Charge asymmetry of lepton production in photon collisions

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May 15, 2008

Motivation

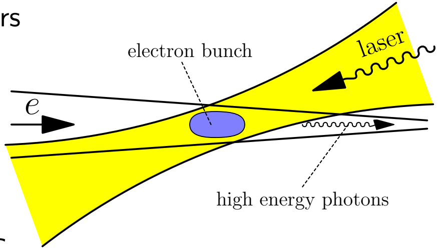
- Different asymmetries are used in searches of New Physics.
- Due to P nonconservation in SM there is a charge asymmetry in processes like $\gamma\gamma \to \mu^- \mu^+ \nu \bar{\nu}$ with polarized photons.
- To test such processes Photon Collider can be built as an extention of Linear Collider

Photon Collider (PC)

- The next generation of high energy e^+e^- colliders will be Linear Colliders (LC).

$\Rightarrow$ Proposal to convert e^+e^- LC into Photon Colliders using laser light backscattering.

- Now this Photon Collider mode is included in all modern projects of LC (ILC, CLIC, JLC,...)



I.F.Ginzburg, G.L.Kotkin, V.G.Serbo,V.I.Telnov. JETP Lett. **34** (1981) 514–518; NIMR **205** (1983) 47–68;+S.L.Panfil NIMR **219** (1983) 5.

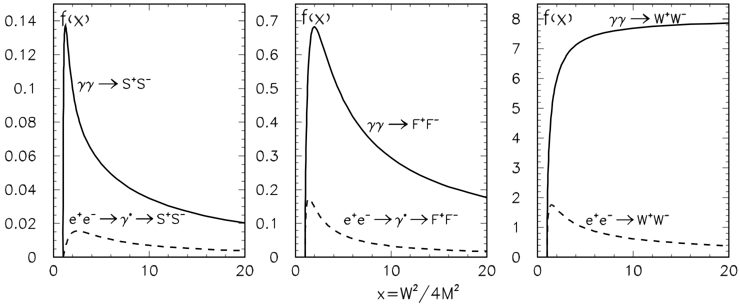
Main features of Photon colliders

- Maximal photon energy $E_\gamma^{max} \approx 0.8 E_e$.

High energy peak of the spectrum

- Luminosity $\mathcal{L}_{\gamma\gamma} \approx \mathcal{L}_{ee}/3$, $\mathcal{L}_{e\gamma} \approx \mathcal{L}_{ee}/4$ (for ILC $200 \div 150$ fb^{-1}/year)
- Mean energy spread $< \Delta E_\gamma > \approx 0.07 E_\gamma$.
- Mean photon helicity $< \lambda_\gamma > \approx 0.95$, easily variable.

Physics at Photon colliders



- $\gamma\gamma$ cross sections are evidently higher than the corresponding e^+e^- collisions
- The $\gamma\gamma$ cross sections much slower decrease with energy
- Access to polarization provides the opportunity to know spin of produced particles

Charge asymmetry in lepton production

Charge asymmetry

- P nonconservation in the SM

$\Rightarrow$ Big difference between distributions of ℓ^+ and ℓ^- in processes like

$$\gamma\gamma \to \ell^+\ell^-\nu_\ell\bar{\nu}_\ell,\ \gamma\gamma \to W^\pm\ell^\mp\nu_\ell, \qquad (\ell = e \text{ or} \mu)$$

- For definiteness we will further use $\ell = \mu$
- Numerical calculations are done for $\gamma\gamma \to W^\pm\mu^\mp\nu_\mu$, $E_\gamma = 250 GeV$

Diagrams

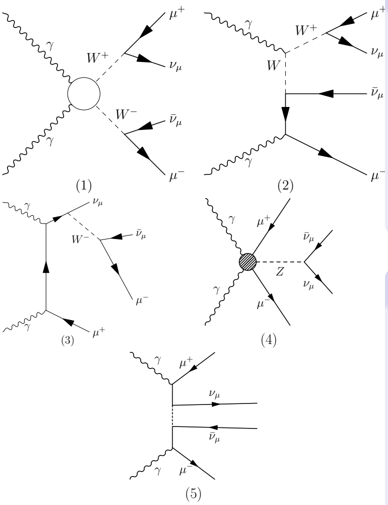


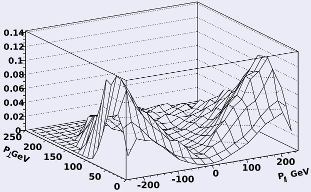
Diagram Classes

1. With WW pair production (DRD)
2. With W exchange in t-channel SRD
3. With lepton exchange in t-channel
4. With radiation of Z boson
5. Multi-peripheral diagrams

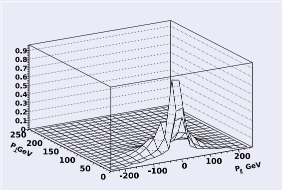
Contribution

- (3),(4) and (5) are negligible in comparison with DRD (1).
- The interference of SRD with DRD is destructive.
- DRD contribution covers almost entire (98.7 %) cross section.

Both photons are left polarized $\gamma_-\gamma_-$. $\partial^2\sigma/\partial p_l \partial p_t$

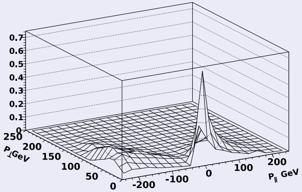


Negative μ distribution.

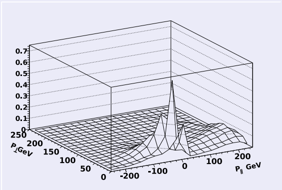


Positive μ distribution.

First photon is left polarized, second is right polarized: $\gamma_-\gamma_+$.



Negative μ distribution.



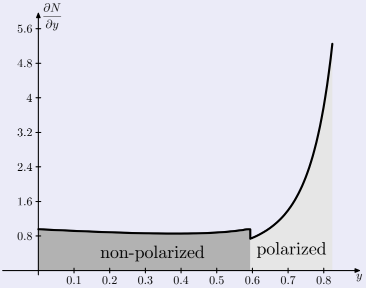
Positive μ distribution.

Cascade processes

- Processes $\gamma\gamma \to W\tau\nu \to W\mu\nu\nu\nu$ give same observable final state.
- Decay $\tau \to \mu\nu_\tau\nu_\mu$ involves 3 particles, the effective mass of the $\nu\bar{\nu}$ system $m_{\nu\nu}$ varies from 0 to m_τ.
- The μ distribution is *contracted* in comparison with τ distribution:

$$E_\mu \le E_\tau(1 - m_{\nu\nu}^2/m_\tau^2)$$

Effects of photon non-monochromaticity

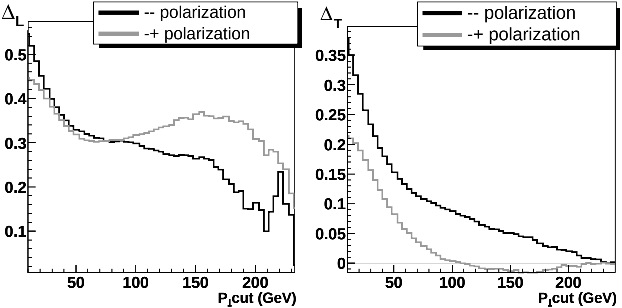


- Non-polarized low energy part of the spectrum depends strongly on the details of experiment
- Polarized high energy part ($E_\gamma > E_\gamma^{max}/\sqrt{2}$) is independent of experimental set up.
- In our sumulations we used some "realistic" photon spectrum

- We introduce asymmetry quantities

$$\Delta_L = \frac{\int p_{\parallel}^{-} d\sigma - \int p_{\parallel}^{+} d\sigma}{\int p_{\parallel}^{-} d\sigma + \int p_{\parallel}^{+} d\sigma}, \quad \Delta_T = \frac{\int p_{\perp}^{-} d\sigma - \int p_{\perp}^{+} d\sigma}{\int p_{\perp}^{-} d\sigma + \int p_{\perp}^{+} d\sigma}$$

- $\Delta_{L,T}$ are not small even at large $p_{\perp}^{cut}$



Conclusions

- Huge and easily observable effect.
- Cascade process and non-monochromaticity weakly affect the asymmetry.
- Introduced quantities (especially Δ_L) large even with large $p^c_{\perp\mu}$ cuts.
- Taking into accont same effects for $e^+ e^-$, $e^+ \mu^-$, $\mu^+ e^-$ enchance statistics by 4 times.

Plans

Consider charge asymmetry for discovery of New Physics effects.