# Research and Development in Hadron Therapy: Implementation and Characterization of a External Vertical Proton Beam


Ezequiel Canay

Supervisors: Francesca Ballarini, Ricardo L. Ramos

Abroad supervisors: Agustina M. Portu, Andrés Arazi

# Presentation

Biomedical Engineer

**PhD in CO-TUTELA**

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Biomedical Engineer

**PhD in CO-TUTELA**

LA UNIVERSIDAD NACIONAL DE SAN MARTÍN
(nuclear technology)

and

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and

LA UNIVERSITÀ DEGLI STUDI DI PAVIA
(Physics)

# Goals

1. Adapt biophysical models for space radiation risk assessment

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**9-month research stay in Pavia**
**2024-2025**

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a) Implementation and Characterization of an External Vertical Proton Beam for radiobiological experiments

# Goals

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9-month research stay in Pavia
2024-2025

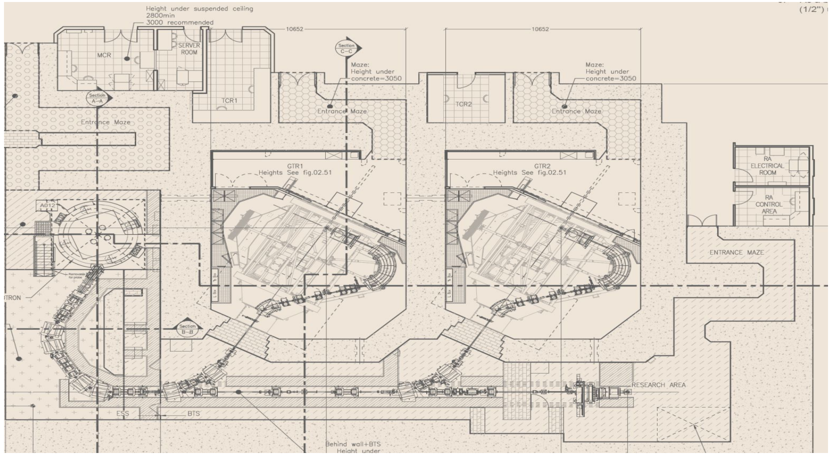
**2. Implement systems for shaping and characterizing proton beams for hadrontherapy**

a) Implementation and Characterization of an External Vertical Proton Beam for radiobiological experiments


b) Upgrade of a vacuum irradiation line to study the behaviour of electronic devices under simulated space radiation conditions.

# Proton therapy in Argentina

## CeArP

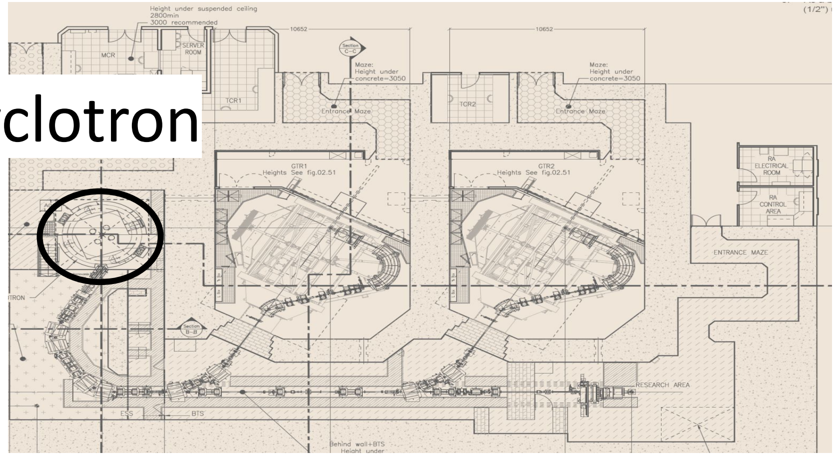



**National Atomic Energy Commission (CNEA)**

# Proton therapy in Argentina

CeArP

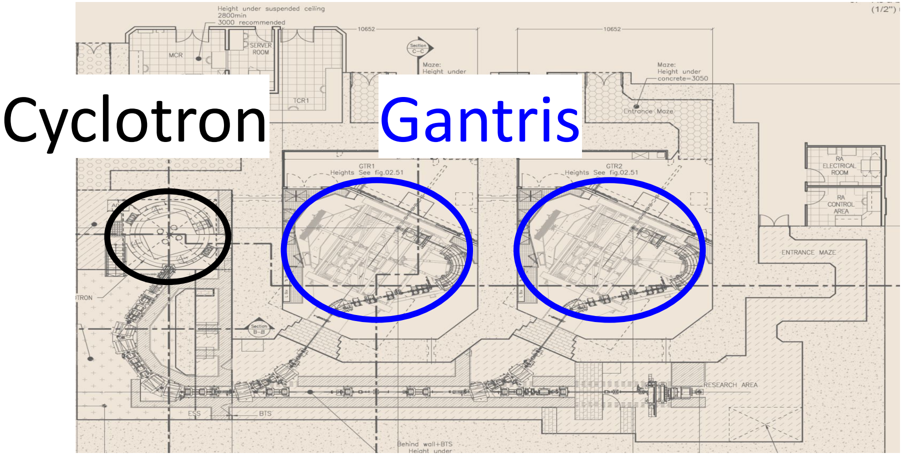
Cyclotron




National Atomic Energy Commission (CNEA)

# Proton therapy in Argentina

CeArP

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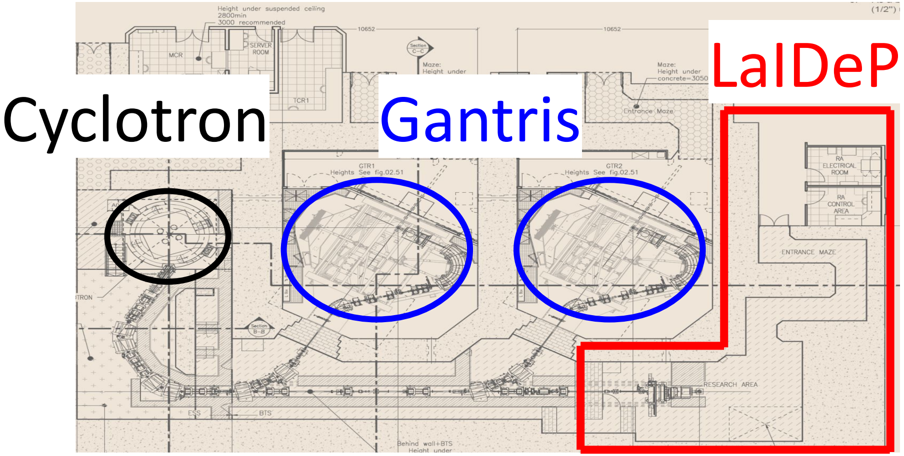


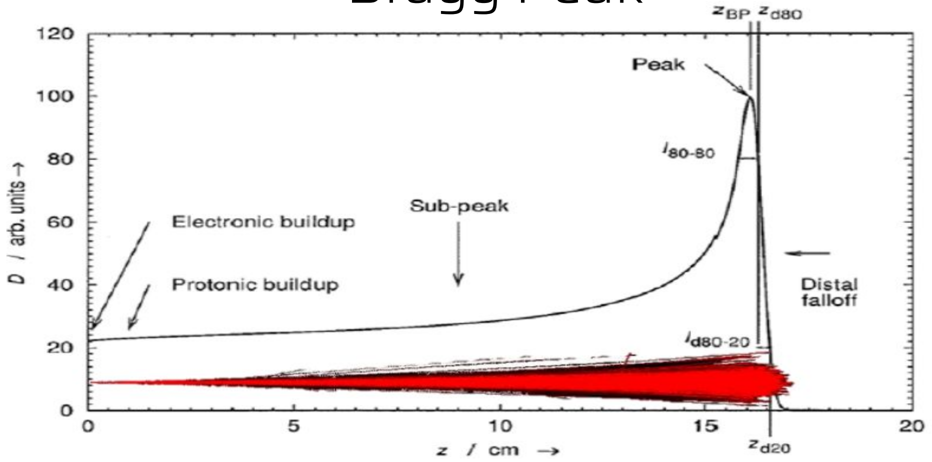

National Atomic Energy Commission (CNEA)

# Proton therapy

## Non-conventional Radiotherapy

External Radiotherapy with Proton Beams

Bragg Peak



# Proton therapy

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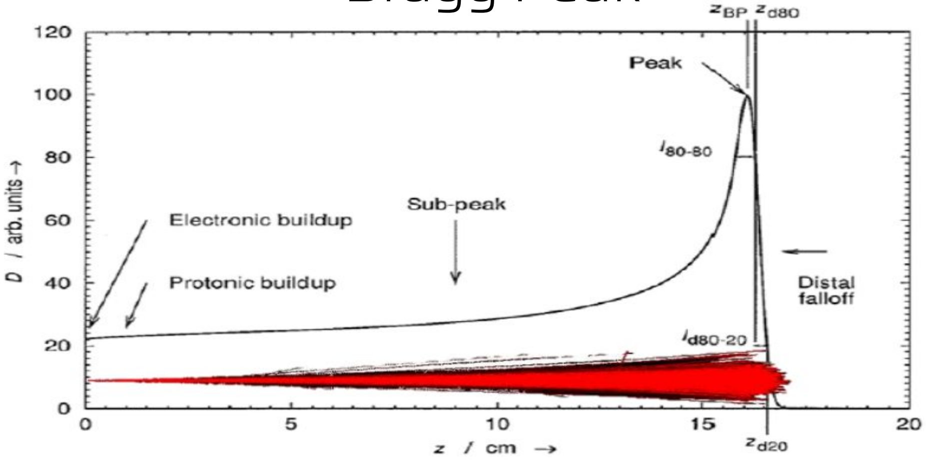
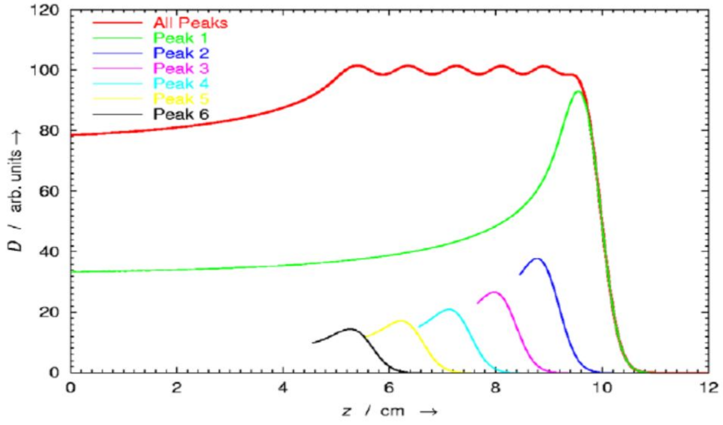



Spread-Out Bragg Peak



# Proton therapy

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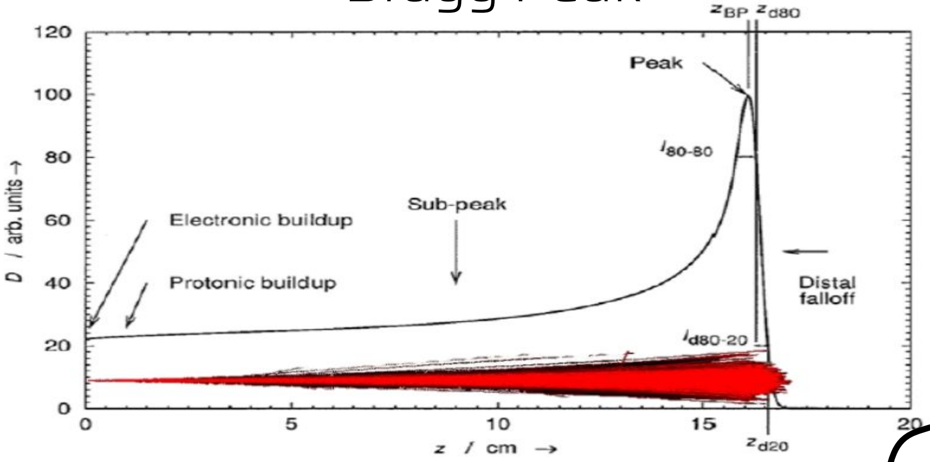


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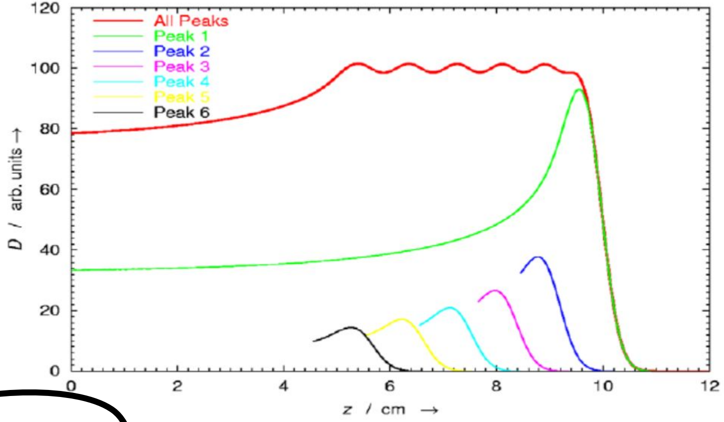


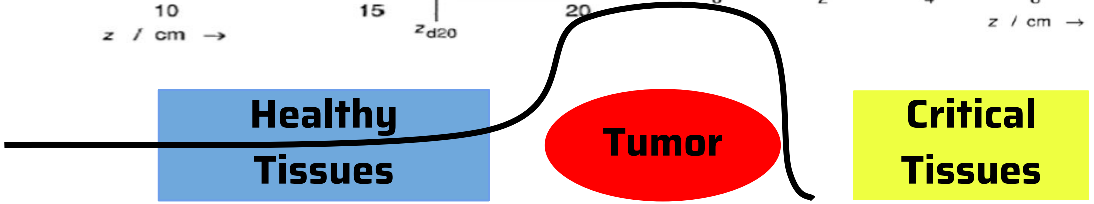

# Proton therapy

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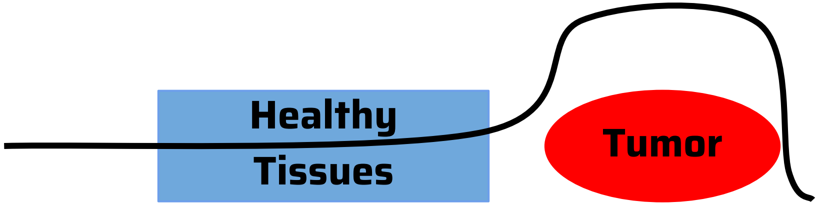
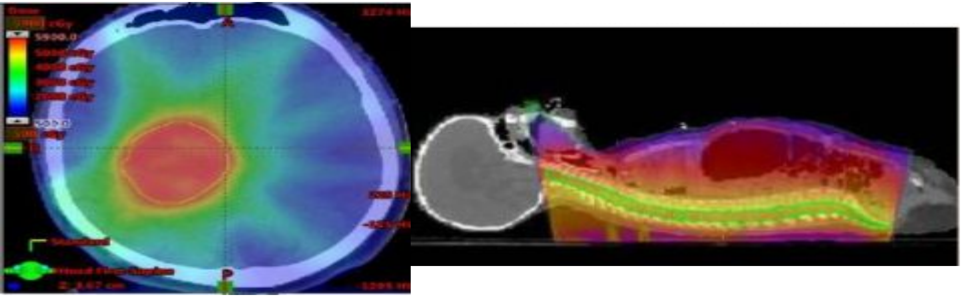
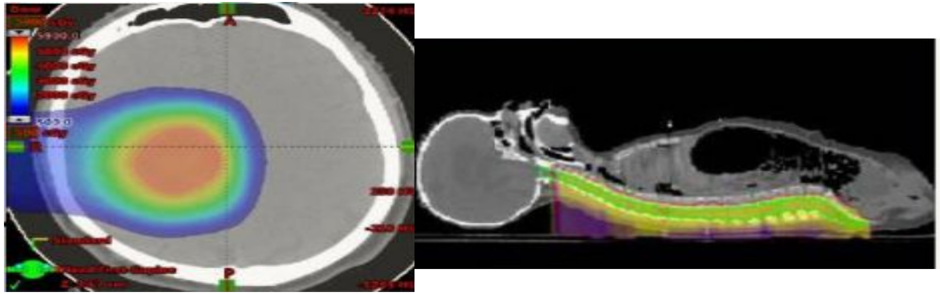



X-rays



Proton



# Proton therapy

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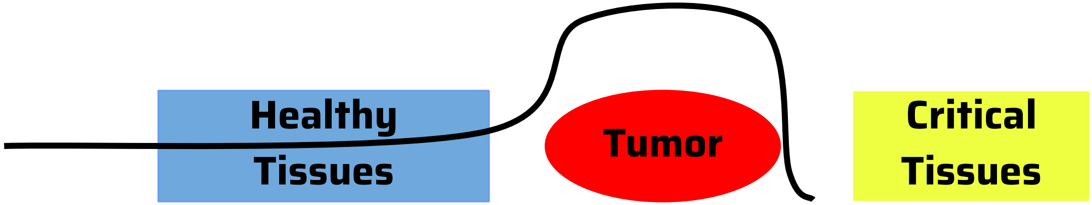


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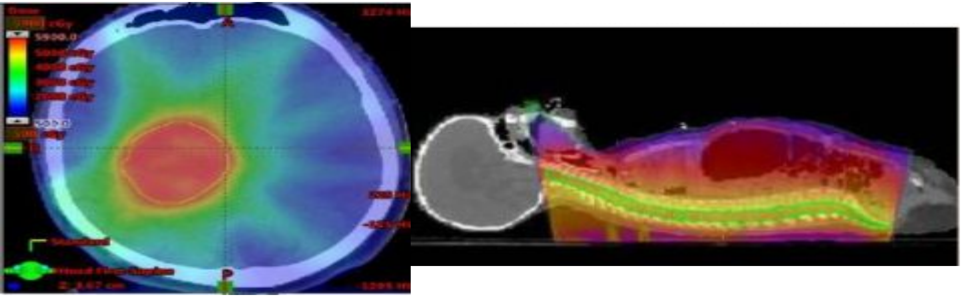

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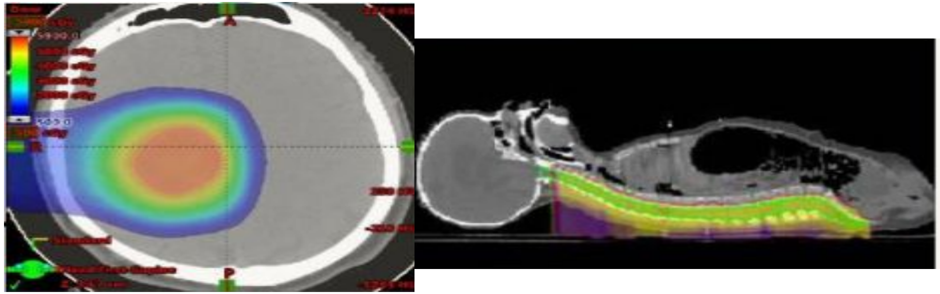

- Little to no radiation behind the tumor

# Proton therapy

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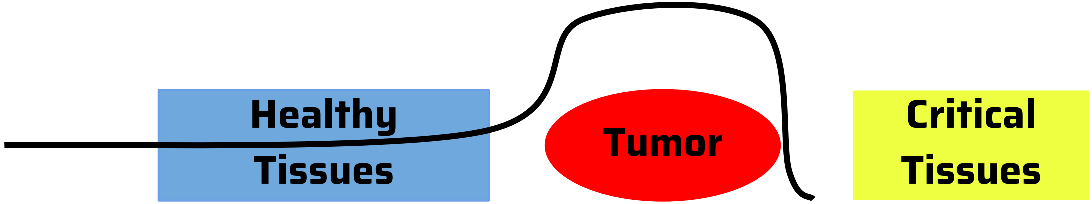
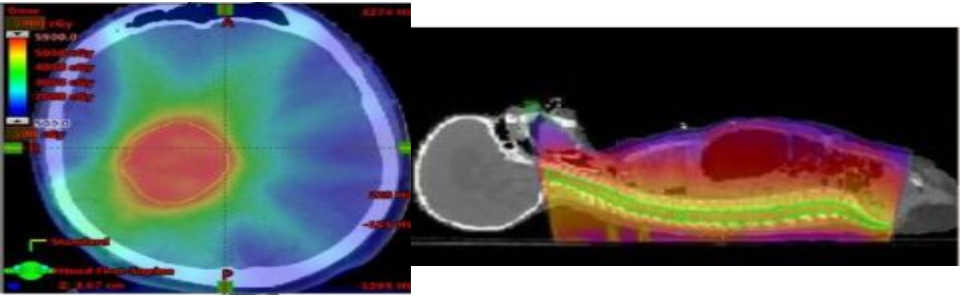
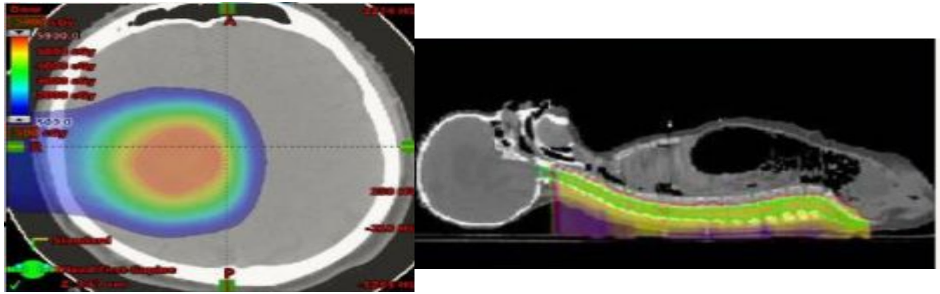



X-rays

Proton





- Little to no radiation behind the tumor
- Low integral dose per treatment

# Proton therapy

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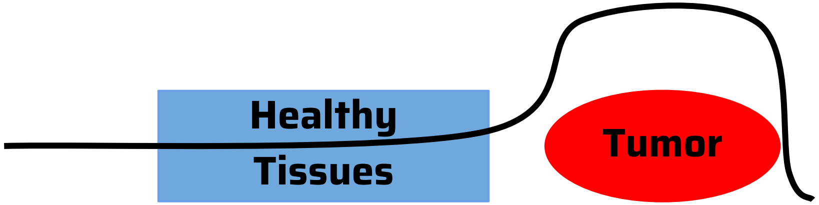


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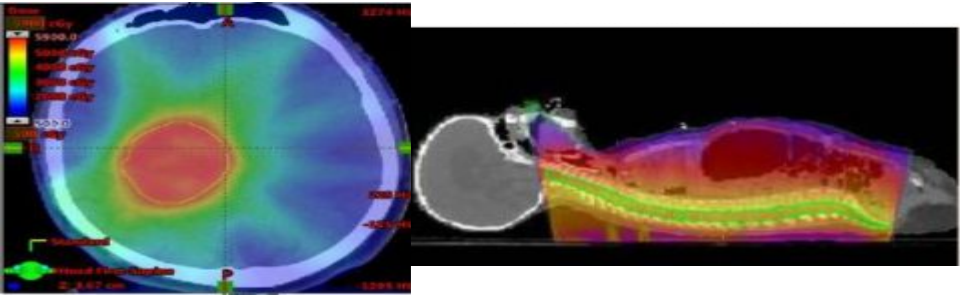

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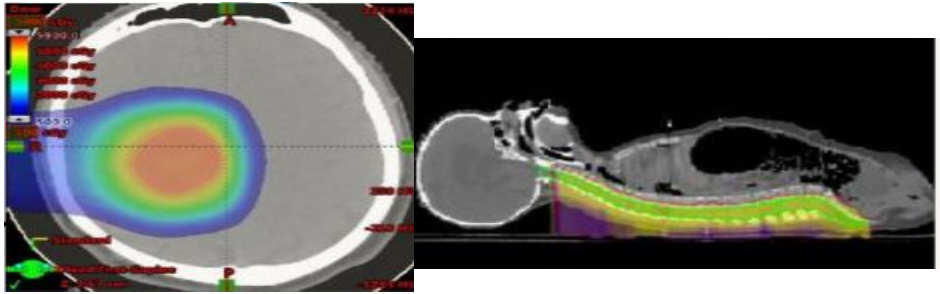


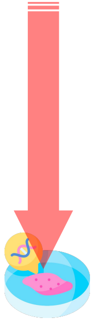
- Little to no radiation behind the tumor
- Low integral dose per treatment
- Reduced side effects

# Proton therapy in Argentina

CeArP

TANDAR

**Study of biophysical models of radiation damage**

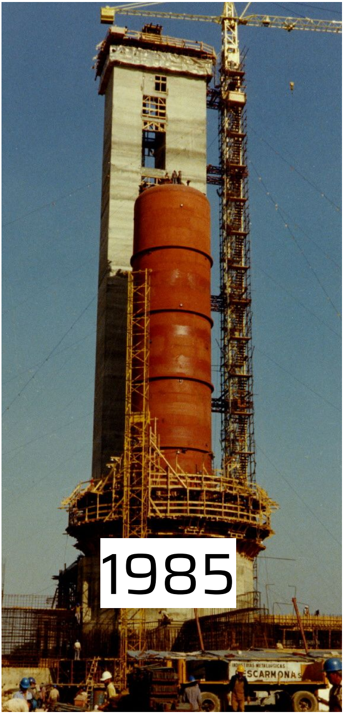


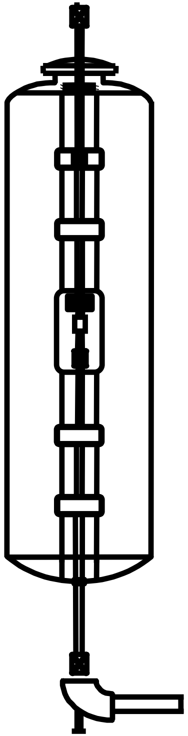
**Proton therapy**

**and more**

# My PhD

## 1. Implementation and Characterization of a External Vertical Proton Beam in TANDAR accelerator



TANDAR
**accelerator**

# My PhD

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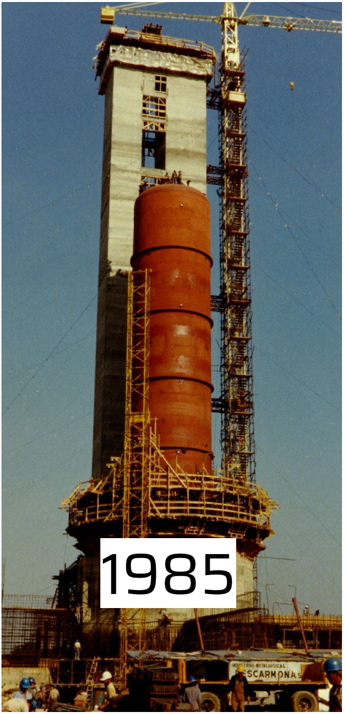


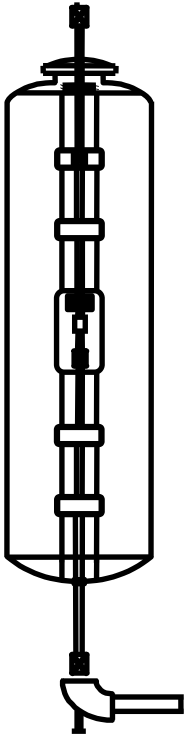

TANDAR
**accelerator**
3-10 MV

H+ 6-20 MeV

# My PhD

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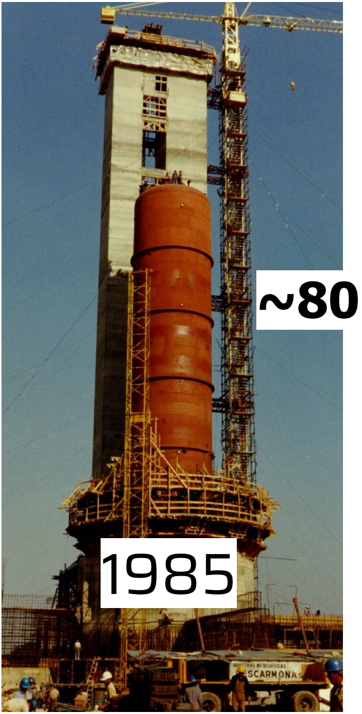
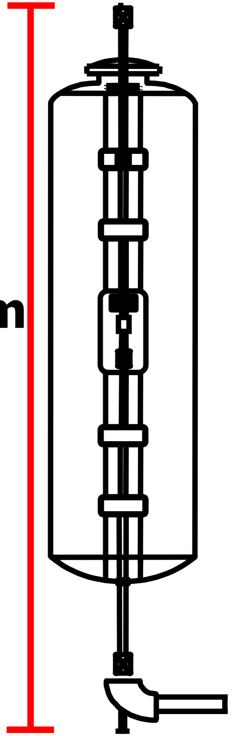



**~80m**



TANDAR

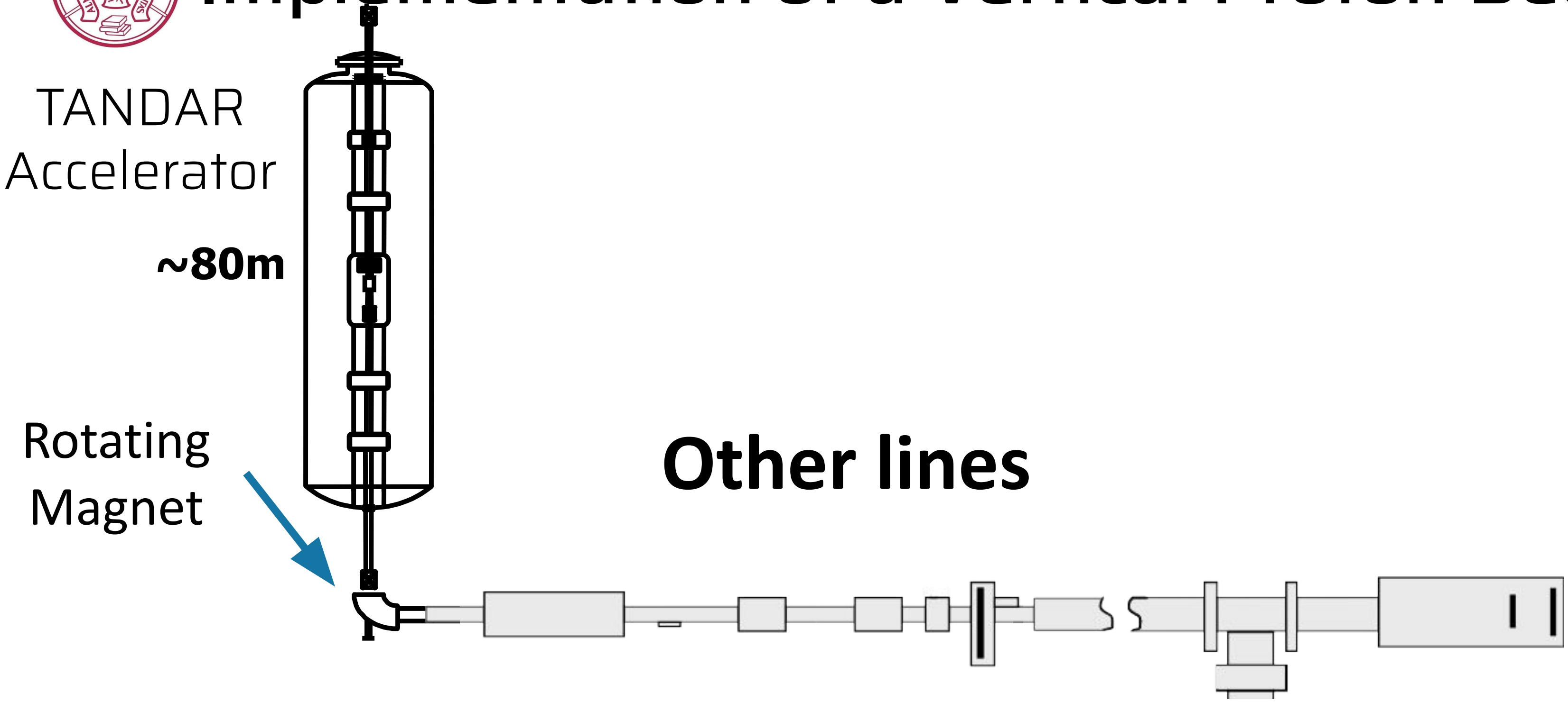
**accelerator**

3-10 MV

↓

H+ 6-20 MeV

# Implementation of a Vertical Proton Beam



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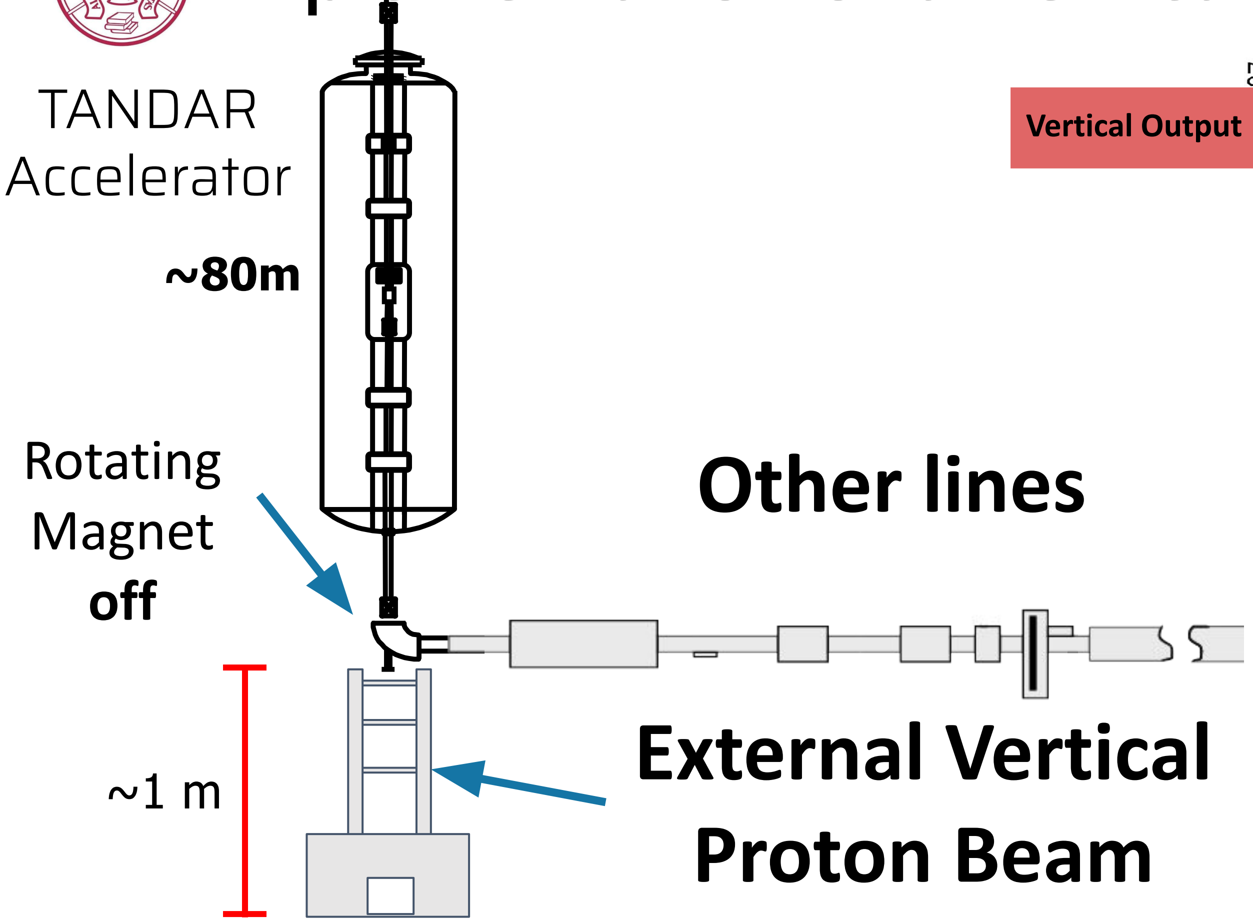


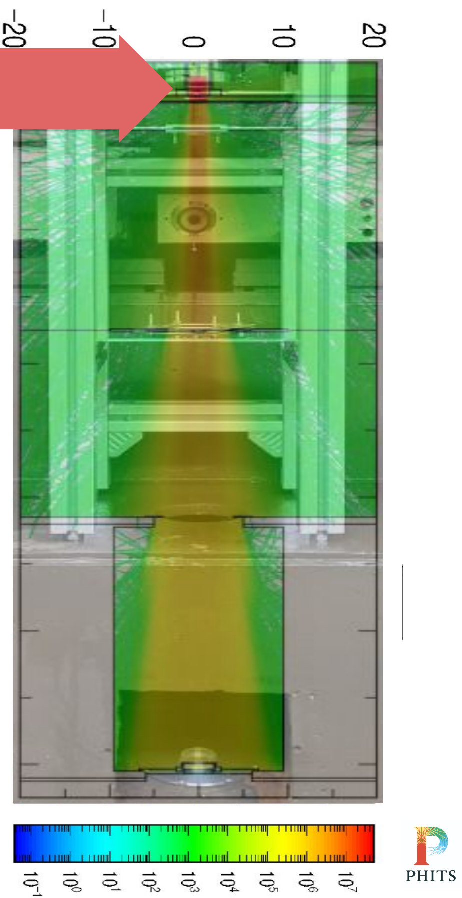

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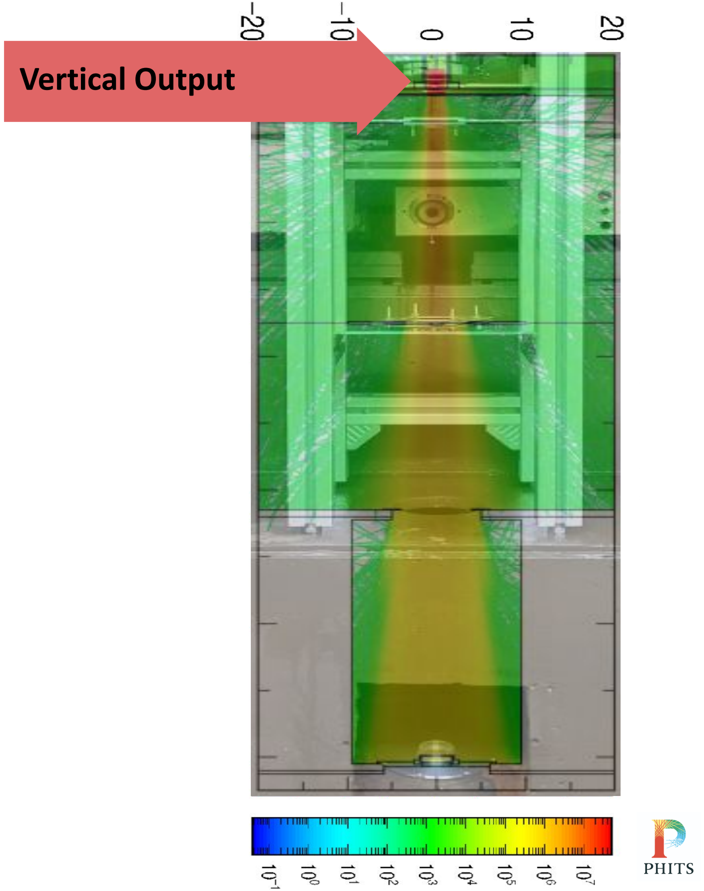

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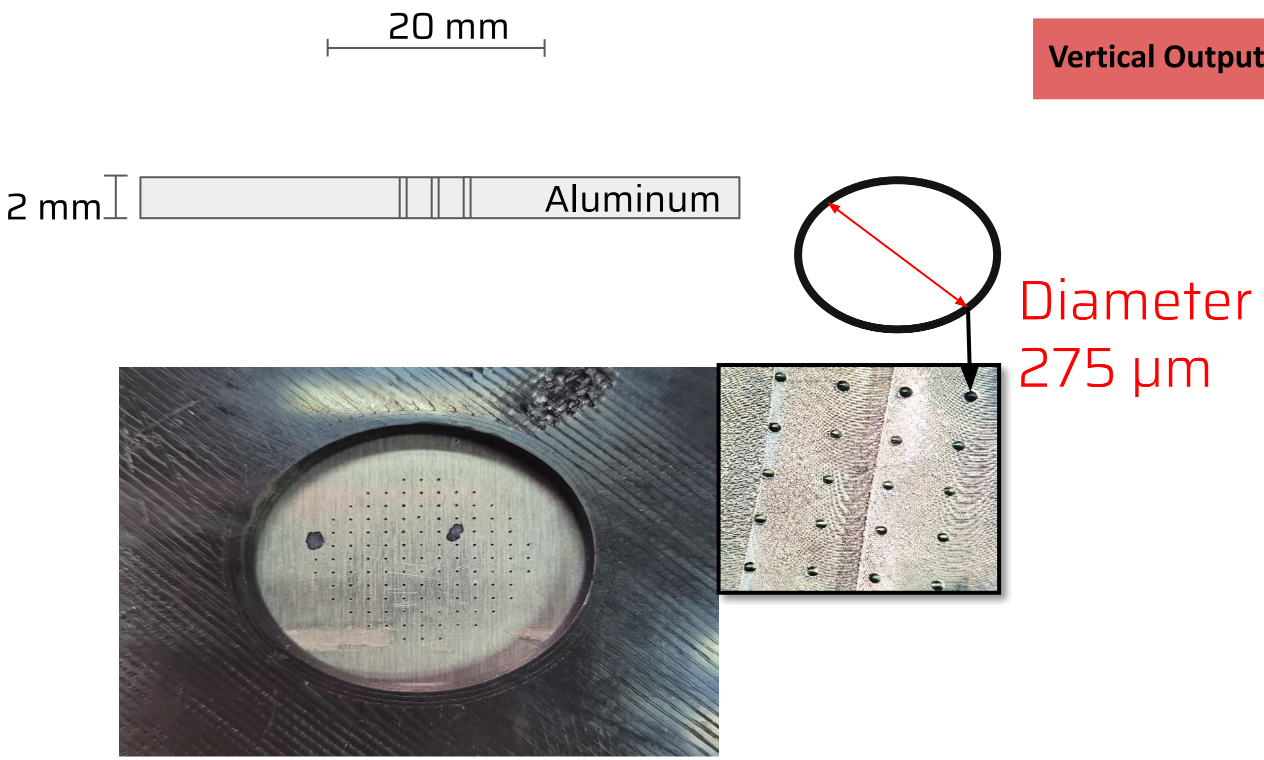


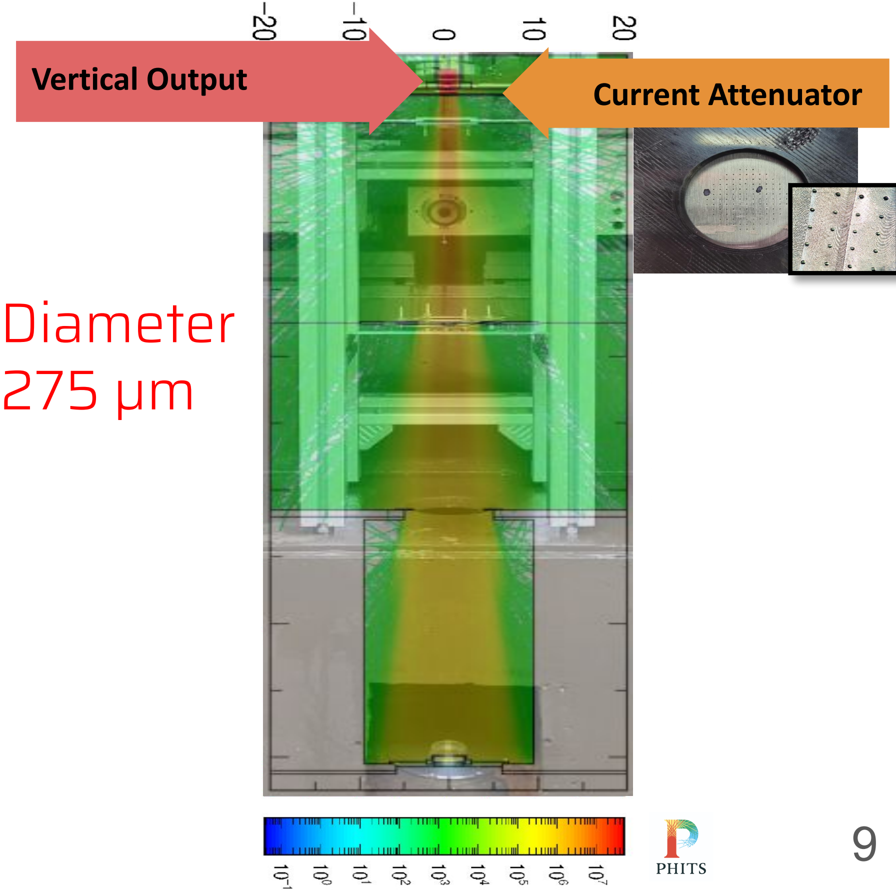

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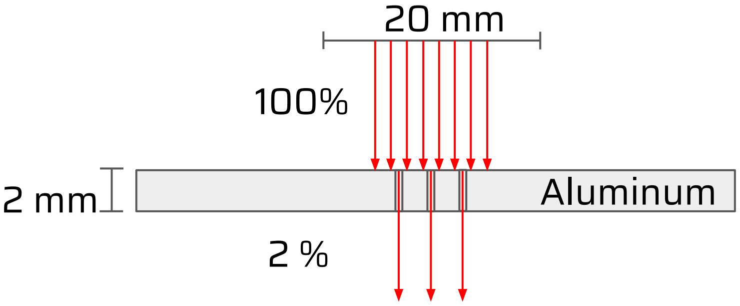
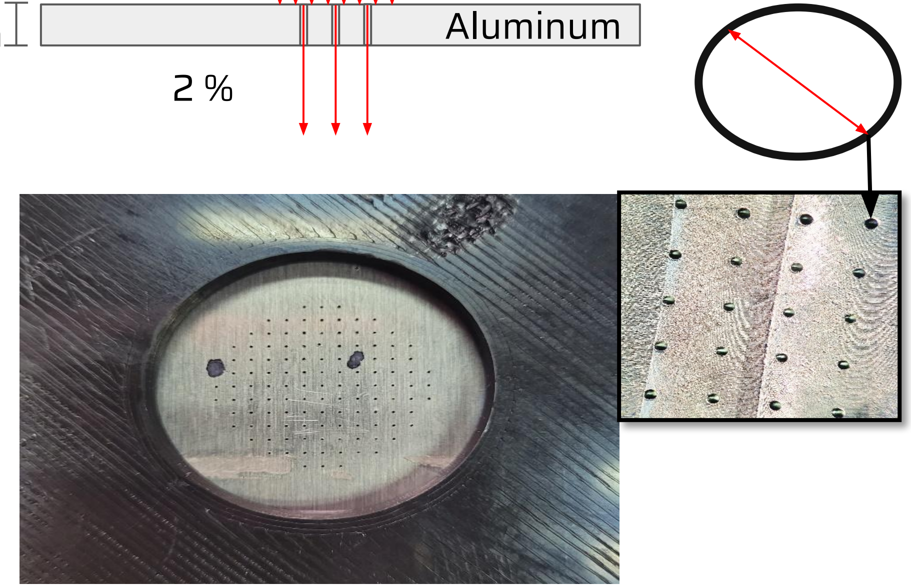
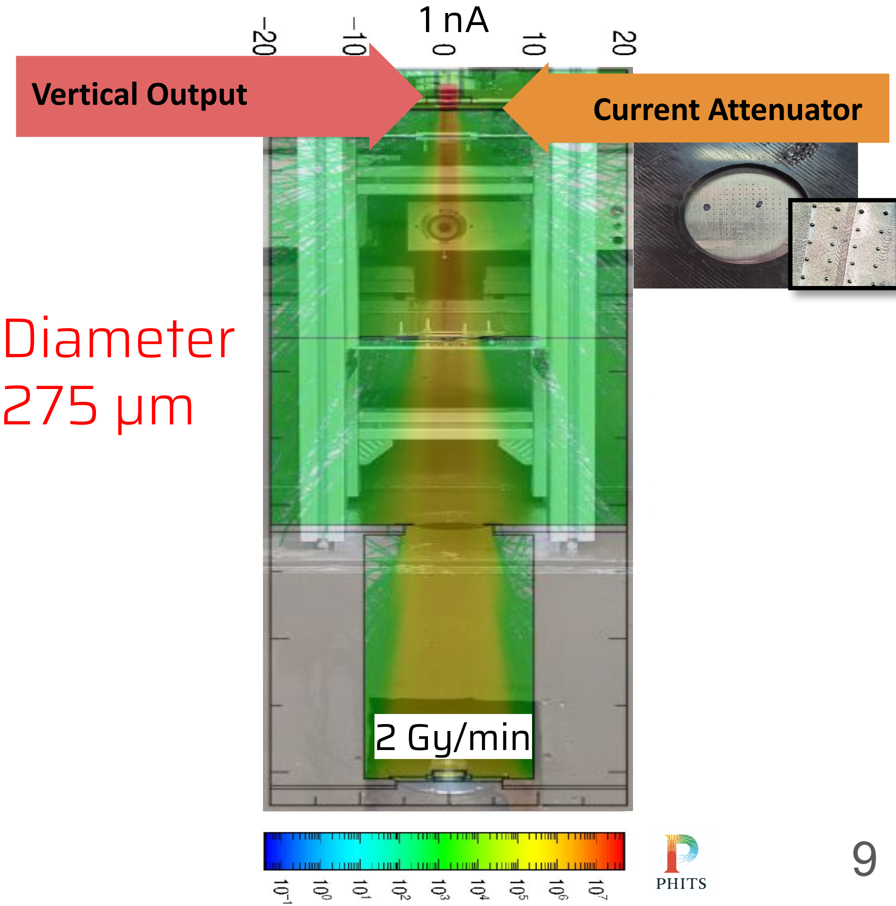


Diameter
275 µm



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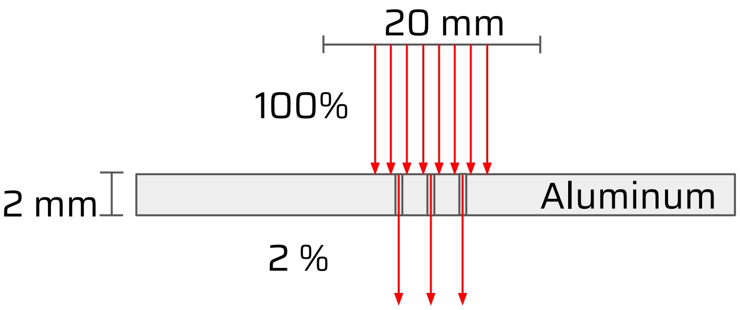


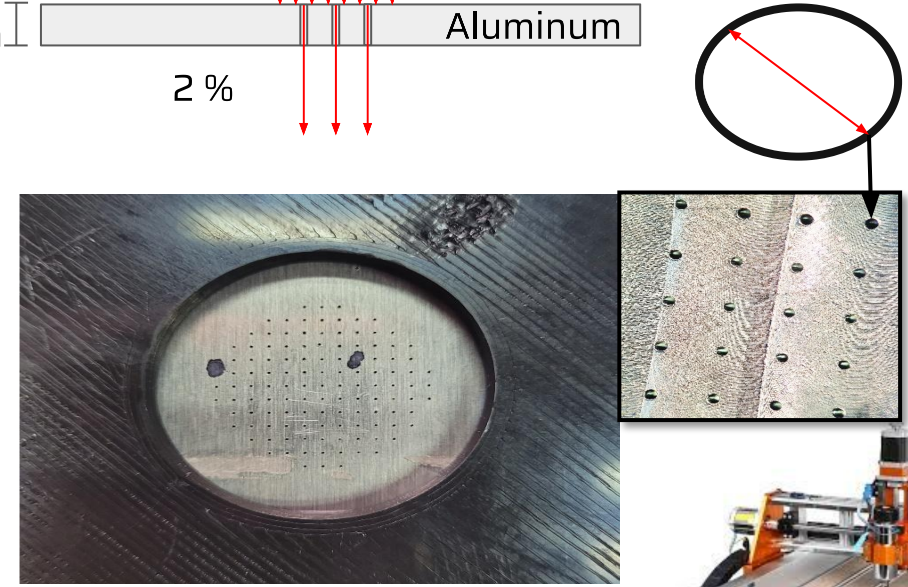

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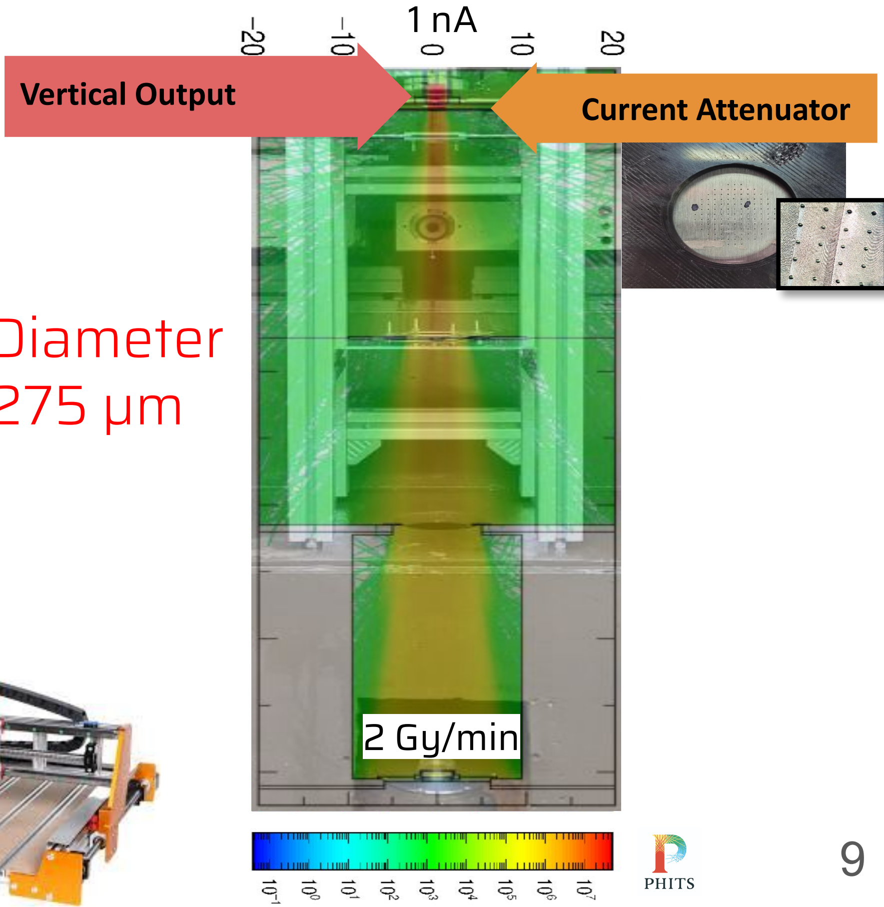

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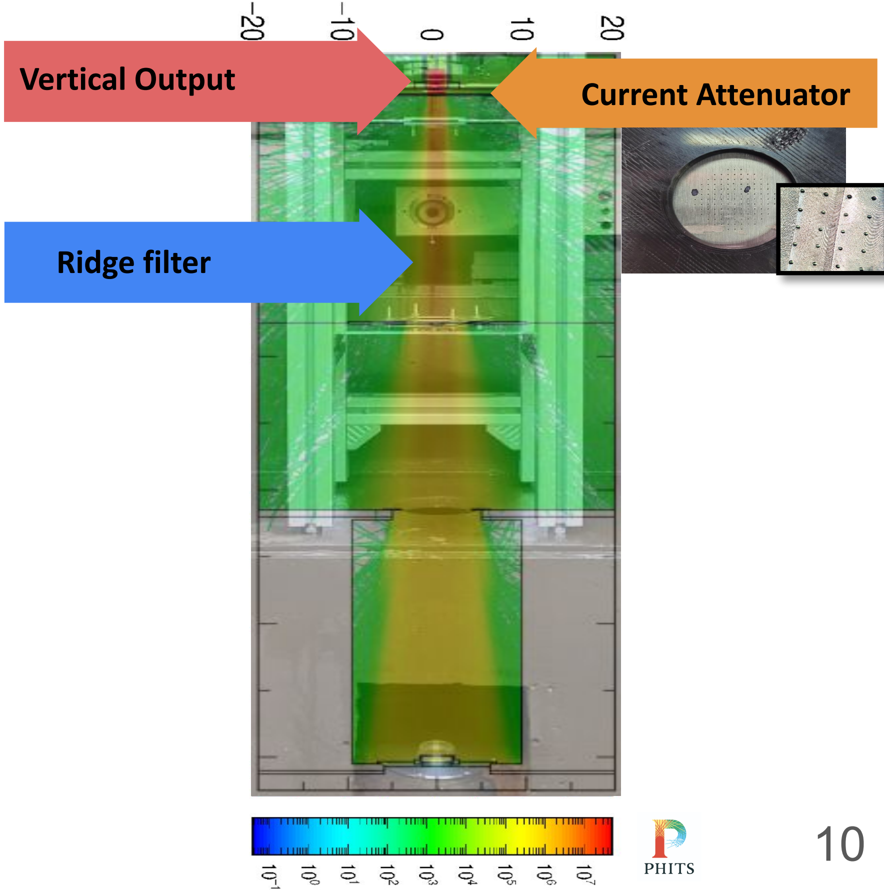

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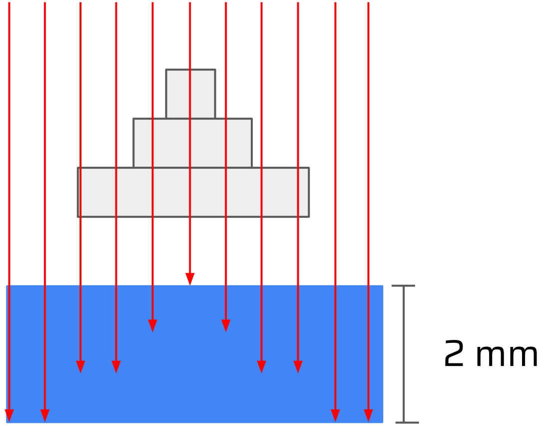


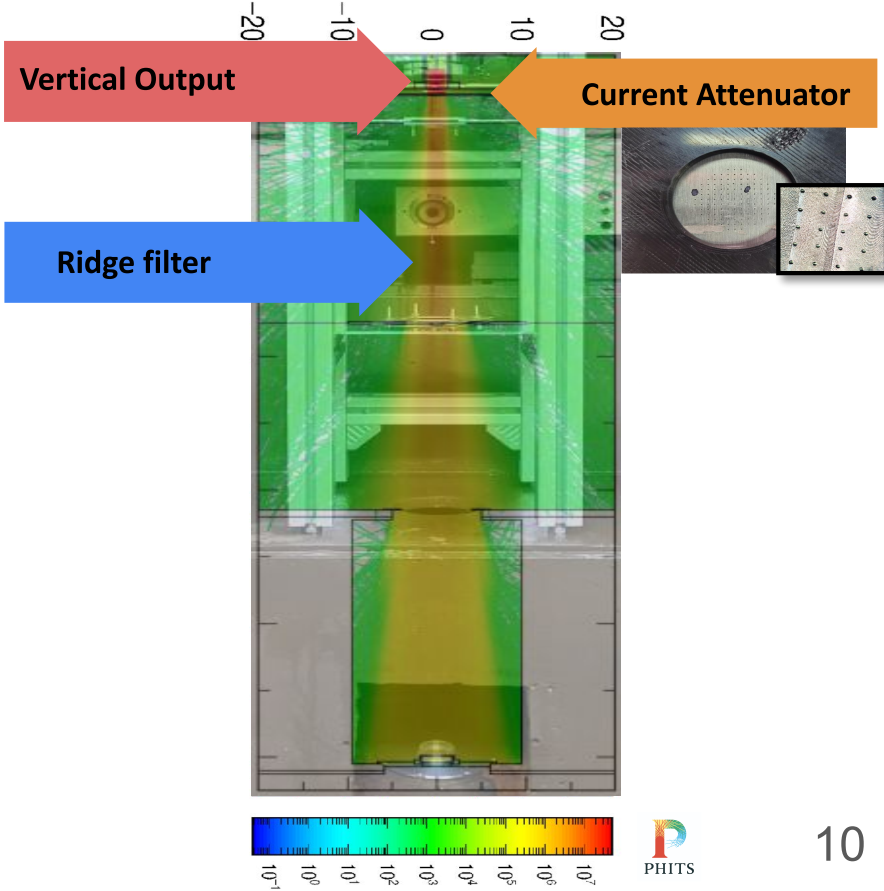

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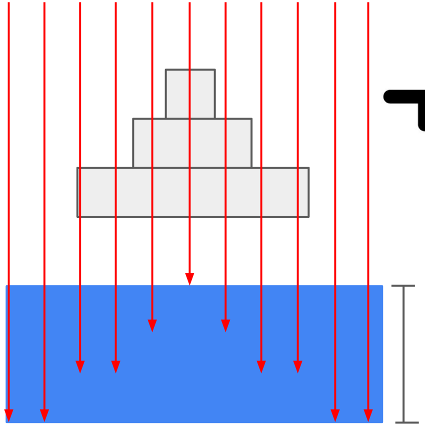


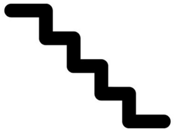


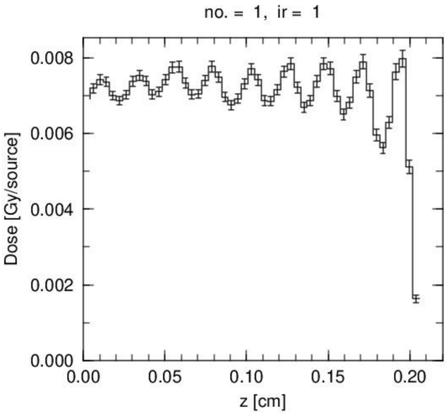


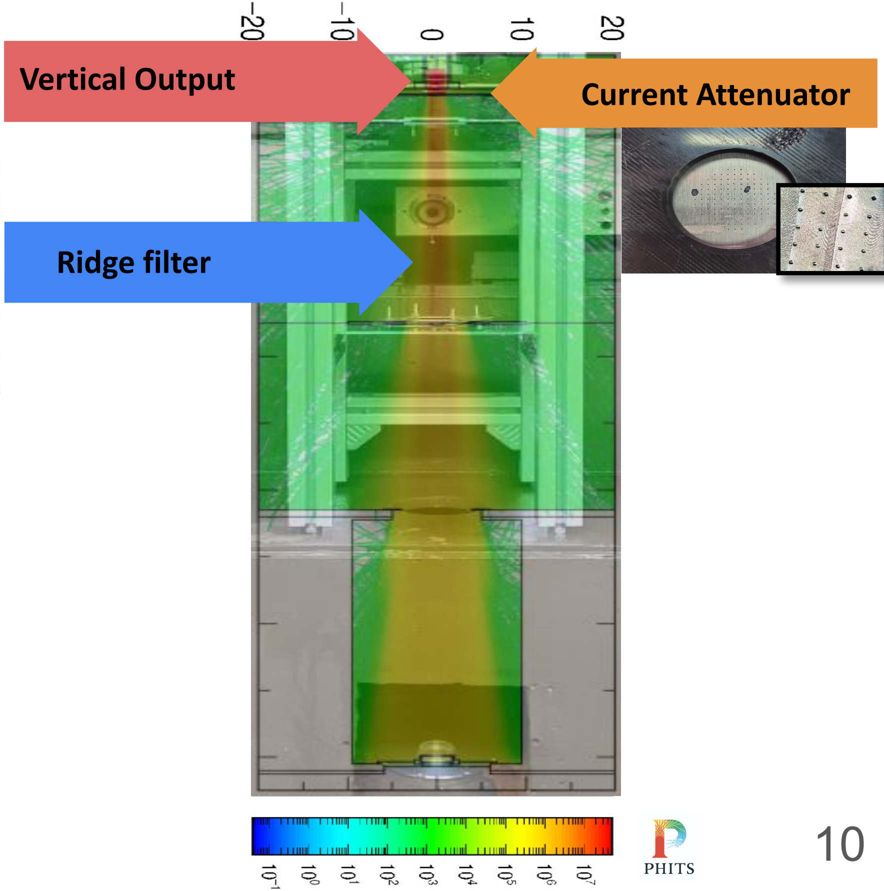

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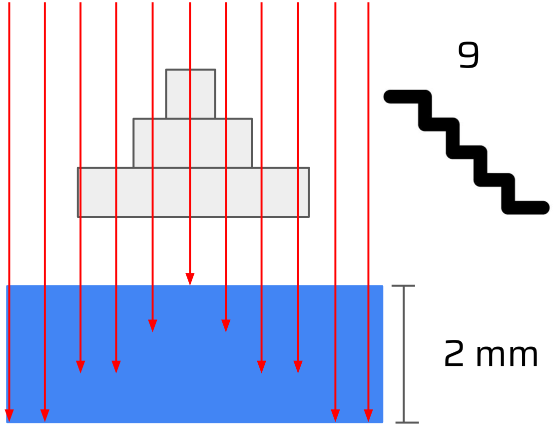
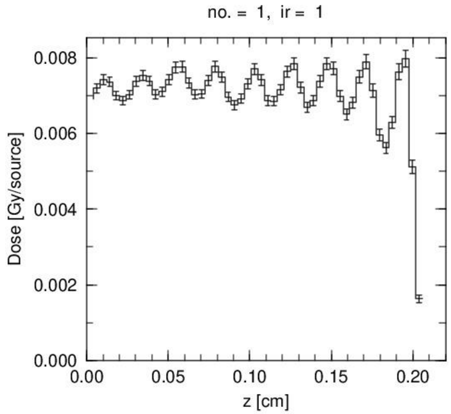
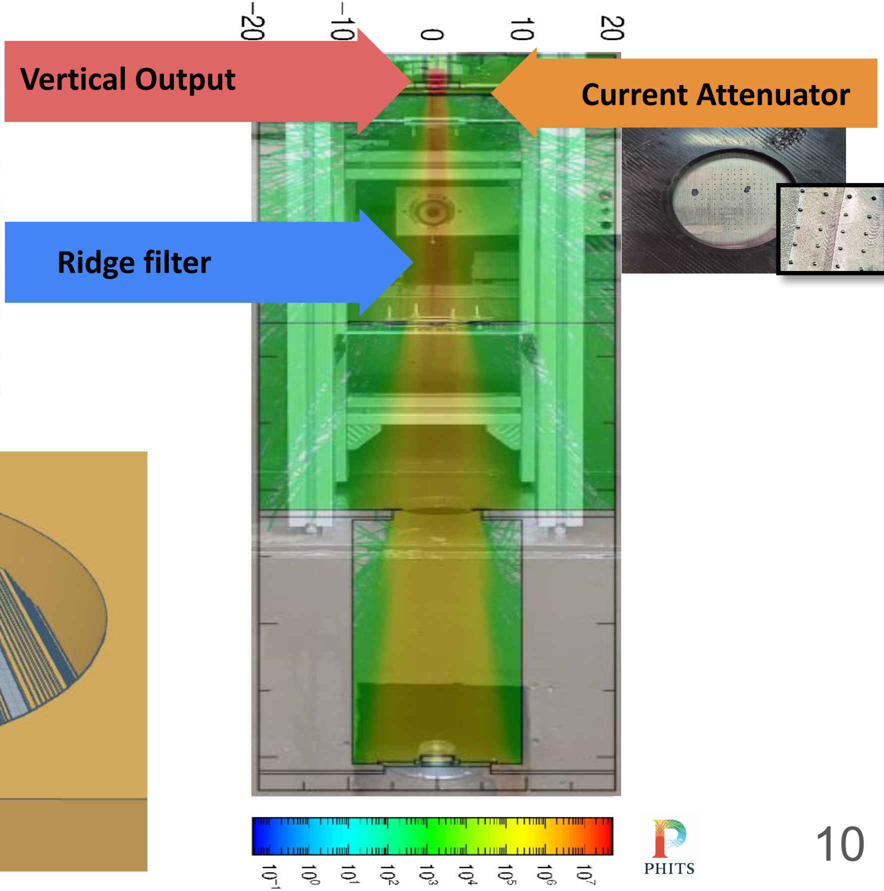
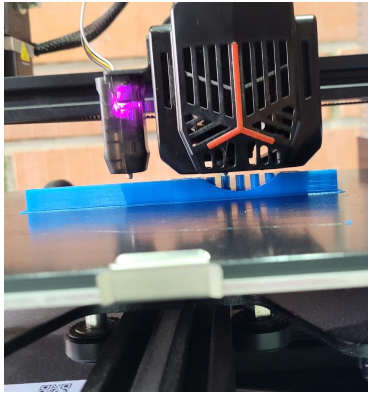
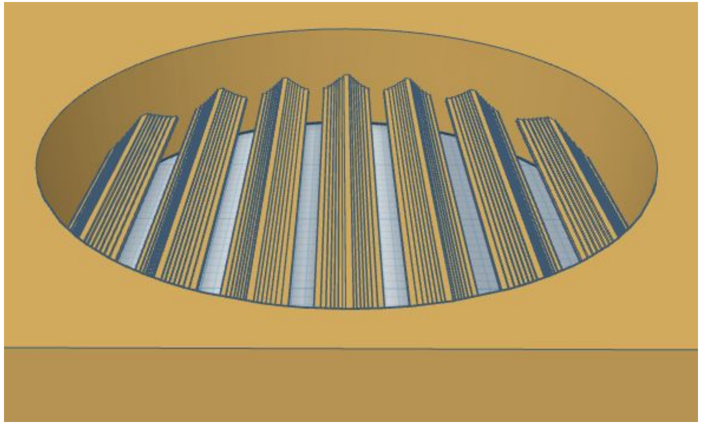


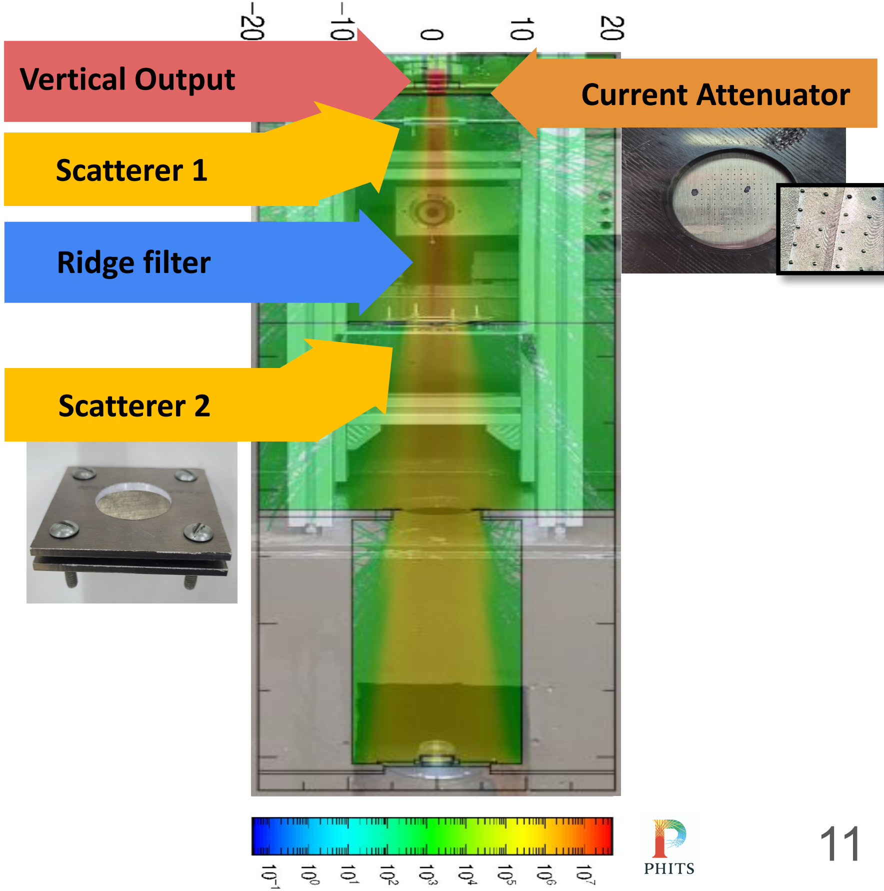





# Implementation of a Vertical Proton Beam

Double-Scattering system
Takada et al. (2002)



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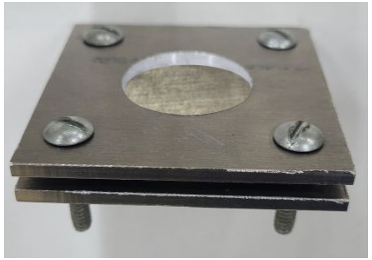

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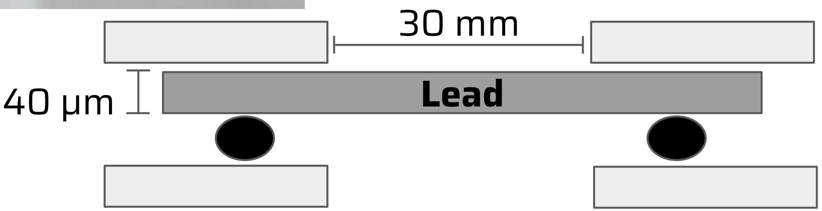


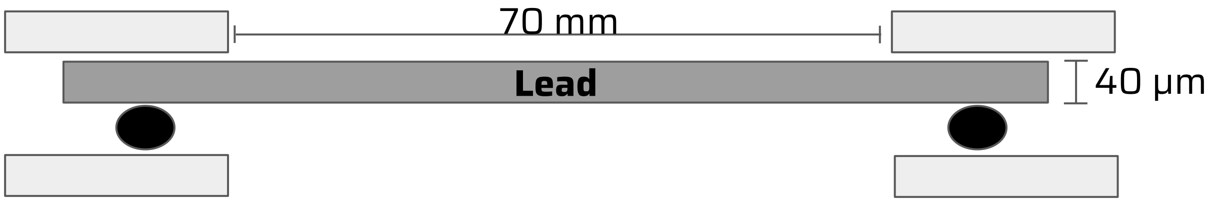


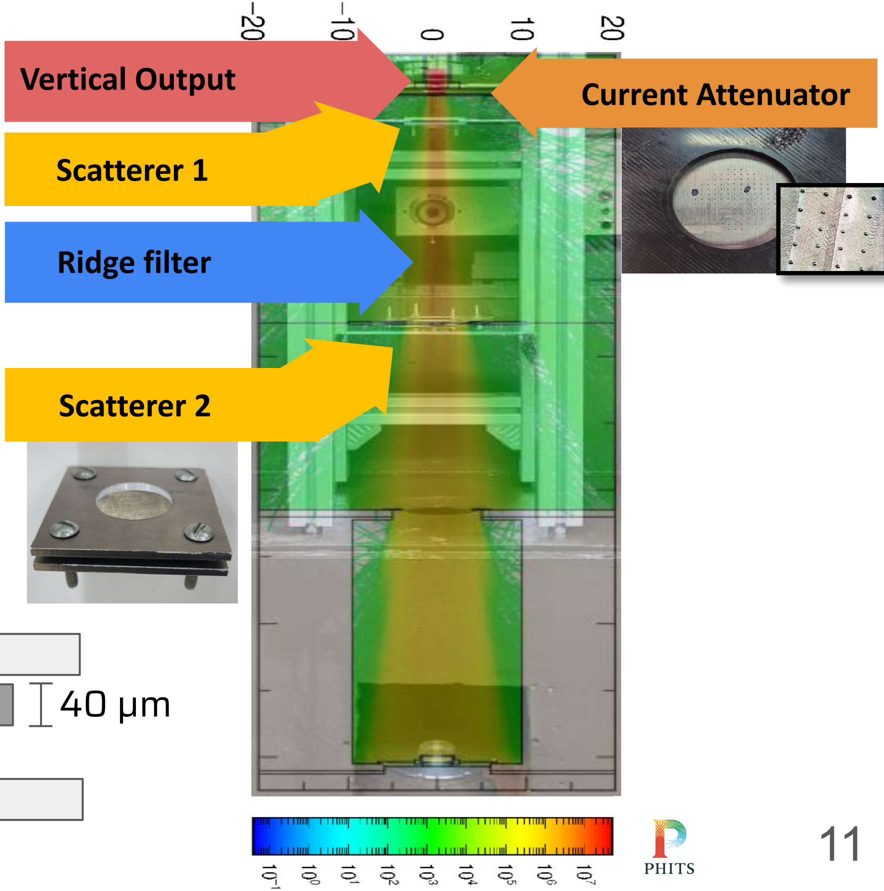


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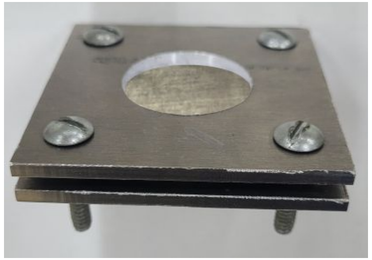

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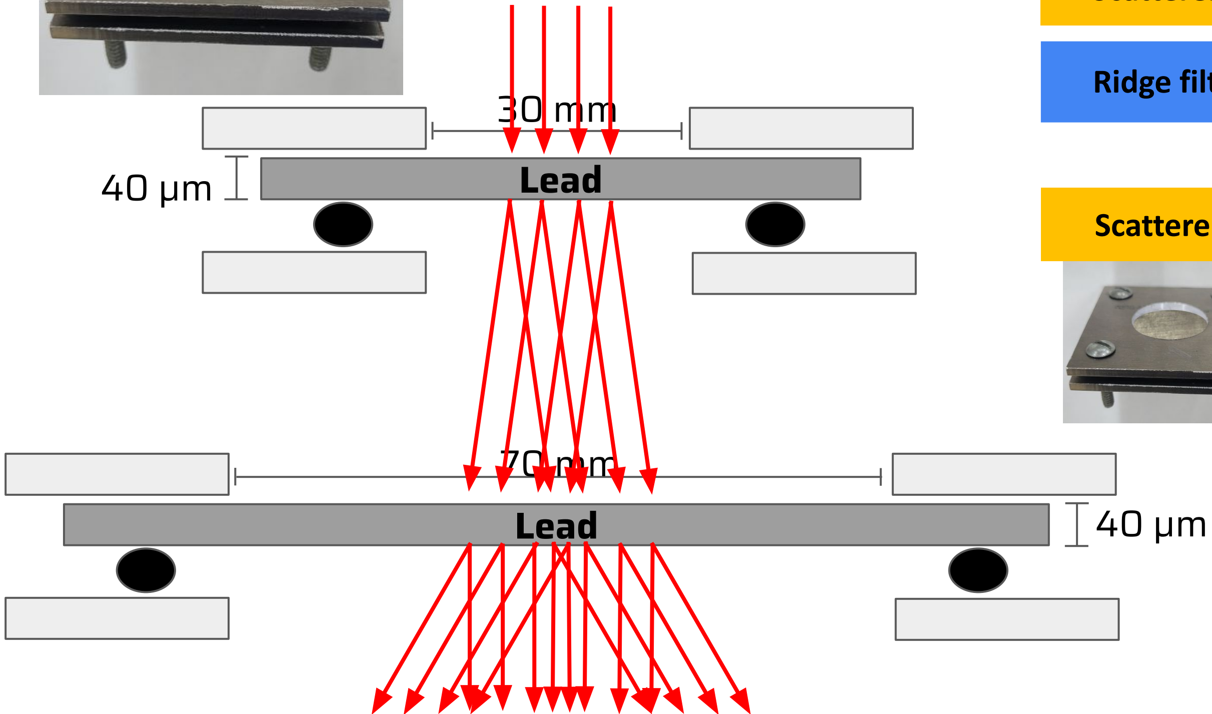


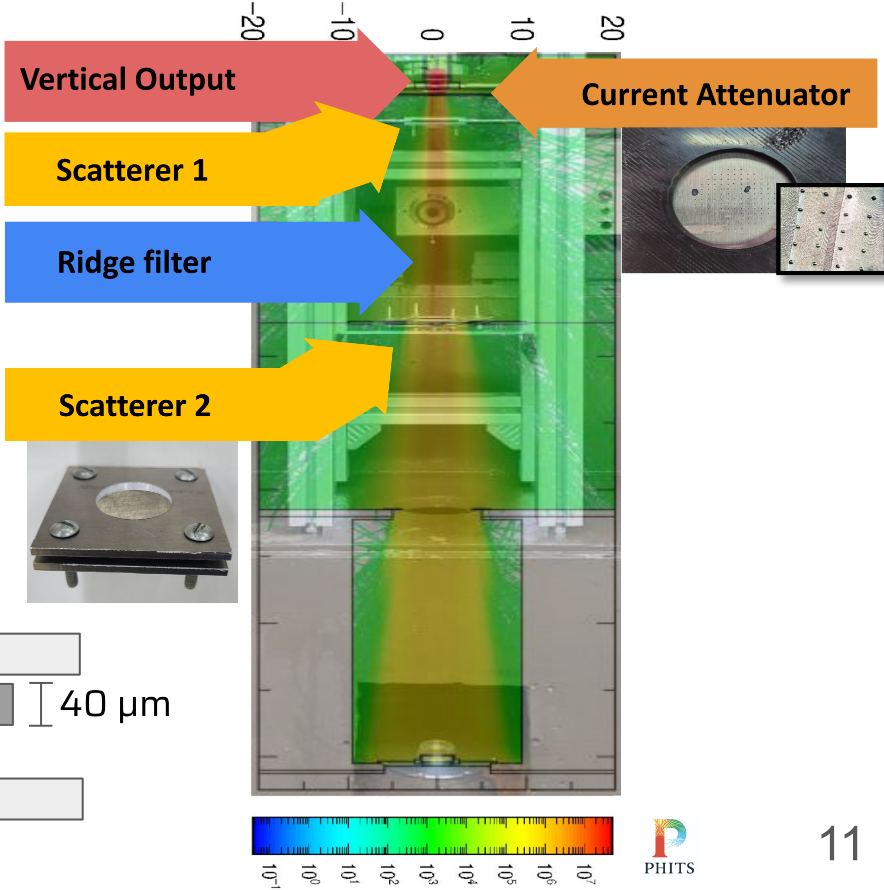

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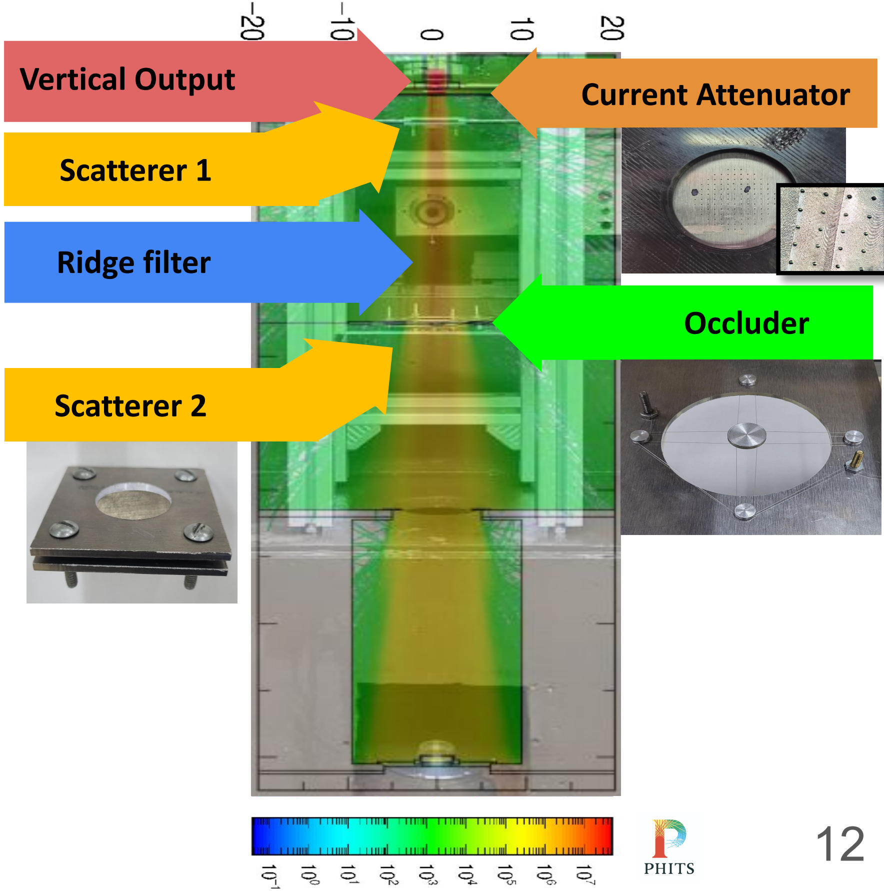

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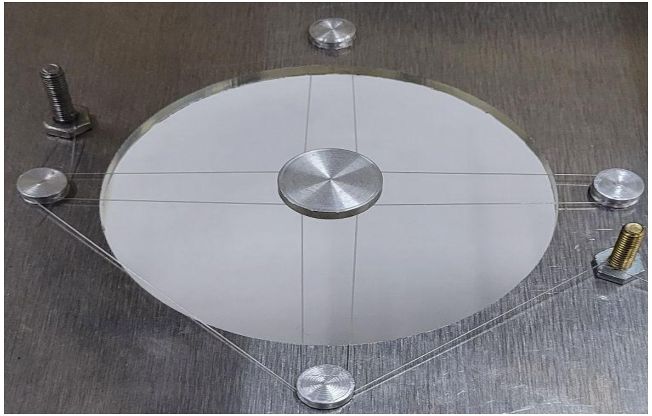

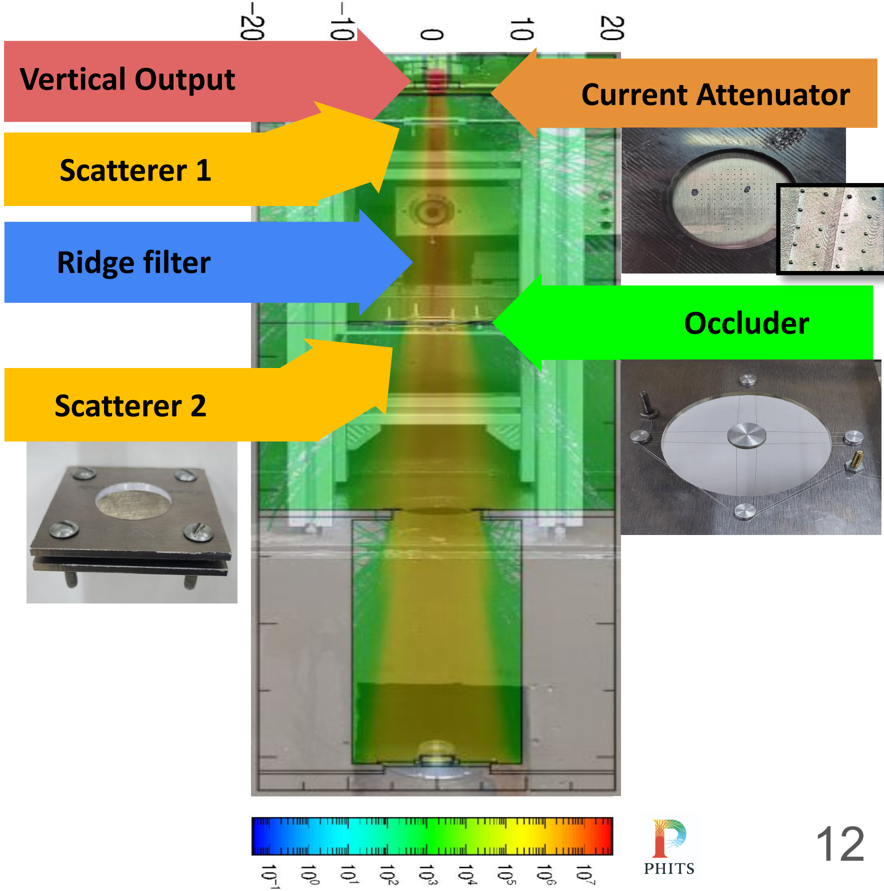

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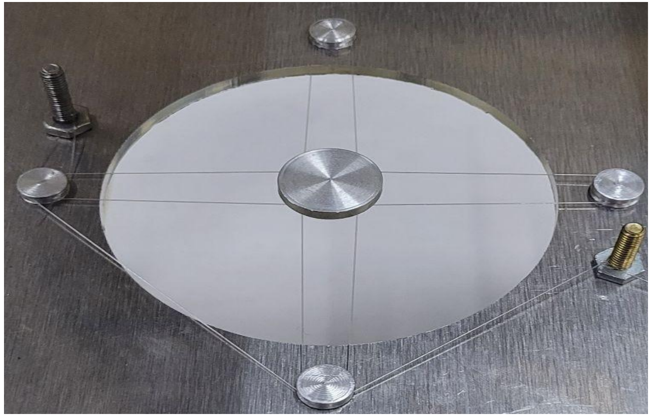
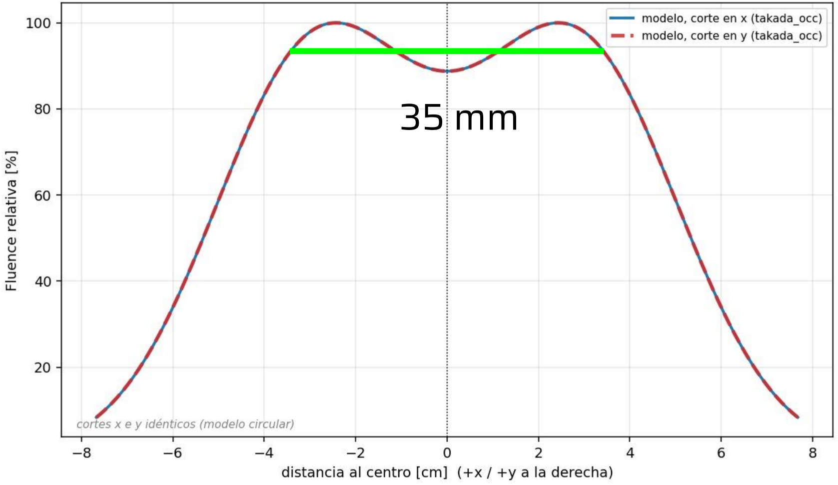
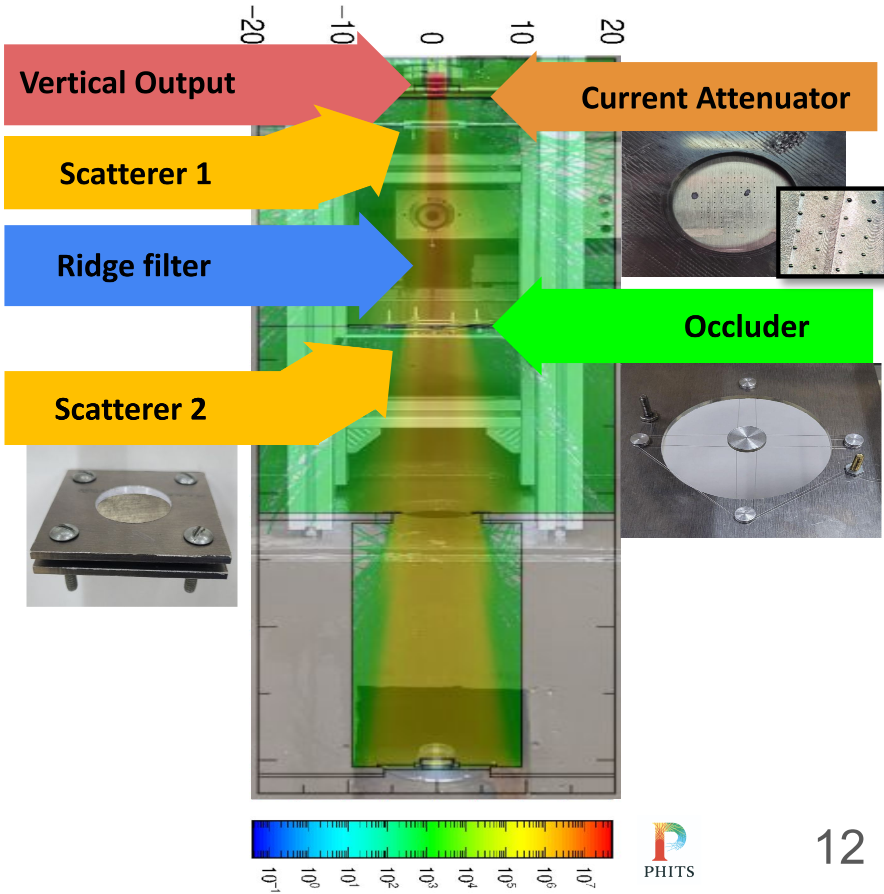
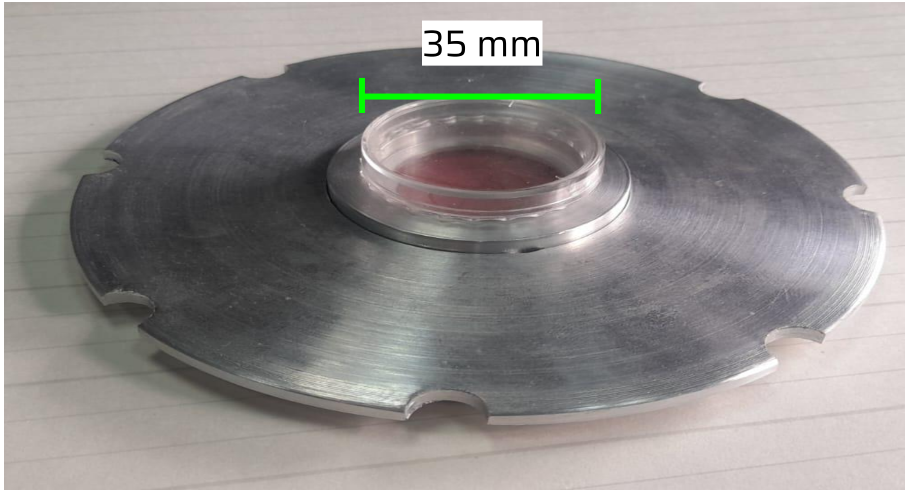
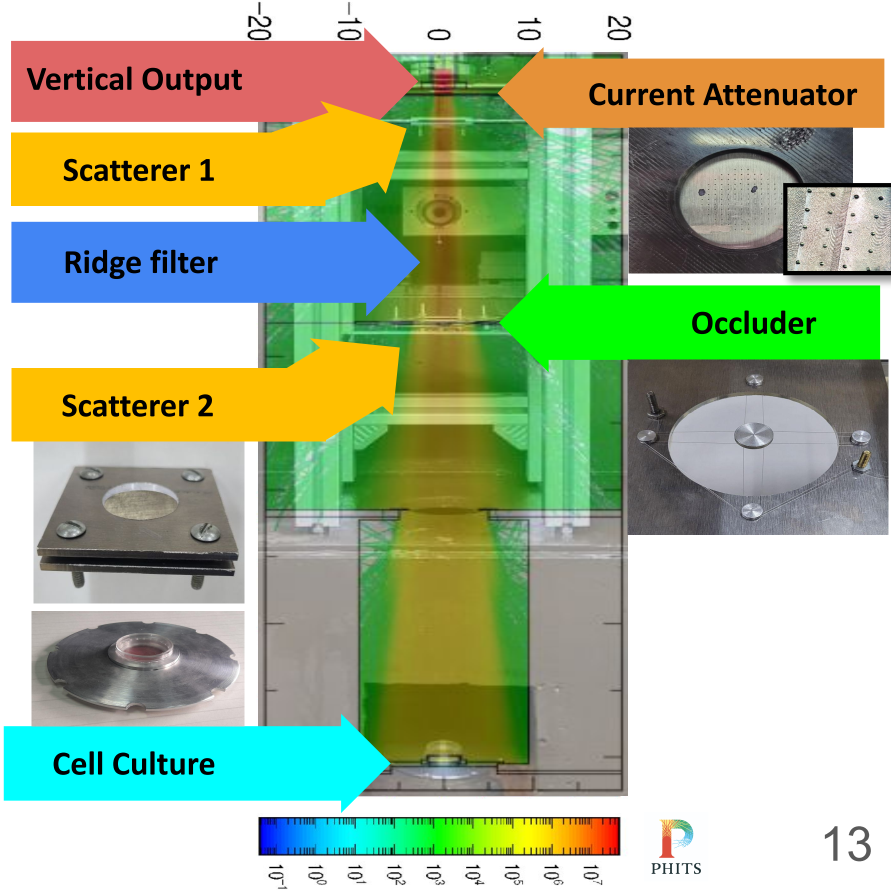




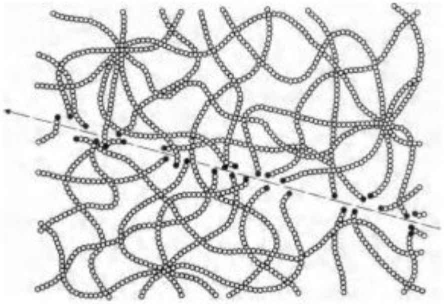
# Implementation of a Vertical Proton Beam

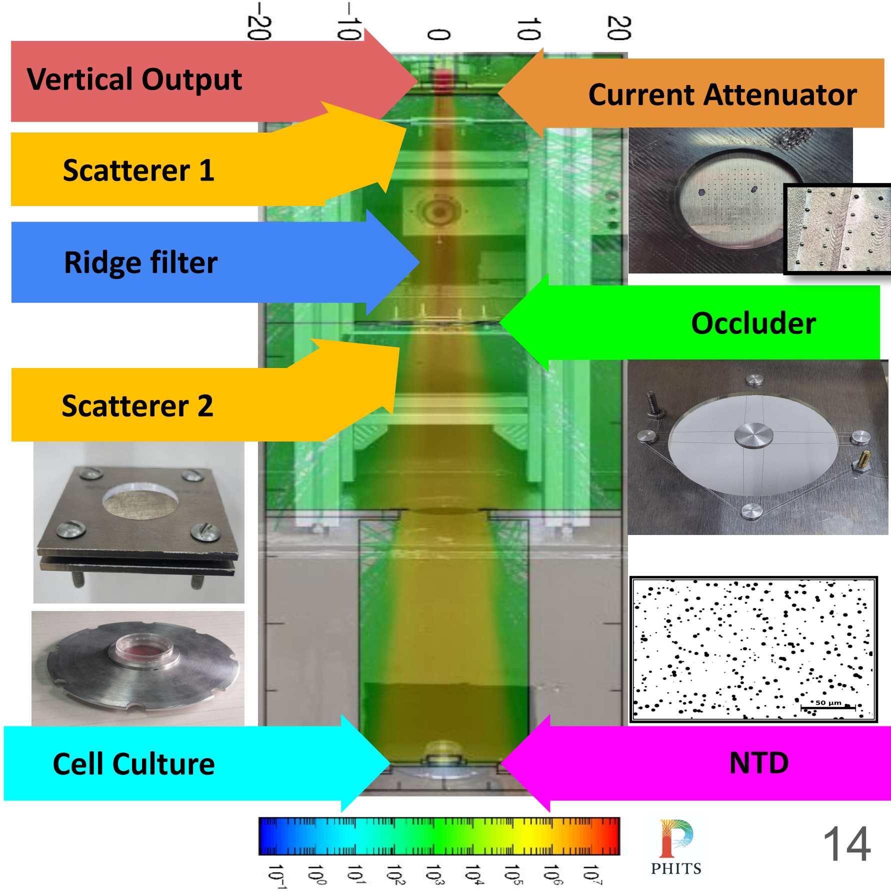


# Characterization of vertical proton beam

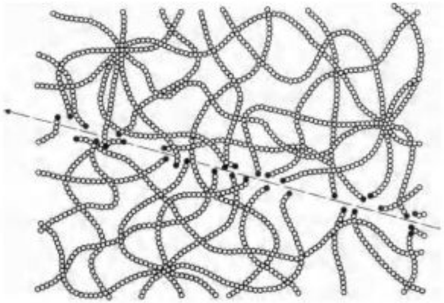
## nuclear track detectors (NTD)

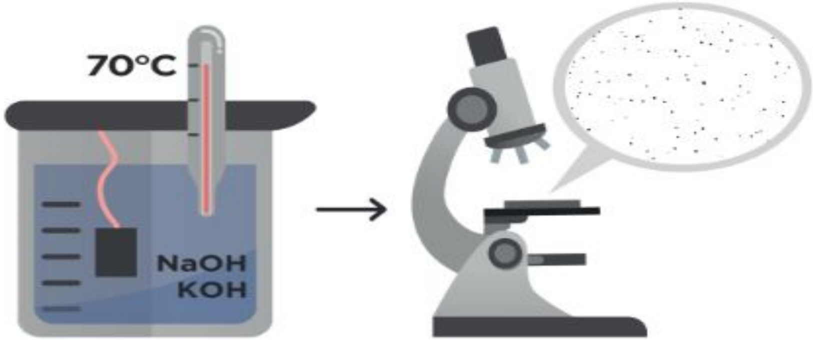


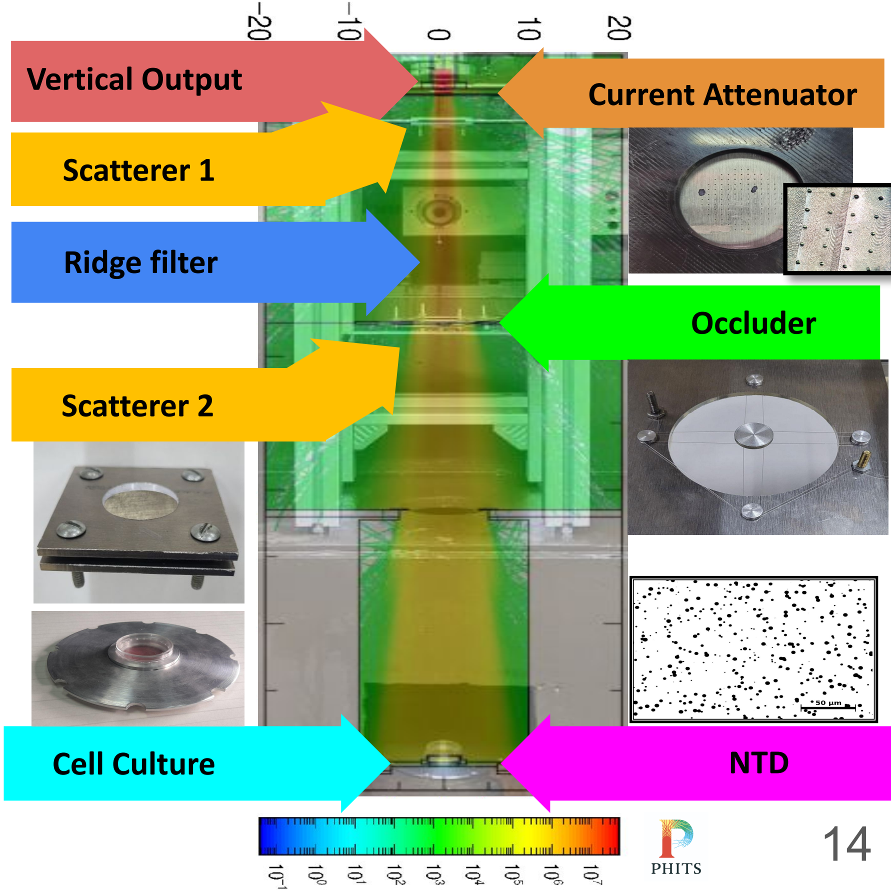


# Characterization of vertical proton beam

## nuclear track detectors (NTD)

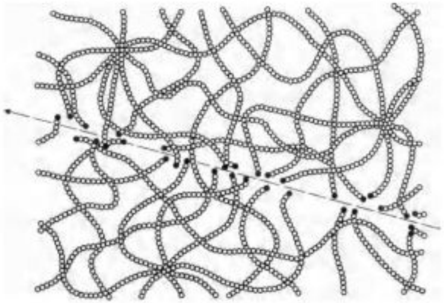


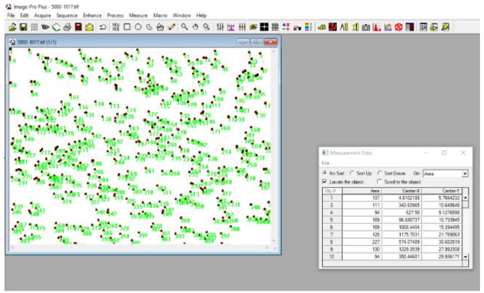


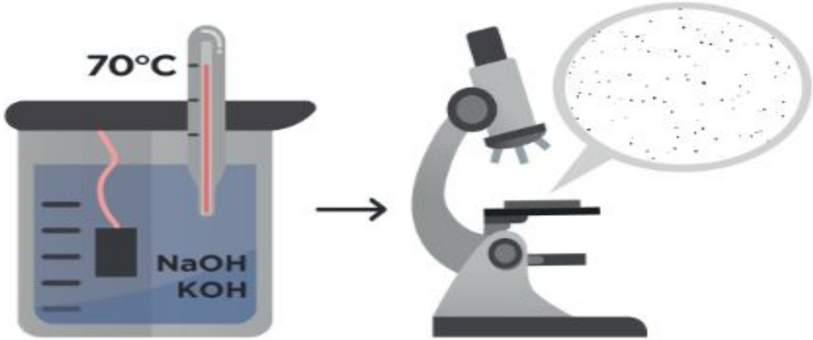



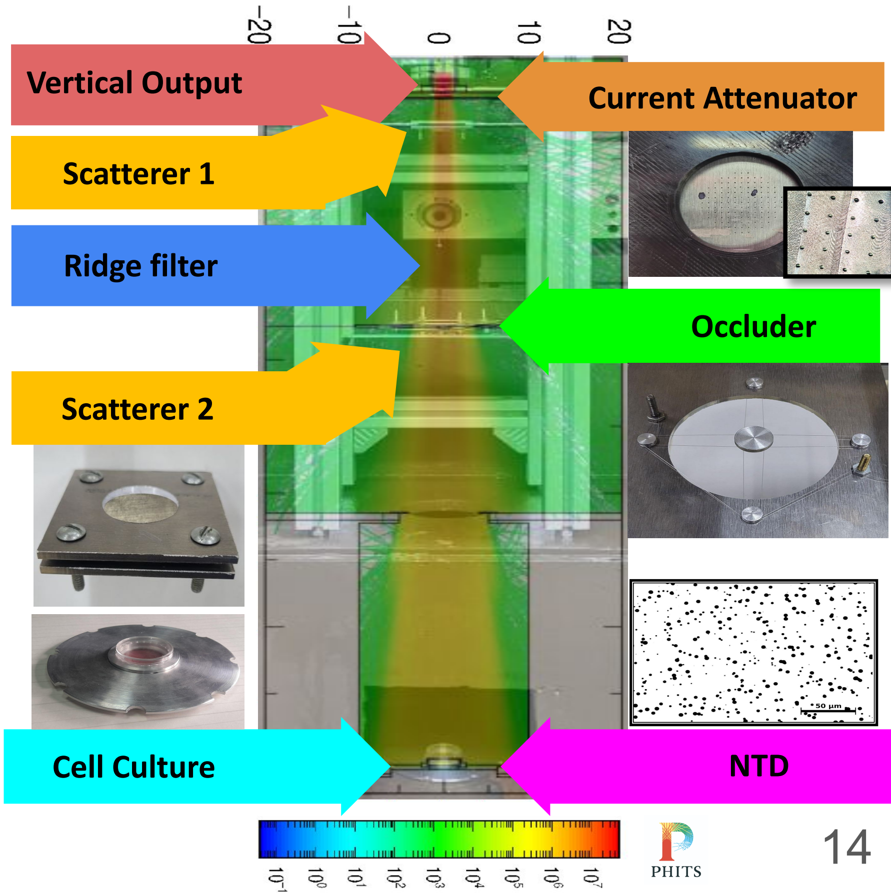
# Characterization of vertical proton beam

## nuclear track detectors (NTD)

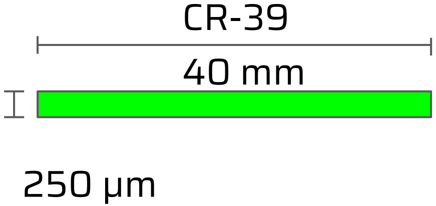






# Set up Characterization methodology



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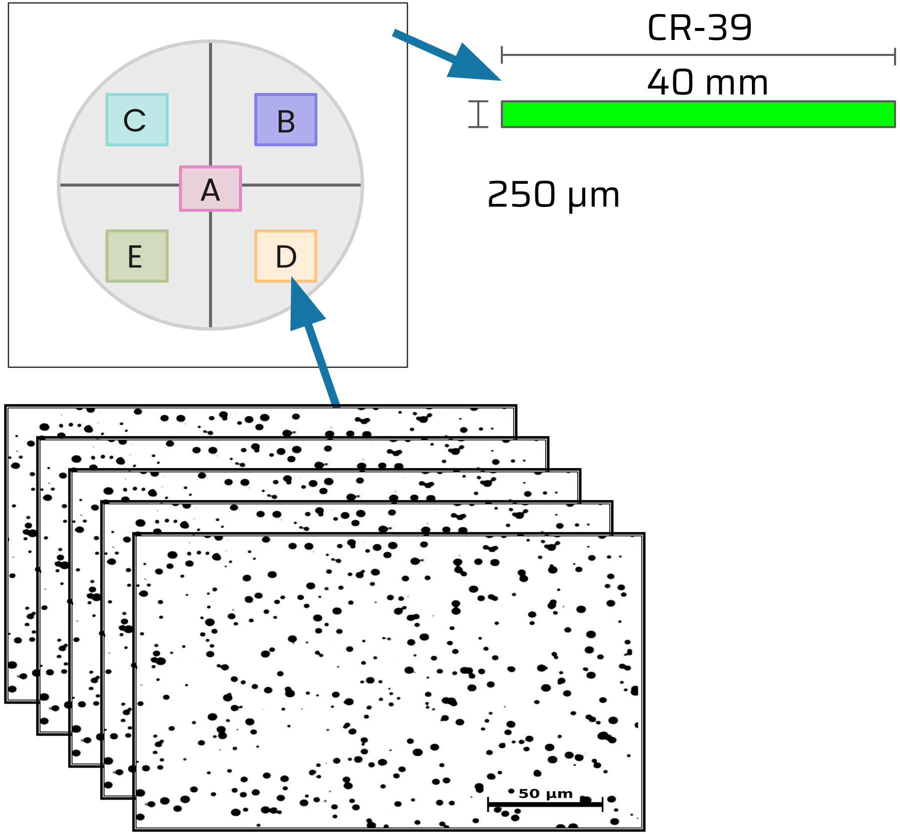
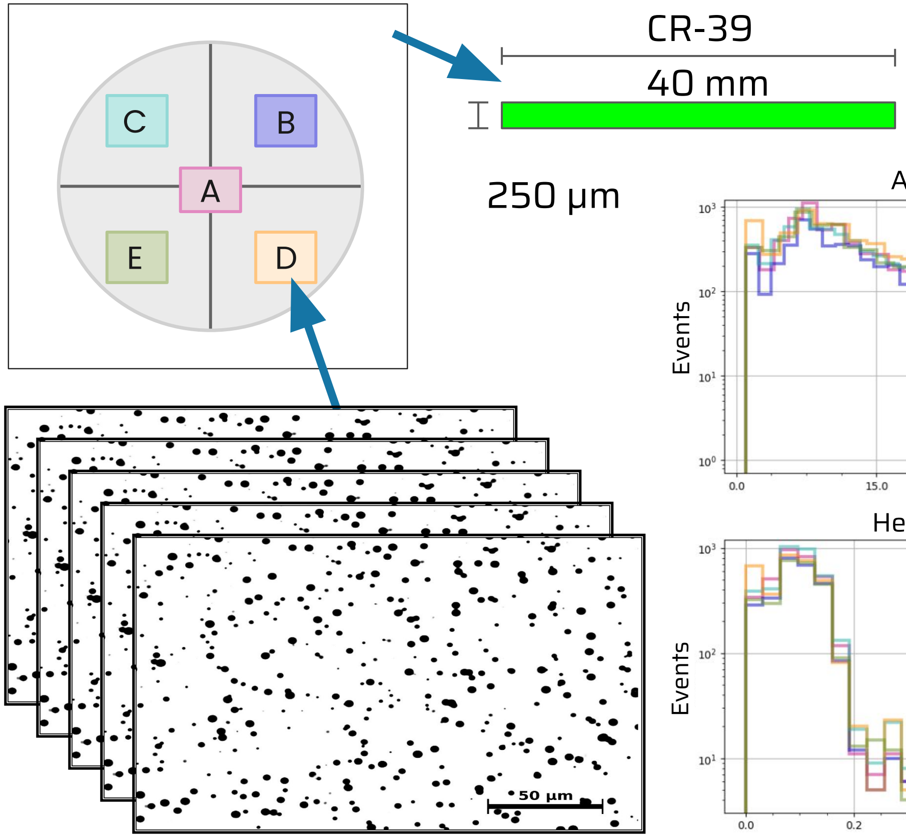
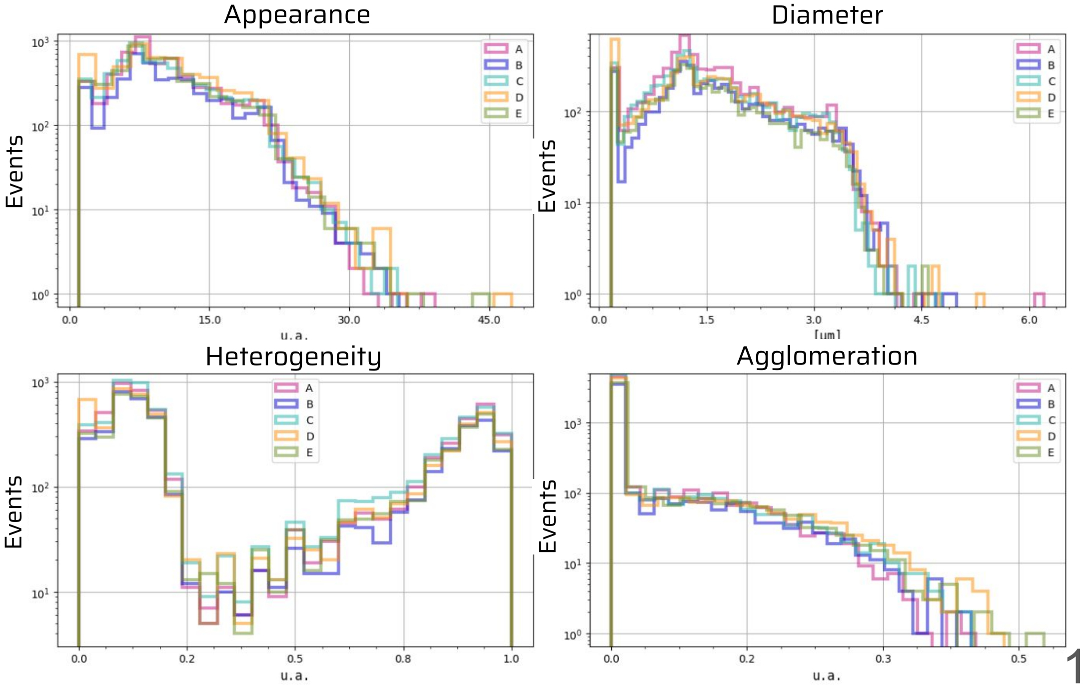


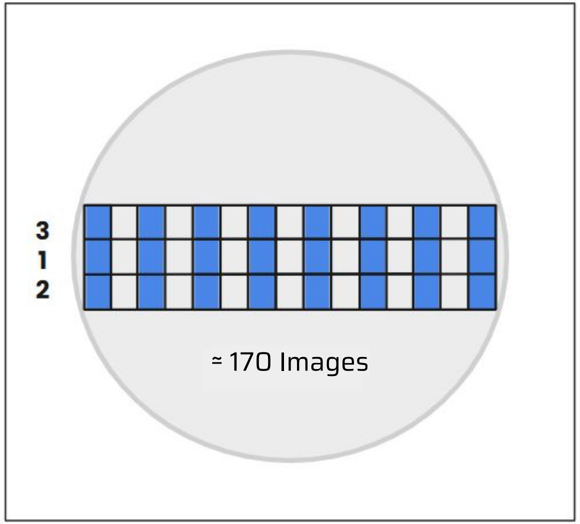
# Set up Characterization methodology



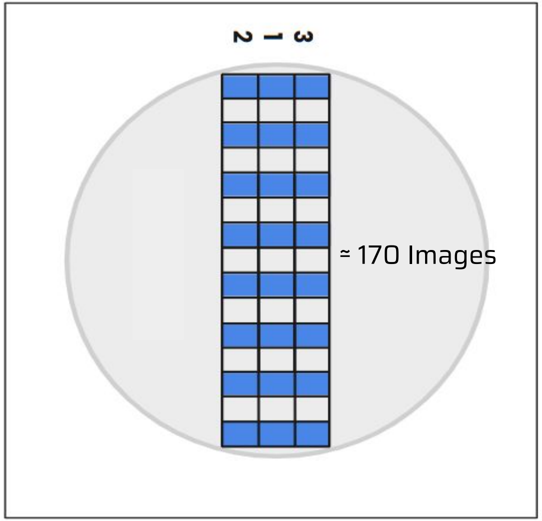



# Spatial uniformity of vertical proton beam

horizontal

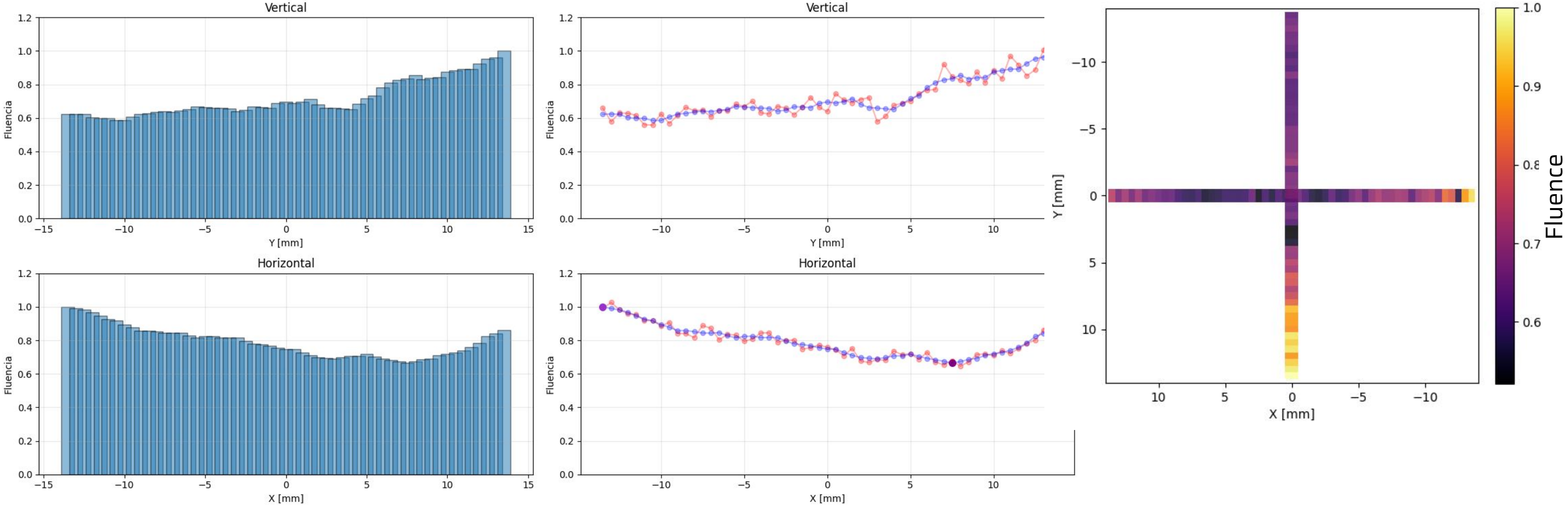



vertical



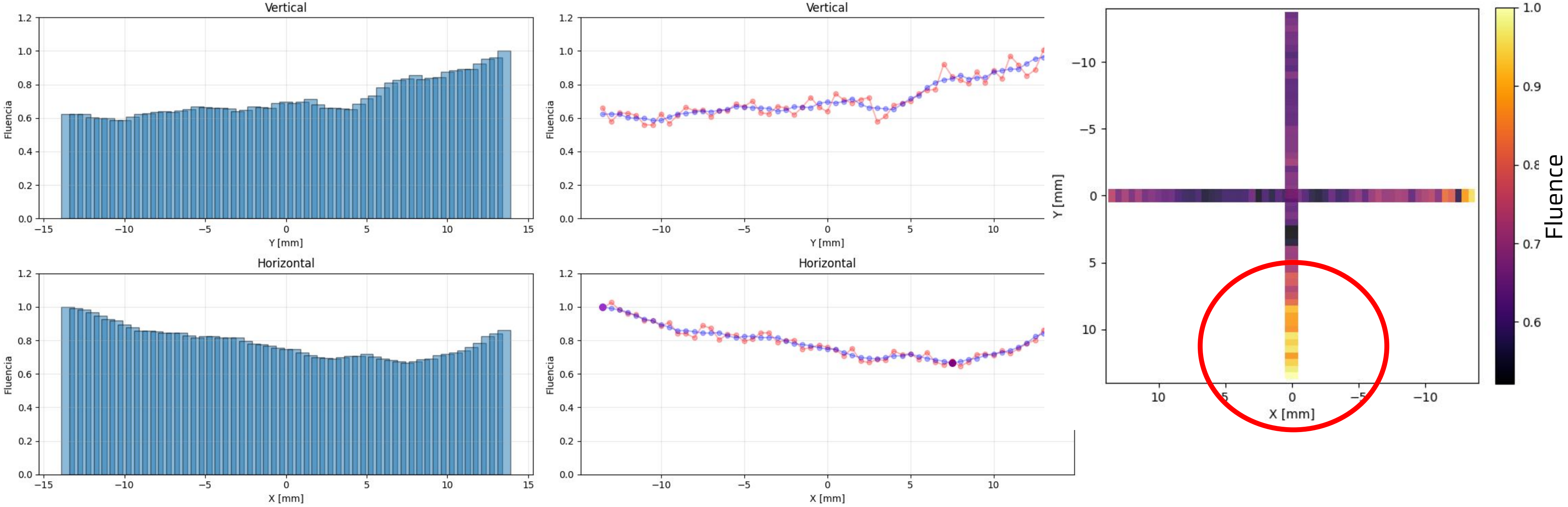
# Spatial uniformity of vertical proton beam

Normalized Fluence



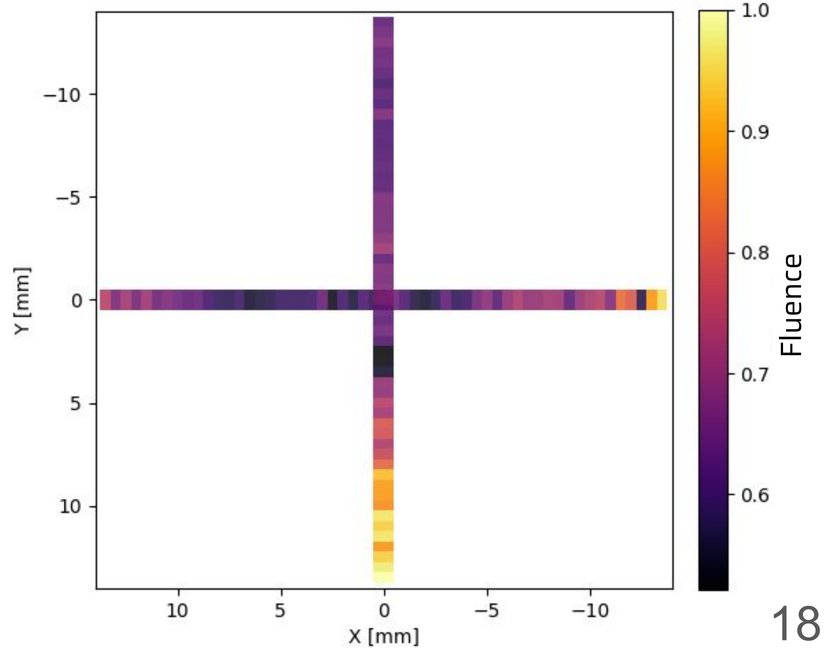
# Spatial uniformity of vertical proton beam

Normalized Fluence



# Spatial uniformity of vertical proton beam

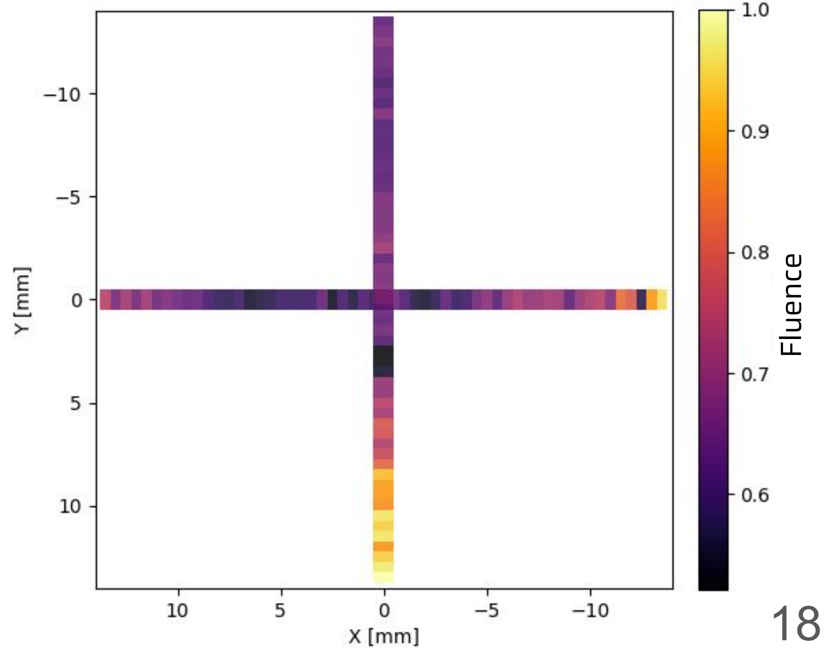
Radiotherapy DVH
Dose-Volume Histogram



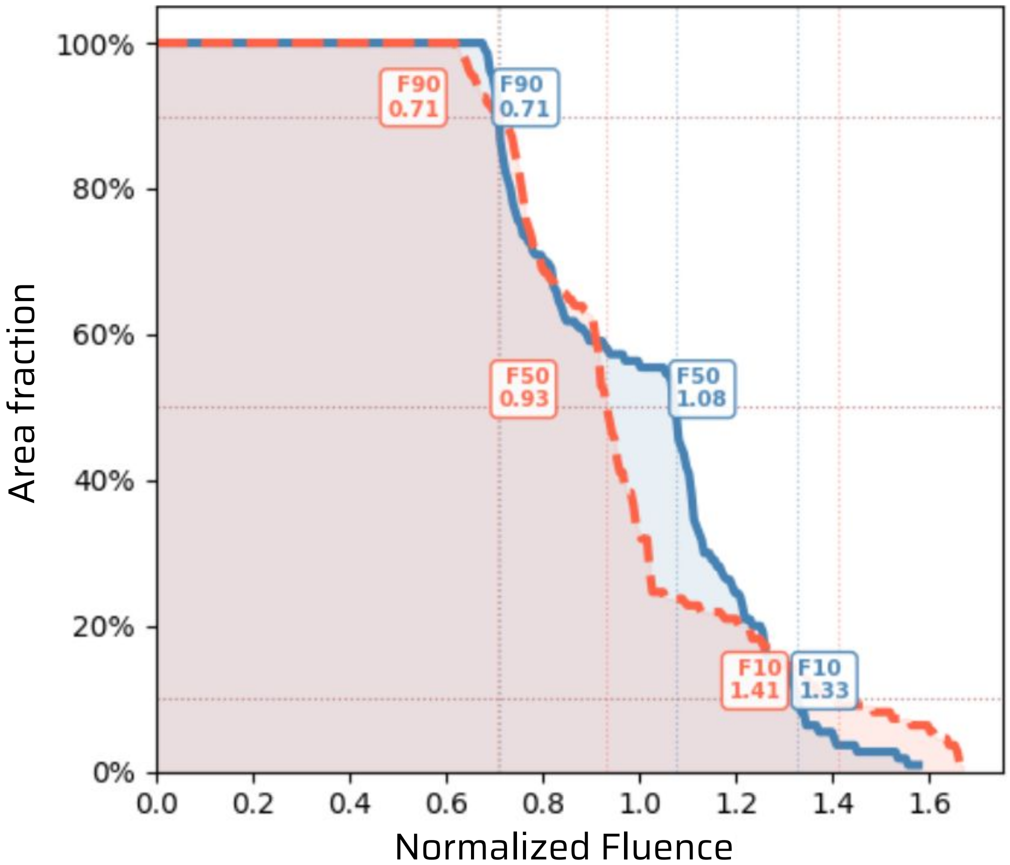
# Spatial uniformity of vertical proton beam

Radiotherapy DVH
Dose-Volume Histogram

Fluence-Area Histogram “FAH”

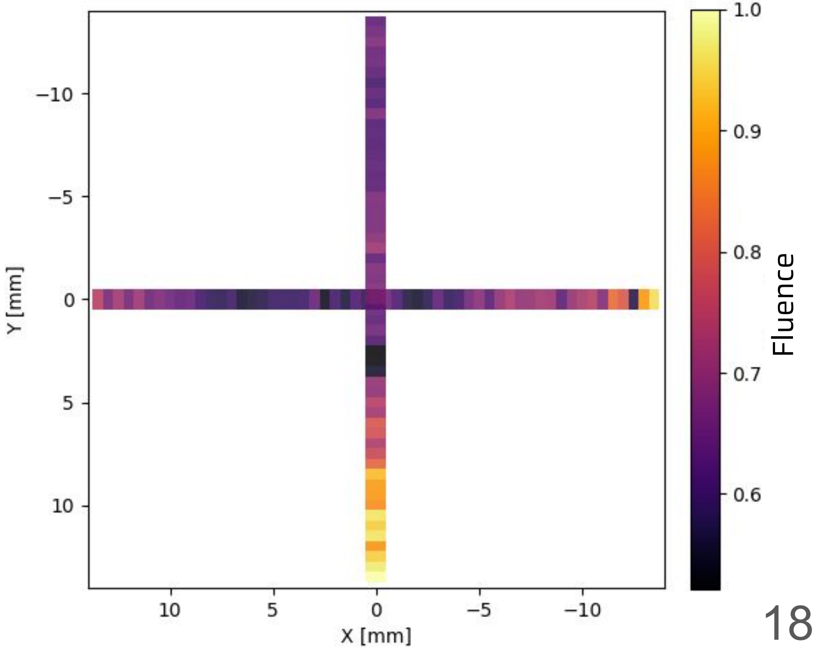


# Spatial uniformity of vertical proton beam

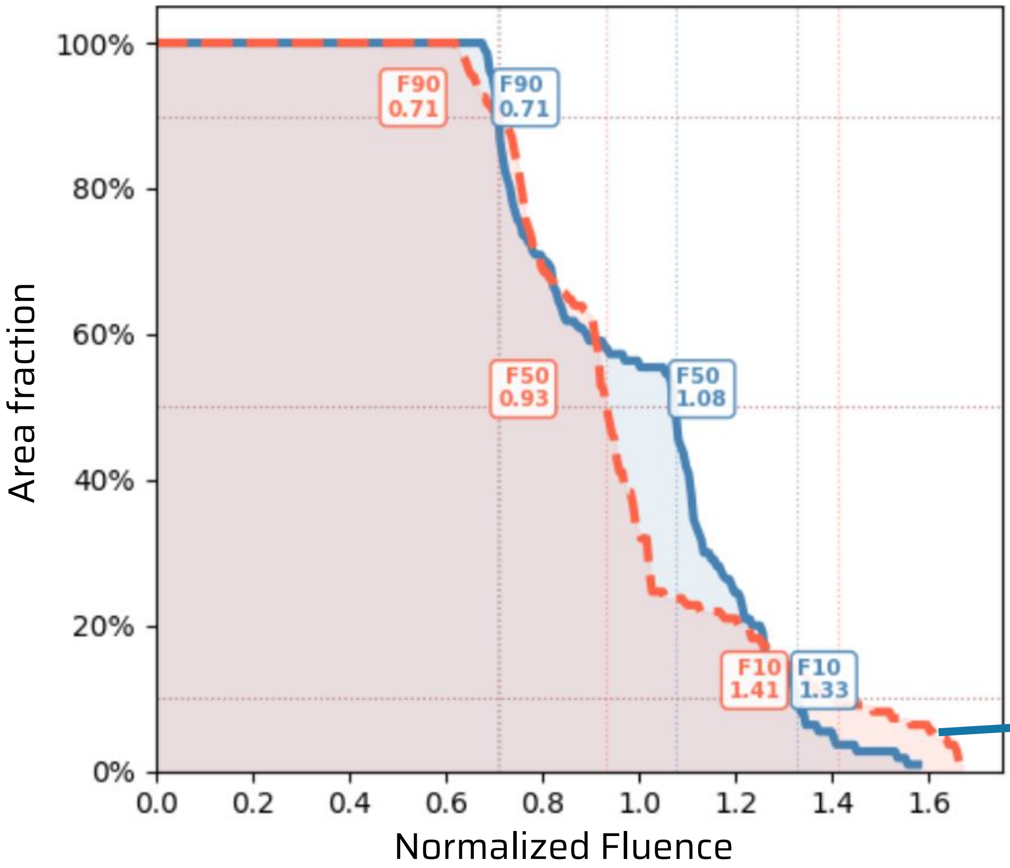



Radiotherapy DVH
Dose-Volume Histogram

Fluence-Area Histogram “FAH”

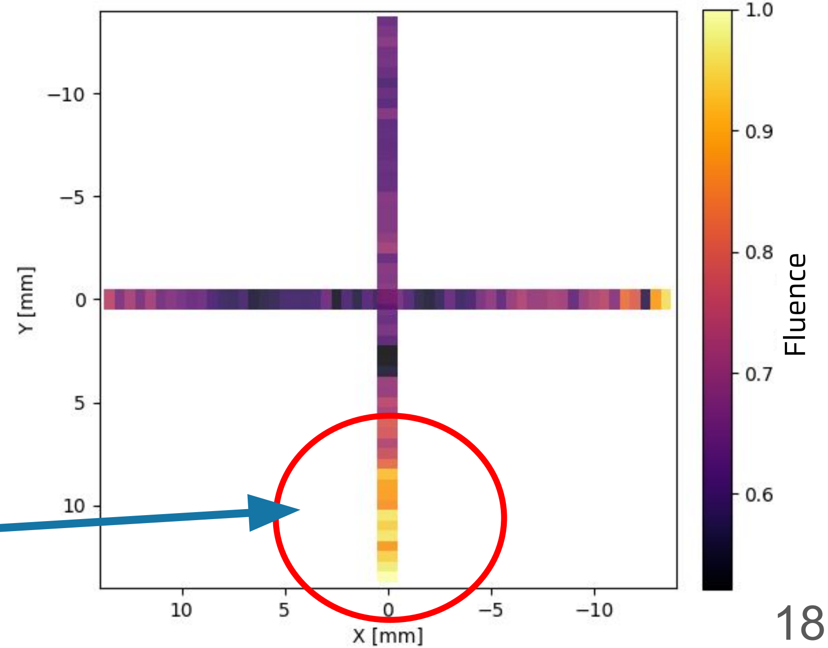


# Spatial uniformity of vertical proton beam



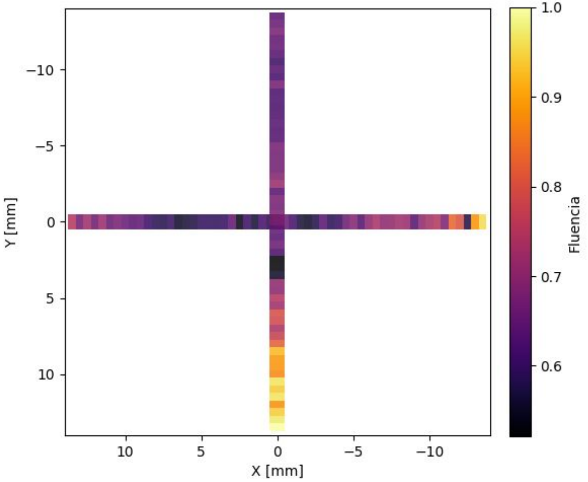

Radiotherapy DVH
Dose-Volume Histogram

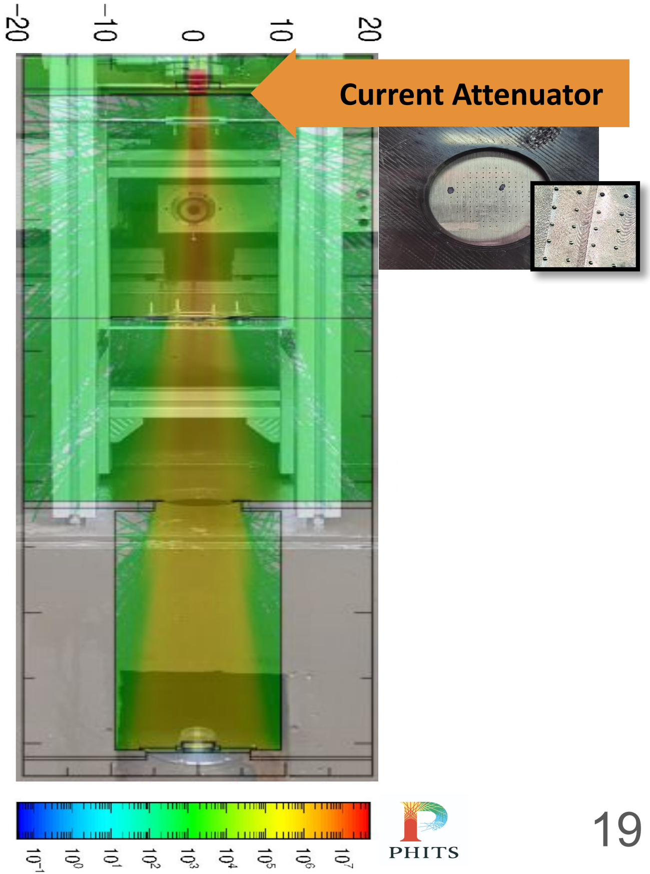
Fluence-Area Histogram “FAH”



# Spatial uniformity of vertical proton beam

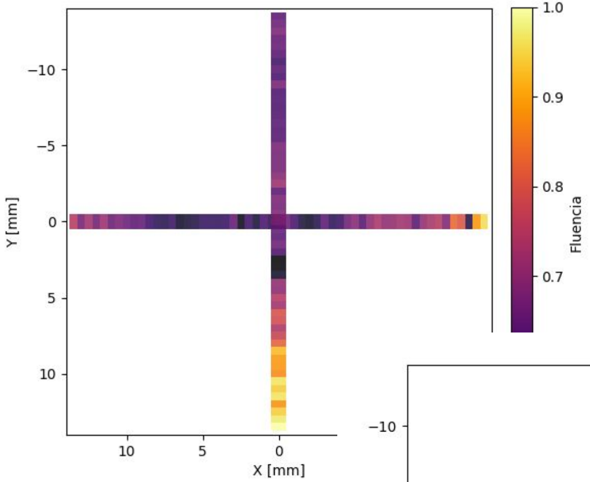
Attenuator in normal position

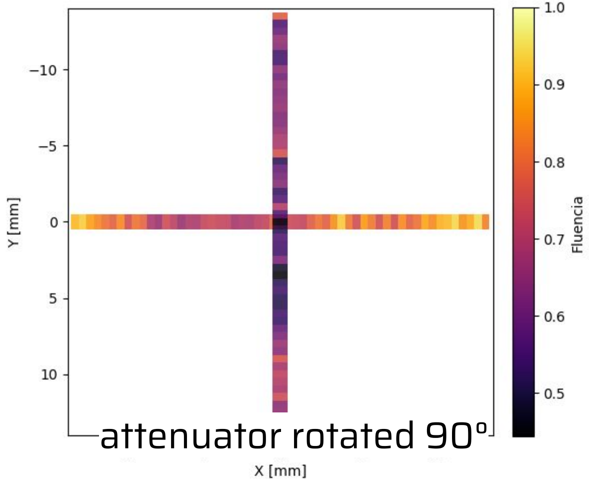


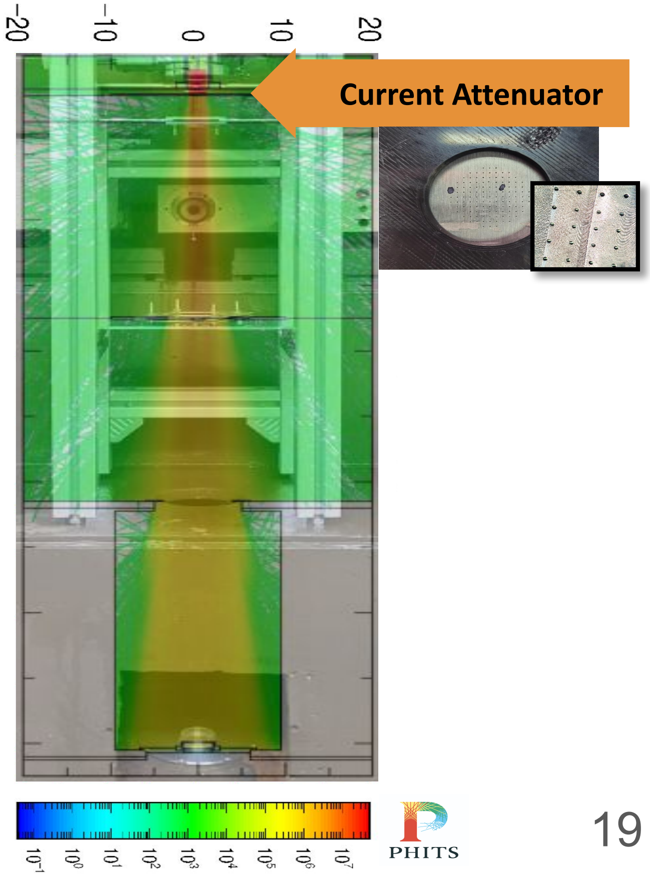
# Spatial uniformity of vertical proton beam

Attenuator in normal position




attenuator rotated 90º



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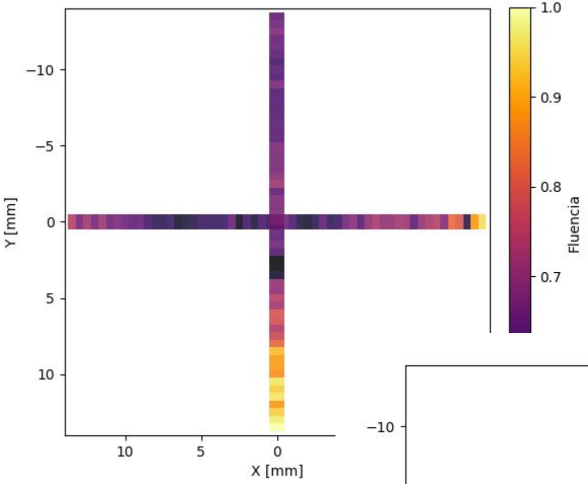
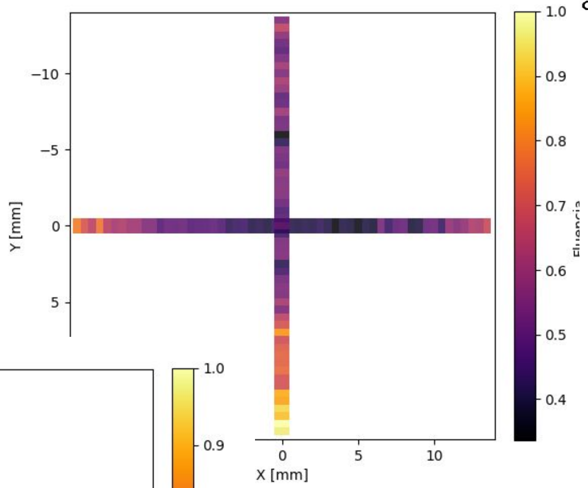
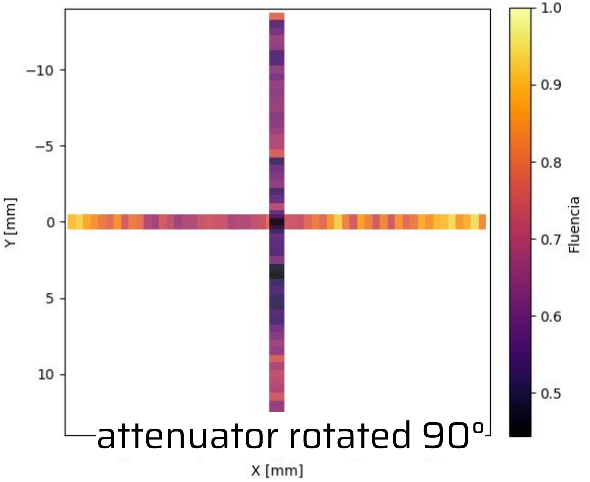
Attenuator in normal position

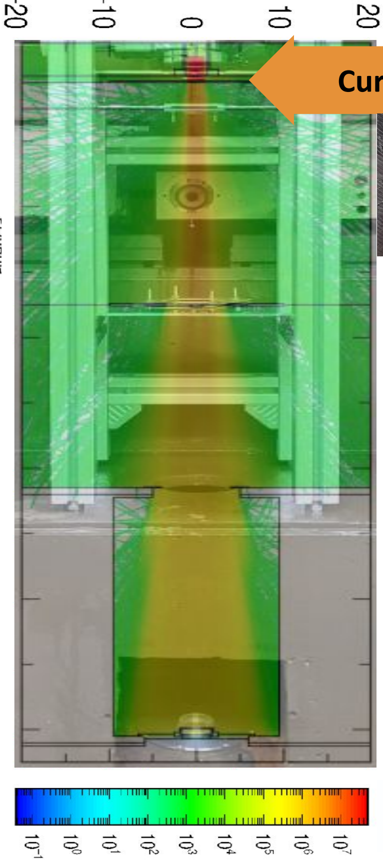


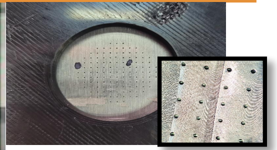

Attenuator returned to normal position



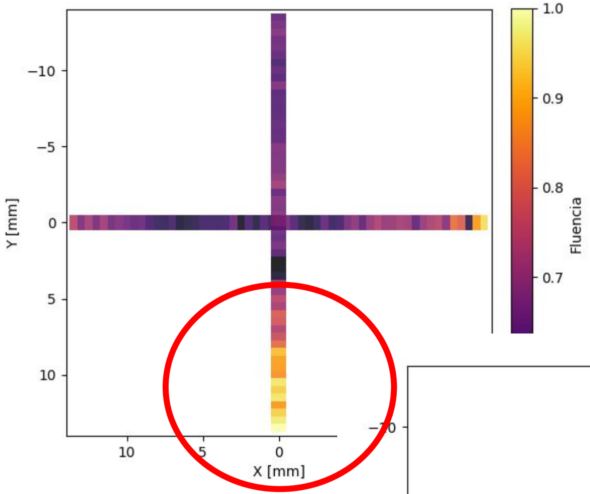

attenuator rotated 90º



# Spatial uniformity of vertical proton beam

Attenuator in normal position

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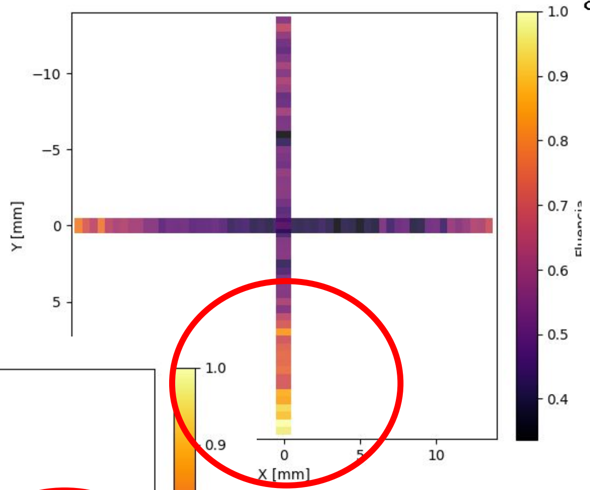
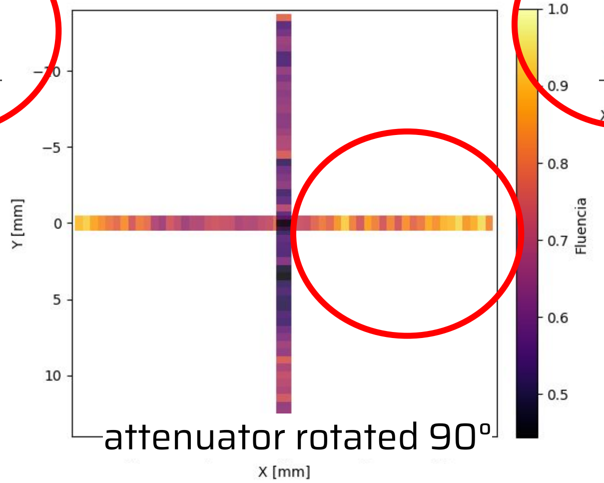
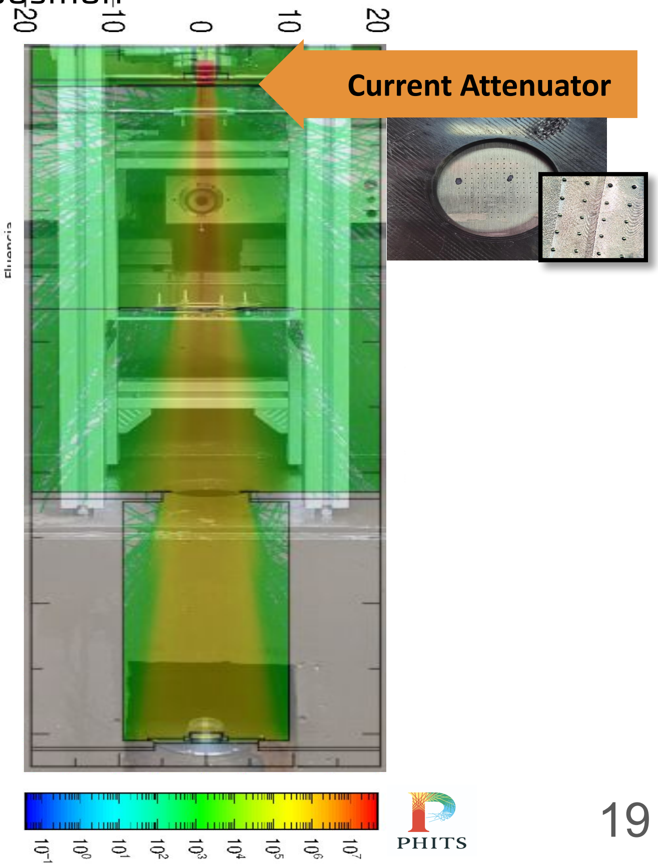
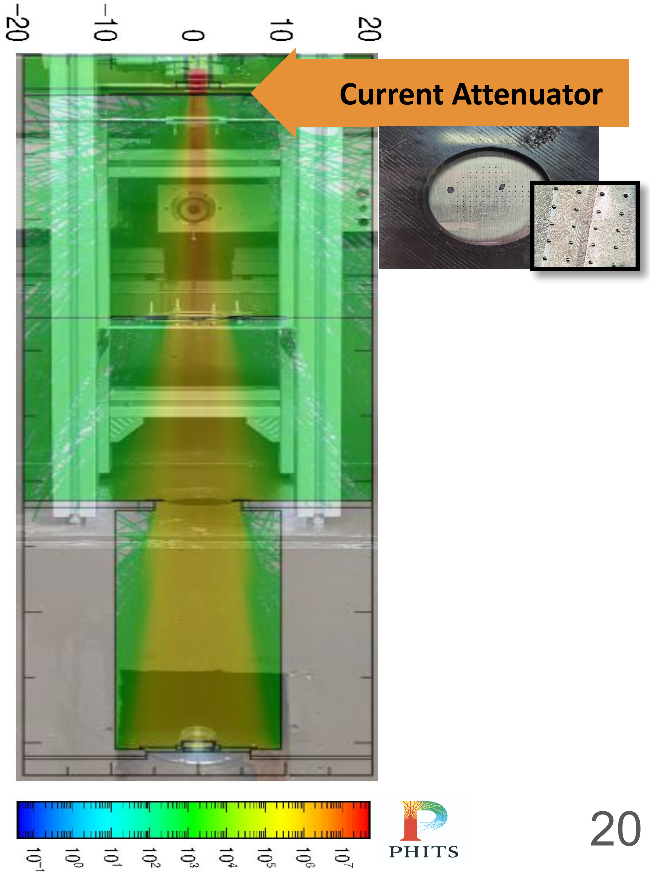


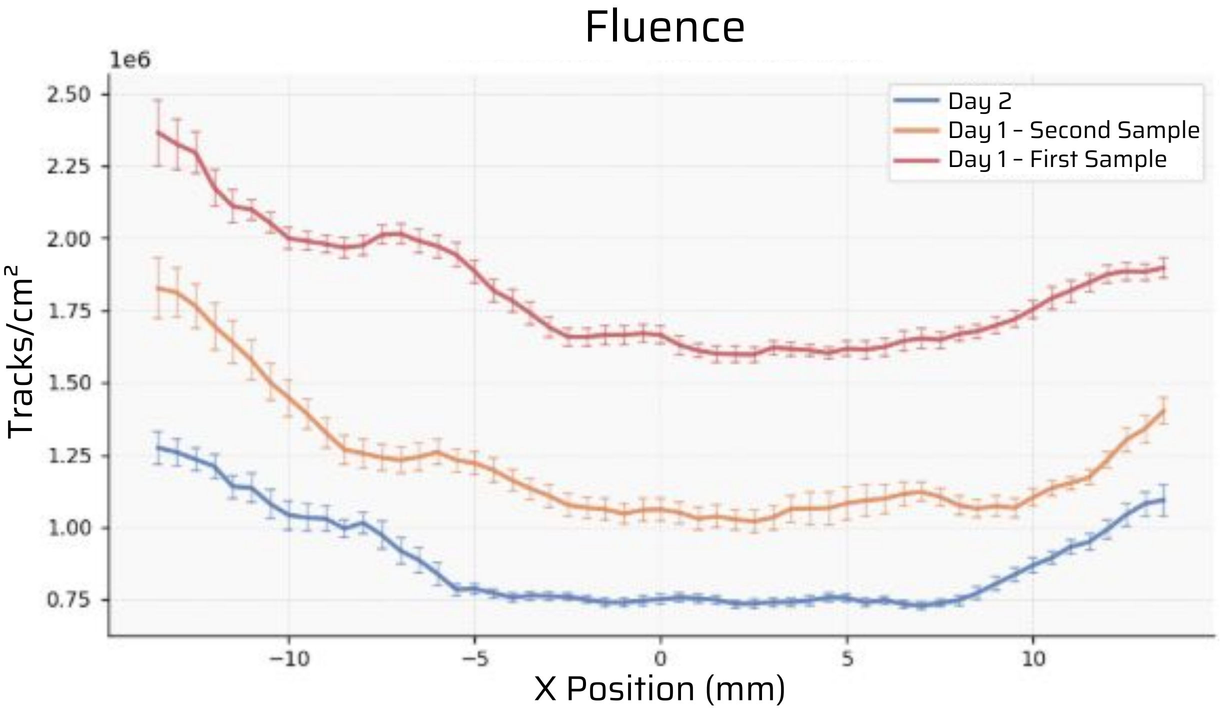

attenuator rotated 90º

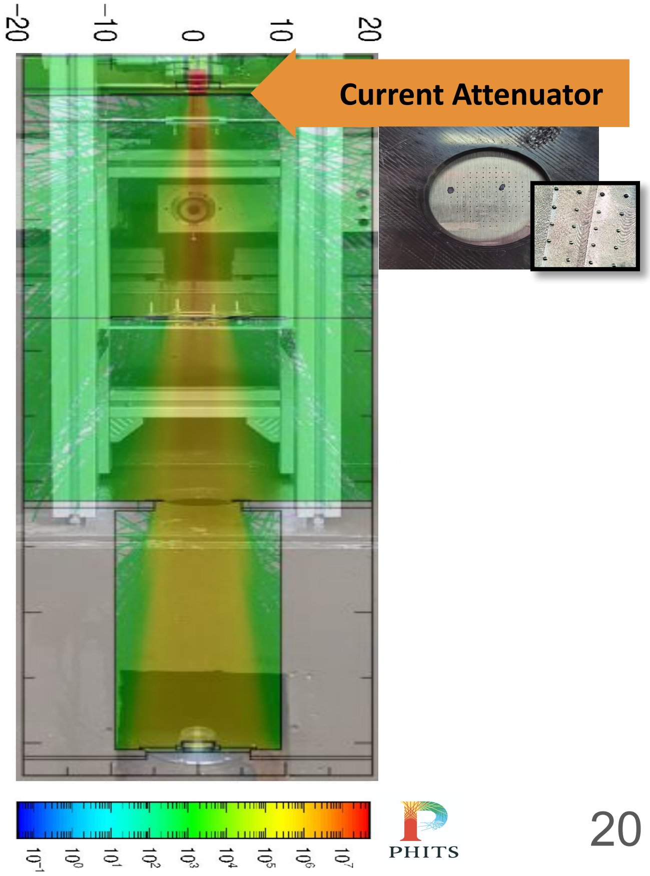


# Fluence variation of vertical proton beam



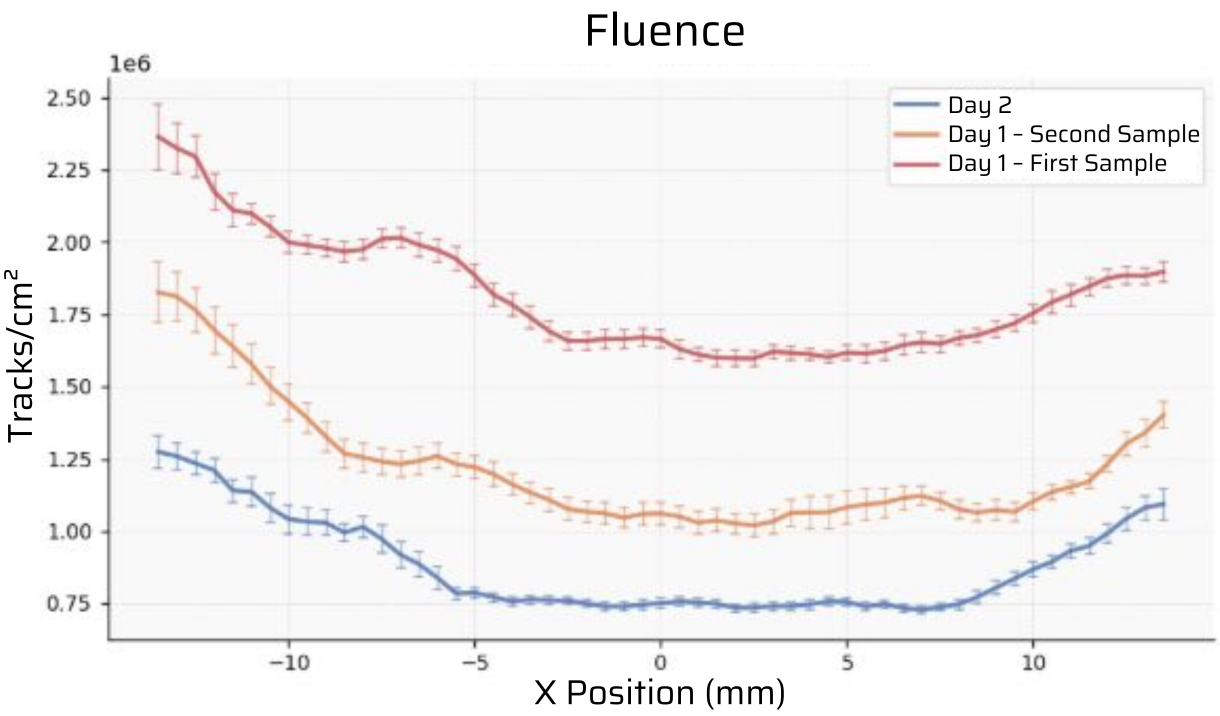
# Fluence variation of vertical proton beam

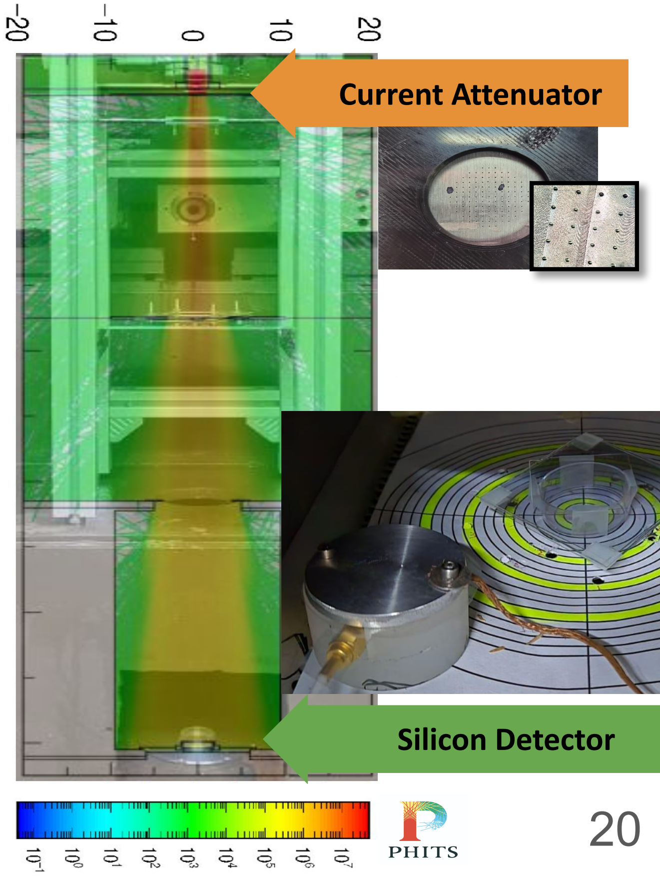



**Fluence differences of 44%**

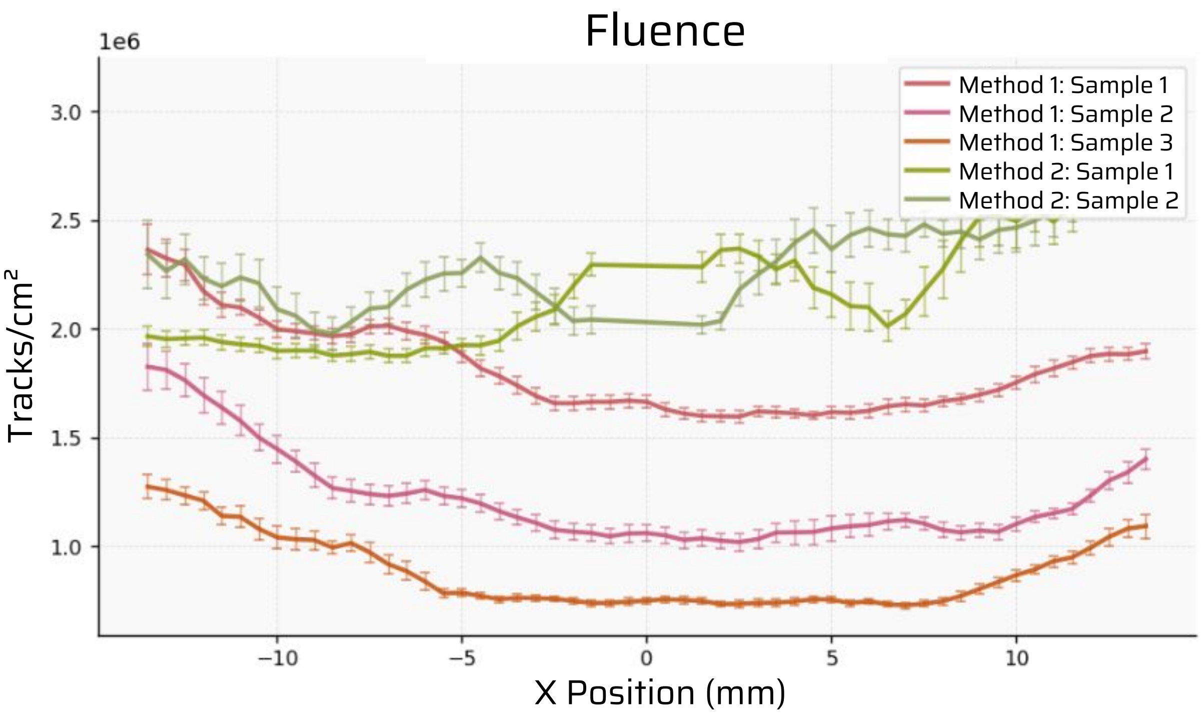
# Fluence variation of vertical proton beam

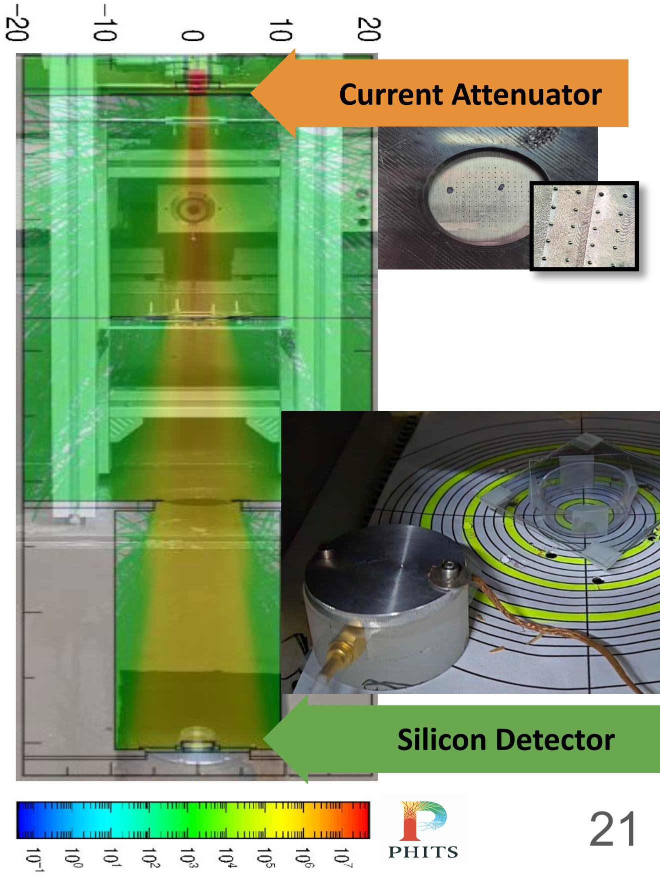



**Fluence differences of 44%**

# Fluence variation of vertical proton beam




**Fluence differences of 44% -> 0.4%**

# Operational Status and Irradiation Activities

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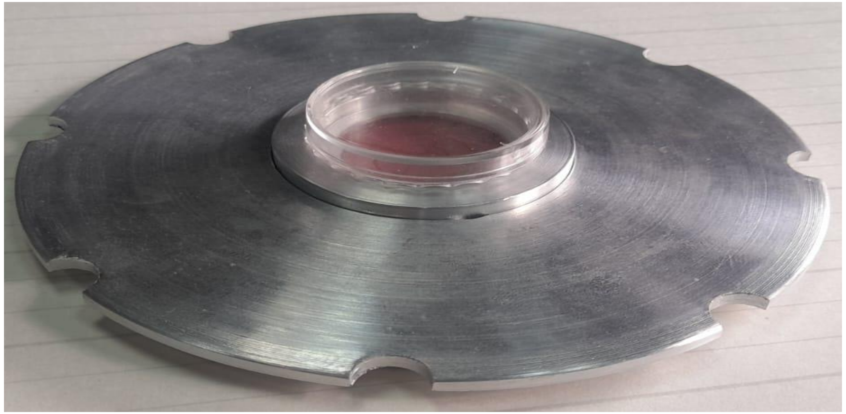
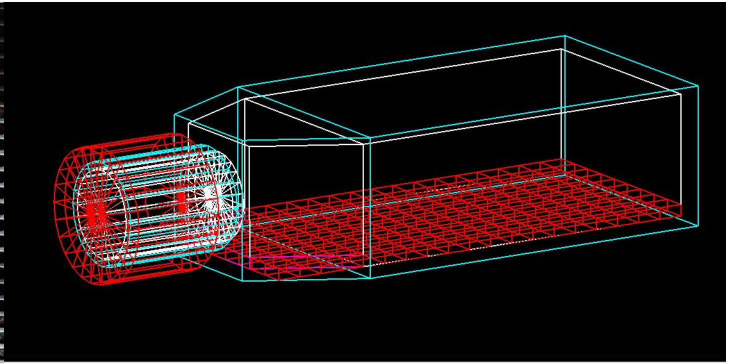
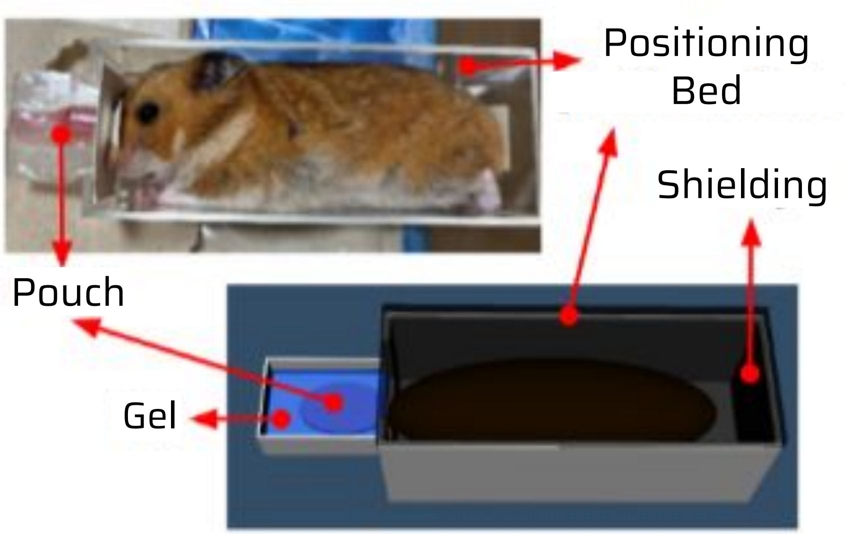


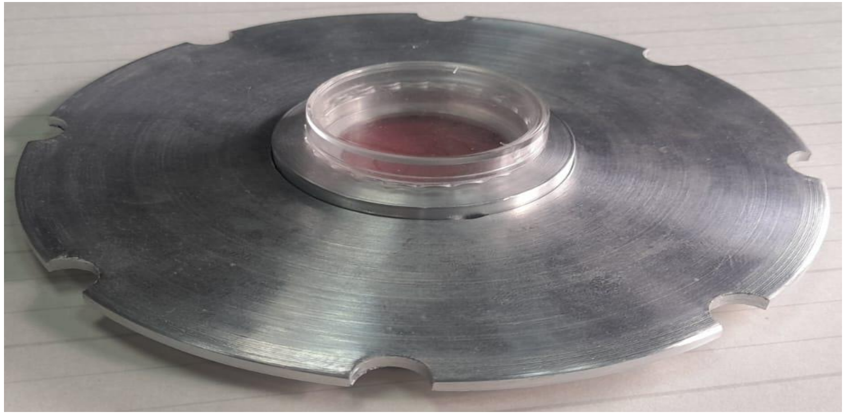


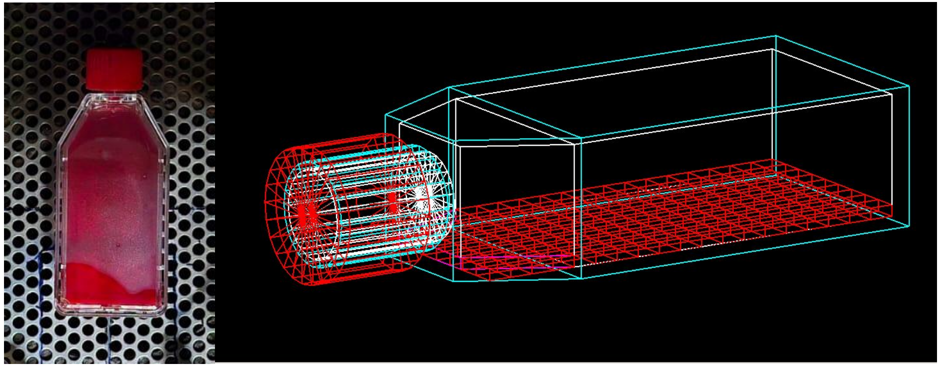
***In Vitro***

# Operational Status and Irradiation Activities

***In Vivo***





***In Vitro***

# Plan for next year

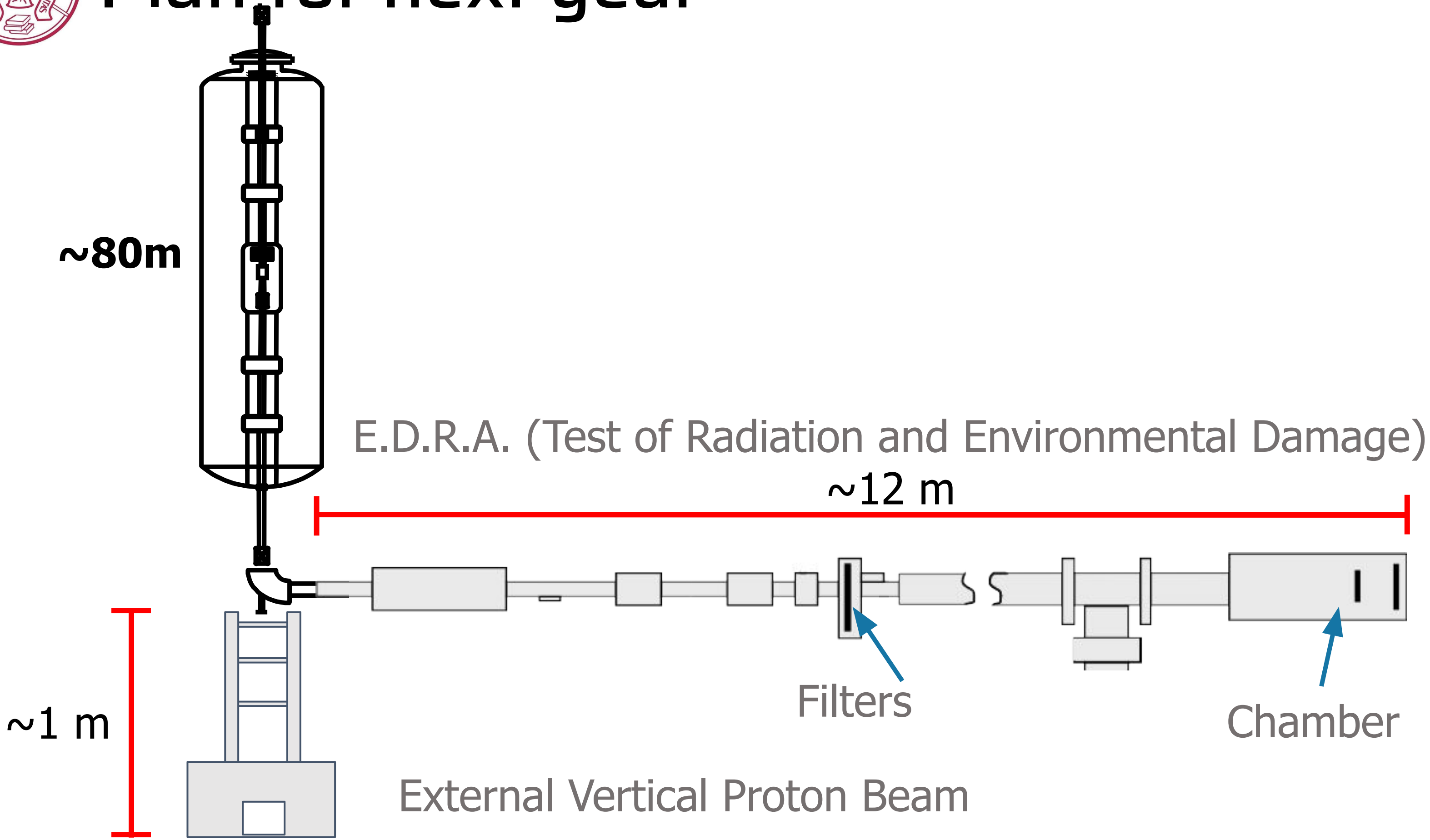
1. Adapt biophysical models for space radiation risk assessment

**2. Implement systems for shaping and characterizing proton beams for hadrontherapy**

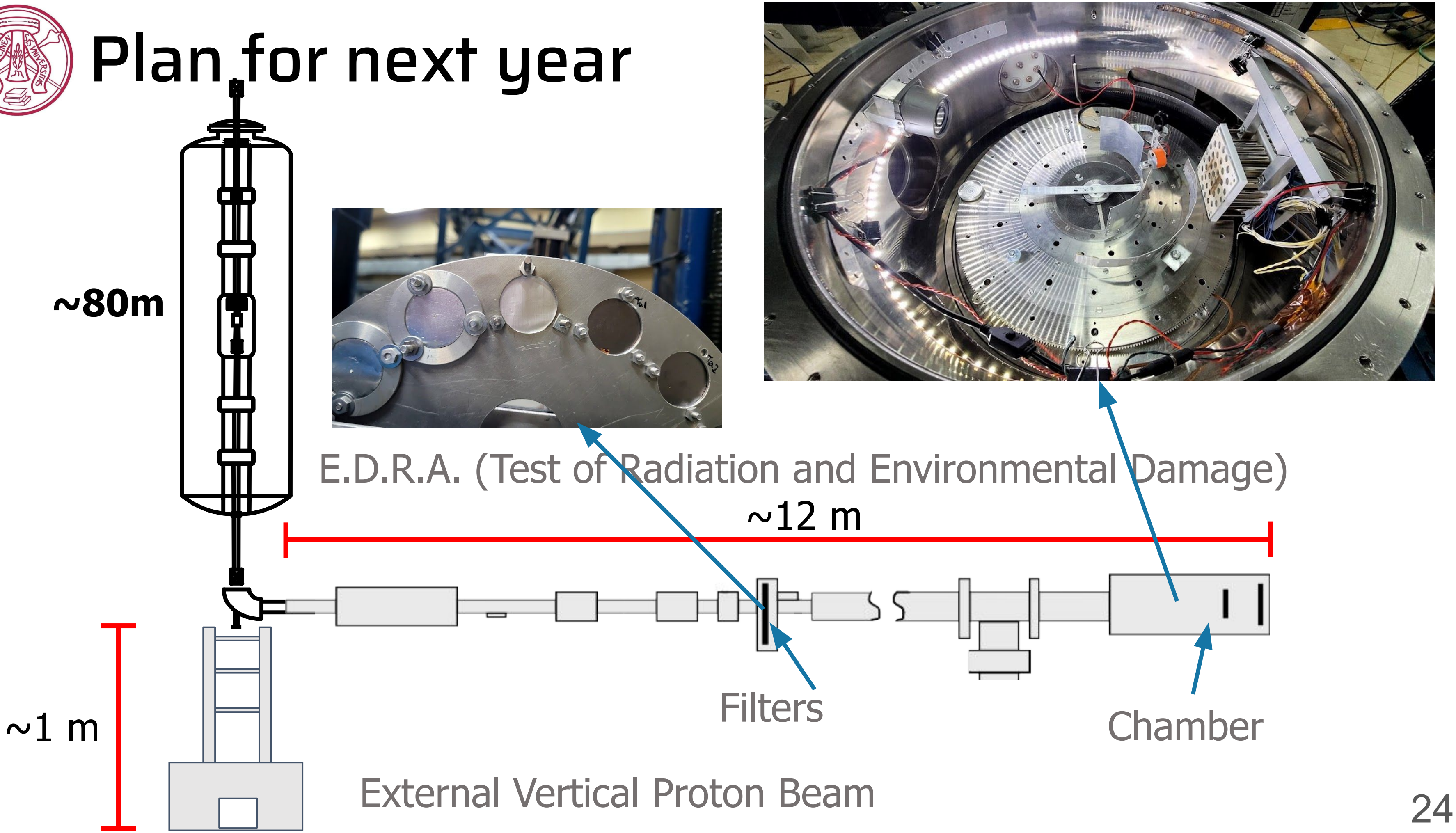
a) Implementation and Characterization of an External Vertical Proton Beam for radiobiological experiments

b) Upgrade of a vacuum irradiation line to study the behaviour of electronic devices under simulated space radiation conditions.

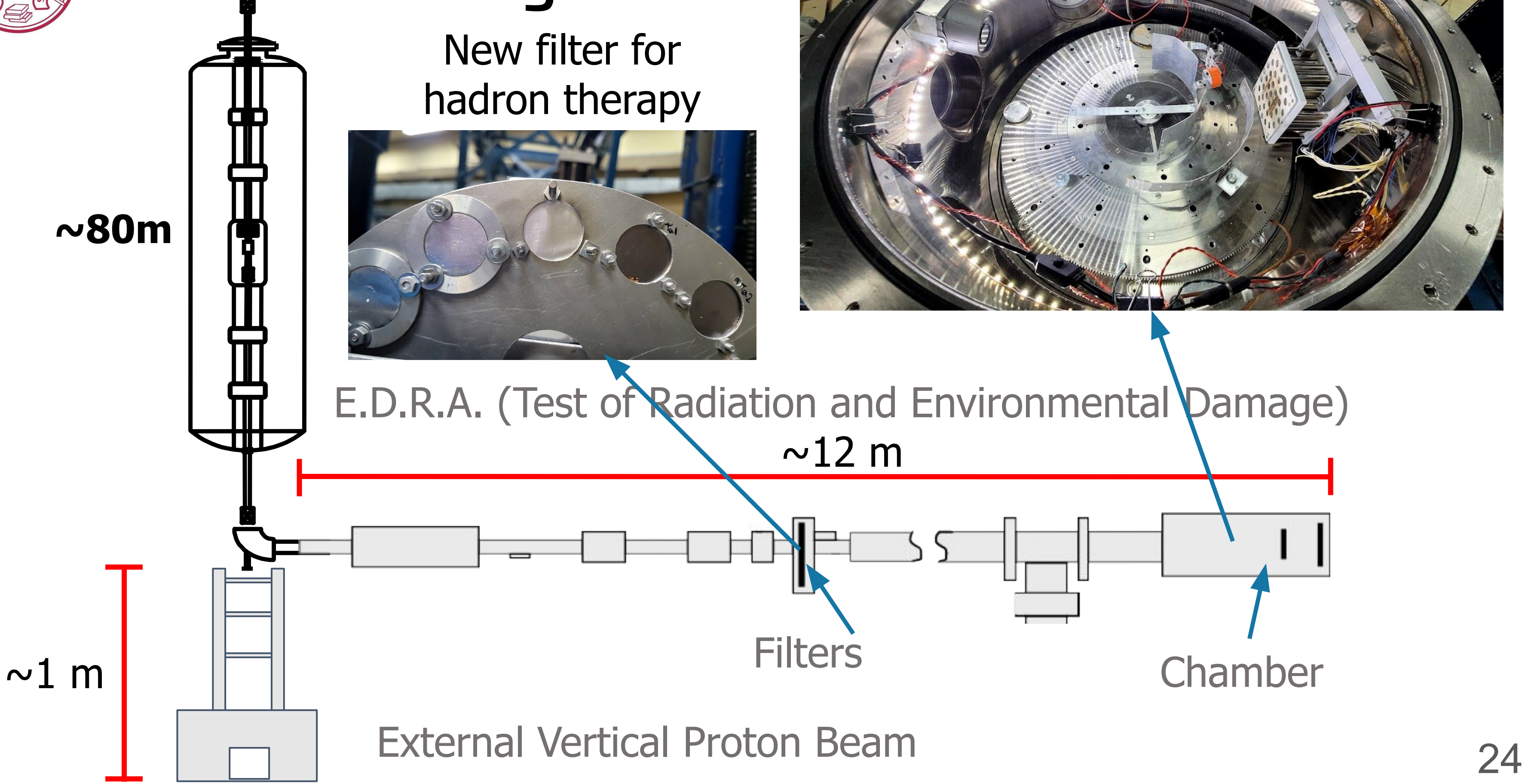
# Plan for next year



# Plan for next year



# Plan for next year



# Grazie mille per la vostra attenzione

ecanaycnea@gmail.com
National Atomic Energy Commission (CNEA) — UNSAM — UniPV