R&D for Polarized RF Guns

• What may be possible
• What is required by the colliders
• What are the problems
Polarized RF Gun Workshop

• Purpose:
  – Generate a roadmap, a list of R&D objectives which would lead to a usable Polarized RF gun.

• Why?
  – Use for future colliders may become important.
  • Generate 0.5 - 4 nC in each bunch in a train.
  • With an RF gun which has a $10^{-5} \, \text{π m•rad emittance}$
  • Operate with flat beams:
    \[ \varepsilon_x = 10^{-4} \, \varepsilon_y = 10^{-6} \, \text{π m•rad possible} \]
    Makes damping ring operation easier
    Does not eliminate the need for a damping ring

• Can it be done? What is the Polarization?
NLC/JLC Polarized e⁻ Source
Damping Ring Parameters

Both source designs provide a train of 95 bunches spaced by 2.8 ns. at 1.98 GeV.

<table>
<thead>
<tr>
<th></th>
<th>NLC</th>
<th>JLC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charge per bunch</td>
<td>2.56</td>
<td>1.9</td>
</tr>
<tr>
<td>Injected emittance</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Damped beam emittance x</td>
<td>3</td>
<td>2.6</td>
</tr>
<tr>
<td></td>
<td>y</td>
<td>0.03</td>
</tr>
<tr>
<td>Damping time</td>
<td>5.2</td>
<td>3.9</td>
</tr>
<tr>
<td>Damping cycles</td>
<td>4.8</td>
<td>4.8</td>
</tr>
<tr>
<td>Repetition time</td>
<td>3 x 8.3</td>
<td>3 x 6.7</td>
</tr>
</tbody>
</table>
TESLA/CLIC Polarized e\(^-\) Sources

Damping Ring Parameters

The TESLA (500) design provides a train of 2820 bunches spaced by 337 ns. at 5 GeV. The CLIC design provides a train of 154 bunches spaced by 0.66 ns. at 1.98 GeV.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>TESLA</th>
<th>CLIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charge per bunch</td>
<td>3.2</td>
<td>0.8</td>
</tr>
<tr>
<td>Injected emittance</td>
<td>10</td>
<td>7</td>
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<tr>
<td>Damped beam emittance x</td>
<td>8</td>
<td>.43</td>
</tr>
<tr>
<td>Damped beam emittance y</td>
<td>0.02</td>
<td>0.003</td>
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<tr>
<td>Damping time</td>
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<td>21</td>
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<tr>
<td>Damping cycles</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Repetition time</td>
<td>1 x 200</td>
<td>12 x 10</td>
</tr>
</tbody>
</table>

Notes:
- 10\(^{-6}\) \(\pi m \cdot \text{rad (normalized)}\)
- 10\(^{-6}\) \(\pi m \cdot \text{rad (normalized)}\)
Polarized e⁻ RF Guns

R&D Issues - photocathode

1. Charge output: Can sufficient charge be brought off of the semiconductor photocathode in a small spot (emittance), in the short pulse, & in a pulse train? (unexplored territory)
   i. Emission Time
   ii. Impacts on Surface Charge Limit
   iii. Bulk charge depletion, is this any different than the case of Cu or CsTe photocathodes?

2. Is there a better cathode / surface treatment
   i. Much effort has gone into higher DC polarization.
   ii. What about better vacuum integrity.
   iii. Does an NEA photocathode emit dark current at the high gradients?
   iv. Do we need to develop a stable PEA (other III-V?) photocathode?

3. Cathode polarization
   i. In a magnetic field
      a. easily measured with a dc gun
      b. reference…
   ii. in the presence of the rf field, needs a working system?
Polarized $e^-$ RF Guns

R&D Issues - RF

4. Dark current
   i. Can a gun operate at sufficient gradient with low enough dark current?
      a. What is ‘low enough’?
   ii. Studies of clean structures, good materials
   iii. RF choke joint: is this a problem or are there solutions

5. RF Processing
   i. How can a fresh photocathode be brought into the gun without having to repeat RF processing. -or- How high can one go without re-processing?

6. Beam loading considerations:
   i. Is this an issue
   ii. Fixed with RF pulse shaping?
   iii. Should be amenable to a calculation (shunt impedance and filling time)
Polarized e$^-$ RF Guns

R&D Issues - system

7. Vacuum: baseline and pulsed pressure limits
   i. Cleaner materials and processing (HIP Cu and DI H2O rinsing)
   ii. Open structures for higher pumping conductance, the UCLA PWT gun is an example
   iii. Cryopumping

8. Polarimetry at a few MeV
   Eg. J-lab Mott, 5 MeV, 172° backscatter

9. Lasers (eventually)
   i. Are there perceived limitations to laser performance
   ii. How difficult are the proof of principle lasers (do not need stable performance
   iii. What are the basic concerns in this regard

10. What is good enough such that it is time to charge on and assemble the full thing?
    Which R&D items are separable and which are not

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April 18, 2001