Director’s Corner
David L. Burke

A lot has happened since the last NLC News. This issue features articles from LC02, the 9th International Workshop on Linear Colliders held at SLAC in February. All the world was on campus as LC02 took place against a backdrop of strong international support for a linear collider. SLAC hosted the first “LC” workshop in 1988 as initial and often painful experiences with the SLC were unfolding. The maturity that has since been reached in our understanding of the physics and technologies of linear colliders was apparent in the depth and breadth of the discussions at this latest in the LC series.

The confidence of LC02 is also reflected in the work of the international Technical Review Committee (TRC) sponsored by the International Committee on Future Accelerators (ICFA). The TRC, chaired by Greg Loew of SLAC, expects to deliver later this year a report that will be an important input to the ultimate design and selection of technologies for a TeV linear collider. ICFA is also playing a very active role promoting international cooperation in the pursuit of a linear collider. Organization of an international steering committee has begun with a group headed by Maury Tigner of Cornell to draft a charge and proposed membership for consideration at the summer meeting of ICFA. Establishment of such a steering body will be an important step forward.

In the U.S., the DOE/NSF High Energy Physics Advisory Panel (HEPAP) has approved the strong recommendation of the Bagger-Barish Subpanel (NLC News, Vol. 2, No. 11) to seek construction of a TeV energy linear collider. The U.S. LC Steering committee conceived in the report has been constituted, and will hold its first meeting later this month. Similar committees are being established in Europe and Asia with the intent to guide regional actions and progress, and provide input to the international committee established by ICFA. It sounds like a complicated affair, but should bring focus at an international scale, while allowing regional issues to be dealt with regionally.

The U.S. NLC Collaboration welcomed the addition of Brookhaven National Laboratory at its spring meeting held earlier this month at Fermilab (http://www-project.slac.stanford.edu/lc/NLC-tech.html). This was an important meeting of the Collaboration as construction of the 8-Pack (NLC News, Vol. 2, No. 10) is moving ahead rapidly. Budget constraints this year, and now expected for FY03, have forced a careful review of Collaboration goals and plans. Completion of the 8-Pack is the highest priority and will need full concentration. But to meet the goal to begin operations in 2004 will require squeezing the remainder of the R&D program into a significantly smaller budget. The Collaboration has worked hard over the last months to evaluate what is needed to support a conceptual design of the collider, and has done a superb job redirecting work toward remaining key issues of beam dynamics and stability. Many important and well-thought-out investigations and demonstrations will need to be halted or not started. These priorities were presented to the Machine Advisory Committee (MAC) in a three-day session immediately following the Collaboration meeting. The MAC gave full support to the evaluations and judgments of the Collaboration. This has been an important process, and NLC News will cover the details in coming issues.

LC02 Working Group 1: Sources and Damping Rings
Andy Wolski

The issues for the sources and damping rings concern the luminosity of the collider, and polarization of the beams. Discussions at the workshop covered the challenges of producing high charge, low emittance polarized electron and positron beams; potential performance limitations affecting damping rings; and ideas for sources and damping rings that offer the prospect of significant advantages over current systems, but which will require significant research and development to reach their potential. The diagnostics that will be essential for a future linear collider to reach full luminosity are not yet fully developed, although groups working on the ATF at KEK are making great progress. The main challenge is making fast, precise and non-invasive measurements of very small emittance beams. A number of speakers presented encouraging results from a range of standard and innovative techniques, including the use of wire scanners, synchrotron radiation, and optical diffraction radiation. Y. Honda (Kyoto University) showed measurements of beam sizes below 10 µm using a laser wire on the ATF. The ATF remains an important facility for a range of studies relating to the sources and damping rings, and particularly for development of instrumentation.

Work by researchers at SLAC and at Nagoya University, has shown that the surface charge limit on a photocathode polarized electron source can be overcome by using a highly doped surface layer. C. Suzuki (Nagoya University) presented results suggesting that electron beams with polarization of 90% or more, could be produced using a two-photon excitation process; a laser system capable of delivering shorter pulses than used so far, will be required to demonstrate such high levels of polarization. Polarized RF guns offer the prospect of lower emittance beams, which would benefit any future linear collider, but require significant further development before they could replace existing technology.

The positron production scheme for NLC uses conventional target technology, and requires parallel operation of three stations to avoid terminal damage to the target. There is interest in the TESLA scheme, based on an undulator placed at the end of the electron main linac, and J. Sheppard (SLAC) led a discussion on a proposal to use a micro-undulator with the SLAC linac, to study positron production. The goals would include demonstration of the viability of this type of source for both polarized and unpolarized beams.
and the development of a range of equipment and instrumentation. Polarized positron beams are of interest as a possible upgrade for a linear collider, and there remains much research to be done before a suitable source can be demonstrated.

The damping rings present significant challenges in areas including dynamical stability, and alignment tolerances and mechanical stability. Discussions focused on collective effects that could limit the achievable vertical emittance. Present estimates suggest that electron cloud, as observed for example in the B Factories, will be significant in both TESLA and NLC damping rings; methods to mitigate the effects of electron cloud were identified as a priority for future research and development. Intra-beam scattering is a further effect that could lead to a detrimental increase in beam size. IBS has been observed in the ATF, and is expected to be a particular problem in the CLIC damping rings, though it is also a potential problem for the NLC. Further studies will be required before the effects of IBS can be predicted with confidence.

**Working Group 2: Linac Power Sources and Structures**

*Chris Adolphsen*

The Linac Power Sources and Structures Working Group (WG2) attracted a large number of participants with 62 presentations in total. To accommodate this many speakers, the presentations were given in two parallel sessions, one covering klystrons, modulators, rf distribution and system operation, and one devoted to accelerator design and operation.

On the klystron development front, the most recent results presented were on the testing of SLAC’s latest 75 MW Periodic Permanent Magnet (PPM) focused klystron (XP3-1). It has produced 76 MW, 2.8 microsecond rf pulses at 10 Hz with a 58% efficiency. In the coming weeks, it will be tested at the design rf pulse width (3.2 microseconds) and repetition rate (120 Hz). KEK has achieved similar results for a PPM klystron developed with Toshiba, although running with 1.4 microsecond pulses (the JLC rf system design requires only 1.6 microsecond pulses).

In addition to their PPM klystron programs, both SLAC and KEK are pursuing more novel klystrons designs with the goal of reducing costs (simpler parts, lower modulator voltage) and improving efficiency and reliability (lower beam current and rf energy density). KEK is designing a 150 MW multibeam klystron (six beamlets) and SLAC is working on a 75 MW sheet-beam klystron, which may allow the use of a gridded gun and thus a simpler modulator.

To power the PPM klystrons, SLAC in collaboration with LLNL has developed a solid-state switched induction modulator. It promises a significant improvement in efficiency and reliability over the traditional pulse-forming-network approach that uses thyatron switching. A prototype modulator that is designed to drive up to eight klystrons has been built at SLAC and tested at a few Hz repetition rate with water loads (500 kV, 650 A, 2.5 microseconds) and with two S-Band klystrons (400 kV, 450 A, 3.0 microseconds). The results bode well for its eventual operation with eight klystrons at 120 Hz with 500 kV, 2000 A, 3.2 microsecond pulses. KEK is pursuing similar technology to drive four PPM klystrons in one of the rf system designs being considered for the JLC.

During the sessions on accelerator structures, it was clear that a big issue for all linear collider groups is rf system performance. This issue will be addressed more seriously in the next few years with the construction of several facilities including the TTF2 FEL light source at DESY, the Spring-8 Compact SASE Source in Japan, the 8-Pack setup at SLAC, the LUFT setup at KEK and the CTF3 drive beam at CERN. These facilities include klystrons, modulators, rf delay-line distribution systems in the cases of SLAC and KEK, and drive beam combiner rings in the case of CERN. The NLC 8-Pack and JLC LUFT facilities will permit rf distribution tests at full power (600 MW) and pulse energies (480 J for NLC, 240 J for JLC) for the first time. At CERN, the CTF3 drive beam current will be lower than that in the CLIC proposal (35 A compared to 240 A), but will be at the full 140-ns pulse length, which will allow more realistic structure testing. With all these facilities in the works, the next Linear Collider Workshop should prove to be very interesting.
Working Group 3: Linac and Beam Delivery Dynamics and Control

P. Tenenbaum

Working group 3 – “Linac and Beam Delivery Dynamics and Control” – included 31 talks distributed over 8 sessions (including 3 joint sessions with other working groups). Participants included about 35 people who primarily attended WG3 sessions, and a significant number of others who joined just one or two sessions.

One of the major topics of discussion was the simulation codes used to predict the performance of linear collider beamlines. The experience of the SLC and FFTB has shown the crucial importance of diagnostics and correction algorithms in the linear collider field, correctly adding these features, as well as simulation of realistic beamline errors, has been a principal activity in the linear collider beam dynamics field for the last several years. Present efforts are directed towards cross-comparison of the various programs that can simulate correction of a beamline with errors (LIAR, MERLIN, and PLACET), and a common understanding of the real-world limitations of tuning algorithms and the diagnostics they require. A second exciting development is the assimilation of beam tracking codes and beam-matter interaction codes into a single software package that can simulate properly, for example, the backgrounds seen at a linear collider detector when collimation, secondary particle showers, synchrotron radiation, beam-gas scattering, and other phenomena are all considered. The combination of these two developments suggests that in the foreseeable future it will be possible to model realistically both the tuning of a linear collider and the way in which the tuning influences the backgrounds seen at the detector. This cross talk between tuning and backgrounds was a major issue for the SLC, and development of tools to model same has been a lofty goal of linear collider fans for many years.

Two sessions concentrated more heavily on design issues in linear colliders: the RF structure design session (joint with WG2) and the beam delivery system session (joint with WG4). The RF structure session discussed the modeling and measurement of transverse wakefields in accelerator structures, which is a crucial issue for any future linear collider, while the beam delivery system session reviewed the proposed designs for TESLA, NLC, and CLIC beamlines. It is interesting to note that, while the beam delivery systems of the various linear collider designs are very similar in their main requirements, the system designs presented in WG3/4 are significantly different. One area of future work is to understand whether the overall collider architecture requirements dictate use of one design over another, or whether all 3 linear collider concepts can unite behind support of a “best” configuration.

A white-hot topic during this meeting was emittance preservation, tuning, beam-based alignment, and the difficulties imposed by ground motion or other sources of misalignment. All proponents of linear colliders recognize the importance of these topics, and all linear collider proposals include algorithms for minimizing emittance growth and preserving performance in the face of ground motion, power supply jitter, and other sources of trouble. Efforts to understand and solve these problems have reached a sufficient level of maturity that the International Linear Collider Technical Review Committee (ILC-TRC) has directed the linear collider groups worldwide to “peer over each other’s shoulders” and attempt to cross-simulate the tuning algorithms (DESY physicists will study CLIC and NLC algorithms, etc.).

A final session focused on the plans for the third CLIC Test Facility (CTF3) Drive Beam system. CTF 3 uses a high-charge, low energy “drive beam” to generate the RF power required to accelerate a low-charge, high energy “main beam.” Thus, the CTF3 drive beam system has to generate a beam with adequate charge, energy, and stability for this purpose. Such a system has unique challenges that combine high-current linac beam dynamics with some features of high-current storage ring beam dynamics.

Working Group 4: Interaction Region and Detector Issues

Jeff Gronberg

The working group opened with contributions and overviews from all of the machines; NLC, TESLA, JLC and CLIC. The basic layout of the interaction regions for the three TeV scale machines has been mature for several years now. The CLIC group’s design is less advanced and they have to struggle with a similar issue to the photon collider, a large disruption angle to the outgoing beam. The NLC group reported a great deal of activity in the design of the final focus. It has been updated with the Pantaleo design, which shortens the length of the final focus region and implements 2nd order chromatic corrections. In conjunction with this the NLC group has revisited the issues of the layout of the tunnels leading from the end of the linac to the IR. The two linac arms have been made co-linear with the collimation and final focus tunnels. This minimizes the amount of bend going to one of the IR’s and allows the possibility of reaching multi-TeV energies. Work has gone into the placement of the second IR relative to the first, taking into account whether cultural noise from one would influence operations at the other. While ground motion has been extensively modeled the effect of cultural noise is less well understood. Additionally, it is unknown whether access to the unused IR would be possible during machine running due to the presence of muon backgrounds from the collimators. The level of these depends heavily on the beam halo population and that is difficult to successfully predict.

In the calculation of backgrounds an exciting development was the interfacing of the GEANT MC with tracking codes. GEANT4 has been interfaced with MAD and GEANT3 has been interfaced with TURTLE. This will allow a much better simulation of beam-based backgrounds and the validation of the current calculations. Interesting new results were shown for the muon backgrounds from the collimators. Now that the length of the final focus tunnel has been reduced the big bend becomes irrelevant to the muon background. A disturbing plot was shown for the CLIC machine where hundreds of muons were shown traversing the detector, superimposed on a physics event. Hopefully this will encourage the physics groups to provide better feedback on what level of muon background can be tolerated.

Photon collider technology is becoming mature, with designs optimized for short and long bunch spacing being presented. The Max Born Institute is pursuing a ring laser architecture, which exploits the long bunch spacing of TESLA to reduce the required laser power. Livermore is developing a high average power laser, optimized for the small bunch spacing of NLC / JLC / CLIC.

A very active group met to discuss recent results on stabilization and feedback. On-going tests of inertial stabilization were presented that show promising initial results. The FONT collaboration has done a lot of work simulating the ability of the various machines to use feedback loops to bring the beams into collision. Feedback is, of course, basic to the TESLA design but was shown to also have value for the warm machines.

A session devoted to the LINX proposal, including gamma-gamma operation, was well attended. The consensus of the working group was that the tests of final quad stabilization, halo reduction through non-linear optics and gamma-gamma operation were all useful and should be pursued.

Break time discussion
Recent Linear Collider Publications
If you would like to have 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/LCNotes/lcc_notes_index.htm

LCC-0078, “RF Accelerator Pressure Profile by Monte Carlo,” Gordon B. Bowden, April 2002.


LCC-0080, “Estimations of Collective Effects in the NLC Main Damping Rings,” A. Wolski and S. de Santis

Calendar of Upcoming Events

Conferences of Interest


US Particle Accelerator School

Santa Cruz Linear Collider Retreat
27-29 Jun 2002, Santa Cruz, California; http://scipp.ucsc.edu/LC/


Particle Accelerator Conference (2003 PAC)
Portland, OR, 12-16 May 2003; Siemann@slac.stanford.edu

Keeping in touch - network access
Deep in Discussion
Attentive Working Group
Induction Modulator Tour
NLCTA Tour