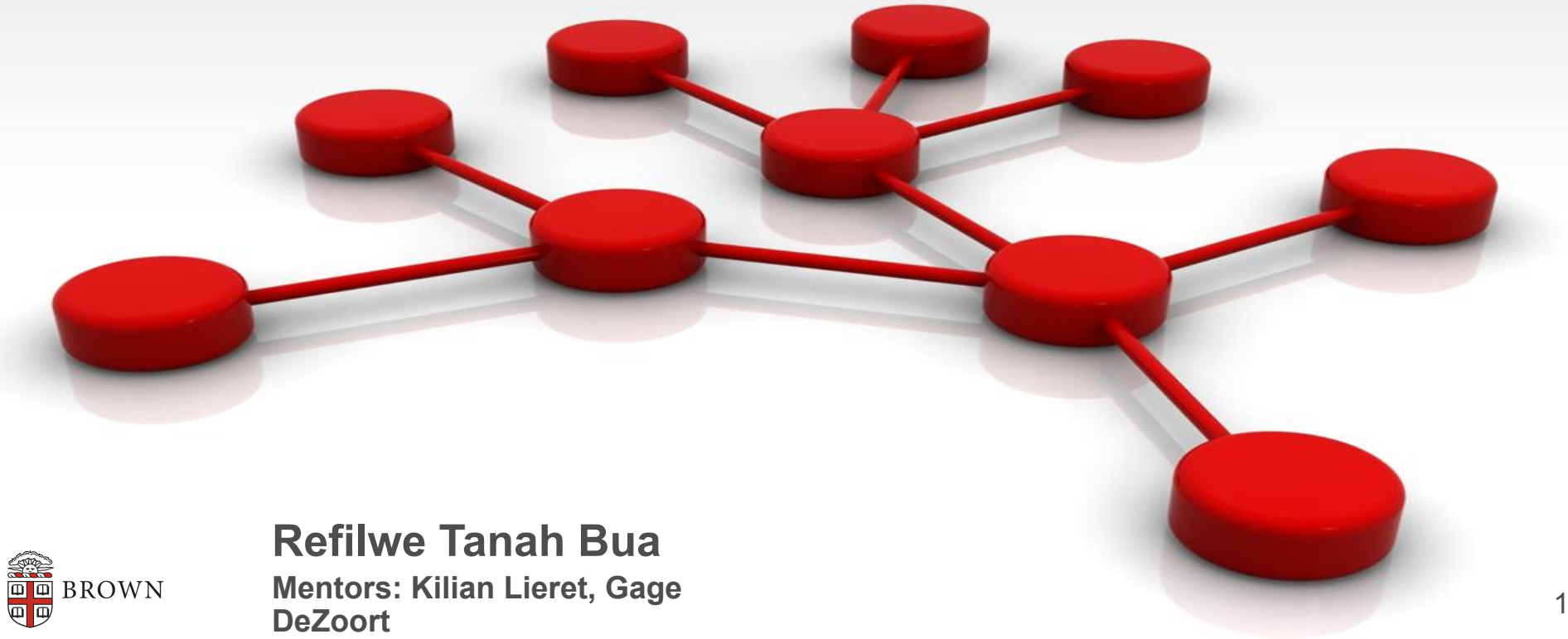
# Novel edge classification architectures for charged particle tracking with graph neural networks

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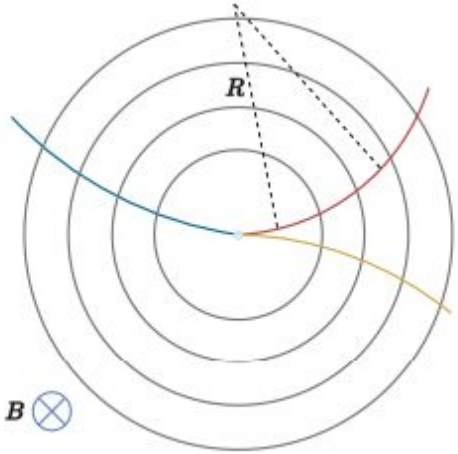
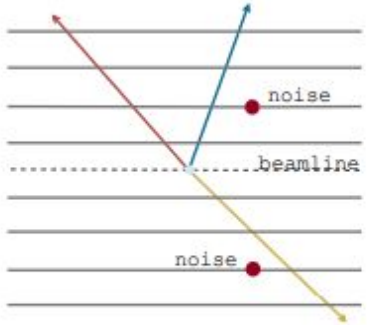
# What is tracking?

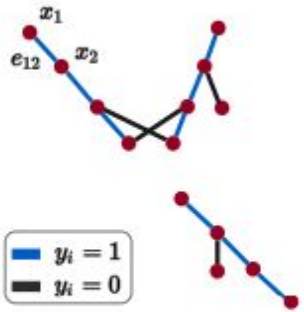
- Tracking the positions, velocities and trajectories of particles over time.
- Data is represented as a graphs where particle hits are nodes, and their trajectories are represented as edges.
- Track reconstruction is essentially connecting the dots.




Transverse View




Unrolled r-z View




Hitgraph View

Image credit: DeZoort et al (charged particle tracking via edge-classifying interaction networks), 2021

# Graph Neural Networks

- Message Passing: To propagate information between connected nodes.

- Node Update and neighborhood aggregation: a transformation function is applied here to combine the aggregated information with our current node's representation. The function used in this instance is a Graph Convolution layer.

- Output Prediction: Inference tasks such as node or edge classification.

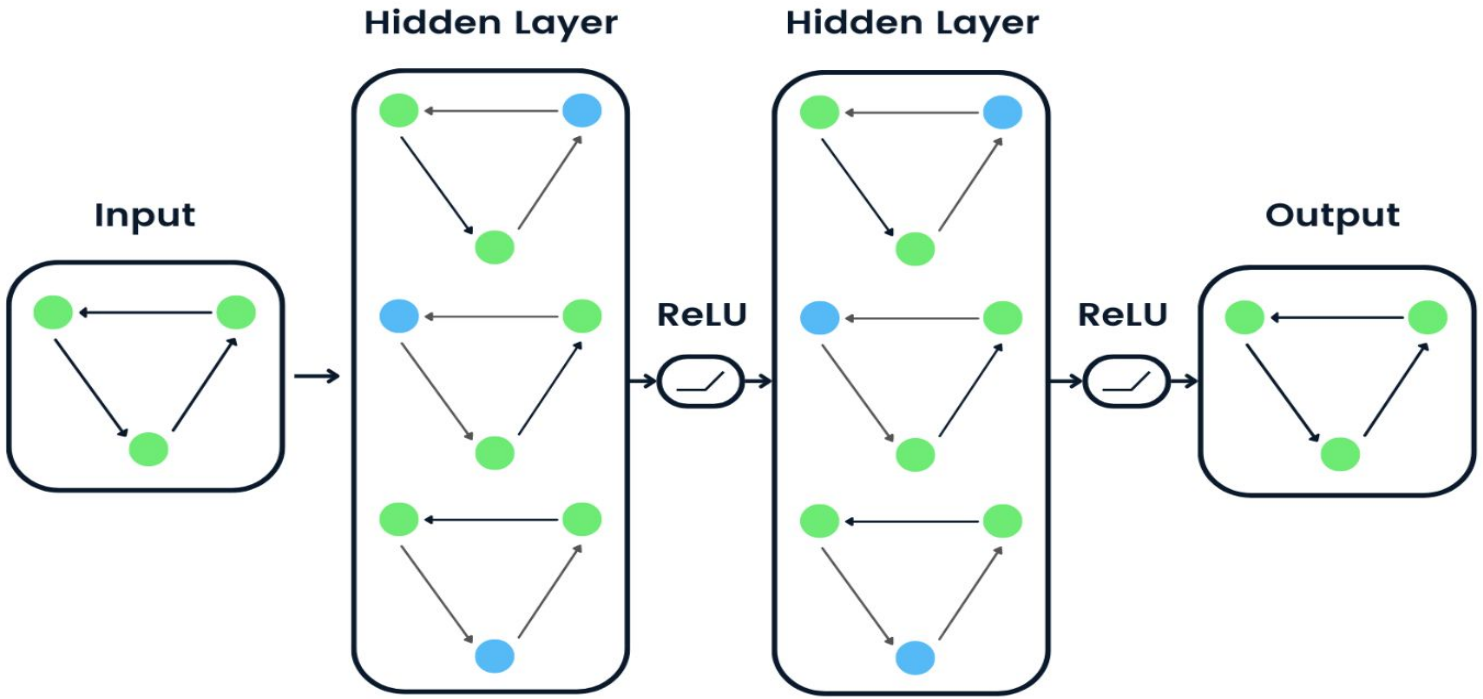



Image credit:datacamp, july 2022

# Edge Classification

- Predict a label or attribute for each edge. E.g a binary classification of either 0 or 1 depending on whether an edge exists between two nodes or not.

- Model Selection: A model called GCN.

  - Takes edge attributes as inputs and passes through linear layers with ReLU activations.

  - A sigmoid activation which outputs the probability of an edge belonging to a certain class.

# ROC curve and AUC

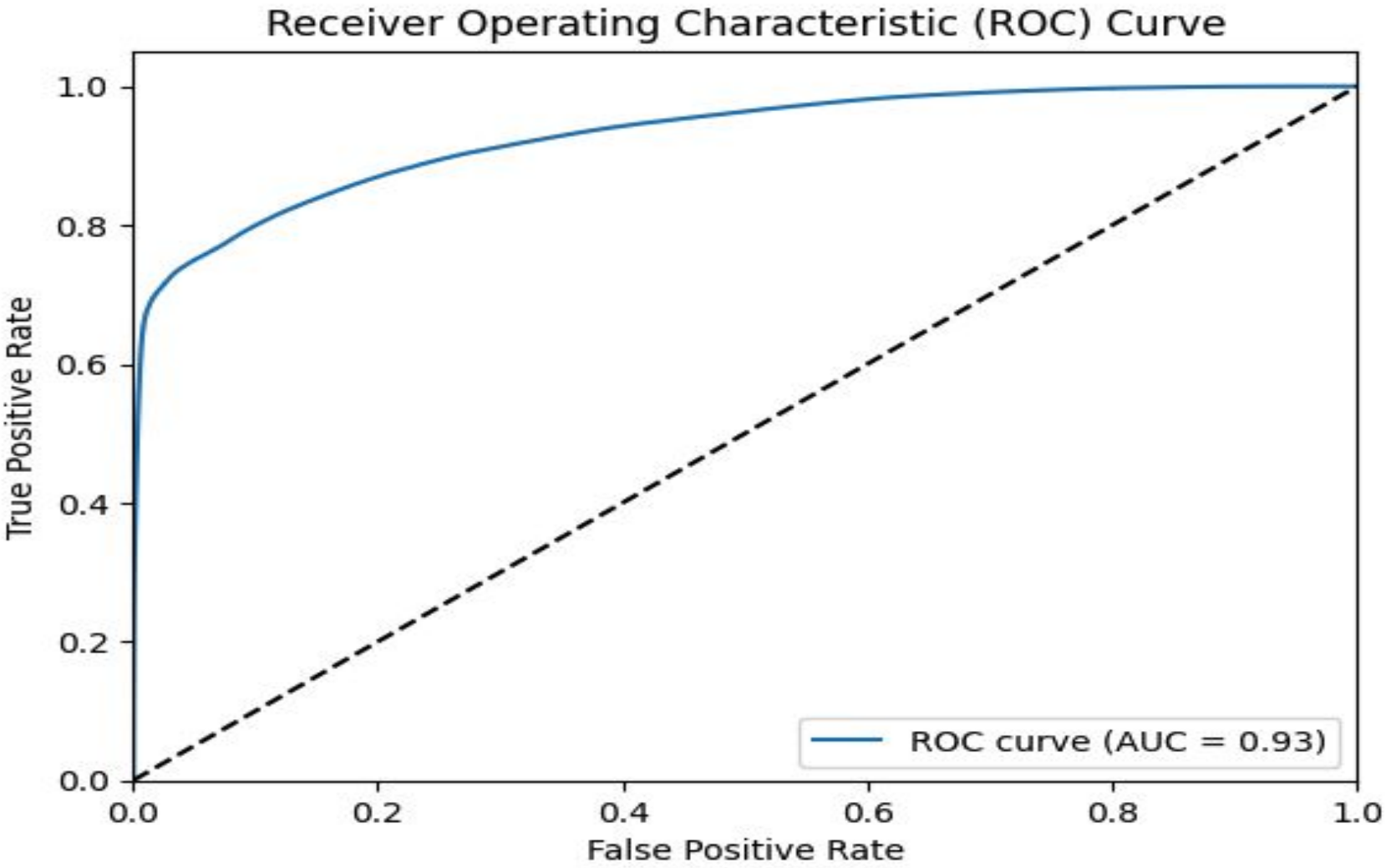
- Assesses the performance of the classification model.

- Visualizing the trade-off between its true positive rate (TPR) and false positive rate (FPR) across different classification thresholds.

$$TPR = \frac{TP}{TP + FN}$$

$$FPR = \frac{FP}{FP + TN}$$

- AUC quantifies the overall performance of a classifier across all possible thresholds.


Receiver Operating Characteristic (ROC) Curve
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (AUC = 0.93)