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AROUND THE WORLD

Seeing beneath the surface

X-ray tomography gives subsurface view of accelerator cavities

by Leah Hesla



Accelerator cavities have their faults, and some pits and cracks hide deep in the walls or in out-of-the-way places where they aren't easily found. Accelerator researchers help improve flawed cavities by taking their fault-finding missions beneath the cavity surface with X-ray computed tomography.

FEATURE

ILC positron collaboration meeting held in Beijing

by Min Zhang

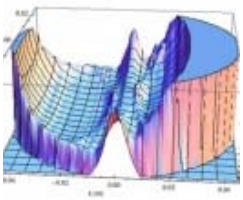


Scientists working on the positron source for a future linear collider gather in Beijing to discuss R&D and accelerator design.

DIRECTOR'S CORNER

Technical baseline reviews: damping rings

by Barry Barish



As part of the process of developing the ILC technical design, the GDE project managers have initiated a set of technical baseline reviews of major subsystems. The first of those reviews on the ILC damping rings was carried out in July in Frascati, Italy.

IMAGE OF THE WEEK



Ancient calligraphy

Image: Min Zhang

Kaoru Yokoya takes in Zhuanti calligraphy one of China's ancient fonts at the National Art Museum of China during the social event for the POSIPOL 2011 workshop.

IN THE NEWS

from ***Wired***
30 August 2011
LHC Experiment Finds No Signs of Supersymmetry
Ruling out supersymmetric particles would cause the physics community to do a serious rethinking. So far however results from CMS and ATLAS haven't been promising and LHCb's data continue that trend.

from ***The Hindu***
27 August 2011
Idea of particle colliders is here to stay
Declaring emphatically that the idea of particle colliders would not "wither" away after the Large Hadron Collider (LHC) Rolf Heuer director-general of CERN (European Organization for Nuclear Research) in Geneva said here on Thursday that there were exciting physics prospects with colliders in the energy frontier beyond the LHC's reach.

from ***CERN Courier***
26 August 2011
ILC Global Design Effort publishes milestone report
The ILC Global Design Effort has released a major milestone report *The International Linear Collider: A Technical Progress Report*.

from ***Hindustan Times***
26 August 2011
Work on science facility to begin by Dec
Work on the India-based Neutrino Observatory (INO) at the Bodhi West Hills Reserved Forest in Tamil Nadu will begin by December.

from ***Deutschlandradio***
26 July 2011
Und es hat CLIC gemacht
Das CERN arbeitet an einem neuartigen Teilchenbeschleuniger

ANNOUNCEMENTS

Accelerator-Driven Subcritical Systems & Thorium Utilization workshop

Registration is now open for the 2nd International Workshop on Accelerator-Driven Subcritical Systems & Thorium Utilization to be held at the Bhabha Atomic Research Centre in Mumbai India from 11-14 December 2011. Sponsored by the India Department of Atomic Energy and Jefferson Lab the workshop will cover topics on SRF ingot niobium technology accelerator systems and enabling technologies fast-spectrum and thorium-based systems and thermal spectrum systems.

Visit the conference website.

CALENDAR

UPCOMING EVENTS

Supersymmetry 2011 (SUSY 2011)
Fermilab, Batavia, IL
28 August- 02 September 2011

XXXI Physics in Collision (PIC 2011)
Simon Fraser University, Vancouver, Canada
28 August- 01 September 2011

2nd International Conference on Micro Pattern Gaseous Detectors (MPGD2011)
Kobe, Japan
29 August- 01 September 2011

The 2nd International Particle Accelerator Conference (IPAC'11)
San Sebastian, Spain
04- 09 September 2011

JSPS specially promoted research: "A global R&D program of a state-of-the-art detector system for ILC"
Sendai, Japan
12- 14 September 2011

LC11: Understanding QCD at Linear Colliders in searching for new and old physics
ECT*, Trento, Italy
12- 16 September 2011

CALICE Collaboration Meeting
Heidelberg, Germany
14- 16 September 2011

Linear Collider Workshop 2011 (LCWS11)
Granada, Spain
26- 30 September 2011

UPCOMING SCHOOLS

CERN Accelerator School: Course on Accelerator Physics
University of Chios, Chios, Greece
18- 30 September 2011

View complete calendar

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AROUND THE WORLD

Seeing beneath the surface

X-ray tomography gives subsurface view of accelerator cavities

Leah Hesla | 1 September 2011



Movie of 2-D scans of a 3.9-GHz higher-order mode coupler. The video takes the viewer from the outside of the structure inward, towards the cavity cell. Video: North Star Imaging

The power of the CAT scan to find tumours or bone fractures has advanced medical science by bringing such ailments to X-ray light, foregoing the need to cut a body open for diagnosis. As particle accelerator research makes its own advances, scientists are exploiting the X-ray in similar ways.

Researchers at the US Department of Energy Fermi National Accelerator Laboratory have been using X-ray computed tomography (CT) to take their search for faults in accelerator cavities and associated structures beneath the surface. Penetrating X-rays can reveal performance-limiting cracks and holes that would otherwise go undetected.

“It’s been a really cool tool for us,” said Fermilab’s Elvin Harms. Unlike its most familiar application in the medical field, X-ray tomography isn’t used to to view a cavity’s innards – there’s nothing in a cavity but empty space. But flaws and other weakness can hide within a cavity’s walls or other places, such as cavity end groups, that are tough to access without breaking cavities apart.

The method of diagnosis of a cavity by X-rays is fundamentally the same as that of a patient in a CAT (computed axial tomography) scanner. It begins by placing the suspected-broken structure inside a radiation-safe X-ray cabinet, between the X-ray tube and a digital detector. The differences in material thickness and density attenuate the X-rays differently. The differences are detected and recorded, and a two-dimensional image is produced from the pattern.

Then the object is rotated half a degree and another image is produced. Once the full 360-degree series of images is acquired, a three-dimensional portrait is constructed from the two-dimensional images.

Fermilab scientists have been working with North Star Imaging, based just outside Minneapolis, US, to create high-resolution images of superconducting radiofrequency (SRF) niobium cavities. In addition to manufacturing X-ray imaging and CT systems and providing imaging services, the company develops software to create the 3-D reconstructions. The software allows its users to control the perspective, zoom, image contrast and value spectrum of the imaged object.

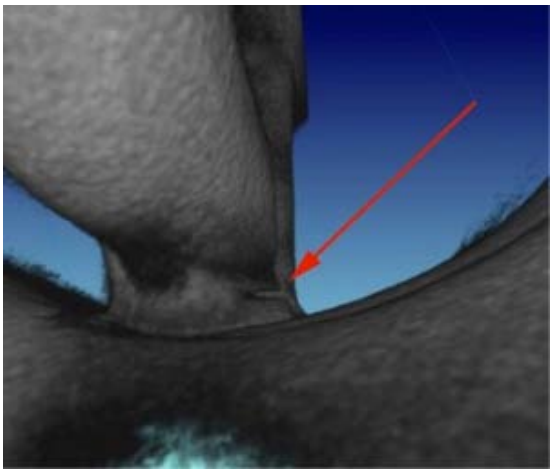
“Now you have really powerful software to be able to take those images, meld them into something you can look around and look through, take out the noise if you need to and really look for faults,” Harms said.

In one case, higher-order mode coupler antennae were suspected of causing multipacting that limited cavity performance. Researchers came at the problem from a number of angles, but they couldn’t positively ID the culprit, despite strong circumstantial evidence.

“It was very clear there was something not right,” Harms said. “You couldn’t see any fault, and we couldn’t get an optical viewing device in there.” The team also didn’t want to ruin the cavity by cutting it apart since it had been performing fairly well until the problem arose. “Well,” he said, “we didn’t have to.”

X-ray tomography revealed a micrometres-thin crack in the back leg of the antenna, one that, even if the team had been able to access it in its out-of-the-way location, wouldn’t have been visible.

Part of the challenge of imaging the cavities is the high density of niobium, which requires using the right X-ray energies and suitable filtration techniques to get clear images of the cavity shape and any faults that are buried in its walls.



3-D X-ray computed tomographic image of a cracked higher-order mode coupler antenna. Image: North Star Imaging

"Whenever you have to image highly dense materials – platinum, molybdenum, niobium – you're going to have challenges," said North Star's Wes Wren. "Any part for which you'll ever need computed tomography is going to need a slightly different technique to create the best X-ray images for that specific part. Better X-ray images create better CT data sets."

The technique you need isn't always straightforward.

"The head of our inspection service lab has been doing this for 20-plus years, and our applications manager has been in the X-ray field for about 30 years," Wren said. "They've used techniques that are counterintuitive to what the books say." The methods for X-ray CT imaging, as with any scientific technique, improve by experiment.

That includes improvements in imaging the cavities' interior surfaces. Because of the cavity's particular geometry and the way the X-rays are reflected inside the cavity, images of the inside wall aren't as crisp as those of the exterior surface. One idea researchers hope to explore is the placement of the X-ray gun inside the cavity, generating images from the inside out.

And, unlike a camera, it could also capture flaws that lie between the inner and outer surfaces.

"There's power in this technique to see below the surface, if that's considered important," Harms said.

Most researchers who work on niobium cavities say it isn't clear whether what lies beneath the inner surface of a cavity *is* important. The topmost 50 or so nanometres of a superconducting cavity's inner wall are responsible for the electric fields that help accelerate a particle beam. What lies beyond those nanometres may or may not matter. Nevertheless, the mechanical integrity of subsurface structure could be important as, if nothing else, indicators of what companies are doing right and wrong with respect to manufacturing cavities.

"What you really want to do is prove that you've mastered the fabricating technology," Harms said. "This might be another useful tool in the SRF game."



Movie of 2-D scans of a single-cell cavity whose welded seam is compromised. The viewer sees the advancing circumference of the cell, which widens as the viewer approaches the center of the cell (cell's polar axis is oriented up-down). Looking closely midway down either edge of the cell (at the equator), one can see alternating black and white spots as the video advances. This indicates that the weld, rather than forming a solid, uniformly dense band around the equator of the cell, was full of voids, tiny pockets that could compromise the strength of the pressurised cell. Video: North Star Imaging

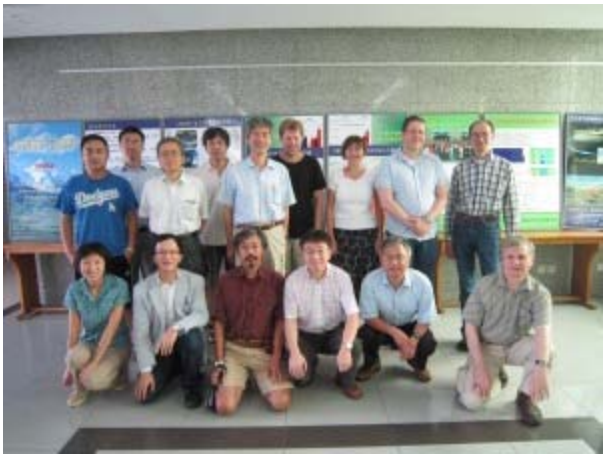
CAVITY | CAVITY DIAGNOSTIC | FERMILAB

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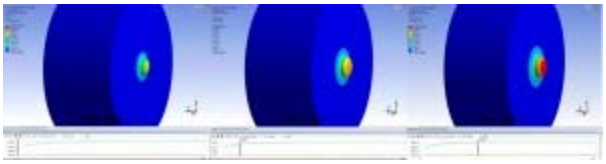
FEATURE

ILC positron collaboration meeting held in Beijing

Min Zhang | 1 September 2011



Attendees of the ILC positron collaboration meeting. Image: Min Zhang



These simulations are a part of a major simulation task for heat and stress loads in components of the ILC positron source. These pictures show the evolution of a time-dependent simulation with ANSYS software tool for the ILC photon beam penetrating a titanium alloy positron production target. Due to energy transfer, which occurs in the sub-microsecond range, the maximal deformation occurs at the back side of the 0.4 X_0-thick target of about 5 micrometres. The diameter of the deformation is equivalent to the diameter of the incident photon beam of about 2 millimetres, which leads to a final positron polarisation degree of 60 percent. Images courtesy of Andriy Ushakov, DESY

On 27 August, one day prior to the POSIPOL 2011 workshop in Beijing – an annual workshop dedicated to polarised positron source R&D for ILC and CLIC – ILC polarised positron source experts gathered to attend an ILC positron collaboration meeting held at the Institute of High Energy Physics, Chinese Academy of Sciences, to discuss the current status of ongoing positron-related R&D, accelerator design and integration studies.

Almost 20 scientists from Europe, Asia and the US, including some following via videoconference, participated in the meeting. “The particular aims of this meeting are to prepare for the ILC *Technical Design Report* (TDR) documentation and the ILC positron technical baseline review, to be held in late October at DESY,” said Wei Gai, the Global Design Effort (GDE) positron technical area group leader and organiser for this meeting, in his opening remarks.

Twelve talks were given by project managers and research scientists. Topics included technical design phase status, undulator research, positron target, optical matching device (OMD), capture optics, collimation, source modeling, remote handling and polarisation. According to the discussions, major progress has been made since their last meeting a year ago, particularly on the collimator design and simulations. Also the OMD design is now completed and prototyping will begin very soon. Scientists also evaluated the potential of R&D on alternative technologies and upgrades to be carried out after the technical design phase, which would fit well with recent discussions on the 1 TeV upgrade and cost containment.

In addition, the group created a schedule for the next twelve months that outlines the actual writing and editing of the ILC TDR and allows for the collection of key supporting documents. “We will be busy fixing every parameter for every major component of the positron system and making sure we have enough confidence in the future to construct the positron source for the ILC,” Gai said.

Stay tuned to *NewsLine* to learn more about the POSIPOL 2011 workshop.

BEIJING | POSIPOL | POSITRON R&D | POSITRON SOURCE

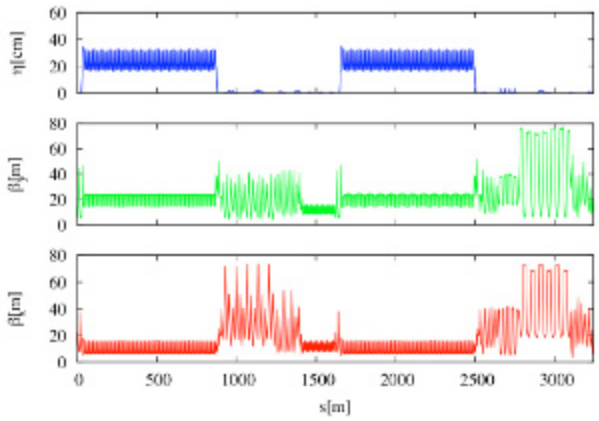
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DIRECTOR'S CORNER

Technical baseline reviews: damping rings

Barry Barish | 1 September 2011



3.242-kilometre damping ring lattice functions reported at the Frascati damping ring review meeting

Over the past two years, the GDE has concentrated its efforts on advancing critical ILC R&D in order to reduce risks and to demonstrate performance. In parallel, we have established a new, more coherent and more cost-effective baseline to be used for the next phase of developing the technical design that will be incorporated in the ILC *Technical Design Report* (TDR) that we plan to complete at the end of 2012. As part of the process of developing the technical design and performing the associated R&D, the GDE project managers have begun to carry out a series of technical baseline reviews on the major subsystems. The first of these reviews, which focused on the damping rings, took place from 7-8 July at Frascati Laboratory in Italy.

Now that we have established a new baseline, the GDE project managers have initiated a process of new status reviews for the TDR design work and associated R&D, in order to guide the scope and issues for the remaining work for the TDR report that is planned for the end of 2012.

The first of the new reviews was focused on the damping ring (DR) systems. The proposed and approved changes to the damping rings, as stated in the proposal, include:

1. A *reduction of the number of bunches* per pulse (n_b) by a factor of two from 2625 to 1312.
2. A corresponding *reduction in the circumference of the damping rings* from 6476 m to 3238 m (i.e. 50%), while maintaining the DR current approximately constant. This includes the associated reduction in DR RF power by approximately 50% (primary cost saving),
3. An increase in the DR tunnel diameter to accommodate the *possibility of installing a third damping ring* (second positron damping ring) at some later date, if required (risk mitigation).



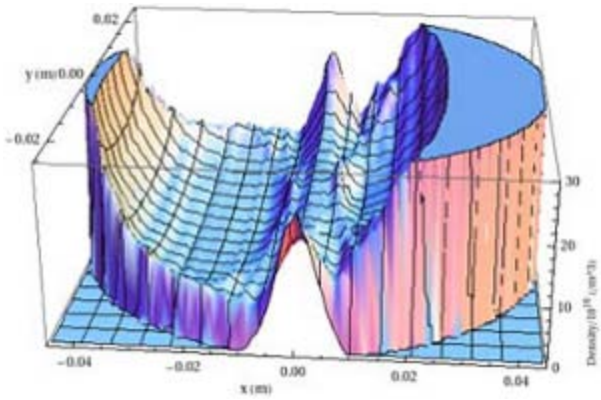
Susanna Guiducci, leader of the ILC Damping Ring Group and host of the Technical Baseline Review at Frascati Laboratory in Italy

The change to a smaller 3.2-kilometre (km) damping ring is a positive step in making a more cost-effective ILC design, but presents a set of new challenges, both in terms of damping ring performance and for the conventional facilities. Much progress has been made in developing the design. For example, in June a new baseline lattice that meets the critical requirements for the damping rings was adopted. This lattice will now be used in completing a more detailed design for the TDR.

The 3.2-km damping rings are being designed to run with different parameter sets in both 5-hertz and 10-hertz operations and with 1300 and 2600 bunches, where the larger number of bunches implies only a 3.1-nanosecond bunch spacing. The challenge for this configuration is whether the electron cloud effects can be adequately mitigated. To cover that risk, provision is being made to install a second positron ring in the same tunnel; both positron rings will have the same baseline parameters. The bunch spacing will be increased by alternating between the two rings.

This first technical baseline review has helped set the stage for the work to the TDR. The present status was reviewed and future tasks identified. Ongoing work on electron cloud effects from CesrTA at Cornell University are crucial to the whole design and the ability to maintain positron beams that are not blown up by these effects. Much work remains on beam dynamics and collective effects for the new lattice, as well as the system designs (including final specifications of transfer lines, corrector magnets, vacuum systems, etc.). Once the damping rings are well defined enough, the damping ring costing for the TDR can be completed.

There is still considerable work in front of us to complete the TDR damping ring design and costing, but the basic concept is now well defined and the Technical Baseline Review was very useful for defining the remaining tasks.



Electron cloud distribution versus position after the acceleration of 10 bunch trains. Progress on electron cloud simulations that are so vital for understanding the ILC positron ring performance were reported by Gerry Dugan at the Frascati meeting.

BASELINE | DAMPING RING | FRASCATI | ILC BASELINE | TDR | TECHNICAL DESIGN REPORT

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