RAL

DESIGN & DISCOVERY

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RUTHERFORD APPLETON LABORATORY

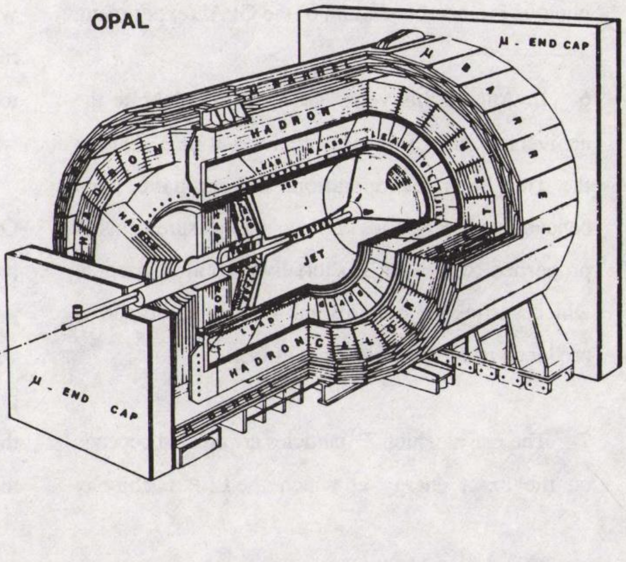
SCIENCE AND ENGINEERING RESEARCH COUNCIL

The OPAL Experiment at LEP

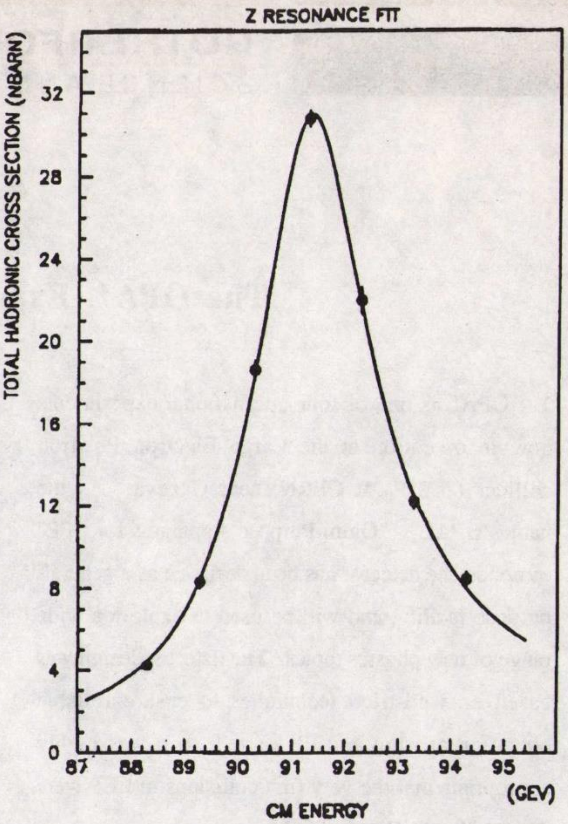
1 OPAL is one of four international experiments now in operation at the Large Electron Positron collider ("LEP") at CERN, near Geneva. As the name "OPAL" - "Omni-Purpose Apparatus for LEP" - implies, the detector has been designed as a general-purpose facility, and will be used to explore a wide range of new physics topics. The detector design was based on well-tried techniques to ensure reliable operation as soon as LEP started, so it was highly appropriate that the very first collisions in LEP were detected by the OPAL team.

2 Design of the experiment began in 1981, with a collaboration of 200 physicists from 24 research institutes in Europe, Israel, North America and Japan. The detector is composed of fourteen parts, five of which were built by physicists from UK universities and the Rutherford Appleton Laboratory. British scientists have also developed a substantial fraction of the computer programs used for data collection and analysis. The experiment has taken six years to build (1983 to 1989), at a cost of some £30 Million, and is now fully operational.

3 The detector, an 8 metre diameter cylinder 10 metres in length and weighing 3000 tons, is housed in a large cavern 100 metres underground. Beams in the LEP machine pass directly through a high-vacuum tube into the heart of the experiment, where some of the electrons and positrons collide to produce an intense sub-microscopic fireball. The experiment detects almost all of the particles emerging from the fire-ball, and can probe into a domain of physics reminiscent of the "Big-Bang", believed to have been present at the start of the universe.



4 A major component of the experiment is its cylindrical magnet, 4 metres in diameter and consuming 5MW of power. Particles emerging from the electron-positron collision follow curved paths in the magnetic field, and their momenta and electric charges can be calculated from the shape of the tracks (slower particles follow tighter curves). Tracks are measured by "Vertex", "Jet" and "Z" tracking detectors. The Vertex detector is closest to the collision point, and measures particle positions to an accuracy better than 1/20 mm - this helps to detect short-lived particles. Tracks in the space between the vertex detector and the magnet are measured by the Jet and Z chambers.



5 Particles passing through these chambers and the magnet then encounter a series of concentric detectors designed to measure total particle energies. The specialised equipment for measuring energies of electrons, positrons and photons is a notable feature of the OPAL experiment.

6 In August this year, OPAL will celebrate the anniversary of its first measurements at LEP. During the first year of operation, efforts have been concentrated on a series of precision measurements of properties of the Z^0, a short-lived neutral particle which carries the electroweak nuclear force and is produced in copious quantities at LEP.

7 The rate at which Z^0 particles are created depends on the exact energy at which the LEP machine is operated, and the curve shown above has been obtained by varying the LEP energy. It is possible to deduce the number of different types of neutrino which exist from the shape of this curve. This measurement is important because it is closely related to the total number of fundamental particles from which the universe is constructed.

Other measurements have been compared with values predicted by a widely accepted mathematical theory of particle physics, the so-called "Standard Model". The very good agreement between the measured and predicted values give the physicist greater confidence that the physical mechanisms represented in the model accurately reflect the forces at work in nature.