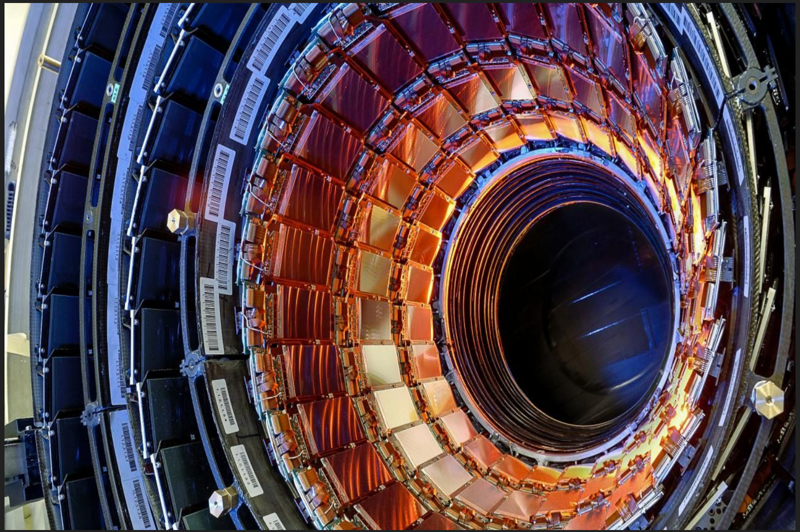
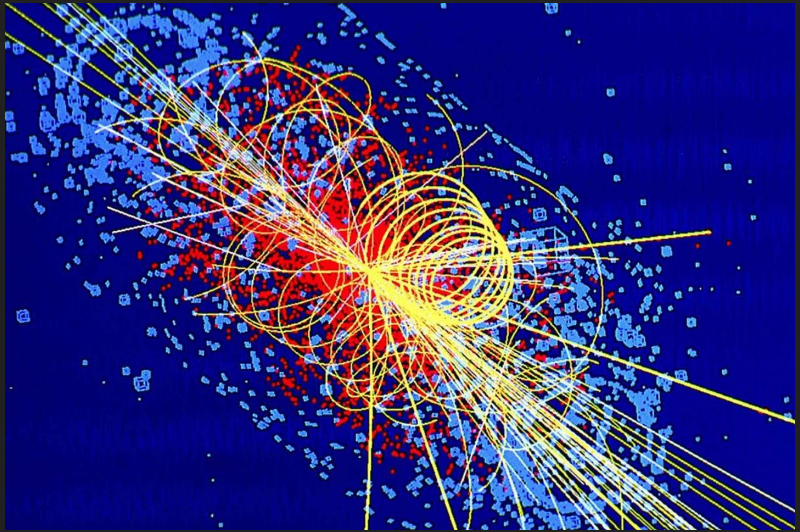
Particle Tracking Using Neural Networks

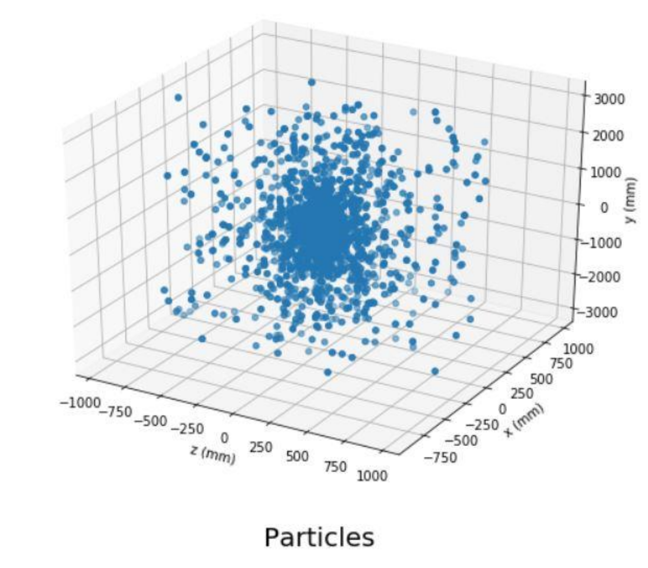


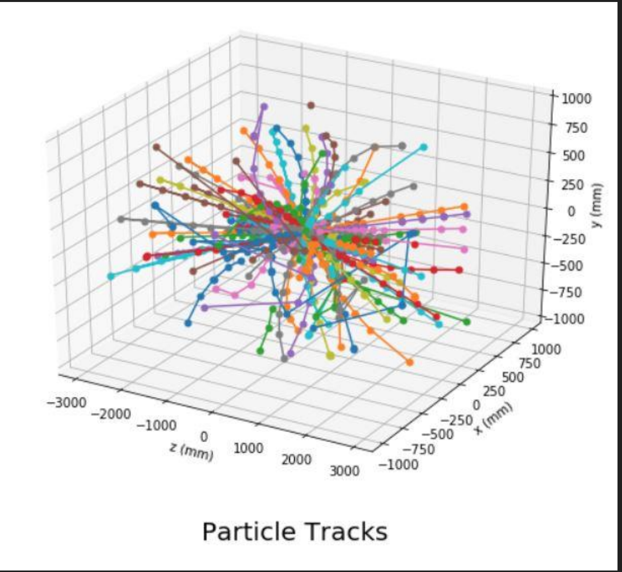


Cameron Marcus and Peter Larsen

Problem Outline

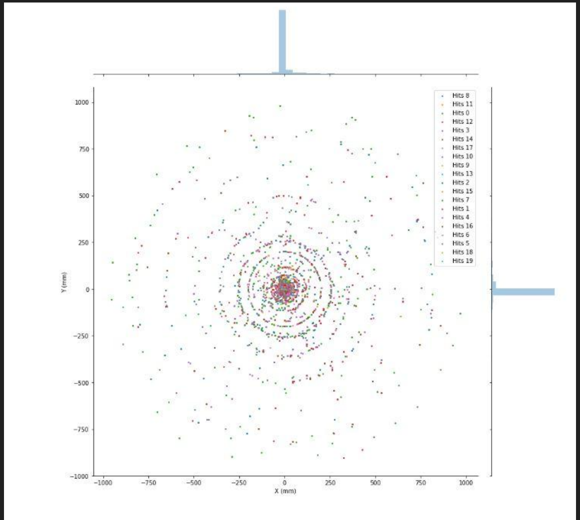
“Build an algorithm that quickly reconstructs particle tracks from 3D points left in the silicon detectors.”





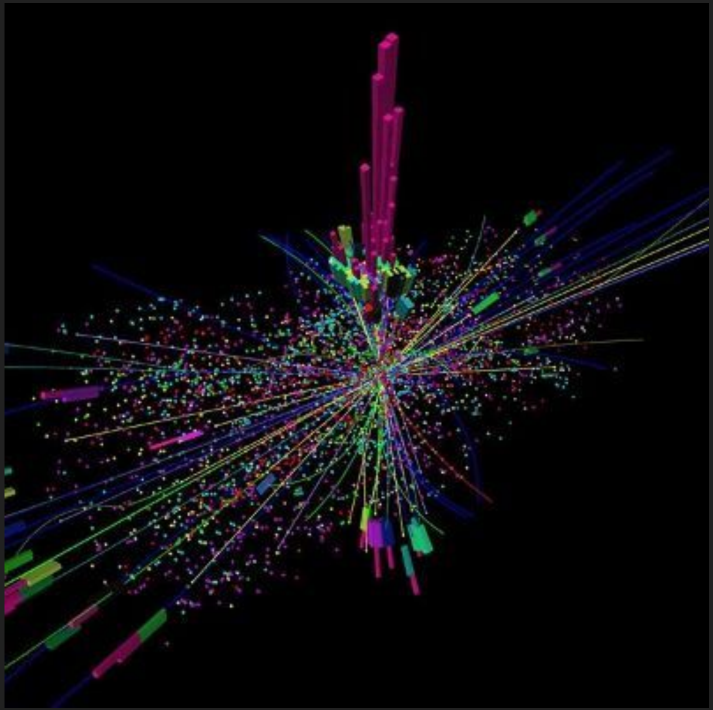
Data

- Four 70Gb training set
- Each set with 1800 events
  - Each event has 120,000 Hits
- Features
  - (x, y, z) coordinates of hits in detector (as well as the volume, layer, and module of the silicon detector.
  - Particles: Each particle's initial position (vx, vy, vz), momentum (px, py, pz), charge (q) and number of hits.
  - Cells (location of where each particle hit a certain module and energy deposited)



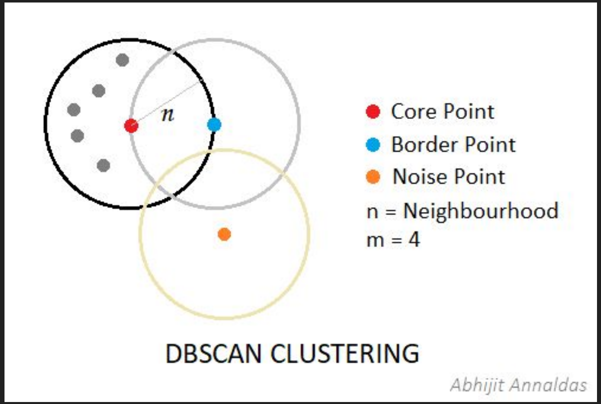
Evaluation

- Hits near the center and near the end have a larger weight than those on the outside
- Hits that from straight tracks have a greater weight
- Random or short tracks have no weight
- Sum of the weights of all hits in an event is 1



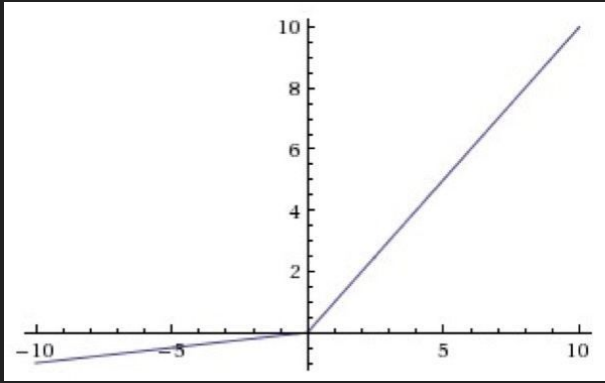
Density Based Spatial Clustering of Applications with Noise (DBSCAN)

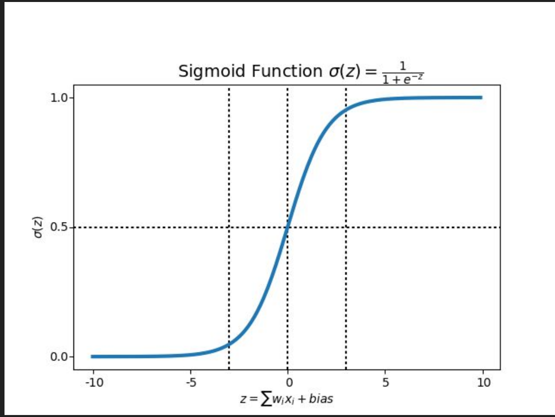
- Arbitrary shape and number of groups
- Clusters groups based on density of points
- Two parameters
  - Eps: Radius of neighborhood
  - MinPts: Minimum number of points in the neighborhood
- $N_{Eps}(q)$: {p belongs to D | dist(p,q) <= Eps}
- Core point condition: $|N_{Eps}(q)| >= MinPts$
- Points can be density-reachable by multiple core points to form density-connected clusters
- Results: 0.204



Neural Network

- Binary classification (seeing if two hits are from same particle track)
- 6 fully-connected layers
- Number of neurons in layers goes from 1024 and decreases each layer by a factor of 2.
- Uses leaky-relu activation function
- Last fully connected layer has a output of one with a sigmoid activation function
- Training took around 40 minutes on a Nvidia GTX 1080
- Predicting takes around 2.5 hours





Prediction

	H1	H2	H3	H4	H5
H1	----	0.42	0.13	0.24	0.75
H2	0.42	----	0.27	0.84	0.34
H3	0.13	0.27	----	0.58	0.66
H4	0.24	0.84	0.58	----	0.29
H5	0.75	0.34	0.66	0.29	----

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- Track 1 = Hit 1 → Hit 5 → Hit 3
- Track 2 = Hit 2 → Hit 4
- Track 3 = Hit 3 → Hit 5 → Hit 1
- Similarities are then merged

That’s cool and all but what about Results?

0.4535

Sources

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