INTRODUCTION

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OPERATION

The primary mission of GFA is to ensure the operation of the accelerator facilities with high performance and maximum availability. The effective availability of the proton machines, during normal production periods, was greater than 90 %, which is comparable to previous years. Some major failures, however, reduced the actual availability averaged over the calendar year to about 85 %, which is down from previous years. The dominant causes were a break down of the main power system and a failure of the machine protection system. The effort to reduce the causes of last year's down time (diagnostics, PSA and operational failures) was, however, successful with these factors contributing only marginally to the down time of this year. On the other hand, failures from other areas now became increasingly important, underlining the importance of a risk assessment initiative that started in 2003 and the need for an accelerated replacement of aging components.

At the SLS, the average delivery of 96.3 % of the scheduled beam time to the users was satisfactorily high. In addition, 175 hours reserve time could be used to compensate for the down time leading to an actual value of 99.7 % for the percentage of scheduled beam time delivered to the users in 2004.

The scientific infrastructure at the SLS was extended with the introduction of two new beamlines: the μXAS beamline for X-ray absorption spectroscopy and the second protein crystallography line PX-II. The latter is financed by the Max-Plank-Gesellschaft and the Swiss pharmaceutical industries Roche and Novartis.

PROTON ACCELERATORS

The highlight of the year was the implementation of the new copper cavity in the main cyclotron. It was successfully taken into operation and tested to a peak voltage of 1.4 MV. The cavity has been operated without problems at a voltage level of 750 kV, equalized to the three old Al-cavities.

The challenge for the magnet section at the beginning of the year was the design and the timely completion of the Low Energy Muon (LEM) transport line (2 solenoids, 3 bending magnets, 12 quadrupoles). Particularly troublesome was the integration of the WSX double solenoid which is placed in an intensive radiation environment, making an indirectly cooled mineral insulated coil system imperative. This rather seldom and complicated technology lead to a delay in the delivery, and only through the extra efforts of the magnet section and the technical support groups could the installation be accomplished before the end of the shut-down period.

Progress has been made in understanding the magnet plugging problem of the 870 keV transfer line between Cockroft Walton and Injector 2. This was found to be due to a deposition of corrosion products suspended in the water. The process could be related to acidity and dissolved oxygen and carbon dioxide in the cooling water. Measures will be taken to remove the oxygen and carbon dioxide and to increase the pH-value by the installation of a degassing facility.

The performance of the accelerators depends largely on the capability to detect deviations from normal behavior and to react in the proper manner to counteract their effects. A continuous improvement of diagnostics and controls is mandatory. This is particularly true for a 1 MW proton beam that would cause severe damage in the event of of mis-steering. Consequently controls sector activities are in progress, e.g. to improve on the ramping procedure by detecting beam position faster and at considerably lower intensities. A new distributed remote control of the profile monitors has replaced the aged system. New slit monitors in the proton beam line to SINQ have been installed in order to enhance of the safety at the planned MEGAPIE target experiment. The safety environment for the UCN kicker magnet was improved by implementing additional protective diagnostic elements close to the ceramic tube in order to avoid overheating of the metallic joints.

ELECTRON ACCELERATORS

One of the operational highlights at the SLS was the integration of a fast orbit feedback system that generated a world leading stability at the sub-micron level. An enhancement of top-up operation by selective refills of bunches was of large benefit for the medium term orbit stability. It is based on a newly developed bunch pattern control with bunch-to-bunch intensity fluctuations of only a few percent.

Further improvement was achieved by an ID feed forward system that decouples the operation of beam lines from each other. Gap changes can be performed individually without affecting the parameters (position and beam size) of the other beam lines.

Scientific highlights include the synchronization experiments and the electron bunch length measurement at the SLS linac with sub-ps resolution. An electro-optical sampling method was applied by using a Ti:Sa laser pulse and coherent transition radiation. Synchronization between the 500 MHz RF-system and the laser repetition to less than 40 fs rms has been achieved.

PROJECTS

Major progress was made with the PROSCAN project with the completion of the assembly and installation at the end of 2004. In March, the COMET cyclotron weighing ~ 90 t was delivered. Although the product of an external contract, major parts were contributed by

PSI, including, among others, the degrader, transfer line, vacuum system, low level RF-system, machine control system. Five weeks after delivery, the cryogenic system was ready to be cooled down. Field mapping and subsequent magnet shimming led to excellent results for the magnet field quality. Following completion of some refinement work, the facility will be ready for commissioning in early 2005.

The Low Emittance Gun (LEG) project, directed towards a new large research installation at PSI, received new drive, after two experienced collaborators joined the LEG team.

Equipment has been developed for testing high gradient acceleration, maximum emission currents for different tip forms and tip materials and the uniformity of emission from an array. An elaborated 100 keV test stand was equipped with diagnostic tools to measure emittance and energy spread. An in-house development of tip arrays has also started.

For the envisaged gun performance, a Free Electron Laser (FEL) concept has been developed targeting a radiation wavelength of 0.1 nm. It features a field emitter array followed by a diode configuration for high gradient acceleration. This system is integrated in a 2 ½ cell cavity structure, which serves as the front end of an injector linac that boosts the energy up to 0.2 GeV. The final acceleration is performed by a ~ 5 GeV, 3 GHz linac with 3 bunch compressors.

In parallel to the hardware developments, extensive simulations of beam dynamics at the micrometer scale (tip) as well as in the mm scale (gap) have been performed. The effects of space charge forces were calculated for emissions from field arrays for the projected emittance and the slice emittance, taking also tip failures into account.

The third large-scale project within GFA is the envisaged intensity increase of the proton accelerators. A beam of 1.8 to 1.85 mA is routinely extracted and operation at 2 mA has been demonstrated. With the installation of the new copper cavities, a further increase of the proton current becomes possible.

A major modification is needed for Injector 2 in order to increase the turn separation at the extraction. The obsolete flat-top resonators must be replaced by single-gap 50 MHz cavities. An additional buncher in the 870 keV line will significantly improve the injection efficiency. For example, a current of 3.4 mA could be accelerated with a DC input beam of 9 mA, compared to 2.2 mA with 12 mA input today.

The proton bunch length at the exit of Injector 2 is typically 2 cm and increases up to 10 cm at the end of the 58 m long transfer line A buncher in the 72 MeV transfer line would improve the matching of the beam to the Ring Cyclotron and possibly make the flat-top cavity obsolete. The engineering of a 500 MHz buncher, based on a double-gap drift tube cavity, including coupler and tuning system, was finalized.

Prediction of performance at higher currents is difficult, since relevant factors are not accessible by the usual beam dynamics calculations. The current limit is given due to losses in the tails and halos, several orders of magnitude smaller than the beam itself. Simulation requires tracking with millions of particles with higher order effects included.

A generic VME Board was developed to achieve unification for the PSI electron and proton accelerator diagnostics. Future applications are the proton accelerator position monitors, data acquisition and data processing for the muon decay experiment and the digital BPMs at the SLS.

Studies were performed on the thermo-mechanical behavior of the UCN spallation target and on the neutron flux optimization. A transport flask for beam line components and for the UCN collimator has been developed. A versatile transport flask usable for eight different components of the proton beam line is now available This will help to reduce the personnel dose during the exchange of highly activated components.

INTERNATIONAL EVENTS

Three international events in the field of particle accelerator physics, although different in scale, were organized by PSI in 2004.

PSI had the privilege to host the ninth European Particle Accelerator Conference, EPAC'04 that took place at the Lucerne Culture and Congress Centre in July 2004. It was attended by over 800 delegates from more than 30 different countries on all continents.

The scientific program spanned four and a half days and included close to eighty invited and contributed oral presentations of very high quality, including the special session for industry and on Technology Transfer, as well as close to 900 poster presentations. The attendance of almost sixty young scientists was made possible through the sponsorship from European laboratories, institutions and industry.

At the second international event, the IWBS2004 workshop, 47 accelerator physicist from 12 countries came together to discuss orbit stability matters, one of the key issues in advanced synchrotron light sources and of even more importance for the linac based next generation light sources which have even tighter requirements.

The third event, the 3rd Workshop on CW and High Power RF-systems for Accelerators was attended by 40 participants. The focus was on operational and reliability issues of high-power amplifiers, as well as on cavity design and low-level control systems. New technologies and applications were introduced, and advanced numerical methods for complete modeling of complex RF-structures and integrated cavity design were presented.

These events were very successful and cemented the reputation of PSI as excellent organizer of international events.