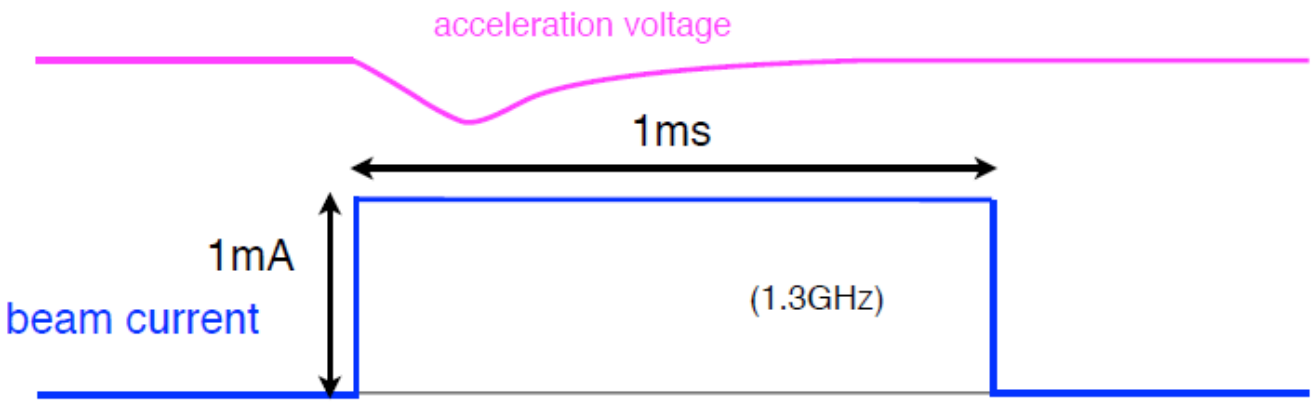
Beam Loading Simulation of Injector Cavities

Feng QIU (KEK)

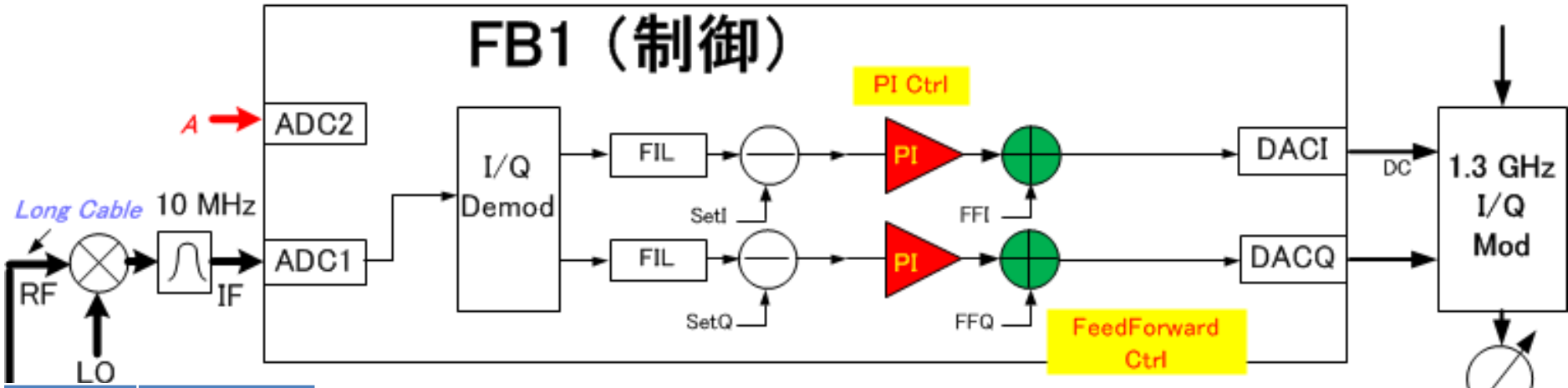
Request of beam loading estimation

Y.Honda (2014.4.18)

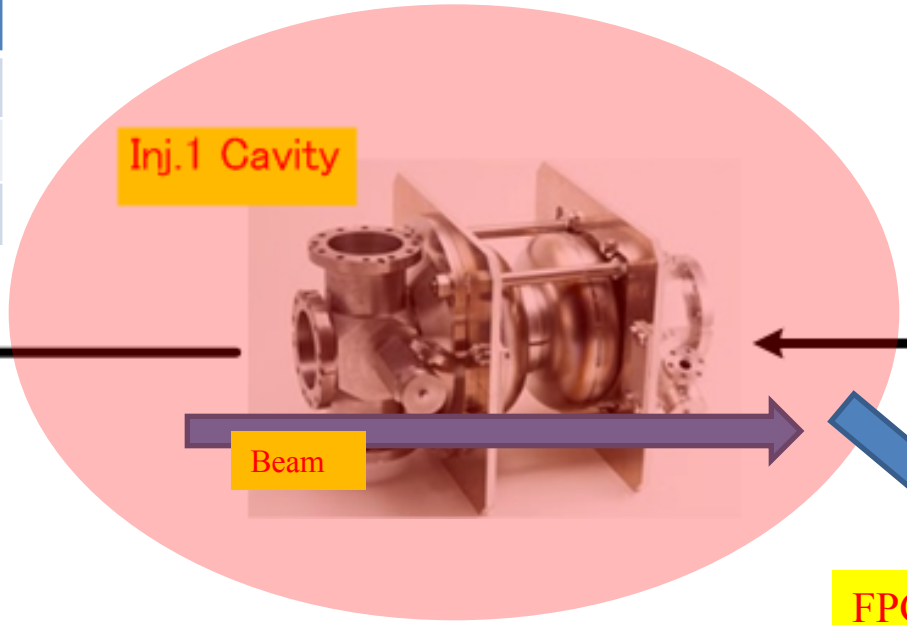
- Purpose
  - Beam operation mode consideration for Laser Compton Light Source commissioning.
  - We will test the beam mode in coming May-June operation.
- Proposed pulse pattern (peak current, pulse train duration, repetition)
  - 1mA, 1ms, 5Hz (average 5μA)
  - 0.1mA, 10ms, 5Hz (average 5μA)
  - 0.005mA, CW (average 5μA)
  - 1mA, 1μs, 1000Hz (average 1μA)
  - other ideas...?
- Beam loading at injector cavities should be checked.
  - Energy extracted by a train of beam is comparable with the stored energy in a SC cavity.
  - Field in the SC cavity will be controlled to be constant by the RF system, but with limited time constant.
  - Energy variation in a pulse train should be estimated.



LLRF system @ Beam Commission

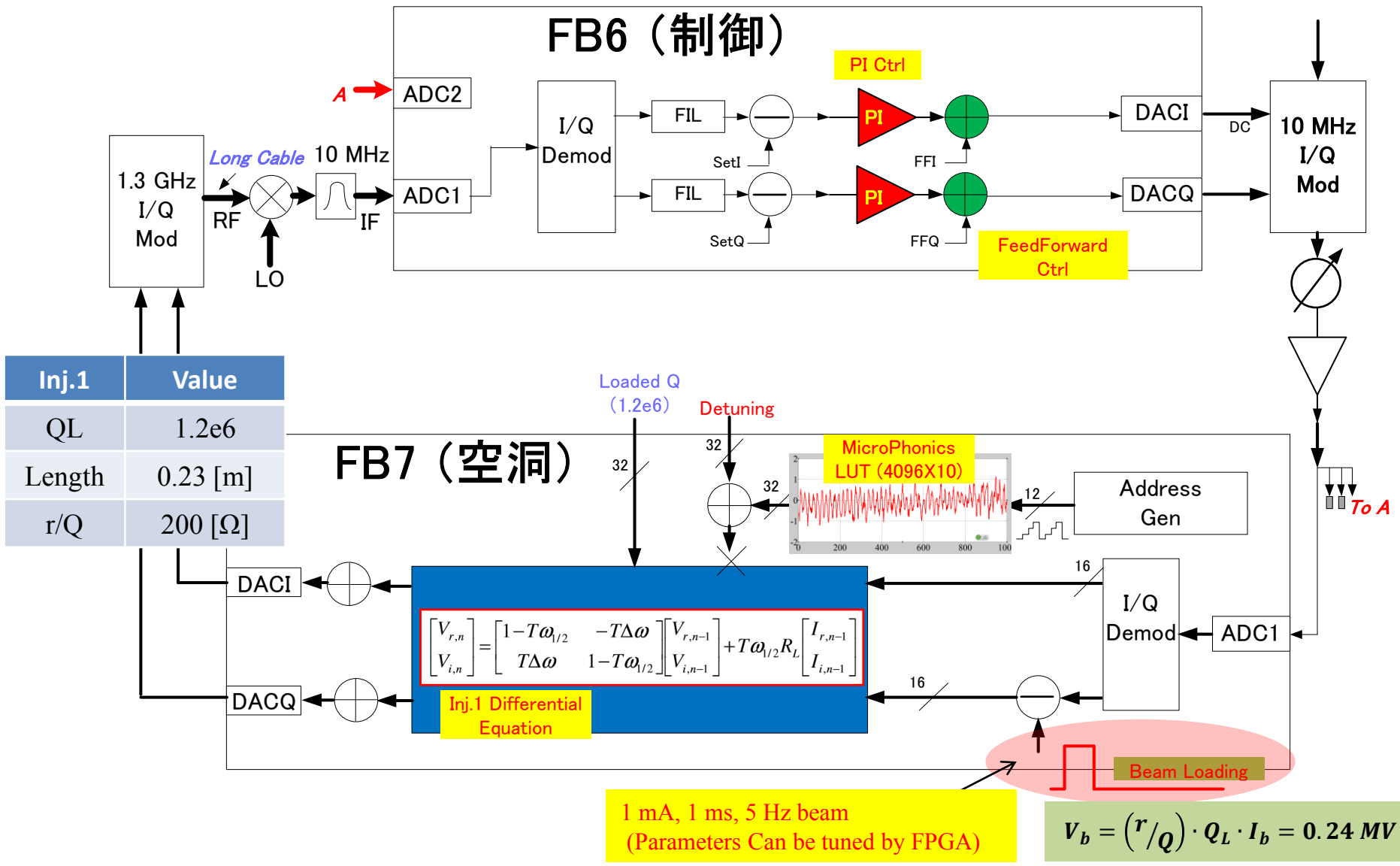


Inj.1	Value
QL	1.2e6
Length	0.23 [m]
r/Q	200 [Ω]



FPGA based Cavity Simulator

Test Bench

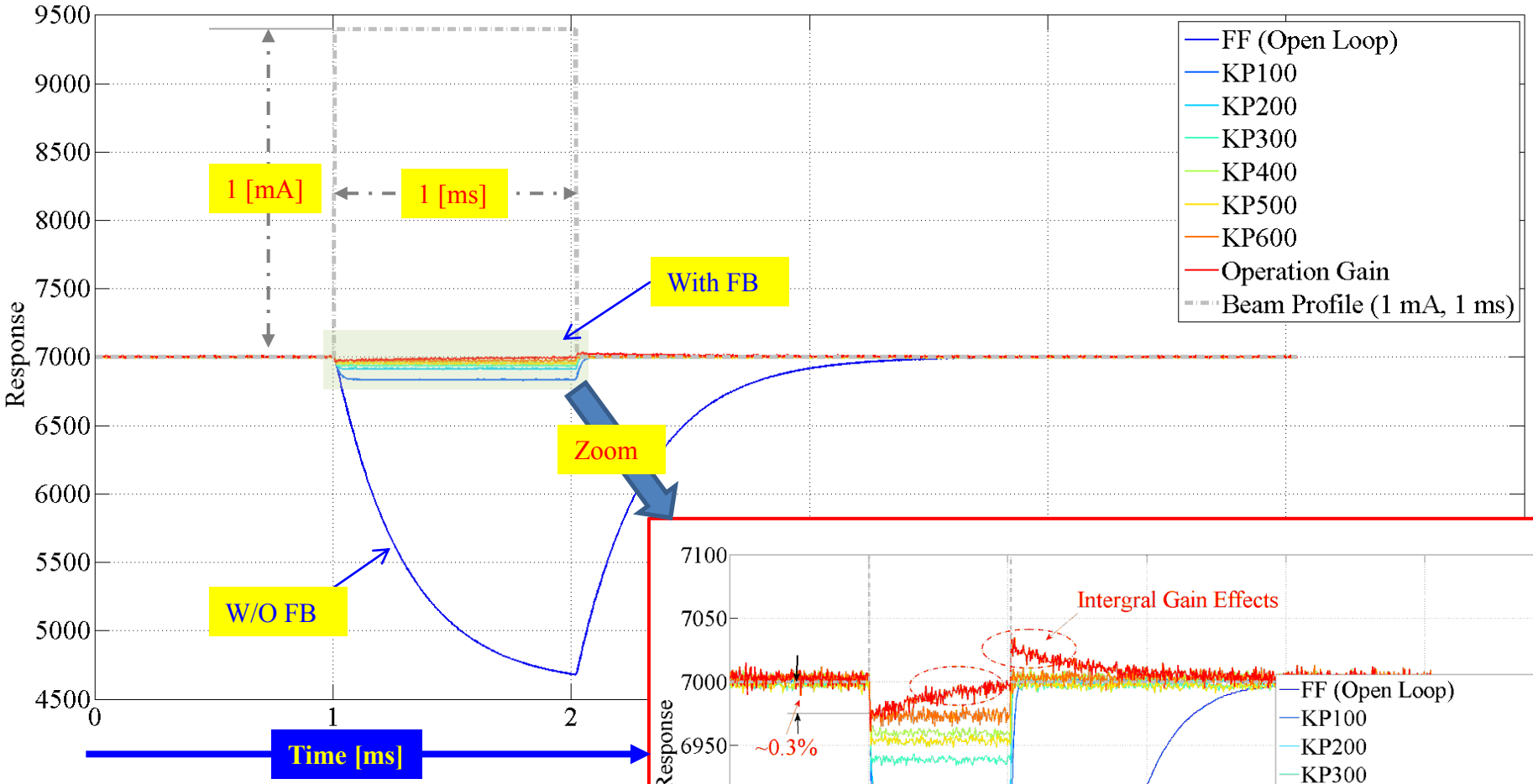


Inj.1	Value
QL	1.2e6
Length	0.23 [m]
r/Q	200 [Ω]

$$\begin{bmatrix} V_{r,n} \\ V_{i,n} \end{bmatrix} = \begin{bmatrix} 1-T\omega_{1/2} & -T\Delta\omega \\ T\Delta\omega & 1-T\omega_{1/2} \end{bmatrix} \begin{bmatrix} V_{r,n-1} \\ V_{i,n-1} \end{bmatrix} + T\omega_{1/2}R_L \begin{bmatrix} I_{r,n-1} \\ I_{i,n-1} \end{bmatrix}$$

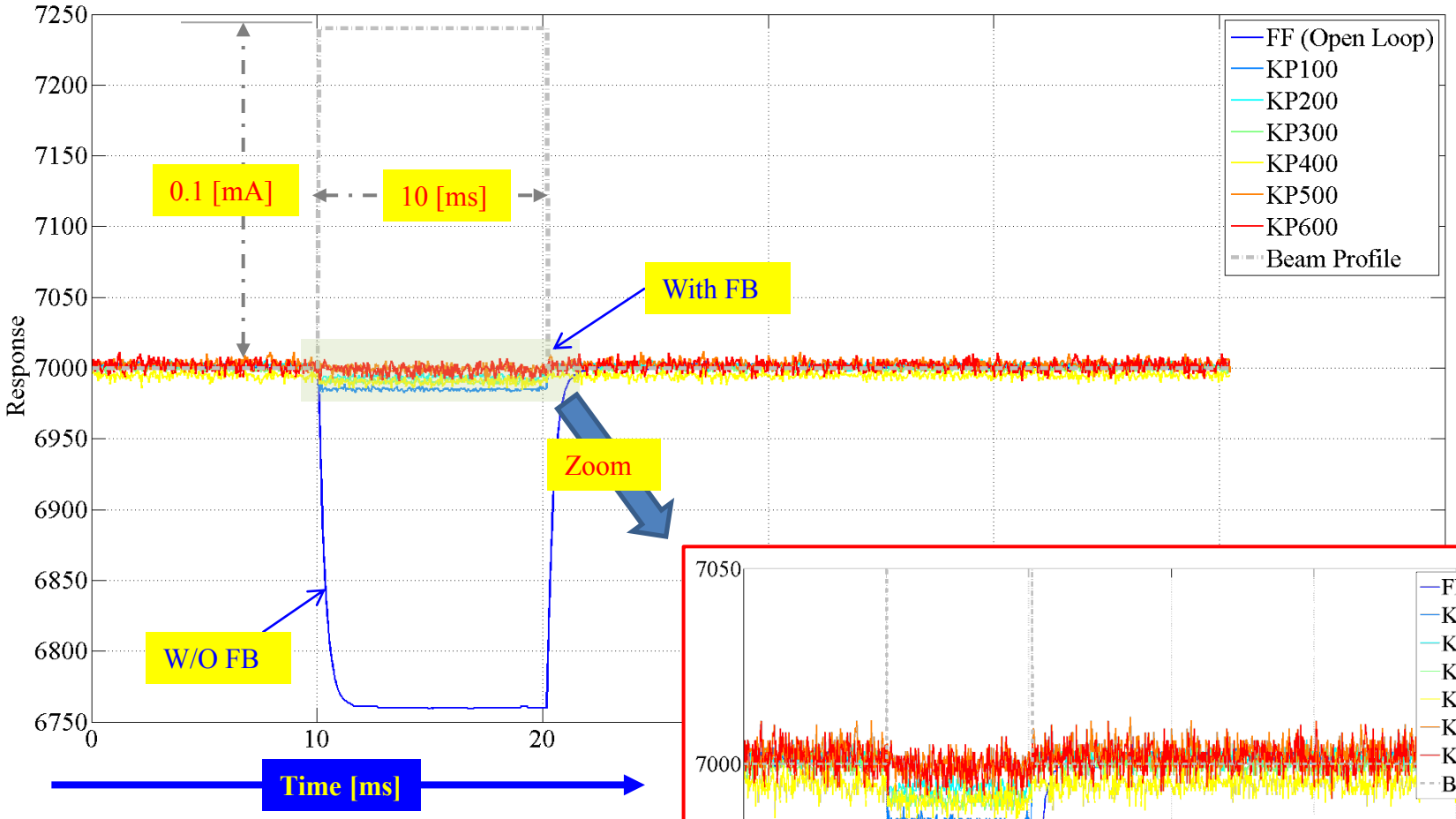
- FBGA based Cavity simulator is used as the emulator for the Inj. 1 cavities

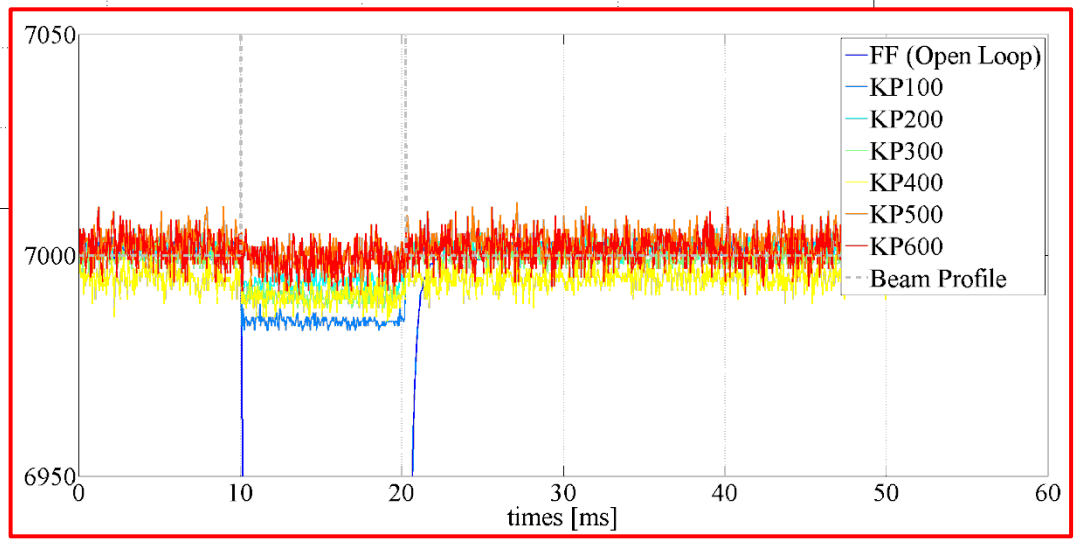
Feedback Effects (1 ms, 1 mA)



- The Beam induced energy error is about 0.3 % (Maximum value) under current PI gains.

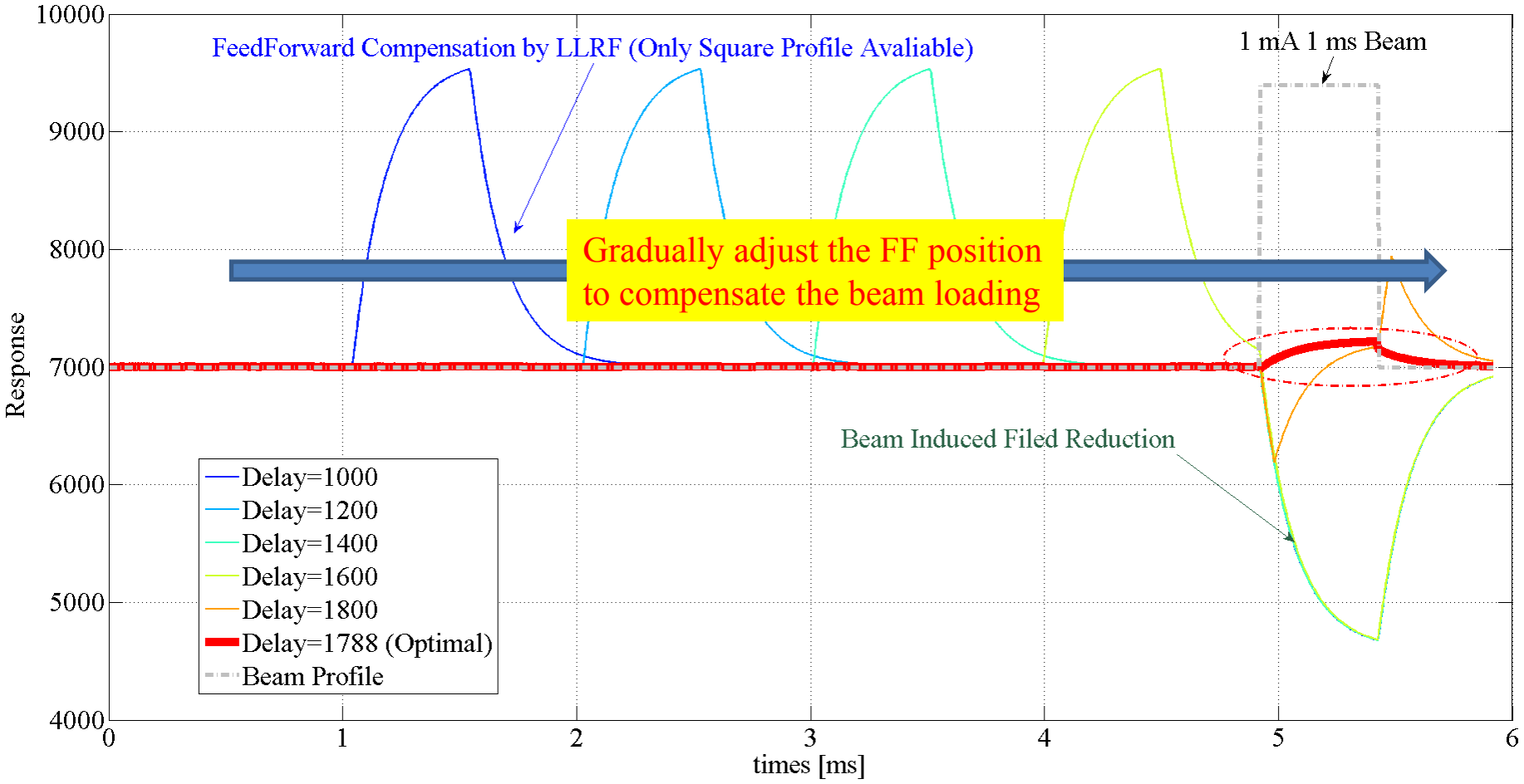
Feedback Effects (10 ms, 0.1 mA)





- Almost can be neglected in the high FB ctrl.

FF compensate(1 ms, 1 mA)



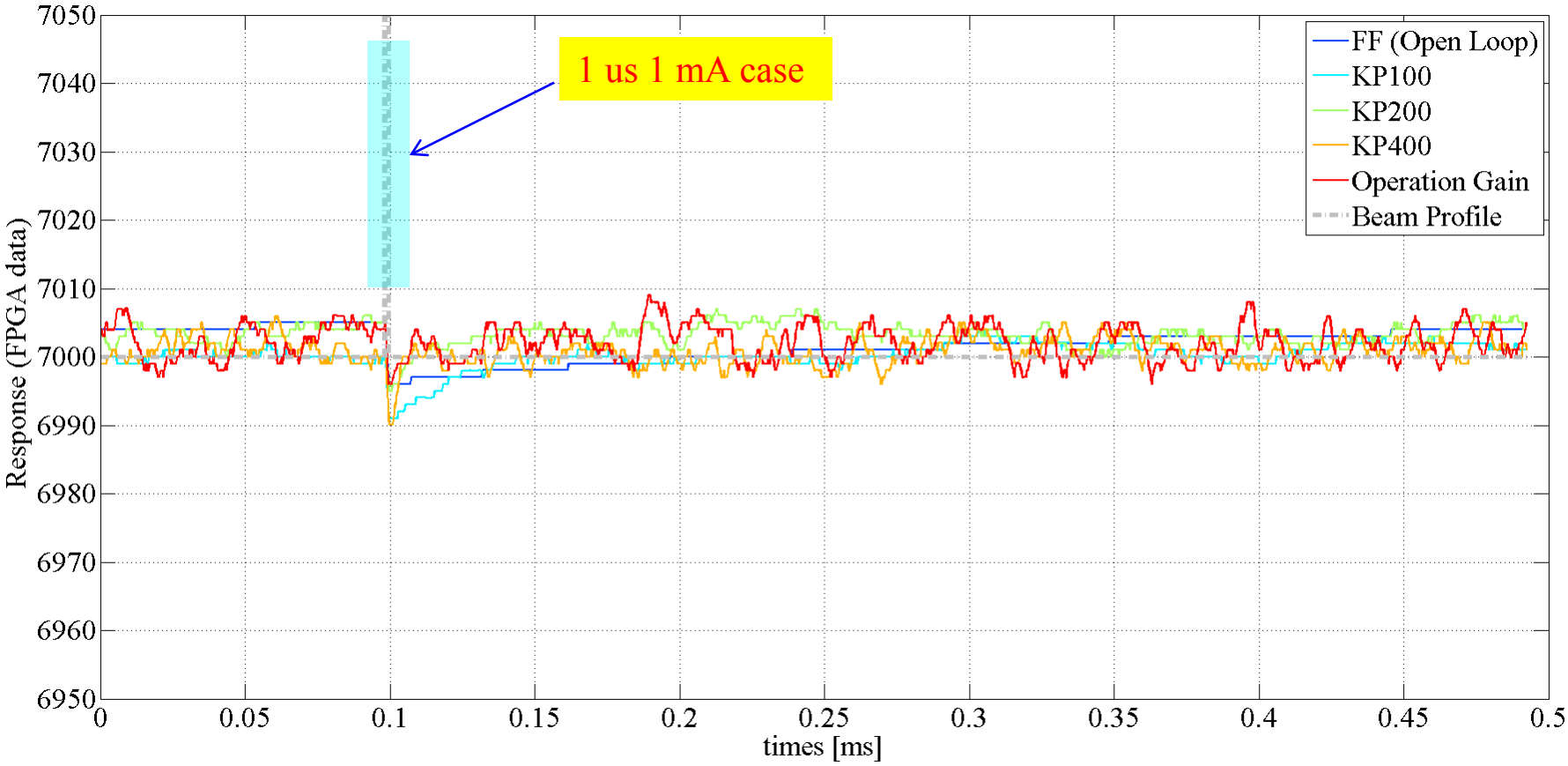
- Feed Forward Compensation can be also effects if the beam profile is square-like wave (The current LLRF system can only realized the square wave FeedForward).

Question?

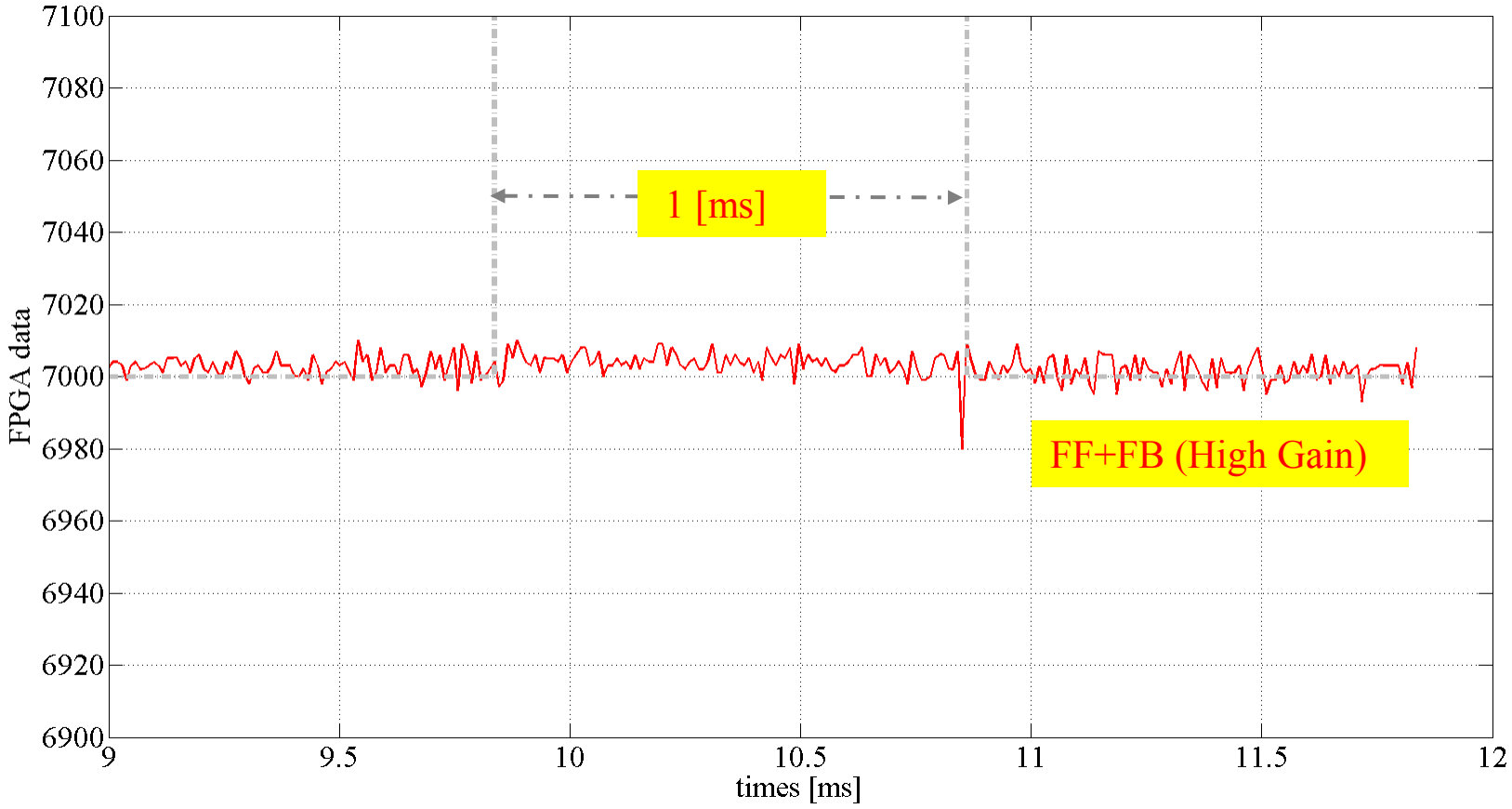
Thank you very much for your attending

Back up

FF compensate(1 us, 1 mA)



FF +FB (1 ms, 1 mA)


7100
7080
7060
7040
7020
7000
6980
6960
6940
6920
6900
FPGA data
9
9.5
10
10.5
11
11.5
12
times [ms]
1 [ms]
FF+FB (High Gain)