

# BEAM SHARING BETWEEN THE THERAPY AND A SECONDARY USER

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## Abstract

The 180 MeV proton beam from the cyclotron at The Svedberg Laboratory is primarily used for patient treatment. Because of the fact that the proton beam is needed only during a small fraction of time scheduled for the treatment, there is a possibility to divert the beam to another location to be used by a secondary user. The therapy personnel (primary user) control the beam switching process after an initial set-up which is done by the cyclotron operator. They have an interface that allows controlling the accelerator and the beam line in all aspects needed for performing the treatment. The cyclotron operator is involved only if any problem occurs. The secondary user has its own interface that allows a limited access to the accelerators control system. Using this interface it is possible to start and stop the beam when it is not used for the therapy, grant access to the experimental hall and monitor the beam properties. The tools and procedures for the beam sharing between the primary and the secondary user are presented in the paper.

secondary user. The beam that is used for the therapy irradiation is a 180 MeV proton beam and although the beam characteristics can be different for the therapy and the secondary user, we can't change neither particle nor it's energy when the beam is shared.

During the "therapy" weeks the beam is available for patients' irradiation according to the following schedule:

- Monday 1 pm. - 8 p.m.
- Tuesday-Friday 8 a.m. – 6 p.m.

The number of patients is usually between 6 and 9 per day and each patient receives two or three fractions (irradiations from different angles). The beam time needed for each fraction is usually less than one minute and repositioning of the patient between the fractions takes about 5 minutes. The quality assurance tests performed every morning before the first treatment require the beam for about an hour. Thus the real beam time (adding usual delays and a beam switching time) using by the therapy is about 3 hours (counting 5 min. for one fraction) a day.

## INTRODUCTION

The synchrocyclotron [1] at The Svedberg Laboratory (TSL), originally built in the early fifties and almost totally reconstructed in the years 1977-86, can accelerate protons and different ions, ranging from helium to xenon. Until 2005 TSL had been so called national facility and was financed from the state budget. The research groups, both from Sweden and abroad, could send the proposals for an experiment to be done at TSL. The beam time has been granted to the projects selected by the lab's Program Advisory Committee. After closing down CELSIUS storage ring at TSL in 2005, the laboratory has been reorganized and changed the orientation from being the laboratory hosting the basic research experiments to an accelerator facility dedicated mainly to patients' irradiations with protons. TSL is financed now by the Uppsala County Council (the patient treatment) and by selling the beam time to the other clients. The contract signed between TSL and the University Hospital in Uppsala specifies that thirty five weeks a year are reserved for the patients' treatment. Because the proton beam is needed in the treatment room only for a small fraction of time scheduled for the therapy irradiation, there is a possibility to use the beam in other experimental areas of the laboratory at "the same" time.

## BEAM SHARING PREREQUISITES

The beam is shared between the irradiation therapy (primary user) and users in other experimental locations (secondary users). The switching between two different beam lines is done with help of a bending magnet but a number of other parameters are also changed in order to satisfy the beam requirements of both therapy and the

## THE PRIMARY USER

The primary user is the one that controls where the beam is led. He can take away the beam from the secondary user at any moment. There is a delay (which is set by agreement between the therapy and a secondary user) between the request to take away the beam from the secondary user and actually doing it. After that delay the beam is switched to the primary user. When taking the beam from the secondary user the therapy operator specifies the expected time (based on number of fractions) the beam will be not available for the secondary user. When sending the beam back to the secondary user, the therapy operator specifies also the approximate time the beam will be available for him before the next switching. The control of the dose delivered to the patient is the responsibility of the therapy operator and is independent of the accelerator control system.

## THE SECONDARY USER

The secondary user gets the beam when the primary user decides to release it. The exact moment when it happens is unknown to the secondary user but there is information when the beam is supposed to be switched. The same is true for taking away the beam from the secondary user, with the exception that there is a delay between the beam request from the therapy and actual switching the beam. This delay is set during the beam switching set-up and depends on the secondary user's requirements.

The secondary user has a very limited access to the control system. He can perform the following actions:

- Forbid and allow access to his experimental hall (clear / release clearing). The hall must be in “cleared” state to put the beam into it.
- Monitor the parameters important for the experiment
- Stop and start the beam if it is available for him or enable/disable the beam when it is used by the therapy. When the beam is directed to the secondary user and it is enabled, it will be turned on, otherwise it will be turned off and the secondary user can start the beam at any time as long the beam is available for him.

## BEAM SHARING SETUP

Before the therapy operator can use the switching procedure the cyclotron operator must set it up. The following steps must be taken:

- Decide what parameters should be changed during the switching process in order to fulfill the requirements for the beam properties (such as intensity, focus, position on target) both for the therapy and the secondary user
- Set the required delay between the beam switching request and actual beam switching when taking the beam from the secondary user
- Set the beam current limits for both therapy and the secondary user
- Set-up the required beam properties to both therapy and the secondary user
- Test the switching procedure
- Set-up the alarm conditions for the secondary user
- Set-up the parameter reservation
- Start/enable the billing for the secondary user’s beam time

When the procedures listed above are completed, the beam switching can be performed by the therapy operator without any help from the cyclotron operator. In fact, the cyclotron operator is usually not longer present in the control room but is doing other job in the laboratory and is available “on call” in case of unexpected problems.

## SERVICES

There are a number of programs that are used to make it possible to share the beam between the therapy and the secondary user without the need for the cyclotron operator. All these programs use the services that are essential for such a beam sharing scheme working satisfactory in real life. The most important services are shortly described below.

### Logging

All programs used by the therapy operator and the secondary user log all their actions using syslog facility. The programs can (and usually are) executed on different computers but syslog daemons are configured so that all the log messages are saved on one syslog server. The entries in the log file are tagged with the time stamp (all computers are synchronized with the network time

server), computer name, user name, log entry priority and the program name. The log file is saved on a week basis and archived on Sunday night (done by a cron job). The log file is an invaluable help when it comes to understand the problem that could have occurred, to spot the unexpected actions of the therapy operator or the secondary user or just to follow the use of the beam. The log file is also used for calculation of the beam time that the secondary user is charged for (billing).

### Alarms

As in any system things might go not as planned. The quick observation of the problem and passing information about it to the cyclotron operator is essential. It is also important that some actions will be performed automatically (like stopping the beam and the billing). The alarms from the programs involved in the beam sharing are distributed by two independent systems:

- Local text paging infrastructure (radio transmitter using a license free 439 MHz frequency band, alphanumeric pagers)
- SMS (via email gateway) to the mobile phones. The message is usually delivered within 1 minute (not guaranteed).

The message sent to the pager or the phone contains the time stamp of the event, originating program’s name and a short description of the failure.

### Parameter Reservation

TSL’s control system has a global mechanism for limiting the rights to access control system’s parameters based on the user’s account uid and gid (uid – user id, gid – group id). The write access rights for every parameter in the control system can be set to the following states based on uid and gid:

- Free – write access for everybody
- Reserved – write access only for the specific uid/gid
- Locked – no write access

After the beam switching is set-up, the cyclotron operator locks the parameters that should not be changed by any user and reserves those that must be changed in the beam switching process for use by the therapy operator. The switching program changes access rights to some parameters during the switching process to allow beam control by the secondary user when the beam is used by them, and to prevent them to control the beam when the beam is used for the therapy.

### Billing

The secondary user is charged for the beam time he has to his disposal. It’s not possible to exactly predict how much time beam time will be used by the therapy and manually keeping track of it is out of question. Therefore there is a virtual parameter BILLING that can be in the following states:

- **Enabled** - the beam is used by the therapy but as soon as it will be switched to the secondary user and the beam’s parameters will be accepted, the state will be changed to “Started”.

- **Started** - the beam is available to the secondary user, the state will change to “Enabled” when the beam is taken back to the therapy or to “Stopped” in case of some failure.
- **Stopped** - the beam is not available to the secondary user, either because of some failure or deliberate action taken by the cyclotron operator.

The secondary user can see the actual state of the billing in his user interface. The cyclotron operator can at any time generate a billing report.

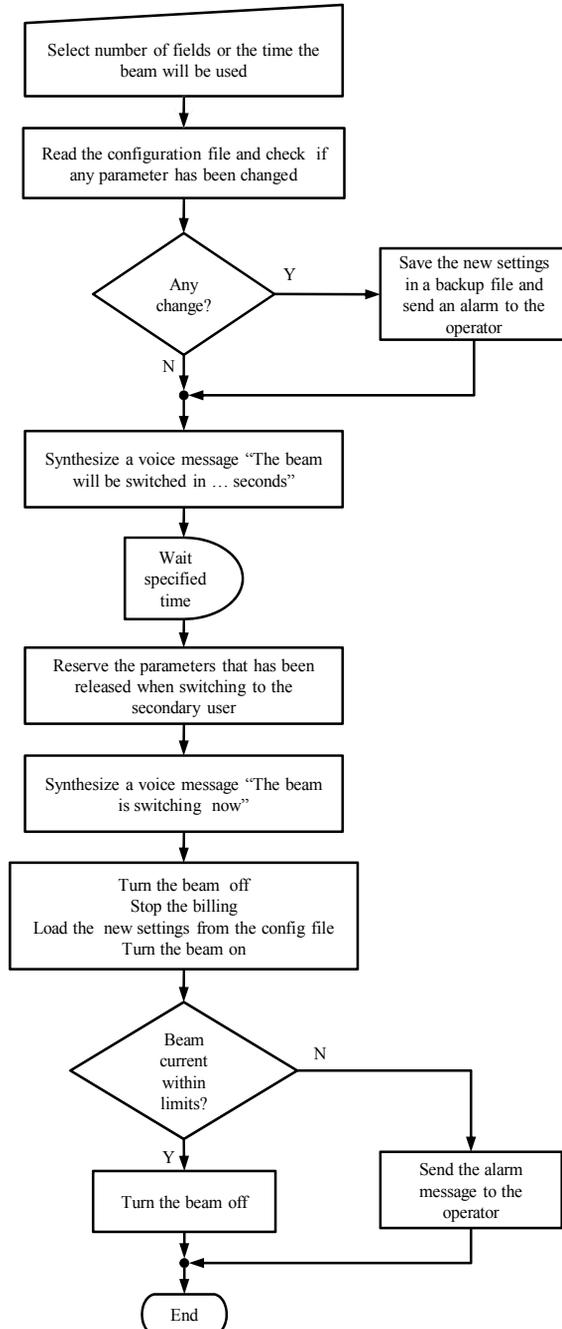


Figure 1: Beam switching from the secondary user to the therapy.

### Synthesized Voice Messages

It turned out to be very useful to create the voice notifications during the switching process and distribute them over the network to different locations in the laboratory. Festival speech synthesis system has been used for implementation of this feature.

### BEAM SWITCHING

As said before the beam switching process is controlled entirely by the therapy operator. The program to control the beam switching is written in tcl/tk and it has slightly different user interface depending on if it is used by the cyclotron or therapy operator (features needed for the beam switching set-up are not visible in the therapy interface).

The main window has only two buttons and one status field indicating into which location (therapy room or experimental hall) the beam is directed. The buttons are for selecting the area the beam should be switched into.

When one of the buttons is pressed the pop-up dialog and status windows are shown during the switching process.

Figures 1 and 3 show the algorithm implemented for switching the beam from the secondary user to the therapy and vice versa.

### USER INTERFACES

The user interfaces are built using TSL’s control system standard tools and components. The therapy operator uses a workstation connected directly to the control system network and controls the accelerator via a “synoptic” program.

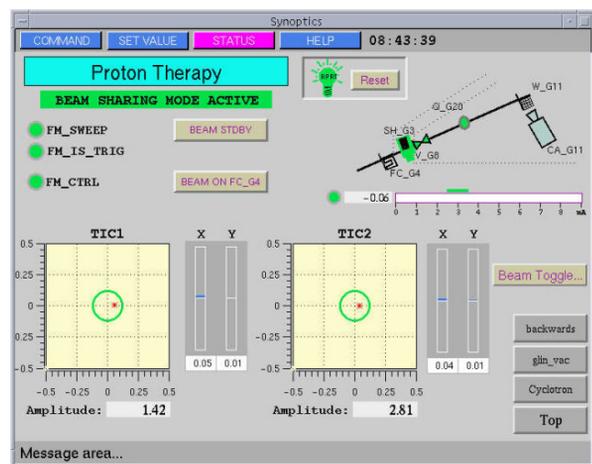


Figure 2: Synoptic screen for the therapy user.

The secondary user works on a workstation connected to the laboratory “public” network and connects to the control system via a firewall using secure shell protocol. The account that he logs into the control system allows only limited access to the control system. The examples of the “synoptic” screens used by the therapy user and the secondary user are shown in figures 2 and 4 respectively.

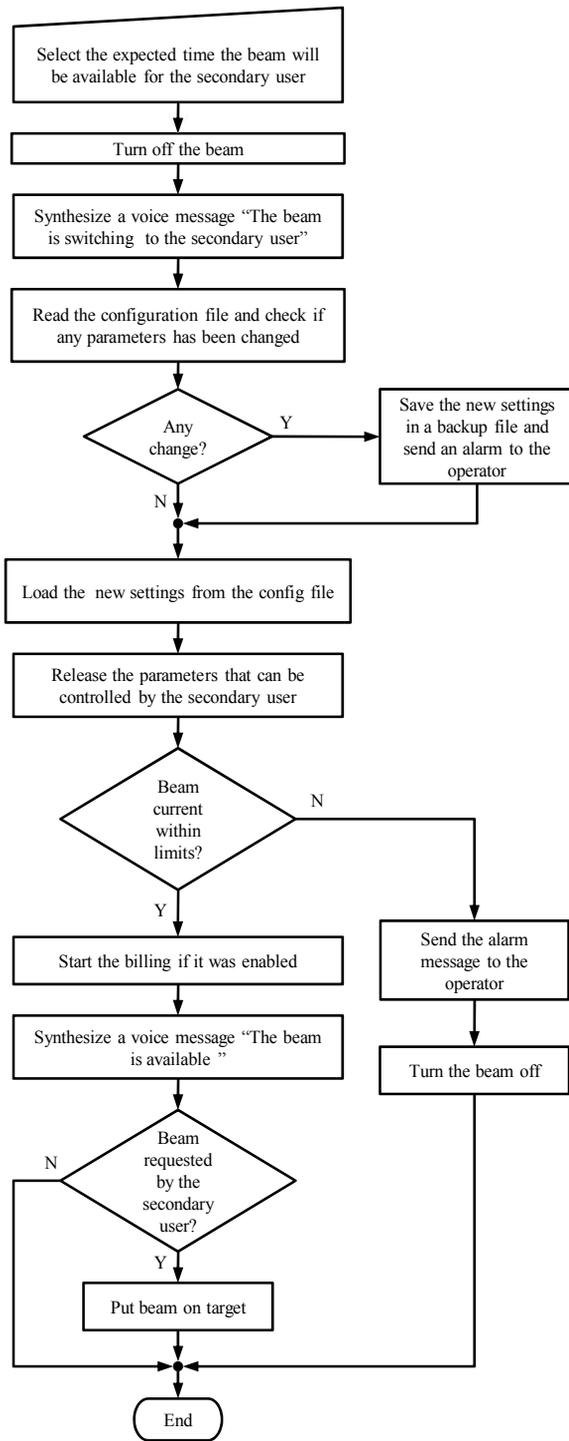


Figure 3: Beam switching from the therapy to the secondary user.

Here follows a short list of the tasks that therapy operator and secondary user can perform using their interfaces to the control system.

*Therapy User*

- Perform the beam switching process
- Monitor the beam position during the irradiation
- Turn on and off the beam
- Check the beam current before starting the irradiation
- Monitor the parameters in the end of the therapy beam line

*Secondary User*

- Control the access rights to the experimental hall (radiation protection).
- Request the beam when it is used by the therapy.
- Turn on/off the beam when it is not used by therapy.
- Monitor the parameters relevant for the specific experiment (beam current, signals from particle detectors, position of the target, billing status)

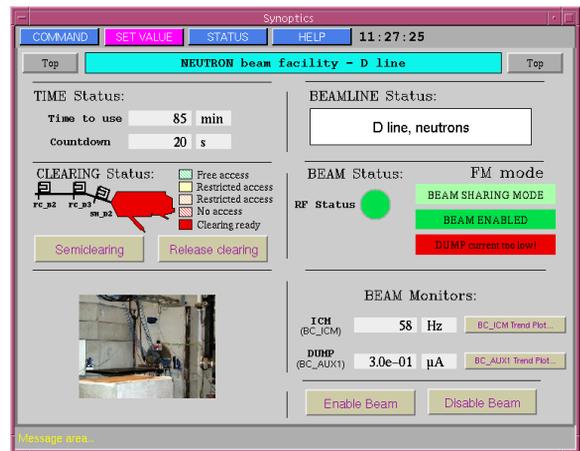


Figure 4: Synoptic screen for the secondary user.

**CONCLUSIONS**

The beam sharing described in this paper has routinely been used at TSL for the last few years. During this time many adjustments has been done to improve the quality of the system and to make the switch process easy to use for the therapy operator. Several synoptic screens for different beam lines and test stations have been created for the secondary users. A possibility to control the beam current by the secondary user is planned to be implemented in the near future.

**REFERENCES**

[1] "TSL Progress Report 1987-1991", The Svedberg Laboratory, Uppsala, Sweden, p. 10