News and Highlights from DESY - FH

ACCLAIM Meeting 09.09.22

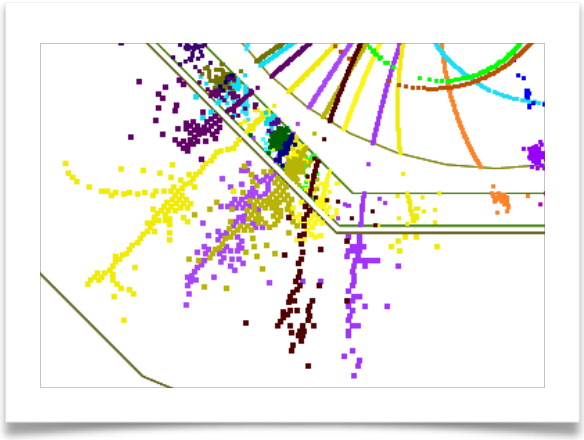
F.Gaede, DESY

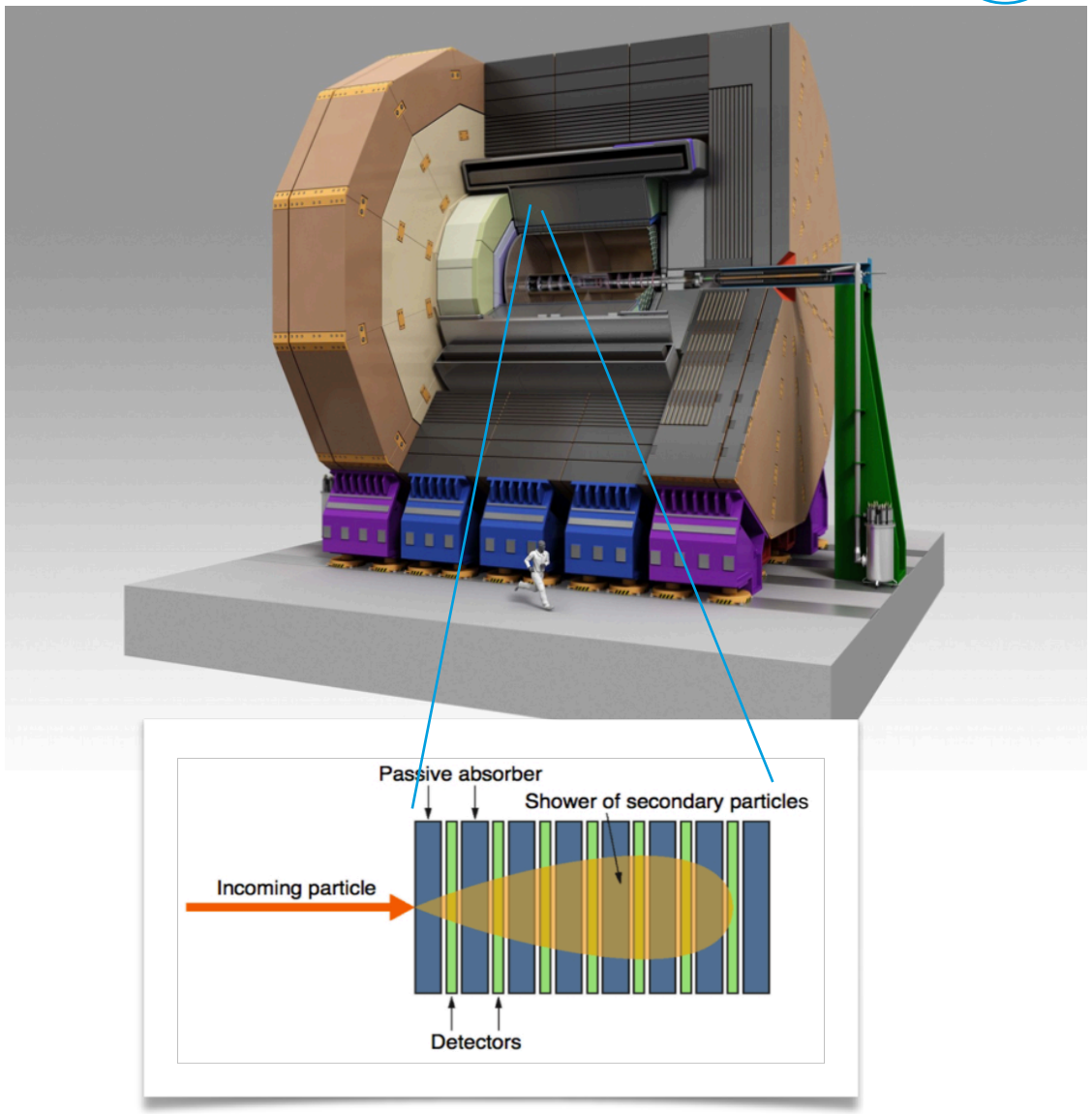
HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

Introduction

…and reminder

- DESY-FH is working on **high fidelity simulation of highly granular calorimeter showers with generative ML** methods
- computing needs in HEP are dominated by calorimeter simulation
- ML methods offer orders of magnitude improvements
- work carried out together with **UHH** in context of **QU** excellence cluster

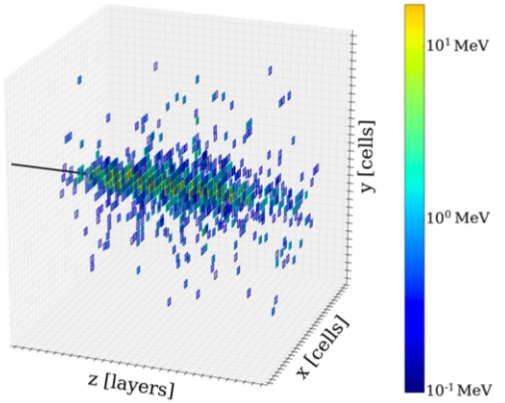


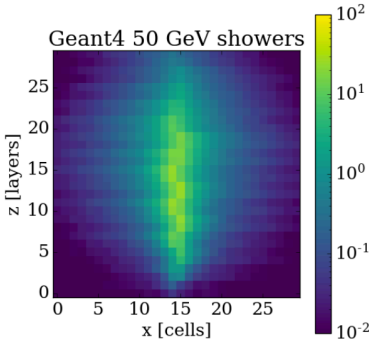


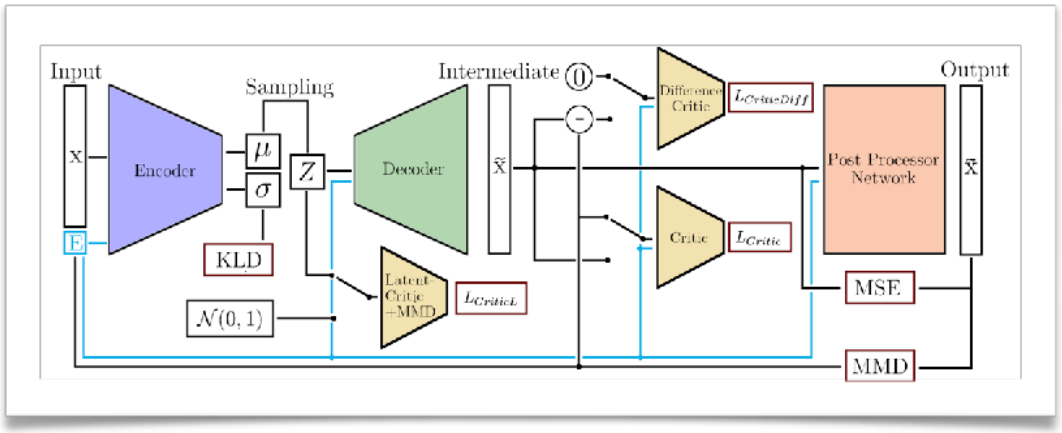
Previous Work

carried out partly in AMALEA

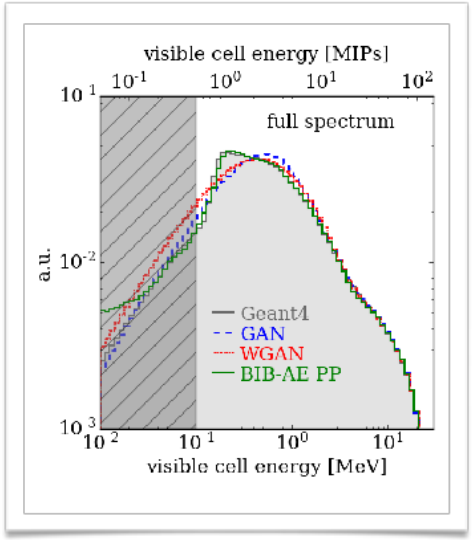
- started work with sample of **photons** at **90 deg impact** angle in ILD Ecal (5x mm^2, SiW) w/ uniform energies 10-100 GeV
- achieve **high fidelity** in distributions of relevant physical variables
- using Bounded-Information-Bottleneck Auto Encoder (**BIB-AE**) w/ post-processing
  - also compared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

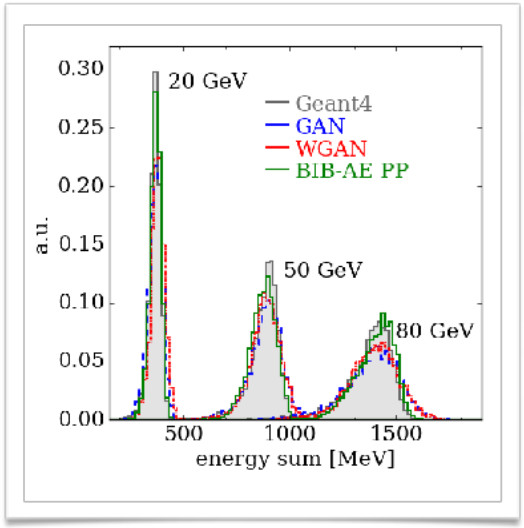






Bounded-**I**nformation-**B**ottleneck **A**uto **E**ncoder with Post Processing

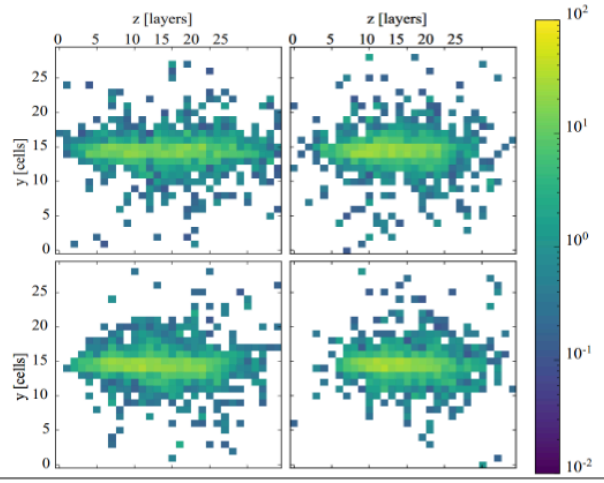




Getting High: High Fidelity Simulation of High Granularity Calorimeters with High Speed, Erik Buhmann (Hamburg U.) Sascha Diefenbacher (Hamburg U.), Engin Eren (DESY), Frank Gaede (DESY), Gregor Kasieczka (Hamburg U.), Katja Krüger (DESY) et al. (May 11, 2020), e-print: 2005.05334 published in Computing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

Extending initial work …

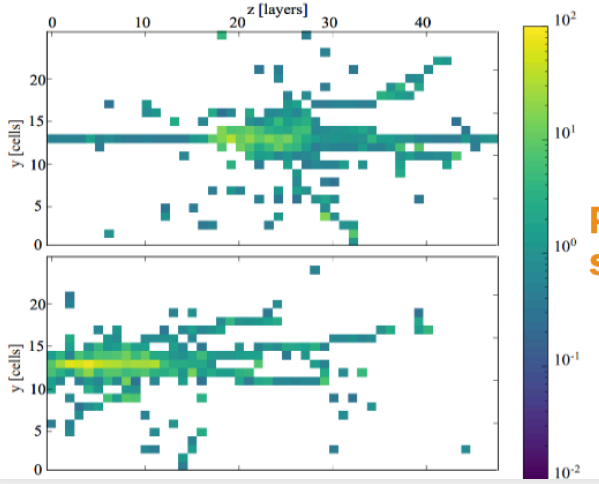
… from electromagnetic showers to hadronic showers at different energies and angles …



Photon showers

- Predominantly governed by EM interactions
- Compact structure

→ **Relatively easy to generalise**



Pion showers

- Hadronic and EM interactions
- Complex structure
- Large event-to-event fluctuations

→ **Hard to learn**

	Energy	Angles θ, ϕ	ECAL +HCAL	Reco
Photon showers	✓	+	N/A	X
Pion showers	+	X	X	+

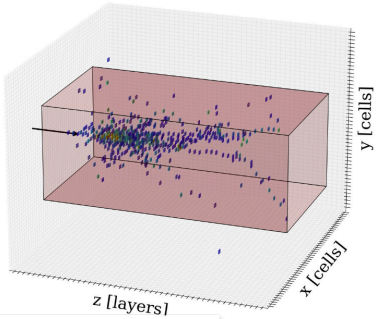
✓ = Achieved X = Yet to be done

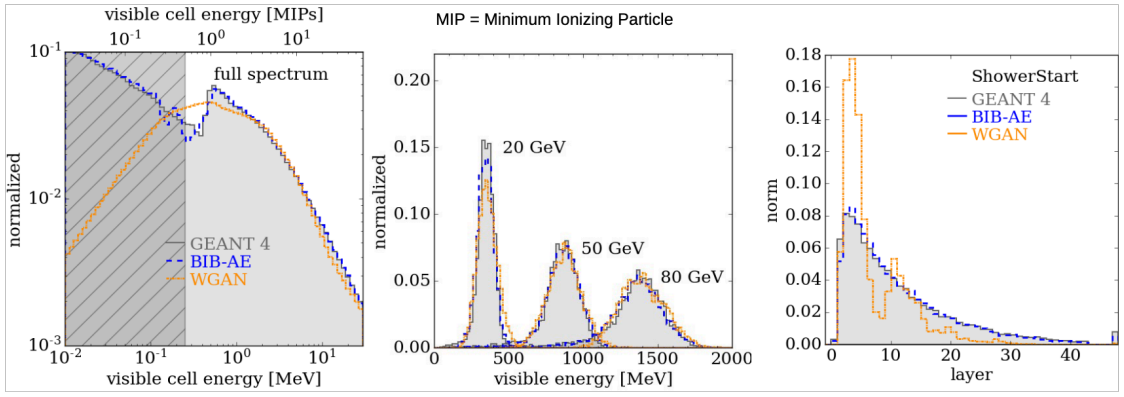
\+ = Addressed here

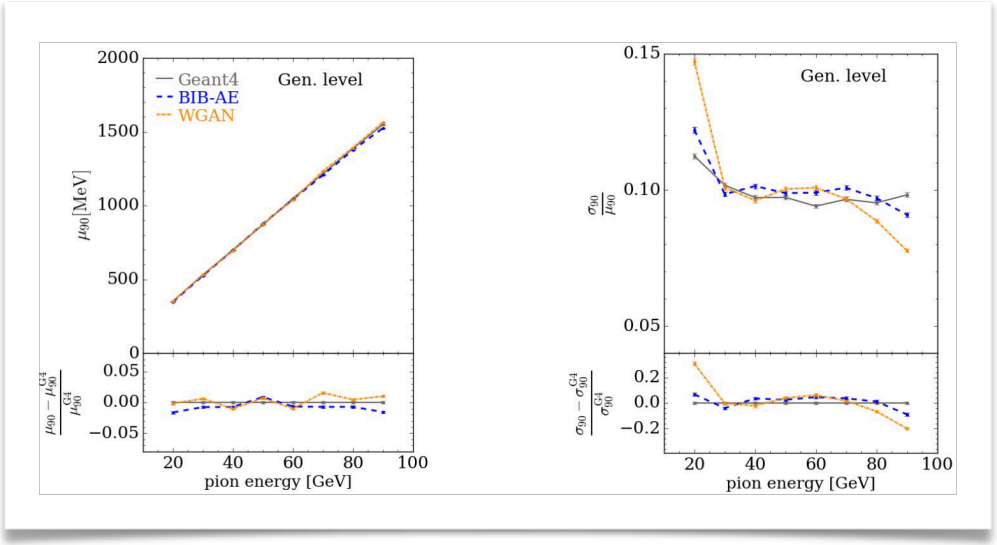
Generation of hadronic showers

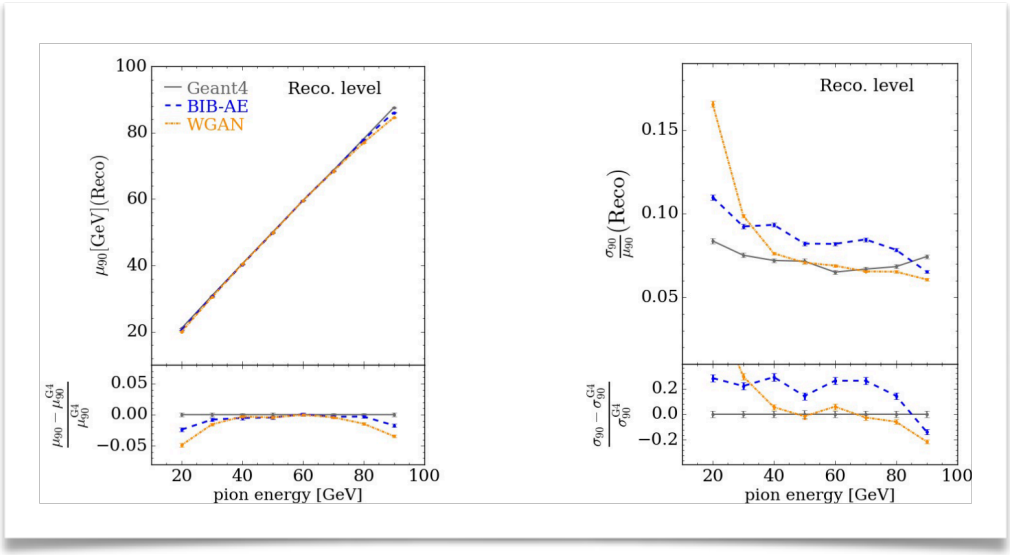
Pions in the HCal (hadronic calorimeter)

- published **first paper** on generative ML methods for **hadronic showers in highly granular calorimeters**
  - *so far HCal only and fixed 90 deg impact angle*
- first look at performance after **reconstruction** (clustering and calibration)







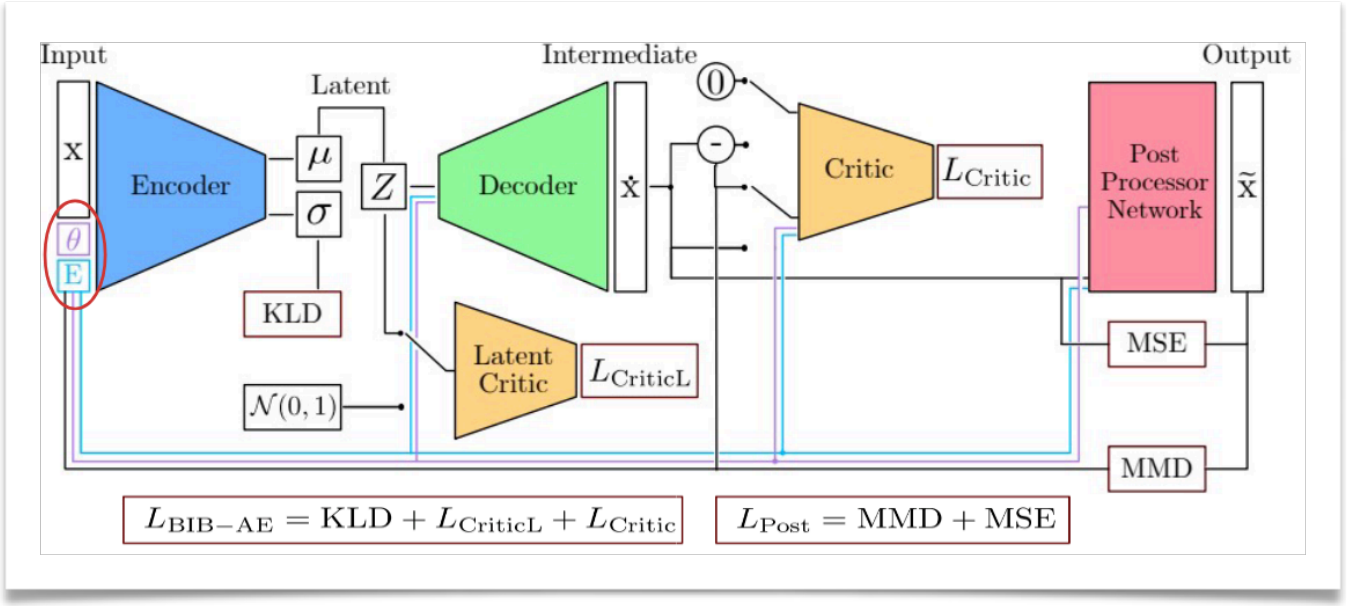


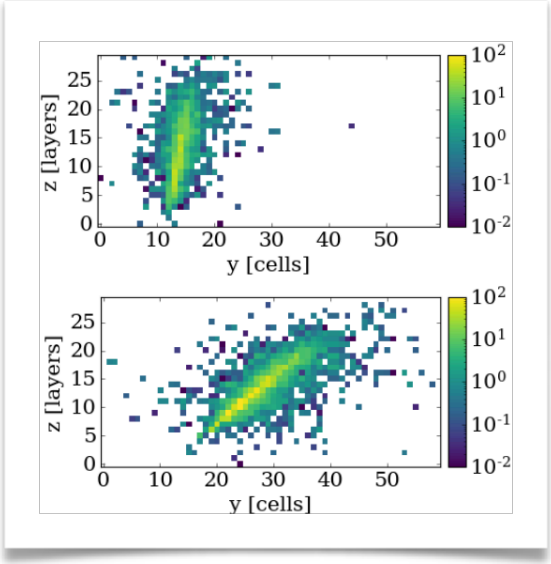
Hadrons, Better, Faster, Stronger
E. Buhmann, S. Diefenbacher, E. Eren, F. Gaede et al
arXiv:2112.09709 submitted to MLST

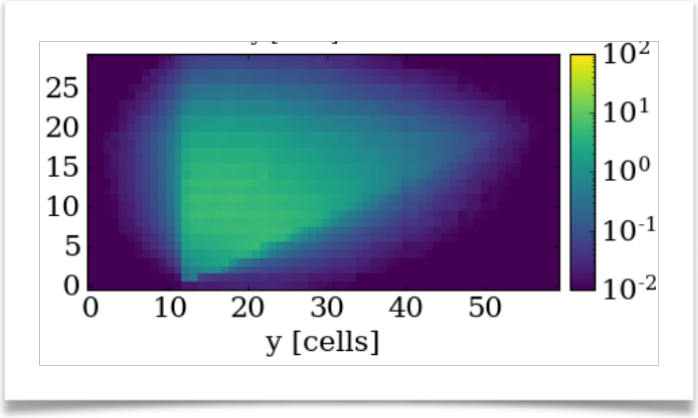
Angular and Energy conditioning

for electromagnetic showers

- extend the BIB-AE architecture to allow for conditioning on the angle and energy
  - next step in getting closer to *real world applications*



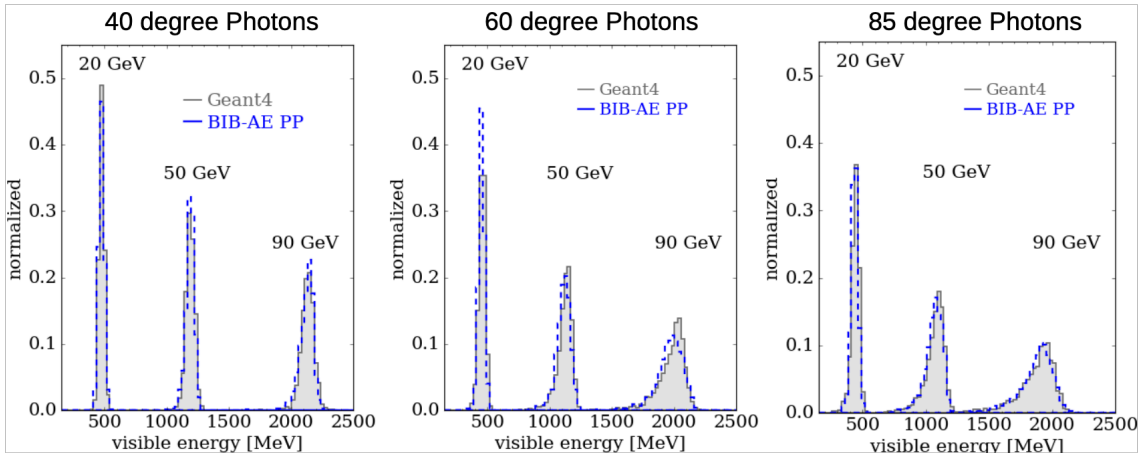


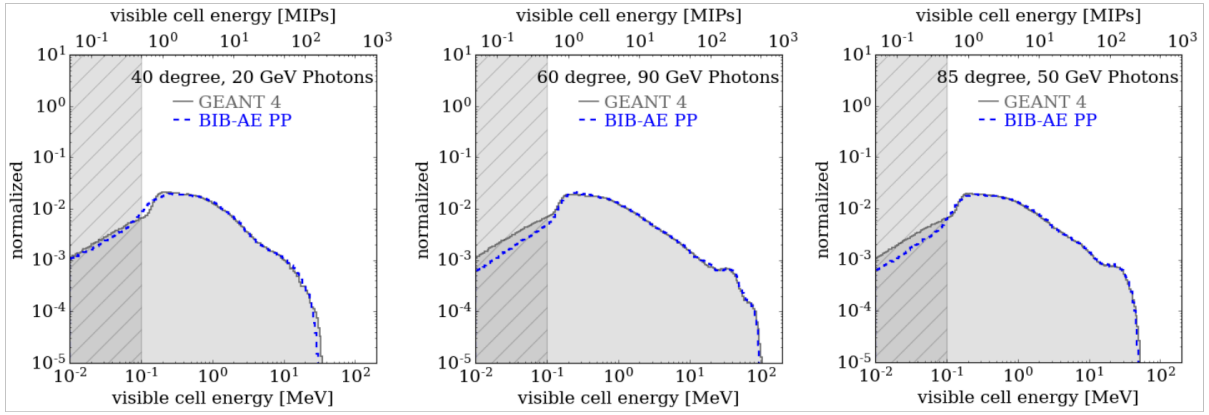


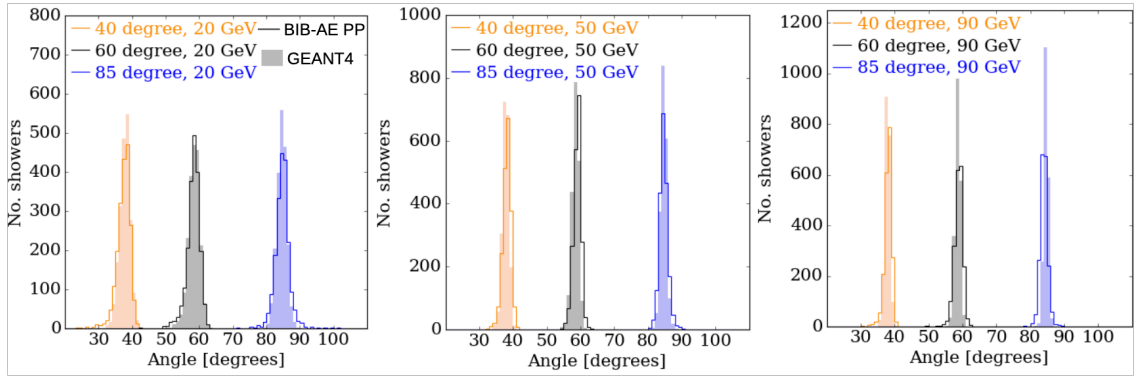
Angular and Energy conditioning

for electromagnetic showers

- extend the BIB-AE architecture to allow for conditioning on the angle and energy
  - next step in getting closer to *real world applications*
- achieve very good results
  - currently writing publication…







Summary

and Outlook

- DESY-FH has continued the work on **high fidelity simulation of highly granular calorimeter showers with generative ML** methods

- generation of pion showers in the HCal
  - to be published in MLST

- conditioning on energy and angle for electromagnetic showers
  - publication in preparation…