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Inverse Compton Scattering of Picosecond CO_2 Laser Pulses

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Proposal for an experiment at the Brookhaven Accelerator Test Facility
Submitted by TMU, KEK, SUNY Stony Brook, and NSLS/ATF
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Study of Compton Scattering of Picosecond Electron and CO_2 Laser Beams to Prototype the Polarized Positron Source for Japan Linear Collider

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ABSTRACT

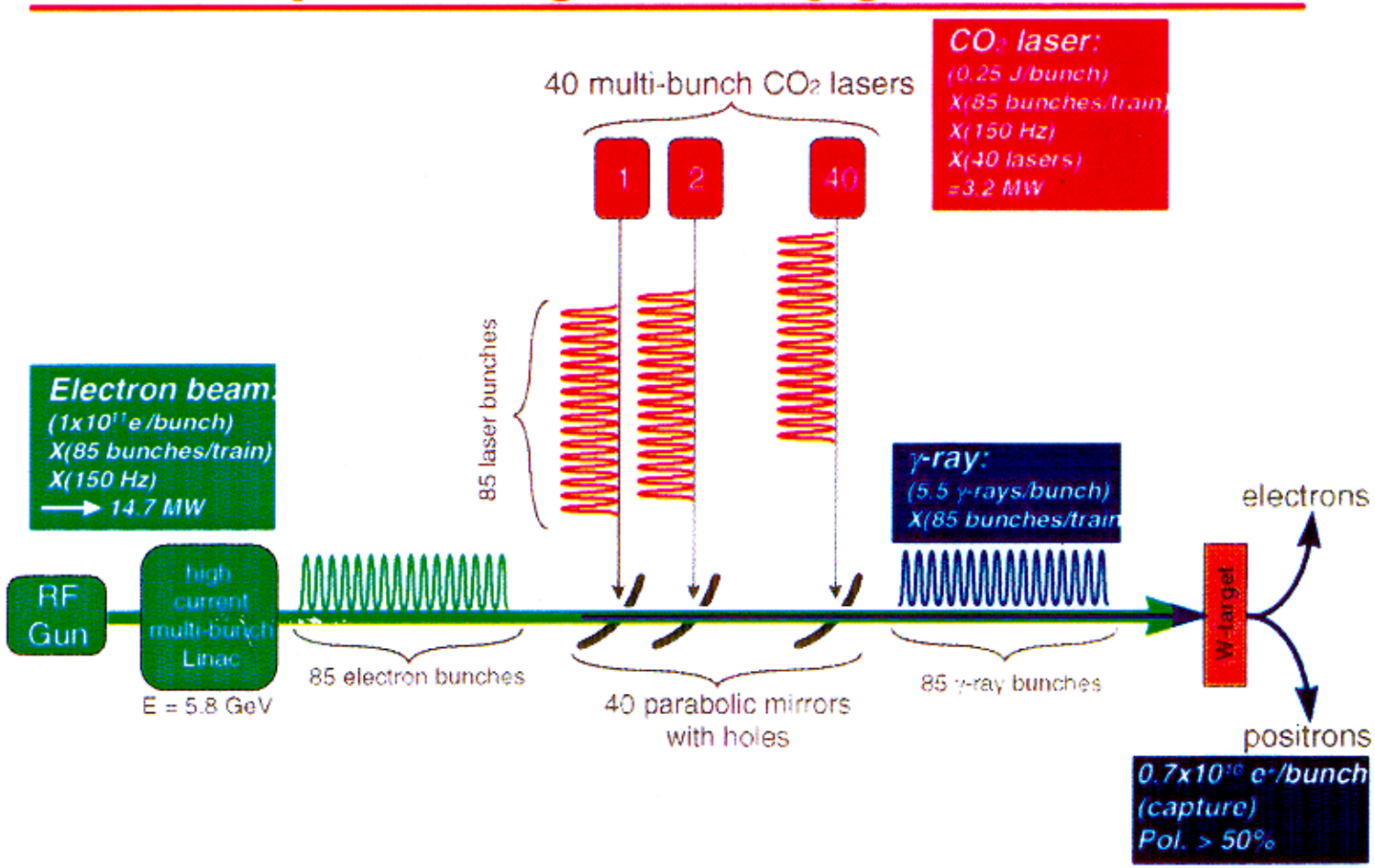
♦The polarized positron source proposed for the Japan Linear Collider (JLC) is based on the production of electron-positron pairs when the polarized gamma-quanta are stopped at the foil target. Compton scattering between the relativistic electrons and polarized laser beam is the source of the polarized gamma-quanta. The requirements for the high peak flux and short pulse duration of the gamma rays specify the high-brightness photocathode electron accelerator and the picosecond subterawatt CO_2 laser as essential components of the projected Compton source. The BNL-ATF is the only user's facility worldwide that features such a combination of equipment.

♦The goal of the US-Japan collaborative project is to demonstrate a high conversion Compton interaction between the laser and electron beams to verify the conceptual design of the polarized positron source.

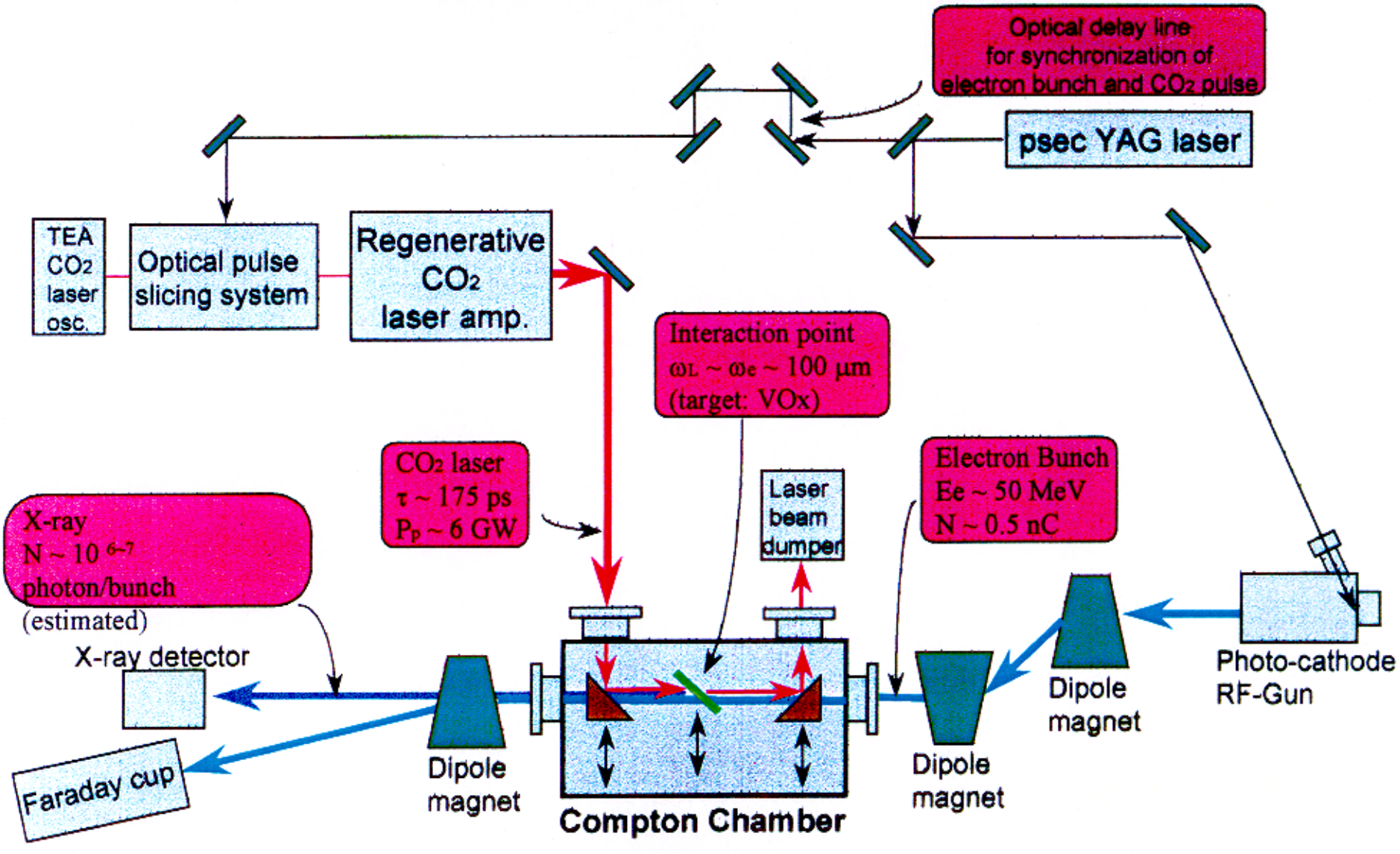
♦We have developed an interaction chamber for the Stage I proof-of-principle experiment, in which counter-propagating CO_2 laser pulses and electron bunches collide at the focal point. Oxidized vanadium coated on a thin mica substrate is used to observe spatial profiles and position of the laser and electron beams at the collision point. Up to 10^7 x-ray photons are estimated to be scattered by 10-μm pulses with the peak power of 10 GW from relativistic electron bunches with the energy of 50 MeV, duration 10 ps, and the charge of 0.5 nC.

♦After the ongoing ATF CO_2 laser upgrade to the TW peak power and electron bunch shortening to 300 fs, further enhancement of the x-ray flux to a 10^{22} photons/sec level will be possible. This is orders of magnitude above the levels achieved with conventional synchrotron sources.

Basic scheme of Multi-pulse laser-Compton scattering for polarized gamma-ray generation



Experimental setup



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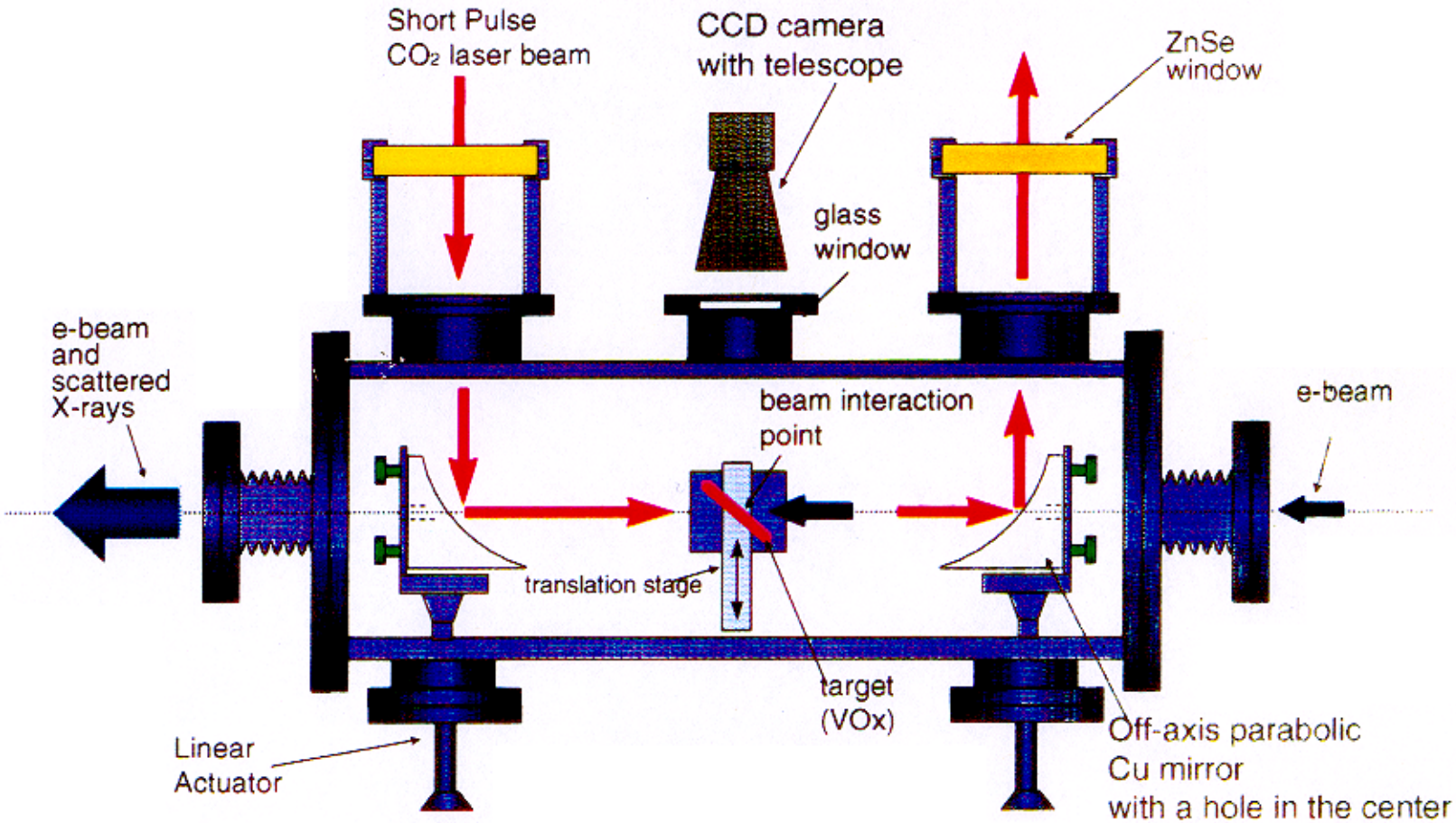
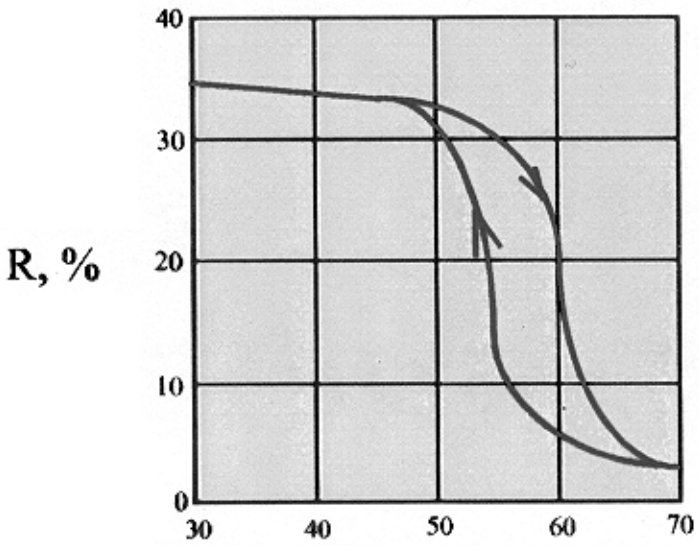
Compton chamber conceptual design



Beam profile monitor for CO_2 laser and e-beam using Vanadium Oxide thin film

Vanadium Oxide thin film target developed and manufactured by OPTOEL Co. (St. Petersburg, Russia) is used to capture beam spot image for both picosecond CO_2 laser pulses and relativistic electron bunches. This enables high resolution beam characterization and fine alignment necessary for Compton scattering experiment.

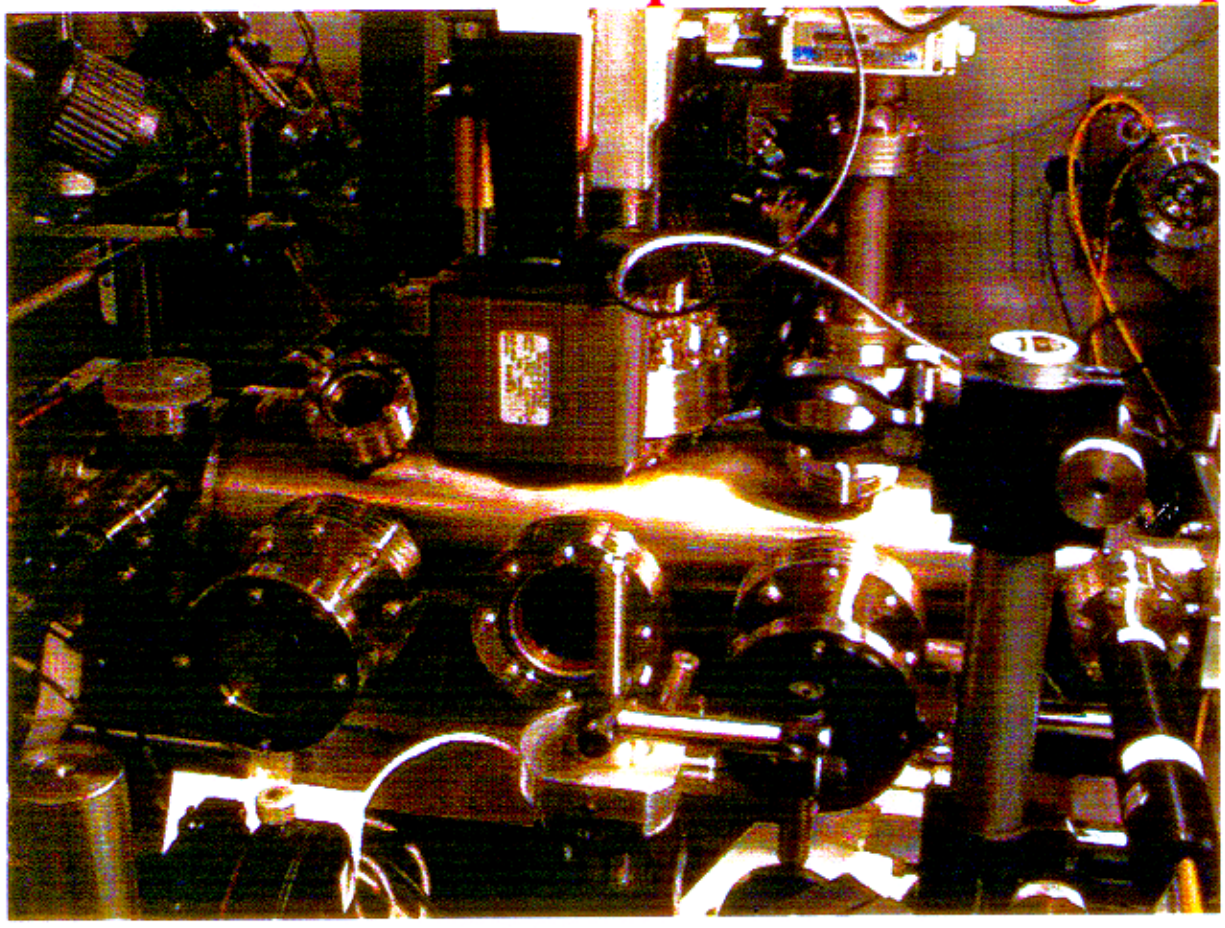
The beam profile image of the CO_2 laser pulse with the waist size of about 100 μm is clearly visible as a blackened spot which is caused by the temperature dependant film reflectivity change in the visible region. Since the reflectivity response to the temperature of the film has a hysteresis nature, the image is "grabbed" by maintaining the target temperature around 55 degree C.

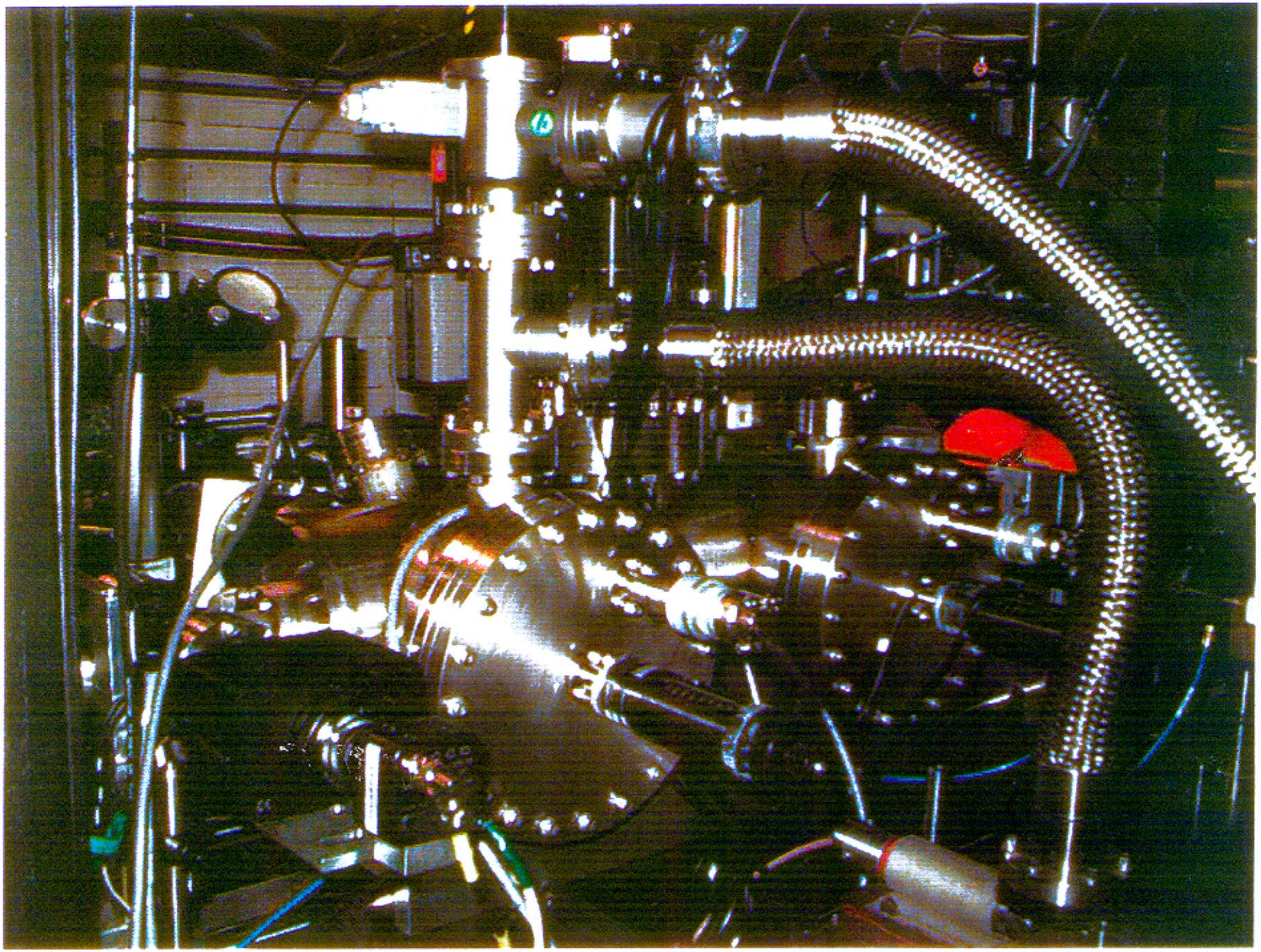


Temperature dependence of the reflectivity in the visible light of Vanadium Oxide thin film.

For the electron beam, spot image was also observed clearly at the same film surface due to the transition radiation effect.

Interaction Cell for ATF Compton Scattering Experiment





Compton scattering experiment at ATF/BNL

Design Parameters for ATF X-Ray LSS

	ATF LSS	NSLS
ELECTRON BEAM		
Energy [MeV]	15-70	2580
Bunch Charge [nC]	0.1-3	0.08
Bunch Duration FWHM [ps]	0.3-10	300
Radius at Focus [μm]	40	
Waist Length [mm]	>10	
Normalized Emittance [mm.mrad]	2	≤0.1
Electron Momentum Spread [%]	~0.1	0.08
CO_2 LASER		
Pulse Duration [ps]	10	
Peak Power [GW]	3000	
Laser Energy [J]	30	
Radius at Focus [μm]	40	
Waist Length [mm]	1.5	
X-RAYS		
Wavelength [Å]	40-1.35	2.8
Pulse Duration [ps]	0.3	300
Angular Spread [mrad]	7	
Spectral Bandwidth [%]	1	0.1
Photons per Pulse	3×10^{10}	10^9
Peak Flux [photons/s]	10^{23}	3×10^{18}