High Quality Beams

at Waseda Univ. and Sumitomo Heavy Industries, Ltd.

Yosuke Katsumura

Extremely Low Emittance Electron Beam & Its Application for the Inverse Compton Scattering

Yasushi Aoki, Fumio Sakai
Sumitomo Heavy Industries, Ltd.

FESTA

Sumitomo Heavy Industries, Ltd.

RISE Waseda University

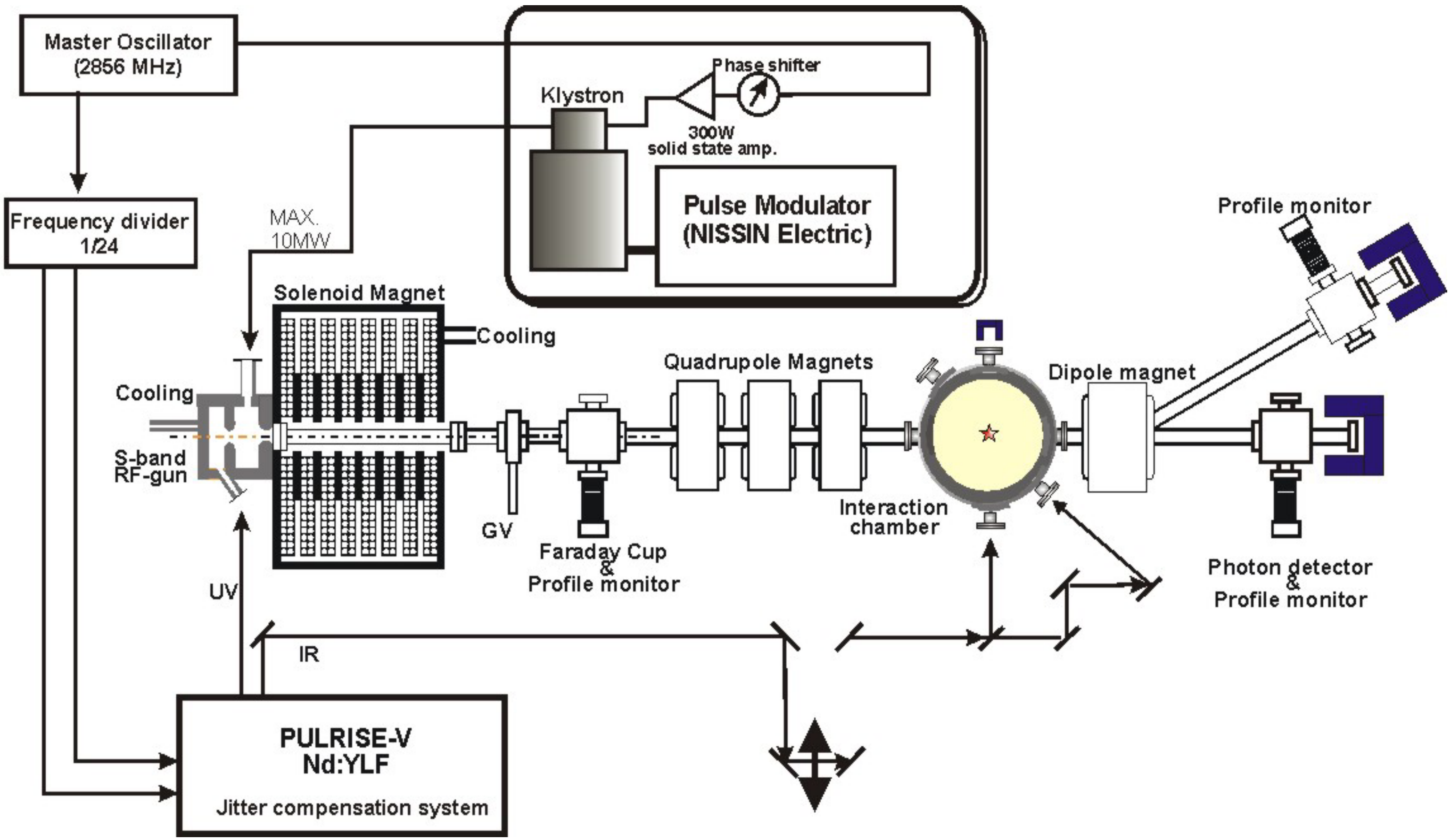
Waseda University

Present status of High Quality Beam Facility at Waseda University

Masakazu WASHIO

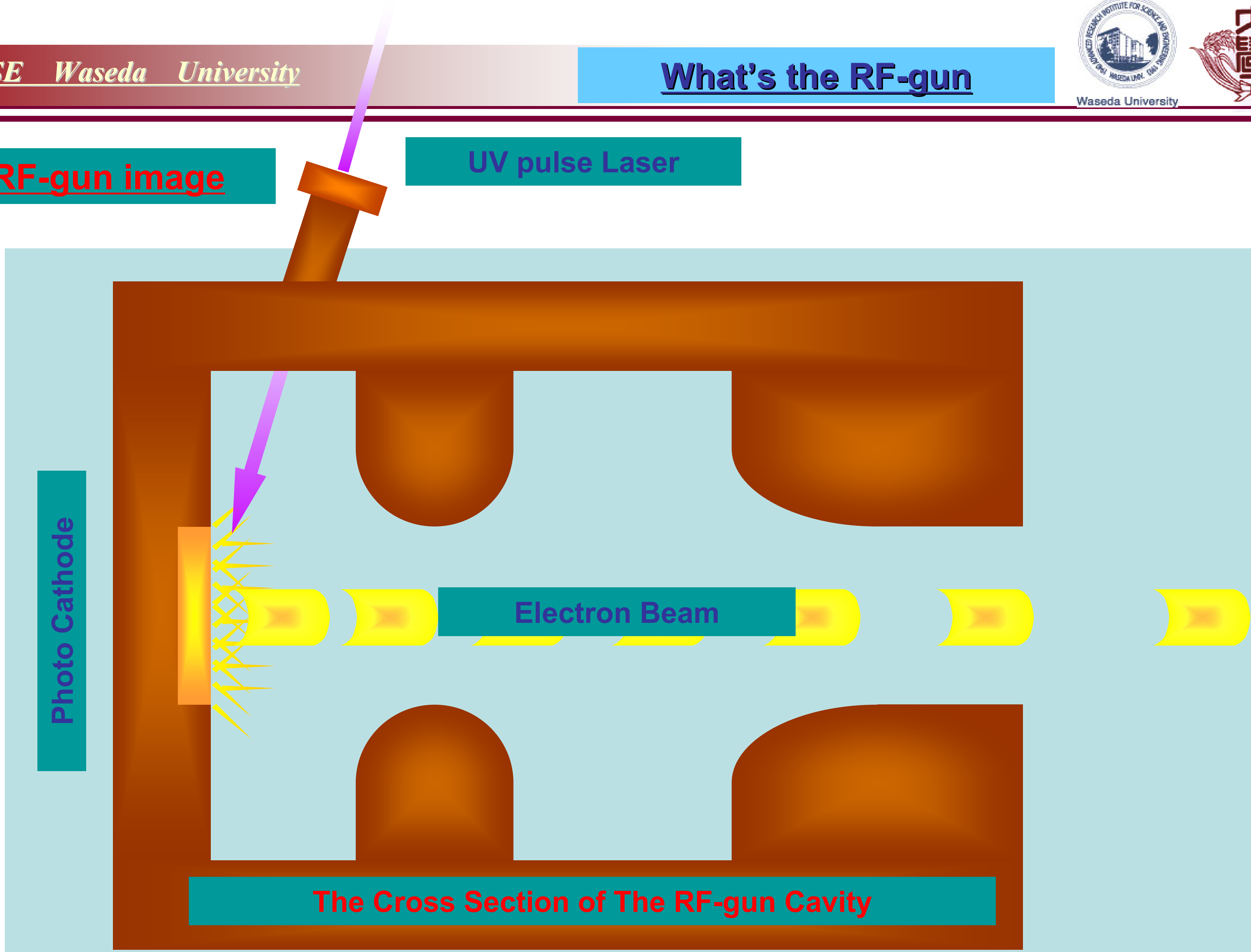
Advanced Research Institute for Science & Engineering
Waseda University

Beam Line at Waseda Univ.

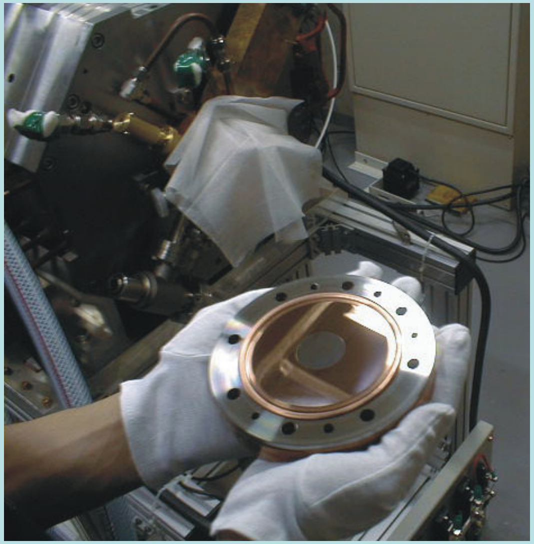


What's the RF-gun

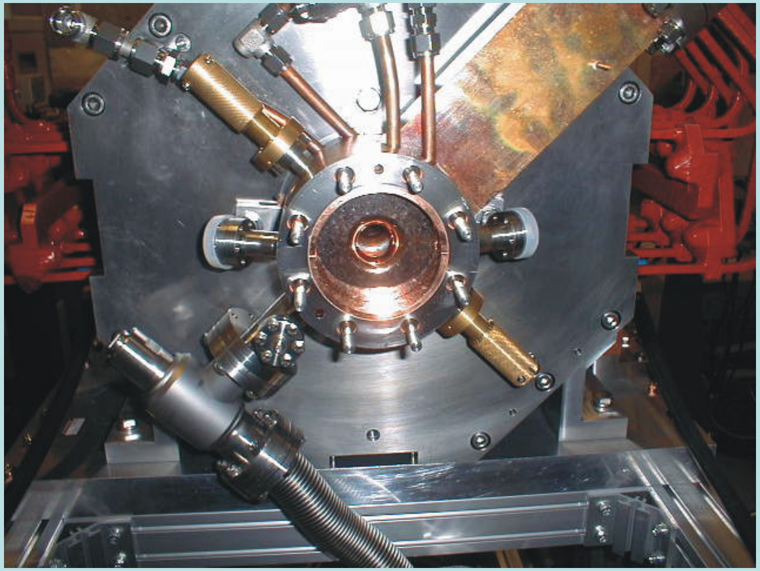
RF-gun image



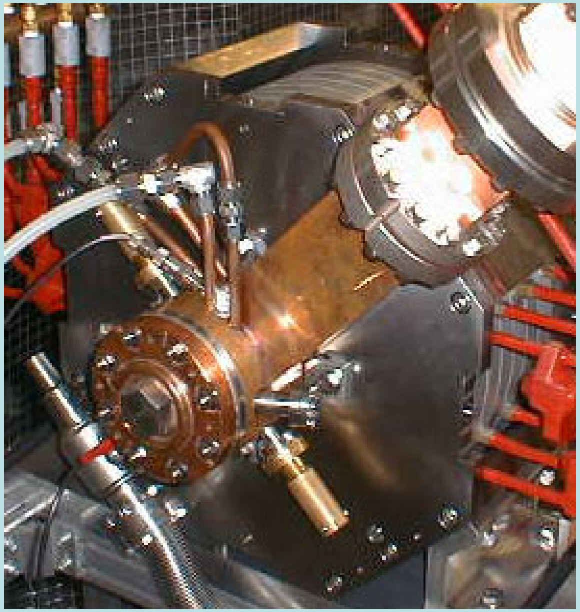
RF Gun Assemble



Cathode Plate



RF-gun Cavity without Cathode



RF-gun

Laser System (Nd:YLF)

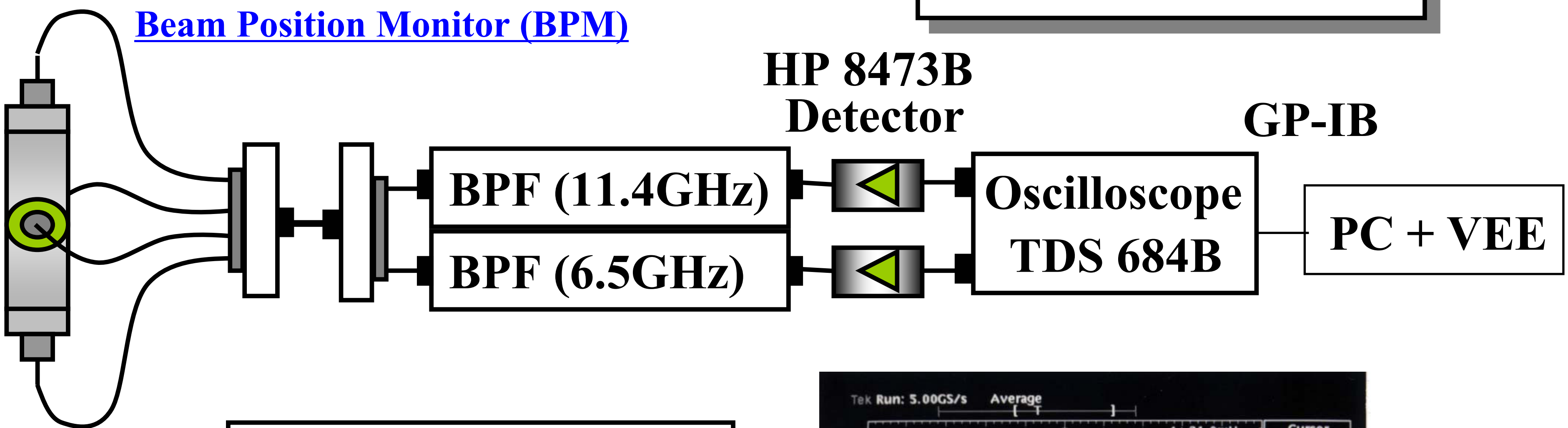
[Pulrise V]

Laser system	:	Nd:YLF
Pulse Width (FWHM)	:	10 ps
Energy per Pulse		
UV (262 nm) for RF-gun	:	0.15 mJ
Green(524nm) Probe light	:	0.4 mJ
IR(1047 nm) Collision and Probe	:	1 mJ
Repetition	:	1-25 Hz

- Timing stabilizer
  (119MHz seed light)
- Intensity stabilizer
  (25 Hz UV light)

• RMS Bunch Length Monitor

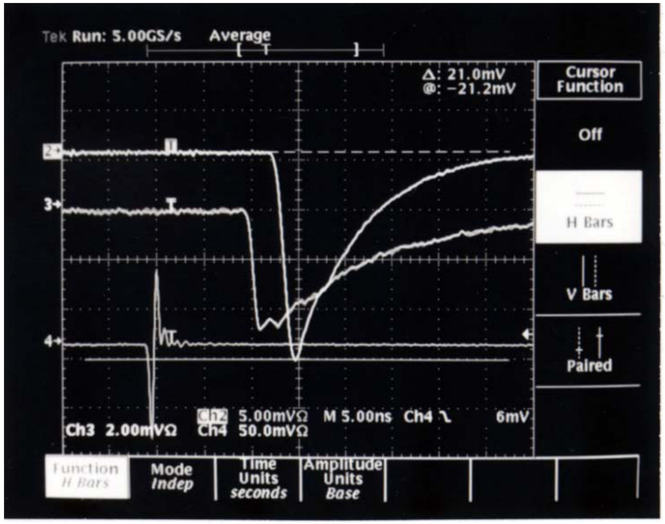
Bunch length Measurement by Beam Spectrum



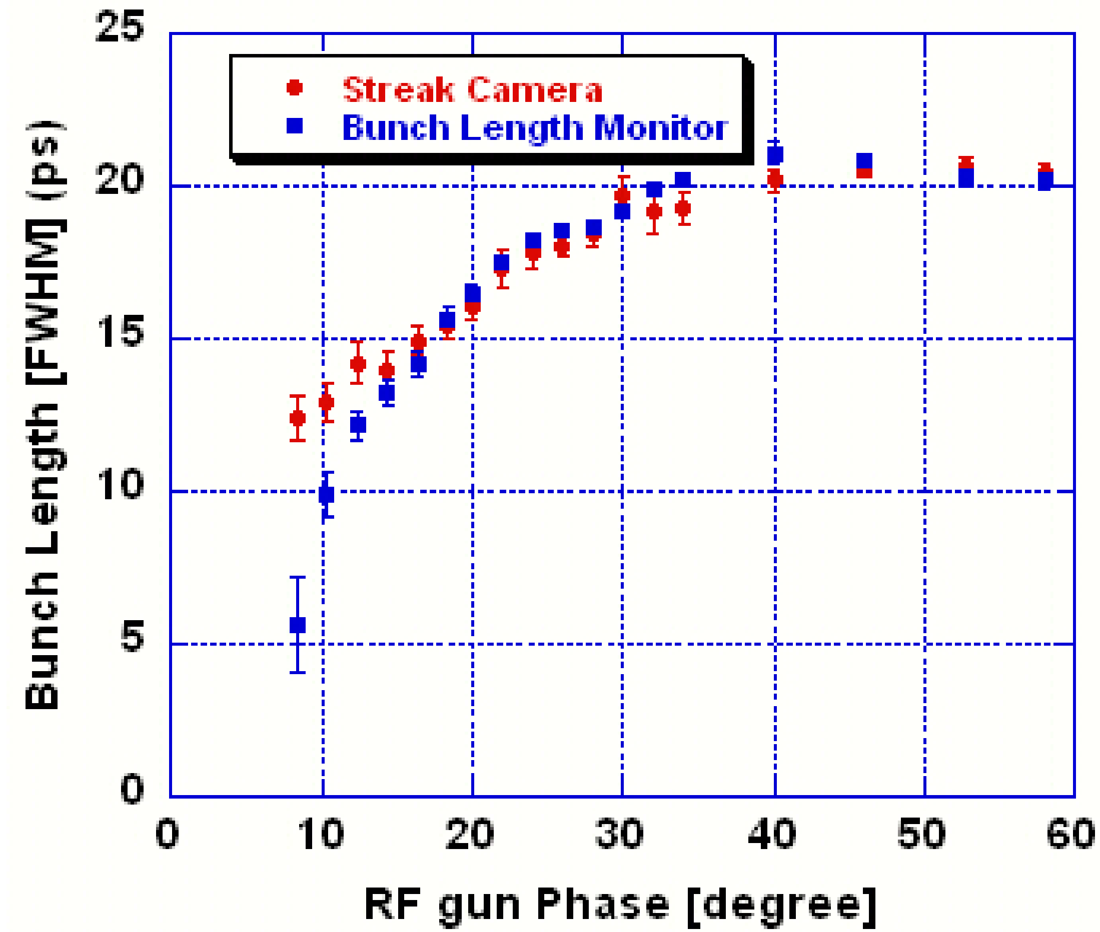
$$\sigma_t = \sqrt{\frac{2}{\Delta\omega^2} \ln\left\{ \frac{|F_1(\omega_1)|}{|F_2(\omega_2)|} \right\}}$$

$$\Delta\omega^2 = \omega_2^2 - \omega_1^2$$

$$\omega_2 > \omega_1$$

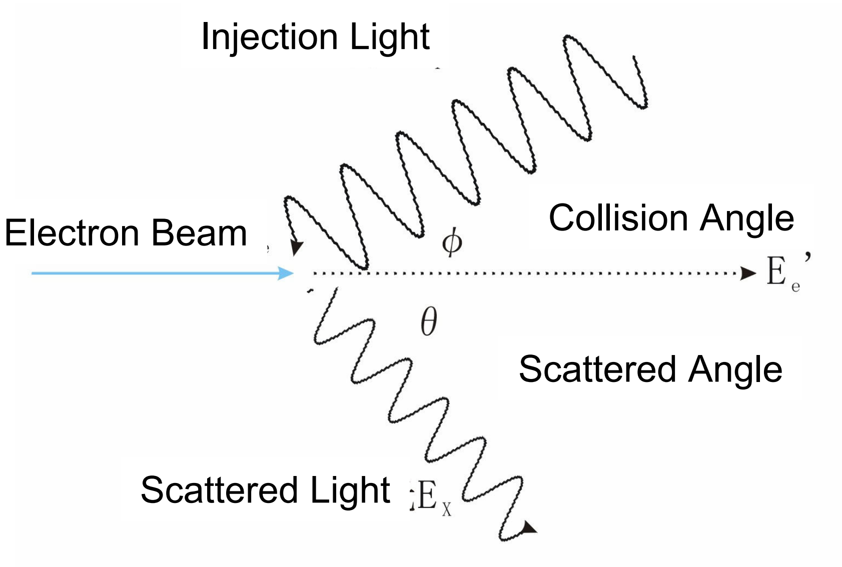


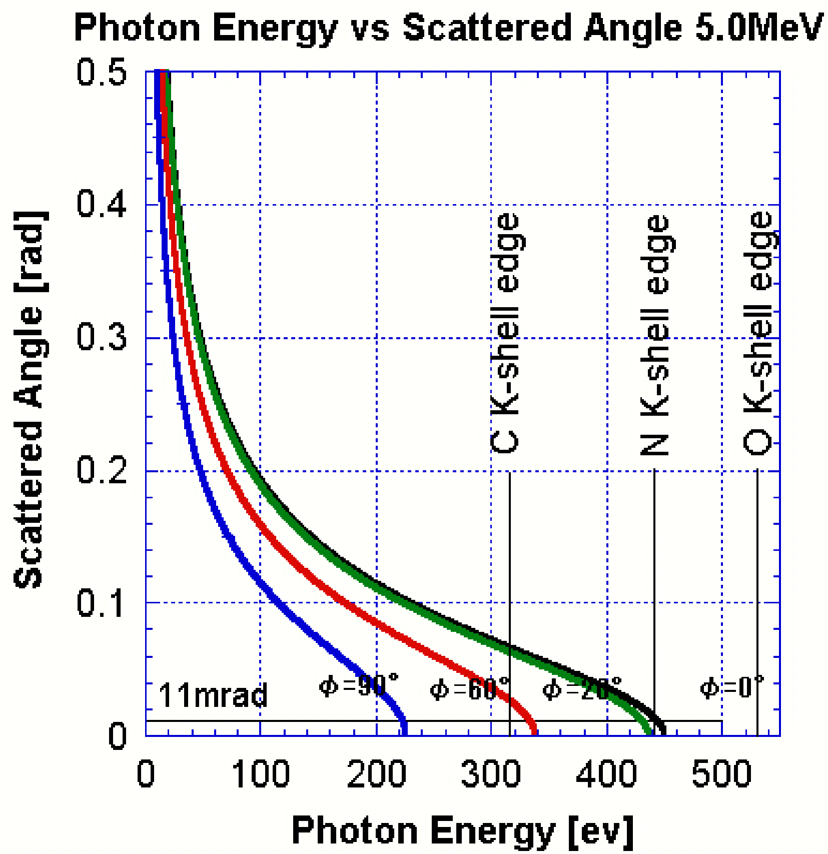
Results



Relationship between Bunch Length and RF Phase for RF-gun

Inverse Compton Scattering





Energy of the X-Ray

$$E_X = \frac{(1+\beta\cos\phi)E_e E_l}{\{1+\cos(\phi+\theta)\}E_e + (1-\beta\cos\theta)E_l}$$

Energy Tunable

- EB Energy
- Wavelength of Laser Light
- Collision Angle

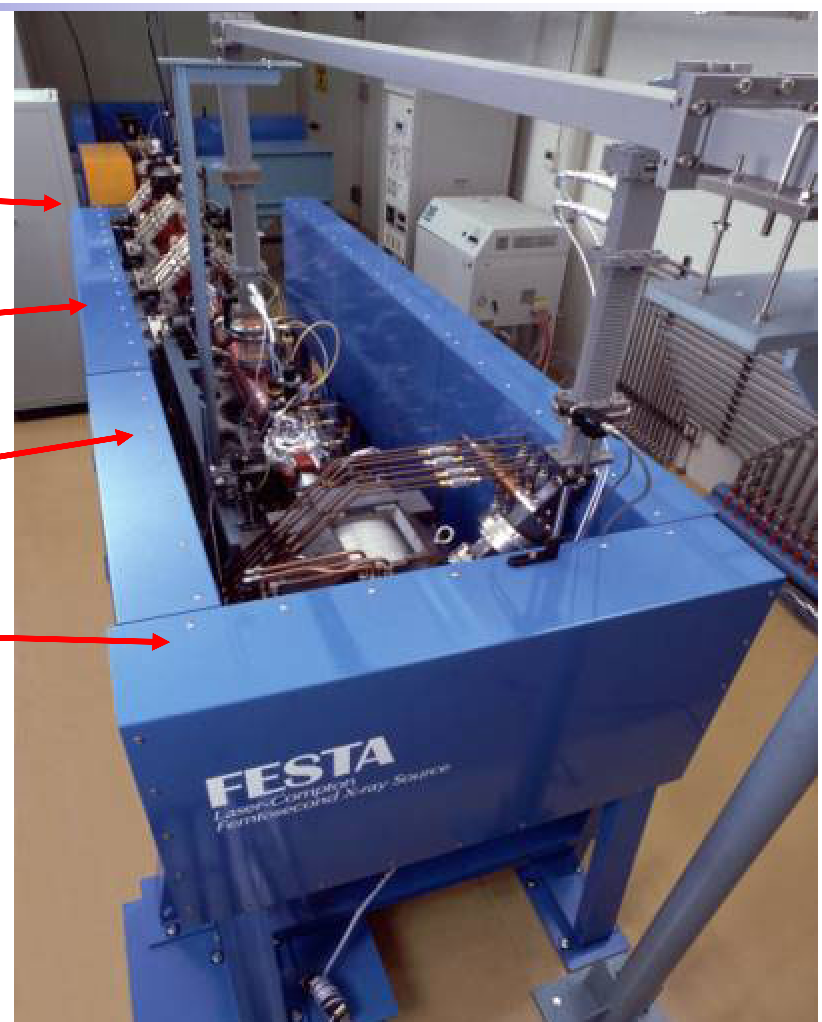
Electron linac system (1st generation)

X-ray detector

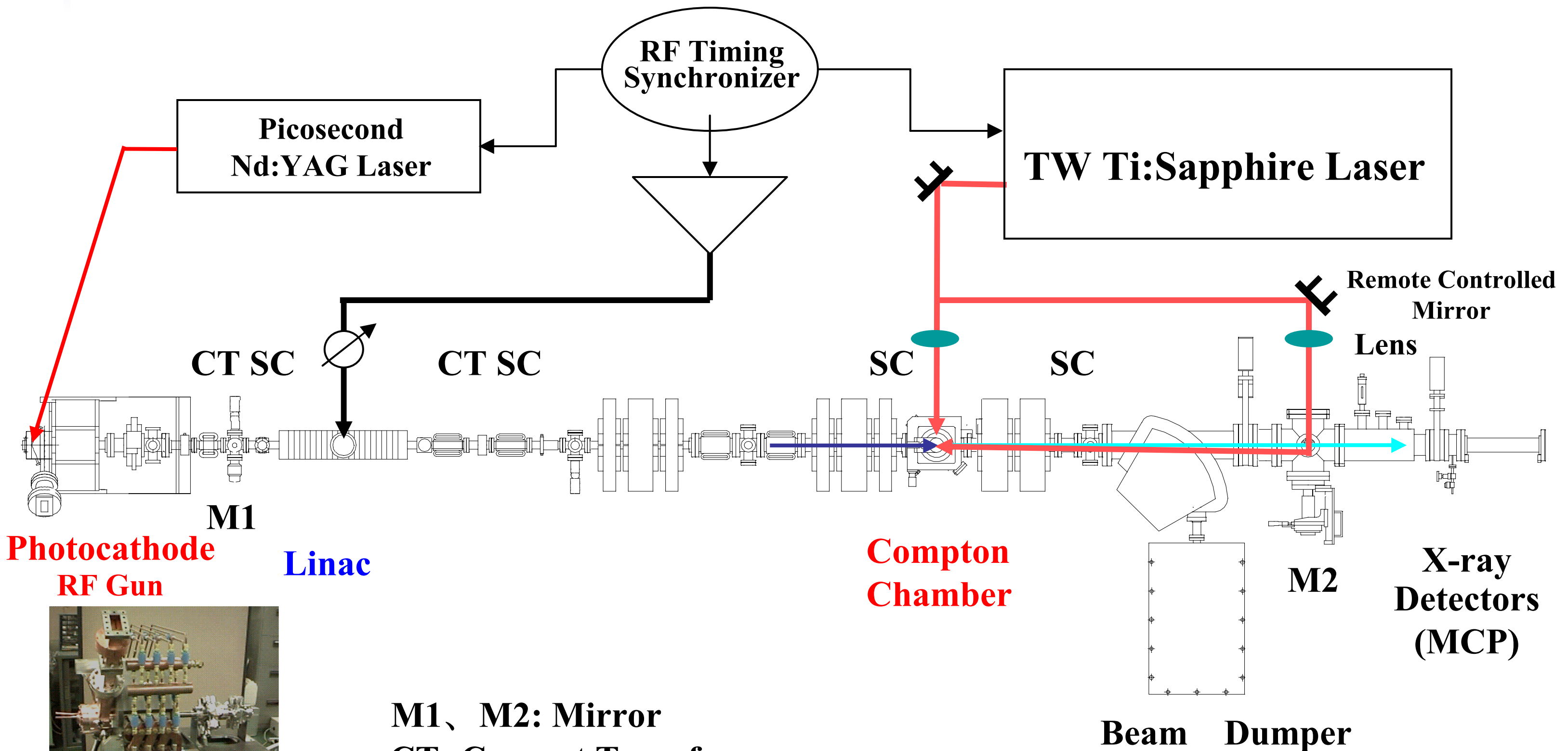
Collision Chamber

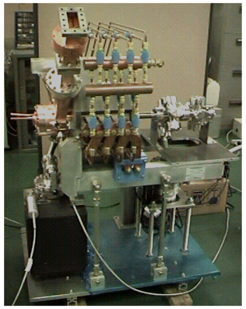
Linac

Photocathode
RF gun



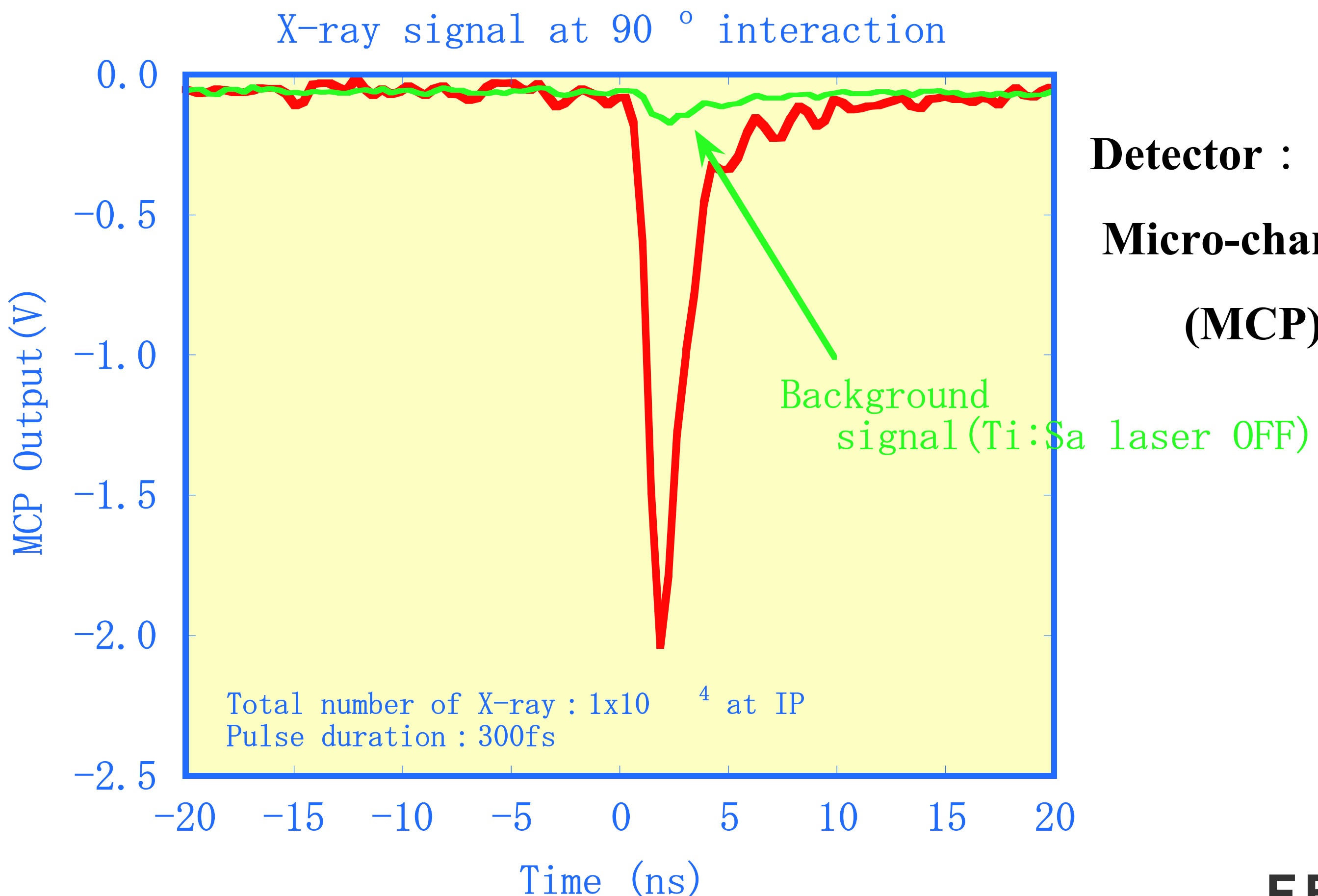
Femtosecond X-ray pulse generation system





M1、M2: Mirror
CT: Current Transformer
SC: Phosphor Screen

Detection of X-ray pulse （ in the case of 90 ° collision ）

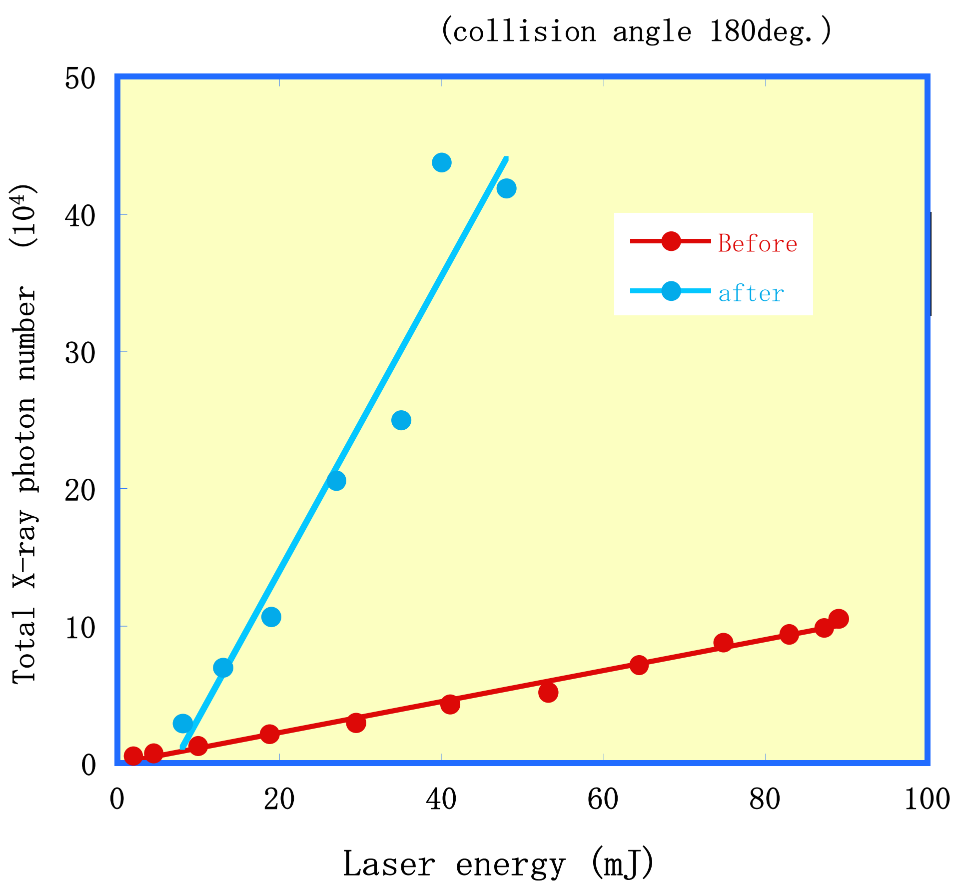


Detector：

Micro-channel plate (MCP)

X-ray yields before and after the system improvement

X-ray intensity vs laser energy



・Increase in X-ray photon intensity is attributed to reduction in the sizes of both beams

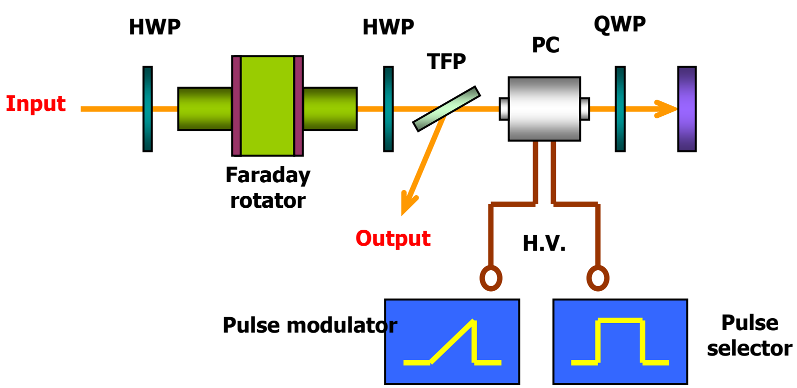
Electron beam :

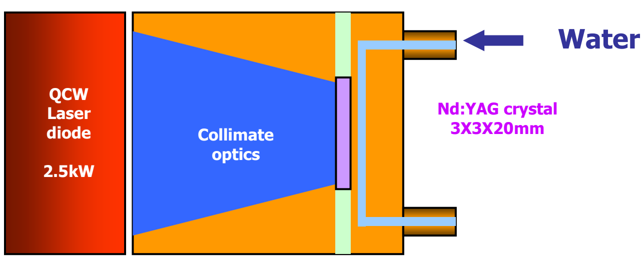
100 μ m → 30-50 μ m

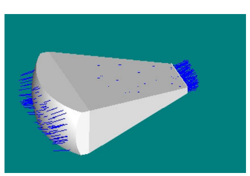
laser :

120 μ m → 40 μ m

Picosecond multi-train laser



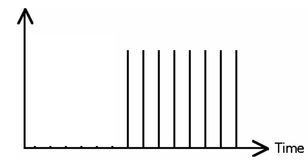




Mode-locked laser

↓

Pulse selector



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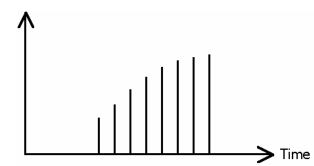
Pulse modulator



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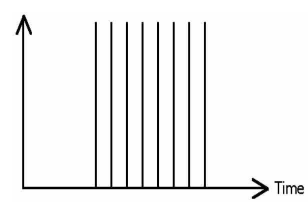
1st stage amplifier

2nd stage amplifier

→



Mg-photocathode RF gun multi-bunch electron beam generation

1 macro pulse

= 50- bunch train

total pulse charge： 5.5nC @ 50-bunch

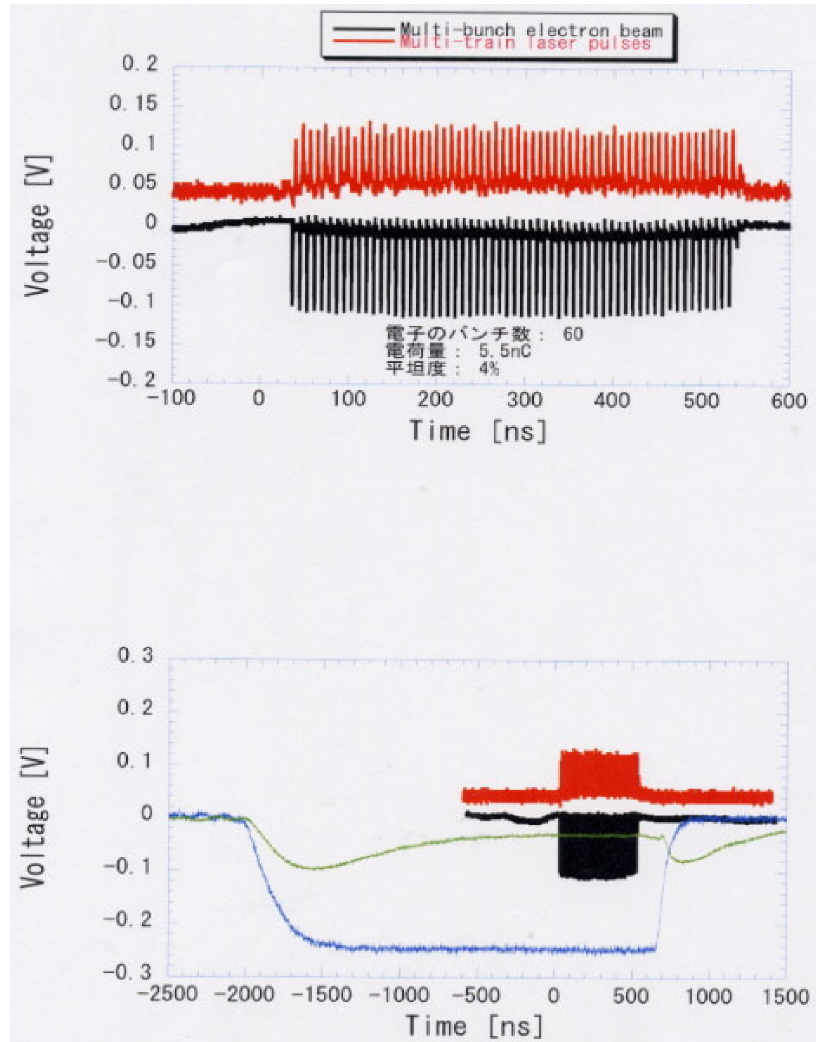
uniformity of pulse energy：

4% @ 50-bunch

the corresponding laser energy :

20-30 μ J

@119MHz and 50bunches



Sumitomo Heavy Industries, Ltd.

Summary

１．Extremely low emittance electron generation system (RF gun and psec laser)

・QE：1×10^{-4}(Cu)、1×10^{-3}(Mg)

・Transverse emittance:2.6mm･mrad @1nC (Nd:YAG 4th harmonics)

・pulse shape control of laser resulted in

extremely low emittance e beam (1.2mm･mrad@1nC)

・multi-train laser system is under development for intense X-ray beam

２．X-ray generation via the inverse Compton scattering

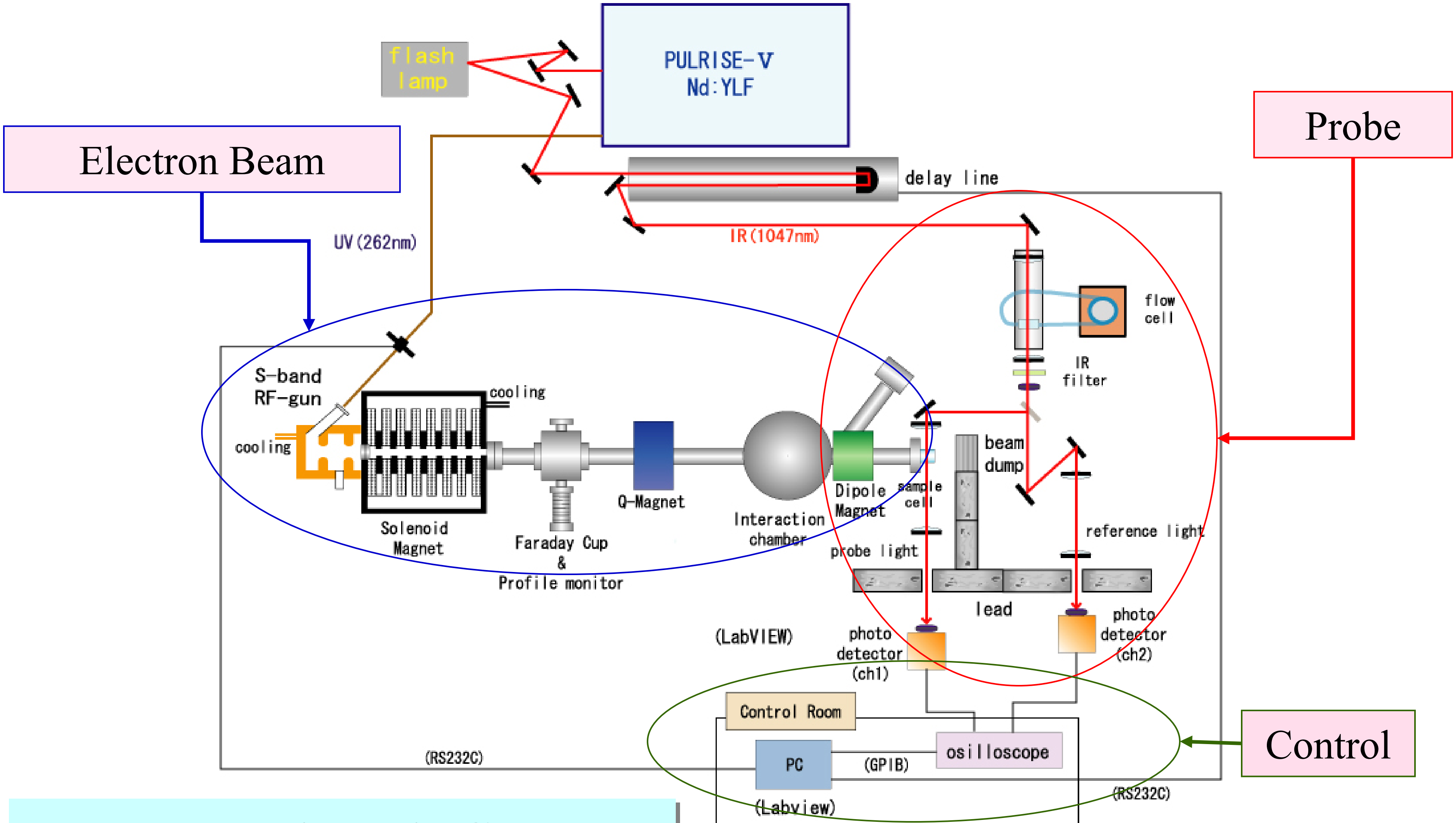
・femtosecond X-ray pulse generation at the incident angle of 90degree

X-ray intensity: $\sim 10^{4}$ photons/pulse

・30keV X-ray generation is planning after system improvement

electron energy ： 40MeV, laser ： 0.5J/pulse

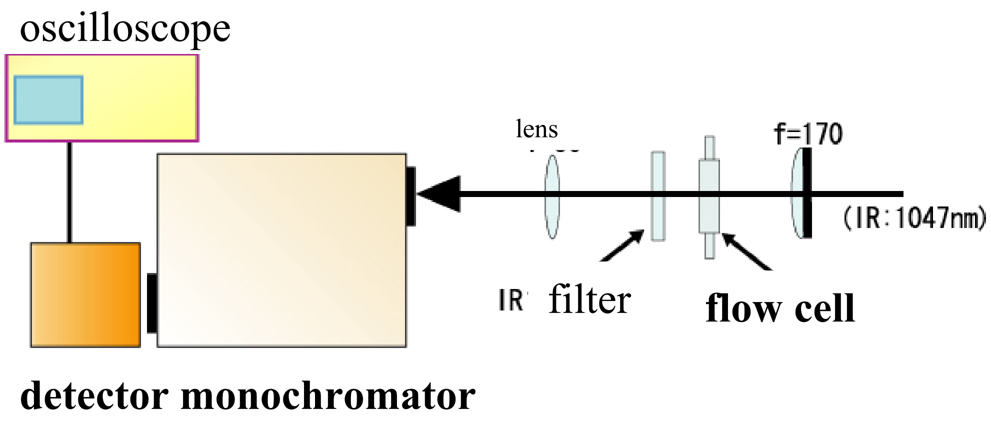
・In the preliminary experiment, around 10-fold increase in intensity was observed.



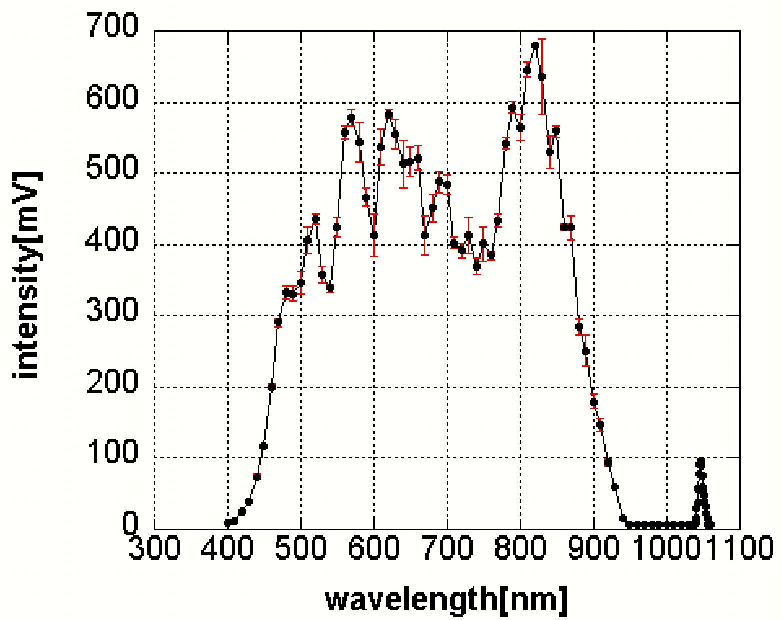
Pulse Radiolysis System

White light generation

Setup for white light generation

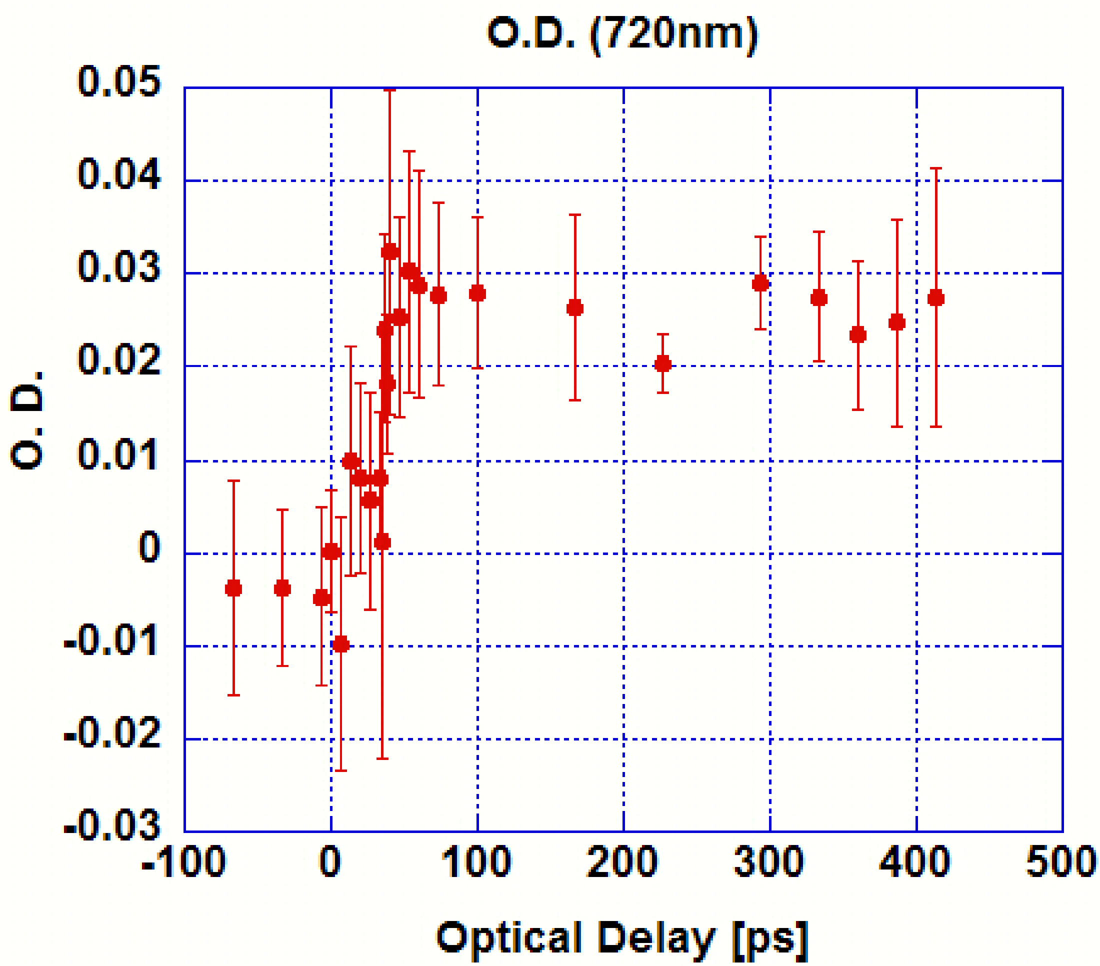


white light generation system



Obtained white light spectrum

Time profile of hydrated electron (at 720nm)



Time resolution : 30ps is achieved!

Summary

1. Development of RF Gun System
   * RF gun is operating well!
2. Beam Diagnosis
   (Emittance and Bunch Length Measurements)
   * Slit scan techniques
   * RF kicker cavity (in progress)
3. X ray Generation (Inverse Compton Scattering)
   * Soft X-ray with 7.7 ps (rms) was generated!
   * 5 x 10^3 Photons/ pulse
4. Pulse Radiolysis System
   * ps Pulse Radiolysis System by Stroboscopic Technique