STATUS OF ISL

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Abstract

The ion beam laboratory ISL produces fast light and heavy ions for research and applications in solid state physics, medicine and industry. Over the last three years the laboratory improved operation procedures, installed and commissioned new target areas, thus widening its users´ experimental opportunities. Several review committees rated the technical standard and the scientific mission of the facility.

ACCELERATOR IMPROVEMENTS

As shown in the artistic view of the facility (fig. 1), two injectors feed their beams into a separated sector cyclotron.

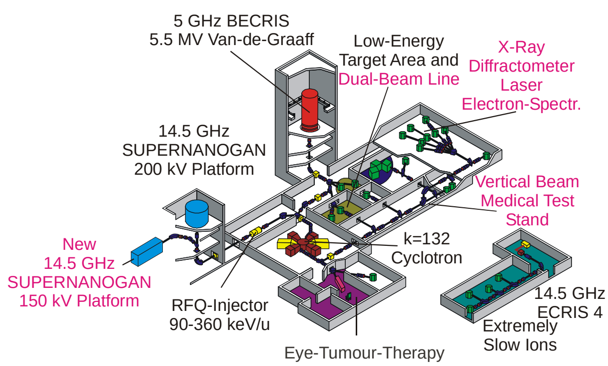

Fig. 1.: Overview of the ISL facility
The equipment marked in red has been installed and commissioned over the last three years

The van de Graaff injector is used for fast and light ions, heavy ions are preferentially pre-accelerated by a frequency-variable RFQ-structure.

Over the last three years several improvements have been implemented concerning i) the control system, ii), RFQ operations, and iii) ion source performance

i) The transfer to the new control system has come close to completion. The monitoring has been fully converted to the VISTA system. This allows faster control such as full overview over all faraday cup status, slits widths, slit currents, as well as fast scans of energy distributions of the beam, turn patterns, charge state distributions for ions from the source etc. These new tools improved the tuning speed and the overall performance.

ii) At the East Lansing meeting we discussed the problems related to the injection of the RFQ beams [1] which results from small energy shifts depending on the relative RF-phase between RFQ1 and RFQ2. We inserted a slit and a Faraday cup behind the first 45° bending magnet upstream of the RFQ. Then we carefully calibrated the magnet for different RFQ-frequencies, i.e. different particle velocities for both, transported and accelerated beams by RFQ2. These calibrations have been performed for different charge to mass ratios and confirmed by producing the same beams with calibrated energies from van de Graaff injector keeping the cyclotron settings untouched.

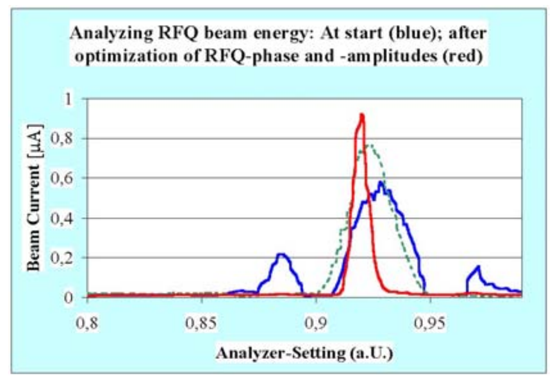

Figure 2: Analyzed RFQ beam before injection into the cyclotron. The beam is tuned by varying the RFQ phase and amplitude to yield a sharp energy distribution at the correct energy (red curve)

Thus, the correct settings of the RFQ phases and amplitudes can be found by setting the magnet by nmr to the correct field, and tuning the respective parameters. Fig. 2 shows the procedure.

Fig. 3: New ion source platform:
The 150 kV new platform with a 14.5 GHz Supernanogan ECR ion source is close to completion

iii) The ion source development concentrated on the production of high intensity and stable Au-ion beams Au-ion beams with energies of 350 and 600 MeV have become the most frequently asked beams. With the latest version of the Supernanogan, continuous improvements of the vacuum and extraction system, stable Au-beams for continuous undisturbed runs of several days are the standard now. This improvement contributes to slightly reduced tuning times as shown in the operations statistics of fig. 4. Nevertheless the initial tuning is still time consuming. To overcome this problem we added a new injection platform. Our first Supernanogan (old version) was modified to a configuration similar to the improved new version and has been installed on the new platform. (see fig. 3). We expect the commissioning of the new platform by the middle of 2005. This new installation should improve operations since we will be able to tune the beam to come while the current experiment is still running.

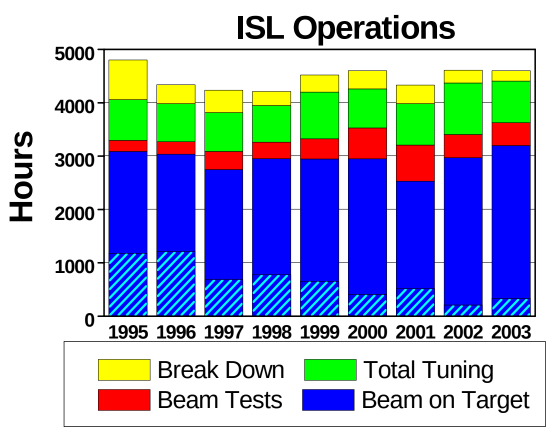

Fig 4: ISL Operations since 1995:

ISL has managed to operate the facility with an average of 3000 hours of beam-time on target. The hatched parts are low energy (van-de-Graaff) beams. It can be observed that i. the demand for high energy beams and the reliability (less breakdowns) increased and ii. the total tuning time stays relatively constant, which is due to the fact that the number of users with different beam settings increased.

OPERATIONS

The new control system, the better performance of the source, and the improved tuning prescriptions for the RFQ-beams have lead to a better overall performance. The unscheduled shutoffs could be kept below 5% of the operation time (see fig. 4). One can also see that the demand for low energies (van de Graff beams) decreased considerably. This reflects the users`s preference of high energy ERDA compared to low energy analysis (RBS).

TARGET STATIONS AND ACTIVITIES

Medical activities

Since 1998, medicine takes a constant share using 68 MeV protons for the therapy of ocular melanomas. The therapy gets 10 periods with 5 consecutive days per year, each therapy day is scheduled for 8 to 16 hours a day depending on the number of patients. The total number of patients varies between 90 and 120 per year and is slightly rising. There are still problems with the public health insurance companies who try to keep the expenses low.

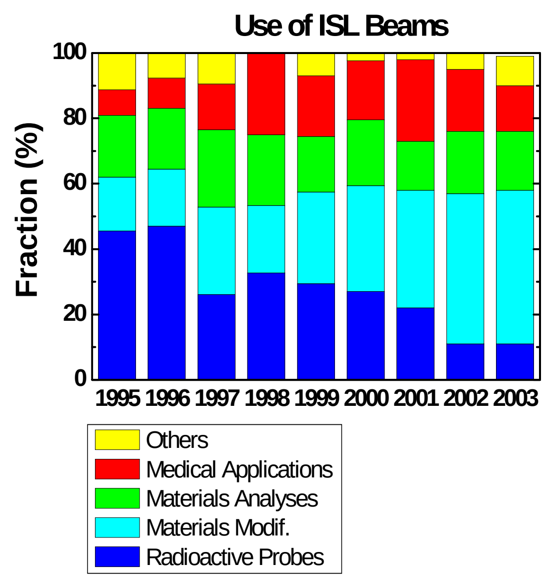

Fig. 5. Use of ISL ion beams

Materials modification studies have become the largest part of the research program at ISL

In the evening of the therapy days and over night, the proton beam is being used for either high energy PIXE or radiation hardness tests. Andrea Denker will present details at this conference [2].

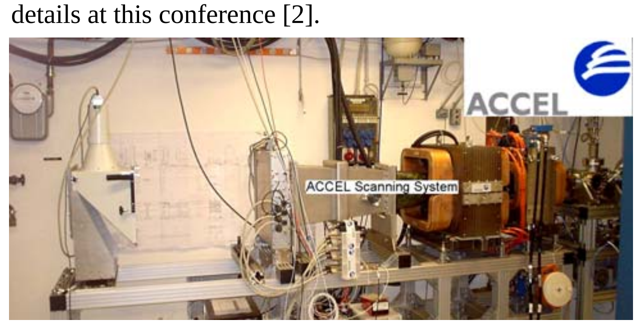

Fig. 6: The ACCEL nozzle and scanning test equipment installed at ISL

Since 2003 there is also an ongoing medical research program to improve proton precision therapy. It is addressed to beam delivery, dosimetry, positioning and related subjects. A new target area has been installed to allow experiments without changing the therapy set-up. This new test facility also includes a vertical beam line. Thus, perpendicular radiation fields can be superimposed. The first users of this new area were our contractors from ACCEL who tested their new nozzle and scanning system (see fig. 6). Details will also be presented at this conference [3].

Materials Analysis

The materials analysis activities use either fast proton beams as mentioned above or Au-ion beams of 350 MeV for Recoil Detection Analysis . Whereas fast protons yield information about the composition deep seated layers [4], elastic recoil detection analysis (ERDA) [5] concentrates on the stoichiometry of thin layers as well as the depth distributions of the different elements. Au-ion beams have become the most favoured projectiles because of the very heavy ion mass. The excellent pulse structure of beams injected from the RFQ with pulse widths between 300 and 500 ps eases the mass identification of the recoiling target atoms by time of flight and energy measurements.

Materials Modifications

The by far largest user group performs material modifications ranging from studies of basic single ion solid interaction over high dose effects to industrial cooperation. This is a growing field due to high rising expectations from nanotechnology connected with the peculiar features of ion tracks or self-organization phenomena observed with high dose irradiation and overlapping tracks. For these studies three new target stations have been commissioned.

i.) a UHV-chamber magnetically shielded for Auger electron spectroscopy induced by ion impact

ii.) a UHV-chamber where a high-power laser passes close to the target to ionize neutral particles sputtered by single ions. These measurements should give an inside view on the energy equilibration after the creation of a track with high energy density.

iii.) a chamber equipped with an in-situ X-ray diffractometer. This will be used for in-situ observation of structural modifications of samples after high dose heavy ion bombardments.

The analysis of ion induced structural modifications by X-ray methods, in particular synchrotron radiation, has become a mayor issue of our activities. Since two years our group operates a 6-circle X-ray diffractometer and installed a small-angle X-ray scattering device at the synchrotron radiation facility BESSYII in Berlin. The combination of ion beam physics with synchrotron radiation has already yielded some exciting and unexpected new results which will be published in the near future.

Last but not least, a new multipurpose irradiation chamber with dual beam access, low energies from the van de Graaff injector and high energies from RFQ-cyclotron combination has been commissioned. The beams can be wobbled for large area irradiations. The chamber houses an X-Y manipulator which can also be rotated around two axes. Residual gas ionisation chambers allow exact dose rate measurements.

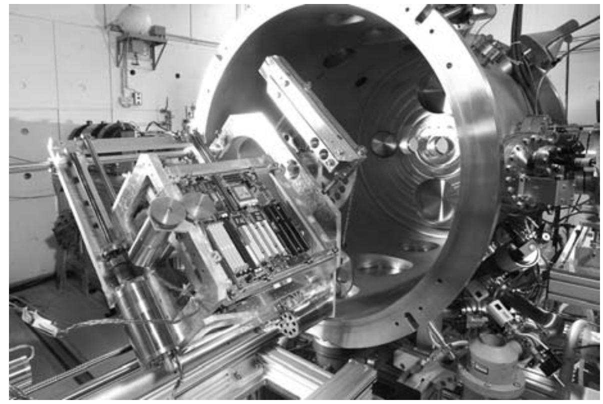

Fig. 7: Multipurpose irradiation area
Low energy beams enter from the left, high energies from the right hand side. The manipulator in front can be loaded with large objects. From both sides the beam can wobbled to cover large areas.

Several cocktail beams have been developed and used at this target station for radiation hardness tests of electronic equipment. With the ISL cyclotron, the production of cocktail beams is a bit more complicated compared to compact machines since not only the RF-frequency but also the injection energy into the RFQ or the energy out of the van de Graaff have to be adjusted to slight changes of the ions´s masses.

SUMMARY AND PERSPECTIVES

Over the last three years we have improved accelerator operations and installed new experimental equipment at ISL. A further step towards higher ion masses and higher energies would be the installation of a superconducting ECR ion source which has been designed and proposed. Several review committees have rated ISL to be an excellent and unique facility for as well the HMI as outside users. Nevertheless, the decision for a long term continuation is currently open.

REFERENCES

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