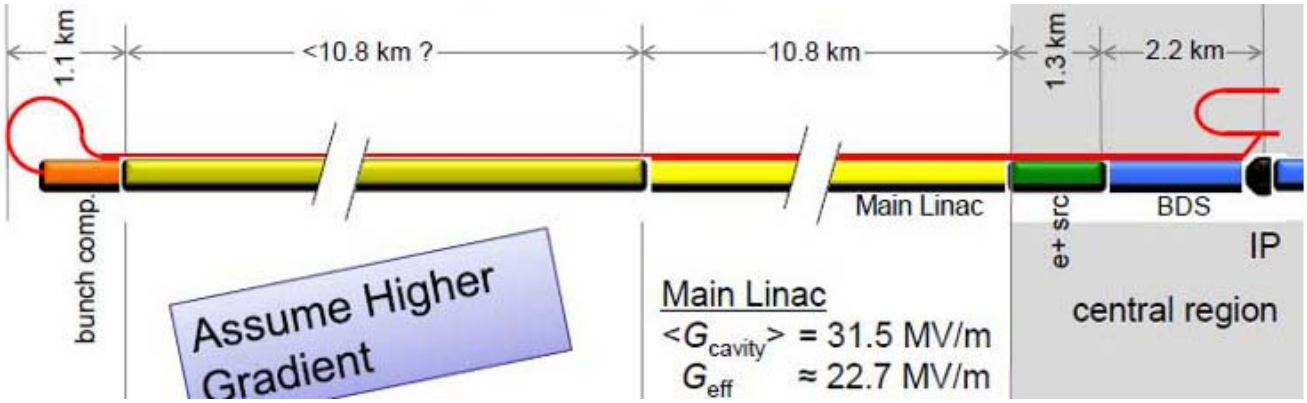
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DIRECTOR'S CORNER

Extending the energy reach of the ILC

by Barry Barish



A new study is being undertaken to extend the maximum energy of the ILC from the present design of 0.5 TeV towards 1.0 TeV, either as a future option or possibly for the initial machine.

FEATURE

From SLAC Today: Will the Real Higgs Boson Please Stand Up?



How can a low-energy experiment like SLAC's PEP II B Factory, originally built to investigate differences between matter and antimatter and no longer even taking data, compete with a monster matter masher like the LHC that was built, in a large part, to find the Higgs?

FEATURE

The fruits of industry

The Global Design Effort collaborates with industrial companies to encourage scientific innovation for ILC technology

by Leah Hesla



The R&D of industry is as vital to the ILC project as research performed in the laboratory. The Global Design Effort has formed close relationships with multiple industry vendors, fostering innovation and reducing costs.

IMAGE OF THE WEEK



TULA tunnels through

Image: European XFEL

The tunnel boring machine TULA (TUnnel for LAser) squeezed through a large hole in the wall of the injector building of the European XFEL facility. The hole, only 40 centimetres wider than the colossus that is TULA, made for a challengingly tight fit.

TULA, which started 7 July 2010 at the European XFEL construction site in Schenefeld (Schleswig-Holstein), arrived a couple of days ago at the DESY site in Hamburg. In 13 months it has completed three tunnels with a total length of 3084 metres of the tunnel system, including the 2.1-kilometre-long linac tunnel.

The second tunnel boring machine AMELI is still on its way to dig the (slightly thinner) rest of the nearly 6-kilometre long European XFEL tunnel system.

TULA is 6.17 metres in diameter and 71 metres long, weighs 550 tonnes and costs 18 million Euros.

IN THE NEWS

from ***Taiwan Today***
9 August 2011
Taiwan chosen as international antimatter monitoring center
A center will be established in Taiwan to monitor the findings of the Alpha Magnetic Spectrometer, an instrument recently placed on the International Space Station, National Science Council Minister Lee Lou-chuang said Aug. 8.

from ***New Scientist***
4 August 2011
Antiproton ring found around Earth
Antiprotons appear to ring the Earth, confined by the planet's magnetic field lines. The antimatter, which may persist for minutes or hours before annihilating with normal matter, could in theory be used to fuel ultra-efficient rockets of the future.

from ***Iwate Nippo***
30 July 2011
ＩＬＣ「しっかり議論」 玄葉担当相が前向き姿勢
玄葉光一郎科学技術政策担当相は２９日の衆院内閣委員会で、本県が受け入れを目指す超大型加速器・国際リニアコライダー（ＩＬＣ）について「（政府の）総合科学技術会議でしっかり議論して、位置付けをしないといけない。大事な問題提起をいただいたと認識している」と述べ、政府として前向きに取り組む姿勢を示した。

from ***The Denki Shimbun***
27 July 2011
「東北に次世代加速器を」 東北経済連合会などが要望書
東北経済連合会（会長＝高橋宏明・東北電力会長）などで組織する東北加速器基礎科学研究会は２６日、先端的研究分野に応用できる超大型加速器「国際リニアコライダー」を岩手県の北上高地に誘致するため、平野達男防災担当相に要望書を手渡した。

from ***Kahoku Shinpo***
26 July 2011
ＩＬＣ誘致国に要望へ 北上山地で建設狙う 東北加速器研

国際プロジェクトで建設される超大型加速器「国際リニアコライダー（ＩＬＣ）」の東北誘致を目指す産学官組織「東北加速器基礎科学研究会」は２６日、国として誘致活動に乗りだすよう求める要望書を政府に提出する。

from ***The Nikkan Kogyo Shimbun***
25 July 2011
次世代直線型加速器、熱帯びる誘致合戦－佐賀・岩手競り合う
素粒子物理学の研究に必要な次世代直線型加速器「国際リニアコライダー」の誘致をめぐる動きが激しさを増してきた。

CALENDAR

UPCOMING EVENTS

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

ILC positron collaboration meeting
IHEP, Beijing, China
27 August 2011

POSIPOL 2011
IHEP, Beijing, China
28- 30 August 2011

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

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

View complete calendar

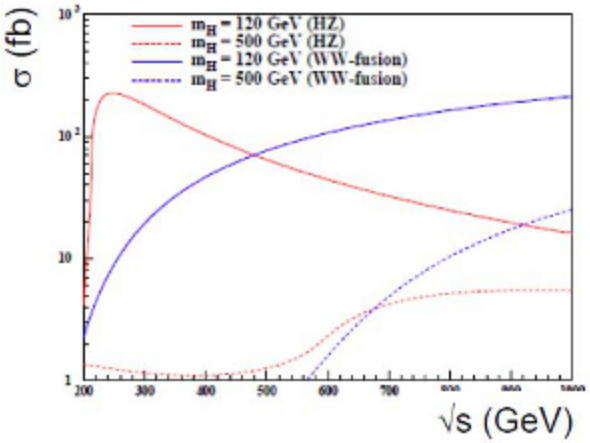
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ilc newsline

DIRECTOR'S CORNER

Extending the energy reach of the ILC

Barry Barish | 11 August 2011



Heavy Higgs production could require a 1-TeV linear collider

The GDE design for the ILC as presented in the *Reference Design Report* (RDR) is for an electron-positron colliding beam facility having a maximum centre-of-mass energy of 500 gigaelectronvolts (GeV). No design or upgrade path to 1 teraelectronvolt (TeV) was presented in the RDR. However, the option to upgrade to higher energies was explicitly maintained in the reference design by ensuring that the beam delivery system could be upgraded, beam dumps were sufficient for higher energy and other considerations. Now, having had significant success achieving high gradients for the baseline machine and anticipating results that will guide the choice of energy from the LHC, we are undertaking a study of paths towards higher energy for the *Technical Design Report* (TDR) and are considering an R&D focus towards cost-effectively reaching higher energy for the post-TDR programme.

The GDE ILC design has been based upon the goals set out in an ILC Steering Committee (ILCSC) study entitled “Parameters for a Linear Collider,” authored by Sachio Komamiya and Dongchul Son (Asia), Rolf Heuer and Francois Richard (Europe), and Paul Grannis and Mark Oreglia (North America) with Rolf Heuer serving as chair. The initial report was written in 2003 and was updated in 2006. The 2006 report gave an energy upgrade the highest priority beyond the baseline for the ILC, as stated below:

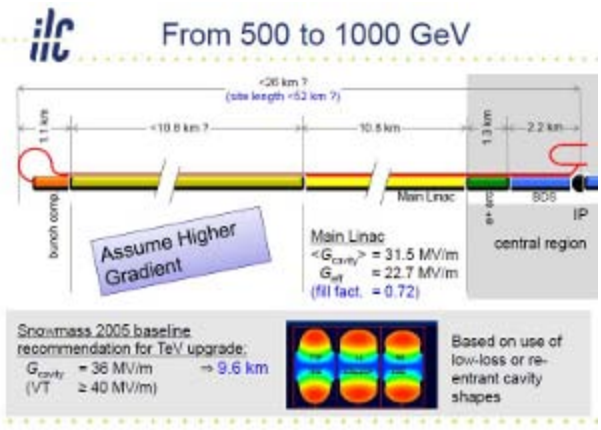
3. Energy Upgrade beyond the Baseline machine

Independent of the results from the first few years of running there are several reasons for an energy upgrade. Examples include higher sensitivities for anomalous gauge boson couplings, measurement of the Higgs boson self coupling, the coupling of the Higgs to the top quark, production thresholds for new massive particles or exploration of extra spatial dimensions. Consequently, the energy of the machine has to be upgradeable.

The strong likelihood that there will be new physics in the 500 – 1000 GeV range means that the upgradeability of the LC to about 1 TeV is the highest priority step beyond the baseline.

- *The energy of the machine should be upgradeable to approximately 1 TeV.*
- *The luminosity and reliability of the machine should allow the collection of order of 1 ab^{-1} (equivalent at 1 TeV) in about 3 to 4 years.*
- *The machine should have the capability for running at any energy value for continuum measurements and for threshold scans up to the maximum energy with the design luminosity (√s scaling assumed).*
- *Beam energy stability and accuracy should be as stated for the baseline machine.*

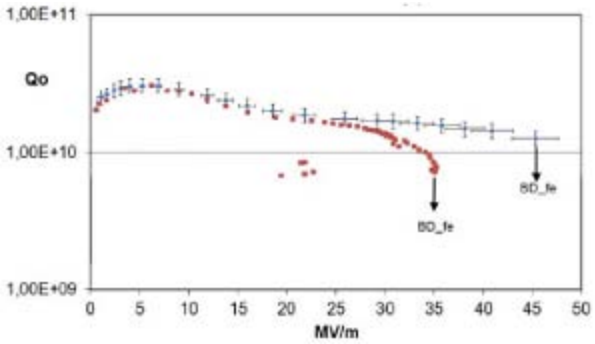
For the new TDR baseline, most of the emphasis regarding energy has involved how to achieve the physics performance requirements at lower energies than 500 GeV. We have been very successful in developing a cost-effective and coherent TDR baseline that can meet the physics requirements, even at low energies. We are now embarking on a similar study of how to extend the energy reach of the ILC beyond 500 GeV cost-effectively and assessing the physics performance that can be achieved. This will give maximum flexibility in using guidance from LHC results for the machine that is proposed.



TeV upgrade scheme, as outlined by GDE Project Manager Nick Walker (DESY)

We are considering two approaches toward higher energy: 1) the option set out in the ILCSC study cited above of upgrading to 1 TeV at some future time, following initial 500 GeV running of several years; and 2) consideration of a more cost-effective direct path to a higher energy machine, especially if that becomes the priority from LHC results.

The first approach involving a future upgrade to follow an initial 0.5-TeV ILC has always been part of the GDE mandate as set out in the ILCSC Parameter memos. The parameters and design of the 500-GeV machine uses today's technologies, the enabling R&D is mostly in hand and we will be able to make a good cost estimate. We can extrapolate what upgrade technologies will be available some years after turn-on. We will be looking at the detailed questions of minimising what will need to be replaced from the initial 500-GeV machine, yet not be too constrained in the upgraded parameters by the initial machine. A specific plan for this option will be presented in the TDR, but the general plan will be to add higher gradient cryomodules to the end of the linac, plus other modifications that have been taken into account in the 500-GeV machine in anticipation of the upgrade.



*High gradients of 45 MV/m achieved with large grain nine-cell cavity at DESY (**Aderhold et al**)*

The second approach is to design as cost-effective and as high-gradient a machine as possible for the initial collider, employing high-gradient cavities that will be tested in the post-TDR R&D programme, cost savings through value engineering and other technical innovations. Designing such a machine will put us in the most flexible position to adapt to whatever is learned from the LHC for the ILC construction proposal. We will use the TDR preparation period to define the post-TDR R&D programme aimed towards higher energy.

We are scheduling a special joint session with the experimentalists on higher-energy options at the LCWS11 meeting in Granada in September, and I will be periodically reporting on this programme as it unfolds.

ENERGY UPGRADE | ILC PARAMETERS | RDR | TDR

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FEATURE

The fruits of industry

The Global Design Effort collaborates with industrial companies to encourage scientific innovation for ILC technology

Leah Hesla | 11 August 2011

As a global science project, the ILC draws on the resources of laboratories in the Americas, Asia and Europe. It also calls on capabilities from industrial factories and plants around the globe.

The ILC Global Design Effort (GDE) has worked to encourage an open exchange of information and ideas among these diverse collaborators and industrial partners to foster innovation, to keep project costs under control and to ensure industrial newcomers have ready access to information.

“We work on a multilateral basis,” said GDE Project Manager Marc Ross. “That’s key to everything the GDE does – a multilateral basis on more than one level.” At the level of laboratory-industry relationships, this has led to a choice to distribute R&D not to one business, but to several.



Project Managers Marc Ross and Akira Yamamoto at the Toshiba company in Japan. They stand in front of a display case of magnet windings and a test cavity. Image: Akira Yamamoto

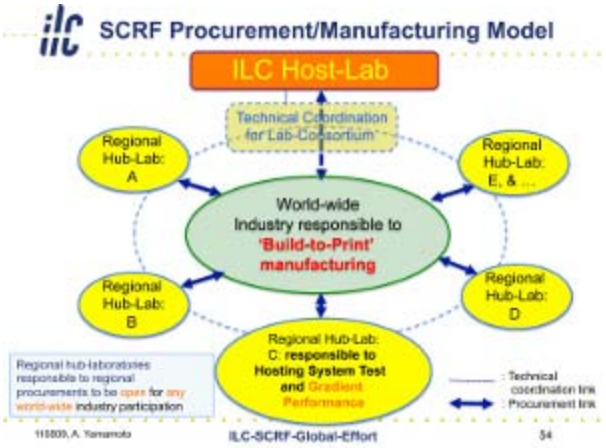
The GDE has been actively cultivating partnerships with industry since 2009, communicating regularly with participant companies about their R&D in accelerator technology and bringing new companies into the community.

By encouraging multiple companies to develop, say, effective accelerator cavities, the GDE creates plural opportunities for science and technology innovation. That benefits the ILC while reaching beyond accelerators to other areas of science, says Project Manager Akira Yamamoto.

“Current technology may not be smart enough to open new physics. That’s why you need to innovate. What comes out of this is very nice science. Even if it might not be directly high-energy physics, in and of itself, it is science.”

The new science that springs from ILC research could be a better understanding of the physical properties of niobium or an eco-friendly method for polishing it. The scientific benefits of those kinds of breakthroughs aren’t limited to large, underground particle machines. Other fields of science can profit from ILC-fostered research. So could industry.

“Suppose accelerator-driven subcritical systems become a method for producing power,” said Fermilab’s Bob Kephart. “All of the sudden a cavity manufacturer has a market that’s in the energy production business.”



Industry is at the center of the GDE management model. Any hub laboratory can access any industry around the world. Image: Akira Yamamoto

Part of the intent of working with multiple businesses is to keep the competition broad. This accompanies a GDE effort to be reasonably transparent, making the community's bigger-picture progress available to everyone. Encouraging research in the direction of decentralisation helps keep competition open when it's construction time.

Also, spreading the research around is, for the GDE, simply practical given the large scope of the ILC's research activities.

"It's better to distribute the research and development effort to multiple companies, rather than to one (or two)," Yamamoto said. Superconducting radiofrequency (SRF) technology, perhaps the most significant advancement to come out of ILC research, is a relatively young field, so the majority of businesses that develop SRF components are on the smaller scale, not large assembly-line plants. By distributing the weight of production to multiple companies, the GDE parcels tasks at a scale – 200 cavities instead of 1,000 – that these reasonably compact or medium-scale businesses can ably manage, both in cost and labor.



Industry representatives meet with scientists at a recent ILC-sponsored satellite meeting of the SRF2011 conference. Image: Akira Yamamoto

For the ILC, this distribution also means built-in redundancy, a kind of insurance policy. In the event that one vendor's cavities cannot meet specifications, there are other industrial sources to fill the gap.

"There should be no need to carry a large risk factor," Yamamoto said.

Keeping multiple companies in the mix is fitting given the nuts and bolts of high-energy physics machines. While colliders are large, their parts are not. A few people can pick up an accelerator cavity unit and handle it without heavy crane work. So long as the components fit together when it's constructed, the separate parts don't have to come from a single company. Quite the contrary, the different parts would almost certainly come from different sources.

"It's basically segmentable," Ross said. "The nature of the technology is such that the slicing could actually work. If the linac is made of one type of cryomodule at one end and another type at the opposite end, we don't care as long as they can be connected to one another."

The GDE takes advantage of the ILC's segmentability to explore technologies that are so-called plug-compatible.

"You can go to the store and buy a replacement part for your automobile that isn't made by the company that made the automobile, just because they have standards," Kephart said, explaining the concept of plug-compatibility. "That's the strategy here – you want to make functionally equivalent parts produced in different parts of the world."

The ILC's open door to different suppliers doesn't imply that companies' innovations are written in an open book. Companies' innovations belong to them. Yet should the issue arise, the GDE would work to protect company interests while maintaining its own intellectual property rights so that, in the interest of science, others can share in the innovation.

The hope is that a multilateral management approach to designing the collider brings innovation to high-energy physics, both in the proliferation of new technologies and in project management.

Thirteen companies participating in ILC research were represented at a satellite meeting of the recent SRF2011 conference. View their presentations.

GDE | GDE PROJECT MANAGERS | INDUSTRY

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Will the Real Higgs Boson Please Stand Up?

August 9, 2011

Feature Story
SLAC Today Story
SLAC Today Issue:
2011-08-09 [1]
by Lori Ann White

Although physicists from two experiments at CERN's Large Hadron Collider [2] and from Fermilab's Tevatron collider [3] recently reported at the Europhysics Conference on High Energy Physics that they didn't find the Higgs boson, they're continuing to home in on the elusive particle, prompting Rolf-Dieter Heuer, the Director General of CERN, to go on record [4] that he believes a neutral Higgs boson will be found by the LHC by the end of 2012.

Meanwhile, at the same conference but during a different session, BaBar collaboration member and SLACer Manuel Franco Sevilla delivered his own report touching on the Higgs. In its own way, Sevilla's contribution was even more curious than the reports from the LHC, because the Higgs boson that the BaBar collaboration didn't find is not the same Higgs boson that the CMS and ATLAS experiments at the LHC could not find in their data.

Wait a minute! In both cases the Higgs is that mysterious particle responsible for bestowing mass upon its subatomic brethren, right? But – as it happens – not all Higgs bosons are created alike.

"The ATLAS and CMS results refer to a neutral Higgs boson," said SLAC's Steve Robertson, the current physics analysis coordinator for BaBar. The neutral, or uncharged Higgs boson is the only member of the Standard Model's rogues' gallery of subatomic particles to remain at large after decades of searching.

Or – the neutral Higgs boson could be a member of a family of Higgs bosons, including electrically-charged versions, mandated by supersymmetry [5]. Supersymmetry is the theory that says every particle in the Standard Model has a much heavier partner particle that also hasn't been found yet.

The Higgs boson BaBar didn't find must have a charge. That means it’s not just a Higgs, but a non-Standard Model Higgs.

Which leads one to wonder – how can a low-energy experiment like SLAC’s PEP II B Factory, originally built to investigate differences between matter and antimatter and no longer even taking data, compete with a monster matter masher like the LHC that was built, in a large part, to find the Higgs?

"It turns out we're actually very sensitive to the indirect effects of charged Higgs particles," Robertson explained, "but finding them is hard work for the LHC."

PEP II, like the LHC – and indeed like every other particle collider ever built – turns the energy released by collisions into new particles that decay almost as fast as they're created. Experiments examine the decay products for hints of new physics. The BaBar detector was built to detect *B* and anti-*B* mesons, short-lived particles consisting of bottom quarks and anti-bottom quarks, and search for differences in their creation or decay – and to look for an odd phenomenon that might explain why the universe is made of matter rather than antimatter.

Sevilla's study focused on one particular set of decays sensitive to charged Higgs particles – the decay of a *B* meson to a *D* meson, a heavy cousin of the electron called a tau lepton, and its partner the tau neutrino. This decay normally proceeds via the W boson, by now a well-known particle. But in general, Higgs particles affect processes involving heavy particles more strongly. Since the *B* and *D* mesons and the tau lepton are relatively heavy, if a charged Higgs exists, it could also contribute to this decay. To conduct this study, The BaBar researchers had to make precise measurements of how frequently the decay of the *B* boson to a *D* boson and tau lepton-neutrino pair takes place.

It was not an easy job.

One big problem is that pesky tau neutrino, as well as two other neutrinos originating from the subsequent decay of the tau lepton – multiplied by millions of possible events. Neutrinos have almost no interaction with matter, and zip through a detector without leaving a trace. To account for the neutrinos produced in a collision, scientists must subtract the total amount of energy and momentum coming out of the collision from the total mass and energy that went into it. The balance may account for the energy and momentum carried by the neutrinos, but whether it actually does is another question – missing energy and momentum can also be the result of more mundane processes, such as improperly reconstructed particles or electronic noise.

"Accounting for one neutrino is pretty hard," Sevilla said, "but accounting for all three per decay is a nightmare." He's confident they've done it. "We have computer algorithms that we've been working on for the last few years that are super efficient" at distinguishing these decays, he said. Thanks to the sophisticated analysis, the BaBar result is the most precise measurement of this particular decay rate to date. Sevilla has more work to do to improve the precision of his results.

So what precisely did Sevilla and his teammates find?

They found slightly more of the *B* mesons decaying into *D* mesons and tau leptons than expected – more than the Standard Model predicts. In more technical terms, the new BaBar results favor the existence of a charged Higgs boson with a significance of about 1.8 – "not considered particularly compelling," Robertson emphasized, "but interesting." Even more interesting, this small discrepancy with respect to the Standard Model prediction matches the results of another process, where the *B* meson decays into a tau lepton and a tau neutrino without creating a *D* meson, as measured by BaBar – and by Belle, a Japanese experiment that also looks at *B* meson decay.

Unfortunately, none of this means the BaBar collaboration is going to scoop the LHC on the charged Higgs. As Robertson explained, BaBar simply doesn't have enough data to make a definitive statement about the charged Higgs one way or another. "This will really be the territory of 'super-B factories'" – upgraded versions of PEP II and KEKB, the Japanese collider that's the home of Belle. Super-B factories planned for Italy and Japan will generate about a hundred times more data, placing a charged Higgs, within reach. But until the new super-B factories come on line, the LHC will continue to generate record-setting numbers of proton-proton collisions and gather ever more data in order to make the CERN director-general's deadline of the end of 2012.

But whether it's a neutral Standard Model Higgs or a neutral supersymmetric Higgs will still be the question, and the answer will involve the existence – or non-existence – of a charged Higgs boson.


[6]

BaBar and PEP-II Particle Physics

SLAC National Accelerator Laboratory, Menlo Park, CA | Operated by Stanford University for the U.S. Dept. of Energy Office of Science

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[5] http://www.symmetrymagazine.org/cms/?pid=1000081
[6] https://news.slac.stanford.edu/features/will-real-higgs-boson-please-stand