

News from abroad

Dr. Budker photographed during one of his seminars given at CERN on the Novosibirsk plans for particle-antiparticle colliding beam experiments.

Novosibirsk

For two weeks at the end of April, the Intersecting Storage Rings Department was host to a group of scientists from the Laboratory for Nuclear Studies, Novosibirsk, USSR. (See also Comment, page 82). The party consisted of the Director of the Laboratory, Dr. A. Budker, his wife, Dr. B. Sidorov and Dr. B. Chirikov.

Dr. Budker gave two seminars during his visit, entitled 'Current electron-electron and electron-positron colliding beam experimentation at Novosibirsk' and 'The construction of colliding beam machines for 25 GeV proton-antiproton and 3 to 5 GeV electron-positron experiments at Novosibirsk'.

The first talk was concerned with the storage rings already built: VEP 1, an electron-electron device built principally to study the problems of particle beam storage but which, with difficulty, has been used for some experiments; and VEP 2, an electron-positron device (2×700 MeV) designed for experiments, at which some significant physics with colliding beams has already been done.

Two fascinating short films were shown of the synchrotron radiation coming from the orbiting particles. The synchrotron light enables the beam behaviour in the rings to be observed in detail. It is easily possible to follow with the naked eye the effect of induced instabilities on the beam profile by observing the light. Conversion of radio-frequency power fed into the beam, to synchrotron light emitted is practically 100% efficient. Indeed, Dr. Budker said that one electron could be traced from the light it emits. Since the storage rings hold the particles in orbit for many hours, it is possible to watch a single electron, go home to bed, and return next morning to see the same electron still turning round the ring.

The second talk concerned the very ambitious storage rings project for which building is now well under way at Novosibirsk. The intricate system is designed to make possible electron-positron experiments at 3 to 5 GeV per beam and proton-antiproton experiments at 25 GeV per beam.

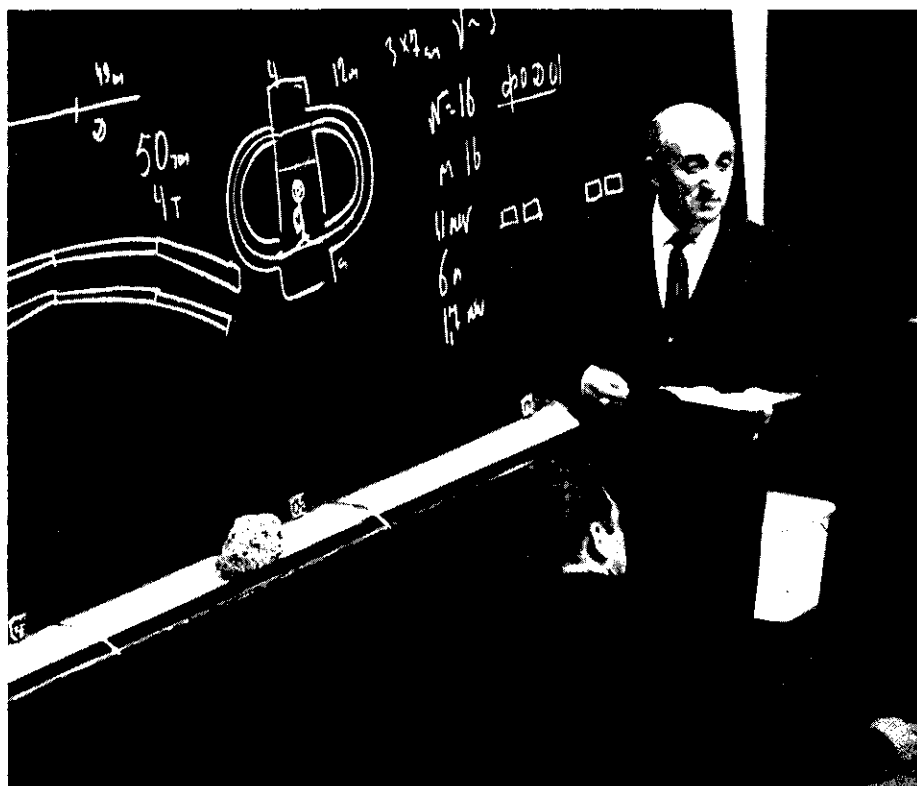
The electron-positron device for energies up to 3 GeV is a small oval shaped magnet 'ring' with ends of 8 m radius and straight sections of 12 m. The vacuum vessel cross-section is 3×7 cm and the magnets, to give a field up to 18 kG, are cast in 50 ton blocks each block giving one FODO sequence. Electrons are injected after acceleration to 650 MeV in a small ironless synchrotron of 1 m radius. They are directed onto a target to produce positrons.

New techniques have been developed to achieve a high and controllable yield of positrons. They involve the use of a special magnet lens system (an x-x lens — so called because of the shape of the pole profiles) which gives extremely high magnetic field gradients resulting in a very short focal length for the particle beam. The target sits at the focal point between two of these x magnets and the beam approaches the target with such wide angles that scattering in the target does not add much to angular spread and the second magnet catches a high intensity positron beam.

A further refinement, known as 'the dollar system' from the shape it had in its initial conception, introduces an omega shaped loop in the beam. In the loop the beam traverses wedges of triangular cross-section — the faster particles, at greater radii, pass through more of the wedge and are slowed down most. This system compresses the energy spread to about 1% before the beam is directed onto the target giving an increase of a factor of four in the yield of positrons, though involving some increase in the angular divergence of the positron beam.

The positrons are captured in the ring and their oscillation amplitudes are damped by radiation. There is then room for the injection of more positrons and injection proceeds until the desired beam intensity is obtained. Electrons are then fed in and the electron and positron beams are simultaneously accelerated to the desired energy for colliding beam experiments.

They hope to complete the electron-positron ring by the end of this year and to start experiments with it by the end of 1968.



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In preparation for the proton-antiproton system, experiments have been carried out on the use of gas jets for charge exchange injection into accelerating rings. In the experimental set-up, a 1.5 MeV Van de Graaff machine produces negative hydrogen ions. These are converted to neutral ions by being passed through a fairly low velocity jet which strips off one electron, and then injected into a small diameter betatron ring. There, another gas jet, with a velocity of twelve times the speed of sound, converts them into protons which can be accelerated to 600 MeV.

This use of jets is another novel development at Novosibirsk. Efficiencies of 75 % in particle conversion are achieved and the very fast jets in the accelerating rings do not cause much disturbance to the high vacuum. Good injection of charged particles into very small rings would be practically impossible.

The proton-antiproton system starts by charge exchange injection into an ironless synchrotron of 1 m radius. It is expected that 3×10^{11} protons can be accelerated to 3 GeV in this ring.

The protons are then injected into a large oval with ends of 45 m radius and 36 m straight sections, around which the experimental halls are built. Acceleration continues in the large oval to 25 GeV and the protons are then directed onto a target to produce antiprotons. It is hoped to achieve about 10^{-7} antiprotons per pulse.

The antiprotons are stored in the smaller oval used for the electron experiments and there they are 'electron cooled'. This new technique was described in CERN COURIER vol. 6, page 219. It serves to take the random motion out of the antiproton beam which then reduces to 1 mm diameter. The whole cycle, as described above, will be repeated about 1000 times to accumulate an antiproton beam of 10^{10} particles.

A further 120 pulses of 3 GeV protons are injected into the big oval and will build up a proton beam of 10^{14} particles.

When the large oval is filled with protons, the magnet fields in the two ovals are equalized and the antiproton beam is brought into the big oval and the energy of the protons and antiprotons is raised

to the desired value for colliding beam experiments. An interaction rate of $2 \times 10^4/\text{s}$ has been calculated which is ample for experiments, allowing a large safety factor if all the complicated processes do not operate as efficiently as expected.

Construction of one large experimental hall and of the tunnel for the big oval is complete. They hope to have all the components of the big oval installed by the end of 1968 and to be ready for experiments by 1970.

Stanford

Two articles in the April issue of 'Physics Today' report on the performance of the 20 GeV electron linear accelerator and on the experimental programme coming into effect at the Stanford Linear Accelerator Centre.

In January of this year, the design energy of 20 GeV was achieved. (High energy beams (10 GeV) first travelled the full length (3 km) of the accelerator in May 1966.) The beam current is between 15 - 30 μA at a pulse repetition rate which can increase to 360 per second. About 90 % of the beam current measured close to the injector can be accelerated along the full length of the machine. It is possible to accelerate simultaneously at least three time-interlaced beams to different energies and with pulse-length and intensity independently controlled — thus experiments can proceed at the same time in several physically separated areas.

A positron beam is required to emerge about $2/3$ along the accelerator length for the proposed electron-positron storage ring to be built in association with the linear machine. A converter can be introduced about $1/3$ along to produce positrons and it is hoped that positron beams of 2.5×10^{11} particles with an energy spread of about 1 % can be accelerated.

For the experimental programme, electron, positron, photon and muon beams in particular will be available. Detection equipment will include three large spectrometers (the largest weighs 1700 t and is 50.2 m long); two magnet spark chambers (one using a magnet of 500 t with a field of 15 kg) and a streamer spark chamber $2.4 \times 1.2 \times 0.6$ m in volume; and two

hydrogen bubble chambers (one of 1.02 m diameter and one with an effective length of 2.08 m).

The approved experiments include elastic electron-proton scattering to continue the examination of the electromagnetic structure of the proton; photoproduction experiments (including the photoproduction of antiprotons and of strange particles), a search for new particles (particularly those having only electromagnetic or weak interactions); and muon-proton elastic and inelastic scattering.

Frascati

The electron-positron storage ring, ADONE, with a maximum energy of 1.5 GeV per beam, is nearing completion at the Frascati Laboratory, Italy.

The injection system was completed in Autumn 1966. It provides pulses of electrons of up to 100 mA peak current within an energy spread of 2 %, at an energy of 350 to 400 MeV. Pulses of positrons are produced at up to 1 mA peak current. The linac injector can operate at 250 pulses per second and can send beams direct to an experimental hall as well as feeding the storage ring (only 2 or 3 pulses per second are needed for the storage ring).

Acceleration to 1.5 GeV takes place in the storage ring itself where two r.f. cavities are installed to accelerate the particles and to make up the energy lost by synchrotron radiation. The ring has a mean diameter of 16.7 m (the radius of the magnet sections is 5 m) with four beam intersection regions. The cross-section of the vacuum vessel is 14×7 cm. It is hoped to store 2×10^{11} particles per beam.

Japan

The Japanese Government has approved the construction of a 40 GeV alternating-gradient synchrotron. This was recommended by the Japanese Science Council in the 'First-Five-Year Plan' for long range research projects, presented in October 1965.