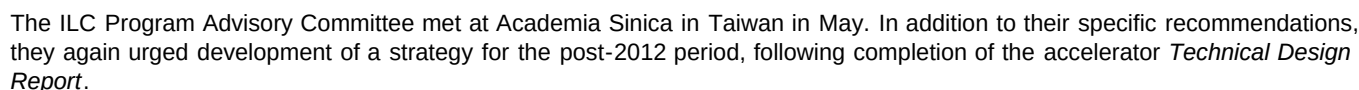


by Barry Barish



Dr. Robert M. Waymouth is a distinguished chemist and a member of the National Academy of Sciences. He is currently a professor at the University of California, Berkeley, where he has been working for over 30 years. His research focuses on the development of new chemical reactions and the study of the mechanisms of chemical reactions. He has published numerous papers in the field of organic chemistry and has received several awards for his contributions to the field.

I got involved in particle accelerators as a graduate student because I wanted to work in an area that had the potential to have a positive impact on people's lives in 10 to 20 years. Near the end of my PhD studies, I attended a talk by Herman Winick, who introduced the audience to synchrotron radiation sources and the research going on at the SPEAR ring at what is now the Stanford Synchrotron

by Leah Hesla



Keeping accelerating cavities tuned to the right frequency requires continual, gentle hammering by a little device called a piezoelectric tuner. DESY scientists have mastered the art and science of applying the piezo to cavities, bringing them to within several ten-thousandths a percent of the desired frequency.

IMAGE OF THE WEEK



Cavities in stereo

Image: DESY

Users can take a virtual tour through the European XFEL tunnel, currently under construction, walking through the newly planned facilities to get an idea of its space and future working conditions.

The nine-cell structures of pure niobium are designed to speed up the electrons at DESY's FLASH, the European XFEL, and the ILC. The picture was taken in DESY's IPP stereo projection room, where it is possible to project and view three-dimensional models on a 1:1 scale.

IN THE NEWS

from **BBC News**

1 July 2011

Antimatter Tevatron mystery gains ground

US particle physicists are inching closer to determining why the Universe exists in its current form, made overwhelmingly of matter.

from **BBC News**

29 June 2011

Dark matter may solve 'radio filaments' mystery

Unexplained "filaments" of radio-wave emission close to our galaxy's centre may hold proof of the existence of dark matter, researchers have said.

from **Fermilab**

24 June 2011

Fermilab experiment weighs in on neutrino mystery

Scientists of the MINOS experiment [...] announced [...] the results from a search for a rare phenomenon, the transformation of muon neutrinos into electron neutrinos. The result is consistent with and significantly constrains a measurement reported 10 days ago by the Japanese T2K experiment...

CALENDAR

UPCOMING EVENTS

Damping Ring Baseline Technical Review

INFN-LNF, Frascati, Italy

07- 08 July 2011

German Linear Collider forum

MPI Munich, Germany

14- 15 July 2011

International Europhysics Conference on High-Energy Physics (EPS-HEP 2011)

Grenoble, France

21- 27 July 2011

BLOGLINE

27 June 2011

Aidan Randle-Conde

Quantum bugs

26 June 2011

Flip Tanedo

CERN mug summarizes Standard Model, but is off by a factor of 2

The 2nd workshop on SCRF Cavity Technology and Industrialization for the ILC
Sheraton Chicago Hotel & Towers, Chicago, IL
24 July 2011

15th International Conference on RF Superconductivity (SRF2011)
Sheraton Chicago Hotel & Towers, Chicago, IL
25- 29 July 2011

Meeting of the Division of Particles and Fields of the American Physical Society (DPF 2011)
Brown University, Providence, Rhode Island, USA
09- 13 August 2011

Lepton Photon 2011 XXV International Symposium on Lepton Photon Interactions at High Energies
Tata Institute of Fundamental Research, Mumbai, India
22- 27 August 2011

[View complete calendar](#)

PREPRINTS

ARXIV PREPRINTS

[1107.0570](#)
top-BESS Model and its phenomenology

[1107.0245](#)
Higgs Boson Self-Coupling at High Energy $\gamma\gamma$ Collider

[1106.5863](#)
Development of a modular and scalable data acquisition system for calorimeters at a linear collider

DIRECTOR'S CORNER

PAC meeting in Taiwan: a discussion of long-term issues

Barry Barish | 7 July 2011



Our host Shih Chang (S.C.) Lee hosted a banquet at '101,' until recently the world's tallest building. He is sitting between Roy Rubinstein, PAC secretary, and Jon Bagger, ILCSC chair.

The ILC Program Advisory Committee (PAC) held their semi-annual review of the ILC detector and accelerator programmes at Academia Sinica in Taipei, Taiwan from 19-20 May. In addition to their specific recommendations on the detector and accelerator programmes, they repeated their general recommendation: "As at the previous PAC meeting, the PAC again recommends the need for ILCSC [ILC Steering Committee] and ICFA [International Committee for Future Accelerators] to work towards a post-2012 strategy for ILC activities, so that the accelerator and detector teams can efficiently continue their work after completion of the TDR [Technical Design Report] and DBD [Detailed Baseline Design] documents." I comment on this crucial issue from the standpoint of the Global Design Effort today and will address the committee's specific recommendations next week.

The Program Advisory Committee is the technical subcommittee of the International Linear Collider Steering Committee that provides oversight for the GDE effort for the scientific community. The PAC conducts semi-annual reviews jointly of the progress of both the detector and accelerator programmes. Although the main part of the meeting was focused on detailed technical reviews, the committee discussed longer-term strategic issues. They discussed with us both the scope and content of the final deliverable from our programme, the TDR, and strategic issues regarding the next steps beyond the TDR.

Below, I share some of the key points we made regarding the post-2012 programme during the review. I emphasise that this is an ongoing dialogue and we expect the plans will both evolve and become more definite over the coming year. However, the next meeting of the International Linear Collider Steering Committee will be especially important as they plan to place special emphasis on this issue.

The crux of the issue is illustrated in the timeline. At the end of 2012, we are planning to complete the mandate for the Global Design Effort to produce a complete the *Technical Design Report*. As of today, we are on schedule to complete that task, including the critical R&D demonstrations needed to make a solid construction proposal to the world's funding agencies. However, in order to make such a proposal, the physics case needs to be established from CERN's Large Hadron Collider (LHC) results, including determining the energy and other parameters required for a new machine to complement the LHC in exploiting terascale physics.

The LHC is now running very well and the amount of data that we project will be collected and analysed by the end of 2012 could go



The possible timeline for initiating an ILC project

a long way towards establishing the physics case, or it may require the long shutdown and the following run at higher energy before we are ready to propose a linear collider. Also, depending on these results, we hope to determine the maximum energy needed for the companion lepton collider in order to most effectively exploit LHC physics. The LHC results will more generally help guide ILC parameters, and give us some idea whether other technical approaches like the Compact Linear Collider (CLIC) Study technology or a muon collider need to be pursued to reach high enough energy.

With all of this in mind, we have been considering what type of ILC programme makes sense after completion of the TDR, assuming there will be a significant time gap before a decision can be made to proceed with a new project. The general theme we have been considering for a post-2012 programme is one focused on R&D towards a higher energy machine of about one teraelectronvolt (TeV) (the primary design for the TDR is for 0.5 TeV). This would provide us with a flexible way to optimise the design up to about 1 TeV, again depending on LHC results. The challenge will be to

achieve higher energy without significantly increasing the cost and power consumption. A combination of achieving higher operating gradients through continuing superconducting radiofrequency research and through value engineering optimisation of the TDR design will be central to this programme. The higher gradients may be possible through work on materials, cavity shapes, etc., and cost containment through improved cryomodule design and other design simplifications.

One consideration that we consider central to all detailed plans for a programme beyond 2012 is the need to preserve certain features that have been so successful in the GDE organisation. Perhaps the most important of those attributes have been the ability of the GDE to set priorities and make decisions globally and our ability to centrally coordinate the actual R&D programme. As mentioned above, the next serious step in considering the post-2012 period will be at the ILCSC meeting during the Lepton-Photon Conference in Mumbai in August.

[DBD](#) | [ILCSC](#) | [PAC](#) | [PAC REVIEW](#) | [TDR](#)

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Reaching for the sky! The '101' building, which served as a very appropriate banquet venue for the PAC review.

Adventures of a light-source bum

I got involved in particle accelerators as a graduate student because I wanted to work in an area that had the potential to have a positive impact on people's lives in 10 to 20 years. Near the end of my PhD studies, I attended a talk by Herman Winick, who introduced the audience to synchrotron radiation sources and the research going on at the SPEAR ring at what is now the Stanford Synchrotron Radiation Lightsource, SSRL.

Of course I had been aware of SPEAR, because physicists had recently discovered the J/psi particle in collisions there. But this colloquium was my first introduction to synchrotron light sources, which use the light generated by charged particles accelerating around a ring to probe matter on a very small scale. At that time, light sources were generally small research facilities harvesting light from accelerators that were primarily used for particle physics, and SSRL was no exception. Herman described how scientists there had measured changes in the environment of the iron atom in hemoglobin that occur when it picks up oxygen for transport in the bloodstream. Here was an accelerator used for physics research that could affect and improve people's lives within my own lifetime. I wanted to work on *that* kind of thing.

SPEAR was designed to run as a particle physics facility. Brookhaven National Laboratory's Rena Chasman and Ken Green had recently proposed the first electron storage ring designed from the ground up to be a light source, optimized to produce the brightest possible X-ray beam. When the time came for me to get a job, Green hired me in 1977 to work on the design and construction of this project, the National Synchrotron Light Source.

Even this designed-from-scratch light source relied heavily on the technology and experience developed at the world's electron/positron colliders: ADONE, ACO, CESR, PEP, and PETRA. When I arrived at Brookhaven I got right into it, reading large numbers of reports from what is now SLAC National Accelerator Laboratory to get up to speed on the state of the art in accelerator design.

By the time we got the NSLS up and running, Claudio Pellegrini had arrived at Brookhaven from Italy's Frascati National Laboratories to work on a colliding-beam proton machine for particle physics. Pellegrini got Brookhaven researchers interested in free-electron lasers—a new generation of light sources that promised even greater brightness, as well as the ability to resolve processes that take place on ultrafast timescales—and we spent many late nights at

the 700 MeV Vacuum Ultraviolet Ring on FEL-related experiments. I learned techniques for storing more current in the NSLS rings from Flemming Pederson, who had applied these techniques to the Proton Synchrotron at CERN, the European particle physics facility.

I have become sort of a “light-source bum,” moving on to Argonne National Laboratory to build and operate the Advanced Photon Source there, and in 2001 to SLAC, which had resolved to pursue Pellegrini's 1992 proposal to turn a 0.6-mile segment of the 2-mile-long linear accelerator into the world's most powerful X-ray free-electron laser. This project, the Linac Coherent Light Source, opened for research in late 2009, on time and under budget, in what may be the smoothest startup ever for any large-scale accelerator facility. This could not have happened without the thorough understanding of the linac developed during four decades of operation for particle physics and the skills developed in steering and focusing beams for the Stanford Linear Collider.

With the LCLS up and running, we have already started to design a major expansion, LCLS II. Other free-electron laser projects are under way in Europe and Asia. All use concepts and hardware developed in the worldwide effort to produce more powerful accelerators for high-energy physics. Research on light-source technology has taken on a life of its own and is coming full circle. For instance, at DESY, the German national laboratory, the TESLA project was a striking example of a thoroughly integrated accelerator research program in pursuit of both particle physics and ultrafast science with X-rays. The TESLA Test Facility is now FLASH, a highly productive X-ray free-electron laser user facility that opened in 2005. Now DESY is collaborating on the construction of the European XFEL, whose operation starting in 2015 may inform the design of the proposed International Linear Collider for particle physics.

As for me, I am still a bum but a happy one, working on the beautiful combination of physics and technology (and really every kind of creativity that goes into the planning, construction and operation) of light sources.

John Galayda directed the construction of the Linac Coherent Light Source at SLAC National Accelerator Laboratory, and is now project director for LCLS II.



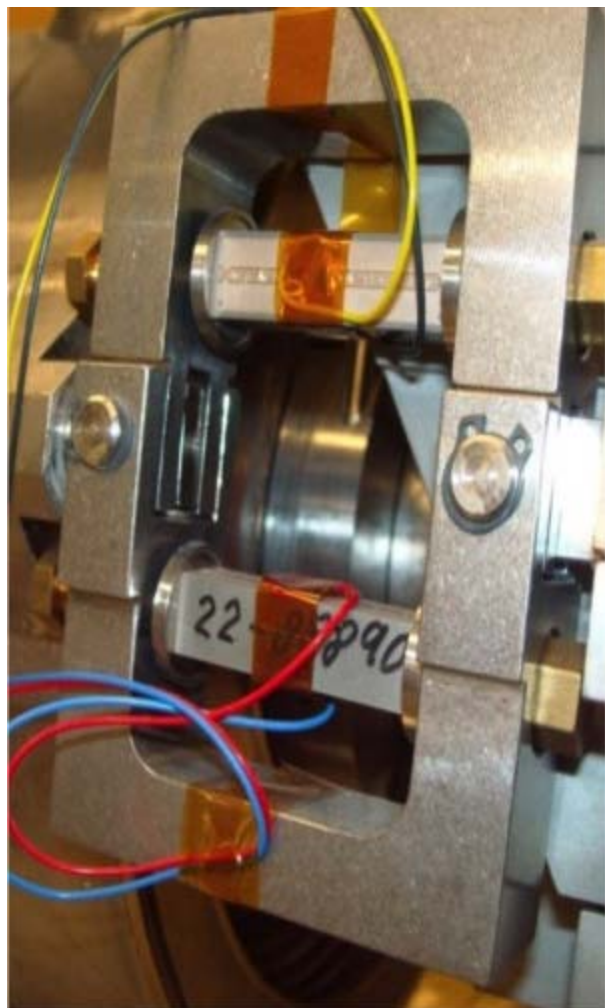
Photo: Brad Plummer, SLAC

AROUND THE WORLD

Achieving cavity resonance

DESY scientists fine-tune cavity frequencies

Leah Hesla | 7 July 2011



Two piezoelectric tuners, the smaller horizontal pieces wrapped in tape, are shown fixed to the end of a superconducting accelerating cavity. Image: DESY

Accelerator scientists have been busy creating and combining sine waves and nonlinear curves to form a straight, horizontal line – the flat top of a signal pulse of electric field-accelerating electrons. The flat, even profile signifies the untroubled transfer of power from source to electrons, one that occurs when a cavity is in tune with the accelerator's needs.

During last February's [9 milliamp tests](#) at DESY's FLASH facility, DESY scientists used an automated piezoelectric system to successfully tune ILC-type cavities to within several ten-thousandths of a percent of their resonant frequency. It was the first time this system was able to tune the cavity so closely to resonance, 1.3 gigahertz. Mariusz Grecki of DESY's Machine Beam Control (MSK) group presented their results at the May [long bunch train workshop](#).

"Having an automatic procedure that keeps the cavity tuned to the resonant frequency is a great success," Grecki said. The more resonant the cavity's frequency is with that of the power being fed to it, the more readily it accepts it and the less power is wasted.

"The piezo tuners are all about saving radiofrequency power, and therefore both capital and running costs," said DESY's Nick Walker, project manager for the ILC.

A piezoelectric tuner, or 'piezo' for short, converts electromagnetic signals into tiny mechanical movements. Fixed to the ends of meter-long superconducting cavities, these Lego block-sized devices ping the cavity to stretch or contract its length by nearly imperceptible amounts – only micrometres. The small change in shape makes a significant difference in the cavity's frequency.

The necessity of sculpting the cavity arises from an unfortunate, unavoidable phenomenon called Lorentz force detuning: every time a cavity is filled with electric field, the Lorentz force pushes apart atoms in the cavity wall, changes its shape and so brings it out of tune.

By feeding the right signals to the piezo, scientists counteract the frequency changes that come from detuning and ping it back to its desired shape. If all goes well, the voltage signals to the piezo result in an exact cancellation of the signal that arises

from the cavity's Lorentz force deformation, resulting in a nice, flat pulse top that lasts for as long as the beam is accelerated in the cavity – about 800 microseconds.

The MSK team was able to nearly fully compensate for the detuning, achieving signal that was within 10 hertz of the resonant 1.3-gigahertz (1,300,000,000 hertz) frequency. With the superconducting cavities so close to resonance, power can flow freely from the power station to the cavity without fear or annoyance of being bounced back.

Other ILC collaborators have also been working to overcome Lorentz force detuning. A Fermilab group, for example, [achieved similar results](#) using different algorithms.

More work remains to combat related nuisances. A different phenomenon called microphonics – small vibrations from sources outside the accelerator tunnel, like a train passing by – also detunes the cavity. An additional piezo could help compensate for these little disturbances.

“The microphonics contribution is a lot smaller compared to Lorentz force detuning, but it exists,” Grecki said. It could alter the cavity frequency by a few hertz, an incredibly tiny departure from resonance: if your wristwatch were off by a comparable degree, you’d reset it once every few years to be correct to the second.

That’s why piezos are handy. Like the smaller screws at the bases of violin strings, the piezo acts as a fine tuner.

“The piezo tuner is pretty much the only ‘knob’ we have on each cavity to fight detuning,” Walker said. Other control systems regulate the electric field over groups of cavities.

Having experimentally determined a method for detuning, DESY scientists are also working on the pencil-and-paper calculation for predicting the cavity’s tune when it’s loaded with a particle beam. (They’ve already hit upon the tuning calculation for a cavity that’s absent beam.) The very presence of beam complicates the equation substantially, and researchers continue to search for detuning’s correct expression.

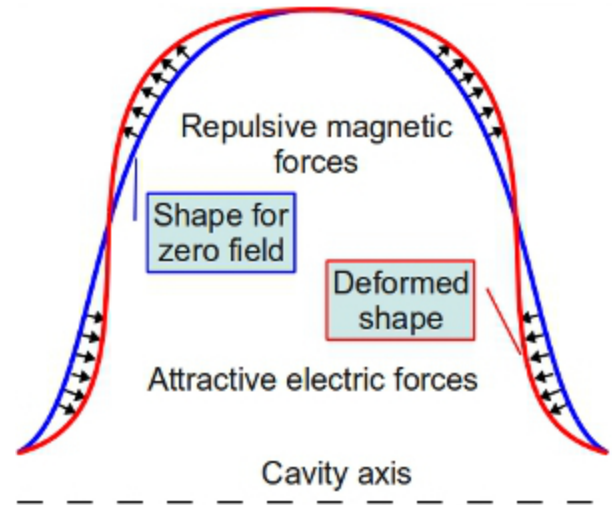
The detuning studies for the 9-mA experiments at FLASH provide ILC researchers with methods for saving power and reducing cost. And because they require the FLASH accelerator to increase its beam current from what it’s accustomed to providing to its regular users, the 9-mA experiments also gives the FLASH programme a chance to show sides of itself that it otherwise wouldn’t.

“The ILC needs experiments with the highest possible accelerating gradients and the highest possible beam current. At FLASH, we don’t usually use such high current,” Grecki said. “It was a very good opportunity to make a check-out of equations for beam contribution – the perfect situation to make such calculations.”

[9 MA EXPERIMENT](#) | [DESY](#) | [FLASH](#) | [LORENTZ FORCE DETUNING](#) | [MICROPHONICS](#) | [PIEZOELECTRIC TUNER](#)

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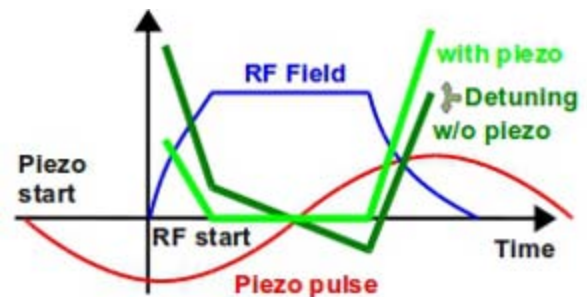
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$$P_s = \frac{1}{4} (\mu |\vec{H}|^2 - \epsilon_0 |\vec{E}|^2)$$

$$\Delta f_0 = (f_0)_2 - (f_0)_1 = -K E_{acc}^2$$

Lorentz force detuning deforms the cavity shape and, therefore, its frequency. Image: Mariusz Grecki



The blue curve represents the desired pulse shape of the accelerating field in the cavity. Image: Mariusz Grecki