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Program Director's Corner:

David L. Burke

The U.S. NLC Collaboration recently held its second meeting with the Machine Advisory Committee (MAC), and I am happy to report that this interaction continues to become increasingly important and useful. (See accompanying article by Peter Tenenbaum.) The meeting focused on the technical progress and plans of the NLC R&D program. The discussions were open, frank, and focused on the important issues raised at the first meeting with the MAC last June at Fermilab. Advice from the committee has already proven invaluable, and the discussions at this most recent meeting likewise will help guide the efforts of the Collaboration. I want to thank personally the members for sharing their time and talent with us.

A key issue discussed with the MAC is the lifetime of high-power accelerator structures. Major upgrades of the NLCTA over the past two years have allowed unattended 24/7 testing of full-power systems. Unexpected damage to structures operated at NLC design gradients for thousands of hours has been observed. This is a central problem for future TeV-scale linear colliders, and has attracted strong interest from researchers at CERN as well as KEK and SLAC. The recent workshop held at SLAC (NLC News, September 2000) was attended by physicists from all of these labs as well as long-time specialists in the field. We are well along on the most important of the ideas for R&D generated at this workshop. The MAC was fully supportive of the Collaboration's efforts and priorities on this critical problem. We will keep the Collaboration posted on progress in the News.

Word from Washington is good. At last accounting Congress sent a bill to the White House with broad support for science that would allow the DOE to move ahead with its proposal for funding of NLC R&D. While not signed into law yet, the importance of science and technology to the health of the Nation has crept into the fabric of the government … the result of a unity in the science community missing in the past, and a welcome sign for the future.

High Power Component Testing

Karen Fant

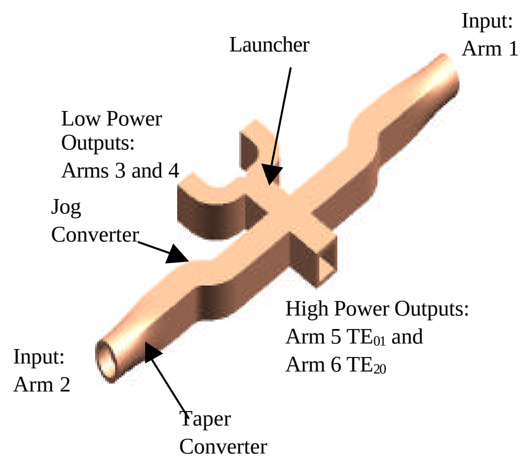
In FY01 a major R&D project for the NLC Main Linacs is to build, install, test and evaluate at power levels up to 800 MW, several high power rf components at the Next Linear Collider Test Accelerator (NLCTA). These components represent a sample of the devices required to construct the Multimode Delay Line Distribution System (MDLDS) [1], the current rf distribution model for the NLC Main Linac. The components used for MDLDS must have reliable high power handling capabilities and high efficiency.

The MDLDS uses a pulse compression technique that matches high power rf sources, which provide a longer than required pulse, with a high gradient linear accelerator structure, which requires input power that is greater than directly achievable. Although several other schemes for pulse compression have been explored, the MDLDS provides the best compromise of high efficiency, flat pulse, and compactness. It is a more cost effective option due to a significant reduction in the number of klystrons and modulators.

Phase patterns are used to distribute the combined power from the klystron to separate accelerator feeds during different time bins of the common rf pulse duration. The present configuration of the multimoded system for the NLC uses eight klystrons operating at 11.424 GHz. Each produces 75 MW of power with a 3-µs pulse width. These klystrons feed a multimode launcher, which then injects the two lowest loss circular modes, TE_{01} and TE_{12} [2], into highly overmoded circular waveguide. The rf power is then transported upstream and is successively extracted so that the later arrival of the beam combines with the waveguide delay to allow time for the structures powered by each consecutive feed to be filled. The extractor directs one mode into the accelerator feed while passing the other modes unperturbed. This system has an effective pulse compression factor of eight. Individual components will carry a peak power of 600 MW and may see as much as 900 joules; therefore rf breakdown is a serious concern and high power testing of these components is essential.

A number of the required components are designed using a planar symmetry, which allows an arbitrary height to be selected that will keep the electric field below 40 MV/m while minimizing resistive losses. These components include the launcher, extractor, overmoded H-plane bend, jog converter bend, step taper and overmoded E-plane bend. These components operate with the rectangular TE_{10} and TE_{20} modes [3]. In order to transition from the planar components to the overmoded circular waveguide, a taper converter had to be developed to efficiently convert the rectangular TE_{10} and TE_{20} modes to their associated circular modes TE_{01} and TE_{11} [4]. The final component required to complete the system's mode conversion is a device designed in collaboration with Calabazas Creek Research, Inc [5]. It generates the TE_{12} mode, needed for transmission, from the TE_{11} mode produced by the taper converter. This small-diameter device uses an adiabatic mode converter with wall undulations designed to pass TE_{01} unperturbed, and then tapers up to the desired 4.75" diameter overmoded circular waveguide.

Although the rf design and some cold testing have been completed on these components, they have all not been tested at high power, which is the goal for the test at NLCTA. However, the H-plane hybrid has been tested up to 470 MW with a 150-ns pulse width[6]. Two pairs of X-band, 50 MW peak power, 1.5-µs-pulse width, klystrons will generate the RF power. Each klystron pair is fed into a SLED pulse compression system with peak output power of 400 MW and a pulse width of 250 ns. The rf power from each of these outputs will be transmitted through circular waveguide in the TE_{01} mode and combined in a modified launcher to produce 800 MW and possibly as much as 400 joules.



This launcher (see figure) will incorporate a taper converter and a jog converter into the two inputs (1 and 2), thus allowing the circular TE_{01} mode to be converted to the rectangular TE_{10} mode required by the Launcher. The two arms (3 and 4) opposite the output are isolated for this application and will have low power loads attached. By properly phasing the inputs, the output arm (5 and 6) will produce either TE_{10} or TE_{20} in rectangular waveguide and then be converted via another taper converter to their respective circular modes TE_{01} and TE_{11}. In phase one

[1] Tantawi et al, Proc. AAC Workshop, pp.967 – 974, July 1998

[2] Tantawi, S., et al., PRST-AB, vol. 3, 082001 (2000), 21 pp.
[3] Nantista, C., et al., LINAC 2000, August 2000.
[4] Tantawi, S., et al., Proc. PAC99, pp. 1435-1437, Apr. 1999.
[5] Neilson, J., Internal Report, Calabazas Creek Research, Inc., 1999.

[6] Tantawi, S., et al., *IEEE Trans. MTT,* **47**(3): 2539-2546, Dec. 1999.

of the test program, a second taper converter will be connected directly to the first output taper converter to eliminate the need to transmit the high-loss TE_{11} mode. In the second phase, two adiabatic mode converters with wall undulations will be added that will allow the addition of a transmission line using the more efficient TE_{12} mode.

After leaving the launcher, the power will enter the extractor. In NLC operation this device will extract the TE_{10} mode from one arm feeding the local accelerator structures and will pass the TE_{20} mode for relaunching into the delay lines, so that it may feed accelerators further upstream. For this test the extractor will pass either the TE_{10} mode through one output arm or the TE_{20} mode through the other output arm depending on the phasing of the klystrons. Each of the two output ports, transmitting 800 MW, will then be connected to a load tree designed to first split the power evenly into four arms and then again into two arms, for a total of eight arms per load tree. A high-powered load is attached at the end of each arm. These loads have been successfully tested above 100 MW at 300 ns.

In addition to testing the launcher, extractor, taper converter and jog converter this test will also provide the opportunity to high power test the vacuum pump port design and a vacuum/RF flange capable of transmitting circular modes TE_{01} and TE_{11}. A square bend that has been successfully tested to 200 MW will also see 800MW for this test. The step taper will be incorporated into arms 3 and 4 of the launcher, but is not expected to see much power. The overmoded H-plane bend and overmoded E-plane bend may be tested in the second phase of this test.

The Vision: Collaboration and MAC Meeting: Part I of II

Peter Tenenbaum

The US collaboration for the Next Linear Collider met at SLAC from October 3 to 7, 2000. The meeting was attended by all formal US NLC collaborators (SLAC, Fermilab, LBNL and LLNL), as well as assorted celebrities of the high-energy physics world. In parallel, the NLC Machine Advisory Committee (MAC) met from October 4 to 6, and the collaboration presented its recent developments to the MAC in plenary sessions.

SLAC Director Jonathan Dorfan, who reviewed exciting recent developments in particle physics, opened both meetings. In particular, he presented the new and mounting evidence for a Higgs boson with a rest mass of 114 GeV. Such a discovery, if verified, would generate tremendous excitement in the particle physics world, and enhance the enthusiasm for a linear collider in the NLC's energy regime. NLC Project Director David Burke then summarized NLC design progress and future R & D plans.
A few major NLC design and R&D highlights:

1) Configuration for Dual Interaction-Region (IR) continual operation: the most exciting potential change to the NLC is a complete revision of the beam delivery and interaction region design. The Big Bend (10 mrad arc in beam delivery) is removed, and the linacs are arranged with a 20 mrad total crossing angle; the principal IR beamlines are collinear with the linacs; beamlines to the second IR include 20 mrad Super Big Bend on each side, which limits the energy reach of the second IR due to synchrotron radiation emission; beams for the second IR are extracted at appropriate points in the main linac by pulsed kicker magnets, which in turn permits simultaneous operation of both experiments. In this model (dubbed the "HiLo" option), extraction points are provided for the LoIR for center-of-mass energies of 90, 250, 350, and potentially 500 GeV. Furthermore, because the HiIR has no arc between the linac and the IP, the energy reach of the HiIR is potentially unlimited.

In order to accommodate the luminosity requirements of the dual IRs, the accelerator must operate with a base rate of 180 Hz (rather than 120 Hz) in the injectors and the upstream regions of the main linacs. The implications of the change in base rate were discussed vigorously during the week.

2) Injector Systems. The system that is most severely impacted by the base-rate change is the main damping ring complex. John Corlett (LBNL) reviewed Berkeley's growing participation in the damping ring design. A design with two identical and independent main damping rings on each side of the NLC is the primary consideration, although a single very large ring per side or a two-ring chain on each side are also being evaluated. John Sheppard (SLAC) discussed possible central injector options and the tentative decision to use S-band rather than C-band rf systems for the injector linacs.

3) Main Linac Systems. Main linac discussions centered on achieving high accelerating gradients in room temperature copper structures. A recent workshop at SLAC on the topic brought participants from all over the world, each of which had observed the central "gradient mystery" plaguing the NLC design. See NLC News, Sept. 2000 for detail. Other main-linac system reports were extremely encouraging: modulator, klystron, pulse compression, and high-power RF transport components all show excellent performance.

4) Beam Delivery Systems. The optics design for a new collimation system was presented; the design permits a straight tunnel from the linac to the IP, which in turn preserves the option for unlimited collider energy upgrades. Construction of a prototype "consumable" collimator has begun, while feasibility studies are under way for a "renewable" collimator to demonstrate the feasibility of an essential tin collimating surface, which solidifies onto a niobium wheel and is rolled to the desired flatness. First results from the collimator wakefield experiment indicate short-range deflections much smaller than those predicted by the closed-form analytic expressions, although MAFIA simulations are in reasonable agreement for these first test collimators. Graphite collimators from DESY will be used for beam tests in FY01, and a second set of SLAC collimators is waiting test.

Additional NLC design and R&D highlights will be included in the November issue of the NLC News.

Conventional Facilities News

Jon Ives

In July, a purchase order was issued to C. W. Anderson and Associates for an updated cost estimate for the NLC underground construction, based on revised drawings reflecting the actual topography at a representative site in California. These new estimates were recently completed and reflect an overall cost for this work that is modestly lower than our prior in-house estimates. A significant decrease of almost 17% is shown for the injector region cost. This reflects the refinements in alignment made in the 135D version to place the Injectors in more favorable topography. The increase in IR Halls reflects a revised configuration. In the earlier estimate, the IR halls were not as deep, were open to the surface, and were covered by a pre-engineered building. In the 135D configuration, the halls were deeper, and had a concrete roof with earth cover.
The consultant's estimate was entirely independent from our earlier in-house work. The fact that the two estimates are so close is a credit to our two in-house estimators, Clay Corvin and John Cogan.

Recent Linear Collider Publications

Note: If you would like an NLC-related paper listed, please send information to amlarsen@slac.stanford.edu

I. Linear Collider Collaboration Notes

LCC-00047, "A Transverse RF Deflecting Structure for Bunch Length and Phase Space Diagnostics," Paul Emma, Josef Frisch, Patrick Krejcik, 08/00.

Calendar of Upcoming Events

I. Conferences

5th International Linear Collider Workshop (LCWS 2000), 12-28 Oct 2000, Batavia, Illinois,http://d0server1.fnal.gov/users/hefisk/LCWS2000/Linear_Collider_Workshop_2000.htm

The 22nd Advanced ICFA Beam Dynamics Workshop, Nov. 6-9, 2000, SLAC, Menlo Park, CA http://www-project.slac.stanford.edu/lc/wkshp/GM2000/default.htm

Nuclear Science Symposium, Lyon, France, October 15 – 20, http://NSS2000.in2p3.fr/

2001 Particle Accelerator Conference, Chicago, IL, June 17-22, 2001.

ICALEPCS 2001, San Jose, CA, Nov. 27 – 30, 2001, http://icalepcs2001.slac.stanford.edu

II. Meetings

November 14 – 17, ISG 6, KEK, Tsukuba, Japan.