



NLC News -

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Program Director's Corner:

David L. Burke

International collaboration has always been a hallmark of High Energy Physics. The LCWS2000 Workshop¹, held recently at Fermilab, reinforced the need to think ever more globally as we look to the future. Against the backdrop of a decade of beautiful experiments at CERN, Fermilab, and SLAC, the reality of physics at the energy frontier has become vivid: New physics must exist that we have not yet found - and its image is emerging directly in front of us! But to focus fully this image will require planning on an unprecedented scale.

Combined analysis of studies of the W (at the Tevatron and LEP II), the Z (at LEP I and SLC), and the top quark (at the Tevatron) are exquisitely sensitive to the structure of the electroweak interaction. And the data cannot be explained by the particles we have observed so far! Something else must be there. This is the Higgs boson in the Standard Model - and the theory predicts the mass of the Higgs to be very near indeed. [The analysis tell us $m_H < 210$ GeV (95%

CL).] Even as the CERN management has struggled the past months with conflicts between continued pursuit of tantalizing hints at LEP II of the Higgs and construction of the Large Hadron Collider (LHC), the upgraded Fermilab Tevatron rushes toward start of operations this Spring. This will be the next opportunity on the world scene for discovery of the Higgs, or whatever physics mimics its effects. But, the Tevatron will not be enough. Neither will its descendant, CERN's LHC - even though the LHC will open new territory at higher energies, and will generate a wealth of new data. This conclusion has been clearly drawn by the International Committee on Future Accelerators (ICFA):

*To explore and characterize fully the new physics that must exist will require the Large Hadron Collider plus an electron-positron collider with energy in the TeV range. Just as our present understanding of the physics at the highest energy depends critically on combining results from LEP, SLC, and the Tevatron, a full understanding of new physics seen in the future will need both types of high-energy probes.*²

Particle physics needs a TeV-scale linear collider. The world is preparing to build it.

Workshop on Ground Motion in Future Accelerators

Andrei Seryi

The 22nd Advanced ICFA Beam Dynamics Workshop on Ground Motion in Future Accelerators was held at SLAC from November 6 to 9, 2000. Widespread interest in this topic was evident in the 58 participants from 20 laboratories worldwide, as well as universities and companies.

A next-generation linear collider will have tight tolerances on alignment and position jitter, so tight that ground motion and vibration can be limiting factors in the performance. Ground motion and vibration are also important in other areas including: synchrotron light sources; large circular colliders; some fields of industry and non-accelerator experiments requiring high precision such as gravitational wave detection. Teams from many different projects are working on these problems and, in many cases, converging on similar solutions.

The Ground Motion Workshop provided a venue to collect and compare the data, resolve outstanding issues, sharpen the contradictions, outline further studies and, most importantly, unify the worldwide efforts to prepare for the challenges of future machines. Topics discussed included:

- Theoretical considerations of the influence of ground motion on accelerators including proper methods to represent and model the ground motion
- Measurement, interpretation and classification of ground motion
- Fast motion, cultural noise and their correlation properties
- Slow motion and the relation between diffusive and systematic components
- Girder design and tunnel construction techniques and their contribution to vibration and ground motion
- Beam independent methods to ameliorate ground motion effects, including passive damping and active methods of stabilization

The Workshop opened with a review of the ground motion and vibration problems in various accelerators, such as large hadron colliders (SSC, VLHC and LHC), linear colliders and synchrotron light sources. Ground motions cause different problems in these machines. For example, the primary effect of fast (second to millisecond time scale) ground motion and vibration in large circular machines is to produce emittance growth, while for light sources the beam stability is an issue, and for linear colliders a bigger concern is beam separation at the interaction point.

Although ground motion problems affect each particular accelerator differently, the phenomena to be understood are similar: ground motion amplitudes and their spatial and temporal correlation properties. For all accelerators, the technical solution for ground motion problems is to first locate the accelerator in a quiet place if possible, then minimize the generation of additional vibrations, use beam-based feedback and, if necessary, apply additional stabilization technique to the components.

Participation by LIGO researchers was invaluable to the workshop. Fast ground motion can mimic gravitational waves and therefore the detecting masses must be isolated by many layers of passive and active stabilization. The impressive vibration suppression methods developed for LIGO have set a benchmark for what is ultimately possible. The LIGO team also described some of the issues in achieving maximal stabilization feedback performance by using very careful design, proper combination of sensors, and choice of the right algorithm. Collaboration with the gravitational wave experiments may prove fruitful to future linear collider development.

There have been extensive measurements worldwide of fast ground motion and correlation functions. Mathematical models of the motion have been created in order to evaluate the effect on an accelerator. One of the outstanding questions is the effect of "cultural noise" which can be generated in the vicinity of the accelerator and can vary significantly over short distances. This noise has not yet been satisfactorily modeled. The synchrotron light source community has extensive experience with cultural noise and vibration studies, and their presentations underscored how difficult these problems can be if external and in-tunnel noise sources are not carefully avoided by proper design and site selection. Light source researchers have also studied in detail the optimal design of support girders, which cannot be perfect and always represent a tradeoff, a fact that tends to be ignored. The NLC girder design will need more attention in the future.

A major Workshop discussion was of slow motion (minutes - years time scale). Two different models for slow motion have been proposed so far: a diffusive model governed by the ATL law: $\langle X^2 \rangle = A \cdot T \cdot L$ and a systematic model which behaves as $\langle X \rangle = A \cdot T \cdot L$. Here, X is the transverse misalignment, A is a coefficient, T is time and L is the distance between two points. Measurements presented showed evidence for both types of motion where the systematic component seems to dominate on the year time scale, and the diffusive for

¹ LCWS2000, Fermilab, http://d0server1.fnal.gov/users/hefisk/LCWS2000/Linear_Collider_workshop_2000.htm.

² For the complete ICFA statement see, http://www.fnal.gov/directorate/icfa/icfa_LCstatement.html.

shorter periods. The difficulty in measuring such motion, and the lack of data with sufficiently good statistics both in space and time, still allows considerable controversy over the interpretation of existing data. In particular, the evidence for an L dependence in diffusive motion has been questioned. On the other hand, during the Workshop there was significant progress on a systematic approach to the analysis of existing data, including proper decomposition of measurement errors from real motion. Such an approach has been applied to the LEP alignment data (700 quadrupoles measured yearly over 10 years) and plans were made for collaboration between CERN and SLAC to further analyze the LEP data. In addition, SLAC, FNAL and BINP will collaborate in a series of experiments to measure the dependence of slow motion on temporal and spatial separation and on geological conditions.

A thoughtful review of the implications of geology and tunnel construction techniques returned the discussion to real life. The question of how to balance an affordable cost with the requirements for tunnel stability was discussed and a specialized tunnel engineering workshop was proposed. It is clear that not all of the impacts of tunnel engineering on ground motion are understood. For example, there is evidence that bored tunnels may be more stable than those which used blasting. There are also questions about the effects of discontinuities due to the tunnel that modify the external noise and trap the internal noise. Little is known about the hour to day stability of existing tunnels such as LEP and this certainly warrants future measurements.

All participants considered the Workshop a success. In addition to the healthy exchange of technical details and solutions, it provided links between groups working on similar problems for different applications. A follow-up Workshop is planned in 1–2 years to keep track of progress in this exciting field. For further information, copies of the presentations are available on the Workshop web site: www-project.slac.stanford.edu/lc/wkshp/GM2000/ The Proceedings will be published as a SLAC report.

Update on X-Band Structures Testing

Chris Adolphsen

Two X-Band accelerator structures are being rf processed at the Next Linear Collider Test Accelerator (NLCTA), as part of a program to understand the acceleration gradient limits using X-band (11.4 GHz) rf. This program was reemphasized and refocused earlier this year when it was discovered that several of the prototype NLC structures showed damage after operation for several hundred hours at gradients less than 55 MV/m, which is well below the NLC requirement of 73 MV/m.

The damage appeared both as a pitting of the cell irises in the structures and an increase in the rf phase advance through the structures. In particular, these changes occurred mainly

in the upstream ends of the structures where the group velocity of the rf that travels through these nearly constant-gradient structures is highest. This may be explained if one views the structures as transmission lines, in which case higher group velocity translates into lower line impedance. Thus, if rf breakdown acts as a low impedance load, more energy will be absorbed for upstream breakdowns since the impedance mismatch there is smaller. Indeed, early gradient studies at X-band, which were done mainly with low group velocity structures because of rf power limitations, yielded higher gradients than the current high group velocity structures.

These observations have led to a program to build and test various low group velocity structures. The first, now being processed, was made from the downstream portion of one of the damaged NLC prototype structures. The last 52 cells of this 206-cell structure were used, and although there was some pitting on the irises of these cells, there was no discernable phase shift in this region. Thus far, this 'sawed-off' structure (see Figure) has been run for about 1000 hours in the NLCTA at gradients up to 70 MV/m. At this level, the interval between breakdowns has been much longer (hours) than in the previous full-length structure when processed to this gradient. To monitor for damage, the phase profile of rf induced by a short bunch train traversing the structure is measured about once a week. A few-degree phase shift, much smaller than the 50 degrees measured for the previous full-length structure, has been observed under comparable running conditions.

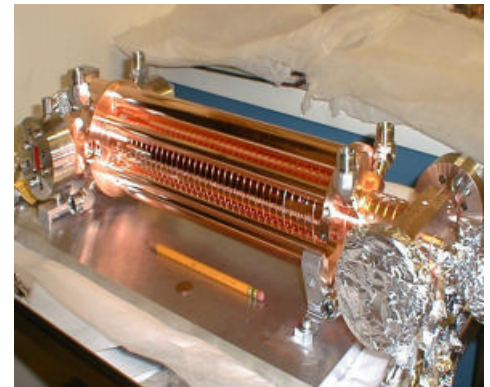
In parallel to this study, a previously unpowered NLC prototype structure is being processed. The goal is to see if a different processing approach will prevent damage, and if not, to assess how the damage evolves with gradient in this high group velocity structure. The new processing technique involves running with a series of progressively longer rf pulses, each until a target gradient has been reached. Also, the reset time after a trip has been increased (5 minutes) to allow for additional pumping of the gas generated by rf breakdown, and a new trip circuit has been added that is sensitive to much smaller breakdown events.

The initial target gradient was 40 MV/m and was achieved at full pulse length (250 ns) after about 200 hours of processing without any measurable phase shift. However, after an additional 200 hours of running at this gradient, a few-degree shift is evident in the first few upstream cells. This structure will continue to be run at the 40 MV/m gradient; if no further damage occurs, the gradient will be increased.

In the next six months, a series of new structures with different lengths and group velocities (including a standing wave version) will be processed and the results compared to narrow down possible new structure designs for the NLC. Also, different structure cleaning, degassing, handling and processing techniques will be evaluated. This program

will involve the concerted effort of a number of groups including NLCTA Operations, the new Electronics and Software Engineering Department and the Klystron Department, whose combined efforts recently led to significant improvement in the up-time of the NLCTA rf stations (see "Modulator Developments: NLCTA and 4-Dog" in the November NLC News).

Structure development to date has been the result of active collaboration between SLAC and KEK in both design and construction where progress is evaluated at regular ISG meetings such as that held in Japan in November. Much of the future structure fabrication work will also be done as a joint SLAC and KEK effort. Additionally, FNAL is ramping up their structure manufacturing capabilities and will produce structures for testing in the longer term. Finally, LLNL is studying structure assembly techniques and will produce diamond-turned cells for some of the near-term structures.



The 52-Cell Structure Now Being Processed

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

LCC-00049, "Beam Losses in the NLC Extraction Line for High Luminosity Parameters," Y. Nosochkov and K. A. Thompson, 11/00.

LCC-00050, "NLC Pulsed Extraction for 250 GeV Beams," P. Tenenbaum, 12/00.

Calendar of Upcoming Events

Collaboration Meetings

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

May 14 – 16, 2001, NLC MAC Meeting, LBNL.

Conferences of Interest

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>.

*The NLC Community wishes you all
a Joy-filled Holiday Season
and a Bright New Year*