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THE COSY – JÜLICH PROJECT – A SYNCHROTRON AND STORAGE RING FOR MEDIUM ENERGY PHYSICS

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Abstract The cooler synchrotron COSY at Jülich, a synchrotron and storage ring will serve protons and light ions in the energy range of 40 to 2500 MeV. The phase space density of the beams will be increased by electron and stochastic cooling. The cooled beams will be used for experiments with internal as well as via slow extraction with external targets. The COSY facility consists of the cyclotron JULIC, the 100 m long injection beamline, the ring with the circumference of 184 m and the extraction beamlines to the experimental areas. An overview of the actual scheme and realisation status is given. The start of the users operations is provided to be in autumn 1992.

INTRODUCTION

The COSY lattice consists of two 180–deg bending arcs and two straight sections. The two arcs consist of six mechanical identical periods. The straights, four optical tripletts, provide free space for internal target areas, for the RF–stations, and for phase space cooling devices. The straight sections are built as 1:1 telescopes. This enables first order optical decoupling of bending and straight sections. The phase advance in both telescopes can either be π or 2π. The machine parameters are summarized in Table 1.

The magnetic lattice of COSY is based on a six fold symmetry. Each of the mirror symmetric half cell has a QF–bend–QD–bend structure. By interchanging the focussing and defocussing property additional flexibility of the tune is given. The momentum dispersion in the straights can be zero'd with a supersymmetry two. Variable supersymmetries will provide lattice functions suitable for internal and external experiments[1]. The high beam quality requires stabilities of better than 10^{-4} for the main power supplies. The vacuum system is designed for pressures less than 10^{-10} hPa. For acceleration a ferrite tuned station with a peak RF voltage of 8 kV and a frequency swing from 0.4 to 2 MHz will be used. The separate stochastic cooling systems for longitudinal, horizontal and vertical directions will operate in the frequency range between 0.5 and 3 GHz. The electron cooling will be used for preparation of the beam at injection energy. The diagnostic

particles:		protons:	bending magnets:	24	
maximum momentum:	3.5	GeV/c	bending radius:	7	m
injection:	275	MeV/c	field at 3.5 GeV/c:	1.67	T
max. $B\rho$:	12	Tm	quadrupoles in bending sections:	24	
max. particle number:	10^{11}		number of families:	3	
typical cycle:			eff. length:	0.29	m
injection:	< 0.01	s	$\partial B/\partial r$ at 3.5 GeV/c:	7.50	T/m
e–cooling:	= 2	s	quadrupoles in straight sections:	32	
ramping to maximum:	1.6	s	number of families per sect.:	4	
flat top:	< 100	s	eff. length:	0.65	m
ramping down:	< 1.6	s	$\partial B/\partial r$ at 3.5 GeV/c:	7.65	T/m
spill length:	< 100	s	rf–system (h=1):		
circumference:	184	m	f at injection:	0.46	MHz
length straight section:	40	m	f at 3.5 GeV/c:	1.6	MHz
length 180 degree bend:	52	m	energy gain per turn:	1.3	keV
free length for experimental area:			CW (peak) voltage:	5 (8)	kV
TP1/TP2:	4 / 6	m	vacuum chamber:		
length e–cooler:	8	m	ϕ in straight section:	150	mm
length of e–beam section:	2	m	bend region:	150x60	mm²
			vacuum:	$<10^{-10}$	hPa

TABLE 1: COSY machine parameters

instrumentation will consist of a system which measures the orbit deviation, the phase relationship between the RF phase and the beam phase and the intensity. Strip–line units will be used for low beam intensity investigations. The control system will be realized in a hierarchical manner of three levels of functionallyties. Most of the accelerator components will have their own controller. They are built on the basis of VME systems to achieve autonomous functions. An expert system is under development to support commissioning and operation. As injector serves the upgraded isochronous cyclotron JULIC[2]. The layout of the COSY facility is given in Fig. 1.

HARDWARE STATUS

Geodesy

The concrete plate of the accelerator hall with an area of 119 x 41 m² and a thickness of 1 m was produced by continuous casting without expansion joints. During the construction of the hall settling of the building was observed by precision nivellement with 10 m distance of the reference points. Fig. 2 shows the isolines. These values are in agreement with the results obtained from soil bearing tests.

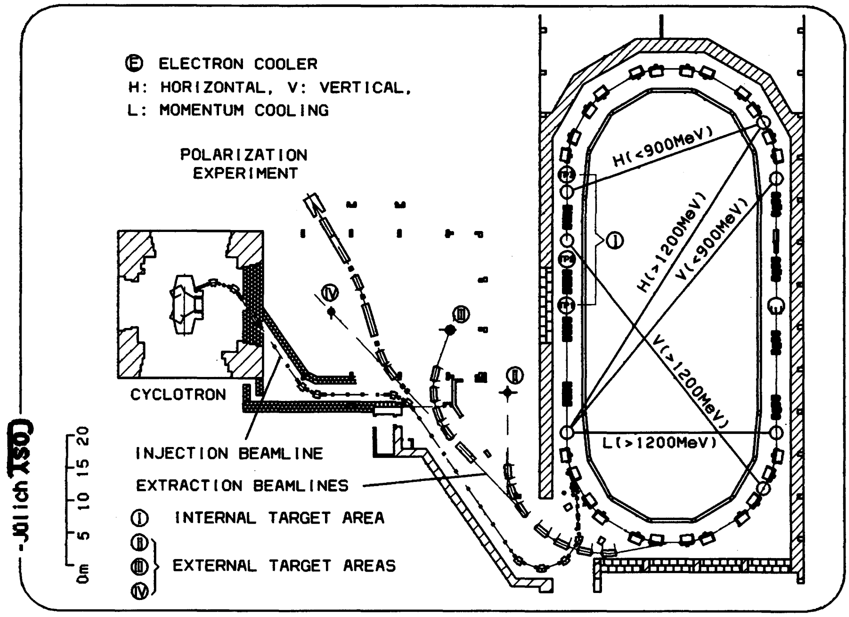

FIGURE 1: The COSY accelerator and experiment facility

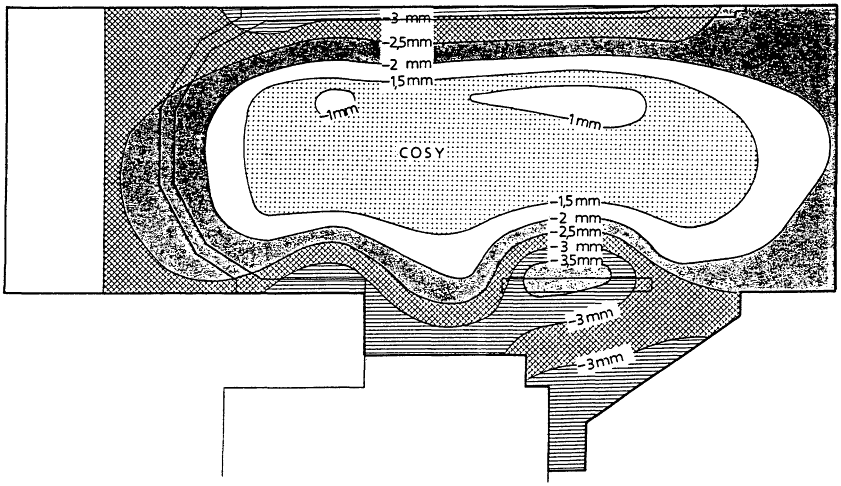

FIGURE 2: The isolines of the concrete plate of the accelerator hall

Vaccum System

The COSY ring beam pipe is now fixed in detail. By the use of a computer aided design system all components of the 184 m long beam pipe are designed in a 1:5 scale, whereby each single component in contact or in the close surrounding of the beam pipe is controlled to be free of bodily collisions. All these components are marked by a specific alpha–numeric identification code and fixed in terms of a rectangular coordinate system, especially drawn over all buildings of the COSY facility.

The technical layout of the vacuum chambers is settled and the major features verified by tests on 1:1 prototypes. The wall thickness was set to 2.0 mm for the circular and generally to 3.0 mm for the rectangular chambers. To avoid supply– and mostly quality–problems for the used SS 316 LN all required sheet– and forge–materials were ordered in a lot.

Control

The control system for the dipole power converter has been operated and successfully tested during the official acceptance procedure at the power converter manufacturer AEG. The main power converter can thus be controlled. The control system of the cyclotron has been installed, the first parameters of the cyclotron being measured and processed.

The user interface is being tested at the cyclotron to gain useful information for the further development of the operator's view.

Phase Space Cooling

To yield the beams of high phase space density stochastic and electron cooling is foreseen. The stochastic cooling will cover a energy range below 900 MeV and energy range above 1200 MeV to the upper energy bound of the ring. This approach avoides the transition energy crossover. Frequency bands starting at 0.5 GHz and ending at 3 GHz correspond to the selected energy ranges. The location of the pick–up and kicker structures are in the remaining space between the magnets and the diagnostic elements. Five different signal ways, three for higher energies and two for the medium energies (600 .. 900 MeV) are drawn in Fig. 1. The suitable cooling paths were determined for different magnet settings. The paths with the best qualification were selected as cooling and feed–back ways. The maximum energy for a pick–up kicker pair is estimated using the transit time of the traveling–wave signal. The timedelay taken into account of all elements in the cooling path is estimated to 60 ns for an 130 dB amplifier system. The wave speed of the air filled coaxial lines is set to 0.92 c. The pick–up and kicker structures will built as TEM coupled strip lines. The structures will be mounted in banks of 0.5 .. 0.75 m and will be matched in phase and group delay to the different beam velocities.

The primary role of electron cooling will be the preparation of cooled beams at injection, corresponding to an electron energy of 22 KeV. However, specific components like the coils for the magnetic field and the high voltage platform will be prepared for a higher operating voltage in order to facilitate a later upgrading of the electron energy. With an electron current of 2 A, an electron beam of 2.5 cm diameter an equilibrium cooling time in the range of 1 to 2 second for 40 MeV, 20 π mm mrad proton beam is expected.

The Accelerating Station h = 1

The h = 1 cavity will be placed in the cooling telescope in a dispersion–free section (Fig. 1). The ferrite tuned station will provide a peak accelerating RF voltage of 8 kV in the frequency range of 0.4 ... 2 MHz. Most of the constructive details are taken from the CERN LEAR[3]. Additional measures decrease feeding electro–magnetic dipol and quadrupol modes in order to reduce the transverse impedance derivative.

The technical–design work of the accelerating structure is finished, most of the parts are machined. The ferrite rings are mechanically and geometrically selected. The measured magnetical properties are well acceptable for a 8 kV gap voltage at 60% duty factor. A safe operation is given even if the errors of the μ_Δ values would be in the order of 15%. Specifications of the power amplifier and the analog and digital control system has been collected.

The bias–current supply will be divided in a 2 kHz 1 kA amplifier and a 30 kHz ± 30 A amplifier. Both operate on 2 separated bias windings in order to increase the band width of the regulation loop. Additionally, the reproducibility in the remanence state will be improved[4].

EXPERIMENTAL AREAS

The flexibility of the magnetic lattice of the COSY ring will be used to realize different beam qualities at the internal target stations TP1, TP2, TP3 (area I) and at the external experimental areas II, III, IV (Fig. 1). The extraction beam line has been designed to meet different requirements for a large target spot size

(10 mm) at area II, a medium target spot (5 mm) at area IV, and a very small target spot (1 mm) with an achromatic beam at area III, useful for experiments with a high resolution spectrometer[5]. Between area III and IV an additional beam line with a longitudinal spin flip facility will be installed.

SUMMARY

The carcass had been finished in May 1989. The prototype of the bending magnet and the corresponding power supply are already handover. About 80% of the other equipment has been ordered and delivery has been envisaged within the foreseen time–schedule.

To supplement the COSY facility, installations in order to produce and to handle polarized proton and deuteron beams are under study. It is proposed to build a collision–type atomic beam source which produces more than 30 μA of polarized H^- or D^- within an emittance of about 60 π mm mrad.

More advanced stochastic cooling systems are under discussion.

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