



# Inference with Geant4

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LPCC Fast Detector Simulation, November 23, 2021

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## Inference within C++ framework

- Fast simulation with ML within Geant4
- New Par04 extended example to be released in December in Geant4 11.0
- Demonstrates how to incorporate inference libraries
  - ONNX Runtime
  - LWTNN
- VAE trained on a provided geometry, conditioned on the energy and angle of the particle
- Example can run full and fast simulation (if any of the inference libraries is available, e.g. via LCG)

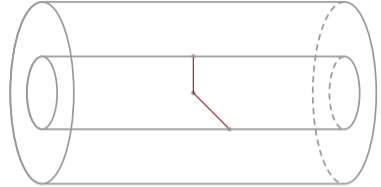
## Par04 example: geometry

- Detector geometry is simplistic and easy to configure
- Collider-style concentric cylinders with up to two materials (active and optionally passive)



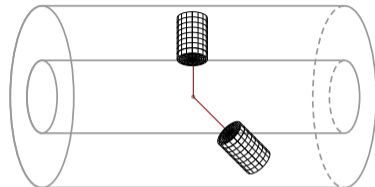
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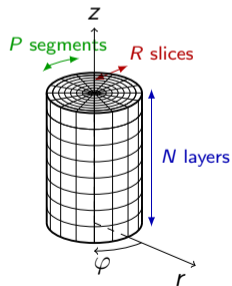
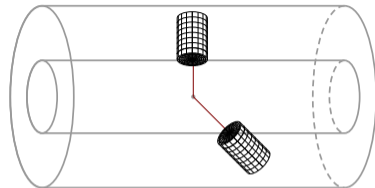
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- Scoring of energy deposits is done relative to the particle direction
- Similar 'pictures' are obtained independently on angle

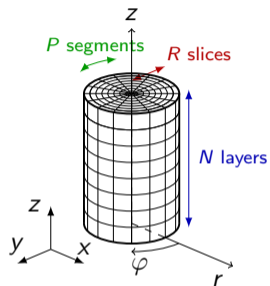


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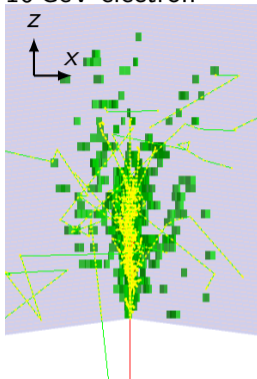
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- Granularity of shower deposition is configurable



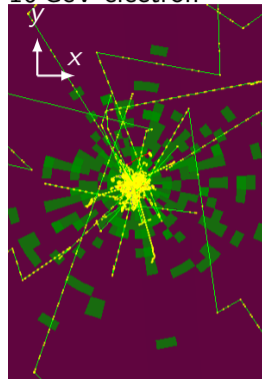
## Par04 example: showers



10 GeV electron

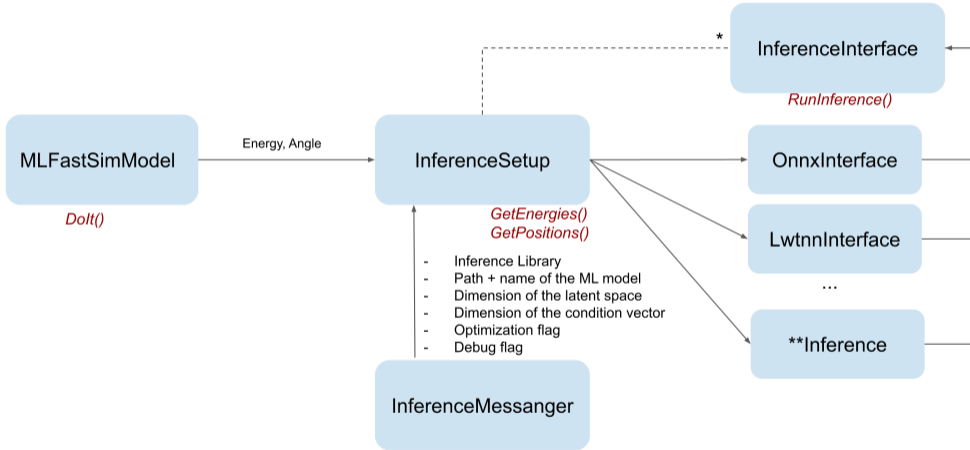


10 GeV electron



- Example uses 0.3 mm Si and 1.4 mm W layers
- Readout granularity is  $\Delta r \times \Delta \phi \times \Delta z = 2.3 \text{ mm} \times \frac{2\pi}{50} \times 3.4 \text{ mm}$  aiming for  $\Delta r \approx 0.25 R_M$  and  $\Delta z \approx 0.6 X_0$
- Number of readout cells is  $R \times P \times N = 18 \times 50 \times 45$  aiming for 95% containment of 1 TeV particles

# Par04 example: inference





## Summary

- `examples/extended/parameterisations/Par04` available in Geant4 11.0 release (Dec 2021)
- Geant4 fast simulation models are used (allowing to seamlessly mix fast and full simulation)
- Base for ML fast sim studies in EP-SFT
  - Systematic studies on training
  - Inference libraries comparison (time, size, memory footprint)
- We will publish also the simulated dataset