



NLC News -

January 2001
Volume 2 Number 1

Program Director's Corner:

David L. Burke

As we enter 2001, NLC teams are actively working on a wide range of issues in the design and technologies of the collider. The baseline design is being updated for this year's Summer Study at Snowmass to include results from the ongoing R&D program and continued analysis of beam optics and dynamics. (See article by P. Tenenbaum in the October issue of NLC News.) Options and features in the baseline configuration are being reviewed with the broader physics community, and a number of specifications for the model of the machine to be used for Snowmass have recently been settled. (See accompanying article by Paul Grannis.) This interaction between the machine physicists and the particle physicists is very important, and continued face-to-face discussions are needed.

The R&D program is moving ahead well. An extensive program of trouble-shooting NLCTA operations has yielded spectacular improvements in reliability and running time for this key test facility - operating efficiencies in excess of 90 % are now the norm. This has significantly extended lifetime data on X-Band rf components, and smoothed our attack on the limitations in structure accelerating gradients that have recently been much in the news. We have some distance to go to fully solve this problem, but a strong attack on structure design, manufacture, and processing has been mounted in collaboration with our colleagues at KEK. (See ISG-6 article by N. Toge.) A first test structure with low rf group velocity has performed well at gradients of 50-60 MV/m, and is now running at still higher fields. A range of manufacturing and processing techniques are being investigated, and results from new test structures will be in hand in the next couple of months. Work on tests of high-power DLDS components at the NLCTA is underway (NLC News, October 2000), and the ETF at Fermilab is being prepared to house initial tests of full-length rf distribution systems. These will all be important topics for discussion at the next NLC Collaboration meeting at Fermilab at the end of February.

KEK-SLAC Linear Collider International Study Group (ISG) Meeting

Nobu Toge, KEK

The 6th KEK-SLAC Linear Collider International Study Group Meeting (ISG6) was held from Nov. 14, 2000 through Nov. 17, 2000 at KEK. This was the 6th meeting in its series that was initiated by the Memorandum

of Understanding (MOU) between the directors of KEK and SLAC that was signed in 1998. The meeting was attended by 18 members from US labs, including SLAC, LBNL and LLNL, about 30 from KEK, 4 from Russia who have been working with KEK, and 9 from Japanese universities.

The meeting was held in the now-traditional workshop style. Three work groups (WGs) were formed: (WG1+2) machine parameters, injectors and beam instrumentation, (WG3) accelerating structure, and (WG4+5) rf power sources and distribution. The discussions focused on a review of the results from the past collaborative work as well as planning the important research agenda for the next six months to a year.

Active exchanges of ideas were made at the injectors WG on the interpretation of the effects of intra-beam scattering in small emittance beams at KEK ATF and LBNL ALS. The Japanese side also presented the latest progress status of the proof-of-principle experiment on the production of polarized positrons and beam size measurement by using finely focused laser optics (laser wire). The US side reported on the new design of the damping ring. Of particular interest was the new idea, formed at SLAC, on the general layout of the linear collider, where the beam source and injector complex are concentrated near the beam collision point. It looks as if, contrary to the past general notion, the SLC is truly the ancestor of next-generation linear colliders, not only in terms of general concept, but also in terms of the machine topology. The structure WG concentrated on discussions on the recent data on discharge damages in high-power rf processing and possible solutions. It was decided that in addition to more than a half dozen test structures that have been already built or were under fabrication in 2000, several more would be built in early 2001. The rf power source WG shared the development status of X-band klystrons, rf windows and the DLDS (delay-line distribution system). Then it went on with detailed planning for the second test experiment on low-power testing of DLDS rf transmission, which was to take place at KEK in late November 2000.

All the materials presented at ISG6 are available at <http://lcdev.kek.jp/ISG/ISG6.html>. The next ISG meeting is tentatively scheduled for May 2001 at SLAC, pending the decision by the lab directors.

Fermi Physics/Machine Meeting

Paul Grannis - SUNY (Stony Brook)

On Jan. 5, a meeting was held at Fermilab (by video for participants at SLAC, LBL, BNL,

UC Davis, Michigan and Indiana) to review the NLC baseline specification for the 2001 discussion at Snowmass and the forthcoming HEPAP subpanel. Additionally, the group discussed plans for the book describing the physics case for the linear collider, and for arranging seminars and discussions at universities and laboratories prior to Snowmass.

Dave Burke, Tor Raubenheimer, Tom Markiewicz and Nan Phinney summarized the status of the NLC R&D and design. Dave focused on issues related to the rf power production and distribution, and on R&D plans for understanding and fixing the structure accelerating gradient limitations. Tor, Tom and Nan focused on the current parameter specifications with particular emphasis on those controlling IP luminosity and on the nature of the IP layout and possible second interaction region. As a result of these discussions, several choices were made for the 2001 baseline NLC specification:

1. There should be two detectors in the baseline.
2. There will be two IRs, one that runs with no big bend and can operate to the full machine energy at any time, and one that has a bend and a maximum energy of 500 GeV. (Continued attention should be given to options that could raise the energy of this second IR to 1 TeV.)
3. The baseline design will be for sequential running of the two IRs (no interleaved pulse trains), but work should continue to investigate possible 'simultaneous' operation.
4. The tunnel should be sized for full 500 GeV beam energy ($E_{cm}=1$ TeV)
5. The baseline should be based on 70 MV/m gradients with short structures but the cost penalty for reduction to a 50 MV/m gradient should be included for information until the structure damages issues are resolved.

A book giving the physics case for the linear collider will be prepared for Snowmass, with the provisional title "Physics Experimentation at a Linear e^+e^- Collider." One section will be the July 2000 article "The Case for a 500 GeV e^+e^- Linear Collider." Another section will be devoted to more detailed exposition of specific physics opportunities. A section will describe the possible detector designs and rough costs. There will be one section that outlines how the case for the linear collider is to be made for a variety of scenarios for new developments in physics between now and its start. The outlines for this book (of about 300 pages) are in place, and the draft versions of the sections are due March 1.

In conjunction with the preparation of the book, the US linear collider working group members will seek to give seminars or journal clubs in as many universities and laboratories as possible, to outline the physics case for the linear collider and review the baseline machine parameters and nature of the ongoing R&D. As a part of this exercise, a list of questions for further study, both within the US linear-collider working group and at the Snowmass workshop, is being drawn up.

Overview of NLC R&D at LLNL: Part 1

Karl van Bibber – LLNL

Lawrence Livermore National Laboratory has been involved with SLAC in R&D towards TeV-scale linear colliders for more than a decade. The 'prehistory' of our current program began in the late 1980s, with a joint venture between the two labs on the Relativistic Klystron – Two Beam Accelerator program. This coupled Livermore's historical expertise in induction linacs – which efficiently produce high-current low-energy electron beams – and SLAC's historical expertise in klystron technology. Technically the program was a great success, and the RK/TBA appeared to be a promising avenue towards a future rf power source for energies much greater than a TeV, although cost was identified as an issue. In 1994, the Laboratory partnered with SLAC and LBNL to do a pre-conceptual design for a photon collider, which became part of the *Zeroth Order Design Report*¹ presented at Snowmass in 1996.

Our participation in the present-day 4-lab (LLNL, LBNL, FNAL, SLAC) NLC R&D consortium began with a series of meetings between LLNL and SLAC in 1996 to identify and connect technical challenges of the Next Linear Collider with areas of unique expertise at Livermore. Out of those meetings grew our current program, principally in four areas. These are the accelerator structures, the modulators, the high-power positron production target, and a design of a gamma-gamma collider, also known as a 'photon collider.'

Precision engineering has been long-standing core-competency of the Lab; Livermore has been a pioneer in the very design and construction of large diamond-turning machines on which ultra-precise components are made, ranging in size from two-meter-diameter space-based mirrors, to 100-micron size targets for laser fusion experiments. That coupled with our expertise in advanced manufacturing, the X-band accelerator structures were a natural area for joint work with SLAC. These structures require mass production – literally millions – of diamond-turned copper cells with micron-level machining and alignment tolerances. Over the years, the Livermore structure program, led by Steve Jensen, Jeff Klingmann and John Elmer, encompassed fundamental studies of machining methodology and surface finish, brazing and

bonding studies, investigations of alternative assembly schemes, and construction of a full 1.8 meter DDS-3 structure (Figure 1). The DDS-3 (standing for 'Damped-Detuned Structure', indicating how disruptive wakefields are mitigated) was a three-way venture. In the partnership, LLNL developed the machining procedure and fabricated all 206 cells, each of slightly different interior dimensions, KEK in Japan performed the diffusion bonding of all the cells into one structure, and SLAC finished the structure with couplers, etc. and performed the wake-field characterization of it with the ASSET facility. Much was learned from DDS-3, including an entirely new method for measuring beam position based on the relative power spectra from each of the four damping manifolds. Currently, the Livermore team is making cells for a short standing-wave structure to investigate and circumvent breakdown and gradient limitations in the X-band structures. We are aiming to finish the cells by the end of February, in order to have results in time for Snowmass in June.

Pulsed power is another area of special expertise at LLNL, which prepared the way for a radical change in the design of the high voltage modulator for the NLC. The modulator is the system that transforms line power into fast DC pulses needed to drive the klystrons. Until the proposal discussed in 1996 and the formation of a three-way LLNL-Bechtel/Nevada-SLAC team, the modulator technology for practically every electron linac in the world was a hydrogen thyratron-fired pulse-forming network. The new concept would involve an inductive voltage-adder circuit, a transformer consisting of a stack of multiple identical primary stages, threaded by a common secondary. The stages consist of modern fast high-current solid-state switches, to discharge the energy storage capacitors through a single-turn coil exciting a low-loss ferrite core, made of Metglas. This architecture promises significantly reduced capital cost, much longer mean time between failures, and higher efficiency than the old design. The practical implementation of this concept drew on two long-standing programs at LLNL. The first was the induction linac program, which provides solutions to the needs for high-current, low-energy beams for national security applications and as a possible inertial fusion driver. The second was the Atomic Vapor Laser Isotope Separation program (AVLIS), in which years had been spent industrializing highly reliable pulsed-power supplies for their copper-vapor lasers. This combination of technologies and expertise provided a unique opportunity for a program to develop a new NLC modulator in a timely and cost-effective way. The program additionally inherited a long existing relationship between LLNL and Bechtel/Nevada, a DOE contractor organization with both a permanent workforce on the Livermore site, as well as a complete design-to-manufacture capability in Las Vegas. Simply put, the LLNL-Bechtel/Nevada team could hit the ground running in making solid-state induction stages for a series of prototypes modulators of increasing size. Under the direction of Ed Cook, the core team consists of Jim Sullivan, Steve Hawkins and Brad

Hickman of LLNL, and Craig Brooksby and John Yuhas of Bechtel/Nevada. At present, a 10-stage modulator with step-up transformer is in performance trials driving a SLAC 5045 klystron, and a full 76-stage modulator (the '4-Dog') is nearing final assembly in SLAC's Power Conversion Lab, which will drive four 5045 modulators (Figure 2). The ultimate design envisioned for the NLC will be an '8-Pack' modulator, driving eight X-band klystrons, with a peak power of 1 gigawatt (500 kilovolts, 2000 ampere pulses, 3 microseconds in duration with a 120 Hz repetition rate)!

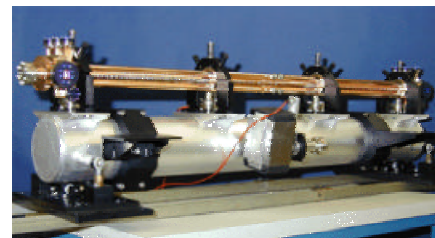


Figure 1. The SLAC-KEK-LLNL 1.8 meter DDS-3 X-band accelerating structure.



Figure 2. The 'Four-Dog' 76-stage modulator prototype, nearing completion.

Recent Linear Collider Publications

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

I. Linear Collider Collaboration Notes

http://www-project.slac.stanford.edu/lc/lc/TechNotes/LCCnotes/lcc_notes_index.htm

LCC-00053, "Tolerance to Offsets for a Plasma Lens in NLC," K. A. Thompson and P. Chen, 01/01.

Calendar of Upcoming Events

Collaboration Meetings

? Feb. 27 – March 2, 2001, Collaboration Meeting, FNAL (tentative).

? May 16 – 18, 2001, NLC MAC Meeting, LBNL.

Conferences of Interest

? HEACC01, March 26 - 30, 2001 Tsukuba, Japan, <http://conference.kek.jp/heacc2001/>

? 2001 Particle Accelerator Conference, Chicago, IL, June 17-22, 2001, <http://pac2001.aps.anl.gov/>.

? 2001 Nuclear Science Symposium, San Diego, CA, Nov. 4 – 6, 2001. Abstract deadline, April 20, 2001, <http://www.nss-mic.org/>.

? ICALEPCS 2001, San Jose, CA, Nov. 27 – 30, 2001, Abstract deadline April 20, 2001, <http://icalepcs2001.slac.stanford.edu>.

¹ Zeroth-Order Design Report for the Next Linear Collider, 2 Vols. LBNL-5424, SLAC-474, UCRL-ID-124161, UC-414, May 1996.