Experimental Authorization

Date: December 3, 2002
Experiment: 8-Pack - August Tests
NLCTA Safety Officer: Keith Jobe

Experimental Authorization Valid:
From: 12/1/2002
To: 5/31/2002

1. Description of this experiment
The 8-pack is in the north half of End Station B, immediately adjacent to the NLCTA Accelerator Enclosure.

This experimental program consists of the first IGBT modulator stack (built for the “4-dog” tests) installed onto the high voltage oil tank. The modulator is designed to produce 1.6 us pulses at 405 kV. The modulator is not expected to be a source of radiation.

Installed on the oil tank are either one or two pairs (2 or 4 total) XL-4 klystrons. These klystrons are designed, shielded, and tested to operate at the modulator pulse voltage and duration, and each klystron can produce up to 50 MW of rf power at this voltage. Each pair of klystrons are combined with a power combiner to generate a 1.6 us pulse of 100 MW which power a high power water cooled load.

Additionally, one or two klystrons may be installed onto the oil tank with their output directly terminated into an rf load. This configuration may be pursued for life testing of the klystron or as an additional power load for the modulator.

Initial commissioning consists of a single pair of klystrons mounted to the modulator. Later, the second pair of klystrons (or one or two individual klystrons) may be added to the modulator.

The scope of this Experimental Authorization is for:

- pairs of klystrons (1 or 2 pairs) with:
  - klystron rf output combined and powering a single rf load
- and / or individual klystrons (1 or 2 klystrons) with:
  - klystron rf output each directly powering a single rf load
- maximum pulse length of around 2.5 us (1.6 us typical)
- maximum rf power in any individual component is less than 130 MW
- klystron beam voltage approximately 405 kV
- maximum repetition rate of 60 PPS
- to be renewed coincident with the NLCTA BAS
- authorization to proceed may be withdrawn at any time by Radiation Physics
2. Sketch of device or system indicating locations of radiation sources and proposed shielding for initial operation:

Seen below are four klystrons configured as two pairs. Klystrons may also be configured to directly power a load for life testing (not shown). The rectangular high voltage oil tank and the lead shielding are visible below the klystrons.

3. Brief description of the expected radiation production. Identify shielding to address this source:

Klystron: The klystron’s electron beam generates X-rays at any point of beam interception. The major sources of radiation are the tank, gun, the body, and the collector. The klystron is equipped with gun, body and collector shielding adequate for the expected mode of operation. The modulator tank peripheral walls (line of sight) are shielded with ¼ inch lead/plywood shielding.

Rf Power combiner: The planar hybrid that combines the power of the klystrons to generate 1.6 us at 100 MW. Similar units have operated at 1.2 us at 120 MW without significant problems.
Rf loads: These loads are a low group velocity disk loaded-like waveguide made of slightly magnetic stainless steel with water cooling. These units do not support an accelerating mode but may be a radiation source.

4. Discussion of the maximum radiation produced under Operating Conditions:
Klystrons shielding is designed to result in radiological emissions less than 100 mR/hr on contact and 2 mR/hr “at the rope” (approximately 1.5 m).

Combiner has been seen at a “few mR/hr” at similar operating values (1.2us@120MW). Shielding will be added as needed.

Rf loads have operated at similar values and been measured at lower pulse length. At 0.150us@100MW, the peak contact dose for normal operation at the hottest cell was 12 mR/hr. Shielding will be added as needed.

5. Discussion of the maximum radiation produced under Fault Conditions:
Rf combiner and loads have fault modes that may produce significantly increased radiation. The “processing” of the devices results in erratic and higher radiation levels often accompanied by increases in vacuum pressure, increased reflected energy, and occasional breakdown events (arcs). The breakdown pulse is detected by operational protection devices and result in a delay, reduction, or cessation of rf power.

6. Does the device or system present any unusual radiation sources or hazards? Please explain unusual sources and related controls.
Rf processing and the generation of radiation from high-power rf transport devices are both poorly understood. One program of the 8-pack project is to increase understanding of these processes. After processing, the radiation levels should be low.

7. Description of the initial requirements for shielding:
Klystrons is shielded according to test lab recommendations. Modulator tank is shielded to reduce gun-based radiation. Rf components are not installed with additional shielding.

Klystron may be delivered with sufficient documentation in the traveler to determine that the shielding configuration as installed corresponds to a recent survey in the tube’s prior operational location. Note that the run up plan branches based on the state of this documentation.

8. Description of shielding upgrade options (discuss locations and type of shielding modifications considered likely):
Combiner and loads are likely sources of radiation. Local shielding will be added as needed to limit radiological exposure.

Additional shielding will be installed as needed to maintain emission levels at less than 100 mR/hr on contact and less than 5 mR/hr at the Radiation Boundary. Note that radiation levels of up to 100 mR/hr at 30 cm is permitted for short periods to allow surveys and shielding requirements to be determined.

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1 S. Tantawi, private communication.
2 A. Vlieks, private communication.
9. **Run up and Operation plan. Indicate hold points for radiological surveys and subsequent survey frequency:**

1. Modulator running into a resistive load – no radiological measurements required.

2. If klystron shielding documentation is absent or inadequate, survey using Initial Klystron Radiation Survey sheet that follows at 150 kV and at each 50 kV operational step.


4. If klystron shielding is removed (and reinstalled) or modified, repeat full voltage survey using Initial Klystron Radiation Survey sheet.

5. Klystron at full voltage (405 kV), surveys will be documented when running at 50%, 80%, 100% output power. Survey using 8-Pack Radiation Survey Sheet (NLCTA Operations Document 02-03-13).

6. As indicated according to diagnostics of problems (e.g.: vacuum activity, reflected rf, erratic processing, etc.). Survey using 8-Pack Radiation Survey Sheet that follows or a revised version if available.

7. Following any removal and reinstallation or modification of any shielding on any rf component. Survey using 8-Pack Radiation Survey Sheet that follows or a revised version if available.

8. Regular walkthrough radiological surveys by Operational Health Physics. OHP may be using their own survey sheet.

Daily operation meetings are held to discuss the program of the NLCTA and the 8-Pack. Rf processing history and program is an agenda at this meeting. Radiological monitoring needs (item 6) are based on the operational program and adjusted in accordance to the program and based on prior measurements.

All survey sheets are be filed in NLCTA Radiation Survey Binder in the NLCTA control room.

10. **Specific plan of Radiation Measurements.**

Survey with radiation detector as determined by Operational Health Physics. Survey operational klystrons and rf transport components as indicated on survey sheet and suggested by rf diagnostic information.

11. **Radiation Engineering Controls.**

Klystron modulator power supply is interlocked to BSOIC monitors. Two monitors near klystrons and one on the roof are likely to respond to radiation production of the 8-pack systems. These devices are set according the NLCTA BAS to trip at 10 mR/hr and cannot be bypassed. NLCTA Operations has a procedure BSOIC Trip Alarm Response Procedure (02-05-05-01) that details the response by an Operator to the trip.

The BSOIC locations are currently specified by Radiation Physics in the NLCTA BAS and may be moved using a Radiation Safety Work Control Form (both signed by Radiation Physics). For this phase of the experiment, one BSOIC detector is moved to the Dance Floor railing near the rf devices under test. The BSOIC Interface and power supply interlock is installed, tested, and certified by the PPS group of ESD according to their standard practices.
Rf signals are connected to interlock systems (ala MPS systems) which detect anomalous rf breakdown processes. Interlock system response is to interrupt triggers (reduce rate to 0), reducing power, and/or changing of rf phase or pulse length controls.

12. Radiation Procedural Controls.
The End Station B is a RCA (Radiologically Controlled Area). An area surrounding the klystrons and high power rf systems shall be posted as a Radiation Area as requested by Operational Health Physics.

Event Monitors (thermoluminescent dosimeters) shall be placed near the racks and at several places near the installed klystrons. Locations are as determined by NLCTA Operations and Radiation Physics. Area Monitors (also thermoluminescent dosimeters) may be placed in the area by Operational Health Physics.

14. Envelope of Global Operating Parameters not to be exceeded (operating safety envelope)
This authorization is for operation as described in section 1.

15. Experiment operators:
Operation of the 8-Pack is a responsibility of the NLCTA Operations Group. Operational and safety management of this project are as described in the NLCTA procedures. ADSO and Radiation Physics shall continue to provide radiological safety support for the 8-Pack.

NLCTA qualified operators shall run this experiment. The NLCTA training, safety oversight, and operational procedures appropriate for the 8-Pack operation shall be applied. 8-Pack operation is independent of NLCTA accelerator components and is not described in the NLCTA BAS.

All NLCTA operators will be qualified as Radiation Generating Device operators (RGD, EH&S core course 270) after the course is modified to include the End Station B activities. This course has been expanded to cover NLCTA and 8-Pack operation.

Operations management, safety, and operator qualifications, training, safety, and are described in the NLCTA Directives [02-02-00], NLCTA Safety Procedures [02-03-00], and NLCTA Operator Training [02-04-00]. Oversight in these areas is provided by ADSO and Radiation Physics.

The 8-Pack is run by NLCTA Operators. Management of the program is included in the daily operations meeting, and the status of the experiment is included in the operations log. The pulsed power devices (the modulator and the klystrons) may operate without the continuous attendance of the operators similar to the “Unattended Operation – Without Beam” mode as described in the NLCTA BAS.

Daily and weekly checklists for the NLCTA shall be performed by trained operators and shall be augmented to include appropriate 8-pack related checks. The checklists are continually modified as necessary to include items which, for operational or safety reasons, need operator verification. An example of such a change is an addition to verify special shielding placed on a device to maintain acceptable area radiation levels.
16. **Operational Requirements:**
Daily and weekly checklists must be maintained and filled out as described in NLCTA Operations Documents and NLCTA BAS.

17. **Document Approvals:**
Approval to run this experiment as described above is granted. Any change in the experimental equipment or operating parameters not described herein is prohibited. Any change in this document must be initialed by the Safety Officer or ADSO, and must be initialed by Radiation Physics.

8-Pack Manager: ___________________ Dave Schultz _______ _______
NLCTA Operations Manager: _____________ Marc Ross ____________ _______
NLCTA Safety Officer: _________________ Keith Jobe ___________ _______
ADSO: _______________________________ __________________ _______
Operational Health Physics: _______________ Jim Allan __________: _______
Responsible Radiation Physicist: ____________________ __________________ _______

19: **Copies**
__ Radiation Physics m/s 84
__ OHP Field Operations m/s 84
__ NLCTA BAS Binder
__ Original to be posted at the 8-pack
Pre-Run Conditions

The following items must be completed and signed off prior to operation:

<table>
<thead>
<tr>
<th>Item</th>
<th>Date</th>
<th>Ckd. by</th>
<th>OIC Ackn.</th>
<th>Pre-Running Condition</th>
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<tbody>
<tr>
<td>1</td>
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<td>BSOICs must be calibrated and trip circuits checked per “NLCTA BSOIC Certification Procedure (with source)” [02-03-05]</td>
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<td>Location of BSOICs must be checked by Radiation Physics</td>
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<td>3</td>
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<td>PPS Interlock circuit for HVPS 3 must be certified to trip under BSOIC fault conditions by PPS group [18-29-04]</td>
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