**Abstract**

High intensity, multi-megawatt proton accelerator facilities, such as the proposed Project X at Fermilab, offer the opportunity to explore science in multiple experiments and programs simultaneously. The reliable operation of the associated target facilities is critical to the success of the experimental program as the high intensity proton accelerator itself. The targetry requirements for the Project X experimental program range from 1-GW, 1.2 MW, CW proton beam on a high-Z target (possibly liquid metal) to 120 GeV, 2.3 MW, pulsed proton beam on a low-Z target and include stringent, experiment-specific operating environments such as high magnetic fields from superconducting magnets and/or moderators, argon for optimal neutron production. Meeting the challenges presented by such wide-ranging and interrelated requirements calls for coordinated and cross-cutting R&D activities. Areas of interest applicable to many of the experimental facilities include radiation damage, thermal shock, radiological protection, and target instrumentation. Descriptions of these challenges and Fermilab R&D activities to overcome these difficult challenges are presented.

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**The High Intensity Frontier Presents Critical Targetry Challenges:**

**Thermal Shock**

- Fast expansion of material surrounded by cooler material creates a sudden local area of compressive stress generating stress waves (not shock waves) moving through the target.

**Typical Effects:**
- Strength
- Ductility
- Creep
- Oxidation
- Dimensional changes
- Sonic velocity
- Gas production (from transmutation)

**Radiation Damage**

- Annealing at temperatures higher than irradiation temperature reverses many radiation damage effects. Thermal expansion annealing is shown to the right. The sample length decreases as the temperature is held constant.

**Effects from low energy neutron irradiations do not equal effects from high energy proton irradiations. Table compares typical irradiation parameters.**

<table>
<thead>
<tr>
<th>Irradiation Source</th>
<th>DPA rate (dpa/MeV)</th>
<th>He gas production (app/MeV)</th>
<th>Irradiation Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed spectrum fusion reactor</td>
<td>3e-7</td>
<td>0.1</td>
<td>180-200</td>
</tr>
<tr>
<td>Fusion reactor</td>
<td>1e-6</td>
<td>10</td>
<td>400-1000</td>
</tr>
<tr>
<td>High energy proton beam</td>
<td>6e-3</td>
<td>100</td>
<td>100-800</td>
</tr>
</tbody>
</table>

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**Spallation Source For Nuclear Materials Irradiation And Particle Physics**

**Thermal Spectrum Test Module:**
- LWR, HTGR, MSR
- 1 MW
- 1 GeV
- CW
- 1-2 cm sigma
- Pb-208 liquid target
- Or rotating tungsten target

**High Intensity Muon Facility**
- 1 MW
- 1 GeV
- CW
- <1 cm sigma
- Rotating graphite target
- Or liquid gallium waterfall target

**High Intensity Kaon Facility**
- 1 MW
- 1 GeV
- CW
- <1 cm sigma
- Rotating graphite target
- Or liquid gallium waterfall target

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