Karlsruhe Institute of Technology

FAST SIMULATION OF BELLE II ECL USING DEEP LEARNING

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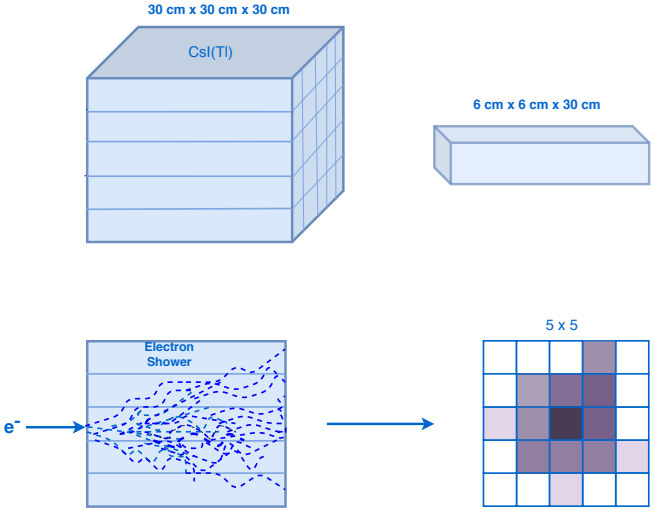
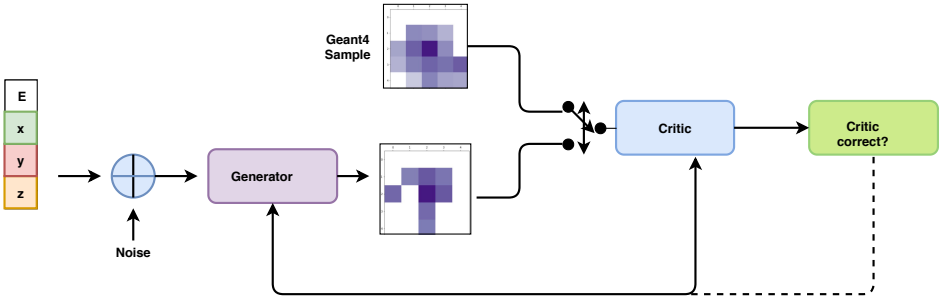
MOTIVATION

- Simulation of particle showers in ECL is a computationally expensive and time consuming process.
- The fast simulation is studied using a configuration of 5x5 CsI(Tl) crystals, as in the Belle II ECL.
- Electrons of energies 0.5 GeV, 1 GeV, 1.5 GeV, 2.5 GeV are used for training and testing.
- Electrons of energy 2.0 GeV are used for interpolation.

PARTICLE SHOWER SIMULATION

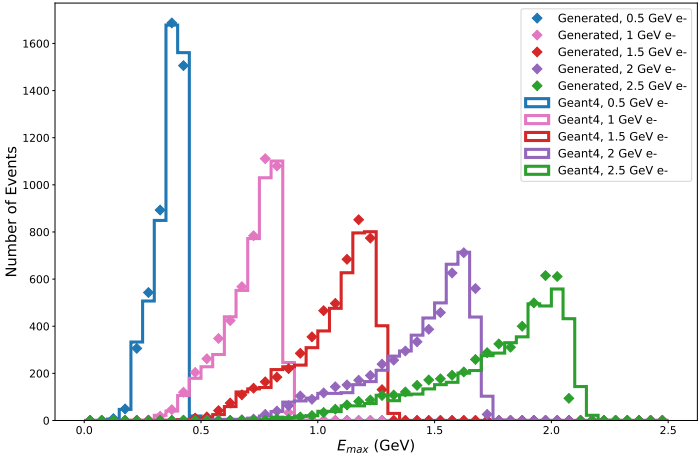


WASSERSTEIN GAN



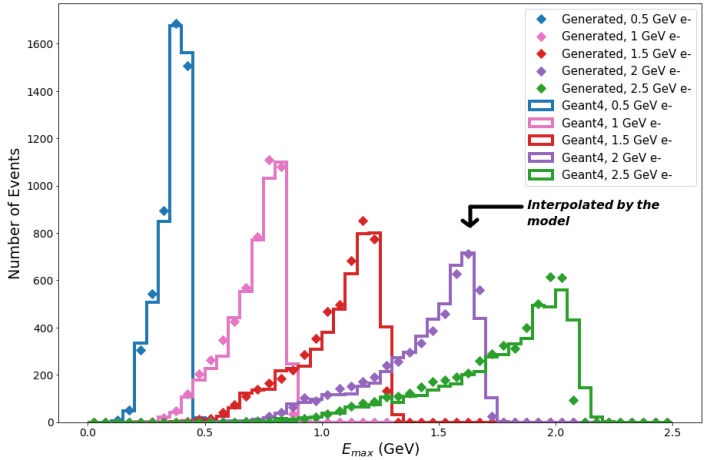
- **Critic** outputs a score based on how real the input images are.
- **Generator** outputs synthetic image from noise and labels.
- Additional **Energy** and **Position** constrainer networks are added to the model.

RESULTS



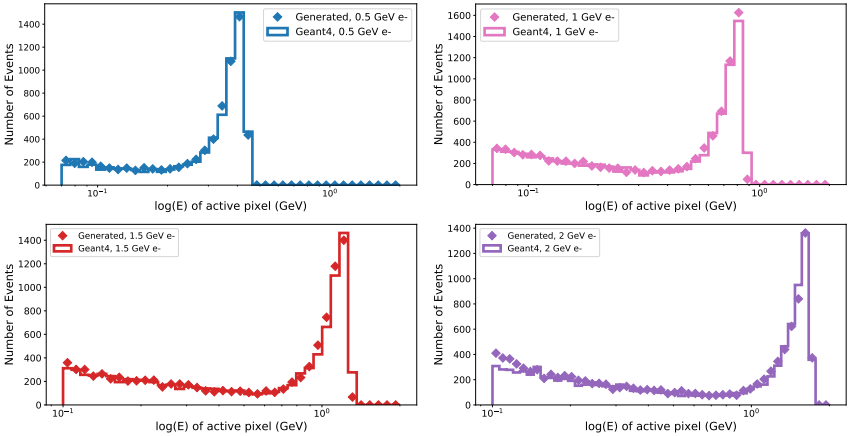
Maximum value of energy deposited in the 5 x 5 crystals

RESULTS



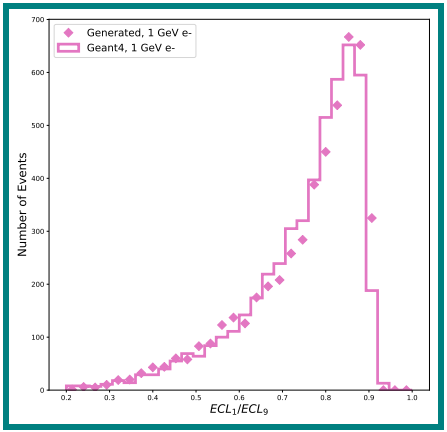
Maximum value of energy deposited in the 5 x 5 crystals

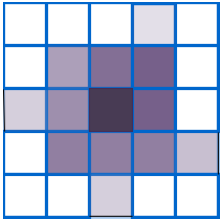
RESULTS



Distribution of single cell energy depositions

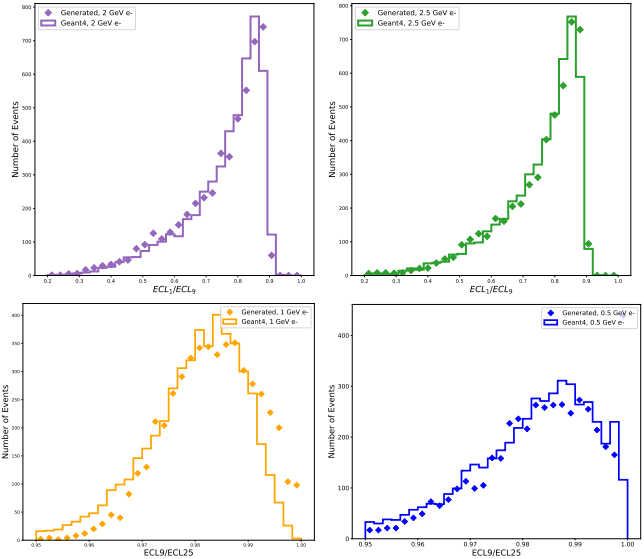
RESULTS



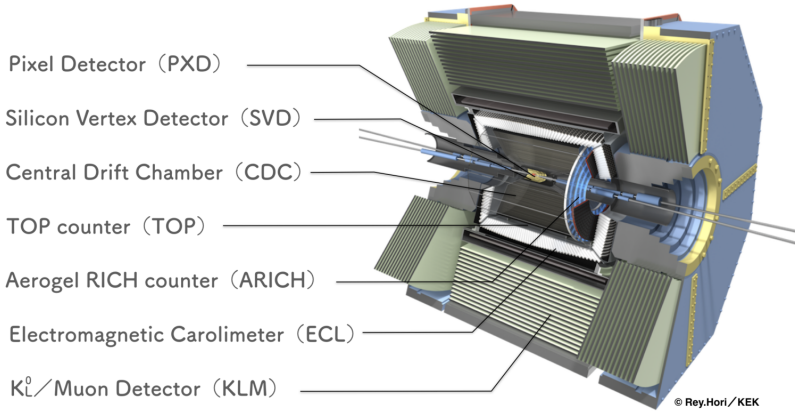


Ratio of energies of the central crystal and 3x3 crystals around the central crystal.

RESULTS

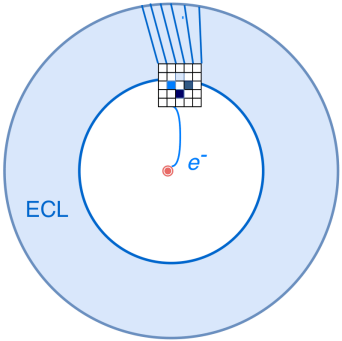

Generated, 2 GeV e-
Geant4, 2 GeV e-
Number of Events
ECL_1/ECL_9
Generated, 2.5 GeV e-
Geant4, 2.5 GeV e-
Number of Events
ECL_1/ECL_9
Generated, 1 GeV e-
Geant4, 1 GeV e-
Number of Events
ECL9/ECL25
Generated, 0.5 GeV e-
Geant4, 0.5 GeV e-
Number of Events
ECL9/ECL25

TEST THE MODEL FOR MC SHOWERS IN BELLE II ECL

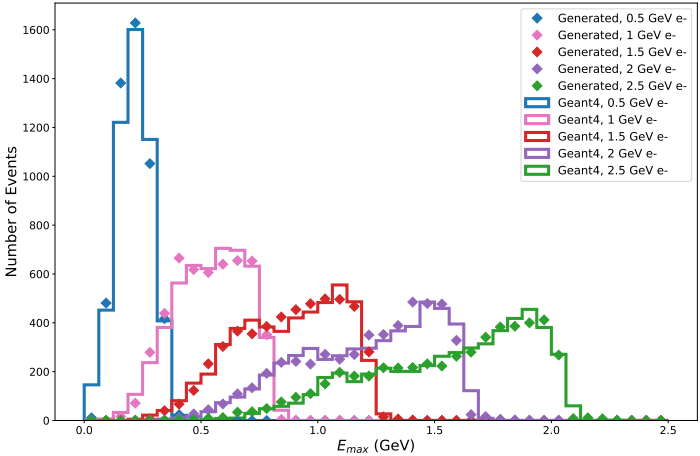


PARTICLE GUN CONDITION

- Beam background level: **BGx1**
- e^- samples, 1 particle per event.
- $11.4\,^\circ < \theta_{generated} < 156.1^\circ$
- $0\,^\circ < \phi_{generated} < 360^\circ$
- Basf2 *release* $-$ 04 $-$ 01 $-$ 04
- Energy generated $\rightarrow 0.5GeV, 1GeV, 1.5GeV, 2GeV, 2.5GeV$

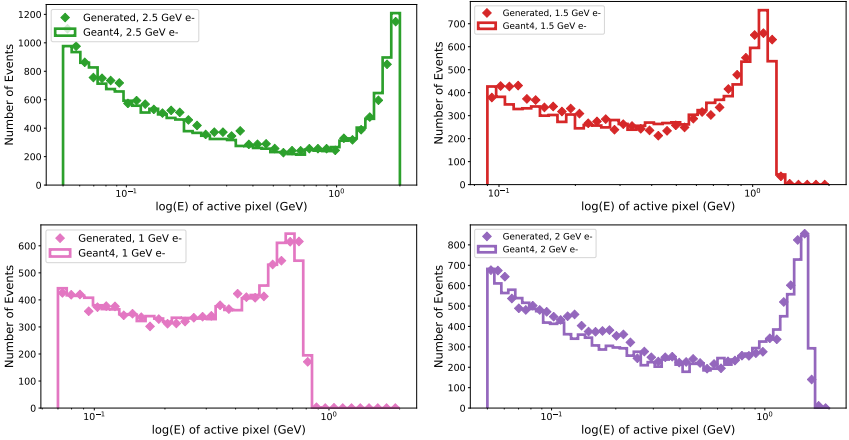


RESULTS



Maximum value of energy deposited in the 5 x 5 crystals

RESULTS

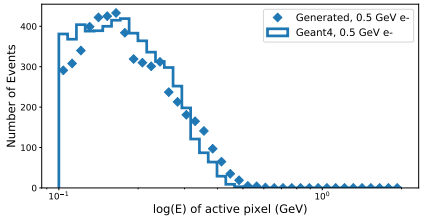


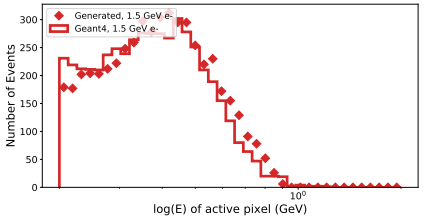
Distribution of single cell energy depositions

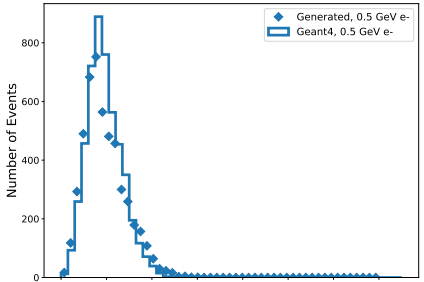
SIMULATION OF PION SHOWERS

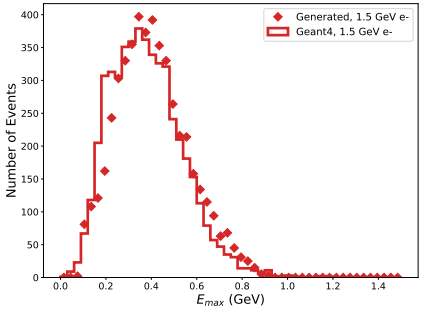
- Crystals are almost 1 interaction length deep, so we expect e^{-1} around 37% of incident hadrons not to interact.
- For pions interaction length is even longer.
- So around 45% of incident pions does not shower in the crystal.
- Using the First hadronic Interaction depth, select the pions which shower inside the crystals.

RESULTS


Generated, 0.5 GeV e-
Geant4, 0.5 GeV e-
Number of Events
log(E) of active pixel (GeV)


Generated, 1.5 GeV e-
Geant4, 1.5 GeV e-
Number of Events
log(E) of active pixel (GeV)


Generated, 0.5 GeV e-
Geant4, 0.5 GeV e-
Number of Events
E_{max} (GeV)


Generated, 1.5 GeV e-
Geant4, 1.5 GeV e-
Number of Events
E_{max} (GeV)

SUMMARY

- The WGAN simulated results 0.5, 1.0, 1.5, 2.5 GeV electrons on 5x5crystals show good agreement with the electrons simulated by Geant4.
- The model is able to interpolate 2.0 GeV electrons well.
- The model is working for Belle II MC electron showers as well.
- Studies of pion shower simulations in ECL is currently ongoing.