Analysis of \( \gamma \gamma \rightarrow J/\psi \) (two-photon process)

At an e+e- collider, we can observe a hadronic system from collisions of virtual or real photons. A virtual photon is expressed by emitting a pair of quarks (\( Q^+ Q^- \)).

The world’s highest luminosity: \( 2.11 \times 10^{36} \text{cm}^{-2} \text{s}^{-1} \)

Radiative photon from the beam is virtual. Virtual \( Q^+ Q^- \) (4-momentum of virtual photon) is expressed by a form factor:

\[
Q^+ = \frac{4E E'}{\sqrt{s}} \cos \theta
\]

Hadron production from two-photon process

• In the case of \( P\)-balance, \( \Delta M = 0 \) requirement of the hadronic system, we can measure the resonance angular distribution from the \( P\)-real photons colliding (\( Q^+ \)).

• Assuming a quasi-real photon collision, we can measure two-photon decay widths (\( \chi \)).

• Observing the quasi-real collisions, we can measure two-photon decay width (\( \chi \)). From cross-section of the produced resonance, \( \Gamma \), gives information of internal structure of produced meson.

The contents of the analysis:

• In order to measure properties and internal structure of charmonium-like states, we analyze the channel of \( \gamma \gamma \rightarrow J/\psi \). J/\psi \rightarrow l^+ l^- (\( l = e \) or \( \mu \)).

• To perform the following:
  1. More precise measurement of \( x_{\gamma \gamma} \).
  2. Search for new charmonium-like states.
  3. Analysis with \( P\)-balance.

Analysis of \( \gamma \gamma \rightarrow J/\psi \) (two-photon process)

Belle Experiment

Analysis Motivation (Analysis of Charmonium-like States)

In this century, heavy quarkonium spectroscopy has been developed from the result of many experiments.

For establishing theory of hadron formation from quarks, we have to research properties, internal structure of the hadrons and discover more hadrons.

In 2000, X(3872) which is considered as exotic hadron, was discovered at Belle experiment. After that, many particles which may be exotic have been discovered at various experiments. Exotic hadrons become a popular field at the moment.

We will analyze charmonium states and charmonium-like (candidate of exotic charmonium “X(3872)” states) states to develop heavy quarkonium spectroscopy.

Evaporative hadrons:

· The total energy deposit on ECL is less than 6.0 GeV.
· Decay length of the hadron is less than 1 cm.
· Transverse momentum of total out for two-photon process is less than 0.15 GeV/c.

Summary and next step

To test models describing the nature of heavy quarkonia, we study \( \gamma \gamma \rightarrow J/\psi \) production at the Belle 1 experiment with the data sample.

An estimate of the yield of each channel (like states) and confirm the stability of our fit by performing the fitter test. From them, we evaluate \( \Gamma_{\gamma \gamma} \) and extract \( \Gamma_{\gamma \gamma} \), (\( \gamma \gamma \) → channel). As the result, the systematic error will be 1%.

After the MC study, we start the analysis using the data sample to measure and search charmonium-like states.