LUMINESCENT DIAGNOSTICS OF LOW INTENSITY PROTON BEAMS AT INR RAS LINAC

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THPSC39

Abstract

INR RAS linear accelerator is a high-intensity accelerator, mostly used for rare isotopes production and neutron experiments. However low-intensity beam research is also presented at INR linac and requires appropriate diagnostics, such as luminescent diagnostics, which is implemented at a new proton irradiation facility. Important experimental results of beam position, size and intensity measurements during accelerator run are discussed.

Introduction

Low-intensity experiments such as irradiation of materials and proton therapy are presented at INR RAS linac and require diagnostics that can provide information about beam position, size and pulse. System of luminescent diagnostics is an appropriate one.

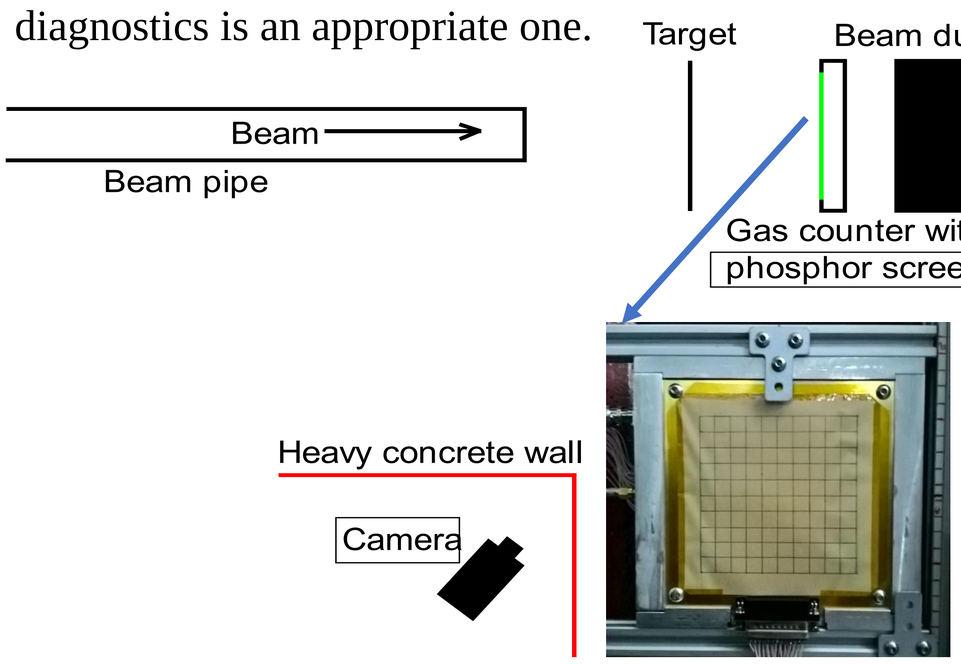

Fig. 1. Layout of luminescent diagnostics components and phosphor screen at INR PIF.

Experimental results

During accelerator runs in system of luminescent diagnostics was used at the proton irradiation facility with beam energies from 20 to 209 MeV. It was used for beam control during irradiation of electronic components such as flash drives, microchips and hard drives (figure 4).

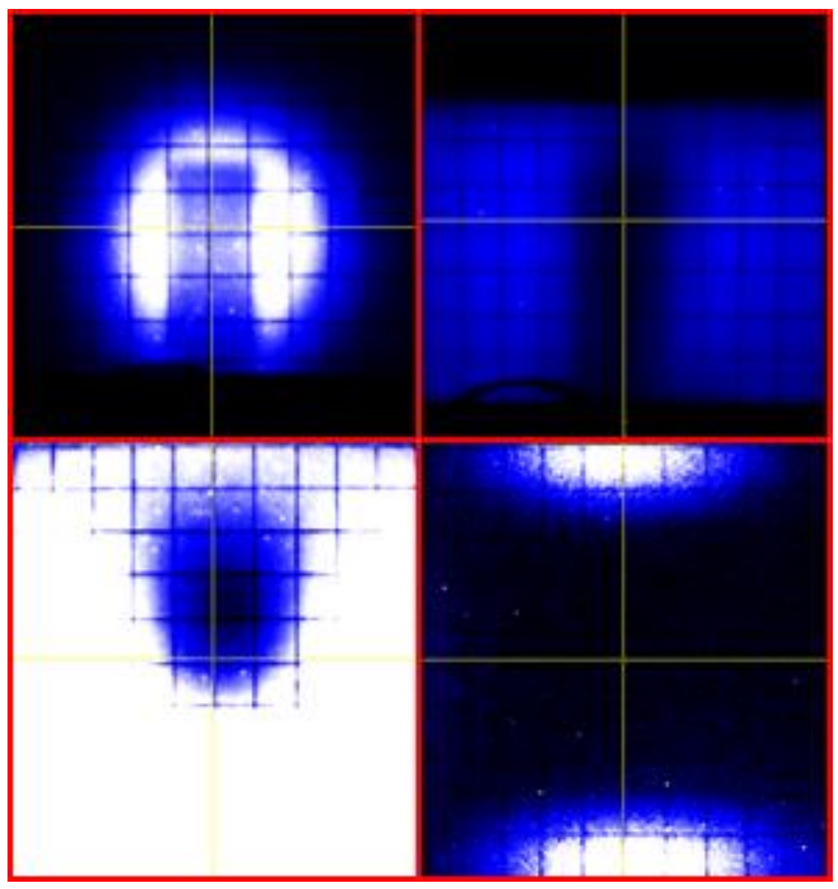

Fig. 4. Beam images during irradiation of flash drives, hard drive and microchip.

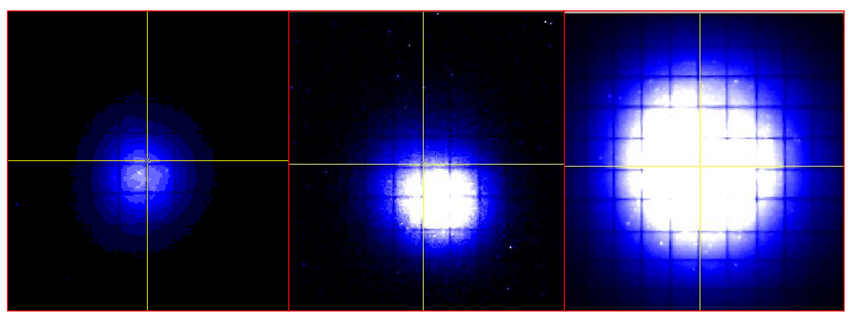

Fig. 5. Beam images during accelerator run.

Design and software features

Phosphor screen is a P43 luminophore molten with Kapton™. CCD camera used for image registration is hidden behind heavy concrete wall. Basler acA780-75gm camera is used for image registration. Camera is displaced non-perpendicularly to luminescent screen plane and image is distorted. A LabVIEW program was written to make an image correction. Stages of correction are presented in figure 2. This program also provides information about image position, size and pulse charge on desktop frame (figure 3). Main program features are presented in table 1.

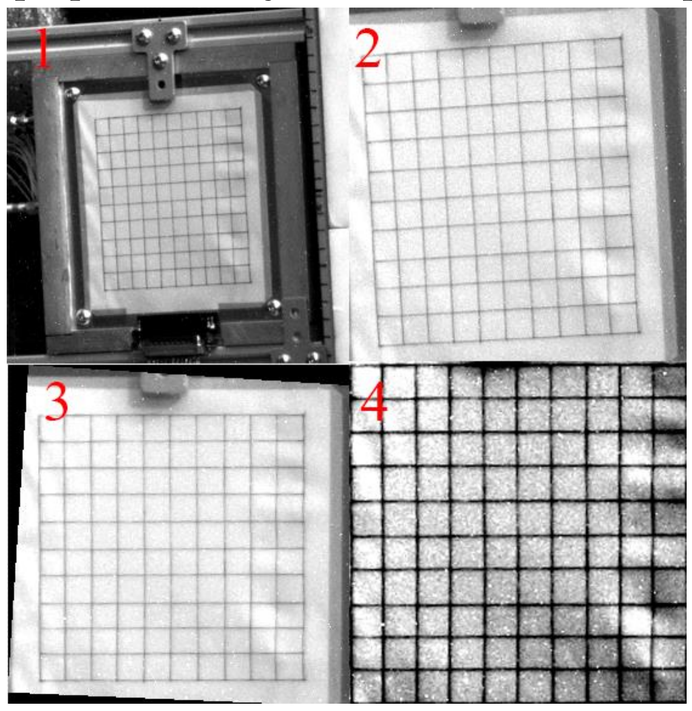

Fig. 2. Image correction procedure.

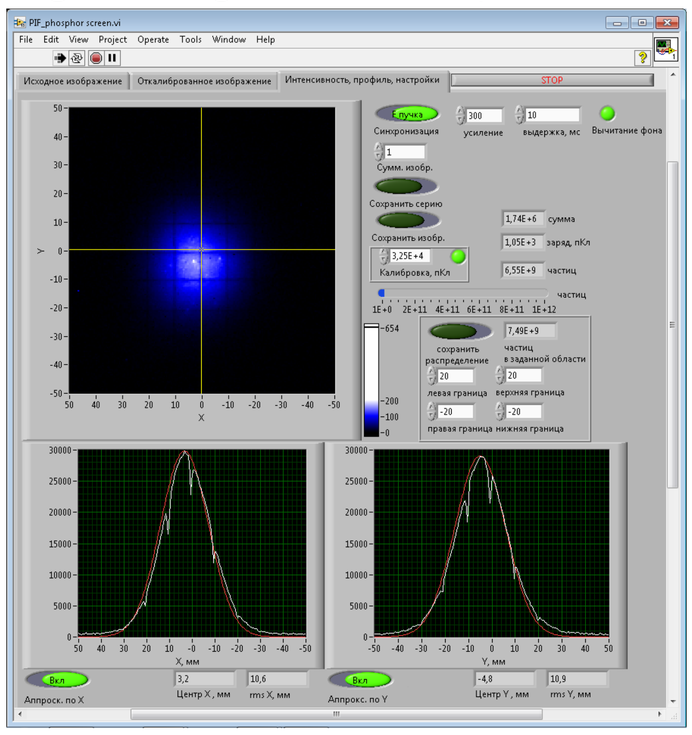

Fig. 3. Desktop frame.

Program functions
Background subtraction
Synchronization switch (external or camera internal)
Preliminary calibration of pulse charge with reference diagnostics
Beam profiles with gaussian fitting
Beam position calculation
Beam size calculation
Pulse charge calculation
Pulse charge calculation in preferred region
Saving beam image and all parameters
Saving sequential 50 images
Changing camera gain and exposure without recalibration

Table 1. Program functions.

Diagnostics limits

There are some limits which restrict luminescent diagnostics working range. If camera exposure is less than luminophore emission decay time light will not be collected by the camera entirely. Minimal exposure time is 8 ms (figure 6). A problem of camera pixel saturation exists, which leads to an increase in pulse charge measurement error. Figure 7 shows that error significantly grows from pulse charge of 16 nC/pulse.

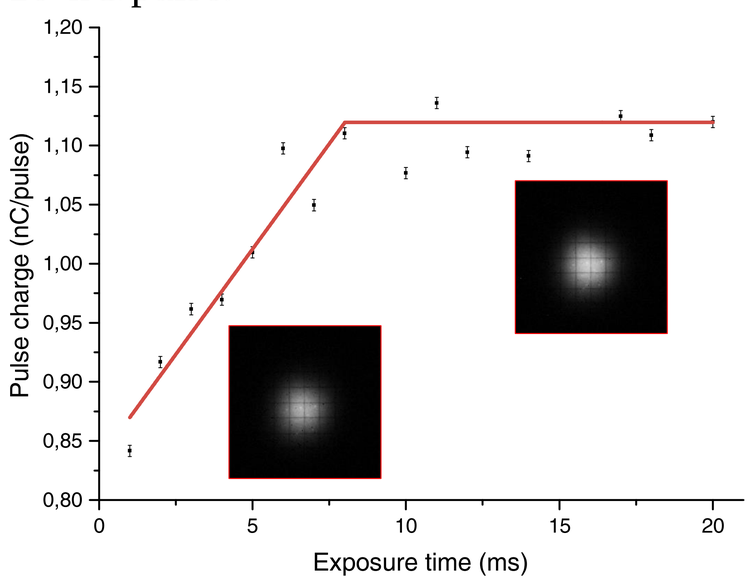

Fig. 6. Dependence of measured pulse charge on camera exposure.

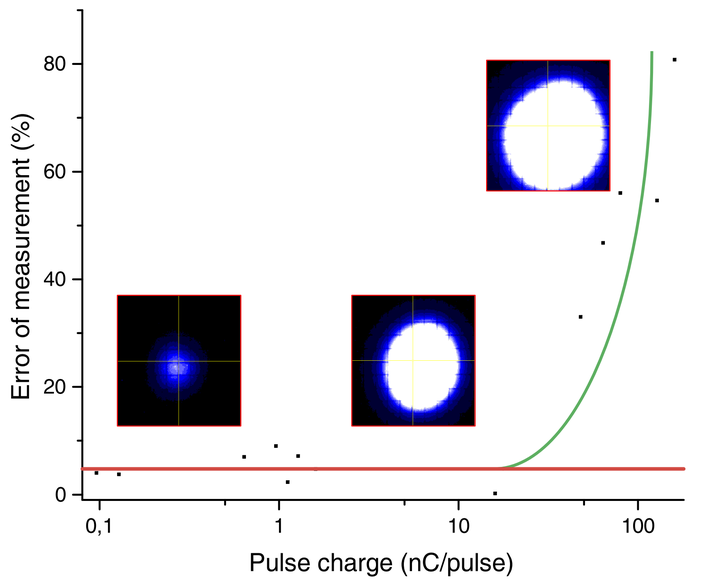

Fig. 7. Dependence of measurement error on pulse charge.