Development of pulse width measurement techniques of ultra-short gamma-ray pulses

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1. Motivation

New photon source; Ultra-short gamma ray pulses

We have developed an ultra-short pulse gamma ray source using a laser Compton scattering technique at an electron storage ring, UVSOR-II.

Energy, pulse width, and intensity of gamma rays

In a 90° collision

Maximum energy: 6.8 MeV

Vertical collision

Pulse width: 850 fs (FWHM)

Intensity: 2.4 x 10⁷ photons s⁻¹

Horizontal collision

Pulse width: 4.8 ps (FWHM)

Intensity: 3.4 x 10² photons s⁻¹

Appliciation of the ultra-short gamma ray pulses

Positron annihilation lifetime study

How do we measure the pulse width of the ultra-short gamma rays?

2. UVSOR-II electron storage ring

Synchrotron radiation facility

Energy: 750 MeV

Stored current: 300 mA

Natural emittance: 27.4 nm-rad

Circumference: 53 m

3. Pulse width measurement

Goal

Evaluation of the gamma ray pulse width in the femtosecond range based on a pump-probe technique.

Evaluation of an upper bound value of the gamma ray pulse width in the picosecond range by using a photodetector with a picosecond time resolution.

Estimation of the upper bound value

If the pulse width of the gamma rays ($T_1$) is larger than 82 ps, a measured timing distribution ($T_2$) is larger than a time resolution of a MPPC module ($T_3$) in the ideal condition where a time-jitter is negligible.

The shortest pulse width that a MPPC can evaluate is 82 ps.

Measurement of the upper bound value

We measured a timing distribution output signals of a MPPC crossed a slice line.

The main reason of a large time-jitter is considered as low S/N ratio of the trigger signal.

By increasing a S/N ratio of the trigger signal, we can lower the upper bound value of the gamma ray pulse width.

4. Conclusion

- Measurement techniques in the femtosecond and picosecond range of the gamma ray pulse width is being developed.
- We have succeeded in measuring the gamma ray pulse width including a time-jitter as 540 ps.