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21 APRIL 2011

FEATURE

The sound of accelerator cavities

Liquid helium's curious properties help scientists focus on cavity defects.

by Leah Hesla

Elegant and inexpensive, the second-sound detection system developed at Cornell University helps scientists triangulate the location of hard-to-see accelerator cavity flaws. Helium helps.

RESEARCH DIRECTOR'S REPORT

"Crazy" years await us – or maybe not

This month's Research Director's Report was written by Juan Fuster, co-chair of the Worldwide Study and regional detector contact for Europe.

by Juan Fuster

Though the road ahead is long, the ILC collaboration has made considerable strides designing the machine and its two detectors, contributing to the advancement of other fields and bringing together a global community. Now we must keep up the energy for the remaining stretch as we fulfil our mandate to deliver its technical design.

DIRECTOR'S CORNER

Positron source relocated to the end of the linac

by Barry Barish

The last of four proposed major changes to the ILC baseline is to move the positron source to the end of the linac. That proposal has been adopted after evaluating the advantages and the possible options to retain low-energy performance.

SLIDESHOW

Electron beam welding machine arrives at KEK

KEK received its new electron beam welding machine from a German company last week. It will be installed in the laboratory's Cavity Production Pilot Plant.

Images: Nobu Toge

IN THE NEWS

from ***Reuters***
20 April 2011
NASA clears shuttle Endeavour for April 29 launch
The primary purpose of the flight is to deliver the $2 billion Alpha Magnetic Spectrometer, or AMS, particle detector, an instrument designed to detect dark matter, antimatter and other exotic phenomena.

from ***INFN***
19 April 2011
INFN The Italian Government Approved the Long-Term Funding for SuperB
The SuperB project uses the assumption that particle accelerators, smaller than the current 'giants', operated at a low energy, can enable excellent scientific results complementary to the high energy frontier. The crucial element consists in getting particle beams – which are extremely compact, small, short and very dense – to collide.

from ***INFN***
15 April 2011
New data from XENON100 narrows down the search for dark matter
After analyzing one hundred days of data taken with the XENON100 experiment, they see no evidence for the existence of Weakly Interacting Massive Particles (WIMPs), the leading candidates for the mysterious dark matter.

from ***Nature***
14 April 2011
Dark matter no-show confronts supersymmetry
The XENON100 experiment has placed the tightest limits yet on the properties of dark matter.

from ***Wired***
13 April 2011
South Pole Neutrino Detector Comes Up Empty
After years of waiting, the world's biggest and best neutrino detector has started its search for the source of ultrahigh-energy cosmic rays that constantly bombard the Earth's atmosphere. And it's seen exactly zilch.

from ***New York Times***
13 April 2011
Particle Hunt Nets Almost Nothing; the Hunters Are Almost Thrilled
This could have been the day they discovered dark matter.

from ***Science***
12 April 2011
Energy Department's National Labs Avoid Major Disruptions
Since early February, scientists supported by the Department of Energy's (DOE's) Office of Science have been bracing for massive layoffs at the department's 10 national laboratories and the temporary closure of many of the large user facilities located there.

CALENDAR

UPCOMING EVENTS

Linear Collider Power Distribution and Pulsing workshop
LAL, Orsay, France
09- 10 May 2011

ILD Workshop 2011
KEK, Tsukuba, Japan
23- 25 May 2011

Second Workshop on linac operation with long bunch trains
DESY, Hamburg, Germany
06- 08 June 2011

Technology and Instrumentation in Particle Physics 2011 (TIPP 2011)
Chicago, IL
09- 14 June 2011

UPCOMING SCHOOLS

École IN2P3 - Pays Méditerranéens des Accélérateurs de Particules
Gammarth-Tunis, Tunisia
09- 14 May 2011

USPAS sponsored by Stony Brook University
Melville, New York
13- 24 June 2011

View complete calendar

BLOGLINE

11 April 2011
Fermilab
10 Questions for a Particle Physicist

PREPRINTS

ILC MEMO

2011-006
GDE Change Evaluation Panel – TLCC-4 – Decision Memo

2011-005
GDE Change Evaluation Panel – TLCC-3 – Decision Memo

ILC INTERNAL NOTE

2011-052
Sixth International Accelerator School for Linear Colliders – Curriculum

ARXIV PREPRINTS

1104.3851
The Chromoelectric Dipole Moment of the Top Quark in Models with Vector Like Multiplets

1104.3645

Isolating CP-violating γZZ coupling in e+e- \to γZ with transverse beam polarizations

1104.3624
Studying Very Light Gravitino at the ILC

1104.3534
The lepton flavor violating decays $Z\to l_i l_j$ in the simplest little Higgs model

1104.2600
The Spectrum of Goldstini and Modulini

1104.2431
Status report of the baseline collimation system of CLIC. Part II

1104.2426
Status report of the baseline collimation system of CLIC. Part I

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FEATURE

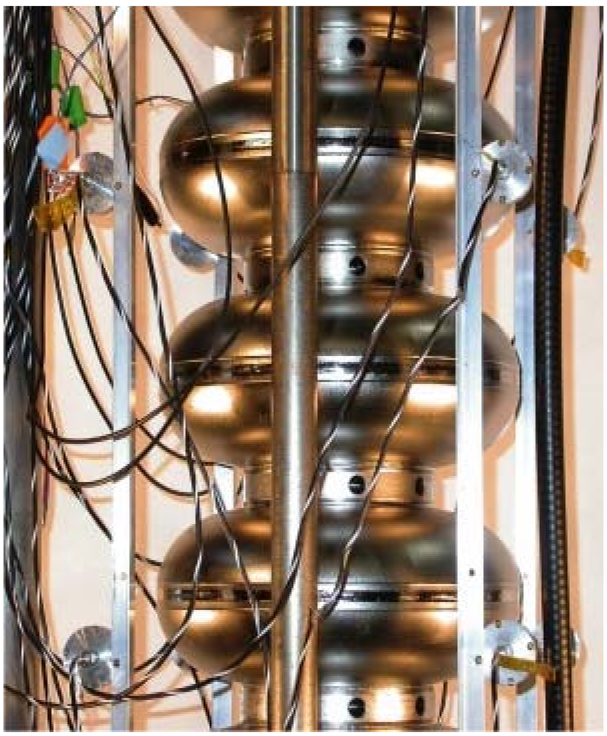
The sound of accelerator cavities

Liquid helium's curious properties help scientists focus on cavity defects.

Leah Hesla | 21 April 2011

Heat waves aren't always a bad thing. For scientists working on accelerator cavities, they provide a simple way to locate hard-to-see surface defects, which can turn an otherwise superconducting cavity into a dud.

Cornell University's second-sound detection system homes in on a cavity defect, such as a pit hiding in the cavity wall, by tracking the heat that emanates from it once the cavity reaches a certain accelerating gradient.



An ILC-type cavity soon to be tested for defects using second-sound detection. The sensors, oscillating super-leak transducers, are the small metal discs connected to cables. Image: Zach Conway.

"It's turned out to be a very convenient, fast and effective way of isolating the defect location to less than an inch," said Don Hartill, member of the SRF (superconducting radiofrequency) group at Cornell University. Because it calls for very little equipment, it's also inexpensive.

In second-sound detection, sensors are positioned outside and around the cavity. The sensors and the cavity, powered by a radiofrequency transmitter, are submerged in a bath of liquid helium.

When the voltage gradient of a defective cavity is cranked up past what the cavity can handle, it quenches – goes from superconducting to normal-conducting – and the cavity suddenly loses its stored energy. At the same time, the cavity's temperature rises at the defect responsible for the energy loss, so unmasking the pit as ground zero for a heat wave.

Together, the strategically placed sensors act as a kind of positioning system to locate the hot spot that marks the defect's whereabouts.

"With this system, we can very easily detect where a quench comes from," said Georg Hoffstaetter, head of Cornell's SRF group.

Here, heat propagates in unfamiliar ways because of a surprising property of liquid helium whose temperature is lowered below its so-called lambda point, 2.18 kelvin. The heat doesn't fill up the helium the way heat from a fireplace fills up a room. Rather, it's a pulse that advances through the helium like a sound wave, slowly making its way towards the sensors at about 20 metres per second.

That pulse is the second sound, and it doesn't refer to an echo. It's a mathematical term in the equation that describes heat when liquid helium is cold enough.

Below its lambda point, liquid helium takes on a split personality. Ultra-cold liquid helium has both a normal part and a superfluid part. The superfluid component has zero viscosity and can pass through the tiniest pores without friction. The normal helium component can't.

When the helium's temperature changes, so do the relative amounts of the two components, like pans in a beam balance – the overall density of the fluid remains constant.

The sensors that detect second-sound waves, called oscillating super-leak transducers, are capacitors. One capacitor plate is an aluminium-coated plastic film with micrometre-scale holes. The superfluid, able to move freely through the holes, behaves as if the film wasn't even there.

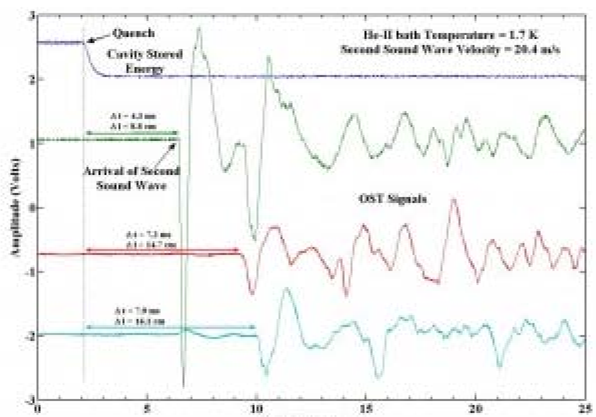
When the heat pulse arrives at the sensor, the rise in temperature results in a drain of superfluid from the capacitor through the holes. Normal fluid from outside can't push its way through the holes to compensate. Since ultra-cold helium can't tolerate an overall density loss, the capacitor volume diminishes to make up for it. The first plate is drawn closer to the second (a solid metal), and – *voilà !* – the capacitance goes up and the voltage goes down.

Components of an oscillating super-leak transducer. The plastic film with micrometre-scale holes is shown in the lower right corner. Image: Zach Conway.

That's the signal that temperature wave, which originated at the quench, has arrived.

Researchers measure the time from the sudden powering down of the cavity to the onset of the wave at the transducers, so deducing the distance from each transducer to the culprit area. With multiple transducers, the distances uniquely determine the quench spot.

"It's as if you make a string as long as the travelling distance, and you check where all the strings from the sensors meet," said Hoffstaetter. "That's where the quench happened."



A read-out of the sensor signals. The top curve indicates the onset of the quench, when the cavity's transmission power goes to zero. The second, third and fourth curves show when the temperature wave, propagating through liquid helium, reaches three different sensors. The precipitous drop in each curve indicates the arrival of the wave for that sensor. Image courtesy of Georg Hoffstaetter.

Right now, Cornell can resolve the quench spot to about two centimetres. Beyond that, a mirror system and a telescope allow researchers to zoom in to a resolution of a few micrometres if necessary.

The idea to use second-sound detection for cavity research originated in an advanced laboratory course taught by Hartill at Cornell's physics department. Second-sound is in general used to perform tomographic studies with liquid helium.

"A few years ago, it dawned on me that we could actually use it for our ILC test programme," he said. The Cornell team has been honing the system ever since. They recently increased the number of transducers around the cavity from eight to 16, which means more of them can be positioned in a direct 'line of sight' from the quench location.

The Cornell-developed transducers are now being used at laboratories around the world: Argonne National Laboratory, Fermilab and Jefferson Lab in the US, IHEP in China, INFN in Italy and KEK in Japan. DESY in Germany also uses transducers based on Cornell’s design.

There’s a reason for the popularity of second-sound quench detection. The only thing that surprised people about it, said Hartill, was “how easy it was to use.”

CAVITY | CAVITY DIAGNOSTIC | CAVITY INSPECTION | CAVITY SURFACE | CORNELL | CORNELL UNIVERSITY | OSCILLATING SUPERLEAK TRANSDUCERS | SECOND SOUND | SUPERCONDUCTING CAVITY

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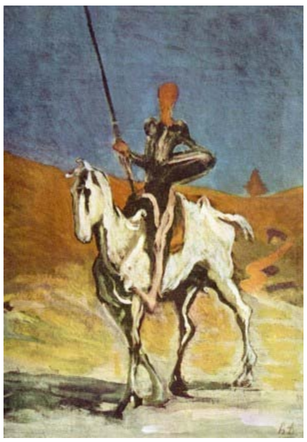
RESEARCH DIRECTOR'S REPORT

"Crazy" years await us – or maybe not

This month's Research Director's Report was written by Juan Fuster, co-chair of the Worldwide Study and regional detector contact for Europe.

Juan Fuster | 21 April 2011



Don Quijote and Sancho Panza drawn by Honoré Daumier. Image: Verlagsgesellschaft mbH under the GNU Free Documentation License.

"*…acreditó su ventura, morir cuerdo y vivir loco*"
(… a crazy man his life he passed, but in his senses died at last)

Epitaph of Samson Carrasco upon the tomb of
The Ingenious Gentleman Don Quixote of La Mancha (Part two 1615)

The book written by Miguel de Cervantes Saavedra in 1605 (part I) and in 1615 (part II), *The Ingenious Gentleman Don Quixote of La Mancha,* constitutes a master lesson on the greatness and the misery of the human condition. In Spain, this book is studied in primary school, but I realised that it is not until now that I start to understand it. The story is driven by Don Quixote, who behaves like a crazy person but who often argues with admirable common sense. Cervantes unveils the importance of the ideals and shows the value of freedom and justice. He also warns about the very subtle distinction between reality and appearance in most circumstances. The unfortunate adventures of Don Quixote teach about life and brim with generosity, absurd situations, loyalty, and imaginary heroic deeds of a high spirit.

I write in this section of *ILC NewsLine* for the first time, and as Sakue Yamada suggested to me, this constitutes an opportunity to show my views on the International Linear Collider project. In this sense the story of *Don Quixote* comes very often to my mind when thinking on it. The ILC project, accelerators and detectors, is an extremely demanding scientific and technological challenge that requires the detached effort of many people all over the world, only some of whom, by the way, are physicists. Furthermore its fulfilment is not guaranteed by the viability or technological results obtained as it requires other additional conditions, more sociologically based, to be achieved as well. This is due to its large scale and the amount of needed resources.

Today the ILC project status is in my opinion in an excellent but dramatic situation. It is 'excellent' because all R&D activities have successfully demonstrated the viability of the project, the acceleration principle is shown to work and its technical construction is proven to be feasible. The detector concepts have been studied and first complete designs exist already. A physics programme including a light Higgs scenario, top physics studies and searches for new physics has been developed complementary to that of the Large Hadron Collider (LHC). In addition, a large number of spinoffs have been derived from all these activities as, for example, the European X-ray Free Electron Laser project, new vertex and calorimeter technologies of present use in other experiments and several applications to industry and other scientific disciplines like astrophysics or biology and medical physics. New international structures involving worldwide panels and committees are continuously being explored and created to guide the project.

On the other hand, the situation is also 'dramatic' because most of the developed programmes are coming to their conclusions and the moments to make decisions for further actions are either approaching or have already arrived.

Continued funding represents a hitting problem. The present world economic situation and, again, the large scale of the project further complicate the situation. If we were running the marathon our present situation in the race would be very far from the start but still quite a way to the finish. It is at this moment when the runner feels exhausted and he or she cannot think reasonably, the body has consumed all glycogen and needs to change to its reserves in fat. This is known as 'the wall' and it is when most doubts occur. Strong physical and psychological training is then necessary to overcome this step. It is the moment for the best Don Quixote. In our case we should remind to ourselves that we still keep a very good position in the race and our option to battle for the win remain untouched. Furthermore, LHC results might soon provide us with additional fresh sugar in the form of new discoveries. Our next provisioning will, in any case, happen in about year and a half from now, by the end of 2012, when the detailed technical documents will be produced. These are the *Technical Design Report* for the machine and a *Detailed Baseline Design Report* for the two detectors, ILD and SiD. We need to keep the rhythm of work and the motivation high until then.

The ILC accelerator superconducting technology represents a suitable solution for a linear collider with an energy range from
0.5 TeV to probably 1 TeV. For higher energies other acceleration techniques need to be pursued. This is the case for the Compact Linear Collider (CLIC) concept. The energy range of the CLIC machine covers the range from about 0.5 or 1 TeV to up to 2 or 3 TeV. The development of the CLIC project is in a more early stage than the ILC but has the potential to reach higher energies. It is foreseen that the *CLIC Concept Design Report* (CDR) will be produced by the second half of 2011. The search for synergies between the two projects is important, and it is happening. The ILC community is now also involved in producing the CDR documents and later the CLIC community has committed to also help in producing the TDR and DBD documents. This cooperation represents a remarkable achievement.

My present appointment as chair of the ECFA study on positron-electron linear colliders, which extends until 2013, succeeds that of CNRS/LAL's Francois Richard, who was in this position since 2005. It is a great honour for me to take this responsibility and especially to replace Francois, whom I've known for a long time, ever since we worked for DELPHI at LEP in the early 1990s. I hope to reach his level of enthusiasm and efficient work serving the ILC project. As European regional contact I am also very pleased to join the team of the detector management, which is coordinated by Sakue Yamada and includes Hitoshi Yamamoto (Asia) and Jim Brau (Americas).

Under European scientific policy, our next plan for the European Strategy for Particle Physics has to be defined by the end of 2012 and consequently the documents produced by the ILC and CLIC communities will be of major importance and use. The discussion will be held in the European field but in reality the opinion and sensitivities of all regions will play an essential role.

The coming years are thus going to be extremely exciting and, I hope, will not necessarily drive us crazy, though there is some risk of that. Intense scientific discussion will follow the interpretation of LHC results and ideas about strategic plans will be offered. The high moral virtues and heroic deeds of our beloved and very wretched character, Don Quixote, should be a guiding example for our actions. However we should also learn from him that to die, it is not unavoidable to reach common sense.

To finish, I would also like to profit from these lines to announce the next Linear Collider Workshop, LCWS11, which will be held in Granada, Spain from 26 to 30 September this year and which will be common to the two linear collider concepts, ILC and CLIC. The city of Granada is located at the foot of the Sierra Nevada mountains, at the confluence of three rivers, Beiro, Darro and Genil. The Alhambra, a Moorish citadel and palace, is in Granada and is one of the most famous buildings of the Islamic historical legacy in Spain. The Almohad urbanism, with some fine examples of Moorish and Morisco constructions, is also preserved at the part of the city called the Albaicín. The Alhambra and the Albaicín are both UNESCO World Heritage Sites. The city is very open and welcoming for visitors, a very pleasant place to enjoy talking about the linear collider together with the latest results from LHC.

CLIC | DBD | ILC | LCWS11 | TDR

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DIRECTOR'S CORNER

Positron source relocated to the end of the linac

Barry Barish | 21 April 2011

Three major changes to the *Reference Design Report* (RDR) baseline have previously been adopted. Today, I announce the approval of the fourth and final top-level baseline change that has been proposed by the Global Design Effort project managers. The undulator-based positron source will be relocated from the 150 GeV energy point to the exit of the main electron linac, resulting in several system integration improvements. Our motivations behind making these changes is to evolve the design for the *Technical Design Report* such that we improve elements of the design and, most importantly, such that we find ways to reduce costs to compensate known areas of cost growth.

Discussions of the proposal to relocate the positron source during the Baseline Assessment Workshop at SLAC in January 2011.

A number of important systems integration benefits result from moving the positron source and were listed in the original SB2009 proposal:

- The undulator source can be better integrated into the upstream area of the beam delivery system (BDS), where more tunnel space and more freedom of lattice design are available than in the main linac.
- Machine protection systems for the smaller acceptance undulator and BDS beamlines can be effectively combined into a single system, located immediately downstream of the main linac.
- All sources of restricted energy bandwidth are now localised in the central region, leaving both the main superconducting radiofrequency linac as systems with nearly identical contiguous high bandwidth. This greatly facilitates their commissioning and tuning.
- Moving the positron target and capture system to the end of the linac consolidates all the high-radiation environment systems within the central area, which is expected to be beneficial for certain host sites (radiation safety and environmental impact).
- A large energy overhead is available to drive the undulator source, which allows operational margin for the early commissioning in the event that the maximum-performance of the main linacs system is not achieved (i.e., maximum gradient at full beam loading).

The change in the location of the positron source gives increased flexibility for linac operations and upgrades, and results in some cost savings by eliminating duplication of some underground volume and systems. However, at lower energies (for example, below 300 GeV), modifications such as including ten-hertz operation will be required to maintain high luminosity. Accommodating ten-hertz operation will increase costs and compensate some of the overall cost savings.

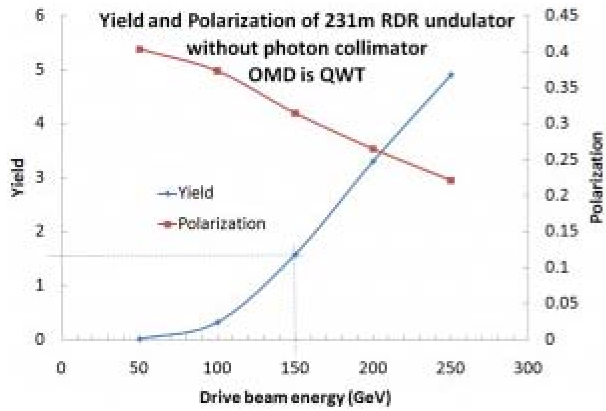
Ewan Paterson discusses central integration for the relocated positron source

The new baseline proposal includes a description of the possible low-energy operations scheme (ten-hertz alternate pulse running) that is consistent with the RDR. “Physics runs are possible for every energy above $\sqrt{s}$ = 200 GeV”. The positron yield is greater than 1.5 over this energy range and enables operation with the RDR parameters or the ‘reduced beam parameter set'.

during the Baseline Assessment Workshop at SLAC.

The design yield is 1.5 at 150 GeV (corresponding to 300 GeV centre-of-mass operation). Below 150 GeV, the yield reduces until it becomes 1.0 at 125 GeV (250 GeV centre-of-mass). At this and lower beam energies, where the yield is predicted to be less than 1 for these parameters, it is proposed to switch to the ten-hertz alternate pulse.

To enable the ten-hertz operation, a variety of changes will be necessary, including modifying the damping rings magnet lattice and damping wigglers to double the damping rate, increasing the radiofrequency power, as well as making some modifications to the electron source and adding a beamline and switched magnet system. The auxiliary positron source will be integrated with the main power source, eliminating the separate standalone source. Some alternatives to the ten-hertz solution have been suggested, but require study.



Yield and polarisation as a function of drive electron beam energy.

Now that all the top level changes to the baseline have been determined, the detailed design work will be carried out to develop an integrated design for the *Technical Design Report*. The GDE process of developing the new baseline has been successful. There are still other changes to be considered and the detailed design is yet to be carried out, but we now should have a clear path towards developing a well-understood and integrated ILC technical design.

BASELINE ASSESSMENT WORKSHOP | ILC BASELINE | POSITRON SOURCE | TOP LEVEL CHANGE CONTROL