# Beam diagnostics and instrumentation upgrade for multipurpose research complex of INR RAS

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## Abstract

Accelerated proton beam of INR linac is used for various facilities in multipurpose research complex of INR RAS, including experiments of neutron investigations and medical physics laboratories. In recent years beam instrumentation for transport channels of the complex has been upgraded and supplemented. Electrostatic pick-ups, beam current transformers, ionization chambers, multiwire SEM-grids, as well as its front-end and processing electronics were developed and combined to improve beam diagnostics. Some technical details and available results of beam measurements are presented in the paper.

## Introduction

Multipurpose research complex (MRC) of INR RAS includes four beam outlets (Fig. 1): three neutron facilities of neutron investigations laboratory (time-of-flight RADiation Experiment, pulse neutron source IN-06, lead neutron slowing-down spectrometer LNS-100) and research Complex of Proton Therapy, which is a part of medical physics laboratory. Depending on beam user requirements INR RAS linac has to provide beam parameters in a wide range of values:

beam energy 100÷209 MeV,
pulse current 0.01÷15 mA,
pulse repetition rate 1÷50 Hz,
pulse duration 0.3÷180 μs.

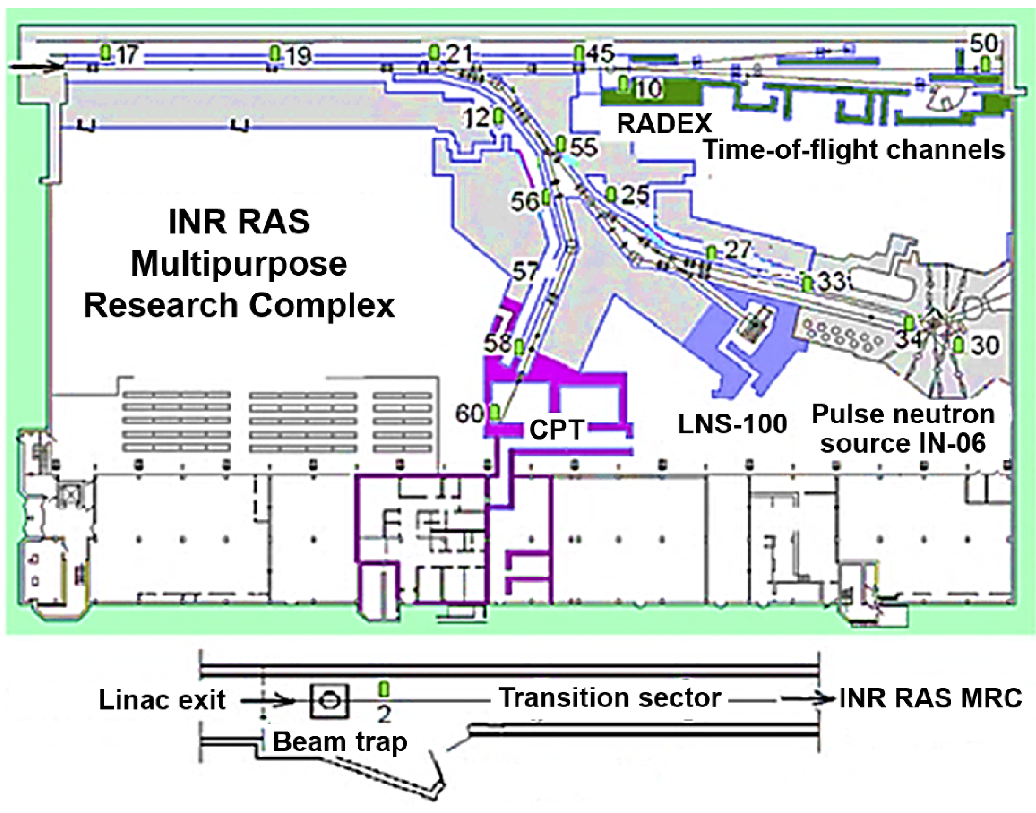


**Fig. 1:** Layout of INR RAS MRC.

## Diagnostics at the linac exit

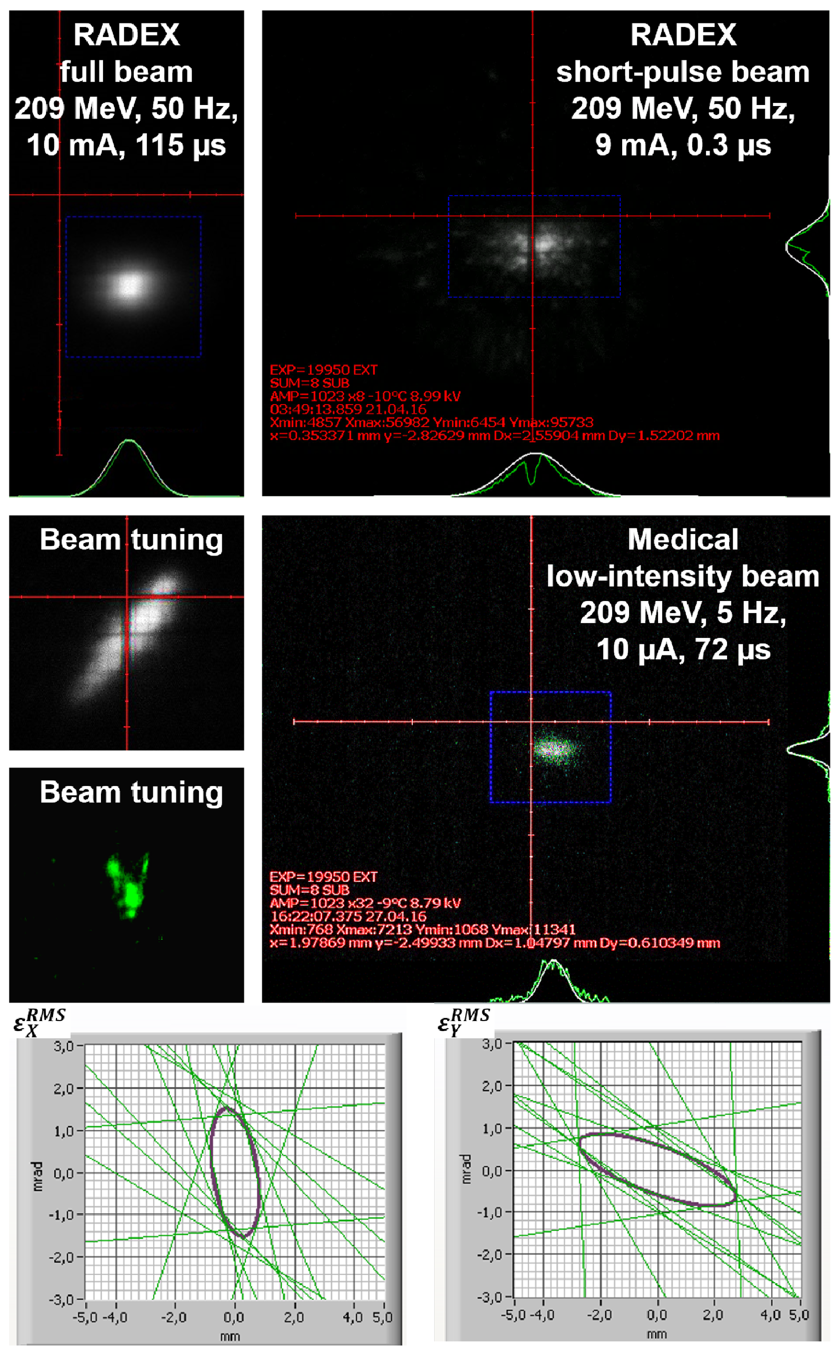


**Fig. 2:** BCSM measurements.

Beam emittance and position measurements at the linac exit are of importance for proper matching with the linac-MRC transition sector. In-flight beam diagnostics before a beam trap is provided by Beam Cross Section Monitor (BCSM).

The monitor, utilizing a residual gas ionization, enables to observe 2D beam cross section, beam position and profiles, as well as transverse emittance ellipses (Fig. 2), which can be reconstructed from beam profiles data during linear transformations in phase space by variation of fields in upstream quads.

## Electrostatic pick-ups

Beams with given energies are transported about 400÷500 m to the research facilities without acceleration. Due to the momentum spread a beam bunch structure ($T_{Bunch} \approx 200$ ps, $f_{RF} = 198.2$ MHz) is lost and the measurements are done for debunched coasting beams. Linear-cut electrostatic pick-ups (Fig. 3) upstream and downstream of elements with reduced aperture are installed for non-destructive measurements of beam position and tilt.

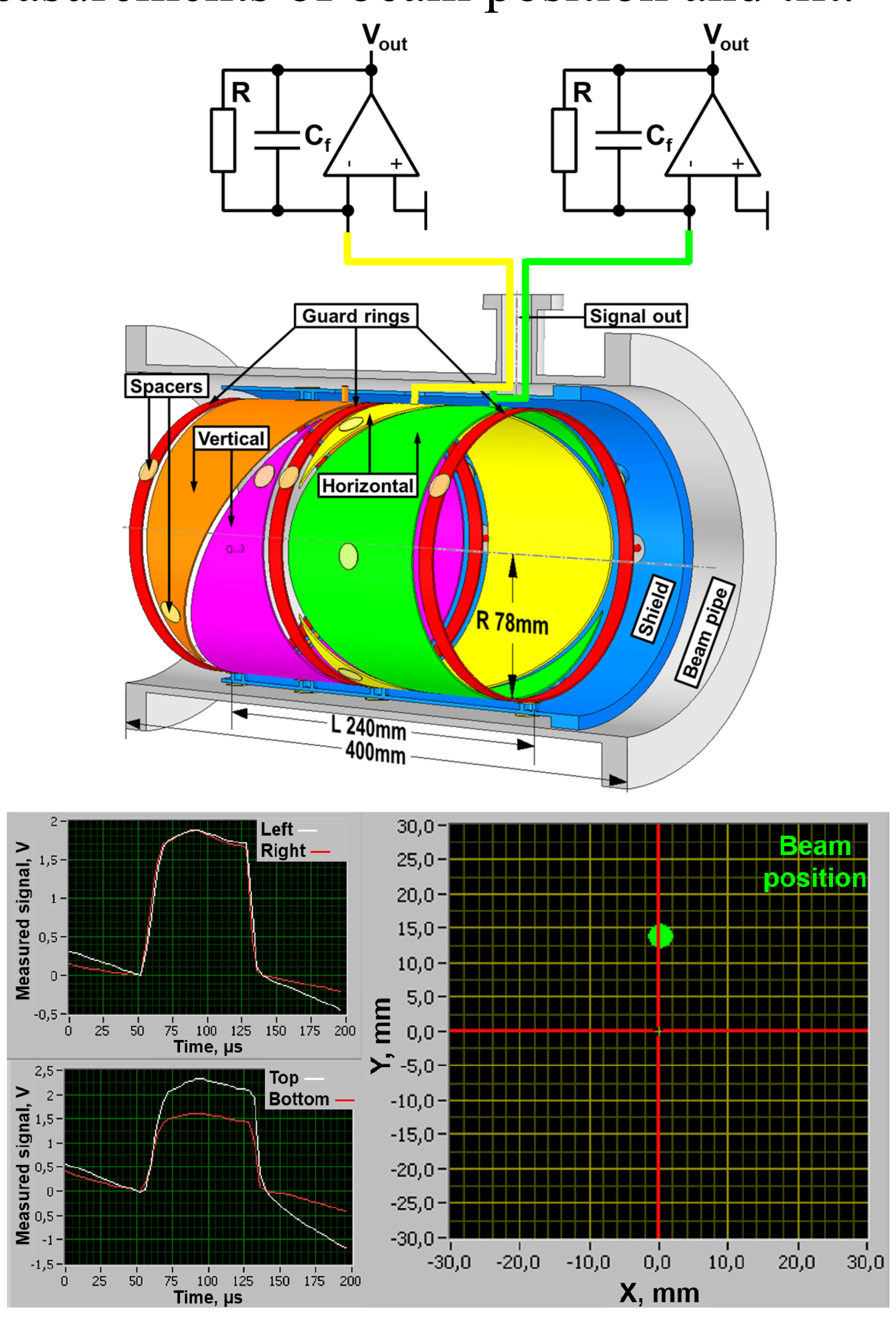


**Fig. 3:** Pick-up scheme and signals.

## BCTs & ionization chambers

Beam losses control system is based on beam current transformers and ionization chambers. Fast (Fig. 4) and sensitive BCTs register an absolute value of beam losses by a beam current difference between the linac exit and entrances to the research facilities.

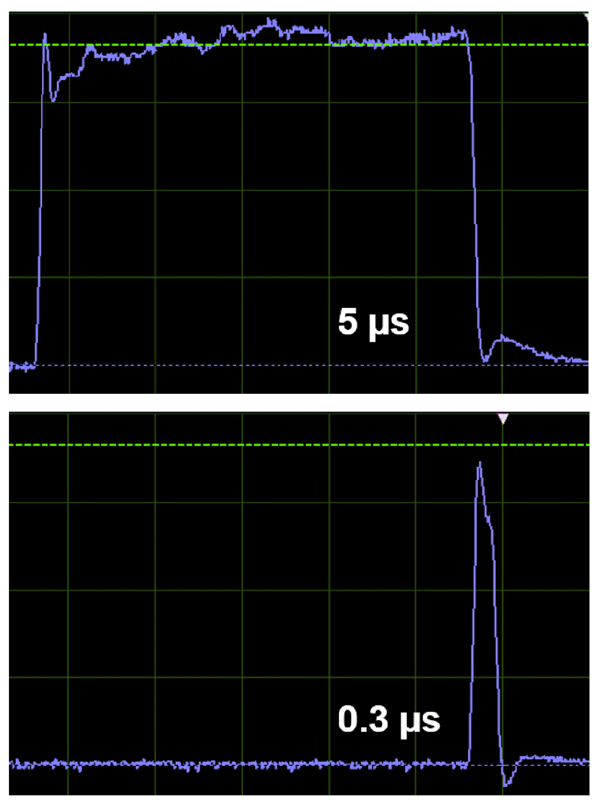


**Fig. 4:** BCT signals from short-pulse beams.

ICs measure a relative value (Fig. 5): protons and neutrons ionize air in a volume, enclosed by comb electrodes with 600 V potential difference, that produces a current proportional to the dose rate.

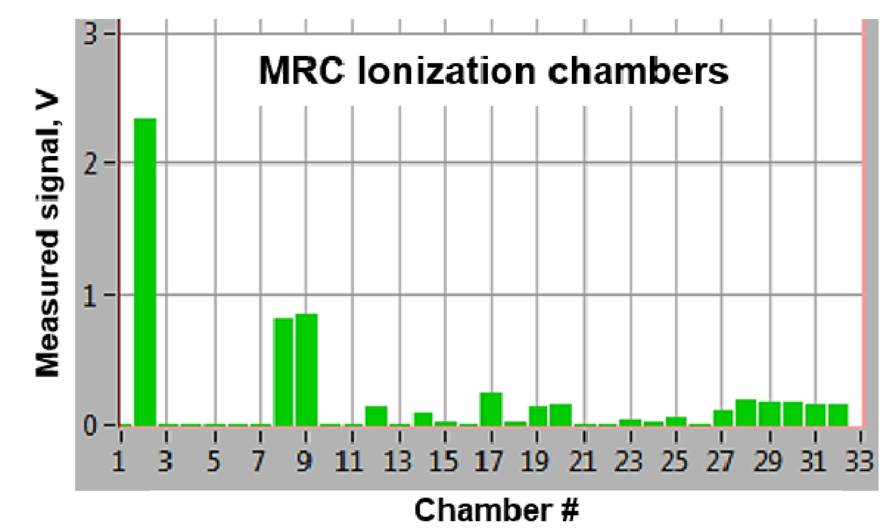


**Fig. 5:** IC signals along MRC channels.

## Multiwire SEM-grids

Multiwire SEM-grids are used to control beam profiles and position at inlets of the research facilities. There are 16 tungsten wires 100 μm diameter with 4 mm spacing in each horizontal X- and vertical Y-plane of the grid. Polarization grids are not used. Such coarse grids are proved to be sufficient, because it needs to retain beam transverse sizes as big as possible with RMS value about 10 mm (Fig. 6) for a thermal load reduction of the neutron production targets. 120 mm aperture of grids enables continuous in-flight control during the whole accelerator run without an appreciable influence on a beam. The signal readout is done by time multiplexing with channel switching time equal to 10 μs.

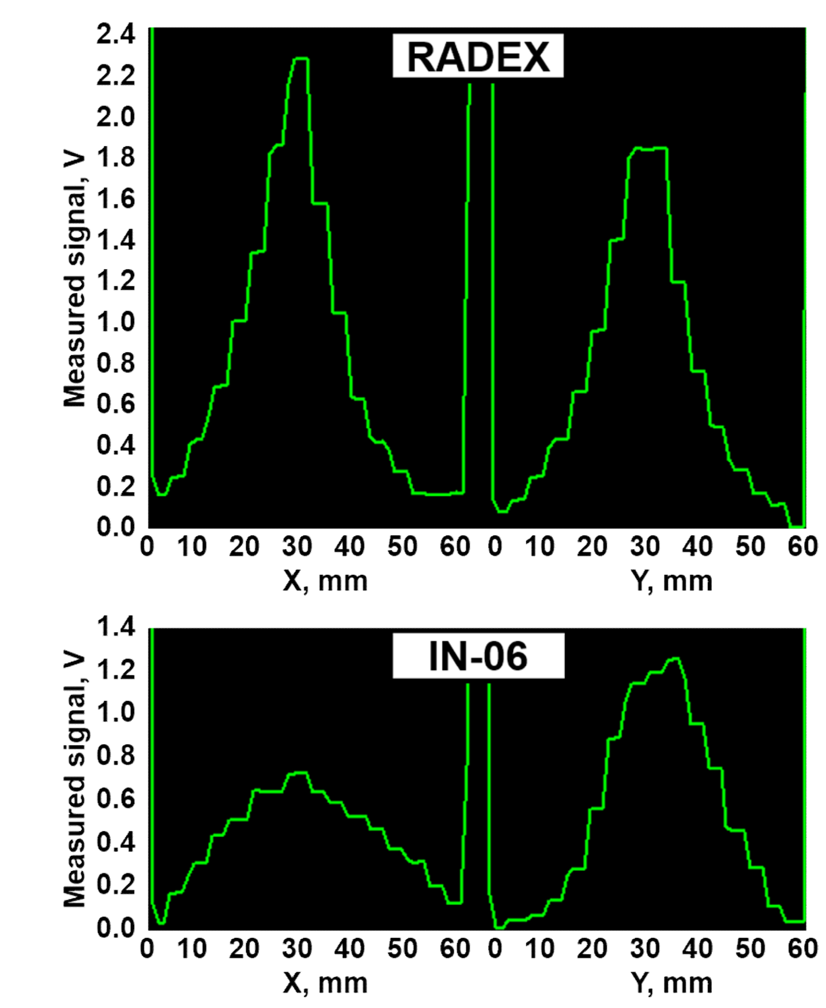


**Fig. 6:** Profiles at RADEX & IN-06 inlets.