DORIS - A STATUS REPORT

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Storage Ring Operation

The double storage ring DORIS produces now 4900 hours per year luminosity for experiments at the two interaction points. The energy ranged between 1.5 GeV and 2.7 GeV per beam. Runs at higher energies up to 3 GeV were done for tests only.

The peak value of luminosity achieved at present is $3.5 \times 10^{30}\ s^{-1} cm^{-2}$ at 2.6 GeV. More important than this peak value for high energy experiments are the integrated luminosities averaged over longer periods. As a result of special machine studies it was possible to enlarge the average luminosity continuously as shown in fig. 1. The best value was 810 nb^{-1} per week at an energy of 2.6 GeV. Between experimental runs nearly 1600 hours per year are available for detailled studies of beam properties.

The reliability of DORIS has reached a satisfactory operating standard: 82 % of the scheduled operating time was available for experiments. Only 1/3 of the break down time was caused by the DORIS system itself.

Increase of Luminosity

DORIS was originally designed for all 480 buckets per ring homogeneously filled with particles. This mode of operation is still practised at low energies. The luminosity increases according to the beam-beam limit as E^4 up to 1.5 GeV where the currents per ring reach 240 mA (fig. 2). Above this currents a strong multi-bunch single beam instability makes another filling scheme necessary.

Attempts to fill a fraction of the ring circumference (1/4 for example) were not successful since the instability becomes worse with decreasing length of the filled part. The successful method consists in filling every 2nd or 4th bucket and we now use in standard experimental runs 240 identical bunches up to 1.8 GeV and 120 bunches above 1.8 GeV. In this way we reach 400 mA in both rings at 2.6 GeV without encountering instabilities.

Because of the higher currents and the intense synchrotron radiation at 2.6 GeV vacuum problems are starting and the

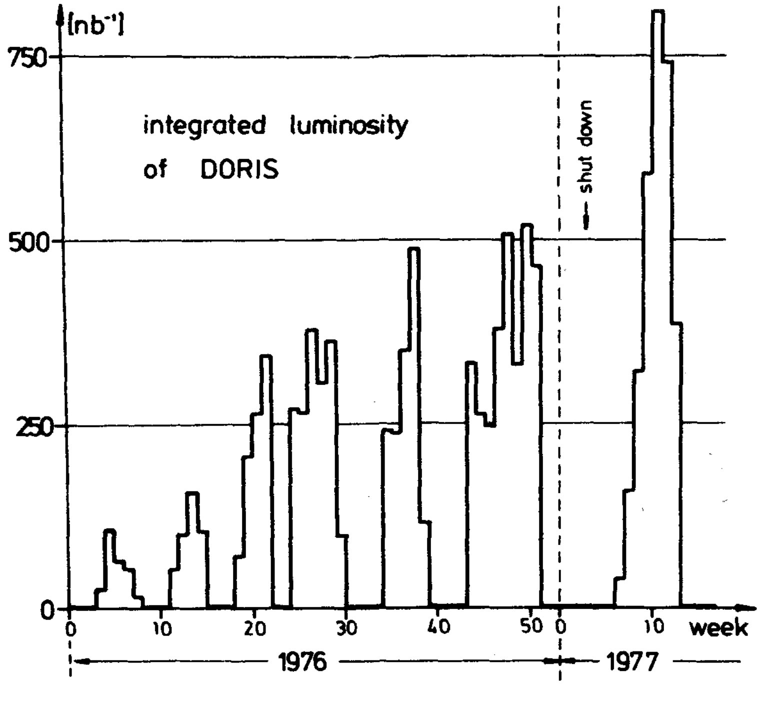

fig.1 Integrated Luminosity per interaction point averaged over one week. Gaps are due to maintainance and machine studies.

background for the experiments will increase. Therefore only every 8th bucket will be filled beyond this energy. The beam-beam limit is found to be at $\Delta Q = 0.01$. This fairly low limit is caused by betatron-synchrotron resonances which are produced by the beam-beam interaction with crossing angle, as shown in experimental and theoretical investigations /1,2/. The resonance frequencies are given by $Q_\beta = (p + rQ_s)/q$, where p,q,r are integers and Q_β and Q_s are the betatron and synchrotron wave numbers, respectively. The strongest betatron -synchrotron resonances found in analytical investigations as well as in computer simulations are shown in fig. 3.

The measurements in DORIS were done at 1.8 GeV. The behaviour of weak positron bunches colliding with strong electron bunches was studied. In order to measure this effect the lifetime of the weak positrons was observed while continuously varying the vertical betatron frequency keeping the synchrotron frequency constant. Lifetime was found to be drastically reduced while crossing satellite resonance frequencies. 25 vertical resonances were observed and most of them could

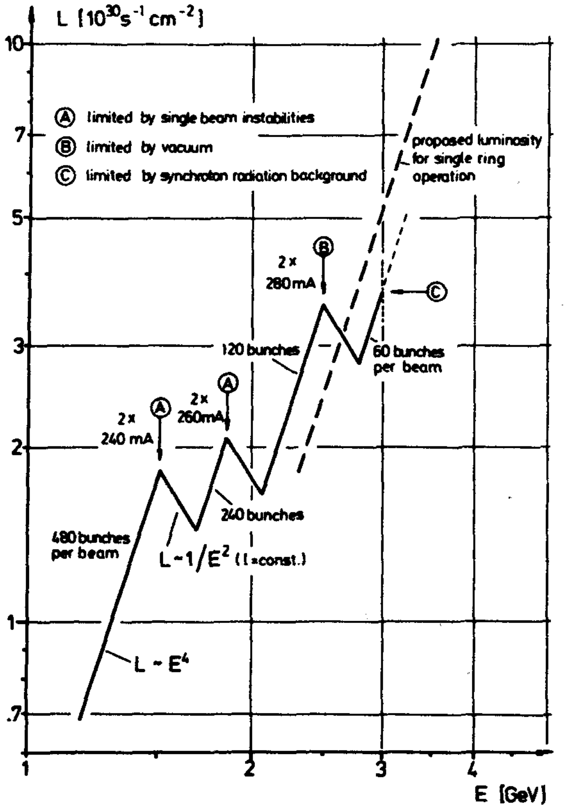

fig. 2 Luminosity of DORIS versus energy

be identified. A horizontal satellite resonance was not found. The experimental results are in good agreement with the theoretical prediction. The consequence of this investigation, namely the reduction of the strength of the satellite resonances by selecting a vertical Q_Z nearer to an integer needs additional studies.

Chromaticity Compensation

The 12 strong sextupole magnets per ring are not sufficient to compensate the energy dependence of the tune without reduction of the acceptance. Instead of installing a large number of additional sextupoles we sent currents through already existing auxiliary windings of the quadrupoles. These windings are wired to generate a superposed sextupole field in the magnet. With some care we could compensate the so created undesired dipole fields. In the past the available current limited the chromaticity compensation to a maximum energy of 2.3 GeV.

During the shut down at the beginning of this year a new sextupole arrangement with new powersupplies was installed at DORIS. In order to enlarge the effect for compensation of the vertical chromaticity ironshims were mounted at the ends of some bending magnets producing additional sextupole fields. Since then it is possible to compensate the chromaticity of DORIS up to 4.1 GeV.

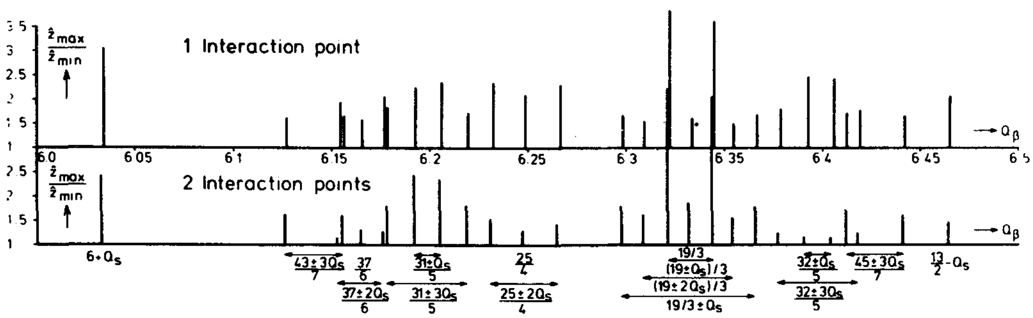

fig. 3 Amplitude of betatron- and satellite resonances produced by beam-beam interaction with crossing angle.

Damping of Cavity Modes

Earlier exact studies have shown that simulteniously with particular strong beam instabilities parasitic cavity oscillation modes occured in the cavities. In addition many not properly identified modes have been observed above the cut off frequency of the vacuum chamber (1.5 GHz).

Two antennae were radially introduced from the outside into the cavity to attenuate some of these modes removing their energy and dissipating it in a resonance absorber. Damping ferrites were installed at both sides of each cavity near the beam to absorbe the energy of modes above 1.5 GHz.

From the mode damping point of view this system works perfectly but, unfortenately, at higher beam currents the ferrites absorb much rf-energy directly out of the beam so that the temperature increases beyond critical values. This in turn causes intense gas desorption with a critical vacuum pressure above 10^{-7} torr. Due to this effect the maximum currents in DORIS were limited to 200 mA.

After detailed investigations in the laboratory[3] a new 3-antenna system was developed using ferrite absorbers encapsulated in glas as shown in fig. 4. All DORIS cavities are equiped with these absorbers and have the predicated damping quality. Now the vacuum problems at higher beam currents are removed so that higher luminosities were reached. The normal vacuum pressure around the ring during experimental runs is about 10^{-9} torr and the lifetime is between 5 and 10 hours.

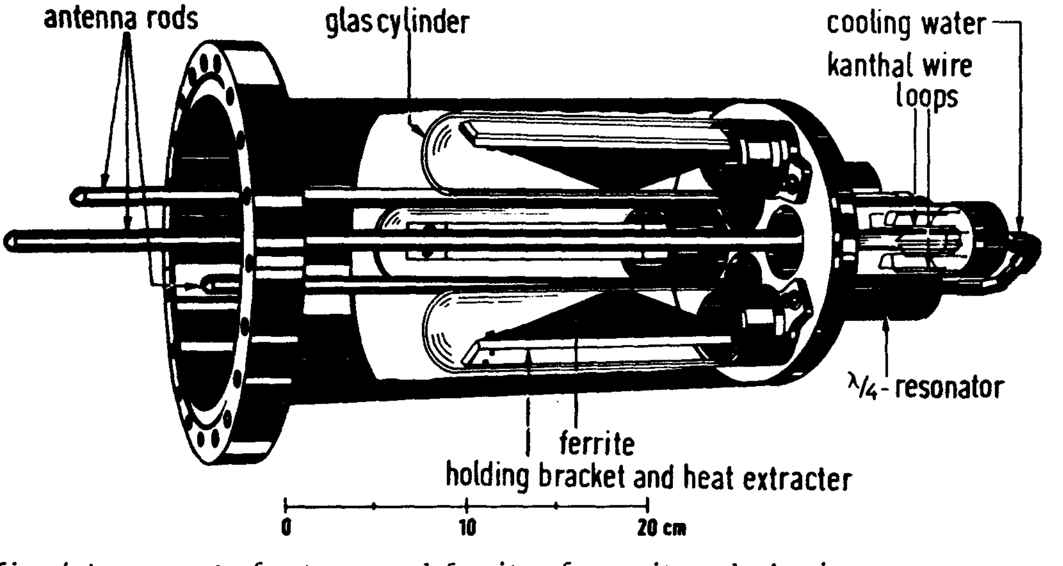

fig. 4 Arrangement of antennae and ferrites for cavity mode damping

Machine Studies and Future Developements

At energies above 3 GeV the double ring facility with multibunch operation leads to a strong background of hard synchrotron radiation (fig. 2) which makes it it hard to use DORIS for high energy experiments. This radiation is mainly produced in the quadrupole magnets next to the interaction points. Within these magnets the principal orbit is 10 cm out of axis and has a vertical bending radius of 16 m.

In order to reduce this background at energies up to 4 GeV per beam it is planned to rebuild DORIS during the summer shut down allowing a single ring operation with head on collision of two bunches. The expected luminosity is shown in fig. 2.

Single bunch experiments were performed in order to get informations about bunch quality for single ring operation of DORIS and to investigate bunchlengthening in the light of different models. One of the important results of these investigations was that for a widened bunch the tails of the energy distribution of particles are less widened than the core of this distribution. This seems to be in agreement with theoretical considerations[4]. More details are presented in[5].

The use of DORIS as an intermediate storage ring for e^+-injection into PETRA needs a special single ring optic which uses the two upper half rings. This optic was succesfully tested as well as the whole injection-ejection procedure[6].

References:

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