NLC News

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Klystron Successes

John Cornuelle

To draw a poor analogy, the 75-MW klystron program has been a little like a relay race where the last runner drops the baton while their team is ahead. As the old saying goes, "close only counts in horseshoes." Recently, this situation has been pretty thoroughly reversed due to lots of hard and skillful effort and the benefit of many tubes being built and tested.

The recent TRC review did not place the klystron for the GLC/NLC in the so-called "R1" category, which was reserved for items that had to be demonstrated to show that the accelerator could be built at all. It was instead tagged as an "R2," still important and therefore deserving of substantial R&D efforts. These have been and continue to be underway at both SLAC and our collaborator KEK, with Toshiba building the klystrons for KEK. The KEK klystrons have demonstrated required peak power and pulse width simultaneously (75 MW at 1.6 microseconds), but not at the planned repetition rates for the GLC/NLC (150 Hz and 120 Hz respectively). The SLAC klystrons have demonstrated the average power required, but not at the right operating point for the accelerator. Unfortunately, two SLAC klystrons built last year both had to be removed from test and be rebuilt due to problems unrelated to demonstrating simultaneously peak and average power (the baton-dropping situation).

The 75-MW klystron program has had much more favorable results this year, due in part to the large number of devices that have been built and tested. It is not the simple statistical benefit of more attempts, but the learning implicit in the classical build-test-fix cycle. A total now of four very similar tubes have been built by Toshiba under the guidance of SLAC's collaborator KEK, and a rebuild of a SLAC tube is presently at test at SLAC with at least two more coming in FY04. One of the KEK tubes is also at SLAC for testing. Aside from the very technical differences that would be noted by a klystron engineer, these tubes have effectively identical designs except for the magnetic focusing structure for the permanent magnets and the degree of cooling along the body of the tube (where the RF is generated and interception of the beam can produce cooling challenges). Several of the Japanese tubes have demonstrated the peak power and pulse width required, but not the average power due to limitations in the maximum repetition rate possible with the modulator. One of these tubes is now at test at SLAC on a modulator that has no such limitation, and the tube has been processing (being conditioned to the high voltage, high electric fields, and high power) somewhat slowly but fairly monotonically. The SLAC klystron now at test has demonstrated all of the necessary requirements, including average power, simultaneously, but has been rebuilt in the attempt to remove a periodic break-up in the collector current and RF pulse. The cause of this break-up may not yet be known but does not appear to be fundamental (it has not shown up on any of the other tubes, SLAC or KEK, and does not cause any other symptoms such as gas outbursts that would be a cause for concern). Other than this pulse break-up, this particular klystron ran effortlessly at the parameter set required for the NLC (the GLC requires 150 Hz); in fact, it appeared that the tube could operate at even higher power levels if desired.

In addition to the performance results, the best of which are presented in the table below, the most favorable development is that there do not seem to be any fundamental limitations to the operation of a klystron at X-band at these peak and average power levels. Several of the KEK klystrons have had to have their output RF windows replaced, but since that is not an issue on the SLAC tubes the problem is not fundamental. The SLAC tubes have had to be rebuilt to correct gun oscillations, parts assembled in the wrong orientation, and parts damaged during the rework process, but none of these is obviously fundamental. The most recent SLAC tube, now at test, aside from the pulse break-up condition, seems to be far from the edge of any physical limits in the operating space in which it has been tested. Even after being reworked for the pulse break-up, the tube came up to operating voltage (490 kV) and then ran with no applied RF almost instantly, including no excessive gas on the internal vacuum pumps. If a microwave tube is very close to some physics limit at its operating point, so that it constantly has to be "babied" and fine-tuned, then the klystron engineer would find this very disconcerting even if the tube meets all the requirements of the specification. He/she would much rather have a tube that might not yet be perfect but seems to have margin left

at its operating point. We appear to be in this latter condition with these tubes.

We are well into the last lap, and it looks like this time the baton is going to stay where it belongs.

75XP-3 Klystron Drift Tube Closeup

75XP-3 Klystron Gun Stem with Loss Rings

Best simultaneous (concurrent) performance values[1,2]

Device	***Peak Power***	***Pulse Width***	***Repetition Rate***	***Average Power***
Requirement	75 MW	1.6 µs	120 Hz	14.4 kW
KEK PPM-2	75 MW	1.6 µs	25 Hz	3.0 kW
KEK PPM-4	75 MW	1.6 µs	50 Hz	6.0 kW
SLAC XP3-1	50 MW	3.2 µs	120 Hz	19.2 kW
SLAC XP3-3	75 MW	1.6 µs	120 Hz	14.4 kW

Notes:

1. KEK modulator limited to 50 Hz.
2. Best peak power: 79 MW at 2.8 µs for SLAC 75XP1.

SLED-II Installation Complete

Dave Schultz and Albe Larsen

The week of September 15 records a landmark for the 8-Pack Program. All elements of the SLED-II system have been installed. Figure 1 shows the Cross Potent assembly, the last element to be positioned, being moved by crane into place. Figure 2 shows it in its final location near the SLED lines to which it will shortly be attached.

Figure 1: The cross potent being moved by crane into the SLED II assembly

Next week the job of final assembly of all the SLED system components and their in situ cold testing will be completed. Early in October the system will be baked out and by mid- to late-October, high power testing will begin. Watch for further stories as these tests proceed.

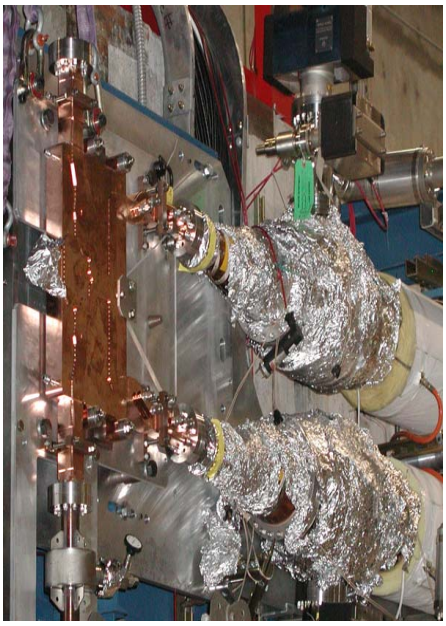

Figure 2: The cross potent in place

Summer Intern Develops NLC Graphic

Nicolle Rager, a Master's student in Science Illustration at University of California Santa Cruz has spent her summer internship and final project for graduation working in the office of Communications Director Neil Calder. Nicolle's principal assignment was to produce a section drawing of the NLC main linac *in situ*, which will be shown in the November issue of the NLC News. Watch for it!

Nicolle comes to SLAC with a bachelor's degree in biochemistry from Lewis and Clark College. Prior to enrolling at UC Santa Cruz, she spent three years in a biochemistry/molecular biology lab at the Oregon Health Science University where she was part of a group studying tropical parasites such as malaria and leishmania. All this is a far cry from a graphic arts degree with an internship at a high energy physics lab! Nicolle discovered that, while she loved science, she didn't love the day-to-day troubleshooting involved in basic research. She had always loved art and stumbled serendipitously on the science illustration program at UC Santa Cruz, which seemd to her a perfect way to blend her love of science with her artistic skills and interest. Nicolle came, enthusiastically, to SLAC with only a basic college physics course behind her, but she was up to the challenge of learning about a new area of science that gave her the opportunity to develop her ability in illustrating difficult abstract concepts. She found SLAC scientists and staff welcoming and willing to guide her through accelerator and HEP basics. She extends her thanks to them for their teaching and encouragement. We look forward to the unveiling of her NLC illustration in November.

Late Breaking News

Dave Finley

On September 18, 2003 Fermilab shipped to SLAC the fifth and last of the FXB structures. These 60-cm structures are all of the same RF design, but have been assembled using different procedures. The RF design incorporates detuning but not damping. The intent of this series of structures is to understand the effects of different assembly procedures on the high-gradient performance of the structures.

Linear Collider Collaboration Notes

http://www-project.slac.stanford.edu/lc/ilc/TechNotes/LCCNotes/lcc_notes_index_htm

LCC-0123, "Design Guideline Summary Based on the GEOVISION Report of Stanford Linear Accelerator Tunnel Vibration Measurements," Parsons, August 2003.

LCC-0124, "Recent Electron Cloud Simulation Results for the NLC and for the TESLA Linear Colliders," M. T. F. Pivi, T. O. Raubenheimer, M. A. Furman, September 2003

Conferences and Workshops of Interest

8th International Conference on Advanced Technology and Particle Physics (ATPP2003); Astroparticle,Particle; Space Physics, Detectors and Nuclear Physics Applications, 6-10 October 2003, Como, Italy, http://villaolmo.mib.infn.it/conference2003.html/

Workshop on High Gradient RF , October 7 - 9, 2003, Argonne National Laboratory, http://www.hep.anl.gov/rf/.

30th Advanced ICFA Beam Dynamics Workshop on High Luminsity e+e- Collisions, October 13-16, 2003, Stanford, CA. http://www-conf.slac.stanford.edu/icfa03/

9th International Conference on on Accelerator and Large Experimental Physics Control Systems (ICALEPCS2003), 13-17 October 2003, Gyeongju, Korea, http://icalepcs2003.postech.ac.kr

International Workshop on Astroparticles and High Energy Physics (AHEP2003) 14-18 October 2003, Valencia, Spain, http://nacisific.uv.es/conference/index.html

87th APS NYSS Semiannual Symposium of Particle Accelerator Frontiers and New Physics Potential, 17-18 October 2003, Upton, NY, http://www.aps.org/meet/calendar.html

IEEE Nuclear Science Symposium and Medical Imaging Conference (NSS/MIC 2003) October 19-24, 2003, Portland, Oregon, USA. http://www.nss-mic.org/.

18th International Conference on MAgnet Technology (MT18), 20 - 24 October, 2003, Morioka, Japan, http://akahoshi.nims.go.jp/MT-18/

Communication Tools for a Global Accelerator Network, October 29-31, 2003, Trieste, Italy, http://www.elettra.trieste.it/cotogan2003/

9th International Workshop on Advanced Computing and Analysis Techniques in Physics Research (ACAT03), 1-5 December 2003, Tsukuba, Japan,http://www-conf.kek.jp

International Conference on Linear Colliders (LCWS), 19-24 April 2004, Paris, France.

11th Advanced Accelerator Concepts Workshop (AAC 2004), 20-25 June 2004, Stony Brook, New York.