THE PROSCAN PROJECT: OBJECTIVES AND PROGRESS REPORT

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OBJECTIVES OF THE PROJECT

Based on the developments and successes of the proton therapy the PSI directorate decided in 2000 for an expansion of the activities in this field and launched the so-called project PROSCAN. The objectives of PROSCAN are:

- the further development of the PSI Spot-Scanning technology (i.e. with faster scan methods to overcome the organ motion problem) into a new Gantry, which can be implemented in a hospital environment
- the optimisation of the treatment methods, including the treatment of additional indications
- the transfer of the technology and of the know-how to industry and to radiation therapy centres, including education and training of specialised personnel

With PROSCAN PSI will implement and operate a base technology laboratory for the further development and advancement of proton therapy using own system techniques and applications. The program is based on the experience with the technology at the compact PSI Gantry for the treatment of deep seated tumours and on the treatment of eye tumours at the OPTIS facility.

The project PROSCAN is an interdisciplinary development of several laboratories and divisions at PSI.

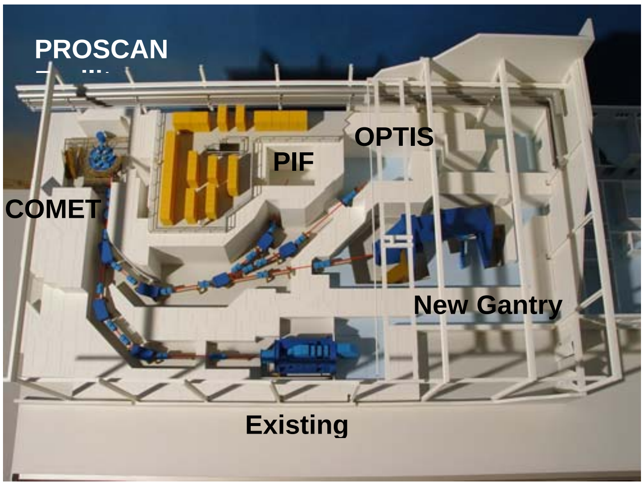

Fig. 1: shows a model of the layout of the facility. The existing Spot-Scanning Gantry will be connected through a new beam transport system to COMET. The new Gantry with additional features will be installed in a new treatment area. Two horizontal beam lines are also included in the design: the OPTIS area for eye treatments (transferred from the Philips cyclotron) and the PIF area dedicated to basic research in biology, dosimetry and for other R&D activities.

EXPANSION OF THE EXISTING FACILITY

A major drawback of the existing system is the parasitic use of the beam of the large 590 MeV proton cyclotron in a multi-user environment with the long shutdown periods needed for maintenance and upgrades of the accelerators and the experimental facilities, which are mainly used for basic physics research, materials sciences and for structure analysis and spectroscopy. The expansion of the PSI facility started in May 2001 by ordering of the dedicated compact medical cyclotron COMET from the company ACCEL Instruments GmbH. The large pieces of the 250 MeV superconducting cyclotron were delivered in March 2004 and fitted together during the second half of 2004. The commissioning phase started end of the year. The machine should be operational for scanning experiments and for reliability tests in the first half of 2005. PSI contributed to the design and development of the new accelerator, for example by analysing the static and dynamic 3D magnetic and electric fields. Special effort has been put into the optimisation of the beam extraction region. Reaching a high extraction efficiency, the activation of structures and production of radioactivity can be minimised. A double steering magnet has been designed to correct the beam direction right after extraction.

The COMET cyclotron with an approximate weight of 90 tons was aligned by the PSI group with a laser tracker system in March 2004. The vacuum system for COMET has been designed by PSI. A strong emphasis has been placed on a hydrocarbon free system and on the long term leak tightness. The degrader and the beam lines have been designed and realised by PSI. In order to cope with the organ motion problem with a scanned beam, great attention was paid to the goal to provide high speed in changing the energy of the beam, so that fast and multiple target rescanning will be feasible. A fast kicker and a comprehensive diagnostics system are installed in front of the degrader to provide a good control of the beam extracted from the cyclotron, before the beam is led through the degrader and the beam lines.

Before commissioning of the new proton therapy facility a new operating license will be required from the Swiss Federal Office of Public Health. The first safety report for the licensing process has been delivered to the authorities and the approval for the start-up procedures and for the commissioning of the COMET cyclotron was achieved before end of 2004.

STRENGTHEN THE MEDICAL PROGRAM

With the dedicated cyclotron and the expansion of the facility we expect to be able to treat a larger number of cancer patients (three to four times more than now, i.e. about 150 to 200 patients with deep seated tumours). With such an enhanced but still clinical R&D program, running in parallel to the various technological developments, we intend to contribute, in the international framework together with other centres, to the demonstration of the strengths and the potential of this treatment method, including treatment of moving targets with the scanning technology. In parallel, in the frame of a ten years program, we aim to support the education of technical and medical specialists in view of the introduction of this new and advanced therapy method into hospitals.

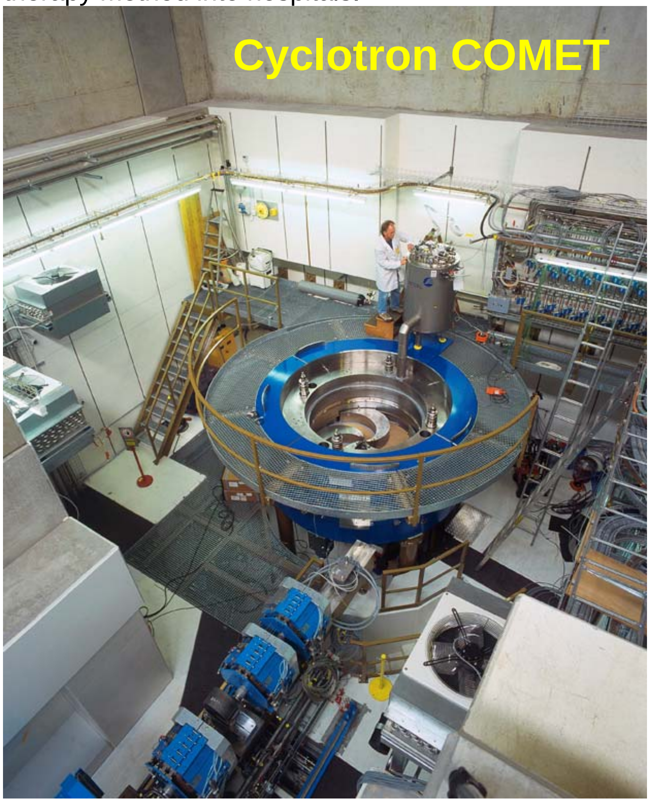

Fig. 2: shows the mounting of the superconducting cyclotron COMET from ACCEL Instruments GmbH in May 2004. The accelerator is housed in a bunker with 3 to 4 m shielding walls. Visible in the foreground are beam extraction area and first part of the beam line.

IMPROVEMENTS FOR EXISTING GANTRY

The major challenge to proton therapy is coming from new sophisticated beam delivery methods developed in conventional radiotherapy (like IMRT= intensity modulated radiation therapy). These new methods are now being widely introduced in the hospitals. The PSI scanning technology is attracting world wide interest, since it is presently the only system capable of providing intensity modulated radiotherapy with protons. This approach could be a “must” if proton therapy wants to continue to play the leading role in precision radiation therapy also in the future. Most of the further work for implementing IMPT (intensity modulated proton therapy) into clinical practice is being done with the existing gantry, including the development of treatment planning, dosimetry and quality assurance methods. About twenty patients have been treated fully or partly with IMPT during the last years. The existing Gantry will continue to play an important role in the development of proton therapy at PSI. Based on the operational experience of the patient treatments, an improvement and revision program is in progress to improve the reliability and the comfort of the existing Gantry. The new patient table allows irradiating multiple fields in the same fraction without intervention of personnel in the treatment room, which allows shorter treatment time and higher patient throughput in commercial facilities.

THE NEXT GENERATION GANTRY

Beam scanning methods are more sensitive to organ motions than passive scattering foil techniques. For solving this problem we develop faster beam scanning technologies (to be able to apply multiple target repainting without compromising the size of the pencil beam). The new options for improving scanning being considered in the frame of PROSCAN are: a) double magnetic scanning on the gantry, b) dynamic energy variation using the degrader, and c) use of intensity modulation at the ion source.

With the designed beam optics we achieved to maintain the beam parallel to the central axis during scanning in both directions of a 2-dimensional treating field. The parallelism of the beam will bring practical advantages, i.e. for therapy planning, patching field techniques, use of collimators and compensators. A much faster beam scanning technique should allow multiple target-repainting in a single fraction, in order to be able to replace completely scattering foil options.

The new Gantry conceptual design was reviewed mid 2004 by an international committee of experts. The committee judged positively the overall concept with the proposed advanced scanning features and made technical and organisational recommendations for the realisation of the project. The suggestions, i.e. to investigate the optimal choice of the dimensions of the parallel scanning field, were well taken by the group and adapted into the Gantry design.

During the second half of 2004 alternative concepts for the isocentric mechanical layout of the Gantry has been studied, with an option of the beam line supported on a single support in the middle of the Gantry structure. The aim of the studies was reduction of construction costs and allowance of additional freedom in the design and layout of the treatment room. Investigated were also the advantages and the disadvantages of a robotic system as patient table. The new Gantry design has been further developed, so that it will be ready to be realised in 2005/2006.

CONCLUSIONS

The expansion of the PSI proton therapy facility will provide new interesting technological and clinical research opportunities. It will allow the investigation of advanced scanning features for the treatment of additional medical indications, including moving tumours and it will consolidate PSI worldwide as a technology base laboratory for advanced proton therapy application.