



Long-Lived Particle Search with Lepton Colliders

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- Particles decaying a macroscopic distance are defined to be long-lived particles.
- BSM theories predict existence of LLPs.

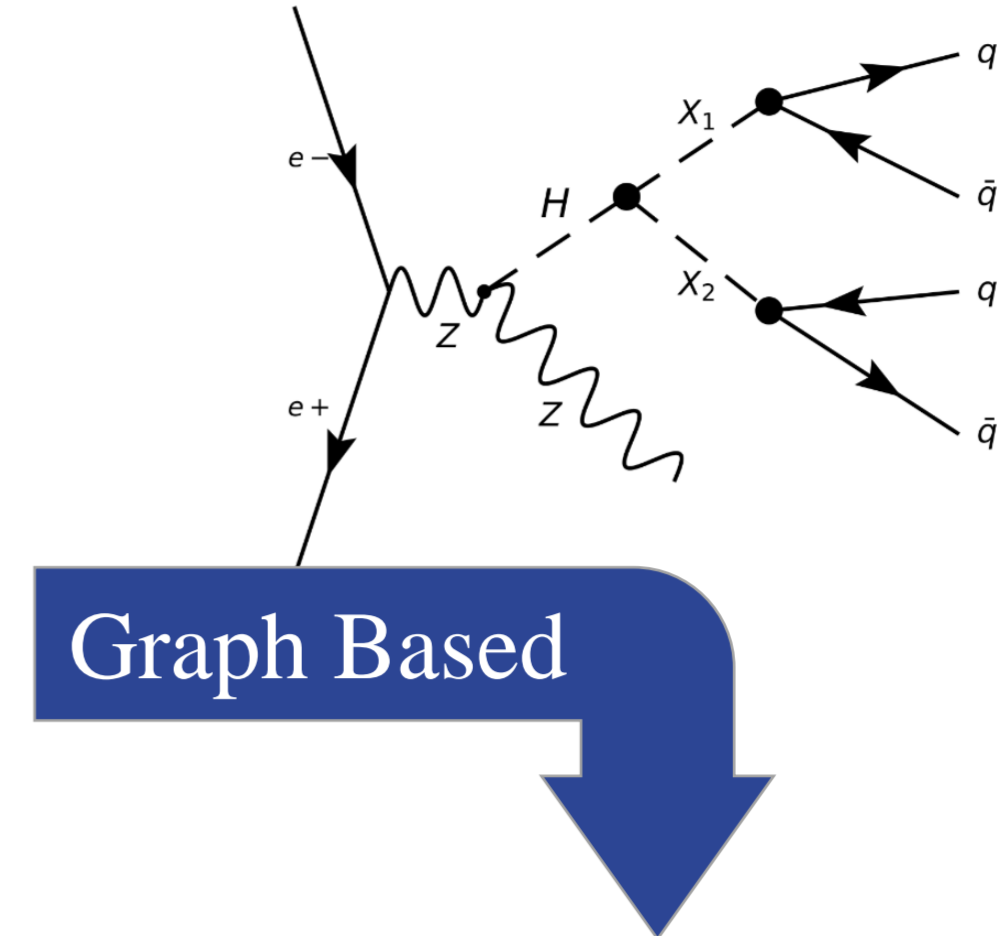
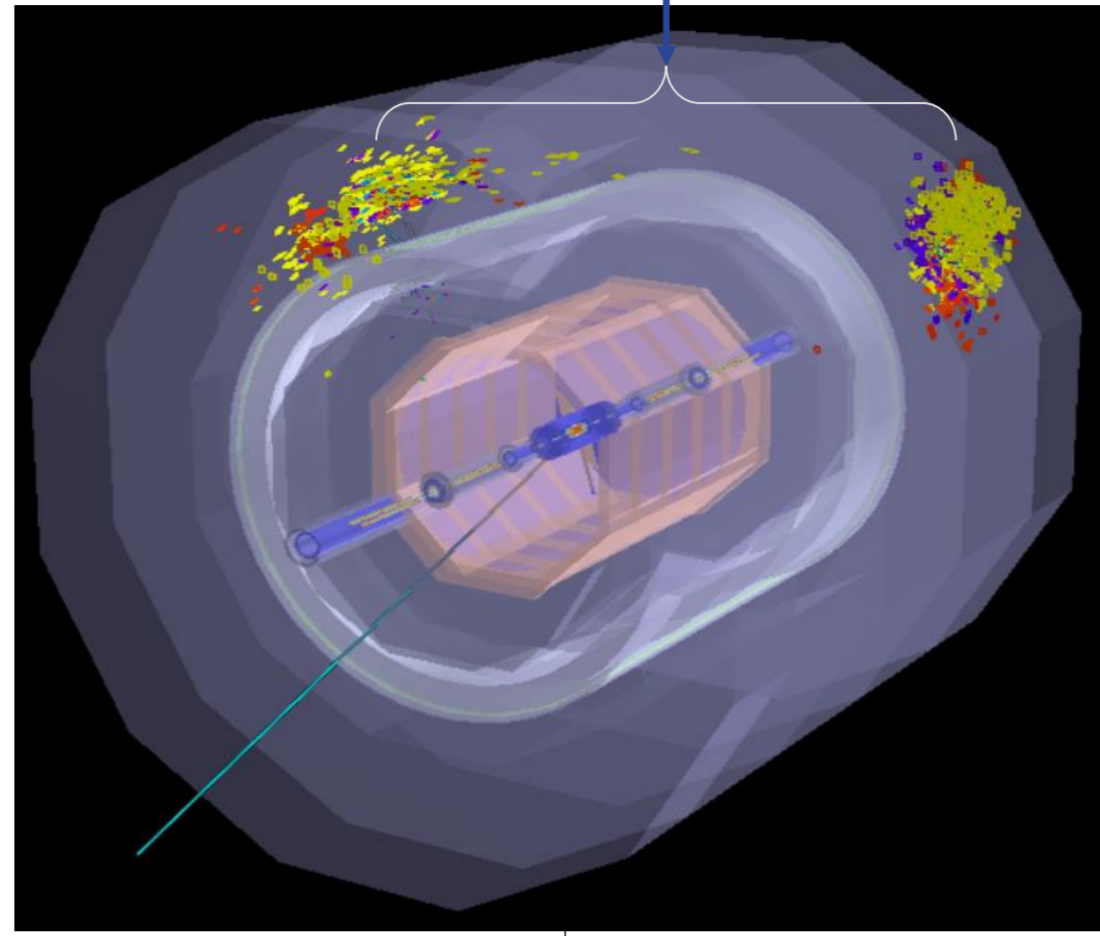
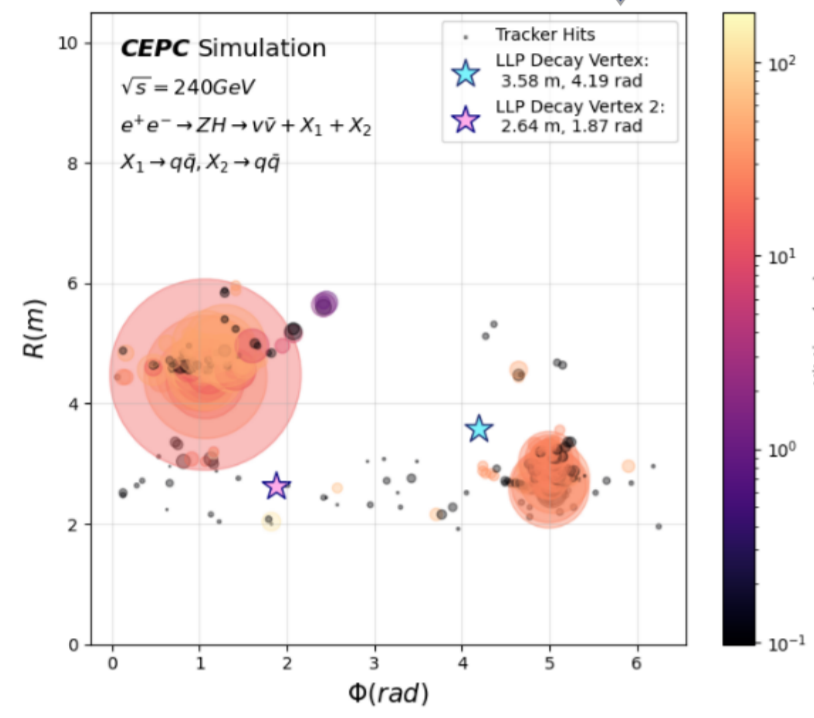


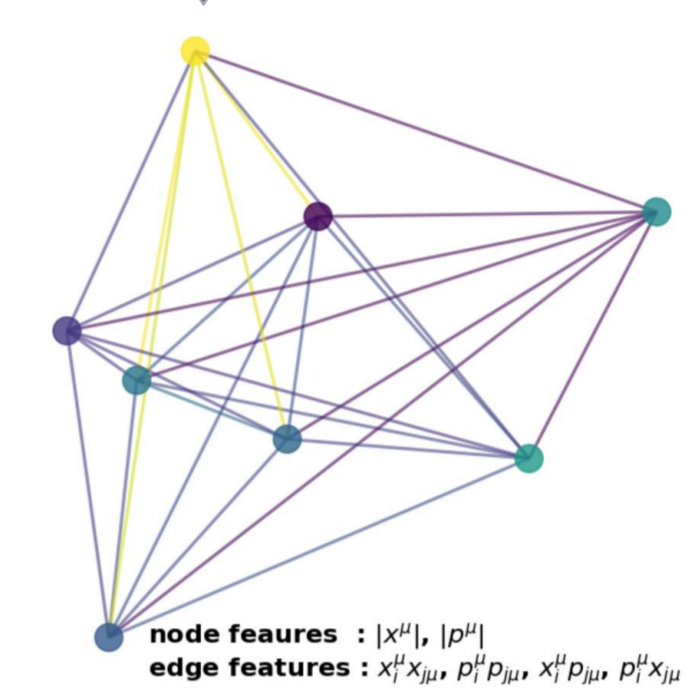
Image Based

Graph Based

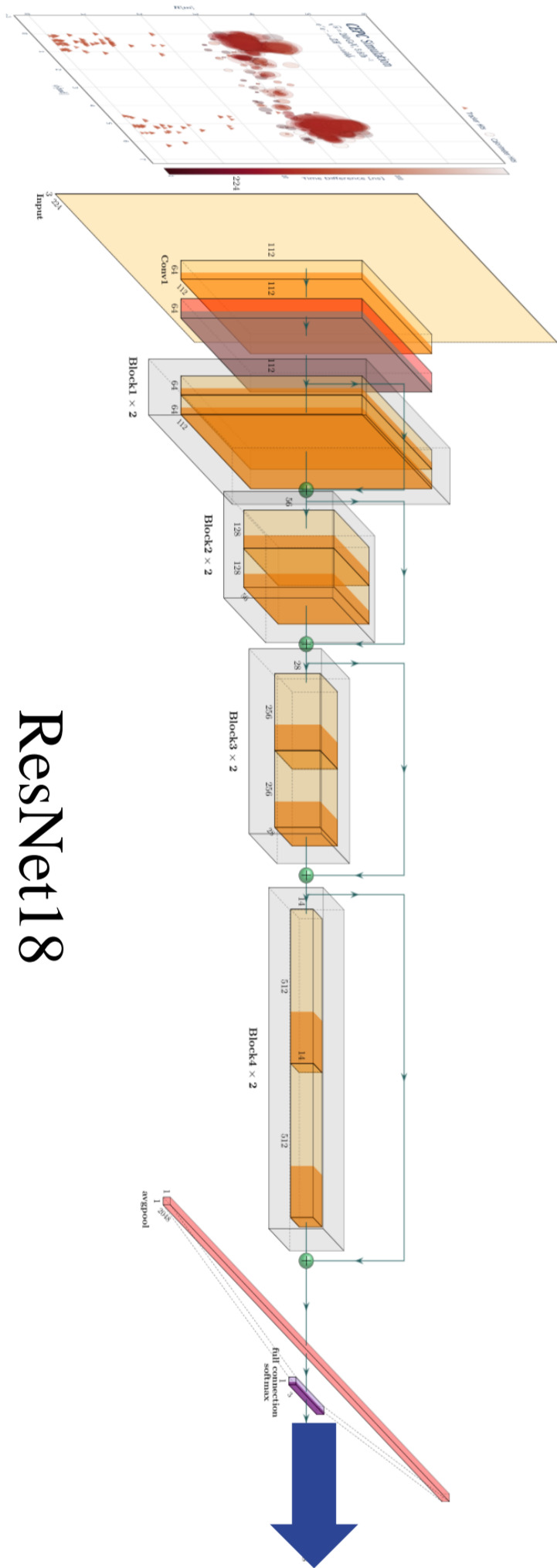


Full simulated samples are transformed into images with 200×200 pixels and 2 channels.

Hits of full simulated samples are clustered and are represented by nodes in a graph.



Features of nodes are X^μ and P^μ of clusters.

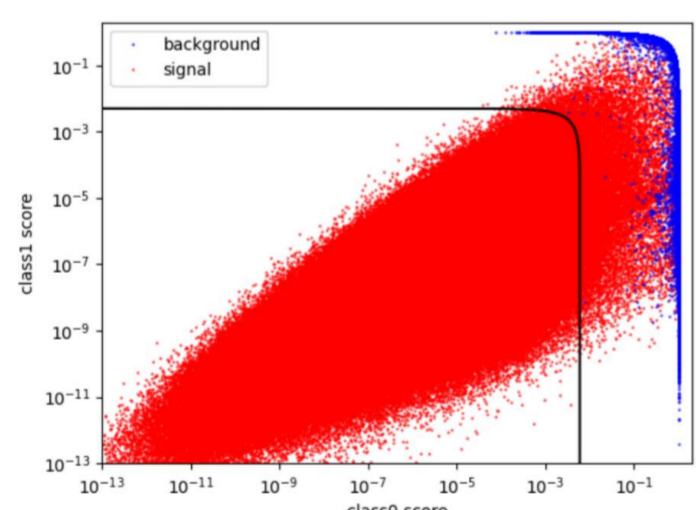


Each slice represents output of corresponding CNN layer.

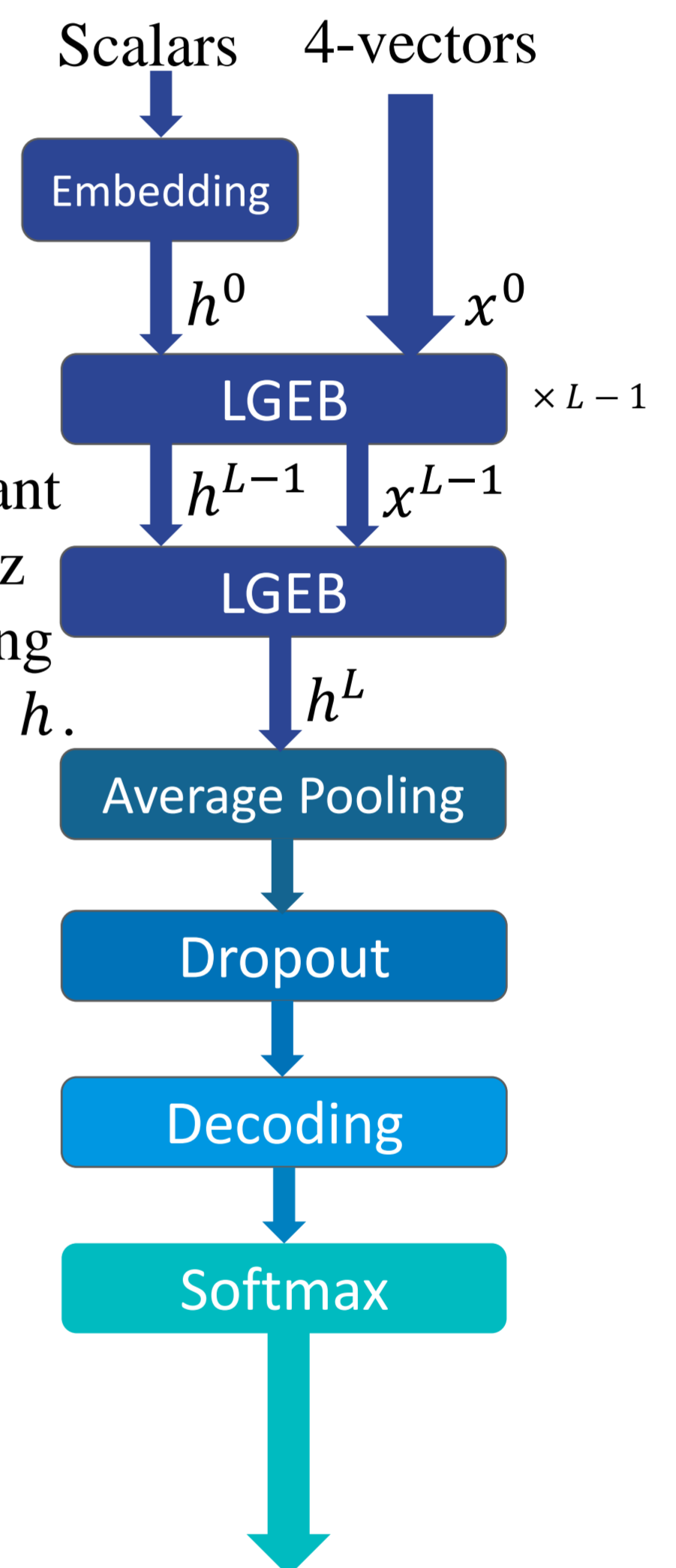
Broken lines are short cuts of ResNet to reduce overtraining.

Thin sticks are various features extracted by CNN.

10^6 signal events
 2×10^6 background events

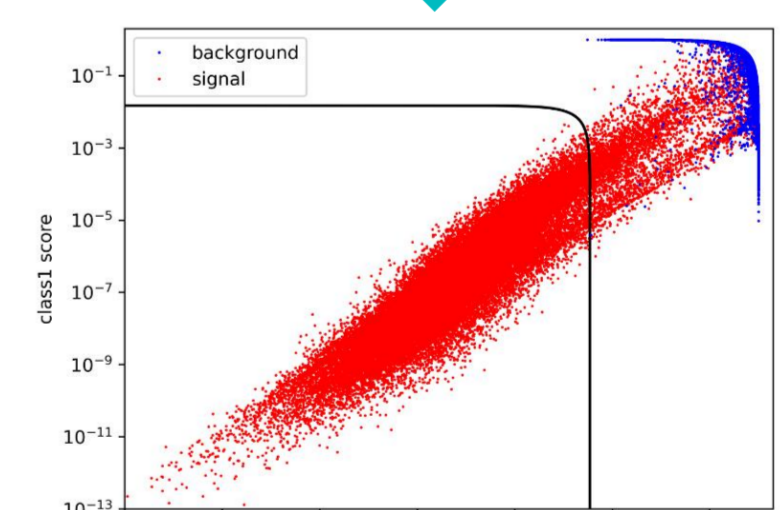


Signal efficiency with 0 background cut
98.18%



Lorentz Group Equivariant Blocks maintains Lorentz symmetry while extracting feature into latent vector h .

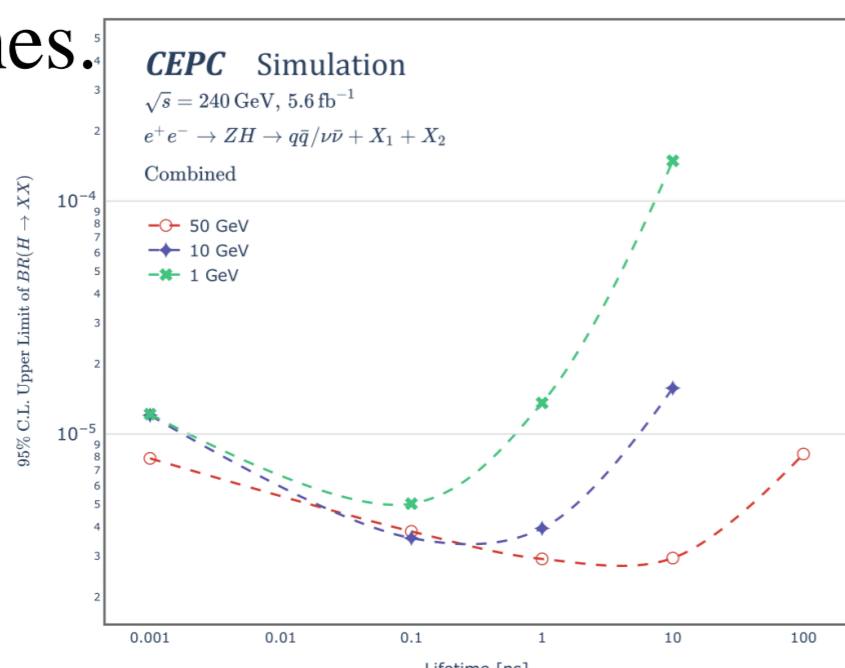
5×10^4 signal events
 10^5 background events



Signal efficiency with 0 background cut
89.25%

Preliminary Results

- Applied deep learning techniques (CNN and GNN) to LLPs search and CNN gives the best limit.
- Under 95% confidence level, the exclusion limit for branch ratio of LLPs can reach 2×10^{-6} with (expected) 10^6 Higgs statistics, which is one of the most stringent limit for low mass LLPs searches.



Signal Efficiency (CNN)	Lifetime [ns]				
	0.001	0.1	1	10	100
Mass	0.001	0.1	1	10	100
50GeV	0.381	0.771	0.981	0.982	0.926
10GeV	0.248	0.862	0.786	0.413	\
1GeV	0.245	0.594	0.447	0.306	\

Outlook

- Modified clustering methods can help increase signal efficiency of GNN.
- Faraway detector can further improve geometry acceptance and exclusion limit.