# Analysis of fake asymmetry for the MTV experiment

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The Mott polarimetry for T-Violation (MTV) experiment aims to search for a large time-reversal symmetry violation (T-violation) in polarized $^8$Li $\beta$ decay. This experiment was conducted at the TRIUMF Isotope Separator and Accelerator (TRIUMF-ISAC). T-Violation may arise in triple-vector correlation (R-correlation) in beta decay. R-correlation causes electron transverse polarization and it can be measured by detecting the angle symmetry of electron Mott scattering using a cylindrical drift chamber (CDC). Figure 1 shows a schematic of how $\beta$ rays are detected. A $^8$Li beam is stopped at the beam stopper placed at the center of CDC, and an electron is emitted. CDC can detect the track of the electron scattered on an analyzer foil.

The electron emission distribution of $\beta^-$ decay, $\omega$, is expressed as[1)]

$$\omega dE_{\mathrm{e}} d\Omega_{\mathrm{e}} \propto 1 + R\vec{\sigma} \cdot \left[ \frac{\langle \vec{J} \rangle}{J} \times \frac{\vec{p_{\mathrm{e}}}}{E_{\mathrm{e}}} \right] + A \frac{\langle \vec{J} \rangle}{J} \cdot \frac{\vec{p_{\mathrm{e}}}}{E_{\mathrm{e}}} + \ldots . \quad (1)$$

The definition of $R$-correlation can be found in this function, where $\vec{J}$ is the spin polarization of the parent nuclei and $\vec{\sigma}$, $\vec{p_e}$, and $E_e$ are the spin polarization, momentum, and electron energy, respectively. $A$-correlation is the anisotrpy of $\beta$-ray emission. In the case of $^8$Li, $A = -\frac{1}{3}$. Both $A$- and $R$-correlation terms are proportional to the parent nuclei's polarization. Therefore, we adopt $R$-asymmetry (Mott Scattering angle asymmetry) divided by $A$-asymmetry ($\beta$ ray emission rate asymmetry) as a scale of coefficient $R$.

In our previous studies, we recognized a systematic effect that causes a large fake $R$-asymmetry. It is estimated that the source of this systematic effect is accidental coincidence, and it shows an obvious dependence on the width of the coincidence window and beam intensity.[2)] We assume an evaluation model function of fake asymmetry $Asym(x)$. The variable $x$ is presented as a product of the beam intensity and the width of the coincidence window in arbitrary units.

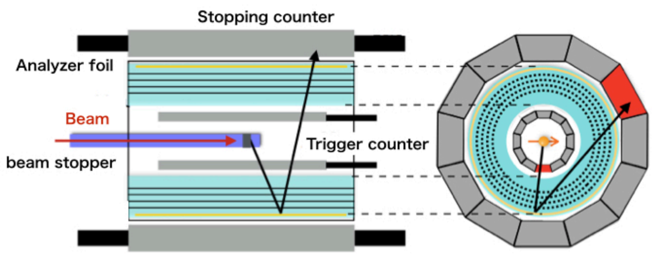


Fig. 1. Schematic of CDC.

$$Asym(x) = \frac{a}{1 + \frac{b}{x}} + \frac{c}{1 + \frac{x}{b}}. \quad (2)$$

The parameter $a$ represents fake asymmetry caused by accidental coincidence, $b/x$ represents the ratio of the number of real Mott scattering events to accidental coincidence events, and $c$ is the asymmetry of real Mott scattering events. The limit of $Asym(x)$ as $x$ approaches 0 is c. This means that the y-intercept of this function is the coefficient R, which we want to know. Figure 2 shows 1183 measured asymmetry data points acquired in 2017. The measurement time was 400 s per plotted data point. The beam intensity was about $10^{5-7}$ pps, and the coincidence window varies from 100 ns to 3000 ns. This shows that our model is suitable for evaluating the scale of fake asymmetry as a function of the product of beam intensity and the width of the coincidence window.

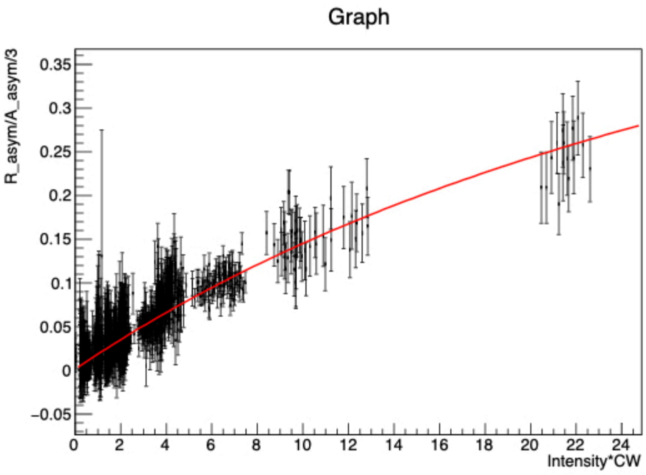


Fig. 2. Beam-intensity and coincidence-window dependence of Mott scattering asymmetry. The red line indicates fitting with Eq. (2).

The accidental coincidence model we use is assumed with consideration of the double coincidence of $\beta$ rays, but there can be triple or more coincidence events. Multiple coincidence could cause other effects of fake asymmetry. We need to evaluate this factor to draw a conclusion from our data.

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