

CERN Courier Archive: 1974

A LOOK BACK TO CERN COURIER VOL. 14, FEBRUARY 1974, COMPILED BY PEGGIE RIMMER

NEWS

All the world's a hadron

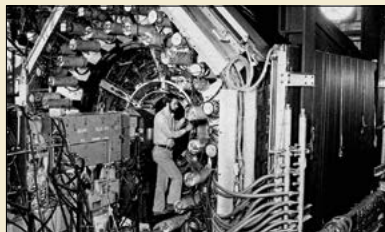
Following the coming into operation of the 6 GeV Bevatron at Berkeley in February 1954, the particle population explosion defied understanding. Then came a beautiful application of unitary symmetry theory, which grouped particles in an orderly way with well-defined relationships between them. Noting an absent member in one of these groups, the omega minus was predicted and, in February 1964, Brookhaven identified this particle, crowning one of the great achievements of high-energy physics.

The famous quark hypothesis is one attempt to explain the particle grouping and relationships. It postulates three types of fractionally charged particles [up, down and strange] coming together in different ways to build up the multitude of discovered hadrons (which respond to the strong interaction). However, quarks have never been isolated as separate entities despite a multitude of searches, and some results do not line up precisely with predictions.

The past 10 years have seen no let-up in the accumulation of fresh information. This has been particularly true of recent years when the opening up of new energy ranges has produced fascinating results. The 76 GeV proton synchrotron at Serpukhov, the CERN Intersecting Storage Rings [ISR], and the 400 GeV proton synchrotron at NAL Batavia have all contributed something new. Fresh surprises from experiments on electron-positron storage rings were reported by B Richter (SLAC) at the American Physical Society Meeting in Chicago, 4–7 February.

The high-energy collision of an electron and a positron brings matter and antimatter together, resulting in annihilation into energy. This energy (photons) can convert into hadrons (predominantly pions). Thus hadrons emerge from lepton collisions.

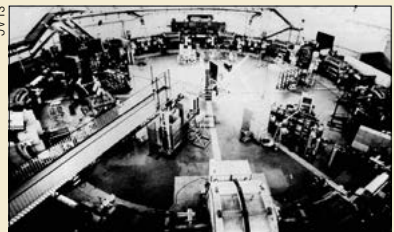
The first inkling that things were going adrift came from experiments at the electron-positron storage ring ADONE at Frascati. Measurements indicated the hadron-production cross-section up to 3 GeV centre-of-mass energy is over twice that expected. A few measurements with electrons and positrons at energies up to 5 GeV centre of mass then came from the Cambridge bypass. They were very much higher than predictions, but the accelerator was closed down before they could be checked. In recent months the same energy range has been



The detection system surrounding a beam collision region at SPEAR, used in gathering the new astonishing results on hadron production.

covered at the electron-positron storage ring [SPEAR] at Stanford. Experiments there have resoundingly confirmed the Cambridge measurements and completely overturned our understanding of what is going on. The total cross-section for the production of hadrons is about 25 nb and is virtually constant over energies up to 5 GeV. This is in complete contradiction to the prediction of the quark model, which says that the cross-section should fall off as the square of the energy.

The quark model gets another jolt when the total cross-section for producing hadrons is compared with that for producing pairs of muons. The simple quark model says the ratio should be constant at 2/3, independent of energy. ADONE results had already upset the apple cart but they were still compatible with a more complicated variant of the quark model involving "coloured" quarks (introducing a property for the quarks like an ultra-strangeness). The coloured variant still insisted on a constant value for the ratio, this time of 2. But the Cambridge and SPEAR



The ADONE storage ring at Frascati, where combined electron-positron energies of up to 3 GeV had already indicated that the hadron-production cross-section was high.

measurements can be explained by no quark model, no matter how coloured. They show the ratio rising with increasing energy and by 5 GeV it has reached a value of about 6.

The results can also be applied subversively to another revered concept – scaling. Scaling makes it possible to predict the energy distribution of the hadrons at any energy once they have been measured at another energy. It has worked beautifully in studies of lepton-hadron interactions, for example the elastic scattering of electrons off nucleons. Why then does scaling not apply for electron-positron collisions?

It is also intriguing that the hadron energy distribution from electron-positron collisions looks like that in very high energy proton collisions, such as pion production data at 90° in the centre of mass at NAL and the ISR. It is as if the electron is sensitive to the strong interaction within a tiny radius of 10^{-16} cm. So, is even the best-known lepton really a hadron at heart?

● Compiled from texts on pp39–42.

Compiler's Note



In 1964, Gell-Mann and Zweig proposed a quark model of hadrons, purely for bookkeeping purposes. But increasing accelerator energies brought growing evidence that the hypothetical up, down and strange quarks were in fact real and point-like. For example, particles with high transverse momentum were emerging from proton-proton collisions at the ISR, reminiscent of the large-angle scattering of alpha particles that led to Rutherford's discovery of the atomic nucleus. The GIM mechanism, proposed by Glashow, Iliopoulos and Maiani in 1970, required the existence of a fourth, heavier quark, and by the end of 1974 it had been identified, by Richter at SLAC and Ting at BNL, in the charm/anticharm J/ψ meson. And with real quarks, there was no need for hadronic leptons.



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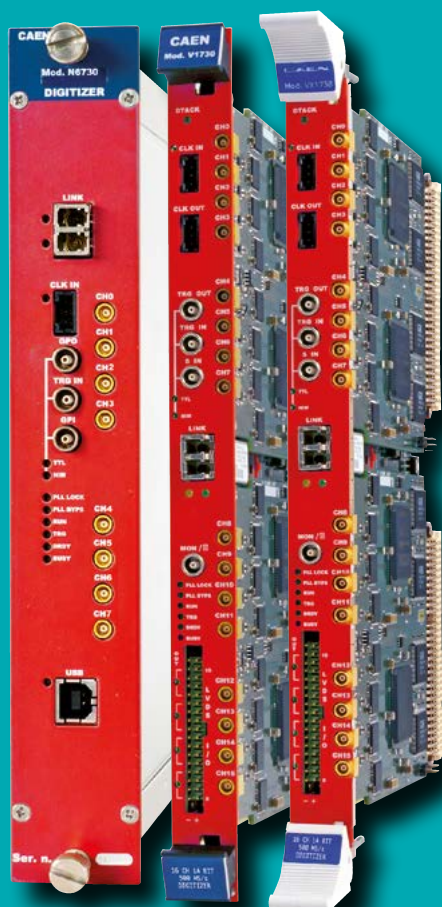
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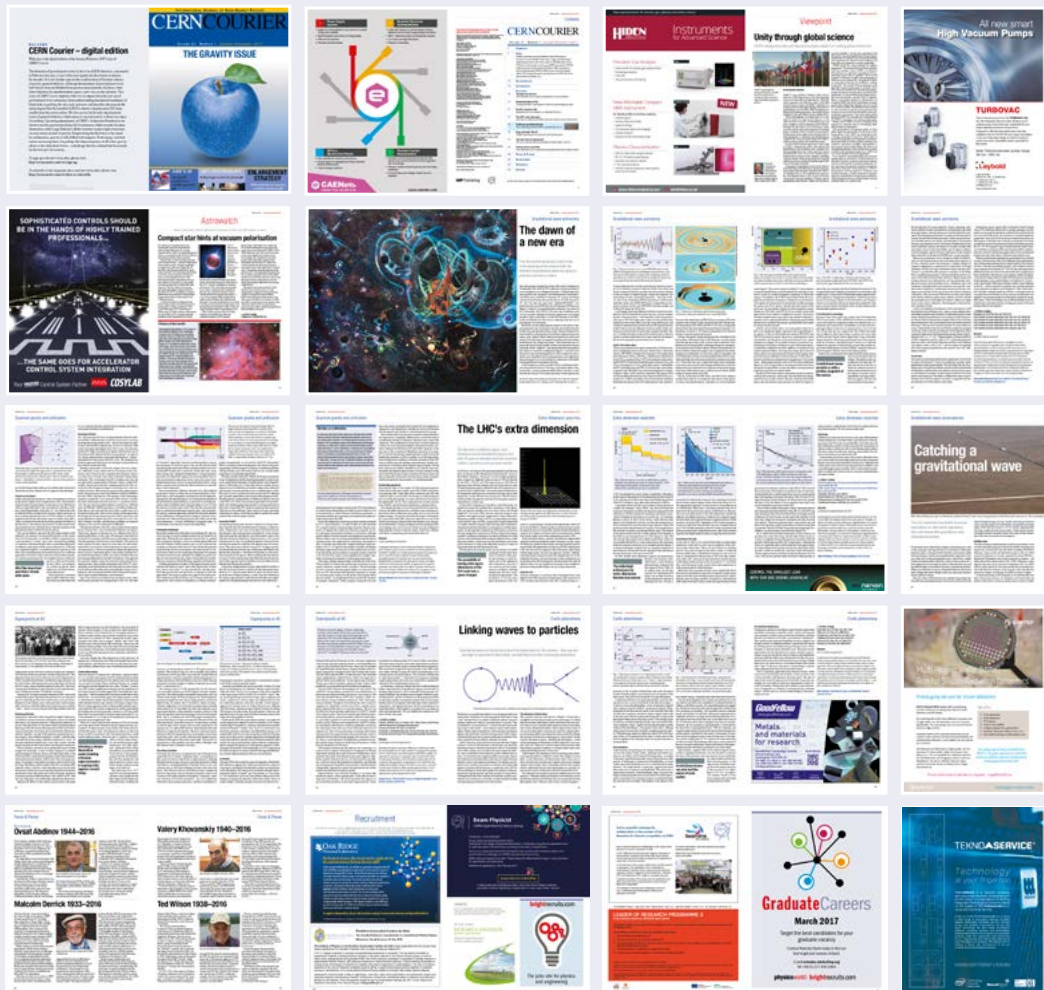


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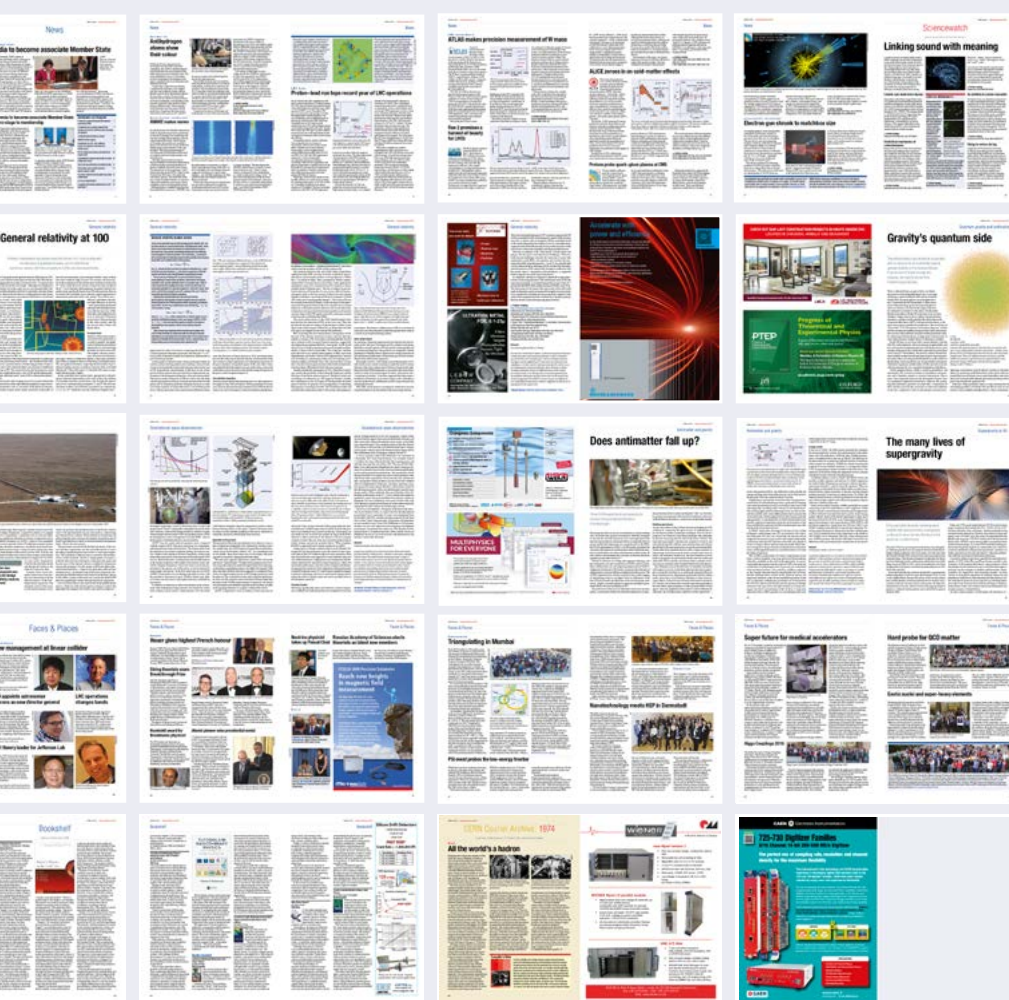
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WELCOME

CERN Courier – digital edition

Welcome to the digital edition of the January/February 2017 issue of *CERN Courier*.

The detection of gravitational waves by the twin aLIGO detectors, announced in February last year, is one of the most significant discoveries in physics for decades. It is also further spectacular confirmation of Einstein's theory of gravity, general relativity. Although the existence of gravitational waves had already been established from precise measurements of pulsars, their direct detection by interferometers opens a new vista on the universe. This issue of *CERN Courier* explores what we can expect from the new era of gravitational-wave astronomy, from understanding the internal machinery of black holes to probing the very early universe, and describes the remarkable technological feat that enabled aLIGO to detect a displacement 200 times smaller than the proton radius. We also survey the broader experimental status of general relativity, which enters its second century without any signs of cracking. Upcoming experiments at CERN's Antiproton Decelerator are about to test the gravitational free-fall of antiatoms, while searches for extra dimensions at the Large Hadron Collider continue to place tight constraints on more exotic models of gravity. Despite being the first force to be tamed by mathematics, gravity is still riddled with enigmas. Dark energy and dark matter are among them, but perhaps the deepest mystery of all is how gravity relates to the other three forces – a challenge that has outfoxed the best minds for the best part of a century.

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