TOMSK POLYTECHNIC UNIVERSITY

tpu.ru

Concept of intensity measurement method of charged particle beam distribution

4th International School on Beam Dynamics and Accelerator Technology

agrigorieva@tpu.ru

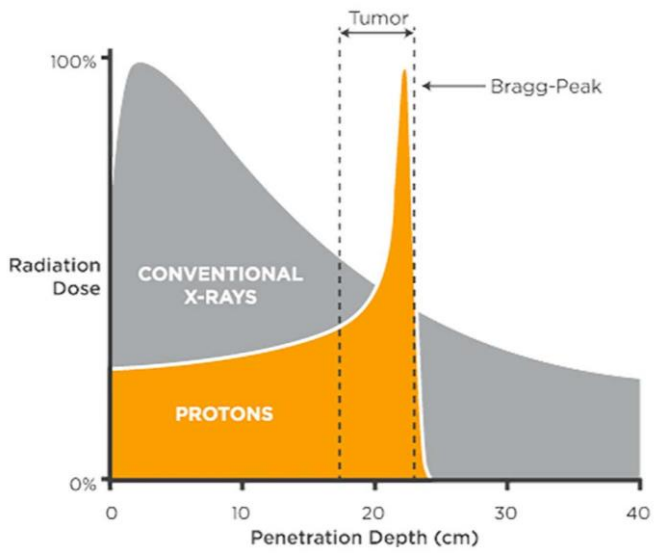
Grigorieva Anna

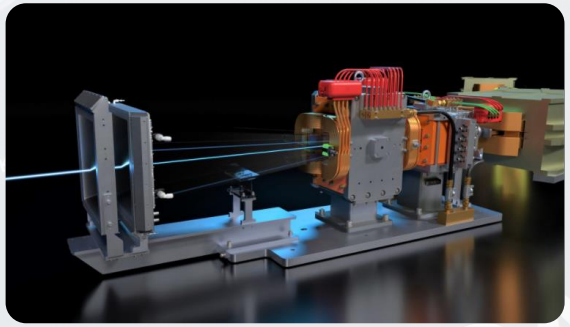
PhD student of TPU

21-27 February, 2022

RELEVANCE

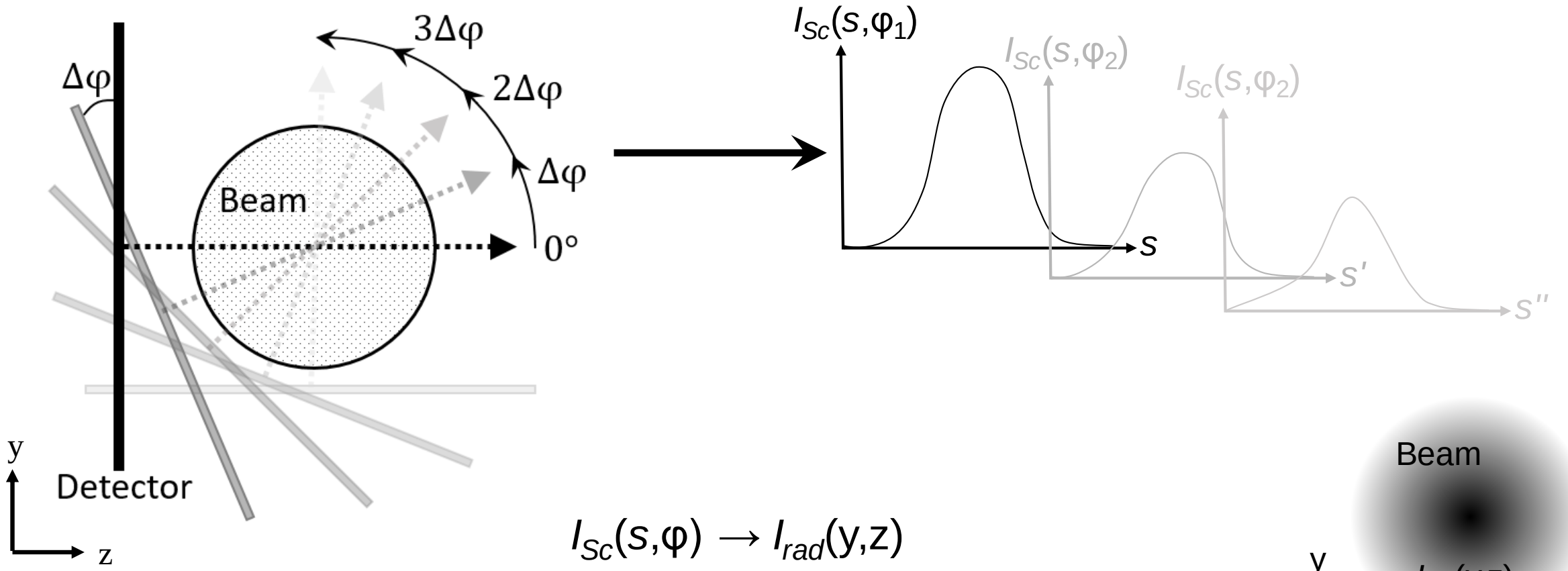
The development of new methods for determining the beam's spatial parameters during creation and modernization of installations for hadron radiation therapy is a vital task





The aim of the study: development of a method for scanning hadron beams, designed for high-precision control of the spatial and dose characteristics of beams in real time.

THE METHOD OF MULTIANGULAR WIRE SCANNING

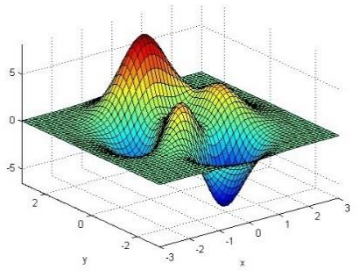


$$I_{Sc}(s,\varphi) \rightarrow I_{rad}(y,z)$$

$I_{Sc}(s,\varphi)$ – dependence of light photons intensity generated in scintillator on scintillation strip position

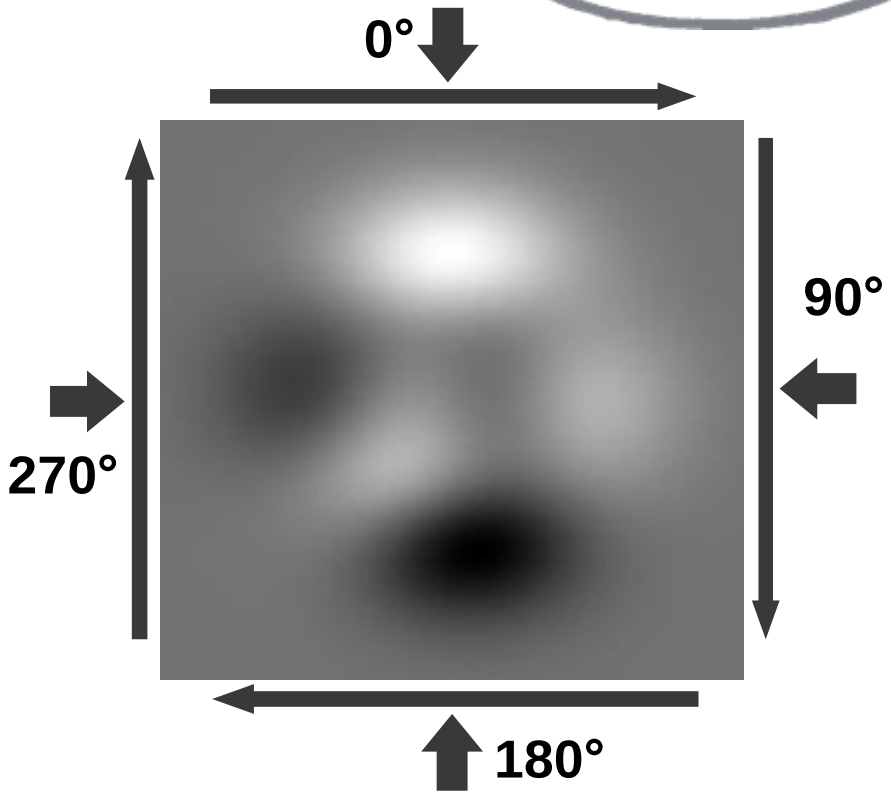
$I_{rad}(y,z)$ – intensity distribution in beam cross-section

NUMERICAL SIMULATION WITH MATLAB PACKAGE

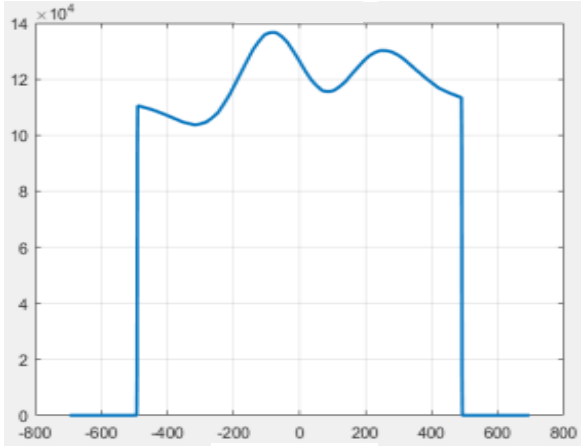


$$f(x,y) = 3 * (1-x)^2 * e^{-x^2-(y+1)^2} - 10 * \left(\frac{x}{5} - x^3 - y^5\right) * e^{-x^2-y^2} - \frac{1}{3} * e^{-(x+1)^2-y^2}$$

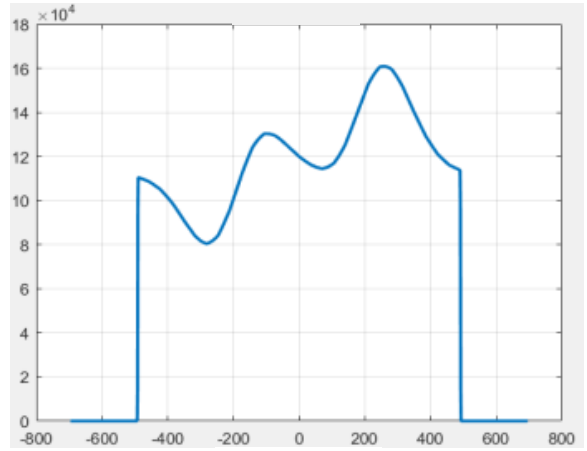
Test data of the complex Gaussian distribution



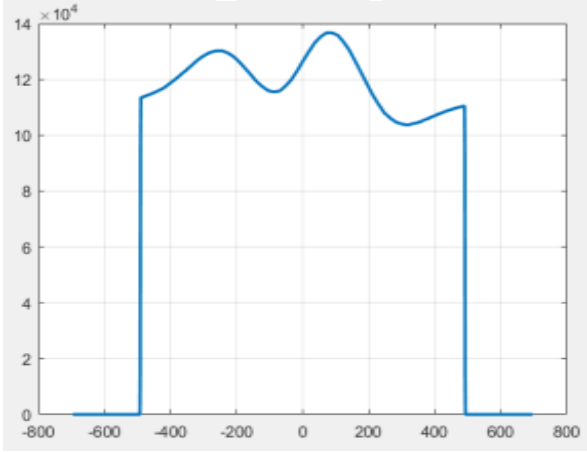
0°



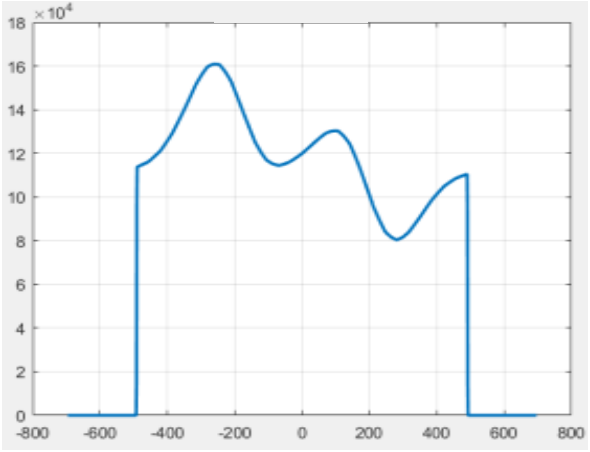
90°



180°

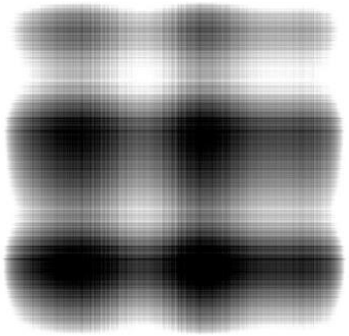


270°

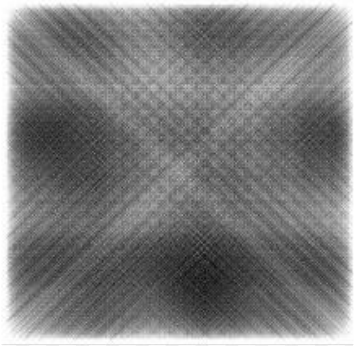


THE RESULTS OF MATHEMATICAL RECONSTRUCTION

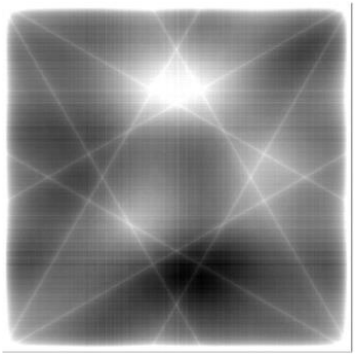
2 projections step 90°



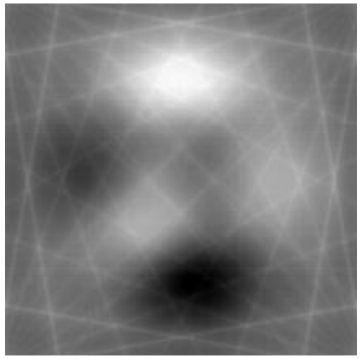
4 projections step 45°



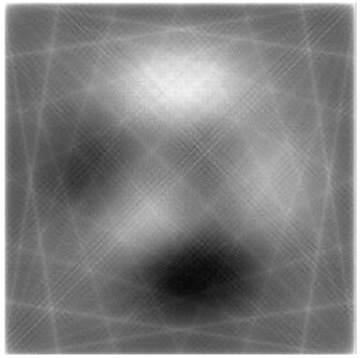
6 projections step 30°



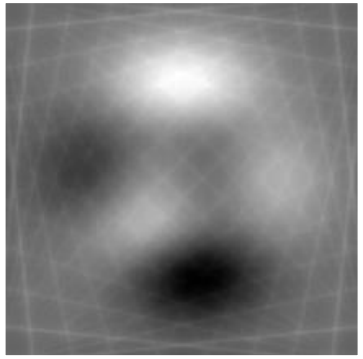
18 projections step 10°



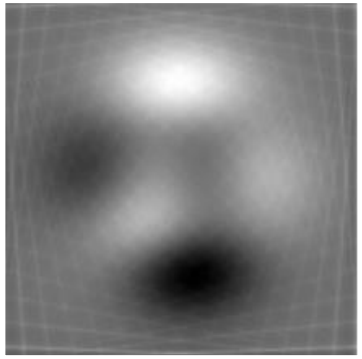
36 projections step 9°



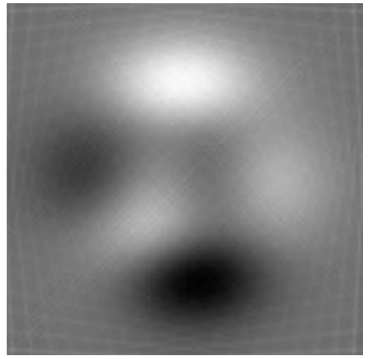
30 projections step 6°



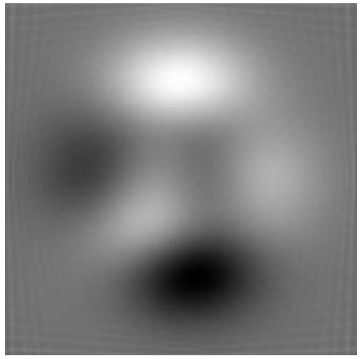
45 projections step 4°



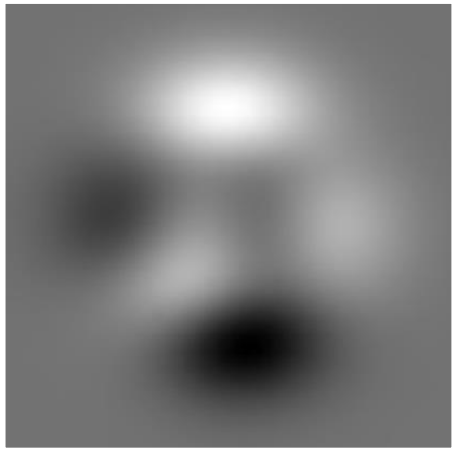
60 projections step 3°



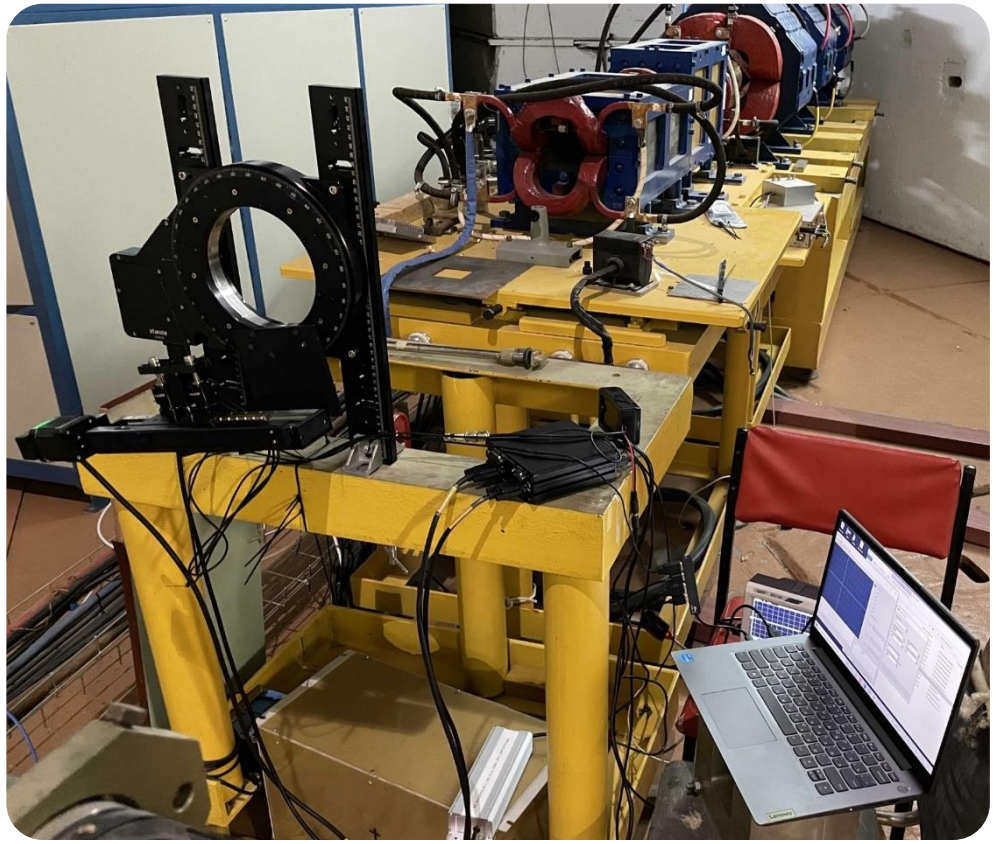
90 projections step 2°



Original image



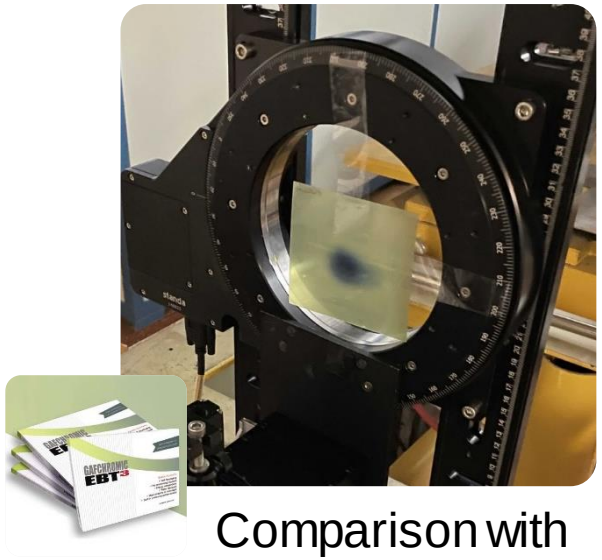
EXPERIMENT ON THE C^{+6} ION BEAM (U-70 accelerator, Protvino, Russia)



Experimental setup

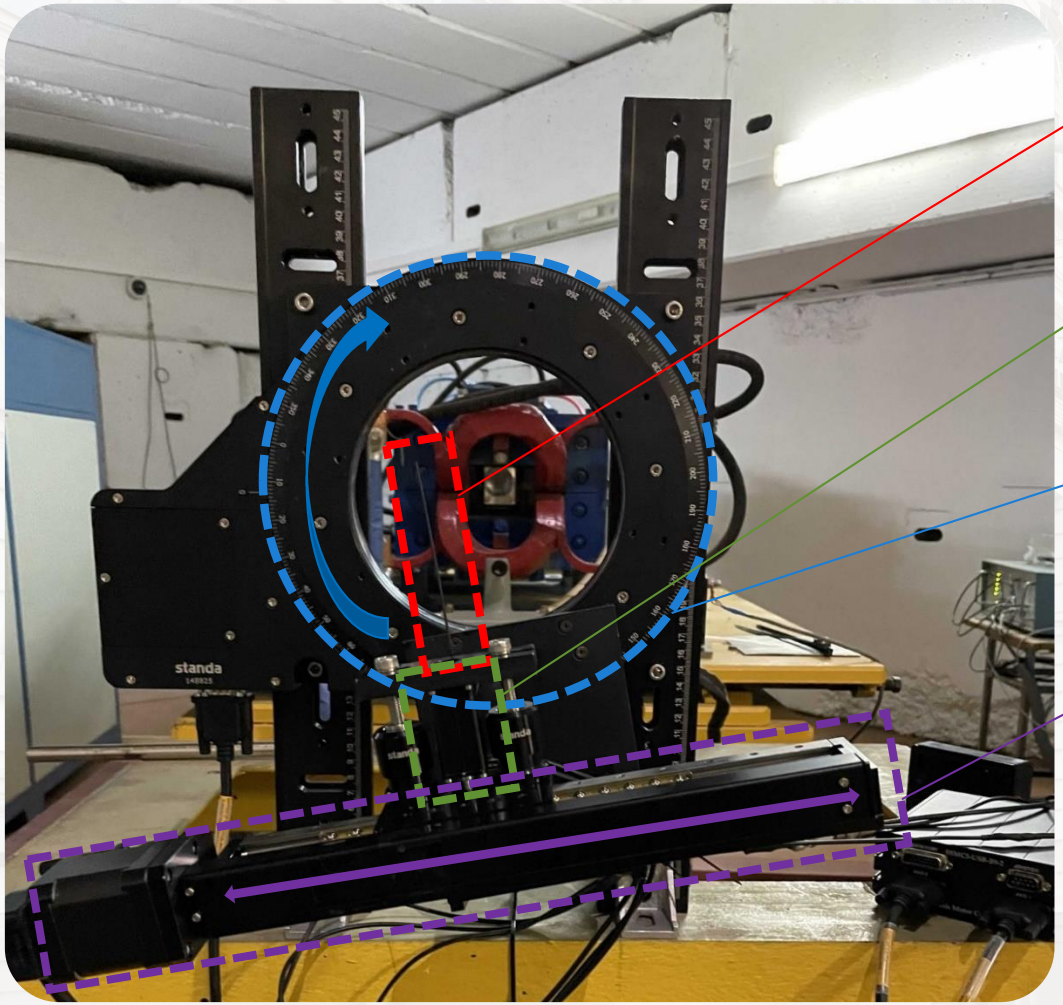
Experiment parameters:

- Beam energy – 300, 400 MeV/nucleon
- Detector pitch - 4 mm
- Angular offset - 18°



Comparison with dosimetric film

DETECTING SYSTEM



Saint-Gobain Scintillation fiber

KETEK Silicon Photomultiplier Tube

Standa Motorized Rotation Stage

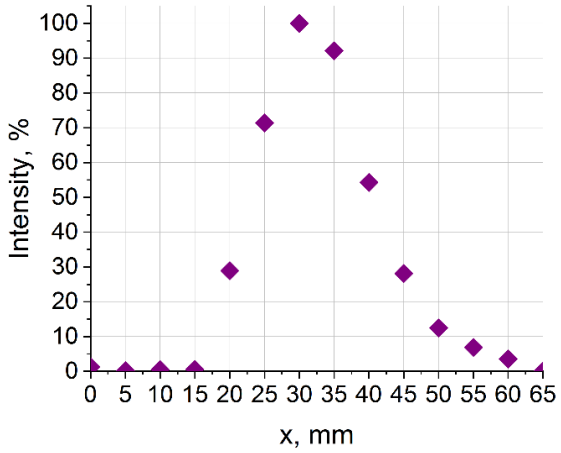
Standa Motorized Line Translator

BEAM PROFILES FOR DIFFERENT OPERATING MODES OF THE ACCELERATOR

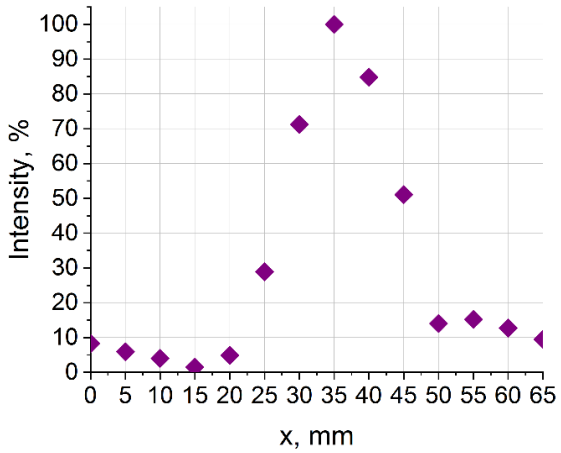
Without wobbler magnets

Energy, MeV/nucleon

300

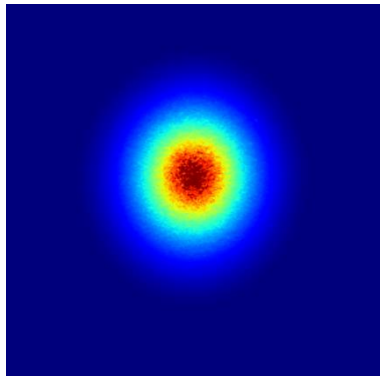


400

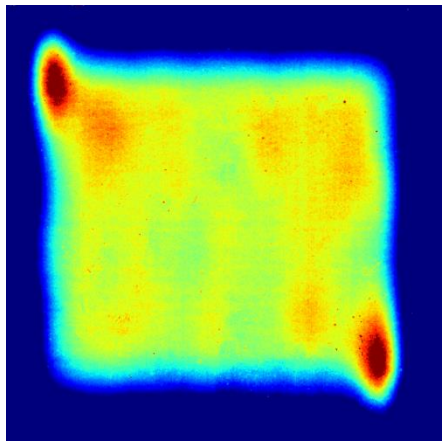


Multiangular wire scanning

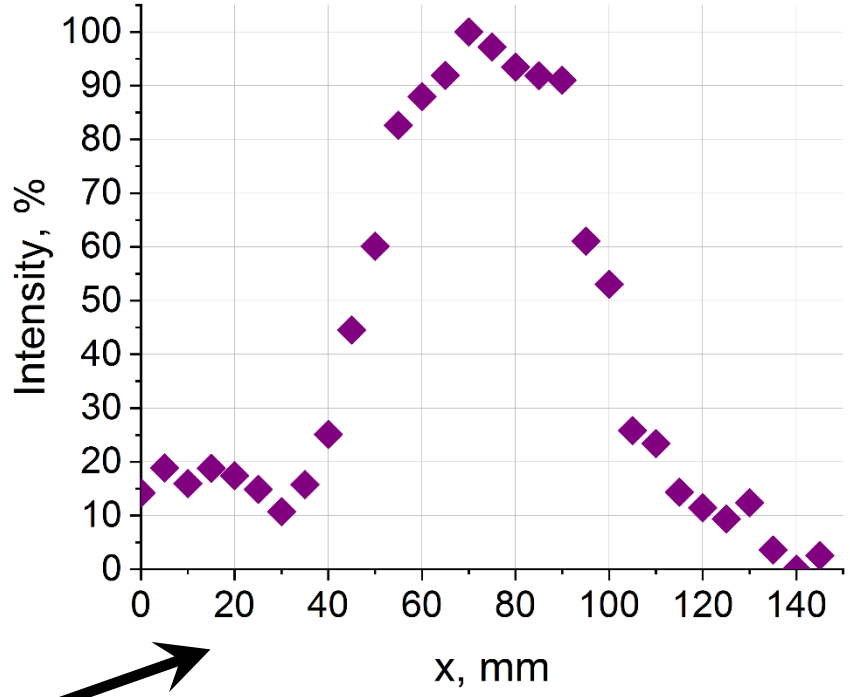
50x50 mm



EBT3 film
120x120 mm



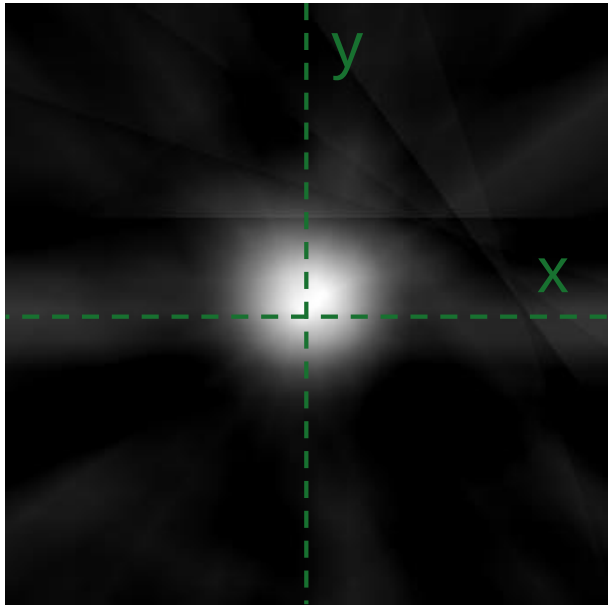
With wobbler magnets
Energy – 400 MeV/nucleon



Multiangular wire scanning

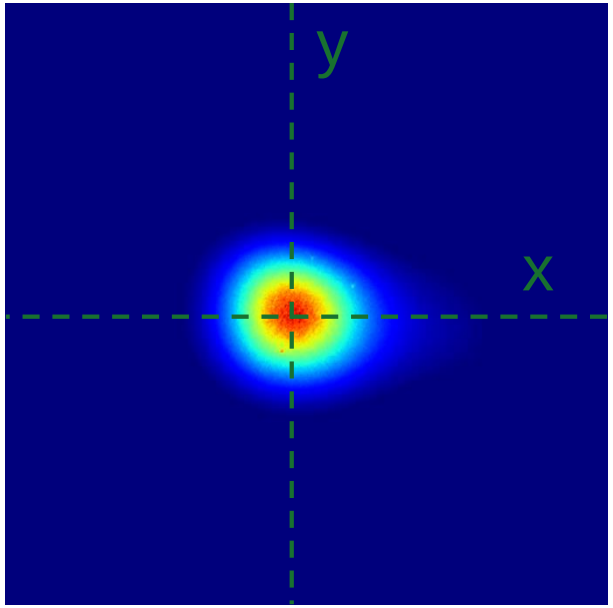
BEAM SCAN RESULTS

80x80 mm



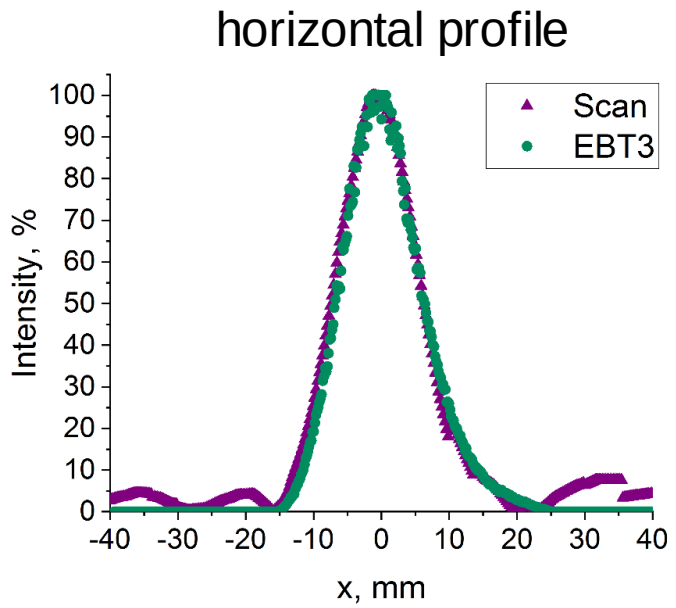
Multiangular wire scanning

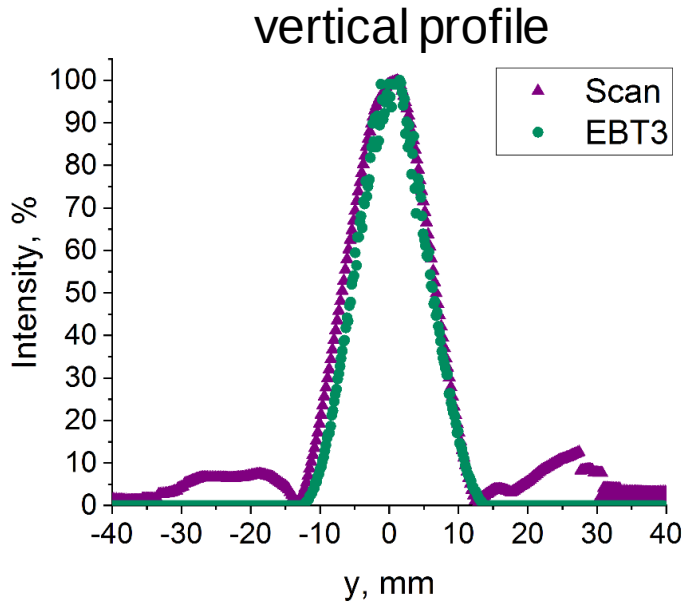
80x80 mm



EBT3 film

Width at half-height of the vertical and horizontal profiles - 15 mm





CONCLUSION

- The development of new methods for the beam parameters determination during the construction, installation and application of hadron beam accelerator facilities is a vital task.
- In this study, the concept of intensity measurement method of charged particle beam distribution was introduced.
- The optimal number of scans required to obtain the results in the minimum time was determined for an experimental setup based on a scintillation wire detector.
- The proposed method was tested on a carbon ion beam and showed good results.

This work is supported by the Russian Science Foundation, project No. 21-79-00252

TOMSK POLYTECHNIC UNIVERSITY

tpu.ru

Concept of intensity measurement method of charged particle beam distribution

4th International School on Beam Dynamics and Accelerator Technology

THANKS FOR ATTENTION!

agrigorieva@tpu.ru

21-27 February, 2022

Grigorieva Anna

PhD student of TPU

TOMSK POLYTECHNIC UNIVERSITY

tpu.ru

CONTACTS

Anna A. Grigorieva

PhD Student of Tomsk Polytechnic University

Lenin Ave, 30, Tomsk, Russia, 634050

+7-983-230-3659

agrigorieva@tpu.ru