



Electron/photon (e/γ) discrimination with Graph Neural Networks(GNNs).

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Link to poster

Motivation

In analysis like the search for a Beyond the Standard Model (BSM) low mass (60-110 GeV) Higgs boson decay to two photons, the discrimination between electrons and photons is crucial for rejecting the background coming from the resonant production of Z bosons decaying to two electrons.

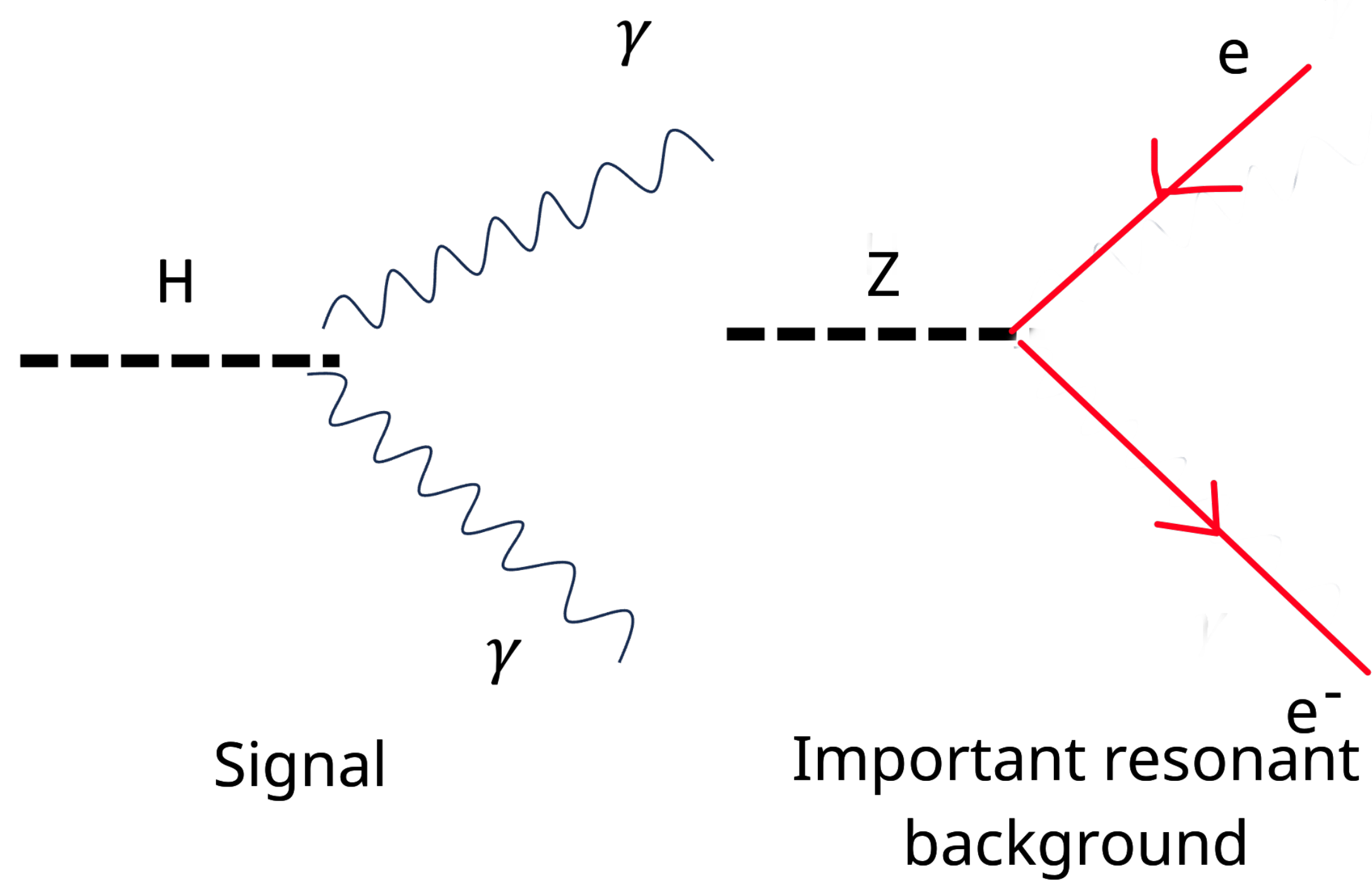


Figure 1: Feynman diagram of the $H \rightarrow \gamma\gamma$ process and the main resonant background.

Why graph neural networks

The introduction of Boosted Decision Trees (BDT) represented a great leap forward on the electron/photon discrimination for the RUN2 diphoton analysis.[1]

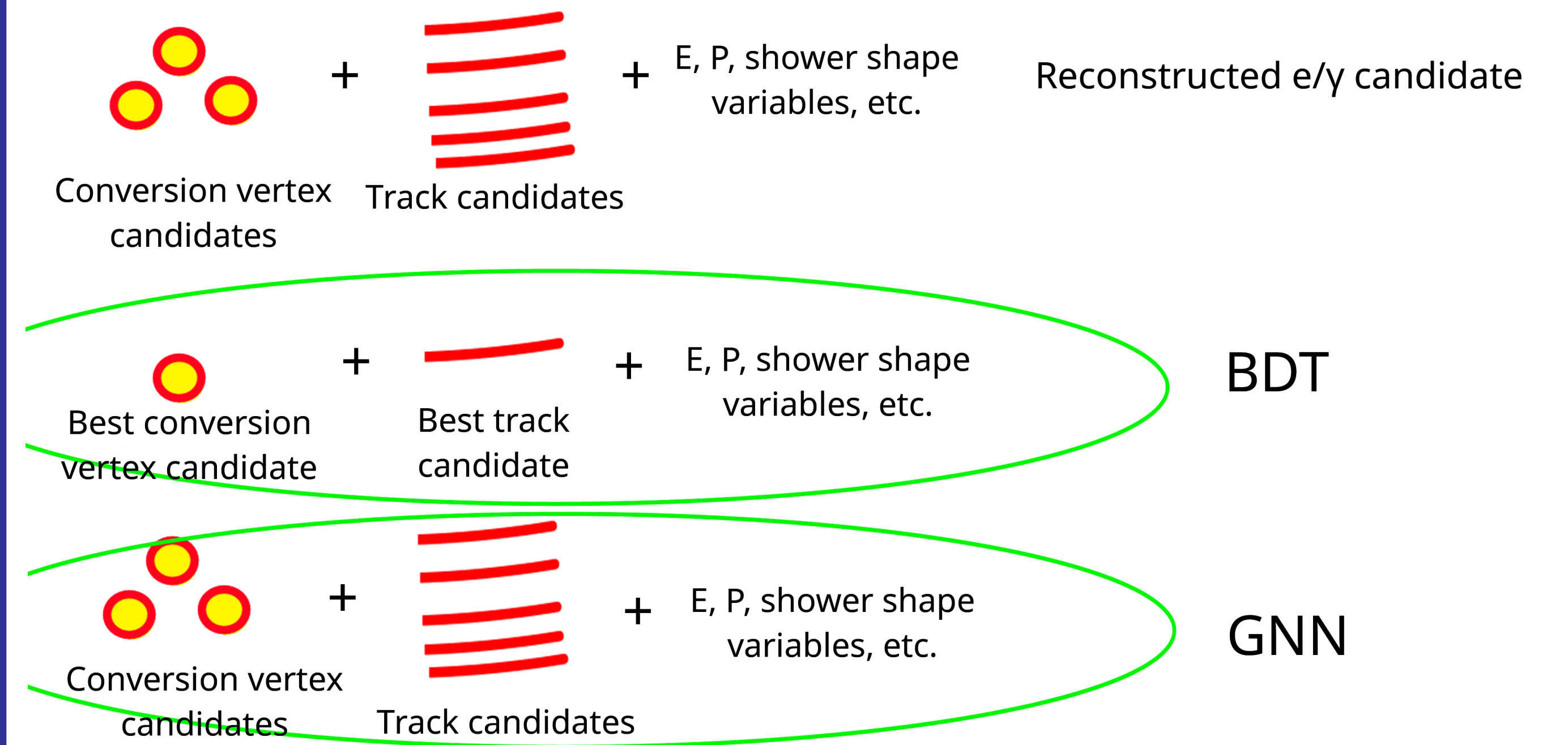


Figure 4: For all the good things the BDT has it is limited to only the best track, and best conversion vertex candidates. This is a problem because the information from the other tracks and conversion vertex candidates is lost. .

Particle reconstruction

e/γ reconstruction is a complex process that involves the combination of information from the inner detector, the electromagnetic calorimeter and the hadronic calorimeter. Due to the many similarities between the two objects, instead of referring to the reconstructed objects as electron or photon candidates, they are often referred to as e/γ candidates.

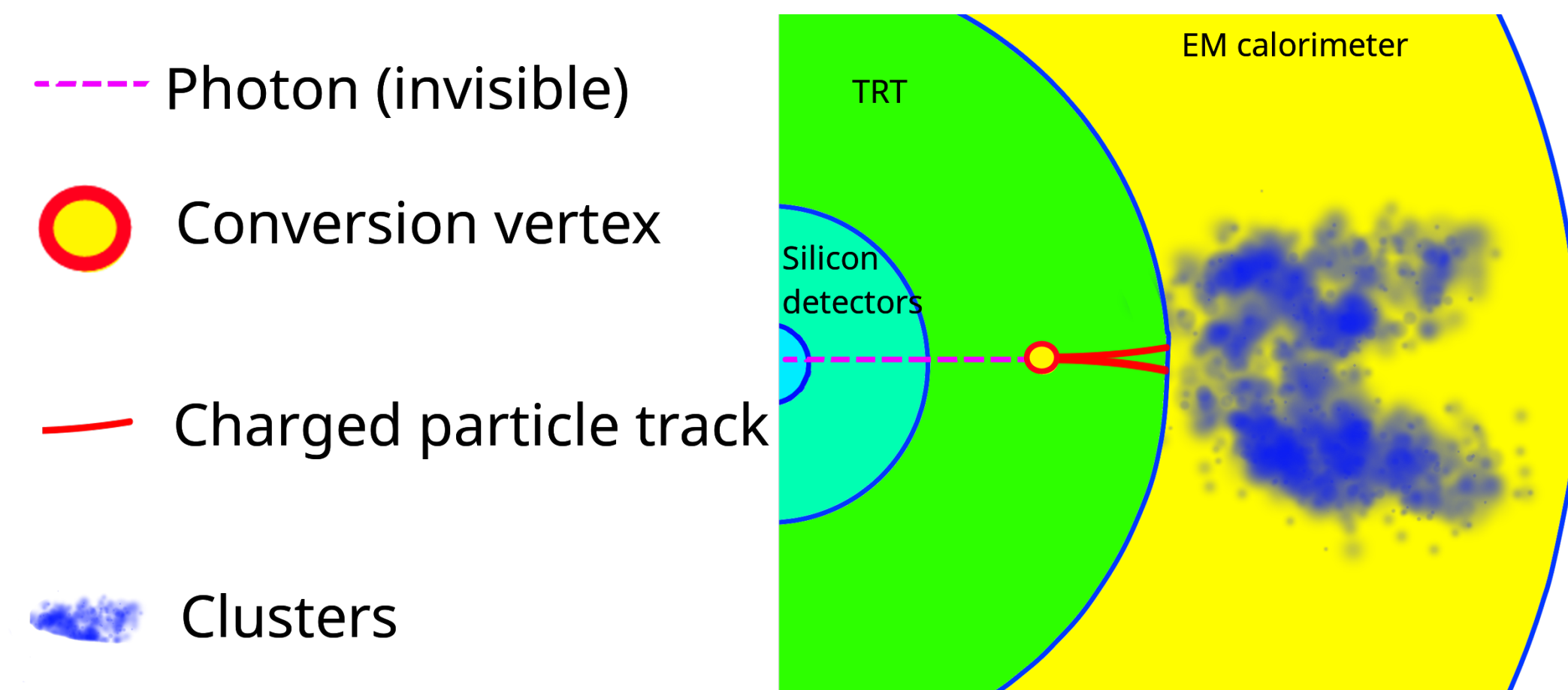


Figure 2: Parts of a reconstructed e/γ candidate.

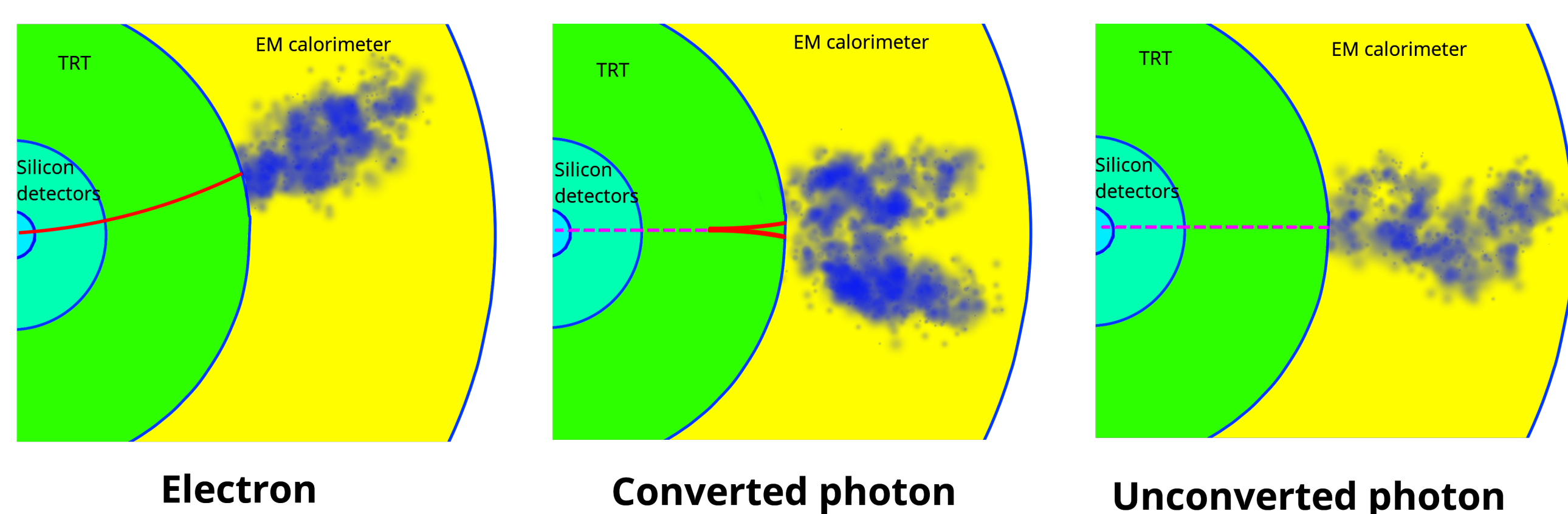


Figure 3: The e/γ candidates are divided into 3 categories: electrons, converted photons and unconverted photons. Converted photons can be especially challenging to discriminate from electrons

e/γ discrimination with GNNs

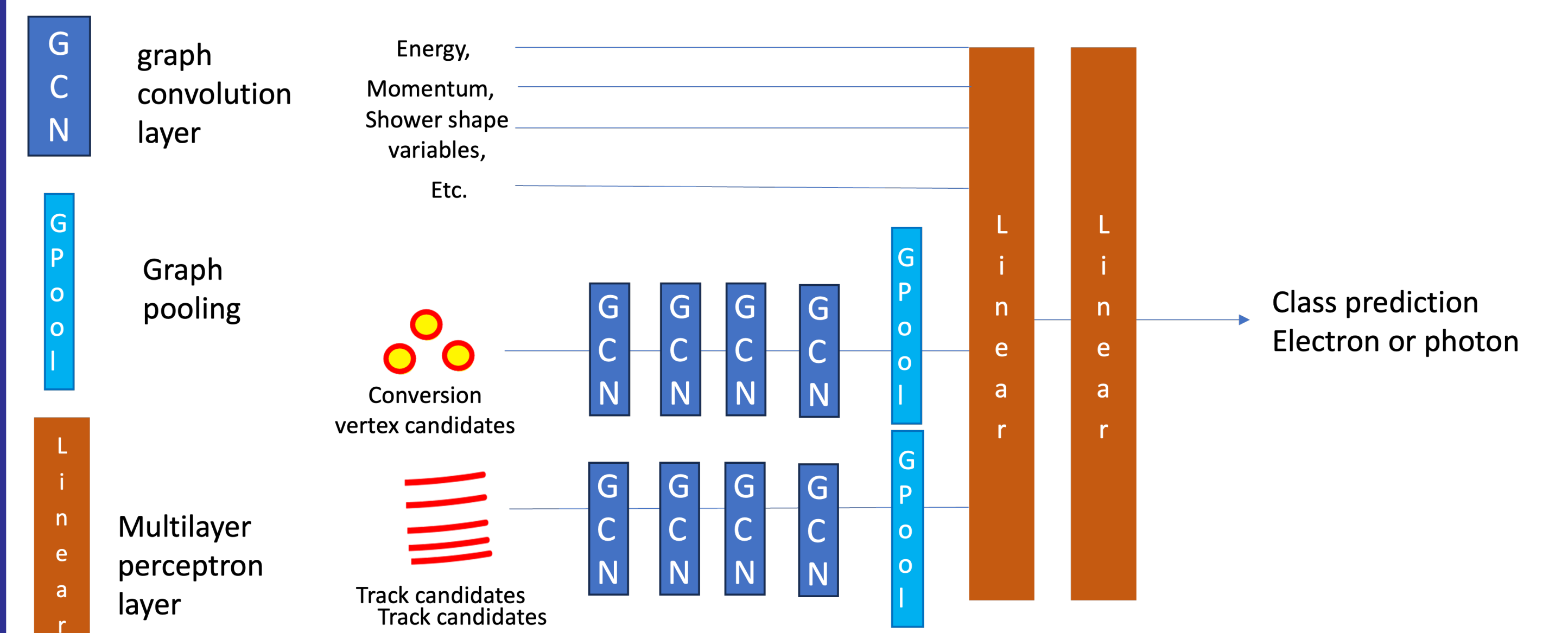


Figure 5: The GNN model is trained with the information from all the tracks and conversion vertex candidates, the network itself decides which information is important from each candidate before pooling the information from all the candidates.

Results from the GNN are not available yet, but the expectation is that the GNN will be able to improve the discrimination between electrons and photons.

Summary

- e/γ discrimination is a crucial part of the data analysis for search such as the BSM low mass Higgs boson decay to two photons.
- Currently the BDT is the main tool for this discrimination, but it is limited to only the best track, and best conversion vertex candidates.
- The GNN is expected to improve the discrimination between electrons and photons by considering all the tracks and conversion vertex candidates.

KEY REFERENCES

- [1] Search for diphoton resonances in the 66 to 110 GeV mass range using 140 fb^{-1} of 13 TeV pp collisions collected with the ATLAS detector. Tech. rep. All figures including auxiliary figures are available at <https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/CONFNOTES/ATLAS-CONF-2023-035>. Geneva: CERN, 2023. URL: <https://cds.cern.ch/record/2862024>.

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