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DIRECTOR'S CORNER

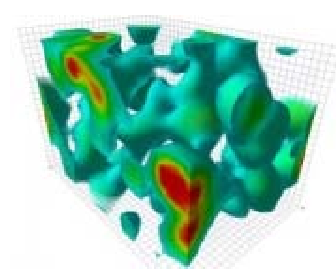
Baseline Technical Review 4 – conventional and unconventional facilities

by Barry Barish

The fourth and final Baseline Technical Review was held at CERN on 22 and 23 March. The completion of this review marks an important milestone en route to producing the ILC *Technical Design Report*. The subject matter of this final review was conventional facilities, including a variety of site-dependent issues.

FEATURE

From CERN Bulletin: Much ado about Nothing – exploring the vacuum with the LHC



Empty space is anything but. Remove everything you can from an area of space and it will still bustle with activity. A veritable abundance of particles and all-pervasive fields fill space with energy. Empty space even weighs something. Indeed, studying 'nothing' can tell us almost everything about the universe we live in.

Learn more about the relationship between vacuum and "virtual" particles, the Higgs boson, supersymmetry and dark energy

VIDEO OF THE WEEK

Fermilab's Cryomodule 2 installation

Video: Jim Shultz

Last week Fermilab's Cryomodule 2 was transported to the laboratory's NML building. Watch trucks, cranes and people move and install the ILC-type cryomodule in a time-lapse video.

IN THE NEWS

from ***The New York Review of Books***
10 May 2012
The Crisis of Big Science
… So in the next decade, physicists are probably going to ask their governments for support for whatever new and more powerful accelerator we then think will be needed. …

from ***Kahoku Shinpo***
02 May 2012
誘致「復興の象徴」 鳩山元首相、岩手知事に協力表明
鳩山由紀夫元首相は 日、岩手県庁に達増拓也知事を訪ね、県が目指す超大型加速器「国際リニアコライダー 」誘致に協力する考えを示した。

from ***IBC***
01 May 2012
鳩山元首相「 誘致、手伝いたい」
鳩山由紀夫元総理がきょう達増知事と懇談し、がれきの広域処理の促進や、国際リニアコライダーの誘致などへ積極的に行動することを伝えました。

from ***The Register***
30 April 2012
Boffins cross atom-smasher streams, 'excited' beauty pops into being
Like Weird Science on a sub-atomic scale

from ***Deutschlandfunk***
30 April 2012
Dunkel ohne Materie?
Bewegung der Sterne in der Sonnenumgebung lässt am Standardmodell der Astronomen zweifeln

from ***Nikkei***
29 April 2012
宇宙の起源に迫る 超大統一理論の検証へ第一歩
でヒッグス粒子が見つかっても、質量の起源であることを完全に証明するわけではない。(Subscribers only)

from ***Iwate Nippo***
28 April 2012
県 推進協が発足 誘致へ機運醸成図る
県内経済界が中心となり、本県への国際リニアコライダー 誘致を目指す県国際リニアコライダー推進協議会が 日、設立された。

from ***CMS Experiment***
27 April 2012
Observation of a new Xi_b^*0 beauty particle
The CMS experiment has submitted a paper for publication describing the first observation of a new, excited beauty baryon known as the Ξ*b0, with a statistical significance of more than 5 standard deviations (5σ) above the expected background. The mass is measured to be 5945.0 ± 2.8 MeV.

from ***Physics Today***
May 2012
Shhhh. Listen to the data
Sifting through large amounts of data, monitoring data streams, and communicating results are promising areas for sonification.

CALENDAR

UPCOMING EVENTS

FCAL Workshop
DESY, Zeuthen
07- 09 May 2012

International Particle Accelerator Conference 2012 (IPAC12)
New Orleans, USA
20- 25 May 2012

ILD Workshop 2012
Kyushu University, Fukuoka, Japan
23- 25 May 2012

15th International Conference on Calorimetry in High Energy Physics (CALOR 2012)
Santa Fe, New Mexico
04- 08 June 2012

UPCOMING SCHOOLS

The 2012 European School of High-Energy Physics
Anjou, France
06- 19 June 2012

View complete calendar

ANNOUNCEMENTS

Registration is now open for the International Workshop on Future Linear Colliders, LCWS12, hosted by the University of Texas at Arlington, US. The workshop will be held from 22-26 October 2012.

US visa information and instructions are on the conference website.

Register early! Hotel rooms may book quickly due to possible World Series playoff games in the Arlington area. Early registration ends 31 August.

We look forward to meeting many of you in Arlington, Texas at LCWS12!

– *LCWS12 local organising committee*

Visit the LCWS12 website | Register for the workshop

PREPRINTS

ARXIV PREPRINTS

1204.5743
Status of ASIC readout for electromagnetic calorimeter

DIRECTOR'S CORNER

Baseline Technical Review 4 – conventional and unconventional facilities

Barry Barish | 3 May 2012

Vic Kuchler, Fermilab, Americas Conventional Facilities Leader

John Osborne, European Conventional Facilities Leader

Atsushi Enomoto, KEK, Asian Conventional Facilities Leader

The fourth Baseline Technical Review, held at CERN on 22 and 23 March, focused on conventional facilities and siting. All significant changes to the 2007 *Reference Design Report* (RDR) baseline were reviewed and evaluated for impacts on performance, cost and related systems. This was the last of the formal reviews of the *Technical Design Report* baseline, so the main activity now officially moves to producing the TDR by the end of 2012. Some further changes may still be incorporated as costing information becomes available or because of other new considerations over the coming months. However, we now consider the TDR baseline as established. The main task now is now to produce the report.

There has been a set of changes to the RDR baseline, many of which have impacts on the conventional facilities. For example, we have changed to a single excavated tunnel for all sites, changing the tunnelling requirements; the electrical and mechanical loads are changed; the damping rings have been reduced in size, reducing the amount of tunnel required; the interaction region configurations and requirements are better defined; and a detector platform and moving system has been defined. Other systems have been refined and the better information is being used for the TDR costing.

One change that became obvious sitting through these conventional facility TDR reviews is how the design and issues have become more refined and the ways in which the detailed solutions are site-dependent. At the time of the RDR, we expected to see differences between sites and, for that reason, we asked and received a sample site from each region (Europe, Asia and the Americas). But in fact, at that time our knowledge of technical details and sites was limited, so we presented one design that would be used in any of the three sites. For the TDR design, many technical features are site-dependent. That means both the technical solutions (for example, distribution of high-level radiofrequency (RF) power), and the tunnelling and other solutions are site-dependent, even the shape of the underground tunnels. This leaves us grappling with the dilemma of how to present the multiple schemes we have studied. I will discuss this issue further, as we decide how to best handle these variations in the design in the TDR.

The conventional facility designs as presented for each region are considerably more detailed, especially regarding the mechanical, electrical and safety systems. A very productive pre-meeting was held on 21 March, reviewing with industrial consultants the detailed electrical and mechanical systems, and taking advantage of the expertise and experience that exists at CERN. Representatives from the Asian region presented mechanical and electrical designs that have been developed using the Asian region high-level RF system that are suitable for a mountain site in Japan. Representatives from the Americas region presented mechanical and electrical designs that have been developed for the klystron cluster RF system for the Americas sample site.

In addition to the changes and refinements discussed above, there is a much better understanding of the interaction region and of how to compatibly incorporate the two detector groups' "Letters of Intent" in a push-pull scheme to enable alternating which detector is on the beamline. I will address this whole region and the present concept and issues in a separate column.

BASELINE TECHNICAL REVIEW | BTR | CFS | CONVENTIONAL FACILITIES AND SITING | DRFS | ILC SITE

Much ado about Nothing - exploring the vacuum with the LHC

Empty space is anything but. Remove everything you can from an area of space and it will still bustle with activity. A veritable abundance of particles and all-pervasive fields fill space with energy. Empty space even weighs something. Indeed, studying 'nothing' can tell us almost everything about the universe we live in.

Setting the stage

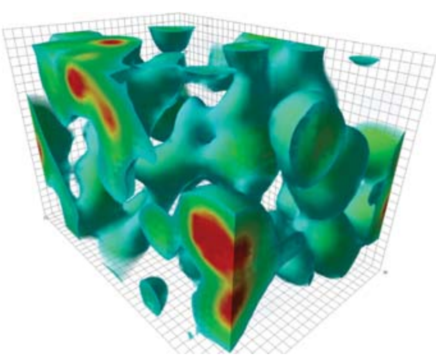
The 54 km of LHC beam pipes are pumped down to one of the best vacuums humankind can produce. Air pressure is higher on the moon than inside the LHC. This engineering feat is worthy of articles in itself, but the kind of vacuum we ask you to imagine here is something altogether different. It is quite simply the emptiest the laws of Nature allow.

The vacuum is defined as the physical state with the lowest possible energy. Lowest possible… but not zero. This is because both particles and fields exist in the vacuum and both can be thought of in terms of energy. While some components are constant, others fluctuate wildly due to the indistinctness inherent in quantum theories. Together these different contributions combine to make the vacuum a surprisingly busy place.

The cast of particles

The laws of quantum mechanics allow particles to pop in and out of existence for undetectably small fractions of time. The more massive these "virtual" particles, the shorter the amount of time they can exist. This quantum fuzziness animates the vacuum with a constant buzz of particles and anti-particles.

In addition, quantum chromodynamics, the underlying theory of the strong interaction, brings something altogether more tangible to the vacuum: an effect that allows quark-antiquark pairs to exist in what is known as a chiral condensate. This condensate is one of the phenomena that contributes mass to particles and, by doing so, it also adds energy to the vacuum.



The constantly changing contributions to the vacuum from quantum chromodynamics, the theory of the strong interaction.

The chiral condensate is studied in lead ion collisions at the LHC where the high temperature and density allows the ALICE experiment to explore the conditions when the effect switched on in the early universe.

Leading role - the Higgs

In addition to the fluctuating activity of quantum fields, the vacuum is also filled with something far more substantial – the Higgs field. Omnipresent and permanent, even in the vacuum, this is the field that could be responsible for the different masses of all fundamental particles. The existence of the Higgs field would be definitively proven with the discovery of its accompanying particle - the Higgs Boson - and after promising signs from ATLAS and CMS last December, results from 2012 data are eagerly awaited.

Waiting in the wings - Supersymmetry

Whatever the findings this year for the Higgs, it will certainly not be the last surprise the vacuum has in store. One unsolved mystery arises from the incessant activity of virtual particles, because although they may not be directly detectable, they do interact with the Higgs field. Being virtual, quantum mechanics allows all kinds of interactions to take place. In fact, the sum of all possible interactions of heavy virtual particles with the Higgs field should contribute an infinite energy to the vacuum.

Theories such as Supersymmetry (SUSY) attempt to resolve this problem. In SUSY, particles interact on a multi- dimensional stage called superspace. This has consequences at higher energies where the theory excludes infinite contributions from virtual particles to the vacuum.

Evidence for this may be uncovered at the LHC. Experiments are looking out for signs of a whole family of new particles that are predicted by SUSY. The lack of any such signs in LHC data to date only means that a certain subset of models has been ruled out, not that the theory has been disproved.

A full house - Dark energy

The power of nothing is not restricted to the minute world of particles, it can also be seen on cosmic scales. The energy in the vacuum, although tiny on laboratory scales, becomes considerable on astronomical ones, where great voids of space are filled with mere pin pricks of matter. Indeed, it is the energy of the vacuum – collectively known as dark energy - that causes the expansion of the universe to get faster and faster. Last year's Nobel prize in physics was awarded to the astronomers who made the first large scale measurements of this acceleration by studying the light emitted from supernova explosions.

These measurements led to one of the greatest mysteries in physics today. The rate of acceleration of the universe does not correspond to what we can calculate about the vacuum. And it's no small discrepancy! The supernovae observations suggest that the vacuum energy is over 20 orders of magnitude smaller than what is expected from known particles and fields. The missing piece of the puzzle will be inextricably linked to our understanding of the universe on both small and very large scales.

Such is the large cast of particles and fields that comprise the vacuum. And the LHC may yet uncover more. So, just as in the Shakespeare play, 'nothing' is a source of much agitation also at CERN. Whereas Shakespeare made his play a comedy, here at CERN it is more a question of drama at its most thrilling. As LHC data taking starts again, expect a year of highs and lows, intrigues and suspense, as audacious theories are slain and new particles take centre stage.

Emma Sanders

Did you know?

Higgs bosons are not automatically present everywhere in the Higgs field, they are only produced when energy is injected. Concentrating the right amount of energy in proton-proton collisions at the LHC excites the Higgs field, which resonates at a precise energy corresponding to the mass of the boson. Higgs bosons momentarily form from the energy of this disturbance before decaying into other particles. The LHC experiments look for these decay products. Some theories predict the existence of multiple Higgs bosons.