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ACCELERATOR DEPARTMENT
Informal Report

Bypass Layout of ISABELLE Proton and Electron
Rings and Study of e-p Interaction Region

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DESY

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Rings and Study of e-p Interaction Region

1. Layout of p- and e- rings

During the course of the ISABELLE summer study it became increasingly apparent to a number of participants that, in view of the complex nature of the storage rings and large solid angle experiments, a bypass-layout of the storage rings would be wanted that allows to decouple the setting up of beams and experiments. The layout shown in Fig. 1 includes suggestions from many participants (R. Chasman, H. Hahn, J. Lancaster, J. Patterson, M. Schwartz, A. van Steenbergen, L. Teng, G. Voss et al.) and evolved as an attempt to combine some of the expressed views.

The layout has the following main features.

- The length of the long straight sections of the proton rings is increased to 500 m, giving a circumference length of 3 times that of the AGS.
- The increased length (plain beam transport tunnel) is used to switch the beams into either one of two bypasses with a minimum of additional bending.

The first bypass requires an added bending angle of $2 \times 8^\circ = 16^\circ$ total and is thought of as a plain shielded beam transport tunnel to contain the beam during experimental setup.

The second bypass can be added as a future option for additional experiments; it needs an extra bending angle of $2 \times 14^\circ = 28^\circ$ total.

Fig. 1: Bypass Layout of e- and p- Rings

- (1) Beam line for p-p and e-p interaction
 - (2) Plain beam transport bypass (length 500m, $2 \times 8^\circ$)
 - (3) Bypass for p-p interaction; can be added later
 (~500m plain transport + exp. hall, $2 \times 14^\circ$)
- Length of p-rings: $3 \times \text{AGS} = 2422\text{m}$
- a) Plain beam transport
 - b) Bypass for e-p interaction

About half of the estimated bypass cost given in Fig. 2 is needed for the cryogenic vacuum chamber and may be strongly reduced by going to a large aperture chamber at room temperature.

The length for experiments is left unaltered, allowing to install several interaction regions in series as shown in the preliminary ISABELLE proposal. Thus, in its final state the proton ring will have four fully developed experimental straight sections of which two (four combinations!) can be simultaneously run with beam. Compatibility problems (e.g. energy, intensity) are greatly eased in this system, and a beam time of 6-7000 hours per year for data-taking is ultimately conceivable.

- The electron ring, as a future option, is inside the proton rings at a somewhat smaller radius, allowing its non-interferent construction and test operation.
- For e-p interaction, the electron beam is guided into a bypass that intersects one of the proton rings under a small angle (10 mrad) in two interaction points (I.P). Interaction with both proton rings as well as construction of a double electron ring may be considered.

2. e-p Interaction Region

Summary. A preliminary design study of the e-p interaction region is given, providing 2 interaction points with small amplitude functions for electrons ($\beta_0 = 0.4\text{m}$) and protons ($\beta_0 = 0.7\text{m}$), a small crossing angle (>10 mrad total) and a free length of 20 m for experiments each.

Assumed beam properties.

	<u>p-beam</u>	<u>e-beam</u>
Energy	200 GeV	15 GeV
Emittance of beam envelope (horiz. = vert., allowing full coupling)	1×10^{-5} rad.m	3×10^{-5} rad.m (PEP note 23)

Fig. 2: Detail of e-p Interaction

No. of interaction points:	2
Crossing angle (total):	10 mrad
Length of interaction straight section:	20m
Electron energy (max.):	15 GeV

Description of System. The design objective was a simple low- β system composed of conventional quadrupoles and bending magnets. The system has two interaction points spaced 54 m apart and is symmetric about its center (bending magnet $B_e 3$, Fig. 2). The quadrupoles for focusing the proton beam onto the interaction points are 22 m away from these, i.e. have a clearance of 44 m between them. They have an aperture diameter of 20 cm and produce an amplitude function of 0.7 m at the I.P. Interlaced are the quadrupole doublets for the electron beam, one at each side of each I.P, with a free space of 20 m between them for experiments. They are centered about the electron beam and need an aperture of about 30 cm $\emptyset$ to produce an amplitude function of 0.4 m at the I.P. (Most numbers given are approximate and subject to further optimization.) Since the proton beam passes through the same aperture, the crossing angle must be smaller than 10 mrad. Figs. 3 and 4 show the limiting case of a 10 mrad crossing angle and a quadrupole aperture of 34 cm $\emptyset$. Even at this aperture, the quadrupole can be made strong enough; at a length of 2m the required strength is 0.18m^{-2} which, for 15 GeV/c particles, corresponds to a field gradient of 0.9 kG/cm or 15.3 kG at the pole center.

The overall electron system between bending magnets $B_e 1$ (Fig. 2) is, by virtue of its symmetry, nearly nondispersive and can fully be made so by adjusting the strengths of the doublets. This means that there will be no dispersion outside this system in the long straights of the bypass, which, for matching, is a highly desirable property.

The dispersion at the I.P. is zero. This does not only result in a narrower beam but also, in linear approximation, makes the dispersion function and the momentum compaction factor of the ring independent of the strong lens represented by the space charge of the other beam.

The effect of the electron quadrupoles and bending magnet fringe fields

Fig. 3: e-p interaction region: optics and beam envelopes.

Fig. 4: p- and e- Envelopes
at entrance of
quadrupole Q_{c1} .

on the proton beam has been neglected here. Since the 200 GeV protons are an order of magnitude more rigid, the effect can easily be corrected for in the proton beam optics.

System Parameters

Crossing angle	<10 mrad total
Free length for experiments	20 m
Amplitude function at I.P.	
Electron beam	0.4 m (can be made smaller for $E < 15$ GeV)
Proton beam	0.7 m
Proton quadrupoles: aperture	20 cm diam.
Electron quadrupoles:	
Aperture	< 34 cm diam.
Length	2 m
Strength	$\leq 0.18\text{m}^{-2}$