The 8-Pack Project

Four 50 MW XL4 X-band klystrons installed on the 8-Pack

DOE SLAC Review, April 10, 2003
The 8-Pack Project
Demonstrate an NLC power source

**Two Phases:**

8-Pack Phase-1 (current):
- Multi-moded SLED II power compression
- Produce NLC baseline power: 475 MW 400 ns.

LC TRC R1 requirement for JLC/NLC:
‘Demonstration of the SLED II pulse compression system RF power and energy handling capability at the design level.’

8-Pack Phase-2 (2004):
- Use the SLED II system for a Linac sub-unit test:
  A full power demonstration of an RF feed to 4.8 m of high gradient structures on the NLCTA beamline.

One of the LC TRC R2 requirement for JLC/NLC:
‘A linac subunit test’

DOE SLAC Review, April 10, 2003
The 8-Pack Project – Phase 1

8-Pack Phase-1: Multi-moded SLED II power compression

- Assemble a system with:
  - Four XL4 klystrons to power the SLED (ea. 50 MW, 1.6 µs),
  - A solid state modulator,
  - The m-SLED II system (4x time compression, ~3.2x power).

- Produce NLC baseline power: 475 MW 400 ns (@ loads)
  1 RF sys. fault / $10^7$ pulses
Current klystron layout for Modulator & LLRF commissioning

Four 50 MW klystrons on modulator; HV checkout, RF checkout, ongoing.

Sufficient power for Phase 1 & 2

The modulator and LLRF systems will be exercised while the SLED system is being installed.
Phase 1 Summer ’03
m-SLED ‘Straight-up’ layout

Allows SLED commissioning and full power operation.

Milestone:
475 MW, 400ns at the load tree
June 2003

Test capability:
540 MW, 400ns
# The 8-Pack Project

## Phase 1&2 baseline goals

<table>
<thead>
<tr>
<th></th>
<th>NLC Baseline</th>
<th>Phase 1</th>
<th>Phase 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Klystrons @ power</td>
<td>2 @ 75 MW</td>
<td>4 @ 50 MW</td>
<td>4 @ 50 MW</td>
</tr>
<tr>
<td>Pulse length</td>
<td>1.6 μs</td>
<td>1.6 μs</td>
<td>1.6 μs</td>
</tr>
<tr>
<td>Klys. - SLED power transfer efficiency</td>
<td>95%</td>
<td>90% (1)</td>
<td>90% (1)</td>
</tr>
<tr>
<td>SLED power multiplier</td>
<td>3.3</td>
<td>3.0 - 3.2 (2)</td>
<td>3.0 - 3.2 (2)</td>
</tr>
<tr>
<td>Power at SLED output</td>
<td>475 MW</td>
<td>540 - 576 MW</td>
<td>540 - 576 MW</td>
</tr>
<tr>
<td>Pulse length</td>
<td>400 ns</td>
<td>400 ns</td>
<td>400 ns</td>
</tr>
<tr>
<td>SLED - structure power transfer efficiency</td>
<td>95%</td>
<td>n/a</td>
<td>90% (1)</td>
</tr>
<tr>
<td>Power at structures - total</td>
<td>450 MW</td>
<td>486 - 518 MW</td>
<td></td>
</tr>
<tr>
<td>Structure gradient</td>
<td>65 MV/m</td>
<td>66 - 68 MV/m</td>
<td>(3)</td>
</tr>
</tbody>
</table>

Notes:
1) Phase 1 power handling inefficiency is due to liberal use of WR90
2) Phase 1 SLED power multiplier low due to potential mode conversion inefficiency
3) Eight 60 cm. structures
8-Pack Phase 1 Status

The view from End Station B.

The modulator, TWTs, klystron power supplies, and klystrons

Electronics racks

XL4 klystrons

DOE SLAC Review, April 10, 2003
8-Pack Phase 1 Status

The view from End Station B.

SLED line tubes being test-fitted into position.  11/4/02

SLED tubes to begin installation 4/14

DOE SLAC Review, April 10, 2003
8-Pack Phase 1 Status

**Infrastructure:**
Complete, with utilities sized for the phase 2 upgrade.
Supports for components being installed now.

**Control system:**
Backbone system complete (PLC, CAMAC, VME, Ethernet)
PLC control of modulator is commissioned.
Software commissioning of LLRF controls needs hardware.
8-Pack Phase 1 Status:

**LLRF:**

The system for LLRF **control** is in and being commissioned.
The system for LLRF **monitoring** is being commissioned as installed.

Power from 2 klystrons combined and sent to alternate loads on the hybrid.

~80-100 MW combined

50 ns/div.

Both pairs of klystrons have been so tested.

From Steve Smith

Complete commissioning 4/03.
Modulator:

Solid state modulator.
76 boards with an IGBTs
Driving a three turn secondary
Improved efficiency and lifetime over thyratron / PFN systems
8-Pack Phase 1 Status

**Modulator:**
The modulator is operational on the 8-pack.
It has delivered enough power for four XL4 klystrons.
IGBT problems solved.

Modulator test pulse into a water load
8-Pack Phase 1 Status

Modulator:

The voltage pulse is made flat by delaying the turn-on of some of the driver cards.

Currently:

Flattening the RF power pulse at full voltage.

19 boards delayed to flatten overshoot.

Runs at 30 Hz, additional boards to be modified for 60 Hz operation.

Flatness for 4 XL4s at 400 kV
1.6 μs, ± 0.7%  4/7/03

M. Nguyen
8-Pack Phase 1 Status:

**Klystrons:**

Four XL4 klystrons are installed and connected to the modulator. All have been run, each delivering ~50MW at 400 kV. These are sufficient to perform all high power tests, for 8-Pack phases 1 & 2.

KEK/Toshiba klystron PPM2, which achieved 70 MW @ 1.5 µs at KEK, is now under test at SLAC. Activity at one RF window has limited power to 75 MW @ 100 ns, now processing to full pulse length.

KEK/Toshiba klystron PPM4 is to be shipped to SLAC mid-May.

One of the LC TRC R2 requirement for JLC/NLC:

‘A full test of a PPM klystron at 120 or 150 Hz.’
8-Pack Phase 1 Status:

Klystrons:

SLAC PPM klystron, XP3-3, is being tested.
Eliminate transverse magnetic fields.
Re-defeat 11.7 GHz oscillation.

The second unit, XP3-4, is in design.
Convert to an integral polepiece design.
Re-optimize cavity tuning for max. RF power.
XP3-4 on test 7/03

PPM klystron XP4 is finishing design.
More robust design.
Larger gun ceramic for lower gradients.
Integral polepiece design as XP3-4.
XP4-1 on test 11/03
XP4-2 on test 3/04

XP3-3 under test at SLAC
High power RF system:

The design of the planar components has been validated through cold testing. We will continue to cold test parts as they come out of fabrication.

The design of the ‘Circular-rectangular mode converter’ has been cold tested and tuned.

A point of concern as there are 8 of these units in the ‘Straight-up’ configuration.

The ‘step’ tapers for the SLED lines have been cold tested and shown to work.

Unwanted TE01-TE02 mode conversion seen in a test of a short SLED line could lead to ~5% degradation in SLED power multiplication (3.3 → 3.2 or 3.0)
8-Pack Phase 1 Status:

**High power RF system:**
All ‘Straight-up’ configuration components are in fabrication (or ready).

**Critical Items:**
The Combiner, the Cross Potent, Splitter
– all parts machined, in the 1st brazing cycle

**All these require:**
parts machined
sub-assembly braze
post-braze machining
further sub-assembly braze
post-braze machining
final assembly braze (with circular-to-rectangular converters)

Circular-to-rectangular converters (8) – parts have been machined,
8-Pack Phase 1 Status

High power RF system: Cross Potent body
High power RF system: Multimoded coupler
8-Pack Phase 1 Status

High power RF system: Combiner parts, machined at LBL, ready for brazing
Project schedule overview
Phase 1

4 klystrons, RF commissioning 4/03 (current configuration)
High power RF components installed 6/03
“Straight-up” configuration RF commissioning 6/03
475 MW 400 ns milestone 7/03
The 8-Pack Project – Phase 2

One of the LC TRC R2 requirement for JLC/NLC:
‘A Linac subunit test’

8-Pack Phase-2:
Use the SLED II system for a full power demonstration of an RF feed to 4.8 m of high gradient structures on the NLCTA beamline.

Install eight 60 cm long high gradient RF structures
Transmit the high power from the SLED II system to the beamline.
Split the high power to the high gradient RF structures
Gain experience with a JLC/NLC RF feed at full power and full rep. rate
Phase 2 8-Pack Layout

Schematic of the power handling to the beamline
Power handling components are copies of those used in Phase 1, or morphed from them.

From SLED

Mechanical/vacuum system in conceptual design
Phase 2 schedule overview

Begin system design; underway
Fabrication Jun.– Nov ‘03
System installation Oct.– Nov. ‘03
  (working around the structure test program)
Commission / Process structures in sets
65 MeV/m milestone Feb. 2004
Integrate >2000 hours of high-power, high-gradient operation.
  (see the talk by C. Adolphsen)