DESY FH: Fast Simulation for Calorimeters

ML-Methods for efficient Simulations WP4 (DESY/HZDR)

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What are we interested in?

Most of you know what we are in interested in (stolen from Engin's final AMALEA talk)

Calorimeters in a HEP Experiment

- Incoming particle initiates the showers and secondary particles are produced
- These secondary particles further produce other particles until the full energy is absorbed



One type of EM calorimeter: sampling calorimeter

- Alternating layers of passive absorbers and active detectors
- Only **fraction** of particle energy is recorded (visible energy)



AMALEA results on calorimeter GANs

Results: Cell energy and Number of hits



visible cell energy [MIPs]

• This has been a coop. with UHH

See arxiv:2005.05334

Now focus on CMS future HGCal (High Granularity Calorimter)

Extremely complex geometry



HGCAL = Sampling calorimeter

- Hexagonal silicon sensor based modules in CE-E and high radiation regions of CE-H.
- "Cassettes": multiple modules mounted on cooling plates with electronics and absorbers.
- Scintillating tiles with on-tile SiPM readout in lowradiation regions of the CE-H.

Both endcaps	Silicon	Scintillators
Area	~640m ²	~370m ²
#Modules	~30000	~4000
Channel size	0.5 - 1 cm ²	4-30 cm ²
#Channels	~6.1 M	~240k
Op. temp.	-30 ° C	-30 ° C
	Both endcaps Area #Modules Channel size #Channels Op. temp.	Both endcapsSiliconArea~640m²#Modules~30000Channel size0.5 - 1 cm²#Channels~6.1 MOp. temp30 ° C

Per endcap	CE-E	CE-H (Si)	CE-H
Absorber	Pb, CuW, Cu	, CuW, Cu Stainless steel, Cu	
Depth	25.5 X ₀ , 1.7 λ	~7.	8λ
Layers	28	8	14
Weight	Weight ~200 t / endcap		





- Hexagonal modules
- About 3x10⁶ channels/side
- Irregular shapes at the edges
- Different absorber materials
- Electromagnetic and Hadronic showers







Person power and plans

- 1 PostDoc (preparing the job ad)
- 1 PhD
- We will continue the successful collaboration with UHH in context of the QUexcellence cluster that we had started in AMALEA
 - At UHH a PhD student has started to look into HGCal simulations with G4
- We will share forces with another project (DeGeSim Helmholtz.ai) dedicated to fast simulation with generative NNs (one PhD recently hired)
 - Has joined the trainings data preparation effort
- We will in a later phase explore generative algorithms on Quantum Computers (qGANs)
 - Already exploring possibilities in another project at CERN