SPEAR III

Lecture # 6

March 6, 1998

Dr. Jeff Corbett
SPEAR III

Lecture #6

March 6, 1998

Dr. Jeff Corbett

SPEAR 3 Upgrade Project

Jeff Corbett
March 6, 1998

What is SPEAR 3?

1. Helicopter ride over SLAC + in the tunnels
2. Synchrotron radiation
3. Synchrotron radiation science
4. SPEAR 3 Optics upgrade
5. Properties of SPEAR 3
6. Engineering SPEAR 3
"We Have Accelerated Electrons"

Mark III Accelerator at Stanford
Near its completion in 1952
Figure 1.3. Emission patterns of radiation from electrons in circular motion. Case I: at a low velocity compared to the velocity of light, and Case II: approaching the velocity of light.

Fig. 4.2. Time structure of synchrotron radiation.

R. Birgeneau (MIT) - Chairman
Z.-X. Shen (Stanford) - Vice-Chairman

from the Executive Summary:

"The most straightforward and most important conclusion of this study is that over the past 20 years in the United States synchrotron radiation research has evolved from an esoteric endeavor practiced by a small number of scientists primarily from the fields of solid state physics and surface science to a mainstream activity which provides essential information in the materials and chemical sciences, the life sciences, molecular environmental science, the geosciences, nascent technology and defense-related research among other fields."
To facilitate MES research at SSRL by providing:
- User support
- Infrastructure, operations, and technical support
- Original scientific research
- Assistance in the education of students and postdocs

- X-ray crystal structures of the ligand-bound and free forms of the variable domains of a catalytic antibody and its germline precursor
- Binding of ligand (yellow) to the germline antibody (blue and purple) results in structural changes that lead to improved complementarity
- Mutations in the antibody that occur as an immune response (green and red) lead to a high-affinity, lock-and-key binding interaction

Science, 13 June 1997, cover page
**SPEAR 3 Upgrade Goals**

<table>
<thead>
<tr>
<th></th>
<th>SPEAR 2</th>
<th>SPEAR 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emittance (with IDs)</td>
<td>160 nm-rad</td>
<td>18 nm-rad</td>
</tr>
<tr>
<td>Energy (nom/max)</td>
<td>3/3 GeV</td>
<td>3/3+ GeV</td>
</tr>
<tr>
<td>Current (at E_{max}/E_{min})</td>
<td>100 mA</td>
<td>200 mA/60 mA @ 3.5 GeV (up to 500/270 mA future)</td>
</tr>
<tr>
<td>Lifetime (at max current)</td>
<td>30 h</td>
<td>30 h</td>
</tr>
<tr>
<td>Injection energy</td>
<td>2.3 GeV</td>
<td>3 GeV</td>
</tr>
</tbody>
</table>

- Insertion device beam line alignment unchanged; minor realignment of bending magnet beam lines
- Reuse RF system (same ring path length)
- Stable beam properties
- Minimize impact on users
  - 6 month lattice conversion + 4 normal 2-month down times
- Maximal reuse of existing components to minimize cost and conversion time
- Lower magnet power costs
- Minimize cost
- Provision for future upgrades

Along with SPEAR 3,
- Upgrade beam lines for low emittance, 200 mA
Beam Lifetime

Gas Scattering

- $0.6\text{nTorr CO pressure at 200 ma}$

  => Bremsstrahlung: 120 hr

  => Coulomb: 344 hr

  => Net scattering: 90 hr

Touschek Scattering

- $\varepsilon_s = 18\text{nm-rad, 1\% coupling, 140 bunches}$

- Natural bunch length

- Dynamic aperture limited

  => Touschek: 47 hr

Net Lifetime at 200 ma: 31 hr (6 amp-hour)
**Orbit Feedback System**

- 54 electron BPMs
- beam line vertical photon monitors
- 54 orbit correctors per plane
- unified global/local correction algorithm (DSP)
  
  - **global** correct dominant orbit eigenmodes (SVD)
  - **local** correction at source points for precise control
    angle and position
- e-BPMs for source point position and horizontal angle control
- photon BPMs aid vertical angle control
- 50 Hz unity gain bandwidth
  
  1/10 reduction of 5 Hz noise with ideal system
  1/4 reduction of 12.5 Hz

**Multibunch Stability**

**Mitigate sources of instabilities:**

- Minimize vacuum chamber impedance
- Control RF cavity temperature and tuners to avoid HOMs
  ±0.1°C

**Use feedback systems:**

- Cavity operating point feedback
- Zero-mode feedback through klystron control system
- Transverse multibunch feedback systems
  reduce transverse oscillations to micron levels
- Longitudinal multibunch feedback can be added in future if high phase stability needed (<0.3° is possible)