THE PROSCAN PROJECT: A PROGRESS REPORT

M. Jermann, J. Duppich, E. Pedroni, G. Goitein, M. Schippers and the PROSCAN team

OBJECTIVES OF THE PROSCAN PROJECT

Based on the past developments and successes, PSI decided in 2000 to expand the proton therapy activities and launched the so-called project PROSCAN. The objectives of PROSCAN are:

- the further development of the PSI Spot-Scanning technology into a new Gantry, which can be implemented in a hospital environment (i.e. with faster scan methods to overcome the organ motion problem),
- the optimisation of the treatment methods, including treatment of mobile tumours,
- 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 in-house system techniques and applications. The program is based on the experience with the technology for the treatment of deep seated tumours at the existing PSI Gantry and on the treatment of uveal melanomas at the OPTIS facility.

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

EXPANSION OF THE PROTON THERAPY 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 shut-down periods of about four months per year needed for maintenance and upgrade of the accelerator facility. In May 2001, PSI signed a contract for the delivery of the 250 MeV superconducting cyclotron COMET. This is now under construction at the company ACCEL Instruments GmbH and will be delivered in March 2004. A period of nine months has been planned for the commissioning work and the acceptance tests. In 2003, PSI contributed to the development of the new accelerator by investigating possible beam losses due to distortions of the magnetic field, i.e. by vertical shift of the coil position. The new cyclotron and the degrader will be capable of providing reliable stable beams of varying energy in three treatment areas and one experimental area during the whole year.

By the end of 2003, the first cooling down and the first powering of the coil as well as the quenching of the coil were successfully completed. The field mapping and magnet shimming will take place in February 2004.

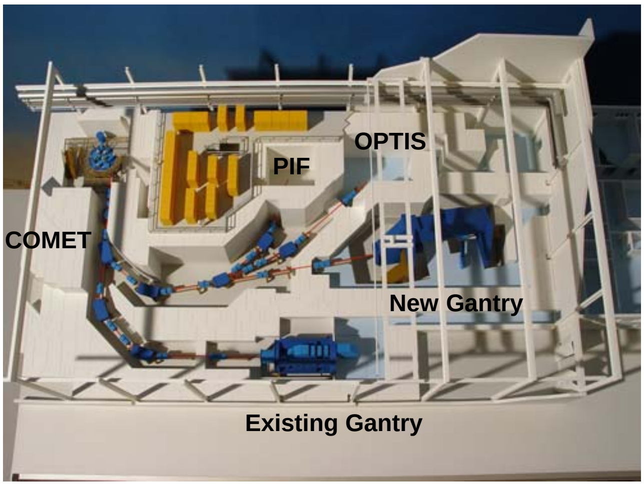

Fig. 1: Model of the facility. The existing Spot-Scanning Gantry will be connected to COMET through a new beam transport system. A new treatment area is foreseen for the new Gantry, which will be equipped with a 2-dimensional fast parallel scanning system. Two additional horizontal beam lines, one mainly used for eye treatment (transfer of the OPTIS program from Injector 1) and the PIF area dedicated to experiments (biology, dosimetry and other activities), are included as further options in the design.

Fig. 2: The superconducting cyclotron COMET at ACCEL Instruments GmbH ready for the cooling down tests in November 2003. The system will be delivered to PSI in March 2004.

The degrader and the beam lines are being designed and realised internally at PSI. The degrader unit is used to adjust the proton beam energy within the required range of 250 MeV to 70 MeV. The degradation of the beam is achieved at the cost of beam losses. The resulting activation of the degrader unit and support structures has been calculated and a concept for the handling and service of the degrader system was developed in 2003. After degradation, the proton beam will be delivered through the beam lines to the treatment areas (Gantry 1 and new Gantry, and two fixed beam areas). Fast energy variations of the proton beam are foreseen for the treatment with the spot-scanning method in the new Gantry. Several beam diagnostic systems will control the beam parameters in the different modes of operation. Ionisation chambers and secondary emission monitors will be used as current monitors and, in a multi-strip configuration, as profile monitors for the beam lines. For fast beam energy and momentum-spread measurements, a multi-layer Faraday cup has been developed and tested during 2003. New VME-based electronics for the diagnostics are being developed.

Before commissioning of the new proton therapy facility, a new operating license will be required from the Swiss Federal Office of Public Health BAG (**B**undes**a**mt für **G**esundheit). The safety report for the licensing process of the first phase (commissioning of the cyclotron and degrader unit) was delivered to the authorities in November 2003 and the approval is expected in the first quarter of 2004.

STRENGTHEN THE CLINICAL PROGRAM

With the dedicated cyclotron and the expansion of the facility, we will have the capacity to treat 100 to 150 patients per year. The higher patient load will allow the extension of the clinical R&D program. Running in parallel to the various technological developments, we will contribute, within the international framework, to the demonstration of the strengths and the potential of proton therapy. Furthermore, we aim to support the education and training of medical and technical specialists in view of the introduction of this new and advanced therapy method into hospitals.

R&D FOR THE EXISTING GANTRY 1

The major challenge to proton therapy is coming from new sophisticated beam delivery methods widely implemented in conventional photon therapy centres, such as IMRT (**i**ntensity **m**odulated **r**adiation **t**herapy). The PSI scanning technology is attracting large international interest, since it is presently the only comparable system using protons. This approach will be a "must" if particle therapy wants to maintain its leading role in precision radiation therapy in the future. Most of the further work for implementing IMPT (**i**ntensity **m**odulated **p**roton **t**herapy) into clinical practice will be done with the existing Gantry 1, including the development of treatment planning, dosimetry and quality assurance methods. Several patients have been successfully treated with IMPT in 2002 and 2003. The Gantry 1 improvement program continues. The new range shifter with a modified nozzle shape allows the patient to be positioned closer to the range shifter. The new arrangement permits delivery of more conformal dose distributions.

THE NEXT GENERATION GANTRY

Beam scanning methods are more sensitive to organ motions than the conventional passive scattering foil techniques. To solve this problem, we are developing faster beam scanning technologies. 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 shall maintain the beam parallel to the central axis during scanning in both directions within a treatment field of 10 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. The faster beam scanning technique will allow multiple target repainting in a single fraction without compromising the size of the pencil beam, in order to be able to completely replace scattering foil options.

The new concept developed for the mechanical layout of the new Gantry is isocentric and has a fixed open floor to ensure good accessibility to the patient at any time during the treatment. It will be possible to install a CT scanner together with other diagnostic devices.

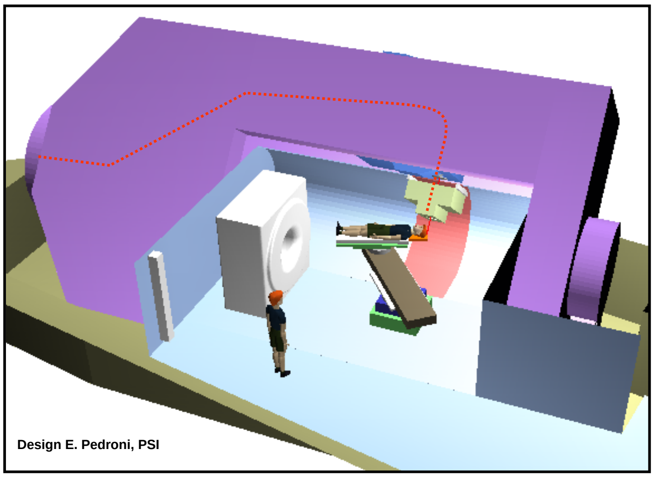

Fig. 3: Model of the next generation PSI Gantry, which should be ready for patient treatment in 2006.

The proposed system will be reviewed in the middle of 2004. Tests of the new scanning features are scheduled for the first half of 2005. The new Gantry should be ready for patient treatment at PSI at the end of 2006, in parallel with the implementation of the new OPTIS facility.

CONCLUSIONS

The expansion of the PSI proton facility will provide new interesting research opportunities. It will facilitate the investigation of improved scanning technologies and the treatment of additional medical indications (i.e. mobile tumours). The new facility will consolidate PSI worldwide as a technology base laboratory for advanced proton therapy application.