COMET-CTH simulation

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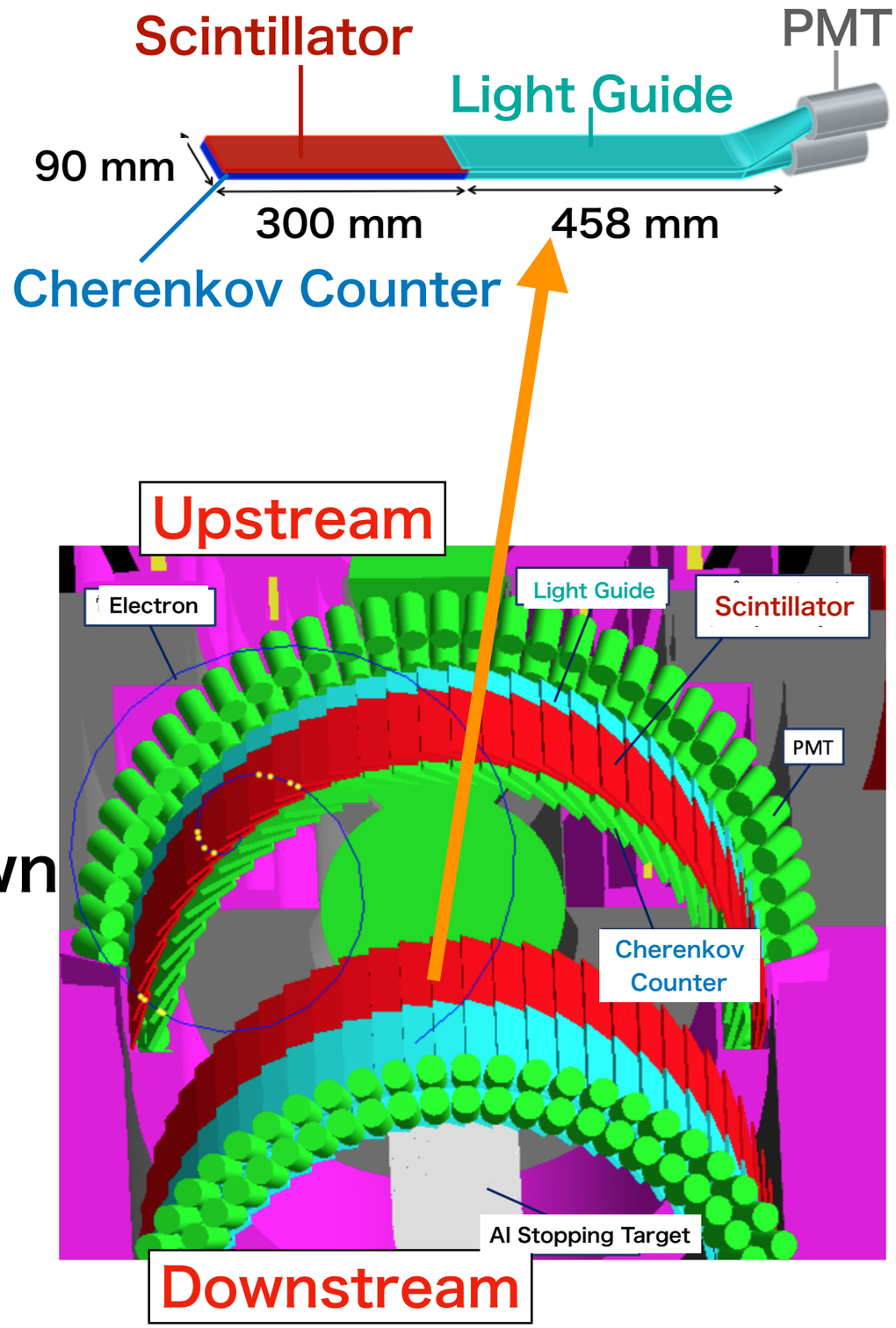
CTH(Cylindrical Trigger Hodoscope)

- Trigger system in CyDet(Cylindrical Detector System), which is a main detector in COMET Phase-I

- CTH consists of plastic scintillator, cherenkov counter, light guide, PMT

- CTH is placed at the upstream and down stream ends of the CDC

- 48 channels at each side



Purpose

We should improve the CTH design

<Example>

- Channel number 48 is enough?
- Light fiber can be used instead of light guide?
- Cherenkov counter is necessary?
- Background rate is no problem?

→Purpose is to consider some improvements with simulation

Problem of The Simulation

- **Software : ICEDUST (Integrated Comet Experimental Data User Software Toolkit)**

Current Monte Carlo Simulation File

The last large-scale Phase-I simulation was MC4(0):

- Proton bunches simulated: 1216
- Total number of POT events: 10^{10}
- Average calculation time per event: 2.7 seconds
- Total end-to-end calculation time: 833 years
- Equivalent real-time: **1.4 ms**
- Disk space occupied: **8+ terabytes**

Although MC4 is our best Phase-I database so far, it only corresponds to a tiny fraction of our real run time.

Phase-I All Simulation

Could we simulate the real-time equivalent of the Phase-I run time?

- Phase-I run time: 150 days
- Total number of POT events: 10^{20}
- Required end-to-end calculation time: 8×10^{12} years
- How many MC4's is that? **9 billion**
- How much disk space? $9 \times 10^{9} \times 8$ TB = **too much.**

Simulating the full run time of COMET Phase-I through traditional simulation seems difficult.

Space and **computing resources** are the primary constraints.

We can't simulate all the data of COMET Phase-I using Monte Carlo simulation

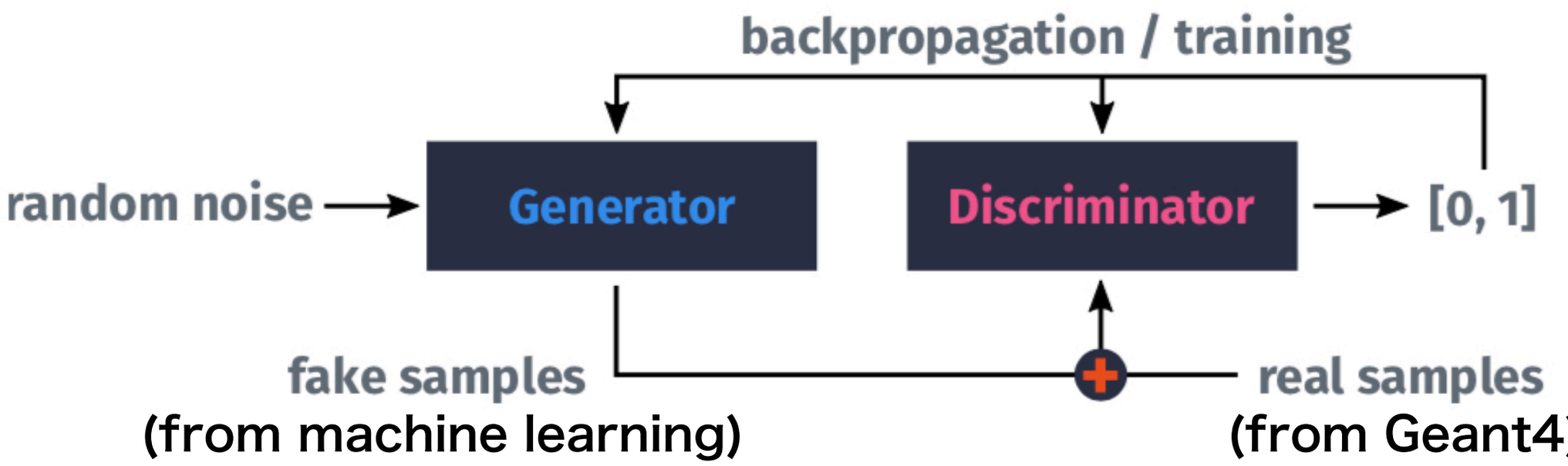
From COMET CM29 Matthias' slide

Machine Learning

- **Speed up the simulation using machine learning**

(We use machine learning to make much fake data using real samples from Geant4)

Two neural networks, a generator and a discriminator, are thrown against each other into a game.



The discriminator tries to tell the difference between real samples and fake samples, while the generator tries to fool the discriminator.

From COMET CM29 Matthias' slide

Machine Learning

- After training the two networks together using real samples from Geant4, the generator can produce large amounts of fake data very quickly
- Typically, the sampling rate is many orders of magnitude faster than a full Geant4 simulation

- Imperial College group (in UK) is working on this study of CDC

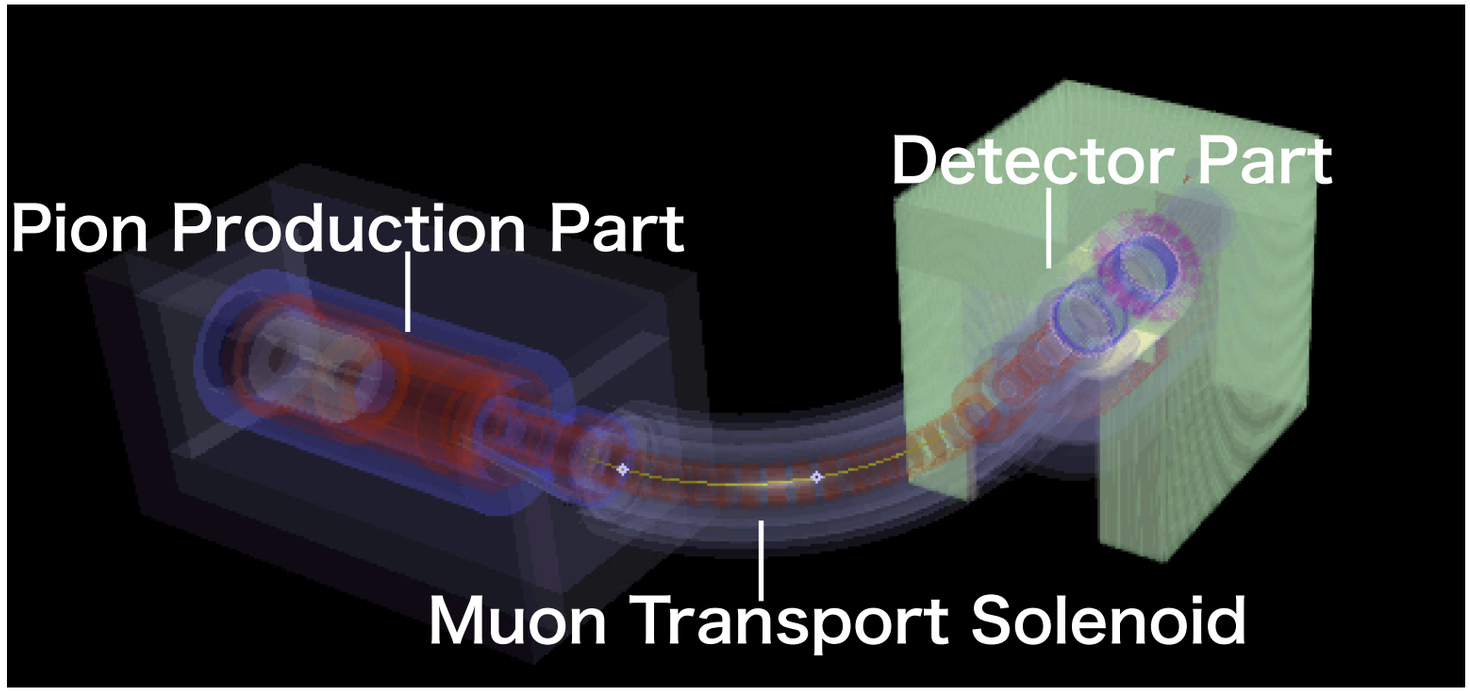
- So I went to UK, and I worked with them

CTH Hit Simulation(from MC4o file)

- As a first step, I simulated the CTH hits using MC4o RooTracker file(only Monte Carlo simulation)
- This RooTracker file includes particles which insert to transport solenoid
- I simulated 50/210 bunch of POT(Protons On Target) = 1,904,000 protons

<Result>

- Types : number
  - electron : 14
  - r : 22
  - proton : 69
  - (total : 105)

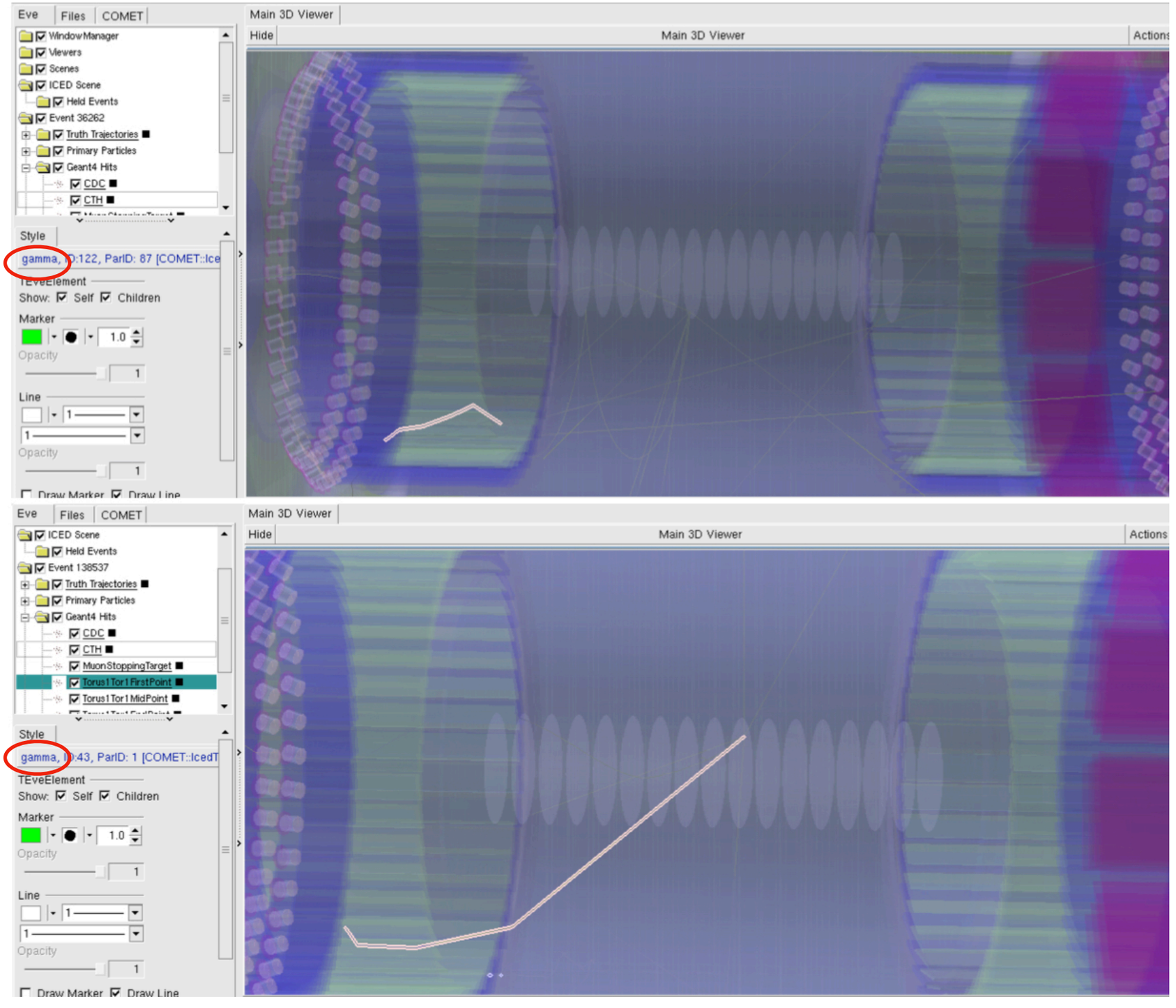


- This result is only from 50/210 bunch, but I can get about 536,256 hits using all MC4o file (1214 bunches)
- This number is enough to make fake data with machine learning
- However, it takes about 6 hours to simulate 50/210 bunch, and too much time for all MC4o file…

Events of Hit Simulation

<Event Example>

These are hits which are detected as electron hits, they seem to be generated from gamma.



Future

- MC4o file has a problem(2/5 data doesn't include inserting particles)

- So I should simulate CTH hits with MC4r file

- I will make fake data of CTH hits using real samples from Geant4

- This process will be done with Imperial group which is working on the same process of the CDC.

Summary

- CTH(Cylindrical Trigger Hodoscope) is a rigger system in CyDet(Cylindrical Detector System), which is a main detector in COMET.

- We should consider some improvements of the CTH design with simulation improve.

- However, simulation has a problem. We can’t simulate all the data of COMET Phase-I using Monte Carlo simulation.

- Using machine learning, we can solve the problem.

- As a first step, I simulated CTH hits with MC4o file.

- I will start making fake data of CTH hits.