Dependence of the e^+e^- and $\gamma\gamma$ luminosities on the crab-crossing angle.

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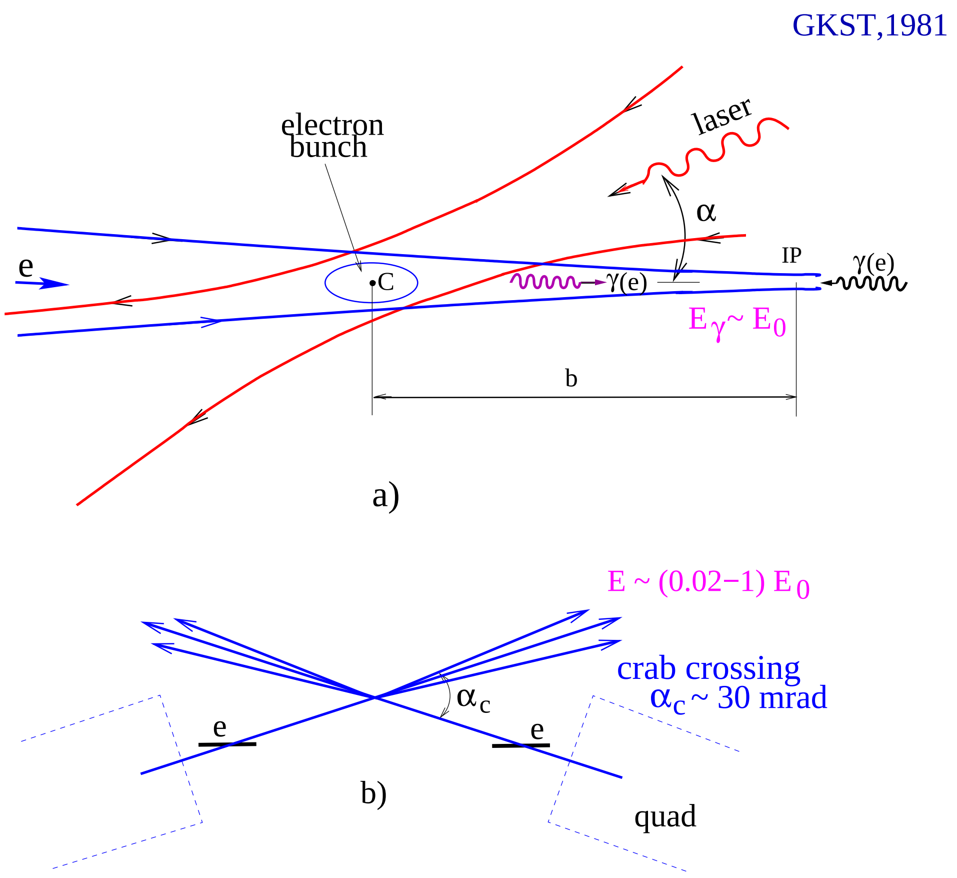
The crossing angle



After the collision the beams have a large energy spread: $E \sim (0.02-1)E_0$ and disruption angles $\theta_d \sim$ 10-12 mrad (the background from particles with larger angle is less than from unavoidable backgrounds).

The removal of disrupted beams need large crab-crossing angle:

$\alpha_c \sim R_{quad}/L^* + \theta_d$

$\sim 6/400 + 0.01 \sim 25$ mrad.

(For e^+e^- $\alpha_c = 20$ mrad is one of possible options.)

It is very desirable to have the crossing compatible with both collision modes, i.e. ≥ 25 mrads.

Synchrotron radiation in the detector field

Large crossing angles lead to the increase of σ_y due to synchrotron radiation of electrons in the solenoid. After emission of the photon(s) the electron comes to the IP with some vertical deflection. This effect leads to the decrease of the luminosity. A simple theory gives $\sigma_{y,SR} \propto (L_s B_s \alpha_c)^{5/2}$.

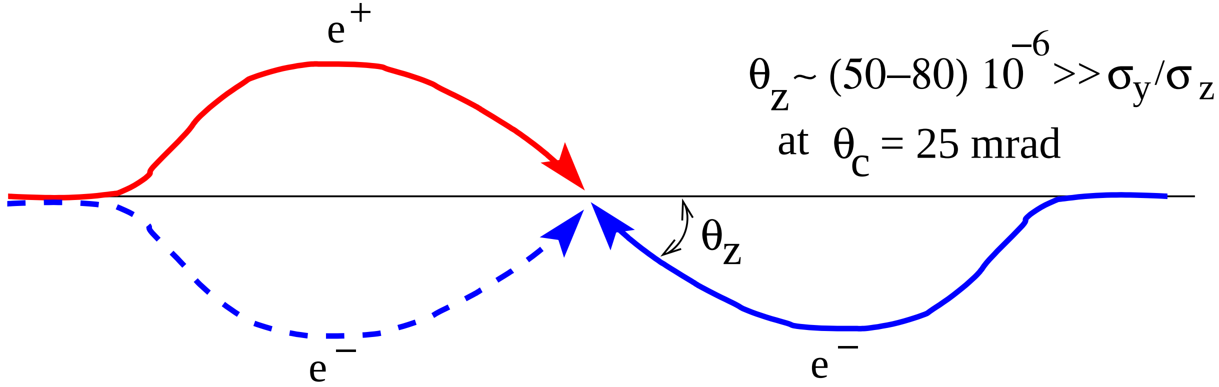
The number of SR photons/e $N_\gamma \propto L_s B_s \alpha_c = \mathcal{O}(1)$, therefore the distribution on Δy is not Gaussian, also the fields in the detectors are rather complicated (the fringe field gives also a comparable contribution), therefore a detailed simulation is desirable.

The simulation was done using PHOCOL code (Telnov,1994), which simulated beam collisions at the LC in all modes. It was used for simulation of photon colliders for NLC ZDR, TESLA CDR, TESLA TDR.

The considered effect was accounted in the following way: using the map of the magnetic field in the detector (B(z,0,0) is sufficient) SR is simulated and the deviation of the electron from the case when there is no SR is calculated for each electron. This deviation is added to the initial Gaussian position of the electron at $z = 0$. Then all particles are shifted according to there coordinates and angles at $z = 0$ to there starting positions at $z > 5\sigma_z$ (or CP-IP distance at the photon collider) and the simulation with account of all collision effects starts.

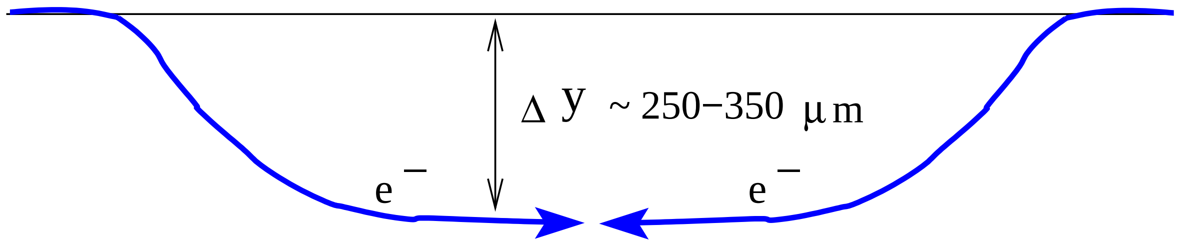
In the given simulation (e^+e^- at 2E=1 TeV) only attraction between particles was switched on, other processes are not essential.

Trajectories of e^+e^- and e^-e^- beams



OK for e+e−, but not OK for e−e−(gamma−gamma)

Vertical shifts of final qurds helps
for e−e−($\gamma\gamma$)



Precession of the spin in e^+e^- case due to the crab crossing $O(1^o)$ is neglegibly small and can be corrected by the spin rotator.

The verical displacement of the IP in the e^+e^- case is also not essential.

Beam parameters

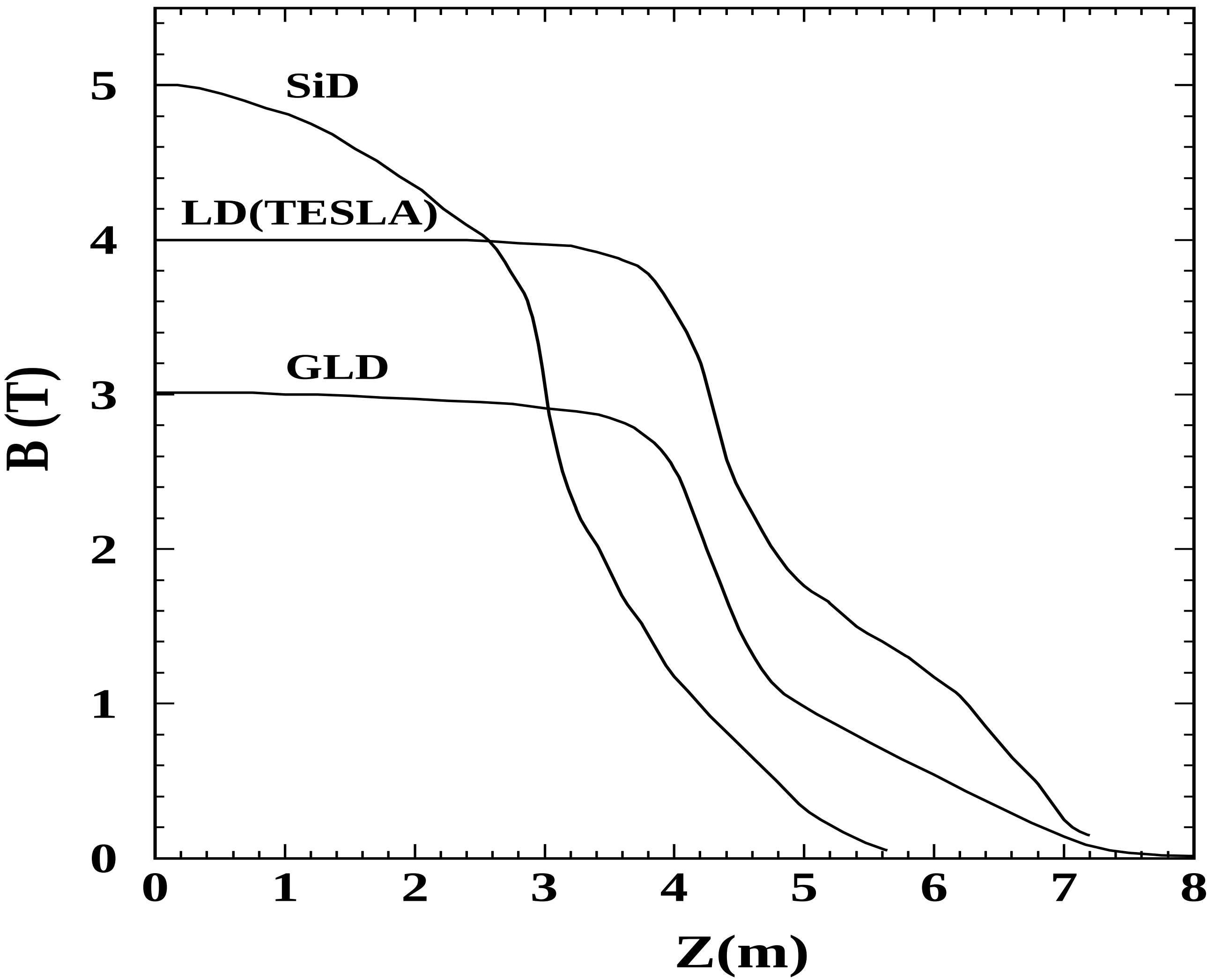
Parameters of beams are taken from U.S. Linear Collider Technology Option Study:

$2E_0 = 1$ TeV, $N = 2\times 10^{10}$, $\sigma_z = 0.3$ mm, ϵ_{nx}=9.6$\times 10^{-6}$ m, ϵ_{ny}=0.04 $\times$ 10^{-6} m, $\beta_x = 24.4$ mm, $\beta_y = 0.4$ mm, $\sigma_x =$ 490 nm, $\sigma_y = 4$ nm.

For $\gamma\gamma$ case $\sigma_y(\gamma\gamma) = \sqrt{2}\sigma_y(\mathrm{e}^+\mathrm{e}^-)$ (for e$^-$e$^-$ collisions it should be even larger due to disruption effects).

The position of the first quard (shifted in the e$^-$e$^-$($\gamma\gamma$) case) is $\sim$ 3.5-5.7 m for all detectors.

B(z,0,0) in LD, SID and GLD detectors



Results on $L(\alpha_c)/L(0)$

e^+e^- collisions

α_c(mrad)	0	20	25	30	35	40
LD	1.	0.98	0.95	0.88	0.83	0.76
SID	1.	0.995	0.985	0.98	0.95	0.91
GLD	1.	0.995	0.98	0.97	0.94	0.925

$\gamma\gamma$ collisions

α_c(mrad)	0	20	25	30	35	40
LD	1	0.99	0.96	0.925	0.86	0.79
SID	1	0.99	0.975	0.955	0.91	0.86
GLD	1	0.995	0.985	0.98	0.97	0.93

Statistical accuracy about $\pm 0.5\%$.

Conclusion: $\alpha_c = 25$ mrad is OK for all detectors.

For $\alpha_c = 30$ mrad the luminosity loss for LD is somewhat large, but possible can be optimized by proper shaping of the magnetic field (tails).