γγ at the SLC/SLD IR

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The Basic Proposal

• **Goal:**
  - Proof-of-principle of $\gamma\gamma$ collision at SLD/SLC IR
    ➔ Measure luminosity, validate our developing tools
  - Test required optics for a JLC/NLC $\gamma\gamma$

• **Requirements:**
  - Revive the SLC, <$2M
  - Install laser and new beampipe
  - Run and observe $\gamma\gamma \rightarrow e^+e^-$ in the SLD calorimeter (LAC), and luminosity monitors (LUM)
Hardware to be tested

- Optical assembly design
- Wavefront and optics quality requirements
  - Key elements for laser power and on-axis beam intensity
- Beam pipe design
- Alignment system for mirrors
- Beamsplitter for laser pulses
• Luminosity Measurement versus predictions from available beam simulation packages

• $e \rightarrow \gamma$ conversion efficiency
Engineering Test Facility at SLC

Parameter list

<table>
<thead>
<tr>
<th>Beam Energy</th>
<th>LIXN</th>
<th>Minimal SLC</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\gamma e_{x,y}$ (m-rad)</td>
<td>30 GeV</td>
<td>30 GeV</td>
</tr>
<tr>
<td>$\beta_x / \beta_y$</td>
<td>1600 / 160</td>
<td>5500 / 900 m</td>
</tr>
<tr>
<td>$\sigma_z$</td>
<td>8 / 0.1 mm</td>
<td>3.6 / 4.13 mm</td>
</tr>
<tr>
<td>$\sigma_{x,y}$</td>
<td>0.1 – 1.0 mm</td>
<td>1.0 mm</td>
</tr>
<tr>
<td>$N^\pm$</td>
<td>1500/55 nm</td>
<td>1500/650 nm</td>
</tr>
<tr>
<td></td>
<td>6.0E9</td>
<td>4.0E10</td>
</tr>
</tbody>
</table>

<$2M to revive the SLC
Laser assumptions and rates

- Laser: 1\(\mu\)m, 0.1 Joule laser pulse
  (25% \(e \rightarrow \gamma\) conversion efficiency)
- Event rates at Min-SLC is around 10x\(\text{LINX}\)

<table>
<thead>
<tr>
<th>Process</th>
<th>Cross Section</th>
<th>Event Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\gamma\gamma \rightarrow e^+e^-)</td>
<td>(nb)</td>
<td>(\text{LINX (sec}^{-1})</td>
</tr>
<tr>
<td>LUM</td>
<td>2</td>
<td>(10^{-5})</td>
</tr>
<tr>
<td>LAC</td>
<td>210</td>
<td>(10^{-3})</td>
</tr>
<tr>
<td>(\gamma e^- \rightarrow \gamma e^-)</td>
<td>0.5</td>
<td>(10^{-5})</td>
</tr>
<tr>
<td>LUM</td>
<td>0.5</td>
<td>(10^{-5})</td>
</tr>
<tr>
<td>LAC</td>
<td>78</td>
<td>(10^{-3})</td>
</tr>
<tr>
<td>(e^-e^- \rightarrow e^-e^-)</td>
<td>228</td>
<td>0.02</td>
</tr>
<tr>
<td>LUM</td>
<td>228</td>
<td></td>
</tr>
<tr>
<td>LAC</td>
<td>94</td>
<td>(10^{-3})</td>
</tr>
</tbody>
</table>
Photon Collider at SLC/SLD

Optical Assembly

½ scale version of the NLC design
Position of final quads in SLC sets the scale

Final focus optics are fixed
Steering mirrors are on piezo movers

- Unknown factor: Optics damage
  - IP cannot often be opened up to fix the optics
    - Radiation damage to the coating
    - Laser power damage to the mirrors
Initial design of a beampipe has been done
  - New beampipe must be plug replaceable with the old
  - Can this be done before demounting the old beampipe?
  - Other IP hardware in this region that must be integrated?

New quads or old?
  - Can the old quads accommodate light pipe?
  - The old setup may not have any wiggle room.
Photon Collider at SLD/SLC
Alignment System

→ Optical system aligned before installed in IR

- Similar systems in use
  - ½ Scale prototype of optics / alignment system is currently under construction
  - Operation in end of FY02
  - Demonstration of alignment tolerance
Experimental program

- Pulse-to-pulse conversion measurement
  - Electrons that have interacted are off-energy
    - They will be lost in the extraction line
  - Measure the bunch charge before the IP and just before reaching the beam dump
  - Collect data on the stability and consistency of the laser light delivered to the conversion point

- Direct luminosity measurement
  - $\gamma\gamma \rightarrow e^+e^-$
  - The SLD calorimeter will be revived in order to observe this process
e⁻ and γ beams at SLC γγ

Comparison of CAIN with a simple PANDORA parameterization

Allowable conversion rate at SLC-γγ is limited by the need to minimize multiple Compton backscatters… radiation of tunnel & heating of beam components
Kinematic separation of $ee \rightarrow \gamma \gamma$, $e\gamma \rightarrow e\gamma$, $ee \rightarrow ee$

- The 3 possible scatters can be separated solely with their kinematic information:
  - Identify two hit events in the calorimeter
  - No tracking required
• $\gamma\gamma$ is peaked forward much less strongly than $ee$
• Full calorimetric coverage in angle will greatly improve the counting rate
• 1000 $\gamma\gamma \rightarrow ee$ takes 4 month with Min-SLC design & only using LUM, 100x faster with LAC
Outstanding issues

- **Tunnel radiation simulation**
  - Particle losses are known, contact radiation group at SLAC for limits and remediation

- **Installation plan**
  - The old beam pipe surely needs to come out and be measured before we will be ready to begin construction on the new
  - Otherwise, laser installation should be orthogonal

- **Run plan**
  - Mainly a question of the luminosity delivered and how long it will take to make a measurement in the Calorimeter

- **Costing**
  - Should be driven by achieving the best luminosity/cost ratio
    - Maximize bunch charge
    - FF improvements useful?