Talk at ECFA meeting

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A SHORT DESCRIPTION OF THE ACOL PROJECT*

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1. Introduction

The $\bar{p}$ stacking rate at present runs short of the initial design figure by a factor of about 4-5. The $\bar{p}$ production rate is only half as large as originally expected and the remaining factor is mainly caused by non-linear effects in the AA focusing system that prevent storage of particles with large oscillation amplitudes in both transverse planes.

To increase the stacking rate, it is proposed to build the new ACOL ring around the AA as shown in Fig. 1. This ring has much stronger focusing so that the transverse acceptances are 200π mm.mrad ($\sim 90\pi$ for AA) and the momentum acceptance is 6% (1.5% for AA). After a bunch rotation process to reduce the momentum spread, the $\bar{p}$'s will be precooled in ACOL and then each pulse will be transferred to the AA ring to be stacked. In this way we expect a stacking rate of 7.5×10^{10} p/h, which is 10 × the best present rate.

The reason that the stronger focusing structure was not adopted for the AA in the first place is twofold. Firstly, with stronger focusing the revolution frequency spread is smaller and the mixing of particle samples is therefore slower. This - as well as the higher intensity - makes cooling more difficult and requires the use of novel systems with larger bandwidth that we did not dare to propose when the AA was built. Secondly, the momentum spread reduction by bunch rotation coud not have been combined with keeping a stack in the same ring.

The final stack intensity in the AA will be the same as originally planned, but stronger cooling systems will ensure a higher density, so that transfer to the SPA will be possible in six batches of 10^{11} $\bar{p}$ with a longitudinal emittance of 0.46 eVs each.

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* More details in "Design Study of an Antiproton Collector for the Antiproton Accumulator (ACOL), CERN 83-10 (October 1983).

2. Layout

Earlier designs of this new ring assumed a location in a new tunnel outside the AA area, or in the I1 building of ISR. At first sight, it seemed hardly possible to accommodate the ring and its transfer lines inside the existing hall. At R. Billinge's suggestion, a solution was nevertheless found; everything fits precisely. The advantage of this arrangement is a considerable saving in civil engineering cost and effort. The very short transfer line from ACOL to AA and the common ACOL-AA control room will also simplify operation. On the other hand, ACOL will be inacessible while a stack is kept in the AA and a somewhat longer AA shutdown (9 months) will be needed for installing and commissioning the new ring. Note, however, that the AA will have to be modified to accept the higher $\bar{p}$ flux so that a lengthy shutdown would in any case have been required.

The two rings will be covered by a common concrete shield, necessary because of the larger flux injected into the hall. Some additional shielding outside the building will also be needed.

3. Antiproton Production

To fill the larger transverse acceptances, the matching to the target will have to be changed. The plans foresee a replacement of the present horn by a lithium lens to provide a larger opening angle (Fig. 2). At the same time, the target (a 10 cm long copper rod of 3 mm diameter) will be pulsed; i.e. it will conduct a strong current that will keep the antiprotons together so that the apparent spot size seen by the lithium lens will be smaller. Since the same current will defocus the primary protons, a further lithium lens upstream of the target will provide stronger focusing. This last lens will be very similar to the one developed at Novosibirsk and Fermilab and tested at CERN; the one after the target will have a larger aperture.

The pulsed power supplies for these devices will be housed in a new equipment building near the target area.

4. Lattice

The horizontal and vertical tunes will be near 5.4, i.e. more than twice as high as in the AA. Correspondingly, the FODO quadrupoles are spaced at half the interval (Fig. 1). There are four long straight sections, all with zero dispersion. The quadrants in between are symmetric with respect to their centre. The value of $\eta = p \; df_0/f_0 \; dp$, an important parameter for cooling and bunch rotation, will be about 0.02.

An arrangement of sextupole corrections (incorporated into some of the quadrupole profiles) has been found that will reduce the chromaticity to zero while assuring zero dispersion in the long straight sections for all momentum values of interest. A detailed analysis by ray tracing has shown that the emittance increase caused by these corrections will be small. The non-linear coupling from which we suffered in the AA should not be dangerous in ACOL because this time we have assumed a round beam to start with. In addition, we have adopted apertures that will accept up to 1.2 times the nominal emittance.

5. Bunch Rotation

The $\bar{p}$'s will arrive in five short bunches. This will enable us to use bunch rotation, followed by adiabatic debunching, to reduce the initial momentum spread by about a factor 4. Without this reduction, the subsequent momentum cooling would hardly be realizable, since it would require 16 times more output power.

The rotation and debunching will take only 10 ms. It requires two cavities delivering 750 kV each. Since the frequency is fixed, high-Q cavities without ferrite may be used and the power stage will be of a reasonable size, the more so because of the low duty cycle.

A requirement for this process is that the ACOL circumference must be an exact multiple of the distance between bunches. It so happens that for a harmonic number of 6 the ring will just fit around the AA and inside the AA (1. One bucket will then be empty. This simplifies the design of the injection kicker because it allows a long fall time of the kicker pulse.

6. Cooling

To fit into the AA acceptance, the $\bar{p}$ beam will have to be precooled in ACOL. Within the available 2.4 seconds, each pulse will first be cooled horizontally and vertically, then longitudinally. This order is preferable because the reduction of the momentum spread will inevitably reduce the mixing of the particles and therefore decrease the cooling rate.

For momentum cooling, the same pick-ups, power amplifiers and kickers will be used as for transverse cooling; this is possible because the pick-ups and kickers may be used in the difference or sum mode alternatively or even simultaneously.

Because of the low-dispersion lattice used (necessary to reduce the aperture required to accept the initial $\Delta p/p$ of 6%) the mixing will be about 5 × slower than in the AA. Therefore, the cooling systems will have to work at higher frequency. The range from 1 to 3 GHz has been adopted.

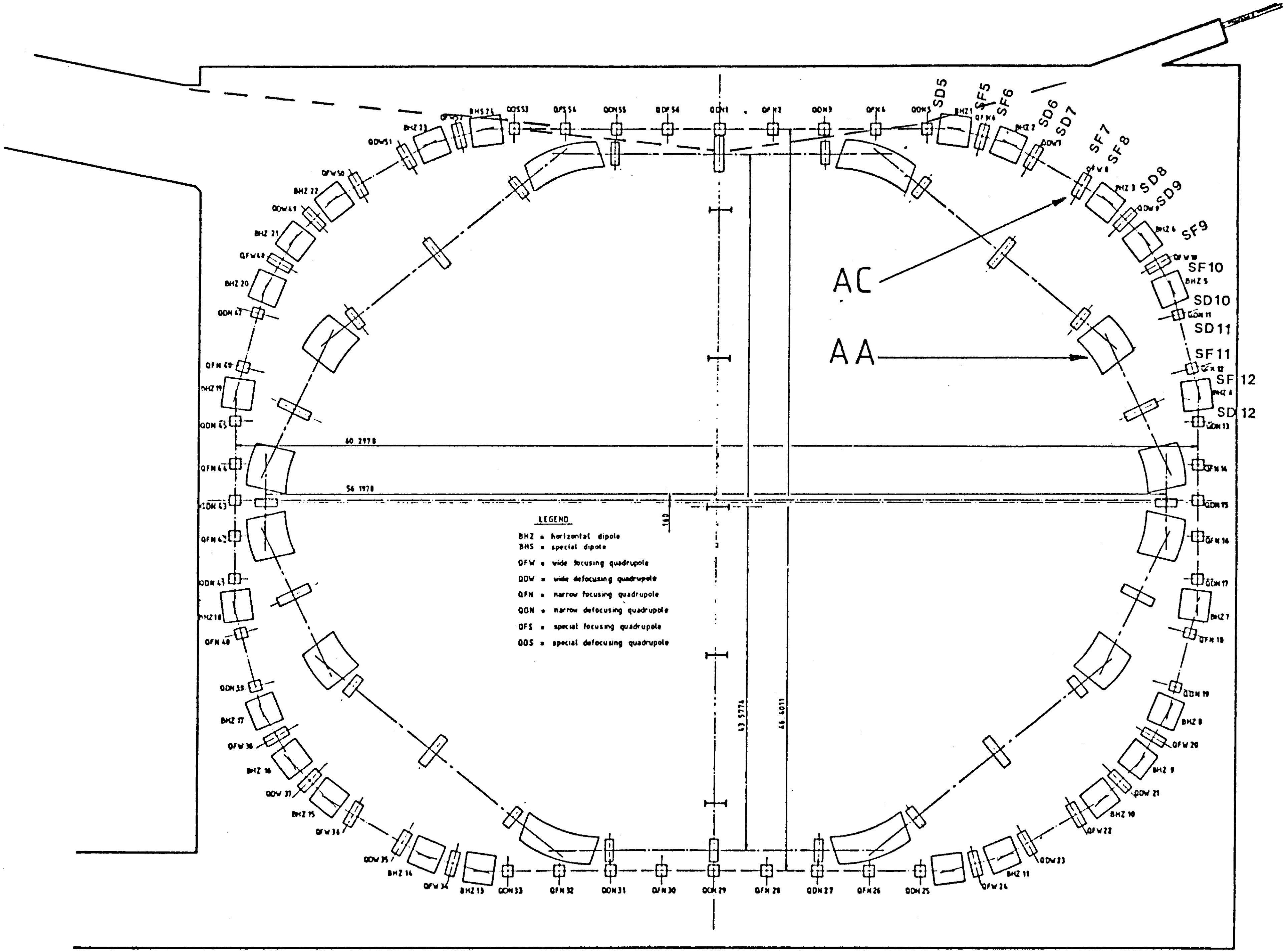
The pick-ups and kickers will each consist of 112 quarter-wave loop pairs per transverse plane, occupying in total about 17 m of straight section space (Fig. 3). A power of 2.6 kW will be needed. It turns out that, both to reduce the power and to improve the signal-to-noise ratio, it is necessary to adjust the pick-up and kicker apertures continuously during the transverse cooling interval. This will be done by means of hydraulic servo systems.

The preamplifiers and terminating resistors at the pick-ups will be cooled to 40°K to reduce the thermal noise.

As a result of this cooling, we expect to reduce the transverse emittances to 5π mm.mrad and the momentum spread to 1.8 $^{0}/_{00}$.

The AA cooling systems will also be rebuilt for higher frequency to cope with the increased $\bar{p}$ flux.

All cooling systems are designed to cope with 10^8 particles per pulse, i.e. twice the nominal value. It is hoped that this will ensure the expected performance in spite of the usual small imperfections.



The new AC ring around the old AA Fig. 1

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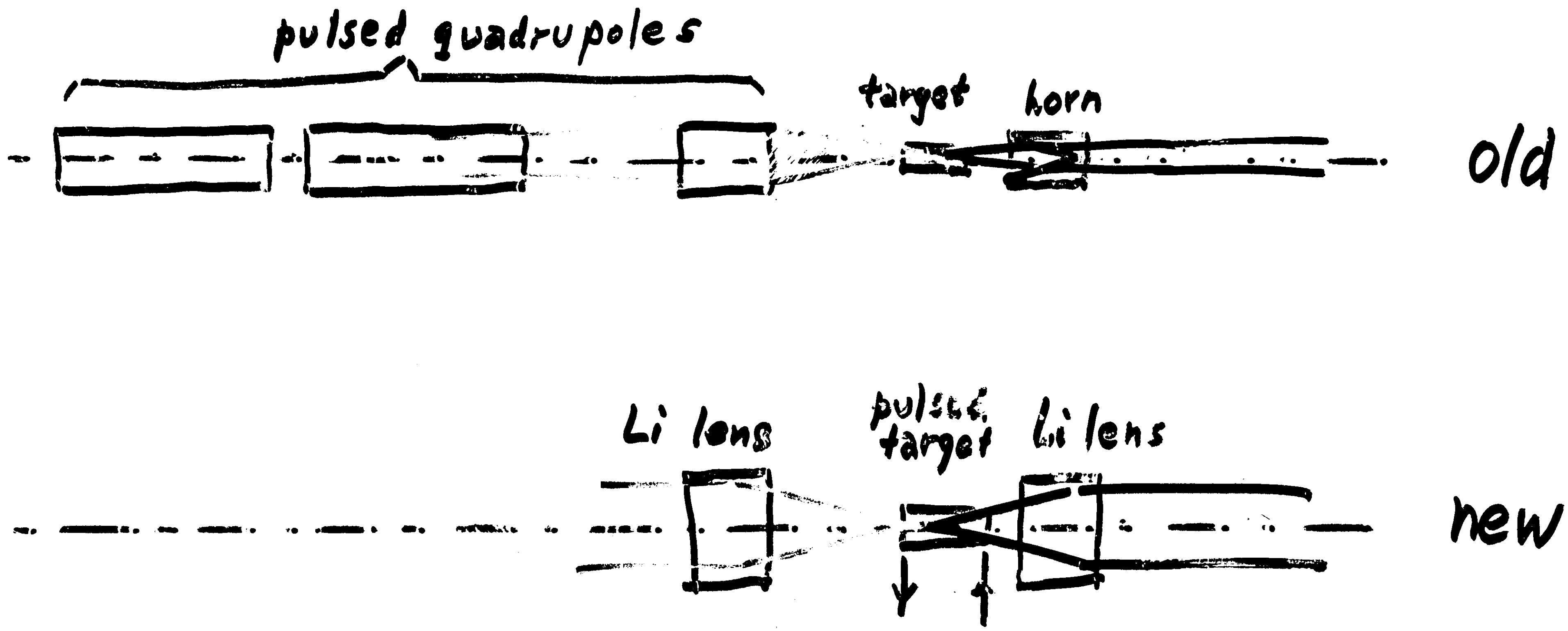
pulsed quadrupoles
target
horn
old
Li lens
pulsed target
Li lens
new
Fig. 2

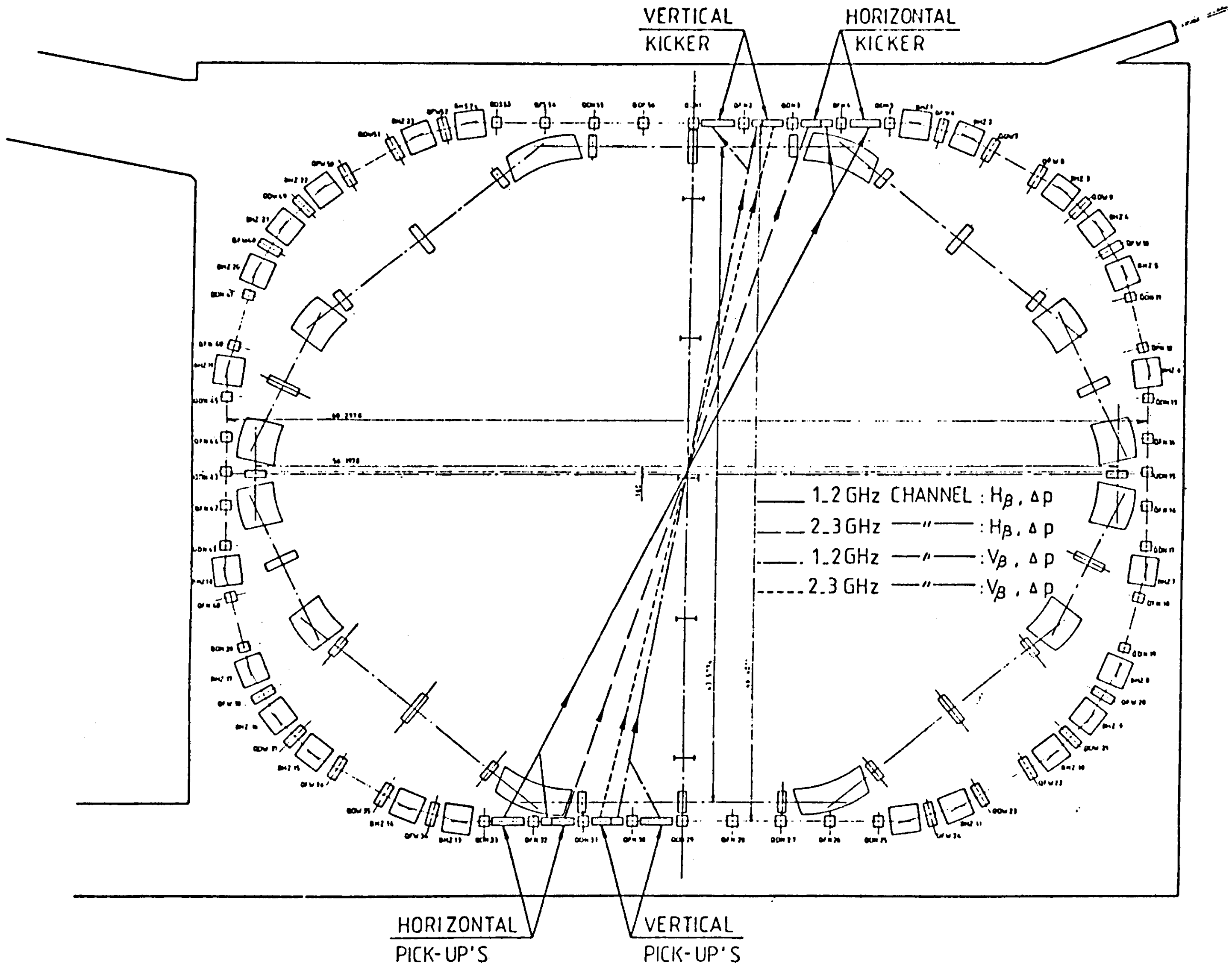

Fig. 3 LAY_OUT OF STOCHASTIC COOLING SYSTEM