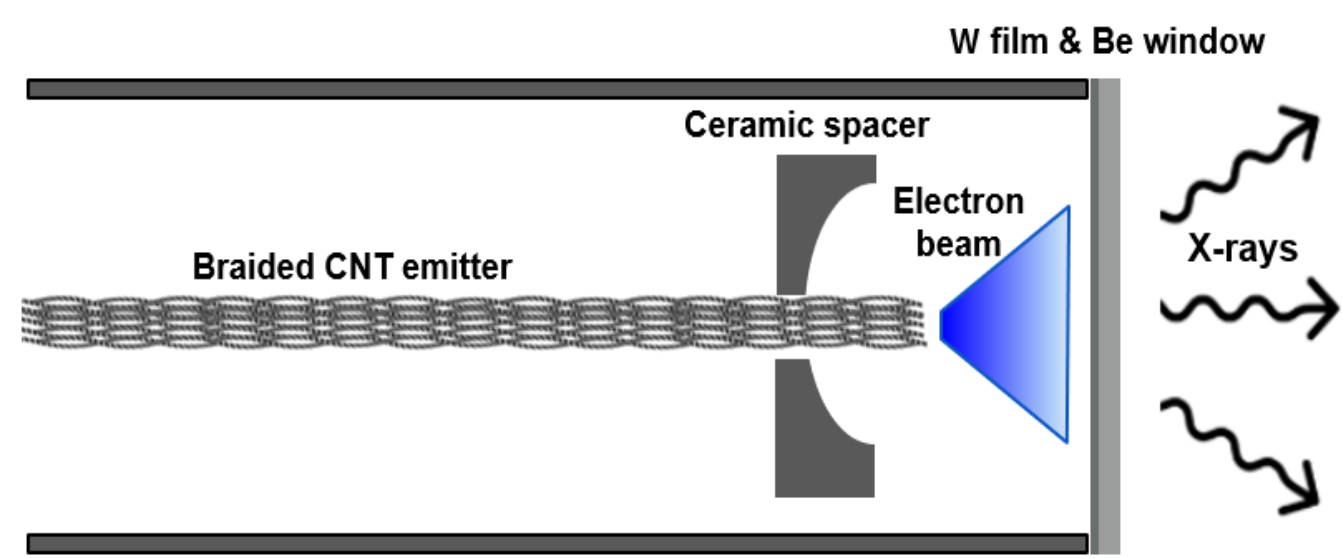


Introduction

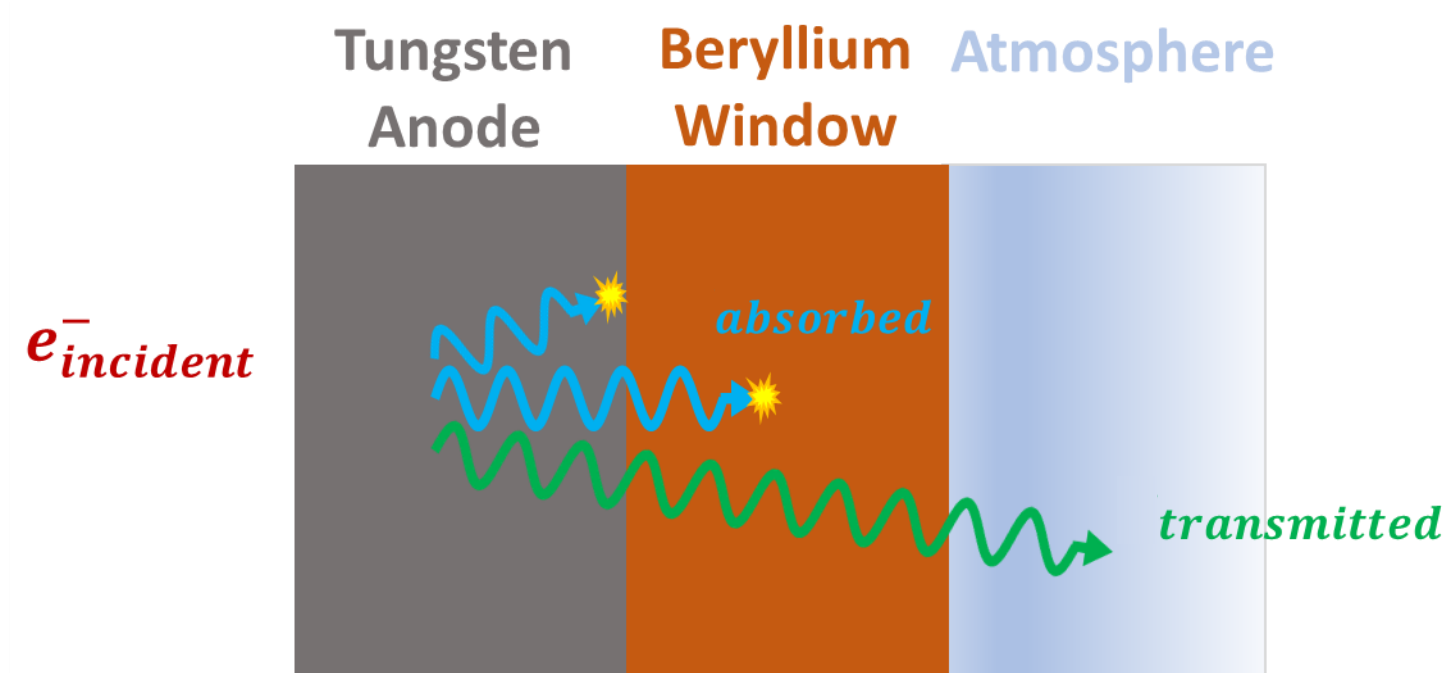
❖ Carbon Nanotube(CNT) X-ray tube

- CNT is a tube which emits electron due to high electric field[1].
- Emitted electrons are accelerated at high speed and collide with the target and generates X-rays.

CNT X-ray tubes' view



Mechanisms of x-ray transmission



❖ Low energy X-ray source application

- Radiographic scan of human body, non-destructive testing[2].

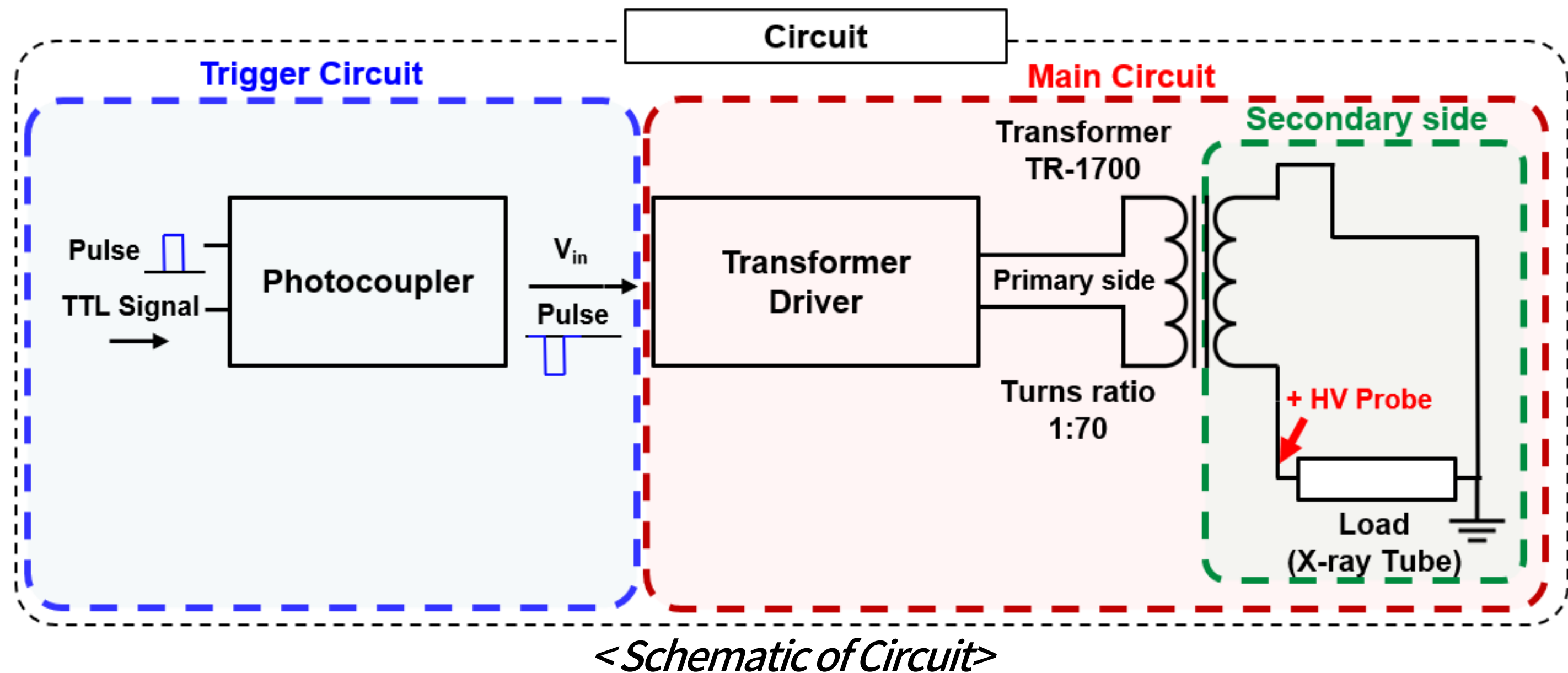
❖ Necessity of operating pulse mode

- When applied DC voltage, tube can be damaged due to the temperature rise and Large current application.
- Short pulse improves time resolution in medical imaging field.
- In this study, X-ray spectrum was analyzed for various operating voltages.

Experimental Setup

❖ Development of X-ray pulse generator

- Pulse generator consists of a trigger circuit and main circuit.
- Transformer with 1:70 ratio is used to generate high voltage pulses repetitively.
 - Frequency : 0.1 kHz
 - Duty : 0.1%

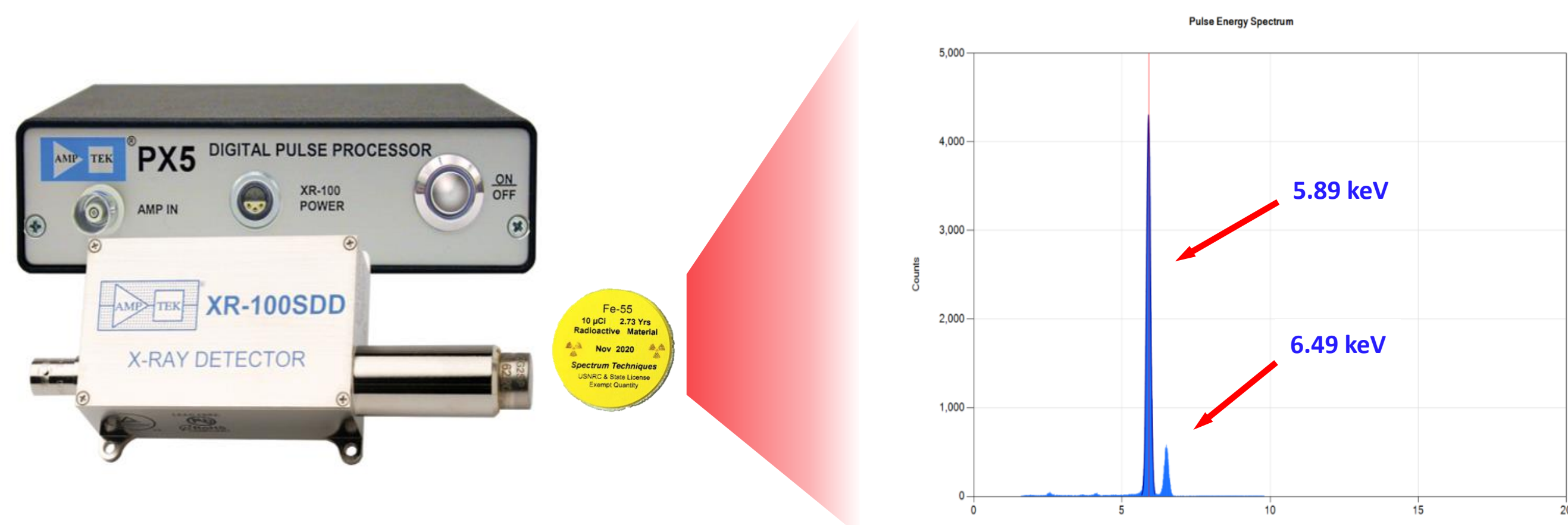


1 st Side (V)	65	70	75	80
Load (V)	9,500	10,500	11,500	14,000

→ Inductive kickback effect (HV, short Pulse)

❖ Detection of X-ray spectrum

- X-ray tube composed of CNT cathode and tungsten anode.
- The emitted electrons interact with the tungsten target, producing bremsstrahlung or characteristic X-rays.
- X-ray energy spectrum was measured using fast silicon drift detector(XR-100SDD).
- Measurement distance from the X-ray tube is set to 0.8 m to minimize the pile-up phenomenon in the detector.
- Fast SDD was calibrated using Fe-55 source, which are commonly used for low-energy calibration[3].

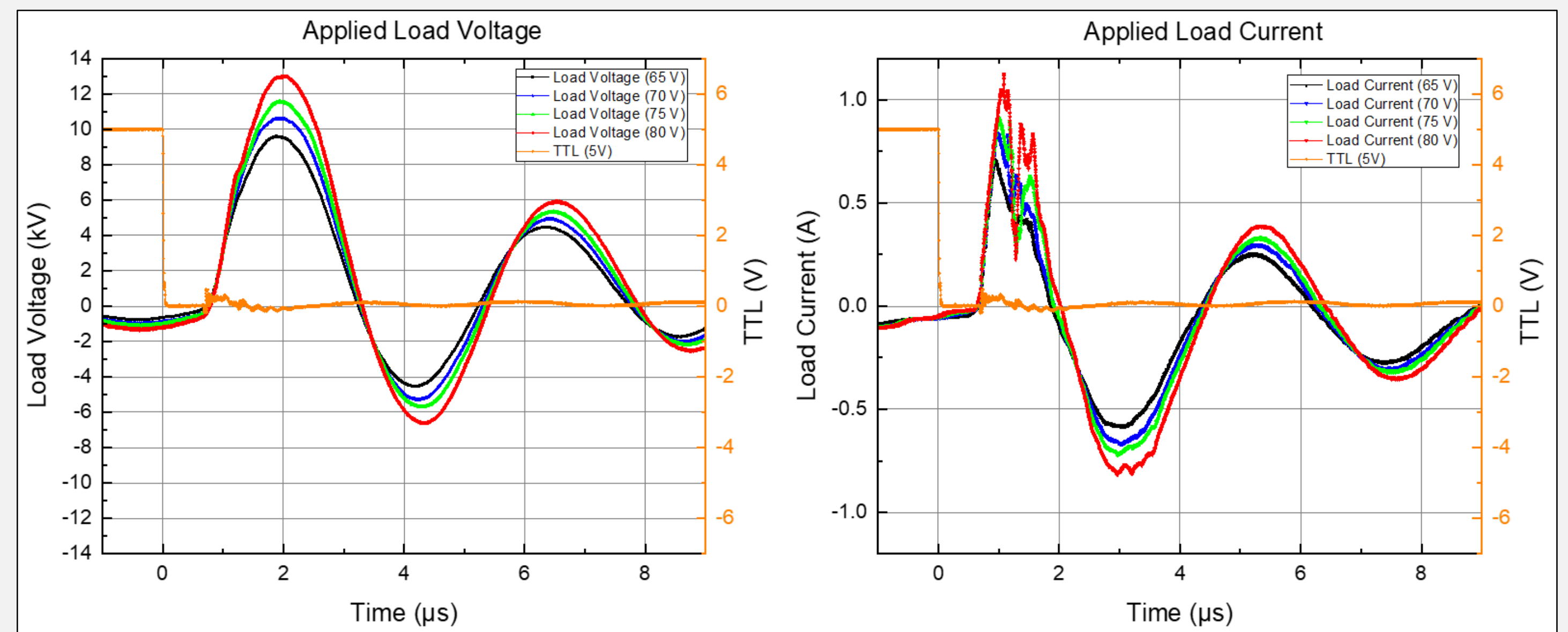


<Calibration of fast SDD>

Results & Discussion

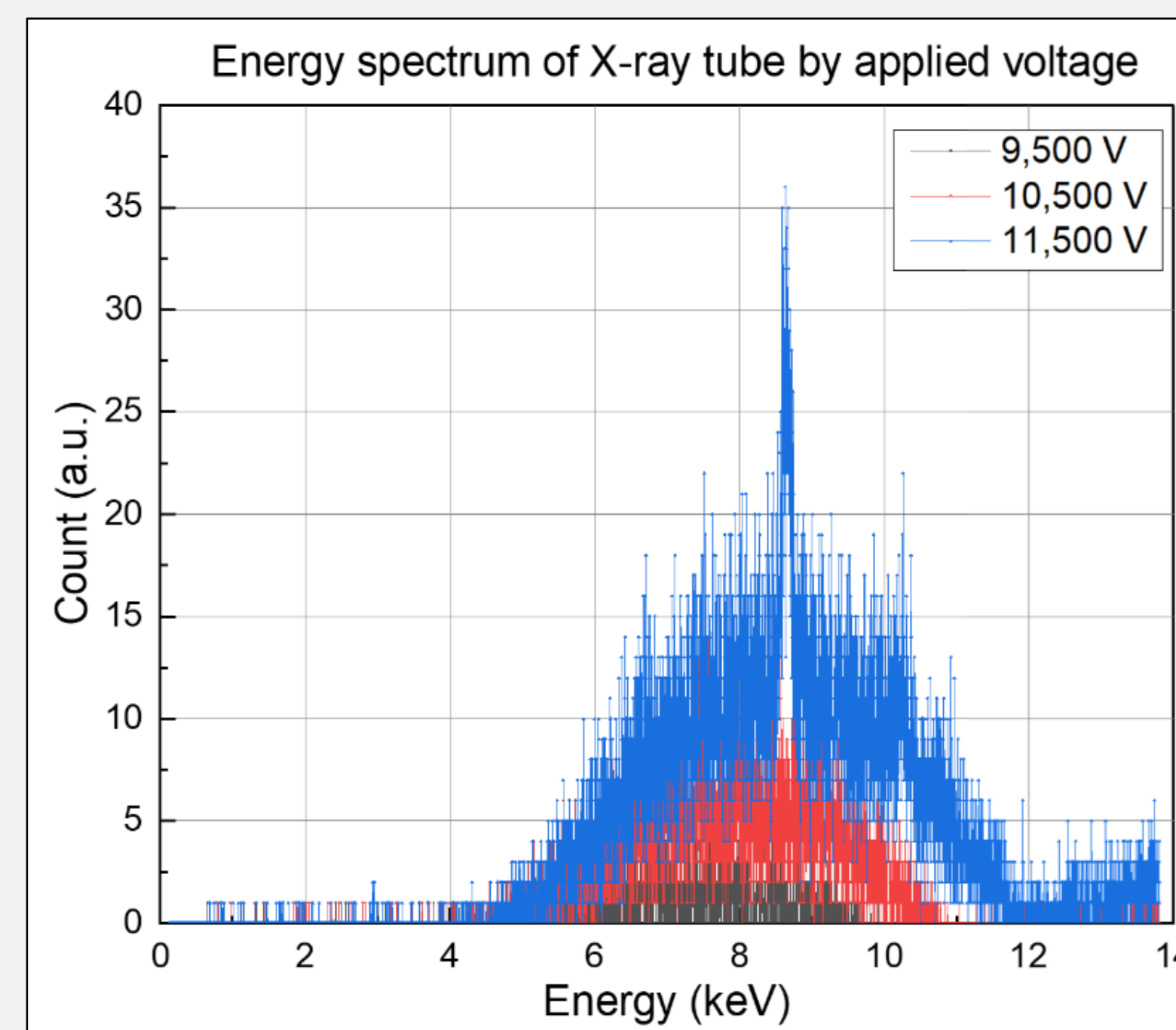
❖ Applied Voltage and Current at Load

- Before TTL signal is applied, voltage oscillation phenomenon is considered to occur during transformer charging.
- Rise Time was about 800 ns, and maximum voltage applied to the CNT tube was about 9.5, 10.5, 11.5, 13 kV respectively.
- Maximum current for each case was 0.7, 0.8, 0.9, 1.3 A respectively
- After about 1.2 μ s, the current shows a tendency to oscillate.
- It is judged that result of the virtual cathode effect occurs when voltage reaches around 7 kV which discharge begins.



❖ Energy spectrum of X-ray tube by applied voltage

- X-ray spectrum broadened as the applied voltage increased from 9.5 to 11.5 kV range.
- It appeared characteristic X-ray of tungsten around 8.5 keV.
- It consistent with the usual bremsstrahlung phenomenon, which produces stronger X-ray emission at higher voltages in X-ray tube[4].



Element	La_1	La_2
W-74 (keV)	8.397	8.335

Conclusion & Future work

- ❖ In this study, about 10 keV X-ray spectrum was investigated with CNT tube.
- ❖ CNT tube operating at pulsed mode offer advantages for high voltage application.
- ❖ Electron emission dynamics of diode structures were investigated.
- ❖ It was observed phenomenon presumed to virtual cathode effect.
- ❖ In the future, we will develop high voltage pulse generator using solid-state based switch.

Acknowledgement

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