THE PROSCAN PROJECT: A 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 scanning methods to overcome the organ motion problem) into a second generation Gantry, which can be implemented in a hospital environment,
- the optimisation of the treatment methods, including the treatment of additional indications,
- the transfer of technology and know-how to industry and to radiation therapy centres.

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 long-term program is based on the experience with the technology at the compact PSI Gantry for the treatment of deep seated tumours.

The project PROSCAN is a joint development of several laboratories and divisions within PSI. Many people involved in the practical realisation of the expansion of the facility belong to the GFA and LOG departments of PSI. One of the purposes of this report is to provide here a cross-reference to the scientific report of the life sciences department BIO of PSI, where additional information can be found.

EXPANSION OF THE EXISTING FACILITY

A major drawback of the existing system is the parasitic use of the beam of the 590 MeV proton cyclotron in a multi-user environment with long annual shutdown periods of several months, needed for maintenance and up-grades 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 was officially started in May 2001 by signing the contract for the delivery of a dedicated compact medical cyclotron, named COMET. This 250 MeV superconducting cyclotron is under construction at the company ACCEL Instruments GmbH and shall be operational at PSI in 2004. PSI contributes to the development of the new accelerator, for example by analysing the static and dynamic 3D magnetic and electric fields with the in-house developed particle tracking program TRACK. Special effort has been put into the optimisation of the beam extraction region, where the protons leave the cyclotron. Reaching a very high extraction efficiency, the activation of structures and production of radioactivity can be minimised.

The new degrader system shall be capable of providing reliable stable beam of variable energies in several treatment areas during the whole year.

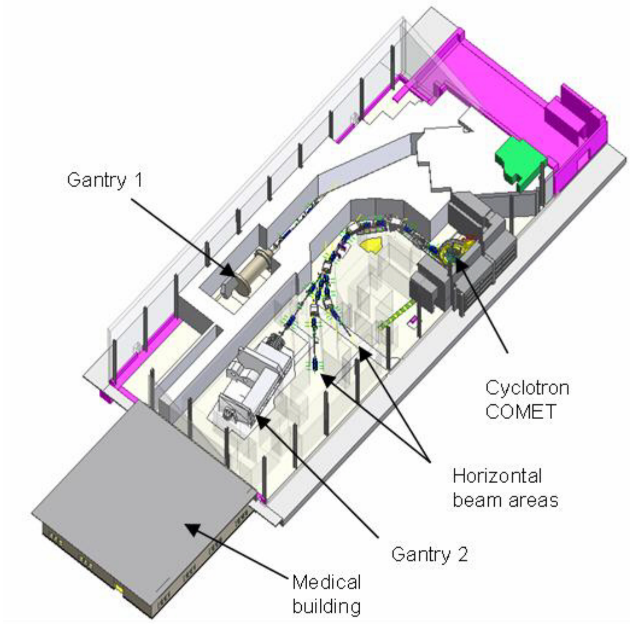

Fig. 1: Layout of the facility. The existing Spot-Scanning Gantry 1 will be connected through a new beam transport system to COMET. A new treatment area is foreseen for a new Gantry with additional features and improvements compared to the present one. Two additional horizontal beam lines, one for eye treatments (transfer of the OPTIS program from the Injector 1) and one area dedicated to experiments (biology, dosimetry and other activities) are included.

The vacuum system for COMET has been designed by PSI. High compression ratio turbo molecular vacuum pumps will be used in combination with dry mechanical vacuum backing pumps.

The degrader and the beam lines are being designed and realised internally at PSI. The optical design for the final layout of the beam lines have been performed with in-house developed transport and Monte-Carlo simulation codes. An alignment concept for the beam line components was developed, which is similar to the other beam lines at PSI: several beam line components are mounted on a girder, only the dipole magnets are standalone components, attached to the floor. This system allows, that most of the assembly work can be performed outside of the beam line areas. The construction of the degrader system has been started. Great attention was paid to the goal to provide high speed in changing the energy of the beam during scanning (to provide multiple target rescanning – for the treatment of moving targets with scanned beams – in order to cope with the organ motion problem).

The intensity losses in the degrader at lower energy are compensated by increasing the intensity of the beam in the ion source. Scattering foils in front of the degrader will be optionally used to reduce the dynamics of the changes of beam intensity when the energy is varied. A fast kicker and a comprehensive diagnostics system are provided 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. The shielding design for the degrader and for the different treatment areas has been almost finalised.

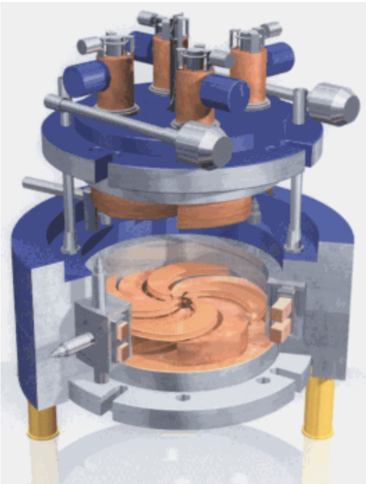

Fig. 2: Artist view of the superconducting cyclotron COMET (courtesy of ACCEL GmbH). The accelerator will be optimised for a stable well-controlled intensity of the beam and for high extraction rates.

Before commissioning of the new proton therapy facility a new operating license will be required from the Swiss Federal Office of Public Health (BAG). The requirements for the licensing process have been discussed with the authorities and the layout of the safety report has been developed.

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 (3 to 4 times more than now). With an extended, but limited 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. 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.

R&D FOR GANTRY 1

The major challenge to proton therapy is coming from new, sophisticated beam delivery methods developed in conventional radiotherapy (like IMRT= "**I**ntensity **M**odulated **R**adiation **T**herapy"). 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 is a "must" if proton therapy wants to continue to play a leading role in precision radiation therapy in the future. Most of the work for implementing IMPT (**I**ntensity **M**odulated **P**roton **T**herapy) into clinical practice is being done with Gantry 1, including the development of treatment planning, dosimetry and quality assurance methods. Several patients have been treated with IMPT in 2002. Gantry 1 will continue to play an important role in the development of proton therapy at PSI. An improvement and revision program for Gantry 1 has been initiated to adapt the level of reliability and comfort to new components that are foreseen for the PROSCAN facility. In this context, a modified patient table was implemented, which allows to irradiate multiple fields during one treatment fraction without intervention of personnel in the treatment room.

DEVELOPMENT OF GANTRY 2

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 repaintings without compromising the size of the pencil beam). The new options for improved 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 the goal to maintain the beam parallel to the central axis during scanning in both directions over a treating field of 8 cm x 20 cm. 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 repaintings in a single fraction, in order to be able to completely replace scattering foil options. In the context of the fast energy variation of the beam the eddy current effects in the 90 degree dipole magnet have been evaluated in a design study.

A new concept for the mechanical layout of Gantry 2 has been developed. The system will be isocentric and will have a fixed floor providing sufficient space around the patient table for good access to the patient at any time during the treatment. The layout will offer the possibility to install a CT scanner and other diagnostic devices in the treatment room, close to the Gantry. The entire design is supposed to be available for commercial negotiation at the beginning of 2004.

CONCLUSIONS

The expansion of the PSI proton therapy facility will provide new interesting research opportunities. It will facilitate the investigation of new medical indications and it will consolidate PSI as a technology base laboratory for advanced proton therapy application.