High-power experiment of X-band thermionic cathode RF gun for Compton scattering X-ray source

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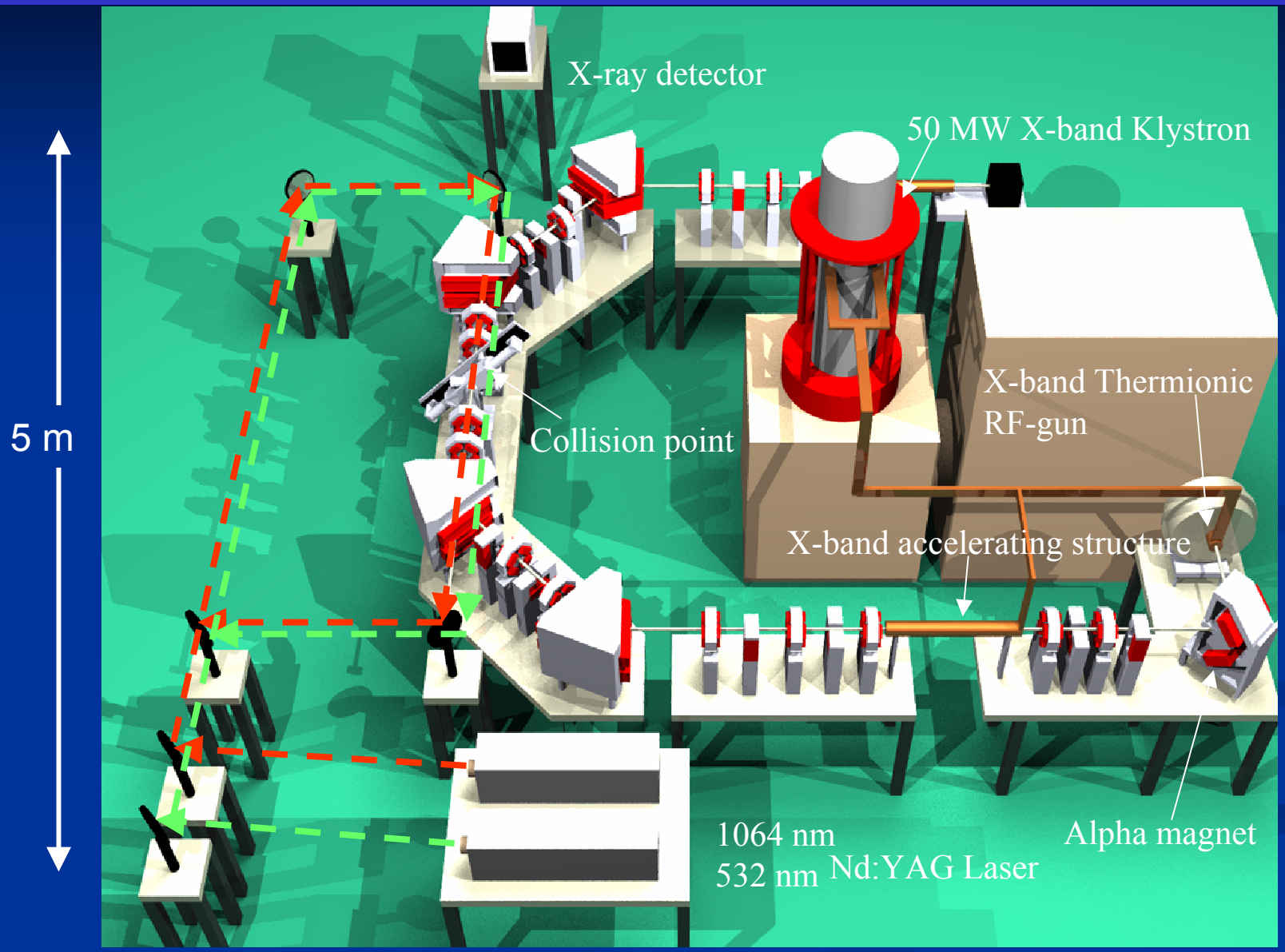
Outline

- System of compact Compton scattering X-ray source based on X-band linac at the Univ. of Tokyo
- High power experiment of X-band thermionic cathode RF gun
- Summary and Future works

Compton scattering monochromatic X-ray source at the Univ. of Tokyo



Performance of Compton scattering X-ray source

Electron beam

Frequency : 11.424 GHz (X-band)
Injector : 3.5-cell thermionic RF-gun (3.0 MeV)
Energy : 35 MeV (+alpha-magnet)
Charge : 20 pC/bunch
Micropulse duration : ~ psec
Multi-bunch : 10^4 bunches/RF pulse
RF pulse length : 1 μsec

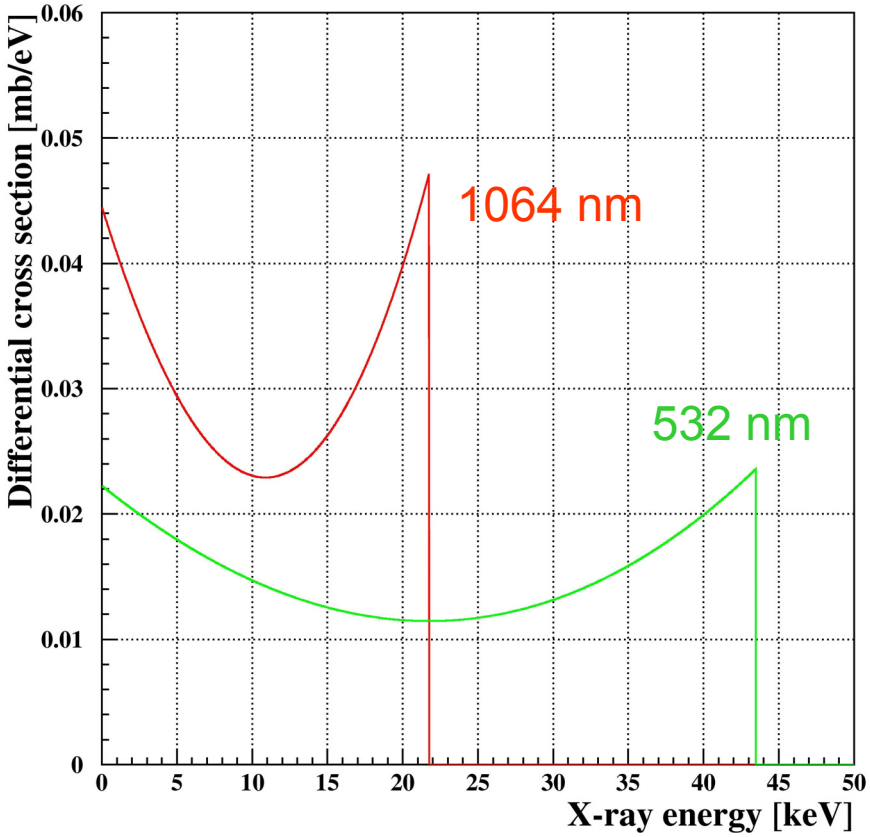
Laser

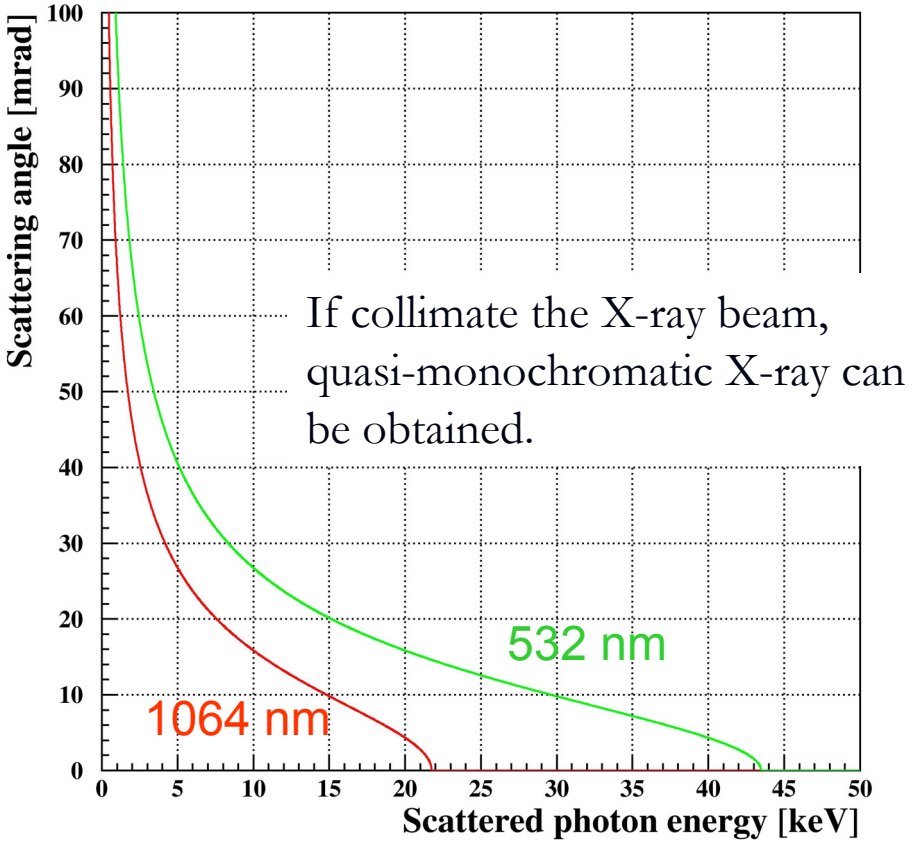
Q-switch Nd:YAG laser: 1064 nm, 2J /10ns
532 nm, 1.4 J/10 ns

X-ray

Energy :21.9 keV (1064 nm), 43.8 keV(532 nm)
Intensity :10^8 photons/sec

Spectrum of Compton scattering X-ray





Spectrum

Angular distribution

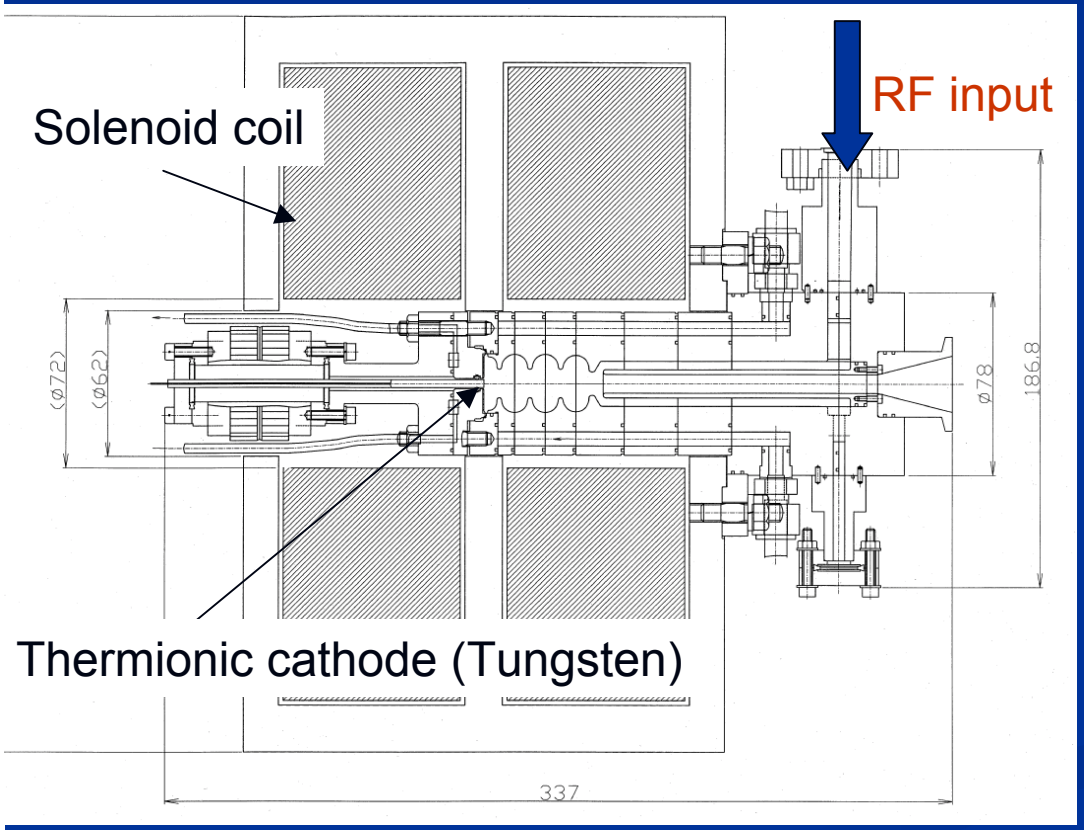
Electron beam : 35 MeV, 20 pC

Laser pulse : 1064 nm, 2 J X-ray : 21.9 keV

532 nm, 1.4 J : 43.8 keV

3.5-cell X-band thermionic cathode RF gun

3.5-cell X-band thermionic cathode RF gun
（IHI: Ishikawajima-harima Heavy industry）



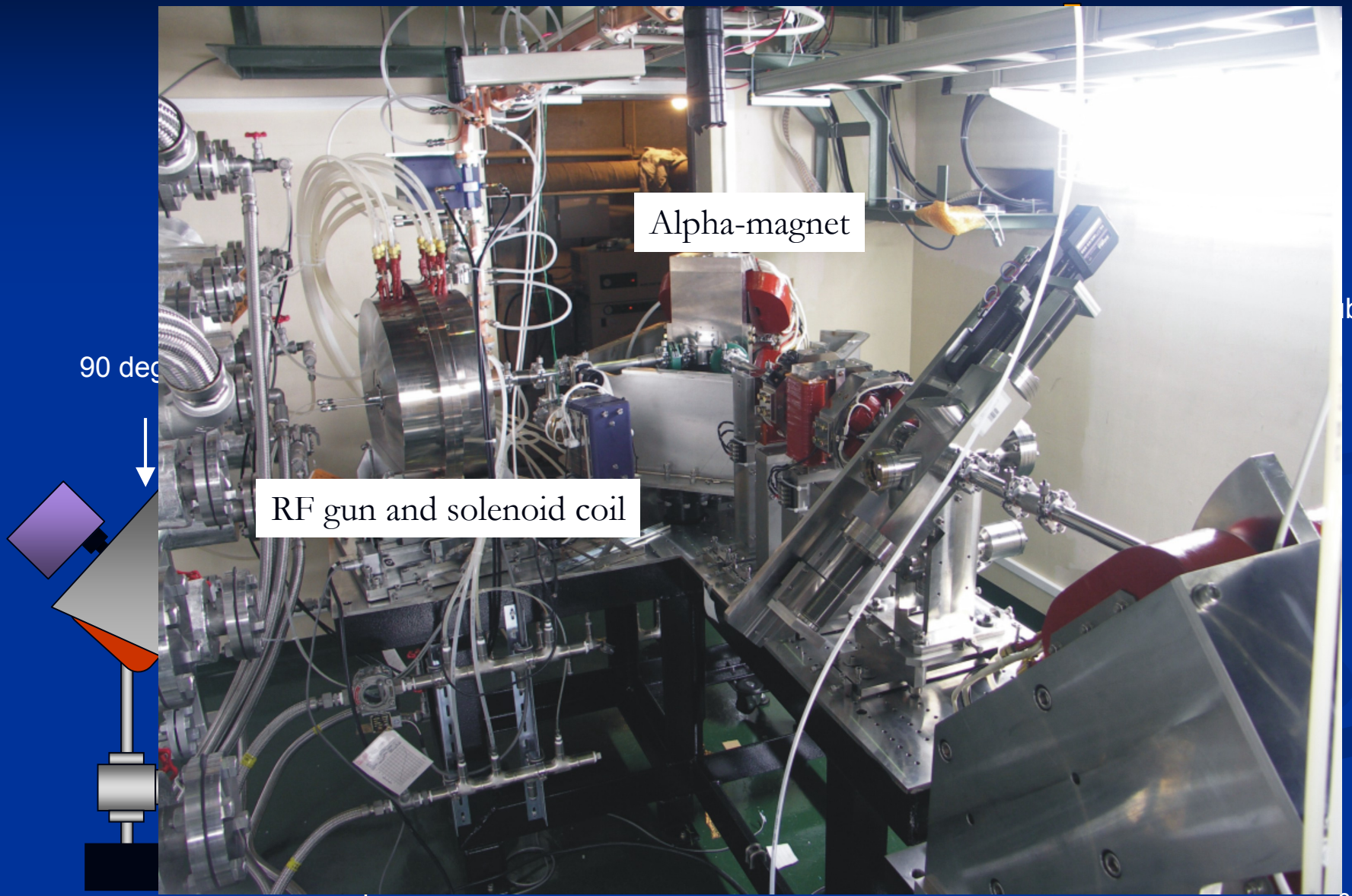
Beam parameters
at exit of the alpha-magnet

Energy : 3.0 MeV (5 MW feed)
Emittance: : 10 πmm-mrad
Charge/bunch : 20 pC
Bunch duration : <1 ps (FWHM)
RF pulse width : 1 μs (10^4 bunches/pulse)
Peak beam power : 400 kW
Average beam power : 4 W
(Rep.rate : 10 pps)

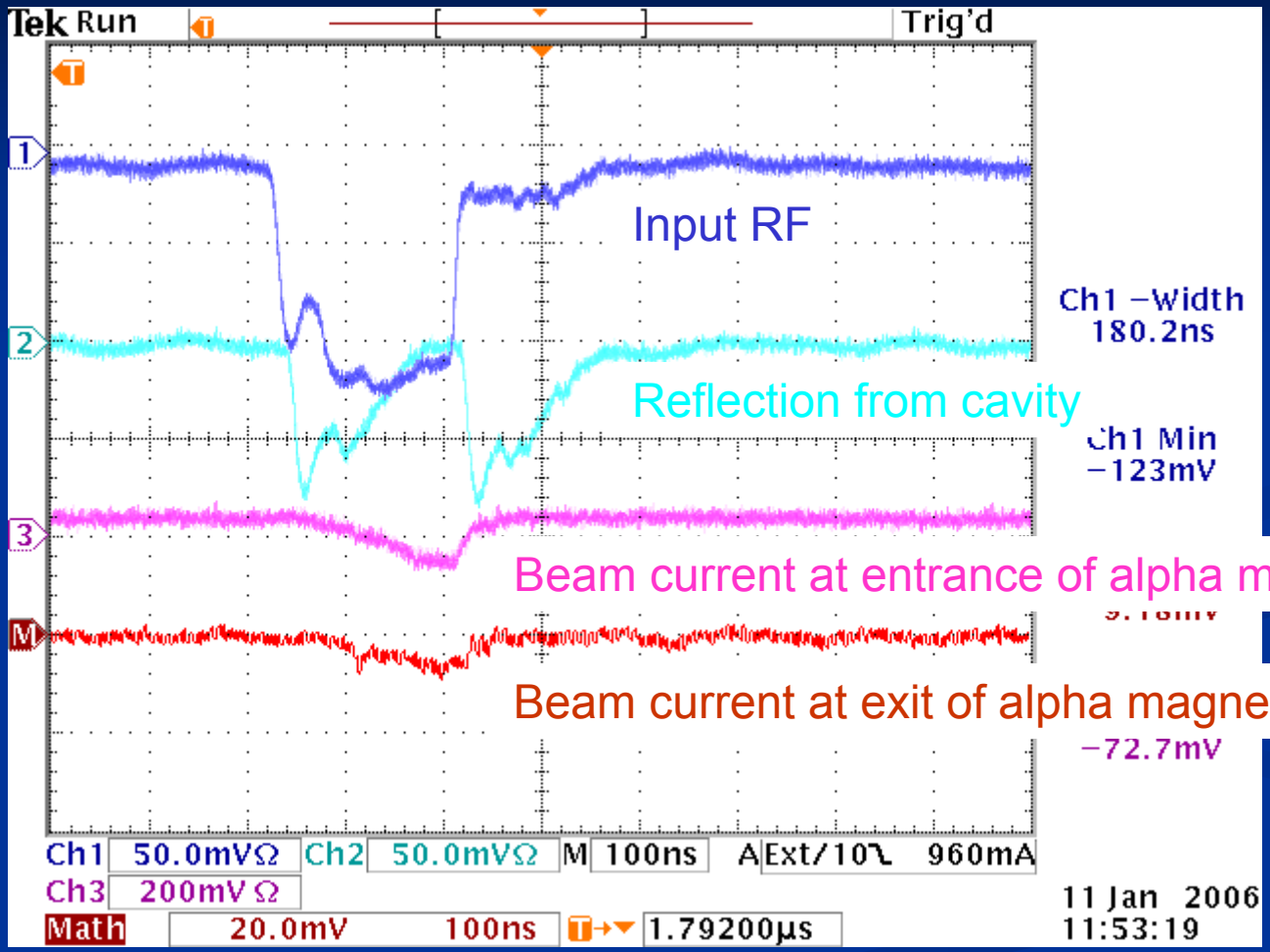
Properties of RF gun cavity

Resonant frequency	11.424 GHz
Resonant mode	π mode
Number of cells	3.5
Transit time factor	0.703
Filling time	400 nsec
Q value	9350
Beam Energy (5 MW feed)	3.0 MeV
Electric field at cathode surface	150 MV/m (5 MW feed)
Shunt impedance	2.46 MΩ

Experimental setup for RF gun test

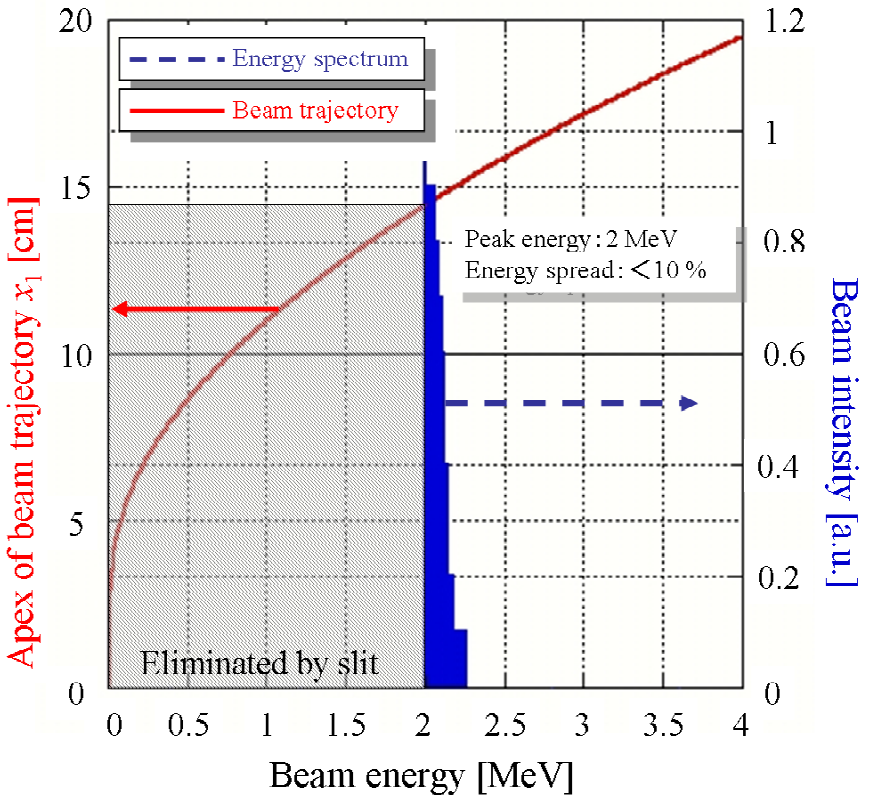


Waveform of RF into and reflect from gun cavity



We measured the beam energy by observing the transmission of beam current passing through alpha magnet.

Energy spectrum of electron beam



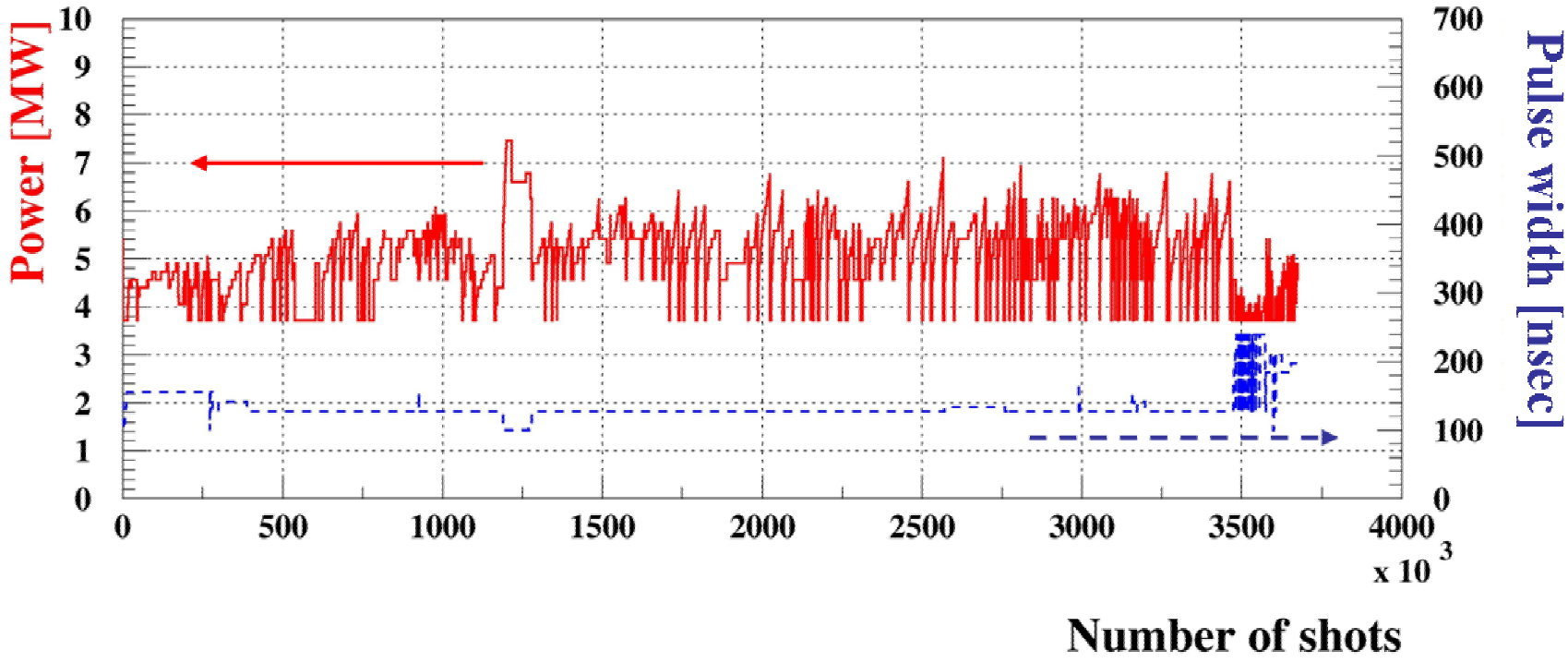
	Nominal value	Experimental results
Energy	3.0	2.0 (<10 %)
Beam current	2 μA	0.15 μA
Charge/bunch	20 pC	1 pC
RF input Power	5 MW	5 MW
RF pulse width	1 μs	200 ns

(Filling time : 400 ns)

Peak : 2 MeV, energy spread : <10 % electron beam is observed.

Due to the fact that the RF pulse width cannot be extended over cavity filling time, nominal value are not observed.

History of RF processing of RF gun cavity

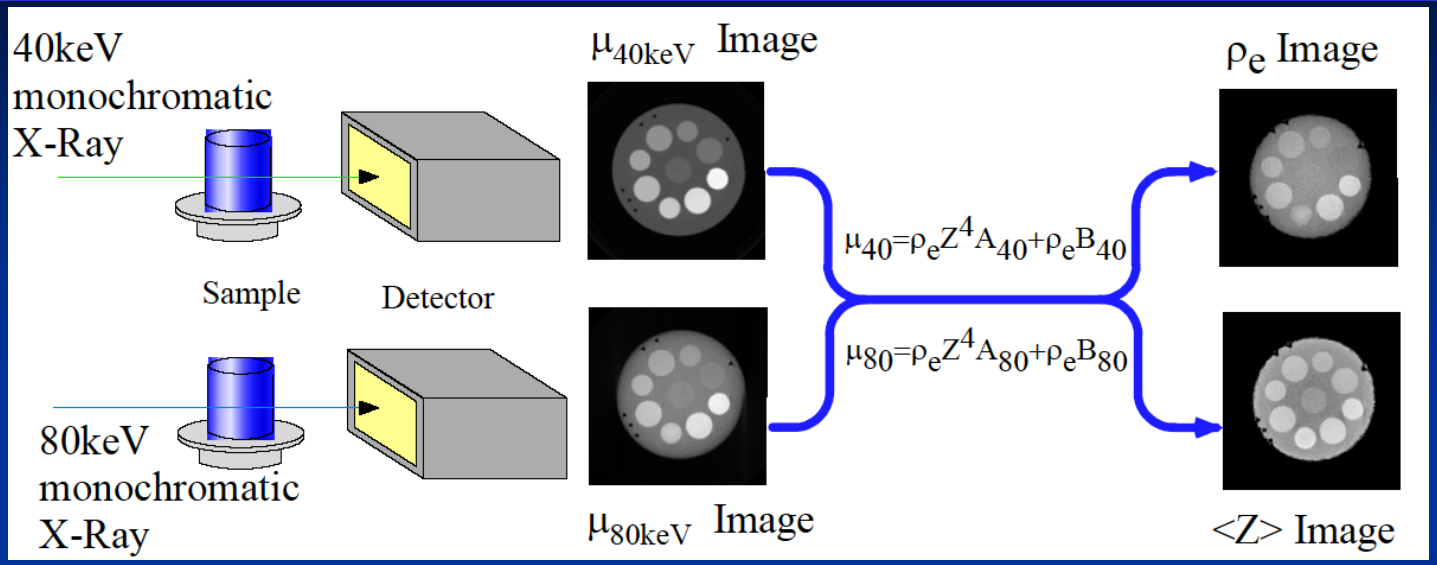


Sometime breakdown occurred in the cavity. 5 MW, 200 ns is limitation.

Precise location and breakdown factor are being investigated.

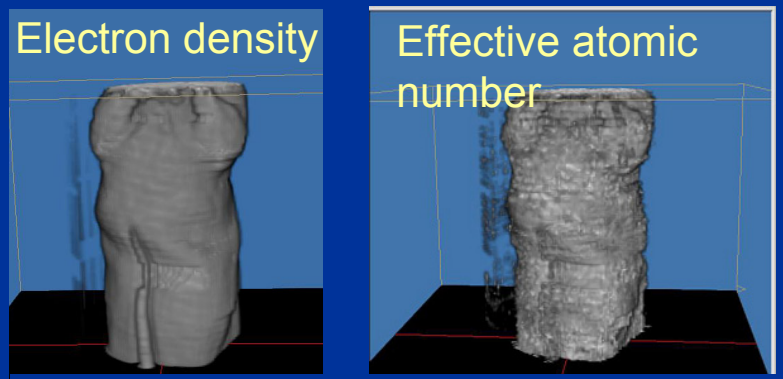
(Filling time of RF gun cavity is 400 ns.)

Application of monochromatic X-ray (Future works)



Attenuation coefficience of X-ray depend on the X-ray energy and electron density (effective atomic number)

CT images of dual-energy X-rays determine the effective atomic number distribution



Example of rat (X-ray: 40keV,70keV)

M. Torikoshi et al., Phy. Med. Biol. 48,673(2003)

Summary and Future works

- We are developing a monochromatic hard X-ray source based on X-band linac at the Univ. of Tokyo.
  - 2 MeV electron beam from X-band thermionic cathode RF gun was observed.
  - Preparation for beam acceleration and Compton scattering experiments are under way.