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## ABSTRACT

The CERN experimental facility ISOLDE has been moved from the 600 MeV synchrocyclotron to the 1 GeV PS Booster accelerator, thus enabling CERN to close down the 33-year old SC machine. ISOLDE is an on-line isotope separator facility where two mass separators supply radioactive ions from the whole nuclear mass range to about 250 physicists making experiments in the domain of atomic and nuclear physics, astrophysics, nuclear medicine, and surface and solid state physics. This new facility has the potential to yield higher intensities than the old Isolde at the SC machine, and there are distinct advantages for the users; however, it will mean running the Booster at high intensity for long periods. Building construction is completed, and the first test of the proton beam transport system was done at the end of 1991. Installation of one separator is completed and experiments have started. The second separator should be in place by the end of 1992.

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## ABSTRACT

The CERN experimental facility ISOLDE has been moved from the 600 MeV synchrocyclotron to the 1 GeV PS ooster accelerator, thus enabling CERN to close down the 3-year old SC machine. ISOLDE is an on-line isotope separator facility where two mass separators supply radioactive ions from the whole nuclear mass range to about 250 physicists making experiments in the domain of atomic and nuclear physics, astrophysics, nuclear medicine, and surface and solid state physics. This new facility has the potential to yield higher intensities than the old Isolde at the SC machine, and there are distinct advantages for the users; however, it will mean running the Booster at high intensity for long periods. Building construction is completed, and the first test of the proton beam transport system was done at the end of 1991. Installation of one separator is completed and experiments have started. The second separator should be in place by the end of 1992.

## 1. THE FACILITY

Two years after the approval of the project, the CERN on-line isotope separator facility Isolde is now installed in its new location close to the PS Booster. Operation for physics started at the end of June after most of the milestones had been successfully reached within the initial time schedule.

The reasons for the move of Isolde, the new layout and the evolution of the project have already been described [1,2]. The main features of the facility are illustrated on Fig.1. The 1 GeV protons from the Booster are delivered to the Isolde targets via a new 100m long transfer line coming from the right in the Figure. The beam can hit one of two target stations which feed the General Purpose Separator (GPS) or the High Resolution Separator (HRS).

The radioactive ions produced in the target are accelerated to 60 kV, analysed in the separators and then distributed to the experiments. The central GPS line and the deflected HRS beam line feed a common beam transport system via a

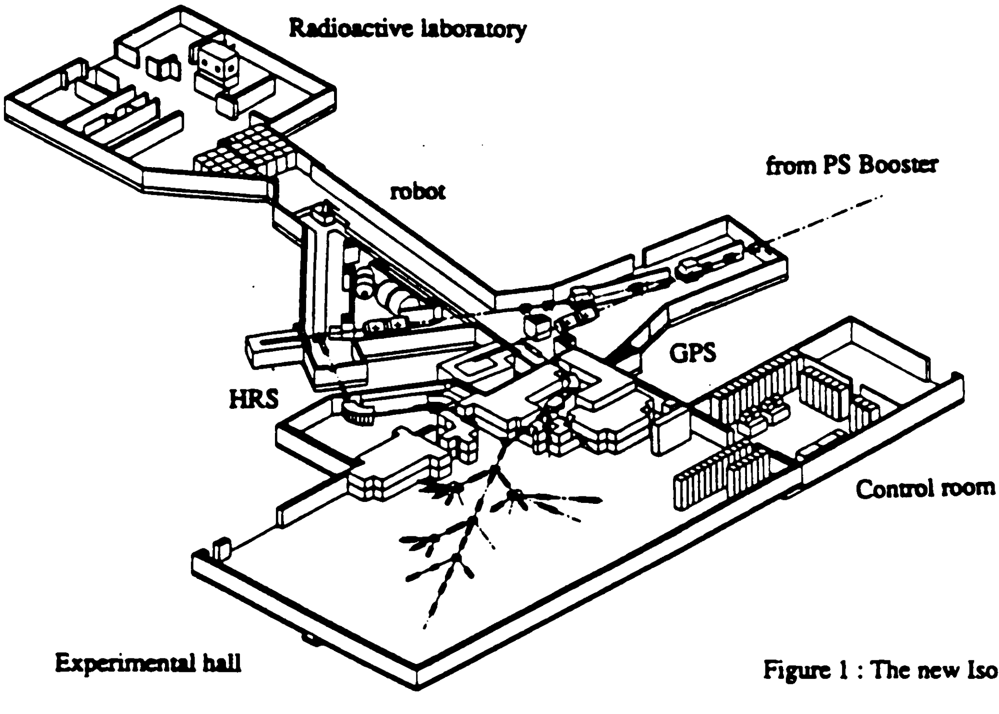

Figure 1 : The new Isolde Facility

"merging switchyard" so that most of the experiments can receive beam from either separator.

The GPS is a simple device made of a "front end" (target, coupling flange, 60 kV acceleration gap, and an electrostatic quadrupole triplet) following by some lenses and a double focusing 70° magnet. An electrostatic switchyard downstream allows three experiments to be fed simultaneously with ion beams within ± 15% of the central mass. The mass resolving power of the GPS is of the order of 2400. The HRS will be commissionned at the beginning of 1993 ; its mass resolution should be 30,000.

The most critical issues of this facility are the following:

i) The ion accelerating voltage has to be maintained constant to a few parts in $10^5$ in spite of the ionisation around the target with a pulsed high intensity proton beam impinging on it (up to $3.10^{13}$ particles per burst, 2.4 microsecond long);

ii) The very high radiation level produced in the target area; much effort has been put into adequate shielding and ventilation of the radioactive zones, where , in addition to steel and concrete blocks around the targets, the whole beam gallery is covered by up to 8 m of earth. Attention has also been paid to the safe handling of the highly radioactive Isolde target/source units by the use of a robot on rails and by installing a small radioactive laboratory (for storage, inspection and repair of faulty units).

## 2. THE TARGET VOLTAGE MODULATOR

Stable voltage of 60 kV ± 1 V must be applied to the target assembly for acceleration of the secondary ion beams. This voltage, usually derived from a highly stabilised hard tube regulated supply, would be seriously perturbed by each impacting Booster proton burst because of ionisation caused by this intense beam in the air surrounding the target.

To minimise the effects of such ionisation and to decrease the risk of flashover the target voltage is modulated to zero during the 2.4 µs impact period. The modulator circuit is shown in Fig. 2. The target assembly C4 is connected to one secondary pole of pulse transformer TX1. Capacitor C2, two orders of magnitude larger than C4, is connected to the other secondary pole. Initiation of the modulation by discharging C1, precharged by power supply PS1, into the transformer primary causes C4 to be discharged in 33 µs. Full voltage builds up again on C4 in <100 µs, which is then stabilised by the 60 kV hard tube regulated supply PS2 connected to C2. Diode D1 limits target overvoltage during the recovery to < 2 kV. Precision voltage dividers R7 and R8 provide respectively feedback for PS2 and monitoring of target voltage. Beam gates interrupt the secondary ion beams from just prior to target voltage modulation until stabilisation to the ± 1 V level occurs some 6 ms later (see Fig.3). This stabilisation time is approximately independent of the intensity of the proton beam. For fuller details see Ref. [3].

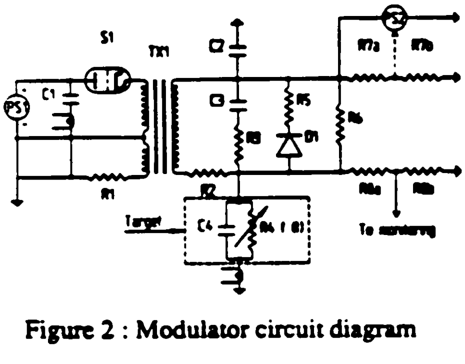

Figure 2 : Modulator circuit diagram

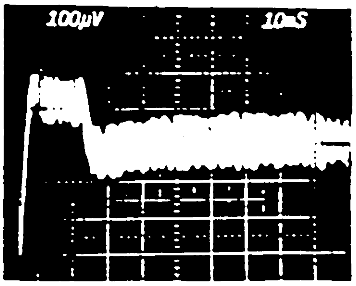

Figure 3 : Target voltage recovery after PSB beam impact

## 3. THE SEPARATOR CONTROLS

The architecture chosen for the Isolde control system is the now classic CERN SPS system with front end computers connected to the equipment, a network, console computers for the operators, and a central file storage for all the data and programs. At the end of the 1980's there had been some proposals to use mass market solutions so in autumn 1990 the decision to try a Personal Computer solution for Isolde was made. By spring 1991 the results were sufficiently convincing for the solution to be adopted definitively. The technology is based on the PS office automation network and consists of Olivetti PCs linked together by Ethernet and using Novell Netware for the file server and network software.

The front end computers are linked to the hardware using PC plug-in boards from Blue Chip Technology for digital, analogue and status inputs. Other connection methods used are serial CAMAC to recuperate some previous Isolde hardware, GPIB, and RS232 for Siemens Simatic control. The operating system is MS-DOS. The equipment is driven by "equipment modules" written by the Isolde construction team. Real time, such as for the beam scanners, is handled by DOS "terminate and stay resident" programs hooked to the hardware interupts. More details may be found in Ref. [4].

The console computers are Olivetti 486's running Microsoft Windows with 21" screens. One server program, usually running iconised, handles the communication with the front end computers. Control applications communicate with this application using Dynamic Data Exchange, the standard Windows method. This allows applications to be created using any proper Windows product. Isolde applications are mainly created using Excel and Visual Basic. These allow applications to be created simply and quickly so that the

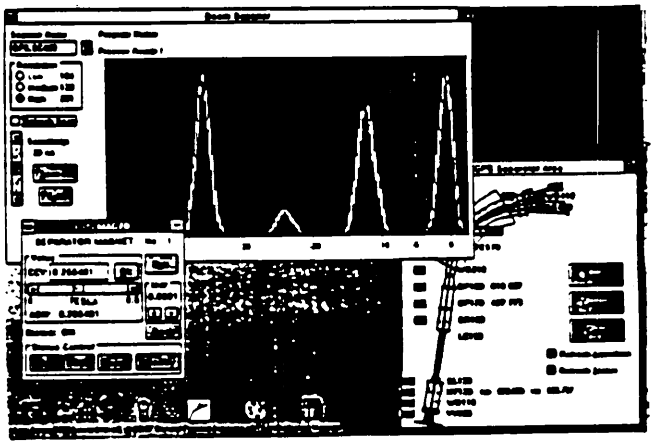

Figure 4 : An example of a screen layout

supply of applications for Isolde has easily kept pace with requirements. Figure 4 shows an example screen layout.

The whole system is database driven, including the connection of the individual ADCs etc. to the equipment. This allows installation, modification and repair by simply updating the database and re-initialising the equipment drive software. The database used is Excel. The "system software" consists of the optimised DDE server in the consoles, the network interfacing, and the equipment module client software in the front end computers. This cost about 1.5 man-years to write, test and demonstrate and is the software heart of the system. This allows equipment modules and applications to be created using only a small fraction of the effort required for traditional systems.

## 4. FIRST OPERATION

### 4.1 Proton Beam

The first (pencil) beam from one Booster ring was delivered to a screen at the GPS target position in December 1991, after a few hours of setting-up. Since then only a limited number of protons was available for tuning the line, in order not to irradiate the zones ; full intensity was only used for the HV supply test and for beam transformer calibration/ development. The latter plays a crucial role in continuous automated monitoring of beam losses in the line and eventual rapid shut-off.

More experience will have to be gained with continuous high-intensity operation of the PSB, interleaved with its traditional cycles delivering hadron beams to the CERN accelerator complex. The marginal stability of the dual RF system of the PSB constitutes the present intensity limit. As well as requiring frequent retuning of the acceleration, any losses in the Booster will raise the level of induced radioactivity in this machine. However, only minor problems are expected up to 80% of the maximum design intensity.

Table 1 - PS-Booster beam parameters

| | |
|---|---|
| Beam energy | 1 GeV |
| Max. intensity on target | $3.2\ 10^{13}$ p/pulse |
| Pulse length | 2.4 μs |
| Repetition time (typ.) | 2.4 s |
| Average current (max) | 2.1 μA |

### 4.2 GPS running-in

After only a few months of installation work the GPS is now being commissioned. In May 1992, Xe ions were accelerated for the first time in this new device, and in June the whole system for on-line production of radioactive particles was put into operation. Figure 4 shows a scan in the focal plane of the GPS magnet of the beams of stable Xe isotopes. Already in the preliminary tests the resolving power of this new isotope separator was about 900 and there is good hope that by careful adjustment of the ion source and the optics system the design figure of more than 2000 will be reached. Radioactive Ne isotopes from a MgO target were then measured in the downstream detectors where full advantage was taken of the pulsed structure of the Booster beam. There is evidence of enhancement of the release of radioactive reaction products from the ISOLDE target due to the very short, high intensity bursts of protons. In Fig. 5 the release delay curve for $^{19}$Ne from the MgO target is shown. The delay half life is 300 msec which is three times faster than the value measured from the same target at the CERN SC.

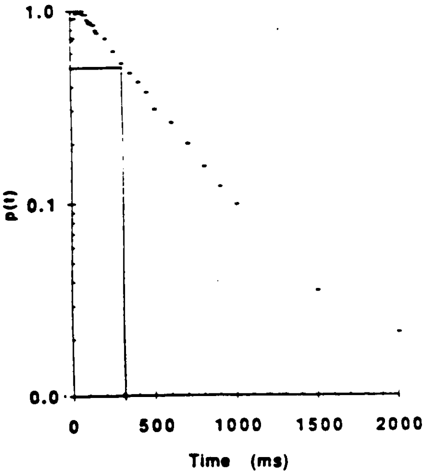

Figure 5 : The release delay curve for $^{19}$Ne from a MgO target at 1000°

## 5. OUTLOOK

In order to exploit fully the features of the new facility an intensive beam development programme is planned. This is expected to yield bunched radioactive beams, and beams of higher intensity obtained via the higher cross-sections and thicker targets made possible by the 1 GeV proton beam. Higher purity of the beams can now be obtained by means of the newly developed laser ion source which makes use of stepwise resonant excitation to autoionizing states.

Recently, experiments with accelerated radioactive beams have attracted worldwide interest. In Europe it has been recommended by NuPECC that a two stage accelerator would be the best concept to provide beams in the medium energy range; ISOLDE is ideally suited as a source of the ions [5]. Presently a collaboration is preparing a proposal for a RFQ/Linac accelerator of singly-charged beams from ISOLDE to cover the energy range 0.2-0.5 MeV/A for masses up to A=80.

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