

Particle factories

Physicists' attention is increasingly turning to the high luminosity frontier – providing enough collisions to amass sizable numbers of rare events – to complement the traditional quest for higher energies. This month we cover three areas where projects are now being considered.

Phi-factory workshop

Following an initiative by Conrad Kleinknecht of Mainz, Guido Barbiellini of Trieste and Walter Hoogland of the Dutch NIKHEF Laboratory, the interesting possibilities opened up by a high-luminosity electron-positron collider operating near the phi resonance at 1020 MeV were investigated at a recent two-day informal workshop at NIKHEF.

Such a phi factory is being considered at the Soviet Novosibirsk Laboratory, where a collider is already operational at that energy range, and ideas are also being actively explored at Mainz, Trieste, Frascati and NIKHEF.

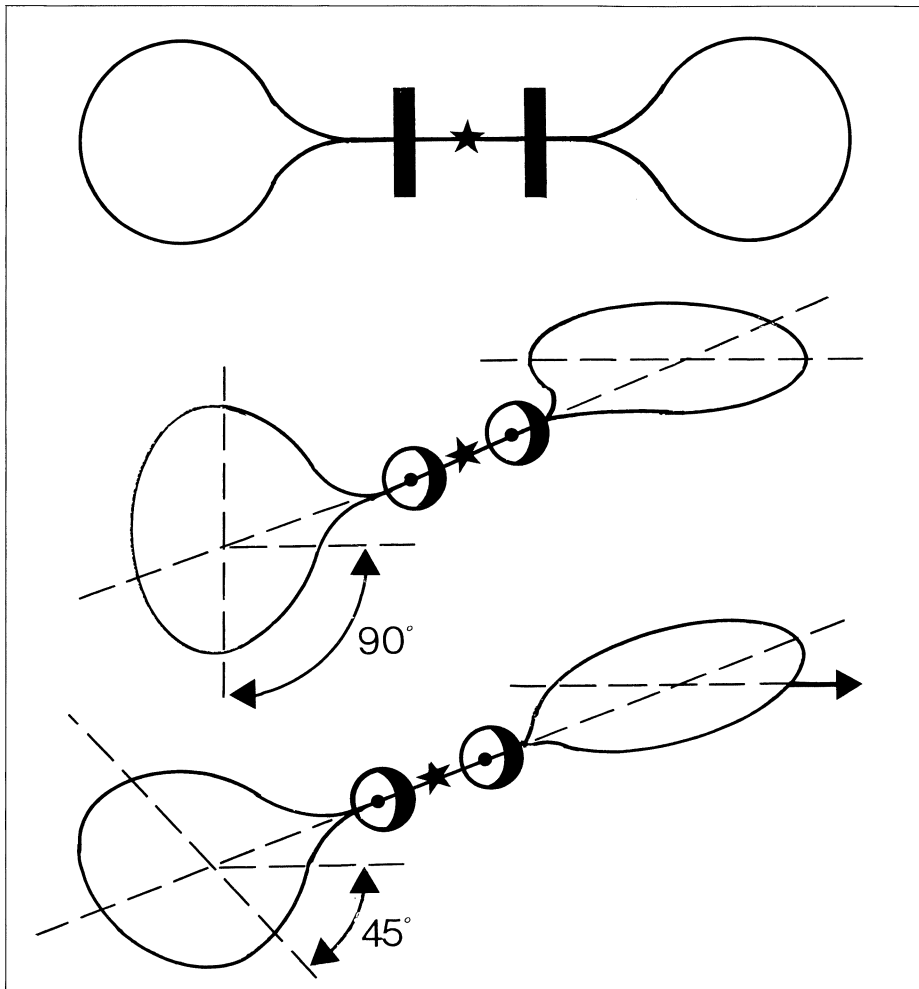
Associated physics objectives have to do with violation of the combined left-right reflection and particle-antiparticle reversal (CP) symmetry – a physics effect still not fully understood 25 years after its discovery.

The decay of a phi into a short-lived and a long-lived kaon, with both kaons decaying into two pions, produces unique interference effects due to the antisymmetric character of the phi. Experiments in this domain would have an impact if up to 10^{10} decays into two charged and two neutral pions

could be collected. The workshop considered both the prospects to reach a high enough collision rate (luminosity well beyond 10^{32} per sq cm per s) and the design of suitable detectors.

The discussions on CP violation began with Heinrich Wahl (CERN) surveying past, present and proposed CP violation experiments. Detector designs covering a nearly complete solid angle for an electron-positron collider were described by Guido Barbiellini of Trieste and Claudio Santoni of Basel, Klaus Peters of Mainz and Frits Ern  of NIKHEF. The kinematics of phi factories would provide interesting new opportunities to study

Proposed 'dog-bone' schemes for small electron-positron colliders.



delicate effects in the decays of short- and long-lived neutral kaons.

A lot of imagination has gone into the design of suitable circulating-beam colliders, described at the meeting by Andreas Streun of Mainz. The possibilities included circular rather than flat beam solutions, combined with separate rings for electrons and positrons, and bunches alternating between the two rings. Luminosities above 10^{33} , with large tune shifts, up to 0.12, seem possible with such schemes. A more conservative approach for NIKHEF (Jan Botman – Eindhoven) promises a few 10^{32} .

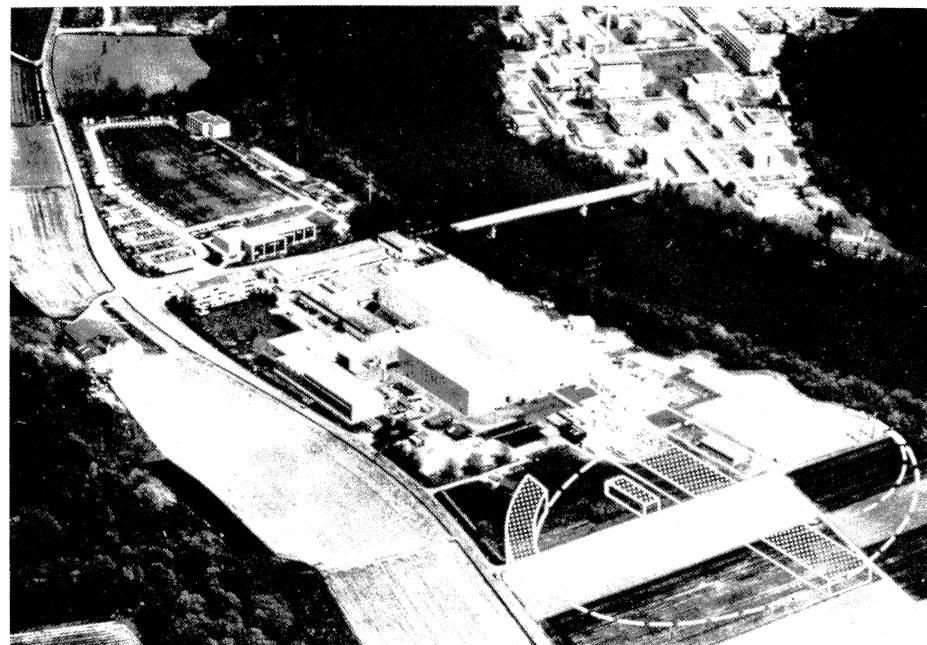
Antonio Dainelli from Padua considered the possibilities of posi-

trons in a superACO ring colliding with electrons supplied by a superconducting linac. Such schemes originating from John Rees and recently revived by P. Grosse-Wiesmann of Stanford have been looked at for a phi-factory by Carlo Rubbia and Albin Wrulich in connection with the planned Elettra synchrotron light source at Trieste. Luminosities of a few times 10^{32} seem within reach, but Sergio Tazzari of Frascati underlined potential difficulties due to possible instabilities due to significant energy deposited in the interaction point, and a beam disruption parameter of the order of 50, leading to curled up beams.

John Jowett of CERN, summarizing this session, argued that the double storage ring machines looked more promising than schemes involving linacs. However these schemes to push storage ring technology to its limits were beginning to look almost 'conventional' compared with some of the other ideas presented at the workshop. Although no phi particle factory has yet been built, a luminosity of 10^{32} seems within reach.

A final session looked at other physics opportunities. Mike Albrow (Rutherford/Stockholm) considered radiative decays, with imaginative photon detection using liquid noble gases. Bernard Jean-Marie of Orsay reviewed physics results between 1 and 2 GeV achieved so far using relatively modest collision rates. Mario Greco showed the need for accurate hadron production measurements over a wide energy range to make precision corrections to the mass of the Z boson and the magnetic moment of the muon.

In conclusion, Frits Ern  underlined how a phi-factory with luminosities in the 10^{32-33} area would give a substantial boost to CP vio-



The Paul Scherrer Institute (formerly SIN) spanning the River Aare in Switzerland, showing the twin-ring structure of the proposed B-meson factory.

lation measurements. Building an electron-positron collider to guarantee this performance is far from straightforward, and the first task is an extensive programme of calculations to firm up the existing proposals. NIKHEF Director Walter Hoogland remarked that the cost leaves room for only one such facility in Europe.

PSI Planning for B meson factory

The rich physics potential of a copious supply of B mesons (containing the heavy b quark) has awakened interest in B-meson 'factories'.

Worldwide more than ten groups are looking at possibilities for electron-positron colliders with total energies around 10 GeV and with luminosities in the 10^{33-34} per sq cm per s range. These very high

collision rates are necessary to see the violation of the combined left/right reflection particle/antiparticle (CP) symmetry in B-decays, should its strength be as predicted by the Standard Model. So far, CP violation physics has been confined to the neutral kaon sector.

But CP-violation is just one of many interesting topics at B-factories – neutral B mixing, rare B-decays and upsilon spectroscopy are also on the menu, while charmed baryons and the tau lepton wait for complete investigations.

In addition to high luminosity it is important to have lots of running time, a small diameter beam pipe at the interaction points for good resolution of the fine details of the collisions, and low background in the detectors.

A pioneer and now well advanced proposal is the double storage ring project at the Paul Scherrer Institute (PSI – formerly SIN) in Villigen, Switzerland. After endorsement by an international review committee, a physics, machine and detector proposal was

Worth a closer look...

No. 1/1989

LB Landolt-Börnstein NEWSLETTER

Printed Data Collections or Data Banks?

In the age of computer storage of scientific data the role of printed data collections has to be discussed. Will floppy disks and CD-ROM's take the place of printed books? Will the LANDOLT-BÖRNSTEIN Series be replaced by a data bank in the near future?

The answer can only be that both are necessary, printed data collections and computer stored data. Data banks are no substitute for printed information. Electronic retrieval can provide very fast access to individual items of information and large amounts of data can be stored and distributed on-line. However, if a broader scope is required, a computer search can lead to an avalanche of redundant information which the user then has to condense and to evaluate, not knowing who has - when and according to what criteria - put this information into the computer. Furthermore, such a search can be more expensive than the price of a good printed data collection on this field. Even, looking for a single value, it is often advantageous to have a table available with data collected, condensed and assessed by a well-known specialist.

Thus, printed data collections should not compete with data bases by presenting data in exactly the same way. Rather, they should complement one another. Since the first edition more than a hundred years ago, LANDOLT-BÖRNSTEIN has followed a policy consistent with this aim. It provides data with all information necessary for its assessment, e.g. the experimental conditions and method of measurement and evaluation as well as due reference to the original paper. Graphical representations are used to an increasing extent to replace tables of data. LANDOLT-BÖRNSTEIN thus presents an overall picture, permitting direct

access to single items of data as well as a ready comparison between various data and providing a complete view of all relevant material on a particular physical quantity. Last but not least the reader is kept informed on who has chosen and assessed the data selected from the huge amount published in scientific papers.

Nevertheless, the great mass of data published does raise the question as to whether selected parts of the contents of LANDOLT-BÖRNSTEIN should not be made available on-line, in floppy disk or compact disk forms as well as (or instead of) the printed version. Discussions are currently in progress as to whether such changes can and should be implemented in the future. We will keep you informed in due course in one of our Newsletters.

Otfried Madelung
Editor-in-Chief

LANDOLT-BÖRNSTEIN NEWSLETTER

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Alvaro de Rujula's view of lower energy electron-positron collider physics. Left, the DORIS (DESY) and SPEAR (SLAC) rings grew fat on charmonium resonances, while the proposed tau-charm factories (top) have a good chance of grasping rare physics. Centre, Cornell's CESR ring with a harvest of heavy quark fruits. Right, PETRA (DESY) and PEP (SLAC), lean and mean on a physics diet largely restricted to inter-quark glue.

recommended for further evaluation. Hopefully it will be formally forwarded to the Swiss government this fall, the final step being approval by the Swiss Parliament. Construction could begin at the earliest by the end of next year with first electron-positron collisions expected during 1995.

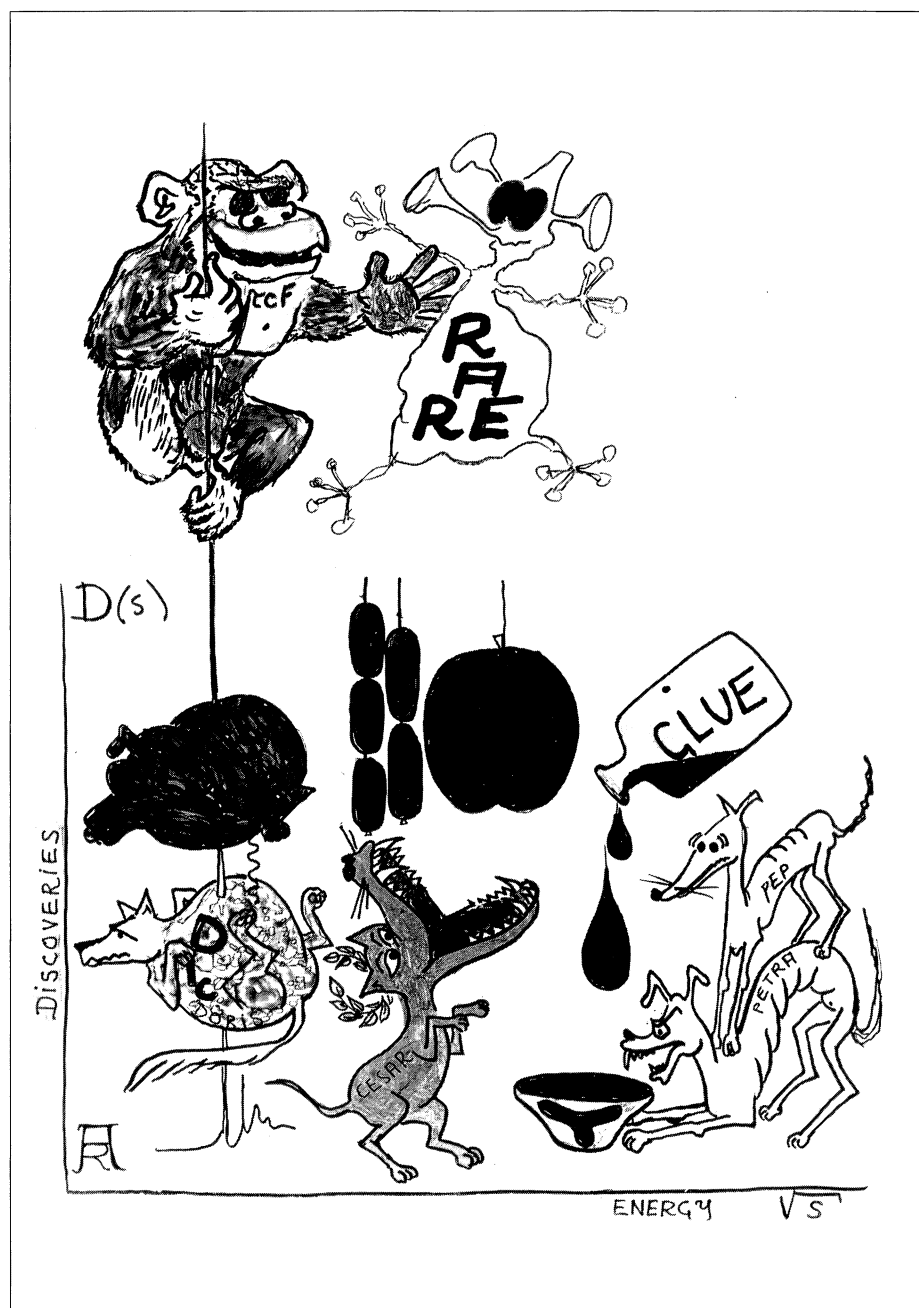
The collider design is based on a multi-bunch double storage ring with two interaction regions and zero degree beam crossing angle. Beam separation uses either electrostatic deflection plates or a radiofrequency magnet. Energy extends from 1.5 to 7 GeV per beam, with injection using two linear accelerators of 200 and 400 MeV, a 400 MeV accumulator ring and a 6 GeV synchrotron.

A luminosity of 10^{33} should be reached after one year of commissioning. Fivefold higher luminosities could eventually be attained by storing higher currents. The collider could operate either in a symmetric mode with beams of equal energy or asymmetrically with 4 on 7 GeV to produce B-mesons with a relativistic boost.

According to designer K. Wille (Dortmund), the luminosity in the asymmetric mode is expected to be a few times lower than with symmetric operation. But experiments using the asymmetric mode would profit from a better reconstruction of short-lived B-meson decays.

The rings could accommodate two experiments. A contender for one of the intersections is the Crystal Barrel experiment now running at CERN's LEAR Low Energy Antiproton Ring. At PSI, this experiment would look at the physics of J/psi and psi prime particles.

About 50 interested physicists from Germany, France, Poland, Switzerland and the US are presently working towards a detailed



proposal for the other interaction region. The detector aims for excellent vertex resolution of 20 microns for B decays using a thin silicon vertex detector, pion/kaon separation up to 2.5 GeV momentum with a fast ring imaging Cherenkov (RICH) counter and good neutral pion reconstruction in a finely segmented cesium iodide calorimeter. So far there have been eight plenary meetings of the detector study group, the latest having been in Paris at the end of March. The next one will take place in the last week of September at Fribourg, Switzerland. Further information from R. Eichler (ETH/PSI) and K.R. Schubert (Karlsruhe).

Tau-charm factory

Late in May a workshop at Stanford (SLAC) explored the idea of a high-luminosity electron-positron collider operating between 3.0 and about 4.2 GeV. Such a 'tau-charm factory' would manufacture up to 10^{10} J/psi particles (with 'hidden charm'), 10^8 charmed mesons and almost 10^8 tau leptons per year at its design luminosity of 10^{33} per sq cm per s.

First proposed by Jasper Kirkby at CERN, such a collider is now under consideration at SLAC, and by institutions in Japan, Spain and the

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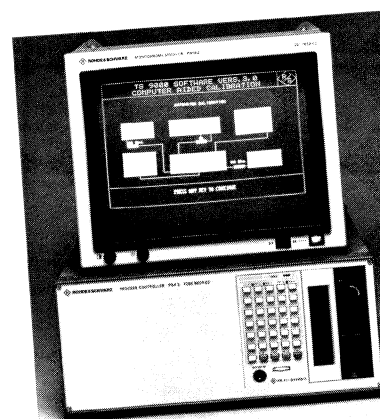
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Soviet Union, as a logical next step in storage ring development after the newly-commissioned BEPC machine in Beijing.

Attracting almost 200 participants from 12 countries, including 40 accelerator physicists, the workshop began with plenary sessions, with working groups subsequently examining various aspects of machine and detector design, and physics prospects.

Machine discussions began with John Jowett's design for a double ring machine with a single clash-point. Electrostatic separators would enable each ring to carry 24 bunches and a fat beam current of half an ampere. Other designs also used a two-ring scheme. Gus Voss of the German DESY Laboratory suggested using about 400 bunches and 'crab crossing' to increase the luminosity to 5×10^{33} . Susumu Kamada of the Japanese KEK Laboratory outlined the idea of a tau-charm factory in the TRISTAN Accumulator Ring. During an evening session, Juan Antonio Rubio of CERN and CIEMAT (Madrid) outlined Spanish plans to build a tau-charm factory near Seville.

While the accelerator physicists deliberated how to build a tau-charm factory, the rest of the participants studied how to use it for research. CERN's Alvaro de Rujula launched discussions among the physics and detector groups, pointing out the complementary particle physics frontiers of high energy and high luminosity.

The working group on tau physics stressed how the tau lepton and its neutrino are less well understood than the other leptons, largely because of the small supply available so far. Current tau measurements still allow large deviations from the Standard Model, and 'new physics' could emerge from higher statistics. Tau decays

would be an excellent testbed for the Standard Model, and the tau neutrino mass could also be fixed.

Led by Rafe Schindler, the charmed meson working group examined precision measurements of inter-quark couplings, leptonic decays of D mesons, neutral D mixing and rare D decays. There was also plenty of interest in the possibility of observing CP violation in the D meson system either directly or through mixing.

Fifteen years after its discovery, charmonium (charmed quarks and antiquarks bound together) is still an exciting field. A group led by Walter Toki examined the potential of a tau-charm factory for glueballs (particles composed of the gluon carriers of the inter-quark force), quark/gluon hybrids and exotic four-quark states. An enormous number of J/psi and psi-prime decays would provide a good probe of the force between charmed quarks.

Organized by Jasper Kirkby, the detector group produced a design using fairly low-risk technologies (a high-resolution central tracking chamber with large solid angle, and a crystal electromagnetic calorimeter) that nevertheless satisfied the stringent constraints imposed by the physics and accelerator groups. Particle identification and full coverage of all emerging particles (hermeticity) are stressed, the latter accomplished using an outer fine-grained neutral hadron tagger, and allowing good coverage of tau neutrinos.

On the final morning of the workshop, John Jowett concluded for the machine builders. A double-ring electron-positron collider operating in the tau-charm energy range could indeed be built with the desired luminosity, but it would require a dedicated injector/accumulator to 'top off' the beams fre-

quently, keeping the machine near its peak luminosity. At the highest currents, multibunch instabilities and ion trapping in the electron ring would need a lot of attention.

In a final summary, Martin Perl of SLAC, who discovered the tau lepton more than a decade ago, estimated a tau-charm factory to have a useful research lifetime of 10 to 15 years. The physics, he observed, 'would be broad, deep, and exciting.'

From Rafe Schindler

ANNIVERSARY 25 years without CP

In 1964 a small group of Princeton University physicists led by Jim Cronin and Val Fitch performed a landmark experiment at Brookhaven. Using a double-arm spectrometer, they showed that long-lived neutral kaons occasionally decayed into a pair of pions – violating the hitherto sacrosanct CP symmetry of combined mirror reflection and particle-antiparticle switching (April, page 4).

From May 21-26 scientists gathered at the Château de Blois, southwest of Paris, to celebrate the 25th anniversary of this achievement. In an opening session, surveys and reminiscences of the principal experiments on CP violation were presented by Robert Adair, Abraham Pais and Jack Steinberger. Surprisingly absent from this nostalgia was any detailed discussion of the Cronin-Fitch experiment that started all the fuss.

That afternoon the four principals in the 1964 experiment outlined their current research pro-