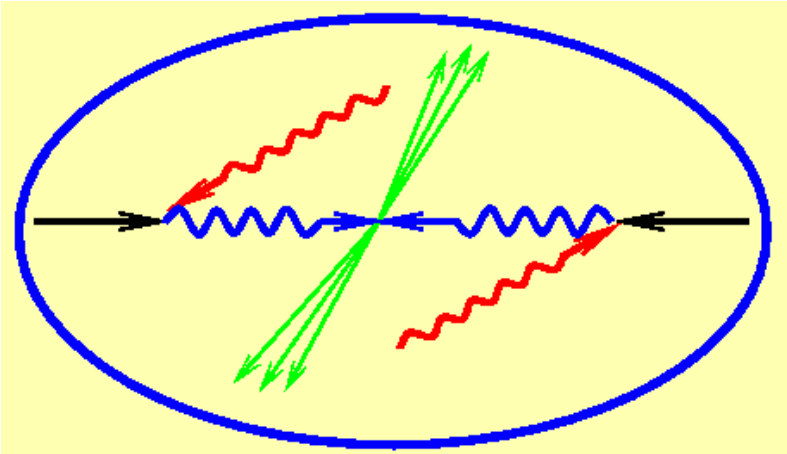

Present status of the Photon Collider, what next?

Valery Telnov

LCWS-ILC-07, June 1, 2007, DESY

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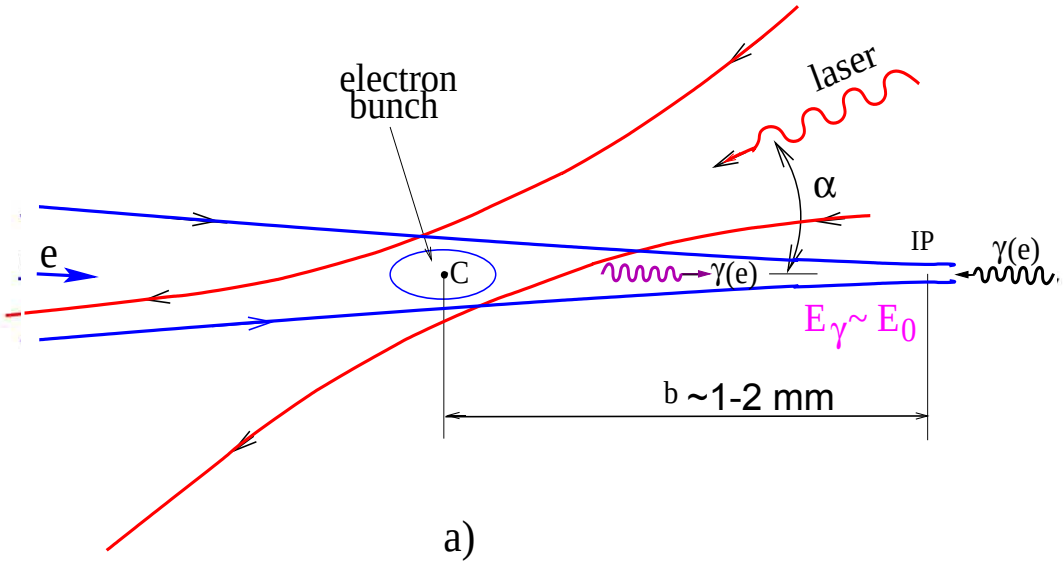
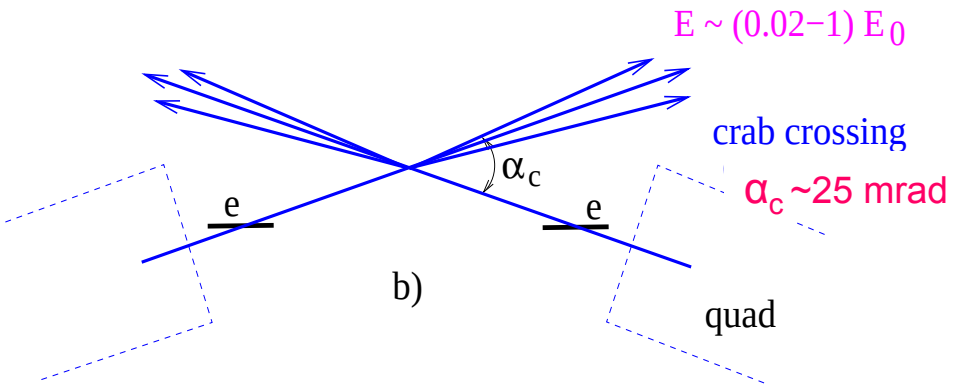
- Introduction, physics motivation, parameters
- What is most important now?
- Crossing angle
- ILC RDR (Ref. Design Report) without the photon collider. What does it mean, who decided?
- Luminosity, laser optics, detector
- Organization questions

Scheme of $\gamma\gamma$, γe collider



a)



b)

$$\omega_m = \frac{x}{x+1} E_0$$

$$x \approx \frac{4E_0\omega_0}{m^2c^4} \simeq 15.3 \left[\frac{E_0}{\text{TeV}}\right]\left[\frac{\omega_0}{\text{eV}}\right]$$

$E_0 = 250$ GeV, $\omega_0 = 1.17$ eV
$(\lambda = 1.06\ \mu\text{m}) \Rightarrow$
x=4.5, $\omega_m = 0.82E_0 = 205$ GeV

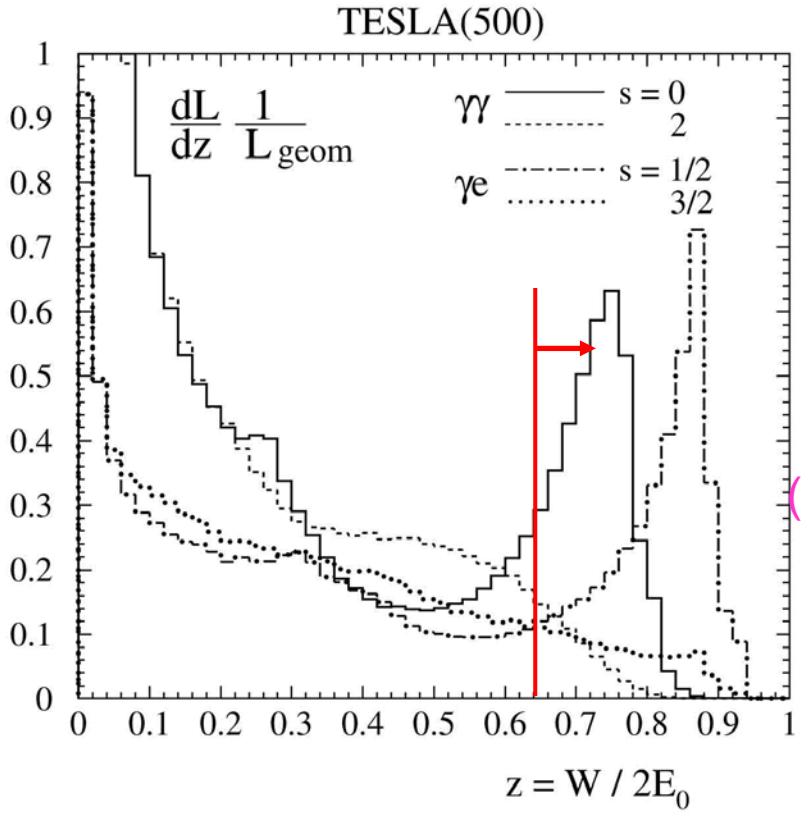
$x = 4.8$ is the threshold for
$\gamma\gamma_L \to e^+e^-$ at conv. reg.

$\omega_{max} \sim 0.8\ E_0$

$W_{\gamma\gamma,\,max} \sim 0.8 \cdot 2E_0$
$W_{\gamma e,\,max} \sim 0.9 \cdot 2E_0$

Luminosity spectra

(decomposed in two states of J_z)



Usually a luminosity at the photon collider is defined as the luminosity in the high energy peak, $z>0.8z_m$.

For ILC conditions

$L_{\gamma\gamma}(z>z_m) \sim (0.17\text{-}??)\, L_{e+e-}(nom)$

(but cross sections in $\gamma\gamma$ are larger by one order!)

First number - nominal beam emittances
Second - can be ~3 times larger
(needs optimization of DR for $\gamma\gamma$)

For γe it is better to convert only one electron beam, in this case it will be easier to identify γe reactions and the γe luminosity will be larger.

Physics motivation: summary

In $\gamma\gamma$, γe collisions compared to e^+e^-

1. the energy is smaller only by 10-20%
2. the number of events is similar or even higher
3. access to higher particle masses
   (H,A in $\gamma\gamma$, charged and light neutral SUSY in γe)
4. higher precision for some phenomena
5. different type of reactions
   (different dependence on theoretical parameters)

One example: $2E_0$=500 GeV

For e+e- $M_{H,A}$(max)~250 GeV (H,A are produced in pairs)

For $\gamma\gamma$ ~400 GeV (single resonance)

What is important now.

It is important to make design decisions on the baseline ILC project not prohibitive or unnecessarily difficult for the photon collider, which allow to reach its ultimate performance and rather easy transition between e^+e^- and $\gamma\gamma$, γe modes. The PLC needs:

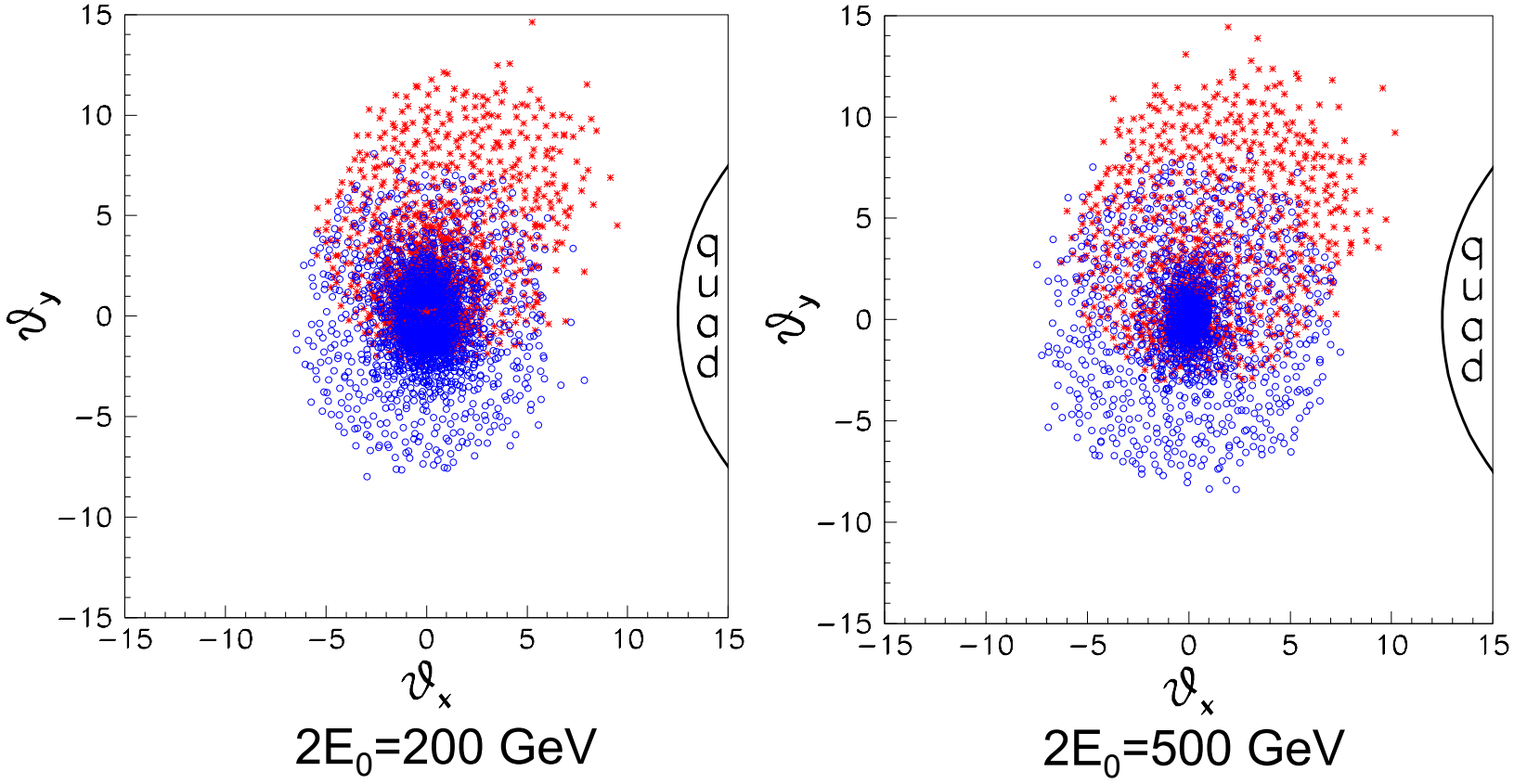
- the IP with the crossing angle ~ 25 mrad (the upgrade from 14 to 25 mrad should not require new excavation);
- place for the beam dump and the laser system;
- R&D on the laser system;
- detector, which can be easily modified for $\gamma\gamma$ mode;
- DR with as small as possible beam emittances.

Crossing angle

Disrupted beam with account of the detector field at the front of the quad (blue - without, red –with the field)

Telnov, Snowmass2005

L=4m, B=4T



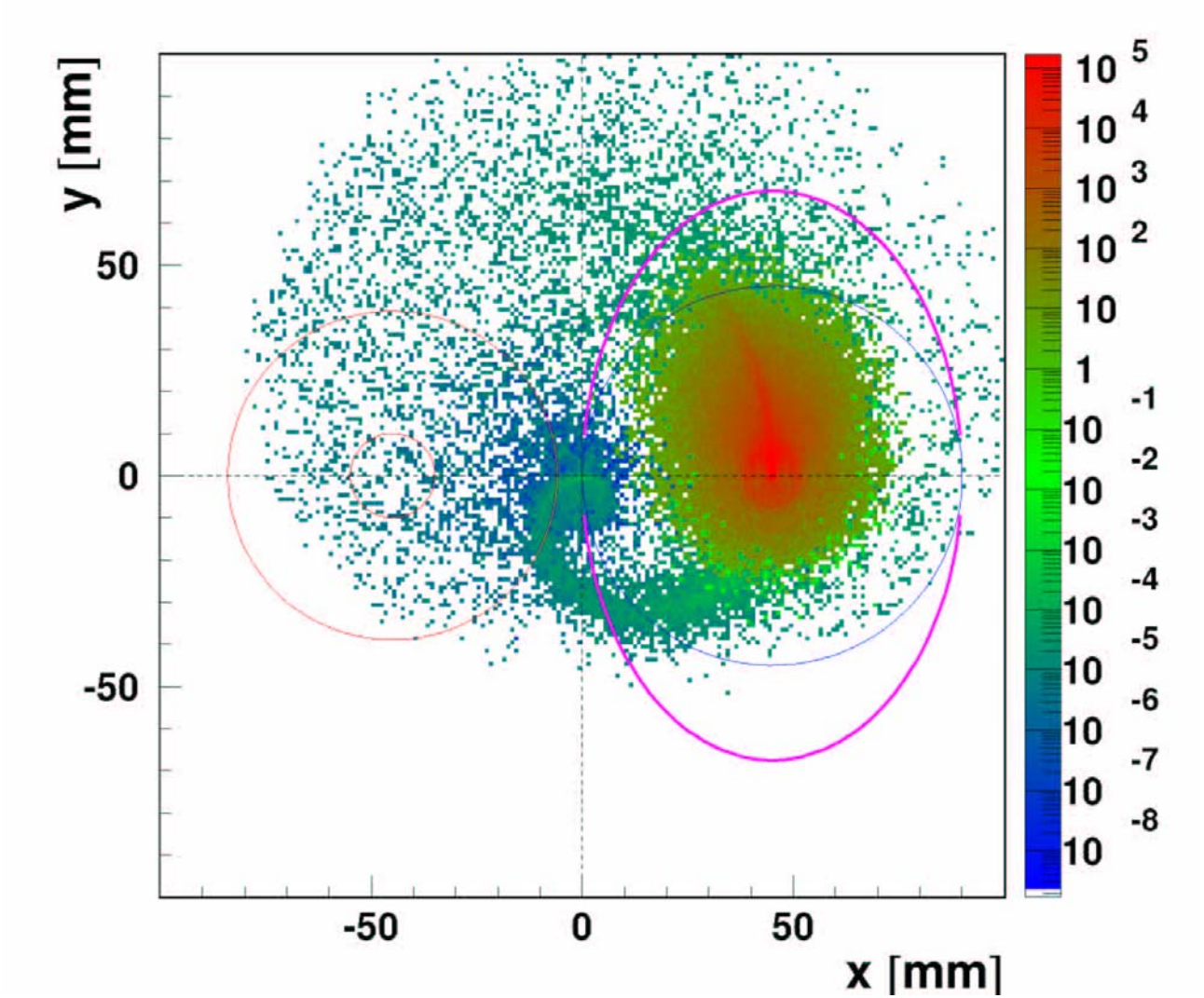
$2E_0$=200 GeV

$2E_0$=500 GeV

With account of tails the save beam sizes are larger by about 20 %.

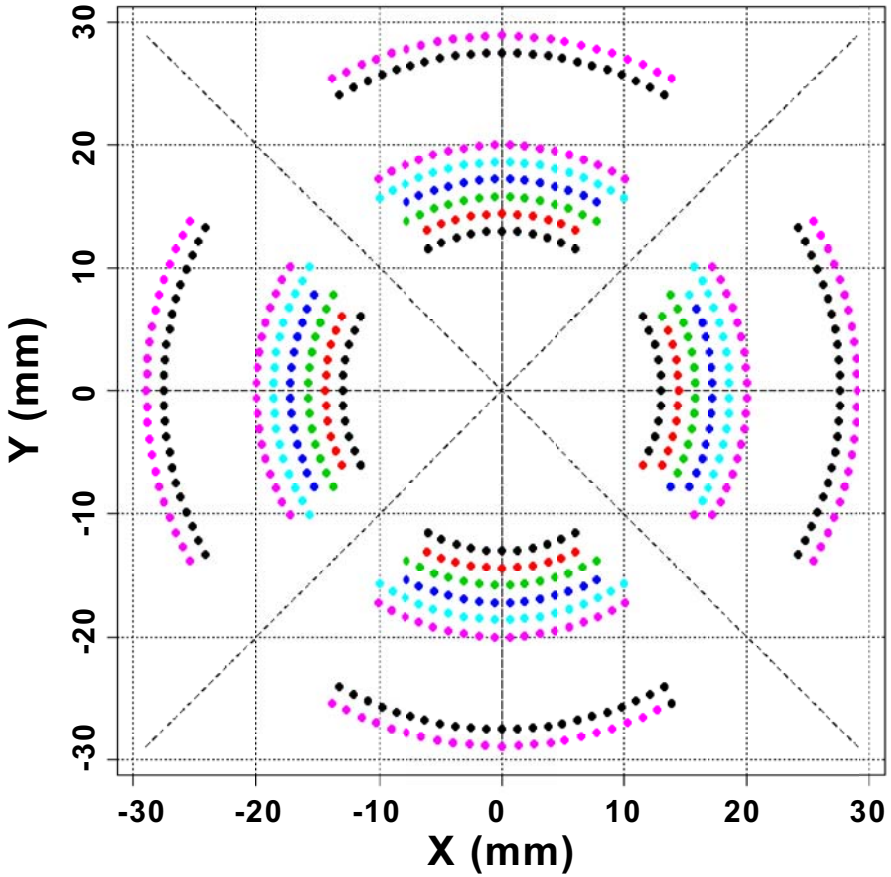
at L=4.5 m

A.F.Zarnecki, LCWS06



$P_{quad} < 1$ W

The radius of the self compensated quad with the cryostat is about 5 cm. (B.Parker, Snowmass 2005)

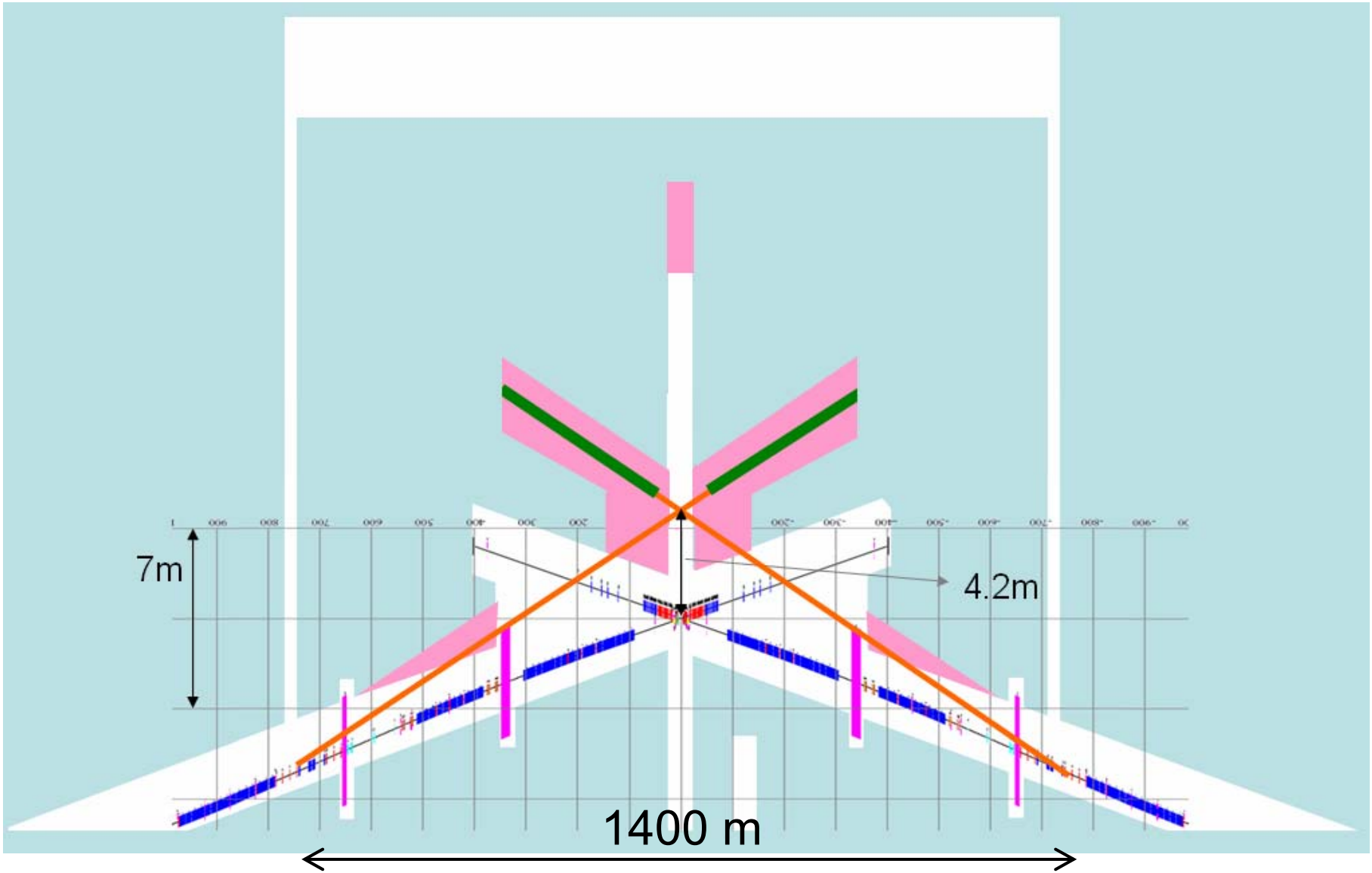


For compensation
G_{in} = 160 T/m
at I_o = 767 A
G_{out} = -20 T/m
at I_o = 517 A
for G_{eff} = 140 T/m
L_{mag} = 2.200 m
L_{coil} = 2.228 m

$$\alpha_c = (5/400)*1000 + 12.5 \sim 25 \text{ mrad}$$

14mr => 25mr

A.Seryi, LCWS06



- additional angle is 5.5mrad and detector need to move by about 4.2m

Possible upgrade of 14 mr (e^+e^-) to 25 mr ($\gamma\gamma$)

- Tunnel in FF area may need to be wider
- For transition from e+e- to $\gamma\gamma$ one should shift the detector and about 700 m long upstream FF system. May be it is not so difficult, if beamline elements are situated on long movable platforms.
- The same angle, 25 mrad, for e+e- and $\gamma\gamma$ is also possible, but e+e- people want special extraction line with beam diagnostic (energy, spectrum, polarization), while $\gamma\gamma$ needs clear way to the beam dump.

  Replacements will be difficult due to induced radioactivity. So, different crossing angles are even more preferable.

Unfortunately, in the RDR (2007,draft) only one IP with 14 mrad crossing angle is assumed with two detectors working in pull-push mode. $\gamma\gamma$ can not work in parallel with e+e- in pull-push mode (because needs larger angle and different beam dump).

Moreover, in the RDR the photon collider is not considered at all!

There is only one comment to this decision

(B.Barish's response to my letter to the LCWS07 program committee) :

"Valery ….
You certainly have every right to disagree with the ILC baseline, but it has resulted from an unprecedented worldwide process. A photon collider is one of the alternatives or options to that baseline and **yes, in the present version it will require excavation** to carry out that option. **Why is that so bad?** …Let me assure you for the n-th time that we will be considering both technical and scientific alternatives as we move forward."

Barry

In my opinion, this decision on the photon collider is a part of one chain:

1) 2E=500 GeV (1 TeV needs excavation);
2) One IP with two pull-push detectors;
3) No PLC, no fix target experiments.

(Very likely that at the end only one detector will be left)

Overwhelming part of the LC community is against these decisions. Everybody understand that these decisions decrease only somewhat the initial ILC cost but considerably increase the total cost and complicate the life.

Nobody can imaging excavation around the IP in several meters from beamlines and detectors.

Instead, ILC leaders should vigorously argue at all levels that

1) the ILC based on the SC technology is a perfect machine up to 2E=1 TeV, and for economy of resources tunnels should be made on full energy from the start.

2) The linear e+e- collider gives an unique opportunity to study new physics also in $\gamma\gamma$, γe collisions almost for free. That are very justified expenses, and in order to make transition from e+e- to these modes cheap this option should be considered in the project from the very beginning.

3) Two IPs are necessary because this provides continues experimentation, easy transition to $\gamma\gamma$, γe collisions (without several years stop), e.t.c.

Due to importance of the above items and absence of the agreement, these questions should be voted by LC physics-detector community or their representatives (members of all regional WWS OC and group conveners).

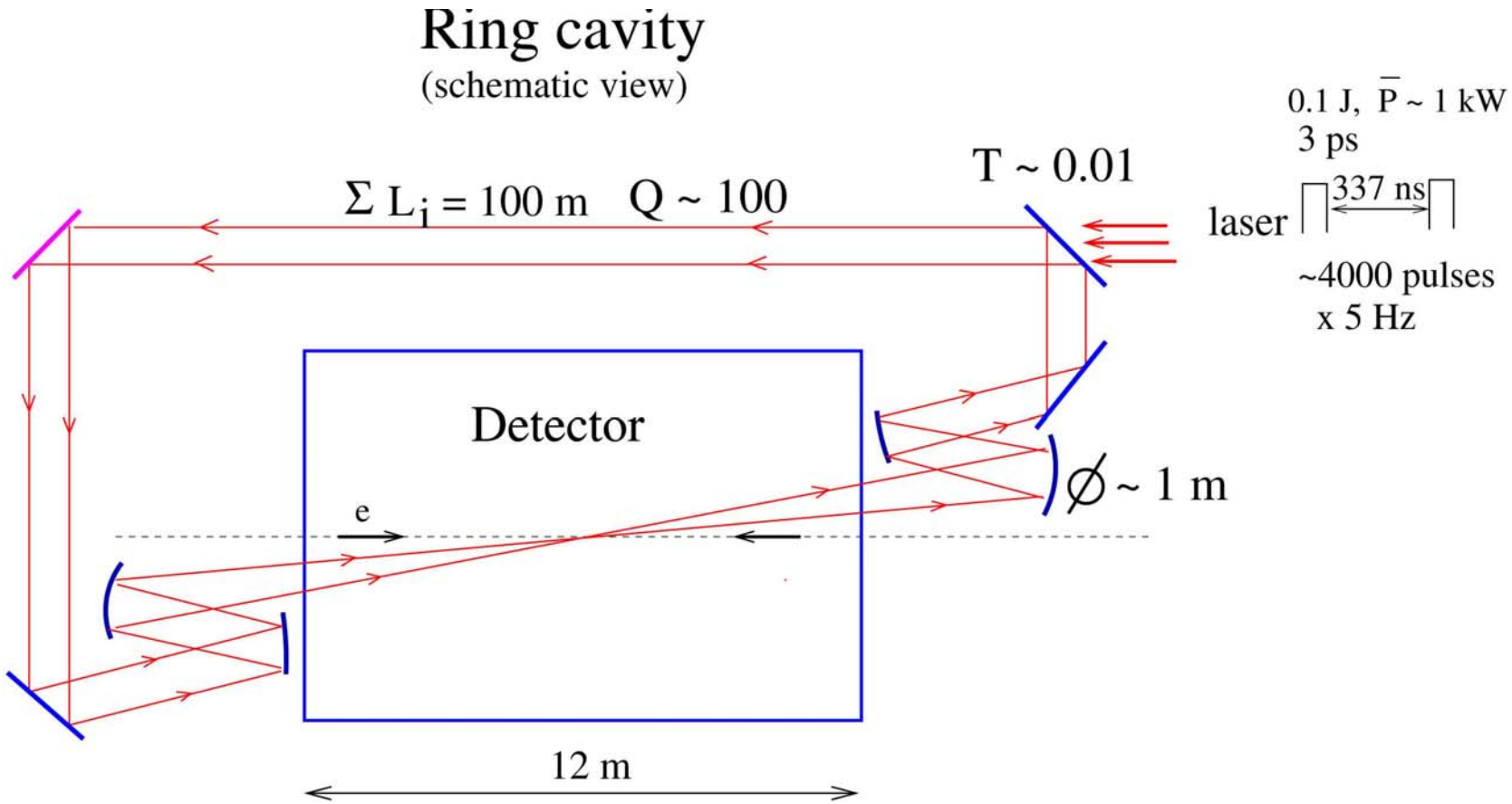
Any ILC manager should remember that the ILC is the result of great scientific efforts of many creative people around the world during the last two-three decades! They are real godfathers and their opinion should not be ignored!

Luminosity

In $\gamma\gamma$ collisions the luminosity (in ILC case) is just proportional to the geometric e-e- luminosity.
So, one needs smallest product of transverse beam emittances and smaller (than in e+e-) β_x .

One should further optimize damping rings and try to find a solution which gives smaller emittances. The increase of the $\gamma\gamma$ luminosity by a factor of 2-3 is important and surely possible.

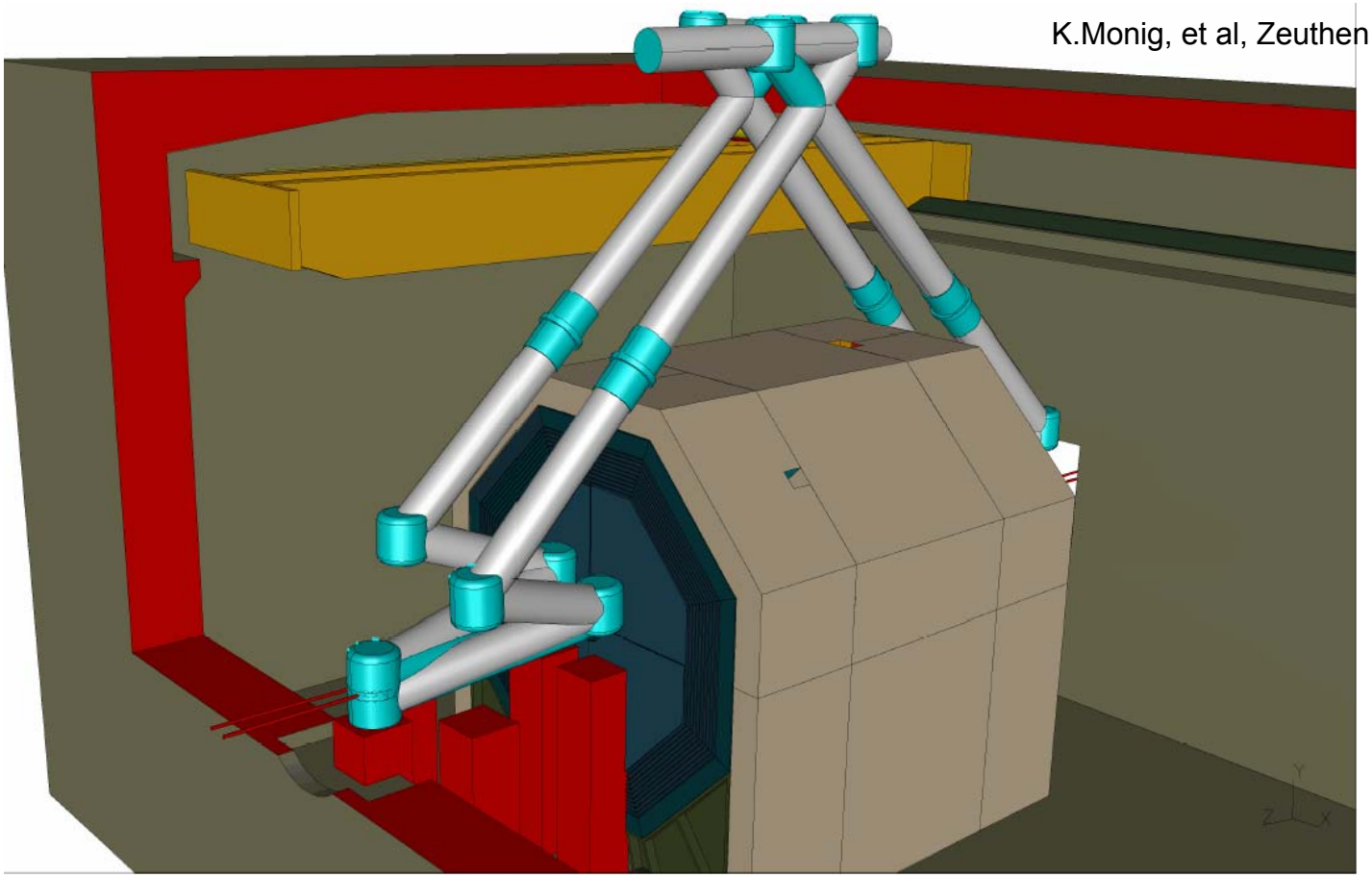
Laser system



The cavity includes adaptive mirrors and diagnostics. Optimum angular divergence of the laser beam is ±30 mrad, A≈9 J (k=1), $\sigma_t \approx 1.3$ ps, $\sigma_{x,L}$~7 μm

View of the detector with the laser system

(the pumping laser is in the building at the surface)



For easier manipulation with bridge crane and smaller vibrations it may be better to hide the laser tubes under the detector

Laser experts attracted by D.Miller (meeting in Daresbury, January 2006) critically considered requirements to the optical cavity for the photon collider and have not revealed any stoppers.

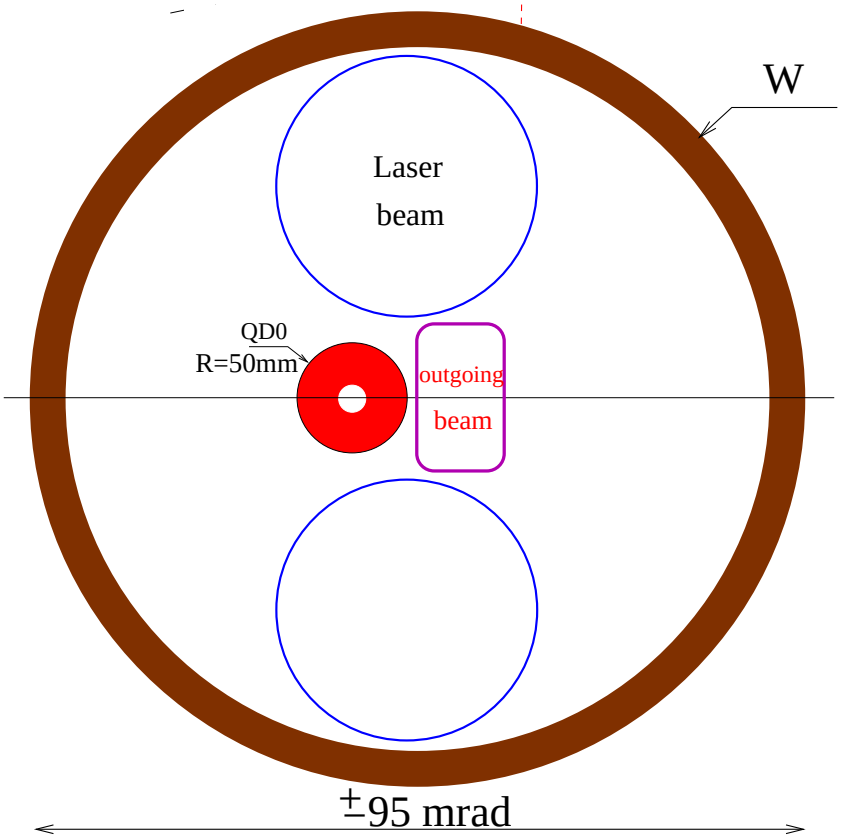
At present there is very big activity on development of the laser pulse stacking cavities at Orsay, KEK, CERN, BNL for

ILC polarimetry
Laser wire
Laser source of polarized positrons(ILC,CLIC,Super-B)
X-ray sources

All these developments are very helpful for the photon collider.

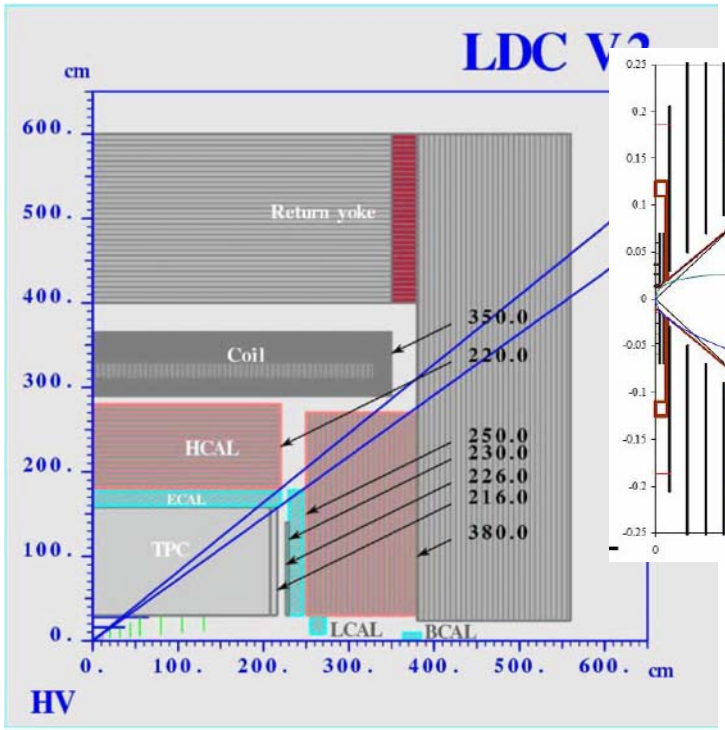
Interference of the laser optics with the detector

Layout of the quad, electron and laser beams at the distance 4 m from the interaction point (IP)



Open angles in detectors

LDC



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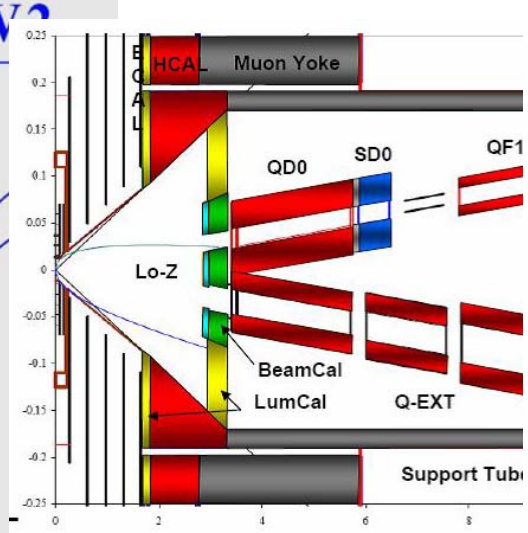
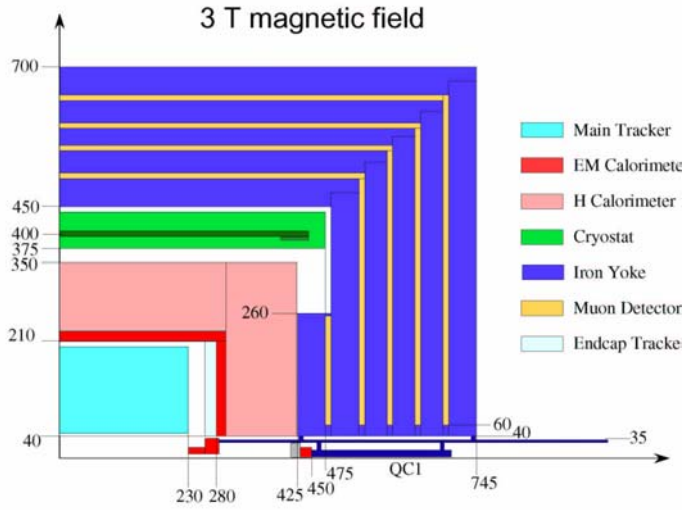


GLD



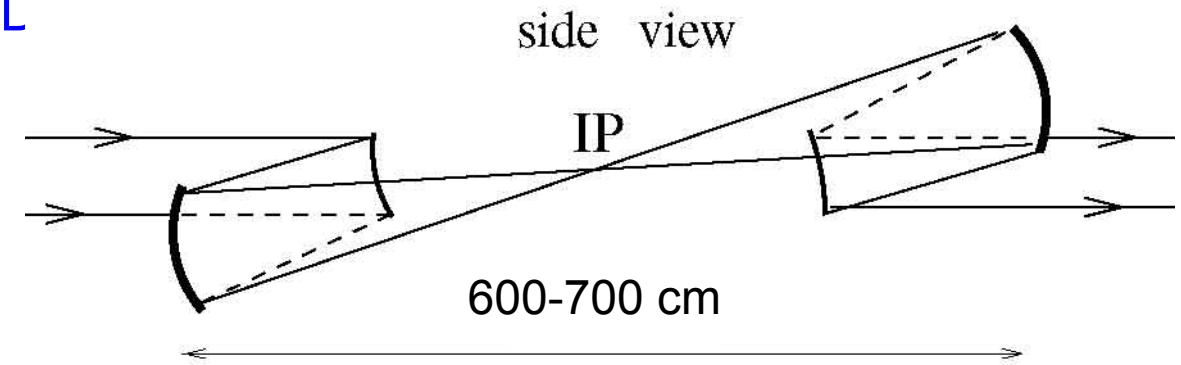
θ=±45 mrad ±33 mrad ±50 mrad

that is less than required 95 mrad

Some problems with laser optics

- If the final mirror is outside the detector at the distance ~15 m from the center, its diameter is about d~90 cm, very large.
- Detectors have holes in forward direction ±33-50 mrad (previous slide) while the photon collider needs ±95 mrad, so there should be special removable parts in ECAL, HCAL and the yoke.

Alternative solution: pairs of mirrors inside the detector as was assumed in TESLA TDR



Then the diameter of focusing mirror is about 20 cm and that of the auxiliary mirror about 11 cm. The dead angle for tracking remains as before about ±95 mrad, but smaller for calorimetry. The laser density is far below the damage threshold, the average power is the most serious problem.

Organization questions

Linear colliders provide a unique opportunity to study $\gamma\gamma$,γe interaction at high energies and luminosities. About 20-25% of all publications on LC physics are related to this subject.

The PLC considerably influence baseline ILC design and detector, joint work with many groups is needed. However, it is difficult to do anything when it is beyond present GDE interests.

- There are no PLC representatives in GDE and other ILC committees, there is no such group in the ILC structure.
- Photon collider is not mentioned in the BCD, RDR e.t.c.
- In absence of political and financial support further progress is problematic.

Some people suggest “keep open (and do nothing) until very strong physics case appears”.

That is wrong. The photon collider can not appear "tomorrow“, when physics will be clear. It needs many years for development, many special features should be foreseen in basic designs of the ILC and detectors. Existing physics motivation is sufficient for justification of a very small (relative) additional cost.

All these problems were discussed with the top ILC management. The necessity of the photon collider was confirmed in the updated scope document (Valencia, 11,2006), but nothing happened since that time. Moreover, the RDR without PLC creates additional problems. Who will work on the option which is even not mentioned in RDR?

This is the task for WWS OC and Steering Committee to resolve these “organization” problems. We need clear status and plans for options.