Status of the Project COSY Jülich

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1. Summary

An overview over the actual design and realisation status of the cooler storage ring COSY-Jülich is presented.

Details are given in several contributions to this conference [1]-[9]. Start of users' operation will be achieved in autumn 1992.

2. The Concept

The Cooler Synchrotron COSY is designed to accelerate protons for the first operation and light ions, as well as to operate as a storage ring with phase space cooling yielding beams of high phase space density. It can be used for experiments with internal targets and it delivers an extracted beam for external experiments.

The upgraded cyclotron Julic [1] will produce a 40 MeV per nucleon beam of H_2 for injection. After stripping [2] the protons will be accelerated up to any energy between 200 MeV and 2.5 GeV. The data for a typical operation cycle and for the accelerating rf-system [3] are summarized in Tab. 1.

The maximum particle number of protons amounts to 2×10^{11}.

The magnet lattice is designed to fulfill a variety of requirements from the experimental point of view. It is based on a sixfold symmetry. The 180° bending sections consisting of three periods each are interrupted by two long telescopic straight sections, each 40 m long. The straights give free space for cooling devices and experimental set-ups for internal targets. Inside the straights the beta-functions and the dispersion can be varied over a large range to fulfill the experimental requirements. The high beam quality up to energies of about 2.5 GeV together with the extracted beam open up a new type of experiments in nuclear physics and in the medium-energy domain.

3. History

The actual design of COSY is a cowork of scientists of Kernforschungsanlage Jülich (KFA) and nearby universities in Nordrhein-Westfalen together with the inputs of the accelerator community.

The steps were:
- January 1980: First ideas to build a recirculating ring in connection with the existing cyclotron Julic.
- May 1982: First proposals of a synchrotron with phase space cooling.
- 1985: Establishment of CANU, a working group of nuclear physicists from neighboured universities.
- 1985: Decision of the board of directors of KFA Jülich to establish a COSY design group. The technical description of COSY had been finished in July 1986 [10].
- December 1986: Positive vote of the KFA supervisory board.
- February 1987: Establishment of the project management.
- August 1987: Formal approval of the company partners.

The total budget of the facility is limited to 84.3 Mio DM except the budget for personnel. The design and construction duration is aimed at five years.

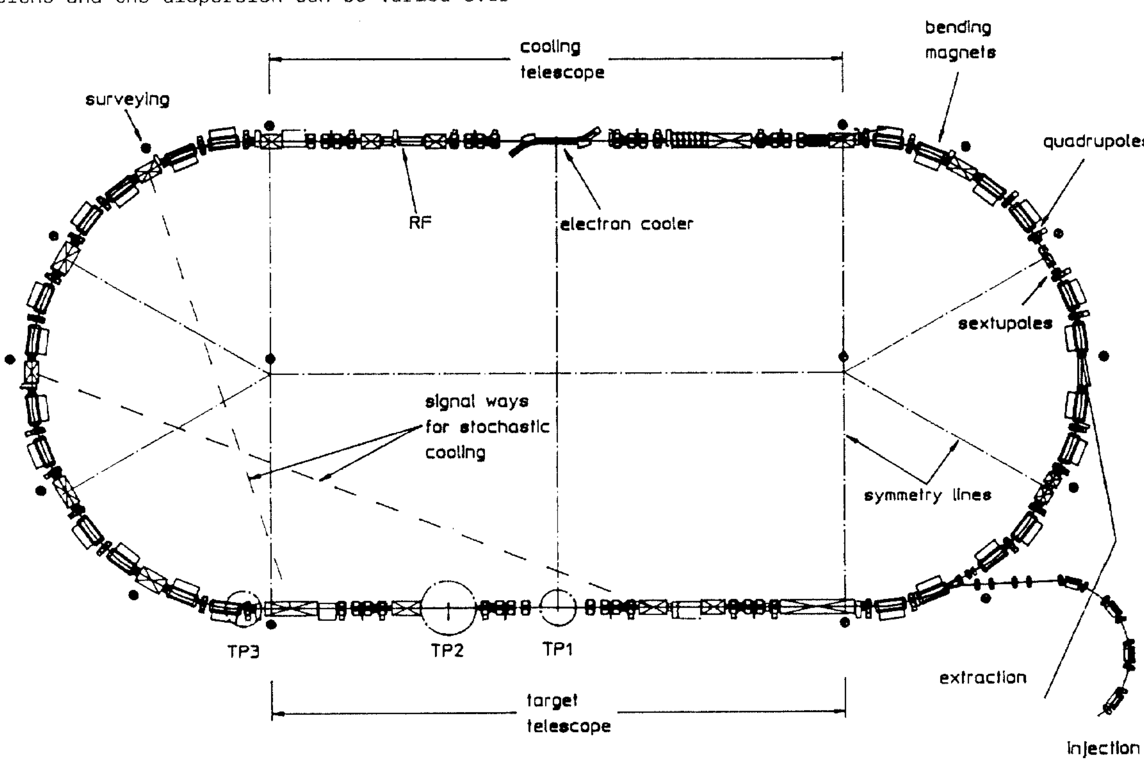

Fig. 1: COSY Layout

4. Project Organization

Since the beginning of 1987 the organization structure of the project has been established.

The project is devided into seven subprojects covered by different institutes of the KFA:

- buildings, infrastructure
- power supplies
- magnets
- vacuum system and construction
- control/diagnostic/cooling
- injector
- theory.

International experts and users are represented by the different advisory committees:

- Scientific Council consisting mostly of members of the board of directors of international accelerator centers advising the KFA board of directors.
- Machine Advisory Committee (MAC) a permanent design review committee consisting of accelerator experts.
- Committee Experiment-Accelerator (KEB) which defines the experimental requirements on the machine.
- Physics Advisory Committee (PAC) responsible for setting priorities among experimental proposals.

5. Schedule

The evaluation of the time chart comprising more than 1000 single activities leads to the following milestones:

- July 1987 official start of the project;
- May 1988 preparation of the building site; beginning of civil engineering work [4];
- July 1988 laying of the foundation stone;
- August 1990 start of assembly of magnets, water cooling systems, vacuum system, etc.;
- January 1991 completion of buildings;
- December 1991 start of commissioning;
- July 1992: 100 turns
- Autumn 1992: Start of users' operation.

6. Facility Description

6.1 Machine design

The layout of the ring consisting of 24 bending magnets, 56 quadrupoles and 16 sextupoles is shown in Fig. 1. The machine parameters are summarized in Tab. 1. The lattice structure is based on a sixfold symmetry [5].

The beam parameters are compiled in Tab. 2. The machine and beam parameters have been reviewed by a design review committee in December 1987.

6.2 Magnets

The specification of the dipole magnets was reviewed in May 1987. The actual design data and the layout of the bending magnets can be found in [6].

The nominal field strength of the already ordered magnets is 1.6 T corresponding to a proton energy of 2.5 GeV.

All 24 bending magnets of the ring will be supplied in series by a single power supply. The tolerance of the power supply covers the range of 10^{-4}.

Specifications and drawings of the quadrupoles are prepared for tendering. Each straight section contains 4 families of quadrupoles, totally 32. With a magnetic length of 0.65 m and an inner diameter of 170 mm a field gradient of about 7,65 T/m can be achieved. The bending sections are provided with 3 families of totally 24 quads, with a magnetic length of 0.29 m and an inner diameter of 170 mm the field gradient is about 7.5 T/m.

6.3 Diagnostics

About 30 position monitors are placed along the ring allowing for closed orbit control. A system of transformers measures the beam current intensities on different time scales.

The emittance of the circulating beam can be defined by a system of slits and scrapers. A fast kicker in one of the straight sections will be installed for working point measurements also during the accelerator cycle.

The beam will be analyzed by two Schottky noise stations.

Table 1: COSY machine parameters

particles:		protons
maximum momentum:	3.5	GeV/c
injection:	275	MeV/c
max. $B\rho$:	12	Tm
max. particle number:	$2\cdot 10^{11}$	
typical cycle:		
injection:	< 0.01	s
e–cooling:	≈ 2	s
ramping to maximum:	1.6	s
flat top:	< 1000	s
ramping down:	< 1.6	s
spill length:	< 100	s
circumference:	184	m
length straight section:	40	m
length 180 degree bend:	52	m
free length for experimental area:		
TP1 / TP2:	4 / 6	m
length e–cooler:	8	m
length of e–beam section:	3	m
bending magnets: 24		
bending radius:	7	m
field at 3.5 GeV/c:	1.67	T
quadrupoles in bend sections: 24		
number of families:	3	
eff. length:	0.29	m
$\partial B/\partial r$ at 3.5 GeV/c:	7.50	T/m
quadrupoles in straight sections: 32		
number of families per sect.:	4	
eff. length:	0.65	m
$\partial B/\partial r$ at 3.5 GeV/c:	7.65	T/m
rf–system ($h = 1$):		
f at injection:	0.462	MHz
f at 3.5 GeV/c:	1.58	MHz
energy gain per turn:	1.3	keV
peak voltage:	5	kV
vacuum chamber:		
$\emptyset$ in straight section:	150	mm
bend region:	150x60	mm^2
vacuum:	$< 10^{-10}$	hPa

Table 2: Beam Parameters

COSY RING

periodicity:	6 (FDDF or DFFD)	
horiz./vert. tune:	3.87/4.12	
γ_{tr}:	≈ 2.4	
aperture radius		
horiz./vert.:	70/30	mm
horiz./vert. acceptance:		
(FDDF)	50/16	π mm mrad
(DFFD)	180/36	π mm mrad
$\Delta p/p$:		
(FDDF)	± 0.53%	
(DFFD)	± 0.42%	
β_H/β_V at TP1 (D = 0 m):		
(FDDF)	5.1/6.7	m
(DFFD)	1.2/21.6	m
β_H/β_V at TP2 (D = 0 m):		
(FDDF)	1.9/4.4	m
(DFFD)	8.0/1.4	m

6.4 Cooling

It is planned to use electron cooling at injection energy of 40 MeV protons corresponding to 22 KeV electrons. The electron cooler with an active length of about 3 m is located in the cooler telescope (Fig. 1).

The stochastic cooling will work in a first step at a proton energy of about 800 MeV. Longitudinal, horizontal and vertical cooling will be done by separate systems operating in the frequency range from 0,5 to 2 GHz. Fast feed back damper systems will counteract the coherent instabilities [8].

6.5 Control

The control system is realized in a hierarchical manner of three levels of functionalities.

Most of the accelerator components have their own controller. They are built on the basis of VME systems to achieve autonomous functions.

The backbone of COSY control is the data communication system carried on different local area networks. A test version for the control of power supplies and diagnostics is under operation.

An expert system is under development to support commissioning and operation [9].

6.6 Vacuum system

The vacuum system of COSY is designed for pressures less than 10^{-10} hPa. The vacuum chambers with a diameter of 150 mm in the straights and a rectangular cross section of 150 x 60 mm^2 in the bend regions made from Inconel 625 will be fabricated in smaller parts with flanges, compensators and seals with metal gaskets. The system will be bakeable.

The pumping cycle will be done in successive steps, starting with turbomolecular pumps, followed by sputter ion pumps and Titanium-sublimation pumps. Additionally NEG pumps will come to operation at special locations.

First tests to qualify the components have been done [7].

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