COMMISSIONING OF THE JYFL MCC30/15 CYCLOTRON

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Abstract

The new MCC30/15 cyclotron from NIIEFA, St. Petersburg, Russia, arrived at Jyväskylä on 10th of August, 2009, as a partial compensation of the Former Soviet Union debt to Finland. The cyclotron required an extension for the old experimental hall. The building of the extension started in late August, 2008, and it was scheduled to be ready by Midsummer, 2009. Both the cyclotron and the building projects took a little more time than planned. However, the delay of both projects was less than two months, and so the building was ready to host the cyclotron by the beginning of August, 2009.

The installation of the cyclotron was done by the manufacturer's (NIIEFA) specialists. Before the end of November 2009 the maximum extracted proton intensity (in pulses) was 200 μA, twice the guaranteed value, and 62 μA for deuterons, which is also more than guaranteed (50 μA). The final acceptance protocol was signed on 30th of April, 2010.

BACKGROUND

The operation of the K130 cyclotron has been very extensive. The total cyclotron operating time since 1996 has been over 6000 hours/year, the maximum being about 7500 h/year. So, there has not been much time for machine development, and also the time for maintenance has been limited. About one third of the beam time has been protons and deuterons. Thus it was a natural choice to investigate the possibility of acquiring a separate cyclotron for protons and deuterons in addition to the K130 cyclotron. The plan became a reality when a 30 MeV H^- cyclotron was approved on the list of equipment as partial compensation of the former USSR debt to Finland. An Inter-governmental Agreement between Finland and Russia was signed in 2006 to settle the old debt partially by goods and services. The Contract of the 30 MeV H^- cyclotron, MCC30/15, was approved in June 2007. The cyclotron was be built by NIIEFA, D.V. Efremov-Institute, St. Petersburg, Russia.

THE MCC30/15 CYCLOTRON PROJECT

The first negotiations on the new cyclotron started in 2004. It was already then obvious that the cyclotron should be in the debt conversion program between Finland and Russia. Finally the order could be placed in June, 2007. According to the contract the delivery time was two years from the order plus additional time of six months for installation of equipment and training the local users. There were small delays both in the cyclotron and the building projects However, the building was ready for the cyclotron to be installed in the end of July, 2009. The arrival of the cyclotron was re-scheduled to the beginning of August, 2009.

Everything else but the cyclotron magnet arrived on Friday, 7th of August, on three trucks, two days delayed due to customs problems in St. Petersburg. The Russian team together with the local people unloaded the trucks into the new experimental hall, and everything was prepared for Monday, 10th of August, to get the magnet in the cyclotron bunker. The last two trucks carrying the cyclotron magnet finally arrived at 9.20 pm and the unloading started immediately. Everything took place on the roof of the parking hall, which was supported by hundreds of steel pillars to take the heavy weight. Due to local weight limitations the lifting had to be done with extreme care. The first half of the cyclotron, weighing 24 tons, was put into its final position exactly at midnight (see Fig. 1). The second half was on its place one hour later.

Figure 1: The first half of the MCC30/15 cyclotron is being lifted into the cyclotron cave.

The Russian (NIIEFA) team started the installation of the accelerator immediately after it had arrived. Everything went smoothly and the first beam tests could be carried out in November 2009, and before the end of the month the maximum extracted proton intensity (in pulses) was 200 μA, twice the guaranteed value, and 62 μA for deuterons, which is also more than guaranteed (50 μA).

The final acceptance tests were done in April, 2010. They included maximum intensity test for maximum and minimum energies for both protons and deuterons, as well as stability tests and dual beam tests. All results reached or exceeded the guaranteed values. The maximum proton current at both 30 MeV and 15 MeV was 200 μA. The maximum deuteron current at 15 MeV was 62 μA.

The MCC30/15 Cyclotron

The contract included a fully operating cyclotron with two beamlines on opposite sides of the cyclotron up to the dipole magnets which bend the beam to the targets.

The main characteristics of the MCC30/15 cyclotron were reported in [1]. The magnet (maximum power 14 kW) is vertical thus allowing sideways opening and easy access for maintenance (Fig. 2). The field for protons and deuterons is changed using rotating shims in two opposite valleys. The shims are rotated pneumatically. The fields are shown in Fig. 3. All shims (central, rotating, 2[nd] harmonic compensation) are shown in Fig. 4. The fully installed cyclotron is shown in Fig. 5 and the multi-cusp ion source is shown in Fig. 6.

Figure 2: The NIIEFA team installing the matching dipole. The cyclotron magnet opens sideways on precision rails.

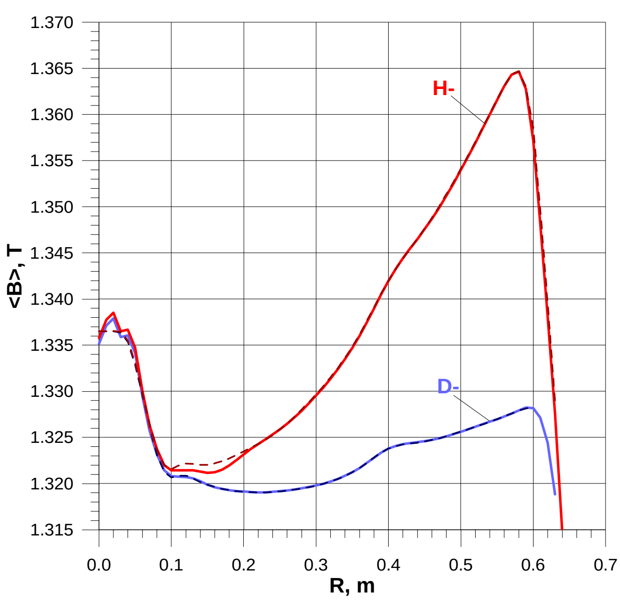

Figure 3: Simulated and required fields in the MCC-30/15 median plane. Upper curve for H^- acceleration, lower curve for D^- acceleration.

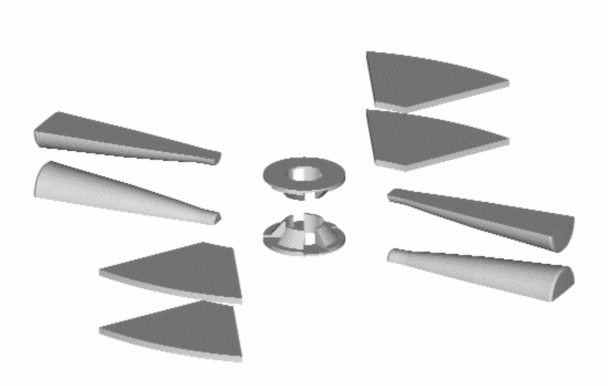

Figure 4: Set of shims for MCC30/15.

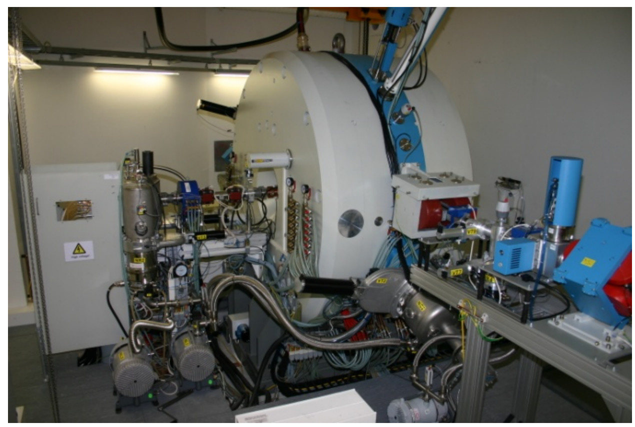

Figure 5: The fully installed cyclotron. The injection line from the ion source is seen on the left and part of the beamline to the isotope production cave on the right.

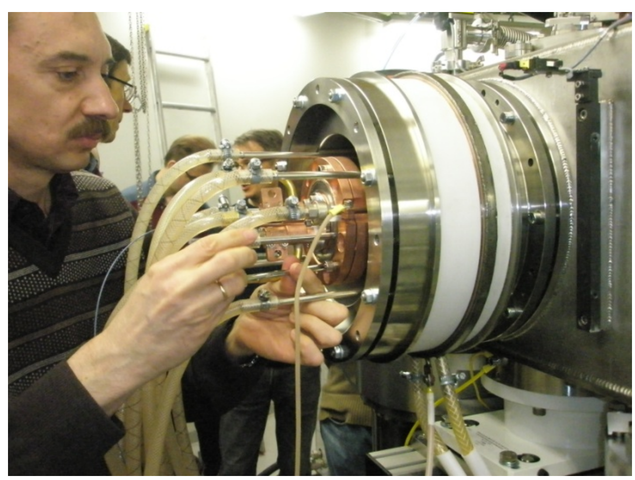

Figure 6: Sergey Grigorenko, NIIEFA, shows how to change the filament in the ion source.

The RF system consists of two dees, and the operating frequency is 40.68 MHz the RF generator output power being 25 kW, which produces a dee voltage of 40 kV.

The vacuum is pumped by two cryopumps in the cyclotron (10^{-7} mbar region) and by turbopumps in the beamlines.

Control of the cyclotron is done with a PC-based control system and PLC's. The MCC30/15 control system is coupled to the main control system of the K130 cyclotron, which controls the radiation safety of the whole laboratory.

Use of the MCC30/15 Cyclotron

The IGISOL facility [2], the main user of the proton beams, is being moved from the old experimental hall to the extension, served both by the new MCC30/15 H^- cyclotron as well as the K130 heavy-ion cyclotron. The move started in June 2010 and it is assumed to be ready during the first half of 2011. The work with IGISOL will extend the discovery potential to earlier unexplored exotic nuclei which are important in explosive nucleosynthesis scenarios. In addition, planned charge breeding of trapped ions will lead to unprecedented accuracy in mass measurements for weak interaction tests in atomic nuclei.

In addition to the scientific work with the IGISOL facility, the new MCC30/15 cyclotron is planned to be used for medical radioisotope production, mainly 123-I and 18-F. Negotiations on the isotope production are underway.

Building

An extension for the accelerator laboratory was needed to house the new cyclotron. After financial negotiations it was decided to build the extension in full size allocated in the architect's original plan, thus enabling to move the main scientific proton beam user (IGISOL) to the extension and to have the radioisotope production area also close to the cyclotron. The size of the extension is 50 x 13.5 m^2.

In conjunction with the IGISOL facility move other changes in the old experimental area lay-out were planned. The new floor plan of the laboratory is shown in Fig. 7. The area left free after IGISOL move will host the new MARA separator [3]. Some other minor modifications will be done, too. Two new dipole magnets (65 degrees and 90 degrees) have been ordered to guide the beam from the K130 cyclotron to the new IGISOL site and to the MARA separator.

REFERENCES

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[2] J. Äystö, Nucl. Phys. A 693, 2001, p. 477.

[3] J.Sarén, et al., Nucl. Instrum. Meth. Phys. Res. B 266, 2008, p. 4196.

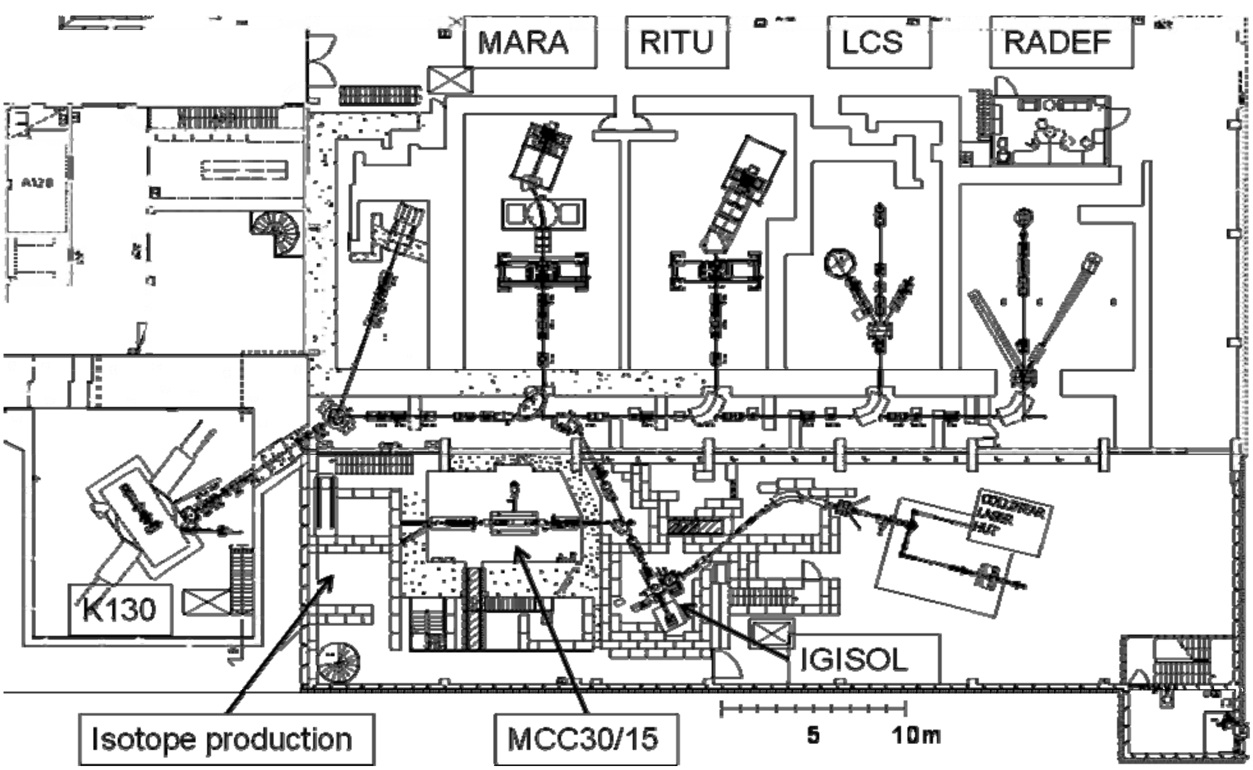

Figure 7: Layout of the JYFL Accelerator Laboratory including the planned changes. The vacuum recoil separator MARA will be installed left from the existing gas filled recoil separator RITU in the space from where IGISOL facility was moved into the extension of the experimental hall. The walls of all caves except for the proton irradiation cave left from MARA will be slightly modified in order to meet better the new needs. The extension is the 50 m long and 13.5 m wide space right from the K130 cyclotron and down from the long horizontal beam line.