



# Beam Dynamic Simulation and Design of Filtering System for FLASH Electron Therapy Experimental Station at PBP CMU Electron Linac Laboratory

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## The 7th International School on Beam Dynamics and Accelerator Technology (ISBA24)





Objectives



Introduction & Methodology



Theory & Result



Summary & Future Work

## OBJECTIVES OF THE STUDY

- At PCELL, We are developing the FLASH radiotherapy experiment.
- The new pathway to future treatment: *FLASH-RT utilizes mean high dose rate at over 40 [Gy/s]*. CONV-RT utilizes dose rate under 1 [Gy/min]
- This work models the electron beam through a linear accelerator, increasing particles energy within the range of 10–25 MeV. For this study, *the maximum energy of 10 MeV* is used, applying beam dynamics and Monte Carlo simulation techniques.



# INTRODUCTION & METHODOLOGY

@ PCELL's accelerator hall, there is a electron linear accelerator system (e-linac).

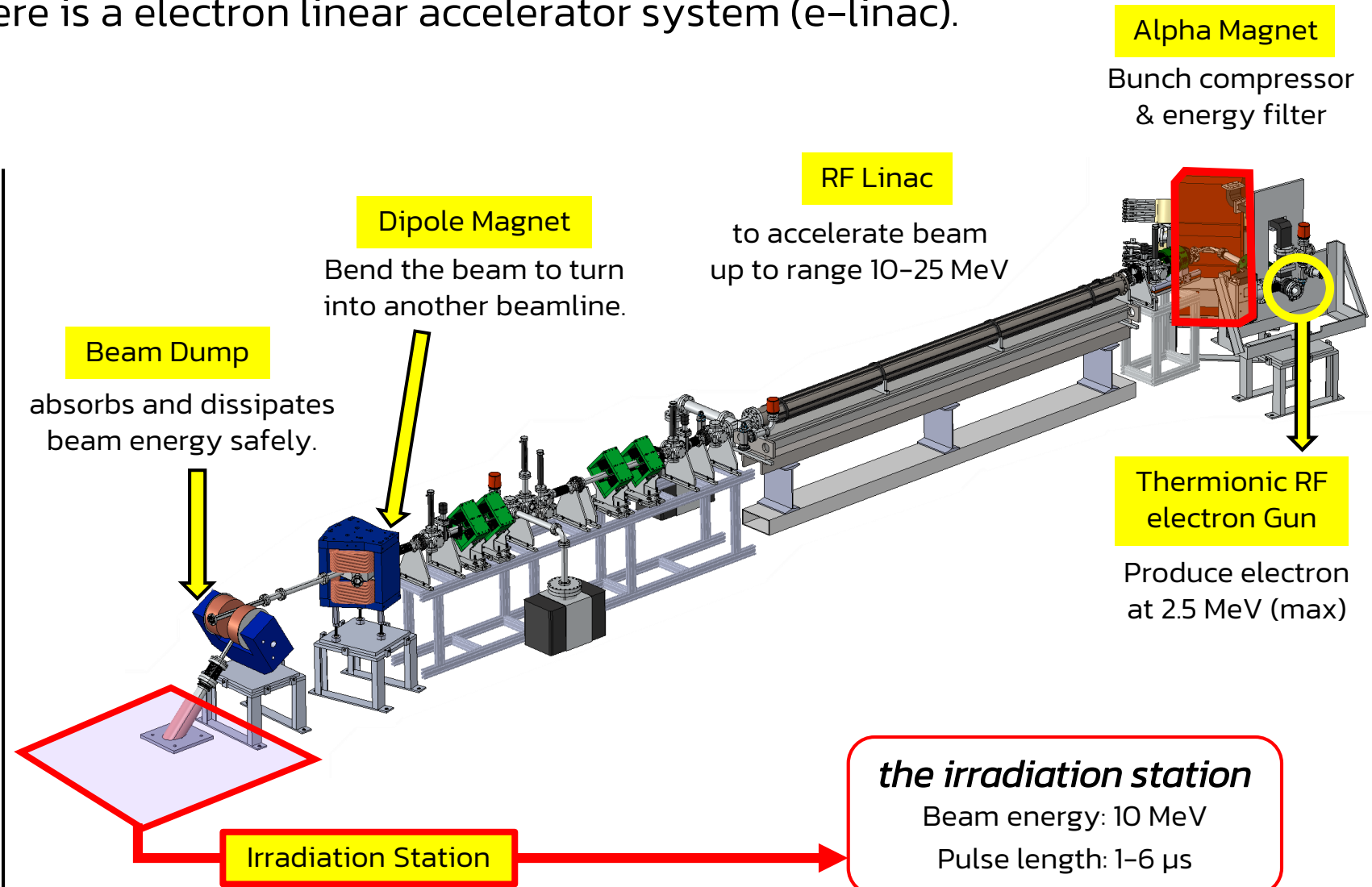
## Beam dynamic using ASTRA

- Magnetic fields from CST
- Track electrons in accelerator system
- Calculate space charge



## Monte Carlo using GEANT4

- Interaction of particle with matter



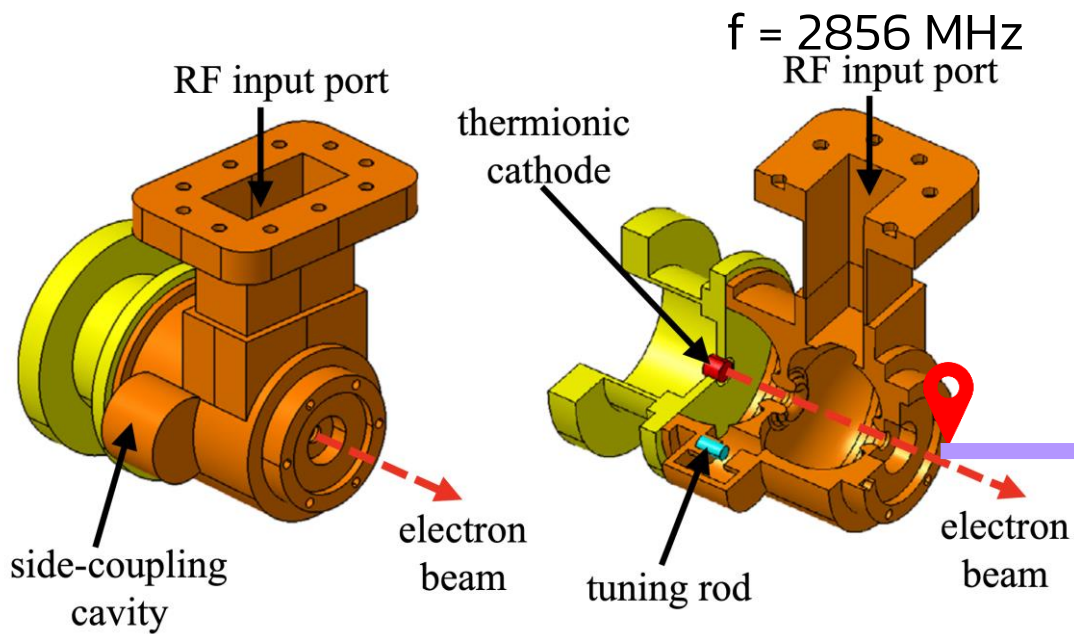
The experimental area conducts FLASH-RT



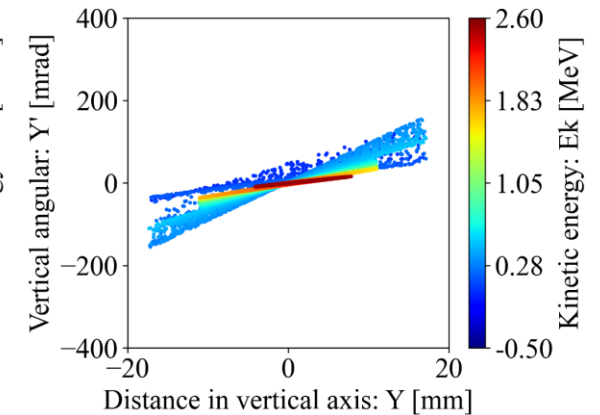
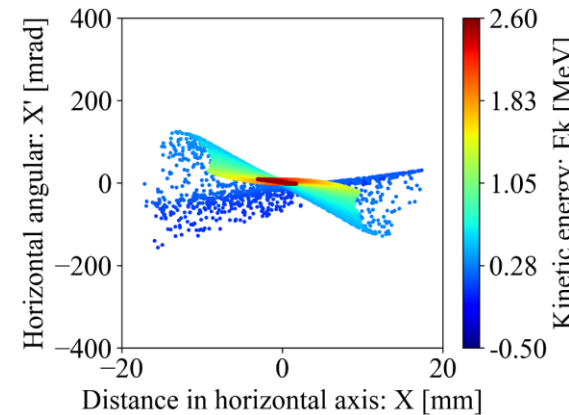
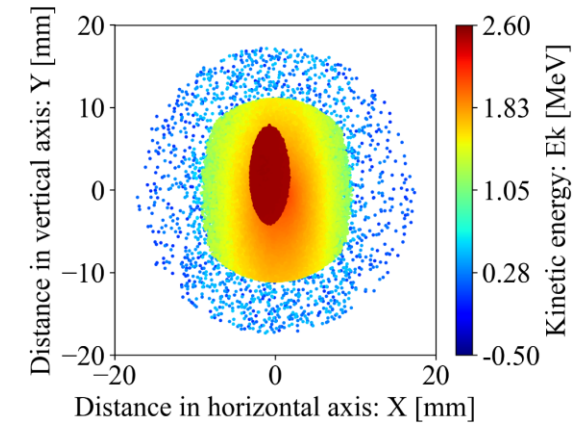
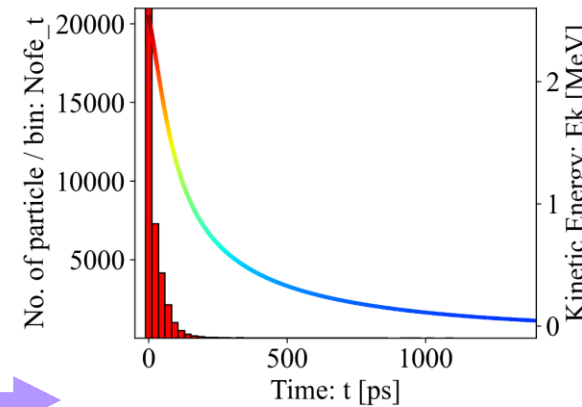
# THEORY & RESULT

## PART 1: Thermionic RF Gun

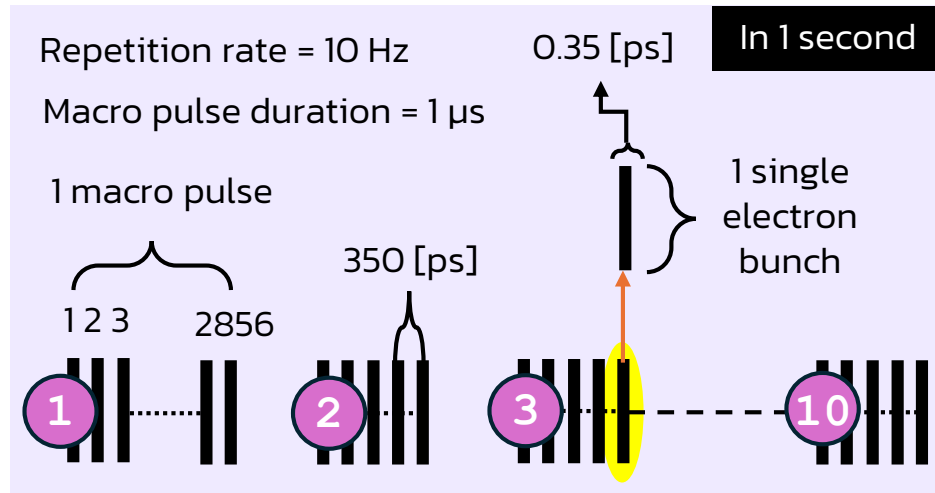
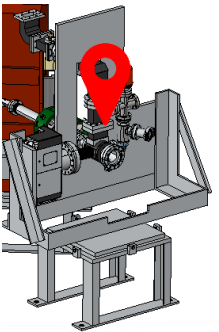
### *electron generator*



a single electron bunch @ electron gun exit



You're here



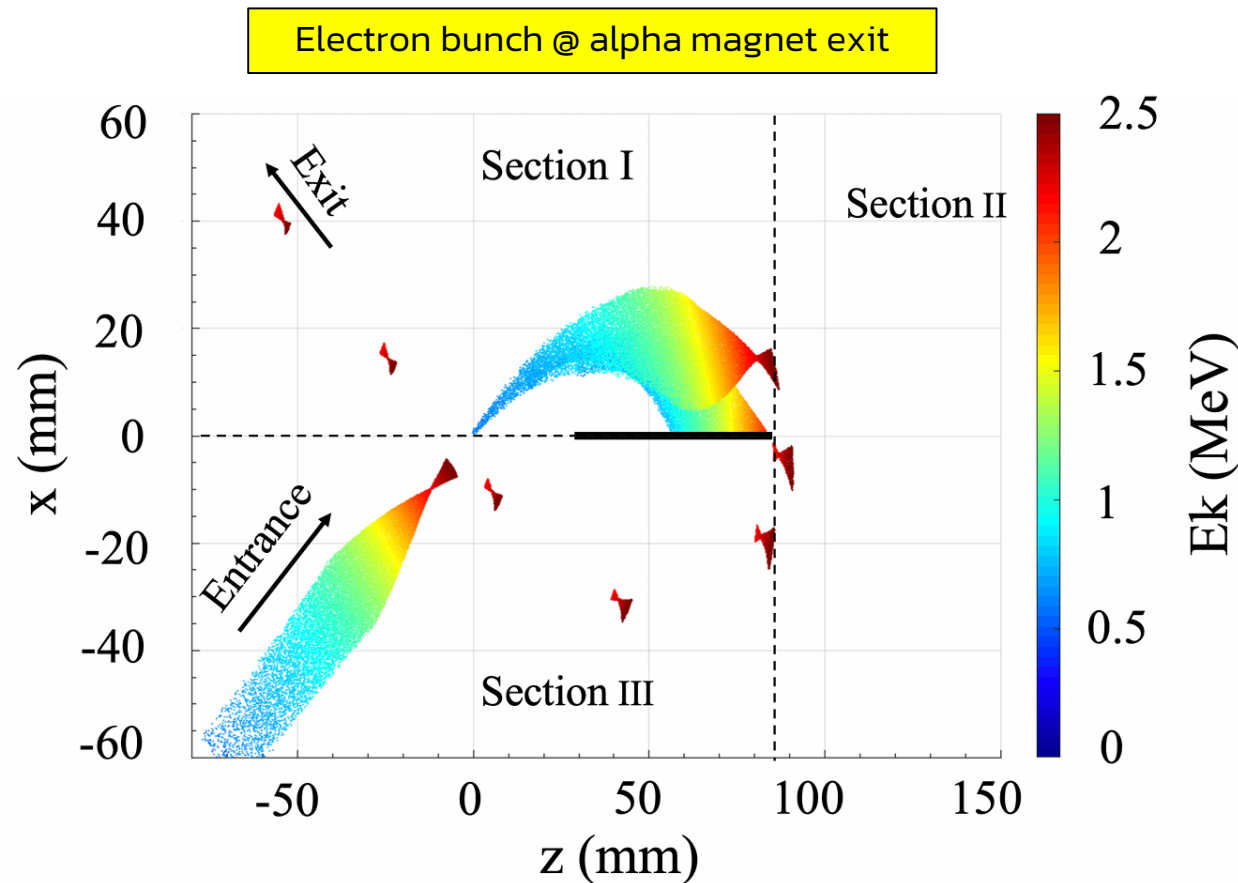
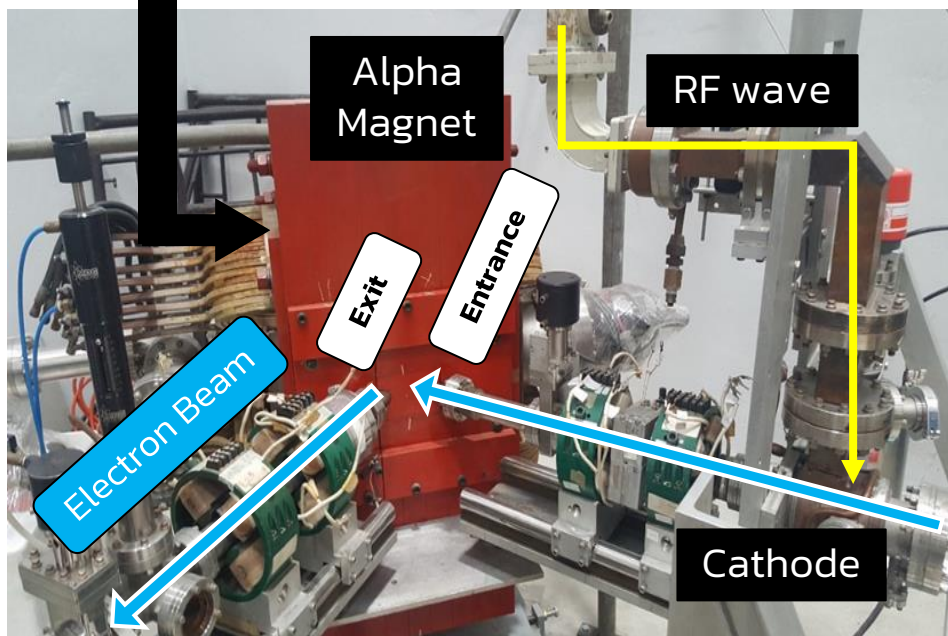
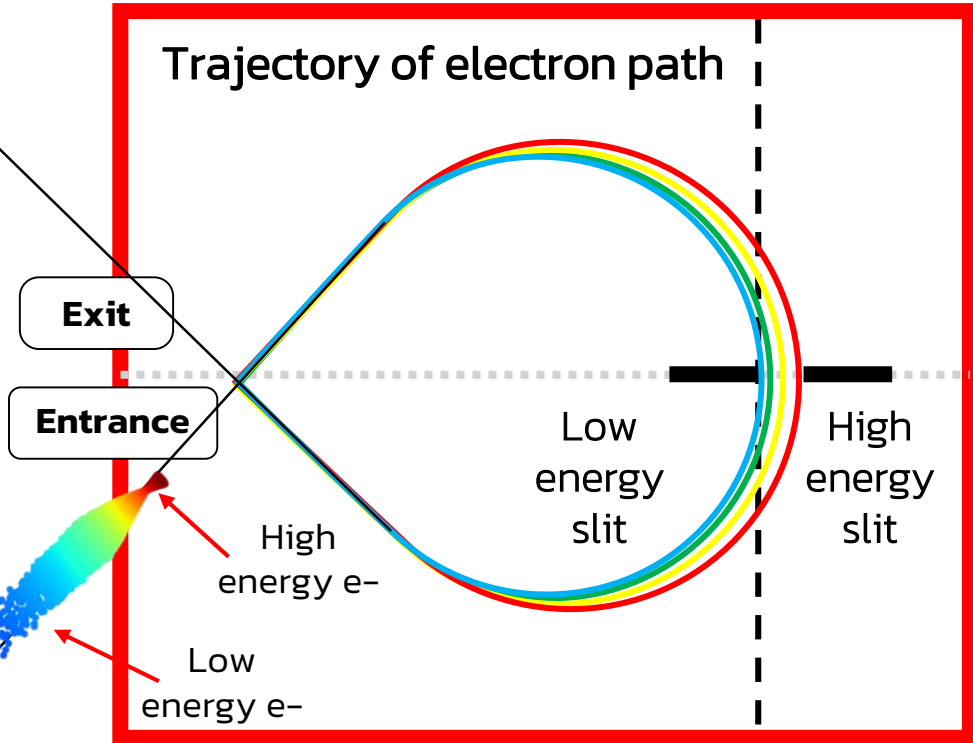
1 second has 10 macro pulse  
So, there are 28,560 electron bunch / sec

Xrms	= 1.8	[mm]
Yrms	= 3.2	[mm]
Emittance X	= 10.99	[mm.mrad]
Emittance Y	= 13.35	[mm.mrad]

<b>Ek mean</b>	<b>= 2.14</b>	<b>[MeV]</b>
Ek rms	= 423.25	[keV]
<b>Bunch charge</b>	<b>= 169.14</b>	<b>[pC]</b>
<b>Bunch length</b>	<b>= 68.36</b>	<b>[ps]</b>



### *bunch compressor and energy filter*



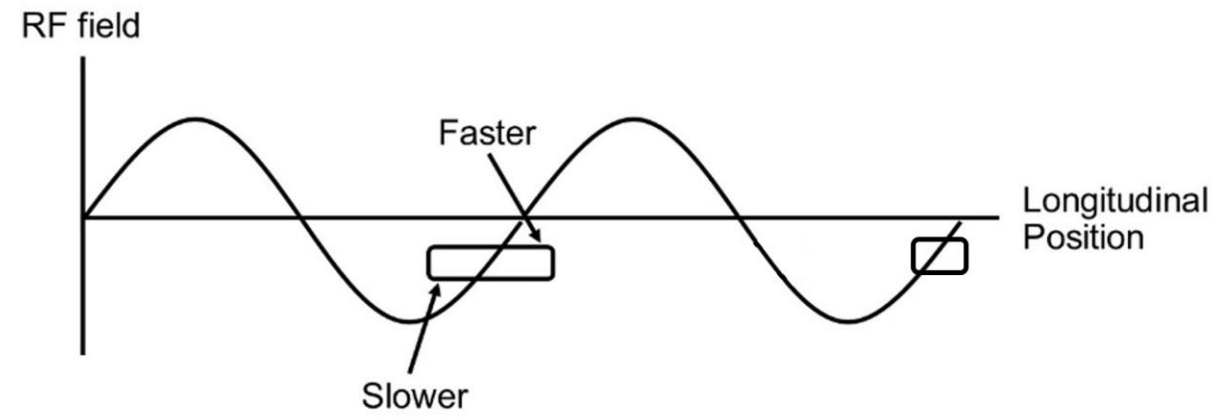
Xrms	= 0.52	[mm]
Yrms	= 0.53	[mm]
Emittance X	= 13.62	[mm.mrad]
Emittance Y	= 1.13	[mm.mrad]

<b>Ek mean</b>	<b>= 2.50</b>	<b>[MeV]</b>
Ek rms	= 23.60	[keV]
<b>Bunch charge</b>	<b>= 50.27</b>	<b>[pC]</b>
<b>Bunch length</b>	<b>= 1.18</b>	<b>[ps]</b>

# THEORY & RESULT PART 3: Linear Accelerator

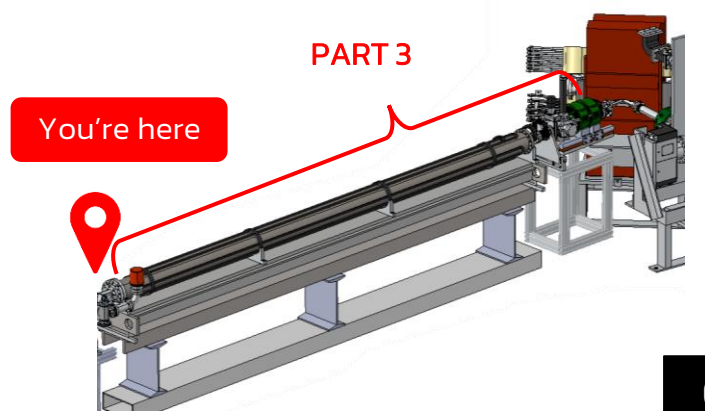
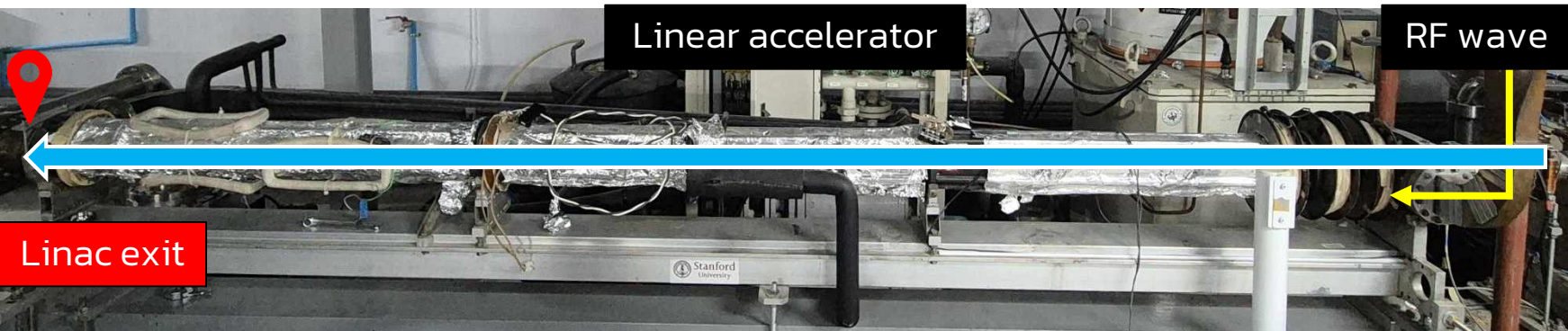
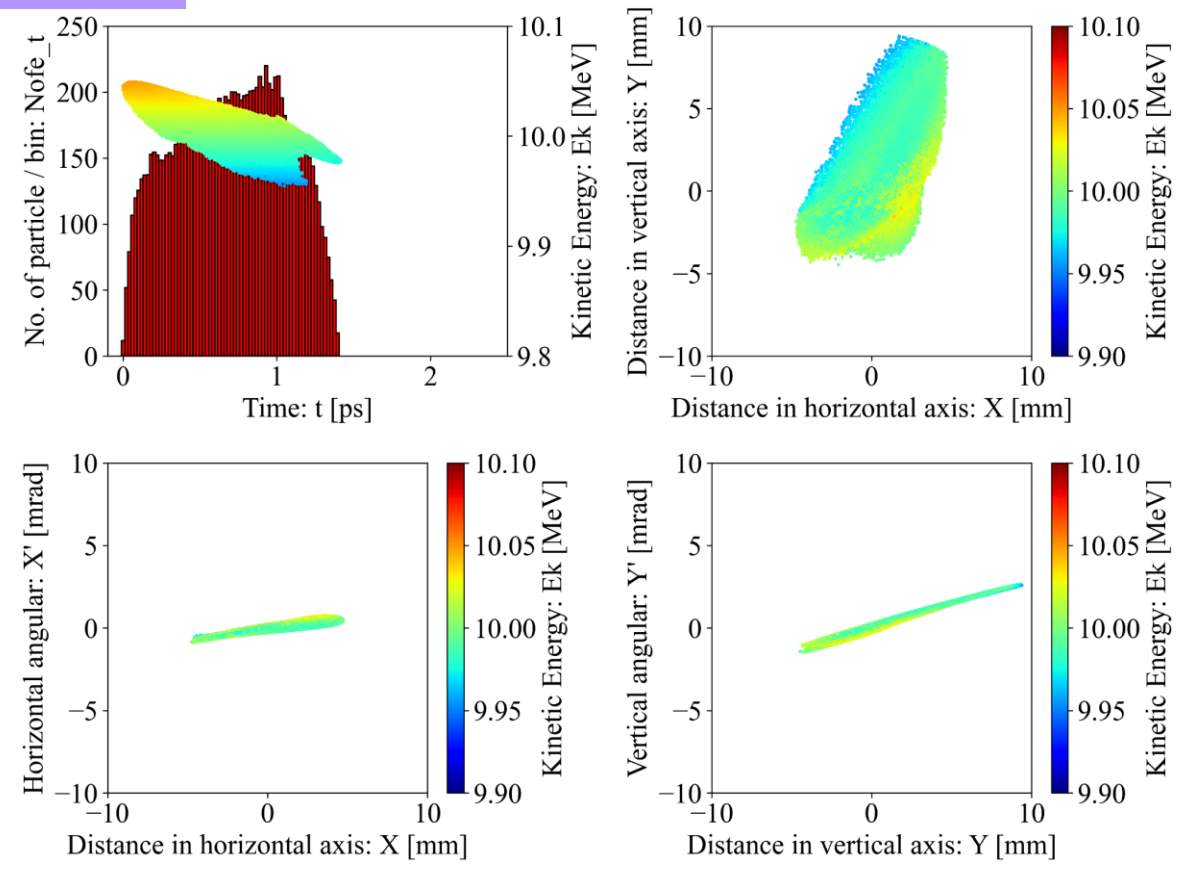
## Electron bunch @ the linac exit

*energy beam booster*



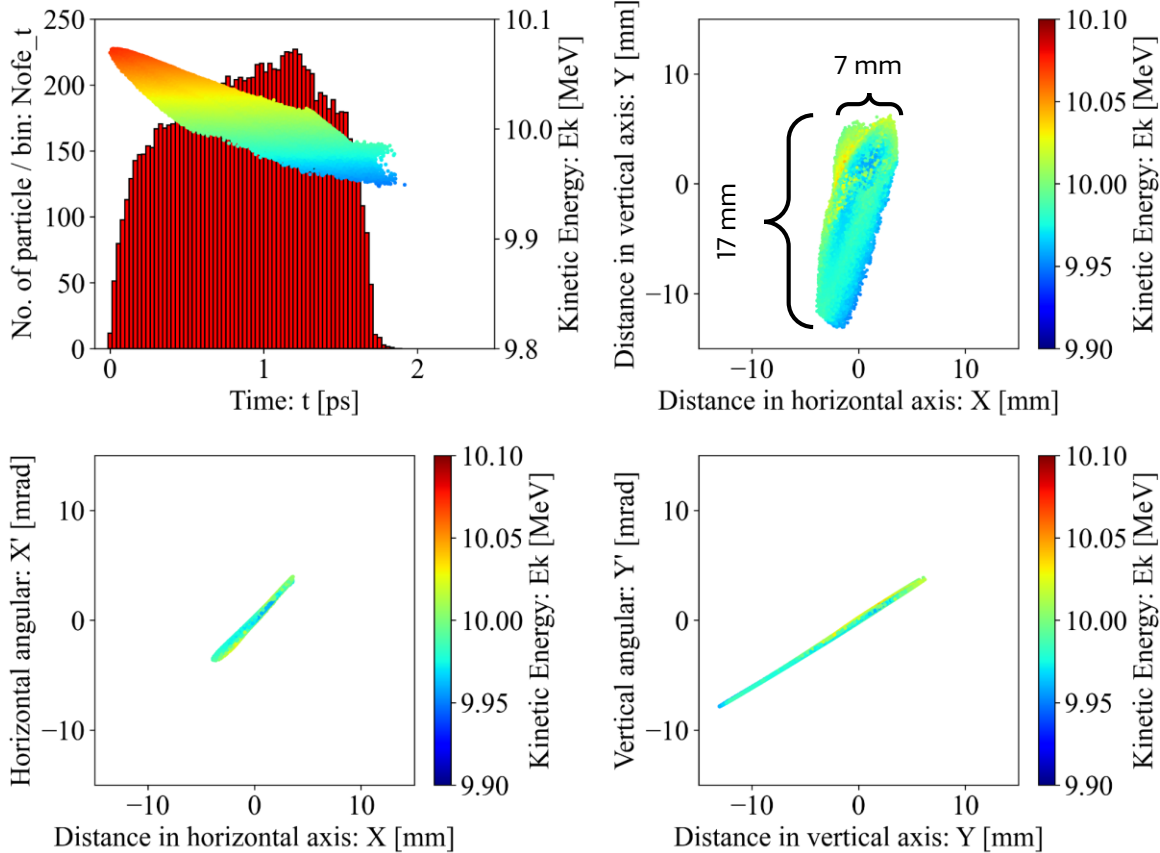
Xrms	= 2.1	[mm]
Yrms	= 2.3	[mm]
Emittance X	= 0.25	[mm.mrad]
Emittance Y	= 0.27	[mm.mrad]

<b>Ek mean</b>	<b>= 10.01</b>	<b>[MeV]</b>
Ek rms	= 18.13	[keV]
<b>Bunch charge</b>	<b>= 50.23</b>	<b>[pC]</b>
<b>Bunch length</b>	<b>= 0.35</b>	<b>[ps]</b>



# SUMMARY

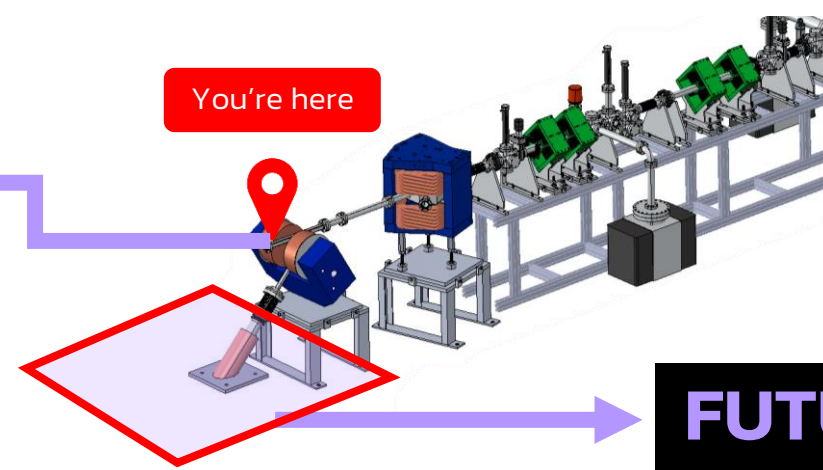
Electron bunch @ 4.37 m after the linac exit



ASTRA

Xrms	= 1.6	[mm]
Yrms	= 3.3	[mm]
Emittance X	= 0.29	[mm.mrad]
Emittance Y	= 0.29	[mm.mrad]

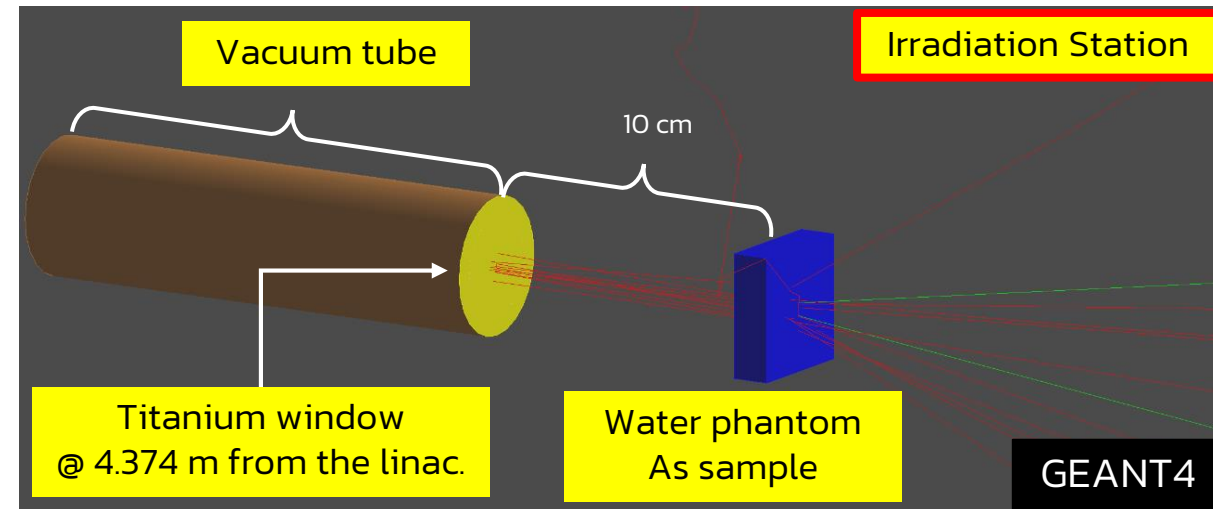
<b>Ek mean</b>	<b>= 10.01</b>	<b>[MeV]</b>
Ek rms	= 28.13	[keV]
<b>Bunch charge</b>	<b>= 50.21</b>	<b>[pC]</b>
<b>Bunch length</b>	<b>= 0.44</b>	<b>[ps]</b>



ASTRA

FUTURE WORK

- Optimize the beam size parameters to be suitable for the FLASH-RT experiment.

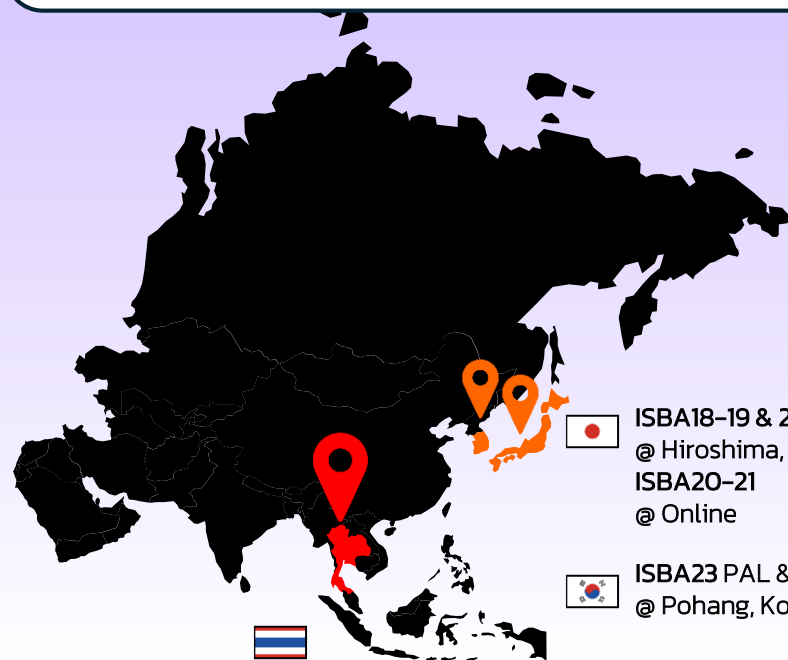



- Design a filter to achieve a flat-top dose distribution and enable dose absorption in a water phantom.

# Thank You For Your Attention

## Acknowledgements

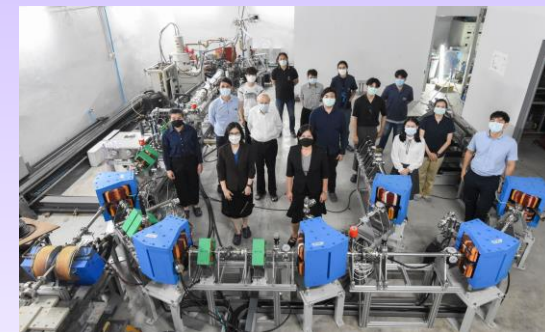
- *Asst. Prof. Dr. Sakhorn Rimjaem*, Lab Leader
- *Kittipong Techakaew*, PhD. Physics Student
- *Kanlayaporn Kongmali*, PhD. Physics Student
- *Surawadee Khammee*, Master Physics Student
- All Student / RA / Scientist / Post Doc at PCELL & Collaborative Agencies
- PBP-CMU Electron Linac Laboratory (PCELL)
- Plasma and Beam Physics Research Facility, Chiang Mai University
- Thailand Center of Excellence in Physics (ThEP Center)
- Program Management Unit for Human Resources & Institutional Development, Research and Innovation (PMU-B)
- The 7th International School on Beam Dynamics and Accelerator Technology (ISBA24)



 ISBA18-19 & 22 Hiroshima University  
@ Hiroshima, Japan  
ISBA20-21  
@ Online

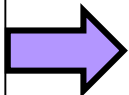
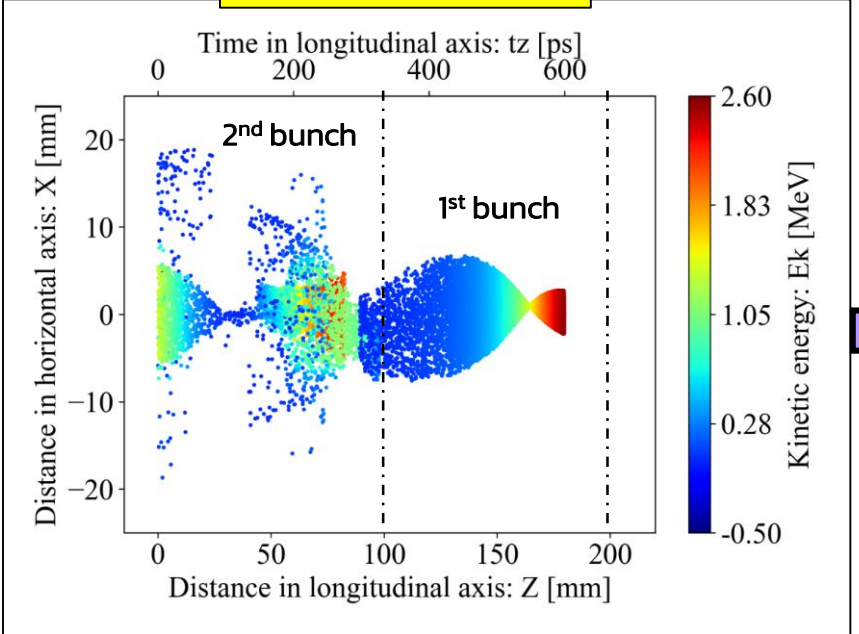
 ISBA23 PAL & KOMAC KAERI  
@ Pohang, Korea

ISBA24 PCELL Chiang Mai University + ThEP  
@ Chiang Mai, Thailand

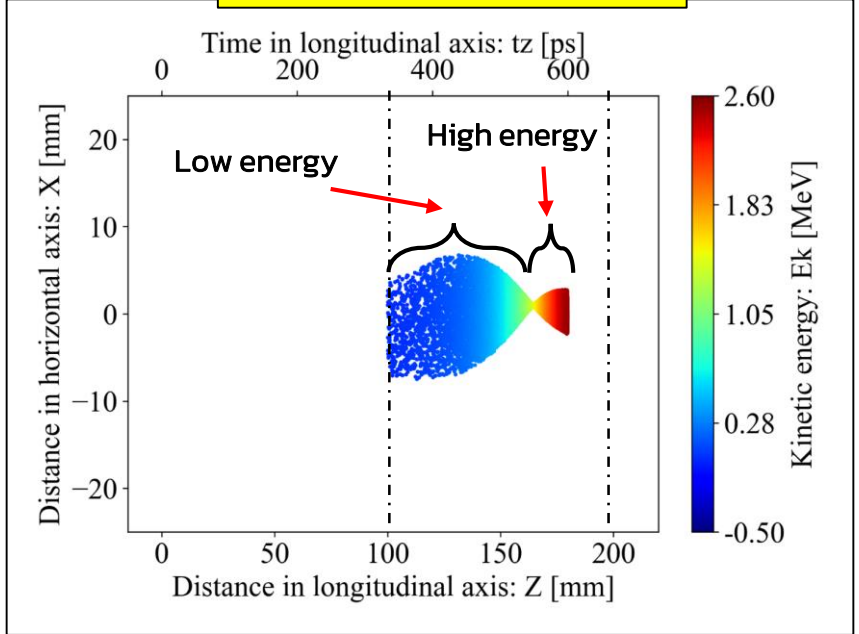


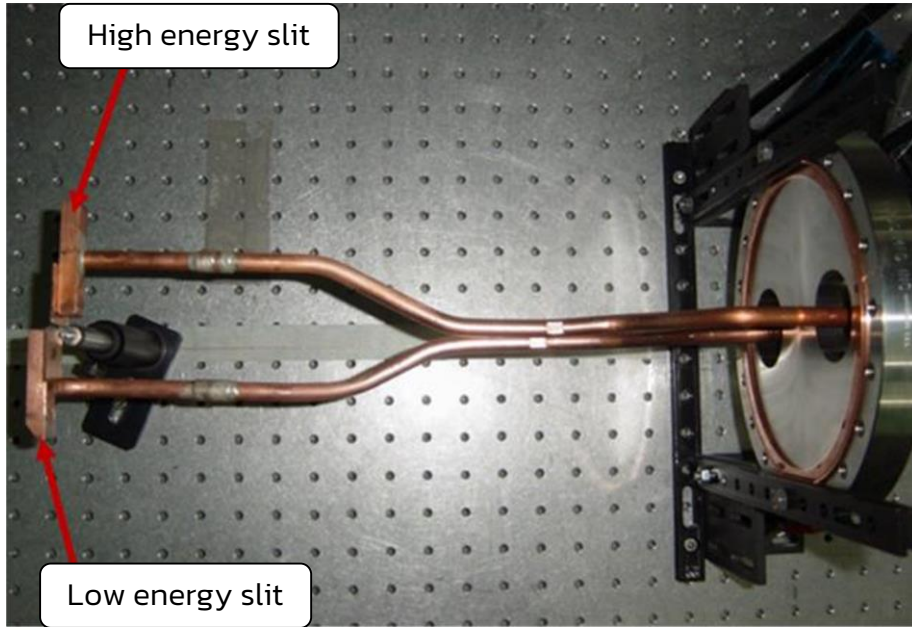


few electron bunch

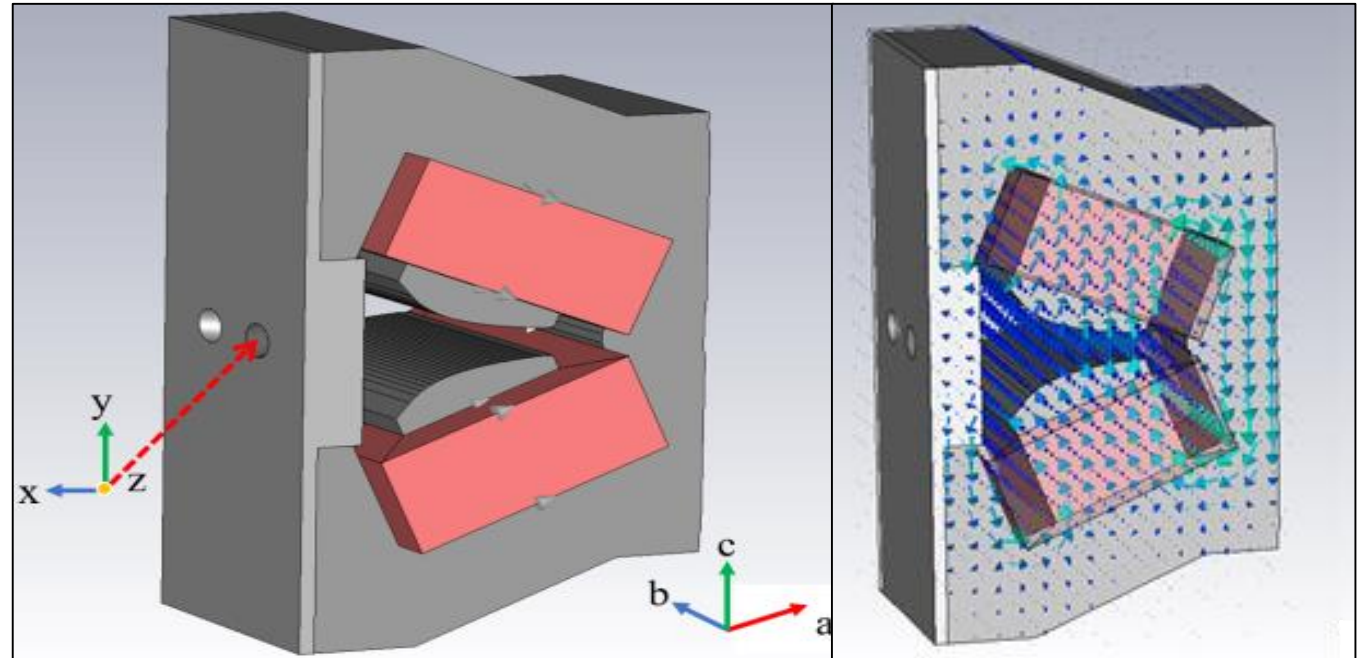


a single electron bunch





Energy slit made by copper



Alpha magnet model from CST program