

A 3D simulation showing a dense beam of green lines representing particles entering from the left and hitting a complex, multi-layered detector structure. The detector is rendered in a wireframe style with various colored components (red, blue, green). The background is white with faint green lines radiating from the detector.

Simulation and Reconstruction of the RICH Upgrade Test Beam

Michele Piero Blago

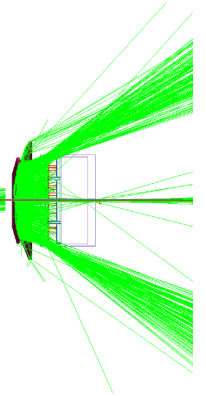
Supervised by Sajjan Easo



RUPRECHT-KARLS-
UNIVERSITÄT
HEIDELBERG

About me

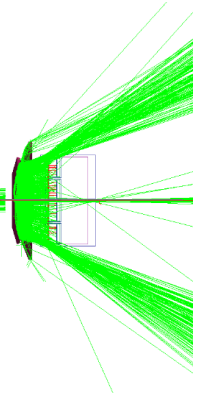
- Master Project at University College London, UK
- BSc in Physics at University of Heidelberg, Germany
- Currently Master Student at University of Heidelberg



My Project

- Simulation of the RICH Upgrade test beam
- Online monitoring program for the test beam
- Reconstruction and preliminary analysis of the data

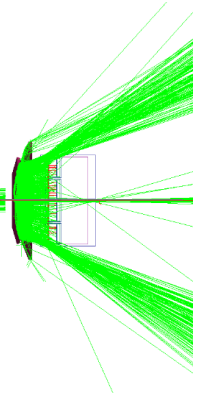
Timescale:



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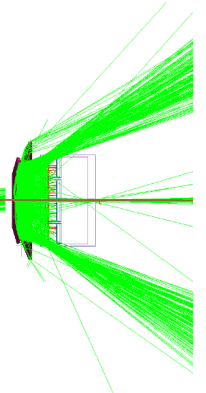
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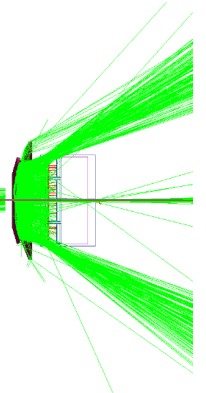
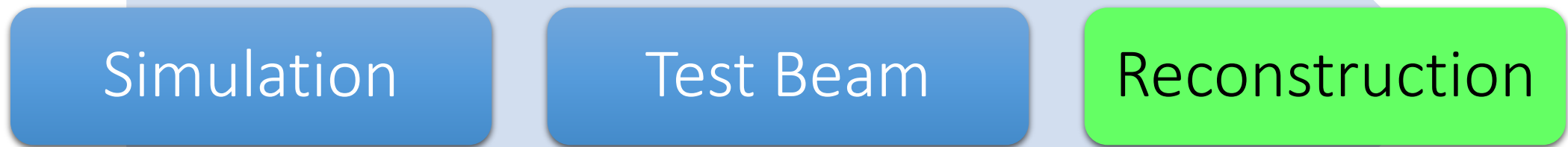
Timescale:



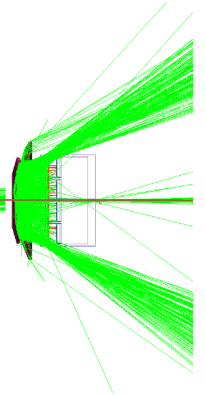
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RICH Test Beam Key Points

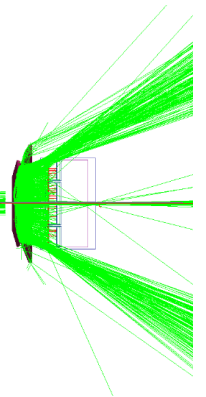


- In general
 - Testing of prototypes for the RICH Upgrade
- Purpose of test beam, testing of...
 - PMTs
 - New readout chip
 - Mechanical Structure, e.g. cooling
- Interesting quantities to measure
 - Cherenkov angle resolution
 - Number of photon hits per track

Simulation

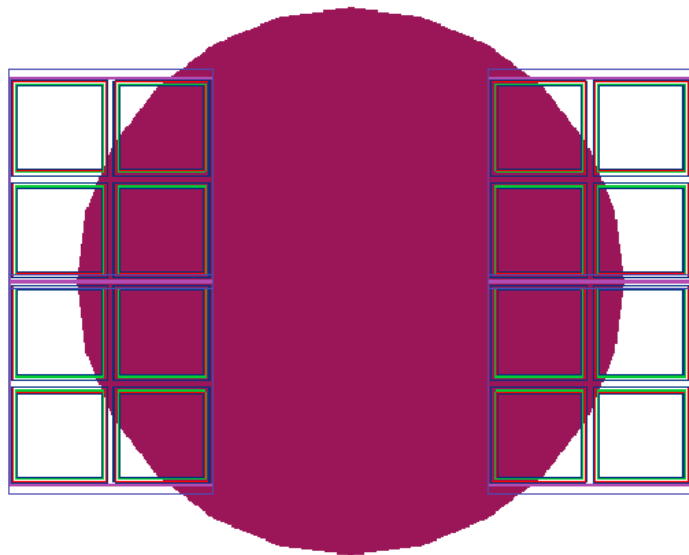
Simulation of the Setup (GEANT4)

Monte Carlo Event Generation

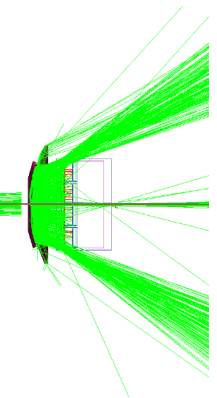
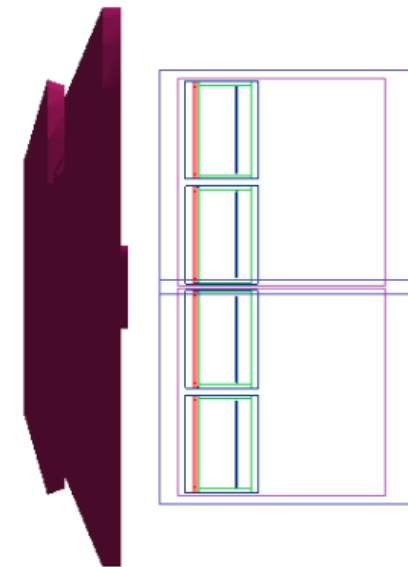


Simulation of the Setup (GEANT4)

Upstream perspective

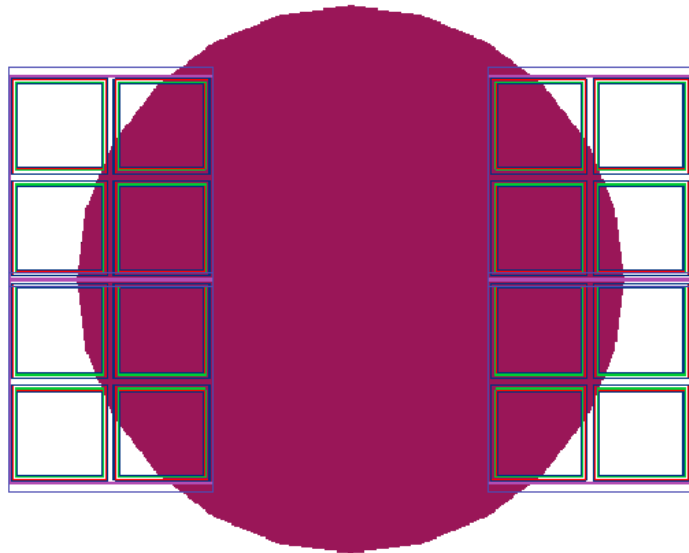


Side perspective



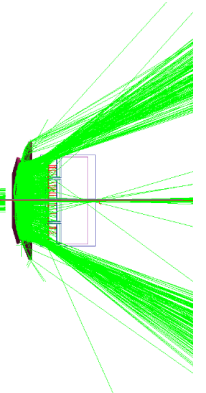
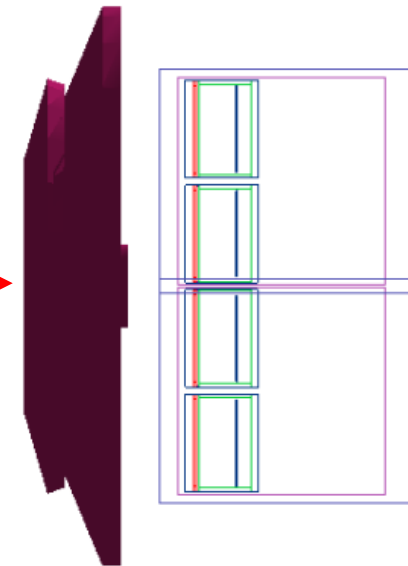
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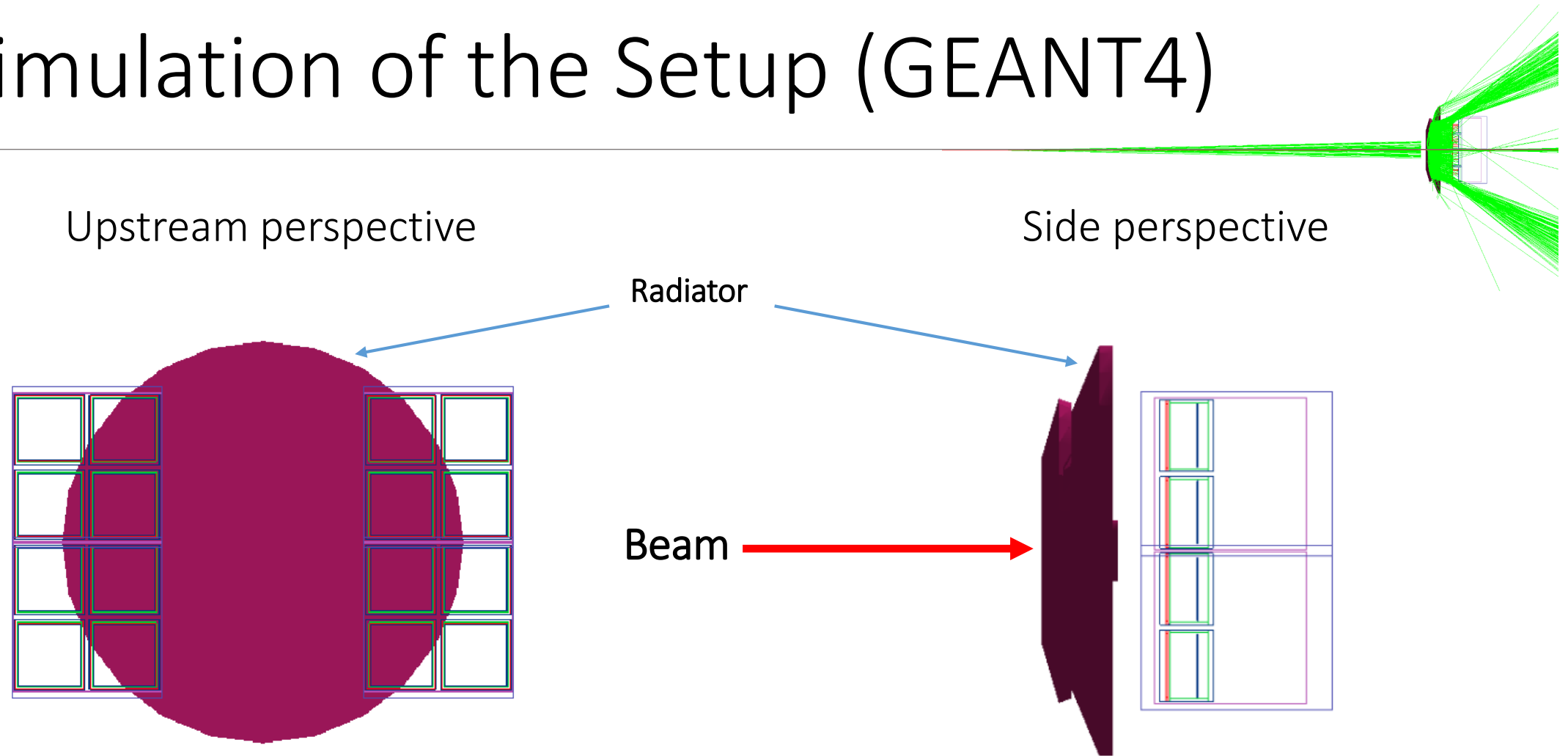


Side perspective

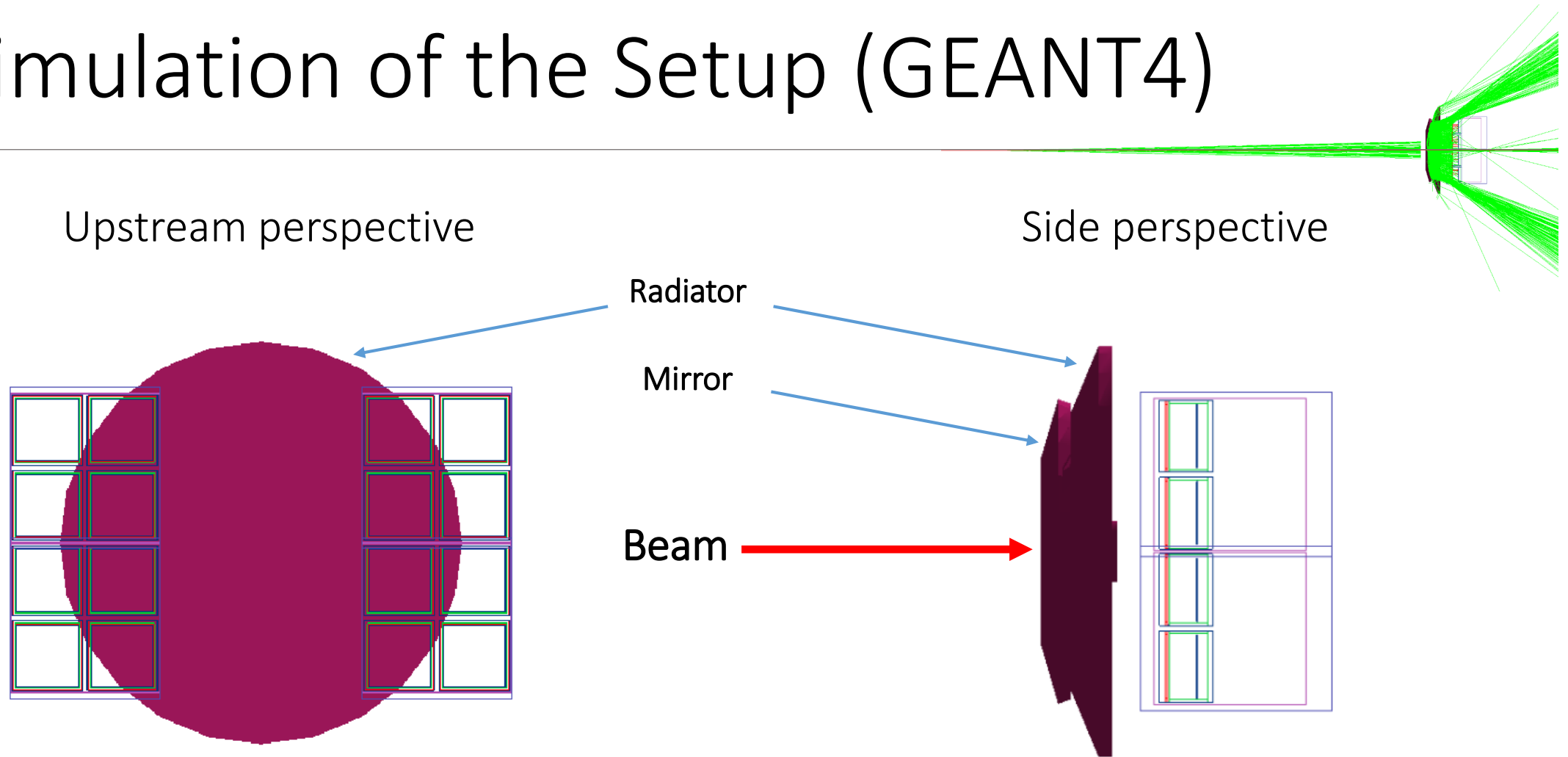
Beam



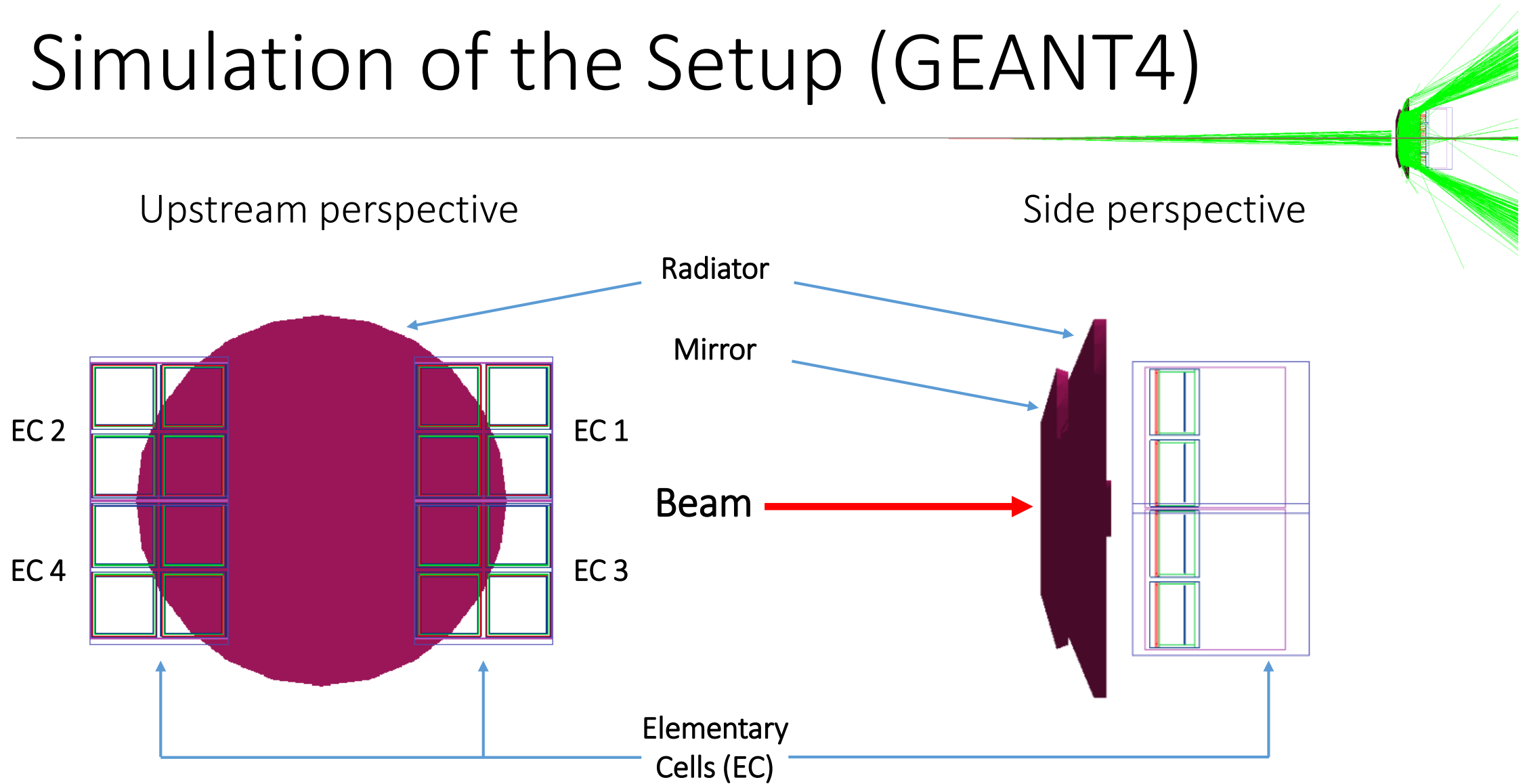
Simulation of the Setup (GEANT4)



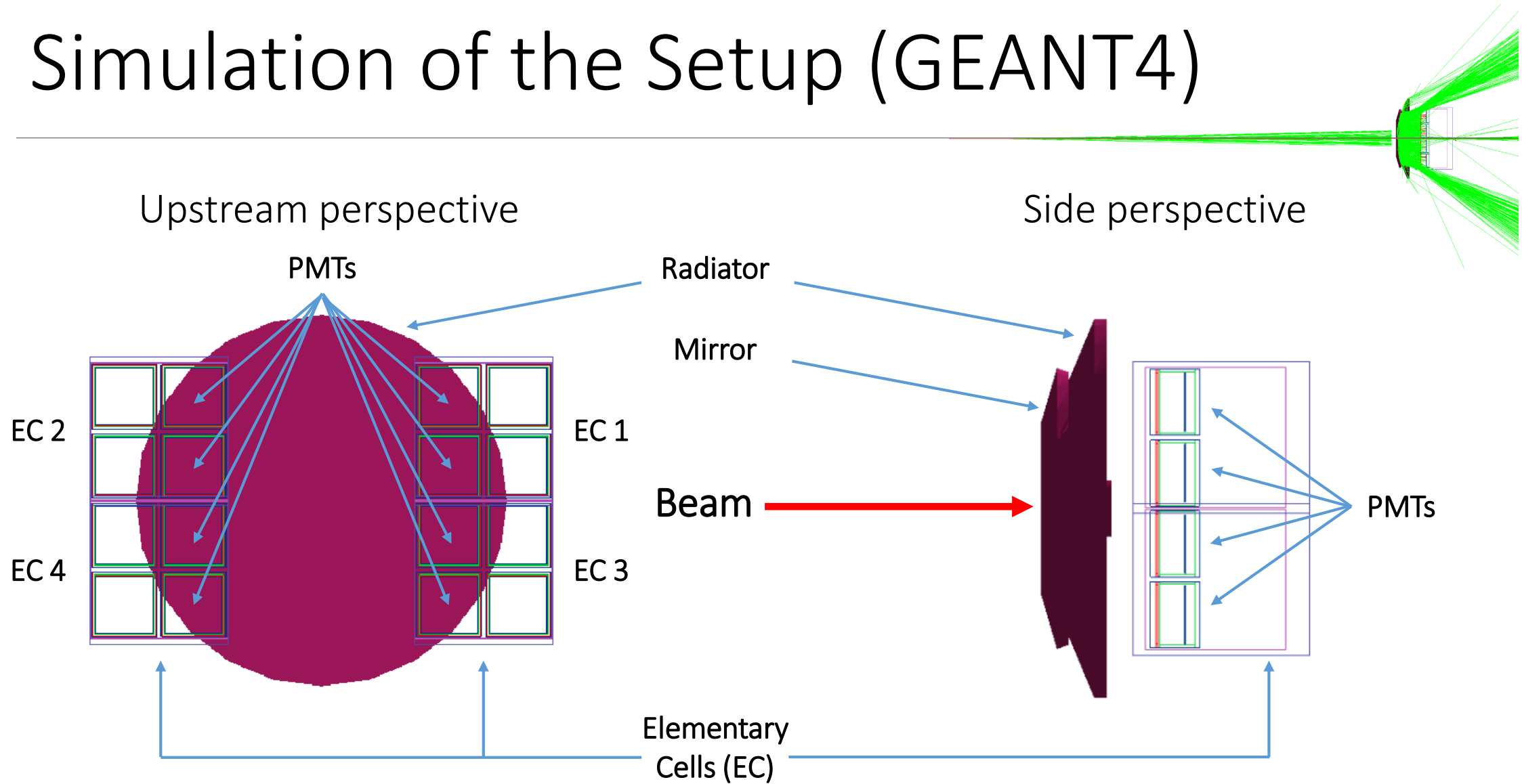
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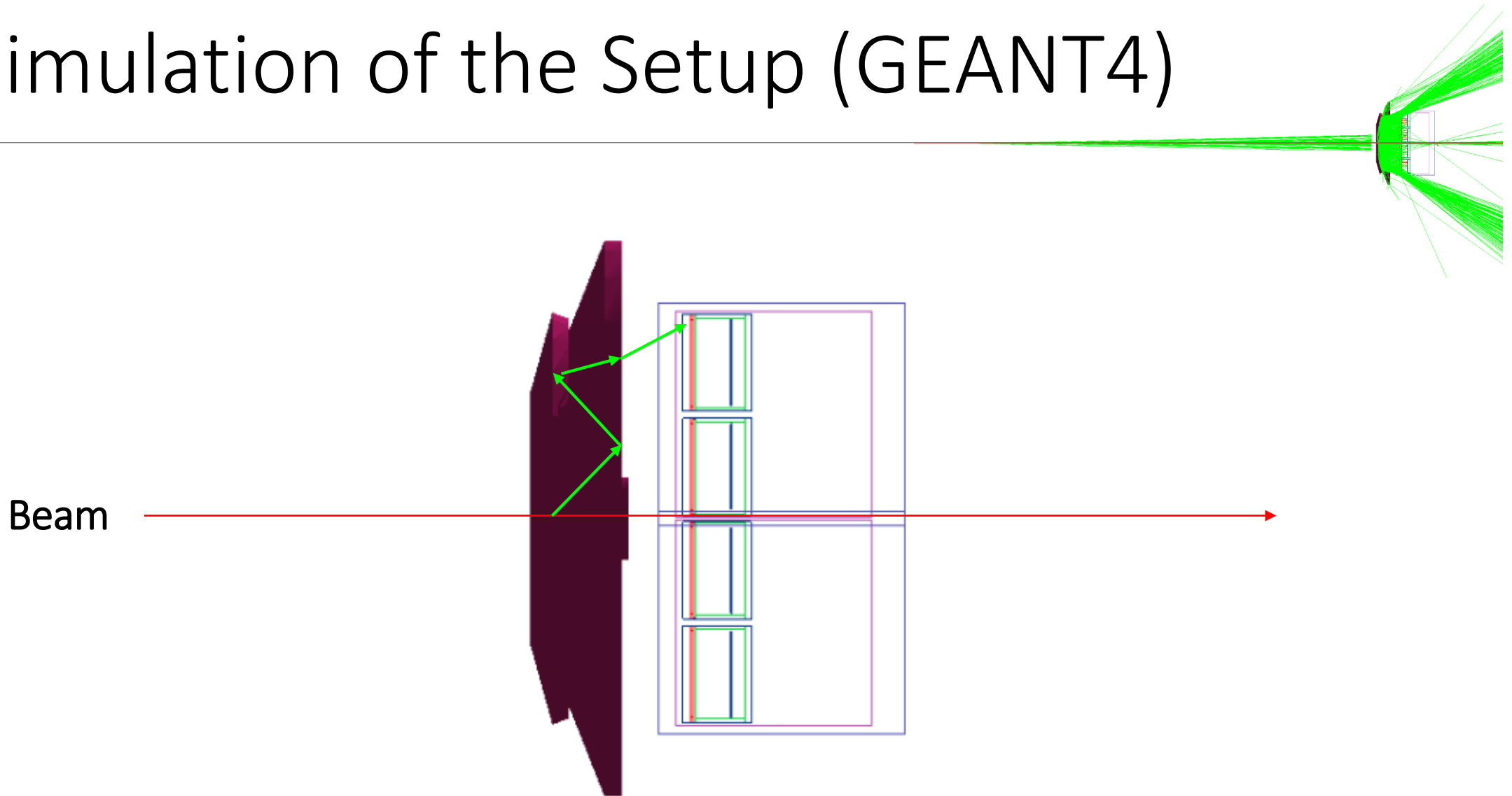
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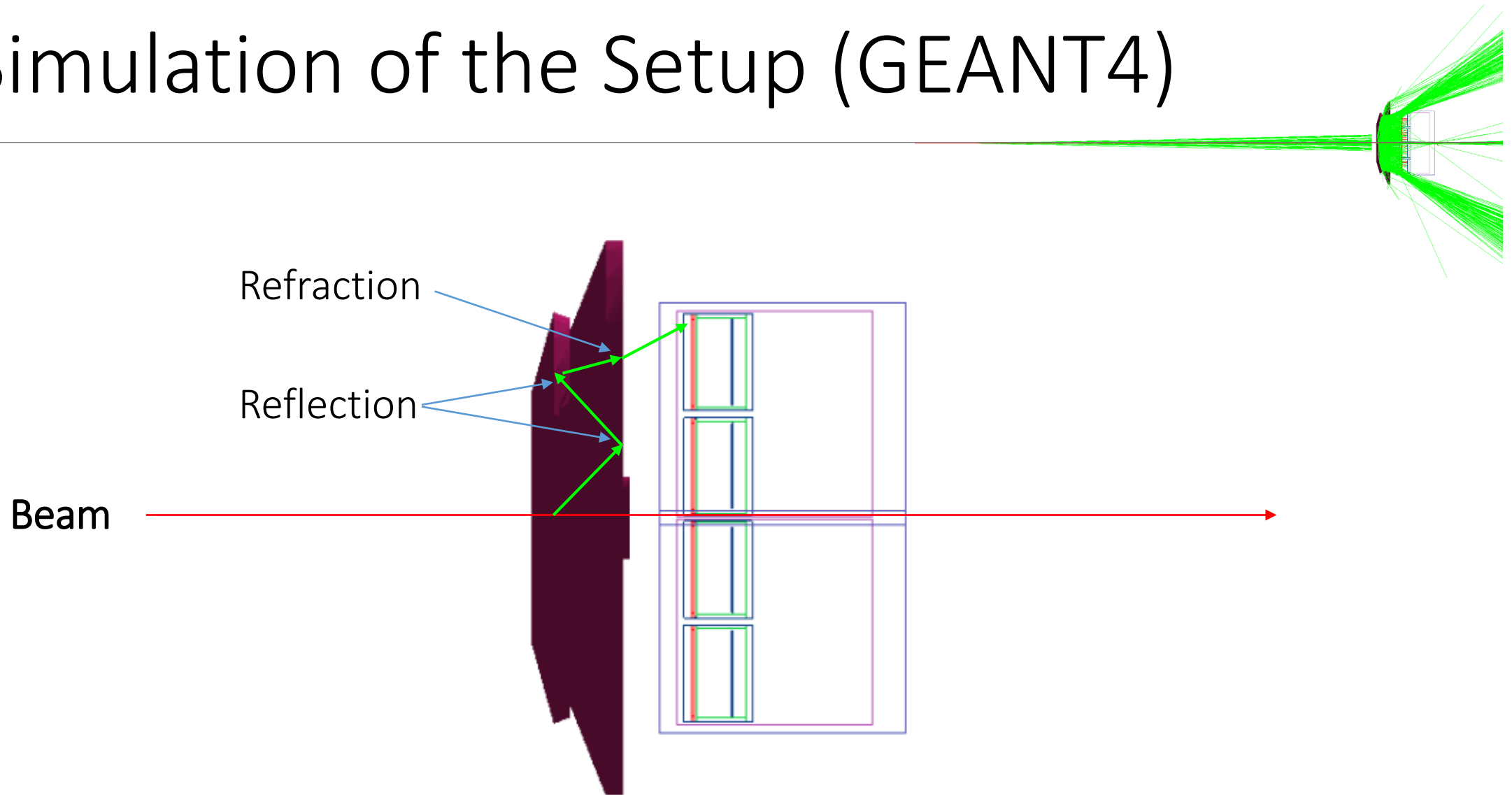
Simulation of the Setup (GEANT4)



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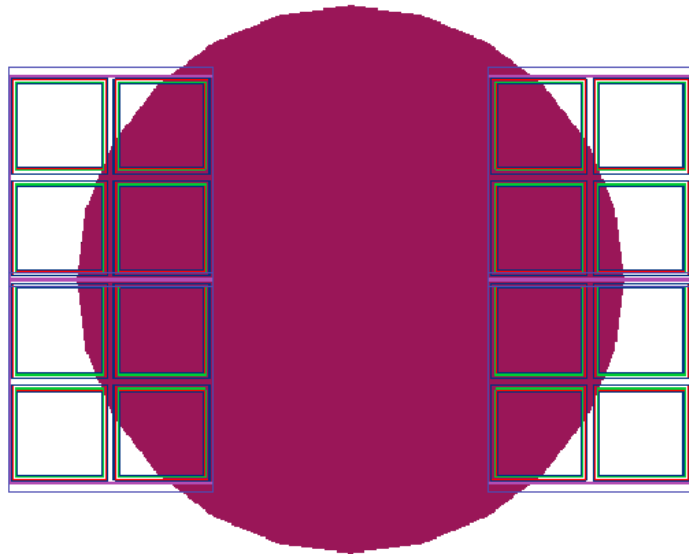


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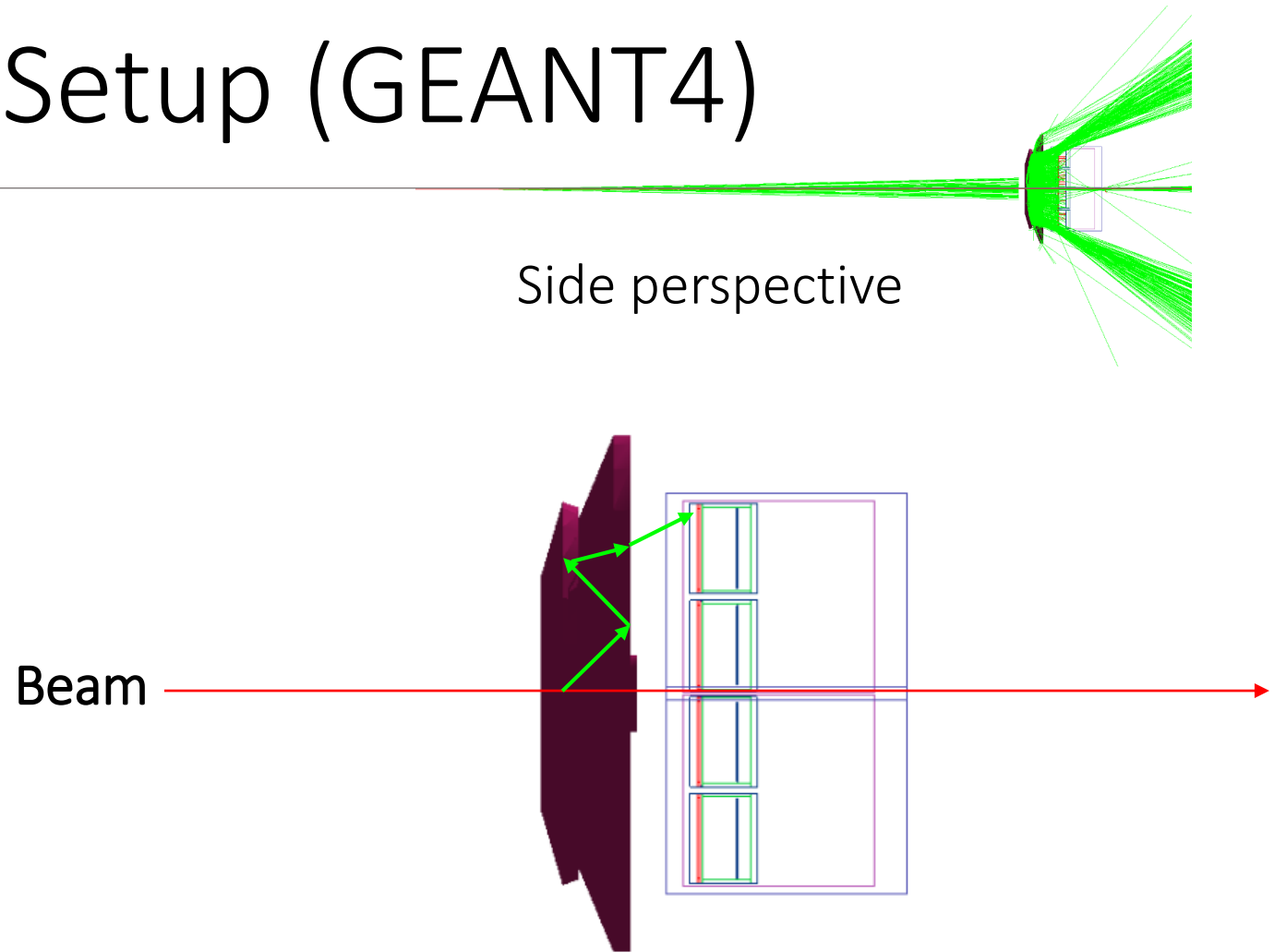


Simulation of the Setup (GEANT4)

Upstream perspective

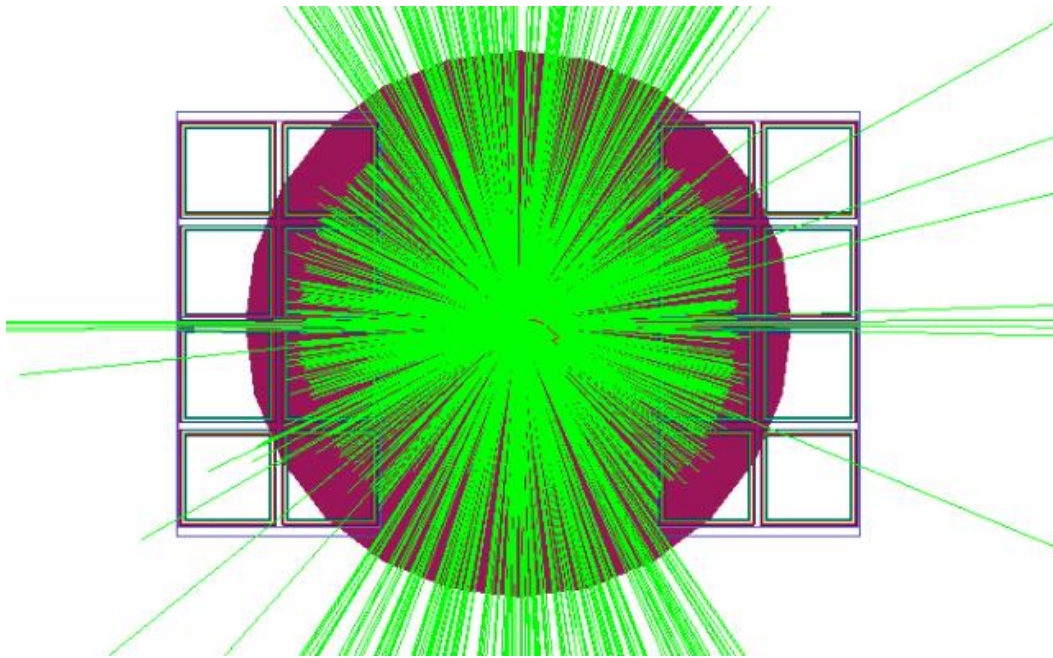


Side perspective

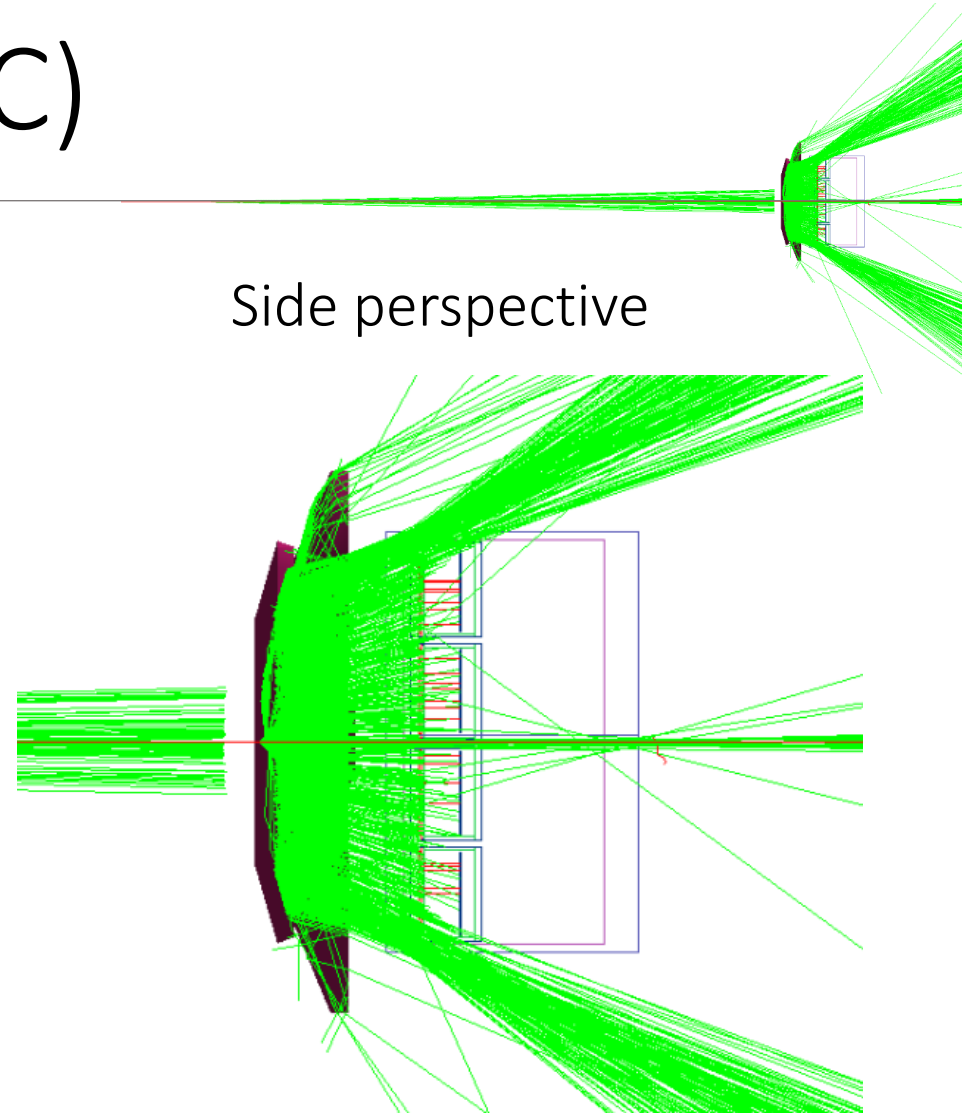


Simulation of Events (MC)

Upstream perspective

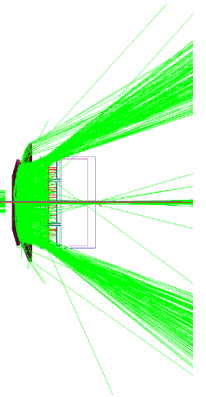


Side perspective

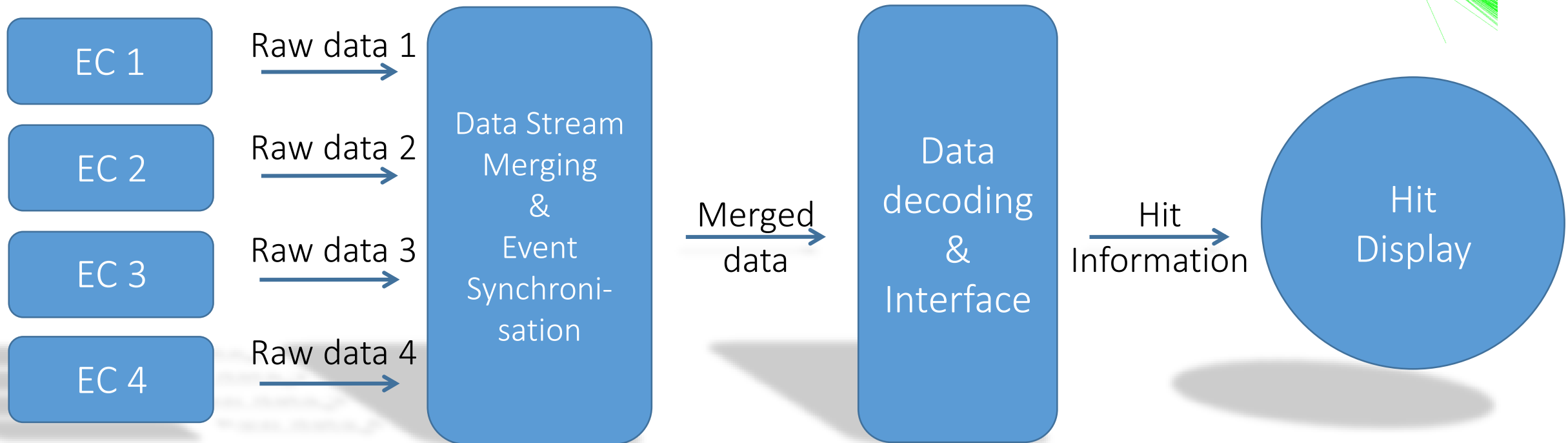


Test Beam

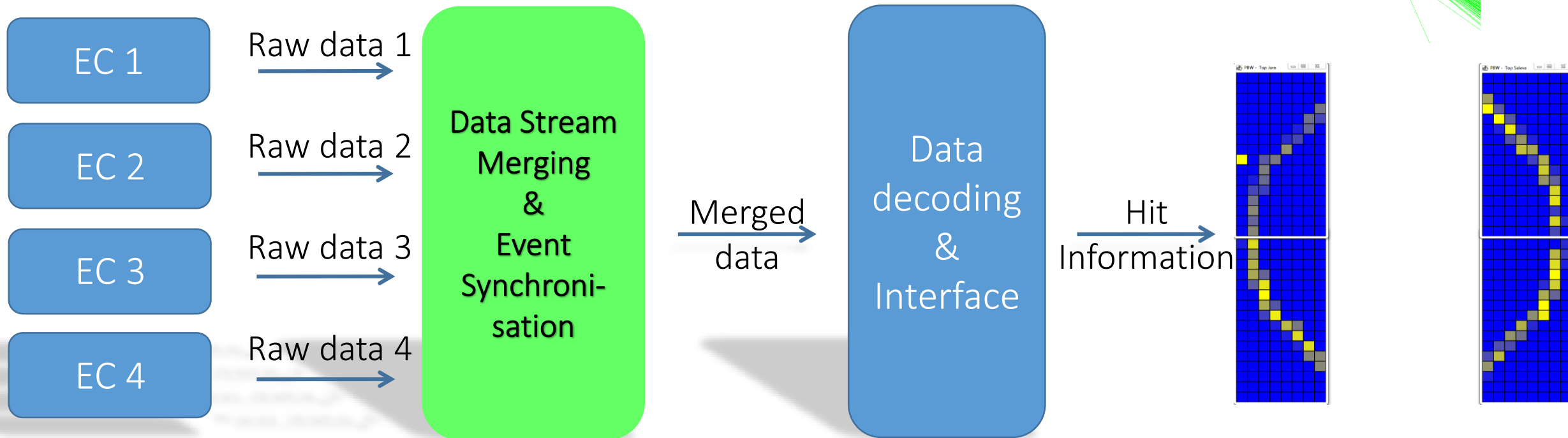
Online Monitoring Program



Online Monitoring Program (Java, C++)



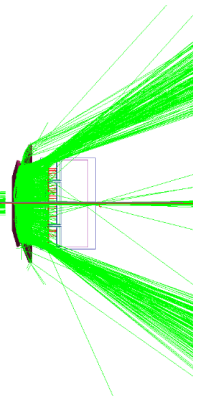
Online Monitoring Program (Java, C++)



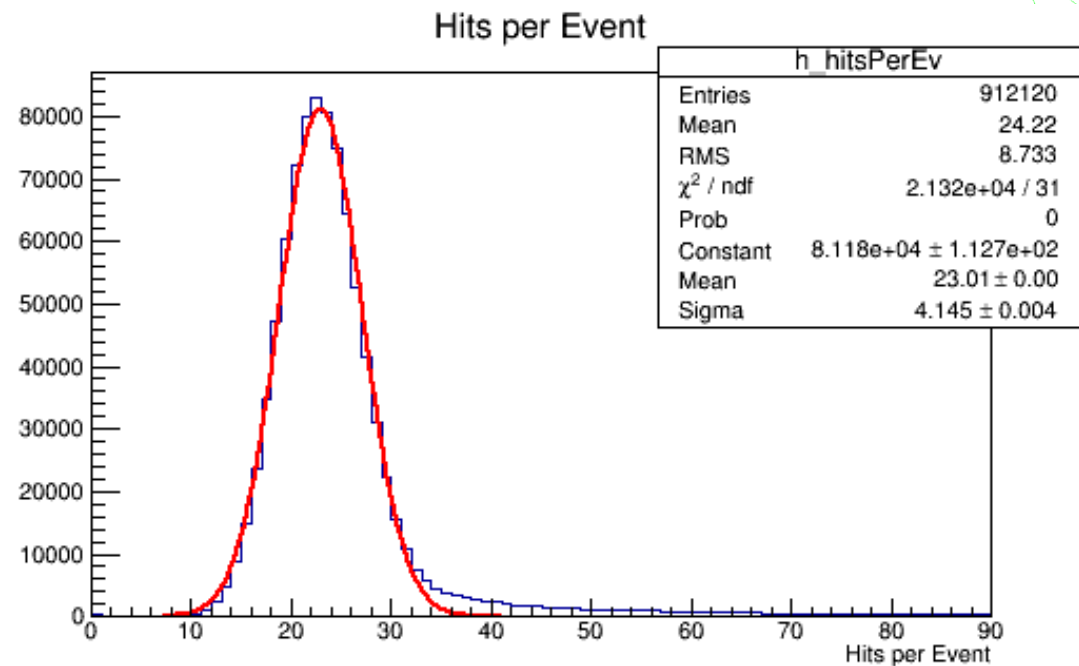
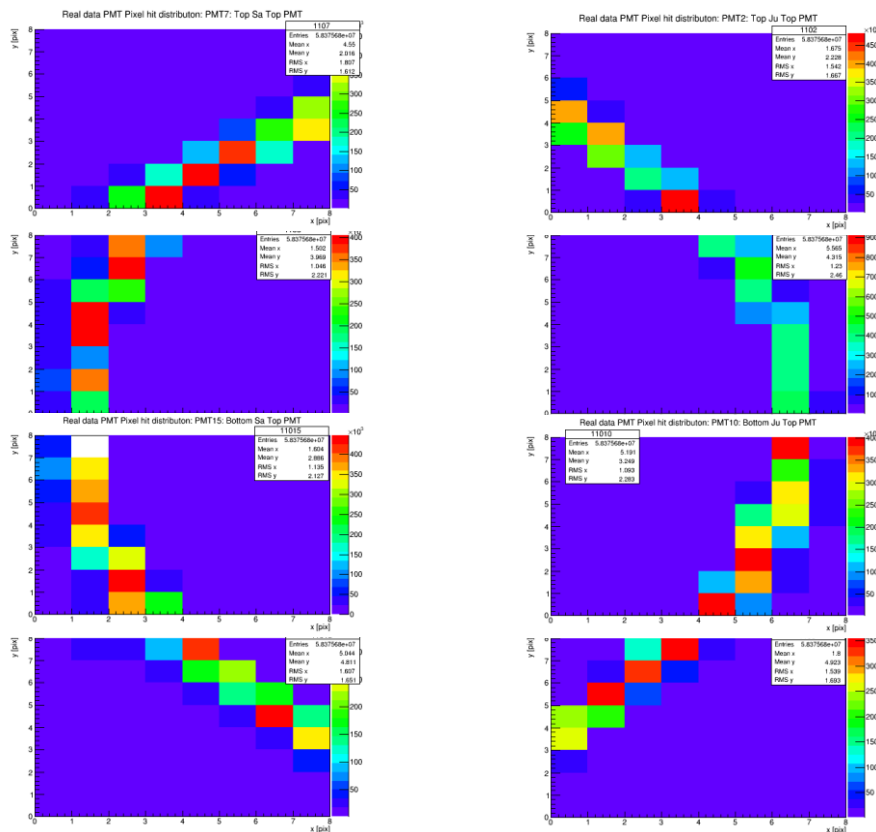
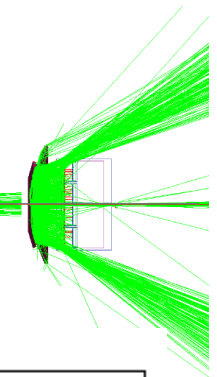
Reconstruction

Real Data Reconstruction

Comparison with MC Data Reconstruction

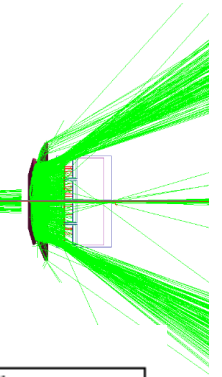


Number of Hits per Track (Real Data)



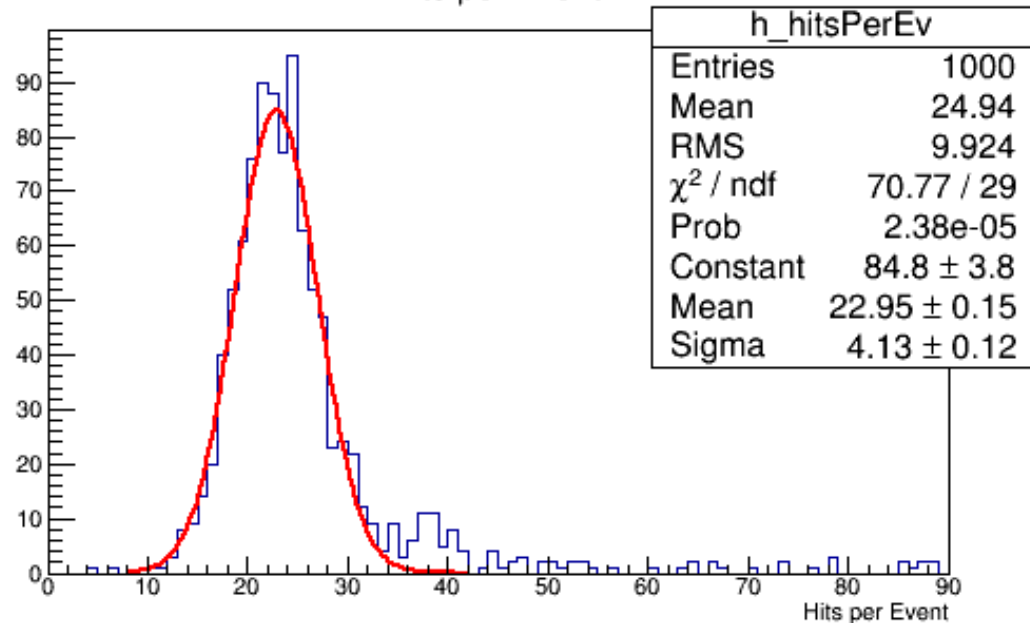
$$\# \text{hits/track} = 23 \pm 4$$

Number of Hits per Track Comparison



MC Data

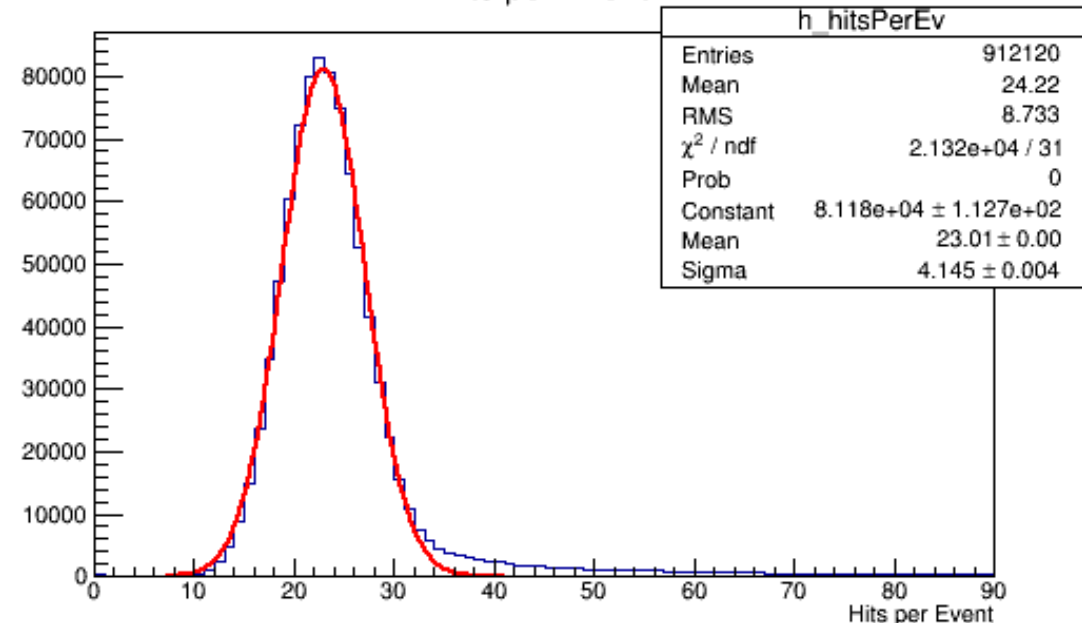
Hits per Event



#hits/track = 23 ± 4

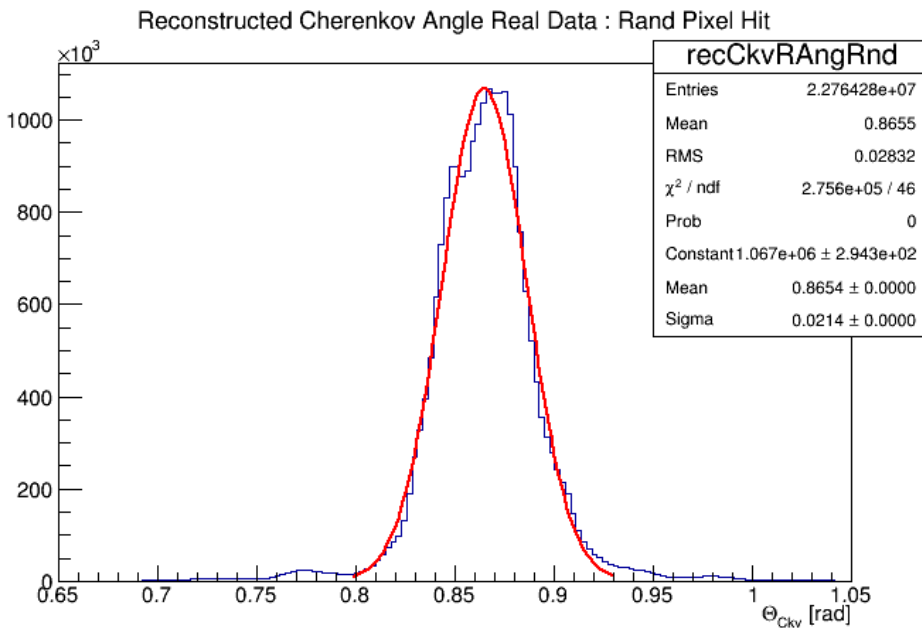
Real Data

Hits per Event

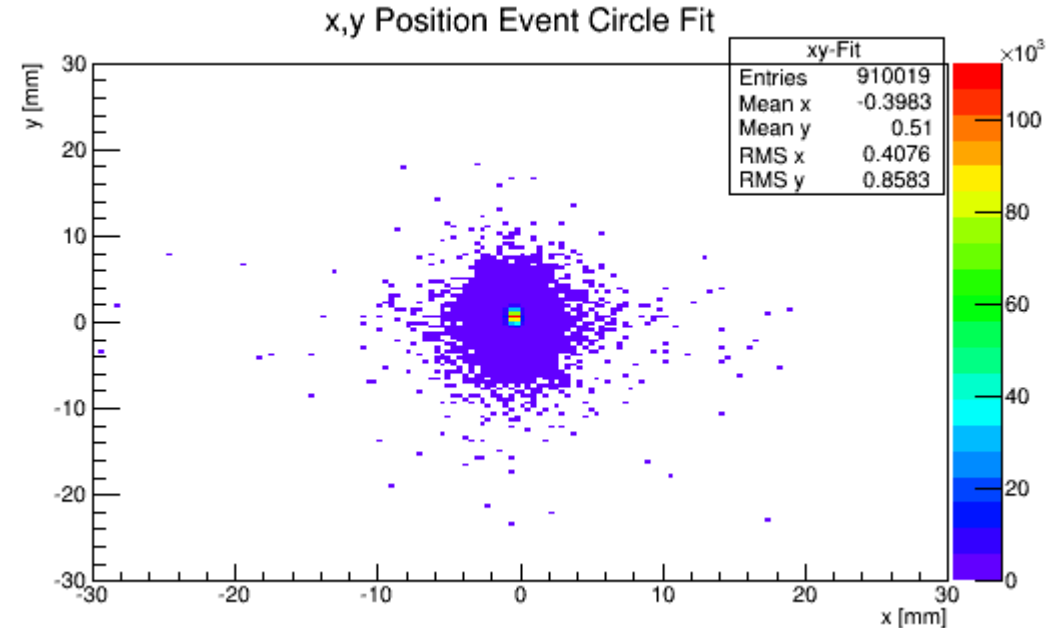


#hits/track = 23 ± 4

Reconstructed Cherenkov Angle Real Data

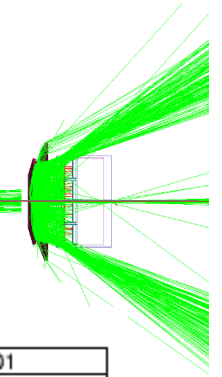


$$\theta_{Ckv,real} = 865 \pm 21 \text{ mrad}$$



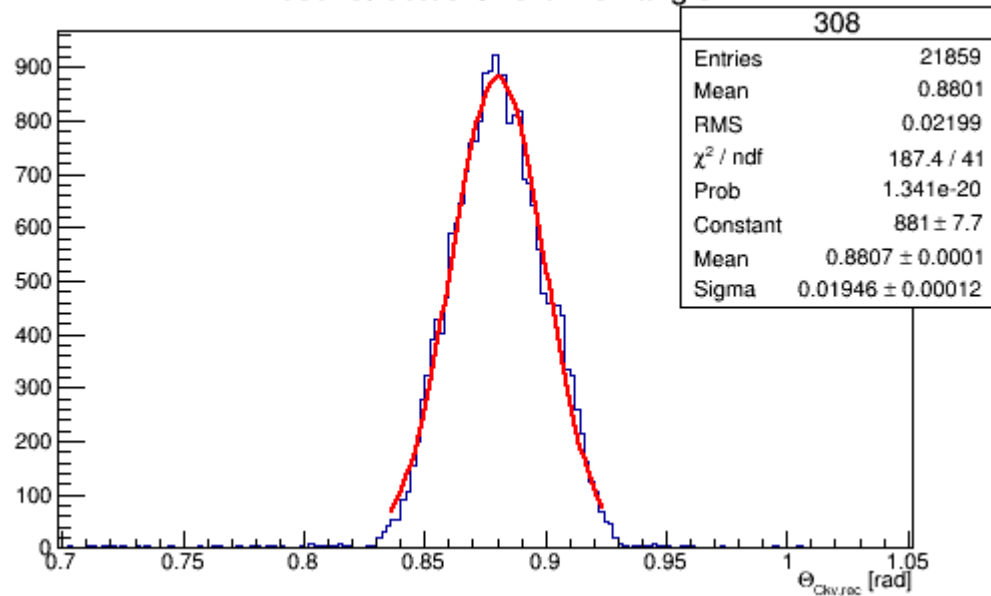
$$(x_{ctr}, y_{ctr}) = (-0.4, 0.5) \text{ mm}$$

MC Data Reconstruction Comparison



Reconstructed MC Ckv Angle

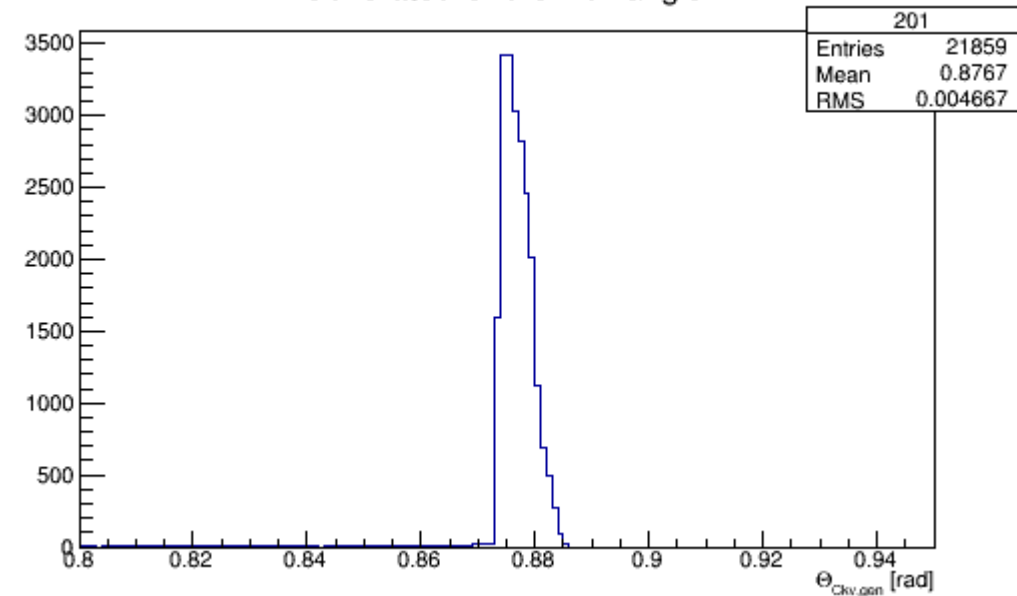
Reconstructed Cherenkov angle



$$\theta_{Ckv,MC} = 880.7 \pm 19.4 \text{ mrad}$$

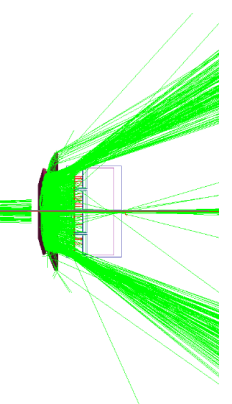
Generated Ckv Angle

Generated Cherenkov angle



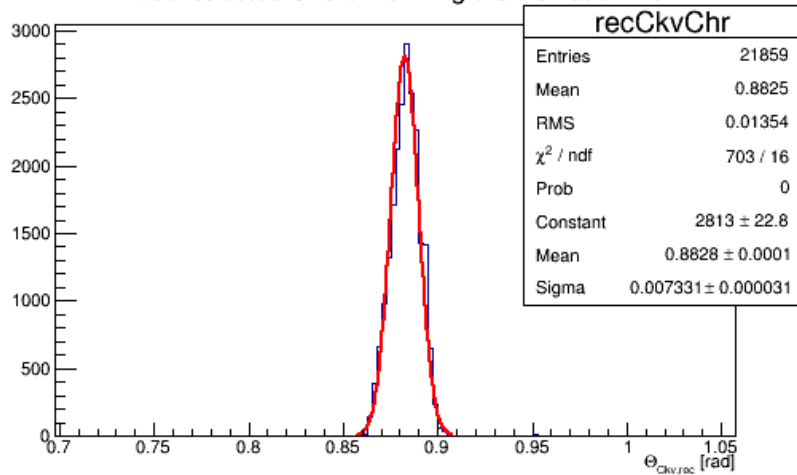
$$\theta_{Ckv,gen} = 877 \pm 5 \text{ mrad}$$

Reconstruction Uncertainty



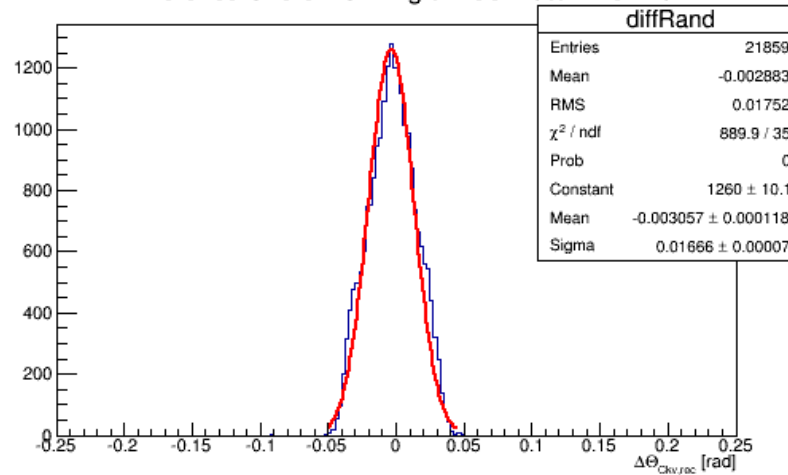
$$\sigma_{tot}^2 = \sigma_{chromatic}^2 + \sigma_{pixel}^2 + \sigma_{emissionPoint}^2$$

Reconstructed Cherenkov Angle Chromatic Error



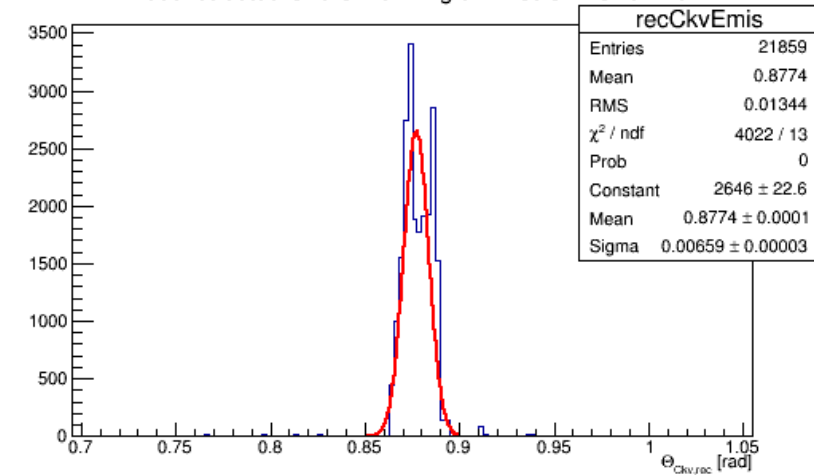
$\sigma_{chromatic} = 7.3 \text{ mrad}$

Difference Cherenkov Angle True Hit to Pixel Hit



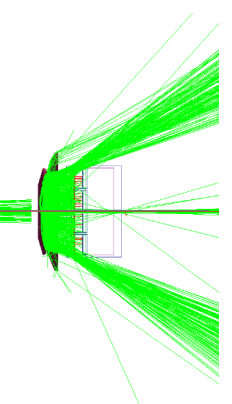
$\sigma_{pixel} = 16.7 \text{ mrad}$

Reconstructed Cherenkov Angle Emission Point Error



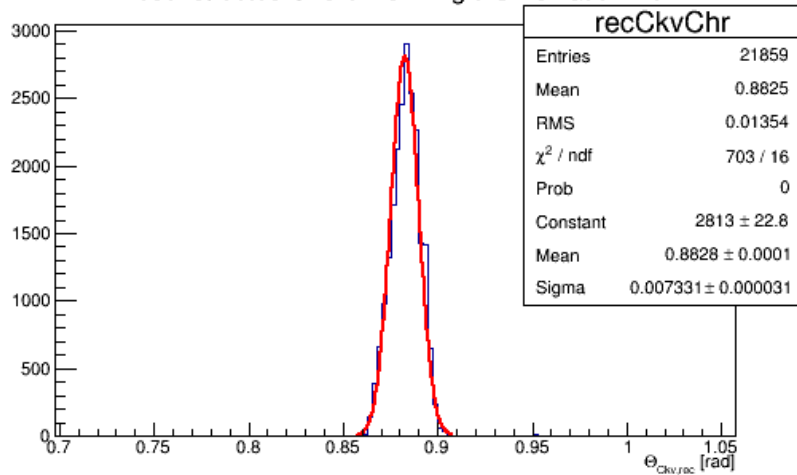
$\sigma_{emissionPoint} = 6.6 \text{ mrad}$

Reconstruction Uncertainty



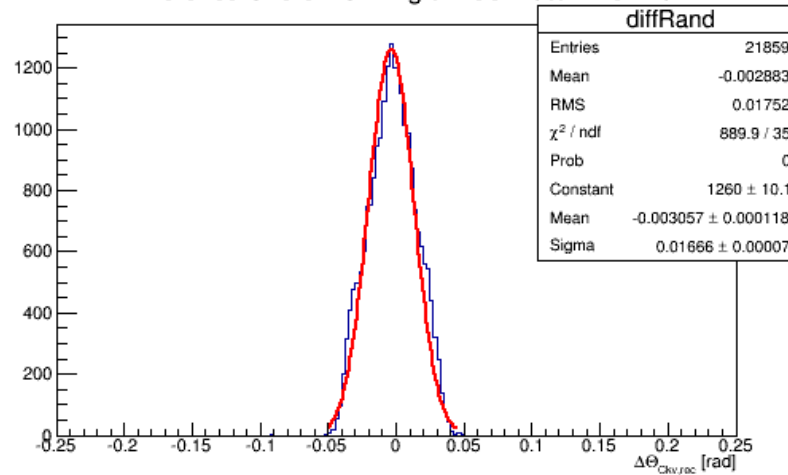
$$\sigma_{tot}^2 = \sigma_{chromatic}^2 + \sigma_{pixel}^2 + \sigma_{emissionPoint}^2$$

Reconstructed Cherenkov Angle Chromatic Error



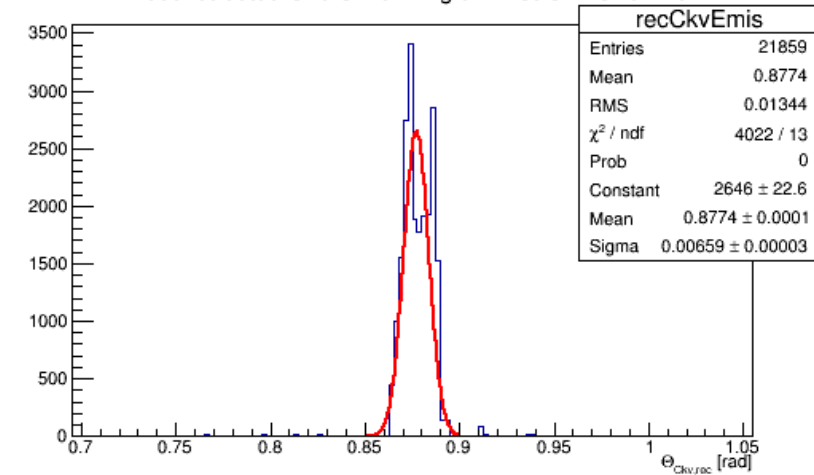
$$\sigma_{chromatic} = 7.3 \text{ mrad}$$

Difference Cherenkov Angle True Hit to Pixel Hit



$$\sigma_{pixel} = 16.7 \text{ mrad}$$

Reconstructed Cherenkov Angle Emission Point Error

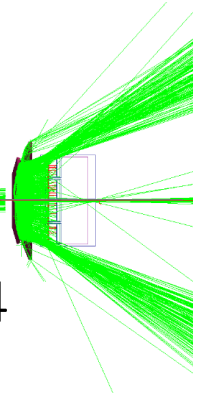


$$\sigma_{emissionPoint} = 6.6 \text{ mrad}$$

$$\sigma_{tot,calc} = 19.4 \text{ mrad}$$

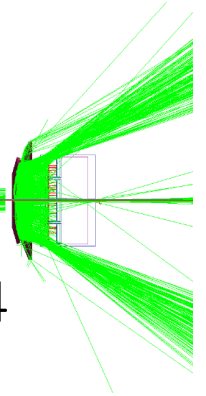
$$\sigma_{tot,mc} = 19.4 \text{ mrad}$$

Summary



- RICH Upgrade test beam setup is simulated and reconstructed using GEANT4
 - Resolutions and photon yield are determined and in accordance with MC data
 - Online monitoring proved being a useful tool during the test beam
- Online monitoring and offline analysis ready to be used in future test beams!

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Thanks to the RICH Upgrade test beam group!

Thank you for your attention

Questions please

