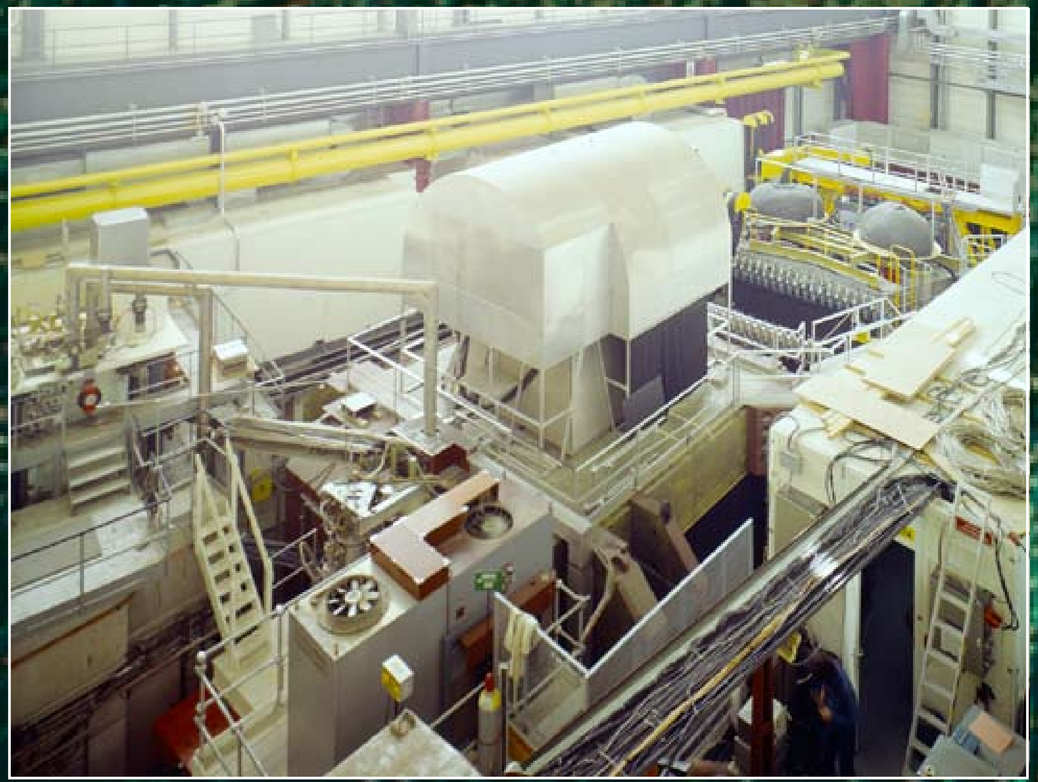
Fixed target physics *at the SPS*

CERN has a long and varied history of fixed target experiments, contributing to a diverse programme of research. Over the years, experiments have used neutrino, muon, hadron and photon beams from the PS and the SPS.

OMEGA

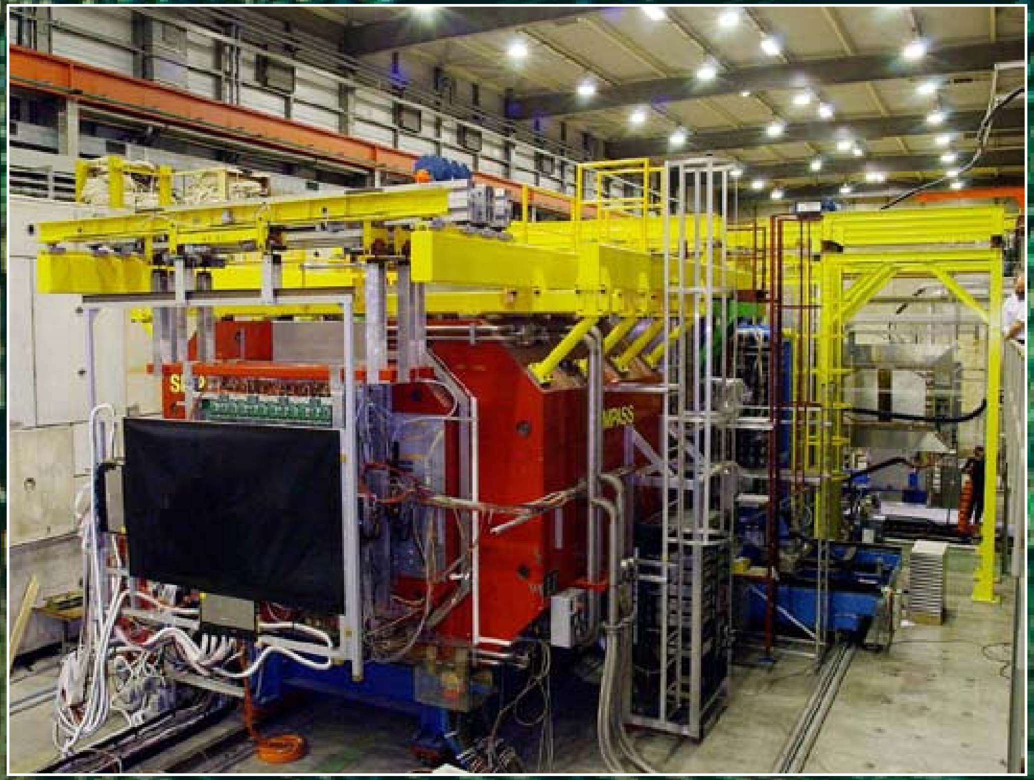
The OMEGA spectrometer operated as a facility for some 48 experiments from 1972 to 1996. In the first five years, experiments were devoted to low-energy interactions. In 1976, higher energy beams became available from the SPS and OMEGA published the first physics results from the SPS, on the production of the J/psi particle. By 1986, the research programme at OMEGA was predominantly devoted to the study of particles carrying charm or beauty quarks and of 'gluonia', particles containing only the 'glue' that holds quarks together. OMEGA also played a significant role in the heavy ion programme at CERN with experiments studying the production of strange baryons, particles containing strange quarks.



The OMEGA spectrometer in 1977.

Using muons as probes

The smaller the object to be investigated, the higher the energy of the probe needed to see into its interior. When it comes to probing inside the protons and neutrons that form the nuclei of atoms, the probes themselves must be small, and the most handy to use are pointlike electrons or their heavier relatives, the muons.
A long line of experiments have made use of this technique, including the European Muon Collaboration (EMC), the BCDMS (NA4) experiment, the New Muon Collaboration (NMC), and the Spin Muon Collaboration (SMC). Today, the COMPASS experiment uses a muon beam to probe the spin of the proton.



Installing the COMPASS experiment in 2002.

The NA4 experiment in 1978.

CP violation

The basic building blocks of the Universe behave approximately symmetrically. If a quark moving from A to B is turned around it should follow exactly the reversed path from B to A. If the quark follows some other path, the forces making it move are said to violate parity (P). A similar argument can also be made when considering charge (C). In weak interactions, the combination of C and P is sometimes seen to be violated. These tiny discrepancies could have huge consequences on cosmological scales, contributing to the matter-antimatter imbalance in the universe today.

CP violation experiments at the SPS used neutral K mesons, made ofa quark and an antiquark. The most successful experiments were theNA31 experiment, taking data from 1986 to 1989 and presenting its first significant results in 1993, and its successor NA48. This latter experiment determined the tiny difference in the decay rates of neutral K mesons and their antiparticles with a precision of one part in a million. Today , the NA62 experiment uses a kaon beam to study rare decays, searching for new physics beyond the Standard Model.

The NA48 experiment in 1996.

"In 1988 we had an enormous surprise in EMC regarding the spin of the proton, which did not depend simply on the spins of the quarks inside. This result has now been cited well over a thousand times in the scientific literature, and was further investigated and confirmed by the SMC, but what does it really mean? We still don't know."

Barbara Badelek *Infinitely CERN, 2004*

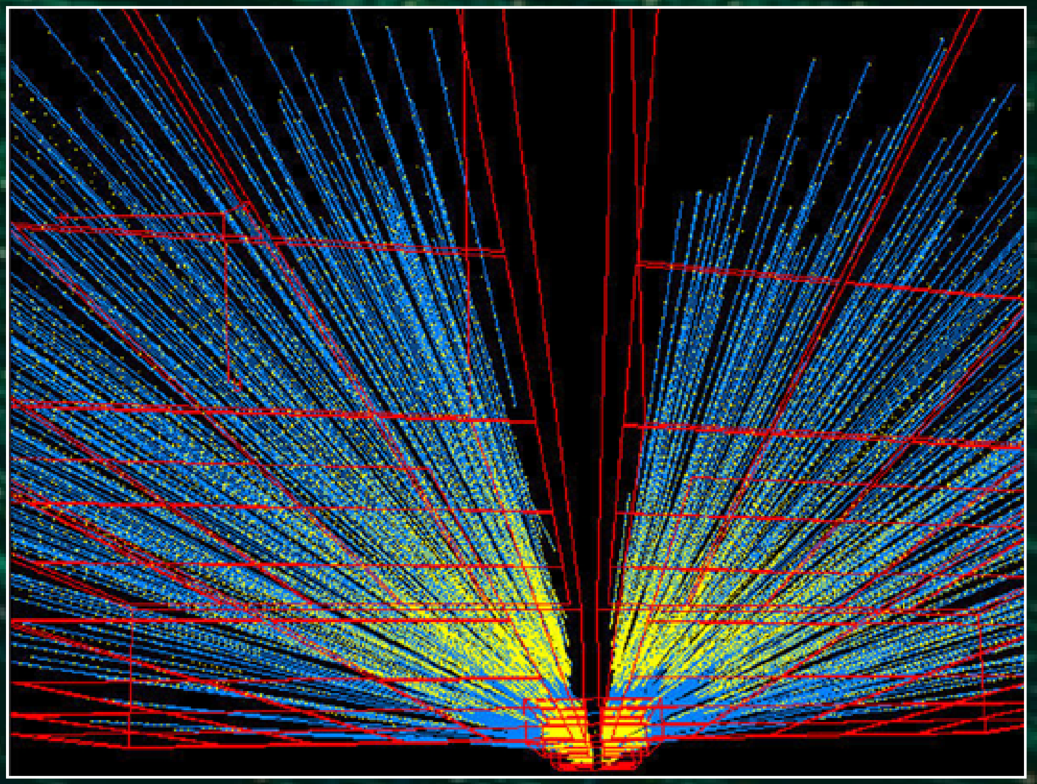
"In early 2000, the discovery of 'a new state of matter' was announced by CERN. This discovery has been a process, not a single event. It was the conclusion to all the data gained in the previous years. And still we could not be sure if this new state is the real QGP, or only some precursor."

Jürgen Schukraft, Infinitely CERN, 2004

Heavy Ions

The heavy ion programme at the SPS was designed to recreate and detect a new state of matter: the plasma of quarks and gluons that existed in the first instants of the universe. To 'deconfine' quarks, heavy nuclei have to be accelerated and smashed together at ultra-high energies. The larger the colliding nuclei and the higher the energy, the greater the chance of creating a Quark Gluon Plasma (QGP).

The first experiments had to use relatively light nuclei such as oxygen and sulphur. These preliminary investigations showed collisions were probably sufficient for the production of a QGP. A second generation of experiments using lead ions started taking data from 1994 onwards. After the whole picture was put together in 2000, the combined results gave compelling evidence that a new state of matter had indeed been created at CERN. The next big step at CERN will be ALICE, a dedicated heavy-ion experiment at the Large Hadron Collider.



A lead ion collision in NA49.