CONDITIONING THE COOLER SYNCHROTON COSY FOR INTERNAL EXPERIMENTS

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Abstract

COSY-Jülich is a cooler synchrotron and storage ring delivering protons in a momentum range from 270 to 3300 MeV/c. Internal as well as external experiments are possible. At present three internal experiments are installed: COSY-11, COSY-13, and EDDA. To circumvent crossing transition energy while ramping up the machine the COSY-lattice offers the flexibility to shift transition energy upwards so that the beam never crosses that point. This is of great importance for the EDDA experiment which takes data during the acceleration phase. Beam stability measurements during the whole ramp cycle will be discussed. The experiments COSY-11 and COSY-13 require nearly zero dispersion at the target places. Therefore, after debunching the beam at flat-top energy the optics is modified to ensure the specific needs of the experiments. If desired, rebunching of the beam with reduced transition energy is then possible at small loss rates. Examples will be presented.

1 DESCRIPTION OF THE ACCELERATOR

COSY is a COoler SYnchrotron and storage ring designed for protons between 40 and 2500 MeV kinetic energy (momentum scale: 270 MeV/c - 3300 MeV/c). The highest momentum delivered to users so far is 3.481 GeV/c. The ring has a circumference of 183.47 m. One machine cycle typically lasts between 5 seconds and one hour. Figure 1 shows the synchrotron and storage ring.

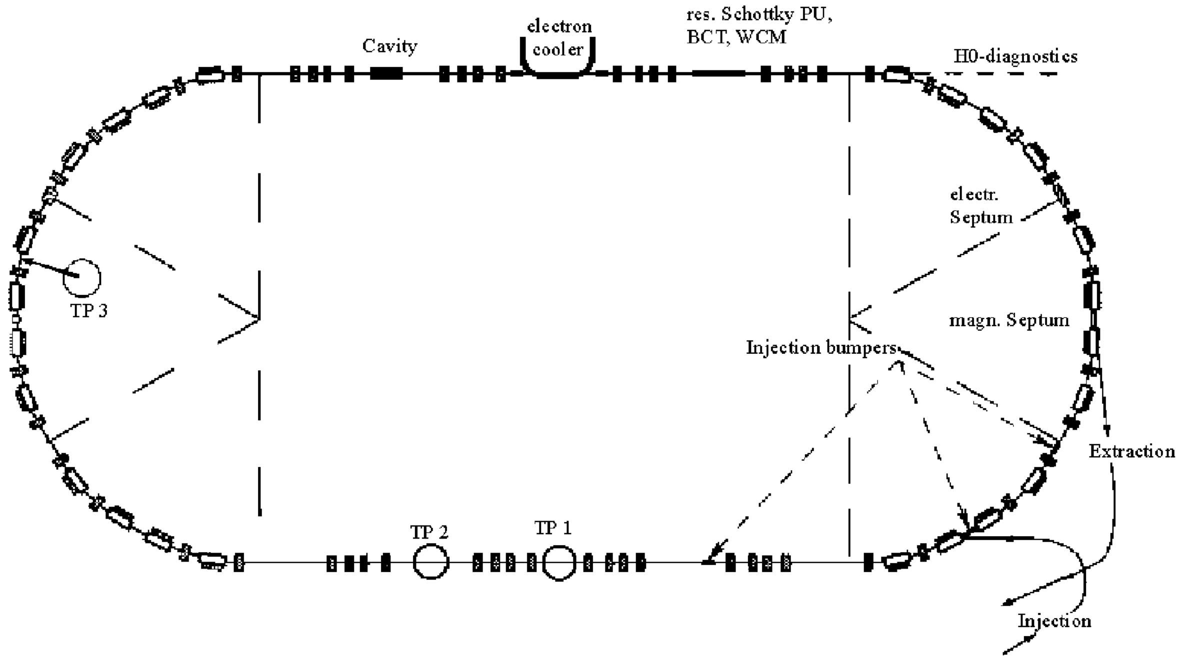

Fig 1: Floorplan of the COSY-Ring. Unit cells are indicated. At the places TP1 - TP3 experiments are installed. Some characteristic devices are labelled.

After the stripping injection of H^--ions at p = 296 MeV/c (45 MeV kinetic energy) the protons may be used by experiments installed at the internal target places TP1, TP2, or TP3. At injection the ring is filled with $2*10^{11}$ protons which is the space charge limit. At maximum momentum $2*10^{10}$ protons are measured. A more detailed description of COSY can be found in [1].

The most important feature of COSY concerning the internal experiments is the great flexibility of the lattice. In the 2 telescopic straight sections there are 32 quadrupole magnets grouped into 8 families, in the 2 half circle bending sections there are 24 quadrupoles in 6 families. Each of the 14 quadrupole families can be ramped individually. This feature can be used to tune e.g.

the horizontal beta function and the dispersion at the targetplace of interest. Furthermore control over transition energy is achieved. For fine adjustments there are in addition about 40 correction dipoles and 18 sextupole magnets (11 families).

Resonant extraction for external experiments was achieved for momenta above 600 MeV/c. Up to now a maximum of 2 - 4 * 10^9 protons per machine cycle have been extracted. For details concerning extraction and separatrix refer to the contributions of J. Dietrich et al. and H. Stockhorst et al., this conference.

2 THE EDDA EXPERIMENT

2.1 Description

The EDDA experiment has been set up to measure proton - proton excitation functions with high precision. A very thin fibertarget (typically 4µm x 4µm) of carbon or polypropylene (CH_2) is mounted horizontally and can be moved across the beam starting from the rest position under the beam at a user defined time in the machine cycle. The CH_2 target fiber is coated with 20 µg/cm^2 Aluminum film to make it electrically conducting. Ejectiles are recorded in a cylindrical detector surrounding the thin walled beam pipe. Due to its construction the EDDA experiment is not only a tool for medium energy physics but also an excellent probe for investigating and verifying beam properties of COSY with high precision.

2.2 EDDA and γ-transition

To record excitation functions in an effective manner data are taken during the acceleration ramp of the synchroton. This means that e.g. the transition instability has to be avoided, otherwise this experiment would not be possible. The standard acceleration cycle in COSY starts with γ_{tr} = 2.2 at 295 MeV/c. The quadrupole families in the arcs are ramped such that at 3.3 GeV/c γ_{tr} typically is about -7. So the transition energy is never crossed.

2.3 EDDA as a diagnostic tool

The possibilities to measure beam data with EDDA cover horizontal and vertical beam positions, beam widths, and the polarization, if the circulating protons are polarized. Two examples are presented here:

Fig. 2 shows the momentum ramp together with the horizontal beam position at the EDDA target as deduced from the experiental data via vertex reconstruction. It is clearly visible that the beam moves outwards during ramping up and stays constant when reaching flat top momentum of 3.4 GeV/c. At flat top momentum the beam was moved across the target by two steerers in the vicinity of the EDDA target to check the luminosity: The quality of the filament, especially its contents of hydrogen, was expected to change due to radiation damage.

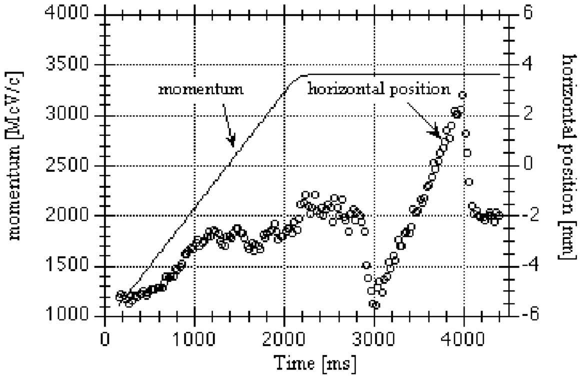

Fig. 2: Momentum ramp and horizontal beam position at the EDDA experiment. The special shape of the position curve between 2.6 s and 4.2 s arises from a luminosity check required by the experiment. See text.

Fig. 3 shows in a snapshot of the first beam time with polarized protons at COSY the raw data resembling the change of asymmetry during acceleration as the first two depolarizing resonances are crossed. At T = 108 MeV (p = 464 MeV/c) the first imperfection resonance is crossed. It could be crossed equally good either with vertical orbit deviations or solenoids. The first intrinsic resonance at T = 308 MeV (p = 820 MeV/c) was not compensated. The data shown are recorded with a mean scattering angle of 11.5 degree. The polarization of the incident beam was about 0.75. Further details concerning this topic are presented at the spin96 conference (September '96) at NIKHEF in Amsterdam by A. Lehrach et al.

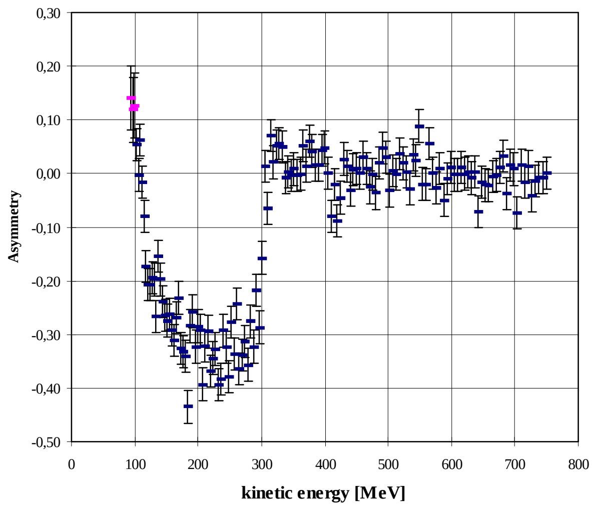

Fig. 3: Asymmetry during the acceleration in COSY as recorded by the EDDA detector. The first depolarizing resonance (imperfection) is enhanced to produce a spin flip, the second one (intrinsic) is not compensated. The data shown are raw data.

3 THE EXPERIMENTS COSY-11 AND COSY-13

Both experiments take data during flat top phase. They have similar requirements for the circulating beam and are discussed together. The methods to fulfil the requirements are similar.

3.1 Description of COSY-13

COSY-13 is designed to detect Λ-particles which are produced in a collision of protons with a Uranium nucleus. The target is a carbon foil which at the bottom is coated with uranium. The foil is mounted a few mm above the circulating beam. After reaching the top momentum, the proton beam is slowly steered upwards to the target foil. Protons being scraped by the target foil are used for the experiment. The parameters of the steerer ramp are used to produce a constant luminosity and optimal countrate. A quadrupole setting with a small horizontal beam dimension at the target place has to be choosen.

3.2 Description of COSY-11

This experimental facility has been designed to study production, internal structure, and decay of mesons as well as meson-nucleon and meson-meson interactions. For this reason a cluster target is placed in front of a C-type dipole magnet which is used as an analysator magnet for the ejectiles. The vacuum chamber inside this dipole had to be modified to bear a thin exit window (appr. 1.8 m long, 15 cm high; ramping conditions: $\Delta B \approx 1$ T at about 1 T/s speed). The inevitably increased thickness of the walls of this vacuum chamber gives rise to eddy currents which cause local deviations in the field map of this dipole magnet during ramping. The deviations concerning the dipole, quadrupole, and sextupole field components have been compensated to still allow the acceleration of protons over the whole momentum range of COSY.

3.3 Requirements

As the cluster target produces a hydrogen cluster beam of appr. 10 mm diameter the intersecting circulating proton beam should be of comparable size, so a low beta function has to be choosen. Furthermore, as the protons loose a small fraction of their energy as they traverse the cluster target, zero dispersion at the cluster target is also required to prevent movement of the interaction region.

3.4 Shifting γ_{tr} at flat top momentum

The standard acceleration cycle in COSY starts with γ_{tr} = 2.2. The quadrupoles are driven such that at flat top energy γ_{tr} typically is about -7. Although these conditions are fine for the EDDA experiment one consequence is that dispersion and beamsize at the COSY-11 target are not tolerable. To achieve matching the COSY-11 requirements an appropriate quadrupole setting for the flat top energy is calculated. At flat top energy the beam is debunched adiabatically and afterwards the quadrupoles in the arcs are ramped to the calculated strengths thus tuning the lattice to the desired values. In this process γ_{tr} is typically shifted to values between 2 and 3.5. So at flat top energy γ_{tr} is crossed. The shift of transition energy can be shown, if the beam again is bunched by the RF system. A typical example is shown in fig. 4 where the phase between RF and bunch signal changes by 180 degrees.

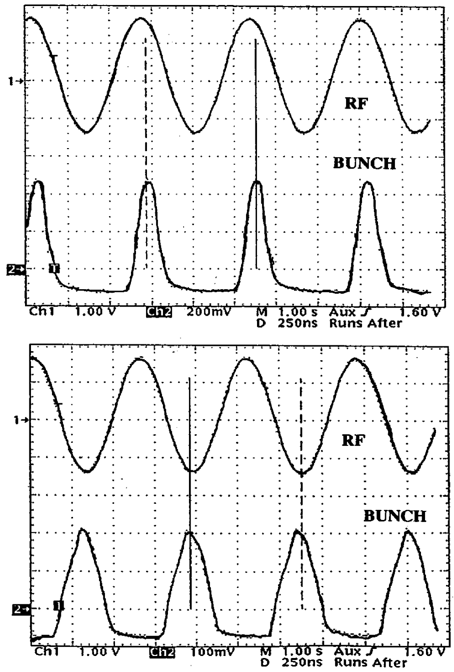

Fig 4: RF and bunch signal before and after shifting transition energy at flat top energy.

REFERENCES

[1] R. Maier, U. Bechstedt, J. Dietrich, U. Hacker, S. Martin, D. Prasuhn, P.v. Rossen, H. Stockhorst, R. Tölle: Status of COSY, EPAC 94 (London), p.165