

RF Processing of L-band RF Gun for KEK-STF



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Abstract

- KEK-STF : Superconducting Accelerator R&D for International Linear Collider(ILC) and Q-Beam project (Laser Compton) by MEXT.
- Beam acceleration test: examine LLRF control and demonstrating high average current and long macro pulse acceleration.
- Issue: 1ms long macro pulse operation of NC RF gun; Suppress the dark current even lower than the beam current.

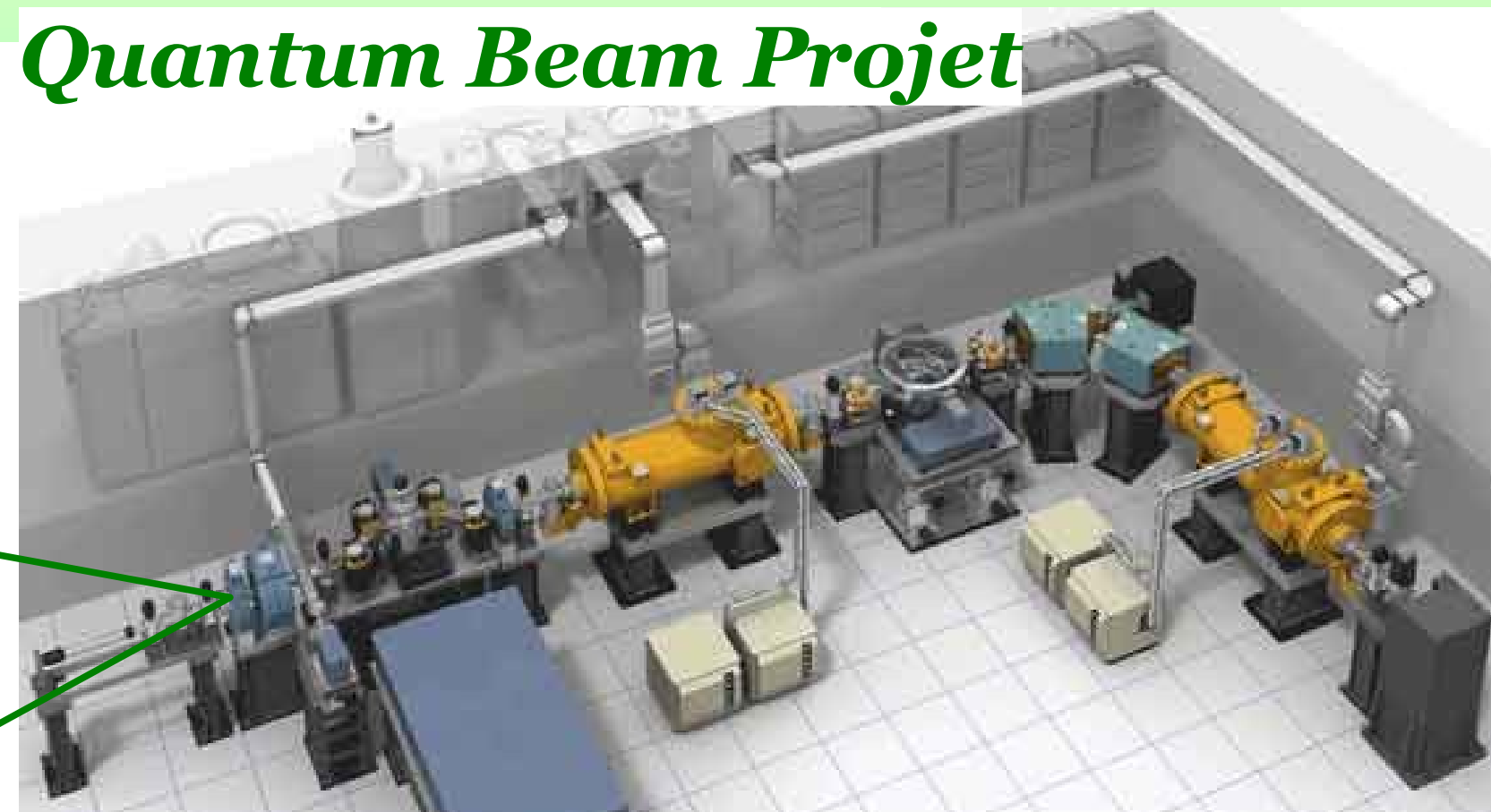
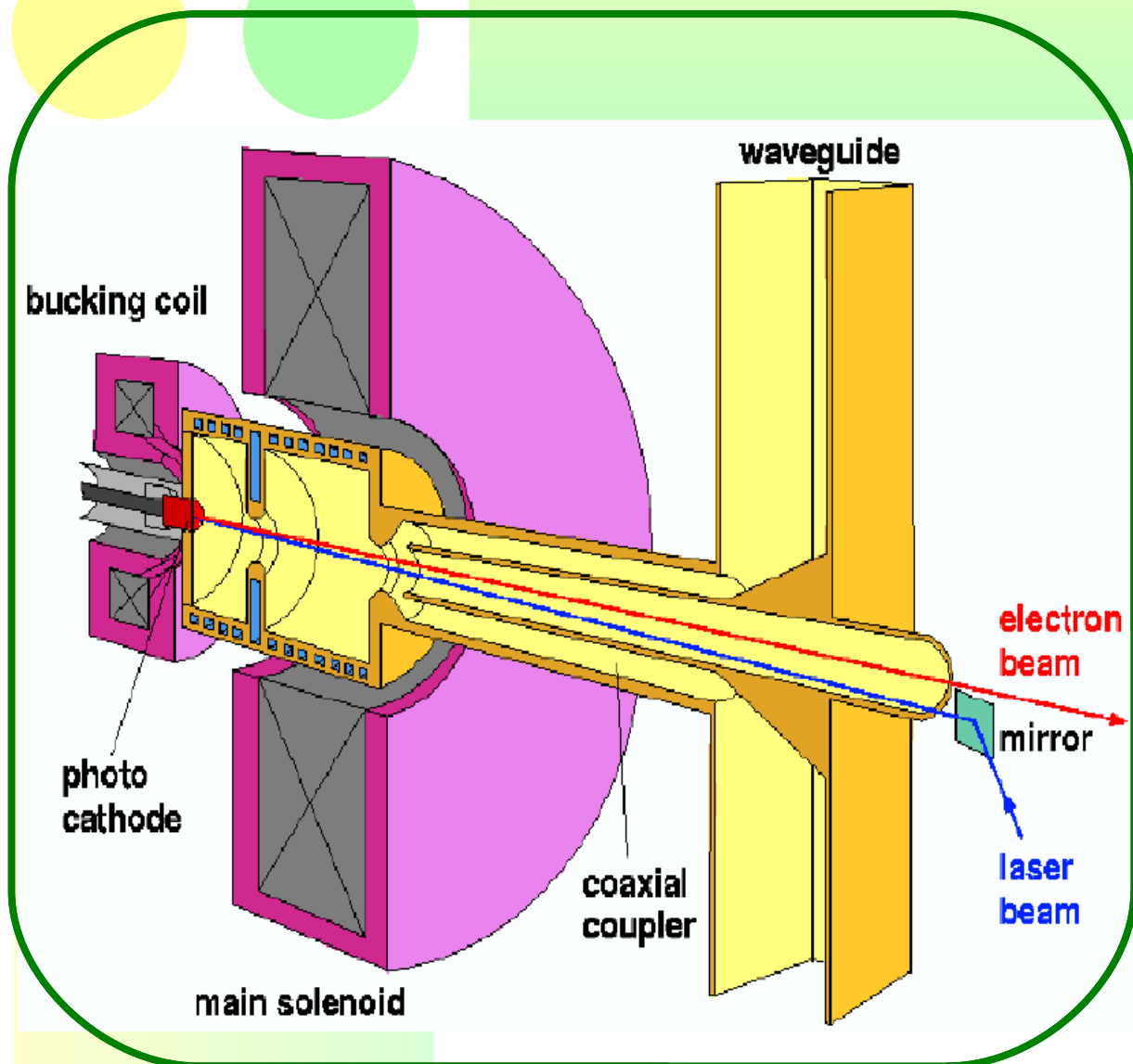
Beam Parameters

- Purpose of STF is demonstrating SC accelerator technology.
- Quantum beam project is high brightness X-ray generation by inverse Compton scattering between electron beam and laser. It will be carried out at STF. The beam parameter is different, but the average beam power is similar.
- By replacing the cathode drive laser system, the beam format can be switched for ILC mode and Q-beam mode.
- Cathode material is Cs₂Te, which requires 260nm light for photo-electron emission.
- Cathode evaporation chamber is completed by April 2011. Quantum efficiency at 266nm UV light was observed as 7%.

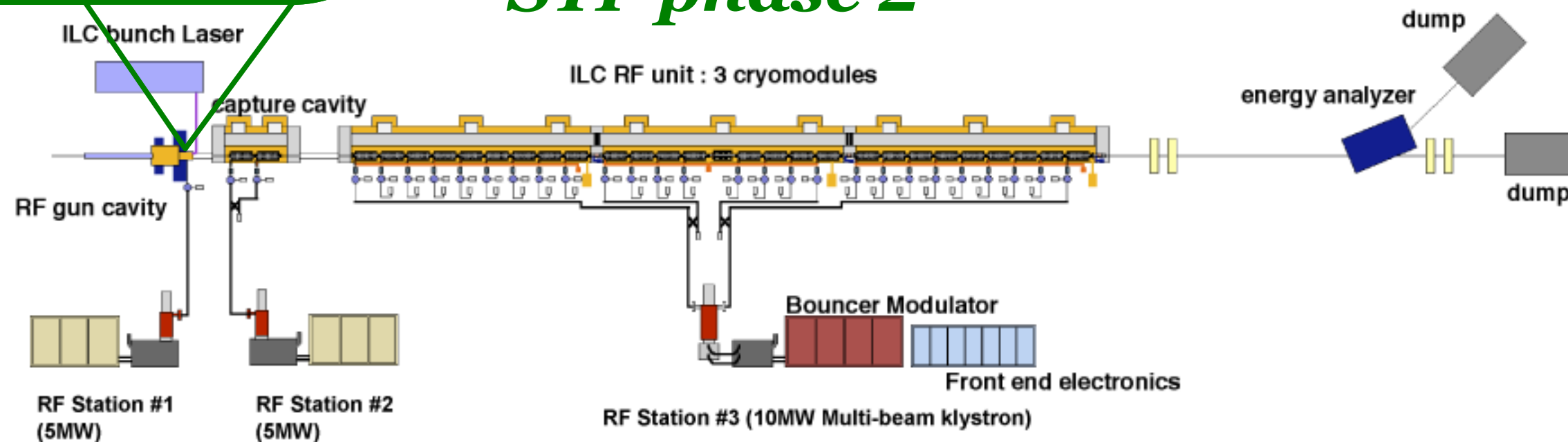
Parameters	ILC	STF	Q-Beam
Pulse length	0.97ms	0.9ms	0.9ms
Pulse repetition	5Hz	5Hz	5Hz
# of micro bunches in a pulse	2625	2439	162500
Bunch separation	369ns	369ns	6.2ns
Bunch charge	3.2nC	3.2nC	65pC
Micro bunch length at source	1ns	10ps	10ps
Peak current	3.2A	320A	65A
Electron Polarization	80%	0%	0%
Type of Gun	DC PC	RF PC	RF PC
Cathode	GaAs	Cs ₂ Te	Cs ₂ Te
Laser Wavelength	780nm	260nm	260nm

STF Injector System

Quantum Beam Project

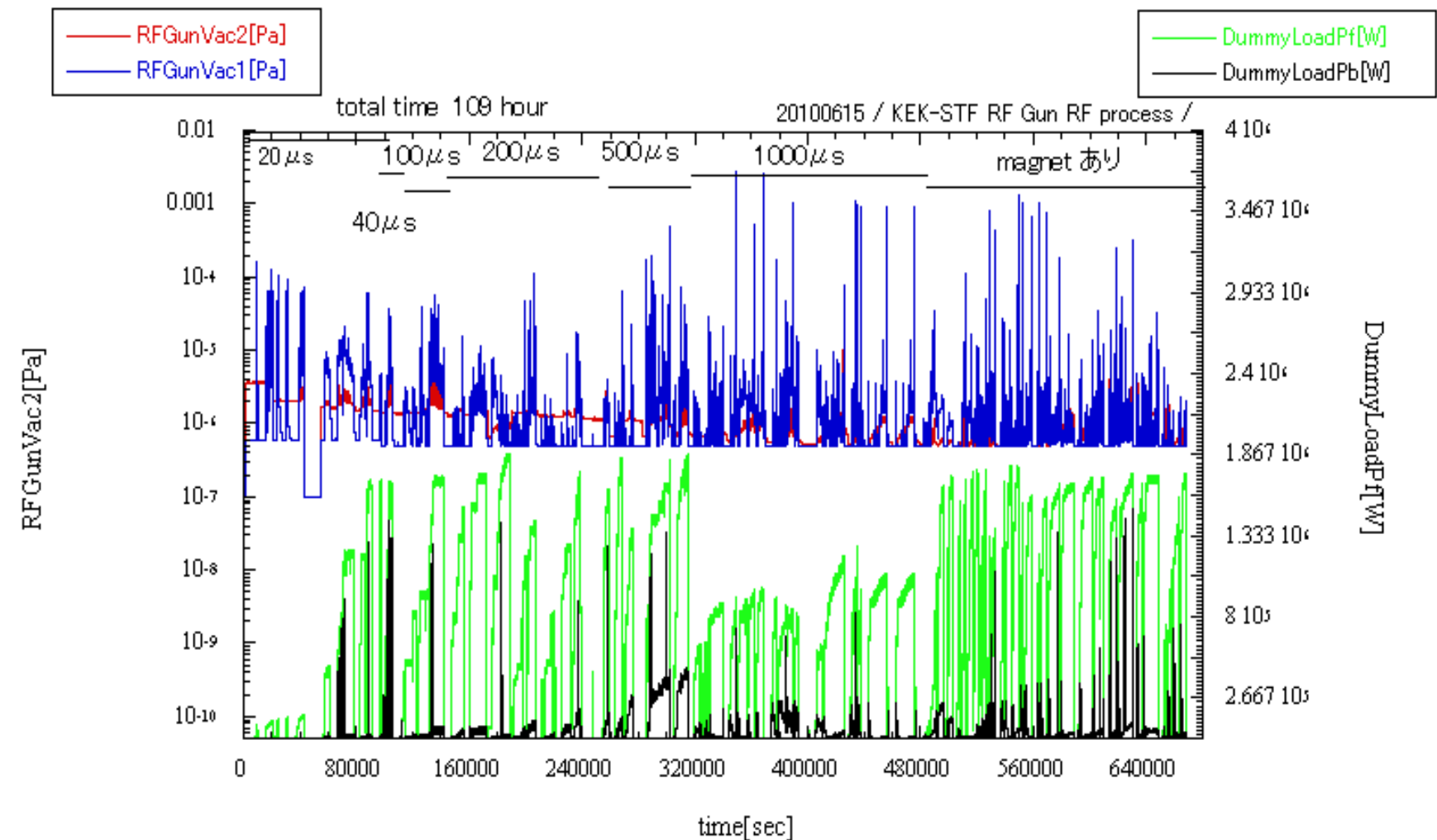
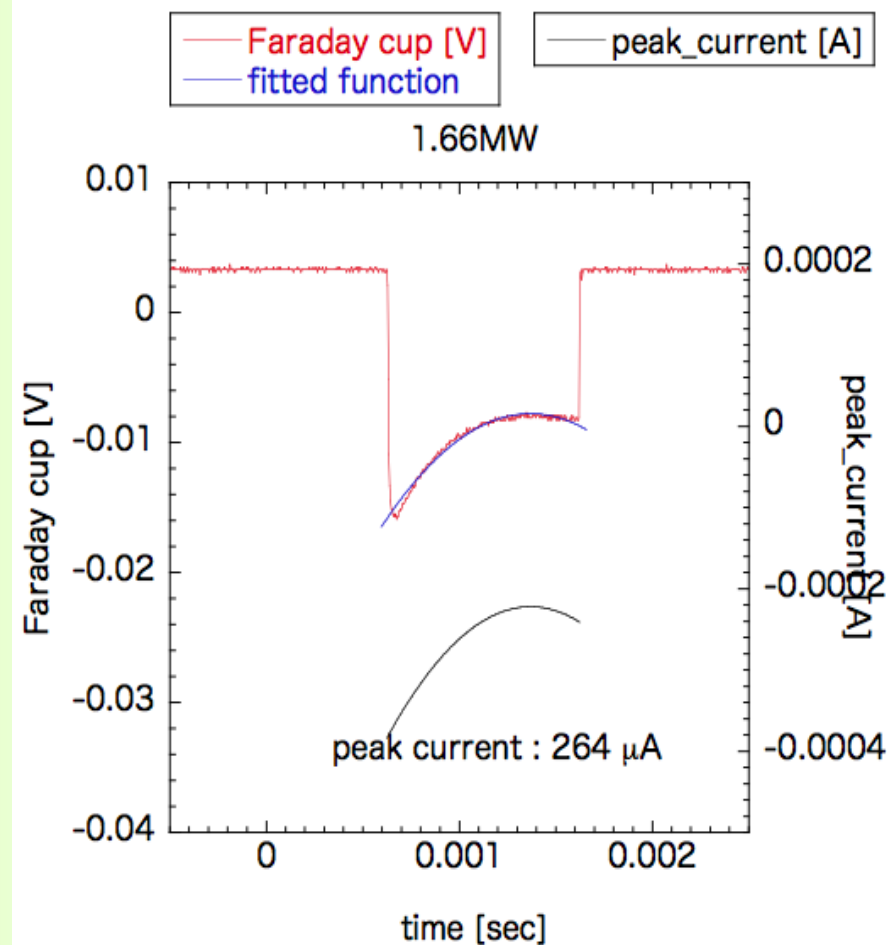
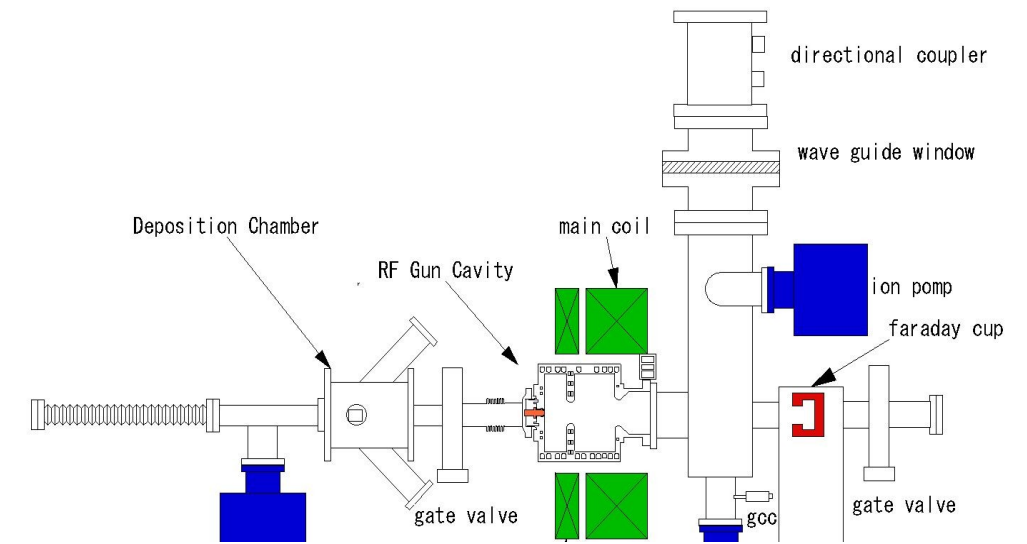


STF phase 2



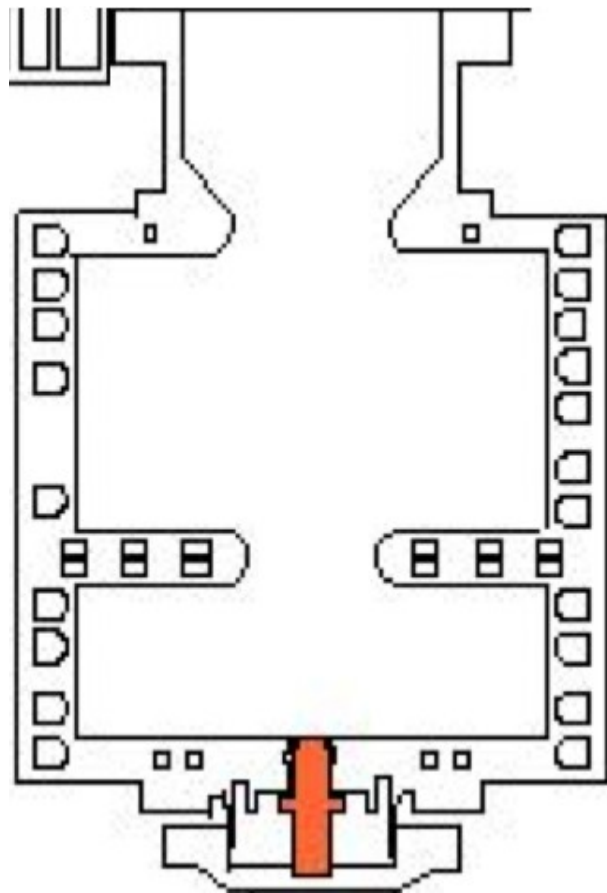
First RF Processing

- Starts from April 2009.
- The maximum available RF power is 1.7 MW with 1000 μ s duration.
- Starts from 20 μ s duration and it takes 109 hours to reach the max.
- Large dark-current was observed by Faraday cup, 280 μ A at 28 MV/m.



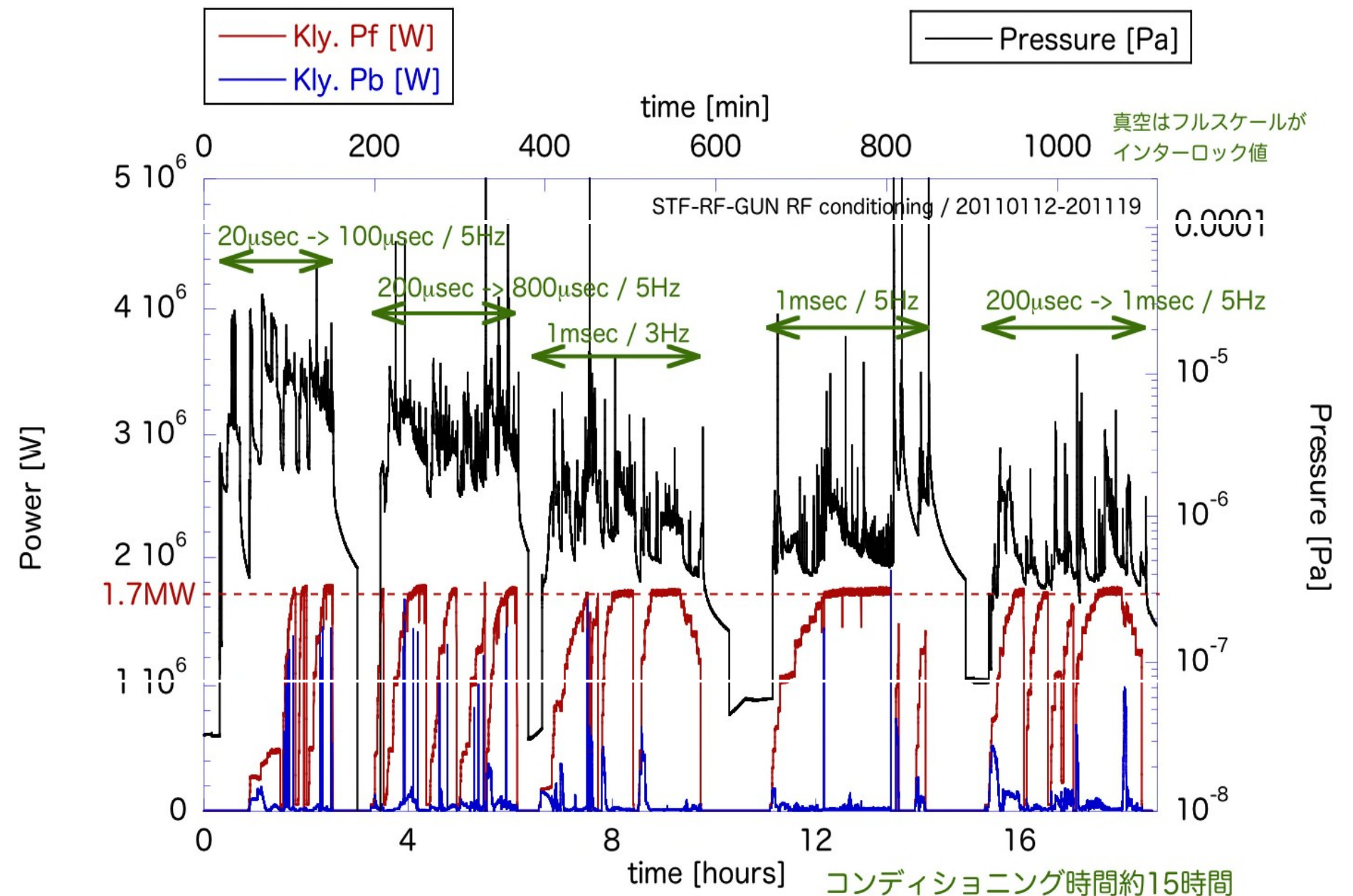
Ethanol Treatment

- To suppress the dark current from the gun cavity by field emission, ethanol rinse with sponge tumbling.
- Several dark spots were observed before the treatment. The spots were not removed.
- Rinse by pure ethanol followed by hot water, and dried.



Second RF Test

- Start from 20 μ s pulse duration.
- It takes 15 hours to reach the maximum power and duration, 1.0 ms and 1.7 MW.
- It should be compared to 109 hours at the first test.
- Very fast processing in the second test comparing to the first.
- 18 μ A dark current was observed at 28MV/m.



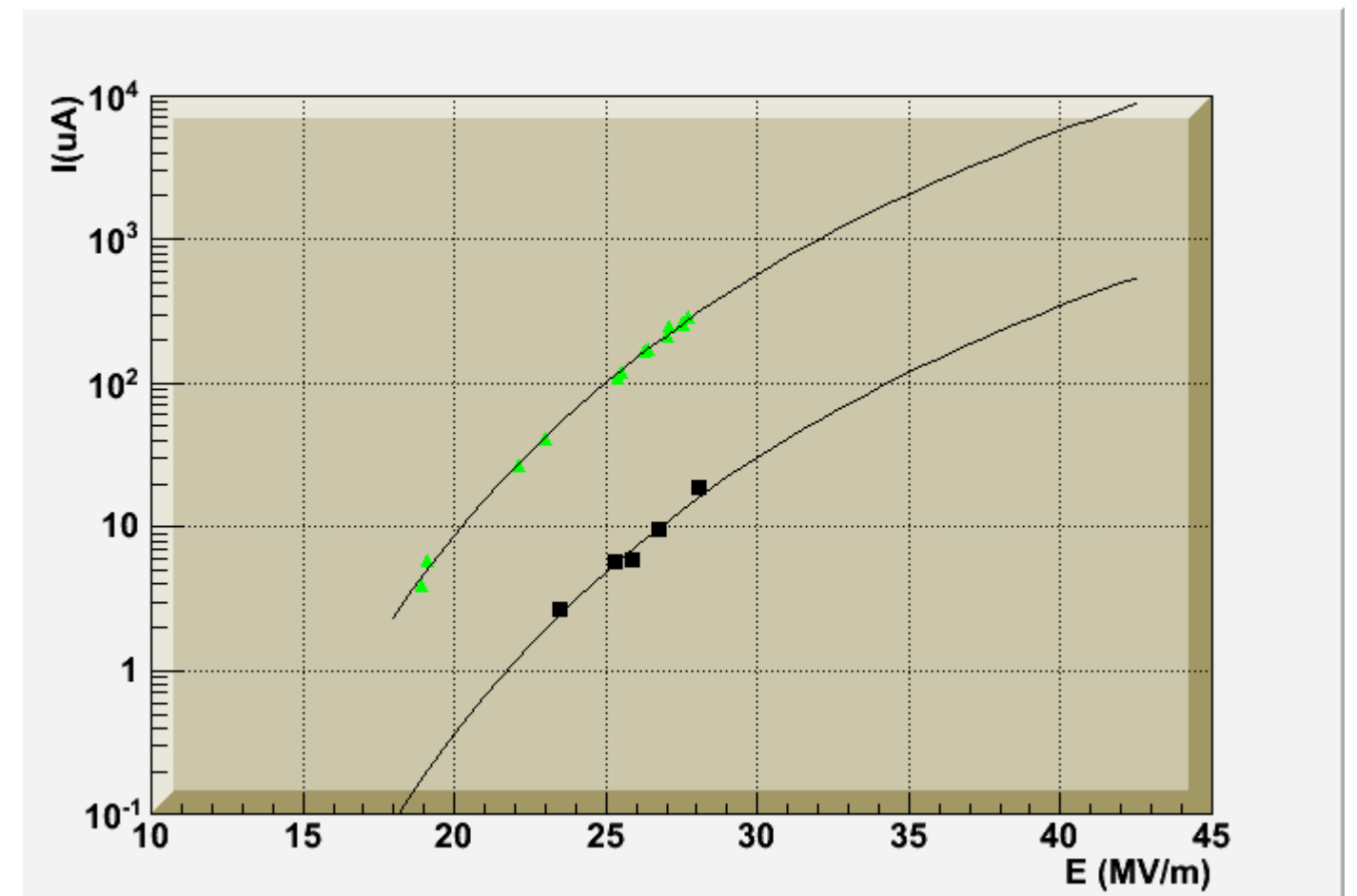
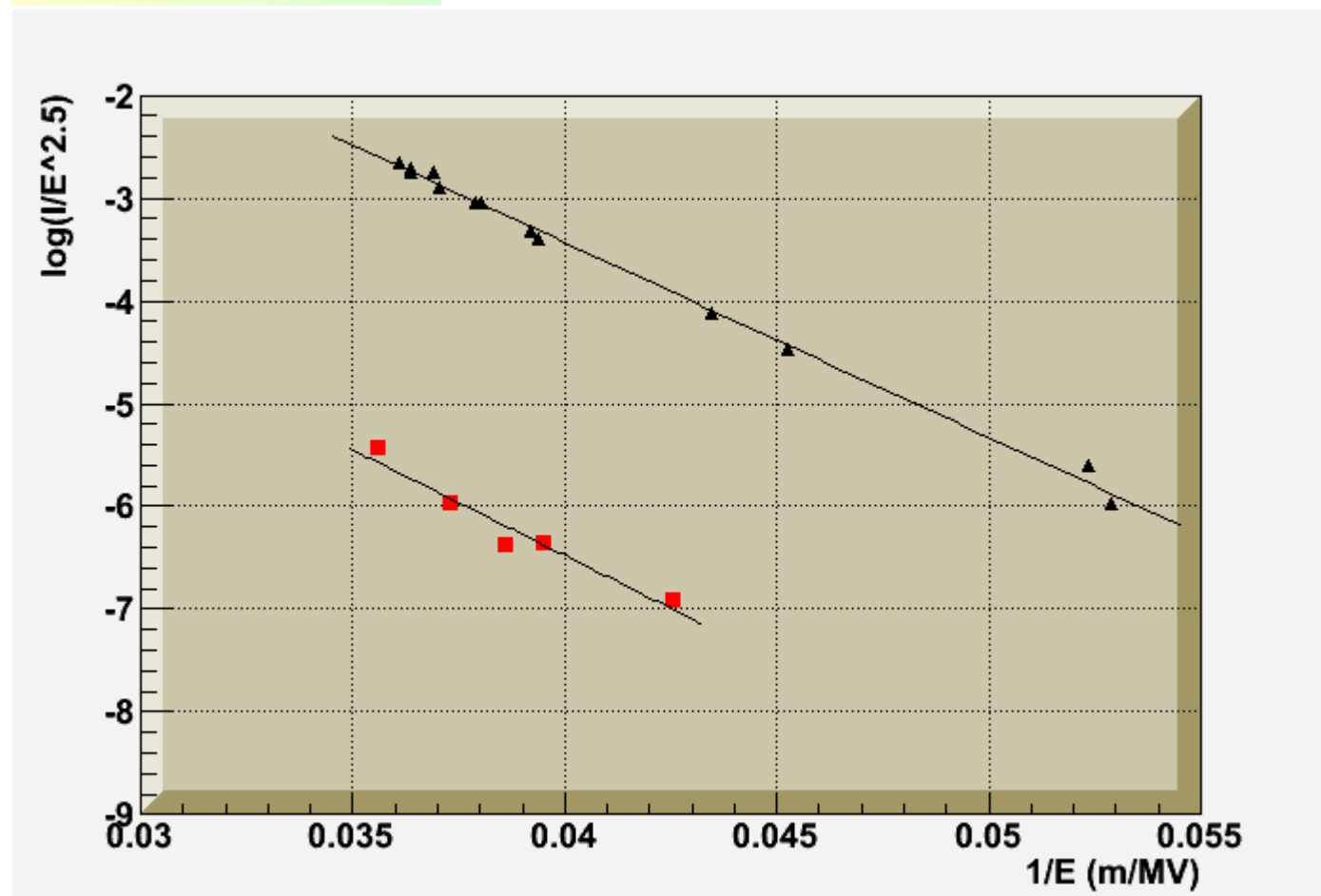
Dark Current

- The dark-current is decreased by the treatment by more than one order of magnitude.
- The dark-current is analyzed with F-N theorem by assuming field emission. The field enhancement factor, β is found to be
 - 350 for the first test.
 - 324 for the second test.
- Expected dark current by extrapolation at 40MV/m.
 - 5.7mA before the treatment.
 - 0.34mA after the treatment.

Field emission in RF case

$$I \propto (\beta E)^{2.5} \exp\left(\frac{-6.53 \times 10^9 \phi^{1.5}}{\beta E}\right)$$

$$\phi = 4.7 \text{ eV for Cu}$$





Summary

- High power RF processing of L-band RF gun has been carried out at KEK-STF.
- Large dark current was observed in the first test $280\mu\text{A}$ at 28MV/m .
- By ethanol rinse treatment, the dark current is decreased down to $18\mu\text{A}$ at 28MV/m .
- The processing time of the second RF test was much less than that of 1st test.
- Expected dark current at 40MV/m is 5.7mA for 1st processing and 0.34mA for 2nd processing.
- Further RF processing is necessary with higher RF power. New power source will provide up to 3.5 MW .
- The next RF test will be carried out in September 2011.