The COSY-Jülich Project April 1991 Status

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Abstract

The cooler synchrotron COSY-Jülich, a synchrotron and storage ring for protons and light ions is at present being built in the Forschungszentrum Jülich GmbH (KFA). The facility will deliver protons in the momentum range from 270 to 3300 MeV/c. To increase the space density electron and stochastic cooling will be applied for experiments with internal and after slow extraction for external targets. The facility consists of different ion sources, the cyclotron JULIC as injector, the injection beamline with a length of 100 m, the ring with a circumference of 184 m and the extraction beamlines to the external experiments.

I. Introduction

The COSY ring consists of two 180 degree bending arcs and two straight sections. The two arcs are composed of six mechanically identical periods. Each of the mirror symmetric half cells is given a QF-bend-QD-bend structure leading two a six fold symmetry of the total magnetic lattice. By interchanging the focusing and defocusing properties additional flexibility for adjusting the tune is given. The momentum dispersion in the straights can be set to zero with the supersymmetry two. The straights are acting as 1:1 telescopes with a phase advance either π or 2 π. Bridged by four optical triplets each they provide free space for the RF stations, for phase space cooling devices and for internal target areas. The main machine and beam parameters are shown in table I, the layout of the total facility in figure 1.

Two cooling systems will be installed, the electron cooler being foreseen from the beginning of experimental operation. The transverse stochastic cooling system is built as a two band system with an overall bandwidth of 2 GHz [1] the bands extending from 1 two 1.7 GHz and 1.7 to 3 GHz respectively allowing cooling in the energy range of 0.8 to 2.5 GeV. The system offers a cooling rate of $7 \cdot 10^{-2}$ Hz for 10^{10} protons the lowest emittance being expected at 1 π mm mrad. It is foreseen not to cross the transition energy but to shift it slowly during ramping to energies above proton energy and decrease it after debunching prior to experiments.

The COSY control system is hierarchically organized and divided into three major layers [2]. Implementation of the control operations is made in the system layer, the work cells and the process I/O layer. The experimentators are offered to get access to the COSY databases and to use machine data for reduction of experimental data.

Table I
COSY Basic Parameters

momentum range	275-3300 MeV/c
max. no. of stored protons	$2 \cdot 10^{11}$
typical cycle	
injection	~ 10 ms
ramp up/down	1.5 s/1.5 s
e-cooling	1-4 s
s-cooling	10-100 s
bending magnets, no./radius/ field at 3.5GeV/c	24/7 m/1.67 T
quadrupoles, no./no. of families/magnetic length/ max.grad. at 3.5GeV/c	
arc	24;6;0.29m;7.5 T/m
telescope	32;4;0.65m;7.65 T/m
focusing structure	6periods,sep.functions FoBoDoBooBoDoBoF
betatron wave no.	3.38/3.38
γ_{tr}	2.06
aperture limit hor/vert	70/27.5 mm
geom.acceptance hor/vert	130/35 π mm mrad
vacuum system pressure	10^{-10} - 10^{-11} hPa
RF system	
frequency range(h=1)	0.462 - 1.572 MHz
gap voltage (at duty cycle)	5kV(100%)/8kV(50%)

The diagnostic instrumentation will deliver measuring data of the beam intensity, the orbit deviation, the phase relationship between beam phase and RF [3]. The beam will be excited in vertical and horizontal direction by stripline units thus enabling fast measurements of the betatron tunes and evaluation of beam stability thresholds. The diagnostic devices of the beamlines in particular the transverse wire arrays as beam position and profile monitors have also been defined and partially ordered.

Acceleration of the injected particles to the required experimental energy, at maximum 2.5 GeV (per nucleon), will be achieved by the RF acceleration station. The revolution frequency changes from 460 kHz to 1.6 MHz. As the cavity will work at the first harmonic, this is also the frequency span to be covered by the acceleration system. The system is fabricated by a cooperation

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between the LNS SATURNE and Thomson Tubes Electronique, France.

In the first stage of development COSY will be filled with protons from the stripping reaction of H_2^+ via the injection beamline [4] from the upgraded isochronous cyclotron JULIC as injector. The beamline is designed for particles of a maximum rigidity of 2 T·m and has been ordered turn-key. Assembly of the components has just begun.

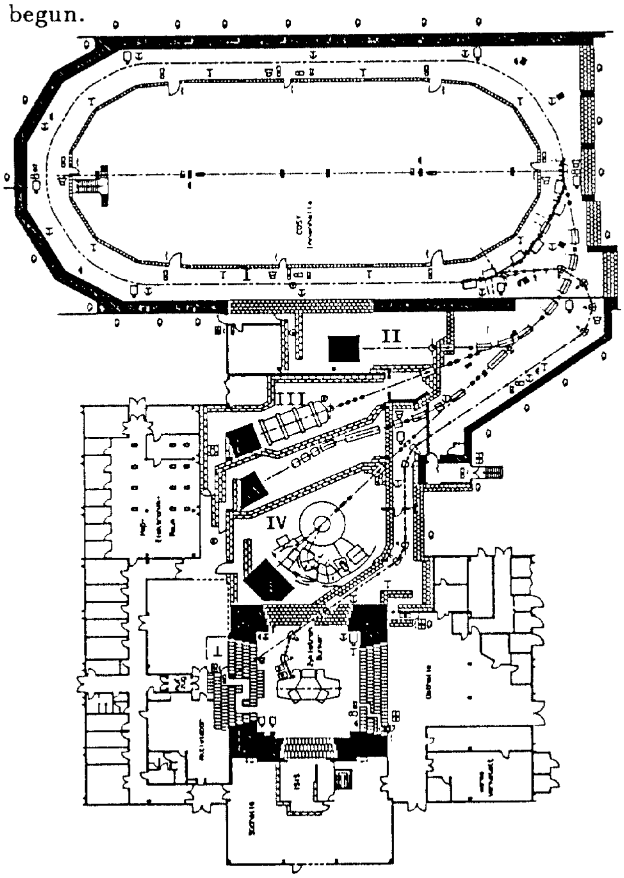

Figure 1. Layout of the COSY facility.

II. Accelerator Components

A. Magnets

All of the 25 dipole magnets of the COSY ring have been installed after measuring the field properties. As they will be fed by a single power converter in series the equality of magnetic length better than $2\cdot10^{-4}$ is needed for identical bending angles. Therefore precise measurements of the magnetic field have been made based on the use of long integrating coils moved stepwise on two 2D-tables along x and y axis of the magnet air gap. The integrated voltages over each step give the change of flux. The deviations of the effective lengths after adjusting with the removable endpieces were measured at a homogeneous field strength of 1 T. After the shimming procedure the excitation curves were measured. Saturation was found to appear around 1.1 T compared to the maximum field in COSY of 1.8 T. The relative deviation of bending angles at all field strengths is less than 0.2 mrad. Cycling procedures to measure hysteresis effects proved the reproducibility of the effective length within the tolerable limits. The series production of the 24 arc quadrupoles and 32 telescope cell quadrupoles has been delayed because the prototypes failed to fullfill the specifications. The prototypes from a new manufacturer are delivered in May this year. The sextupole magnets for the ring have been delivered and field measurements are running. The steering magnets are manufactured, too. Injection and extraction septum magnets are ready for testing.

B. Power Converters

Very stable power converters with a wide dynamic operation range and nominal outputs between 100 kW and several MW are required for most of the magnets in the COSY ring. The power converter feeding all 25 dipole magnets in series provides an output voltage of 1300V to produce a field slope of 1.6 T during 1.6 s particle acceleration phase. The required minimum current during injection and cooling is 235 A, the maximum current amounts to 5000 A. The stability requirement is 10^{-4} of the actual value. The converter will be tested under full load after finishing the assembly of the dipole magnets. Each of the 14 quadrupole families is fed by one power converter delivering a rated dc current of 520 A. Due to the different types of magnets the output voltages show different values of 188 V, and 270 V maximum value during acceleration. The tolerance margins during acceleration are equal to those of the dipole power converter but strongly reduced during injection and storage modes. The prototype converter has been tested successfully. The delivery of the converters in quantity has started. They will be tested under operation conditions after the delivery of the quadrupole prototypes. The power converters for the sextupole magnets, the steering magnets and of septa magnets have been ordered and partially manufactured.

C. Vacuum Components

The COSY vacuum system is specified to operate at an average pressure of 10^{-10} hPa in the ring. The total ring beampipe can be divided into 12 separate sections by vacuum valves. The assembly of the beampipe vacuum chambers of two sections has started in March this year. Prior to assembling in the ring and in the beamlines each vacuum exposed component is given to a final vacuum test run. The base pressure in the test facility is in the 10^{-12} hPa regime and the components are heated up to bakeout temperature of 300 centigrade. The ultra high vacuum test area contains also systems for the test of gauges, gas analysers, ceramic breaks and linear motion feedthrougs. Up to now the vacuum chambers for more than 140 m length of the ring of totally 184 m were annealed and vacuum tested including the chambers for the kicker magnet and the electrostatic septum. The special chambers for H_0- and laser-diagnostics as well as the chambers at injection and extraction have been ordered. A further component in the manufacturing phase is the remote controlled multi stripper target with a 8-fold magazine. The self-controlling subsystems for the bake-out heating system and for vacuum control are just before completion including the software. These systems will be linked to the COSY main control system. Auxiliary components for the vacuum and heating system are ready for assembly.

D. Electron Cooler

The electron cooling in COSY was intended to prepare the beam prior to acceleration at proton injection energy of 40 MeV corresponding to an electron energy of 22 keV. By this a highest storable phase space density in a fast cycling operation can be achieved. The transverse emittance of the injected beam by phase space condensation is reduced down to the order of 1 π mm mrad and the momentum spread is reduced to appr. 10^{-4}. Meanwhile we succeeded in incorporating the planned second stage of extension to electron energies up to 100 keV corresponding to proton energies of 184 MeV into the first stage terminated at the beginning of experimental operation by reconstruction of gun and collector. The electron cooler has been detailed completely and ordered for machining. The active cooling length of 2 m will be built in into the 7.2 m long free section of the cooler telescope. The main magnets and coils and the main power converter are manufactured. Gun, collector, high voltage platform and transmission line for 100 kV are in the tendering phase. Field measurements in the single coils and in the assembly to adjust the correction coils are in preparation.

E. Ultra Slow Extraction

The users' requests for a low emittance beam together with the requested maximum duty cycle will be met by the method of the ultra slow extraction (USE). A third order resonance will be driven by a proper set of sextupoles to fulfil the conditions for resonance extraction. Additional sextupoles are needed for tuning chromaticity to optimal values while a cavity puts a RF noise onto the beam. This moves the particles chromatically to the extraction resonance. It is expected to extract a beam with an emittance of less than 1 π mm mrad at a momentum spread of less than $2 \cdot 10^{-4}$. The hardware is under construction following the LEAR design [5].

F. Extraction Beamlines

COSY will be used as a facility with internal and external targets. The internal targets in the ring serve mostly for high luminosity experiments in the recirculator mode. Most of the experimental proposals aim at using external targets. The beamlines to 3 external experimental areas are shown in figure 1 :
Area III serves the beam to a Time Of Flight spectrometer(TOF). Area IV will be used for the magnetic spectrometer BIG KARL, which is already existing and going to be upgraded. For the areas III and IV a beam with a minimum spot size (less than 1mm) and a high stability has been requested. Therefore these two beam lines have been designed like achromats with a demagnification of about a factor of 20. The main components for the beamlines have been ordered.

III. Summary

Approximately 85% of the components of the accelerator and storage ring COSY have been ordered or delivered. The assembly of components is in a progressive status. The cyclotron JULIC has been upgraded as injector and the injection beamline is in the assembly phase. The main components for the extraction beamlines to external target places have been ordered. For resolution of charged products with momenta $\lesssim$ 1.3 GeV/c the spectrometer BIG KARL will be available. Outside the present project an additional beamline for polarization experiments is under discussion and design. Start of users' operation of COSY-Jülich is aimed at April 1993.

IV. Acknowledgement

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V. References

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