International Linear Collider

\( \gamma \gamma / e \gamma / e-e- \)

Physics and Technology

Tohru Takahashi
Hiroshima University

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Principle of $\gamma\gamma$, $e\gamma$, e-e-Collider

Spectrum, polarization, depends on electron/laser polarization

$J_z = 0$

electron polarization is essential
this workshop

• 4 sessions
  – 3 for physics
  – 1 for technology
• Physics
  – 8 talks on $\gamma\gamma$, 2 for $e\gamma$
    • 6 for Higgs related
    • $WW,\mu\mu+\nu$
• Technology
  – How to accommodate options
  – impact of the “COLD” on the $\gamma\gamma/e\gamma$ technology
Physics: Improvement

• $\Gamma(h\rightarrow\gamma\gamma)\text{Br}(h\rightarrow bb)$ for SM ,,,, Niezuraski
• $\gamma\gamma\rightarrow H\rightarrow bb$ in MSSM,,,,,,,,,,,,,,,, Niezurawski

γγ collider would work as advertised

– QCD bg, OE, x-angle, ww bg, tuning of cuts
• $\Gamma(h\rightarrow\gamma\gamma)\text{Br}(h\rightarrow bb)$ for SM ,,,,,,,,, Rosca
– Shapa,,, event generator for qqq
• Precise calculation for $\gamma\gamma\rightarrow WW\rightarrow 4f,,,,,Dittamier$
  – including radiative correction

Important as γγ collider is a W factory
dk,λ measurement,BG
Physics: New Ideas

- CP phase in cMSSM via $\Gamma(h\rightarrow\gamma\gamma)\text{Br}(h\rightarrow bb)$
  - sensitive to complex MSSM
- $\gamma\gamma\rightarrow H/A$ mixing in CP 2HDM
  - Utilize Linear Polarization!
- $\gamma\gamma\rightarrow A\rightarrow H+W$ in 2HDM
- Charge asymmetry in $\gamma\gamma\rightarrow \mu\mu\nu\nu$
  - signal for new physics
- Charge asymmetry in $e\gamma\rightarrow eWW$, Ginzburg
  - a probe for strong interacting sector
Technology

- What are specific for $\gamma\gamma/e\gamma$  
  - J.Gronberg

- e-e- beam (polarization)  
  - K.Moenig

- Beam optics

- Beam Crossing angle  
  - V.Telnov

- Beam dump

- Lasers

- Laser Optics  
  - Y.Honda
# Beam parameters

<table>
<thead>
<tr>
<th></th>
<th>ILC optimistic</th>
<th>ILC w/ e+e-</th>
<th>NLC γγ</th>
<th>e+e-</th>
</tr>
</thead>
<tbody>
<tr>
<td>$f_{\text{rep}}$</td>
<td>Hz</td>
<td>5</td>
<td>5</td>
<td>120</td>
</tr>
<tr>
<td>$n$</td>
<td>2820</td>
<td>2820</td>
<td>95</td>
<td>2820</td>
</tr>
</tbody>
</table>

- **same emittance (dumping ring), tune final focus to achieve small spot size**

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<th>NLC γγ</th>
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<tbody>
<tr>
<td>$p_{x^<em>}/p_{y^</em>}$</td>
<td>mm</td>
<td>1.5/0.3</td>
<td>1.5/0.3</td>
<td>4/0.08</td>
</tr>
<tr>
<td>$\varepsilon_{x_n}/\varepsilon_{y_n}$</td>
<td>μm rad</td>
<td>2.5/0.03</td>
<td>10/0.03</td>
<td>3.6/0.071</td>
</tr>
<tr>
<td>$L_{\text{geom}}^{ee}$</td>
<td>cm$^{-2}$s$^{-1}$</td>
<td>11.8x10$^{33}$</td>
<td>5.9x10$^{34}$</td>
<td>4.0x10$^{34}$</td>
</tr>
</tbody>
</table>

- very important that the baseline use standard ILC parameters

Gronberg
Crossing angle consideration for $\gamma \gamma$

- Bottom line

\[
\theta_x = \theta_d + \theta_Q
\]

\[
\theta_Q = \frac{R_Q}{L^*}
\]

$\theta_d \approx 10 \text{mr}$ beam simulation

$\theta_Q$ depend on QD and FF optics

Laser beam simulation
Compensation Coils

This is the first of two coil geometries proposed for a gamma-gamma IR.

Note: Both magnets share common cryostat.

The compensator magnet has sextupole, quadrupole and dipole coil windings with 38 mm radius clear inner aperture (10 mr x 3.8 m).

QD0 is now more compact and made only from cable with inner coil gone (outer layers have moved inward).

Second solution with QD0 inside compensator.

For normal IR outer magnet has a much smaller radius.
• 20mr may be possible but need investigation

• $e^+e^-$ luminosity depends on $Bz$ distribution of detector solenoid but 25 mr looks OK for all detector concept. Telnov

Note: $e^-e^-$ mode is not operative at 2 mr as cannot let the outgoing beam through final doublet.
Lasers

~3000 bunches/1 ms

need to amplify (feed energy to) 3000 pulses in 1ms

electrons <- SCRF
Solid state Laser <- none

way out ,, ,,, construct Hi Q (pulse stacking ) cavity
out side the laser
A Detector with Cavity

100m long pulse laser cavity

K. Moeing
Short pulse stacking cavities are under development

- Y. Honda et al. KEK
  - 7 ps pulses
  - Developed for laser wire application

- A good start, but...
  - Nowhere near $\gamma\gamma$ power levels
  - Nowhere near $\gamma\gamma$ small laser focus
  - Nowhere near $\gamma\gamma$ cavity size ~20m

J. Gronberg - LLNL
Issues for Snowmass

• IR layout, final focus for $\theta_x = 20\text{mr} \ (25\text{mr})$:
  – minimize horizontal beta function
• beam dump design for disrupted beam and collimated photons.
  – full beam tracking FF to beam dump
  – detector background and masks
  – compatibility with e+e- detector
• Design pulse cavity, need laser optics person
  • feed back
  • stability
  • damage
  • nonlinear index
• compatibility with e+e- detector

Get ILC community (BDS, detector) agreed with the design
• Why
  – Optional operation is desired for all physics case.
• When/How long should we run options?
  – Physics will tell us,,, not a current issue.
• How ,,,, issue to be discussed now
  – to share accelerator w/ e+e-
  – to share detectors
  – to develop laser sytem
• who will work on
  – synergetic w/ base ILC program
  – BDS, detectors, polarimeters, laser wire, pol. e+,,,,
Laser facilities at ATF2

- Proposals being prepared
  - not just for $\gamma\gamma$,
  - polarimeters, polarized e+ test facilities
Other issues

• Background
  – large disruption angle
  – angle between

background are similar to e+e- but <7.5deg dead

K. Moenig
Beam dump

- Electrons
  - $\pm 10\text{mr}$ beam pipe
  - large momentum spread, no sophisticated optics
- Photons
  - collimated ($10\mu\text{r}$), concentration of heat at beam dump
- probably incompatible with $e^+e^-$
Contributions

• Review by Jeff Gronberg
• Spin transport,,,,,,,,,, Klaus Moenig
  – how to deliver desired helicity states to two IR
• e+e- beam vs e-e-,,,,, Telnov
• e+e- luminosity for 20mr and 25 mr,,,,, Telnov
  – in MDI session but important information
  – no big difference between 20mr and 25 mr
• Pulse stacking cavity at KEK-ATF,,,, Honda
  – working example of the laser cavity
Crossing angle consideration

- Bottom line

\[ N = 2.0 \times 10^{10} \]

Simulation by CAIN w/ TESLA parameters

*Density is for visual effect only, not proportional to # of particle.