Synchrotron Radiation Study for the CEPC Using BDSIM

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Outline

- Introduction

- BDSIM configuration

  - Geometry, Magnetic Field, Aperture

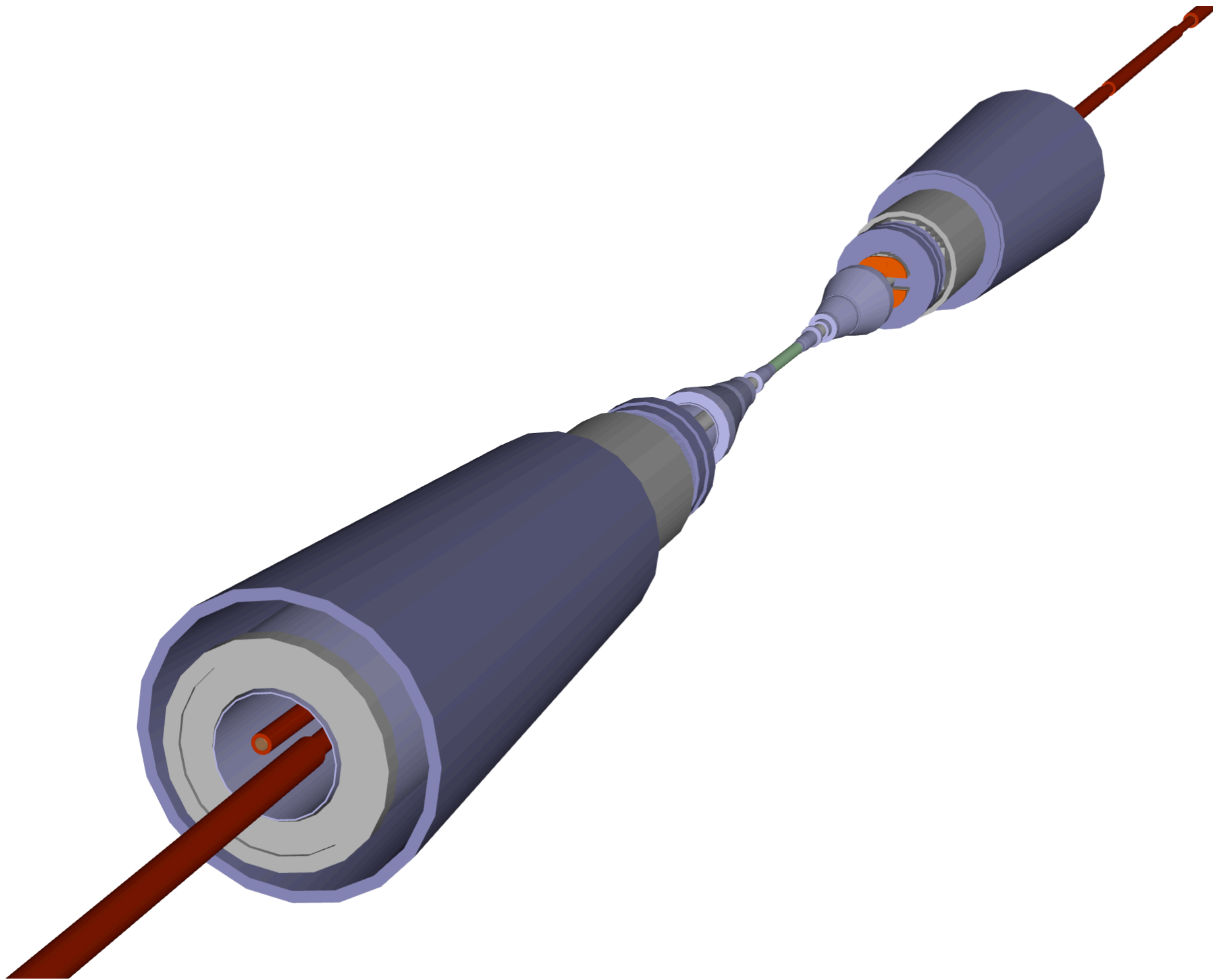- Trajectory Analysis

- Summary

Introduction

- SR (Synchrotron Radiation) is curtail for the safety and performance of the detector

  - The CEPC TDR reports the SR effect with a safety number of 10, indicating a conservative estimate due to uncertainties in the results

  - The difficult point is that the beam population is $10^{11}@\sqrt{s} = 240\text{GeV}$, and we do not have such a huge computer to simulate them. Therefore we need to develop an efficient method

  - In TDR study, it takes 10 hours and 5000 cpus to simulate 10^9 events

    - **Include accelerator [-/+ 150 m, field only] and full detector**

- BDSIM(Beam Delivery Simulation) is used in this study, it is utilized by LHC, photon source projects
  - Particle tracking in Geant4 is a numericalyl based method
  - **Particle motion in accelerator has analytical solution**
  - BDSIM combines the two method and enables communication between them
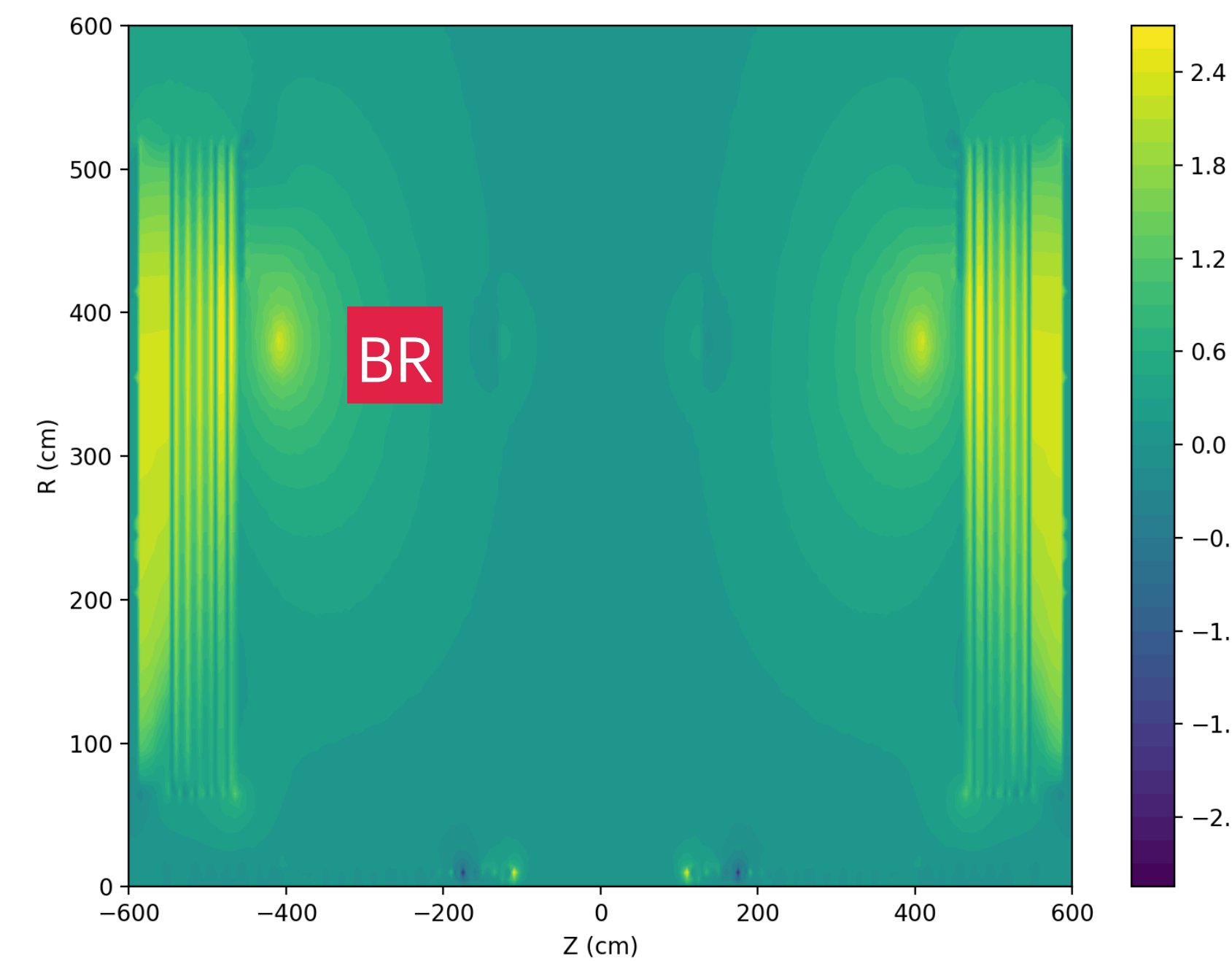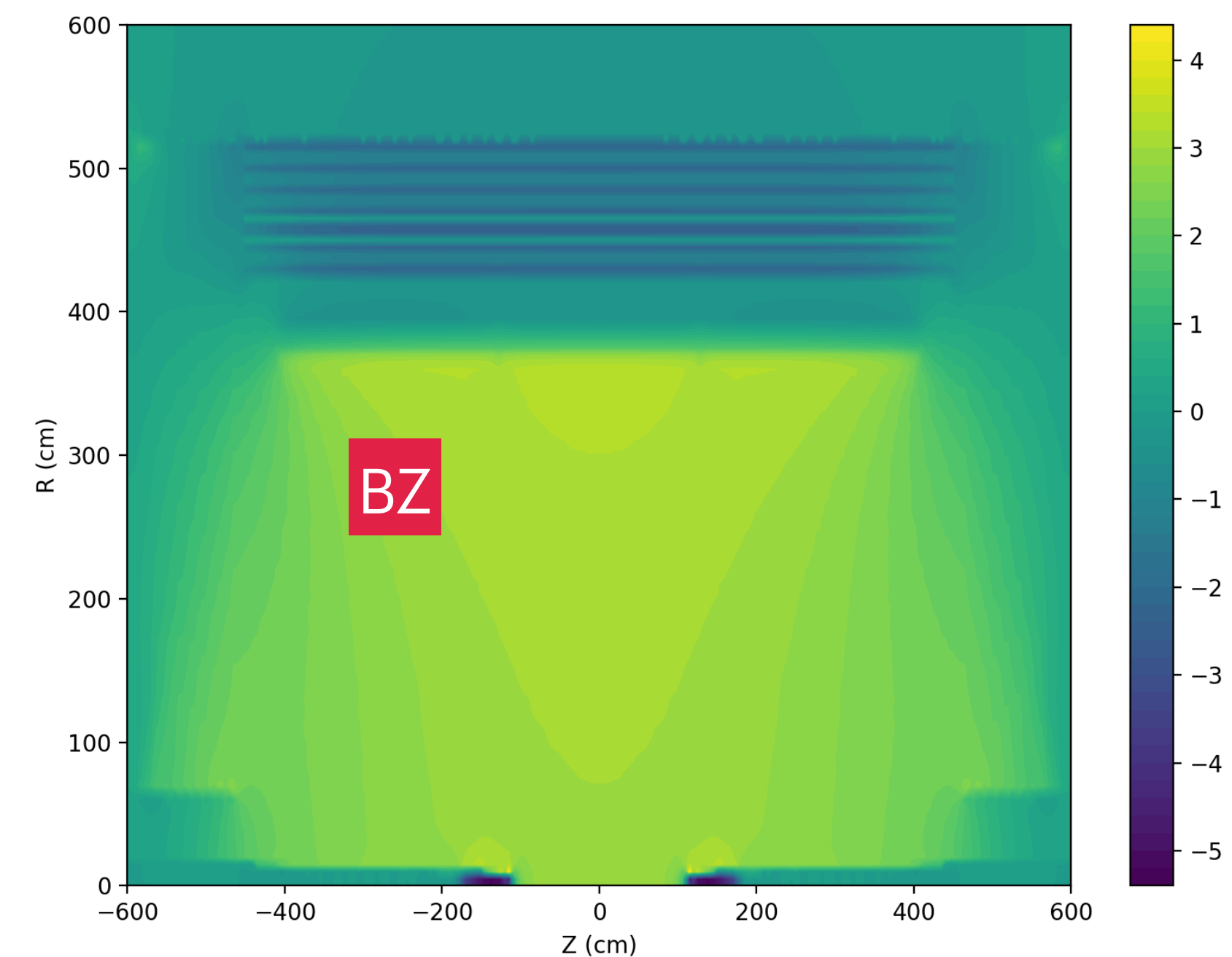
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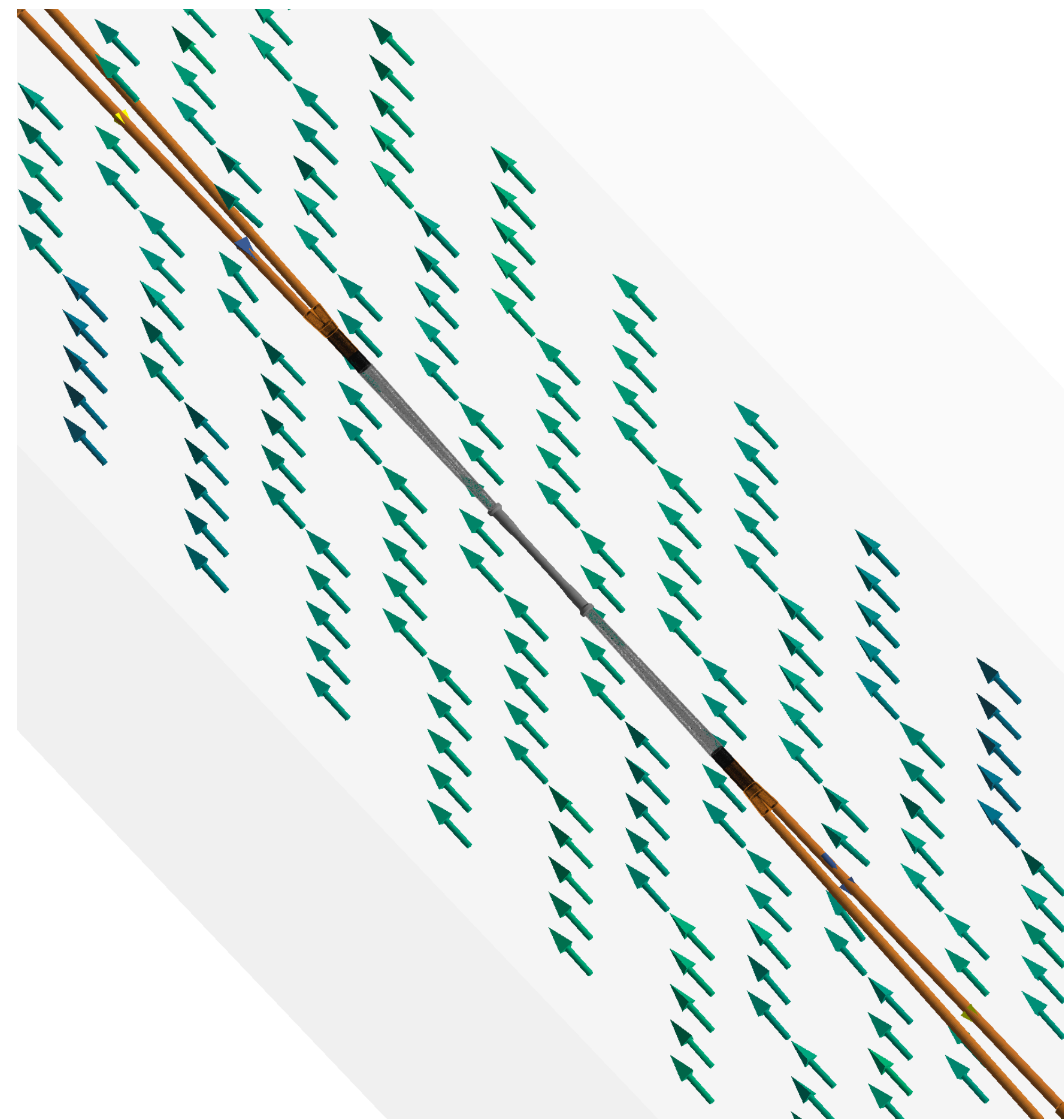- Trajectory Analysis

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BDSIM (Geometry)

- Accelerator elements within ± 150m of the IP are simulated

- BDSIM can not communicate with CEPCSW natively

  - Migrate some MDI components from CEPCSW to BDSIM

  - Geometry of the centre beam pipe between the final quadrupoles [+/- 1.9 m]
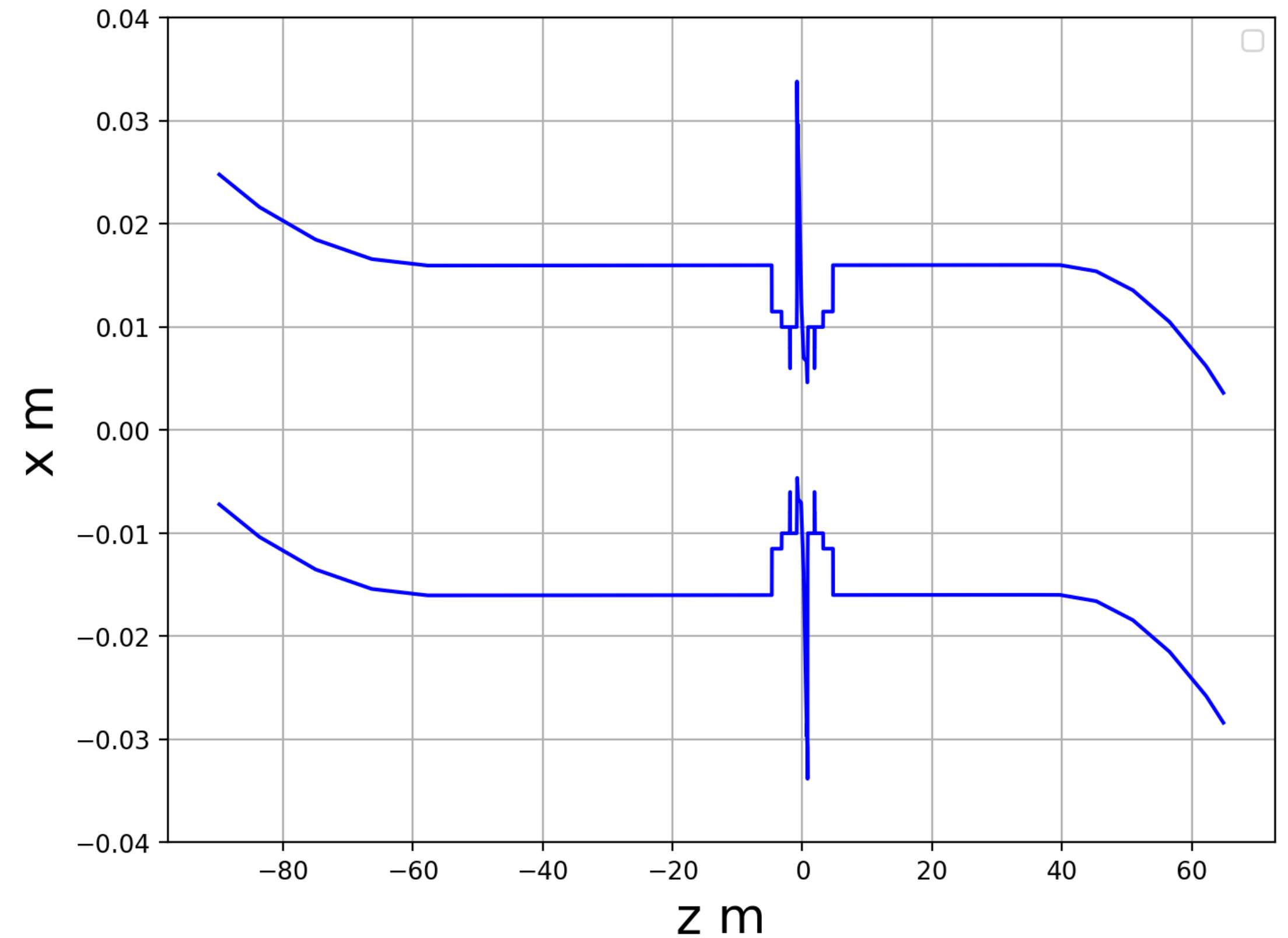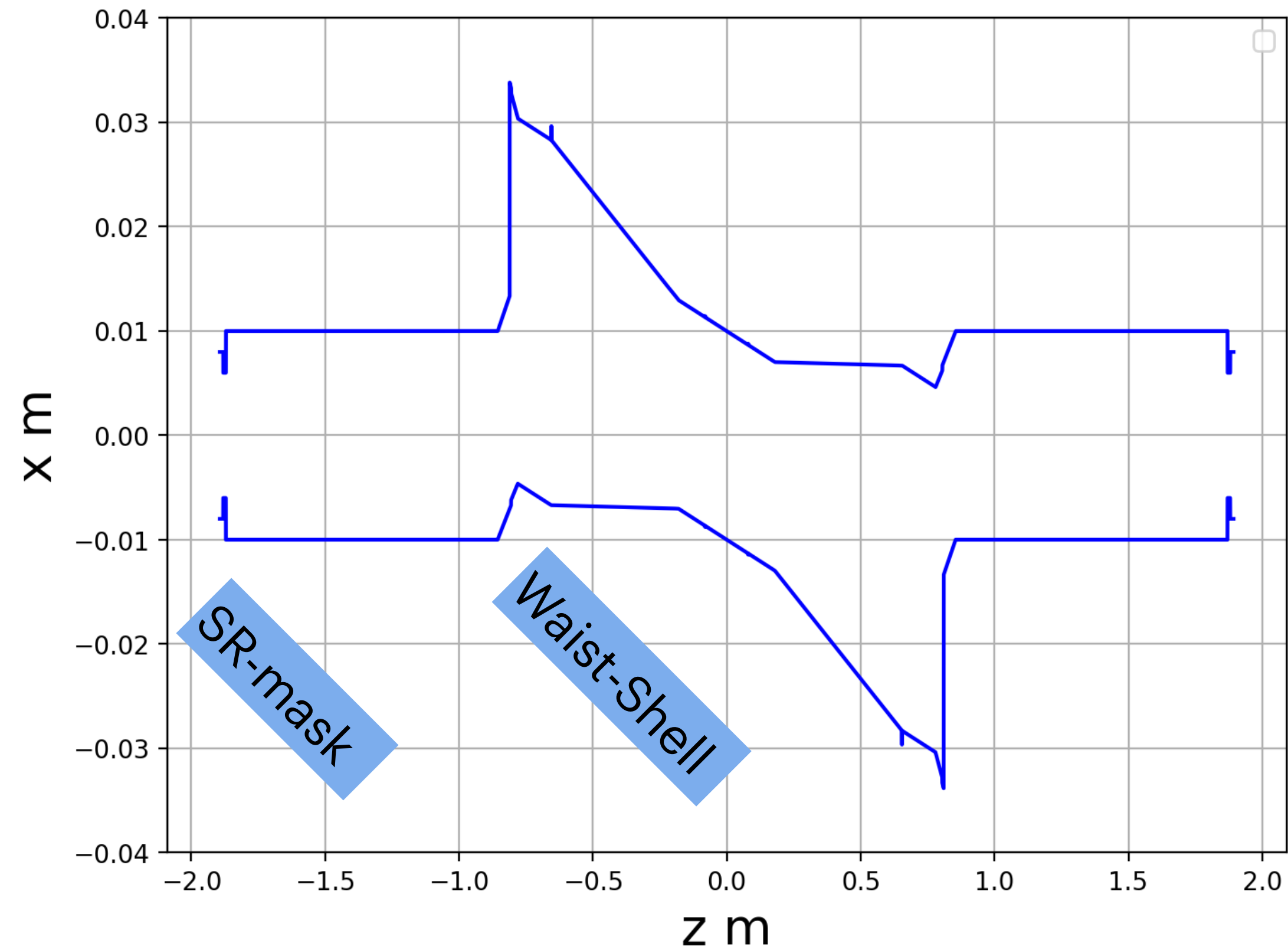
  - Include lumical.

BDSIM (B-field)

- Left plots show the non-uniform magnetic field from CEPCSW

- Convert them into a suitable format for BDSIM

Aperture

- Left: Aperture profiling within a view of +/- 2 m
  - Two incoming pipes merge in the waist area, causing the aperture to narrow there
  - This makes the waist-shell is higher than the SR mask from the beam's point of view
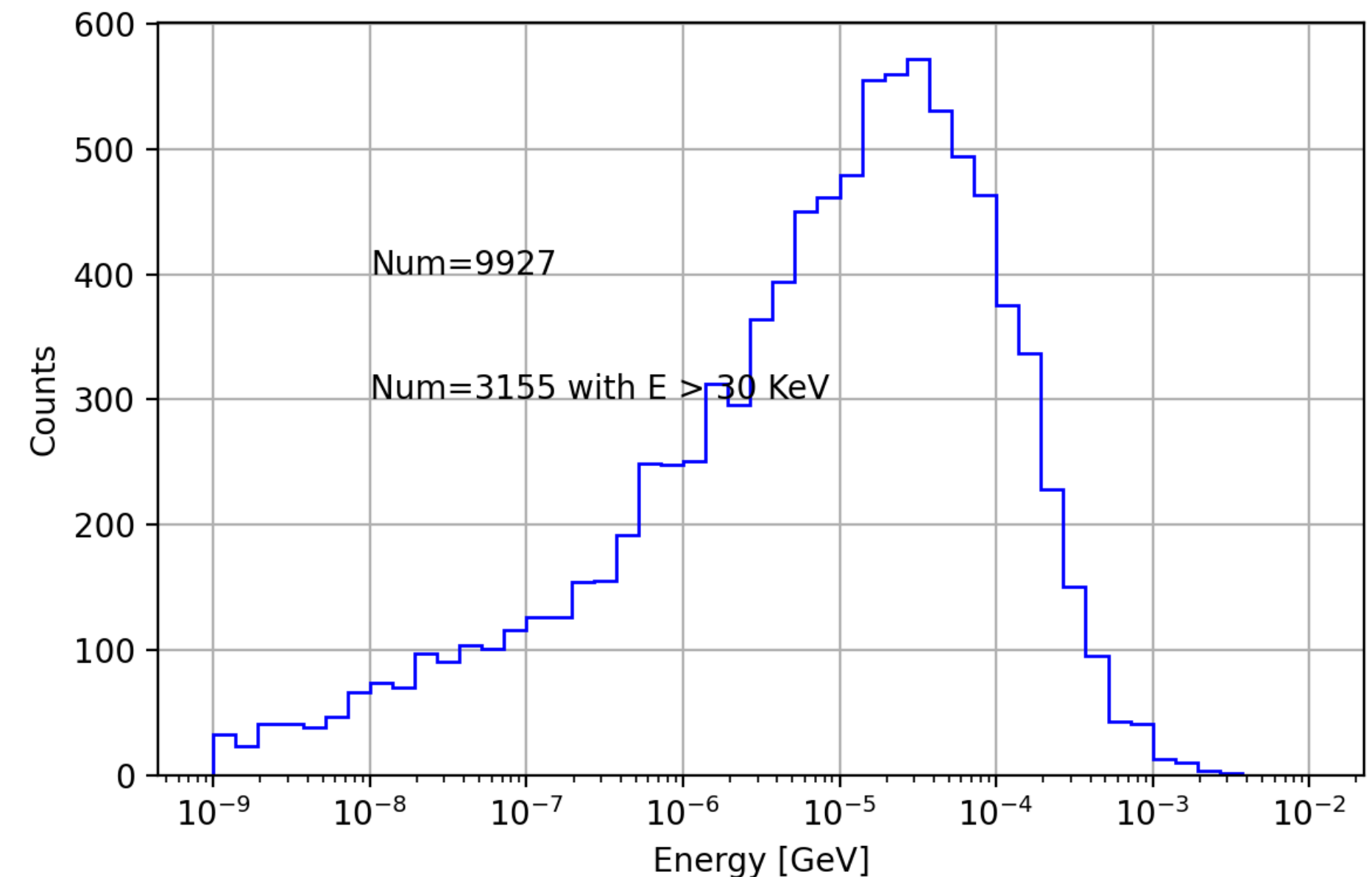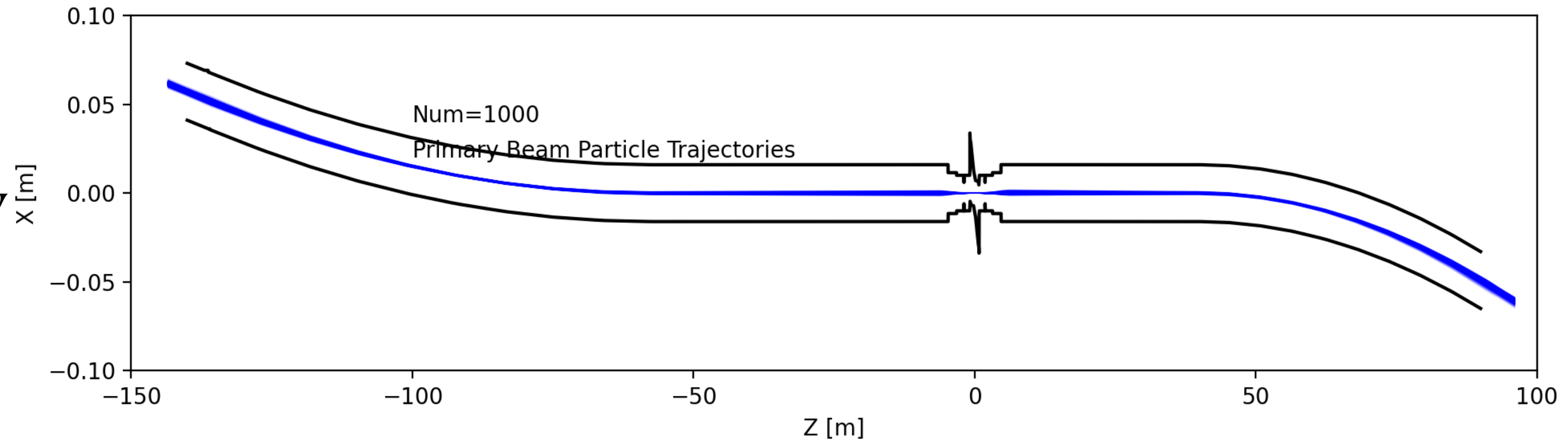- Right: Aperture profiling within a larger view

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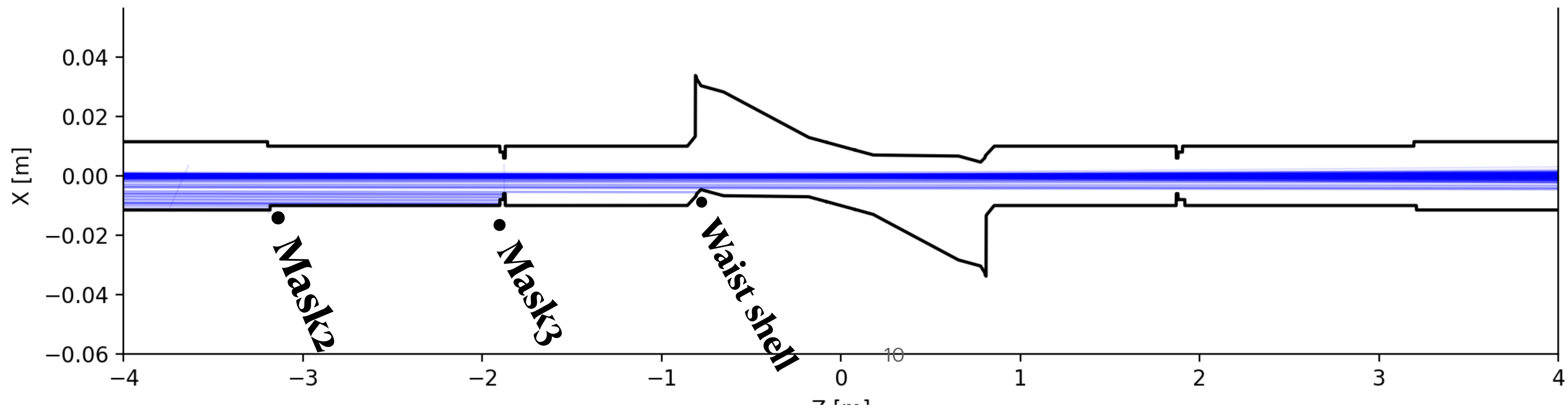
- **Trajectory Analysis**

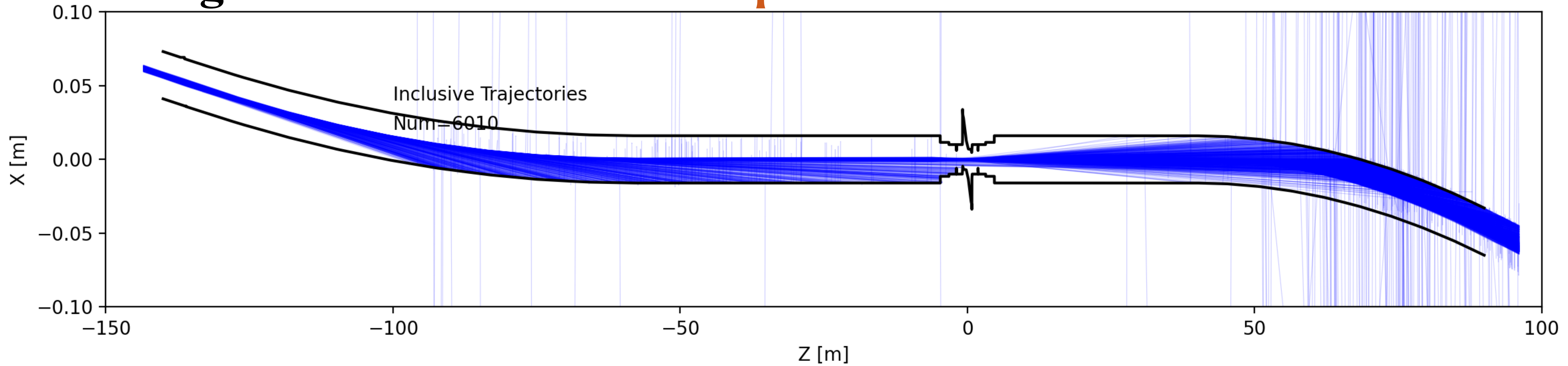- Summary

Trajectory

- *Comparison with the TDR SR result*

  - *± 150 m around IP*

  - *SR photon energy threshold: 30KeV*

  - *No solenoid field*

  - *No magnet yoke*

- **1000 beam particles** from left hand side to the right

  - Beam is stable

  - Optical behaviour

- SR Photon yield is the same as the TDR

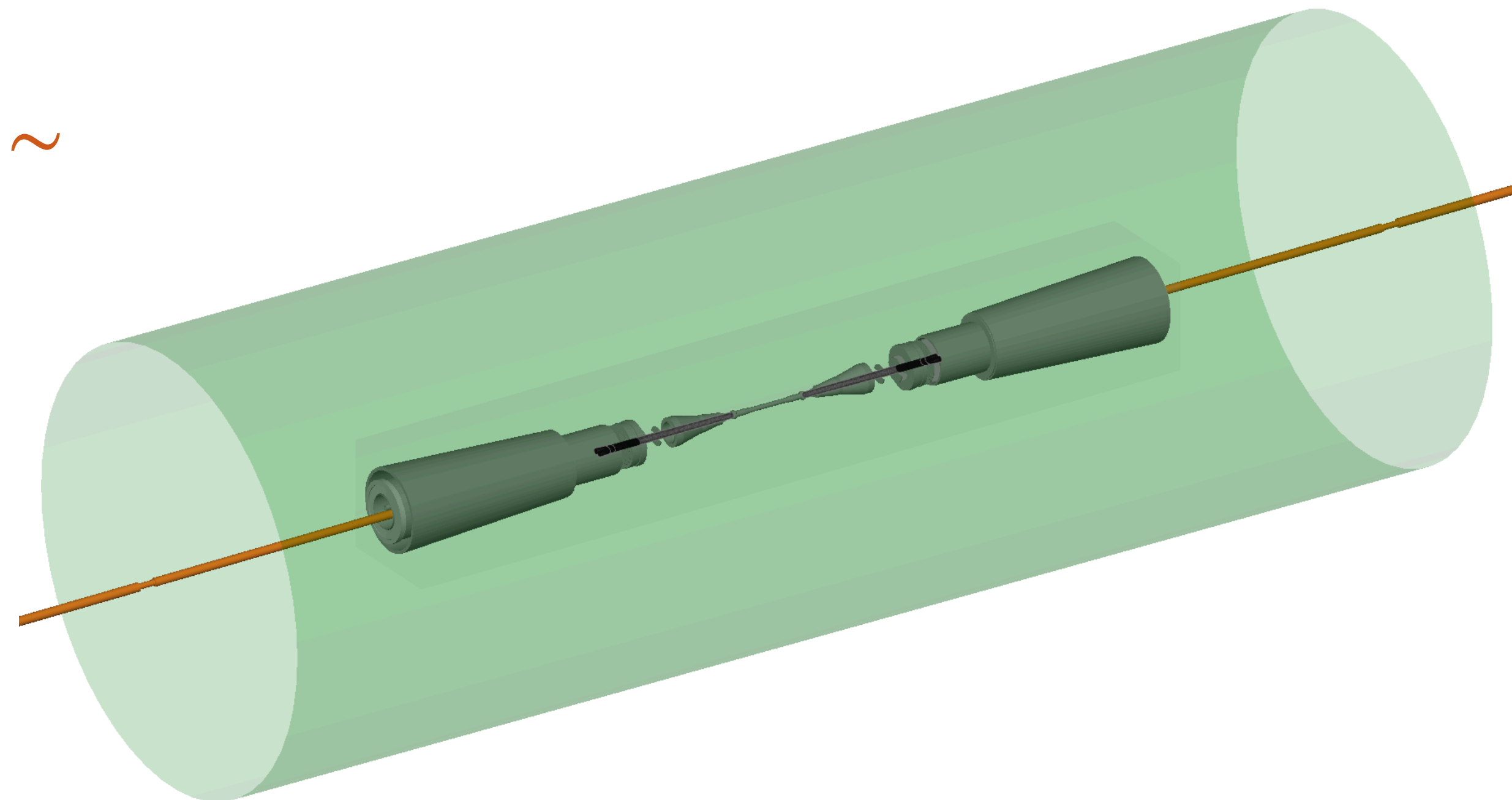 - Within ±150 m, No solenoid, **3 photons per beam particle**

Trajectory

- **A global view with 1000 beam particles**

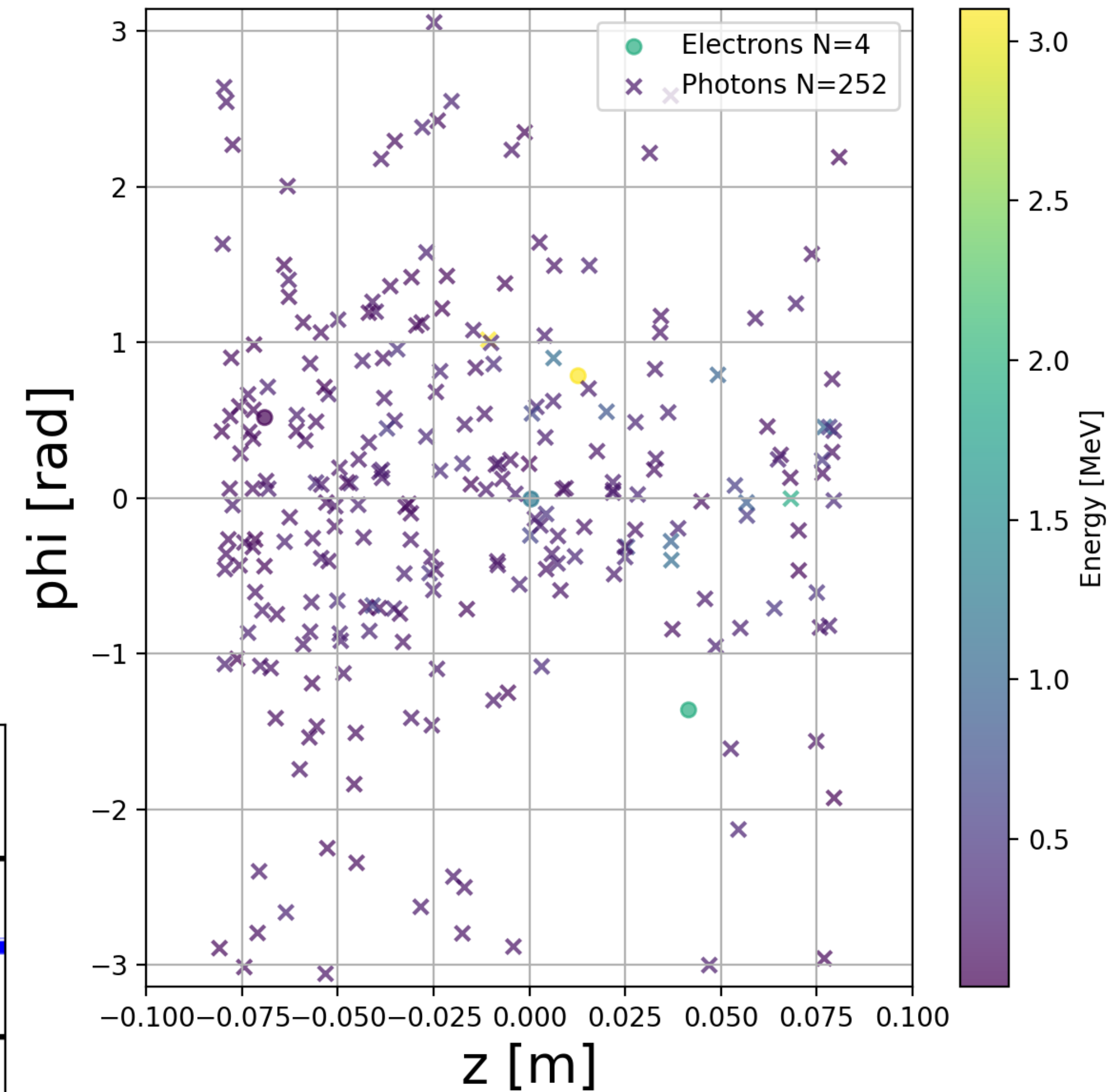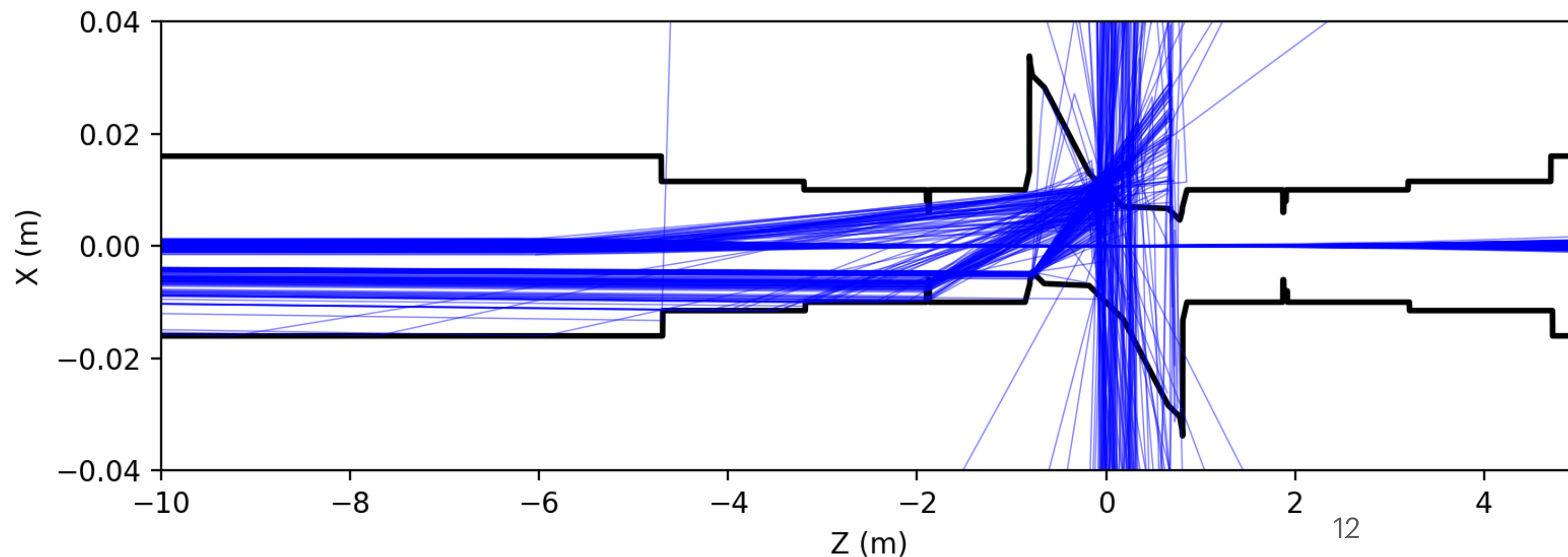Inclusive Trajectories
Num=6010

Mask2

Mask3

Waist shell

Trajectory

- A concept about SamplerSurface

  - A surface built in BDSIM records all particles passing trough it

  - The tracker system is not included in this simulation

    - A cylinder surface with length = 161.4 mm and radius = 11.1 mm is used for VTX L1

  - Hit rate of this layer @ $\sqrt{s} = 240\text{GeV}$ ~ 112hits / 10^9beam particles

Trajectory

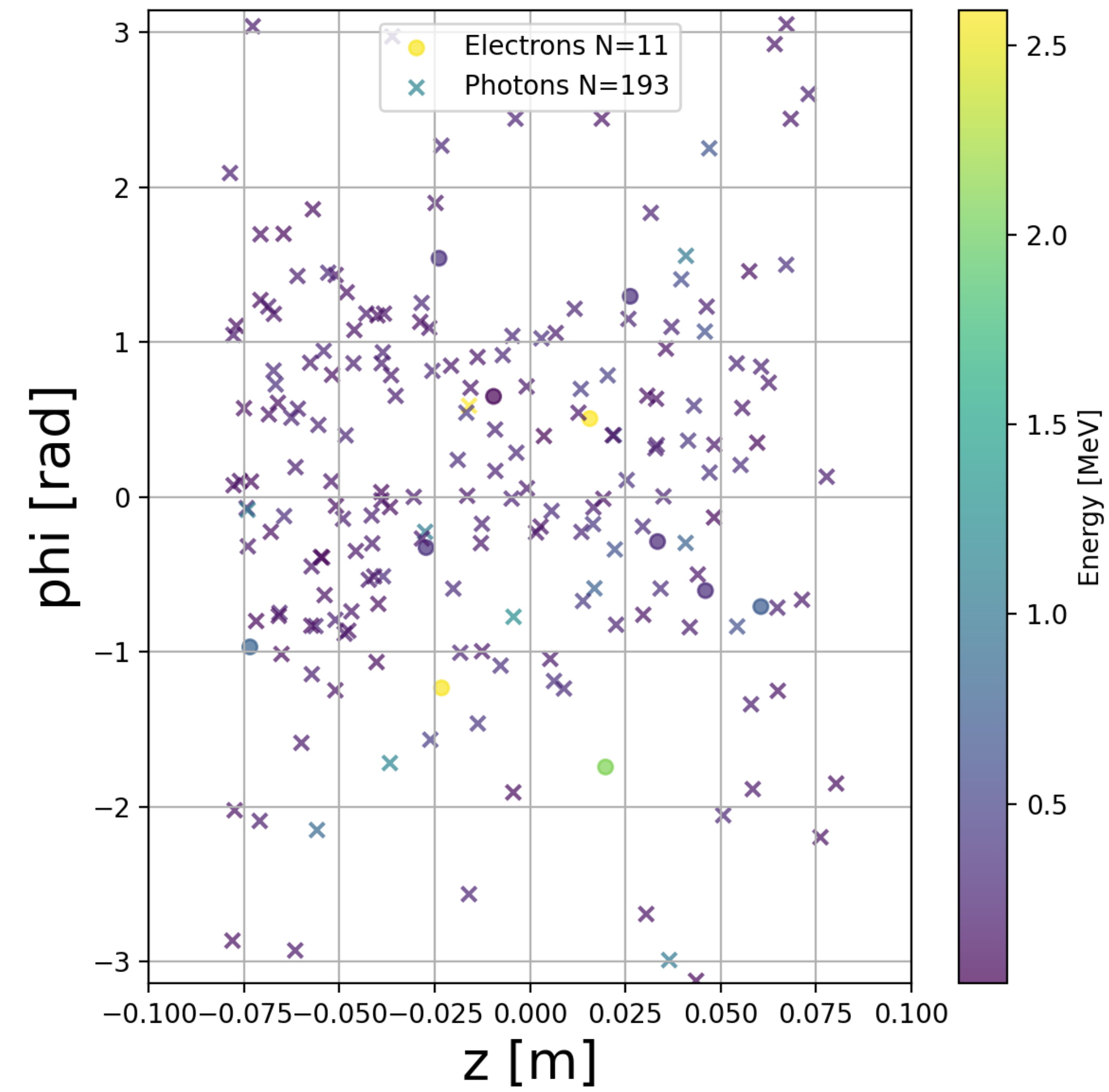- *Comparison with the TDR SR result*

  - *± 150 m around IP*

  - *SR photon energy threshold: 30KeV*

  - *No solenoid field*

  - *No magnet yoke*

- *Simulate 10^9 beam particles, only record the trajectories that cross the SamplerSurface*
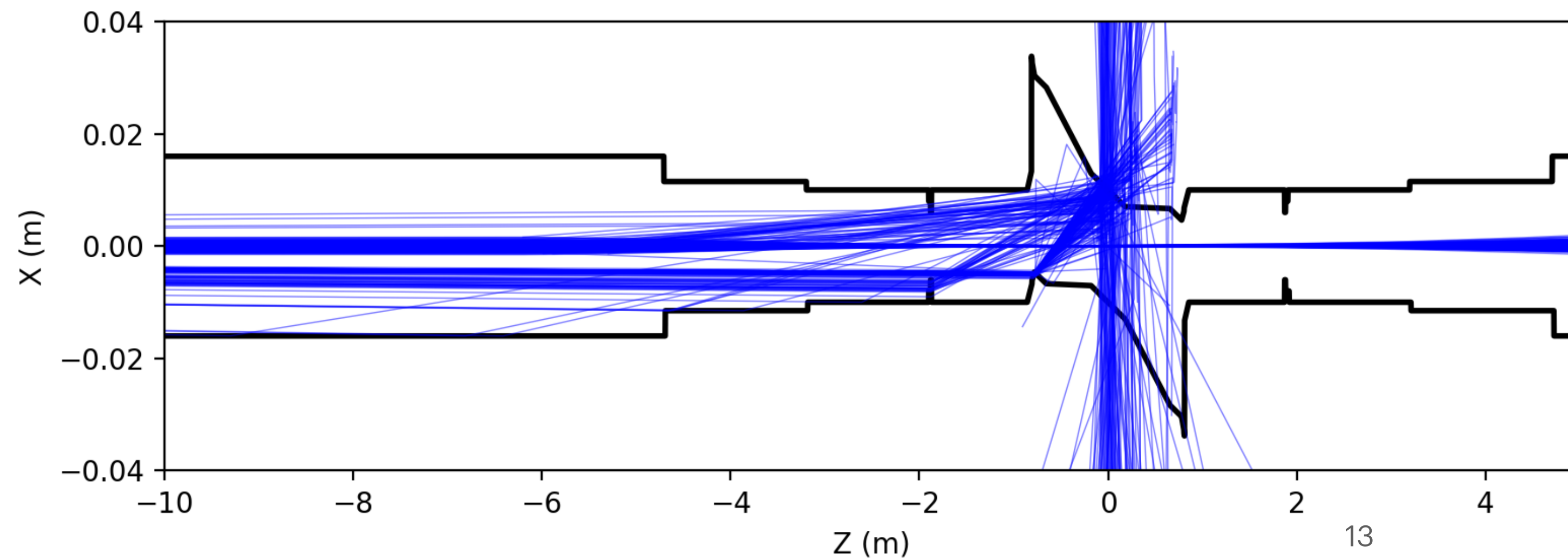
- *1000 jobs, 1 h*

Trajectory

- *Comparison with the TDR SR result*

  - *± 150 m around IP*

  - *SR photon energy threshold: 0 KeV*

  - *No solenoid field*

  - *No magnet yoke*

- *Simulate 10^9 beam particles, only record the trajectories that cross the SamplerSurface*
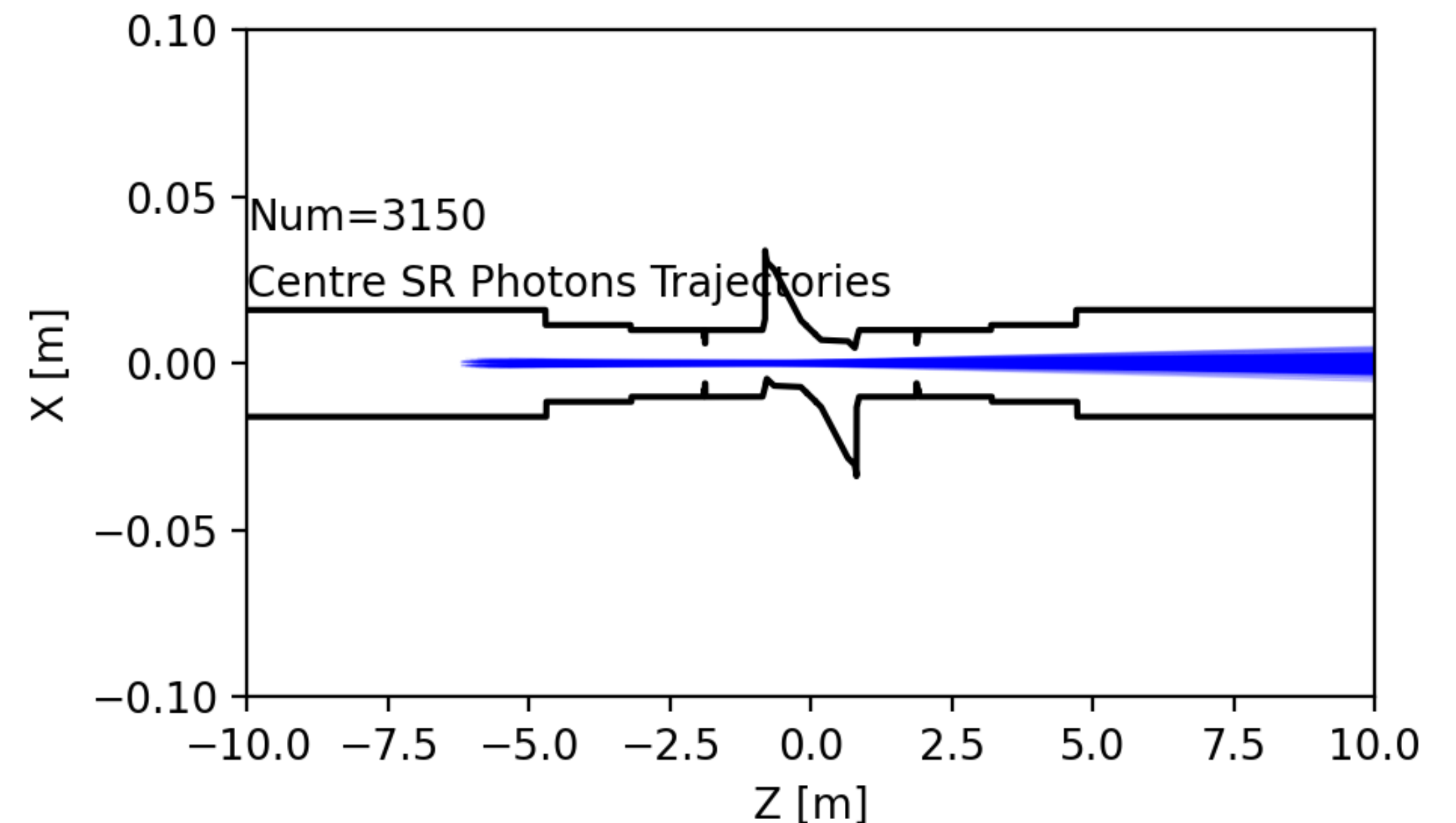
- *1000 jobs, ~2h*

Trajectory

- *Comparison with the TDR SR result*

  - *± 150 m around IP*

  - *SR photon energy threshold: 0 KeV*

  - *Add solenoid field*

  - *No magnet yoke*

- *Demonstrate the effects of solenoid field using only 10^3 beam particles*

  - *More SR photons are generated in the centre region*

  - *Most of them go to far downstream*

Trajectory

- *Comparison with the TDR SR result*

  - *± 150 m around IP*

  - *SR photon energy threshold: 0 KeV*

  - *Add solenoid field*

  - *No magnet yoke*

- *Simulate 10^9 beam particles, only record the trajectories that cross the SamplerSurface*

- *1000 jobs, 4h*
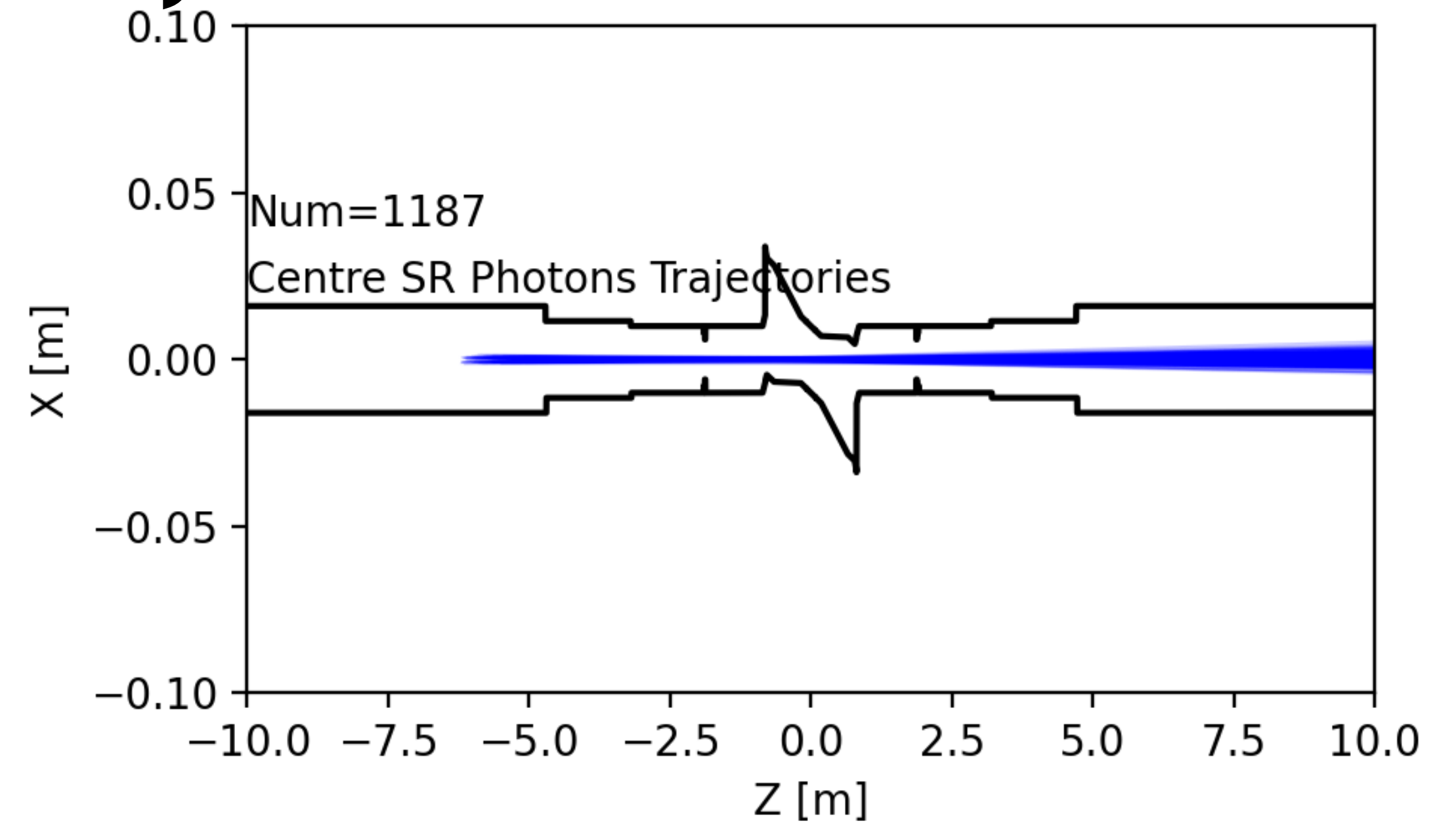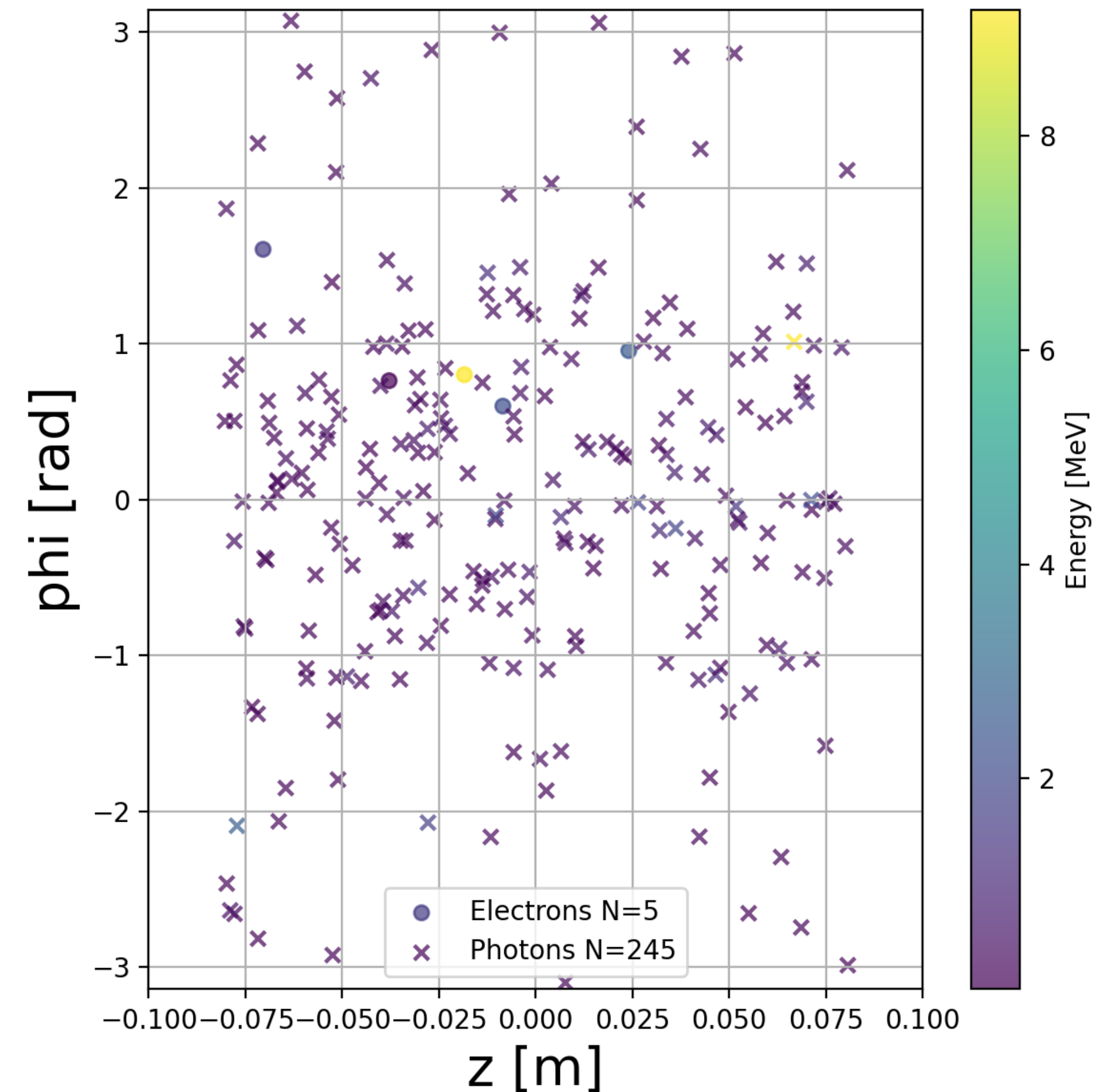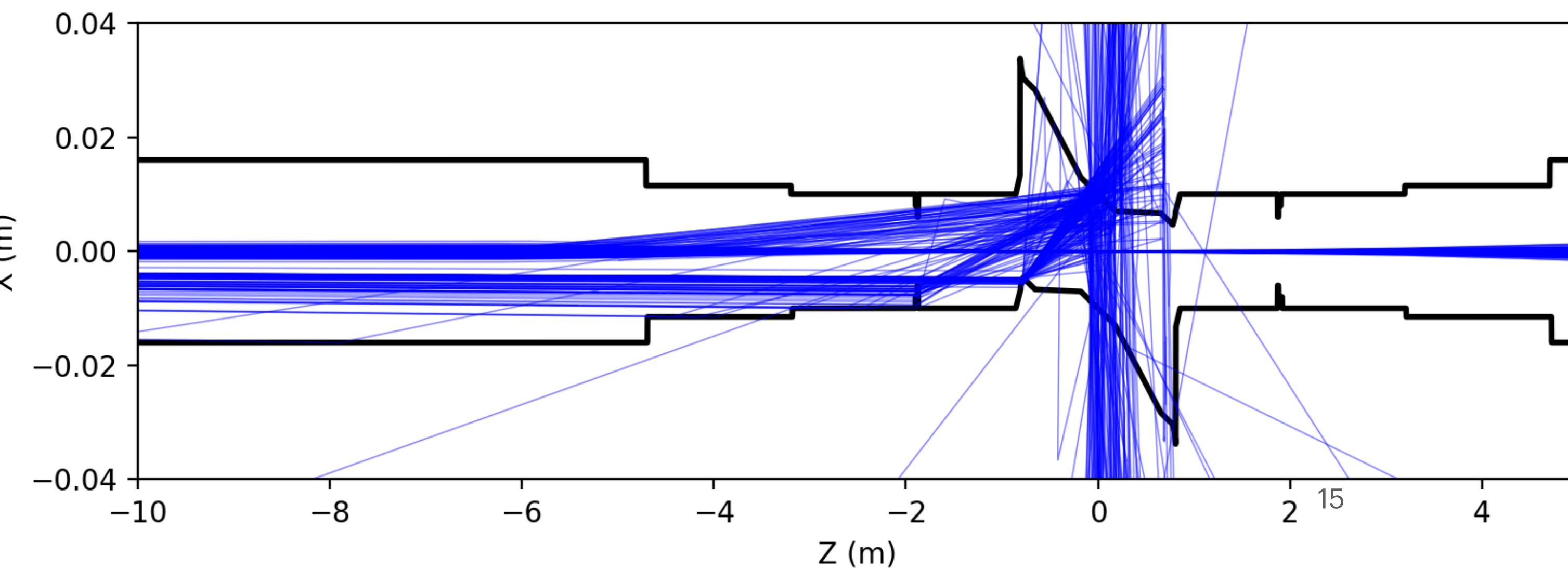
Trajectory

- *Comparison with the TDR SR result*

    - *± 150 m around IP*

    - *SR photon energy threshold: 0 KeV*

    - *Add solenoid field*

    - *Add magnet yoke*

- *Simulate 10^8 beam particles, only record the trajectories that cross the SamplerSurface*

- *100 jobs, 10h*

Running…

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Summary

- **A new framework for SR study vs. TDR**

10^9 beam particles	Number of CPU	Time	Hit at VXD L1/ 10^9 beam particles	
TDR	5000	10h	112	**Full detector simulated**
BDSIM baseline [the same settings as TDR]	1000	1h	256	**Only centre pipe and lumical**
BDSIM baseline, E_thr = 0	1000	2h	204	
BDSIM baseline, E_thr=0, add solenoid	1000	4h	250	
BDSIM baseline, E_thr=0, add solenoid and magnet yoke	1000	10h	-	

- **New result agrees with the TDR at the same order of magnitude , more details need to be checked**

- **To add more detector elements to the simulation**