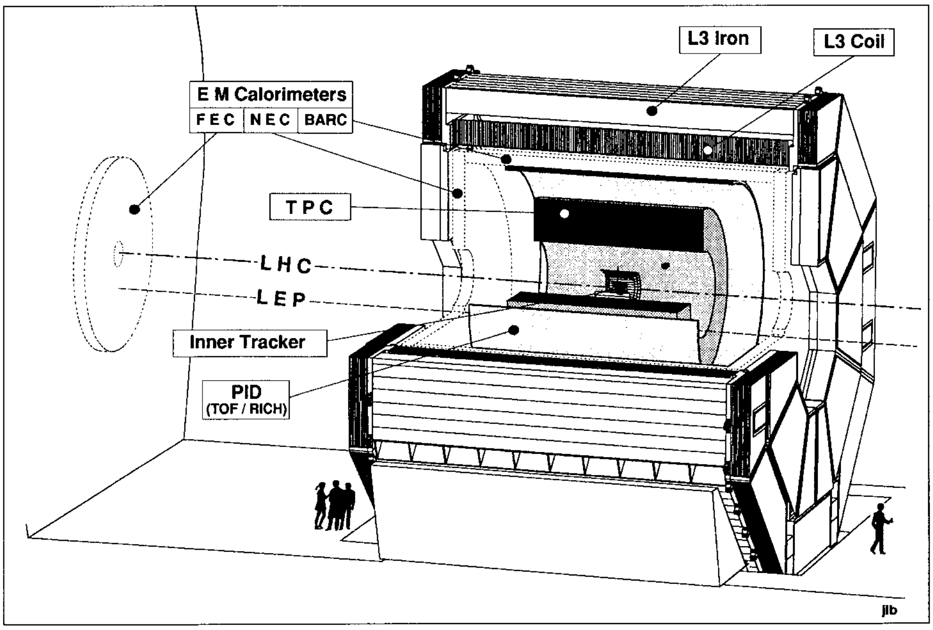
Around the Laboratories

The proposed ALICE detector to study heavy ion collisions in the LHC ring to be built in CERN's 27-kilometre LEP tunnel.



CERN
ALICE in the looking-glass

While proton-proton collisions will provide the main research thrust at CERN's planned LHC high energy collider to be built in the LEP tunnel, its 27-kilometre superconducting magnet ring will also be able to handle all the other high energy beams on the CERN menu, opening up the possibility of both heavy ion and electron-proton collisions to augment the LHC research programme.

A major new character in the LHC cast - ALICE (A Large Ion Collider Experiment) - has recently published a letter of intent, announcing its intention to appear on the LHC stage.

Three letters of intent for major LHC proton-proton experiments were aired last year (January, page 6), and ALICE, if approved, would cohabit with the final solution for the proton-proton sector (see box).

Only a single major heavy ion experiment is envisaged. The proton-proton detectors have some heavy ion capability, but could only look at some very specific signals.

(Detailed plans for LHC's electron-proton collision option are on hold, awaiting the initial exploration of this field by the new HERA collider which came into operation last year at the DESY Laboratory in Hamburg.)

Describing the ALICE detector and its research aims, spokesman Jurgen Schukraft echoes T.D.Lee's observations on the state of particle physics. It is becoming increasingly clear that resolving some of today's particle puzzles require a deeper understanding of the vacuum. Rather than being an empty void, the vacuum is full of all virtual processes allowed by the Uncertainty Principle - mechanisms funded by borrowed energy, and subsequently paid back in full.

Rather than pumping in more and more energy to pinpoint finer structures, Lee advocates probing this rich vacuum by another approach - investigating bulk phenomena by smearing out high energy over an extended volume. This is where heavy ion physics comes in.

Current high energy heavy ion physics at CERN's SPS synchrotron and the future programme at Brookhaven's RHIC collider aim to see signs of quarks breaking loose from their proton and neutron confinements to form the long-awaited 'quark-gluon plasma'. This new state of matter for the laboratory would recreate conditions a fraction of a millisecond after the Big Bang.

Even if ongoing experiments see initial signs of this plasma, LHC heavy ion studies would be poised to study the plasma under better conditions. 'At these very high matter and energy densities, something is bound to happen!', say the LHC heavy ion experimenters confidently.

A particular requirement for heavy ion physics is having to deal with the thousands of secondary particles produced. In addition, quark-gluon plasma is expected to announce itself in subtle ways, through new thresholds, for example in J/psi or upsilon production.

The ALICE configuration would be offset from the beam axis to optimize size and cost. The existing magnet from the L3 experiment at the LEP electron-positron collider in its location at LEP/LHC Intersection 2 is high on ALICE's want list, but an alternative solenoid design has been tabled. As well as the L3 magnet, the BGO electromagnetic calorimeter and some of its muon chambers could also be taken over.

Secondary particles would be picked up on an event-by-event basis. For inner tracking a range of possible ALICE technology is under study, silicon pixels close to the beam pipe, augmented further out by silicon drift chambers, silicon strips and/or microstrip gas chambers.

Beyond the inner tracker would be a Time Projection Chamber for additional tracking and momentum measurement and time-of-flight or ring-imaging Cerenkov counters for particle identification. All this would be contained in the ALICE central barrel, with single arm electromagnetic calorimetry outside and supplemented by forward-backward detectors very close to the beam direction.

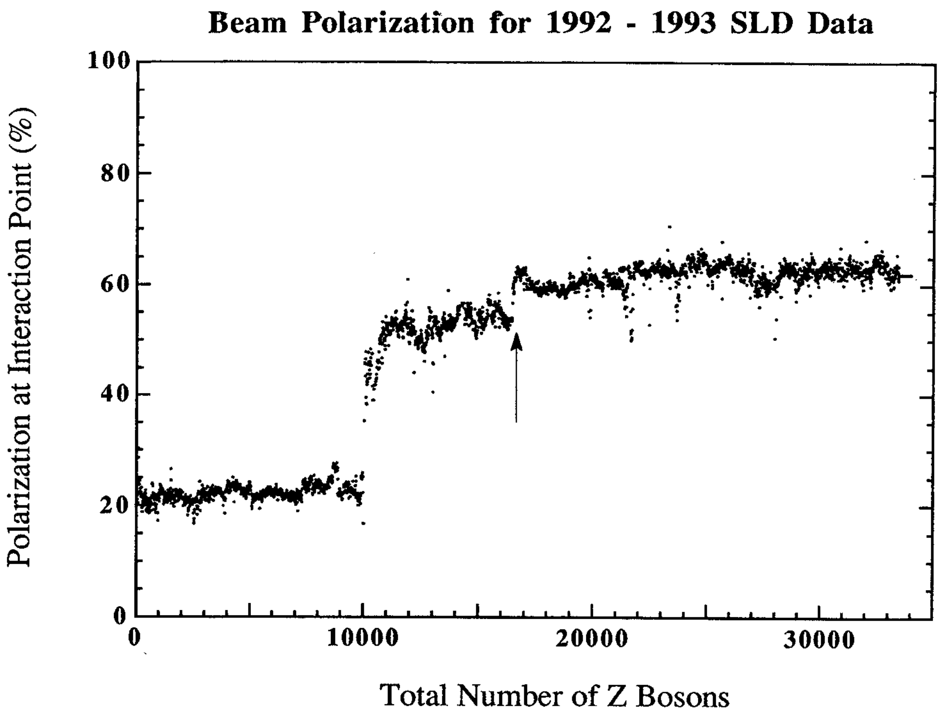
A full programme of ALICE detector component development work geared to the special requirements of heavy ion physics is underway.

Heavy ion physics and ALICE will add a third dimension to LHC physics, with main proton-proton studies attacking the high energy frontier and secondary proton studies looking at the high precision frontier of particles containing heavy quarks.

LHC proton-proton experiments

Last year, three letters of intent - ATLAS, CMS and L3P - were submitted for major detectors to study proton-proton collisions in the LHC ring to be built in CERN's 27-kilometre LEP tunnel. After discussions in the LHC Experiments Committee and CERN's Research Board, the ongoing decision is that the main thrust of the LHC proton-proton programme should be based on two core designs, ATLAS and CMS. In view of the tight funding, further optimization of the two designs is expected to make the two detectors more complementary.

Now using 'strained' semiconductors, 1993 polarization levels at the Stanford SLC linear collider are considerably up on those of 1992. The arrow shows when the wavelength of the laser beam illuminating the photocathode was increased from 853 to 865 nanometres.



STANFORD
Highly polarized SLC electron beams

Using specialized photocathodes made with 'strained' gallium arsenide, physicists at the Stanford Linear Accelerator Center (SLAC) have generated electron beams with polarizations in excess of 60 percent a year ahead of schedule. Together with recent luminosity increases, this breakthrough will have a major impact on the physics output of the Stanford Linear Collider (SLC).

Beam polarization was almost tripled using photocathodes in which a gallium arsenide layer was grown epitaxially over a substrate of gallium arsenide phosphide. The mismatch between these two layers deforms the crystal structure and removes a degeneracy in the valence band structure, permitting selective optical pumping of one unique spin state. Whereas conventional gallium arsenide photocathodes are limited to 50 percent polarization because of this degeneracy (and realistic cathodes fall substantially below this theoretical limit), such strained crystal lattices have the potential to yield polarizations close to 100 percent.

Polarization enhancement with strained lattices was first demonstrated in 1991 by a SLAC/Wisconsin/Berkeley group (May 1991, page 6) with a 71 percent polarization in a laboratory experiment. More recently this group has achieved polarization in excess of 90 percent, reported last November at the Nagoya Spin Symposium. (In a complementary development, a Japanese KEK/Nagoya/KEK obtains polarized beams using a 'superlattice' - May 1991, page 4.)

The 1993 SLC run, the strained gallium arsenide photocathode technique's debut in an operating