Linac Coherent Light Source – II
Status Update

John N. Galayda
March 8, 2019
New Injector and New Superconducting Linac

Existing Electron Bypass Line

New Transport Line

Two New Undulators And X-Ray Transport

New Cryoplant

Remove SLAC Linac from Sectors 0-10

Exploit Existing & Upgraded Experimental Stations

Re-purpose Near Experiment Hall
BESAC Report: 7/25/2013
CD-0 9/27/2013
CD-1 8/26/2014
CD-2, CD-3 3/21/2016
81% complete 1/31/2019
100% complete 5/30/2021
CD-4 6/30/2022
TPC: $1,045M
### LCLS-II Project Key Performance Parameters

#### LCLS-II Mission Need and Key Performance Parameters Based on Findings of the Report of the BESAC Subcommittee on Future X-ray Light Sources

<table>
<thead>
<tr>
<th>Performance Measure</th>
<th>Threshold</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable Gap Undulators</td>
<td>2 (SR &amp; HXR)</td>
<td>2 (SR &amp; HXR)</td>
</tr>
<tr>
<td><strong>Super Conducting Linac Based FEL System</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Super Conducting Linac Energy</td>
<td>3.5 GeV</td>
<td>≥ 4 GeV</td>
</tr>
<tr>
<td>Electron Bunch Repetition Rate</td>
<td>93 kHz</td>
<td>929 kHz</td>
</tr>
<tr>
<td>Super Conducting Linac Charge per Bunch</td>
<td>0.02 nC</td>
<td>0.1 nC</td>
</tr>
<tr>
<td>Photon Beam Energy Range</td>
<td>250-3,800 eV</td>
<td>200-5,000 eV</td>
</tr>
<tr>
<td>High Repetition Rate Capable End Stations</td>
<td>≥ 1</td>
<td>≥ 2</td>
</tr>
<tr>
<td>FEL Average Power (10^-3 BW)</td>
<td>5x10^8 (10x spontaneous @2,500 eV)</td>
<td>&gt;10^11 @ 3,800 eV</td>
</tr>
<tr>
<td><strong>Normal Conducting Linac Based FEL System</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal Conducting Linac Electron Beam Energy</td>
<td>13.6 GeV</td>
<td>15 GeV</td>
</tr>
<tr>
<td>Electron Bunch Repetition Rate</td>
<td>120 Hz</td>
<td>120 Hz</td>
</tr>
<tr>
<td>Normal Conducting Linac Charge per Bunch</td>
<td>0.1 nC</td>
<td>0.25 nC</td>
</tr>
<tr>
<td>Photon Beam Energy Range</td>
<td>1,000-15,000 eV</td>
<td>1,000-25,000 eV</td>
</tr>
<tr>
<td>Low Repetition Rate Capable End Stations</td>
<td>≥ 2</td>
<td>≥ 3</td>
</tr>
<tr>
<td>FEL Photon Energy (10^-3 BW)</td>
<td>10^10 (lasing @ 15,000 eV)</td>
<td>&gt; 10^12 @ 15,000 eV</td>
</tr>
</tbody>
</table>
The Linac: 35 1.3 GHz cryomodules Required

“HL” = two cryomodules with 3.9 GHz cavities to shape energy vs. position of electrons in the bunch

CM01-CM35 each with eight 9-cell XFEL cavities
16MV/m produces 4.25 GeV acceleration
Usable gradient of cryomodules tested to date: 18.5 MV/m

Good margin for reliable running at 16 MV/m

Laser “heater” to control energy spread of electron bunch
Two bunch compression chicanes
Copper linac removed---Superconducting accelerator and supporting infrastructure being installed

Out with copper, In with niobium
1.3 GHz Cryomodules: 7 of 35 (+5 Spares) Delivered

“Nitrogen doping” increases Q(cavity “quality factor”) and reduces heat load on helium refrigeration system.

A. 2.4 K subcooled supply
B. Helium gas return pipe (HGRP)
C. Low temperature intercept supply
D. Low temperature intercept return
E. High temperature shield supply
F. High temperature shield return
G. 2-phase pipe
H. Warm-up/cool-down line
High Q Nitrogen Doped Cavities

• ~3X improvement in “quality factor” $Q$ (hence 1/3 power required to create the desired gradient) with nitrogen-doped superconducting RF cavities (Martinello, et al) A. Grassellino group

• Cooling requirement for CW operation is reduced dramatically

• Average for cryomodules so far: $<Q>$ nearly $3 \times 10^{10}$
JLAB-Designed Cryoplants
Subsystems Installation Underway
X-Ray Undulators

- All Soft XR undulators now @ SLAC

Hard XR undulators being prepared for installation by ANL, LBNL, SLAC

- “First light” from these undulators will be demonstrated using the LCLS “copper” linac
- Reestablishment of FEL operation begins 1/2020
Equipment Removal is Complete from the Near Hall and FEE

Hutch 1.1

Hutch 1.2

Removed Equipment

Removed Equipment
LCLS-II Coming to Life

- Electron gun & its laser - checkout completion now

- New Hard X-Ray Undulator online February 2020 with electrons from the LCLS copper linac

- Cryomodules installed April 2020

- Cryoplant #1 commissioning April 2020

- “First light” using SC linac March 2021
Thank You

SLAC and DOE for the opportunity to work on LCLS-II

LCLS-II collaboration for dedication and resourcefulness

Experts from across the National Lab system for invaluable information and advice

DESY and XFEL for advice & help in all areas superconducting