Task 12.3: Simulation

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On behalf of Task 12.3

AIDAInnova WP12 General Meeting

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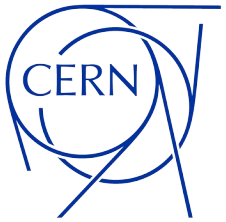


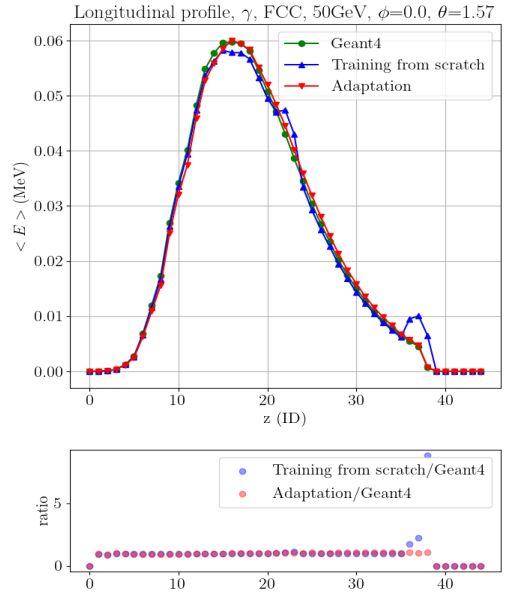
CERN

- Prior to Hackathon: good preliminary results for adaption to different detector geometries with the CaloDiT diffusion model

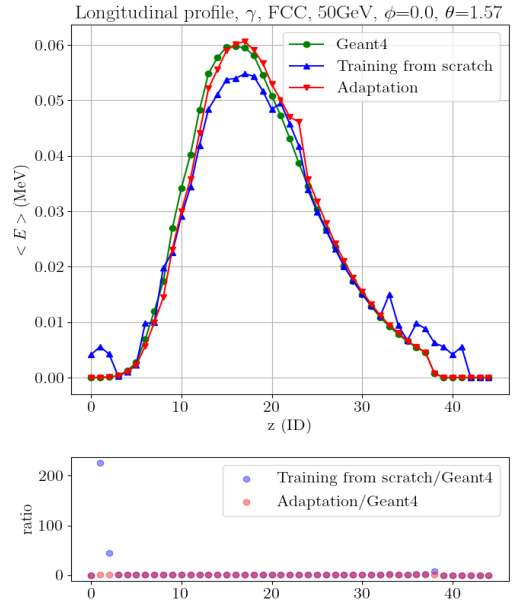
- Currently in the process of generating more data using the following detectors:
  - Par04 SciPb – Done!
  - Par04 PbWO4 – Done!
  - FCCee CLD – In Progress!
  - FCCee ALLEGRO – In Progress!

- Continuing to explore alternative diffusion processes/mixer models with IBM

400K samples

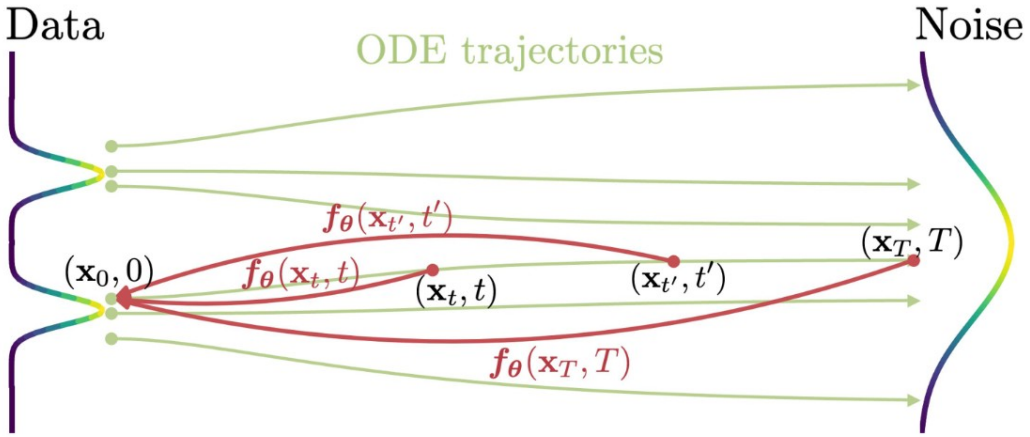


200K samples

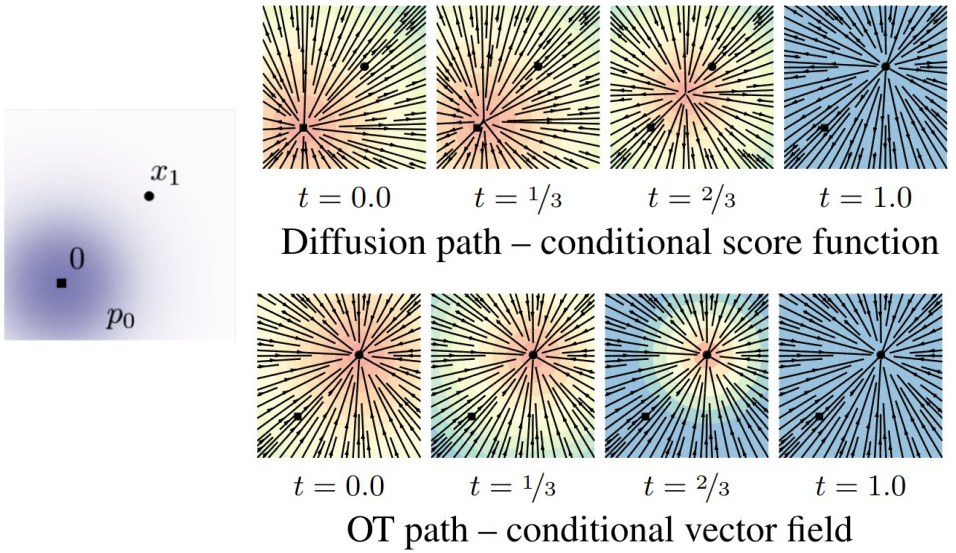


CERN

- Number of diffusion steps dominates the inference time for CaloDiT
- Investigating various approaches to speeding up diffusion model with a GSoC student and a summer student
- Approach based on Denoising Diffusion Implicit Models (DDIM) did not yield sufficient improvement
- Now shifting focus to **Consistency Models** and **Flow Matching**



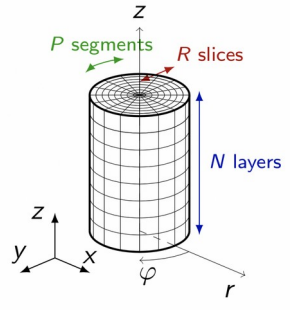
Y. Song et al., *Consistency Models*, (2023) arXiv:2303.01469



Y. Lipman et al., *Flow Matching for Generative Modeling*, (2022), arXiv:2210.02747

CERN

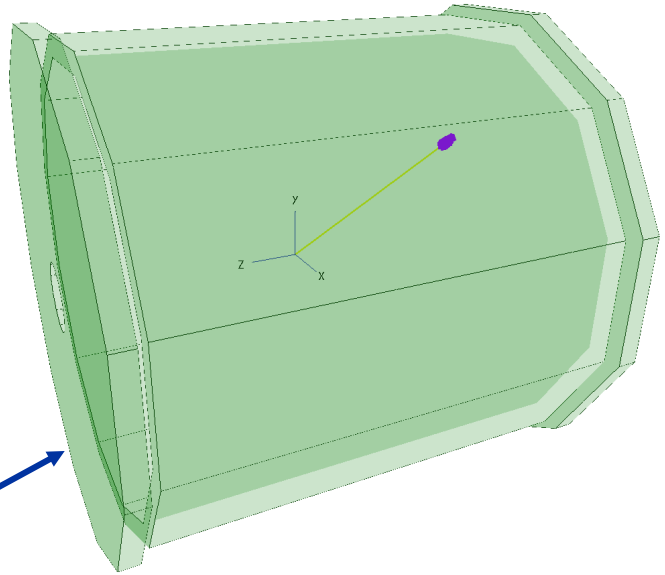
- Continued work from Hackathon towards integrating CaloChallenge-like cylindrical readouts in DDFastShowerML

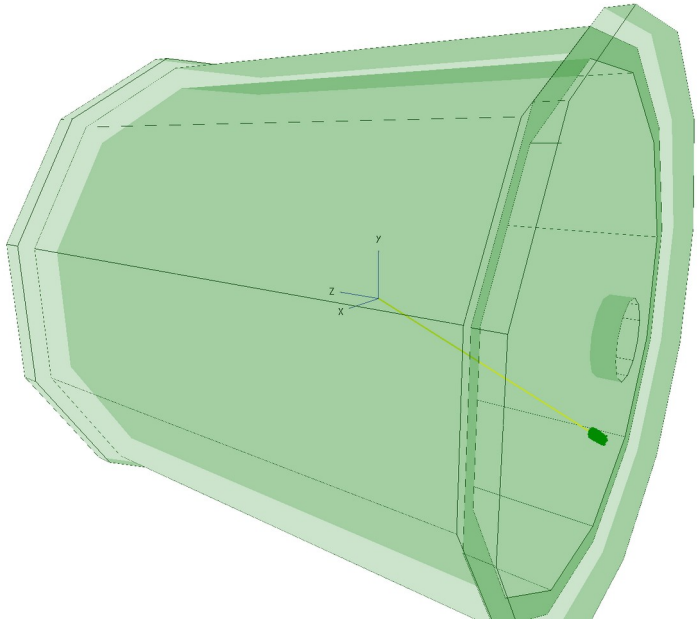


- Ultimately need to study performance in actual detector readout
  - For model validation, using a ‘fully active’ calorimeter system
  - General solution still work in progress…

- Chose CLD as test suite to benefit from existing infrastructure

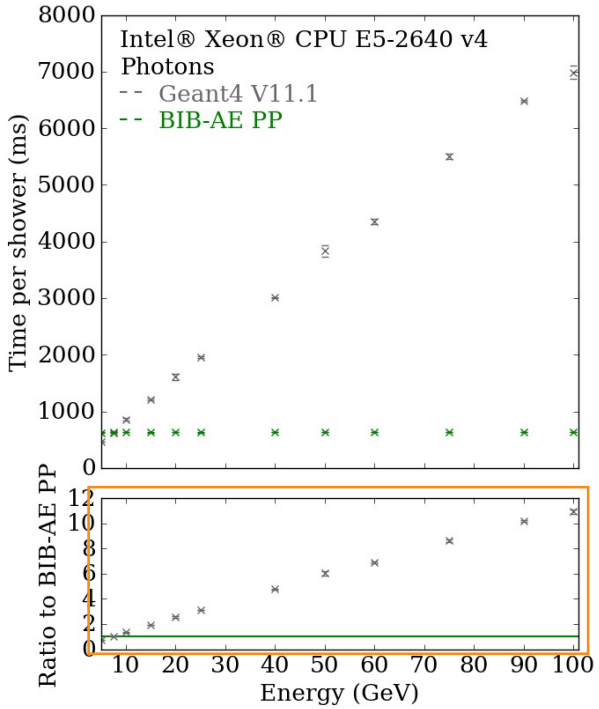
- Now possible to run inference (with dummy VAE) in barrel/endcap of CLD ECAL
  - Validation with a correctly trained (CaloDiT) model ongoing work of summer student



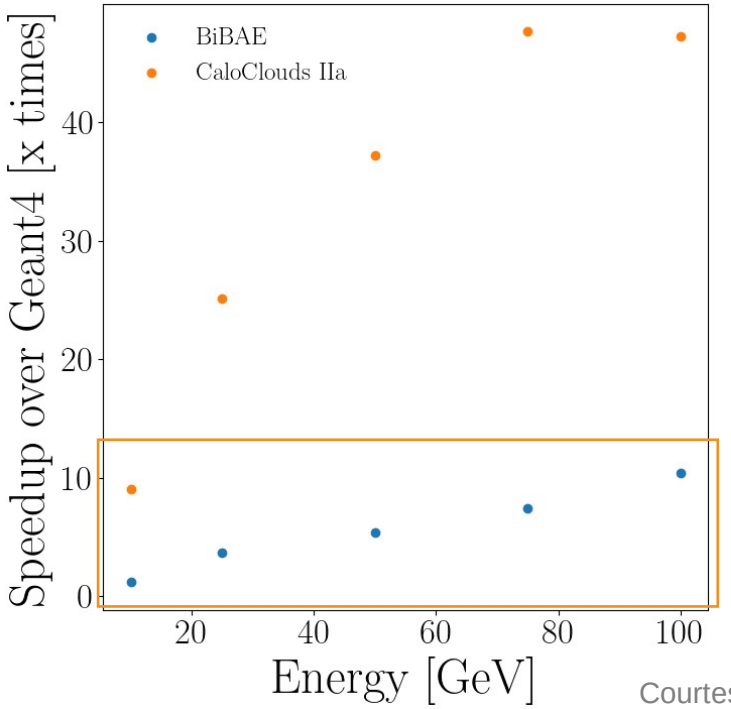


DESY

- Angular CaloClouds model now integrated into DDFastShowerML
- Investigating same physics benchmark based on the process $e^+e^- \rightarrow \tau^+\tau^-$ for ILD as was done for the BIB-AE
- Numerous improvements in dataset creation etc. compared to previous study
  - BIB-AE re-training on this dataset for fair comparison in progress (P.M.)
- CaloClouds model shows potential for significant performance gain!



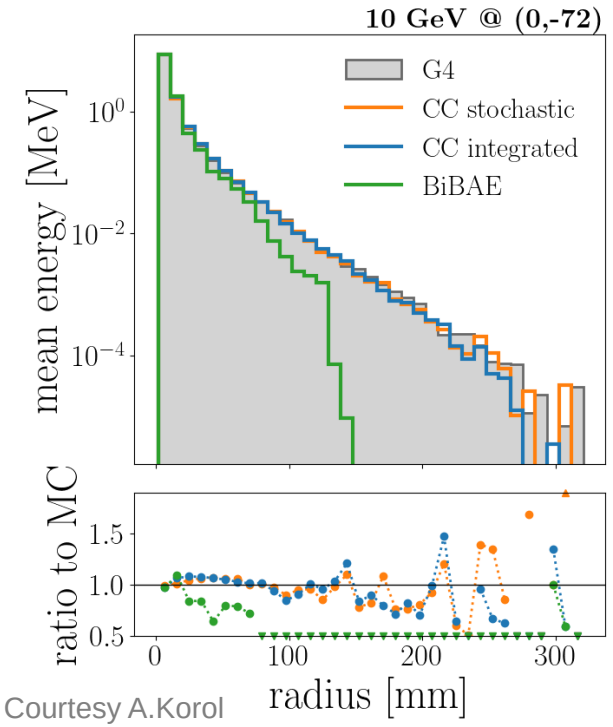
P.M., PhD Thesis (2024)



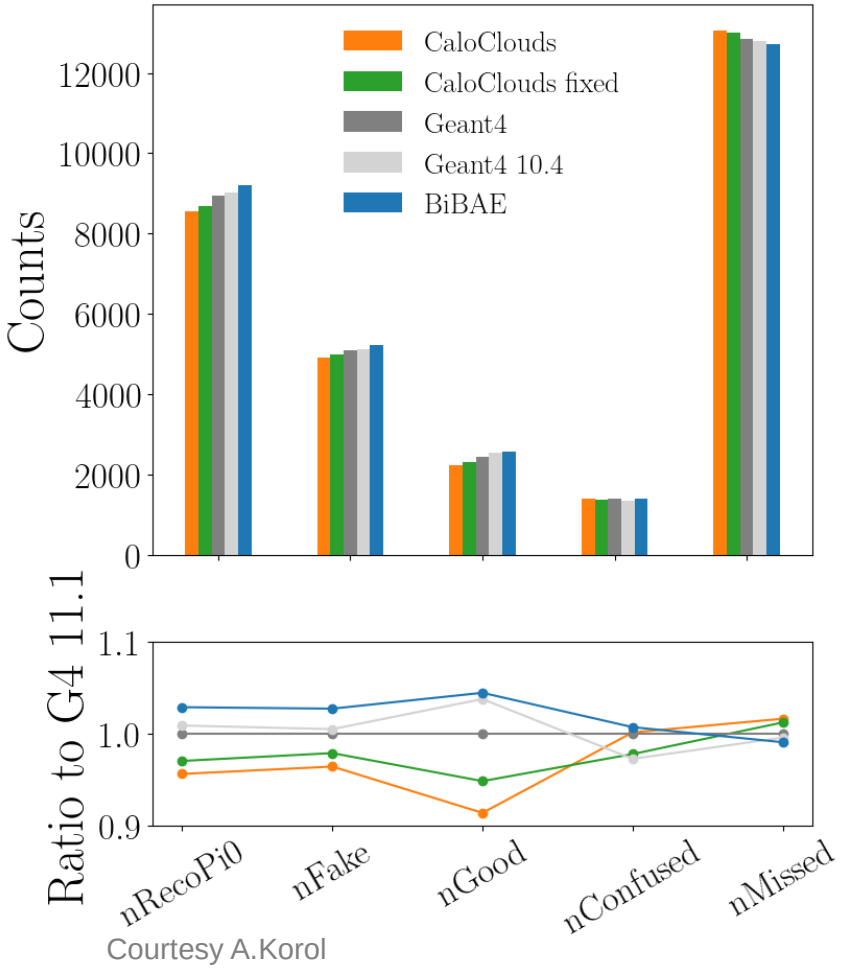
Courtesy A.Korol

DESY

- Despite improved modeling of calorimetric observables + more geometry independence in CaloClouds, physics performance after reconstruction needs further investigation
  - Look at **more physics observables** from BIB-AE study (Pi0 invariant mass etc.)
  - **Di-photon separation** (controlled environment)



Courtesy A.Korol



Courtesy A.Korol

Summary and Outlook

- **CaloDiT** model developments ongoing @CERN
  - **Geometry adaption** study progressing
  - Numerous avenues for **model speed-up** being explored

- Continue to investigate **CaloClouds** model in process $e^+ e^- \rightarrow \tau^+ \tau^-$ @DESY
  - Want to perform fair comparison with BIB-AE+other models
- Looking into **hadronic showers**: ECAL+HCAL point cloud “PionClouds” @DESY

DDFastShowerML library- Developments @CERN and @DESY!

- **CaloClouds Model integrated** @DESY
- Ongoing efforts towards integrating **cylindrical readouts** (CaloChallenge-like) @CERN

Future plans (near+longer term):

- More common physics benchmarks
- Use as basis for inference in next CaloChallenge (ODD)
- Integrate more models
- Add support for other calorimeter technologies (e.g. ALLEGRO)