EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH
CERN – ACCELERATORS AND TECHNOLOGY SECTOR

CERN-ATS-2012-109

STATUS OF THE MEDAUSTRON ION BEAM THERAPY CENTRE

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Abstract

MedAustron is a synchrotron based light-ion beam therapy centre for cancer treatment as well as for clinical and non-clinical research currently in its construction phase. The accelerator design is based on the CERN-PIMMS study and its technical implementation by CNAO. This paper presents a status overview over the whole project detailing the achieved progress of the building construction & technical infrastructure installation in Wiener Neustadt, Austria, as well as of the accelerator development, performed at CERN and partially at PSI. The design and procurement status and future planning of the various accelerator components is elaborated.

Presented at the International Particle Accelerator Conference (IPAC'12) –

May 20-25, 2012, N. Orleans, USA

Geneva, Switzerland, May 2012

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CIVIL ENGINEERING

The building construction is already well advanced in Wiener Neustadt, Austria (Figure **1**). The construction of the building shell of both the conventional and the accelerator part has already finished. The installations inside the conventional building are progressing well, allowing personnel to start moving in by the end of this year.

Figure 1: Current status of the building construction in Wiener Neustadt, Austria. The opening in the lower right corner remains for the installation of a 120 ton, 90 degree dipole for a vertical irradiation line.

The survey reference network has already been established, the blue lining of the beam line is done and the installation of girders and supports has started (Figure 2). In parallel the installation of the technical infrastructure for the accelerator is ongoing.

Figure 2: Synchrotron hall with first supports and girders installed

INJECTOR TEST STAND AT CERN

Since January, an Injector Test Stand (ITS) is operational at CERN. Currently it consists of one ion source, a spectrometer magnet and several subsequent beam diagnostic elements. In the final stage it will contain elements up to the RFQ, which will be installed by mid 2012.

Figure 3: The MedAustron ITS at CERN, currently consisting of an ECR ion source, a spectrometer magnet and several different beam diagnostic tanks

ACCELERATOR

While few minor modifications in the layout are still being performed for integration optimization, the accelerator design and layout is frozen by now.

Ion source

The first ECR - ion source has been delivered in November 2011 to CERN for installation into the ITS and has been operated since January 2012 for the production of H_3^+ beams.

The influence of all the available tuning parameters on the beam intensity has been studied and by now an H_3^+ beam current of up to 650 µA can be extracted. Further investigations will be performed in order to reach the design H_3^+ current of more than 1mA. A typical dependence of the extracted beam current on one of the ion source parameters – the amount of injected H_2 gas – is presented in Figure 4.

Several factors affecting the beam stability have already been identified – e.g.: the coupling of the plasma to the bias electrode, the excitation of different RF modes in case of a non optimized RF injection, the influence of other ion species present in the beam on the H_3^+ stability. The next step is to minimize the beam emittance.

The generation of C^{4+} beams is not yet done routinely because of radiation protection aspects in the accessible zone around the source and the beam line. The significantly higher involved RF power causes a correspondingly higher X-ray dose that requires further improvement of the shielding. As a first step towards the reduction of the dose, a redesigned plasma lens, made out of Tantalum instead of Aluminium, was installed. The final step will consist in the implementation of an additional shielding structure, up to the spectrometer magnet.

The integration of the ion source control system into the global control system was successfully performed.

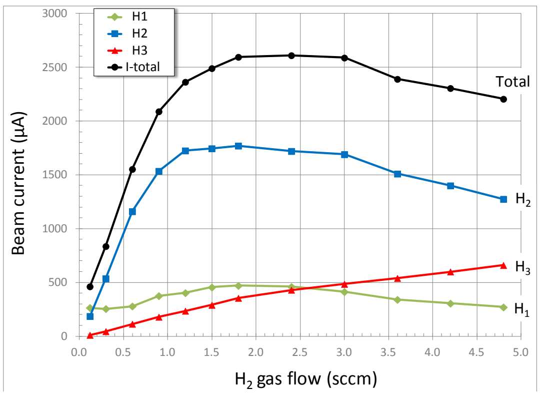

Figure 4: Measured dependence of the ion source beam current on the H_2 gas flow.

Linac

The RFQ (Figure 5) is a new design developed by IAP University Frankfurt and is foreseen to be delivered to CERN by mid summer this year. The IH tank production (Siemens AG, Figure 5) has finished and the tank will be delivered directly to Wiener Neustadt, by the end of 2012 for hardware commissioning.

The 250kW RF amplifier for powering the RFQ is already available at the ITS at CERN. Factory acceptance tests for the 1.5MW stage for the IH linac will be done by May this year.

The integration of the complete injector LLRF system and the power amplifiers into the control system was already successfully performed.

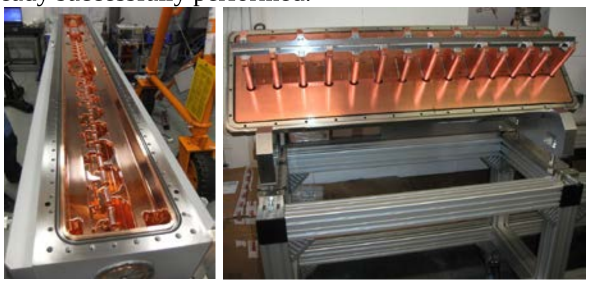

Figure 5: left: The IH tank is provided by Siemens. right: the redesigned RFQ by IAP Frankfurt.

Magnets

- Prototypes of the LEBT quadrupole triplet and corrector magnets and the MEBT quadrupole magnets are currently being tested at CERN. Within the next two months, prototypes of the HEBT quadrupole and the synchrotron dipole will be delivered for magnetic measurements.
- The design of all magnets of the injector and synchrotron (except the betatron core) is finished and all elements are already tendered.
- The HEBT dipoles will be tendered soon.
- The design work on the scanning magnets and the 90 dipole of the vertical beam line and all gantry magnets will start mid 2012.

Special magnets

- The contract for all magnets (magnetic septa and kicker magnets) has been placed and the final design reports are presently being reviewed.
- All power converters are already in production, the only excepting being the HEBT chopper.
- The electrostatic septa and the LEBT fast deflector are under production at CERN.
- Work on the control system interface is stepping up.

Synchrotron RF system

The synchrotron RF cavity and the corresponding LLRF system is being developed in collaboration with CERN, exploiting synergies with the new PS-Booster RF system development. One single prototype cell has been constructed and power tests were successfully completed. The procurement of the solid state RF amplifiers is on-going. Beam tests of the newly developed LLRF system are foreseen for the second half of 2012 in the PS-Booster. The integration of the synchrotron RF system into the control system has already started.

Power converters

In total, 280 converters will be installed for the whole facility, summing up to a total installed power of 17 MVA. At one time, the maximum peak load will be 9.8 MVA at an average power of 4.3 MW.

All power converters are switch-mode converters where all, but the lowest power ones, are equipped with an active filter front end which abolishes the need for a network compensator.

Based on previous CERN developments, a current regulation board (CRB) for a high precision current loop has been designed. The second prototype iteration is already available and tests of the complete chain including converters are starting. The use of the CRB in all except the simplest converters provides a single interface to the control system for all different converter families which is an important advantage.

The contracts for all power converters, except the scanning magnet power converters, have been awarded and first prototypes start to become available.

Work on the online B-field measurement system has started. This system will allow for B-field distribution by both analogue up/down signal and in absolute values at 300 kHz. A synthetic B-train, transparent to the end-user will also be available. The synthetic data will be generated like the waveform (2 kHz) of the power converters via the CRB with only one additional module attached to it for over-sampling it to 300 kHz.

Gantry

MedAustron will have a proton gantry in the irradiation room 4 based on the PSI Gantry 2 design. Currently minor adaptations to the mechanical layout are studied with the aim of facilitating installation and maintenance of beam line elements.

Although fed by a synchrotron (compared to a cyclotron at PSI), the beam optics performance of the MedAustron Gantry is comparable to the PSI installation. At present further beam optics studies are under way, assessing the beam quality in conjunction with the rotator system.

Vacuum:

- The procurement of vacuum instrumentation has finished.
- The production of the synchrotron dipole chambers (a 0.4 mm thick corrugated chamber) has started. The ceramic chambers for fast magnetic elements are being tendered at the moment.
- The vacuum control system is routinely operating in the ITS and has been integrated into the global control system.

Beam diagnostic and intercepting devices

Approximately 50% of the required beam diagnostic devices are already produced and the design of all different types has been completed. By spring 2013 all the hardware and electronics will be available. Some of the monitors are already in operation in the ITS in stand-alone mode. The interface to the global control system is the last remaining major task.

The beam intercepting devices – beam dumps, beam stoppers and scrapers - are in the final design stage. Wherever possible, standard beam diagnostics components like moving mechanism are being reused. The procurement stage has already been started.

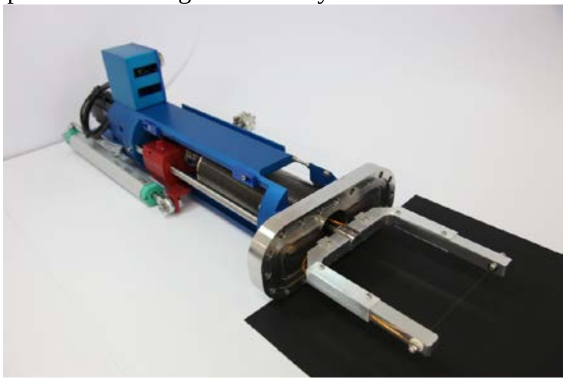

Figure 6: MedAustron wire scanner prototype

Control system

Apart from the successful integration of sub-systems (e.g. ion source control system), the following progress has been achieved.

- A cycle builder allows to generate timing and set-point sequences.
- The importing and exporting of device configurations, timing sequences, set-point sequences into the central database works for at least the already integrated systems.
- The main timing system is implemented and was successfully tested during integration of the available subsystems.
- The beam interlock and patrol control system (including the corresponding rules) have been defined and are currently being implemented. The installation is planned starting from July lasting until the end of the year.
- PVSS: expert and operator panels for several subsystems have been implemented and used during integration tests. Visualisation of measurements from the already integrated systems is possible.
- ProShell: First procedures such as running cycles on the accelerator and generically controlling beam diagnostics devices are under development.

CONCLUSION AND OUTLOOK

The building construction in Wiener Neustadt is well advanced with installation of the technical infrastructure ongoing. With most of the accelerator components already being tendered, MedAustron is exactly on schedule and moving towards to next stage of contract follow up and integration of all components into the control system. An injector test stand at CERN has confirmed the ion source performance and will be extended to incorporate elements up to (including) the RFQ by mid summer 2012.