NEW MCC30/15 CYCLOTRON FOR THE JYFL ACCELERATOR LABORATORY

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Abstract

The operation of the K130 cyclotron during the last 10 years has been very extensive. The total cyclotron operating time of the in 2006 was 7500 hours. Almost one third of the beam time was devoted to protons for proton induced fission studies and for isotope production (123-I). For some time we have had plans to acquire a separate accelerator for light ions (protons and deuterons) to help with the load on the main K130 cyclotron. This plan has now been realized in conjunction with the partial compensation of the former Soviet Union debt to Finland. A 30 MeV H^- cyclotron (MCC30/15) for the University of Jyväskylä made by NIIEFA, St. Petersburg, is one of the products that have been accepted into the list. After the contract with the seller (Machinoimport), the manufacturer (NIIEFA) and the “buyer” (University of Jyväskylä) was signed and then approved by the Finnish Ministry of Trade and Industry, the delivery time from approval for the cyclotron is two years plus six months for installation. The new cyclotron will need a new building, which will be an extension of the present experimental hall. The project to design and build the new laboratory has started.

STATISTICS

The K130 cyclotron was taken in use in the summer of 1992, when the experimental hall was ready but not yet equipped with all experimental devices. In 1996 we reached a level of 6000 hours/year of total beam time, including injection line and cyclotron tuning times. Typically the beam time available for experiments, including the stand-by time caused by the user, has been about 300 hours less than the total time shown in Fig. 1. A grand-total of 90,000 hours was reached on August 13th, 2007.

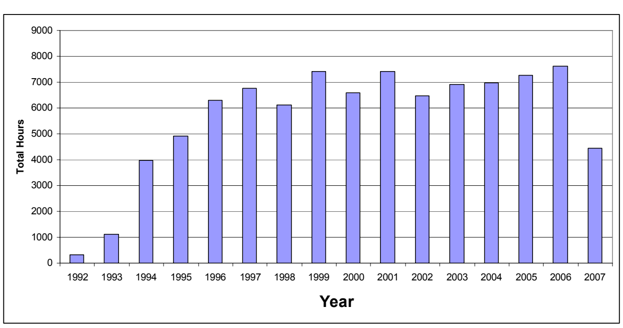

Figure 1. Total hours of the K130 cyclotron use from 1992 until September 16th, 2007

The estimated total time in 2007 is 6200 hours. The main reason for the reduction is the quench in the superconducting solenoid of the Penning trap at IGISOL (Ion Guide Separator On-Line)[1], which caused cancellation of several runs for which no substitutes could be found at such short notice.

Table 1 shows the statistics from 2006 excluding the time for ion source tuning. Altogether about 30 different isotopes were accelerated (from protons to Xe). Although the cyclotron was initially optimized for heavy ions, proton beams have accounted for about 30 % of the beam time.

Table 1: Use of the K130 Cyclotron in 2006

ECR I Injection	27	h	0.3	%
ECR II Injection	219	h	2.5	%
LIISA (H^-) Injection	103	h	1.2	%
Beam Tuning	374	h	4.3	%
Beam Developing	24	h	0.3	%
Beam on Target	6201	h	70.8	%
Stand-by	679	h	7.7	%
Cancelled	351	h	4.0	%
Beam off (Service)	782	h	8.9	%
	8760	**h**	**100.0**	**%**

THE NEW 30 MEV H^- CYCLOTRON, MCC30/15

Background

As can be seen from Fig.1 and Table 1, we have not had much time for machine development, and also the time for maintenance has been limited. Moreover, since proton beams are requested regularly (123-I production and proton induced fission studies) we started to investigate the possibility of acquiring a separate cyclotron for protons and deuterons in addition to the K130 cyclotron. After a few years of negotiation we managed to get a 30 MeV H^- cyclotron 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 on August 15th, 2006 to settle the old debt partially by goods and services. The final list was approved by the corresponding Ministries of both countries in January, 2007, and the Contract of the 30 MeV H^- cyclotron, MCC30/15, was signed on February 20th, 2007. It took another four months for the corresponding Russian and Finnish Ministries to approve the contract for the cyclotron, after which the order could be placed. According to the contract, the delivery time of the cyclotron is 24 months from the final approval of the contract plus an additional time of six months for installation and training. The cyclotron will be built by NIIEFA, D.V. Efremov-Institute, St. Petersburg, Russia.

Cyclotron Characteristics

The MCC30/15 cyclotron will be mounted vertically, which will give easier access to the inside of the vacuum chamber than a horizontal orientation. Since the ion source is on the side there is no need for a cellar below the cyclotron, which reduces somewhat the building costs. Table 2 shows the main characteristics of the cyclotron.

Table 2: Main characteristics of the MCC30/15 cyclotron

Beam	
type of ions	
-accelerated	H^-/D^-
-extracted	H^+/D^+
energy, MeV	18 – 30/9 – 15
current, μA	100/50
Power consumption	
stand-by condition, kW, max	15
beam on the target, kW, max	120
Magnetic structure	
pole diameter, cm	140
number of sectors (per pole)	4
average induction, T	1.336
DC power in coils, kW	10
magnet weight (Fe/Cu), tons	40/2.5
Radio-frequency system	
number of dees	2
dee angle	42^0
frequency, MHz	40.68
dee voltage, kV	35 – 40
dissipated RF power/dee, kW, max	8
RF - generator output power, kW	25
Ion source	
type of source	CUSP
location	external
arc power, kW, max	3
current, mA	1.5/0.7

The cyclotron will have two extraction systems, opposite one another. The contract includes two beam lines, both having a quadrupole doublet, a Faraday-cup, a beam scanner, a dipole (30 and 65 degrees) and the vacuum system. The dipoles will be designed at JYFL. In addition, there is one more diagnostics station with a Faraday-cup and a scanner included in the contract. The control system of the cyclotron and beam transport system is included in the contract and it is based on a programmable controller with a computer. As a whole, the contact includes a fully operating cyclotron with two beam lines up to the dipole magnets with control, cooling (inner loop) and vacuum systems.

Building

There are two new major future projects at JYFL: the new MCC30/15 cyclotron for protons and deuterons and a vacuum-mode recoil separator, MARA[2]. Both of them need space which the present experimental hall cannot provide. Therefore an extension of the accelerator laboratory is needed. Fortunately, we have a space reserved for a possible extension next to the present experimental hall.

An initial design with a budget plan was organized by the University. According to it and due to some constraints in the building process (weight limit on the parking hall roof next to the experimental hall) we decided to propose the maximum size of the extension. The size of the extension will be 52 x 13.5 m^2. The lay-out of the proposed extension with a part of the present building is shown in Fig. 2. We propose to move the proton-induced fission studies (IGISOL) to the new premises, as well as the present 123-I production (MAP Medical Technologies). After this and by partly re-arranging the experimental hall we can place the new vacuum-mode recoil separator MARA next to the gas-filled recoil separator RITU[3], and also the space electronics test station (RADEF) can be moved closer to the K130 cyclotron allowing higher intensity proton irradiations than are possible at the moment. Since IGISOL also uses heavy ions a beam line from the K130 cyclotron must merge with the proton beam line from the MCC30/15 as shown in Fig. 2. The new site for IGISOL is larger than the present one, and will allow for new set-ups to detect the radioactive fission products and possibly also to house a post-accelerator. The clean room for radiochemistry will be located one floor above the cyclotron.

The proposed lay-out has been forwarded to Senate Properties, which is a government-owned enterprise responsible for managing, developing and letting the property assets of Finnish state. The final architect plans will be started during the fall of 2007 and the construction should start in the spring of 2008. The building should be ready for the arrival of the cyclotron (early summer 2009, according to the contract).

Use of the MCC30/15 cyclotron

As mentioned above 123-I production together with MAP Medical Technologies will move to the new building and use only the proton beam from MCC30/15. Also IGISOL (mainly proton-induced fission studies) will move and use the new cyclotron but it also needs beams from the K130 cyclotron. Due to increasing interest in PET-scanners in Finland the new laboratory will have space for possible 18-F production. It will be done in co-operation with a medical company. There will also be space for a neutron target station for neutron irradiations. There the proton beam from the cyclotron will be directed downwards mainly for radiation safety reasons.

REFERENCES

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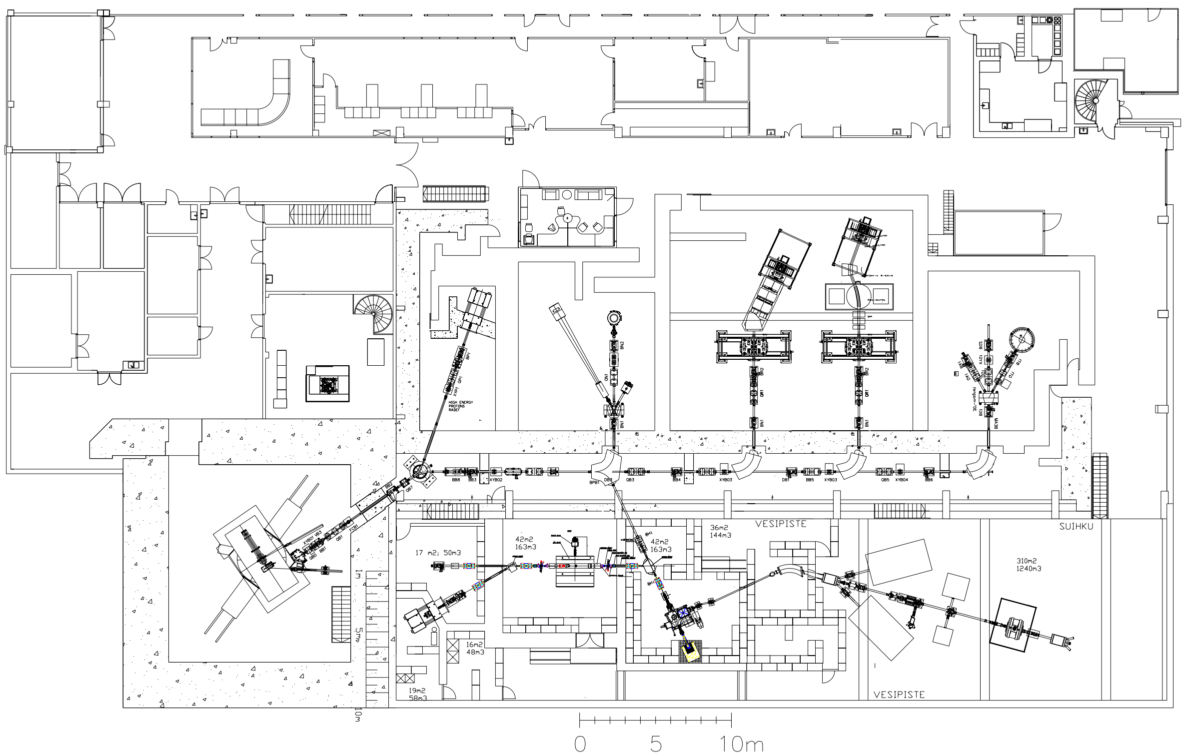

Figure 2. Proposed lay-out of the extension of the experimental hall housing the MCC30/15 cyclotron, 123-I production (MAP Medical Technologies), IGISOL (proton-induced fission) and a reservation for 18-F production. The extension is to the right of the K130 cyclotron and down from the horizontal beam line delivering beams from the K130 cyclotron to different experimental stations. The proposed new lay-out of devices in the present hall is also shown. The first cave is for proton irradiations (now 123-I production) and the second is the RADEF facility mainly for space electronics testing (ESA collaboration). The next cave will house the gas-filled recoil separator RITU and the new (coming) vacuum-mode recoil separator MARA. A 1.5 m diameter scattering chamber and two multi-purpose beam lines are located in the last cave.