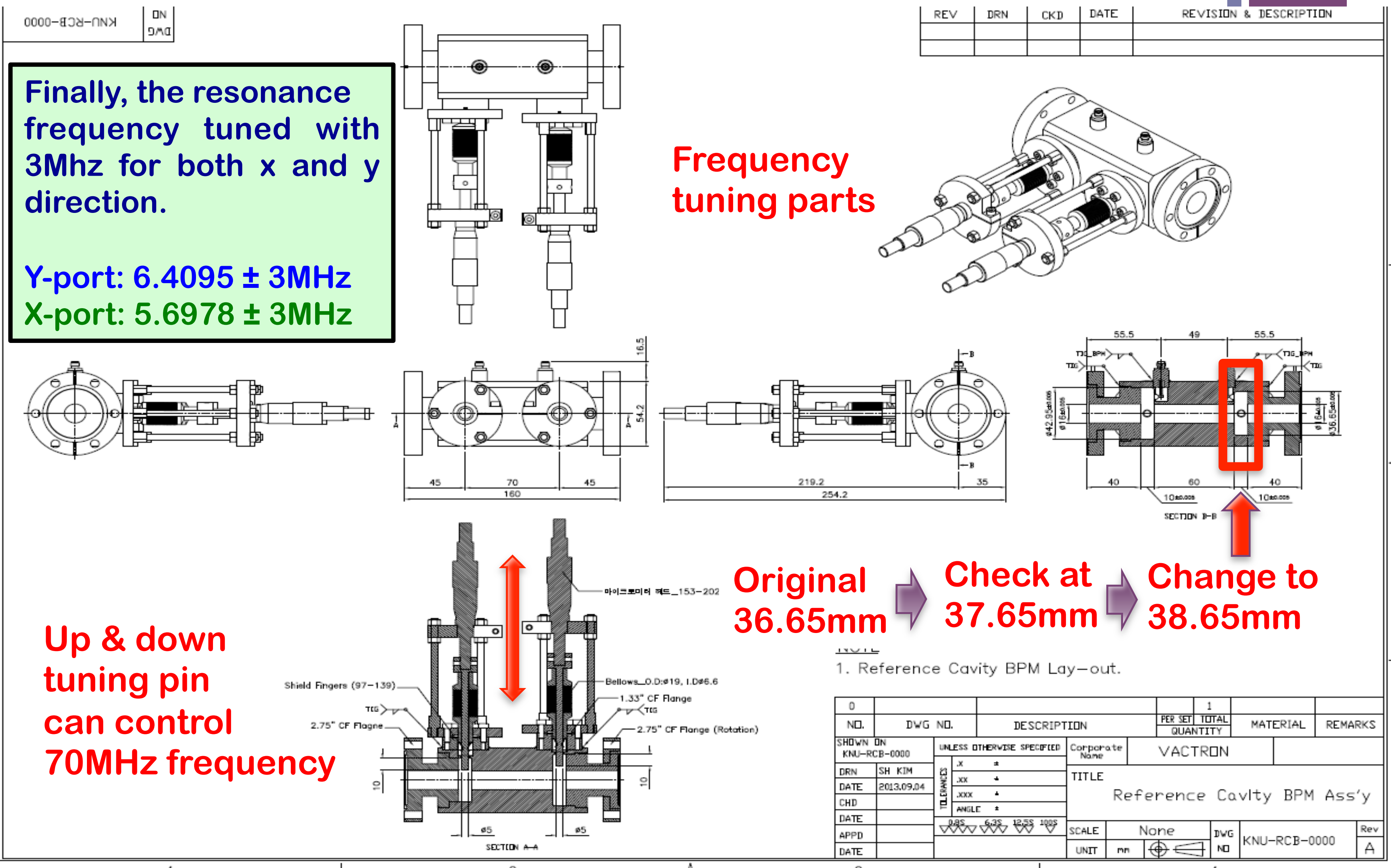
Output signal strength
= 22 ~ 5dB (1.6nC ~ 0.32nC)
This output strength too strong to connect LO input. So, we add 20dB attenuator.

Port	f_0 (GHz)	Aim f_0	β	Q_0	Q_{ext}	Q_L	τ (ns)
X-port	5.7107	5.6978	0.00964	1201.20	124578	1189.73	33.157
Y-port	6.4148	6.4095	0.01528	1228.83	80421.2	1210.34	30.029

Reference cavity BPM design

Finally, the resonance frequency tuned with 3Mhz for both x and y direction.

Y-port: 6.4095 ± 3MHz
X-port: 5.6978 ± 3MHz

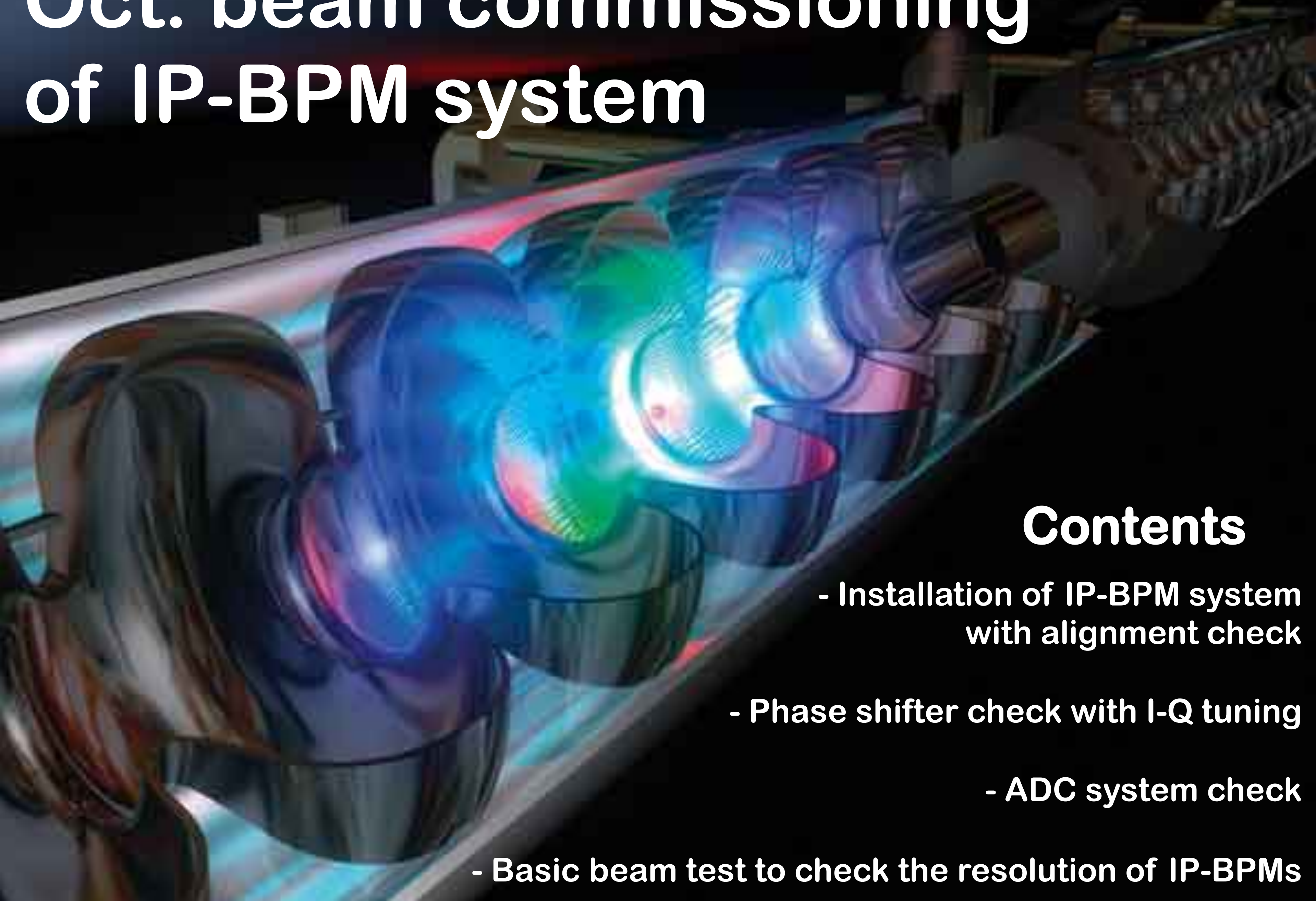


Frequency tuning parts

Up & down tuning pin can control 70MHz frequency

Original 36.65mm → Check at 37.65mm → Change to 38.65mm

Oct. beam commissioning of IP-BPM system

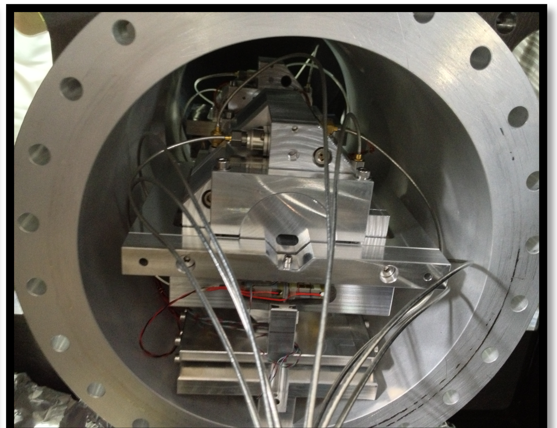
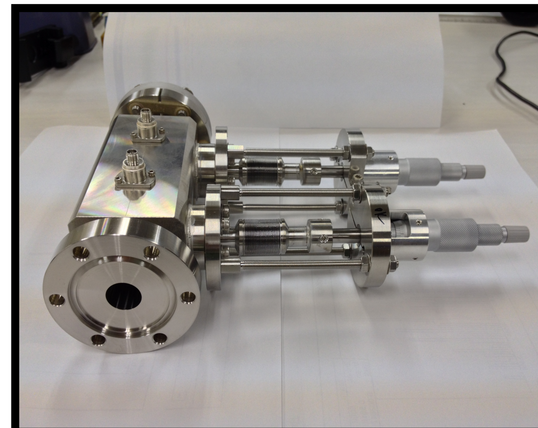
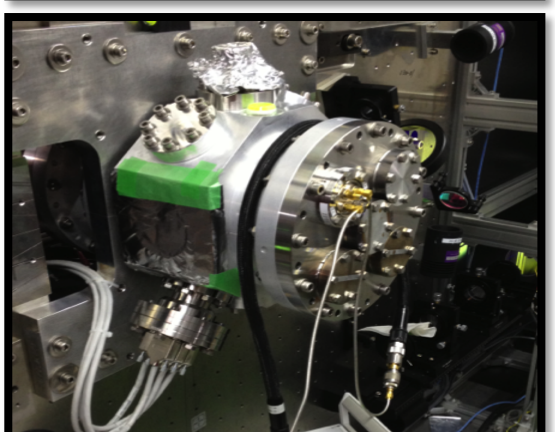


Contents

- Installation of IP-BPM system with alignment check
- Phase shifter check with I-Q tuning
- ADC system check
- Basic beam test to check the resolution of IP-BPMs

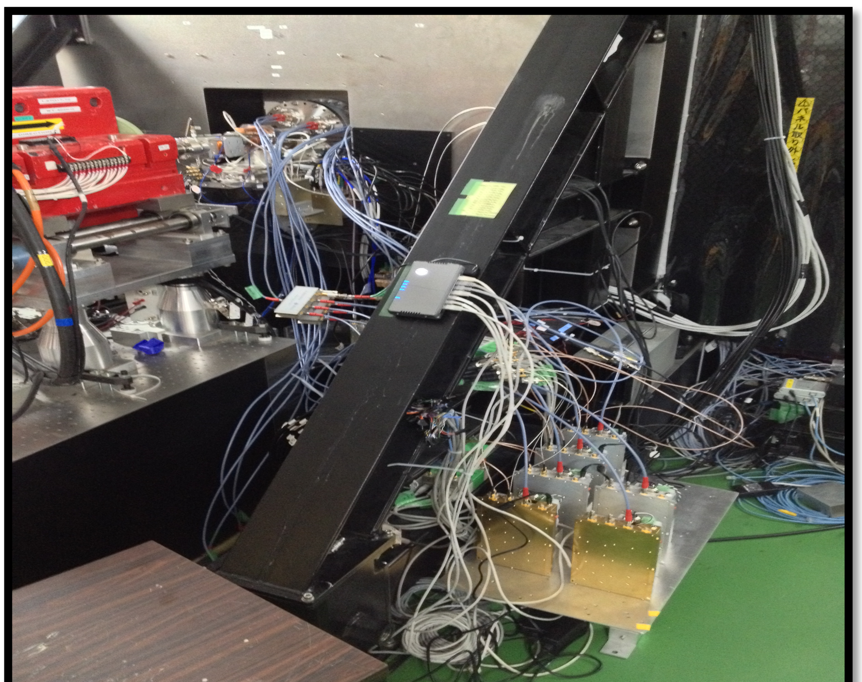
Installation of IP-BPM system with alignment check

- **The IP-BPM system installation**

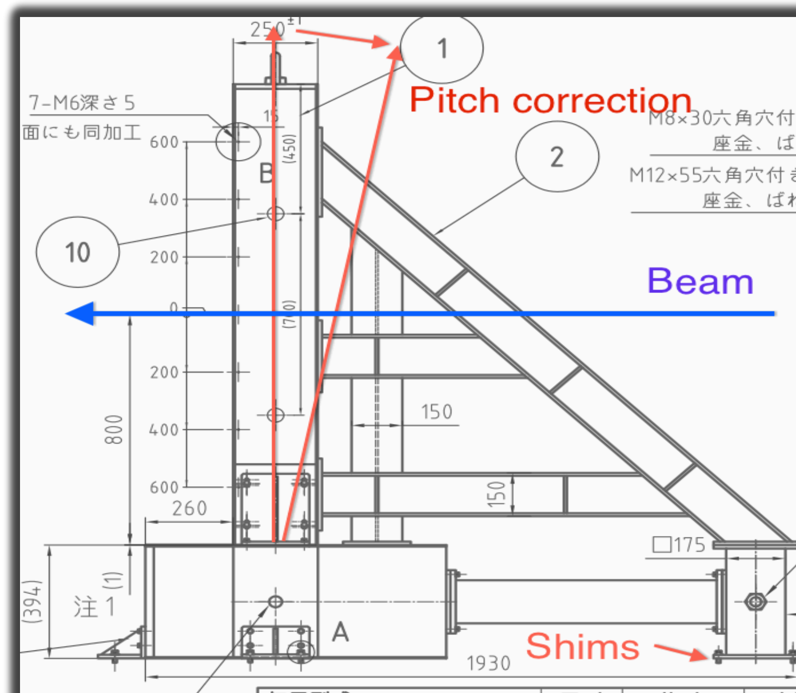




Installation of IP-BPM system with alignment check

- **All of the IP-BPM system was installed inside tunnel near the IP-region. The electronics, LO signal splitter, and variable attenuators(x8) are installed. The cable connection scheme was shown in the Left bottom figure.**



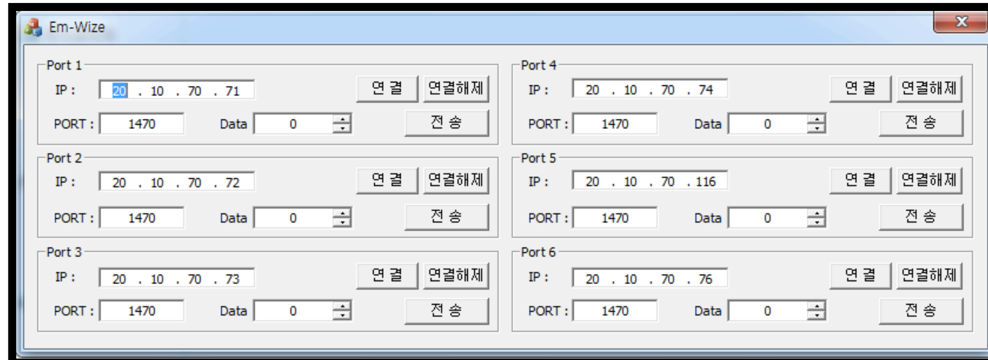
Electronics w/ cable connection



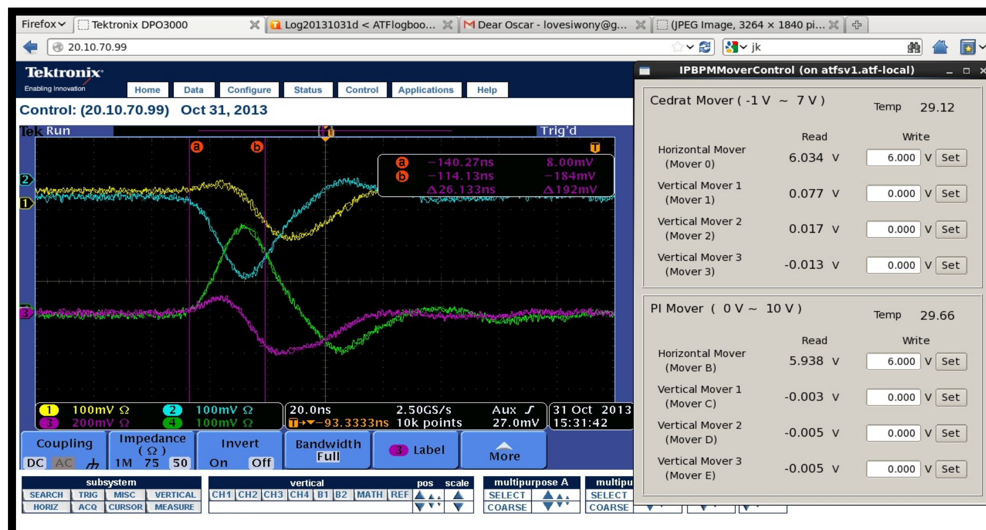
IP-chamber re-align by using IP-BPMs

Phase shifter check with I-Q tuning

- The phase shifter was controlled remotely.
- The phase between I and Q signal can be changed from 0 degree to more than 360 degree.
- The IPBPM mover control software also prepared by ATF people.
- I-Q tuning was well works with 20dB LO attenuator!



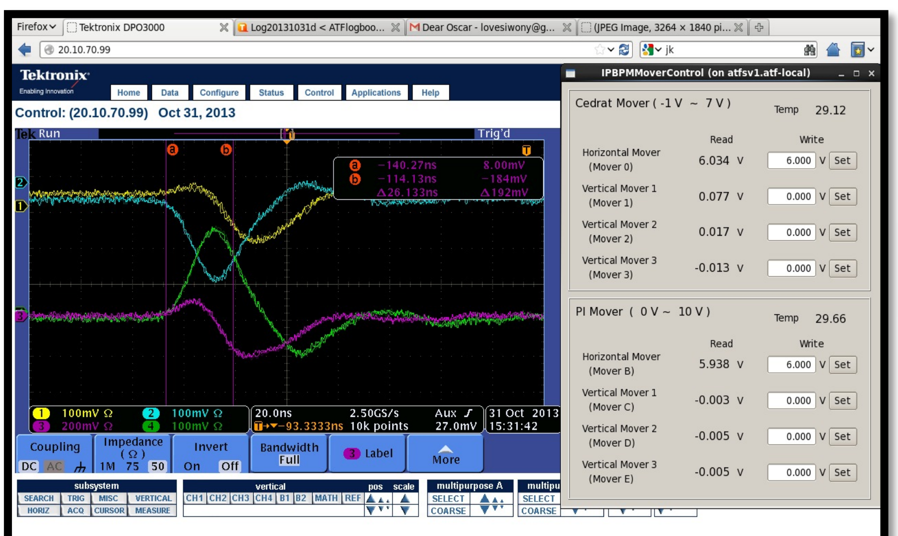
Phase shifter control software

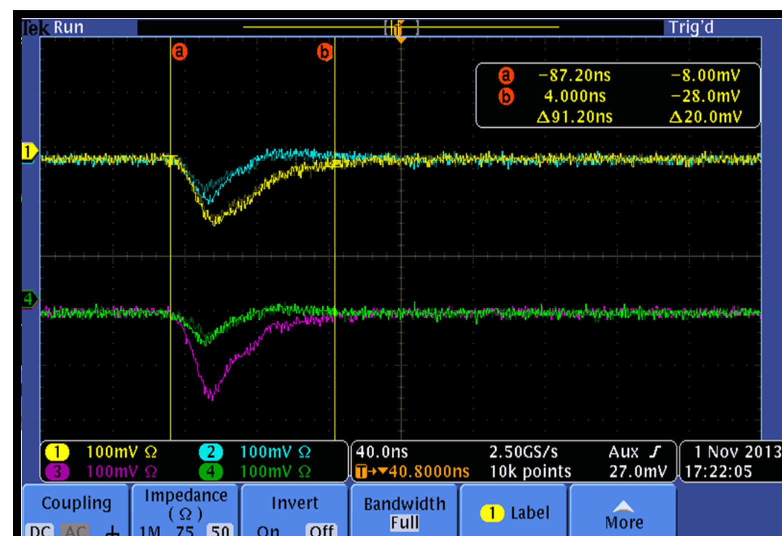


I-Q tuning with mover system

Solving the problem of the bipolar waveform IF signals

- The IPBPM output signals shows as bipolar waveform during I-Q tuning. To fix this strange situation, we performed several studies. Finally, we found the solution of the problem of IP-BPM I-Q tuning with bipolar waveform. The output signal level of Ref. cavity BPM was too high than designed electronics input level. Therefore, the mixed I and Q signals shows very strange motion during I-Q tuning study. The designed L.O. input level was below 10dB level, but the input beam signal level was more than 20dBm. Thus, we attached 20dB attenuator in front of L.O. signal splitter. Then we got the very clear mixed I and Q signals until 0dB att. RF signal case.

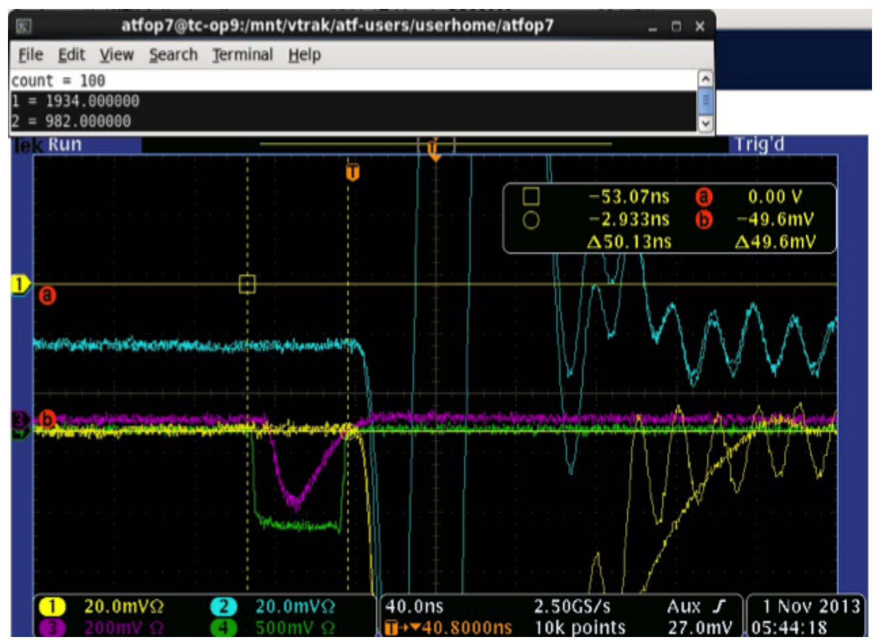




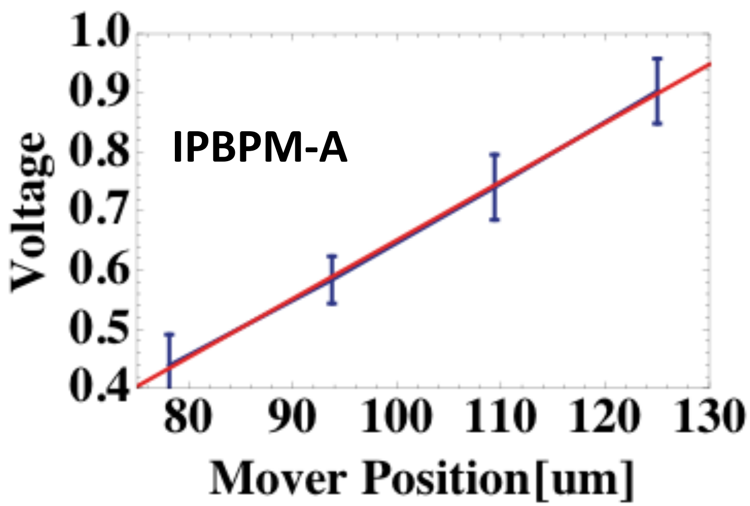
ADC system check

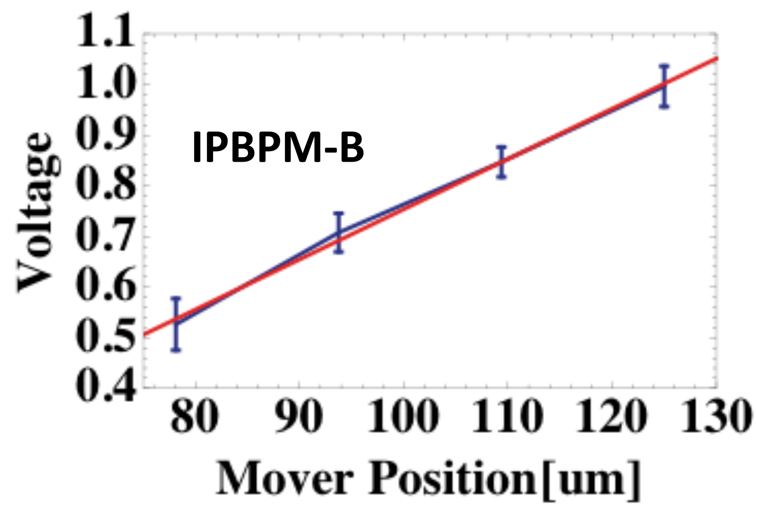
- ADC(c009h) pedestals were measured with 50ns gate time.
- An available measure range of ADC is -500mV square signal with 50ns. Which signals correspond to -500pC of limit of ADC.
- Thus, the measurable output voltage range will be 0mV to -500mV with square signal for c009h ADC.
- Therefore, the expected dynamic range for ADC was narrow than oscilloscope beam commissioning case.

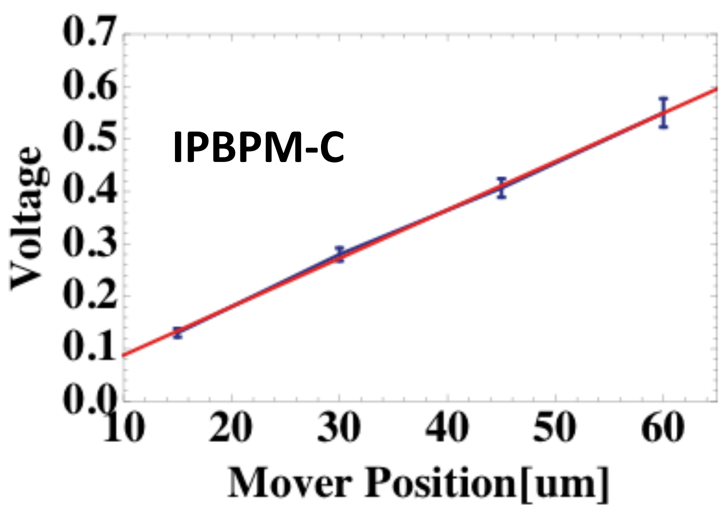
	Electronics offset	Measured pedestal of ADC	Corresponded pC of ADC
IPBPM A YI	-50mV	1934 counts (+370 counts)	-60pC
IPBPM A YQ	-24mV	982 counts (+350counts)	-30pC



Basic beam test to check the resolution of IP-BPMs (Calibration run with 30dB att.)







	IP-BPM A [uV/nm]	IP-BPM B [uV/nm]	IP-BPM C [uV/nm]
30dB att.	9.9113	9.9105	9.2349
0dB att.	313.42	313.39	292.03

The method to calculate the residual of IP-BPMs

We take an extrapolating method by using geometrical relation between three IP-BPMs.

Differences are expressed by ;

$$f_1 = I_1 - \frac{I_2 Z_{13} - I_3 Z_{12}}{Z_{23}} = \frac{I_1 Z_{23} - I_2 Z_{13} + I_3 Z_{12}}{Z_{23}}$$

$$f_2 = I_2 - \frac{I_3 Z_{12} + I_1 Z_{23}}{Z_{13}} = \frac{-I_1 Z_{23} + I_2 Z_{13} - I_3 Z_{12}}{Z_{13}}$$

$$f_3 = I_3 - \frac{I_2 Z_{13} - I_1 Z_{23}}{Z_{12}} = \frac{I_1 Z_{23} - I_2 Z_{13} + I_3 Z_{12}}{Z_{12}}$$

$$f_0 \equiv I_1 Z_{23} - I_2 Z_{13} + I_3 Z_{12}$$

$$f_1 = \frac{f_0}{Z_{23}}, \quad f_2 = \frac{f_0}{Z_{13}}, \quad f_3 = \frac{f_0}{Z_{12}}$$

$$\frac{\partial f_0}{\partial I_1} = Z_{23}, \quad \frac{\partial f_0}{\partial I_2} = -Z_{13}, \quad \frac{\partial f_0}{\partial I_3} = Z_{12}$$

Residuals are expressed by ;

$$\begin{pmatrix} \Delta f_1^2 \\ \Delta f_2^2 \\ \Delta f_3^2 \end{pmatrix} = \begin{pmatrix} 1 & (\frac{Z_{13}}{Z_{23}})^2 & (\frac{Z_{12}}{Z_{23}})^2 \\ (\frac{Z_{23}}{Z_{13}})^2 & 1 & (\frac{Z_{12}}{Z_{13}})^2 \\ (\frac{Z_{23}}{Z_{12}})^2 & (\frac{Z_{13}}{Z_{12}})^2 & 1 \end{pmatrix} \begin{pmatrix} \sigma_1^2 \\ \sigma_2^2 \\ \sigma_3^2 \end{pmatrix} = A \begin{pmatrix} \sigma_1^2 \\ \sigma_2^2 \\ \sigma_3^2 \end{pmatrix}$$

Since det A is zero, $\sigma_1 = \sigma_2 = \sigma_3 \equiv \sigma$

$$\sigma = \Delta f_1 / \sqrt{1 + (\frac{Z_{13}}{Z_{23}})^2 + (\frac{Z_{12}}{Z_{23}})^2} = \Delta f_2 / \sqrt{(\frac{Z_{23}}{Z_{13}})^2 + 1 + (\frac{Z_{12}}{Z_{13}})^2} = \Delta f_3 / \sqrt{(\frac{Z_{23}}{Z_{12}})^2 + (\frac{Z_{13}}{Z_{12}})^2 + 1}$$

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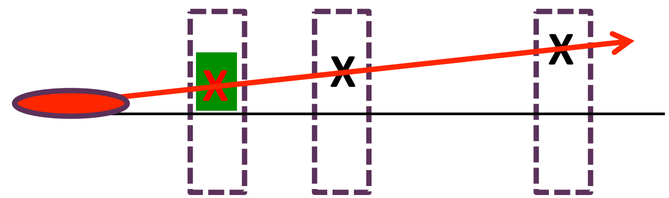
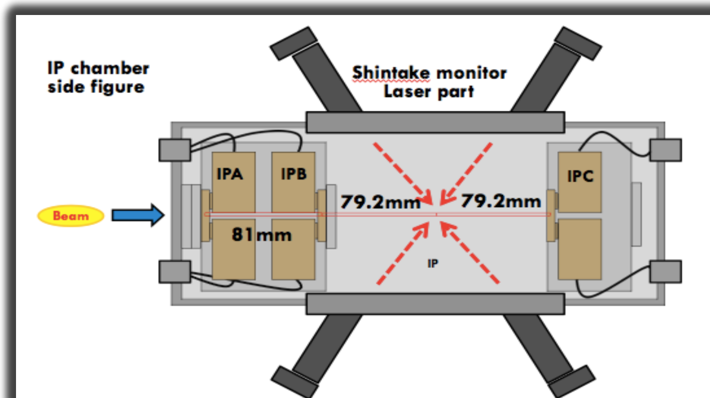
2013年 11月 8日 金曜日

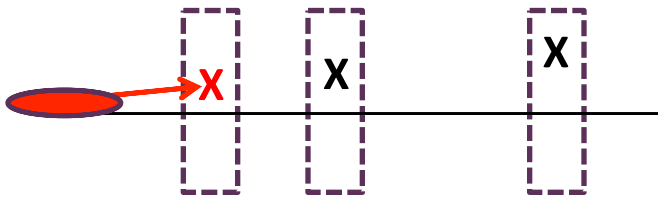


Beam position measurement and prediction

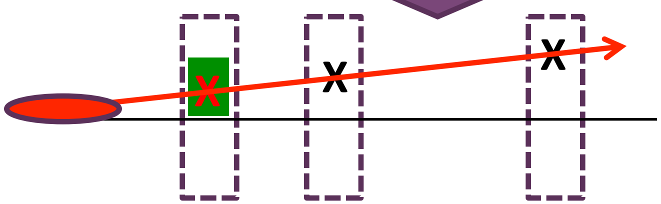
	IPBPM-A (Interpolated by IPBPM-B and C)	IPBPM-B (Interpolated by IPBPM-A and C)	IPBPM-C (Interpolated by IPBPM-A and B)
Geometrical factor	0.531065	0.802629	0.271567



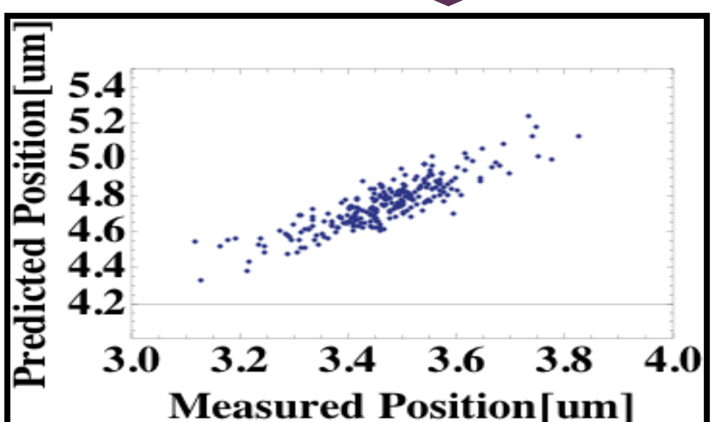
Basic beam test to check the resolution of IP-BPMs (Resolution run of IPBPM-A with 0dB att.)



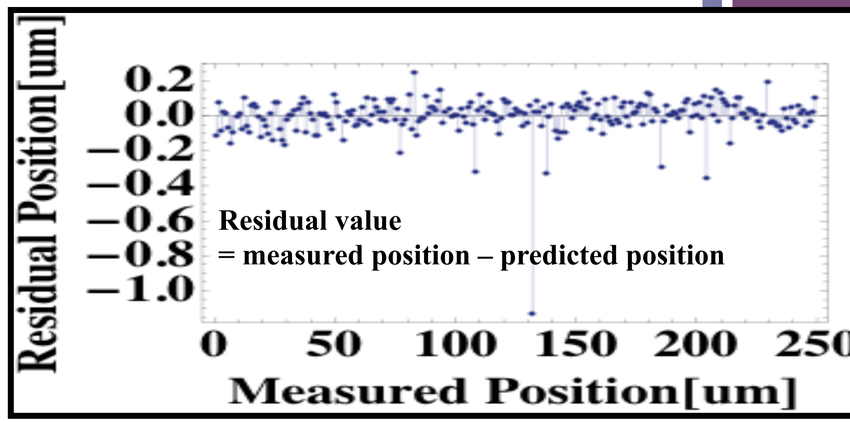
Beam position prediction♪



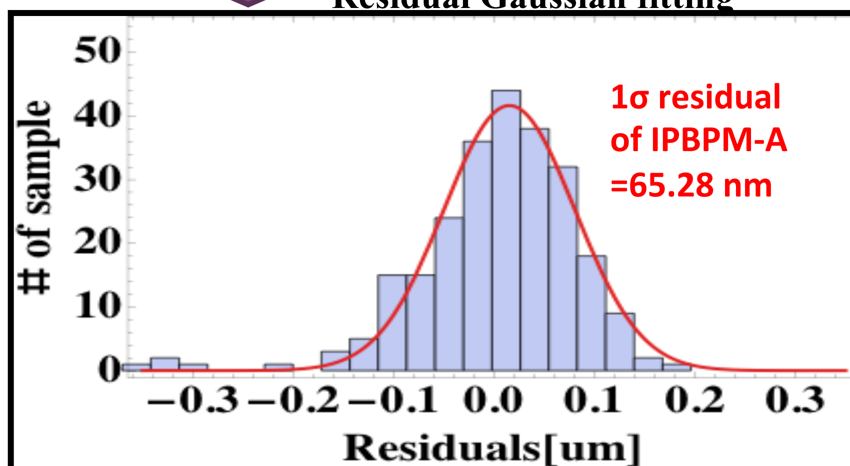
Beam position measurement



Convert to residual

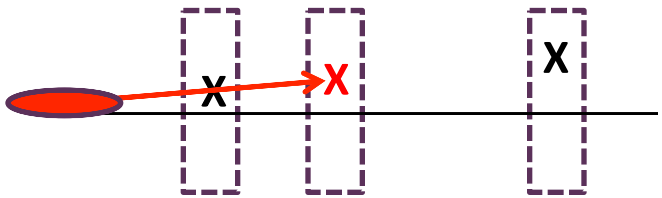


Residual Gaussian fitting

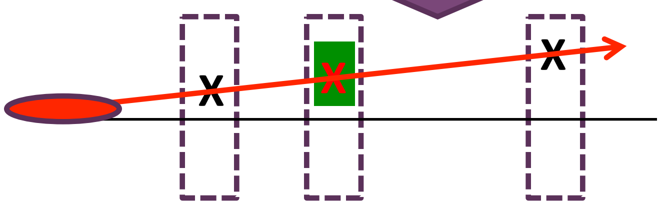


$$\text{Resolution} = G.factor \times \frac{\text{Residual}}{\text{Calibration factor}} = \boxed{34.60 \text{ nm}}$$

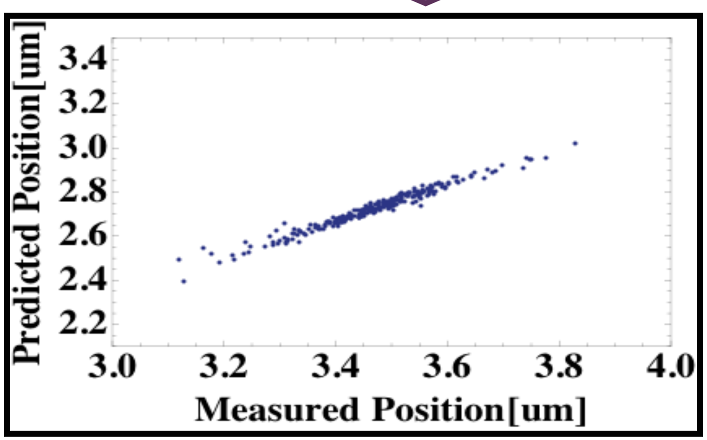
Basic beam test to check the resolution of IP-BPMs (Resolution run of IPBPM-B with 0dB att.)



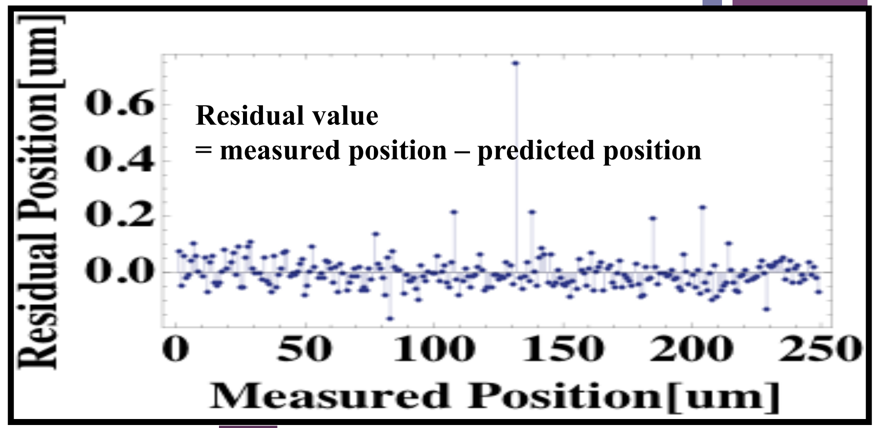
Beam position prediction♪



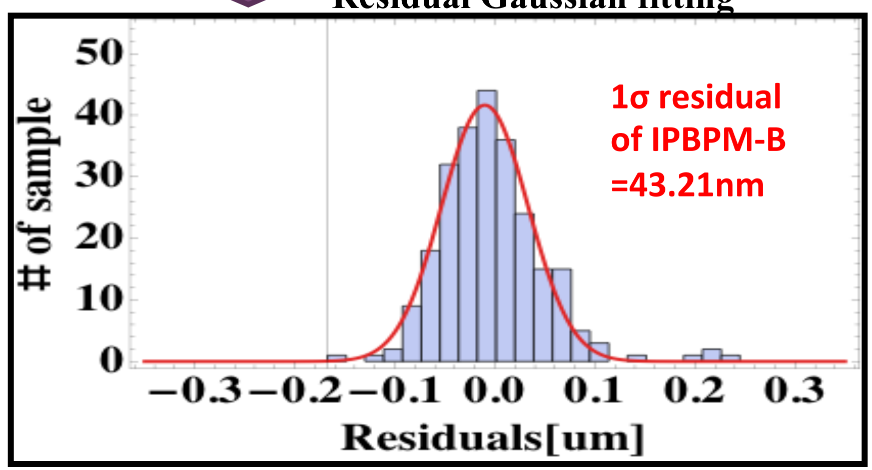
Beam position measurement



Convert to residual

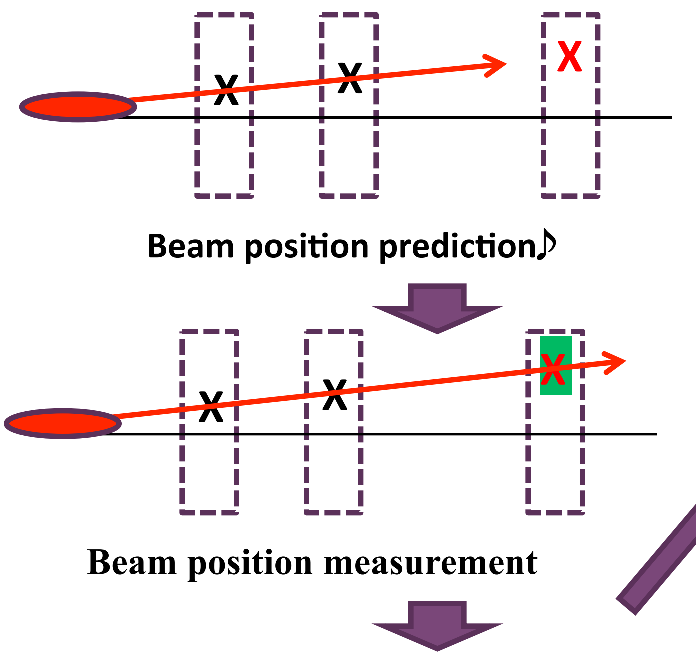


Residual Gaussian fitting

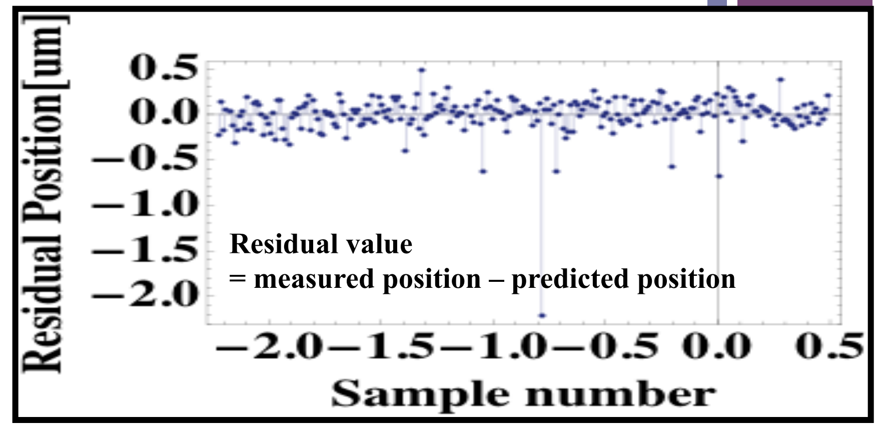


$$\text{Resolution} = G.factor \times \frac{\text{Residual}}{\text{Calibration factor}} = \boxed{34.57\ \text{nm}}$$

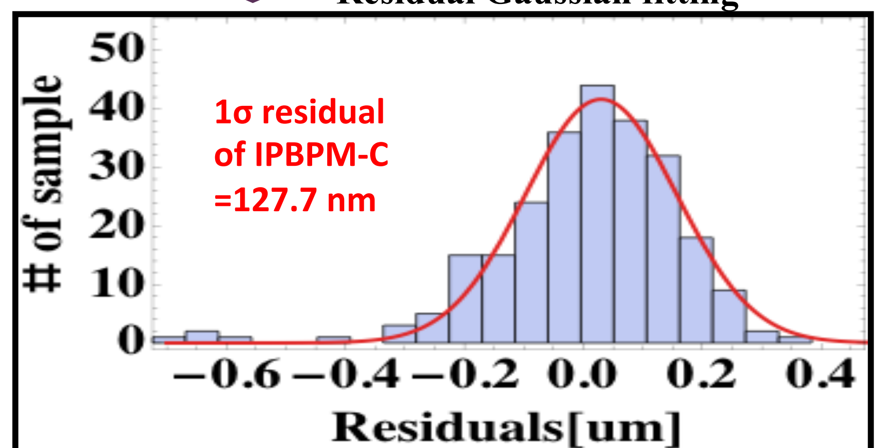
Basic beam test to check the resolution of IP-BPMs (Resolution run of IPBPM-C with 0dB att.)

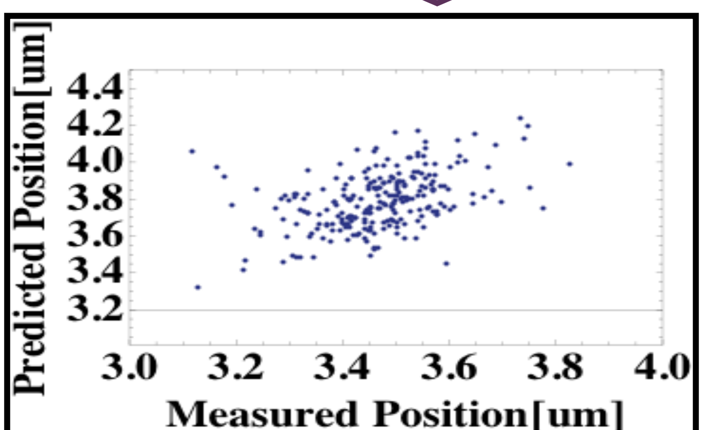


Convert to residual



Residual Gaussian fitting





$$\text{Resolution} = G.factor \times \frac{\text{Residual}}{\text{Calibration factor}} = \boxed{34.47\ \text{nm}}$$

Future beam commissioning plan of IP-BPM system

Contents

- IP-BPM resolution check with oscilloscope
- IP-BPM resolution check with ADC

IP-BPM resolution check with oscilloscope and ADC

- IP-BPM resolution check with oscilloscope (2weeks in Nov.)
  - Re-calibration with out 10dB attenuator after electronics.
  - One by one synchronization of IP-BPM signal with ref. signal.
  - More perfect I-Q tuning by changing the IP-waist.
  - Ref. signal calibration by using oscilloscope.
- IP-BPM resolution check with ADC (2weeks in Dec.)
  - An available measurement dynamic range check with 0dB att.
  - Calibration run with ADC module.
  - Resolution run with ADC module.
- etc.

Summary

- We installed all of IP-BPM system. The all of system works well.
- The basic software are prepared to test IP-BPM system.
- The first measurement results of IP-BPM resolution was 34nm with 0.69 x 1.6nC. If we change the beam condition to 1.6nC then we can expect 24nm level.
- During Nov. and Dec. beam commissioning, we will performed more detailed IP-BPM resolution test with oscilloscope and ADC module.