ACTIVITIES AT THE COSY/JÜLICH INJECTOR CYCLOTRON JULIC

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Abstract

The operation and development of the accelerator facility COSY is based upon the availability and performance of the isochronous cyclotron JULIC as the pre-accelerator. The cyclotron has been commissioned in 1968 and exceeded 241 000 hours of operation. In parallel to the operation of COSY the cyclotron beam is also used for irradiation and nuclide production. A brief overview of activities, performance, new and improved installations und procedures is presented.

INTRODUCTION

The institute for nuclear physics at the Forschungszentrum Jülich is dedicated to fundamental research in the field of hadron, particle, and nuclear physics. The aim is to study the properties and behaviour of hadrons in an energy range that resides between the nuclear and the high energy regime. Main activities are the development of the high energy synchrotron ring HESR, operation and improvement of the Cooler Synchrotron COSY-Jülich [1], with the injector cyclotron JULIC [2-4], as well as the design, preparation, and operation of experimental facilities at this large scale facility, and theoretical investigations accompanying the scientific research program.

The accelerator HESR, part of the GSI FAIR project [5], synchrotron is dedicated to the field of high energy antiproton physics with high quality beams over the broad momentum range from 1.5 to 15 GeV/c to explore the research areas of hadron structure and quark-gluon dynamics. An important feature of the new facility is the combination of phase space cooled beams with internal targets which opens new capabilities for high precision experiments. The tools to reach the required quality are tested at COSY. The cooler synchrotron COSY offers excellent research opportunities for hadron physics experiments and for essential preparatory studies for the machine development of HESR. A 2 MeV electron cooler is under construction, Detector tests for PANDA and polarization build-up studies for PAX are performed.

EXPERIMENTS AT COSY

The cooler synchrotron and storage ring COSY delivers unpolarized and polarized beams of protons and deuterons with momenta up to 3.7 GeV/c for three internal experiments — ANKE, PAX and WASA — and one experiment — TOF — at an external target position. All four detection systems are operated by large international collaborations [6].

At ANKE, Apparatus for Studies of Nucleon and Kaon Ejectiles, is a large acceptance forward magnetic spectrometer at an internal target station in the COSY ring. First double polarized experiments have been performed with a polarized internal target with a storage cell.

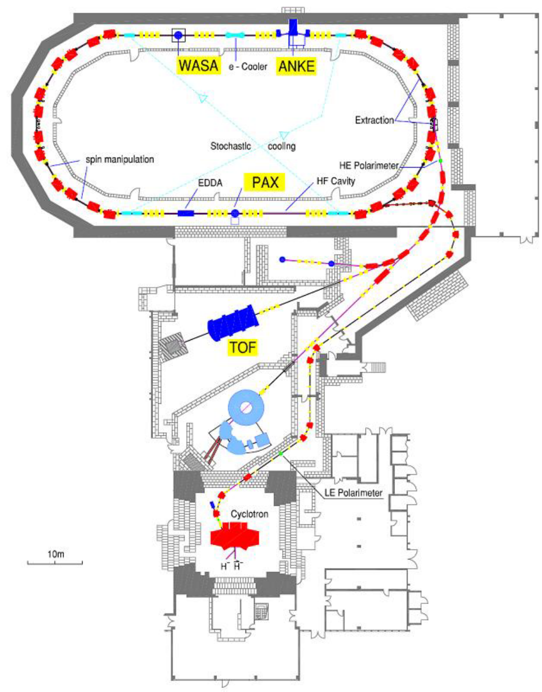

Figure 1: Layout of the COSY facility.

The 4 pi spectrometer for neutral and charged particles, WASA, Wide Angle Shower Apparatus, is operated also with the internal COSY beam. The barrier bucket cavity of COSY was successfully used to optimize the compensation of the main energy loss, which is introduced by the WASA frozen-pellet target.

An advanced grant of the European Research Council has been obtained for the polarization of anti-protons. Additionally installed quadrupoles in the mid of the straight target section provides the needed low beta values for the newly installed former HERMES polarized target as a polarized internal gas target. This is an important step to provide polarized antiprotons for FAIR.

In addition, the unique COSY capabilities are used by the SPIN@COSY-, dEDM- and PAX-collaborations to investigate spin-manipulations, to build a dedicated EDM-storage ring experiment, and to prepare experiments on polarization build-up in storage rings.

NEW METHODS AT COSY

The 2 MeV electron cooler project for COSY is funded and is expected to boost the luminosity in the presence of

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beam heating by high density internal targets. In cooperation with the Budker Institute of Nuclear Physics, BINP Novosibirsk (Russia), the manufacturing has been started. The cosy section has been prepared to insert the cooler at the former position of the rf cavity [7].

Theoretical investigations of stochastic momentum cooling for the HESR clearly reveal that the strong mean energy loss induced by the interaction of the beam with an internal pellet target can not be compensated by cooling alone. At COSY stochastic cooling and internal targets are available similar to those which will be operated at the HESR. A barrier bucket cavity is routinely in operation. The COSY machine is exquisitely suited for beam dynamic experiments in view of the HESR. Important feasibility studies to compensate the large mean energy loss induced by an internal pellet target similar to that being used by the PANDA experiment at the HESR with a barrier bucket cavity (BB) have been carried out [8, 9].

CYCLOTRON OPERATION

The operation and development of the accelerator facility COSY is based upon the availability and performance of the isochronous cyclotron JULIC used as the pre-accelerator. The cyclotron has been commissioned in 1968 and exceeded 241000 hours of operation in 2010. A fraction of the run time since 2000 is shown in the upper part of fig. 2. The lower part shows the distribution of the available beam species, protons and deuterons, polarized or unpolarized.

Table 1: Runtime and failures

Year	Available / h	Unavailable / h
2007	6590	300
2008	7303	156
2009	6716	164
2010/07/01	3621	40
Since 1989	132800	-
Since 1968	241000	-

Table 1 reflects the high availability of the cyclotron from 2007 to mid 2010. Only about 3 % of the scheduled beam time could not be provided to experiments, due to failures at the cyclotron. Excluded were short events, like spark recovery, which are fixed automatically or by the operator. The most common reasons for such events were power drops, shortage in water cooling, septum exchange and failures in the rf subsystems.

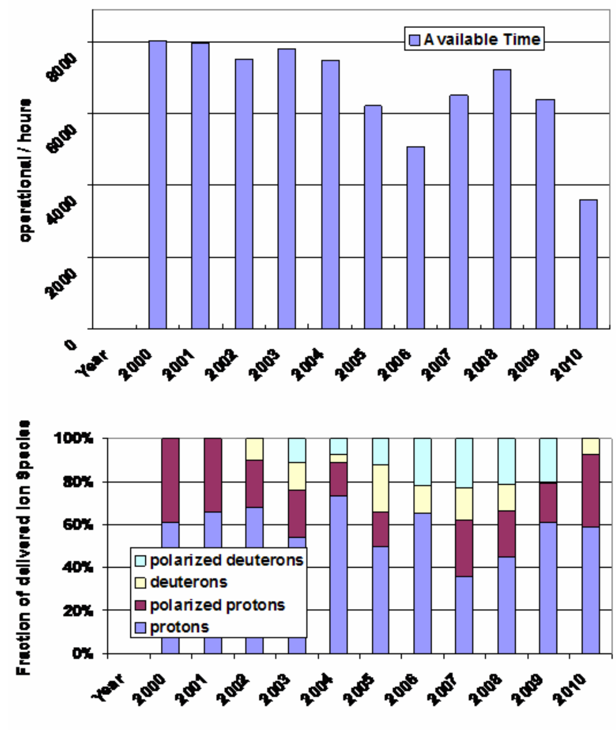

Figure 2: Beam usage statistics.

A special effort went into having replacement parts for critical systems and systems with limited lifetime. The electrostatic septum has to be replaced about once every year. Especially run periods with elevated voltages or irradiation with continuous operation are detrimental for the septum. So we have two spare septa under vacuum for quick exchange. At least one replacement is provided for motor-driven tuning elements and capacitor set-ups.

IRRADIATION FACILITIES

The cyclotron is equipped with 5 ports for radial moveable targets. Today two targets are used routinely. The target behind the septum provides special support for fast exchange of irradiated target constructions. For tuning of the beam extraction one needs the two targets behind the electrostatic septum and the magnetic extraction elements. An inherent problem is the contamination by out gassing of the target material. Accompanying detail improvements the external target station is extended to use production targets for radio isotopes. The principal user of the external target station investigates radiation defects on semiconductors and electronic elements for space missions. The focus of the user with internal targets for radiopharmaceutical products is data measurement and production of longer living PET isotopes at higher beam energies. A new external target station, adopted from one of the cyclotrons of the on-site nuclear chemistry institute, was developed to irradiate solid state targets. Table 2 gives an overview of irradiations at JULIC. Additional activities are planned for the second half of 2010 to get the new target station fully operational. The included helium-cooled double window separates the vacuum around the target from the cyclotron chamber. That provides fast recovery to routine injector operation.

The new target set-up is shown schematically in fig. 3. By replacing the target by an appropriate aluminium window the situation for the other users is kept unchanged. The reduction of beam path length in air is compensated by proper selection of the thickness of the window.

Table 2: Irradiations at JULIC

Year	internal	external
2007	4	-
2008	7	6
2009	7	6
2010/07/01	4	3
Since 1973	233	29

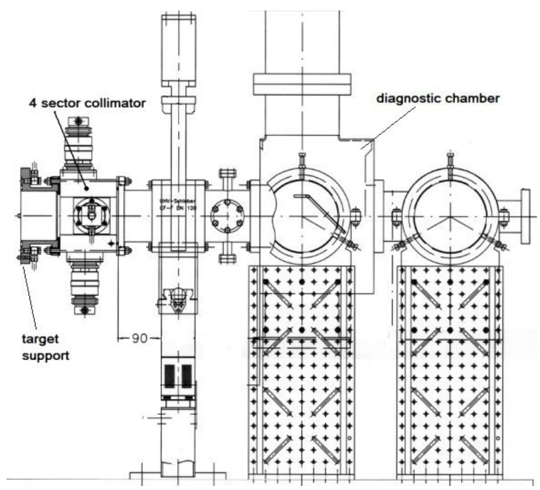

Figure 3: Layout of the actual high current target station.

POLARIZED BEAMS

During the last years the demand for precise polarization measurements, especially for deuterons with various polarization states is increasing. Another motivation has been an observed reduction of polarization for experiments. To exclude effects in the vicinity of the cyclotron and in the path to the synchrotron additional polarimeters have been constructed. There was no significance for polarization losses there.

Since 2009 data from the routine polarimeter can be collected by controlled transmission of beam from the source to the polarimeter. The beam is dumped behind the polarimeter. This monitoring feature enables the judgment of stability up to the polarimeter. Fig. 4 shows an example for polarized deuterons; the data is collected over a period of 11 days. The current status of the polarized ion source and polarimetry at the injector were described in a contribution to the workshop for Polarized Sources, Targets and Polarimetry at Ferrara, Italy [10].

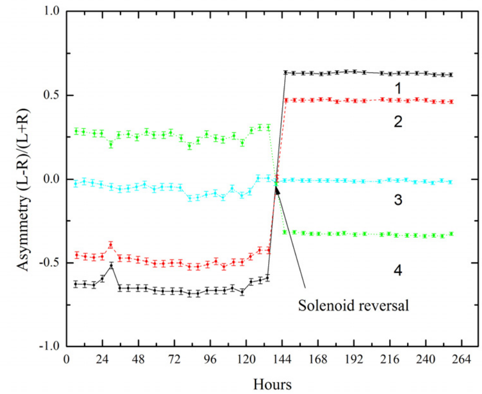

Figure 4: Monitoring the polarized beam behind JULIC. The averages of the measured left-right asymmetries from four different states are plotted.

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