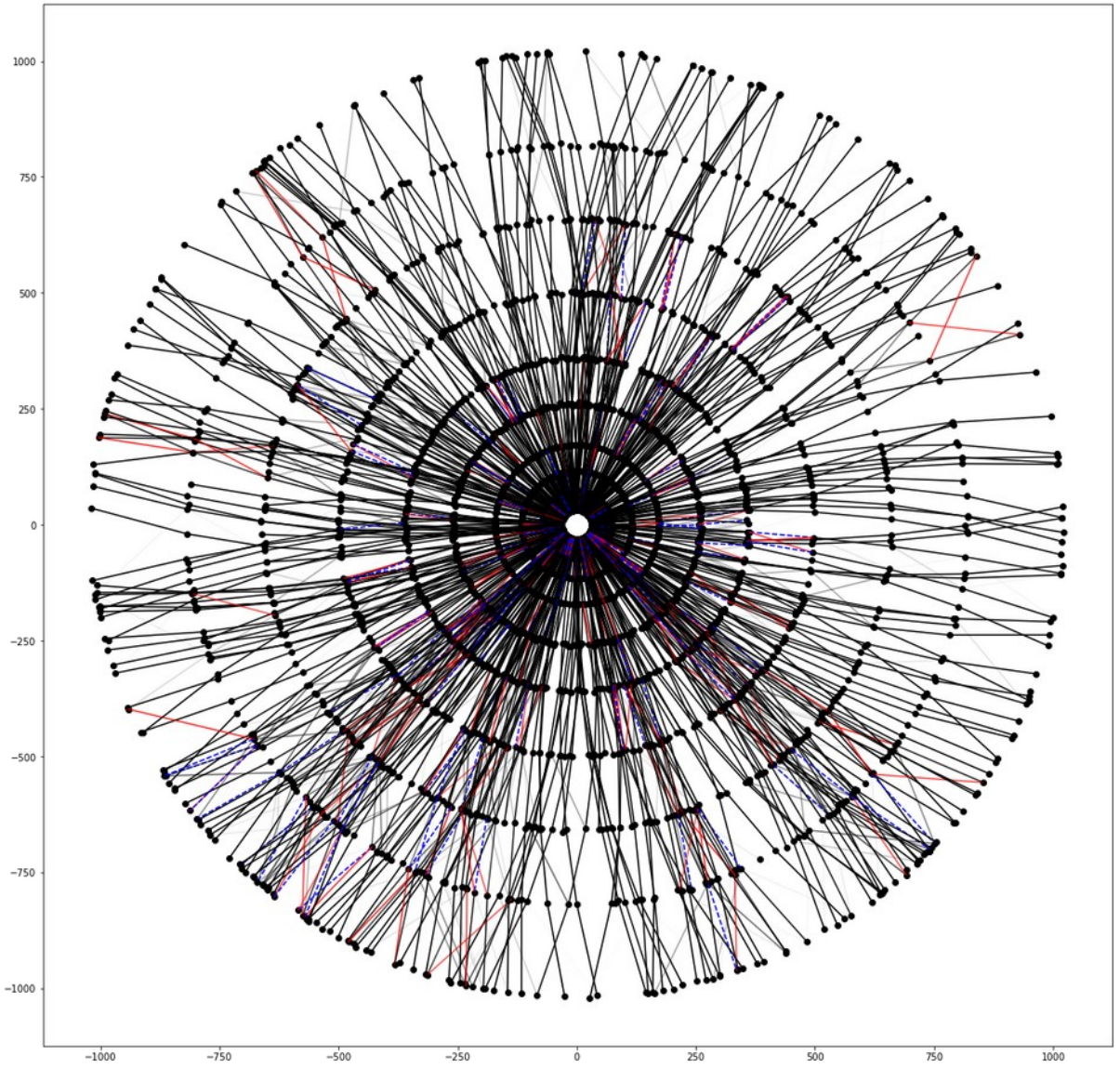
Reconstruction of particle tracks using Deep Neural Networks



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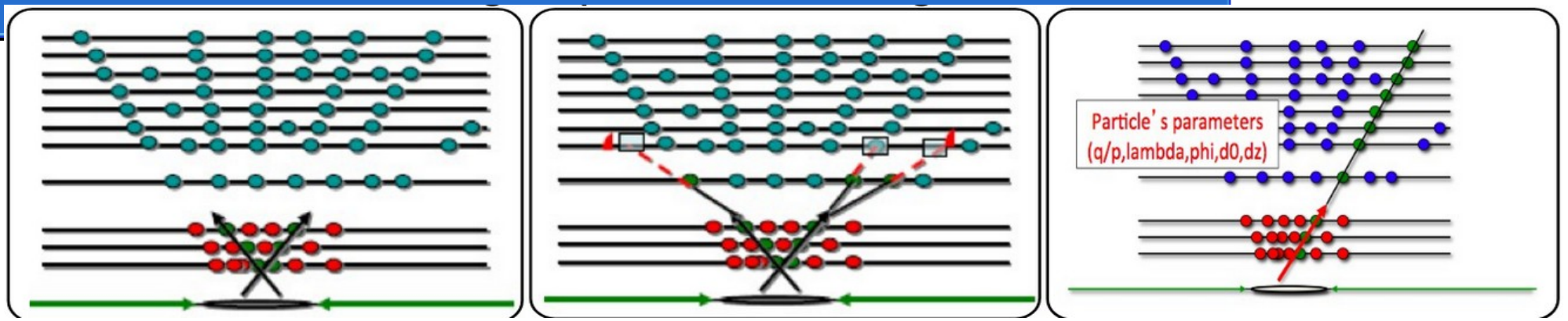
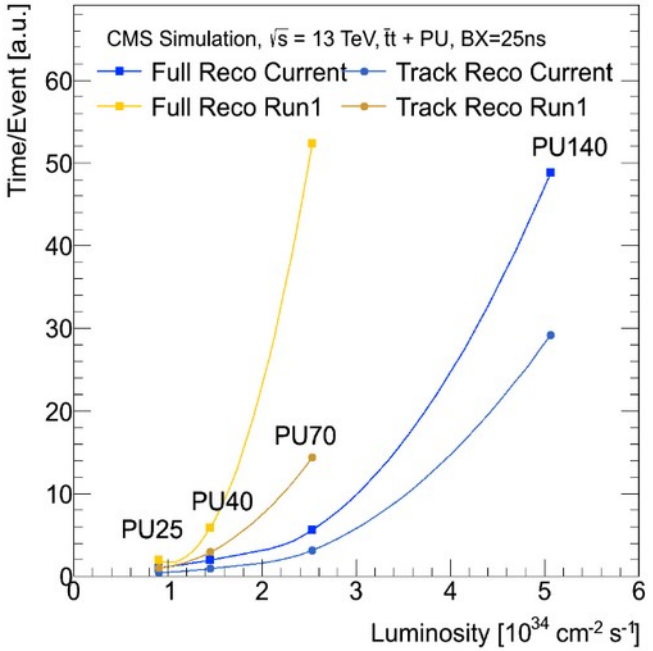
Track reconstruction



Seeding **Track Building** **Track Fitting**

Usually this method works fine, is robust and efficient!

- **Problem:**
  - The time needed to process one event grows quickly (worse than quadratic) with luminosity (number of collisions).
  - Huge part of CPU consumption by the track finding.

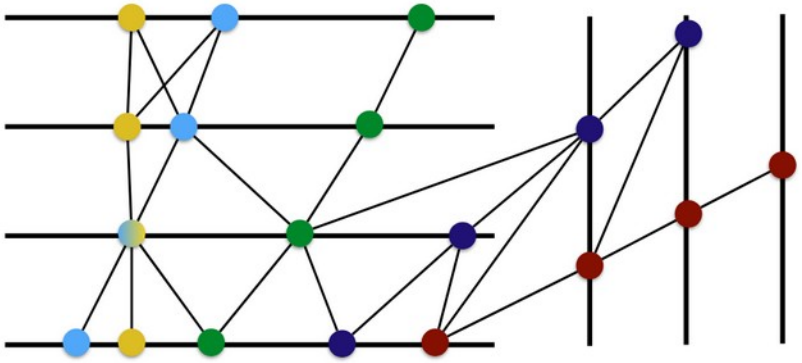


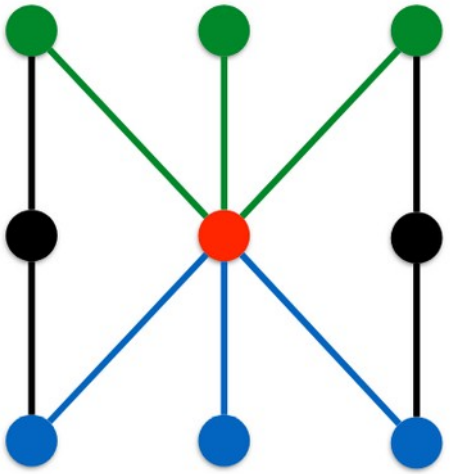
Solution: use Neural Network!

Graph Neural Network

Structure tracking data as a graph of connected hits:

- What kinds of models can we apply to this representation?
- Traditional architectures designed for graphics (photos) don't work efficiently enough...
- ...but there's a growing sub-field of ML called Geometric (Graph) Deep Learning





Graph Neural Networks: two main components operate on the graph locally:

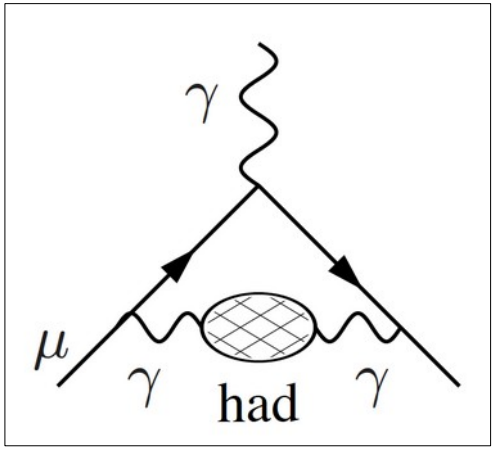
- Edge network uses the node features to compute edge weights
- Node network aggregates forward and backward node features with the edge weights and updates node features.

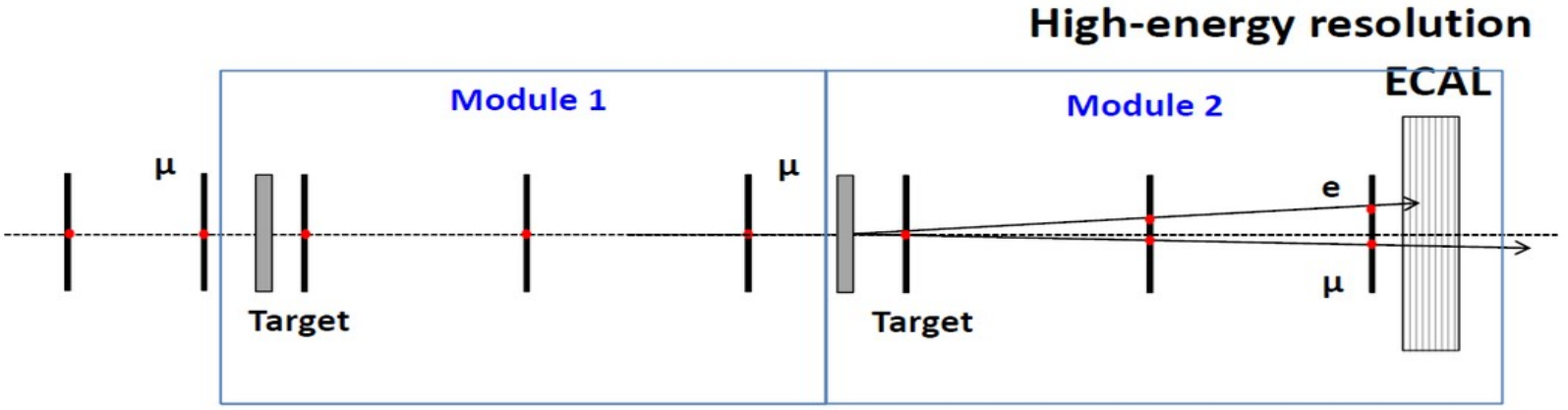
Task – GNN for MuonE experiment

- MuonE – future CERN experiment dedicated to measure a hadronic correction to the anomalous muon magnetic moment.

- **TASK: apply GNN to the simulated test beam data:**
  - No magnetic field – straight tracks
  - Few detector layers
  - Layers detecting X and Y position with so called stereo layers rotated by 45 degrees

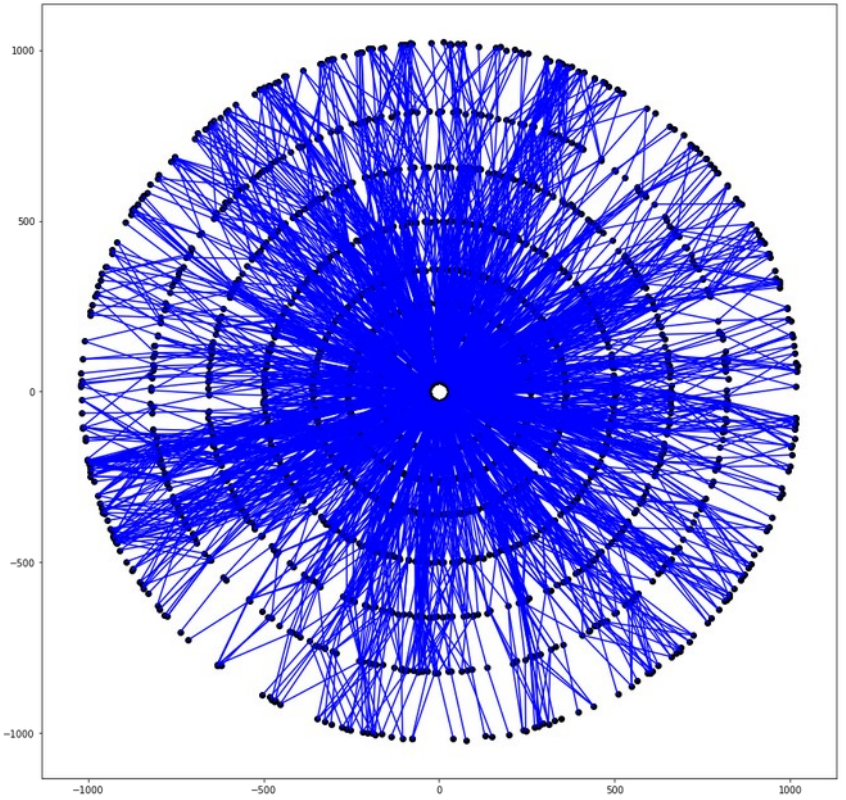
hadronic vacuum polarization





Information about Graph Neural Networks

- Great page: http://geometricdeeplearning.com/
- Nice lecture: https://ucbrise.github.io/cs294-ai-sys-sp19/assets/lectures/lec03/gnn.pdf
- Presentation about GNN tracking:
- https://indico.cern.ch/event/658267/contributions/2881175/



See the code of a toy example on github

- It is pretty compact:

  https://github.com/marcinwolter/Tracking/blob/master/GNN_Tutorial_Colab.ipynb

- Plus input data:
  https://drive.google.com/open?id=1NNZadxZcrxkm0NJv3CgeNGwBnsnByioV

And you can run it on Google Colab: https://colab.research.google.com