Clustering of layer clusters to reconstruct tracksters using Gaussian Mixture Model

HACKATHON WITH CERN, 14/07/2021

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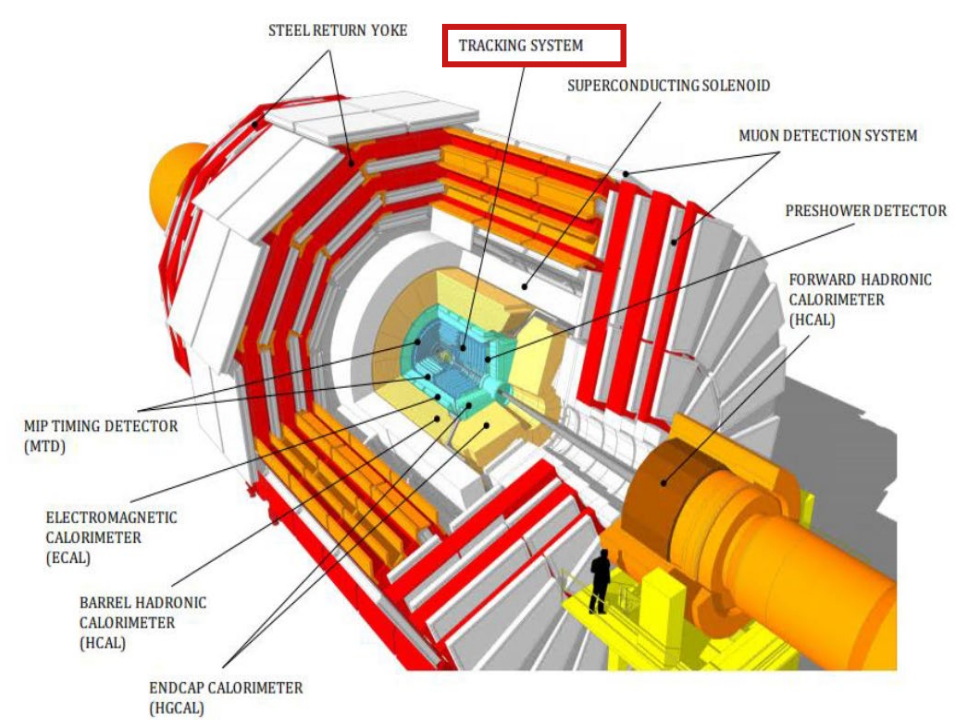
Background

- Compact Muon Solenoid (or CMS) detector
- Trackers – hits (bent charged particle hits silicon)

Goal:
Reconstruct the tracksters (first three for each lc) by putting the puzzle of each hit or layer clusters together



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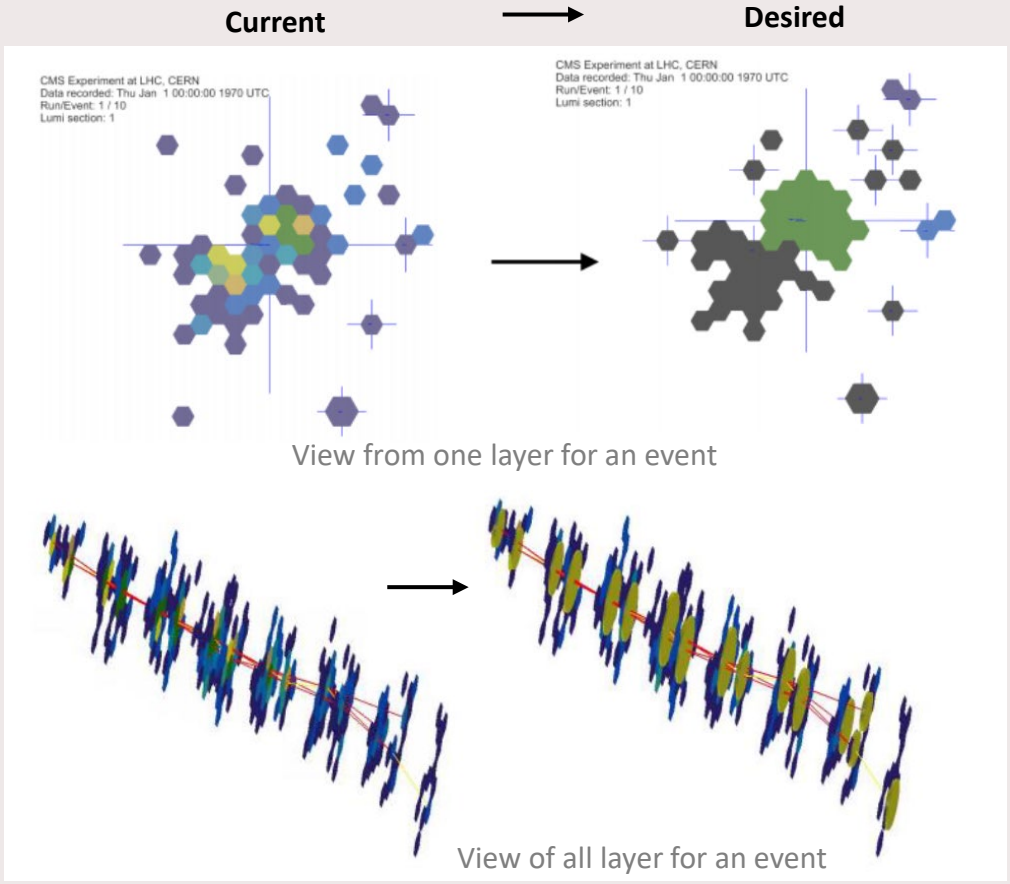
Background

One event

- ✓ Captured for 25ns
- ✓ Contains several points based on hits
- ✓ Each hit/layer cluster/point contains:
  - 3D coordinates (x,y,z)
  - Eta, phi
  - Energy
- ✓ Can contain single or multi particles



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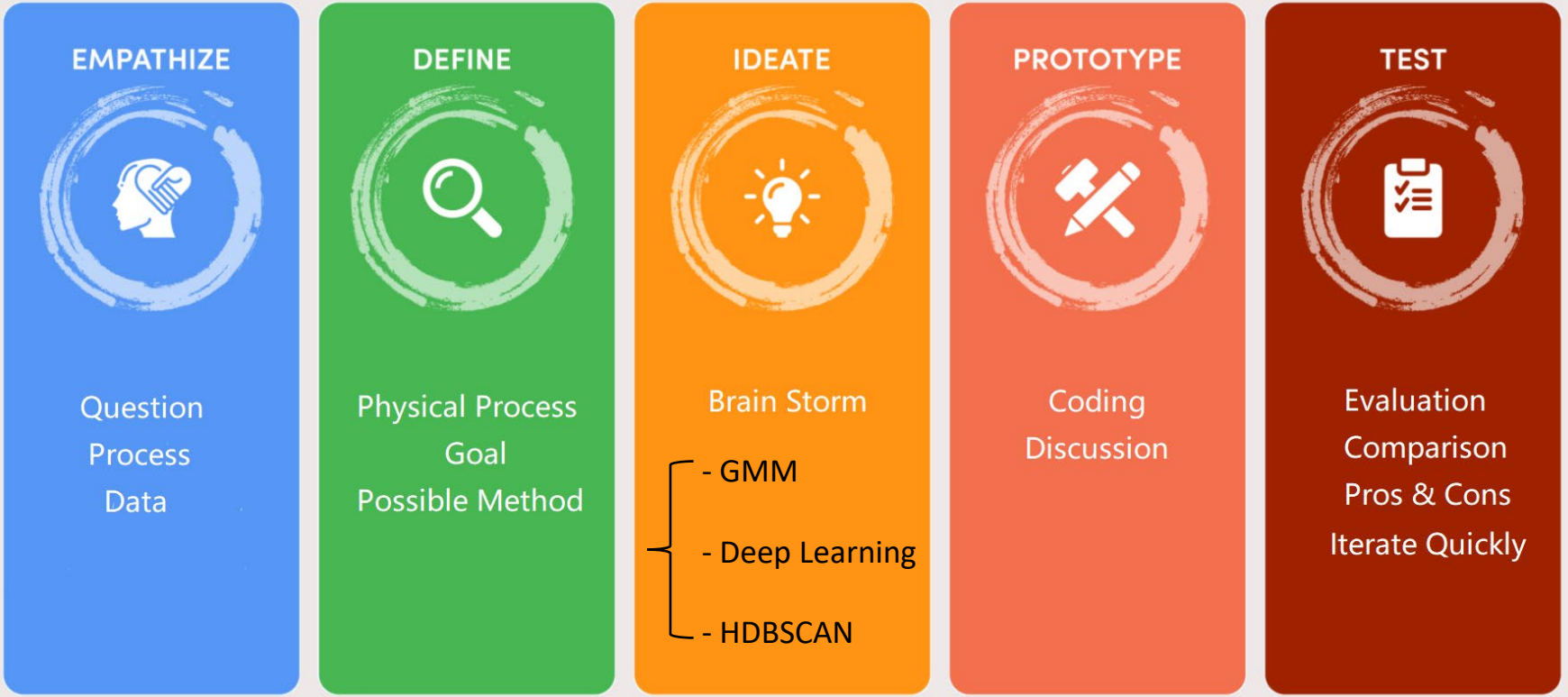
Design Pipeline



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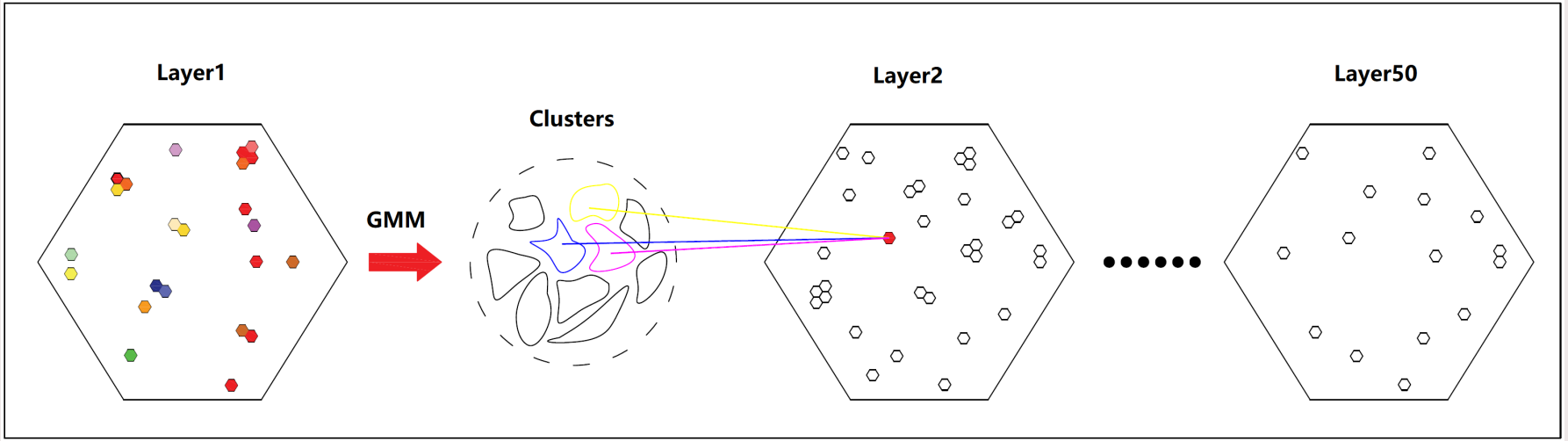
Method: idea



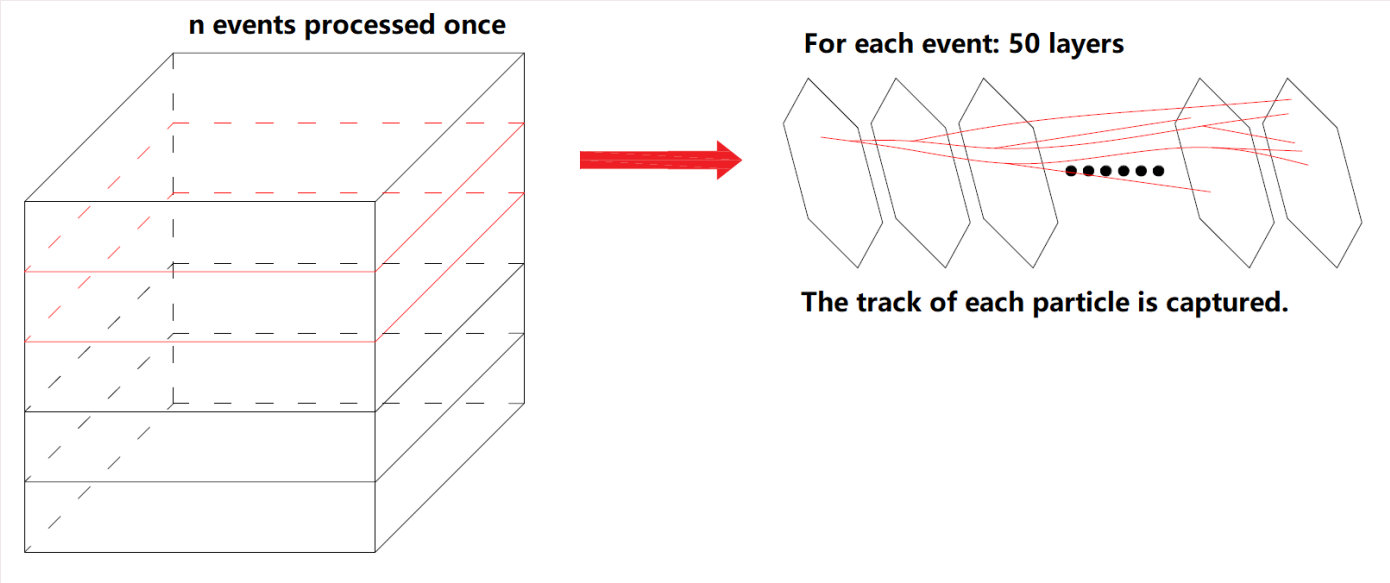
For one event:

Step1 : Use GMM to cluster the 1st layer (each hit recognized as a particle and made into a cluster)

Step2 : For later layers (Layer2 to Layer50), for each hit, use the existing GMM clustering model to predict the possibilities to all the clusters this hit belongs. Choose the top 3 candidates as its source.

Step3 : Store the output information (source index, energy fraction, trackster).

Method: implementation

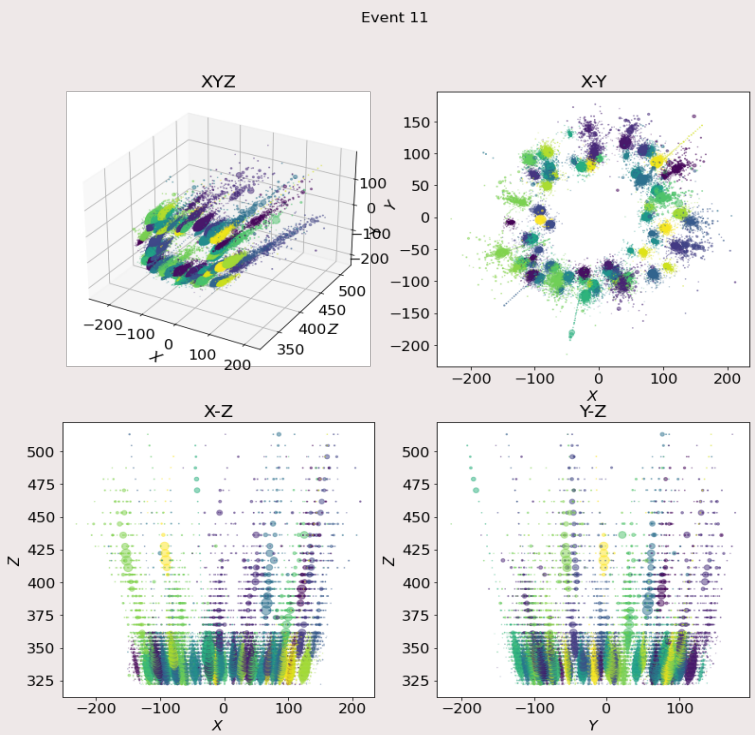


Process the events one by one and stack the results in one output array for each output value (source index, energy fraction and trackster).

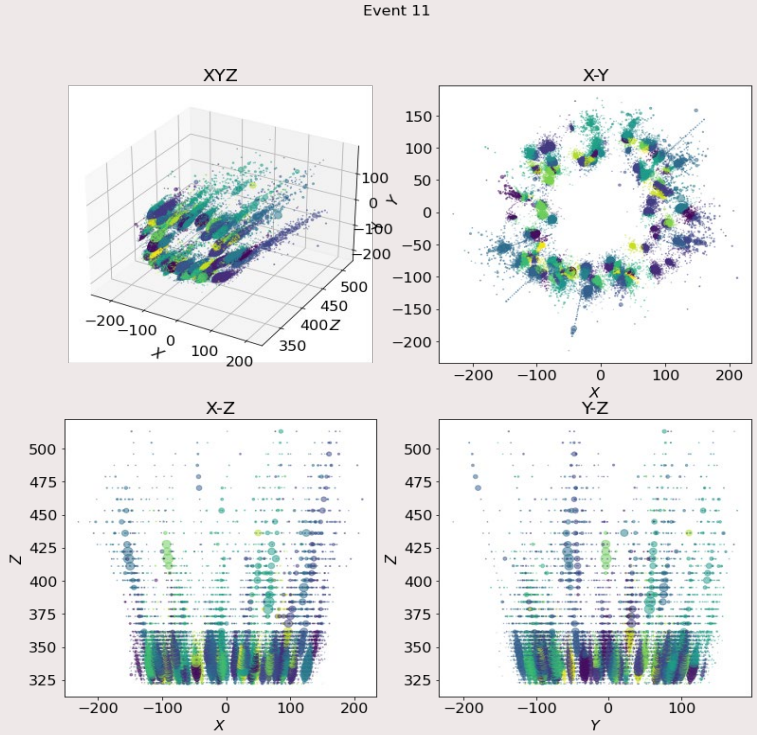
Result

fourparts_merged_test.root, event 11

Ground truth



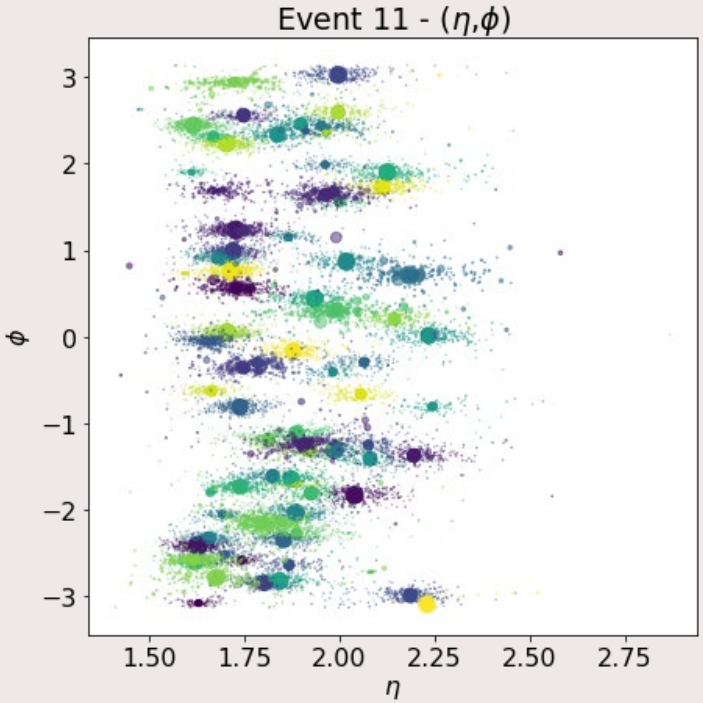
Predict



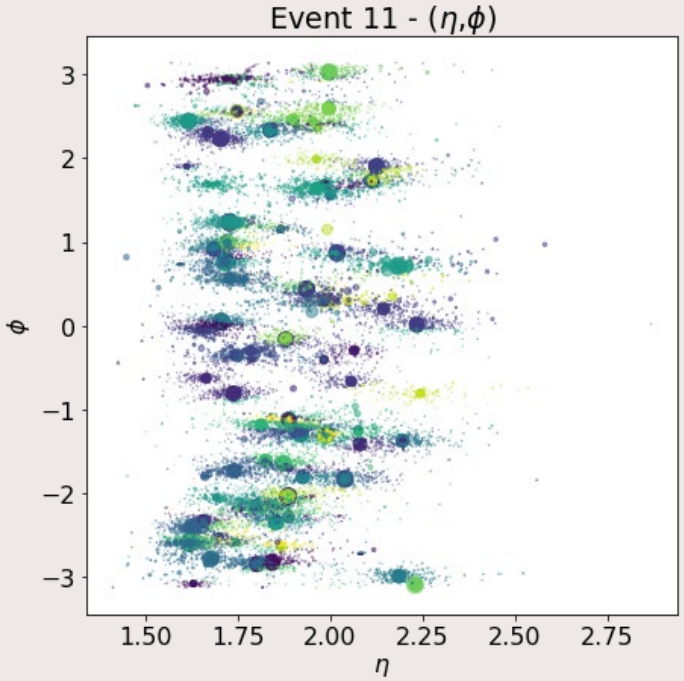
Result

fourparts_merged_test.root, event 11

Ground truth



Predict



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Result

fourparts_merged_test.root, 100 Events

Evaluation Metrics	GMM Performance	Demo Performance
Reco trackster efficiency	0.896	0.533
Reco trackster purity	0.818	0.861
Shooting rate	2.49111423153382	18.475

Yay!

Conclusion

Advantages	Room for Improvements
It is logic: The particles in Layer 1 are very likely belongs to a solo cluster	What if there is **no** Layer 1?
For each event, we have different center of clusters.	We assume that one particle results in only one hit in Layer1. That's why our shooting rate is larger than 1.

Future scope

- **No Layer 1**

Solution: Instead of using layer 1, we can check which is the first layer that a point appears, then treat that layer as "**layer 1**".

- **Too few points in Layer 1**

Solution: If there are too few points in layer 1, we can treat the second layer as the target of cluster as well.

- **Not all hits in Layer 1 is one specific particle.**
- But this needs more effects to investigate....