5. Beam energy measurement

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Beam energy measurement systems have been developed at HIL for several years. Presently Time-of-Flight and Rutherford scattering methods are implemented for this purpose. One of the two existing TOF set-ups and the scattering set-up are installed on the beam line, which is common to all the experimental caves, while another TOF arrangement serves the C1.1 line only (IGISOL experiments).

The common TOF implementation [1,2] employs two sets of induction plates placed 6530 mm one from another. The charge pulse induced in each plate is amplified, shaped, and displayed on the oscilloscope, allowing to measure the time of flight of the ions. An example of such an oscilloscope picture is shown in Fig. 1. Note that the time of flight between the two induction plates is longer than the typical beam repetition time and thus a multiple of beam periods corresponds to the measured time of flight.

Another method is implemented in the beam scattering system [3]. The diagnostic set-up comprises a dedicated beam scattering chamber with a charged particle detector and cyclotron RF reference feed. It allows to measure the beam energy as well as its energy and time spread. A gold target (typically 100 μg/cm^2) is used. The particle detector is placed at 45° scattering angle. Such geometry ensures that only elastically scattered particles are registered. This condition is valid for any ion accelerated by the cyclotron. Energy calibration is made with an alpha source built into the device. A spectrum for $^{32}S^{+5}$ beam is presented in Fig. 2.

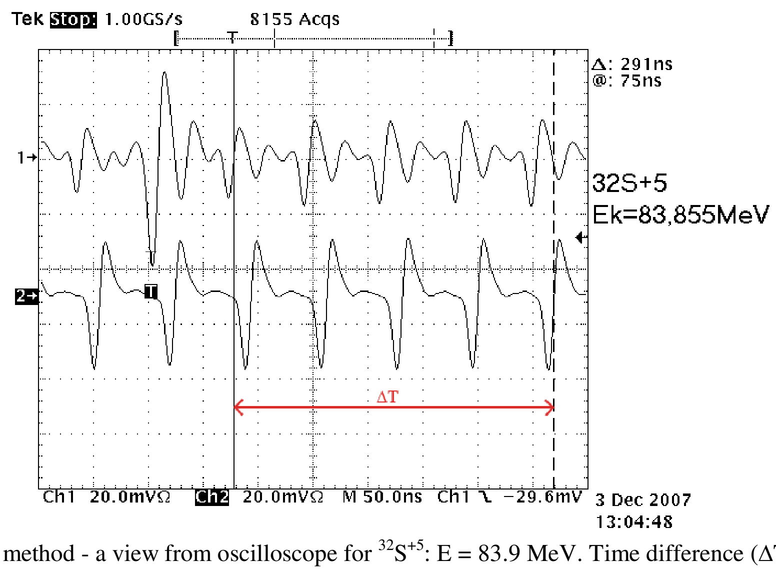

Figure 1. TOF method - a view from oscilloscope for $^{32}S^{+5}$: E = 83.9 MeV. Time difference (ΔT = 291 ns) used for energy determination is marked.

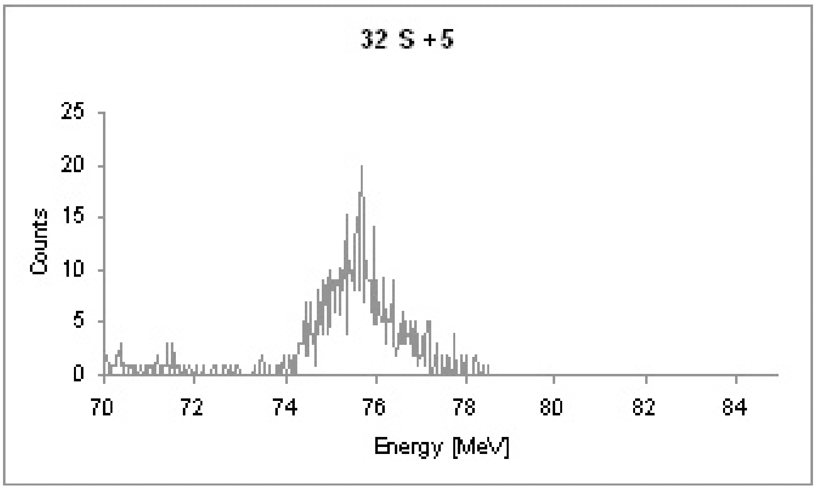

Figure 2. A sample spectrum from the beam scattering set-up ($^{32}S^{+5}$ beam). To calculate the beam energy, the energy of scattered ions measured by the detector should be divided by a factor resulting from the scattering kinematics. In this case the factor is equal to 0.91, therefore E = 75.6 MeV / 0.91 = 83.1 MeV.

The third device, installed on the C1.1 beam line, works also on the principle of time-of-flight (TOF) measurement. This apparatus is located in the experimental set-up area, so it can be used only for IGISOL experiments.

Results of beam energy measurements performed using set-ups described above agree with each other. A comparison of such measurements for recently extracted beams is presented in Table 1.

Table 1. Comparison of beam energies determined using various diagnostic set-ups available at HIL.

ion	TOF	beam scattering	TOF at IGISOL
$^{18}O^{+4}$	82.9 ± 0.8 MeV	82.3 ± 1.6 MeV	-
$^{32}S^{+5}$	83.9 ± 0.8 MeV	83.0 ± 0.8 MeV	-
$^{16}O^{+4}$	97.8 ± 1.0 MeV	-	96.6 ± 1.0 MeV

Each method has its strengths and weaknesses. The TOF technique is convenient to use and rather precise but requires high beam intensity. The beam scattering method suffers from energy calibration uncertainty, but can be used for lower beam intensities and allows to determine other beam parameters.

References:

[1] J. Miszczak *et al.*, HIL Annual Report 2001
[2] M. Sobolewski *et al.*, HIL Annual Report 2002
[3] J. Iwanicki *et al.*, HIL Annual Report 2005

6. Computer network at HIL

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In 2007 the layout of the computer network at HIL was modified. What was once a single network was divided into 2 subnetworks. The first subnetwork connects servers (WWW,