LC NEWSLINE
THE NEWSLETTER OF THE LINEAR COLLIDER COMMUNITY

AROUND THE WORLD

Pixel party

Marcel Vos (IFIC Valencia, Spain), with help from Igor Rubinsky and Hanno Perrey (DESY, Germany), Carlos Marinas and Theresa Obermann (Bonn University, Germany), and David Cussans (Bristol University, UK)

Three detector R&D collaborations working on tomorrow's pixel detectors for charged particles joined forces in a combined test in a beam of particles. With the successful read-out of the three devices in a single data acquisition, they reach another milestone of the EU-sponsored AIDA Project. Work continues towards a more versatile telescope infrastructure to be made available to a broad user community.

AROUND THE WORLD

Hydrides: the nemesis of high-quality SRF cavities?

Fermilab researchers make headway towards improving SRF cavities by understanding more about how hydrides may limit their quality factors

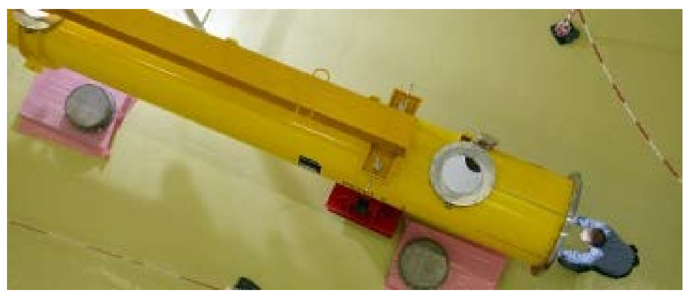
by Julianne Wyrick

Hydrogen has long been known as a possible enemy of superconducting radiofrequency (SRF) cavities - like those needed for the ILC - thanks to its potential to form non-superconducting hydrides that limit cavity quality factor (Q) and gradient. Researchers at Fermilab have made further progress in understanding the full physics behind hydrogen involvement, which is an important step towards improvements in cavity processing.

DIRECTOR'S CORNER

The challenge of technology

by Mike Harrison



Now that the ILC *Technical Design Report* is published, does it mean the design is frozen? In this corner, ILC Director Mike Harrison explains how maintaining the technical flexibility to obtain the maximum benefit from ILC R&D and other current projects is both a challenge and a necessity, especially for major cost drivers like the ILC cryomodules.

IN THE NEWS

from ***Yomiuri Shimbun***
24 July 2013
誘致署名　万人 実現する会が知事に報告
「国際リニアコライダー　」の脊振山地への誘致活動に弾みをつけようと、佐賀、福岡両県の若手経営者らでつくる「九州への　誘致を実現する会」のメンバーは　日、県庁を訪れ、約　万人分の署名を集めたことなどを古川知事に報告した。(To accelerate the activity to invite ILC to Sefuri area, the group of business persons around Fukuoka and Saga prefectures visited Saga Governor Furukawa on 23 July, and reported that they collected 350 thousands signatures to support the invitation of the ILC)

from ***Nikkei***
22 July 2013
東北、復興加速に期待 参院選与党圧勝
与党が圧勝した参院選で、東北　選挙区は改選　議席のうち自民が　議席を占めた。東北経済連合会の高橋宏明会長は素粒子研究の大型実験施設「国際リニアコライダー　」の東北への誘致を求めた。(LDP, the ruling party of Japan won the election of the Lower House in a landslide, and LDP took over five out of seven re-election seats in Tohoku electoral districts. Horoaki Takahashi, chair of Tohoku Economical federation asked for the Abe administration to invite the ILC to tohoku area)

from ***The Guardian (Blog)***
19 July 2013
T2K neutrino experiment reports new oscillation results
History has shown us that the more we understand about neutrinos the more secrets of nature they uncover. The observation made by T2K opens up a whole new way of observing neutrinos

from ***Phys.org***
19 July 2013
Discovery of rare decay narrows space for new physics
Physicists did not have enough data to make a definitive statement about this decay in this analysis, but their work shows that they will be able to gather evidence of it after the LHC restarts in 2015 at higher energy.

from ***Nature***
17 July 2013
Particle physics: Let it B
A phenomenon known as CP asymmetry, which explains our very existence, has been observed in the decays of Bs0 mesonic particles. The finding represents yet another triumph of the standard model of particle physics.

from ***Sankei***
16 JUly 2013
国際リニアコライダーの誘致を
「国際リニアコライダー　」の誘致候補地が今夏にも一本化される。候補地が決まったら、政府は早急に誘致へ向けた取り組みを強化すべきだ。　は日本の成長を加速させる可能性があるからだ。(The Japanese ILC candidate will be decided this summer. Japanese government should increase the effort to invite the ILC as quickly as possible. ILC has a potential to accelerate the nation’s growth)

from ***CERN Courier***
12 July 2013
ILC Technical Design Report is published
The ILC – a 31-km electron–positron collider with a total collision energy of 500 GeV – was designed to complement and advance LHC physics. The report contains all of the elements needed to propose the collider to collaborating governments, including the latest, most technologically advanced design and implementation plan optimized for performance, cost and risk.

from ***Kahoku Shinpo***
10 July 2013
専門家の意見聴取終了　検討委、　月に意見集約
日本学術会議は　日、「国際リニアコライダー　」の国内誘致の是非を審議する検討委員会の第　回会合を都内で開き、専門家　人から国際プロジェクトの在り方などを聞いた。専門家の意見聴取は今回で終了。検討委は　月中に意見を集約する。(Science Council of Japan held third meeting to discuss the invitation of the ILC to Japan on 9 July. Two experts explained the modalities of an international project. Council’s hearings from experts from various fields was completed in this meeting, and the final report will be published in August.

ANNOUNCEMENTS

Register now for LC13 Workshop

The LC13 Wokshop: “Exploring QCD from the infrared regime to heavy flavour scales at B-factories, the LHC and a Linear Collider” will take place in Trento, Italy from 16 to 20 September 2013. LC13 agenda and registration pages are now online. Registration will end on 30 August 2013. For more information, contact Giulia Pancheri.

CALENDAR

Upcoming events

Snowmass on the Mississippi (CSS 2013)
Minneapolis, Minnesota, USA
29 July- 06 August 2013

POSIPOL 2013
Argonne National Lab
04- 06 September 2013

LC13 Workshop
Villazzano (Trento), Italy
16- 20 September 2013

View complete calendar

PREPRINTS

ARXIV PREPRINTS

1307.5740
Detecting interactions between dark matter and photons at high energy e^+e^- colliders

1307.5495
Another Detector for the International Linear Collider

1307.5288
Physics at the CLIC e+e- Linear Collider — Input to the Snowmass process 2013

1307.5248
Physics Case for the ILC Project: Perspective from Beyond the Standard Model

1307.4074
Bilinear R Parity Violation at the ILC – Neutrino Physics at Colliders

1307.3962
Exploring Quantum Physics at the ILC

1307.3915
Limitation on the luminosity of e+e- storage rings due to beamstrahlung

1307.3893
Higgs factories

1307.3676
Discriminators of 2 Higgs Doublets at the LHC14, ILC and MuonCollider(125): A Snowmasss White Paper

1307.3566
Tackling light higgsinos at the ILC

IC NEWSLINE
THE NEWSLETTER OF THE LINEAR COLLIDER COMMUNITY

AROUND THE WORLD

Pixel party

Marcel Vos (IFIC Valencia, Spain), with help from Igor Rubinsky and Hanno Perrey (DESY, Germany), Carlos Marinas and Theresa Obermann (Bonn University, Germany), and David Cussans (Bristol University, UK) | 25 July 2013

Three detector R&D collaborations developing the next generation of pixel detectors tested their systems in a combined test beam. The goal is to build a beam telescope that will bring users not only precise information about where particles went, but also when they passed through the device under test – a much-needed novelty for many future detector tests. The work forms part of the EU-sponsored AIDA project.

These are the components of the combined beam test: the MIMOSA telescope, the ATLAS-FEI4 arm and the DEPFET device under test.

The philosophy of the AIDA project is to bring together institutes from all over Europe to solve common problems. Once the problem is solved, the solution is made available to the entire community. A good example is the 'beam telescope' that AIDA has made available to users from all over Europe. R&D groups that come to DESY, Germany or CERN, Switzerland to test their devices in a beam of particles find a whole range of commodities that make their life easier.

Primarily, of course, there is the hardware, the telescope itself. It must provide a precise reference position of incoming particles to characterise the spatial resolution of new detector prototypes. To this end particle physicists need a telescope with a resolution that exceeds that of the device under test. And the telescope material must not disrupt the trajectory of the particles. The latter is relatively easy for the high-energy beams at CERN. To do well at DESY, however, requires that the sensors must be made extremely thin. In the past, detector R&D groups had to devote considerable effort to find or build a telescope, and the results were not always very satisfactory.

The first telescope to serve a large user community was provided by the EUDET project, AIDA's predecessor in the previous round of EU subsidies (FP6) (further reading). For over five years, this telescope based on MIMOSA sensors has served a very large number of groups. Several copies have been made – a good indication of their success.

But AIDA provides much more. A flexible DAQ solution (EUDAQ) allows users to plug in their devices with a minimal effort. The Trigger Logic Unit (TLU) that forms the heart of this system has been reproduced in multiple copies. The analysis software (EuTelescope) has a large number of users.

The first goal of the sub-project responsible for the telescope was to provide continued support for the telescope user community, so the AIDA project makes sure the infrastructure remains operational and also supports the TimePix telescope developed by institutes involved in the Large Hadron Collider's LHCb.

The core of the AIDA telescope project is the upgrade and extension of the telescope. For many users who work on LHC applications a precise reference position is not enough. They also need to know the exact time of arrival of the particle. It's hard to find a single system that can provide both at the required precision. Devices with a fast response tend to be less precise in the spatial domain or they put too much material in the way of the particle's trajectory. To provide both we combine two technologies – MIMOSA sensors with their spatial resolution and thin sensors provide the position, while special detectors called FE14 from the LHC's ATLAS provide time information with the desired LHC structure.

In this respect the first beam test in 2012 with a combined MIMOSA-FEI4 telescope was something of a milestone. A collage of photographs of the components involved in the setup in the DESY beam line is shown in Figure 1. Charged particles from the accelerator – electrons in this case – first traverse three read-out planes of the MIMOSA sensors, then the device under test, the second triplet of MIMOSA planes and, finally, the ATLAS-FEI4 arm. The user group that acted as guinea pig in this experiment is the DEPFET collaboration. In a single metre the electrons thus traverse pixel detectors from three major detector R&D collaborations.

The point of the multi-technology telescope is to take advantage of the strong points of each technology. Combining the precise time information from the ATLAS-FEI4 and the excellent spatial resolution brings together the best of both worlds. The combined test beam is an important step towards the production of a versatile and user-friendly telescope that can follow the particle trajectory very precisely in space and provide precise information in the time domain. Now that the devices can successfully be read out together, work can continue to improve the infrastructure available to users towards the end of the AIDA project.

However, there is an additional advantage that the people who drew up the proposal three years ago hadn't realised. The ATLAS FEI4 chip has self-triggering capability. The chip can issue a trigger signal based on the response of the pixels. If we overlay the response of the FEI4 pixel matrix with a programmable mask and feed the resulting signal into the trigger logic we can trigger on a very small area. The definition of the triggered area is much more flexible than the traditional trigger based on scintillators; to change it, all we need to do is to upload a new mask to the device. This turns out to be a very useful feature if the prototypes under test cover a very small area.

The institutes involved in the AIDA project are developing the follow-up to the EUDET telescope used by many detector R&D groups that submit devices to test beams at DESY and CERN. The combined read-out of three different pixel detector technologies – MIMOSA, ATLAS-FEI4 and DEPFET – is an important milestone towards a more versatile system that can provide a precise reference position and time information.

Further reading: AIDA-NOTE-2012-005.pdf

AIDA | BEAM TELESCOPE | DEPFET | DETECTOR R&D | EUDET TELESCOPE | TEST BEAM

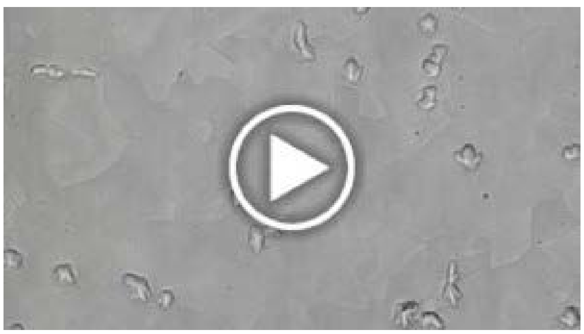
ILC NEWSLINE
THE NEWSLETTER OF THE LINEAR COLLIDER COMMUNITY

AROUND THE WORLD

Hydrides: the nemesis of high-quality SRF cavities?

Fermilab researchers make headway towards improving SRF cavities by understanding more about how hydrides may limit their quality factors

Julianne Wyrick | 25 July 2013



This video shows hydrides forming in a sample of niobium. In order to simulate how hydride forms in an operational-accelerator environment, the niobium was treated with a cavity processing procedure known to load it with hydrogen; then, the niobium was cooled to cryogenic temperatures (160 kelvins). Over time, the hydrides grow as hydrogen diffuses from the surrounding niobium and binds with the existing hydrides. These large hydrides are responsible for hydrogen Q disease. Photos: Fedor Barkov, Video: Julianne Wyrick

Hydrogen has long been known as a possible enemy of superconducting radiofrequency (SRF) cavities – like those needed for the ILC – because of its potential to form non-superconducting hydrides that limit cavity quality factor (Q) and gradient. Researchers at Fermilab have made further progress in understanding the full physics behind hydrogen involvement, which is an important step towards improvements in cavity processing.

Hydrogen in the walls of niobium SRF cavities can bond to the niobium, forming compounds called hydrides that cause a known quality-factor limiting – and menacing-sounding – condition: hydrogen Q disease. While baking the cavities at the right temperatures was successfully used to "cure" the Q disease, scientists have never understood the full details of hydride formation. Over the past two years, Fermilab researchers Alex Romanenko and Fedor Barkov have developed a technique for directly observing how hydrides form. This technique allowed them to model another hydride-related limitation called high field Q slope, and simultaneous experiments shed light on how this condition is "cured" by a different bake.

"Fundamental understanding is the easiest and most natural path to improved performance," said Romanenko, who is part of Fermilab's Superconducting Materials Department and led this research. "As soon as you understand the physics behind the problem, then you can develop strategies on how to overcome it."

ILC cavities require high Qs in order to efficiently reach the high gradient required by the ILC. Gradient refers to the energy transferred to a particle over a particular distance. Q, or the unloaded quality factor of a cavity, is related to the cavity's power dissipation: the higher the Q of an SRF cavity, the lower the power required for the cavity to achieve a certain gradient. Therefore, higher Q cavities lead to more compact and cost-effective accelerators. ILC cavities must have a Q of at least 8 billion and a gradient of 31.5 megavolts per metre.

But hydrogen that enters a cavity's niobium wall during cavity processing can limit the Q if allowed to clump together to form hydrides when the cavity is cooled to its cryogenic operating temperature.

Hydrogen Q disease refers to a large decrease in Q and gradient that occurs when large hydrides form on the inner surface of an SRF cavity. The decrease occurs because the hydrides aren't superconducting like the rest of the cavity and cause extra surface resistance. Scientists learned in the past that baking the cavities at 600-800 °C for several hours can cure and prevent the disease; in fact, this bake is part of the ILC cavity processing procedure. However, researchers had never actually observed the hydrides that cause Q disease in cavity niobium, meaning they knew little about their structure and formation. In 2012, Romanenko and Barkov's direct observation of hydrides literally shed light on the process, capturing images of the formation of hydrides in real time using a laser confocal scanning microscope coupled with a cryostage.

“We directly observed what was known to cause a limitation but was never actually seen,” Romanenko said.

But hydrogen Q disease may not be the only cavity problem caused by hydrides. Even after a cavity undergoes a 600-800 °C bake to prevent Q disease, hydrogen still exists in the 100-nanometre layer closest to the inner surface of the cavity. Romanenko’s group proposed a mechanism linking another condition called high field Q slope to the formation of the smaller hydrides. These hydrides only sustain superconductivity up to a certain magnetic field level, roughly 100 milliteslas. When the hydrides lose their superconductivity, they can limit cavities’ gradient and Q, just like they do in hydrogen Q disease. In 2013, Romanenko and his team published a model showing how the hydrides may cause this quality-limiting condition.

Like Q disease, high field Q slope can also be removed by a bake, this time at 120 °C for 48 hours. This bake is also a part of the ILC cavity processing procedure. Though researchers have known the bake works, they haven’t understood how it works. Using a technique called positron-annihilation spectroscopy, Romanenko and his team collaborated with the University of Bath, UK, and the University of Western Ontario, Canada, to discover that prior to the bake, hydrogen atoms are located in between the cavity’s niobium atoms and are free to move and form hydrides upon cooldown. During the bake, vacancies, or missing niobium atoms in the niobium crystal structure, form near the surface layer. These vacancies bind hydrogen so that it can’t form the small hydrides that may cause the high-field Q slope. The group published a paper last month detailing the findings.

According to Romanenko, understanding the mechanism of the 120 °C bake can help researchers think of methods for preventing Q disease or high field Q slope that might have additional benefits to cavity performance.

“This research really adds to our basic understanding of high-field Q slope,” said Camille Ginsburg, deputy department head of Fermilab’s SRF Development Department and Fermilab SRF cavity coordinator, in regard to Romanenko’s hydride research. “If we have that basic understanding, then we can more efficiently plan our cavity processing, which may reduce costs.”

Despite all the new information about hydrides and their role, researchers’ search to understand them is not over. According to Romanenko, the next step is to visualise the small hydrides at cryogenic temperatures, just as they did with the large hydrides.

“Understanding the underlying physics of SRF materials for accelerator applications is a must if we want to enable further technological advances, such as even higher gradient cavities for ILC,” said Slava Yakovlev, head of Fermilab’s SRF Development Department. “This is yet another demonstration of how important the basic SRF R&D is.”

CAVITY | CAVITY R&D | FERMILAB | QUALITY FACTOR | SCRF | SRF TECHNOLOGY | SUPERCONDUCTING CAVITY

LC NEWSLINE
THE NEWSLETTER OF THE LINEAR COLLIDER COMMUNITY

DIRECTOR'S CORNER

The challenge of technology

Mike Harrison | 25 July 2013

How will technological advances change the design of the cryomodule? We don't know yet, but we know we have to keep looking, says Mike Harrison. Image: DESY

Mastery of difficult technologies is in the DNA of high-energy physics and the accelerators that enable the science. For many decades ever increasing beam energies and intensities have given rise to not just spectacular science results but also to a well documented stream of technical innovations which have resulted in spin-offs in many non-related fields. One of the most prominent –except maybe the web – has been the superconductor development for high-field accelerator magnets and its subsequent use in modern medical imaging. The ILC follows this tradition, and superconducting radiofrequency (SRF) technology, the basis for the main linac, can be found in most modern accelerators, be they light sources, free-electron lasers, high-intensity linacs or high-energy colliders. High technology, though, generally implies risk, and while the necessity for the technology is evident, what is less obvious is how to make the use of it optimal. An example of this is the choice of the accelerating gradient in the SRF cavities: if the design gradient is too low, the linac is longer than necessary and the costs increase; if the design gradient is too high, either the centre-of-mass energy ends up lower than required or many cavities fail to meet performance specifications, resulting in excessive costs and time delays.

In a very large project such as the ILC, there is a great deal of leverage in getting these basic decisions correct. The time-honoured method of establishing the technology is via an R&D programme. R&D was a major part of the Global Design Effort (GDE) programme over the past five years. For most projects at the end of the R&D phase, the technical design is frozen and the project moves into a construction phase. While this approach works in principle, it's not quite that straightforward for the ILC. In a large international project in its initial stages the overall schedule is quite often not accurately known, and thus the boundary between R&D and construction can be uncertain. The ILC is in such a position today. Technological evolution of the cryomodule and cavity gradient processing continues in several laboratories, and we wish to derive the maximum benefit from these activities. We need to be certain however that any changes we choose to make do not introduce problems which are only revealed at a later stage. One of the (successful) goals of the GDE R&D programme was to identify and mitigate technical risks. If we choose to freeze the design of the major cost driving elements of the *Technical Design Report* baseline design, we will minimise project risk but miss out on any technical improvements made in the next several years. Introducing technical changes however obviously increases the risk of unforeseen difficulties at a later date. An example of the relentlessly dynamic nature of technology is the observation that today a single Google search request uses more processing power than the entire Apollo moon programme. While nobody is suggesting placing server farms into lunar orbit, it does illustrate why delaying technology decisions can sometimes be beneficial.

A major cost driver for the ILC is the cryomodule, and cryomodule design changes will be considered in the foreseeable future. Since the current design has been shown to meet the technical specifications we will proceed carefully in adopting any new features. Our ability to contemplate such an evolution is greatly helped by the concept of plug compatibility. This feature was incorporated into the cryomodule design at an early stage in the GDE programme. It allows individual cryomodule components to be replaced by other "plug-compatible" ones without requiring changes to other parts of the design. This provides a straightforward set of ground rules on how to make design changes which minimise the impact on other components and thus technical risk. With the European X-Ray Free-Electron Laser (XFEL) cryomodule construction now fully underway, it seems likely that during the next several years there will be some lessons learned that would be beneficial for the ILC programme. Maintaining the technical flexibility to obtain the maximum benefit from these activities is both a challenge and a necessity.

ACCELERATOR R&D | ILC | ILC BASELINE | PLUG COMPATIBILITY | SRF CRYOMODULE | XFEL