INTRODUCTION

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THE BEGINNING OF A NEW ERA

Those groups operating the two large accelerator facilities experienced major changes in year 2002, triggered by the occasion of the Swiss Light Source (SLS) entering routine operation. There were now two highly skilled accelerator teams at the PSI, one serving the High Intensity Proton cyclotron, the other the SLS. Since we are never looking upon ease and happiness as ends in themselves (A. Einstein), it was only logical to merge this twofold expertise into one organizational structure. The machine division of the SLS was united with their counterparts from the proton accelerators and their technical support structures. The old name Large Research Facilities (GFA) was retained by the new organization.

This transfer was performed in the middle of the year and Erich Steiner, Department Head of the former GFA, nearing retirement, handed over to me. Great progress was achieved during his period of charge. The availability of the proton machines was impressively improved upon and the intensity of the current increased. Several new projects were started. To name just two, the reconstruction of the centre of the 590 MeV cyclotron and the upgrade in beam intensity by replacing the old aluminum cavities with new ones made out of copper.

In the new organization, activities in areas of machine systems such as controls, diagnostics, vacuum, survey/alignment and operation were united. Apart from creating synergies, this will also lead to a convergence of technical systems on a long-term scale, with all its beneficial consequences regarding manpower and costs. This change also implies a convergence of cultures. The long-term experience of the ‘old team’ that has successfully operated and upgraded the proton cyclotron to the highest power worldwide, meets the storm and stress of the ‘young team’ that has constructed the light source with the highest performance worldwide. After some initial irritation, the union began to bear fruit, although not necessarily at equal rates in all areas.

PROTON ACCELERATORS AND BEAMLINES

The start of the ring cyclotron after a long Shut-down is always an exciting phase, sometimes requiring all the effort of the experts. This year’s start was hindered by mechanical damage to the support structure of a beam stopper within the cyclotron. The full skill of the operators was called on in order to temporarily circumvent this problem through anomalous parameter settings. In this way a beam could be provided that allowed user operation to commence on schedule. In additional unscheduled development periods the fault could be traced within a short period of time. In spite of this initial problem and a series of failures in the cooling system that very often have severe time consuming consequences, an average availability of 88.6% could be reached for the year 2002.

Large modifications on the proton accelerator system were performed during the 2002 Shut-down. Also, in view of the planned future intensity increase, the cyclotron centre was reconstructed. The goal was to improve the accessibility and to modify hardware in such a way that a fast exchange can be performed in the event of a failure. This will reduce the exposure to radiation for the personnel involved. Furthermore, the vacuum system was segmented by means of two additional vacuum valves. This was already seen to largely pay off in the year 2002 when the replacement of two magnets in the ring centre became necessary. Due to the segmented structure of the vacuum system, the electrostatic elements of injection and extraction no longer need to be exposed to air as was previously the case. A more stable operation was the result and in spite of the two interventions in the ring centre, no replacement of the electrostatic deflectors became necessary in year 2002.

Even after 30 years of lifetime for the proton cyclotron, work is still going on to enhance its understanding and consequently improve performance.

A better knowledge of cavity mode excitation was reached with an advanced numerical code developed in house. Higher order modes are deteriorating the beam quality and can be the reason for increased beam losses. A better understanding of phase space distortions, due to higher order modes will help to minimize the occurrence of beam losses.

Further hardware upgrade of the machine will provide higher performance but is also triggered by the need for preventive maintenance after 30 years of operation. A new current probe head was installed that allows the scanning of all but the first seven beam revolutions. With this new diagnostic system, a distortion in the main magnetic field has been discovered. Studies were made to understand the observed vertical betatron oscillation with the goal of correcting it and to minimize its adverse effects on the beam.

Towards the end of the year, the prototype of the new cyclotron cavity was close to completion. Acceptance tests at the factory revealed excellent results regarding quality factor and resonance frequency. The mechanical performance of the hydraulic tuning yokes was also verified and extensively tested.

A device for sealing-surface reconditioning of the cyclotron cavities was constructed and successfully tested. Due to aging, the vacuum seals between cavity and vacuum chamber show increasing leak rates. The new device will speed up the reconditioning of the cavity sealing-surfaces in case of a vacuum failure.

The controls system of the High Intensity Proton facility is in the process of being gradually upgraded to

VME hardware. The main driving force behind this is the need to replace magnet power supplies with new digitally controlled ones that also are more precise and stable.

Also the Run Permit system, based on hardware connections that constantly monitor the status of the hardware is in the process of being upgraded. The present CAMAC modules will be replaced with IP modules. The UCN kicker makes use of this new hardware, an in house developed carrier board with an on-board DSP. For the test of the UCN kicker this new system was successfully operated. Later it will also be used for the Patient Safety system of PROSCAN.

Excellent performance was also reached with the new pion production target. The improvement of target E paid off and an operation period of more than six months without any degradation was the result. The ulterior lifetime limits will be explored in 2003.

THE LIGHT SOURCE

The year 2002 was the first full year of user operation for the SLS. To attract high quality science, an excellent system performance coupled with the highest beam quality is mandatory. The beam current was gradually increased from 150 mA to 300 mA, which was finally reached in October. The higher intensity was attained without compromising other parameters. On the contrary, the stability in position, intensity and energy was further increased. Crucial for this achievement was the successful commissioning of the superconducting higher harmonic cavity, the first of its kind, working successfully in a storage ring. Machine performance was improved in terms of current and lifetime. An unexpected effect was that the dispersion in phase generated by the harmonic cavity, combined with an incomplete ring filling, became an efficient way to longitudinally de-correlate the bunches. This allowed the first stable operation of the SLS at the design current of 400 mA. A lifetime improvement larger than a factor of two was measured up to the maximum current.

The average beam availability for the SLS was 94%. Efforts will be made to improve this number in the second year of SLS operation. The meantime between two unscheduled beam interruptions, already at a respectable level, was further increased to 30 hours. It is remarkable that the installation of the 5 mm gap vacuum chamber for the Material Science beamline, the lowest gap worldwide in a medium energy light source, caused no deterioration in performance.

Top-up has become the standard operation mode for the SLS, providing ‘infinite’ lifetime. The great advantage is that all storage and beamline components remain in thermal equilibrium, providing excellent mechanical stability. Values of less than 1 μm could be reached at the insertion device source points for short term and long-term stability. By combining the orbit correction with an adjustment of the RF-frequency, the average orbit deviation is minimized and consequently the relative energy spread can be kept between +/- 2×10^{-5}.

PROJECTS

Major GFA resources have been bound to the Proscan project. These include the theoretical work for the new cyclotron - newly developed code was used for more precise RF-field calculations, the static magnetic field and the time dependent electric field were superimposed in order to calculate the trajectories - and hardware design and construction. All beamlines for beam distribution have been designed and components are being ordered.

A new beamline (LEM) at μE4 will provide considerably increased muon flux. The solenoids and the first bending magnet of the beamline have to be made out of radiation hard material. The original plan, to perform the reconstruction during the Shut-down of 2003 could not be adhered to because of a delay in the delivery of the radiation hard coils. The company had evidently underestimated the technical difficulties involved. To minimize the impact of this delay, installations that can be undertaken during machine operation are anticipated allowing reconstruction to be completed in Shut-down 2004.

A fast kicker for the Ultra Cold Neutron (UCN) experiment was installed in the primary proton channel. First tests of the switching procedure were performed with 20 μA beam current, dumped onto the Pirex target station. The beam was deflected for eight seconds and reached the Pirex target station without any corrections to the magnet settings. The results are very encouraging and demonstrate that the envisaged 2 mA beam current can be switched with tolerable losses.

Thorough work throughout the year 2002 was performed by the Technical Support and Co-ordination (ATK) division. Although their activities are usually less visible and spectacular, they are essential for the maintenance of existing accelerators and beamlines, the modification of experiments, the realization of new projects and the removal of radioactive waste, which has to be executed with great care.

A STEP INTO THE FUTURE

Although our priorities clearly lie with the operation of the facilities and their ongoing upgrades and improvements, a fraction of time is dedicated to a possible future large research facility at the PSI. A new concept for the generation of extremely small electron emittances is being explored, based on nano-structured tip-arrays with high gradient acceleration and space charge compensation techniques. This would allow the construction of a Free Electron Laser in the Angstrom regime with drastically reduced dimensions and costs. Single shot imaging of large biological complexes and time resolved studies at the atomic level would become possible. First simulation results look very promising. The future is ours.