Towards LHC experiments

From 5-8 March, Evian-les-Bains on the shores of Lake Geneva was the scene of a major meeting on the experiments for CERN's planned LHC proton collider in the 27-kilometre LEP tunnel.

As plans for the LHC proton collider to be built in CERN's 27-kilometre LEP tunnel take shape, interest widens to bring in the experiments exploiting the big machine. The first public presentations of 'expressions of interest' for LHC experiments featured from 5-8 March at Evian-les-Bains on the shore of Lake Geneva, some 50 kilometres from CERN, at the special 'Towards the LHC Experimental Programme' meeting. (A report from the meeting will be included in our next issue.)

This event followed soon after CERN Council's unanimous December 1991 vote that the LHC machine, to be installed in the existing 27-kilometre LEP tunnel, is 'the right machine for the advance of the subject and for the future of CERN'. With detailed information on costs, feasibility and prospective delivery schedules to be drawn up before the end of next year, and now with plans for experiments under discussion, the preparations for LHC move into higher gear. The Evian meeting was a public forum for a full range of expressions of interest in LHC experiments, setting the stage for the submission of Letters of Intent later this year and cementing the proto-collaboration arrangements.

So that all interested physicists can eventually access LHC, another important aim of the Evian meeting was to acquaint the potential physics community with the full range of proposals and ideas. As well as plans for experiments, participants at the meeting also heard the latest news on LHC machine studies, and the thinking on preparations for experimental areas and LHC physics potential.

CERN is very aware of the challenges of the LHC for its detectors - handling collision rates more than a thousand times those of existing colliders and having to withstand intense radiation levels. In 1990, a special Detector Research and Development Committee was set up along the lines of traditional Experiments Committees, but this time with the objective of stimulating and fostering the new technology needed to reap the LHC physics rewards (November 1991, page 2). This scheme was deliberately set up before global detector designs emerged, so that the final configurations would benefit from this new technology.

As well as its main objective of proton-proton collisions, LHC also opens up possibilities for ion-ion collisions, for fixed target studies and eventually for electron-proton collisions as well. Most of these areas were covered at Evian.

LHC beams can in principle collide at eight points. Four of these coincide with the four big experiments at the LEP electron-positron collider. Of the remaining four points, one, deep under the Jura mountains, will have to be used for an LHC 'beam cleaning' system to ensure high performance by reducing troublesome beam halo. Another will be reserved for the beam dump where the LHC protons will be absorbed once the circulating beams are no longer required. This leaves room for two big new LHC collider detectors, plus the potential of the existing LEP experimental areas, using either adapted LEP experiments or new apparatus mounted in push-pull to alternate with LEP running.

At Evian, four major detectors for studying proton-proton collisions were being tabled, three of which are new, and one a development from an existing LEP experiment.

The ASCOT (Apparatus with SuperCOnducting Toroids) general purpose detector is proposed by a team from CERN, the UK (Edinburgh and Rutherford Appleton Laboratory), Germany (Wuppertal and Munich MPI and University), France (Saclay) and Russia (Moscow, Dubna and Protvino). It is based on a 24 metre-long superconducting toroid instrumented with drift tubes for precision muon detection.

Inside the magnet, the emphasis is

78 *Circle advertisement number on reader service form*

Prince K. Malhotra of Bombay's Tata Institute of Fundamental Research died while attending the Evian meeting. A tribute will appear in the May issue.

on electrons, with a lead/liquid argon electromagnetic calorimeter, and tracking through interleaved layers of scintillators and transition radiation detectors, with semiconductor pads close to the beam pipe. A 1.5T superconducting solenoid in front of the electromagnetic calorimeter distinguishes electrons and positrons. Hadron calorimetry uses iron and liquid argon.

The EAGLE (Experiment for Accurate Gamma, Lepton and Energy measurements) collaboration proposes a comprehensive detector to cover a wide range of physics, and already involves physicists from 14 CERN Member States, plus Canada, Russia, Australia, Brazil and Israel.

EAGLE foresees a powerful inner electron detector inside a 2T central superconducting solenoid. The design features high quality electromagnetic sampling calorimetry combined with fine-grained electron and photon preshower detection, a high precision vertex detector for lower collision rates, hadron calorimetry, and a conventional toroid muon spectrometer.

Many different detector technologies are under study, and a final choice of the specification for the various EAGLE components will be made when R and D work is complete.

The Compact Muon Solenoid (CMS) LHC detector is designed to be compatible with the highest LHC collision rates, and is built around a 15 m-long superconducting solenoid providing a 4T field. The strong field gives relatively compact muon measurement. R and D work for the muon detectors is looking at resistive plate chambers and parallel plate chambers for timing information and honeycomb strip chambers and wall-less drift chambers for spatial information.

The central tracker will use small cells, based on silicon (or gallium arsenide) strip detectors and microstrip gas chambers, to ensure good pattern recognition under the stringent LHC conditions. Also inside the coil is a high resolution electromagnetic calorimeter and a hadron calorimeter.

CMS involves a team from 12 CERN Member States, plus Byelorussia, Bulgaria, Estonia, Georgia, Hungary, Russia and the US. A wide range of ongoing R and D work examines the possible detector technologies before deciding on final solutions.

The L3 experiment at LEP was originally designed for use at both LEP and LHC, with a large experimental hall and magnet. Upgrade for LHC would involve improving the muon resolution, adding a fine-grain hadron calorimeter, increasing the magnetic field, and being able to lift the detector 120 centimetres from the LEP position to the LHC beams above. For the work, 39 institutes from the L3 LEP line-up have been joined by 20 more, mainly from China and the former Soviet bloc.

Supplementing the main proton-proton LHC programme are a range of other experiments, including fixed target studies. Expressions of interest received so far include ideas for two neutrino experiments and three studies concentrating on CP-violation in B-particle decays, one using a gas-jet target, one using extracted beams and one a colliding-beam setup.

Although not the spearhead of LHC physics, ion-ion collisions will still play a major role, continuing a CERN tradition in this field (page 8). For ion collisions, three teams are interested - one using CMS, another using the (suitably modified) Delphi experiment at LEP, and a third using a new dedicated detector.

Around the Laboratories

CERN
LEP in the Alps

With CERN's 27-kilometre LEP electron-positron collider shut down for the winter, LEP specialists met in Chamonix in the French Alps from 19-25 January to review the machine's 1991 performance (January/February, page 6) and to look at ways of improving it.

Nine specialist areas were covered - operations, instrumentation, machine optics, the 'pretzl' scheme to increase the number of colliding bunches, energy calibration and polarization, beam-beam interactions, optics for the LEP2 energy upgrade, and radiofrequency to power LEP2.

Operational experience had shown the machine's limitations. While the total number of collisions in 1991 was twice that of the previous year, actual beam intensity had not changed significantly. Experience had also shown the need for better measurements of machine optics parameters. A long list of problems await further investigation, and the machine physicists warn that experiments may have to learn to live with higher backgrounds if beam intensities are to be improved.

In the instrumentation sector, the specially developed streak camera had shown its worth in investigating little understood beam behaviour, and will be better exploited with a direct link to the control room.

From the start, LEP has continually tried different tuning schemes to find an optimal working point, with 'split' horizontal and vertical tunes being popular. Additional options are to change the phase of the transverse (betatron) oscillations. Each choice has advantages and disadvantages,