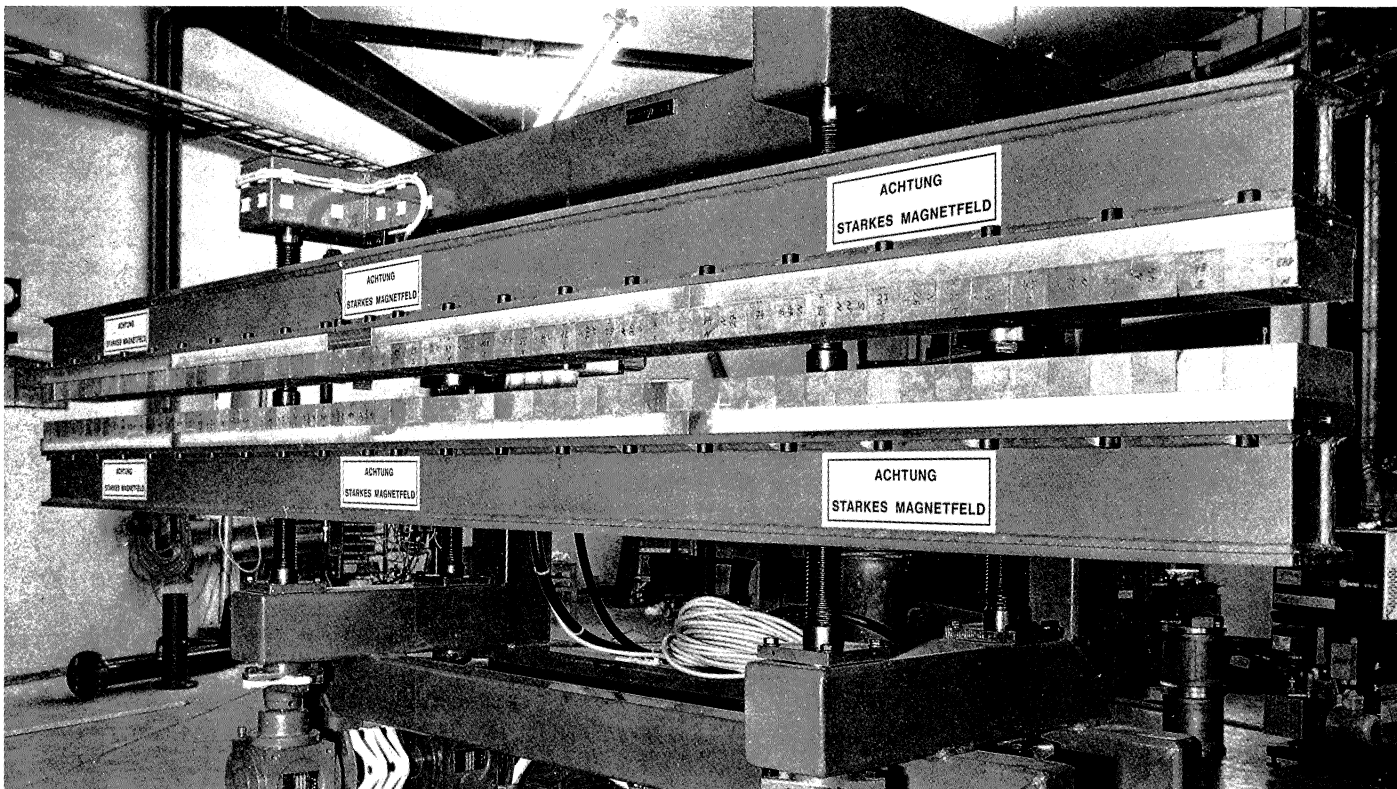


The wiggler magnet now installed at DORIS II, showing its small component samarium-cobalt blocks.

(Photo DESY)



## DESY Wiggling at DORIS

This summer, a 2 metre-long wiggler magnet closed its magnetic teeth around the slim beam pipe of the DORIS II storage ring, running with 60 milliamps of electrons at 3.7 GeV. Exactly 361 watts of emitted photon radiation were immediately registered in the beam direction — compared with 365 computed from theory. This corresponds to a factor of 10 to 50 — depending on the photon energy — more than the synchrotron radiation obtained under similar angular conditions in a normal bending magnet. Machine operators were very happy to find no deterioration of the beam or of the running conditions. They also injected new particles into the storage ring without removing the wiggler

magnets and did not find any problems.

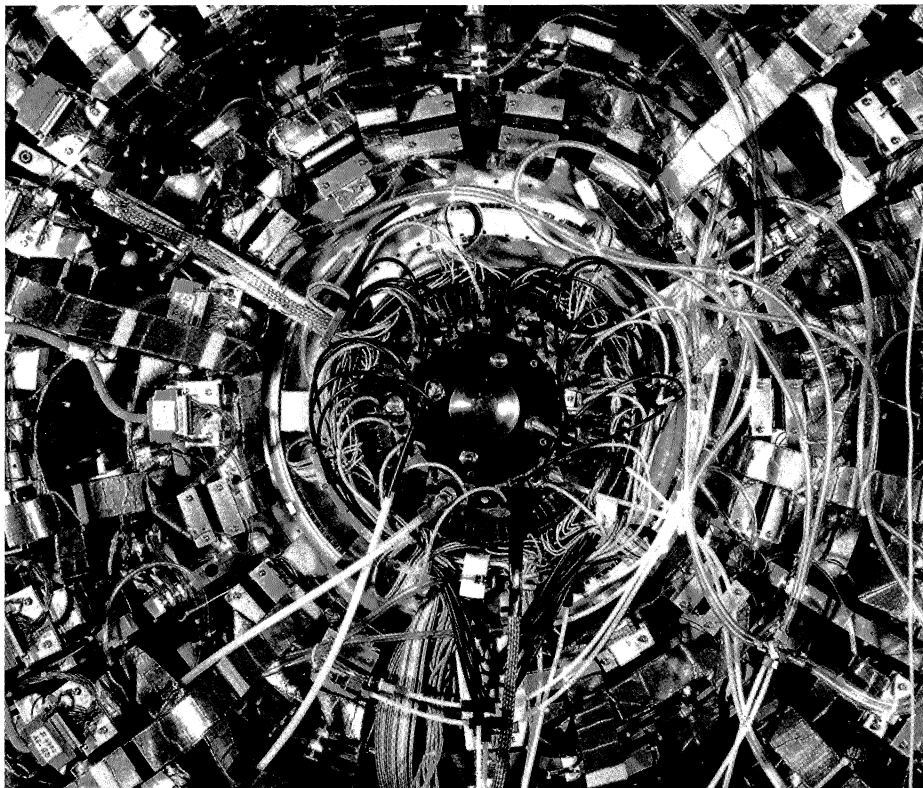
(As well as running as an electron-positron collider for particle physics experiments, the DORIS II ring at the German DESY Laboratory also runs periodically with just electrons, supplying synchrotron radiation for HASYLAB — the Hamburg Synchrotron Radiation Laboratory.)

Wigglers for the production of synchrotron radiation have already been installed in several Laboratories (see March 1983 issue, pages 47-49). Pioneer work was done on this field by Klaus Halbach (permanent magnet design) and by Hermann Winick (designing and operating wigglers for SSRL, the Stanford Synchrotron Radiation Laboratory) at Berkeley and Stanford. Winick was previously at the Cambridge (USA) Electron Accelerator, where Ken Robinson had proposed using wigglers to increase radiation damp-

ing of stored beams. Soviet physicists also made early and original contributions. In Western Europe, wigglers were developed for ADONE at Frascati, for DCI at Orsay, for Daresbury and recently for LEP (see June issue, page 191).

The wiggler now operating at DORIS was designed in 1982 by Peter Gürtler (from HASYLAB) and visitor Alan Jackson from Daresbury. It is optimized for the production of synchrotron radiation in the particular conditions of the DORIS II storage ring. It was built at HASYLAB, and installed at DORIS in April. One of the problems which had to be overcome was that particle injection takes place just where the wiggler is installed!

Small permanent magnets built from blocks of samarium-cobalt provide a field of .6 tesla with a gap of 34 mm. Four blocks form a period 132 mm long and the whole magnet



*End-on view of the ASTERIX detector at the CERN LEAR Low Energy Antiproton Ring which has succeeded in seeing the K spectral lines from the lowest lying energy level transitions in antiprotonic hydrogen. In the centre can be seen the special X-ray drift chamber which surrounds the hydrogen gas target.*

*(Photo CERN 399.9.83)*

is made of 16 periods. The opening angle of the produced photon beam is 2.2 mrad with 3.5 GeV electrons and 1.5 mrad at 5.0 GeV.

While at low energy machines, strong wiggler magnets are used to shift the spectrum of the emitted photons to higher energies, at DORIS this is not necessary. The machine already has an excellent spectral range reaching hard X-rays, due to the high energy of the circulating particles. At DORIS the wiggler can be optimized to deliver higher photon fluxes in the horizontal aperture.

The photon beam from the wiggler goes into the main HASYLAB hall (see May 1981 issue, page 157) which is at present one of the best facilities available for experiments with synchrotron radiation. There are 24 fully installed measuring stations using beams from the DORIS II bending magnets. The new wiggler beamline will cater for experiments in the X-ray range, for surface structure analysis (surface EXAFS, surface Bragg diffraction and X-ray standing waves) and in the soft X-ray region for photoemission and photon stimulated desorption experiments. The latter will also help to understand and solve vacuum problems in electron storage rings.

There are new plans for an additional experimental hall at DORIS to be supplied with a wiggler beam optimized for hard X-rays. This photon

beam should be well suited for medical applications like computer angiography of blood vessels in the heart region (see March 1983 issue, page 47). The new facility is proposed to be ready in 1986.

*(From E.-E. Koch)*

## CERN K-LEAR signal

The study of exotic atoms, in which an orbital electron of a conventional atom is replaced by an antiproton or other negatively-charged particle, can supply a wealth of detailed information on nuclear forces and has long been a speciality at CERN. The availability of intense beams of low energy antiprotons at CERN's LEAR ring considerably extended the possibilities with antiprotonic atoms (see March issue, page 54).

Information on the forces at work between protons and antiprotons can be gleaned from the spectroscopy of the simplest exotic atom — protonium or antiprotonic hydrogen — with a proton and an antiproton orbiting round each other under the influence of their electromagnetic attraction.

Antiprotonic hydrogen can be formed simply by stopping a beam of antiprotons in a hydrogen target. Using liquid targets it is easy to stop all

the antiprotons, but most of the produced atoms undergo too many collisions with the surrounding hydrogen molecules and annihilate before reaching the ground state, leaving no trace of low-lying spectral lines which could provide vital information on the strong forces.

Using hydrogen gas targets, collision effects are reduced by a factor of about a thousand, so that in principle the very soft (down to 2 keV and therefore difficult to detect) X-rays from the lowest energy level transitions can be reached. However to stop the same amount of incident antiprotons the target must be much longer.

Even before the advent of LEAR, an X-ray detector with large angular acceptance and low threshold, used with a gas target, succeeded in seeing the antiprotonic hydrogen 'L' lines — transitions to the energy level just one rung up from the antiprotonic ground state. But the 'K' lines — transitions down to the ground state — remained hidden. There was even speculation whether the 'nuclear' forces between protons and antiprotons were so strong as to completely mask the atomic ground state.

The low energy antiprotons from LEAR stop much more readily. For antiprotonic hydrogen studies, all LEAR groups use gas targets, while new detectors and techniques were developed. The ASTERIX (Antiproton STop Experiment with tRigger on Initial X-rays) experiment by a CERN / Mainz / Munich / Orsay / TRIUMF / Zurich group constructed a 'Spiral Projection Chamber' — an X-ray drift chamber using a radially decreasing electric field providing energy measurement and three-dimensional localization of the produced X-rays. Final annihilation products are picked up in the outer DM1 magnetic spectrometer inherited from electron-po-