Photoinjector for sub-picoseconds pump and probe experiments

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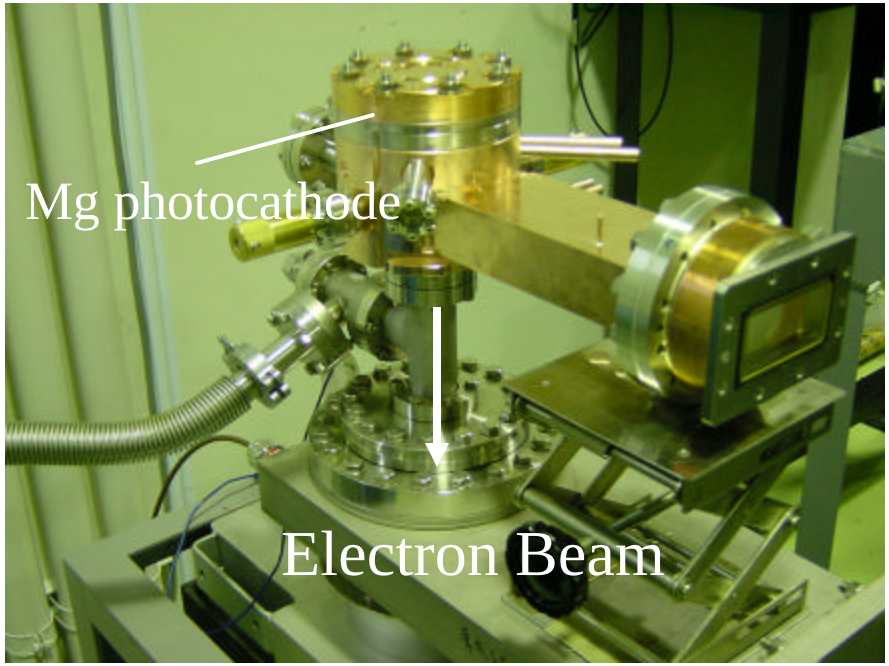
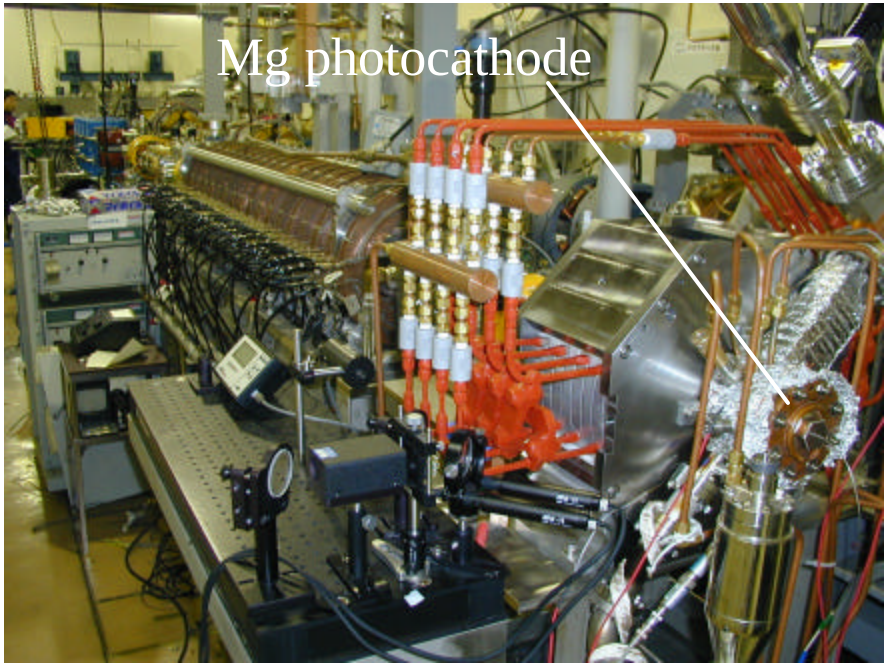
U. Tokyo, UTNS Linac & Mg Photocathode RF Gun

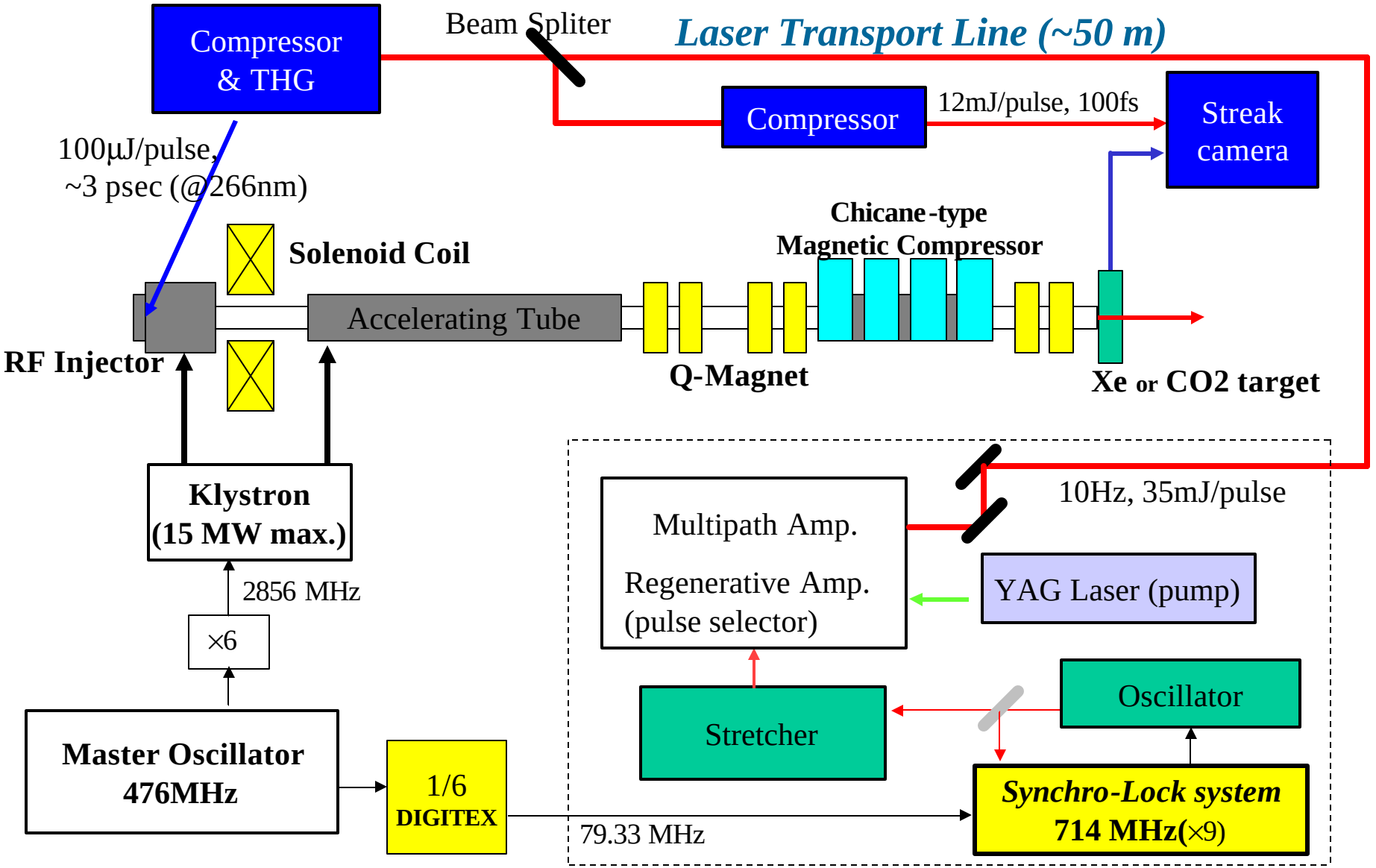


? 18 MeV Linac with the RF gun



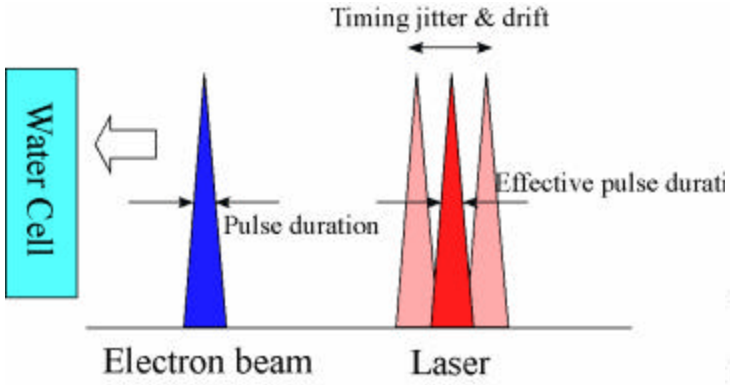
? Mg photocathode
+
BNL type IV RF gun

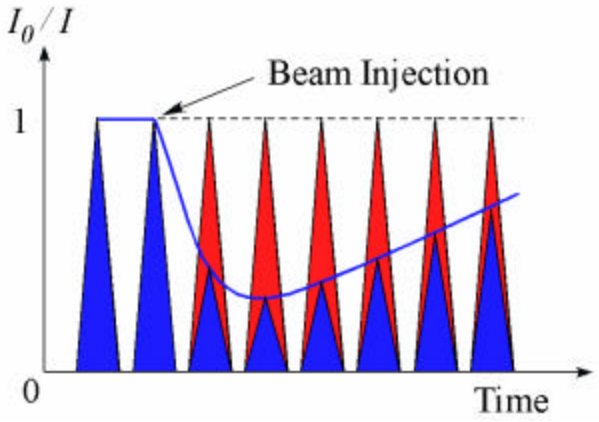
Experimental setup and Synchronization System



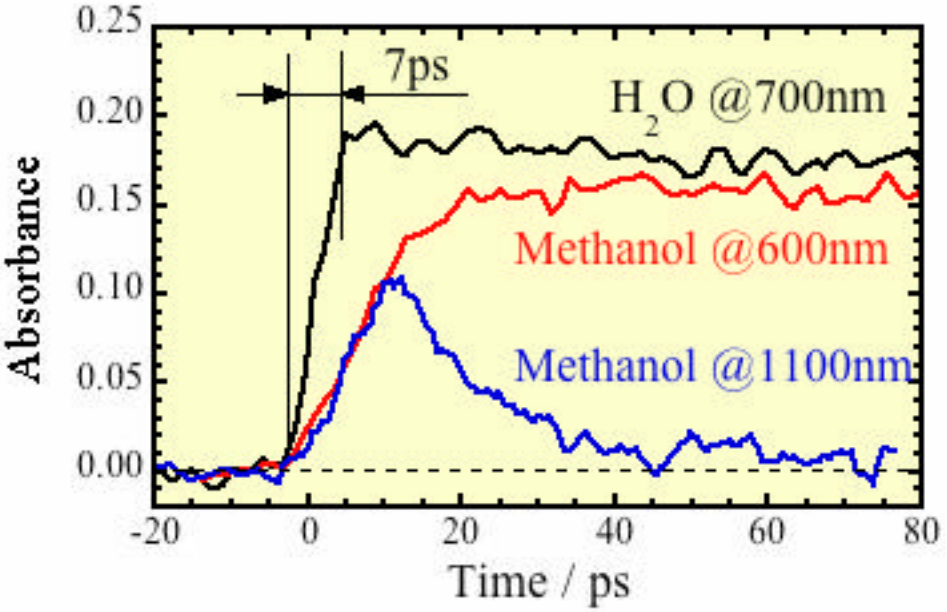
Pump and Probe experiments

Pulse radiolysis method





Chemical reaction of water



NERS U. Tokyo Y. Muroya et al.,

Requirements

For Pumping beam

Short pulse
Single beam, low dark current
High intensity

For Probe beam

Short pulse
Synchronization to pumping beam
Tunable wavelength

fs laser(Ti:Sapphire laser)
+
Photocathode RF gun

Suitable combination

Pulse radiolysis in a time range of sub-picosecond

(Ultra-short bunch and laser)

I Stable synchronization

II Intense electron bunch

Requirement of stable synchronization

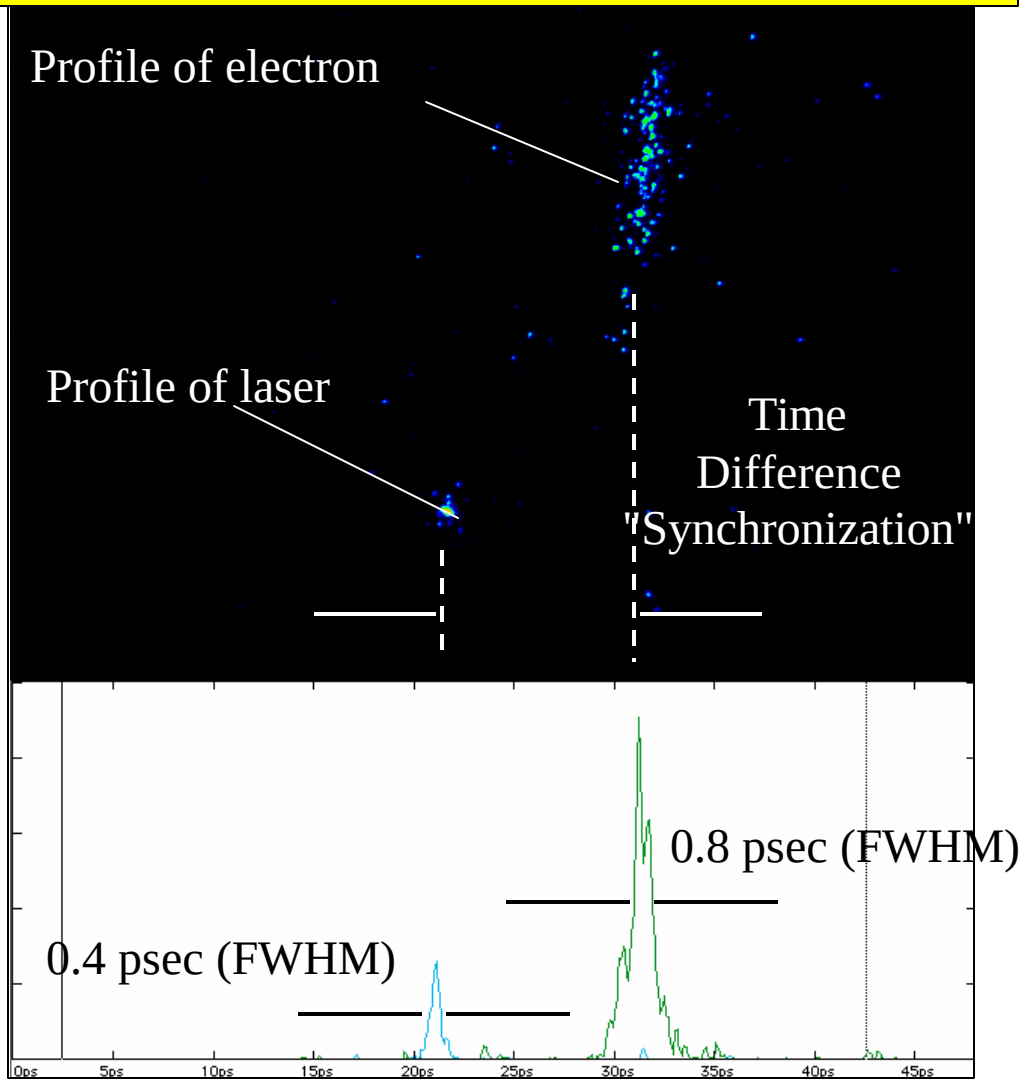
Typical Femtosecond Streak Camera Image of Synchronization

• The S-band linac with Mg photocathode RF injector has been developed for radiation chemistry.

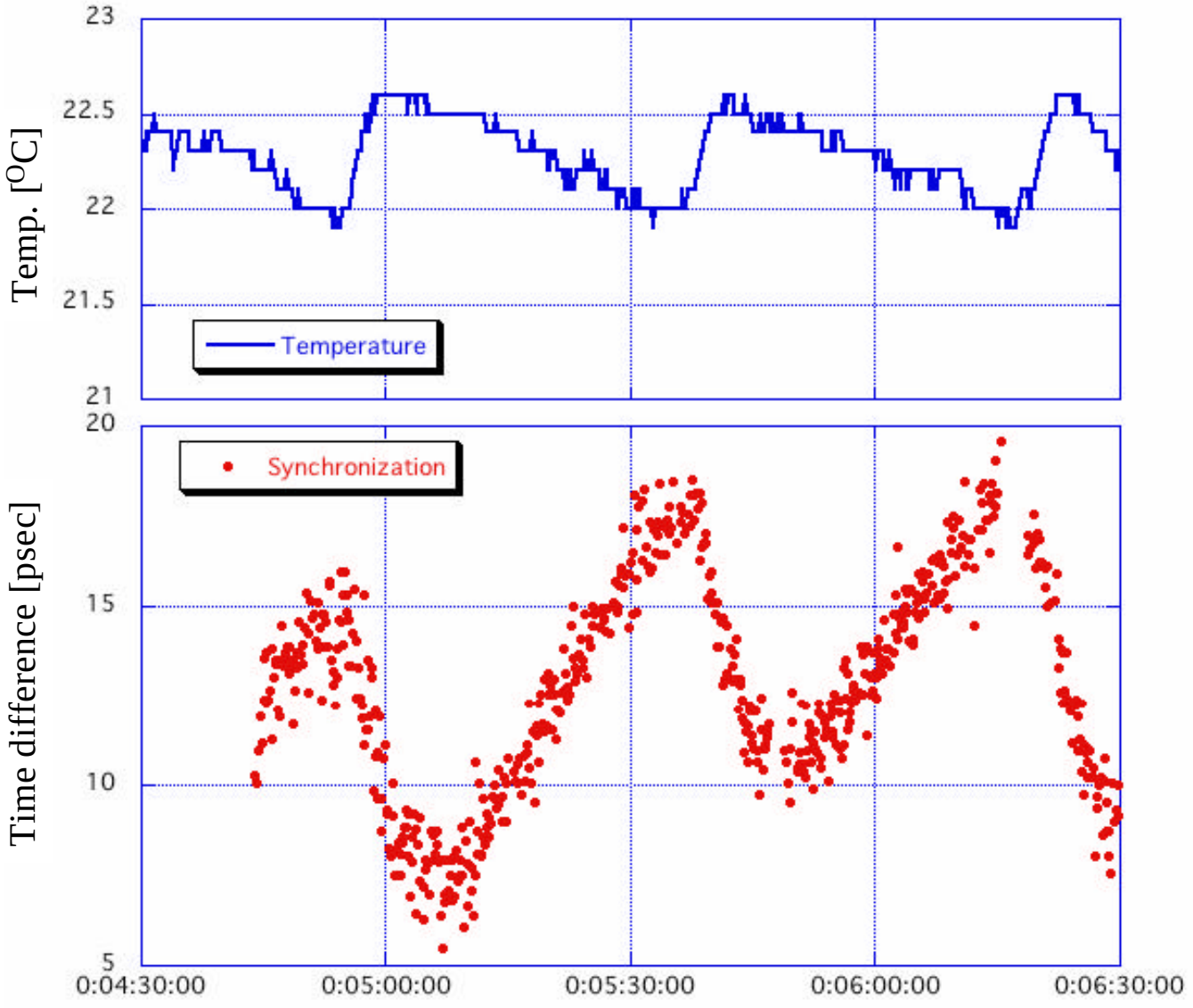
• The radiation chemistry experiment requires a time resolution in a range of sub-picosecond.

• The time resolution is defined by… *pulse duration of pump-beam, and probe-laser, synchronization between the beam and laser, and the beam intensity*.

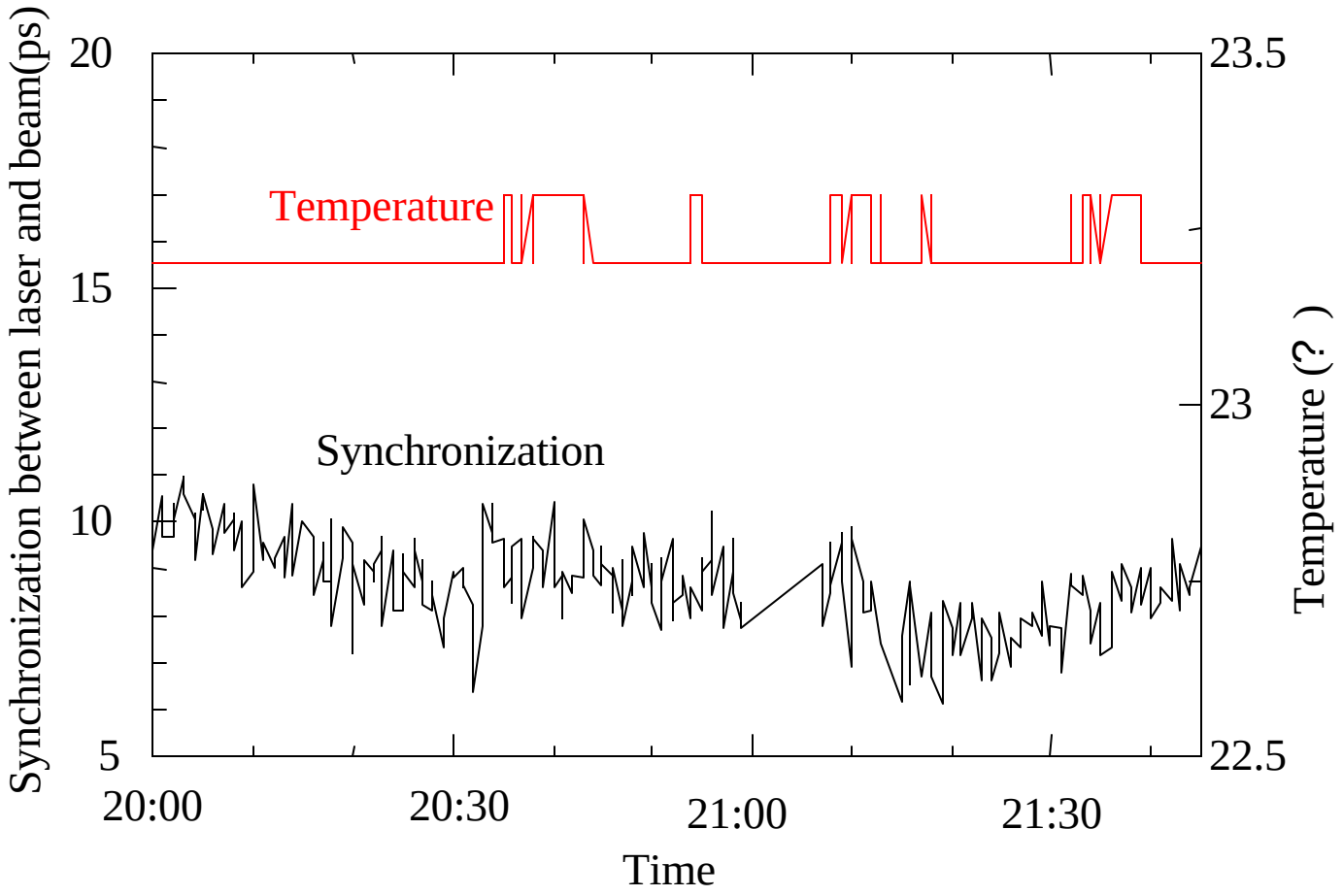
We can control the time difference between laser and electron beam by optical delay line.
The fluctuation of time difference is important.



The drift of the Laser-room temperature has much effort to Synchronization between laser and electron beam

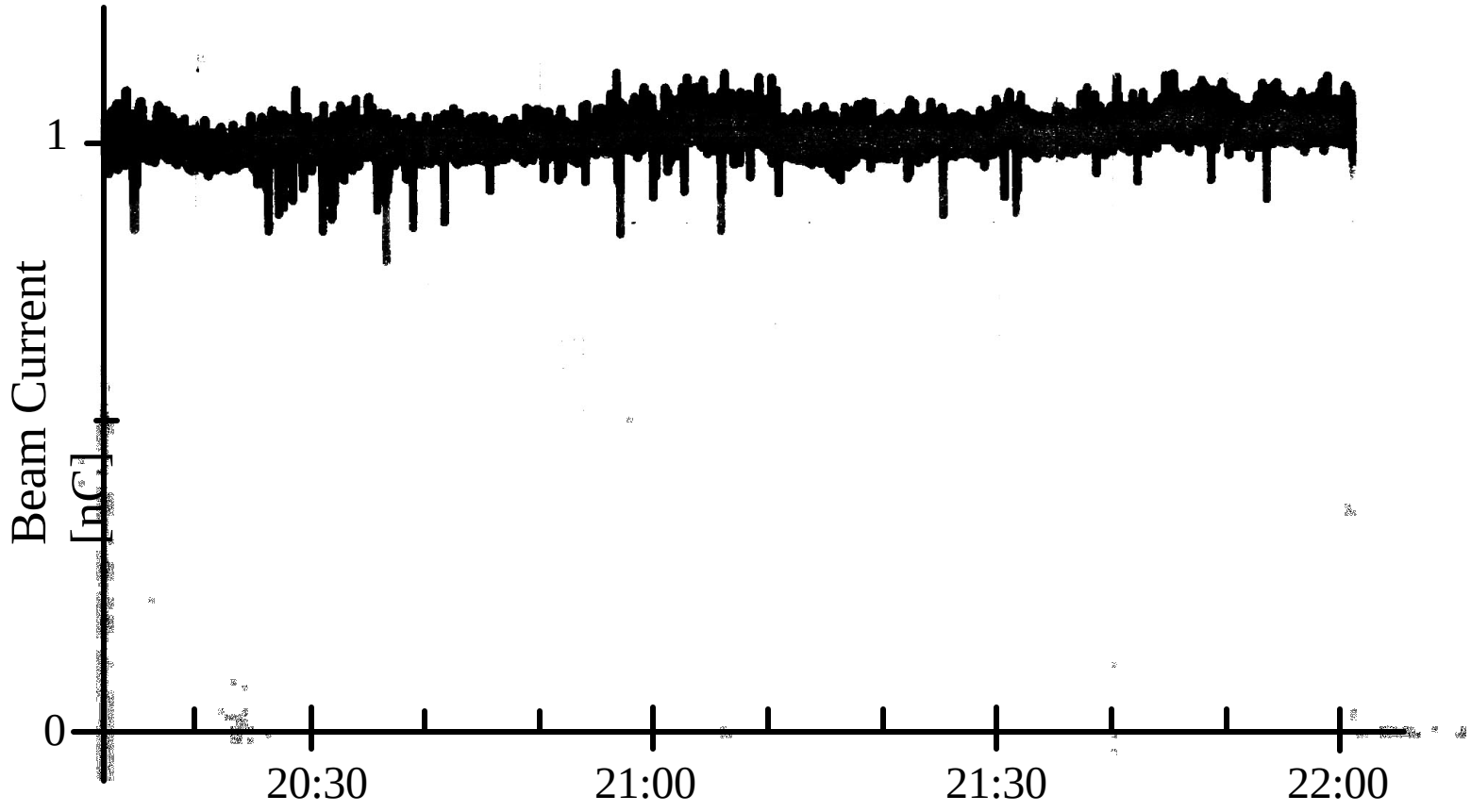


Correlation between Laser-room temperature and Synchronization



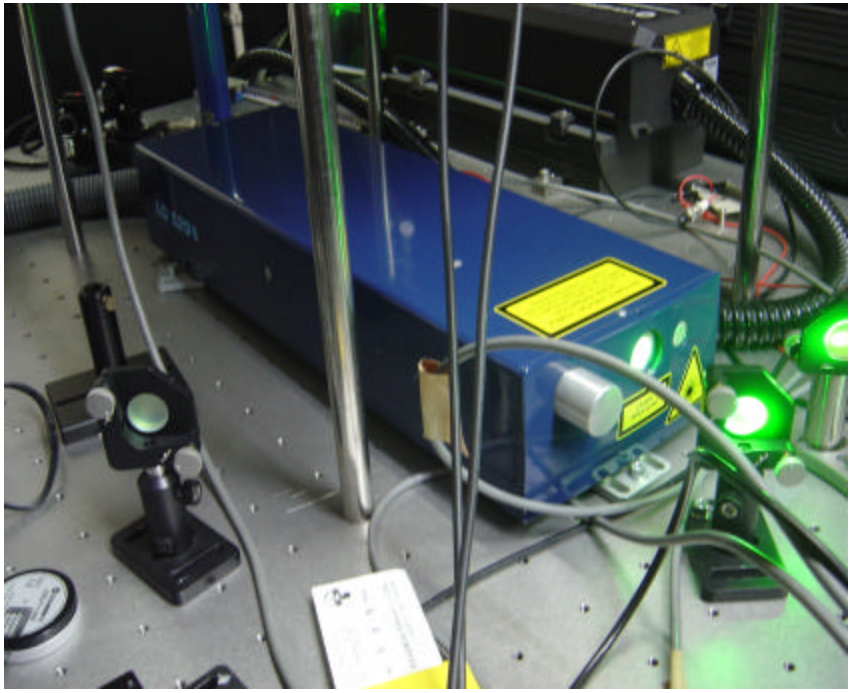
From 20:00 to 21:30, we could keep the laser room temperature shift within 0.1 ? , so that we could see no-drift and timing jitter is estimated as 600 fs (rms).

Beam current stability



The electron beam stability is 4%(rms) during 1 hour (20:30-21:30).

High stability of Pumping laser



Change to Solar laser inc. 529A

To decrease flash lamp jitter by temperature controlled water plate, the stability of power reaches to less than 1%.

We will suppress the beam current fluctuation…

In order to use High QE cathode, we will install the Cathode handling system in vacuum

Advantage

No surrounded by air, water, oxygen….

-> No (or few) damage or deplete QE at handling.

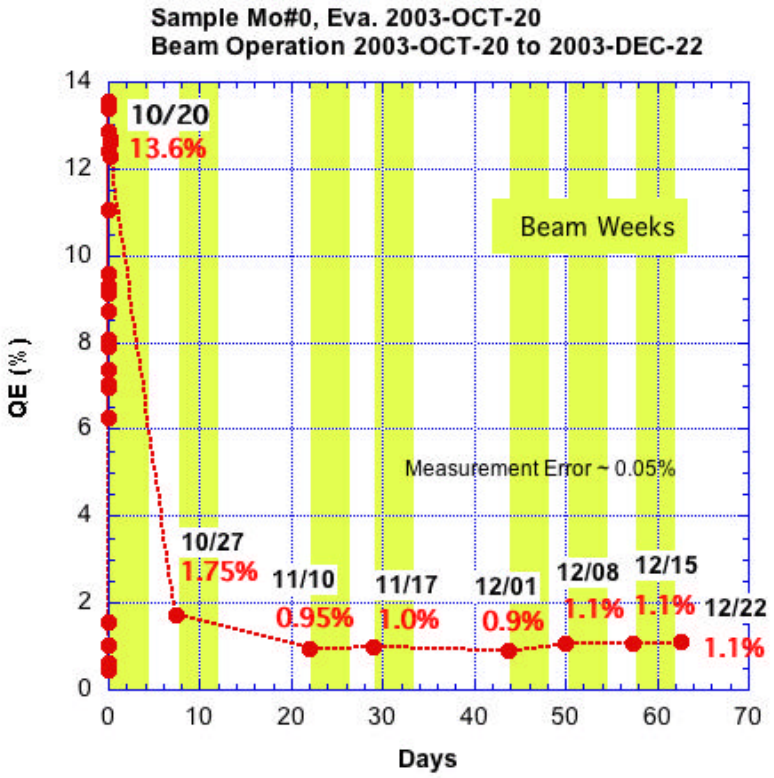
We can use a high QE cathode, as Cs2Te, also Mg, etc…..

There are mainly “load lock” type or “cartridge type”

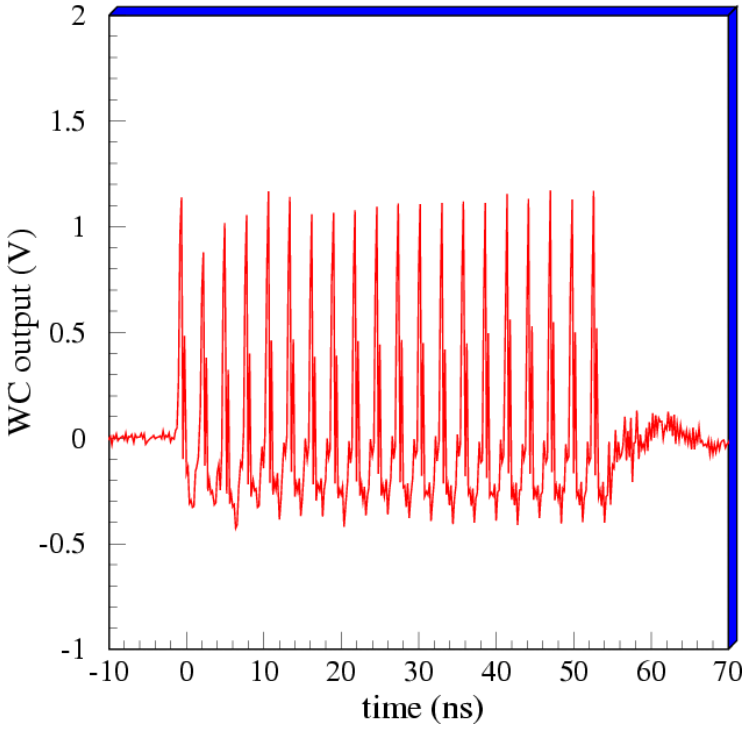
Status

From KEK

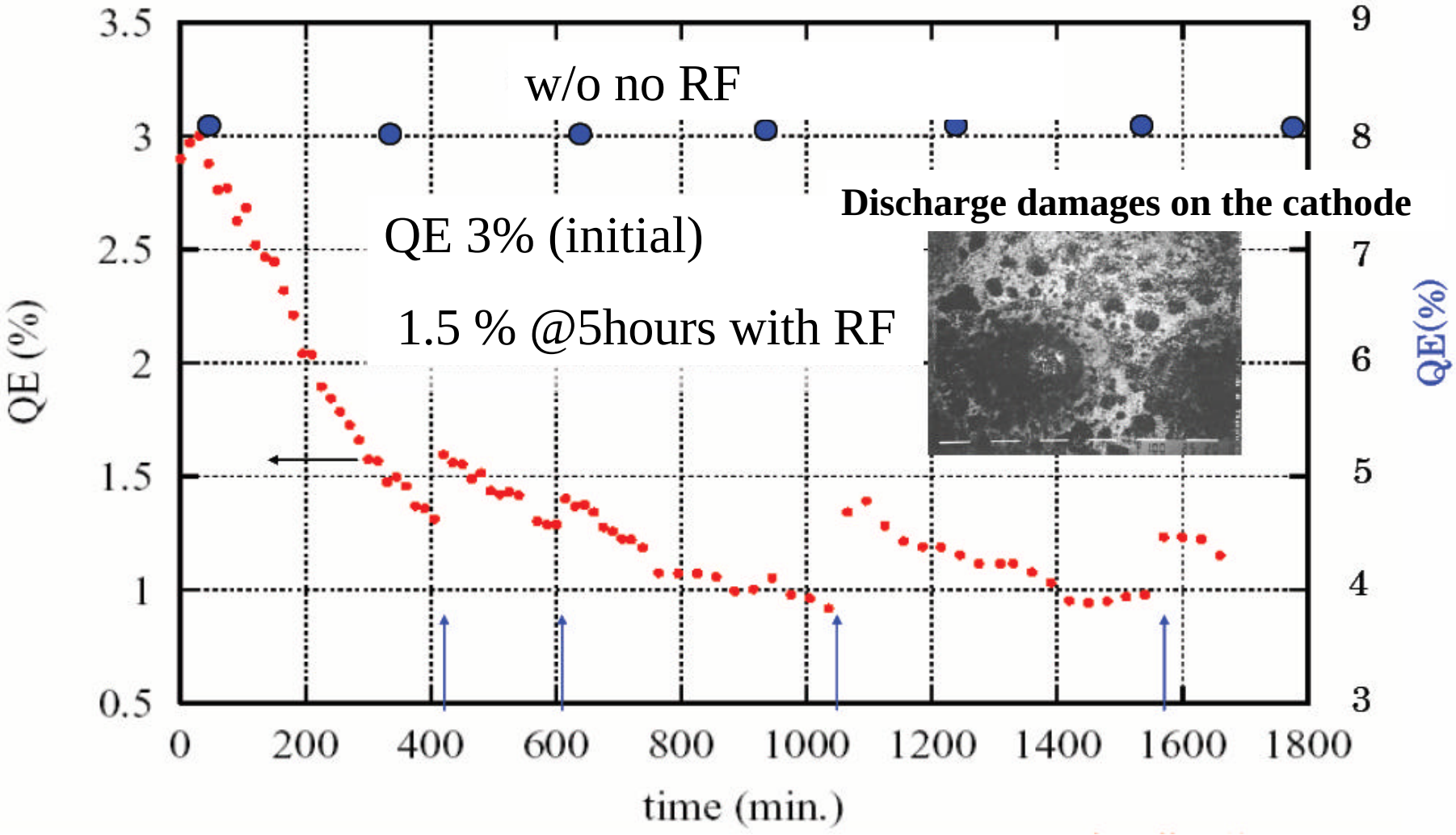
- QE that was initially more than 10% was decreased rapidly and then kept around 1%.
- It was operated routinely and stably in Multi-bunch (~20 with 2.8ns spacing).



Generated multi-bunch beam
Measured by WC monitor

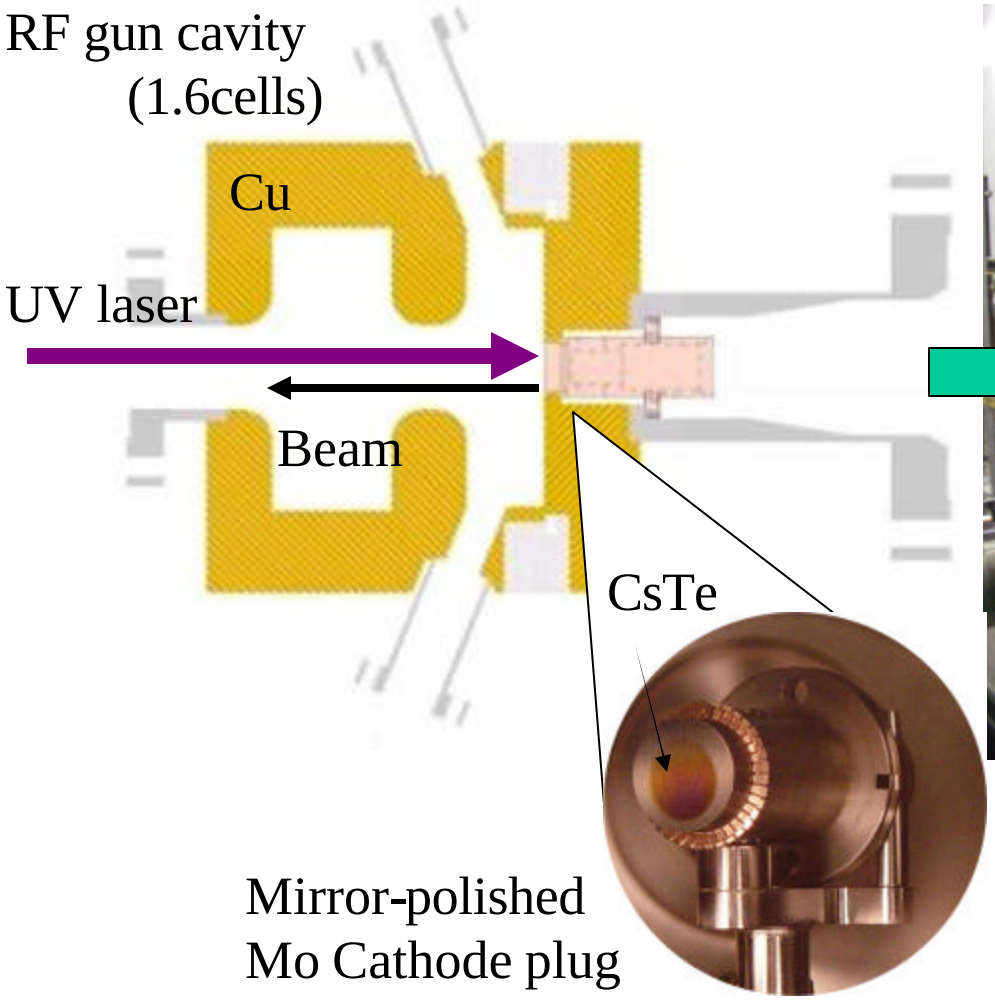


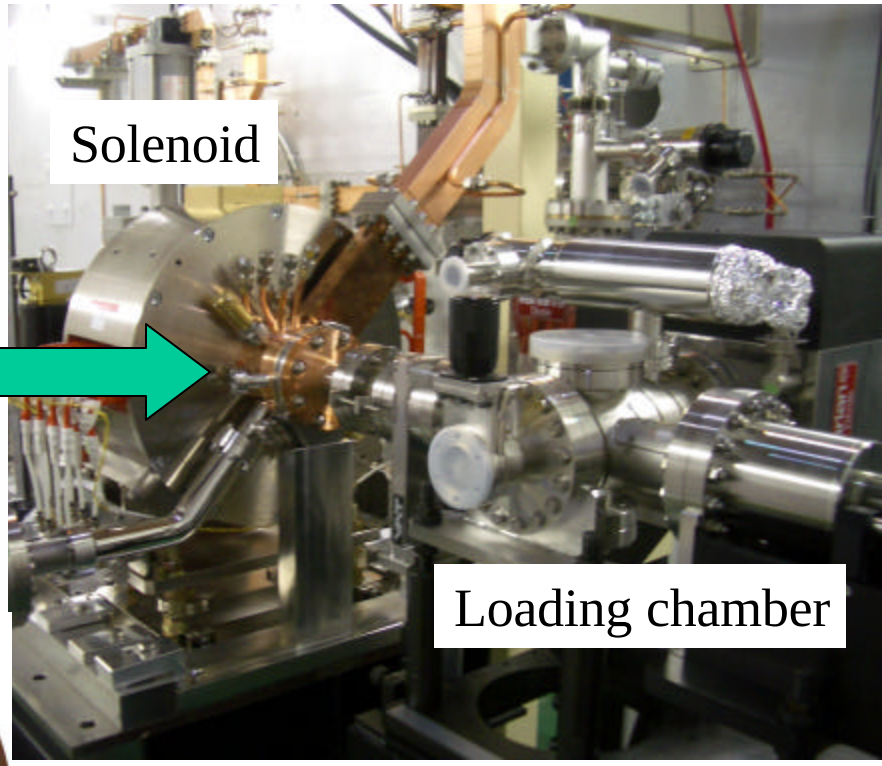
Life time of Cs_2Te cathode at Spring-8



Vacuum 1.6×10^{-7} Pa, Acc. Field 90 MV/m, Laser 120 μJ

RF-gun Cavity & Cathode Plug of KEK -ATF

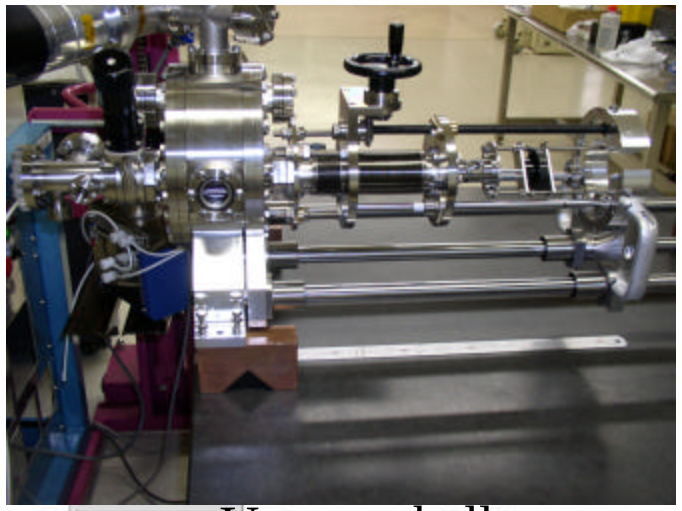


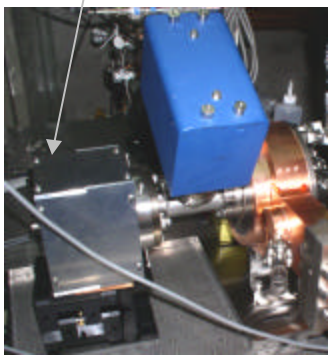


RF-Cavity with a cathode-module at SPring-8

•Laser: 197-1000 nm?
8-20 ps? 10Hz

•12 plugs in one revolver
•~1.2m length
from back plate





R F IN

G ate valve

R F cavity

Vacuum bellows

Faraday Cup

R/L motion feedthrough

e

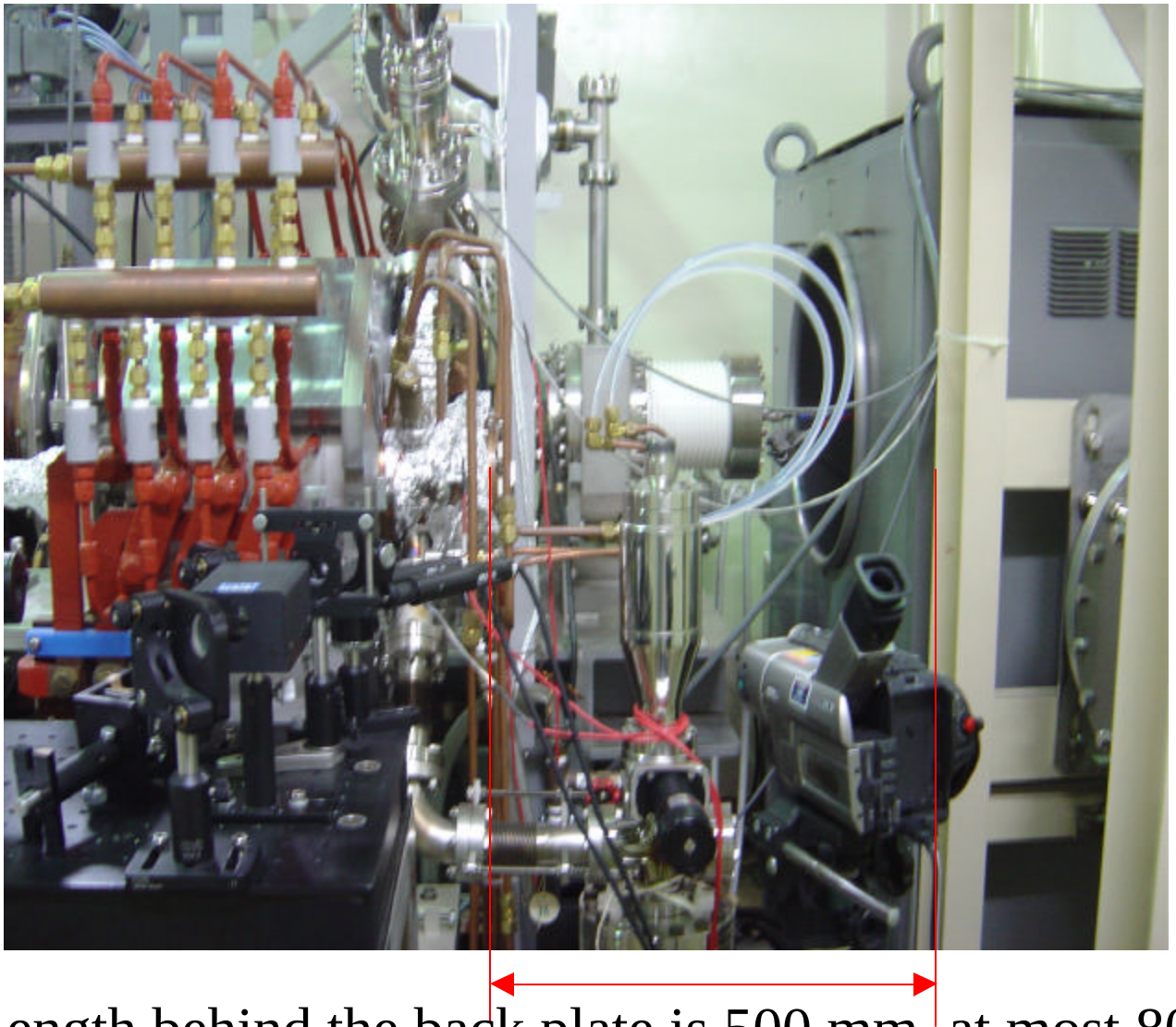
Cathode plug

Revolver-type
Cartridge holder

R F
OUT

cf, http://www.spring8.or.jp/ja/support/download/publication/report_series/publicfolder_view

Space around the RF gun at U. Tokyo

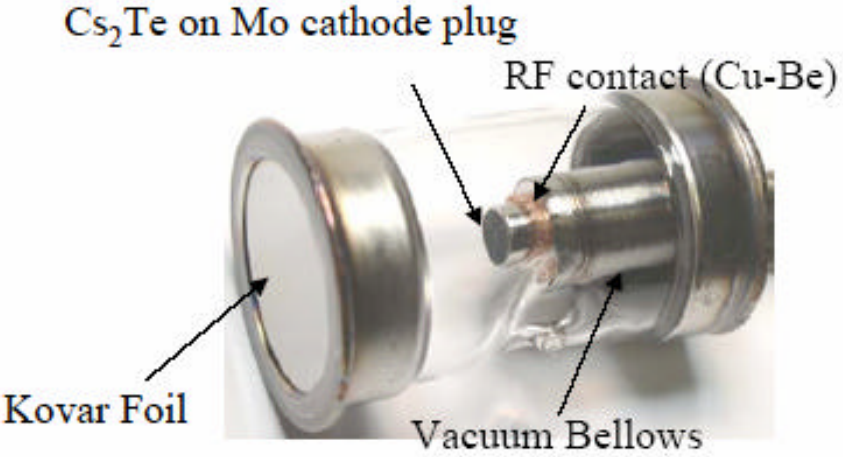


Length behind the back plate is 500 mm, at most 800mm.

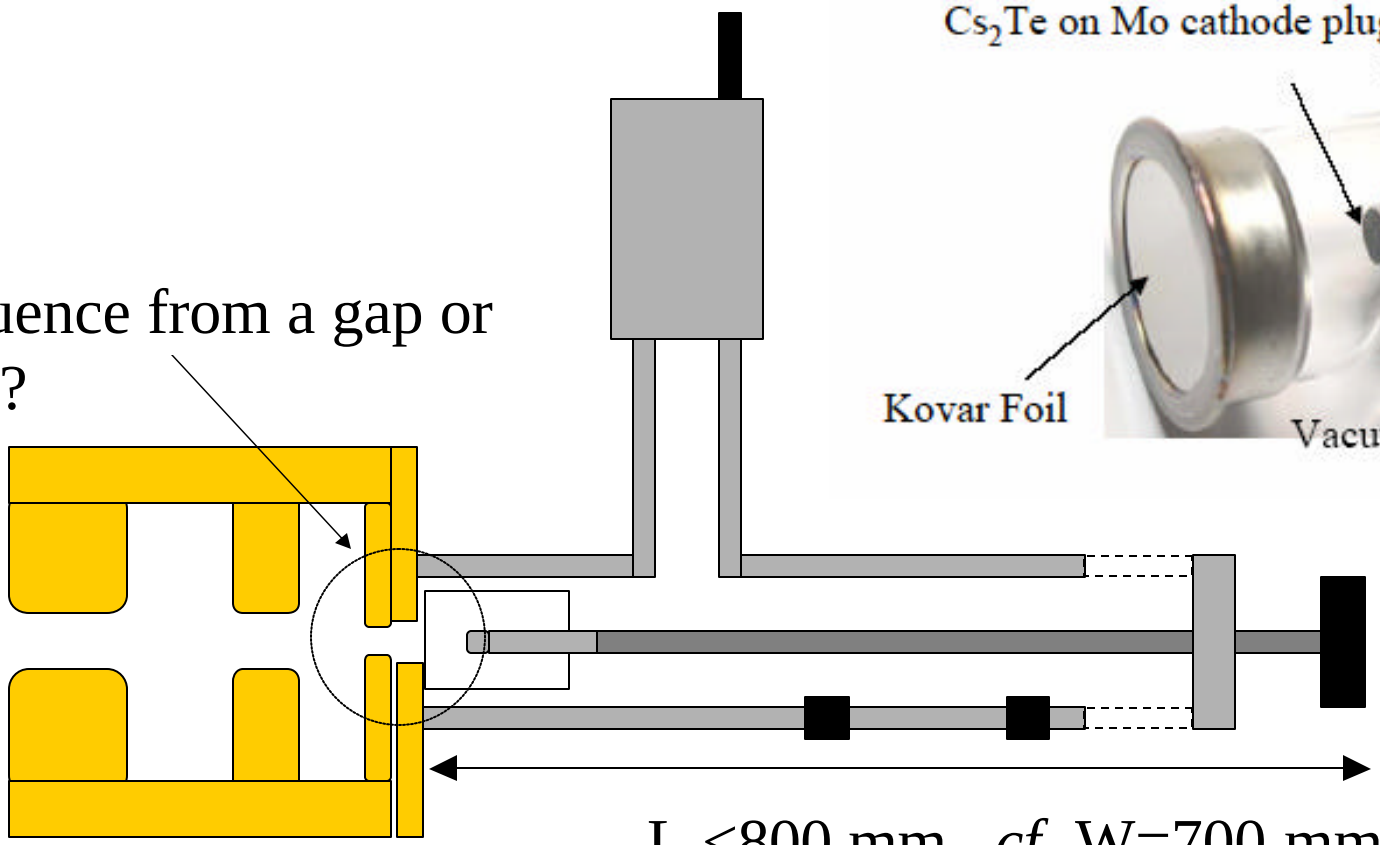
We have to develop a compact system.

Prototype Compact Cartridge system for BNL-IV 1.6cells RF gun

Plugs made by HPK inc.



Influence from a gap or hole?

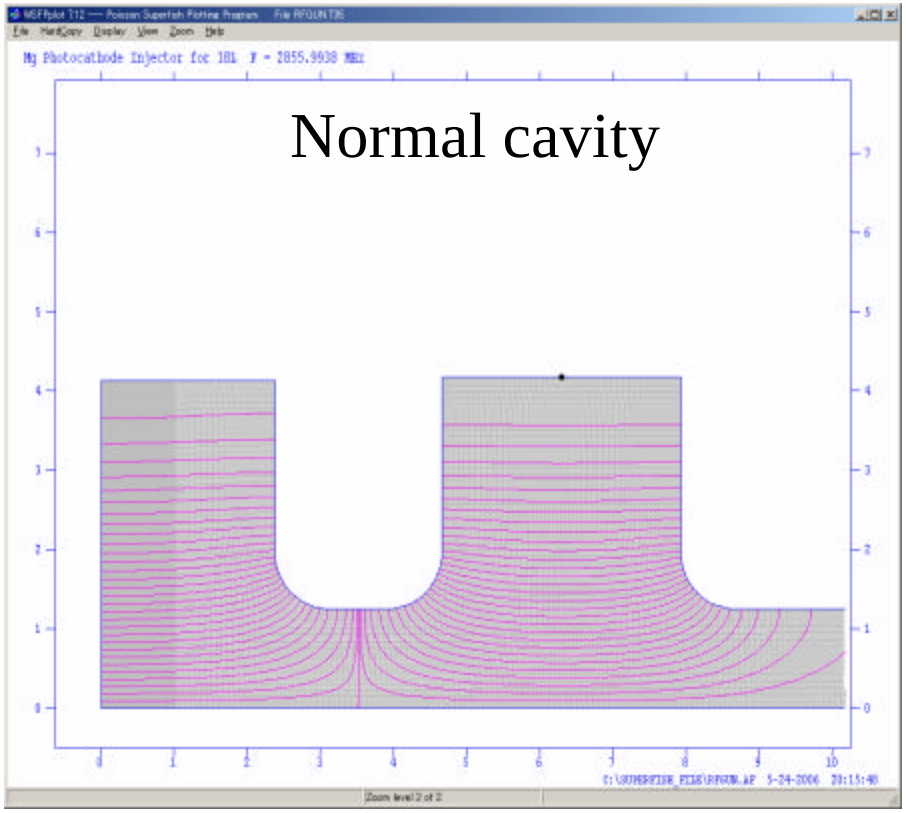


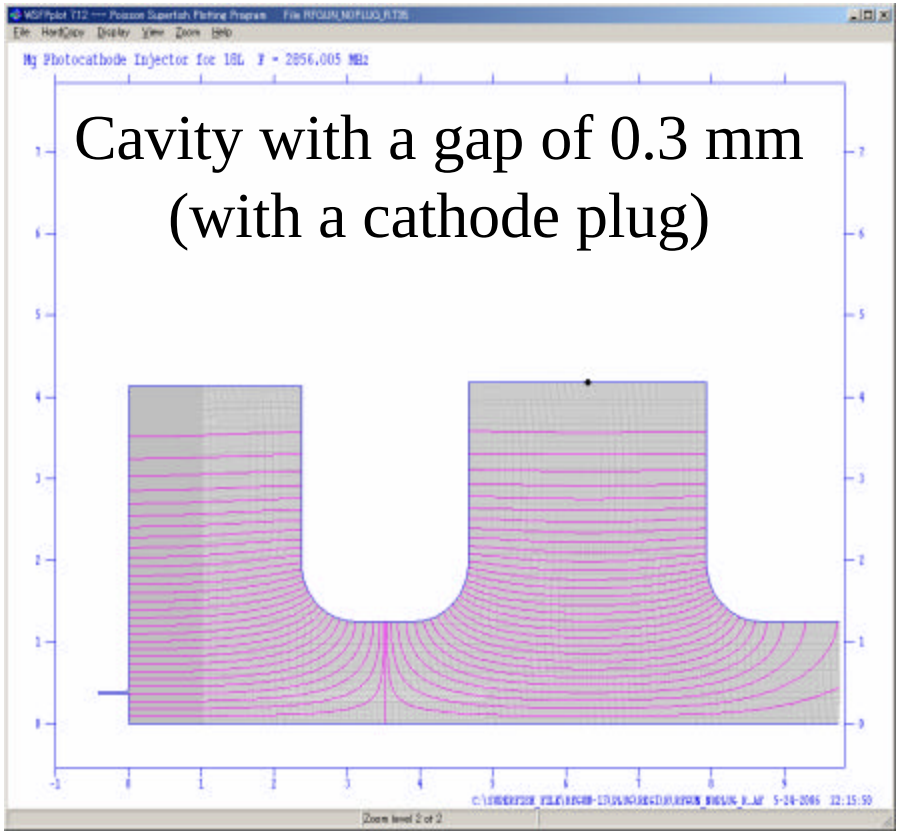
L <800 mm, *cf* W=700 mm

We can use several cathodes by cartridge-type exchange system.

Electric field distribution of pi-mode

By superfish

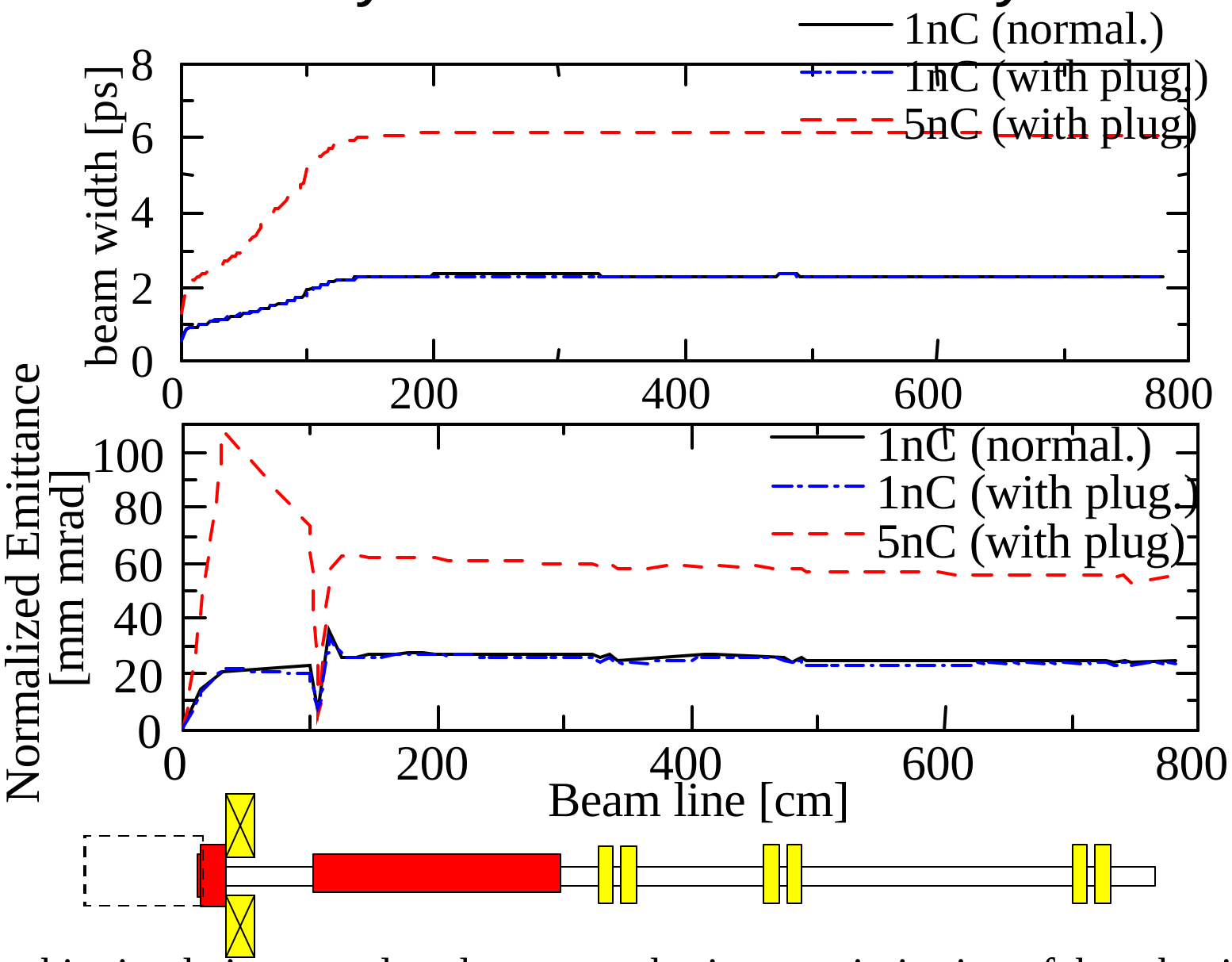




Parameters of each cavity

	Normal cavity	With a plug
Frequency (MHz)	2855.95420	2855.93688
Q	13650.7	13648.2
Shunt impedance (Z) (MOhm/m)	45.846	45.841
Transit-time factor (T)	0.5872646	0.5874091
Z*T*T (MOhm/m)	15.811	15.817
Stored energy (Joules)	4.2269074	4.2310995

Beam Dynamics Simulation by PARMELA



•In this simulation, we placed more emphasis on optimisation of bunch width and less on that of emittance.

Summary 1

· We can reduce the fluctuation of room temperature within 0.1 degrees.

•We can observe a good synchronization of 600 fs between the pumping electron beam and the probe laser in an hour.

(In order to synchronize in long period as one-day, we are developing to new feedback system of phase matching and point stabilizing.)

Summary

We are developing the compact cartridge system, which consists of the back plate with a hole, the cartridge-type vacuum tubes, and the linear feeder.

We performed numerical design of RF gun and beam dynamics simulation.

We calculated the beam transportation with a charge of 5 nC. We expect that the bunch width of 6 ps without a magnetic compressor, corresponding to the almost same magnitude of the bunch length at the experiment. We will estimate the beam transportation with magnetic compressor.

Scheduling

2006 2007

6. 7. 8. 9. 10. 11. 12. 1. 2. 3.

Manufacture of back plate

Test of resonance and RF inducing

7/17-28, 8/14-25, 9/18-22

Cartridge system install

Cartridge system Test with Cs_2Te Test for other cathodes

Thank you.

Special thanks to KEK, Spring-8, and colleagues of U-Tokyo.