STATUS OF THE COOLER SYNCHROTRON COSY-JUELICH

D.Prasuhn, U.Bechstedt, J.Dietrich, R.Gebel, K.Henn, A.Lehrach, B.Lorentz, R.Maier, A.Schnase, H.Schneider, R.Stassen, H.J.Stein, H.Stockhorst, R.Toelle, Forschungszentrum Juelich GmbH, Postfach 1913, D-52425 Juelich, Germany

Abstract

The cooler synchrotron COSY delivers unpolarized and polarized protons and deuterons in the momentum range 300 MeV/c up to 3.65 GeV/c. Electron cooling at injection level and stochastic cooling covering the range from 1.5 GeV/c up to maximum momentum are available to prepare high precision beams for internal as well as external experiments in hadron physics. The beam is fed to external experiments by a fast kicker extraction or by stochastic extraction. Results of extracted electron cooled beams and developments to increase the number of stored particles and to increase the degree of polarization during acceleration are reported.

INTRODUCTION

The accelerator facility COSY [1] consists of the injector cyclotron and the synchrotron and storage ring with 184 m circumference. It accelerates unpolarized and polarized protons and deuterons in the momentum range between 300 and 3650 MeV/c. The floor plan of COSY with the 4 internal and 3 external experimental areas is shown in figure 1. The main topic of research is the production and interaction of strange mesons close to threshold.

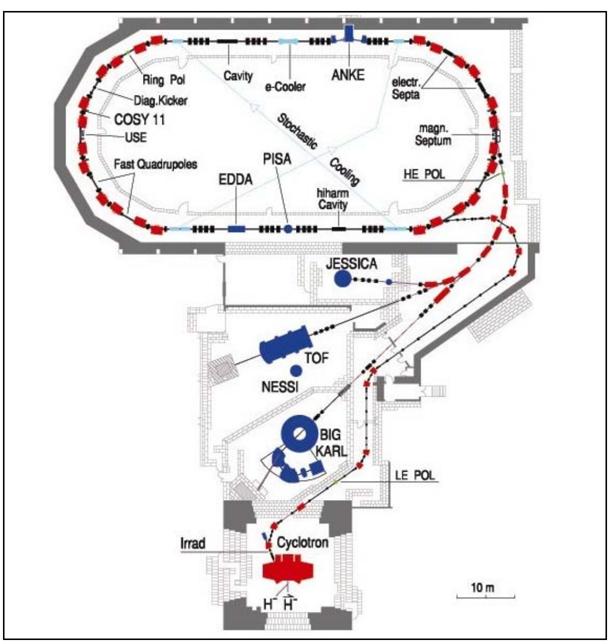

Figure 1: The COSY floor plan

BEAM TIME STATISTICS

COSY has improved its yearly running over the 10 years of operation from 3500 h per year in 1993 up to 7500 h in 2002. And for the year 2003 more than 7700 operational hours are scheduled. The past reliability of COSY increased from 80% in the first year of operation to more than 90% afterwards. More than 2/3 of the available time is dedicated to user operation.

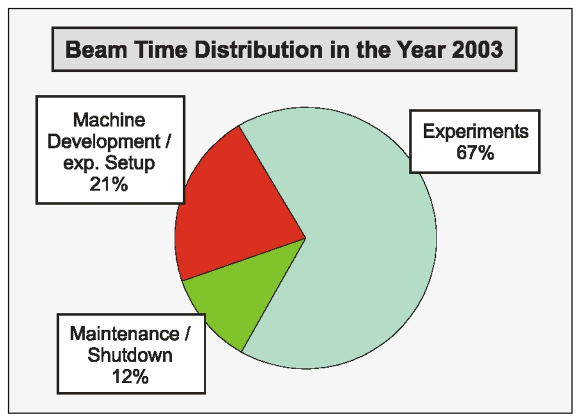

Figure 2: Distribution of the available time in the COSY operation

During the first years of operation only unpolarized protons were asked for by the COSY user community. But this has changed during the last years. Besides polarized protons the demand for unpolarized and polarized deuterons is increasing. The ratio of different requested ion species in the year 2002 is shown in figure 3.

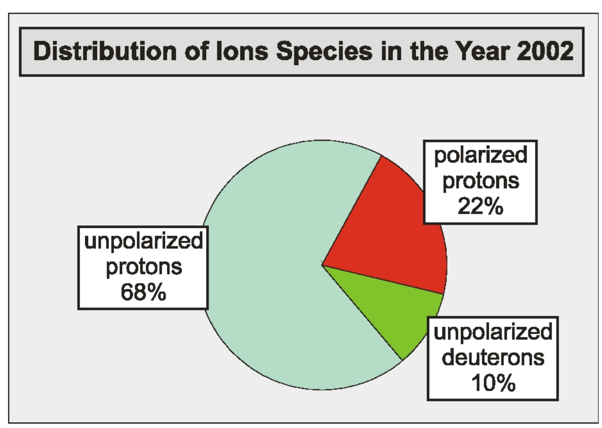

Figure 3: Demand for the different ion species in the COSY operation

ELECTRON AND STOCHASTIC COOLING

Increasing the phase space density by electron cooling at injection momentum and conservation of beam emittance in internal experiments at high momenta are outstanding features at COSY [2].

The electron cooler, designed for an electron energy up to 100 keV and an electron current up to 4 A, is nowadays only used at injection energy, i.e. at 22 keV and with an electron current between 170 mA and 250 mA. It is used with a single injection to decrease the beam emittance and momentum spread without major beam losses. By this we can accelerate $1.5*10^{10}$ protons (or deuterons). This is needed for external experiments. In the case of slow stochastic extraction the pre-cooling decreases the amount of “halo-particles” of the extracted beam by a factor of 50 relative to the uncooled beam, which is important for the high resolution experiments with small hole veto detectors at the target location. For the one-turn kicker extraction the beam has to be pre-cooled, so that the small beam can be steered closed enough to the extraction septum foil and a small kick amplitude kicks the whole beam across the foil within one turn. This is necessary at COSY because no extraction kicker is installed in COSY and a rather small diagnostic kicker has to take over the task of extraction.

Another need for the electron cooler came up with the demand of polarized protons. The intensity of the polarized ion beams is limited by the intensity of the ion source to a factor 10 less than the intensity of the unpolarized beams. And especially internal experiments with thin cluster or atomic beam targets suffer from low counting rates. On the other side the internal experiments show a long cycle time with long beam lifetimes. So a combined cooling and stacking injection can increase the intensity of the polarized ion beams. Figure 4 shows the intensity increase due to 500 injections every 2 sec with an injected intensity which is comparable to that of the polarized ion source. The intensity of the stacked beam can be increased from $2*10^9$ to $3*10^{10}$.

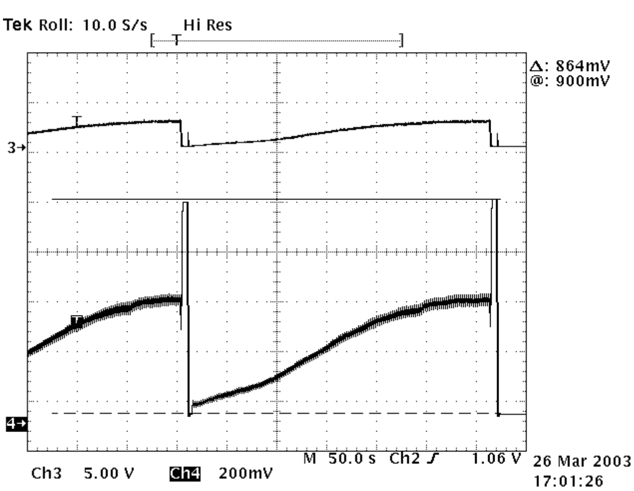

Figure 4: Intensity increase due to electron cooling and stacking

The transverse stochastic cooling at COSY compensates the emittance growth due to small angle Coulomb scattering for internal experiments with cluster targets, the longitudinal system compensates the momentum loss and momentum spread due to target heating. By this the beam-target overlap and thus the luminosity for the experiment stays constant over one hour. Figure 5 illustrates the contrast in counting rate behaviour with and without stochastic cooling.

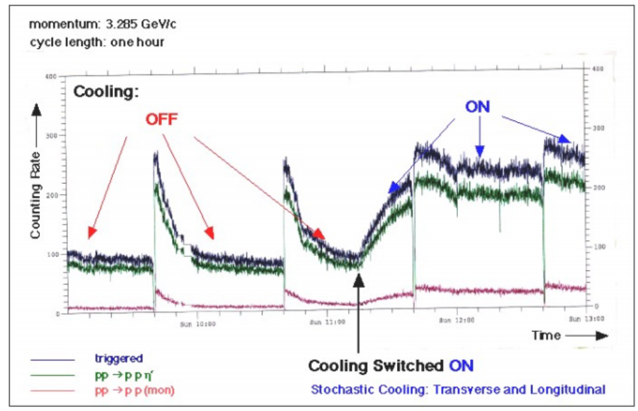

Figure 5: Counting rate of an internal target experiment without and with stochastic cooling

POLARIZATION

Some COSY experiments investigate the spin observables in the nucleon-nucleon scattering. Thus there is a need to conserve the polarization of protons during the acceleration. In the momentum range of COSY there are 5 imperfection and 10 intrinsic resonances. The imperfection resonances which depend only on the momentum are increased in strength by a vertical orbit bump to excite a total spin flip. The momentum and tune dependent intrinsic resonances are compensated by a fast tune jump which increases the speed of resonance crossing [3]. In figure 6 we show a typical acceleration cycle of polarized protons with the necessary tune jumps and vertical orbit bumps.

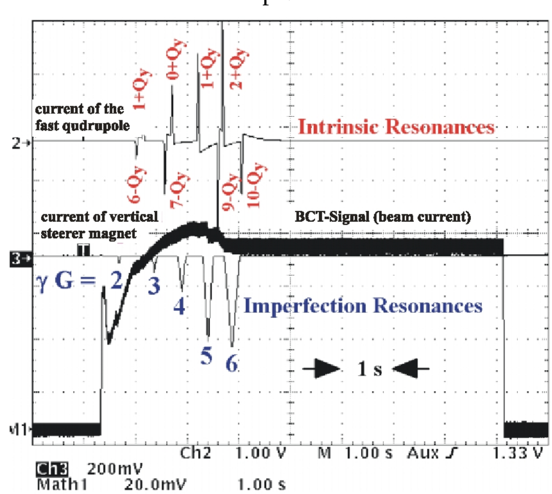

Figure 6: The acceleration with polarized protons

In figure 7 the polarization of protons as a function of the momentum, measured by EDDA during the acceleration ramp, is shown. The strongest ($8-q_y$)-resonance may either be compensated by a tune jump, which usually leads to beam losses, or can be increased in strength by a special tune setting in the acceleration ramp to excite a total spin flip without beam losses.

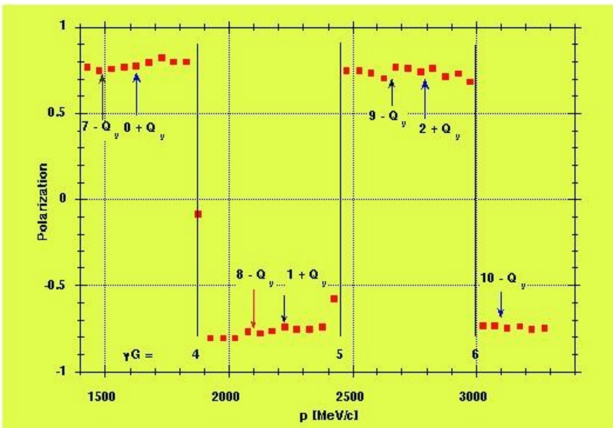

Figure 7: Polarization of protons as a function of the momentum

In February 2002 for the first time vertically polarized deuterons have been accelerated in COSY. For the acceleration of polarized deuterons, additional correction provisions are not necessary to preserve polarization during acceleration because depolarizing resonances do not occur within the momentum range of COSY at ordinary transversal betatron tunes. Asymmetries of polarized deuterons have been measured with the EDDA detector.

SUMMARY

COSY is a unique accelerator in the medium energy range for (un-) polarized proton and deuteron beams with the combination of electron and stochastic cooling, with both internal and external experiments. It delivers beam to users for more than 5400 hours per year with a high reliability of more than 90%. A super conducting LINAC [4] was proposed as a new injector to increase the intensity of polarized ions up to the space charge limit.

REFERENCES

[1] H.Stockhorst, U.Bechstedt, J.Dietrich, R.Gebel, K.Henn, A.Lehrach, B.Lorentz, R.Maier, D.Prasuhn, A.Schnase, H.Schneider, R.Stassen, H.J.Stein, R.Tölle, "Progress and Developments at The Cooler Synchrotron COSY", Proceedings of the 8th European Particle Accelerator Conference (EPAC 2002) -92-9083-198-7, p. 629

[2] D.Prasuhn, J.Dietrich, K.Fan, V.Kamerdjiev, R.Maier, H.J.Stein and H.Stockhorst, "Cooling at COSY", Proceedings of the Workshop Beam Cooling and Related Topics (ECOOL 2001), Schriften des Forschungszentrums Jülich, Reihe Materie und Material, Vol. 13, 3-89336-316-5

[3] A.Lehrach, "Acceleration of Polarized Protons and Deuterons in the Cooler Synchrotron COSY", 15th International Spin Physics Symposium, Brookhaven, 2002

[4] R.Tölle, U.Bechstedt, N.Bongers, J.Dietrich, R.Eichhorn, O.Felden, R.Gebel, K.Henn, H.Jungwirth, A.Lehrach, R.Maier, U.Pfister, D.Prasuhn, P.v.Rossen, A.Schnase, H.Schneider, Y.Senichev, R.Stassen, H.Stockhorst, E.Zaplatin, A.Schempp, "COSY-SCL, The Super conducting Injector LINAC for COSY", contribution to this conference