Luminosity stabilization at the photon collider

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Beam collisions (luminosity) at linear colliders can be controlled by the beam–beam deflection. It is considered as a basic method for e^+e^- collisions and is assumed for $\gamma\gamma$ as well.

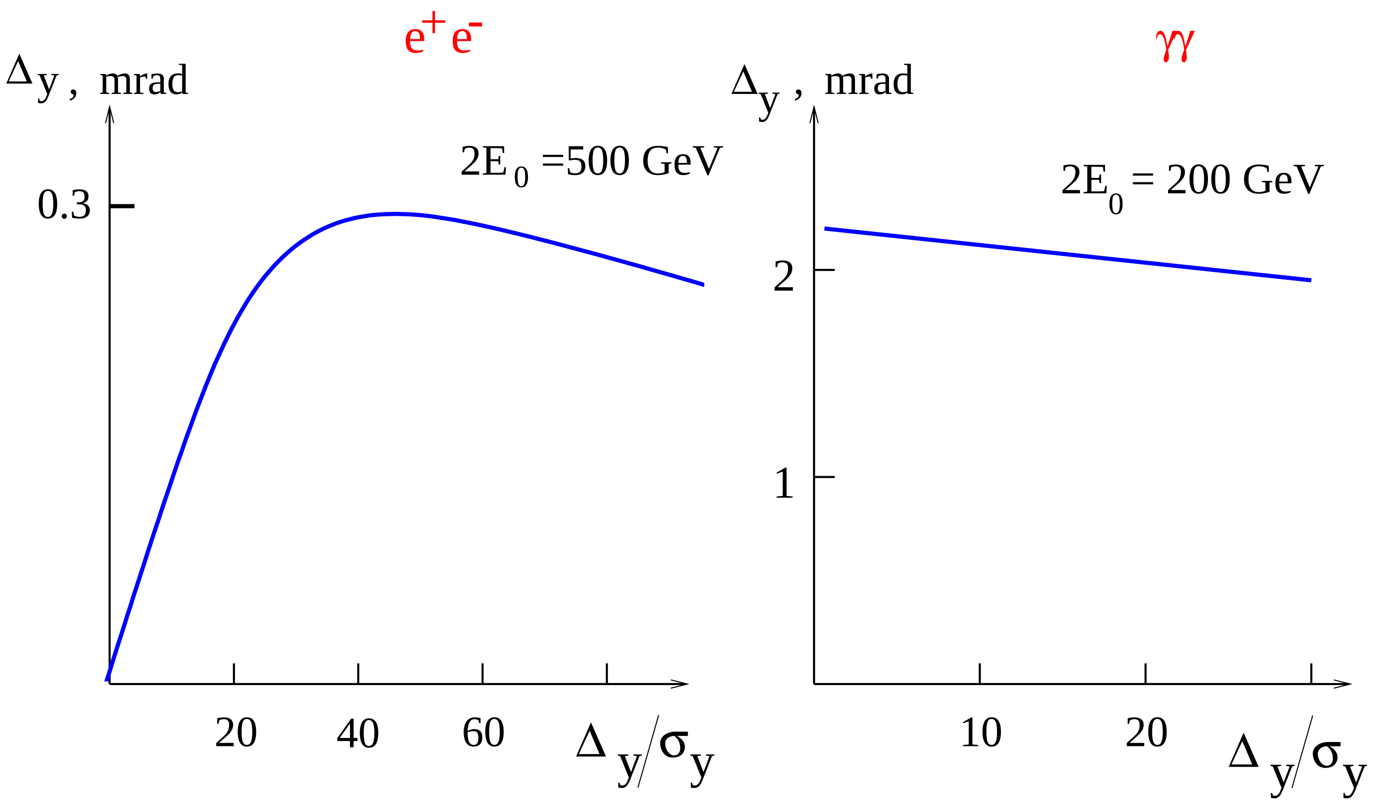
Difference between e^+e^- and $\gamma\gamma$ cases:

1. In the e^+e^- case, at small vertical displacement the beams attract and oscillate inside each other. In $\gamma\gamma$ case (e^-e^-) as well) the beams repel each other. As result the deflection angle is larger.

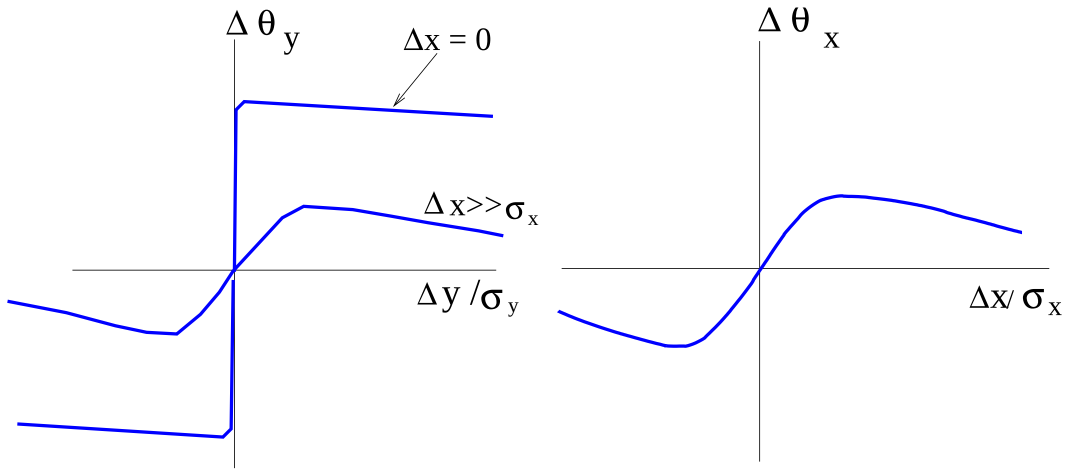
2. In $\gamma\gamma$, due to the Compton scattering the average energy in the disrupted beam is several times smaller than the beam energy which leads to the increase of the deflection angle.

3. In $\gamma\gamma$ collisions σ_x is 2–5 times smaller than in e^+e^- case. Due to a very strong beam-beam instability the kick is large and almost independent on the initial displacement.

Typical deflection curves in e^+e^- and $\gamma\gamma$ collisions



$\gamma\gamma$ — more general case of beam deflection



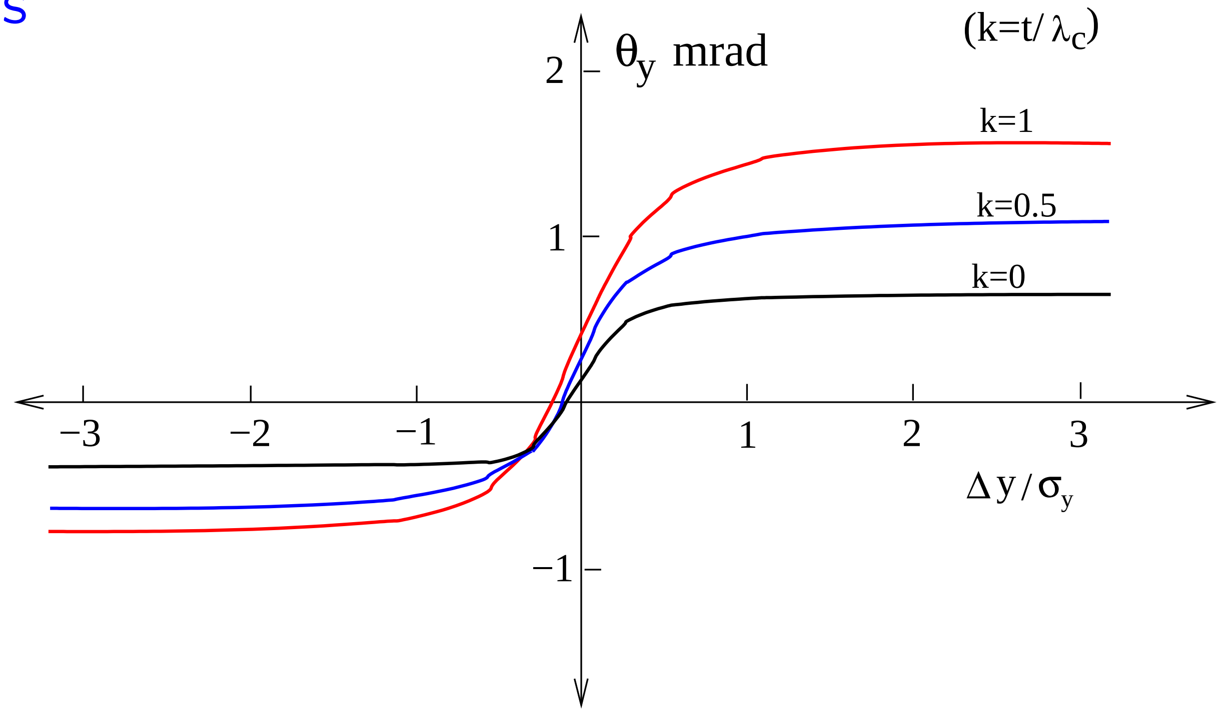
The main difference from e^+e^- is the step-like behavior of the ϑ_y on the displacement Δ_y.

Complications:

- The deflection curve depends on the conversion efficiency.
- Due to the crossing angle the disrupted beam is deflected vertically by the detector field. This additional deflection is comparable to the beam-beam deflection angle and also depends on the conversion probability. This effect shifts the zero point and makes problem for stabilization of beam-beam collisions.

$\gamma\gamma$ — the general case

Simulation for the photon collider at the ILC nominal beam parameters

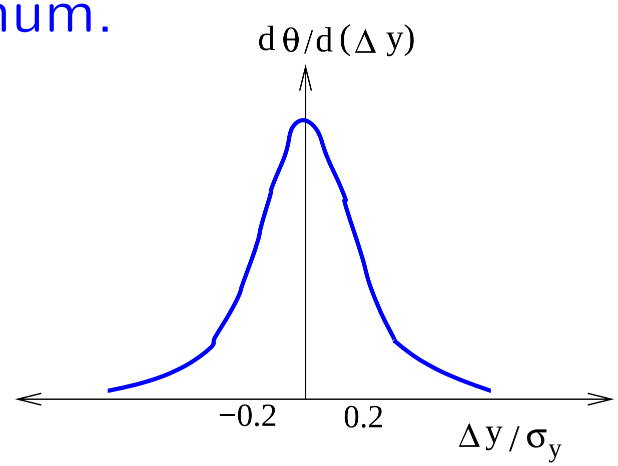


We see that the deflections depends on the conversion coefficient, deflection curves are symmetric but shifted vertically due to the detector field on some variable value.

How to find the vertical beam positions corresponding to the maximum $\gamma\gamma$ luminosity???

Solution of the problem

All deflection curves $\theta_y = f(\Delta y)$ have one common feature: the derivatives f' have maximum at the point of zero beam shifts where $L_{\gamma\gamma}$ is maximum.



The width of this "resonance"curve is about $\pm 0.2\sigma_y$ (for considered cases).

The prescription for the $\gamma\gamma$,γe luminosity stabilization:

1. Varying Δy by decreasing steps (under control of a computer code) we find the position of the jump in the deflection curve with an accuracy about $2\sigma_y$;

2. Continue the scan with the step $0.1\sigma_y$ up and down around the point with the maximum derivative. The loss of $L_{\gamma\gamma}$ due to walking around the zero point will be negligibly small.

3. The horizontal zero point can be found in a similar way by varying the horizontal separation and measured horizontal deflection or by varying the horizontal separation and measuring the vertical deflection (the maximum vertical deflection corresponds to the zero horizontal point).

4. In addition, the deflection by the detector field is very useful for optimization of the $e \to \gamma$ conversion. One just move the laser beam and measure the vertical position of the outgoing beam in peak-ups at the distance about 4 m from the IP. The maximum beam displacement corresponds to the maximum conversion efficiency. The corresponding beam displacement is about 0.5 mrad or 2 mm in pick-ups.

Conclusion

The beam-beam deflection is a good method for stabilization of $\gamma\gamma$, γe luminosities at the ILC. The required algorithm looks not difficult for implementation owing to a large train length.

The "parasitic"additional deflection of the disrupted beams by the detector field (due to the crab-crossing) complicates the picture but not too much, moreover it helps to adjust the $e \to \gamma$ conversion.