Defect production in W-Re targets due to electron irradiation
M.-J. Caturla¹, S. Roesler², J. Marian¹, B. Wirth¹, W. Stein¹, A. Sunwoo¹
¹Lawrence Livermore National Laboratory
²SLAC, Stanford

Irradiation conditions

<table>
<thead>
<tr>
<th></th>
<th>SLC</th>
<th>NLC</th>
<th>Test Target 1</th>
<th>Test Target 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (GeV)</td>
<td>30</td>
<td>6.2</td>
<td>45</td>
<td>2.0</td>
</tr>
<tr>
<td>Beam radius (mm)</td>
<td>0.8</td>
<td>1.6</td>
<td>1.6</td>
<td>1.6</td>
</tr>
<tr>
<td>Electrons per pulse</td>
<td>3.5x10^{10}</td>
<td>1.35x10^{12}</td>
<td>2.2x10^{11}</td>
<td>1.35x10^{12}</td>
</tr>
<tr>
<td>Thickness (mm)</td>
<td>20.6</td>
<td>13.0</td>
<td>19.0</td>
<td>12.25</td>
</tr>
<tr>
<td>Frequency (Hz)</td>
<td>120</td>
<td>120</td>
<td>10</td>
<td>120</td>
</tr>
<tr>
<td>Spots in target</td>
<td>60</td>
<td>126</td>
<td>1</td>
<td>126</td>
</tr>
<tr>
<td>Total exposure time</td>
<td>3 years</td>
<td>3 years</td>
<td>2 weeks</td>
<td>3 years</td>
</tr>
<tr>
<td>Total number of electrons</td>
<td>6.62x10^{18}</td>
<td>1.22x10^{20}</td>
<td>2.66x10^{18}</td>
<td>1.22x10^{20}</td>
</tr>
</tbody>
</table>

UCRL-PRES-144459
Methodology to compute damage

**FLUKA**
3D distribution of energetic particles produced by the electron irradiation

3 types of energetic particles
- Recoil nuclei
- Spallation products
- Neutrons

From their energy we calculate:
1) Energy deposited in nuclear collisions (using the Lindhard model)
2) Number of defects using the Kinchin-Pease model (with corrections from Molecular dynamics simulations)

We use the code SPECTER to calculate the number of defects produced by the neutrons at different energies

We sum all the contributions to get the final number of defects
Results from Fluka: recoil distribution and energies

Simulation set-up

Recoil distribution from FLUKA for the NLC target

From the center of the beam

As a function of depth (z)

The total number of recoils is larger at the back surface
Defects PER ELECTRON produced in the SLC case

Damage is calculated in volumes of size
- $X = 0.66 \text{ mm}$
- $Z = 0.68 \text{ mm}$
- $Y = 2\text{ mm}$

Most of the damage is due to the energetic neutrons
The total number of defects PER ELECTRON is larger in the SLC and Test target 1 cases than in NLC due to the lower energy of the NLC beam.
Total number of defects FOR FINAL DOSE

Total time = 3 years

Total time = 2 weeks

The total number of defects FOR THE TOTAL DOSE is larger in the NLC case than in SLC and Test targets and the lowest in the New Target 2 configuration.
## Analysis

<table>
<thead>
<tr>
<th>Target</th>
<th>Energy (GeV)</th>
<th>Max DPA Value</th>
<th>Max DPA Value (Normalized to SLC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLC</td>
<td>30.0</td>
<td>0.5</td>
<td>1</td>
</tr>
<tr>
<td>NLC</td>
<td>6.2</td>
<td>0.8</td>
<td>1.6xSLC</td>
</tr>
<tr>
<td>New Target 1</td>
<td>45.0</td>
<td>0.1</td>
<td>0.2xSLC</td>
</tr>
<tr>
<td>New Target 2</td>
<td>2.0</td>
<td>0.3</td>
<td>0.6xSLC</td>
</tr>
</tbody>
</table>
Conclusions

The damage per electron due to 30GeV electrons (SLC) is larger than in the case of 6.2 GeV (NLC) ~10x larger

The total dose in NLC is ~18x larger than in SLC, as a result the damage is NLC target should be ~2x larger than in SLC

In the case of the New target 1, the maximum damage is slightly smaller than in the SCL target, probably due to the beam size and longer range of the electrons. The dose is also smaller, resulting in a maximum damage ~5x smaller than in SLC

Finally, the New Target 2 configuration results in a much smaller defect per electron due to the low energy (2 GeV), and the final damage is ~1.6x smaller than in SLC