DIRECTOR'S CORNER

Investing in particle physics

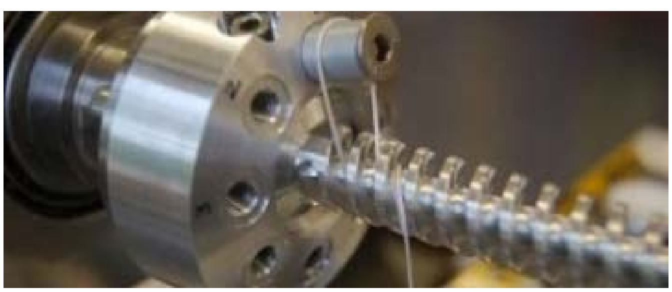
by Barry Barish

Happy New Year! This is my first column of 2011 and I am very pleased to begin the year by reporting on the significant new investment in particle physics by the Italian government. The Italian Ministry for Education, University and Research has announced the funding of the proposed €400-million Super *B* project of the Italian National Institute of Nuclear Physics (INFN). The present plan is to site the machine at or near the Frascati Laboratory and to reuse magnets and other apparatuses from the PEP-II accelerator and the *BABAR* detector at SLAC in the US, both keeping costs down and enabling a rapid construction schedule, perhaps as short as five years.

FEATURE

A new generation of undulator magnets

by Leah Hesla



Lately, scientific communities are in need of higher-energy light particles.

To do this, scientists are extending the existing technology of undulator magnets, or undulators. The device uses magnets

AROUND THE WORLD

From symmetrybreaking: Tevatron to shut down at end of FY2011

Today we received the news that we will not receive funding for the proposed Tevatron extension and consequently the Tevatron will close at the end of FY2011 as was previously planned. The present budgetary climate did not permit DOE to wiggle a particle beam into giving up light, which can then be used for a whole host of scientific applications.

to secure the additional funds needed to run the Tevatron for three more years as recommended by the High Energy Physics Advisory Panel.

IMAGE OF THE WEEK

Winter wonder lab

Image: Reidar Hahn

It's been a snowy winter in the Chicago, Illinois area. A Fermilab cooling pond has begun icing over. Wilson Hall stands in the background.

IN THE NEWS

From Nature News
11 January 2011
Tevatron faces final curtain
Depending on who you talk to, it is either a disappointing blow or a clean break heralding an exciting new era. After much debate, officials at the US Department of Energy's Office of Science revealed this week that they have decided not to extend funding for the Tevatron, the proton–antiproton collider at Fermilab in Batavia, Illinois, by an additional three years.

From BBC News
11 January 2011
Antimatter caught streaming from thunderstorms on Earth
A space telescope has accidentally spotted thunderstorms on Earth producing beams of antimatter.

From Scientific American
6 January 2011
New Subatomic Particle Could Help Explain the Mystery of Dark Matter
…Sterile neutrinos don't even interact with ordinary matter via the weak force, the ephemeral hook that connects neutrinos to the everyday world. Recently, however, new experiments have revealed tantalizing evidence that sterile neutrinos are not only real but common.

CALENDAR

UPCOMING EVENTS

Second Baseline Assessment Workshop (BAW-2)
SLAC
18- 21 January 2011

UPCOMING SCHOOLS

US Particle Accelerator School (USPAS)
Old Dominion University, Hampton VA
17- 28 January 2011

BLOGLINE

Introducing: laboratory blogs
Quantum Diaries, the home of blogging particle physicists from around the world, started the new year by introducing a new group of bloggers: physics laboratories. Brookhaven, CERN, Fermilab and TRIUMF will be posting regular updates to Quantum Diaries and have already gotten started.

Read more on Quantum Diaries

Excellence in Detectors and Instrumentation Technologies (EDIT 2011)
CERN, Geneva, Switzerland
31 January- 10 February 2011

View complete calendar

PREPRINTS

ILC NOTE

2011-058
Numerical Study on High K, Short Period Undulator for ILC Positron Source

ARXIV PREPRINTS

1101.2140
Supersymmetric mass spectra and the seesaw scale

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DIRECTOR'S CORNER

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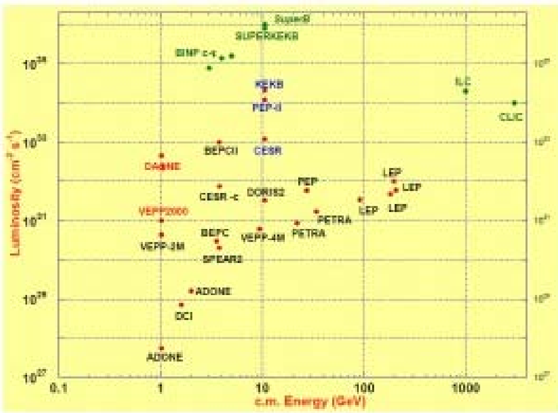
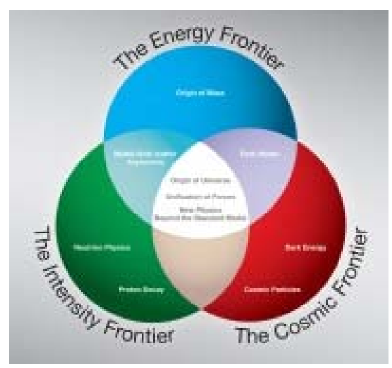
Barry Barish | 13 January 2011



Peak luminosity of electron-positron colliders. The Super B will be at the intensity frontier, shown at the top of the graph, while the ILC and CLIC are at the energy frontier, shown on the right side.

Happy New Year! This is my first column of 2011 and I am very pleased to begin the year by reporting on the significant new investment in particle physics by the Italian government. The Italian Ministry for Education, University and Research has announced the funding of the proposed €400-million Super *B* project of the Italian National Institute of Nuclear Physics (INFN). The present plan is to site the machine at or near the Frascati Laboratory and to reuse magnets and other apparatuses from the PEP-II accelerator and the *BABAR* detector at SLAC in the US, both keeping costs down and enabling a rapid construction schedule, perhaps as short as five years.

Particle physics is often described as having three complementary frontiers, which was emphasised in the US Department of Energy's HEPAP P5 report on future directions for the American high-energy physics programme. The HEP community has been particularly productive at the intensity frontier over the last two decades, especially with the discovery of neutrino oscillations and subsequent follow-up experiments, as well as with the extensive *B* physics results from the *B* factories. *B* physics results include the first observations of CP violation outside the K meson system and the measurements of the Cabibbo-Kobayashi-Maskawa (CKM) parameters provided experimental verification for the 2008 Nobel Prize in physics awarded to Makoto Kobayashi and Toshihide Maskawa.

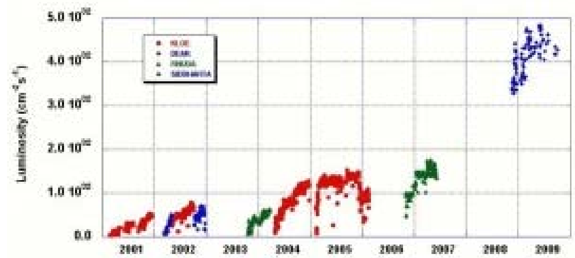


The three frontiers of particle physics as represented in the US DOE P5 report

I reported in July 2010 that Japan had approved the initial funding for SuperKEKB, an upgrade to the present Japanese *B* factory toward their version of a very high-luminosity machine. Now, with the Italian announcement, there will be two efforts worldwide to build such high-luminosity machines, following the precedent of having two *B* factories, SLAC and KEK. In that case, the competition and variation of approaches proved to be extremely valuable, and this should again be true for the next-generation higher-luminosity machines.

On the other hand, one might reasonably wonder whether such duplications are optimal for a field with limited potential resources to realise its many exciting ambitions for future projects. These include long baseline neutrino initiatives, dark energy and dark matter experiments, upgrades to the LHC and, of course, a future high-energy lepton collider. In spite of the difficulty of realising all of these ambitious endeavours, we must recognise that high-energy physics research and facilities are undertaken by individual countries (or regions), except for projects so large that they must be global (like the ILC). Many factors beyond balancing the global particle physics programme go into determining which large science projects are undertaken. We must accept these realities and work hard to realise our ambitions one by one. The new Super *B* project in Italy represents a big step towards assuring a rich future at one of our three frontiers of particle physics.

Advances in accelerator physics have enabled the design of these ambitious next-generation machines. Pantaleo Raimondi of INFN's Frascati Laboratory proposed the key ideas that could enable such high luminosities, in particular the "crab waist" sextupole tranformation. The general idea is to collide the electron and positron beams at a large angle, reducing the disruption of the beams at the collision point. However, to accomplish high luminosities in such a scheme, several new tricks are employed involving tilting and rotating the beams, in order to make the required small focus possible. Experimental verification has been provided from experiments at the DAΦNE accelerator at Frascati.



The DAFNE performances of its four experiments, validating improvements as a result of the large-angle collision scheme

Funding of large projects is a very complicated process and it is not always easy to determine when (if ever) firm government commitments have been made. There are clearly many steps still ahead for the Italian Super *B* project, including the selection of the site, producing a detailed technical design report and developing international collaborations and commitments, among others. Nevertheless, the recent action by the Italian government is a very encouraging and big step towards a real project. Roberto Petronzio, president of INFN, has said of this action, “I’m quite confident it’s the real beginning of the project.”

I heartily congratulate our colleagues who have worked so hard towards making the Italian Super *B* project a reality.


Group photo during the 15th Super B Workshop held at Caltech (December 2010)

B FACTORY | B PHYSICS | ELECTRON-POSITRON COLLIDER | INFN | ITALY | SUPER B

ilc newsline

FEATURE

A new generation of undulator magnets

Leah Hesla | 13 January 2011

Lately, scientific communities are in need of higher-energy light particles.

To do this, scientists are extending the existing technology of undulator magnets, or undulators. The device uses magnets to wiggle a particle beam into giving up light, which can then be used for a whole host of scientific applications.

An early, 42-magnetic-pole test coil of Argonne National Laboratory's planar superconductor undulator. A planar undulator has two cores, each wound with superconducting wire, which are placed on opposite sides of the electron beam. The electron wiggles will lie in a plane, and the resulting photons will be linearly polarised. Image: Yury Ivanyushenkov

“Undulators are specialised beasts,” said Elizabeth Moog, head of the Magnetic Devices Group at Argonne National Laboratory. Different applications require different characteristics in their light.

Argonne in the US and Daresbury and Rutherford-Appleton laboratories in the UK are developing superconducting undulators to meet both high-energy physics and light source scientific communities’ various photon needs.

One goal of the two UK labs is to help fulfil the ILC’s need for a positron source. Jim Clarke, recent Positron Technical Area Group Leader for the Global Design Effort, oversees undulator work at the UK labs. Last year his group successfully produced two 1.75-metre undulator prototypes.

Argonne has also developed an undulator prototype for other science programmes. Theirs is the first real planar superconducting undulator being built for installation in the United States.

The name of the technology relates its modus operandi: it causes an otherwise straight-shooting particle beam to undulate.

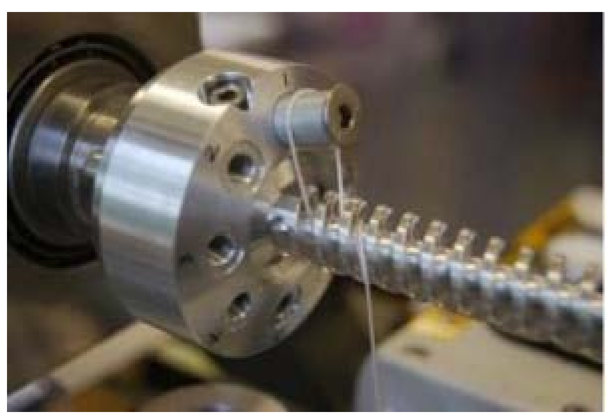
A row of magnets of alternating polarity manoeuvres an electron beam to wiggle as it travels down the axis of the magnet row. With every turn in its sinusoidal path, the electron beam radiates light particles, or photons.

In the ILC plan, the radiated photons are directed at a metal target, and the resulting collision produces positrons. The process calls for 10-megaelectronvolt photons. In 2006, when the UK labs began collaborating on the project, photon production of that energy was out of reach.

“Nobody had looked into whether that was practical or not,” said Clarke. “No magnets with our parameters had been made before.”

One difficulty lay in squeezing enough magnetic field into a short enough distance to achieve the required photon wavelength for a particular beam energy and geometry.

The same challenge faced researchers on the other side of the Atlantic at Argonne. They’d been developing undulators for their Advanced Photon Source (APS), a synchrotron light source that provides X-ray beams to hundreds of scientists in fields as diverse



Daresbury and Rutherford-Appleton laboratories' helical superconducting undulator at the beginning of a winding. Wires arranged are around the beam tube like stripes on a barber pole. This allows the photons to be circularly polarised, which can then produce circularly polarised positrons. Image:

as biology, geology and materials science. Argonne's undulators are designed to produce photons in a variety of wavelength ranges; the superconducting undulator is being designed to produce 20- to 25-kiloelectronvolt photons.

Traditional undulators have made use of permanent magnets. DESY and the European XFEL use them for their undulators. But for many of the newer science projects, those magnets wouldn't pass muster since the fields of permanent magnets are only so strong and so uniform.

Superconducting electromagnets, on the other hand, can pack a good deal more magnetic strength into a few millimetres of undulator. The greater magnet strength leads to higher-energy photons.

Superconducting undulator magnets are constructed by winding superconducting wire around a core. The electron beam travels nearby. The greater the current in the wire, the stronger the resulting magnetic field seen by the electron beam.

Jim Clarke

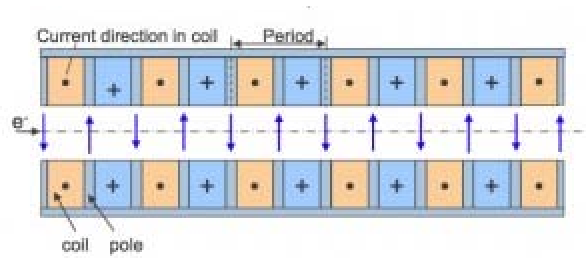


Diagram of an undulator cross-section. An undulator period is measured from one winding to the next of the same polarity. An electron beam passes down the axis of the series of magnets, undulating as a result of the alternating polarities. The direction of the arrows in the undulator gap show the direction of the magnetic field seen by the electrons. Image: Yury Ivanyushenkov

"We've been able to produce the best-looking magnetic field of any undulator I've seen," said Moog.

Increasing the electron beam energy does have a cost, so scientists also try to draw out higher-energy photons by doing something less expensive – reducing the so-called period length. The period length is the distance from one turn of wire to the next. Shrinking that distance bolsters the photons' energy.

After four years, the Daresbury-Rutherford-Appleton team has been able to shrink what was originally a 14-millimetre period to one only 11.5 millimetres long, the desired period length for producing the ILC's 10-MeV photons. In Argonne's prototype, the team has chosen a 16-millimetre period length to meet the requirements of APS users. The standard APS permanent-magnet undulator has a period length of 33 millimetres.

Even the simple act of winding comes with its own set of complications. Both Argonne and the UK scientists have tested their undulator using niobium-titanium wire, a tried-and-true material for the superconducting magnets. But another material, niobium-tin, has the potential to kick up the critical current even higher. The problem is that the standard insulation doesn't survive the high-temperature treatment process required to make it superconducting in the first place. Researchers are continuing tests to determine whether niobium-tin is a viable superconductor option for this application.

"Though the magnet design is quite simple, realising it in practice is very difficult," said Clarke.

Daresbury and Rutherford-Appleton labs have now produced a working, full-scale model capable of generating their target photon energy and Argonne hopes to follow suit in a couple of years.

"It's such interesting technology both for the ILC and for so many other applications," said Yury Ivanyushenkov, technical leader for the superconducting undulator at Argonne. "It's promising, and once the technology is well established, many people, we believe, will be interested."

ACCELERATOR R&D | ARGONNE | DARESBURY | POSITRON SOUCE | RUTHERFORD-APPLETON | UNDULATOR | UNDULATOR MAGNET