

The 6th French-Ukrainian workshop on the  
instrumentation developments for HEP

**Detectorized Phantom for studies at CPO (Orsay)  
- status and prospective.**

Dmytro Ramazanov, Andrii Chaus

*Institute for Nuclear Research National Academy of  
Sciences of Ukraine*



**Kyiv Institute  
for Nuclear  
Research**

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# Introduction

Therapeutic centers in the world are developing several methods for treating tumors using bundles of charged hadrons for which gamma-quantum gambling is not effective.

Among that methods are the subject of this work: MRT (microbeam radiation therapy) and MBRT (minibeam radiation therapy).

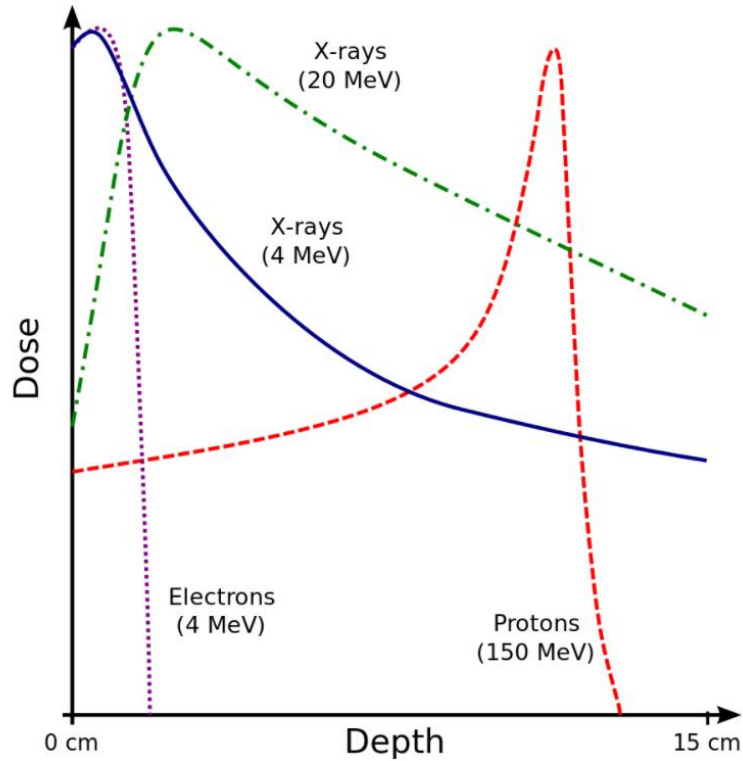
These techniques can deliver a high dose to the tumor while providing a tolerable dose for healthy tissue.

A significant factor in improving the effectiveness of radiation therapy is the spatial fractionation of the dose in the irradiation of tumors. This is due to high local doses and the provision of low doses in the area of healthy tissues.

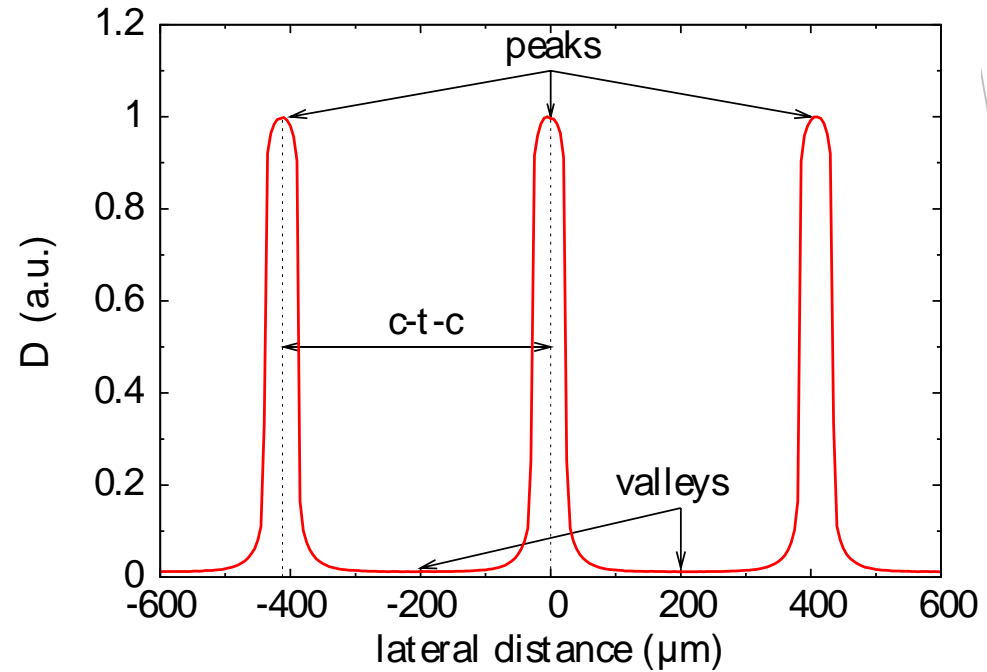
## The purpose of the work

- ▶ The development of a detectorized phantom which contains radiation-resistant detectors for research in the field of spatially fractionated therapy.
- ▶ Characteristic investigations of detectorized phantom prototypes on available sources of ionized radiation.
- ▶ Evaluate the possibility of using this phantom by Monte Carlo simulations on CPO environment.

# The idea of proton multi-beam therapy



Bragg peaks for different types of irradiation.



PVDR(peak to valley dose ratio) .

## Old prototypes of collimators for the formation of multi-beam structures

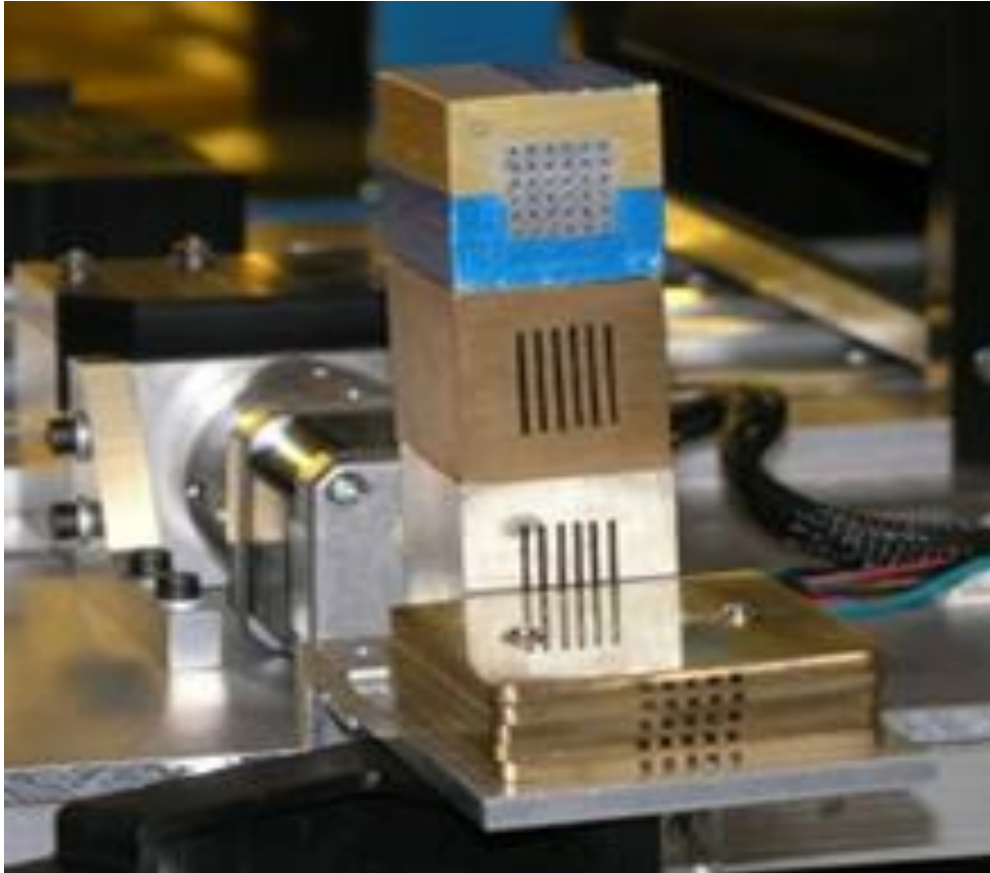


Photo of collimators. From top to bottom: yellow and blue - aluminum matrix collimator 6 x 6 holes 1 mm in diameter, 2.5 mm pitch; Yellow color - slit collimator made of brass, width of six cracks - 1 mm, step 2.5 mm; white color - slit collimator made of aluminum, width of six cracks - 1 mm, step 2.5 mm; golden color - matrix collimator made of brass, 5 x 5 holes 1 x 1 mm<sup>2</sup>, step 3.0 mm.

# Track length of protons and electrons in the different materials

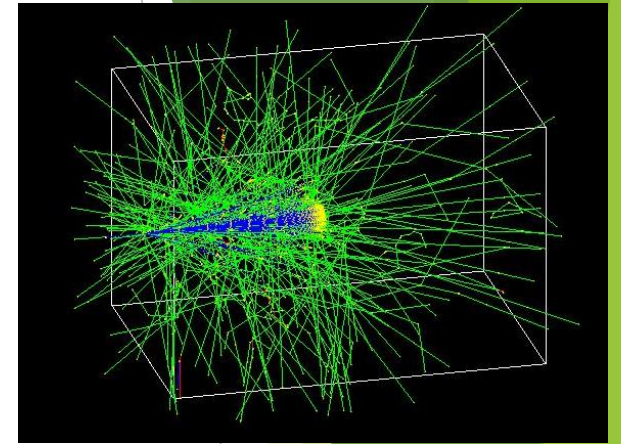
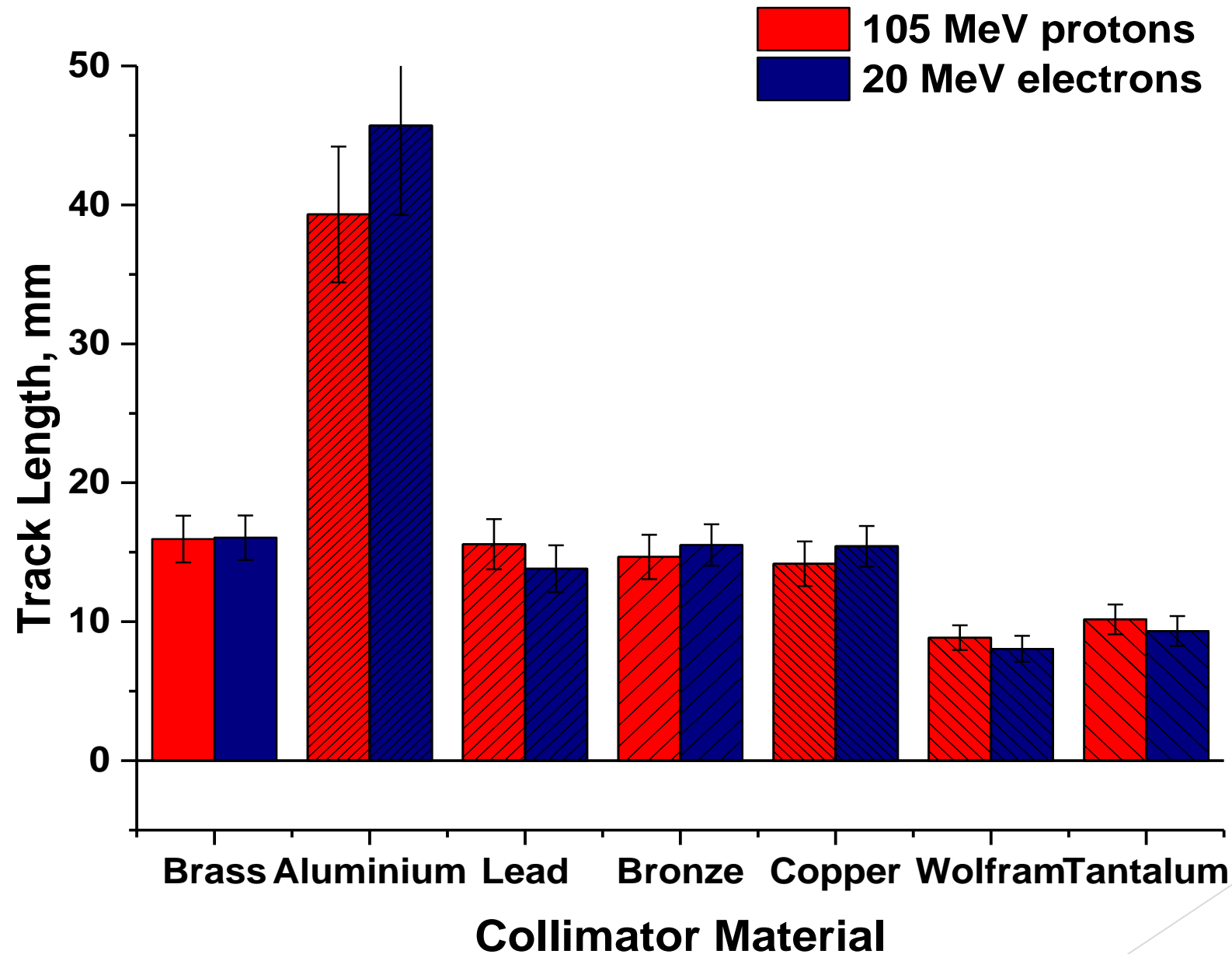


Image of simulation

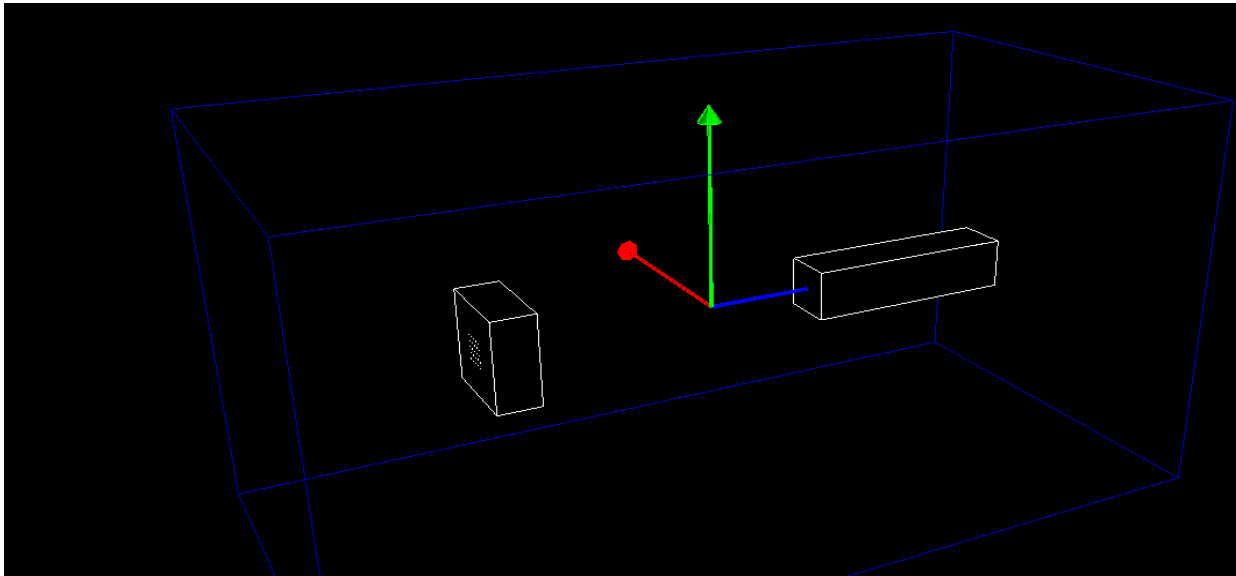
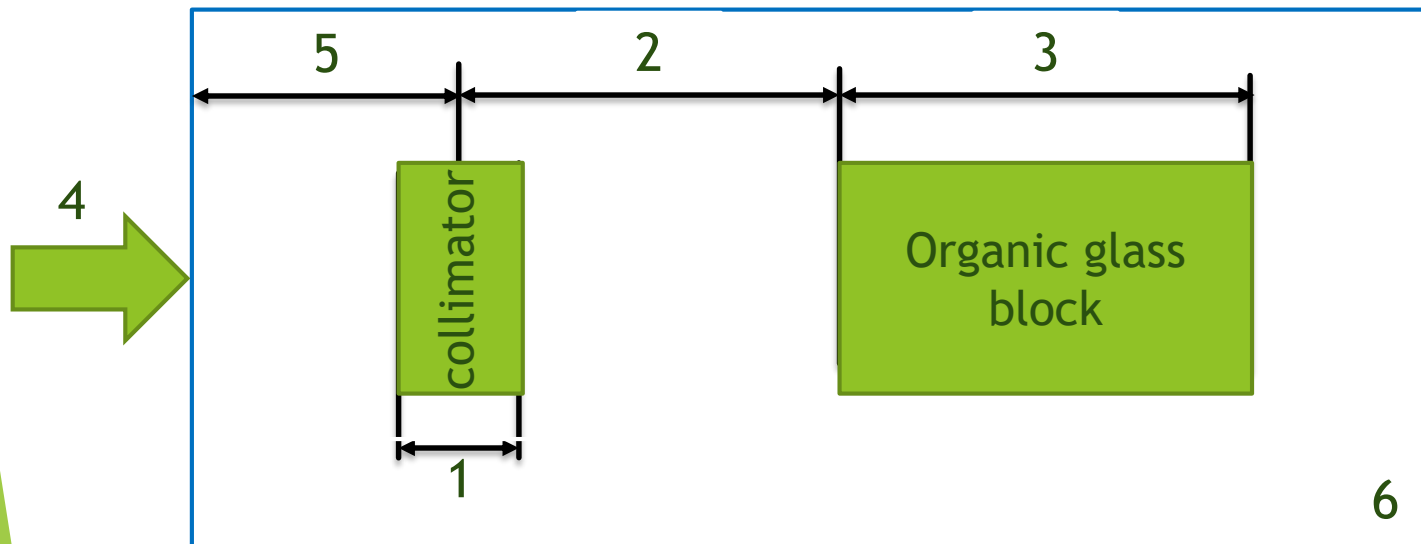


Image of simulation



Scheme of simulation geometry

1) Size of Matrix collimator  
4.5 cm x 4.5cm x 2-7cm

2) Distance between collimator center and organic glass block is 15cm

3) Size of organic glass block  
2.5cm x 2.5cm x 10cm

4) 105MeV proton beam, size of beam  
2cm x 2cm (CPO energy)

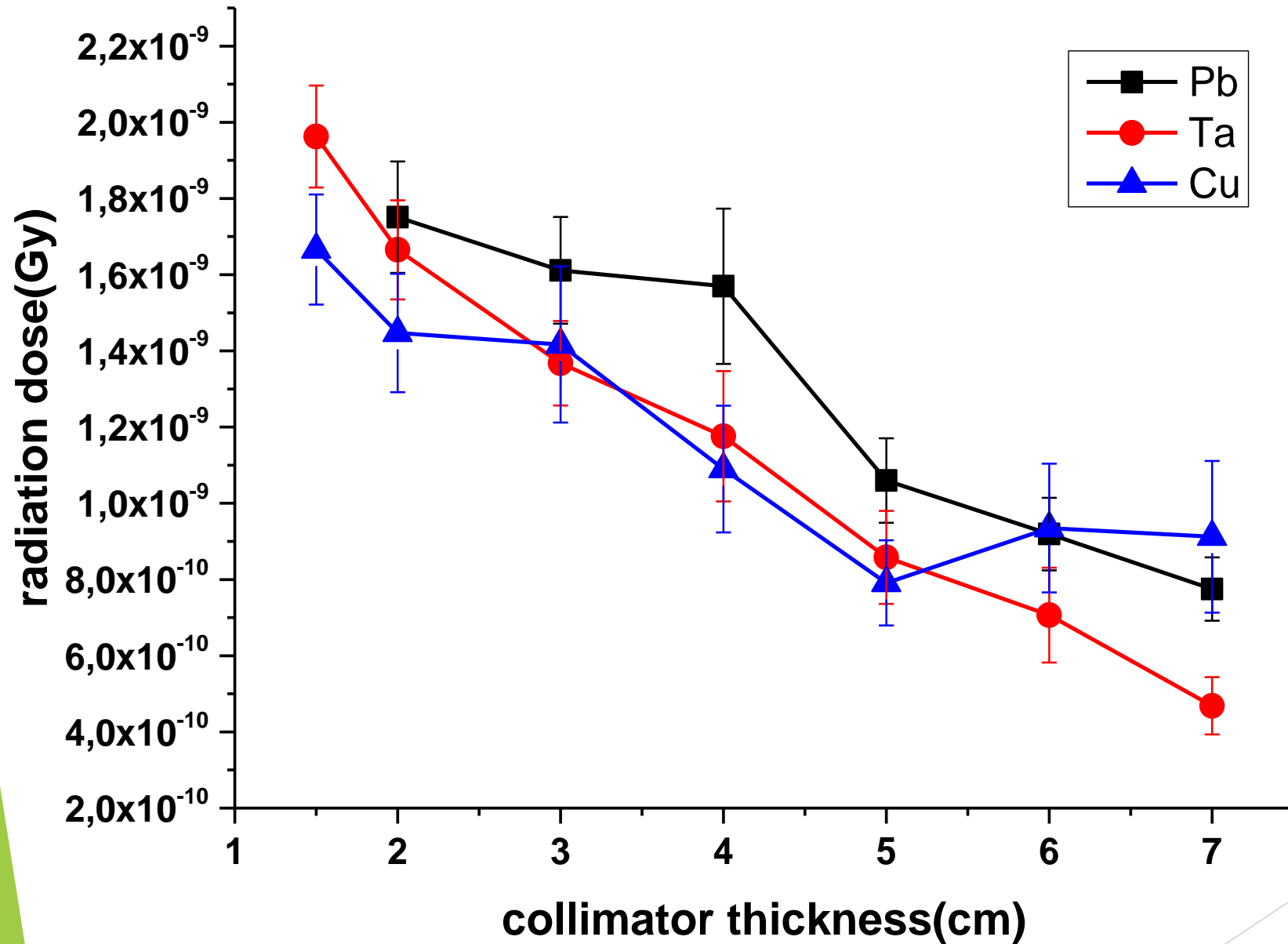
5) Distance between beam source and collimator center is 10cm

6) World size 20cm x 20cm 40cm,  
world contains air.

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Geant4 10.4 patch 01  
Phys.list QGSP\_BERT\_HP  
10<sup>6</sup> events

# Dose delivered to organic glass phantom



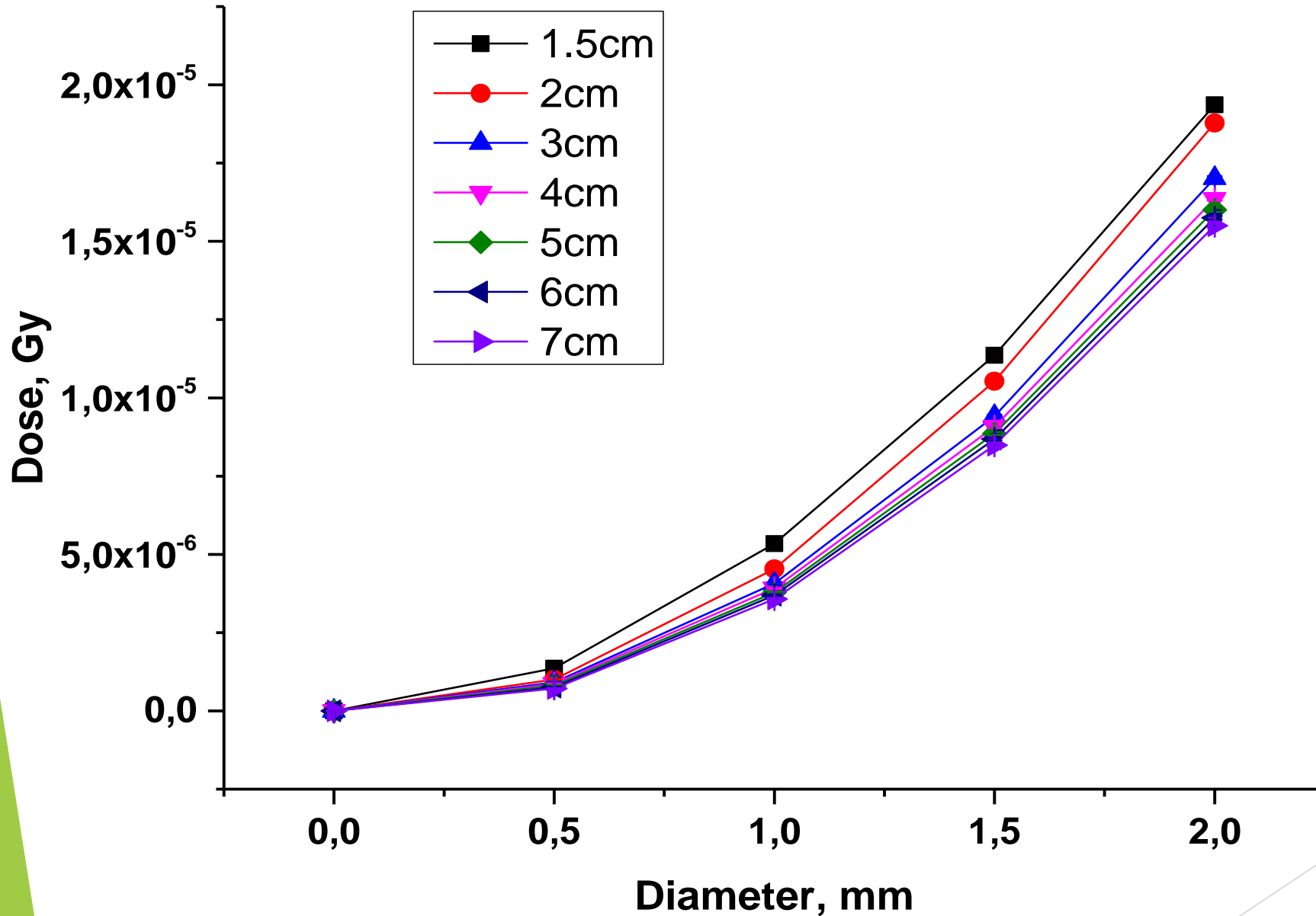
Dependence of the received dose by a phantom on the thickness of a Matrix collimator without holes for lead, tantalum and copper

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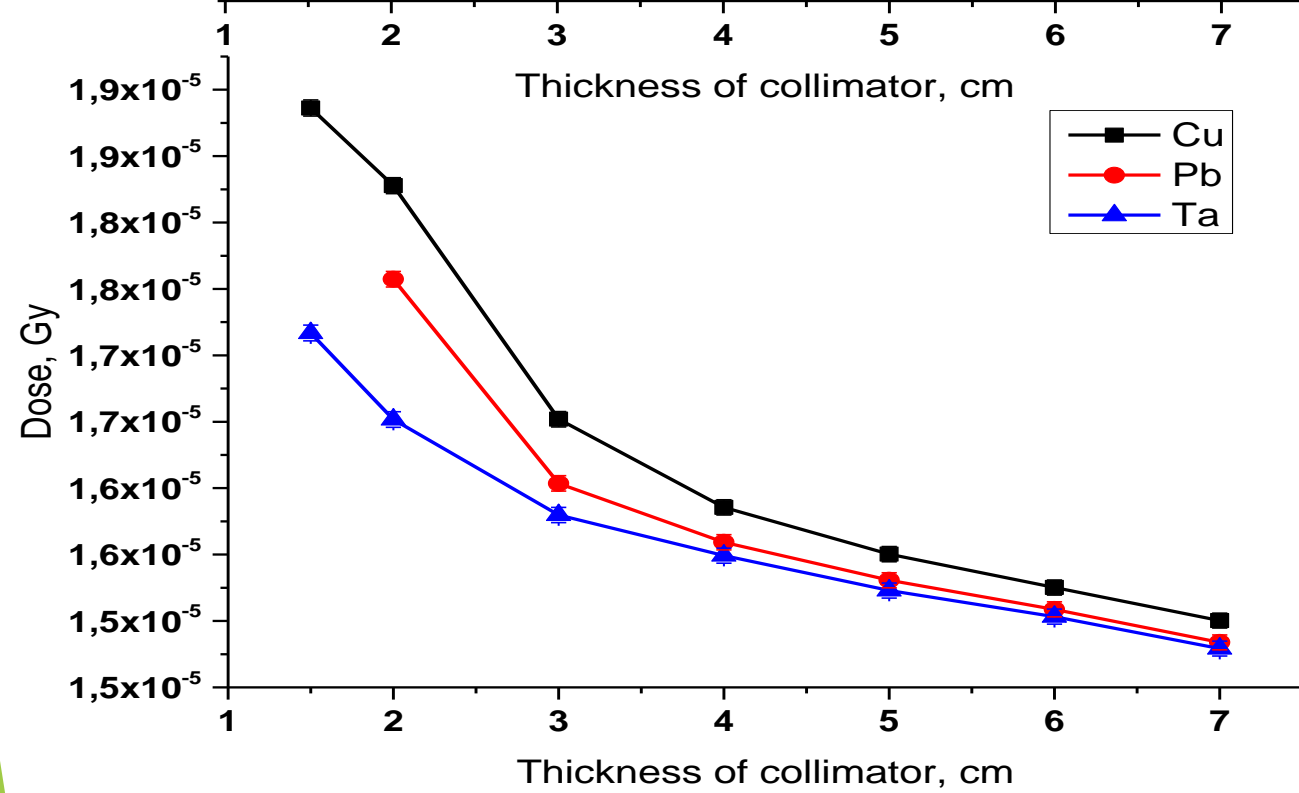
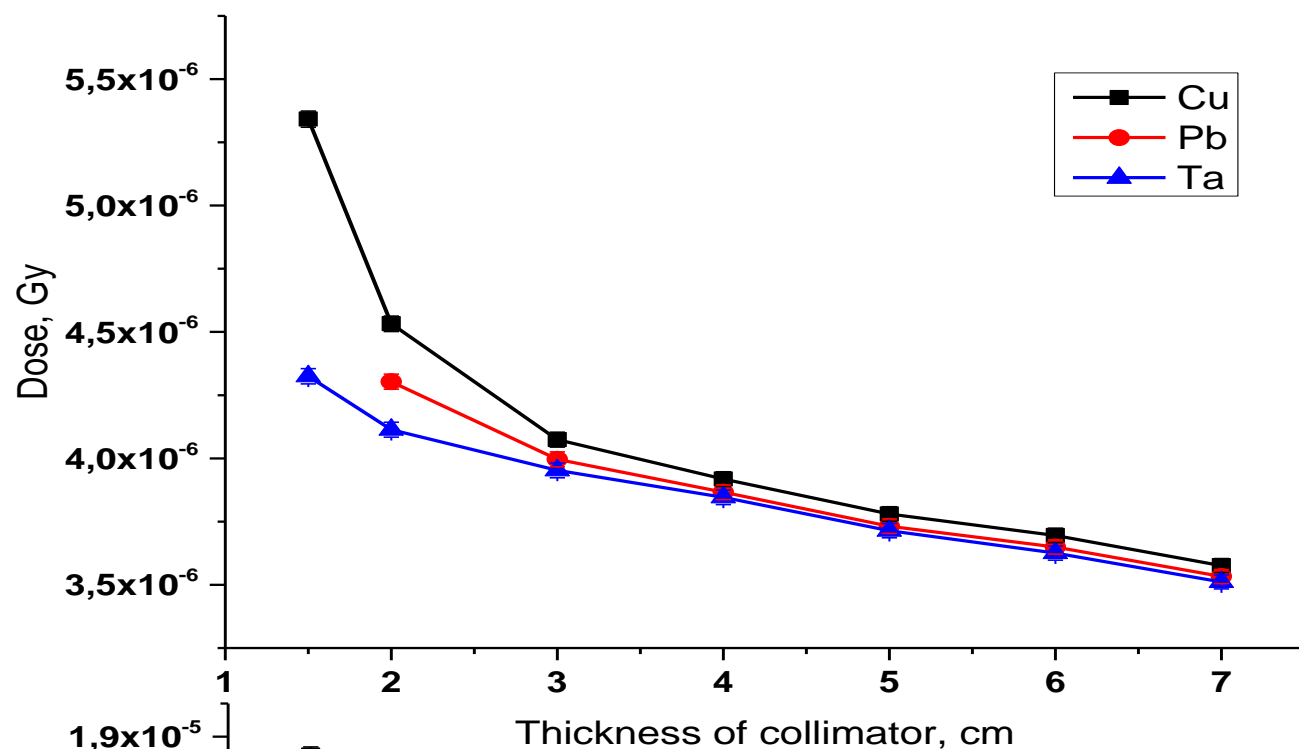
Geant4 10.4 patch 01  
Phys.list QGSP\_BERT\_HP  
 $10^6$  events



# Dose delivered to organic glass phantom



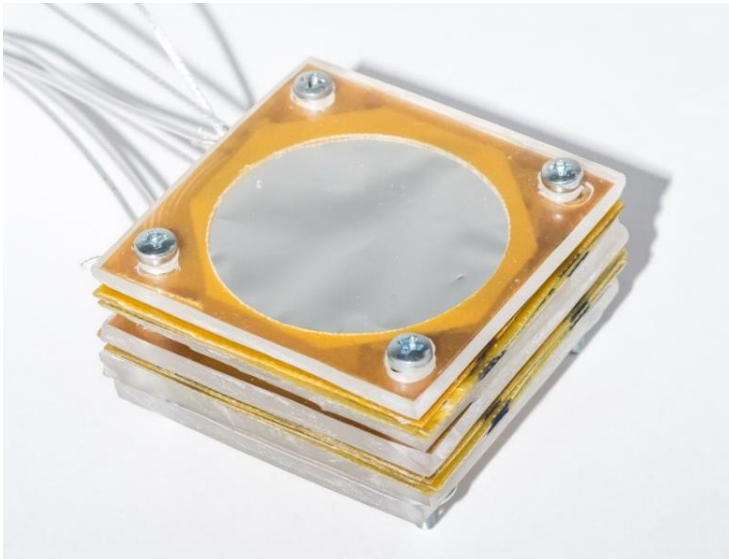
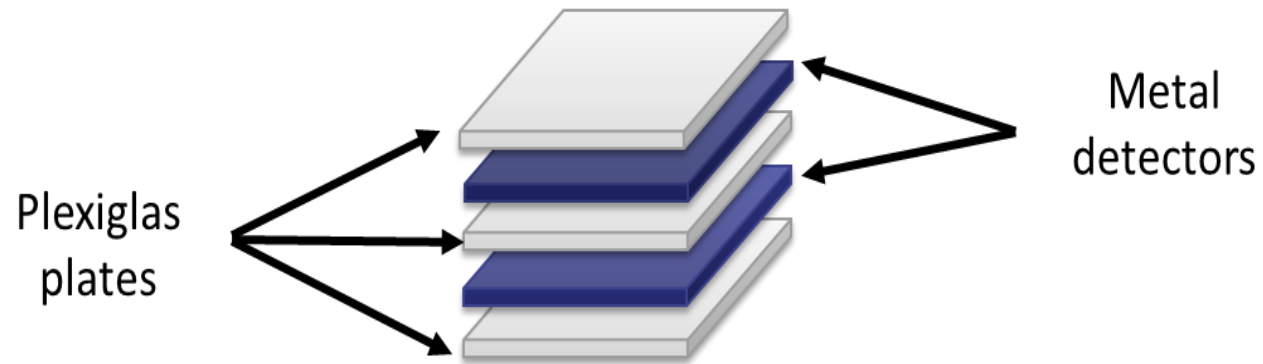
The dependence of the dose received by the phantom on the thickness of the copper Matrix collimator and the size of its holes



Dependence of the received dose by a phantom on the thickness of Matrix collimator with a radius of holes of 0.5mm for lead, tantalum and copper

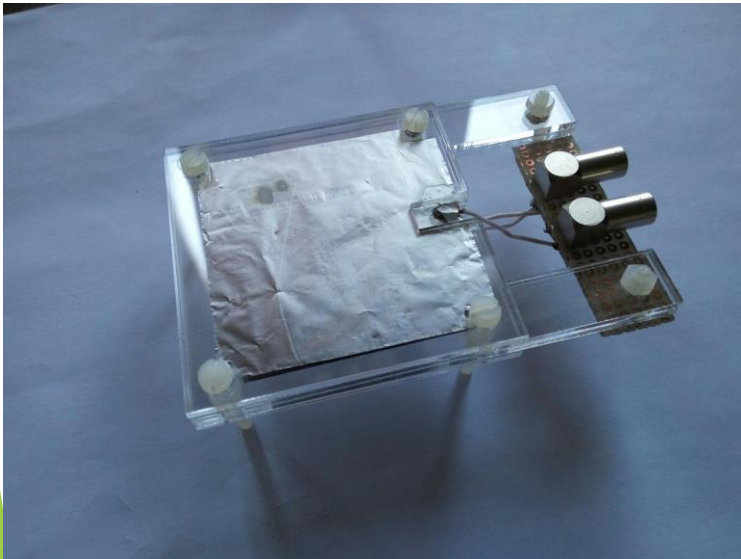
Dependence of the received dose by a phantom on the thickness of Matrix collimator with a radius of holes of 1mm for lead, tantalum and copper

# Detectorized phantom development

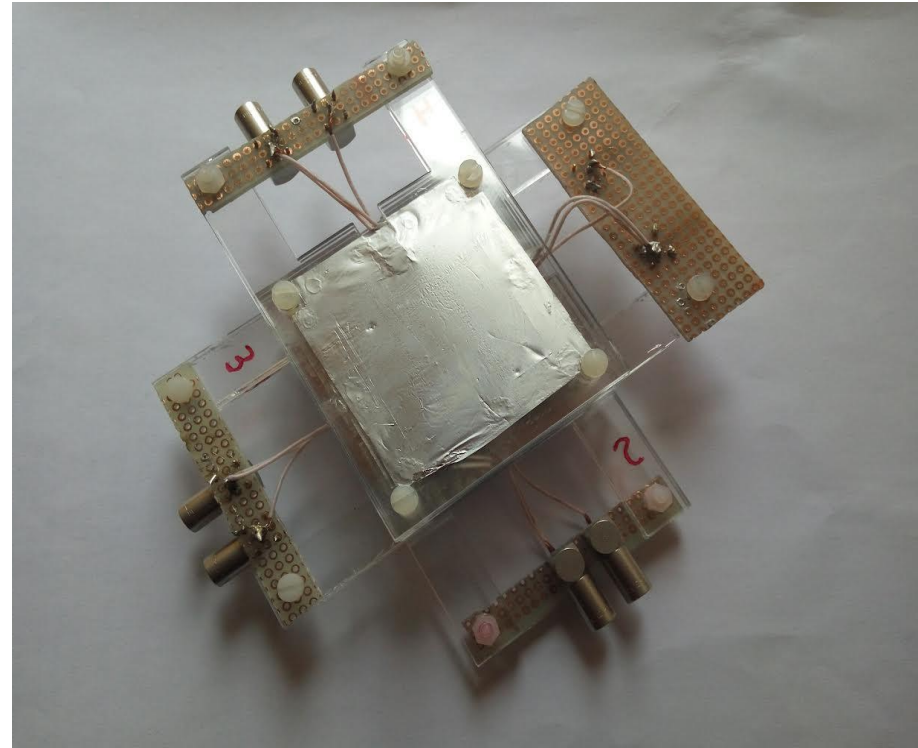


Prototype of a multi-layer detector phantom based on MFD. Phantom consists layers of organic glass and metal foil detectors. Phantom has a modular structure that allows to change the thickness of the working body (Plexiglas) and the amount of detectors.

# The phantom structure



The final prototype of the detectorized phantom made of organic glass and aluminum.

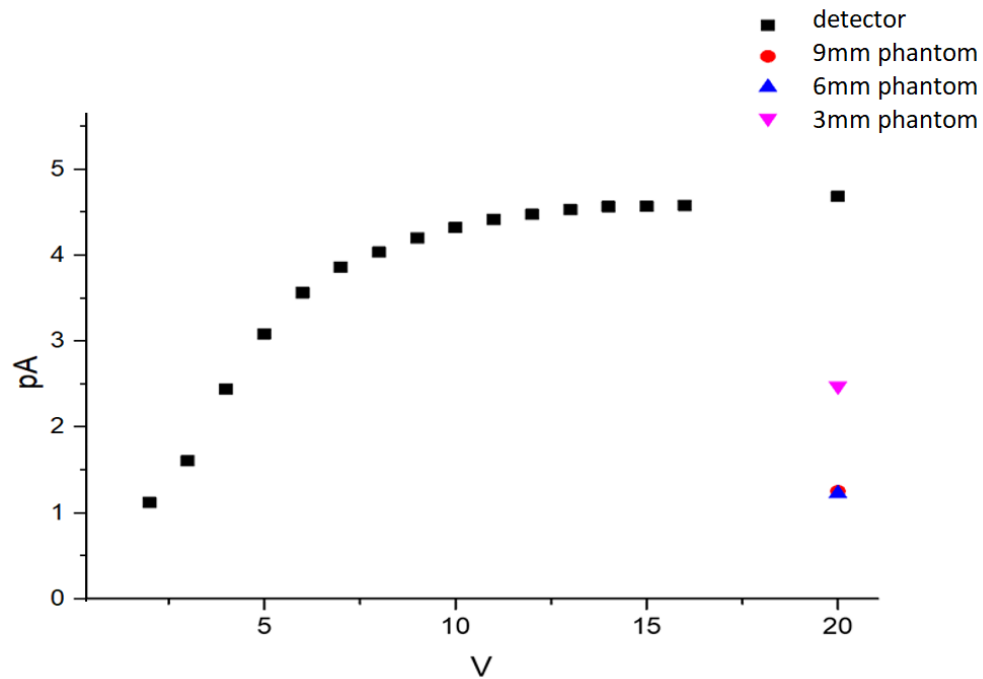


Detectorized phantom.

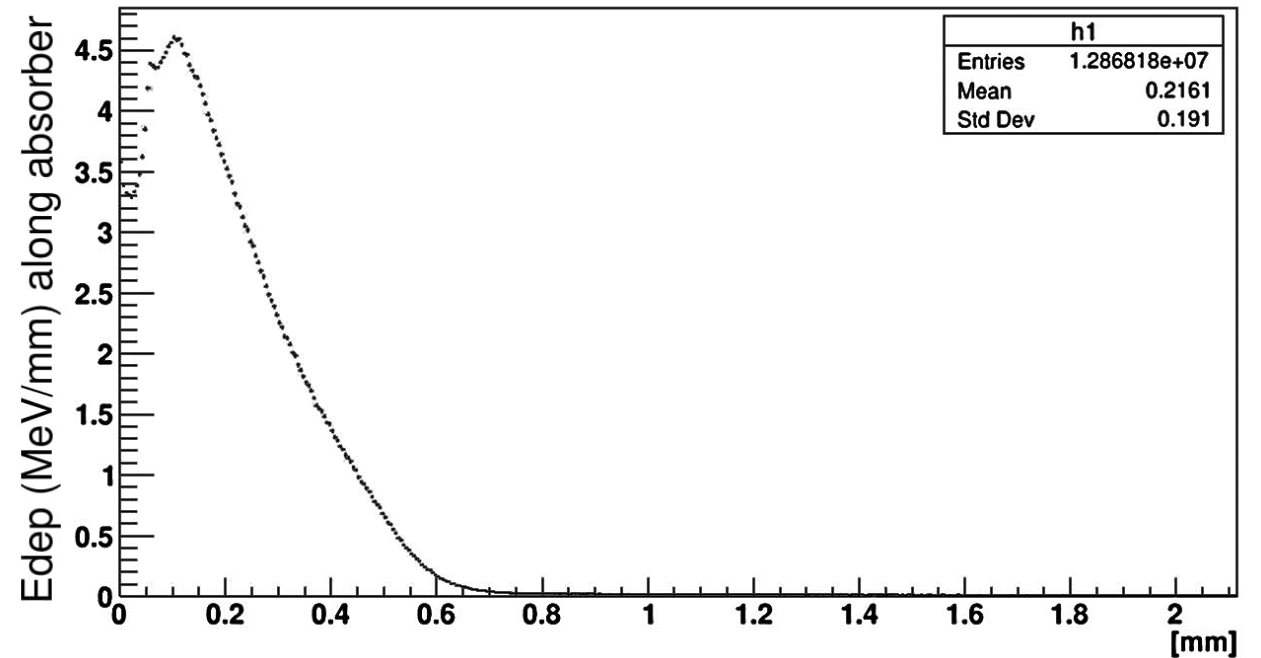


Model of the detectorized phantom.

# Feedback of metal-foil detector prototype ( $\beta$ - particles, Sr-90)

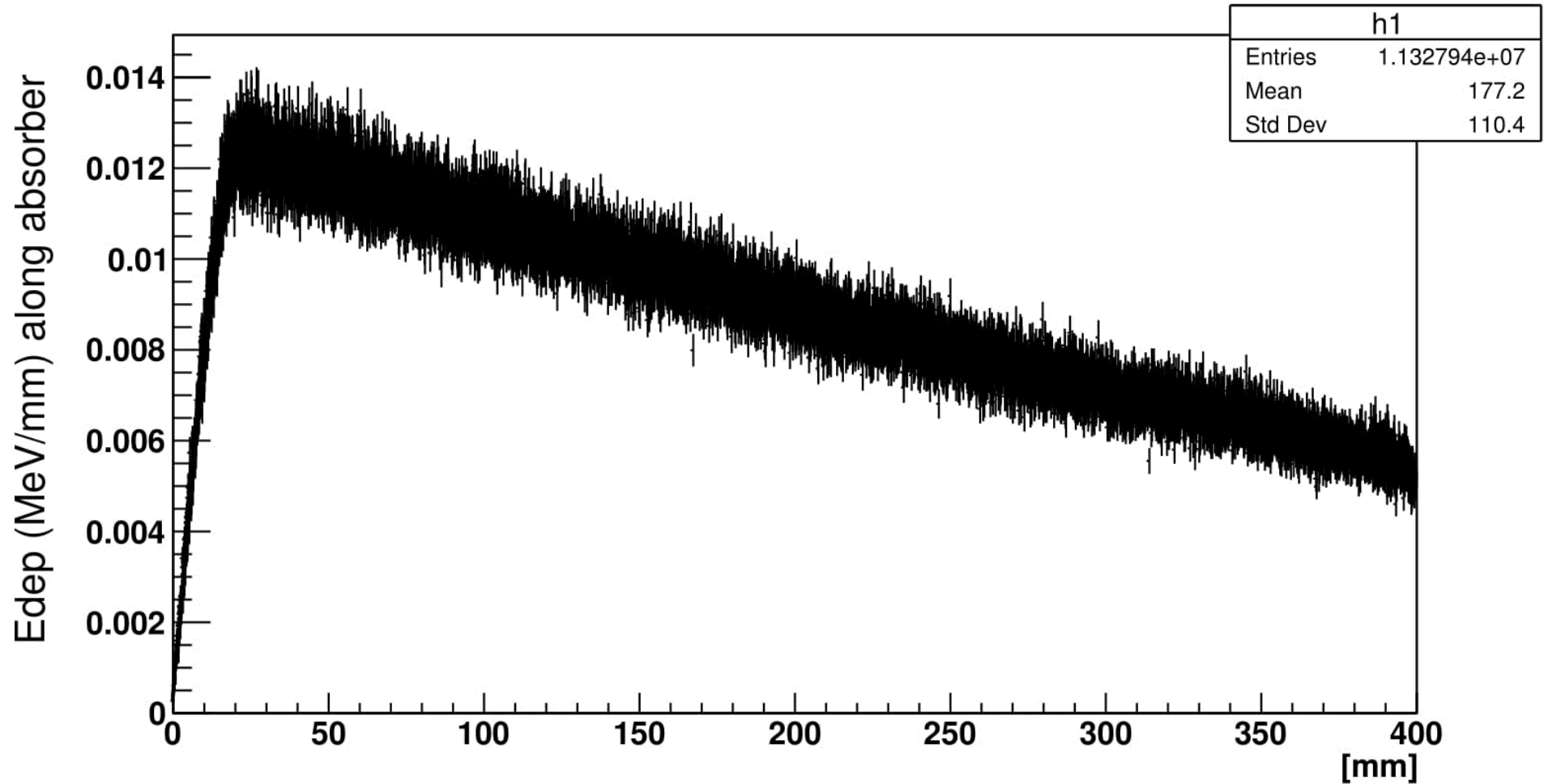


Volt-ampere characteristic of detector under irradiation by electrons with energy 2 MeV



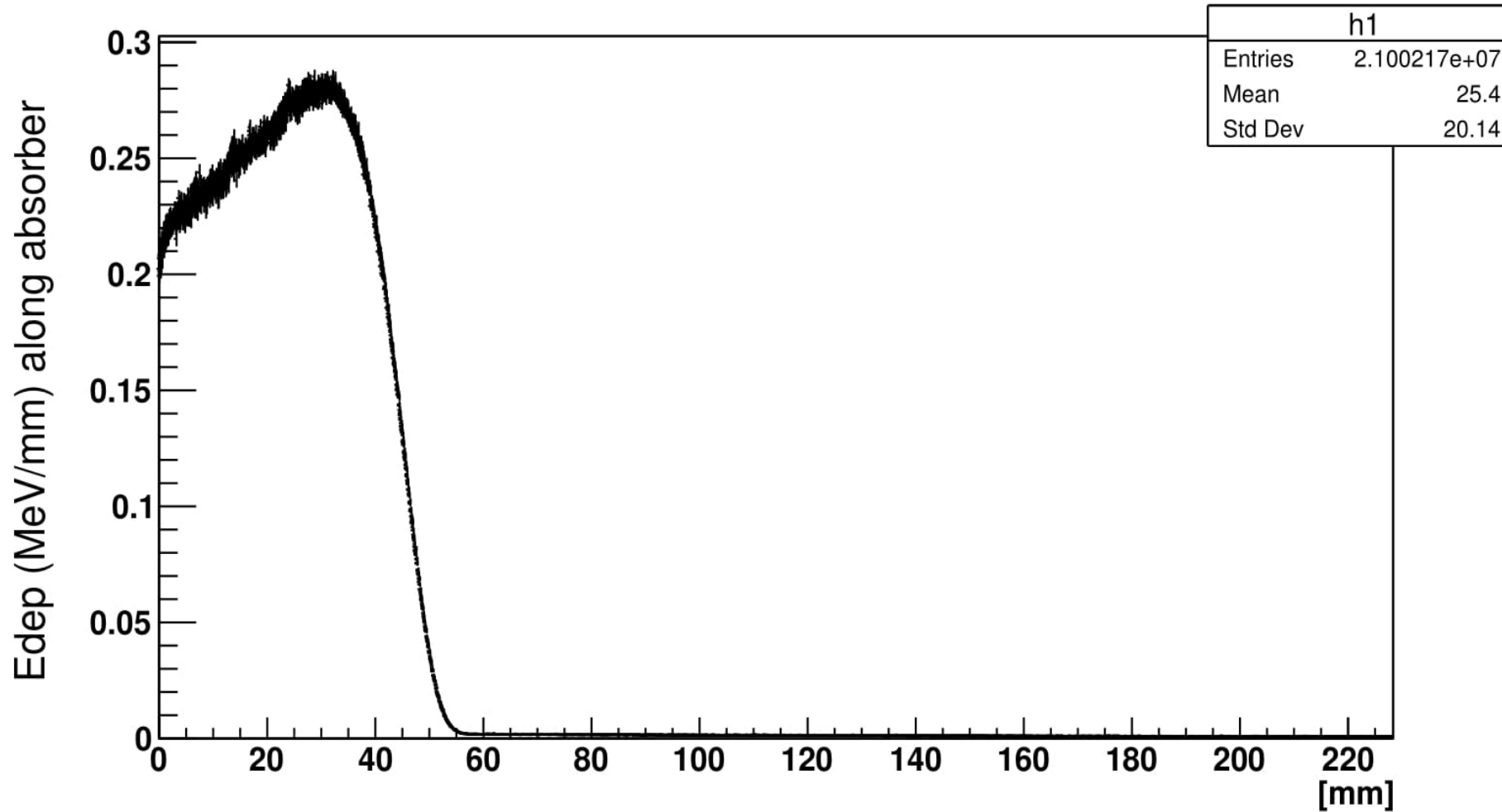
Deposited energy of 2 MeV electron beam to Plexiglas phantom

# The total energy deposited along the trajectory of the beam



Deposited energy of 6 MeV gamma ray to Plexiglas phantom

# The total energy deposited along the trajectory of the beam

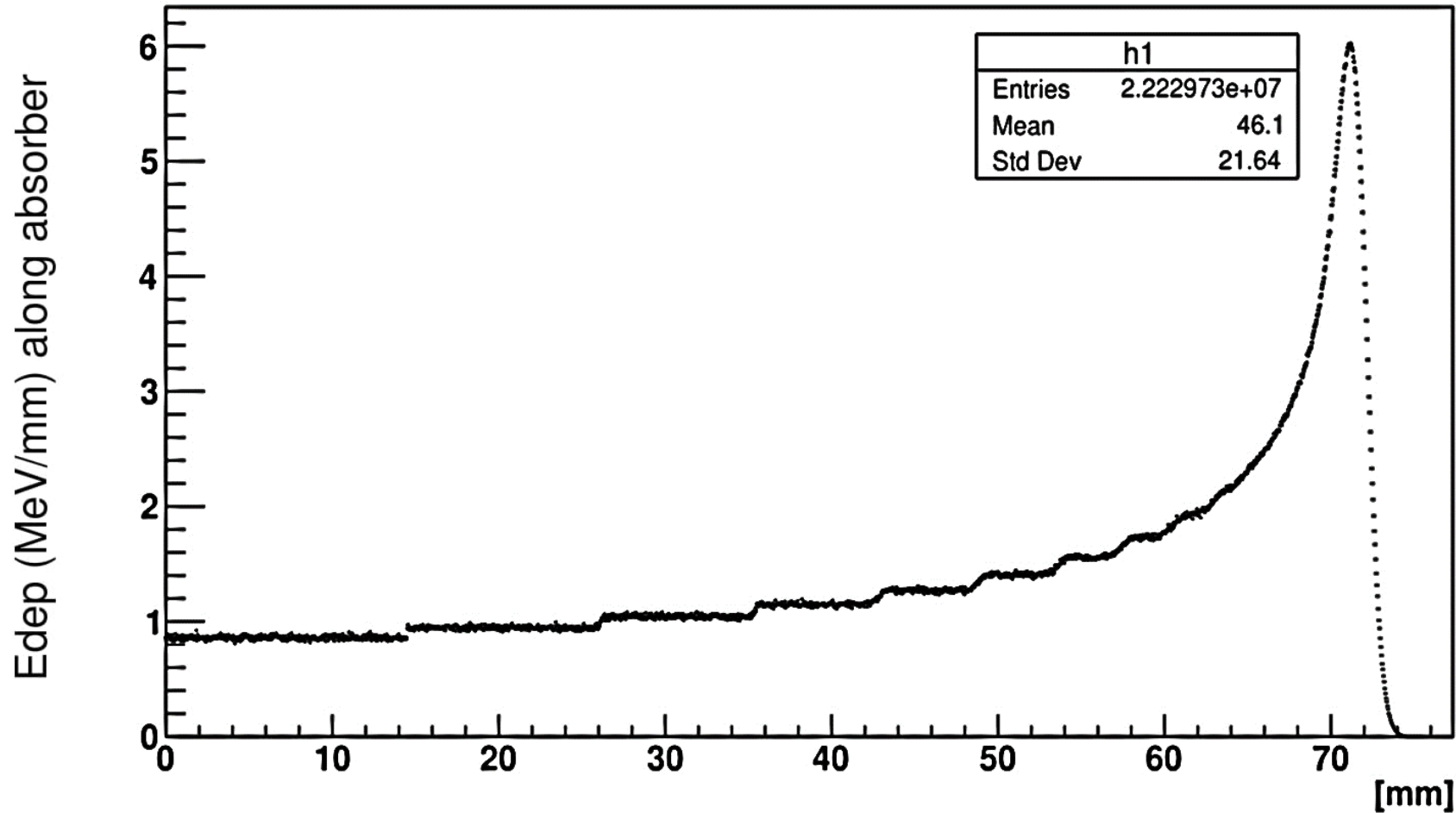


Deposited energy of 12 MeV electrons to Plexiglas phantom

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Geant4 10.4 patch 01  
Phys.list QGSP\_BERT\_HP  
10<sup>6</sup> events

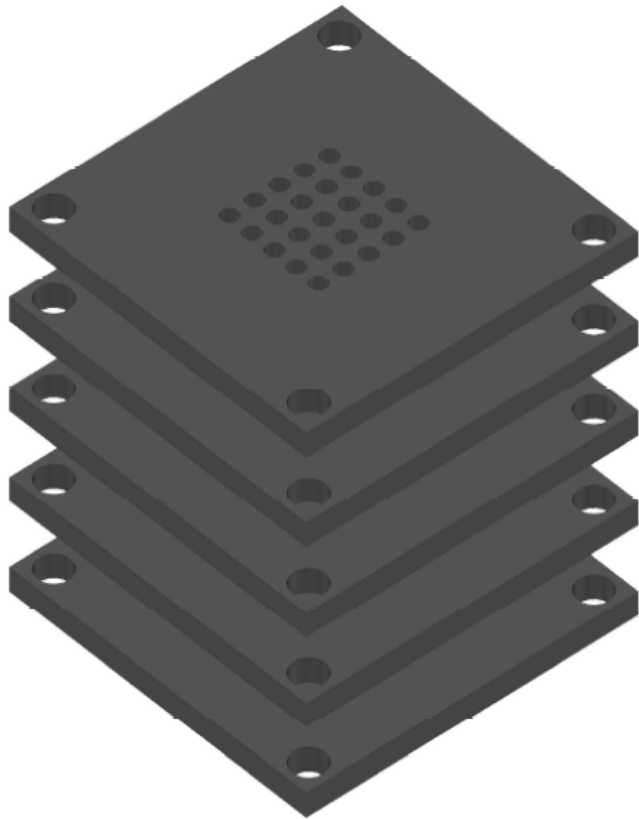
# The total energy deposited along the trajectory of the beam



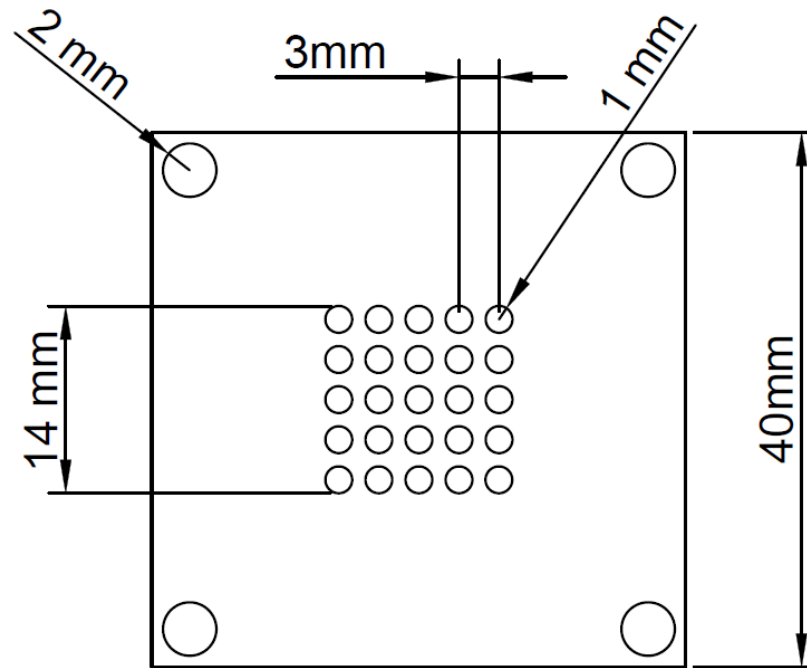
Deposited energy of 105 MeV protons to Plexiglas phantom,  
the so-called Bragg peak



# Blueprint of new collimators for the formation of multi-beam structures



3D model of matrix collimator



Blueprint of collimator plate, thickness is 5 mm

# Summary

- ▶ The elementary detectorized phantom prototype was created on the basis of metallic foil detectors with organic glass as a material of phantom and aluminum foil as metal detector sensors.
- ▶ Development of the detectorized phantom for dose delivery verification based on MMD has been started.
- ▶ The material and the thickness of the collimator do not affect the effective dose starting at a thickness of 4 cm, but at a thickness of 7 cm the dose from protons with 105 MeV energy scattered by the collimator decreases by a factor of 10.
- ▶ Simulations are carried out which allow optimizing the formation of spatial fractionation, thereby increasing the useful dose and PVDR
- ▶ Development of collimators for spatial fractionation different beam types is in progress.

**Thank you for attention**

## **Acknowledgements**

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