

what happens in gaseous helium, and the Tokyo group, together with researchers from CERN and Munich's Technical University, are planning an experiment at CERN's LEAR Low Energy Antiproton Ring.

Other experiments at LEAR (September 1989, page 24) have used Penning traps and complementary cooling techniques to store antiprotons, the record being 60 days.

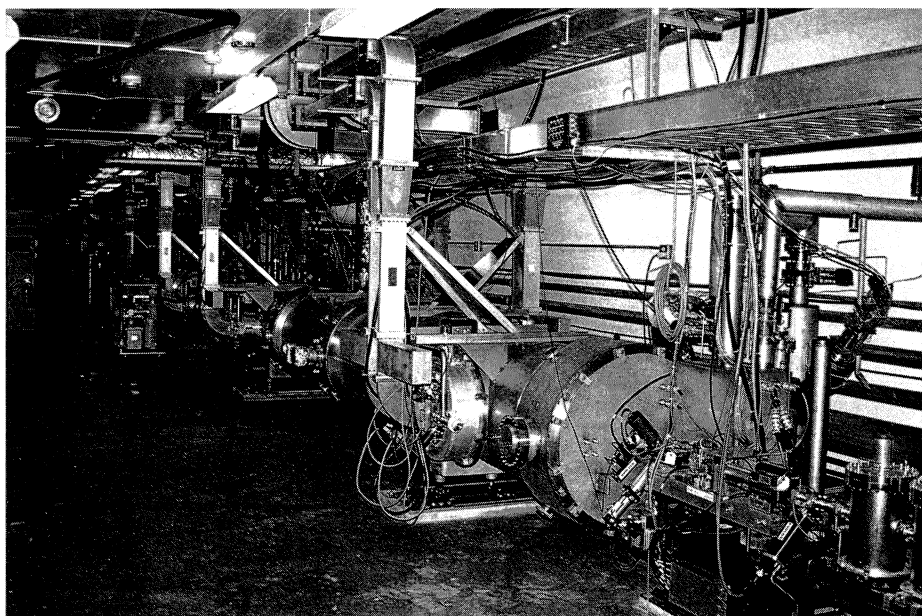
CEBAF Superconducting injector reaches design energy

On 11 June the superconducting injector at the Continuous Electron Beam Accelerator Facility (CEBAF) accelerated an electron beam to 45 MeV – design injection energy for the 4 GeV superconducting accelerator under construction in Newport News, Virginia.

Earlier, a partial injector configuration had reached 5 MeV using the injector's initial two-superconducting-cavity quarter-cryomodule to begin CEBAF's Front End Test (FET) of permanently installed components. In April, with 1 1/4 cryomodules, the FET reached 25 MeV (June, page 10). The injector's second full cryomodule was installed in May. The 20 MeV (nominal) cryomodules are identical to those being prepared for the main CEBAF accelerator.

Supplying FET liquid helium is CEBAF's central refrigeration plant, which is in commissioning and had operated for some 2100 hours for the test when 45 MeV was reached.

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GUT feeling

CERN's LEP electron-positron collider is going full blast, with each of the four big experiments – Aleph, Delphi, L3 and Opal – now able to see thousands of Z particles (the electrically neutral carrier of the weak nuclear force) in a day.

For the moment, these physics results line up solidly behind the 'Standard Model', the twin picture of the electroweak unification of electromagnetism and the weak nuclear force on one hand, and the field theory of quark dynamics on the other.

Unfortunately as a physics theory the Standard Model is transparent, being riddled with unresolved questions. But its very solidity now means that physicists can use it as a springboard in their quest for the deeper theory which will finally answer these questions.

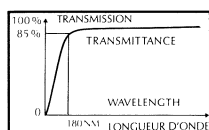
The main trouble with the Standard Model is its lack of predictive power – too many things have to be measured in experiments, and the values put into the theory by hand.

A classic example came in 1989 with initial results from Stanford's SLC Linear Collider and from LEP. These showed that there is room for only three kinds of lepton (weakly interacting particle). In the Standard Model each lepton – electron, muon and tau – is paired with its respective neutrino and two kinds of quark, but there is no limit on the number of allowed leptons. What did this evidence for a closed scenario of six leptons and six quarks tell physicists?

As well as not explaining its own spectrum of particles, the Standard Model cannot account for the mysterious charge-parity (CP – combined particle/antiparticle and

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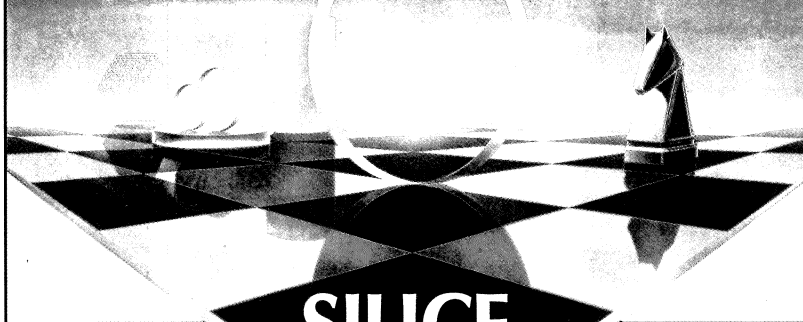
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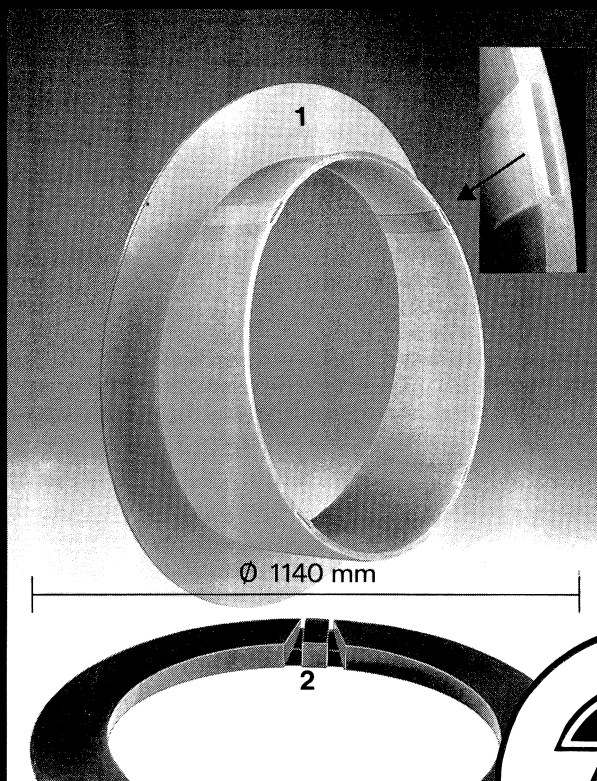


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Dr. Norman K. Glendenning, Chair, Search Committee, c/o Employment Office, MS 90-1042, Job #A6691, Lawrence Berkeley Laboratory, One Cyclotron Road, Berkeley, CA 94720, USA. The Lawrence Berkeley Laboratory is an equal opportunity/affirmative action employer.



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Postdoctoral Positions Experimental Particle Physics University of California, Santa Barbara

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Interested candidates should send a letter of application, statement of research interests, vita, and list of publications to:

Professor Harry N. Nelson
Department of Physics
University of California
Santa Barbara, CA 93106-9530
Bitnet: HNN@SBHEP
Decnet: 45181::HNN
Internet: HNN@SBHEP.PHYSICS.UCSB.EDU

and arrange to have at least three letters of recommendation sent to the same address. Applications should be received by September 15, 1991; later applications will be considered if a position is still open. Proof of U.S. citizenship or eligibility for U.S. employment will be required prior to employment (Immigration Reform and Control Act of 1986). We encourage applications from minority candidates, and from women. The University of California is: An Equal Opportunity/Affirmative Action Employer.

The Standard Model includes six leptons – the electron, the muon and the tau, each with its associated neutrino – and six quarks – ‘up’, ‘down’, ‘strange’, ‘charm’, ‘bottom’ and the long-awaited ‘top’.

GENERATION FAMILY	1	2	3	Electric Charge
1	ν_e	ν_μ	ν_τ	0
2	e^-	μ^-	τ^-	-1
3	u	c	t	$+\frac{2}{3}$
4	d	s	b	$-\frac{1}{3}$

left/right reversal) symmetry violation known for more than 25 years in the decays of neutral kaons.

CP violation can be accommodated, but not explained, by a matrix of the various inter-quark couplings. As this (Cabibbo/Kobayashi/Maskawa) matrix has simple symmetry properties, not all the inter-quark couplings need to be known, and some uninformed predictions are possible. For CP violation to happen, at least six types of quark are needed, but more than six are not ruled out.

In the 1970s, when the Standard Model first started looking good, ambitious theorists looked for a wider ‘Grand Unified Theory’ (GUT). In the same way that the electroweak picture synthesized electromagnetism and the weak nuclear force, so GUT would encompass both electroweak and quark

effects, and hopefully pointing to the origins of the quark-lepton spectrum and CP violation.

One encouraging early GUT prediction was for the vital mixing parameter (‘Weinberg angle’) linking the two electrically neutral carrier particles of the electroweak picture – the photon of electromagnetism and the Z of the weak force. The Standard Model cannot predict this mixing angle.

Another GUT prediction was that the proton has to be slightly unstable, with a lifetime of some 10^{32} years. With the proton, like the electron, previously considered absolutely stable, physicists had to backtrack, but with the age of the Universe ‘only’ about 10^{10} years, there is plenty of room for proton instability on this scale!

A wave of proton decay searches got underway, but with

no positive sightings yet reported, the simplest GUT theory, proposed by Howard Georgi and Sheldon Glashow in 1974, has had to be abandoned. With many more elaborate GUT theories still on the market, experiments with higher sensitivity test for still longer proton lifetimes.

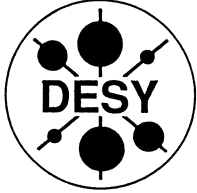
Another early GUT result, developed by a rolling collaboration at CERN’s Theory Division, gave interesting interrelations between the quark and lepton masses, and suggested strongly that there was room only for six types of quark.

GUT dynamics would have ruled the first tiny fraction (10^{-30}) of a second of the Universe after the Big Bang, until it cooled to the stage where the quark and electroweak sectors separated out.

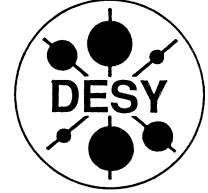
Looking at the implications of these dynamics for the early history of the Universe, astrophysicists calculated the amount of helium formed a few minutes after the Big Bang. This limited the number of lepton types to four (and thus eight quarks), a limit subsequently improved with better helium abundance data.

High energy experiments allow physicists to look back towards this GUT era. Confident measurements of the coupling strength of inter-quark forces in the energy range opened up by LEP (April, page 3) give a first tiny lever arm pointing back towards the GUT limit around 10^{14-16} GeV. These first extrapolations suggest that if electroweak and quark effects are to merge smoothly together, some new physics, such as ‘supersymmetry’, will have to make an appearance.

In the meantime the precision of Standard Model results improves steadily. Sooner or later the strain will begin to tell.



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