Modern Beam Monitoring Systems During SEE Testing on ISDE&JINR Heavy Ion Facilities

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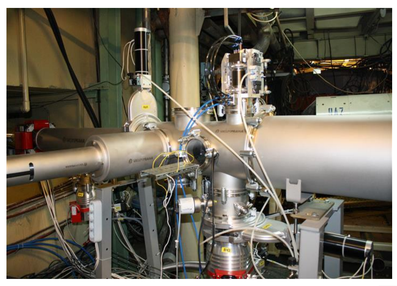
Introduction

Beams of accelerated ions of low intensity are required for applied research, e.g., research of radiation resistance of electronics or in biology.

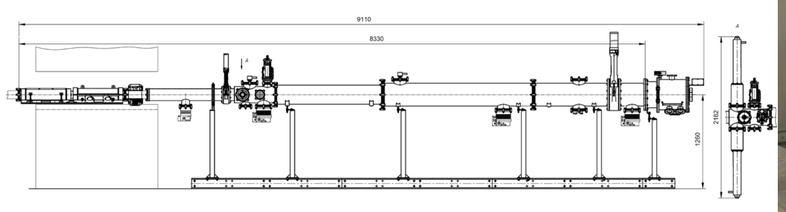
Three beam-lines have been built in the accelerator complex of the FLNR JINR for testing electronic components: two low energy beam-lines (3-9 MeV/nucleon) and one high energy beam-line (15-60 MeV/nucleon). For testing, it is necessary to know the following parameters of heavy ion beams: ion energy, flux density and uniformity of beam distribution. To determine these parameters during the tests, a system for diagnosing ion beams based on scintillation detectors was developed. But this system does not meet all requirements. First, online flow density control is conducted away from the test sample. Secondly, on the high-energy channel, there is no direct measurement of energy at the location of the sample. Third, there are no ion beam profile detectors on the low energy channel.

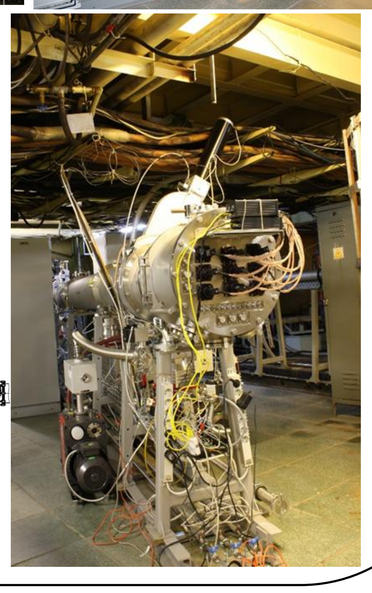
Diagnostics systems of ion beam parameters were modernized to eliminate shortcomings. A multichannel ion beam profile detector, scintillation detectors on flexible fibers, and a system for measuring ion energy at the location of the test sample were created.

The low energy beam-line based on U400

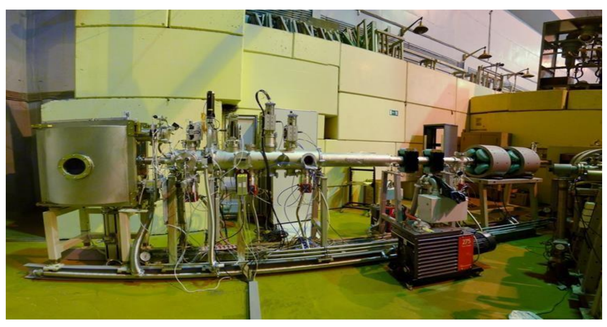

Main features of the new facility are:
- 200 mm x 155 mm irradiation area
- beam uniformity over irradiation area better then 20%
- Ne, Ar, Fe, Kr, Xe, Bi ions with 3-9 MeV/nucleon
- LET range of 4.5-100 MeV/(mg/cm2).
- Fluent energy variation in the U400R will allows changing the ion energy without degraders.

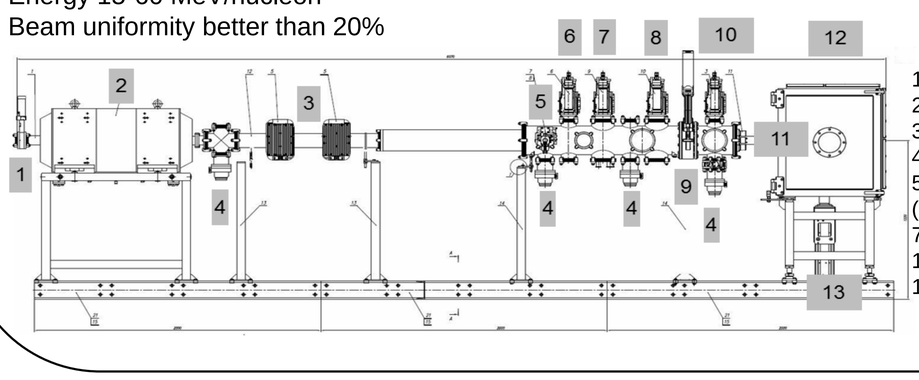




The high energy beam-line based on U400M

Design of the experimental chamber allows:
- the SEE testing in vacuum (10^{-2} Torr) and air ambient
- irradiation area of 60 mm in diameter.
- automatic movement of the DUT in two orthogonal axes (X and Y) in respecting of the beam direction (Z)
- to change beam incident angle in the range of 0-90 degrees.
- installation of degraders set.
- Energy 15-60 MeV/nucleon
- Beam uniformity better than 20%





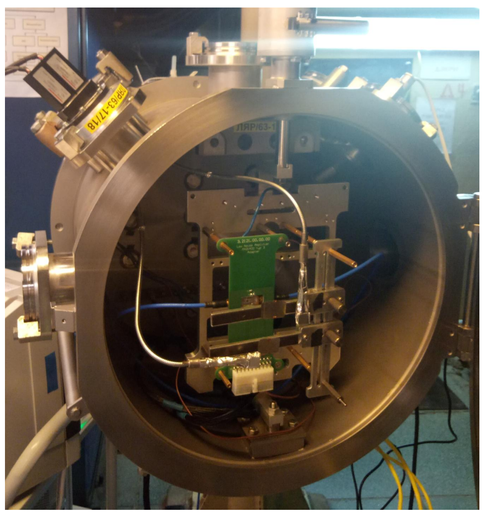
1.vacuum gate valve (1 and 9)
2.quadrupole lenses
3.steering magnets
4.turbo molecular pumps
5.beam monitoring system (5, 6, 8, 10, and 11)
7.energy measurement system
12.the user target chamber
13.remote movement

Scintillation detectors based on flexible optical fibers

- Designed to online flux measurement near DUT.
- Detectors are consist of PMT H10721 (Hamamatsu), wavelength shifting fibers Y-11 (200) (Kuraray) and plastic scintillator.
- The area of plastic scintillator is 1 cm^2.
- Up to 8 detectors to each beamline.
- Detectors are calibrated with polycarbonate or polyethylene terephthalate track detectors. Some results of the calibration are presented in the Table 1.

Table 1

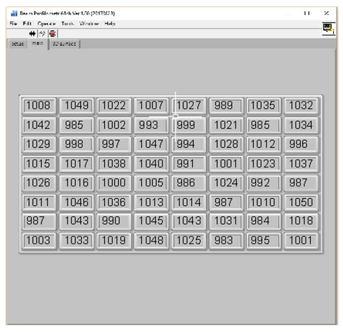
№	№ of detector	The scint. detector fluence	The track detector fluence	k
83	1	5.50E+07	5.90E+07	1.07
	2	5.11E+07	5.60E+07	1.10
84	1	5.41E+07	5.50E+07	1.02
	2	4.96E+07	5.60E+07	1.13
85	1	5.38E+07	5.70E+07	1.06
	2	5.11E+07	6.10E+07	1.19
86	1	5.57E+07	5.85E+07	1.05
	2	5.29E+07	5.90E+07	1.12
87	1	1.98E+07	2.10E+07	1.06
	2	1.85E+07	1.80E+07	0.97
88	1	1.98E+07	2.10E+07	1.06
	2	1.83E+07	2.30E+07	1.26



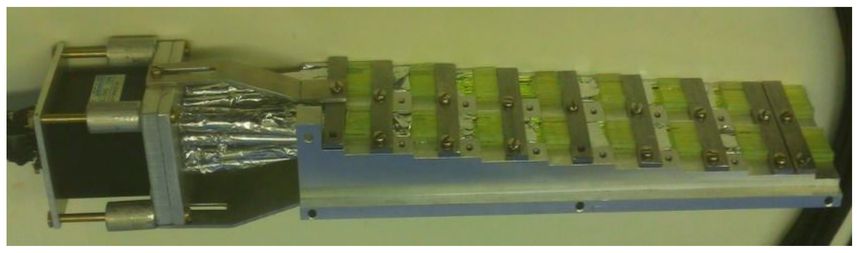
Detectors in the test chamber

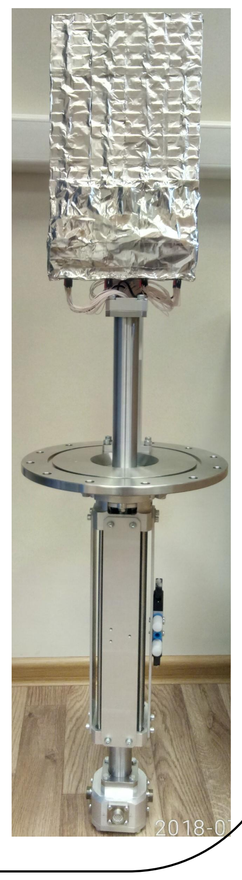
Multichannel beam profile detector for the low energy beam-line based on U400

- Designed to beam profile measurement at the low energy beam-line based U400.
- Sensitive area of the detector is 200*200 mm^2.
- The detector is consist of 4 16 channel PMT H12445 (Hamamatsu), wavelength shifting fibers Y-11 (200) (Kuraray) and 64 plastic scintillator with area 1 cm^2.
- Thickness of the scintillator is 1 mm.
- Distance between the centers of scintillator is 25 mm.



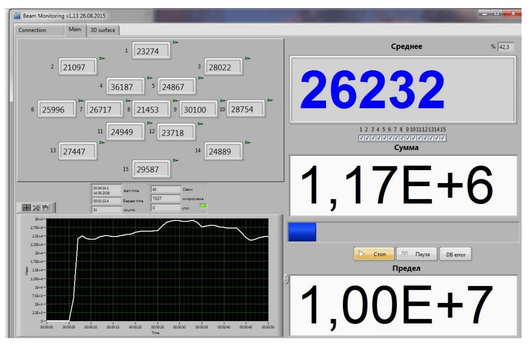
Software of multichannel beam profile detector



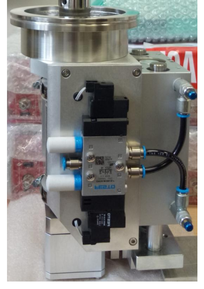


15-channel beam profile detector for the high energy beam-line based on U400M

- Designed to beam profile measurement at the high energy beam-line based U400M.
- Sensitive area of the detector is 60 mm in diameter.
- The detector is consist of 16 channel PMT H12445 (Hamamatsu), wavelength shifting fibers Y-11 (200) (Kuraray) and 15 plastic scintillator with area 1 cm^2.
- Thickness of the scintillator is 5 mm.
- Scintillators are located inside 2 circles. There are 6 scintillators inside the circle with a diameter of 40 mm, 8 scintillators - inside the circle with a diameter of 60 mm and one detector - in the center.

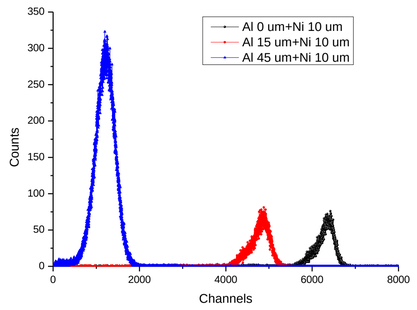


Software of 15-channel beam profile detector

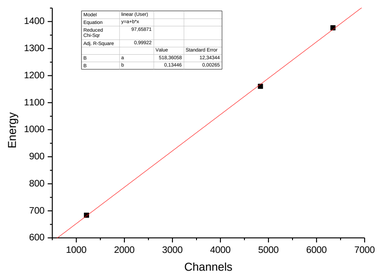


Energy measurement system for the high energy beam-line based on U400M

- Designed to measure energy at the location of the test sample.
- The system consist of two detectors: silicon detector (500 um) and scintillation CsI (5 mm) detector. The system is calibrated with TOF detectors.
- The silicon detector is designed to measure energy of heavy ions such as Xe, Kr and Bi.
- The scintillation CsI detector is used to measure energy of light ions such as Ar, Ne and O.



Amplitude spectra of Xe ion beams at energies 10.43, 8.79, and 5.18 MeV / nucleon



The energy of Xe ion beams as a function of the channel number

Conclusions

Diagnostic systems of ion beam parameters were modernized at beam-lines for electronic tests at FLNR accelerator complex. Scintillation detectors based on flexible optical fibers, multichannel and 15-channel beam profile detectors and energy measurement system for the high energy beam-line based on U400M were created.