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NEW PROPOSED ACCELERATOR FACILITIES IN WESTERN EUROPE

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Introduction

In Western Europe there is an extended collaboration in elementary particle physics among scientists from many independent countries. The formal part of this collaboration is manifested through CERN. However, most of the Western European countries have their own national programme, partly centred around national laboratories with their own accelerators, partly based on research groups working with or at the CERN accelerators. Even these national activities have had a very constructive informal co-ordination. Priorities have to a considerable extent been influenced by Europe-wide discussions and evaluations. There is every sign that the same will happen in the decision-making process on the next generation of high-energy facilities in Western Europe. Nevertheless, a co-ordinated programme has not been established yet, and I will therefore give an account of the individually proposed high-energy facilities under discussion without passing too much judgement on how we can expect them to be co-ordinated.

The present paper is limited to major projects for elementary particle physics. This means that there are a number of medium large projects that are not included, such as the conversion of SATURNE to a nuclear structure facility and NINA to a synchrotron light facility, to mention two examples.

Proposed $e^+ - e^-$ Facilities

There is in Western Europe already a long tradition in electron storage rings through devices like ADA, ADONE, ACO, DORIS. As we all know, the physics from colliding electron beams has, in the last few years, become richer than most people had dared hope for, culminating with the exciting discoveries last autumn. It has therefore been natural for some of the European laboratories to consider if it would be desirable and possible to follow up this line with even more powerful devices. The primary aim would, of course, be to strengthen high energy physics in general in this way. A not unimportant secondary aim is, however, to see if such projects cannot also help in strengthening some of the local centres and keep alive the powerful physics environments that have developed around the national laboratories, as a counterbalance to the strong centralizing forces constituted by a laboratory like CERN.

The Design of the 14 GeV Electron-Positron Storage Ring System (EPIC) at the Rutherford Laboratory

Introduction

The basic design of EPIC was reported at the IXth International Conference on High Energy Accelerators held in May, 1974, and a status report with several new or alternative features will be printed in the Proceedings of the present Conference. Authorization has since been sought to proceed with the construction of the 14 GeV electron-positron colliding beam system at the Rutherford Laboratory. While the proposal is being assessed by the British Science Research Council, design studies continue.

The Machine Design

An important element in the machine design has been to make as much use as possible of existing equipment at the Daresbury and Rutherford laboratories and to exploit existing Rutherford site facilities. An overall perspective of the EPIC electron-positron machine complex on the Rutherford Laboratory site is illustrated in Fig. 1. Main parameters are listed in Table I.

Table I: EPIC Parameters

Energy	2 × 5 to 14 GeV
Luminosity	3×10^{31} cm^{-2} s^{-1} at 14 GeV
Current max.	90 mA
RF power	4 MW
Frequency	400 MHz
Total length of cavities	42 m
Number of bunches/beam	2
Number of intersections	4
Free length of experiments	17 m
Circumference	2192 m
Bending radius	172 m
Focusing	FODO
Injection energy	5.3 GeV
Amplitude functions at intersection $\beta x^*/\beta y^*$	1.5m/0.15 m

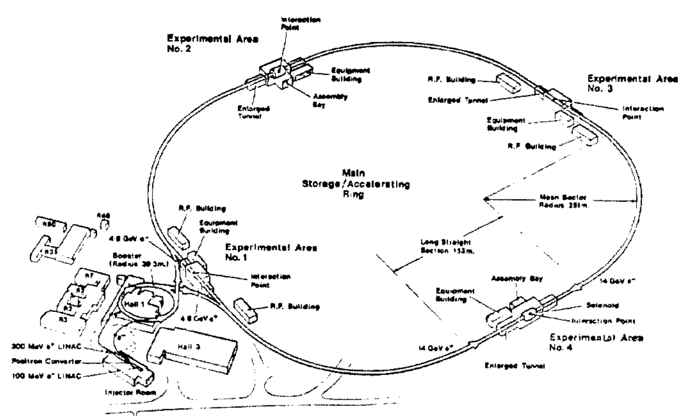

Fig. 1 - The EPIC 14 GeV Electron-Positron Storage Ring.

Starting at the bottom left corner of the Fig. 1 perspective diagram, linear accelerators inject pulses of electrons or positrons into the booster synchrotron, which accelerates them to 5.4 GeV. The booster cycles at a repetition rate of eight pulses per second. From this synchrotron they are transferred to the main accelerator storage ring. When enough particles of each type have been injected into the main ring they are accelerated to the desired operating energy for collisions and stored at that energy. The peak operating energy in EPIC is 14 GeV, and the minimum is about 5 GeV. Bunches of electrons and positrons circulate in opposite directions in the racetrack, and at the selected energy they are steered to make head-on-collisions at the centres of the four long straight sections.

The lattice design is of the conventional FODO type with dipoles and quadrupoles. The tunnel is 4 m in diameter, thus leaving above the standard lattice ample space for adding a proton ring if required.

The ratio of vertical to horizontal emittance, set by coupling between these two degrees of freedom will be 1:10 - similar to the value achieved in SPEAR. The magnet aperture has been designed to take a ratio 1.66:10.

The vertical aperture inside the vacuum vessel is 50 mm, allowing for ± 10 mm for closed orbit distortion and leaving ± 15 mm for the beam. The radial width of good field is 65 mm, allowing ± 10 mm for the closed orbit, ± 8 mm for momentum spread, ± 37 mm for the betatron motion and ± 10 mm for the sagitta.

EPIC plans for an installed RF power of 4 MW, in this case made up of 1.4 MW synchrotron radiation losses and 2.6 MW cavity losses, including those due to the higher modes induced by the very short electron bunches passing through. The assumed length of RF cavities is 42 m, arranged symmetrically about the straights. It will be possible, if necessary, to extend the cavities to 230 m of structure and 8 MW of power.

The vacuum system is fairly conventional, using aluminium tube, ion pumps, and a good pumping speed - 30 times that required for clean surfaces after a long period of operation.

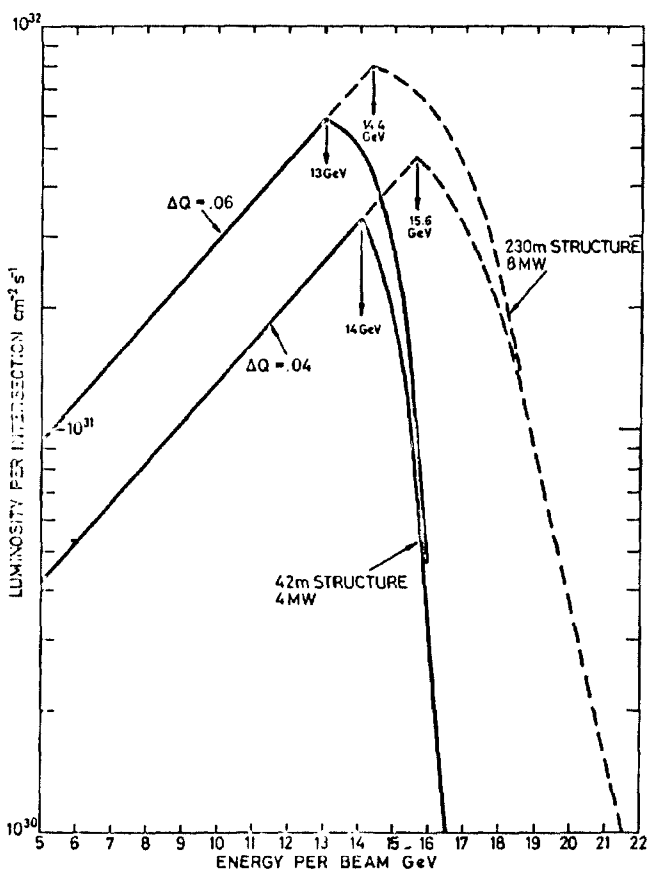

Fig. 2 - Luminosity versus energy for EPIC.

The graph in Fig. 2 shows estimated luminosity as a function of energy. The rise from bottom energy to a peak at 14 GeV was limited by the effect of beam-beam interaction. At higher energy the limiting factor is the amount of RF power available. If the assumed acceptable beam-beam tune shift of 0.04 should turn out to be too pessimistic, the low energy part of the curve can be moved upwards. If more RF power is made available, the high-energy part of the curve can be lifted.

The site described in the official proposal extends over the ample agricultural land to the south of Rutherford Laboratory (Fig. 1), but since then an alternative lay-out had also been investigated, which has the advantage of more central placing and of using land already owned by SRC or AEA. The foundation is good chalk shown by boreholes to be very hard. It will provide a stable foundation for the machine and be good for tunnelling.

The Development Potential of EPIC

The design group of EPIC attaches importance to its development potential. They list possible options for the future as:

a) Addition of more RF power and cavity to raise the energy. The limit will be set by machine physics and money rather than available space for RF cavities.

b) Provision of a system to produce longitudinal polarisation.

c) Provision of an additional magnet ring for protons. The design report states that a conventional magnet system could reach 80 GeV, a niobium-titanium magnet 200 GeV and a niobium-tin system could possibly reach 400 GeV.

d) A further extension is then possible to permit use of a deuteron beam.

Present Status

The Advisory Board on Research Councils (ABRC), above the SRC in the UK decision-making process, has given a favourable reception to the project as early as July 1974. The SRC, though it accepted the science case for EPIC in November 1974 and has authorized continued studies at a high rate, has not yet been able to judge whether the necessary construction funds could be made available. The Rutherford Laboratory considers the prospects for the project to be good.

PETRA, an Extension of the Storage Ring Installations at DESY Laboratory

Introduction

The second $e^+ - e^-$ colliding beam facility that is presently under discussion and evaluation in Western Europe is the proposal made by the DESY Laboratory in West Germany. They aim at a maximum energy of 2×19 GeV and a peak luminosity of about 10^{32} cm^{-2} s^{-1} at 2×14 GeV. An essential feature is the use of the 7.5 GeV synchrotron and the 3.5 GeV storage ring DORIS for injection and prestorage. (Hence the name Positron-Electron-Tandem-Ring-Accelerator.) The DESY Laboratory feels that PETRA is a natural extension of the present DESY programme. Its basic design has been reported in a contributed paper to this conference, but I shall nevertheless recount its main features.

Machine Design

PETRA is a single ring with a circumference of 2304 m. The ring consists of eight 45° arcs separated by four short straight sections (each 64 m long) and four long straight sections (each 108 m long) (see Fig. 3 and Table II). Initially, the four short straight sections will be used for colliding beam experiments. The free space foreseen for standard experiments will be 10 m and can be increased for special experiments up to 20 m. In two of the long straight sections the RF cavities will be installed. The other two long straight sections or, if required, all four can be equipped with additional experimental areas, and hence in total eight experimental areas are available.

Table II: PETRA Parameters (1st stage)

Energy	2 × 5 to 18.5 GeV
Luminosity	$> 10^{31}$ cm^{-2} s^{-1}
Current max.	95 mA
RF power	4 MW
Frequency	500 MHz
Total length of cavities	134.4 m
Number of bunches/beam	1 to 4
Number of intersections	4 (8)
Free length for experiments	10 (20) m
Circumference	2304 m
Bending radius	197.15 m
Focusing	FODO
Injection energy	7 GeV
Amplitude function at intersection $\beta x^*/\beta y^*$	3.0 m/0.15 m

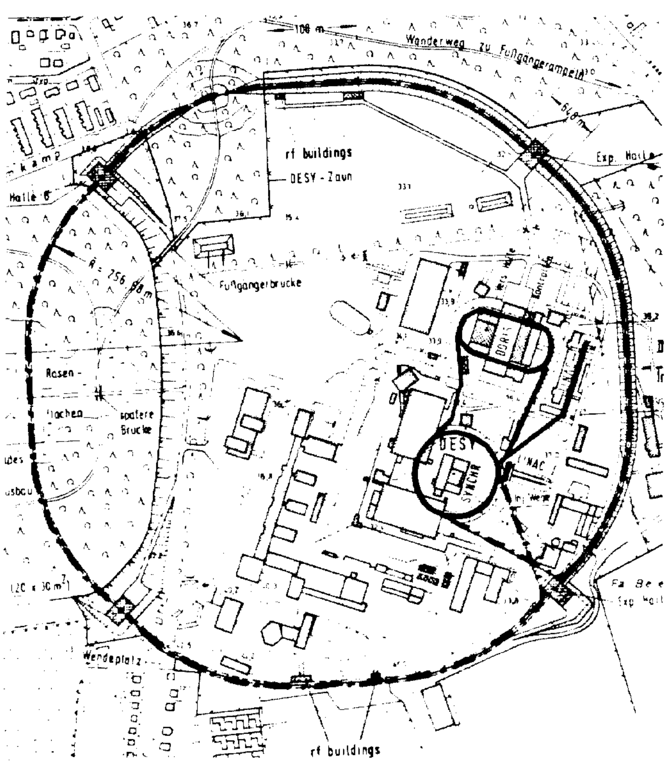

Fig. 3 - The PETRA 18.5 GeV Electron-Positron Storage Ring.

The magnet system consists of 192 identical half-cells each composed of a bending magnet, a quadrupole and a sextupole and may be excited to a maximum energy of 23 GeV. Two different apertures (5 and 7 cm bore radius) are foreseen for the quadrupoles. Different focusing strengths are achieved by three different quadrupole lengths.

In the first stage an RF power of 4 MW will be installed. The total length of the accelerating cavities will be 134.4 m which is needed to reach 19 GeV. At lower energies a shorter RF structure might be more favourable and hence part of the cavities could be shortened or removed from the ring. Normally four particle bunches will be stored; however, at the highest energies where the current is limited by RF power this number will be decreased to one.

The vacuum chamber is fabricated of aluminium and in the bending magnets integrated ion pumps will be installed. The overall pumping capacity is such that beam life times of several hours should become possible comparable to what has been achieved with DORIS.

The luminosity depends on the operating mode of the storage ring. In the simplest mode the optics is not changed with the operation energy E in which case the luminosity varies with E^4. If the focusing is reduced at lower energies, the beam emittance and the beam currents can be increased and as a consequence the luminosity changes as $\sim E^{2.4}$ (see Fig. 4).

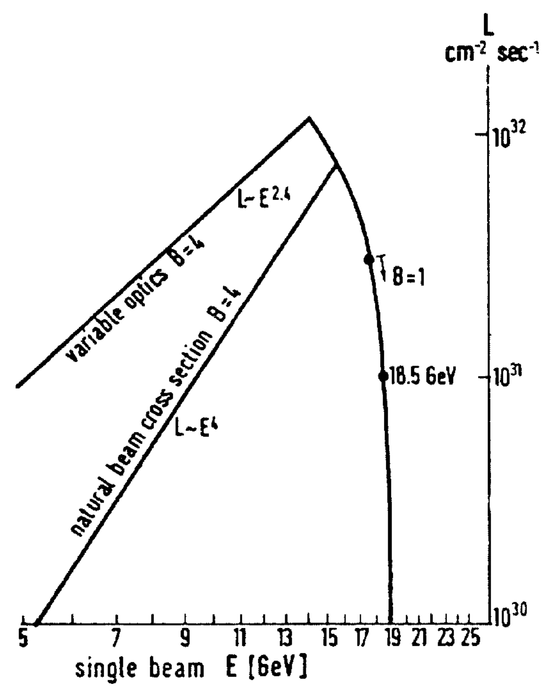

Fig. 4 - Luminosity in PETRA (P_{rf} = 4 MW, L_c = 134.4 m).

The ring tunnel will be built by a cut-and-fill method. The transfer channels from DESY to PETRA will contain magnetic elements only at the ends and hence most of their lengths will consist of cheap simple pipes. Four experimental halls are planned for the beginning, each 20 × 30 m^2 with the possibility of an easy expansion if required for special experiments. Apart from four light buildings for the RF transmitters no other buildings besides those mentioned above have to be constructed since the main control room, power supplies, central computer, cooling equipment, etc. exist already or can be accommodated in available buildings. The land necessary for the extension of the site is owned by the state and has been reserved in the long-term planning for DESY by the authorities.

Integration of PETRA into the Laboratory Programme

By changing the emphasis in the programme of utilization of the existing facilities it will be possible to integrate PETRA in such a way that besides the injection system other components will become available and a considerable saving in capital and operating funds can be achieved. When PETRA will come into operation, DORIS will be restricted from its present possible maximum energy of 2 × 5 GeV to energies below its original design energy of 2 × 3.4 GeV. This will still permit a full programme at these lower energies, but because of the energy reduction certain components of DORIS will become free for PETRA. This includes the complete power supply for the PETRA magnets, 1 MW of RF power and general power and cooling installations. In addition certain other valuable items are already on hand.

Since only short time intervals are needed for injection into PETRA the physics programme at DORIS and DESY will continue.

The Development Potential of PETRA

If the physics results at lower energies should justify it, PETRA could be developed in the following ways:

1) The proposed ring is designed for energies up to 23 GeV. In particular the already existing power supplies would permit to go to such an energy, and the number of quadrupoles foreseen in the design is sufficient for such energies. However, more RF power and more RF cavities will be needed. These could be added if funds become available.

2) A second magnet ring could be added in order to allow the observation of $e^- - e^-$ collisions. The tunnel cross-section is large enough for this purpose. The RF system would be used to accelerate the beams in both rings.

3) If superconducting accelerating cavities become technically feasible it might be possible to push the maximum energy into the region of 30 GeV with luminosities of about 10^{30} cm^{-2} s^{-1}.

4) No e - p option is foreseen.

Injection

You will notice that up to this point I have not described injection into either of the two machines in detail for this subject has been the matter of some debate as the two design studies evolved. Since luminosity lifetimes are of the order of hours, filling times should be of the order of 5 to 10 min and two rate problems arise. First, at injection energies (typically as high as 1/3 of maximum design to alleviate Touschek lifetime and instability problems) the betatron and synchrotron damping times are still long - of the order a few hundred ms. This implies injection pulse rates of no higher than 10 Hz. Second, these high energy machines operate with only a few bunches per beam, so a way must be found to put all the charge, and remember positrons must also be created, into a few of the many available buckets. Although quite different in concept, the designers of both projects have found novel solutions to these problems and now claim comparable and adequate rates.

In the DESY design, use is made of both the existing DESY synchrotron and DORIS as intermediate storage and accelerating devices. Briefly, their scheme is as follows:

1) Only 30 equally spaced bunches (out of 480) are continuously accumulated in DORIS at 50 Hz via acceleration by DESY to 2 GeV.

2) Then every 140 ms one of the stored bunches is ejected, re-injected into DESY while it is ramping to 7 GeV, ejected from DESY at the top and placed into a single PETRA RF bucket.

3) The next in line of the 30 DORIS bunches is treated the same way while the others are still accumulating.

This scheme requires some sophisticated synchronization and fast kicker technology but the designers are confident of their plans since the first half of the system is already operational. The potential enhancement, over using just DESY without DORIS, is a factor of 200 and a filling rate of 7 min is said to result.

The EPIC designers propose to use the Daresbury synchrotron as a booster but since they do not posses an intermediate storage device, have added several interesting wrinkles such as post-linac energy compression and high frequency booster phase compression. Recently revised details are listed below:

- 100 MeV electron linac with gun modulation to give 4 A pulses 10 ns long.

- Energy compression system to give a reduced energy spread.

- Injection into the booster (modified NINA) into 8 buckets of a 58 MHz RF system.

  Acceleration in the booster to 2.2 GeV.

  Flat in the booster for damping.

  Change-over to existing high power 408 MHz RF system.

  Accelerate.

- Inject 8 bunches into one bunch in the main ring by 8-turn injection into transverse phase space.

- Electron and positron bunches are filled on alternate booster cycles.

This scheme gives, with the parameters listed, the following performance:

Booster repetition rate	8 Hz
Positrons per booster fill	3.6×10^9
Booster energy	5.3 GeV
Main ring damping time	0.3 s
Time to fill 4 bunches: (1.6×10^{12} e^+ and 1.6×10^{12} e^-) (excl. operational set-up)	4.5 min

In the new design 50% injection efficiency into the main ring is assumed.

Even more recently an alternative scheme, following ideas originating at Cornell, has been worked out. Briefly, the idea is to store many bunches (the number being determined by fast kicker technology) in the main ring. The many bunches are then accreted into one by taking each main ring bunch, transferring it into the booster where it circulates at approximately fixed energy for the appropriate time so that on retransfer to the main ring it is co-incident with the accreting bunch. Obviously, there have to be appropriate relationships between the circumference of the two rings, the length of the transfer lines, the numbers of bunches in each ring and the RF frequencies in the two rings. The scheme allows the use of a fast cycling synchrotron ($\sim$ 50 Hz) without the requirement for an intermediate storage ring.

It appears to me that necessity is truly the mother of invention in this field and we look forward with fascination as the designers of these projects try to outdo each other.

General Remarks on Exploitation

The two $e^+ - e^-$ projects that I have described, have been proposed by two national laboratories and, as I understand it, the construction of each of them will be the responsibility of the proposing laboratory. However, both laboratories as well as their supporting authorities express the strong wish that their exploitation should to a large extent be international. This is very important for the physics community in Europe, in particular since it seems very unlikely that more than one of the proposals will be built. It is very encouraging that the two teams involved are already in very close contact with each other and with other physicists.

Some Ideas on Possible Future Storage Rings at CERN

Introduction

Electron machines and proton machines have in the past been complementary for elementary particle physics research, and this will probably continue in the future. Colliding beams have successfully entered the field also for protons through the CERN Intersecting Storage Rings (ISR), and it has been natural for CERN to start studying proton storage ring projects for higher energies than the present ISR.

Experience on the ISR, together with studies at several laboratories in the world, have in fact shown the feasibility of building colliding beam p - p devices up to the highest energies of accelerators in existence or under construction and such a facility could be constructed in connection with the SPS at CERN.

Two models for Large Storage Rings (LSR) are under study, viz.:

(a) 400 GeV rings using normal iron magnets.

(b) 400 GeV rings using superconducting magnets.

Model (a) has been the main preoccupation of a CERN study until a few months ago. There is now confidence that large storage rings with normal magnets and good performance can actually be built. In order to achieve a luminosity of 10^{33} cm^{-2} s^{-1} in a short interaction length of not more than 1 m, as desired by the experimentalists, 7 A of circulating protons will be necessary.

The problem of dumping such a beam with its corresponding stored energy must be solved. First indications from an engineering study are that this can be done with an external beam dump.

Model (b) has so far been looked at only superficially though CERN is following closely the considerable design and superconducting effort going on in the various laboratories. Attention is now being turned more in this direction.

Machine Lattice

The circumference of the machine is made up by two contributions: the normal lattice which occupies the greater part, and the colliding beam insertions which occupy the rest. Consequently, the largest contributions to single beam space charge phenomena come from the normal lattice, while the beam-beam space-charge (and high-energy physics) phenomena only occur in the insertions. It has therefore been convenient for the preliminary analysis to consider these two contributions separately.

Experience with the ISR has shown that the Q-values have to be controlled with rather high precision if one is to avoid enhanced beam decay rates due to non-linear resonances in the stacked beam. This imposes many tight tolerances on such a machine. In particular, the design of the machine must ensure that the image-dominated incoherent tune shift is below the acceptable limit, and that the circulating beam is transversely stabilized by the small Q-spread available. These requirements can be met by choosing a sufficiently large aperture over most of the circumference of the machine. This is in fact the determining factor in the choice of aperture of a large-radius storage ring. A large machine aperture further helps to reduce the beam-induced gas desorption vacuum problems.

A formalism which takes these space-charge phenomena into account and leads to the physical parameters of a machine was described by Keil at the IXth International Conference on High Energy Accelerators held in May, 1974. Two sets of machine parameters arrived at in this manner are shown in Table III; one for a conventional-magnet machine and one for a superconducting machine.

Types of Interaction Regions

For given energy and stacked current, the maximum design luminosity of an interaction region is limited mainly by two factors, viz. the non-linear electromagnetic beam-beam interaction, and the maximum acceptable values of betatron function in the neighbouring quadrupoles. The first is fundamental but not well-quantified, and the second is limited by chromaticity and tolerances. Both factors lead to a situation in which a compromise must be made between luminosity and field-free length around the interaction region.

TABLE III

Parameter list for large storage rings

	Conventional Magnets	Superconducting Magnets
Maximum momentum	400 GeV c	400 GeV c
Maximum bending field	1.8 T	4 T
Circumference	8300 m	6130 m
Average radius of normal lattice	1066 m	617 m
Stored current	7 A	7 A
Stored energy in beam	77.4 MJ	57 MJ
Vacuum chamber aperture radius	30 mm	25 mm
Betatron wave number	35.25	33.25
Period length	62 m	40.4 m
Quadrupole length	3.3 m	1.6 m
Bending magnet length	7.2 m	3.7 m
Number of periods	108	96
Half period arrangement	$\frac{1}{2}$FBBB$\frac{1}{2}$D	$\frac{1}{2}$FBBB$\frac{1}{2}$D

One is therefore led to consider a machine with two or more types of interaction regions, each designed to be suitable for a particular class of experiment. So far three types of interaction regions have been considered at CERN; a high-luminosity low-β region, a general-purpose interaction region with plenty of unencumbered space, and a high-β region with special optics for measurements of very small scattering angles. Parameters of examples of such interaction regions are summarized in Table IV.

TABLE IV

Performance estimates for three model-insertions

	Low Beta	General Purpose	High Beta
Luminosity (cm^{-2} s^{-1})	1.0×10^{33}	3.1×10^{31}	6.5×10^{30}
β_v^*(m)	1.0	12	400
β_h^*(m)	5.5	45	300
β_v max	560	430	400
β_h max	560	430	400
Crossing angle (mrad)	2.4	19.4	19.4
Field-free half-length (m)	5	80	18
Total length of insertion (m)	270	300	300

The above data are for:

Stacked current $I = 7$ A
Normalised emittance $\varepsilon = 30\pi \times 10^{-6}$ rad m (both planes)
Energy 400 GeV ($\gamma = 426.3$)

Number of Insertions

The number of insertions is determined by the scale and scope of the physics programme which the storage rings are supposed to support. In addition, special insertions will be required for injection and beam dumping. I seems likely that a minimum of six interaction regions will be required for physics experimentation, i.e. two of each of the three different types listed in Table IV.

A racetrack configuration with grouped interaction regions has been chosen. Fig. 5 shows a possible layout for the superconducting version. Any machine with six intersection regions of three types has the low superperiodicity of two.

In the model at present considered, the injection and dumping insertions would be in the arcs of the racetrack configuration.

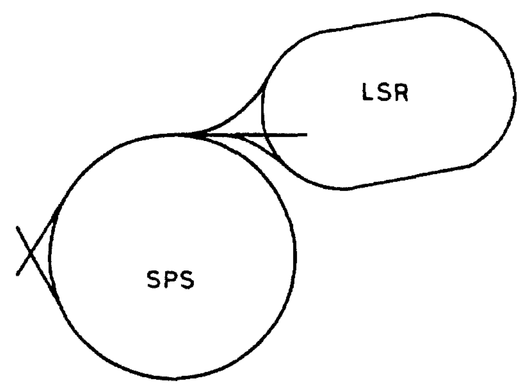

Fig. 5 - Possible lay-out of 400 GeV storage rings.

Possibilities of Colliding Other Particles

A disadvantage with colliding beam devices is that one can normally only study interactions between particles of one type, p - p, in the kind of project described above. The question therefore arises, what possibilities exist for incorporating other particle options in such a project.

Anti-Protons in One of the Rings

The method would be first to fill one of the LSR rings with 400 GeV protons, say to 7 A. These protons are ejected and made to hit an anti-proton-producing target from which 14 GeV anti-protons are guided towards the SPS, injected and accelerated in this machine and then stacked in the other LSR ring. The process is repeated till the available aperture is filled, giving $\bar{p}$ circulating beam of about 2 mA. When this beam collides with the proton beam in the other ring, one might reach a luminosity of 10^{28} cm^{-2} s^{-1} to 10^{29} cm^{-2} s^{-1}. The filling time comes out uncomfortably long, about two days, and operational considerations may therefore restrict the luminosity to, say, an order of magnitude less. The main extra equipment would be ejection/injection devices, a target complex and an additional beam transport channel between the LSR and the SPS.

e - p Option

One question being asked more and more persistantly is: "What would it imply to add an electron ring to the 400 GeV proton rings, and what performance could be expected?" Strong wishes have been expressed for 25 GeV electrons against 400 GeV protons. A luminosity of about 10^{32} cm^{-2} s^{-1} is generally considered necessary to achieve adequate event rates.

It may be difficult to satisfy both these requirements simultaneously, however, preliminary evaluations seem to indicate that it is feasible to add an e-ring to give 10^{32} cm^{-2} s^{-1} up to about 20 GeV electron energy, and with about one third of this luminosity at 25 GeV. More understanding is required on proton beam stability and lifetime in the presence of an electron beam, however, before firm conclusions can be drawn.

Concluding Remarks on Proton Rings

What has been presented in this chapter of my paper should only be taken as illustration of the possibilities in case the supporting authorities can be convinced that this kind of research facility is worth having. As yet, such a process has not even been started among the CERN member states.

Remarks on Time Schedule

Both EPIC and PETRA aim at an early decision (1975/76) and fast construction with finishing dates around 1979/80 This is an important element for the future users of these facilities. A new p - p facility at CERN cannot hope for such a fast decision process. A natural development may be that an $e^+ - e^-$ project and a p - p project come in series, which means that the projects I have described to-day, when they hopefully become reality, will cover a very large time-span in the future of elementary particle physics in Europe.

Other Project Studies

There are a few other projects that should be listed:

i) There has been one more serious $e^+ - e^-$ proposal in Europe, the so-called Super-Adone for 2×10 GeV, put forward by the Frascati Laboratory in Italy. A study report as extensive as the ones for EPIC and PETRA has been issued. Although the authorities have not definitely said no, the reaction has been sufficiently negative to discourage the proposers to pursue the case. However, out of the discussion of this project came encouragement to the Italian physicists to try and follow up this interesting field through international collaboration.

ii) On the p - p side another possible CERN project should just be mentioned, namely a conversion of the ISR by replacing their magnets by superconducting ones. With niobium-titanium magnets one could hardly get above 100 GeV per ring, and that is considered by most physicists as a too small step.

iii) Fixed target machines have not been mentioned in this talk. CERN is in the final stage of constructing the 400 GeV SPS. A superconducting energy doubler was considered a few years ago. Again the feeling seems to be that the step is too small.

A multi-TeV machine has not been paid much attention to yet, but this may change when the SPS has been put into operation.

Concluding Remarks

It is evident that there is a great variety of exciting possibilities for the high energy physicists to choose from when they want to determine their future tools. Unfortunately, the real issue is not what the physicists would prefer but what society is prepared to spend on research in general and on high energy physics specifically. The last few years have perhaps not been too encouraging in this respect, but there is no reason why we should not hope for a better future! Basic research is important, and maybe society in general will again realize that investment in increasing basic knowledge is a good long-term investment, and a kind of investment for which we, who belong to the rich part of the world, have a special responsibility.

Acknowledgements

I have chosen to omit references to specific publications, as I found it difficult to make proper and balanced references. I have, however, only reported on other people's work and I am, in particular, grateful for the information supplied to me by the Rutherford and Daresbury laboratories, the DESY Laboratory and the CERN Laboratory.