Beam Diagnostics at the COSY Injection Beamline

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Abstract

The 100 m long injection beamline at KFA Jülich from the 45 MeV/n cyclotron JULIC to the 2.5 GeV cooler ring COSY is presently under construction. We present the beam diagnostic concept, which is related to the particle optics and to the control system. The diagnostic instrumentation comprises slits, wire grids, viewers, faraday cups and phase probes. Measurements of the cyclotron beam properties, like emittance and energy spread, yield a full knowledge of the injection parameters into COSY under variable conditions.

Introduction

The cyclotron JULIC [1], which is operating at KFA since 1969, will be used as an injector for the Cooler Synchrotron COSY [2]. The ions with a maximum energy of 45 MeV/n will be transported to COSY by a beam transport line with a length of approximately 100 m, the path beeing chosen in order to leave the maximum possible space for the experimental areas. Interatom in 1989 got the contract for the design, construction, and commissioning of the beamline, the diagnostic system and all other subsystems.

The beamline matches the phase space of the cyclotron beam to the acceptance of the storage ring, providing the needed flexibility for different tune values and injection modes of COSY. The beam diagnostic instrumentation system allows to measure the displacements and the phase space of the beam along the line and is the basis for the injection tuning.

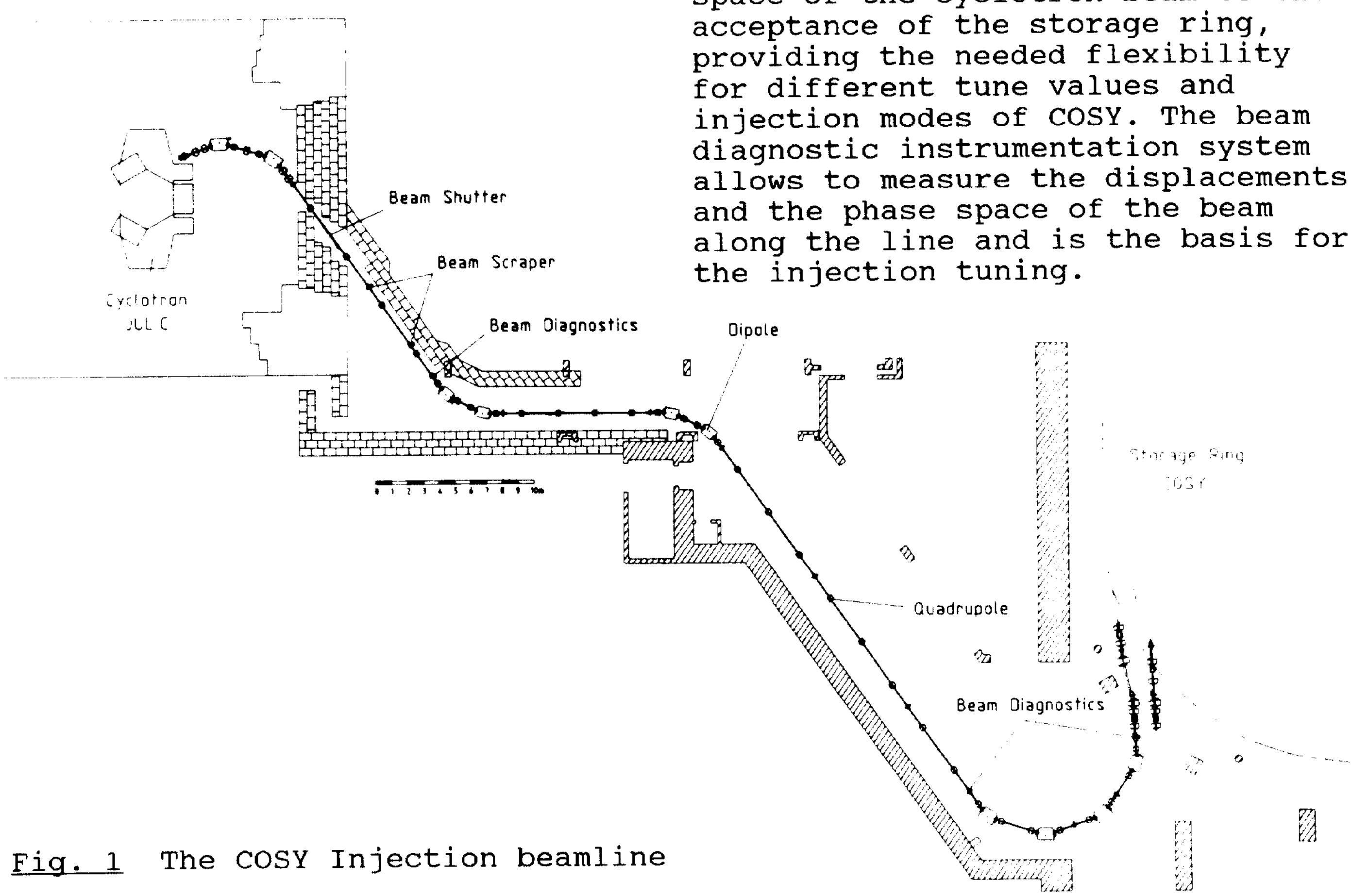

Fig. 1 The COSY Injection beamline

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Layout of the Beamline

The layout of the beamline is shown in Fig. 1. It consists of the following subsections: The cyclotron achromat, a FODO transfer line, the transfer achromat, another FODO line, the injection achromat, and the injection section.

The beamline consists of six dipole magnets with a deflecting angle of 38.25° and four dipoles with an angle of 27.5°. The 39 quadrupoles of the beamline have a magnetic length of 300 mm, the maximum gradient used is 14.5 T/m.For orbit correction, 12 x/y-steerer magnets are placed along the beam line.

The cyclotron beam has a rigidity between 0.9 and 2 Tm, an emittance of 3.2 π mrad mm horizontally resp. 6.4 π mrad mm vertically, a Dispersion of D_x = -0.12 m and D_x' = -3.35 mrad/%, and a momentum spread of $\delta p/p$ = 0.15 %.

The different operational modes of the COSY storage ring require different injection conditions: The beamline allows to adjust the beta functions at the injection point between the values β_x = 7.0 m, β_y = 15.4 m and β_x = 15.4 m, β_y = -7.0 m, with a compensated dispersion function.

The matching of the beta functions and the dispersion is accomplished by the first achromat of the beamline, which is laid out slightly asymmetric and has six degrees of freedom (quadrupole parameters).

Beam Diagnostic System

The beam current is measured by faraday cups, which are equipped with electrical and magnetical secondary electron suppressors. The cups are water cooled and laid out for a beam load of 2 kW c.w. One cup is positioned at the beginning of the beamline, which at the same time serves as a security beam shutter. A second cup at this location, working as a security shutter only, gives the necessary redundancy. At the end of the first FODO line, and at the end of the injection achromat, respectively, further faraday cups are installed to control the beam transmission along the line.

The beamline is equipped with eigth x/y-beam profile monitors, located at the starting point of the beamline and at the end points of the seven subsections (achromats and FODO structures, respectively). Wire grid harps with 0.1 mm Tungsten-Rhenium wires are used. For each direction (x and y), a grid consists of a number of 39 wires, spaced by 1.5 mm each, thus giving a reasonable spatial resolution of the position and of the intensity profile of the beam. The wires are mounted with Duratherm springs on a ceramic frame with an aperture of 60 x 60 mm². Each harp is mounted on a linear feedthrough with a membrane bellow and a stroke of 100 mm.

The electrical nA signals of the grids are electronically processed in multichannel charge amplifiers with FET multiplexers. In order to keep the cabel lengths below 50 meter, two electronic cabinets at different places along the beamline are used, where each of them handles the signals of four x/y-grids.

For the definition of the emittance of the injected beam, three pairs of x/y-slits are used. The first is directly at the start of the beamline, the second and the third are placed at two locations in the first FODO line, about a quarter betatron wavelength apart. The two blades of each water cooled slit are moved independently by stepper motors.

Three phase detection probes allow to measure the longitudinal phase space of the cyclotron. One probe is at the beginning of the beamline. A probe at the beginning of the long FODO section and a probe at its end form a time of flight section.

The injection beamline has its own computer control system, which is based on a workstation and a VME front end system, connected to the workstation via an Ethernet branch. The menu oriented software allows to display and modify interactively the beamline parameters and handles all measured data of the beam diagnostic system. Application programs, such as an orbit correction program and an emittance measurement program, have direct access to the central database, which keeps all parameters of the beamline.

Control of electric drives for diagnostic components, like stepper motors for the slits, is done directly by VME interface cards. The multichannel amplifier electronics of the diagnostic grids are adressed via V24.

With its beam optical properties, the beamline provides an excellent tool for the diagnostics of the beam quality which is delivered by the cyclotron and injected into COSY. The beam emittance will be determined with the help of the grids in the downstream part of the beam line by variation of quadrupole focussing lengths.

Vacuum Considerations

The vacuum system of the beamline with all its diagnostic boxes is fully metal sealed. In the first two thirds of the beamline, the vacuum conditions will be similar to the vacuum in the cyclotron, i. e. between 10^{-6} and 10^{-7} mbar. In the downstream end, however, the pressure has to be brought down to the UHV of the COSY ring, and at the end of the beamline a vacuum of better than 10^{-10} mbar will be maintained. Therefore, all vacuum materials in the injection achromat and in the following section are subject to special specifications and will be baked out during fabrication. Also, the vacuum system in the last part of the beamline will be baked out in situ.

The two beam profile grids and the faraday cup in this section are correspondingly laid out for bake out.

Status of the Project

All diagnostic components for the beamline are delivered. The development of the control system is completed. Installation of the magnets and the vacuum system has started. The first beam will be transported in autumn 1991.

References

[1] W. Bräutigam et al., Upgrading JULIC as Injector for COSY-Jülich, 1st Eur. Part. Accel. Conf., Rome 1988

[2] U. Pfister et al., The COSY-Jülich Project, 2nd Eur. Part. Accel. Conf., Nice 1990