Noise study of the charge measuring system in PITZ

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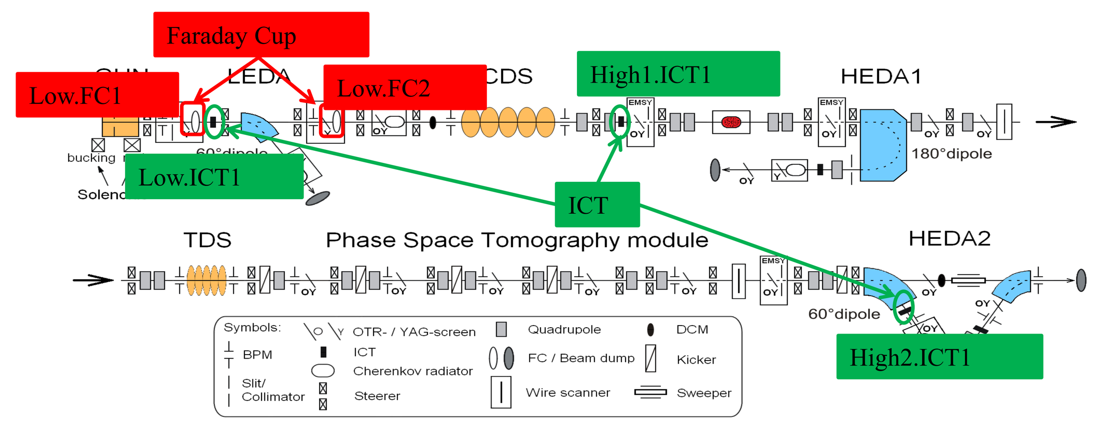
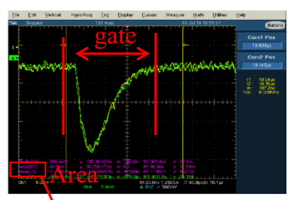
Introduction



Finally, Charge is presented :

$$Q = \langle Q \rangle \pm \sigma_Q = \langle Q^R \rangle - \langle Q^B \rangle \pm \sigma_Q^R$$

Signals from ICTs and faraday cups are transmitted to the control room and read by the same oscilloscope. The area of the signal in the gate is calculated by the oscilloscope and then used to get the value of charge.



ICT:

$$Q = \frac{A^R - A^B}{50} \times 40 \times Cal$$

FC:

$$Q = \frac{A^R - A^R}{50} \times Cal$$

R: raw data (with E-beam)
B: Background data (without E-beam)

The cause of overall error σ_Q^R can be roughly divided in two categories:

1. Stability of laser, RF, …
2. Charge measuring system, e.g, measurement error of the oscilloscope and the device, electronic noise. The related error of the background measurement is defined as background error σ_Q^B which is found comparable to σ_Q^R

In order to compare the σ_Q^R between different devices, normalizing σ_Q^R to σ_A^R which is the error of the area measured by the oscilloscope and has the unit pVs.

For ICT, $\sigma_Q^R = \sigma_A^R/1.15$, for faraday cup, $\sigma_Q^R = \sigma_A^R/50$

Vertical scale of scope	Low.FC1	Low.FC2	Low.ICT1	High1.ICT1	High2.ICT1
1mV	6	6	20	17	10
5mV	6	6	18	19	10
10mV	7	6	18	17	10
20mV	9	8	21	19	12
50mV	13	15	25	22	18
100mV	45	40	50	63	44
200mV	70	60	70	70	70
500mV	150	140	150	120	155
1V	600	500	520	480	480
2V	600	700	700	650	700

Common range for ICT

Common range for FC

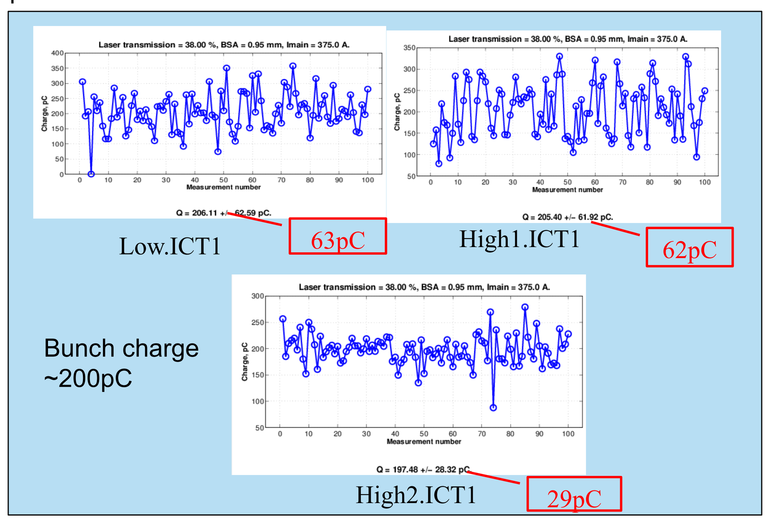
Result:

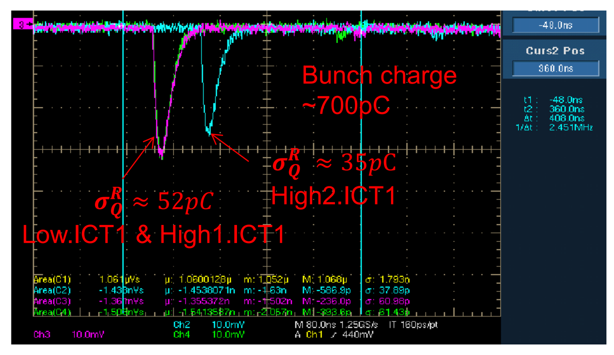
Faraday cup: σ_Q^R is dominated by the measurement error of the oscilloscope.

ICT: σ_Q^R is dominated by the electronic noise

Difference of σ_Q^R observed between ICTs

All of the ICTs are bought from Bergoz company and have the same parameters.





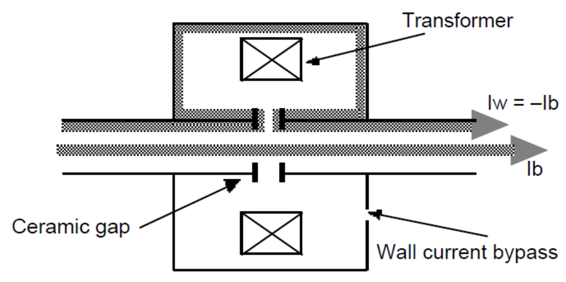
Cross check of the charge measured by the ICTs for the same setting of the E-beam.

σ_Q^R of High2.ICT1 is much lower than that of Low.ICT1 and High1.ICT1.

Installation of ICT

All of the ICTs are bought from Bergoz company and have the same parameters:

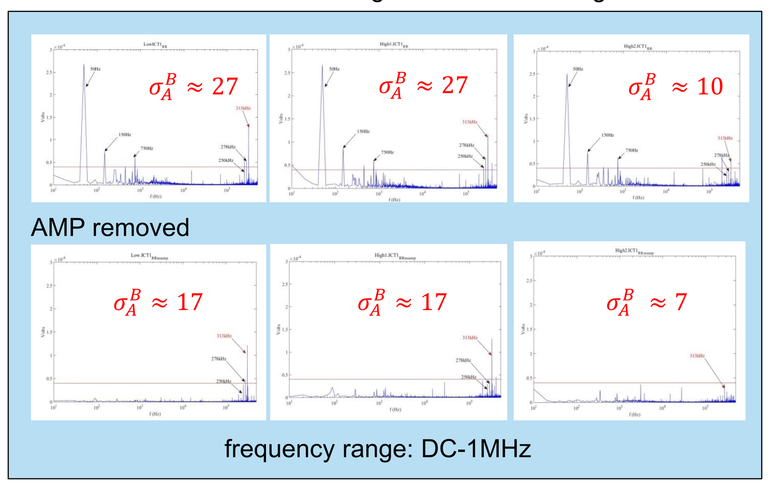
- transform ratio: 40/1 (input Q/output Q)
- 3dB band width: 3 kHz – 12 MHz



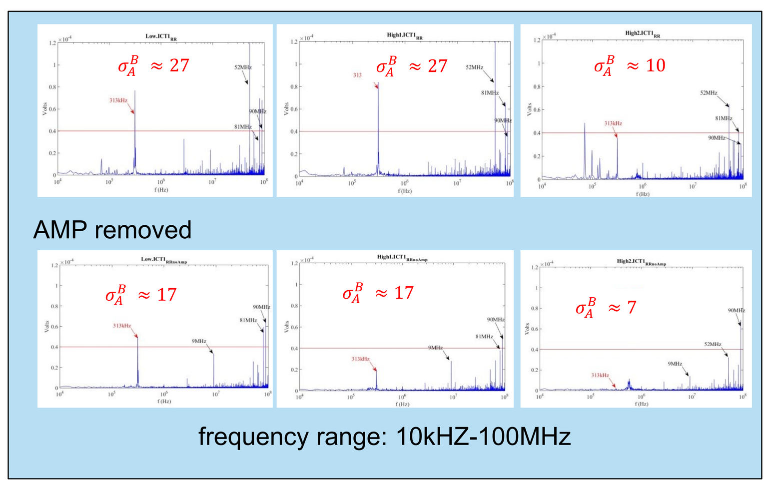
Installation of ICT:

- The vacuum chamber is electrically break by a ceramic gap
- ICT is installed outside the ceramic gap
- Outside of the ICT, a solid metal shield is attached to the vacuum chamber in either side of the electrical break which acts as both wall current by-pass and the RF shield.

Spectrum of the background signal of ICTs



frequency range: DC-1MHz



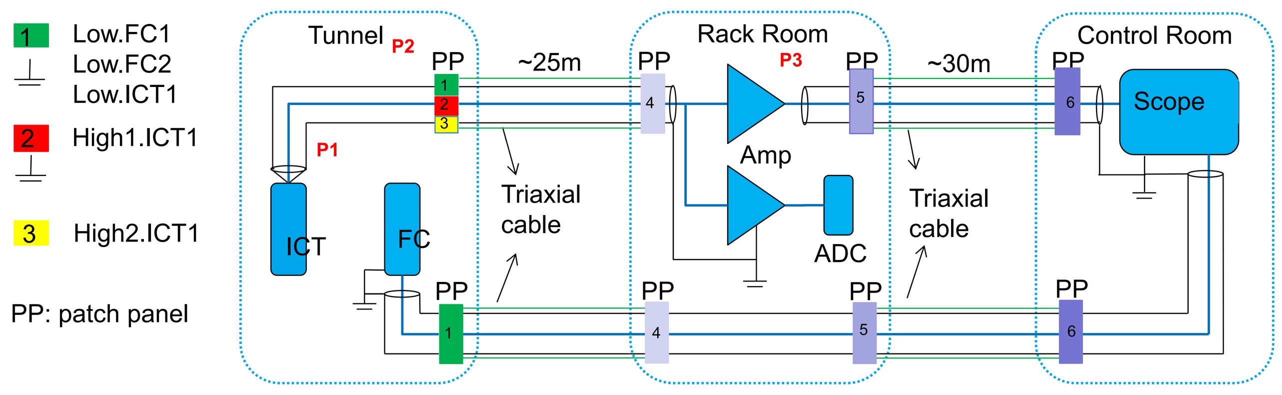
frequency range: 10kHZ-100MHz

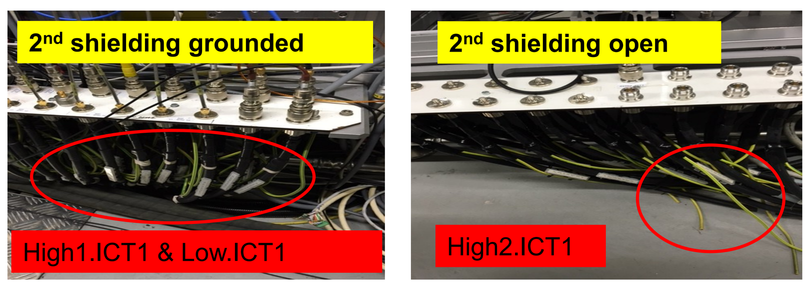
The electronic noise of ICT can be separated into 3 parts:

- ✓ noise from the power line: e.g. 50Hz, 150Hz, 750Hz
- ✓ noise from the timing system: e.g. 9MHz, 81MHz, 90MHz
- ✓ **strange 300kHZ noise which is the reason for the different values of σ_Q^R between ICTs and contributes much to σ_Q^R**

Analysis on the strange 300kHZ noise

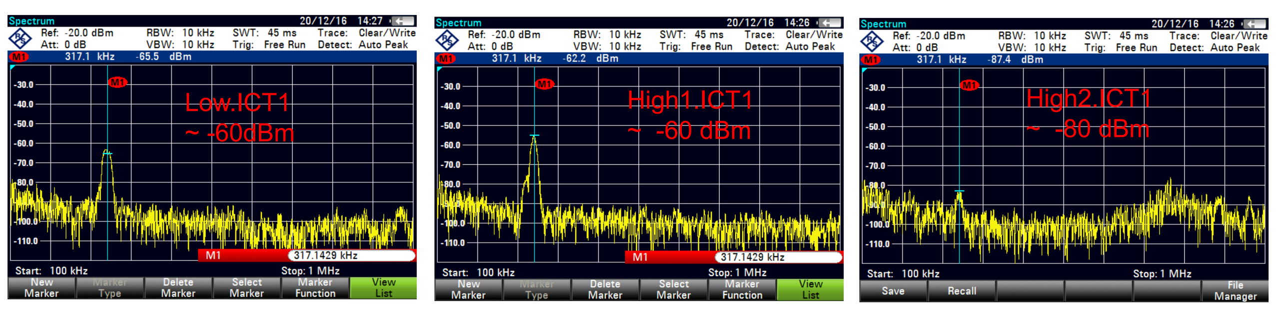
➢ Cabling and grounding of the charge measuring system in PITZ



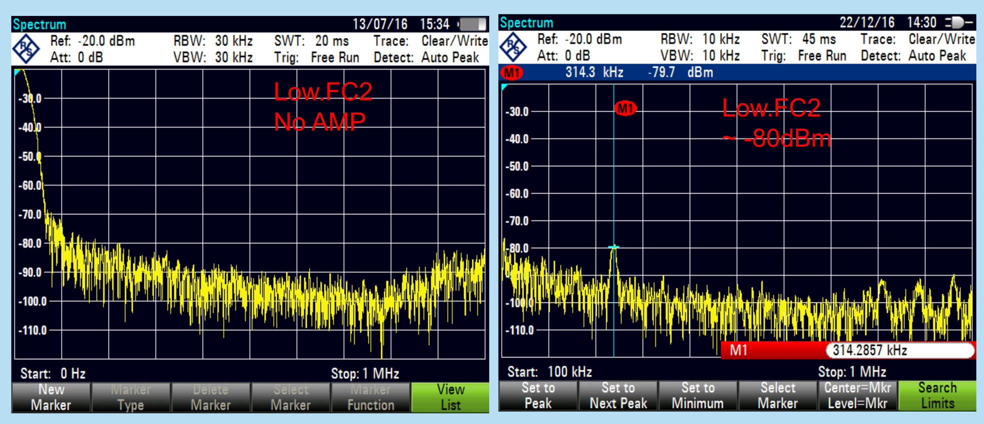


All the second shielding of the tri-axial cable are open on both side except that the seconding shielding at PP1 and PP2 are grounded.

R&S handy spectrum analyzer
frequency range: 9kHZ- 8GHz
Battery powered



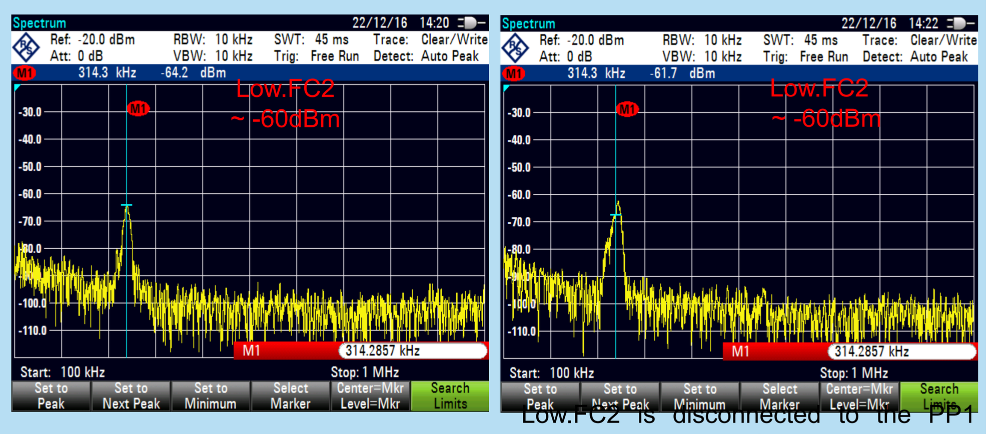
- Spectrum of the background signal measured at the output of the AMP, i.e. position P3.
- The 300kHZ noise of High2.ICT1 is 20dBm lower than that of Low.ICT1 and High1.ICT1.
- The amplifiers of the ICT are checked and not the reason for different σ_Q^R of the ICTs



Spectrum of the background signal of Low.FC2 measured at the output of PP4. No 300kHz noise observed.

Spectrum of the background signal of Low.FC2 measured at P3 after connecting the FC to the AMP.

Keep connecting the FC to the AMP and measure the spectrum at P3.



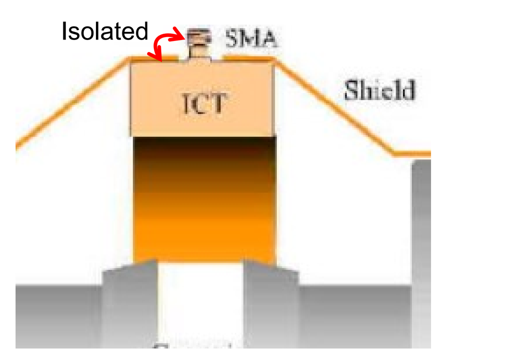
Low.FC2 is disconnected to the PP1 and the connector of PP1 is open.

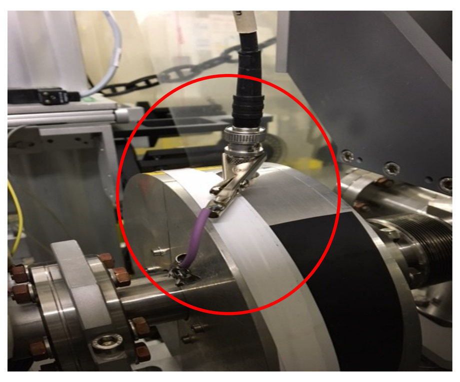
Low.FC2 is disconnected to the PP1 and the connector of PP1 is terminated with a 50Ω load.

Results and Solutions

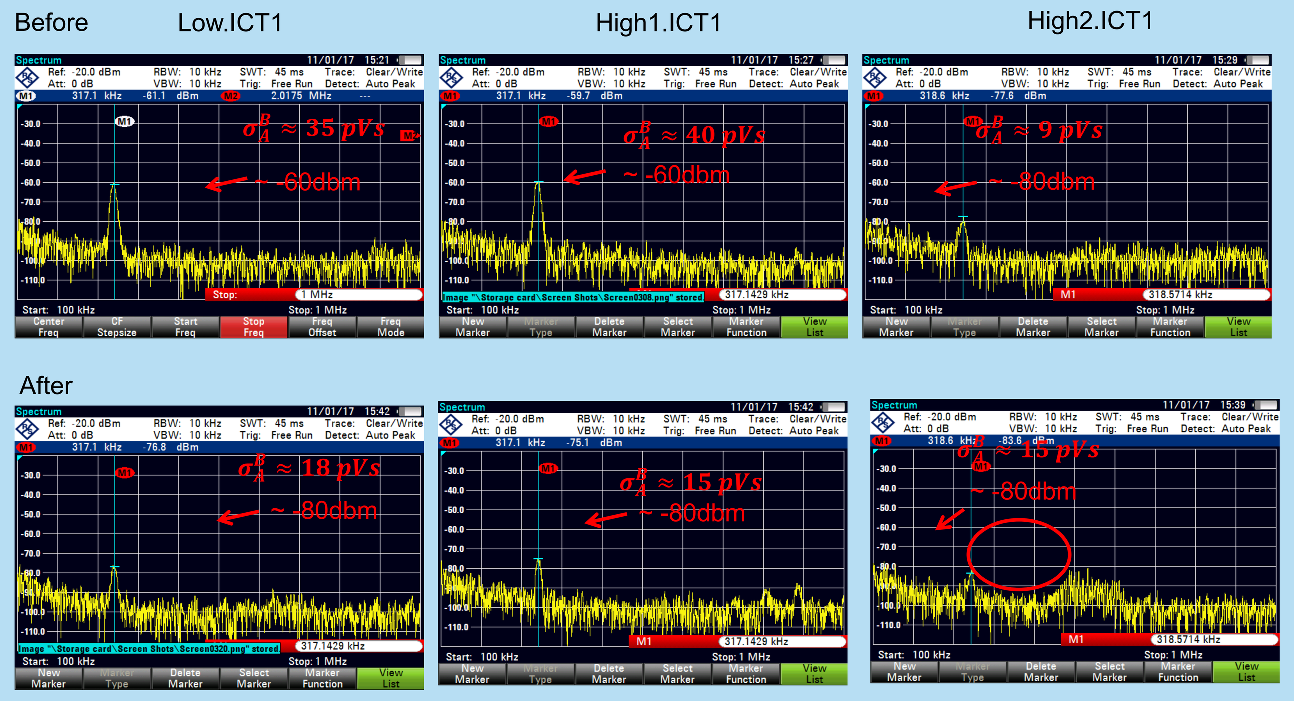
The 300kHz noise is related to the ground loop between the tunnel and rack room.

- ✓ For Low.ICT1 and High1.ICT1: the ground loop exists between the patch panel in the tunnel and the amplifier in the rack room, as the 2nd shield of the triaxial cable is grounded at PP1
- ✓ For High2.ICT1: the ground loop exists between the ICT and amplifier in the rack room, as the ICT is not good isolated from the wall current by-pass.

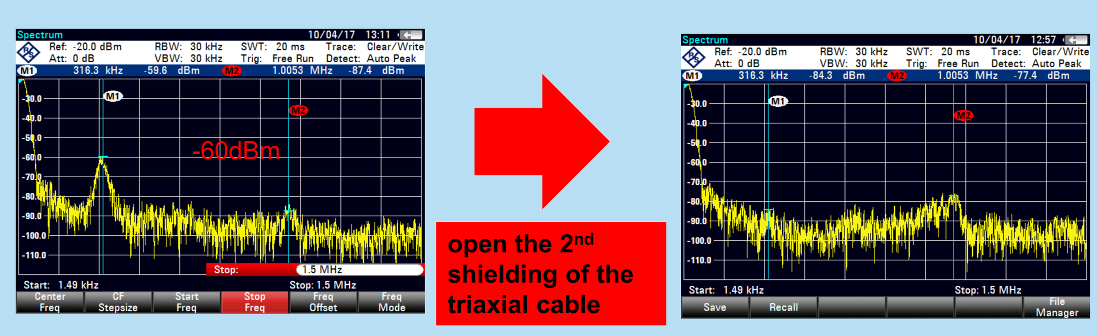




Solution 1



Solution 2



Two attempted solutions:

1. Connect the shield of the coaxial connector at the output of ICTs to the vacuum chamber (shown in the picture). Then, the 300kHZ noises of Low.ICT1 and High1.ICT1 decrease 20dBm. However it doesn't work at High2.ICT1 and make things worse by introducing new noise.
2. Open the 2nd shield of the tri-axial cable at the patch panel in the tunnel. Then it's found that the 300kHZ noise disappear for Low.ICT1 and High1.ICT1.

Conclusions

1. In order to increase the accuracy of the charge measurement in PITZ, the electronic noise should be reduced, especially for the ICT, of which the measurement error is dominated by the electronic noise.
2. Most of the electronic noise observed at ICT come from the power supply and the timing system. In addition, a strange 300kHZ ripple is observed and contributes much to the measurement error .
3. The 300kHZ noise is related to the ground loop between the patch panel in the tunnel and the amplifier in the rack room and comes from the vacuum system in the rack room.
4. To eliminate the 300kHZ noise, a temporary solution is to open the second shield of the tri-axial cable in the tunnel, with which the measurement error of Low.ICT1 and High1.ICT1 reduce twice.
5. However, to take advantage of the tri-axial cable, the second shield should be grounded in a proper way. The improvement of the grounding and cabling in PITZ is on going.