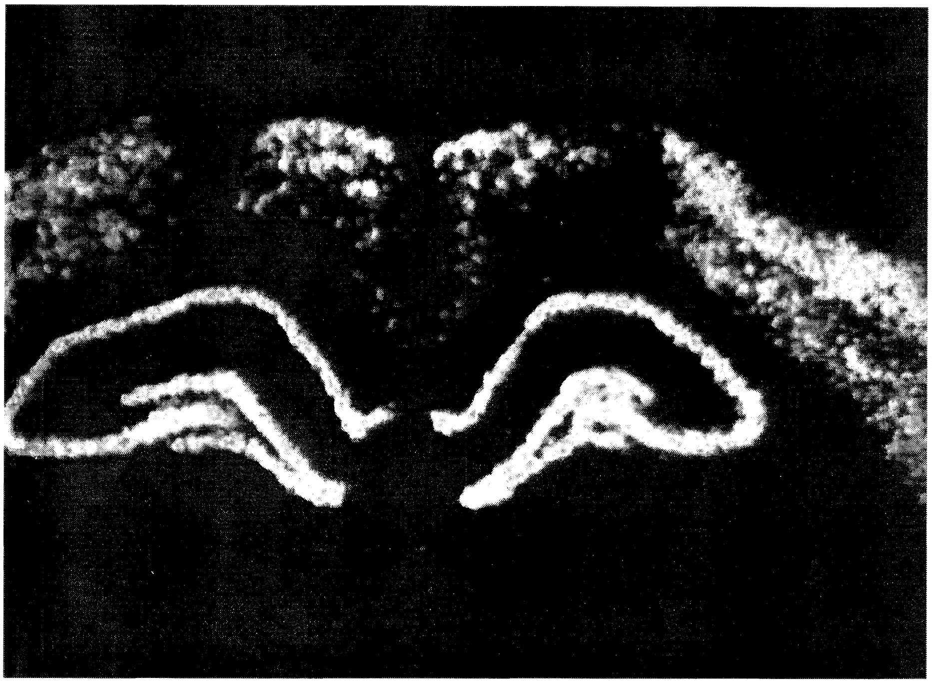
Scintillating fibres in action. A high resolution CCD beta radio imager using a proximity focused image intensifier coupled to a CCD to pick up light from scintillating fibres has produced this frontal section of a rat brain. This has already given new insights into the role played by genes in memory.



DETECTORS
Scintillating fibres

In the continual search for improved detection techniques, new materials are continually proving profitable. A good example is scintillating plastic fibres - tiny transparent threads sometimes finer than a human hair which transmit light.

The narrowness and flexibility of these fibres was a major breakthrough for endoscopy - non-invasive techniques for viewing the otherwise inaccessible in surgery or machine inspection. In a more sophisticated form, these fibres find ready application in communications technology, where the goal is to transmit information rather than electrical power, replacing conventional and unwieldy current-carrying wire conductors.

In particle physics, fibres have long been used to take the tiny scintillations produced when high energy particles hit fluorescent materials and 'conduct' them to photosensitive detectors some distance away.

A newer application is in tracking, using an array of fibres as a sensitive target, where the pattern of produced light helps reconstruct the trajectory of the particle.

A pioneer large fibre tracker was built in the mid-1980s as part of the upgrade programme of the UA2 detector at CERN's proton-antiproton collider. A cylinder containing 60,000 fibres, each 1 millimetre across, greatly improved the reconstruction of the complex collisions taking place inside the detector.

Among ongoing projects, an important fibre application example is the Chorus experiment, which along with the Nomad detector will exploit from this year the new neutrino beams at CERN (November 1991, page 7).

Chorus will catch its neutrinos in an 800-kilogram block of photographic emulsion. To localize the interaction for subsequent emulsion scanning, the outgoing tracks will be picked up immediately downstream in arrays of fibres. The resulting light will be amplified, as in UA2, by multiple stages of image intensifiers feeding CCDs for final readout. Put end to end, the two million individual fibres used in Chorus would stretch across five thousand kilometres. (Meanwhile the UA2 readout systems have been recycled for the WA98 heavy ion experiment at CERN.)

An alternative fibre tracking readout technique has been developed in the US by Muzaffer Atac. This Visible Light Photon Counter is based on a Rockwell solid state photomultiplier with a gain of 20,000 but its 7K operating temperature demands a cryogenic environment. This technique was initially proposed for an upgrade of the D0 detector at Fermilab's Tevatron proton-antiproton collider, and for use at the ill-fated SSC Superconducting Supercollider.

Fibre techniques are also being developed at CERN in the context of the Italian-funded LAA scheme. To cope with the higher interaction rates of tomorrow's physics, fused fibre bundles have been developed with diameters of several millimetres, containing thousands of individual fibres. Special dopants amplify the scintillation, reducing 'cross-talk' between neighbouring fibres, while readout is handled by new image intensifiers based on a single silicon diode.

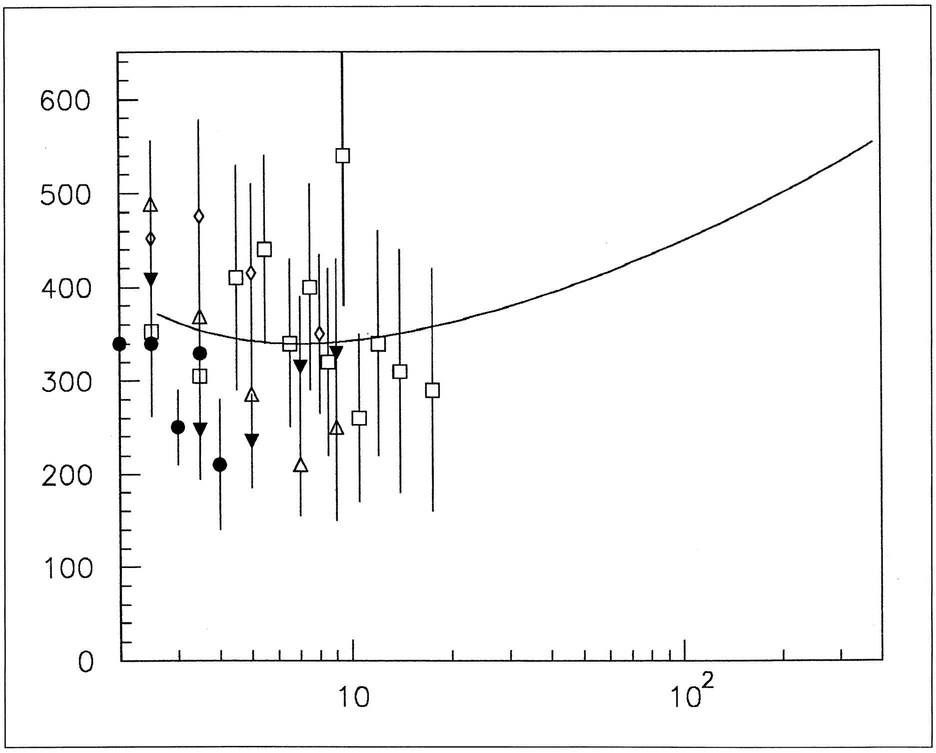
With fibre tracking now well established in particle physics, the next stage could be new spinoff applications. For instance a group of French physicists (IPN Orsay/Paris) has been developing commercial instruments based on scintillating fibres and image intensifiers aimed mainly for biology, an applications target picked out by Georges Charpak.

A high resolution CCD beta radio

imager, whose main components are a proximity focused image intensifier coupled to a CCD, has also been developed, the device being self triggered by the intensifier's anode pulse. With samples carrying a suitable radioactive tracer, such as sulphur 35, a resolution of 15 microns is achieved, with the image built up a hundred times faster than conventional emulsion-based recorders.

Another instrument, the scintillating optical fibre imager, is designed to handle a much larger sample area. The radioactive sample is immediately above two orthogonal layers of fibres and the resulting light read out from the ends of the fibres at the edges of the layers. This technique is more powerful than X-ray methods and can be used in geology and other applications as well as biology.

The photon-photon reaction rate (cross-section) showing the data collected so far by a range of experiments and its expected extrapolation into the region to be covered by LEP working at higher energies.



Tale of two photons

A very profitable spinoff from electron-positron collisions is two-photon physics. Rather than the electron and positron interacting directly via an exchanged photon, two virtual (transient) photons, one from each particle, get tangled up.

With new electron-positron colliders appearing on the scene, a topical meeting on two-photon physics - 'From DAPHNE to LEP 200 and beyond' - held from 2 - 4 February in Paris, in the premises of the Ministry of Higher Education and Research, was particularly timely. Some 60 physicists, both experimentalists and theorists, participated, with some thirty speakers.

The meeting (sponsored by IN2P3-CNRS, DAPNIA-CEA and Collège de France and organized by J. Parisi of Collège de France and F. Kapusta of LPNHE Paris) was motivated by the ongoing or planned building of new electron-positron colliders covering a wide spectrum of energies and expected to have, as a common feature, a luminosity (a measure of their collision rate) of some 10^{33} cm^{-2} s^{-1}, much higher than machines of the previous generation. Their integrated luminosities of the order of 10^{40} cm^{-2} should considerably boost two-photon physics.

The first part of the meeting was devoted to DAPHNE, a machine of total energy 1 GeV presently being built at Frascati, with its detector (KLOE) and a tagging system planned for two-photon experiments. Prospects for two-photon physics include the production of charged and neutral pion pairs near threshold, as well as of low-mass resonances. Calculations of the pion pair production by two photons at low energy were presented by several theorists using different approaches.

The second part of the meeting was devoted to machines of somewhat higher energy - a Tau/Charm Factory of total energy 3 - 6 GeV that might be built somewhere in Europe, and the B Factory for Stanford (SLAC). Two-photon physics at the Stanford B Factory and its detector (BABAR) could open up meson spectroscopy (up to and including charmonium) and examine the kinematic behaviour of resonance production, where quantum chromodynamics (QCD) has made interesting predictions. There are particular implications for the production of quark-antiquark mesons having non-zero orbital angular momentum, as well as the production of gluonic mesons ("glueballs").

LEP 200 - the energy upgrade of CERN's LEP collider - was the subject of the third part of the meet-