

# Beam Monitoring System for Cyclotron Proton Beams at ICNAS

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LABORATÓRIO DE INSTRUMENTAÇÃO E  
FÍSICA EXPERIMENTAL DE PARTICULAS



Institut de physique  
Nucléaire de Lyon

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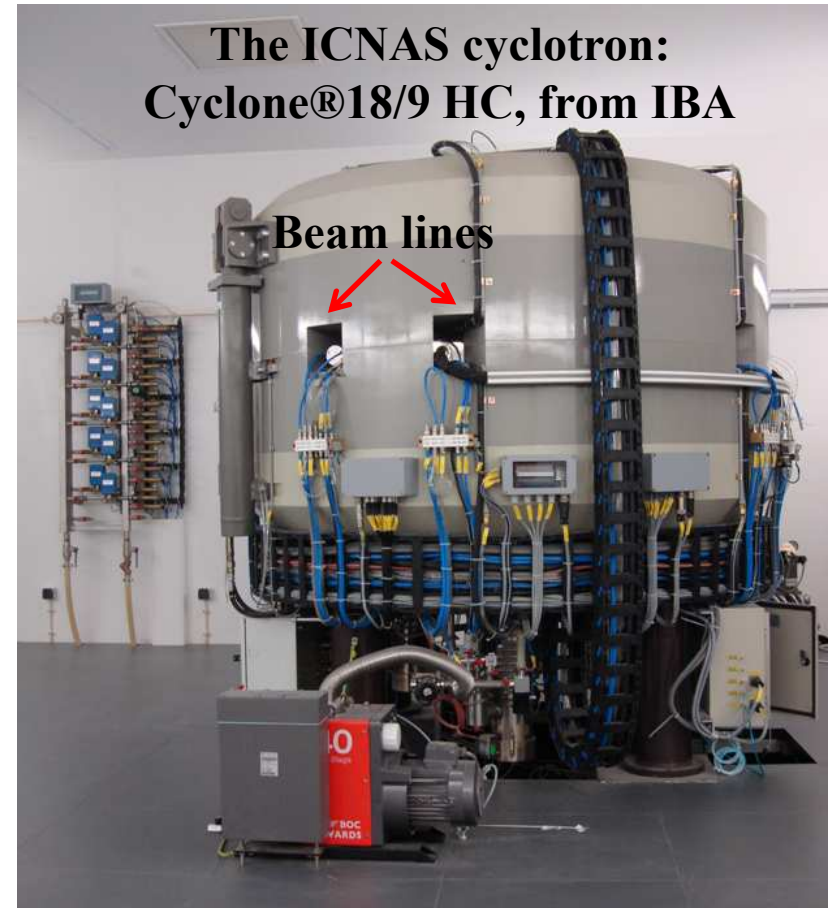
1. ICNAS
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4. Characterization of in-air beam divergence
5. Neutron and  $\gamma$ -ray dose contribution
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# 1. ICNAS: Instituto de Ciências Nucleares Aplicadas à Saúde

Acceleration	H-	D-
Extracted beam	p	d
Energy (MeV)	18	9
Intensity ( $\mu\text{A}$ )	150	40

$1 \times 10^{15}$  particles/s

For production of short-lived radioisotopes for medical use such as  $^{15}\text{O}$  and  $^{18}\text{F}$  widely applied in PET



## Radiobiological and dosimetric studies!

## 2. Beam monitoring system

The precise measurements of a proton beam characteristics are very important for many experiments:

1. Radiobiological experiments
2. Radiation hardness test of devices for spacecraft
3. Detector development
4. For nuclear physics studies
5. Among others

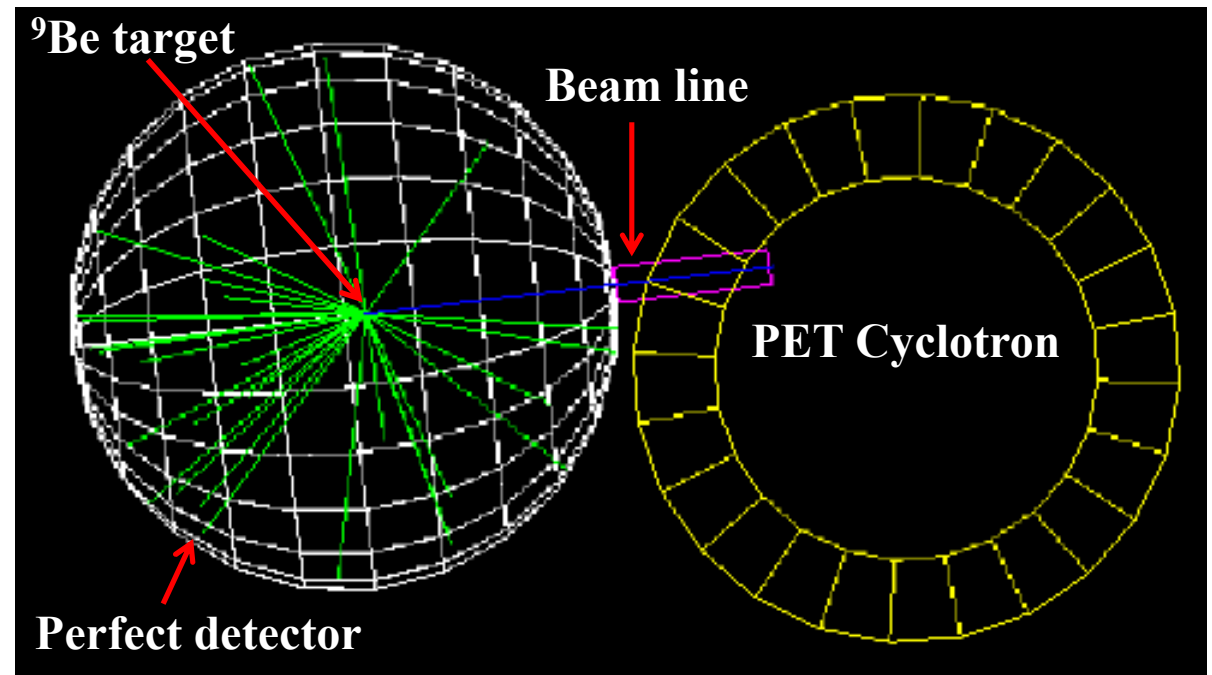


1. Beam energy
2. Beam current
3. Beam profile
4. Fluence
5. Dose and dose rate

### 3. Monte-Carlo validation

Geant4 version 9.3.p01,  
QGSP\_BERT\_HP  
physics package

Pinto, MSc U. Coimbra

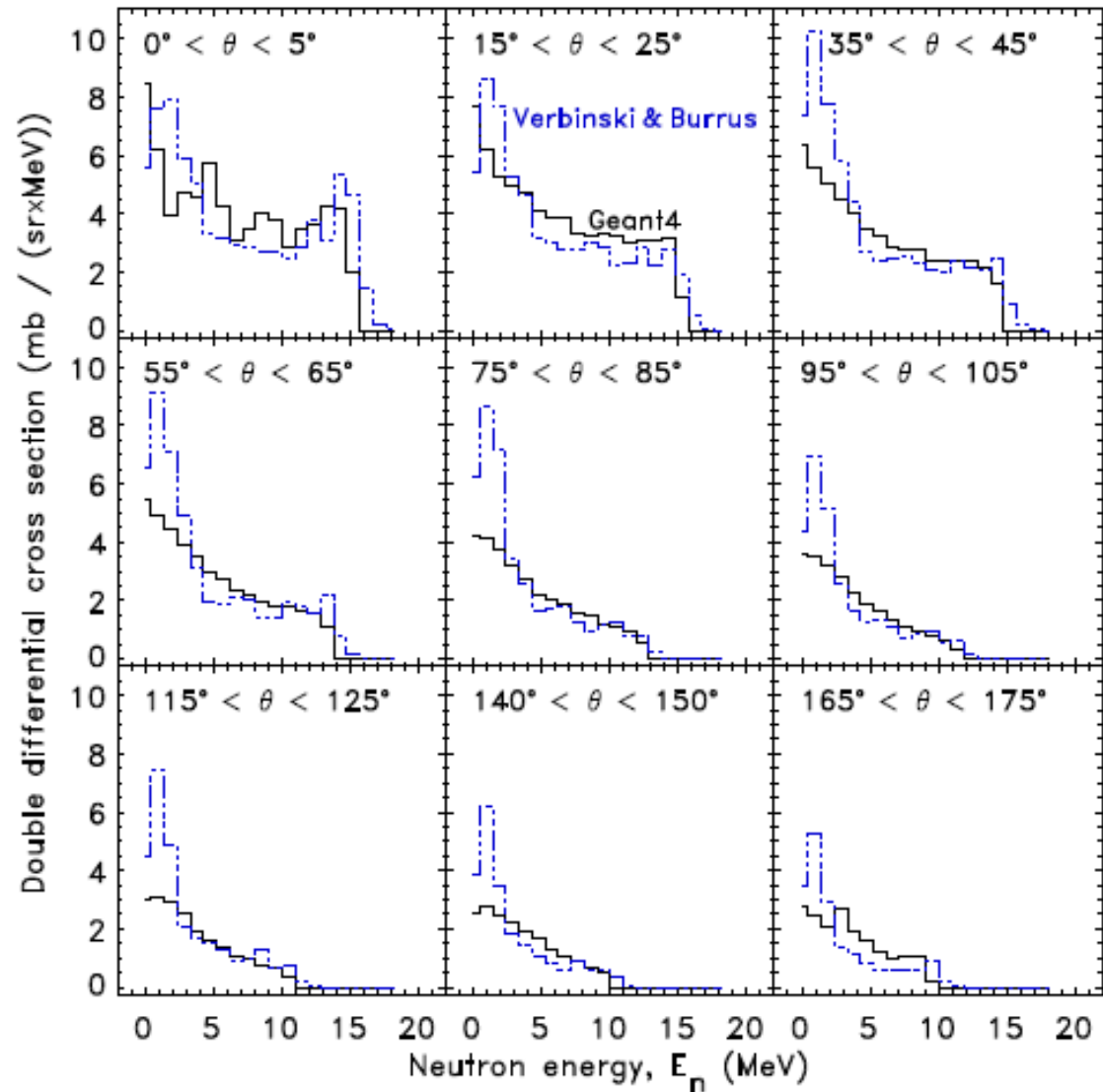


A proton beam with 18.5-MeV energy was shot in vacuum through  
a 25.2- $\mu\text{m}$ -thick  $^9\text{Be}$  target

Verbinski and Burrus

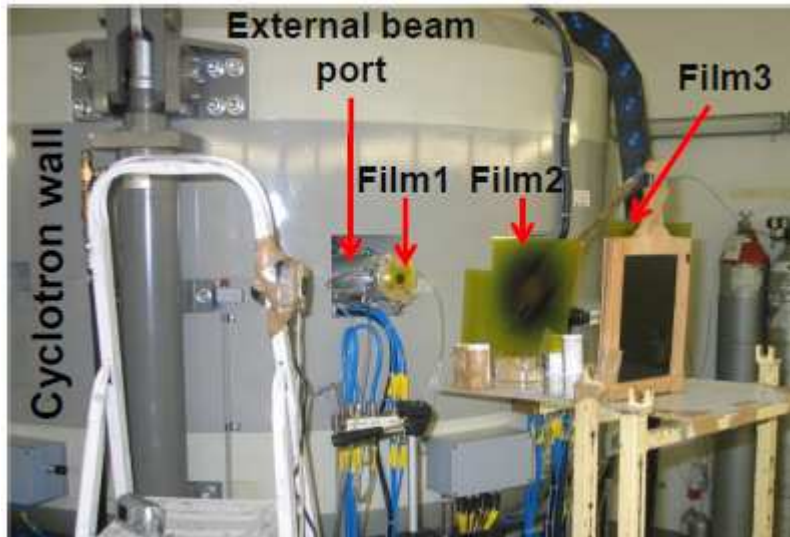
### 3. Monte-Carlo validation

**Remarkable  
agreement  
between  
Simulation and  
experimental  
data**



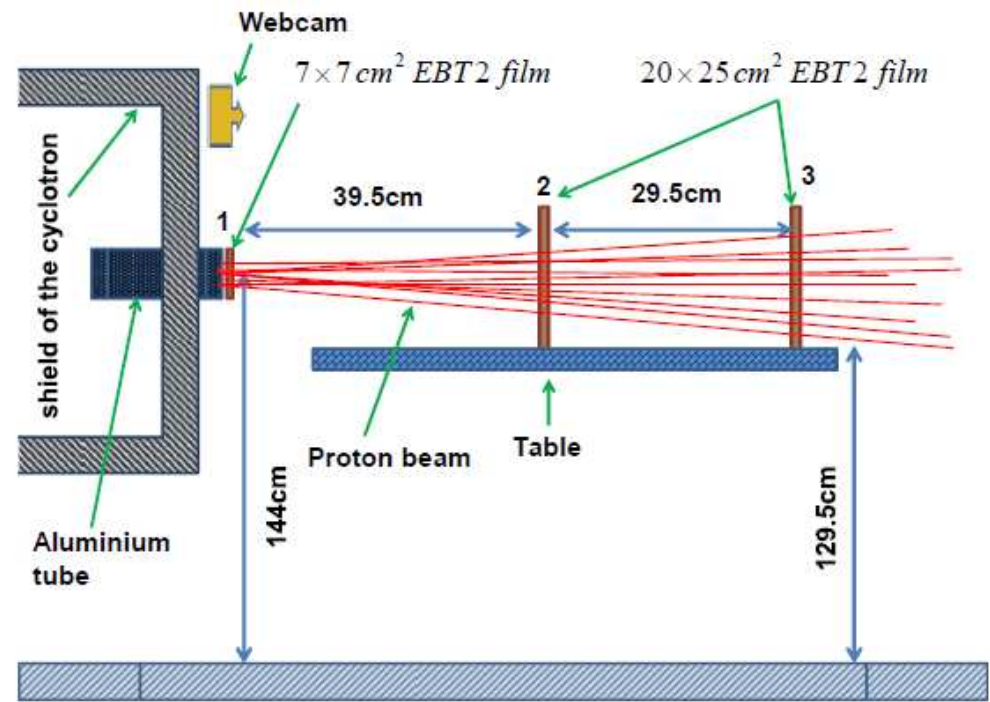
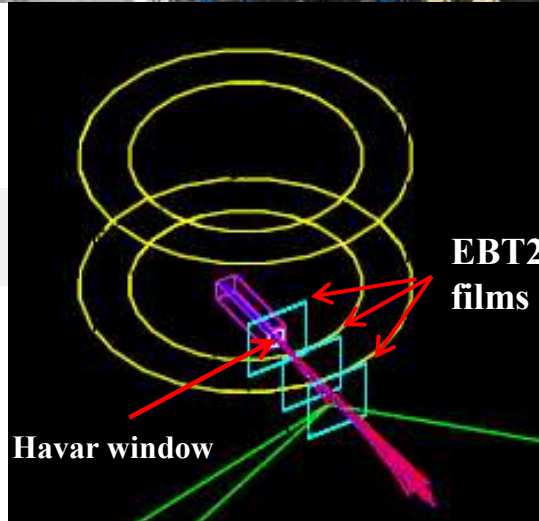
## 4. Characterization of in-air beam divergence

### 4.1 Experiment at the PET cyclotron at ICNAS



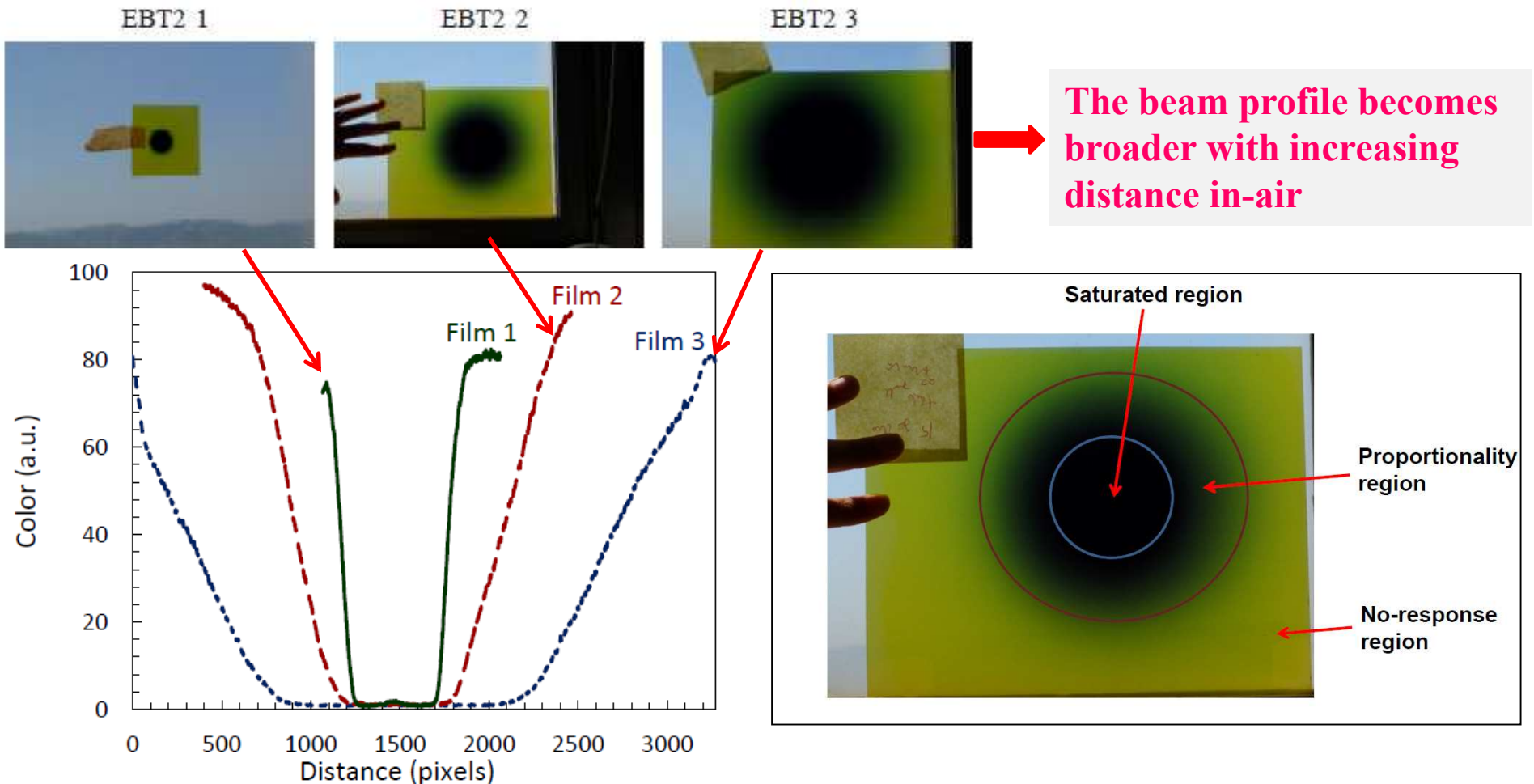
ICNAS

Geant4



## 4. Characterization of in-air beam divergence

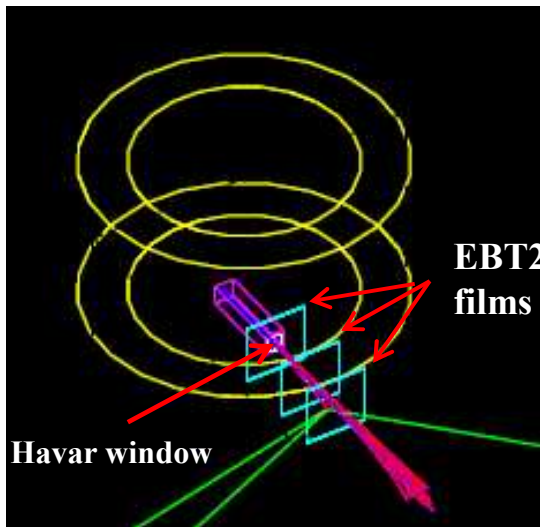
### 4.1 Experiment at the PET cyclotron at ICNAS



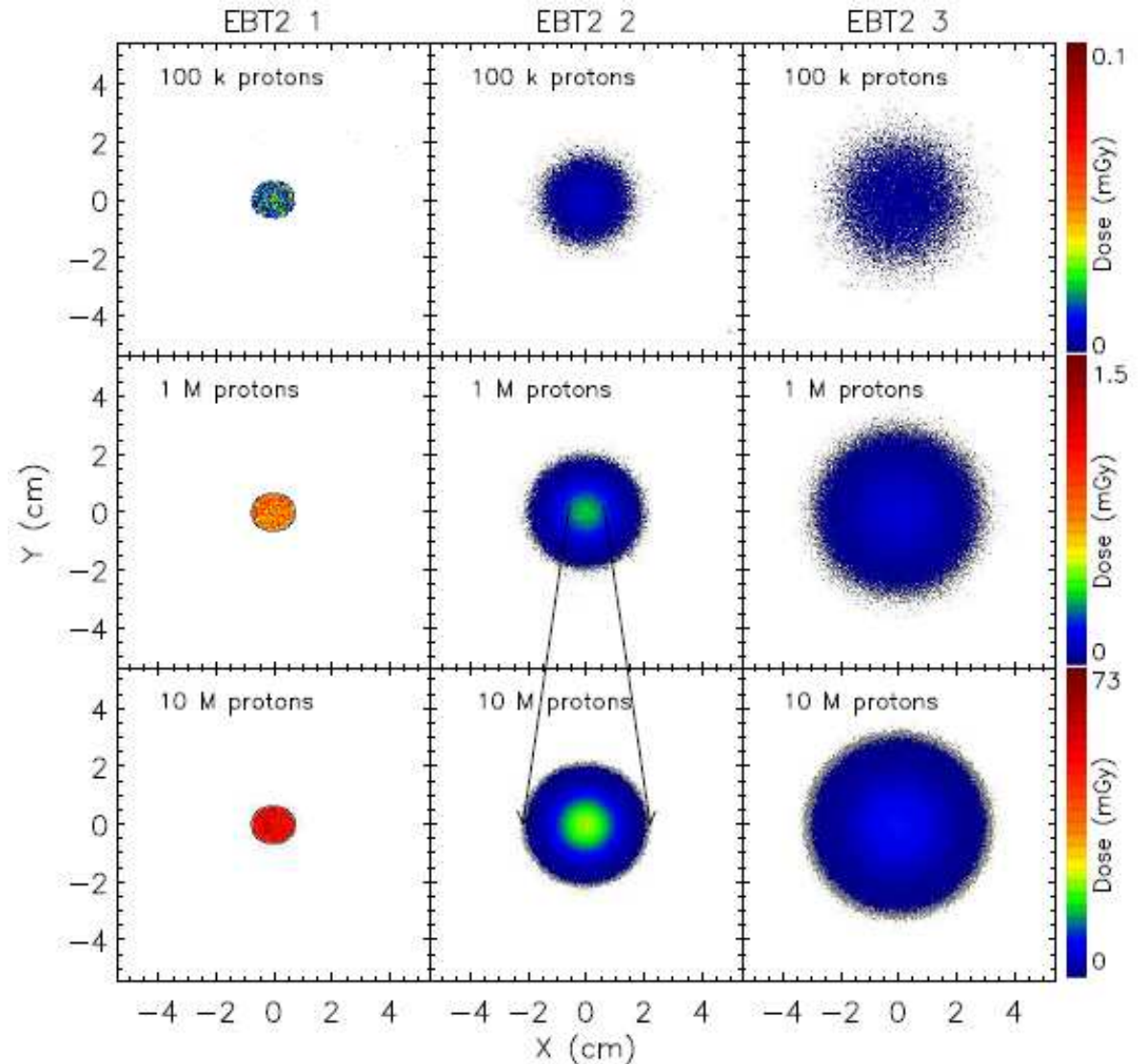
The normalized beam profiles of the three films

## 4. Characterization of in-air beam divergence

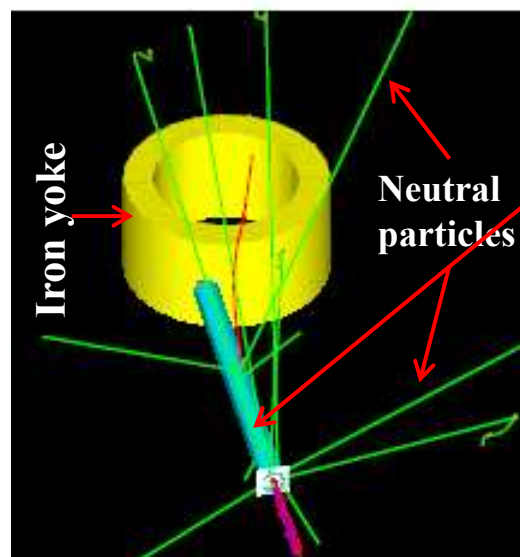
### 4.2 Geant4 simulations



View of the setup  
simulated with Geant4

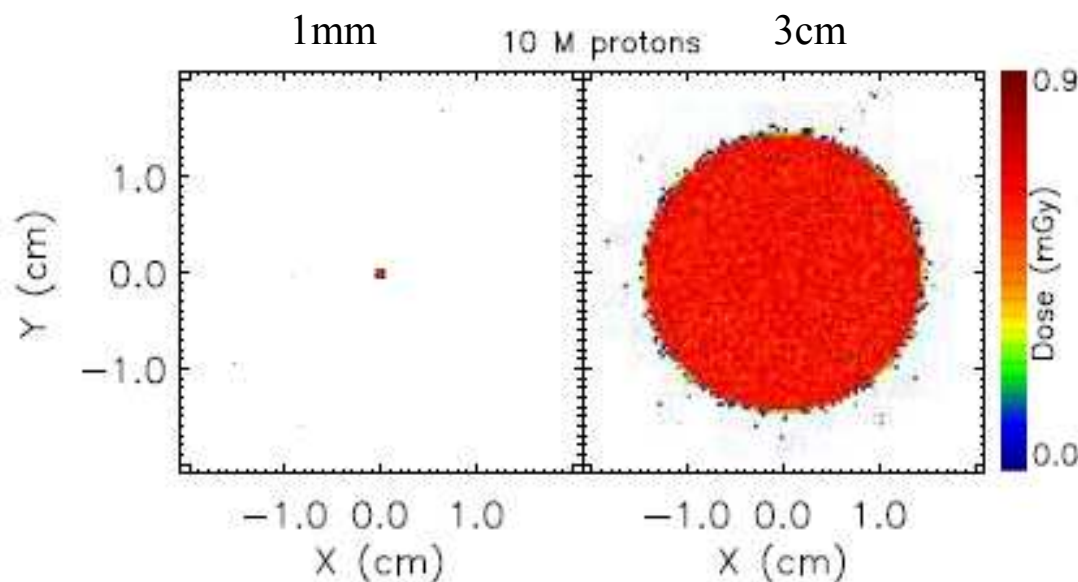


## 5. Neutron and $\gamma$ -ray dose contribution



View of the irradiation setup simulated with Geant4

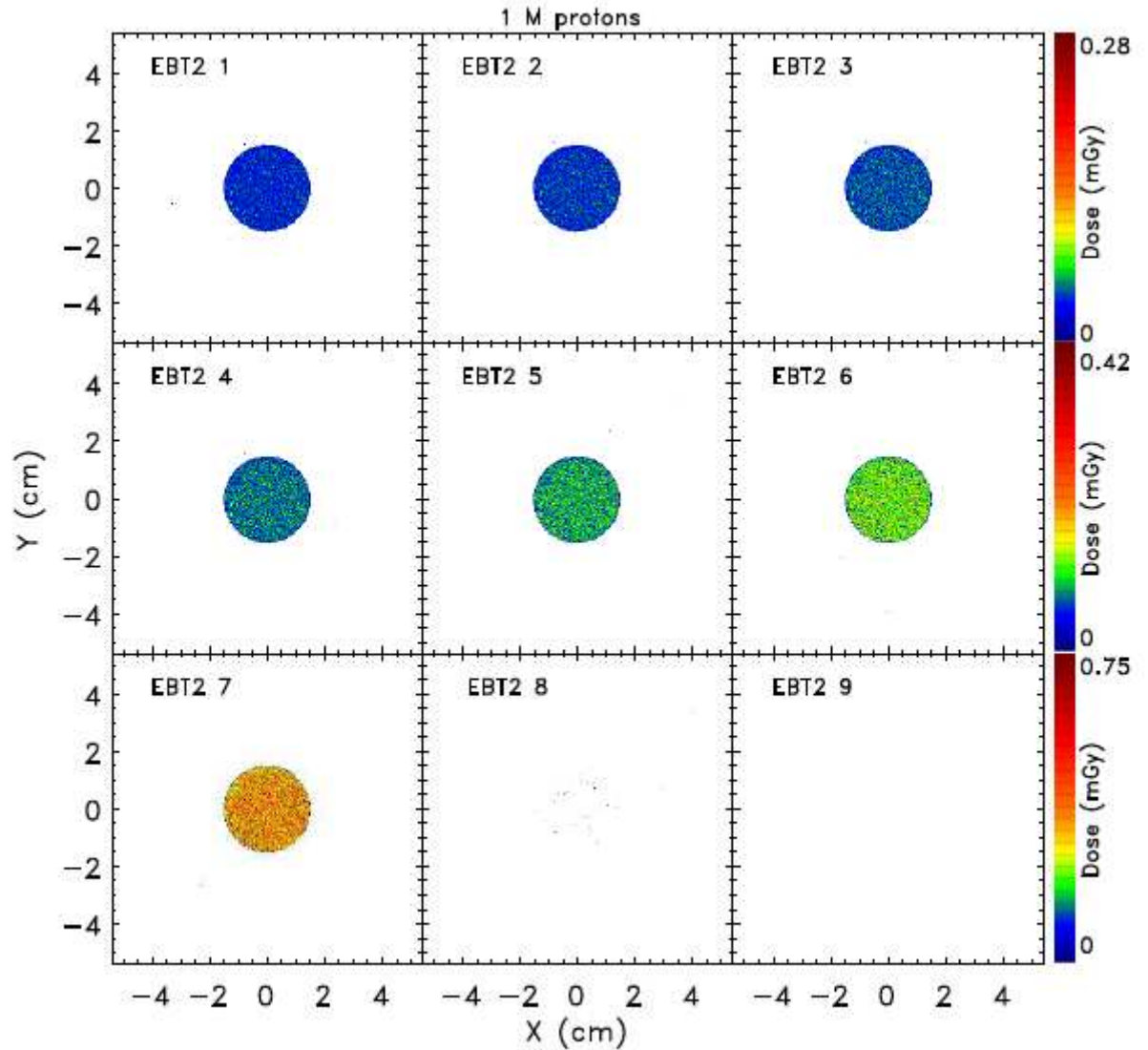
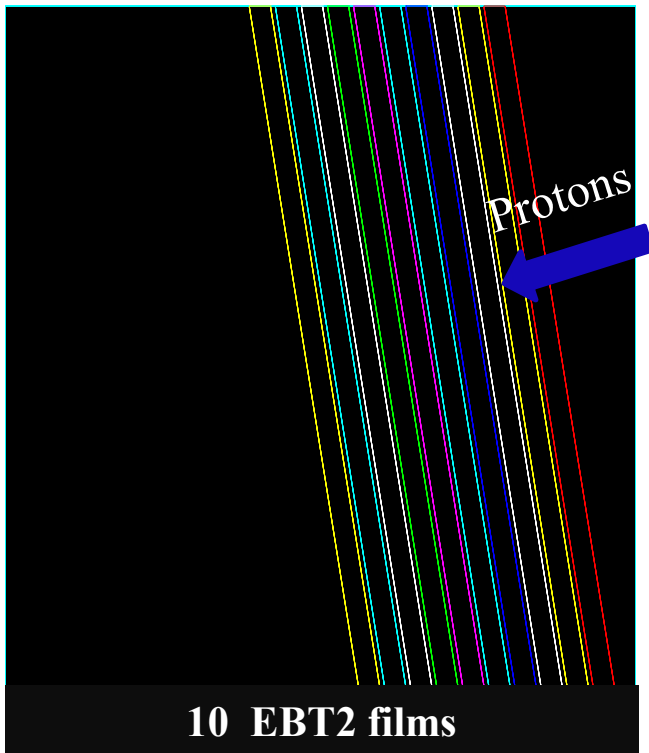
Pipe length : 3 m



The dose contribution from neutrons and  $\gamma$ -rays is negligible down to at most the 1% level

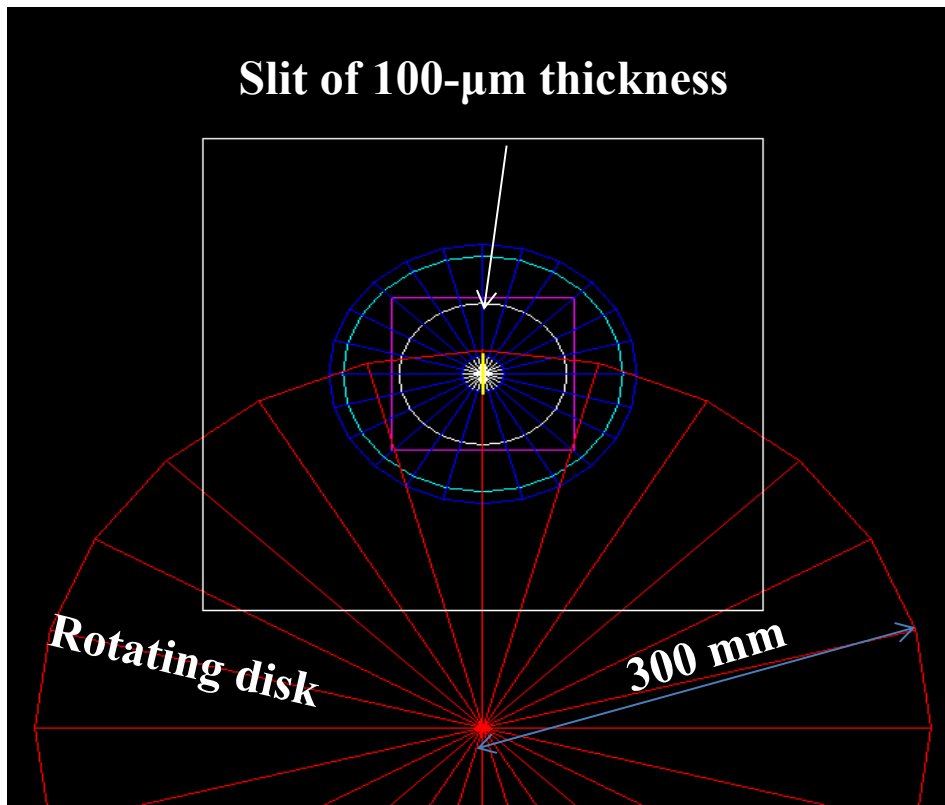
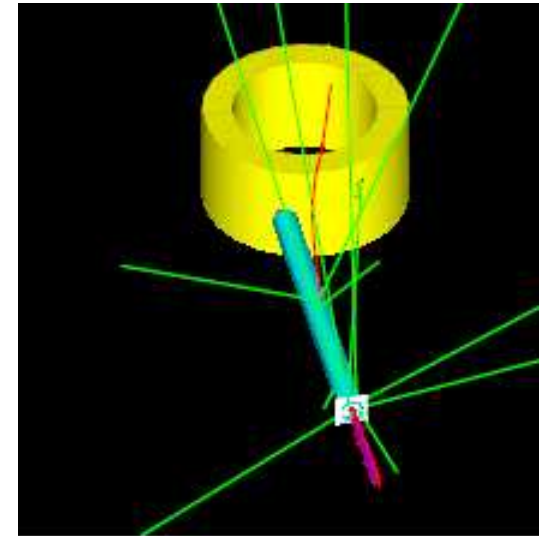
Ten million protons were simulated for a beam current of  $1.5 \mu\text{A}$ , corresponding to a film dose rate of 1 kGy/s (plateau), 3 kGy/s (Bragg peak)

## 5. Neutron and $\gamma$ -ray dose contribution



## 6. Discussion and Conclusions

Target dose rates between 1 Gy/s and 100 Gy/s



Allows for decreasing target dose rates by a factor  $10^{-4}$ , from kGy/s down to Gy/s

Installing a simple mechanical shutter capable of 10 ms exposure timings allows to further bring down the dose on target to units of cGy

## 6. Discussion and Conclusions

**Measured beam profiles show good qualitative agreement with simulations performed with Geant4**

+

**The dose achievable with the proposed setup may span 4-orders-of-magnitude, ranging from 10 mGy to 100 Gy**

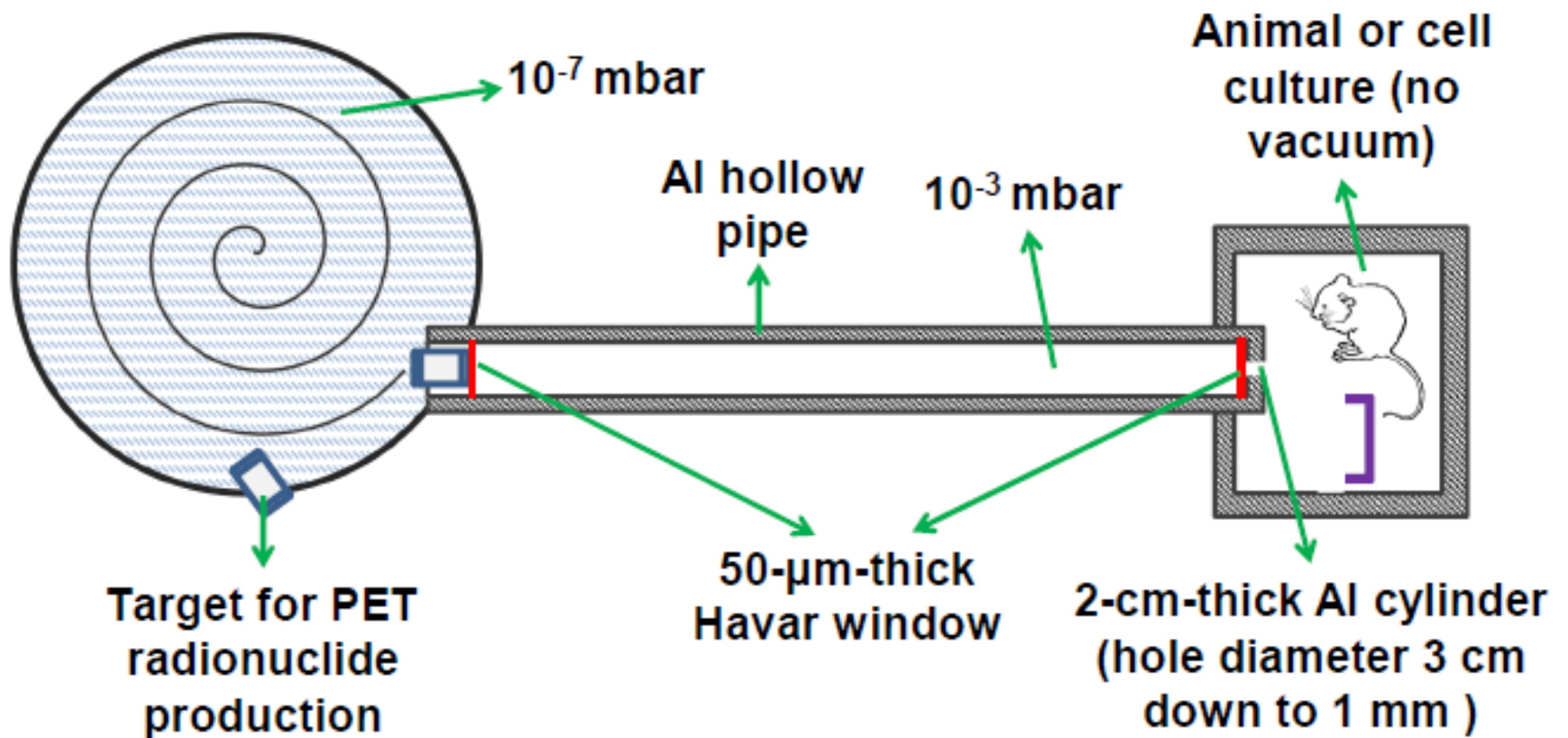
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**The dose contribution from neutron and  $\gamma$ -ray on a target is negligible down to at most the 1% level when compared to the proton dose**

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**It is possible and feasible to use the cyclotron proton beam to perform radiobiological and dosimetric studies among others**

## 7. On-going



## **ACKNOWLEDGMENTS**

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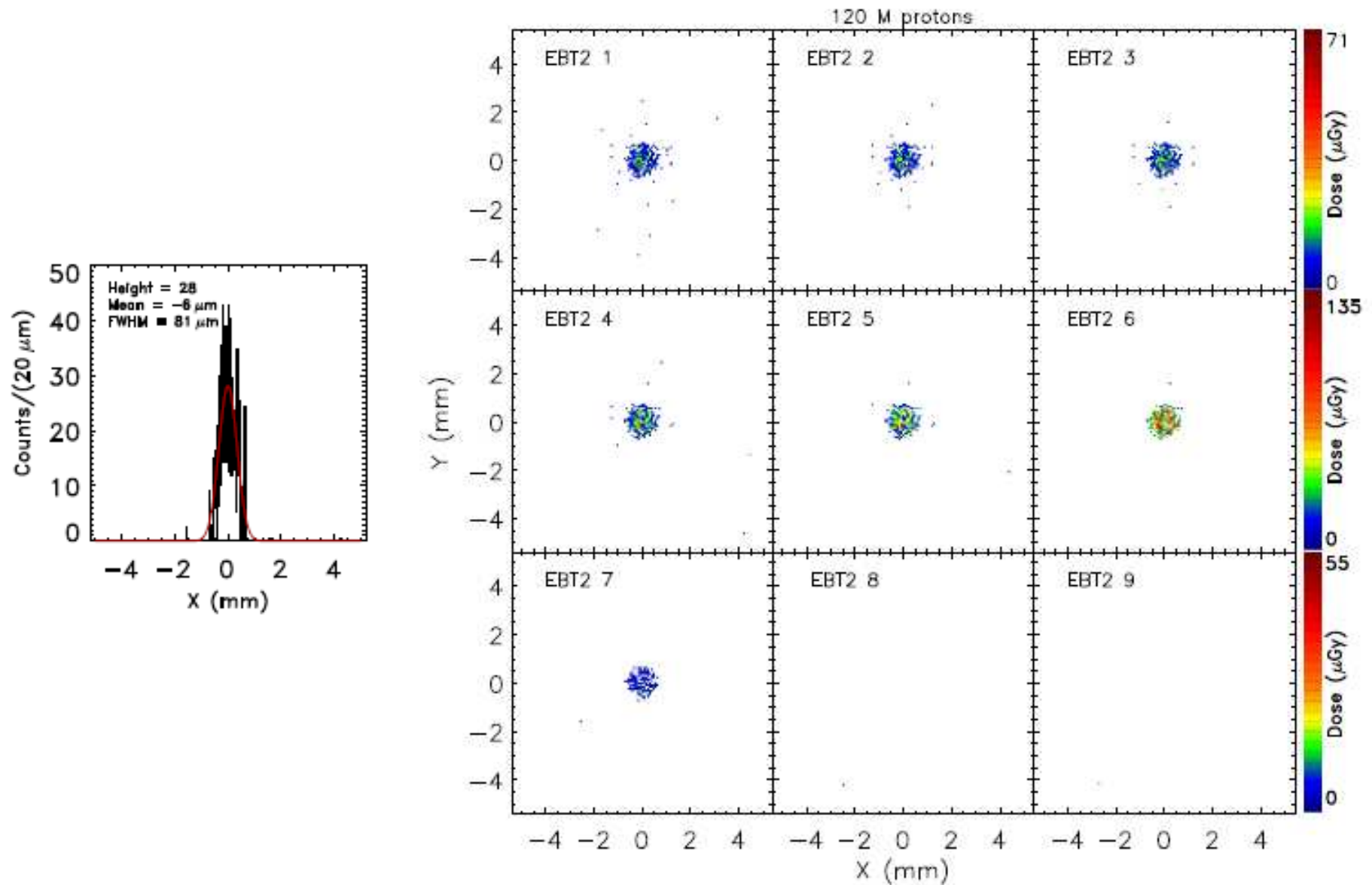
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**THANK YOU FOR YOUR ATTENTION!**

## 5. Neutron and $\gamma$ -ray dose contribution



## 7. On-going

Top view of the setup without vacuum

