

Around the Laboratories

CERN LHC progress

The push for CERN's next major project, the LHC proton collider to be built in the 27-kilometre LEP tunnel, is advancing on a wide front. For the machine itself, there has been considerable progress in the detailed design. While the main thrust is for proton-proton collisions, heavy ions are also on the LHC collision menu. On the experimental side, proposals are coming into sharper focus.

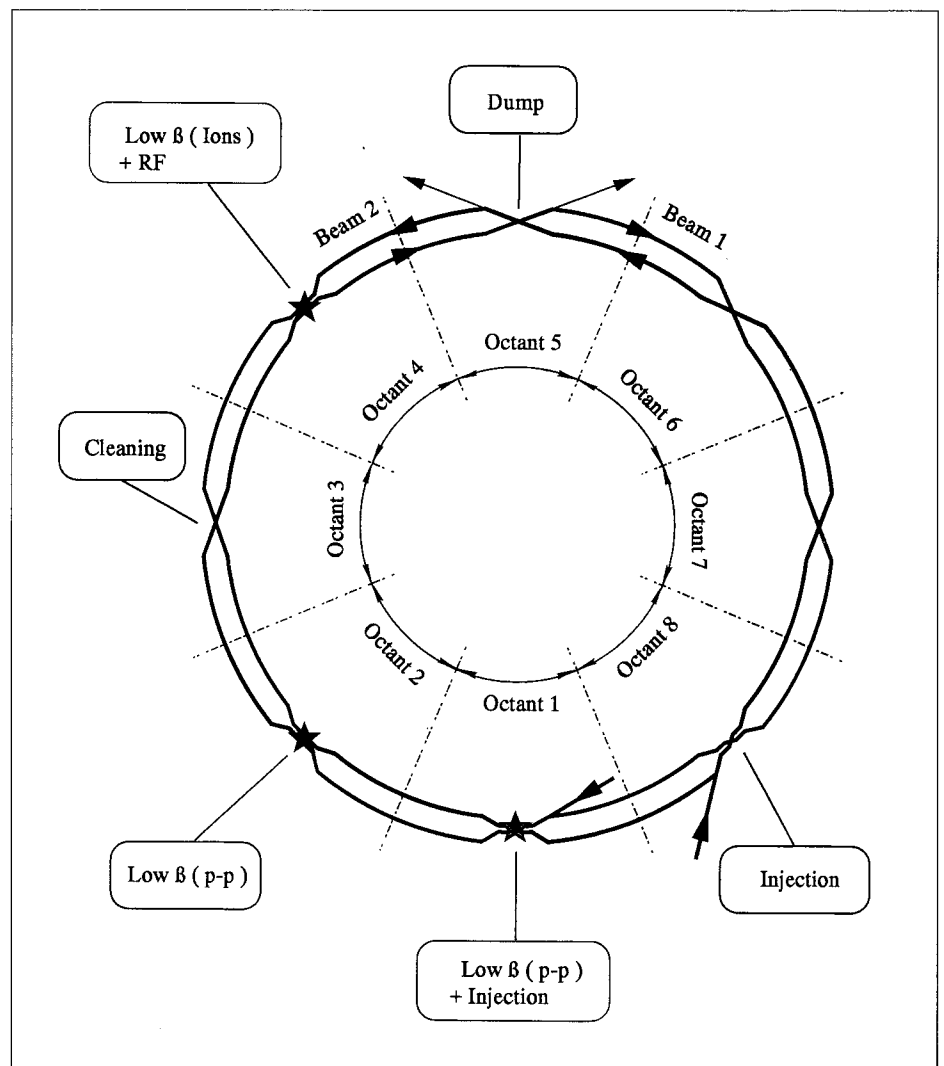
For the machine, the main aim is for the highest possible proton collision energies and collision rates in the confines of the existing LEP tunnel, and the original base design looked to achieve these goals in three collision regions. Early discussions on the experimental programme quickly established that the most probable configuration would have two collision regions rather than three. This, combined with hints that the electronics of several detectors would have to handle several bunch crossings at a time, raised the question whether the originally specified bunch spacing of 15 ns was still optimal.

A new analysis of machine performance for only two high luminosity experiments suggested that a longer gap between bunches could lead to

higher luminosity per experiment, and this was later confirmed when the reduction in long range beam-beam forces was also taken into account. With 25ns bunch spacing, the attainable luminosity (beam-beam limit) in each of two collision points can be expected to be around $2.5 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$ instead of 1.6×10^{34} . This modest increase requires only a slightly higher bunch intensity, felt to be within the possibilities of the injectors and still far from single bunch instabilities.

When the gaps needed for injection and dumping are taken into account, a bunch spacing of 25 ns results in a total of 2835 possible bunches. This bunch spacing requires that the new radiofrequency cavities needed in the PS proton synchrotron (part of the LHC injector chain) should work at 40MHz instead of 67MHz. They are of course somewhat larger but can still be accommodated, while for acceleration in the SPS it was quickly established that 80 MHz would be the most appropriate frequency.

The LEP tunnel has eightfold symmetry, with the even-numbered pits currently housing major LEP experiments. For LHC, the intervening odd-numbered pits would also come into use. This shows a possible scenario, however many options remain open. Point 3 is reserved for the very important beam cleaning insertion, needed to prevent the beam halos reaching the superconducting magnets. The beam dump, also a complete straight section, will be installed at Point 5.



Once it had been clearly established that the machine would be better suited to 25ns bunch spacing, it was the turn of the experimental proposals to establish if physics performance would be degraded by the increased number of overlapping events. Spokesmen for all three major Letters of Intent (CMS, ATLAS and L3P - see below) indicated their preference for 25ns in view of the potential luminosity benefits.

Dipole magnets and beam energy

The initial design was modified for a higher ratio of beam energy to magnetic field, 0.81 TeV/Tesla. Subsequent studies showed that this is better optimized if the main dipole inner coil diameters were increased from 50 to 56mm.

Ongoing studies have also suggested attacking two alternative options with slightly different magnetic fields and hence beam energies. One option retains the original design philosophy and subsequent modifications, while the second option acknowledges that some 30% increase in the amount of superconductor per metre produces only about a 5 % increase in the magnetic field.

This was signalled last year (June 1992, page 21) when a magnet using SSC superconductor exceeded 10 Tesla when cooled to 1.75 K (rather than the standard 4K SSC temperature).

This second option is therefore based on a magnet with cables of the SSC type with similar strands but with the number of strands and the copper/superconductor ratio adapted to the higher field.

This design is expected to provide a quench field of 9.5 Tesla and hence an operational energy (per beam) of at least 7 TeV, approaching that of

the first option. Meanwhile a 1m model using SSC cable will see what field this cheaper cable will give for LHC. SSC cable cannot be used for full length LHC magnets as the copper to superconductor ratio is inadequate to ensure protection in case of a quench.

LHC experiments

Preparations for LHC experiments are advancing well. After presentations of initial Expressions of Interest at Evian in March 1992, the LHC Committee (LHCC) was set up to examine Letters of Intent for proton-proton experiments.

The LHCC was asked to recommend to the CERN management which collaborations should proceed with a Technical Proposal and monitor the development of these proposals, ensuring that an approved programme is in place when the LHC gets its official go-ahead.

Three Letters of Intent were publicly presented at the first Open LHCC Session last November - CMS, a compact design with strong emphasis on muon detection; L3P, using experience and equipment from the L3 experiment at LEP to make precision lepton and photon measurements far from the intersection point; and ATLAS, based on a large toroidal muon magnet complemented by an inner superconducting solenoid. ATLAS is a merger of the ASCOT and EAGLE ideas presented at Evian.

The LHCC felt that at least two proton-proton experiments were essential for a healthy programme, but cost clearly ruled out more than two. A major goal was therefore to see how the three Letters of Intent could be compressed into two Technical Proposals. The committee

found that the detector concepts proposed by ATLAS and CMS addressed the essential issues more convincingly. After further discussion, the committee decided in June to recommend provisionally that ATLAS and CMS should proceed to a Technical Proposal, and agreed on milestones for a further review in November.

Other areas of physics have not been neglected. The ALICE Letter of Intent (July, page 4) aims to see quark-gluon plasma in the dense matter formed in ion-ion collisions.

To examine the LHC's considerable potential for B physics (particles containing the fifth - 'beauty', or b, quark), the LHCC held a B physics workshop in May. While the general-purpose experiments could do some interesting physics with B particles, their capabilities in this sector are limited. Dedicated experiments would be required to explore this physics to the full, and three different ideas were tabled. One (COBEX) would run in the proton-proton collider with an open-geometry forward detector. Another (GAJET) would use a gas jet target in one of the LHC proton beams. The third (LHB) would use a fixed target, with a beam extracted by a bent crystal in the halo of the circulating beam.

SUPERCOLLIDER Pros and cons

As this issue goes to press, proponents and opponents of the US Superconducting Supercollider (SSC), now under construction in Ellis County, Texas, are preparing for a major confrontation in the US Senate. (In June, the House of Representatives voted 280-150 to