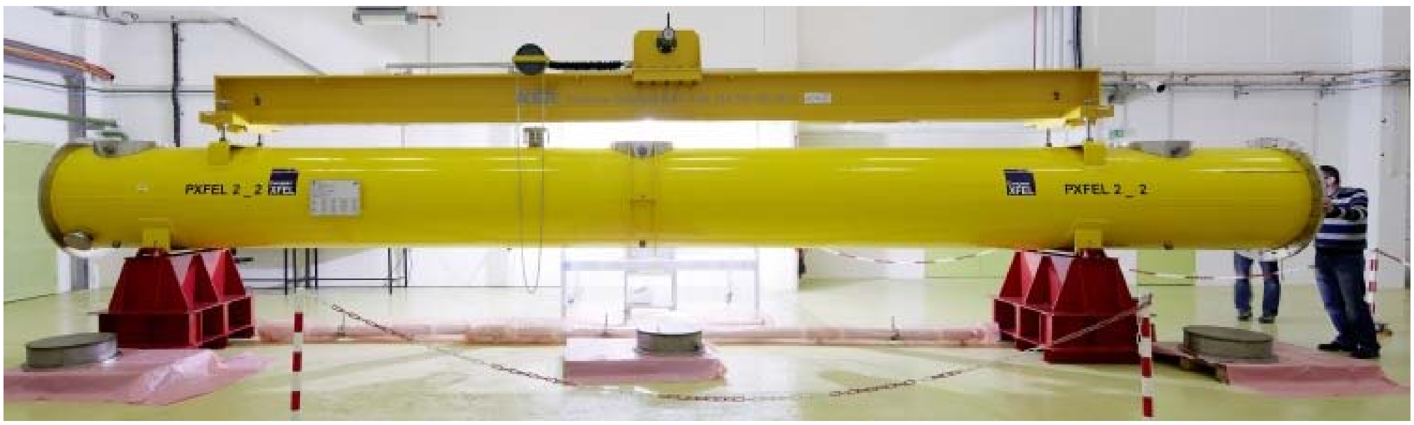
FEATURE

Cryo conveyor belt

Industrial study looks at serial production of cryomodules

by Barbara Warmbein



An industrial study commissioned by the Global Design Effort in collaboration with experts from CERN gives a clearer picture of how cryomodules for the ILC could be mass-produced by industry. The study, whose results were recently presented at a meeting between accelerator experts from different labs. A similar study has looked at cavity serial production. One of the scientists leading the cryomodule study, Vittorio Parma from CERN, was the driving force behind the cryostat assembly for 2000 cryomagnets for CERN's Large Hadron Collider between 2003 and 2008 and thus predestined to lend his experience to the project.

FEATURE

From *Fermilab Today*: This week's FALC meeting

Pier Oddone reports from the latest meeting of FALC at Fermilab. "It is a particularly interesting time for this organization with the discovery at CERN of a Higgs-like particle and the statements by the Japanese high-energy physics community of their strong desire to host the International Linear Collider in Japan. While the Japanese government has not issued a formal statement inviting the world to help Japan build this global facility, the ILC clearly enjoys strong political support in Japan, where it is part of a broader effort to create a new global city. It is natural in the interim for our Japanese colleagues to seek support from the rest of the world, which would help convince their government to go ahead with such a project."

DIRECTOR'S CORNER

Major goal achieved for high-gradient ILC SCRF cavities

by Barry Barish

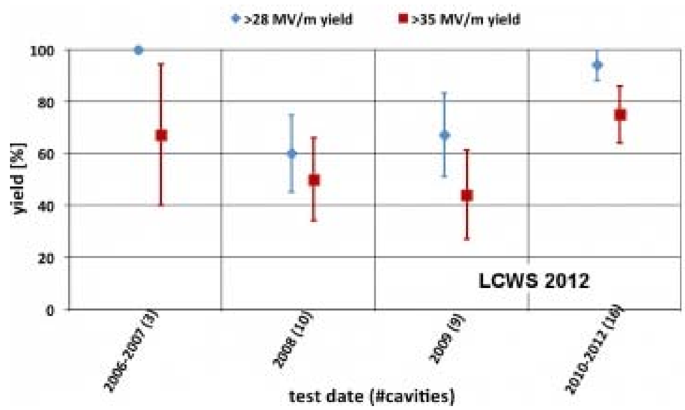


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IMAGE OF THE WEEK

Geometries of a future Higgs factory

Last week at Fermilab, a select group of experts discussed whether an accelerator to purely exploit the science around the Higgs(-like) particle found at the LHC should be linear, circular or something completely different. The participants compared the options of a linear 250-GeV electron-positron collider and a circular 125 GeV electron-positron collider from the accelerator point of view as well as physics requirements for a Higgs Factory and other options for a Higgs Factory, including a muon collider and a gamma-gamma collider. More about the workshop and an article in symmetry magazine.

IN THE NEWS

from ***BBC World Service***
15 November 2012
Is supersymmetry being squeezed?
At a major gathering of particle physicists at the Hadron Collider Physics Symposium in Kyoto, researchers from the Large Hadron Collider Beauty collaboration presented evidence of one of the rarest particle decays ever observed.

from ***Scientific American***
14 November 2012
New Higgs Results Bring Relief—and Disappointment
Alas, most of the Higgs results being presented this week at the Hadron Collider Physics symposium in Kyoto, Japan, have been well within our standard understanding.

from ***New Scientist***
13 November 2012
Time to think beyond the Large Hadron Collider
In these straitened times that won't be an easy sell, especially as the LHC still feels so shiny and new. But a successor was always part of the long-term plan and will eventually be needed to make more progress. Whatever the LHC found, the public was captivated. Now is a good time for physicists to start – subtly – making their case.

ANNOUNCEMENTS

12 June 2013: Save the date

On Wednesday 12 June 2013, the work of many years of ILC accelerator and detector research and development will culminate in a big celebration all around the world. In each of the three regions, Asia, Europe and the Americas, a scientific symposium, a public talk and a party starting at 5 p.m. local time will celebrate the completion of the GDE mandate and the start of a new era. At the end of each event, that region will hand the celebratory baton to the next, culminating in the official handover of the final Technical Design Report to the International Committee for Future Accelerators, ICFA.

CALENDAR

UPCOMING SCHOOLS

Seventh International Accelerator School for Linear Colliders
Indore, India
27 November- 08 December 2012

View complete calendar

PREPRINTS

ARXIV PREPRINTS

1211.4448
Higgs inflation in a radiative seesaw model

1211.4382
A Novel Self-supporting GEM-based Amplification Structure for a Time Projection Chamber at the ILC

1211.4008
Dark Matter Search at a Linear Collider: Effective Operator Approach

1211.3745
One-loop effects on MSSM parameter determination via chargino production at the LC

1211.3449
Electroweak Phase Transition, Higgs Diphoton Rate, and New Heavy Fermions

1211.3134
Consistent on shell renormalisation of electroweakinos in the complex MSSM: LHC and LC predictions

1211.2429
Singularities in the single lepton energy spectrum for precise measuring mass and spin of Dark Matter particles at the e^+e^- Linear Collider

1211.2254
Illuminating Dark Matter at the ILC

1211.2195
Long-lived charged sleptons at the ILC/CLIC

1211.1981
More Energy, More Searches, but the pMSSM Lives On

1211.1864

Comparison of the Standard Theory Predictions of M_W and Sin^2 theta^lept_eff with their Experimental Values

1211.1693
The Constrained NMSSM with a 125 GeV Higgs boson — A global analysis

ilc newsline

FEATURE

Cryo conveyor belt

Industrial study looks at serial production of cryomodules

Barbara Warmbein | 21 November 2012

An industrial study commissioned by the Global Design Effort in collaboration with experts from CERN gives a clearer picture of how cryomodules for the ILC could be mass-produced by industry. The study, whose results were recently presented at a meeting between accelerator experts from different labs. A similar study has looked at cavity serial production. One of the scientists leading the cryomodule study, Vittorio Parma from CERN, was the driving force behind the cryostat assembly for 2000 cryomagnets for CERN's Large Hadron Collider between 2003 and 2008 and thus predestined to lend his experience to the project.

Having a good look at cryomodule production: an industrial study produced interesting results. Pictured: a cryomodule for the European XFEL under construction at CEA Saclay. Image: DESY / Heiner Müller-Elsner.

For the ILC, cryomodules could be assembled in labs – just like those for the European XFEL are built at CEA in Saclay, France –, or in industry. A cryomodule for the ILC consists of eight cavities plus a quadrupole or of nine cavities in a string, each cavity embedded in a helium tank, plus insulation, support pipes and extractions pipes, couplers and much more. The work that needs to be done is similar in complexity to the production of the magnets and cryostats for the LHC at CERN, with cryostats for dipoles being less complex than a full cryomodule, but quadrupoles a lot more complex. As nobody has ever industrially produced a series of cryomodules (some 1800 will be needed for the ILC), the production of 100 XFEL cryomodules is an important, and almost the only, point of input.

For the study, the ILC/CERN team worked together with the German company Babcock Noell, who they knew from previous contracts and who based their industrial study on cryomodule production for the European XFEL. Study leader from the industrial side was Christian Boffo. The goal was to find out the most cost-effective way of producing ILC cryomodules by studying the assembly phases and the production lines and factory layouts required in order to produce the about 1800 cryomodules with the required quality and within a time frame of about four to five years. "You would need enormous facilities of up to 40 000 square metres surface area that will have to be built and planned from scratch," predicts Parma. These facilities would house a number of cleanrooms of unprecedented size, with a few hundred people in the facilities at any time.

The goal of the study was also to look at possible processes that can be automated to save time and labour cost. But there are also assembly steps that can only be done by humans. "We have to tell industry the competency limits of both machines and of workers," explains Parma. "Can the couplers be inserted by a robot? Probably not. Can the string of cavities in the cleanroom be aligned by a robot? Possibly – there is a proposal for an alignment table. But we may need some type of validation for that. We also touched orbital welding of the cavities, but the cleanliness of a class-10 cleanroom make this option unacceptable with the technologies available and would require a considerable redesign effort. This is all stuff the industry needs to hear from us."

By the way: there is another possibility for an automated process that could reduce the time spent on this particular part of the assembly process: leak-checking of welds on cryomodule piping by using the so-called clam-shell method, as proposed and patented by CERN. Considering the time saving and reliability of this technique; the European XFEL could be adopting it soon during the assembly of their cryomodules at CEA Saclay.

The study looked at two possible scenarios: 100% production by a single company and 30% production by three different companies. The latter is not an unlikely model because the cryomodules for the ILC could be produced in the three different regions by different vendors, rather than by just one vendor from one region. The study showed that the 30-percent model would indeed need one third of the infrastructure and staff. “This 30-percent option indeed seems more reasonable,” concludes Parma. Size and infrastructure of the individual facilities around the world would be easier to handle, and could be exploited for future use by the hub laboratory where the facilities would be set up.

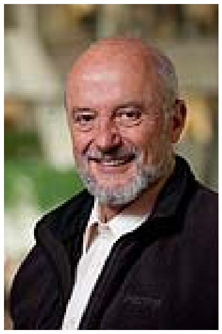
After eight months of intense study and several meetings and visits, the company passed on their conclusions in October. After reviewing these, the ILC/CERN team has worked out their own conclusions. “I would say that the study has provided a solid and valuable *input* for the ILC cost estimate,” resumes GDE Project Manager Nick Walker from DESY. “This study (like those that preceded it) demonstrate that this level of production is quite feasible. Although the facility is quite large, it is not unreasonable. Industry is quite capable of gearing such facilities up.”

Vittorio Parma was not only responsible for the cryostat assembly of the 2000 cryomagnets, the superconducting magnets that keep the protons on their path, fitted inside a cryostat not dissimilar to the ones the ILC will use and that FLASH and the European XFEL at DESY, Hamburg, Germany are already using. He was also key in setting up a large-scale, industry-like production line at CERN to build them.

“Originally it was planned to assemble the dipole magnet inside their cryostats at CERN and the quadrupole magnets in industry,” explains Parma. But the company went insolvent. In order to be ready for the LHC start-up in 2008, the machine experts decided to assemble everything at CERN: dipoles, quadrupoles and their cryostats. “We did a work that was typically industrial – basically we learnt how to set up a factory,” says Parma. Labour workforce was found through external contractors, while planning buildings and infrastructure, devising production procedures and studying tooling options and possibilities for automatisation became daily business. “We did it the dirty way because we had to do it within limited time, without the typical preparation phases with prototyping which normally preceeds series productions; and we hope we can help both the European XFEL and the ILC with the experiences we have made”, concludes Parma.

CEA SACLAY | CERN | CRYOMODULE | EUROPEAN XFEL | INDUSTRIALISATION | SERIAL PRODUCTION

This week's FALC meeting



Fermilab Director
Pier Oddone

The Funding Agencies for Large Colliders organization, known as FALC, was formed in 2003 with a different name—the Funding Agencies for the Linear Collider. One of FALC's early activities was to set up a common fund to support the Global Design Effort that would carry out the R&D and the design of the ILC. The L in FALC was generalized from "Linear" to "Large" a few years later.

FALC is a voluntary organization set up by the agencies of the principal countries that support particle physics. It meets twice a year to discuss all issues relevant to the construction of very large global facilities. It has served to acquaint the senior managers of the various national agencies with their counterparts in other regions of the world, helping to build the trust necessary to someday embark on a large global facility. FALC also invites three laboratory directors, one each from the Americas, Asia and Europe, to participate in their meetings.

The latest meeting of FALC took place yesterday at Fermilab. It is a particularly interesting time for this organization with the discovery at CERN of a Higgs-like particle and the statements by the Japanese high-energy physics community of their strong desire to host the International Linear Collider in Japan. While the Japanese government has not issued a formal statement inviting the world to help Japan build this global facility, the ILC clearly enjoys strong political support in Japan, where it is part of a broader effort to create a new global city. It is natural in the interim for our Japanese colleagues to seek support from the rest of the world, which would help convince their government to go ahead with such a project.

FALC has undertaken the writing of a report on the Global Design Effort activities of the last few years with the purpose of articulating the lessons learned for both the science community and the funding agencies. To this end, FALC heard extensive presentations from GDE members on their successful experience in completing the R&D and the technical design of the ILC, despite turbulence in the various collaborating regions. The GDE will complete the technical design for the ILC before the end of the year. Then, in December, an augmented ILC Project Advisory Committee will review the design at KEK. Early in the New Year an ad-hoc committee led by Norbert Holtkamp of SLAC will conduct an independent cost review. Finally, at the February 2013 meeting of the International Committee on Future Accelerators, a new linear collider organization will begin, merging the management of the ILC and CLIC efforts under Lyn Evans' leadership.

Members of the Funding Agencies for Large Colliders met this week at Fermilab. *Photo: Reidar Hahn*

DIRECTOR'S CORNER

Major goal achieved for high-gradient ILC SCRF cavities

Barry Barish | 21 November 2012

A one-metre-long nine-cell ILC SCRF niobium cavity.

One of the most important goals of the Global Design Effort has been to demonstrate that high-gradient cavities can be reliably produced in industry. We established two gradient goals: to produce cavities qualified at 35 Megavolts per metre (MV/m) in vertical tests and to demonstrate that an average gradient of 31.5 MV/m is achievable for ILC cryomodules. Furthermore, we set a goal of producing these high-gradient cavities in industry with 50% yield by 2010 and 90% yield by the end of 2012. We have recently achieved these ambitious goals!

The ILC reference design layout was based on an average operational gradient of 31.5 MV/m, although at that time we had not demonstrated the reality of achieving this average gradient. Our confidence came from limited R&D laboratory experiments. We then undertook a worldwide programme to qualify industrial vendors, standardise our procedures, create an integrated database and analysis, and develop techniques for identifying problems in produced cavities and fix them. (See ***ILC NewsLine*** cavity archive.)

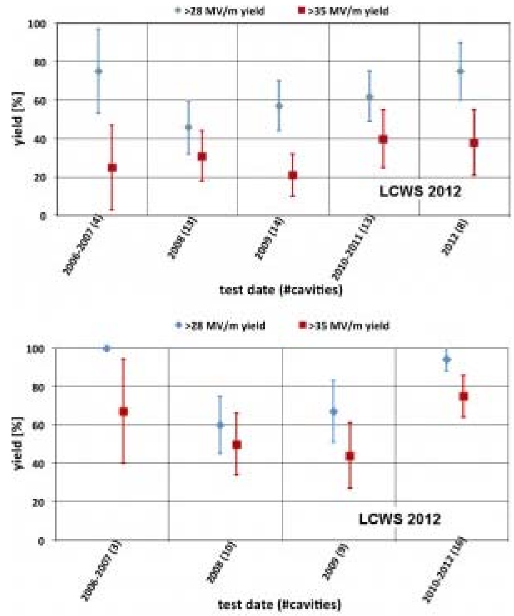
We initiated a globally consistent up-to-date database for recording test results from different laboratories and made standard and clear definitions of achieved gradients for first-pass and second-pass yields. Rules for cavity selection were also established. We created an ILC Global Cavity Database Team that included members from Fermilab, DESY, JLab, Cornell and KEK, to carry out the analysis, present and update results so that progress of cavity R&D could be tracked. At present, the database contains information on 133 cavities, including cavities produced purely for ILC gradient R&D and others produced for other accelerator R&D.

The plots show cavities from qualified vendors that were processed according to the baseline processing cycle, which includes electropolishing. The first-pass test results drive the second-pass re-processing. If gradient exceeds or equals 35 MV/m and the quality factor Q_0 exceeds or equals 8×10^9, the cavity is accepted; if not, the cavity is given a second-pass re-processing. The choice of second-pass process is made by the test laboratory based on first-pass test results, but a standard second-pass processes (high pressure rinse, 120°C baking, or a second standard electropolishing cycle) must be used.

The improvements are primarily due to improved diagnostic tools developed through our R&D programme that better direct the second-pass process. Incorporating second-pass re-treatment or re-processing will bring significant cost savings compared to the “over production” model used in the RDR. The technical design baseline accepts cavities with a ± 20% spread (for example more than 28 MV/m) and for our set of cavities the average gradient of the sample that exceeded that limit is actually 36.8 MV/m, somewhat higher than our 35 MV/m goal. Thus, though the statistics are limited, the two-pass standard processing has met our goals!

It is worth pointing out that there is promise of cost-effectively going beyond the yields reported above. We are developing two repair techniques that promise to improve cavity yields. The first technique involves localised grinding, a technique implemented at KEK, based on finding defects in a cavity by optical inspection and subsequently removing the defects with a miniature grinding tool. A second technique, being developed at Fermilab, uses a week-long cycle, where up to four cavities can be tumbled in parallel using progressively finer abrasive until at the end a mirror-like finish is achieved. As part of the tumbling process, light electropolishing is performed. Both techniques have already been shown to improve cavity performance.

In conclusion: we have achieved the goal of producing SCRF cavities with good yield in industry that perform at or beyond our established baseline gradient. The production process includes a standard second pass for the cavities that fail the first pass. Further, encouraging new techniques that could yield cost-effective ways are being developed to further improve cavity yields. These results establish the practicality of producing cost-effective high-gradient cavities in industry for an ILC project.



The most recent data for first-pass (top) and second-pass (bottom) yield results. Yield is the fraction of produced cavities exceeding 28 MV/m (lower cutoff) and 35 MV/m (goal). The most recent second-pass yield beyond our 28-MV/m cutoff is greater than our 90% goal.

ACCELERATOR R&D | CAVITY GRADIENT | SUPERCONDUCTING CAVITY | TDR