OPERATION WITHOUT OPERATORS

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Abstract
Small facilities like ISOLDE cannot afford to have enough operators to serve experiments with beam 24 hours a day. In year 2000 almost 40 research groups worked at ISOLDE to perform 70 different experiments lasting from several hours to several days. The guest researchers operate the separator themselves during their beam time, and are only assisted in case of technical problems by local specialists. This implies an easily-understandable user interface, considerable user training and a reliable and robust machine.

1. INTRODUCTION

Facilities that run 24 hours a day and 7 days a week need a certain minimum number of operational staff, like 7 operators working in 8 hour shifts plus several machine specialists and supervisors. This need of personnel is in severe contrast to the manpower available at ISOLDE. For the year 2000 only four staff spent 50% of their time dedicated to ISOLDE operation. It is therefore a long tradition, that the users, i.e. the guest researchers, operate the facility themselves during the performance of their experiments.

2. FACILITY DESCRIPTION

The on-line isotope mass separator, ISOLDE, is a facility dedicated to the production of a large variety of radioactive ion beams. The radioactive nuclides are produced in thick high-temperature targets via spallation, fission or fragmentation reactions. The targets are placed in the external proton beam of the PS Booster, which has an energy of 1 or 1.4 GeV and an average intensity of 2 μA. The facility consists of two mass separators, a General Purpose Separator (GPS) and a High Resolution Separator (HRS) with a separate target station for each. Isotopes produced at these target stations are ionised and accelerated with 60 kV. The ion beam is sent through a magnet, and the mass-separated beam is guided into the experimental hall. This hall is accessible during all operations. It should be noted here that all beam steering and focusing elements are electrostatic, i.e. mass independent. Therefore beam tuning can always be performed with a conveniently strong ion beam of a non-radioactive isotope. For an experiment interested in radioactive species, after the successful tuning it is sufficient to change the magnetic field of the mass separator magnet and the desired isotope will pass to the experiment. The intensities of such radioactive beams used at ISOLDE vary from 10^{12} particles per second to below 1 particle per hour.

A layout of the facility is shown in Fig. 1, also showing the target handling facilities like the two robots and a hot cell. The different names in the experimental hall label the different beam-lines and permanently installed experiments. Normally the whole facility is controlled from the ISOLDE control room but remote interventions are also possible through CERN's office network.

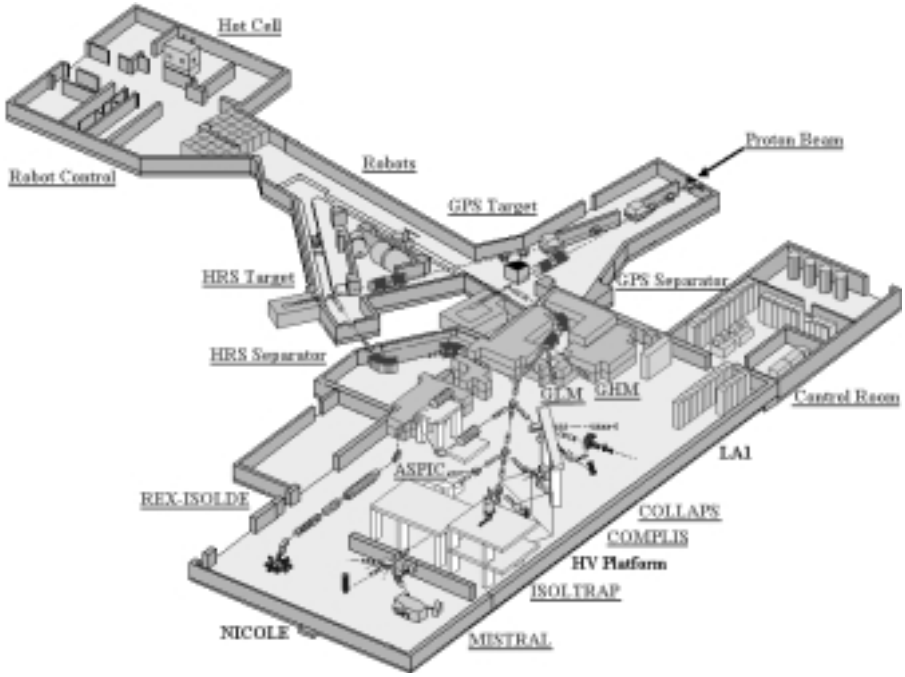

Fig. 1: Layout of the ISOLDE facility

3. ISOLDE OPERATION

ISOLDE is fully integrated into CERN's accelerator structure and therefore generally runs from April until the beginning of December. During that period the beam time is organised in shifts of 8 hours, distributed by the physics co-ordinator to approved experiments. The typical running time of a target/ion source unit is between several days and a few weeks, depending on the physics demands and on the performance of the unit itself. Then a target change follows, causing a one to four days interruption of the physics programme of that separator. This down-time of the facility can be considerably reduced by running the two separators GPS and HRS in a so-called push-pull mode, i.e. setting-up one separator while the other one is serving the physics programme. In year 2000 about 350 shifts of radioactive ion beams have been delivered to the experiments.

The ISOLDE standard operation can be split into two parts:

1. The target change is done by an ISOLDE supervisor (ISS) using the robots. After a period of heating-up the target and ion-source to its nominal temperature, the ISS also sets up the ion beam from the ion source to the focal plane of the separator magnet. The set-up procedure includes the tuning of the ion source, the beam steering and an initial calibration of the mass separator magnets. The proper adjustment of the proton beam onto the target is also done by the ISS.
2. After this, the users take over the beam and do the remaining beam tuning from the focal plane to their experimental set-up. From the moment of taking over, the users are also responsible for the surveillance of the whole facility including target and ion source as well as the proton beam.

The setting up of the first part takes only a minor part of the running time, meaning that the facility is mainly operated by non-specialists.

3.1 Users as operators

The fact that non-specialists operate the facility during most of the time implies that they need proper training and that the control system should offer a rather self-explanatory user interface. In order to hand over the machine smoothly from one experiment to the other, good documentation of the operation history via logbooks, and communication with the surveying ISS is needed.

3.1.1 User training

From each group of users, at least one member should be able to operate the whole separator at a basic level. In order to ensure this, ISOLDE organises separator courses every year for new users. Here they are trained and introduced to the duties of the so-called 'physicist in charge' (PIC). One course lasts two full days and is attended by at most four students. It is a real hands-on course showing all aspects of the operation of ISOLDE.

The course starts with a general introduction to the tasks of the PIC, and provides a list of the most important contact points during the beam-time: the ISOLDE physics co-ordinator, the ISS, CERN's radio-protection service and the PS control room. It also introduces future users to the layout of the beam-lines, the actual location of the equipment and the naming conventions, allowing the PIC to make a first attempt to recover the machine in case of failure before calling in the ISS for assistance. About 75% of the time is used to learn how to focus and steer an ion beam through the beam-lines, observing it with tools like beam scanners, wire grids and Faraday-cups by sending it to different points in the experimental hall. Using the GPS's ability to run up to three beams in parallel allows the students to run a beam on their own most of the time and to become familiar with the control system. While facing their first problems, the students collect experience in fault finding and solving, and in co-ordinating with each other. Important procedures like the calibration of the mass separator magnets or the changing of the acceleration voltage are also explained thoroughly. The course ends by pointing out safety hazards of the facility, in particular during the operation with radioactive ion beams.

3.1.2 A user friendly control system

As the typical ISOLDE user only occasionally uses the separator, it would be hard to memorise the exact names of all beam-line elements. They are therefore not listed in working sets but displayed by a synoptic program which can be seen in Fig. 2. This kind of user interface is almost self-explanatory, especially as it runs in a standard office environment, i.e. on personal computers (PCs) with MICROSOFT Windows as operating system. To gain control over a particular element, it is sufficient to click on the graphical display and the assigned control window will pop up. This possibility exists for almost every element of the separator, including beam observation and vacuum control. The use of standard PCs also offers to registered users an easy way to control the ion beam from near their experimental set-ups by just connecting additional computers to the CERN network.

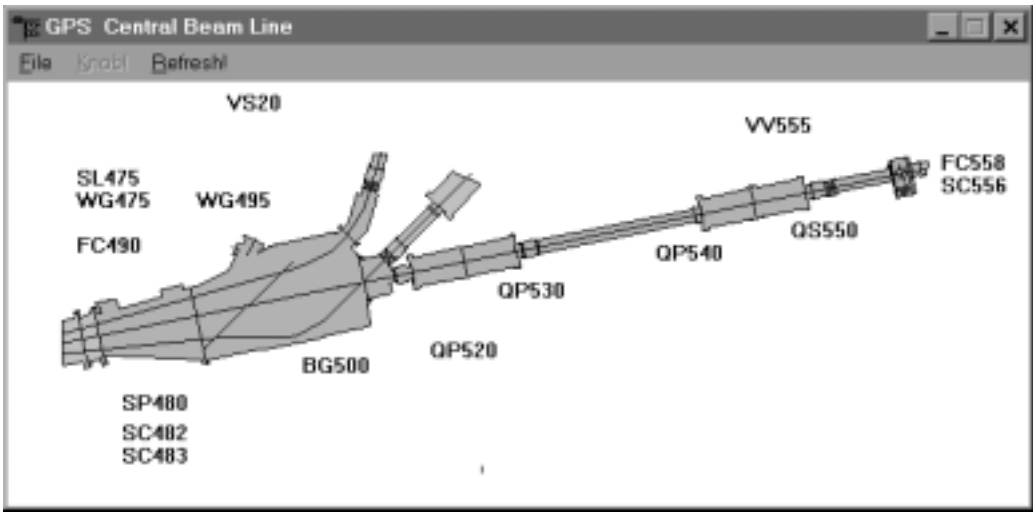

Fig. 2: Synoptic of the GPS central beam-line

3.1.3 Communication and documentation

A very crucial point, when the operators change so often, is to establish communication and to pass information between not only the ISOLDE staff, but also other CERN groups, as for example the operational team of the proton accelerators.

The on-going operation is documented in an electronic logbook, running on a dedicated PC — one for each separator. These logbook files are publicly available all over CERN via the office network. In the logbooks the users as well as the ISS mark important information like the current status of the operation, who is in charge of the machine, and detected problems and failures. These notes serve later as input for technical support groups in case an intervention needs to be scheduled. Information that describes certain procedures like the calibrationof the separator magnets or the use of implantation chambers is available from a web-based help system. There the user can also find some documentation pages about the use and properties of equipment installed in the separator, like the beam-gates or the availability of timing signals. Other pages help in case the user needs assistance from specialists or the ISS.

3.2 ISOLDE supervision

Up to now, one ISS was in charge for the entire run of a particular target. His duty started with mounting the target on the machine and ended when the next target was put on. He did the initial setting-up as explained above, and was on call to assist the users in case of technical problems with the separator during the performance of their experiments. These service periods lasted typically between five days and two weeks. In case that the GPS and the HRS were running in parallel, two ISS were on duty.

From 2001, the on-call service of the ISSs will be implemented in a new way. There will be only one ISS on duty per week, regardless of whether one or two separators are running. The set-up of a target will be made by another ISS during normal working hours the week before it is to be used. In the optimal case this will be the ISS who will also be first in charge of the running of that target unit. During the outgasing and heating, the target and ion-source parameters will be monitored by the operating team of the PS Booster.

4. CONCLUSION

The method of operation outlined above has worked very well for a long time. However it may not be easy to apply it to other facilities. One reason is that the machine should be of limited complexity, allowing one to gain control over all main parameters rather quickly. For ISOLDE this is certainly the case. Once everything is set up, the operation consists mostly of surveillance. There are periods of many hours when no action on the machine is needed. By comparison with highly sophisticated timing sequences usually applied in accelerators, it should be noted that the timing system of ISOLDE consists of less that 10 signals. Most of them are even provided by the PS Booster, and all have fixed settings independent of the actual running mode. Also the risk of damage to the machine due to failure during the operation is rather limited at ISOLDE. There are occasionally radiation hot-spots created due to losses of radioactive beams inside the beam-lines, but there is no risk of really damaging the beam-line tubes with the beam, as the intensity and energy are by far too low. Those hot-spots are normally caused by rather short-lived isotopes, meaning that they will decay rather quickly.

The exchange of information should be considered as a major challenge. It is really a problem to keep everybody up to date when the number of operators is unlimited, and it needs lots of discipline concerning keeping the logbook. Another problem is the efficiency of using the machine, which might be slightly lower than with professional operators. However the financial saving of 7 operators' posts far outweighs these problems.

For the future it is planned that the users will continue to do the operation as they did in the past, but in case of problems, the ISS contacts will be replaced by the PS operating team, who will organise assistance from the various specialists who are on call anyway for the PS accelerators.