NLC News

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Director's Corner:

David L. Burke

Last year went out with a flurry of activity in December just before the holiday season got underway. The NLC MAC met at SLAC in the second week, and the GLC/NLC ISG-XI collaboration meeting was held at KEK immediately following. The focus of the two meetings was quite similar even if the formats were not. The X-Band R&D has made significant progress in recent months, and activity in the first half of 2004 will be intense. The International Technical Recommendation Panel (ITRP) has been launched by the International Steering Committee, and will soon visit KEK and SLAC to review and hear about the X-Band collider. Direction of the R&D and preparation for the ITRP were central topics with the MAC and at ISG-XI.

The Collaboration was able to present very positive reports to the MAC on recent successes with modulators, klystrons, and the new SLED-II pulse compression system. Progress with structure gradients, and plans to integrate the new power source with structures to accelerate beam in Phase 2 of the SLED-II demonstration, were strongly supported. The MAC closed-out with encouragement to get on with pressing the strong case that is there to be made for the X-Band technology.

Japanese and American physicists and engineers met at the eleventh ISG meeting at KEK in what by now is a very familiar pattern of work and planning. Articles by Yong Ho Chin and Tor Raubenheimer in this issue of NLC News highlight the proceedings. Much of the meeting was devoted to coordination of plans for the upcoming discussions with the ITRP.

The new year promises to be good for the linear collider.

Report on ISG-XI RF Technology Working Group

Yong Ho Chin - KEK (ISG XI Convenor)

The 11th KEK-SLAC ISG Meeting (ISG-XI) on linear colliders (LCs) was held at KEK from Dec.16 through Dec.19, 2003. The ISG-XI meeting is a continuation of the ISG meeting series that started in early 1998. There were about 30 participants from the USA (SLAC, LBNL, FNAL and BNL) and an almost equivalent number of participants from various parts of Japan. The important topics of ISG-XI were 1) to discuss the 8-pack project at SLAC, the status, what is to be done, and what to do together, how to approach the International Technical Recommendation Panel (ITRP) and 2) to discuss together how we are going to present the X-band technology to the ITRP. The working groups were organized into two large groups, with subgroups and leaders as indicated below:

WG1: Luminosity Group (Urakawa, Raubenheimer)
Subgroup 1a: Beam Source (Ohmori, Sheppard)
Subgroup 1b: Damping Ring (Kuroda, Wolski)
Subgroup 1c: Beam Delivery (Kubo, Markiewicz)
Subgroup 1d: Instrumentation (Hayano, Rossi)

WG2: RF Technology Group (Chin, Schultz)
Subgroup 2a: Klystron (Chin, Vlieks)
Subgroup 2b: Modulator (Chin, Schultz)
Subgroup 2c: Pulse Compression (Chin, Tantawi)
Subgroup 2d: Accelerating Structures (Higo, Wang)

In what to follows, I have briefly summarized the RF Technology working group activities and discussions. A companion article by Tor Raubenheimer discusses the Luminosity working groups.

1 SLED-II

1.1 In early December 2003, the SLED-II pulse compression system at NLCTA successfully produced 585-MW power with a 400-ns pulse at the exit of the SLED-II, after combining and compressing the total input power of 180 MW at 1600-ns pulse length from the four XL-4 klystrons. The repetition rate was limited to 30 Hz due to the performance of the 8-pack modulator. This will be upgraded to 60 Hz in February 2004.

1.2 The ILC-TRC R1 requirement was satisfied.

1.3 The 8-Pack Project Phase 2 will begin in April 2004. In Phase 2, the power distribution system from the SLED-II exit to accelerating structures will be built. It will start with the four structures (Phase 2a) and then advance to the final eight-structure powering version (Phase-2b). Phase-2a will be completed successfully by late spring 2004, to fulfill the TRC R2 requirement. KEK provides 6 dB and 4.8 dB power splitters in addition to the 3 dB power splitter (the former backup power combiner). SLAC is responsible for the production of the rest.

2 PPM Klystrons

2.1 The SLAC XP3-3 klystron achieved the maximum power of 75 MW at 1.6 μs pulse length and 120 repetition rates last October. It succeeded to sustain full power for about a half hour without a vacuum trip. The tube had also been run continuously at 65 MW, 1.6 μs and 30 Hz without tripping for over a week. After returning to full testing at 75 MW, 1.6 μs and 120 Hz for a long run, the tube became gassy and the beam transmission deteriorated, so testing was terminated. The KEK PPM-2 klystron has achieved the maximum power of 75 MW at 1.7-μs pulse length at 60 Hz, and 68 MW at 1.7 μs at 120 Hz. It attained 97% full average power GLC/NLC klystron specification. The testing was terminated after the cathode voltage was raised to 500 kV (corresponding to 72 MW power) at 1.7 μs and 120 Hz and the gun started to arc. The JLC-X PPM-4 klystron was tested at KEK and achieved the maximum power of 75 MW at 1.7 μs at 50 Hz. The repetition rate was limited to 50 Hz due to the performance of the modulator.

2.2 The ILC-TRC R2 requirement was therefore satisfied.

2.3 The lifetime test at full specifications is planned for NLCTA starting this spring and using a newly developed 2-pack IGBT induction modulator. For this test, both KEK and SLAC will each provide one PPM klystron. KEK will provide the JLC-X PPM-4 klystron with the PPM-5 klystron as a backup. SLAC will provide the XP3-4 klystron with XP3-5 as a backup. Testing of the JLC-X PPM-4 klystron is currently in progress at KEK, following replacementof the windows with more robust Kazakov TE01 windows. The testing should be finished by the end of January and then the klystron will be shipped to SLAC for a full test at 120 Hz in March. The JLC-X PPM-5 klystron has been built and will be tested in February. Its water-cooling system provides a two-fold cooling improvement, and it is equipped with the SLAC TE01 windows. The gain cavities were also retuned for higher efficiency. This klystron will be shipped to SLAC in April for a full test at 120 Hz after the full specifications, except the repetition rate (limited to 50 Hz), are met. The NLC XP3-4 klystron was baked out in December 2003, and will be ready for testing at the end of January. The NLC XP3-5, the former XP3-3, is currently being rebuilt for testing in March. Both klystrons will have integral-pole-piece PPM focusing instead of the clamp-on magnet stack.

3 IGBT Modulators

3.1 Due to the IGBT heating problem, the operation of the 8-Pack IGBT induction modulator has been limited to 30 Hz. By applying better heat sinks on the chiller, the repetition rate is expected to be doubled to 60 Hz in February 2004.

3.2 TRC R2 requirement is yet to be satisfied.

3.3 A new 2-pack IGBT modulator will be operational at the full power of 515 kV at 120 Hz in March 2004. This will help to satisfy the TRC R2 requirement and will be used also to life test the two PPM klystrons. The production of the KEK IGBT induction modulator will be completed in spring 2004 and testing will start in May.

4 Structures

4.1 The average breakdown rate of all 60-cm-long structures produced so far for the unloaded gradient of 65 MV/m is still an order of magnitude larger than the GLC/NLC specification (0.1 events per hour). At the unloaded gradient of 60 MV/m, the breakdown rate satisfies the GLC/NLC specification. However, there are some objections to this kind of statistical argument, which says that we should argue based on the best result (0.2 events in an hour), instead of averaging apples and oranges.

4.2 TRC R1 requirement is yet to be satisfied.

4.3 The top priority is still to satisfy the TRC R1 requirement for structures. Throughout this spring, many new 60-cm-long structures are scheduled to be tested and they will help to satisfy the TRC R1 requirement. If necessary, we should focus investment of efforts and resources on the satisfaction of this R1 requirement even if this may delay the production of structures for the wakefield study. The selection of structures for the 8-Pack Phase 2 tests will also start soon.

The presentations made during the meeting are available at the ISG-XI home page at http://www-proc.kek.jp/ISG11.htm.

ISG-XI Luminosity Sessions

Tor Raubenheimer

The Eleventh International Study Group (ISG) Linear Collider collaboration meeting opened with a half day of plenary talks and closed with reports from the working groups on the last morning. The rest of the time was spent in working group sessions of the two large working groups, one on RF Technology and the other on Luminosity. This report summarizes the Luminosity Working Group sessions.

The ISG meeting was held in an atmosphere of considerable excitement over the recent success of the high power pulse compression tests at NLCTA. KEK has also made enormous progress developing their own test facility, GLCTA, and a tour of the facility was given on Thursday afternoon. Another important topic was the recently formed International Technology Recommendation Panel (ITRP). This group of 12 physicists from Asia, Europe and the US are charged with making a down select between the normal conducting X-band and superconducting L-band technologies for a linear collider. SLAC and KEK, as the leading proponents of X-band technology, will want to work closely together to present the best case for X-band to the ITRP. The ISG working groups were asked to identify R&D that could be completed on a time scale which would be relevant for the ITRP considerations, as well as further R&D needed over the next few years.

Summary document for ITRP: Two afternoon plenary sessions focused on interactions between the NLC/GLC groups and the ITRP. The group attempted to identify topics for R&D that could produce results on a time scale relevant to the ITRP deliberations. Documentation was also discussed. While a great deal has been written about many different aspects of the LC, the material is scattered and not easily accessible for the novice. It was agreed that the X-band collaborators should produce a brief document outlining issues and studies, with links to the appropriate documents for further detail.

Luminosity Working Group: The luminosity group sessions were divided among four areas: Sources, Damping Rings, Diagnostics, and Beam Delivery and Interaction Region. In addition, there was one joint session with a portion of the RF Technology group, which focused on the accelerator structure wakefields and dark current issues, and two sessions to discuss perceived luminosity risk issues throughout the collider.

Sources: The Sources session focused on the generation of polarized and unpolarized positrons. John Sheppard reported on recent work at SLAC on a conventional positron source for a superconducting linear collider. Members of Omori-san's group presented work on positron generation using backscattered photons. While both approaches are interesting, there are also a few additional studies that would be relevant on the ITRP timescale.

Other source system highlights included discussions of high field dc breakdown studies of candidate cathode materials being conducted at KEK by a joint group of KEK and Nagoya University researchers; design studies toward a 10.6 μm FEL for use in polarized positron production; proposed positron target material radiation damage experiments; and the status of the SLAC experiment E166 to demonstrate the production of polarized positrons.

Diagnostics: The focus of the Diagnostics session was on the ATF NanoBPM program. This is an ambitious program that will lead to improved diagnostics and demonstrations of nanometer-level stability. The timescale for these studies is relatively long. However, during recent runs, <100 nm resolution was demonstrated with the rf BPMs. Additional studies could be made of the BPM stability that would address one of the outstanding technical issues regarding the linac tuning strategies.

Damping Rings: The Damping Ring sessions discussed the recent results from the ATF prototype damping ring and the design of the NLC damping ring. The recent ATF results are very exciting. The discrepancy between IntraBeam Scattering measurements and theory appears to have been resolved with better emittance diagnostics in the ring and the beam-based alignment and tuning techniques have led to vertical beam emittances that are smaller than those specified in the NLC/GLC design.

A number of damping ring studies were identified which might support a the ITRP decision-making process. In particular, additional studies to benchmark the dynamic aperture code predictions against the ATF performance, to make comparisons between theory and measurements of the Fast Beam Ion Instability at the ATF, to make additional measurements of the jitter compensation of the ATF dual kicker system, and to make comparisons of measurement and theory for the longitudinal microwave instability in the ATF are all possible.

Mauro Pivi reported the latest developments on electron-cloud simulations and also on experimental studies performed at SLAC. The simulations were for the NLC and TESLA damping rings, and for the NLC beam delivery and three bunch compressor sections. In particular, a low secondary electron yield (SEY) ~1.2 at the vacuum chamber surface is needed in the wigglers of both rings. Single bunch instability studies showed that a strong head-tail may occur at electron-cloud densities larger than 2E+11 e/m**3 with growth times of the order of 100 μs. Laboratory measurements of the TiN and the TiZrV nonevaporable getter alloy are underway at SLAC to test the SEY durability of the materials under vacuum and the conditioning effect. Oide-san of KEK has recently proposed an experiment to study the electron-cloud effect in detail in the ATF using positrons transported from the KEK-B ring through a relatively short beam-transport line.

Beam Delivery: There were two Beam Delivery sessions held within the ISG-11 Luminosity Subgroup. The first subject to be discussed was that of the technology to be used for the Interaction Region (IR) Quadrupole Doublet. The Japanese have continued to pursue a permanent magnet technology based on Rare-earth Cobalt (REC) materials. At this point, as reported by Mihara-san, a 10-cm-long prototype has been made that delivers 2.1 T/cm gradient over a 7-mm radius aperture and that has better than the required harmonic tolerances. A temperature compensating medium has been added to its endplates and the temperature sensitivity of the magnet reduced by a factor of two. It is expected that this will be improved as the properties of the compensating material are better understood. The major impediment to using REC magnets is the apparent lack of flexibility in integrated field strength. Assuming that the accelerator optics allow for a magnet that contains alternating disks of focusing and defocusing elements, Kyoto University (Iwashita-san and colleagues) have designed a magnet with motor-driven alternating segments that permit a five-fold variation in integrated magnetic field strength.

BNL is continuing its work on compact superconducting magnets. The plan for this year is to wind a full length (2 m) quadrupole coil on a 1-cm-radius pipe using the recently developed "serpentine" winding pattern. This could comprise the inner of the two coil packages that the current 1.44 T/cm design stipulates. At this point, the innermost of the

five layers has been wound. Upon completion, the package will be cold tested and measured in a vertical dewar.

Studies to understand the source of magnet vibration, the propagation of vibration and in particular ways to suppress it, continue to be a highlight of the ISG workshop. Sugahara-san reported on the use of a commercial package with sensors and pneumatic actuators sold to stabilize table-like support platforms. Thorough tests, similar to those carried out in 2002 at CERN, indicate that such systems can deliver two or more orders of magnitude of vibration suppression between 10 and 50 Hz; below 10 Hz and between 50-100 Hz less suppression is observed. Sugahara-san also reported on site vibration measurements at KEK and at SPRING-8. The different geologies of the sites are evident in the observed spectral power densities.

Fred Asiri from SLAC spoke of the vibration tests performed this past summer in parallel tunnels of the Los Angeles Metro System. The causes of the large vibration transmission between tunnels and along the tunnel directions call for further study. Plans for the near future include the commissioning of geological simulation studies based on the program “SASSI,” which was used, for example, to evaluate the LIGO project. It is also planned to instrument two quasi-parallel tunnel segments at SLAC (the ‘Adit’ access tunnel and the SLC arc tunnel) with vibration-producing machinery, vibration-reducing isolation platforms and sensors. Measurements of transmission and the effect of vibration suppression schemes will be made.

Tor Raubenheimer summarized the breadth of SLAC R&D in the areas of low cut-off frequency non-magnetic sensors, mechanical prototypes of the final quadrupole doublet magnet, and feedback algorithms. The need for redundant background-protected robust BPMs to ensure the operational reliability of the feedback systems was emphasized.

Nicolas Delarue reported on the status of the ATF-based intratrain feedback experiment designated ‘FEATHER.’ Tests of feedback and feedforward using a new electrostatic kicker with moveable electrodes are planned as soon as the kicker’s operation with its new high power 500 MHz ~ 1 GHz amplifier is better understood. Circuit latency of 35 ns should permit operation with the 56-ns ATF bunch train. The NLCTA-based intratrain feedback experiment denoted as ‘FONT’ was improved over the last year and recently took its first data. Markiewicz showed this preliminary data. The 170-ns bunch train held 3 latency periods of the circuit and a x10 improvement on beam offset was observed in the witness BPMs. The operation of the so-called “beam-flattener,” a circuit to remove residual spatial variation based on prior-train measurements, still requires more study.

The last talks were updates to background calculations (Markiewicz) and the beam delivery lattice (Phinney). Recent GEANT3 calculations tracking the e^+e^- pair background that carries 200 TeV of total energy per bunch crossing into the magnets and detectors nearest the interaction point have been carried out. While heat loads appear small, the maximum radiation dose (on the front of the extraction line quad) is 100 MRad/year.

The optics of the final focus have been tuned to provide negligibly different luminosity at maximum design energy (1.3 TeV) to either the straight-ahead interaction point or to the interaction point that is noncollinear with the linacs.

E166 Update

J. C. Sheppard

E166 is an experiment to demonstrate undulator-based production of polarized positrons for use in linear colliders. At present count, the experiment has 47 collaborators from 16 institutions. Kirk McDonald of Princeton University and John Sheppard of SLAC are co-spokesmen for the experiment. All of the laboratories actively engaged in linear collider R&D are represented as well as virtually everyone involved in positron production for the linear colliders. The validation of the method of undulator-based polarized positron production provided by E166 applies to both cold and warm machine designs

E166 was formally approved in June, 2003 by the SLAC Experimental Program Advisory Committee (EPAC) with the proviso that effort be spent in understanding the expected backgrounds and background mitigation prior to scheduling the data run. After significant study, much discussion, and consideration of the FFTB operating schedule, it has been decided to forego a formal background test and to proceed with the full experiment. A letter from the SLAC Director Jonathan Dorfan, dated December 9, 2003, spells out the running schedule for E166: 3 weeks in October, 2004 followed by a 4 week run in January, 2005 - a welcome Christmas present indeed. With formal approval in June, the turn-on of funding in October, and scheduling in December, E166 now has the three necessary conditions for advancing: approval, funds, and schedule.

The experiment uses the low-emittance electron beam at 50 GeV in the SLAC FFTB in conjunction with a 1-meter-long, 2.4-mm-period helical undulator to produce circularly polarized photons in the energy of up to about 10 MeV. Longitudinally polarized positrons are generated through pair production when the photons hit a relatively thin conversion target (0.25-0.5 radiation lengths of material). The polarization of the photons with energies greater than 5 MeV is 75% and the polarization of the positrons is greater than 50% for the entire ensemble of positrons. E166 will measure the flux and polarization of positrons for different thicknesses of Ti and W conversion targets as well as the flux and polarization of the undulator photons. Figures 1 and 2 show schematically the layout of the experiment and measurement apparatus.

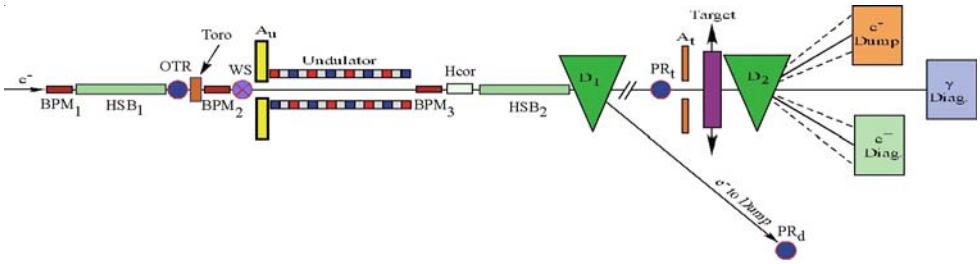

Figure 1: Layout of E166 in the FFTB at SLAC: a 1-m long helical undulator is located just upstream of the FFTB dump line magnets. Positron and photon diagnostics are located about 35 m downstream, near to the back wall of the FFTB shielding enclosure.

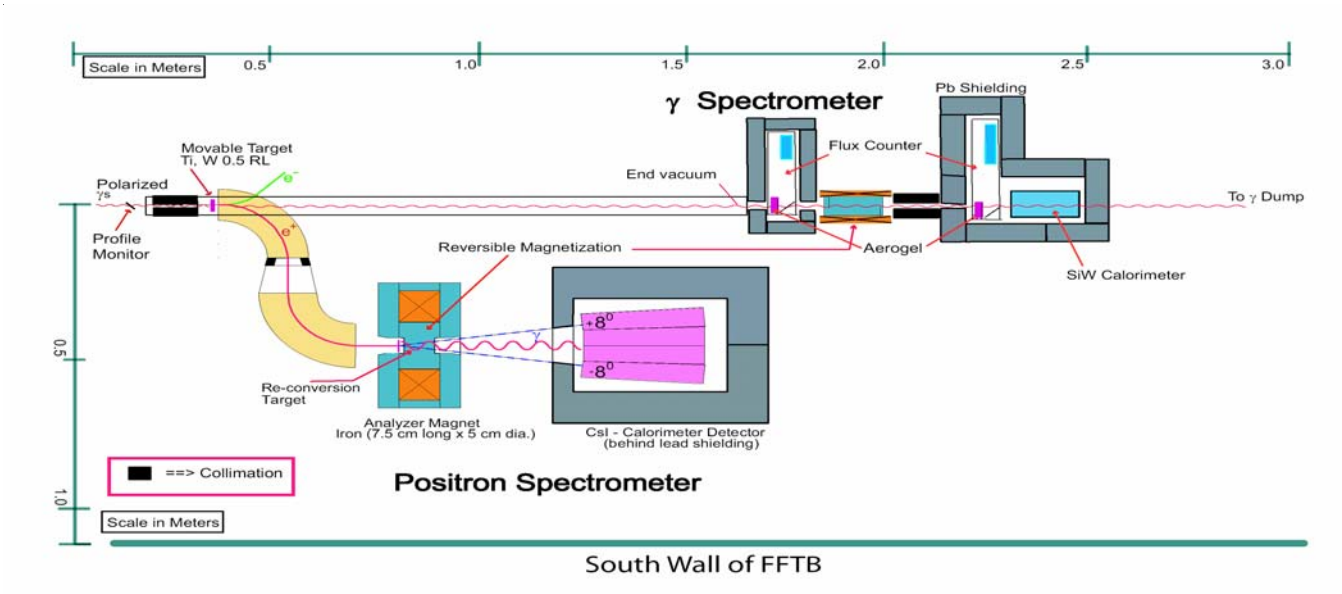

Figure 2: The positron and photon diagnostics being developed by the E166 collaboration for use in measuring the flux and polarization of positrons and photons produced in the experiment.

More details of the experiment can be found in **Proposal E-166-bis, May 16, 2003** on the E166 web page, http://www.slac.stanford.edu/exp/e166/, and at the links from the collaboration web.

Detector and data acquisition development (DAQ) for E166 began in April, 2003 under the designation of T467, a test-beam experiment. This activity operates parasitically to present FFTB beam running. To date, working prototypes of all four E166 detector types have been installed in the FFTB. The various detectors include: Cerenkov-aerogel flux counters, a SiW calorimeter, a Si-G10 flux counter, and a CsI calorimeter. The E165 DAQ has been shamelessly copied and is now up and running in Bldg. 407. A team from DESY Zeuthen and Humboldt University (Berlin) will arrive be at SLAC in February to test a pair of CsI detector configurations in the FFTB.

With the December, 2003 announcement of the running schedule, E166 begins the period of final equipment design and fabrication. The full experiment will be installed in the FFTB tunnel in the period of August/September, 2004. After a week of linac turn on, without PEP, E166 will run from October 8-November 1, 2004 for background checks and an initial data run. The Subpicosecond Pulse Source experiment (SPPS) will run during November and December, 2004 and E166 will take the month of January, 2005 for its full data run.

The E166 collaboration held a mini-workshop on backgrounds in July, 2003 with a participation of about 15 collaboration members. The October E166 collaboration meeting attracted nearly half the collaboration. The next E166 collaboration meeting will be held in May or June in Berlin, sponsored by Humboldt University.

We look forward to a busy and productive year in the business of making polarized positrons.

Upcoming Conferences and Workshops

Joint Universities Accelerator School: Two Courses On Physics, Technologies And Applications Of Particle Accelerators (JUAS 2004) 5 Jan - 12 Mar 2004, Archamps, France. http://juas.in2p3.fr

American Linear Collider Physics Group Winter Workshop (ALCPG 2004) 7-10 Jan 2004, Menlo Park, CA, http://www-conf.slac.stanford.edu/alcpg04/Default.htm

U.S. Particle Accelerator School (USPAS 2004) 19-30 Jan 2004, Williamsburg, Virginia, http://uspas.fnal.gov/

Aspen 2004 Winter Conference On Particle Physics: Where We Are And Where We Are Going, 1-7 Feb 2004, Aspen, Colorado http://gate.hep.anl.gov/berger/Aspen04/

Annual APS March Meeting 2004 22-26 Mar 2004, Montreal, Canada, http://www.aps.org/meet/MAR04

International Conference on Linear Colliders (LCWS), 19-24 April 2004, Paris, France. http://polywww.in2p3.fr/LCWS2004

CERN Accelerator School: Course On Power Converters For Particle Accelerators , 12-18 May 2004, Warrington, England, United Kingdom http://cas.web.cern.ch/cas/

11th Advanced Accelerator Concepts Workshop (AAC 2004), 20-25 June 2004, Stony Brook, New York, http://www.bnl.gov/atf/AAC04.htm