

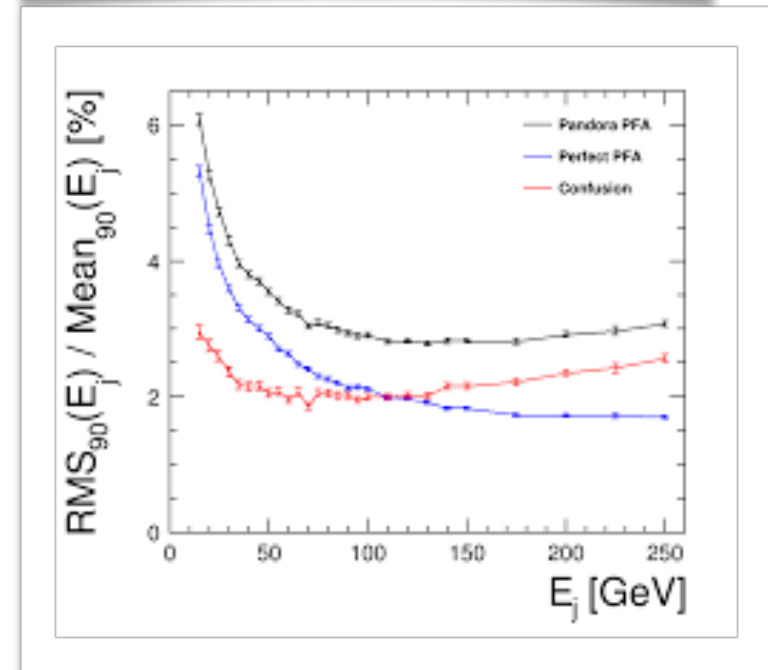
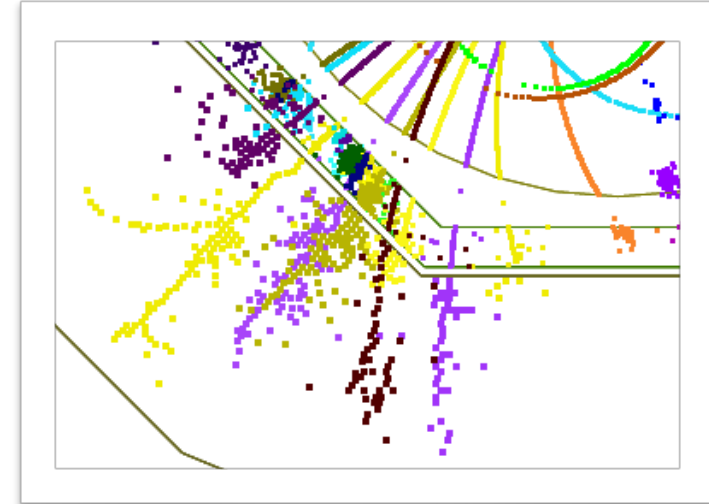
# Fast ML Simulation in Hamburg

## Machine Learning for Simulation meeting

Frank Gaede,  
Gregor Kasieczka  
22.04.2021

# Introduction

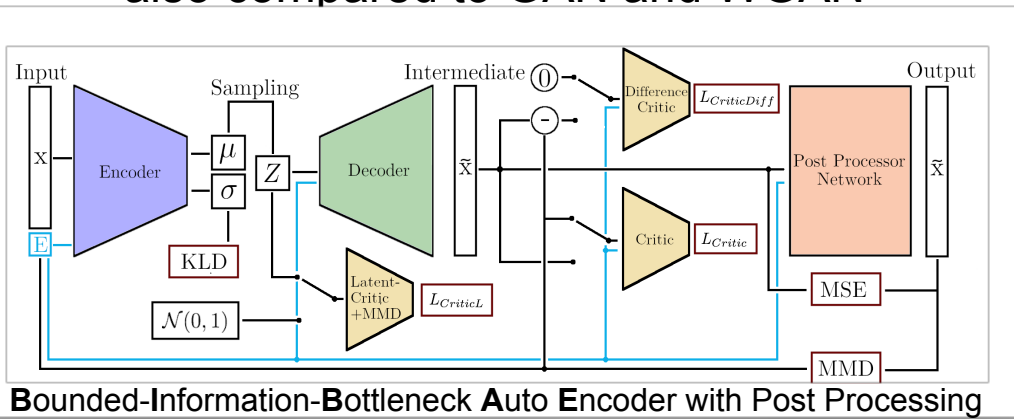
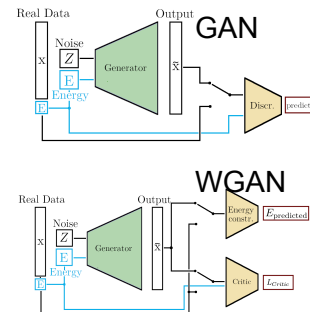
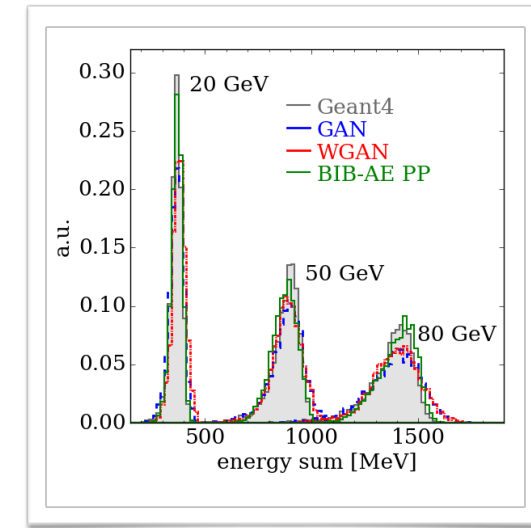
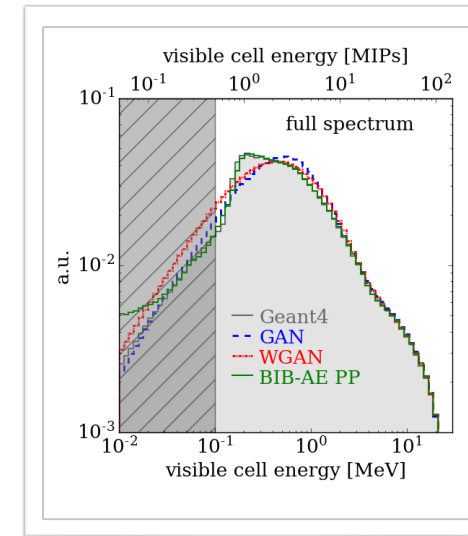
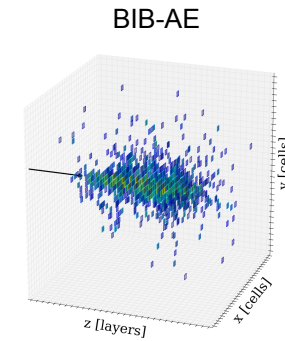
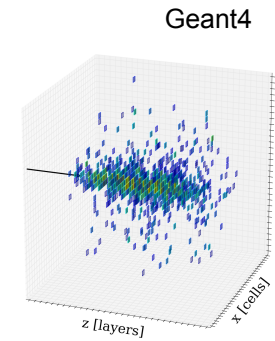
- working group at **DESY** and **UHH**
  - in context of **QU excellence cluster** :
- investigate ML generative methods for **fast simulation** of particle showers in **highly granular calorimeters**
  - as foreseen for future Higgs factories such as the ILC
  - detects at ILC (e.g. ILD) optimised for particle flow:
    - aim at correctly reconstruct every individual particle
    - charged in the tracker
    - photons in the ECal
    - neutral hadrons in the HCal
  - important to get the **detailed properties** of the individual showers right
  - -> aim at **high fidelity of simulation**
    - as good as Geant4 ?



# High fidelity Simulation

## of photons in highly granular ILD-ECal

- use sample of photons at 90 deg impact angle in ILD Ecal (5x mm<sup>2</sup>, SiW) w/ uniform energies 10-100 GeV
- achieve **high fidelity** in distributions of relevant physical variables
- using Bounded-Information-Bottleneck Auto Encoder (BIB-AE) w/ post-processing
- also compared to GAN and WGAN

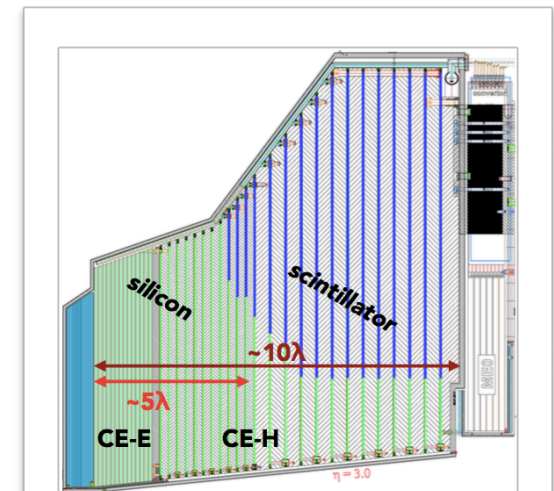
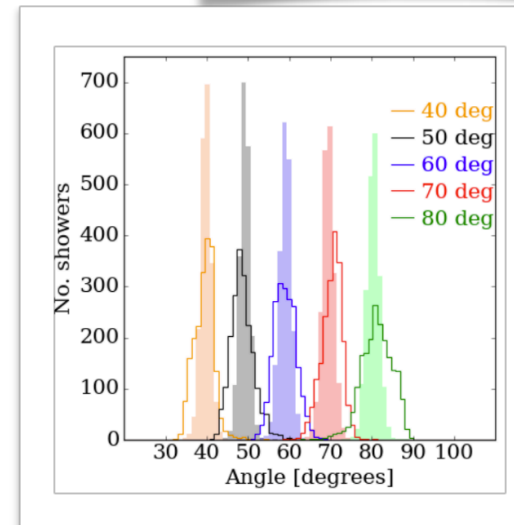
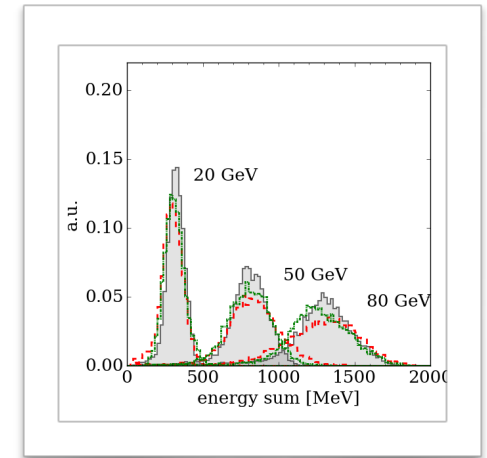
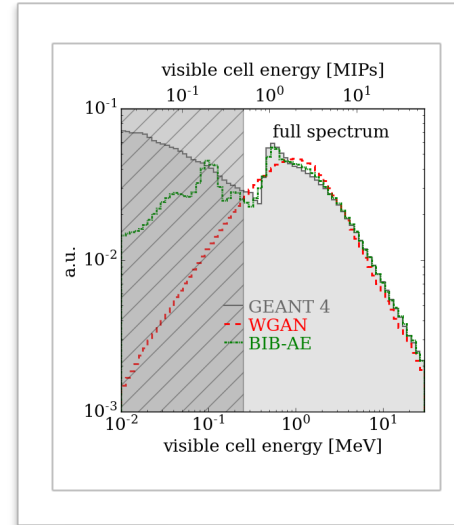
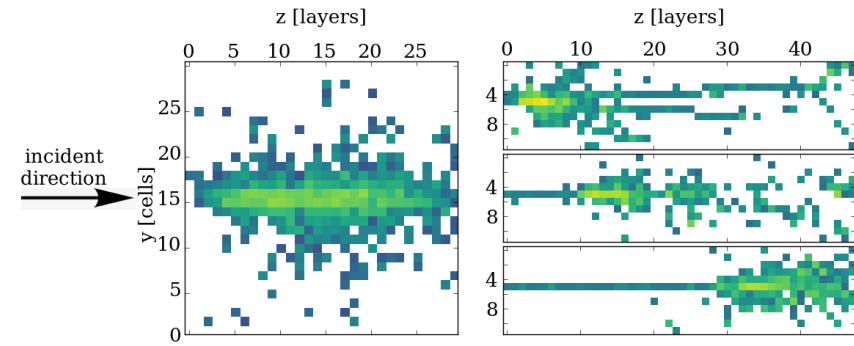


Getting High: High Fidelity Simulation of High Granularity Calorimeters with High Speed, Erik Buhmann (Hamburg U.) Sascha Diefenbacher (Hamburg U.), Engin Eren (DESY), Frank Gaede (DESY), Gregor Kasieczka (Hamburg U.) et al. (May 11, 2020), e-print: [2005.05334](https://arxiv.org/abs/2005.05334) to be published in Computing and Software for Big Science

# current work

## and next steps

- work on further improving generative performance by optimising the **latent space distributions**
  - see: [arxiv\\_2102.12491](https://arxiv.org/abs/2102.12491)
- working on fast simulation of **hadron showers** (pions) in the ILD AHCaI (3cmx3cm, steel-scintillator)
  - more complex shower structure -> harder to get right - WIP ...
  - see also talk at vCHEP “#148, *Fast and Accurate Electromagnetic and Hadronic Showers from Generative Models*”
- started to look into **angular conditioning** for photon showers
  - first w/ simple GAN, WGAN and BIB-AE to follow...
- also started work on **CMS HGCaI** fast shower generation
  - ...



# People and Projects



Universität Hamburg  
DER FORSCHUNG | DER LEHRE | DER BILDUNG

CLUSTER OF EXCELLENCE  
QUANTUM UNIVERSE



- people working on ML for calorimeter simulation at DESY and UHH
  - ~ 2-3 seniors
  - 3 post docs
  - 4-5 PhD students
- projects:
  - **Quantum Universe** - Cluster of Excellence
  - **ACCLAIM** (Helmholtz Innovation Pool project)
  - **AIDainnova** (<https://indico.cern.ch/event/1003419/>)
  - **CDCS**: Center for Data and Computing in natural Science (<https://www.cdcs.uni-hamburg.de/>)
  - **DeGeSim** (Helmholtz AI Projekt)

